Laboratório de Instrumentação e Física Experimental de Partículas

Relatório de Actividades

2009

Contents

Chapter 1

Overview

1.0.1 Resumo

O LIP é uma associação científica e técnica de utilidade pública que tem por objectivos 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 Detectores, a Computação Avançada e aplicações a outros campos, em particular a Física Médica. O LIP desenvolve ainda um grande número de actividades 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 actividades de investigação e desenvolvimento são enquadradas com actividades de investigação em Física experimental, em ligação à comunidade científica téorica. A maior parte dos projectos 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 projectos científicos comuns, o LIP contribui com os seus próprios recursos técnicos e científicos. Nos seus dois pólos, 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 actualmente utilizadas por uma comunidade internacional de mais de 150 instituições de investigação. Durante 2009 foram executadas no LIP mais de 1 milhão de tarefas computacionais 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 projectos ambiciosos na área da Física Médica, o LIP trabalha conjuntamente com centros de investigação, hospitais e com o sector privado, através da partilha de instalações de pesquisa - o Laboratório do Tagus LIP para Física Médica.
Assim, o LIP mantém as suas actividades 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 nacional e internacional.

1.0.2 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.
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 2009, LIP hosted more than 1 million computing jobs coming from all around the world. 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 centres, 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 and in close connection to related communities, at both the national and international levels.

1.0.3 Objectives

Experimental Particle Physics
2009 is marked by the beginning of the LHC operation. During the previous 14 years LIP has been deeply involved in the construction of the CMS and the ATLAS detectors for the LHC. Both Detectors have a visible contribution from LIP well recognized by both collaborations. LIP has also coordinated the Portuguese Engineers training program in international scientific organizations. More then 140 engineers during the last 10 years contributed to the LHC machine and LHC detectors under this program, which counts as 208 man year. Our commitments towards other accelerator experiments, COMPASS at CERN and the HADES at GSI, with a large financial support from EU, have been pursued.
Experimental Astroparticle Physics
During 2009, the strong involvement of LIP in Experimental Astroparticle Physics was consolidated. Our involvement extends from underground to space-based experiments, covering topics from Dark Matter to Neutrinos and High Energy Cosmic Rays: we are full members of well established international collaborations, and work also in several different smaller projects.
Instrumentation and Detectors R&D
The R&D activities related to Detectors, mainly in Coimbra, were continued. Attention has been given to establish a strong connection between Detectors R&D and Physics experiments but also to exploit new fields of application for our developments, namely in the areas of Medical Physics and Medical Imaging.
Medical Physics
The PET mammography R&D was pursued with tests in clinical environment starting in Porto. While this opens a new era in the field, other applications are also being considered.
Computing
LIP has finished the deployment of the largest Computer Centre ever built in Portugal. The Central node at LNEC is now operational. LIP has now the capacity of providing more then 30 million of equivalent computing hours. The computing support for LHC is well over our commitments towards the Worldwide LHC Grid (around 3% of the total) and will establish a world base to be exploited during the next 4 years.
Outreach, dissemination and training
A large number of activities including Master Classes and a CERN School for physics teachers have been realized in collaboration with Agência Ciência Viva. In 2009 and for the first time physics teachers from Mozambique (5) and Brazil (15) participated in the CERN School. LIP was also involved in establishing a new program - Ibercivis - that will mobilize voluntary computing to run scientific programs.
Industrial Liaison Office and Technology Transfer
LIP began the installation of an Industrial Liaison Office for the International scientific organizations where Portugal is a member, and mainly CERN. LIP has also joined the European Network for Technology Transfer which is a consortium of the major high energy physics European laboratories.
Education
LIP has been involved in the organization of the Particles, Astroparticles and Cosmology School (PASC) now established as a joint venture of LIP and theoretical groups at IST.
Education in a close collaboration with the Universities under the framework of the Bolonha Process are becoming now one of the main concerns of the laboratory that will have strong implications in the laboratory programs for the years to come.

1.0.4 Achievements

We will summarize only a few topics on LIP activities in 2009:
Experimental Particle Physics
In spite of the incident that took place at the LHC, the machine produced beam collisions by the end of the year. CMS and ATLAS communities at Lisbon and Coimbra were highly motivated, as the hardware and software developed at LIP could be successfully tested in real collision operations for the first time.
Our commitments towards the other accelerator activities where we are involved both at CERN (COMPASS) and the GSI (HADES) were not affected. Both technical responsibilities and physics analysis are on-going in these experiments and are fully described in the projects reports.
Experimental Astroparticle Physics
The LIP Pierre Auger Observatory team is active in data taking and in the preparation of the Southern Observatory extensions, in the physics program of the collaboration and following closely the developments towards the installation of the Northern Observatory.
Our involvement in Dark Matter searches (ZEPLIN-III) has been consolidated in Coimbra, where competence in Xenon detectors is now supporting an ambitious physics program. Our interest in Experimental Neutrino Physics is targeted at continue establishing, in the future, a sustainable scientific activity, and a MoU has been signed with SNOLAB.
Also space-based activities are being actively pursued, being in the preparation of the AMS experiment or in the follow-up of ESA contracts.
Instrumentation and Detectors R&D
R&D on Radiation Detectors continued to be central in the LIP-Coimbra activity. In addition to important progresses made on the different projects considered under this research line during this year, the delivery to GSI of most of the RPC TOF wall, at present in the commissioning phase, was the highlight of 2009.
Along with detector R&D, attention continued to be paid to basic physics issues underlying their operation.
Medical Physics
Our involvement in Medical Physics is now well established, the beginning of clinical environment trials of the PEM-mammography sets up a new phase for developments in this area.
For the RPC-PET, the year 2009 was a standby year in terms of hardware development, as there was no funding available. However, the year was very fruitful in terms of simulation and consolidation of the RPC-PET concept.
Computing
The Computing facilities installed in 2008 and 2009 are operational. The number of CPU units, the storage capacity and the gigabit connectivity already installed puts LIP in the frontline of computing support for the LHC era. Together with this effort LIP was responsible for the installation and is responsible for the operation of the largest computing facility ever installed in Portugal: the Grid Central Node at the National Laboratory of Civil Engineering. This implementation has been done in collaboration with FCCN (National Foundation for Scientific Computing). LIP has been appointed to coordinate the global EGI tasks on middleware rollout processes and the virtual organizations. This is a major recognition for the work developed along nine years of grid research and development activity.
Outreach, Dissemination, Training, Industrial Liaison and Technology Transfer
Initiatives like the CERN School for Physics Teachers, Masterclasses and the Radiation and Environment project at high schools are now implemented as regular activities in our laboratory. During 2009 a School for high school teachers of São Tomé e Príncipe, "What do we know about the Universe?"was organized.
In 2009, LIP was certified as an official formation entity, for all legal purposes.
Again during 2009, LIP become responsible for the Industry Liaison Office for CERN, ESO and other international laboratories under a special agreement signed with FCT.

1.1 Sources of Funding for LIP Lisboa

Project	Code	Funding	Entity	Start	End
ATLAS	CERN/FP/83551/2008	285.000 €	FCT	2008-10-01	2009-12-31
	CERN/FP/109309/2009	290.000 €	FCT	2009-11-02	2010-10-31
CMS	CERN/FP/83516/2008	290.000 €	FCT	2008-10-01	2009-12-31
	CERN/FP/109343/2009	300.000 €	FCT	2009-11-01	2010-10-31
COMPASS	CERN/FP/83542/2008	140.000 €	FCT	2008-10-01	2009-12-31
	CERN/FP/109323/2009	150.000 €	FCT	2009-11-01	2010-10-31
GRID	GRID/GRI/81842/2006	180.700 €	FCT	2007-09-10	2010-09-09
	EGEE-III	307.000 €	EU	2008-05-01	2010-04-30
	GRID 233/7.2/C/NAC	1.165.376 €	FCT	2007-06-01	2009-06-30
HECR	CERN/FP/83484/2008	125.000 €	FCT	2008-10-01	2009-12-31
	CERN/FP/109286/2009	145.000 €	FCT	2009-11-01	2010-10-31
	PTDC/FIS/65308/2006	155.000 €	FCT	2007-04-22	2009-10-31
OUTREACH	PTP 2009 CERN	42.500 €	Ciência Viva	2009-08-29	2009-09-04
	OCJF 2009	1.949 €	Ciência Viva	2009-06-01	2009-10-31
	Masterclasses and En v.Rad.	15.000 €	Ciência Viva	2009-10-01	2010-07-31
	Masterclasses 2009	6.000 €	Ciência Viva	2009-03-01	2009-05-31
PET - Mammography	Pet - Mammography II -b	504.344 €	AdI	2008-07-01	2009-12-31
	PIC/IC/83228/2007	67.550 €	FCT	2009-03-26	2011-03-25
SNO	CERN/FP/83548/2008	10.000 €	FCT	2008-11-01	2009-11-30
Space	PDCTE/CTE-SPA/81678/ 2003	69.552 €	FCT	2008-01-01	2010-12-31
	ESA:223981/09/NL/PA	150.000 €	ESA	2009-05-01	2011-04-30
	ESA:18121/04/NL/CH/2	100.000 €	ESA	2006-11-01	2009-02-28

1.2 Sources of Funding for LIP Coimbra

Project	Code	Funding	Entity	Start	End
Air Scintillation	CERN/FP/83527/2008	15.000 €	FCT	2008-10-01	2009-12-31
ATLAS	CERN/FP/83515/2008	30.000 €	FCT	2008-11-01	2009-10-31
ATLAS GRID	GRID/GRI/81727/2006	140.000 €	FCT	2007-04-12	2010-10-11
Compton in PET	PTDC/FIS/67002/2006	72.000 €	FCT	2009-01-01	2010-12-31
GEMs	FP7-GA226507	80.640 €	EU	2009-02-01	2012-01-31
HADES	CERN/FP/83560/2008	15.000 €	FCT	2008-10-01	2009-09-30
	CERN/FP/109373/2009	10.000 €	FCT	2009-10-01	2010-09-30
	EU Contract 515876 D IRAC-Phase-1	52.000 €	EU	2005-10-01	2011-03-31
	LIP-GSI contract	414.000 €	GSI	2005-10-01	2011-03-31
Human PET	PTDC/FIS/67002/2006	72.000 €	FCT	2009-01-01	2010-12-31
Participation in the RD51 Collaboration	CERN/FP/83524/2008	20.000 €	FCT	2008-10-01	2010-03-31
Phenomenological Studies at the LHC	CERN/FP/83588/2008	35.000 €	FCT	2008-10-01	2009-09-30
	CERN/FP/109372/2009	35.000 €	FCT	2009-11-01	2010-10-31
ZEPLIN	CERN/FP/83501/2008	75.000 €	FCT	2008-10-01	2009-12-31

1.3 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	5	3	20	6	2			4		3		2
CMS	22	6	6	18		1	2	14		1	2	8
COMPASS	4	4	7	8								
HADES	8	3										
Phenomenological Studies at the LHC	9	9										
GRID			12	11		2	2	1				1
ATLAS GRID			1	3								
AMS	1	1	5									
SNO	2			4			1					
ZEPLIN	5	5	1	3	1						1	
HECR	5	1	8	15	3						1	1
Air Scintillation	1	1		2								
Space			2	5	1	2						1
PET - Mammography	3	3	5	1	1					3	1	
Human PET	1	1			1	1						
Compton in PET												
MC in Medical Physics										1		
Participation in the RD51 Collaboration	5	5		1								
GEMs	2	2										
OUTREACH	1	1	1					30				13
TTN-ILO												
Scientific Conferences and Seminars												2
Totals:	74	45	68	75	9	6	5	48		8	5	28

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.)

1.4 Human resources (people)

Project	Researchers	Technicians	Post-Docs	Students			
				D	M	G	O
ATLAS	17	6	3	6	8		3
CMS	5	2	5	5	4		2
COMPASS	4	2	1	2	3		
HADES	6	9					
Phenomenological Studies at the LHC	10	1	2		4		
GRID	7	3					
ATLAS GRID	8		3	2	1		
AMS	3		1	1			
SNO	4	5		1	1		1
ZEPLIN	5	2	3	2	1		
HECR	14	2	4	2	1		12
Air Scintillation	8	3	1	1			
Space	5		4	1	1		
PET - Mammography	1	3	3	2	5		
Human PET	9	6	2	1			
Compton in PET	6	6	2	1			
MC in Medical Physics	3			2	1	3	2
Participation in the RD51 Collaboration	6	9					
GEMs	5			1			
OUTREACH	10	1	1	1			
TTN-ILO		1					
Scientific Conferences and Seminars							
Totals:	79	24	20	24	25	3	20

Legend:

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

FTE: Full Time Equivalent

1.5 Human resources (FTE)

Project	Researchers	Technicians	Post-Docs	Students				total
				D	M	G	O	
ATLAS	6.47	1.42	1.95	4.91	3.00		2.58	24.26
CMS	4.05	1.09	5.00	2.53	3.35		1.08	17.85
COMPASS	3.47	2.00	0.17	2.00	2.43			10.07
HADES	1.21	0.77						1.98
Phenomenological Studies at the LHC	1.50	0.02	1.60		3.00			6.20
GRID	6.70	3.00						9.70
ATLAS GRID	1.92		0.30	0.75	0.50			3.47
AMS	0.75		0.20	1.00				2.08
SNO	0.56	0.19		1.00	0.35		0.25	2.35
ZEPLIN	2.40	0.50	2.12	2.00	0.29			7.31
HECR	5.72	1.05	1.77	2.00	0.82		7.36	18.72
Air Scintillation	1.30	0.40	0.05	0.25				2.00
Space	0.90		1.35	1.00	1.00			4.25
PET - Mammography	0.40	1.94	2.94	1.78	2.42			10.48
Human PET	1.60	0.45	0.25	0.20				2.50
Compton in PET	1.45	0.45	0.25	0.20				2.35
MC in Medical Physics	2.20			1.40	0.10	1.30	0.66	5.66
Participation in the RD51 Collaboration	1.90	0.70						2.60
GEMs	1.28			0.92				2.20
OUTREACH	1.66	0.20	0.10	0.10				4.01
TTN-ILO		0.33						0.33
Scientific Conferences and Seminars								
Totals:	47.44	14.51	18.05	22.04	17.26	1.30	11.93	

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 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 as actividades de manutenção e funcionamento do detector e para os estudos de Física. Estamos activos na certificação, operação e estudos de desempenho do calorímetro hadrónico TileCal e do sistema de trígger de alto nível, bem como na construção e certificação do monitor de luminosidade absoluta ALFA. Em termos de estudos de Física, o nosso foco é nos estudos com quarks top e bosões W, bem como na pesquisa do bosão de Higgs.

As principais actividades passaram a ser estudos de Física, nomeadamente estudos para o commissioning de ATLAS com os acontecimentos das primeiras colisões do LHC. Estas actividades incluem a calibração de Jactos de Partículas, e a preparação do commissioning de ATLAS com bosões W e quarks Top.

Continuaram as actividades de software offline do TileCal, em que passámos a ter a co-responsabilidade da coordenação, e que incluiram o desenvolvimento e manutenção do software de reconstrução de muões cósmicos. Foram prosseguidos também os estudos de performance do calorímetro em resposta de tempo e energia, usando muões cósmicos e dados de single beam do LHC. O grupo tem também a co-responsabilidade pela edição de um artigo de sumário dos resultados do commissioning do TileCal com os sistemas de calibração, muões cósmicos e single beam.

Continuamos com o envolvimento no Sistema de Controlo do TileCal (DCS). Fez-se a actualização do software aproveitando a paragem do LHC, e o sistema está completamente operacional. Fomos responsáveis pela co-coordenação das actividades do DCS do TileCal.

Foram finalizadas as actividades relacionadas com o projecto, aquisição, teste de componentes ópticas e sua construção, mantendo algumas actividades no domínio da óptica, tal como o melhoramento da funcionalidade do sistema de monitorização com laser. Foi ainda mantida uma pequena 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 bem como as tarefas de calibração e alinhamento do Detector Interno de ATLAS. Estas tarefas passaram a estar incluídas neste projecto por recomendação da Comissão do FUNDO CERN de 2008.

Quanto às actividades em calorimetria hadrónica no ATLAS, e orientadas pela física do LHC, aumentaram as nossas responsabilidades no desempenho dos jactos. Desde Setembro 2009, somos o único instituto a trabalhar na calibração do segundo nível de trigger (LVL2). A calibração de jactos a nível de LVL2, aplicando de forma simplificada os procedimentos de calibração offline aos algoritmos da reconstrução de jactos no LVL2 e a avaliação do seu desempenho são parte do nosso trabalho que incluiu também a coordenação. Uma investigadora do LIP juntou-se a esta actividade e sendo especialista em física do Plasma de Quarks e Gluões está ao mesmo tempo a promover estudos de jactos com Iões Pesados no detector ATLAS. Organizámos o 5º workshop de calibração hadrónica de ATLAS que decorreu em Portugal com a participação de cerca de uma centena de membros da

colaboração.
Vários canais de física serão fundamentais para o commissioning, tais como a reconstrução dos bosões W e Z e a produção e decaimento do quark Top. A secção eficaz de produção inclusiva de W no canal W a decair em mu+nu será um dos primeiros estudos de física a realizar no LHC, e será útil para o conhecimento do desempenho do detector e do trigger. Nesta fase, o decaimento do quark Top também será importante, pois pode ser usado como teste para identificação do quark b e calibração da escala de energia.
O projecto inclui também uma componente de divulgação, que foi intensa ao longo de 2009, com vários dos membros deste projecto a participarem nas MasterClasses organizadas pela EPPOG, na escola para professores de língua portuguesa no CERN e numa escola de Física de Partículas em S.Tomé e Príncipe, 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 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 electro-weak symmetry breaking and the origin of mass, through the search for the missing cornerstone of the Standard Model, the Higgs boson. The generic detector structure will also allow the sensitivity to new physics signals, such as the 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. 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. In terms of Physics studies, we focus on early studies with the top quark and the W boson, as well as searches for the Higgs boson.
The ATLAS detector construction, commissioning and Physics studies proceeded. They were centred in the Physics commissioning of the ATLAS detector, with the preparation of the measurement of the W boson cross section, and top quark properties. The calibration of jets in trigger Level 2 was also studied and implemented. The commissioning of Tilecal and the complete ATLAS detector with cosmic muons proceeded. The Tilecal DCS was upgraded and commissioned, being operational. The involvement in the construction of the ALFA luminosity detector and in optics ageing studies continued. The LHC started operation in 2008 and for a few days single beam data was taken. One year later and after a huge repair program, it restarted in November 2009 and the first collisions were taken at center of mass energies of 900GeV and 2.36 TeV.

2.1.3 Objectives

The main goals were the following:
Commissioning, operation and maintenance of the Tilecal laser monitoring system.
Optimization and maintenance of the Tilecal reconstruction software and development of test procedures for trigger level 2 objects and topological clusters with origin in Tilecal cells.
Operation and maintenance of Tilecal DCS
Improvement of the lifetime estimate of the optical components of Tilecal, using natural ageing and eventually irradiation of the optical components
Participate in the construction and tests of the ALFA luminosity detector
Continuation of the detector commissioning using physics events, namely the production cross section of the W boson using the decay channel W-> mu nu
Development of physics simulations with the ATLAS detector, contributing to the jet calibration at level 2 trigger system.
Study the sensitivity of ATLAS for the detection of heavy neutrinos
Study the top quark physics, with emphasis in the detector commissioning and in the anomalous couplings of this quark.

2.1.4 Achievements

The laser system is fully commissioned and working according to the specifications, and is being used in a regular way for calibration and monitoring tasks of Tilecal.
The Tilecal Detector Control System is commissioned and operational.
The cosmics timing analysis reached a mature level, and a set of timing constants was obtained from it, for more than 60% of the TileCal channels. In general, these agree well, within 2 ns, with the constants obtained both from the laser calibration and, for a subset of channels, with the ones from single beam data.

Calculation of the response uniformity from a module-level analysis of the muon dE/dx. This allowed the setting of an upper limit to the non-unifomity over the whole phi range of a few percent for the both the barrel and the extended barrel.
A methodology for the correction of the Tilecal cells correlated noise was proposed.
Inter-calibration in eta using di-jet events: it was found out that the maximum accuracy of the method is 3% for jets up to 200 GeV and better than 1% for higher pT values. A 3% statistical uncertainty can be reached with about 30 pb-1 of integrated luminosity.

2.1.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83551/2008	285.000 €	2008-10-01	2009-12-31
CERN/FP/83515/2008	30.000 €	2008-11-01	2009-10-31
CERN/FP/109309/2009	290.000 €	2009-11-02	2010-10-31

2.1.6 Team

Project coordinator: Amélia Maio

Name	Status	%of time in project
Ademar Delgado	Master student (LIP)	24
Agostinho Gomes	Researcher (LIP)	99
Alberto Palma	PhD student (LIP/FCT) *	100
Amélia Maio	Researcher (LIP/FCUL)	55
Américo Pereira	Technician (LIP)	5
António Amorim	Researcher (FCUL)	23
António Morais	Master student (LIP)	75
António Onofre	Researcher (LIP)	40
Belmiro Pinto	Researcher	83
Bruno Fernandes	Master student (LIP)	25
Bruno Jesus	Student	92
Emiliano Pinto	Master student (LIP)	13
Filipe Veloso	Post-Doc (LIP)	90
Guiomar Evans	Researcher (FCUL)	8
Helena Santos	Researcher (LIP)	28
Helmut Wolters	Researcher (LIP/FCTUC)	46
Inês Ochoa	Master student (LIP)	13
Jaime Villate	Researcher (FEUP)	25
Joana Miguéns	Master (LIP) *	100
João Carvalho	Researcher (LIP/FCTUC)	40
João Faustino	Technician (LIP)	25
João Gentil	PhD student (LIP/FCT)	100
João Pina	PhD student (LIP/FCT)	100
João Simões	Researcher	4
Joaquim Oliveira	Technician (LIP)	5
Jorge Moita	Technician	10
José Maneira	Researcher (LIP)	70
José Silva	PhD student (LIP)	50
José Soares Augusto	Researcher (IST/INESC/FCUL)	8
Juan Aguilar-Saavedra	Researcher (LIP)	5
Lourenço Lopes	Master (LIP/FCUL) *	100
Luís Gurriana	Technician (LIP)	87
Luís Seabra	Master student (LIP) *	96
Manuel Maneira	Researcher (LIP/FCTUNL)	19
Mara Soares	On leave (LIP) *	100
Miguel Fiolhais	Master student (LIP)	41
Nuno Anjos	Post-Doc (LIP/FCT)	100
Nuno Castro	Post-Doc (LIP/UGR)	5
Nuno Ribeiro	Master (LIP) *	93
Patricia Conde	Researcher (LIP)	75
Paulo Martins	PhD student (LIP/FCT) *	66
Paulo Pereira	Student (FCUL)	83
Pedro Jorge	PhD student (LIP/FCT)	75
Ricardo Neves	Student (FCUL)	83
Rui Alves	Technician (LIP)	10
Susana Santos	Master student (LIP)	13
Yuri Nunes	Researcher (LIP)	19

2.1.7 Publications

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

- *Testbeam studies of production modules of the ATLAS Tile Calorimeter*
  P. Adragna et al
  NIM A 606 (2009) 362-394

- *Study of the response of the ATLAS central calorimeter to pions of energies from 3 to 9 GeV*
  E. Abat et al
  NIM A 607 (2009) 372-386

- *Commissioning of the CMS Experiment and the Cosmic Run at Four Tesla*
  CMS Collaboration
  JINST_008T_1109

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

- *Performance of the CMS Hadron Calorimeter with Cosmic Rays and Accelerator Produced Muons*
  CMS Collaboration
  JINST_018T_1109

- *Readiness of the ATLAS Liquid Argon Calorimeter for LHC Collisions*
  Atlas collaboration
  arXiv:0912.2642v3

International Conference Proceedings

- *Hadronic Calibration for the ATLAS Jet Trigger*
  N. Anjos et al
  Proceedings of Physics at LHC 2008, ATL-DAQ-PROC-2009-001

- *Implementation and Performance of the ATLAS Jet Trigger*
  P. Conde Muino et al
  Proceedings of 2009 Europhysics Conference on High Energy Physics, ATL-DAQ-PROC-2009-029

National Conference Proceedings

- *Um Controlador Digital de uma Experiência de Medição do Tempo de Vida de Muões Cósmicos*
  J. Silva et al
  Actas das V Jornadas sobre Sistemas Reconfiguráveis - REC´2009

Collaboration notes with internal referee

- *Testbeam Studies of Production Modules of the ATLAS Tile Calorimeter*
  P. Adragna et al
  ATL-TILECAL-PUB-2009-002 ; ATL-COM-TILECAL-2009-004

- *Configuration and Control of the ATLAS Trigger and Data Acquisition*
  G. Lehmann-Miotto et al
  ATL-COM-DAQ-2009-065

- *Overview and Performance Studies of Jet Identification in the Trigger System*
  Atlas collaboration
  ATL-PHYS-PUB-2009-032

- *Triggering on Long-Lived Neutral Particles in the ATLAS Detector*
  The ATLAS Collaboration
  ATL-PHYS-PUB-2009-082 ; ATL-COM-PHYS-2009-233

- *Electroweak boson cross section measurements*
  Atlas collaboration
  ATL-COM-PHYS-2009-101

- *Inner Detector Alignment within the ATLAS Full Dress Rehearsal*
  J. Alison et al, B. Pinto
  ATL-COM-INDET-2009-033

- *ATLAS tile calorimeter LASER calibration system*
  Alves, R ; Calvet, D ; Carvalho, J ; et al.
  ATL-COM-TILECAL-2009-012

- *Heavy Ion Physics with the ATLAS Detector at the LHC*
  A. Angerami et al
  ATL-COM-PHYS-2009-439

- *Implementation and Performance of the ATLAS Jet Trigger*
  P. Conde Muino et al
  ATL-DAQ-PUB-2009-010 ; ATL-COM-DAQ-2009-091

- *Implementation and Performance of the ATLAS Jet Trigger*
  P. Conde Muino et al
  ATL-DAQ-PROC-2009-029 ; ATL-COM-DAQ-2009-112

- *Measurement of Pion and Proton Response and Longitudinal Shower Profiles up to 20 Nuclear Interaction Lengths with the ATLAS Tile Calorimeter*
  P. Adragna et al
  ATL-TILECAL-PUB-2009-009 ; ATL-COM-TILECAL-2009-011

- *Commissioning of the ATLAS Tile Calorimeter*
  J. Maneira et al
  ATL-TILECAL-SLIDE-2009-350 ; ATL-COM-TILECAL-2009-025

- *Detector Control System of Tile Calorimeter Low Voltage Power Supplies System*
  G. Arabidze, A. Gomes, J. Pina, et al
  ATL-COM-TILECAL-2009-032

- *Minimizing the TileCal correlated noise effect: a simple approach*
  M. Fiolhais, A. Onofre
  ATL-COM-TILECAL-2009-019

- *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

- *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

Books

- *Expected Performance of the ATLAS Experiment : Detector, Trigger and Physics*
  The ATLAS Collaboration
  arXiv:0901.0512 ; CERN-OPEN-2008-020

2.1.8 Presentations

Oral presentations in international conferences

- *Top physics at LIP/ATLAS*
  presented by António Onofre
  at Workshop on Top quark physics at the LHC in Lisbon.
- *Anomalous couplings at the Wtb vertex*
  presented by Nuno Castro
  at Workshop on Top quark physics at the LHC in Lisbon.
- *Rare Top decays and FCNC at ATLAS*
  presented by Filipe Veloso
  at Workshop on Top quark physics at the LHC in Lisbon.
- *Implementation and Performance of the ATLAS Jet Trigger*
  presented by Patricia Conde
  at 2009 Europhysics Conference on High Energy Physics in Krakow, Poland.
- *Monitoring systems for the TileCal detector in ATLAS/LHC*
  presented by João Carvalho
  at PASC Winter School in Sesimbra.

