Laboratório de Instrumentação e Física Experimental de Partículas

Relatório de Actividades

2007

Contents

Chapter 1

Overview

The Lip scientific and technical activities during 2007, described shortly here, had followed, in their mainlines, the plan established and approved.

Areas of Research:

Experimental Particle Physics

CERN, and particularly LHC, were the focal point of our activities in this area: the Portuguese commitments towards CMS and ATLAS in the last stage of the construction and commissioning of the detectors, to prepare for full operation in 2008 were all respected: scientific, technical and financial. This was the end of a period of 13 years of sustained activity and the LIP teams have now achieved maturity, reasonable size and visibility being prepared for the next and crucial phase.
Our involvement in Compass and NA60, at CERN and the Hades collaboration at GSI, with a large financial support from EU, were consolidated.

Experimental Astroparticle Physics

After becoming full member of the Auger Observatory, this collaboration is beginning to emerge as the largest and long term astroparticle activity in the area of Astroparticle Experimental Physics in our Laboratory.
The remarkable scientific results of the 2007 runs are an extraordinary encouragement to consolidate and develop our commitments, namely following closely the developments towards the installation of the North Hemisphere Observatory.
Dark Matter (ZEPLIN) is becoming a central activity in Coimbra linking together competence in Xenon detectors with an ambitious physics program. Neutrinos (SNO and SNO+) are being followed with the ambition to establish a sustainable scientific activity and a reasonably sized team.
The uncertainties about the future of AMS were not clarified during 2007.

Instrumentation and Detectors R&D

The R&D activities related to Detectors, mainly in Coimbra, confirmed the excellence and scientific relevance of a team that, for decades, has been and persists to be an international reference. The large spectrum of activities, namely in the recent and encouraging developments of the RPC technology, are being more connected to applications both in the areas relevant to Experimental Particle Physics but also in the other areas, being particularly promising in the area of medical imageology.

Medical Physics

Medical Physics Instrumentation, Systems and Tools, exploiting technologies developed for Particle Physics are now established in our Laboratory, both in Lisbon and Coimbra, as a sustained domain of activity.The development of a state of the art PET system came close to completion, ready for clinical tests during 2008.

Computing

In order to support the LHC Physics activities, we began the installation of a very large infrastructure for Grid Computing. A Consortium has been established between LIP, FCCN and LNEC to install and run the largest Computer Centre ever built in Portugal. An investment of more than 3, 5 MEuro was made available for an infrastructure at the scale of thousands of CPU units, Petabytes of Storage Capacity and multi Gigabit connectivity. LIP is responsible for the technical design and operation of the infrastructure. Operations are scheduled to begin in September 2008.

Outreach, Dissemination and Training

Our involvement in these areas is becoming more and more an independent area of activity in our Laboratory. New initiatives have been added to our current activities. Particularly successful was the organization at CERN of a week School for Portuguese teachers in Portuguese language. The School was attended by 43 participants. We plan to repeat this activity during 2008.

Other:

The Associated Laboratory: the contracts that have been negotiated for the first five years term were all signed (10 Senior Researchers + 9 Engineers and Technicians) but the mid term evaluation and the consequent renewal of the contract for the next five years term has been postponed. It will take place during 2008.
The Consortium FISICA-N: the members of the consortium (LIP, ITN, IPFN and FCCN) have defined the legal framework of the Consortium and defined the Scientific Program and the Installation Plan. However no formal public commitment by the Ministry and FCT was taken during 2007.
During 2007 LIP has received letters of intent from two theoretical Research Centres (CENTRA and CFTP) to establish closer relations with LIP. We were reviewing and considering on the best ways of making stronger the links between the Particle Physics Community as a whole and the Universities in order to implement a more ambitious strategy. Particularly relevant in this sense was the
Creation of the PASC Initiative.

1.1 Fundings for LIP Lisboa

Project	Code	Funding	Entity	Start	End
AMS	PDCTE/FNU/50364/2003	40.000 €	FCT	2004-11-01	2007-10-31
ATLAS	POCI/FP/81934/2007	225.000 €	FCT	2007-07-01	2008-06-30
	POCI/FP/63936/2005	220.000 €	FCT	2006-09-01	2007-08-31
CMS	POCI/FP/63922/2005	255.000 €	FCT	2006-09-01	2007-10-31
	POCI/FP/81930/2007	260.000 €	FCT	2007-09-01	2008-08-31
COMPASS	010.6/B009/2005	252.000 €	EU	2004-01-01	2008-12-31
	POCI/FP/63939/2005	130.000 €	FCT	2006-09-01	2007-10-31
	POCI/FP/81973/2007	150.000 €	FCT	2007-07-01	2008-06-30
GRID	EELA (026409)	78.000 €	EU	2006-01-01	2007-12-31
	int.eu.grid (IST-7-0 31857)	154.000 €	EU	2006-05-01	2008-04-30
	GRID 233/7.2/C/NAC	695.336 €	FCT	2007-06-01	2008-09-30
	EGEE-II (RI-031688)	274.888 €	EU	2006-04-01	2008-04-30
	GRID/GRI/81842/2006	180.700 €	FCT	2007-09-10	2010-09-09
HECR	POCI/FP/63917/2005	100.000 €	FCT	2006-09-01	2007-10-31
	POCI/FP/81914/2007	125.000 €	FCT	2007-07-01	2008-06-30
	PTDC/FIS/65308/2006	155.000 €	FCT	2007-04-22	2009-04-21
MC in Medical Physics	POCI/FP/63909/2005	30.000 €	FCT	2006-09-01	2007-10-31
	POCI/FP/81924/2007	25.000 €	FCT	2007-12-18	2008-12-17
Mobilidade	HELEN	19.800 €	EU	2007-01-01	2008-12-31
NA60	POCI/FP/81945/2007	15.000 €	FCT	2007-09-01	2008-08-31
	POCI/FP/63919/2005	25.000 €	FCT	2006-09-01	2007-12-31
OUTREACH	2006-204/176	56.000 €	Ciência Viva	2007-04-01	2008-06-01
	PTP 2007 CERN	32.000 €	Ciência Viva	2007-09-09	2007-09-14
	POCTI/DIV/2005/00087	50.000 €	FCT	2005-06-01	2007-03-31
	OCJF2007	3.000 €	Ciência Viva	2007-07-01	2007-09-30
PET - Mammography	PET - Mammography II	768.280 €	AdI	2007-01-01	2008-06-30
SNO	POCI/FIS/56691/2004	35.000 €	FCT	2005-01-01	2007-03-31
Space	ESA:19770/06/NL/JD	78.200 €	ESA	2006-07-01	2008-05-31
	ESA:18121/04/NL/CH	80.000 €	ESA	2006-11-01	2008-10-31

1.2 Fundings for LIP Coimbra

Project	Code	Funding	Entity	Start	End
Air Scintillation	POCI/FP/81944/2007	20.000 €	FCT	2007-07-01	2008-09-30
	POCI/FP/63913/2005	20.000 €	FCT	2006-11-01	2007-10-31
ATLAS GRID	GRID/GRI/81727/2006	140.000 €	FCT	2007-04-12	2010-04-11
ATLAS TDAQ	POCI/FP/81940/2007	95.000 €	FCT	2007-07-01	2008-06-30
GEMs	RII3-CT-2003-505925	88.000 €	FCT / EU	2004-01-01	2007-12-31
	POCI/FP/81974/2007	15.000 €	FCT	2007-07-01	2008-06-30
HADES	LIP-GSI contract	414.000 €	GSI	2005-11-01	2009-10-31
	POCI/FP/81982/2007	20.000 €	FCT	2007-07-01	2008-06-30
	EU Contract 515876 D IRAC-Phase-1	52.000 €	EU	2005-11-01	2009-10-31
Human PET	POCI/SAU-OBS/61642/2 004	47.160 €	FCT	2005-01-01	2008-06-30
Oficina-Coimbra	REEQ/573/FIS/2005	441.000 €	FCT	2005-03-01	2007-12-31
Physics at LHC	POCI/ FP/63926/2005	20.000 €	FCT	2006-11-01	2007-10-31
	POCI/FP/81950/2007	30.000 €	FCT	2007-07-01	2008-06-30
RPCs	POCI/FP/81981/2007	25.000 €	FCT	2007-07-01	2008-12-31
ZEPLIN and n-TOF	POCI/FP/63925/2005	60.000 €	FCT	2006-11-01	2007-10-31
	POCI/FP/81928/2007	75.000 €	FCT	2007-07-01	2008-06-30
	POCI/FP/63446/2005	55.000 €	FCT	2005-09-01	2007-01-31

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	1	1	5	2	2							
ATLAS TDAQ			3		3							
CMS	1	1	9	9				4				1
COMPASS	7	7	10	3						1		
HADES	1			1								
NA60	2	2	12								1	
Physics at LHC	5	5	3	7			3					
DELPHI	3	3									1	
GRID			8	10			4	2				4
ATLAS GRID			1									
AMS			1									
SNO	2	2		3			1					
ZEPLIN and n-TOF	8	7		4								1
HECR	3	2	3	9	4		6			2		
Air Scintillation				1								
Space				3	1							
PET - Mammography			2	1		2					2	
Human PET	2	2		3								1
MC in Medical Physics	1	1	6	2	1	1				1	1	2
RPCs	2	2	1									
GEMs	1	1									1	
OUTREACH				3	1		1	5		1		12
Scientific Conferences and Seminars												4
Totals:	38	35	64	61	12	3	15	11		5	6	24

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				FTE
				D	M	G	O	
ATLAS	9	6	2	7	1	1	4	15.41
ATLAS TDAQ	10			1			2	3.01
CMS	6	5	4	5		3	1	17.18
COMPASS	5	2		2	1			7.51
HADES	6	3						1.35
NA60	2	2	2	2			4	6.54
Physics at LHC	9	1	1	2	1	2	1	4.69
DELPHI	2		1	1				1.19
GRID	4	6	1					10.84
ATLAS GRID	8		2	3		2		2.52
AMS	4			2				2.66
SNO	2		1	1			1	1.50
ZEPLIN and n-TOF	7	7	1	3	1		1	8.49
HECR	10	2	1	3		3		10.25
Air Scintillation	7	6	1	3		1		2.57
Space	5			3			1	3.01
PET - Mammography	1	2	1	4	3			8.08
Human PET	10	6						1.65
MC in Medical Physics	9			3	4	2	2	7.17
RPCs	4	4						0.89
GEMs	5	7		2	1			3.49
OUTREACH	10	2		3		1	1	3.92
Scientific Conferences and Seminars								
Totals:	77	28	12	33	11	12	17	123.92

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				FTE
				D	M	G	O	
ATLAS	3.28	3.21	1.10	5.02	0.42	0.59	1.50	15.41
ATLAS TDAQ	1.92			0.50			0.59	3.01
CMS	2.49	3.05	2.84	3.64		2.37	1.00	17.18
COMPASS	4.34	1.13		2.00	0.04			7.51
HADES	0.90	0.45						1.35
NA60	1.37	1.00	1.39	1.78			1.00	6.54
Physics at LHC	1.44	0.10	0.50	0.55	1.00	0.50	0.50	4.69
DELPHI	0.16		1.00	0.03				1.19
GRID	3.84	6.00	1.00					10.84
ATLAS GRID	1.23		0.25	0.32		0.72		2.52
AMS	0.88			1.78				2.66
SNO	0.30		0.10	1.00			0.10	1.50
ZEPLIN and n-TOF	1.69	0.39	1.00	3.00	0.82		0.42	8.49
HECR	4.00	0.76	0.90	2.11		2.48		10.25
Air Scintillation	1.06	0.64	0.13	0.24		0.50		2.57
Space	0.91			1.10			1.00	3.01
PET - Mammography	0.25	0.85	0.08	3.90	3.00			8.08
Human PET	1.15	0.50						1.65
MC in Medical Physics	2.34			0.82	1.86	0.65	0.66	7.17
RPCs	0.44	0.45						0.89
GEMs	1.16	0.63		0.70				3.49
OUTREACH	0.99	0.24		0.29		0.01	0.89	3.92
Scientific Conferences and Seminars								
Totals:	36.14	19.40	10.29	28.78	7.14	7.82	7.66	123.92

Legend:

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

FTE: Full Time Equivalent

Chapter 2

Accelerator physics

2.1 Collaboration in the ATLAS experiment at CERN

2.1.1 Activity Report

Resumo:

Ao longo do ano de 2007, o grupo Português envolvido no projecto ATLAS prosseguiu as suas actividades, centradas no "commissioning" do Tilecal e na preparação do "commissioning" do detector ATLAS utilizando acontecimentos de Física de LHC. Nestes últimos, destaca-se a medição da secção eficaz do bosão W e o estudo das propriedades do quark top. As actividades de construção estão quase concluídas, com excepção do detector de luminosidade ALFA.
Na finalização da construção de componentes ópticas, foram produzidos, instalados e testados os cabos de fibras ópticas de 125 m que conduzem a luz do laser (sistema de monitorização) até aos barris laterais do Tilecal. Os conectores foram limpos, reparados quando necessário e instalados de novo nos módulos. Foi também instalado o painel de ligação das fibras, onde foram montados os conectores que permitem o ajuste da quantidade de luz em cada fibra. No DCS do Tilecal desenvolveu-se o sistema de controlo e monitorização da alta tensão, e iniciou-se o programa de análise dos dados monitorizados pelo mesmo. A máquina de estados finitos (FSM), foi actualizada com versões mais robustas e versáteis e foi testada a integração durante as semans de "Milestone" M4, M5 e M6.
O grupo esteve fortemente envolvido nos testes de "commissioning" de ATLAS com muões cósmicos, tendo realizado a análise dos dados de Tilecal dos vários períodos de tomada de dados em que o Tilecal participou em conjunto com os restantes detectores de ATLAS. O algoritmo de reconstrução de muões cósmicos TileMuonFitter, actualmente muito usado nos estudos de performance do calorímetro combinado (Tilecal + LAr), foi melhorado. No que respeita aos estudos de desempenho de Tilecal com muões cósmicos, foi dado relevo: aos estudos de resolução em tempo, importantes para a reconstrução da energia no calorímetro com o método de filtro óptimo; aos estudos de uniformidade da resposta do detector; aos estudos de qualidade dos dados, como por exemplo a identificação de canais demasiado ruidosos.
Como preparação para o "commissioning" do detector e do sistema de trigger, estamos a trabalhar na calibração de jactos no segundo nível do trigger. As ferramentas usadas na calibração offline são aplicadas aos jactos do trigger, mas estes são reconstruídos com algoritmos mais simples e rápidos. A avaliação destes métodos demonstrou que, depois da calibração, a escala de energia dos jactos está determinada com uma precisão de +/-2%.
A nossa participação na preparação do "commissioning" da Física continuou. Estamos a preparar a medida da secção eficaz de produção do W no canal de desintegração W->mu nu. Os métodos de análise estão a ser avaliados com dados Monte Carlo, para serem aplicados depois aos dados reais.
Os decaimentos FCNC do quark top (t-> qgamma, t-> q Z and t-> q g) produzidos em LHC individualmente ou aos pares, foram estudados utilizando a simulação rápida do detector ATLAS. A radiação de estado inicial e final foi tida em conta no presente estudo bem como as contribuições dos vários erros sistemáticos. Os resultados obtidos foram apresentados de duas formas distintas: considerando um limiar de descoberta de 5 sigma na razão sinal-ruído, ou sob a forma de limites a 95% de nível de confiança na ausência de sinal. Foram ainda avaliadas várias contribuições para os erros sistemáticos como são por exemplo, a radiação de estado inicial e final, a variação na massa do quark top e a calibração de energia dos jatos.
As actividades de I&D no envelhecimento de fibras ópticas e cintiladores plásticos prosseguiram, tendo agora como motivação extra os cenários de Super-LHC com níveis de radiação até 10 vezes mais elevados do que

os previstos em LHC, e um tempo de vida do detector mais extenso. As estimativas mais pessimistas de perda de luz ao longo dos anos prevêem no final do SLHC 30% da luz inicial, o mínimo necessário para o bom funcionamento do calorímetro. Relativamente ao detector de luminosidade, ALFA, foi construída no CEFITEC/UNL a máquina de aluminização do corpo das fibras ópticas cintilantes. Um conjunto de fibras foi aluminizado, mas foram detectados problemas na adesão do alumínio, pelo que se está a refazer o sistema. O projecto inclui também uma componente de divulgação, que foi intensa ao longo de 2007, com vários dos membros deste projecto a participarem no "Master Class" organizado pela EPOG e em actividades do programa Ciência Viva para jovens estudantes do Verão.

Progress report

The activities related with the construction and commissioning of the ATLAS detector 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. Calibration of jets in trigger level 2 was also studied. The commissioning of Tilecal with cosmic muons proceeded and Tilecal DCS was tested intensively. The involvement in the construction of the ALFA luminosity detector and in optics ageing studies continued. Detailed progress in the several tasks that we are involved is reported in the following sections.

Construction and mounting of components for the Laser calibration system
The laser monitoring system for the Tilecal photomultipliers is in the final phase of installation at the ATLAS experimental area. Bundles of 125 m long clear optical fibres for light transport to the Tilecal extended barrel modules were produced, installed in place and tested. The connectors were cleaned, repaired and installed in the modules, and all the fibers and connectors went through a quality control procedure. It was built and installed a patch panel for the adjustable connectors, used to ensure the uniformity of light being sent to the different modules. Finally it was the routing and labelling of all the fibers in the patch panel.

Scintillating fibres for the ALFA luminosity detector
Our participation in the construction of the luminosity detector for ATLAS started in 2005. This detector (ALFA - Absolute Luminosity For ATLAS) uses square 0.5x0.5 mm2 scintillating fibres staggered in 20 layers. These fibres need to be aluminized both along their body and in one of the ends. The aluminization at the end aims to increase the light yield and the aluminization of the body is used to eliminate the cross talk between the optical fibres of that tracking system.
The sputtering machine to aluminize the fibres along the body was put to work at CEFITEC/UNL. A set of 1400 fibres was aluminized along the body but the fibres did not fulfill all the ATLAS requirements, so it was necessary to review all the system and replace several components in order to obtain better adhesion of the aluminium film. Some tests were done using existing cathodes but they were not suitable for the very demanding conditions of these aluminizations. Good adhesion and reflectivity was obtained in some samples, but not yet in all the wavelength range needed. A huge effort was made to prepare a planar rectangular cathode, using the knowledge acquired in the analysis of the fibres of these test sets, and several companies were identified to make the several components of the system.
A set of fibres was aluminized in the top and sent to CERN to be aluminized along the body still using evaporation technique.
We have participated in the test beam setup and data taking of the ALFA detector in October 2006. The test had as main objective to validate the first electronics prototype and confirm the detector tracking resolution in a high energy proton/pion beam. During 2007 we have participated in the analysis of the test beam data, and in particular, in the evaluation of the cross talk, noise and fibre efficiency. The results were summarized in a publication of the ALFA group in JINST.

Tilecal Detector Control System (DCS)
The development, installation and commissioning of the Tilecal Detector Control System (DCS) proceeded. During summer of 2007 most of the effort was devoted to the implementation and debugging of the High Voltage (HV) control and monitoring software, mainly the communication with the electronics located inside the drawers. The addresses of the cards of each module were corrected in order to get response of all the modules. Software for the analysis of the HV fluctuations was prepared and a preliminary analysis started.
The FSM was upgraded for the ATLAS Milestone Week M5 in October, and again for the M6 week in March. Several missing panels were added or corrected to have the required functionality. Several configurations were tried in order to get a better description of the hardware dependencies in the code used for the switch on and off of the Low Voltage Power Supplies and HV. The current configuration still requires about one hour to start

one partition of the calorimeter after a power cut or global switch off, but since those situations will not happen frequently and it is the only way to have a safe power on, it is acceptable. Some intermediate states are still being studied in such a way to have a better implementation without preventing the shifter of knowing the correct state of the hardware at all the time.

Commissioning of ATLAS with cosmic muons

Our group was strongly involved in the commissioning of ATLAS with cosmic muons. The final phase of the ATLAS detector commissioning proceeded in the second semester of 2007. In late July was carried out the fourth subsystem integration week (Milestone week M4), in which the Inner Detector was brought online in the ATLAS cavern. During this period, the TileCal dedicated trigger was still used. In October took place the M5 integration week, bringing online the Muon Detector and the Level 1 Trigger systems.

Our involvement was centered on the participation in data taking shifts (during M4 and M5), in the analysis of those data for the TileCal detector and in software integration activities for the general ATLAS reconstruction. From the TileCal data analysis, we obtain the validation of the data taken and the characterization of the detector state throughout those periods: description of the TileCal coverage though identification of modules with signal, identification of dead and noisy channels, sinchronization of the detector signal with the trigger, etc... These results are useful for the field teams responsible for the calibration and refurbishment of TileCal components. In addition, we continued the tasks already initiated of calibration of timing offsets with cosmic muons (as a cross-check of the Laser system calibration) and energy response uniformity studies with the PMT imbalance (as a cross-check of the Cesium calibration). Both these tasks are expected to be completed soon.

The software activities consist in the maintenance and improvement of the TileCal reconstruction functionalities, in a context of a progressive integration of more ATLAS subsystems (calorimeters, tracking detectors, muon chambers, trigger systems) and of successive developments of the software infra-structure. This context implies a constant control on the quality of the data processing, with each change in software versions. Until the beginning of LHC collisions, cosmic muons provide a good option for these tests, since they produce signals in all the ATLAS subdetectors.

Characterization of scintillators, WLS fibres and ageing

The ATLAS detector is planned to have an operational life of about 7 years (LHC), followed by about 1 year of shutdown, with a possible extension of 5 years (SLHC). The period of detector construction and commissioning spanned about 9 years. From previous measurements, the expected light loss in the fibres and scintillators due to natural ageing, is about 1% per year. So, in this extended operation scenario, the natural and accelerated ageing studies play a central role in predicting the evolution of the detector performance throughout its operational life, at the end of which the optical components will be more than 20 years old.

We followed the optical ageing, performing the optical quality control of reference fibres, aluminized and non-aluminized mass production fibres and irradiated fibres.

After following for 6 years (8 years for the reference fibres) the light output and transmission of these sets of WLS fibres, we reached these conclusions:

- The fibre-to-fibre light output in each group of 16 fibres is at the level of 5% or less, the typical precision level of this measurement setup, as requested for the Tilecal performance.
- Degradation on the attenuation length due to natural ageing for 4 years is lower than 5%.
- No degradation of the mirror reflectivity is observed, within the experimental accuracy of 5%.
- Global degradation, combining emission and transmission losses, for non-irradiated fibres can in some cases be up to 2% per year

With these results, estimates of total light loss for LHC + SLHC scenarios were done, combining light loss due to natural ageing and light loss due to irradiation. In the worst scenarios, for the most irradiated tiles, the light loss after 22 years (end of 5 year period of SLHC) is expected to be of the order of 70%. With this light loss, the number of npe/GeV is expected to be of the order of 20, the minimum needed to keep acceptable performance of the calorimeter.

Jet Calibration at the Second Level Trigger

The Second Level Trigger of ATLAS (LVL2) runs simple reconstruction algorithms with the aim of accepting or rejecting the signals provided by the first hardware trigger, in about 10 ms processing time. Given the fact that the dominant background for jets are also jets, the main difficulty of the jet trigger consists on measuring correctly the jet energy scale, with the best possible resolution, allowing to reject low energetic jets while keeping high efficiency for the jets over threshold. Therefore, the calibration is the main problem for the LVL2 jet reconstruction.

During the year 2006, our group started to work in the jet calibration for the LVL2. In the first few months of the project, we implemented the software tools that were necessary to apply to the offline available calibration

procedures in the LVL2. We chose a simple calibration method that is very robust and adequate for the short processing times of the trigger. The performance of this method was evaluated using Monte Carlo data samples generated at CERN. The calibration constants were produced running the calibration jobs in the GRID, allowing to process very large amounts of data in short time. Afterwards, the jet energy scale and resolution were studied. We reached an energy scale that is correct within +/-2%. The calibration procedure also improves the resolution by a few %, for all energies.
The results obtained with this work were presented in several collaboration meetings, including two dedicated calibration workshops.
This year, our main effort was invested in the study of realistic data samples, that include mis-alignments and a wrong description of the detector material distribution. These samples simulate the expected knowledge we will have of the detector at the beginning of the data taking and provide a realistic estimation of our expected resolution when starting.
We have also started developing the methods that will allow us to extract or validate the calibration constants with real data, once the LHC starts. In particular, we started to study a calibration procedure that uses events where there is a Z decaying to two muons and a jet. The energy of the Z is well reconstructed at electromagnetic scale. Given the fact that in the transverse plane the total energy of the event should be balanced, the energy of the Z could be used as a measurement of the truth energy of the jet, allowing to extract the calibration constants. We started by estimating the expected accuracy of this method, in order to evaluate its applicability. The work is still ongoing.

W-> mu nu production cross section measurement
The physics commissioning of the detector will start at the end of the year 2008, when the first proton-proton collisions at the LHC will happen. During this period, the first physics studies will be done, at the same time that the detector performance (resolutions, trigger and reconstruction efficiencies) is evaluated with real data. One of the first expected measurements at ATLAS will be the production cross sections of the electroweak bosons W,Z. In 2006, the group started already the preparation for these first physics studies using Monte Carlo simulated data to develop a procedure to measure the W production cross section in the decay channel W-> mu nu.
The work started with the optimization of the signal selection requirements and the implementation of the software tools that were necessary. It continued with the preparation of the methods to extract the reconstruction efficiencies (tracking, muon identification and trigger) with real data, that are needed for the calculation of the cross section. We used Z decays to two muons where one muon is fully identified and the other is used as a probe. The method was demonstrated to be reliable, providing an efficiency compatible to the one obtained by using the MC truth information.

Identification of Jet Flavours With Multivariate Techniques
The correct identification of jets produced by the fragmentation of b quarks is an essential requisite for precision measurements in the top quark sector and for searches for the Higgs boson and physics beyond the Standard Model at the LHC. Tagging techniques exploit specific properties of B-hadrons, such as a long lifetime and large mass, to differentiate them from the large background of jets produced by light quarks and gluons. Boosted decision trees (BDT) is a powerful learning technique in which several decision trees are aggregated to form a classifier given by a weighted majority vote of classifications predicted by individual trees.
BDT can be applied to any classification problem. In particular, they permit the combination of several b-tagging algorithms into a single classifier for discriminating b-jets from light jets. The tagging performance of BDT and artificial neural networks (ANN) was compared using a toy Monte Carlo simulation of WH -> lv qqbar events.
In this study, BDT and ANN classifiers were optimized on a training sample containing b-jet and light jet patterns. Each jet was described by 7 attributes obtained from track impact parameters and reconstructed secondary vertices. The results show that for a b-tagging efficiency of 60% the light jet rejection given by BDT is about 35% higher than that given by ANN. It was also shown that a cascade training technique can improve the performance of BDT and ANN at this b-tagging efficiency level by about 35% and 80% respectively. The tagging performance of BDT was also evaluated using a full simulation of the ATLAS detector. Each jet instance was described by 18 attributes consisting of jet weights from transverse and longitudinal impact parameters, jet weights from reconstructed secondary vertices, jet weights from soft muon and soft electron taggers, an assortment of variables from secondary vertex reconstruction routines and single track based variables, such has the largest transverse impact parameter significance
of tracks in the jet. The results show that for WH events (with mH=120 GeV) and for a b-tagging efficiency of 60% the light jet rejection given by BDT is about 50% higher than that given by a likelihood ratio classifier

based on impact parameters and reconstructed secondary vertices. For t-tbar events and for this efficiency level the rejection given by BDT is about 70% higher.

Top quark physics
In the top quark physics, the work was concentrated in angular asymmetries and Flavour Changing Neutral Currents (FCNC). The LHC will be a top factory with a total t-tbar production cross-section of around 800 pb and single top production of about 300 pb. 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, in particular in placing limits on the amplitude of possible anomalous couplings. For the top quark FCNC processes, the main goal is to study signals of physics beyond the Standard Model (SM) associated to top quark rare decays at the LHC. The FCNC decays t->qgamma, t-> q Z and t-> q g, were studied in the double top production channel. The analysis software was developed for all the channels, optimizing the signal to background ratios, using a probabilistic approach. A careful study of the statistical and systematic errors allowed to extract the 95% confidence level limits in the different channels. In these studies the full simulation of the ATLAS detector was used, which implied a new level of complexity in the software development, and in the access the generated data samples via the Grid computing and data sharing facility. The main goal was to estimate the sensitivity of the ATLAS experiment in these physics channels with the first samples of data acquired after the start of LHC. These studies were presented in several meetings and conferences, and were published as ATLAS notes and in international scientific journals.

2.1.2 Fundings

Code	Funding	Start	End
POCI/FP/63936/2005	220.000 €	2006-09-01	2007-08-31
POCI/FP/81934/2007	225.000 €	2007-07-01	2008-06-30

2.1.3 Team

Project coordinator: Amélia Maio

Name	Status	%of time in project
Agostinho Gomes	Researcher (LIP)	100
Alberto Palma	Graduate student (LIP)	59
Alexandre Moita	Technician (LIP)	7
Amélia Maio	Researcher (LIP/FCUL)	52
André Wemans	Researcher (FCTUNL)	7
António Amorim	Researcher (FCUL)	3
António Morais	Student (LIP)	67
António Onofre	Researcher (LIP/UCPFF)	40
Carlos Marques	Technician (LIP)	99
Carlos Silva	Technician (LIP)	10
Fernando Moita Ribeiro		11
Filipe Veloso	PhD student (LIP/FCT)	50
Helmut Wolters	Researcher (LIP/FCTUC)	7
João Bastos	Post-Doc (LIP)	28
João Carvalho	Researcher (LIP/FCTUC)	30
João Faustino	Technician (LIP)	100
João Gentil	PhD student (LIP/FCUL/FCT)	97
João Pina	PhD student (LIP/FCUL/FCT)	100
João Santos	Master student (LIP)	42
Jorge Moita		8
José Maneira	Researcher (LIP/FCT) *	75
José Pinhão	Technician (LIP)	5
José Silva	PhD student (LIP/FCUL)	67
Luís Gurriana	Technician (LIP)	100
Manuel Maneira	Researcher (FCTUNL)	14
Marta Mimoso	Student (LIP)	25
Nuno Castro	PhD student (LIP/FCT)	60
Patricia Conde	Post-Doc (LIP/FCT)	82
Pedro Jorge	PhD student (LIP/FCT)	82
Rita Monteiro	PhD student (LIP)	46
Sílvia Barros	Student (LIP)	25
Yuri Nunes		10
Zita Lopes	Student (LIP)	33

2.1.4 Publications

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

- *Hadron beam test of a scintillating fibre tracker system for elastic scattering and luminosity measurement in ATLAS*
  F. Anghinolfi et al
  JINST 2 P07004

International Conference Proceedings

- *Implementation and Performance of the ATLAS Second Level Jet Trigger*
  P. Conde Muino et al
  (accepted)

Internal Notes

- *Aluminization of Scintillating Fibers for the Luminosity Detector of ATLAS*
  J.P. Santos, J.G. Saraiva, Y. Nunes, A. Wemans, A. Maio, M.J.P. Maneira

ATL-COM-LUM-2007-001

- *TileMuonFitter: an algorithm for the reconstruction of cosmic muons with the ATLAS tile calorimeter*
  J. Maneira
  ATL-COM-TILECAL-2007-007; ATL-TILECAL-INT-2007-003 (accepted)

- *The Production and Qualification of Scintillator Tiles for the ATLAS Hadronic Calorimeter*
  J. Abdallah et al
  ATL-TILECAL-PUB-2007-010

- *Noise and Cross Talk Studies of the ALFA Prototypes in 2006 Testbeam at CER*
  P. Conde, S. Franz, M. Heller, C. Joram, A. Mapelli, C. Marques, A. Maio
  ATL-COM-LUM-2007-010

2.1.5 Presentations

Oral presentations in international conferences

- *Commissioning of the ATLAS offline software with cosmic rays*
  presented by José Maneira
  at IEEE Nuclear Science Symposium in Honolulu, Hawaii, USA.

