Laboratório de Instrumentação e Física Experimental de Partículas

RELATÓRIO DE ACTIVIDADES

2004

Table of Contents

LIP LISBOA
and ALGARVE POLE

Introduction

We summarize here the main lines of LIP activities during 2004.

The strong commitment with CERN has been pursued, still centred in the LHC experiments and technologies, namely ATLAS, CMS and LCG. The COMPASS Collaboration was consolidated.

The involvement in space related activities was continued, namely with the participation in the AMS and EUSO collaborations and the radiation environment simulation contracts with ESA.

The GRID Computing activities were enlarged, LIP being now a relevant partner of the EU EGEE project.

Medical Physics research, including the ambitious PET project, maintained a sustained activity. In a joint venture with TagusPark, LIP inaugurated a new laboratory, the Tagus-LIP facility, for supporting Medical Physics research.

The LIP Algarve team is involved in the medical physics projects, namely in the PET project, and is a main partner of the ISPA and RD39 collaborations at CERN.

In 2004, LIP participated in numerous education and outreach activities. In particular, LIP had a full involvement in the 50th CERN Anniversary with a programme that included multiple initiatives.

Finally, the two three-year research positions opened during 2003 were formalized by regular contracts with the two selected candidates.

During 2004, negotiations were initiated for the establishment of agreements of cooperation with several Portuguese universities.

In July 2004, LIP was the object of an evaluation by an International Committee. This Committee produced a report with the following conclusion:

"*In summary, we regard the recent performance and future plans of the Associate Laboratory to be entirely consistent with the rating of EXCELLENT that LIP has received in previous evaluations"*.

The full text of the report then produced is annexed with the executive summary presented to the Committee.

Project Funding

The funding granted to the projects is listed in the following table:

PROJECT	REFERENCE NUMBER	FUNDING 2003	REFERENCE NUMBER	FUNDING 2004
CALORIMETRY	POCTI/FNU/49527	227.000€	POCTI/FP/FNU/50206	180.000€
CMS	POCTI/FNU/49481	260.000€	POCTI/FP/FNU/50131	170.000€
DELPHI	POCTI/FNU/43674	90.000€	POCTI/FP/FNU/50204	15.000€
NA50	POCTI/FNU/43727	80.000€	POCTI/FP/FNU/50194	15.000€
COMPASS	POCTI/FNU/49501	104.000€	POCTI/FP/FNU/50192	110.000€
MODELOS COL. C/GEANT4	POCTI/FNU/49497	15.000€	POCTI/FP/FNU/50129	10.000€
MEDICAL PHYSICS	POCTI/FNU/43672	55.000€	POCTI/FP/FNU/50127	20.000€
RD39 COLLABORATION			POCTI/FP/FNU/50133	20.000€
SILICON DETECTORS IMAG. DETECTORS	POCTI/FNU/43681	20.000€	POCTI/FNU/47678	25.000€
AMS	DIV 1179	75.000€	PDCTE/FNU/50364	40.000€
GEANT4/ESA 2	ESTEC/17097/03	50.000€	ESTEC/1821/04	50.000€
EUSO	POCTI/FNU/43515	120.000€	PDCTE/FNU/49727	60.000€
CROSSGRID	IST-2001-32243	55.900€	IST-2001-32243	55.900€
PRSATLHC	HPRN-CT-2002-00326	54.540€	HPRN-CT-2002-00326	54.540€
EGEE	508833	123.750€	508833	123.750€
RICH-UE			506078	63.000€
CIÊNCIA VIVA	PV0124	69.339€	PV0124	25.000€
PET		163.000€		163.000€
	TOTAL	**1.562.529€**	**TOTAL**	**1.200.190€**

Legend:

Publications - Journ-I: publications in international journals with scientific peer review co-authored by LIP members
Journ-II: Subset of publications Journ-I in which LIP members had a major responsibility
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences - Oral Presentations by LIP members in International/national Conferences
Seminars - Invited Seminars in Institutes and Universities
Outreach Seminars - Seminars for students and general public
Students - Number of Students active in the project (31 Dez 2004)
Thesis - Theses concluded in the period: G - Graduation, M - Master, D - PhD.
Post-Doc - Number of Post Doc fellows active in the project
Organisation - Organisation of major events (Conferences, Workshops, Collaboration Meetings, etc.)

Project	Publications			Conferences		Seminars	Outreach Seminars	Students	Thesis			Post-Doc	Organisation
	Journ-I	Journ-II	Other	International	National				G	M	D		
ATLAS				5			2	7(*)				1	
CMS	1	1	4	3				3	1			2	
COMPASS			6		4	1	1	2				2	
NA50	3	2		3	2		1	1			1	1	
DELPHI	20	3	5	4	2	1	2	1		2			1
GRID			5	1		1	4	1				1	2
AMS	1	1		2	2		1	3		1		1	
EUSO	1	1	2	3		1	2	3		1		1	1
ESA contr.	1	1	1	2				2					
PET	3	3	5	3				5				1	
Medical Physics	3	3	1	3				3			1		
Silicon Det.	2	1	1										
Medical Imaging				1				1					
Geant 4	2	2	1	1				1					
Outreach							9	1					3
Totals:	37	18	31	31	10	4	22	27	1	4	2	10	7

(*) Includes two PhD students from LIP Coimbra

Human Resources

	December 2003	March 2004	March 2005
Administrative Staff	5	5	5
Technical Staff	5	7	7
Researchers	15	16	15
Post-doc Fellowships	11	11	9
PhD Students	16	16	15
BIC/BTI Fellowships and Master Students	18	16	16
TOTAL	**70**	**70**	**68**

This table includes LIP Lisbon and LIP Algarve staff

Staff list (March 2005):

Administrative Staff:
Lina Barata, Claúdia Delgado, Sandra Dias, João Vargas, Natália Antunes

Technical Staff:
José Carlos Nogueira, José Carlos Aparício, João Paulo Conceição, José Carlos da Silva, Miguel Ferreira, Nuno Dias, Adarsh Jain.

Researchers:
Amélia Maio, Agostinho Gomes, Conceição Abreu*, Fernando Barão, Gaspar Barreira, João Varela, Jorge Gomes, José Mariano Gago, Luís Peralta, Mário Pimenta, Maria Catarina Espírito Santo, Paula Bordalo, Pedro Abreu, Sérgio Ramos.

Post-Doc Fellowships:
Bernardo Tomé, Catarina Quintans, Helena Santos, José Maneira, Mário David, Malgorzata Kazana, Patricia Gonçalves, Pedro Rato*, Reyes Alemany Fernandez.

PhD Students:
Ana Keating, Andreia Trindade, Catarina Ortigão, Gonçalo Borges, José Manuel Silva, Maria Luísa Arruda, Nuno Almeida, Nuno Anjos, Patrick Sousa*, Pedro Assis, Pedro Ribeiro, Pedro Rodrigues, Rui Moura, Rui Pereira, Sandra Moreno.

BIC – BTI (Initiation to Research) Fellowships and Master students:
Ana Catarina Farinha, Bruno Carriço*, Carlos Marques, Celso Franco, David Sora, Dário Passos*, João Costa, João Pina, João Pires, João Saraiva, Luís Silva, Marco Quintero*, Miguel Paulos, Ruben Conceição, Sandra Brás*, Sónia Rodrigues*.

(*) LIP Algarve Staff

PROGRESS REPORT 2004

Project Title: Collaboration in the ATLAS experiment

Project References	Funding
POCTI/FP/FNU/50206/2003	180 000 €

Resumo:

Ao longo do ano de 2004, o grupo Português envolvido no projecto, design, construção do detector ATLAS prosseguiu as suas actividades, centradas na construção do sub-detector TILECAL e na simulação de canais de Física a estudar no LHC com o detector ATLAS. O grupo esteve envolvido activamente no design, aquisição e teste dos componentes ópticos. Até agora foi já construída a maior parte destes componentes para todos os 65 módulos do barril central e os 130 módulos dos barris laterais (EB), tendo sido construídos dois módulos no último ano e restando apenas um para ser finalizado. Foram preparados os cabos de fibras ópticas que vão conduzir a luz do laser (sistema de monitorização) até ao barril central do TILECAL, e produzidos os painéis onde as fibras e os respectivos conectores ajustáveis vão ser ligadas. O cilindro do barril central do calorímetro TILECAL foi montado na caverna de ATLAS. No Sistema de Controlo do detector (DCS) TILECAL fomos responsáveis pelo "upgrade" e pela manutenção do sistema existente na zona de testes em feixe, durante a participação no teste combinado dos vários sub-detectores de ATLAS que ocorreu entre Maio e Novembro de 2004. O grupo esteve envolvido na tomada de dados com feixe de teste no CERN e está agora envolvido na análise dos resultados, tanto do teste combinado de 2004 como de testes anteriores. 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 γ, 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. Uma versão mais avançada do vídeo (em animação 3D) que foi iniciado em Lisboa e está centrado agora no laboratório LBL foi apresentada na semana ATLAS de Outubro em Freiburg tendo sido bem recebida pela comunidade de ATLAS.

Team:

Project Coordinator: Amélia Maio
Team Members:

Name	Status	% of time in the project
Amélia Maio	Researcher/LIP-FCUL	50
João Carvalho	Researcher/LIP Coimbra -FCTUC	20
António Onofre	Researcher/LIP Coimbra – UCP	50
António Amorim	Researcher/FCUL	5
Helmut Wolters	Researcher/UCP	5
Viriato Esteves	Researcher/FCUL	25
Manuel Maneira	Researcher/UNL	4
Agostinho Gomes	Researcher/LIP	95
José Maneira(1)	Post-Doc/FCT grant	75
Nuno Castro	PhD Student/LIP Coimbra/FCT grant	60
Filipe Veloso	PhD Student/LIP Coimbra/BIC(2)	60
José Silva	PhD Student/LIP grant	90
João Saraiva	Master Student/BIC(2)	100
João Pina	Master Student/BIC(2)	100
Carlos Marques	Master Student/BIC(2)	100
João Santos	Master Student/IP Beja	50
José Pinhão	Engineer/LIP Coimbra	5
Rui Alves	Engineer/LIP Coimbra	10
Alexandre Moita	Technical staff/LIP Coimbra	20
Luis Raposeiro	Technical staff/IDMEC	5
José Nogueira	Technical staff/LIP	5
Carlos Silva	Technical staff/LIP Coimbra	25

(1) Started November 200 ; (2) BIC:LIP Initiation to research grant

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Summary of Activities:

During 2004 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 physics channels that will be studied in the LHC using the ATLAS detector. During the year the last modules (modules number 65) of the Tilecal Barrel and of one of the Extended Barrels were instrumented, and the Barrel cylinder was assembled in the pit.

Construction and mounting of components for the Laser calibration system

The long clear optical fibers for the TileCal Barrel modules, for the transmission of the laser from the electronics cavern to the detector, were cut and polished, and the adjustable connectors glued to its ends. The adjustable one-to-one connectors were produced by the Portuguese industry and the patch panel for the adjustable connectors was produced in the LIP mechanical workshop.

TILECAL Detector Control System (DCS)

The Tilecal Detector Control System (DCS) implementations (testbeam and surface tests at building 185) were upgraded for new versions of the software PVSS and Framework. The NI PCIcan cards of the low voltage control and monitoring CANbuses were replaced by Kvaser cards and most of the old ELMB cards were replaced by new ones. The temperature sensors of the cooling unit at building 185 were recalibrated. New lists of datapoint elements were prepared for the storage of the DCS testbeam data in the

conditions database. Tilecal participated in the simple integrated ATLAS DCS that was prepared for the testbeam using the Finite State Machine prototype.

Ageing of PMTs, fibres and scintillators and characterization of scintillators

The 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. For our study it was found that the measurement for 61 of these combinations would be required. At the moment 32 of them have been measured.

Combined test beam and data analysis

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 are currently participating in the analysis of the muon data taken. The analysis of data from the previous calibration periods was also continued:

- the photostatistics was calculated and values in the range from 50 to 100 photoelectrons/GeV were found using the slice method
- the fluctuations (rms) in the PMTs high voltage was found to be of the order of 0.1 V

These results will be part of a paper that the collaboration is preparing.

Physics simulation and software development

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.

The FCNC decays of the top quark ($t \rightarrow q Z$, $q\gamma$, q gluon) were investigated at the ATLAS experiment using the fast simulation library of the detector (ATLFAST). The top quarks were produced via single top or t-tbar production and were generated by the TOPREX and ALPGEN Monte Carlo libraries. Both generators were interfaced with the PYTHIA or HERWIG libraries for the hadronization of the events at parton level. These libraries were also used to generate the Standard Model background. The results were presented in two different ways: the branching ratio sensitivities assuming a 5 sigma significance discovery and 95% confidence level limits on the branching ratios in the hypothesis of absence of signal. Two ATLAS notes are in preparation (one for the single top FCNC decays and the other for the t-tbar FCNC decays). A scientific note with the results is also in preparation.

The Forward-Backward asymmetries in top quark decays were investigated at the ATLAS experiment. The experimental sensitivity, within the framework of the Standard Model was studied with the fast simulation of the detector. TOPREX and ALPGEN were used to study the asymmetry value at the generator level. PYTHIA and HERWIG were used for hadronization and shower reconstruction. Initial State Radiation and Final State Radiation were considered. Preliminary results show that the measurement will be dominated by the systematic errors. The sensitivity to new physics was also discussed.

Academic Training:

Study of top quark decays and the structure of the Wtb vertex / Nuno Castro /PhD / in progress
Production and decay of top quarks via FCNC at the LHC / Filipe Veloso/PhD/in progress
Monitorization and intercalibration of the Tilecal and PMT qualification/ José Silva/PhD / in progress
Studies on the Performance of the ATLAS Tile Calorimeter/João Saraiva /Master / in progress
Influence of the High Voltage in the Tilecal performance/ João Pina / Master / in progress
Systematic Uncertainties on the W mass measurement with the ATLAS Detector/ Carlos Marques/ Master/ in progress
Caracterização de fibras WLS com LEDs/João Santos/ Master/ in progress

Publications:

The ATLAS Hadronic Tile Calorimeter: From Construction towards Physics, P. Adragna et al, to be published in Proceedings of IEEE NSS, Rome, Italy, Oct. 2004

Internal Notes:

Light Yiled Studies of the ATLAS Tile Calorimeter, J.G. Saraiva, S. Nemecek, A. Maio and A. Gomes, to be submitted soon

Systematic uncertainties on the W mass measurement with the ATLAS Detector, C. N. Marques et al, to be submitted soon

Conferences:

"The Atlas Tilecal Detector Control System", Agostinho Gomes, XI International Conference on Calorimetry in High Energy Physics, Perugia, Italy, 29 March-2April 2004
"W mass measurement with ATLAS", Carlos Marques, Physics at LHC, Vienna, Austria, 13-17 July 2004
"Electroweak Physics with ATLAS", Carlos Marques, Meeting of The Division of Particles and Fields of the American Physics Society, Riverside, USA, 26-31 August 2004
"Status of the ATLAS Tile Calorimeter", João Saraiva, XI International Conference on Calorimetry in High Energy Physics, Perugia, Italy, 29 March-2April 2004
"The Atlas Tilecal Detector Control System", João Pina, IEEE, Rome, Italy, 2004

Seminars:

"O que fazem os físicos no LHC", Amélia Maio, Portugal nos 50 anos do CERN, IST, Lisboa, 2 Dec 2004

"Tilecal, a construção de um grande detector", Agostinho Gomes, A Universidade na Fronteira do Conhecimento – Duas décadas de cooperação com o CERN, FCUL, 20 Dec 2004

Statistics:

Theses:	PhD	Master	Graduation
In Progress	3	4	
Concluded in 2004			

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
			5			2	

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Collaboration in the CMS Experiment at CERN

Project References	Funding
POCTI/FNU/50131/03	170 000 €

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.

Team:

Project Coordinator: João Varela

Team Members:

Name	Status	% of time in the project
João Varela	Researcher LIP/IST	50
Paula Bordalo	Researcher LIP/IST	8
Sérgio Ramos	Researcher LIP/IST	8
Reyes Alemany	Post-Doc LIP/ FCT grant	100
Alexander Mishev[1]	Post-Doc LIP/ EU Marie Curie grant	100
Malgorzata Kazana[2]	Post-Doc LIP/ EU Marie Curie grant	100
Marcelino Santos	Researcher INESC/IST	20
Carlos Almeida	Researcher INESC/IST	20
João Paulo Teixeira	Researcher INESC/IST	25
J. Augusto	Researcher INESC/IST	25
F.M. Gonçalves	Researcher INESC/IST	20
Isabel Teixeira	Researcher INESC/IST	25
Nuno Almeida	PhD Student LIP / FCT grant	100
Gustavo Ordonez	Master Student LIP	100
Pedro Ribeiro	PhD Student LIP/ FCT grant	100
José Carlos Silva	Technical staff LIP	100
Adarsh Jain	Technical staff LIP	100

[1] Ended April 2004
[2] Started September 2004

Jorge Gomes	Technical staff LIP	5
Miguel Ferreira	Technical staff LIP	50
Jorge Semião	Technical staff INESC	20
Octávio Dias	Technical staff INESC	10

Summary of Activities:

The ECAL trigger and readout electronics system, redesigned since mid-2002, is now entering in production phase. The Portuguese group has important responsibilities in the project. New prototypes of the trigger and data acquisition hardware were designed, built and validated in test beam. The new 12-bit ADC in 0.25-micron rad-hard technology, developed by the Portuguese company Chipidea under contract with LIP, is now integrated in the ECAL front-end electronics. For this achievement, the company has received a CMS Gold Award.

The CMS calorimeter trigger system is a massive parallel processor, working in pipeline mode. The scale of the system is several orders of magnitude above the trigger systems developed so far, given the large number of channels to process and the very high repetition rate of the LHC collider. The ECAL readout system is responsible for collecting data from 80000 detector channels, storage in pipeline memories, data selection, event formatting, data integrity checking and data transmission to the DAQ system. A high degree of innovation is required in the project. For the first time a large number of optical data links is used in HEP.

The LIP activity in CMS has been so far successful. In October-November 2004, for the first time a complete ECAL Supermodule, integrating 1700 crystals, was operated in an electron beam at CERN. The data acquisition hardware and software of the crystal detector was a full responsibility of LIP. The data acquisition system performed very well allowing the acquisition of good quality data. The success of this test beam was acknowledged by the CMS Collaboration.

Synchronization and Link Board (SLB)

LIP has conducted a long-term effort aiming at a Synchronization Circuit for the calorimeter trigger primitive data. This circuit is the heart of a method developed by LIP for synchronization of the calorimeter trigger pipeline system. This circuit is integrated in the Synchronization and Link Board (SLB), together with the Giga-bit trigger link (Vitesse 7216). The ECAL Electronics System Review in May 2004 found that the SLB project meets the specifications and that preparations for production should be made. However, the final prototype of the SLB could only be totally validated at the end of 2004, allowing the start of the production of 1210 boards in January 2005. The production has a delay of nine months relative to the planning presented last year, due to the lack of human resources.

The PCBs are now in production and the assembling company was selected after international tender. A first batch of 100 boards will be assembled and tested in March/April. The production of the second batch is expected to be concluded by end May. A SLB test system integrating the various components was installed at CERN. A second test system is being installed at INESC. It includes the SLB-Tester (transmitter) and five STC boards (receiver) in a VME crate. A complete software package for production tests was finalized. Due to lack of resources the final BIST (Built-In Self-Test) of the synchronization FPGAs was not concluded.

Data Concentrator Card (DCC)
The DCC module receives 72 high-speed optical links from the detector front-end boards, includes an input stage responsible for data filtering and performs the data merging and transmission to the DAQ system. This board is the major component of the ECAL data acquisition system.The DCC high-speed optical input stage is based on 6 NGK 12-channel optical receivers, which are followed by de-serializer circuits integrated in 9 Virtex FPGAs. These FPGAs include also the data filtering algorithms and the input memory. Three event-builders working in parallel allow an integrated bandwidth of 4.2 Gbit/s. The board collects also trigger data through LVDS high-speed links. In addition, it interfaces to four external systems, namely the central Selective Readout Processor (SRP), the Trigger Timing and Control system (TTC), the Trigger Throttling System (TTS) and the central Data Acquisition system (DAQ), using different data transmission technologies.
A dedicated VME-9U board called DCC-Tester was build. The DCC-Tester emulates all the inputs of the DCC, in particular the 72 high-speed optical links.
In the first part of 2004 the DCC board was tested in laboratory using the dedicated test system (DCC-Tester). A reduced version of the firmware was implemented (not including the data filtering algorithms not required in the test beam). Problems with the DCC-Tester did not allow a full validation in the Lab. Due to lack of manpower no engineer could be assigned to the debugging of the test system.
Despite the difficult conditions, the group managed to operate the DCC successfully at the H4 test beam reading data for an ECAL Supermodule housing 1700 crystals.

Hardware Modeling and Simulation
In order to guarantee that the required functionality and performance of the ECAL data acquisition system is achieved, a model, at system level, of its constituting modules has to be developed and simulated. This need comes from the fact, that it is not possible to prototype all modules and interfaces of such a complex system. Thus, the use of system-level simulation is mandatory for achieving this purpose. In previous phases of this project, a model of the ECAL readout and trigger system was implemented using Rational ROSE RT (Real Time). A complete simulation of the DCC was achieved, putting emphasis on the validation of the event builder design and communication protocols.
The activity in 04 was considerably delayed due to funding restrictions and late availability. In particular, the adaptation of the simulation to the new design of the ECAL electronics was not achieved.

Boundary Scan Test System
The set of hardware and software boundary scan tools we have developed in the past years are now in a state to be used for testing and diagnosing interconnections of the SLB and DCC modules under production.However the VME based boundary scan controller board we have developed is still in a prototype stage. Due to lack of resources the conclusion of this work was not possible.
In particular, the production of the Boundary Scan Controllers (25 boards) required by the ECAL off-detector electronics was delayed due to the departure of the main design engineer. Replacement could not be materialized due to long delays in funding availability.

Data Acquisition and Monitoring SoftwareThe development of ECAL Data Acquisition Software was largely expanded in 2004 in the context of the ECAL test beam in Oct-Nov last year. The software installed at the H4 site had the following characteristics:

- Configuration of the data acquisition VME crate and configuration of the data acquisition DCC hardware;
- Access to configuration database;
- Data readout via the spying channel (VME);
- Data readout via the fast DAQ link (S-Link);
- On-line monitoring of the data quality;
- Distribution of event data to clients (Data storage, Detector monitoring, Laser monitoring);
- Data channel to Filter Farm Unit running the reconstruction program ORCA;
- Graphical user interface for DCC operation;
- Specialized graphical user interface for DCC tests.

