

LIP

Laboratório de Instrumentação e Física Experimental de Partículas

ACTIVITY REPORT

2002

LIP-COIMBRA

Introduction

The scientific activities of LIP-Coimbra are carried on in the Physics Department of the University of Coimbra. In the framework of the School of Science and Technology (FCTUC), to which this Department belongs, the scientific staff is organised in two research groups (Grupo de Física da Radiação and Grupo de Física Experimental de Altas Energias) that integrate the Research Centre (Centro de Física da Radiação e dos Materiais). Besides, we count on the collaboration of three senior physicists who are professors of physics at Instituto Superior de Engenharia (The engineering school of Instituto Politécnico de Coimbra) and at the Universidade Católica, in Figueira da Foz. The research students involved in LIP-Coimbra activities are either undergraduate or MSc and PhD students of FCTUC. At present, the number of senior physicists is 14 and we have 8 research students, corresponding to a stable situation in the last three years.

The evolution of LIP-Coimbra during 2002 along the various directions of activity pursued can be summarised as follows.

2002 was the first year of activity under the contract of "Laboratório Associado" celebrated in November 2001 between LIP and FCT. One first important change was the contract of one technician ("técnico superior") for our laboratory, A. Blanco, a physicist with a degree of Universidade de Santiago de Compostela, who previously worked in our team for about two years as a research student. Later on, a computer technician ("técnico de informática") was also hired. In this case, we had to announce the position in the press (both at local and national level). Based on the information supplied on their curricula about ten people among the numerous candidates were called to an interview. The person selected was João Silva, who happens to have some sound knowledge of administration of LINUX based services.

It should be noted that the collaboration between LIP-Lisboa and LIP-Coimbra increased significantly this year. Besides of the common effort in the ATLAS project going on for several years, the collaboration for the "CLEAR PEM" started, the preparation of the GRID Project advanced and contacts were established in view of a possible collaboration for the COMPASS Experiment. For the CLEAR –PEM, experimental work in Coimbra is starting in February 2003. Concerning the GRID Project, a realistic test-bed is foreseen, with two nodes (two computer farms) installed at LIP-Lisboa and LIP-Coimbra. While waiting for the decisions on funding from POSI, the work is also starting, with specific training of our computer technician at LIP-Lisboa.

Looking at the evolution of the various projects during this year, we observe that the lab has a good international visibility in all of them. Considering the three directions of research in detector physics (liquid Xe, RPCs and GEMs), we should stress two facts: in all of them our researchers were invited to present oral communications at international conferences or give seminars abroad; in all of them we are currently preparing the presentation of JRPs (Joint Research Projects) for the EC 6th Framework Programme, in one of the cases with the co-ordination of one of the research groups.

The main difficulty we can identify is related to the number of research students and post-docs.

Although at undergraduate level the number of students involved is adequate (notice that the number of all the students that finish the degrees in Physics and Physics Engineering

in Coimbra in recent years is about ten or less), the number of MSc and PhD students is below our needs.

Also our efficiency in finding post-docs has not been satisfactory in recent years. Since there are now positions foreseen in the framework of the Laboratório Associado, we announced last summer in the CERN Courier that such positions will be soon available for people with a few years experience after PhD and curricula of excellence. This way, we identified a few promising candidates and, once the situation is clarified, a call for applications can be announced.

The following table shows the work performed during this year by the Mechanical Workshop.

