Laboratório de Instrumentação e Física Experimental de Partículas

Relatório de Actividades

2010

Contents

Chapter 1

Overview

1.1 Resumo

O LIP é uma associação científica e técnica de utilidade pública que tem por objetivos a investigação no campo da Física Experimental de Altas Energias e da Instrumentação Associada. Os domínios de investigação do LIP têm crescido por forma a englobar além da Física Experimental de Partículas, a Física Experimental de Astropartículas, a Investigação e Desenvolvimento em Instrumentação e Detetores, a Computação Avançada e aplicações a outros campos, em particular a Física Médica.
O LIP tem sempre manifestado uma atenção sustentada à formação científica avançada que culminou em 2010 com a criação da IDPASC, um consórcio internacional de Universidades e Grandes Centros de Investigação Internacionais que se estruturam para a realização comum e distribuída de programas de doutoramento em Física de Partículas, Astropartículas e Cosmologia (ver http://www.idpasc.lip.pt/).
O LIP desenvolve ainda um grande número de atividades de divulgação, treino e iniciativas de treino avançadas nestas várias áreas, e contacta regularmente o mundo industrial como Industrial Liaison Office do CERN e de outros laboratórios internacionais, sendo também responsável pela transferência de tecnologia de diversas organizações internacionais para a indústria Portuguesa.
O LIP é um Laboratório Associado avaliado como ´Excelente´ em quatro avaliações sucessivas por painéis internacionais.
As atividades de investigação e desenvolvimento são enquadradas com atividades de investigação em Física experimental, em ligação à comunidade científica teórica. A maior parte dos projetos de investigação são desenvolvidos no âmbito de grandes colaborações no CERN e em outras organizações internacionais e grandes infraestruturas dentro e fora da Europa, como o ESA, o SNOLAB, o GSI, a NASA e o Observatório Pierre Auger. Nestes projetos científicos comuns, o LIP contribui com os seus próprios recursos técnicos e científicos.
Nos seus dois polos, em Coimbra e em Lisboa, o LIP tem aproximadamente 170 colaboradores, dos quais mais de 70 são doutorados, sendo muitos professores nas universidades locais. No início de 2010, o LIP estabeleceu com a Universidade do Minho um protocolo sob o qual o LIP irá estar presente no Departamento de Física daquela Universidade como uma equipa de investigação autónoma.
As infraestruturas computacionais do LIP, as maiores na comunidade científica e académica Portuguesa, são atualmente utilizadas por uma comunidade internacional de mais de 150 instituições de investigação. Durante 2010 foram executadas no LIP mais de 67 milhões de horas equivalentes de computação originárias de todo o mundo.
Também outras infraestruturas técnicas do LIP, como as oficinas de precisão mecânica, se encontram abertas às necessidades da comunidade científica Portuguesa e internacional. E, ao desenvolver projetos ambiciosos na área da Física Médica, o LIP trabalha conjuntamente com centros de investigação, hospitais e com o setor privado, através da partilha de instalações de pesquisa - o Laboratório do Tagus LIP para Física Médica.
Assim, o LIP mantém as suas atividades de investigação na Física experimental de partículas e de instrumentação associada, estendendo-as a novas áreas e estabelecendo ligações com as comunidades relacionadas, a nível nacional e internacional.

1.2 Abstract

LIP is a non-profit scientific and technical association of public utility that has for goal the research in the fields of Experimental High Energy Physics and Associated Instrumentation. LIP´s research domains have

grown, to encompass now Experimental High Energy Physics and Astroparticle Physics, R&D in Detectors and Instrumentation, Advanced Computing and applications to other fields, especially Medical Physics.
LIP has always demonstrated a sustained attention to the advanced scientific formation which culminated, in 2010, with the creation of IDPASC, an International network of Universities and major Investigation Centers which have gathered to the common realization of distributed PhD programs in Particles Physics, Astroparticles and Cosmology (cfr. http://www.idpasc.lip.pt)
Moreover, LIP develops a large number of outreach activities, advanced training initiatives, contacts regularly the industrial world as Industrial Liaison Office for CERN and other international laboratories, being also responsible for technology transfer from large international organizations to the Portuguese industry.
LIP is an Associated Laboratory assessed as ´Excellent´in four successive evaluations by international panels.
The research and development activities are based on experimental Physics research in close contact with the theoretical physics community. The main research activities of the laboratory are developed in the framework of large collaborations at CERN and at other international organizations and large facilities in Europe and elsewhere, such as ESA, SNOLAB, GSI, NASA and the Pierre Auger Observatory. In these common projects, LIP contributes with its own resources, technical and scientific, to the purpose of the common scientific programs.
In its two laboratories in Coimbra and Lisbon, LIP has about 170 people, out of which more than 70 hold a PhD degree, and many are professors at the local universities. In the beginning of 2010, LIP established with the Minho University a protocol under which LIP will be present at the Minho University Physics Department as an autonomous research team.
LIP computing facilities, the largest in the Portuguese scientific and academic community, are currently used by an international community of more than 150 research institutions. During 2010, LIP hosted more than 67 million hours equivalent of computing providing computing power to the global scientific community.
Also other technical LIP infrastructures, like the precision mechanics workshops, are open to the needs of the Portuguese and international scientific community.
And, when developing ambitious projects in the area of Medical Physics LIP works together with research centers, hospitals and the private sector, through a shared research facility - the Tagus LIP Laboratory for medical physics.
LIP thus keeps its main activities in experimental particle physics and associated instrumentation, extending it to new areas including advanced academic training in cooperation with the universities and in close connection to related communities, at both the national and international levels.

1.3 Objectives

LIP is committed to the continuous consolidation and growth of its main 6 grand areas of activity as already described. One of the main objectives of the overall LIP activities is the continuous effort to train scientists and integrate promising young scientists in our established and supported program of research. Subjacent to all the areas of LIP activities, but primarily to the basic research areas, is a continuous effort of linking strongly research with higher education. The participation in ambitious higher education programs with the creation of the IDPASC consortium in 2010 received the adequate institutional infrastructure to become a reference for students and teachers.
We definitely are now centering a large effort in the Education Area as a strategical line of activity for the years to come.

1.4 Achievements

We will summarize only a few topics on LIP activities in 2010:

Experimental Particle Physics:
LIP was created in 1986 as the reference National Laboratory for collaboration with CERN in the area of accelerator experiment Particle Physics. LIP keeps this commitment as its central domain of research, not only at CERN but where accelerators facilities can be used like GSI in Germany. Our main effort has been centered for the last 15 years on the design, construction and commissioning of the two main LHC experiments: ATLAS and CMS.
The LHC began operations during the last quarter of 2009 and started in 2010 a 18 to 24 months of continuous running, at half the nominal energy. During the 2010 LIP participated enthusiastically in the harvest of physics data. After the commissioning of the detectors, these data allowed us to start the exploration of a rich spectra of LHC physics.

However, LIP keeps its accelerator program diversified, with sustained collaborations with the COMPASS (CERN) and Hades (GSI) experiments, for which both technical responsibilities and data analysis are ongoing. The Future Plans in the LIP Experimental Particle physics research is based in very long term experiments. The described LHC commitments will last for the next 12 to 15 years including the LHC upgrade (super-LHC) and the corresponding detectors upgrade. LIP will consider carefully new opportunities for collaboration with future European Accelerator R&D and facilities namely CLIC (CERN), FAIR (GSI) and SuperB factory (LN-Frascati).

Experimental Astroparticle Physics:
Experimental Astroparticle Physics is now also an established strong area of activity of this Laboratory. The consolidation of this area will continue, namely, with a strong analysis effort on the current data from the Pierre Auger
Observatory for high energy cosmic rays, and work towards the Observatory extensions but also in reinforcing LIP participation in ambitious R§D programs on instrumentation strategical for Astroparticle Experiments.
We also remain committed to other Astroparticle Physics projects. In Dark Matter search, the large team at Coimbra, evolved from the UK based ZEPLIN project and became a member of a larger collaboration - LUX, in the USA. Once the combined analysis of the full SNO data will be finished, our efforts in Neutrino Physics will now be fully dedicated to SNO+.
2010 was also marked by the preparation for the installation of AMS in the International Space Station.

Instrumentation:
The follow-up of current R&D work in various projects is assured. We will continue the studies of basic properties of interest for detector development and the long terms R&D programs on GEMs and RPCs detectors. The integration of these detectors in experimental set-ups will be followed closely and influence the physics analysis which we will concentrate on for those experiments. New applications in Particle Physics Experiments and Medical Physics are being considered.

Medical Physics:
LIP has continued to be involved in several lines of research:
a) ClearPEM scanners for breast cancer detection
The construction of a second ClearPEM scanner for integration with ultrasound in collaboration with CERN and other partners is well under way (ClearPEM-Sonic Project). We intend also to develop technology for a Positron Emission Tomography (PET) scanner for large animal imaging, suitable for association with Magnetic Resonance Imaging.
b) RPC-PET
The RPC-PET concept is being consolidated. This project specifically aims at designing building, testing and developing a first prototype of a full-size human whole body TOF-PET scanner.
c) Dosimetry and development of new dosimeters for clinical and radioprotection
applications

Outreach, Training & Industrial Liaison and Technology Transfer:
LIP has engaged its researchers in actively promoting the outreach in Particle and Astroparticle Physics, training of high-school students and teachers, support to the media in news related to the areas of research at LIP, and definition inside LIP of an Industrial Liaison Officer and the adhesion of LIP to the CERN´s Technology Transfer Network.
In 2011, LIP will celebrate its 25th anniversary and the 30 the anniversary of the public exhibition "What are things made of?", coupled to the EPS High Energy Physics conference in 1981, that launched the joining of Portugal to CERN. In 2012, LIP will participate in the celebration worldwide of the 100th anniversary of the experiments from Victor Hess that discovered Cosmic Rays.

Computing:
R&D on distributed computing for scientific applications has been the main area of focus. Grid computing infrastructures are now actively used by many research communities. We will focus on improvements to the robustness and usability and also study the combined use of grid and new distributed computing approaches like cloud computing over such virtualized environments. Another new topic of research is the preservation of data and processes aimed at recovering and replaying old computational tasks.
We will continue to address other topics such as operations management, monitoring, interactivity, prioritization, resource management, and advanced computing in the grid environment.

These activities are carried out in the context of the European Grid Initiative, Iberian Grid Initiative, Worldwide LHC Computing Grid and Portuguese National Grid Initiative.

1.5 Sources of Funding for LIP Lisboa

Project	Code	Funding	Entity	Start	End
ATLAS	CERN/FP/109309/2009	290.000 €	FCT	2009-11-02	2010-12-31
CMS	CERN/FP/109343/2009	300.000 €	FCT	2009-11-01	2010-12-31
COMPASS	CERN/FP/109323/2009	150.000 €	FCT	2009-11-01	2010-12-31
GRID	IBERGRID	4.250 €	LIP	2007-01-01	2011-12-31
	G-CAST	1.000 €	FCT	2008-01-01	2010-12-31
	EGEE-III	307.000 €	EU	2008-05-01	2010-04-30
	EGI InSPIRE	485.000 €	EU	2010-05-01	2014-04-30
	GRID/GRI/81842/2006	180.700 €	FCT	2007-09-10	2010-09-09
HECR	CERN/FP/109286/2009	145.000 €	FCT	2009-11-01	2010-12-31
OUTREACH	PTP 2010 CERN	45.655 €	Ciência Viva	2010-09-04	2010-09-10
	MC2011_RadAmb2010-2011	15.000 €	Ciência Viva	2010-10-01	2011-06-30
	OCJF 2010	1.200 €	Ciência Viva	2010-06-01	2010-10-31
	Masterclasses and Env.Rad.	15.000 €	Ciência Viva	2009-10-01	2010-07-31
PET - Mammography	PIC/IC/83228/2007	67.550 €	FCT	2009-03-26	2011-03-25
	Pet - Mammography II -b	504.344 €	AdI	2008-07-01	2010-12-31
Space	ESA:223981/09/NL/PA	150.000 €	ESA	2009-05-01	2011-04-30
	PDCTE/CTE-SPA/81678/ 2003	69.552 €	FCT	2008-01-01	2010-12-31

1.6 Sources of Funding for LIP Coimbra

Project	Code	Funding	Entity	Start	End
ATLAS GRID	GRID/GRI/81727/2006	140.000 €	FCT	2007-04-12	2011-04-11
Compton in PET	PTDC/FIS/67002/2006	72.000 €	FCT	2009-01-01	2011-12-31
GEMs	FP7-GA226507	80.640 €	EU	2009-02-01	2012-01-31
	CERN/FP/109359/2009	10.000 €	FCT	2010-01-01	2010-12-31
HADES	LIP-GSI contract	414.000 €	GSI	2005-10-01	2011-03-31
	CERN/FP/109373/2009	10.000 €	FCT	2009-10-01	2010-12-31
	EU Contract 515876 DIRAC-Phase-1	52.000 €	EU	2005-10-01	2011-03-31
Human PET	PTDC/SAU-BEB/104630/ 2008	120.856 €	FCT	2010-04-01	2013-03-31
Phenomenological Studies at the LHC	CERN/FP/109372/2009	35.000 €	FCT	2009-11-01	2010-10-31
RD51	CERN/FP/83524/2008	20.000 €	FCT	2008-10-01	2010-03-31
	CERN/FP/109355/2009	30.000 €	FCT	2010-04-01	2011-03-31
ZEPLIN	CERN/FP/109320/2009	70.000 €	FCT	2010-01-01	2010-12-31

1.7 Scientific Statistical data

Project	Publications			Conferences			Semi-	Outr.	Theses			Evts.
	Jrn-I	Jrn-II	other	int.o	int.p	nat.	nars	Sem.	G	M	D	
ATLAS	15	3	5	4	1	10	1			4	1	
CMS	12	5	23	15	1	4	16	5			1	
COMPASS	5	4	9	5		3				1		
HADES	4	1	1	1								
Phenomenological Studies at the LHC	6	2	1									
GRID			10	7		11	4	1				1
ATLAS GRID			3	2		1				1		
AMS	3	3	1	3		1		2			1	
SNO	2	1	1	1	1	3	2					1
ZEPLIN	3	3	1	1		5				1	1	
HECR	10	6	1	10	1	3				1		3
Air Scintillation				1								1
Space				3	2	3	1					
PET - Mammography			1									
Human PET	1	1	1	1								
Compton in PET				1								
MC in Medical Physics	1	1	2	4	6	7		1		1	1	2
RD51	6	6	1	1	1							
GEMs	3	3			2							1
OUTREACH				3		5		40				21
TTN-ILO												
Scientific Conferences and Seminars												3
Totals:	71	39	61	63	15	56	24	49		9	5	33

Legend:

Publications:

Jrn-I: Publications in international journals with scientific peer review co-authored by LIP members

Jrn-II: Subset of publications Jrn-I in which LIP members had a major responsibility

Other: Internal notes, conference proceedings, etc. with direct involvement of LIP members

Conferences:

Int.o: Oral presentations by LIP members in international conferences

Int.p: Poster presentations by LIP members in international conferences

Nat.: Presentations by LIP members in national conferences

Seminars: Invited seminars in Institutes or Universities

Outr. Sem.: Seminars for students or general public

Theses: Theses concluded during this year (G - Graduation, M - Master, D - PhD)

Evts: Organisation of events (conferences, workshops, collaboration meetings, etc.)

1.8 Human resources (people)

Project	Researchers	Technicians	Post-Docs	Students			
				D	M	G	O
ATLAS	13	1	3	8	5	1	
CMS	4	2	8	1	3		1
COMPASS	3	1	1	3	3		
HADES	6	2					
Phenomenological Studies at the LHC	9	1	2		2	1	
GRID	7	3		1			
ATLAS GRID	8		3	2	2		
AMS	3		2				
SNO	4	5		1	1		1
ZEPLIN	5	2	4	1	1		
HECR	16	3	4	3	2		2
Air Scintillation							
Space	6		3	1	2		
PET - Mammography	1	3	1	3	1		
Human PET	4	8					
Compton in PET	7	5	3				
MC in Medical Physics	4			1		1	4
RD51	6	10					
GEMs	5	3		1			
OUTREACH	9	2	1				
TTN-ILO		1					
Scientific Conferences and Seminars							
Totals:	73	22	25	23	20	2	8

Legend:

Students: D - PhD, M - Master, G - Graduation, O - Other

FTE: Full Time Equivalent

1.9 Human resources (FTE)

Project	Researchers	Technicians	Post-Docs	Students				total
				D	M	G	O	
ATLAS	6.38	0.50	2.20	6.55	3.92	0.38		21.93
CMS	3.50	1.08	8.00	1.00	2.50		0.50	16.58
COMPASS	3.00	1.00	1.00	3.00	3.00			11.00
HADES	0.66	0.20						0.86
Phenomenological Studies at the LHC	1.90	0.10	1.60		1.50	0.50		5.60
GRID	6.63	3.00		0.25				9.88
ATLAS GRID	1.92		0.30	0.75	0.92			3.89
AMS	0.75		1.20					1.99
SNO	0.60	0.55		1.00	0.25		0.25	2.65
ZEPLIN	2.25	0.60	3.75	0.50	1.00			8.10
HECR	6.63	1.47	2.13	2.05	0.97		1.34	14.59
Air Scintillation								
Space	1.30		2.40	1.00	1.25			5.95
PET - Mammography	0.20	1.29	1.00	3.00	1.00			7.16
Human PET	0.57	0.71						1.28
Compton in PET	1.55	0.40	0.45					2.40
MC in Medical Physics	3.00			0.80		0.30	2.64	8.54
RD51	1.48	0.82						2.30
GEMs	2.30	0.40		1.00				3.70
OUTREACH	1.60	0.37	0.10					3.87
TTN-ILO		1.00						1.00
Scientific Conferences and Seminars								
Totals:	46.22	13.49	24.13	20.90	16.31	1.18	4.73	

Legend:

Students: D - PhD, M - Master, G - Graduation, O - Other

FTE: Full Time Equivalent

Chapter 2

Particle Physics with Accelerators

2.1 Collaboration in the ATLAS experiment at CERN

2.1.1 Resumo

ATLAS é uma das experiências que operam no Grande Colisionador de Hadrões (LHC) no CERN, onde se dão colisões protão-protão e entre iões pesados a altas energias e luminosidades, abrindo uma nova fronteira na Física de Partículas. O objectivo é o estudo das propriedades fundamentais da matéria, principalmente a natureza da quebra da simetria electro-fraca e a origem da massa, através da procura da peça que falta no Modelo Padrão, o bosão de Higgs. A estrutura genérica do detector vai também permitir a sensibilidade a sinais de nova Física que se poderão manifestar a altas energias, como o modelo da Supersimetria, que pode explicar a abundância de Matéria Escura no Universo.
O grupo português de ATLAS contribui para os estudos de Física e para as actividades de manutenção e funcionamento do detector. Em termos de estudos de Física, o nosso foco é nos estudos com quarks top e bosões W com as primeiras observações e medições à escala de energia do LHC, ao mesmo tempo que se avança na pesquisa do bosão de Higgs e em estudos respeitantes ao comportamento de jactos de partículas em ambiente de colisão de iões pesados. Estamos activos na certificação, operação e estudos de desempenho do calorímetro hadrónico TileCal e do sistema de trigger de alto nível, bem como na construção e certificação do monitor de luminosidade absoluta ALFA.
O commissioning de ATLAS baseia-se no estudo de vários processos, tais como a produção e decaimento dos

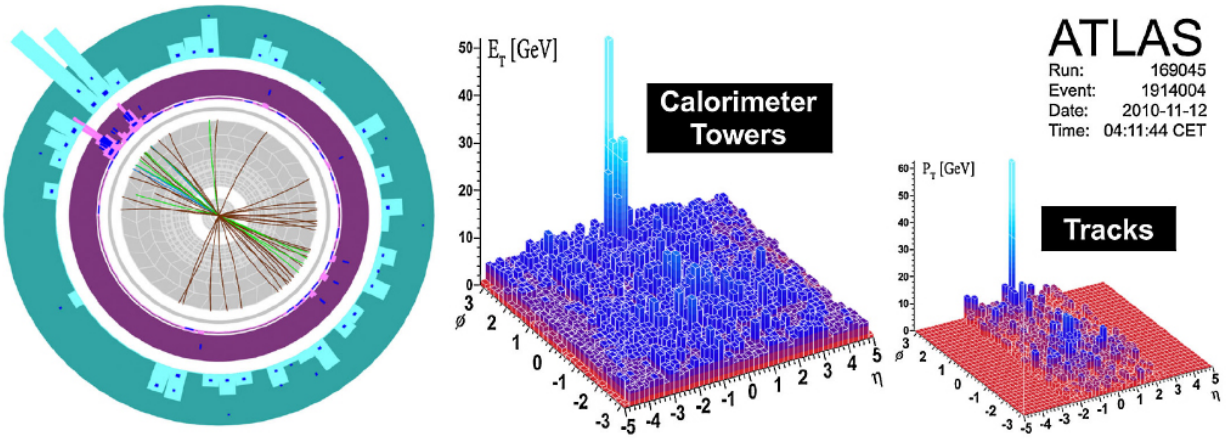

Figura 2.1: Event display of a highly asymmetric dijet event in heavy ion collisions, with one jet with ET > 100 GeV and no evident recoiling jet and with high-energy calorimeter cell deposits distributed over a wide azimuthal region. By selecting tracks with pT > 2.6 GeV and applying cell thresholds in the calorimeters (ET > 700 MeV in the electromagnetic calorimeter, and E>1 GeV in the hadronic calorimeter), the recoil can be seen dispersed widely over the azimuth.

bosões W e Z e do quark top. A medição da secção eficaz de produção inclusiva de W no canal em que o W decai em muão+neutrino foi um dos primeiros estudos de Física no LHC, com utilidade para o conhecimento do desempenho do detector e do trigger. Nesta fase, o decaimento do quark top também é importante, pois pode ser usado como teste para identificação do quark b e calibração da escala de energia. A observação da supressão de jactos no plasma de quarks e gluões resultante da colisão de iões pesados foi um dos resultados publicados por ATLAS em tempo recorde, e para isso contribuiu fortemente uma colaboradora da nossa equipa que foi responsável pela configuração da infraestrutura da qualidade dos dados de jactos no ambiente de iões pesados.
A calibração em energia de jactos do segundo nível de trigger (LVL2) prosseguiu, aplicando de forma simplificada os procedimentos de calibração offline aos algoritmos da reconstrução no LVL2. O bom desempenho da calibração permitiu já a validação do trigger LVL2 de jactos na região central do detector.
Nas actividades offline do TileCal, foram concluídos os estudos de performance do calorímetro em resposta em energia e sincronização, usando muões cósmicos e dados provenientes do uso de um feixe único do LHC. Foi publicado um artigo de resumo dos resultados do commissioning do TileCal com os sistemas de calibração, muões cósmicos e feixe único, do qual um dos membros da nossa equipa foi co-responsável pela edição.
Continuamos com o envolvimento no Sistema de Controlo do TileCal (DCS). O sistema está operacional, e foi implementada a interface de transferência dos dados do DCS para o ambiente Athena onde se efectua a análise dos dados de Física.
No que diz respeito às componentes ópticas do TileCal mantiveram-se algumas actividades, tal como o melhoramento da funcionalidade do sistema de monitorização com laser. Foi ainda mantida a participação na construção do detector de fibras cintilantes (detector ALFA) para medição da luminosidade de ATLAS e também estudos de avaliação do envelhecimento da óptica do TileCal com vista ao Super-LHC.
As actividades de bases de dados do Trigger/DAQ para controlo, configuração e monitorização de dados continuaram, centradas na ferramenta de apresentação de histogramas de controlo de qualidade Node2 e infraestrutura associada.
O projecto inclui também uma componente de divulgação, que foi intensa ao longo de 2010, com vários dos membros deste projecto a participarem nas MasterClasses em várias universidades, na escola para professores de língua portuguesa no CERN, em actividades do programa Ciência Viva para jovens estudantes do Verão e em exposições destinadas ao público em geral.

2.1.2 Abstract

ATLAS is one of the experiments that operates at the CERN Large Hadron Collider (LHC) where proton-proton and heavy ion collisions take place at unprecedented high energies and luminosities, opening a new frontier in particle physics. The goal is to study the fundamental properties of matter, mainly the nature of the electroweak symmetry breaking and the origin of mass, through the search for the missing cornerstone of the Standard Model, the Higgs boson. The general purpose detector structure will also allow the sensitivity to new Physics, such as Supersymmetry, that could explain the abundance of Dark Matter in the Universe.
The portuguese group contributions to ATLAS concern both Physics studies and detector performance and operation. In terms of Physics studies, we focus on early studies with the top quark and the W boson, heavy ion collisions, as well as searches for the Higgs boson. We are active in the commissioning, operation and performance studies of the TileCal hadronic calorimeter and High-Level Trigger and in the construction and commissioning of the ALFA absolute luminosity monitor.
The ATLAS detector construction, commissioning and Physics studies have been continued. They were centred in the Physics commissioning of the ATLAS detector, with the measurement of the W boson cross section, top quark properties and jet suppression in heavy ion collisions. The calibration of jets in the Level 2 of the trigger system was also studied, implemented and validated. The commissioning of TileCal and the complete ATLAS detector with cosmic muons was accomplished. The TileCal DCS was operational and the interface to transfer the respective data to Athena was implemented. The involvement in the construction of the ALFA luminosity detector and in optics ageing studies continued. The LHC restarted operations in November 2009 and it operated very well along the year, allowing to record an integrated luminosity of 45pb-1 that is being analysed.
The LIP members had the following positions in ATLAS:
- Publications Committee (A. Onofre)
- TileCal software co-coordinator (J. Maneira)
- TileCal readiness paper co-editor (J. Maneira)
- TileCal Speakers Committee (A. Gomes)

2.1.3 Objectives

Exploitation of the full physics potential of the ATLAS/LHC experiment at CERN is our final goal.
The commissioning of the ATLAS detector with LHC collision events and data analysis started and related objectives are the measurement of the production cross section of the W boson in the channel W-> mu nu, participation in the development of W benchmark tools, study of the top quark physics with emphasis in the anomalous couplings and measurement of the forward-backward asymmetry in top decays, starting of heavy ion activities with jets and preparation and validation of the jet calibration at trigger level 2 system.
Higgs boson searches in the channel H->b bbar at low mass range and high pT is a very important goal.
The finishing of the commissioning of the TileCal detector using cosmic rays and related Tile readiness paper should be accomplished.
Operation and maintenance activities in TileCal including reconstruction software, second laser setup and laser monitoring, correlated noise studies and DCS system activities, and in Trigger-DAQ tasks include mainly the development and support of NODE2 histograms browser and associated infrastructure are part of our long term responsibilities.
It is planned to improve the lifetime estimate of the optical components of TileCal, using natural and/or accelerated ageing, to participate in the construction, tests with high energy particle beams and analysis of the ALFA luminosity detector, and also in several outreach activities, such as Masterclasses and the School for portuguese language teachers at CERN.

2.1.4 Achievements

The ATLAS detector is taking collisions data since late 2009 when LHC restarted operation. The main tasks carried out have been the finalization of the commissioning tasks, operation of the detector and Physics and Performance studies, either with cosmic muons or with p-p and heavy ions collision events. A summary of the main achievements follows.

- Determination of the W production cross section and acceptance with the FEWZ simulator at NNLO was done as well as estimation of several systematic uncertainties of the W production.

- We participated in the definition of the ATLAS top quark Working Group common reconstruction criteria, namely in studies for photon reconstruction in the tt final states. Dedicated analysis were developed to study the Wtb vertex. The PROTOS generator was integrated in the ATLAS software framework. Specific analysis were developed for the rare decays of the top quark through FCNC.

- The existing software for jet reconstruction data quality developed for the p+p collisions was adapted for the heavy ions environment and our team has been also responsible for the configuration of the Jets infrastructure.

- For the jet calibration at the Second Level Trigger (LVL2) we studied the pT balance in di-jet events to determine the pT dependence of the jet energy scale. But the main effort went on the validation of the LVL2 jet trigger with real data. Thanks to our studies, the LVL2 central jet trigger was declared validated.

- For the analysis of H->bb in association with W or Z, we started exploring the tools that are needed to study the jet substructure in the boosted regime, at generator level and full simulation. We have also carried out studies of this channel in a non-boosted regime at 7 TeV, profiting from the possible scenario of more than one year of LHC data taking at this intermediate energy.

- The study to validate the Local Hadronic Calibration method using testbeam data showed that it is possible to recover 98% of the initial 180 GeV pion energy and 92% for pions with 2 GeV, and that for pions with momenta below 10 GeV the data are well described by the MC within 10%, while for pion momenta above 10 GeV the data are described within 2%.

- The commissioning of TileCal with cosmic muons included the validation of the energy scale calibration and the synchronization of the calorimeter. The usage of the TileMuonFitter algorithm developed by our team allowed to measure the response uniformity with an almost full coverage of the calorimeter. A final internal note detailing this work was prepared and submitted for review.

- The Tile readiness paper that documents the results of commissioning of TileCal with cosmics was completed and published.

- Tools to transfer TileCal DCS data to Athena were developed and implemented and these data now is available for the offline reconstruction.
- In what concerns TDAQ, several new functionalities have been added to Node2Gui to increase its usage efficiency.
- Optical ageing studies were centered in the PMTs. Recent measurements shown a clear increase in DC gain.
- The ALFA detector was built and tested with high energy particle beams at CERN. Track reconstruction analysis is underway.

2.1.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/109309/2009	290.000 €	2009-11-02	2010-12-31

2.1.6 Team

Project coordinator: Amélia Maio

Name	Status	%of time in project
Ademar Delgado	Master student (LIP)	100
Agostinho Gomes	Researcher (LIP)	85
Alberto Palma	PhD student (LIP/FCT)	100
Amélia Maio	Researcher (LIP/FCUL)	55
António Amorim	Researcher (FCUL)	15
António Onofre	Researcher (LIP/UMinho)	40
Belmiro Pinto	Researcher (LIP)	100
Bruno Galhardo	Graduate student (LIP)	38
Filipe Veloso	Post-Doc (LIP)	90
Helena Santos	Researcher (LIP)	100
Helmut Wolters	Researcher (LIP/FCTUC)	40
Inês Ochoa	Master student (LIP)	100
Joana Miguéns	PhD student (LIP/FCT) *	100
João Carvalho	Researcher (LIP/FCTUC)	40
João Gentil	PhD student (LIP/FCT)	100
João Pina	PhD student (LIP)	75
José Maneira	Researcher (LIP)	70
José Silva	PhD student (LIP)	50
Juan Aguilar-Saavedra	Researcher (LIP)	3
Lourenço Lopes	Master (LIP/FCUL)	100
Luís Gurriana	Technician (LIP)	50
Luís Seabra	Master student (LIP)	50
Manuel Maneira	Researcher (LIP/FCTUNL)	5
Mara Soares	On leave (LIP)	100
Mário Sargedas Sousa	PhD student (LIP) *	100
Mikael Chala	Master student	42
Nuno Anjos	Post-Doc (LIP/FCT)	100
Nuno Castro	Post-Doc (LIP/UGR/FCT)	30
Patricia Conde	Researcher (LIP)	80
Paulo Martins	PhD student (LIP/FCT)	50
Pedro Jorge	PhD student (LIP/FCT)	80
Susana Santos	Master student (LIP)	100
Yuri Nunes	Researcher (LIP)	5

2.1.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Measurement of Pion and Proton Response and Longitudinal Shower Profiles up to 20 Nuclear Interaction length with the ATLAS Tile Calorimeter*

Tilecal Collaboration
NIM A 615 (2010) 158-181

- *Study of energy response and resolution of the ATLAS barrel calorimeter to hadrons of energies from 20 to 350 GeV*
  Tilecal Collaboration
  NIM A 621 (2010) 134-150

- *Readiness of the ATLAS Tile Calorimeter for LHC collisions*
  ATLAS Collaboration
  Eur. Phys. J. C 70 (2010) 1193-1236

Articles in international journals (with indirect contribution from LIP members)

- *Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector*
  Atlas Collaboration
  (accepted)

- *Measurement of the W->lnu and Z/gamma*->ll production cross sections in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector*
  Atlas Collaboration
  JHEP 1012:060,2010 (accepted)

- *Observation of a Centrality-Dependent Dijet Asymmetry in Lead-Lead Collisions at sqrt(sNN) = 2.76 TeV with the ATLAS Detector at the LHC*
  Atlas Collaboration
  (accepted)

- *Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC*
  The ATLAS Collaboration
  arXiv:1003.3124v1 [hep-ex]

- *Charged Particle Multiplicities From p-p Interactions at sqrt(s)=900 GeV measured with the ATLAS Detector at the LHC*
  ATLAS Collaboration
  Phys Lett B 688 (2010) 21-42

- *Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions*
  ATLAS Collaboration
  Eur. Phys. J. C 70 (2010) 723-753

- *The ATLAS Inner Detector commissioning and calibration*
  ATLAS Collaboration
  Eur. Phys. J. C 70 (2010) 787-821

- *Performance of the ATLAS Detector using First Collision Data*
  ATLAS Collaboration
  J. High Energy Phys. 09 (2010) 056

- *The ATLAS Simulation Infrastructure*
  ATLAS Collaboration
  Eur. Phys. J. C 70 (2010) 823-874

- *Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC*
  Atlas Collaboration
  Phys. Rev. Lett. 105 , 16 (2010) 161801

- *Drift Time Measurement in the ATLAS Liquid Argon Electromagnetic Calorimeter using Cosmic Muons*
  ATLAS Collaboration
  Eur. Phys. J. C 70 (2010) 755-785

- *Commissioning of the ATLAS Muon Spectrometer with Cosmic Rays*
  ATLAS Collaboration
  Eur. Phys. J. C 70 (2010) 875-916

Collaboration notes with internal referee

- *Test Beam 2008: First Measurements with an ALFA Roman Pot Prototype*
  B. Allongue et al, A. Maio, A. Morais, A. Palma, P. Conde Muino
  ATL-LUM-INT-2010-001 ; ATL-COM-LUM-2009-018

- *Implementation and Performance of the ATLAS Jet Trigger*
  N. Anjos et al
  ATL-DAQ-PROC-2010-003 ; ATL-COM-DAQ-2010-001

- *Top quark properties with ATLAS*
  N. Castro et al
  ATL-PHYS-PROC-2010-004 ; ATL-COM-PHYS-2010-014

- *Synchronization of the ATLAS Tile calorimeter with cosmic muon data*
  J. G. Saraiva et al
  ATL-TILECAL-INT-2010-002 ; ATL-COM-TILECAL-2009-024

- *Performance of the ATLAS Jet Trigger in the Early sqrts=7 TeV Data*
  The ATLAS collaboration
  ATLAS-CONF-2010-094

2.1.8 Presentations

Oral presentations in international conferences

- *Measurement of top properties in ATLAS*
  presented by Filipe Veloso
  3rd International Workshop on Top Quark Physics — Bruges, Belgium.

- *Heavy Ion Physics with the ATLAS Detector*
  presented by Helena Santos
  Physics at the LHC 2010 — Hamburg, Germany.

- *Commissioning of the ATLAS Tile calorimeter with Single Beam and First collisions*
  presented by João Gentil
  12th Topical Seminar on Innovative Particle and Radiation Detectors — Siena, Italy.

- *ATLAS Status and First Results*
  presented by Patricia Conde
  International Conference on QCD, Theory and Experiment (QCD@work) — Martina Franca, Italy.

Poster presentations in international conferences

- *The ATLAS/TileCal Detector Control System*
  presented by Helena Santos
  IEEE RealTime 2010 — Lisbon, Portugal.

Presentations in national conferences

- *ATLAS a funcionar: primeiras colisões e resultados*
  presented by Alberto Palma
  Jornadas do LIP 2010 — Braga, Portugal.
- *Commissioning do Tilecal, calorímetro hadrónico do ATLAS*
  presented by João Gentil
  Jornadas do LIP 2010 — Braga, Portugal.
- *Calibração do Tilecal*
  presented by Paulo Martins
  Jornadas do LIP 2010 — Braga, Portugal.
- *Estudo do Ruido Correlado no Tilecal*
  presented by Miguel Fiolhais
  Jornadas do LIP 2010 — Braga, Portugal.
- *Jactos em ATLAS*
  presented by Joana Miguéns
  Jornadas do LIP 2010 — Braga, Portugal.
- *Performance of the ATLAS Tile Calorimeter with cosmic ray muons*
  presented by Mário Sargedas Sousa
  Física 2010 — Univ. Trás-os-Montes e Alto Douro.
- *Measuring High Energy Hadrons at the LHC: the ATLAS Tile Calorimeter*
  presented by Agostinho Gomes
  Física 2010 17ª Conferência Nacional de Física — Vila Real, Portugal.
- *Measurement of top properties in ATLAS*
  presented by Filipe Veloso
  Física 2010 17ª Conferência Nacional de Física — Vila Real, Portugal.
- *Prospects for the Discovery of the Higgs Boson in the Channel pp->WH->mu nu b bbar*
  presented by Joana Miguéns
  Física 2010 17ª Conferência Nacional de Física — Vila Real, Portugal.
- *Observation of first W bosons with the ATLAS detector*
  presented by Pedro Jorge
  Física 2010 17ª Conferência Nacional de Física — Vila Real, Portugal.

Oral presentations in collaboration meetings

- *LASER system intervention*
  presented by Bruno Galhardo
  TileCal Operation Weekly Meeting — CERN.
- *HLT Studies with 900GeV Data*
  presented by Joana Miguéns
  Jet Trigger Signature Group Meeting — CERN.
- *Tile Readiness paper*
  presented by José Maneira
  TileCal Institutes Board — CERN.

- *Analysis of the EUDET telescope data ALFA test beam analysis*
  presented by Luís Seabra
  — .
- *Calibration of LVL2 Jets with Numerical Inversion (and first look at energy scale with data)*
  presented by Nuno Anjos
  — .
- *Calibration of the LVL2 Jet Trigger*
  presented by Patricia Conde
  Jet Calibration Task Force — CERN.
- *Analysis of the EUDET telescope data ALFA test beam analysis*
  presented by Luís Seabra
  — .
- *Status of Tile readiness paper*
  presented by José Maneira
  Tile Management meeting — CERN.
- *Analysis of the EUDET telescope data ALFA test beam analysis*
  presented by Luís Seabra
  — .
- *HLT at EM scale: Status report*
  presented by Nuno Anjos
  — .
- *Readiness of the ATLAS Tile Calorimeter for LHC collisions*
  presented by José Maneira
  TileCal readiness paper: first draft open presentation — CERN.
- *LVL2 Jets at 7 TeV*
  presented by Nuno Anjos
  — .
- *Analysis of the EUDET telescope data ALFA test beam analysis*
  presented by Luís Seabra
  — .
- *Jet Trigger Performance at L2 with 7TeV Data*
  presented by Joana Miguéns
  Jet Trigger Signature Group Meeting — CERN.
- *Calorimeter and Conditions: TileCal*
  presented by José Maneira
  ATLAS Reconstruction meeting — CERN.
- *OTP report for January-June 2010*
  presented by José Maneira
  Tile Management meeting — CERN.
- *Analysis of the EUDET telescope data ALFA test beam analysis*
  presented by Luís Seabra
  — .
- *status and plans for the TileCal LASER 2 system*
  presented by João Carvalho
  TileCal week — CERN.
- *Performance of the LVL2 jet trigger at 7 TeV*
  presented by Nuno Anjos
  — .

- *Update on the LVL2 jet trigger performance at 7 TeV*
  presented by Nuno Anjos
  — .
- *Update on the LVL2 jet trigger performance at 7 TeV*
  presented by Nuno Anjos
  — .
- *status of the TileCal LASER events analysis*
  presented by João Carvalho
  Tilecal Calibration, Data Quality, Performance and Processing — CERN.
- *Update on the LVL2 jet trigger performance at 7 TeV*
  presented by Nuno Anjos
  — .
- *LVL2 Jet Trigger Status and Validation*
  presented by Patricia Conde
  Jet Trigger Signature Group Meeting — CERN.
- *Update on laser analysis*
  presented by João Carvalho
  TileCal meeting — CERN.
- *LVL2 Jet Trigger Validation*
  presented by Patricia Conde
  Jet Trigger Signature Group Meeting — CERN.
- *LVL2 Jet Trigger Validation*
  presented by Patricia Conde
  Trigger General Meeting — CERN.
- *Looking at Distances between Jets*
  presented by Joana Miguéns
  Jet Trigger Signature Group Meeting — CERN.
- *Laser 1 results and comparison with Cs*
  presented by João Carvalho
  TileCal meeting — CERN.
- *Boosted WH Update from Lisbon*
  presented by Patricia Conde
  HSG5 H->bb Meeting — CERN.
- *First look at the non boosted regime at 7 TeV (WH)*
  presented by Joana Miguéns
  HSG5 H->bb Meeting — CERN.
- *Energy response uniformity to cosmic muons with a calorimeter-based reconstruction*
  presented by Mário Sargedas Sousa
  Tilecal Calibration, Data Quality, Performance and Processing — CERN.
- *Cut-flow and preliminary material from Lisbon*
  presented by José Maneira
  HSG5: CONF Note on WH, H->bb — CERN.
- *status of theTileCal LASER II system*
  presented by João Carvalho
  TileCal Week Operations/Maintenance — CERN.
- *TileCal DCS conditions in ATHENA (UPDATE)*
  presented by Helena Santos
  — .

- *status and plans for the TileCal LASER system*
  presented by João Carvalho
  Tilecal Calibration, Data Preparation and Performance in Tile Week — CERN.
- *update on the TileCal LASER events analysis (and comparison with Cs)*
  presented by João Carvalho
  TileCal meeting — CERN.
- *Jet Data Quality Monitoring for the Pb+Pb run*
  presented by Helena Santos
  — .
- *LVL2 Calibration*
  presented by Nuno Anjos
  Jet Trigger Signature Group Meeting — CERN.
- *Status Report on Pileup Studies*
  presented by Helena Santos
  — .
- *Jet Data Quality Monitoring for the Pb+Pb run*
  presented by Helena Santos
  — .
- *Jet Data Quality Monitoring for the Pb+Pb run*
  presented by Helena Santos
  — .
- *LVL2 Jet Trigger Validation and Status*
  presented by Nuno Anjos
  — .
- *Jet Data Quality Monitoring for the Pb+Pb run*
  presented by Helena Santos
  — .
- *Status of the Non-boosted WH Analysis from LIP-Lisbon*
  presented by Joana Miguéns
  HSG5 H->bb Meeting — CERN.
- *Jet Data Quality Monitoring in the Pb+Pb run*
  presented by Helena Santos
  — .
- *Jet Kinematics in HI collisions*
  presented by Helena Santos
  — .
- *Test Beam 2010 Analysis - Layer Efficiency*
  presented by Luís Seabra
  — .
- *Multiplicities and layer efficiencies ALFA test beam 2010 analysis*
  presented by Luís Seabra
  — .
- *WH, H->bb status for Summer CONF note,*
  presented by Patricia Conde
  HSG5 H->bb Meeting — CERN.
- *A first look at the Underlying Event in Pb+Pb*
  presented by Helena Santos
  — .

Seminars

- *Physics in the LHC Era: First ATLAS Physics Results*
  presented by Patricia Conde
  LIP-Seminar — Lisboa.

(unspecified Communications)

- *Jet Data Quality Monitoring in the Pb+Pb run*
  presented by Helena Santos
  — .

2.1.9 Academic Training

PhD Theses

- *Integrated studies of the ATLAS Detector calibration and alignment processes and their impact in the scientific discovery potential*
  Belmiro Pinto, 2010-11-20
- *The Control System of the ATLAS/Tilecal*
  João Pina, 2011-01-21
- *Measurement of the W -> mu nu production cross section with the ATLAS detector*
  Pedro Jorge, (on-going)
- *Calibration and Performance of the Tile Calorimeter of ATLAS with cosmic ray muons*
  João Gentil, 2011-01-27
- *Medição da secção eficaz de produção do bosão W em ATLAS/LHC/CERN*
  Alberto Palma, (on-going)

Master Theses

- *Uniformity of the energy response of the ATLAS hadronic Tile calorimeter to cosmic muons*
  Mário Sargedas Sousa, 2010-10-27
- *Contribuição para a construção e testes de performance do detector ALFA/ATLAS/LHC*
  Luís Seabra, (on-going)
- *Study of ATLAS sensitivity to the single top Wt-channel cross section*
  Inês Ochoa, 2010-07-22
- *Study of ATLAS sensitivity to the single top s-channel production*
  Susana Santos, 2010-07-23
- *Linearity Studies of the TileCal detector PMTs of ATLAS/LHC experiment, with the Laser monitoring system*
  Bruno Galhardo, 2010-07-22

2.1.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
Articles in international journals (with indirect contribution from LIP members)	12
Collaboration notes with internal referee	5
Oral presentations in international conferences	4
Poster presentations in international conferences	1
Presentations in national conferences	10
Oral presentations in collaboration meetings	51
Seminars	1
(unspecified Communications)	1
PhD Theses	1
Master Theses	4

2.2 Collaboration in the CMS experiment at CERN

2.2.1 Resumo

O LIP é membro da experiência Compact Muon Solenoid (CMS) no acelerador Large Hadron Collider (LHC) actualmente em construção no CERN. O objectivo da experiência é o estudo de colisões de protões e núcleos pesados a muito alta energia. Pretende-se investigar as propriedades fundamentais da matéria e, em particular, estudar a natureza da quebra de simetria na interacção electrofraca e a origem da massa das partículas. A actividade do LIP tem três componentes principais:
1) O desenvolvimento, operação e manutenção do trigger e do sistema de leitura de dados do calorímetro electromagnético;
2) Física das colisões protão-protão, em particular a física do quark top incluindo o decaimento em Higgs carregado, o estudo dos eventos com fotões isolados e produção associada W-gamma, e a pesquisa de dimensões suplementares e explorando as possibilidades de descoberta proporcionadas pela energia do LHC;
3) Física de iões pesados, em particular o estudo do plasma de quarks e gluões através da análise da produção de quarkonia.
4) Investigação e desenvolvimento para o ´Upgrade´ do sistema de Trigger a alta luminositade (SLHC).