Physics Simulation, Reconstruction and Selection

The activities in Physics Simulation, Reconstruction and Analysis were substantially incremented in 04, due to the availability of a new pos-doc (EU fellowship) and a new PhD student (FCT fellowship).

In 2004 a first study of the CMS discovery potential for reactions predicted in the Universal Extra-Dimensions Model was done. Based on physics assumptions different from the ADD and RS models, the UED model predicts a rich phenomenology at LHC, with multi-lepton, multi-jet and missing Et final states.

The study was performed at the generator level, with a crude description of the detector acceptance and efficiency. The work required to produce a suitable UED event generator, which was achieved in collaboration with the UED, COMHEP and PYTHIA authors.

The reactions analyzed include four leptons and missing energy in the final stage. These results suggested that the study is worth to pursue including the detailed detector description and simulation (OSCAR, ORCA).

Academic Training:

PhD Theses:

- Aquisição de Dados e *Trigger* do Calorímetro Electromagnético da Experiência CMS no CERN, Nuno Almeida (on-going).
- Search for Universal Extra-Dimensions in proton-proton collisions at 14 TeV center-of-mass energy, Pedro Ribeiro (on-going).

Master Thesis:

- Physics Simulation and Reconstruction of Universal Extra Dimensions Models in the CMS Experiment, Gustavo Ordonez (interrupted in August 2004).

Graduation Thesis:

- Physics Reconstruction and Simulation in the CMS Experiment, Pedro Ribeiro (concluded in September 2004).

Research training:

- Alexander Mishev, Pos-Doc member of the Training Network PRSATLHC funded by European Union.
- Malgorzata Kasana, Pos-Doc member of the Training Network PRSATLHC funded by European Union.

Publications:

Papers in international journals with scientific peer review in which LIP members had a major direct responsibility:

- *A Software Package for the Configuration of Hardware Devices following a Generic Model,* N.Almeida, R.Alemany, J.C. da Silva, J.Varela, LIP,Lisbon, Portugal, F.Glege, CERN, Geneva, Switzerland, CMS NOTE 04-14, Computer Physics Communications 163 (2004) 41–52.

Papers in conference proceedings in which LIP members had a major direct responsibility:

- *CMS ECAL Off-Detector Electronics,* R. Alemany et al., proceedings CALOR 2004, 11th International Conference On Calorimetry In High Energy Physics, Perugia, Italy, 29 Mar 2004, and CMS CR 2004-022.
- *Calorimeter Trigger Synchronization in CMS, Implementation and Test System,* N. Almeida, R.Alemany, J.C. Silva, J.Varela, LIP-Lisbon, accepted at 10th LECC 2004 Workshop on Electronics for LHC Experiments, Boston, USA, September 2004.
- *Test results of the Data Concentrator Card of the CMS Electromagnetic Calorimeter Readout System,* J. C. Silva, J R.Alemany, N.Almeida, M.Husejko, A. Jain, and J.Varela, accepted at 10th LECC 2004 Workshop on Electronics for LHC Experiments, Boston, USA, September 2004.

Technical notes:

- *Revised CMS Calorimeter Trigger Primitive Generator to Level 1 Regional Trigger Interface,* E. Machado, J. Rohlf, J. Elias, J. da Silva, J. Varela, P. Busson, D. Baden, T. Grassi, C. Tully, P. Chumney, S. Dasu, M. Jaworski, J. Lackey, W. H. Smith, CMS IN-2004/008

Conferences:

Oral presentations by LIP members in international conferences:

1. *CMS ECAL Off-Detector Electronics,* presented by R. Alemany, LIP-Lisbon, 11th International Conference On Calorimetry In High Energy Physics, Perugia, Italy, 29 Mar 2004.
2. *Calorimeter Trigger Synchronization in CMS, Implementation and Test System,* presented by N. Almeida, LIP-Lisbon, 10th LECC 2004 Workshop on Electronics for LHC Experiments, Boston, USA, September 2004.
3. *Test results of the Data Concentrator Card of the CMS Electromagnetic Calorimeter Readout System,* presented by J. C. Silva, LIP-Lisboa, 10th LECC 2004 Workshop on Electronics for LHC Experiments, Boston, USA, September 2004.

Other Presentations:

Oral presentations of LIP members in meetings of the CMS Collaboration:

1. *Report on Universal Extra Dimensions,* R. Alemany, SUSY-BSM Meeting Physics Reviews, 21-09-04
2. *ECAL Configuration database,* R. Alemany, CMS Database Workshop, 25-02-04
3. *ECAL Data Acquisition System,* R. Alemany, Off-Detector Electronics Meeting, 08-12-04
4. *ECAL Data Acquisition System at H4 Test Beam (Nov 04),* R. Alemany, Online Software Working Group Meeting, 10-11-04
5. *Software strategy for the 2004 ECAL test beam,* R. Alemany, Online Software Working Group Meeting, 05-04-04

6. *Configuration Database for the ECAL,* R. Alemany, ECAL Technical Coordination Meeting, 01-06-04
7. *On-line Software for the 2004 ECAL Test Beam,* R. Alemany, ECAL H4 Test Beam Analysis Meeting, 06-10-04
8. *H4 Test Beam Data Quality/Data Integrity,* R. Alemany, ECAL H4 Test Beam Analysis Meeting, 07-12-04
9. *ECAL Raw Data Format,* N. Almeida, CMS ECAL e-gamma Workshop, CERN, 21/11/2004
10. *ECAL Trigger Software,* N. Almeida, CMS TriDAS Week, CMS Trigger Software Meeting, CERN, 09/11/2004
11. *Off-Detector Software,* N. Almeida, CMS Electronics Week, Electronics System Review of ECAL Off-Detector Electronics, CERN, 05/05/2004
12. *SLB & DCC Test Systems and Software,* N. Almeida, CMS ECAL Week, CMS ECAL OD Electronics Meeting, CERN, 27/04/2004
13. *Search for Universal Extra Dimensions signals at CMS (4 leptons final state),* P. Ribeiro, CMS Week, Physics Meeting, 9/06/2004
14. *Update on the Search for Universal Extra Dimensions signals at CMS(4 leptons final state),* P. Ribeiro, CMS Week, Physics Meeting, 7/12/2004
15. *DCC and DCC Tester Status,* J. C. Silva, CMS ECAL Off Detector Meeting, CERN, 25 February 2004.
16. *Status of the Synchronization project (SLB-s and SLB-Tester),* J. C. Silva, CMS Week, Trigger Meeting, CERN, 16 March 2004.
17. *Status Report of the Synchronization project,* J. C. Silva, CMS ECAL Week, CMS ECAL OD Electronics Meeting, CERN, 27/04/2004
18. *ECAL DCC Design Report,* J. C. Silva, CMS Electronics Week, Electronics System Review of ECAL Off-Detector Electronics, CERN, 05/05/2004.
19. *Status Report of the Synchronization project,* J. C. Silva, CMS Electronics Week, Electronics System Review of ECAL Off-Detector Electronics, CERN, 05/05/2004
20. *DCC Design Status,* J. C. Silva, CMS ECAL Week, ECAL Electronics Meeting, CERN, 7 July 2004.
21. *SLB Status,* J. C. Silva, CMS Week, Trigger Meeting, CERN, 20 September 2004.
22. *Status of the Synchronization project (SLB),* J. C. Silva, CMS Week, Trigger meeting, CERN, 7 December 2004.
23. *Requirements of CMS on the BST,* J. Varela, LEADE WG Meeting, CERN, 29 March 2004
24. *DCS Issues,* J. Varela, CMS Technical Coordination Meeting, CERN, 5 April 2004
25. *Overview of the DCS Systems,* J. Varela, Electronics Week – DCS Review, 6 May 2004
26. *DCS Tools in First Runs,* J. Varela, CMS Run Meeting, CERN, June 3, 2004
27. *Online databases in ECAL,* J. Varela, CMS Database meeting, CERN, 9 June 2004
28. *CMS L1 Trigger Overview,* J. Varela, PRSATLHC Training Network Meeting, Louvain, 28 June 2004
29. *Overview of the Trigger Software,* J. Varela, CMS Annual Review, CERN, 21 September 2004
30. *Integration of DCS and RCMS Systems,* J. Varela, CMS TriDAS Week, DAQ Meting, Nov 10, 2004
31. *Synchronization in Magnet Test,* J. Varela, CMS Run Meeting, 3 December 2004

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress	**2**	**1**	
Concluded in 2004			**1**

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
1	**1**	**4**	**3**				

PROGRESS REPORT 2004

Project Title: Collaboration in the COMPASS experiment

Project References	Funding
POCTI/FNU/50192/2003	110 000 €

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 energias 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 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 reacção 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, câmaras 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 'front-end' e num sistema distribuído de 'event-builders'.

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

Team:

Project Coordinator: Paula BORDALO

Team Members:

Name	Status	% of time in the project
Paula Bordalo	Researcher/LIP-IST	65
Sérgio Ramos	Researcher/LIP-IST	65
Catarina Quintans	Post-Doc/FCT grant	82
Maria Varanda[1]	Post-Doc/BI	100
João Bastos[2]	Post-Doc/BI	100
Helena Santos[3]	Post-Doc/LIP	20
Luis Silva[4]	PhD student/BI	100
David Sora	Master student/BTL	100
Francisco Mota[5]	Software Engineer	100

(1) Ended in June 2004
(2) Ended in April 2004
(3) Started in July 2004
(4) Started in October
(5) Started in October

Summary of Activities:

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 Delta G through the fusion process photon-gluon to ccbar. This implies, indeed, the open charm

asymmetry 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 baryons).

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 surrounded 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).

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 2004, 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

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

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

Detector Control System:

The COMPASS DCS system is being redesigned in order to meet the Collaboration requirements of reliability, robustness and speed. In fact, prior to our arrival in COMPASS, no group was responsible for the task, and the system was developed in a casuistic way.

The COMPASS Detectors Control System used, during the 2003/2004 running periods, the SCADA PVSS II package chosen for the LHC experiments, dealing with an amount of several thousand channels, in its version 2.12, together with the corresponding version of the JCOP Framework, and a COMPASS Framework.

A SLiC-OPC server was specially developed in order to control some new detectors for which OPC servers are still not stable or not reliable. This big effort has already interested some ALICE groups, who asked to use the package in their test beam controls.

Concerning the analog measurements control in COMPASS, one uses the ATLAS developed ELMB cards, each having an ADC incorporated. A lot of stability problems showed up. In some cases, the problems were partially cured using splitted power supplies. A major change is foreseen with respect to this sub-system.

In this context, the LIP-Lisbon group program was the following during 2004:

- to continue with the implementation of the COMPASS Detector Control System, namely to speed up and to give more reliability to specific DCS branches;
- to integrate some missing detectors in the slow-control system;
- to take immediate actions and help detector people during the five months of data taking.

During the five months of the data-taking period, our group members accomplished the following tasks:

- online control of the system performance;
- daily help to DCS users;
- immediate assistance to detector people, namely due to hazardous hardware changes implying DCS reconfigurations;
- weekly main backups to CERN storage systems;
- data base management.

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 issues, but is also a problem, preventing the system to run in standalone mode (as everytime a sub-system is controlling some detector).

The analysis instruments used in the Collaboration, concerning software programs, libraries, etc., were installed in the LIP-Lisbon COMPASS servers. The aim was to establish an analysis framework similar to the one used at CERN to work in specific channels. In view of that, a huge amount of reconstructed data was brought to Lisbon and installed in our servers' mass storage devices.

Some studies relative to the quality of the reconstructed events have been made. This lead to the conclusion that the Compass reconstruction algorithms are still not fully optimized, mainly 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. That is why one of us worked several months in this subject, developing a neuronal reconstruction algorithm approach. The first part of the work was completed, but an optimisation of the algorithm has still to be performed. We foresee the continuation of this work.

New members initiated two physics subjects, namely the Ksi_c reconstruction and the pentaquark search. The Compass reconstruction program is far from its final optimal version. One of us will work on the time optimisation crucial for processing in reasonable time the huge amount of raw data (~1000 TeraByte up to now).

Academic Training:

- ✓ Luís Silva, Experimental Particle Physics PhD Thesis, starting.
- ✓ David Sora, Software Engineering Master Thesis, starting.

Publications:

The first COMPASS results (from data collected in years 2002 and 2003) are very recent. The Collaboration started to show them in the Conferences and beginning to write the draft of the first papers to be published in 2005.

Technical internal notes:

- o João Bastos, "CELTIC -- A cellular automaton for tracking in COMPASS", 20/04/04.
- o Catarina Quintans, Several technical presentations to the Collaboration meetings reporting the DCS implementations.
- o David Sora, "Drift Chambers and MicroMegas integration", 25/03/2004
- o David Sora, "Iseg HV Modules for Silicon", 24/05/2004.
- o David Sora, "Iseg HV Modules for STRAWS", 20/05/2004.
- o Catarina Quintans, "How to integrate CAEN HV in PVSS" , 08/07/2004.
- o DCS group, "DCS-COMPASS requirements for the Experiment's 2nd phase, 28/10/2004.

Conferences:

Communications presented by LIP members:

- o Paula Bordalo, "The Compass Experiment", presented at 3º Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal
- o Maria Varanda, "Compass First Results" ", presented at 3º Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal
- o Sérgio Ramos, "Pentaquarks experimental status", presented at 3º Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal
- o David Sora, "Interfaces para controlo de hardware na experiência COMPASS",VIII Semana das Engenharias, Dia da Engenharia Informática, Instituto Politécnico de Bragança.

Technical communications:

- o Catarina Quintans, Several technical presentations to the Collaboration meetings reporting the DCS implementations.

Seminairs:

- Catarina Quintans, "First COMPASS results, November 2004, at IST, Lisbon Portugal.
- Paula Bordalo, "The COMPASS/CERN experiment, December 2004, at FCUL, Lisbon Portugal.

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress	**1**	**1**	
Concluded in 2004			

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
		6		**4**	**1**	**1**	

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Collaboration in the NA50 experiment

Project References	Funding
POCTI/FNU/50194/2003	15 000 €

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.

Os principais resultados obtidos no decurso de anteriores tomadas de dados, bem como na experiência precedente NA38, foram:

- *a supressão normal do J/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 J/ψ 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 J/ψ e ψ', em relaçãao às 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 J/ψ 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 J/ψ, quer em colisões periféricas, quer em colisões centrais e compará-lo com os resultados obtidos nas colisões induzidas por protões.

Team:

Project Coordinator: Paula BORDALO

Team Members:

Name	Status	% of time in the project
Paula Bordalo	Researcher/LIP-IST	25
Sérgio Ramos	Researcher/LIP-IST	25
Catarina Quintans	Post-Doc/FCT grant	17
Helena Santos	PhD student/FCT grant	80
Gonçalo Borges	PhD student/FCT grant	100
Ruben Shahoyan	Post-Doc/FCT grant	17

Summary of 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 Ultra-relativistic Ion Acceleration CERN Program, whose data taking periods with oxygen 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 explained in previous reports

Here, we just concentrate on the tasks of our responsibility concerning the year 2004:

- Participation in the Collaboration and Steering Committee meetings.
- Participation in the Collaboration and Steering Committee meetings.
- Contribution to lead and proton induced data analyses:
  - Comparative study of J/ψ and ψ' production and of the ratios ψ'/ J/ψ, in p-A, using different targets, and S-U interactions (in order to establish J/ψ and ψ' baseline productions)
  - Study of charmonia suppression in lead-lead collisions, namely the J/ψ and ψ' production as a function of centrality
  - Comparison among the three years of analysis concerning the low-mass resonances production, as functions of centrality and of transverse momentum.

The two first subjects have lead to communications presented in January to the 2004 Quark Matter Conference (the most important one in our field). The two LIP PhD students working on these subjects have been the only NA50 representatives giving presentations at this important Conference.

Academic Training:

- ✓ Helena Santos, "Study of high-mass vector-meson production in lead-lead collisions at ultra-relativistic energies", PhD Thesis, concluded.
- ✓ Gonçalo Borges, "Study of charmonia production in collisions of protons with different targets and in S-U interactions", PhD Thesis, in conclusion.

Publications:

- "Fission cross sections of lead projectiles in Pb-nucleus interactions at 40 and 158 GeV/c per nucleon", Physical Review C 69 034904 (2004).

- "Charmonium production and nuclear absorption in p-A interactions at 450 GeV" European Physics Journal C33 (2004) 31.
- "A new measurement of J/ψ suppression in Pb-Pb collisions at 158 GeV per nucleon", European Physics Journal C39 (2004) 335.

Conferences:

- Helena Santos, "ψ' production in nucleus-nucleus collisions at the NA50/SPS CERN experiment", to be published in Proc. of Quark Matter 2004, January 2004, Oakland, U.S.A.
- Gonçalo Borges, "J/ψ and ψ' nuclear absorption in p-A and S-U collisions at the CERN SPS", to be published in Proc. of Quark Matter 2004, January 2004, Oakland, U.S.A.
- Gonçalo Borges, "The normal nuclear absorption of J/ψ production", to be published in Proc. of Hard Probes 2004, November 2004, Ericeira, Portugal.:
- Gonçalo Borges, "Charmonia production in light interacting nuclei at the NA50 experiment", at 3°Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal.
- Helena Santos, "Centrality dependence of the ψ'suppression at the NA50 experiment", at 3°Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal.

Seminars:

- Paula Bordalo, "Discover of the new state of matter: The Quark Gluon Plasma", at IST and at FCUL, Lisbon, Portugal.

Statistics:

Theses:	PhD	Master	Graduation
In Progress	1		
Concluded in 2004	1		

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
3	2		3	2		1	

Legend:
Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
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Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Collaboration in the DELPHI Experiment

Project References	Funding
POCTI/FP/FNU/50204/2003	15 000 €

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 2004 foram publicados 2 artigos, e foi preparado e publicado 1 artigo, ambos sob responsabilidade ou com contribuições importantes de membros do LIP/DELPHI. Foram ainda enviadas, na forma de Notas DELPHI, cinco comunicações científicas a conferências internacionais, numa média por autor ou por instituto largamente acima da média da Colaboração (20 artigos publicados ou aceites para publicação em 2004 para cerca de 350 autores, e 44 comunicações ou notas internas de física, com revisão científica por membros da colaboração). A qualidade do trabalho desenvolvido foi reconhecida pela Colaboração, ao escolher quatro membros de LIP/DELPHI para apresentarem os resultados alcançados em conferências internacionais, em representação da Colaboração DELPHI (em três casos foram apresentados os trabalhos realizados pelos próprios). Neste período foram ainda concluídas e defendidas com sucesso duas teses de Mestrado, por Nuno Castro e Filipe Veloso, no Departamento de Física do Instituto Superior Técnico / Universidade Técnica de Lisboa.

Team:

Project Coordinator: Pedro Abreu

Team Members:

Name	Status	% of time in the project
Mário Pimenta	Researcher/LIP-IST	20
António Onofre	Researcher/LIP-FCTUCFF	15
Pedro Abreu	Researcher/LIP-IST	40
M. Catarina E. Santo	Researcher/LIP	10
Bernardo Tomé	Post-Doc fellow/FCT grant	10
Patrícia Gonçalves	Post-Doc fellow/FCT grant	10
Nuno Anjos	Ph. D. Student/LIP grant	100
Nuno Castro (1)	Ms. C. Student/FCT grant	100
Filipe Veloso (1)	Ms. C. Student/LIP grant	100

(1) Until March 2004 (working at 10% after that)

Summary of Activities:

In the year 2004, 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 analsyses, the papers are in advanced stage of preparation. Nevertheless there were still new ideas that come up in 2004, and new analyses performed. DELPHI is still one of the most active LEP Collaborations, and the data collected in the eleven years of LEP operation are still the best clean sample needed in many analyses, for many years to come. In 2004, two papers were published and one paper was finalised, submitted and published, both under our responsibility or with important contributions from the LIP-DELPHI team. In 2004 LIP members wrote also five communications to international conferences, and four members of the LIP/DELPHI team presented the DELPHI or LEP results in International Conferences, as listed below. During this period, two Master theses were concluded and defended with great success, by Nuno Castro and Filipe Veloso, in the Physics Department of Instituto Superior Técnico / Universidade Técnica de Lisboa.
The active channels/analyses with important contributions by the members of the LIP/DELPHI team, in the period of 2004, are listed below.

Searches for New Physics and Electroweak Measurements
(contact person: Mário Pimenta)

- Search for composite and exotic fermions
- Search for Leptoquarks
- Search for 4th Generation b'-quark
- Search for top quark via Contact Interactions
- Search for $\gamma\gamma(\gamma)$ events

Hadronic Physics
(*contact person: Pedro Abreu*)

- Interconnection effects in WW events
- Search for Pentaquarks in the hadronic decays of the Z^0 boson(K^0p,K^+p channels)
- Review of DELPHI QCD results – section on Soft QCD

Academic Training:

- Search for 4th Generation *b'*-quarks in the DELPHI experiment –Nuno Castro – Master thesis – concluded in March 2004.
- Search for single top quark production at LEP via four-fermion contact interaction at $\sqrt{s}$=189-209 GeV – Filipe Veloso – Master thesis – concluded in March 2004.
- Hadronic final states at LEPII – Nuno Anjos – Ph.D. – in progress, conclusion foreseen in 2005.

Publications by the DELPHI Collaboration:

In the list below, the ➢ (❑) symbol marks the papers published in 2004 (prepared, submitted and published in 2004), under the responsibility of LIP/DELPHI members or with important contributions from LIP/DELPHI members.