Poster presentations in international conferences

- *Implementation and Performance of the ATLAS Jet Trigger*
  presented by Nuno Anjos
  at HCP09 in Evian, France.
- *Commissioning of the ATLAS Tile calorimeter*
  presented by José Maneira
  at Hadron Collider Physics Symposium in Évian, France.

Oral presentations in international meetings

- *Performance of the ATLAS detector on cosmic-ray data,*
  presented by João Carvalho
  at New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Principe.

Oral presentations in collaboration meetings

- *Cosmic Muon 97249 Run Analysis*
  presented by Joana Miguéns
  at ATLAS Jet Trigger Meeting in CERN.
- *Status of L2 Calibration*
  presented by Nuno Anjos
  at TAPM Jet Trigger meeting in CERN.
- *TileCal time calibration with single beam*
  presented by Nuno Ribeiro
  at Tile Timing group meeting in CERN.
- *Time offsets: beam vs cosmics*
  presented by João Gentil
  at Tile Timing group meeting in CERN.

- *Status of Si reconstruction*
  presented by António Morais
  at ALFA Test Beam Analysis Meeting in CERN.
- *Discussion on timing plots approval for public conferences:Cosmics timing (2/2)*
  presented by João Gentil
  at Tile Timing group meeting in CERN.
- *Status of L2 Calibration*
  presented by Nuno Anjos
  at TAPM Jet Trigger meeting in CERN.
- *RIG news*
  presented by José Maneira
  at TileCal Week Computing in CERN.
- *Tile DPD maker*
  presented by José Maneira
  at TileCal Week Computing in CERN.
- *Timing calibration status*
  presented by José Maneira
  at TileCal Week Data Preparation in CERN.
- *TileCal timing analysis with single beam*
  presented by Nuno Ribeiro
  at TileCal Week Performanca session in CERN.
- *Laser stability studies*
  presented by João Carvalho
  at Calibration performance and Tools in CERN.
- *DQ Leader Report*
  presented by João Carvalho
  at TileCal Operation Weekly Meeting in CERN.
- *DQ Leader Report*
  presented by João Carvalho
  at in CERN.
- *DQ leader report*
  presented by João Carvalho
  at Data Quality, Performance and Processing in CERN.
- *DQ leader report*
  presented by João Carvalho
  at TileCal Operation Weekly Meeting in CERN.
- *DQ Leader Report*
  presented by João Carvalho
  at TileCal Operation Weekly Meeting in CERN.
- *DQ Leader Report*
  presented by João Carvalho
  at TileCal Operation Weekly Meeting in CERN.
- *Analysis of long laser stability runs*
  presented by Paulo Martins
  at Combined meeting on DQ, Calibration and Performance in CERN.
- *Laser stability with a light diffuser*
  presented by João Carvalho
  at Calibration Performance and Tools in CERN.
- *PMTs stability and linearity with the laser*
  presented by João Carvalho
  at TileCal Calibration, Performance and Tools in CERN.

Outreach seminars

- *Detectar para descobrir (no LHC)*
  presented by Agostinho Gomes
  at Masterclass FCUL-LIP 2009 in FCUL, Lisbon.
- *O CERN e o LHC*
  presented by Patricia Conde
  at Masterclass FCUL-LIP 2009 in FCUL, Lisbon.
- *Partículas no CERN*
  presented by Agostinho Gomes
  at in Externato Ribadouro, Porto.
- *O Detector ATLAS e a participação portuguesa*
  presented by Agostinho Gomes
  at CERN Portuguese Teachers Programme 2009 in CERN, Geneva.

2.1.9 Academic Training

PhD Theses

- *O sistema de controlo do detector TILECAL/ATLAS"*
  João Pina, (on-going)
- *Measurement of the W -> mu nu production cross section with the ATLAS detector"*
  Pedro Jorge, (on-going)
- *Calibração do Calorímetro TileCal com muões cósmicos e jactos de partículas"*
  João Gentil, (on-going)
- *The TileCal laser monitoring and calibration system for the ATLAS/LHC experiment, and anomalous copuplings and rare top quark decays"*
  Paulo Martins, (on-going)

Master Theses

- *Measurement of efficiency and resolution of the prototype 2 fibre detector for the ALFA/ATLAS project in the LHC"*
  António Morais, 2009-11-11
- *Performance of the ATLAS Tile calorimeter with first beam and cosmic muons"*
  Nuno Ribeiro, 2009-11-11
- *Evolution of calibration and overall trigger performance using comsic muons and intercalibration in eta"*
  Joana Miguéns, 2009-11-11
- *Single top quark decays, and the TileCal laser monitoring and calibration system for the ATLAS/LHC experiment"*
  Inês Ochoa, (on-going)

2.1.10 Events

- *ATLAS Hadronic Calibration Workshop*
  Workshop, Foz do Arelho, Portugal, 2009-06-23
- *Lessons on Statistics and Data Analysis*
  Seminar organization, Lisbon, 2009-09-16

2.1.11 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
Articles in international journals (with indirect contribution from LIP members)	2
International Conference Proceedings	2
National Conference Proceedings	1
Collaboration notes with internal referee	16
Books	1
Oral presentations in international conferences	5
Poster presentations in international conferences	2
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	21
Outreach seminars	4
Master Theses	3
Workshops	1
Seminar organizations	1

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 caimento em Higgs carregado, o estudo dos eventos 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.

2.2.2 Abstract

LIP is a member of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC), presently in preparation at CERN. The experiment will study very high energy collisions of proton and nuclear beams. The experiment 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 three main components: 1) Development of hardware and software for the trigger and the readout system of the electromagnetic calorimeter; 2) Proton-proton physics, in particular top physics studies including search for decays in charged Higgs, study of the events W-gamma and extra-dimension searches, exploiting the discovery opportunities offered by the new LHC energy; 3) Heavy-ion physics, in particular the study of the QGP through measurements of quarkonia production.

2.2.3 Objectives

Project Coordination:

- Group coordinator: João Varela
  - Detector and computing coordinator: João Varela
    - DAQ/trigger coordinator: André David
    - Electronics coordinator: José Carlos Silva
    - Computing coordinator: Nuno Almeida
  - Proton-proton physics coordinator: Michele Gallinaro
  - Heavy-ion physics coordinator: João Seixas

Summary of Activities:

The ECAL trigger and readout electronics system was fully commissioned and operated with first LHC beam in 2009. The LIP group has important responsibilities in the project. The Synchronization and Link Boards (SLB, 1210 boards), which are required to synchronize and transmit the ECAL and HCAL trigger data, are operational. The Data Concentrator Cards (DCC, 70 boards), used for the data acquisition of the ECAL detector (and also of the RPC detector) have been proved to work at the maximum trigger rate of 100 kHz. The group has a major role in the development and coordination of the ECAL online software, and in the commissioning of the ECAL Off-Detector electronics. In 2009 various improvements on the firmware and online software were implemented and tested.
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 CMS Global Runs. The group participated also actively in the commissioning of the CMS ECAL trigger system. In 2009 the following tasks were undertaken: a) integration tests with central CMS DAQ and Trigger; b) developments of the data acquisition software and online monitoring software; c) improvement of data acquisition firmware; d) operation and data taking during CMS Global Runs. The group was directly involved in the ECAL and Trigger operation during the Cosmic Runs (CRAFT 08 and 09) and the first LHC Physics Runs in November 2009. Activities

in the off-line CMSSW software were pursued, in particular the maintenance of the ECAL raw-data unpacking software.
In the last year LIP/CMS GRID activities were focused in the deployment of the LIP Tier-2, which is a federated center between Lisbon and Coimbra sites. Following these efforts the LIP/CMS group joined the CMS Debugging Data Transfer (DDT) program and the CMS Monte Carlo production activities. Fully debugged and operational links between the Portuguese Tier-2 and other CMS Tiers (PIC and CERN) have been delivered to the collaboration. The functionality of the LHC Grid computing system as a whole was tested during the Common Computing Readiness Challenge (CCRC08) and during the CMS October Exercise (October 2009). The CMS dataflow and data processing workflows were tested at the LIP Tier-2 with the available computational resources. In 2009 the LIP/CMS Tier2 showed consistently high efficiency.
The preparation for physics analysis is now a major area of activities in the LIP/CMS group. Proton-proton physics activities at LIP include Top quark physics including search for decays in charged Higgs, W-gamma physics and Extra Dimension searches. The Top quark physics studies aim to perform a measurement of the SM and compare with expectations, in a channel with two leptons in the final state, which represents a background for the Extra Dimensions (ED) process. The W-gamma study aims at testing the three-boson SM couplings, in W-events with one energetic photon. The aim of the Extra Dimension searches is to exploit the potential of reaching for new physics at the LHC in a process with four leptons in the final state. The work in these topics is strongly correlated. The detailed study of backgrounds was one of the main areas of activity. The group contributed with the tau-dilepton analysis which was approved by the CMS collaboration. The analysis of the heavy flavour content in top events was also approved in 2009. The LIP group was involved in developing the electron and tau identification algorithms, and estimate the background contribution directly from data.
Investigations of quarkonia production in p-p collisions were carried out in 2009, namely the study of J/psi polarisation measurements and the study of a dedicated triggers for J/psi with low transverse momentum.
The group was responsible for the analysis of the electron and photon trigger efficiency using cosmic ray data collected in CRAFT 08 and 09. The results were approved by the collaboration and are included in a CMS paper submitted for publication in JINST.
LIP/CMS group members have the following CMS management positions:
- CMS Trigger Project Manager, member of the CMS Management and Executive Boards (J. Varela)
- ECAL Data Acquisition and Trigger Coordinator (until Sep 09, A. David)
- ECAL Run Coordinator, member of the CMS Commissioning Technical Board member (after Sep 09, A. David)
- ECAL Electronics Deputy Coordinator (J. C. Silva).
-In 2009, A. David was also CMS Run Field Manager and Shift Leader during CRAFT and LHC runs.
A series of seminars on LHC Physics (Physics on the road to discovery) was organized in collaboration with CFTP/IST. Six seminars by invited speakers took place in 2009.

2.2.4 Achievements

- Final commissioning and operation of the ECAL data acquisition and online monitoring in CRAFT and LHC runs.
- Operation of the LIP/CMS Tier2 consistently with high efficiency.
- Analysis of the electron and photon trigger efficiency using cosmic ray data collected in CRAFT 08 and 09, included in CMS Trigger Performance paper
- Analysis of the heavy flavour content in top events approved by CMS
- Analysis of the tau-dilepton top cross-section measurement approved by CMS
- Analysis of the search for universal extra-dimensions endorsed by the Exotica Physics group and approved for publication in PhD thesis
- Analysis of J/psi polarization and trigger studies presented to the collaboration and in international conferences.
- Participation in the management of the experiment at ECAL and Central levels
- Presentation of Standard Model searches with the top quark at the Large Hadron Collider at the 2009 Europhysics Conference on High Energy Physics
- Six seminars on LHC Physics (Physics on the road to discovery) organized in collaboration with CFTP/IST.

2.2.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83516/2008	290.000 €	2008-10-01	2009-12-31
CERN/FP/109343/2009	300.000 €	2009-11-01	2010-10-31

2.2.6 Team

Project coordinator: João Varela

Name	Status	%of time in project
André Tinoco Mendes	Researcher (LIP/IST/FCT) *	98
Aruna Nayak	PhD student (LIP)	8
David Christian Soares	Student (LIP)	8
Giuliano Mini	Master student (LIP)	80
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)	82
Jorge Neves	PhD student (LIP/FCT)	18
José Carlos Silva	Technician (LIP)	82
Leonardo Pedro	Master student (LIP)	63
Luís Raposo	Master student (LIP)	92
Marcelo Jordão	Master (LIP) *	75
Mário Sargedas Sousa	Student (LIP)	100
Michele Gallinaro	Researcher (LIP)	100
Miguel Ferreira	Technician (LIP)	27
Nuno Almeida	Post-Doc (LIP/FCT)	100
Pasquale Musella	PhD student (LIP/FCT)	100
Pedrame Bargassa	Researcher (LIP)	75
Pedro Manuel Silva	Post-Doc (LIP/FCT) *	100
Pedro Martins	PhD student (LIP/IST)	27
Pedro Parracho	PhD student (LIP/AdI)	100
Pedro Ribeiro	Post-Doc (LIP/FCT) *	100
Pietro Faccioli	Post-Doc (LIP/FCT)	100

2.2.7 Publications

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

- *The CMS experiment at the CERN LHC*
  The CMS Collaboration
  2008 JINST 3 S08004

- *J/psi polarization from fixed-target to collider energies*
  P. Faccioli, C. Lourenco, J. Seixas, H.K. Woehri
  CERN-PH-EP/2008-024, Phys. Rev. Lett. 102, 151802 (2009)

- *The CMS barrel calorimeter response to particle beams from 2 to 350 GeV/c*
  S. Abdullin et al., CMS HCAL/ECAL Collaborations
  The European Physical Journal C: Volume 60, Issue 3 (2009), Pages 359-373.

- *Performance and Operation of the CMS Electromagnetic Calorimeter*
  CMS Collaboration
  JINST_002T_1009

- *Measurement of the muon stopping power of Lead Tungstate*
  CMS Collaboration
  JINST_001P_1209

- *Performance of the CMS Level-1 Trigger during Commissioning with Cosmic*
  CMS Collaboration
  JINST_002T_1209

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

- *Commissioning and Performance of the CMS Pixel Tracker with Cosmic Rays*
  CMS Collaboration
  JINST_001T_1209

- *Commissioning and Performance of the CMS Silcon Strip Tracker with Cosmic Ray Muons*
  CMS Collaboration
  JINST_017T_1109

- *Alignment of the CMS Silicon Tracker During Commissioning with Cosmic Ray*
  CMS Collaboration
  JINST_003T_1009

- *Data Processing Workflows During an Extended Cosmic Ray Run*
  CMS Collaboration
  JINST_007T_1109

- *Performance study of Barrel CMS Resistive Plate Chambers with Cosmic Rays*
  CMS Collaboration
  JINST_006T_1109

- *Performance of the CMS Cathode Strip Chambers with Cosmic Rays*
  CMS Collaboration
  JINST_019T_1109

- *Performance of CMS Muon Reconstruction in Cosmic-Ray Events*
  CMS Collaboration
  JINST_020T_1109

- *Precise Mapping of the Magnetic Field in the CMS Barrel Yoke using Cosmic*
  CMS Collaboration
  JINST_004T_1109

- *Alignment of the CMS Muon System with Cosmic-Ray and Beam-Halo Muons*
  CMS Collaboration
  JINST_003T_1109

- *Aligning the CMS Muon Chambers with the Muon Alignment System during an Extended Cosmic Ray Run*
  CMS Collaboration
  JINST_016T_1109

- *Performance of CMS Hadron Calorimeter Timing and Synchronization using Cosmic Ray and LHC Beam Data*
  CMS Collaboration
  JINST_010T_1109

- *Identification and Filtering of Uncharacteristic Noise in the CMS Hadron Calorimeter*
  CMS Collaboration
  JINST_011T_1109

- *Commissioning of the CMS High-Level Trigger with Cosmic Rays*
  CMS Collaboration
  JINST_012T_1109

- *Performance of the CMS Drift-Tube Chamber Local Trigger with Cosmic Rays*
  CMS Collaboration
  JINST_013T_1109

- *Calibration of the CMS Drift Tube Chambers and Measurement of the Drift Velocity with Cosmic Rays*
  CMS Collaboration
  JINST_014T_1109

- *Fine Synchronization of the CMS Muon Drift-Tube Local Trigger using Cosmic Rays*
  CMS Collaboration
  JINST_015T_1109

International Conference Proceedings

- *CDF experimental results on diffraction*
  Michele Gallinaro
  arXiv:0904.2098v1 [hep-ex]

- *Beyond the SM searches with top (LHC)*
  Pedro Silva
  PoS(EPS-HEP 2009)359

- *The ECAL online software in the commissioning of the CMS detector*
  Pasquale Musella
  FDFP09

Collaboration notes with internal referee

- *Probing the Heavy Flavor Content in the ttbar Dilepton Channel at sqrt(s) = 10 TeV*
  CMS collaboration (approved)
  CMS Physics Analysis Note PAS-TOP-09-01, CMS AN-2008/112

Book Chapters

- *Measuring dimuons produced in proton-nucleus collisions with the NA60 experiment at the SPS*
  C. Lourenco, H.K. Woehri
  Lecture Notes in Physics, Springer, 2009

- *Quarkonium production and absorption in proton-nucleus collisions*
  C. Lourenco, P. Faccioli, H.K. Woehri
  Lecture Notes in Physics, Springer, 2009

2.2.8 Presentations

Oral presentations in international conferences

- *Cold nuclear matter effects in J/psi production in proton-nucleus collisions*
  presented by Hermine Wöhri
  at 47th International Winter Meeting on Nuclear Physics in Bormio, Italy.

- *Some progress in understanding charmonium production and absorption*
  presented by Pietro Faccioli
  at Workshop on High-Density QCD at the LHC and in Cosmic Rays in Santiago de Compostela, Galicia, Spain.

- *Questions on J/psi polarization*
  presented by Pietro Faccioli
  at Light hadrons workshop in IST Lisbon.

- *Top quark physics at LIP with the CMS detector*
  presented by Michele Gallinaro
  at workshop on "Top quark physics at the LHC"in Lisbon.

- *Kinematic Dependence of J/psi Polarization Measurements in Hadronic Collisions*
  presented by Pietro Faccioli
  at XVII International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS 2009) in Madrid.

- *Overview of the CMS Trigger System*
  presented by João Varela
  at 16th IEEE NPSS Real Time Conference in Beijing.

- *CMS: from commissioning to first beams*
  presented by André Tinoco Mendes
  at SUSY09 - Int. Conf. on Supersymmetry and the Uniﬁcation of Fundamental Interactions in Boston, Massachusetts .

- *J/psi polarization from a data-driven perspective*
  presented by Pietro Faccioli
  at Quarkonium in Hot Media: from QCD to Experiment in Seattle, USA.

- *Experimental results on diffractive dijets at CDF*
  presented by Michele Gallinaro
  at workshop on "Soft diffractive physics at the LHC"in CERN.

- *Extra Dimensions: mUED: Z1Z1 in 4l+MET+jets*
  presented by Pedro Ribeiro
  at Four lepton channels in CMS 2009 in Paris, France.

- *Beyond the SM searches with top (LHC)*
  presented by Pedro Manuel Silva
  at EPS HEP 2009 in Cracow, Poland.

- *CDF experimental results on diffraction*
  presented by Michele Gallinaro
  at Multi-Parton Interaction workshop in Perugia, Italy.

- *Probing a Universal Extra Dimension with the CMS experiment at the LHC*
  presented by Pedro Ribeiro
  at PASC Winter School in Sesimbra, Portugal.

- *Wgamma production with early LHC data*
  presented by Pasquale Musella
  at PASC Winter School in Sesimbra, Portugal.

- *Search for the charged Higgs at the LHC*
  presented by Leonardo Pedro
  at PASC Winter School in Sesimbra, Portugal.

Presentations in national conferences

- *Probing the heavy flavor content of ttbar events at the LHC*
  presented by Pedro Manuel Silva
  at Workshop on Top quark physics at the LHC in IST, Lisboa.

Oral presentations in international meetings

- *CMS: last steps with cosmics, first steps with beams*
  presented by André Tinoco Mendes
  at PASC Winterschool 2009 in Sesimbra, Portugal.
- *Tau leptons in ttbar decays at the LHC*
  presented by Nuno Almeida
  at PASC Winterschool 2009 in Sesimbra, Portugal.
- *Probing New Physics with the Heavy Flavor Content of top quark event*
  presented by Pedro Manuel Silva
  at PASC Winterschool 2009 in Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *J/psi polarization measurements*
  presented by Pietro Faccioli
  at CMS B-physics PAG in .
- *Vtb in dileptons*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.
- *Trigger reliability and spares policy*
  presented by João Varela
  at CMS Electronics week in CERN.
- *DAQ status: open problems*
  presented by André Tinoco Mendes
  at ECAL Days in Milano, Italy.
- *Characterization high energy cosmic events in ECAL*
  presented by Pedro Parracho
  at ECAL cosmics meeting in CERN.
- *R (V_tb) in e+mu+jets events (part II)*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.
- *Discovery potential for UED in the four lepton final state*
  presented by Michele Gallinaro
  at CMS Exotica PAG meeting in .
- *L1 Trigger introduction/planning*
  presented by João Varela
  at CMS L1 Trigger meeting in CERN.
- *ECAL trigger software*
  presented by André Tinoco Mendes
  at L1 online software review in CERN.
- *Calibration sequence - online overview*
  presented by André Tinoco Mendes
  at ECAL DAQ and Trigger meeting in CERN.
- *Wgamma reconstruction at 10 TeV*
  presented by Pasquale Musella
  at CMS Electroweak PAG meeting in CERN.
- *R (V_tb) in di-lepton channel: (Part 3)*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.

- *Requirements on Level 1 trigger*
  presented by João Varela
  at CMS Integration Center (b904) Workshop in CERN.
- *Update on high energy and trigger studies*
  presented by Pasquale Musella
  at CMS ECAL POG meeting in CERN.
- *Electron Trigger Efficiency in CRAFT*
  presented by Pedro Parracho
  at L1 Trigger DPG meeting in CERN.
- *BMX : Beam Monitoring eXchanger*
  presented by Pedro Parracho
  at CMS ECAL DAQ and Trigger meeting in CERN.
- *Electron trigger efficiency in CRAFT*
  presented by Pasquale Musella
  at CMS ECAL DPG meeting in CERN.
- *Update on L1 electromagnetic trigger studies*
  presented by Pedro Parracho
  at ECAL DPG in CERN.
- *ECAL TPGs and Electron trigger efficiency*
  presented by Pedro Parracho
  at CRAFT analysis workshop in Torino, Italy.
- *Trigger and DAQ report*
  presented by André Tinoco Mendes
  at ECAL Days in CERN.
- *Pre-approval: Heavy-flavor content in ttbar dileptons*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.
- *Update on the UED analysis*
  presented by Michele Gallinaro
  at CMS Exotica PAG meeting in .
- *Wgamma status*
  presented by Pasquale Musella
  at CMS Electroweak Multiboson PAG meeting in CERN.
- *Status of ttbar cross section in the e+tau and mu+tau*
  presented by Nuno Almeida
  at Top Quark Meeting in CERN.
- *V_tb in the dilepton channel*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.
- *Electron trigger efficiency update*
  presented by Pedro Parracho
  at CMS ECAL cosmics meeting in CERN.
- *L1 Trigger introduction/planning*
  presented by João Varela
  at CMS L1 Trigger meeting in CERN.
- *Status report on the EM trigger efficiency studies*
  presented by Pedro Parracho
  at ECAL DPG in CERN.

- *Estimate of fake background in the tau dilepton channel*
  presented by Nuno Almeida
  at Top Quark Meeting in CERN.

- *L1 Trigger*
  presented by João Varela
  at CMS Executive+PMs meeting in CERN.

- *Search for the charged Higgs*
  presented by Michele Gallinaro
  at CMS Higgs meeting in .

- *L1 Trigger introduction*
  presented by João Varela
  at CMS L1 Trigger meeting in CERN.

- *Combined measurement of Vtb and cross section in the dilepton e-mu channel*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.

- *TOP-09-001: Heavy Flavor Content in the ttbar Dilepton Channel at sqrt(s) = 10 TeV*
  presented by Pedro Manuel Silva
  at CMS Physics Approval in CERN.

- *General software status*
  presented by Pasquale Musella
  at CMS ECAL DAQ meeting in CERN.

- *Update on Wgamma analysis*
  presented by Pasquale Musella
  at CMS Electroweak Multiboson PAG meeting in CERN.

- *Systematic uncertainty on Quarkonia dsigma/dpT from their unknown polarization*
  presented by Pietro Faccioli
  at CMS B-Physics PAG in .

- *E/gamma trigger efficiency and ECAL L1 energy scale*
  presented by Pasquale Musella
  at CMS ECAL DPG meeting in CERN.

- *L1 Trigger Concerns*
  presented by João Varela
  at CMS Executive Board in .

- *L1 egamma efficiency and energy scale studies in CRAFT08*
  presented by Pasquale Musella
  at CMS Egamma POG meeting in CERN.

- *Thesis pre-approval talk: Search for UEDs in the 4 lepton channel*
  presented by Pedro Ribeiro
  at CMS Exotica PAG meeting in CERN.

- *ECAL Unpacker and Packer software*
  presented by Nuno Almeida
  at ECAL DPG reconstruction software workshop in CERN.

- *Search for Universal Extra Dimensions*
  presented by Pedro Ribeiro
  at PhD Thesis endorsement talk, CMS Plenary Session in CERN.

- *Update on Wgamma in muon channel analysis*
  presented by Pasquale Musella
  at CMS Electroweak Multiboson PAG meeting in CERN.

- *Run field manager report*
  presented by André Tinoco Mendes
  at CMS Run Meeting in CERN.

- *Report on recent running*
  presented by Pasquale Musella
  at CMS ECAL DPG meeting in CERN.

- *Run field manager report*
  presented by André Tinoco Mendes
  at CMS Run Meeting in CERN.

- *Towards a first measurement of the polarization of Y(1S) mesons produced in pp collisions at sqrts=10 TeV*
  presented by Pietro Faccioli
  at Quarkonium Task Force Workshop in CERN.

- *Introduction and DAQ overview*
  presented by André Tinoco Mendes
  at ECAL DAQ and Trigger review in CERN.

- *ECAL DAQ expert on call*
  presented by Pedro Parracho
  at CMS ECAL DAQ and Trigger Readiness Review in CERN.

- *Core software*
  presented by Pasquale Musella
  at CMS ECAL review meeting in CERN.

- *Preparation for the October exercise at LIP*
  presented by Michele Gallinaro
  at CMS Top dilepton meeting in .

- *October Exercise in LIP/Lisbon*
  presented by Pedro Manuel Silva
  at Top Dileptons Working Group Meeting in CERN.

- *Electronics upgrades for phase 1, 1.5 an 2*
  presented by João Varela
  at CMS ECAL Upgrade meeting in .

- *Standard Model W+gamma and Exotic Processes*
  presented by Pasquale Musella
  at CMS High-PT Photon Exotica PAG meeting in CERN.

- *Progress in the October Exercise in LIP/Lisbon*
  presented by Pedro Manuel Silva
  at Top Dileptons Working Group Meeting in CERN.

- *SigmaIEtaIEta*
  presented by Pasquale Musella
  at CMS QCD Photon POG meeting in CERN.

- *SigmaIEtaIEta purity*
  presented by Pasquale Musella
  at CMS Egamma POG meeting in CERN.

- *DAQ configuration database*
  presented by Pasquale Musella
  at CMS ECAL review meeting in CERN.

- *Trigger and DAQ Progress and Status*
  presented by André Tinoco Mendes
  at ECAL Days in CERN.

- *Plans for Startup next week*
  presented by André Tinoco Mendes
  at CMS Run Meeting in CERN.

- *L1 Trigger*
  presented by João Varela
  at CMS readiness for data-taking meeting in .

- *Status report on the charged Higgs analysis*
  presented by Leonardo Pedro
  at CMS Higgs meeting in CERN.

- *RFM report*
  presented by André Tinoco Mendes
  at CMS Run Meeting in CERN.

- *L1 Trigger introduction*
  presented by João Varela
  at CMS L1 Trigger meeting in .

- *Trilepton skim for Exotica*
  presented by Pedro Ribeiro
  at CMS Exotica PAG meeting in CERN.

- *First look at top mass in ttbar dilepton events*
  presented by Pedro Manuel Silva
  at Top Quark Physics Meeting in CERN.

- *Wgamma reconstruction at 10 TeV*
  presented by Pasquale Musella
  at CMS Electroweak Multiboson PAG meeting in CERN.

- *Code organization: the sandbox and other tools*
  presented by Pasquale Musella
  at CMS ECAL DAQ meeting in CERN.

- *First feedback from superclusters*
  presented by Pasquale Musella
  at CMS Egamma POG meeting in CERN.

Seminars

- *Probing the Standard Model using Top quarks*
  presented by Michele Gallinaro
  at Colloquium in University of Coimbra.