2.2.2 Abstract

LIP is a member of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) at CERN. The experiment studies very high energy collisions of proton and nuclear beams. The experiment´s scope is the investigation of the most fundamental properties of matter, in particular the study of the nature of the electroweak symmetry breaking and the origin of mass. The LIP activity has the following main components:
1) The operation and maintenance of the trigger and the readout system of the CMS electromagnetic calorimeter;
2) Proton-proton physics analyses, in particular top physics studies and searches for top decays in charged Higgs bosons, study of the events with isolated photons and the associated production W-gamma, and extra-dimension searches in multi-lepton events, exploiting the discovery opportunities offered by the new LHC energy;
3) Heavy-ion physics analyses, in particular the study of the QGP through measurements of quarkonia production;
4) Research and development in view of the upgrade of the CMS trigger system at high luminosity (SLHC).
The LHC resumed operation in November 2009 providing proton collisions at 900 GeV. After a short winter shutdown, collisions at 7 TeV were for the first time achieved the 30th March 2010. In general the performance of the LHC machine and of the experiments detectors was outstanding. The proton-proton 2010 run was pursued

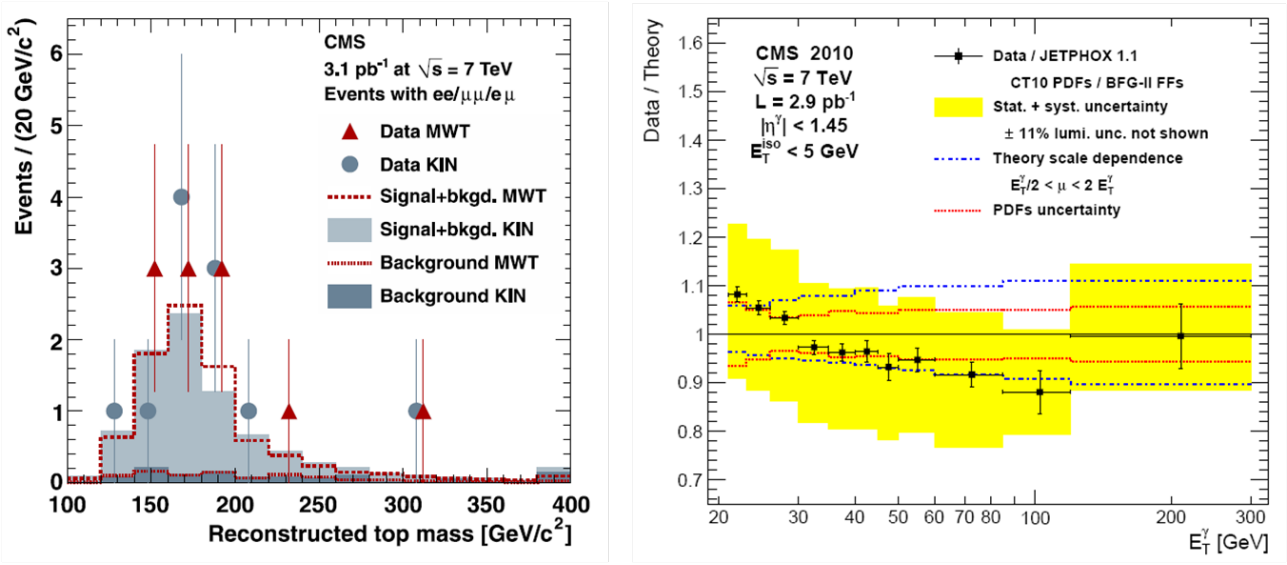

Figura 2.2: Examples of results obtained by the LIP/CMS group with 2010 data: (left) spectrum of the reconstructed mass of the top quark with the KIN method; (right) comparison of the measurement of the isolated prompt photon production cross section with next-to-leading-order perturbative QCD calculations.

until the end October and was followed by one month running with lead ions in 2010. The LHC luminosity in 2010 increased by several orders of magnitude, from 10ˆ27cm-2s-1 in the first runs up to 10ˆ32cm-2s-1 presently. The CMS detector operated with very high efficiency (above 90%) and provided data of very high quality for physics. The GRID computing has operated flawlessly and the offline-software quality allowed event reconstruction, data analysis and physics results in an unprecedented short time scale. The full spectrum of known processes in proton collisions were already measured, including jet production, low mass resonances, b-quark production, W and Z vector boson production, and recently top quark production. Up to now, all the results appear to be compatible with the predictions of the Standard Model. The CMS detector is now ready to engage in the search of new phenomena allowed by the higher luminosity expected in the 2011 run.
The LIP group has been very activity in many areas of the CMS experiment. The group had a strong participation in the commissioning and operation of the detector, and participated actively in several physics analysis, in particular in the first measurement of the top quark cross-section and in the measurement of the isolated photon production cross-section.

2.2.3 Achievements

Summary of Activities

The LIP group has important responsibilities in the maintenance and operation of the CMS detector, namely the ECAL trigger and data acquisition system, including hardware and software, following its strong participation in the CMS construction. It includes the SLB boards which are used to synchronize and transmit the ECAL and HCAL trigger data, and the DCC boards used for the data acquisition of the ECAL detector and the ECAL online software.
The LIP group has a team of five people in permanence at CERN dedicated to the commissioning and operation of the ECAL data acquisition and online monitoring, in particular during the LHC Collision Periods. In the last year the following tasks were undertaken:
a) maintenance of the ECAL Off-Detector Crates in the experiment;
b) upgrades of the DCC firmware to correct several problems identified during data taking;
c) maintenance and updates of the online software;
d) integration tests with CMS central DAQ and central Trigger.
The group was directly involved in the ECAL and Trigger operation during the first LHC beams. Several members of the group are ´experts on-call´ available during LHC runs to intervene in case of system faults. The group assured a number of data taking Shifts both in ECAL and in the central Trigger, as required by the Collaboration. Members of the group also served as Run Field Manager, Shift Leader and Trigger Field Manager at several occasions during the data taking periods.
The LIP group is also responsible for the operation of the ECAL data acquisition hardware and software in the CMS Electronics Integration Center (904) and at the H2/H4 test-beam lines, where the spare ECAL Supermodule (SM37) is installed. In 2010, we have deployed the DAQ system of the SM37 in the test beam and updated the ECAL Off-Detector test setup in the Integration Center.
In the last year LIP/CMS GRID activities were focused in the deployment of the new NCG (LNEC) site, which is part of the Portuguese LHC Tier-2 Federation. NCG site was entirely commissioned and is now part of the CMS Monte Carlo production and physics analysis workflows. The activities on LIP and NCG centers were reorganized to meet the different installed computing resources. The LIP center is now supporting the activities of CMS central operations, while NCG site supports the central Monte Carlo production and the activities of physics groups. Both sites serve as well the computing needs of the local physics community. The Tier-2 has been continuously monitored and proven to operate with high computing efficiencies and data transfer throughputs and quality on both download and upload streams.
The participation in the detector commissioning and physics analysis of the first LHC data was a major goal of the LIP/CMS group in 2010, which was fully achieved.
The group had major roles in the commissioning with data of the electromagnetic calorimeter and of the associated trigger system. These included the study of electromagnetic physics objects and photon reconstruction and identification with first LHC data, as well as many studies of trigger synchronization and efficiency.
The group was actively involved and/or had a leading role in various physics analysis. This includes the participation in the first measurement of top-quark pair production cross section; the results obtained by the LIP group on the top quark mass determination with the first top dilepton events; a top dilepton analysis by the LIP group including optimized event selection and data-driven background estimation methods; the measurement led by the LIP group of the isolated prompt photon cross section based on the cluster shape analysis method developed in the group; the study by the LIP group of the measurement of the top production cross-section in the tau-dilepton channel; the study with simulation data of the possible observation of decays of the top quark in charged Higgs bosons coupling to tau leptons.

The Heavy Ion group was very active in the measurement of the J/Psi prompt and non-prompt cross sections in pp collisions.
A more detailed description of these studies will be included in the next section.The LIP/CMS group members have the following CMS management positions:
- CMS Trigger Project Manager, member of the CMS Executive Board (J. Varela)
- ECAL Run Coordinator (A. David,)
- ECAL Electronics Coordinator (J. C. Silva).
One member of the group (J. C. Silva) has been awarded in 2010 with a ´CMS Lifetime Achievement Award´, for outstanding contributions to the ECAL and HCAL Trigger/DAQ electronics.
A series of seminars on LHC Physics (´Physics on the road to discovery´) was organized in collaboration with CFTP/IST. Eleven seminars by invited speakers took place in fall 2009 and 10. A one-day Workshop on ´Multi-lepton final states in search of New Physics at the LHC´ was organized in collaboration with the LIP/ATLAS team and the theory group of CFTP/IST. An LHC Symposium with the participation of the former LHC project Leader, and the former Spokespersons of the ATLAS and CMS Collaboration was organized at IST, was very successful in presenting the LHC project to a wide audience of students, researchers and faculty members.

Physics studies

Proton-proton physics
The group was actively involved and/or had a leading role in the physics analysis listed below. The CMS references PAS (Physics Analysis Summary) are public. The references AN (Analysis Note) are detailed analysis documents internal to the Collaboration.
a) Top Quark Physics Analysis Group (PAG)
- First Measurement of Top-Quark Pair Production Cross Section in Proton-Proton Collisions at sqrt(s) = 7 TeV (CMS PAPER TOP-10-001, published Physics Letters B), includes the determination of the top quark mass.
- Selection of Top-Like Events in the Dilepton and Lepton-plus-Jets Channels in Early 7 TeV Data (CMS-PAS-TOP-10-004)
- Study of the mass distributions in Top quark dilepton events with early sqrt(s) = 7 TeV data (CMS AN-2010/267): detailed results by the LIP group of the top quark mass determination with the first top events.
- Study of Top quark events in the dilepton channel with early data (CMS AN-2010/200): full top dilepton analysis by the LIP group, including optimized event selection and data-driven background estimation methods.
- Measurement of the ttbar production cross section in the dilepton channel at sqrts=7TeV (CMS AN - 2010-414): analysis of the LIP group performing the cross-section measurement in the bin Njet=1. This result is combined with measurements from other groups in Njet=2 or larger in the final CMS result with 2010 data (CMS PAPER TOP-10-005 to be published).
- Top quark mass and jet energy scale in dilepton events in pp collisions at sqrt(s) = 7 TeV with early data (CMS AN-2010/198): detailed study by the LIP group with simulation data of methods of top quark mass measurement
- Probing the heavy flavor content of the ttbar dilepton channel in proton-proton collisions at sqrt(s)=10 TeV (CMS-PAS-TOP-09-001): detailed study by the LIP group with simulation data of the methods of measurement of the top quark branching ratio.
- Prospects for the measurement of the t-tbar cross section ratio of the e-tau and mu-tau dilepton channel in pp collisions at sqrt(s) = 10 TeV (CMS AN-2009/177): detailed study by the LIP group with simulation data of the measurement of the top cross-section in the tau-dilepton channel.
- Study of tau reconstruction algorithms using pp collisions data collected at sqrt(s)=7TeV, CMS AN-2010/207, approved as PAS PFT-10-004: commission the algorithms for reconstruction and identification of tau lepton hadronic decays.
b) Higgs Physics Analysis Group (PAG)
- Search for the charged Higgs boson in proton-proton collisions at 10 TeV (CMS AN-2010/135): study with simulation data of the possible observation of decays of the top quark in charged Higgs bosons coupling to tau leptons.
c) Electron/photon Physics Object Group (POG):
- Electromagnetic physics objects commissioning with first LHC data (CMS-PAS-EGM-10-001): reconstruction of electromagnetic clusters in the ECAL and comparison to Monte-Carlo simulation.
- Photon reconstruction and identification at sqrt(s)=7 TeV (CMS-PAS-EGM-10-005): reconstruction and photon ID with early CMS data
d) QCD Photons Physics Analysis Group (PAG)

- Measurement of the Isolated Prompt Photon Cross Section in pp Collisions at sqrt(s)=7 TeV (CMS Paper): paper led by the LIP group based on the cluster shape method developed in the group to determine the signal and background fractions from data. Published in Physics Review Letters.
- Prediction of Isolated Photon Cross Section at sqrt(s)=7 TeV from JetPhox and Correction of Underlying Event Effects (CMS AN-2010/272)
- Measurement of isolated photon production cross section in pp collisions at sqrt(s)=7 TeV (CMS AN-2010/268, CMS AN-2010/221, CMS AN-2010/114): detailed analysis describing the measurement of the prompt photon cross-section with CMS data.
e) Electroweak Physics Analysis Group (PAG)
- Towards the measurement of W-gamma coupling in the muon channel in pp collisions at sqrt(s)=10 TeV (CMS AN-2010/065): study with simulation data.

Heavy-ion physics

In 2010, the group was actively involved in the quarkonia and b-physics analysis group (PAG), and contributed significantly to the following studies:
- J/Psi prompt and non-prompt cross sections in pp collisions at sqrt(s) = 7 TeV (CMS-PAS-BPH-10-002): first measurement with CMS data
- Inclusive total and differential production cross section of J/psi and b-hadron production in pp collisions at sqrt(s) = 7 TeV with the CMS experiment(CMS AN-2010/138): detailed analysis study
Apart from the being co-authors of the above mentioned instrumentation and physics CMS papers, in 2010 the group was also very active in the setting up of the quarkonia polarization analysis. In the context of such studies the group has published 3 papers devoted to new methods for polarization measurements along the lines proposed in our previous PRL paper:
- P. Faccioli, C. Lourenço and J. Seixas, Rotation-invariant relations in vector meson decays into fermion pairs, Phys. Rev. Lett. 105 (2010) 061601, arXiv:1005.2601 [hep-ph].
- P. Faccioli, C. Lourenço and J. Seixas, A New approach to quarkonium polarization studies, Phys. Rev. D81 (2010) 111502(R), arXiv:1005.2855 [hep-ph].
- P. Faccioli, C. Lourenço, J. Seixas and H. K. Wöhri, Towards the experimental clarification of quarkonium polarization, Eur. Phys. J. C (to appear), arXiv:1006.2738 [hep-ph].
This work is entirely developed by the CMS LIP Lisbon Quarkonia Group, in collaboration with Carlos Lourenco (CERN).
As a sequel to these studies the group also applied the methods developed for polarization measurement to the case of W and Z, from which resulted a publication recently submitted to Phys. Rev. D:
- P. Faccioli, C. Lourenço, J. Seixas and H. K. Wöhri, Rotation-invariant observables in parity-violating decays of vector particles to fermion pairs

Triggers at SLHC

The activity in 2010 aimed at the conceptual design of an optical trigger interface (oSLB) between the ECAL and HCAL calorimeters and the regional calorimeter trigger, as foreseen the in CMS Upgrade Technical Proposal submitted to the LHC Committee (LHCC).

Publications

Publications by the CMS Collaboration are available at:
http://cdsweb.cern.ch/collection/CMS%20Papers?ln=en

2.2.4 Sources of Funding

Code	Funding	Start	End
CERN/FP/109343/2009	300.000 €	2009-11-01	2010-12-31

2.2.5 Team

Project coordinator: João Varela

Name	Status	%of time in project
André Tinoco Mendes	Researcher (LIP)	100
Aruna Nayak	Post-Doc (LIP) *	100
David Christian Soares	Student (LIP)	50
Hermine Wöhri	Post-Doc (LIP/FCT)	100
João Pela	Master student (LIP/IST)	100
João Seixas	Researcher (LIP/IST)	50
João Varela	Researcher (LIP/IST)	100
José Carlos Silva	Technician (LIP)	100
Leonardo Pedro	Master student (LIP)	50
Luís Raposo	Master student (LIP)	100
Michele Gallinaro	Researcher (LIP)	100
Miguel Ferreira	Technician (LIP)	8
Nuno Almeida	Post-Doc (LIP/FCT)	100
Pasquale Musella	Post-Doc (LIP/FCT) *	100
Pedro Manuel Silva	Post-Doc (LIP/FCT)	100
Pedro Martins	Post-Doc (LIP/IST/FCT) *	100
Pedro Parracho	PhD student (LIP/AdI)	100
Pedro Ribeiro	Post-Doc (LIP/FCT)	100
Pietro Faccioli	Post-Doc (LIP/FCT)	100

2.2.6 Publications

Articles in international journals (with direct contribution from LIP members)

- *Probing the flavor of the top quark decay*
  P. Silva, M. Gallinaro
  Nuovo Cimento B, Volume 125 Issue 08 pp 983-998

- *Towards the experimental clarification of quarkonium polarization*
  P. Faccioli, C. Lourenço, J. Seixas and H.K. Wöhri
  Eur. Phys. J. C 69, 657 (2010)

- *New approach to quarkonium polarization studies*
  P. Faccioli, C. Lourenço and J. Seixas
  Phys. Rev. D81 (2010) 111502(R)

- *Rotation-invariant relations in vector meson decays into fermion pairs*
  P. Faccioli, C. Lourenço and J. Seixas
  Phys. Rev. Lett. 105, 061601 (2010)

- *Measurement of the Isolated Photon Production Cross Section in pp Collisions at sqrt(s) = 7 TeV*
  CMS Collaboration
  accepted PRL, CMS-QCD-10-019, CERN-PH-EP/2010-053

Articles in international journals (with indirect contribution from LIP members)

- *Transverse-momentum and pseudorapidity distributions of charged hadrons in pp collisions at $\sqrt{s}$ = 0.9 and 2.36TeV*
  CMS Collaboration
  2010, 10.1007/JHEP02(2010)041

- *Observation of Long-Range Near-Side Angular Correlations in Proton-Proton Collisions at the LHC*
  CMS Collaboration
  JHEP 09 (2010) 091

- *First Measurement of Bose-Einstein Correlations in Proton- Proton Collisions at sqrt(s) = 0.9 and 2.36 TeV at the LHC*
  CMS Collaboration
  . Rev. Lett. 105 (2010) 032001

- *Transverse-momentum and pseudorapidity distributions of charged hadrons in pp collisions at sqrt(s) = 7 TeV*
  CMS Collaboration
  Phys. Rev. Lett. 105 (2010) 022002

- *Measurement of the charge ratio of atmospheric muons with the CMS detector*
  CMS Collaboration
  Phys. Lett. B692 (2010) 83–104

- *Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at sqrt(s) = 0.9 and 2.36 TeV*
  CMS Collaboration
  JHEP 02 (2010)041

- *Search for Dijet Resonances in 7 TeV pp Collisions at CMS*

  Phys. Rev. Lett. 105 (2010) 211801, 1010.0203

International Conference Proceedings

- *Experimental results on diffraction at CDF*
  M. Gallinaro
  Forward physics at LHC, La Biodola, May 27-29, 2010

- *ECAL front-end monitoring in the CMS experiment*
  R. Arcidiacono et al.
  J. Phys. Conf. Ser. 219 (2010) 022013

- *The CMS ECAL database services for detector control and monitoring*
  R. Arcidiacono et al.
  J. Phys. Conf. Ser. 219 (2010) 022016

Collaboration notes with internal referee

- *Electromagnetic physics objects commissioning with first LHC data*
  CMS Collaboration
  CMS-PAS-EGM-10-001

- *Photon reconstruction and identification at sqrt(s)=7 TeV*
  CMS Collaboration
  CMS-PAS-EGM-10-005

- *J/Psi prompt and non-prompt cross sections in pp collisions at sqrt(s) = 7 TeV*
  CMS Collaboration
  CMS-PAS-BPH-10-002

- *Approved Calorimeter Trigger Synchronization Results*
  Arun Nayak

- *Study of the mass distributions in Top quark dilepton events with early sqrt(s) = 7 TeV data*
  P. Silva, M. Gallinaro, J. Varela
  CMS AN-2010/267

- *Study of Top quark events in the dilepton channel with early data*
  N. Almeida, P. Bargassa, M. Gallinaro, A. Nayak, P. Ribeiro, P. Silva, J. Varela
  CMS AN-2010/200

- *Search for the charged Higgs boson in the etau and mutau dilepton channels of Top quark pair decays in pp collisions at sqrts=7 TeV*
  N. Almeida, M. Gallinaro, A. Nayak, L. Pedro, P. Silva, J. Varela
  CMS AN-2011/015

- *Measurement of the ttbar production cross section in the dilepton channel at sqrts=7 TeV*
  P. Bargassa, M. Gallinaro, A. Nayak, P. Ribeiro, J. Varela
  CMS AN-2010/414

- *Measurement of the Top quark mass in the dilepton channel in pp collisions at sqrts=7≈TeV*
  P. Silva, M. Gallinaro, J. Varela
  CMS AN-2010/374

- *Study of the mass distributions in Top quark dilepton events with early sqrts=7 TeV data*
  P. Silva, M. Gallinaro, J. Varela
  CMS AN-2010/267

- *Measurement of Inclusive Photon Spectrum in pp Collisions at sqrts=7 TeV using the CMS Detector at LHC*
  S. Ganjour, S. Ahuja, B. Choudhary, P.Musella, A. David, M. Gallinaro, J. Varela, C.M. Kuo, S.W. Li, Y.J. Lu, D. Mekterovic, S.S. Yu, R.S. Lu, V. Chetluru, V. Gaultney, S.L.Linn, Y. Kim, Y.J. Lee, A. Debenedetti, R.Rusack,
  CMS AN-2010/221

- *Study of tau reconstruction algorithms using pp collisions data collected at sqrts = 7 TeV*
  C. Veelken, M. Gallinaro, A. Nayak, et al.
  CMS AN-2010/207

- *Top quark mass and jet energy scale in dilepton events in pp collisions at sqrts=7 TeV with early data*
  P. Silva, M. Gallinaro, J. Varela
  CMS AN-2010/198

- *Search for the charged Higgs boson in proton-proton collisions at 10 TeV*
  L. Pedro, N. Almeida, A. David, M. Gallinaro, P. Martins, P. Silva, J. Varela
  CMS AN-2010/135

- *Data Flow for the CMS Exotica Group for Early Running*
  E. Barberis, O. Boeriu, J. Brooke, G. Bruno, J. Chen, J.P. Chou, K. F. Chen, A. De Roeck, S. Eno, M. Gallinaro, S. Harper, C. Hill, G. Landsberg, M. Mozer, J. Pela, S. Rappoccio, A. Rizzi, K. Rossato, P. Rumerio, A. Safono
  CMS AN-2010/071

- *Towards the measurement of W-gamma coupling in the muon channel in pp collisions at sqrts=10 TeV*
  P. Musella, A. David, M. Gallinaro, P. Silva, J. Varela
  CMS AN-2010/065

- *Selection of Top-Like Events in the Dilepton and Lepton-plus-Jets Channels in Early 7 TeV Data*
  CMS Collaboration
  CMS-PAS-TOP-10-004

- *Combined measurement of the top quark mass in proton-proton collisions at sqrts=7 TeV data*
  J. Andrea , A. Avetisyan, U. Heintz, M. Gallinaro, M. Narain, P. Silva, T. Speer, J. Varela
  CMS AN-2010/311

- *Measurement of isolated photon production cross section in pp collisions at sqrts=7 TeV*
  S. Ganjour, S. Ahuja, B. Choudhary, A. David, M. Gallinaro, P. Musella, J. Varela, C.M. Kuo, S.W. Li, Z.K. Liu, Y.J. Lu, D. Mekterovic, S.S. Yu, R.S. Lu, V. Chetluru, V. Gaultney, S.L. Linn, Y. Kim, Y.J. Lee, A. Debenedett
  CMS AN-2010/268

Book Chapters

- *Quarkonium production and absorption in proton-nucleus collisions*
  C. Lourenco, P. Faccioli, H.K. Woehri
  in The Physics of the Quark-Gluon Plasma, edited by S. Sarkar, H. Satz and B. Sinha, Lect. Notes Phys. 785, 199-218, Springer (2010)

2.2.7 Presentations

Oral presentations in international conferences

- *Review of diffractive physics results from the CDF experiment at the Tevatron´*
  presented by Michele Gallinaro
  Workshop on "Diffractive and electromagnetic processes at the LHC-– Trento, Italy.

- *Recent progress in understanding quarkonium polarization*
  presented by Pietro Faccioli
  7th International Workshop on Heavy Quarkonia — Fermilab, Chicago, USA.

- *First results of Trigger and DAQ systems of the LHC experiments*
  presented by João Varela
  17th IEEE NPSS Real Time Conference — Lisbon, Portugal.

- *The CMS Iberian Computing Sites performance in the advent of the LHC era*
  presented by Nuno Almeida
  , 4th Iberian GRID Infrastructure Conference — Braga, Portugal.

- *Experimental results on diffraction at CDF*
  presented by Michele Gallinaro
  Workshop on "Forward physics at LHC — La Biodola, Elba, Italy.

- *Performance of the electromagnetic calorimeter and first results on electromagnetic physics objects from CMS*
  presented by Pasquale Musella
  Physics at the LHC 2010 — Hamburg, Germany.

- *Search strategies for charged Higgs bosons in CMS*
  presented by Michele Gallinaro
  Third International workshop on "Prospects for charged Higgs discovery at colliders", Charged2010 — Uppsala, Sweden.

- *CMS results from pp collisions at the LHC*
  presented by Hermine Wöhri
  Hard Probes 2010: 4th Int. Conf. on Hard and EM Probes of High-Energy Nuclear Collisions — Eilat, Israel.

- *Quarkonium polarization in proton-proton and proton-nucleus collisions*
  presented by Pietro Faccioli
  Hard Probes 2010: 4th Int. Conf. on Hard and EM Probes of High-Energy Nuclear Collisions — Eilat, Israel.

- *Observation of Top-Quark Production at 7TeV at CMS*
  presented by Pedro Ribeiro
  Heavy Quarks and Leptons 2010 — Frascati, Italy.

- *Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC*
  presented by João Seixas
  6th International Conference on Physics and Astrophysics of Quark Gluon Plasma (ICPAQGP 2010) — Goa, India.

Poster presentations in international conferences

- *Early QCD analyses with photons at CMS*
  presented by Pasquale Musella
  35th International Conference on High Energy Physics — Paris, France.

Presentations in national conferences

- *CMS: last steps with cosmics, first step with beam*
  presented by André Tinoco Mendes
  Jornadas, LIP — Braga, Portugal.

- *Preparation for new Physics with the CMS detector*
  presented by Pedro Manuel Silva
  Jornadas, LIP — Braga, Portugal.

- *Connection to the CMS control room*
  presented by André Tinoco Mendes
  — Lisbon, Portugal.

- *Polarization measurements at the LHC*
  presented by Pietro Faccioli
  LHC seminars — Lisbon, Portugal.

Oral presentations in international meetings

- *Multi-leptons: from the Tevatron to the LHC*
  presented by Michele Gallinaro
  Workshop on "Multi-lepton final states in search of New Physics at the LHC-– Lisbon, Portugal.

- *Multi-leptons in SUSY searches*
  presented by Pedro Ribeiro
  Workshop on "Multi-lepton final states in search of New Physics at the LHC-– Lisbon, Portugal.

- *CMS status and spin physics at the LHC*
  presented by Pietro Faccioli
  SPIN 2010, 19th International Spin Physics Symposium — Forschungszentrum Jülich, Germany.

- *Highlights from the first year of LHC Physics with the CMS detector*
  presented by Pedro Manuel Silva
  PASC Winter School — Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *Subsystems needs re central shifts*
  presented by André Tinoco Mendes
  CMS Commissioning Workshop — CERN.

- *DCC Report on Error Handling*
  presented by José Carlos Silva
  ECAL Off-detector Meeting — CERN.

- *Summary of Error Handling in the Unpacker*
  presented by Nuno Almeida
  ECAL Off-detector Meeting — CERN.

- *Preliminary Design of the oSLB*
  presented by José Carlos Silva
  CMS Trigger Upgrades Meeting — CERN.

- *TTbar with topological selections*
  presented by Pedrame Bargassa
  Top Dileptons Working Group Meeting — CERN.

- *ECAL + HCAL Trigger Study*
  presented by Aruna Nayak
  L1 Trigger DPG meeting — CERN.

- *RFM report from MWGR*
  presented by André Tinoco Mendes
  CMS Run Meeting — CERN.

- *W-gamma production at sqrt(s) = 10 TeV*
  presented by Pasquale Musella
  CMS EWK Meeting — CERN.

- *Top quark mass measurement in the dilepton channel*
  presented by Pedro Manuel Silva
  Top Dileptons Working Group Meeting — CERN.

- *L1 fine-grain filter studies*
  presented by Aruna Nayak
  ECAL DPG — CERN.

- *L1 Filter of ECAL Spikes*
  presented by Aruna Nayak
  ECAL DPG — CERN.

- *FOM-oriented dilepton analysis without b-tagging*
  presented by Pedrame Bargassa
  Top Dileptons Working Group Meeting — CERN.

- *Towards a multi-lepton trigger*
  presented by Pedro Ribeiro
  High pt electron meeting — CERN.

- *Readiness of ECAL for 7 TeV Running*
  presented by André Tinoco Mendes
  CMS week ECAL plenary — CERN.

- *Muon triggers for quarkonium and B physics*
  presented by Hermine Wöhri
  CMS week Physics plenary — CERN.

- *Early observation of dileptons in 7 TeV pp data*
  presented by Pedro Manuel Silva
  Top Dileptons Working Group Meeting — CERN.

- *Dilepton analysis with Figure Of Merit, and without b-tagging*
  presented by Pedrame Bargassa
  Top Quark Physics Meeting — CERN.

- *Towards a multi-lepton trigger*
  presented by Pedro Ribeiro
  H->ZZ Meeting — CERN.

- *MET and Jet scale systematics studies*
  presented by Pedrame Bargassa
  Top Dileptons Working Group Meeting — CERN.

- *Calorimeter trigger timing scan*
  presented by Aruna Nayak
  CMS Trigger Meeting — CERN.

- *J/psi->e+e- selection*
  presented by Pedro Manuel Silva
  EGamma POG Meeting — CERN.

- *ECAL status*
  presented by André Tinoco Mendes
  CMS Run Meeting — CERN.

- *Calorimeter Trigger Synchronization*
  presented by Aruna Nayak
  L1 Trigger DPG meeting — CERN.

- *Trigger and DAQ Progress and Status*
  presented by André Tinoco Mendes
  CMS ECAL days — CERN.

- *Timing Scan And Synchronization*
  presented by Aruna Nayak
  L1 Trigger DPG meeting — CERN.

- *Electron fake rate*
  presented by Pedro Ribeiro
  EGamma POG Meeting — CERN.

- *Top dilepton selection with a Figure Of Merit*
  presented by Pedrame Bargassa
  Top Dileptons Working Group Meeting — CERN.

- *Fake rates and particle id in 7 TeV data*
  presented by Pedro Ribeiro
  Top Dileptons Working Group Meeting — CERN.

- *Cost Optical SLB*
  presented by José Carlos Silva
  CMS Trigger Upgrades Meeting — CERN.

- *Studies of data driven methods to estimate top di-lepton backgrounds*
  presented by Pedro Ribeiro
  Top Dileptons Working Group Meeting — CERN.

- *PF Tau Efficiency and Fake Rate*
  presented by Aruna Nayak
  Tau ID Commissioning Meeting — CERN.

- *DCC Report on Error Handling*
  presented by José Carlos Silva
  ECAL DPG PFG Meeting — CERN.

- *Multi-lepton triggers*
  presented by Pedro Ribeiro
  Multi-leptons UED Meeting — CERN.

- *Tau fake rates: a data-driven background estimate*
  presented by Nuno Almeida
  Charged Higgs Meeting — CERN.

- *ECAL activities during technical stop*
  presented by André Tinoco Mendes
  ECAL Operations Management — CERN.

- *Top quark mass measurement in the dilepton channel*
  presented by Pedro Manuel Silva
  Top 7 TeV analysis results — CERN.

- *Early observation of dileptons in 7 TeV pp data*
  presented by Pedro Manuel Silva
  Top Quark Physics Meeting — CERN.

- *Update of sigmaIetaIeta template results*
  presented by André Tinoco Mendes
  QCD Photon Meeting — CERN.

- *TOP- Dilepton cross section*
  presented by Pedro Manuel Silva
  PAGs Jamboree — CERN.

- *J/psi polarization in pp collisions at sqrt(s) = 7 TeV - A first look at the data*
  presented by Hermine Wöhri
  Physics Jamboree — CERN.

- *Calorimeter TPG energy scales*
  presented by Aruna Nayak
  L1 Trigger DPG meeting — CERN.

- *Status of AN/PAS/paper for 3/pb barrel publication*
  presented by André Tinoco Mendes
  QCD Photon Meeting — CERN.

- *L1 Calo TPG Energy Scales*
  presented by Aruna Nayak
  L1 Trigger DPG meeting — CERN.

- *Photon Papers*
  presented by André Tinoco Mendes
  QCD Meeting — CERN.

- *ECAL data errors and recovery*
  presented by José Carlos Silva
  ECAL DPG PFG Meeting — CERN.

- *H+ (Leptonic Modes)*
  presented by Nuno Almeida
  Higgs PAG Meeting — CERN.

- *Inclusive photon cross section*
  presented by Pasquale Musella
  QCD Meeting — CERN.
- *Status of inclusive photon cross section*
  presented by Pasquale Musella
  QCD Meeting — CERN.
- *Top dilepton cross section: optimizing selections*
  presented by Pedrame Bargassa
  Top Dileptons Working Group Meeting — CERN.
- *Upgrade to Optical SLB*
  presented by José Carlos Silva
  CMS upgrade week — CERN.
- *H+ leptonic. Progress report towards December Higgs Review*
  presented by Nuno Almeida
  CMS H2Tau group meeting — CERN.
- *Dilepton Tau Analysis*
  presented by Nuno Almeida
  Top Quark Physics Meeting — CERN.
- *Status of QCD-10-019 PAS/Paper for Wed. approval*
  presented by André Tinoco Mendes
  QCD Photon Meeting — CERN.
- *Search for the charged Higgs boson in the etau/mutau final state: status report*
  presented by Michele Gallinaro
  CMS H2Tau group meeting — CERN.
- *Charged Higgs in the Tau dilepton channel*
  presented by Aruna Nayak
  CMS H2Tau group meeting — CERN.
- *Status of QCD-10-019 after CWR*
  presented by André Tinoco Mendes
  QCD Photon Meeting — CERN.
- *Preliminary Design of the oSLB*
  presented by José Carlos Silva
  CMS Trigger Upgrades Meeting — CERN.
- *Measurement of the top quark mass in the dilepton channel: status report*
  presented by Michele Gallinaro
  CMS Top dilepton group — CERN.
- *Search for the charged Higgs boson in the etau/mutau final state: progress report*
  presented by Michele Gallinaro
  — CERN.
- *Top dilepton cross-section with FOM & 35 pb-1*
  presented by Pedrame Bargassa
  Top Dileptons Working Group Meeting — CERN.
- *Search for the charged Higgs boson in the etau/mutau final state*
  presented by Michele Gallinaro
  CMS H2Tau group meeting — CERN.
- *RFM report*
  presented by André Tinoco Mendes
  CMS Run Meeting — CERN.

- *Search for the charged Higgs boson in top quark decays*
  presented by Michele Gallinaro
  Higgs Review — CERN.

- *Top quark mass measurement in the dilepton channel*
  presented by Pedro Manuel Silva
  Top Quark Physics Meeting — CERN.

Seminars

- *Progress in understanding quarkonium polarization measurements*
  presented by Pietro Faccioli
  Workshop "Quarkonium production at the LHC-– CERN.

- *Frame-dependence and frame-invariance in polarization measurements (the quarkonium example*
  presented by Pietro Faccioli
  LIP seminar — Lisbon, Portugal.

- *Como funciona CMS: Ligação directa à Sala de Controlo*
  presented by André Tinoco Mendes
  CMS day 2010 — Lisbon, Portugal.

- *Understanding quarkonium polarization*
  presented by Pietro Faccioli
  CERN seminar — CERN.

- *Understanding quarkonium polarization*
  presented by Pietro Faccioli
  HEPHY Seminar — Vienna, Austria.

- *Perspectives for quarkonia studies for ICHEP and beyond*
  presented by Hermine Wöhri
  HEPHY Seminar — Vienna, Austria.

- *Understanding quarkonium polarization*
  presented by Pietro Faccioli
  BNL seminars — Brookhaven National Laboratory, USA.

- *Frame-dependence and frame-invariance in polarization measurements (quarkonium and more)*
  presented by Pietro Faccioli
  CFTP Seminar — Lisbon, Portugal.

- *Quarkonium absorption in proton-nucleus collisions and initial-state energy loss from Drell-Yan data*
  presented by Hermine Wöhri
  Quarkonium 2010, Three days of Quarkonium Production in pp and pA collisions, École Polytechnique — Paris, France.

- *Towards the experimental clarification of quarkonium polarization*
  presented by Pietro Faccioli
  Quarkonium 2010: Three days of Quarkonium Production in pp and pA collisions, École Polytechnique — Paris, France.

- *How to measure chi_c and chi_b polarizations*
  presented by Pietro Faccioli
  Quarkonium 2010, Three days of Quarkonium Production in pp and pA collisions, École Polytechnique — Paris, France.

- *The CMS Detector and the participation of Portugal / O Detector CMS e a participação portuguesa*
  presented by André Tinoco Mendes
  — CERN.

- *TOP- Dilepton cross section*
  presented by Pedro Manuel Silva
  LIP Seminar — LIP, Lisboa.

- *Measurement of Isolated Photon Cross Section at 7 TeV*
  presented by André Tinoco Mendes
  CMS approval talk — CERN.

- *The CMS ECAL - from the end of the cold war to the LHC first physics*
  presented by André Tinoco Mendes
  CERN Detector Seminar — CERN.

- *Measurement of the isolated photon production cross section with the CMS experiment*
  presented by Pasquale Musella
  LIP seminar — Lisbon, Portugal.

Outreach seminars

- *O meu trabalho, o CERN e a Física de Partículas*
  presented by Pedro Ribeiro
  — Escola Secundária Raúl Proença.

- *Portugal, CERN and CMS*
  presented by André Tinoco Mendes
  CERN Visitors — CERN.

- *Como se prepara uma experiência no LHC*
  presented by Pedro Manuel Silva
  MasterClass 2010 — Lisbon, Portugal.

- *O que se espera descobrir em CMS*
  presented by Pedro Manuel Silva
  CMS day 2010 — Lisbon, Portugal.

- *Portugal, CERN and CMS*
  presented by André Tinoco Mendes
  CERN Visitors — CERN.

(unspecified Communications)

- *Prompt vs direct J/Ψ polarization*
  presented by Pietro Faccioli
  LPCC/CERN workshop on heavy flavour and quarkonium production — CERN.

2.2.8 Academic Training

PhD Theses

- *Measurement of the inclusive photon production cross section and study of associated W-photon production in proton-proton collisions at the LHC*
  Pasquale Musella, 2010-12-13

- *Trigger de electrões e fotões na experiência CMS no SLHC*
  Pedro Parracho, (on-going)

2.2.9 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	5
Articles in international journals (with indirect contribution from LIP members)	7
International Conference Proceedings	3
Collaboration notes with internal referee	19
Book Chapters	1
Oral presentations in international conferences	11
Poster presentations in international conferences	1
Presentations in national conferences	4
Oral presentations in international meetings	4
Oral presentations in collaboration meetings	64
Seminars	16
Outreach seminars	5
(unspecified Communications)	1
PhD Theses	1

2.3 Collaboration in the COMPASS experiment at CERN

2.3.1 Resumo

A experiência COMPASS dedica-se ao estudo da estrutura do nucleão através da difusão inelástica profunda de muões na matéria, nomeadamente à medição da polarização do gluão Delta G/G (usando a produção de charme e a física de elevado p_T), às funções de estrutura relativas às componentes transversas e longitudinais do spin, e às funções de fragmentação.
Com um feixe de hadrões COMPASS tem por objectivo o estudo de algumas questões espectroscópicas de actualidade, como a produção de novos mesões, nomeadamente exóticos ou híbridos.
COMPASS usa feixes de alta intensidade, de muões polarizados (ou de hadrões) interagindo com um alvo polarizado longitudinalmente ou transversalmente (ou um alvo de hidrogénio líquido) ao qual se segue um espectrómetro duplo: a primeira parte tem uma grande aceitância angular, e é seguida a jusante por outra de aceitância reduzida, concebida para a detecção de partículas ultrapassando os 100 GeV/c. Cada espectrómetro é formado por um magnete rodeado por detectores de posição, um conjunto de calorímetros electromagnético e hadrónico, filtros de muões e um detector de Cherenkov do tipo RICH para identificação de partículas.
O sistema de aquisiçã&#65533;o de dados baseia-se na leitura em paralelo da electrónica de front-end e num sistema distribuído de event-builders, especialmente concebidos para tratar grandes volumes de dados. De facto,todo o programa de muões que decorreu de 2002 a 2007 perfez um total de 1700 TB. O programa de 2008 e 2009 foi dedicado ao programa de hadrões. Em 2010 uma última tomada de dados com alvo de amónia transversalmente polarizado permitiu concluir o programa de transversidade.
A farm de processamento de dados de COMPASS tem um desempenho do nível requerido em LHC, pelo que a experiência foi usada pelos grupos técnicos de apoio do CERN em vários domínios relativos à aquisição e ao controlo dos dados como um ambiente de teste em grande escala.
Neste contexto, a aposta do grupo do LIP-Lisboa de, ao ingressar em COMPASS em finais de 2002, tomar a total responsabilidade do Sistema de Controlo de Detectores (DCS), revelou-se muito importante para a estratégia de evolução do grupo no plano tecnológico. Daí o notável esforço de recursos humanos que foi necessário.
O objectivo principal do grupo do LIP, atingido em anos anteriores, era o desenvolvimento de uma nova arquitectura para o DCS de COMPASS. Mas continuadas evoluções e adaptações têm sido necessárias.

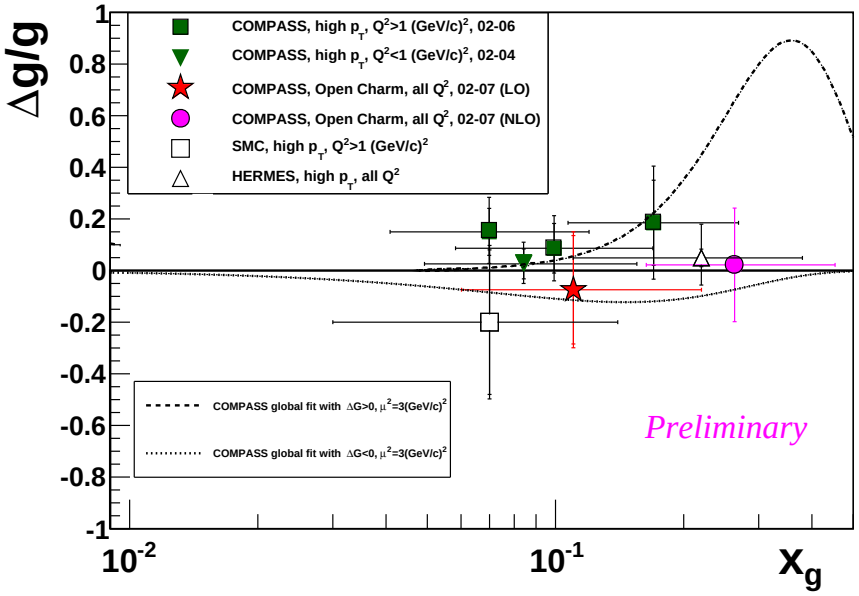

Figura 2.3: Among the several LIP activities on COMPASS, we only show the results obtained by LIP analyses on the determination of the polarised gluon structure function by two methods: from high pT hadrons (green points) and from production of open charm mesons - the Golden Channel (red and magenta points).

Na verdade, o DCS não pode ser um sistema estático ou um produto finalizado pois é constituído por várias camadas de packages cujas versões têm de ser compatíveis entre si, pelo que a alteração de um deles, muitas vezes com aspectos incompatíveis em relação à sua versão precedente, implica em geral a adaptação de todos os outros, o que é uma tarefa muito pesada.
Por outro lado, devido à contínua instalação de novos detectores específicos dos diferentes programas com feixes de muões e hadrões, o software do DCS (bem como o seu hardware de interface) tem vindo a aumentar constantemente o seu grau de complexidade (interfaces de novo tipo, novos drivers), devido à não uniformidade dos detectores e do seu hardware. Em consequência, em 2010 transformou-se o DCS numa arquitectura paralela.
Paralelamente, o grupo tem também levado a cabo um conjunto de tarefas, tanto relativas ao offline, como o estudo de geradores físicos e da sua simulação no detector, como em relação À análise de dados, nomeadamente estudos da polarização do gluão através do processo de charme aberto ou de eventos de grande p_T, e ainda sobre as assimetrias de sabor do mar do nucleão.
Nos primeiros meses de 2010, o grupo do LIP-Lisboa assumiu um papel de destaque na preparação da Proposta de COMPASS para o futuro Programa experimental (entretanto entregue), na secção relativa a estudos de transversidade através do processo de Drell-Yan polarizado, e tem entretanto vindo a participar activamente nos estudos de optimização do espectrómetro.

2.3.2 Abstract

The COMPASS experiment is dedicated to the study of the structure of the nucleon through the deep inelastic scattering of muons, namely the gluon polarization DeltaG/G (from open charm photoproduction and high p_T physics), the longitudinal and the transverse spin structure and the fragmentation functions.
With a hadron beam, COMPASS aims to study some spectroscopy issues, as the production of new mesons, namely exotics or hybrids.
COMPASS uses high intensity beams, that is, a polarized muon (or hadron) beam impinging on a longitudinally or transversely polarized target (or liquid hydrogen target) followed by a two stage spectrometer: a first one with a large angular acceptance, followed downstream by a second one with a reduced acceptance, designed to detect particles up to more than 100 GeV/c. Each spectrometer is equipped with a magnet sorrounded by trackers, a set of electromagnetic and hadronic calorimeters, muon filters and a Cerenkov detector (RICH) for particle identification. The data acquisition system is based in a parallel read-out of the front-end electronics plus a distributed set of event-builders, specially designed to cope with huge data volumes. In fact, during the whole muon program, from 2002 till 2007, COMPASS collected a total of 1700 TeraByte of data. The years 2008 and 2009 were dedicated to the hadron program. In 2010, a last data taking with an ammonia target, transversely polarised, took place, allowing to finalise the muon transversity program.
COMPASS data processing farm also requires a LHC-like performance. That is why the experiment was used as large scale test environment by some CERN support technical groups in several data acquisition and data control domains.
In this context, the fact that when the LIP-Lisbon group ingressed in COMPASS in the late 2002, we took the full responsibility of the Detector Control System (DCS), was very important to the evolving strategy of the group on a technological ground. In that view, a big effort in human resources was undertaken.
The main purpose of our group was the development a new DCS architecture, which has been previously achieved. But a constant evolution of the system is needed.
In fact, DCS can not be a static system or a finalised product, because it is formed by a set of several packages, disposed in layers but strongly interacting.
This means that the packages versions must be compatible among them. Thus, changing one package version, which may even be not backward compatible with its previous one, may imply the change of all other packages versions. This is usually a heavy task.
On the other hand, COMPASS continues its hardware upgrade, namely in what concerns new detectors specific to muon or hadron programs. In view of this, the DCS is always increasing in complexity (new types and number of hardware interfaces with the detectors, new drivers), namely due to the non uniformity of the COMPASS detectors hardware.
As a consequence, in 2010 the DCS was transformed into a parallel architecture.
In parallel, a great effort concerning the offline and data analysis tasks is being performed. It includes the development of new physics generators and their simulation through the detector, as well as the analysis of physics channels, namely studies on the gluon polarisation from the open charm process or high p_T events, and the flavour asymmetries of the nucleon sea.
In the first 2010 months, our group has taken an important role in the preparation of the COMPASS Proposal concerning to the future Physics experimental program, in the section concerning transversity studies through

the polarised Drell-Yan process. Later, it has actively participated in the spectrometer optimisation studies in that view.

2.3.3 Objectives

LIP is member of the COMPASS experiment. COMPASS studies the structure of the nucleon in terms of its spin using polarised targets and beam. It also addresses the study of modern issues in hadronic spectroscopy.
LIP has the full responsibility of the Detector Control System (DCS) of the experiment, since it has been accepted as a member of the COMPASS Collaboration, in September 2002.
Another major activity of LIP is analysis. Indeed, the subjects carried on by LIP members are the most important analysis channels of the experiment, concerning deep inelastic muon scattering.
The COMPASS experiment LIP group carried on the matters related with the working activities, namely: general activities; full responsibility of the Detector Control System (DCS); and offline and data analysis.

2.3.4 Achievements

General Activities
COMPASS LIP-Lisbon members participated in the following general activities:

- Participation in the Collaboration meetings
- Participation in the Steering Committee meetings (the Project Leader)
- Participation in the monthly offline and analysis meetings
- Participation in the technical friday meetings
- Participation in the data taking periods and their preparation.

Detector Control System
In view of the preparation of the 2010 muon run with transverse target polarisation, new detectors were installed (and others reinstalled) in the experimental area. These detectors were included in the new DCS sheme.
The DCS has also proceeded with the study of the issues for the integration of some already existing standalone detectors, as the LV systems for the RICH and Straw chambers. A new development concerning calorimeters monitoring was carried out. This was a major task, as the total number of DCS channels doubled.
One should stress that the DCS has to deal with a vast variety of COMPASS equipments that are being or will be controlled or monitored. While for some devices commercial supervision solutions exist (like OPC servers), for many others these solutions do not. That is why case-by-case solutions must be applied, namely by writing the drivers to control/monitor such devices, and integrate them in PVSS, whenever necessary.
It is worth noting that the DCS system works practically 12 months per year. In fact, during the no-beam part of the year, several DCS sub-systems run, in order to control some devices, as it is the case of detectors gas systems. This requires the permanent presence of one DCS expert.

