Laboratório de Instrumentação e Física Experimental de Partículas

RELATÓRIO DE ACTIVIDADES

2005

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Overview

We summarize here the main lines of LIP activities during 2005.

As in the years before, the strong commitment with CERN has been pursued, with a strong involvement in the LHC experiments and technologies, namely ATLAS, CMS and the Worldwide LHC Computing Grid. COMPASS Collaboration was continued.

The involvement in space related activities was continued, namely with the participation in the AMS and the collaboration with ESA was reinforced.

The GRID Computing activities were enlarged and LIP-Lisbon was able to begin the installation of a new computer centre

Medical Physics research was continued, including the PET project, maintained a sustained activity now in the new laboratory, the Tagus-LIP facility, for supporting Medical Physics research. The LIP Algarve team is collaborating with the Hospital Particular do Alvor, Hospital do Litoral Alentejano and Siemens- Medical Solutions.

In 2005, LIP continued to participate in numerous education and outreach activities. In particular, LIP had a full involvement in the 20th. Anniversary of Portugal joining CERN as a member state, with a programme that included multiple initiatives.

LIP maintained its involvement in the Program "Training Engineers at CERN" selecting 16 candidates to follow a two years training program at CERN.

During 2005 LIP-Lisbon negotiated the participation in two new experiments being now a full partner of the Auger and SNO collaborations.

The Portuguese team involved in the CERN NA60 collaboration as an independent group asked to join LIP and was accepted. They have decided to merge with the LIP team at ATLAS.

LIP organized during 2005 the following events:

- Co-organizer of New worlds in Astroparticle Physics, January, Algarve
- Organizer of the 2005 EPS Particle Physics Conference that had 800 participants and was a large success. Lisbon, July
- The biannual LIP Workshop, in Carvoeiro, December where all the LIP scientific activities were reviewed.

Finally, in March, Jose Mariano Gago left the LIP board of Directors to become the Minister for Science, Technology and the Universities. Gaspar Barreira took his position, as President of the Board.

Now, especially for the LIP in Coimbra, a short summary follows:

The most important changes in the activities in Coimbra were a result of the engagement of a new senior physicist, António Onofre, in the framework of the contract as Associate Laboratory. Also in 2005, Alessio Mangiarotti, another senior physicist, was selected for an equivalent position to start in February 2006.

As for commitments abroad, we should note the important responsibility undertaken by LIP at GSI, in the framework of the European project "DIRAC-PHASE-1". Besides of the participation in the R&D as a normal partner of the European project, LIP assumed the task of construction and delivery of the new TOF wall for the HADES experiment.

The LIP team within the UK Dark Matter Collaboration has also undertaken important tasks during 2005, in order to allow for the fast extraction of data to be assessed by the funding agency PPARC, in view of the continuation of this important experiment

In the framework of the MILAND project (NMI3 - JRA2), measurements in neutron beams have shown that the scintillation Anger camera principle works.

In the direction of Astroparticle Physics, improved measurements of the nitrogen UV fluorescence as a function of pressure and temperature were performed, in an attempt to obtain reliable and precise data on air fluorescence yields, including a detailed study of the response of the components of the set-up to temperature variations.

For the Mechanical Workshop of LIP the year of 2005 was an important turning point, in view of the acquisition of two modern machine tools financed by the National Programme for Scientific and Technical Re-Equipment.

Considering the infrastructures, we hired Helmut Walters, a senior physicist with a long experience in information technologies, to co-ordinate the services of computing and networking in Coimbra, including the efforts to install in Coimbra one GRID node. Following preliminary contacts with the Centre for Computational Physics (CFC), a research unit belonging to the Physics Department of the University of Coimbra, it is now foreseen to establish a formal collaboration between both teams, thus providing the computing means necessary to have the GRID node operational already in the first half of 2006.

Finally, the evolution of the relationship with the University of Coimbra was further clarified in a protocol signed in July between the UC Rector and various research centres not belonging to this university, but whose activity counts with university staff.

Funding Summary

Funding for LIP - Lisboa

Project	Code	Funding	Entity	Start	End
AMS	**PDCTE/FNU/50364/2003**	**40.000 €**	**FCT**	**2004-11-01**	**2007-10-31**
ATLAS	**POCTI/FP/FNU/50206/2003**	**180.000 €**	**FCT**	**2004-07-04**	**2005-09-30**
	POCI/FP/63422/2005	**225.000 €**	**FCT**	**2005-06-01**	**2006-05-31**
CMS	**POCTI/FNU/50131/03**	**170.000 €**	**FCT**	**2004-07-04**	**2005-09-30**
	POCI/FP/63434/2005	**225.000 €**	**FCT**	**2005-08-01**	**2006-07-31**
	RTN2-2001-00571	**166.320 €**	**EU**	**2003-03-01**	**2006-09-30**
COMPASS	**POCTI/FNU/50192/2003**	**110.000 €**	**FCT**	**2004-07-04**	**2005-09-30**
	POCI/FP/63431/2005	**120.000 €**	**FCT**	**2005-05-01**	**2006-04-30**
	010.6/B009/2005	**252.000 €**	**EU**	**2004-01-01**	**2006-12-31**
DELPHI	**POCTI/FP/FNU/50204/2003**	**15.000 €**	**FCT**	**2004-09-01**	**2005-12-31**
ESA	**ESA: 18121/04/NL/ch**	**100.000 €**	**ESA**	**2004-04-01**	**2006-09-30**
	ESA 19100/05/NL/HB	**23.240 €**	**ESA**	**2005-09-11**	**2006-02-28**
Grid Computing	**EGEE-complement (010.6/B002/2005)**	**119.250 €**	**FCT**	**2005-04-01**	**2006-03-31**
	CrossGrid (IST-2001-32243)	**186.921 €**	**EU**	**2002-01-05**	**2005-04-30**
	EGEE (INFSO 508833)	**247.500 €**	**EU**	**2004-04-01**	**2006-03-31**
	EGEE-additional (POCI/V.5/A016/2005)	**100.000 €**	**FCT**	**2005-05-01**	**2006-04-30**
High Energy Cosmic Rays	**PDCTE/FNU/49727/2003**	**60.000 €**	**FCT**	**2004-03-01**	**2005-02-28**
	POCTI/FIS/55759/2004	**80.000 €**	**FCT**	**2005-03-01**	**2006-12-31**
MC in Medical Physics	**POCTI/FNU/50127/2003**	**20.000 €**	**FCT**	**2004-09-01**	**2005-08-31**
	POCTI/FP/FNU/20129/2003	**10.000 €**	**FCT**	**2004-07-04**	**2005-12-31**
	POCI/FP/63448/2005	**36.000 €**	**FCT**	**2005-09-01**	**2006-08-31**
NA50	**POCTI/FNU/50194/2003**	**15.000 €**	**FCT**	**2004-07-04**	**2005-07-03**
OUTREACH	**POCTI/DIV/2005/00087**	**50.000 €**	**FCT**	**2005-06-01**	**2006-09-30**
	000 CRESCERE	**23.400 €**	**EU**	**2005-07-01**	**2006-02-28**
	OCJF2005	**1.200 €**	**Ciência Viva**	**2005-07-01**	**2005-09-30**
PET - Mammography	**POSI/DGDR-SIFEC/14/01/03/FDR/00134**	**569.000 €**	**AdI**	**2003-01-01**	**2006-12-31**
RD39	**POCTI/FP/FNU/50133/2003**	**20.000 €**	**FCT**	**2004-07-04**	**2005-10-03**

RPC's	**010.6/B009/2005**	**110.000 €**	**FCT**	**2004-01-01**	**2006-12-31**
SNO	**POCI/FIS/56691/2004**	**35.000 €**	**FCT**	**2005-01-01**	**2006-12-31**

Funding for LIP - Coimbra

Project	Code	Funding	Entity	Start	End
Air Scintillation	**POCI/FP/63440/2005**	**30.000 €**	**FCT**	**2005-07-04**	**2006-07-03**
	POCTI/FP/FNU/50340/2003	**15.000 €**	**FCT**	**2004-07-04**	**2005-10-30**
CAMCAO	**POCTI/FNU/43843/2001**	**237.900 €**	**FCT**	**2002-06-07**	**9999-12-31**
HADES	**EU Contract 515876 DIRAC-Phase-1**	**52.000 €**	**EU**	**2005-11-01**	**2009-10-31**
	LIP-GSI contract	**414.000 €**	**GSI**	**2005-11-01**	**2009-10-31**
HERA-B	**POCTI/FP/FNU/50196/2003**	**15.000 €**	**FCT**	**2004-07-04**	**2005-07-03**
Human PET	**POCI/SAU-OBS/61642/2004**	**47.160 €**	**FCT**	**2005-01-01**	**2007-12-31**
LHC Physics	**POCI/FP/63420/2005**	**36.000 €**	**FCT**	**2005-06-01**	**2006-05-31**
Microstructure Gas Detectors	**CERN/FNU/43735/2001**	**50.000 €**	**FCT**	**2002-03-11**	**2006-06-30**
	RII3-CT-2003-505925	**120.000 €**	**FCT / EU**	**2004-01-01**	**2006-12-31**
	POCTI/FP/FNU/50338/2003	**25.000 €**	**FCT**	**2004-07-04**	**2006-04-30**
Oficina-Coimbra	**REEQ/573/FIS/2005**	**441.000 €**	**FCT**	**2005-03-01**	**2006-12-31**
RPC's	**POCTI/FP/FNU/50171/2003**	**17.838 €**	**FCT**	**2004-07-04**	**2005-12-31**
	POCI/FP/63411/2005	**34.540 €**	**FCT**	**2005-06-01**	**2006-11-09**
	RII3-CT-2003-506078	**110.000 €**	**EU**	**2004-01-01**	**2007-12-31**
	CERN/FNU/47323/2001	**60.000 €**	**FCT**	**2002-04-01**	**2005-07-31**
ZEPLIN and n-TOF	**POCTI/FP/FNU/50208/2003**	**60.000 €**	**FCT**	**2004-10-01**	**2006-02-28**
	POCI/FP/63446/2005	**55.000 €**	**FCT**	**2005-09-01**	**2006-08-31**
	CERN/FNU/43729/2001	**140.000 €**	**FCT**	**2002-01-02**	**2005-09-30**

Scientific Statistical data:

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 presentation by LIP members in international conferences
Nat. - Presentations by LIP members in national conferences
Seminars: Invited seminars in Institutes or Universities Outreach Seminars: Seminars for students or general public
Students: Students Active in the project Theses: Theses concluded during the year Post-Doc: Post-Doc Fellows active in the project
Events: Organisation of events (conferences, workshops, collaboration meetings, etc.)

Project	Publications			Conferences			Seminars	Outreach	Students	Theses			Post-Doc	Events
	Jrn-I	Jrn-II	other	int.o	int.p	nat.		Seminars		G	M	D		
ATLAS			7	2	2	1			8		2		1	
CMS	2		10	3					4			1	2	1
COMPASS	2	1	3	1		2			6				2	
HADES				1										
LHC Physics	3	3	3	4	2	1	1		2				1	
HERA-B	2	1							3		2	1	1	
NA50	2	2	6	5		2	2					1	1	
DELPHI	9		2	3					3					1
Grid Computing			3	2		1	1	2					2	
AMS				6		1			2				1	
SNO	3	1	1	1									1	
ZEPLIN and n-TOF	5	4	3	4	1				3	1			1	1
High Energy Cosmic Rays	1	1	6	5					5	1			1	
Air Scintillation				2		1			3					
ESA	1	1	3	8					4				1	
PET - Mammography	5	5	9	4	2	1	3		6	1			1	1
Human PET				1										
MC in Medical Physics	1	1	8	1	3	6			12		1			
RPC's	4	4		8	1	1								
Microstructure Gas Detectors	1	1							4					
CAMCAO					1									
OUTREACH			1	3		1		6	5					8
Totals:	41	25	63	62	11	18	7	8	52	3	5	3	14	12

Human Resources

Human Resources for LIP Lisboa in 2005-12-31

Name	Position
Agostinho Gomes	**Researcher**
Amélia Maio	**Researcher**
Catarina Espírito Santo	**Researcher**
Conceição Abreu	**Researcher**
Enrico D'Abramo	**Researcher**
Fernando Barão	**Researcher**
Gaspar Barreira	**Researcher**
João Varela	**Researcher**
Jorge Gomes	**Researcher**
Luis Peralta	**Researcher**
Mário Pimenta	**Researcher**
Paula Bordalo	**Researcher**
Pedro Abreu	**Researcher**
Pedro Brogueira	**Researcher**
Peter Sonderegger	**Researcher**
Rui Ribeiro	**Researcher**
Sérgio Ramos	**Researcher**
Bernardo Tomé	**Post-Doc**
Catarina Quintans	**Post-Doc**
Gonçalo Borges	**Post-Doc**
Helena Santos	**Post-Doc**
José Maneira	**Post-Doc**
Malgorzata Kazana	**Post-Doc**
Mário David	**Post-Doc**
Patrícia Gonçalves	**Post-Doc**
Pedro Amaral	**Post-Doc**
Pedro Rato	**Post-Doc**
Reyes Alemany	**Post-Doc**
Ruben Shahoyan	**Post-Doc**
Adarsh Jain	**Student**
Ana Catarina Farinha	**Student**
Ana Keating	**Student**
Andreia Trindade	**Student**
Bernardo Morgado	**Student**
Bruno Carriço	**Student**
Carlos Marques	**Student**
Catarina Ortigão	**Student**
Celso Franco	**Student**
David Sora	**Student**
Florbela Rego	**Student**
Francisco Mota	**Student**
Gonçalo Borges	**Student**
Gonçalo Pires	**Student**

Helena Moreira	**Student**
João Costa	**Student**
João Gentil	**Student**
João Pina	**Student**
João Pires	**Student**
João Santos	**Student**
José Silva	**Student**
Lina Moniz	**Student**
Luis Silva	**Student**
Luisa Arruda	**Student**
Margarida Fragoso	**Student**
Miguel Pato	**Student**
Miguel Paulos	**Student**
Nuno Almeida	**Student**
Nuno Anjos	**Student**
Patrick Sousa	**Student**
Pedro Assis	**Student**
Pedro Jorge	**Student**
Pedro Silva	**Student**
Pedro Ribeiro	**Student**
Pedro Rodrigues	**Student**
Ruben Conceição	**Student**
Rui Faísca Pereira	**Student**
Rui Moura	**Student**
Sandra Brás	**Student**
Sandra Soares	**Student**
Sérgio Pino	**Student**
Sónia Rodrigues	**Student**
Dário Passos	**Technician**
José Aparício	**Technician**
José Carlos Nogueira	**Technician**
José Carlos Silva	**Technician**
Maria Francisca Calheiros	**Technician**
Miguel Ferreira	**Technician**
Nuno Dias	**Technician**
Cláudia Delgado	**Administrative**
João Pedro Santos	**Administrative**
Lina Barata	**Administrative**
Sandra Dias	**Administrative**

Summary

Position	Number
Researchers	**19**
Post-Docs	**12**
Students	**42**
Technicians	**7**
Administrative Staff	**4**

Human Resources for LIP Coimbra in 2005-12-31

Name	Position
António Onofre	Researcher
Armando Policarpo	Researcher
Ermelinda Antunes	Researcher
Francisco Fraga	Researcher
Helmut Wolters	Researcher
Isabel Lopes	Researcher
João Carvalho	Researcher
João Lima	Researcher
José Pinto Da Cunha	Researcher
Margarida Fraga	Researcher
Orlando Oliveira	Researcher
Paulo Fonte	Researcher
Paulo Mendes	Researcher
Pedro Martins Ferreira	Researcher
Renato Guedes Júnior	Researcher
Rui Marques	Researcher
Rui Santos	Researcher
Sónia Pereira	Researcher
Vitaly Chepel	Researcher
João Bastos	Post-Doc
Vladimir Solovov	Post-Doc
Alexandre Lindote	Student
Filipa Balau	Student
Filipe Veloso	Student
Francisco Neves	Student
João Batista	Student
Luís Margato	Student
Matilde Castanheira	Student
Nuno Castro	Student
Rui Matos	Student
Susete Fetal	Student
Alberto Blanco	Technician
Américo Pereira	Technician
Carlos Silva	Technician
João Silva	Technician
Joaquim Jesus	Technician
Joaquim Oliveira	Technician
Jorge Correia Moita	Technician
José Pinhão	Technician
Luís Lopes	Technician
Nuno Carolino	Technician
Rui Alves	Technician
Elisabete Neves	Administrative
Isabel Melo	Administrative
Teresa Marques	Administrative

Summary

Position	Number
Researchers	**19**
Post-Docs	**2**
Students	**10**
Technicians	**11**
Administrative Staff	**3**

LIP-Coimbra Mechanical workshop Activities

In the framework of "Programa Nacional de Reequipamento Científico", the LIP Mechanical Workshop was allocated funds for the acquisition of two large machine tools. The international call for tenders concerning the Turning Centre was launched in December (*DR, 3ª série, de 13 de Dezembro de 2005* and *JOUE 2005/S 234-230939*).

In order to profit of this opportunity to strengthen this infrastructure, we started actions in view of evaluating the performance of the Mechanical Workshop and re-defining its main goals. Contacts with ISQ (Instituto de Soldadura e Qualidade) permitted to profit from their expertise and, within their EC project CINCO, an assessment of the workshop took place. This efforts will go on in 2006, along with the finalisation of the contract for the Turning Centre and the whole process of acquisition of the "Machining Centre".

Funding:

Code	Funding	Start	End
REEQ/573/FIS/2005	441.000 €	2005-03-01	2006-12-31

Project Coordinator: João Carvalho

Team Members:

Name	Status	% of time in project
António Onofre	Researcher (LIP/UCPFF)	8
Armando Policarpo	Researcher (LIP/FCTUC)	17
Carlos Silva	Technician (LIP)	84
Fernando Moita Ribeiro	Technician (LIP)	84
Francisco Fraga	Researcher (LIP/FCTUC)	8
Isabel Lopes	Researcher (LIP/FCTUC)	8
João Carvalho	Researcher (LIP/FCTUC)	25
Joaquim Oliveira	Technician (LIP)	84
José Pinhão	Technician (LIP)	84
José Pinto Da Cunha	Researcher (LIP/FCTUC)	8
Margarida Fraga	Researcher (LIP/FCTUC)	17
Maria do Carmo Lopes	Researcher (IPO-Coimbra)	8
Paulo Fonte	Researcher (LIP/ISEC)	17
Paulo Mendes	Researcher (LIP/FCTUC)	8
Rui Alves	Technician (LIP)	84
Rui Marques	Researcher (LIP/FCTUC)	17
Vitaly Chepel	Researcher (LIP/FCTUC)	8

The next table summarises the activities of the workshop for different projects and institutions during 2005.

	Man-Power (%)	(HH)	Cost €	Charged Value €
ATLAS				
OUTREACH				
PET -	5,22	255	3.531	3.531
MAMOGRAPHY	3,79	185	2.657	2.657
MEDICAL	0,27	13	168	168
PHYSICS	1,78	87	1.154	1.154
LIP-Lisboa	***11,05***	***540***	***7.510***	***7.510***
I3HP	21,66	1.058	29.887	0
NMI3	7,23	353	9.962	0
RPC	1,58	77	1.095	1.095
GEMs and SCINTILLATION	2,33	114	1.609	1.609
LIQUID XENON	6,12	299	4.223	4.223
ESO – CAMCAO	33,51	1.637	22.030	22.030
LIP-Coimbra	***72,43***	***3.538***	***68.806***	***28.957***
Physics Department UC	***8,19***	***400***	***12.936***	0
Outside customers	***8,33***	***407***	***9.738***	***9.874***
TOTAL	***100,00***	**4.885**	**98.990**	**46.341**

PROGRESS REPORTS 2005

Accelerator physics:

Project Title: Collaboration in the ATLAS experiment at CERN

Resumo:

Ao longo do ano de 2005, o grupo Português envolvido no projecto, "design" e construção do detector ATLAS prosseguiu as suas actividades, centradas na construção e "commissioning" do sub-detector TILECAL e na simulação de canais de Física a estudar no LHC com o detector ATLAS. Foram instalados os cabos de fibras ópticas que vão conduzir a luz do laser (sistema de monitorização) até ao barril central do TILECAL, e também os painéis onde as fibras e os respectivos conectores ajustáveis vão ser ligadas. O cilindro de um dos barris laterais do calorímetro TILECAL foi montado na caverna de ATLAS. No Sistema de Controlo do detector (DCS) TILECAL fomos responsáveis pelo desenvolvimento do sistema de controlo das fontes de baixa tensão e pela maior parte das actividades de "commissioning" do sistema de controlo.

O grupo esteve envolvido na preparação dos testes de "commissioning" com raios cósmicos, tendo participado na tomada de dados dos primeiros acontecimentos de um sub-detector de ATLAS na caverna em Junho de 2005, tendo também participado na simulação e análise dos dados adquiridos. Continuou-se a analisar os resultados obtidos tanto no teste combinado dos sub-detctores de ATLAS como nos testes anteriores, especialmente os resultados obtidos com muões que são extremamente importantes para a preparação dos testes com raios cósmicos como para a calibração do detector e determinação da rendimento luminoso e uniformidade dos elementos activos do detector (cintiladores e fibras).

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. A nossa participação na simulação de Física aumentou significativamente. Centra-se no estudo das medições de massa e largura do bosão W e estudo de algumas propriedades do quark top e no teste e desenvolvimento de software. A precisão na medição da massa do bosão W é critica pois este valor é um dos parâmetros fundamentais do Modelo Padrão. Neste trabalho procura-se estimar a precisão com que tal será medido na experiência

ATLAS. O erro estatístico é inferior a 2 MeV e os erros sistemáticos já avaliados contribuem com menos de 20 MeV para o erro total. Sendo a massa do W cerca de 80.400 GeV, a precisão é de cerca de 0.025%, duas vezes melhor que o valor actual. Os decaimentos FCNC do quark top ($t \rightarrow q\ Z$, $q\ \gamma$, q glúão) produzidos individualmente ou aos pares, foram estudados em LHC 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 na presença de sinal, ou sob a forma de limites a 95% de nível de confiança na ausência de sinal.

O projecto inclui também uma componente de divulgação, que foi muito intensa ao longo de 2005, com vários dos membros deste projecto a participarem activamente no projecto "Crescere" – experiências remotas com muões cósmicos feitas via internet e destinadas principalmente aos alunos das escolas secundárias.

Funding:

Code	Funding	Start	End
POCTI/FP/FNU/50206/2003	180.000 €	2004-07-04	2005-09-30
POCI/FP/63422/2005	225.000 €	2005-06-01	2006-05-31

Team:

Project Coordinator: Amélia Maio

Team Members:

Name	Status	% of time in project
Agostinho Gomes	Researcher (LIP)	95
Amélia Maio	Researcher (LIP/FCUL)	50
André Wemans	Researcher (FCTUNL)	6
António Amorim	Researcher (LIP/FCUL)	5
António Onofre	Researcher (LIP/UCPFF)	50
Carlos Marques	Student (LIP/FCUL)	100
Carlos Silva	Technician (LIP)	19
Filipe Veloso	PhD student (LIP/FCT)	60
Helmut Wolters	Researcher (LIP/UCPFF)	4
João Carvalho	Researcher (LIP/FCTUC)	24
João Gentil	Student (LIP/FCUL) *	98
João Pina	PhD student (LIP/FCUL)	100
João Santos	Master student (LIP)	50
Jorge Correia Moita	Technician (LIP)	15
José Carlos Nogueira	Technician (LIP)	4
José Maneira	Researcher (LIP/FCT)	75
José Pinhão	Technician (LIP)	4
José Silva	PhD student (LIP/FCUL)	94
Luis Raposeiro	Technician (IST)	4
Manuel Maneira	Researcher (FCTUNL)	7
Maria Francisca Calheiros	Technician (LIP)	59
Nuno Castro	PhD student (LIP/FCT)	60
Pedro Jorge	Student (LIP)	8
Rui Alves	Technician (LIP)	7
Viriato Esteves	Researcher (FCUL)	19

Summary of the Activities:

During 2005 the activities related with the design and construction of the ATLAS detector proceeded, centred in the construction of the Tilecal calorimeter and in the simulation of some of the physics channels that will be studied in the LHC using the ATLAS detector.

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. The clear optical fibers for light transmission to the central barrel modules were cut to length, polished, labelled, and then connectors installed at their ends. The connectors patch panel was also produced and installed in the ATLAS electronics cavern.

Scintillating fibres for luminosity detector

Preliminary tests of aluminization of 0.5x0.5 mm^2 long squared SCF-3HF optical scintillating fibres were performed in Lisbon using the Magnetron Sputtering technique. The fibres have been polished in a milling machine with a diamond blade and aluminium coated at one end. The other end was polished at CERN. Two sets of 10 fibres have been used. One set was cut and polished at 90^o with the axis of the fibre.

The end of the other set has been cut at 45^{o}. For accidental reasons, neither the polishing machine neither the aluminization machine were optimised for this task. The reflectivity of the aluminium mirror has been measured in a dedicated test bench. Very preliminary results give a value of reflectivity of 51% for the fibres with a 90^{o} cut.

TILECAL Detector Control System (DCS)

The Tilecal Detector Control System (DCS) proceeded in direction of installation and commissioning of the detector. Software was prepared for the control and monitoring of the new finger low voltage power supplies (LVPS), both for LVPS testbenches and for the commissioning in the cavern. The production of the finger LVPS boxes started with substantial delay, and the auxiliary boards used for the respective control arrived only in November, due to many problems found by our colleagues of the design and hardware implementation team. Unfortunately, the units produced were unsafe and dangerous for themselves and for the electronics in the drawers. The problems were discovered only in December and January when installing and testing the finger LVPS in the calorimeter. A significative effort was dedicated to the understanding of the malfunction of the equipment.

Characterization of scintillators, WLS fibres and ageing

The light source used in the setup for WLS optical fibres characterization (fibrometer) is a scintillator excited by a ^{90}Sr radioactive source. Tests were performed to evaluate the possibility of replacement of this light source by a pulsed LED. A dedicated setup based on a pulse generator HP 8082A and a PMT Amperex 1962 was prepared. Using fast pulses (~6ns), several types of LEDs and neutral density filters, it was determined a region of linearity wide enough to study 2 m long WLS fibres. The attenuation lengths calculated using both light sources showed average differences below 10%. Further developments of the mechanical system that positions the light source are under way in order to achieve a better reproducibility of the positioning of the light source.

The Tilecal cells scintillator-WLS fibres light budget re-evaluation study is underway. It started with the characterization of 46 scintillating tiles from the production batches for the Tilecal calorimeter. Fifteen of these tiles with different sizes were selected for the measurements of the next phase of this study. Simultaneously we proceeded with the characterization of Wave Length Shifter optical fibers of Tilecal production batches for all the 28 fiber lengths used in the calorimeter. In Tilecal there are 100 different combinations of tile and fiber sizes.