Poster presentations in international conferences

- *Implementation and Performance of the ATLAS Second Level Jet Trigger*
  presented by Patricia Conde
  at CHEP 07 (Computing in Higcs h Energy Physics) in Victoria, BC (Canada).
- *The ATLAS/TILECAL Detector Control System*
  presented by João Pina
  at ICALEPCS 07 in Knoxville, Tennessee, USA.

Oral presentations in international meetings

- *Study of ATLAS sensitivity to FCNC top decays*
  presented by Filipe Veloso
  at PASC Winter School in Sesimbra.

Oral presentations in collaboration meetings

- *Timing corrections from cosmics*
  presented by José Maneira
  at TileCal Team 4+5+Performance in CERN.
- *TileCal trigger for the combined cosmic run in April*
  presented by José Maneira
  at Inner Detector Offline Cimmissioning in CERN.
- *PMT energy imbalance in cosmics*
  presented by João Gentil
  at Tilecal Team-4,5 + Performanc in CERN.
- *Same cell PMT intercalibration with cosmics*
  presented by João Gentil
  at TileCal Commissioning in CERN.
- *Phase 3 Status and plans*
  presented by
  at TileCal Week Commissioning in CERN.

- *HV analysis*
  presented by Carlos Marques
  at TileCal DCS Meeting call in .

- *LVL2 jet calibration study*
  presented by Patricia Conde
  at ATLAS TAPM meeting in CERN.

- *LVL2 jet calibration study*
  presented by Patricia Conde
  at ATLAS Trigger&Physics Week in CERN.

- *Noise, Cross talk and Stability using 10_2_16 prototype*
  presented by Patricia Conde
  at ALFA test beam analysis meeting in CERN.

- *Jet re-calibration in physics analyses*
  presented by Patricia Conde
  at ATLAS Hadronic Calibration Meeting in Milano, Italy.

- *Jet energy scale corrections for particle level*
  presented by Patricia Conde
  at ATLAS Hadronic Calibration Meeting in Milano, Italy.

- *Overview of the trigger issues of jet calibration*
  presented by Patricia Conde
  at ATLAS Hadronic Calibration Meeting in Milano, Italy.

- *Cross talk studies with the prototype 10_2_16*
  presented by Patricia Conde
  at ALFA test beam analysis meeting in CERN.

- *ALFA paper: 10_2_16 Data Quality*
  presented by Patricia Conde
  at ALFA test beam analysis meeting in CERN.

- *Status of Tile Reconstruction*
  presented by José Maneira
  at ATLAS Offline commissioning meeting in CERN.

- *In-situ validation of the LVL2 Jet Energy Scale*
  presented by Patricia Conde
  at ATLAS TAPM meeting in CERN.

- *Muon Spectrometer Tracking and Muon Isaloation Efficiency*
  presented by Pedro Jorge
  at CSC note W&Z inclusive X-section in CERN.

- *Summary of noise studies*
  presented by Patricia Conde
  at ALFA TB noise analysis meeting in CERN.

- *Tile M3 Reconstruction and analysis*
  presented by José Maneira
  at ATLAS Software Week/Offline commissioning meeting in CERN.

- *Cross talk 10_2_16 prototype*
  presented by Patricia Conde
  at ALFA TB noise analysis in CERN.

- *Conditions data-base*
  presented by Carlos Marques
  at TileCal DCS in CERN.

- *Requirements from Jets Performance Group*
  presented by Patricia Conde
  at Mini-workshop on Trigger Menus in CERN.

- *Conditions data-base*
  presented by Carlos Marques
  at TileCal DCS in CERN.

- *LVL2 jet energy scale for different data samples*
  presented by Patricia Conde
  at TAPM open meeting in CERN.

- *LVL2 jet plans for release 13.1.0*
  presented by Patricia Conde
  at TAPM open meeting in Milano, Italy.

- *TileCal offline status*
  presented by
  at ATLAS Software Week/Offline commissioning meeting in CERN.

- *Overview of calibration needs for the HL*
  presented by Patricia Conde
  at TileCal Calibration Worksho in CERN.

- *Jet & Bjet Slice Status Report*
  presented by Patricia Conde
  at ATLAS Trigger/DAQ workshop (TAPM plenary session) in CERN.

- *Progress on LVL2 jet energy calibration*
  presented by Patricia Conde
  at ATLAS TAPM Jet meetign in CERN.

2.1.6 Academic Training

PhD Theses

- *Study of top quark decays and the structure of the Wtb vertex"*
  Nuno Castro, (on-going)

- *Production and decay of top quarks via FCNC at the LHC"*
  Filipe Veloso, (on-going)

- *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)

2.1.7 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
International Conference Proceedings	1
Internal Notes	4
Oral presentations in international conferences	1
Poster presentations in international conferences	2
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	29

2.2 Information Systems and Data Acquisition for ATLAS

2.2.1 Activity Report

Introduction

The project team has a long-standing collaboration in the Trigger and DAQ system for the ATLAS experiment. Our continuous participation has accumulated expertise, understanding and deep involvement in the problems and challenges facing the ATLAS TDAQ, in particular in what relates to the database systems technologies. This work is complemented by efforts on the FLT electronics and the online alignment procedures relevant for the HLT.
The main tasks that reflect our responsibilities are:

1. Within the Monitoring and Configurations groups, the official support and extension of the interface for the storage at the central conditions databases of the information available online - ONASIC and ONASIC2.

2. Within the Monitoring group, the development finalization, the deployment and the support for the visualization tool for the ATLAS monitoring DB archive: NODE.

3. Within the FLT electronics group, the continuation of the deployment and testing of the programing electronics of the routing module for the ATLAS central trigger processors.

4. Within the Inner Detector and HLT communities, the continuing development and deployment of the ATLAS/ID calibration streams for TDAQ facilities.

5. Within the online Database group, the further consolidation of the groups tool for object embedding and visualization tools for LCG/COOL databases: TIDB.

This project concentrates the Portuguese efforts associated with the collaboration in the ATLAS TDAQ system. It was felt that a separate evaluation of the different components of the collaboration with ATLAS would increase the dynamism of the different teams while avoiding the possible conflicts in deciding on the sharing of resources. The team includes several students that have been with us for several years.

Tasks

Consolidation of the object embedding and visualization tools for LCG/COOL databases: TIDB

The Time-based Instrumental DataBase (TIDB) is an Application Programming Interface which developed from the the expertise gathered with the creation and operation of a Conditions database interface. The TIDB core provides the main interface for managing time-oriented data, and its functionalities are implemented by a collection of purposely-developed runtime plug-ins which are loaded on-demand. These plugins are comprised of two sets, one for database interaction and another for special object interaction. The first set implements the database backend abstraction layer, to allow a seamless integration with the LCG/COOL database backends as well as other commercial and open-source database interfaces such as Oracle, MySQL and PostgreSQL, as well as the implementation of object Interval of Validity and of table name hierarchy. The second plugin set provides the means to interact with special objects (such as ROOT histograms or OKS database objects) stored as Binary Large Objects in the database backend. The TIDB plugin set gives access to very useful funcionalities, such as table schema evolution or special object streams (which allow object readout and automatic filling of homonym database table fields).
The TIDB library is available as a C++ API, also with C and Fortran interfaces, with very minimal compilation and linkage requirements; a basic ROOT interface implementation is also available. It is the basis of several of our projects described throughout this Report and that have gathered significant interest within the TDAQ community, namely: ONASIC, OKS2COOL, DBStressor, KTIDBExplorer and NODE. The first four have already been tested and deployed, and the fifth project is under development.

Participate in the setup and the systematic large scale evaluation of the ATLAS online Database infrastructure: DBSTRESSOR

Our group is responsible for the maintenance and setup of the ATLAS Oracle COOL databases where both Conditions and Configurations data is stored.

Since the integration or both ONASIC and OKS2COOL in the TDAQ s/w releases, the following technical runs have produce large amounts of data stored in these databases.
A testbench to evaluate ATLAS database infrastructure is now fully functional, using the DBStressor set of tools which has been ran on LXSHARE cluster for the ATLAS production and Integration databases, As DBStressor is now been fully extended to support a generic test bench facility for both LCG/COOL and TIDB2 (Oracle, MySQL, LCG/COOL, PostGresSQL) read accesses, the evaluation of the core module of our main applicatons will be undergoing.
Along with the evaluation being made on the ATLAS Point1 infrasctructure, we have succefully completed the setup of a testbed based on one private host running Scientific Linux 4.5 (syncronized with both LXSHARE and ATLAS P1 clusters) and which periodically checks out the source code of all TDAQ packages and then builds localy the realese, by compiling all the packages using CMT tools. This will allow to sistematicly prepare an image file with all TDAQ up to date s/w for deploying on the GRIDPT cluster resource, making therefore possible to run evaluation tests in esclusive mode more frequently.

Development and deployment of the ATLAS/ID calibration streams for TDAQ Tier0 facilities

Since June 2006 we are developing the software package "InDetAlignStream", which will allow the selection and gathering of all the information needed to compute the first alignment/calibration contants – i.e., the Inner Detecter Alignment and Calibration Stream. This software will process the Express Stream, which successively looks for tracks suitable for the alignment requirements, builds a list of ROBs with hit information from this tracks, passes the track list to EventFilter (EF) for partial event building, and writes to stream.
All this chain was tested in the recent Full Dress Rehearsal 1 (FDR1) with excellent results.

Implementation and support of the "NODE"visualization tool for the ATLAS Monitoring Database Archive
The TDAQ Monitoring Working Group (MWG) is developing and testing the Monitoring Data Archive (MDA), a framework to archive the ROOT histograms generated by the TDAQ Online software. Our team has taken the task to provide the MWG with a graphical tool to display the histograms stored by MDA. To this effect, we have chosen KTIDBExplorer as the implementation basis for the histogram display tool, the oNline Objects extended Database browsEr (NODE). KTIDBExplorer uses Qt for implementing its graphical user interface and the TIDB2 application programming interface which we develop and maintain. TIDB2´s ability to connect to COOL databases also makes NODE a tool to navigate the contents of those databases.
We have implemented a plugin set for TIDB2 and KTIDBExplorer as the means to develop the interaction with the MDA. This system was tested on its storage functionality since the latest Milestone M5 general TDAQ tests in early November 2007, but is still lacking a functional application interface with which we can interact. However, we have already implemented a TIDB2/KTIDBExplorer plugin set to interact with the CASTOR file storage infrastructure which will be used by MDA for offline histogram archival.

The interface from Trigger/DAQ to the ATLAS conditions databases: ONASIC

ONASIC has been completely and successfully migrated, deployed and evaluated into ONASIC2, now using TIDB2 as a middle layer.
This task also implied a follow up through written documentation, tutorials and several meetings done to approach the users to this tool.
After which, the development of the onasic on the fly configuration has been studied and developed to meet directly the sub-detectors needs.
The full deployment of ONASIC2 has been done for the ATLAS TDAQ Technical run of Jan/2008 where onasic_oks2cool has been setup as a service within the initial TDAQ partition, for which, previously we´ve performed a exhaustive code review making onasic_oks2cool a safe application to be a central service in the tdaq core infrastructure.
Regarding OKS2COOL, as with ONASIC, it has also been migrated into OKS2COOL2 now using TIDB2 as a middle layer, and integrated in the tdaq initial partition infrastructure. It has been succefully used on the ATLAS Technical runs since Jan/08. Since then, also some important performance enhancements have been made, increasing OKS2COOL2´ relyability.

2.2.2 Fundings

Code	Funding	Start	End
POCI/FP/81940/2007	95.000 €	2007-07-01	2008-06-30

2.2.3 Team

Project coordinator: António Amorim

Name	Status	%of time in project
António Amorim	Researcher (FCUL)	15
Belmiro Pinto	Researcher	50
Diana Urbano	Researcher (FEUP)	8
Guiomar Evans	Researcher (FCUL)	5
Helmut Wolters	Researcher (LIP/FCTUC)	15
Jaime Matiz	Researcher (FEUP)	15
João Batista	Researcher	50
João Simões	Researcher	20
José Soares Augusto	Researcher (IST/INESC/FCUL)	5
Lourenço Lopes	PhD student (FCUL)	50
Miguel Oliveira	Researcher (LIP)	9
Paulo Pereira	Student (FCUL)	9
Ricardo Neves	Student (FCUL)	50

2.2.4 Publications

International Conference Proceedings

- *Alignment data streams for the ATLAS Inner Detector*
  B Pinto, A Amorim, P Pereira, M Elsing, J Schieck, R Hawkings, S Garcia
  Proceedings of the International Conference for Computing in High Energy Physics CHEP2007, Victoria BC, Canada (accepted)

- *Large Scale Access Tests and Online Interfaces to ATLAS Conditions Databases*
  A Amorim, L Lopes, P Pereira, J Simões
  Proceedings of the International Conference for Computing in High Energy Physics CHEP2007, Victoria BC, Canada (accepted)

- *Implementing a Modular Framework in a Conditions Database Explorer for ATLAS*
  A Amorim, J Batista, J Simões, P Pereira
  Proceedings of the International Conference for Computing in High Energy Physics CHEP2007, Victoria BC, Canada (accepted)

2.2.5 Presentations

Poster presentations in international conferences

- *Alignment data streams for the ATLAS Inner Detector*
  presented by Belmiro Pinto
  at CHEP2007 in Victoria BC, Canada.

- *Large Scale Access Tests and Online Interfaces to ATLAS Conditions Databases*
  presented by António Amorim
  at CHEP2007 in Victoria BC, Canada.

- *Implementing a Modular Framework in a Conditions Database Explorer for ATLAS*
  presented by António Amorim
  at CHEP2007 in Victoria BC, Canada.

Oral presentations in collaboration meetings

- *ONASIC & OKS2COOL - current issues and proposals*
  presented by Lourenço Lopes
  at Configuration & Controls meeting in CERN.

- *Update on ID Calibration Streaming*
  presented by Belmiro Pinto
  at Inner Detector Alignment Phone Meeting in CERN.
- *Inner Detector Calibration Stream design*
  presented by Belmiro Pinto
  at ATLAS "PT"meeting in Coimbra, Portugal.
- *TIDB2 e KTIDBExplorer*
  presented by João Batista
  at ATLAS "PT"meeting in Coimbra, Portugal.
- *B physics Algorithms for ATLAS High Level Trigger / Offline Histogram Browsing (NODE)*
  presented by Ricardo Neves
  at ATLAS "PT"meeting in Coimbra, Portugal.
- *Interface da Infraestrutura do Online Software para a Conditions Database*
  presented by Lourenço Lopes
  at ATLAS "PT"meeting in Coimbra, Portugal.
- *ID alignment stream status/plans*
  presented by Belmiro Pinto
  at FDR planning meeting in .
- *Update on ID alignment stream*
  presented by Belmiro Pinto
  at ID Alignment Phone Meeting in .

2.2.6 Project Summary

	number
International Conference Proceedings	3
Poster presentations in international conferences	3
Oral presentations in collaboration meetings	8

2.3 Collaboration in the CMS experiment at CERN

2.3.1 Activity Report

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 pesquisa de dimensões suplementares e física do quark top 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.

Project Coordination:

- Group coordinator: João Varela
  - Proton-proton physics coordinator: Michele Gallinaro
  - Heavy-ion physics coordinator: João Seixas
  - Detector and computing coordinator: João Varela

Summary of Activities:
The testing and installation of the barrel ECAL trigger and readout electronics system in the CMS experimental cavern was concluded in 2007. The final commissioning with the ECAL barrel was started in June 2007 and is being pursued in 2008. The LIP group has important responsibilities in the project. The Synchronization and Link Boards (SLB, 1210 boards), which are required to synchronize the ECAL and HCAL trigger data, were produced and tested. The testing of the Data Concentrator Cards (DCC, 70 boards), used for the data acquisition of the ECAL detector (and also of the RPC detector) was concluded. The group has also a major role in the development and coordination of the ECAL online software, and in the commissioning of the ECAL Off-Detector electronics in the underground service cavern USC55.
The LIP group has a team of six 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 (cosmics runs). The group is also actively participating in the commissioning of the CMS Trigger system. During 2007 the following tasks were undertaken: a) installation and commissioning of ECAL OD Crates in USC55; b) deployment of the online software in the underground PCs; c) integration tests with CMS DAQ and Trigger; d) developments of the data acquisition software; e) developments of the online monitoring software; f) operation and data taking during CMS Global Runs.
The LIP group is responsible for the operation of the ECAL data acquisition hardware and software in several integration setups and test beams at CERN since 2004. In 2007, this included the final detector assembling in the ECAL Detector Integration Center, where barrel Supermodules and endcap Dees are assembled and tested, the integration tests of ECAL Off-Detector Crates in the CMS Electronics Integration Center and ECAL Detector Calibration (H4 beam area). These activities are being pursued for the ECAL endcap detector which is not yet installed in CMS.
Activities in the off-line CMSSW software were pursued, in particular the work on the ECAL raw-data unpacking software.
The installation of the CMS software in the LIP computing farm, the exploitation of GRID facilities and the interface with the Tier-2 was also part of our program. LIP participated in several CMS GRID exercises with remarkable efficiency.
Analysis of beam data taken in 2006 was concluded and the results published in JINST: a) the analysis of the H2 beam data to study the efficiency and selectivity of the electron trigger algorithms; b) analysis of the trigger data and validation of the SLB synchronization methods (pending). LIP took the full responsibility in these studies.
The preparation for physics analysis is becoming a major area of activities in the LIP/CMS group. Proton-proton physics activities at LIP include Extra Dimension searches and Top quark physics. 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 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 the background for the ED process. The work in these two topics is strongly correlated. The analysis of Universal Extra-Dimensions models (4-lepton events) was ported from the old ORCA framework to the new CMSSW analysis framework. The detailed study of backgrounds was one of the main areas of activity. The group contributed with the tau-dilepton analysis to the study "Measurement of the Top quark pair production cross section with L=100 pb-1 using the CMS detector" (CMS Analysis Note). The LIP group was involved in developing the electron and tau identification algorithms, and estimate the background contribution directly from data.
The Heavy Ion Physics group is largely composed by elements which up to now have worked in NA60. Two new posdocs joined recently the group allowing to reinforce substantially this area. Initial investigations of quarkonia production in p-p collisions were carried out in 2007.
Members of the group presented results in international conferences and schools (9 talks) and in meetings of the CMS collaboration (55 talks)
LIP/CMS group members had in 2007 the following CMS management positions: CMS Trigger Project Manager (J. Varela); ECAL Data Stream Hardware Coordinator (J. C. Silva); ECAL Data Acquisition Deputy Coordinator (A. David.
An outreach effort was done organizing the CMS Day at IST, dedicated to the physics students. Visits of groups of students and high-school teachers to the CMS experiment at CERN took place in 2007 with the help of the LIP/CMS team.

2.3.2 Fundings

Code	Funding	Start	End
POCI/FP/63922/2005	255.000 €	2006-09-01	2007-10-31
POCI/FP/81930/2007	260.000 €	2007-09-01	2008-08-31

2.3.3 Team

Project coordinator: João Varela

Name	Status	%of time in project
Ana Vila Verde		33
André Tinoco Mendes	Post-Doc (LIP/IST/FCT)	61
Carlos Almeida	(INESC/IST)	21
João Pela	Graduate student (LIP/IST)	85
João Seixas	Researcher (LIP/IST)	50
João Teixeira	(IST/INESC)	21
João Varela	Researcher (LIP/FCT)	64
Jorge Semião	Technician (INESC)	21
José Carlos Silva	Technician (LIP)	97
José Soares Augusto	Researcher (IST/INESC/FCUL)	21
Malgorzata Kazana	Post-Doc (LIP)	90
Marcelino Santos	(INESC/IST)	21
Marcelo Jordão	Graduate student (LIP)	85
Michal Bluj	Post-Doc (LIP)	33
Michal Husejko	Student (LIP)	100
Michele Gallinaro	Researcher (LIP)	100
Miguel Ferreira	Technician (LIP)	80
Nuno Almeida	Post-Doc (LIP/FCT)	100
Pasquale Musella	PhD student (LIP/FCT)	100
Paula Bordalo	Researcher (LIP)	7
Pedro Bento	PhD student (INESC)	42
Pedro Manuel Silva	PhD student (LIP/FCT)	100
Pedro Martins	PhD student (LIP/IST)	22
Pedro Parracho	Technician (LIP/AdI)	67
Pedro Ramalhete	Technician (LIP/AdI)	40
Pedro Ribeiro	PhD student (LIP/FCT)	100
Reyes Alemany		83
Rui Neto	Graduate student (LIP)	67
Sérgio Ramos	Researcher (LIP)	7

2.3.4 Publications

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

- *Study of the electron trigger efficiency of the CMS experiment using test beam data*
  P Q Ribeiro, M Gallinaro and J Varela
  J. Inst. 2 No 12 (December 2007) P12001

International Conference Proceedings

- *Inclusive SUSY reach and studies with leptons in the final state,*
  Malgorzata Kazana
  42d RENCONTRES DE MORIOND, QCD PROCEEDINGS hep-ex arXiv:0705.3733

- *First beam operation of the CMS calorimeter trigger synchronization boards,*
  André David, Nuno Almeida, José da Silva, Pedro Silva and João Varela
  IEEE NPSS 15th Real Time Conference, Fermilab, Batavia IL, April 29 - May 4, 2007

- *The CMS Electromagnetic Calorimeter Data Acquisition System at the 2006 Test Beam,*
  P. Musella et al.
  IEEE NPSS 15th Real Time Conference, Fermilab, Batavia IL, April 29 - May 4, 2007.

- *Data Filtering in the readout of the Electromagnetic Calorimeter,*
  N.Almeida, P.Silva, J.C. Da Silva, M.Husejko, A. Jain, P.Musela, A.Mendes, M.Gallinaro, J.Varela, J.-L. Faure, P. Gras,P.Busson,P.Paganini,
  IEEE NPSS 15th Real Time Conference, Fermilab, Batavia IL, April 29 - May 4, 2007

- *Hard Physics with Heavy Ions in CMS*
  Andé David
  EPS 2007, CMS CR-2007/073, Journal of Physics: Conference Series

Collaboration notes with internal referee

- *First beam operation of the CMS calorimeter trigger synchronization boards*
  Andre David, Nuno Almeida, Jose Da Silva, Pedro Silva, Joao Varela
  CMS NOTE-2007/026

- *Measurement of the Top quark pair production cross section with L=100 pb-1 using the CMS detector,*
  N. Almeida, M. Bluj, M. Gallinaro, M. Jordao, J. Varela et al.
  CMS AN-2007/025

- *Study of the electron trigger efficiency of the CMS experiment using test beam data,*
  P. Ribeiro, M. Gallinaro, J. Varela
  CMS Note-2007/025

Internal Notes

- *The Top Quark Analysis Framework*
  M. Gallinaro et al.
  CMS IN-2007/06

2.3.5 Presentations

Oral presentations in international conferences

- *Inclusive SUSY reach and studies with leptons in the final state*
  presented by Malgorzata Kazana
  at Moriond QCD in La Thuile, Italy.
- *First beam operation of the CMS calorimeter trigger synchronization boards*
  presented by André Tinoco Mendes
  at EEE NPSS 15th Real Time Conference in Fermilab, Batavia IL.
- *The CMS Electromagnetic Calorimeter Data Acquisition System at the 2006 Test Beam,*
  presented by Pasquale Musella
  at IEEE NPSS 15th Real Time Conference in Fermilab, Batavia IL.
- *Data Filtering in the readout of the Electromagnetic Calorimeter*
  presented by Nuno Almeida
  at IEEE NPSS 15th Real Time Conference in Fermilab, Batavia IL.
- *Hard Physics with Heavy Ions in CMS,*
  presented by André Tinoco Mendes
  at EPS HEPP 2007 Europhysics Conference on High Energy Physics in Manchester, England, 19-25 July 2007.

Oral presentations in international meetings

- *Tau Identification in CMS*
  presented by Marcelo Jordão
  at PASC Winter School in Sesimbra.
- *CMS discovery potential for Minimal Universal Extra Dimensions*
  presented by Pedro Ribeiro
  at Les Houches 2007 in Les Houches, France.
- *CMS discovery potential for minimal Universal Extra Dimensions*
  presented by Pedro Ribeiro
  at PASC Winter School in Sesimbra.
- *Measuring Vtb*
  presented by Pedro Manuel Silva
  at PASC Winter School in Sesimbra.

Oral presentations in collaboration meetings

- *Partitioned Running, Trigger view*
  presented by João Varela
  at CMS DAQ-Trigger-Detector meetings in .
- *ccache and distcc*
  presented by André Tinoco Mendes
  at CMS-ECAL DAQ meeting in .
- *Non-event data monitoring*
  presented by André Tinoco Mendes
  at ECAL monitoring and DQM discussion in .
- *L1 electron trigger study using H2 data*
  presented by Pedro Ribeiro
  at CMS Trigger Meeting in .
- *ECAL Off detector electronics status*
  presented by José Carlos Silva
  at ECAL general meeting in .

- *SLB Status and Cabling*
  presented by José Carlos Silva
  at CMS Trigger Meeting in .

- *Speeding up the unpacking code*
  presented by Nuno Almeida
  at CMS Week, ECAL detector performance in .

- *ECAL Readout*
  presented by André Tinoco Mendes
  at CMS-Week Heavy-Ions Meeting in .

- *Electron and Muon rejection in Top analysis*
  presented by Marcelo Jordão
  at Tau meeting in .

- *SLB Status & Cabling*
  presented by André Tinoco Mendes
  at CMS Trigger Meeting in .

- *Trigger Latency Update*
  presented by João Varela
  at CMS Trigger Meeting in .

- *ECAL unpacking code*
  presented by Nuno Almeida
  at CMS L1 & HLT Commissioning & Software in .

- *ECAL TPGs*
  presented by André Tinoco Mendes
  at CMS L1 & HLT Commissioning & Software in .

- *ECAL TPGs*
  presented by André Tinoco Mendes
  at CMS L1 & HLT Commissioning & Software in .

- *SLB Status & Cabling*
  presented by André Tinoco Mendes
  at CMS Trigger Meeting in .

- *Validation of J/psi generation in Pythia 8*
  presented by André Tinoco Mendes
  at CMS HI Fortnightly Meeting in .

- *L1 monitoring*
  presented by João Varela
  at CMS Luminosity Workshop in .

- *Introduction/news*
  presented by João Varela
  at CMS L1 & HLT Commissioning & Software in .

- *Plans for tau-ID in the TQAF*
  presented by Michele Gallinaro
  at CMS Top Quark Analysis Framework (TQAF) in .

- *Top physics with tau and early data*
  presented by Michele Gallinaro
  at CMS Tau workshop in Pisa.

- *Trigger HW deployment, Commissioning Status*
  presented by João Varela
  at CMS Annual Reviews (AR07) in .

- *SLB Cabling Installation and Test*
  presented by José Carlos Silva
  at CMS Trigger Meeting in .

- *Report from LV1 Trigger Team*
  presented by João Varela
  at CMS WEEK Plenary Commissioning in .

- *Trigger achievements and future goals*
  presented by João Varela
  at CMS Run organization Meetin in .

- *Status and Commissioning of Lvl-1 Hardware*
  presented by João Varela
  at CMS LHCC Comprehensive Review - CR07 in .

- *Tau reconstruction in Top events*
  presented by Michele Gallinaro
  at CMS Tau Meeting in .

- *Cross section of tau-lepton channels*
  presented by Michele Gallinaro
  at CMS EWK/TOP Workshop in .

- *ECAL Interface to Trigger Supervisor*
  presented by André Tinoco Mendes
  at CMS Trigger Meeting in .

- *Introduction/Planning*
  presented by João Varela
  at CMS Trigger Meeting in .

- *Handling of calibration events in the DCC*
  presented by José Carlos Silva
  at CMS-ECAL DAQ meeting in .

- *Monitoring of ECAL SLBs*
  presented by André Tinoco Mendes
  at CMS Trigger Meeting in .

- *ECAL status: mip Trigger and TS integration*
  presented by André Tinoco Mendes
  at Trigger Meeting in .

- *Introduction/news*
  presented by João Varela
  at CMS L1 & HLT Commissioning & Software in .

- *Introduction/Planning*
  presented by João Varela
  at CMS Trigger Meeting in .

- *Status of UED in 4 lepton analysis*
  presented by Pedro Ribeiro
  at SUSYBSM meeting CMS Week in .

- *Level-1 Trigger*
  presented by João Varela
  at Joint Detector-Trigger Calibration and Alignment Workshop in .

- *Electron ID performance using PTDR settings*
  presented by Pedro Ribeiro
  at Egamma Physics Object Group meeting in .

- *Status of tau dilepton channel*
  presented by Michal Bluj
  at CMS Top meeting in .
- *Status of the tau di-lepton channel*
  presented by Michele Gallinaro
  at Joint QCD/EWK/TOP meeting in .
- *Update of di-lepton tau channels*
  presented by Michele Gallinaro
  at Joint QCD/EWK/TOP meeting in .
- *Introduction/Planning*
  presented by João Varela
  at CMS Trigger Meeting in .
- *ECAL Off detector integration and commissioning*
  presented by Pedro Manuel Silva
  at ECAL Week in .
- *Cross section tau channels (category 2)*
  presented by Michele Gallinaro
  at Joint QCD/EWK/TOP CMS meeting in .
- *Discriminating taus from electrons and muons*
  presented by Marcelo Jordão
  at CMS Particle Flow &TauID meeting in .
- *ECAL Trigger Startup*
  presented by André Tinoco Mendes
  at CMS L1 & HLT Commissioning & Software in .
- *Status of tau dilepton channel*
  presented by Michal Bluj
  at CMS Top meeting in .
- *Update of the tau dilepton channel*
  presented by Michal Bluj
  at CMS Top meeting in .
- *ECAL Trigger Commissioning*
  presented by André Tinoco Mendes
  at CMS L1 & HLT Commissioning & Software in .
- *UED search in 4 lepton channels*
  presented by Malgorzata Kazana
  at SUSY meeting in .
- *Pending problems in ECAL*
  presented by José Carlos Silva
  at CMS Run organization Meeting in .
- *CMS Community in Portugal and Introduction to Portuguese Tier-2s*
  presented by Nuno Almeida
  at in PIC, Barcelona.