Offline and Data Analysis
The offline and analysis task has been a major concern of our group. The analysis subjects carried on by LIP members are among the most important analysis channels of the experiment. As a consequence, our members have presented their results in several International Conferences, on the behalf of COMPASS.
In 2010 the following subjects were addressed:

- The analysis of high p_T events, putting together four years of data taking, and which purpose is the derivaton of the gluon polarisation, has continued.
- The open charm studies, in view of the Delta G/G extraction, has proceeded. It analyses five physics channels spanned over 5 years of data taking.
- Extensive systematic studies in view of physical asymmetries extraction were initiated.
- Studies on the COMPASS setup in order to optimize it to the future polarised Drell-Yan process experiment have proceeded.

2.3.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/109323/2009	150.000 €	2009-11-01	2010-12-31

2.3.6 Team

Project coordinator: Paula Bordalo

Name	Status	%of time in project
António Pacheco	Master student (LIP)	100
Catarina Quintans	Researcher (LIP)	100
Celso Franco	PhD student (LIP/FCT)	100
Christophe Pires	Technician (LIP)	100
Hugo Fonseca	Master student (LIP)	100
Luis Silva	PhD student (LIP/FCT)	100
Márcia Quaresma	Master student (LIP)	100
Marcin Stolarski	Post-Doc (LIP/FCT)	100
Paula Bordalo	Researcher (LIP/IST)	100
Sérgio Ramos	Researcher (LIP/IST)	100
Sofia Nunes	PhD student (LIP)	100

2.3.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *The spin-dependent structure function of the proton g1p and a Test of the Bjorken Sum Rule*
  P. Bordalo, C. Franco, C. Quintans, A.S. Nunes, S. Ramos, H. Santos, L. Silva et al.
  PLB 690 (2010) 466-472

- *Measurement of the Collins and Sivers asymmetries on transversely polarised protons*
  P. Bordalo, C. Franco, C. Quintans, A.S. Nunes, S. Ramos, H. Santos, L. Silva et al.
  PLB 692 (2010) 240-246

- *Azimuthal asymmetries of charged hadrons produced by high energy muons off longitudinally polarized deuterons*
  P. Bordalo, C. Franco, C. Quintans, A.S. Nunes, S. Ramos, H. Santos, L. Silva et al.
  EPJC 70 (2010) 39-49

- *Quark Helicity Distributions from Longitudinal Spin Asymmetries in Muon-Proton and Muon-Deuteron Scattering*
  P. Bordalo, C. Franco, C. Quintans, A.S. Nunes, S. Ramos, H. Santos, L. Silva et al.
  PLB 693 (2010) 227-235

Articles in international journals (with indirect contribution from LIP members)

- *Observation of a JPC = 1-+ exotic resonance in diffractive dissociation of 190 GeV/c pi- into pi-pi-pi+*
  P. Bordalo, C. Franco, C. Quintans, A.S. Nunes, S. Ramos, H. Santos, L. Silva et al.
  PRL 104 (2010) 241803

International Conference Proceedings

- *New COMPASS results on DG/G using D0 production asymmetries*
  C. Franco et al., for COMPASS Collaboration
  Procs. of 18th International workshop on Deep Inelastic Scattering and related subjects

- *Longitudinal spin studies with COMPASS*
  M. Stolarski et al., for COMPASS Collaboration
  Procs. of XV International QCD Conference

- *Future Drell-Yan measurements at COMPASS*
  C. Quintans et al., for COMPASS Collaboration
  Procs. of 19th International Spin Physics Symposium

- *DG/G from the COMPASS experiment for Q^2>1 high-pt hadrons*
  L. Silva et al., for COMPASS Collaboration
  Procs. of 19th International Spin Physics Symposium

Collaboration notes with internal referee

- *Measurement of deltaG/G via Open Charm using (2002, 2007) data*
  C. Franco, P. Bordalo, S. Ramos et al.
  COMPASS Release Note 5

- *Estimation of the Drell-Yan process cross-section and of some important parameters for luminosity calculation for the future Drell-Yan measurements at COMPASS*
  C. Quintans et al.
  COMPASS Note 2010-4

- *Drell-Yan beam test 2009*
  C. Quintans et al.
  COMPASS Note 2010-5

- *Determination of Delta G/G for Q^2>1 (GeV/c)^2 from 2002-2006 high p_T data*
  P. Bordalo, S. Ramos, M. Stolarsky, L. Silva et al.
  COMPASS Note 2010-12

Proposals

- *COMPASS-II Proposal*
  P. Bordalo, C. Franco, C. Quintans, A.S. Nunes, S. Ramos, M. Stolarsky, L. Silva et al.
  CERN-SPSC-2010-014

2.3.8 Presentations

Oral presentations in international conferences

- *New COMPASS results on DG/G using D0 production asymmetries*
  presented by Celso Franco
  DIS 2010- 18-th International workshop on Deep Inelastic Scattering and related subjects — Firenze, Italy.

- *Longitudinal spin studies with COMPASS*
  presented by Marcin Stolarski
  QCD 10- XV International QCD Conference — Montpellier, France.

- *Future Drell-Yan measurements at COMPASS*
  presented by Catarina Quintans
  SPIN 2010 - 19th International Spin Physics Symposium — Juelich, Germany.

- *DG/G from the COMPASS experiment for Q2>1, high-pt hadrons*
  presented by Luis Silva
  SPIN 2010 - 19th International Spin Physics Symposium — Juelich, Germany.

- *Spin structure of the nucleon in COMPASS*
  presented by Catarina Quintans
  PASC Winter School — Sesimbra, Portugal.

Presentations in national conferences

- *COMPASS activities and future Drell-Yan program*
  presented by Catarina Quintans
  Jornadas LIP — Braga, Portugal.

- *Measurement of the gluon spin contribution in the COMPASS experiment*
  presented by Celso Franco
  Jornadas LIP — Braga, Portugal.

- *The COMPASS Detector Control System : Status and prospects*
  presented by Sofia Nunes
  Jornadas LIP — Braga, Portugal.

2.3.9 Academic Training

PhD Theses

- *COMPASS - Contribution of the gluon to the nucleon spin via D0 e D* production*
  Celso Franco, (on-going)

- *COMPASS - Gluon Polarisation through high PT hadron production*
  Luis Silva, (on-going)

- *Study of asymmetries with polarised proton target at low Q2*
  Sofia Nunes, (on-going)

- *Drell-Yan polarised studies in COMPASS-II*
  Márcia Quaresma, (on-going)

Master Theses

- *Study of the Drell-Yan proccess in pi-p interactions in COMPASS*
  Márcia Quaresma, 2010-12-03

- *Study of muon pairs coming from pi and K decays in hadronic interactions*
  António Pacheco, (on-going)

- *Study of spin dependent deep inelastic processes in the COMPASS experiment*
  Hugo Fonseca, (on-going)

2.3.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	4
Articles in international journals (with indirect contribution from LIP members)	1
International Conference Proceedings	4
Collaboration notes with internal referee	4
Proposals	1
Oral presentations in international conferences	5
Presentations in national conferences	3
Master Theses	1

2.4 Collaboration in the HADES experiment at GSI

2.4.1 Resumo

A colaboração HADES (www-hades.gsi.de), acrónimo de "High Acceptance Di-Electron Spectrometer", é uma experiência internacional de Física das Partículas, onde participam 17 instituições de 9 países europeus entre os quais Portugal, através do Laboratório Associado LIP (www.lip.pt). Esta experiência está instalada no laboratório GSI (www.gsi.de), situado em Darmstadt, na Alemanha.
Fazendo colidir núcleos atómicos pesados acelerados no acelerador SIS18 do GSI, a experiência pretende criar um estado nuclear muito mais denso que o habitual. Essa densidade acrescida, ao provocar alterações mensuráveis nas propriedades das forças nucleares, permitirá estudar algumas propriedades destas forças que são responsáveis pela maior parte da massa da matéria comum.
A participação portuguesa nesta experiência, assegurada por uma equipa do LIP, consiste no projecto, construção e operação de um detector de partículas de concepção original que ajudará a identificar com mais rigor o tipo de partículas que emergem das referidas colisões nucleares. Este novo detector será capaz de medir o tempo de voo das partículas (desde o ponto da colisão até ao detector) com uma precisão equivalente ao tempo que demora a luz a percorrer uma distância de 3 cm (100 picosegundos, isto é 0,0000000001 s). Esta informação permite por sua vez determinar a velocidade das partículas, o que é um passo importante para identificar o tipo de partícula de que se trata.
Uma vez em funcionamento, o que deverá acontecer em 2011, pretendemos também estudar um aspecto particular da Física Nuclear que pode ter relevância para a estabilidade das estrelas de neutrões - objectos celestes exóticos de grande interesse para a Astronomia e a Astrofísica.

2.4.2 Abstract

The HADES collaboration (www-hades.gsi.de), "High Acceptance Di-Electron Spectrometer", is an international Particle Physics experiment in which participate 17 institutions from 9 European countries, including Portugal via the "Associated Laboratory"LIP (www.lip.pt). The experiment is installed in the laboratory GSI (www.gsi.de), located in Darmstadt, Germany.

Figura 2.4: Installed RPC TOF-Wall

By colliding heavy atomic nucleus accelerated by GSI´s SIS18 accelerator the experiment aims at creating a nuclear state much denser than usually. This increased density, causing changes in the measurable properties of the nuclear forces, will allow the study of some properties of these forces that are responsible for most of the mass of ordinary matter.
The Portuguese participation in the experiment, assured by a team of LIP, includes the design, construction and operation of an original particle detector that will help to identify more accurately the kind of particles that emerge from the nuclear collisions. This new detector will be able to measure the time of flight of the particles (from the collision point to the detector) with a precision equivalent to the time that it takes the light to cross a distance of 3cm (100 picoseconds, or 0.0000000001 s). This information allows the determination of the velocity of the particles, which is an important step to identify the particle.
Once in operation, which should happen in 2011, we intend to study also a particular aspect of Nuclear Physics that may be relevant for the stability of the neutron stars - celestial objects of great interest for Astronomy and Astrophysics.

2.4.3 Objectives

The HADES detector is dedicated to the study of heavy ion collisions at energies below 2 AGeV and elementary reactions below 4 GeV.
In recent years HADES has produced a series of relevant physics results, mostly with elementary particles or light ions owing to granularity limitations in the forward time-of-flight (TOF) detector. From 2010 onwards the work will be continued with heavy ions. Furthermore, the experimental program is expected to be continued at the higher beam energies (8-10 AGeV) available at the future FAIR facility.
Since several years LIP is contributing to the upgrade of HADES. The involvement of LIP has been mostly technical with the design, construction and commissioning of a large RPC wall (8 square meters), which will cover the most forward region of the spectrometer and provide time of flight information with a resolution of $\approx$70 ps.
Our group is responsible for all detector hardware and auxiliary systems of the RPC TOF Wall, while the detector electronics, both front-end and digital acquisition, are the responsibility of groups from the Universities of Santiago de Compostela and Valencia, Spain, and from GSI.
LIP assures also the general coordination of the HADES RPC group and of the RPC slow control tasks. The RPC-specific software is a responsibility of the University of Santiago de Compostela.
With the completion of this large task, LIP is expected to take a major role in the exploration of the new system (2011 onwards), joining other international institutions in sharing the load of running the experimental setup, by taking part into beamtimes and by leading the scientific investigation into physics subtopics of the main goals (i.e. the precision spectroscopy of in medio effects in heavy ion and elementary collisions).
Specifically we aim to contribute to a physics subtopic within the potential capabilities of the wall: the measurement of kaon and anti-kaon flow in heavy ion collisions below the threshold energy per nucleon for kaon production in nucleon-nucleon collisions. This information, equivalent to the experimental detection of a collective motion pattern of the kaons leaving the densest phase of compressed nuclear matter formed in the collision, could reveal the presence of a potential different from the one in vacuo. A clear impact on current astrophysical models of neutron star interiors is apparent through the possibility of anti-kaon condensation. Experimentally, the detection of anti-kaon flow at sub-threshold energies is still open due to their extreme rarity: about one per 10000 anti-pions. Clearly, stringent requirements on the apparatus time response as well as granularity are imposed and demand a careful simulation study.
These simulation studies, necessary for the request of future beam periods, are being performed integrated into a thematic group within HADES, with full participation of our group.

2.4.4 Achievements

HADES RPC TOF WALL

The RPC TOF Wall has been operating since January 2010 with all major hardware components active. The operation has been perfectly smooth.
We participated in 3 commissioning beam times during this year, confirming the excellent characteristics of the RPC system: resolution close to 80 ps and matching efficiency above 90%. The RPC had no difficulty to cope with the highest count rates foreseen in HADES.
Work progressed on small auxiliary systems, including: a spare electronics box for the gas system, connection of the gas system to the slow control via CANBUS, readout of the small reference chambers installed within

the gas boxes for gas monitorization purposes, remote readout of the multiplicity trigger signals for debugging purposes.

PARTICIPATION IN THE PHYSICS PROGRAM

The preparation for analysing the real data continued with the usual emphasis on the strangeness sector and in particular kaon production. Some refinements have been done to the stand-alone simulation tool internally developed by the group. Moreover, continuing the efforts toward the final aims of possibly measuring the anti-kaon flow, the data concerning reaction plane resolution archived with the forward beam hodoscope, when it was installed in the KaoS experiment, have been studied in detailed and extrapolated to the expected condition in HADES during the upcoming Ag+Ag beam at 1.65 AGeV. The basis of this work has been the analytic theory developed by J.-Y. Ollitrault. Moreover the expected error on the reconstructed directed and elliptic flow parameters (v1 and v2) have been estimated as a function of the number of reconstructed kaons per slice of rapidity by means of a simplified Monte-Carlo developed in house.

FUNDING

The participation in HADES is now formalized via a Memorandum of Understanding (MOU) celebrated between the Collaboration, GSI and FCT. Within this MOU, FCT has committed to support the maintenance of the system and the common fund until 2012.
Funding of 91742€ for these activities was granted by the project PTDC/FIS/113339/2009 over three years.

2.4.5 Sources of Funding

Code	Funding	Start	End
EU Contract 515876 DIRAC-Phase-1	52.000 €	2005-10-01	2011-03-31
LIP-GSI contract	414.000 €	2005-10-01	2011-03-31
CERN/FP/109373/2009	10.000 €	2009-10-01	2010-12-31

2.4.6 Team

Project coordinator: Paulo Fonte

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	10
Alessio Mangiarotti	Researcher (LIP)	30
Carlos Capela	Researcher (ESTGL)	5
Carlos Neves	Researcher (ESTGL)	1
Carlos Sousa	Researcher (ESTGL)	10
Luís Lopes	Technician (LIP)	10
Milena Vieira	Researcher (ESTGL)	10
Paulo Fonte	Researcher (LIP/ISEC)	10

2.4.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *RPC HADES-TOF wall cosmic ray test performance*
  A. Blanco, D. Belver, P. Cabanelas, J. Díaz, P. Fonte, J.A. Garzon, A. Gil, D. Gonzalez-Díaz, W. Koenig, B. Kolb, L. Lopes, M. Palka, A. Pereira, M. Traxler and P. Zumbruch
  Nucl. Instrum. and Meth. in Phys. Res. A

Articles in international journals (with indirect contribution from LIP members)

- *Origin of the low-mass electron pair excess in light nucleus-nucleus collisions*
  The HADES collaboration
  Phys. Lett. B 690 (2010) 118-122

- *Lambda-p femtoscopy in collisions of Ar + KCl at 1.76AGeV*

  Phys. Rev. C 82 (2010) 021901

- *In-medium effects on K-0 mesons in relativistic heavy-ion collisions*
  The HADES collaboration
  Phys. Rev. C 82 (2010) 044907

Institute reports

- *Status of the HADES RPC Time Of Flight Wall*
  The HADES RPC group
  GSI Scientific Report 2009

2.4.8 Presentations

Oral presentations in international conferences

- *RPC HADES-TOF wall cosmic ray test performance*
  presented by Alberto Blanco
  X Workshop on Resistive Plate Chambers and Related Detectors, February 9-12, 2010 — GSI, Darmstadt, Germany..

Oral presentations in collaboration meetings

- *Status RPC*
  presented by Paulo Fonte
  HADES Collaboration Meeting XXI, 22-26 March 2010 — GSI, Darmstadt, Germany,.

2.4.9 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Articles in international journals (with indirect contribution from LIP members)	3
Institute reports	1
Oral presentations in international conferences	1
Oral presentations in collaboration meetings	1

2.5 Phenomenological Studies at the LHC

2.5.1 Resumo

Resumo:
Um importante esforço conjunto de preparação da comunidade experimental e teórica de Física de Partículas Elementares é necessário por forma a responder ao desafio do LHC. Este esforço deve ser concentrado não apenas no estudo dos melhores observáveis em LHC que permitam realizar testes de precisão do Modelo Padrão (SM) da Física Elementar de Partículas, mas também no desenvolvimento de novas ideias de Física para além do SM. Com o objectivo de concretizar uma estreita colaboração entre a comunidade de Físicos Experimentais e Teóricos de Partículas, foram propostas várias tarefas no âmbito do presente projecto, e cujo estado actual se passa a descrever.
A primeira tarefa envolveu o estudo de processos associados a correntes neutras com troca de sabor (FCNC) na produção simples de quarks top em LHC. Para o efeito foi desenvolvido um modelo teórico efectivo e estudado o impacto de novos acoplamentos em observáveis físicos em LHC. Os novos processos foram incluidos em geradores Monte Carlo de LHC (TopRex, Madgraph e CalcHep) e verificou-se que a sua importância não pode ser ignorada em LHC face aos canais normais de produção directa. O gerador Pythia foi utilizado para a hadronizacao dos acontecimentos.
Uma segunda tarefa envolveu o estudo da produção de bosões de Higgs através do processo gg(qq)->h+jatos->tau+tau-+jatos. Foi realizado um estudo detalhado a nível partónico e os resultados foram aplicados a alguns modelos de física para além do Modelo Padrão que preveêm um aumento significativo da largura de decaimento do Higgs para dois taus. Os resultados levam à conclusão que várias regiões do espaço de fase dos parâmetros podem ser excluídas com uma luminosidade de apenas alguns fb-1 em LHC. Este estudo foi também estendido a experiencias do LHC e constitui o tema de um dos seminários de um estudante de Mestrado em Fisica.
Outra tarefa desenvolvida no âmbito deste projecto, envolveu o estudo de assimetrias angulares em decaimentos

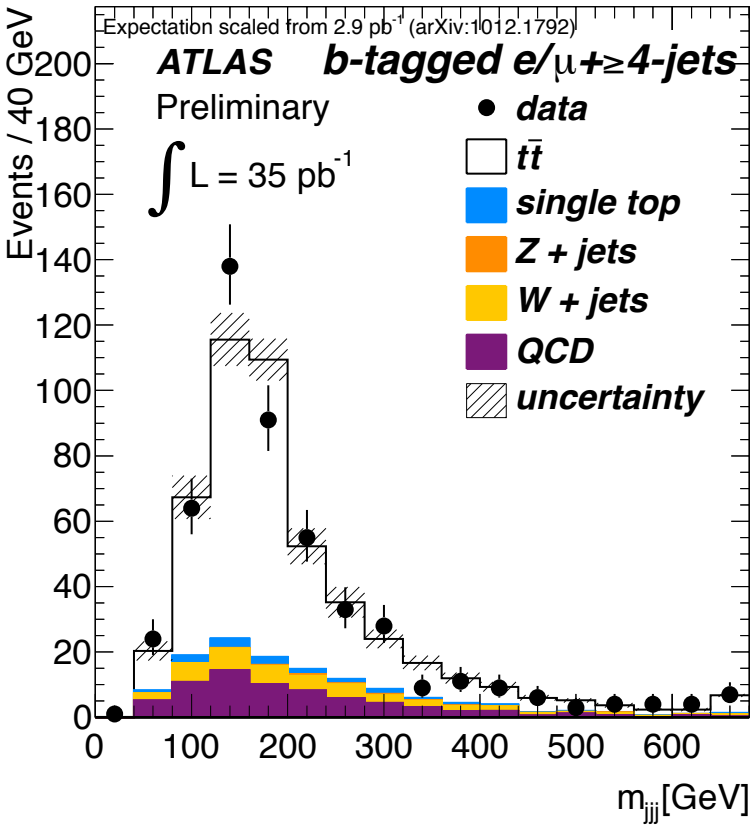

Figura 2.5: Distribution of m_{jjj}, the invariant mass of the 3-jet combination having the highest p_T, for events passing the electron or muon plus jets selection.

do quark top produzidos aos pares e de forma simples em LHC. No SM o vértice Wtb é considerado puramente esquerdo com uma intensidade proporcional ao elemento Vtb da matriz de Cabibbo-Kobayashi-Maskawa (CKM). Apesar da secção eficaz de produção dupla de quarks top em LHC não ser sensível ao valor de Vtb, as correlações angulares dos produtos de decaimento destes quarks podem dar informação valiosa sobre a estrutura do vértice Wtb. Novas assimetrias foram introduzidas (A+ e A-) bem como novas razões entre as polarizações dos bosões W (ρR e ρL). Foi possível verificar que os novos observáveis introduzidos são mais sensíveis aos acoplamentos anómalos vectoriais e tensoriais do que os previamente utilizados em LHC. Foram estudadas as correlações entre os vários observáveis e desenvolveu-se o programa (designado por TopFit) que permite fazer o ajuste global de todos os observáveis (quer associados à produção simples quer dupla de quarks top em LHC) em função dos novos acoplamentos anómalos. Foram obtidos limites preliminares nos acoplamentos anómalos em experiencias do LHC.
No âmbito do presente projecto foram ainda desenvolvidos novos Modelos Teóricos e implementados em geradores de sinal.

2.5.2 Abstract

Summary of the Activities:

In order to address the physics potential of the LHC program, a significant joint effort of the experimental and theoretical particle physics community is required. This effort must consider not only the study of the best physical observables to perform a precise test of the Standard Model (SM) of Elementary Particle Physics at LHC, but also to develop new ideas for physics beyond the SM. Several tasks were proposed in the present project to implement a strong collaboration between experimental and theoretical particle physicists. The status of such tasks is summarized in what follows.

Top Quark FCNC Processes

The main goal of this task is to study signals of physics beyond the SM in single top quark Flavour Changing Neutral Currents (FCNC) processes at LHC. Following the development of a model independent analysis for single top production via FCNC (where dimension 5 and 6 effective flavour changing and flavour conserving quark-gluon vertices were considered), the impact of these new couplings on the physical observables at LHC were studied.
Current status of the present task: the theoretical model is well developed (with publications in international scientific journals and presentations in conferences) and its implementation within the framework of the TOPREX generator is done. New contributions associated to the electroweak sector were calculated and the amplitudes were included in the Monte Carlos generators (MadGraph and CalcHep). The Pythia generator has been used to perform quark hadronization. Several generators produced by the team members are already available (Protos). Studies already performed show that the new contributions cannot be ignored at the LHC when compared to the direct process: they give the same order of magnitude contributions to the overall single top production cross-section via FCNC.

Non-Standard Higgs Production

Until a thorough experimental Higgs analysis is performed it will be very hard to distinguish between the different models proposed associated to the Higgs physics (2HDM,Fermiophobic Higgs,etc.). The main goal of this task was to test, for a chosen set of luminosities (from the first year of data taken at the LHC to the full Super-LHC sample), which models could be tested and for which regions of the parameter space.
Current status of the present task: Together with the theoretical group at NExT (University of Southampton), a detailed study at parton level was performed for the production of Higgs bosons through the processes gg(qq)->h+jets->tau+tau-+jets. The obtained results were interpreted in terms of parameter phase space exclusion regions for few models of Physics Beyond the Standard Model. It was shown that even with few fb-1 of luminosity at the LHC, significant portions of the phase space can be excluded. First studies on a general purpose experiment at LHC were performed which constituted the core study of one Master student seminar.

Study of Top Quark Couplings in ttbar and Single Top Events

The LHC will be a top factory with a total t-tbar production cross-section of around 800pb and single-top production of around 300pb. This fact allows to measure with high precision the Wtb vertex and the couplings of the top quark. Although the double top production is insensitive to the Vtb CKM matrix element, the angular asymmetries between the top quark decay products can nevertheless give valuable information on the

structure of the Wtb vertex. New right-handed couplings can be introduced within an effective lagrangian approach which can be probed at the LHC.
Current status of the present task: New asymmetries (A+ and A-) and new W polarization states ratios (ρR and ρL) were introduced and tested at the LHC. The studies performed with several Monte Carlo generators (TOPREX, ALPGEN, MC@NLO, etc.) have shown that the new observables are more sensitive to vector and tensor like (right and left) anomalous top couplings. The program, TopFit was upgraded to perform a global fit of all relevant observables (taking into account the correlations between them) in order to set the most stringent limits to the anomalous couplings. The ttbar and single top physics were combined to get a global fit from both channels at the LHC. First preliminary limits on the anomalous couplings were derived for general purpose experiments at the LHC.

Theoretical Models and Monte Carlo Generators

One of the fundamental tasks of this project is the development of theoretical models which allow a better comprehension of the SM and physics beyond the SM.
Current status of the present task: although several models have already been developed (see tasks 1 and 2 of the project) associated either to the single top quark production via FCNC or with the top quark decays (and the study of the Wtb vertex), this task is still in development: it is still necessary to introduce a new interpretation of the electroweak couplings associated to the top quark, as well as the measurement of the angular asymmetries in the top quark decays. The contribution of the Higgs channel started but the study is not yet complete. The new PROTOS generator was developed and his available to the community. This generator has implemented the correct parameterization of the anomalous couplings for ttbar and single top production. All couplings are on-mass shell. A new Monte Carlo generator (based on MadGraph and interfaced with Pythia and the simulations of the LHC experiments simulations) is under development for the study of top quark electroweak couplings (ttgamma and ttZ) for the LHC.

2.5.3 Objectives

In order to address the physics potential of the LHC program, a significant joint effort of the experimental and theoretical community is required. This effort must consider not only the study of the best physical observables to perform a precise test of the Standard Model (SM) of Elementary Particle Physics at LHC, but also to develop new ideas for physics beyond the SM. In the present project, specific topics of the physics program of the LHC are addressed from both the experimental and theoretical points of view. Following the work previously developed by the experimental team at LEP, HERA and more recently LHC, the inclusion of new members from the field of theoretical particle physics allow us to develop a High Energy Physics group specifically dedicated to the physics at the LHC. The aim of this project is to support this group giving special emphasis to the training of MSc and PhD students and motivation to new undergraduate students. The project was very successful in the past in attracting students (from portuguese and foreign universities) and provided the correct framework for the development of several MSc and PhD thesis already, both in experimental and theoretical physics. The project in itself is very valuable once it brings together the experimental and theoretical communities under a common goal of research, with the long term objective of exploring in an efficient way the data that will be collected at the LHC. As was done in the past, regular meetings are foreseen in the course of the project, and seminars are expected to be held in order to motivate the scientific community to the physics potential of the LHC.

2.5.4 Achievements

- New Monte Carlo generators were developped (and continue to be developped) i.e., Protos and new MadGraph, CalcHep interface with Pythia for FCNC studies
- New developments on the TopFit software to allow the combination of ttbar and single top observables to set limits on possible anomalous couplings at the Wtb vertex
- New publications and presentations at Conferences
- Several Master and PhD students were trained and the interaction between experimentalists and theoreticians is beeing strengthened

2.5.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/109372/2009	35.000 €	2009-11-01	2010-10-31

2.5.6 Team

Project coordinator: António Onofre

Name	Status	%of time in project
António Onofre	Researcher (LIP/UMinho)	30
Augusto Barroso	Researcher (FCUL)	20
Bruno Galhardo	Graduate student (LIP)	50
Francisco del Aguila Giménez	Researcher (UGR)	20
João Carvalho	Researcher (LIP/FCTUC)	30
Juan Aguilar-Saavedra	Researcher (LIP)	20
Miguel Fiolhais	Master student (LIP)	100
Miguel Won	Master student (LIP)	50
Nuno Castro	Post-Doc (LIP/UGR/FCT)	60
Orlando Oliveira	Researcher (LIP/FCTUC)	10
Pedro Ferreira	Technician (LIP/FCT)	10
Renato Guedes Júnior	Researcher (LIP/FCUL)	20
Rita Monteiro	Post-Doc (LIP)	100
Roberto Pittau	Researcher (UGR)	20
Rui Santos	Researcher (LIP/FCUL)	20

2.5.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Higgs boson phenomenology in tau+ tau- final states at the LHC*
  A. Belyaev, R. Guedes, S. Moretti and R. Santos
  Journal of High Energy Physics 1007 (2010) 051

- *Using single top rapidity to measure V_td, V_ts, V_tb at hadron colliders*
  J.A. Aguilar-Saavedra, A. Onofre
  : arXiv:1003.3173 [hep-ph] (accepted)

Articles in international journals (with indirect contribution from LIP members)

- *Double Neutral Higgs production in the Two-Higgs doublet model at the LHC*
  A. Arhrib, R. Benbrik, C.-H. Chen, R. Guedes and R. Santos
  Journal of High Energy Physics 0908 (2009) 035

- *Zt, gamma t and t production at hadron colliders via strong flavour-changing neutral couplings*
  J.A. Aguilar-Saavedra
  Nucl.Phys.B837:122-136,2010. e-Print: arXiv:1003.3173 [hep-ph]

- *Very Light Higgs Bosons in Extended Models at the LHC*
  A. Belyaev, R. Guedes, S. Moretti and R. Santos
  Phys. Rev. D 81 (2010) 095006

- *Effective four-fermion operators in top physics: A Roadmap*
  J.A. Aguilar-Saavedra
  Nucl.Phys.B843:638-672,2011.e-Print: arXiv:1008.3562 [hep-ph]

Institute reports

- *Double Higgs production at a photon collider*
  Rui Santos, et. al.
  DESY-PROC-2009-03, Jan 2010.

2.5.8 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	2
Articles in international journals (with indirect contribution from LIP members)	4
Institute reports	1

Chapter 3

Computing

3.1 Grid Computing

3.1.1 Resumo

Durante 2010 o grupo de computação do LIP centrou as suas actividades em três tópicos, a operação do Tier-2 Português para o "Worldwide LHC Computing Grid"(WLCG), a operação de um serviço nacional de computação grid integrado na infraestrutura Ibérica (IBERGRID), e a transição para o "European Grid Initiative"(EGI).
O Tier-2 Português continuou a exibir um desempenho excelente. Durante 2010 foi o oitavo maior fornecedor de capacidade de processamento a nível mundial entre os Tier-2 de ATLAS e CMS.
No contexto da Iniciativa Nacional Grid, o LIP continuou a operar o nó central de computação grid, o maior centro Português de computação científica. O centro disponibiliza recursos computacionais a comunidades de investigadores de múltiplos domínios, incluindo as experiências do LHC.
O ano foi também assinalado pelo final do projecto EGEE, que deu lugar ao "European Grid Initiative"e ao estabelecimento de um novo modelo para a computação grid na Europa.

3.1.2 Abstract

During 2010 the LIP computing group centred its activities around three main topics, the operation of the Portuguese Tier-2 for the Worldwide LHC Computing Grid (WLCG), the operation of a national grid computing service integrated in the Iberian grid infrastructure (IBERGRID), and the transition to the European Grid Initiative (EGI).
The Portuguese WLCG Tier-2 has continued to show excellent performance. During 2010 it was the 8th largest processing capacity provider among the ATLAS and CMS Tier-2 centres worldwide.

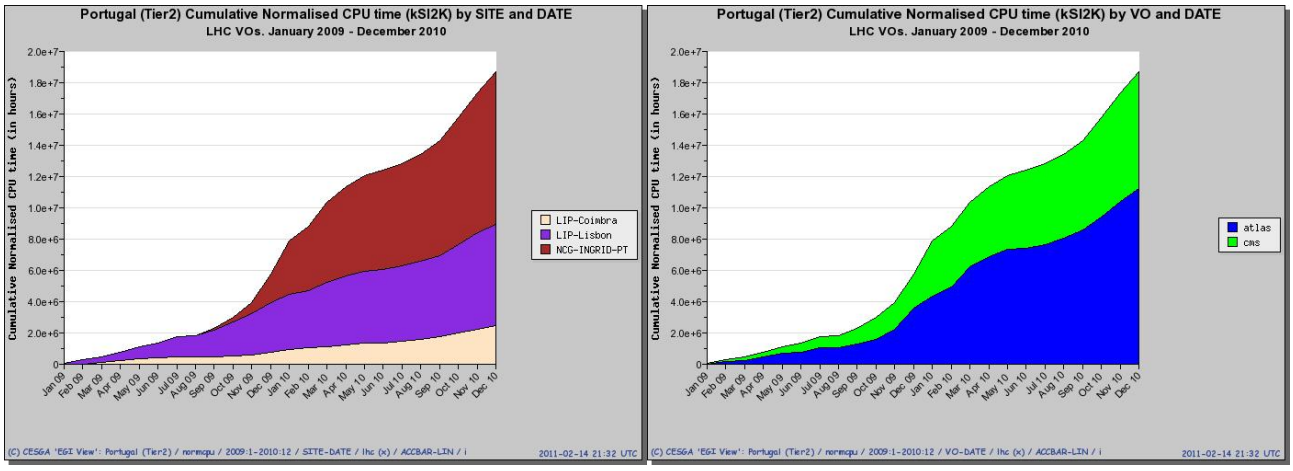

Figura 3.1: Portuguese federated Tier 2 cumulative CPU time per site and per VO since January 2009

In the context of the Portuguese national grid initiative, LIP continued to operate the main node for grid computing (NCG) the largest scientific computing infrastructure in the country. This centre is providing computing capacity to research communities from multiple scientific domains including the LHC experiments.
Finally 2010 was marked by an important event for the future of distributed computing in Europe. The project Enabling Grids for E-sciencE (EGEE) ended and the transition towards a new European grid computing model has started.

Worldwide LHC Computing Grid
The Portuguese federated Tier-2 is composed by resources provided by three grid computing sites: LIP-Lisbon, LIP-Coimbra and "main node for grid computing"(NCG). The three centres have shown outstanding performance. The Portuguese Tier-2 was the 8th largest ATLAS and CMS provider with 1.7% of the overall worldwide Tier-2 processing capacity. This percentage was 0.1 higher than in the previous year.
Though its complexity and challenging nature the Portuguese Tier-2 is successfully fulfilling and exceeding the Portuguese obligations assumed in the WLCG memorandum of understanding. During 2010 the efforts were focused in optimizing the performance and improving the reliability of the three centres. The goal was to provide a stable high-performance production service in close collaboration with the ATLAS and CMS communities.

Enabling Grids for E-science
The project Enabling Grids for e-sciencE (EGEE) was pioneer in operating a production quality grid infrastructure for European researchers from multiple scientific domains including the WLCG. The EGEE project ended in April 2010 after six years of successful results. LIP was one of the EGEE partners. The LIP responsibilities included among others, the integration and coordination of the national grid computing centres, and the provisioning of user support.
LIP assumed these responsibilities until the end of the project. LIP also worked to ensure a smooth transition from EGEE towards the new model established by the European Grid Initiative.

European Grid Initiative
The European Grid Initiative (EGI) is an organization based in Amsterdam whose goal is to coordinate a sustainable European wide grid computing infrastructure. The EGI stakeholders are the National grid Initiatives (NGI) endorsed by the governments. Each NGI operates a national grid service based on computing resources provided by the local scientific community. LIP had an important role in the creation of the Portuguese NGI and in the adhesion of Portugal to EGI. In 2010 LIP worked towards the setup of both the EGI organizational structure and deployment of the EGI/NGI infrastructure operations.
The EGI infrastructure is funded by the NGIs with assistance from the European Union through a new project designated Integrated Sustainable Pan-European Infrastructure for Researchers in Europe (EGI-Inspire). LIP is a member of the EGI-Inspire collaboration and acts as Portuguese NGI representative.
LIP ensured the smooth migration of the EGEE regional infrastructure to the new EGI/NGI model in close collaboration with the Spanish NGI. The IBERGRID initiative was used to provide a joint collaboration framework to enable both countries (NGIs) to share the responsibilities and effort of providing all the services and capabilities necessary for an effective participation in EGI.
A migration plan was established and successfully executed. The Portuguese and Spanish computing infrastructures are now operated as a single EGI entity known as NGI_IBERGRID. Both countries retain autonomy and independence at the political and administrative level. In this sense LIP and UMIC (the Portuguese government agency responsible for the Portuguese NGI) are representing the Portuguese NGI at the EGI council.
Furthermore Portugal and Spain through IBERGRID have been appointed to coordinate some of the most important EGI global tasks. In this context LIP in Portugal, together with IFCA, CESGA and UPV in Spain, are performing the following tasks on behalf of the whole EGI community:

- Coordination of the middleware rollout process
- Definition of middleware acceptance criteria
- Verification of middleware acceptance criteria
- Coordinate the provisioning of VO technical services

Portuguese National Grid Initiative (Portuguese NGI)
In the EGI model each country is represented by an NGI. Therefore the Portuguese NGI has now added responsibilities and increased importance. The Portuguese NGI administrative and political management is

performed by UMIC that also pays the country EGI fee. LIP continues to act as the grid infrastructure technical coordinator. Both organizations share the EGI council seat.
The cornerstone of the Portuguese grid infrastructure is the main node for grid computing (NCG), the largest scientific computing facility in the country. NCG was built in the context of the Portuguese NGI and provides computing and storage resources for the Portuguese research community. The Portuguese Tier-2 is one of the customers of this centre. The NCG grid resource centre is managed by LIP.
Several other national researchers and international projects are also benefiting from the NCG services. During 2010 several new user communities have joined, and the LIP computing team assisted them. Most of these users needed parallel computing and considerable effort was put in supporting the MPI parallel computing service at NCG. This service has been very successful. Furthermore the first steps to integrate the LNEC parallel computing cluster have been performed with the addition of several LNEC computing nodes to the NCG cluster.
LIP also coordinated the Portuguese grid sites integrated in the NGI infrastructure including the WLCG Tier-2 sites and sites from other academic and research organizations. Furthermore LIP operated the central grid services that enable the integration of the Portuguese NGI resources into a single coherent infrastructure. In this context the LIP Certification Authority (CA) provided the authentication credentials needed for Portuguese grid users and services. The LIP CA is member of both the European Policy Management Authority and International Grid Trust Federation where it has an active role.

IBERGRID
IBERGRID joins the Portuguese and Spanish NGIs together for the purpose of sharing computing resources at the Iberian level and acts as a common umbrella for a joint Iberian participation in EGI. During 2010 a plan to migrate the old EGEE Southwest Regional Operations Centre to a common operations model based on IBERGRID was prepared and implemented. In addition a range of common IBERGRID virtual organizations was established in both countries enabling the sharing of computing resources across borders. The Iberian grid users can now profit from a common infrastructure, common procedures and common resources.

LIP Computing Infrastructures
The restructuring of the LIP computing services in Coimbra has been started. The plan to deploy a computing site supporting the new LIP centre at the University of Minho has been postponed due to financial limitations. Resources from the Tier-2 have been borrowed to CMS and ATLAS and Tier-3 capacity for local users was deployed in Lisbon and Coimbra.
In Lisbon preliminary research aimed at improving the computing service processes applying the ITIL methodology took place as part of a master thesis.

HEPIX
The HEPiX forum unites the information technologies experts from the High Energy and Nuclear Physics. HEPIX is the most important forum for exchange of technical information and experiences among the HEP computer centres. LIP has been very active in this forum and organized the HEPiX Spring 2010 event in Lisbon.

3.1.3 Objectives

- Contribute to the development of distributed computing technologies for scientific computing and complex problem solving.
- Promote the uptake of grid computing by the scientific community.
- Coordinate the deployment and operation of the Portuguese grid in the context of the Portuguese National Grid Initiative, and provide computing services to the scientific community.
- Operate the Portuguese federated Tier-2 for the Worldwide LHC Computing Grid in coordination with CERN and the ATLAS and CMS experiments.
- Contribute to the structuring and sustainability of grid computing in Europe.
- Consolidate IBERGRID as an Iberian infrastructure and as a platform for a common Portuguese and Spanish participation in the European Grid Initiative.

3.1.4 Achievements

- Provisioning of a production quality Tier-2 exceeding the WLCG requirements and service level agreements.
- From January 2010 to December 2010 the Portuguese Tier-2 was the 8th largest Tier-2 providing resources to ATLAS and CMS.
- LIP is performing several global tasks for EGI which include the coordination of activities such as the middleware rollout.
- LIP participates in grid decision making bodies such as the EGI council and the WLCG deployment board.
- Successful transition from the EGEE administrative, organizational and operational model to the new NGI/IBERGRID/EGI model.
- Consolidation of the Portuguese NGI and successful provisioning of computing services to Portuguese researchers from several domains.
- Contribution to successfully establish the EGI vision in Europe.

3.1.5 Sources of Funding

Code	Funding	Start	End
IBERGRID	4.250 €	2007-01-01	2011-12-31
GRID/GRI/81842/2006	180.700 €	2007-09-10	2010-09-09
G-CAST	1.000 €	2008-01-01	2010-12-31
EGEE-III	307.000 €	2008-05-01	2010-04-30
EGI InSPIRE	485.000 €	2010-05-01	2014-04-30

3.1.6 Team

Project coordinator: Jorge Gomes

Name	Status	%of time in project
Carlos Manuel	Technician (LIP)	100
Gaspar Barreira	Researcher (LIP)	63
Gonçalo Borges	Researcher (LIP)	100
Hugo Gomes	Technician (LIP)	100
João Martins	Researcher (LIP)	100
João Pina	PhD student (LIP)	25
Jorge Gomes	Researcher (LIP)	100
José Aparício	Technician (LIP)	100
Mário David	Researcher (LIP)	100
Miguel Oliveira	Researcher (LIP)	100
Nuno Dias	Researcher (LIP)	100

3.1.7 Publications

International Conference Proceedings

- *GRID, PaaS for e-science*
  J. Gomes, G. Borges, M. David
  CLOUDVIEWS 2010 2nd Cloud Computing International Conference, ISBN: 978-989-96985-0-5, Pages: 33-40

- *Ibergrid Transition to EGI*
  Javier Lopez Cacheiro, Gonçalo Borges, Jorge Gomes, Mario David, Hugo Gomes et al
  4th Iberian Grid Infrastructure conference proceedings, Ed.: Netbiblo ISBN: 978-84-9745-549-7, Pages: 19-23

- *Provisioning of Grid Middleware for EGI in the framework of EGI-Inspire*
  Mario David, Gonçalo Borges, Jorge Gomes et al
  4th Iberian Grid Infrastructure conference proceedings, Ed.: Netbiblo ISBN: 978-84-9745-549-7, Pages: 24-35

- *The road to Production: SGE Integration Process with CREAM-CE*
  Esteban freire García et al (including Gonçalo Borges)
  4th Iberian Grid Infrastructure conference proceedings, Ed.: Netbiblo ISBN: 978-84-9745-549-7, Pages: 71-79

- *Contribution of the Iberian Grid Resources to the Production of Simulated Physics Events for the ATLAS experiment*
  M. Kaci et al (including G. Borges, M.David, J. Gomes, J. Martins M. Oliveira)
  4th Iberian Grid Infrastructure conference proceedingsm, Ed.: Netbiblo ISBN: 978-84-9745-549-7, Pages: 165-176

- *The CMS Iberian Computing Sites performance*
  E. Accion et al (including G. Borges, M. David, J. Gomes J. Martins, M. Oliveira)
  4th Iberian Grid Infrastructure conference proceedings, Ed.: Netbiblo ISBN: 978-84-9745-549-7, Pages: 177-188

- *Portuguese Tier-2 readiness*
  Gonçalo Borges, Gaspar Barreira, Mario David, Nuno Dias, Hugo Gomes, Jorge Gomes, João Martins, Miguel Oliveira
  4th Iberian Grid Infrastructure conference proceedings, Ed.: Netbiblo ISBN: 978-84-9745-549-7, Pages: 201-211

- *Iberian ATLAS Cloud response during the first LHC collisions*
  Villaplana, M; Amorós, G; Borges, G; Borrego, C; Carvalho, J; David, M; Espinal, X; Fernández, A; Gomes, J; González de la Hoz, S; Kaci, M; Lamas, A; Nadal, J; Oliveira, M; Oliver, E; Osuna, C; Pacheco, A; Pardo, JJ; et al
  Proceedings of the International Conference on Computing in High Energy and Nuclear Physics (CHEP 2010)

Collaboration notes with internal referee

- *Transition Plan for O-E-9 Middleware Roll-Out*
  M. David, G. Borges, J. Gomes et al

- *IBERGRID Transition Plan to the National GRID Infrastructure Based Model*
  J. Lopez, A. Simon, I. Campos, J. Gomes, M. David, G. Borges

3.1.8 Presentations

Oral presentations in international conferences

- *GRID, PaaS for e-science*
  presented by Jorge Gomes
  CloudViews 2010 - 2nd Cloud Computing International Conference — Porto, Portugal.
- *Provisioning of Grid Middleware for EGI in the framework of EGI-Inspire*
  presented by Mário David
  IBERGRID 2010 — Universidade do Minho, Braga.

- *Portuguese Tier-2 readiness*
  presented by Gonçalo Borges
  IBERGRID 2010 — Universidade do Minho, Braga.

Presentations in national conferences

- *Infra-estruturas de computação do LIP (LIP-Coimbra)*
  presented by Miguel Oliveira
  Jornadas LIP 2010 — Universidade do Minho, Braga.
- *Computação no LIP*
  presented by Jorge Gomes
  Jornadas LIP 2010 — Universidade do Minho, Braga.
- *Infra-estruturas de computação do LIP (LIP-Lisboa)*
  presented by Mário David
  Jornadas LIP 2010 — Universidade do Minho, Braga.
- *Actividades e projectos de computação*
  presented by Gonçalo Borges
  Jornadas LIP 2010 — Universidade do Minho, Braga.
- *Actividades e projectos de computação (Computação Avançada)*
  presented by Miguel Oliveira
  LIP Workshop 2010 — Universidade do Minho, Braga.
- *Actividades e projectos de computação (LCG)*
  presented by Mário David
  LIP Workshop 2010 — Universidade do Minho, Braga.
- *Grid Computing*
  presented by Jorge Gomes
  Jornadas RCTS 2010 — FCCN, LNEC Conference Centre, Lisboa.
- *Grid Computing Infrastructure Projects*
  presented by Jorge Gomes
  Infraestruturas de Investigação do 7ºPQ — Instituto Superior Técnico - Lisboa.
- *Cloud Computing from implementation to scientific applications*
  presented by Jorge Gomes
  Encontro Ciência 2010 — Lisboa.
- *The Portuguese Grid Initiative and the LHC Challenge*
  presented by Miguel Oliveira
  Ciência 2010 — Lisboa.
- *Topics in High Performance Computing*
  presented by Miguel Oliveira
  Workshop on HPC — de Telecomunicações, Coimbra.

Oral presentations in international meetings

- *MPI in a SGE CreamCE*
  presented by Gonçalo Borges
  MPI Task Force Meeting — IFCA, Santander, Spain.
- *LIP and Grid in Portugal*
  presented by Gonçalo Borges
  Hepix Spring 2010 — Lisbon .
- *Hyperthreading influence on CPU performance*
  presented by João Martins
  Hepix Spring 2010 — Lisbon.

- *VO Services in EGI*
  presented by Jorge Gomes
  EGI Technical Forum — Amsterdam.

Oral presentations in collaboration meetings

- *Middleware release workflow, staged rollout and communication channels with the EGI operations community*
  presented by Mário David
  EGI operations kick-off meeting — Amsterdam.
- *NGI_IBERGRID Progress Status*
  presented by Gonçalo Borges
  EGI operations kick-off meeting — Amsterdam.
- *gLite 3.1 to 3.2: migration proposal*
  presented by Mário David
  Operation Management Board Meeting — Amsterdam.