Calibration with cosmic muons, combined test beam and data analysis

With the aim of increasing software and analysis activities at LIP-Lisboa, in 2005 a new task was started for the analysis of cosmic muons data and simulation. The first cosmic muon data-taking with an ATLAS subdetector in the cavern was carried out with the Tilecal in June 2005 and our group was involved in the data-taking and analysis. Preparatory steps for this started in November 2004, with the analysis of the 2004 combined test beam data, in which the uniformity of the TileCal response to muons in eta was checked. During early 2005, GEANT3 simulated cosmic muon data in ATLAS was processed with the most up-to-date energy reconstruction algorithms and analysed in order to obtain the rate/threshold dependencies. With these analysis tools in place, in June 2005, the first data was promptly analysed and compared with the Monte Carlo predictions. The agreement was good, within the limited MC

statistics. In September 2005, our group praticipated in further cosmics data-taking, that was however limited by the noise introduced by the finger low voltage power supplies. In addition, we participated in the reconstruction and validation of a new cosmic muon simulation, now with the GEANT4 package, containing the most up-to-date detector description model. As of yet, the poorer agreement of the GEANT4 simulation with the data and the previous GEANT3 simulation is unresolved.
We have participated in the ATLAS combined testbeam data taking that took place from May to November of 2004, mainly in the preparation of the setup, in the making of the Tilecal DCS setup and the respective maintenance, in the data taking itself and we have participated in the analysis of the muon data taken. The analysis of data from the previous calibration periods was also continued.
In terms of performance studies one of the subjects that we studied was the photostatistics of the Tilecal detector. The Npe level (>20pe/GeV) is crucial to guarantee a S/N separation, energy resolution that can cope with the expected ageing of the detector during 10 years of operation. A study was performed for the detector modules used in the calibration Test Beams at CERN from 2000 to 2003. In these studies were compared methods and the impact of the characteristics of the different optical components of the detector: Scintillating tiles, optical WLS fibers and quantum efficiency of photomultipliers. It was verified that the scintillating tiles light yield differences dominated over the dispersion of other optical characteristics either of the optical fibers (light yield) and the photomultipliers (quantum efficiency). Depending on the scintillating tile light yield the measured Npe was of 80 pe/Gev for the low light yield tiles and 100 pe/Gev for the high light yield tiles for the central barrel modules. The achieved results were in accordance with the measurements of characterization of scintillating tiles done in the laboratory.
These results will be part of a paper that the collaboration is preparing.

Precision measurements – W mass and width
In the W mass measurement, after the estimation of the statistical error of the order of 1.8 MeV, the systematics were studied. There was special focus on:
- the absolute scale of the lepton momentum, which contribution to the total uncertainty was found to be about 11 MeV,
- parton distribution functions studied with the CTEQ6 pdf distribution which provided an uncertainty of about 20 MeV, but this is expected to improve to the order of 10 MeV when LHC data becomes available.
- lepton resolution is expected to contribute with less than 5 MeV if the resolution is known to a precision of 15%.
- The Recoil model was studied by generating a sample of $Z \rightarrow ll$ events and adding one of the lepton momentum to the recoil. This Z sample will also be used to the calibration mentioned above and some backgrounds.
The results of the already evaluated contributions sum a total uncertainty of about 26 MeV (considering the 20 MeV for the pdfs) or around 18 with 10MeV for the pdfs.

Top quark physics
In the top quark physics, our work focus on 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. New right-handed couplings can be introduced within an effective lagrangian approach which can be probed at the LHC. The correct implementation in several MC generators (TOPREX, ALPGEN, MC@NLO, etc.) of the processes associated with the t-tbar production at the LHC, allowed to study the Forward-Backward asymmetry and its sensitivity to the new vector and tensor like (right and left handed) couplings. The close collaboration between experimentalists and theoreticians led to the introduction of two new asymmetries (the A+ and the A-) which have proven to be more sensitive to the new anomalous couplings. These studies were presented in several conferences and were published in ATLAS notes, and are waiting to be published in international scientific journals.
In terms of FCNC, the main goal is to study signals of physics beyond the Standard Model (SM) in top quark FCNC processes in LHC. The FCNC decays t->q gamma, t->q Z and t->q g were studied both in the double top and single top channels. 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 estimate the limits on the branching ratios for the different channels in the five sigma discovery and in the 95% confidence level limits. The results were presented in international conferences and workshops and were published as ATLAS notes. A publication in an international scientific journal is in preparation.

Publications:

International Conference Proceedings:

- *"The Atlas Tilecal Detector Control System",*
  Agostinho Gomes,
  Proceedings of the Eleventh International Conference on Calorimetry in Particle Physics, World Scientific, 2005.
- *"Status of the ATLAS Tile Calorimeter",*
  João Gentil Saraiva,
  Proceedings of the Eleventh International Conference on Calorimetry in Particle Physics, World Scientific, 2005.

National Conference Proceedings:

- *"A Robot for Fiber Insertion in a profile",*
  Carlos Cardeira, José Sá da Costa, Agostinho Gomes, Jorge Gouveia, Amélia Maio, José Pinhão,
  Robótica 2005 – Actas do Encontro Científico, Coimbra, 29 de Abril de 2005, pp. 95-103.

Internal Notes:

- *"Light yield Studies of the ATLAS Tile Calorimeter",*
  J. G. Saraiva, A. Gomes, A. Maio, S. Némécek,
  ATLAS Internal Note, ATL-COM-TILECAL-2005-010 *(submitted)*.
- *"A Robot for Fiber Insertion in a Profile",*
  C. Cardeira, J. Sa da Costa, A. Gomes, J. Gouveia, A. Maio and J. Pinhao,
  ATLAS Internal Note ATL-TILECAL-PUB-2005-007.
- *"Study of the ATLAS sensitivity to FCNC decays in single top events",*
  Carvalho, J; Castro, N; Onofre, A; Veloso, F,,
  ATL-PHYS-PUB-2005-026; ATL-COM-PHYS-2005-059 *(accepted)*.

- *"Study of the ATLAS sensitivity to angular asymmetries in top quark decays",* Aguilar-Saavedra, J A; Carvalho, J; Castro, N; Onofre,A;Veloso,F, ATL-COM-PHYS-2005-060 *(submitted)*.

Communications:

Oral presentations in international conferences:

- *"Study of ATLAS sensitivity to FCNC top decays",*
  presented by Filipe Veloso
  at ATLAS Physics Workshop in Roma.
- *"The Atlas Tile Calorimeter Road to Physics",*
  presented by Agostinho Gomes
  at HEP2005 International Europhysics Conference on High Energy Physics in Lisbon, Portugal.

Poster presentations in international conferences:

- *"Study of ATLAS sensitivity to FCNC decays in single top events",*
  presented by Filipe Veloso
  at The 2005 European School of High-Energy Physics in Kitzbühel, Áustria.
- *"Study of ATLAS sensitivity to FCNC top quark decays",*
  presented by Nuno Castro
  at The 2005 European School of High-Energy Physics in Kitzbuhel, Austria.

Presentations in national conferences:

- *"A EXPERIÊNCIA ATLAS",*
  presented by Agostinho Gomes
  at Física 2005 – Física para o século XXI in Porto, Portugal.

Oral presentations in collaboration meetings:

- *"Top asymmetries studies",*
  presented by António Onofre
  at ATLAS Physics Week in CERN, Geneve.

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)

Master Theses:

- *"Contribution to the TILECAL DCS and Performance",*
  João Pina, 2005-05-30
- *"Estudos de desempenho do calorimetro hadrónico TileCal para ATLAS",*
  João Gentil, 2005-12-12

- *"Systematic Uncertainties on the W mass measurement with the ATLAS Detector",*
  Carlos Marques, (on-going)

Project Statistics

	number
International Conference Proceedings	**2**
National Conference Proceedings	**1**
Internal Notes	**4**
Oral presentations in international conferences	**2**
Poster presentations in international conferences	**2**
Presentations in national conferences	**1**
Oral presentations in collaboration meetings	**1**
Master Theses	**2**

Project Title: Collaboration in the CMS experiment at CERN

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 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.

A actividade do LIP tem duas componentes principais:

1) o desenvolvimento de hardware e software para o trigger de calorimetria e para o sistema de leitura de dados do calorímetro electromagnético. O projecto é desenvolvido em colaboração com o INESC;

2) a pesquisa de dimensões suplementares em colisões protão-protão no LHC.

O trigger de calorimetria da experiência CMS/LHC no CERN é um sistema electrónico e computacional de elevado desempenho que processa em-linha os dados do detector provenientes de cerca de cem mil canais, para seleccionar electrões, fotões," taus" e eventos com energia perdida, assim como amostras de "jets". O sistema de trigger executa a primeira etapa do processo de selecção na pesquisa de novas reacções físicas.

O Calorímetro Electromagnético (ECAL) é um detector de electrões e fotões composto por oitenta mil cristais $PbWO_4$. A granularidade extremamente fina e a excelente resolução em energia tornam este instrumento particularmente bem adaptado para a medida de electrões e fotões no LHC. O sistema de leitura de dados é responsável pela recolha dos dados em 80000 canais.

Funding:

Code	Funding	Start	End
RTN2-2001-00571	166.320 €	2003-03-01	2006-09-30
POCTI/FNU/50131/03	170.000 €	2004-07-04	2005-09-30
POCI/FP/63434/2005	225.000 €	2005-08-01	2006-07-31

Team:

Project Coordinator: João Varela

Team Members:

Name	Status	% of time in project
Adarsh Jain	Master student (LIP)	100
Carlos Almeida	Researcher (INESC/IST)	20
Fernando Gonçalves	Researcher (IST/INESC)	15
Isabel Teixeira	Researcher (IST/INESC)	25
João Teixeira	Researcher (IST/INESC)	23
João Varela	Researcher (LIP/FCT)	50
Jorge Semião	Technician (INESC)	20
José Carlos Silva	Technician (LIP)	100
José Soares Augusto	Researcher (IST/INESC)	25
Malgorzata Kazana	Researcher (LIP)	100
Marcelino Santos	Researcher (INESC/IST)	20
Miguel Ferreira	Technician (LIP)	67
Nuno Almeida	PhD student (LIP/FCT)	100
Octávio Dias	Technician (INESC)	7
Paula Bordalo	Researcher (LIP)	8

Pedro Manuel Silva	PhD student (LIP)	25
Pedro Ribeiro	PhD student (LIP/FCT)	100
Reyes Alemany	Researcher (LIP)	100
Rui Ribeiro	Researcher (LIP)	7
Sérgio Ramos	Researcher (LIP)	8

Summary of the Activities:

In 2005 the construction and testing of hardware for the ECAL trigger and readout electronics system was pursued. The Portuguese group has important responsibilities in the project. In 2005 the group concluded the production of 1210 Synchronization and Link Boards (SLB) boards. The test of the full production was concluded in December at INESC, Lisbon. The pre-production of a series of 8 ECAL Data Concentrator Cards (DCC) was concluded successfully. The tender for the final production of 65 DCC 9U boards was published and the selection made in October. A first batch of 10 DCC's was already received. One hundred thousand 12-bit ADC chips in 0.25-micron rad-hard technology developed by the Portuguese company Chipidea under contract with LIP, were produced and integrated in the ECAL frontend boards.

In 2005 various DCC boards were operated in different ECAL detector integration and test stands (Supermodule Assembly Area, Electronics Integration Center, Test Beam H4 Area) performing the data readout of full ECAL Supermodules. One ECAL data acquisition crate was installed in the Magnet Test/Cosmic Challenge area (SX5) and tested successfully with the central CMS event builder DAQ system, preparing for the first CMS global operation. An integration test of the ECAL and HCAL trigger systems equipped with the SLB boards transmitting synchronized data to the Calorimeter Regional Trigger system was successfully accomplished at the CMS Electronics Integration Center.

The online-software activities are becoming increasingly more relevant. A member of the LIP group assumed in 2005 the coordination of the ECAL Data Acquisition Software and the group is developing large parts of the online software.

Physics analyses were pursued vigorously. The four lepton channel predicted by universal extra-dimension models was analyzed in full detail. This work will be part of the Physics TRD VolII in preparation.

Our schedule was seriously delayed (about 10 months) relative to the planning, resulting from the lack of human resources in previous years. The somewhat better conditions allowed in the last half year need to be maintained and if possible improved to allow the full commissioning of the ECAL data acquisition before LHC starts.

A member of the group continues to serve as CMS Trigger and Detector Controls Coordinator.

Publications:

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

- *"Conceptual Design of the CMS Trigger Supervisor",*
  Ildefons Magrans de Abril, Claudia-Elisabeth Wulz, and João Varela,
  IEEE TRANSACTIONS OF NUCLEAR SCIENCE, VOL. 1, NO. 11, NOVEMBER 2005.
- *"Results of the first performance tests of the CMS electromagnetic calorimeter",*
  The CMS Electromagnetic Calorimeter Group,
  Eur Phys J C 44, s02, 1–10 (2006).

International Conference Proceedings:

- *"Calorimeter Trigger Synchronization in CMS, Implementation and Test System",*
  N. Almeida, J.C. Da Silva, R. Alemany, J. Varela, LIP, Lisbon, Portugal, 10th LECC 2004 Workshop, Boston, USA, September, 2004, CMS CR-2004/068.
- *"The Data Acquisition System of the CMS ECAL Test Beam of 2004",*
  R. Alemany-Fernández on behalf of the CMS Collaboration,
  IEEE Medical Imaging Conference, Puerto Rico, USA, October 2005.
- *"Design of a Data Concentrator Card for the Compact Muon Solenoid Electromagnetic Calorimeter Readout",*
  J.C.da Silva, A. Jain, R.Alemany, N.Almeida, N.Cardoso, M.Husejko and J.Varela,
  DCIS'05 XX Conference on Design of Circuits and Integrated Systems.
- *"The CMS trigger system",*
  J. Varela,
  EPS (July 21st-27th 2005) in Lisboa, Portugal, PoS (HEP2005) 392 *(accepted)*.

Collaboration notes with internal referee:

- *"Concept of the CMS Trigger Supervisor",*
  I. Magrans de Abril, C.-E. Wulz Institute for High Energy Physics of the Austrian Academy of Sciences, Vienna, Austria/ Joao Varela LIP - Lab. de Instrumentacao e Fisica Exp. de Particulas, Lisboa, Portugal, also with CERN, CMS NOTE-2005/011.
- *"Electromagnetic Calorimeter Raw Data Format",*
  N. Almeida, R. Alemany, A. Jain, J.C. da Silva and J. Varela LIP Lisbon, Portugal/ M. Bercher, P. Busson, M. Cerutti, Y. Geerebaert, P. Paganini LLR, CNRS/IN2P3 Paliseau, France/ M. Dejardin, J.L. Faure, P. Gras, I. Mandja, CMS NOTE-2005/021.

Internal Notes:

- *"Description of the Synchronization and Link Board. ECAL and HCAL Interface to the Regional Calorimeter Trigger",*
  N. Almeida, J. C. Silva, J. Varela, LIP, Lisbon, Portugal,
  CMS IN-2005/007.
- *"Integration of Run Control and Detector Control Systems",*
  J. Varela, LIP, Lisbon, Portugal, CMS Trigger, DAQ Group,
  CMS IN-2005/015.
- *"Search for Universal Extra Dimensions Signals in the 4 Leptons + pTmiss Final State",*
  R. Alemany, P.Q. Ribeiro, J. Varela, LIP, Lisbon, Portugal,
  CMS IN-2005/019.

- *"DataBase Requirements for the CMS ECAL",*
  Rick Egeland, University of Minnesota, USA/ Francesca Cavallari, Giovanni Organtini, Shahram Rahatlou, Univ. Roma and INFN Roma, Italy/ Reyes Alemany, LIP, Portugal/ G. Dissertori, ETH Zurich, Switzerland/ P. Busson, LLR,,
  CMS IN-2005/029.

Communications:

Oral presentations in international conferences:

- *"The CMS trigger system",*
  presented by João Varela
  at EPS 2005 in Lisboa, Portugal.
- *"The Data Acquisition System of the CMS ECAL Test Beam of 2004",*
  presented by Reyes Alemany
  at IEEE Nuclear Science Symposium in Puerto Rico, USA.
- *"Design of a Data Concentrator Card for CMS ECAL",*
  presented by José Carlos Silva
  at DCIS'05 - XX Conference on Design of Circuits and Integrated Systems in Lisbon.

Oral presentations in collaboration meetings:

- *"Status of UED analysis (4 leptons final state)",*
  presented by Malgorzata Kazana
  at CMS SUSY/BSM meeting in CERN.
- *"ECAL DAQ-DCS status and plans",*
  presented by Reyes Alemany
  at CMS ECAL/Central DAQ Meeting in CERN.
- *"Experience with JCOP DCS Tools",*
  presented by João Varela
  at Joint Controls Project Coordination Board in CERN.
- *"Measurments of the PEM Detector Modules",*
  presented by Catarina Ortigão
  at Crystal Clear Collaboration Meeting in CERN.
- *"ECAL Configuration DB",*
  presented by Reyes Alemany
  at CMS ECAL DDH Meeting in CERN.
- *"ECAL Readout Architecture for 867, H4, Magnet Test and Final System",*
  presented by Reyes Alemany
  at ECAL TCG Meeting in CERN.
- *"ECAL Data Acquisition Software with XDAQ3",*
  presented by Reyes Alemany
  at CMS OLSWG Meeting in CERN.
- *"Status of the CMS SLB project (Mar05)",*
  presented by José Carlos Silva
  at CMS Trigger Meeting in CERN.
- *"ECAL Configuration DB",*
  presented by Reyes Alemany
  at CMS Database Working Group Meeting in CERN.

- *"Trigger Software and DCS",*
  presented by João Varela
  at CMS Week DAQ General Meeting in CERN.
- *"ECAL Configuration database",*
  presented by Reyes Alemany
  at CMS Off-Detector Electronics Workshop in Lisbon.
- *"ECAL Trigger and Readout Software architecture and integration",*
  presented by Reyes Alemany
  at CMS Off-Detector Electronics Workshop in Lisbon.
- *"SLB and DCC commissioning for 904",*
  presented by José Carlos Silva
  at CMS ECAL Off Detector Workshop in Lisbon.
- *"TTC system and test synchronization",*
  presented by João Varela
  at CMS ECAL Off-Detector Electronics Workshop in CERN.
- *"Update of the ECAL DAQ-DCS status and plans",*
  presented by Reyes Alemany
  at CMS ECAL/Central DAQ Meeting in CERN.
- *"ECAL Local TriDAS",*
  presented by Reyes Alemany
  at CMS Run workshop in CERN.
- *"Status of the SLB project (May05)",*
  presented by José Carlos Silva
  at CMS Trigger Meeting in CERN.
- *"ECAL Configuration BD",*
  presented by Reyes Alemany
  at CMS Electronics Week, Trigger SW in CERN.
- *"ECAL Current Integration Plans for 904",*
  presented by Reyes Alemany
  at CMS Electronics Week in .
- *"ECAL Off-detector electronics, DAQ and Commissioning",*
  presented by Reyes Alemany
  at CMS ECAL Annual Review in CERN.
- *"Overview of the Trigger Software (2005)",*
  presented by João Varela
  at CMS Annual Review in CERN.
- *"Status of the SLB project (Aug05)",*
  presented by José Carlos Silva
  at CMS Trigger Meeting in CERN.
- *"Laser data DAQ",*
  presented by Reyes Alemany
  at CMS Workshop on Laser Calibration in CERN.
- *"Run Issues, Trigger and Detectors",*
  presented by João Varela
  at CMS Run Definition Meeting in CERN.
- *"Status of the SLB project (Sep05)",*
  presented by José Carlos Silva
  at CMS Trigger Meeting in CERN.

- *"Trigger Software and Integration Issues",*
  presented by João Varela
  at CMS Trigger Meeting in CERN.
- *"UED in 4-leptons Update",*
  presented by Malgorzata Kazana
  at CMS SUSY-BSM Meeting in CERN.
- *"Status of the SLB project (Oct05)",*
  presented by José Carlos Silva
  at CMS Trigger Meeting in CERN.
- *"Trigger Software Summary",*
  presented by João Varela
  at CMS Trigger Meeting in CERN.
- *"Status of the ECAL TriDAS at the magnet test and final system",*
  presented by Reyes Alemany
  at CMS ECAL OD Electronics meeting in CERN.
- *"DCC Status (Nov05)",*
  presented by José Carlos Silva
  at CMS ECAL Off-Detector meeting in CERN.
- *"ECAL Software Review: Control, Operation and Readout",*
  presented by Reyes Alemany
  at CMS ECAL Software Review in CERN.
- *"DCS integration and Magnet Test",*
  presented by João Varela
  at CMS Week DAQ Meeting in CERN.
- *"Status of the SLB project (Dec05)",*
  presented by José Carlos Silva
  at CMS Week, Trigger meeting in CERN.
- *"DCC Project Status (Dec05)",*
  presented by José Carlos Silva
  at CMS Week, ECAL electronics meeting in CERN.
- *"UED Analysis Update",*
  presented by Malgorzata Kazana
  at CMS SUSY-BSM Meeting in CERN.

Academic Training:

PhD Theses:

- *"Data Acquisition and Filtering in the Electromagnetic Calorimeter of the CMS Experiment",*
  Nuno Almeida, 2005-04-30
- *"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)

Events:

- *"ECAL OFF-Detector Electronics Workshop",*
  Collaboration Meeting, LIP, Lisboa, 2005-04-07

Project Statistics

	number
Articles in international journals (with indirect contribution from LIP members)	**2**
International Conference Proceedings	**4**
Collaboration notes with internal referee	**2**
Internal Notes	**4**
Oral presentations in international conferences	**3**
Oral presentations in collaboration meetings	**36**
PhD Theses	**1**
Collaboration Meetings	**1**

Project Title: Collaboration in the COMPASS experiment at CERN

Resumo:

Os primeiros estudos sobre a difusão inelástica profunda polarizada foram realizados em SLAC no início da década de 80. As experiências, realizadas a baixa energia e possuindo um domínio cinemático relativamente restrito, confirmaram na altura as regras de soma de Bjorken e de Ellis-Jaffe. Mais tarde, com o advento de feixes polarizados de energies muito mais elevadas (i.e., uma ordem de grandeza superiores), a experiência EMC do CERN/SPS, concebida com um domínio cinemático muito mais lato, descobriu uma clara violação da regra de soma de Ellis-Jaffe. Tal significa, no quadro do modelo dos quarks-partões, que a contribuição total dos spins dos quarks para o spin do protão é pequena. Neste contexto, foi proposta mais tarde no CERN uma experiência sua sucessora, SMC, com o objectivo de medir novamente a difusão inelástica profunda polarizada usando um alvo de protões polarizados, bem como de realizar uma primeira medida usando um alvo de deuterões polarizados. Os seus resultados, combinados com os de EMC, permitiram concluir que tanto a função de estrutura do protão como a do neutrão estão de acordo com a regra de soma de Bjorken e implicam a violação da de Ellis-Jaffe. Apesar de em SMC já haver um procedimento de selecção de sabor do quark que absorve o fotão virtual, compreendeu-se que seria necessária a reconstrução total do jet desse quark, nomeadamente para a medida de $\Delta G/G$ através do processo de fusão $fotão - gluão \rightarrow ccbar$.

Tal implica, de facto, a medida da assimetria de charme aberto, para a qual é necessária a identificação completa dos produtos da reacção. Outros assuntos, exigindo também medidas semi-inclusivas de difusão inelástica profunda, começaram entretanto a despertar grande interesse na comunidade, nomeadamente a transversidade.

Neste contexto, decorre no CERN a experiência COMPASS, cujo objectivo é duplo: o estudo da estrutura de spin do nucleão, nomeadamente a polarização do gluão e a decomposição das distribuições de helicidade dos quarks; o estudo de temas específicos de espectroscopia hadrónica, como sejam a polarizabilidade de partículas instáveis usando a reacçãoo de Primakov, a procura de estados exóticos e híbridos, e a física do charme (nomeadamente a pesquisa de bariões charmosos duplos). Neste sentido, COMPASS usa feixes de muões (de hadrões) de alta intensidade interagindo com um alvo polarizado (alvo de 'microstrips' de silício) ao qual se seguem dois magnetes que, em conjugação, permitem obter uma grande aceitância geométrica. Estes são intercalados por conjuntos de detectores de posição (micromegas e GEMS, que suportam alto fluxo; MWPCs, cãmaras de deriva planares e de tubos capilares) e de hodoscópios de cintilação, por um RICH e dois conjuntos de calorímetros electromagnético e hadrónico (alguns dos quais ainda não construídos).O sistema de aquisição de dados baseia-se na leitura em paralelo da electrónica de 'frontend' e num sistema distribu´ıdo de 'event-builders'.

Na experiência COMPASS, o grupo do LIP-Lisboa tem a responsabilidade total do sistema de controlo dos detectores (DCS).

Funding:

Code	Funding	Start	End
010.6/B009/2005	252.000 €	2004-01-01	2006-12-31
POCTI/FNU/50192/2003	110.000 €	2004-07-04	2005-09-30
POCI/FP/63431/2005	120.000 €	2005-05-01	2006-04-30

Team:

Project Coordinator: Paula Bordalo

Team Members:

Name	Status	% of time in project
Catarina Quintans	Researcher (LIP/FCT)	90
Celso Franco	Student (LIP)	100
David Sora	Master student (LIP)	100
Francisco Pedro Mota	Student (LIP/CERN)	100
Helena Moreira	Undergraduate student (LIP)	33
Helena Santos	Researcher (LIP/FCT)	90
Luis Silva	Student (LIP)	100
Paula Bordalo	Researcher (LIP)	82
Sérgio Pino	Student (LIP)	8
Sérgio Ramos	Researcher (LIP)	82

Summary:

The first studies concerning polarized deep inelastic scattering were done at SLAC around 1980. These experiments, working at low energy and dealing with a somewhat restrict kinematical domain, have confirmed the Bjorken and Ellis-Jaffe sum rules. Later, with the disponibility of high energy polarized beams (typically, one order of magnitude higher), the CERN/SPS EMC experiment, conceived with an enlarged kinematical domain, established a clear violation of the Ellis-Jaffe sum rule. This means that, in the framework of the quark-parton model, the total quark spins contribution to the proton spin is small.
In this context, a new CERN experiment, SMC, was proposed, with the aim of measuring the polarized deep inelastic scattering using polarized hydrogen and deuterium targets. Its results, when combined with those coming from EMC, allowed to conclude that both the proton and the neutron structure functions are in agreement with the Bjorken sum rule, but imply the violation of the Ellis-Jaffe's one.
Although a flavour tagging procedure of the struck quark already existed in SMC, in was soon realized that the full quark jet reconstruction was necessary in order to measure _G through the fusion process photon − gluon ! c¯c. This implies, indeed, the open charm assymmetry measurement, to which the complete identification of the reaction products is necessary.
Meanwhile, other subjects, also needing semi-inclusive deep inelastic scattering measurements, have began deeply interesting the international community, such as transversity.
In this context, the COMPASS experiment was approved at CERN. Its aims are twofold:
the study of nucleon spin structure, namely the gluon polarization and the decomposition of the quarks helicity distributions; the study of specific subjects of hadronic spectroscopy: the polarizability of instable particles through the Primakov reaction, the search of exotic and hybrid states and charm physics (namely double charmed bayons). In this framework, COMPASS uses high intensity muon (hadron) beams impinging on a polarized target (silicon microstrips target) by a double spectrometer allowing to achieve a very good acceptance. The two main magnets are sorrounded by sets of position detectors (MicroMegas and GEMs, which stand high rates; MWPCs, planar and straw drift chambers) and of scintilating hodoscopes, by two RICHs and two sets of electromagnetic and hadronic calorimeters (some of them not yet built). The data acquisition system is based in a parallel read-out of the front-

end electronics plus a distributed set of event-builders. The LIP-Lisbon commitment in COMPASS is the full responsibility of the Detector Control System (DCS).