	MANPOWER				Invoiced €	Real value €
	<i>Permanent Staff</i>		<i>All personnel</i>			
	<i>HH</i>	<i>%</i>	<i>HH</i>	<i>%</i>		
LIP – Lisboa						
ATLAS	974	32%	3632	63,5%	29.163	58326
TRC (Cosmic ray telesc.)	26	1%	26	0,5%	209	418
LIP-Coimbra						
RPC	440	14%	440	7,7%	4.102	8203
GASEOUS DET.	33	1%	33	0,6%	347	693
LIQ. XENON	472	15%	472	8,3%	3.927	7859
<i>Maintenance/Servicing</i>	279	9%	279	4,9%	0	2.554
Physics Department UC	375	12%	375	6,6%	0	7.398
Outside customers	461	15%	461	8,1%	10.190	10.190
Total	3059	100%	5718	100%	47.937	95.636

It is visible that, roughly speaking, 1/3 of the activity was devoted to the projects of LIP-Lisboa (mainly ATLAS, in its last year of "production") and 1/3 to LIP-Coimbra, the remaining 1/3 corresponding to projects of the Physics Department and of other (outside) research institutes. Just a little support has been given to industries during the present year. In the framework of the existing contract, the services to our host institution, the Physics Department (up to 15% of the activity of the workshop permanent staff), corresponded in 2002 to 12% of the overall activity.

Important to notice is also the fact that the total "real value" of the services delivered in this period corresponded essentially to the value of salaries paid. Since we essentially manufacture prototypes, the costs involved in acquiring such services from the industry would certainly be much higher.

PROGRESS REPORT

Project Title: Construction of CAMCAO – an infrared camera for the Very Large Telescope of the European Southern Observatory

FCT, Programa Operacional "Ciência, Tecnologia, Inovação" – ESO/FNU/43843/2001

Team

Project Coordinator: Armando J.P.L.Policarpo

PhD: R. Ferreira Marques

Students:

Technical Staff: J. A. Pinhão, R. Fernandes

Summary:

The project, submitted by Fundação da Faculdade de Ciências da Universidade de Lisboa (FFCUL) under the co-ordination of Prof. António Amorim (FCUL) was financed by FCT in the framework of the Portugal-ESO Agreement.

The aim of this project is to build and validate a near infrared camera to be used in the VLT (Very Large Telescope) of ESO (European Southern Observatory) fitted with a new system of "multi-conjugate adaptive optics" (MCAO). This will be the first high-resolution wide field of view camera using extended correction of the atmospheric turbulence.

Besides of the FCUL team (reponsible for WP2 - Integration, Cryogenics and Control), the project has the collaboration of ESO (Dr. João Alves; WP1 - MCAO Technology transfer), INETI (Prof. José Rebordão; WP4 - Optics) and **LIP-Coimbra (WP3 - Mechanics)**. The project will last for three years, but the participation of LIP will extend for the first two years only.

This project comprises the complete construction and testing of the CAMCAO camera, including the full design and manufacturing of the mechanical housing (LIP), cryogenic and vacuum systems (FCUL), the construction of the optical system and subcontracting the mirrors manufacturing (INETI). The instrument control will be designed implemented and integrated in the camera to function under the supervision of the VLT software running in the instrument workstation. The instrument control, detector image acquisition and vacuum systems will be conforming to the ESO standards to assure a smooth integration in VLT framework.

After full validation in national laboratories (with the infrared detector and adequate light sources), the CAMCAO camera will be delivered to ESO, in Garching, to be integrated in the MCAO demonstrator. Later, the CAMCAO will be shipped and reassembled at the Paranal laboratories and installed in the Nasmyth F/15 focus of the UT3 of the VLT for sky observations. During all these phases, the Portuguese team will maintain a high level of support in order to ensure the smooth operation of the instrument.

Description of WP3 – Mechanics

1 - Detailed 2D and 3D mechanical drawings.

- 1.1 Preparation of the final drawings for all mechanical parts;
- 1.2 Review of the drawings and specifications for manufacture.

2 - Manufacturing of mechanical components

- 2.1 Mechanical parts for the optical subsystem;
Supports for the optical subsystem, and filter-wheel;
Detector case, vacuum chamber and cryostat enclosure.

3 - Tests

- 3.1 Tests of the mechanical parts and systems;
- 3.2 Leak tightness of dewar and vacuum enclosure.