Seminars

- *Advanced Computing Workshop*
  presented by Miguel Oliveira
  LNEC Training — LNEC, Lisboa.
- *Access to resources in the Grid environment INGRID + EGEE + IBERGRID*
  presented by Gonçalo Borges
  IBERGRID 2010 — Universidade do Minho, Braga.
- *Access to a thin-node MPI cluster in a Grid environment*
  presented by Miguel Oliveira
  IBERGRID 2010 — Universidade do Minho, Braga.
- *Cloud e Grid Computing*
  presented by Jorge Gomes
  Seminarios de Computação — Universidade Lusófona.

Outreach seminars

- *O LHC e as GRIDs*
  presented by Miguel Oliveira
  Quark Project — University of Coimbra.

3.1.9 Events

- *Hepix Spring 2010*
  Workshop, LNEC Conference Center, Lisboa, 2010-04-19

3.1.10 Project Summary

	number
International Conference Proceedings	8
Collaboration notes with internal referee	2
Oral presentations in international conferences	3
Presentations in national conferences	11
Oral presentations in international meetings	4
Oral presentations in collaboration meetings	3
Seminars	4
Outreach seminars	1
Workshops	1

3.2 GRID for Simulation and Data Analysis in ATLAS/LHC

3.2.1 Resumo

As capacidades de computação da colaboração ATLAS implicam a necessidade da adopção do paradigma de computação GRID. Durante 2010 a equipa esteve envolvida na operação do cluster Tier 2 de Grid de LHC (LCG/EGEE), em Portugal, numa federação entre os laboratórios de Coimbra e de Lisboa (em dois locais), onde foi instalado novo equipamento e novo software e serviços. Foi adquirida nova capacidade de armazenamento, que corre o sistema Lustre, para armazenar os dados de ATLAS, tanto reais como simulados, necessários para a análise local de física. O sistema esteve em produção para a colaboração ATLAS e outras organizações virtuais, tendo sido utilizado no processamento, armazenamento, simulação e análise de dados obtidos no LHC, o qual está a funcionar em modo de colisão desde Março de 2010. O sistema apresentou um desempenho excelente, com elevados níveis de eficiência, contribuindo deste modo para o sucesso dos primeiros meses de operação do LHC, com a disponibilização de dados processados pouco tempo após a sua aquisição. Foi ainda continuado o trabalho na área da execução de trabalhos remotos, com o desenvolvimento de soluções de segurança, bem como a criação de bibliotecas que permitem aos binários do BOINC correrem em máquinas virtuais.

3.2.2 Abstract

The computing needs of the ATLAS collaboration imply the adoption of the GRID computing paradigm. During 2010 the team was involved in the operation of the portuguese LHC Tier 2 GRID cluster (LCG/EGEE), in a federation between the Coimbra and Lisbon laboratories, where it was installed new equipment, software and services. New storage capacity was acquired, running the Lustre system, to store ATLAS data, both real and simulated events, necessary for the local physics analyses. The system is in production and being used, by the ATLAS collaboration and other virtual organizations, to process, store, simulate and analysis of LHC data samples. The LHC was run in collision mode since March 2010. The system has shown an excellent performance, with high efficiency levels, contributing in this way to the success of the first months of LHC operation, with the availability of processed data a short time after its acquisition. It was also continued the task in the area of remote job execution, with the development of security solutions, and also the production of libraries which allow the BOINC binaries to run in virtual machines.

3.2.3 Objectives

The ATLAS production activities of the LIP sites are well integrated in the ATLAS activity within the Iberian cloud, which is part of the Worldwide Large Hadron Collider Computing Grid (WLCG), with infrastructures in Spain and Portugal, including a Tier-1 at PIC, in Barcelona, with several Tier-2s in Spain and the federated Tier-2 at LIP in Coimbra and Lisbon and at the Portuguese Grid central node (NCG).
In the ATLAS computing model, the ATLAS production system uses the LCG for simulation and analysis of experimental data. The ATLAS production system provides a common framework where any Grid flavour can be integrated. It connects several individual elements which provide the required functionality for the submission, tracking, recovery and validation of jobs.

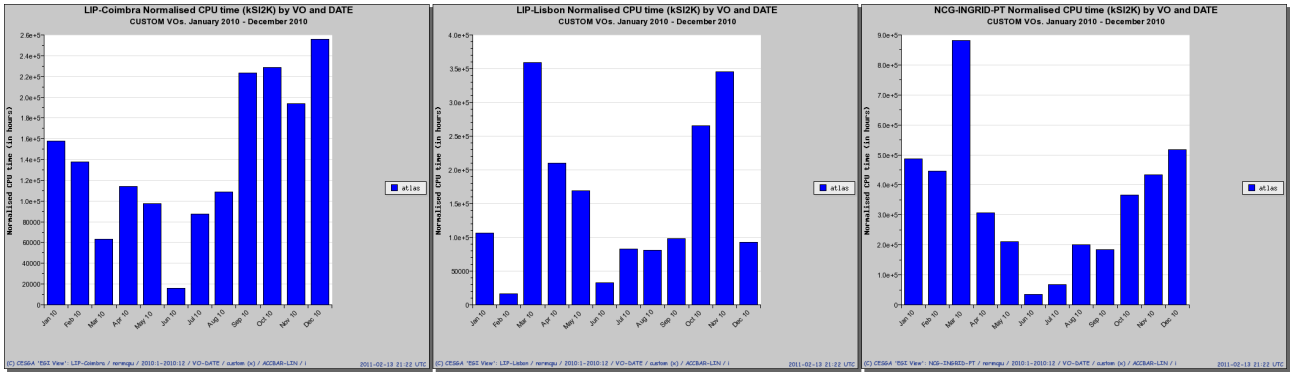

Figura 3.2: Normalised CPU time used by the ATLAS collaboration on the three Portuguese sites.

The project aim is the operation of the Grid infrastructure processing, storage, simulation and analysis of data for the ATLAS collaboration, supporting the local physics analysis team.

3.2.4 Achievements

The Tier-2 Grid nodes at LIP in Lisbon and Coimbra and in the NCG have undergone important upgrades during the last year. The storage capacity was greatly increased in order to keep large real data and simulated event samples acquired and produced by the ATLAS collaboration, for local physics analysis. New services were implemented, as gLite-APEL and CREAM-CE. It was also implemented a hardware and services monitoring solution.
A Tier3 for local user analysis is integrated in the clusters, sharing the same hardware and software with the Tier2 infrastructure. A fair share queuing system guarantees that on a medium time scale the official Atlas production (Tier2) and the local user tasks (Tier3) obtain the negotiated share of processing power. This mechanism allows a more efficient use of the installed infrastructure and resources than if separate clusters would be mounted for Tier2 and Tier3. The Tier 3 service was extended for ATLAS at the national level, covering all the sites and users.
The Iberian cloud and the Portuguese Tier2 have shown excellent results in the operation during the last year. The reliable operation of the Grid infrastructure contributed to the great success of the first year of LHC operation, with data processed and available a short time after data taking. The concept of distributed computing is enhanced in the Iberian cloud as there are two Tier-2 Federations (Spain and Portugal) which overcome eventual outages very easily. During the first heavy data flow, after the start of the LHC collision operation mode in March 2010, the Spanish cloud and, in particular, the Portuguese Tier2, have shown excellent performance.
Members of the project have attended several seminars, workshops, schools and conferences that have been instrumental at achieving the main goal. Participation on international conferences [IBERGRID2010, EGEE User Forum, HEPiX Spring 2010, HPC Advisory Council Workshop] has allowed the presentation of the work being carried out on site. It was also important the formation activities for other users and operators of Grid and high performance computing.

Self-organizing clusters
In 2010, the work focused on creating a library to enable BOINC binaries to run under a virtual machine. Sand-boxing technologies in general, and virtual machines in particular, can provide the security that volunteers expect, while, at the same time, they can also simplify the task of project creators. The followed approach can bring a number of very interesting byproducts, such as simplified check-pointing. The solution achieved in the end of the project can bring security to volunteers and simplicity to project owners.
Concerning this work there was one publication and Diogo Ferreira, to whom was awarded a grant by the project, finished his M. Sc. titled "Sandboxes in Desktop Grid Projects". The overall work resulted in the following contributions:
- A library called "Libboincexec", which extends BOINC with the capability to run applications in any generic execution environment.
- Several execution plugins which support VMWare, VirtualBox, QEMU and also local execution environments.
One of the highest points of this period was a meeting with David Anderson, the creator of BOINC platform, who invited the team to participate in the 6th BOINC Workshop in London, in August 31st and September 1st to present the work that has been doing to the BOINC community.
The project will finish by April 2011 and the activities will continue integrated in another projects and funding. The main objectives of the project were achieved and, in some cases, exceeded.

Publications
1. Diogo Ferreira, Filipe Araujo and Patricio Domingues. "Custom execution environments in the BOINC middleware". In 4th Iberian Grid Infrastructure Conference (IBERGRID 2010), Braga, Portugal, May 2010.
2. G. Borges et al., "Portuguese Tier-2 readiness", Proceedings of IBERGRID, "4th Iberian Grid Infrastructure Conference", Alberto Proença et. al. (Eds.), Universidade do Minho, ISBN 978-84-9745-549-7
3. M. Kaci et al., "Contribution of the Iberian Grid Resources to the Production of Simulated Physics Events for the ATLAS Experiment", Proceedings of IBERGRID, "4th Iberian Grid Infrastructure Conference", Alberto Proença et. al. (Eds.), Universidade do Minho, ISBN 978-84-9745-549-7

Presentations
1. E. Acción et al., "Distributed Computing and Data Analysis in the CMS Experiment: the

Spanish and Portuguese case", 5th EGEE User Forum, Uppsala, Sweden, April 12-16, 2010, http://indico.cern.ch/contributionDisplay.py?sessionId=19&contribId=165&confId=69338
2. X. Espinal et al., "ATLAS Distributed Computing in Spain and Portugal: From data challenges to real data", 5th EGEE User Forum, Uppsala, Sweden, April 12-16, 2010, http://indico.cern.ch/contributionDisplay.py?sessionId=19&contribId=4&confId=69338
3. M. Oliveira, "Topics in Advanced Computing", Workshop in High Performance Computing, http://www.ccc.ipt.pt/≈hpc/Presentations/Pres

3.2.5 Sources of Funding

Code	Funding	Start	End
GRID/GRI/81727/2006	140.000 €	2007-04-12	2011-04-11

3.2.6 Team

Project coordinator: João Carvalho

Name	Status	%of time in project
António Onofre	Researcher (LIP/UMinho)	20
Délio Almeida	Researcher (Critical Software)	30
Diogo Ferreira	Master student	42
Filipe Araújo	Researcher (FCTUC)	10
Filipe Veloso	Post-Doc (LIP)	10
Helmut Wolters	Researcher (LIP/FCTUC)	50
João Bastos	Post-Doc (LIP)	10
João Brito	Researcher (Critical Software)	10
João Carvalho	Researcher (LIP/FCTUC)	25
Miguel Oliveira	Researcher (LIP)	22
Miguel Won	Master student (LIP)	50
Nuno Castro	Post-Doc (LIP/UGR/FCT)	10
Patricia Conde	Researcher (LIP)	25
Paulo Martins	PhD student (LIP/FCT)	50
Pedro Jorge	PhD student (LIP/FCT)	25

3.2.7 Publications

International Conference Proceedings

- *Portuguese Tier-2 readiness*
  G. Borges et al.
  Proceedings of IBERGRID, "4th Iberian Grid Infrastructure Conference", Alberto Proença et. al. (Eds.), Universidade do Minho, ISBN 978-84-9745-549-7

- *Contribution of the Iberian Grid Resources to the Production of Simulated Physics Events for the ATLAS Experiment*
  M. Kaci et al.
  Proceedings of IBERGRID, "4th Iberian Grid Infrastructure Conference", Alberto Proença et. al. (Eds.), Universidade do Minho, ISBN 978-84-9745-549-7

- *IBERIAN ATLAS Cloud response during the first LHC collisions*
  M Villaplana, G Amorós, G Borges, C Borrego, J Carvalho, M David, X Espinal, A Fernández, J Gomes, S González de la Hoz, M Kaci, A Lamas, J Nadal, M Oliveira, E Oliver, C Osuna, A Pacheco, J J Pardo, J del Peso, J Salt, J
  Proceedings on Conference on Computing in High Energy and Nuclear Physics 2010, Taipei, Taiwan, 18 - 22 Oct 2010

3.2.8 Presentations

Oral presentations in international conferences

- *ATLAS Distributed Computing in Spain and Portugal: From data challenges to real data*
  presented by
  5th EGEE User Forum — Uppsala.

- *Custom execution environments in the BOINC middleware*
  presented by Diogo Ferreira
  4th Iberian Grid Infrastructure Conference (IBERGRID 2010) — Braga.

Presentations in national conferences

- *Topics in Advanced Computing*
  presented by Miguel Oliveira
  Workshop on High Performance Computing — Coimbra.

3.2.9 Academic Training

Master Theses

- *Sandboxes in Desktop Grid Projects*
  Diogo Ferreira, 2010-07-15

3.2.10 Project Summary

	number
International Conference Proceedings	3
Oral presentations in international conferences	2
Presentations in national conferences	1
Master Theses	1

Chapter 4

Astroparticle Physics

4.1 Collaboration in AMS - Alpha Magnetic Spectrometer

4.1.1 Resumo

O modelo standard da cosmologia (modelo do Big Bang) baseia-se na expansão do Universo a partir de um estado inicial muito quente e denso e tem como suporte experimental as descobertas do movimento de recessão das galáxias por Hubble em 1929 e da radiação cósmica de fundo por Penzias e Wilson em 1964. No estado inicial do Universo, iguais quantidades de matéria e antimatéria terão sido produzidas. No entanto, o que se observa actualmente nos raios cósmicos que são detectados na Terra é uma clara assimetria na sua composição no que respeita a matéria e antimatéria. A procura de eventuais aglomerados de antimatéria no Universo e o entendimento do mecanismo que produziu esta assimetria são questões essenciais na astrofísica actual. Outra questão fundamental é a compreensão da natureza da matéria que compõe o Universo. Mais de 90% da matéria existente é não-luminosa, isto é, matéria escura, mas a sua composição permanece um mistério. Os raios cósmicos são compostos de partículas neutras e carregadas que atravessam a galáxia em todas as direcções. Um melhor entendimento dos mecanismos de aceleração e propagação requer uma medida dos fluxos de raios cósmicos tão

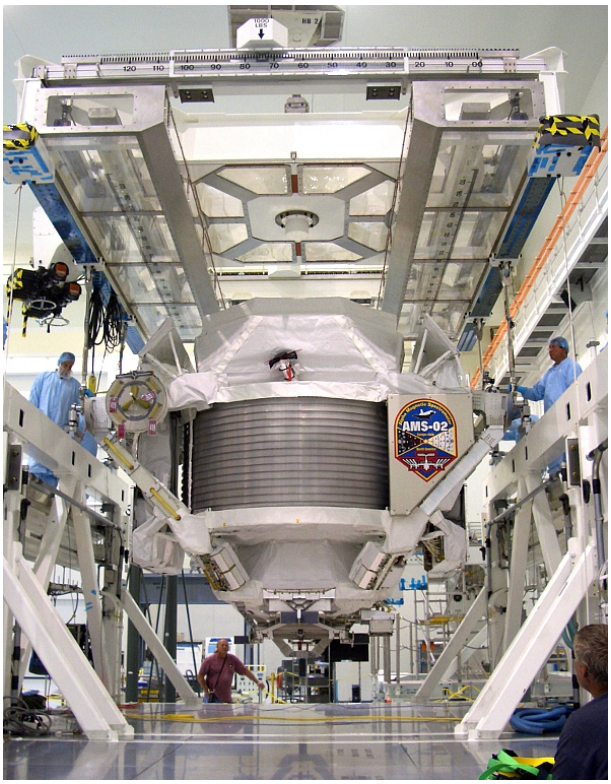

Figura 4.1: AMS-02 detector to be installed on the ISS in April 2011

precisa quanto possível e abrangendo o maior intervalo de energias. O detector AMS, a ser instalado na Estação Espacial Internacional por um período de três anos em Abril de 2011, permitirá prospectar a existência de antimatéria e matéria escura com uma precisão nunca antes alcançada.

4.1.2 Abstract

The standard model of cosmology (Big Bang model) is based on the Universe expansion from an extremely hot and dense initial state and has as experimental support the discoveries of the recession movement of the galaxies by Hubble in 1929 and of the cosmic microwave background radiation by Penzias and Wilson in 1964. In the initial state of the Universe, equal amounts of matter and antimatter would have been produced. However, what is now observed in the cosmic rays detected at Earth is a clear asymmetry in their composition in what concerns matter and antimatter. The search for eventual clusters of antimatter in the Universe and the understanding of the mechanism that produced such asymmetry are essential issues for present astrophysics. Another fundamental question is the understanding of the origin of the matter of which the Universe is composed. More than 90% of the existing matter is non-luminous, i.e, dark matter, but its composition remains a mystery. Cosmic rays are composed of neutral and charged particles that cross the galaxy along all directions. A better understanding of the acceleration mechanisms and propagation requires a measure of the cosmic-ray fluxes as accurate as possible and over a wider range of energies. The AMS detector, to be installed on the International Space Station for a three-year period in April 2011, will allow to search for the existence of antimatter and dark matter with an unprecedented accuracy.

4.1.3 Objectives

AMS (Alpha Magnetic Spectrometer) is a particle physics experiment to be installed in the International Space Station facility (ISS) that orbits around earth at an altitude of around 400 km. The main physics objectives will be the search for antimatter and dark matter and the study of the cosmic ray spectrum composition with an unprecedented statistics. Such measurements will contribute to a better understanding of the propagation and confinement of cosmic rays in the Galaxy.
The capabilities of the AMS spectrometer, compared to the one which flew in the space shuttle Discovery on June 1998, were largely improved and extended through the inclusion of new detectors, a Ring Imaging Cerenkov Detector (RICH), an Electromagnetic Calorimeter (ECAL) and a Transition Radiation Detector (TRD). The Electromagnetic calorimeter will provide AMS with the capability of identifying electrons/positrons and photons up to 1 TeV. The inclusion of a TRD will allow AMS to distinguish antiprotons from electrons with a rejection power of 10ˆ5. The detector RICH will provide both an independent measurement of the particle velocity and of the electric charge. A resolution goal on velocity for singly charged particles of the order of 10ˆ-3 and on charge of around 0.2 units of charge is aimed. Such a precision will allow to distinguish nuclei up to iron and perform mass separation up to energies of ≈15 GeV/nucleon.
In three years of data taking AMS will gather about 10 million positrons and 1 million antiprotons up to an energy of 400 GeV.

4.1.4 Achievements

Along the year of 2010 the AMS detector, fully assembled, was intensively tested.
The main objectives of the tests were the following:

- have a final decision on the magnet of the detector taking into account the increase of the ISS lifetime to 20 years
- test of the DAQ chain
- evaluation of the detector performance
- calibration and alignement

On February 2010, the detector was moved to the Large Space Simulator (LSS) at ESA´s research and technology centre, ESTEC, in Noordwijk, the Netherlands, where vacuum and thermal conditions similar to the ones existing in space were recreated. The simulation of the space conditions was crucial to prove the design of the overall detector and to ensure the mission time duration. The tests in the LSS indicated that the superconducting magnet first planned for the mission had to be substituted by the permanent magnet that had flown in the first flight.

The detector returned to CERN on May. The re-integration of the AMS-02 spectrometer went ahead and was completed by the end of July. A reconfiguration of the Silicon Tracker extended to 9 planes, instead of 8, was made in order to increase the bending power for the new magnetic field of 0.15 T. AMS underwent extensive tests and the final integration of the thermal blankets was done before being exposed at CERN to a beam of high energy particles for the final calibration. The new alignment of the tracker planes took place and the results confirmed that with the new tracker and magnet configuration the experiment exhibits almost identical measuring accuracy.
Then it flew to Florida in 26th August, transported on a C5 of the US Air Force leaving from the Geneva airport with destination the KSC Shuttle landing strip.
During 2010 several long periods of tests with electron, proton beams and cosmics were performed on the complete detector with the following purposes:

- tracker alignment, calibration and resolution
- electromagnetic calorimeter energy measurement
- magnetic field mapping
- charge reconstruction
- velocity reconstruction
- evaluation of the electron/proton separation

Beams of 400 GeV protons inciding with different angles and at different positions on the detector, electrons (350, 200, 150 GeV) and photons were used as well as cosmic-rays at the sea level (muons essentially). The beam tests took place at CERN in February and in August 2010.
A continuous evaluation of the detector was done since August with cosmics on Kennedy Space Center. A large number of events were collected for detector performance studies and trigger monitoring. End-to-end tests simulating the detector acquisition conditions on space and data transfer to ground were also performed. Some members of the team spent some time on KSC and have been participating actively on data taking tasks.
Along the year 2010 the Lisbon group was involved on the following tasks:

- AMS software: the AMS software includes the reconstruction algorithms. The Portuguese group developed reconstruction algorithms for the RICH detector. The collected data was used to evaluate and fine tune the reconstruction algorithms developed by the group for velocity and charge. All the LIP developed algorithms were updated to run in multithread context according to the collaboration directives. In addition, the code was optimized to reduce the computing time.

- RICH reconstruction performance: the velocity and charge reconstruction of the cosmic events with the LIP algorithms is used to monitor their accuracy and also to monitor the RICH detector, namely on the light yield, reflectivity of the mirror and refractive index of the aerogel.

- Isotopic separation: the degradation of the tracker resolution from 2 to around 8% imposes strong limitations on the classical mass separation method that uses both the velocity and rigidity measurements. For instance, the beryllium mass separation requires around 3% of mass resolution which seems impossible with the current permanent magnet. The study and implementation of a new mass separation method relying both on the geomagnetic cutoff and the very accurate measurement of the velocity made by the RICH is being performed. The first results indicate that the beryllium mass separation is feasible up to around 15 GeV/n.

The outcome of the Lisbon group has been regularly presented in the collaboration meetings, conferences and in several outreach activities.

4.1.5 Sources of Funding

Code	Funding	Start	End

4.1.6 Team

Project coordinator: Fernando Barão

Name	Status	%of time in project
Fernando Barão	Researcher (LIP/IST)	65
Gaspar Barreira	Researcher (LIP)	5
Luisa Arruda	Post-Doc (LIP/FCT)	20
Marcelo Jordão	Master (LIP)	4
Patrícia Gonçalves	Researcher (LIP)	5
Rui Faísca Pereira	Post-Doc (LIP/FCT) *	100

4.1.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *In-beam aerogel light yield characterization for the AMS RICH detector*
  M. Aguilar-Benitez et al.
  Nuclear Instruments and Methods in Physics Research A 614 (2010) 237-249

- *Characterization study of silica aerogel for Cherenkov imaging*
  Y. Sallaz-Damaz et al.
  Nuclear Instruments and Methods in Physics Research A 614 (2010) 184-195

- *Relative Composition and Energy Spectra of Light Nuclei in Cosmic Rays. Results from AMS-01*
  M. Aguilar et al.
  Astrophysical Journal 724 (2010) 329-340

International Conference Proceedings

- *The AMS-02 RICH detector: performance during ground-based data taking at CERN*
  R. Pereira, on behalf of the AMS RICH collaboration
  doi:10.1016/j.nima.2010.09.036 (accepted)

4.1.8 Presentations

Oral presentations in international conferences

- *AMS detector performances*
  presented by Fernando Barão
  La Physique d´AMS: Enjeux et Perspectives Scientifiques — Annecy, France.

- *The AMS-02 RICH detector: performance during ground-based data taking at CERN*
  presented by Rui Faísca Pereira
  7th International Workshop on Ring Imaging Cherenkov Detectors (RICH 2010) — Cassis, France.

Presentations in national conferences

- *AMS status: assembly and cosmic tests*
  presented by Rui Faísca Pereira
  Jornadas LIP 2010 — Braga, Portugal.

Oral presentations in international meetings

- *AMS - a large acceptance detector on the ISS*
  presented by Fernando Barão
  PASC Winter Workshop — Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *Status report on SW & Analysis from Portugal*
  presented by Luisa Arruda
  AMS Technical Interchange Meeting — Geneva, Switzerland.

Outreach seminars

- *AMS02 - The Alpha Magnetic Spectrometer Experiment*
  presented by
  Space Forum — Lisboa, Portugal.
- *AMS: Detecção de raios cósmicos na Estação Espacial Internacional*
  presented by Rui Faísca Pereira
  Semana Mundial do Espaço - Observatório Astronómico de Lisboa — Lisboa, Portugal.

4.1.9 Academic Training

PhD Theses

- *Reconstruction methods and tests of the AMS RICH detector - Sensitivity to light isotope measurements and dark matter searches*
  Rui Faísca Pereira, 2010-09-27

4.1.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
International Conference Proceedings	1
Oral presentations in international conferences	2
Presentations in national conferences	1
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	1
Outreach seminars	2
PhD Theses	1

4.2 Collaboration in the SNO and SNO+ experiments

4.2.1 Resumo

O grupo de Física de Neutrinos do LIP foi formado em 2005 para participar na experiência de Neutrinos Solares, SNO (Sudbury Neutrino Observatory), e integrou desde 2006, a proposta da experiência sucessora, SNO+. Os resultados de SNO comprovaram o fluxo total previsto de neutrinos solares de ^8B, medido por interacção de corrente neutra (sensível a todos os sabores de neutrinos), e simultaneamente a diminuição da taxa de neutrinos do electrão, medida por correntes carregadas - confirmando a oscilação de neutrinos e resolvendo o chamado Problema dos Neutrinos Solares.
A inovação da experiência SNO consistia na utilização de 1000 ton de água pesada como alvo e meio activo, numa esfera central de 6m de diâmetro, tornando possivel a interacção de neutrinos de baixa energia por corrente carregada e por corrente neutra. Estas interacções resultam na produção de radiação de Cherenkov, detectada por cerca de 9000 PMTs colocados numa estrutura geodésida com 8m de diâmetro. A medição das correntes neutras implica a detecção de neutrões, feita de três formas distintas em diferentes fases da experiência (I - por captura na água pesada; II - por captura em ^{35}Cl com maior secção eficaz e maior sinal; III - com contadores proporcionais, permitindo uma separação evento-a-evento e não só estatística como anteriormente). Os resultados separados das várias fases e da combinação das duas primeiras foram já publicados, estando a análise combinada de todos os dados a ser finalizada. No passado, o grupo do LIP desenvolveu várias análise e melhorias na calibração óptica do detector. Mais recentemente, tem a responsabilidade da análise final de oscilações de neutrinos.
Reutilizando o detector SNO, substituindo o alvo e meio activo de água pesada por cerca de 800 ton de cintilador líquido, SNO+ está em fase avançada de preparação no SNOLAB, entretanto expandido. Em Junho de 2009, o financiamento da experiência foi aprovado pelas agências científicas canadianas. Em Dezembro de 2009, a Fundação para a Ciência e a Tecnologia (FCT), o LIP, a colaboração SNO+ e o SNOLAB celebraram um acordo de cooperação científica, sob a forma de um Memorandum of Understanding. A participação do LIP é financiada pela FCT através de um projecto do concurso "Todos os domínios científicos", por três anos a partir de 2011.
Os objectivos científicos de SNO+ são múltiplos, sendo o principal a pesquisa com elevada sensibilidade do sinal de duplo declíneo beta sem neutrinos (Neutrinoless Double Beta Decay - 0NDBD), a assinatura mais promissora do eventual carácter de Majorana dos neutrinos massivos. A utilização de cintilador líquido permitirá baixar significativamente o limiar de energia, de modo a medir neutrinos solares pep e CNO, geo-neutrinos e anti-neutrinos produzidos em reactores nucleares, aumentar a sensibilidade a neutrinos de supernovas, e procurar o sinal de 0NDBD do isótopo ^{150}Nd, dissolvido em grande quantidade no cintilador.

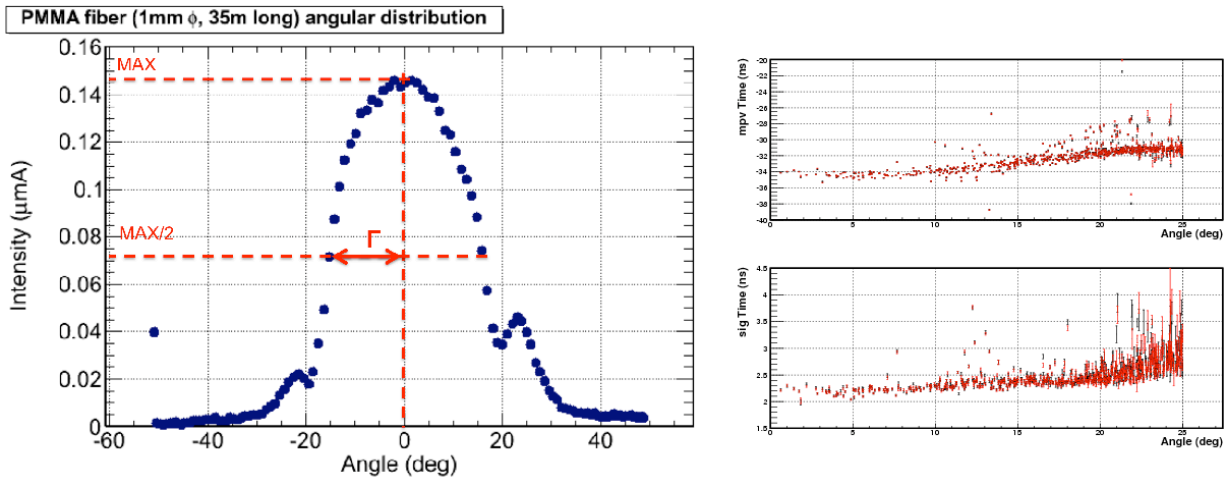

Figura 4.2: Left: Measurement of angular distribution of a 1 mm core PMMA fiber, done with the ATLAS group fiber test bench setup, adapted for the SNO+ fibers — Right: Results of PMT calibration tests with a LED+fiber system in the SNO detector (during the 2008 light water fill). Shown are the PMT time distribution peak (top) and width (bottom) in function of angle with respect to the fiber light cone axis.

Em SNO+ o grupo efectuou já vários estudos para a optimização do detector e de sensibilidade a análises de Física, assim como planos para a futura calibração e reconstrução de dados.
Implementámos a geometria de SNO+ nos dois códigos de simulação utilizados (um deles adaptado do código original de SNO, extensivamente testado, o outro baseado em GEANT4 que o deverá substituir a curto prazo) e estudámos em detalhe os fundos externos, com um impacto directo no desenho final do detector, estabelecendo requisitos de radiopureza dos novos materiais a utilizar.
Estamos a desenvolver um novo sistema de calibração em tempo dos fotomultiplicadores (PMTs), fundamental para uma eficiente reconstrução dos eventos e redução do ruído de fundo. Este sistema deve ser não-invasivo, baseado em vários cabos longos de fibra óptica, com ligação sequencial a um laser já existente e a LEDs. As fibras serão instaladas em posições fixas no detector, reduzindo a necessidade de introdução de fontes dentro do volume interno de cintilador. Para o desenvolvimento, testes e construção do novo sistema são utilizadas as instalações do grupo ATLAS no Centro de Física Nuclear da Universidade de Lisboa, e os testes realizados em 2009 e 2010 permitiram já elaborar o design do sistema. O sistema final será construído pelo LIP, nas oficinas de Coimbra, e instalado em SNO+ em 2011. Neste projecto colaboramos com as Universidades de Sussex e Leeds (UK), que são responsáveis pela iluminação das fibras com LEDs.
Devido à experiência adquirida em SNO, a calibração óptica de SNO+ irá ser uma das nossas responsabilidades principais no futuro. O nosso grupo é desde já responsável por este subgrupo de trabalho, em que estamos a desenvolver o plano de análise.
Propomo-nos também desenvolver um conjunto de ferramentas de reconstrução de dados bem adaptado às caracteristicas ópticas e temporais do detector, que será utilizado nos vários estudos de física, para a reconstrução de energia, que é fundamental para a identificação dos sinais de 0NDBD ou dos neutrinos solares pep, e a reconstrução de eventos não pontuais, fundamental para a identificação e redução de fundos. Estes algoritmos serão inicialmente testados em simulações Monte Carlo e posteriormente adaptados de acordo com as medições mais precisas das propriedades do cintilador líquido e do dopante ^{150}Nd.
Focando os aspectos organizativos, o grupo do LIP organizou em Lisboa a reunião de colaboração de 2010, e ocupa a vice-presidência da "Collaboration Board".

4.2.2 Abstract

The LIP group on Neutrino Physics was created in 2005 to participate in the solar neutrino experiment SNO (Sudbury Neutrino Observatory), SNO, and integrated since 2006 the proposal for its successor experiment SNO+.
The SNO results confirmed the predicted total ^{8}B solar neutrino flux by measuring neutral current interactions, sensitive to all neutrino flavors, and simultaneously proved the disappearance of electron neutrinos measured by charged current interaction - proving neutrino oscillations and solving the so-called Solar Neutrino Problem. The innovation in SNO consisted in the use of 1000 tons of heavy water as target and active medium, in a 6m diameter central sphere, allowing for the neutral and charged current interaction of low energy neutrinos, and the production of Cherenkov radiation, detected by around 9000 PMTs mounted on a 8m diameter geodesic structure. The measurement of neutral current implies the detection of the neutron, made differently in different phases of the experiment (I - by capture in heavy water; II - by capture in ^{35}Cl, with higher cross-section and light output; III - in proportional counters, allowing for an event-by-event, and not only statistical, identification). The separate results obtained in each phase and the combination of the first two were already published and the full data set combined analysis is being finalized. In the past, the LIP group carried out several analyses and improvements in the optical calibration of the detector. More recently, it has the responsibility for the final neutrino oscillation analysis.
Re-using the SNO detector, replacing the target and active medium of heavy water by about 800 tons of liquid scintillator, SNO+ is in an advanced stage of preparation at the extended SNOLAB. In June 2009, the experiment funding was approved by the Canadian scientific agencies and, in December 2009, a Memorandum of Understanding for scientific cooperation was signed between FCT, LIP, the SNO+ Collaboration and SNOLAB. The LIP participation is funded bY FCT through a project in the "All Scinetific Domains"call, for three years, starting in 2011.
SNO+ has multiple scientific goals, the main one being the high sensitivity search for Neutrinoless Double Beta Decay (0NDBD), the most promising signature for the possible Majorana character of massive neutrinos. The liquid scintillator will allow for a significantly lower energy threshold, so that SNO+ can measure pep and SNO solar neutrinos, geo-neutrinos, and nuclear reactor anti-neutrinos, increase the sensitivity to supernova neutrinos, and search for the 0NDBD signal from the ^{150}Nd isotope dissolved in high quantities in the scintillator.
The LIP group has already developed several studies for the detector optimization and sensitivity to physics channels, and plans for future calibration and data reconstruction in SNO+.
We´ve implemented the SNO+ geometry in the two simulation codes used (one adapted from the original SNO

code, extensively tested, and another based on Geant4 which should replace it soon) and studied the external backgrounds, with a direct impact in the final detector design, by establishing the radiopurity requirements for the new materials.
We are developing a new method for PMT timing calibration, fundamental for the efficient event reconstruction and background reduction. The system should be non-invasive, based on several long cables of optical fibers, with a sequential connection to LEDs or an existing laser. The fibers should be placed in fixed positions in the detector, reducing the need to introduce sources inside the scintillator internal volume. The ATLAS group lab at Centro de Física Nuclear da Universidade de Lisboa is being used for the development, test and construction of this system - a design has already resulted from this work. The final system will be built by LIP, in the Coimbra workshops, and installed in SNO+ in 2011. We collaborate with the Sussex and Leeds Universities (UK), which are responsible for the LED illumination.
Taking advantage of the experience acquired in SNO, in the future we will take the SNO+ optical calibration as one of our main tasks. Our group is already responsible for this analysis subgroup, for which we are developing the analysis plans.
We also propose to develop a set of data reconstruction tools well adapted to the optical and timing characteristics of the detector, to be used in the several physics studies for energy reconstruction, fundamental for the ONDBD and pep-neutrino signals identification, and for reconstruction of non point-like events, fundamental for background identification and reduction. These algorithms will first be tested with Monte Carlo simulations, and progressively adapted with more precise measurements of the liquid scintillator and ^{150}Nd loading.
Focusing on the organizational aspects, the LIP group organized in Lisbon the 2010 collaboration meeting, and serves as chair-elect for the Collaboration Board.

4.2.3 Objectives

The main objectives for 2010 were the completion of the SNO analysis, the construction of the SNO+ time calibration system (to be installed in 2011) and the preparation of reconstruction algorithms for the future SNO+ analysis.

SNO

Having carried out the main developments of the neutrino oscillation three-phase analysis in 2009, the goal for 2010 was to apply them to the real data for the production of the final results. Several verification and documentation tasks were needed for this analysis to be approved for publication. We also expected to use the SNO data to give some indication on the sign of the $\Delta\ m^2_{13}$ parameter and to improve the limits on the sterile neutrino model.

SNO+

The goal for the calibration and monitoring task for 2010 was to provide a final design and prototype for the external fiber PMT time calibration system. The production of the final system optical fiber cables and holder was also expected to start at the Coimbra workshop, but this was contingent on the project funding.
For the development of the reconstruction algorithms and physics analysis:
- External background and pile-up reduction:
The goal was to start from the external background studies to check the possible separation of spatially extended gamma events from point-like neutrino events. The same kind of techniques can be applied to identify pile-up caused by spatially separated double beta decays (with neutrinos).
- Reactor anti-neutrino oscillations
We expected to proceed with the analysis of fully simulated events for the reactor anti-neutrino oscillations analysis, using it as a test bench to check the reconstruction and identification algorithms. The goal was to test the feasibility of this measurement during the ^{150}Nd loading phase, in which pile-up can mimic the time coincidence characteristic of the anti-neutrino signal.
As a longer term goal, we intended to adapt the SNO optical calibration analysis to SNO+, to increase the sensitivity to the PMT angular response, previously shown to have a degradation with time.

4.2.4 Achievements

SNO

In SNO, the verification, validation and documentation of the solar neutrino analysis was completed and approved by the internal SNO collaboration review. Its application to real data was not yet carried out due to

the delay in approval of the Signal Extraction analysis, a necessary step that is not under the responsibility of our group. We expect this step to be overcome in early 2011.

SNO+

The main activity for SNO+ was the preparation of the PMT calibration system with optical fibers.

Calibration

- Measurement of optical properties of fibers. The measurements continued in 2010 using the ATLAS group setup for fiber characterization. These allowed us to conclude that PMMA optical fibers have the aperture necessary ($\approx$ 15 deg) to illuminate all the detector PMTs with a reasonable ($<$ 100) number of fibers.
- Analysis of 2008 LED data. In 2008, an early prototype of the system was installed in the detector by the Sussex group. We have carried out a detailed analysis of the data taken, to verify the timing and angular properties of the pulse. The results showed that a synchronization of the PMTs within our requirements can be achieved with PMMA fibers.
- Simulation. The propagation of the light beams in the SNO+ detector was simulated, to evaluate the effects of absorption and scattering, confirming that the chosen number of fibers (91) is more than enough, guaranteeing redundancy in the system.
- Construction and tests of prototype. Fiber holders were designed and prototypes built in the Coimbra workshop. All the other components of the fiber system (including the fibers) were purchased and full prototype sets were sent for tests: water compatibility tests in Brookahven, radioactivity and accelerated ageing in Sussex, mounting in the PMT structure at SNOLAB.

Simulation and analysis

We continued our studies of sensitivty to reactor neutrino oscillations, and also started new studies for the sensitivity to solar neutrinos. The activities related to gamma events identification were postponed, due to the tight schedule for the calibration tasks.

Organizational
The LIP group organized the 2010 SNO+ collaboration meeting (see "Events"), held at the Museu da Ciência in Lisbon. More than 60 people attended.
Roles held by LIP group members in the SNO+ collaboration structure:

- National spokesperson for Portugal;
- Chair-elect of the Collaboration Board;
- Convenor of the In-Situ Optics analysis subgroup;

4.2.5 Sources of Funding

Code	Funding	Start	End

4.2.6 Team

Project coordinator: José Maneira

Name	Status	%of time in project
Amélia Maio	Researcher (LIP/FCUL)	10
Carlos Silva	Technician (LIP)	10
João Carvalho	Researcher (LIP/FCTUC)	5
Joaquim Oliveira	Technician (LIP)	10
José Maneira	Researcher (LIP)	30
Luís Gurriana	Technician (LIP)	10
Luís Seabra	Master student (LIP)	25
Nuno Barros	PhD student (LIP/FCT)	100
Orlando Cunha	Technician (LIP)	15
Rui Alves	Technician (LIP)	10
Sofia Andringa	Researcher (LIP)	15
Sofia Leitão	Student (LIP)	25

4.2.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Low Energy Threshold Analysis of the Phase I and Phase II Data Sets of the Sudbury Neutrino Observatory*
  SNO Collaboration (N. Barros, J. Maneira among ≈140 authors)
  Phys. Rev. C 81, 055504 (2010) (accepted)

Articles in international journals (with indirect contribution from LIP members)

- *Searches for High Frequency Variations in the ^8B Solar Neutrino Flux at the Sudbury Neutrino Observatory*
  SNO Collaboration (N. Barros, J. Maneira among ≈140 authors)
  Astrophysical Journal 710 (2010) 540-548

Internal Notes

- *Analysis of the fiber tests in 2008 water runs*
  S. Andringa, J. Maneira
  SNO+ Document 649-v1

4.2.8 Presentations

Oral presentations in international conferences

- *Status and Prospects of SNO+*
  presented by José Maneira
  NOW2010, Neutrino Oscillation Workshop — Otranto, Italy.

Poster presentations in international conferences

- *A Three-Phase Combined Analysis of the Sudbury Neutrino Observatory*
  presented by Nuno Barros
  XXIV International Conference on Neutrino Physics and Astrophysics — Athens, Greece.

Presentations in national conferences

- *Towards the final SNO results*
  presented by Nuno Barros
  Jornadas LIP — Universidade do Minho.

- *SNO+ activities and plans*
  presented by José Maneira
  Jornadas LIP — Universidade do Minho.

- *Solar Neutrino Physics: recent results and prospects*
  presented by José Maneira
  PASC Winter Workshop — Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *SNO+ Timing fibers*
  presented by José Maneira
  SNO+ Collaboration meeting — Museu de Ciência, Lisboa.

Seminars

- *Physics goals and challenges of SNO+*
  presented by José Maneira
  — Technical University Dresden, Germany.

- *3-flavour neutrino oscillation analysis*
  presented by Nuno Barros
  — Technical University Dresden, Germany.

4.2.9 Academic Training

PhD Theses

- *Optical calibration and neutrino oscillation measurements at the Sudbury Neutrino Observatory (SNO)*
  Nuno Barros, (on-going)

4.2.10 Events

- *SNO+ Collaboration Meeting*
  Collaboration Meeting, Museu de Ciência, Lisboa, 2010-06-09

4.2.11 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Articles in international journals (with indirect contribution from LIP members)	1
Internal Notes	1
Oral presentations in international conferences	1
Poster presentations in international conferences	1
Presentations in national conferences	3
Oral presentations in collaboration meetings	1
Seminars	2
Collaboration Meetings	1

4.3 Participation in the ZEPLIN-III Experiment and R&D of Liquid Xenon Detectors for Dark Matter Search

4.3.1 Resumo

Este projecto centrou-se na participação do LIP-Coimbra no programa ZEPLIN-III que tem como objectivo a detecção directa de matéria escura.
Na última década assistiu-se ao grande desenvolvimento da cosmologia observacional. As observações em causa são muito diversas, incluindo a análise da anisotropia da radiação cósmica de fundo, distribuição de aglomerados de galáxias, efeitos de lente gravitacional, formação de grandes estruturas, luminosidade de supernovas. Da combinação de toda esta informação conclui-se que o universo tem cerca de 14 biliões de anos e é constituído por 4% de matéria bariónica, 23% de matéria escura e 73% de energia escura.
Todavia não se sabe de que é feita a energia escura, nem qual é a sua natureza ou origem. A evidência mais tangível seria a detecção directa das partículas que hão-de constituir a matéria escura. Contudo, as partículas WIMP (Weakly Interacting Massive Particles) que hipoteticamente compõem a matéria escura nunca foram detectadas.
Os WIMPs do halo de matéria escura devem poder ser detectados directamente por observação de recúos nucleares em meios detectores com muito baixo ruido. Várias experiências procuram actualmente sinais dessas colisões usando diferentes técnicas. Não há até agora nenhuma evidência da existência de tais colisões, à parte a variação sazonal reportada por DAMA, a partir de dados recolhidos durante 9 anos com cintilação de cristais de NaI. Porém esta não foi confirmada por qualquer outra experiência com limites de exclusão abaixo do sinal reportado.
A taxa de acontecimentos prevista varia de 10^{-6} a 10 events/kg/day, dependendo da distribuição de WIMPs no halo galáctico, da massa e da secção eficaz de colisão WIMP-nucleão. A energia de recúo nuclear será apenas da ordem de alguns keV, e tem que ser identificada entre o ruido muito mais abundante de recúos de electrões. Para tal é necessário observar dois sinais diferentes, seja: ionização e scintiliação (ZEPLIN-III; XENON); ionização e fonões (CDMS; EDELWEISS); ou cintilação e fonões (CRESST; ROSEBUD).
ZEPLIN-III é um detector de xénon de duas fases (líquida e gasosa). Em 2007 começou a ser instalado na Mina de Boulby, a aproximadamente 1100 metros de profundidade. A primeira tomada de dados com o detector foi concluida em Setembro de 2008 com uma exposição de 850 kg.days.
No seguimento da publicação em 2009 dos resultados obtidos durante a 1ª fase da experiência, o sistema de detecção foi melhorado com vista a uma segunda fase da experiência. Essa actualização consistiu em substituir os fotomultiplicadores por uns de muito menor radioactividade intrínseca e por se substituir a blindagem passiva por um veto activo, i.e., um detector que sinaliza os neutrões e raios-gama que por ele passam ou nele são absorvidos. Foi também adicionado um sistema baseado em LEDs e fibras ópticas para calibração e monitorização dos PMTS in-situ. Depois de completar estas alterações, deu-se início a novo período de acquisição de dados que teve início

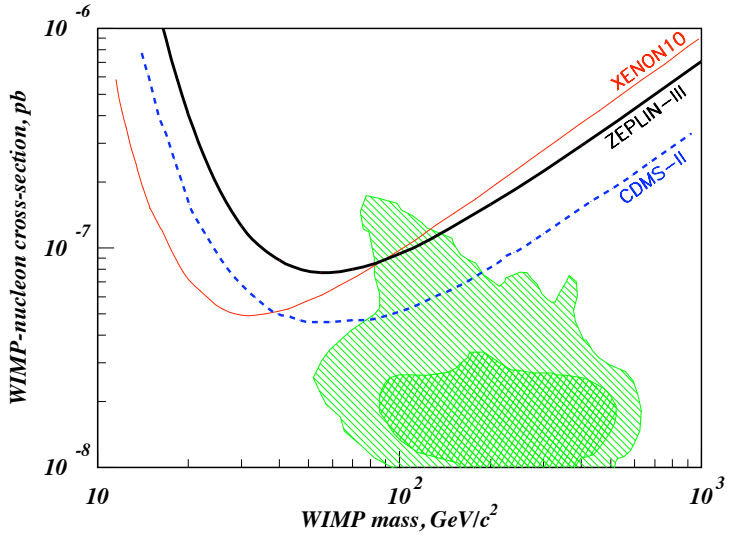

Figura 4.3: Limits on WIMP-nucleon spin-independent cross-sections from the first science run of ZEPLIN-III

a 21 de Junho de 2010 e ainda decorre. A aquisição de dados está a decorrer extremamente bem (obteve-se uma exposição de 1347 kg.days em 2010) esperando-se atingir uma sensibilidade de 2×10^{-8} pb para 60 GeV/c^2 no final de Fevereiro de 2011.
As alterações feitas ao sistema de detecção obrigaram à alteração do software de tratamento de dados, assim como de muitos aspectos da análise de resultados, que se iniciaram também durante o ano de 2010.
Durante este ano, a equipa do LIP teve uma participação contínua na actualização do detector e dos sistemas auxiliares a ele associados. Para além de ter participado directamente no turnos para montagem e teste do detector (num total de 152 dias de shifts underground), assim como para a preparação do início da aquisição de dados, teve à sua inteira responsabilidade as seguintes tarefas: actualização dos sistemas de control, de aquisição de dados e de calibração dos PMTs, assim como do software de redução e análise de dados, do ZEPLIN-III. No que respeita ao tratamento e análise dos resultados, teve à sua responsabilidade a adaptação, melhoramento e implementação do algoritmo de reconstrução de posição em ZEPLIN-III e a análise dos eventos de um só electrão nos dados adquiridos durante a primeira fase da experiência. Esses eventos são muito frequentes e a sua caracterização permite a calibração do sinal de carga do detector e a sua monitorização. Para além disso, é muito importante investigar a sua origem e o seu impacto na sensibilidade do detector.
Quanto às actividade de I&D, continuou-se a investigar a utilização de novos fotodetectores nos detectores de xénon líquido e de duas fases.