Summary of the Activities:

Our LIP-Lisbon group has been accepted by the COMPASS Leader Board to become a member and is thus participating in COMPASS activities at CERN since September 2002. COMPASS Leader Board has also attributed to LIP members the full responsibility of the Detector Control System (DCS) of the experiment, which was very slow and not reliable.
During 2005, 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.

Detector Control System
In 2005, profiting from the shutdown, we have evolved PVSS II to its newly supported version 3.0, together with the suitable Frameworks versions. This software update imposed major modifications in the objects structure, as the new versions are not compatible with the previous ones.
As the COMPASS spectrometer is being completed with additional detectors, they have been included in the new DCS sheme (photon detectors for RICH, additional chambers for W45, new SciFi detectors, etc.). The DCS has also proceeded with the integration of some already existing standalone detectors, as the LV systems for the RICH and Straw chambers.
In fact, here is a vast variety of equipments that are or will be controlled or monitored by the COMPASS DCS. While for some commercial supervision solutions exist (like OPC servers), for others these solutions do not. So, case-by-case solutions have been applied, namely by writing the drivers to control/monitor such devices, and integrate them in PVSS, whenever necessary.
In what concerns ELMBs, due to their stability problem, we have changed all old version motherboards and cards of the two existing lines and replaced them by the new version ones, as well as installed a third new version ELMB line to control the new detectors. One should stress that the DCS system works practically 12 months per year (apart from short shutdown periods), as during no-beam period still part of the systems run, thus requiring control, as is the case of detectors gas systems. This may be an advantage to test some software improvement, apart from scalability isues, but is also a problem, preventing the system to run in standalone mode (as everytime a sub-system is controlling some detector).

Offline and Data Analysis
Extensive studies relative to the quality of the reconstructed events have been made in view of obtaining a good reconstruction efficiency for the low momentum tracks. This is a problem for very complicated channels, e.g., with multiple vertices. This study is based on a cellular automaton algorithm, a kind of neuronal reconstruction approach. Deep inelastic scattering semi-inclusive asymmetries analyses concerning all 2002, 2003 and 2004 statistics have been initiated.
Geometrical studies concerning the description of photon trajectories in the new photon detection system of the RICH detector, using the simulation/reconstruction COMPASS packages, were performed. The new photon detectors — multi-anode photomultipliers, are to be installed in the 2006 data taking period.

Publications:

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

- *"Search for the Phi(1860) pentaquark at COMPASS",*
  COMPASS Collaboration (P. Bordalo, C. Quintans, S. Ramos, M. Varanda et al.),
  Eur Phys J C41 (2005) 469.

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

- *"Measurement of the spin structure of the deuteron in the DIS region",*
  COMPASS Collaboration (P. Bordalo, C. Quintans, S. Ramos, M. Varanda et al.),
  Phys Lett B612 (2005) 154.

International Conference Proceedings:

- *"Recent gluon polarization results from COMPASS",*
  COMPASS Collabration (C. Quintans et al.),
  (accepted).
- *"Design and Status of COMPASS FAST-RICH",*
  A. Ferrero, P. Bordalo, L. Silva et al.,
  Beaune05 Proceedings : 4th International Conference on New Developments in Photodetection *(accepted)*.

Internal Notes:

- *"CAEN OPC Performance Tests",*
  David Sora,
  .

Communications:

Oral presentations in international conferences:

- *"Recent gluon polarization results from COMPASS",*
  presented by Catarina Quintans
  at QCD05 in Montpellier, France, July 2005.

Presentations in national conferences:

- *"Ξ^{--} pentaquark search in the COMPASS experiment",*
  presented by Sérgio Ramos
  at IV Encontro Nacional de Física Hadrónica in Coimbra, Portugal.

- *"New physics results from the COMPASS experiment",*
  presented by Catarina Quintans
  at IV Encontro Nacional de Física Hadrónica in Coimbra, Portugal.

Oral presentations in collaboration meetings:

- Catarina Quintans, Several technical presentations to the Collaboration meetings reporting the DCS implementations.
- Helena Santos, Several physics presentations to the Analysis meetings.

Academic Training:

PhD Theses:

- *"COMPASS - Experimental Particle Physics Thesis",*
  Celso Franco, (on-going)
- *"COMPASS - Experimental Particle Physics Thesis",*
  Luis Silva, (on-going)

Master Theses:

- *"COMPASS - Software Engineering Master Thesis",*
  David Sora, (on-going)

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**1**
Articles in international journals (with indirect contribution from LIP members)	**1**
International Conference Proceedings	**2**
Internal Notes	**1**
Oral presentations in international conferences	**1**
Presentations in national conferences	**2**

Project Title: Collaboration in the HADES experiment at GSI

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.

Funding:

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

Team:

Project Coordinator: Paulo Fonte
Team Members:

Name	Status
Alberto Blanco	Technician(LIP)
Alessio Mangiarotti	Researcher (LIP)
Carlos Capela	Researcher (ESTGL)
Carlos Neves	Researcher (ESTGL)
Carlos Sousa	Researcher (ESTGL)
Luís Lopes	Technician(LIP)
Milena Vieira	Researcher (ESTGL)
Paulo Fonte	Researcher (LIP/ISEC)

Summary of the Activities:

This Project was spawned from previous activities of the "RPCs" project and has just received a substantial financing from GSI and the EU. The production will amount to around 1200 individual detectors, to be installed on 6 gas enclosures (sextants) of approximately 1 m^2 area.
The new LIP investigator Alessio Mangiarotti, with considerable experience in the field of heavy ion physics, will allow us to enter also into the physics-related activities, in perfect complement to the detector activities.

Communications:

Oral presentations in international conferences:

- *"HADES experiment: Di-lepton spectroscopy in p+p (2.2 GeV) and C+C (1 and 2 A GeV) collisions",* presented by P. Fonte
  at XXIX Mazurian Lakes Conference on Physics in August 30–September 6, 2005, Piaski, Poland.

Project Statistics

	number
Oral presentations in international conferences	**1**

Project Title: LHC Physics

Resumo:

Por forma a cobrir o campo de física aberto pelo programa do Large Hadron Collider (LHC) que se encontra em fase de instalação no Centro Europeu de Pesquisa Nuclear (CERN) em Genebra, é fundamental um importante esforço conjunto de preparação da comunidade experimental e teórica de Física de Partículas Elementares. Este esforço deve ser concentrado não apenas no estudo dos melhores observáveis físicos disponíveis no LHC, para 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. O principal objectivo desta tarefa é estudar sinais de Física para além do SM em processos associados à 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.

Outra tarefa desenvolvida no âmbito deste projecto, envolveu o estudo de assimetrias 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. A implementação correcta dos processos associados à produção dupla de quarks top em LHC nos vários geradores (TOPREX, ALPGEN, MC@NLO, etc.), permitiu efectuar um estudo comparativo destas assimetrias e da sua dependência com novos acoplamentos anómalos vectoriais e tensoriais.

No âmbito do presente projecto foi também iniciado o estudo dos acoplamentos eletrofracos do quark top. Esta pesquisa que incidirá, numa primeira fase, no estudo da produção dupla de quarks top acompanhados de um fotão energético, permitirá realizar posteriormente outras medidas como são os factores de forma associados ao quark top ou ainda a determinação da sua carga. Foi ainda realizado em Coimbra (entre os dias 12 e 15 de Janeiro de 2006) o primeiro workshop internacional sobre a física do quark top (International Workshop on Top Quark Physics, TOP2006) que contou com a participação de cerca de 80 físicos experimentais e teóricos de todo o Mundo.

Funding:

Code	Funding	Start	End
POCI/FP/63420/2005	36.000 €	2005-06-01	2006-05-31

Team:

Project Coordinator: António Onofre

Team Members:

Name	Status	% of time in project
Amélia Maio	Researcher (LIP/FCUL)	3
António Onofre	Researcher (LIP/UCPFF)	18
Augusto Barroso	Researcher (FCUL)	3
Filipe Veloso	PhD student (LIP/FCT)	18
João Bastos	Researcher (LIP)	41

João Carvalho	Researcher (LIP/FCTUC)	23
João Silva	Technician (LIP)	6
Nuno Castro	PhD student (LIP/FCT)	18
Orlando Oliveira	Researcher (LIP/FCTUC)	3
Pedro Martins Ferreira	Researcher (LIP/FCUL)	3
Renato Guedes Júnior	Researcher (LIP/FCUL)	3
Rui Santos	Researcher (LIP/FCUL)	3

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 sumarized in what follows.

1.Single Top via FCNC
The main goal of this task is to study signals of physics beyond the SM in 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 under way.

2. Forward-Backward 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: the correct implementation in several MC generators (TOPREX, ALPGEN, MC@NLO, etc.) of the processes associated to the t-tbar production at the LHC, allowed to study the Forward-Backward asymmetry and its sensitivity to the new vector and tensor like (right and left handed) couplings.

3. Study of Electroweak Top Quark Couplings
The study of the electroweak couplings of the top quark started with the pp->tt gamma process which seems to be more promising at the moment. This study will also 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 at its initial phase and has started with the study of the t-tbar production cross-sections (with and without energetic photons) at the LHC.

Publications:

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

- *"Flavour changing strong interaction effects on top quark physics at the LHC",*
  P. M. Ferreira, O. Oliveira and R. Santos,
  Phys.Rev.D72 (2005) 075010;hep-ph/0507128 *(accepted)*.
- *"CHARGE BREAKING BOUNDS IN THE ZEE MODEL",*
  A. Barroso and P.M. Ferreira,
  Phys.Rev.D72 (2005) 075010 *(accepted)*.
- *"CHARGE AND CP SYMMETRY BREAKING IN TWO HIGGS DOUBLET MODELS",*
  A. Barroso, P.M. Ferreira and R. Santos,
  Phys.Lett.B632 (2006) 684-687; hep-ph/0507224 *(accepted)*.

Internal Notes:

- *"Study of the ATLAS sensitivity to FCNC decays in single top events",*
  Carvalho, J; Castro, N; Onofre, A; Veloso, F,,
  ATL-PHYS-PUB-2005-026; ATL-COM-PHYS-2005-059 *(accepted)*.
- *"Study of ATLAS sensitivity to FCNC top decays",*
  Carvalho J.; Castro N.; Onofre A.; Veloso, F.,
  ATL-PHYS-PUB-2005-009; ATL-COM-PHYS-2005-023.
- *"Study of the ATLAS sensitivity to angular asymmetries in top quark decays",*
  Aguilar-Saavedra, J A; Carvalho, J; Castro, N; Onofre,A;Veloso,F,
  ATL-COM-PHYS-2005-060 *(submitted)*.

Communications:

Oral presentations in international conferences:

- *"Study of top anomalous couplings and FCNC with the ATLAS detector",*
  presented by Nuno Castro
  at Flavour in the era of the LHC in CERN, Geneve.
- *"SOME REMARKS ON TREE-LEVEL VACUUM STABILITY IN TWO HIGGS DOUBLET MODELS",*
  presented by Rui Santos
  at International Conference on High Energy and Mathematical Physics in Marrakech, Morocco.
- *"TREE-LEVEL VACUUM STABILITY IN MULTI HIGGS MODELS",*
  presented by Pedro Martins Ferreira
  at EPS International Europhysics Conference on High Energy Physics in Lisboa, Portugal.
- *"Study of ATLAS sensitivity to FCNC top decays",*
  presented by Filipe Veloso
  at ATLAS Physics Workshop in Roma.

Poster presentations in international conferences:

- *"Study of ATLAS sensitivity to FCNC decays in single top events",*
  presented by Filipe Veloso
  at The 2005 European School of High-Energy Physics in Kitzbühel, Áustria.

- *"Study of ATLAS sensitivity to FCNC top quark decays",*
  presented by Nuno Castro
  at The 2005 European School of High-Energy Physics in Kitzbühel, Áustria.

Presentations in national conferences:

- *"Física do quark top na experiência ATLAS",*
  presented by João Carvalho
  at Física 2005 - Física para o séc. XXI - Porto in Porto, Portugal.

Oral presentations in collaboration meetings:

- *"CERN- Search for FCNC top quark decays",*
  presented by Nuno Castro
  at in CERN.
- *"CERN- Study of FB Asymmetries in top decays",*
  presented by João Carvalho
  at in CERN.
- *"CERN- Study of the sensitivity to the Forward-Backward Asymmetry in top decays",*
  presented by João Carvalho
  at in CERN.
- *"CERN- Study of the sensitivity of ATLAS to single top FCNC decays",*
  presented by Filipe Veloso
  at in CERN.
- *"CERN-Asymmetries in quark top decays",*
  presented by António Onofre
  at in CERN.
- *"CERN-Study of the Atlas sensitivity to angular asymmetries in top quark",*
  presented by António Onofre
  at in CERN.
- *"CERN-Study of ATLAS sensitivity to FCNC top decays",*
  presented by Nuno Castro
  at in CERN.
- *"Top asymmetries studies",*
  presented by António Onofre
  at ATLAS Physics Week in CERN, Geneve.

Seminars:

- *"IST-O quark top em ATLAS",*
  presented by António Onofre
  at in IST.

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**3**
Internal Notes	**3**
Oral presentations in international conferences	**4**
Poster presentations in international conferences	**2**
Presentations in national conferences	**1**
Oral presentations in collaboration meetings	**8**
Seminars	**1**

Project Title: Collaboration in the HERA-B experiment at DESY

Resumo:

O grupo português entrou oficialmente na experiência HERA-B, em DESY, em Outubro de 1997. Nos últimos meses de 2002 e no início de 2003 HERA-B foi adquirida uma amostra, final, de dados de qualidade com uma elevada estatística. Após o esforço inicial na construção operação do detector, e da aquisição de dados, o esforço concentrou-se nas três tarefas atribuídas ao grupo português. O detector de reconstrução de anéis de efeito Cherenkov funcionou como requerido, e os dados adquiridos mostram que é fundamental para a identificação de partículas, em particular a separação de protões de mesões K e pi. Na experiência toda a reconstrução, incluindo a calibração e o alinhamento, fazem um uso extensivo de sistemas de base de dados, tanto online como offline, os quais são da responsabilidade do grupo português. Na parte final a tarefa do grupo centra-se na manutenção e melhoramento do sistema. Finalmente o run de 2002-3 forneceu uma amostra de dados que permitiu melhorar as medidas anteriores e realizar estudos de fisica em áreas diferentes. O grupo português esteve envolvido na medida da secção-eficaz b-anti-b, na determinação da luminosidade dos dados adquiridos e na implementação de um novo paradigma de análise de dados recorrendo à tecnologia de base de dados.

O financiamento do projecto terminou em Julho de 2005 mas o trabalho continuou de forma a escrever, submeter e publicar os últimos artigos e teses. Vários estudantes estiveram envolvidos neste trabalho, tendo um doutoramento e dois mestrados sido terminados em 2005.

Funding:

Code	Funding	Start	End
POCTI/FP/FNU/50196/2003	15.000 €	2004-07-04	2005-07-03

Team:

Project Coordinator: João Carvalho

Team Members:

Name	Status	% of time in project
António Amorim	Researcher (LIP/FCUL)	5
Armando Policarpo	Researcher (LIP/FCTUC)	3
Helmut Wolters	Researcher (LIP/UCPFF)	10
João Bastos	Researcher (LIP)	3
João Batista	Master student (LIP)	38
João Carvalho	Researcher (LIP/FCTUC)	20
Luis Silva	Student (LIP)	50
Matilde Castanheira	Undergraduate student (LIP)	35
Rui Matos	Student (LIP)	50
Vasco Amaral	Researcher (LIP)	50

Summary of the Activities:

The Portuguese group joined officially the HERA-B experiment, in DESY, in October 1997. In the last months of the year 2002 and beginning of 2003 HERA-B acquired a large, and final, sample of high quality data. After the initial effort in the detector setup, commissioning and data acquisition, the work was concentrated in the three tasks attributed to the Portuguese group.

RICH detector

The RICH detector was dedicated to the identification of particles by the measurement of the Cherenkov angle, which has a simple relation with the particle velocity. This velocity, together with the particle momentum measured by the tracking detectors, allows the particle mass to be estimated, and then to identify it. The main objective was the separation of protons and K and pi mesons. The Cherenkov photons were detected in a finely segmented photomultiplier array, after reflection in a spherical and a planar mirror.

The RICH detector showed a very good performance, achieving its design goals with high reliability, during data taking. The acquired data shows that the information from the RICH is fundamental for particle identification.

Database system

In the experiment all the reconstruction, including calibration and alignment procedures, run online and offline, making extensive usage of the database systems. Five dedicated database server machines support the HERA-B environment. It was within the group tasks to maintain and upgrade this infrastructure as part of its main responsibilities towards the database system.

The work continued in different tasks in the database offline system, as:

+ users support
+ database system monitoring, maintenance and upgrade
+ releases of new alignment constants (keytables)

The database system worked as expected, in a reliable and efficient way.

Data simulation and analysis

The 2002-3 long run provided a large sample of high quality data, which allowed to improve previous measurements, and to perform physics studies in different areas.

The HERA-B acquired and simulated data samples were processed, and the resulting ntuples were transferred and analyzed locally. The Portuguese group was involved in the following data analysis tasks:

+ the determination of the b-anti-b production cross-section at the HERA-B center of mass energy through the selection of semileptonic decays of the B mesons. The double semileptonic decays are selected and the number of events found is normalized to the number of direct J/Psi decays (with origin in the primary beam-target interaction), with known production cross-section, estimating the relative efficiencies from the Monte Carlo simulated data samples.
+ the determination of the acquired data luminosity using different methods, with information from independent sets of sub-detectors, searching for the variables with best linear behaviour with the number of simultaneous interactions, and estimating the efficiency and systematic errors associated with the different detector and reconstruction quantities. The luminosity of the acquired data was estimated counting the number of inelastic events in the HERA-B detector in the minimum bias data sample.
+ implementation and test of a new paradigm of data analysis, with the use of databasing technology and data query languages, which can be used in future particle physics experiments. A prototype was cdeveloped and tested with the HERA-B data sample.

The Portuguese group was well integrated in the data analysis tasks, and was responsible for some important channels and new developments. The financing of the

project finished by July 2005 but the work continued in order to write, submit and publish the last physics papers and students thesis. Several students were involved in the Portuguese HERA-B team, of which one Ph.D. and two M.Sc. thesis were finished in 2005.

Publications:

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

- *"HERA-B framework for online calibration and alignment",*
  J.M. Hernandez et al.,
  Nucl.Instrum.Meth.A546:574-583,2005.
- *"Measurement of the J/Psi Production Cross Section in 920 GeV/c Fixed-Target Proton-Nucleus Interactions",*
  HERA-B Collaboration,
  hep-ex/0512029 *(submitted)*.

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

- *"Charm, beauty and charmonium production at HERA-B",*
  HERA-B collaboration,
  European Physical Journal C 43 (1-4): 179-186 Aug 2005.

Academic Training:

PhD Theses:

- *"Increasing productivity in High Energy Physics data mining with a Domain Specific Visual Query Language",*
  Vasco Amaral, 2005-02-17

Master Theses:

- *"Medida da secção eficaz de produção de pares b-bbar em decaimentos semileptónicos de hadrões B em colisões de protões em alvo fixo",*
  Luis Silva, 2005-01-18
- *"From CP violation in primordial baryogenesis to the role of detector alignment in the HERA-B spectrometer",*
  João Batista, 2005-11-11

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**1**
Articles in international journals (with indirect contribution from LIP members)	**1**
PhD Theses	**1**
Master Theses	**2**

Project Title: Collaboration in the NA50 experiment at CERN

Resumo:

A experiência NA50 é uma colaboração internacional de cerca de 100 físicos oriundos de doze Laboratórios e Universidades Europeus que se desenrola junto do acelerador SPS (Super Proton- Synchroton) do CERN. Estuda colisões ultrarelativistas de feixes de iões de chumbo e protões com alvos pesados, através da produção de pares de muões correlacionados com a energia transversa neutra do evento, com a multiplicidade das partículas secundárias carregadas e com a energia incidente não envolvida na interacção. NA50 tem por objectivo a pesquisa de um novo estado da matéria, o Plasma de Quarks e Gluões (QGP), através do estudo das suas características, nomeadamente a temperature e a densidade bariónica correspondentes à transição da fase hadrónica para a de plasma.

As assinaturas que têm vindo a ser estudadas são as supressões do ψ e do ψ', o aumento de produção do ϕ, bem como o excesso de dimuões na região de massa intermédia. A presente Proposta é a continuação dos Projectos anteriormente financiados e visa essencialmente o prosseguimento da análise de dados, nas suas diferentes vertentes. Os principais resultados obtidos no decurso de anteriores tomadas de dados, bem como na experiência precedente NA38, foram:

- a supressão normal do ψ , i.e., a sua absorção por outras partículas secundárias que o acompanham (comovers, para as quais é preciso postular uma grande densidade, várias vezes superior à densidade nuclear)

- a supressão do ψ', em reacções induzidas por iões (enxofre, urânio), contrastando com a sua produção normal em colisões protão-núcleo

- o aumento da produção do ϕ para sistemas de maior número de massa e com a centralidade da colisão

- o excesso de produção de dimuões na região de massas intermédias (entre as ressonâncias ϕ e ψ), em relação `as fontes conhecidas.

Estes interessantes resultados permitiam antever que a experiência NA50, com o acumular de estatística de qualidade, tanto em interacções centrais como em periféricas, pudesse vir a detectar efeitos da formação do plasma de quarks e gluões.

Na realidade, um importante resultado foi recentemente obtido, nomeadamente um efeito de limiar na supressão anómala do Psi em interacções chumbo-chumbo o que, por si só e também conjugado com os resultados precedentes, obtidos por NA38, e relativos a outros sistemas (p-N, O-U, S-U), é naturalmente explicado no quadro da formação de QGP,

e constitui pois um grande desafio para os que tinham proposto explicações hadrónicas 'clássicas' para os efeitos previamente observados em NA38.

Com a análise dos últimos dados adquiridos, em que se usou um alvo de Pb no vácuo, procura-se clarificar melhor o comportamento da supressão do ψ, quer em colisões periféricas,quer em colisões centrais. Pretende-se ainda, agora que os métodos de análise atingiram a sua máxima sofisticação, fazer um estudo sistemático de todos os conjuntos de dados de NA50.

Funding:

Code	Funding	Start	End
POCTI/FNU/50194/2003	15.000 €	2004-07-04	2005-07-03

Team:

Project Coordinator: Paula Bordalo

Team Members:

Name	Status	% of time in project
Catarina Quintans	Researcher (LIP/FCT)	10
Gonçalo Borges	Researcher (LIP/IST)	75
Helena Santos	Researcher (LIP/FCT)	10
Paula Bordalo	Researcher (LIP)	10
Ruben Shahoyan	Researcher (LIP)	10
Sérgio Ramos	Researcher (LIP)	10

Summary of the Activities:

The Lead Beam Acceleration Program started at CERN in 1992, its aim being the search of a new state of matter, the quark-gluon plasma (QGP), as well as the study of nuclear matter at high density. It came after the Exploratory Ultrarelativistic Ion Acceleration CERN Program, whose data taking periods with oxigen and sulphur beams took place from 1986 till 1992. LIP has been participating in these Ion Programs included in the NA38 and NA50 experiments. Our group represents 20% and 15%, respectively, of the total Collaboration's members.
The study of QGP signals, together with nuclear collective flow phenomena, is performed in NA38/NA50 by means of muon pair detection (muon spectrometer) in correlation with the neutral transverse energy released (electromagnetic calorimeter), the charged particle multiplicity (multiplicity detector) and the spectators' energy (zero degree calorimeter).
The NA50 experiment took data during several years, with ion and proton beams, from 1994 till 2001. The tasks and responsibilities concerning the previous phases of the experiment, concerning its design and run, were already extensively reported.
Here, we just concentrate on the tasks of our responsibility concerning the year 2005:

- Participation in the Collaboration and Steering Committee meetings
- Participation in specific technical analysis meetings
- Contribution to lead and proton induced data analyses:
    - Comparative study of ψ and ψ' production and of the ratio ψ'/ψ, in p-A, S-U and Pb-Pb interactions.
    - Study of low-mass vector-meson multiplicities in ion induced reactions and finalresults merging the three data taking periods.

All subjects in the first point have lead to communications in several international Conferences, most of them presented by LIP members.

Publications:

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

- *"A new measurement of J/PSI suppression in Pb-Pb collisions at 158 GeV per nucleon",*
  NA50 Collaboration (P. Bordalo, G. Borges, C. Quintans, S. Ramos, H. Santos R. Shahoyan et al.),
  Eur Phys J C39 (2005) 335.
- *"The production of rho, omega and phi vector-mesons by protons and sulphur ions with incident momentum of 200 GeV/c per nucleon",*
  NA38 Collaboration (MC Abreu, P. Bordalo, G. Borges, R. Ferreira, J. Guimarães, C. Quintans, S. Ramos, H. Santos, R. Shahoyan et al.),
  Eur. Phys. J C 44 (2005), 375.

- *"The normal J/Psi nuclear absorption",*
  NA50 Collaboration (G. Borges et al.),
  Eur. Phy. J C43 (2005) 161.

International Conference Proceedings:

- *"J/psi and psi' production in nucleus-nucleus collisions at the CERN/SPS",*
  NA50 Collaboration (H. Santos et al.),
  Proceedings of Probing QCD with High Energy Nuclear Collisions, January 2005, Hirshegg, Austria.
- *"Experimental Overview of Ultra-Relativistic Heavy Ions Physics",*
  P. Bordalo,
  Proceedings of International Conference on High Energy Physics, HEP2005 PoS (HEP2005) 414, July 2005, Lisbon, Portugal.
- *"Bottomonium and Drell-Yan Production in p+A collisions at the CERN SPS"*,
  Proceedings of International Conference on High Energy Physics, July 2005, Lisbon, Portugal.
- *"Charmonia production at the CERN/SPS",*
  NA50 Collaboration (G. Borges et al.),
  Proceedings of XL Rencontres de Moriond (2005) 403,
  March 2005, La Thuile, Italy.
- *"Final results on charmonia suppression from NA50",*
  NA50 Collaboration (C. Quintans et al.),
  Proceedings 9th International Conference in Physics and Astrophysics of the Quark Gluon Plasma, February 2005, Calcuta, India.
- *"Quarkonium production and suppression in Pb-Pb and p-A collisions at SPS energies",* in Proc. of Quark Matter 2005, Aug 2005, Budapest, Hungary.
- *Bottomonium and Drell-Yan Production in p+A collisions at the CERN SPS"*,
  in Proc. of Quark Matter 2005 Conference, Aug 2005, Budapest, Hungary.

Communications:

Oral presentations in international conferences:

- *"Final results on charmonia suppression from NA50",*
  presented by Catarina Quintans
  at 9th International Conference in Physics and Astrophysics of the Quark Gluon Plasma (ICPAQGP) in Kolkata, India, February 7-12, 2005.
- *"J/psi and psi' production in nucleus-nucleus collisions at the CERN/SPS",*
  presented by Helena Santos
  at Hirschegg05 in Hirschegg, Austria, January 16-22, 2005.
- *"Charmonia production at the CERN/SPS",*
  presented by Gonçalo Borges
  at XL-th Rencontres de Moriond in La Thuile, Italy, March 12-19, 2005.
- *"What we have learnt on charmonia production from NA38 to NA50 experiments",*
  presented by Paula Bordalo
  at Meeting on Percolation, Heavy Ion Collisions and Cosmic Rays in Lisbon, Portugal, April 2005.
- *"Experimental Overview of Ultra-Relativistic Heavy Ions Physics",*
  presented by Paula Bordalo
  at HEP2005 in Lisbon, Portugal, July 2005.