- *Searches for New Physics with Top quark events produced in proton-proton collisions at the LHC*
  presented by Pedro Manuel Silva
  at Physics on the road to discovery in IST, Lisboa.

Outreach seminars

- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.

- *LIP Masterclasses*
  presented by Nuno Almeida
  at in IST, Lisboa.

- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.

- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN´s travelling exhibition*
  presented by André Tinoco Mendes
  at in Geneva, Switzerland.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN´s travelling exhibition*
  presented by André Tinoco Mendes
  at in Geneva, Switzerland.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *Guided visit of CERN to portuguese-speaking group*
  presented by André Tinoco Mendes
  at in CERN.
- *CERN Portuguese Teachers Programme 2009*
  presented by André Tinoco Mendes
  at in CERN.

2.2.9 Academic Training

PhD Theses

- *Search for Universal Extra-Dimensions in proton-proton collisions at 14 TeV center-of-mass energy"*
  Pedro Ribeiro, 2009-12-16
- *Probing the Heavy Flavor of Top quark decays produced in proton-proton collisions at the Large Hadron Collider with the CMS experiment"*
  Pedro Manuel Silva, 2009-12-14
- *Physics Simulation and Reconstruction of Universal Extra Dimensions Processes in the CMS Experiment"*
  Pasquale Musella, (on-going)
- *Trigger de electrões e fotões na experiência CMS no SLHC"*
  Pedro Parracho, (on-going)

Master Theses

- *Tau lepton identification with the CMS detector"*
  Marcelo Jordão, 2009-09-01

2.2.10 Events

- *Joint CMS ECAL DAQ and Commissioning meeting*
  Collaboration Meeting, CERN, 2009-01-15
- *CMS ECAL DAQ and Trigger meeting*
  Collaboration Meeting, CERN, 2009-01-29
- *CMS ECAL DAQ, DPG and Commissioning meeting on the use of the test pulse*
  Collaboration Meeting, CERN, 2009-02-12
- *CMS ECAL DAQ and Trigger meeting*
  Collaboration Meeting, CERN, 2009-02-26
- *Short CMS ECAL DAQ and Trigger meeting during the MWGR*
  Collaboration Meeting, CERN, 2009-03-26
- *Joint CMS ECAL DAQ/Trigger and P5/Commissioning meeting*
  Collaboration Meeting, CERN, 2009-04-16
- *CMS ECAL DAQ and Trigger meeting*
  Collaboration Meeting, CERN, 2009-07-02
- *CMS ECAL DAQ and Trigger Readiness Review*
  Collaboration Meeting, CERN, 2009-09-16

2.2.11 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	6
Articles in international journals (with indirect contribution from LIP members)	16
International Conference Proceedings	3
Collaboration notes with internal referee	1
Book Chapters	2
Oral presentations in international conferences	15
Presentations in national conferences	1
Oral presentations in international meetings	3
Oral presentations in collaboration meetings	70
Seminars	2
Outreach seminars	14
PhD Theses	2
Master Theses	1
Collaboration Meetings	8

2.3 Collaboration in the COMPASS experiment at CERN

2.3.1 Resumo

A experiência COMPASS dedica-se ao estudo da estrutura da matéria, nomeadamente à polarização do gluão DeltaG/G (através da fotoprodução de charme e da física de elevado pT), às funções de estrutura relativas às componentes transversas e longitudinais do spin, e às funções de fragmentação. Com um feixe de hadrões, tem por objectivo o estudo de algumas questões espectroscópicas de actualidade, como a produção de novos mesões e bariões, nomeadamente exóticos, híbridos e partículas com charme duplo.
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 aquisição 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 1700TB. O programa de 2009 foi dedicado ao programa de hadrões.
A farm de processamento de dados de COMPASS tem um desempenho do nível requerido em LHC, pelo que a experiência é usada pelos grupos técnicos de apoio do CERN em vérios domínios relativos à aquisição e ao controlo dos dados como um ambiente de teste em grande escala de soluções futuras.
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.
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 das próximas tomadas de dados com feixes de muões e de 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.
Paralelamente, o grupo também tem feito um grande reforço de recursos humanos, tanto em offline, no 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 pT , e ainda sobre as assimetrias de sabor do mar do nucleão e do mesão Psi.
Nos últimos meses o grupo do LIP-Lisboa tem assumido um papel de destaque na preparação da futura Proposta de COMPASS, na secção relativa a estudos de transversidade através do processo de Drell-Yan polarizado.

2.3.2 Abstract

COMPASS experiment is dedicated to the study of the structure of matter, namely the gluon polarization DeltaG/G (from open charm photoproduction and high pT physics), the longitudinal and the transverse spin structure and fragmentation functions. With a hadron beam, COMPASS aims to study some spectroscopy issues, as the production of new mesons and baryons, namely exotics, hybrids and double charmed particles.
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 year 2009 was dedicated to the hadron program.
COMPASS data processing farm also requires a LHC-like performance. That is why the experiment is used as large scale test environment for future solutions 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 future muon and hadron beam runs, which are presently being installed for the 2009 data taking. 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.
In parallel, a great effort in human resources for offline and data analysis is being done. 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 pT events, and the flavour asymmetries of the nucleon sea and of the Psi meson.
In the last months our group has taken an important role in the preparation of the future COMPASS Proposal, in the section concerning transversity studies through the polarised Drell-Yan process.

2.3.3 Objectives

LIP is member of COMPASS experiment. COMPASS studies the structure of the nucleon in terms of its spin using targets and beams polarised as well as addresses the study of 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.
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 2009 hadron run, new detectors were installed in the experimental area. These detectors were being 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 required 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 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 2009 the following subjects were addressed:

- The study of semi-inclusive DIS events, in order to extract all years spin flavour asymmetries and to obtain spin dependent structure functions, was completed
- The analysis of high pT events, which purpose is the derivaton of the gluon polarisation, has continued
- The open charm studies, in view of the DeltaG/G extraction, has proceeded addressing new channels never studied before
- The J/Psi spin asymmetries study has continued
- Studies on transversity, by means of the simulations of the polarised Drell-Yan process and of its correlated and uncorrelated backgrounds, in order to include the subject in the nearcoming COMPASS-2 Proposal, have proceeded.

2.3.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83542/2008	140.000 €	2008-10-01	2009-12-31
CERN/FP/109323/2009	150.000 €	2009-11-01	2010-10-31

2.3.6 Team

Project coordinator: Paula Bordalo

Name	Status	%of time in project
António Pacheco	Master student (LIP)	84
Catarina Quintans	Researcher (LIP)	100
Celso Franco	PhD student (LIP/FCT)	100
Christophe Pires	Technician (LIP)	100
Helena Santos	Researcher (LIP)	47
Hugo Fonseca	Master student (LIP)	75
Luis Silva	PhD student (LIP/FCT)	100
Márcia Quaresma	Master student (LIP)	84
Marcin Stolarski	Post-Doc (LIP)	17
Paula Bordalo	Researcher (LIP/IST)	100
Sérgio Ramos	Researcher (LIP/IST)	100
Sofia Nunes	Technician (LIP)	100

2.3.7 Publications

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

- *Collins and Sivers iasymmetries for pions and kaons in muon-deuteron DIS*
  P. Bordalo, C. Franco, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  PLB 673 (2009) 127-135

- *Gluon Polarisation in the Nucleon and Longitudinal Double Spin Asymmetries from Open Charm Muoproduction*
  P. Bordalo, C. Franco, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  PLB 676 (2009) 31-38

- *Flavour Separation of Helicity Distributions from Deep Inelastic Muon-Deuteron Scattering*
  P. Bordalo, C. Franco, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  PLB 680 (2009) 217-224

- *Measurement of the Longitudinal Spin Transfer to Lambda and Lambda-bar Hyperons in Polarized Muon DIS*
  P. Bordalo, C. Franco, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  EPJC 64 (2009) 171-179

International Conference Proceedings

- *New results on gluon polarisation from COMPASS*
  C. Franco et al., for COMPASS Collaboration

- *COMPASS Results on the Strange Quark Polarisation*
  H. Santos et al. for COMPASS collaboration

- *COMPASS RESULTS ON GLUON POLARISATION FROM HIGH PT HADRON PAIRS*
  L. Silva et al., for COMPASS Colaboration

- *Polarized Drell-Yan measurements in COMPASS*
  C. Quintans et al., for COMPASS Collaboration

Collaboration notes with internal referee

- *Polarized parton distributions*
  H. Santos et al.
  COMPASS Release Note SIDIS

- *Measurement of DeltaG/G via Open Charm on 2002,2003, 2004 and 2006 data*
  C. Franco et al.
  COMPASS Release Note 4

- *Kinematical plots from Drell-Yan beam test 2007*
  C. Quintans et al.
  COMPASS Release Note DY

2.3.8 Presentations

Oral presentations in international conferences

- *Polarized Drell-Yan in the COMPASS Experiment*
  presented by Catarina Quintans
  at IWHSS09 - International Workshop on Hadron Structure and Spectroscopy in Mainz, Germany.
- *New COMPASS results on semi-inclusive polarised DIS*
  presented by Helena Santos
  at IWHSS09 - , International Workshop on Hadron Structure and Spectroscopy in Mainz, Germany.
- *COMPASS Results on the Strange Quark Polarisation*
  presented by Helena Santos
  at DIS09, XVII International Workshop on Deep-Inelastic Scattering and Related Subjects in Madrid, Espanha.

- *Open-Charm results on gluon polarisation from COMPASS*
  presented by Celso Franco
  at DIS09, XVII International Workshop on Deep-Inelastic Scattering and Related Subjects in Madrid, Espanha.
- *Polarized Drell-Yan measurements in COMPASS*
  presented by Catarina Quintans
  at Transverse Partonic Structure of Hadrons in Yerevan, Armenia.
- *COMPASS results on gluon polarisation from high pT hadron pairs*
  presented by Luis Silva
  at DSPIN-09 - XII Workshop on High Energy Spin Physics in Dubna, Russia.
- *Delta G/G COMPASS results from high pT hadrons*
  presented by Luis Silva
  at PASC Winter School in Sesimbra, Portugal.
- *Gluon polarisation from D0 production at COMPASS*
  presented by Celso Franco
  at PASC Winter School in Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *Studies on HCALs for 2006 High pT data*
  presented by Luis Silva
  at in .
- *Inclusive and SIDIS Asymmetries with Q2 > 0.7 (GeV/c)2*
  presented by Helena Santos
  at in .
- *Analyses of 2007 longitudinal data*
  presented by Helena Santos
  at in .
- *Status report of the Open Charm analysis*
  presented by Celso Franco
  at in .
- *Drell-Yan*
  presented by Catarina Quintans
  at in .
- *New contributions from the D* channel to our measured DeltaG/G*
  presented by Celso Franco
  at in .
- *Asymmetries from 2007 data*
  presented by Helena Santos
  at in .
- *2006 Data/MC comparison for HiPT*
  presented by Luis Silva
  at in .
- *DY 2007 test beam results*
  presented by Catarina Quintans
  at in .
- *Status report of the Open-Charm analysis*
  presented by Celso Franco
  at in .
- *Data-MC comparison study on PDFs in high-pT Analysis*
  presented by Luis Silva
  at in .

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)

Master Theses

- *Study of the Drell-Yan proccess in pi-p interactions "*
  Márcia Quaresma, (on-going)
- *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
International Conference Proceedings	4
Collaboration notes with internal referee	3
Oral presentations in international conferences	8
Oral presentations in collaboration meetings	11

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 2010, 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.
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 2010, 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 commissioning of the new system (2009-2010) and subsequently to join 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 most dense 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
All sectors were transported from Coimbra to GSI, equipped with final electronics and tested with cosmic rays at GSI. LIP supported all mechanical operations involving the detectors, the gas supply management, some ancillary systems and the cosmic-ray data analysis.
During this period LIP took charge of coordinating directly the RPC-specific slow control system.
Finally, in November 2009, all sextants were mechanically installed in the spectrometer.

ORGANISATION OF THE HADES COLLABORATION MEETING XX
The HADES Collaboration meeting XX (http://hades.coimbra.lip.pt/CM_XX/) was organized this year by the LIP team. It took place in Sesimbra the 5-10 May 2009. There were 64 registered participants, which delivered 56 communications.
This represented a fruitful occasion for surveying the status of the HADES detector upgrade, a task in which LIP is playing an important role. It was also a possibility for the group to acquire visibility within the collaboration.

PARTICIPATION IN THE PHYSICS PROGRAM

This year the work concentrated almost exclusively on the next three beam time requests. As in previous years, the focus of LIP contribution is in the study of strangeness production due to the excellent kaon identification capabilities of the newly installed RPC ToF wall.
A detailed simulation on the bidimensional evolution of the achievable kaon purity as a function of rapidity and transverse momentum has been completed.
Moreover, due to a convergence of the interest of several groups inside HADES, the selected medium size system is Ag+Ag at 1.65AGeV. The necessary parameters to simulate these events in PLUTO have been estimated and the simulations of the kaon PID repeated, confirming again the expected good overall performance of the RPC ToF, especially if a two layer coincidence will be used. The simulations have also been extended to the ToF scintillator wall to cover as much phase space as possible with HADES.

FUNDING

The participation in HADES has been formalized via a Memorandum of Understanding (MOU) recently celebrated between the Collaboration, GSI and FCT.
The early design and prototyping work was supported by detector development projects financed by the CERN program and the construction was financed by an EU project on the "Construction of New Infrastructures"initiative with a budget of 466kEUR. More recently, as LIP became an official member of the collaboration, funding for beamtime shift duty, physics studies and collaboration meeting attendance was received from the CERN program.
It can be appreciated that the CERN program has been fundamental on the continued support of this endeavor. However, in the two most recent years, the policy of this program has been changed towards a much more CERN-centered approach. This may be evaluated by the progressively smaller amounts granted to this activity and, explicitly, by the appreciation of the panel to the HADES funding request of 2009:

"This project is valuable and represents the completion of the detector development financed over the last few years. The future activities are only marginally related to CERN activities."
It is clear that to comply with the long term duties towards the experiment funding must be sought elsewhere. Therefore, we have submitted a HADES project to the FCT/PTDC call (all scientific domains), requesting support for the participation in the HADES experiment for the next 3 years, corresponding essentially to the period covered by the current MOU. The activities will include the operation and calibration of the RPC TOF wall and selected physics topics, as detailed above.
It should be noted that no funds were requested for materials or technical manpower for the physical maintenance of the RPC system, as the former will be supported by FCT in the framework of the MOU with an amount of 10kEUR/year and the later by LIP´s technical staff.

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/83560/2008	15.000 €	2008-10-01	2009-09-30
CERN/FP/109373/2009	10.000 €	2009-10-01	2010-09-30

2.4.6 Team

Project coordinator: Paulo Fonte

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	20
Alessio Mangiarotti	Researcher (LIP)	75
Alexandre Moita	Technician (LIP)	4
Américo Pereira	Technician (LIP)	7
Carlos Capela	Researcher (ESTGL)	5
Carlos Neves	Researcher (ESTGL)	1
Carlos Silva	Technician (LIP)	4
Carlos Sousa	Researcher (ESTGL)	10
Joaquim Oliveira	Technician (LIP)	4
Luís Lopes	Technician (LIP)	20
Milena Vieira	Researcher (ESTGL)	10
Nuno Carolino	Technician (LIP)	7
Orlando Cunha	Technician (LIP)	7
Paulo Fonte	Researcher (LIP/ISEC)	20
Rui Alves	Technician (LIP)	4

2.4.7 Publications

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

- *In-beam measurements of the HADES-TOF RPC wall*
  A.Blanco, P.Cabanelas, D.Belver, E.Castro, J.Diaz, P.Fonte, A.Gil, J.A.Garzon, D.Gonzalez-Diaz, T.Heinz, W.Koenig, L.Lopes, C.Muentz, M.Palka, J.Pietraszko, A.Rustamov, E.Schwab, Y.Sobolev, A.Tarantola,K.Teilab,M.Traxler,R
  Nucl. Instrum. and Meth. in Phys. Res. A 602 (2009) 691-695

- *The identification of rare charged kaons in heavy ion collisions at relativistic energies by time-of-flight with the HADES spectrometer*
  A.Mangiarotti, P.Fonte, A.Blanco
  Nucl. Instrum. and Meth. in Phys. Res. A 602 (2009) 830-834

- *The HADES RPC inner TOF Wall*
  D.Belver, A.Blanco, P.Cabanelas, N.Carolino, E.Castro, J.Diaz, P.Fonte, J.A.Garzón, D.Gonzalez-Diaz, A.Gil, W.Koenig, L.Lopes, A. Mangiarotti, O.Oliveira, A.Pereira, C.Silva, C.C.Sousa, M.Zapata

Nucl. Instrum. and Meth. in Phys. Res. A 602 (2009) 687-690

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

- *MESON AND DI-ELECTRON PRODUCTION WITH HADES*
  The HADES Collaboration
  International Journal of Modern Physics 24 (2009) 317-326

- *Measurement of charged pions in C-12+C-12 collisions at 1 A GeV and 2 A GeV with HADES*
  The Hades Collaboration
  Eur. Phys. J. A 40 (2009) 45-59

- *Measurement of low-mass e(+)e(-) pair production in 1 and 2 A GeV C-C collision with HADES*
  The Hades Collaboration
  Eur. Phys. J. C 62 (2009) 81-84

- *phi decay: A relevant source for K- production at energies available at the GSI Schwerionen-Synchrotron (SIS)?*
  The Hades Collaboration
  Physical Review C 80, 025209 (2009)

- *Deep Subthreshold Xi(-) Production in Ar plus KCl Reactions at 1.76A GeV*
  The Hades Collaboration
  Physical Review Letters 103, 132301 (2009)

2.4.8 Presentations

Oral presentations in collaboration meetings

- *RPC upgrade status*
  presented by Paulo Fonte
  at HADES Collaboration Meeting XIX, 5-10 May 2009 in Sesimbra, Portugal.

2.4.9 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
Articles in international journals (with indirect contribution from LIP members)	5
Oral presentations in collaboration meetings	1

2.5 Phenomenological Studies at the LHC

2.5.1 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.
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.
Outra tarefa desenvolvida no âmbito deste projecto, envolveu o estudo de assimetrias angulares em decaimentos 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 (ρ_R e ρ_L). 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.
No âmbito do presente projecto foram ainda desenvolvidos novos Modelos Teóricos e foi organizado um Workshop em Grenoble sobre a Física do Quark Top que contou com a participação de físicos teóricos e experimentais.

2.5.2 Abstract

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.
1.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). Studies already performed show that these 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.
2.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.
3.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 (ρ_R e ρ_L) 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.
4.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.
5.Workshop on Top Physics : from the TeVatron to the LHC
Just like for the year before, the interplay between the Tevatron and the LHC in what concerns the top quark physics program was explored, from the theoretical and experimental points of view. The discussion covered the Monte Carlo tools, the theoretical and experimental frameworks to better explore the results from both colliders and combine them. The workshop was held at Grenoble.

2.5.3 Objectives

The main objective of the project is to continue and strengthen the collaboration between experimental and theoretical physicists for phenomenological studies with a special impact on the LHC physics. The discussion is intended to be concentrated in the top quark and Higgs physics specially related to Flavour Changing Neutral Current processes associated with single top quark production at colliders (Tevatron and LHC), asymmetries in top quark decays (within the SM) and anomalous couplings (beyond the SM), and the study of the electroweak couplings of the top quark. For each physics channel, dedicated Monte Carlo generators will be developed and upgraded in order to implement the correct parameterization of the physics models under study. New students will be trained, as was done in the past, focused on the phenomenology of the theoretical models and also in their implementation in general purpose Monte Carlo generators. Tevatron and Hera results will be interpreted for several physics observables and expected limits will be set for the LHC.

2.5.4 Achievements

-A strong collaboration was achieved between experimental and theoretical physicists. Although the work as focused mainly in the Top Quark physics, other subjects were addressed like the Higgs physics.
- Monte Carlo generators were developped by the team and made available already to the community. PROTOS, which was developed by the team, has been already used by the LHC experiments and full simulation samples have been generated to study several physics processes (pair production and single production of top quark events).

-The TopFit package has been made available to the community. This package performs a global fit to several top quark observables to set limits on possible anomalous couplings present a the Wtb vertex.
-Several presentations, publications and reports were done during the course of the current project.
-The work developed within the project allowed the training of young physicists. The strong collaboration achieved between experimentalists and theoreticians allowed the development of several Master and PhD thesis both in experimental and theoretical top quark physics.
-Meetings and Workshops have been organized within the project

2.5.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83588/2008	35.000 €	2008-10-01	2009-09-30
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)	30
Augusto Barroso	Researcher (FCUL)	20
Bruno Galhardo		8
Francisco del Aguila Giménez	Researcher (UGR)	3
Inês Ochoa	Master student (LIP)	75
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)	60
Orlando Oliveira	Researcher (LIP/FCTUC)	14
Pedro Ferreira	Technician (LIP/FCT)	2
Pedro Martins Ferreira	Researcher (LIP/FCUL)	7
Renato Guedes Júnior	Researcher (LIP/FCUL)	3
Rita Monteiro	Post-Doc (LIP)	100
Roberto Pittau	Researcher (UGR)	3
Rui Santos	Researcher (LIP/FCUL)	20
Susana Santos	Master student (LIP)	75

2.5.7 Publications

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

- *Distinctive Higgs Signals of a Type II 2HDM at the LHC*
  Shinya Kanemura, Stefano Moretti, Yuki Mukai, Rui Santos, Kei Yagyu
  Phys.Rev.D79:055017,2009, arXiv:0901.0204

- *Dimension six FCNC operators and top production at the LHC*
  R.A. Coimbra, P.M. Ferreira, R.B. Guedes, O. Oliveira, A. Onofre, R. Santos and M. Won
  Phys.Rev. D79 (2009) 014006, (arXiv:0811.1743 [hep-ph])

- *Heavy lepton pair production at LHC: Model discrimination with multi-lepton signals.*
  J.A. Aguilar-Saavedra
  arXiv:0905.2221, Nucl.Phys.B828:289-316,2010

- *A minimal set of top anomalous couplings*
  Juan Antonio Aguilar-Saavedra
  Nucl.Phys. B812 (2009) 181-204 (arXiv:0811.3842v1 [hep-ph])

- *Identifying top partners at LHC.*
  J.A. Aguilar-Saavedra
  JHEP 0911:030,2009, arXiv:0907.3155

- *Trilepton signals: the golden channel for seesaw searches at LHC*
  F. del Aguila, J.A. Aguilar-Saavedra, J. de Blas
  Acta Phys.Polon.B40:2901-2911,2009, arXiv:0910.2720

- *A minimal set of top-Higgs anomalous couplings*
  J. A. Aguilar-Saavedra
  Nucl.Phys.B821:215-227,2009 arXiv:0904.2387v2

- *Impact of FCNC top quark interactions on BR(t -> b W)*
  P.M. Ferreira, R. Santos
  Phys.Rev.D80:114006,2009 arXiv:0903.4470 [hep-ph]

- *Combined analysis of Z´ – t t-bar and Z´ – t t-ar j production for vector resonance searches at LHC.*
  F. del Aguila, J. A. Aguilar-Saavedra, M. Moretti, F. Piccinini, R. Pittau, M. Treccani
  arXiv:0912.3799, Phys.Lett.B685:302-308,2010

2.5.8 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	9

Chapter 3

Computing

3.1 Grid Computing

3.1.1 Resumo

O ano de 2009 foi assinalado pela reentrada em funcionamento do LHC. A infra-estrutura de computação do Worldwide LHC Computing Grid (WLCG) foi pela primeira vez sujeita a uma utilização intensa em que o Tier-2 do LIP exibiu um excelente desempenho.
Ao nível nacional o nó central de computação grid (NCG) da Iniciativa Nacional Grid entrou em produção. O NCG é a maior infra-estrutura de cálculo científico Portuguesa e é operado pelo grupo de computação do LIP. Também o processo de construção de uma infra-estrutura sustentável de computação grid na Europa deu um passo crucial com a formação do European Grid Initiative (EGI). O LIP participou activamente neste processo que culminou na adesão oficial de Portugal ao EGI.

3.1.2 Abstract

The year of 2009 was marked by the restart of the LHC collider. The Worldwide LHC Computing Grid (WLCG) was for the first time exposed to intensive usage by the experiments during which the Portuguese Tier-2 operated by LIP has shown outstanding performance.
At national level the main node for grid computing (NCG) entered in production. This centre operated by the LIP computing group is the largest scientific computing facility in Portugal.
The creation of a European sustainable grid gave a crucial step with the establishment of the European Grid Initiative (EGI). LIP has contributed actively to this process that culminated with the official adhesion of Portugal to EGI.

LIP Computing Infrastructures
The improvement of the LIP computing facilities in Coimbra initiated in 2008 was finished in the first months of 2009 adding a completely renewed site to the Portuguese Tier-2.
Additional funding was obtained in April making possible further improvements in Lisbon and Coimbra. These included the AVAC upgrade, improvement of UPS systems, upgrade of the storage servers and core switches to ten gigabit Ethernet, fast storage for the VO software and scratch space, small increase of computing capacity, fire detection and extinguishing systems in Lisbon, and upgrade of the Lisbon tape library.
A layer 2 network cloud was established been the two LIP sites and the main node for grid computing (NCG) enabling high speed connectivity between the three sites.

Worldwide LHC computing grid
The Portuguese federated Tier-2 is now in full production and is composed of resources provided by three sites: LIP-Lisbon, LIP-Coimbra and main node for grid computing (NCG). The three sites are managed by the LIP computing group. A huge effort was committed to improve the sites performance, reliability and availability. These efforts resulted in good metrics in the WLCG reports and in very good overall performance. Between November and December of 2009 Portugal was the 8th largest CPU provider among all ATLAS and CMS Tier-2s.
LIP has also contributed to the relevant WLCG bodies namely the grid deployment board and the resource review board.

Portuguese National Grid Initiative
During the first half of 2009 the work was focused in the deployment of the main node for grid computing (NCG). After a technically complex and challenging process the site become operational in July of 2009.
The main node for grid computing is the cornerstone of the grid service from the Portuguese National Grid Initiative (NGI). The NCG houses the core grid services that enable the integration of Portuguese grid sites, and provides computing and storage resources to be shared by Portuguese research communities. Included in these communities is the Portuguese WLCG Tier-2.
A small upgrade of the NCG computing resources and service systems was also performed by LIP and completed in October 2009 introducing a new generation of CPU servers. Simultaneously the housing conditions were improved with fire detection and extinguishing systems and more UPS units installed by FCCN.
In October of 2009 the LIP computing group began to create new virtual organizations and setup NCG to support new users in the context of the Portuguese National Grid initiative.

EGEE
The Enabling Grids for E-sciencE (EGEE) is the largest multidisciplinary grid worldwide. It supports a wide range of virtual organizations from many scientific domains including the WLCG. LIP continued to be responsible for the EGEE infrastructure and services in Portugal, simultaneously LIP contributed to the EGEE global and regional tasks (Portugal and Spain).
The work consisted in the operation of core grid services, support for user and site administrators in Portugal and elsewhere, routing and tracking of helpdesk tickets at regional and global level, development and packaging of the gLite Computing Element for SGE, providing training and dissemination, coordinate Portuguese sites, operate the Portuguese Certification Authority for grid computing, monitor the regional infrastructure to detect and report issues, and provide seed resources.
LIP worked with EGEE, IBERGRID and EGI-DS to prepare the transition towards EGI.

European Grid Initiative
Following the success of EGEE the European Grid Initiative aims to establish a long term sustainable European wide grid infrastructure for e-science. The sustainability model is based on direct contributions from the governments through fees paid by the NGIs and some assistance from EU projects where the costs will be assumed mostly by the NGIs.
The work took place in the context of the European Grid Initiative Design Project (EGI-DS) where LIP was present both as chair and member of the policy board. The board prepared the foundations for the establishment of EGI and worked in the transition roadmap. In the summer of 2009 the European governments including Portugal have signed the EGI MoU and have paid the corresponding fees.
Simultaneously LIP worked in the technical and administrative organization of the EGI infrastructure. A very important component of this work was the preparation of the EGI InSPIRE project through which the core of the EGI infrastructure will be funded. Again LIP will be a member of this project representing the Portuguese NGI. The EGI InSPIRE will be a four year project partially funded by the EU with an increased contribution of the governments.