Outreach seminars

- *The LHC proton-proton physics*
  presented by Michele Gallinaro
  at CMS day at IST in .
- *Introduction to LIP/CMS*
  presented by João Varela
  at CMS day at IST in .

- *The CMS experiment at LHC*
  presented by André Tinoco Mendes
  at CMS Day at IST in .
- *Hardware developments for CMS*
  presented by José Carlos Silva
  at CMS day at IST in .

2.3.6 Academic Training

PhD Theses

- *Search for Universal Extra-Dimensions in proton-proton collisions at 14 TeV center-of-mass energy"*
  Pedro Ribeiro, (on-going)
- *Study of Universal Extra Dimensions signals with two photons and missing energy in the final state"*
  Pedro Manuel Silva, (on-going)
- *Physics Simulation and Reconstruction of Universal Extra Dimensions Processes in the CMS Experiment"*
  Pasquale Musella, (on-going)

2.3.7 Events

- *CMS Day at IST*
  Outreach Event, IST, Lisboa, 2007-10-11

2.3.8 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
International Conference Proceedings	5
Collaboration notes with internal referee	3
Internal Notes	1
Oral presentations in international conferences	5
Oral presentations in international meetings	4
Oral presentations in collaboration meetings	51
Outreach seminars	4
Outreach Events	1

2.4 Collaboration in the COMPASS experiment at CERN

2.4.1 Activity Report

Sumário

A experiência COMPASS dedica-se ao estudo da estrutura da matéria, nomeadamente à polarização do gluão $\Delta G/G$ (através da fotoprodução de charme e da física de elevado p_T), às funções de estrutura relativas às componentes transversas e longitudinais do spin, e às funções de fragmentação. Com um feixe de hadrões, 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. Na sua concepção original, formulada na Proposta então aprovada, 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 1700 TB.
A farm de processamento de dados de COMPASS tem um desempenho do nível requerido em LHC e os primeiros resultados sobre medidas de assimetria têm vindo a ser publicados.
Desde a tomada de responsabilidade do Sistema de Controlo de Detectores (DCS) de COMPASS em fins de 2002, que o grupo do LIP-Lisboa tem vindo a desenvolver uma nova arquitectura, com notável esforço de recursos humanos.
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 hadrões, o software do DCS (bem como o seu hardware de interface) tem de 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 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.

Summary

COMPASS experiment is dedicated to the study of the structure of matter, namely the gluon polarisation $\Delta G/G$ (from open charm photoproduction and high p_T 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 polarised 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. In the original design, as stated in the accepted Proposal, 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.
COMPASS data processing farm also requires a LHC-like performance, and first results concerning asymmetries started to be published. Since late 2002, when our LIP-Lisbon group took in COMPASS the responsibility of the Detector Control System (DCS), a new system architecture has been developed. In that view, a big effort in human resources was undertaken.
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 the hadron beam runs, which are presently being installed for the 2008 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 p_T events and the flavour asymmetries of the nucleon sea and of the psi meson.

Summary of the Activities

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.
Since 2007, 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)
- Offline and data analysis.

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.

Detector Control System

In view of the preparation of the future hadron runs, new detectors were installed in the experimental area. These detectors are 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.
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 is the case of detectors gas systems. While this requires the permanent presence of one DCS expert, it also prevents the system to run in standalone mode (as everytime a sub-system is controling some detector).

Offline and Data Analysis

Simulation and reconstruction studies dealing with different event generators used as a tool to the analyses of the gluon polarisation and of the polarised Drell-Yan process.
The 2006 data started to be analysed in all physics channels. Its merge with the previous 2002-2004 data analyses in deep inelastic scattering inclusive asymmetries has been initiated.
Also, semi-inclusive asymmetries studies, in view of the separation of the spin flavour components, has pursued.
Both physics channels concerning the gluon polarisation, namely its extraction from high p_T events, as well as from the open charm mesons production, have been pursued.
The study of the psi meson spin asymmetries has been initiated.

Academic Training

- Luís Silva, PhD Thesis, pursuing: Gluon Polarisation through high pT hadron production;
- Celso Franco, PhD Thesis, pursuing: Contribution of the gluon to the nucleon spin via D0 e D* production;
- David Sora, Software Engineering Master Thesis, concluded. Title: "Formal Specification of an Object-Oriented Framework for Designing Control Systems"

2.4.2 Fundings

Code	Funding	Start	End
010.6/B009/2005	252.000 €	2004-01-01	2008-12-31
POCI/FP/63939/2005	130.000 €	2006-09-01	2007-10-31
POCI/FP/81973/2007	150.000 €	2007-07-01	2008-06-30

2.4.3 Team

Project coordinator: Paula Bordalo

Name	Status	%of time in project
Catarina Quintans	Researcher (LIP)	100
Celso Franco	PhD student (LIP/IST)	100
Christophe Pires	Technician	17
David Sora	Master student (LIP)	4
Helena Santos	Researcher (LIP/FCT/IST) *	100
João Cruz	Researcher (LIP/FCTUNL)	60
Luis Silva	PhD student (LIP/IST)	100
Paula Bordalo	Researcher (LIP)	87
Sérgio Ramos	Researcher (LIP)	87
Sofia Nunes	Technician (LIP)	96

2.4.4 Publications

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

- *The Polarised Valence Quark Distribution from semi-inclusive DIS*
  P. Bordalo, C. Franco, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  CERN-PH-EP/2007-024 (accepted)

- *A new measurement of the Collins and Sivers asymmetries on a transversely polarised target*
  P. Bordalo, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  Nucl. Phys. B765 (2007) 31-70

- *The Deuteron Spin-dependent Structure Function g1d and its First Moment*
  P. Bordalo, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  PLB 647 (2007) 8-17

- *Spin asymmetry A1d and the spin-dependent structure function g1d of the deuteron at low values of x and Q2*
  P. Bordalo, C. Quintans, S. Ramos et al.
  PLB 647 (2007) 330-340

- *The Compass Experiment at CERN*
  P. Bordalo, C. Franco, F. Mota, C. Quintans, S. Ramos, H. Santos, D. Sora, L. Silva et al.
  NIMA 577 (2007) 415-518

- *Double spin asymmetry in exclusive rho0 muonproduction at COMPASS*
  P. Bordalo, C. Franco, C. Quintans, S. Ramos, H. Santos, L. Silva et al.
  EPJ C52 (2007) 255-265

- *Read-out electronics for fast photon detection with COMPASS RICH-1*
  P. Bordalo, L. Silva et al.
  NimA (2007)

International Conference Proceedings

- *Fast photon detection for COMPASS RICH-1*
  P. Bordalo, L. Silva et al.
  Nucl. Instrum. Methods Phys. Res., A 572 , 1 (2007) 419-421, Proceedings of the 10th Pisa Meeting on Advanced Detectors

- *Measurements of the Spin-dependent Structure Function g1d(x,Q2) at COMPASS*
  H. Santos et al.
  Procs. of Rencontres de Physique de La Vallée d´Aoste, March 4-10 2007, La Thuile, Italy

- *Inclusive and semi-inclusive DIS results from COMPASS*
  H. Santos et al.
  Procs. of BNL workshop

- *The COMPASS RICH-1 detector upgrade*
  F. Nerling, P. Bordalo, L. Silva et al.
  Procs. of SPIN-Praha-2007, Prague, Czech Republic, July 8-14, 2007.

- *Fast photon detection for particle identification with COMPASS RICH-1*
  P. Bordalo, L. Silva et al.
  NimA 580 (2007) 906-909, Imaging 2006 - Proceedings of the 3rd International Conference on Imaging Techniques in Subatomic Physics, Astrophysics, Medicine, Biology and Industry

- *Fast photon-detection for COMPASS RICH-1*
  M. Chiosso, P. Bordalo, L. Silva et al.
  Procs. of 10th ICATPP Conference on Astroparticle, Particle, Space Physics, Detectors and Medical Physics Applications

- *The fast photon detection system of COMPASS RICH-1*
  F. Tessarotto, P. Bordalo, L. Silva et al.
  NIMA 581 (2007) 419-422, Proceedings of the 11th International Vienna Conference on Instrumentation

- *Fast photon detection for the COMPASS RICH detector*
  P. Bordalo, L. Silva et al.
  Nucl. Phys. B172 (2007) 75-78, Proceedings of the 10th Topical Seminar on Innovative Particle and Radiation Detectors

- *Pattern Recognition and PID for COMPASS RICH-1*
  F. Sozzi, P. Bordalo, L. Silva et al.
  Procs. of RICH2007, Trieste, Italy, October 15-25 , 2007.

- *COMPASS results on inclusive and semi-inclusive polarised DIS*
  H. Santos et al.
  Procs. of DSPIN-07 - XII Workshop on High Energy Spin Physics - Sept. 3-7, 2007, Dubna, Russia

2.4.5 Presentations

Oral presentations in international conferences

- *Measurements of the Spin-dependent Structure Function g1d(x,Q2) at COMPASS*
  presented by Helena Santos
  at Rencontres de Physique de La Vallée d´Aoste in La Thuile, Italy.
- *Inclusive and semi-inclusive DIS results from COMPASS*
  presented by Helena Santos
  at BNL workshop: Parity-Violating Spin Asymmetries at RHIC in Brookhaven, USA.
- *COMPASS results on inclusive and semi-inclusive polarised DIS*
  presented by Helena Santos
  at DSPIN-07 - XII Workshop on High Energy Spin Physics in Dubna, Russia.

2.4.6 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

- *COMPASS - Software Engineering Master Thesis: "Formal Specfication of an Object-Oriented Framework for Designing Control Systems""*
  David Sora, 2007-09-05

2.4.7 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	7
International Conference Proceedings	10
Oral presentations in international conferences	3
Master Theses	1

2.5 Collaboration in the HADES experiment at GSI

2.5.1 Activity Report

Resumo:

A experiência HADES, no instituto alemão GSI, destina-se a investigar as propriedades dos mesões leves no seio da matéria nuclear. Esta investigação ajudará a esclarecer a origem física da maior parte da massa existente na matéria vulgar.
A participação do LIP nesta investigação, em associação com a Escola Superior de Tecnologia e Gestão de Leiria, consiste no projecto, teste, construção, instalação e exploração de um detector para identificação de partículas por tempo-de-voo.

Summary of the Activities:

A completely instrumented full-size prototype sector was built and beam-tested with satisfactory performance. Production of the six final sectors was initiated.
The LIP researcher Alessio Mangiarotti resumed his work on the measurement of K- flow in HADES, towards a full simulation that may serve as a basis for a beam request. It is hoped that this work will be ready for a publication in the RCP2007 proceedings.
A detailed simulation of the RPC tof wall response within the HADES detector is progressing. After integration of a realistic geometry into the HADES Geant 3 framework (delayed by several technical difficulties related to a full update of the GSI software environment), the problem of the sensitivity of the final spectrometer to the K- flow is under investigation. The effect of the non-isotropic RPC cell occupancy with respect to the reaction plane (typical of heavy-ion collisions) needs to be quantified, especially because a double coincidence from the two wall layers is required to safely identify kaons up to the mid-rapidity region of the phase space. Such a study of possible systematic effects limiting the sensitivity to K- flow may serve as a basis for a future beam request. In particular, the minimum required beam statistics could be estimated. It is hoped that this work will be ready for a publication in the RCP2007 proceedings.

2.5.2 Fundings

Code	Funding	Start	End
EU Contract 515876 DIRAC-Phase-1	52.000 €	2005-11-01	2009-10-31
LIP-GSI contract	414.000 €	2005-11-01	2009-10-31
POCI/FP/81982/2007	20.000 €	2007-07-01	2008-06-30

2.5.3 Team

Project coordinator: Paulo Fonte

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	20
Alessio Mangiarotti	Researcher (LIP)	23
Carlos Capela	Researcher (ESTGL)	10
Carlos Neves	Researcher (ESTGL)	4
Carlos Sousa	Researcher (ESTGL)	15
Luís Lopes	Technician (LIP)	15
Milena Vieira	Researcher (ESTGL)	15
Nuno Carolino	Technician (LIP)	10
Paulo Fonte	Researcher (LIP/ISEC)	23

2.5.4 Publications

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

- *Dielectron production in 12C+12C collisions at 2 AGeV with HADES*
  J.Markert and the Hades Collaboration
  Journal of Physics G 34 (2007)s1041

2.5.5 Presentations

Oral presentations in international meetings

- *Electronic developments for HADES RPC wall: overview and progress*
  presented by
  at TWEPP - Topical Workshop on Electronics for Particle Physics in Prague, Czech Republic, 3 to 7 September 2007.

2.5.6 Project Summary

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

2.6 Participation in the NA60 experiment at CERN

2.6.1 Activity Report

The NA60 experiment is a fixed target experiment at the CERN/SPS accelerator which studies prompt dimuon and open charm production in collisions induced by high energy proton and heavy-ion beams.
During 2005-2007 the Portuguese group involved in NA60 participated in the two major tasks of the Collaboration: data analysis and maintenance of the experimental site. The latter is to a large extent finished, while the former is expected to continue during the next year, since the high quality proton-nucleus data is still to a large extent not analyzed.
We will now specify by task the work done.

Electronics Pool
The first detailed inventory of the Electronics Pool items in possession of NA60 was performed during this period. Given the large number of items NA60 is renting and the fact that many of them were unaccounted for, and had not been in use in NA60, it was not an easy task. A number of iterations between our group, the Electronics Pool and several labs in NA50 and NA60 were required to perform this task. An important fraction of the "lost"items were found.
In May it was decided to return all the Electronic pool modules to the Electronic pool, and we were in charge of this task.
A presentation about this subject was presented during the collaboration meeting on June 2006.

Data quality assurance
After the data collection (more than 3 terabytes) we need to start a number of checks over that data to make sure that the data available for analysis was collected during the correct operation of all the parts of the detectors and the DAQ systems.
DCS during data taking wrote in excess of 18 million entries in the original database. We went through the entries in the electronic logbook and checked whether the values in the fields of the database were correct. Furthermore a new database was created with a selection of the variables relevant for decisions related to the sampling of the initial data. After that we added two new fields to the database, viz. the raw size and number of segments that each run is occupying in tape.

Data selection
During the Proton run 2004, the NA60 apparatus suffered several changes, so after the run we tracked these changes and wrote setup files reflecting these changes in order that the reconstruction software could work correctly. This task also led to a division of the data sample in more manageable data sets.
The tasks performed in this context were
1. January - March 2005 : Preliminary analysis of the 2004 proton data, performing the first data sampling
2. June - September 2005 : Participation in the cataloguing of the 2004 data and the creation of tools for detector alignment
3. October 2005 - January 2006 : organization and selection of data samples in the 2004 data for a subsequent integration in the alignment and reconstruction processing
February - May 2006 : Vertex Telescope (VT) alignment for the different experimental setups. Tool development for the second reconstruction phase of the data (prod2) (not yet finished) Preliminary alignment of the NA60 Vertex Tracker detectors in view of the 2004 pA data first reconstruction.
Coordination of efforts on the final realignment of the Vertex Tracked used in 2003 In-In run and reconstruction of the 2003 In-In data. Significant improvement of the tracking quality is achieved in still ongoing reconstruction.
4. Creation of an interface between the databases of the Detector Control System (DCS), the electronic logbook and na60root, the programming interface used for the NA60 physics analysis
5. Creation of a tool for data indexation(burst tagging tool).
6. June - July 2006 : Second data reconstruction phase. Starting of the production study of J/Ψ and Ψ' in the 400 GeV p-A reconstructed data.

Resynchronization of the data
During the Indium run 2003 it was observed that sometimes the data recorded from the pixel detector was shifted by one to 3 events. During the data analysis of this run, a software tool was developed in NA60 that allowed the study of the correlation between the several pixel planes, the Zero Degree Calorimeter (ZDC) and the Interaction counter, and from these correlations he could get the number of events by which the data was shifted allowing thus the recovery of some of the data.

In the proton run 2004 the ZDC was not used and Microstrip modules were added to the vertex telescope. We changed the above mentioned code so that it could cope with the setup changes and to be able to run in the CERN Batch Services (lxbatch).
After thorough testing he did the resynchronization over ≈20% of the data collected in 2004 that is currently being processed in later stages.
This task was presented to the collaboration in the meeting of the 03-04 May 2006.

Work made on the Silicon Strip Detector
One of the detectors in the NA60 experiment is the Microstrip Telescope composed of several sensors of silicon microstrips. The purpose of this telescope is to track the secondary particles, including muons, produced as a result of an interaction in the target, before they enter in the hadron absorber. In conjunction with the Pixel Telescope it allows to:
1. Extract the coordinates of the interaction point
2. Measure the momentum and angles of the muons
3. Determine the muons offsets
4. Track the e+e- pair in the protons runs, coming from the converted γ of the χ_c´s radiative decay.
Charge Sharing
Whenever a silicon strip is hit by a particle, the adjacent strips share some of the deposited charge. If this information is used, we can obtain a better spatial resolution, deposited charge and maybe even improve the hit detection method.
After experimenting with many different methods, we tried using an algorithm named "Entropy Distance"and this one was able to identify with very good confidence the events where the charge sharing effect occurs.
This work is still in progress and will continue with the data from the 2004 run. Parallel to this, new more robust methods to detect hits in the Silicon Strip Detector are also being investigated and will be tested on the 2004 data.
Amplitude and Timing of Digits
We have devised several new methods to obtain the Amplitude and Time of a digit in the Silicon Strip detector (of NA60) and are currently fine-tuning them. The best of these methods seems to provide very accurate results with an error less than 7 ns for the time resolution which will allows eliminating digits that are out-of-time from the reconstruction process and in this way, have a more efficient reconstruction of events.

Basic software and hardware coordination activities

Our group has since the beginning of NA60 been responsible for a number of basic software and hardware activities in the Collaboration, namely:
1. System administration
2. Web page creation and NA60 site maintenance using Zope
3. Computer hardware maintenance
4. Setting up and constructing the PC farm used for Monte Carlo and data processing of NA60.
5. Disk server administration, where the reconstructed data and other relevant information is stored
Offline status and data analysis
The topic of intermediate masses dimuons production in In-In collisions, which is one of the main points in NA60 program, was studied intensively: NA50 experiment has observed in Pb-Pb collisions an excess over expected dimuon sources in the range 1.2<M<2.7 GeV/c. The shape of the excess would favor en enhancement of open charm by factor ≈3 in central interactions which would be difficult to explain within pQCD framework. Thanks to its ability to measure the offset of the muons from the interaction point with precision of 40-50 mum NA60 can solve this puzzle by distinguishing between the prompt dimuons and those originating in the open charm decays.
Within the responsibilities for the offline framework and data reconstruction of the group:
- Development of methods and software for the subtraction of the:
i) combinatorial background from uncorrelated Pi, K -> mu decays in
NA60 dimuon spectra.
ii) background from the "fake matches"between the muons from the
Muon Spectrometer and tracks in the Vertex Tracker of NA60.
Large samples of background dimuons were generated for further signal
extraction.
- Preparation of summary ntuples with matched dimuons from first reconstruction of 2003 In-In data and corresponding artificial background samples.

They are used in the studies of all NA60 topics related to dimuon data. A major topic in the NA60 physics programme is intermediate masses dimuon production in In-In collisions: the NA50 experiment has observed in Pb-Pb collisions an excess over expected dimuon sources in the range 1.2<M<2.7 GeV/c. The shape of the excess would favor en enhancement of open charm by factor ≈3 in central interactions which would be difficult to explain within pQCD framework. Thanks to its ability to measure the offset of the muons from the interaction point with precision of 40-50 mum NA60 can solve this puzzle by distinguishing between the prompt dimuons and those originating in the open charm decays.
The analysis confirmed the excess observed by NA50 and showed that it is caused by prompt (Drell-Yan and/or thermal) dimuons rather than open charm decays. Preliminary results of this study were presented at several conferences and will be published in the proceedings. These analysis continue using new reconstruction of In-In 2003 data.
Major results in the low mass region have also seen the light during 2005-2006. A first measurement of the spectral function has been presented and a comparison with the available theoretical models has been made for the first time in heavy ion physics, which allowed ruling out some of these models and showing that in some cases no available models could accommodate part of the existing NA60 data.

Reconstruction of the 2004 Proton Run data
In the month of February P. Parracho performed the resynchronization of the first batch of the NA60 2004 400 GeV proton-nucleus data, in view of the complete reconstruction of the data collected during 2004.
Study of D0 production and hadronic decay
The study of the D0 production and hadronic decay in the NA60 In-In collisions is mainly performed by Pedro Parracho and is one of the major topics of his PhD. Thesis. This study involves two tasks:
Monte Carlo Generation
In order to understand how the D0 decay will look in the NA60 apparatus, a Monte Carlo procedure was used to simulate an In-In collision producing a D0 that would fly and decay in the detector. To do that, P. Parracho had to learn how to work with Pythia 6.326-EKS98 inside NA60ROOT, which took most of September 2006. The first version of the macro that generates events D0 ->Pi + K was finished in the middle of October and month of test and changes followed.
Study of the Cuts
Once it was clear that the D0 generated was as close to reality as possible, it was necessary to discover in what way a pair of tracks produced by the D0 is different form all the other tracks of a normal event. In order to do that it was necessary to overlay a Monte Carlo event on a real collision, so that a direct comparison of the two sets of tracks (Monte Carlo tracks in which one sees signal, and data tracks that are considered as background) could be done. At this point the problem is to know which variables are best in order to distinguish the tracks. A program was written that goes through all the tracks in a event, combines them into a possible D0, and calculates a number of geometric and kinematical quantities (e.g. tracks distance at secondary vertex, distance between secondary and primary vertex, rapidity of the D0, Xf). At his point around 20 different variables are calculated per each track pair. After having these "possible D0"pairs and its variables calculated we can use the Monte Carlo tags on the track to separate them and plot the Monte Carlo track and the data track spectrum for each variable. Looking at the superposition of the two spectra we can pinpoint the spots where they different the most, thus picking the areas to cut. This is an on-going process which has been pursued since last November. On 07 November 2006 P. Parracho gave a talk to the collaboration to present the status of the study. The talk was called: "Measuring hadronic decays of D mesons (first view)"and can be found in http://na60.cern.ch/www/Members/parracho/presentations/Measuring_hadronic_decays_of_D_mesons_1.ppt/download.
Study of "smart"algorithms to separate signal from background
The biggest problem of measuring the D0 hadronic decay, is that the amount of background is very important, so big that the usual "box"cuts applied to the data will not be enough to get a signal with the purity level required to perform the study. So, more sophisticated methods of background separation have to be used. P. Parracho and João Seixas have tried several methods and combination of variables in order to find the best one. A final conclusion of the best method was not achieved in March, so this is an ongoing work. At the same time P. Parracho will be perfecting the cuts on the available variables.
Study of the production of J/Psi, Psi´ and Chi_c mesons in proton-nucleus collisions
This work has been performed mainly by P. Martins and constitutes the basic element of his PhD. Thesis subject. The NA60 data is reconstructed and analyzed through a set of software programs called NA60ROOT. One of the first and most important tasks to perform before the final reconstruction, is the alignment of the several components of each detector, together with the alignment of the detectors themselves. This process is particularly relevant on the detectors belonging to our Vertex Telescope, namely the pixel and microstrips detectors. The Vertex Tracker region contains a box with a predefined set of positions, which can house microstrips or pixel detectors in a flexible way. An improvement introduced in the alignment was the grouping

of the data with respect to the each experimental setup used, since the detectors position within the Vertex Telescope changed with each setup. The alignment is done with a precision of the order of micrometers, which prohibits the possibility of making this process completely automatic. This experimental setups, called data sets, allow the usage of the alignment tools in an almost automatic way.
The reconstruction of our data collected in 2004 comprises two steps: an initial task (called prod0), which reconstructs the muons at the Wire Chambers and Trigger Hodoscopes (the Muon Spectrometer) level and a later (called prod1) where the tracks are reconstructed at the Vertex Telescope level and matched with the muon tracks obtained in prod0. After the prod0 reconstruction, we have started studying the Physics on the data, with a double goal: testing the quality of the data and starting to prepare relevant physics results for my thesis. These preliminary studies, related with the analysis of physical quantities common in the Particle Physics field (mass, linear momentum, rapidity, etc.), have the objective of comparing our data with experiments previous to NA60, namely NA50 and NA38, which used the same Muon Spectrometer. When prod1 ends, we´ll finish comparing the results for each nuclear target used, for the quantities mentioned above. The comparison of the data between the two beam energies used in 2004 (158 and 400 GeV) will also become an appreciated contribution for the global analysis.
This study has already allowed for the update of two figures which were used in the talk given by P. Martins at the conference "QCHS 7"(see the List of Presentations in Conferences bellow) and in the report given to the SPS Committee at CERN.
(available at http://doc.cern.ch//archive/electronic/cern/preprints/spsc/public/spsc-2006-024.pdf)
After the Collaboration Meeting held on the 6th of November, it was clear that an extra effort was needed to decode the data provided by the microstrips detectors. This is mainly due to their difference in design, when compared to the pixel detectors. Therefore, new tools were developed which will be used for the alignment of those detectors.
Recently, P. Martins has been working with the PYTHIA Monte Carlo generator, presently on its 8.010 version. This is a major breakthrough in Monte Carlo Generators in the Particle Physics field, since PYTHIA is now written in the C++ programming language, deprecating the old FORTRAN language. This version of PYTHIA is a glimpse of what future Monte Carlo generators will be. For this reason, Pedro Martins has been working on the interface between the framework ROOT (and our NA60ROOT, which is strongly dependent on ROOT) and PYTHIA, with the aim of describing our experimental setup and physics phenomena with the maximum accuracy.
Ultraperipheral Heavy Ion Collisions
This a new area of research which has been pursued very recently and is undertaken by P. Ramalhete, J. Seixas and C. Loureno within NA60. It is still too soon to evaluate the final outcome of this new approach, but first results have been presented by Pedro Ramalhete recently in a Workshop in Trento (see List of Presentations in Conferences bellow).

2.6.2 Fundings

Code	Funding	Start	End
POCI/FP/63919/2005	25.000 €	2006-09-01	2007-12-31
POCI/FP/81945/2007	15.000 €	2007-09-01	2008-08-31

2.6.3 Team

Project coordinator: João Seixas

Name	Status	%of time in project
André Tinoco Mendes	Post-Doc (LIP/IST/FCT)	39
tila Neves	PhD student (LIP)	100
David Seixas	Student (LIP)	25
João Seixas	Researcher (LIP/IST)	37
Marco Robalo	Student (LIP)	25
Pedro Martins	PhD student (LIP/IST)	78
Pedro Parracho	Technician (LIP/AdI)	40
Pedro Ramalhete	Technician (LIP/AdI)	60
Ricardo Nunes	Student (LIP)	25
Rob Veenhof	Researcher (CFTP)	100
Ruben Shahoyan	Post-Doc (LIP/CERN)	100
Samuel Abreu	Student (LIP)	25

2.6.4 Publications

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

- *NA60 results on charm and intermediate mass dimuons´ production in In In 158-GeV/A collisions*
  R Shahoyan (NA60 Collaboration)
  J. Phys. G: Nucl. Part. Phys. 34 S1029-S1032

- *J/psi production in indium-indium collisions at 158-GeV/nucleon*
  NA60 Collaboration
  Phys. Rev. Lett. 99, 132302 (2007)

International Conference Proceedings

- *NA60 results on the rho spectral function in In-In collisions*
  S. Damjanovic (NA60 Collaboration)
  Nucl.Phys.A783:327-334,2007

- *J/psi production in In-In and p-A collisions*
  E Scomparin (NA60 Collaboration)
  J. Phys. G: Nucl. Part. Phys. 34 S463-S469

- *New results from NA60 and other SPS experiments*
  Gianluca Usai (NA60 Collaboration)
  J. Phys. G: Nucl. Part. Phys. 34 S233-S241

- *J / psi production in in-in and p-A collisions*
  E. Scomparin (NA60 Collaboration)
  J.Phys.G34:S463-470,2007

- *J/ psi suppression in In-In collisions at 158-GeV/nucleon*
  NA60 Collaboration
  Nucl.Phys.A783:261-268,2007

National Conference Proceedings

- *J/psi production and suppression in heavy-ion collisions at the CERN SPS*
  P Martins (NA60 Collaboration)
  AIP Conf.Proc.892:410-412,2007

Collaboration notes with internal referee

- *Pile-up estimates for NA60 detectors*
  Pedro Ramalhete
  NA60 Note 2007-2

- *Measuring the Dead Times of the trigger systems of NA60 using the timing information of the Beam Tracker*
  Pedro Ramalhete
  NA60 Note 2007-3

- *Using the Beam Tracker timing information to reject Indium-Indium events with pile-up in the ZDC or QB*
  Pedro Ramalhete and Carlos Lourenco
  NA60 Note 2007-4

- *Calibration of the Quartz Blade detector using the 2003 Indium-Indium prod2 data files*
  Pedro Ramalhete
  NA60 Note 2007-6

- *Using the Interaction Counter to reject events with interaction pile-up in the 2003 Indium-Indium data*
  Pedro Ramalhete
  NA60 Note 2007-7

- *Preliminary steps for the reconstruction of the p-A data collected by NA60 in 2004*
  P. Martins, R. Nunes, P. Parracho, P. Ramalhete
  NA60 Note 2007-5

2.6.5 Academic Training

PhD Theses

- *Lambda, anti-lambda and K0s Production in In-In and In-Si Collisions at 158 GeV/nucleon"*
  tila Neves, 2007-06-23

2.6.6 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	2
International Conference Proceedings	5
National Conference Proceedings	1
Collaboration notes with internal referee	6
PhD Theses	1

2.7 Physics at LHC

2.7.1 Activity Report

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) e verificou-se que a sua importância não pode ser ignorada em LHC face aos canais normais de produção directa.
Outra tarefa desenvolvida no âmbito deste projecto, envolveu o estudo de assimetrias angulares em decaimentos do quark top. 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 (Rho_R e Rho_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.
No âmbito do presente projecto tem sido ainda estudada a radiação dos quarks tops (para gluões, fotões e Zs). Esta pesquisa incide numa primeira fase, no estudo da produção dupla de quarks top acompanhados de um fotão energético que vai permitir estudar os factores de forma do quark top em LHC.

Summary of the Activities:

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

Single Top Production via FCNC

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. 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.

Angular asymmetries

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 (Rho_R and Rho_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.

Study of Electroweak Top Quark Couplings

The study of the electroweak couplings of the top quark is performed with the pp->ttgamma process which is the more promising channel at the moment. This study will allow to probe the top quark charge and will lead to a better understanding of the form factors associated to the top quark.
Current status of the present task: this task is under way. A new Monte Carlo generator at parton level was developed to generate the ttgamma physics process and the interface with other generators is performed. This generator will enable a comparative study of the t-tbar production cross-sections (with and without energetic photons) at the LHC.