Coherent Soft Particle Production in \mathbf Z Decays into Three Jets
PH-EP 2004-18 (3 May 2004)
(Physics Letters B605 (2005) 37-48)

❑ **Determination of the e+e- \to *gam gam* (*gam*) cross-section at LEP 2**
PH-EP 2004-017 (27 April 2004)
(Eur. Phys. J. C37 (2004) 405-419)

➢ **Search for fermiophobic Higgs bosons in final states with photons at LEP 2**
EP 2003-087 (10 December 2003)
(Euro. Phys. J.c35 (2004) 313-324)

Measurement of the energy dependence of hadronic jet rates and the strong coupling \as\ from the four-jet rate with the DELPHI detector at LEP
PH-EP 2004-036 (26 April 2004)
(Euro. Phys. J. C38 (2005) 413-426)

Determination of A_FB^ b at the Z pole using inclusive charge reconstruction and lifetime tagging
PH-EP 2004-062 (30 November 2004)
(Accepted by Eur. Phys. J. C)

- **Search for single top production via FCNC at LEP at sqrt(s) =189-208 GeV**
  EP 2003-066 (16 September 2003)
  (Phys. Lett. B590 (2004) 21-34)

The measurement of \as\ from event shapes with the DELPHI detector at the highest LEP energies
EP 2004-007 (06 January 2004)
(Accepted by Euro. Phys. C37 (2004) 1-23)

Search for B^0_s - \barB^0_s oscillations in DELPHI using high- p_t leptons
EP 2003-089 (6 October 2003)
(Euro. Phys. J. C35 (2004) 35-52)

Measurement of the W-pair Production Cross-section and W Branching Ratios in e+e- Collisions at sqrt(s) = 161-209 GeV
EP 2003-071 (4 November 2003)
(Eur. Phys. J. C34 (2004) 127-144)

Photon Events with Missing Energy in e+e- Collisions at sqrt(s) = 130 to 209 GeV
EP 2003-093 (18 December 2003)
(Euro. Phys. J. C38 (2005) 395-411)

A Precise Measurement of the \BP, \BZERO and Mean b-hadron Lifetime with the DELPHI Detector at LEP I
EP 2003-065 (28 Mai 2003)
(Eur. Phys. J.C33 (2004) 307-324)

Measurement of \Vcb using the semileptonic decay \Bdb -> \Dstarp *l*- \bar\nu_\ell
EP 2003-057 (18 June 2003)
(Eur. Phys. J.C33 (2004) 213-232)

Study of Tau-pair Production in Photon-Photon Collisions at LEP and Limits on the Anomalous Electromagnetic Moments of the Tau Lepton
EP 2003-058 (2 September 2003)
(Eur. Phys. J. C35 (2004) 159-170)

Search for supersymmetric particles assuming R --parity non-conservation in e+e- collisions at sqrt(s) = 192 to 208 GeV
EP 2003-092 (23 September 2003)
(Eur.Phys.J.C36(2004) 1-23; Erratum Eur.Phys.J.C37(2004) 129-131)

Searches for Neutral Higgs Bosons in Extended Models
EP 2003-061 (12 June 2003)
(Eur. Phys. J. C38 (2004) 1-28)

Search for Charged Higgs Bosons at LEP in General Two Higgs Doublet Models

EP 2003-064 (23 September 2003)
(Eur. Phys. J. C34 (2004) 399-418)

Searches for invisibly decaying Higgs bosons with the DELPHI detector at LEP
EP 2003-046 (18 June 2003)
(Eur. Phys. J. C32 (2004) 475-492)

Measurement of the Forward-Backward Asymmetries of e+e-\ -> Z\ -> b \barb and e+e-\ -> Z\ -> c \barc using prompt leptons
EP 2003-083 (22 October 2003)
(Eur. Phys. J C34 (2004) 109-125)

Final results from DELPHI on the searches for SM and MSSM Neutral Higgs bosons
EP 2003-008 (11 February 2003)
(Eur. Phys. J. C32 (2004) 145-183)

ZZ production in e^+ e^- interactions at sqrt(s) = 183 - 209 GeV
EP 2003-009 (6 February 2003)
(Eur. Phys. J. C30 (2003) 447-466)

Measurement of the \bold Lambda b^0 Decay Form Factor
EP 2003-056 (1 April 2003)
(Phys. Lett. B585 (2004) 63-84)

Search for SUSY in the AMSB scenario with the DELPHI detector
EP 2003-048 (14 July 2003)
(Eur. Phys. J. C34 (2004) 145-156)

Reports:

List of internal/technical notes and communications to international conferences, with direct involvement of LIP/DELPHI members (names underlined).

2004-002 CONF 683
- S.Raducci, P.Abreu, A. De Angelis
- **Search for Pentaquarks in the Hadronic Decays of the Z Boson**
- 8 March 2004

2004-023 CONF 698
- V. Obraztsov, S. Slabospitsky and O. Yushchenko, S. Andringa, N. Castro, P. Gonçalves, A. Onofre, M. Pimenta, B. Tomé and F. Veloso
- **Search for single top production via FCNC at LEP at sqrt=189-208 GeV**
- 20 July 2004

2004-024 CONF 699 CONF 700
- W. Adam, S. Andringa, N. Castro, M.C. Espírito Santo, P. Gonçalves,
- **Search for excited leptons in e+e- collisions at sqrt=189-208**
- 27 July 2004

2004-036 CONF 711
- M. C. Espírito Santo, P. Gonçalves, A. Onofre, M. Pimenta and B. Tomé
- **Determination of the e+e- -> gamma gamma cross-section at LEP2**
- 28 July 2004

2004-044 CONF 719
- P. Abreu, N. Anjos, J. D'Hondt, N. Kjaer
- **Update on the Investigation of Colour Reconnection in WW Pairs using Particle Flow and mw Estimators**
- 29 July 2004

Conferences:

List of oral presentations of DELPHI or LEP results in International Conferences, by members of the LIP/DELPHI team:

- Filipe Veloso, *Single Top Production via Contact Interactions*, Lake Louise Winter Institute 2004, February 2004, Lake Louise, Alberta, Canada.
- Nuno Anjos, *Colour Reconnection and Bose-Einstein Correlations in WW decays*, 12th International Workshop on Deep Inelastic Scattering "DIS'2004", April 2004, Štrbské Pleso, High Tatras, Slovakia.
- Patrícia Gonçalves, *Determination of the e+e- =>gam gam(gam) Cross-Section at LEP-2*, American Physical Society "APS April Meeting", May 2004, Denver, Colorado, U.S.A.
- Pedro Abreu, *Bose-Einstein Correlations in DELPHI WW Events at LEP-2*, 11th International Conference in Quantum Chromodynamics "QCD'04", July 2004, Montpellier, France.

List of oral presentations of DELPHI or LEP results in National Conferences, by members of the LIP/DELPHI team:

- N. Anjos, *Colour Reconnection in DELPHI* , 3º Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal
- P. Abreu, *Search for Pentaquarks in Z decays*, 3º Encontro Nacional de Física Hadrónica, April 2004, Lisbon, Portugal

Seminars:

P. Abreu, QCD at DELPHI, IFM, Lisbon, Portugal

Other presentations:

- P. Abreu, *LEP – da Teoria à Fábrica dos bosões W e Z*, Celebration of the 50th Anniversary of CERN, IST, Lisbon, November 2004
- B. Tomé, A *participação portuguesa na experiência DELPHI do LEP*, Celebration of the 50th Anniversary of CERN, FCUL, Lisbon, December 2004

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress	**1**		
Concluded in 2004		**2**	

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
20	**3**	**5**	**4**	**2**	**1**	**2**	**1**

Legend:
Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Grid Computing

Project References	Funding
EU CrossGrid (IST-2001-32243) EU EGEE (INFSO 508833) LHC Computing Grid	CrossGrid 374,000 € over 3 years (1) EGEE 489,000 € over 2 years for human resources (2)

(1) The CrossGrid project will finish in April of 2005 (50% of the budget must be covered by LIP funds)
(2) The EGEE project will finish in March 2006 (50% of the budget must be covered by LIP funds)

Resumo:

A computação Grid é um paradigma de computação recente 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. O LIP participou durante 2004 no projecto do CERN LHC Computing Grid (LCG), e nos projectos Europeus CrossGrid e Enabling Grids for E-Science (EGEE).

Team:

Project Coordinator: Jorge Gomes

Team Members:

Name	Status	% of time in the project
Jorge Gomes	Researcher/LIP	80
Gaspar Barreira	Researcher/LIP	25
Mário David	Post-Doc/FCT grant	100
João Martins	Technical staff/LIP	20
Nuno Dias	Technical staff/LIP	80
Ana Simões	BsC Student	10
Luís Bernardo	Researcher	5

Summary of Activities:

During 2004 the LIP computing team continued its line or work in Grid computing. These activities were performed mostly in the context of international and European Union grid research and deployment projects. The team was involved in the CERN project LCG (LHC Computing Grid) and in the European Union funded projects EGEE (Enabling Grids for E-SciencE) and CrossGrid. 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:

- LCG is a CERN project that aims to build the computing infrastructure for the LHC experiments. The project was launched after the careful 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 LCG project is closely related with the European Union project EGEE that is currently providing the operations and user support for LCG in Europe.
- EGEE is a European Union funded project coordinated by CERN. EGEE aims to deploy a production Grid infrastructure for scientific computing open to all scientific domains. EGEE provides middleware engineering, support, integration and coordination of computing resources. The EGEE infrastructure is already the largest Grid in the world with more than 11,000 CPUs in more than 120 sites covering 31 countries and includes all LCG resources. 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 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 has 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.

The LIP participation in LCG and EGEE was mostly centred in the infrastructure operations namely in the context of the Southwest federation. LIP is operating a small cluster of 4 dual CPU systems integrated in the LCG/EGEE infrastructure and is providing central services for the federation including a Resource Broker and a Replica Location Service that are being used by researchers in Portugal and Spain. The central services are hosted at the Portuguese Academic Network facilities where they take profit of a direct connectivity to the Géant European network backbone. In parallel LIP is playing an important role in the user support and is responsible for the coordination of the user and site support in the Southwest federation. LIP is developing efforts in the dissemination area with the objective of finding new resource centres in the country willing to join the EGEE infrastructure and share computing resources. LIP is also involved in the middleware test activities that are now starting inside EGEE and aim to establish a pre-production service where the new EGEE middleware (gLite) will be tested prior to deployment in the production infrastructure.

The CrossGrid project final review was held in Amsterdam during February of 2005. Included in the review, live demonstrations of the applications, tools and services were performed to a large audience of researchers. The project achievements were highly acknowledged, all deliverables were accepted and the project was considered a success story of the European Union F2 unit.

LIP had a fundamental role in the CrossGrid testbed activities namely:

- LIP maintained all the production central services for the whole testbed.
  - Resource Brokers, Replica Location Services, Information Index
- LIP maintained central services for the production and development testbeds.
  - Monitoring services, Virtual Organizations server, Myproxy repository
- LIP provided user and site administrator support to a community of international users.
- LIP was deputy of the international testbed organization and responsible for the testbed quality control and for all test and validation activities including the validation of middleware, tools and testbed services. LIP had an important role in the coordination of the testbed activities.
- LIP performed software developments in the area of monitoring and validation.
- LIP participated actively in the integration of the project developments.
- LIP participated actively in the certification authorities workgroup and helped to setup new certification authorities in Poland, Spain, Slovakia and Greece.
- LIP also contributed to the coordination of the testbed activities with other projects such as LCG and EGEE.

LIP was the organizer of the 5th CrossGrid integration meeting that was held in Lisbon in October of 2004. In the context of the integration meeting LIP organized a "grid open day" dedicated to the dissemination of grid computing that counted with the participation of more than 120 researchers. The event counted also with the presence of the Secretary of state for "Science Technology and Innovation" and representatives from the EU grid technologies unit, and from the EGEE management. A strong participation of the CrossGrid team ensured the technical presentations and live demonstrations.

At national level LIP aims at creating a thematic network on Grid Computing and continued its collaboration with national academic organizations on this subject. New contacts have also been established. LIP continued to maintain the Portuguese Grid Certification Authority (CA). The LIP certification authority was upgraded both in terms of policies, operation and software, a new CA compatible with the most recent authentication requirements and with national scope was deployed. Two new registration authorities subordinated to the LIP Certification Authority have been created at two Universities (UAL and Lusíada).

The activities of this project were severely affected by the lack of national funding. Some of the activities were funded by the European Union under the 5th and 6th Program Frameworks. However, this funding covers only 50% of the actual costs and **excludes equipment**. National funding is essential to cover the remaining 50% and to complement the funded activities with the necessary equipment. National funding is also fundamental to deploy the national computing infrastructure for LHC. Currently LIP has only 8 CPUs in the LCG/EGEE Grid infrastructure. Unfortunately during 2004 LIP was unable to obtain national funds for any of these activities.

Academic Training:

"GFM: a Grid File Manager" /Ana Simões/UAL, Graduation

Publications:

EU Deliverables

- CrossGrid – CG4-D4.6 – Testbed Status
  - EU deliverable (Jesus Marco, Jorge Gomes, M.Hardt, S.Gonzales, J.Astalos)
- CrossGrid – CG4-D4.8 – Final testbed with all applications integrated
  - EU deliverable (Jorge Gomes and Jesus Marco)
- CrossGrid – CG4-D4.9 – Testbed final report
  - EU deliverable (Jesus Marco, Jorge Gomes and the CrossGrid WP4)

Conference Proceedings

"MPICH-G2 implementation of an interactive artificial neural network training", 2nd European Across Grids Conference, Nicosia, Cyprus, David Rodriguez, Jorge Gomes, Jesus Marco, Rafael Marco, Celso Martinez-Rivero

Conferences:

"The EGEE SouthWest federation", First EGEE Conference, Cork Ireland
Jorge Gomes (oral presentation)

Outreach

- Organization of meetings:
  - "Lisbon Grid Open Day" – 21st of October 2004
- Presentations:
  - "The CrossGrid project", Grid Open Day, Lisbon
    - *Jorge Gomes*
  - "Grid Computing in Portugal", Grid Open Day, Lisbon
    - *Mario David*
  - "Grid Computing", Oracle, Lisbon
    - *Mario David*
  - "Da Web à Grid", commemorations of the CERN 50 years at IST, Lisbon
    - *Jorge Gomes*
- Articles:
  - "A Computação Grid", FCCN newsletter, Lisbon
    - *Jorge Gomes*

Other presentations

- "CrossGrid testbed status", 4th CrossGrid Integration meeting, Dagsthul, Germany
  - *Jorge Gomes*
- "Computação Grid e a Autoridade de Certificação do LIP", Encontro de Centros de Informática, Guarda, Portugal

- "Computação Grid investigação, desenvolvimento e ensino", encounter of national thematic networks, Aveiro, Portugal
  - *Gaspar Barreira*

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress			**1**
Concluded in 2004			

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
		5	**1**		**1**	**4**	**2**

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
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Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: AMS

Project References	Funding
DIV 1179	40 000 €

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.

Team:

Project Coordinator: Fernando Barão

Team Members:

Name	Status	% of time in the project
Gaspar Barreira	Researcher /LIP	10
Mário Pimenta	Researcher/LIP-IST	10
Fernando Barão	Researcher /LIP-IST	75
Patrícia Gonçalves	PostDoc/FCT grant	60
Luísa Arruda	PhD Student/FCT grant	100
Rui Pereira	PhD Student/FCT grant	100
João Borges (1)	Master Student/LIP grant	100
Fernando Carmo	Master Student	20

(1) Until November 2004

Summary of 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 Cherenkov 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=1.05) 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 developed algorithms for velocity and charge reconstruction.

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 Cherenkov 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 (tuning of the signal peaking time) were tested. The physics program included the testing of different aerogel radiators, the testing of the mirror material and the reconstruction of inclined particles.

The activities where the group was involved along the year 2004 were the following:

- Monitoring and fine tuning of the Velocity and charge reconstruction algorithms
- Running of the velocity reconstruction algorithm in the full AMS simulation
- Characterization of the aerogel surface with a AFM microscope and its simulation with the Geant4 package
- Measurements of the magnetic field effects on the photomultiplier gain
- Calibration and tests of photomultipliers
- Data Analysis of 2003 test beam:
    - Velocity resolution and Charge resolution evaluations; comparison with the test beam simulation

- Reflectivity measurement
- Sodium Fluoride velocity and charge resolution
- Development of a method for charge identification based on two scintillator measurements

Academic Training:

Master Theses

"Velocity Reconstruction with the RICH detector of the AMS experiment", Joao Borges Thesis presented on Jan 2004, Instituto Superior Tecnico (Lisbon)

“Study of the light guide signal for electric charge determination in the RICH”, Fernando Carmo, Ongoing Thesis

PhD Theses

“Low charge nuclei identification with the AMS spectrometer”, Luisa Arruda, Ongoing Thesis (2004-)

“Deuterium measurements and Dark Matter searches with the AMS experiment”, Rui Pereira, Ongoing Thesis (2005-)

Publications:

"AMS - A magnetic spectrometer on the International Space Station", Fernando Barao Nuclear Instruments and Methods in Physics Research A 535 (2004) 134.

“Isotopic mass separation with the RICH detector of the AMS experiment”, Luisa Arruda Proceedings of International School of Cosmic Ray Astrophysics, Ed. Kluwer Nato Proc. Series

Conferences:

International

"AMS - A magnetic spectrometer on the International Space Station", Fernando Barao Feb 2004, Vienna Conference on Instrumentation (VCI)

"Velocity and Charge Reconstruction with the RICH detector of the AMS experiment - Isotopic Separation for helium and beryllium elements", Luisa Arruda, Jul 2004, International School of Cosmic Ray Astrophysics, Erice, Italy

National

"Reconstrucao de Velocidade e carga electrica com o detector RICH da Experiencia AMS", Luisa Arruda, Jul 2004, XIV Encontro Nacional de Astronomia e Astrofísica, Azores

"Determinacao da carga electrica com detectores de cintilacao", Rui Pereira, Jul 2004, XIV Encontro Nacional de Astronomia e Astrofísica, Azores

Other presentations:

"AMS: the Alpha Magnetic Spectrometer", Patrícia Gonçalves, April 2004, Poster presented in "Forum Empresarial e de I&D Tecnológico do Espaço 2004", Centro de Congressos de Lisboa.

"AMS - Um espectrómetro magnético na estação especial internacional", Luísa Arruda Dec 2004, "50 years of CERN", Lisboa.

Statistics:

Theses:	PhD	Master	Graduation
In Progress	2	1	
Concluded in 2004		1	

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
1	1		2	2		1	

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: EUSO and ultra high energy cosmic rays phenomenology

Project References	Funding
PDCTE/FNU/49727/2003	60 000 €

Resumo:

Os raios cósmicos de energia extrema (RCEE) constituem um campo de investigação recente e prometedor. A existência de partículas cósmicas com energias superiores a 10^{20} eV está hoje estabalecida. No entanto, inúmeras questões se encontram ainda em aberto. Do ponto de vista teórico, tanto a aceleração de partículas a energias tão elevadas como o facto de estas poderem ter percorrido grandes distâncias até atingir a Terra são, em certa medida, inesperados. Do ponto de vista experimental, o problema principal é o baixíssimo fluxo destes acontecimentos, que faz com que a estatística até hoje recolhida seja claramente insuficiente para a caracterização do espectro nesta gama de energias. O próximo passo será dado com a experiência Auger, actualmente em construção. Para ir mais além são necessárias áreas de detecção de escala planetária, só possíveis com métodos inovadores de observação a partir do Espaço como o proposto por EUSO. EUSO pretende observar, a partir do Espaço, a luz de fluorescência induzida pela interacção dos RCEE na atmosfera terrestre. Neste relatório apresentam-se as principais actividades do grupo do LIP na área dos RCEE durante o ano de 2004. O grupo do LIP participou na Fase A de EUSO, contribuindo para que esta fosse concluida com sucesso. O grupo Português foi responsável por todos os estudos referentes ao desenvolvimento do segmento de Terra científico da missão (SODC), teve responsabilidades no desenvolvimento de software de simulação e análise (nomeadamente na simulação do trigger), participou no programa de actividades experimentais de apoio a EUSO e em actividades de divulgação. Em paralelo, o grupo desenvolveu trabalho na área da fenomenologia dos RCEE, que conduziu já à publicação de dois artigos.

Team:

Project Coordinator: Mário Pimenta

Team Members:

Name	Status	% of time in the project
Mário Pimenta	Researcher/LIP-IST	50
M. Catarina Espírito Santo	Researcher/LIP	70
Bernardo Tomé	Post-Doc/FCT grant	50
Pedro Abreu	Researcher/LIP-IST	30
António Onofre	Researcher/LIP-UCFF	10
Jorge Gomes	Researcher/LIP	10
Pedro Brogueira	Researcher/LIP-IST	10
Luís Melo	Researcher/LIP-IST	10
Pedro Assis	PhD Student	100
Miguel Paulos	Undergraduate (3)	50
Filipe Cardoso (1)	Undergraduate (3)	50
Ruben Conceição (2)	Undergraduate (3)	50

(1) Until June 2004; (2) Started October 2004; (3) LIP Initiation to Research grant

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Summary of Activities:

The study of Ultra High Energy Cosmic Rays (UHECR) is a recent and promising field. Indeed, although the existence of cosmic rays with energies above 10^{20} eV is now established, the subject is still largely open. From a theoretical point of view, both the acceleration of particles to such energies and the fact that they may travel relatively large distances before reaching Earth are to some extent unexpected, making UHECR a privileged probe to the Universe. Experimentally, the main issue stems from the very low arrival rate on Earth of these events, which makes the statistics collected up to now clearly insufficient for the characterisation of the cosmic ray spectrum in this energy range. An important step forward is the Pierre Auger Observatory, presently under construction, expected to collect in one year more than the total presently available statistics. To proceed even further, a planetary scale detection area is required, only possible with a Space-borne approach such as the one proposed by the Extreme Universe Space Observatory (EUSO). EUSO will detect from above the fluorescence light produced in the interaction of the UHECR with the atmosphere, watching a very large atmospheric area.

In this report, the activities of LIP in the area of UHECR during the year 2004 are briefly summarised. The EUSO LIP group participated in the Phase A of EUSO, contributing to its successful completion in July 2004. The Portuguese team was responsible for the coordination of the Phase A of the SODC, the scientific ground segment of the mission. Furthermore, the team had responsibilities in the development of the simulation and analysis software for EUSO (namely in the trigger simulation), participated in the program of experimental support activities for EUSO (in particular in the ULTRA experiment) and developed communication and outreach activities. In parallel, a line of work devoted to the phenomenology of UHECR was established and led already to the publication of two papers. Some details on the main topics are given below:

EUSO SODC – Science Operations and data Centre

The LIP team was responsible for the coordination of the Phase A of the EUSO Science Operations and Data Centre (SODC), the scientific ground segment of the mission. The main task in 2004 was the preparation, discussion and revision of the end of Phase A documentation required by ESA. The SODC team has contributed to the general instrument report with a chapter on EUSO operations. In fact, the definition of a generic operations concept, covering both the flight and the ground segments, is crucial for the correct dimensioning of the system and for the outlining of a coherent end-to-end mission concept. The EUSO operations system outlined in Phase A accommodates the different operational modes and states required for the achievement of the science goals and the safety of the instrument, while involving a considerably degree of on-board autonomy. Further progress will require a more detailed specification of several instrument subsystems and mission aspects. Furthermore, a specific document on "EUSO operations: flight and ground" was prepared and delivered to ESA. Only minor corrections were requested before final acceptance. After the conclusion of Phase A, small preparatory work has been performed, mainly concerning the organisation of the mission archives and databases.

Simulation and reconstruction software for EUSO

The LIP group has significantly increased its participation on the development of ESAF – EUSO Simulation and analysis framework, a successful collaboration effort to develop an integrated, modular framework for simulation and reconstruction, based on C++ and Root. The LIP group took the responsibility of the implementation of the EUSO trigger simulation, and a preliminary version is now fully working. The high segmentation of the

EUSO focal surface, the limit electronics and computation resources (due to the restrictive mass and power budgets), the low signal to noise ratio and the limited telemetry budget make the EUSO trigger system rather challenging. In connection to these activities, a PhD work on trigger and data acquisition systems in cosmic ray air shower experiments is in development.
Furthermore, studies on the effects of the atmosphere in energy reconstruction and work on the simulation of high energy extensive air showers using the standard code CORSIKA were performed and included the development of undergraduate research projects.