4.3.2 Abstract

This project is the continuation of our participation in the ZEPLIN program which aims at direct detecting dark matter using dual phase xenon detectors (i.e. liquid and vapour).
Evidence of dark matter would be the direct detection of any dark matter particles. However, the hypothesised WIMPs (Weakly Interacting Massive Particles) making cosmic dark matter still go undetected. Whether, these are particles already predicted by supersymmetric theories is unknown. Recent evidence of an excess of high energy positrons in cosmic rays by Fermi, Pamela and ATIC instruments may hint at a tantalising detection of dark matter annihilation. Yet, compelling evidence has to come from mono-energetic gamma rays whose energy and direction are not degraded in space.
Direct detection experiments are therefore central in his research. In recent years they became sensitive enough to start probe the parameter space favoured by some supersymmetric models of dark matter. The discovery of new particles at LHC (notably the neutralino) could greatly narrow the search space for WIMPs. However, such discovery would still not prove it is making the galactic halo, unless it is observed in there.
WIMPs from the dark matter halo should be directly detected by looking at nuclear recoils resulting from scattering with nuclei in a ultra-low background target detectors deployed underground. Various experiments are searching for these interactions using different techniques. No evidence of a WIMP-like signal was given so far, apart from the seasonal variation reported by DAMA, from 9 years of NaI scintillation data, but this has not been confirmed by any of the experiments that set upper limits well below the reported signal.
The predicted event rate ranges from 10^{-6} to 10 events/kg/day, depending on the distribution of WIMPs in the galactic halo, its mass and WIMP-nucleon scattering cross-section. The nuclear recoil energy can be a mere couple of keV, which has to be seen in a crowd of far more abundant electron recoils. This can be done by looking at pairs of signals, either: ionisation plus scintillation (ZEPLIN-III; XENON); ionisation plus phonons (CDMS; EDELWEISS); or scintillation plus phonons (CRESST; ROSEBUD).
ZEPLIN-III is a dual-phase xenon time projection chamber with a fiducial mass of 6.5 kg. In 2009, the analysis of data from a ZEPLIN-III raw exposure of 847 kg.days has excluded a WIMP-nucleon elastic scattering spin-independent cross section above 7.7×10^{-8} pb at 55 GeV/c^2 with a 90% CL. Moreover, it produced a world-leading result in the spin-dependent channel. Following the publication of the first run results mentioned above, ZEPLIN-III was upgraded which included the replacement of the photomultipliers by very low background ones and the installation of an active scintillator veto. The slow control and DAQ systems were also upgraded for integrating the veto and adding some additional features. A LED system was also installed to allow for calibrating and monitoring the PMTs in-situ. After the commissioning of the upgraded detector and ancillary systems, a second science run (SSR) started on 21 st June 2010 and it is presently under way at Boulby, UK. The run is progressing extremely well (an exposure of 1347 kg.days was accumulated in 2010) and a 2×10^{-8} pb sensitivity to 60 GeV/c^2 is expected to be reached by the end of February 2011.
The LIP-Coimbra team was deeply involved in the upgrade of the detector and its auxiliary systems and their commissioning. Besides the work on-site in a total of 152 days of shifts underground, LIP had full responsibility for the upgrade of the slow control, of the data acquisition system, the data reduction and analysis software (ZE3RA). Furthermore LIP designed, constructed and commissioned a new system for calibrating and monitoring the ZEPLIN-III photomultipliers in-situ. Regarding the data analysis, LIP was responsible for the upgrade of the position reconstruction software and for the comprehensive analysis of single electron events in

ZEPLIN-III.
In addition to the participation in the ZEPLIN program, the project had also a R&D component that included issues relevant for the design of the next generation of dark matter detectors: the operation of GEMs (Gas Electron Multipliers) in dual-phase xenon chambers and the detection of xenon scintillation by silicon photomultipliers (SiPM). Both, GEMs and SiPM, are regarded as promising readout alternatives to PMTs for xenon detectors (single-phase and dual-phase) for very-low background experiments.

4.3.3 Objectives

The main objectives of this project were:

- To complete ZEPLIN-III upgrade: participation in the detector upgrade underground and delivering the upgraded slow control and DAQ systems, as well as the LED+fiber system for calibrating and monitorising the PMTs, that were LIP full responsibility.
- To complete ZEPLIN-III underground commissioning: participation in the shifts underground for commissioning the detector and its auxiliary systems.
- To initiate the second science run (SSR) of ZEPLIN-III and to participate in the experiment operations.
- To prepare the tools for data analysis of SSR that were full responsibility of LIP group, i.e. the Zeplin 3 Reduction & Analysis (ZE3RA) system and the software for the position reconstruction.
- To study the single electron events in ZEPLIN-III using the first science data and a dedicated run that was carried out before starting the detector upgrade.
- To measure the quantum efficiency of a silicon photomultiplier for xenon scintillation.
- To measure the gain obtainable with a GEM viewed by an APD as the charge readout in a two-phase xenon detector.

4.3.4 Achievements

All the objectives mentioned above were accomplished, as described below.

Slow control system upgrade
This upgrade added the following functionalities:

- remote control of the detector cooling and liquid nitrogen refill
- automatic insertion of gamma-source for daily calibration
- automatic recovery mode for high voltage supplies
- low-power mode that allows to maintain the system in stand-by in case of a general power failure up to 10 hours
- a scripting system and a set of scripts for non-routine situations, such as vacuum loss, overpressure and over-cooling
- a detailed plan for system shut-down and wake-up in case of a power outage
- control of the DAQ including automatic stop and restart of science data
- acquisition for daily calibrations; it also controls the detector calibration with radioactive sources and the calibration of the PMTs with LEDs.

This upgrade allowed the experiment to be monitored remotely since middle of 2010, without the need of having personnel underground every day.The upgrade of the slow control system and its maintenance was a full responsibility task of the LIP team.

DAQ upgrade
The DAQ was upgraded in view of: i) reducing dead time associated with event acquisition and data management; ii) the implementation online analysis algorithms capable of discarding unwanted events without degrading the acquisition dead time; iii) the addition of the two additional channels to the DAQ for the veto; iv) synchronizing the ZEPLIN III DAQ with the veto. The LIP team was responsible for this upgrade of the DAQ and keeps the responsibility for its maintenance.

ZEPLIN-III Data Reduction and Analysis (ZE3RA) tool upgrade
ZE3RA (ZEplin 3 Reduction and Analysis) is a software application that takes this raw information, analyzes it and produces a set of physical quantities (e.g. pulse height, width, area, time constants) for each event that can be directly used in the next step of the data analysis chain.
In 2010, many new features were added to ZE3RA in order to remove noise, deal with the ringing and afterpulses of the PMTs and to improve the identification of the small signals. ZE3RA had to be modified also in view of the inclusion of the veto. Moreover, the human interface both for graphical and batch operation was improved.
The successive versions of the code incorporating these modifications were released (versions ZE3RA v3.1 to ZEBRA v3.5).

System for the calibration of the PMT array of ZEPLIN-III (31 PMTs)
The LIP team was fully responsible for the design, production and installation of the new system (hardware and software) for routine calibration and monitoring of the ZEPLIN-III PMTs. This system was part of the upgrade of ZEPLIN-III for the SSR. The system is composed by 7 independent LEDs, placed outside the detector, each connected to an optical fiber that goes into the detector and delivers the light pulses on the top of the liquid sensitive volume. It also includes electronic drives for the LEDs and the generation of the trigger signal for the DAQ system. The software tools to analyze the calibration data were also design and implemented. The system is in operation for weekly calibration and monitoring of PMTs since the beginning of the SSR.

Improvement of position reconstruction tool for ZEPLIN-III
Several improvements were introduced in the position reconstruction tool (developed by the LIP group for the first science run of ZEPLIN-III) for getting better position resolution and the identification of multiple scattering events. Modifications were also introduced in order to deal with some characteristics of the new PMTs such as their cross-talk. As result of these improvements, the light response function (LRF) reconstruction from the calibration data takes now several hours compared to several days for the previous version, while the position reconstruction speed improved by approximately a factor of 2. The spatial resolution was also improved. Using a copper phantom grid projection, spatial resolution (FWHM) was estimated to be about 2 mm for S2 and 14 mm for S1 for 122 keV gamma rays from a Co57 source.

Analysis of single electron events in ZEPLIN-III
Secondary scintillation signals due to spontaneously produced single electrons in the liquid xenon target of the ZEPLIN-III dark matter detector were studied in depth. Their amplitude distribution, timing properties and spatial distribution across the liquid were obtained. It was found that a single electron emerging from the liquid xenon in ZEPLIN-III produces 31.1 ± 0.2 photoelectrons on the photocathodes of the photomultipliers, in total. The photomultiplier amplitude spectrum is well described with a Gaussian function with sigma of 7.8 photoelectrons. This shows high sensitivity and good resolution of the detector for extremely low ionisations (a few electrons) especially important for future experiments on coherent neutrino scattering. The results also indicate relatively high rate ($\approx$ 13 Hz) of spontaneous emission of single electrons, which takes place both in the bulk of the liquid and from the surface of the wire grid kept at high voltage. This spontaneous electron emission will constitute background for the neutrino experiments although does not have a significant impact in the case of dark matter search. The results will be submitted for publication soon. They were part of the Master Thesis in Physics presented by Edward Santos at University of Coimbra this year.

Alternative readouts for dual-phase xenon detectors
Two types of devices were investigated as promising alternative readouts for dual-phase detectors: silicon photomultipliers (SiPM) and the Gas Electron Multiplier (GEM).
A windowless SiPM with inverted structure (i.e. a p-on-n SiPMs developed to shift the peak of detection efficiency towards $\approx$ 400 nm compared to $\approx$500 nm of the n-on-p structure) produced by Hamamatsu was investigated at room temperature and down to -35°. The measurements carried out included the determination of the dark count rate, the gain and the absolute value of the photon detection efficiency. In spite of the low

noise (<1 Hz for pulses of 1 phototelectron or larger) and high gain ($> 10^6$) being very promising, parameters like the photon detection efficiency for the xenon scintillation light (<3%) and afterpulsing (≈20% probability for 1 photoelectron) seem to impose a serious drawback for its use in xenon detectors.
As regarding to GEMs, in our previous work we achieved stable operation of a single GEM in a dual-phase xenon chamber with gains up to 150 and good energy resolution (16% for alpha-particles from a 241Am source). In order to increase the gain of the GEM, approaching it to that of the PMTs currently used in dual-phase xenon detectors, a cascade of a GEM and an APD was used so that the secondary scintillation light produced by the GEM is detected and further multiplied by the APD. A double phase liquid xenon detector was set-up with an Advanced Photonix large area APD mounted on top of a GEM. The cascade was operated successfully and a gain up to ≈3000 electrons per primary electron was achieved, but the energy resolution was deteriorated somehow.

4.3.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/109320/2009	70.000 €	2010-01-01	2010-12-31

4.3.6 Team

Project coordinator: Isabel Lopes

Name	Status	%of time in project
Alessio Mangiarotti	Researcher (LIP)	15
Alexandre Lindote	Post-Doc (LIP)	85
Américo Pereira	Technician (LIP)	35
Cláudio Silva	Post-Doc (LIP/FCT) *	100
Edward Santos	Master student (LIP)	100
Filipa Balau	PhD student (LIP)	50
Francisco Neves	Post-Doc (LIP)	90
Isabel Lopes	Researcher (LIP/FCTUC)	55
José Pinto Da Cunha	Researcher (LIP/FCTUC)	35
Luiz de Viveiros	Post-Doc (LIP)	100
Nuno Carolino	Technician (LIP)	25
Vitaly Chepel	Researcher (LIP/FCTUC)	30
Vladimir Solovov	Researcher (LIP)	90

4.3.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Reflectance of polytetrafluoroethylene (PTFE) for Xenon Scintillation Light*
  C. Silva, J. Pinto da Cunha, A. Pereira, V. Chepel, M. I. Lopes, V. Solovov
  J. Appl. Phys. 107, 064902 (2010)

- *The ZEPLIN-III anti-coincidence veto detector*
  D.Akimov et al.
  Astropart, Phys. 34: 151-163 (2010)

- *Limits on inelastic dark matter with ZEPLIN-III*
  D.Akimov et al.
  Phys. Lett. B 692: 180 (2010)

International Conference Proceedings

- *Results from the first science run of ZEPLIN-III*
  M I Lopes for the ZEPLIN-III Collaboration
  J. Phys: Conf. Ser. 203 (2010) 012025

4.3.8 Presentations

Oral presentations in international conferences

- *The ZEPLIN-III Dark Matter Detector: Second Science Run & Beyond*
  presented by Alexandre Lindote
  PASC 2010 — Sesimbra, Portugal.

Presentations in national conferences

- *Reflectance of teflon® for ultraviolet light: measurements and modeling*
  presented by Cláudio Silva
  Jornadas do LIP 2010 — Universidade do Minho, Braga, Portugal.
- *The ZEPLIN-III dark matter detector: first results and future prospects*
  presented by Alexandre Lindote
  Jornadas do LIP — Universidade do Minho, Braga, Portugal.
- *A new method for the calibration of photo-detector arrays*
  presented by Francisco Neves
  Jornadas do LIP 2010 — Universidade do Minho, Braga, Portugal.
- *ZEPLIN-III: the Single Electron Response*
  presented by Edward Santos
  Jornadas do LIP 2010 — Universidade do Minho, Braga, Portugal.
- *ZEPLIN-III dark matter detector: first results and second science run*
  presented by Alexandre Lindote
  Física 2010 — Vila Real, Portugal.

Oral presentations in collaboration meetings

- *Slow Control System Upgrade*
  presented by Alexandre Lindote
  2010 ZEPLIN-III Collaboration Meeting — Boulby, UK.
- *Effect of dummy PMTs on position reconstruction*
  presented by Luiz de Viveiros
  2010 ZEPLIN-III Collaboration Meeting — Boulby., UK.
- *R&D related to Xenon Dark Matter Detectors*
  presented by Isabel Lopes
  2010 ZEPLIN-III Collaboration Meeting — Boulby, UK.
- *Position Reconstruction Algoritm: Mercury*
  presented by Vladimir Solovov
  ZEPLIN-III Collaboration Meeting 2010 — Boulby, UK.

4.3.9 Academic Training

PhD Theses

- *Reflection Distribution of the Fluoropolymers for the Xenon Scintillation Light*
  Cláudio Silva, 2010-10-13

Master Theses

- *Direct Dark Matter Detection using Liquid Xenon Detectors*
  Edward Santos, 2010-07-23

4.3.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
International Conference Proceedings	1
Oral presentations in international conferences	1
Presentations in national conferences	5
Oral presentations in collaboration meetings	4
PhD Theses	1
Master Theses	1

4.4 High Energy Cosmic Rays

4.4.1 Resumo

O Observatório Pierre Auger é uma colaboração internacional de 17 países que estuda os raios cósmicos de energia extrema, e procura dar resposta a algumas das questões mais fascinantes da ciência actual.
O observatório do hemisfério sul, situado na Argentina, está agora em plena operação. Trata-se de um detector híbrido com uma área de cerca de 3000 km^2, combinando uma matriz de mais de 1600 detectores no solo, com 24 telescópios de fluorescência agrupados em quatro localizações. Milhares de chuveiros com energias superiores a cerca de 10^{18} eV estão a ser recolhidos anualmente (várias dezenas acima de 10^{20} eV). Os primeiros resultados publicados por Auger demonstraram o elevado potencial do Observatório, e tiveram grande impacto na comunidade científica. Um *cutoff* do tipo GZK (resultante da interacção dos raios cósmicos de energias muito elevadas com os fotões da radiação cósmica de fundo) é claramente observado no espectro de energia. As fontes dos raios cósmicos de energia mais alta não estão distribuídas isotropicamente. Os resultados na medida da extensão dos chuveiros contradizem as expectativas. A componente muónica dos chuveiros não é descrita de modo satisfatório pelos modelos hadrónicos existentes. Os resultados de Auger abrem um novo canal de astronomia, mas, ao mesmo tempo, representam uma janela única para a física de partículas a energias muito superiores às do LHC.
Portugal tornou-se membro do Observatório Pierre Auger em Março de 2006. Auger mostrou ser o ambiente ideal para o enquadramento de estudantes aos vários níveis (primeiro, segundo e terceiro ciclo) e com vários perfis de formação. É também um ambiente favorável à colaboração próxima entre físicos teóricos e experimentais.
A participação Portuguesa no Observatório Pierre Auger está centrada na exploração da componente de física de partículas que estes acontecimentos de energia extrema nos podem revelar. É um objectivo muito exigente que passa pela compreensão detalhada do detector, pela introdução de novas variáveis de análise que permitam uma melhor caracterização do desenvolvimento dos chuveiros, pelo estudo e desenvolvimento de modelos teóricos que integrem todos os dados existentes e, em particular, os resultados que já começaram a ser revelados no LHC.
Os primeiros resultados obtidos pelo Observatório Pierre Auger acentuaram o interesse da comunidade de raios cósmicos na exploração da física de partículas nesta escala de energias. Um esforço de R&D está neste momento a ser lançado, em conjugação com os outros grandes projectos internacionais na área das Astropartículas. O LIP vai estar envolvido na exploração de novos photo-sensores, nomeadamente os detectores SiPM, e na possibilidade de utilizar detectores RPCs em experiências de raios cósmicos a céu aberto.

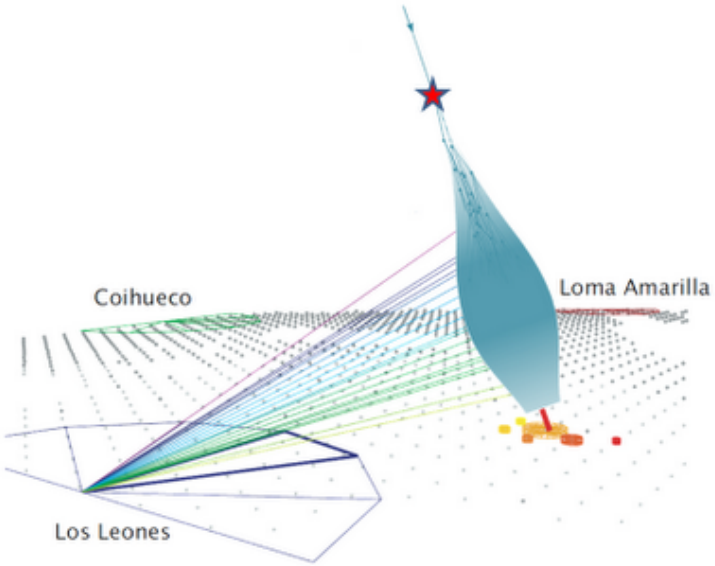

Figura 4.4: Auger: LIP works on several aspects of Auger, from the phenomenology of the first interaction on the top of the atmosphere, to R&D for new muon detectors and optical detectors. The analysis are centred in shower development and hadronic interaction studies and the search for exotic physis.

4.4.2 Abstract

The Pierre Auger Observatory is a worldwide collaboration of 17 countries which studies the cosmic rays of extreme energy and seeks to answer some of the most fascinating questions of today´s science.
The observatory of the South Hemisphere situated in Argentina is now in full operation. The Observatory is a hybrid detector with an area of aproximately 3000 km^2, combining a ground array of more then 1600 detectors, with 24 air fluorescence telescopes grouped in four locations. Millions of air showers with energies above 10^{18} eV are being annually collected (several dozens above the 10^{20} eV). The first results published by Auger have demonstrated the Observatory´s high potential and had a great impact in the scientific community. A GZK *cutoff* (resulting of the interaction between the highest energy cosmic rays with the cosmic microwave background) it is clearly observed in the energy spectrum. The sources of the highest energy cosmic rays are not isotropically distributed. The results of the air shower extension contradict the expectations. The muonic component of the air showers is not satisfactorily described by the existing hadronic models. The Auger results open a new channel of astronomy but, at the same time, represent a unique window of opportunity to the physics of particles with much higher energies then those from LHC.
Portugal has joined the Pierre Auger Observatory in March 2006. Auger has demonstrated to be an ideal environment for students at several levels (first, second and third cycle) and with diferent formation profiles. It´s also a favourable environment to the close collaboration between theoretical and experimental physicists.
The Portuguese participation in the Pierre Auger Observatory is centred in the exploitation of the particle physics component that these extreme energy events can reveal. It´s a very demanding goal which involves the detailed understanding of the detector, the introduction of new analysis variables that allow a better characterization of the development of the air showers, the study and development of theoretical models that integrate all the existing data and, in particular, the results that have already started to be revealed in the LHC.
The first results obtained by the Pierre Auger Observatory have increased the interest in the community of cosmic rays in the exploitation of particle physics in this scale of energies. An effort of R&D is, presently being launched along with other major international projects in the astroparticle field. LIP will be involved in the development of new photo-sensors, namely, in the SiPM detectors and in the possibility of using RPCs detectors in outdoor cosmic rays experiences.

4.4.3 Objectives

The Auger South site is working smoothly and high quality data is being acquired. The results published by Auger gave already new insights in the fields of astronomy and particle physics but further progress will be reached with an even better understanding of the detector and of the data, as well as an important increase of the statistics. The control of the systematic uncertainties, the design of new analysis , the development of phenomenological models dealing with both the UHECR and the recent LHC data as well as the development of an ambitious R&D program towards the construction of a new generation of High Energy Cosmic ray detectors have now a clear priority.
In 2010 the main topics of our work were centred in:

- Contribution to understanding the halo problem
- Shower profile & hadronic interactions studies
- Exotics in Auger
- R&D on new detectors

4.4.4 Achievements

The main contributions of the LIP Auger team were:

- The development of several studies in the long-standing issue of the width of the shower images in the FD cameras being wider than expected (known as the *halo problem*). The LIP team had a very active role in several aspects, in fact the Geant4 simulation of the FD developed in Lisbon was the crucial tool on the tracing back of the effect. Several possible halo sources were investigated by our team, including laboratory tests of the PMTs, performed at LIP-Coimbra, and very detailed studies of the scattering effects on the atmosphere above Auger involving the participation in dedicated laser rover campaign.

- The development of a new parametrization of the shower longitudinal profile (the USPV) in which the main features of the shower electromagnetic and hadronic components are isolated in different variables. It was shown that these new variables do give information about the primary particle type and are useful to disentangle it from the properties of its hadronic interactions.

- The development of innovative analyses concerning the study of the muon component of the shower. In particular the possibility of using muons to measure the longitudinal development of the shower using the Surface Detector, were pursued (the Muon Production Distance - MPD - method).

- The development of new tools to cope with the search for rare and/or exotic events. No striking new physics candidate showers have been found yet, but the path is now ready for preparing a more complete, faster and smoother follow up of the data, both model-independently and in specific channels.

- The launch of an ambitious R&D program on the development of new detector for Astroparticle Physics. In particular LIP had a central role in the organization of the photosensors workpackage inside the HEAP-MM proposal submitted to EU last November. The use of RPC in an outdoor environment was proposed by LIP in the framework of the ASPERA.

4.4.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/109286/2009	145.000 €	2009-11-01	2010-12-31

4.4.6 Team

Project coordinator: Mário Pimenta

Name	Status	%of time in project
Alessandro de Angelis	Researcher	10
Andreia Trindade	Post-Doc (LIP/FCT)	29
Bernardo Tomé	Researcher (LIP)	80
Catarina Espírito Santo	Researcher (LIP)	95
Eva Santos	PhD student (LIP/FCT)	100
Fernando Barão	Researcher (LIP/IST)	30
Francisco Diogo	Master student (LIP)	17
João Carvalho	Researcher (LIP/FCTUC)	10
João Espadanal	Master student (LIP)	80
Jorge Dias de Deus	Researcher (LIP/IST)	10
Jorge Romão	Researcher (LIP/IST)	10
José Carlos Silva	Technician (LIP)	5
José Milhano	Researcher (LIP/IST)	10
Liliana Apolinário	PhD student (LIP)	5
Lorenzo Cazon	Researcher (LIP)	100
Luís Mendes	Technician (LIP)	100
Luisa Arruda	Post-Doc (LIP/FCT)	80
Mário Pimenta	Researcher (LIP/IST)	80
Miguel Ferreira	Technician (LIP)	42
Patrícia Gonçalves	Researcher (LIP)	50
Paulo Fonte	Researcher (LIP/ISEC)	0
Pedro Abreu	Researcher (LIP/IST)	65
Pedro Assis	Post-Doc (LIP/FCT)	75
Pedro Brogueira	Researcher (LIP/IST)	20
Pedro Lourenço	Student (LIP)	67
Pedro Rodrigues	Post-Doc (LIP/FCT)	29
Ruben Conceição	PhD student (LIP/FCT)	100
Sofia Andringa	Researcher (LIP)	85
Thomas Schweizer	Researcher (LIP)	8
Vera Patrício	Student (LIP)	67

4.4.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *A Study of the Effect of Molecular and Aerosol Conditions in the Atmosphere on Air Fluorescence Measurements at the Pierre Auger Observatory*
  The Pierre Auger Collaboration
  Astroparticle Physics 33 (2010) 108

- *Measurement of the energy spectrum of cosmic rays above 10ˆ18 eV using thePierre Auger Observatory*
  The Pierre Auger Collaboration
  Physics Letters B 685 (2010) 239-246

- *Measurement of the Depth of Maximum of Extensive Air Showers above 10ˆ18 eV*
  The Pierre Auger Collaboration.
  Physical Review Letters, 104, 091101 (2010)

- *The Fluorescence Detector of the Pierre Auger Observatory*
  The Pierre Auger Collaboration
  Nucl. Instrum. Meth. A 620 (2010) 227-251

- *Update on the correlation of the highest energy cosmic rays with nearby extragalactic matter*
  The Pierre Auger Collaboration
  Astroparticle Physics 34 (2010) 314-326

- *Mass composition and cross-section from the shape of cosmic ray shower longitudinal profiles*
  S. Andringa, R. Conceição, M. Pimenta
  Astroparticle Physics 34 (2011) 360

Articles in international journals (with indirect contribution from LIP members)

- *The Northern Site of the Pierre Auger Observatory*
  The Pierre Auger Collaboration.
  New Journal of Physics 12 (2010) 035001.

- *The exposure of the hybrid detector of the Pierre Auger Observatory*
  The Pierre Auger Collaboration
  Astroparticle Physics 34 (2011) 368-381

- *The Pierre Auger Observatory Scaler Mode for the Study of Solar Activity Modulation of Galactic Cosmic Rays*
  The Pierre Auger Collaboration
  JINST 6, P01003 (2011)

- *Search for First Harmonic Modulation in the Right Ascension Distribution of Cosmic Rays Detected at the Pierre Auger Observatory*
  The Pierre Auger Collaboration
  Astropart. Phys. 34 (2011), 627-639

Collaboration notes with internal referee

- *Composition analysis with MPD distributions: A case study at 60 degree zenith angle*
  D. Garcia-Gamez, A. Bueno, L. Cazon, S. Navas and M. Pimenta
  GAP-2010-100

4.4.8 Presentations

Oral presentations in international conferences

- *Results from the Pierre Auger Observatory on Astroparticle Physics*
  presented by Sofia Andringa
  Rencontres de Moriond EW 2010 — La Thuile, Italy.

- *Mass composition and cross-section from the shape of cosmic ray shower longitudinal profiles*
  presented by Ruben Conceição
  22nd European Cosmic Ray Symposium — Turku, Finland.

- *Cosmic Ray Cherenkov and Fluorescence Imaging: Photosensors and Data Acquisition Systems for a New Generation of Focal Planes*
  presented by Pedro Rodrigues
  8th Workshop on Science with the New Generation of High Energy Gamma-ray Experiments — Trieste, Italy.

- *Reconstructing the longitudinal development of muons with RPCs*
  presented by Lorenzo Cazon
  7th Air Fluorescence Workshop — Coimbra, Portugal.

- *SiPMs for Cosmic Rays Cherenkov and Fluorescence Telescopes*
  presented by Pedro Assis
  7th Air Fluorescence Workshop — Coimbra, Portugal.

- *Results from the Pierre Auger Observatory*
  presented by Lorenzo Cazon
  Hadron-Hadron & Cosmic-Ray Interactions at multi-TeV Energies — ECT, Trento, Italy.

Poster presentations in international conferences

- *Multiple scattering measurement with laser events*
  presented by Ruben Conceição
  22nd European Cosmic Ray Symposium — Turku, Finland.

Presentations in national conferences

- *The Pierre Auger Observatory Present and Future*
  presented by Ruben Conceição
  Jornadas LIP 2010 — Braga, Portugal.

- *LIP activities in the Pierre Auger Observatory*
  presented by Eva Santos
  Jornadas LIP 2010 — Braga, Portugal.

- *The GAW project - A R&D experiment for a very large field-of-view Imaging Atmospheric Cherenkov Telescope*
  presented by Luisa Arruda
  Jornadas LIP 2010 — Braga, Portugal.

Oral presentations in international meetings

- *Mass Composition and Cross-section from the Shape of Cosmic Ray Shower Longitudinal Profiles*
  presented by Sofia Andringa
  QCD at High Density and High Energy — IST, Lisboa, Portugal.

- *Accessing the hadronic cascade in EAS through the Muon Production Depth*
  presented by Lorenzo Cazon
  QCD at High Density and High Energy — IST, Lisboa, Portugal.

- *HEAPNET and PHOTODAC*
  presented by Thomas Schweizer
  HEAPnet Meeting — Paris, France.

- *Charm in Ultra High Energy Cosmic Rays*
  presented by Pedro Abreu
  Charm in UHE Cosmic Rays — LIP, Lisboa.

Oral presentations in collaboration meetings

- *Updates on the TelescopeSimulator LX*
  presented by Pedro Assis
  Auger Collaboration Meeting — Malargue, Argentina.
- *Generating exotic showers with PYTHIA*
  presented by Pedro Abreu
  Auger Collaboration Meeting — Malargue, Argentina.
- *How strange are standard events?*
  presented by João Espadanal
  Auger Collaboration Meeting — Malargue, Argentina.
- *Sensitivity to double shell events using the MPD*
  presented by Eva Santos
  Auger Collaboration Meeting — Malargue, Argentina.
- *The CUSCA_Lx framework*
  presented by Catarina Espírito Santo
  Auger Collaboration Meeting — Malargue, Argentina.
- *Outreach in Portugal in Particle and Astroparticle Physics*
  presented by Pedro Abreu
  Auger Collaboration Meeting — Malargue, Argentina.
- *Towards an elongation rate with the Muon Production Depth*
  presented by Lorenzo Cazon
  Auger Collaboration Meeting — Malargue, Argentina.
- *Measurements of the PMT non-uniformities*
  presented by Pedro Assis
  Auger Collaboration Meeting — Malargue, Argentina.
- *Laser Light: Data vs. Geant4 Laser Simulation*
  presented by Ruben Conceição
  Auger Collaboration Meeting — Malargue, Argentina.
- *Multiple scattering with lasers*
  presented by Ruben Conceição
  Auger Collaboration Meeting — Lecce, Italy.
- *Update on FD Geant4 simulation*
  presented by Pedro Assis
  Auger Collaboration Meeting — Lecce, Italy.
- *Multiple-scattering studies: laser data vs Geant4 simulation*
  presented by Bernardo Tomé
  Auger Collaboration Meeting — Lecce, Italy.
- *3D shower simulation for the FD*
  presented by Patrícia Gonçalves
  Auger Collaboration Meeting — Lecce, Italy.
- *Limits on cross section from muon production height*
  presented by Lorenzo Cazon
  Auger Collaboration Meeting — Lecce, Italy.
- *Universal Shower Profile Analysis for Mass Composition and Cross-Section*
  presented by Sofia Andringa
  Auger Collaboration Meeting — Lecce, Italy.

- *Update on double shells with the MPD method*
  presented by Eva Santos
  Auger Collaboration Meeting — Lecce, Italy.

- *Status of CUSCA_Lx*
  presented by Catarina Espírito Santo
  Auger Collaboration Meeting — Lecce, Italy.

- *Charm in CORSIKA*
  presented by Pedro Abreu
  Auger Collaboration Meeting — Lecce, Italy.

- *Reconstruction of the longitudinal profile of muons with RPCs*
  presented by Lorenzo Cazon
  Pierre Auger 2010 European Meeting — Lisboa, Portugal.

- *Increasing the detail on the electromagnetic longitudinal profile*
  presented by Sofia Andringa
  Pierre Auger 2010 European Meeting — Lisboa, Portugal.

- *The PSF of the FD*
  presented by Bernardo Tomé
  Pierre Auger 2010 European Meeting — Lisboa, Portugal.

- *Using novel photosensors for fluorescence & Cherenkov detectors*
  presented by Thomas Schweizer
  Pierre Auger 2010 European Meeting — IST, Lisboa.

- *Concepts for an RPC array at Auger*
  presented by Paulo Fonte
  Pierre Auger 2010 European Meeting — IST, Lisboa.

- *Simulation of PMT reflectivity in TelescopeSimulatorLX*
  presented by Bernardo Tomé
  Auger Collaboration Meeting — Malargüe, Argentina.

- *The 2010 roving lasers and the PSF of the FD: first results*
  presented by Bernardo Tomé
  Auger Collaboration Meeting — Malargüe, Argentina.

- *3D EAS Shower Simulation vs. Real Data*
  presented by Patrícia Gonçalves
  Auger Collaboration Meeting — Malargüe, Argentina.

- *Status of CUSCA*
  presented by Catarina Espírito Santo
  Auger Collaboration Meeting — Malargüe, Argentina.

4.4.9 Academic Training

PhD Theses

- *Sensitivity to Cosmic Ray Composition and Hadronic Models from the Fluorescence Detector Data of the Pierre Auger Observatory*
  Ruben Conceição, 2011-01-11

- *Cosmic Rays at the Ankle: Auger South Enhancements*
  Eva Santos, (on-going)

Master Theses

- *Non-standard events at the Pierre Auger Observatory*
  João Espadanal, 2010-11-25

4.4.10 Events

- *QCD at High Density and High Energy*
  Workshop, IST, Lisboa, 2010-06-11
- *Charm in UHE Cosmic Rays*
  Workshop, LIP, Lisboa, 2010-10-13
- *Pierre Auger 2010 European Meeting*
  Collaboration Meeting, IST, Lisboa, 2010-10-11

4.4.11 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	6
Articles in international journals (with indirect contribution from LIP members)	4
Collaboration notes with internal referee	1
Oral presentations in international conferences	6
Poster presentations in international conferences	1
Presentations in national conferences	3
Oral presentations in international meetings	4
Oral presentations in collaboration meetings	27
Master Theses	1
Workshops	2
Collaboration Meetings	1

4.5 Study of the primary air scintillation in air for cosmic ray detection

4.5.1 Resumo

A detecção da cintilação UV do azoto, produzida na atmosfera pelos chuveiros cósmicos extensos (EAS), é uma técnica usada em várias experiências tais como Auger, HiRes e Telescope Array. A luz gerada por uma partícula carregada do chuveiro é emitida isotropicamente e é proporcional à perda de energia por ionização. Esta luz, emitida entre os 280 e os 430 nm, resulta da desexcitação radiactiva de estados electrónicos excitados das moléculas de N2 e N2+ (sistemas 2P e 1N, respectivamente). Estes estados podem também ser desactivados por colisões de dois corpos com moléculas do ar nos seus estados fundamentais (quenching). A dependência da eficiência de desactivação colisional com a densidade do gás, temperatura e composição gasosa leva a uma variação da quantidade de luz emitida por partícula com a altitude. Os detectors de fluorescência medem a distribuição da luz de fluorescência ao longo do desenvolvimento do EAS e fornecem uma medida calorimétrica da energia da partícula primária. É, pois, necessário o conhecimento correcto não só do valor absoluto do nº de fotões emitido pelo ar à superfície mas também da sua variação ao longo de uma gama de pressões e temperaturas correspondentes a altitudes que poderão ir até ≈16 km, de forma a minimizar a incerteza sistemática no cálculo da energia da partícula primária.
O projecto está em fase de conclusão e já não teve financiamento durante o ano de 2010. Durante este ano pretendíamos concluir os estudos da fluorescência do ar com a realização das medidas resolvidas no tempo usando o canhão de electrões como fonte de excitação, e com a discussão de um modelo cinético que descreva o comportamento observado para as dependências da luz emitida com a pressão e temperatura. O sistema está operacional, foram feitas medidas e testes preliminares e verificou-se que é possivel fazer as medidas para pressões desde 500 hPa até pressões inferiores a 1 hPa.
É ainda de referir que a organização do encontro anual sobre Cintilação do Ar, "7th Air Fluorescence Workshop", foi este ano da resposabilidade do LIP-Coimbra, em colaboração com o Departamento de Física da FCTUC. Este encontro teve lugar, em Coimbra, em Setembro de 2010, e contou com a participação de cerca de 45 investigadores nacionais e estrangeiros. Foram apresentadas 26 comunicações orais das quais 7 em representação das grandes experiências (Auger, Telescope Array e JEM-EUSO) e 10 relacionadas com os estudos dos mecanismos da fluorescência do ar e técnicas de detecção. As 9 restantes foram dedicadas a novos métodos de detecção de raios cósmicos de ultra alta energia.
Este projecto suscitou ainda o interesse de um grupo de Química Computacional da FCTUC que está a estudar a dinâmica de formação e decaimento de moléculas N4. Este estudo poderá explicar os resultados obtidos relativos à variação com a temperatura dos tempos médios de vida efectivos dos estados excitados do N2 responsáveis pela cintilação UV. Membros da presente equipa estão envolvidos neste projecto.

4.5.2 Abstract

The detection of the nitrogen UV scintillation produced in the atmosphere by extensive air showers (EAS) generated by the interaction of incoming ultra high energy cosmic rays (UHECR) with air molecules is a technique used by several experiments like Auger, HiRes and Telescope Array. The fluorescent light emitted by a charged particle is assumed to be isotropic and proportional to the energy loss by ionization. This light, extending from 280 to 430 nm, result from the radiative de-excitation of electronic excited states of N2 and N2+ (2P and 1N systems, respectively). These states can also be deactivated by two body collisions with air molecules in their ground states (quenching). The dependence of the quenching efficiency on gas density, temperature and gas composition leads to a variation of the fluorescence yield with the altitude. Fluorescence detectors measure the distribution of the fluorescence light along the development of the EAS and provide a calorimetric measurement of the primary particle energy. An accurate knowledge not only of the absolute fluorescence yield at ground level but also its variation over a range of pressures and temperatures corresponding to altitudes up to ≈ 16 km is thus required in order to minimize the systematic uncertainty in the calculation of the energy of the primary particle.
We intended to conclude this year the air fluorescence project with some additional measurements at low pressures, using 10 keV electrons from an e-gun as excitation source, and with the discussion of a kinetic model that can explain the observed pressure and temperature dependences. However, the project was not funded and the members of the team were fully involved in other projects. Nevertheless, some improvements have been introduced in the set-up that is now fully operational and some preliminary measurements were performed, in the pressure range from 500 hPa down to below 1 hPa.
The "7th Air >Fluorescence Workshop"took place this year in Coimbra, organized by LIP-Coimbra in collaboration with the Physics Department of FCTUC. The Workshop took place in Coimbra, on 22-24 September

2010, with 45 participants. During the three days 26 talks were presented: seven on behalf of the large collaborations that use fluorescence detectors (Auger, Telescope Array and JEM-EUSO) and ten related to the studies of the mechanisms of air fluorescence and detection techniques. The remaining nine were devoted to new methods of detection of ultra high energy cosmic rays.
This project has also developed the interest of a group in computational chemistry (FCTUC) that is now studying the dynamics of formation and decay of molecules N4. This study may explain the results concerning the variation with temperature of the effective lifetimes of the nitrogen molecular excited states responsible for UV scintillation. Members of this team are involved in this project.

4.5.3 Objectives

- To perform time resolved measurements for the 0-0 band (337 nm) of the 2nd positive system of N2, using a pulsed electron beam (10 keV electrons) from an e-gun as excitation source, for pressures between 500 hPa and 1 hPa;
- To establish a kinetic model that can explain the observed pressure and temperature dependences.

4.5.4 Achievements

Considerable improvements have been introduced in the set-up, namely in what concerns
- the magnetic screening of e-gun,power supply, photomultiplier;
- the charging up of the entrance window, that contributed to a significant reduction of the counting rate with time;
- the solid angle for the light collection;
- gas system with the installation of a new pumping unit.
- the associated electronics.
The set up is now fully operational and preliminary time measurements were already performed, in the pressure range from 500 hPa down to below 1 hPa.
The analysis of these data are under way.

4.5.5 Presentations

Oral presentations in international conferences

- *On the possible role of triplet electronic states of N4 on the quenching of N2(C3Piu) by N2(X1Sg+): An ab initio study*
  presented by
  7th Air Fluorescence Workshop — Coimbra, Portugal.

4.5.6 Events

- *7th Air Fluorescence Workshop*
  Workshop, Coimbra, Portugal, 2010-09-22

4.5.7 Project Summary

	number
Oral presentations in international conferences	1
Workshops	1

4.6 Radiation interaction simulations for space missions

4.6.1 Resumo

As actividades desenvolvidas no âmbito do projecto "Space/ESA: Radiation interaction simulations for space missions"(ESA: European Space Agency) centram-se na utilização da ferramenta de simulação Monte Carlo Geant4 a estudos em astropartículas e de ambiente de radiação no espaço. Algumas das actividades apresentadas derivam da aplicação e desenvolvimento da ferramenta Geant4 neste caso em aprticular aplicada a estudos no espaço. Estas actividades têm permitido a integração de novos estudantes no LIP para quem estes temas se tem revelado interessantes e atractivos para desenvolverem os seus trabalhos e teses e têm igualmente permitido ao LIP a colaboração com institutos externos e académicos.
Neste contexto o contracto entre o LIP e a ESA denominado CODES-III é ums das principais linhas de investigação em 2010. O projecto teve inicio em Maio de 2009 com uma duração de dois anos. De acordo com a agenda aprovada para o projecto, iniciou-se em Janeiro de 2010 o segundo e terceiro periodos e desta forma o ano de 2010 tornou-se crucial para o desenvolvimento do projecto.As actividades definidas para esta fase focaram o estudo dos efeitos da radiação em componentes electrónicos com aplicação relevante para missões espaciais bem como na fase final de desenvolvimento do método "SV-fit"na implementação do software CODES e na revisão do conceito "surface LET". Em 2010 o LIP continuou e finalizou a sua participação na Heliospheric Network em colaboração com Dalmiro Maia do Observatório Astronómico da Universidade do Porto. Esta actividade centrou-se no estudo do ambiente de radiação interplanetário, no qual a ferramente da simulação Geant4 foi utilizada para simular o desempenho de detectores em voo nas missões Ulysses e ACE missions por mais de uma década e para as quais uma simulação detalhada torna-se necessária para uma correcta análise e compreensão dos dados colectados. Uma nova linha de investigação focada na Next Generation Radiation Monitor for Space Missions foi iniciada em 2010. Esta actividade teve o suporte do "Cosmic Ray Electronics Laboratory"do LIP e tem como prinicipal objectivo o desenho, estudo de desempenho e desenvolvimento de um monitor de radiação adequado aos requisitos da ESA para recolha de dados científicos em missões espaciais.

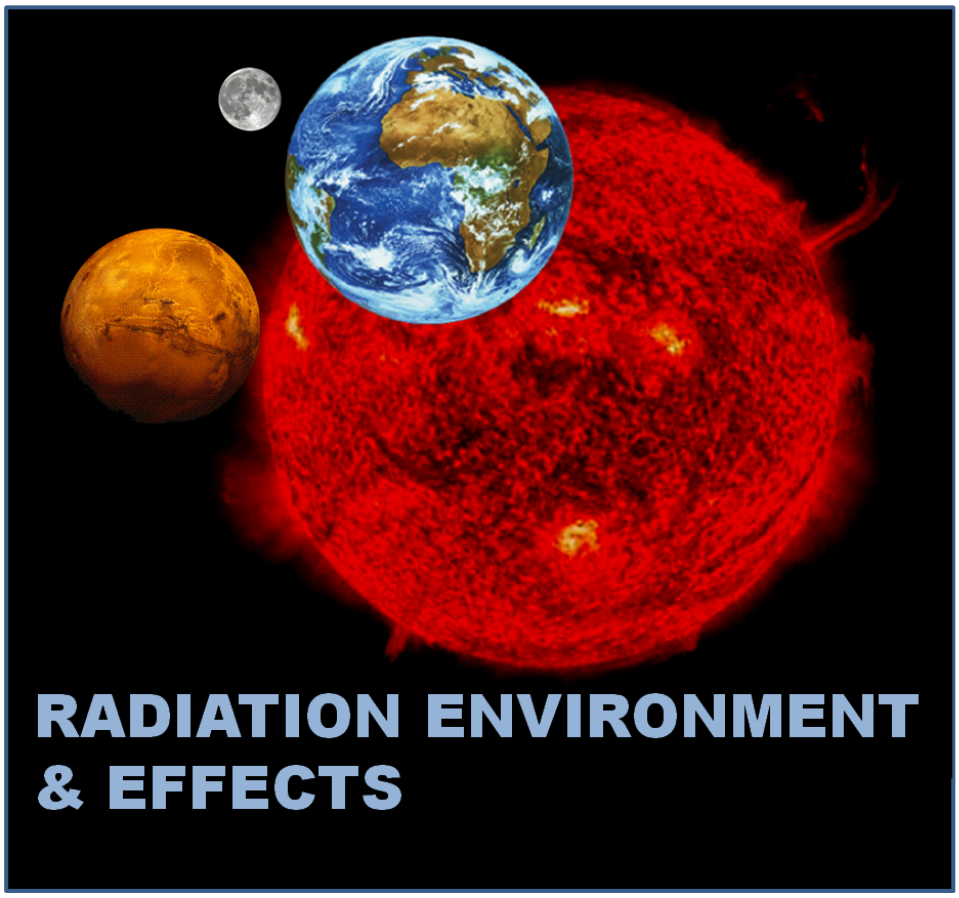

Figura 4.5: Radiation Environment and Effects

Tiveram igualmente inicio em 2010 as actividades relacionadas com a preparação de um novo contrato com a ESA denominado CTTB In-Flight Component Irradiation Test Data Analysis para o desenvolvimento das ferramentas de armazenamento e análise de dados do sistema de monitorização de radiação em voo no satélite Alphasat, cujo lançamento está previsto para 2012. A elaboração da proposta foi realizada em colaboração com as empresa EFACEC S.A. e EVOLEO Technologies, Lda.. A empresa EFACEC S.A. irá apresentar-se como instituição gestora deste novo contracto. A proposta deste novo contracto foi aceite pela ESA em finais de Dezembro de 2010.