2.7.2 Fundings

Code	Funding	Start	End
POCI/ FP/63926/2005	20.000 €	2006-11-01	2007-10-31
POCI/FP/81950/2007	30.000 €	2007-07-01	2008-06-30

2.7.3 Team

Project coordinator: António Onofre

Name	Status	%of time in project
Amélia Maio	Researcher (LIP/FCUL)	5
António Onofre	Researcher (LIP/UCPFF)	30
Augusto Barroso	Researcher (FCUL)	10
Filipe Veloso	PhD student (LIP/FCT)	32
Helmut Wolters	Researcher (LIP/FCTUC)	32
João Bastos	Post-Doc (LIP)	50
João Carvalho	Researcher (LIP/FCTUC)	35
João Silva	Technician (LIP)	10
Juan Aguilar-Saavedra		10
Matilde Castanheira	Master student (LIP)	100
Miguel Fiolhais	Student (LIP)	50
Miguel Won	Graduate student (LIP)	25
Nuno Castro	PhD student (LIP/FCT)	23
Orlando Oliveira	Researcher (LIP/FCTUC)	8
Paulo Martins	Graduate student (LIP)	25
Pedro Martins Ferreira	Researcher (LIP/FCUL)	10
Renato Guedes Júnior	Researcher (LIP/FCUL)	4
Rui Santos	Researcher (LIP/FCUL)	10

2.7.4 Publications

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

- *Lepton flavour violating processes at the International Linear Collider*
  P. M. Ferreira, R.B. Guedes, R. Santos
  Phys.Rev.D75(2007)055015 (hep-ph/0611222)

- *Tagging heavy flavours with boosted decision trees*
  J. Bastos
  arXiv:physics/0702041

- *A multivariate approach to heavy flavour tagging with cascade training*
  J. Bastos, Y. Liu

JINST 2 P11007 (2007) (arXiv:0704.3706 [physics.data-an])

- *Study of ATLAS sensitivity to FCNC top decays*
  J.Carvalho; N.Castro; L.Chikovani; T.Djobava; J.Dodd; S.McGrath; A.Onofre; J.Parsons; F.Veloso
  Eur.Phys.J. C52 (2007) 999-1019

- *ATLAS sensitivity to Wtb anomalous couplings in top quark decays*
  J. A. Aguilar-Saavedra, J. Carvalho, N. Castro, A. Onofre and F. Veloso
  Eur.Phys.J. C53 (2008) 689-699

International Conference Proceedings

- *Testing the Standard Model in ttbar and single top production at the LHC*
  António Onofre
  ATL-PHYS-CONF-2007-004

Internal Notes

- *Performance of boosted decision trees for combining ATLAS b-tagging methods*
  J. Bastos
  ATLAS internal note ATL-PUB-PHYS-2007-019

- *Study of ATLAS sensitivity to FCNC top decays (07)*
  J.Carvalho; N.Castro; L.Chikovani; T.Djobava; J.Dodd; S.McGrath; A.Onofre; J.Parsons; F.Veloso
  SN-ATLAS-2007-059 (accepted)

2.7.5 Presentations

Oral presentations in international conferences

- *Flavour and Top Physics - experimental summary*
  presented by Nuno Castro
  at Flavour in the era of the LHC (final meeting) in CERN.
- *Exotics summary*
  presented by Juan Aguilar-Saavedra
  at Flavour in the era of the LHC (final meeting) in CERN.
- *Study of ATLAS sensitivity to asymmetries in single top events*
  presented by Miguel Fiolhais
  at International Conference of Physics Students 2007 in University College of London.

Oral presentations in international meetings

- *Prospects for Top properties measurements in Atlas*
  presented by António Onofre
  at Workshop on Top Physics: from the TeVatron to the LHC in Grenoble.
- *Lepton Flavour Violating Processes at the International Linear Collider*
  presented by Renato Guedes Júnior
  at PASC Winter School in Sesimbra.
- *Vacuum Structure of N Higgs Doublet Models*
  presented by Pedro Martins Ferreira
  at PASC Winter School in Sesimbra.
- *Study of ATLAS sensitivity to Wtb anomalous couplings*
  presented by Nuno Castro
  at PASC Winter School in Sesimbra.

Oral presentations in collaboration meetings

- *Anomalous Wtb coupling in top quark decays*
  presented by Nuno Castro
  at T7 CSC Meeting in CERN.
- *Study of ATLAS sensitivity to FCNC top decays*
  presented by Filipe Veloso
  at T7 CSC Meeting in CERN.
- *Tagging the charge of b-jets with multivariate techniques*
  presented by João Bastos
  at T7 CSC Meeting in CERN.
- *Report from T7 CSC note*
  presented by António Onofre
  at Top WG Meeting in CERN.
- *Anomalous Wtb coupling in top quark decays*
  presented by Nuno Castro
  at T7 CSC Meeting in CERN.
- *Study of ATLAS sensitivity to FCNC top decays*
  presented by Filipe Veloso
  at T7 CSC Meeting in CERN.
- *Status of T7 note and related studies*
  presented by António Onofre
  at Top WG Meeting in CERN.
- *T7 CSC note status: top properties*
  presented by António Onofre
  at ATLAS Trigger and Physics Week in CERN.
- *Status Report on the Wtb Anomalous Couplings Analysis*
  presented by Nuno Castro
  at T7 CSC Meeting in CERN.
- *Towards a Model-Independent Measurement of the Wtb Interaction*
  presented by Juan Aguilar-Saavedra
  at T7 CSC Meeting in CERN.
- *Study of ATLAS sensitivity to FCNC top decays*
  presented by Filipe Veloso
  at T7 CSC Meeting in CERN.
- *Update on top properties CSC note*
  presented by António Onofre
  at Top WG Meeting in CERN.
- *Recent studies on Wtb couplings*
  presented by Juan Aguilar-Saavedra
  at Top WG Meeting in CERN.

Seminars

- *Testing the SM with Top Quark Physics at the LHC*
  presented by Nuno Castro
  at Departamento de Física Teórica y del Cosmos Seminar in Universidad de Granada.
- *The top quark from LHC to ILC*
  presented by Juan Aguilar-Saavedra
  at Institut de Física d´Altes Energies in Barcelona.
- *Prospects of Top Properties at ATLAS*
  presented by António Onofre
  at Particle Physics Group Seminar in Royal Holloway, University of London.

2.7.6 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	5
International Conference Proceedings	1
Internal Notes	2
Oral presentations in international conferences	3
Oral presentations in international meetings	4
Oral presentations in collaboration meetings	13
Seminars	3

2.8 Collaboration in the DELPHI experiment at CERN

2.8.1 Activity Report

Relatório de Actividades

A participação portuguesa na Colaboração DELPHI em 2007 concentrou-se, à semelhança de anos anteriores, na preparação de artigos finais a enviar para publicação.
Três artigos foram concluídos em 2007 e enviados para publicação, com participação directa e importante de membros do LIP. Destes, dois artigos foram responsabilidade de membros do LIP.
Manteve-se a responsabilidade da Linha de Pesquisa de QCD da Colaboração DELPHI, tendo sido coordenadas as actividades de preparação de artigos finais pela Colaboração DELPHI nesta área de pesquisa.
Foi preparado um artigo de revisão dos resultados de QCD em DELPHI, por uma grande equipa co-coordenada por um membro do LIP, que foi enviado para discussão pela Colaboração.
Finalmente, foi concluída e defendida com sucesso uma tese de doutoramento, no Departamento de Física do Instituto Superior Técnico.

Activity Report

The portuguese participation in The DELPHI Collaboration at CERN has proceeded in 2007, as in previous years, along the lines of preparation of final articles.
Three articles were published in 2007 by The DELPHI Collaboration with a direct contribution of LIP/DELPHI members, of which two were prepared by LIP/DELPHI members.
The Chairmanship of the QCD Research Line was mantained, which entails the coordination of the activities related to the preparation of final articles by The DELPHI Collaboration in the area of QCD.
A review article prepared by a large team, with direct contribution and co-coordination by a member of the LIP/DELPHI team, was submitted for discussion in the Collaboration.
Finally, a Ph.D. thesis was concluded and defended with success in the Physics Department of Instituto Superior Técnico.

2.8.2 Fundings

Code	Funding	Start	End

2.8.3 Team

Project coordinator: Pedro Abreu

Name	Status	%of time in project
António Onofre	Researcher (LIP/UCPFF)	1
Filipe Veloso	PhD student (LIP/FCT)	3
Nuno Anjos	Post-Doc (LIP/FCT) *	100
Pedro Abreu	Researcher (LIP/IST)	15

2.8.4 Publications

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

- *Search for a fourth generation b´ -quark at LEP-II at sqrt(s)=196-209 GeV*
  J. Abdallah et al. (The DELPHI Collaboration)
  Eur. Phys, Journal, Volume 50 (2007) p.507-518

- *Investigation of Colour Reconnection in WW Events with the DELPHI detector at LEP-2*
  J. Abdallah et al. (The DELPHI Collaboration)
  Eur. Phys. Journal C, Volume 51 (2007) p.249-269

- *Search for pentaquarks in the hadronic decays of the Z boson with the DELPHI detector at LEP*
  J. Abdallah et al. (The DELPHI Collaboration)

Physics Letters B,Vol. 653, p.151-160

2.8.5 Academic Training

PhD Theses

- *Studies of Colour Reconnection in WW Events with the DELPHI Detector at LEP2"* Nuno Anjos, 2007-12-14

2.8.6 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	3
PhD Theses	1

Chapter 3

Computing

3.1 Grid Computing

3.1.1 Activity Report

Relatório de Actividades:

O LIP participa em vários projectos nacionais e internacionais que têm por objectivo o desenvolvimento e a aplicação de tecnologias de computação grid para cálculo científico. Estas actividades estão intimamente ligadas ao desenvolvimento e implementação da infra-estrutura de computação para o LHC. Em 2007 as duas principais áreas de acção foram a participação em actividades relacionadas com o desenvolvimento das tecnologias de computação grid, e a participação em infra-estruturas internacionais de computação grid, disponibilizando recursos e serviços. Simultaneamente o LIP participou em actividades de coordenação relacionadas com o desenvolvimento e a expansão da computação grid a nível nacional e internacional.

Activity report:

The LIP participation in the LHC experiments ATLAS and CMS has been the main driven force behind the grid computing activities developed by the laboratory in the last years. Fully dedicated to support the computing needs of the LHC research community the Worldwide LHC Computing Grid (WLCG) is the world's largest grid infrastructure. The Portuguese responsibilities towards this CERN project are defined in the WLCG MoU signed by the Portuguese government and include the deployment of a WLCG Tier-2 resource centre in Portugal operated by LIP and integrated in the WLCG global infrastructure.
The LIP grid computing activities in 2007 were focused in the WLCG project. The work consisted in supporting the LIP grid users, operating grid resources and improving the services. In 2007 the LIP federated Tier-2 got a major capacity improvement with the deployment of a second site in Coimbra. The Lisbon site has a capacity of 88 CPU cores and is housed at the LIP Computer Centre while the Coimbra site has a capacity of 84 CPU cores and is housed at the Centre for Computational Physics (CFC) in the University of Coimbra. Both clusters at operated by personnel from the LIP computing group.
The grid computing activities also included the support for non-LHC experiments. The LIP computing group has provided support for the AUGER and COMPASS grid virtual organizations. LIP users working on these experiments are now using grid computing for data transfer and processing. Simultaneously the LIP sites are also supporting several virtual organizations from other scientific fields such as biomedicine, digital libraries, economy and computational chemistry.

Main node for grid computing
The capacity offered by the Lisbon and Coimbra sites is still not enough to satisfy simultaneously the needs of the Portuguese LHC researchers and the Portuguese obligations assumed in the MoU. Therefore in the summer of 2007 a project was launched to build a large grid computing centre in partnership with the Portuguese NREN (FCCN) and the Portuguese Civil Engineering laboratory (LNEC). This project aims to build the main node for grid computing for the Portuguese national grid initiative. This centre will provide computing and storage capacity for the Portuguese scientific community and the core services to integrate other Portuguese computing resources into a grid infrastructure. The ATLAS and CMS scientific community will be a main user of this centre that will be integrated with the LIP federated Tier-2. During 2007 LIP worked together with FCCN and LNEC to establish the technical design for the datacenter that will be the largest scientific computing facility in

the country. LIP will be responsible for the operation and management of the grid systems and services housed at the centre.
Also in the context of this project the LIP datacenter in Lisbon and CFC datacenter in Coimbra have been improved to accommodate several upgrades that will take place in 2008. The LIP-Lisbon site wide area network connectivity was upgraded to 1Gbps over dedicated fibre.

INGRID
The Portuguese National Grid Initiative is a government programme that aims to foster the development of grid computing in the country. The initiative is currently funding 15 pilot projects that are developing technologies and application prototypes. LIP has been playing a coordination role in this initiative.
The main node for grid computing is an LIP endeavour that is taking place in the context of the national grid initiative. The main node for grid computing will establish the foundations for a national grid infrastructure unifying resources from universities and research centres and providing computing capacity for scientific research.
Two smaller projects funded by INGRID started in 2007. These projects are supporting the grid computing activities in the context of the Portuguese participation in the ATLAS experiment, and the test and validation of grid middleware in the context of the EGEE and Int.Eu.Grid projects.
Also in the context of the Portuguese national grid initiative and with the support of the European projects EGEE and int.eu.grid LIP has provided training on grid technologies to Portuguese researchers. Three gLite training sessions for end-users were performed during 2007. Simultaneously grid computing training was given to master students at the University of Minho. Dissemination activities and seminars were also performed to raise the awareness on grid technology.

EGEE-II
The Enabling Grids for E-Science is the largest multidisciplinary grid infrastructure worldwide. The EGEE project is a key component of the WLCG infrastructure. In Europe the WLCG infrastructure is built on top of the gLite middleware and EGEE grid services.
LIP together with other EGEE partners in Spain has established the Southwest federation one of the main regional structures of the EGEE grid. The LIP activities in the EGEE project during 2007 were:

- Operate grid core services to support virtual organizations and resource sharing
- Coordinate the middleware deployment in Portugal
- Coordinate the site deployment in Portugal
- Certificate new sites in Portugal
- Support users and site managers from the Southwest federation
- Manage the Southwest federation helpdesk trouble tickets
- Participate in the EGEE Global Grid User Support by providing a TPM team.
- Operate a pre-production facility for the validation of new middleware releases
- Coordinate first middleware tests in the pre-production
- Operate the Portuguese national Grid certification authority and coordination of its activities with the relevant international bodies
- Develop solutions to enable resource integration
- Integrate and support the SGE batch system in gLite
- Operate grid resource centres in Lisbon and Coimbra
- Create contents for user training
- Deliver training sessions
- Disseminate the project

int.eu.grid
The Int.EU.Grid project operates an international grid infrastructure focused on parallel processing and interactivity for compute and data intensive applications. The infrastructure is based on the gLite middleware developed by EGEE but also includes components developed within the Int.EU.Grid project. These components offer a wide range of capabilities that enable interactivity and MPI support in the grid environment. In the Int.EU.Grid project the LIP activities were:

- Operate production grid core services for the whole infrastructure
- Coordinate the site and middleware deployment
- Manage the virtual organizations authorization service
- Coordinate the middleware validation process
- Validate middleware components
- Operate a grid resource centre in Lisbon supporting grid parallel and interactive applications
- Study interoperability scenarios for resource sharing across infrastructures
- Provide assistance to the project management
- Create materials for training sessions
- Deliver training sessions
- Disseminate the project

Many Int.Eu.Grid developments were adopted by several regional and international grid infrastructures such as EGEE, EELA and others.

EELA
The EELA project has successfully deployed an international grid infrastructure for scientific research in Latin America. European partners from Spain, Portugal and Italy helped their Latin America counterparts to establish a gLite grid computing infrastructure and the required support services. In the EELA project the LIP activities were:

- Coordinate the authentication and virtual organizations task
- Coordinate the deployment of certification authorities in Latin America
- Represent the EELA infrastructure near the International Grid Trust Federation bodies
- Manage of the virtual organizations management system (VOMS)
- Provide user and site manager support for authentication and authorization issues
- Operate core services such as the LFC file catalogue
- Develop accounting tools for VOMS

The project finished successfully in December of 2007.

IBERGRID
Resulting from agreements between the governments of Portugal and Spain the IBERGRID initiative aims to establish common e-science infrastructures between Portugal and Spain. The initiative has fours areas of activity: grid computing, High Performance Computing, Networking and Applications. In 2007 LIP was deeply involved in the coordination of the IBERGRID initiative and in the technical coordination of the grid-computing area. In this context LIP worked in cooperation with Spanish research organizations to establish the architecture for this international grid infrastructure.

E-IRG
The main objective of the e-IRG is to support on the political, advisory and monitoring level, the creation of a policy and administrative framework for the easy and cost-effective shared use of electronic resources in Europe across technological, administrative and national domains. As Portuguese representative LIP is following and contributing to the e-IRG activities. This participation is extremely important to align the Portuguese strategy on e-Infrastructures with the European guidelines and policies.

EGI
The European Grid Initiative aims to provide a future sustainable grid infrastructure in Europe based on the national grid initiatives and driven by the needs and requirements of the research community. EGI is expected to enable the next leap in research infrastructures, thereby supporting collaborative scientific discoveries in the European Research Area. EGI will replace the EGEE infrastructure after 2010. Until then the EGI design project (EGI-DS) will study and establish the structure for a long-term European Grid infrastructure. LIP is representing the Portuguese national grid initiative at the EGI-DS advisory board.

3.1.2 Fundings

Code	Funding	Start	End
EELA (026409)	78.000 €	2006-01-01	2007-12-31
EGEE-II (RI-031688)	274.888 €	2006-04-01	2008-04-30
int.eu.grid (IST-7-031857)	154.000 €	2006-05-01	2008-04-30
GRID 233/7.2/C/NAC	695.336 €	2007-06-01	2008-09-30
GRID/GRI/81842/2006	180.700 €	2007-09-10	2010-09-09

3.1.3 Team

Project coordinator: Jorge Gomes

Name	Status	%of time in project
Bruno Silva	Technician (LIP)	100
Gaspar Barreira	Researcher (LIP)	84
Gonçalo Borges	Technician (LIP)	100
Hugo Gomes	Technician (LIP)	100
João Martins	Researcher (LIP)	100
Jorge Gomes	Researcher (LIP)	100
José Aparício	Technician (LIP)	100
Manuel Montecelo	Technician (LIP)	100
Mário David	Post-Doc (LIP/FCT)	100
Miguel Oliveira	Researcher (LIP)	100
Nuno Dias	Technician (LIP)	100

3.1.4 Publications

International Conference Proceedings

- *VOMS Server replication process in I2G and EELA projects*
  Bruno Rodrigues SIlva, Jorge Gomes, Manuel Montecelo
  Proceedings of the Third EELA Conference, Catania, Italy (accepted)

- *The EELA Project e-Infrastructure update*
  D.Carvalho, Jorge Gomes, Pedro Henrique Rausch Bello, Michel Stanton, Alexandre Duarte, Bruno SIlva, et al.
  Proceedings of the Third EELA Conference, Catania, Italy (accepted)

- *South-West Regional Operations Centre: Operation and Management as part of the EGEE Grid infrastructure*
  M. David, G. Barreira, G. Borges, N. Dias, J. Gomes, J. P. Martins, et al
  proceedings of the IBERGRID 1st Iberian Grid Infrastructure Conference Proceedings

- *Sun Grid Engine, a new scheduler for EGEE middleware*
  G. Borges, M. David, J. Gomes, et al
  Proceedings of the IBERGRID 1st Iberian Grid Infrastructure Conference Proceedings

Collaboration notes with internal referee

- *I2G Infrastructure Operation Report*
  Jorge Gomes, Gonçalo Borges, lvaro Garcia
  i2g-DSA1_3-v1_0-LIP-InfrastructureOperationReport

- *EELA Final Authentication and Authorization Status Report*
  Jorge Gomes
  EELA EU DELIVERABLE: DWP2.2.2 (accepted)

- *EELA Authentication and Authorization Status Report*
  Jorge Gomes, Roberto Barbera, Philippe Gavillet
  EELA EU DELIVERABLE: DWP2.2.1

- *I2G Infrastructure Operation Status Report (advanced release)*
  Jorge Gomes, D. Rodriguez, C. Fernandez, L. Garcia, S. Stork, S. Kenny, J. Marco, R. Valles
  i2g-DSA1.2-v1.0-LIP-InfrastructureOperationStatusReport

3.1.5 Presentations

Oral presentations in international conferences

- *South-West Regional Operations Centre: Operation and management as part of the EGEE Grid infrastructure*
  presented by Mário David
  at IBERGRID 1st Iberian Grid Infrastructure Conference Proceedings in Santiago de Compostela, Spain.
- *Sun Grid Engine a new scheduler for the EGEE middleware*
  presented by Gonçalo Borges
  at IBERGRID 1st Iberian Grid Infrastructure Conference in Santiago de Compostela Spain.
- *A step towards interoperability between Int.EU.Grid and EGEE Grid infrastructures*
  presented by Gonçalo Borges
  at EGEE´07 conference in Budapest, Hungary.
- *The EELA Project e-Infrastructure update*
  presented by
  at 3rd EELA Conference in Catania, Italy.
- *VOMS Server replication process in I2G and EELA projects*
  presented by Bruno Silva
  at 3rd EELA Conference in Catania Italy.

Oral presentations in international meetings

- *EELA Task 2.2 Status Certification Authorities and Virtual Organizations*
  presented by Bruno Silva
  at EELA workshop in Lima - Peru.
- *LIPCA The Certification Authority for the Portuguese Academic Community*
  presented by Nuno Dias
  at 9th EUGRIDPMA meeting in Abingdon, UK.

- *EELA Task 2.2 Status Certification Authorities and Virtual Organizations*
  presented by Bruno Silva
  at EELA workshop in Lima, Peru.

- *I2G SA1 - Grid Infrastructure Operation*
  presented by Jorge Gomes
  at 1st I2G review in Brussels, Belgium.

- *The Portuguese National Grid Initiative (INGRID)*
  presented by Jorge Gomes
  at e-IRG Open Workshop on e-Infrastructures in LNEC, Lisbon.

Oral presentations in collaboration meetings

- *LIP Data Processing Infrastructure*
  presented by Mário David
  at LIP Workshop 2008 in Luso, Portugal.

- *EGEE South West Europe ROC Partner Review*
  presented by
  at EGEE SA1 SWE review in Karlsruhe, Germany.

- *I2G SA1 status*
  presented by Gonçalo Borges
  at I2G review preparation in HLRS, Germany.

- *The int.eu.grid SA1 status*
  presented by Jorge Gomes
  at Int.Eu.Grid integration meeting in LNEC, Lisbon.

- *I2G SA1 infrastructure status*
  presented by Gonçalo Borges
  at Int.Eu.Grid integration meeting in LNEC, Lisbon.

- *EGEE NA2 report for LIP-Lisbon*
  presented by
  at EGEE-II NA2 partner review in Prague.

- *Portugal T2: Lisbon and Coimbra*
  presented by Mário David
  at LCG CMS T1 T2 meeting in Barcelona, Spain.

Seminars

- *Run your jobs around the World*
  presented by Gonçalo Borges
  at CENTRA/IST seminar in IST, Lisbon.

- *An overview of grid infrastructure projects in Europe*
  presented by Jorge Gomes
  at JORTEC in FCT/UNL.

- *Grid Computing basics: Don´t be afraid... and use it!*
  presented by Gonçalo Borges
  at LIP Seminar in LIP, Lisbon.

- *Grid Computing*
  presented by
  at in University of Minho.

Outreach seminars

- *Grid Computing back to basics*
  presented by Gonçalo Borges
  at in Faro, Portugal.
- *A Portuguese perspective on GRID computing*
  presented by Jorge Gomes
  at HP GRID and HPTC in Oeiras Park, Lisbon.

3.1.6 Events

- *INT.EU.GRID Integration Meeting*
  Collaboration Meeting, LNEC, Lisbon, 2007-11-12
- *1st gLite and INT.EU.GRID training for end-users*
  Seminar organization, LNEC, Lisbon, 2007-11-14
- *2nd gLite and INT.EU.GRID training for end-users*
  Seminar organization, LIP, Lisbon, 2007-12-12
- *3rd gLite and INT.EU.GRID training for end-users*
  Seminar organization, LIP, Lisbon, 2007-12-20

3.1.7 Project Summary

	number
International Conference Proceedings	4
Collaboration notes with internal referee	4
Oral presentations in international conferences	5
Oral presentations in international meetings	5
Oral presentations in collaboration meetings	7
Seminars	4
Outreach seminars	2
Collaboration Meetings	1
Seminar organizations	3

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

3.2.1 Activity Report

Resumo

As necessidades de computação da colaboração ATLAS implicam a necessidade de adopção do paradigma de computação GRID. Para isso foi instalado em 2007, numa federação entre os laboratórios de Coimbra e de Lisboa, um nó Tier 2 de Grid de LHC (LCG/EGEE). Para isso foi reconfigurado o cluster de computação paralela Centopeia, com 108 máquinas, com a adição de algumas máquinas para serviços específicos, que constitui o nó inicial de Grid/ATLAS no Laboratório de Computação Avançada em Coimbra. Este sistema entrou em produção e participou em todas as produções e testes entretanto executados. Foi ainda realizado trabalho na área da execução de trabalhos remotos em máquinas mais poderosas e/ou com o software requerido instalado, de uma forma anónima, tendo sido desenvolvido o primeiro protótipo.

Report

The ATLAS production activities of the LIP-Coimbra site are well integrated in the ATLAS activity within the Iberian cloud, which makes 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. During 2007 the deployment of a GRID tier 2 site at LIP-Coimbra has been achieved. The site is fully operational both in the data production and storage requirements. It started its operational period on June 2007 and has increased its workload ever since.
In the Atlas computing model, the Atlas production system makes use of the LCG for simulation and analysis of experimental data. The ATLAS production system provides a common framework where any grid flavour may be integrated. It is formed from several individual elements which provide the required functionality for the submission, tracking, recovery and validation of the jobs. The first results on the February 2008 tests of the whole ATLAS production system show that the Iberian cloud is fully integrated within the brand new ATLAS production model, which is based on the usage of the pilot jobs, showing a good performance of both CPU clusters and storage resources.
Data distribution is the basic and most critical service for the ATLAS distributed computing project. Both simulated production and data replication rely on it to spread the data over the sites allowing physicists to perform their analysis on the data.
Members of the project have attended several seminars at CERN that have been instrumental at achieving the main goal. Participation on international conferences [IBERGRID2007,EGEE2008] has allowed presentation of the work being carried out on site. A seminar for outreach purposes has been organized [Jan2008] and the team is actively encouraging visits from high schools to attract new students. The use of the local Grid infrastructure has been stimulated outside HEP by supporting external virtual organizations.

Self-organizing clusters
In the first year of activity of the project a prototype of an application called "RMrun"was built, which enables the execution of remote interactive applications by anonymous users. The architecture of RMrun comprises three main entities: 1) a central server which contains all the relevant information, such as the list of all application available for execution (and where), which users exist in the system and the resources they already consumed; 2) a host computer where the installed applications are going to run and 3) a client computer that uses the application. The interaction with the user takes place in the client computer, while the application executes in the remote host computer. The most interesting feature of RMrun is that it allows anonymous users to execute programs without having to explicitly get authorization in the remote destination machine. Another underlying idea in RMrun is to allow execution of tasks in an environment similar to a desktop grid of volunteer computers, like in BOINC, XtremWeb or OurGrid. The RMrun prototype was mainly written in Java and uses open protocols like Secure Shell (SSH) and the X Windows System, typical of Unix systems where they are widely available.

3.2.2 Fundings

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

3.2.3 Team

Project coordinator: João Carvalho

Name	Status	%of time in project
António Onofre	Researcher (LIP/UCPFF)	14
Délio Almeida	Researcher (Critical Software)	22
Filipe Araújo	Researcher (FCTUC)	7
Filipe Veloso	PhD student (LIP/FCT)	7
Helmut Wolters	Researcher (LIP/FCTUC)	36
João Bastos	Post-Doc (LIP)	7
João Brito	Researcher (Critical Software)	7
João Carvalho	Researcher (LIP/FCTUC)	18
Luís Moura Silva	Researcher (FCTUC)	3
Miguel Oliveira	Researcher (LIP)	16
Miguel Won	Graduate student (LIP)	36
Nuno Castro	PhD student (LIP/FCT)	7
Patricia Conde	Post-Doc (LIP/FCT)	18
Paulo Martins	Graduate student (LIP)	36
Pedro Jorge	PhD student (LIP/FCT)	18

3.2.4 Publications

International Conference Proceedings

- *Centopeia: A New GRID cluster at LIP Coimbra*
  M.Oliveira, A.Onofre, J.Carvalho, H.Wolters, J.Bastos, F.Veloso, N.Castro
  IBERGRID (1st Iberian GRID Infrastructure Conference Proceedings), Ed. J.García Tobío et al., pp.389-392 (2007)

3.2.5 Project Summary

	number
International Conference Proceedings	1

Chapter 4

Astroparticle Physics

4.1 Collaboration in AMS - Alpha Magnetic Spectrometer

4.1.1 Activity Report

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 2009, permitirá prospectar a existência de antimatéria e matéria escura com uma precisão nunca antes alcançada.

Activities Foreseen:

AMS (Alpha Magnetic Spectrometer) is a particle physics experiment to be installed in the International Space Station Facility (ISS). The main physics objective will be the search for Antimatter and Dark Matter. In addition, it will study the propagation and confinement of cosmic rays in the galaxy.
The capabilities of the AMS spectrometer, compared to the one which flew in the Discovery shuttle in 1998, were largely improved and extended through the inclusion of new detectors: a Ring Imaging Cerenkov Detector (RICH), an Electromagnetic Calorimeter (ECAL) and a Transition Radiation Detector (TRD). The RICH will provide an independent measurement of both the particle velocity and the electric charge. A velocity goal resolution for singly charged particles of the order of permil is envisaged. Such a resolution, together with an improved measurement of the particle rigidity due to a higher magnetic field (0.9T), will allow to obtain a very good isotopic separation on a large kinetic range (up to 10 GeV per nucleon).
The RICH is a conical shaped detector with a dual radiator index configuration on the top made of aerogel (n=1.05) and sodium fluoride (n=1.33), a matrix of photodetectors on the bottom and an enveloping outer mirror of very large reflectivity. A RICH prototype made of a radiator and 96 photomultipliers separated by an expansion volume similar to the final one, was assembled at the Institut de Sciences Nucléaires (Grenoble). Following previous tests with cosmic data (2001,2002) and a fragmented Lead ion beam of 20 GeV per nucleon (October 2002, CERN), a new prototype run was performed with a fragmented Indium beam of 158 GeV per nucleon (October 2003, CERN). New readout electronics and new readout settings (tuning of the signal peaking time) were tested. The physics program included the testing of different aerogel radiators, the testing of the mirror material and the reconstruction of inclined particles.
The Portuguese team is involved in the RICH simulation and developed algorithms for velocity and charge reconstruction. In addition, the team worked on isotope identification, relying in the AMS full simulation and on the RICH detector skills. Reconstruction of particle velocity has to deal with an essentially flat background

from photomultipliers noise and photon scattering on aerogel radiator. Additionally, complex photon patterns can be set at the detector plane due to the mirror. A least squares and a likelihood method were developed and tested.
A method for charge reconstruction with the RICH detector was also developed. The existence of background photons, uncorrelated with the Cerenkov photon ring, which differ from event to event due to the ring geometrical acceptance and event kinematics implied a charge reconstruction method based on an overall efficiency estimation on a event by event basis. The efficiency estimation relies on a semi-analytical method. A typical charge resolution (DZ) of the order of 20% is obtained for protons.
On the year 2007, the AMS detector pre-integration started in a dedicated clean room at CERN. In the pre-integration phase it is intended to assemble all the detectors and related hardware excluding the superconducting magnet. This one will be integrated later this year.
During 2007 the group participated in the following activities:

- RICH Software simulation package: there exists a stand-alone package based on Geant3 that simulates the RICH detector behavior. The group made several contributions for the package. In particular in 2007, an improved description of the readout cell made of a light guide and magnetic shielding was implemented.
- RICH reconstruction: the RICH capability of making reconstructions relying only on data signals collected by the detector was evaluated. In addition, the possibility of using information from the Time of Flight (TOF) detector was studied. Both these modes can be useful in case of tracking reconstruction failure or in case an additional constraining to normal track reconstruction is needed. The results obtained for simulated samples show a reasonable accuracy in the reconstructed velocity; the resolution is a factor 4 worse than the one observed when the information on track is present. The addition of the TOF track element improves both the accuracy of the method and efficiency.
- RICH physics analysis: physics analysis activities related to the RICH particle identification were performed. The antideuteron analysis is a difficult and promising channel for dark matter search. Very important background from protons is present and has to be rejected. RICH based analysis observables were developed and the stand alone reconstruction can be used for track selection. The AMS sensitivity to the antideuterons on the RICH domain was obtained. Larger statistical samples have to be used.
- Aerogel Light Yield: A re-analysis of the test beam data with the purpose of evaluating the aerogel light yield evaluation, was done. An estimation of the expected light yield for proton events, to be observed with the flight detector, was produced. A good agreement is observed with the simulation prediction.