IBERGRID
In the new EGI model the NGIs will have to provide many more services and functionalities. These were previously provided centrally by EGEE at CERN and some other locations. IBERGRID will enable both countries to share not only their computing resources but also these new responsibilities. In this context LIP worked closely with IFCA and CESGA in Spain as these organizations have a leading technical role in the Spanish NGI.
A pilot for the IBERGRID infrastructure was established between Portuguese and Spanish sites enabling demonstrations and trials across borders. The objective was to prepare and test the NGI infrastructures of both Portugal and Spain for a tighter integration to act as a federated regional infrastructure in EGI. A structure of regional IBERGRID virtual organizations and the services to support them was planned and deployed. This work has become the basis for the migration plan from EGEE to EGI in the Iberian region. The IBERGRID infrastructure is now ready for the transition to EGI and to assume its coordinating role and the provisioning of services at regional and European level.

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.
- Coordinated the deployment and operation of grid computing infrastructures for e-science within the context of national and international initiatives.
- Deploy and operate the Portuguese federated Tier-2 for the Worldwide LHC Computing Grid in coordination with CERN and the LHC experiments
- Contribute to the structuring and sustainability of grid computing in Europe

3.1.4 Achievements

- Successful deployment of the main node for grid computing the largest scientific computer centre in Portugal
- Successful upgrade of the main node for grid computing
- Successful upgrade of the LIP computing sites in Lisbon and Coimbra
- Successful participation of the Portuguese Tier-2 in the WLCG
- The Portuguese Tier-2 was the 8th largest Tier-2 providing resources to WLCG in the last months of 2009
- LIP won the bid to coordinate the EGI middleware processes for the whole European infrastructure
- Successful contribution to the creation of the European Grid Initiative
- Portuguese formal adhesion to the European Grid Initiative

3.1.5 Sources of Funding

Code	Funding	Start	End
GRID 233/7.2/C/NAC	1.165.376 €	2007-06-01	2009-06-30
GRID/GRI/81842/2006	180.700 €	2007-09-10	2010-09-09
EGEE-III	307.000 €	2008-05-01	2010-04-30

3.1.6 Team

Project coordinator: Jorge Gomes

Name	Status	%of time in project
Carlos Manuel	Technician (LIP)	100
Gaspar Barreira	Researcher (LIP)	70
Gonçalo Borges	Researcher (LIP)	100
Hugo Gomes	Technician (LIP)	100
João Martins	Researcher (LIP)	100
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

- *INGRID main grid computing centre: the seed infrastructure for the Portuguese NGI*
  G. Borges, J. Gomes, M. David, J. Martins, N. Dias
  IBERGRID 2009 (3rd Iberian Grid Infrastructure Conference Proceedings) Ed. V. Hernández et al., pp19-28

- *Grid Enabled Storage Systems at LIP*
  M. David, G. Borges, J. Gomes, J. Martins, M. Oliveira
  IBERGRID 2009 (3rd Iberian Grid Infrastructure Conference Proceedings) Ed. V. Hernández et al., pp 85-95

- *IBERGRID, an interoperable Grid infrastructure for the Iberian research area*
  I. Campos, J. Gomes et al.
  IBERGRID 2009 (3rd Iberian Grid Infrastructure Conference Proceedings) Ed. V. Hernández et al., pp 9-18

- *The Readiness of CMS computing centres on the WLCG grid: The Spanish and Portuguese case*
  J. Flix, M. David, J. Gomes, J. Martins, M. Oliveira, N. Almeida et al.
  IBERGRID 2009 (3rd Iberian Grid Infrastructure Conference Proceedings) Ed. V. Hernández et al., pp 210-221

- *Iberian ATLAS computing: Facing data taking*
  X. Espinal, H. Wolters, G. Borges, J. Carvalho, M.David, N. Dias, J. Gomes, M. Oliveira et al
  IBERGRID 2009 (3rd Iberian Grid Infrastructure Conference Proceedings) Ed. V. Hernández et al., pp 187-209

- *Iberian ATLAS computing: Facing data taking*
  X. Espinal, H. Wolters, G. Borges, J. Carvalho, M.David, N. Dias, J. Gomes, M. Oliveira et al
  IBERGRID 2009 (3rd Iberian Grid Infrastructure Conference Proceedings) Ed. V. Hernández et al., pp 187-209

Internal Notes

- *SWE ROC/NGIs model (Portugal)*
  J. Gomes, G. Borges, M. David

- *EGEE SA1 QR3 quarterly report*
  G. Borges, J. Gomes

- *EGEE NA2 QR3 quarterly report*
  G. Borges

- *EGEE-III Country Review Report (Portugal)*
  J. Gomes, G. Borges, M.David

- *NCG centre*
  G. Borges et al.
  LIP Boletim

Proposals

- *European Grid Initiative: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe*
  The EGI InSPIRE collaboration

3.1.8 Presentations

Oral presentations in international conferences

- *IBERGRID, an interoperable Grid infrastructure for the Iberian research area*
  presented by Jorge Gomes
  at 3rd Iberian Grid Infrastructure Conference in Valencia, Spain.
- *INGRID main grid computing centre: the seed infrastructure for the Portuguese NGI*
  presented by Gonçalo Borges
  at 3rd Iberian Grid Infrastructure Conference in Valencia, Spain.
- *Grid Enabled Storage Systems at LIP*
  presented by Mário David
  at 3rd Iberian Grid Infrastructure Conference in Valencia, Spain.
- *Grid Computing Storage, Parallel Computing and Interactivity tutorial*
  presented by Gonçalo Borges
  at UIMP: Grids and e-Science 2009, an Advanced Workshop on the future and sustainability of production Grids in Santander Spain.
- *INGRID and the European Grid Infrastructures*
  presented by Jorge Gomes
  at UIMP: Grids and e-Science 2009, an Advanced Workshop on the future and sustainability of production Grids in Santander Spain.
- *e-Infrastructures in Portugal*
  presented by Jorge Gomes
  at UIMP: Grids and e-Science 2009, an Advanced Workshop on the future and sustainability of production Grids in Santander Spain.
- *Site report on LIP facilities and branches*
  presented by Miguel Oliveira
  at HEPIX Fall Workshop 2009 in Berkeley, United States.
- *Benchmarking at LIP*
  presented by Miguel Oliveira
  at HEPiX Fall 2009 in Lawrence Berkeley National Laboratory, USA.
- *LIP Site Report*
  presented by Miguel Oliveira
  at HEPiX Fall 2009 in Lawrence Berkeley National Laboratory, USA.

Presentations in national conferences

- *gLite tutorial*
  presented by Gonçalo Borges
  at ISPDC 2009 conference: gLite tutorial in Fundação Caluste Gulbenkian, Lisboa, Portugal.
- *Infra-Estruturas de Computacao Grid: Nacional, Ibérica e Europeia*
  presented by Jorge Gomes
  at Encontro Ciência 2009 in Fundação Calouste Gulbenkian Lisboa Portugal.

Oral presentations in international meetings

- *The Portuguese National Grid Initiative*
  presented by Jorge Gomes
  at IBERGRID Coordination Meeting in Spanish Minsitry of Science and Innovation, Madrid, Spain.
- *LIPCA The Certification Authority for the Portuguese academic community*
  presented by Nuno Dias
  at 17th EUGridIPMA in Berlin, Germany.

Oral presentations in collaboration meetings

- *STORM - T2 feedback*
  presented by Mário David
  at Pre-GDB - Storage Support in CERN, Geneva, Switzerland.

Seminars

- *Infrastruturas Grid Nacionais: Presente e Futuro*
  presented by Mário David
  at in Observatorio Astronomico de Lisboa.
- *Overflowing your buffer*
  presented by Gonçalo Borges
  at LIP seminar in LIP Lisbon.

Outreach seminars

- *Computação Avançada no LIP*
  presented by Jorge Gomes
  at Hewllet Packard HPC Computing in Evora.

3.1.9 Events

- *gLite tutorial @ ISPDC*
  Outreach Event, ISPDC conference, fundação Calouste Gulbenkian, Lisboa, 2009-07-01

3.1.10 Project Summary

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Presentations in national conferences	2
Oral presentations in international meetings	2
Oral presentations in collaboration meetings	1
Seminars	2
Outreach seminars	1
Outreach Events	1

3.2 GRID para simulação e análise de dados de ATLAS/LHC

3.2.1 Resumo

As necessidades de computação da colaboração ATLAS implicam a adopção do paradigma de computação GRID. As actividades de produção de ATLAS em Portugal estão bem integradas nas actividades ATLAS da cloud ibérica, que é parte da Worldwide Large Hadron Collider Computing Grid (WLCG), com infraestruturas em Espanha e Portugal, incluindo um Tier-1 no PIC, em Barcelona, com vários Tier-2 em Espanha e um Tier-2 no LIP, em Coimbra e em Lisboa, e no Nó Central de Grid português (NCG). Durante 2009 foi operado o cluster Tier 2 de Grid de LHC (LCG/EGEE), e foi instalado novo equipamento e novo software. Foram adquiridas novas máquinas de instalação em rack, e nova capacidade de armazenamento, no sistema de ficheiros Lustre. O sistema esteve em produção para a colaboração ATLAS e outras organizações virtuais, tendo sido utilizado no processamento, armazenamento, simulação e análise de dados. Foi continuado o trabalho na área da execução de trabalhos remotos em máquinas mais poderosas e/ou com o software requerido instalado, de uma forma anónima, bem como o recurso a máquinas virtuais.

3.2.2 Abstract

The computing needs of the ATLAS Collaboration require the adoption of the Grid computing paradigm. The ATLAS production activities of the LIP-Coimbra site 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). During 2009 a LHC (LCG/EGEE) Grid Tier 2 cluster was operated, and new equipment and software was installed. New rack mounting machines were acquired, along with new storage, in the Lustre system. The system was in production for the ATLAS Collaboration and other virtual organizations, and it was used in data processing, storage, simulation and analysis. The work in the subject of remote job running in more powerful and/or with the required software installed, in an anonymous way, as well as using virtual machines.

3.2.3 Objectives

The main objective is the operation and monitoring of the local Tier-2 and Tier-3 cluster with respect to the ATLAS production activities. These include the transfer, storage, processing, reconstruction, distribution and analysis of large volumes of data, and also the production of simulated samples. It also supports the users from the Portuguese ATLAS team and has a fruitful interaction with the European South West Grid cloud (the Iberian cloud) in order to monitor and solve the common issues of operation and integration of activities.
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 flavor can be integrated. It is formed from several individual elements which provide the required functionality for the submission, tracking, recovery and validation of jobs.
The Tier-2 Grid nodes at LIP, in Lisbon and Coimbra, and in the NCG have undergone important upgrades during the last year. Lisbon increased their capacity while in Coimbra the infrastructure inherited from the former Centopeia parallel computer cluster was completely replaced by a modern rack based system. Storage systems both in Lisbon and Coimbra now implement Lustre as the underlying file system and SToRM as the SRM interface. A third node also operated by LIP was deployed at the LNEC/FCCN campus in Lisbon (NCG).

3.2.4 Achievements

Tier2

The Iberian cloud and the Portuguese Tier2 have shown excellent results in all tests during the last year. Almost all ATLAS distributed computing areas have been tested, and continuous improvement has been demonstrated in both central services and sites. The main concern, shared among all the Grid community, is the site stability, but the concept of distributed computing is enhanced in the Iberian cloud as there are two Tier-2 Federations (Spain and Portugal) which could overcome eventual outages very easily. Problems that occurred during the tests were mostly related to software version issues - each upgrade of a middleware component carries the risk of minor incompatibility problems with user software. To keep these problems under control, permanent testing runs have been performed in the cloud. During the first heavy data flow after the startup of the LHC in November 2009, the Spanish cloud and, particularly, the Portuguese Tier2, have shown excellent performance.

The storage servers network connectivity was improved, with the installation of a 10 Gbps link. It was prepared the future connection to the national network backbone at 10 Gbps. The storage capacity was also much increased.
A Tier3 for local user analysis has been 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 much more efficient use of the installed infrastructure than if separate clusters would be mounted for Tier2 and Tier3. It was also implemented a solution for hardware and services monitoring.
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 [IBERGRID2009, HEPiX Fall 2009] has allowed the presentation of the work being carried out on site.

Self-organizing clusters

In 2009, the work was focused on two main issues: virtual machines and remote job submission, which are related to the self-organizing clusters task. In terms of virtual machines the performance of different virtual machines were compared. During the year of 2009, it was defined an architecture to extend the BOINC middleware, with the possibility to run projects inside virtual machines at the volunteer client machines. Currently it is being started the implementation of this architecture.
Simultaneously there has been work on the implementation of a prototype that will enable direct job submission to remote machines, through the use of the Extensible Messaging and Presence Protocol (XMPP). XMPP is an open XML communications technology, currently used by Google Talk and many other Instant Messaging applications. The idea is to take advantage of this protocol, which is mainly used for sending messages, to submit jobs. In this way, it will be possible to form ad-hoc groups of users, thus leveraging on available resources owned, for instance, by friends or colleagues.

3.2.5 Sources of Funding

Code	Funding	Start	End
GRID/GRI/81727/2006	140.000 €	2007-04-12	2010-10-11

3.2.6 Team

Project coordinator: João Carvalho

Name	Status	%of time in project
António Onofre	Researcher (LIP)	20
Délio Almeida	Researcher (Critical Software)	30
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)	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

- *Iberian ATLAS computing: facing data taking*
  X. Espinal, H. Wolters et al.
  IBERGRID 2009 (3rd Iberian GRID Infrastructure Conference Proceedings), Ed. V. Hernández Garcia et al., pp.187-197 (2009)

3.2.8 Presentations

Oral presentations in international conferences

- *Operation of the Portuguese Tier 2 (Storage Element Component)*
  presented by Mário David
  at HEPiX 2009 Spring in Umea University, Finland.
- *Benchmarking at LIP*
  presented by Miguel Oliveira
  at HEPiX Fall 2009 in Lawrence Berkeley National Laboratory, USA.
- *LIP Site Report*
  presented by Miguel Oliveira
  at HEPiX Fall 2009 in Lawrence Berkeley National Laboratory, USA.

3.2.9 Project Summary

	number
International Conference Proceedings	1
Oral presentations in international conferences	3

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 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 2010, 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 2010, 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 future International Space Station Facility (ISS). The main physics objectives will be the search for antimatter and dark matter. In addition, it will study the propagation and confinement of cosmic rays in the Galaxy.

4.1.4 Achievements

During 2009, the AMS detector was fully re-assembled in the building 867 clean room, at CERN. The detector integration included all the detectors and the superconducting magnet that arrived at CERN at the end of 2008. The setup was fully equipped with power and acquisition systems. Cosmic data were gathered in the end of 2009. The collaboration prepared the AMS detector for a beam test in 2010, for detector alignment and calibration.
In the year 2009 the following activities were pursued by the LIP group:

- AMS software: the AMS software includes the reconstruction algorithms for the different detectors. The Portuguese group developed reconstruction algorithms for the RICH detector concerning velocity and charge evaluation. The algorithm evaluation as well as their maintenance were carried.

- Cosmic data taking: the AMS detector collected a large amount of cosmic data in 2008 without magnetic field. Analysis of this data was done on the framework of the PhD thesis currently being finished by Rui Pereira.

- Aerogel Light Yield: The group published an article on the aerogel light yield from analysis of data samples collected on test beams 2002 and 2003. A cross-check of the RICH light yield prospects derived from those data samples was done with the cosmic data taken in 2008.

Talks and Publications

- "Cosmic B/C ratio with AMS-01"

N. Tomassetti, for the AMS collaboration
Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- "The AMS-02 experiment on the ISS: status and perspectives"

P. Zuccon, for the AMS-02 collaboration
Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- "The AMS-02 Silicon Tracker Status"

A. Oliva, for the AMS-02 collaboration
Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- "The AMS-02 Tracker Alignment System: design and performances"

S. Natale, for the AMS-02 collaboration
Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- "The Anticoincidence Counter System of AMS-02"

Ph. von Doetinchem et al., for the AMS-02 collaboration
Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- "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

Collaboration meetings

- "Analysis of the 2008 cosmic-ray data using the AMS RICH: update"

(Madrid, 27-01-2009)

- "Comparison of light yield results in AMS simulations and cosmic data"

(Madrid, 27-07-2009)

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) *	13
Patrícia Gonçalves	Researcher (LIP)	5
Rui Faísca Pereira	PhD student (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 (accepted)

International Conference Proceedings

- *The AMS-02 Tracker Alignment System: design and performances*
  S. Natale, for the AMS-02 collaboration
  Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- *The AMS-02 Silicon Tracker Status*
  A. Oliva, for the AMS-02 collaboration
  Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- *The AMS-02 experiment on the ISS: status and perspectives*
  P. Zuccon, for the AMS-02 collaboration
  Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- *Cosmic B/C ratio with AMS-01*
  N. Tomassetti, for the AMS collaboration
  Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

- *The Anticoincidence Counter System of AMS-02*
  Ph. von Doetinchem et al., for the AMS-02 collaboration
  Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland 2009)

4.1.8 Presentations

Oral presentations in collaboration meetings

- *Analysis of the 2008 cosmic-ray data using the AMS RICH: update*
  presented by Rui Faísca Pereira
  at AMS RICH meeting in Madrid, Spain.

- *Comparison of light yield results in AMS simulations and cosmic data*
  presented by Rui Faísca Pereira
  at AMS RICH meeting in Madrid, Spain.

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, (on-going)

4.1.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
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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 geodésica 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. O grupo do LIP manteve responsabilidades importantes na calibração óptica do detector, estando igualmente envolvido na 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. E, 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.
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.
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 médio 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.
Para além da calibração óptica, pretendemos desenvolver um novo sistema de calibração em tempo dos foto-multiplicadores (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 ou 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 permitiram já elaborar um design preliminar, a ser aperfeiçoado e implementado em 2010. 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.
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 nos dois códigos de simulação de SNO+ que irão sendo adaptados de acordo com as medições mais precisas das propriedades do cintilador líquido e do dopante ^{150}Nd.

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 ^8B 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. The LIP group keeps important responsibilities in the optical calibration of the detector and is also involved in 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. 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.
Besides keeping responsibilities for the optical calibration, we´re 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 preliminary design has already resulted from this work, and should be perfected and implemented in 2010. 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.
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 in the two simulation codes, which will be continuously adapted with precise measurements of the liquid scintillator and ^{150}Nd loading.

4.2.3 Objectives

SNO

The main objective of our activity in SNO in 2009 was the improvement of the neutrino oscillation analysis for the three-phase combined data. The collaboration developed a global solar neutrino analysis with the full three flavor model and we planned to extend that to the KamLAND reactor neutrino experiment. In a global analysis, this is important in order to reduce the available parameter phase-space, and obtain the best possible precision on the θ_{12} mixing angle. We also planned the implementation of an analytic model, which is valid only in the best-fit region, but allows a more accurate determination of the allowed contours, since no interpolation is needed between energy bins, and a finer grid in parameter space is computationally possible.
In addition, we planned to continue the analysis of the total flux measurement through the subtraction of energy spectra in different phases ("subtraction analysis"), with different neutron capture efficiencies.

SNO+

Our group proposed a new PMT time calibration system for SNO+, based on optical fibers located externally to the Acrylic Vessel. In 2009, the main task was to characterize the angular and time dispersion properties of different fibers, in order to choose the most adequate ones. For this task, the experimental setup of the ATLAS group at CFNUL was used. These properties are essential to define the feasibility and design of the system, namely in terms of number and type of fibers, that we also needed to provide.
We also planned to estimate the sensitivity to the neutrino oscillation parameters with a reactor neutrino analysis. In terms of detector performance studies, we planned to improve our external background estimations by using the full simulation (including optical photon tracking) and reconstruction.
A longer term goal, related to these topics, and to the timing calibration, is the development of new methods for event reconstruction and identification.
- An energy reconstruction algorithm, using the information of all PMTs;
- A time signal analysis to identify pile-up events expected during the ^{150}Nd phase, and that should be adapted to identify background gammas as extended events.

4.2.4 Achievements

SNO

During 2009, the LIP SNO group gave a strong contribution to the neutrino oscillation analysis of the SNO data. We were solicited by the collaboration to contribute to improvements of the two-phase combined analysis, so we studied the uncertainties associated with an analytic parameterization of the survival probability function, and implemented the three-neutrino analysis of the KamLAND reactor neutrino experiment. The "Low Energy Threshold"paper used this analysis, and obtained the most accurate measurement to date of θ_{12}, as well as competitive limits on θ_{13}. In addition, for the upcoming paper on the full three-phase analysis, we adapted the oscillation analysis code to use an implementation of the survival probability calculation that allows improvements in the mixing angle precision.
The work on the subtraction analysis was interrupted, due to the solicitation we had to increase our contribution to the two-phase combined analysis, that was submitted for publication in 2009.
We also provided the internal review of the phase 3 day-night analysis and internal refereeing of a paper on the distributed calibration sources in SNO.

SNO+

With the lab measurements of the optical fibers for the SNO+ timing calibration system, we achieved one of our main goals for 2009. The time and angular dispersion properties of the 1 mm PMMA fibers (respectively, 2.5 ns and 15 °) were found to be adequate for the system requirements, so the design work is now proceeding.
For the first time, we studied the performance of SNO+ for external background with full simulation and reconstruction. A preliminary conclusion is that, in the ^{150}Nd double-beta decay energy region, the effective background signal is smaller than expected from the deposited energy since gamma rays have a lower response in the external region.
We´ve also started preparing the analysis of reactor anti-neutrino oscillations. Having identified that the sensitivity - with expected detector energy scale and resolution - is competitive with existing results, we will proceed with the full Monte Carlo simulation to include the correct treatment of backgrounds and reconstruction efficiencies.

4.2.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83548/2008	10.000 €	2008-11-01	2009-11-30

4.2.6 Team

Project coordinator: José Maneira

Name	Status	%of time in project
Amélia Maio	Researcher (LIP/FCUL)	10
Carlos Silva	Technician (LIP)	2
João Carvalho	Researcher (LIP/FCTUC)	1
Joaquim Oliveira	Technician (LIP)	2
José Maneira	Researcher (LIP)	30
Luís Gurriana	Technician (LIP)	10
Luís Seabra	Master student (LIP) *	35
Nuno Barros	PhD student (LIP/FCT)	100
Orlando Cunha	Technician (LIP)	3
Rui Alves	Technician (LIP)	2
Sofia Andringa	Researcher (LIP)	15
Sofia Leitão	Student (LIP)	25

4.2.7 Publications

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

- *Measurement of the Cosmic Ray and Neutrino-Induced Muon Flux at the Sudbury Neutrino Observatory*
  SNO Collaboration (including N. Barros, J. Maneira)
  Phys. Rev. D 80, 012001 (2009)

- *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

4.2.8 Presentations

Oral presentations in international conferences

- *SNO Status update*
  presented by José Maneira
  at New Worlds in Astroparticle Physics, 7th edition in São Tomé, São Tomé e Príncipe.

- *The SNO+ project*
  presented by José Maneira
  at New Worlds in Astroparticle Physics, 7th edition in São Tomé, São Tomé e Príncipe.

- *Prospects for the SNO combined 3-phase neutrino oscillation analysis*
  presented by Nuno Barros
  at XXXI International School of Nuclear Physics : Neutrinos in Cosmology, in Astro-, Particle- and Nuclear Physics in Erice, Italy.

Oral presentations in international meetings

- *Reactor anti-neutrino oscillations with SNO+*
  presented by Sofia Leitão
  at PASC Winter School 2009 in Sesimbra, Portugal.

Seminars

- *Ver o Sol a 2 km de profundidade: A Física de Neutrinos em SNO e no SNOLAB*
  presented by
  at Invited Seminar in Cefitec, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa.

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 Project Summary

	number
Articles in international journals (with indirect contribution from LIP members)	2
Oral presentations in international conferences	3
Oral presentations in international meetings	1
Seminars	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 constituiriam 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 com 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 ruído 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 ZEPLIN-III foi concluida em Setembro de 2008 com uma exposição de 850kg.days.
Em 2009 foram analisados os dados adquiridos que permitiram excluir que a secção eficaz WIMP-nucleão seja maior que 7.7×10^{-8} pb para 55GeV/c^2 a 90% CL. Este resultado está entre os 3 melhores resultados a nível mundial. Os outros dois foram obtidos pelas experiências XENON10 e CDMS-II. Os resultados obtidos para interacções dependentes e independentes do spin foram objecto de duas publicações já disponíveis (uma na Physics Review D e outra Physical Review Letters).
A equipa do LIP teve uma participação preponderante na análise dos dados. Para além de ter estado envolviva em várias subtarefas, teve à sua inteira responsabilidade o desenvolvimento e implementação de: i) o sistema de redução e análise de dados (ZE3RA); ii) um método inovador para a calibração dos fotomultiplicadores do detector utilizando os dados aquiridos durante a própria "science run"; iii) um novo método de reconstrução em posição dos eventos no detector que se revelou crucial para a obtenção do resultado final; iv) optimização do procedimento de equalização dos fotomultiplicadores.
Durante o período a que se refere este relatório, completou-se também a actualização do ZEPLIN-III e dos seus sistemas periféricos para a realização da segunda tomada de dados que tem em vista obter sinais devido a WIMPs ou conseguir melhorar o limite superior da secção eficaz de interacção dos WIMPs de cerca de uma ordem de grandeza. Os principais aspectos desta actualização foram: i) a substituição dos fotomultiplicadores por outros de muito mais baixa radioactividade diminuindo-se assim muito substancialmente o número de eventos detectados devidos ao fundo proveniente dos fotomultiplicadores; ii) a instalação de um veto exterior, baseado num cintilador plástico, que rodeia o detector o que vai possibilitar eliminar muitos eventos devidos à radioactividade externa. Em consequência destas alterações, também o sistema de aquisição de dados, o sistema de slow control e o sistema de redução e análise dos dados (ZE3RA) tiveram que ser actualizados. Estas tarefas foram da responsabilidade da equipa do LIP.
Quanto às actividades de I&D, prosseguiram-se as medidas e a modelização da reflectividade de fluoropolímeros muito usados como reflectores em detectores de xénon. Os resultados foram objecto de 3 papers já publicados. Também no âmbito do nosso programa de I&D, construímos e testámos uma montagem experimental, incluindo parte da electrónica associada, para o estudo do desempenho de fotomultiplicadores de silício a baixa temperatura e para a detecção da luz de cintilação do xénon. Caracterizamos fotomultiplicadores de silício da Hamamatsu à temperatura ambiente e para luz visível como etapa prévia aos estudos a baixa temperatura e com luz de ultravioleta que serão efectuados durante 2010.

Os indicadores obtidos (i.e. artigos publicados e comunicações em conferencias internacionais) excederam os que tinham sido previstos na proposta do projecto.