Presentations in national conferences:

- *"Summary on NA38/NA50 J/psi normal nuclear absorption",*
  presented by Gonçalo Borges
  at IV Encontro Nacional de Física Hadrónica in Coimbra, Portugal.
- *"Final results on charmonia production at the NA50 experiment",*
  presented by Helena Santos
  at IV Encontro Nacional de Física Hadrónica in Coimbra, Portugal.

Seminars:

- *"A produção de J/Psi e Psi' em colisões núcleo-núcleo no CERN-SPS",*
  presented by Helena Santos
  at in Coimbra, Portugal.
- *"The charmonia suppression and its reference",*
  presented by Helena Santos
  at in CFIF, Lisbon, Portugal.

Academic Training:

PhD Theses:

- *"J/Psi and Psi' production in p-A collisions at 400 GeV and S-U interactions at 200 GeV/nucleon",*
  Gonçalo Borges, 2005-12-16

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**2**
International Conference Proceedings	**6**
Oral presentations in international conferences	**5**
Presentations in national conferences	**2**
Seminars	**2**
PhD Theses	**1**

Project Title: Collaboration in the DELPHI experiment at CERN

Resumo:

O grupo DELPHI do LIP tem desenvolvido as suas actividades segundo o plano anteriormente definido, e que consiste na obtenção dos melhores resultados possíveis a partir dos dados da experiência DELPHI, cujo detector funcionou no acelerador LEP do CERN entre 1989 e 2000. As análises de dados efectuadas podem ser divididas em dois subgrupos: Pesquisas de sinais de nova física, e Física Hadrónica. Em ambos os casos, a participação dos membros de DELPHI do LIP teve lugar nos grupos de física associados, bem como na coordenação destes e das respectivas linhas de pesquisa.

No ano de 2005 foi publicado 1 artigo, sob responsabilidade ou com contribuições importantes de membros do LIP/DELPHI. Foram ainda enviadas, na forma de Notas DELPHI, duas comunicações científicas a conferências internacionais (com revisão científica por membros da colaboração). A qualidade do trabalho desenvolvido foi reconhecida pela Colaboração, ao escolher três membros do grupo LIP/DELPHI para apresentarem os resultados alcançados em conferências internacionais, com a importância da 'EPS-HEP 2005', em representação da Colaboração DELPHI.

Foram ainda preparados 4 artigos que foram submetidos à Colaboração e que estão neste momento em diferentes estados de discussão ou preparação avançada.

Funding:

Code	Funding	Start	End
POCTI/FP/FNU/50204/2003	15.000 €	2004-09-01	2005-12-31

Team:

Project Coordinator: Pedro Abreu

Team Members:

Name	Status	% of time in project
António Onofre	Researcher (LIP/UCPFF)	15
Bernardo Tomé	Researcher (LIP/FCT)	5
Catarina Espírito Santo	Researcher (LIP)	5
Filipe Veloso	PhD student (LIP/FCT)	10
Mário Pimenta	Researcher (LIP/IST)	5
Nuno Anjos	PhD student (LIP)	100
Nuno Castro	PhD student (LIP/FCT)	10
Pedro Abreu	Researcher (LIP/IST)	35

Summary of the Activities:

In the year 2005, the LIP/DELPHI group carried on the intense program of finishing the analyses and preparation of papers and communications to international conferences, as detailed in the previous plan of activities.

In many channels the final papers were published in 2004, and in most of the remaining analyses, the papers are in advanced stage of preparation.

In 2005, one paper was published under our responsibility or with important contributions from the LIP-DELPHI team. In 2005 LIP members wrote also two communications to international conferences, and three members of the LIP/DELPHI team presented the DELPHI or LEP results in International Conferences, with the importance of 'EPS-HEP 2005'.

The Ph. D. program of Nuno Anjos, with the title of "Hadronic final states at LEPII" has progressed and is expected to be concluded soon.

Publications:

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

- *"Determination of the b quark mass at the M_Z scale with the DELPHI detector at LEP",*
  J. Abdallah et al., The DELPHI Collaboration,
  CERN PH-EP 2005-020 (accepted by EPJC) *(accepted)*.
- *"Charged Particle Multiplicity in Three-Jet Events and Two-Gluon Systems",*
  J. Abdallah et al., The DELPHI Collaboration,
  Eur. Phys. J. C44 (2005) 311-331.
- *"Single Intermediate Vector Boson production in e+e- collisions at sqrt(s) = 183 - 209 GeV",*
  J. Abdallah et al., The DELPHI Collaboration,
  Eur. Phys. J. C45 (2006) 273-289.
- *" Study of double-tagged gamgam events at LEPII",*
  J. Abdallah et al., The DELPHI Collaboration,
  CERN PH-EP 2005-029 (accepted by EPJC) *(accepted)*.
- *"Bose-Einstein Correlations in W ^ + W ^ - events at LEP2",*
  J. Abdallah et al., The DELPHI Collaboration,
  Eur. Phys. J. C44 (2005) 161-174.
- *"Flavour Independent Searches for Hadronically Decaying Neutral Higgs Bosons",*
  J. Abdallah et al., The DELPHI Collaboration,
  Eur. Phys. J.C44 (2005) 147-159.
- *"Production of \Xi_c^0 and \Xi_b in Z decays and lifetime measurement of \Xi_b",*
  J. Abdallah et al., The DELPHI Collaboration,
  Eur. Phys. J. C44 (2005) 299-309.
- *" A Determination of the Centre-of-Mass Energy at LEP2 using Radiative 2-fermion Events",*
  J. Abdallah et al., The DELPHI Collaboration,
  CERN PH-EP 2005-050 (subm. to EPJC) *(accepted)*.
- *"Determination of heavy quark non-perturbative parameters from spectral moments in semileptonic B decays",*
  J. Abdallah et al., The DELPHI Collaboration,
  Eur. Phys. J. C45 (2006) 35-59.

Collaboration notes with internal referee:

- *" Search for excited leptons in e+e- collisions at sqrts=189 - 209 GeV",*
  J. Abdallah et al., The DELPHI Collaboration,
  DELPHI note 2005-009 CONF 729.
- *"Search for Pentaquarks in the Hadronic Decays at the Z Boson with the DELPHI Detector at LEP",*
  P. Abreu, M. Chapkin, A. De Angelis, P. Gavillet, F. Mandl, J. Mc.Naughton, N. Pukhaeva, S. Raducci,
  DELPHI note 2005-019 CONF 739.

Communications:

Oral presentations in international conferences:

- *"Final state QCD studies at LEP: Part I",*
  presented by Pedro Abreu
  at HEP2005 International Europhysics Conference on High Energy Physics in 21 - 27 July 2005, Lisboa, Portugal.
- *"Search for Excited fermions",*
  presented by Bernardo Tomé
  at HEP2005 International Europhysics Conference on High Energy Physics in 21 - 27 July 2005, Lisboa, Portugal.
- *"Final state QCD studies at LEP: Part II",*
  presented by Nuno Anjos
  at HEP2005 International Europhysics Conference on High Energy Physics in 21 - 27 July 2005, Lisboa, Portugal.

Academic Training:

PhD Theses:

- *"Hadronic Final States at LEP II",*
  Nuno Anjos, (on-going)

Events:

- *"Deep Inelastic Structure Functions at small x",*
  Seminar organization, Centro de Física Teórica de Partículas (co-organizou), 2005-12-09

Project Statistics

	number
Articles in international journals (with indirect contribution from LIP members)	**9**
Collaboration notes with internal referee	**2**
Oral presentations in international conferences	**3**
Seminar organizations	**1**

Computing:

Project Title: Grid Computing

Resumo:

A computação Grid é um paradigma de computação que consiste na agregação de recursos computacionais autónomos, heterogéneos e distribuídos numa única infra-estrutura. Uma Grid esconde as especificidades dos recursos que a constituem possibilitando um acesso fácil e transparente a meios de cálculo poderosos.

A motivação das Grids reside na resolução de problemas computacionalmente complexos com exigências de cálculo elevadas. As experiências do LHC enquadram-se neste contexto pois possuem requisitos na ordem das dezenas de milhares de processadores. As experiências ATLAS e CMS a realizar no LHC e nas quais o LIP participa escolheram o paradigma Grid como solução para a integração dos recursos computacionais pertencentes às instituições participantes.

O LIP encontra-se envolvido em vários projectos internacionais que têm por objectivo o desenvolvimento e a aplicação de tecnologias Grid para cálculo científico e em especial para o LHC. Durante 2005 o LIP participou no projecto Worldwide LHC Computing Grid (WLCG), e nos projectos Europeus CrossGrid e Enabling Grids for E-Science (EGEE).

Funding:

Code	Funding	Start	End
CrossGrid (IST-2001-32243)	186.921 €	2002-01-05	2005-04-30
EGEE (INFSO 508833)	247.500 €	2004-04-01	2006-03-31
EGEE-complement (010.6/B002/2005)	119.250 €	2005-04-01	2006-03-31
EGEE-additional (POCI/V.5/A016/2005)	100.000 €	2005-05-01	2006-04-30

Team:

Project Coordinator: Jorge Gomes

Team Members:

Name	Status	% of time in project
Gaspar Barreira	Researcher (LIP)	34
Gonçalo Borges	Researcher (LIP/IST)	25
João Martins	Researcher (LIP)	100
Jorge Gomes	Researcher (LIP)	100
José Aparício	Technician (LIP)	100
Mário David	Researcher (LIP/FCT)	100
Nuno Dias	Researcher (LIP)	100

Summary of the Activities:

During 2005 the LIP computing team continued its line or work in Grid computing. As in previous years these activities were performed mostly in the context of international grid research and deployment projects. The team was involved in the

CERN project WLCG (Worlwide LHC Computing Grid) and in the European Union funded projects EGEE (Enabling Grids for E-SciencE) and CrossGrid. Additionally and for the first time these activities were also supported by the Portuguese funding agencies in the context of two projects that complemented the national participation in EGEE. These activities were aimed to acquire know-how and prepare the LIP computing services to support the LIP participation in the LHC experiments and in future research activities requiring Grid computing. The projects are briefly described:

- WLCG is a CERN project that aims to build the computing infrastructure for the LHC experiments. The project was launched after the selection of Grid computing as the basis for the development of the LHC computing infrastructure. This infrastructure will integrate more than 70,000 computers in high-energy physics laboratories worldwide. The WLCG project is closely related with the European Union project EGEE that is currently providing the operations, user support and training for WLCG in Europe. WLCG aims to develop, adapt, build and maintain a global grid infrastructure for the LHC experiments. The WLCG is now the biggest grid computing infrastructure in the world.
- EGEE is a European Union funded project coordinated by CERN. EGEE coordinates a production Grid infrastructure for scientific computing open to all scientific domains. EGEE provides middleware reengineering, support, integration and coordination of computing resources. The EGEE infrastructure is the largest multidisciplinary Grid in the world. The WLCG resources are managed as part of the EGEE infrastructure. Similarly many of the LCG and EGEE services are being shared by both infrastructures. The project has 70 partners (in Europe, US and Russia) and is divided in 12 regional federations. LIP is an EGEE partner and is a member of the EGEE Southwest federation jointly with several Spanish research institutes.
- CrossGrid is a European Union funded project that was launched following the EU DataGrid project (in which CERN was coordinator) with the aim of extending the DataGrid technologies to support interactivity, user-friendly interfaces and parallel computing. CrossGrid worked closely with DataGrid and later with LCG and EGEE. The CrossGrid project had 21 European partners and its testbed infrastructure has 17 sites in 10 European countries. The project developed a wide range of middleware services and applications.

During 2005 the LIP participation in WLCG and EGEE was mostly centred in the Southwest federation infrastructure operations in which LIP contributed to the Regional Operations Centre (ROC), whose responsibilities are divided between Portugal and Spain. LIP is operating a cluster of computing systems integrated in the LCG/EGEE infrastructure and additionally is providing central services for the federation including a Resource Broker, Information Index and a Replica Catalogue that are being used by researchers in Portugal and Spain. The central services are hosted at the Portuguese Academic Network facilities where they enjoy direct connectivity to the Géant European network backbone.

In parallel LIP is playing an important role in the user support where is responsible for the coordination of the user and site support in the Southwest federation. The LIP team contributed to the Global Grid User Support (GGUS) Ticket Processing shifts by providing a TPM team and collaborating in providing GGUS TPM training at CERN

and FZK. The TPM shifts constitute a fundamental part of the EGEE/LCG User Support coordination. In this context the LIP team was called to perform frequent one week shifts during which took the management of the trouble tickets processing system for the whole EGEE/LCG project.

LIP is also deeply involved in the EGEE pre-production service. This service is basically a parallel grid infrastructure for testing future EGEE production middleware. In this context LIP deployed several pre-production systems including a small cluster that has been used to test LCG and gLite middleware components. LIP took active participation in these tests.

The LIP participation in EGEE was supported by the EU and by two national FCT projects. The national projects enabled LIP to obtain funds to complement the EU contribution and also to developed activities that although related with the EGEE were not considered in the project proposal. These included the improvement of the EGEE central services at FCCN and of the LIP grid cluster. Additionally within the context of the LIP facilities improvement the upgrade of the LIP datacenter was started.

LIP continued to develop efforts in the dissemination area with the objective of finding new Portuguese resource centres in the country willing to join the EGEE infrastructure and share computing resources. Several meetings were organized aiming to establish contacts.

In the area of grid authentication LIP continued to maintain the Portuguese Grid Certification Authority (CA) and participating in the EUgridPMA grid CA coordination activities.

The CrossGrid project ended officially in February of 2005 with excellent results. The project obtained an extension of 3 months during which the final documentation and reports were prepared. After the end of the project the CrossGrid testbed infrastructure continued to be operated by the project partners enabling the pursuance of many of the partner's grid research activities and the use of the infrastructure for several dissemination and scientific computing applications. The infrastructure was maintained operational and will be the basis of a new EU funded grid project.

Publications:

International Conference Proceedings:

- *"Experience with the International Testbed in the CrossGrid Project",*
  J.Gomes, M.David, J.Martins, L.Bernardo, A.Garcia, M.Hardt, H.Kornmayer, J.Marco, R.Marco et al,
  P.M.A. Sloot et al. (Eds.): EGC 2005, LNCS 3470, pp. 98-110, 2005.
  Springer-Verlag.
- *"International Grid CA Interworking, Peer Review and Policy Management Through the European DataGrid Certification AUthority Coordination Group",*
  J.Astalos,R.Cechini,BCoghlan,R.Cowles,U.Enpting,T.Genovese,J.Gomes,D.Groep et al,

P.M.A. Sloot et al. (Eds.): European Grid Conference 2005, LNCS 3470, pp. 285-295, 2005. Springer-Verlag.

Collaboration notes with internal referee:

- *"Testbed Final Report",*
  Jesus Marco, Jorge Gomes, CrossGrid integration team,
  CG4-D4.9-v1.2-CSIC021-WP4-Testbed-Final-Report.

Communications:

Oral presentations in international conferences:

- *"Experience with the International Testbed in the CrossGrid Project",*
  presented by Jorge Gomes
  at European Grid Conference in Amsterdam.
- *"The Ticket Processing Manager: duties and tasks",*
  presented by Mário David
  at GGUS Tutorial for Supporters in FZK - Karlsruhe.

Presentations in national conferences:

- *"Grid Computing: a experiência do LIP nos projectos europeus DataGrid, CrossGrid e EGEE",*
  presented by Mário David
  at JETC'05, Terceiras Jornadas de Engenharia de Electrónica e Telecomunicações e de Computadores in Instituto Superior de Engenharia de Lisboa.

Seminars:

- *"Grid Computing @ LIP",*
  presented by Jorge Gomes
  at in UMIC.

Outreach seminars:

- *"Distributed computing using the GRID",*
  presented by Mário David
  at in INESC.
- *"Grid Computing @ LIP",*
  presented by Jorge Gomes
  at in FCT/UNL.

Project Statistics

	number
International Conference Proceedings	**2**
Collaboration notes with internal referee	**1**
Oral presentations in international conferences	**2**
Presentations in national conferences	**1**
Seminars	**1**
Outreach seminars	**2**

Astroparticle Physics:

Project Title: Collaboration in AMS – Alpha Magnetic Spectrometer

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 2007, permitirá prospectar a existência de antimatéria e matéria escura com uma precisão nunca antes alcançada.

Funding:

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

Team:

Project Coordinator: Fernando Barão

Team Members:

Name	Status	% of time in project
Fernando Barão	Researcher (LIP/IST)	75
Gaspar Barreira	Researcher (LIP)	10
Luisa Arruda	PhD student (LIP/FCT)	100
Mário Pimenta	Researcher (LIP/IST)	10
Patrícia Gonçalves	Researcher (LIP/FCT)	30
Rui Faísca Pereira	PhD student (LIP/FCT)	100

Summary of the Activities:

AMS (Alpha Magnetic Spectrometer) is a particle physics experiment to be installed in the future International Space Station Facility (ISS). The main physics objectives will be the search for antimatter and dark matter. In addition, it will study the propagation and confinement of cosmic rays in the galaxy.

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 both an independent measurement of the particle velocity and of the electric charge. A velocity goal resolution for singly charged particles of the order of 10^{-3} 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=1.050) and sodium fluoride (n=1.33), a matrix of 680 photodetectors on the bottom and an enveloping outer mirror of very large reflectivity.

The portuguese team is involved in the RICH simulation and developped algorithms for velocity and charge reconstruction. In addition, the team started exploring isotopes identification physics analysis, 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 compared leading to a velocity determination for protons with a resolution less than 0.1%.

A method for charge reconstruction with the rich detector was also implemented. 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-analitical method. A typical charge resolution (ΔZ) of the order of 20% is obtained for protons.

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 (tunning 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 group continued the analysis activities in the data gathered during the 2003 test beam. Studies concerning both radiators, aerogel and NaF, mirror reflectivity and a full data/MC agreement, were performed. The aerogel light yield evolution with the beam energy was also extracted from both data from 2002 and 2003. The results obtained have shown a good behaviour of the photon readout cells at different incident angles.

The assembling of the RICH detector started in 2005 at the CIEMAT institute (Madrid, Spain). A large readout module made of 143 complete cells (light guide, photomultiplier, electronics, shielding) was assembled in November, 2005 and by the

same time, the large conical reflector arrived in Madrid.

In parallel, the first batches of aerogel tiles (11.5x11.5 cm) arrived to LPSC (Grenoble, France). Optical characterization of the tiles within 10-4 is required to both a good charge separation and velocity resolution. The portuguese team participated in the running operations of the setup built in Grenoble for measuring the refractive index of the aerogel.

The activities where the group was involved along the year 2005 were the following:

- ***Velocity and charge reconstruction algorithms*** *with the RICH detector*

- ***Data Analysis of the 2003 test beam****:*
  - Velocity resolution and Charge resolution evaluations; comparison with the test beam simulation
  - mirror reflectivity monitoring
  - Sodium Fluoride velocity and charge resolution
  - aerogel optical properties monitoring
  - Measurement of the aerogel light yield for different beam energies

Publications:

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

- *"Prototype Study of the cherenkov imager of the AMS experiment",*
  P. Aguayo et al.,
  Nuclear Instruments and Methods in Physics Research *(submitted)*.

Communications:

Oral presentations in international conferences:

- *"Velocity and charge reconstruction with the AMS/RICH detector",*
  presented by Luisa Arruda
  at V New Worlds in Astroparticle Physics (2005) in Algarve, Portugal.
- *"Isotope separation with the RICH detector of the AMS experiment",*
  presented by Rui Faísca Pereira
  at 5th International Workshop on New Worlds in Astroparticle Physics in Faro, Portugal.
- *"Cosmic Ray velocity and electric charge measurements in the AMS experiment",*
  presented by Luisa Arruda
  at 2005 Lake Louise Winter Institute in Lake Louise, Canada.
- *"Astrophysics with the AMS-02 experiment",*
  presented by Rui Faísca Pereira
  at HEPP-EPS 2005 International urophysics Conference on High Energy Physics in Lisboa, Portugal.
- *"The Ring Imaging Cherenkov Detector (RICH) of the AMS experiment",*
  presented by Fernando Barão
  at 29th International Conference on Cosmic Rays in Pune, India.
- *"Isotopic separation of cosmic rays with the AMS experiment: the role of the RICH detector",*

presented by Rui Faísca Pereira
at Les Houches International Predoctoral School - Session XX - Dark matter and neutralinos: Astronomical observations & experimental strategies in Les Houches, França.

Presentations in national conferences:

- *"AMS - Um espectrómetro magnético na Estação Espacial Internacional",* presented by
at XV Encontro Nacional de Astronomia e Astrofíica in Lisboa, Portugal.

Academic Training:

PhD Theses:

- *"Charge and velocity reconstruction with the RICH detector of the AMS experiment; performance studies of a rich prototype with test beam data",* Luisa Arruda, 2007-10-01
- *"Deuterium and light isotopes measurements and Dark matter searches with the AMS experiment",*
Rui Faísca Pereira, 2008-10-01

Project Statistics

	number
Oral presentations in international conferences	**6**
Presentations in national conferences	**1**

Project Title: Data analysis and calibration of the solar neutrino detector Sudbury Neutrino Observatory (SNO)

Resumo:

As actividades desenvolvidas consistiram na tomada (2 semanas de turnos) e análise dos dados de calibração óptica do detector SNO, na redacção e edição de um artigo, na participação em reuniões da colaboração e na organização de uma sessão de trabalho do grupo da calibração óptica. O objectivo da calibração óptica é determinar os parâmetros que descrevem a propagação e detecção de luz no detector (a atenuação da água pesada e leve e a resposta angular dos PMTs), de modo a aplicá-los no cálculo do estimador da energia dos eventos. Na terceira fase de SNO, a presença no volume de D_2O de um conjunto de 40 contadores proporcionais de ^3He (5 cm de diâmetro, ~10 m de comprimento) obriga a uma selecção muito mais apertada de PMTs para análise óptica, devido às sombras. Com o método até agora utilizado na calibração óptica, a normalização dos PMTs era feita com uma run central, o que limita ainda mais essa selecção de PMT. O trabalho de análise de dados neste projecto centrou-se principalmente no estudo das eficiências relativas dos 9000 PMTs e no desenvolvimento de um método alternativo de obtenção das constantes de calibração com base nessas eficiências. O novo método desenvolvido permite duplicar o número de PMTs disponíveis e foi aplicado com sucesso à calibração da terceira fase de SNO. Para além da calibração óptica da terceira fase, as eficiências dos PMTs são também utilizadas na melhoria da calibração em energia das fases precedentes, no âmbito do grupo de trabalho LETA ("Low Energy Threshold Analysis"). Como consequência das actividades desenvolvidas, a calibração óptica da terceira fase de SNO encontra-se bastante avançada e prevê-se que um conjunto preliminar de constantes possa ser fornecido à colaboração dentro em breve.

Funding:

Code	Funding	Start	End
POCI/FIS/56691/2004	35.000 €	2005-01-01	2006-12-31

Team:

Project Coordinator: José Maneira

Team Members:

Name	Status	% of time in project
Amélia Maio	Researcher (LIP/FCUL)	5
José Maneira	Researcher (LIP/FCT)	25

Summary of the Activities:

In 2005, the LIP participation in the SNO experiment consisted in the following activities:

- **Detector-related**. We participated in two calibration data-taking periods, taking shifts of calibration hardware operation: one week of optical calibrations in February and one week of neutron calibrations in August.
- **Meetings**. We participated in the Winter Collaboration meeting in Oxford (U.K.), presenting results from the optical calibration analysis. We organized two Optics working group meetings, one in Sudbury in August (during neutron calibration week), and another at LIP-Lisboa in December. We

participated in several phone meetings throughout the year, for the Energy & Optics (E&O) group, for the Low Energy Threshold Analysis (LETA) group, for the general analysis group and the SNO collaboration board.

- **Analysis**. The analysis activities were developed within the framework of the optical calibration. The purpose is to determine the parameters that describe the propagation and detection of light in the detector (the attenuation of the media and the PMT angular response), in order to apply them in the energy estimator calculation. During this year, the activities were focussed mainly on the study of the 9000 PMT relative efficiencies and in the development of an alternative method for the measurement of the calibration constants, based on those efficiencies. In the third phase of SNO, the presence in the D_2O volume of a set of 40 He-3 proportional counters (5 cm diameter x 10 m length) forces a much more stringent PMT selection, due to the shadowing effect. With the method of optical calibration used until now, the PMT normalization was done with a central run, which limits even more that selection. The new method, using the relative efficiencies for that normalization, allows the duplication of the number of PMTs available for the analysis. This method was now successfully applied to the the calibration of the third phase of SNO. In addition to the third phase optical calibration, the PMT efficiencies are also used in improvements to the energy calibration of the previous phases, in the scope of the "Low Energy Threshold Analysis" (LETA) group activities. Moreover, verification and quality checks of the reprocessing of phase one and two data were carried out. In general, significant progress on the phase three optical calibration was accomplished, so that a preliminary set of constants will be released soon.
- **Papers**. We had the responsibility for editing, substantially re-writing and submitting the paper "Optical Calibration Hardware for the Sudbury Neutrino Observatory". We contributed figures and suggestions for the paper "Electron energy spectra, fluxes, and day-night asymmetries of 8B solar neutrinos from measurements with NaCl dissolved in the heavy-water detector at the Sudbury Neutrino Observatory".
- **Talks/seminars**. We gave a talk on the SNO results at the V International Meeting on New Worlds in Astroparticle Physics. We gave seminars on SNO at LIP-Coimbra, LIP-Lisboa and CFTC-Lisboa, as well as a lecture on Neutrino Physics for the IST course on Astroparticle Physics.

Publications:

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

- *"Optical Calibration Hardware for the Sudbury Neutrino Observatory",*
  J. Maneira, B.A. Moffat, R.J. Ford, F.A. Duncan, K. Graham, A.L. Hallin, C.A.W. Hearns, P. Skensved, D.R. Grant,
  Nucl. Inst. & Meth. A 554 (2005) 255-265.

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

- *"Electron Energy Spectra, Fluxes, and Day-Night Asymmetries of B-8 Solar Neutrinos from the 391-Day Salt Phase SNO Data Set",*
  SNO Collaboration (J. Maneira et al.),
  Phys. Rev. C72, 055502 (2005).

- *"A Search for Periodicities in the B-8 Solar Neutrino Flux Measured by the Sudbury Neutrino Observatory",*
  SNO Collaboration (J. Maneira et al.),
  Phys. Rev. D72, 052010 (2005).

Internal Notes:

- *"Update on PMT efficiencies",*
  J. Maneira,
  SNO Manhattan note 6G7L7K.

Communications:

Oral presentations in international conferences:

- *"SNO: Results from phase II and preparation of phase III",*
  presented by José Maneira
  at New Worlds in Astroparticle Physics 2005 in Faro, Portugal.