ULTRA – UV light Transmission and Reflection in the Atmosphere
The ULTRA experiment aims at providing quantitative measurements of the reflection/diffusion signal produced by extensive air showers impacting on the Earth surface, overcoming the lack of information in this field. A scintillator array and UV light detectors will operate simultaneously, to detect the shower in coincidence with the UV light reflected/diffused on Earth. The LIP team has been responsible for the data acquisition system and the synchronisation of the experiment. A PCI-based board for data acquisition and for time-tagging the arrival of the shower, using GPS receivers was developed, with an overall time accuracy better than 10 ns. The system, which successfully acquired and pre-processed the data in the two ULTRA engineering runs previously performed, has during this year been accepted by the collaboration as the standard data acquisition system for the final configuration. During 2004, the ULTRA setup was mounted at the LPSC in Grenoble and thoroughly tested. The LIP data acquisition system, previously used for the scintillator array, was adopted also for the UV light detectors. Much progress was made on the understanding and control of the collected UV data. A master thesis on the subject was successfully concluded in 2004.

UHECR phenomenology
a line of work devoted to the phenomenology of UHECR was established. The main goal is to perform studies of interest for the next generation of UHECR experiments, in particular Auger and EUSO, centred in the search for signatures of interesting and exotic processes. In fact, in spite of the low and uncertain fluxes and of the poorer detection capabilities, and thanks to the extremely high energies reached, UHECR may constitute the only window into new physics well beyond the TeV scale. These activities encourage a strong collaboration between the experimental group at LIP and theoreticians of different Portuguese institutions working in related fields, and make the bridge with accelerator particle physics at LEP and at the LHC. Furthermore, they foster the integration of the LIP group in the UHECR community and large.
The first work was devoted to a possible signature of the production of microscopic black holes in high energy neutrino-nucleus collisions in the atmosphere. Such possibilities arise in scenarios in which there are compactified extra dimensions in our Universe, and will be searched for at the LHC. In UHECR, a double bang signature could arise from the production and prompt decay of a mini black hole (first bang) followed, at a measurable distance, by the decay of a very energetic tau lepton (second bang) originating from the decay of the black hole.
A study on the sensitivity of cosmic ray air shower experiments for the production of excited leptons has followed. Excited leptons are expected in models with compositeness in the fermionic sector and have been thoroughly searched for at colliders. They could be produced in the interaction of ultra high energy cosmic neutrinos with the atmosphere, and the possibility of detecting their interaction and decay products in large air shower experiments would considerably extend the accessible mass region.

Within this line of work, a graduation thesis on the search for new phenomena in UHECR interactions is being developed. The group has actively participated in the organisation of the 5th international workshop "New Worlds in Astroparticle Physics", held in Faro in January 2005, which has been for several years now a privileged discussion forum for the Portuguese astroparticle physics community.

Communication and Outreach

Exploring the highest energy objects ever measured and using an innovative observation principle from space, EUSO has a large outreach potential. The education and public outreach activities included several seminars for students and the collaboration with the project TRC-Cosmic Rays Telescope to run a cosmic ray detector in high schools. A group with one representative per country has been set up within the EUSO Collaboration in order to coordinate the outreach activities.

Academic Training:

- "The Setup and engineering run of the ULTRA experiment", P. Assis, Master thesis, Presented to IST and discussed in December 2004.
- "Data Acquisition and Control systems in Cosmic Ray Experiments", P. Assis, PhD Thesis, in progress.
- "Search for new physics in very high energy cosmic ray showers", M. Paulos, Graduation Thesis, to be presented to IST in the Summer 2005.
- Short duration undergraduate training activities:
  - Energy reconstruction in EUSO, M. Paulos, *Initiation to Research* grant (concluded Summer 2004)
  - Test of a new generation of GPS receivers, F. Cardoso, *Initiation to Research* grant (concluded Summer 2004)
  - Simulation of ultra high energy extensive air showers with CORSIKA, R. Conceição, *Initiation to Research* grant (started October 2004)

Publications:

Publications in international journals with scientific peer review:

- "Microscopic black hole detection in UHECR: the double bang signature", V. Cardoso, M.C. Espírito Santo, M. Paulos, M. Pimenta, B. Tomé, Astroparticle Physics 22 (2005) 399-407, [hep-ph/0405056].

Other publications:

- "The sensitivity of large cosmic ray experiments to excited lepton production", M.C. Espírito Santo, M. Paulos, M. Pimenta, J.C. Romão, B. Tomé, submitted to Astroparticle Physics, [hep-ph/0412345].
- "EUSO operations: flight and ground", M.C. Espírito Santo, M. Pimenta, EUSO-SODC-SP-003-2.C, 31 January 2004, document presented to the European Space Agency.

Conferences:

- "Frontiers in Ultra High Energy Cosmic Rays", M. Pimenta, 6th Symposium on Frontiers in Fundamental and Computational Physics, Udine, September 2004.
- "Microscopic black hole detection in UHECR: the double bang signature", V. Cardoso, M.C. Espírito Santo, M. Paulos, M. Pimenta, B. Tomé, Poster presentation at the 19th European Cosmic Ray Symposium, Firenze, August-September 2004.
- "The ULTRA experiment", ULTRA Collaboration, poster presentation at the 19th European Cosmic Ray Symposium, Firenze, August-September 2004.

Seminars:

Invited seminars:

- "Ultra High Energy Cosmic Rays", M. Pimenta, SISSA, Trieste, May 2004.

Other presentations:

- "Particle Physics on Earth and in the Skies", M. Pimenta, IST, Lisbon, May 2004.
- "Raios cósmicos de Energia Extrema", M.C. Espírito Santo, Encontro Nacional de Ciência e Tecnologia 2004, Aveiro, October 2004
- "Ultra high energy cosmic rays", M.C. Espírito Santo, Celebration of the 50 years of CERN, FCUL, Lisbon, December 2004

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress	**1**		**1**
Concluded in 2004		**1**	

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
1	**1**	**2**	**3**		**1**	**2**	**1**

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
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Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: ESA contracts for the developments and Applications of the GEANT4 Toolkit to Astroparticle Physics Experiments

Project References	Funding
ESA: 17097/03/NL/LvH/bj	25 000 €
ESA: 18121/04/NL/ch	27 500 €

Resumo:

O toolkit *de simulação GEANT4 é um software de simulação em* open-source *desen-volvido 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. No contexto das aplicações à física do espaço e astrofísica de partículas, foram desenvolvidas várias actividades no LIP utilizando o* toolkit *de simulação GEANT4, intituladas:* "Radiation Interaction Simulations for the Astrophysics Experiments EUSO and AMS", "Integrated Radiation Environment**,** Effects and Component Degradation Simulation Tool" *e* "Software Models for the Portuguese Interplanetary Particle Surveyor*". A primeira actividade correspondeu ao desenvolvimento de um ambiente de simulação comum aplicável a vários estudos conduzidos no âmbito da participação do LIP nas experiências EUSO e AMS; a segunda a estudos conducentes 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; e finalmente a terceira actividade correspondeu a estudos preliminares em torno do conceito de instrumento denominado PIPS (*Portuguese Interplanetary Particle Surveyor*), um monitor de radiação para futuras missões espaciais.*

Team:

Project Coordinator: Mário Pimenta / Bernardo Tomé
Team Members:

Name	Status	% of time in the project
Bernardo Tomé	Post-Doc fellow/FCT grant	40
Mário Pimenta	Researcher/LIP-IST	25
Patrícia Gonçalves	Post-Doc fellow/FCT grant	30
M. Catarina Espírito Santo	Researcher/LIP	20
Ana Keating[3]	PhD Student/FCT grant	100
Andreia Trindade	PhD Student/FCT grant	5
Pedro Rodrigues	PhD Student/FCT grant	5
João Costa [4]	Student/BIC LIP grant(*)	100

(*) BIC: initiation to search grant

Summary of Activities:

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

[3] Started in April 2004.
[4] Started in September 2004.

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.

Radiation Interaction Simulations for the Astrophysics Experiments EUSO and AMS

In the fulfilment of the contract 17097/03/NL/LvH/bj "Radiation Interaction Simulation for High-Energy Astrophysics Experiments EUSO and AMS", celebrated between LIP-Lisboa and ESA/ESTEC, a software framework based on the GEANT4 toolkit, integra-ting simulation, event reconstruction and data analysis capabilities, was developed. The framework baseline configuration uses ROOT for analysis and persistency mechanism, but integration with LCG PI/AIDA and LCG POOL, offering new capabilities, was eva-luated. The framework includes a standalone digitisation module for simulation of read-out electronics. This framework was exploited in a range of astroparticle applications, namely in the scope of the EUSO and AMS experiments. The project has been successfully concluded and ESA considered that all requirements and deadlines were met by LIP with a very professional approach.

Within the EUSO experiment there is an on-going program of critical design parameter studies, implying a set of dedicated experiments. The detection of the Cherenkov light associated with the EAS (Extensive Air Showers), measuring UV light diffusion coefficients of different types of media at the surface of the Earth, is the main goal of the ULTRA project (ULTRA-UV Light Transmission and Reflection in the Atmosphere). ULTRA is a hybrid detector, composed by an array of scintillation detectors, the ETscope, and a UV detection system, the UVscope. The simulation of ULTRA allowed the detailed study of the expected performance and capabilities of the detectors and implied the mastering of different aspects within GEANT4. A GEANT4 Advanced Example, addressing relevant aspects like the simulation of optical processes and the description of Fresnel lenses, based on the simulation of the UVscope, was included in the GEANT4 4.7.0 release. In the analysis of the test beam data taken at CERN with the AMS RICH detector prototype, it was found that there was an additional forward scattering effect affecting the Cherenkov photons produced in the aerogel radiator, which was not being reproduced by the detector simulation. In fact, this effect extended to the different aerogel types undergoing the test beam. In order to describe this effect in a more realistic way, a surface micro-facet sampling method was developed, making use of Atomic Force Microscopy (AFM) maps, which were interfaced to the GEANT4 toolkit in which a simplified design of the AMS/RICH radiator had been implemented. The surface maps obtained by AFM were also used to infer a parameterisation of the surface properties used in the context of an extended UNIFIED model for the description of the interactions of

radiation and surfaces. The design of this twofold implementation, included in the GEANT4 official list of planned developments and releases, was concluded.

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 will terminate by the end of 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 it is currently being modelled using GEANT4. The result of the studies, which are taking place, will be 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 has recently issued a first *scientific and technical plan* in which a preliminary concept for a Portuguese Interplanetary Particle Surveyor (PIPS) was proposed. The Portuguese Interplanetary Particle Surveyor is designed to measure the flux and energy distributions of interplanetary protons and ions in the energy range 0.5-150 MeV per nucleon and electrons in the energy range 0.1-20 MeV. The GEANT4 toolkit is an ideal framework to be used in the development of software models, which will enable the validation of the concept and may even open up the possibility to explore alternative concepts for the instrument. As a preliminary activity within LIP, the proposed setup for the PIPS concept was implemented in the framework of the GEANT4 toolkit and the first performance studies were carried. This activity was done in collaboration with Dalmiro Maia (PhD) of *Centro de Investigação em Ciências Geo-espaciais* (CICGEO) of *Observatório Astronómico do Porto*.

Academic Training:

- **Title***:* "Integrated Radiation Environment, Effects and Component Degradation Simulation Tool"/**Author:** Ana Keating/ **Degree:** PhD/ **Status:** In progress.

Publications:

Publications In International Journals With Scientific Peer Review

- "Applications of GEANT4 in Astroparticle Experiments", Maria Catarina Espírito-Santo, Patrícia Gonçalves, Mário Pimenta, Pedro Rodrigues,Bernardo Tomé, and Andreia Trindade, IEEE Transactions on Nuclear Science, Vol. 51, No. 4, August 2004, 1373.

Other publications and internal notes:

- Final Report on ESTEC Contract No.17097/03/NL/LvH/bj, "Radiation Interac-tion Simulations for High-Energy Astrophysics Experiments EUSO and AMS", prepared by M.Catarina Espírito-Santo, Patrícia Gonçalves, Mário

Pimenta, Pedro Rodrigues, Bernardo Tomé, and Andreia Trindade, for ESA/ESTEC.

- "STD - Surface Topography Description Tool", proposal in response to 04.179.02, AO/4669/04/NL/HE, prepared by LIP.
- "Integrated Radiation Environment, Effects and Component Degradation Simulation Tool: Extension of Activity – Experimental Verification ", proposal in response to 04.179.02, AO/4669/04/NL/HE, prepared by LIP.

Conferences:

- *"*Radiation Interaction Simulations For High-Energy Astrophysics Experiments EUSO And AMS ". presented by Patrícia Gonçalves at the *"GEANT4 Space Users Workshop",* 8-10 May 2004, Vanderbuilt University, Nashville, USA.
- *"*Integrated Radiation Environment, Effects and Component Degradation Simulation Tool". presented by Ana Keating at the *"GEANT4 Space Users Workshop",* 8-10 May 2004, Vanderbuilt University, Nashville, USA.

Other Presentations and Posters:

- "Radiation Interaction Simulations for High-Energy Astrophysics Experiments EUSO and AMS*"*, presented by Mário Pimenta, Pedro Rodrigues and Bernardo Tomé, 19 February 2004,ESA/ESTEC.
- "Topography of Surfaces and Simulation of their Optical Properties", Bernardo Tomé, ESA Round Table On Radiation Effects Software R&D, 7 June 2004, ESA/ESTEC.
- "Software For Radiological Risk Assessment", Andreia Trindade, ESA Round Table On Radiation Effects Software R&D, 7 June 2004, ESA/ESTEC.
- "Radiation Interaction Simulations for High-Energy Astrophysics Experiments EUSO and AMS", poster presented in "*Forum Empresarial e de I&D Tecnológico do Espaço 2004*", 21 April 2004, *Centro de Congressos de Lisboa*.
- "Integrated Radiation Environment, Effects and Component Degradation Simulation Tool", poster presented in "*Forum Empresarial e de I&D Tecnológico do Espaço 2004"*, 21 April 2004, *Centro de Congressos de Lisboa*.

Statistics:

Theses:	PhD	Master	Graduation
In Progress	1		
Concluded in 2004			

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
1	1	1	2				

Legend:
Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
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Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Development of Positron Emission Mammography

Project References	Funding
POSI/ DGDR-SIFEC/14/01/03/FDR/00134	LIP funding (2003-05): 569 000 euros

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.

Team:

Project Coordinator: João Varela

Team Members:

Name	Status	% of time in the project
João Varela	Researcher / LIP-Lisboa/ IST	30
Rui Ribeiro	Researcher / LIP-Lisboa/ FEUP	50
Luís Peralta	Researcher / LIP-Lisboa/ FCUL	20
Sérgio Ramos	Researcher / LIP-Lisboa, IST	5
Paula Bordalo	Researcher / LIP-Lisboa, IST	5
Pedro Rodrigues	PhD student/ LIP-Lisboa /FCT grant	100
Andreia Trindade	PhD student/ LIP-Lisboa /FCT grant	100
Rui Moura	PhD student/ LIP-Lisboa /FCT grant	100
Catarina Ortigão	PhD student/ LIP-Lisboa	100
José Carlos Silva	Technical staff/ LIP-Lisboa	10
Miguel Ferreira	Technical staff/ LIP-Lisboa	50

Conceição Abreu	Researcher / LIP-Algarve/ UALG	5
Pedro Rato Mendes	Post-Doc/ LIP-Algarve/ FCT grant	50
Bruno Carriço	Master student/ LIP-Algarve/ BIC	100
Patrick Sousa	PhD student/ LIP-Algarve/ FCT grant	10
Francisco Fraga	Researcher / LIP-Coimbra/ Univ. Coimbra	5

Summary of Activities:

In the second year of the PEM project global engineering design of the scanner was concluded and validated by full simulation and image reconstruction. A first prototype of the final detector module was built and experimentally validated. The architecture of the electronics systems was reviewed allowing a more reliable implementation. The design of the frontend ASIC was concluded and a first prototype was received. The design of the data acquisition system was also concluded, and the PC boards are now being produced. The engineering design of the PEM manipulator is in advanced state.

The installation of the TagusLIP laboratory infrastructure was concluded.

A patent of the PEM system was submitted.

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 0,06 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.
- Two new image reconstruction algorithms were implemented (MLEM and OSEM) and its performance was compared to ART. This study is under way at IBEB.

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 1.7 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 first 100 arrays will be delivered in March 2005.
- The Crystal Clear Collaboration signed a frame contract with Photonic Materials for the production of LYSO and LuAP crystals. Under this contract LIP placed an order for the production of 6300 LYSO crystals for the PEM scanner.
- 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.

- 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.
- 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

- By LIP initiative, 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 was submitted by INESC-ID for production in November 04, with four months delay relative to the initial schedule. Part of this delay was due to the redefinition of the system architecture.
- The design and simulation of the FPGAs DAQ and Trigger/DCC was concluded at INESC-ID. Additional work is now being pursued to include self-test features in the system. 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 was concluded at INOV as well as the electrical design of the DAQ board. The PCB layout of this board is now being concluded. Work is pursuing on the second board, the Trigger and Data Concentrator board. The fast link to the data acquisition PC (Star Fabric) was received.
- A prototype of the frontend service board (HV regulation, temperature monitoring) was developed and tested successfully by LIP.
- The basic architecture of the on-line software was defined (IBILI).

Mechanical and Cooling Systems

- The mechanical project of the Detector Modules was concluded at INEGI and the first prototype was produced. The design aimed a precision of 0.1 mm in the relative positioning of crystal and APD pixels. The mechanical design of the Detector Supermodule which integrates the frontend electronics boards was also concluded.
- 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 principles of the water based cooling system were defined by INEGI.
- The design of the PEM manipulator is pursuing within schedule at INEGI.

Academic Training:

PhD Theses

- Modelização e avaliação do desempenho do sistema de aquisição de dados de um detector PET para mamografia, Pedro Rodrigues (on-going).
- Avaliação do desempenho de um detector PET dedicado a mamografia, Andreia Trindade (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 e desenvolvimento de biópsia guiada por imagens PET, Rui Moura (on-going).

Master Theses

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

Publications:

Papers in international journals with scientific peer review in which LIP members had a major direct responsibility:

- *Electronics and Data Acquisition in Radiation Detectors for Medical Imaging,* J. Varela, Nuclear Instruments and Methods in Physics Research A 527 (2004) 21–26.

- *Breast imaging with a dedicated PEM,* R. Ribeiro, C. Abreu, P. Almeida, F. Balau, P. Bordalo, N.C. Ferreira, S. Fetala, F. Fraga, P. Lecoq, M. Martins, N. Matela, R. Moura, C. Ortigão, L. Peralta, S. Ramos, P. Rato, P. Rodrigues, A.I. Santos, A. Trindade, J. Varela, Nuclear Instruments and Methods in Physics Research A 527 (2004) 87–91.

- R. Moura, C. Ortigao, L. Peralta, M.G. Pia, P. Rodrigues, A. Trindade, J. Varela "Geant4 Applications and Developments for Medical Physics Experiments", IEEE Trans. Nucl. Sci. vol 51(4), pp. 1412-1419, 2004.

- *Design and Evaluation of the Clear-PEM Detector for Positron Emission Mammography,* Maria C. Abreu, João D. Aguiar, Fernando G. Almeida, Pedro Almeida, Pedro Bento, Bruno Carriço, Miguel Ferreira, Nuno C. Ferreira, Fernando Gonçalves, Carlos Leong, Filipe Lopes, Pedro Lousã, Mónica V. Martins, Nuno Matela, Pedro R. Mendes, Rui Moura, João Nobre, Nuno Oliveira, Catarina Ortigão, Luís Peralta, Rui Pereira, Joel Rego, Rui Ribeiro, P. Rodrigues, José Sampaio, Ana I. Santos, Luís Silva, José C. Silva, Patrick Sousa, Isabel C. Teixeira, João P. Teixeira, Andreia Trindade and João Varela, submitted to Transactions on Nuclear Science.

- *The Clear-PEM Electronics System,* Edgar Albuquerque, Pedro Bento, Carlos Leong, Fernando Gonçalves, João Nobre, Joel Rego, Paulo Relvas, Pedro Lousã, Pedro Rodrigues, Isabel C. Teixeira, João P. Teixeira, Luís Silva, M. Medeiros Silva, Andreia Trindade and João Varela, submitted to Transactions on Nuclear Science.