Activities in 2002

In July we hired an engineer, Rui Fernandes, who is working full time for the project (see point 1 of LIP's Work Package). Since then, the overall drawings of the optical box, mirrors and support were prepared. This involved visits to ESO, Garching, of José Pinhão and Rui Fernandes.

Meanwhile a contract was established between FFCUL and LIP-Coimbra, which states clearly the administrative and financial aspects of the collaboration.

PROGRESS REPORT

Project Title: Active gaseous scintillators for detecting neutron and other radiations CERN/FNU/437735/2001 (1st year)

Project Coordinator: Francisco Amaral Fortes Fraga

PhD Researchers: Armando José Ponce de Leão Policarpo, Rui Ferreira Marques, Ermelinda Pedroso de Lima, Maria Margarida Feteira Ribeirete de Fraga, Paulo Jorge Baeta Mendes

PhD Students: Luís Manuel Silva Margato

MsC Student: Susete Fetal

Ungraduate Students: Filipa Balau

Technical Staff: Americo Pereira, Nuno Carolino

Introduction: This document reports on the first year of the project. As the project was financed at less than 50%, the execution of some parts of the program were compromised, mainly the study of optical readouts, that would involve expensive acquisitions, although some parts of the project are running ahead of schedule, such as study of GEM gaseous scintillators in pulse mode. The study of the Xe-TMA 5 bar quencher for ^3He thermal neutron detectors and X-ray imaging mixture was quite successful, both with CCDs in integral mode and in pulse mode. The fundamental studies of gaseous scintillating mixtures (spectral emission and light yields) carried on until now have supplied us with information needed. Medical applications (scintillation screen for radiotherapy) have been idling during the last months due to project rearrangement, although we just have enrolled a PhD student for this task. The outcome of this work was substantial, as shown by the eight presentations made during the last twelve months at international conferences and the six papers published or submitted for publication in international papers with referee.

Summary of activities:

Thermal neutron detection

Considering that Xe can be used as a quencher for the triton and proton in ^3He detectors and the good results previously obtained with the Xe TMA mixture using GEMs, we carried on a study of the operation of the Xe-TMA at 3 and 5 bars, using both a recently acquired UV CCD and PMTs. Although our studies were primary aimed at neutron detection, these results are also of high interest for X-ray detection, as a 25 mm thick conversion volume at 5 bar Xe/TMA will have ~ 90% detection efficiency for 17.5 keV X-rays and only 50 mm will be needed to get 80% efficiency at 25 keV. These results were presented at the SAMBA 2002 (Symposium on Applications of Particle Detectors in Medicine, Biology and Astrophysics II) in Trieste.

The scintillation operation in pulse mode was studied with He-CF₄ and Xe-TMA using PMTs and a fast digitizer (Tektronix TDS 7104) to measure simultaneously the light and charge signals. Light signals were very fast (rise-time was typically around 40 ns) and faster than the

charge signals from X-rays. This difference was more evident at high pressure. It was also shown that, in photon counting mode, time and energy resolution are compatible with applications that can take advantage of energy discrimination capabilities. We are now observer members of TECHNI, (due to EC regulations, it was not feasible to add new effective members during the project execution), and have filled a joint intention with several teams to integrate a new emerging collaboration within FP6, coordinated by the NMI3.

Optimization of GEM scintillation

Considering the need of data on GEM scintillation and the recent acquisition of the new CCD sensitive in the UV, we carried on some detailed studies on the spectral distribution of the secondary scintillation emitted by Ar-CF₄, Ar-TEA, Xe-TEA and He-CF₄ mixtures in a GEM detector and the light emission mechanisms. The wavelength region under study extended from 200 to 900 nm. Total light yields in those mixtures were measured. Integral light measurements were made either with a UDT planar-diffused silicon photodiode (PIN-25DP) or by a 56TUVP photomultiplier (PM), operating in pulse mode.