Project Statistics

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

Project Title: Development of liquid xenon detectors for WIMPs Search and CERN experiment PS213

Resumo:

Do movimento das estrelas e das galáxias, assim como de outras observações do domínio da astronomia e da astrofísica, conclui-se que a matéria bariónica (i.e., a matéria constituída por protões, neutrões e electrões) constitui apenas cerca de 5% da massa total do Universo. Dos restantes 95% da matéria do universo, pensa-se que 23% são constituídos pela chamada matéria escura (não-bariónica). Os WIMPs (Weakly Interacting Massive Particles) são apontados como possíveis constituintes de parte dessa matéria escura. Estas partículas podem eventualmente ser detectadas por registo da energia ganha 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 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 de importancia crucial. Para comprovar a existência de WIMPs desenvolvem-se detectores optimizados para este fim e que são colocados em laboratórios subterrâneos para minimizar o ruído constituído pela radiação cósmica e ambiente.

Um dos objectivos deste projecto é o desenvolvimento de um detector de xénon líquido para a pesquisa de WIMPs. Durante o ano de 2005 fez parte do programa de trabalho deste projecto a instalação de um detector de xénon líquido numa mina de sal no Reino Unido e os testes de laboratório (no Imperial College of London) de um outro detector que constitui uma versão aperfeiçoada e mais complexa do primeiro. Ambos os detectores foram especialmente concebidos para a pesquisa da matéria escura. Para além disso, o programa de R&D foi continuado com o estudo de alguns dos problemas relevantes para o aperfeiçoamento e interpretação dos resultados deste tipo de detectors. São exemplo destes estudos, as medidas de reflectividade de materials geralmente utilizados nestes detectores, a utilização de novas tecnologias de amplificação do sinal de carga e o desenvolvimento de algoritmos de reconstrução de posição adequados aquele tipo de detectores.

Funding:

Code	Funding	Start	End
CERN/FNU/43729/2001	140.000 €	2002-01-02	2005-09-30
POCTI/FP/FNU/50208/2003	60.000 €	2004-10-01	2006-02-28
POCI/FP/63446/2005	55.000 €	2005-09-01	2006-08-31

Team:

Project Coordinator: Isabel Lopes

Team Members:

Name	Status	% of time in project
Alexandre Lindote	PhD student (LIP)	99
Américo Pereira	Technician (LIP)	33
Armando Policarpo	Researcher (LIP/FCTUC)	21
Carlos Silva	Technician (LIP)	3
Cláudio Silva	PhD student	33
Francisco Neves	PhD student (LIP)	100
Isabel Lopes	Researcher (LIP/FCTUC)	67
João Silva	Technician (LIP)	3
Joaquim Oliveira	Technician (LIP)	3

Jorge Correia Moita	Technician (LIP)	3
José Pinhão	Technician (LIP)	2
José Pinto Da Cunha	Researcher (LIP/FCTUC)	73
Nuno Carolino	Technician (LIP)	3
Paulo Mendes	Researcher (LIP/FCTUC)	42
Rui Marques	Researcher (LIP/FCTUC)	21
Vitaly Chepel	Researcher (LIP/FCTUC)	66
Vladimir Solovov	Researcher (LIP)	98

Summary of the Activities:

This report refers to the scientific activity developed in the period from January 1, 2005 to December 31, 2005. The main results obtained can be summarized as follows:

ANALYSIS OF THE DATA TAKEN WITH A NEUTRON BEAM IN 2004

The analysis of the data taken with the neutron beam was carried out in view of: 1) Determining the ratio of scintillation yield due to nuclear recoils and to electrons for nuclear recoils of energy from 5 keV to 100 keV. 2) Obtaining the shape of scintillation pulses due to nuclear recoils of energy from 5 keV to 100 keV. 3) Investigating the neutron/gamma discrimination based on the scintillation pulse shape. 4) Testing the position reconstruction algorithm developed. 5) Obtaining information on the light collection efficiency in the chamber.

DEVELOPMENT OF POSITION RECONSTRUCTION ALGORITMS

1. A position reconstruction algorithm, based on the maximum likelihood (ML) technique was implemented for a liquid xenon scintillation camera aiming to reduce the uncertainty in the measurement of the energy of nuclear recoils from neutron scattering. The performance of the algorithm was assessed both with simulated and experimental data. A resolution of 6.7 mm (sigma) was measured with 122 keV γ-rays at the bottom of the chamber. For 10 keV γ-rays simulated events, a resolution $\leq$ 20 mm was obtained for 80% of the active volume of the detector. By means of the position reconstruction, the uncertainty of the nuclear recoil energy in the neutron scattering experiment was reduced by a factor of 2 to 3, depending on the energy.

2. In the framework of our participation in the ZEPLIN program of UKDMC, we developed a method for reconstructing the scintillation hit position in two-phase liquid xenon chambers, namely the ZEPLIN detectors. It is fast enough for on-line operation and provides a resolution of a few millimetres (FWHM). It also allows to increase the fiducial volume with low contamination from out-lying events and good reconstruction accuracy.

EXTENSIVE SIMULATIONS OF THE BARREL CALORIMETER PROPOSED FOR DETECTING GAMMAS IN NEUTRON CAPTURE CROSS SECTION MEASUREMENTS (work carried out in the framework of experiment PS213 at n-TOF, CERN)

The feasibility study of a liquid xenon calorimeter for detection of the gamma-cascades produced in the neutron capture processes was accomplished. The relevant characteristics of the detector were obtained by Monte-Carlo simulation considering different scenarios. A design for a module of such device was proposed based on those studies. A comparison was made with currently available alternatives regarding not only the overall performance of the detector but also the price.

DIRECT PARTICIPATION IN THE ZEPLIN PROGRAM

This task concerns our direct commitment with the ZEPLIN programme. ZEPLIN II is a 30 kg liquid xenon detector based on readout of the primary scintillation in the liquid and secondary scintillation in the gas by 7 PMTs placed in the gas phase. ZEPLIN-III is a 6 kg fiducial volume xenon detector equipped with 31 PMTs, and constitutes an improved and more complex version of ZEPLIN II. We participated in the deployment of ZEPLIN II in Boulby Mine, UK, and in its data taking and data analysis program.

As part of our participation in the ZEPLIN project, we also had the responsibility of implementing the DAQ (Data Acquisition System) and the slow control system of ZEPLIN III detector.

MEASUREMENTS OF REFLECTIVITY

A large vacuum chamber in stainless steel and quartz windows was constructed to allow the measurements of the reflectivity of several materials at xenon emission wavelength to be carried out in an inert atmosphere. This is necessary because of the absorption of the VUV light (the xenon emits scintillation light at 178 nm) by air. The sample and the photodetector, as well as the accessories to detect of the reflective light as function of the incident angle, are all mounted inside that chamber. The chamber allows the measurements to be carried out with the source placed inside or outside the chamber. Firstly, the measurements were tried using VUV sensitive photographic film as photodetector. However, this method was revealed to be too expensive and without the necessary reliability. The set-up was then adapted so that the light is detected by a photomultiplier which can be moved with high precision around the sample. Data taking with this new set-up is under way.

PERFORMANCE OF GEMS (GAS ELECTRON MULTIPLIERS) IN ULTRAPURE XENON VAPOR:

Measurements of the gain in room temperature xenon and in cooled vapour were carried out as a function of the applied voltage. Gains of the order of a few hundreds can be obtained. The stability of the operation of the GEM in highly purified xenon vapour is being investigated. These measurements started in 2004 and they are going on.

STUDY OF SECUNDARY SCINTILLATION IN XENON VAPOR:

The number of secondary scintillation photons emitted per electron was measured as a function of the reduced electric field in the region of production of secondary scintillation. The calibration in number of photons was done using primary scintillation in room temperature gas as reference. These measurements started in 2004 and they were completed in 2005.

ORGANIZATION OF THE IEEE 15th INTERNATIONAL CONFERENCE ON DIELECTRIC LIQUIDS

We organized the IEEE 15th International Conference on Dielectric Liquids which was held in Coimbra from 26th June to 1st July, 2005. There were over 140 attendees with approximately equal numbers from industry and universities. There were 110 papers accepted and published in the Conference Proceedings that were printed as a book (Proceedings of 2005 IEEE International Conference on Dielectric Liquids", Coimbra, Portugal, IEEE Press, IEEE Cat. Nº 05CH37643, 2005) and issued as CD-ROM. In addition to the Conference Proceedings, a special issue of the IEEE

Transactions on Dielectrics and Electrical Insulation (TDEI) on Dielectric Liquids will be published in June 2006 with contributions presented at the conference. The Associated Editors of this special issue are M.I. Lopes, V. Chepel and W.F. Schmidt.

Publications:

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

- *"Performance of a Chamber for Studying the Liquid Xenon Response to Gamma-Rays and Nuclear Recoils",*
  F. Neves, V. Chepel, V. Solovov, A. Pereira, M. I. Lopes, J. Pinto da Cunha, P. Mendes, A. Lindote, C.P. Silva, R. Ferreira Marques and A. J.P.L. Policarpo,
  IEEE Trans. on Nucl. Sci. *(accepted)*.
- *"Primary scintillation yield and alpha/beta ratio in liquid xenon",*
  V. Chepel, M.I. Lopes and V. Solovov,
  Radiat. Phys. and Chem. 74, 2005, 160-167.
- *"New approach to the calculation of the refractive index of liquid and solid xenon",*
  A. Hitachi, V. Chepel, M. I. Lopes, V. N. Solovov,
  Journal of Chemical Physics 123, 2005, 234508.
- *"Preliminary results on position reconstruction for ZEPLIN III",*
  A. Lindote, H. M. Araujo, J. Pinto da Cunha, V. Chepel, M. I. Lopes et al.,
  Nucl. Instrum. and Meth A. *(accepted)*.

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

- *"The data acquisition system of the neutron time-of-flight facility n_TOF at CERN",*
  U. Abbondanno et al. (n-TOF Collaboration),
  Nucl. Instrum. and Meth. A 538, 2005, 692-702.

International Conference Proceedings:

- *"Study of Liquid Xenon Scintillation for Dark Matter Search",*
  F. Neves, V. Chepel, V. Solovov, A. Pereira, M. I. Lopes, J. Pinto da Cunha, P. Mendes, A. Lindote, C.P. Silva, R. Ferreira Marques and A. J.P.L. Policarpo,
  Proceedings of 2005 IEEE International Conference on Dielectric Liquids,
  IEEE Press, IEEE Cat. Nº 05CH37643, 2005,pp.333-336.
- *"A multiwire chamber triggered by scintillation for positron emission tomography",*
  M.I. Lopes, V. Chepal and V. Solovov,
  Proceedings of Workshop on Applications of Xenon on Science and Technology (XeSAT 2005), pp.23-28.

Book Chapters:

- *"Rare Gas Liquid Detectors",*
  M. I. Lopes and V. Chepel,
  in “Electronic Excitations in Liquified Rare Gases”, Edited by W. Schmidt and E. Illenberger, American Scientific Publishers, 2005, pp.331-385..

Communications:

Oral presentations in international conferences:

- *"Response of liquid xenon to gamma-rays and neutrons",*
  presented by Isabel Lopes
  at Workshop on Applications of Rare Gas Xenon (XeSAT 2005) in Waseda University, Tokyo, Japan.
- *"A multiwire chamber triggered by scintillation for positron emission tomography",*
  presented by Isabel Lopes
  at Workshop on Applications of Xenon on Science and Technology (XeSAT 2005) in Waseda University, Tokyo, Japan.
- *"Study of Liquid Xenon Scintillation for Dark Matter Search",*
  presented by Vladimir Solovov
  at 2005 IEEE International Conference on Dielectric Liquids in Coimbra, Portugal.
- *"Preliminary results on position reconstruction for ZEPLIN III",*
  presented by Alexandre Lindote
  at 7th International Position Sensitive Detectors Conference in Liverpool, UK, 12-16 September 2005.

Poster presentations in international conferences:

- *"Position Reconstruction in a Liquid Xenon Scintillation Chamber for Low Energy Nuclear Recoils and Gamma-Rays",*
  presented by Francisco Neves
  at 7th International Position Sensitive Detectors Conference in Liverpool, U.K., 12-16 September 2005.

Academic Training:

PhD Theses:

- *"Application of liquid xenon to the dark matter detection",*
  Francisco Neves, 2006-12-31
- *"Data acquisition and analysis of ZEPLIN detectors",*
  Alexandre Lindote, (on-going)
- *"Liquid xenon detectors for WIMP search",*
  Cláudio Silva, (on-going)

Graduation Theses:

- *"Performance of GEMs (Gas Electron Multipliers) in ultrapure xenon vapor",*
  Rui Meleiro, 2005-02-01

Events:

- *"15th IEEE International Conference on Dielectric Liquids (ICDL 2005)",*
  Conference, Coimbra, Portugal, 2005-06-26

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**4**
Articles in international journals (with indirect contribution from LIP members)	**1**
International Conference Proceedings	**2**
Book Chapters	**1**
Oral presentations in international conferences	**4**
Poster presentations in international conferences	**1**
Graduation Theses	**1**
Conferences	**1**

Project Title: High Energy Cosmic Rays

Resumo:

A astrofísica de alta energia é hoje um campo de investigação extremamente activo, nas suas vertentes teórica e experimental. Como previsto no plano de trabalho, em 2005 as actividades do grupo de raios cósmicos de energia extrema (RCEE) do LIP centraram-se em duas linhas complementares, com o objectivo fundamental de consolidar e alargar a participação Portuguesa nesta área. Culminando com a adesão de Portugal e do LIP ao observatório Pierre Auger, pode-se dizer que 2005 foi um ano decisivo para a definição das actividades do LIP na área da física das astropartículas nos próximos anos.

As duas linhas de actividade de 2005 podem-se resumir do seguinte modo:

- *Actividades experimentais:*

  Estreitamento dos laços com o Observatório Pierre Auger, e aceitação do grupo do LIP e de Portugal na colaboração em Novembro de 2005; Participação em estudos e na elaboração da proposta do projecto GAW, um projecto de I&D na área da detecção de raios gama na região do TeV explorando as técnicas de detecção inovadoras propostas por EUSO.

- *Fenomenologia:*

  A pesquisas de nova física no âmbito dos RCEE, em colaboração com físicos teóricos de áreas relacionadas, constitui uma continuação natural do trabalho desenvolvido em LEP e um complemento interessante às pesquisas no LHC. Em 2005 os trabalhos publicados insidiram sobre: Procura de partículas exóticas em experiências de RCEE; Procura de nova física nas interacções hadrónicas de altas energias em cascatas de raios cósmicos.

Funding:

Code	Funding	Start	End
PDCTE/FNU/49727/2003	60.000 €	2004-03-01	2005-02-28
POCTI/FIS/55759/2004	80.000 €	2005-03-01	2006-12-31

Team:

Project Coordinator: Mário Pimenta

Team Members:

Name	Status	% of time in project
António Onofre	Researcher (LIP/UCPFF)	2
Bernardo Tomé	Researcher (LIP/FCT)	46
Catarina Espírito Santo	Researcher (LIP)	65
Gonçalo Pires	Student (LIP)	34
Jorge Dias de Deus	Researcher (IST)	8
Jorge Romão	Researcher (IST)	8
Mário Pimenta	Researcher (LIP/IST)	44
Miguel Pato	Undergraduate student (LIP)	25
Miguel Paulos	Undergraduate student (LIP)	58
Patrícia Gonçalves	Researcher (LIP/FCT)	10
Pedro Abreu	Researcher (LIP/IST)	10
Pedro Assis	PhD student (LIP/FCT)	90
Pedro Brogueira	Researcher (LIP/IST)	15
Ruben Conceição	Undergraduate student (LIP)	50
Rui Santos	Researcher (LIP/FCUL)	8

Summary of the Activities:

High energy particle astrophysics is today an extremely active field of research, both experimentally and theoretically. As foreseen in the Activity Plan, in 2005 the activities of the LIP Ultra High Energy Cosmic Rays (UHECR) team were centred in two complementary research lines with the main goal of pursuing, consolidating and extending the Portuguese participation in the field of UHECR. With Portugal and LIP joining the Pierre Auger Observatory (PAO) in November 2005, we can say 2005 was a crucial year for the definition of the activities of LIP in the area of astroparticle physics in the next years. The two main lines of activity are detailed below.

Experimental Activities

The main experimental activities of the team in 2005 included the preparatory work for the entrance in the PAO, and the preparatory work for the presentation of a proposal by the GAW collaboration. These are shortly described below. In addition, the LIP team participated in the successful final run of the ULTRA experiment, and is involved in the preparation of the final NIM publication now in progress.

PAO - Pierre Auger Observatory

The LIP team has developed in the last years knowledge and experience in data acquisition and trigger systems in UHECR detectors, as well as in air shower and detector simulation, namely in what concerns the air fluorescence technique. During 2005, the existing links with the PAO were strengthened and LIP has joined the observatory in November 2005. As agreed, the participation of LIP in the PAO will be centered in the fluorescence detectors (FD), and cover different aspects such as detailed detector simulation, data analysis, the participation in detector upgrades and in regular detector operation. Preparatory work has been performed in 2005. Concerning academic training, undergraduate students have already been included in this task.

GAW – Gamma Air Watcher

Keeping in mind the interest and experience in air fluorescence detectors, the technique proposed by EUSO, with a very fine spatial and time segmentation, is innovative and promising. The excellent resolution would allow the detailed study of air shower development, GAW - Gamma Air Watcher, is an R&D project on the detection of high energy gamma rays. GAW is an Italian-Spanish-Portuguese collaboration aiming at the installation of a prototype high-segmentation compact telescope in the observatory of Calar Alto (Spain), for the detection of the Cherenkov light associated to TeV gamma air showers. In 2005 a detailed GAW proposal has been prepared by the collaboration and submitted. The LIP team has responsibilities in the detector simulation (coordination of the simulation framework and detailed simulation of the optics using GEANT4) and in the development of the data acquisition system. The team participated in the preparation of the proposal, conducted of the required studies in the fields under its responsibility.

Finally in 2005 a small cosmic ray electronic laboratory financed in the framework of "Programa de re-equipamento" started to be installed in the basement of the LIP premises at Lisbon. This laboratory will have the capability of development and test of dedicated data acquisition boards. The Laboratory has already performed the

prototype and batch production of GPS support boards for the "Telescópio de Raios Cósmicos", certifying the production capability of the Laboratory.

Phenomenology

The essential goal of this line of activity, started in 2004, is the development of phenomenological work in the context of UHECR and beyond, by a team involving experimental and theoretical physicists. It involves theoreticians from several Portuguese research centres, namely CENTRA, CFTP and CFTC, and is a natural follow-up of the work developed at LEP and an interesting complementary activity to the very promising searches at the LHC.
During 2005 this work gave rise to several publications and conference presentations and was centred in two main areas:

Search for exotic particles in UHECR showers
UHECR provide particle beams that, in spite of the low and uncertain fluxes and of the poorer detection capabilities, are still the highest energy beams accessible and can be a relevant complement to searches at colliders, once an adequate statistics is collected in future UHECR experiments. This phenomenological work explores the consequences of different scenarios and models and studies the observation prospects in realistic future experiments. The production of exotic particles in high energy neutrino–nucleus interactions in the atmosphere has been recently addressed by our team. After the work developed in the search for microscopic black hole production (in the context of models with extra-dimensions), excited leptons and leptoquarks were considered. The sensitivity of present and planned very high energy cosmic ray experiments to the production of excited leptons and leptoquarks was estimated and discussed. These particles arise in composite models with substructure in the fermionic sector. Leptoquarks also arise naturally in models attempting the unification of the quark and lepton sectors of the standard model of particle physics. Such exotic particles could be produced in the interaction of high energy quasi-horizontal cosmic neutrinos with the atmosphere, originating extensive air showers observable in large cosmic ray experiments. The double bang, in which a second shower is produced at measurable distance from the first one due to the decay of a very energetic tau lepton arising from the exotic particle decay, was explored as a distinctive signature. Several publications and presentations in international conferences related to this line of work are listed below.

Percolation effects in UHECR hadronic interactions
In the development of atmospheric showers initiated by UHECR, the first few hadronic interaction take place at energies orders of magnitude above those reached at accelerators. This implies that the uncertainties arising from the hadronic models in the simulation of extensive air showers are, at these energies, very large, and with important consequences in the energy estimation performed in UHECR experiments. A characterisation of the first interactions was performed in the framework of CORSIKA, and the different available hadronic interaction models were compared. On the other hand the high energies involved imply that UHECR showers can be used to test the predictions of high energy hadronic interaction models, such as percolation. In String Percolation Models for hadron-hadron collisions, at low energy valence strings are formed, forward and backward in the centre-of-mass, containing most of the collision energy, and particles are produced from these strings. As the energy

increases, additional sea strings, central in rapidity, are created, taking away part of the energy carried by the valence strings. Softer secondaries are produced, and the inelasticity increases with energy. As density increases, strings start to overlap and merge: percolation occurs, leading to the creation of clusters of strings. From the larger percolated strings (clusters) faster particles are produced. As a consequence the inelasticity starts to decrease with the energy. In this work we explored the idea that including percolation effects in the development of EAS, the predicted behaviour of the inelasticity could explain a number of puzzles in UHECR observations, such as the discrepancy between ground array experiments and fluorescence detectors or the dependence of the depth of the shower maximum with the primary energy, which shows a change in slope around 10^{17} eV. This work is being pursued, with the study of the muon component of the shower.

Publications:

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

- *"Microscopic black hole detection in UHECR: the double bang signature",*
  V. Cardoso, M.C. Esprito-Santo, M. Paulos, M. Pimenta and B. Tomé,
  Astroparticle Physics 22(2005)399..
- *"Percolation Effects in Very High Energy Cosmic Rays",*
  J. Dias de Deus, M.C. Espirito Santo, M. Pimenta, C. Pajares,
  hep-ph/0507227 *(submitted)*.
- *"Percolation and cosmic ray physics above 10^{17}eV",*
  P. Brogueira, J. Dias de Deus, M.C. Espirito Santo, M. Pimenta,
  hep-ph/0511279 *(submitted)*.
- *"The sensitivity of cosmic ray air shower experiments for excited lepton and leptoquark detection",*
  M.C. Espirito Santo, A. Onofre, M. Paulos, M. Pimenta, J. C. Romão, B. Tomé,
  hep-ph/0508100 *(submitted)*.

International Conference Proceedings:

- *"Results from the ULTRA experiment in the framework of the EUSO project",*
  G. Agnetta, P. Assis, B. Biondo, P. Brogueira, A. Cappa, O.Catalano, J. Chauvin (LPSC), G. D'Ali Staiti, M. Dattoli, M.C.Espirito-Santo, L. Fava, P. Galeotti, S. Giarrusso, G. Gugliotta, G. La Rosa,D. Lebrun (LPSC), M.C. M,
  Proceedings of ICRC 2005, Pune, India [astro-ph/0602151].
- *"GAW, Gamma Air Watch - A Large Field of View Imaging Atmospheric Cherenkov",*
  M.C. Maccarone, G. Agnetta, P. Assis, B. Biondo, et all,
  Proceedings of ICRC 2005, Pune, India [astro-ph/0509706].
- *"Sensitivity of large air shower experiments for excited lepton detection",*
  M.C. Espirito Santo, A. Onofre, M. Paulos, M. Pimenta, J. C. Romão, B. Tomé,
  Proceedings of ICRC 2005, Pune, India [hep-ph/0412345].
- *"How to select UHECR in EUSO",*
  Pedro Assis,
  Proceedings of the V International Workshop New Worlds in Astrop Phys, Faro, Portugal, Jan 2005 *(accepted)*.
- *"Microscopic black holes detection in UHECR",*
  Miguel Paulos,

Proceedings of the V International Workshop New Worlds in Astrop Phys, Faro, Portugal, Jan 2005 *(accepted)*.

- *"Sensitivity of large air shower experiments for new physics searches",*
  V. Cardoso, M.C. Espirito Santo, A. Onofre, M. Paulos, M. Pimenta, J. C. Romão, B. Tomé,
  Proceedings of EPS 2005, Lisbon, Portugal *(submitted)*.

Communications:

Oral presentations in international conferences:

- *"How to select UHECR in EUSO",*
  presented by Pedro Assis
  at Fifth International Workshop on New Worlds in Astroparticle Physics 8-10 January in Faro, Portugal.
- *"Microscopic black holes detection in UHECR",*
  presented by Miguel Paulos
  at Fifth International Workshop on New Worlds in Astroparticle Physics 8-10 January in .
- *"Measuring the EAS cascade parameters",*
  presented by Mário Pimenta
  at 7th Meeting on Percolation, Heavy Ion Collisions and Cosmic Rays in Lisboa, Portugal.
- *"Ultra High Energy Cosmic Rays",*
  presented by Mário Pimenta
  at Third Workshop on Science with the New Generation of High Energy Gamma-ray Experiments in Cividale, Italy.
- *"Sensitivity of large air shower experiments for new physics searches",*
  presented by Catarina Espírito Santo
  at HEP2005 International Europhysics Conference on High Energy Physics in Lisboa, Portugal.

Academic Training:

PhD Theses:

- *"Data acquisition and control systems in cosmic ray experiments",*
  Pedro Assis, (on-going)

Graduation Theses:

- *"Search for new physics in very high energy cosmic ray showers",*
  Miguel Paulos, 2005-07-01
- *"Characterisation of high energy air showers using CORSIKA",*
  Ruben Conceição, 2006-09-30

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**1**
International Conference Proceedings	**6**
Oral presentations in international conferences	**5**
Graduation Theses	**1**

Project Title: Study of the primary scintillation in air for cosmic ray detection

Resumo:

A detecção de radiação de fluorescência produzida na atmosfera por raios cósmicos incidentes de muito alta energia, é uma técnica que tem vindo a ser utilizada pela nova geração de experiências como Hires e Auger. Este método baseia-se na excitação das moléculas de azoto pelas partículas carregadas do chuveiro produzido no ar (electrões e positrões) seguido da emissão de fotões num comprimento de onda na região entre 300 e 400nm. A emissão de radiação de fluorescência produzida pelas partículas carregadas é considerada isotrópica e proporcional à energia perdida por unidade de comprimento no ar. Uma medida precisa da quantidade de luz emitida por fluorescência, em camadas finas de gás, em condições atmosféricas diversas é, pois, essencial para a calibração absoluta dos detectores de raios cósmicos de ultra alta energia que se baseiam neste método de detecção.
Este projecto visa contribuir para uma melhor compreensão quer dos processos físicos que estão na origem da fluorescência do ar quer dos mecanismos que contribuem para a sua inibição e junta pessoas com experiência tanto na área da física das astropartículas como na dos processos fundamentais em física da radiação. O nosso principal objectivo é continuar as medidas que temos vindo a realizar (no laboratório, com fontes radioactivas) das quantidades de luz emitida em função da pressão e temperatura. Neste sentido planeamos estender as medidas até temperaturas da ordem dos –40ºC e melhorar a precisão das medidas. Prevemos realizar estudos resolvidos no tempo, ou seja, medidas dos tempos médios de vidas dos estados emissores das moléculas de azoto em função da pressão e temperatura. Estes resultados deverão contribuir para uma melhor compreensão dos mecanismos de excitação e desexcitação envolvidos. O estudo da influência do vapor de água e outros gases presentes na atmosfera como gases minoritários (argon, por exemplo), é um aspecto importante que será tomado em consideração.