4.3.2 Abstract

There is a strong evidence for the existence of dark matter in galactic halos, for example, on measurements of the rotation curves of spiral galaxies and observations of gravitational lensing of galaxies clusters. The results of the WMAP on the cosmic microwave background strongly reinforce that evidence and they support the conclusion that cold dark matter accounts for about 23% of the mass of the universe.
The cold dark matter may be comprised by Weakly Interacting Massive Particles (WIMPs) of which the strongest candidate is the neutralino predicted by supersymmetry. WIMPs may be directly detected through elastic scattering off nuclei in an ultra-low background detector. Detector technologies currently affording the best limits on the WIMPs cross section are cryogenic semiconductor devices and two-phase (liquid‖gas) xenon detectors.
ZEPLIN Collaboration was pioneer in using xenon as detector medium for dark matter search. It has deployed and operated underground three detectors with increasing sensitivity: a pure xenon scintillator (ZEPLIN-I) followed by two-phase xenon detectors (ZEPLIN-II and ZEPLIN-III). The results achieved by ZEPLIN-I and ZEPLIN-II were world competitive at the time of publishing.
ZEPLIN-III was deployed underground in 2007.The first science run of ZEPLIN-III was completed in September 2008.
This project is the continuation of our participation in the ZEPLIN experiment which aims at direct detecting dark matter using double phase xenon detectors (i.e. liquid and vapour). The activity since the beginning of this project has been split between the participation in the ZEPLIN-III experiment and the R&D work carried out at LIP Coimbra Laboratory.
Regarding ZEPLIN-III experiment, the data analysis took place during 2009 and the results were object of two main publications, already accepted, one in Physics Review D and the other in Physical Review Letters. The results ruled out the scalar WIMP-nucleon interactions with world competitive sensitivity (90% CL upper limit of 8.1×10^{-8}pb at 55GeVc^{-2}), similar to those of the world´s leading experiments, CDMS-II and XENON10, which are both US-led. ZEPLIN-III has out-performed all European experiments by a significant margin.
A new independent paper has appeared confirming the non-linear dependence of the relative efficiency for nuclear recoils claimed by ZEPLIN-III. This means the XENON10 limit shown be revised upwards, leaving ZEPLIN-III second only to CDMS-II.
The LIP-Coimbra team was deeply involved in the data analysis of the first science run. Besides the participation in other sub-tasks, we had full responsibility for the development and implementation of: i) the data reduction and data analysis system (ZE3RA); ii) a innovative method for the in-situ calibration of the PMT array; iii) a new position reconstruction method used in the data analysis; iv) optimization of the flat-field procedure.
During the period covered by this report, the upgrade of ZEPLIN-III and its ancillary systems was almost completed. The main features of this upgrade are the replacement of the photomultipliers by very low background ones and the installation of a scintillator veto. In consequence of this upgrade, the data acquisition system (DAQ), the slow control and the data reduction & data analysis system had also to be upgraded, tasks that LIP team took full responsibility for.
Regarding the R&D activities, we pursued the measurements and modelling of the reflectivity, including its angular distribution, of fluoropolymers for the xenon scintillation light. Three papers, already accepted for publication, resulted from the studies on the reflectance of PTFE and others fluoropolymers. Also in the framework of our R&D program, we built-up and fully tested the setup and readout electronics for studying the performance of silicon photomultipliers at low temperature and for the detection of liquid xenon scintillation. The characterization of Hamamatsu silicon photomultipliers at room temperature and for visible light was carried out before starting the measurements at low temperature and VUV light. This work is to be continued by investigating the use of MPPCs at low temperature for the detection of xenon scintillation light (175 nm).
One can conclude that the initial objectives of the project were accomplished and there were no significant deviations with respect to the project proposal. However there was a delay in the execution of the project relatively to the proposal. In fact, the preparation of the second science run of ZEPLIN-III suffered a delay of several months due to the late delivery of the new photomultipliers by ETL.
The deliverables/output indicators (i.e. papers published and communications in international conferences) obtained exceeded in those expected in the project proposal.

4.3.3 Objectives

This project is the continuation of our participation in the ZEPLIN program which aims at direct detecting dark matter using double phase xenon detectors (i.e. liquid and vapour). The main aims of the project were the following:
1) to analyze the data from the first science run and publish the result; 2) to upgrade ZEPLIN-III with two major improvements: replacement of the photomultiplers and installation of a veto; 3) to commission the upgraded detector and ancillary systems; 4) to carry out a one-year science run; 5) to work out a proposal for the development of a preliminary design for a one-ton experiment in the framework of the recently established LUX-ZEPLIN collaboration.
In addition, we aim at pursuing R&D activities related to the study of alternative light and/or charge readouts for liquid xenon detectors, namely SiPM, and continue the measurements and modelling of the reflectivity of PTFE for VUV light (175 nm).

4.3.4 Achievements

Activity since the beginning of this project has been split between the participation in the ZEPLIN-III experiment and the R&D work carried out at LIP Coimbra Laboratory.

ZEPLIN-III first science run: data analysis
The first science run (FSR) of ZEPLIN-III acquired 847 kg.days of raw data. An analysis of that data has excluded a WIMP-nucleon elastic scattering spin-independent cross section above 8.1×10^{-8} pb at 60 GeV/c^2 WIMP mass and a WIMP neutron spin-dependent cross section above 1.9×10^{-2} pb at 55 GeV/c^2 both with a 90% confidence two-sided limit. These results are similar to those of the world´s leading experiments, CDMS-II and XENON10, which are both US-led. ZEPLIN-III has out-performed all European experiments by a significant margin. The data analysis and the results are detailed in two main publications (V.Lebedenko et al., Phys.Rev.D 2009 and V.Lebendenko et al. Phs.Rev.Lett. 2009).
The LIP team was deeply involved in practically all areas of the experiment, playing a key role in some of them. For the FSR data analysis we took full responsibility for:

- The development of a novel method for calibrating arrays of photomultiplier tubes (F. Neves et al., Astroparticle Phys. 2010). This allowed establishing the response linearity of our experiment to small signals. The technique developed by the Coimbra team is already attracting the interest of competitor experiments and others who want to apply it to detector arrays.
- The proposal and implementation of a position reconstruction algorithm which proved to be quite efficient and reliable. The event position reconstruction is important for increasing the fiducial volume and to reject multiple scattering events and close-to-the-wall collisions resulting from radioactive decays from the materials of the detector, playing a key role in setting the ultimate sensitivity to WIMPs.
- Statistical characterisation of the gamma-ray background population in the first science run data which contributed to the tight limits the experiment went on to place on the hypothetical presence of a WIMP signal.

ZEPLIN-III upgrade towards second science run
ZEPLIN-III has been upgraded in view of a second science run. Since the photomultipliers were the dominant source of background in the first science run they were replaced by pin-by-pin compatible ones manufactured with materials of higher radiopurity. It is expected that the gamma-ray and neutron backgrounds will be improved by a factor of ≈30.
An active scintillator veto, surrounding the detector inside the lead castle, replaced the previously used passive neutron shielding. It consists of 52 plastic scintillator modules placed around and above the detector. Each module has a 3 inch photomultiplier at one end, a mirror at the other end and it is wrapped with PTFE along length followed by a black outer wrap. A 15 cm thick 1% gadolinium loaded polypropylene was placed between the scintillator and the target working as neutron moderator.
The second science run is expected to start in the beginning of 2010.
For the preparation of the second run, the LIP team has taken full responsibility of the upgrade of the DAQ, the slow control system and the Data Reduction and Analysis Software.

R&D activities
1. Silicon Photomultipliers

- The setup for the study of the silicon photomultipler (also referred to as MPPC that stands for Multi-Pixel Photon Counter)) at low temperature was constructed, assembled and tested. This setup is composed of a test chamber and a cooling system. The setup allows to carry out measurements at the temperature down to liquid nitrogen temperature at temperature stability better than 1°C.
- A pulsed pure xenon light source made of a xenon scintillation chamber equipped with an internal alpha-source was built and tested for the measurements to be carried out at the xenon scintillation light wavelength (175 nm).
- The readout electronics for the MPPC was built.
- A Hamamatsu MPPC (100 pixels and 1mm^2 area) was tested at room temperature using blue and UV (250 nm) LEDs. The gain and dark count as a function of the bias voltage was measured.
- Measurements of the dark count rate at low temperature were carried out down to 100°C. The noise was observed to decrease by 5 orders of magnitude (down to $\approx$ 1count/s at -100°C) but the afterpulse rate seems to increase. This effect is currently being studied in detail.

2. Reflectivity measurements
The measurements of reflectance of materials employed in liquid xenon detectors, as well as the analysis of the data acquired, were continued.

- Various samples of PTFE, manufactured by different processes (extruded, expanded, skived and pressed) have been studied. The data were interpreted with a physical model comprising both specular and diffuse reflections. The reflectance obtained for these samples ranges from about 47% to about 70% for VUV light in vacuum. The total reflectance for PTFE in contact with liquid xenon was estimated to be higher than 90%. Fluoropolymers, namely ETFE, FEP and PFA were also measured.
- An improved reflection model with three components, a specular spike, a specular lobe and a diffuse lobe was developed.
- This model was successfully applied to describe the data on reflection of xenon scintillation light (175 nm) by PTFE and other fluoropolymers. The measured data favours a Trowbridge-Reitz distribution function of ellipsoidal micro-surfaces.

This work has been carried out in the framework of a Ph.D thesis. Three papers were already accepted for publication. A conference presentation was made at ISRP11 (20-25 September, Melbourne, Australia) that won the prize of the best student poster presentation.

4.3.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83501/2008	75.000 €	2008-10-01	2009-12-31

4.3.6 Team

Project coordinator: Isabel Lopes

Name	Status	%of time in project
Alessio Mangiarotti	Researcher (LIP)	15
Alexandre Lindote	Post-Doc (LIP) *	100
Américo Pereira	Technician (LIP)	25
Ana Patrícia Eliseu	Master student	29
Cláudio Silva	PhD student (LIP/FCT)	100
Filipa Balau	PhD student (LIP)	100
Francisco Neves	Post-Doc (LIP)	100
Isabel Lopes	Researcher (LIP/FCTUC)	55
José Pinto Da Cunha	Researcher (LIP/FCTUC)	25
Luiz de Viveiros	Post-Doc (LIP)	12
Nuno Carolino	Technician (LIP)	25
Vitaly Chepel	Researcher (LIP/FCTUC)	45
Vladimir Solovov	Researcher (LIP)	100

4.3.7 Publications

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

- *A model of the reflection distribution in the vacuum ultra violet region*
  C. Silva, J. Pinto da Cunha, A. Pereira, V. Chepel, M. I. Lopes, V. Solovov, F. Neves
  NIM A (accepted)

- *Simulation of neutrons produced by high-energy muons underground*
  A.Lindote, H. M. Araújo, V. Kudryavstev, M. Robinson
  Astroparticle Physics 31 (2009), 366-375

- *Results from the First Science Run of the ZEPLIN-III Dark Matter Search Experiment*
  V.N. Lebedenko, H.M. Araújo, E.J. Barnes, A. Bewick, R. Cashmore, V.Chepel, et al
  Physical Review D, Vol.80, No.5 (2009) 052010, [14 pages]

- *Limits on the spin-dependent WIMP-nucleon cross sections from the first science run of the ZEPLIN-III experiment*
  V.N. Lebedenko, H.M. Araújo, E.J. Barnes, A. Bewick, R. Cashmore, V.Chepel, et al,
  Phys. Rev. Lett. 103, 151302 (2009) [4 pages]

- *Calibration of Photomultiplier Arrays*
  F. Neves, V. Chepel, D. Yu. Akimov, H. M. Araujo, E. J. Barnes et al,
  Astroparticle Physics (accepted)

International Conference Proceedings

- *Results from the first science run of ZEPLIN-III*
  M I Lopes for the ZEPLIN-III Collaboration
  Journal of Physics, Conference Series (accepted)

4.3.8 Presentations

Poster presentations in international conferences

- *A model of the reflection distribution in the vacuum ultra violet region*
  presented by Cláudio Silva
  at ISRP11 - International Symposium on Radiation Physics in Melbourne, Australia.

Oral presentations in international meetings

- *Results from the first science run of ZEPLIN-III*
  presented by Isabel Lopes
  at TAUP09 International Conference on Topics in Astroparticle and Underground Physics in Rome, Italy.

- *First results of the ZEPLIN-III dark matter detector*
  presented by Alexandre Lindote
  at 7th New Worlds in Astroparticle Physics in S. Tomé e Principe.

- *Results from the first science run of ZEPLIN-III dark matter experiment*
  presented by Isabel Lopes
  at ISRP11 - International Symposium on Radiation Physics in Melbourne, Australia.

Oral presentations in collaboration meetings

- *Slow control in the SSR*
  presented by Vladimir Solovov
  at ZEPLIN-III Collaboration Meeting in Abingdon, UK.
- *Data compression testing*
  presented by Alexandre Lindote
  at ZEPLIN-III Collaboration Meeting in Abingdon, UK.
- *PMT calibration & ZE3RA 3.0*
  presented by Francisco Neves
  at ZEPLIN-III Collaboration Meeting in Abingdon, UK.
- *Single electrons in dedicated datasets*
  presented by Vladimir Solovov
  at ZEPLIN-III Collaboration Meeting in Abingdon, UK.
- *R&D related to liquid xenon detectors for dark matter search*
  presented by Isabel Lopes
  at ZEPLIN-III Collaboration Meeting in Abingdon, UK.
- *To recombine or not to recombine: that is the question"*
  presented by Vitaly Chepel
  at in ITEP, Moscow, Russia.

4.3.9 Academic Training

PhD Theses

- *Data acquisition and analysis of ZEPLIN detectors"*
  Alexandre Lindote, 2009-05-20
- *Liquid xenon detectors for WIMP search"*
  Cláudio Silva, (on-going)

4.3.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	5
International Conference Proceedings	1
Poster presentations in international conferences	1
Oral presentations in international meetings	3
Oral presentations in collaboration meetings	6
PhD Theses	1

4.4 High Energy Cosmic Rays

4.4.1 Resumo

As actividades do LIP na área dos raios cósmicos de alta energia continuaram centradas na participação no Observatório Pierre Auger (Auger). A participação em GAW - Gamma Air Watch, um projecto de I&D na área da detecção de raios gama, foi também mantida. O laboratório de electrónica de raios cósmicos tem apoiado estas actividades bem como assegurado a capacidade de ensino dirigido a alunos do segundo ciclo. O grupo do LIP em Auger tem também apostado na divulgação da física dos raios cósmicos em escolas e outros locais.
Auger é uma colaboração internacional para investigação na área dos raios cósmicos de muito alta energia, permitindo simultaneamente abrir uma nova janela para a exploração do Universo e estudar colisões de partículas a energias muito superiores às que se conseguem obter em aceleradores na Terra. Questões como de onde vêm e o que são estes raios cósmicos ainda não têm uma resposta cabal, mas os resultados já obtidos permitem esperar progressos significativos nos próximos anos.
O Observatório opera um detector híbrido que consiste num detector de superfície, constituído por uma rede de tanques de água para a detecção das partículas carregadas das cascatas atmosféricas, e um detector de fluorescência, constituído por um conjunto de telescópios que observam a luz de fluorescência produzida na atmosfera acima do detector de superfície.
Os resultados mais recentes do Observatório Pierre Auger consistem em: medição do espectro de energia, em que se observa claramente o ´tornozelo´ e uma supressão do fluxo compatível com o efeito ´GZK´; evidência da existência de anisotropia nas direcções de chegada dos raios cósmicos de maior energia (acima de 55 EeV); limites superiores para o fluxo de fotões com energias acima de 10 EeV e 3EeV, usando repectivamente o detector de superfície e o detector de fluorescência; limite no fluxo de neutrinos do tau ´Earth-skimming´; um novo limite no fluxo de neutrinos independente do sabor, obtido através da observação de chuveiros quasi-horizontais; análise estatística da profundidade do máximo dos chuveiros (Xmax) para energias até 30EeV. Em particular os resultados do espectro de energia, das direcções de chegada e da distribuição de Xmax são impressionantes e constituem um novo passo na compreensão da origem destes raios cósmicos e das interacções a energias extremas.
Portugal aderiu ao Observatório Pierre Auger em Março de 2006. Em 2009 a participação portuguesa esteve centrada no detector de fluorescência e em projectos para a extensão da sensibilidade de Auger para energias inferiores (AMIGA e HEAT). O trabalho na área da fenomenologia que tem vindo a ser realizado em colaboração com teóricos portugueses foi também mantido. No verão de 2009, o nosso grupo recebeu 4 alunos do ensino secundário num estágio científico, em que foram trabalhados os dados públicos disponibilizados pelo Observatório Pierre Auger.
Finalmente, o nosso grupo tornou-se um membro activo da Organização Virtual de Auger para a computação Grid.
GAW (Gamma Air Watch) é um projecto de I&D que junta grupos de investigação de Itália, Espanha e Portugal. Este projecto pretende testar um novo conceito de telescópio para detecção de cascatas iniciadas por raios gama (IACTs), baseado em lentes de Fresnel e fotomultiplicadores multiânodo, com o objectivo de conciliar uma elevada sensibilidade e uma grande abertura angular. O grupo do LIP tem responsabilidades no desenvolvimento da simulação do telescópio, no desenho e implementação dos sistemas de aquisição e sincronização dos dados, no desenvolvimento de "firmware"para a electrónica de GAW e no desenvolvimento de algoritmos de "trigger"e a sua implementação no "firmware"do "trigger"de GAW.

4.4.2 Abstract

The main activities of LIP in the field of High Energy Cosmic Rays (HECR) remained focused in the participation in the Pierre Auger Observatory (Auger). The participation in GAW - Gamma Air Watch program, an R&D project in the field of gamma ray detection, was also pursued. The Cosmic ray electronic laboratory provided a support for such activities and has ensured the teaching environment for second cycle courses. The LIP Auger group have also carried outreach activities at schools and other places.
Auger is a worldwide collaboration for research on very high energy cosmic rays. The study of high energy cosmic rays opens a new window in the exploration of the Universe. It also gives access to particle collisions at energies far above the ones reacheable at accelerators. The fundamental questions related to the origin and nature of such cosmic rays do no yet have a full answer, but the Auger results obtained so far make us expect significant progress in the next few years.
The Observatory is a hybrid detector including a ground array of water Cherenkov tanks (the surface detector) and a set of air fluorescence telescopes observing the atmosphere above the array (the fluorescence detector).
The latest results of the Pierre Auger Observatory comprise: an energy spectrum with a clearly observed ankle and a ´GZK´-like suppression; clear evidence for anisotropy on the arrival directions of the highest energy

cosmic rays (above 55 EeV); limits on the photon flux at 10 EeV (using the surface detector) at 3 EeV (using the fluorescence detector); a limit on the Earth-skimming tau neutrino flux; a new limit on the neutrino flux of all flavours using nearly-horizontal showers; and a statistical analysis of the depth of the shower maximum (Xmax) for energies up to 30 EeV. In particular, the results on the energy spectrum, on the arrival directions and on the Xmax distribution are striking and may point to a new understanding of the field.
Portugal has joined the Pierre Auger Observatory in March 2006. In 2009, the Portuguese participation has been centered in the fluorescence detector data and in the enhancement projects. The phenomenological work done in collaboration with Portuguese theoreticians was also pursued. Our group is now an active member of the Auger Virtual Organization for Grid computing. Finally, our group has received 4 high-school students, in the scope of the Ciência Viva program "summer in the science", that have analysed the public events made available by the Pierre Auger Observatory.
GAW (Gamma Air Watch) is an Italian-Spanish-Portuguese R&D project to test the feasibility of a new concept of Imaging Atmospheric Cherenkov Telescope, based on Fresnel lenses as the light collector and an array of multi-anode photomultipliers working in single photoelectron counting mode.The main goal of the GAW concept is to reach a large field-of-view and a high flux sensitivity.The LIP team has specific responsibilities in the detector simulation, in the design and implementation of the data acquisition and synchronization systems, in the development of firmware for the GAW electronics and in the development of trigger algorithms and their implementation on the firmware of the trigger system.

4.4.3 Objectives

The Auger South site is now working smoothly and high quality data is being acquired. The first 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 site and the overall design of Auger North are now established. The control of the systematic and the design of new analysis tools have from now on a clear priority. In 2009 the main topics of our work were centred in:
-Light collection in the fluorescence telescopes
-Longitudinal shower profile parameterisation
-3D simulation
-Exotic searches in Auger
-Contribution to the Auger Offline software framework
-Participation in Auger North
-Activities of the cosmic ray electronics laboratory
-Outreach of cosmic rays physics
In the initial scheduling of the GAW project the first telescope was expected to be already operational and taking data. However the bidding process in Spain for the manufacture of the Fresnel lens was delayed due to administrative reasons.The contract for the production of the lens was finally signed in the summer of 2009 between the Spanish government and the lens manufacturer. The central piece of the lens is now expected to be ready during 2010 and the first validation tests and commissioning at the Calar Alto Observatory could start soon after the lens delivery.

4.4.4 Achievements

The main contributions of the LIP Auger team were:
-A detailed and innovative study of the light collection efficiency non-uniformities within each pixel of the fluorescence detector cameras using laser events. Larger non-uniformities than expected were found. As a consequence, the need to perform laboratory measurements in order to map this efficiency has been recognized. Such measurements were conducted at LIP, in Coimbra.
-The detailed analysis of the laser data in order to disentangle the contribution for the shower lateral width of the multiscatering components and of the detector effects.
-The proposal of a new parameterisation of the air shower longitudinal profile, based on variables more independent from each other and with a more clear physical interpretation.
-The development of a 3-dimensional simulation tool, which will allow a more accurate treatment of several critical aspects of light production and scattering in air shower development, was pursued. Both the fluorescence, direct Cherenkov and scattered Cherenkov light components are at present fully implemented.
-The design and first implementation of tools for the search of events with non-standard longitudinal profiles, namely, with the so called double bang topology. Both Model dependent and Model independent approach were followed.

-The production in the LIP workshop in Coimbra of full scale prototype of the mirror supporting structures for the Auger North fluorescence telescopes.
-The activities in outreach of cosmic rays physics include the summer occupation of 4 high-school students, seminars at schools, and a formation program for teachers co-organized at Amadora High-School. A more detailed report of these activities is provided in the report of the LIP Outreach project.
During 2009 the main line of work of the LIP GAW team was the consolidation of the end-to-end simulation and reconstruction framework. The GAWsoft (GAW software offline tool) package is composed of several modules, each corresponding to a well defined stage of the physics and detector simulation: generation of high-energy gammas, air shower development, telescope optics, electronics and trigger. The baseline version of this framework includes the detailed simulation of the telescope using the Geant4 toolkit, the integration of the Corsika shower generator and the definition and implementation of the data elements being recorded along this chain. Besides reading the Corsika event structure, the GAWsoft package allows to use alternative physics event generators. Presently three types of external photon generators are implemented as an input: a Vega-like spectrum, monochromatic photons or following a Cerenkov spectrum and the night sky background.The steering program has been made configurable at running time through data cards files and the relevant information produced at the different levels is stored in a ROOT tree.
In 2009 the cosmic ray electronics laboratory has been actively working.A special emphasis was given to the support of teaching activities, namely the start up of the PCLD ("Projecto e Controlo em Lógica Digital") (Project and Control with Digital Logic) course. Also several students undergraduated students (1st cycle of Bologna) were trained in digital electronic through the development of small projects. The research and outreach activities were pursued namely the final design of LPV3 was accomplished. This work was done in close collaboration with José Carlos Silva.

4.4.5 Sources of Funding

Code	Funding	Start	End
PTDC/FIS/65308/2006	155.000 €	2007-04-22	2009-10-31
CERN/FP/83484/2008	125.000 €	2008-10-01	2009-12-31
CERN/FP/109286/2009	145.000 €	2009-11-01	2010-10-31

4.4.6 Team

Project coordinator: Mário Pimenta

Name	Status	%of time in project
Alessandro de Angelis	Researcher	10
André França	Student (LIP)	67
Andreia Trindade	Post-Doc (LIP/FCT)	5
Bernardo Tomé	Researcher (LIP)	80
Catarina Espírito Santo	Researcher (LIP)	95
Cristóvão Silva	Student (LIP)	67
Eva Santos	PhD student (LIP/FCT)	100
Fernando Barão	Researcher (LIP/IST)	30
Gonçalo Terça	Student (LIP)	67
João Caldeira	Student (LIP)	67
João Carvalho	Researcher (LIP/FCTUC)	10
João Espadanal	Master student (LIP)	82
Jorge Dias de Deus	Researcher (LIP/IST)	10
Jorge Romão	Researcher (LIP/IST)	10
Jorge Tiago Santos	Student (LIP)	67
José Carlos Silva	Technician (LIP)	5
José Milhano	Researcher (LIP/IST)	10
Lorenzo Cazon	Researcher (LIP)	17
Luís Mendes	Technician (LIP)	100
Luís Pires	Student (LIP)	67
Luisa Arruda	Post-Doc (LIP/FCT)	80
Mário Pimenta	Researcher (LIP/IST)	80
Patrícia Gonçalves	Researcher (LIP)	50
Pedro Abreu	Researcher (LIP/IST)	65
Pedro Assis	Post-Doc (LIP/FCT) *	87
Pedro Black Henriques	Student (LIP)	67
Pedro Brogueira	Researcher (LIP/IST)	20
Pedro Lourenço	Student (LIP)	33
Pedro Rodrigues	Post-Doc (LIP/FCT)	5
Raquel Queiroz	Student (LIP)	67
Ruben Conceição	PhD student (LIP/FCT)	100
Sara Tavares	Student (LIP)	67
Sofia Almeida	Student (LIP)	67
Sofia Andringa	Researcher (LIP)	85
Vera Patrício	Student (LIP)	33

4.4.7 Publications

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

- *A Model for net-baryon rapidity distribution*
  J. Alvarez-Muniz, R. Conceição, J. Dias de Deus, M. C. Espírito Santo, J. G. Milhano, M. Pimenta
  Eur. Phys. J. C (2009) 61 391-399

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

- *Limit on the diffuse flux of ultrahigh energy tau neutrinos with the surface detector of the Pierre Auger Observatory*
  J. Abraham et. al., The Pierre Auger Collaboration.
  Phys. Rev. D 79, 102001 (2009)

- *Upper limit on the cosmic-ray photon fraction at EeV energies from the Pierre Auger Observatory*
  J. Abraham et. al., The Pierre Auger Collaboration.

Astroparticle Physics 31 (2009) 399-406

- *Atmospheric effects on extensive air showers observed with the Surface Detector of the Pierre Auger Observatory.*
  J. Abraham et. al., The Pierre Auger Collaboration.
  Astroparticle Physics 32 (2009) 89-99

- *Trigger and Aperture of the Surface Detector Array of the Pierre Auger Observatory*
  J. Abraham et. al., The Pierre Auger Collaboration.
  Nuclear Instruments and Methods in Physics Research A613(2010)29-39

International Conference Proceedings

- *Net-Baryon Physics Basic Mechanisms*
  J. Alvarez-Muniz R. Conceição J. Dias de Deus M. C. Espírito Santo J. G. Milhano, M. Pimenta
  Proceedings of the 21st European Cosmic Ray Symposium

- *A model for net-baryon rapidity distribution*
  R. Conceição, J. Alvarez-Muñiz, J. Dias de Deus, M.C. Espírito Santo, J. G. Milhano, M. Pimenta
  Proceedings of the 31st International Cosmic Ray Conference, Lodz, 7-15 July 2009, Poland

- *A simulation of the fluorescence telescopes of the Pierre Auger Observatory using Geant4*
  P. Assis, for the Pierre Auger Collaboration
  Proceedings of the 31st International Cosmic Ray Conference, Lodz, 7-15 July 2009, Poland

- *Increased Sensitivity to Electromagnetic and Hadronic Features of Air Showers from a New Parameterization of the Longitudinal Profiles*
  S. Andringa, R. Conceição, M. Pimenta
  Proceedings of the 31st International Cosmic Ray Conference, Lodz, 7-15 July 2009, Poland

Collaboration notes with internal referee

- *Mass Composition and Cross-section Sensitivity from a New Parameterization of the Longitudinal Profiles*
  S. Andringa, R. Conceição, M. Pimenta
  Pierre Auger Collaboration Internal Note, GAP2009-058

- *Mapping the FD pixel non-uniformities with laser events*
  S. Andringa, P. Assis, R. Conceição, M.C. Espirito Santo, P. Gonçalves, M. Pimenta, B. Tomé
  Pierre Auger Collaboration Internal Note, GAP2009-067

- *Simulation of the fluorescence telescopes of the Pierre Auger Observatory using GEANT4*
  P. Assis, P. Gonçalves, M. Pimenta, B. Tomé
  Pierre Auger Collaboration Internal Note, GAP2009-104

Internal Notes

- *AUGER Fluorescence Detector Mirrors Regulation System*
  R. Alves, J. Carvalho, J. Oliveira, C. Silva

4.4.8 Presentations

Oral presentations in international conferences

- *GAW - A very large field-of-view Imaging Atmospheric Cherenkov Telescope*
  presented by Luisa Arruda
  at 44th Rencontres de Moriond-Very High Energy Phenomena in the Universe in La Thuile, Val d Aosta, Italy.