4.6.2 Abstract

The activities developed in the framework of the "Space/ESA: Radiation interaction simulations for space missions"(ESA: European Space Agency) project are focused on the application of the Geant4 simulation toolkit to astroparticle and space studies. Some of the reported activities are spin-offs of the application and development the Geant4 simulation toolkit, in this case, applied to space experiments. These activities have enabled the integration of new students in LIP, for whom the planetary and interplanetary radiation environment studies are an attractive subject and are also a source of collaboration between LIP and external and academic institutions and scientists.
In this context, the CODES-III contract between LIP and ESA is one of the main research lines. The project, with duration of two years, started in May 2009. According to the project schedule, the second and third periods of CODES III has started in January 2010 and therefore this was a crucial year for the development of the project. It is an activity concerning the study of the radiation effects in electronic components relevant for the space missions and consists on the final development of the SV-fit method, on CODES top level framework implementation and on the review of "surface LET"concept. LIP will continue its participation in the Heliospheric Network in collaboration with Dalmiro Maia from the "Observatório Astronómico da Universidade do Porto", which was completed in the end of 2010. This activity was centred on the study of the interplanetary radiation environment, where the Geant4 simulation toolkit was used to simulate the performance of detectors which have been flying on the Ulysses and on the ACE missions for more than a decade and for which a full simulation was required in order to fully understand the collected data. A new research line to perform design studies for the Next Generation Radiation Monitor for Space Missions was conducted in 2010. This activity was pursued with the support of LIP´s Cosmic Ray Electronics Laboratory and aims to develop a modular radiation monitor to be used in scientific space missions according to the ESA standards. New activities concerning the development of data handling and analysis tools for a radiation monitoring facility in space which will fly on Alphasat satellite whose launch is foreseen for 2012, has started in 2010 in collaboration with EFACEC S.A. and EVOLEO Technologies, Lda. During 2010 LIP has prepared the proposal to the present to ESA as "Intended Invitation To Tender"with the title CTTB In-Flight Component Irradiation Test Data Analysis. The new contract was accepted and approved by ESA in last December 2010.

4.6.3 Objectives

The objective regarding the CODES-III contract with ESA during 2010 was the successful continuation of the project, in which the second of the contract was covered. In CODES second phase the CODES top level framework was implemented, verify and evaluated and in the third phase surface LET calculation methods were studied and possibly improved on. The project Portuguese Participation in the Heliospheric Network has reach completion by the end of 2010. However, this subject will continue to be studied at LIP, and the collaboration with Dalmiro Maia will be pursued in the future. Concerning the development of a radiation monitor concept to integrate the Next Generation Radiation Monitor, LIP´s objectives were to optimize the design that can match the strict weight, power and size requirements for this type of instrument and at the same time be able of performing as a scientific instrument with improved capabilities with respect to the existing technologies. In collaboration with EFACEC S.A. in CTTB In-Flight Component Irradiation Test Data Analysis invitation to tender, LIP´s objective was to write the proposal already presented and approved by ESA. A second goal is to consolidate the radiation monitoring studies and CODES project by connecting these activities with the EEE components analyzed in beam lines that will be flown in CTTB experience boards.

4.6.4 Achievements

Integrated radiation environment, Effects and component degradation Simulation tool : CODES-part III

CODES, the software framework provides the tools for analyzing and predicting radiation effects electronic components in general and SEE in particular. The framework is interfaced with Geant4 applications and

allows computation of radiation effects in EEE components. CODES involves two approaches, statistical and microscopic.
With the statistical approach: sCODES Geant4 is employed to simulate the energy spectra and particle species at component level. The simulated primary and secondary spectra above the SEE threshold are then integrated over the experimental SEE cross-section curves. The basis of this method is similar as CREME with the additional capability of analyzing non-RPP shaped SVs and with the improved particle transport of Geant4. It was important to provide users with similar capabilities to CREME and to allow validation of the developed methods.
The microscopic approach (mCODES) relies on the simulation of micro-dose in the device. Non-RPP Sensitive Volumes at component level and component material description are implemented in Geant4, which is used to simulate particle transport and interactions inside the component. The optimization of simulation parameters relies on ground based test data. It allows the characterization of the device sensitivity and the analysis of Single Event Effects on EEE components.
During 2010 the final CODES architecture was frozen and the final design makes it a powerful user friendly integrated framework enabling prediction of radiation induced degradation under different space environment scenarios based on both microscopic and statistic simulation of device response function. This framework is being implemented during 2011.
Additionally the extensive data obtained was obtained for the Reference SEU Monitor under irradiation test beams at LNS (Catania) and at UCL (Belgium). The description of SEU cross section using combined information of the surface LET and $\beta\gamma$ indicates a possible way to evaluate direct and indirect ionization contributions to SEU cross section.
Simulation work together with data and theory showed that the primary ion´s stopping power contribution decreases with increasing ion momentum. On the other hand nuclear process for a specific fixed device the probability of nuclear interactions contributing to indirect ionization increases with ion momentum. Therefore for a specific device its response to different $\beta\gamma$ ion irradiation may be indicative of the relative sensitivity to nuclear reactions that may occur in packaging or shielding for low LET ions. Since this effect is not taken into account in current radiation hardness assurance processes results may severely be underestimated. This model is expected to give an increased contribution for degradation rates calculation for current and future scaling down technologies. These technologies tend to be radiation hardened, minimizing the effects of direct ionization in SEE at low LET are more sensitive to high energy particles secondary production. It is therefore promising the use of methodologies relying on ground based irradiation testing that allow identification of different mechanisms contributing to degradation and subsequently evaluate and optimize SEU rate predictions under real in-orbit environment.
Finally the work developed on this activity during 2010 was submitted to NSREC 2011 (IEEE) and is expected to be submitted also for RADECS 2011.
= Participation in the Heliospheric Network = During 2010, the simulation of the HI-SCALE detector aboard the Ulysses spacecraft was successfully completed thoroughly tested and the results were used to improve the calibration applied to the data gathered by the instrument. The finished simulation was then used to analyze the detector response to simulated SEP events propagated between the Sun´s surface and the instrument using genetic algorithms. Using this process we were able to establish statistical how much and by witch way, the parameters of a SEP are actually altered by the instrument and we hope to use that data in the future to validate the SEP transport codes. We are now in the process of writing paper that we will submit to the relevant publications, detailing the process and exhibiting the results of this work.

Next Generation Radiation Monitor for Space Missions

In this research activity, a novel particle spectrometer was developed to fulfil the need to map the space radiation environment for future space missions and to provide more accurate scientific data. The concept of the instrument brings together new radiation-hard technologies, for the photo-sensors and scintillating materials that will improve the quality of the data, while taking into account the limited resources such as mass, power and accommodation, allocated for space radiation monitors and pre-defined by ESA.
The Multi-channel Array Particle Spectrometer (MAPS), can measure fluxes and energy distributions of protons, ions, electrons and gammas in a wide energy range based on the 3D reconstruction of the particle track through the detector and its deposited energy in the active volume. It consists on a 8 x 8 segmented scintillator block built from 3.2 x 3.2 x 20 mm3 individual that are readout at both ends by two Silicon Photo-Multipliers (SiPMs) matrices Each SiPM matrix is readout by a 64 channel mixed signal analog-digital ASIC, offering both particle identification and particle counting capabilities. Power cycling design of the ASIC allows activating the particle identification block only during a pre-determined time slice, keeping the total power budget of less than 1 mW/channel as required by ESA. Whenever a charged particle crosses the segmented volume of the

detector, the XY coordinates, given by the pixelized crystal positions, and the deposited energy in each crystal is recorded.. As a result of determining the interaction coordinates and the topology of the energy depositions in the different layers of crystals, the type, incident energy and direction of the incoming particles can be reconstructed. A direct outcome of this concept is the up-down discrimination and lateral veto for radiation background rejection while keeping a simple readout arrangement. Using this segmented, independent channel approach, a maximum count-rate of 1.3 MHz/cm2 and 6.3 MHz/cm2 for a 1% and 5% event pileup probability, respectively, was estimated.
In this work, the Geant4 Monte Carlo simulation toolkit was used to demonstrate the MAPS design feasibility and to assess its performance in different radiation scenarios. First results have shown the capability to measure protons from 1 to 350 MeV and alphas from 5 to 800 MeV, representing a significant increase in the energy range of traditional scintillator-based radiation monitors and with almost no ambiguity in particle discrimination. As a result of the proposed concept based on compact photo-sensors and electronics architecture, the current design of MAPS points to a power budget of 1-3Watt, a mass of 0.5-0.7 kg and a total dimension of 10 x 10 x 10 cm3 matching the requirements for space applications.

CTTB In-Flight Component Irradiation Test Data Analysis

CTTB will carry three experiment boards: a Memory Test Board (MTB) including SEU and SEL experiments and a 8Gbit NAND flash memory technology demonstration; a GaN technology experiment to assess potential radiation issues (cumulative or destructive single event) on GaN MESFETs and an intra satellite optical link technology demonstration board. Several ground irradiation campaigns of the embedded components were already performed and the analysis of the available radiation ground test data will be carry out. Each one of the three boards of the CTTB test facility embeds a RADFET package and variation of the RADFET threshold voltage will give information on the actual dose levels received during the flight. The relation between the RADFETs gate threshold voltage shift and the dose, can strongly depend on the production processes parameters of the RADFETs and therefore needs to be experimentally determined before actual use on space missions which represents the first part of the project. A second part consists on the analysis of single event rates, threshold voltage shift on RADFETs, degradation of oscillator power output for the background environment as well as for solar event. The analysis will also examine future courses of action for improvements of the prediction models as well as new ground test campaigns. CTTB is able to provide a flux of telemetry data that can be grouped in two main blocks: housekeeping data and science data. A real-time monitoring, web-based interface will be developed to provide science data over the internet. The third part of the project comprehends therefore the design, development and implementation of the data analysis software and a data base with a web interface to store and provide over the internet the analysed science data.
During 2010 and in collaboration with EFACEC, S.A. and EVOLEO Technologies, S.A a proposal to this specific ESA "Intended Invitation To Tender"call was prepared and later approved. The contract starts in January 2011 and has a maximum duration of 18 months. As previously described, the activities related with "Alphasat radiation Environment and Effects Facility (AEEF) Component Technology Test-Bed (CTTB), Preparation of In-Flight Data Analysis"were partitioned in several work packages with the aim to prepare the analysis of the science data from the three AEEF CTTB in-flight experiments. In the approved contract, LIP has the responsibility for the following work packages: 1. RADFET Calibration Test Plan Definition (WP1100); 2. RADFET Calibration Test (WP1200) and 3. Analysis of Radiation Ground Test Data (WP2000). EVOLEO Technologies, Lda. will be responsible for software development for in-flight data mining and analysis software (WP3100 to WP3400) with EFACEC responsible for the contract management (WP4).

4.6.5 Sources of Funding

Code	Funding	Start	End
PDCTE/CTE-SPA/81678/2003	69.552 €	2008-01-01	2010-12-31
ESA:223981/09/NL/PA	150.000 €	2009-05-01	2011-04-30

4.6.6 Team

Project coordinator: Patrícia Gonçalves

Name	Status	%of time in project
Alessandro de Angelis	Researcher	10
Ana Keating	Post-Doc (LIP/FCT)	100
Andreia Trindade	Post-Doc (LIP/FCT)	70
Bernardo Tomé	Researcher (LIP)	25
Bruno Morgado	PhD student (LIP)	100
Mário Pimenta	Researcher (LIP/IST)	20
Patrícia Gonçalves	Researcher (LIP)	45
Pedro Aparício	Master student (LIP/IST)	25
Pedro Brogueira	Researcher (LIP/IST)	5
Pedro Rodrigues	Post-Doc (LIP/FCT)	70
Sara Valente	Master student (LIP)	100
Thomas Schweizer	Researcher (LIP)	25

4.6.7 Presentations

Oral presentations in international conferences

- *A fully integrated model for Ulysses/HISCALE and ACE/EPAM data*
  presented by Bruno Morgado
  ECRS 2010 — Turku, Finland.

- *CODES : component degradation simulation tool*
  presented by Ana Keating
  ESA/TEC-EES Final presentation day — ESTEC, Netherlands.

Poster presentations in international conferences

- *A Fully Integrated Model for Ulysses/HISCALE and ACE/EPAM Data*
  presented by Bruno Morgado
  AGU Meeting of americas 2010 — Foz do Iguaçu.

- *Space Radiation Environment and Effects- LIP activities*
  presented by Patrícia Gonçalves
  Joint European and National Astronomy Meeting — Universidade de Lisboa, Faculdade de Ciências.

Presentations in national conferences

- *From radiation modelling towards radiation monitoring and back*
  presented by Patrícia Gonçalves
  Jornadas do LIP 2010 — Braga - Universidade do Minho - Portugal.

- *Participation in the Heliospheric Network: Virtual modelling and simulation of the HI-SCALE instrument aboard the Ulysses spacecraft*
  presented by Bruno Morgado
  Jornadas do LIP 2010 — Braga - Universidade do Minho - Portugal.

- *CODES: A Component Degradation Simulation Tool*
  presented by Ana Keating
  Jornadas do LIP 2010 — Braga - Universidade do Minho - Portugal.

Oral presentations in international meetings

- *Study of a Multi-channel Array Particle Spectrometer (MAPS) for Space Missions*
  presented by Pedro Rodrigues
  Generation Radiation Monitor (NGRM) Round Table, — ESTEC, Netherlands.

Oral presentations in collaboration meetings

- *Space Radiation Monitoring*
  presented by Andreia Trindade
  — LIP, Lisboa.

Seminars

- *Radiation in Space*
  presented by Patrícia Gonçalves
  — LIP.

4.6.8 Project Summary

	number
Oral presentations in international conferences	2
Poster presentations in international conferences	2
Presentations in national conferences	3
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	1
Seminars	1

Chapter 5

Medical Physics

5.1 Development of Positron Emission Mammography

5.1.1 Resumo

O projecto de investigação científica e tecnológica ´Development of PET Technologies´ é realizado no âmbito do Consórcio PET-Mamografia e liderado cientificamente pelo LIP. Os equipamentos de imagem médica em desenvolvimento exploram tecnologias desenvolvidas para experiências de física de altas energias.

5.1.2 Abstract

The research and development project ´Development of PET Technologies´ is carried out in the frame of the PET Mammography Consortium under LIP scientific leadership. The medical imaging equipment under development exploit technologies developed for accelerator experiments.

5.1.3 Achievements

The PET Consortium pursued the PET technologies development program. The activity is carried out by eight national institutions and about forty researchers. The development program has three main lines.
1) The consolidation of PET technologies in clinical trials
The first phase of the clinical trials with the ClearPEM equipment was concluded in December 2009 at IPO Porto. The data collected was used to improve the image reconstruction algorithms providing images of good quality.

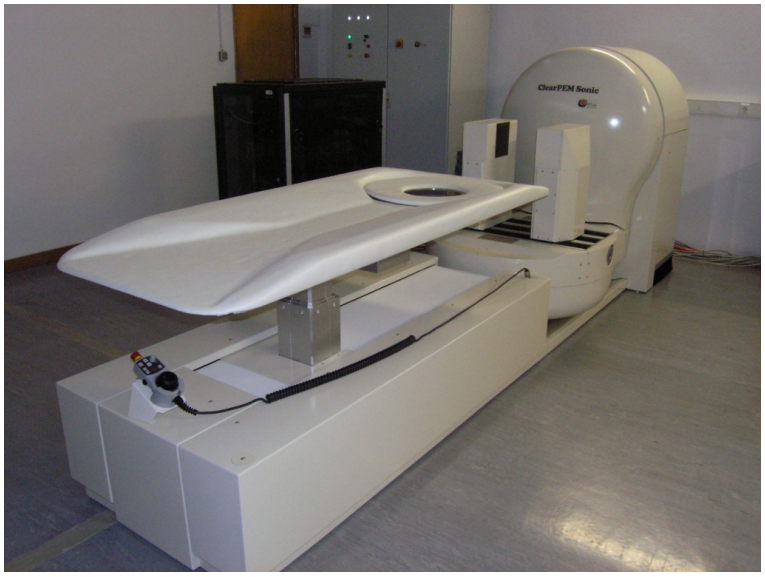

Figura 5.1: Scanner ClearPEM-Sonic installed at the University Hospital, Marseille.

In April 2010 the Consortium concluded a negotiation with ICNAS (Instituto de Ciências Nucleares Aplicadas à Saúde), Coimbra, to perform the next phases of the clinical tests in this research and clinical center, providing conditions not available at IPO. The equipment was transported and installed at ICNAS. The validation testes were concluded. Studies with phantoms and exams with small animals were performed.
2) Development of PET-Ultrasound technologies (ClearPEM-Sonic project)
The development of the second ClearPEM prototype for integration with an ultra-sound probe introduced important modifications based on the experience obtained with the first machine. In particular the robotic equipment was completely changed.
The construction of the scanner ClearPEM-Sonic was concluded. The mechanical integration of the ultra-sound probe was developed by our partners. The tests with phantoms showed a better performance that with the first prototype.
The equipment was transported and installed at hospital Timone, Marseille, in December 2010.
3) The investigation of new nuclear imaging technologies
The objective of this task was the development of new PET technologies, in particular the association of PET with magnetic resonance. In 2010 we have developed the conceptual design of a PET-MR insert for medium size animals. The engineering design of amplifier suitable for silicon photomultipliers was also carried on.

5.1.4 Sources of Funding

Code	Funding	Start	End
Pet - Mammography II-b	504.344 €	2008-07-01	2010-12-31
PIC/IC/83228/2007	67.550 €	2009-03-26	2011-03-25

5.1.5 Team

Project coordinator: João Varela

Name	Status	%of time in project
Catarina Ortigão	Post-Doc (LIP/FCT)	100
Cláudia Sofia Ferreira	PhD student (LIP/FCT)	100
Gonçalo Silva	Master student (LIP)	100
João Varela	Researcher (LIP/IST)	20
Jorge Neves	PhD student (FCT)	100
José Carlos Silva	Technician (LIP)	15
Manuel Rolo	PhD student (LIP) *	100
Miguel Ferreira	Technician (LIP)	14
Ricardo Bugalho	Master (LIP)	67
Rui Silva	Technician (LIP)	100

5.1.6 Publications

International Conference Proceedings

- *The ClearPEM breast imaging scanner*
  Jorge A.Neves on behalf of the ClearPEM Collaboration
  Nuclear Instruments and Methods in Physics Research, Volume 628, Issue 1, 1 February 2011, Pages 444-447

5.1.7 Academic Training

PhD Theses

- *Estudo da localização espacial de tumores cancerígenos na glândula mamária com um detector PET dedicado*
  Rui Moura, (on-going)
- *Estudo do tomógrafo Clear-PEM no diagnóstico do cancro da mama*
  Cláudia Sofia Ferreira, (on-going)
- *Development and evaluation of combined PET-MRI imaging*
  Jorge Neves, (on-going)

5.1.8 Project Summary

	number
International Conference Proceedings	1

5.2 PET with Resistive Plate Chambers (RPC-PET)

5.2.1 Resumo

Objectivo

A Tomografia de Emissão de Positrões (PET) é uma técnica poderosa de imagiologia molecular funcional. O nosso objectivo é o desenvolvimento um tomógrafo baseado numa tecnologia radicalmente nova de TOF-PET, que envolve todo o corpo do paciente, com resolução espacial a atingir os limites físico da técnica PET e sensibilidade uma ordem de grandeza superior à dos sistemas comerciais correntes, sem aumento de custo. Uma tal inovação fornecerá aos clínicos capacidades superiores de diagnosticar e detectar doenças oncológicas e de outros tipos, bem como de estudar mecanismos de doença, constituindo uma mudança de paradigma no uso clínico de PET. Realizados já os estudos básicos de viabilidade, neste projecto pretende especificamente desenhar, construir, testar e desenvolver um primeiro protótipo de dimensão real de um tomógrafo para corpo inteiro, com um campo de visão axial (AFOV) de 2m e uma abertura de 90 cm.
A demonstração desta tecnologia, radicalmente diferente da dos cristais tradicionalmente usados na detecção de raios gama, pode, aliás, abrir perspectivas totalmente novas na detecção de raios gama em áreas extensas, para lá das aplicações médicas.

Ideia Fundamental

A sensibilidade é um parâmetro fundamental dos sistemas PET, determinando a quantidade de traçador radioactivo a administrar ao paciente, o tempo de observação e o nível de ruído para uma dada granularidade da imagem. Qualquer melhoria na sensibilidade permite o correspondente melhoramento num destes parâmetros ou numa combinação deles. Deve contudo garantir-se que qualquer nova tecnologia forneça os melhoramentos esperados sem contudo conduzir a um aumento significativo de custos relativamente aos sistemas disponíveis no mercado. Ora tal não é o que se passa com muitas das soluções que estão actualmente em estudo, podendo ser necessários compromissos [ERI06].
A nossa proposta para PET de alta sensibilidade a custo moderado envolve a técnica TOF-PET e o aumento

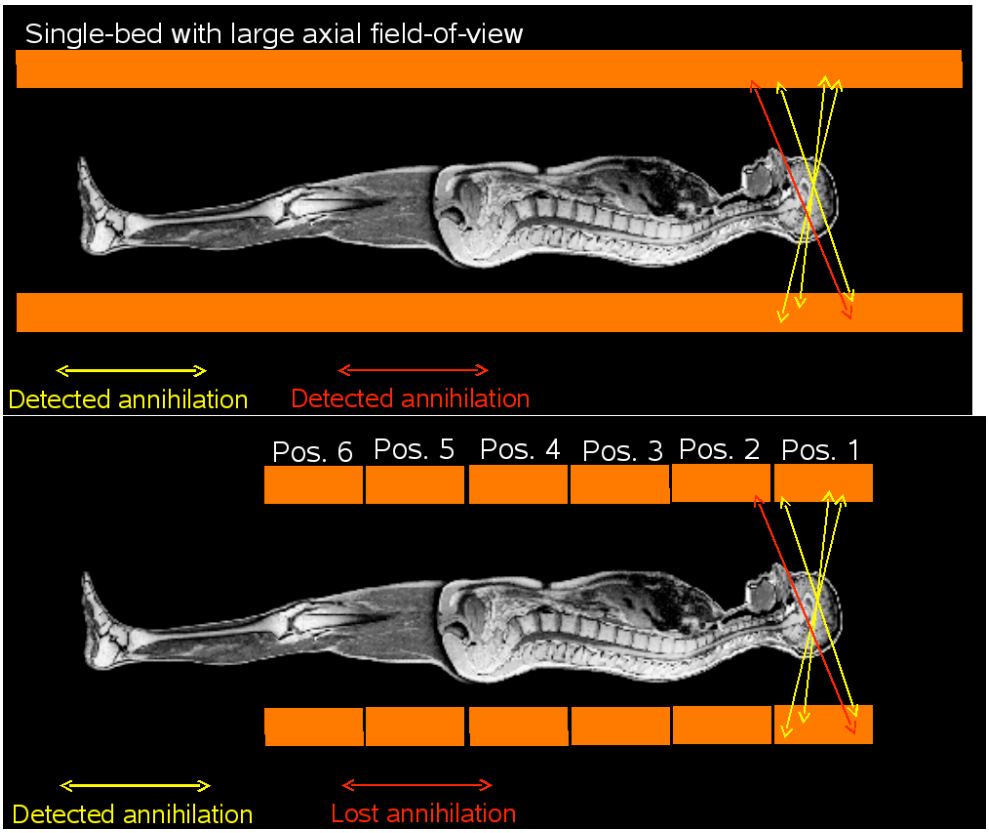

Figura 5.2: single-bed RPC-PET

dramático do AFOV [BLA03, ERI08] até uma dimensão de corpo inteiro (2 m) graças a um detector de radiação com custo por unidade de área moderado, capaz de fornecer excelente resolução espacial, uniforme ao longo do FOV, sensível à profundidade de interacção e com uma resolução de 300 ps para tempo de vôo.
Um campo de visão muito extenso, capaz de abranger todo o corpo dum paciente ("single bed"), tem ainda outras vantagens sobre os sistemas com AFOV reduzido. Entre elas, está a possibilidade de, obtendo imagens simultâneas de todo o corpo, permitir o estudo completo de processos dinâmicos graças a uma segmentação temporal melhorada. Outra vantagem está na possibilidade de obter uma melhor quantificação da actividade através duma melhor correcção de difusão ("scatter"), dado não haver actividade fora do FOV.

Aproximação inovadora

A nossa aproximação baseia-se numa tecnologia de detecção já em uso na Física de Partículas para a medida de tempo de vôo de partículas elementares carregadas: as "timing Resistive Plate Chambers"(tRPCs). Esses detectores gasosos foram desenvolvidos para cobrir áreas de mais de uma centena de metros quadrados a preços moderados, fornecendo ao mesmo tempo excelente resolução temporal, abaixo dos 100 ps rms.
Há alguns anos este grupo propôs a aplicação destes detectores à tecnologia TOF-PET, tanto para tomógrafos de corpo inteiro para humanos, como para pequenos animais [BLA03]. Tal aplicação baseia-se no princípio das "placas conversoras"e tira partido da estrutura natural "em camadas"das tRPCs e de a sua construção em áreas grandes ser económica. A baixa eficiência naturalmente esperada para os fotões de 511 keV é mais que compensada [COU07a, ERI08, CRE09] pela possibilidade de alcançar campos de visão extensos, que poderão ir até 2 m.
O conceito foi também revisto independentemente [ERI08], embora assumindo condições diferentes, confirmando-se que poderá para corpo inteiro substituir com vantagem os tomógrafos de cristais que constituem o "state-of-the-art".

5.2.2 Abstract

Aim of the Project

Positron Emission Tomography (PET) is a powerful diagnostic technique employed in functional medical imaging (molecular imaging). Our overall objective is to develop a radically new technology for TOF PET systems targeted at human whole-body scanning, with resolution down to the physical limit of the PET technique and with a sensitivity improved by over one order of magnitude with respect to current commercial systems, without increase in cost. Such breakthrough would provide physicians with superior capabilities for diagnosing and detecting oncological and other diseases and investigating disease mechanisms, potentially allowing a paradigm shift in PET clinical use.
As the basic feasibility studies have been already carried out, this project specifically aims at designing building, testing and developing a first prototype of a full-size human whole body TOF-PET scanner with a field-of-view of 2 m and a borehole of 90 cm (Fig. 1).
The demonstration of this technology, offering a radically different alternative to crystal-based gamma detection systems, may open totally new avenues for future research in large-area gamma detection, even beyond medical applications.

Fundamental Idea

Sensitivity is a fundamental parameter of PET systems. It determines the amount of radioactive tracer to be administered to the patient, the observation time and the noise level in the image for a given image granularity. Any improvement in system sensitivity will allow a corresponding improvement in one of these parameters or in a combination of them.
However, a practical view should be kept in that a successful new technology should provide the expected benefits without any significant increase in cost over the presently available commercial systems. This is by far not evident with many of the currently researched approaches and some compromise may be necessary [ERI06].
Our proposal for high-sensitivity PET at reasonable cost involves the TOF-PET technique along with a dramatic extension of the FOV [BLA03, ERI08], up to whole-body size (2 m), using a low-cost per unit area particle detector, with excellent spatial resolution, uniform in the Field-of-View owing to its Depth-of-Interaction capability and time-of-flight resolution of 300 ps.
Furthermore, a very large field-of-view, taking the whole image simultaneously (single-bed), has supplementary potential advantages over narrow-FOV PET. These include the possibility of imaging simultaneously the whole body, allowing a more complete study of dynamic processes, covering the whole subject at any given instant

with a better temporal segmentation. Other advantages include the possibility of achieving better quantitation through improved scatter correction, since there is no activity outside the FOV.

Innovative Approach

Our approach is based on a detector technology already used in High Energy Physics Experiments for time-of-flight measurements on charged elementary particles: timing Resistive Plate Chambers (tRPCs). Such gaseous detectors have been deployed in areas over one hundred square meters at reasonable cost, while generally providing an excellent time resolution below 100 ps rms.
Several years ago our group proposed that such detectors might find useful application in TOF-PET technology, both for whole-body human scanning and small animal imaging [BLA03]. The application is based on the "converter plate"principle and takes decisive advantage of the naturally layered structure of tRPCs and of its economic construction in large areas. The expectable low efficiency for 511 keV photons is more than offset [COU07a, ERI08, CRE09] by the possibility to afford a very large field of view (FOV), on the order of 2 m.
The concept has also been independently reviewed [ERI08], although on a different set of assumptions, confirming that it may replace with advantage the present state-of-the-art crystal-based scanners for whole-body scanning.
[BLA03] Perspectives for positron emission tomography with RPCs, Blanco, A; Chepel, V; Ferreira-Marques, R; Fonte, P; Lopes, M.I; Peskov, V; Policarpo, A., Nucl. Instrum. and Meth. A 508 (2003) 88-93.
[COU07a] RPC-PET status and perspectives, M.Couceiro, A.Blanco, Nuno C.Ferreira, R.Ferreira Marques, P.Fonte, L.Lopes., Nucl. Instrum. and Meth. A 580 (2007) 915-918.
[CRE09] Whole-body single-bed time-of-flight RPC-PET: simulation of axial and planar sensitivities with NEMA and anthropomorphic phantoms, P. Crespo et al., 2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC), Jan 2010, Page(s): 3420 - 3425
[ERI06] Future instrumentation in positron emission tomography, L. Eriksson et al., 2006 IEEE Nuclear Science Symposium Conference Record, Volume 4, Oct. 29 2006-Nov. 1 2006 Page(s): 2542 - 2545.
[ERI08] Potentials for large axial field of view positron camera systems, L. Eriksson et al., 2008 IEEE MIC Conference, published in the Conference Record.

5.2.3 Objectives

To develop a full-size prototype that will demonstrate scientifically the RPC-PET concept. Translate this result into a useful clinical tool.

5.2.4 Achievements

A national project (PTDC/SAU-BEB/104630/2008 – "RPC-PET - A novel technology for single-bed whole-body human molecular imaging with higher sensitivity and resolution") went into execution with a global budget of 190k€ over 3 years. LIP´s budget amounts to 120k€, intended for the development of a single-layer, full-size, scanner.
During this year we have re-developed the timing front-end electronics for taking advantage of new, less noisy, RF amplifiers. Also repackaged the previously developed charge amplifiers to adapt them to higher channel density and to the electrical requirements of the ADCs mentioned below.
We acquired and deployed in LIP, with the help of our collaborators from GSI, a "slice"of the very modern HADES DAQ (recently upgraded) including 192 ADC channels, 256 TDC channels, trigger processor and data hub. This state-of-the-art and highly configurable system will form the base for the data acquisition in this project.
The firmware for the ADCs was modified by their developers from the Jagiellonian University of Cracow to allow the use of Digital Pulse Processing.
A first prototype, aimed at demonstrating the electronic readout system with realistic electrodes and signals was also built and preliminary results look very satisfactory.
The mechanical structure and detector layout for the final RPC-PET scanner was designed. Development started on the required special electrodes.
A national patent was granted for the technical method of economically reading out the signals in RPC-PET. The international extension of this patent was requested, in the framework of the above-mentioned project.
A study of the expectable spatial resolution of human RPC-PET was presented at the X Workshop on Resistive Plate Chambers and Related Detectors, GSI, Darmstadt, Germany, February 9-12, 2010 and accepted for publication in NIM (http://dx.doi.org/10.1016/j.nima.2010.07.078).

5.2.5 Sources of Funding

Code	Funding	Start	End
PTDC/SAU-BEB/104630/2008	120.856 €	2010-04-01	2013-03-31

5.2.6 Team

Project coordinator: João Lima

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	15
Américo Pereira	Technician (LIP)	8
Carlos Silva	Technician (LIP)	8
Joaquim Oliveira	Technician (LIP)	8
Miguel Couceiro	Researcher (LIP/ISEC)	15
Nuno Carolino	Technician (LIP)	8
Orlando Cunha	Technician (LIP)	8
Paulo Crespo	Researcher (LIP/ISEC)	15
Paulo Fonte	Researcher (LIP/ISEC)	19
Ricardo Caeiro	Technician (LIP)	8
Rui Alves	Technician (LIP)	8
Rui Marques	Researcher (LIP/FCTUC)	8

5.2.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Spatial resolution of human RPC-PET*
  M. Couceiro, P. Crespo, L. Mendes, N. Ferreira, R. Ferreira Marques and P. Fonte
  (accepted)

International Conference Proceedings

- *Whole-body single-bed time-of-flight RPC-PET: simulation of axial and planar sensitivities with NEMA and anthropomorphic phantoms*
  P. Crespo, J. Reis, M. Couceiro, A. Blanco, N. C. Ferreira, R. Ferreira Marques, P. Fonte
  2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC), pp. 3420 - 3425

5.2.8 Presentations

Oral presentations in international conferences

- *Spatial resolution of human RPC-PET*
  presented by Miguel Couceiro
  X Workshop on Resistive Plate Chambers and Related Detectors, February 9-12, 2010 — GSI, Darmstadt, Germany..

5.2.9 Academic Training

PhD Theses

- *Study of PET systems of very wide field of view*
  Miguel Couceiro, (on-going)

5.2.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
International Conference Proceedings	1
Oral presentations in international conferences	1

5.3 Feasibility study of using Compton scattering for medical imaging with positrons

5.3.1 Resumo

Este projecto visa o estudo da dispersão Compton dos raios gama em imagiologia médica com positrões. Em particular, pretende-se avaliar por meios computacionais o impacto na imagem da inclusão dos acontecimentos, que envolvem a dispersão Compton no detector, na reconstrução da imagem em PET. É também um dos objectivos a avaliação do efeito da polarização dos fotões gama provenientes da aniquilação na distribuição espacial da dispersão no meio detector com o objectivo de avaliar a importância desta informação para a reconstrução da imagem. Além disso, está planeado um esforço experimental para tentar medir a orientação dos traços dos electrões com o objectivo de obter informação sobre a polarização dos fotões detectados. Se for bem sucedido, esta informação poderá impor constrangimentos adicionais para a reconstrução dos acontecimentos que envolvem a dispersão Compton e deste modo possibilitar a sua utilização para a reconstrução da imagem.

5.3.2 Abstract

This project aims at studying the feasibility of using Compton scattering of gamma-rays in medical imaging with positrons. In particular, our intent is to evaluate, by computational means, the impact on the PET image of inclusion of the events, involving Compton scattering in the detectors, into the input data for the image reconstruction. We also plan to evaluate the effect of the polarization of the annihilation photons on the spatial distribution of the scattered gamma-rays in the detection medium in order to assess to what extend this information can be useful for the image reconstruction. Finally, it is our objective to attempt to measure the orientation of the recoil electron track in the gamma-ray detector with the purpose of obtaining information on the polarization of the incoming photon. This can allow setting additional constraints on the reconstruction of the Compton sequences thus making feasible the use of scattered events for the image reconstruction.

5.3.3 Achievements

During the second year, the following steps has been done.
1. A module describing the Derenzo PET phantom has been developed. It allows various configurations of radiation source placement and sizes to be generated. The code is intended for future integration into GEANT4 simulation.
2. Detector response function taking into account detector resolution and threshold has been developed and tested. The code is intended to be used on the interaction pattern obtained from GEANT4 physics simulation.
3. Consistency tests of several methods describing polarized Compton scattering in the GEANT-4 distribution package against the theory have been carried out. The low energy extension was found to be the most adequate while the standard method has been found incorrect.
4. The effect of polarization of the annihilation photons on detector response in PET has been assessed.
5. Image reconstruction for 3D objects using single slice rebinning method has been added into the computational framework which is being developed.
6. Cryogenic, purity and thermal stability tests of the xenon setup have been successfully carried out. Electron emission from liquid xenon and secondary scintillation in gaseous phase has been observed.
7. Analysis software for processing the acquired timelines from the dual phase xenon chamber has been developed and tested. It will allow to determine contributions to the observed signal from secondary scintillation in the uniform field above the liquid surface and in the GEM.

5.3.4 Sources of Funding

Code	Funding	Start	End
PTDC/FIS/67002/2006	72.000 €	2009-01-01	2011-12-31

5.3.5 Team

Project coordinator: Vitaly Chepel

Name	Status	%of time in project
Alessio Mangiarotti	Researcher (LIP)	15
Alexandre Lindote	Post-Doc (LIP)	15
Américo Pereira	Technician (LIP)	15
Armando Policarpo	Researcher (LIP/FCTUC)	20
Carlos Silva	Technician (LIP)	5
Cláudio Silva	Post-Doc (LIP/FCT) *	20
Francisco Neves	Post-Doc (LIP)	10
Isabel Lopes	Researcher (LIP/FCTUC)	25
Joaquim Oliveira	Technician (LIP)	5
José Pinto Da Cunha	Researcher (LIP/FCTUC)	20
Nuno Carolino	Technician (LIP)	10
Orlando Cunha	Technician (LIP)	5
Rui Marques	Researcher (LIP/FCTUC)	10
Vitaly Chepel	Researcher (LIP/FCTUC)	45
Vladimir Solovov	Researcher (LIP)	20

5.3.6 Presentations

Oral presentations in international meetings

- *Study of Compton scattering by Monte Carlo simulation with GEANT4*
  presented by Vitaly Chepel
  CHERNE2010 — Coimbra, Portugal.

5.3.7 Project Summary

	number
Oral presentations in international meetings	1

5.4 Monte Carlo methods applied to dosimetry in medical radiologic exposures

5.4.1 Resumo

As actividades do projecto desenvolveram-se em três componentes distintas

1. Desenvolvimento de dosimetros de cintiladores plásticos
2. Exposição ambiental ao Radão
3. Protecção contra radiações produzidas por fontes clínicas de raios-X

Na primeira componente desenvolveu-se e testou-se um dosimetro de fibra óptica de pequenas dimensões, lido por um fotodiodo e adequado à utilização em braquiterapia. O prototipo foi testado em ambiente clínico tendo-se mostrado capaz de medir a dose fornecida por uma fonte clínica de Ir-192 com rigor equivalente a uma câmara de ionização.
Na componente de Exposição ao Radão realizou-se um estudo de concentração de radão na cidade e arredores da Guarda, envolvendo 185 habitações. Desse estudo detectou-se que 2/3 das habitações monitorizadas apresentavam valores de concentração média de radão superiores ao limite de 400 Bq/m3 impostos por lei.
Na componente de radioprotecção iniciou-se o estudo da razoabilidade da espessura das barreiras de protecção em salas com equipamentos modernos produtores de radiação-X. Adquiriram-se dados experimentais de uma fonte laboratorial de raios-X e iniciou-se o estudo por simulação Monte Carlo do campo de radiação por ela produzida. Esse estudo servirá para a obtenção de espectros de radiação primária e secundária existente numa sala de exames radiológicos.

Figura 5.3: Fiber Dosimeter prototype "DosFib"tests in the Hospital de Santa Maria in Lisbon

5.4.2 Abstract

The project activities developed into three distinct components

1. Development of plastic scintillator dosimeters
2. Environmental exposure to Radon
3. Protection against radiations produced by clinical sources of X-rays

The first component developed and tested a small fiber optic dosimeter, read by a photodiode and suitable for use in brachytherapy. The prototype was tested in a hospital and has proved capable of measuring the dose delivered by a clinical source of Ir-192 with accuracy equivalent to an ionization chamber.
In the component Exposure to Radon a study of concentration of radon in the city and outskirts of the Guard, was performed, involving 185 households. From this study it was found that two thirds of the monitored houses had an average concentration of radon above the 400 Bq/m3 limit imposed by law.
In the component of radiation protection we began to study the reasonableness of the thickness of the protection barriers in examination rooms with modern X-ray equipment. Experimental data were obtained from a laboratory X-ray source and the Monte Carlo simulation study of the radiation field produced by them began. This study will serve to obtain spectra of primary and secondary radiation existing in a room of radiological examinations.

5.4.3 Objectives

1) Development of a scintillating optical fiber dosimeter capable of measuring doses delivered by X and gamma radiation in the tens of keV up to a few hundred of keV. The device consists of a blue-emitting, 5 mm-long plastic scintillating optical fiber (2 mm in diameter), coupled to a non-scintillating plastic optical fiber 300 mm-long. The scintillation light produced in the fiber is collected and conducted by the non-scintillating fiber to a photodiode with good spectral response to the produced light.
2)In the Exposure to Radon gas project a pilot dosimetric study in the town of Guarda region was made. The study included 160 randomly chosen dwellings within a 8 km radius from downtown. The 185 participants in the study are people from both genders, smokers and non-smokers, between 25 and 70 years old, living in the study geographical area. For the dosimetric study, all the detectors were placed inside each dwelling within a time interval of 90 minutes. These detectors were collected 60 days after their placement and were developed and analyzed at the Natural Radioactivity Laboratory at Coimbra.
3) Shielding design for X-ray imaging facilities have been established by scientific international committees. These recommendations are now adopted by many countries in their national laws in ionizing radiation protection . However, preliminary studies, suggest that adopted methodologies overestimate the shielding barriers with a significant impact in the cost-benefit of the facility. This is particularly relevant in the case of mammographic installations with machines operating between 25-35 keV. We addressed the validity of these studies with systematic measurements of shielded and non-shielded kerma values in x-ray laboratories and real mammographic facilities. These measurements supported by detailed Monte Carlo (MC) simulations that in the future will be used to develop a code package available to help qualified radiation experts in shielding calculations.

5.4.4 Achievements

1) The optical fiber dosimeter has been tested for several X-rays beams in the 20 to 100 kVp and the influence of fluorescence light was measured. After fluorescence subtraction a variation of 5% in the sensitivity was measured in the 40 to 100 kV range. The device was tested in the Hospital de Santa Maria in Lisbon. A water phantom and a clinical Ir-192 source were used in the tests. For comparison data was also taken with a standard thimble 0.125 cc ionization chamber. Depth dose curves were obtained for both measuring devices, and a very good agreement between them was obtain, proving the suitableness of the fiber dosimeter for clinical used in brachytherapy.
2) The preliminary results of the Radon study indicate that 66% of the dwellings present radon concentrations above 400 Bq/m3, being 33% above 800 Bq/m3. It is not yet clear from the data if the radon concentration levels inside the dwellings is or not conditioned by the existence of tap water. Also it is not clear in the data a correlations between the type of construction and the radon concentration inside the dwelling. This may be an indication that the soil where the dwelling was build is the dominant factor. Some very high concentrations values (above 3000 Bq/m3) giving testimony of the uranium-zone were the dwellings are build were also measured.

3) Measurements of filtered spectra have been performed with a x-ray tube at different angles and a SiLi detector. A simple MC simulation of the experimental layout was implemented with the code package PENELOPE. In the first step we compute the primary and the scattered radiation by a phantom in a realistic mammographic facility. The scattered spectra will be used as an input for the second simulation of the attenuation by different shielding thicknesses and materials.
4) The 1st Portuguese Physics for Health Summer School was organized by our team at Covilhã between 26 and 28 of July. This 1st Summer school payed special attention to radiotherapy topics.

5.4.5 Sources of Funding

Code	Funding	Start	End

5.4.6 Team

Project coordinator: Luis Peralta

Name	Status	%of time in project
Alina Louro		80
Carmen Oliveira	Collaborator	80
Conceição Abreu	Researcher (LIP)	50
Florbela Rego	Researcher (LIP) *	80
João Monteiro	Student (LIP)	67
Jorge Sampaio		20
Luis Filipe Silva	Student (LIP)	80
Luis Peralta	Researcher (LIP/FCUL)	90
Maria do Anjo Albuquerque	PhD student (LIP)	80
Nuno Silva	Student (LIP)	67
Rui Carvalhal	Graduate student (LIP)	30
Sandra Soares	Researcher (LIP/UBI)	80
Tiago Ribeiro	Student (LIP)	50

5.4.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Calibration of an alpha particle irradiator for in vitro cells irradiation*
  Belchior, A., Peralta, L., Almeida, P. and Vaz,
  Int. J. Low Radiation, Vol. 7, No. 6, (2010) pp. 500-510

International Conference Proceedings

- *A plastic scintillating optical fiber dosimeter with photodiode readout*
  Florbela Rêgo, Luis Peralta, Mafalda Gomes
  Physics for Health in Europe Workshop, pp. 73

- *A Scintillating Optical Fiber Dosimeter*
  F. Rêgo, L. Peralta, M. Gomes and M. C. Abreu
  European Conference on X-Ray Spectrometry, 20-25 de Junho de 2010, Figueira da Foz, Portugal (accepted)

5.4.8 Presentations

Poster presentations in international conferences

- *A Scintillating Optical Fiber Dosimeter*
  presented by Luis Peralta
  Physics for Health in Europe Workshop — CERN, Geneve, Suiça.

- *Risco para a saúde humana da exposição ao radão habitacional - Projecto SOS Radão Guarda*
  presented by Alina Louro
  II Congresso Internacional de Riscos, VI Encontro Nacional de Riscos — Coimbra, Portugal.

- *Comparison of X-Ray Production Models*
  presented by Florbela Rego
  European Conference on X-Ray Spectrometry — Figueira da Foz, Portugal.

- *Environmental Radon Exposure and Human Health Risk*
  presented by Sandra Soares
  CHERNE 2010,6th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection — Coimbra, Portugal.

- *Environmental Radon Exposure and Human Health Risk*
  presented by Alina Louro
  Portuguese Physics for Health Summer School — Covilhã.

- *Environmental Radon Exposure and Human Health Risk*
  presented by Sandra Soares
  6th Conference on Protection Against Radon at Home and at Work — Praga, República Checa.

Presentations in national conferences

- *Radão na Guarda*
  presented by Alina Louro
  Jornadas do Radão — Guarda.

- *Radão: o Inquilino Silencioso*
  presented by Sandra Soares
  Jornadas do Radão — Guarda.

- *Projecto: Riscos para a saúde humana da exposição ambiental ao radão*
  presented by Luis Peralta
  Jornadas do Radão — Guarda.

- *Estaremos a sobrestimar o dimensionamento das barreiras de protecção nas salas de mamografia?*
  presented by Luis Filipe Silva
  Fisica 2010, 17a Conferencia Nacional de Física — Vila Real, Portugal.

- *Dosimetro de Fibra Óptica Cintilante*
  presented by Florbela Rego
  Fisica 2010, 17a Conferencia Nacional de Física — Vila Real, Portugal.

- *Risco para a saúde humana da exposição ao radão habitacional*
  presented by Alina Louro
  Fisica 2010, 17a Conferencia Nacional de Física — Vila Real, Portugal.

- *Riscos para a saúde humana da exposição ao radão habitacional na Região da Guarda*
  presented by Alina Louro
  Jornadas da SPPCR 2010 — IST, Lisboa.

Oral presentations in international meetings

- *A Scintillating Optical Fiber Dosimeter*
  presented by Florbela Rego
  European Conference on X-Ray Spectrometry — Figueira da Foz, Portugal.

- *A Scintillating Optical Fiber Dosimeter*
  presented by Florbela Rego
  Portuguese Physics for Health Summer School — Covilhã.

- *In vivo dosimetry implementation tests in HDR 192Ir brachytherapy*
  presented by Tiago Ribeiro
  Portuguese Physics for Health Summer School — Covilhã.

- *Are we over-shielding mammographic x-ray imaging installations?*
  presented by Jorge Sampaio
  International Conference on Radiation Protection in Medicine — Varna, Bulgaria.

Outreach seminars

- *Radão: O Inquilino Silencioso*
  presented by Sandra Soares
  — Escola Secundária da Sé - Guarda.