Funding:

Code	Funding	Start	End
POCTI/FP/FNU/50340/2003	15.000 €	2004-07-04	2005-10-30
POCI/FP/63440/2005	30.000 €	2005-07-04	2006-07-03

Team:

Project Coordinator: Margarida Fraga

Team Members:

Name	Status	% of time in project
Américo Pereira	Technician (LIP)	20
António Onofre	Researcher (LIP/UCPFF)	23
Armando Policarpo	Researcher (LIP/FCTUC)	18
Carlos Silva	Technician (LIP)	5
Ermelinda Antunes	Researcher (LIP/FCTUC)	7
Filipe Veloso	PhD student (LIP/FCT)	10
Francisco Fraga	Researcher (LIP/FCTUC)	7
João Silva	Technician (LIP)	2
Joaquim Oliveira	Technician (LIP)	5
Jorge Correia Moita	Technician (LIP)	5
Margarida Fraga	Researcher (LIP/FCTUC)	32
Mário Pimenta	Researcher (LIP/IST)	10
Nuno Carolino	Technician (LIP)	15

Nuno Castro	PhD student (LIP/FCT)	10
Rui Marques	Researcher (LIP/FCTUC)	10
Susete Fetal	PhD student (LIP/ISEC)	7

Summary of the activities:

Improved measurements of light yields in pure nitrogen were performed using the alpha particles of Am-241 as excitation source. The radioactive source was placed outside the main chamber, in a secondary chamber that can be evacuated.
The light yields for the main emission band of the nitrogen molecule (WL=337 nm) were obtained for various temperatures between +25ºC and –23ºC. During each cooling cycle, the density of the gas was kept constant. These measurements were repeated for several gas densities and the analysis of the results is underway.
An important part of the analysis involves a simulation of the set-up. This simulation is being developed using the GEANT 4 code. To simulate the transmission of the interference filter one needs to know its dependence both on the angle of incidence and on the temperature. Since the manufacturer only provides data for angles of incidence below 15º, we need to measure this dependence. Preliminary measurements of the transmission of the interference filters were performed as a function of the angle of incidence of the light beam.

The study of the response of the photomultipliers as a function of the temperature is also an important part of the analysis. Measurements performed for the three PMTs have shown that the gain slightly increases with decreasing temperature (less than 0.2%/ºC). The dependence on the temperature of the detection efficiency of the two PMTs working in the single photon counting mode has also been investigated but the results were not conclusive suggesting that the experimental set up still needs further improvements.

Preliminary tests with the Sr-90 source were also performed using a thick plastic scintillator coupled to a photomultiplier as the electron detector. Results showed both that the scintillation yield was very low and that there was an important background component. Studies were performed in order to identify the origin of the background component and to improve the signal to noise ratio. The re-evaluation of the electron detection system (used as trigger for the time resolved measurements) was also taken into consideration: since the plastic scintillator is also photon sensitive, we considered the possibility of using in its place a photodiode as the electron detector. Preliminary tests were performed both at room temperature and at lower temperatures and the results were promising in spite of the low detection efficiency of our photodiode.

Publications:

International Conference Proceedings:

- *"Pressure and temperature dependence of the primary scintillation in air",*
  M. Fraga, A. Onofre, N. F. Castro, R. Ferreira Marques, S. Fetal, F. Fraga, M. Pimenta, A. Policarpo, F. Veloso,
  Proceedings of the Fifth Meeting on New Worlds in Astroparticle Physics, Faro, Portugal, 8-10 January, 2005 (*accepted*).

Communications:

Oral presentations in international conferences:

- *"Pressure and temperature dependence of the primary scintillation in air",*
  presented by Margarida Fraga
  at Fifth Meeting on New Worlds in Astroparticle Physics, in Faro, Portugal.
- *"Temperature dependence of the primary scintillation of nitrogen",*
  presented by Margarida Fraga
  at IWFM05 in Habère-Poche (74), France, Feb. 2-5, 2005,.

Presentations in national conferences:

- *"Estudos da fluorescência do ar para a detecção de raios cósmicos",*
  presented by Margarida Fraga
  at Física 2005 in Porto, Portugal.

Project Statistics

	number
International Conference Proceedings	**1**
Oral presentations in international conferences	**2**
Presentations in national conferences	**1**

Project Title: ESA:
Radiation Interaction Simulations for Space Missions

Resumo:

O LIP tem vindo a estabelecer actividades em cooperação a ESA, European Space Agency*, no contexto da aplicação do* toolkit *de simulação GEANT4 a experiências de física de astropartículas e na descrição e estudo do ambiente de radiação no sistema solar e do seu efeito em componentes electrónicos. O* toolkit *de simulação GEANT4 é um software de simulação em* open-source *desenvolvido por uma colaboração mundial de instituições e laboratórios. O seu domínio de aplicação engloba o desenvolvimento de ferramentas de simulação para física de altas energias, física médica, astrofísica de partículas. Durante 2005 estiveram em curso dois contratos, intitulados "*Integrated Radiation Environment**,** Effects and Component Degradation Simulation Tool*" e "*Design study for an energetic particle spectrometer for planetary missions*". O primeiro corresponde à elaboração de uma ferramenta de simulação de ambiente e efeitos de radiação e de degradação de componentes electrónicas tendo em vista uma missão espacial a Marte; o segundo corresponde ao estudo de uma nova geração de monitores de radiação compactos, leves (<1kg) e com baixo consumo (<1W) que está a ser desenvolvida, tendo em vista missões espaciais futuras. Neste contexto foi estudado um conceito simples baseado num cristal cintilante de modo a permitir a utilização do detector como instrumento científico. O LIP foi responsável pela simulação do instrumento utilizando o toolkit de simulação Geant4 e pelo estudo da resposta do instrumento tendo em conta o ambiente de radiação esperado para a missão BepiColombo a Mercúrio.*

Funding:

Code	Funding	Start	End
ESA: 18121/04/NL/ch	100.000 €	2004-04-01	2006-09-30
ESA 19100/05/NL/HB	23.240 €	2005-09-11	2006-02-28

Team:

Project Coordinator: Patrícia Gonçalves

Team Members:

Name	Status	% of time in project
Ana Keating	PhD student (LIP/FCT)	100
Andreia Trindade	PhD student (LIP/FCT)	5
Bernardo Tomé	Researcher (LIP/FCT)	39
Catarina Espírito Santo	Researcher (LIP)	20
João Costa	Undergraduate student (LIP)	67
Mário Pimenta	Researcher (LIP/IST)	30
Patrícia Gonçalves	Researcher (LIP/FCT)	50
Pedro Rodrigues	PhD student (LIP/FCT)	5

Summary of the Activities:

LIP has been cooperating with ESA, European Space Agency, in the application of the GEANT4 simulation toolkit to astroparticle experiments and in the description and

study of the solar system radiation environment and its effect on electronic components relevant for ESA future space missions.
The GEANT4 toolkit is an open-source software developed by a worldwide collaboration of institutions and laboratories. It had its first public release in 1998. Its general capabilities include coupled hadron-lepton-photon transport in 3D geometries of arbitrary complexity. Two sets of electromagnetic physics categories are available: Standard Physics and Low Energy. Standard physics handles the basic process for charged particles and photons from 1 keV to 10 TeV (up to 1000 PeV for muons) while the low energy extensions provide alternative models down to 250 eV, based on the EEDL97/EADL/EPDL97 libraries. An extensive set of hadronic physics models, spanning over 15 orders of magnitude in energy starting from neutron thermal energies, are also included, coupled with a realistic treatment of radioisotope decay, through the Radioactive Decay Module. The same physics process can be treated by alternative implementations, which can have different energy validity ranges, accuracy and computing time. In addition, the user can add new physics processes without the need to modify the underlying framework. In GEANT4 the user can interface her/his simulation code with different primary event generators, namely the General Particle Source. This generator fulfils several requirements from the space simulation community, in particular due to the possibility of considering a wide variety of source properties, including user-defined emission spectra, and is being extensively used in astroparticle experiments simulation.

Integrated Radiation Environment, Effects and Component Degradation Simulation Tool

The contract 18121/04/NL/ch "Integrated Radiation Environment, Effects and Compo-nent Degradation Simulation Tool", celebrated between LIP-Lisboa and ESA/ESTEC, started in April 2004 and will terminate in September 2006. It is divided into four Work Packages, WP: Literature Study, Radiation Environment Selection and Modelling, Radiation Effects Selection and Modelling and Verification Procedures and Execution. The first WP was successfully concluded in September 2004 and the corresponding Study Report was presented. The second WP started in October 2004 and terminated in September 2005. Its requirements were the choice of a specific mission scenario for which radiation environment models with interface to GEANT4 and SPENVIS would be developed and the expected radiation environment would be studied, also including spacecraft shielding effects. Fulfilling the second Work Package, a Mars mission - the Exomars Mission - was chosen. The radiation environment for that mission was characterised and modelled using GEANT4. The result of the studies was presented in October 2005 in the corresponding Study Report. One PhD thesis is currently in progress in the framework of this activity.

Software Models for the Portuguese Interplanetary Particle Surveyor

ESA issued a *scientific and technical plan* in which a preliminary concept for a Portuguese Interplanetary Particle Surveyor (PIPS) was proposed. A contract was celebrated between LIP and EFACEC, under the ESA/EFACEC contract ESTEC 19100/05/NL/HB, "Design study for an energetic particle spectrometer for planetary missions", which started in September 2005 and will terminate in February 2006. The contract concerns the study of a new generation of compact (~5x5x5 cm), light weight (less than 1 kg) and low power consuming (< 1 Watt) radiation monitors for future

space missions, namely for the Bepi Colombo mission to Mercury. A simple concept based on a scintillating crystal was studied, consisting of an instrument capable of performing not only as a radiation switch, providing ancillary trigger information for the spacecraft, but also as a scientific instrument, which will measure fluxes and energy distributions of electrons, protons and ions in relevant energy ranges: 0.5-150 MeV per nucleon for protons and ions and 0.1-20 MeV for electrons.

Under the EFACEC/LIP contract, LIP is responsible for: the GEANT4 simulation of the instrument and of the corresponding structural model; the study of the radiation dose and of the effect of secondary particles expected in the instrument for the total duration of the Bepi Colombo mission to Mercury; the derivation of transfer functions for the signal observed in the different detector components (a two plane silicon tracker and a CsI scintillating crystal read by five photo diodes) to be implemented in the instrument simulator; and for the final assessment of the performance of the instrument as a scientific instrument. As of the 31st of December 2005, the project status was ongoing: the implementation of the GEANT4 model of the instrument and corresponding structural model had been concluded and there was a preliminary version of the transfer functions for the instrument simulator.

Publications:

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

- *"A Model for Mars Radiation Environment Characterization",*
  A. Keating, A. Mohammadzadeh, P. Nieminen, D. Maia, S. Coutinho, H. Evans, M. Pimenta, J.-P. Huot, and E. Daly,
  IEEE Trans. on Nuc. Sci., 2005. *(accepted)*.

International Conference Proceedings:

- *"Simulation of space radiation monitors",*
  Bernardo Tomé,
  World Sci., NEW WORLDS IN ASTROPARTICLE PHYSICS, Proceedings of the Fifth International Workshop *(accepted)*.
- *"GEANT4 detector simulations- radiation interaction simulations for the high energy astroparticle experiments EUSO and AMS",*
  Patrícia Gonçalves,
  World Sci., NEW WORLDS IN ASTROPARTICLE PHYSICS, Proceedings of the Fifth International Workshop , Faro, Portugal 8 - 10 January 2005 *(accepted)*.
- *"Simulation of radiation monitors for future space missions",*
  Patrícia Gonçalves, Bernardo Tomé and Mário Pimenta,
  (submitted).

Communications:

Oral presentations in international conferences:

- *"Simulation of space radiation monitors",*
  presented by Bernardo Tomé
  at NWAPP2005 in Faro, Algarve.

- *"GEANT4 detector simulations- radiation interaction simulations for the high energy astroparticle experiments EUSO and AMS",*
  presented by Patrícia Gonçalves
  at NWAPP 2005 in Faro, Portugal.
- *"A Model for Mars Radiation Environment Characterization",*
  presented by Ana Keating
  at NSREC in Seattle, United States.
- *"Mars Radiation Environment Characterization: A GEANT4 based Model",*
  presented by Ana Keating
  at SPENVIS- GEANT4 Workshop in Leuven-Belgium.
- *"Simulation of radiation monitors for future space missions",*
  presented by Bernardo Tomé
  at SPENVIS & GEANT4 workshop in Leuven, Belgium.
- *"Simulation of radiation monitors for future space missions",*
  presented by Patrícia Gonçalves
  at 9th ICATPP Conference on Astroparticle, Particle, Space Physics, Detectors and Medical Physics Applications in Villa Olmo, Como, Italy.
- *"Simulation of radiation monitors for future space missions",*
  presented by Patrícia Gonçalves
  at Geant4 2005, 10th user conference and collaboration workshop in Bordeaux, France.
- *"A GEANT4 based simulation for Fresnel lenses",*
  presented by Bernardo Tomé
  at 2005, 10th user conference and collaboration workshop in Bordeaux, France.

Academic Training:

PhD Theses:

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

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**1**
International Conference Proceedings	**3**
Oral presentations in international conferences	**8**

Medical Physics:

Project Title: Development of Positron Emission Mammography

Resumo:

A elevada incidência de cancro da mama e a relativa inadequação dos métodos tradicionais de detecção (em particular a mamografia com raios-X) apontam para a necessidade de técnicas e de equipamentos específicos com desempenho complementar. Este projecto visa responder a esta necessidade, propondo um novo equipamento, compacto e económico, baseado na detecção de fotões gama resultantes do decaimento de um átomo emissor de positrões (o Flúor-18). A detecção dos fotões provenientes do decaímento do átomo radioactivo permite localizar o tumor em três dimensões, constituindo a base do PET (Positron Emission Tomography em inglês). Ao contrário da mamografia com raios-X, eminentemente anatómica, a mamografia PET retratará o funcionamento das células tumorais vivas.

O projecto "Desenvolvimento de Tecnologia PET para Mamografia" é um projecto de investigação científica e tecnológica realizado no âmbito do Consórcio PET-Mamografia, liderado cientificamente pelo LIP. O equipamento PET proposto decorrerá de investigação científica e de desenvolvimento tecnológico desde a investigação até ao protótipo para realização de testes clínicos, estando envolvidos no Projecto cerca de 40 pessoas (desde alunos de licenciatura a médicos especialistas em Medicina Nuclear) de 8 instituições diferentes, de Universidades a Hospitais.

Este equipamento explora tecnologia de detecção de fotões desenvolvida no CERN e integra um sistema electrónico de aquisição de dados inovador em desenvolvimento pelo consórcio. A associação destes factores permitirá uma melhoria significativa da qualidade das imagens relativamente aos sistemas PET actuais.

Funding:

Code	Funding	Start	End
POSI/DGDR-SIFEC/14/01/03/FDR/00134	569.000 €	2003-01-01	2006-12-31

Team:

Project Coordinator: João Varela

Team Members:

Name	Status	% of time in project
Andreia Trindade	PhD student (LIP/FCT)	100
Bruno Carriço	Master student (LIP/UALG)	100
Catarina Ortigão	PhD student (LIP)	100
Conceição Abreu	Researcher (LIP/UALG)	5
Francisco Fraga	Researcher (LIP/FCTUC)	5
João Varela	Researcher (LIP/FCT)	30
José Carlos Silva	Technician (LIP)	10
Luis Peralta	Researcher (LIP/FCUL)	20
Miguel Ferreira	Technician (LIP)	50
Patrick Sousa	PhD student (LIP)	10
Paula Bordalo	Researcher (LIP)	5

Pedro Amaral	Researcher (LIP)	33
Pedro Rato	Researcher (LIP)	37
Pedro Rodrigues	PhD student (LIP/FCT)	100
Rui Moura	PhD student (LIP)	100
Rui Ribeiro	Researcher (LIP)	50
Sérgio Ramos	Researcher (LIP)	5

Summary:

The global engineering design of the PET-mammography scanner is concluded. First prototypes of the final detector module were built and experimentally validated. Quality assurance tests of 200 detector modules proceeds now at full speed. The design of the frontend ASIC was concluded and a first prototype was received. A second submission of a test ASIC was required and was done end February. The design of the data acquisition system was also concluded, the electronic boards were produced and are now under test. Detailed simulations allowed the development of online trigger algorithms. The engineering design of the PEM detector heads, cooling system and PEM robot is concluded, parts are produced or acquired. The first complete assembly of the PEM robot was done successfully. Detailed simulation work allowed to validate the image reconstruction software and assess the expected tumor detection sensitivity.

Background and overall project status:

The project was officially started the 1st January 2003. However due to initial resistances the financing contract was signed in July 2003. Funding difficulties delayed the start of critical parts of the project, namely the ASIC project, which was initiated in September 2003.

The first year of the project was dedicated to the development of the detector concept and to prove the basic principles by simulation and experimental measurements. In the second year the design of scanner was developed, including the detector heads, the front-end electronics, the data acquisition systems, the mechanical gantry and the image reconstruction and visualization software. Detailed simulation work followed the whole development allowing to assess the expected image performance. Acquisition of scanner components, construction, testing and quality control of the various sub-systems was carried out during the third year of the project. The fourth year is being dedicated to the final scanner assembling and testing before initiating the clinical trials.

System conceptual design, simulation studies and experimental proof of basic principles were concluded in 2003, confirming the possibility of obtaining spatial resolution of the order of a millimeter (LIP). The development of the Detector Module design was done in 2004 (LIP, INEGI) and the experimental validation was done in the new laboratory infrastructure TagusLIP created in 2004 for the development of nuclear medicine equipment.

The work done in 2003-04 allowed to submit a national patent request of the PET system in September 2004. In September 2005 an international (PCT) patent request was submitted as well.

The production of all the required scintillating crystals (~6200) needed for the assembly of 200 Detector Modules was concluded in 2005. In July 2005 the

production of the 400 avalanche photodiode arrays (APD arrays) integrating the detection system was concluded at Hamamatsu. The detector module boxes were produced and the first modules produced and tested. The measured performance confirms the expectations and the production quality. Three independent test systems were developed and installed at TagusLIP and are being used in detector quality control.

The projects of the PET Detector Heads, of the Cooling System and of the PET Robot were concluded (INEGI). The components of the Robot were acquired and fabricated. The thermal simulation of the Detector Head was concluded. The production of parts and assembly of the Detector Heads will follow.

The non-conventional geometry of the PET-mammography system obliged to develop dedicated image reconstruction algorithms. This work is basically concluded (IBEB, INEGI). The algorithms were validated using data from a detailed simulation of the detector system (LIP). Studies of tumor detectability were performed showing images of millimetric tumors with good visibility (LIP, IBEB, HGO). The first version of the scanner operating software, including event reconstruction and online trigger, of the online databases and of the software for visualization, manipulation and storage of images are already available.

The innovations in the electronics systems (signal processing analog electronics and digital data acquisition electronics) are critical for the final system performance. It is a complex project with multiple components involving four research teams (INOV, INESC-ID/Analog systems, INESC-ID/Digital systems, LIP) that is taking longer to develop than initially expected. As a consequence of the initial R&D effort, a deep revision of the system architecture was required in 2004 to fulfill the overall system requirements.

The engineering project of the digital trigger and data acquisition system was concluded and prototypes of the different system boards were produced. The firmware of the data acquisition boards was fully developed, integrated in the hardware and tested successfully. The board interfacing to the operation PC was also produced and is now being tested. Firmware for this board is in the final development stage.

The frontend ASICs are responsible to process the electrical pulses generated by around 12000 detection elements. These are very small pulses (a few tens femto-coulomb) that need to be amplified, sampled and selected by very low-noise state-of-the-art integrated electronics. The chips are fabricated in CMOS 0.35μm technology by the AMS company. The first test chip was fabricated in February 2005. Large parts of the circuit were functioning properly, however the amplifier didn't perform as expected.

In September 2005 the Consortium signed a consultancy contract with a world-wide recognized expert in frontend ASICs. This decision implied a full revision of the ASIC design which delayed the submission of the second test system. A test chip with few channels is now being submitted for fabrication. A substantially more robust design is now achieved and the team is highly confident about the success of the ASIC V2.

The delay in the ASIC sub-project is now affecting the overall schedule of the project. Nevertheless the Consortium is taking all possible steps to minimize the delays aiming at a fully assembled PET system in 2006.

Detailed report:

Simulation and reconstruction studies:

- The PEM simulation infrastructure developed at LIP was completed. The detailed simulation of the detector and electronics system confirmed the expected scanner performance (sensitivity 0,04 cps/Bq, space resolution 1-2 mm, random coincidences <30%). Image reconstruction of the detailed simulation data showed a resolution of 1.4 mm for a centered point source and of 1.7 mm for a source 2.5 cm off center. Detailed studies of the trigger and data acquisition efficiency and performance were concluded.
- At IBEB, new image reconstruction algorithms were studied and implemented (ART, MLEM and OSEM) and its performance compared. Both 2D, including Fourier rebinning techniques, and 3D algorithms were studied.
- A new image visualization tool was developed at IBEB.
- Monte-Carlo simulation methods were used at LIP to estimate the sensitivity correction of the images, allowing removal of scanner induced image artifacts.

Detector design, prototyping and construction:

- The mechanical and electrical design of the basic detector module was concluded. The module includes a matrix of 32 crystals and two APD-arrays at the two ends. The first prototypes were built and evaluated at TagusLIP. The measured DoI resolution is 2 mm (FWHM) compatible with expectations based on previous measurements.
- Under LIP leadership, the Crystal Clear Collaboration signed a frame contract with Hamamatsu for the production of APDs arrays S8550SPL. An order of 400 arrays for the PEM scanner was placed. The full production was delivered.
- The APD arrays follow a dedicated quality control protocol implemented at TagusLIP. This include the measurement of the mechanical properties, the measurement of dark current and gain as a function of bias voltage, and the measurement of individual pixels relative gain. Two dedicated setups are used in these measurements. The full production (400 arrays) is already tested confirming the good quality of the Hamamatsu APDs.
- The Crystal Clear Collaboration signed a frame contract with Photonic Materials for the production of LYSO and LuAP crystals. Under this contract LIP already acquired the 6300 LYSO crystals needed for the PEM scanner.
- The quality control of the crystal pixels was done on a sampling basis (~10% of the full production) and is now concluded. It included the measurement of the crystal surface roughness, and the measurement of the crystal light yield and energy resolution. This work was done at CERN using the miniACOS machine.
- Two different methods of assembling the crystal matrices (Tyvek and BaSO4 reflectors) were investigated. The BaSO4 matrices assembled by Sinocera, China, showed better performance and were adopted. A first batch of 24 matrices was produced and tested at TagusLIP to confirm the quality. The batch with the remaining 170 crystal matrices was delivered in March and is now under test.

- The equipment needed for the production, assembling and quality control of the detector modules was installed at TagusLIP. This includes an optical system and an automatic gluing robot to mount the APD arrays. The quality control system includes two independent electronics and data acquisition setups for measurement of the APDs and of the final detector modules.
- A total of 165 APD arrays ware glued to the dedicated connecting PCBs, allowing full validation of the APD gluing procedure.
- A special mechanical jig prototype that guaranttees the correct APD-PCB alignment in the gluing process was developed and fabricated at INEGI.
- The assembling of 24 Detector Modules was concluded, using the dedicated module boxes built at INEGI by stereolitography method.
- The Detector Modules were for the first time integrated with the front-end electronics boards in a Detector Supermodule. This integration confirmed the mechanical robustness of the system. Electrical tests confirmed that the distribution of a large number of bias voltage lines to the APD arrays is working properly.
- Collaboration between LIP and ITN, Sacavém, was established to use the ITN Nuclear Reactor to produce positron emitters and other sources needed for the experimental work at TagusLIP. A Fe-55 X-ray source was already produced.

Electronics Systems and Software:

- The architecture of the electronics systems was reviewed in July 04 in order to reduce the interconnections to the FrontEnd and to use digital links with better reliability. The new system has larger power consumption in the frontend, which implied the need for a more sophisticated cooling system.
- The first version of the frontend ASIC (ASIC V1) was tested in the first part of 2005. These tests showed that the control logic and the fast analog memories are functioning according to specifications. However a problem was identified in the bias regulation circuit of the front-end amplifier.
- The difficulty of the ASIC project and impact that its development has in the overall project motivated special measures taken by the Consortium. A dedicated ASIC review with the project team and a review committee with five world-wide experts took place at CERN in June 2005. The findings of the committee confirmed the soundness of the design but highlighted a number of points were careful attention should be placed. In September 2005 a recognized expert on detector frontend ASICs accepted a consultancy contract to follow the remaining part of the project. The consultant is working in close connection with the project team. The new prototype ASIC (ASIC V2) submitted in February has substantial modifications relative to first chip. A substantially more robust design is now achieved and the team is highly confident about the success of the ASIC V2.
- The design and simulation of the FPGAs DAQ and Trigger/DCC was concluded at INESC-ID. Additional work was pursued to include self-test features in the system, which was concluded for DAQ and almost concluded for Trigger/DCC. The implementation of the DAQ trigger algorithms was validated by a bit-to-bit comparison with the results of a functional simulation developed at LIP.

- The design of the crate backplane buses and of the DAQ and TRG/DCC boards was concluded at INOV. The DAQ board was produced and the tests are concluded successfully. The second board, the Trigger and Data Concentrator board, was already produced and is now under test. Final design of the PCI FPGA is well advanced. The fast link to the data acquisition PC (Star Fabric) was received.
- The first prototypes of the front-end electronic board were produced (10 boards). These boards were used for mechanical tests and validation of the bias voltage distribution scheme in the Detector SuperModule. The same boards equipped with dissipation resistors will be used for tests of cooling system in the near future, using built-in temperature sensors.
- A second prototype of the front-end electronics board to be used with ASIC V2 was designed and will be sent to production soon.
- A prototype of the front-end service board (HV regulation, temperature monitoring, pressure monitoring, low-voltage distribution, clock distribution, etc.) was developed and tested successfully by LIP. The final service board is now being designed. The final matrix board providing bias voltage interconnectivity was produced and tested. The high-voltage crate system was ordered and is already received. The low-voltage power supplies were selected and ordered.
- The architecture of the on-line software was defined at IBILI. A first version of the data acquisition tool was implemented. The communication protocols were defined, allowing interfacing to the event reconstruction, monitoring and database software already implemented at LIP.

Mechanical, Electro-Mechanical and Cooling Systems:

- The mechanical project of the Detector Modules boxed was concluded at INEGI and prototypes were produced and tested successfully. The design provided a precision of 0.1 mm in the relative positioning of crystal and APD pixels. Forty-eight boxes were fabricated at INEGI.
- The mechanical design of the Detector Supermodule integrating the frontend electronics boards was also concluded. The mechanical validation was done proving the robustness of the assembly.
- A thermal simulation of the PEM detector box was done at INEGI. This study was complemented by the measurement of the heat conductivity of APDs and crystals performed at LIP-Algarve. The design of the water based cooling system was concluded by INEGI.
- The mechanical design of the detector head, including the cooling cold plates and water circuits, is now concluded. The fabrication of parts is being prepared.
- The design of the PEM manipulator was concluded at INEGI. The production drawings are done and the parts were fabricated. Motors, axis and other components were received.A complete assembly of the robot was already achieved. Tests are under way.
- The robot control system is based on a commercial solution. The system was ordered and is being installed.

Patents:

Patent request nb 103200 at Portuguese Patent Office, 30-09-2004, “Sistema de tomografia por emissão de positrões (PET)”. International patent (PCT) requested in September 2005.