Papers in conference proceedings in which LIP members had a major direct responsibility:

- *Clear-PEM: A dedicated PET camera for improved breast cancer detection,* L. Peralta et al., ICRS10-RPS2004, Madeira, Maio 2004

- *Algebraic Reconstruction Technique (ART) using Linograms,* N. Matela et al., EANM´04 - Annual Congress of the European Association of Nuclear Medicine, Helsinki, Sept 04

- *Design and Evaluation of the Clear-PEM Detector for Positron Emission Mammography,* A. Trindade et al., IEEE-Medical Imaging Conference, Rome, Oct 2004

- *Architecture and First Prototype Tests of the ClearPEM Electronics Systems,* C. Leong et al., IEEE-Medical Imaging Conference, Rome, Oct 2004

- *System Matrix Calculation for Clear-PEM Using ART and Linograms,* N. Matela et al., IEEE-Medical Imaging Conference, Rome, Oct 2004

Conferences:

Oral presentations or posters by LIP members in international conferences:

- *Clear-PEM: A dedicated PET camera for improved breast cancer detection,* L. Peralta et al., ICRS10-RPS2004, Madeira, Maio 2004

- *Design and Evaluation of the Clear-PEM Detector for Positron Emission Mammography,* A. Trindade et al., IEEE-Medical Imaging Conference, Rome, Oct 2004

- *Architecture and First Prototype Tests of the ClearPEM Electronics Systems,* C. Leong et al., IEEE-Medical Imaging Conference, Rome, Oct 2004

Other Presentations:

Oral presentations by LIP members in meetings of the Crystal Clear Collaboration:

1. *Simulation of PEM Front-end Electronics and Trigger/DAQ System,* P. Rodrigues, Crystal Clear Collaboration Meeting, Lyon, 10-11 March 2004

2. *Breast Phantoms and PEM Simulation,* A. Trindade, Crystal Clear Collaboration Meeting, Lyon, 10-11 March 2004

3. *Results of DoI measurements with double crystal readout,* R. Moura, Crystal Clear Collaboration Meeting, Lyon, 10-11 March 2004

4. *Front-end chip for PEM,* J. Varela, Crystal Clear Collaboration Meeting, Lyon, 10-11 March 2004

5. *Mechanics of detector modules with APD for PEM,* J. Varela, Crystal Clear Collaboration Meeting, Lyon, 10-11 March 2004

6. *Characterization of Hamamatsu S8550 APD coupled to an LYSO:Ce matrix as a detector element for PEM,* P. Rato, Crystal Clear Collaboration Meeting, Lyon, 10-11 March 2004

7. *Measurements with crystals and APDs for PEM,* P. Rato, Crystal Clear Collaboration Meeting, CERN, 29-30 September 2004

8. *ClearPEM Electronics Systems,* J. Varela, Crystal Clear Collaboration Meeting, CERN, 29-30 September 2004

9. *ClearPEM Status,* J. Varela, Crystal Clear Collaboration Meeting, CERN, 29-30 September 2004

Oral presentations by LIP members in meetings of the PEM Consortium:

1. *Medidas DoI,* R. Moura, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 27-29 January 2004

2. *Testes no Algarve / Medidas com APDs,* P. Rato, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 27-29 January 2004

3. *Simulation studies with PEM breast phantoms,* A. Trindade, PEM Consortium Meeting, Simulation, Tests & Reconstruction,27-29 January 2004

4. *Simulation of PEM data acquisition system,* P. Rodrigues, PEM Consortium Meeting, Simulation, Tests & Reconstruction,27-29 January 2004

5. *Estado e perspectiva do projecto PEM,* J. Varela, PEM Consortium Meeting, Technical Board, 27-29 January 2004

6. *Analise de dados das medidas de DoI,* R. Moura, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 4 March 2004

7. *Characterization of Hamamatsu S8550 APD coupled to an LYSO:Ce matrix as a detector element for PEM,* P. Rato, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 4 March 2004

8. *Resultados da simulação da região da axila,* C. Ortigão, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 4 March 2004

9. *Estado da simulação PEM – I,* A. Trindade, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 4 March 2004

10. *Estado da simulação PEM – II,* P. Rodrigues, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 4 March 2004

11. *Estado do Projecto PET – Mamografia,* J. Varela, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 22 April 2004

12. *Tolerancias Mecanicas das Placas PEM,* J. Varela, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 22 April 2004

13. *Testes em Laboratorio com Electronica Discreta de 32 canais e APD Hamamatsu S8550,* P. Rato, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 22 April 2004

14. *Estudo Térmico,* R. Pereira, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 22 April 2004

15. *How to reduce the cabling and more?,* J. Varela, PEM Consortium Meeting, Electronics, 13 May 2004

16. *Estado da simulação de performance do detector,* A. Trindade, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 24-29 June 2004

17. *Estado da simulação Trigger/DAQ,* P. Rodrigues, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 24-29 June 2004

18. *Estado da simulação da axila,* C. Ortigão, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 24-29 June 2004

19. *Estado dos testes no Algarve,* P. Rato, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 24-29 June 2004

20. *Planos para testes no TagusLIP,* R. Ribeiro, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 24-29 June 2004

21. *Introdução ao software on-line,* J. Varela, PEM Consortium Meeting, Online Software, 24-29 June 2004

22. *Sistemas de alimentação e monitoragem de temperatura,* M. Ferreira, PEM Consortium Meeting, Electronics, 24-29 June 2004

23. *Estado da Simulação,* L. Peralta, PEM Consortium Meeting, Technical Board, 24-29 June 2004

24. *Testes protótipos,* P. Rato, PEM Consortium Meeting, Technical Board, 24-29 June 2004

25. *Projecto em fusão de imagem,* R. Ribeiro, PEM Consortium Meeting, Technical Board, 24-29 June 2004

26. *Estado do projecto e plano de trabalhos,* J. Varela, PEM Consortium Meeting, Technical Board, 24-29 June 2004

27. *Medidas de parâmetros térmicos,* R. Pereira, PEM Consortium Meeting, Mechanics, 24-29 June 2004

28. *Estudos de Simulação da Região Axilar - status report 4,* C. Ortigão, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 6 October 2004

29. *PEM system performance in breast examination,* A. Trindade, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 6 October 2004

30. *On-line and Off-line energy/time algorithms,* P. Rodrigues, PEM Consortium Meeting, Simulation, Tests & Reconstruction, 6 October 2004

31. *Sistema de QC dos módulos do detector,* P. Rato, PEM Consortium Meeting, Technical Board, 5 November 2004

32. *Discussão do plano de trabalhos,* J. Varela, PEM Consortium Meeting, Technical Board, 5 November 2004

Statistics:

Theses:	PhD	Master	Graduation
In Progress	4	1	
Concluded in 2004			

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
3	3	5	3				

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Monte Carlo Techniques and Detector Development Applied to Medical Physics

Project References	Funding
POCTI/PAL/43672/2002	55 000 €

Resumo:

O presente projecto tem duas vertentes i) Desenvolvimento de programas de simulação Monte Carlo para aplicação na determinação de doses fornecidas por fontes de radiação ionizante a meios biológicos ii) participação no desenvolvimento de detectores de radiações ionizantes para aplicações na medicina. Estes são importantes domínios de transferência tecnológica da área da Física de Altas energias para as Ciências da Saúde Humana. O projecto é desenvolvido com uma participação importante do polo do Algarve do LIP.

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. Nos últimos anos tem existido um aumento continuo do desenvolvimento de detectores para aplicações médicas usando técnicas nascidas no seio da Física de Altas Energias. Um exemplo, são os detectores de silício e de determinados tipos especiais de cintiladores em imagiologia com base em raios-X ou gama. Este tipo de materiais usados correntemente em Física de Altas Energias, podem melhorar significativamente o contraste e resolução das imagens obtidas. Permitem também, de uma forma simples, a obtenção e tratamento de imagens digitais.

Team:

Project Coordinator: Luis Peralta

Team Members:

Name	Status	% of time in the project
Luis Peralta	Researcher/LIP-FCUL	40
M.Carmo Lopes	Researcher/IPO	50
M.Conceição Abreu	Researcher/LIP-UA	25
Pedro Rato	Post-Doc/LIP-Alg/FCT grant	20.
Andreia Trindade	PhD Student/FCT grant	10
Pedro Rodrigues	PhD Student/ FCT grant	10
Catarina Ortigão	PhD Student/LIP grant	15
Adérito Chaves	PhD Student/IPO	70
Carla Oliveira	Master Student/IPO	70
Patrick Sousa	PhD Student/LIP-Alg/ FCT grant	50
Sandra Brás	M.Sc.Student/LIP-Alg/BIC grant(*)	100
Sónia Rodrigues	M.Sc.Student/LIP-Alg/BIC grant(*)	25
Sandra Soares	PhD Student	50

(*)LIP initiation to research grant

Summary of Activities:

Problems and solutions to face radiosurgery dosimetry and calculations

Radiosurgery is a highly specialized radiotherapy technique that treats small dimension tumors and arteriovenous malformations localized in the brain. In Coimbra Oncology Hospital the narrow photon beams are created by interposing radiosurgery additional collimators in the linear accelerator Siemens Mevatron KD2 in 6 MV photon mode. Two major problems are encountered when dealing with measurements and calculations in radiosurgery. The first one is the difficulty in obtaining accurate basic dosimetrical data due to the lack of electron equilibrium for these very small sized photon beams. The second major problem is the accuracy given by the treatment planing systems in the dose distribution calculations. To overcome these difficulties, Monte Carlo (MC) method appears as a powerful tool since it enables a full assess to the details of the dose deposition process.

MC code MCNP4C has been used to simulate the geometry of the accelerator head plus the additional collimators, following the classical approach consisting in tracking particles from the source until the patient. Output factors and depth dose curves in water were calculated; results were compared with measurements and a good agreement was found. Using Monte Carlo simulations, some details about basic dosimetric data such as the behavior of the point of maximum dose along the beam central axis were explained .

Development and validation of a multiple source model for radiosurgery.

In the past few years, MC simulations appear as powerful tool to access photon beam characterization in radiotherapy. These detailed studies have lead to the development of multiple source models. These models are based on the fact that particles originated in the same component of the accelerator head have similar distributions: position, direction, energy, weight. A reconstructed radiation beam is then composed by particles from various virtual sources representing each relevant component of the accelerator head. The application of this idea to radiosurgery narrow photon beams seems attractive since the reduction in time and data storage is particularly important. The goal of this work is to develop a multiple source model for radiosurgery narrow photon beams. The model will

be validated through comparisons with measurements in a water phantom. MCNP4C code was used to produce the phase space data (PSD) of each additional collimator. Eight photon relevant virtual sources were extracted from an extensive characterization of these PSDs. These virtual sources were introduced in the very fast MC code DPM for dose calculations in a water phantom. The size of the voxels in water was fixed to 1mm x 1mm x 5mm. Calculated depth dose curves and profiles were compared with measurements in water for all the additional collimators. Results are within accepted international tolerances.

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 homogenous 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.

Detectors for Medical Physics - Participation in the ISPA Group

The work of the LIP group on the development of detectors for medical imaging can be grouped into two main lines of activity:

a) Characterization and MC simulation of radiation sensors (ISPA tubes);
b) Design of electronics cards for detector front-end and data readout;

Characterization and simulation of radiation sensors (ISPA tubes)

The Monte Carlo simulation of a γ-camera based on YAP:Ce crystals coupled to an ISPA (Imaging Silicon Pixel Array) tube has been done. This study allowed a deeper understanding of the performance and potential benefits of this new kind of detectors which can be used in Nuclear Medicine. Such γ-camera represents an excellent tool to improve pediatric thyroid gland and small organs imaging maintaining a low administered

dose, being also suitable for Molecular Biology studies. Intraoperative imaging system to assist surgeon in some surgical procedures is foreseen.
Alternative configurations were explored in order to optimize detector arrangement, namely different crystal coatings and reflector properties, several surface treatments and polish types. Some collimator designs were also studied to evaluate the system spatial resolution and sensitivity.
A reliable Monte Carlo simulation study is of significant importance to evaluate the performance of a YAP-ISPA γ-camera and search for compromises between energy resolution, spatial resolution and sensitivity. The developed simulation package, based on GEANT3, has allowed an accurate radiation transport description including photon attenuation in high-Z collimators. The tracking of optical photons due to scintillation inside the crystal is also taken in account by simulation.
Monte Carlo results were evaluated in order to achieve the best compromise between spatial and energy resolution. For crystal coating the following several were explored. The best performance was obtained with the aluminum coating configuration. For the surface treatment it was simulated from 100% polished to completed roughness (0.05% polished). The best case was achieved with the most polished crystal, although lower polishing had also good results and is less expensive.
Several crystal matrices and planar crystal thicknesses were simulated for different applications. As expected the thinner crystals achieve better spatial resolutions but have lower sensitivities. With crystal matrices it is possible to increase the camera active surface. The introduction of a beryllium window was also appraised. This improvement allows the crystal to be under vacuum within the tube. Simulation results showed that below 3mm thick Be windows can be considered without affecting the detector performance. The spatial resolution of the system combined with high resolution collimators is 3 to 10 times better than conventional NaI:Tl imaging systems.

Design of electronics cards for detector front-end and data readout

The current gamma camera readout system operating at CERN laboratories, consists of an ISPA-tube, a full-custom front-end readout card, a discrete analogue system based on NIM modules, different power supplies to provide threshold and bias voltages, a VME-based data acquisition board and a Linux workstation. This laboratory setup is very useful for testing but it is obviously too large and complex to allow usage inside clinical environment.
Reasons to provide easier set-up and utility of the ISPA-tube for clinical studies and basic research, lead us to re-design new electronics for full control and real-time processing of ISPA-tubes. The new readout system consists of a compact printed circuit board (PCB) to connect the ISPA-tube, and two main electronics cards, one plugged onto the other.
The first one is an upgrade of an existing prototype for high energy physics experiments at CERN, and performs the first analysis of the data. The second one, whose layout was achieved within the ISPA Group, was specially design for phototube readout and data acquisition. Those cards were both placed and ordered at CAEN and were already available for this past year 2003.
Through this readout system overview, we have concluded the assembly of a PCB to substitute the present analogue front-end by integrated components and the two electronic cards are currently in the final phase of their programming for communication and control tests at CERN laboratories. Several contributes of the LIP group in this task were performed, but the significant achievement work underway is the implementation of the parallel port protocol for external communication. These allow the card to manage the interface with a standard personal computer through which the user is able to control the system and acquire data. This task is the responsibility of LIP.

Academic Training:

"Simulação Monte Carlo do acelerador Varian 4000C com cunhas dinâmicas", Sandra Soares, PhD thesis- Conclusion foreseen 2006

"Simulação Monte Carlo de uma câmara gama e validação experimental", Sónia Rodrigues, master thesis, University of Algarve – Conclusion foreseen 2005

"Medição das doses recebidas pelos pacientes em radiologia com dosímetros termoluminiscentes", Sandra Brás, master thesis, University of Algarve – Conclusion foreseen 2005

Adérito Chaves, PhD Thesis - "Monte Carlo Simulation Applied to Dosimetry of Narrow High-Energy Photon Beams used in Radiosurgery", University of Lisbon, 2004

Publications:

Fast Electron Beam Simulation and Dose Calculation in Radiotherapy, A. Trindade, P. Rodrigues, L. Peralta, M.C. Lopes, C. Alves, A. Chaves, Nucl. Intr. Meth. A 522 (2004) 568-578

Application of GEANT4 Monte Carlo toolkit to dose calculations on homogeneous and anthropomorphic phantoms, A. Chaves, C. Alves, M. Lopes, P. Rodrigues, L. Peralta, A. Trindade , Applied Radiation and Isotopes 61 (2004) 1451-1461

A Monte Carlo multiple source model applied to radiosurgery narrow photon beam, A.Chaves, M.C.Lopes, C.C.Alves, C.Oliveira, L.Peralta, P.Rodrigues, A.Trindade, Medical Physics 31 (2004) 2192-2204

Internal Notes

A Monte Carlo study of a high resolution gamma-detector for small organ imaging in Nuclear Medicine, LIP/04-01

Conferences:

Simulação Monte Carlo do Acelerador Varian Clinac 600C Utilizando Cunhas Dinâmicas, S.Moreno, A.Chaves, L.Peralta, M.C.Lopes, III Iberian Latin American and Caribbean Congress of Medical Physics and the IX Brazilian Congress of Medical Physics, Rio de Janeiro, Set. 26-29, 2004 (S. Moreno, Poster Presentation)

Analog tests of the new ISPA-tube readout system, Rome2004, Nuclear Science Symposium Medical Imaging Conference, Rome, 16-22 Outubro 2004 (Patrick Sousa, Poster Presentation).

A Radiosurgery Monte Carlo Based Treatment Planning, 23th ESTRO Annual Meeting, Amsterdam, The Netherlands, 24-28 October 2004 (Adérito Chaves, Poster presentation).

Uma Câmara Gama Compacta para Medicina nuclear, Feira da Inovação do Algarve, Loulé, Portugal 24 a 27 de Março de 2004 (P. Sousa, Poster presentation)

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress	**1**	**2**	
Concluded in 2004	**1**		

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
3	**3**	**1**	**3**				

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
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Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Development of radiation hard silicon detectors

Project References	Funding
POCTI/FP/FNU/50133/2003	20 000 €

Resumo:

*O projecto "Desenvolvimento de detectores de silício resistentes à radiação - Participação na Colaboração RD39 do CERN" é da responsabilidade do LIP - Laboratório de Instrumentação e Física Experimental de Partículas - no âmbito das actividades do laboratório do LIP sito na Universidade do Algarve, em Faro.O objectivo deste projecto consistiu em prosseguir os esforços do laboratório iniciados em 1999 no desenvolvimento dos detectores de silício resistentes à radiação que irão ser utilizados no futuro acelerador do CERN, o grande colisionador de hadrões (LHC). O programa de RD39, aprovado até 2005, pretende caracterizar detectores irradiados até 10**16 neutrões de 1 MeV por cm2, o limite previsto para a segunda fase de operação de LHC (denominada Super LHC).*

Este projecto propõe-se continuar o esforço da equipa do LIP em RD39, através da melhoria da instalação existente estendendo o seu uso a tensões de polarização mais elevadas. Durante toda a duração do projecto terão lugar as medições pelas quais o grupo é responsável em RD39, bem como a análise dos dados à luz dos modelos de danificação do silício pela radiação. Além disso, está previsto desenvolvimento e implementação de instrumentação para a caracterização dos detectores durante a sua irradiação.

Team:

Project Coordinator: Pedro Rato Mendes

Team Members:

Name	Status	% of time in the project
Pedro R. Mendes	Post-Doc/LIP-Algarve/FCT grant	25
Maria Abreu	Researcher/LIP-Univ. Algarve	25
Patrick Sousa	Ph.D. student, Univ. Algarve/FCT grant	25
José F. Mariano	Researcher/LIP-Univ. Algarve	25
Sónia Rodrigues	M.Sc. student, Univ. Alg/BIC grant(1)	25
Jaime Rodriguez	Univ. Los Andes Colombia/Alfa grant(2)	

(1) LIP initiation to research grant; (2) Europe–Latin America interchange program grant

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Summary of Activities:

During this year new data has been collected on the time and temperature dependence of the CCE of highly irradiated detectors aiming at both validating and improving the above model. Analysis of the data in terms of both time and temperature dependence will allow for a test of the consistency of parameters obtained independently: the temperature dependence of the CCE give information on the cross-sections and densities of both deep levels and trapping centers, whereas the degradation of the CCE with time at a given fixed

temperature allows the evaluation of trapping in terms of trapping and detrapping times [Ref1], which are related to the above parameters. Under reverse bias operation at low temperatures, the fast decay of the CCE with mip is believed to be due to trapping of the carriers, according the detector polarization model [Ref1], therefore analysis of the time dependence of CCE can yield valuable information on trapping and detrapping times, that can subsequently be cross-checked with results from fitting CCE temperature dependence data. Measuring the so-called operational time, the time interval during which the detector is fully -depleted and the CCE is at maximum before degradation begins, and the time evolution of the CCE due to trapping we expect to be able to extract parameters related to deep levels, thus validating and extending the new spectroscopy technique based on the Lazarus effect quoted above [Ref2].

Recently, the setup used by RD39 for time and temperature characterization of the CCE of heavily irradiated detectors (described in [Ref2]) has been used in order to investigate the operation of samples irradiated above 10**16 n/cm2. Two samples made from MCZ silicon irradiated by protons in Karlsruhe have been measured down to 95 K with minimum ionizing particles from a Sr90/Y90 but no clear signal has been detected up to 500 V both reverse and forward bias. The absence of signal may be interpreted as due to two reasons: on one hand, these detectors may have full depletion voltages up to 1000 or even 2000 and, more important, the existence of a shallow radiation-induced center, the so-called A-center (O-V) at Ec-0.18 eV with a capture cross-section of 10**-15 cm-2 [Ref3]. This trapping center may be responsible for the fact that we observe no signal down to 95 K, as at this temperature the detrapping time constant is calculated to be about 10 ms, meaning that even with a fully depleted detector mostly all the charge is trapped during charge collection by readout electronics, resulting in no observable mip ionization charge signal. In order to further clarify this point, the RD39 Collaboration is developing at CERN a cryogenic system based of liquid helium that will allow CCE measurements down to lower temperatures, at which one may freeze the A-center and obtain a higher CCE for detectors at these irradiations.

References:

[Ref1] B. Dezillie, V. Eremin, Z. Li, E. Verbitskaya, “Polarization of silicon detectors by minimum ionizing particles”, Nucl. Instr. Meth. in Phys. Res. A 452 (2000) 440-453

[Ref2] P. Rato Mendes, M.C. Abreu, V. Eremin, Z. Li, T. O. Niinikoski, S. Rodrigues, P. Sousa, E. Verbitskaya, “A new techniquefor the investigation of deep levels on irradiated silicon based on the Lazarus effect”, IEEE Trans. Nuc. Sci. 51 (2004) 3069-3075

[Ref3] J. Haerkoenen et al. (RD39 Collaboration), “Recent results from the RD39 collaboration on super-radiation
hard cryogenic silicon detectors for LHC and LHC upgrade", Nucl. Instr. Meth. in Phys. Res. A 535 (2004) 384-388

Academic Training:

One Ph.D. student and a Master student working part-time in this project with theses belonging to other projects.

Publications:

1. P. Rato Mendes et al., A new technique for the investigation of deep levels on irradiated silicon based on the Lazarus effect, IEEE Trans. Nuc. Sci. 51 (2004) 3069-3075 (major LIP responsibility)

2. J. Haerkoenen et al., Recent results from the CERN RD39 Collaboration on super-radiation hard cryogenic silicon detectors for LHC and LHC upgrade, Nucl. Instr. Meth. in Phys. Res. A 535 (2004) 384-388

3. K. Borer et al., RD39 Status Report, CERN-LHCC-2004-034, 34pp.

Conferences:

None since project start (July 2004).

Statistics:

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
2	1	1					

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Radiation imaging detectors

Project References	Funding
POCTI/FNU/47678/2002	25 000 €

Resumo:

Com este projecto pretende-se desenvolver novas tecnologias de imagem digital de radiações ionizantes, contribuindo assim para o avanço das técnicas de imagiologia médica e, consequentemente, para a melhoria da qualidade de vida. Técnicas de imagem funcional, onde, para além da informação morfológica, se observa a actividade metabólica de determinadas substâncias nos tecidos, são cada vez mais utilizadas, nomeadamente em oncologia, dado que permitem reconhecer tecidos anómalos através do seu metabolismo elevado, antes de se darem alterações morfológicas. Nestas técnicas, uma substância metabólica é marcada com um isótopo radioactivo, e a quantidade de radiação emitida por um dado tecido é proporcional à fixação e ao metabolismo dessa substância no tecido. Para se poder avaliar correctamente esta última são pois necessários detectores sensíveis à radiação emitida e capazes de efectuar imagens com elevada resolução espacial. Deste projecto fizeram parte desenvolvimentos de detectores baseados em tubos ISPA bem como simulações Monte Carlo para validação da tecnologia e comparação com equipamento comercial.

Team:

Project Coordinator: Pedro Rato Mendes

Team Members:

Name	Status	% of time in the project
Pedro R. Mendes	Post-Doc/FCT grant/LIP Algarve	25
Maria Abreu	Researcher/LIP-Univ. Algarve	25
Patrick Sousa	Ph.D. student/FCT grant/LIP-Algarve	25
José Mariano	Researcher/LIP-Univ. Algarve	25
Sónia Rodrigues	Master student/FCT grant LIP-Algarve	50

Summary of Activities:

This project follows from 3 years of research activity funded by FCT through POCTI program and is reaching its final phase with the deliverance of a fully tested and characterized working prototype at the end of the project's duration. The work developed during 2004 consisted in advances in the instrumentation for the readout of ISPA tubes and in the Monte Carlo simulation of existing commercial equipment in order to validate the Geant4 software in applications to gamma camera imaging.