Poster presentations in international conferences

- *A model for net-baryon rapidity distribution*
  presented by Ruben Conceição
  at 31st International Cosmic Ray Conference in Lodz, Poland.
- *Increased Sensitivity to Electromagnetic and Hadronic Features of Air Showers from a New Parameterization of the Longitudinal Profiles*
  presented by Sofia Andringa
  at 31st International Cosmic Ray Conference in Lodz, Poland.
- *A simulation of the fluorescence telescopes of the Pierre Auger Observatory using Geant4*
  presented by Pedro Assis
  at 31st International Cosmic Ray Conference in Lodz, Poland.

Oral presentations in international meetings

- *Net Baryon Physics*
  presented by Ruben Conceição
  at Workshop on high-density QCD at the LHC and in cosmic rays in Santiago de Compostela, Galicia, Spain.
- *Universality of the Extensive Air Shower profiles*
  presented by Sofia Andringa
  at Workshop on high-density QCD at the LHC and in cosmic rays in Santiago de Compostela, Galicia, Spain.
- *Exploration of double-bang signatures in cosmic ray experiments*
  presented by Catarina Espírito Santo
  at Pierre Auger Observatory Workshop on Exotic Physics in Cosmic Rays in Lisboa, Portugal.
- *Interfacing the Pythia generator with the Auger environment*
  presented by Pedro Abreu
  at Pierre Auger Observatory Workshop on Exotic Physics in Cosmic Rays in Lisboa, Portugal.
- *Generation of exotic events using CONEX*
  presented by Bernardo Tomé
  at Pierre Auger Observatory Workshop on Exotic Physics in Cosmic Rays in Lisboa, Portugal.
- *Telescope Simulations with Geant4*
  presented by Pedro Assis
  at 7th International Workshop on New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Príncipe.
- *The AMIGA Project*
  presented by Eva Santos
  at 7th International Workshop on New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Príncipe.
- *The GAW project*
  presented by Luisa Arruda
  at 7th International Workshop on New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Príncipe.
- *A model for net-baryon rapidity distributions*
  presented by Ruben Conceição
  at 7th International Workshop on New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Príncipe.

- *Analysis of cosmic-ray shower longitudinal profiles*
  presented by Sofia Andringa
  at 7th International Workshop on New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Príncipe.
- *Exotic Physics in High Energy Cosmic Rays*
  presented by Bernardo Tomé
  at 7th International Workshop on New Worlds in Astroparticle Physics in S. Tomé, S. Tomé e Príncipe.
- *The GAW project*
  presented by Luisa Arruda
  at PASC Winter School, 2009 in Sesimbra, Portugal.
- *Pierre Auger Observatory: A physics challenge*
  presented by Ruben Conceição
  at PASC Winter School in Sesimbra, Portugal.
- *Pierre Auger Observatory - Double ShellEvents*
  presented by Eva Santos
  at PASC Winter School in Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *Status of 3D simulation and direct Cherenkov light studies*
  presented by Catarina Espírito Santo
  at Auger Collaboration Meeting in Malargue, Argentina.
- *Non-uniformities of the FD camera*
  presented by Ruben Conceição
  at Auger Collaboration Meeting in Malargue, Argentina.
- *Universal shower profile variables for mass composition and cross-section*
  presented by Sofia Andringa
  at Auger Collaboration Meeting in Malargue, Argentina.
- *A simulation of the fluorescence detectors of the Pierre Auger Observatory using GEANT4*
  presented by Pedro Assis
  at Auger Collaboration Meeting in Malargue, Argentina.
- *Commissioning of the GAW telescope with a reduced PMT matrix*
  presented by Luisa Arruda
  at GAW Coll. Meeting in Granada, Spain.
- *Status of the GAWsoft package*
  presented by Luisa Arruda
  at GAW Coll. Meeting in Granada, Spain.
- *Diffraction Grating Class Implementation on Geant4*
  presented by Bernardo Tomé
  at GAW Coll. Meeting in Granada, Spain.
- *Measurement of the PMT non-uniformities*
  presented by Pedro Assis
  at Auger Collaboration Meeting in Malargue, Argentina.
- *Evaluating the Multi-Scattering contribution with laser, flasher events*
  presented by Ruben Conceição
  at Auger Collaboration Meeting in Malargue, Argentina.
- *Outreach activities at LIP/Portugal*
  presented by Sofia Andringa
  at Auger Collaboration Meeting in Malargue, Argentina.
- *Exotica Search Status at Lisboa*
  presented by Eva Santos
  at Auger Collaboration Meeting in Malargue, Argentina.

4.4.9 Academic Training

PhD Theses

- *Data acquisition and control systems in cosmic ray experiments"*
  Pedro Assis, 2009-01-14
- *Hadronic Models in EAS"*
  Ruben Conceição, (on-going)
- *Cosmic rays in the ankle region at the Pierre Auger Observatory"*
  Eva Santos, (on-going)

Master Theses

- *Non-standard events at the Pierre Auger Observatory"*
  João Espadanal, (on-going)

4.4.10 Events

- *Pierre Auger Observatory Workshop on Exotic Physics in Cosmic Rays*
  Workshop, Lisbon, Portugal, 2009-07-03

4.4.11 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Articles in international journals (with indirect contribution from LIP members)	4
International Conference Proceedings	4
Collaboration notes with internal referee	3
Internal Notes	1
Oral presentations in international conferences	1
Poster presentations in international conferences	3
Oral presentations in international meetings	14
Oral presentations in collaboration meetings	11
PhD Theses	1
Workshops	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.
Resultados anteriores, tanto em azoto puro como em ar seco, na banda dos 337 nm, indicaram um claro desvio relativamente ao modelo teórico geralmente aceite para a dependência da fluorescência do ar com a temperatura do gás. Este ano foram realizadas medidas complementares da luz emitida em ar seco, em função da temperatura, que validaram as nossas medidas anteriores. A análise dos dados relativos a medidas de intensidades luminosas e de constantes de decaimento (medidas resolvidas no tempo) ficouconcluída tendo dado origem a uma publicação numa revista internacional com arbitragem. Desenvolveram-se e aperfeiçoaram-se ainda as ferramentas de simulação que são usadas na validação dos modelos físicos propostos.
Em paralelo, foi montado um novo sistema experimental que permite medir os tempos médios de vida moleculares utilizando um feixe de eletrões de baixa energia (≈10 keV) como fonte de excitação. Os testes preliminares foram já realizados e o sistema está pronto para a aquisição de dados. Este sistema foi desenvolvido em colaboração com o grupo do Prof A. Ulrich da Faculdade de Física da Universidade Técnica de Munique. O objetivo é medir as constantes de decaimento a pressões muito baixas e extrair informação sobre a dependência com a pressão da taxa de desactivação colisional por moléculas de azoto no estado fundamental. Esperamos que esta informação, juntamente com os resultados dos cálculos teóricos que estão a ser realizadas no Departamento de Química da Universidade de Coimbra permita o esclarecimento dos processos envolvidos na cintilação UV do N2.
Na última Air Fluorescence Workshop, realizado em L´Aquila, na Itália, em Fevereiro de 2009, foi decidido que o próximo encontro seria realizado em Coimbra, em Setembro de 2010, organizado pelo nosso grupo. A organização deste evento está em andamento.

4.5.2 Abstract

The detection of the nitrogen UV scintillation produced in the atmosphere by extensive air showers (EAS) 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.
Previous results, both in pure nitrogen and in dry air, for the 337 nm band, clearly indicated a deviation from the generally accepted theoretical model for the dependence of air fluorescence on gas temperature. Complementary measurements have been performed in dry air as a function of temperature which validated our former measurements. The analysis of the light yield data and time resolved measurements was completed and a paper was published. The simulation tools for the validation of the physical models were also developed.
In parallel, a new set-up has been assembled to allow the measurement of molecular lifetimes using a low energy electron beam (10 keV) as excitation source. All the preliminary tests have been performed and the system is ready for data acquisition. This work has been developed in collaboration with the group of Prof. A. Ulrich

of the Physics Faculty of the Technical University of Munich. The objective is to measure lifetimes at very low pressures and extract information on the dependence on pressure of the quenching rate constant by N2(X) molecules. This information together with the results of theoretical calculations that are being carried out by in the Chemistry Department of the University of Coimbra will allow the clarification of the processes involved in the UV nitrogen scintillation.
In the last Air Fluorescence Workshop, held in L´Aquila, Italy, in February 2009, it has been decided that next workshop would be held in Coimbra, in September 2010, organized by our group. The organization of this event is under way.

4.5.3 Objectives

This project aims to contribute to a better understanding of the physical processes that lead to the UV air fluorescence. The objectives were
1. to perform complementary measurements of the temperature dependence of the 2P (0,0) band intensity in dry air, under alpha particle excitation;
2. to analyze and compare time resolved and light yield measurements;
3. to study the pressure dependence of the quenching rate constant of the N2(C, v’=0) state by N2(X), using low energy electron beams as excitation source;
4. to investigate the influence of water vapor in the temperature dependence of the light emitted.
5. to develop and validate a kinetic model for the nitrogen UV emission

4.5.4 Achievements

1. Light yield measurements have been performed in dry air, confirming our previous results;
2. The analysis and comparison of light yield and time resolved measurements showed a very good agreement and a paper has been published; However, there are still uncertainties in what concerns the population mechanisms of the emitting states.
2. The experimental set-up for time resolved measurements using an electron beam as excitation source (including gas system, gas cell, electron gun tube and associated electronics), has been assembled and tested and the data taking is about to start.
3. The influence of water vapor on the temperature dependence of the total light yield has been simulated; for the experimental study, contacts have been established with the Chemical Department of the University of Leeds.
4. A kinetic model has been developed together with the simulation tools for the validation of this model. Collaboration with a theoretical group from the Chemical Department of UC is under way.

4.5.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83527/2008	15.000 €	2008-10-01	2009-12-31

4.5.6 Team

Project coordinator: Margarida Fraga

Name	Status	%of time in project
Américo Pereira	Technician (LIP)	20
Andreas Ulrich	Researcher (LIP)	5
Andrey Morozov	Researcher (LIP)	25
António Onofre	Researcher (LIP)	10
Armando Policarpo	Researcher (LIP/FCTUC)	5
Francisco Fraga	Researcher (LIP/FCTUC)	20
João Bastos	Post-Doc (LIP)	5
João Silva	Technician (LIP)	5
Luís Pereira	PhD student (LIP)	25
Margarida Fraga	Researcher (LIP/FCTUC)	50
Mário Pimenta	Researcher (LIP/IST)	5
Nuno Carolino	Technician (LIP)	15
Rui Marques	Researcher (LIP/FCTUC)	10

4.5.7 Publications

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

- *Temperature dependence of the quenching of N2(C 3Piu, v´=0,1) by N2(X) and O2(X)*
  L. Pereira, A. Morozov, M.M. Fraga, T. Heindl, R. Krücken, J. Wieser and A. Ulrich
  Eur. Phys. J. D 56, 325-334 (2010)

4.5.8 Presentations

Oral presentations in international conferences

- *Temperature dependence of the quenching of N2 (C 3Piu) by N2 (X) and O2 (X)*
  presented by Luís Pereira
  at 6th Air Fluorescence Workshop in L´Aquila, Italy.

- *Temperature dependence of the 2P (0-0) band intensity in N2 and dry air*
  presented by Margarida Fraga
  at 6th Air Fluorescence Workshop in L´Aquila, Italy.

4.5.9 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Oral presentations in international conferences	2

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"centram-se na aplicação da ferramenta de simulação Geant4 a experiências de astropartículas e a estudos de ambiente de radiação no espaço e noutros planetas.
A continuação da actividade CODES, cujo contracto com a ESA termino a 28 de Fevereiro de 2009, teve início a 1 de Maio de 2009. Esta actividade terá a duração de 2 anos, visa o estudo e modelização dos efeitos da radiação em componentes electrónicos, e consiste no desenvolvimento final da ferramenta SV-fit e do framework CODES, que será integrado num ambiente gráfico de modo a facilitar a sua utilização, assim como no estudo e revisão do conceito de "LET de superfície"utilizado na comunidade dos efeitos de radiação em componentes.
O LIP prosseguiu a sua participação no projecto "Participação Portuguesa na Rede Heliosférica", cujo segundo ano decorreu em 2009.Esta actividade centra-se no estudo do ambiente de radiação na heliosfera através do estudo de dados recolhidos durante o último ciclo solar pelas missões Ulysses e ACE, em que a ferramenta de simulação Geant4 é utilizada para melhor compreender o desempenho dos detectores.
As actividades desenvolvidas baseam-se na utilização da ferramenta de simulação Geant4, neste caso aplicada ao ambiente espacial. As actividades desenvolvidas no LIP no âmbito deste projecto têm vindo não só a possibilitar a integração de estudantes com interesse na área espacial, como também se têm revelado uma fonte de colaboração entre o LIP e outros institutos e cientistas externos.

4.6.2 Abstract

The activities developed in the framework of the Space (ESA: European Space Agency) are centred in the application of the Geant4 simulation toolkit to astroparticle and space experiments and studies.
The follow up of the CODES activity, whose contract with ESA, terminated in February 2009, entitled CODES-III started in May 2009, and will have the duration os two years. It is an activity concerning the study of the radiation effects in electronic components relevant for the space missions and will consist on the final development of the SV-fit method, whose preliminary implementation was performed in the previous contract.
LIP continued its participation in the Heliospheric Network in collaboration with Dalmiro Maia from "Observatório Astronómico da Universidade do Porto". This activity is centred on the study of the interplanetary radiation environment, where the Geant4 simulation toolkit is being 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.
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 institutions and scientists.

4.6.3 Objectives

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

LIP, submitted this proposal for extension of the ESA 18121/04/NL/CH activity, closed in 2008, in response to RFQ/3-12606/08/NL/PA. The proposal was accepted, and a two year contract with ESA, concerning this activity, was initiated on the 1st May 2009.
The proposed activity aims at freezing the technical baseline for the general SV-Fit method developed under activity with contract number 18121/04/NL/CH, verifying the SV-fit method by employing HI irradiation test data in application cases, automating the current software framework developed under part 2 of this activity to optimise for speed the iterative process required by SV-fit module, implementing the SV-fit module under the software framework, developing an intuitive and simple graphical user interface. Additionally, the activity aims at investigating current LET calculation methods and propose the most appropriate LET calculation method for general SEE rate prediction applications.
The work is broken down into three technical phases. The first phase regards SV-fit implementation, design freeze and verification. The second phase concerns CODES top level framework implementation, verification and evaluation. The third phase regards the study and improvement, if possible, of "surface LET"calculation methods and the revision of the definition of LET and its calculation methods. The first phase was finalized. The third and second phases will be discussed in 2010 project plan.

Participation in the Heliospheric Network

The heliospheric network is a dedicated group of researchers addressing the challenges and puzzles raised by the data collected in the previous and present solar cycles by the extended and expanded set of heliospheric missions: IMP8, Voyager I and II, SOHO, ACE, Ulysses, WIND, Cluster and Stereo. A proposal for a three year project, entitled "Portuguese participation in the Heliospheric Network", was approved by "Fundação para a Ciência e a Tecnologia"(FCT) and started in 2008. This project is a collaboration between LIP and Dalmiro Maia from Faculdade de Ciências da Universidade do Porto with the finality of developing Heliosphere Radiation Environment Models from Interplanetary Data.
This activity is described in detail in the 2008 Progress Report of the Space(ESA) activity. In summary it consists on the comparison of the properties of Solar Energetic Particle events (SEP) measured at different points in the heliosphere using data from one complete solar cycle from the ACE and Ulysses missions collected with similar detectors, EPAM and HISCALE. LIP tasks concentrate on the simulation of the instruments (EPAM /HISCALE) response using Geant4 and on the comparison of the propagation models interfaced with the instrument simulation with mission real data. The goal of the project is to obtain an as accurate as possible description of SEP characteristics in different locations of the heliosphere, one of the applications being for example the assessment of the necessary requirements for radiator monitors to fly on future heliospheric missions.

4.6.4 Achievements

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

The CODES - II contract consists of three phases, the first 8 month phase was reaching completion by the end of 2009. This first phase was divided into two technical work packages. The first phase terminated in October 2009 and consisted of freezing the technical baseline of SV fit, whereas the second work package consisted of the verification of the SV-Fit method using beam-line component irradiation data. During this phase a review of other existing tools was also undertaken, in order to have a comparative performance study of the SV-Fit tool.

Participation in the Heliospheric Network

In 2009 the activities of the LIP team were centred on the development of a Geant4 application for the simulation of the EPAM instrument aboard the ACE mission and of the HISCALE instrument aboard the ULYSSES mission. The EPAM and HISCALE instruments are based on the same design. The Geant4 toolkit is being used to simulate, in particular, the performance of the LEFS detector systems of the EPAM/HISCALE instruments in order to more accurately understand their response to electrons. The full implementation of the EPAM/HISCALE detectors simulation was performed, the simulation is being validated and its first results are being produced. The validation of the simulation consists of the comparison of simulation results with the expected detector performances and with calibration data obtained, prior to the detectors having been sent to space, using radioactive sources.
A PhD thesis on this subject was initiated at LIP in October 2009.

4.6.5 Sources of Funding

Code	Funding	Start	End
ESA:18121/04/NL/CH/2	100.000 €	2006-11-01	2009-02-28
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	1
Ana Keating	Post-Doc (LIP/FCT)	100
Andreia Trindade	Post-Doc (LIP/FCT)	17
Bernardo Tomé	Researcher (LIP)	20
Bruno Morgado	PhD student (LIP) *	100
Mário Pimenta	Researcher (LIP/IST)	17
Patrícia Gonçalves	Researcher (LIP)	47
Pedro Assis	Post-Doc (LIP/FCT) *	1
Pedro Brogueira	Researcher (LIP/IST)	5
Pedro Rodrigues	Post-Doc (LIP/FCT)	17
Sara Valente	Master student (LIP)	100

4.6.7 Publications

International Conference Proceedings

- *MarsREM:The Mars Energetic Radiation Environment Models*
  Patricia Goncalves, Ana Keating, Sara Valente, Pete Truscott, Fan Lei, Laurent Desorgher, Daniel Heynderick, Norma Crosby, Hilde de Witt, Gerald Degreef, Petteri Nieminenk and Giovanni Santin

Book Chapters

- *The Mars Energetic Radiation Environment Models*
  Patrícia Gonçalves, Ana Keating, Sara Valente, Pete Truscott, Fan Lei, Laurent Desorgher, Daniel Heynderickx, Norma Crosby, Hilde de Witt, Gerald Degreef, Petteri Nieminen, Giovanni Santin
  (accepted)

4.6.8 Presentations

Oral presentations in international conferences

- *Virtual modelling and simulation of the HI-SCALE instrument aboard the Ulysses spacecraft*
  presented by Bruno Morgado
  at 6th Geant4 Space Users Workshop in Madrid, Spain.

- *GEANT4 at LIP*
  presented by Ana Keating
  at 6th Geant4 Space Users Workshop in Madrid, Spain.

- *Virtual modeling and simulation of the HISCALE instrument*
  presented by Bruno Morgado
  at New Worlds in Astroparticle Physics 2009 in São Tomé, São Tomé e Príncipe.

- *Heliospheric Network, HI-SCALE*
  presented by Bruno Morgado
  at PASC Winter School 2009 in Sesimbra, Portugal.

Poster presentations in international conferences

- *MarsREM:The Mars Energetic Radiation Environment Models*
  presented by Patrícia Gonçalves
  at ICRC2010 in Lodz, Poland.

Presentations in national conferences

- *Space Radiation Enviroment and Effects*
  presented by Patrícia Gonçalves
  at ENAA - XIX Encontro Nacional de Astronomia e Astrofísica in Universidade de Aveiro, Aveiro, Portugal.

- *LIP & Exomars*
  presented by Patrícia Gonçalves
  at Workshop Aurora-Exomars in FCT, Lisboa, Portugal.

Oral presentations in international meetings

- *Virtual modelling and simulation of the HI-SCALE instrument aboard the Ulysses spacecraft*
  presented by Bruno Morgado
  at HI-SCALE Team Meeting 2009 in Belmont Conference Center, Elkridge, MD, USA.

Oral presentations in collaboration meetings

- *Specification of Mars atmospheric and surface environments (MEREM Preprocessor)*
  presented by Ana Keating
  at MarsREM, Final Presentation in ESTEC, Noordwijk, Holanda.

- *Component Degradation simulation Tool*
  presented by Ana Keating
  at CODES III, Kick-off Meeting in ESTEC, Noordwijk, Holanda.

- *Component Degradation simulation Tool, progress developments?*
  presented by Ana Keating
  at CODES III, 1st Progress Meeting in ESTEC, Noordwijk, Holanda.

4.6.9 Events

- *Radiation Environment and Effects Course*
  Seminar organization, LIP, Lisboa, Portugal, 2009-06-17

4.6.10 Project Summary

	number
International Conference Proceedings	1
Book Chapters	1
Oral presentations in international conferences	4
Poster presentations in international conferences	1
Presentations in national conferences	2
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	3
Seminar organizations	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 Objectives

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 the breast cancer detection PET technologies in clinical trials
2) Development of PET-Ultrasound technologies (ClearPEM-Sonic project)
3) The investigation of new nuclear imaging technologies, in particular the multimodality PET-MRI applied to brain and large animal imaging.

5.1.4 Achievements

1) The consolidation of the breast cancer detection PET technologies in clinical trials
The first ClearPEM scanner was installed at the IPO, Porto, in December 2008, following unavailability of a suitable installation at HGO, Almada. The final scanner integration was done at IPO as well as the validation tests with phantoms. The technical performance of the detector is as expected and the results were presented at the IEEE/MIC 09 conference. Clinical tests with eleven patients indicated for PET/CT (not breast cancer) were performed in the second part of the year. The collected data is now being used to improve the image reconstruction algorithms.
Considerable attention from the engineering team was required during the first phase of operation. This task was considerably more difficult than expected due the location of the system at Porto, whereas the engineering team is based in Lisbon. On the other hand the PET room where the system is installed is also used for the PET/CT patients, being available for technical intervention only during nights and week-ends. The availability for tests with patients is also very limited.
2) Development of PET-Ultrasound technologies (ClearPEM-Sonic project)
The design of the second ClearPEM scanner for integration with ultrasound is largely based in the first prototype. However many important modifications have been introduced based on the experience acquired with the construction of the first machine. In particular the ClearPEM robot was totally re-engineered.
The construction of the ClearPEM-Sonic scanner is progressing according to the plan, except for detector electronics and mechanics where delays of the order of four months were accumulated. All the detector modules and electronics have now been produced and are under test. Prototypes of the mechanical integration of the PEM with the ultrasound probe were developed in collaboration with our partners.

3) The investigation of new nuclear imaging technologies, in particular the multimodality PET-MRI applied to brain and large animal imaging.
Various developments towards PET-MRI were carried out. A new avalanche photodiode developed in collaboration with RMD, Inc, was tested. First measurements with new silicon photomultipliers were performed with promising results. The design of a new version of the ASIC compatible with silicon photomultipliers is progressing at INESC. The concept of a PET-MR brain scanner was developed.

5.1.5 Sources of Funding

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

5.1.6 Team

Project coordinator: João Varela

Name	Status	%of time in project
Andreia Trindade	Post-Doc (LIP/FCT)	97
Bruno Carriço	Master student (LIP)	16
Catarina Ortigão	Post-Doc (LIP/FCT) *	100
Cláudia Sofia Ferreira	PhD student (LIP/FCT) *	100
Gonçalo Silva	Master student (LIP)	59
Inês Rolo	Master student (LIP)	67
João Pinheiro	Master student (LIP)	25
João Varela	Researcher (LIP/IST)	40
Jorge Neves	PhD student (LIP/FCT)	78
José Carlos Silva	Technician (LIP)	11
Mário Frade	Master student (LIP)	75
Miguel Ferreira	Technician (LIP)	83
Pedro Rodrigues	Post-Doc (LIP/FCT)	97
Ricardo Bugalho	Master (LIP) *	100
Rui Silva	Technician (LIP)	100

5.1.7 Publications

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

- *Experimental characterization of the 192 channel Clear-PEM frontend ASIC coupled to a multi-pixel APD readout of LYSO:Ce crystals*
  E. Albuquerque et al.
  Nuclear Instruments and Methods in Physics Research A 598 (2009) 802-814

- *Characterization of avalanche photodiode arrays for the ClearPEM and ClearPEM-Sonic scanners*
  R Bugalho, B Carriço, C S Ferreira, M Frade, M Ferreira, R Moura, J Neves, C Ortigão, J F Pinheiro, P Rodrigues, I Rolo, J C Silva, R Silva, A Trindade and J Varela
  2009 JINST 4 P09009

- *Experimental characterization of the Clear-PEM scanner spectrometric performance*
  R Bugalho, B Carriço, C S Ferreira, M Frade, M Ferreira, R Moura, C Ortigão, J F Pinheiro, P Rodrigues, I Rolo, J C Silva, A Trindade and J Varela
  2009 JINST 4 P10011

International Conference Proceedings

- *On-Detector electronics of the Clear-PEM scanner*
  E. Albuquerque et al.

International Conference on Biomedical Electronics and Devices Biodevices 09

- *Data Acquisition Electronics for PET Mammography Imaging*
  C. Leong et al
  International Conference on Biomedical Electronics and Devices Biodevices 09

- *Avalanche Photodiodes For High-Resolution PET Imaging Systems*
  R. Bugalho et al
  International Conference on Biomedical Electronics and Devices Biodevices 09

- *Characterization of the Clear-PEM Breast Imaging Scanner Performance*
  ClearPEM Collaboration
  IEEE09 Nuclear Science Symposium and Medical Imaging Conference, Orlando, USA

- *Development of component-based normalization correction for the Clear-PEM system*
  C. Guerreiro, N. C. Ferreira, R. Bugalho, A. Trindade, N. Matela, M. V. Martins, L. Mendes, C. S. Ferreira, P. Almeida, J. Varela
  IEEE09 Nuclear Science Symposium and Medical Imaging Conference, Orlando, USA

5.1.8 Presentations

Oral presentations in international conferences

- *Avalanche Photodiodes For High-Resolution PET Imaging Systems*
  presented by Bruno Carriço
  at in Porto, Portugal.

Poster presentations in international conferences

- *On-Detector electronics of the Clear-PEM scanner*
  presented by José Carlos Silva
  at International Conference on Biomedical Electronics and Devices Biodevices 09 in Porto, Portugal.