Publications:

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

- *"Clear-PEM: A dedicated PET camera for improved breast cancer detection",*
  M. C. Abreu, P. Almeida, F. Balau, N. C. Ferreira, S. Fetal, F. Fraga, M. Martins, N. Matela, R. Moura, C. Ortigão, L. Peralta, P. Rato, R. Ribeiro, P. Rodrigues, A. I. Santos, A. Trindade and J. Varela,
  Radiation Protection Dosimetry (2005), Vol. 116, No. 1–4, pp. 208–210.
- *"A PET imaging system dedicated to mammography",*
  J. Varela,
  Accepted for publication in Radiation Physics and Chemistry (in press) *(accepted)*.
- *"Desing and Evaluation of the Clear-PEM Scanner for Positron Emission Mammography",*
  PET-Mammagraphy Consortium (LIP authors: M. C. Abreu, B. Carriço, M. Ferreira, P. R. Mendes, R. Moura, C. Ortigão, L. Peralta, R.Pereira, R. Ribeiro, P. Rodrigues, J. C. Silva, P. Sousa, , A. Trindade and J. Varela),
  Accepted for publication in Transaction on Nuclear Science *(accepted)*.
- *"The Clear-PEM Electronics System",*
  E. Albuquerque, P. Bento, C. Leong, F. Gonçalves, J. Nobre, J. Rego, P. Relvas, P. Lousã, P. Rodrigues, I. C. Teixeira, J. P. Teixeira, L. Silva, M. Medeiros Silva, A. Trindade and J. Varela,
  Accepted for publication in Transaction on Nuclear Science *(accepted)*.
- *"Performance Simulation Studies of the Clear-PEM DAQ/Trigger System",*
  P. Rodrigues, P. Bento, F. Gonçalves, C. Leong, P. Lousã, J. Nobre, J. C. Silva, L. Silva, J. Rego, P. Relvas, I. C. Teixeira, J. P. Teixeira, A. Trindade and J. Varela,
  Accepted for publication in Transaction on Nuclear Science *(accepted)*.

International Conference Proceedings:

- *"FPGA Based Architecture for the Data Acquisition Electronics of the Clear-PEM System",*
  J. Varela, P. Bento, C. Leong, I. C. Teixeira, J. P. Teixeira, J. Nobre, J. Rego, P. Lousã, P. Relvas, P. Rodrigues, A. Trindade,
  International Workshop on Applied Reconfigurable Computing (ARC 2005).
- *"Design and Test of a Reconfigurable Data Acquisition Electronics System for Medical Imaging using PEM",*
  P. Lousã, P. Relvas, P. Rodrigues, A. Trindade, J. Varela, P. Bento, C. Leong, J. P. Teixeira, I. C. Teixeira,
  8th IEEE Workshop on Design and Diagnostics of Electronic Circuits and Systems (DDECS 2005).
- *"Comparison of Different Image Reconstruction Strategies in Clear-PEM",*
  N. Matela, A. Trindade N. C. Ferreira, M. V. Martins P. Rodrigues, N. Oliveira, J. Varela, P. D. Almeida,
  Second International Conference on Computational Intelligence in Medicine and Healthcare, The BIOPATTERN Conference.

- *"Design and Test Methodology for a Reconfigurable PEM Data Acquisition Electronics System",*
  C. Leong, P. Bento, P. Rodrigues, A. Trindade, J. C. Silva, P. Lousã, J. Rego, J. Nobre, J. Varela, J. P. Teixeira, I. C. Teixeira,
  15t International Conference on Field Programmable Logic and Applications, FPL05.
- *"Breast Cancer Imaging Studies by Monte Carlo Simulation with Clear–PEM",*
  Andreia Trindade, Pedro Almeida, Nuno C. Ferreira, Mónica V. Martins, Nuno Matela, Nuno Oliveira, Pedro Rodrigues, and João Varela,
  IEEE-Medical Imaging Conference, 2005.
- *"Reconstruction of Clear-PEM data with STIR",*
  Mónica V. Martins, Nuno Matela, Pedro Rodrigues, Andreia Trindade, Nuno Oliveira, Marta Correia, Hugo Cordeiro, Nuno C. Ferreira, João Varela and Pedro Almeida,
  IEEE-Medical Imaging Conference, 2005.
- *"First Experimental Results with the Clear–PEM Detector",*
  PET-Mammography Consortium (LIP authors: M. C. Abreu, P. Amaral, B. Carriço, M. Ferreira, P. R. Mendes, R. Moura, C. Ortigão, L. Peralta, R. Ribeiro, P. Rodrigues, J. C. Silva, A. Trindade and J. Varela),
  IEEE-Medical Imaging Conference, 2005.
- *"Design and Test Methodologies for High Complexity FPGA based Systems",*
  P. Bento, C. Leong, P. Rodrigues, A. Trindade, J C. Silva, J. Nobre, J. Rego, P. Lousã, I. C. Teixeira, J. P. Teixeira, J. Varela,
  DCIS'05 XX Conference on Design of Circuits and Integrated Systems, 2005.

National Conference Proceedings:

- *"Reconfigurable Design of a Clear-PEM Data Acquisition Electronics Subsystem",*
  J. Varela, P. Bento, C. Leong, I. C. Teixeira, J. P. Teixeira, J. Nobre, J. Rego, P. Lousã, P. Relvas, P. Rodrigues, A. Trindade,
  Jornadas sobre Sistemas Reconfiguráveis (REC 2005).

Communications:

Oral presentations in international conferences:

- *"Performance Simulation Studies of the Clear-PEM DAQ/Trigger System",*
  presented by Pedro Rodrigues
  at 14th IEEE-NPSS Real Time Conference 2005 in Stockholm.
- *"A PET imaging system dedicated to mammography",*
  presented by João Varela
  at 8th International Workshop on Positron and Positronium Chemistry in Coimbra.
- *"Experimental characterization of the ClearPEM Detector Module",*
  presented by Rui Moura
  at European Physical Society, 19th Nuclear Physics Divisional Conference, New Trends in Nuclear Physics Applications and Technology in Pavia, Itália.
- *"Clear-PEM: The dedicated PET device for early breast cancer detection",*
  presented by Catarina Ortigão
  at Forum PET in Galiza.

Poster presentations in international conferences:

- *"First Experimental Results with the Clear–PEM Detector",*
  presented by João Varela
  at IEEE-Medical Imaging Conference, 2005 in Puerto Rico, USA.
- *"Breast Cancer Imaging Studies by Monte Carlo Simulation with Clear–PEM",*
  presented by Andreia Trindade
  at IEEE-Medical Imaging Conference, 2005 in Puerto Rico, USA.

Presentations in national conferences:

- *"ClearPEM, um novo detector PET dedicado a mamografia",*
  presented by Pedro Amaral
  at X Congresso Nacional de Medicina Nuclear in Lisboa.

Oral presentations in collaboration meetings:

- *"Measurments of the PEM Detector Modules",*
  presented by Catarina Ortigão
  at Crystal Clear Collaboration Meeting in CERN.
- *"ClearPEM development status",*
  presented by João Varela
  at Crystal Clear Collaboration Meeting in CERN.
- *"Overview of the ClearPEM development status",*
  presented by João Varela
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"ClearPEM software trigger and databases",*
  presented by Pedro Rodrigues
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Monte-Carlo estimation of sensitivity correction in ClearPEM",*
  presented by Andreia Trindade
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Overview of the experimental program at TagusLIP",*
  presented by Pedro Amaral
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Performance measurements of ClearPEM Detector Modules",*
  presented by Rui Moura
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Measurement of cross-talk in ClearPEM Detector Modules",*
  presented by Catarina Ortigão
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Quality control of APDs for ClearPEM",*
  presented by Bruno Carriço
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Estimation of ClearPEM counting rates",*
  presented by Andreia Trindade
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.
- *"Performance analysis of the Clear-PEM hardware and software trigger",*
  presented by Pedro Rodrigues
  at Crystal Clear Collaboration Meeting in Museu da Ciência, Lisboa.

Seminars:

- *"ClearPEM, um sistema de imagem PET dedicado a Mamografia",*
  presented by João Varela

at Conferência Física, Tecnologia e Saúde - FiTS2005 in Escola Superior Tecnologia da Saúde, Lisboa.

- *"PET Project Status and Plans",*
  presented by João Varela
  at Jornadas LIP 2005 in Peniche.
- *"Overview of Activities at TagusLIP",*
  presented by Pedro Amaral
  at Jornadas LIP 2005 in Peniche.

Academic Training:

PhD Theses:

- *"Avaliação do desempenho de um detector PET dedicado a mamografia",*
  Andreia Trindade, (on-going)
- *"Modelização e avaliação do desempenho do sistema de aquisição de dados de um detector PET para mamografia",*
  Pedro Rodrigues, (on-going)
- *"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:

- *"Controlo de qualidade dos módulos de detecção de um detector PET para mamografia",*
  Bruno Carriço, (on-going)

Graduation Theses:

- *"The study of energy auto-calibration of a PEM detector with Lu-based crystals",*
  Joke Bikkembergs, 2005-05-31
- *"Experimental Characterization of the APD arrays of the ClearPEM detector modules",*
  Joan Luyken, (on-going)

Events:

- *"Crystal Clear Collaboration Meeting",*
  Collaboration Meeting, Museu da Ciência, Lisboa, Portugal, 2005-10-03

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**5**
International Conference Proceedings	**8**
National Conference Proceedings	**1**
Oral presentations in international conferences	**4**
Poster presentations in international conferences	**2**
Presentations in national conferences	**1**
Oral presentations in collaboration meetings	**11**
Seminars	**3**
Graduation Theses	**1**
Collaboration Meetings	**1**

Project Title: Human PET

Resumo:

As Câmaras de Placas Resistivas para medida de tempos foram desenvolvidas conjuntamente pelo INFN-Bolonha, CERN, ITEP-Moscow e LIP-Coimbra no decurso da fase de R&D da experiência ALICE no CERN/LHC. Desde então o LIP-Coimbra tem procurado activamente aplicar esta tecnologia em experiências de HEP, no CERN e no GSI, tendo igualmente considerado aplicações em "imagiologia de radioisótopos". Com base nos resultados dum projecto anterior, propomos aqui estudar a viabilidade da aplicação da técnica de "RPC TOF-PET" com vista a aumentar a sensibilidade dos exames de PET humano de corpo inteiro por uma ordem de grandeza. Muitos aspectos de reconstrução de imagem devem ainda ser estudados antes de qualquer tentativa de construção dum tomógrafo de corpo inteiro utilizando esta técnica. Uma forma produtiva de iniciar tal projecto será o desenvolvimento dum PET para pequenos animais utilizando a mesma tecnologia, e relativamente ao qual trabalhos prévios de simulação fazem esperar a excelente resolução em posição de 0,4 mm FWHM. Um protótipo anterior demonstrou já, aliás, uma resolução de 0,6 mm FWHM sem qualquer tratamento de imagem. Tanto quanto sabemos, esta é a melhor resolução de PET alguma vez publicada. A equipa planeia explorar um tal instrumento e estimar o seu potencial máximo, iniciando o trabalho pelo estudo da estrutura do detector e da electrónica de leitura para um tomógrafo que possa ser usado para investigação biomédica.

Funding:

Code	Funding	Start	End
POCI/SAU-OBS/61642/2004	47.160 €	2005-01-01	2007-12-31

Team:

Project Coordinator: João Lima

Team Members:

Name	Status	% of time in project
Alberto Blanco	Technician (LIP)	20
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
Jorge Sousa	Researcher (ISEC)	20
José Pinhão	Technician (LIP)	10
Luís Lopes	Technician (LIP)	5
Nuno Carolino	Technician (LIP)	10
Nuno Fonseca	Researcher (IBILI)	10
Paulo Fonte	Researcher (LIP/ISEC)	10
Rui Marques	Researcher (LIP/FCTUC)	5

Summary of the Activities:

The main goal of this project, formally started on the 1st January 2006 (first funds received in September only), is to assess the feasibility of a large size (whole-body) PET scanner based on RPC detectors. The project, carried on in collaboration with researchers of the Physics Department (ADDF) and of the School of Medicine (IBILI), University of Coimbra, consists of tasks, more or less independent at the present stage, whose advancements are summarised below.

i) Development of RPC detectors for large-area gamma imaging (LIP)

The first prototype was designed, based on previous simulation work. The search for the appropriate electrodes was initiated with experimental measurements on candidate materials being made – the first one was soda lime glass. The mechanical parts necessary for assembling the first prototype of an RPC-PET head are in production. This head consists of 10 RPC-PET units staked together, each one made of six glass plates (50x50x0.4 mm) with 0.2 mm spacing, defining 5 gaps filled with gas. Each gap has a sensitive volume of 48x48x0.2 mm3. The first signals of the prototype are expected to be obtained soon.

Measurements carried out on a previous RPC module indicate that, both in terms of dark current and background rate, a good detector performance will be achieved. The detection efficiency, the reference parameter for this type of device, was measured with that module. Although the results were slightly lower than expected, such difference could be recovered with the new acquisition electronics that is being developed.

ii) Data acquisition electronics (ADDF)

Study of data acquisition architecture is under development, with two major architectural guidelines: 1) use of high speed ADCs with serialized LVDS outputs combined with 2) last generation SerDes devices for 10 Gbps data transfer rates – preferably on copper.

iii) Simulation of a very large axial Field-Of-View PET scanner based on RPCs (LIP + IBIL)

Simulations are being performed using GEANT4. The PET scanner geometry was defined and other geometries are also being considered. The RPC detector is being parameterized in order to increase the speed of the simulations. To accomplish this task, simulations of penetration of medium and low energy electrons on dense materials were run and successfully compared with published experimental data.

The detection efficiency of the RPC stack is being simulated and an analytical model is under development. Preliminary results are in good agreement with the experimental data. Some test phantoms, based on the standard PET performance measurements NEMA NU-2 2001, are being used to compare the performance of the simulated scanner with that of existing PET scanners. Some routines for data analysis have also been developed.

iv) Image Reconstruction and Data Corrections for large axial Field -Of-View Scanners (IBILI)

Simulations were performed using the emission tomography simulation package SimSET, with the goal of understanding the geometrical corrections involved when rotating objects, possibly not accurately centered, are placed in the Field Of View (FOV) of the existing functional PET-RPC prototype. This step is required for subsequent measurements with larger objects, emulating a full-ring scanner. A method of correction was developed.

Software for displaying and defining PET data organization and compression schemes ("Michelograms") was implemented for scanners with a large axial FOV. Data compression schemes are being investigated, as well as reconstruction methods based on list-mode data. Ways of efficiently producing datasets with the purpose of testing three-dimensional image reconstruction algorithms for a large axial FOV scanner are also being developed. The feasibility of integrating the scanner with other imaging techniques is being investigated.

Communications:

Oral presentations in international conferences:

- *"High resolution PET with Resistive Plate Chambers",*
  presented by Paulo Fonte
  at 8th International Workshop on Positron and Positronium Chemistry in 4 - 9 September, 2005, Coimbra, Portugal.

Project Statistics

	number
Oral presentations in international conferences	**1**

Project Title: Monte Carlo Methods Applied to dosimetry in medical radiologic exposures

Resumo:

Um exemplo paradigmático da utilização da simulação Monte Carlo é o da Radioterapia Externa, onde grandes benefícios podem ser alcançados com a utilização destas técnicas. A simulação Monte Carlo pode ajudar uma determinação mais rigorosa das doses efectivamente fornecidas ao volume tumoral, contribuindo desta forma para um combate mais eficaz do cancro. Mas a radioterapia não é a única área de aplicação. Outras técnicas que utilizam radiações ionizantes podem beneficiar dum cálculo de doses mais rigoroso, usando as técnicas de simulação Monte Carlo.

Juntamente com as simulações MC, este projecto participa no desenvolvimento e construção de um protótipo de um detector híbrido para radiação gama para ser utilizado em aplicações médicas.

Funding:

Code	Funding	Start	End
POCTI/FP/FNU/20129/2003	10.000 €	2004-07-04	2005-12-31
POCTI/FNU/50127/2003	20.000 €	2004-09-01	2005-08-31
POCI/FP/63448/2005	36.000 €	2005-09-01	2006-08-31

Team:

Project Coordinator: Luis Peralta

Team Members:

Name	Status	% of time in project
Adérito Chaves	Researcher (IPO-Coimbra)	63
Amélia Maio	Researcher (LIP/FCUL)	2
Ana Catarina Farinha	Undergraduate student (LIP)	33
Ana Maria Pinto	Master student (FCUL)	13
Andreia Trindade	PhD student (LIP/FCT)	50
Bernardo Tomé	Researcher (LIP/FCT)	10
Carla Oliveira	Researcher (IPO-Coimbra)	57
Catarina Espírito Santo	Researcher (LIP)	10
Conceição Abreu	Researcher (LIP/UALG)	20
Enrico D'Abramo	Researcher (LIP)	5
Florbela Rego	PhD student (LIP)	30
João Gentil	Student (LIP/FCUL)	2
José Coucelo Martins	Researcher (*)	7
Luis Peralta	Researcher (LIP/FCUL)	75
Marco Quinteiro	Researcher (*)	33
Margarida Fragoso	Student (LIP)	53
Maria do Carmo Lopes	Researcher (IPO-Coimbra)	40
Maria dos Anjos Neves	Researcher (ITN)	7
Marília Pedrosa	Researcher (*)	7
Patrícia Gonçalves	Researcher (LIP/FCT)	10
Patrick Sousa	PhD student (LIP)	33
Pedro Rato	Researcher (LIP)	18
Pedro Rodrigues	PhD student (LIP/FCT)	50

Rui Moura	PhD student (LIP)	25
Sandra Brás	Master student (LIP)	100
Sandra Soares	PhD student (LIP)	92
Sónia Rodrigues	Master student (LIP)	67
Zita Lopes	Student (LIP)	25

(*) Hospital Particular do Alvor, Hospital do Litoral Alentejano, Siemens-medical solutions

Summary of the Activities:

Monte Carlo simulation of the Varian Clinac 600c accelerator with dynamic wedges

The advent of linear accelerators (linac) with computer-controlled dynamic collimation systems and functional and anatomical imaging techniques allowed a more exact delimitation and localisation of the target volume. These advanced treatment techniques inevitably increase the complexity level of dose calculation because of the introduction of the temporal variable. On account of this, it is mandatory the usage of more accurate modelling techniques of the collimator components, as it is the case of Monte Carlo (MC) simulation, which has created an enormous interest in research and clinical practice.

Because the patients bodies are not homogeneous nor are their body surfaces plane and regular, the dose distribution may differ significantly from the standard distribution from the linac calibration. It is in the treatment planning systems, which include algorithms that are usually measured in homogeneous water phantoms specific for each correction that the dose distributions from each case are obtained. In a real treatment, exception made to superficial lesions, two or more radiation fields are used in order to obtain the recommended dose distributions. The simplest arrangement is made from two parallel and opposed fields that originate a homogeneous dose distribution in almost all the irradiated volume. The available resources are, for example, different types of energies and of radiation, the application of bolus, the protection of healthy structures, the usage of wedged filters and the application of dynamic wedges. A virtual or dynamic wedge, modelled through the movement of one of the jaws, when compared with a set of physical wedges offers an alternative calculation method of an arbitrary number of wedged fields, instead of the four traditional fields of 15º, 30º, 45º and 60º angle and obtained with physical wedges.

The goal of this work consists in the study of the application of dynamic wedges in tailoring the radiation field by the Varian Clinac 600C linac. For such, the influence of the virtual wedge on a 4 MV photon beam, produced by the Varian Clinac 600C linac, was studied using the MC codes GEANT3 and DPM.

Experimental validation of a gamma camera Monte Carlo study

In this work we have studied a Siemens E.Cam Duet gamma camera [1] with the aim of improving the current understanding of the operation of existing systems and contribute to the development of new and better detectors for medical imaging with ionizing radiations. This camera is presently used in SPECT (Single Photon Emission Computed Tomography) and planar imaging in Nuclear Medicine.

The gamma camera considered in this work was simulated using the GEANT4 code, which allows a complete Monte Carlo treatment of all physical interactions involved, from the production of initial gamma rays to the generation and tracking of optical photons originated by scintillation inside the crystal.
The simulated camera consists of a doped NaI(Tl) scintillation crystal, a Low Energy High Resolution (LEHR) collimator and an array of photomultipliers.

The source considered in this work is a Tc-99m isotropic source emitting 140 keV photons within a solid angle adjusted to the geometry. The position, momentum, energy, angular distribution and number of events are adjusted by the user at the beginning.

There are several types of collimators available for the Siemens E.Cam Duet, but only the LEHR was simulated because it is the one used with Tc-99m and other low energy sources. This collimator features parallel holes with hexagonal cells separated by thin septa.

The crystal within the gamma camera is a monolithic 44.5 x 59.1 cm^2 NaI(Tl) with 9,5 mm thickness to allow complete absorption of 140 keV photons. This scintillator a light yield of 40000 optical photons per MeV of energy deposited. The GEANT4 code allows a realistic description of optical photon transport, reflection and refraction.

The light generated by scintillation in the NaI(Tl) crystal is read by a matrix of photomultiplier (PM) tubes. The position of each incident gamma ray is calculated by determining the centroid of the distribution of the light collected by each PM, taking into account such details as individual PM position inside the camera and quantum efficiency for optical photons.

Comparison between Monte Carlo and experimental measurements have been made for a 5 mm diameter spherical source placed at 5 cm distance from the collimator (LEHR) in the center of the FOV. In the simulation 500000 events within a solid angle of 20º were considered for a measured source activity of 18.6 MBq. In this example, the difference observed between simulation and experiment, probably is due to different counting statistics. Other examples with extended sources and radiological phantoms will be studied.

[1] Siemens Medical webpage. (Apr, 2005). Available from:
http:// www.siemensmedical.com

Dosimetry in radiology

One of the basic principles of the system of radiological protection of the ICRP is the principle of the optimization, being that the responsible medical doctor for the exposition and the technician who executes it, must be sure that all the exposition for medical purposes, are kept as low as possible, having in account the intended information of diagnosis.

According to the present Portuguese legislation, in the scope of the radiological expositions, the installation responsible must assure the establishment of recommendations about the radiation doses that patients receive and to assure their

availability to the medical doctor who prescribes the examination. The installation responsible must also assure that the expositions are in agreement with the reference levels for radio-diagnostic examinations, considering the European levels of diagnosis reference, when they exist (97/43/EURATOM). The aim of this work is to establish a protocol of dose measurement received by patients in radiology in order to determine the "levels of reference" of diagnosis for some of the carried out radio-diagnosis examinations at IPOFG-CROC, S.A..

Publications:

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

- *"A NEW LOW-ENERGY BREMSSTRAHLUNG GENERATOR FOR GEANT4",*
  L. Peralta, P. Rodrigues, A. Trindade and M. G. Pia,
  Radiation Protection Dosimetry (2005), Vol. 116, No. 1–4, pp. 59–64.

International Conference Proceedings:

- *"Monte Carlo simulation and experimental validation of a Gamma Camera",*
  S. Rodrigues, M. Abreu, P. Rato, B. Tomé, N. Santos, M. Pedrosa,
  IPEM Annual Scientific Meeting & IBEX 2005 Exhibition, Glasgow 2005, UK.
- *"Comparison between simulated and measured skin doses applied to PET",*
  Z. Lopes-Kellomaki, J Gentil, A. Maio,
  Radiation and Oncology 76 Suppl.2 (2005) S152.
- *"Interstitial Brachytherapy Breast implants, planning and optimization",*
  C. Alves, M Lopes, M. Fragoso,
  Radiation and Oncology 76 Suppl.2 (2005) S32.
- *"TG43 and TG43U1-based dose calculations for I-125 brachytherapy seeds",*
  M. Fragoso, C. Alves, M. Lopes,
  Radiation and Oncology 76 Suppl.2 (2005) S26.

National Conference Proceedings:

- *"Dosimetria do Paciente em Radiologia no IPOFG-CROC, S.A",*
  S. Brás, M.C. de Sousa e M.C. Lopes,
  I Jornadas Luso Brasileiras de Protecção contra Radiações e XI Jornadas Portuguesas de Protecção contra Radiações.
- *"Fisica das radiações Aplicada à Fisica Medica",*
  M.C. Abreu, B Carriço, J Costs, M Quinteiro, P Rato Mendes, S Rodrigues e P Sousa,
  14ª Conferencia Nacional de Física.
- *"Aplicação do Método de Monte Carlo em Radioterapia no IPOFG-CROC, S.A.",*
  A. Chaves, M.C.Lopes, L. Peralta, C. Oliveira, P. Rodrigues, S. Moreno, A. Trindade, M. Fragoso,
  14ª Conferencia Nacional de Física, pp. 199-200.
- *"Da Física das Radiações à Física Médica",*
  L. Peralta, A. Maio, C. Ortigão, P. Rodrigues, S. Soares, A. Trindade, Z. Lopes Kellomaki, C. Alves, A. Chaves, M.C.Lopes,
  14ª Conferencia Nacional de Física, pp 210-211.

Communications:

Oral presentations in international conferences:

- *"TG43 and TG43U1-based dose calculations for I-125 brachytherapy seeds",* presented by Margarida Fragoso
  at 8th Biennial ESTRO Meeting on Physics and Radiation Technology for Clinical Radiotherapy in Lisboa.

Poster presentations in international conferences:

- *"Monte Carlo simulation and experimental validation of a Gamma Camera",* presented by Sónia Rodrigues
  at IPEM Annual Scientific Meeting & IBEX 2005 Exhibition in Glasgow.
- *"Comparison between simulated and measured skin doses applied to PET",* presented by Zita Lopes
  at 8th Biennial ESTRO Meeting on Physics and Radiation Technology for Clinical Radiotherapy in Lisboa.
- *"Interstitial Brachytherapy Breast implants, planning and optimization",* presented by
  at 8th Biennial ESTRO Meeting on Physics and Radiation Technology for Clinical Radiotherapy in Lisboa.

Presentations in national conferences:

- *"Radiocirurgia no IPOFG-CROC: passado, presente e futuro",* presented by Adérito Chaves
  at Painel: A Física Médica em Portugal in Auditório do IPOFG-CROC, S.A, Coimbra.
- *"Braquiterapia Intersticial guiada por imagens",* presented by Carla Oliveira
  at Painel: A Física Médica em Portugal in Auditório do IPOFG-CROC, S.A, Coimbra.
- *"Dosimetria do Paciente em Radiologia no IPOFG-CROC, S.A.",* presented by Sandra Brás
  at I Jornadas Luso Brasileiras de Protecção contra Radiações in Lisboa.
- *"Fisica das radiações Aplicada à Fisica Medica",* presented by Sónia Rodrigues
  at 14ª Conferencia Nacional de Física in Porto.
- *"Aplicação do Método de Monte Carlo em Radioterapia no IPOFG-CROC, S.A.",* presented by Maria do Carmo Lopes
  at 14ª Conferencia Nacional de Física in Porto.
- *"Da Física das Radiações à Física Médica",* presented by Luis Peralta
  at 14ª Conferencia Nacional de Física in Porto.