Talks and Publications

The group was involved in the following talks and publications:

- "Particle identification with the AMS-02 RICH detector". PASC Winter School, Sesimbra, December 19, 2007.
- "The RICH detector of the AMS-02 experiment: status and physics prospects". 2007 Villa Olmo International Conference (10th IACTPP Conference), October 2007, Italy. Published: arXiv:0801:3250
- "Particle identification with the AMS-02 RICH detector: D/p and anti-D/anti-p separation". New Worlds in Astroparticle Physics, September 2007, Faro, Algarve Published: arXiv:0801.3243, In Proceedings of 6th International Workshop on New Worlds in Astroparticle Physics
- "AMS-RICH velocity and charge reconstruction". ICRC 2007 (30th), Merida, Mexico. 3-11 July, 2007. Published: arXiv:0709.2154, In Proceedings of the 30th International Cosmic Ray Conference, Merida, 1094, Mexico (2007)
- "RING Imaging Cherenkov Detector (RICH) For the AMS Experiment", ICRC 2007 (30th), Merida, Mexico. 3-11 July, 2007. Published: In Proceedings of the 30th International Cosmic Ray Conference, Merida, 1145, Mexico (2007)
- "Deuteron-Proton separation with the RICH detector of the AMS-02 experiment". XXXV SLAC Summer Institute "Dark Matter: From the cosmos to the Laboratory"2007, July 30 - August 10, Stanford, USA

PhD Thesis

- "Charge and Velocity Reconstruction with the RICH detector of the AMS experiment: analysis of the RICH prototype data", Luisa Arruda. Instituto Superior Tecnico, Technical University of Lisbon.

4.1.2 Fundings

Code	Funding	Start	End
PDCTE/FNU/50364/2003	40.000 €	2004-11-01	2007-10-31

4.1.3 Team

Project coordinator: Fernando Barão

Name	Status	%of time in project
Fernando Barão	Researcher (LIP/IST)	69
Gaspar Barreira	Researcher (LIP)	9
Luisa Arruda	PhD student (LIP/FCT)	78
Mário Pimenta	Researcher (LIP/IST)	5
Patrícia Gonçalves	Researcher (LIP) *	5
Rui Faísca Pereira	PhD student (LIP/FCT)	100

4.1.4 Publications

International Conference Proceedings

- *The Ring Imaging Cherenkov detector of the AMS experiment: test beam results with a prototype*
  L. ARRUDA, F. Barao, P. Goncalves, R. Pereira
  Proceedings of the 10th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD06), Nuclear Physics B (Proc. Suppl.) 172 (2007) 32-35

4.1.5 Academic Training

PhD Theses

- *Charge and velocity reconstruction with the RICH detector of the AMS experiment: Analysis of the RICH prototype data"*
  Luisa Arruda, 2008-01-18
- *Deuterium and light isotopes measurements and Dark matter searches with the AMS experiment"*
  Rui Faísca Pereira, 2008-10-01

4.1.6 Project Summary

	number
International Conference Proceedings	1

4.2 Data analysis and calibration of the solar neutrino detector Solar Neutrino Observatory (SNO)

4.2.1 Activity Report

Sumário

O ano de 2007 foi um ano de transição para o grupo de Física de Neutrinos do LIP. Em SNO, mantivemos o empenho na nossa responsabilidade principal, de análise de dados da calibração óptica, mas as actividades ligadas à tomada de dados acabaram já no final de 2006. O grupo cresceu e tem progressivamente aumentado o empenho nas actividades de SNO+.
Num contexto mais geral, durante 2007, a colaboração SNO prossegiu a análise dos dados da fase 3 e a análise combinada dos dados das fases 1 e 2, com baixo limiar de energia, para procura de distorções espectrais. Ambas estas análises incluem contribuições do trabalho realizado em anos anteriores no LIP. Prevê-se que estejam concluídas em 2008, e o passo seguinte será a análise final, combinada, das 3 fases. neste contexto que se inclui o trabalho de 2007, a optimização da calibração óptica para o reprocessamento final dos dados.
Em 2007 foi também anunciada uma primeira fase do financiamento da experiência SNO+, que pretende reutilizar o detector SNO com cintilador líquido para procura do declínio beta duplo sem neutrinos e de neutrinos solares de baixa energia. Durante os próximos anos, será feita a instalação de sistemas adicionais de purificação e de segurança do balão de acrílico, prevendo-se o início da tomada de dados para 2011.
Actividades do grupo em SNO:

- Detector: Não houve actividades relacionadas com o detector. Estava prevista uma tomada de dados de calibração óptica para 2007, com a participação do LIP, mas foi adiada para 2008 (devido a uma campanha de medição de fundos radioactvos), quando o detector já estará cheio com água leve.
- Análise: Em 2007, os dados da terceira fase de SNO foram processados com o primeiro conjunto de constantes de calibração óptica, produzidas já em 2006. Depois desta primeira análise (cujos resultados são esperados em 2008), será feita uma última análise de todos os dados e, para tal, o grupo do LIP tem a responsabilidade de calcular as constantes de calibração finais, que incluirão uma série de melhorias, que constituíram a maior parte do trabalho efectuado pelo grupo em 2007:
  - Cortes geométricos devidos aos NCDs. Os detectores de correntes neutras (NCDs), instalados em SNO durante a terceira fase, causam sombras à luz detectada nos PMTs e, para esses PMTs, é necessário implementar cortes de rejeição. Para as sombras principais, causadas pelo corpo dos detectores (tubos com 5 cm de diâmetro e 10 m de comprimento), esses cortes já tinham sido incluídos na análise de 2006. Em 2007, foram desenvolvidos e testados cortes para os PMTS ensombreados pelos cabos e pelos módulos de ancoragem das NCDS.
  - Correcção das reflexões nos NCDs. Apesar do corte de tempo de chegada dos fotões aos PMTs, as reflexões nos NCDs causam um acréscimo residual de contagens nos PMTs usados na calibração (da ordem de 1%), o que falseia a medida da atenuação da água pesada (na ordem de 10%). O LIP desenvolveu um método para a correcção deste efeito por via de simulações Monte-Carlo. Durante 2007, a actividade principal foi a preparação e execução das simulações necessárias (que exigem elevado poder de cálculo) na "farm"do LIP.
  - Assimetria cima-baixo do detector. Na sequência do trabalho iniciado em 2006, os resultados sobre a assimetria na resposta angular dos PMTs entre diferentes regiões do detector, foram usados para calcular o erro sistemático associado a esta incerteza na uniformidade de resposta.
  - Simulação de dados de calibração. Foram produzidas na "farm"do LIP as simulações dos dados obtidos com uma fonte externa de Tório, na posição nominal (e com duas deslocações segundo o eixo dos zz), necessárias para o cálculo preciso das distribuições de fundo externo residual nos dados de neutrinos. Não sendo a responsabilidade principal do LIP em SNO, esta tarefa permitiu uma contribuição adicional para a análise de baixo limiar de energia, usando os recurso já disponíveis no LIP.

O grupo de Física de Neutrinos do LIP cresceu principalmente nas actividades ligadas a SNO+. Com esta nova experiência, pretende-se renovar o detector SNO ao substituir a àgua pesada por cintilador líquido, transformando-o num detector de neutrinos de baixa energia. Em 2007, estudos feitos na colaboração mostraram que SNO+ poderá realizar medidas muito competitivas no âmbito do declínio-beta duplo sem neutrinos, dopando o cintilador com Nd-150. Este é então agora o objectivo principal da colaboração (para o qual foi já recebido financiamento parcial do governo canadiano).
Actividades do grupo em SNO+:

- Simulação. A actividade principal do grupo em SNO+ é a simulação Monte Carlo do desempenho do detector e, em 2007, foi desenvolvida em três vertentes:
  - Estudos de fundo externo. Utilizando um software dedicado (da experiência Borexino), foi simulada a propagação de fotões gama provenientes de impurezas radioactivas nos materiais externos ao vaso de acrílico. Estas simulações permitiram fazer a primeira estimativa do fundo externo e do volume fiducial em SNO+, bem como fornecer uma indicação de limite de aceitabilidade para a contaminação radioactiva do novo sistema de cordas de ancoragem.
  - Implementação de nova geometria. A simulação actual de SNO+ não inclui ainda o sistema de cordas de ancoragem do balão de acrílico (que serão necessárias devido à baixa densidade do cintilador). Durante 2007 implementámos no software de simulação a geometria deste novo sistema, de modo a poder estudar o impacto de designs diferentes na resolução e uniformidade de resposta do detector.
  - Implementação em GEANT4. A simulação actual de SNO e SNO+ é realizada em FORTRAN com um código desenvolvido exclusivamente para SNO. Em 2007 implementámos uma série de elementos geométricos de SNO (vaso de acrílico, cordas de suporte, placas de ancoragem das cordas e NCDs) num novo software de simulação, baseado em no pacote GEANT4 (e, por isso, mais sustentável a longo prazo), com vista a uma futura substituição do software existente.
- Fenomenologia. Colaborámos com o Prof. João Pulido (IST) na realização de um estudo de sensibilidade de SNO+ a um modelo alternativo de oscilação de neutrinos, em que o efeito de precessão de spin-sabor devido ao campo magnético do Sol induz uma variação temporal no fluxo de neutrinos de baixa energia. Este trabalho foi já publicado.

Summary

2007 was a transition year for the Neutrino Physics group at LIP. In SNO, we remained committed to our main responsibility, of data analysis for the optical calibration, but the data taking activities were completed in the end of 2006. The group grew and progressively increased its activities in SNO+.
In a broader context, during 2007, the SNO collaboration continued the analysis of phase III data and the combined analysis of phases I and II, with a low energy threshold, for a spectral distortion search. Both these analyses include contributions from the work carried out in previous years at LIP. They will be completed in 2008, and the next step will be the final, three-phase combined analysis. The work done in 2007 is part of this context: the optimization of the optical calibration for the final data reprocessing.
In 2007, initial funding for the SNO+ experiment was announced. SNO+ will reuse the SNO detector with liquid scintillator for the search of neutrinoless double beta decay end low energy solar neutrinos. During the next few years, scintillator purification and acrylic vessel safety systems will be installed, the start of data-taking being expected for 2011.
Group activities in SNO:

- Detector: No detector-related activities. An optical calibration week was scheduled for 2007 (with LIP participation), but was postponed to 2008 (due to a background measurement campaign), when the detector will be filled with light water.
- Analysis: In 2007, the phase III data were processed with the first set of the optical calibration constants, produced already in 2006. After this initial analysis (the results of which should be published during 2008), a final analysis of the full SNO dataset will be carried out. LIP has the responsibility of calculating the final optical calibration constants, including a series of improvements, that wewre the bulk of the group´s work in 2007:
  - NCD geometry cuts. The neutral current detectors (NCDs), installed in SNO during phase III, cause shadows in the light detected by the photomultipliers (PMTs) and, for those PMTs, it is necessary to implement rejection cuts. For the main shadows, caused by the detector body (5 cm diameter, 10 m length tubes), the cuts were already included in the 2006 analysis. In 2007, we developed and tested cuts for PMTs shadowed by the NCD cables and anchors.
  - NCD reflection correction. in spite of the hit PMT timing cut, NCD reflections cause a residual occupancy increase in the PMT data used for calibration (around 1%), which fakes an increase in the heavy water attenuation (of around 10%). LIP has developed a method to correct for this effect via Monte-Carlo simulations. During 2007, the main activity was the preparation and execution of the necessary simulations (with demanding CPU requirements) in the LIP computing farm.

- Detector up-down assimetry. Following the work started in 2006, the results on the PMT angular response assimetry between different detector regions, were used to calculate the systematic error associated to this uncertainty in the response uniformity.
- Simulation of calibration data. We produced in the LIP computing farm the simulations of the external Thorium calibration source, in the nominal position, and with two zz axis shifts. These were needed for the accurate calculation of the residual external background in the neutrino data. Even if this was not LIP´s main responsibility, this task allowed for an extra contribution to the low energy threshold analysis, using already existing resources at LIP.

The Neutrino Physics group at LIP grew mainly in the SNO+ activities. With this new experiment, the SNO detector will be renewed by replacing heavy water by liquid scintillator, transforming it in a low energy neutrino detector. In 2007, studies performed in the collaboration have shown that SNO+ should be able to carry out very competitive measurements ro limits of neutrinoless double-beta decay, by doping the scintillator with Nd-150. This is now the main goal of the collaboration, and initial funding was already granted by the Canadian government.
Group activities in SNO+:

- Simulation. The main activity of the group in SNO+ is Monte Carlo simulations of the detector performance and, in 2007, it was developed in three aspects:
  - External background studies. Using a dedicated software (from the Borexino experiment), we simulated the propagation of gamma photons coming from radioactive impurities in the materials external to the acrylic vessel. These simulations have aprovided a first estimate of the external background and fiducial volume in SNO+, as well as a radiopurity requirement for the vessel hold-down rope system material.
  - Implementation of the new geometry. The present SNO+ simulation does not include yet the acrylic vessel hold-down rope system (that will be necessary due to the low density of the scintillator). During 2007 we have implemented the geometry of this new system, so that the impact of different designs on response resolution and uniformity can be studied.
  - GEANT4 implementation. The present simulation of SNO and SNO+ is a custom, FORTRAN-based software. In 2007 we have implemented a series of geometrical elements of the SNO detector (acryilic vessel, support ropes, NCD and rope anchor plates) in a new simulation software package, based on GEANT4 (and so, more sustainable in the long run), with the goal of replacing the present software.
- Phenomenolgy. We have collaborated with Prof. João Pulido (IST) in carrying out a SNO+ sensitivity study for an alternate neutrino oscillation model, in which the effect of spin-flavor precession due to the Sun´s magnetic field induces a time variation of the low energy neutrino flux. This work was already published.

4.2.2 Fundings

Code	Funding	Start	End
POCI/FIS/56691/2004	35.000 €	2005-01-01	2007-03-31

4.2.3 Team

Project coordinator: José Maneira

Name	Status	%of time in project
Amélia Maio	Researcher (LIP/FCUL)	5
João Rodelo	Student (LIP)	10
José Maneira	Researcher (LIP/FCT) *	25
Nuno Barros	PhD student (LIP/FCT)	100
Sofia Andringa	Post-Doc (LIP/FCT)	10

4.2.4 Publications

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

- *Measurement of the nu(e) and total B-8 solar neutrino fluxes with the Sudbury neutrino observatory phase I data set.*

SNO Collaboration, (includes J. Maneira)
Accepted by Physical Review C (accepted)

- *SNO+: Predictions from standard solar models and spin flavour precession.*
Marco Picariello, João Pulido, Sofia Andringa, Nuno Barros, José Maneira
JHEP11(2007)055 (accepted)

4.2.5 Presentations

Oral presentations in international conferences

- *Neutrino Physics with SNO+*
presented by José Maneira
at Sixth New Worlds in Astroparticle Physics in Faro, Portugal.

- *Detector response calibration in SNO*
presented by Nuno Barros
at Sixth New Worlds in Astroparticle Physics in Faro, Portugal.

Oral presentations in international meetings

- *Detector calibrations for precise measurements in the Sudbury Neutrino Observatory (SNO)*
presented by Nuno Barros
at PASC Winter School in Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *PMT assymetries and AV anchors*
presented by Nuno Barros
at LETA workshop in Oxford, UK.

- *Petals degradation: new fit of the February 2000 scan*
presented by José Maneira
at SNO Energy and Optics in MIT, Cambridge MA, USA.

- *NCD MC reflectivity studies*
presented by Nuno Barros
at SNO Energy and Optics in MIT, Cambridge MA, USA.

- *NCD Anchors effects in the optical calibration and assymetries studies*
presented by Nuno Barros
at SNO Energy and Optics in MIT, Cambridge MA, USA.

Seminars

- *Studying the Universe from 2 km underground: SNO and the new SNOLAB*
presented by
at LIP in Lisbon.

4.2.6 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	2
Oral presentations in international conferences	2
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	4
Seminars	1

4.3 Development of liquid xenon detectors for WIMPs search and CERN experiment PS213

4.3.1 Activity Report

Resumo

A existência da matéria negra e a sua natureza é um dos aspectos mais actuais da Física. As WIMPs (Weakly Interacting Massive Particles) são apontadas como possíveis constituintes de parte dessa matéria negra. Estas partículas podem eventualmente ser detectadas através do registo da energia adquirida por núcleos atómicos de um meio detector ao colidirem com um WIMP. A baixa probabilidade destas colisões e a baixa energia dos recúos nucleares que elas produzem tornam esta observação muito difícil. Além disso, a separação dos sinais devidos aos WIMPs (muito raros) dos sinais devidos a toda a radiação cósmica e ambiente (muito frequentes) é um requisito crucial. Para comprovar a existência de WIMPs desenvolvem-se detectores que são colocados em laboratórios subterrâneos para minimizar o ruído constituído pela radiação ambiente e cósmica.
O LIP é membro da colaboração ZEPLIN que utiliza detectores de xénon líquido para a procura da material negra. Durante o ano de 2007 a equipa do LIP participou na análise dos dados adquiridos pelo detector ZEPLIN-II, na instalação do detector ZEPLIN-III no Laboratório subterraneo e na preparação deste detector para começar a adquirir dados em 2008. Para além da participação no programa da colaboração ZEPLIN, este projecto tem uma componente de I&D que é realizada no Laboratório do LIP em Coimbra e que é constituída pelo estudo de problemas relevantes para o aperfeiçoamento dos detectors ZEPLIN e similares. No âmbito dessa componente de I&D, continuaram-se as medidas de reflectividade no ultravioleta de materials geralmente utilizados nestes detectors, o estudo do desempenho de novas tecnologias de amplificação do sinal de carga para detectores de duas fases semelhantes aos ZEPLINs e a modelização do processo da perda de energia dos recúos nucleares de muito baixa energia (<100 keV) no xénon líquido.

Summary of Activities:

The dark matter search is nowadays an extremely active field of research and liquid xenon detectors are among the most suitable detection technologies for that search. ZEPLIN Collaboration relies on double phase xenon detectors (i.e. liquid in equilibrium with its vapour). The recoil nucleus resulting from the elastic scattering of a hypothetical WIMP will produce ionisation and scintillation in liquid xenon. Under a strong electric field (typically a few kV/cm) the ionisation electrons escape recombination and drift into the vapour where they produce secondary scintillation (also referred to as electroluminescence). The vapour on the top of the liquid allows the amplification of the small ionisation signal. An array of photomultipliers detects both the primary and secondary scintillation light. As in liquid xenon the ratio scintillation/ionisation is different for a nuclear recoil or an electron (or gamma ray), the ratio secondary to primary scintillation allows a very efficient suppression of background due to gamma rays.
ZEPLIN Collaboration has two double-phase xenon detectors at the Boulby Underground Laboratory (North Yorkshire, UK): ZEPLIN II and ZEPLIN III. In 2007, the first underground scientific run of ZELIN II took place. The data was analysed and published. Following the surface commissioning, ZEPLIN III was deployed underground. The detector and its ancillary systems were reassembled and re-commissioned underground and the shielding enclosure was constructed. The LIP-team played an essential role in these tasks due to the expertise of the team in the field.
During 2007 the LIP team consolidated and extended its participation in the ZEPLIN collaboration. Moreover the R&D program regarding liquid xenon detectors for dark matter search and related topics was continued at LIP Laboratory in Coimbra. The main tasks and results obtained can be summarized as follows:

DATA ANALYSIS OF ZEPLIN-II

The analysis of the data taken during the first scientific underground run was carried out and the results obtained were published. LIP-Coimbra was deeply involved in the analysis of the ZEPLIN II data. We had a very significant participation in several tasks such as the reduction data software optimisation, the definition of the cuts, and calculation of their respective efficiency, necessary for the data analysis and the definition of the acceptance window. Furthermore we had full responsibility of the development of an algorithm for the position reconstruction of the interactions in ZEPLIN II.

ZEPLIN-III UNDERGROUND COMMISSIONING

In 2007, the underground commissioning of ZEPLIN-III comprised the following main tasks:

1. Reassembly of the detector.
2. Deployment and commissioning of the ancillary systems: gas and cryogenic systems, slow control and data acquisition systems.
3. Construction of the passive shielding: a combination of neutron shielding (30 cm thick "cage" of hydrocarbon) and gamma shielding (30 cm thick "cage" of boxed lead).
4. Functional tests of the detector:
   (a) cool-down, liquefaction,
   (b) stability after filling over several days without permanent attendance underground;
   (c) single-phase operation for PMT checkout which included single photoelectron calibration of all PMTs, to establish the PMT operation settings and assessment of the light collection in the detector by using a 57Co source;
   (d) two-phase operation of the detector assessment: identification and characterization of two-phase signals (i.e., S1 and S2), electron lifetime measurement (using S2/S1), performance as function of electric field, levelling and stability;
   (e) detector calibration with gamma and neutron sources.

The expertise of the LIP-team in liquid xenon detectors played a key role in all these tasks. In total, we have provided about 120 man.days in Boulby Mine Laboratory since the ZEPLIN III deployment started. Moreover, we are fully responsible for the installation, upgrade to the underground conditions and maintenance of the software for the slow control and data acquisition systems, as well as for the data reduction software for ZEPLIN III.
The collaboration has two general meetings per year. In 2007, one of those meetings was hold in Coimbra and it was organized by LIP-Coimbra.

SLOW CONTROL SYSTEM

The proper performance of ZEPLIN-III requires a number of parameters to be maintained with high precision during long periods of time. These parameters include temperature, pressure and level of liquid xenon. In addition several high voltage supplies (for the detector and photomultipliers) and vacuum meters require constant monitoring. The underground operation of the detector demanded additional requirements. They are mainly related to the need to have remote access to the monitored information and the consequent possibility of remotely acting according to the circumstances. Moreover, several safety features are required since the detector will stay long periods of time (in average, more than half-day every 24 hours) unattended due to the constraints imposed by the operation of Boulby Mine where the detector installed.
After the upgrade carried out during 2007, the slow control system is now able to provide:

1. the ability to maintain the conditions necessary for operation of the detector for a period from 12 to 24 hours without an operator intervention;
2. the safe operation of HV supplies including all necessary interlocks and safeguards;
3. the ability to monitor the state of the detector (temperature, pressure, liquid level) and of HV supplies from a remote computer.

Moreover, a publicly accessible web interface, hosted by LIP-Coimbra (http://polaris.fis.uc.pt/slowcon/), makes it possible to access the current state of slow control parameters including temperature, pressure, level, vacuum, as well as to the settings and current status of HV supplies. This information is updated in real-time with maximum delay of about 1.5 minutes. The real-time plots of key parameters are also provided.
The upgrades and maintenance of the slow control system is a responsibility of the LIP team in the Collaboration.

DATA ACQUISITION SYSTEM SOFTWARE

The Data Acquisition (DAQ) software for the ZEPLIN-III detector was first used for data taking in 2006 during surface tests at ICL, but was at the time in a minimal state, and since then several issues have been solved and some upgrades introduced. Major updates include additional information being recorded for each event, namely a time stamp (microsecond precision) which will allow to estimate of the system dead time more accurately and coincidence studies between events, and slow control information such as pressures and temperatures, making

possible the assessment of the system stability over time and to correct data for variations of these parameters. Other minor updates concern mainly the user interface, with the most important ones being the possibility of the DAQ system to automatically take single photoelectron data for the 31 photomultiplier tubes (PMTs), automatic logging of each data run to the ZEPLIN-III electronic logbook, keeping track of its particular settings and conditions, and monitoring of the current acquisition (DAQ rate, current file being acquired, number of acquired events and slow control information).
The dead time of the data acquisition systems is a very important parameter, which affects the exposure time and ultimately the dark matter exclusion limit of the detector. Measurements of the maximum trigger rate of the system allowed us to estimate this dead time to be $\approx$12% for a 5 Hz trigger rate, the expected for background runs.

DATA REDUCTION AND ANALYSIS SOFTWARE (ZE3RA)

In ZEPLIN-III the signals from 31 photomultipliers are split into a dual dynamic range data acquisition system. These 62 channels are sampled at 500 MS/s by 8-bit AQIRIS digitizers. The large amount of raw information produced is not suitable for direct analysis thus requiring an intermediate software layer capable of analyzing and producing a set of physical quantities (pulse height, width, area and time constants) that can be directly used in data analysis.
The development, maintenance and upgrade of the software application that carries out that task - ZE3RA (ZEplin 3 Reduction and Analysis) - is one of the responsibilities of the LIP team in the Collaboration. ZE3RA reads the files from the DAQ system and outputs a set of numeric parameters describing each pulse found on each waveform. The software comprises the reduction algorithms which process the waveforms from each channel and an event viewer.
In 2007 the data analysis algorithms were improved along the following lines:

1. a better statistical processing of the baseline
2. improvement of determination of the start time and the time constants of S1 (the primary scintillation, i.e., scintillation in the liquid) and S2 (the secondary scintillation, i.e., electroluminescence produced in the gas by the electrons extracted from the liquid in to the gas) pulses
3. development and implementation of a new algorithm for establishing the correspondence between pulses recorded in the 62 channels of DAQ; this new algorithm led to an improvement in the correct determination of the tails of S1 and S2 pulses
4. extraction of information required for the use of the single photoelectron spectra (SPE spectra) acquired by each photomultiplier for the periodic calibration of the detector; the validation of the procedure is being studied;
5. improvement of the user interface
6. inclusion of the information coming from the slow control system, such as high voltage settings, pressure and temperature reading. This information is important to allow to implement corrections to the data resulting from small changes in those parameters.

The new version of the code incorporating these modifications was released as ZE3RA v2.2.

WEB SERVER SERVICE FOR ZEPLIN-III

A web server service that integrates several operation services related with ZEPLIN III was developed and installed at https://polaris.fis.uc.pt/ by the LIP-team. It is a document archive/server that has several features and services, namely:

- the logbook of the experiment;
- a forum for exchange of information and for discussion;
- the database with the results of the experiment;
- a database of documents;
- a guide that contains useful information about the detector, ancillary systems and associate software, was well as a description of routine procedures;
- a contact database.

This web server service has been an essential tool for the collaboration.

MUON-INDUCED NEUTRON BACKGROUND STUDIES

Background from muon-induced neutrons is one of the most important limitations to the detector sensitivity for rare event searches such as the direct dark matter detection. The muon-induced neutron flux at the Boulby Underground Laboratory was measured and simulated. The experiment was carried out with 0.73 tonne liquid scintillator that also served as an anticoincidence system for the ZEPLIN-II direct dark matter search. Delayed coincidence method was used to detect a muon (the first pulse in an event) and gamma-rays resulted from neutron capture on hydrogen or other elements (secondary, delayed, pulses). Muon-induced neutron rate was measured as 0.079 0.003 (stat.) neutrons/muonusing neutron-capture signals above 0.55 MeV in a time window of 40-190 microseconds after the muon trigger. Accurate Monte Carlo simulations of the neutron production, transport and detection in a precisely modeled laboratory and experimental setup were carried out using the GEANT4 toolkit. The results will be submitted for publication soon.

MEASUREMENTS OF REFLECTANCE

The measurements of reflectance of materials employed in liquid xenon detectors were continued. We measured the reflectance of various samples used in the xenon detectors, namely the angular distribution of VUV light that is reflected by samples of PTFE and copper. The measurements were carried out at different wavelengths from 175 nm to 420 nm. Both the reflection profile and the absolute value of the reflectivity were measured. The data is being analysed and compared with the Monte Carlo simulation of the reflection processes implemented in GEANT4. We have introduced a new model in GEANT4 simulation which consists of a diffuse lobe plus a specular lobe. The diffuse lobe is described by the Wolff-Oren-Nayar model which takes into account the roughness of the surface. The specular lobe is described by the geometrical model of Torrence and Sparrow. The model introduced is valid for high and low reflectivities and also for dielectrics and metals. For validation of the experimental procedure and data analysis, the well known reflectivity of quartz was also measured. The results will be submitted for publication soon. Part of them were presented at the 12th Geant4 Collaboration Workshop, Hebden Bridge, West Yorkshire, UK, 13-14 September 2007.

PERFORMANCE OF GEMS (GAS ELECTRON MULTIPLIERS) IN A TWO PHASE (LIQUID||GAS XENON DETECTOR

One of the most important issues of WIMP detection is the radioactive background of the detector itself. The photomultiplier tubes are known to be a source of the background, even if only the low background materials are used for their manufacturing. It is therefore important to continue to search for alternative readout methods. One of the possibilities is to use Gaseous Electron Multiplier (GEM). We studied the operation of GEM (Gaseous Electron Multipliers) in the gas phase of a two-phase xenon chamber. The measurements were carried our with a purified xenon in a clean chamber equipped with an 241Am alpha-source at the cathode and a GEM placed parallel to the cathode. The space of 11.1 mm between the cathode and the GEM was partly filled with liquid xenon which formed a layer of 5 mm. Electrons emerging from the GEM were collected to a multiwire electrode. The 241Am amplitude spectra were recorded at different voltages at the GEM and the gain as a function of the voltage across the GEM was measured. The measurements were done at the temperature of 108C corresponding to the vapour density of 4.7110ˆ19cmˆ-3Ṡtable operation (more than 1 hour) of the GEM with the visible gain up to 140 was achieved at these conditions. The energy resolution as good as 16% (fwhm) was obtained for 5.5 MeV alpha-particles. The 241Am 60 keV gamma-rays, as well as ≈30 keV xenon escape peak are clearly visible in the spectra; 14 keV 237Np X-rays can also be distinguished. The results will be submitted for publication soon.