5.1.9 Academic Training

PhD Theses

- *Development and Experimental Study of a Detector Module for Positron Emission Mammography"*
  Catarina Ortigão, 2009-11-25

- *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)

Master Theses

- *Protótipo do Intelligent Frontend Board para aquisição de dados em tomógrafos PET"*
  Ricardo Bugalho, 2009-09-01

- *Evaluation of the Clear-PEM scanner in Clinical Environment"*
  Mário Frade, 2009-09-01

- *Performance evaluation of new upgrades on ClearPEM detector modules"*
  Inês Rolo, 2009-09-01

5.1.10 Project Summary

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

5.2 PET with gaseous detectors (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 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

The year 2009 was a standby year in terms of hardware development, as there was no funding available.
Projects were submitted to the EU ERC/IDEAS and HEALTH programs, but unsuccessfully.
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") was approved with a global budget of 190kEUR over 3 years. The LIP´s budget amounts to 120kEUR, intended for the development of a single-layer, full-size, scanner. Further details may be found in the Plan.
However, the year was very fruitful in terms of simulation and consolidation of the RPC-PET concept. A very detailed study was made and presented at the 2009 IEEE Medical Imaging Conference [CRE09], confirming that the RPC-PET concept may be more than 20 times more sensitive than the state-of-the-art narrow-field crystal PET concepts.
A national patent request was placed for the technical method of economically reading out the signals in RPC-PET.
[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

5.2.5 Sources of Funding

Code	Funding	Start	End
PTDC/FIS/67002/2006	72.000 €	2009-01-01	2010-12-31

5.2.6 Team

Project coordinator: João Lima

Name	Status	%of time in project
Alessio Mangiarotti	Researcher (LIP)	15
Alexandre Lindote	Post-Doc (LIP) *	15
Alexandre Moita	Technician (LIP)	5
Américo Pereira	Technician (LIP)	15
Armando Policarpo	Researcher (LIP/FCTUC)	20
Carlos Silva	Technician (LIP)	5
Cláudio Silva	PhD student (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
Nuno Fonseca	Researcher (LIP/IBILI)	5
Orlando Cunha	Technician (LIP)	5
Paulo Crespo	Researcher (LIP/ISEC)	0
Rui Marques	Researcher (LIP/FCTUC)	10
Vitaly Chepel	Researcher (LIP/FCTUC)	45
Vladimir Solovov	Researcher (LIP)	20

5.2.7 Publications

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

- *Efficiency of RPC detectors for whole-body human TOF-PET*
  A. Blanco, M. Couceiro, P. Crespo, N. C. Ferreira, R. Ferreira Marques, P. Fonte, L. Lopes, J. A. Neves
  Nucl. Instrum. and Meth. in Phys. Res. A 602 (2009) 780-783

5.2.8 Presentations

Poster presentations in international conferences

- *Whole-body single-bed time-of-flight RPC-PET: simulation of axial and planar sensitivities with NEMA and anthropomorphic phantoms*
  presented by Paulo Crespo
  at IEEE 2009 Nuclear Science Symposium and Medical Imaging Conference in Orlando, FL, USA..

Presentations in national conferences

- *Novas tecnologias em PET: o PET-RPC*
  presented by Paulo Fonte
  at XII Congresso Nacional de Medicina Nuclear, 12 a 14 de Novembro de 2009 in Mealhada, Portugal.

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
Poster presentations in international conferences	1
Presentations in national 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 first year following steps has been done.
1. The Monte Carlo simulation code based on GEANT4 has been developed with the following features. Detector geometry - simplified, generic detectors. Consists of a ring of 80 cm diameter composed by 36 detectors. At the moment, liquid xenon is used as detector material; other materials can be easily used. Physical processes - photoelectric absorption, Compton scattering (unpolarized or polarized) for gamma rays; Bremsstrahlung, multiple scattering and ionization for electrons. Source - single or multiple point sources; circular phantom. EventAction module - saves complete information on physical interactions.
2. The initial version of the image reconstruction module has been developed using Matlab image processing libraries. The module accepts externally calculated lines of response, constructs sinograms and reconstructs 2-dimensional image. Tested with single point source and two point sources with lines of response generated by Monte Carlo simulation for an ideal detector (infinit Z and density; 100% photoelectric fraction). Similar tests has been carried out also within the IDL environment for comparison.
3. The GATE simulation environment has also been installed and tested with the purpose of using some of the PET specific routines for the simulation, which is being developed.
4. Modifications to the existing gas purification system and double-phase liquid xenon chamber have been introduced to allocate gaseous electron multiplier. First operation tests have been done.

5.3.4 Sources of Funding

Code	Funding	Start	End
PTDC/FIS/67002/2006	72.000 €	2009-01-01	2010-12-31

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	PhD student (LIP/FCT)	20
Francisco Neves	Post-Doc (LIP)	10
Isabel Lopes	Researcher (LIP/FCTUC)	25
Joaquim Oliveira	Technician (LIP)	5
Jorge Moita	Technician	5
José Pinto Da Cunha	Researcher (LIP/FCTUC)	20
Nuno Carolino	Technician (LIP)	10
Orlando Cunha	Technician (LIP)	5
Vitaly Chepel	Researcher (LIP/FCTUC)	45
Vladimir Solovov	Researcher (LIP)	20

5.3.6 Project Summary

(no values to report)

5.4 Monte Carlo methods applied to dosimetry in medical radiologic exposures

5.4.1 Resumo

O projecto encontrou-se no ano de 2009 dividido em duas partes:
1. Desenvolvimento de um dosimetro em fibra óptica de plástico com leitura por fotodiodo.
2. Estudo da exposição ambiental de populações às radiações provenientes do gás radão.

5.4.2 Abstract

During 2009 the project was divided into two branches:
1. Plastic scintillating optical fiber dosimeter with photodiode readout
Inorganic scintillating crystals and plastics have been used as dosimeters for a long time. A dosimeter made of scintillating plastic optical fiber have many advantages (the similarity to water is a big one) and some limitations. For instance, the production of Cherenkov light in the fiber by electrons in the hundred-keV range has been seen as a major drawback to this type of dosimeter, introducing a noise in the detected signal. However this problem does not arise in radiology and brachytherapy applications because the beam energy is often below the Cherenkov production threshold.
2. Environmental radon exposure and human health risk
Radon gas presents a high environmental risk, affecting large populations. It is known that more than half of natural radiation dose is originated from the inhalation of radon daughter nuclides. A survey conducted in Portugal in 2002 by ITN showed the existence of several regions with radon concentrations above 200 Bq/m3 and local communities with levels exceeding 400 Bq/m3.
The relationship between high radon concentrations and lung cancer is now well established. Additionally, epidemiological surveys suggest that radon in homes currently accounts for a considerable number of deaths from lung cancer. In a 2009 report of the World Health Organization radon is recognized as a potential environmental health hazard factor and states that "(...) where indicated, comprehensive radon programmes be developed, preferably in close linkage with indoor air quality and tobacco control programmes". Following these concerns the International Commission on Radiological Protection (ICRP) issued a Statement on Radon (in attachment) recommending the lowering of radon concentrations in dwellings and working places.

5.4.3 Objectives

1. Plastic scintillating optical fiber dosimeter with photodiode readout
The objective of this project branch is the development of a plastic scintillating optical fiber dosimeter with photodiode readout that can be used in clinical environment.
2. Environmental radon exposure and human health risk
The main goal of this project is to assess the health risk posed by radon and its daughters to the population, by combining studies involving different fields of expertise. On a first time dosimetric studies of radon concentration were carried in a previously chosen Guarda region, on water and in indoor dwellings with private wells in order to assess what we think is an underestimation of the alpha particle concentration in these waters. This study helped in understanding the natural geological mechanisms of radon concentration in this region.

5.4.4 Achievements

1. Plastic scintillating optical fiber dosimeter with photodiode readout
The scintillating optical fiber dosimeter developed by our collaboration is a device 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. The device has been tested for several X-rays beams in the 30 to 100 kVp and a small variation of 5% in the sensitivity has been measured for the full range. In-vitro clinical tests are under way.
2. Environmental radon exposure and human health risk
A populational survey, as well as air concentration measurements were performed in the Guarda region in 160 randomly chosen dwellings within a 8 km radius from the centre of town. Bearing in mind that indoor high radon concentrations may be responsible for lung and other respiratory system cancers, 25 dwellings, where one of the inhabitants had a manifestation of oncology disease, related to the respiratory tract were also chosen.

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. Each one of these 185 participants had to answer a set of questions that analysed different variables of interest. Also, for the dosimetric study, the detectors were all placed inside each dwelling within a time interval of 90 minutes of each other. These detectors were collected 60 days after their placement and analysed at the Natural Radioactivity Laboratory at Coimbra.

5.4.5 Sources of Funding

Code	Funding	Start	End

5.4.6 Team

Project coordinator: Luis Peralta

Name	Status	%of time in project
Ana Catarina Farinha	Graduate student (LIP)	50
Ana Filipa Ferreira	Master student (LIP)	10
Conceição Abreu	Researcher (LIP)	50
Florbela Rego	PhD student (LIP)	80
João Monteiro	Student (LIP)	33
Luis Peralta	Researcher (LIP/FCUL)	90
Mafalda Gomes	Graduate student (LIP)	50
Maria do Anjo Albuquerque	PhD student (LIP)	60
Nuno Silva	Student (LIP)	33
Rui Carvalhal	Graduate student (LIP)	30
Sandra Soares	Researcher (LIP/UBI)	80

5.4.7 Academic Training

PhD Theses

- *Desenvolvimento de dosímetros de estado sólido para dosimetria em radiologia e braquiterapia"*
  Florbela Rego, (on-going)

Master Theses

- *Protecção radiológica no serviço de radiologia do Hospital Distrital de Faro"*
  Ana Filipa Ferreira, 2009-12-31

5.4.8 Project Summary

	number
Master Theses	1

Chapter 6

Detectors

6.1 RD51

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 moderada, 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 contributed with a plenary talk in the collaboration meeting on "The physics of streamers and discharges"and initiated the elaboration of a bibliographic review of the breakdown features of gaseous detectors, aiming at the publication of a CERN yellow report.
Along the same line we were invited to talk at the XXIX International Conference on Phenomena in Ionized Gases, July 12-17, 2009, Cancún, México, on "The physics and technology of gaseous particle detectors". An article was submitted to the conference issue of Plasma Sources in Science and Technology (http://arxiv.org/abs/0909.2681v1).
For WG2-T3, we quantified the production of polymeric material and addressed the possibility of adding polymerization inhibitors to the gas mixture. First results will be presented in a plenary talk and a poster at the "X Workshop on Resistive Plate Chambers and Related Detectors", Darmstadt, Germany.
For WG3, progress was made in the design of the scanner. A readout strategy was devised, aimed at providing good differential and integral linearity on a reasonably small number of electronics channels. Indeed, we are reading a region of 10 cm with deep sub-millimetric accuracy with only five analog charge-sensitive channels.
A single detector with double readout in the same coordinate was built to test the performance of the charge-centroiding readout system. The results show an electronics resolution of 0.23 mm FWHM, including a substantial systematic component that may be later corrected. The impact of this figure in the image will be only 0.17mm.
The construction of a full scanner is under way.

6.1.5 Sources of Funding

Code	Funding	Start	End
CERN/FP/83524/2008	20.000 €	2008-10-01	2010-03-31

6.1.6 Team

Project coordinator: Rui Marques

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	10
Alessio Mangiarotti	Researcher (LIP)	10
Alexandre Moita	Technician (LIP)	5
Américo Pereira	Technician (LIP)	10
Carlos Silva	Technician (LIP)	5
Joaquim Oliveira	Technician (LIP)	5
Luís Lopes	Technician (LIP)	10
Miguel Couceiro	Researcher (LIP/ISEC)	50
Nuno Carolino	Technician (LIP)	10
Nuno Fonseca	Researcher (LIP/IBILI)	20
Orlando Cunha	Technician (LIP)	10
Paulo Crespo	Researcher (LIP/ISEC)	50
Paulo Fonte	Researcher (LIP/ISEC)	50
Rui Alves	Technician (LIP)	5
Rui Marques	Researcher (LIP/FCTUC)	10

6.1.7 Publications

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

- *A long-run study of aging in glass timing RPCs with analysis of the deposited material*
  S. Gramacho, L. Lopes, M. Pineiro, P. Fonte, A. M. d´A. Rocha Gonsalves
  Nucl. Instrum. and Meth. in Phys. Res. A602 (2009) 775-779

- *Custom Pulse Generator for RPC Testing*
  A.Gil, E.Castro, J.Díaz, P.Fonte, J.A.Garzón, N.Montes, M.Zapata
  Nucl. Instrum. and Meth. in Phys. Res. A602 (2009) 801-804

- *Progress in Developing Hybrid RPC: GEM-like Detectors with Resistive*
  P.Fonte, P.Martinenengo, E.Nappi, R. Oliveira, V.Peskov
  Nucl. Instrum. and Meth. in Phys. Res. A 602 (2009) 850-853

- *Performances of 4-gap timing RPCs for relativistic ions in the range Z=1-6*
  P.Cabanelas, M.Morales, J.A.Garzon, A.Gil, D.Gonzalez-Diaz, A.Blanco, D.Belver, E.Casarejos, P.Fonte, W.Koenig, L.Lopes, M.Palka, J.Pietraszko, M.Traxler, M.Weber
  Journal of Instrumentation 4 (2009) P11007

- *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

6.1.8 Presentations

Oral presentations in international conferences

- *The physics and technology of gaseous particle detectors*
  presented by Paulo Fonte

at XXIX INTERNATIONAL CONFERENCE ON PHENOMENA IN IONIZED GASES in Cancun, Mexico..

6.1.9 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	5
Oral presentations in international conferences	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 cãmara Anger gasosa para imagiologia com neutrões térmicos.
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

6.2.2 Abstract

The ongoing project involves the development of gaseous radiation detectors with optical readout systems, in this case photomultipliers. The scintillation emitted by the avalanches produced in microstructures enables the localisation of the interactions. The main objective is the development of a gaseous Anger Camera for imaging with thermal neutrons .
These works were developed in the framework of a project financed by the European Seventh Framework Programme (FP7) - Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy (FP7), Project No. 226507 - NMI3. Our team integrates the JRA WP22 Detetcors task - 2.22.

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.

6.2.4 Achievements

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 and are summarized below:
Task 1 .Absolute measurements of primary light emitted by CF4 for pressures between .5 and 5 bar. The system was calibrated using a deuterium lamp in the UV and a tungsten lamp in the visible. Deliverable - spectra at .5, 1, 2, 3,4 and 5 bar with errors; study of dependence with electrical field in the conversion gap. The results were published in two papers in Nuclear Instruments and Methods in Physics Research Section A .
Time resolved spectral studies were also carried.
Task 2 . Study of of photocathode uniformity of the Hamamatsu PMTs . A scanning system was assembled and 10 existing PMTs were scanned with 1 mm resolution. The maps show relative sensitivity within each PMT can vary as much as 18%. These data will be used for the neutron Anger Camera readout simulation.

6.2.5 Sources of Funding

Code	Funding	Start	End
FP7-GA226507	80.640 €	2009-02-01	2012-01-31

6.2.6 Team

Project coordinator: Francisco Fraga

Name	Status	%of time in project
Andrey Morozov	Researcher (LIP)	46
Francisco Fraga	Researcher (LIP/FCTUC)	46
Luís Pereira	PhD student (LIP)	92
Margarida Fraga	Researcher (LIP/FCTUC)	9
Paulo Mendes	Researcher (LIP/FCTUC)	18
Rui Marques	Researcher (LIP/FCTUC)	9

6.2.7 Publications

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

- *The transparent microstrip gas counter*
  Hiroyuki Takahashi, Kaoru Fujita, Takeshi Fujiwara, Hisako Niko, Bruno Guerard, Francisco Fraga and NaokoIyomoto
  Nucl.Instr.andMeth.A(2010),doi:10.1016/j.nima.2010.02.169 (accepted)

- *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 (18 January 2010) (accepted)

6.2.8 Presentations

Oral presentations in collaboration meetings

- *Study on the production of primary scintillation light in CF4*
  presented by Andrey Morozov
  at FP7 NMI3 Neutron GSPC Meeting in FRM2 Munich.

- *Measurement of PMT photocathode uniformity*
  presented by Luís Pereira
  at FP7 NMI3 GSPC – Meeting in FRM2 Munich.

6.2.9 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	2
Oral presentations in collaboration meetings	2

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 the 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 year 2009 was a year of rethinking and renewal of the OM. At the end of 2008 the engineer that supported the newly acquired lathe and milling machines left for another job, circumstance that opened the way for a reorganization of the OM.
In sequence, an auditing of the OM was commissioned to a panel of two external experts from the industry, for assessing the OM´s organization and efficiency. The panel recommended that the Project and Production activities should be decoupled and that the Production area should be headed by an engineer experienced in actual mechanical production.
In October 2009 a new engineer with experience in modern industrial production was hired to operate the CNC machines and head the Production. The Project area was separated from the Production, both placed under the direct control of the directorate.

Short training courses on CNC technologies were undertaken by all staff.
Nevertheless, in 2009 the OM realized, with limited benefit from the modern machines, the following works. Among them, it should be highlighted the study for the possible production of mirror positioning elements and "fixed points"for the future AUGER NORTH experiment.

Descrição	Projecto	Entidade
Abertura de rasgos no Filter plate da re...	ANIFC	ANIFC
Bitolas NP EN 12003	CTCV	CTCV
Anel Transdutores	DEEC	DEEC
40 suportes de amostras em acrilico	CEMDRX	DF
Aplicação de apoios anti-vibratórios em ...	CEMDRX	DF
Bonecos Didácticos	Divulgação	DF
Comboio de levitação	Divulgação	DF
Contacto de Hg para ensaios de maquinage...	CEMDRX-GTR	DF
Encaixes em Acrilico	CEMDRX	DF
Ensaios de maquinagem	CEMDRX-GTR	DF
Fluorómetro Ocular -Sist. Reg.Lente	GEI	DF
Fonte de sublimação de metais	CEMDRX	DF
Guia para comboio de levitação	Divulgação	DF
Maquinagem de sistema de fecho	CEMDRX	DF
MFI - Sistema de aperto	CEMDRX–GTR	DF
Montagem Para o MFI	CEMDRX - GTR	DF
Pêndulo de Foucault	Pêndulo	DF
Preparar protecção de radiação	CEMDRX-GTR	DF
Reparação modulo NIM		DF
Sist. de movimentação de fonte radioacti...	TNAM	DF
Sist. de regulação e posicionamento para...	CEMDRX	DF
Sist. Det. Capacidade calorifica + Coef....	Divulgação	DF
Sistema para medição de amostra após pol...	CEMDRX-GTR	DF
Suporte em aluminio	CEMDRX	DF
Suporte para lâmpada UV	CEMDRX-EMPM	DF
Ventilador/Exaustor	Manutenção	DF
Adaptação de Sondas 70º	DQ UC	DQ - PRODEQ
Sist. para periscópio	DQ UC	DQ - PRODEQ
Suporte para aquecimento de amostras	IMAR	IMAR
Placas Acrilico p/ assentamento mamario	IPO	IPO
Placas para sistema de tratamento da mam...	IPO	IPO
Sistema de posicionamento	IPO	IPO
Sup.PMMA para câmara circular de mamogra...	IPO	IPO
Programa de Doutoramento (Formação 1)	ISEC	ISEC
Anel de Al. de sup. e fixação do Nariz d...	Submarino LAUV	ISR
3 Suportes verticais	Hades	LIP-C
Anel em chapa 2mm perfurado	HADES	LIP-C
Apoios para cabos	Hades	LIP-C
Beam Expander-New light mixer V2	CERN-Atlas	LIP-C
Caixa de refrigeração	LCA	LIP-C
Caixa Óptica + Colimador MPPC	Zeplin	LIP-C
Canelas (4)	Cintilação	LIP-C
Canhão de Electrões+Sist. de aperto para...	Cintilação	LIP-C
Cantoneiras de AL	HADES	LIP-C
Cedência de Técnico 50%	HADES	LIP-C
Cedência de Técnico 50%	HADES	LIP-C
Chapas apoio	Hades	LIP-C
Conectores atenuadores + 40atenuadores +...	CERN - Atlas	LIP-C
Controlador de gás	HADES	LIP-C
Copiar tubo existente em acrilico p/ alu...	Laboratorio	LIP-C
Diminuição do diâmetro externo de 200 an...	HADES	LIP-C
Disco de Aço	?	LIP-C
Formação centro de torneamento MAS SP180...	Formação	LIP-C
Formação DMG	Formação	LIP-C
High Voltage Box	Cintilação	LIP-C
Light Mixer	CERN - Atlas	LIP-C
Manutenção Metba	Manutenção	LIP-C
Mecânica PM	Cintilação	LIP-C
Modificação dos suportes dos sectores pa...	HADES (DIRAC)	LIP-C
Peça de Cobre	Xenon	LIP-C

ENTIDADES

Sigla	**Nome**
ANIFC	Associação Nacional de Imagiologia Funcional Cerebral
CTCV	Centro Tecnológico da Cerâmica e do Vidr...
DEEC	Departamento de Engenharia Electrotécnica e de Computadores da Universidade de Coimbra
DF	Departamento de Física da Universidade de Coimbra
DQ - PRODEQ	Departamento de Engenharia Química
IMAR	Instituto do mar
IPO	IPO Coimbra
ISEC	instituto Superior de Engenharia de Coim...
ISR	Instituto de Sistemas e Robótica
LIP-C	LIP Coimbra
LIP-L	LIP Lisboa
MF	MUSEU da FÍSICA
TEandM	Tecnologia e Engenharia de Materiais, SA
UFP	Universidade Fernando Pessoa

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 2009 segundo vários vectores, apresentados de seguida de forma aproximadamente cronológica.

- Foram realizadas as Masterclasses 2009, a 5ª edição de uma actividade já regular no âmbito do grupo EPPOG - European Particle Physics Outreach Group, com a participação recorde de 800 participantes em seis institutos portugueses: Instituto Superior Técnico (IST) e Faculdade de Ciências da Universidade de Lisboa (FCUL) em Lisboa, LIP+Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCTUC) em Coimbra, Faculdade de Ciências da Universidade da Beira Interior na Covilhã, Faculdade de Ciências e Tecnologia da Universidade do Algarve em Faro, e pela primeira vez na Faculdade de Ciências da Universidade do Porto. Para permitir um número tão elevado de participantes, contámos com o apoio voluntário e entusiástico de 15 cientistas nas palestras e aproximadamente 35 cientistas a apoiar as actividades de análise de dados.

- Foi realizada uma pequena exposição no dia 20 de Março, no Centro Ciência Viva de Constância a propósito do seu aniversário, envolvendo os módulos da Câmara de Faíscas e da Vida Média do Muão com o apoio científico adequado (2 cientistas durante 2 dias em permanência na exposição).

- Foram realizados 7 estágios para 26 alunos do ensino secundário, no âmbito do programa *Ocupação Científica de Jovens em Férias* da Agência Ciência Viva, em parceria com o IST, com a FCUL, com a FCTUC, e com a Universidade da Beira Interior. 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.

- As actividades de Outreach do LIP foram apresentadas na 24ª e 25ª Reuniões do grupo EPPOG, que tiveram lugar em Milão em Junho de 2009 e no CERN em Outubro de 2009, 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, e por sugestão do LIP, foi organizada no CERN uma sessão conjunta entre o EPPOG e o EPPCN em Outubro de 2009.

- Em Julho de 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.

- Foi co-organizada com o CERN a 3ª Escola de Física do CERN para Professores Portugueses (´CERN´s Portuguese Teachers Program 2009´). Em resposta a um pedido de colaboração da Unesco e do CERN, foi aberta a participação a professores de escolas de países não-membros do CERN, privilegiando os países em desenvolvimento. Foram convidados a participar 11 professores brasileiros e 5 professores moçambicanos. Foram assim levados ao CERN 44 Professores de escolas portuguesas (de 192 candidatos), 11 professores brasileiros e 5 professores moçambicanos, num total de 60 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. * Foi co-organizada em São Tomé com o Instituto Politécnico de São Tomé, o CENTRA - Centro Multidisciplinar de Astrofísica, e a CPLP - Comunidade dos Países de Língua Portuguesa, uma Escola de Física ´O que sabemos do Universo?´ para comemorar os 90 anos das experiências de Sir Arthur Eddington na Ilha do Príncipe. Foi também co-organizada com a Fundação Mário Soares uma exposição, a propósito do mesmo acontecimento, com o título ´A Luz desviada pelo Sol´.

- Foi realizada em Outubro uma visita de escolas participantes no Projecto Radiação Ambiente à Central Nuclear de Almaraz, Espanha, para preparação das actividades para o ano lectivo 2009/2010. Ainda no âmbito deste projecto foi realizado também em Outubro um Encontro Nacional de Professores, que reuniu em Lisboa cientistas do LIP e mais de 100 alunos e professores. Os participantes vieram das 55 escolas participantes no projecto, e apresentaram os trabalhos por si realizados. Foi também elaborado um protocolo com a Sociedade Portuguesa de Física (SPF), para a partilha de equipamentos e recursos nos dois projectos de radioactividade ambiente (do LIP e da SPF).

- Houve uma participação importante no Stand da Ciência Viva no ´Fórum Portugal Tecnológico 2009´, no qual foram mostrados os detectores do projecto ´Radiação Ambiente´ e a Câmara de Faíscas.

- O LIP foi acreditado como entidade formadora oficial, junto do Conselho Científico-Pedagógico da Formação Contínua, sediado em Braga. Este foi um processo importante, para se poder creditar nos currículos dos professores as várias acções de formação a eles dirigidas. Em particular encontra-se em processo de acreditação as Escolas de Física no CERN em Língua Portuguesa.

- Na Semana de Ciência e Tecnologia, o LIP co-organizou com a Coordenação Educativa do Centro de Ciência Viva da Amadora e a Escola Secundária da Amadora, a acção de formação ´Raios Cósmicos na Amadora´, e participou com duas palestras na Semana de Ciência e Tecnologia na Escola Secundária Ferreira Dias, Cacém, Sintra.

- O LIP recebeu a visita de grupos de alunos de escolas básicas e secundárias ao longo do ano de 2009. 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. Desde Novembro, tem-se mostrado e explicado também a Câmara de Faíscas e os Raios Cósmicos por ela detectados.

- Finalmente foram realizados várias palestras de divulgação em Escolas e outros locais. Em particular foram realizadas palestras de preparação e acompanhamento de visitas de escolas ao CERN, Genebra, Suíça. No total, foram realizadas 39 palestras em escolas e outros locais.

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 been carrying the public dissemination of particle and astroparticle physics along several lines. In the following, a brief summary of these activities is provided in an approximately chronological order.

- The LIP-OR is integrated in several groups and forums dedicated to Particle and Astroparticle physics outreach, at a European and international level. In the meetings of these groups, the LIP-OR presents regularly its activities and ideas. In 2009, the LIP-OR pushed the dialog between the different groups, and a common session between EPPOG and EPPCN was organized at CERN in the respective autumn meetings. 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;
  - 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);

- In March, LIP organized in Portugal the 5th Edition of the EPPOG International Masterclasses in Particle Physics, with the finantial support of Agência Ciência Viva and a record participation of 800 students and teachers of Portuguese high-schools. They took place in six different locations (Lisboa - 2, Coimbra, Covilhã, Faro and Porto). To allow such a large number of participants, we count on the voluntary support of 15 scientists in the talks and about 35 scientists in the data analysis activities.

- For the occasion of the 5th anniversary of Centro Ciência Viva de Constância, a little exhibition was made, displaying our Spark Chamber and the Muon Lifetime Experiment, with the presence of 2 scientists during 2 days on-site (Constância).

- In the scope of the program ´Science in the Summer´ of Agência Ciência Viva, LIP has received in 7 stays a total of 26 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 July, LIP has participated in 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.

- In September LIP has co-organized with CERN the 3rd edition of the CERN’s Portuguese Teachers Program. This edition was very important because there was the participation of 11 Brazilian teachers and 5 Mozambican teachers, in addition to the regular number of 44 portuguese teachers (out of 192 applicants). This was made possible as an answer to a request from UNESCO and CERN, to extend CERN Outreach to non-member states, in particular developing countries. Being accompanied by researchers at all times, the participants also bridged national and international gaps, and fostered cooperation between teachers from such different countries as Brazil, Mozambique and Portugal.

- In September at S.Tomé and Príncipe and in cooperation with Instituto Politécnico de São Tomé, CENTRA - Centro Multidisciplinar de Astrofísica, and CPLP - Comunidade dos Países de Língua Portuguesa, LIP organized a school of physics ´What do we know about our Universe?´, to celebrate the 90th anniversary of the experiments of Sir Arthur Eddington. In parallel the workshop ´7th New Worlds in Astroparticle Physics´ was also co-organized by LIP - see description elsewhere in this report. In cooperation with Fundação Mário Soares a public exhibition ´Light deviated by the Sun´ was also prepared that was displayed during the school and workshop, and is now touring the country (a copy was made to tour in Portugal).

- In October LIP organized a visit to the nuclear power plant at Almaraz, Spain, with the schools participating the project ´Environmental Radiation´, to prepare for the activities in the school year 2009/2010. In the scope of this project, two national meetings were also organized in April and October, that gathered in Vendas Novas and in Lisbon the scientists and about one hundred of teachers and students, that have presented their works. A protocol of cooperation between this project and similar projects was also signed with Sociedade Portuguesa de Física (Physics Portuguese Society), for the sharing of equipment and resources in these common projects.