Regarding instrumentation, advances were made in the programming of the readout cards and in interfacing them with a PC, by means of a USB connection. This work was presented at the IEEE NSS/MIC 2004 Conference in Rome, Italy, in October 2004. Also, a scanning system based on a x-y precision position table was implemented with remote control via PC through a parallel port. This system will allow the acquisition of large

field-of-view images by two-dimensional scanning of larger subjects with the ISPA-tube sensor. Presently, the work being developed by the ISPA Collaboration regard the final part of programming, namely the interface with the pixel chip inside the ISPA tube, after which the final prototype imaging system will be mounted and tested, first at CERN then at the LIP laboratory in the University of Algarve, where it will be integrated in the x-y scanning system described above. We expect a Ph.D. thesis to be concluded from this activity to be presented at the University of Algarve by the end of 2005.
Regarding Monte Carlo simulations, following contacts with a nuclear medicine group in Alvor (in Algarve, Portugal), a Siemens e-cat dual gamma camera is being simulated in order to contribute both to the validation of Geant4 software applied to medical imaging and to a characterization of the operation of commercial medical equipment. From this work we expect to optimize the behavior of the ISPA-tube prototype imaging system under development by having a direct comparison with the existing state of the art. This work will also lead to a Master in Medical Imaging at the University of Algarve due in the second half of 2005.

Academic Training:

"Um detector de alta resolução para imagiologia médica - ISPA", Patrick Sousa, Ph.D. in Physics, Univ. Algarve, due 2005.

Conferences:

P. Sousa et al., "Analog tests of the new ISPA-tube readout system", IEEE NSS/MIC 2004, Rome, Italy, October 16-22, 2004

Statistics:

Theses:	PhD	Master	Graduation
In Progress	1		
Concluded in 2004			

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
			1				

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
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Conferences: Oral or poster presentations by LIP members in international/national conferences.
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Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Low Energy Bremsstrahlung Models for GEANT4

Project References	Funding
POCTI/FNU/49497/2002	15000 €

Resumo:

O Objectivo deste projecto foi o desenvolvimento de um gerador de baixas energias de radiação de travagem, baseado na função 2BN de Koch and Motz, para ser integrado no pacote GEANT4 de simulação Monte Carlo.

Team:

Project Coordinator: Luis Peralta

Team Members:

Name	Status	% of time in the project
Luis Peralta	Researcher/LIP-FCUL	25
Andreia Trindade	PhD Student/FCT grant	5
Pedro Rodrigues	PhD Student/ FCT grant	5
Ana Catarina Farinha	Student	100

Summary of Activities:

The project objective was the development of low energy bremsstrahlung models for the GEANT4 package. The GEANT4 code is developed by an international collaboration where CERN is one of the main partners.

In this project the implementation of a precise and alternative low energy bremsstrahlung angular generator in the GEANT4 Low Energy Electromagnetic Physics category has been done.

Monte Carlo radiation transport codes, like MCNP4 , EGS4, GEANT3 lack dedicated models for low energy (electron kinetic energy less than 500 keV) bremsstrahlung photon angular distributions. EGS4 provides as an option the 2BS Koch and Motz , distribution while GEANT3 and current GEANT4 release uses a parameterization of Tsai double differential cross section . However, for low energies both approaches give rise to deviations that could reach 25-30 degree on the most probable photon emission angle. This can have a significant impact in the accurate simulation of electron bremsstrahlung in very thin targets, like some of the current targets for X–ray imaging units. Recently EGSnrc and PENELOPE codes have incorporated respectively, modified 2BS versions (which converges to 2BN distribution also from Koch and Motz) and analytical distribution with adjustable parameters determined from fitting Kissel wave shape functions, based on the work of Tseng and co-workers. In the framework of the activities of the GEANT4 Low Energy Physics Working Group the implementation of a new design that will allow the user to chose, in a transparent way, the best concrete implementation depending on

simulation time, precision and/or energy range is underway. For the first iteration a design based on a strategy pattern was chosen, which performs the interface with different angular generators concrete implementations. One of the concrete implementations with the 2BN distribution, using an exact fast sampling algorithm was recently developed in this project.
Since the 2BN cross–section is a 2-dimensional non-factorized distribution it cannot be separated into two functions, one that depends on the photon emitted energy and the other on polar angle. In this case the inverse–transform method traditionally used to sample random number according to a given distribution can not be applied. Nevertheless the acceptance-rejection technique can still be used in this case if some basic requirements are met. Using this technique we were able to build a fast 2BN distribution generator, which has a high sampling efficiency in the low energy region.

Publications:

GEANT4 Applications and Developments for Medical Physics Experiments, P. Rodrigues et. al., IEEE Transactions on Nuclear Science, Vol 51, No. 4 (2004) 1412-1419

A new low energy bremsstrahlung generator for GEANT4, L. Peralta, P. Rodrigues, A. Trindade, M.G. Pia, accepted for publication Radiation Protection Dosimetry

Manuals

A section describing the 2BN generator has been written an included in the GEANT4 users-manual: Physics Reference Manual, June 21, 2004, pp. 154-159,

http://geant4.web.cern.ch/geant4/G4UsersDocuments/UsersGuides/PhysicsReferenceManual/html/PhysicsReferenceManual.html

http://geant4.web.cern.ch/geant4/G4UsersDocuments/UsersGuides/PhysicsReferenceManual/print/PhysicsReferenceManual1.pdf

Conferences:

A new low energy bremsstrahlung generator for GEANT4, L.Peralta et al., Poster presentation, ICRS-10/RPS 2004 Conferences, Funchal, Madeira, 13 de Maio de 2004

Statistics:

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
2	2	1	1				

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
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Conferences: Oral or poster presentations by LIP members in international/national conferences.
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Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Particle Physics Education and Public Outreach

Project References	Funding
PV0124	25 000 €

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 2004 ser o ano de comemoração dos 50 anos do nascimento do Laboratório do CERN, 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 2004 e está agora em fase de conclusão. Das actividades promovidas ou realizadas por membros do LIP em 2004, 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 (OCJF2004), a realização de uma excursão ao CERN de 10 alunos e dois professores do ensino secundário, por ocasião do dia aberto do CERN nas comemorações dos seus 50 anos, a organização de palestras públicas comemorativas dos 50 anos do CERN, no Instituto Superior Técnico e na Faculdade de Ciências em Lisboa, e na Universidade do Algarve, e a participação nas reuniões do grupo EPOG. Além destas, foram ainda realizadas várias palestras em escolas secundárias ao longo do ano, para divulgar as grandes questões da Física e motivar os alunos a gostar de aprender Física.

Team:

Project Coordinator: Pedro Abreu

Team Members at LIP:

Name	Status	% of time in the project
Pedro Abreu	Researcher/LIP-IST	30
João Varela	Researcher/LIP-IST	20
Maria Abreu	Researcher/LIP-UAlg.	10
Amélia Maio	Researcher/LIP-FCUL	10
Luís Peralta	Researcher/LIP-FCUL	10
Fernando Barão	Researcher/LIP-IST	10
José Silva	Ph. D. Student/LIP-grant	10
João Pires	Master Student/BIC	100
Pedro Assis	Master Student/FCT grant	10
Dário Passos	Graduation Student/LIP-BIC	50
Miguel Ferreira	Technician/LIP-staff	50
José Silva	Technician/LIP-grant	10
José Nogueira	Technician/LIP-staff	10

Team members at the Schools (contact teachers) involved in the 'TRC':

Name of the Teacher (1)	Name of the School (2)	% of time (3)
Anabela Martins	E.S. D. Pedro V, Lisboa	10
Mª Emília Estadão	E.S. José Gomes Ferreira, Lisboa	10
Adelaide Bello	E.S. Gil Vicente, Lisboa	10
Teresa Sá	E.S. Mª Amália Vaz de Carvalho, Lisboa	10
Fernanda Riflet	E.S. Prof. Herculano de Carvalho, Lisboa	10
Anabela Machado	E.S. Amadora, Amadora	10
Rogério Assis	E.S. Luís de Freitas Branco, Oeiras	10
Balbina Rocha	E.S. Mem Martins, Sintra	10
Francisco Martins	E.S. Diogo de Gouveia, Beja	10
Augusto Moisão	E.S. D. Manuel I, Beja	10
(1) Local coordinator of the sub-project 'TRC'.	(2) High-school of origin. E.S.=Escola Secundária	(3) estimated time spent with the setup.

Summary of 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 the project of "Measurement of Time Correlations in Cosmic Rays" profiting from the equipments installed in the schools.

In both cases, these activities were in previous years split in the projects "Experimental Particle Physics Outreach" and "Cosmic Rays Telescope – Ciência Viva" (TRC). They are now integrated in the same project, and a description of the activities performed per 'section' is provided 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 (EPOG – European Particle physics Outreach Group).

The portuguese representative in this group participated in the two meetings held in 2004, 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 again selected to participate in the program, with CERN support.

The most relevant activities were performed in the scope of the CERN's 50th Anniversary, namely:

- an excursion to CERN on its Open Day, by occasion of its 50th Anniversary, organized by LIP with the support of Gulbenkian Foundation. The group was constituted by 10 high-school students and two teachers, one representative from the "Ciência-Viva" program and a LIP researcher, that guided the group all the way. This excursion constituted a great success with many spin-offs, because the choice

of the student by the school implied that the student made a public seminar at the school about Particle Physics, CERN, and its role in the society of today, and because there was a very strong interaction between the portuguese researchers working at CERN and living in the area and the participants in the excursion.

- a serial of 10 seminars at Instituto Superior Técnico for the great public, depicting the portuguese contributions to the 50 marks selected by CERN to commemorate its 50th Anniversary
- a full-day Workshop in Faculdade de Ciências de Lisboa of the portuguese participation in the CERN activities, with the participation of the Secretary of State for Science, Technology and Innovation, Dr. Sampaio Nunes, that was co-organized by LIP-members. A spin-off of this workshop was a ready-made presentation (auto-show) reviewing the LIP participation at CERN, since its start-up.

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 seminars in high schools, along the year, promoting particle physics, astroparticle physics and medical physics.

LIP members have also actively participated in the organization of exhibitions related to particle physics, of which the most relevant was the "Radioactivity – $\alpha\beta\gamma$" exhibition in display in the Museum of Science of the University of Lisbon, for three months from October 8th, 2004, and which constituted a great success.

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.

Finally, we maintained the outreach page of LIP and, in the scope of the preparation of the European Masterclasses 2005, integrated in the commemorations of the International Year of Physics 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", that closed the year 2003 with a three-days intense course on the detectors, data acquisition and analysis, based on theoretical mornings and practical 'hands-on' sessions in the afternoons, ready-to-use experimental setups were installed in beginning of 2004, in each of the ten high-schools involved in the project. The equipment installed in the high-schools was then used, as a stand-alone laboratory, to familiarize the teachers and the students with the concepts of High Energy Physics and particle detection, data taking and analysis, and to perform several studies to understand the system at each school. In a first stage, only the material needed to run the experiment in the Physics Laboratory of the school was delivered. In a second stage the components needed to the outside were delivered (in particular, the acrylic boxes that will contain the detectors in the outside), and recently we were

concentrated in the interface between the information provided by the GPS for time-tag and the acquisition card, and with the changes in the data acquisition software to reflect this time information.

There was a strong feedback from the teachers using the system, and in many occasions we did return to the high-schools to improve the system and update the participants of the project. There were also 3 occasions in which a public seminar about particle physics and the universe, highly-motivating for the students, was given at the schools.

In the software domain, many changes were implemented in 2004, to make it possible to have the system entirely based on Linux (a freeware operating system (OS)), which was needed because the schools don't have a Windows license of the data acquisition and control software base (LabView), neither did the computers acquired for the project included a license for the Windows OS. A problem that took some time to understand and solve, was the translation of the software controlling the temperature and setting the high tensions of the photomultipliers, from Windows to Linux. Another relevant issue was the improvement of all the interfaces of the system with the user, both at the data acquisition and control interface implemented in LabView, and at the analysis interface, implemented in ROOT (now starts with a menu asking the user specifically what is to be done, with several options).

For the moment there is still the need, in a separated shell (command) window, of running a program translating data from LabView format to ROOT files input format. This program (LOST – LOcal STation analysis) is now in the process of being embedded inside the LabView interface, such that the user does not even need to run it and, consequently, does not need to learn Linux to work with a shell window.

Academic Training:

- Study of Cosmic Rays in the TRC– João Pires –Master thesis–started September'04.

Publications:

There are no publications in the scope of this project so far.

Statistics:

Theses:	PhD	Master	Graduation
In Progress		1	
Concluded in 2004			

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
						9	3

Legend:
Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
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Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
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Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

LIP COIMBRA

Introduction

Concerning the scientific and technical work of 2004, we should underline the following:

ATLAS and LHC Physics – We have confidence in the strengthening of the team of physicists that foresees a leading role in the study of top rare decays from anomalous couplings and Flavour Changing Neutral Currents (FCNC). An international workshop to be held in Coimbra is being prepared.

Dark matter search with liquid Xe – Following previous work and recent advancements carried our in the framework of the CERN n_ToF Collaboration (under an EC contract), LIP is recognized in this UKDM Collaboration as one of the very few laboratories with expertise in the technologies involved in liquid xenon detectors and thus capable of R&D in this field. Future work involves the increasing integration in the Collaboration, both in the particle physics aspects and in the R&D aiming at WIMP search with liquid xenon targets.

Studies of air scintillation for astroparticle physics - Triggered by the LIP participation in the EUSO project, the main goal of this project is the systematic measurements of total yields of scintillation light emitted by nitrogen and dry air as a function of pressure and temperature, when excited by energetic electrons. Clarification of the discrepancies of present experimental data is of great importance for modelling UHE cosmic air showers, a very important tool for various astroparticle experiments..

ToF with RPCs - We are preparing the tests of the ToF wall for the HADES Experiment (at GSI) and we have the responsibility for the delivery of the final detector (partly EC financed). In view of further developments around higher intensity accelerators, the team is also participating in the FP6 *Advanced Time-of-Flight (ATOF)*, a Joint Research Activity within the "I3 Hadron Physics" project, with responsibility for the specific task of high rate detectors.

PET with RPCs - Preliminary work in the direction of PET-RPC seems very promising, particularly with the recent demonstration of a position resolution of 0,4 mm for the reconstruction of a point-like source with a two head prototype detector. Two projects were submitted in 2004 (in collaboration with teams of IBILI and of the Physics Department) to FCT. The one aiming at the assessment of the possible extension of this concept to a whole-body human PET was financed and is now started.

GEM R&D and Applications - Current work in this project concerns the development of a prototype pulse counting imaging detector readout by four PMTs, with possible applications to X-ray polarimetry and microdosimetry and, in parallel, the R&D of a large area (32x32 cm) gaseous 3He detector for thermal neutron imaging. This is supported by an FP6 contract (MILAND, JRA2 of NMI3 HII3-CT-2003-505925) in which our team is responsible for the task related to light readout of *GSPCs.*

Concerning general aspects of personnel and infrastructures, we should mention:

Scientists and Technicians (Coimbra) - The FP6 programs (I3HP and NMI3) are allowing us to strengthen the manpower with one engineer (already hired for the ATOF) one Post Doc (for MILAND). In the framework of our contract as Laboratório Associado, one position for senior physicist was filled in 2004 and another one will be open soon.

Students - There are moderately good prospects concerning the evolution of the number of students (under and post-grad) involved in the various projects.

Infrastructures– The serious funding limitations of recent years has postponed the installation in Coimbra of a moderate size farm that would constitute a second test bed of LIP to be used in the current work for GRID (and LHC-GRID) for which the laboratory is responsible. This would also support the work of the various projects that, despite the efforts made along the years, still lack adequate computing power.

Our mechanical workshop of Coimbra responds to needs resulting from commitments of LIP in international collaborations (at CERN, DESY, GSI, ESO, etc.), while providing technical support to various other R&D groups (mainly from the University of Coimbra). Created and equipped in the eighties, this strategic infrastructure has an urgent need for renewal of some of the machine tools and investment in emerging technologies. Fortunately, the application of LIP to the "Programa Nacional de Reequipamento Científico" has been allocated 441 kEuros to be invested during 2005 and 2006.

The existing agreement between the School of Science and Technology of the University of Coimbra and LIP, concerning the conditions for the use of premises of the Physics Department for the Mechanical workshop, will be renegotiated aiming at a reduction of the costs for LIP.

Another proposal submitted to the "Programa Nacional de Reequipamento Científico", which addressed the important issue of safety in the gas distribution system in our laboratories, was not recommended for funding. For this important problem we did not find yet a convenient response.

In what the visibility of LIP is concerned, both at the levels of the scientific community and of the general public, we may refer:

- The IEEE/ICDL2005, "15th International Conference on Dielectric Liquids" this year organized by LIP collaborators, an event that every second year brings together about one hundred and fifty experts, will take place in Coimbra 26 June-1 July, 2005.
- LIP collaborators gave two seminars at the Physics Department commemorating the 50th anniversary of CERN. It is foreseen to repeat those presentations in secondary schools around Coimbra.
- Along 2005, we will prepare the "International Workshop on Top Quark Physics" that takes place in Coimbra, in January 2006.
- The LIP (Lisboa + Coimbra) proposal on outreach activities, in the framework of "2005 – Ano Internacional da Física" has been approved recently, with an allocation of funds that will allow a reasonable work in various directions.

Project Funding

National funds

PROJECT / SUBJECT	*REF. NUMBER*	*FUNDING 2002*
HERA-b	CERN/FNU/43701/2001	130.000,00
RPCs	CERN/FNU/43723/2001	60.000,00
GEMs	CERN/FNU/43735/2001	50.000,00
LIQUID Xe / WIMPs	CERN/FNU/43729/2001	140.000,00
LIQ. Xe / Praxis - 2ª part	POCTI/SAU/1342/95	33.574,99
CAMCAO (2002-2005)	POCTI/FNU/43843/2001	123.230,00
	TOTAL	536.804,99
PROJECT	*REF. NUMBER*	*FUNDING 2003*
HERA-b	POCTI/FNU/49491/2002	56.000,00
RPCs	POCTI/FNU/49513/2002	40.000,00
GEMs	POCTI/FNU/43735/2002	40.000,00
LIQUID Xe / WIMPs	POCTI/FNU/43729/2002	70.000,00
LIQ. Xe / Praxis - 2ª part	POCTI/SAU/1342/95	33.575,02
CAMCAO (2002-2005)	POCTI/FNU/43843/2001	114.670,00
	TOTAL	239.575,02
PROJECT	*REF. NUMBER*	*FUNDING 2004*
HERA-b	POCTI/FP/FNU/50196/2003	15.000,00
RPCs	POCTI/FP/FNU/50171/2003	30.000,00
GEMs	POCTI/FP/FNU/50338/2003	25.000,00
LIQUID Xe / WIMPs	POCTI/FP/FNU/50208/2003	60.000,00
LIQ. Xe / Praxis - 2ª part		
CAMCAO (2002-2005)		
AIR SCINTILLATION	POCTI/FP/FNU/50340/2003	15.000,00
	TOTAL	145.000,00

European Funds

PROJECT	*REFERENCE NUMBER (period)*	*EC FUNDING*
n-TOF	FIKW-CT-2000-00107 (2000-2004)	132.215,00
I3HP – ATOF	RII3-CT-2003-506078 (2004-2006)	55.000,00
NMI3 - Miland	RII3-CT-2003-505925 (2004-2007)	360.000,00
	TOTAL	547.215,00

Legend:

Publications - Journ-I: publications in international journals with scientific peer review co-authored by LIP members
Journ-II: Subset of publications Journ-I in which LIP members had a major responsibility
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences - Oral Presentations by LIP members in International/national Conferences
Seminars - Invited Seminars in Institutes and Universities
Outreach Seminars - Seminars for students and general public
Students - Number of Students active in the project (31 Dez 2004)
Thesis - Theses concluded in the period: G - Graduation, M - Master, D - PhD.
Post-Doc - Number of Post Doc fellows active in the project
Organisation - Organisation of major events (Conferences, Workshops, Collaboration Meetings, etc.)

Project	Publications			Conferences		Seminars	Outreach Seminars	Students	Thesis			Post-Doc	Organisation
	Journ-I	Journ-II	Other	International	National				G	M	D		
HERA-b	2							2	2	2			
Liquid Xenon	8	3		4				3	3			1	
RPCs	7	7		4				1	1				
GEMs	4	4		2				3	1				
Air Scintillation				1				1					
Totals:	21	14	0	11	0	0	0	10	7	2	0	1	0

Mechanical Workshop Activities

The activities of the Mechanical Workshop in 2004 are summarised in the following table:

LIP-Coimbra Workshop – Summary 2004

		Man-Power (%)	Man-Power (HH)	Cost €	Charged Value €
LIP-Lisboa	ATLAS	***9,20%***	***458***	***3601***	***3601***
	I3HP	5,15%	256	5362	0
	NMI3	8,26%	411	8624	0
	RPC	1,74%	87	1.001	1.001
	GEMs and SCINTILLATION	3,44%	171	1984	1984
	LIQUID XENON	8,97%	446	4212	4212
	ESO – CAMCAO	31,54%	1569	17811	17811
LIP-Coimbra		***59,09%***	***2.939***	***38994***	***25.008***
	MAINTENANCE	***10,04%***	***499***	***4958***	*0*
Physics Department UC		***4,32%***	***215***	***5.034***	0
Outside customers		***17,35%***	***863***	***14.377***	***15.685***
TOTAL		***100,00%***	**4973**	**66.964**	**44.294**

It is worth noticing the importance of the work in the construction of the CAMCAO (Camera for Multi-Conjugate Adaptive Optics), an infra-red camera for the ESO Very Large Telescope, in Paranal, Chile. LIP is a member of the Portuguese team, having the responsibility for the mechanical project and construction of this detector to be delivered in 2005.