ENERGY LOSS MODELLING

The understanding of the energy loss process for very slow heavy ions (i.e. energies between 1 and 100 keV) is very important to predict the response of the proposed detector to particles interacting through nuclear recoils, as is the case of Weakly Interacting Massive Particles (WIMPs). The accurate description of the energy loss process for slow heavy ions requires considering separately the interactions with the nuclei of the material and their electrons. After having carried out a comprehensive survey of the different theories and semi-empirical parameterisations that have been developed over the years, we carried out a validation study of the many different Geant4's stopping power parameterisations for the slowing down of low energy heavy ions in a material. That validation was carried out by simulating proton and alpha emission in different materials, and comparing the total, as well as the electronic and nuclear stopping powers independently with those reported on NIST's databases, SRIM's results and experimental data. We implemented a new physical process in Geant4 simulating the nuclear recoils of the atoms in the substance after the scattering of the incident particle. A full cascade

was implemented. At first, the continuous slowing down approximation was used with the recoil's energy taken from the nuclear stopping parameterization. Next, a full discrete process was implemented taking into account the cross sections. The different quenching factors of the nuclear recoil cascade were then computed for LXe, Si and others and compared with the predictions of Linhard, SRIM and experimental data (when available). The results were presented at the "12th Geant4 Collaboration Workshop", Hebden Bridge, West Yorkshire, UK, 13-14 September 2007. Writing an example to be included in the GEANT4 package is under way.

4.3.2 Fundings

Code	Funding	Start	End
POCI/FP/63446/2005	55.000 €	2005-09-01	2007-01-31
POCI/FP/63925/2005	60.000 €	2006-11-01	2007-10-31
POCI/FP/81928/2007	75.000 €	2007-07-01	2008-06-30

4.3.3 Team

Project coordinator: Isabel Lopes

Name	Status	%of time in project
Alessio Mangiarotti	Researcher (LIP)	15
Alexandre Lindote	PhD student (LIP)	100
Alexandre Moita	Technician (LIP)	1
Américo Pereira	Technician (LIP)	25
Ana Patrícia Eliseu		42
Armando Policarpo	Researcher (LIP/FCTUC)	10
Carlos Silva	Technician (LIP)	1
Cláudio Silva	PhD student (LIP/FCT) *	100
Edward Santos	Student (LIP)	42
Filipa Balau	Master student (LIP)	82
Francisco Neves	PhD student (LIP)	100
Isabel Lopes	Researcher (LIP/FCTUC)	48
João Silva	Technician (LIP)	1
Joaquim Oliveira	Technician (LIP)	1
José Pinhão	Technician (LIP)	0
José Pinto Da Cunha	Researcher (LIP/FCTUC)	37
Nuno Carolino	Technician (LIP)	10
Paulo Mendes	Researcher (LIP/FCTUC)	9
Ricardo Pinho	(LIP)	75
Rui Marques	Researcher (LIP/FCTUC)	10
Vitaly Chepel	Researcher (LIP/FCTUC)	40
Vladimir Solovov	Post-Doc (LIP)	100

4.3.4 Publications

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

- *The ZEPLIN II dark matter detector: Data acquisition system and data reduction*
  G.J. Alner et al.
  Nuclear Instruments and Methods in Physics Research A (in press) (accepted)

- *A survey of energy loss calculations for heavy ions between 1 and 100 keV*
  A. Mangiarotti, M. I. Lopes, M. L. Benabderrahmane, V. Chepel, A. Lindote, P. Sona, J. Pinto da Cunha
  Nucl. Instrum. and Meth A 580 (2007) 114-117

- *Operation of Gas Electron Multipliers in pure xenon at low temperatures*
  V. Solovov , F. Balau F. Neves, V. Chepel, A. Pereira, M.I. Lopes
  Nucl. Instrum. and Meth A. 580 (2007) 331-334

- *Measuring the angular profile of the reflection of xenon scintillation light*
  C.P. Silva, J. Pinto da Cunha, V. Chepel, P. Mendes, A. Pereira, V.Solovov, F. Neves, M.I. Lopes
  Nucl. Instrum. and Meth A 580 (2007) 114-117

- *First limits on WIMP nuclear recoil signals in ZEPLIN-II: a two phase xenon detector for dark matter detection*
  G. J. Alner et al.
  Astroparticle Physics 28 (2007) 287-304

- *Limits on spin-dependent WIMP-nucleon cross-sections from the first ZEPLIN-II data*
  G.J. Alner et al.
  Physics Letters B 653 (2007) 161166

- *The ZEPLIN III Detector; Results from Surface Calibrations*
  T. J. Sumner et al.
  Nuclear Physics B (Proc. Suppl.) 173 (2007) 108112

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

- *Measurement of the radiative neutron capture cross section of [sup 206]Pb and its astrophysical implications*
  C. Domingo-Pardo, et al.
  10.1103/PhysRevC.76.045805

4.3.5 Presentations

Oral presentations in international conferences

- *Liquid xenon detectors: fundamentals and applications*
  presented by Isabel Lopes
  at NSRP-17 in Calcuta, India.

Oral presentations in international meetings

- *Muon-Induced Neutrons Measured with ZEPLIN-II Veto*
  presented by Alexandre Lindote
  at 12th Geant4 Collaboration Workshop in Hebden Bridge, West Yorkshire.
- *New Model for Simulation of Light Reflection in GEANT4*
  presented by Cláudio Silva
  at 12th Geant4 Collaboration Workshop in Hebden Bridge, West Yorkshire, UK.
- *Simulation of Low-Energy Nuclear Recoils Using GEANT4*
  presented by Ricardo Pinho
  at 12th Geant4 Collaboration Workshop in Hebden Bridge, West Yorkshire, UK.

Oral presentations in collaboration meetings

- *Data Acquisition Software for ZEPLIN III*
  presented by Alexandre Lindote
  at ZEPLIN II & III Collaboration Meeting in Edinburgh, UK.
- *ZE3RA Data Reduction Software for ZEPLIN III*
  presented by Francisco Neves
  at ZEPLIN II & III Collaboration Meeting in Edinburgh, UK.
- *ZEPLIN III Slow Control*
  presented by Vladimir Solovov
  at ZEPLIN II & III Collaboration Meeting in Edinburgh, UK.

- *Position Reconstruction in Z3*
  presented by Alexandre Lindote
  at ZEPLIN II & III Collaboration Meeting in Edinburgh, UK.
- *Reflectivity measurements in the UV*
  presented by Cláudio Silva
  at ZEPLIN II & III Collaboration Meeting in Edinburgh, UK.
- *Position Reconstruction in Z2*
  presented by Alexandre Lindote
  at ZEPLIN II & III Collaboration Meeting in Edinburgh, UK.
- *On calibration of ZEPLIN-3 with gamma rays and neutrons*
  presented by Vitaly Chepel
  at ZEPLIN Collaboration Meeting in Coimbra, Portugal.
- *Data Acquisition Software for ZEPLIN-III*
  presented by Alexandre Lindote
  at ZEPLIN Collaboration Meeting in Coimbra, Portugal.
- *Slow Control of ZEPLIN-III*
  presented by Vladimir Solovov
  at ZEPLIN Collaboration Meeting in Coimbra, Portugal.
- *Simulation of low energy LXe nuclear recoils with Geant4*
  presented by Ricardo Pinho
  at ZEPLIN Collaboration Meeting in Coimbra, Portugal.
- *ZE3RA Data Reduction Software*
  presented by Francisco Neves
  at ZEPLIN Collaboration Meeting in Coimbra, Portugal.

4.3.6 Academic Training

PhD Theses

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

Master Theses

- *Estudo de funcionamento dos GEMs em detectores de xénon líquido"*
  Filipa Balau, (on-going)
- *Study of Multi-Pixel Photon Counters at low temperature and for UV light"*
  Ana Patrícia Eliseu, (on-going)

4.3.7 Events

- *ZEPLIN Collaboration Meeting*
  Collaboration Meeting, Coimbra, Portugal, 2007-08-28

4.3.8 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	7
Articles in international journals (with indirect contribution from LIP members)	1
Oral presentations in international conferences	1
Oral presentations in international meetings	3
Oral presentations in collaboration meetings	11
Collaboration Meetings	1

4.4 High Energy Cosmic Rays

4.4.1 Activity Report

Resumo

A física de astropartículas é um campo de investigação extremamente activo, envolvendo físicos de partículas, tanto teóricos como experimentalistas, astrofísicos e cosmólogos. O ano de 2007 foi marcado pela divulgação pública dos primeiros resultados do Observatório Pierre Auger, que abriram prespectivas muito interessantes nos domínios da astronomia/astrofísica e da física de partículas. As actividades do grupo de raios cósmicos de alta energia do LIP centraram-se na participação no Observatório Pierre Auger (com especial envolvimento na análise dos dados recolhidos pelos detectores de fluorescência e nos upgrades do Observatório actualmente em curso), no desenvolvimento de trabalho de fenomenologia, e na preparação do projecto GAW, em particular com o início do desenvolvimento de cartas de interface no laboratório de electrónica.

Summary

Astroparticle physics is a very active research field involving experimental and theoretical physicists from particle physics, astrophysics and cosmology. In 2007 the first and striking results of the Pierre Auger Observatory (PAO) were publicly released, opening very interesting perspectives in the domains of astronomy/astrophysics and particle physics. The activities of the LIP High Energy Cosmic Rays (HECR) team were centered in the participation in the PAO (with particular involvement on the analysis of the fluorescence detector data and on the Observatory enhancement program now under way), in the development of phenomenological work, and in the preparation of the Gamma Air Watcher (GAW) project, in particular with the start of the production of interface cards in the cosmic ray electronics laboratory.

Participation in the Pierre Auger Observatory

The Pierre Auger Observatory has recently published striking results on the arrival directions and on the energy spectrum of HECR. In fact, the anisotropy of the arrival directions of the highest-energy cosmic rays and their extragalactic origin was demonstrated. The observations are consistent with the hypothesis that the rapid decrease of flux measured by the Pierre Auger Observatory above 6x10^19 eV is due to the interactions with the cosmic microwave background (the GZK effect) and that most of the cosmic rays reaching Earth in that energy range are protons from nearby astrophysical sources, either AGN or other objects with a similar spatial distribution. These results were largely reported and were included by several media organizations on the top "scientific stories" of the year 2007. Meanwhile, results on the depth along the atmosphere at which the number of electrons and positrons in the extensive air showers reaches its maximum were also presented by the Pierre Auger Observatory and are in contradiction with the current expectations assuming a light composition. Upper limits of the photon fraction in the HECR spectrum, as well as on the diffuse flux of high-energy tau neutrinos, were also reported. These results open a new astronomy channel to the nearby Universe but also represent a unique window to study Particle Physics at energies well beyond the LHC.
The Southern site of the Pierre Auger Observatory in Mendoza, Argentina, is in the final stage of construction and will reach completion by spring of 2008. It covers 3000 km2 combining the technique of sampling the shower particles reaching the Earth surface, using 1600 water Cherenkov tanks, with the technique of detecting the fluorescence light produced by the shower in the atmosphere, using four groups (eyes) of six fluorescence telescopes. At the end of 2007 more than 1500 tanks were deployed and all the fluorescence eyes were operational. Many thousands of events per year (several tens above 10^20 eV) will be collected. About 10% of the collected events will have simultaneously information from the sampling detector (SD) and the fluorescence detectors (FD). The data collected so far (in the last four years, during construction) corresponds roughly to one year of operation of the complete southern observatory.
An enhancement program of the Auger South site was approved last year. The aims are: to lower the present energy threshold of the experiment, increasing the surface detector density in a small area of the array and improving the muon detection capabilities by introducing new muon detectors in the infill region (AMIGA Auger Muons and Infill for the Ground Array); to enlarge the vertical field of view of the fluorescence detectors (HEAT High Elevation Atmospheric Telescope); and to test the radio detection technique. The first six infill-tanks have been deployed and preliminary work for muon detectors has begun. Most of the components of HEAT are already fabricated and the civil work for the telescope enclosures has already started. Radio detection of showers with an external trigger from the array has been achieved.
The complete sky coverage by the PAO implies the construction of a second site in the northern hemisphere. At the time of the original design report, the two sites were foreseen to be built simultaneously and covering the same surface area (3000 km2). Later, it was decided to build the southern site and take into account its first

results in the elaboration of the final Auger North design. This design is presently being finalized. Lamar, in the Colorado Desert, USA, was chosen, after a detailed evaluation based on criteria such as land access, climate, atmosphere, available surface and local support. In the present preliminary design a much larger surface area (20000 km2) is being considered, thus optimizing Auger North to the highest energies (above 10^20 eV).
Portugal has joined the Pierre Auger Observatory in March 2006. In 2007, the Portuguese participation was centered in the fluorescence detectors data and in the enhancement projects, namely AMIGA.
With the Auger south fluorescence detectors complete and steadily working, a detailed understanding of our data and of the development of air showers becomes fundamental. First of all, it is the key to guarantee high quality results, with well-controlled systematic uncertainties. Furthermore, it is essential for the exploitation of these data as a unique window to particle physics at very high energies. In particular, the search for rare or exotic processes can only be done after this detailed characterization has been achieved. The understanding of the shower development involves the detailed study of both its longitudinal and transverse profiles, and the search for new characterization variables relating to the primary characteristics. There is presently a consensus in the collaboration that some aspects are not fully understood (e.g. the shower width) and also a set of issues that are not controlled at a satisfactory level and could be at least part of the explanation (e.g. multi-scattering, Cherenkov light lateral distribution). The main topics of our work in the PAO FD in 2007 evolved within this frame and are part of this common effort:

- **GEANT4 simulation of the FD:** the development of a complete GEANT4 simulation of the PAO fluorescence detectors was one of the first responsibilities of our team within the collaboration. It was finalized in 2007 and is now part of the PAO offline software.

- **3D reconstruction:** an innovative method developed at LIP was used to study the 3-dimensional structure of air showers. The standard reconstruction method deals with projection of the shower in the FD cameras, integrating the charge vs. time pulse obtained for each pixel. But time in fact corresponds to a third dimension. This is the basis of the 3D method, which looks inside each pixel, exploring the shape of the light pulse in time bins of 100 ns. A complex volume in space can then be associated to each measured charge (per pixel and time bin). This tool has allowed us to confirm in an independent way the indication that the air shower transverse width is larger in data than expected. Detailed crosschecks are presently under way. The 3D tool is also being exploited as a way to quantify the quality of the reconstruction.

- **3D simulation:** the development of a 3D simulation tool, which will allow a more accurate treatment of several critical aspects of light production and scattering in air shower development (e.g. Cherenkov light scattering), was started in 2007. Given the amount of particles involved in the development of air showers, and the number of generated fluorescence and Cherenkov photons, the straightforward methods of creating particle banks are not applicable, and more astute ways had to be found. The fluorescence light component is at present fully implemented. Cherenkov treatment is under way.

- **The Universal Shower Profile (USP):** At present, the longitudinal profile of the showers is fitted with a 4-parameter Gaisser-Hillas function. This curve is in fact too plastic, while detailed CORSIKA simulations show that, at such high energies, there is a universal profile, relatively independent of primary energy and composition. The existence of a USP allowed us to start, during 2007, several promising studies on FD data which will be pursued in the near future, namely along two lines of work:

  - The measurement of the USP in data was initiated by our team and is totally new in the collaboration. Preliminary results have shown a very good overall agreement with expectations in the central part of the longitudinal profile, with interesting differences to be understood closer to the ground, where scattering and Cherenkov effects are more relevant, and allowed to confirm the observations of other methods.
  - Decreasing the number of parameters required to characterize the longitudinal profile, other parameters can be released. Our first studies have included critical parameters such as the ratio between fluorescence and Cherenkov light production and the Cherenkov lateral distribution function. These methods have been implemented and tested on Monte-Carlo and can now be applied to data.

- **The Cherenkov lateral distribution function:** the studies of the Cherenkov lateral distribution function using the USP method mentioned above are part of a more general effort to measure this distribution directly from data, making use of events with a considerable amount of direct Cherenkov light arriving at the telescopes. This already large data set, usually treated as background, has in fact a large physics potential which we are trying to exploit.

Let us now turn to our participation in AMIGA. The AMIGA muon detectors consist of sets of buried scintillator strips, such that all air-shower particles but the muons are absorbed before reaching the detector. Simulations of the underground shower propagation are essential to understand possible backgrounds due to shower tails or secondary particles produced in the earth. Our group developed a Geant4-based simulation of the AMIGA muon detectors deployed underground and its interfacing with air-showers simulations. Studies of the detector performance and possible optimizations were performed at LIP. In particular the contribution from secondary particles giving rise to multi-hits in the muon counters was estimated through simulation. LIP members are also participating in a "ad-hoc" working group, together with Auger collaborators from IAFE, TANDAR and UNAM, to perform a systematic comparison of different simulation suites for the shower development in the atmosphere and underground.
The LIP team was also responsible for two FD shifts, requiring the presence in the Observatory site in Malarge of 2 people for two periods of 3 weeks.
The LIP is also an active member of the Grid computing community within the collaboration. LIP belongs to the Auger Virtual Organization, contributing with a sizable fraction of the computing power used by the simulation production task of the Collaboration. Members of the team are already users of the Auger Grid, in particular for CORSIKA shower simulation.

UHECR phenomenology

For a few years already, the LIP cosmic ray team has been publishing phenomenological work in high-energy cosmic ray physics, in a close collaboration with theoreticians at CENTRA and CFTP. Recently, our team has been particularly motivated for the study of hadronic interactions at very high energies. Hadronic interaction models are a critical aspect in the understanding and simulation of high-energy air shower development. In fact, the extrapolation from accelerator data to the high energies involved in cosmic ray physics has very large uncertainties. Furthermore, present data, and in particular recent Auger data, cannot be explained in a satisfactory way by the existing models.
In previous years we followed a line of work exploiting the potentialities of string percolation models in the interpretation of cosmic ray data above 10^17 eV. In this type of approach, as energy increases, sea strings dominate the phenomenological picture, and valence strings are usually neglected. During 2007, the complementary question has been looked into: what is the relevance of valence quarks, even at high energies? In fact, it is known that in hadronic interactions a sizable fraction of the available energy is carried away by baryons. As the baryon number is conserved, the net-baryon retains information on the energy-momentum carried by the incoming nuclei. At present, net-baryon data are scarce and in most of the existing Monte Carlo models the physics of net-baryon production is very much obscured by the complexity of extensive and detailed codes. In this context, a simple but consistent model of net-baryon production has been developed. The basic ingredients of the model are valence string formation based on standard parton distribution functions with QCD evolution and string fragmentation via the Schwinger mechanism. The obtained results show that a good description of the main features of the existing net-baryon data is possible on the framework of a simplistic model, with the advantage of making the fundamental production mechanism manifest. This work has recently been submitted for publication.

Participation in GAW Gamma Air Watch

GAW is an R&D project to test the feasibility of a new generation of Imaging Atmospheric Cherenkov Telescopes (IACT) for the detection of very-high-energy gamma rays. GAW is an Italian-Spanish-Portuguese collaboration. The main goal of the GAW concept is to achieve both a large field of view and a high flux sensitivity. This will be accomplished by using Fresnel lenses as the light collector instead of the presently used mirror-based optics and an array of multi-anode photomultipliers working in single photoelectron counting mode, instead of the charge integration method widely used in IACT experiments.
The GAW telescopes will be installed at the Spanish-German Astronomical Centre at Calar Alto (CAHA) in Andalucia. In the first phase of the project one telescope will be deployed at CAHA. The telescope building is now close to being finished and the telescope mechanical structure is ready for final inspection and testing at the manufacturer premises in Germany.
The activities of the LIP team during 2007 were related both to the detector simulation and the trigger firmware for the data acquisition system of the telescope:

- The LIP group was responsible for coordinating the implementation of an end-to-end simulation framework for GAW. This framework is composed of several modules, each corresponding to a well defined part of the physics and detector simulation: generation of high-energy gammas, air shower development, telescope optics from the lens to the focal plane, electronics and trigger. A modularized architecture allows choosing

among alternative approaches for a given layer of the simulation chain. Optimization studies of the GAW optics were also pursued, using a comprehensive Geant4-based simulation of the telescopes developed at LIP.

- The study of an alternative method for the shower reconstruction and gamma/hadron separation was undertaken in the framework of the participation in GAW. In this method the images recorded in several telescopes are combined to reconstruct the 3D geometrical characteristics of the shower. Promising results were obtained in view of the performance of the standard algorithms. This has been the subject of a master thesis concluded in 2007.

- LIP is responsible for the development of firmware for several components of the GAW data acquisition system. This activity is developed in close collaboration with the Palermo group. An interface board for the GAW Programmable Data Acquisition unit (ProDAcq) , the LIP-CTrig, was developed at LIP. The LIP group also developed test firmware for the different components of the ProDAcq. Using the LIP-CTrig, test firmware and external equipment, several tests of the ProDAcq were carried on, namely for the protocol configuration, ADC converters, trigger interface and control interface.

Electronics Cosmic Ray Laboratory

In 2007 the cosmic ray electronics laboratory, recently installed in the basement of the LIP premises in Lisbon with funding from "Programa de re-equipamento", has been actively working. The main tasks and status can be summarized as follows:

- The design of the third generation of the LIP-PAD acquisition board has been accomplished.

- In the context of the responsibilities in the GAW data acquisition system, several tasks related to the development and test of the trigger firmware are being carried on. In particular, the development of the interface card for the GAW ProDAcq unit has recently started.

- The preparation of laboratory setups for a course to be given to students of the second cycle (Bologna master) of the IST is ongoing.

- Support to the LIP Cosmic Ray Telescope (TRC) educational project was given along the year.

4.4.2 Fundings

Code	Funding	Start	End
POCI/FP/63917/2005	100.000 €	2006-09-01	2007-10-31
PTDC/FIS/65308/2006	155.000 €	2007-04-22	2009-04-21
POCI/FP/81914/2007	125.000 €	2007-07-01	2008-06-30

4.4.3 Team

Project coordinator: Mário Pimenta

Name	Status	%of time in project
André Pina	Graduate student (LIP/IST)	71
Bernardo Tomé	Researcher (LIP)	75
Catarina Espírito Santo	Researcher (LIP)	90
Eva Santos	Graduate student (LIP)	77
Fernando Barão	Researcher (LIP/IST)	16
Gonçalo Pires	Technician (LIP)	51
Jorge Dias de Deus	Researcher (LIP/IST)	10
Jorge Romão	Researcher (IST)	10
José Milhano	Researcher	5
Luís Mendes	Technician (LIP)	25
Luisa Arruda	PhD student (LIP/FCT)	20
Mário Pimenta	Researcher (LIP/IST)	74
Miguel Pato	Graduate student (LIP)	100
Patrícia Gonçalves	Researcher (LIP) *	50
Pedro Abreu	Researcher (LIP/IST)	50
Pedro Assis	PhD student (LIP/FCT)	91
Pedro Brogueira	Researcher (LIP/IST)	20
Ruben Conceição	PhD student (LIP/FCT)	100
Sofia Andringa	Post-Doc (LIP/FCT)	90

4.4.4 Publications

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

- *Extensive air showers and diffused Cherenkov light detection: The ULTRA experiment.*
  ULTRA collaboration, G. Agnetta et al. (with co-authorship of P. Assis, P. Brogueira, M.C. Espírito Santo, L. Melo, M. Pimenta, J.C. Silva, B. Tomé)
  Nucl. Instrum. Meth. A570 (2007) 22-35.

- *A Geant4 based engineering tool for fresnel lenses*
  J. Costa, M. Pimenta, B. Tomé
  IEEE Trans. Nucl. Sci., vol.54, no. 2, pp 313-319, 2007.

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

- *Correlation of the Highest-Energy Cosmic Rays with Nearby Extragalactic Object.*
  Auger Collaboration
  Science 318 (5852), 938

International Conference Proceedings

- *EAS transverse profiles in the Xmax region at energies of 10^14 - 10^17 eV*
  P. Assis, P. Gonçalves, M. Pimenta
  ECRS-06

- *Percolation and cosmic rays above 10^17 eV*
  J. Alvarez-Muiz, P. Brogueira, R. Conceição, J. Dias de Deus, M.C. Espírito Santo, M. Pimenta
  ecrs06-s4-33

- *Sensitivity of large air shower experiments for new physics searches*
  V. Cardoso, M.C.Espírito Santo, A.Onofre, M.Paulos, M.Pimenta, J.C.Romão, B.Tomé
  ecrs06-s3-39

4.4.5 Presentations

Oral presentations in international conferences

- *Trigger and data acquisition in GAW*
  presented by Pedro Assis
  at Sixth International Workshop on New Worlds in Astroparticle Physics in University of the Algarve, Faro, Portugal..
- *Gamma/hadron separation in IACTs using 3D EAS variables*
  presented by André Pina
  at Sixth International Workshop on New Worlds in Astroparticle Physics in University of the Algarve, Faro, Portugal.
- *3D reconstruction of extensive air showers in the Pierre Auger Laboratory*
  presented by Miguel Pato
  at Sixth International Workshop on New Worlds in Astroparticle Physics in University of the Algarve, Faro, Portugal.

Poster presentations in international conferences

- *3D Reconstruction of Extensive Air Showers from Fluorescence Data*
  presented by Sofia Andringa
  at ICRC07 - 30th International Cosmic Ray Conference in Merida, Mexico.
- *A Geant4 based engineering tool for fresnel lenses*
  presented by Bernardo Tomé
  at ICRC07 - 30th International Cosmic Ray Conference in Merida, Mexico.
- *Gamma Air Watch (GAW): the electronics and trigger concept*
  presented by Pedro Assis
  at ICRC07 - 30th International Cosmic Ray Conference in Merida, Mexico.
- *Gamma/hadron separation in IACTs using 3D EAS variables*
  presented by Mário Pimenta
  at ICRC07 - 30th International Cosmic Ray Conference in Merida, Mexico.

Oral presentations in international meetings

- *Net-Baryon Physics*
  presented by Ruben Conceição
  at 9th Meeting on Percolation and Saturation in Heavy Ion Collisions and Cosmic Rays in Faro, Portugal.
- *The GAW Project*
  presented by Pedro Assis
  at PASC WINTER SCHOOL in Sesimbra, Portugal.
- *AMIGA A direct measurement of muons in Pierre Auger Observatory*
  presented by Eva Santos
  at PASC WINTER SCHOOL in Sesimbra, Portugal.
- *Net-Baryon Physics - basic mechanism*
  presented by Ruben Conceição
  at PASC WINTER SCHOOL in Sesimbra, Portugal.
- *Results from the Pierre Auger Observatory*
  presented by Sofia Andringa
  at PASC WINTER SCHOOL in Sesimbra, Portugal.
- *3D Reconstruction of Extensive Air Showers at the Pierre Auger Observatory*
  presented by Miguel Pato
  at PASC WINTER SCHOOL in Sesimbra, Portugal.

Oral presentations in collaboration meetings

- *A case example: from Corsika to Geant4*
  presented by André Pina
  at GAW Collaboration Meeting in Palermo, Italy.
- *GAW Simulation Framework*
  presented by Bernardo Tomé
  at GAW Collaboration Meeting in Palermo, Italy.
- *A Geant4 simulation for the AMIGA muon counters*
  presented by Bernardo Tomé
  at Auger Collaboration Meeting in Malarge, Argentina.
- *3D reconstruction from Fluorescence Data*
  presented by Sofia Andringa
  at Auger Collaboration Meeting in Malarge, Argentina.
- *The Geant4 Simulation of the FD Telescope*
  presented by Pedro Assis
  at Auger Collaboration Meeting in Malarge, Argentina.
- *Sensitivity to direct Cherenkov light in FD data*
  presented by Catarina Espírito Santo
  at Auger Collaboration Meeting in Malarge, Argentina.
- *3D Reconstruction of Extensive Air Showers from Fluorescence Data*
  presented by Sofia Andringa
  at Auger Collaboration Meeting in Malarge, Argentina.
- *Light Guide properties*
  presented by Fernando Barão
  at GAW Collaboration Meeting in Palermo, Italy.
- *Trigger and data acquisition in GAW*
  presented by Pedro Assis
  at GAW Collaboration Meeting in Palermo, Italy.
- *Corsika/Geant4 simulation of the AMIGA muon counters*
  presented by Bernardo Tomé
  at Auger Coll. Meeting in Malarge, Argentina.
- *Shower Transverse Profiles from 3D reconstruction.*
  presented by Sofia Andringa
  at Auger Coll. Meeting in Malarge, Argentina.
- *Cherenkov-rich events.*
  presented by Catarina Espírito Santo
  at Auger Coll. Meeting in Malarge, Argentina.
- *FD simulations at Lisboa.*
  presented by Bernardo Tomé
  at Auger Coll. Meeting in Malarge, Argentina.

Seminars

- *Very High Energy Cosmic Rays and the Pierre Auger Observatory*
  presented by Sofia Andringa
  at in CFTC - UL.
- *Auger FD simulation (Geant4) and reconstruction (3D, Cherenkov)*
  presented by Pedro Assis
  at in Universidad Nacional de La Plata, Argentina.

- *As actividades do LIP em Auger*
  presented by Sofia Andringa
  at in Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brasil.
- *Astrophysics and Particle Physics with high energy cosmic rays*
  presented by Mário Pimenta
  at in CFTP - Centro de Física Teórica de Partículas, Instituto Superior Técnico.
- *Results from the Pierre Auger Observatory*
  presented by Sofia Andringa
  at LIP in Lisbon.
- *Results from the Pierre Auger Observatory*
  presented by Sofia Andringa
  at in LIP, Coimbra.