- In the Ciência Viva stand of the ´Forum Portugal Tecnológico 2009´, LIP had the responsibility of organizing one day, in which the detectors of the ´Environmental Radiation´ project, the cloud chamber and our spark chamber were displayed. From the spark chamber LIP offered 34 certificates of unique Cosmic Rays to young visitors.

- In November LIP co-organized with the Education Committee of Centro Ciência Viva da Amadora and with Amadora High-School, the teachers formation action ´Cosmic Rays at Amadora´, and made two outreach seminars in the high school ´Ferreira Dias´, Cacém, Sintra.

- In December, LIP was certified as an official formation entity, for all legal purposes. This was an important achievement, so that LIP can also certify its teachers programs, in particular the CERN Portuguese Teachers Programs (certification in progress). With this certification, some credits can be officially added to the teachers curriculum.

- Along the year LIP received the visit of groups of students from basic and high schools, despite the fact that the experiments in which LIP participates are located elsewhere (for example, CERN, Argentina, Canada). Nevertheless LIP shows the local GRID cluster node, the electronics laboratory, and makes an outreach seminar about Particle and Astroparticle Physics. Since November, 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 39 outreach seminars were made at schools and other places, a significant increase from 2008.

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.
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 elsewhere in this report.

EPPOG International Masterclasses in Particle Physics

In this activity in 2009, there was a 6th location engaged into the activity, in Porto, so there was expected a slight increase in the number of participants from 550 in 2008 to about 600. Instead there were 800 participants. 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). 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, is a signal of the increased motivation of the students and of the teachers behind them.

Environmental Radiation project

This subproject of the LIP Outreach had a lot of activities in 2009. In particular there were two meetings (in April and October), and one scientific visit to the nuclear power plant in Almaraz, Spain. The increase of activity and participation in this project is also reflected in the number of 55 schools now participating in the project (that started in 2007 with 10 schools).

Teachers Programs

CERN Portuguese Teachers Program
The 3rd edition of this program featured a new adventure: to receive more participants (60) that put CERN resources to its limits and beyond, so that 11 Brazilian and 5 Mozambican teachers could take part along with 44 portuguese teachers. The contacts established between the teachers and scientists (and between Portuguese, Brazilian, and Mozambican teachers) were very important for the cooperation in education between these countries, as well as for outreaching CERN to places other than the CERN member states.

S. Tomé and Príncipe Physics School
´What do we know about our Universe?´, public exhibition ´Light deviated by the Sun´, coupled to the Workshop ´7th New Worlds in Astroparticle Physics´. This school, exhibition and conference (the later described elsewhere in this report), were instrumental in bringing Particle and Astroparticle Physics to S.Tomé and Princípe, and as a way of cooperation in physics education between the countries of the CPLP - Community of Countries with Portuguese as official language. These activities were also part of the Celebration of the 90th

anniversary of the experiments performed by Sir Arthur Eddington in 1919 that verified the General Relativity of Albert Einstein.

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.

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 and related events (in 2008), 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 2009, LIP-OR members made 39 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 2009	6.000 €	2009-03-01	2009-05-31
OCJF 2009	1.949 €	2009-06-01	2009-10-31
PTP 2009 CERN	42.500 €	2009-08-29	2009-09-04
Masterclasses and Env.Rad.	15.000 €	2009-10-01	2010-07-31

7.1.6 Team

Project coordinator: Pedro Abreu

Name	Status	%of time in project
Agostinho Gomes	Researcher (LIP)	1
Amélia Maio	Researcher (LIP/FCUL)	15
Américo Pereira	Technician (LIP)	20
Ana Rodrigues	Collaborator	20
Ana Fernandes	Collaborator	20
Ana Pinho	Collaborator	20
Ana Pinto	Collaborator	20
António Onofre	Researcher (LIP)	10
Bruna Rico	Collaborator	20
Carlos Bernardino	Collaborator	20
Carmen Oliveira	Collaborator	20
Conceição Abreu	Researcher (LIP)	40
Cristina Melo	Collaborator	5
Fernando Barão	Researcher (LIP/IST)	5
Florbela Rego	PhD student (LIP)	10
Gaspar Barreira	Researcher (LIP)	0
José Rogério Nogueira	Collaborator	5
Luis Peralta	Researcher (LIP/FCUL)	20
Marco Quinteiro	Researcher	20
Maria António	Collaborator	5
Paula Pinho	Collaborator	20
Paulo Nunes	Collaborator	20
Pedro Abreu	Researcher (LIP/IST)	35
Pedro Assis	Post-Doc (LIP/FCT) *	10
Sandra Soares	Researcher (LIP/UBI)	20

7.1.7 Publications

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

- *Radioactivity in the classroom*
  Luis Peralta e Carmen Oliveira
  Science in School Issue 12 (2009) pp. 57- 61

Articles in national journals

- *Projecto Radiação Ambiente*
  Luís Peralta e Conceição Abreu
  Gazeta da Física, Vol. 32 n.1 (2009) p. 41

7.1.8 Presentations

Outreach seminars

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  at in Escola Secundária Vergílio Ferreira, Lisboa.
- *Colidir para descobrir*
  presented by Luis Peralta
  at in Escola Secundária Dr. Ginestal Machado, Santarém.
- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  at Jornadas Nemesianas 2009 in Escola Secundária Vitorino Nemésio, Lisboa.
- *O que fazem os Físicos no CERN?*
  presented by Pedro Abreu
  at in Instituto Superior Técnico, Lisboa (Visita de Escolas ao IST).
- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  at in Escola Secundária da Amadora.
- *As radiações na Medicina*
  presented by Luis Peralta
  at in Escola secundária José Saramago, Mafra.
- *O que fazem os Físicos no CERN?*
  presented by Pedro Abreu
  at in Escola Secundária Braamcamp Freire, Lisboa.
- *As radiações na Medicina*
  presented by Luis Peralta
  at in Escola EB 23 Vasco Santana, Odivelas.
- *LHC e o CERN*
  presented by João Seixas
  at Semana da Física in Centro Cultural de Macedo de Cavaleiros.
- *Partículas no CERN*
  presented by Agostinho Gomes
  at in Externato Ribadouro, Porto.
- *Física de Partículas*
  presented by Filipe Veloso
  at in Escola Secundária de Cinfães.

- *Física de Partículas - 2*
  presented by Filipe Veloso
  at in Escola Secundária de Cinfães.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  at in Escola Secundária Diogo de Gouveia, Beja.

- *O Estranho Mundo das Partículas Elementares*
  presented by Pedro Abreu
  at in Escola Secundária João Gonçalves Zarco, Matosinhos.

- *Entrevista ao canal :2 sobre o Início do LHC e mini-buracos negros*
  presented by João Seixas
  at in .

- *O Estranho Mundo das Partículas Elementares*
  presented by Pedro Abreu
  at in Escola Secundária do Castêlo da Maia (Maia).

- *À Procura do Bosão de Higgs*
  presented by Pedro Abreu
  at in Escola Profissional de Arqueologia, Freixo (Marco de Canaveses).

- *O que fazem os Físicos no CERN?*
  presented by Pedro Abreu
  at in Escola Secundária de São Pedro, Vila Real.

- *Ao Encontro do Infinito*
  presented by Pedro Abreu
  at in LIP (Visita do grupo de estudantes "Mais de 10").

- *As radiações na Medicina*
  presented by Luis Peralta
  at in Escola Secundária Miguel Torga, Massamá.

- *O Estranho Mundo das Partículas Elementares*
  presented by Pedro Abreu
  at in Escola Salesiana Oficinas de São José, Lisboa.

- *O Estranho Mundo das Partículas Elementares*
  presented by Pedro Abreu
  at in Escola Secundária Gama Barros, Cacém, Sintra.

- *As radiações na Medicina*
  presented by Luis Peralta
  at in Colégio Manuel Bernardes, Lisboa.

- *Do infinitamente grande ao infinitamente pequeno*
  presented by João Carvalho
  at in Escola Secundária da Mealhada.

- *aceleradores e detectores: LHC/CERN*
  presented by João Carvalho
  at in Escola Básica Integrada Infante D. Pedro, Penela.

- *As radiações na Medicina*
  presented by Luis Peralta
  at in Escola Secundária Ferreira Dias, Cacém.

- *Das Partículas às Estrelas*
  presented by Pedro Abreu
  at in Escola Secundária Braamcamp Freire, Lisboa.

- *As radiações na Medicina*
  presented by Luis Peralta
  at in Escola Secundária de Camarate.

- *Entrevista ao canal AXN - programa "Descobertas"*
  presented by João Seixas
  at in .

- *Raios cósmicos e câmara de faíscas*
  presented by João Carvalho
  at in Escola Secundária Avelar Brotero, Coimbra.

7.1.9 Events

- *EPPOG Int´l Masterclasses in Particle Physics at Lisboa*
  Outreach Event, IST and FCUL, Lisboa, 2009-03-21

- *EPPOG Int´l Masterclasses in Particle Physics at Covilhã*
  Outreach Event, Universidade da Beira Interior, Covilhã, 2009-03-21

- *EPPOG Int´l Masterclasses in Particle Physics at Coimbra*
  Outreach Event, LIP and FCTUC, Coimbra, 2009-03-21

- *EPPOG Int´l Masterclasses in Particle Physics at Faro*
  Outreach Event, Universidade do Algarve, Faro, 2009-03-25

- *EPPOG Int´l Masterclasses in Particle Physics at Porto*
  Outreach Event, Universidade do Porto, Porto, 2009-03-28

- *2º Encontro Nacional de Escolas do Projecto Radiação Ambiente*
  Outreach Event, Externato Marista, Lisboa, 2009-04-18

- *Workshop on Job Types - About being a Scientist, by Helena Santos*
  Outreach Event, Escola Secundária Quinta do Marquês, 2009-05-05

- *Estágio ´Construção de Detectores de Radiação X´*
  Outreach Event, LIP e FCUL, Edif. C8, Campo Grande, 1749-016 Lisboa, 2009-06-29

- *Estágio ´Caça ao Radão na Beira Interior´*
  Outreach Event, LIP e Universidade da Beira Interior, Covilhã, 2009-06-29

- *Estágio ´Acontecimentos na experiência ATLAS em LHC´*
  Outreach Event, LIP e CFNUL, Av. Prof. Gama Pinto, 2, 2009-07-20

- *Estágio ´Detectores na experiência ATLAS em LHC´*
  Outreach Event, LIP e CFNUL, Av. Prof. Gama Pinto, 2, 2009-07-20

- *Estágio ´Raios Cósmicos de Energia Extrema´*
  Outreach Event, LIP, Av. Elias Garcia, 14, 1., 1000-149 Lisboa, 2009-07-20

- *Encontro Nacional de Professores*
  Outreach Event, FCUL, Lisboa, 2009-10-17

7.1.10 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Articles in national journals	1
Outreach seminars	30
Outreach Events	13

7.2 Technology Transfer Network and Industrial Liaison Office

7.2.1 Resumo

As actividades de Agente de Ligação Industrial (ILO) e as matérias relativas à Transferência de Tecnologia (TT) foram iniciadas no LIP no último trimestre de 2009. Estas duas áreas têm como objectivo principal reforçar o link entre o domínio da investigação fundamental e aplicada com as capacidades tecnológicas da indústria nacional. Para cumprir este objectivo, o LIP colocou recursos na ligação com um projecto liderado pelo CERN chamado, Rede de Transferência de Tecnologia (TTN) e em paralelo assinou um protocolo com a Fundação para a Ciência e Tecnologia (FCT) para a execução das actividades do ILO no apoio à delegação portuguesa no CERN, ESO, ESRF.
Projecto Rede de Transferência de Tecnologia (TTN): A Estratégia Europeia para a Física de Partículas foi aprovada com unanimidade pelo Conselho do CERN numa sessão especial realizada em Lisboa no dia 14 Julho, 2006. Na sessão de matérias complementares (CERN/2685) é dada a particular atenção à participação da indústria europeia no programa da Física de Partículas e o seu acesso às tecnologias resultantes do programa para as suas próprias necessidades tecnológicas. As delegações expressaram um grande interesse em aumentar a eficiência de actividades de Transferência de Tecnologia (TT) nos Estados-Membros. Em Março de 2007, o Conselho do CERN aprovou com unanimidade o estabelecimento de um grupo de trabalho de transferência de tecnologia (TTTF), com o mandato para a elaboração de uma proposta de um programa de trabalho e recursos exigidos para enaltecer o impacto das tecnologias que originam da Física de Partículas na indústria e em favor da sociedade (CERN/FC/5128, CERN /2712). Reconhecendo a necessidade de perícia, recursos qualificados adicionais e a infra-estrutura apropriada a fim de gerir as matérias de transferência de tecnologia e conhecimento (KTT) na área de Física de Partículas, o TTTF recomendou a criação da Rede de Transferência de Tecnologia (TTN) que o Conselho do CERN aprovou numa sessão em Março de 2008 (CERN/FC/5231, CERN/2778). A reunião kick-off do TTN ocorreu no CERN no dia 10 de Abril de 2008. A rede tem operado com uma estrutura onde cada membro é classificado como um nó da TTN e cada nó pertence ao conselho da TTN. Além disso,há um comité de direcção composto de um coordenador de projecto e de um gestor do work-package. Até a data a lista de nós é composta por: CEA/DSM (França), CERN (Suiça), Chalmers (Suécia), Universidade de Copenhaga (Dinamarca), CNRS/IN2P3 (França), DESY (Alemanha), EPFL, serviço de relações industriais (Suiça), GSI (Alemanha), INFN (Itália), Instituto de JSI Joseph Stephan (Eslovénia), Instituto Paul Scherrer PSI (Suiça), Universidade Técnica Nacional de Atenas (Grécia), STFC (Reino Unido), Universidade de Sofia (Bulgária). Para a execução da infra-estrutura e das ferramentas que exigem a operação da TTN, os seguintes work-packages constituem o projecto TTN: WP1, fornecerá um conjunto de princípios e código de conduta para membros da TTN para facilitar a adopção de uma gestão de Propriedade Intelectual (PI) compatível com o modelo Open Science. WP2, vai focar no desenvolvimento de um website relativo à promoção da transferência de tecnologia na área de Física de Partículas. WP3, concentrar-se-á na especificação e na execução dos métodos e dos indicadores para avaliar quantitativa e qualitativamente os resultados das actividades de TT executadas no âmbito da rede TTN. WP4, endereçará a execução de WP1 e WP2 (teste) na avaliação do modus operandi que cobre todos os aspectos do processo de TT, o teste caso está relacionado com os desenvolvimentos relativos aos detectores gasosos, Micro-Pattern Gas Detectors (MPGDs). WP5, as actividades de coordenação do projecto TTN, incluindo a organização e a continuação do programa de trabalhos e do relatório. WP6, centrar-se-á sobre um estudo sobre os mecanismos e os factores que contribuem aos impactos sócio-económicos da Física das Altas Energias e da Física de Partículas na sociedade em geral.
Actividades do ILO: Uma das indicações sobre a missão da FCT é promover, a investigação e desenvolvimento, inovação da indústria em áreas-chave que podem impulsionar a participação da indústria portuguesa em programas e projectos internacionais. Sendo assim, no último mês do ano de 2009, o LIP assinou um protocolo com a FCT para executar o mandato da função de ILO em apoiar a delegação portuguesa no Laboratório Europeu de Física de Partículas (CERN),no Observatório Europeu do Sul (ESO) e Laboratório Europeu de Radiação Sincrotrão (ESRF). O ILO será o canal de activação e de informação entre as necessidades de fornecimento (concursos) para produtos & serviços do CERN, do ESO e do ESRF e as capacidades industriais das empresas portuguesas a responder a estas necessidades de fornecimento (concursos) das organizações. Além desta tarefa desafiante, o ILO irá igualmente promover a carteira de tecnologias disponíveis e know-how do CERN, ESO, ESRF que pode ser apropriado para transferência tecnológica para as empresas portuguesas e/ou centros de I&D nacionais tais como o LIP.

7.2.2 Abstract

The activities of Industrial Liaison Officer (ILO) and matters related to Technology Transfer (TT) were initiated at LIP during the last trimester of 2009. These two areas have the aim of linking fundamental and applied research with the technological capabilities of national industry. To fulfill this aim, LIP is putting efforts on

one hand in a project lead by CERN called, Technology Transfer Network (TTN) and on the other hand signed a protocol with the Foundation for Science and Technology (FCT) for the execution of the ILO activities to support the Portuguese delegation at CERN, ESO, ESRF.
Technology Transfer Network project: The European Strategy for Particle Physics has been unanimously approved by CERN Council at a special session held in Lisbon on the 14th July, 2006. In the section on complementary issues (CERN/2685) it is given particular attention to the involvement of European industry in the Particle Physics program and to its access to the resulting technologies for its own needs. Delegations have expressed a strong interest in increasing the efficiency of Technology Transfer (TT) activities in Member States. In March 2007, CERN Council unanimously approved the setting-up of a Technology Transfer Task Force (TTTF), with the mandate of elaborating an implementation proposal on the organization, programme of work and resources required to enhance the impact of technologies originating from Particle Physics on industry for the benefit of society (CERN/FC/5128, CERN /2712). By recognizing the need for additional expertise and resources and proper infrastructure in order to provide a tangible approach to address Knowledge and Technology Transfer (KTT) issues in Particle Physics, TTTF recommended the creation of a proactive, recognized and professional TTN in Particle Physics which CERN Council approved at its session of March 2008 (CERN/FC/5231, CERN/2778). The kick-off meeting of the TTN took place at CERN on April 10th, 2008. The Network has been operating with a structure where each Member is classified as a TTN Node and each Node belongs to the TTN Board. In addition there is a Steering Committee composed of a Project coordinator and Work-Package Convener. Until date the list of Nodes is composed by: CEA/DSM (France), CERN (Switzerland), Chalmers (Sweden), Copenhagen University (Denmark), CNRS/IN2P3 (France), DESY (Germany), EPFL,Service des relations industrielles (Switzerland), GSI (Germany), INFN, Universita degli dell Insubria (Italy), JSI Joseph Stephan Institute (Slovenia), PSI Paul Scherrer Institute (Switzerland), National Technical University of Athens (Greece), STFC, Science and Technology Facilities Council (UK), University of Sofia (Bulgaria). For the implementation of the infrastructure and tools that require the operation of the TTN the following work-packages constitute the TTN project: WP1, will provide a set of principles and code of practice for members of the TTN to facilitate the adoption of a sensible IP approach compatible with the Open Science model. Together with a set of contract templates for licensing, contracted and collaborative research, this will constitute an IP charter for the use of all Network participants. WP2, will address the development of a TT for Particle Physics promotional website. WP3, will concentrate on the specification and implementation of methods and indicators for evaluating quantitatively and qualitatively the results of TT activities executed in the framework of the TT Network. WP4, will address the implementation of WP1 and WP2 (test and utilize) on new cases assessing the modus operandi covering all aspects of the TT process, the test case will be related to developments related to Micro-Pattern Gas Detectors (MPGDs). WP5, will comprise all TTN project coordination activities, including organization and follow-up of the program of work and reporting. WP6, will focus on a study that will output the Mechanisms and factors contributing to the socio-economic impacts of High Energy Physics and Particle Physics in society at large.
ILO activities: One of the mission statements of the Portuguese Foundation for Science and Technology (FCT) is to promote, support research & development and industry innovation in key-areas that can boost the Portuguese industry participation in international programmes and projects. Therefore, during the last month of 2009, LIP signed a protocol with FCT to execute the mandate of the ILO function in supporting the Portuguese delegation at 3 science research facilities where Portugal is a Member or Associated State: The European Organization for Nuclear Research (CERN), The European Southern Observatory (ESO) and The European Synchrotron Radiation Facility (ESRF). The ILO will be an activation and information channel between the supply needs of products & services of CERN, ESO, ESRF and the industrial capabilities of Portuguese companies to respond to these supply needs. In addition to this challenging task, the ILO will also promote the portfolio of available technologies, know-how in CERN, ESO, ESRF that can be suitable for transfer to Portuguese companies and/or national research centers.

7.2.3 Objectives

TTN project
- LIP approval as a member of the TTN project and join WP4: Implementation (test and utilize) where it is designated to address a number of issues that are related to Micro-Pattern Gaseous Detectors (MPGDs), such as, mapping the developments (review of patents, if any, technologies, expertise, know-how).
Industrial Liaison Activities
- Establish at least 2 company presentations to technical departments and/or groups at CERN and ESO.
- Start establishing 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 potential projects and technologies that can be suitable

to Portuguese companies.

7.2.4 Achievements

TTN Project
- On the 6th of November 2009, LIP sent a letter of interest to the TTN Coordinator at CERN, to join the TTN. The TTN Board and Steering Committee meeting was held at CERN on the 11th November 2009. By unanimous vote of the Network members present, LIP application was approved to become a member (node) of the TTN and joined WP4.
Industrial Liaison Activities
ESO
- Following the notice that the Portuguese company Active Space Technologies won a tender released by ESO called: (Conceptual design of the Adaptive Optics Calibration Unit for the E-ELT), the ILO engaged in actions to promote a general meeting at ESO with the heads of the following departments:
o Electronics Systems;
o Structures;
o Control Systems
o ALMA project: Integrated Product team leader
The general meeting was held at ESO on the 3rd November 2009 with very good feedback from the department heads and the ALMA team leader considering Active Space Technologies as a qualified industrial partner for near-future ESO tenders.
CERN
- Through the efforts of the ILO on the 10th December 2009 the Portuguese company Active Space Technologies was presented to CERN as a potential new supplier to:
o Heads of department Technology and Engineering;
o Head Finance and Procurement;
- In that same presentation meeting the Mechanical & Materials Engineering group was present and in the framework of the Compact Linear Collider Study (CLIC) Active Space Technologies was considered as a potential supplier (to be qualified) to supply a prototype test piece of 11 Ghz - accelerating structure.
CERN, ESO, ESRF
- During the months October, November 2009 several meetings were held with different stakeholders at the organizations to re-inforce the portuguese ILO network, as follows:
CERN: Heads of Knowledge & Technology Transfer (with participation at the bi-annual National Technology Transfer Officers meeting) and Procurement office;
ESO: Procurement officer responsible for contracts with Portugal and a portuguese administrative staff;
ESRF: Procurement officer and a local staff - Portuguese doctoral student doing research in BioPhysics.

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)	33

7.2.7 Project Summary

(no values to report)

Chapter 8

Scientific Conferences and Seminars

8.1 Seminars

Seminars

- *Searching for photons with Haverah Park and with the Pierre Auger Observatory*
  presented by Alan Watson on 2009-01-15
  at in LIP Lisbon.
- *Estudos de Fluorescência e Detecção de Raios Cósmicos*
  presented by Luis Pereira on 2009-01-27
  at Café com Física in Coimbra.
- *Discovery opportunities in electroweak physics at the LHC*
  presented by Tom LeCompte (Argonne Laboratory/CERN) on 2009-01-28
  at LHC seminars in IST.
- *Measuring quarkonium polarization*
  presented by Pietro Faccioli (LIP) on 2009-02-10
  at in LIP Lisbon.
- *O Prémio Nobel da Física de 2008*
  presented by Pedro Ferreira (CFTC/ISEL) on 2009-02-26
  at in LIP Lisbon.
- *Multi-lepton signals from seesaw messengers at LHC*
  presented by Juan Aguilar-Saavedra on 2009-03-12
  at in LIP Lisbon.
- *Towards Top quark physics and beyond in CMS*
  presented by Jorgen D´Hondt (University of Brussels, Belgium) on 2009-03-13
  at LHC seminars in IST.
- *Study of ttbar dilepton and single top events with the CMS detector*
  presented by Andrea Giammanco (University of Louvain, Belgium) on 2009-03-13
  at LHC seminars in IST.
- *Cross-generation flavour physics: The measurement of gamma and how CLEO-c helps*
  presented by Jonas Rademacker on 2009-03-19
  at in LIP Lisbon.
- *The golden years of high energy gamma astrophysics: a selection of recent results from Fermi and from the Cherenkov gamma detectors*
  presented by Alessandro de Angelis on 2009-03-26
  at in LIP Lisbon.
- *The ClearPEM project: basic R&D, clinical application and future developments*
  presented by Pedro Rodrigues on 2009-04-02
  at in LIP Lisbon.

- *Probabilistic reasoning in frontier science*
  presented by Giulio D´Agostini (University of Rome, Italy) on 2009-04-15
  at LHC seminars in IST.

- *Seaching for Dark Matter: from XENON10 to LUX*
  presented by Luiz de Viveiros on 2009-04-16
  at Café com Física in Coimbra.

- *A multidimensional unfolding method based on Bayes´ theorem*
  presented by Giulio D´Agostini (University of Rome, Italy) on 2009-04-17
  at LHC seminars in IST.

- *Particle Populations in the Heliosphere*
  presented by Dalmiro Maia on 2009-04-30
  at in LIP Lisbon.

- *Looking beyond the Standard Model at LHC: SUperSYmmetry & the case for stop*
  presented by Pedrame Bargassa on 2009-05-06
  at in LIP Lisbon.

- *Primeiros Resultados de ZEPELIN III*
  presented by Vladimir Solovov on 2009-05-19
  at Café com Física in Coimbra.

- *Câmaras de planos resistivos (RPCs) da física de partículas à saúde"*
  presented by Alberto Blanco on 2009-05-26
  at Café com Física in Coimbra.

- *Computacao GRID*
  presented by Miguel Oliveira on 2009-06-09
  at Café com Física in Coimbra.

- *Probing the SM using Top quarks*
  presented by Michele Gallinaro on 2009-06-16
  at Café com Física in Coimbra.

- *Processos raros associados ao quark top*
  presented by Rita Monteiro on 2009-06-23
  at Café com Física in Coimbra.

- *Fishing hadronic resonances in the background bin*
  presented by Eef van Beveren (U. Coimbra) on 2009-06-25
  at in LIP Lisbon.

- *Measurement of the Z+jet decaying to two neutrinos cross section*
  presented by Cibran Santamarina Rios on 2009-06-29
  at in LIP Lisbon.

- *Atmospheric monitoring devices at the Pierre Auger Observatory*
  presented by Roberto Mussa (INFN - Torino) on 2009-07-02
  at in LIP Lisbon.

- *ATLAS*
  presented by João Carvalho on 2009-07-07
  at Café com Física in Coimbra.

- *Mini-jornadas da Ocupação: Partículas trocadas por miúdos!*
  presented by Sara Anacleto, Soraya Caixeiro e Diogo Pascoal, André Farinha, Emanuel Sousa e Rafael Vieira, Mariana Santos, Miguel Rodrigues, Ricardo Sousa e Rui Trindade on 2009-07-30
  at in LIP Lisbon.

- *Resultados do Observatório Pierre Auger*
  presented by João de Mello (UFRJ) on 2009-09-14
  at in LIP Lisbon.

- *Jet Studies*
  presented by Tarcisio Del Prete (INFN Pisa) on 2009-09-24
  at in LIP Lisbon.

- *Primary Scintillation from CF4*
  presented by Andrey Morozov on 2009-10-27
  at Café com Física in Coimbra.

- *FCNC quark top decay at ATLAS*
  presented by Miguel Won on 2009-11-10
  at Café com Física in Coimbra.

- *O inicio do LHC*
  presented by João Carvalho on 2009-11-24
  at Café com Física in Coimbra.

- *Overflowing your buffer*
  presented by Gonçalo Borges on 2009-11-26
  at in LIP Lisbon.

- *The Large Hadron Collider: The Big Bang Machine*
  presented by Albert De Roeck (CERN) on 2009-12-16
  at LHC seminars in IST.

8.2 Conferences

- *7th International Workshop on New Worlds in Astroparticle Physics*
  Workshop, S. Tomé, S. Tomé e Príncipe, 2009-09-08

- *PASC Winter School*
  Workshop, Sesimbra, Portugal, 2009-12-19