5.4.9 Academic Training

PhD Theses

- *Desenvolvimento de dosímetros de estado sólido para dosimetria em radiologia e braquiterapia*
  Florbela Rego, 2010-09-20
- *Environmental Radon Exposure and Human Health Risk*
  Alina Louro, (on-going)
- *Assessment of committed radon by micro-EDXRF analysis of Pb concentrations in teeth*
  Maria do Anjo Albuquerque, (on-going)
- *Development of plastic scintillator dosimeters for radiology*
  Carmen Oliveira, (on-going)

Master Theses

- *Desenvolvimento de um sistema de dosimetria para braquiterapia de alta taxa de dose*
  Tiago Ribeiro, 2010-12-10
- *Novas técnicas de cálculo de barreiras de protecção para mamografia e radiografia toráxica*
  Luis Filipe Silva, (on-going)

5.4.10 Events

- *Portuguese Physics for Health Summer School*
  Conference, Covilhã, 2010-07-26
- *Jornadas do Radão*
  Workshop, Guarda, 2010-05-14

5.4.11 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
International Conference Proceedings	2
Poster presentations in international conferences	6
Presentations in national conferences	7
Oral presentations in international meetings	4
Outreach seminars	1
PhD Theses	1
Master Theses	1
Conferences	1
Workshops	1

Chapter 6

Detectors

6.1 Participation in the RD51 Collaboration

6.1.1 Resumo

A colaboração RD51 [RD51] tem como objectivo facilitar o desenvolvimento de tecnologias avançadas de detectores gasosos de partículas e dos sistemas de leitura associados para aplicação na investigação básica e aplicada. O principal objectivo do programa de I&D é o avanço da tecnologia de Detectores Gasosos de Microestruturas. A invenção de Detectores Gasosos de Microestruturas (MPGD), em particular o Multiplicador Gasoso de Electrões (GEM), da Estrutura Gasosa de Micro-grelhas (MICROMEGAS), e mais recentemente outros esquemas de microestruturas, oferece o potencial para desenvolver novos detectores gasosos com resolução espacial sem precedentes, elevada taxa de contagem, grande área sensível, estabilidade operacional e resistência à radiação. Nalgumas aplicações, requerendo a cobertura de áreas muito elevadas com resolução espacial mode-

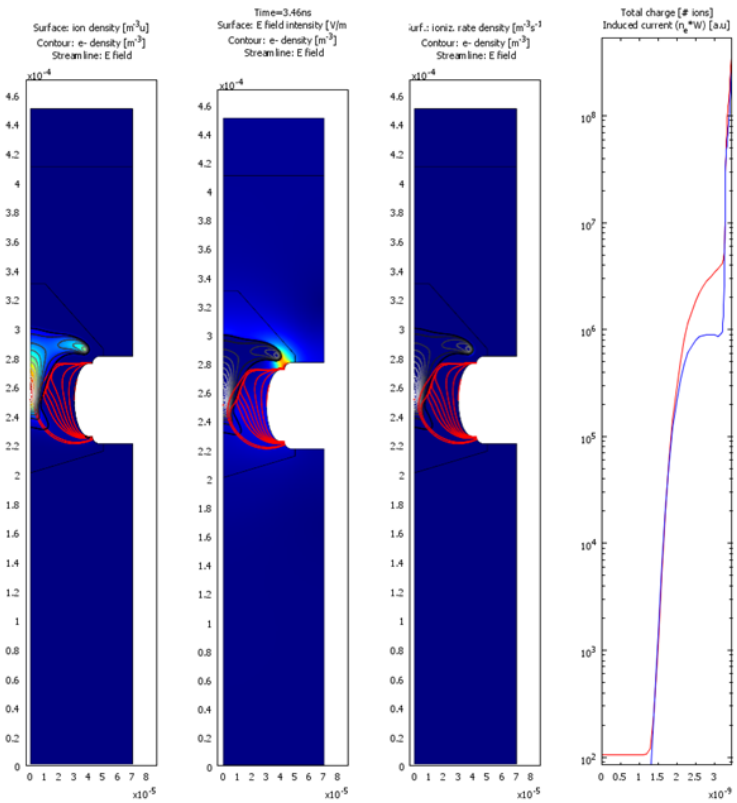

Figura 6.1: Calculation of avalanche and streamer development in MPGDs in an hydrodynamic model

rada, detectores macroestruturados, por exemplo o GEM espesso (THGEM) ou câmaras de placas resistivas estruturadas poderão oferecer uma solução interessante e económica.
A constituição dos novos detectores microestruturados parece adequada à sua produção industrial. Adicionalmente, a disponibilidade de sistemas electrónicos altamente integrados de amplificação e leitura permite o desenvolvimento de sistemas de detectores gasosos com densidade de canais comparável à dos detectores de silício modernos. O pós-processamento moderno de bolachas de silício permite a integração de estruturas de amplificação gasosa directamente em cima de uma pastilha de silício pixelizada. Graças a estes desenvolvimentos recentes, a detecção de partículas através da ionização do gás tem largos campos de aplicação em futuras experiências de física das partículas, nuclear a de astro-partículas, com e sem aceleradores.
A colaboração RD51 envolve ≈350 autores, 59 Universidades e Laboratórios de 20 países na Europa, América, Ásia e África. Todos os parceiros perseguem activamente quer investigação básica, quer aplicada envolvendo uma variedade de conceitos de MPGD. A colaboração estabeleceu objectivos comuns, tais como ferramentas experimentais e de simulação comuns, métodos e conceitos de caracterização, infra-estruturas comuns em feixes de teste e instalações de irradiação, e métodos e infraestruturas para a produção de MPGD.
[RD51] RD51 proposal (http://rd51-public.web.cern.ch/RD51-Public/Documents/RD51Proposal_21082008.pdf)

6.1.2 Abstract

The RD51 collaboration [RD51] aims at facilitating the development of advanced gas-avalanche detector technologies and associated electronic-readout systems, for applications in basic and applied research. The main objective of the R&D programme is to advance technological development and application of Micropattern Gas Detectors.
The invention of Micro-Pattern Gas Detectors (MPGD), in particular the Gas Electron Multiplier (GEM), the Micro-Mesh Gaseous Structure (MICROMEGAS), and more recently other micro pattern detector schemes, offers the potential to develop new gaseous detectors with unprecedented spatial resolution, high rate capability, large sensitive area, operational stability and radiation hardness. In some applications, requiring very large-area coverage with moderate spatial resolutions, more coarse Macro-patterned detectors, e.g. Thick-GEMs (THGEM) or patterned resistive-plate devices could offer an interesting and economic solution.
The design of the new micro-pattern devices appears suitable for industrial production. In addition, the availability of highly integrated amplification and readout electronics allows for the design of gas-detector systems with channel densities comparable to that of modern silicon detectors. Modern wafer post-processing allows for the integration of gas-amplification structures directly on top of a pixelized readout chip. Thanks to these recent developments, particle detection through the ionization of gas has large fields of application in future particle, nuclear and astro-particle physics experiments with and without accelerators.
The RD51 collaboration involves ≈ 350 authors, 59 Universities and Research Laboratories from 20 countries in Europe, America, Asia and Africa. All partners are already actively pursuing either basic- or application-oriented R&D involving a variety of MPGD concepts. The collaboration established common goals, like experimental and simulation tools, characterization concepts and methods, common infrastructures at test beams and irradiation facilities, and methods and infrastructures for MPGD production.
[RD51] RD51 proposal (http://rd51-public.web.cern.ch/RD51-Public/Documents/RD51Proposal_21082008.pdf)

6.1.3 Objectives

The responsibilities of LIP are in the following workgroups (WG) and tasks (T):

- Common Characterization and Physics Issues (WG2):
  - (T2) Discharge studies and spark-protection developments for MPGDs;
  - (T3) Generic aging and material radiation-hardness studies;
- Applications (WG3):
  - (T1) MPGD based detectors for tracking and triggering;
  - (T7) Medical imaging and diagnostics applications.

For WG2-T2 we will collaborate in the elaboration of a bibliographic review of the breakdown features of gaseous detectors, aiming at the publication of a CERN yellow report.
For WG2-T3, we will study the chemical properties of the polymerized material that is produced by the operation of detectors in fluorinated gases and will address the possibility of adding polymerization inhibitors to the gas mixture.

For WG3 we will develop patterned RPCs for two applications: TOFtracker (T1) and small-animal PET (T7). These detectors will be capable simultaneously of sub-millimetric localization accuracy and timing resolution below 100ps.
The TOFtracker device will be aimed at high-multiplicity tracking because it provides a 4th coordinate, time, which can be used to match the hits corresponding to the same track and its correlation with the beam hodoscope readings. This may be of use, for instance, for NA60-like experiments where the exquisite time resolution would help matching the pre-absorber to the post-absorber tracks, while reducing the combinatorial background.
The small animal RPC-PET will feature a world-leading image resolution of close to 0.5 mm FWHM (already demonstrated at small scale [BLA06]), largely dominated by physical limitations and not by instrumental effects. This will be achieved in a compact, low cost, instrument, benefitting from the simplicity of construction of RPCs.
[BLA06] A.Blanco, et al., "RPC-PET: A new very high resolution PET technology", IEEE Trans. Nucl. Sci.53 (2006) 2489-2494

6.1.4 Achievements

For WG2-T2 we developed a new modelling strategy for avalanches and streamers on a hydrodynamic approach solved by finite elements. This was presented in a plenary talk in the collaboration meeting in Freiburg, Germany, June 2010.
For the same workgroup we initiated the elaboration of a bibliographic review of the breakdown features of gaseous detectors, aiming at the publication of a CERN yellow report. This will be also published as a review in JINST, for which a contract has been signed.
For WG2-T3, we continued the study of the production of polymeric material ("ageing") in collaboration with our chemist colleagues.
For WG3 progress was made in the implementation of the animal RPC-PET scanner. A very modern data acquisition system copied from the upgraded DAQ of the HADES experiment at GSI was acquired and installed in Coimbra. The system includes 184 flash ADC channels and 256 100 ps TDC channels. Our custom charge amplifiers, optimized for high input capacity, previously developed in the framework of this project, were remade to match the channel density and electrical characteristics of the new DAQ.
The construction of a full scanner is in an advanced stage.
One year funding of 27k€ was approved by the "CERN program".

6.1.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83524/2008	20.000 €	2008-10-01	2010-03-31
CERN/FP/109355/2009	30.000 €	2010-04-01	2011-03-31

6.1.6 Team

Project coordinator: Rui Marques

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	18
Alessio Mangiarotti	Researcher (LIP)	2
Alexandre Moita	Technician (LIP)	1
Américo Pereira	Technician (LIP)	10
Carlos Silva	Technician (LIP)	9
Joaquim Oliveira	Technician (LIP)	9
Luís Lopes	Technician (LIP)	2
Miguel Couceiro	Researcher (LIP/ISEC)	50
Nuno Carolino	Technician (LIP)	10
Nuno Fonseca	Researcher (LIP/IBILI)	5
Orlando Cunha	Technician (LIP)	10
Paulo Crespo	Researcher (LIP/ISEC)	50
Paulo Fonte	Researcher (LIP/ISEC)	31
Ricardo Caeiro	Technician (LIP)	4
Rui Alves	Technician (LIP)	9
Rui Marques	Researcher (LIP/FCTUC)	10

6.1.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *A dedicated setup for the measurement of the electron transport parameters in gases at large electric fields*
  P. Fonte, A. Mangiarotti, S. Botelho, J.A.C. Gonçalves, M.A. Ridenti and C.C. Bueno
  Nucl. Instrum. and Meth. in Phys. Res. A 613 (2010) 40-45

- *A dedicated setup for the measurement of the electron transport parameters in gases at large electric fields*
  P. Fonte, A. Mangiarotti, S. Botelho, J.A.C. Gonçalves, M.A. Ridenti and C.C. Bueno
  Nucl. Instrum. and Meth. in Phys. Res. A613 (2010) 40-45

- *On the physics and technology of gaseous particle detectors*
  P.Fonte and V. Peskov
  Plasma Sources Sci. Technol. 19 (2010) 034021

- *Systematic study of gas mixtures for timing RPCs*
  L.Lopes, P.Fonte and A. Mangiarotti
  Nucl. Instrum. and Meth. in Phys. Res. A (accepted)

- *Quantification and inhibition of the gas polymerization process in timing RPCs*
  Silvia Gramacho, Luis Lopes, Alexandra Rocha Gonsalves, Marta Pineiro, Paulo Fonte and António M. d´A.Rocha Gonsalves
  Nucl. Instrum. and Meth. in Phys. Res. A (accepted)

- *Advances in the development of micropattern gaseous detectors with resistive electrodes*
  V. Peskov, P. Fonte, P. Martinengo, E. Nappi, R. Oliveira, F. Pietropaolo and P. Picchi
  Nucl. Instrum. and Meth. in Phys. Res. A (accepted)

International Conference Proceedings

- *Studies of Gaseous Multiplication Coefficient in Isobutane*
  Lima I.B., Vivaldini T.C., Goncalves J.A.C., Botelho S., Ridenti M.A., Fonte P., Mangiarotti A., Pascholati P.R., Tobias C.C.B.
  AIP Conf. Proc. 1245 (2010) 149-152

6.1.8 Presentations

Oral presentations in international conferences

- *Summary talk*
  presented by Paulo Fonte
  "X Workshop on Resistive Plate Chambers and Related Detectors", February 9-12, 2010 — GSI, Darmstadt, Germany, .

Poster presentations in international conferences

- *Systematic study of gas mixtures for timing RPCs*
  presented by Luís Lopes
  "X Workshop on Resistive Plate Chambers and Related Detectors", February 9-12, 2010 — GSI, Darmstadt, Germany, .

Oral presentations in collaboration meetings

- *Calculation of streamer development in MPGDs in an axisymmetric hydrodynamic model*
  presented by Paulo Fonte
  5th RD51 Collaboration Meeting,24-27 May 2010 — Freiburg, Germany.

6.1.9 Academic Training

PhD Theses

- *Demonstration of a Positron Emission Tomography small-animal scanner based on Resistive Plate Chambers*
  Paulo Martins, (on-going)

6.1.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	6
International Conference Proceedings	1
Oral presentations in international conferences	1
Poster presentations in international conferences	1
Oral presentations in collaboration meetings	1

6.2 Microstructure Gas Detectors

6.2.1 Resumo

O projecto em curso envolve o desenvolvimento de detectores de radiação gasosos com sistemas de leitura ópticos, neste caso fotomultiplicadores. A cintilação é emitida pelas avalanches produzidas em microestruturas e permite a localização das interacções. Foram considerados especialmente estudos conducentes ao desenvolvimento de uma câmara Anger gasosa para imagiologia com neutrões térmicos.
Conforme se verificou ao longo do projecto o actual desempenho em localização deste tipo de detector é limitado pelo número de fotões recolhidos no sistema de leitura e pelas características físicas do sistema de leitura e janelas dos detectores . Assim o programa de trabalhos pode ser desenvolvido ao longo de duas linhas complementares, mas interligadas – características do sistema de leitura do detector e estudo dos processos de emissão de luz relacionados com a interacção em 3He-CF4, mistura gasosa utilizada nestes detectores.
Várias experiências em Física das Altas Energias têm considerado a utilização do tetrafluoreto de carbono ou CF4, quer como cintilador primário quer como gás de enchimento em contadores proporcionais de fio ou microestruturas, sozinho ou como aditivo. É sabido que o número de fotões emitidos pelo CF4 é menor que o emitido pelos gases raros puros, mas as suas características tais como a velocidade de deriva, coeficente de difusão, espectro de emissão e o custo inferior fazem dele um gás popular. Algumas das características da cintilação do CF4 foram estudadas para aplicações a detectores, mas não existe publicado nenhum trabalho sistemático sobre a sua cintilação. As publicações existentes estão focadas nas necessidades imediatas dos autores e cobrem regiões espectrais limitadas, uma só pressão e fontes de excitação únicas. Por causa das diferentes condições experimentais e dos modelos simplistas assumidos para aspectos básicos estes estudos não permitem comparação mútua e são de pouca utilidade geral. Este trabalho pretende complementar o actual conhecimento sobre a cintilação do CF4, considerando aplicações e fundamentos. O objectivo principal é o estudo detalhado das cintilações primária e secundária do CF4 entre os 200 e os 800 nm para pressões entre os 100 mBar e os 5 Bar e uma clarificação dos mecanismos envolvidos. Os estudos experimentais foram efectuados com sistemas de detecção calibrados (calibração absoluta) e incluíram medidas de espectroscopia resolvida no tempo para correlacionar os espectros com aspectos fenomenológicos de cintilação.
Estes trabalhos foram desenvolvidos numa nova actividade financiada pelo 7º Quadro Comunitário de Apoio - Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy (FP7), Project nº 226507 - NMI3. A nossa equipa está integradada na JRA WP22 Detetcors – tarefa 22.2 e no projecto "Caracterização

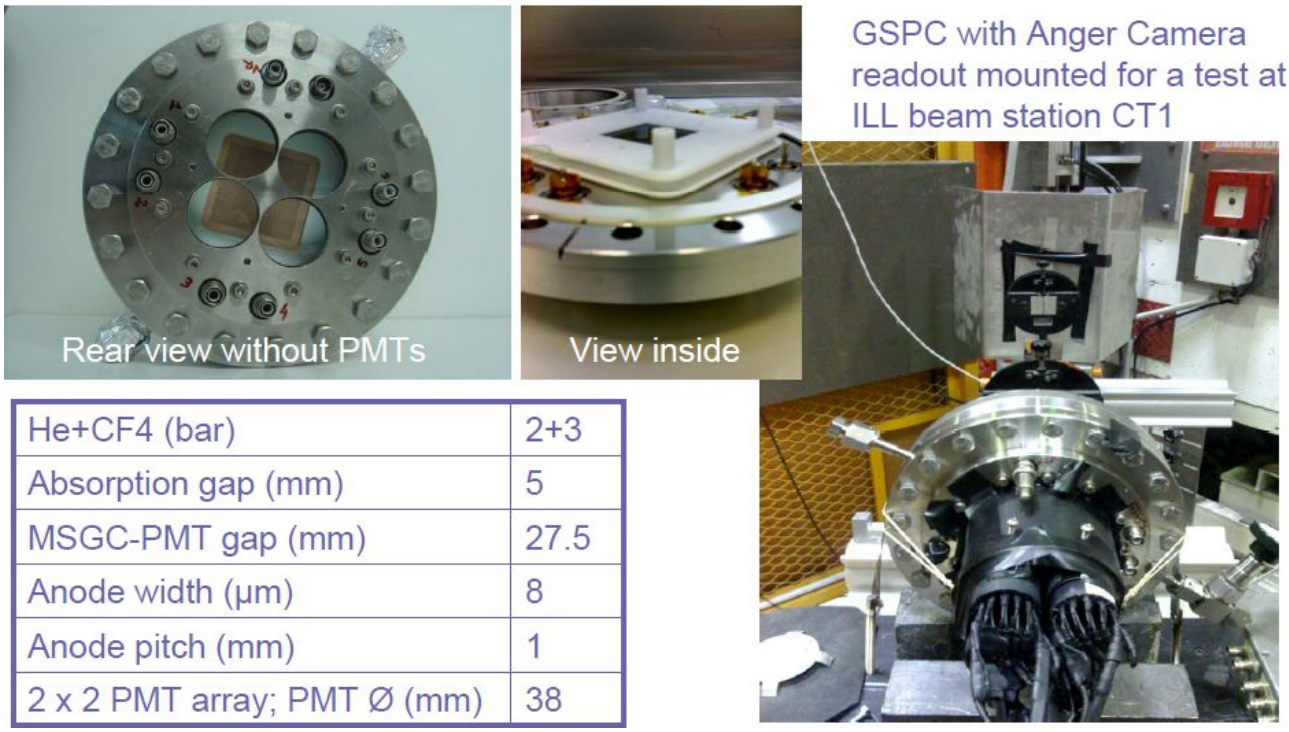

Figura 6.2: Microstructure Gas Detectors

da cintilação do CF4 para aplicações na área do desnvolvimento de detectores", CERN/FP/109359/2009.

6.2.2 Abstract

The present project involves the development of gaseous radiation detectors with optical readout systems, in this case photomultipliers. The scintillation is emitted by the avalanches produced in the microstructures and allows the determination of the position of interactions. Special attention was given to studies leading to the development of an Anger gas chamber for thermal neutron imaging.
As demonstrated during the project, the current performance of this type of detector in localization is limited both by the number of photons collected in readout system and the physical characteristics of the readout system and of the windows of the detectors. Therefore, the program of work is developed along two complementary but interconnected lines – study of the characteristics of the readout system of the detector and study of mechanisms leading to light emission in a 3He-CF4 gaseous mixture, i.e., the gas mixture used in these detectors.
In recent years, CF4 has been considered for several experiments in high energy physics, used either as a primary scintillator or as a proportional counter gas using wires or microstructures. The scintillation yields of CF4 are lower than those of pure rare gases, but its conditions of operation and characteristics such as drift velocity, diffusion coefficient, emission spectra and low cost make it a very popular gas. A few aspects of CF4 scintillation have been studied by the groups considering this gas for detector applications, but no systematic studies of its scintillation properties have been reported. These past valuable works focused mainly in their immediate requirements and were carried on in a limited spectral zone, fixed pressure and single excitation sources. As a consequence of these different experimental conditions and the oversimplified models assumed for the fundamental mechanisms and properties, these results have limited application outside their local community and cannot be mutually compared. This project pretends to complement the actual knowledge about CF4 scintillation, considering both the application in practical developments and the phenomenological aspects. The main goal of this project is the accurate study of the primary and secondary scintillation of CF4 between 200 and 800 nm, for pressures between 100mBar and 6 Bar. The experimental spectral studies were done using systems calibrated in absolute number of photons and included time resolved spectral studies as an attempt to infer a kinetic scheme that will explain the scintillation properties of CF4.
These studies were developed in a new activity funded by the 7th Framework Programme - Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy (FP7), Project n° 226507-NMI3. Our team is integrated in the JRA WP22 Detectors – task 22.2 and project "Characterization of CF4 is scintillation detector development applications", CERN/FP/109359/2009.

6.2.3 Objectives

The aim of this JRA is the development of new detector technologies based on Gaseous Scintillation Proportional Counters (GSPC). These devices have the potential of improving the performance of high position resolution detectors used in reflectometry and time resolved SANS. Present state of the art detectors, such as 3He-based Multi Wire Proportion Chambers already limit the performance of existing reflectometers due to their moderate count rate capability. They only provide limited spatial resolution of x ≈1-2 mm and a time resolution in the microsecond range. More advanced devices based on solid 6Li-doped glass scintillators with Anger camera readout, e.g. as recently developed at the SNS, can partially improve the performance achieving high position resolution (≈1mm) and providing good timing resolution due to the fast scintillation light pulse with a duration of about 200 ns. The low light output of 6Li glass however, diminishes the count rate capability due to the signal integration time required. A major drawback of 6Li based glass scintillation detectors is a non negligible sensitivity to a high gamma background environment.
Micro pattern charge amplifying structures like MSGCs have been shown to be very efficient in the production of fast scintillation light in the visible region when operated in the proportional mode in gas mixtures of 3He-CF4. Photon yields per detected neutron can be ≈100 times larger than that of 6Li-glass and light signal durations of less than 60 ns have been observed. In the proposed JRA particular emphasis is therefore placed on the development and study of new technologies based on these Gaseous Scintillation Proportional Counters with light readout. Our activities for 2009 were the study of light emission in pressurized CF4 and the detailed study of a PMT readout adequate to the neutron Anger Camera.

6.2.4 Achievements

During 2010 the secondary light emitted by the CF4 avalanches was studied at 1,2,3 and 5 bar using microstrip devices. The results will be submitted for publication in the first quarter of 2011.
Emission spectra fully corrected for the spectrometer and PMT sensitivity were obtained. The spectra were scaled using the photons/electron ratios for the visible component. At the moment of writing this report,

measurements show a weak dependence of the secondary scintillation on the CF4 pressure. The highest photon-per-electron ratios are obtained at 3 bar. When He is added (2 bar) there is a slight (≈20%) enhancement of the UV emission and the visible emission is practically the same. Preliminary results indicate ratios of about 0.020 photons per electron in the UV and about 0.015 photons per electron in the visible. These values are considerably less than expected from previous preliminary studies. The spectral profiles of the secondary emission in the UV and in the visible are similar to the corresponding profiles of the primary emission in the presence of an electric field.
These results not only extend the knowledge on the CF4 light emission but also give quantitative information useful for development of new schemes of optical read-out in modern state-of-the art detectors operating with CF4.
Some unforeseen studies of localization of the scintillation above the anode surface of the MSGCs were needed in this programme. The emission of photons is performed very close to the surface and the number of detected photons depends on the anode and substrate reflectivity as well as in the localization of the emission. A CCD photographic system capable of recording the avalanches with 1 micron accuracy from a distance of about an half a mater was developed and the results demonstrated that 75% of the photons are produced above the anode surface at 3 bar. These results were also of of great interest for the prospective studies of MSGCs using optically transparent substrates.
A complete and comprehensive interactive simulation package of the gaseous Anger Camera was developed at LIP Coimbra, incorporating all the factors that can affect localization, such as detector geometry, primary interaction, avalanche properties, spectral emissions of the photons produced, several types of readout configurations, spectral sensitivity of PMTs and PMTs uniformity and angular dependence. Several reconstruction algorithms were incorporated in a later version.
This software package was used for a Workshop in simulation during the conference meeting organized in Coimbra and is now being used to all collaboration members, who are using it for their developments.
The capabilities of using neural networks for position reconstruction in gaseous was studied and preliminary results, presented at the above referred meeting were promising and comparable to other classical methods. This work constitutes the initial part of the studies of a PhD thesis, and are being carried in collaboration with the members of the collaboration responsible for the electronic readout (ISIS, TUM,
All data used for PMT characterization was collected using our system already presented in last year report, and meanwhile improved for faster and more efficient use.
As a side work, some work was carried in collaboration with LIP Lisbon members of the Auger collaboration to study the PMTs used in their systems in our scanning system.

6.2.5 Sources of Funding

Code	Funding	Start	End
FP7-GA226507	80.640 €	2009-02-01	2012-01-31
CERN/FP/109359/2009	10.000 €	2010-01-01	2010-12-31

6.2.6 Team

Project coordinator: Francisco Fraga

Name	Status	%of time in project
Américo Pereira	Technician (LIP)	20
Andrey Morozov	Researcher (LIP)	65
Francisco Fraga	Researcher (LIP/FCTUC)	65
João Silva	Technician (LIP)	5
Luís Pereira	PhD student (LIP)	100
Margarida Fraga	Researcher (LIP/FCTUC)	60
Nuno Carolino	Technician (LIP)	15
Paulo Mendes	Researcher (LIP/FCTUC)	20
Rui Marques	Researcher (LIP/FCTUC)	20

6.2.7 Publications

Articles in international journals (with direct contribution from LIP members)

- *Photon yield for ultraviolet and visible emission from CF4 excited with α-particles*
  A. Morozov, M.M.F.R. Fraga, L. Pereira, L.M.S. Margato, S.T.G. Fetal, B. Guerard, G. Manzin, F.A.F.

Fraga
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 268, Issue 9 (2010) 1456-1459

- *The transparent microstrip gas counter*
Hiroyuki Takahashi, Kaoru Fujita, Takeshi Fujiwara, Hisako Niko, Bruno Guerard, Francisco Fraga and Naoko Iyomotoa
Nucl. Instrum. and Meth A 623 (2010)123

- *Effect of electric field on the primary scintillation from CF4*
A. Morozov, M.M.F.R. Fraga, L. Pereira, L.M.S. Margato, S.T.G. Fetal, B. Guerard, G. Manzin, F.A.F. Fraga
Nuclear Instruments and Methods in Physics Research Section A 628 (2011) 360-363

6.2.8 Presentations

Poster presentations in international conferences

- *Effect of electric field on the primary scintillation from CF4*
presented by Andrey Morozov
The 12th Vienna Conference on Instrumentation, Feb 15-20, 2010 — Viena, Austria.

- *Light emission in CF4 at high pressure*
presented by Margarida Fraga
Molec 2010 — Curia, Portugal.

Oral presentations in collaboration meetings

- *Microphotography of the light emitted by MSGCs operated in CF4*
presented by Luís Pereira
NMI3 GSPC Meeting, Barcelona,May 10-12 , 2010 — Barcelona, Spain.

- *Caracterization of the secondary light from MSGCs in CF4 - preliminary results*
presented by Andrey Morozov
FP7 NMI3 GSPC Meeting, Barcelona 2010 May 10-12 — Barcelona, Spain.

- *Measurements of secondary scintillation in CF4*
presented by Andrey Morozov
FP7 NMI3 GSPC Meeting, Coimbra, December 09-10, 2010 Friday December 10 — UC, Coimbra, Portugal.

- *Anger Camera simulation - software and first results*
presented by Luís Pereira
FP7 NMI3 GSPC – Meeting, Coimbra, December 09-10, 2010 Friday December 10 — UC, Coimbra, Portugal.

- *GSCP prototype study and light measurements at High pressure at ILL*
presented by Luís Margato
FP7 NMI3 GSPC – Meeting, Coimbra, December 09-10, 2010 Friday December 10 — UC, Coimbra, Portugal.

- *Anger camera GSPC - neural network reconstruction*
presented by Luís Pereira
FP7 NMI3 GSPC Meeting, Coimbra, December 09-10, 2010 Friday December 10 — UC, Coimbra, Portugal.

- *Workshop on GSPC Simulation Package*
presented by Andrey Morozov
FP7 NMI3 GSPC Meeting, Coimbra, December 09-10, 2010 Friday December 10 — UC, Coimbra, Portugal.

6.2.9 Events

- *FP7 NMI3 GSPC Meeting*
  Collaboration Meeting, Coimbra, 2010-12-09

6.2.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
Poster presentations in international conferences	2
Oral presentations in collaboration meetings	7
Collaboration Meetings	1

6.3 Oficina-Coimbra

6.3.1 Resumo

A oficina mecânica (OM) do LIP foi estabelecida em 1986 para apoiar as actividades experimentais a realizar em colaboração com o CERN. Foi na altura equipada com equipamento moderno de maquinação CNC e pessoal qualificado.
O equipamento da OM foi recentemente renovado com a entrada ao serviço, em 2008, de duas máquinas-ferramentas (torno e freza) CNC de alto desempenho adquirido no âmbito do Programa Nacional de Reequipamento Científico.
O equipamento disponível e o pessoal técnico altamente qualificado, permitem actualmente assegurar uma larga gama de serviços mecânicos, desde a concepção e desenho, à maquinação, montagem e testes.
A experiência de duas décadas, garante-nos que na ausência da OM não teria sido possível realizar com a elevada qualidade atingida, nem o trabalho de I&D em detectores gasosos centrado em projectos autónomos ou em pequenas colaborações, nem os compromissos assumidos no âmbito de médias e grandes colaborações internacionais (nomeadamente CP-LEAR, DELPHI, HERA-B, ATLAS, HADES).
São igualmente incontestáveis os benefícios para a comunidade nacional de I&D que a intervenção da OM do LIP trouxe aos seus projectos, tanto no plano local e nacional, como em colaborações internacionais, com destaque para o projecto CAMCAO-ESO.

6.3.2 Abstract

The Mechanical Workshop (MW) of LIP was established in 1986 to support the experimental activities to be performed in collaboration with CERN. At this time it was equipped with modern CNC equipment and qualified personnel.
The equipment of the MW was recently renewed with the commissioning, in 2008, of two high-performance CNC machine tools (a mill and a lathe) acquired in the framework of the National Program of Scientific Reequipment.
The equipment available and the highly qualified staff allow presently to perform a large spectrum of mechanical services, from the design to the production and testing.
A two-decades experience assures us that, in the absence of the LIP MW, it wouldn´t have been possible to perform with the same high level of quality the R&D in gaseous detectors performed in the framework of autonomous projects or small collaborations, or the responsibilities undertaken within medium and large international collaborations (CP-LEAR, DELPHI, HERA-B, ATLAS, HADES).
Equally evident are the benefits to the national R&D community of the intervention of the MW in its projects, at the local and national level, with emphasis in CAMCAO/ESO.

6.3.3 Objectives

The LIP OM aims at providing high quality mechanical design and production services to the scientific community, namely:

- Supporting the participation in High Energy Physics or other international collaborations that imply the production of mechanical equipments and systems
- Supporting the research in radiation detectors at LIP
- Providing mechanical engineering and production services to other research institutions
- Providing technology transfer services to other entities.

6.3.4 Achievements

The present year was a year of consolidation after the restructuring that took place in 2009. The new engineer took full hold of the CNC machines and started directing the Production section. The Project section remained independent.
It was negotiated and acquired the modern CAM software TOPSOLID.
In this report we will also list the most important work made at the Detector Lab.
It should be mentioned the construction of three Spark Chambers for: the AUGER Observatory in Malargue, Argentina; Universidad Complutense de Madrid, Spain; Institute of High Energy Physics, Wien, Austria.

Mechanical production

Descrição	Projecto	Entidade
Maquinar peça em Aluminio conforme desen...	CEMDRX	DF
Mesa Canhão de electrões	CEMDRX	DF
Sample Chamber.	CEMDRX	DF
Discos Al.	CEMDRX	DF
Reparações diversas	CEMDRX	DF
Suporte fontes gama	GIAN	DF
Construção de 2 colimadores de chumbo. A...	CEMDRX	DF
Realizar furações em peça fornecida	DF	DF
Reproduzir peças em Aluminio com espessu...	DF	DF
Realização de 50 Encaixes em acrilico	CEMDRX	DF
Abrir rasgo numa peça. Maquinar 2 discos...	GIAN	DF
Flange de Ligação CF para tubo 12mm. Rep...	CEMDRX	DF
Box Test (igual à obra 10/44)	DF	DF
"Ajustar um embolo para um tubo, conforme..."	CEMDRX	DF
Fazer uma anilha de aço inox	DF	DF
Maquinação de 3 colimadores de chumbo	GYAN	DF
Maquinação de 2 Rasgos em peça dada	GYAN	DF
Rebaixar caixa	GYAN	DF
Porca de ligação M5 / M7x0.5	CEMDRX	DF
Fixações para Monitor	DF	DF
Pêndulo Foucault	Pêndulo	DF
Base Chladni - Acrilico	Sala Experimental	DF
Furações para equipamento de tração	GTR	DF
Anel em Inox	CEMDRX	DF
Execução de furos em compositos para est...	GTR	DF
Soldadura de elementos. Anel em Inox 2.	CEMDRX	DF
Anéis em plástico	Olimpiadas de Física	DF
4 Peças iguais em Aluminio	Cosmicos	LIP-C
Beam Expander	Atlas	LIP-C
Peça c/ 28*3*0.8	Cosmicos	LIP-C
Maquinar nova flange em INOX igual à rea...	Xenon	LIP-C
Fazer furos em Flange CF40	Xenon	LIP-C
"2 Peças roscadas em Nylon para stock"	Xenon	LIP-C
Efectuar casquilho conforme desenho em b...	Xenon	LIP-C
Quinar chapas p/ blindagem	Cintiladores	LIP-C
Sample Chamber	CEMDRX	LIP-C
Peças para Colimador	Xenon	LIP-C
Maquinação de 4 elementos	Outreach	LIP-C
Câmara de Faíscas	Raios Cosmicos	LIP-C
PMT Box	Cintilação	LIP-C
Efectuar uma ficha ligação em POM confor...	RD51	LIP-C
Realização de elementos auxiliares à maq...	Oficina	LIP-C
Sistema de Calibração de PMs	SNO	LIP-C
Realização de 10 Chapas para electrodos	RD51	LIP-C
Protectores de PM	RT MON	LIP-C
Maquinação placa Aluminio	DIRAC	LIP-C
Maquinação 3 conectores e cinta de ligaç...	SNO	LIP-C
Base para Camara	DIRAC	LIP-C
Pet-Animal	RPC-2008	LIP-C
Caixa de Al.	Dirac	LIP-C
Peças proteção T SHV	DIRAC	LIP-C
Maquinação de uma peça em aluminio.	Detectores Cintilação	LIP-C
Reflectividade do Teflon	Reflectividade do Teflon	LIP-C

Mechanical production (cont.)

Descrição	Projecto	Entidade
Caixa de Fantoma	<vazio>	LIP-C
Várias peças conforme desenhos enviados.	DIRAC	LIP-C
Pet Humano	RPC 2009	LIP-C
Flange de ligação	Xenon	LIP-C
Reprodução de elementos para laboratório	Laboratório	LIP-C
Maquinação de Flange com ligações CF16 n...	Xenon	LIP-C
Tubo com flanges CF40/KF40	Cosmicos	LIP-C
Detector de raios cósmicos	Cosmicos	LIP-C
Furação de ventilação em porta. Montagem...	Sala Computadores	LIP-C
Placa PVC suporte 1-wire	HADES - DIRAC	LIP-C
Arrefecedor Cobre	Xenon	LIP-C
Sistema para teste de PM	Cosmicos	LIP-L
Eliminar folga do eixo de 2 rodas de um ...	LIP LISBOA	LIP-L
Reparação de Cintilador	Reparação de Cintilador	LIP-L
Projecção e maquinação de fantoma e elem...	Suporte Fantoma	LIP-L
Protecção de sala de Computadores	LIP-L	LIP-L
Focal Plane Auger	Focalplane	LIP-L
Construção de elementos MiniPet	MiniPet	LIP-L
Display Auger - Outreach	Outreach	LIP-L
Telescópio de raios cósmicos	Raios cósmicos	LIP-L
Contrução de componentes da fantoma	Fantoma LX	LIP-L
Realizar uma prateleira de suporte de Ci...	Raios Cósmicos	LIP-L
Maquinação de uma Caixa	Active SpaceTech	Active Spacetech
Furação a elemento dado.	CNC - Biologia Molecular	CNC - Biologia Molecular
Maquinação de 12 Provetes c/ material fo...	Departamento Eng. Civil	DEC
Cortes em elementos de Acrilico conforme...	Alunos	DF
Maquinação de 4 Peças de 2 medidas difer...	Dep. de Quimica	DQ - PRODEQ
Reparação de elementos de deslizamento	FCT	FCT/UNL
GenePredit - Garra	ISR	FCT/UNL
GenePredit - elementos diversos	ISR	FCT/UNL
Componentes de ligação a robô	ISR	FCT/UNL
Execução de 5 paralelipipedos em acrilic...	Fucoli	Fucoli-Somepal
5 Placas c/ 80 furos	IMAR	IMAR
Maquinar Placa de Aço com furos	IMAR	IMAR
Redução de Diametro Peça A/B. Furar e ro...	IMAR	IMAR
Rectificar 1 elemento e fazer 2 para ent...	IMAR	IMAR
Tornear elemento com furo transversal	IPO	IPO
Conjunto novo em AL para tratamento mama...	IPO	IPO
Realização de elementos de acrilico e m...	IPO	IPO
Reproduzir peça em POM	IPO	IPO
Reparações diversas	IPO	IPO
Reprodução de peça	IPO	IPO
Trabalhos doutorais de F. Ferreira	ISEC	ISEC
Maquinação de Pedal Electrico	ISEC	ISEC
Maquinação de madeira balsa p/ F1 in Sch...	LIP	LIP-C
Spark Chamber	LIP	LIP-C
Réplicas de peças de escolas	Museu da Fisica	MF
Maquinação janela termica - Pilot	Sinergiae	Sinergiae
Reparação de sistema de vácuo e refriger...	TeandM	TEandM

Mechanical project

Descrição	Projecto	Entidade
Célula de Som	CLI	DEQ
Mesa para Canhão de Electrões	CEMDRX	DF
Acessorios sist. exaustão	CEMDRX	DF
Sample Chamber	CEMDRX	DF
Replicas Escolas	Museu da Fisica	DF
Isolamento Sonoro e prtecção de moinho	CEMDRX	DF
Peças para sistema de vibração de moinho	CEMDRX	DF
Colimador Pb e suporte estrutural	CEMDRX	DF
Sample Cell 100bar	CEMDRX	DF
Equipamento de detecção de radiação	sistema XP2020	FCTUC
Sistema de ligação a robô	ISR	ISR
Pet Animal	Pet Animal	LIP-C
Sistema de distribuição de Luz	ATLAS	LIP-C
Sistema de distribuição de Luz	ATLAS	LIP-C
PMT Box	Cintilação	LIP-C
Sistema calibração PM´s	SNO	LIP-C
Sistema de Calibração de PMs	SNO	LIP-C
Sistema de distribuição de Luz	Atlas	LIP-C
Pet Humano - Esboço inicial	PET H	LIP-C
Módulo 1	Pet H	LIP-C
Sistema para teste de PM	Raios Cosmicos	LIP-L
Display Auger +	OUTREACH	LIP-L
Isolamento térmico sala computadores	Sala Computadores	LIP-L
Prototipos de teste do Display	OUTREACH	LIP-L

Detector lab.

Descrição	Projecto	Entidade
Construção spark chamber	Spark chamber	LIP-C
Desenho do BLR baseado nos esquemas e la...	BLR Base Line Restorer	LIP-C
Projecto dos elementos de aquecimento 1-...	Elementos de aquecimento 1-wire	LIP-C
Sistema de Gás para o TOF- RPC em HADES	Sistema Gás HADES	LIP-C
HADES Current monitor (air test)	HADES Current monitor (air test)	LIP-C
Multiplexador analogico controlado via 1...	Multiplexer (HADES ref chambers)	LIP-C
Caixa de HV para fotomultiplicadores R58...	Caixa de HV para fotomultiplicadores R58...	LIP-L
Teste de cintiladores	Teste de cintiladores	LIP-L
Bases para fotomultiplicadores xp2020	Bases para fotomultipliadores XP2020	LIP-L

Entidades

ANIFC	Associação Nacional de Imagiologia Funcional Cerebral
CTCV	Centro Tecnológico da Cerâmica e do Vidro
DEEC	Departamento de Engenharia Electrotécnica e de Computadores da U.C.
DF	Departamento de Física da Universidade de Coimbra
DQ - PRODEQ	Departamento de Engenharia Química da U.C.
IMAR	Instituto do mar
IPO	Instituto Português de Oncologia de Coimbra
ISEC	Instituto Superior de Engenharia de Coimbra
ISR	Instituto de Sistemas e Robótica da U.C.
LIP-C	LIP Coimbra
LIP-L	LIP Lisboa
MF	MUSEU da FÍSICA
TEandM	Tecnologia e Engenharia de Materiais, SA
UFP	Universidade Fernando Pessoa
DEQ	Departamento de Engenharia Química da U.C.
Active Spacetech	Active Space Technologies, Lda.
CNC - Biologia Molecular	Centro de Neurociências de Coimbra
DEC	Departamento de Engenharia Civil da U.C.
FCT/UNL	Faculdade de Ciências e Tecnologia da U. Nova de Lisboa
FCTUC	Faculdade de Ciencias e Tecnologia da U.C.
Fucoli-Somepal	Fucoli-Somepal-Fundição de ferro SA
Sinergiae	Sinergiae Energias Renováveis Lda.

Chapter 7

Outreach

7.1 Particle physics education and public outreach

7.1.1 Resumo

A actividade de divulgação do grupo de Outreach do LIP desenvolveu-se em 2010 segundo vários vectores. O grupo manteve a aposta na divulgação para o público escolar, através das acções para alunos e professores, e para os media através dos comunicados de imprensa a propósito de acções específicas ou da adaptação para português dos comunicados de imprensa do grupo InterActions (incluindo o CERN) com relevância para Portugal. Não esquecemos contudo o público em geral, tendo participado em exibições públicas mostrando a Câmara de Faíscas e o que se faz no LIP.
Mantendo a aposta iniciada em 2009 na internacionalização das acções para professores, 2010 foi o ano da sua regularização, tendo-se estendido a Escola no CERN a professores brasileiros, moçambicanos, angolanos, de Cabo Verde e de São Tomé e Príncipe. O financiamento das participações africanas foi partilhado entre o CERN e o LIP.
As actividades realizadas em 2010 são apresentadas de seguida de forma aproximadamente cronológica.

Figura 7.1:

- No átrio do edifício da Universidade do Minho onde se realizaram as Jornadas do LIP em Janeiro de 2010, foi colocada a exposição que esteve em São Tomé - "A luz desviada pelo Sol", e a câmara de faíscas, que despertou algum interesse.

- Em Fevereiro, foram realizadas as Masterclasses 2010, a 6ª edição de uma actividade já regular no âmbito do grupo EPPOG - European Particle Physics Outreach Group, com a participação recorde de 1300 participantes em 9 institutos portugueses. Para permitir um número tão elevado de participantes, contámos com o apoio voluntário e entusiástico de 23 cientistas nas palestras e aproximadamente 50 cientistas a apoiar as actividades de análise de dados. O número de participantes em Portugal foi pela primeira vez maior do que nos outros países (mais 400 alunos do que na Alemanha e na Itália com 900 cada).

- Na sequência da reunião da Colaboração Pierre Auger, onde foi feita uma apresentação sobre a utilização da câmara de faíscas como instrumento de divulgação, que suscitou bastante interesse, foi redesenhada a câmara de faíscas para funcionamento mais autónomo, especialmente no que respeita ao fluxo de gás, para responder a encomendas feitas por institutos membros da colaboração. Em 2010 foram feitas 3 câmaras de faíscas para satisfazer estes pedidos, das quais 2 foram entregues e uma irá ser entregue em 2011. O total de câmaras de faíscas fabricadas nas oficinas de Coimbra ascende a 6 até agora, estando 4 em funcionamento no final de 2010.

- No dia 30 de Março de 2010, e em estreita colaboração com o Pavilhão do Conhecimento, foi feita no auditório deste Pavilhão uma sessão de acompanhamento do arranque do LHC para a Física (primeiras colisões de protões para Física), das 7h30 às 15h30 em directo com o CERN. Nesta sessão participaram cientistas portugueses, estudantes de escolas secundárias e, em video-conferência, investigadores portugueses radicados no CERN, que puderam testemunhar a emoção do acontecimento. Esta sessão foi difundida para a internet, através da CVTV – Ciência Viva TV, e teve um número extraordinário de ligações (3500 neste dia para uma média de 60/dia – resultados dos operadores da CVTV).

- As actividades de Outreach do LIP foram apresentadas na 24ª e 25ª Reuniões do grupo EPPOG, que tiveram lugar em Oslo em Abril de 2010 e no CERN em Outubro de 2010, respectivamente. O LIP tem também intervido nas 2 reuniões anuais do fórum EPPCN - European Particle Physics Communication Network, a rede criada pelo Conselho do CERN para promover a comunicação da Física de Partículas na Europa. Em Outubro de 2010, o EPPOG, o EPPCN e a rede ASPERA - Astroparticles for the ERAnet, organizaram conjuntamente e na sequência das respectivas reuniões de grupo, a IVth Workshop on Cosmic Rays in School Projects.

- O LIP organizou a sessão pública de lançamento da rede IDPASC – International Doctorate in Particle physics, Astrophysics, and Cosmology – a 13 de Maio no Centro de Congressos do I.S.T., com palestras sobre "Fronteiras na Física de Partículas, Astrofísica e Cosmologia", a cargo do Prof. Joseph Silk, Prof. Alan Watson, e do Director-Geral do CERN, Rolf-Dieter Heuer (palestra dada por Gaspar Barreira em sua representação), e com a participação de 300 alunos e professors do IST e de escolas secundárias (http://www.ist.utl.pt/pt/eventos/2010/5/Fronteiras_na_Fisica_de_Particulas__Astrofisica_e_Cosmologia). Esta sessão foi também difundida através da internet.

- No âmbito da Conferência IEEE Real Time 2010 (http://rt2010.ipfn.ist.utl.pt), co-organizada pelo IPFN, IST e LIP, foi feita uma pequena exibição pública onde foram colocados, no stand do LIP, a câmara de faíscas, alguns módulos de placas de electrónica e posters de divulgação.

- Foram realizados 7 estágios para 21 alunos do ensino secundário, no âmbito do programa ´Ocupação Científica de Jovens em Férias´ da Agência Ciência Viva, em parceria com a FCUL e com a FCTUC. Os estágios tiveram duração variável, de 5 a 15 dias, e versaram temas como os detectores em Física de Partículas, a Radioactividade Ambiente, Acontecimentos em ATLAS no LHC e dados públicos da Colaboração Pierre Auger.