4.4.6 Academic Training

PhD Theses

- *Data acquisition and control systems in cosmic ray experiments"*
  Pedro Assis, (on-going)
- *Hadronic Models in EAS"*
  Ruben Conceição, (on-going)

Master Theses

- *Search for new physics in Auger"*
  Miguel Pato, 2007-07-31
- *Image reconstruction in gamma ray telescopes: A new method and its aplication to the GAW project."*
  André Pina, 2007-07-31

4.4.7 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	2
Articles in international journals (with indirect contribution from LIP members)	1
International Conference Proceedings	3
Oral presentations in international conferences	3
Poster presentations in international conferences	4
Oral presentations in international meetings	6
Oral presentations in collaboration meetings	13
Seminars	6
Master Theses	2

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

4.5.1 Activity Report

Resumo:
A detecção da fluorescência do ar é uma técnica que tem vindo a ser usada para detectar raios cósmicos de ultra alta energia (E > 1 EeV) em experiências como Auger (Argentina) e HiRes (EUA). A análise dos dados recolhidos pelos detectores de fluorescência permite estimar a energia das partículas primárias desde que se conheça o número total de fotões emitidos, por desexcitação das moléculas de azoto, ao longo do desenvolvimento do chuveiro cósmico. A quantidade de luz emitida por electrão e por unidade de energia depende da altitude, através da sua dependência com a pressão, temperatura e humidade relativa. O estudo desta dependência, em particular da dependência com a temperatura, e dos mecanismos responsáveis pela excitação e desexcitação dos estados emissores é o objectivo principal deste projecto de investigação.
Summary of activities:
Total light yields of the (0,0) band of the 2nd positive system of N2 were measured as a function of pressure and temperature in pure nitrogen and in dry air. Experimental data need to be corrected by a factor that takes into account several factors: i) deposited energy inside the gas volume (depends on gas density); ii) production of primary and secondary electrons; iii) complete band profile at a temperature T for the 2nd positive system of N2; iv) solid angle of photon collection; v) transmission of the interference filter as a function of wavelength, angle of incidence and temperature; vi) detection efficiency of the photomultiplier (PMT) as a function of temperature.
A detailed study of the filter characteristics and of the PMT response was performed. The following aspects were considered:
1) The transmission of the interference filter (centered at 340 nm, at room temperature) was measured as a function of the wavelength for fixed angles of incidence. To check the consistency of the data, the transmission of the filter was also measured as a function of the angle of incidence for fixed wavelengths. Curve fits were performed and tables were constructed to obtain the transmission of the filter from 300 nm to 360 nm, with a step of 0.1 nm and from -40 to +40 (relative to the normal to the filter surface) with a step of 0.9. The uncertainty on these values is less than 10%.
2) The transmission curve of the filter was also measured as a function of the temperature. The center wavelength decreases when temperature is decreased at a rate of (-0.0012 0.0002) nm/; the transmission at the center wavelength increases when temperature decreases at a rate of (0.09 +/- 0.03)%/;
3) The PMT anode sensibility (includes gain and photocathode efficiency variations) was found to change at a rate of (0.10+/-0.05) %/.
All the uncertainties are a measure of the dispersion of the experimental data, resulting from repeated measurements of the same quantity.
The experimental data were corrected and presented at the "5th Workshop on Air Fluorescence", that took place in El-Escorial (Madrid), September, 2007 and a paper is accepted for publication in Nucl. Instr. and Meth. A.
The energy loss of the electrons (E < 10 keV) in N2 was simulated in order to estimate the relative populations of the different vibrational states of C state.
A new experimental set-up is being assembled.

4.5.2 Fundings

Code	Funding	Start	End
POCI/FP/63913/2005	20.000 €	2006-11-01	2007-10-31
POCI/FP/81944/2007	20.000 €	2007-07-01	2008-09-30

4.5.3 Team

Project coordinator: Margarida Fraga

Name	Status	%of time in project
Alexandre Moita	Technician (LIP)	8
Américo Pereira	Technician (LIP)	20
António Onofre	Researcher (LIP/UCPFF)	9
Armando Policarpo	Researcher (LIP/FCTUC)	15
Carlos Silva	Technician (LIP)	8
Ermelinda Antunes	Researcher (LIP/FCTUC)	12
Filipe Veloso	PhD student (LIP/FCT)	8
Francisco Fraga	Researcher (LIP/FCTUC)	10
João Bastos	Post-Doc (LIP)	13
João Silva	Technician (LIP)	5
Joaquim Oliveira	Technician (LIP)	8
Luís Pereira	Graduate student (LIP)	50
Margarida Fraga	Researcher (LIP/FCTUC)	40
Mário Pimenta	Researcher (LIP/IST)	10
Nuno Carolino	Technician (LIP)	15
Nuno Castro	PhD student (LIP/FCT)	8
Rui Marques	Researcher (LIP/FCTUC)	10
Susete Fetal	PhD student (LIP/ISEC)	8

4.5.4 Presentations

Oral presentations in international meetings

- *Temperature dependent quenching of UV fluorescence of N2*
  presented by Margarida Fraga
  at 5th Fluorescence Workshop in El-Escorial, Madrid, Spain.

4.5.5 Project Summary

	number
Oral presentations in international meetings	1

4.6 Radiation interaction simulations for space missions

4.6.1 Activity Report

Resumo

As actividades desenvolvidas no LIP no contexto dos estudos do ambiente de radiação no sistema solar e dos seus efeitos, centram-se na aplicação do toolkit de simulação Geant4 a este tipo de problemas, em que também se enquadra o design e optimização de monitores de radiação para futuras missões na heliosfera. As actividades que decorreram durante 2007 correspondem a dois contratos com a ESA ("European Space Agency") iniciados em 2006: uma extensão do contrato "Integrated Radiation Environment, Effects and Component Degradation Simulation Tool (correspondendo à verificação experimental dos resultados de um primeiro contratojá terminado), com início em Novembro de 2006 e que terá a duração de 2 anos; e o contrato intitulado "MarsREM: Martian Radiation Environment Models", com início a 1 de Julho de 2006 e com a duração prevista de 18 meses, entretanto alargada por 4 meses, no qual o LIP é responsável por um dos três "Work Packages", intitulado "Development of In-Orbit and Surface Radiation Environment Models".

Summary

The activities developed at LIP in the framework of the study of the radiation environment in the heliosphere and its effects have been centered in the application of the Geant4 toolkit to this type of problem, in which the design and optimisation of radiation monitors for future space missions can also be framed. The activities developed during 2007 correspond to two contracts with ESA (European Space Agency) which had started in 2006: an extension of the contract "Integrated Radiation Environment, Effects and Component Degradation Simulation Tool (corresponding to the experimental validation of some results obtained in the framework of a previous closed contract with ESA) started in November 2006 with a duration of 2 years; and the contract "MarsREM: Martian Radiation Environment Models", started in the 1st of July 2006 and foreseen to have a duration of 18 months (extended in the meanwhile by another 4 months), in which LIP is responsible by one of three technical work packages, entitled "Development of In-Orbit and Surface Radiation Environment Models".

MarsREM: Martian Radiation Environment Models

LIP is engaged in a contract with ESA, in a consortium with three other international institutes/companies. The contract, corresponding to the call ITT/AO/1-4944/05/NL/JD is entitled MarsREM: Martian Radiation Environment Models . The work conducted under this contract is divided into three technical work packages, and one dedicated to maintenance of the software after delivery. The initial duration of the main technical study was of eighteen months, followed by a two-year maintenance period from delivery of all software and acceptance of the Final Contract Report. The main study started in July 2006 (Kick-Off : KO) and its duration was extended by four months, up to May 2008.
The objectives of the main study, related directly with the three first technical Work Packeges (WP) are to:

- Assess existing physics models in Geant4 covering energetic nuclear-nuclear and ion-electromagnetic interactions, and to develop, implement and verify additional or improved models where they are required. (WP1)
- Design, develop, validate and make operationally available engineering tools, based on Geant4, to permit the prediction of the Martian radiation environment for orbital spacecraft, and Mars planetary and moon landers or habitats. The tools shall be easy-to-use by mission designers and planners (rather than developed just for radiation experts), web-based and interfaced with existing radiation shielding and effects simulation tools at the SPENVIS web-site.(WP2)
- Implement models to assess and compare the performance of passive and active radiation shielding, and apply to example cases to assess the performance of some active shielding cases.(WP3)

WP4 consists on software maintenance. The software development should be undertaken in full collaboration with, and should complement, other development activities elsewhere within the Geant4 consortium, where appropriate making full use of the technical expertise within the Geant4 group. Where appropriate, the work should also help expand the utilisation of Geant4 within the European space science community, and make Geant4 the preferred tool for space radiation effects analysis, and support and strengthen the collaboration between ESA, CERN and the Geant4 consortium.
LIP is responsible by WP2, whose breakdown is listed below:

- Mars Energetic Radiation Environment Model framework definition (WP2100)
- Definition of Mars primary particle source (WP2200)
- Definition of atmospheric and surface environments (WP2300)
- Development of detailed radiation model for in-orbit and surface(WP2400)
- Development of engineering model for in-orbit and surface environments (WP2500)
- Implementation of models into SPENVIS (WP2600)
- Validation and application to example cases (WP2700)

The activities described by WP2300, WP2400 and WP2700 are of LIPs executive responsibility whereas the remainder WP2 activities are contractual responsibilities, whose execution is not at LIPs charge.

WP2300

During 2007 WP2300 came to its end. The objective of this work package was to specify the physical environments for Mars, Phobos and Deimos integrating and extending existing models, with up-to-date measurements. These physical environments consist of the atmosphere with diurnal and annual variations, ground composition, presence or absence of localised magnetic fields and their geometry.
The main activities for WP2300 consisted of:

- Review of existing model information and study results in terms of surface material composition; atmospheric composition and density, and their short and long-term variability.
- Update of the MACLIDIG4 (Mars Climate Data Base to Geant4) interface for MCD version 4.0. Integration of available surface material composition information from different space missions for Mars and its moons.
- Development of SOILCOMPI (Soil Composition Interface), an interface to generate a surface soil composition table for Mars and its moons.
- Development of a Pre-processor to create a complete description of the geometries to be used in the MarsREM simulations

The activities developed within the context of WP2300 as well as the obtained results were described in a technical note (MarsREM_TN3).

WP2400

WP2400 had its start date at KO+6m (in the beginning of 2007) and its end date, at KO+15m, was extended up to January 2008. Within this work package, a Geant4 detailed Mars Energetic Radiation Environment Model dMEREM - was developed to predict in-orbit and surface radiation for Mars, Phobos and Deimos. The tasks performed under WP2400 were:

- Definition of software requirements for a detailed model, based on the general Baseline Requirements and interface specifications generated under WP2100.
- Architecture design merging both MARSREC and PLANETOCOSMICS into one unique code with improvements regarding new requirements for Mars and moons to predict in-orbit and surface radiation environment predictions.
- Preliminary testing and validation.

Geometry definition: The geometry is defined by Geant4 geometry construction using data from soil and atmospheric data bases
generated under WP2300.

Physics models: Standard electromagnetic physics is used for rapid calculation of general charged-particle ionisation effects. The hadronic physics lists should be taken from the output of WP1300, however, since these were not yet available, by WP2400 termination, dMEREM uses binary cascade HP model.
Radiation inputs: Input particle source terms are solar X-rays and UV, solar energetic particles (SEP) consisting of protons and other ions, energetic electrons originating in Jupiter's magnetosphere, and galactic cosmic rays which are outputs from work package WP2200.
The source particle definition is based on Geant4 G4GeneralParticleSource class. It can be input to dMEREM either via macro commands or via methods G4UserPrimaryGenerationAction class dedicated methods.
Particle event tallying and normalisation:The quantities to be accumulated (tallied) by the simulation are particle flux or fluence spectra, total ionising absorbed and equivalent dose, and energy-deposition spectra. Depending upon the source particle input results generated, outputs relate to background flux or dose rates (e.g. from GCRs and their secondaries) or worst-case environments integrated over the duration of a solar energetic particle event. The results are being correctly normalised to the incident particle rates inside dMEREM.
The outputs of this work package were: the source code for the dMEREM radiation simulation software and supporting documentation required for ECSS-E-40 software development (Baseline Requirements Document, Software Requirements and Software Design Document, Software User Manual, and the Design Justification Folder documents including documents for validation against the Technical Specification and Requirements Baseline).

Integrated Radiation Environment, Effects and Component Degradation Simulation Tool

The program proposed for this contract is an extension to ESA RFQ/3 310888/03/NL/CH. The final outcome of the proposed work is to generate verification procedures and plan a verification test programme for the developed models and to predict induced degradation levels on a specific family of components due to protons and ions. The contract has the duration of two years. It was initiated in November 2006 and will terminate in November 2008. The work was broken down into four technical phases. The contract phases that took place during 2007 are described in the following paragraphs.

WP1
The first phase consisted of a literature survey and analysis of existing models and technical descriptions of basic mechanisms for charge collection and diffusion. The understanding of the contributions to the SEU rate prediction from all the different primary and secondary particles was studied. The activities corresponding to this WP were developed during 2007, and were closed in November 2007.

WP2
WP2 is ongoing. It started in November 2007, and will terminate in May 2008. The corresponding tasks are to:

- Implement efficiency algorithms,
- Convert Energy Deposition into Electron-hole pairs production
- Convert Electron-hole pairs production into collected charge
- Calculate critical charge
- Predict the SEU rates for different input spectra
- Investigate the availability of in-flight data
- Compare predictions with existing in-flight data

WP4
In WP4 the developed models shall be verified experimentally. WP4 is ongoing during the total duration of the contract. It consists on the following activities:

- Identification of needed experimental testing
- Elaboration of experimental test plan
- Execution of experimental test plan
- Analysis of experimental test plan

During 2007, a part of Work Package 4 aiming at verifying simulation results with experimental irradiation test data and defining the needs for future simulation verification was completed, consisting on the identification of laser mapping tests as interesting for verification of the results as well as on the evaluation of the possibilities of performing such tests.

4.6.2 Fundings

Code	Funding	Start	End
ESA:19770/06/NL/JD	78.200 €	2006-07-01	2008-05-31
ESA:18121/04/NL/CH	80.000 €	2006-11-01	2008-10-31

4.6.3 Team

Project coordinator: Patrícia Gonçalves

Name	Status	%of time in project
Ana Keating	PhD student (LIP/FCT)	100
Andreia Trindade	PhD student (LIP)	5
Bernardo Tomé	Researcher (LIP)	20
Catarina Espírito Santo	Researcher (LIP)	10
Mário Pimenta	Researcher (LIP/IST)	11
Patrícia Gonçalves	Researcher (LIP) *	45
Pedro Brogueira	Researcher (LIP/IST)	5
Pedro Rodrigues	PhD student (LIP)	5
Sara Valente	Student (LIP)	100

4.6.4 Presentations

Oral presentations in international conferences

- *Radiation Environemtn at the Surface of Mars*
  presented by Ana Keating
  at 6th International Workshop: New Worlds in Astroparticle Physics in Faro, Algarve, Portugal.
- *Martian Radiation Environment: The Importance of Seasonal variations and Landing Site*
  presented by Ana Keating
  at European Mars Science and Exploration Conference in ESTEC, Noordwijk, The Netherlands.

Poster presentations in international conferences

- *Geant4 applications in the heliospheric radiation environment*
  presented by Bernardo Tomé
  at 30th International Cosmic Ray Conference in Mérida, Yucatan, México.

Oral presentations in international meetings

- *Planetary Radiation Environment and Effects (JRA)*
  presented by Ana Keating
  at EUROPLANET workshop in ESA ESTEC, Noordwijk, The Netherlands.

4.6.5 Academic Training

PhD Theses

- *A model for Mars Radiation Environment Characterization and Effects on Components"*
  Ana Keating, (on-going)

4.6.6 Project Summary

	number
Oral presentations in international conferences	2
Poster presentations in international conferences	1
Oral presentations in international meetings	1

Chapter 5

Medical Physics

5.1 Development of Positron Emission Mammography

5.1.1 Activity Report

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

Project Coordination:

- Project Director: João Varela
  - TagusLIP Coordinator: Pedro Rodrigues
  - Detector Commissioning and Simulation: Andreia Trindade
  - Integration and new detectors: Pedro Rodrigues

Summary of Activities:
The PET Consortium initiated in January 2007 a new phase of its PET technologies development program, in the frame of the project PET II - Development of PET Technologies - Project 70/00327 Prime-IDEIA. The activity is carried out by eight national institutions and about forty researchers. In parallel the Consortium is developing the strategy for transferring the technology to the market.
The Consortium requested funding for the first phase of 18 months (1/1/07 30/6/08) of an R&D project with three main axes. The project is conceived with a total duration of 3 years (2007-2009), however the funding covers only the first 18 months for operational reasons of the Funding Agency. A funding application for the second phase was submitted to the program QREN-Projectos de I&D em Co-promoção.
In agreement with the defined strategy of valorisation of the PET project results, the company PETsys Medical PET Imaging Systems, SA, was created.
In summary the project status is the following:
Axis 1) Consolidation of the breast cancer detection PET technologies
Many improvements to the ClearPEM technology were developed, in particular:

- Development and production of the frontend ASIC with 192 channels (ASICv3).
- Development of the frontend electronics with the ASICv3 and validation tests with detector modules, and the data acquisition and computing systems.
- Re-design and re-assembling of the PEM robot and detector heads.

Axis 2) Clinical trials in the frame of the ClearPEM-Sonic project
Clinical tests in Portugal (HGO) and in France are being prepared. The trial in France will complement the trial in Portugal and will exploit PET-ultrasound multimodality.

The acquisition of components, the development of production tools, and the production testing towards the assembling of a second prototype of the ClearPEM scanner to be installed in the Hospital de la Méditerranée, Marseille, is under way.

Axis 3) Investigation of new nuclear imaging technologies

Several developments have been concluded or are under way, namely:

- Development of a new PET detector module with improved sensitivity.
- Design of a new PET ASIC with new programming capabilities.
- Study of a new photodetector (Silicon photomultipliers) for time-of-flight PET.
- Development of SPECT multimodality.
- Design of the new Imaging Platform (adapted to Small Animal).

5.1.2 Fundings

Code	Funding	Start	End
PET - Mammography II	768.280 €	2007-01-01	2008-06-30

5.1.3 Team

Project coordinator: João Varela

Name	Status	%of time in project
Andreia Trindade	PhD student (LIP)	95
Bruno Carriço	Master student (LIP)	100
Catarina Ortigão	PhD student (LIP)	100
João Pinheiro	Master student (LIP) *	100
João Varela	Researcher (LIP/FCT)	25
José Carlos Silva	Technician (LIP)	10
Miguel Ferreira	Technician (LIP)	75
Pedro Amaral	Post-Doc (LIP)	8
Pedro Rodrigues	PhD student (LIP)	95
Ricardo Bugalho	Master student (LIP)	100
Rui Moura	PhD student (LIP/FCT)	100

5.1.4 Publications

National Conference Proceedings

- *PEM Physical Realization and Functional Validation*
  Carlos Leong, Pedro Bento, Pedro Machado, Vasco Bexiga, J. Paulo Teixeira, Pedro Rodrigues, Andreia Trindade, José C. Silva, João Varela, Pedro Lousã, Joel Rego, Isabel C. Teixeira
  REC´07, III Jornadas sobre Sistemas Reconfiguráveis, Instituto Superior Técnico, Lisboa

- *Using a Commercial Core to Customise the PCI Protocol to a Specific Environment*
  Pedro Machado, Vasco Bexiga, Carlos Leong, Pedro Bento, J. Paulo Teixeira, Pedro Lousã, Joel, Rego, Pedro Rodrigues, Andreia Trindade, José C. Silva, João Varela, Isabel C. Teixeira
  REC´07, III Jornadas sobre Sistemas Reconfiguráveis, Instituto Superior Técnico, Lisboa

5.1.5 Presentations

Presentations in national conferences

- *Projecto ClearPEM*
  presented by Rui Moura
  at Ciência 2007 in Gulbenkien, 13 Abril 2007.

- *PET in breast cancer detection*
  presented by João Varela
  at 5th Annual Metting of Bio-Medical Engineering in FMUL, Lisboa.

Oral presentations in international meetings

- *A PET imaging system dedicated to breast cancer diagnostics*
  presented by João Varela
  at Workshop on Medical Instrumentation Signal and Imaging, WMISI'07 in Universidade de Aveiro.

Oral presentations in collaboration meetings

- *Status of ClearPEM Gantry and Cooling System*
  presented by João Varela
  at Crystal Clear Collaboration Meeting, 7-9 March 2007 in Madrid.
- *ClearPEM Integration Status Report*
  presented by Pedro Rodrigues
  at Crystal Clear Collaboration Meeting in Madrid.
- *First image with the Clear-PEM modules*
  presented by Andreia Trindade
  at Crystal Clear Collaboration Meeting in Madrid.
- *Status of the data acquisition readout data link*
  presented by Ricardo Bugalho
  at Crystal Clear Collaboration Meeting in CERN.
- *Prospects for an enhanced ClearPEM detector module*
  presented by Catarina Ortigão
  at Crystal Clear Collaboration Meeting in CERN.
- *Exploratory DOI measurements in 30 mm length detector modules*
  presented by Rui Moura
  at Crystal Clear Collaboration Meeting in CERN.
- *ClearPEM integration status & first results with ASIC V3*
  presented by Pedro Rodrigues
  at Crystal Clear Collaboration Meeting in CERN.

5.1.6 Academic Training

PhD Theses

- *Avaliação do desempenho de um detector PET dedicado a mamografia"*
  Andreia Trindade, 2007-12-04
- *Modelização e avaliação do desempenho do sistema de aquisição de dados de um detector PET para mamografia"*
  Pedro Rodrigues, 2007-12-04
- *Estudo da detecção de invasão dos gânglios linfáticos da região axilar na sequência de cancro da glândula mamária com um detector PET dedicado"*
  Catarina Ortigão, (on-going)
- *Estudo da localização espacial de tumores cancerígenos na glândula mamária com um detector PET dedicado"*
  Rui Moura, (on-going)

Master Theses

- *Protótipo do "Intelligent Frontend Board" para aquisição de dados em tomógrafos PET"*
  Ricardo Bugalho, (on-going)
- *Desenvolvimento do sistema de controlo e calibração do tomografo ClearPEM"*
  João Pinheiro, (on-going)

5.1.7 Project Summary

	number
National Conference Proceedings	2
Presentations in national conferences	2
Oral presentations in international meetings	1
Oral presentations in collaboration meetings	7
PhD Theses	2

5.2 Human PET

5.2.1 Activity Report

Sumário

Este projecto pretende desenvolver uma tecnologia para exames radiológicos de Tomografia por Emissão de Positrões (PET) de corpo inteiro completamente nova e que promete aumentos na sensibilidade dos tomógrafos de cerca de uma ordem de grandeza (10 vezes).

Report 2007

Task: Development of RPC detectors for large-area gamma imaging (LIP responsibility)
Following the design phase performed in 2006 a prototype head with active dimensions 30x30cm, 50 glass layers and an electrical length of 2m was built. The readout was designed for simultaneous time and position measurements with resolution below 2mm and DOI accuracy of 5 mm.

Task: Data acquisition and electronics
A 16-channel data acquisition module that will allow the measurement of the event coordinates in the RPC volume is under development. The module is based on a high-speed Xilinx FPGA and is suitable for on-line data reduction. Due to the expected data-reduction capability, a commodity host interface like the USB 2.0 can be used and is being developed. The use of the resources available on the FPGA is also foreseen to generata a time stamp to be added to the data.

Task: Simulation of a very large Axial Field Of View PET scanners based on RPCs
Simulations were performed using the GEANT4 simulation toolkit to access the gain in sensitivity of a PET scanner based on crystal detectors with increasing Axial Field Of View (AFOV). Similar simulations were performed for a PET scanner based on RPCs with Time Of Flight (TOF) information, and the results compared with the sensitivity of present commercial PET scanners. In both cases the sensitivity was assessed following the NEMA NU-2 1994 standard.
Based on previous work, detectors were parameterized in order to increase the speed of simulations. Simulations were validated against published experimental data.

Task: Image Reconstruction and Data Corrections for large Axial Field-Of-Viw (AFOV) Scanners
Reading and reconstruction of the simulated data is now possible using two-dimensional algorithms. Estimates of data sizes for RPC-PET have been obtained and data compression schemes have been implemented in the list-mode to sinogram routines. The large data sizes require time-optimized processing and exact rebinning techniques plus two-dimensional iterative image reconstruction is considered the most practical approach to achieve a good compromise between image quality and processing speed. In this regard, we are implementing the exact rebinning technique FORE-J. The feasibility of correcting for scatter in RPC-PET is also being investigated using simulated data. In what concerns multimodality, an RPC-PET/CT seems feasible and desirable relative to the alternative of having activity sources for transmission measurements.

5.2.2 Fundings

Code	Funding	Start	End
POCI/SAU-OBS/61642/2004	47.160 €	2005-01-01	2008-06-30

5.2.3 Team

Project coordinator: João Lima

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	10
Américo Pereira	Technician (LIP)	5
Antero Abrunhosa	Researcher (IBILI)	5
Armando Policarpo	Researcher (LIP/FCTUC)	5
Carlos Correia	Researcher (FCTUC)	5
Custódio Loureiro	Researcher (FCTUC)	10
Filomena Clemêncio	Researcher (IBILI)	20
João Lima	Researcher (LIP/IBILI)	25
João Silva	Technician (LIP)	10
José Pinhão	Technician (LIP)	10
Luís Lopes	Technician (LIP)	5
Miguel Couceiro	Researcher (LIP/ISEC)	20
Nuno Carolino	Technician (LIP)	10
Nuno Fonseca	Researcher (LIP/IBILI)	10
Paulo Fonte	Researcher (LIP/ISEC)	10
Rui Marques	Researcher (LIP/FCTUC)	5

5.2.4 Publications

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

- *Sensitivity assessment of wide axial FOV PET systems via Monte Carlo simulations of NEMAlike measurements*
  M. Couceiro, N. C. Ferreira, P. Fonte
  Nucl. Instrum. and Meth. in Phys. Res. A 580 (2007) 485-488

- *RPC-PET: status and perspectives*
  M. Couceiro, A. Blanco, Nuno C. Ferreira, R. Ferreira Marques, P. Fonte, L.Lopes
  Nucl. Instrum. and Meth. in Phys. Res. A 580 (2007) 915-918

5.2.5 Presentations

Oral presentations in international conferences

- *RPC-PET: a new technology for human and animal PET*
  presented by Miguel Couceiro
  at Xth EFOMP congress in Pisa, Italy, 20-22 September 2007.

Oral presentations in international meetings

- *RPC-PET: a new technology for human and animal PET*
  presented by Paulo Fonte
  at WMISI´07 - Workshop on Medical Instrumentation Signal and Imaging in 11-12 April 2007, Aveiro, Portugal.

- *RPC-PET: a new technology for human and animal PET*
  presented by Paulo Fonte
  at XXX Reunião de trabalho sobre Física Nuclear no Brasil in 2 to 6 Setember 2007, guas de Lindóia, São Paulo, Brasil.

5.2.6 Events

- *Workshop sobre Reconstrução de Imagem em PET*
  Workshop, Instituto Superior de Engenharia de Coimbra, Coimbra, Portugal, 2007-02-08

5.2.7 Project Summary

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

5.3 Monte Carlo methods applied to dosimetry in medical radiologic exposures

5.3.1 Activity Report

Summary of Activities

Our group worked in several tasks on simulation and detector development.
The simulation of the Varian Clinac 600c accelerator was finished and the final results obtained. One Phd based on this work was presented to the University of Lisbon and a paper was published. Further work was done on the simulation of Brachytherapy Implants and the work presented in two conferences. The experimental and Monte Carlo validation of a dual head gamma camera, located at the Alvor Hospital was done. In this work we were able to simulate the response of a commercial gamma camera, and validate the simulation results with experimental data.
We started the work on the development of dosimetry with optical fibers. This is a new field of development for us and a topic that rises quite a lot of interest in the dosimetry community. Our goal is to develop, new reading techniques of the optical fibres, using solid state detectors.

Task: Monte Carlo simulation of the Varian Clinac 600c accelerator with dynamic wedges
In this task a study was done on the dosimetric characteristics of the Varian Clinac 600C dynamic wedges (DW) and their comparison with the physical wedges (PW) in terms of the differences affecting the dose distributions, beam spectra, energy fluence and angular distributions. The geometry of the 4 MV photon beam and the dose distributions in a water phantom were simulated with GEANT3 and DPM Monte Carlo code systems. The DW was modeled through the constant movement of the upper jaws. The depth dose distributions and lateral profiles for the DW, PW and open fields were measured and compared with the Monte Carlo simulations and the global agreement was found to be within 3%. It was also found that the effects of a DW on beam spectral and angular distributions are much less significant than those produced by a PW. For example, in our study we found out that the 45 PW, when compared with the corresponding open field, can introduce a 30% increase in the mean photon energy due to the beam hardening effect and that it can also introduce a 4.5% dose reduction in the build-up region because of the reduction of the contaminated electrons by the PW. For the DW neither this mean-energy increase nor such dose reduction was found. The PW, when compared to the DW, significantly alters the photon-beam spectrum and these dosimetric differences are significant and further investigation must be performed to quantify the impact in clinical use of these beams.

Task: Monte Carlo and Dosimetry in Temporary Brachytherapy Implants
The 125I brachytherapy seed model 6711 is one of the most investigated seeds in terms of dosimetric parameters in such a way that this seed is considered as the reference for many other seeds used in brachytherapy prostate permanent implants. The AAPM Task Group 43 (AAPM TG43) recommends values of radial, anisotropy dose functions and dose rate constant for the 6711 seed based on consensus values. However, several Monte Carlo (MC) and experimental studies reveal quite large differences of the calculated dosimetric parameters when compared to the recommended values. A possible cause of these differences can be explained by the modeled seed geometry, since the source spatial distribution remains quite unknown.
Using Penelope 2005 MC code, different source distributions were simulated using the same energy distribution recommended by the AAPM TG43. The seed geometry remained unchanged in all simulations. Dose in water at several polar angles and radii, and energy spectra (at 1m in vacuum) were calculated for each initial photon source distribution. Results show that the size of the layer inside the seed silver core where the initial photon position is sampled, and the uniformity or not of the source distribution play a crucial role and have a great influence in the shape of the radial and anisotropy dose functions. In the case where the initial photon position is uniformly sampled, simulations showed that a layer size difference of 0.5mm results in difference of 4%-9% in the values of the anisotropy dose function in some particular situations (small polar angles) although the difference in the dose rate constant value is less than 0.5%. This study has shown how it is important to know the source distribution since it has a non-negligible effect on the calculated MC dose distributions. To improve the present situation, manufactures should provide more accurate information on this seed parameter.

Task: Validation of a gamma camera prototype in a medical research imaging
We have implemented a Geant4 based simulation of a Siemens E.Cam Dual Head gamma camera and performed its experimental characterization in terms of energy resolution, sensitivity, spatial resolution, linearity and imaging of phantoms using 99mTc. The comparison between simulation results and experimental data allowed for the validation of the software codes developed for this work and provided a better understanding of the

operation of the camera at detector level. These codes may now be used for modeling and developing nuclear medicine detector technology and thus contribute to improve the state-of-the-art in the field.

Task: Scintillating optical fibers dosimetry
This task has just start. With this study we aim to develop a dosimetric system based on scintillating optical fibres read by photocathodes. So far we have concentrate our study in the response of the photodiodes to the direct ionization radiation, and its dependence with the temperature. The experimental results are still very preliminary.
Linked with this task is the development of a geometry package (ULYSSES) for the use with the Penelope MC code. The package is already operational and includes an histograming tool, specially design to work with Penelope (ULHISTOS).
The Ulysses package is a new geometry package that allows a user to follow a particle in a complex volume. The package is divided in 2 programs ullib and main and it´s base geometry structure is similar to the one used in GEANT3. Ullib is Ulysses´s library. It has 50 subroutines that can be divided into 4 types: geometry (these group of subroutines define the volumes the user can work with), translation (these group of subroutines makes the transformation of the volume referential to the laboratory and the opposite), tracking and localization (these subroutines allow the user to track and find the particle during it´s motion) and auxiliary routins (these subroutines are not essential or because they help the main routines simplifying them).
The main part of Ulysses has 3 subroutines main (here it´s defined the main variables necessary to the interface with the Monte Carlo simulation program), ulgeo (there subroutine defines the volume necessary parameters) and ulsource (this subroutine set all the beam ou souce parameter). Each one of them has an important part in the interface with the Monte Carlo simulation program which in the present case is PENELOPE. The main was made to be adapted by the user so that he can simulate what he wants.