Human Resources

Researchers

	JANUARY 2004		DECEMBER 2004	
Name	*Position*	*Position*	*Position*	*Position*
	LIP	*Other*	*LIP*	*Other*
Armando Policarpo	LIP Directorate	FCTUC	LIP Director Researcher	FCTUC
M. Salete Leite	Collaborator	FCTUC		
Rui Ferreira Marques	LIP Director Researcher	FCTUC	LIP Director Researcher	FCTUC
Ermelinda Antunes	Collaborator	FCTUC	Collaborator	FCTUC
Francisco Fraga	Researcher	FCTUC	Researcher	FCTUC
M. Isabel Lopes	Researcher	FCTUC	Researcher	FCTUC
Margarida Fraga	Researcher	FCTUC	Researcher	FCTUC
J. Pinto da Cunha	Researcher	FCTUC	Researcher	FCTUC
João Carvalho	Researcher	FCTUC	LIP Director Researcher	FCTUC
António Onofre	Researcher	UCP_FF	Researcher	LIP+UCP_FF
Vitaly Tchepel	Researcher	FCTUC	Researcher	FCTUC
Helmut Wolters	Researcher	UCP_FF	Researcher	UCP_FF
Paulo J.R. Fonte	Researcher	ISEC	Researcher	ISEC
Paulo J.B. Mendes	Researcher	FCTUC	Researcher	FCTUC
Vladimir Solovov	Researcher	LIP	Researcher	LIP

Students

	JANUARY 2004		DECEMBER 2004	
Name	*Position*	*Position*	*Position*	*Position*
	LIP	Other	LIP	Other
Luís Margato	PhD Student	FCT	PhD Student	FCT
Francisco Neves	PhD Student	FCT	PhD Student	FCT
Vasco Amaral	PhD Student	FCT	PhD Student	FCT
Alexandre Lindote	PhD Student	LIP	PhD Student	FCT
Susete Fetal	Researcher	ISEC	Researcher	ISEC
João Batista	PhD Student	LIP	PhD Student	LIP
Luis Silva	MsC Student	LIP		
Luís Lopes	Post-grad Student	LIP		
Filipa Balau	MsC Student	LIP	MsC Student	LIP
Luís Fazendeiro	MsC Student	LIP	MsC Student	LIP
Rui Meleiro	Graduate Stud	LIP	Graduate Stud	LIP
Cláudio Silva	Graduate Stud	LIP	PhD Student	LIP
A.Catarina Fonseca	Graduate Stud	LIP		
Patrícia Maduro	Graduate Stud	LIP		
Rui Matos	Graduate Stud	LIP		
Luís Pereira			Graduate Stud	LIP
Nuno Castro			PhD student	FCT
Filipe Veloso			PhD student	FCT

Administrative and Technical Staff

JANUARY 2004		DECEMBER 2004		
Name	*Position*	*Name*	*Position*	*Lab. Assoc.*
	LIP		LIP	%
Teresa Marques	Secretary	Teresa Marques	Secretary	0
Elisabete Neves	Secretary	Elisabete Neves	Secretary	0
José Pinhão	Mech. Eng.	José Pinhão	Mech. Eng.	50
Rui Alves	Mech. Eng.	Rui Alves	Mech. Eng.	50
Rui Fernandes	Mech. Eng.	Luís Lopes	Engineer	0
Alberto Blanco	Engineer	Alberto Blanco	Engineer	100
Joaquim Oliveira	Mechanician	Joaquim Oliveira	Mechanician	50
Carlos Silva	Mechanician	Carlos Silva	Mechanician	50
Jorge Moita	Mechanician	Jorge Moita	Mechanician	50
Nuno Carolino	Lab. Techn.	Nuno Carolino	Lab. Techn.	50
Américo Pereira	Lab. Techn.	Américo Pereira	Lab. Techn.	50
João Silva	Computer Techn.	João Silva	Computer Techn.	100

PROGRESS REPORT 2004

Project Title: Collaboration in the HERA-B experiment

Project References	Funding
POCTI/FP/FNU/50196/2003	15 000 €

Resumo:

*A colaboração HERA-B, no laboratório DESY, na Alemanha, estuda a colisão de um feixe de protões de 920 GeV em alvos fixos de diferentes materiais. Os resultados obtidos mais importantes são a medida da secção eficaz de produção de pares de quarks b-anti-b a esta energia, e sua relação com os modelos teóricos de produção de quarks pesados, a medida da produção dos mesões phi e K*0, da secção eficaz de produção do mesão J/Psi, a procura de decaimentos através de correntes neutras com troca de sabor D0->mu+ mu-, e a pesquisa de pentaquarks e outros estados exóticos. A experiência está na fase final da análise de dados, com a preparação das últimas publicações, e a finalização das teses por parte dos estudantes.*

Team:

Project Coordinator: João Carlos Carvalho

Team Members:

Name	Status	% of time in the project
António Amorim	Researcher/FCUL	10
Armando Policarpo	Researcher/LIP-FCTUC	5
Helmut Wolters	Researcher/UCP-Beiras	20
João Carvalho	Researcher/LIP-FCTUC	40
João Bastos	Post-Doc fellow/LIP grant	5
João Batista	M.Sc. Student/BIC(*)	75
Luís Silva	M.Sc. Student/BIC(*)	100
Matilde Castanheira	Student/FCTUC	70
Rui Matos	Student/BIC(*)	100
Vasco Amaral	Ph.D. Student/FCT grant	100

(*) BIC: Initiation to research grant

Summary of Activities:

The last year of this project was dedicated to finalize the data analysis and the theses in preparation. The data analysis by the LIP team was dedicated to the determination of the b-bbar production cross-section from double B semileptonic decays, for which we were responsible, and a preliminary result was obtained. The study of the event reconstruction quality, from the tracks and vertices to the particle identification and energy reconstruction, was one of the major contributions of the team. It was also developed and tested a new paradigm of data analysis in particle physics using databasing technologies, which allows a much easier integration in the data analysis activities by encapsulating the more technical details, in a fully transparent way, in layers outside the user scope. Work was also developed in the determination of the acquired data luminosity, a fundamental parameter for the determination of absolute cross sections, in particular in the study of the

different components of the proton-nuclei interaction cross section.
The collaboration in the HERA-B experiment allowed to finish two M.Sc. thesis, one already examined and the other to be submitted soon, and one Ph.D. thesis (exam mid February 2005).

Academic Training:

"Medida da secção eficaz de produção de pares b-anti-b em decaimentos semileptónicos de hadrões B em colisões de protões em alvo fixo" Luís Silva, M.Sc., finished

"CP violation in primordial baryogenesis abd teh role of calibration and alignment in the HERA-B spectrometer" João Batista, M.Sc., to be submitted soon

"Increasing productivity in High Energy Physics data mining with a Domain Specific Visual Query Language" Vasco Amaral, Ph.D., submitted

"Determinação da luminosidade com base em diferentes subdetectores e cálculo da fracção de decaimento do mesão omega em dois muões" Matilde Castanheira, graduation, finished

Publications:

"Search for the flavor changing neutral current decay D0 -> mu+ mu- with the HERA-B detector" HERA-B Collaboration, Phys.Lett.B596:173-183,2004, hep-ex/0405059
"Limits for the central production of Theta^+ and Xi^{--} pentaquarks in 920 GeV pA collisions" HERA-B Collaboration, Phys. Rev. Lett. 93, 212003 (2004), hep-ex/0408048

Statistics:

Theses:	PhD	Master	Graduation
In Progress	1	1	
Concluded in 2004		1	1

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
2							

Legend:
Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

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

Project References	Funding
POCTI/FNU/43729/2002 (9 months; ended) POCTI/FP/FNU/50208/2003 (3 months; running)	70,000 Euros (total funding) 60,000 Euros (total funding)

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 requesito 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 no âmbito da colaboração internacional UKDMC (UK Dark Matter Collaboration). Durante o ano de 2004, fizeram parte do programa de trabalho deste projecto o estudo de alguns dos problemas relevantes para a concepção do detector. A resposta do detector à interacção de WIMPs é estudada usando neutrões de energia adequada (tipicamente alguns MeV) que produzem por colisão elástica recúos nucleares com energia semelhante à esperada das interacções elásticas dos WIMPs.

Team:

Project Coordinator: Maria Isabel Lopes

Team Members:

Name	Status	% of time in the project
M. Isabel Lopes	Researcher/LIP-UC	30
Vitaly Chepel	Researcher/LIP-UC	30
José P. da Cunha	Researcher/LIP-UC	40
Paulo Mendes	Researcher/LIP-UC	20
Rui Ferreira Marques	Researcher/LIP-UC	10
Armando Policarpo	Researcher/LIP-UC	10
Vladimir Solovov	Post-Doc/FCT grant	100
Francisco Neves	PhD student/FCT grant	100
Alexandre Lindote	PhD student/FCT grant	100
Cláudio Silva [(1)]	Student /BIC [(4)]	50
Rui Meleiro[(2)]	Student /BIC [(4)]	40
Ana Catarina Fonseca[(3)]	Student /BIC [(4)]	40
Américo Pereira	Technical staff	25

[(1)] Started 1/10/2004; [(2)] Ended 1/10/2004; [(3)] Ended 31/12/2004 ; (4) BIC: initiation to research grant

Summary of Activities:

This report refers to the scientific activity developed in the period from January 1, 2004 to December 31, 2004. The main results obtained during 2004 can be summarized as follows:

BENCH TESTS,WITH GAMMA-RAYS, OF THE CHAMBER BUILT FOR NUCLEAR RECOIL STUDIES

- Set-up all the front-end electronics and the DAQ system for optimal performance;
- Development of a calibration technique for the gain of the photomultipliers instaled in the chamber.
- Determination of an efficiency of light collection of about 5.5 photoelectrons/kev which is one of the best values ever reported.
- Maping the efficiency of light collection along the bottom of the chamber using γ-rays of 122 keV from a radioactive source.
- Assessement of the energy resolution for 122 keV and 511 keV: 18% and 22% (FWHM), respectively.
- The time resolution was measured with 511 keV gamma-rays. Values of 3.0 ns to 4.4 ns, FWHM, were obtained for deposited energies ranging from 105 keV down to 20 keV. These values are sufficient for distinguishing the fast and slow components of xenon scintillation decay.

MEASUREMENTS AT THE NEUTRON BEAM:

The light yield per unit of deposited energy for nuclear recoils, with respect to that for -rays, was measured in the recoil energy range from 5 to 150 keV using neutrons of 6 and 8 MeV. The data analysis is under way supported by a detailed Monte-Carlo simulation (GEANT4) of the experiment conditions and the response of the liquid xenon chamber to the neutron irradiation.

EXTENSIVE SIMULATIONS IN GEANT 4 OF THE BARREL CALORIMETER PROPOSED FOR DETECTING GAMMAS IN NEUTRON CAPTURE CROSS SECTION MEASUREMENTS (work made in the framework of experiment PS213 at n-TOF, CERN). The performance of the detector was assessed by Monte-Carlo simulation. Experimental results obtained with the chamber served of input for the MC program. The comparision of several scenarios concerning the design of the detector was carried out.

STUDY OF SECUNDARY SCINTILLATION IN XENON VAPOR:

- A cryogenic test chamber equipped with an alpha source and specially designed for allowing secondary scintillation measurements in a uniform electric field was built and tested.
- 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.

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

- A chamber was built to assess the feasibility of operating a Gas Electron Multiplier (GEM) in highly purified xenon gas and vapor.
- Measurements of the gain in room temperature xenon and in cooled vapor were carried out as a function of the applied voltage. According to preliminary results, gains of the order of a few hundreds can be obtained . However, the stability has yet to be investigated.

Academic Training:

- "Study of secundary scintillation in xenon vapor", Ana Catarina Fonseca, 2004, graduation, (finished).
- "Analysis of a Monte Carlo simulation of a liquid xenon chamber and modelling of the reflection processes on the surfaces", Cláudio Silva, graduation (finished).
- "Performance of GEMs (Gas Electron Multipliers) in ultrapure xenon vapor", Rui Meleiro, graduation (experimental work and writing finished).
- "Study of the liquid xenon response to low energy nuclear recoils and gammas-rays", Francisco Neves, PhD., (finishing experimental work).
- "Estudo de simulação Monte Carlo, de análise e reconstrução de acontecimentos envolvendo a eventual interacção de WIMPs em xenon líquido ultra puro", Alexandre Lindote, PhD, (1st year started May 2004).

Publications:

Publications in international journals with scientific peer review (all authors are LIP members)

1. "Performance of a Chamber for Studying the Liquid Xenon Response to Nuclear Recoils", V. Chepel, F. Neves, 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, **accepted** for publication in *IEEE Trans. on Nucl. Sci*.
2. "Primary scintillation yield and α/β ratio in liquid xenon" V. Chepel, M.I. Lopes and V. Solovov, **accepted** for publication in *Radiation Physics and Chemistry*.
3. "Fast Electronics for a Liquid Xenon Scintillation Detector with Very Low Energy Threshold", V. Solovov, F. Neves, V. Chepel, M.I. Lopes, A. Pereira, A.C. Fonseca, R. Meleiro, **submitted** for publication in *IEEE Trans. on Nucl. Sci.*

Publication in international journals with scientific peer review (in which LIP members are co-authors)- major participation of a LIP member

1. "Low-temperature study of 35 photomultiplier tubes for the ZEPLIN III experiment", H. M. Araújo, A. Bewick, D. Davidge, J. Dawson, T. Ferbel, A. S. Howard, W. G. Jones, M. Joshi, V. Lebedenko, I. Liubarsky, J. J. Quenby, T. J. Sumner and F. Neves, *Nucl. Instrum. and Meth.* A 521, 2004, 407-415.

Publications in international journals with scientific peer review (in which LIP members are co-authors)

2. "New Experimental validation of the Pulse Height Weighting Technique for Capture cross-section measurements", U. Abbondanno, et al., *Nucl. Instrum. and Meth.* A 521, 2004, 454-467.
3. "Measurement of the n_TOF beam profile with a micromegas detector", J. Pancin et al., *Nucl. Instrum. and Meth.* A. 524, 2004, 102-114.
4. "Time-energy relation of the n_TOF neutron beam: energy standards revisited", G. Lorusso, et al., *Nucl. Instrum. and Meth.* A 532, 2004, 622-630.

5. "Neutron Capture Cross Section Measurement of Sm-151 at the CERN Neutron Time of Flight Facility (n_TOF)", U. Abbondanno et al., *Phys. Rev. Lett.* 93, 2004,161103.
6. "The data acquisition system of the neutron time-of-flight facility n_TOF at CERN", U. Abbondanno, et al., *Nucl. Instrum. and Meth.* A 538, 2005, 692-702.

Conferences and workshops:

1. "Study of Secondary Scintillation in Xenon Vapour", **A.C. Fonseca**, R. Meleiro, V. Chepel, A. Pereira, V. Solovov and M.I. Lopes, *Conference Record of 2004 IEEE Nuclear Science Symposium and Medical Imaging Conference*, Rome, Italy, 2004 (**poster**).
2. "Fast Electronics for a Liquid Xenon Scintillation Detector with Very Low Energy Threshold", **V. Solovov**, F. Neves, V. Chepel, M.I. Lopes, A. Pereira, A.C. Fonseca, R. Meleiro, *Conference Record of 2004 IEEE Nuclear Science Symposium and Medical Imaging Conference*, Rome, Italy, 2004 (**oral communication**).
3. "Performance of a Chamber for Studying the Liquid Xenon Response to Nuclear Recoils", V. Chepel, **F. Neves**, 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, *Conference Record of 2004 IEEE Nuclear Science Symposium and Medical Imaging Conference*, Rome, Italy, 2004, (**poster**).
4. "Liquid Xenon Detectors for Dark Matter Search", **M. I. Lopes**, *Workshop on Frontier Research in Radiation Physics and Related Areas*, Chengdu, China, 10-14 Novembro de 2004 (**invited talk**).

Statistics:

Theses:	**PhD**	**Master**	**Graduation**
In Progress	**2**		
Concluded in 2004			**3**

Publications			**Conferences**		**Seminars**	**Outreach Seminars**	**Orga-nisation**
Journ-I	**Journ-II**	**Other**	**Internat.**	**National**			
8	**3**		**4**				

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
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Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Title: Applications of Timing Resistive Plate Chambers

Project References	Funding
POCTI/FNU/49513/2002	40 000 €
POCTI/FP/FNU/50171/2003	30 000 €

Resumo:

Este projecto tem vindo a desenvolver-se em duas direcções complementares. Em primeiro lugar, procura-se aplicar as câmaras rápidas do tipo RPC (Resistive Plate Chambers) à identificação de partículas pela técnica de medida do tempo de voo. Em segundo lugar surge a importante aplicação deste mesmo tipo de detector à medicina nuclear, tirando partido quer da rapidez dos detectores, quer da sua excelente capacidade de localização, com vista à tomografia de aniquilação de positrões (PET).

No primeiro caso, a equipa é responsável pelo fornecimento de um detector de tempo de voo para a experiência HADES, no GSI (Gramstadt), que está em vias de ser melhorada. Quanto aos desenvolvimentos em RPC-PET, soube-se recentemente da aprovação de um projecto submetido conjuntamente pelo LIP, por uma equipa do Departamento de Física e por uma outra do IBLI (Faculdade de Medicina da UC), cujo objectivo é o estudo de viabilidade de um tomógrafo RPC-PET de corpo inteiro para humanos.

Team:

Project Coordinator: Paulo Jorge Ribeiro da Fonte

Team Members:

Name	Status	% of time in the project
Armando José Ponce de Leão Policarpo	Researcher/FCTUC da UC	20
Carlos Alexandre Bento Capela	Researcher/ ESTG do I.P.Leiria	25
Nuno D. S. C. da Fonseca Ferreira	Researcher/ FM da UC	8
Rui Ferreira Marques	Researcher/ FCTUC da UC	20
Paulo Jorge Ribeiro da Fonte	Researcher/ ISEC do I.P.Coimbra	50
Carlos Fernando C. de Sousa Neves	Researcher/ ESTG do I.P.Leiria	25
Carlos Manuel Pereira Costa e Sousa	Researcher/ ESTG do I.P.Leiria	25
Jorge Miguel Tavares Couceiro de Sousa	ISEC do I.P.Coimbra	50
Milena Maria Nogueira Vieira	ESTG do I.P.Leiria	25
Luís Alberto Vieira Lopes	Post-Grad./BIC(project); LIP Engineer (from May 2004)	100
Luís Fazendeiro	Post-Grad Student / BIC	100
Alberto Blanco Castro	LIP Engineer	75
João Carlos Sousa Rodrigues da Silva	Comput. Techn.	10
Nuno Miguel de V. da Costa Carolino	Lab. Techn.	50
Américo Manuel de Almeida Pereira	Lab. Techn.	25
José Manuel Anastácio Pinhão	Mech. Eng.	8

Summary of Activities:

This project is being carried on in two complementary directions. In first place, the application of the fast RPCs (Resistive Plate Chambers) to the identification of particles by time of flight, in particle physics experiments. Secondly, the very important application of the same type of detector to nuclear medicine, taking advantage of both its fast timing characteristics and excellent localization properties, for positron emission tomography (PET).
In the first case, we have already taken responsibility for the delivery of a time of flight wall in de upgraded version of the HADES experiment, at GSI. Concerning the RPC-PET developments, we believe we have proven the principle experimentally and by Monte-Carlo simulations. We learned recently that a project submitted jointly by LIP, a team of the Physics Department and a team of IBLI (an Institute belonging to the School of Medicine, University of Coimbra) has been funded. It aims at a feasibility study of a whole-body human RPC-PET scanner.

ToF with RPCs
Starting from the participation in the R&D of the ALICE ToF system, the team made important innovative contributions and it's work is now well recognised. At present, we are involved in the tests of the prototype for the ToF wall of the HADES Experiment (at GSI) and we have the responsibility for the delivery of the final detector. For this part of the project we have the collaboration of a team from ESTG (Instituto Politécnico de Leiria), who took the responsibility for the mechanical design and construction. In view of further developments around higher intensity accelerators, LIP is also participating in the FP6 “Advanced Time-of-Flight (ATOF)”, a Joint Research Activity within the "I3 Hadron Physics" project. The specific task of LIP concerns the development of high rate detectors, a central issue for this type of detection systems.

PET with RPCs
The preliminary work developed in the direction of PET with RPCs seems very promising, particularly since the recent demonstration, with a two head prototype detector, of a position resolution of 0,4 mm in the reconstruction of a point-like source. The developments considered for the coming years are in two complementary directions: the construction of a small animal PET system and the assessment by Monte-Carlo simulation of the possible extension of this concept to a whole-body human PET. This was the subject of two independent projects submitted in June to FCT. Recently we learned that the one aiming at the feasibility study of the whole-body RPC-PET scanner has been approved, receiving 1000 k€ for the period 2005-2007.
These line of work is carried on in collaboration with colleagues of the Physics Department of Coimbra and of IBILI (Faculty of Medicine of the same university). It is obvious that finding an interesting partnership with the industry is an objective for the coming years.

The work developed during 2004 comprised:

- Follow-up of aging studies with electrodes of Al and standard glass in avalanche mode
- Identification and tests of new electrode materials capable of high rate operation: tests with Ensital SD™ (static dissipative sopolymer acetal, used on anti-static applications) and low resistivity ceramic

- Design and begin of construction of the HADES TOF-wall prototype: container, electrodes, front-end electronics (together with the team of USC)
- Test of rate effects (saturation) under controlled temperature; analysis in progress
- Optimization of the EM-ML algorithm, for application to a 2-head RPC-PET prototype
- Data taking with the 2-head RPC-PET prototype; analysis of the data, revealing a fwhm resolution of 0,4 mm upon reconstruction of the events from a point-like source using a standard algorithm (0,3 mm with an iterative EM-ML algorithm)
- Elaboration of proposals for i) small animal RPC-PET prototype; ii) feasibility study of a whole-body RPC-PET tomograph with ToF information (both submitted in June); ii) project for the "CERN Fund" (announced in December 2004))

Academic Training:

"Análise da sensibilidade de uma câmara de placas resistivas para uso em tomografia por aniquilação de positrões", Patrícia maduro, Graduation thesis in Physcs Engineering, FCTUC, December 2004

Publications

Publications in international journals with scientific peer review:

In all publications of this list, LIP members had a major direct responsibility.