Academic Training:

PhD Theses:

- *"Simulação Monte Carlo do Campo de Radiação Produzido por um Acelerador Linear Varian Clinac 600C usando Cunhas Dinâmicas",* Sandra Soares, (on-going)

- *"Desenvolvimento de um detector de alta resolução para imagem médica com radiações ionizantes",*
  Patrick Sousa, (on-going)
- *"Estudo e desenvolvimento de uma câmara PET com fins didácticos",*
  Florbela Rego, (on-going)

Master Theses:

- *"Simulação de uma câmara gama",*
  Sónia Rodrigues, (on-going)
- *"Dosimetria de paciente em radiologia, no IPOFG-CROC,S.A.",*
  Sandra Brás, (on-going)
- *"O estudo das Radiações Ionizantes no 3º ciclo do Ensino",*
  Marco Quinteiro, 2005-06-01

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**1**
International Conference Proceedings	**4**
National Conference Proceedings	**4**
Oral presentations in international conferences	**1**
Poster presentations in international conferences	**3**
Presentations in national conferences	**6**
Master Theses	**1**

Detectors:

Project Title: Applications of Timing Resistive Plate Chambers -RPC

Resumo:

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

Funding:

Code	Funding	Start	End
CERN/FNU/47323/2001	60.000 €	2002-04-01	2005-07-31
RII3-CT-2003-506078	110.000 €	2004-01-01	2007-12-31
010.6/B009/2005	110.000 €	2004-01-01	2006-12-31
POCTI/FP/FNU/50171/2003	17.838 €	2004-07-04	2005-12-31
POCI/FP/63411/2005	34.540 €	2005-06-01	2006-11-09

Team:

Project Coordinator: Paulo Fonte

Team Members:

Name	Status	% of time in project
Alberto Blanco	Technician (LIP)	100
Américo Pereira	Technician (LIP)	53
Armando Policarpo	Researcher (LIP/FCTUC)	30
Carlos Capela	Researcher (ESTGL)	26
Carlos Neves	Researcher (ESTGL)	21
Carlos Silva	Technician (LIP)	26
Carlos Sousa	Researcher (ESTGL)	26
Ermelinda Antunes	Researcher (LIP/FCTUC)	9
Isabel Lopes	Researcher (LIP/FCTUC)	6
João Silva	Technician (LIP)	25
Joaquim Oliveira	Technician (LIP)	26
Jorge Correia Moita	Technician (LIP)	26
Jorge Sousa	Researcher (ISEC)	44
José Pinhão	Technician (LIP)	40
Luís Lopes	Technician (LIP)	32
Milena Vieira	Researcher (ESTGL)	26
Nuno Carolino	Technician (LIP)	74
Nuno Fonseca	Researcher (IBILI)	9
Paulo Fonte	Researcher (LIP/ISEC)	76
Rui Alves	Technician (LIP)	26
Rui Marques	Researcher (LIP/FCTUC)	30

Summary of the Activities:

During this year two projects were spawned from this one: HADES and HUMAN PET.

Collaboration on the CBM experiment at GSI was continued, mostly within the framework of the EU FP6 project I3HP. Ceramic RPCs with very high rate capability were developed for this application.

The small-animal PET prototype in existence was further exploited yielding a position resolution that approaches the physical limits of the PET technique (detector-related effects becoming unimportant). Complementary issues, as the influence of the magnetic field on the resolution and the statistical nature of the image formation processes were further investigated.

Publications:

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

- *"The effect of temperature on the rate capability of glass timing RPCs",*
  D. González-Díaz, D. Belver, A. Blanco, R. Ferreira Marques, P. Fonte, J. A.Garzón, L. Lopes, A. Mangiarotti, J. Marín,
  Nucl. Instrum. and Meth. in Phys. Res. A555 (2005) 72.
- *"RPC-PET: a new very high resolution PET technology",*
  A.Blanco, N.Carolino, N. Chichorro, C.Correia, M. P. Macedo, L. Fazendeiro, R. Ferreira Marques, P.Fonte,
  IEEE Trans. Nucl. Sci. *(accepted)*.
- *"EM Reconstruction Algorithm with Resolution Modelling Applied to an RPC-PET Prototype",*
  L. Fazendeiro, N. C. Ferreira, A. Blanco, P. Fonte, R. Ferreira Marques,
  IEEE Trans. Med. Imag. *(submitted)*.
- *"Very high position resolution gamma imaging with Resistive Plate Chambers",*
  A. Blanco, N. Carolino, C.M.B.A. Correia, L. Fazendeiro, Nuno C. Ferreira, M.F.Ferreira Marques, R. Ferreira Marques, P. Fonte, C. Gil, M. P. Macedo,
  Nucl. Instrum. and Meth. in Phys. Res. A *(accepted)*.
- *"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 *(accepted)*.

Communications:

Oral presentations in international conferences:

- *"Very high position resolution gamma imaging with Resistive Plate Chambers",*
  presented by
  at 4th International Conference on New Developments in Photodetection June 19-24 in 2005 - Beaune, France.
- *"Advances in gaseous time-of-flight detectors",*
  presented by
  at HEP2005 International Europhysics Conference on High Energy Physics in 21-27 July, Lisboa, Portugal.

- *"High resolution PET with Resistive Plate Chambers",*
  presented by Paulo Fonte
  at 8th International Workshop on Positron and Positronium Chemistry in 4 - 9 September, 2005, Coimbra, Portugal.
- *"Resolution studies of a small animal RPC-PET prototype",*
  presented by
  at VIII Workshop on Resistive Plate Chambers and Related Detectors in 10-12 October 2005, Seoul, Korea.
- *"On the deterministic and stochastic solutions of Space Charge models and their impact on high resolution timing",*
  presented by
  at VIII Workshop on Resistive Plate Chambers and Related Detectors in 10-12 October 2005, Seoul, Korea.
- *"An analytical description of rate effects in timing RPCs",*
  presented by
  at VIII Workshop on Resistive Plate Chambers and Related Detectors in 10-12 October 2005, Seoul, Korea.
- *"Ceramic high-rate timing RPCs",*
  presented by
  at VIII Workshop on Resistive Plate Chambers and Related Detectors in 10-12 October 2005, Seoul, Korea.
- *"RIGEL: an Rpc-like sIgnals GEnerator for Laboratory testing",*
  presented by
  at VIII Workshop on Resistive Plate Chambers and Related Detectors in 10-12 October 2005, Seoul, Korea.

Poster presentations in international conferences:

- *"Accurate timing of gamma photons with high-rate Resistive Plate Chambers",*
  presented by
  at 7th International Conference on Position Sensitive Detectors in 12 - 16 September 2005.

Presentations in national conferences:

- *"Desenvolvimento de câmaras de placas resistivas para física nuclear de altas energias e imagiologia de radioisótopos",*
  presented by
  at 14ª Conferencia Nacional de Física in 2-3 December 2005, Porto, Portugal.

Oral presentations in collaboration meetings:

- *"Development of timing RPCs",*
  presented by
  at CBM colaboration meeting in GSI, Darmstadt, Germany, 9-11 March 2005.
- *"RPC Status report (detector/FE/DAQ)",*
  presented by
  at "HADES Collaboration Meeting XV" in June 7 – 12-2005, JINR, Dubna, Russia.
- *"New high-rate RPC technologies and applications of RPCs to other fields",*
  presented by
  at CMS Endcap RPC Completion and Upgrade Workshop in 16 September 2005, CERN, Geneve, Switzerland.

- *"High-rate ceramic timing RPCs",*
  presented by
  at CBM-RPC Workshop in 14-12-2005, GSI, Germany.
- *"Electrically Shielded Timing RPCs for HADES",*
  presented by
  at CBM-RPC Workshop in 14-12-2005, GSI, Germany.

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**4**
Oral presentations in international conferences	**8**
Poster presentations in international conferences	**1**
Presentations in national conferences	**1**
Oral presentations in collaboration meetings	**5**

Project Title: Microstructure Gas Detectors

Resumo

O projecto em curso envolve o desenvolvimento de detectores de radiação gasosos com sistemas de leitura ópticos, neste caso fotomultiplicadores. A cintilação é emitida pelas avalanches produzidas em microestruturas e permite a localização das interacções. São considerados especialmente um detector para imagiologia com neutrões térmicos de 32x32 cm2 e resolução de 1 mm, uma câmara de traços (TPC) e um espctrómetro de neutrões rápidos.
Estes trabalhos são em parte desenvolvidos numa actividade financiada pelo 6º Quadro Comunitário de Apoio - JRA2 - MILAND: Millimetre resolution Large Area Neutron Detector NMI3 - HII3-CT-2003-505925.

Funding:

Code	Funding	Start	End
CERN/FNU/43735/2001	50.000 €	2002-03-11	2006-06-30
RII3-CT-2003-505925	120.000 €	2004-01-01	2006-12-31
POCTI/FP/FNU/50338/2003	25.000 €	2004-07-04	2006-04-30

Team:

Project Coordinator: Francisco Fraga

Team Members:

Name	Status	% of time in project
Alberto Blanco	Technician (LIP)	20
Américo Pereira	Technician (LIP)	30
Armando Policarpo	Researcher (LIP/FCTUC)	35
Ermelinda Antunes	Researcher (LIP/FCTUC)	10
Filipa Balau	Master student (LIP)	100
Francisco Fraga	Researcher (LIP/FCTUC)	75
João Silva	Technician (LIP)	20
Luís Margato	PhD student (LIP)	100
Margarida Fraga	Researcher (LIP/FCTUC)	65
Nuno Carolino	Technician (LIP)	25
Paulo Mendes	Researcher (LIP/FCTUC)	55
Rui Marques	Researcher (LIP/FCTUC)	40
Sónia Pereira	PhD student (LIP)	100
Susete Fetal	PhD student (LIP/ISEC)	90

Summary of the activities:

Introduction

During the second year of the **MILAND** (millimeter large area neutron detector) collaboration we worked in the simulation of the Anger type readout, assembly and calibration of the PMT systems. Two data taking experiments were carried with neutron beams the ILL reactor (July 2005) and the ISIS spallation source at Rutherford Appleton – Laboratory (October 2005). Measurements of primary scintillation of $HeCF_4$ were carried in Coimbra, as well as of secondary light emitted in MSGCs. In October 2005 a new student started developing software for the data acquisition and

analysis of the pulses collected by the PMT arrays, in order to study the time evolution of these signals, anticipating its use for an optical readout TPC, as outlined in the **Gaseous Active Scintillators for Imaging** activity. We also participated in discussions about future neutron detectors using gas scintillation to be considered in FP7.

The choice of the final version of the MILAND detector was made at the end of the year. Considering the status of development of the several possible candidates and the management of risks a classical MWPC chamber with individual readout was chosen, discarding the other possibilities, modular MSGC, delay line readout MSGC and scintillation Anger camera .

Main results

Simulation results

The Monte Carlo simulations were used to find the optimum distance between the GEM plane and the detector array. These results also have shown that the position resolution is dominated by the number of photons collected by PMTs, and therefore, to improve resolution we need to increase the number of detected photons.

Beam tests

For both beam tests the detector was fitted with a MSGC and operated with 2 bar ^{3}He / 2 bar CF_4, although a second detector using a GEM at 1 bar ^{3}He / 1 bar CF_4 was also tested at the ILL. The first tests were carried with a sensitive position Hamamatsu and a position resolution of 3mm was obtained. The next tests at ISIS, using a more promising readout built at LIP using 30mm diameter PMTs were less successful, as the MSGC had to be operated at limited gain at 1 bar CF_4 pressure, that limited the achievable resolution to 5 mm.

Several other topics have been also been addressed, such as the measure the depth of interaction (deduced from the drift time, the time between the primary and secondary light) the drift speed vs. drift field, the electron attachment to impurities or CF_4 itself and the separation between neutron and gamma events by evaluating not only pulse height but also pulse duration, which is expected to be longer due to the longer range of the electron in the gas.

Also from the data collected at the ILL in June with a single PMT it was found that the GEM at 1 bar CF_4 can emit typically between one or two orders of magnitude more light than the microstrip safe operational GEM voltage, but could not be operated with reliability at higher pressures.
The measurements have also shown that the scintillation Anger camera read out system works and we could currently achieve better results than a similar device developed at Jülich using a solid scintillator that has a resolution of 6 mm. Areas for improvement were clearly identified are being considered.

Spectroscopy measurements

Spectroscopy measurements of the primary light of the gas mixture excited with an ^{241}Am alpha source having a linear energy deposit in the gas similar to the proton-triton track energy density were made with He-CF_4 mixtures were made with a

monochromator (Applied Photophysics m. 7300, with a 1200 g/mm grating blazed at 300 nm, using a photomultiplier (RCA C31034), cooled to -20ºC, operating in single photon counting mode. The effect of drift field on primary light was also measured to check for the possibility of electron recombination, that was found to be non-existent. Both the 300 and 620 nm bands were always found, and relative intensities changed with pressure, explaining different results reported in the past by authors using readouts with distinct spectral sensitivities.
Considering that the existing secondary scintillation data, taken exclusively with GEMs, should be complemented with data collected with MSGCs, several measurements of secondary light in detectors operated in pure CF_4 and ^3He-CF_4 were also carried.

Conclusion
All these results were reported in detail in ***the JRA2 - MILAND: Millimetre resolution Large Area Neutron Detector NMI3 - HII3-CT-2003-505925 2005 Annual Report,***

Publications:

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

- *"Advances in detectors for single crystal neutron diffraction",*
  J.C. Buffet, J.F. Clergeau, R.G. Cooper, J. Darpentigny, A. De Laulany, C. Fermon, S. Fetal, F. Fraganex, B. Guérard, R. Kampmann, A. Kastenmueller, G.J. Mc Intyre, G. Manzin, F. Meilleur, F. Millier, N. Rhodes, L. Rosta,,
  Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated EquipmentVolume 554, Issues 1-3, 1 December 2005, Pages 392-405.

Project Statistics

	number
Articles in international journals (with direct contribution from LIP members)	**1**

Project Title: Participation in the CAMCAO project

Resumo:

Encerrou-se em 2005 participação do LIP no projecto CAMCAO (acrónimo de Camera for Multi-Conjugated Adaptive Optics), um projecto liderado pela Faculdade de Ciências da Universidade de Lisboa e com participação do INETI, cujo objectivo é a instalação de uma câmara para equipar o VLT (Very Large Telescope), no observatório do Paranal. Depois de substanciais mudanças no projecto ao longo do ano de 2004, finalizou-se a construção das partes mecânicas e procedeu-se à montagem e testes, primeiro em Coimbra e depois já em Lisboa. O sistema foi entretanto entregue ao ESO e, em Setembro, transferido para Garching, onde prosseguiu a integração das diferentes partes e da electrónica. Os testes entretanto aí realizados permitiram até agora, confirmar as melhores expectativas quanto ao desempenho do sistema.

Tratou-se, pois, de um exemplo de colaboração inter-institucional a que foi possível o LIP corresponder da melhor maneira, utilizando e desenvolvendo o seu know-how em mecânica de precisão.

Funding:

Code	Funding	Start	End
POCTI/FNU/43843/2001	237.900 €	2002-06-07	

Team:

Project Coordinator: Rui Marques

Team Members:

Name	Status	% of time in project
António Amorim	Researcher (LIP/FCUL)	40
Armando Policarpo	Researcher (LIP/FCTUC)	5
José Pinhão	Technician (LIP)	75
Rui Marques	Researcher (LIP/FCTUC)	5

Summary of the Activities:

During 2005 we performed the final tasks attributed to LIP in this project. Most of he mechanical construction was carried on and finalized in summer. This comprised i) the construction, welding and pressure plus vacuum tests of the aluminium tank for liquid nitrogen; ii) the radiation shielding; iii) tubing for liq-N2 filling; iv) manual indexer for the filter wheel; v) detector holder.

At the same time, the system started to be assembled and tested. A series of tests was performed in Coimbra (mainly to check and solve problems related to moving parts and their operation under vacuum, as well as the vacuum tightness of the main chamber). Then, the system was moved to the Physics Department of the University of Lisbon, as it was decided, in view of the tight schedule, that the final assembly and tests took place there before the delivery to ESO.

The system was formally accepted by ESO in a public event in Lisbon, on July 26, with the presence of his Excellency the President of the Portuguese Republic,

representatives of both the Ministry of Science Technology and Universities and of FCT, and a delegation from ESO.

The device was dispatched to the ESO laboratories in Garching (Germany) in September and since then it underwent extremely demanding tests that, so far, have proven an excellent performance.

These activities bring to an end the participation of LIP, whose responsibility, given our manpower limitations, were restricted to the drawings and construction of the mechanics.

Communications:

Poster presentations in international conferences:

- *"The CAMCAO NIR camera:integration and first results,",*
  presented by António Amorim
  at Astronomical Telescopes and Instrumentation 2006 in Orlando, FL (USA),
  24-31 May 2006.

Project Statistics

	number
Poster presentations in international conferences	**1**

Outreach:

Project Title: Particle Physics Education and Public Outreach

Resumo:

A necessidade de divulgação e educação pública da Física das Partículas tem ganho uma importância cada vez maior no seio da comunidade científica. O CERN promoveu a criação de um fórum a nível europeu, o European Particle physics Outreach Group (EPOG), que junta duas vezes por ano as pessoas preocupadas com estas questões, para partilhar ideias e resultados e para organizar actividades em conjunto. Em particular, e aproveitando o facto de 2005 ter sido declarado pela UNESCO como o Ano Internacional da Física – 2005, foram incrementadas substancialmente junto das escolas secundárias e em colaboração com as universidades, as actividades de divulgação da Física das Altas Energias no ano transacto. No caso concreto do LIP, tal deveu-se também às sinergias criadas com o projecto "Telescópio de Raios Cósmicos" (TRC), que teve alguns desenvolvimentos importantes em 2005 e está agora em fase de conclusão. Das actividades promovidas ou realizadas por membros do LIP em 2005, destaca-se a instalação dos detectores de raios cósmicos nos laboratórios das dez escolas envolvidas no projecto TRC, os estágios de Verão no âmbito da Ciência Viva (OCJF2005), a organização de palestras públicas comemorativas do 2005-Ano Internacional da Física, a participação nas reuniões do grupo EPOG, e a contribuição para o Projecto CRESCERE.

No âmbito deste Projecto CRESCERE, em parceria com a Faculdade de Ciências da Universidade de Lisboa, com o LNF/INFN de Frascati, Itália, com o IFIN-HH de Bucareste, Roménia, e financiado pela EU, foi proposta a realização remota de experiências com raios cósmicos, por parte de alunos de escolas secundárias portuguesas, italianas e romenas. O Projecto teve uma aceitação bastante acima das expectativas iniciais, tendo sido realizadas perto de 150 sessões de tomadas de dados com alunos de escolas dos 3 países, algumas em regiões bastante remotas (por ex., Madeira e Mêda, Portugal, Salerno, Itália, e Satu Maré, Roménia), culminando com a presença limitada a 40 alunos de cada país na Conferência Internacional "CRESCERE", no dia 7 de Dezembro de 2005 no Pavilhão do Conhecimento, organizada pelo LIP e pela FCUL.

Funding:

Code	Funding	Start	End
POCTI/DIV/2005/00087	50.000 €	2005-06-01	2006-09-30
000 CRESCERE	23.400 €	2005-07-01	2006-02-28
OCJF2005	1.200 €	2005-07-01	2005-09-30

Team:

Project Coordinator: Pedro Abreu

Team Members:

Name	Status	% of time in project
Amélia Maio	Researcher (LIP/FCUL)	6
Américo Pereira	Technician (LIP)	6
António Onofre	Researcher (LIP/UCPFF)	3
Carlos Silva	Technician (LIP)	6
Conceição Abreu	Researcher (LIP/UALG)	5

Dário Passos	Technician (LIP)	21
Fernando Barão	Researcher (LIP/IST)	10
Gonçalo Pires	Student (LIP)	3
João Carvalho	Researcher (LIP/FCTUC)	10
João Pires	Master student (LIP)	77
João Varela	Researcher (LIP/FCT)	8
José Silva	PhD student (LIP/FCUL)	13
Lina Moniz	Student (LIP)	25
Luis Peralta	Researcher (LIP/FCUL)	10
Miguel Ferreira	Technician (LIP)	30
Pedro Abreu	Researcher (LIP/IST)	55
Pedro Assis	PhD student (LIP/FCT)	10

Summary of the Activities:

The problem of getting the public's attention towards Particle Physics, and in particular end-years high-schools teachers and students (along with their families), is being tackled by two different roads: the maintenance and development of traditional education and public outreach activities, and projects involving the construction and installation of detectors at high-schools, like the project "Measurement of Time Correlations in Cosmic Rays" (TRC), or their operation remotely, as in the Project "CRESCERE" that promotes the realization of real experiments in the field of cosmic rays by high-school students and teachers. The activities performed are described per section below.

Education and Public Outreach

The outreach activity has become a very important issue in experimental particle physics, to promote the field and explain the scientific achievements made for the money invested in the experiments. This much has been recognized at CERN and elsewhere, and a set of concerned people have set-up a working group devoted to the public awareness of particle physics (EPPOG – European Particle Physics Outreach Group).

The portuguese representative in this group participated in the two meetings held in 2005, reporting the local activities related to the outreach of particle physics, and coordinated the local implementation of the CERN training program "HST – High School Teachers at CERN", for which two portuguese teachers were selected to participate in the program, with CERN support.

Some activities involving high school teachers and students had the support of the "Ciência Viva" program, and were organized in the framework of the program "Ocupação Científica de Jovens no Verão" of the Ministry of Science and Superior Education.

Members of LIP have also performed many seminars in high schools, along the year, promoting particle physics, astroparticle physics and medical physics, in particular profiting of the rise in awareness due to the 2005-International Year of Physics declared by United Nations general assembly.

The LIP/Atlas group have also invested some important resources (money, people and time), in preparing educational films about the group's activities, which are now an important part of the educational resources of the Atlas experiment at CERN.

One very successful activity was the EPPOG European Masterclasses 2005, integrated in the commemorations of the International Year of Physics 2005, of which

the Portuguese students were particularly satisfied, as reported in the article in reference. This activity will be repeated around March 2006.

Finally, we maintained the outreach page of LIP and, in the scope of the preparation of the European Masterclasses 2005, we translated into portuguese the complete package of 'Hands-On-CERN', which is a basis of the program. The latest version can be consulted at 'http://www.lip.pt/Maos-nas-particulas.html'.

Most of the activities with the schools were made possible, or reached the intended audience, much because of the contacts established in the joint "Ciência-Viva" project "Telescópio de Raios Cósmicos", of which the report follows. The fact that LIP members supervise the updates of high-school physics teachers in the Faculdade de Ciências de Lisboa, also helped in reached the intended audience for the activities performed.

TRC – "Ciência-Viva"'s Telescópio de Raios Cósmicos
Measurement of Correlations in Cosmic Rays with the High-schools

In the follow-up of the project "Telescópio de Raios Cósmicos", LIP members have finished the installation in the roof of the schools of almost all detector stations (one case in which we were not yet allowed to proceed with the installation), including setting-up the GPS detectors and testing the hardware. Schools are now equipped to detect showers of particles, and the acquisition program is being updated to process the new information (GPS information to give the time tag of each event, synchronized to better than 100 ns precision).

The station at IST was used in the project CRESCERE, in which Portuguese, Italian and Romanian students performed the "Measurement of the Flux of Cosmic Rays", remotely, in data-taking sessions tutored by LIP members. This was part of a Portuguese-Italian-Romanian collaboration involving 4 institutes (LIP, FCUL in Portugal, LNF/INFN in Italy, and IFIN-HH in Romania) with support from EU. The success of this activity was manifested in the International Conference organized by LIP and FCUL in Portugal, in December 2005, with the participation limited to 40 students from each country.

The academic training program of João Pires, with the title "Study of Cosmic Rays in the TRC" for a Master degree, has progressed with the conclusion of the scholar part, and is expected to conclude the thesis in 2006.

Publications:

Books:

- *"O Projecto CRESCERE (em 4 línguas) - Cientista por um dia, cientista para a Vida!",*
  P. Abreu, H. Bilokon, F. Fabbri, A. Maio,
  Livrinho de divulgação (16pp) distribuído pelas escolas secundárias.

Communications:

Oral presentations in international conferences:

- *"TRC - The Cosmic Rays Network in Portuguese Schools",*
  presented by Pedro Abreu

at CRSP'05 - 1st Workshop on Cosmic Rays in School Projects in 7-8 March 2005, Amsterdam, The Netherlands.

- *"Outreach in HEP in Portugal - The use of Detectors to boost physics outreach",*
  presented by Pedro Abreu
  at Communicare Fisica 2005 in 24-27 October 2005, Frascati, Italy.
- *"The CRESCERE Project - aims and methodology",*
  presented by Pedro Abreu
  at CRESCERE International Meeting in 7 December 2005, Pavilhão do Conhecimento, Lisboa, Portugal.

Presentations in national conferences:

- *"O Projecto CRESCERE",*
  presented by Pedro Abreu
  at Um dia CRESCERE no Funchal in Funchal, Madeira.

Oral presentations in collaboration meetings:

- *"OR activities in Portugal",*
  presented by Pedro Abreu
  at EPPOG Autumn meeting in CERN, Geneva, Switzerland.

Outreach seminars:

- *"GPS - Como funciona e aplicações",*
  presented by Pedro Abreu
  at in Escola Secundária José Gomes Ferreira, Benfica, Lisboa.
- *"GPS - Como funciona e aplicações",*
  presented by Pedro Abreu
  at in Escola Secundária D. Pedro V, Sete Rios, Lisboa.
- *"A Física de Albert Einstein",*
  presented by Pedro Abreu
  at in Escola Secundária Prof. Herculano de Carvalho, Olivais, Lisboa.
- *"Do infinitamente grande ao infinitamente pequeno",*
  presented by João Carvalho
  at in Escola Superior de Tecnologia e Gestão de Oliveira do Hospital.
- *"Apresentação do LIP",*
  presented by Pedro Abreu
  at 9ª Semana da Física in Instituto Superior Técnico, Lisboa.
- *"À procura do infinito (do inf. pequeno ao inf. grande)",*
  presented by Pedro Abreu
  at in Quinta do Bom Pastor, Seixal.

Academic Training:

Master Theses:

- *"Estudos de Raios Cósmicos de Energia Média com o TRC",*
  João Pires, (on-going)

Events:

- *"CRESCERE International Meeting",*
  Conference, 7 December 2005, Pavilhão do Conhecimento, Lisboa, Portugal, 2005-12-07
- *"EPPOG - European Masterclasses 2005 - Seja Cientista por um dia!",*
  Outreach Event, LIP e IST, Lisboa, FCUL Lisboa, LIP e FCTUC, Coimbra, 2005-03-12
- *"Participação em Programa de Televisão gravado - "O Melhor de Nós"",*
  Outreach Event, Transmitido na RTP-África, RTP-N, (RTP-)2:,, 2005-04-06
- *"Raios Cósmicos nas nossas cabeças!",*
  Outreach Event, LIP e IST, Lisboa, 2005-07-07
- *" Telhas e Fibras Ópticas a cintilar !",*
  Outreach Event, CFNUL, FCUL, Lisboa, 2005-07-11
- *" A Morte de Muões e a Relatividade de Einstein - 1",*
  Outreach Event, CFNUL, FCUL, Lisboa, 2005-07-11
- *"Jantar de Confraternização entre Estudantes e Cientistas na HEP'2005",*
  Outreach Event, (Conference dinner da EPS-HEP'2005) Mafra, 2005-07-24
- *" A Vida dos Muões e a Relatividade de Einstein - 2",*
  Outreach Event, CFNUL, FCUL, Lisboa, 2005-08-01

Project Statistics

	number
Books	**1**
Oral presentations in international conferences	**3**
Presentations in national conferences	**1**
Oral presentations in collaboration meetings	**1**
Outreach seminars	**6**
Conferences	**1**
Outreach Events	**7**