Task: Radiometry and dosimetry in medical fields
It was initiated an interactive tool based on analytical methods able to map a distribution of direct and scattered radiation over examination room of Faro Hospital and Santiago do Cacém Hospital. The work is reported in the Joao Costa Master Thesis, already submitted to Algarve University and Ana Ferreira Master thesis and Rui Carvalhal "Licenciatura"Project, both on going, but a part of the preliminary results are reported in Internal Report LIP/04-07.
The work gamma camera prototype developed for medical physics it is not finished, but the results obtained were discussed in International Workshop on Medical Instrumentation. Signal and Imaging, WMISI´07, in an invited talk.

5.3.2 Fundings

Code	Funding	Start	End
POCI/FP/63909/2005	30.000 €	2006-09-01	2007-10-31
POCI/FP/81924/2007	25.000 €	2007-12-18	2008-12-17

5.3.3 Team

Project coordinator: Luis Peralta

Name	Status	%of time in project
Adérito Chaves	Researcher (IPO-Coimbra)	42
Amélia Maio	Researcher (LIP/FCUL)	9
Ana Catarina Farinha	Graduate student (LIP)	45
Ana Filipa Ferreira	Master student	2
Bernardo Tomé	Researcher (LIP)	4
Carla Oliveira	Researcher (IPO-Coimbra)	25
Carla Santos	Master student (ITN)	83
Conceição Abreu	Researcher (LIP/UALG)	26
Florbela Rego	PhD student (LIP)	45
João Castro Costa	Master student (LIP/Hospital do Litoral Alentejano)	17
João Gentil	PhD student (LIP/FCUL/FCT)	3
Luis Peralta	Researcher (LIP/FCUL)	39
Marco Quinteiro	Researcher	8
Margarida Fragoso	On leave (LIP/) *	84
Maria do Carmo Lopes	Researcher (IPO-Coimbra)	17
Patrick Sousa	PhD student (UALG)	34
Rui Carvalhal	Graduate student (LIP)	20
Sandra Soares	Researcher (LIP/UBI) *	64
Sérgio Gabriel	Student (LIP)	16
Sónia Rodrigues	Master student (LIP/UALG)	84
Zita Lopes	Student (LIP)	50

5.3.4 Publications

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

- *Monte Carlo Simulation of the Varian Clinac 600C Accelerator Dynamic and Physical Wedges*
  S.Soares, A.Chaves, L.Peralta, M.C.Lopes
  Journal of Physics: Conference Series 73 (2007) 012015

Internal Notes

- *Protocolo de verificação de câmaras de ionização*
  L. Peralta, F. Rego
  LIP/01-07

- *Actividades experimentais sobre radioactividade ambiente*
  Carmen Oliveira e Luis Peralta
  LIP/02-07

- *ULHISTOS histograming package for Ulysses, User Manual*
  L. Peralta and A. Farinha

- *Development of a computational application on the basis of the methodology proposal by NCRP 147 for the determination of the barriers of radiodiagnostic protection: preliminary results*
  R. Carvalhal, P. Sousa, M. C. Abreu
  LIP/04-07

- *Shielding design of a medical x-ray imaging facility based on the methodology used in the NCRP 147 report*
  F. Ferreira; P. Sousa; M. C. Abreu

- *Monte Carlo Simulation and Experimental Characterization of a Siemens E.Cam Dual Head Gamma Camera*
  S. Rodrigues, B. Tomé, M. C. Abreu, N. Santos and P. Rato Mendes
  arXiv:0711.2577 (accepted)

5.3.5 Presentations

Poster presentations in international conferences

- *Geant4 based simulation and experimental characterization of a gamma camera*
  presented by Sónia Rodrigues
  at Workshop on Medical Instrumentation Signal and Imaging, WMISI07 in Aveiro.

Presentations in national conferences

- *Protecção Radiológica em TC*
  presented by Sónia Rodrigues
  at I Jornadas Técnicas de Imagiologia Médica do CHBA in Portimão.

Oral presentations in international meetings

- *Detection of the sentinel lynph node*
  presented by Luis Peralta
  at Workshop on Medical Instrumentation Signal and Imaging, WMISI07 in Aveiro.
- *X and Gamma Ray Imaging with Hybrid Proton Detector*
  presented by Conceição Abreu
  at Workshop on Medical Instrumentation Signal and Imaging, WMISI07 in Aveiro.

5.3.6 Academic Training

PhD Theses

- *Simulação Monte Carlo do Campo de Radiação Produzido por um Acelerador Linear Varian Clinac 600C usando Cunhas Dinâmicas"*
  Sandra Soares, 2007-09-28
- *Desenvolvimento de dosímetros de estado sólido para dosimetria em radiologia e braquiterapia"*
  Florbela Rego, (on-going)

Master Theses

- *Protecção Radiológica da Unidade de Radiodiagnóstico do Hospital do Litoral Alentejano"*
  João Castro Costa, 2007-09-01
- *Desenvolvimento de um novo pacote de geometria para o código Penelope"*
  Ana Catarina Farinha, (on-going)

Graduation Theses

- *Desenvolvimento de uma aplicação computacional com base na metodologia proposta pelo NCRP 147 para a determinação das barreiras de protecção em radiodiagnóstico"*
  Rui Carvalhal, (on-going)

5.3.7 Events

- *New Worlds in Astroparticle*
  Conference, Campus de Gambelas da Universidade do Algarve, Faro (LIP/CENTRA), 2007-09-06
- *7th National Meeting of the Physics Students*
  Outreach Event, Faro, Algarve, 2007-03-31

5.3.8 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Internal Notes	6
Poster presentations in international conferences	1
Presentations in national conferences	1
Oral presentations in international meetings	2
PhD Theses	1
Master Theses	1
Conferences	1
Outreach Events	1

Chapter 6

Detectors

6.1 Applications of Timing Resistive Plate Chambers - RPC

6.1.1 Activity Report

Resumo:

Neste projecto pretendemos desenvolver uma tecnologia de detecção de partículas elementares denominada "Câmaras de Placas Resistivas". Estes detectores têm aplicação em experiências de Física das Partículas e estamos a desenvolver também aplicações na Imagiologia de Radioisótopos.

Summary of the Activities:

Collaboration on the CBM experiment at GSI was continued, mostly within the framework of the EU FP6 project I3HP.
Several possibilities for the continuation of large-scale detector implementation in HEP beyond HADES were investigated. Besides our present involvement on the CBM experiment, which may be re-evaluated in the future, contacts were made with the experiments PANDA and R3B at GSI with generally positive results. However, our present intense involvement on the HADES and HUMAN PET projects excludes any real progress in this area. Unfortunately there are no perspectives for involvement in CERN experiments.
In the framework of an informal collaboration with the Instituto de Pesquisa Energéticas e Nucleares, São Paulo, Brasil, we received the visit of the Brasilian researchers Carmen Tobias and Suzana Botelho from "Intituto de Pesquisa Nuclear (IPEN)". A technique for accurate measurement of the electrons drift velocity and effective gas multiplication coefficient in very high fields has been developed. This line of research continues now in São Paulo, Brasil. The LIP researcher Alessio Mangiarotti was invited to spend 3 months at IPEN and elaborated detailed calculations necessary for theoretical support of the project.
Participation in the RPC2007 workshop in Mumbai, India, was a major highlight of the year. LIP was involved on the presentation of 4 talks and 2 posters.

6.1.2 Fundings

Code	Funding	Start	End
POCI/FP/81981/2007	25.000 €	2007-07-01	2008-12-31

6.1.3 Team

Project coordinator: Paulo Fonte

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	15
Alessio Mangiarotti	Researcher (LIP)	13
Américo Pereira	Technician (LIP)	5
Luís Lopes	Technician (LIP)	15
Margarida Fraga	Researcher (LIP/FCTUC)	3
Orlando Cunha	Technician (LIP)	10
Paulo Fonte	Researcher (LIP/ISEC)	20
Rui Marques	Researcher (LIP/FCTUC)	8

6.1.4 Publications

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

- *Accurate timing of gamma photons with high-rate Resistive Plate Chambers*
  L.Lopes, A.Pereira, P.Fonte, R.Ferreira Marques
  Nucl. Instrum. and Meth. in Phys. Res. A 573 (2007) 4-7

- *RPC-PET: status and perspectives*
  M. Couceiro, A. Blanco, Nuno C. Ferreira, R. Ferreira Marques, P. Fonte, L.Lopes
  Nucl. Instrum. and Meth. in Phys. Res. A 580 (2007) 915-918

Collaboration notes with internal referee

- *Ceramic high-rate timing RPCs*
  L. Lopes, R. Ferreira Marques, P. Fonte, L. Hennetier, A. Pereira and A.M. Sousa Correia
  CBM Progress Report 2006

6.1.5 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	2
Collaboration notes with internal referee	1

6.2 Microstructure Gas Detectors

6.2.1 Activity Report

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. São considerados especialmente um detector para imagiologia com neutrões térmicos (32x32 cm2 e resolução de 1 mm) e uma câmara de traços (TPC).
Estes trabalhos são em parte desenvolvidos numa actividade financiada pelo 6 Quadro Comunitário de Apoio - JRA2 - MILAND: Millimetre resolution Large Area Neutron Detector NMI3 - HII3-CT-2003-505925.
Report 2007
1.MSGC charge and light measurements
After the optimization process carried in 2006 and beginning of 2007 further tests were carried at the ILL Grenoble. The experimental tests were performed with a detector using an ILL6C MSGC readout by 4x 40mm diameter red sensitive PMTs with 3He and 3 bar CF4. The measured resolution was 1.2mm FHWM, and the light pulses were 100 ns long, allowing a very fast readout. These results were presented at the 10th MILAND meeting in October 2007 and will be submitted for publication in 2008. It was shown that the specification of the MILAND detector could be achieved using an optical readout gas detector.
Tests were carried to study the possibility of developing a higher resolution detector using similar techniques, but were unsuccessful.
2.Optical TPC developements
It has been shown that, when operated with adequate gas mixtures, the GEM scintillation can be used for track imaging, using photomultipliers. We have shown that the light signals taken from a photomultiplier were faster than the charge signals, that their risetime was correlated with the track orientation, and could be used for the determination of the track angle in TPCs.
The resolution limits of the method have been measured experimentally for a 3x3 square mount PMT assembly and its variation versus number of photons was measured. An alternate readout using hexagonal mount (2+3+2) was assembled to study the closer packing Anger camera readout.

6.2.2 Fundings

Code	Funding	Start	End
RII3-CT-2003-505925	88.000 €	2004-01-01	2007-12-31
POCI/FP/81974/2007	15.000 €	2007-07-01	2008-06-30

6.2.3 Team

Project coordinator: Francisco Fraga

Name	Status	%of time in project
Alberto Blanco	Technician (LIP)	10
Alexandre Moita	Technician (LIP)	5
Américo Pereira	Technician (LIP)	15
Armando Policarpo	Researcher (LIP/FCTUC)	18
Filipa Balau	Master student (LIP)	0
Francisco Fraga	Researcher (LIP/FCTUC)	40
João Silva	Technician (LIP)	10
Joaquim Oliveira	Technician (LIP)	5
Luís Margato	PhD student (LIP)	10
Margarida Fraga	Researcher (LIP/FCTUC)	25
Nuno Carolino	Technician (LIP)	10
Orlando Cunha	Technician (LIP)	8
Paulo Mendes	Researcher (LIP/FCTUC)	15
Rui Marques	Researcher (LIP/FCTUC)	18
Sónia Pereira		100
Susete Fetal	PhD student (LIP/ISEC)	60

6.2.4 Publications

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

- *Towards a PMT based optical readout GEM TPCFirst results*
  S.T.G. Fetal, F.A.F. Fraga, L.M.S. Margato, M.M.F.R. Fraga, S.R. Pereira, R. Ferreira Marques and A.J.P.L. Policarpo

6.2.5 Presentations

Oral presentations in collaboration meetings

- *Measurement with the MSGC fabricated at the LLB*
  presented by Luís Margato
  at MILAND Meeting #8 in Paris, France.
- *Overview of light spectroscopy measurements during the MILAND project*
  presented by Francisco Fraga
  at MILAND Meeting #8 in Paris, France.
- *Study of the PM readout system*
  presented by Francisco Fraga
  at MILAND Meeting #9 in Munich.
- *Light measurement with GEMs and MSGCs*
  presented by Luís Margato
  at MILAND Meeting #9 in Munich, Germany.
- *Measurements with the LIP GSPC at the ILL*
  presented by Francisco Fraga
  at MILAND Meeting #10 in Bilbao, Spain.
- *Light measurement with GEMs and MSGCs*
  presented by Luís Margato
  at MILAND Meeting #10 in Bilbao, Spain.

6.2.6 Academic Training

PhD Theses

- *Estudo de GEMs (Gas Electron Multiplier); Detecção de Neutrões e Raios-X"*
  Luís Margato, 2007-11-08

6.2.7 Project Summary

	number
Articles in international journals (with direct contribution from LIP members)	1
Oral presentations in collaboration meetings	6
PhD Theses	1

6.3 Oficina-Coimbra

6.3.1 Activity Report

Resumo

Durante o ano de 2007 a oficina mecânica do LIP finalizou as suas novas infraestruturas, com a adaptação de um espaço junto à oficina mecânica, onde foram instalou as duas novas máquinas CNC, torno e centro de maquinagem, no Departamento de Física da Universidade de Coimbra. Foi dada formação ao pessoal técnico para a utilização destes novos equipamentos, e para adaptação a novos métodos de produção CAD/CAM. Foram também adquiridos novos acessórios e ferramentas, bem como máquinas mais pequenas. Foram continuados, e expandidos, os trabalhos que têm sido realizados, tanto na área de projecto como nade produção, com o fornecimento de serviços de mecânica de precisão aos projectos do LIP e de outras instituições de investigação, e a procura de novos projectos que possam tirar partido desta infraestrutura. Foi ainda implementada um novo procedimento de planeamento e calendarização dos trabalhos a realizar

Report

In 2007 the new machines (a lathe and a machining center) were installed at a new space, close to the mechanical workshop, in the Department of Physics. The room infrastructure had to be improved, as the electric power, lighting and compressed air distribution. An important task was the trainning of the workshop personal in the use of the new machines, in particular in the new CAD/CAM possibilities offered by the equipment. These machines also allow for an automatic material feeding, increasing the output rate and opening the possibility of production of larger series of pieces. In the "equipment"project were also chosen, acquired and installed a group of new accessories and tools, and also smaller equipment.
An important new task was the improvement of the divulgation of the workshop capabilities in the University and other research institutions. Several projects, outside the LIP activities, are now regular users of the mechanical workshop. It was also implemented a new web based procedure for the planning and schedulling of the tasks, in order to improve the efficiency and the reponse time.
Several important projects continued to be supported by the workshop, as the detector activities in LIP, the construction of the ToF wall, using the RPC technology, for the HADES experiment, at GSI, the installation and commissioning of the ATLAS/LHC light distribution system, and the support of the outreach activities, as the Cosmic Rays Telescope and the spark chamber.

Staff

Rui Alves	engineer
Joaquim Oliveira	technician
Alexandre Moita	technician
Carlos Silva	technician
José Pinhão	engineer (until Setember 2007)

6.3.2 Fundings

Code	Funding	Start	End
REEQ/573/FIS/2005	441.000 €	2005-03-01	2007-12-31

Chapter 7

Outreach

7.1 Particle physics education and public outreach

7.1.1 Activity Report

Relatório de Actividades

A actividade de divulgação do grupo de Outreach do LIP desenvolveu-se em 2007 segundo vários vectores.

- Foram realizadas as Masterclasses 2007, no âmbito do grupo EPPOG - European Particle Physics Outreach Group, com a participação recorde de +200 participantes em três institutos: Instituto Superior Técnico (IST) e Faculdade de Ciências da Universidade de Lisboa (FCUL) em Lisboa, e LIP+Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCTUC) em Coimbra.
- Houve uma participação na exposição "Ciência 2007"organizada pelo Conselho de Laboratórios Associados.
- Foram realizados 5 estágios no âmbito da Ocupação Científica de Jovens em Férias, em parceria com o IST, com a FCUL, e com a Universidade do Algarve.
- Na sequência das actividades da Ocupação, foi criada a rede de Radioactividade Ambiente - Projecto Radão, envolvendo 11 escolas portuguesas.
- Foram prosseguidas as actividades no âmbito do Telescópio de Raios Cósmicos, tendo sido estudados e desenvolvidos procedimentos de calibração, e realizado um período de aquisição simultânea de chuveiros de raios cósmicos com 4 estações. Neste período foi assinalado um par de acontecimentos em escolas diferentes que ocorreram com uma diferença temporal inferior a um milissegundo. Os resultados deste período de teste foram apresentados na conferência internacional "6th New Worlds in Astroparticle Physics", Faro, em Setembro de 2007.
- Foram realizados vários seminários de divulgação em Escolas e no IST no âmbito da Semana da Física do NFIST (Núcleo de Física do IST).
- Foi organizada a 20 Reunião do grupo EPPOG em Lisboa, como pré-conferência da conferência internacional "18th ECSITE Annual Conference", que teve lugar no Centro de Congressos de Lisboa em Maio de 2007. Foi também apresentada nessa conferência a utilidade do LHC na pesquisa dos grandes mistérios do Universo ("The Cosmic Connection of the LHC"). As actividades de Outreach do LIP foram também apresentadas na 21 Reunião do grupo EPPOG, que teve lugar no CERN em Outubro de 2007.
- Foi ainda traduzida uma nota de imprensa dos resultados de Auger, que foi publicada em dois jornais diários de referência e grande circulação.
- Finalmente foi co-organizada com o CERN a 1 Escola de Física do CERN para Professores Portugueses ("CERN´s Portuguese Teachers Program 2007"). Foram levados ao CERN 43 Professores de escolas portuguesas (de 200 candidatos), e durante uma semana tiveram aulas, sessões experimentais e visitas acompanhadas por investigadores portugueses. Esta escola teve um grande sucesso junto dos participantes, e potenciou o estabelecimento de contactos muito próximos com Professores de escolas remotas no Continente e nas Regiões Autónomas.

Activity Report

The outreach activities of LIP in 2007 followed several directions.

- The EPPOG European Masterclasses in Particle Physics were organized in three institutes in Portugal - LIP + Instituto Superior Técnico (IST) and Faculdade de Ciências da Universidade de Lisboa (FCUL) in Lisbon, and at LIP + Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCTUC) in Coimbra, with a record number of nearly 200 participants.
- There was an active participation in the Exhibition "Ciência 2007"organized by Conselho de Laboratórios Associados.
- In the scope of Ciência Viva´s Ocupação Científica de Jovens em Férias, 5 stays (of about 2 weeks each) for portuguese students were organized at IST, FCUL and at University of Algarve, in Faro.
- Following these summer activities, a network of schools with radioactivity detection kits was established and is working (Projecto Radão), involving 11 portuguese schools.
- The activities in the framework of the TRC Project - Telescópio de Raios Cósmicos were carried out, namely calibration studies and procedures, and a period of simultaneous acquisition of showers in 4 schools was performed, resulting in a pair of events in different schools that ocurred within one milissecond. The results of this pilot run were presented in the international conference "6th New Worlds in Astroparticle Physics", Faro, in September 2007.
- Several outreach seminars were given in secondary schools and at IST, in the scope of the NFIST´s Physics Week (NFIST = Nucleus of Physics Students of IST).
- The 20th meeting of the EPPOG group was organized in Lisbon, as a pre-conference to the 18th ECSITE Annual Conference, that took place at Centro dos Congressos de Lisboa, on May 2007. In this big conference, the usefulness of LHC for the great misteries of the Universe was also presented ("The Cosmic Connection of the LHC"). The Outreach activities of LIP were also presented in the EPPOG´s 21st meeting at CERN, on October 2007.
- The Auger´s Press Release on its Science Article, was translated and motivated a large article in two reference daily newspapers of great circulation.
- Finally, the first school of Physics for Portuguese Teachers was co-organized at CERN ("CERN´s Portuguese Teachers Program 2007"). 43 Portuguese Teachers were selected among 200 candidates, to spend a week at CERN, having update classes of particle physics and the Universe, experimental hands-on sessions, and visits to the CERN´s complex and experiments, accompanied by portuguese researchers at CERN. This school had an enormous success among its participants, and we collected important contacts with remote schools in Portugal (including the Atlantic Islands).

7.1.2 Fundings

Code	Funding	Start	End
POCTI/DIV/2005/00087	50.000 €	2005-06-01	2007-03-31
2006-204/176	56.000 €	2007-04-01	2008-06-01
OCJF2007	3.000 €	2007-07-01	2007-09-30
PTP 2007 CERN	32.000 €	2007-09-09	2007-09-14

7.1.3 Team

Project coordinator: Pedro Abreu

Name	Status	%of time in project
Agostinho Gomes	Researcher (LIP)	1
Amélia Maio	Researcher (LIP/FCUL)	10
Américo Pereira	Technician (LIP)	15
Ana Rodrigues		15
Ana Catarina Farinha	Graduate student (LIP)	1
Ana Fernandes		15
Ana Pinho		15
Ana Pinto		15
António Onofre	Researcher (LIP/UCPFF)	2
Bruna Rico		15
Carlos Bernardino		15
Carmen Oliveira		30
Conceição Abreu	Researcher (LIP/UALG)	10
Fernando Barão	Researcher (LIP/IST)	10
Florbela Rego	PhD student (LIP)	9
Gaspar Barreira	Researcher (LIP)	0
João Carvalho	Researcher (LIP/FCTUC)	10
José Silva	PhD student (LIP/FCUL)	11
Lina Moniz	Student (LIP)	89
Luis Peralta	Researcher (LIP/FCUL)	11
Marco Quinteiro	Researcher	15
Miguel Ferreira	Technician (LIP)	9
Paula Pinho		15
Paulo Nunes		15
Pedro Abreu	Researcher (LIP/IST)	30
Pedro Assis	PhD student (LIP/FCT)	9

7.1.4 Presentations

Oral presentations in international conferences

- *The Cosmic Connection of the LHC*
  presented by Pedro Abreu
  at 18th ECSITE in Centro de Congressos de Lisboa, Lisboa.
- *A network to develop radioactivity experiments in basic and secondary schools*
  presented by Conceição Abreu
  at Frontiers of Physics Education in Opatija, Crocia.
- *Search for extended air showers with TRC*
  presented by Lina Moniz
  at 6th NWAP in Faro, Portugal.

Poster presentations in international conferences

- *A CASA DO RADAO: RADIAO E AMBIENTE*
  presented by Ana Pinho
  at XXXI Bienal Fisica e 17 in Granada, Espanha.

Oral presentations in collaboration meetings

- *Análise de Dados e Actividades nas Escolas*
  presented by Lina Moniz
  at TRC 0/07 in LIP, Lisboa.
- *TRC - Evolução e Início da Aquisição, Planeamento futuro*
  presented by Pedro Abreu
  at TRC 0/07 in LIP, Lisboa.

- *Breve Introdução aos Raios Cósmicos*
  presented by Mário Pimenta
  at TRC 0/07 in LIP, Lisboa.

- *Funcionamento do Sistema de Aquisição do TRC*
  presented by Pedro Assis
  at TRC 0/07 in LIP, Lisboa.

- *Recent Outreach in HEP in Portugal*
  presented by Pedro Abreu
  at XXth EPPOG Meeting in Centro de Congressos de Lisboa, Lisboa.

- *Outreaching CERN in Português*
  presented by Pedro Abreu
  at 21st EPPOG Meeting in CERN, Genebra, Suiça.

- *Report of EPPOG and its 21st Meeting*
  presented by Pedro Abreu
  at Eurocosmics´07 in CERN, Genebra, Sua.

Seminars

- *Como Compreender o Universo*
  presented by
  at LIP in Escola Secundária de Penacova.

Outreach seminars

- *Raios cósmicos e a construção e operação de uma câmara de faíscas*
  presented by Paulo Martins
  at in Escola Secundária da Mealhada.

- *Modelo padrão da partículas elementares*
  presented by António Onofre
  at in Escola Secundária da Mealhada.

- *Aceleradores e detectores de partículas*
  presented by João Carvalho
  at in Escola Secundária da Mealhada.

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

- *Raios cósmicos e a construção e operação de uma câmara de faíscas*
  presented by Paulo Martins
  at in Escola Secundária de Arganil.

7.1.5 Academic Training

Master Theses

- *Estudos de Raios Cósmicos de Energia Média com o TRC"*
  João Pires, 2007-10-01

7.1.6 Events

- *TRC 0/07*
  Collaboration Meeting, LIP, Lisboa, 2007-01-20

- *XXth EPPOG Meeting*
  Collaboration Meeting, Centro de Congressos de Lisboa, Lisboa, 2007-05-29

- *EPPOG - European Masterclasses 2007 - Seja Cientista por um Dia!*
  Outreach Event, FCUL, Lisboa, 2007-03-17
- *EPPOG - European Masterclasses 2007 - Seja Cientista por um Dia!*
  Outreach Event, LIP e IST, Lisboa, e LIP e FCTUC, Coimbra, 2007-03-24
- *Participation in Cincia 2007 - Encontro pblico com a Cincia*
  Outreach Event, Pavilho do Conhecimento, Lisboa, 2007-04-16
- *Estgio "Trovoada Csmica"*
  Outreach Event, LIP e IST, Lisboa, 2007-07-03
- *Estgio "Os Mues Ressuscitados!"*
  Outreach Event, LIP e CFNUL, Lisboa, 2007-07-03
- *Estgio "Colaborao na Experincia ATLAS em LHC"*
  Outreach Event, LIP e CFNUL, Lisboa, 2007-07-03
- *Estgio "Radioactividade Ambiente"*
  Outreach Event, LIP, Lisboa, 2007-07-03
- *Estgio "Radioactividade Ambiente"*
  Outreach Event, Univ. Algarve, 2007-07-03
- *Public Session in 20th European Cosmic Rays Symposium*
  Outreach Event, Lisboa, 2007-09-07
- *Visita ao CERN - Professores de Escolas Portuguesas*
  Outreach Event, CERN, 2007-09-10

7.1.7 Project Summary

	number
Oral presentations in international conferences	3
Poster presentations in international conferences	1
Oral presentations in collaboration meetings	7
Seminars	1
Outreach seminars	5
Master Theses	1
Collaboration Meetings	2
Outreach Events	10

Chapter 8

Scientific Conferences and Seminars

As in previous years, LIP has carried on promoting and organizing Scientific Conferences in Portugal, in partnership with several Universities and Research Centers. The sixth edition of the New Worlds in Astroparticle Physics Workshop took place in Faro as usual, and the PASC Winter School started this year in Sesimbra.
A program of scientific seminars by "internal"and invited speakers was also pursued, with the aim of making it as regular as possible.
The seminar "Café com Física"is a joint venture of the Department of Physics of the University of Coimbra and LIP Coimbra, organised by Constança Providência (FCTUC) and António Onofre (LIP), for divulgation of current scientific work to students.

8.1 Seminars

Seminars

- *Climbing to the Top: Physics towards the LHC*
  presented by Michele Gallinaro on 2007-02-08
  at LIP in Lisbon.
- *Decaimentos Raros do Quark Top em ATLAS*
  presented by Filipe Veloso on 2007-02-13
  at Café com Física in Coimbra.
- *Crystal and Nonlinear Optical Properties of Triphenylguanidine*
  presented by Cláudia Cardoso on 2007-02-27
  at Café com Física in Coimbra.
- *Medidas de Reflexão para Detectores de Matéria Negra*
  presented by Cláudio Silva on 2007-03-13
  at Café com Física in Coimbra.
- *Some results on the NA60 measurement of the rho spectral function*
  presented by João Seixas on 2007-03-22
  at LIP in Lisbon.
- *Detectores de Xenon Líquido*
  presented by Alexandre Lindote on 2007-03-27
  at Café com Física in Coimbra.
- *Estrelas Estranhas*
  presented by Rafael Cavagnoli on 2007-04-24
  at Café com Física in Coimbra.
- *Particle Physics at the Era of LHC*
  presented by Gustavo Castelo Branco on 2007-05-09
  at Café com Física in Coimbra.
- *Neutrinos solares e de reactores*
  presented by José Maneira on 2007-05-11
  at LIP in Lisbon.

- *Direct detection of dark Matter*
  presented by Isabel Lopes on 2007-05-24
  at LIP in Lisbon.

- *Relativistic Heavy Ion Collisions*
  presented by Wojtek Florowski on 2007-05-28
  at Café com Física in Coimbra.

- *Gluões, Fantasmas e Alfaces*
  presented by Paulo Silva on 2007-06-05
  at Café com Física in Coimbra.

- *Imagiologia de Raios-X ao Preço de um Café*
  presented by Hugo Natal on 2007-06-12
  at Café com Física in Coimbra.

- *A Missão Espacial Gamma-Ray Imager*
  presented by Rui Silva on 2007-06-12
  at Café com Física in Coimbra.

- *Symmetries and Conservation Laws*
  presented by Leopold Simmons on 2007-06-13
  at Café com Física in Coimbra.

- *Cristais Líquidos-Um laboratório para Cosmologia e Gravitação*
  presented by Fernando Morais on 2007-06-27
  at Café com Física in Coimbra.

- *String/fluid instabilities and Kaluza-Klein holes*
  presented by scar Dias on 2007-07-05
  at Café com Física in Coimbra.

- *Studying the Universe from 2 km underground: SNO and the new SNOLAB*
  presented by Art McDonald on 2007-09-10
  at LIP in Lisbon.

- *A Importância da Física na Robótica do Mundo Real*
  presented by Norberto Pires on 2007-10-03
  at Café com Física in Coimbra.

- *Charm and beauty production from pp to Pb-Pb collisions, from fixed-target to collider energies*
  presented by Hermine K. Woehri on 2007-10-11
  at LIP in Lisbon.

- *Results from the Pierre Auger Observatory*
  presented by Sofia Andringa on 2007-10-25
  at LIP in Lisbon.

- *CLOUD - after clouds gave particle physics new particles, the time has come for particles and particle physics to help learning about clouds and climate change*
  presented by André Tinoco Mendes on 2007-11-08
  at LIP in Lisbon.

- *Grid Computing basics: Don´t be afraid... and use it!*
  presented by Gonçalo Borges on 2007-11-22
  at LIP in Lisbon.

- *Divulgação de Física de Partículas: Como dar uma ajudinha!*
  presented by Pedro Abreu on 2007-12-06
  at LIP in Lisbon.

- *From CMB to Cosmic Rays: unveiling the galactic magnetic field*
  presented by Domingos Barbosa on 2007-12-13
  at LIP in Lisbon.

- *Forward Proton Tagging as a Tool to Study New Physics at the LHC*
  presented by Valery Khoze on 2007-12-14
  at LIP in Lisbon.

- *Research on Imaging and Accelerators applied to Medicine*
  presented by Jose Bernabeu on 2007-12-18
  at LIP in Lisbon.

8.2 Conferences

- *New Worlds in Astroparticle*
  Conference, Campus de Gambelas da Universidade do Algarve, Faro (LIP/CENTRA), 2007-09-06

- *Open Workshop on e-Infrastructures*
  Workshop, LNEC, Lisboa, 2007-10-11

- *INT.EU.GRID Integration Meeting*
  Workshop, LNEC, Lisboa, 2007-11-12

- *PASC Winter School*
  Workshop, Sesimbra, 2007-12-19