- *A study of aging in timing RPCs. Lopes, L; Ferreira-Marques, R; Fonte, P; Piedade, A.P; Policarpo, A; Nuclear Instruments and Methods in Physics Research A 533 (2004) 121 – 125.*
- *Performance of shielded timing RPCs in a 12C fragmentation experiment, Alvarez-Pol, H; Alves, R; Blanco, A; Carolino, N; Eschke, J; Ferreira-Marques, R; Fonte, P; Garzón, J.A; González-Díaz, D; Pereira, A; Pietraszko, J; Pinhão, J; Policarpo, A; Stroth, J; Nuclear Instruments and Methods in Physics Research A 533 (2004) 79 – 85.*
- *Development of high-rate timing RPCs, Lopes, L; Ferreira-Marques, R; Fonte, P; Pereira, A; Peskov, V; Policarpo, A; Nuclear Instruments and Methods in Physics Research A 533 (2004) 69 – 73.*
- *An RPC-PET prototype with high spatial resolution, Blanco, A; Carolino, N; Correia, C.M.B.A; Ferreira Marques, R; Fonte, P; González-Díaz, D; Lopes, I; Macedo, M.P; Policarpo, A; Nuclear Instruments and Methods in Physics Research A 533 (2004) 139 – 143.*
- *Exactly Solvable Model for the Time Response Function of RPCs, Mangiarotti, A;Fonte, P; Gobbi, A; Nuclear Instruments and Methods in Physics Research A 533 (2004) 16 – 21.*
- *Progress in timing Resistive Plate Chambers, Blanco, A; Carolino, N; Correia, C. M. B. A; Ferreira-Marques, R; Fonte, P; Gobbi, A; González-Díaz, D; Lopes, M. I; Lopes, L; Macedo, M. P; Mangiarotti, A; Peskov, V; Policarpo, A; Nuclear Instruments and Methods in Physics Research A 535 (2004) 272 – 276.*
- *A large area timing RPC prototype for ion collisions in the HADES spectrometer, Alvarez-Pol, H; Alves, R; Blanco, A; Carolino, N; Eschke, J; Ferreira-Marques, R; Fonte, P; Garzón, J.A; González-Díaz, D; Pereira, A; Pietraszko, J; Pinhão, J; Policarpo, A; Stroth, J; Nuclear Instruments and Methods in Physics Research A 535 (2004) 277 – 282.*
- *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, submitted for publication in IEEE Transactions on Nuclear Science.*

- *EM Reconstruction Algorithm with Resolution Modelling Applied to an RPC-PET Prototype, L. Fazendeiro, N. C. Ferreira, A. Blanco, P. Fonte, R. Ferreira Marques, submitted for publication in IEEE Transactions on Nuclear Science.*

Conferences:

- *A large area timing RPC prototype for ion collision in the HADES spectrometer, H. Alvarez-Pol, R.Alves, A.Blanco, N.Carolino, J.Eschke, R.Ferreira Marques, P. Fonte, A.Pereira, J.Pietraszko, J.Pinhão, A.Policarpo, J.Garzon, D.González, J.Stroth Talk presented at, "10th Vienna Conference on Instrumentation", Vienna, Austria - February 16 - 21, 2004*
- *Progress in timing resistive plate chambers A. Blanco, N.Carolino, C.Correia, R.Ferreira-Marques, P. Fonte, A.Gobbi, D.González, I.Lopes, L.Lopes, M.P.Macedo, A.Mangiarotti, V.Peskov, A.Policarpo Talk presented at, "10th Vienna Conference on Instrumentation", Vienna, Austria, February 16 - 21, 2004*
- *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, Poster presented at, "IEEE 2004 Medical Imaging Conference", October 18-21, 2004, Rome, Italy.*
- *EM reconstruction algorithm with resolution modeling applied to an RPC-PET prototype L. Fazendeiro, N. C. Ferreira, A. Blanco, P. Fonte, R. Ferreira Marques Poster presented at, "IEEE 2004 Medical Imaging Conference", October 18-21, 2004, Rome, Italy.*
- *Development of high-rate timing RPCs, P. Fonte, oral communication at the"CBM Colaboration Meeting", GSI, Darmstadt, Germany, 10-12 February 2004.*

Statistics:

Theses:	PhD	Master	Graduation
In Progress			
Concluded in 2004			1

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
7	7		4				

Legend:

Journ – I : All publications in international journals with scientific peer review co-authored by LIP members
Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
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Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

Project Titles:

I Active gaseous scintillators for detecting neutron and other radiations
II MILAND - Millimetre Resolution Large Area Neutron Detector"

Project References	Funding
CERN/FNU/43735 /2002 (2nd year) RII3-CT-2003-505925-NMI-3	40 000 € 180 000 € (50% EC, 50% LIP funding)

Resumo:

O objectivo principal dos presentes projectos é desenvolver o protótipo de um detector de neutrões térmicospara imageologia por contagem de fotões usando fotomultiplicadores para a leitura, com aplicações possíveis em polarimetria de raios X e microdosimetria.

Team:

Project Coordinator: Francisco Amaral Fortes Fraga

Name	Status	% of time in the project
Francisco A. F. Fraga	Researcher/LIP-DFUC	100
Rui Ferreira Marques	Researcher/LIP-DFUC	20
Ermelinda P. de Lima	Researcher/LIP-DFUC	10
M. Margarida R. Fraga	Researcher/LIP-DFUC	25
Paulo J. B. Mendes	Researcher/LIP-DFUC	35
Luís M. S. Margato	PhD Student	100
Susete Fetal	PhD Student	100
Filipa Balau	Master Student	100
Américo Pereira	Technical staff/LIP	20
Nuno Carolino	Technical staff/LIP	20
João Silva	Technical staff/LIP	20

Summary of Activities:

Note: The EC funds for MILAND (NMI3-FP6) were only received at the end of the third trimester of 2004 and the national comparticipation was only confirmed at the beginning of 2005.

After considering several possibilities for the optical readout of the thermal neutron detector was decided that an Anger camera type readout or a center of gravity PMT readout with pulse shape capabilities would be the most promising to fulfill the project specifications in due time. Although position sensitive PMTs and APDs were also considered for the readout, the complexity introduced by the high number of channels needed to readout this devices and the risk associated with a new type of devices excluded them for this time.

The simulation of the localization capabilities of avalanches produced in a GEM foil parallel to the PMTs plane by light division was also carried during this year. The photons emitted by scintillation after a neutron interaction , between 10^7 and 10^8, are isotropically emitted and directly detected without any diffusion. Also its characteristic pulse shape due

to the track drift that could be used to improve localization. This simulation has shown that combining the signals of four adjacent 2" PMTs it is possible to localize a GEM avalanche with an accuracy of 0.5 mm, based on the light distribution and statistics of the avalanche. Further simulations were carried to find optimal distance between GEM planes and PTM diameter, and it was decided to make an order of 38 mm diameter PMTs, that have shown to be the best compromise between blind areas, number of channels and localization limits imposed by the signal to noise ratio.
The experimental work was centered on the assembly of an experimental system to validate the light division method needed for the Anger camera or PMT COG readout A computer controlled sweeping system was developed for this purpose, that is now in operation. It has a position resolution of 50 micron and has been used with an existing array assembled with four 19 mm PMTs and a simulated isotropical light source that emulates the GEM light distribution for preliminary tests. This system will also be used for PMT photocatode uniformity testing, critical for localization purposes. As soon as we receive the new 38 mm PMTs the new geometry with these PMTs will be tested.
The projected PMT system and electronics will be used for the experimental tests of X-ray polarimetry and the developemnt of a four PMT optical TPC.

Academic Training:

Three ongoing thesis on development of radiation detectors using active gaseous scintillators:

- Luís Manuel Silva Margato : PhD. Conclusion foreseen in April 2005
- Susete Fetal : PhD started in late 2002
- Filipa Balau : graduated in 2004, MsC started in 2005

Publications:

A gas proportional scintillator counter for thermal neutrons instrumentation, G. Manzin, B. Guerard, F.A.F. Fraga and L.M.S. Margato, Nuclear Instruments and Methods in Physics Research Section A,
Volume 535, Issues 1-2, 11 December 2004, Pages 102-107

Performance of an optical readout GEM-based TPC, L.M.S. Margato, F.A.F. Fraga, S.T.G. Fetal, M.M.F.R. Fraga, E.F.S. Balau, A. Blanco, R. Ferreira Marques and A.J.P.L Policarpo, Nuclear Instruments and Methods in Physics Research Section A, Volume 535, Issues 1-2, 11 December 2004, Pages 231-235

Breast imaging with a dedicated PEM, R. Ribeiro, C. Abreu, P. Almeida, F. Balau, P. Bordalo, N. C. Ferreira, S. Fetal, F. Fraga, P. Lecoq, M. Martins et al., Nuclear Instruments and Methods in Physics Research , Volume 527, Issues 1-2, 11 July 2004, Pages 87-91

The scintillation of GEMS coated with wavelength shifters, F. A. F. Fraga, S. T. G. Fetal, M. M. F. R. Fraga, E. F. S. Balau, L. M. S. Margato, R. Ferreira Marques, A. J. P. L Policarpo and F. Sauli, Nuclear Instruments and Methods in Physics Research Section A, Volume 525, Issues 1-2, 1 June 2004, Pages 57-61.

Prospects of Scintillation Drift Chambers for single crystal diffraction, J.C. Buffet, J.F. Clergeau, R.G. Cooper, J. Darpentigny, A. De Laulany, C. Fermon, S. Fetal, F. Fraga, B. Guérard, R. Kampmann, A. Kastenmueller, G. Manzina, F. Meilleura, F. Milliera, N. Rhodesg, L. Rostah, E. Schooneveldg, G.C. Smithi, H. Takahashij, P. Van Escha, K.

Zeitelhacke, submitted to Nuclear Instruments and Methods in Physics Research Section A

Conferences:

Performance of an optical readout GEM based TPC, L.M.S. Margato, F.A.F. Fraga, S.T.G. Fetal, M.M.F.R. Fraga,, E.F.S. Balau, A.Blanco, R. Ferreira Marques and A.J.P.L Policarpo, presented at the Wien Conference on Instrumentation, 2004.

A Gas Proportional Scintillator Counter for Thermal Neutrons Instrumentation, G. Manzin, B. Guerard, F.Fraga and L. Margato, presented at the Wien Conference on Instrumentation, 2004.

Statistics:

Theses:	PhD	Master	Graduation
In Progress	2	1	
Concluded in 2004			1

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
4	4		2				

Legend:

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Journ – II : publications in international journals with scientific peer review in which LIP members had a major direct responsibility (thus, a subset of Journ - I).
Other: Internal notes, communications to conferences, etc. with direct involvement of LIP members.
Conferences: Oral or poster presentations by LIP members in international/national conferences.
Seminars: Invited scientific seminars in Institutes and Universities.
Outreach seminars: Seminars for students or general public
Organisation: Organisation of major events (Conferences, Workshops, Collaboration meetings).

PROGRESS REPORT 2004

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

Project References	Funding
POCTI/FP/FNU/50340/2003	15 000 €

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, Auger e, no futuro, por EUSO. 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. Este plano de trabalhos pretende combinar o know-how dos vários membros que constituem a equipa de trabalho, tanto na área da física das astropartículas como na dos processo fundamentais de física da radiação, e assim contribuir para uma melhor compreensão dos processos físicos envolvidos na fluorescência no ar.

O principal objectivo é medir de forma sistemática a quantidade total de luz emitida no azoto e ar seco em função da pressão e temperatura, em determinadas regiões de comprimentos de onda, utilizando electrões energéticos como fonte de excitação. Como complemento deste estudo, serão feitas medidas resolvidas no tempo para as principais bandas moleculares do 2º sistema positivo do azoto em função da pressão e temperatura. O estudo da influência do vapor de água e possívelmente de outros gases presentes na atmosfera como gases minoritários, é também um aspecto importante que será tomado em consideração. Neste estudo será efectuada, para além da medida da luz total emitida em função da concentração do quencher, a análise dos espectros de emissão de forma a verificar se as emissões características desses gases na região de sensibilidade dos fotomultiplicadores são ou não importantes.

Team:

Project Coordinator: Maria Margarida Feteira Ribeirete de Fraga

Team Members:

Name	Status	% of time in the project
Maria Margarida F. R. Fraga	Researcher/LIP-DFUC	30
António J. Onofre Gonçalves	Researcher/LIP-UCP	25
Armando José P. L. Policarpo	Researcher/LIP-DFUC	20
Rui Ferreira Marques	Researcher/LIP-DFUC	10
Francisco A. Fortes de Fraga	Researcher/LIP-DFUC	5
Mário João Martins Pimenta	Researcher/LIP-IST	10
Susete Teresa Gaspar do Fetal	PhD Student	5
Nuno Filipe S. F. de Castro	PhD Student/FCT grant	10
Filipe Manuel Almeida Veloso	PhD Student/FCT grant	10
Luís Pereira [5]	undergraduate student/BIC(*)	100
Nuno Miguel Carolino	Technical Staff	15
Américo Manuel de A. Pereira	Technical Staff	20

(*) BIC: initiation to research grant

[5] Start date – November 1st, 2004

Summary of Activities:

During the past year, an experimental set-up was assembled allowing measurements for temperatures down to –23ºC using either alpha or beta particles as excitation sources. The data acquisition program, using LABVIEW, was implemented and it allows the temperature control of the cooling unit, the recording of three temperature sensors and one pressure sensor as well as the registration of three counting rates. First measurements were performed for pure nitrogen excited by the alpha particles of Am-241. The light yields for the 337 nm band of the N2 molecule 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 which is being developed using the GEANT 4 code. The study of the response of the photomultipliers as a function of the temperature is also an important part of the analysis and it is underway. Preliminary tests with the Sr-90 source have already been performed and suggested some improvements of the experimental set-up.
Besides the studies with radioactive sources, and within the framework of the MacFly collaboration, we also participated at the tests of two detectors (Macfly 1 and MacFly 2) in the beam facility of CERN-SPS. The response of the two detectors was tested, with beams of electrons, pions and muons with energies above 20 and below 100GeV. While MacFly1 was intended to study the fluorescence yield as a function of pressure for each type of incoming particle and energy, MacFly2 was dedicated to the study of the total fluorescence yield produced by the showers from the collisions of the incoming particles with a copper target at the entrance of the detector. Data corresponding to different thicknesses of the target (corresponding to different radiation lengths), energies and pressures was acquired. The analysis of the collected data is under way.

Academic Training:

Since November 2004, one undergraduate student preparing a thesis within the project

Conferences:

"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, poster presented at IEEE Nucl Sci. Symposium, Rome, Italy, October 2004.

Statistics:

Theses:	PhD	Master	Graduation
In Progress			1
Concluded in 2004			

Publications			Conferences		Seminars	Outreach Seminars	Orga-nisation
Journ-I	Journ-II	Other	Internat.	National			
			1				

Annex

Visit to LIP
of the External Evaluation Panel
set up by FCT

17th July 2004

Evaluators:

Prof. Denis Weaire, Trinity College Dublin (chairman)

Prof. Peter Dornan, Imperial College, London

Prof. Minh Quang Tran, École Polytechnique, Lausanne

EXECUTIVE SUMMARY (prepared by LIP)

LIP (Laboratório de Instrumentação e Física Experimental de Partículas) is a technical and scientific non-profit entity created in 1986 by ex-National Board for Scientific and Technological Research (JNICT) and the ex-Instituto Nacional de Investigação Científica (INIC), lately joined by the Associação Nacional dos Industriais de Material Eléctrico e Electrónico (ANIMEE). Following the reorganisation of the scientific public agencies in Portugal, the present institutional partners of LIP are the National Foundation for Science (FCT), the Bureau for International Relations for Science and High Education (GRICES), both under the Ministry of Science and Higher Education, and ANIMEE. The status of Associate Laboratory was granted to LIP by the Ministry of Science and Technology in November 2001.

LIP has two main centres of activity, one at Lisbon and the other at Coimbra. A delegation at Algarve University is currently under development. In the technological areas, Lisbon centre has specialised on calorimetry and data acquisition systems, namely fast electronics, VLSI, optical communications, data acquisition and control software. Coimbra centre has developed competences on detection systems and its activity is also supported on a well-staffed and equipped mechanical workshop. Approximately 60 physicists and engineers participate in LIP activity. Most of LIP researchers are simultaneously university teachers, particularly at the Physics Department of Instituto Superior Técnico (IST), Lisbon and the Science Faculties of the Universities of Lisbon, Coimbra and Algarve, Universidade Católica (Figueira da Foz) and Instituto Superior de Engenharia de Coimbra (ISEC).

LIP was created when Portugal joined CERN as a full member-state and its main objective is the scientific and technological research in the field of Experimental High Energy Physics, Associated Instrumentation and Computation.

The scientific and technological activity of LIP takes place in the framework of international collaborations, aiming at the realisation of experiments, mainly in the European Laboratory for Particle Physics (CERN), in Geneva, Switzerland. LIP does part of its job in Portugal (experiments conception, fundamental research on radiation physics and detectors, technological development and data analysis) executing at CERN or elsewhere all that concerns the direct preparation of experiments and data acquisition.

In close connection with the LHC effort, LIP increased its involvement in computing for LHC, mainly in developing the GRID Computing Paradigm. Together with its participation in the EU Datagrid project, LIP joined as full partner the EU CrossGrid Project, where it plays a central role. LIP is a full partner in the international consortium "Enabling Grids for E-Science and Industry in Europe" (EGEE) to the 6th Framework Program of the European Union.

LIP is also involved in space projects in the framework of the NASA/AMS experiment and of ESA/EUSO experiment. In AMS, LIP main activity is centred in the development of the RICH detector while in EUSO, LIP is responsible for the studies of the Science Operation and Data Centre (SODC). LIP celebrated recently two contracts with ESA to develop specific simulations for space applications.
Research in Monte Carlo Techniques and Detector Development applied to Medical Physics has been carried out in the last years. In Algarve pole, there is a specific line on the development of radiation hard silicon detectors. Recently, an ambitious project for Positron Emission Tomography for Mammography using technology developed at CERN has been prepared and a large consortium involving LIP, hospitals, universities and industry was established.

R&D on detectors for application in fields ranging from HEP and Astroparticle to Medicine and Nuclear Physics, remains a relevant activity of LIP-Coimbra with international recognition, as it can be jugged through the tasks attributed to LIP teams in several international collaborations in which LIP is full member.

This is the case of the expertise in Liquid Xenon (most useful in the UKDM programme), in RPCs (another team is involved in the I3HP FP6 project, with responsibilities in the R&D of high rate RPC detectors for TOF) and in GEMs (a third team is responsible for the development of detectors based on GEM scintillation for neutron detectors, within NMI3 FP6 project). Besides, LIP-Coimbra is also finishing the European n_ToF-ND-ADS project, in which its responsibility is the assessment of a liquid Xe calorimeter for gamma ray cascades.

LIP is a member of European Particle Physics Outreach program that aims to promote education in basic sciences. An experimental set-up for collecting cosmic rays has been developed and is currently being installed in Secondary Schools.

LIP has, in the last two years, lived under unusual constraints. The most important difficulty has probably been financial uncertainty combined with reduced funding.
But LIP has also managed to streamline many of its activities and even to develop new projects. However, the natural expansion of some of its activities were limited.

We have put together on this website the following documents:
- Scientific and financial annual reports (2002, 2003)
- Plans of activity (2002, 2003, 2004)
- Annual Reports issued by LIP International Advisory Board
- A draft plan of activities for the period 2005-2006

LIP management and staff are naturally available for any question concerning these documents (direccao@lip.pt).

Lisbon and Coimbra, July 7, 2004

Evaluation Report

Laboratório de Instrumentação e Física Experimental de Partículas

The history of LIP is an outstanding success story for Portugal. It plays an important role in many CERN projects of high international significance. Given the limited and precarious financial support, the number of these involvements is commendable. Their successful accomplishment is a real triumph, accompanied by the development of technical support facilities and technical staff appointments which need to be emulated elsewhere. This has contributed to the building up of expertise in Portugal and the import of much of this from CERN.

The fusion of Lisbon and Coimbra units in a single entity has been a success and is consistent with international trends towards the creation of large coherent units of critical mass. LIP now has a crucial role in coordinating Portuguese activity in High Energy Physics.

The fluctuating fortunes of science funding and the implementation of approved contracts from FCT impact strongly upon the Laboratory, as upon much else in Portugal. Stability of funding provision (at whatever level is judicious) should be regarded as a "sine qua non" of government science funding policy.

The research conducted at CERN and the technologies employed are of the very highest international standards and therefore it is vital if LIP is to become a significant player in this field that it must aspire and achieve these standards. This takes time and effective organisation with good resources. It is clear that by concentrating its activities in specific directions LIP has managed to achieve competitive results in this field and this is highly commendable.

In the past, the work on the DELPHI and NA50 experiments has been very important with world class results resulting from activities in which LIP personnel have been deeply involved.

Currently the LHC experiments, ATLAS and CMS dominate activities. This is correct, as these experiments will be the most important in the particle physics field over the next decade. In both experiments members of LIP have achieved important roles. The readout of the CMS electromagnetic calorimeter has been a major and very successful activity which required fast modifications after other parts of the readout chain had to be drastically changed. These still have to be verified in the test beam but so far all evidence points to a very successful piece of work. In ATLAS, handling the WLS fibres for the hadronic calorimeter has been another vital and successful activity. This has included the appreciation of the need for a robotic instrument and its design with the aid of local industry. In both experiments the work is first rate and it is pleasing to see that effort is now moving to position the groups to apply themselves to the physics goals of the experiments.

Other activities are based around COMPASS, AMS and EUSO. It is important to have activities outside the LHC area, however here it is harder to judge the effectiveness of the LIP activity, whether there are adequate resources and whether the contribution is of adequate strength.

It is important that a well defined strategy is formulated for non-LHC activities. This is a necessity, both to broaden activity and increase the attractiveness of LIP to a wide range of researchers both in Portugal and abroad. However this has to be in keeping with the resources available and so we would urge the management to establish a well-defined strategy for such a broader activity in particle or astro-particle physics whilst ensuring that the LHC work remains strongly supported. To be able to do this the management must have clear guidelines of the support they can be guaranteed for a significant future period, at least three and preferably five years. The

group is already well involved with space activities but this is a wide, expensive area and so, if this is to be the cornerstone of non-LHC activity, a stronger focus could be beneficial.

In the area of technology transfer the group is doing well, particularly with its moves into medical physics with the PET work using particle physics detection techniques, crystals, RPC's and fast electronics. This appears extremely good and will probably soon be appropriate for patenting and industrial exploitation.

Technical resources and equipment in general seem adequate, although more is always welcome. However in one significant area the equipment is totally inadequate - this is the Computing/Grid area. Exploitation of the LCG Grid will be necessary to enable groups to do analysis and, whilst the idea of distributed computing such that all can use the available resource, it is clear that the amount which Portugal is currently contributing to the hardware resources of European Grid activities is derisory. We were told this presently comprises 20 CPU's of which many are out of date. This is not sufficient for Grid activity here to be credible. CPU power is not now expensive and must be increased so that the team here can contribute to the general activity and compete with other countries. Only with such an investment will it be possible for Portugal to take advantage of the investment it has made on the LHC experiments. A very substantial increase in the amount of hardware, available both to the home community and international partners is needed. Failure to provide this will put Portugal at a substantial disadvantage when it comes to analysis of the LHC data.

At the present stage it is clear that the Laboratory ought to be housed in a proper, purpose-built building, to facilitate its further development and to be a showpiece of science and technology. The present dual (indeed multiple) composition of the Laboratory may pose some problem here. The very technology that the Laboratory is pioneering in the computing/communications area may provide the answer, making possible a prestigious central facility with state-of-the-art links to the rest of Portugal.

Such a vision should be truly European, and look to all of Europe and beyond for staffing, to attract the cream of talent for positions at all levels.

In summary, we regard the recent performance and future plans of the Associate Laboratory to be entirely consistent with the rating of EXCELLENT that LIP has received in previous evaluations.