- Foi co-organizada com o CERN a 4ª Escola de Física do CERN para Professores Portugueses (´CERN´s Portuguese Teachers Program 2010´). Na sequência do sucesso da edição anterior (2009) em que foram convidados a participar 5 professores moçambicanos e, a título experimental, 11 professores brasileiros, foram agora convidados 5 professores moçambicanos, 5 professores angolanos, 1 professor de Cabo Verde, 1 professor de São Tomé e Príncipe, e 20 professores brasileiros. Um professor moçambicano não pôde comparecer devido aos problemas sociais em Maputo no início de Setembro de 2010, e faltaram também os professores angolanos devido a problemas com a obtenção de vistos. Foram assim levados ao CERN 45 professores de escolas portuguesas (de 219 candidatos), 20 professores brasileiros (de 250 candidatos), 4 professores moçambicanos, 1 professora cabo-verdiana e 1 professor santomense, num total de 71

participantes. Durante uma semana tiveram aulas, sessões experimentais e 6 visitas acompanhadas por investigadores portugueses e brasileiros. Esta escola teve um grande sucesso junto dos participantes, e potenciou o estabelecimento de contactos muito próximos com Professores de escolas remotas em Portugal, Brasil, e Moçambique. Esta acção foi acreditada no âmbito do Conselho Científico-Pedagógico para a Formação Contínua (de Professores do Ministério da Educação), tendo sido atribuídos 1,4 créditos aos professores portugueses.

- Na Semana de Ciência e Tecnologia, o LIP co-organizou com o Centro de Ciência Viva da Amadora e a Biblioteca Municipal Fernando Piteira Santos na Amadora, uma sessão de divulgação sobre Física de Partículas no Auditório da Câmara Municipal da Amadora, e participou com duas palestras na Semana de Ciência e Tecnologia na Escola Secundária Ferreira Dias, Cacém, Sintra.

- Houve uma participação importante no Stand da Ciência Viva no "Euroskills – O campeonato Europeu das Profissões", em Dezembro de 2010 na FIL, no qual foram mostradas componentes do detector ATLAS e a Câmara de Faíscas.

- Em 2007, foi lançado o projecto radão: ´Radiação Ambiente´, com 10 escolas, que aumentou para 55 em 2009 e foi limitado a 50 escolas em 2010. É um projecto muito activo com escolas secundárias de todo o país (Norte, Centro, Sul e Ilhas), envolvendo quase 90 professores e perto de 300 alunos. Foram realizados 2 encontros nacionais em 2010, em Maio para avaliar os resultados do ano lectivo 2009/2010 e atribuir os prémios para os melhores trabalhos (com 250 participantes), e em Outubro para preparar o ano lectivo 2010/2011 (http://www.lip.pt/outreach/radao/public/index.php?cmd=smarty&id=4_len). Mais informação sobre este importante projecto pode ser consultada em http://www.lip.pt/oureach/radao.

- Em 2009, o LIP lançou o projecto Ibercivis em Portugal, em parceria com outras organizações (http://www.ibercivis.pt), adaptando o projecto para Português e preparando servidores em Portugal. O LIP ficou responsável pelo portal e pelos servidores da Ibercivis em Portugal, tendo-se em 2010 registado um elevado número de cálculos efectuados para o sub-projecto Amilóide no âmbito desta plataforma (perto de 4 milhões de cálculos efectuados em 2010).

- O LIP recebeu a visita de dois grupos de alunos de escolas básicas e secundárias ao longo do ano de 2010. O LIP tem mostrado o nó GRID do LIP no seu centro de cálculo, o laboratório de electrónica, e é feita uma palestra sobre a Física de Partículas aos visitantes. Tem-se mostrado e explicado também a Câmara de Faíscas e os Raios Cósmicos por ela detectados.

- Finalmente foram realizadas várias palestras de divulgação em Escolas e outros locais, num total de 40. Em particular palestras de preparação e acompanhamento de visitas de escolas ao CERN, Genebra, Suíça.

7.1.2 Abstract

The LIP Outreach Group (LIP-OR) has the tasks of motivating the public and the young to be interested in science, of promoting the field of Experimental Particle and Astroparticle Physics, in particular the activities carried at LIP, and of conveying the importance and excitement of taking part in the development of science at large international research facilities and international collaborations.
The group has kept its main focus in the scholar public, through actions directed at students and teachers, and in the media through press releases on specific events or the adaptation into portuguese of the press releases from InterActions (including CERN) relevant to Portugal. The general public is however not forgotten, with LIP participating in public exhibitions showing the Spark Chamber and the LIP activities.
In 2010 we have co-organized with CERN the second international teachers program in portuguese, opening the regular portuguese teachers program to teachers from Brazil (20), Mozambic (5), Angola (5), Cape Verde (1) and São Tomé and Príncipe (1), as result of the great success of the pilot project in 2009. Thus 2010 marks the year of the regularization of this program, that has set the standard for international editions in other languages, specially those that can congregate countries with different social conditions. The participation of the African countries was financed by CERN and by LIP.
In the following, a brief summary of the activities done in 2010 is provided in an approximately chronological order.

- During the Workshop LIP 2010, held at Univ.Minho in Braga in January, the spark chamber and the exhibition ´Light deviated by the Sun´ shown in São Tomé were displayed in the atrium of the workshop´s auditorium, raising the awareness to such subjects in the university students;

- In February, LIP organized in Portugal the 6th Edition of the EPPOG International Masterclasses in Particle Physics, with the financial support of Agência Ciência Viva and a record participation of 1300 students and teachers of Portuguese high schools. They took place in 9 different locations (Lisboa – IST (twice), Lisboa – FCUL, Coimbra, Covilhã, Faro, Porto, Braga, Vila Real and Bragança). To allow such a large number of participants, we count on the voluntary support of 23 scientists in the talks and about 50 scientists in the data analysis activities. The number of participants was for the first time larger in Portugal than in any other country (more 400 participants than in Germany or Italy).

- In the outreach group meeting of the Pierre Auger Collaboration in Malargüe, Argentina, the Portuguese activities were presented, including the Spark Chamber and its use. This raised considerable interest, and other institutes ordered such Spark Chambers to LIP. LIP profited to redesign the detector for a more autonomous functioning, specially in what concerns the control of the gas flux, and in 2010 three extra Spark Chambers were built to satisfy the requests. Two were delivered and one will be delivered in 2011. The interest in these portable devices is increasing (they fit well within the luggage compartment of a van or a station wagon to go to a school or a temporary exhibition), and we expect more orders to come in the near future. A total of 6 such devices were constructed in the LIP-Coimbra workshop, and 4 are functioning in several places.

- On the 30th of March, following the start-up of LHC for Physics at CERN, a session co-organized with The Pavilion of Knowledge was prepared in the Pavilion´s auditorium, in which Portuguese scientists, the media, and students, followed live what was happening at CERN. During this session, Portuguese scientists at CERN were interviewed, who conveyed the importance and excitement of this event. This session was broadcasted through the internet, via Ciência Viva TV, which had an extraordinary number of connections (3500 in this day, as compared to an average of 60/day).

- The LIP-OR is integrated in several groups and forums dedicated to Particle and Astroparticle physics outreach, at an European and international level. In the meetings of these groups, the LIP-OR presents regularly its activities and ideas. In a common session at the autumn meetings of these groups, the 4th Workshop Cosmic Rays in Schools Projects was co-organized by the groups. In particular, LIP participates in:

  - EPPOG - European Particle Physics Outreach Group, the group created under the framework of ECFA and of the HEP Panel of EPS, which meets twice per year to discuss projects and ideas about the best practices when it comes to promote and outreach Particle and High Energy Physics; at the Autumn meeting, it was decided to change the name to International Particle Physics Outreach Group, to reflect its greater internationality (invitation of representatives from other large laboratories and countries).
  - EPPCN - European Particle Physics Communication Network, a forum created by the CERN Council to assess the problems of communication related to the LHC and to High Energy Physics; the forum meets also twice per year and reports are prepared for the CERN Council;
  - ASPERA Outreach, the group concerned with the outreach of astroparticle physics in Europe, which meets a few times per year (on a less regular basis), and launches a bi-monthly regular newsletter of the field;

- LIP has organized at the Congress Centre of IST the public session on the launch of ID-PASC network – International Doctorate in Particle physics, AStrophysics and Cosmology, on the 13th of May. Talks on the Frontiers of Particle Physics, Astrophysics and Cosmology, were given by Prof. Joseph Silk, Prof. Alan Watson, and Gaspar Barreira representing the CERN´s Director General, Rolf-Dieter Heuer. This session had the participation of 300 students and teachers from high-schools and IST, and was also broadcasted to the internet (http://www.ist.utl.pt/pt/eventos/2010/5/Fronteiras_na_Fisica_de_Particulas_astrofisica_e_Cosmologia).

- In the scope of the international conference "IEEE Real Time 2010"(http://rt2010.ipfn.ist.utl.pt), co-organized by IPFN, IST and LIP, a small public exhibition was prepared, in which the LIP Spark Chamber and some high-end electronic modules, along with experiments outreach posters were displayed.

- In the scope of the program "Science in the Summer"of Agência Ciência Viva, LIP has received in 7 stays a total of 21 high-school students, in partnership with other institutions. The duration of the stays varied from 5 to 15 days, and the themes were Particle Physics Detectors, Environmental Radiation, Atlas Events at LHC and public data events from the Pierre Auger Collaboration.

- In September LIP has co-organized with CERN the 4th edition of the CERN´s Portuguese Teachers Program. This edition was again very important because there was the participation of 20 Brazilian teachers, 4 Mozambican teachers, 1 Capeverdian teacher and one Santomense teacher, in addition to the regular number of 45 portuguese teachers (out of 250 applicants). This marks the regularization of this important program and sets the standard for the internalization of other language editions, specially those that can include countries with different social conditions. In Portugal this was already an action certified by the ´Conselho Científico-Pedagógico para a Formação Contínua´ (scientific-pedagogical council for the continuous training of teachers from the Ministry of Education), following the accreditation of LIP within this entity, and 1.4 credits were attributed to the participating teachers after an assessment test.

- At the Science and Technology week in November, LIP co-organized with Centro de Ciência Viva da Amadora and the Municipal Library ´Fernando Piteira Santos´, the outreach seminar about Particle Physics and the Amadora´s Municipal Auditorium, and collaborated with the high school "Ferreira Dias", Cacém, Sintra, giving two seminars at their Science and Technology week celebration.

- LIP was invited to participate in the Ciência Viva´s stand at the Euroskills (http://www.euroskills2010.pt/Home/tabid/39/language/en-GB/Default.aspx), the European Skills Competition that took place in Lisbon on December 9-12.

- In 2007, LIP has launched the project radon – ´Environmental Radiation´, with 10 schools, that has increased to 55 in 2009 and was limited to 50 high-schools since 2010 (for logistics and support reasons). Is a very active project with high-schools from all over the country (North, Centre, South and Islands), with the participation of almost 90 teachers and nearly 300 students. There were organized two national meetings in 2010, one in May to close the school year 2009/2010 and choose the best works for the prizes (with 250 participants), and one in October to prepare the school year 2010/2011. (http://www.lip.pt/outreach/radao/public/index.php?cmd=smarty&id=4_len). More information related to this important project can be obtained at its site. http://www.lip.pt/oureach/radao.

- In 2010, LIP has continued the adaptation to Portugal of the Ibercivis project (http://www.ibercivis.pt). LIP has the responsibility of the web portal in Portuguese and of the maintenance of the servers sitting at FCCN, and in 2010 a high number of calculus for the sub-project "Amilóide"was performed in this platform (about 4 million calculus were performed in 2010).

- Along the year LIP received the visit of 2 groups of students from basic and high schools. LIP shows the local GRID cluster node, the electronics laboratory, and makes an outreach seminar about Particle and Astroparticle Physics. The Spark Chamber displayed at LIP is also shown and explained.

Finally, several outreach seminars were performed in schools and other places. In particular, outreach seminars about CERN and the Portuguese participation in its experiments are made at schools visiting CERN within one month of the visit. A total of 40 outreach seminars were made at schools and other places.

7.1.3 Objectives

The main objectives of LIP Outreach group are the following:

- motivate the public to be interested in science, and in particular Particle and Astroparticle Physics;

- engage the schools - teachers and students - to promote Particle and Astroparticle Physics in their environments (school, family, friends), through their enthusiasm in participating in activities (co-)organized by LIP;

- engage the scientists to promote Particle and Astroparticle Physics, through their enthusiasm in LIP activities, including public seminars at schools and other places;

- help the portuguese media when it comes to prepare articles and communication pieces about science, physics, particle and astroparticle physics, CERN, LHC, etc. In particular, LIP is adapting contents prepared elsewhere (for ex., CERN brochures, CERN´s Press Releases, etc).

7.1.4 Achievements

The LIP Outreach group (LIP-OR) has achieved its objectives and in some cases surpassed them by large factors.
In particular, a few over-successful examples, namely those cases in which the results were greater than reasonable expectations, are detailed in the following, in approximate chronological order. LIP-OR consider its other successful activities as important achievements, and these are detailed afterwards this report.

- EPPOG International Masterclasses in Particle Physics

In this activity in 2010, there were three more locations engaged into the activity, in particular some of very difficult access – Braga (extreme Northwest, Vila Real and Bragança – extreme Northeast), so there was expected an increase in the number of participants from 860 in 2009 to about 960. There were 1300 participants instead. In some places, the capacities of the institute were stretched to its maximum (for ex., the number of seats in the auditorium available for the talks and for the video-conference), and two days at over-maximum capacity were organized at Lisboa-IST (with more than 300 participants in each day). That so many (more) students exchange their bed and cinema (on a Saturday) for "Be a Scientist for a day ... with Hands-on CERN"at the university, specially in Portugal, is a signal of the increased motivation of the Portuguese students and of the Portuguese teachers behind them.

- Environmental Radiation project

This subproject of the LIP Outreach had a lot of activities in 2010. In particular there were two meetings (in April and October). The increase of activity and participation in this project is also reflected in the number of 50 schools now participating in the project (that started in 2007 with 10 schools).

- CERN Portuguese Teachers Programs – Teachers Programs in Portuguese

The 4th edition of this program featured a new adventure: to receive more participants (71) that pushed CERN resources far beyond its limits, so that 20 teachers from Brazil, 4 from Mozambic, 1 from Cape Verde and 1 from São Tomé and Príncipe could take part. The contacts established between the teachers and scientists (and between Portuguese, Brazilian, Mozambican, Cape Verde and São Tomé and Príncipe teachers) were very important for the cooperation in education between these countries, as well as for outreaching CERN to places far away from the laboratory. The edition – and the fact that happened for the second time with great success, has set the standard and pushed for other editions in different languages (negotiations with France were started at the end of this school, and the Germany representative in EPPOG was very interested to promote a similar edition).

- Spark Chamber and other detectors

LIP has developed, in its workshop at Coimbra, 3 Spark Chambers since 2007. One was sold to the science centre of Amadora, in which is being exhibited as part of their temporary exhibition "A Aventura Espacial". The other two are touring the country (one based at Coimbra, the other based at Lisboa), following seminars at schools and public exhibitions. But in 2010, a great increase in the demand of production was observed, and 3 more chambers were built, one already delivered and in operation. More orders are expected in the near future.

- Seminars at schools and other places

The interest of Society in Particle and Astroparticle Physics has increased in recent years, mostly by the startup of LHC-Physics and related events (in 2010), which in Portugal were also coordinated by LIP (as part of the EPPCN forum). The result of engaging the teachers and students in the LIP Outreach activities (most notable the CERN´s Portuguese Teachers Program and the EPPOG Masterclasses in Particle Physics), was also reflected in the boost of requests to make a seminar (outreach talk) in the school or other places. In 2010, LIP-OR members made 40 such outreach seminars, and some were just before a school went with its students to visit CERN).

7.1.5 Sources of Funding

Code	Funding	Start	End
Masterclasses and Env.Rad.	15.000 €	2009-10-01	2010-07-31
OCJF 2010	1.200 €	2010-06-01	2010-10-31
PTP 2010 CERN	45.655 €	2010-09-04	2010-09-10
MC2011_RadAmb2010-2011	15.000 €	2010-10-01	2011-06-30

7.1.6 Team

Project coordinator: Pedro Abreu

Name	Status	%of time in project
Agostinho Gomes	Researcher (LIP)	5
Amélia Maio	Researcher (LIP/FCUL)	15
Américo Pereira	Technician (LIP)	20
Ana Rodrigues	Collaborator	20
Ana Fernandes	Collaborator	20
Ana Pinto	Collaborator	20
António Onofre	Researcher (LIP/UMinho)	10
Carlos Bernardino	Collaborator	20
Carmen Oliveira	Collaborator	20
Conceição Abreu	Researcher (LIP)	40
Cristina Melo	Collaborator	20
Fernando Barão	Researcher (LIP/IST)	5
Florbela Rego	Researcher (LIP) *	10
José Rogério Nogueira	Collaborator	20
Luis Peralta	Researcher (LIP/FCUL)	20
Maria António	Collaborator	20
Miguel Ferreira	Technician (LIP)	17
Paula Pinho	Collaborator	20
Pedro Abreu	Researcher (LIP/IST)	35
Pedro Assis	Post-Doc (LIP/FCT)	10
Sandra Soares	Researcher (LIP/UBI)	20

7.1.7 Presentations

Oral presentations in international conferences

- *Ionizing Environment Radiation in the Classroom*
  presented by Pedro Jorge
  GIREP-ICPE-MPTL — Reims, França.

- *Projecto Radiação Ambiente: um exemplo de aprendizagem não formal em Física das Radiações*
  presented by Carmen Oliveira
  20º Encontro Ibérico para o Ensino da Física — Vila Real, Portugal.

- *Radiações Ionizantes do 1º Ciclo ao Ensino Superior*
  presented by Florbela Rego
  20º Encontro Ibérico para o Ensino da Física — Vila Real, Portugal.

Presentations in national conferences

- *MEDEA: transdisciplinaridade entre Física, Ensino e Sociedade*
  presented by Conceição Abreu
  17ª Conferência Nacional de Física — Vila Real, Portugal.

- *Parcerias entre vários graus de ensino e a investigação para uma melhor aprendizagem da Física: projecto Radiação Ambiente - um exemplo*
  presented by Conceição Abreu
  IV Jornadas "SOS Terra-– Arouca.

- *O Projecto Radiação Ambiente na Esc. Sec. c/3º ciclo Dr. Joaquim de Carvalho*
  presented by
  IV Jornadas "SOS Terra-– Arouca.

- *Física e Arte*
  presented by Florbela Rego
  17ª Conferência Nacional de Física — Vila Real, Portugal.

- *Utilização da plataforma Moodle num Projecto Educativo Interdisciplinar*
  presented by Luis Peralta
  17ª Conferência Nacional de Física — Vila Real, Portugal.

Outreach seminars

- *Das Partículas às Estrelas*
  presented by Pedro Abreu
  — Escola Secundária da Maia.
- *As radiações na Medicina*
  presented by Luis Peralta
  — E.S.D.Sancho I, Vila Nova de Famalicão.
- *O que fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Secundária Ferreira Dias, Cacém, Sintra.
- *Ibercivis - o seu computador faz Ciência*
  presented by Pedro Abreu
  — Escola Secundária D. Dinis, Lisboa.
- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — LIP (Visita da Escola Secundária Fernando Lopes Graça, Parede, Cascais).
- *Ibercivis - o seu computador faz Ciência*
  presented by Pedro Abreu
  — Escola Secundária da Amadora.
- *Física de Partículas e o Universo*
  presented by António Onofre
  — U. Minho.
- *Aplicações de Física de Altas Energias no âmbito de Física Médica*
  presented by Conceição Abreu
  — E.S. José Belchior, S. Brás de Alportel.
- *Anjos e Demónios na Matéria e Antimatéria*
  presented by Pedro Abreu
  — Escola Secundária da Amadora.
- *O que fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Externato Ribadouro, Porto.
- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — Escola Secundária de Alcácer do Sal.
- *Radiação e sua aplicação*
  presented by João Carvalho
  — Escola Secundária de Carregal do Sal.
- *O Que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Secundária Miguel Torga, Massamá, Sintra.
- *Física das Partículas e tecnologias associadas*
  presented by João Carvalho
  — Escola Secundária de Mira de Aire.
- *Física das Partículas Elementares e Interacções Fundamentais*
  presented by João Carvalho
  — Agrupamento de Escolas de Soure.

- *Física de Partículas e o Universo*
  presented by António Onofre
  — E.S. Mortágua.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — Escola Secundária de Mem Martins.

- *Aplicações de Física de Altas Energias no âmbito de Física Médica*
  presented by Conceição Abreu
  — E.S. Mem Martins, Mem Martins, Sintra.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — Escola Secundária D. Sancho I, Vila Nova de Famalicão.

- *O que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Secundária D. Sancho I, Vila Nova de Famalicão.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — Escola Secundária de Peniche.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — Escola Secundária de Águas Santas, Maia.

- *O que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Secundária de S. Pedro, Vila Real.

- *Física de Partículas e o Universo*
  presented by António Onofre
  — E. S. Amares.

- *O que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Secundária de Ponte de Sôr.

- *O que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Internacional de Torres Vedras.

- *O que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — (Escola) Oficinas de São José, Lisboa.

- *A Aventura do Universo*
  presented by Luis Peralta
  — E.S.Almodôvar.

- *Colidir para Descobrir*
  presented by Luis Peralta
  — Almodôvar.

- *Riscos para a Saúde Humana da Exposição Ambiental ao Radão*
  presented by Luis Peralta
  — E.S. José Saramago, Mafra.

- *Física das Partículas Elementares e Interacções Fundamentais*
  presented by João Carvalho
  — Escola Básica 2,3 Alice Gouveia, Coimbra.

- *As radiações na Medicina*
  presented by Luis Peralta
  — Oficinas de São José (Centro Educativo Salesiano de Lisboa), Lisboa.

- *Riscos para a Saúde Humana da Exposição Ambiental ao Radão*
  presented by Luis Peralta
  — E.S. Pedro Nunes, Lisboa.

- *O que Fazem os Físicos no CERN?*
  presented by Pedro Abreu
  — Escola Secundária de Ferreira Dias, Cacém, Sintra.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  — Escola Secundária dos Casquilhos, Barreiro.

- *Riscos para a Saúde Humana da Exposição Ambiental ao Radão*
  presented by Luis Peralta
  — E.S. Ferreira Dias, Cacém, Sintra.

- *As Partículas e o CERN*
  presented by Pedro Abreu
  — Auditório da Câmara Municipal da Amadora.

- *Raios Cósmicos*
  presented by João Carvalho
  — Escola Secundária Alves Martins, Viseu.

- *Física das Partículas Elementares e Interacções Fundamentais*
  presented by João Carvalho
  — Escola Secundária Alves Martins, Viseu.

- *Radiação e radioactividade*
  presented by Luis Peralta
  — E.S. São João da Talha, Loures, Portugal.

7.1.8 Events

- *3º Encontro Nacional do Projecto Radiação Ambiente*
  Workshop, Beja, Portugal, 2010-05-08

- *Reunião Anual de Professores do Projecto Radiação Ambiente*
  Collaboration Meeting, LIP e Departamento de Física da F.C.T. Universidade de Coimbra, 2010-10-23

- *EPPOG International Masterclasses 2010 at IST, Lisbon*
  Outreach Event, IST, Lisbon, 2010-02-20

- *EPPOG International Masterclasses 2010 at Coimbra*
  Outreach Event, LIP and FCTUC, Coimbra, 2010-02-20

- *EPPOG International Masterclasses 2010 at Covilhã*
  Outreach Event, UBI, Covilhã, 2010-02-20

- *EPPOG International Masterclasses 2010 at U.Minho*
  Outreach Event, U.Minho, Braga, 2010-02-20

- *EPPOG International Masterclasses 2010 at Vila Real*
  Outreach Event, U.T.A.D., Vila Real, 2010-02-24

- *EPPOG International Masterclasses 2010 at Bragança*
  Outreach Event, I.Politécnico de Bragança, 2010-02-26

- *EPPOG International Masterclasses 2010 at Porto*
  Outreach Event, F.C.U.P., Porto, 2010-02-27

- *EPPOG International Masterclasses 2010 at Lisboa, FCUL*
  Outreach Event, F.C.U.L., Lisboa, 2010-02-27
- *EPPOG International Masterclasses 2010 at Lisboa, IST*
  Outreach Event, I.S.T., Lisboa, 2010-02-27
- *EPPOG International Masterclasses 2010 at Faro*
  Outreach Event, F.C.T.U.Algarve, Faro, 2010-03-03
- *Estágio ´Introdução à investigação a baixas temperaturas´*
  Outreach Event, LIP e Departamento de Física da F.C.T. Universidade de Coimbra, 2010-06-28
- *Estágio ´Detecção de raios Cósmicos aplicando Câmaras de Placas Paralelas Resistivas Temporizadoras´*
  Outreach Event, LIP e Departamento de Física da F.C.T. Universidade de Coimbra, 2010-06-28
- *Estágio ´Radiação Ionizante e Ambiente´*
  Outreach Event, Faculdade de Ciências da Universidade de Lisboa (F.C.U.L.), 2010-07-05
- *Estágio ´Raios Cósmicos de Energia Extrema´*
  Outreach Event, LIP, Lisboa, 2010-07-19
- *Estágio ´Detectores da experiência ATLAS em LHC´*
  Outreach Event, Centro de Física Nuclear da Universidade de Lisboa, 2010-07-19
- *Estágio ´Acontecimentos na experiência ATLAS em LHC´*
  Outreach Event, Centro de Física Nuclear da Universidade de Lisboa, 2010-07-19
- *Estágio ´No interior do LHC´*
  Outreach Event, LIP e Departamento de Física da F.C.T. Universidade de Coimbra, 2010-07-19
- *Mini-curso creditado "Radiação Ionizante"*
  Outreach Event, Vila Real, Portugal, 2010-09-01
- *CERN Portuguese Teachers Program 2010 - Escola de Professores no CERN em Língua Portuguesa*
  Outreach Event, CERN, 2010-09-04

7.1.9 Project Summary

	number
Oral presentations in international conferences	3
Presentations in national conferences	5
Outreach seminars	40
Workshops	1
Collaboration Meetings	1
Outreach Events	19

7.2 Technology Transfer Network and Industrial Liaison Office

7.2.1 Resumo

As matérias relacionadas com a Transferência de Tecnologia (TT) e as actividades do Industrial Liaison Officer (ILO) foram iniciadas no LIP durante o último trimestre de 2009. Para 2010, o ponto focal em usufruir das vantagens da adesão do LIP ao projecto Rede de Transferência de Tecnologia (TTN) foi na sensibilização sobre TT e propriedade intelectual (PI) no domínio da Física de Altas Energias (FAE) na comunidade do LIP. Além disso, explorar o site Outreach do LIP, para a publicação de informação sobre TT e PI. Relativamente às actividades de ILO, a responsabilidade de executar o protocolo entre o LIP e a Fundação para a Ciência e a Tecnologia (FCT), foi e é primordial para o LIP manter as proficiências no que diz respeito às matérias de foro industrial da delegação Portuguesa no CERN, ESO, ESRF, em duas direcções paralelas: 1) garantir um retorno positivo e sustentável do coeficiente de retorno industrial de Portugal e 2) colaborar activamente com a indústria nacional para assegurar um fluxo de informação de oportunidades de projectos e tecnologias disponíveis * das organizações acima referidas, que podem ser relevantes para as empresas Portuguesas e / ou laboratórios de investigação nacionais, como o LIP.
Além disso, durante 2010, a rede dinâmica do ILO na sede da FCT ganha o seu impulso com o estabelecimento de uma estreita colaboração com o FCT Space Office, que é responsável pela gestão da delegação Portuguesa na Agência Espacial Europeia (ESA). Nesse contexto, as questões relacionadas com a indústria que está activa em projectos da ESA, levou ao estabelecimento de duas responsabilidades adicionais para o ILO: actuar como representante nacional no Comité de Política Industrial (IPC) da ESA, e garantir que as empresas do espaço Português podem diversificar as suas capacidades técnicas em oportunidades de projectos e tecnologias disponíveis * no CERN, ESO, ESRF e / ou laboratórios de investigação nacionais, como o LIP.
(oportunidades de projectos e tecnologias disponíveis* significa: documentos técnicos sobre oportunidades de concursos para fornecimento de bens e / ou serviços, tecnologias (incluindo patentes, know-how e software), projectos I&D ou colaborações.)

7.2.2 Abstract

The matters related to Technology Transfer (TT) and the activities of the Industrial Liaison Officer (ILO) were initiated at LIP during the last trimester of 2009.For 2010, the primarily focal point in addressing the advantages of LIP membership at the Technology Transfer Network (TTN) project were in raising awareness of TT and intellectual property (IP) issues in the field of High Energy Physics (HEP) within the LIP community. Also, explore LIP current dissemination medium, the Outreach website, to further publish information about TT and IP. Regarding the ILO, the accountability to execute LIP protocol towards the Foundation for Science and Technology (FCT) was and is paramount for LIP. This to underline, that the industrial matters of the Portuguese delegation at CERN, ESO, ESRF are being carried out by the ILO in two parallel paths: 1) ensuring a positive and sustainable industrial return coefficient for Portugal and 2) actively liaise with national industry to ensure an information flow of project opportunities and available technologies* from the abovementioned organizations that can be relevant to Portuguese companies and/or national research laboratories, such as LIP.
Furthermore, during 2010, the dynamic network of the ILO in FCT headquarters gained its momentum by the establishment of a close collaboration with the FCT Space Office, which is in charge of managing the Portuguese Delegation at the European Space Agency (ESA). In this context, matters related to industry active in ESA projects, lead to two additional responsibilities for the ILO: acting as an Industrial Policy Committee (IPC) delegate of Portugal at ESA IPC Committee, and ensuring that Portuguese space companies may diversify their technical capacities to seek project opportunities* and available technologies* in CERN, ESO, ESRF and/or national research laboratories, such as LIP.
(project opportunities and available technologies* means: announcement technical documents of tender opportunities to supply goods and/or services, technologies (including patents, know-how, software), R&D projects or collaborations.)

7.2.3 Objectives

Technology Transfer Network (TTN) project
- When WP1 is endorsed by CERN Council, it is important to implement and promote the IP charter within the LIP community (the outreach website can be a good medium for this internal promotion).
- In the framework of WP4: MPGD pilot, assess the Micro-Pattern Gas Detector Developments within LIP (patents, if any, technologies, expertise and know-how) and present this information to the TTN WP4 convener and its members.

- Invite the TTN Project coordinator for a visit to LIP Lisbon and Coimbra. In that visit organize small workshops to the different communites (Lisbon & Coimbra) to raise awareness about IP issues within the field of High Energy and Particle Physics.
Industrial Liaison Activities
- Establish a website (that will also work as a database for companies) to provide info about CERN, ESO, ESRF, project opportunities and available technologies*. The main purpose of the website is to establish a faster link with Portuguese companies.
- Establish as much as possible, company presentations to technical departments and/or groups at CERN, ESO, ESRF.
- Continue with efforts to establish an active network with the technical departments at CERN, ESO, ESRF and all Portuguese staff operating in those departments. In addition, liaise actively with the procurement and the technology transfer groups to ensure an active information flow of project opportunities and available technologies* that can be suitable to Portuguese companies.
- Co-organize an event that will present the success stories of an internship program being managed by FCT & Agência de Inovação called: Young Trainees at CERN, ESO, ESA.
- Engage in a national road-show to present CERN, ESO, ESRF to Portuguese companies. The road-show will be done jointly with FCT Space Office that has a vast network of innovative companies operating in the space sector.
- Organize an industrial event at CERN called: Portugal at CERN.
- Attend industry trade-shows and/or targeted events (nationally and internationally) to carry through targeted assessments about the different industrial sectors in Portugal and outside Portugal that can leverage the ILO activities.
(project opportunities and available technologies* means: announcement technical documents of tender opportunities to supply goods and/or services, technologies (including patents, know-how, software), R&D projects or collaborations.)

7.2.4 Achievements

- The adoption of the Intellectual Property (IP) charter by the TTN conveners including LIP, was officially accomplished. A first sketch of a web-page to be inserted in LIP Outreach website, was sent to its administrator for consideration. The foreseen headlines stated in the sketch document for the web-page, are: About Technology Transfer (ex: Patenting process) and its importance for LIP, Description of the TTN project and elements of the IP charter and Interesting Links.
- The RD-51 collaboration (http://rd51-public.web.cern.ch/RD51-Public/Welcome.html) on MPGDs account for more than 70 Institutes, around the world interested in developing detectors targeted to their R&D needs. The pilot activities related WP4 of the TTN project, were to assess within LIP if patents, technologies and know-how existed in relation to MPGDs. In July, this assessment was completed by writing to WP4 Convener and its members that three areas of study were being investigated at LIP: Generic gaseous detectors (RPCs), Cryogenic detectors and Medical applications.
- It was organized, during the 3rd trimester of 2010, a 1st LIP Seminar on Technology Transfer at LIP main locations (Coimbra and Lisbon). The key note speakers at this seminar were the Technology Transfer Network coordinator and a Senior CERN Technology Transfer Officer. Around 35 Physicists participated, and the seminar material is available at https://web.lip.pt/seminarios.php.
- A passive webpage is established at the FCT official website, available at: http://alfa.fct.mctes.pt/apoios/cooptrans/espaco/. This webpage is a first milestone before inserting more content about CERN, ESO, ESRF and ESA (under the responsibility of the FCT Space Office) to describe the Portuguese participation at least in three stages (scientific, technical training and industry involvement). Regarding the creation of a database of national companies, the parameters/system specifications are already established based on benchmarking of the following links and documents: big-science piloting innovation (https://www.tieteensuurhankkeet.fi/), CERN suppliers database (https://found.cern.ch) and (http://ILOinfo.cern.ch), ESA technology tree.
- During 2010, the ILO continued in supporting company presentations to technical departments from CERN, ESO, ESRF by establishing different formats of discussion forums (ex: dedicated meeting or industry day). Below it is reported the company name, month of the forum and to whom it was presented, as follows:
CERN
Company: EFACEC (Power supplies system unit, Energy and Switchgear business unit). Month: May. To whom: Engineering Department/Electrical Engineering Group & Technology Department/Electric Power Converters Group

Company: Sirmaf (Electromechanical engineering & engineering services). Month: June. To whom: Engineering Department/Industrial Controls & Electronics Group, Machines & Experimental Facilities Group, Mechanical & Materials Engineering Group & Technology Department/Magnets, Superconductors & Cryostats Group.
Company: ISQ (Technical engineering and auditing services). Month: June. To whom: Compact Linear Collider (CLIC) project leader, CLIC Test Facility 3, CLIC cost and schedule manager.
Company: Feedzai (Software development engineering products & services in large volumes of data in real-time). Month: November. To whom: Head of Information Technology Department.
ESO
Industry day: ESO European Extremely Large Telescope (E-ELT) project presentation at Faculdade de Engenharia do Porto, FEUP. Month: May. Participants: ESO Engineering Division. To whom: Critical Software, ActiveSpaceTechnologies, Spinworks, Lusospace, EFACEC, Edisoft, Multiwave Photonics, ASilva Matos, Solidal SA, Tegopi, Fiber-Sensing, Leica Portugal, Cabelte, Deimos Engenharia, INESC-Porto, INEGI, UPTEC.
ESRF
Company: EFACEC (Aerospace business unit). Month: May. With whom: Director of Research
- As mentioned in the summary, during 2010, there was an increase of responsibilities of the ILO regarding involvement with the European Space Agency (ESA). Therefore, several contacts were established with key departments at CERN, ESO, ESRF and ESA. The ones highlighted are the following: CERN: Engineering and Technology department, Information Technology department, Finance and Procurement department, Knowledge and Technology Transfer group, EU projects office. In addition, in September 2010 a 1st annual meeting was done at CERN with permanent staffs that have distinct positions in some of the abovementioned departments (around 10 were present). ESO: Administration division, Software Development division and Technology division. ESRF: Technical Infrastructure, Administration, Experiments. ESA: Industrial and Procurement Policy department, Technology Transfer Programme department. In addition, in October 2010 a 1st annual meeting was done with permanent staffs working at ESA ESTEC facilities in the Netherlands (around 5 were present).
- The organization of the event designated as Technological Traineeships at CERN, ESO and ESA was accomplished by the ILO during April 2010. There was the support of LIP, the Portuguese Innovation Agency (AdI), FCT Space Office and Pavilhão Ciência Viva, which culminated in presentations of several stakeholders about their experiences as current trainees, ex-trainees working in R&D centres and/or Academic Institutions, working in SMEs or Multinational companies and the ones that established their start-up companies. All information and material about this event can be found at: http://www.adi.pt/estagiosinternacionais.htm
- The collaboration between the ILO and the FCT Space office for the national road-show activities aimed at visiting several companies from different niche sectors that could be potential suppliers or project partners for CERN, ESO, ESRF and ESA, and also, national research laboratories, such as LIP. In the framework of the road-show the companies visited were: Lusospace, EFACEC, Spinworks, Deimos Engenharia, Logica, Inov-Inesc Inovação, Critical Software, Omnidea, ActiveSpaceTechnologies, GMV Solutions, Gustavo Cudell, Sirmaf, ISA.
- Due to a shift of priorities (human resources and financial availability) regarding the organization of the event at CERN called: Portugal@CERN, it was decided that for 2010, the focus went in organizing the following paramount event: the ILO supported the FCT Space Office team in organizing the 4th Space Forum celebrating the 10 years of Portugal Participation as a member of ESA (see link: http://spaceforum.fct.mctes.pt/en/), involving several Portuguese companies and institutes exposing their high-technology products & services, including LIP, and the privileged participation as key speaker guests, ESA Director General and the Minister of Science, Technology and Higher Education.
- Some highlights in 2010 showing that the ILO is an important figure in supporting the internationalization of national companies towards international scientific organizations, is shown in targeted events, such as: in January, a 1st public presentation of the ILO role and responsibilities at Jornadas do LIP 2010, Braga to LIP national community. Still in January, the participation as key note speaker at the industrial event Towards a Portuguese participation in the European Spallation Source (ESS) project where several companies were attending, two well known CERN suppliers, ISQ and EFACEC. In July, speaker at event Ciência 2010 about the topic, Technology Transfer and commercialization. In September the participation as restricted guest at the JENAM 2010 Special Session on: Astronomy Challenges for Engineers & Computer Scientists for ESO. In October, the participation as speaker at the 2nd Annual Conference of the University Technology Enterprise Network (UTEN) in synergy with CERN Technology Transfer group.

7.2.5 Sources of Funding

Code	Funding	Start	End

7.2.6 Team

Project coordinator: Emir Sirage

Name	Status	%of time in project
Emir Sirage	Technician (LIP)	100

7.2.7 Project Summary

(no values to report)

Chapter 8

Scientific Conferences and Seminars

8.1 Resumo

Além dos eventos realizados no âmbito de cada um dos projectos, o LIP mantém um programa de seminários gerais sobre as suas áreas de investigação nas instalações do LIP Lisboa, e co-organiza os seminários *café com física* destinados aos estudantes e investigadores do Departamento de Física da Universidade de Coimbra. Neste ano, realizaram-se também as jornadas bi-anuais do LIP, um encontro de três dias, na Universidade do Minho, em Braga.
O grupo de CMS tem promovido nos últimos anos a série de eventos sobre o LHC, *Physics on the road to discovery*, em colaboração com o CFTP/IST, que este ano teve um evento mais lato, o *Simpósio LHC - After one year of Operations*, realizado em Novembro no IST.
O LIP co-organiza também escolas de formação avançada nas suas áreas de investigação. Este ano realizaram-se pela primeira vez a Escola Portuguesa de Física Médica, na Universidade da Beira Interior (Covilhã), e a Primeira Escola IDPASC, integrada na rede internacional de doutoramento em Física de Partículas, Astrofísica e Cosmologia recentemente criada, e que se juntou à PASC winter workshop já realizada nos anos anteriores, em Sesimbra.
O LIP participou ainda na co-organização de outros grandes eventos em áreas relacionadas, como a Conferência Real Time 2010, com o Instituto de Plasmas e Fusão Nuclear do IST, e o Encontro sobre os Estágios Tecnológicos no CERN, ESA e ESO, em conjunto com a Agência de Inovação.

8.2 Abstract

In addition to the events organized within each project, LIP mantains a general program of seminars in its research areas in Lisbon and help on the organization of Coimbra´s Physics Department seminars, directed to the students and researchers. This year, the bi-anual *Jornadas do LIP* took place in the Universidade do Minho, in Braga, in a three day workshop.
In the last years, the CMS group has also promoted in colaboration with SFTP/IST a series of seminars about the LHC, *Physics on the road to discovery*, which this year has a special edition in November in IST, *LHC sysmposium - after one year of operations*.
LIP also co-organizes shools for advanced training in its areas of activity. This year there were the first Portuguese School on Medical Physics in the Univesrsity of Beira Interior (Covilhã) and the first IDPASC school, integrated in the International Doctorate in Particle, Astrophysics and Cosmology, recently created and joined to the PASC winter workshop which had already took place in the previous years, in Sesimbra.
LIP participated also in the co-organization of other major events in realated areas, like the Real Time Conference, with the IPFN (Plasma and Nuclear Fusion Institute) of IST and the Meeting on Technological Training at CERN, ESA and ESO, with the AdI - Inovation Agency.

8.3 Seminars

Seminars

- *NNLO real corrections to gluon scattering*
  presented by João Pires on 2010-01-05
  Café com Física — Coimbra.

- *JEM-EUSO: status and perspective at the completion of Phase A*
  presented by Osvaldo Catalano (IASF-Palermo) on 2010-01-28
  — LIP-Lisboa.

- *Hydrogen Storage*
  presented by Valdemar Domingos on 2010-02-02
  Café com Física — Coimbra.

- *Radiation Environment and Monitors in the Heliosphere*
  presented by Eamonn Daly (ESA) on 2010-02-04
  — LIP-Lisboa.

- *Novos materiais para a geração de energia fotovoltaica no seculo XXI*
  presented by Silvana Botti on 2010-02-17
  Café com Física — Coimbra.

- *Controlo de Qualidade e Protecção Radiológica*
  presented by Patrick Sousa on 2010-02-18
  — LIP-Lisboa.

- *The future CTA observatory*
  presented by Thomas Schweizer (Max Planck Institute for Physics) on 2010-02-25
  — LIP-Lisboa.

- *Comparison of the disorder induced by annealing and by ball milling in Fe_50 Co_50 alloys*
  presented by João Loureiro on 2010-03-09
  Café com Física — Coimbra.

- *Pattern dynamics in Eutectic solidification*
  presented by Andrea Parisi on 2010-03-16
  Café com Física — Coimbra.

- *Searches of particles constituting the galactic dark matter*
  presented by Tapio Niinikoski (CERN) on 2010-03-26
  — LIP-Lisboa.

- *Double Chooz: On the quest for Theta13*
  presented by Anatael Cabrera (IN2P3) on 2010-04-01
  — LIP-Lisboa.

- *Frame-dependence and frame-invariance in polarization measurements (the quarkonium example*
  presented by Pietro Faccioli on 2010-04-08
  LIP seminar — Lisbon, Portugal.

- *Frame-dependence and frame-invariance in polarization measurements (the quarkonium example)*
  presented by Pietro Faccioli (LIP) on 2010-04-08
  — LIP-Lisboa.

- *Numerical algorithms for Hybrid GPU-Multicore Systems*
  presented by Marc Baboulin on 2010-04-13
  Café com Física — Coimbra.

- *Nuclear physics for compact stars: cluster formation and elementary excitations*
  presented by Camille Ducoin on 2010-04-20
  Café com Física — Coimbra.

- *Progress in time-of-flight PET scintillation detectors based on silicon photomultipliers*
  presented by Dennis Schaart on 2010-04-27
  Café com Física — Coimbra.

- *A procura dos objectos mais distantes no Universo: GRBs e quasares com o GROND*
  presented by Paulo M. J. Afonso on 2010-04-29
  Café com Física — Coimbra.

- *Spectroscopy of light exotic nuclei*
  presented by Sonja Orrigo on 2010-05-04
  Café com Física — Coimbra.

- *Mixtures of Ultracold Fermi Atoms*
  presented by Tommaso Macrí on 2010-05-11
  Café com Física — Coimbra.

- *Atmospheric Research and Monitoring at the University of Leicester, UK*
  presented by Robert S. Blake on 2010-05-18
  Café com Física — Coimbra.

- *Gamma-ray astronomy with Cherenkov telescopes: Status of the MAGIC project and future outlook*
  presented by Thomas Schweizer on 2010-05-25
  Café com Física — Coimbra.

- *Highlights of Astronomy of the Past Decade - a Personal View*
  presented by Anthony F.J. Moffa on 2010-05-27
  Café com Física — Coimbra.

- *Symmetry energy, neutron star crust and neutron skin thickness*
  presented by Isaac Vidaña on 2010-06-01
  Café com Física — Coimbra.

- *LHC a 7 TeV: os primeiros resultados de ATLAS*
  presented by Filipe Veloso on 2010-06-15
  Café com Física — Coimbra.

- *Colaboração XENON - Dark Matter Search*
  presented by Elena Aprile on 2010-06-17
  Café com Física — Coimbra.

- *Role of dissipation in Bose-Einstein condensates: the way of generation of coherent structures*
  presented by Valeriy Brazhnyy on 2010-06-22
  Café com Física — Coimbra.

- *Interface dynamics in microfluidics: Avalanche fronts, viscoelasticity flows and drops*
  presented by Aurora Hernandez-Machado on 2010-06-29
  Café com Física — Coimbra.

- *Hamiltonianos à Sombra da Bananeira*
  presented by Paulo Silva on 2010-07-06
  Café com Física — Coimbra.

- *Ocupação Científica do LIP no Verão*
  presented by Summer Students on 2010-07-29
  — LIP-Lisboa.

- *Technology Transfer*
  presented by Jean Marie Le Goff (CERN) , Hartmut Hillemans (CERN) on 2010-09-16
  — LIP-Lisboa.

- *TOP- Dilepton cross section*
  presented by on 2010-10-15
  LIP Seminar — LIP, Lisboa.

- *First Measurement of Top-Quark Pair Production in the CMS experiment*
  presented by Pedro Silva (LIP) on 2010-10-15
  — LIP-Lisboa.

- *Advances and complications in indirect Dark Matter detection*
  presented by David Maurin (LPNHE) on 2010-10-28
  — LIP-Lisboa.

- *Electronic Properties of Doped Silicon Nanocrystals*
  presented by Estelina Lora on 2010-11-02
  Café com Física — Coimbra.

- *Effects of quark matter nucleation on the evolution of protoneutron stars*
  presented by Domenico Logoteta on 2010-11-09
  Café com Física — Coimbra.

- *Physics in the LHC Era: First ATLAS Physics Results*
  presented by Patricia Conde Muíño (LIP) on 2010-11-11
  — LIP-Lisboa.

- *Desvio de Lamb no hidrogénio muónico e o raio do protão*
  presented by Luis Manuel Panchorrinha Fernandes on 2010-11-23
  Café com Física — Coimbra.

- *Molecules with High intrinsic hyperpolarizability*
  presented by Cláudia Cardoso on 2010-11-30
  Café com Física — Coimbra.

- *CERN RD51 collaboration: activities and Portuguese contributions*
  presented by João Veloso (UAveiro) on 2010-12-02
  — LIP-Lisboa.

- *Medida da secção-eficaz de produção top-antitop em ATLAS*
  presented by Filipe Veloso on 2010-12-07
  Café com Física — Coimbra.

- *Radiation in Space*
  presented by Patrícia Gonçalves (LIP) on 2010-12-09
  — LIP-Lisboa.

- *Measurement of the isolated photon production cross section with the CMS experiment*
  presented by Pasquale Musella (LIP) on 2010-12-16
  — LIP-Lisboa.

- *Measurement of the isolated photon production cross section with the CMS experiment*
  presented by Pasquale Musella on 2010-12-20
  LIP seminar — Lisbon, Portugal.

8.4 Conferences

- *Welcome to the Real-Time 2010 Conference*
  Conference, Lisbon, 2010-05-24

- *First IDPASC Joint School*
  Workshop, Sesimbra, 2010-12-13

- *PASC Winter Workshop 2010*
  Workshop, Sesimbra, 2010-12-18