For the spectral studies the light is analysed by an Applied Photophysics monochromator, mod. 7300, equipped with a 1200 g/mm grating blazed at 500 nm and detected by a RCA C31034A photomultiplier, cooled down to -20°C and operated in single photon counting mode. The results obtained were also of great interest for another related project we are pursuing - a GEM polarimeter with optical readout for X-ray astronomy. The information of the X-ray polarization will be extracted from the scintillation images of the projections of the primary tracks in the GEM plane, and/or pulse risetime. We have also joined a FP6 initiative proposal proposal (Advanced TPC Tracking for Particle Astrophysics, including 23 leading Institutions of Astrophysics research in Europe) that foresees to use this technique for dark matter studies.

Neutron spectrometer - search for a gas mixture

The work developed along these lines: i) simulation of the energy losses of the recoil nucleus in the gas volume to choose a possible candidate and ii) experimental measurements of the accuracy of the optical technique of measuring the track length and energy using the CCD. Considering that we should look for a target nucleus that is not too heavy and the maximum track range should be about 5 cm we are currently considering either pressurized helium or neon, and we are looking for an additive quencher that shifts the light emission towards shorter wavelength. Upon analysis of the neutron crosssections for several usual additive gases, we found that the additive choice and concentration is very critical.

The system for testing the technique has been assembled and the measurements with the CCD, using a collimated alpha source with variable entrance angle to obtain tracks in the gas have been started. The good results obtained in the scintillation measurements using pulse mode suggest that we could complement the information obtained from the CCD image with information from PMT signals, enhancing the accuracy of the system, and this possibility will be considered.

Medical applications - dose imaging in radioteraphy

This work is bound to the project "New methods for 2D-radiation detection in radiation therapy", a joint venture between the Technical University of Delft, the Kernfysich Versneller

Institut, Groningen and the Radiation Oncology Department, Academisch Ziekenhuis Groeninge, extending up to 2005. Recent rearrangements of our international partners, mainly the change of position of one of the project leaders, have delayed for some time the project, that moved its international development to Delft, where now a PhD student paid by the Dutch FOM is also starting to work. Although experimental work on this project has been stopped for a while, a new detector is now being assembled and work on the analysis of the existing results has been carried on, a paper has been submitted for publication to Nucl. Instr. and Meth. It was found that the strange increase of the scintillation under very high count rates should be carefully checked and explained. The importance of our part in the project, mainly the evaluation and correction of the detector non-homogeneity was also confirmed and a new graduate student has also recently joined this work in Coimbra.

Deliverables

The outcome of this work was substantial, as shown by the eight works presented during this period at conferences, the six papers published or submitted for publication in international papers with referee and one MSc dissertation. It should be noted that the interest of the scientific community for our GEM scintillation studies has become notorious during the last year, as confirmed by several invitations we received to present our work at international meetings.

Academic Training

Susete Fetal got her MSc degree in October 2002. She submitted a dissertation thesis entitled "Leitura de cintiladores activos com GEMs por CCDs - Aplicação dosimétrica para radioterapia com prótons" (Readout of active scintillators with GEMs - dosymetry application to proton radiotherapy), worked out in the framework of this project.

Filipa Balau started during 2002 her work for the graduation project.

Publications after the 1st of January 2002

CCD readout of GEM based neutron detectors, *F.A.F. Fraga, L.M.S. Margato, S. T. G. Fetal, M.M.F.R. Fraga, R. Ferreira Marques, A.J.P.L Policarpo, B. Guerard, A. Oed, G. Manzini e T. van Vuure*, Nucl. Instr. and Meth. In Physics Research A 478 (2002) 357.

Performance of a Tracking Device Based on the GEM Scintillation, F.A.F. Fraga, L.M.S. Margato, S. T. G. Fetal, R. Ferreira Marques and A.J.P.L Policarpo, *IEEE Trans. on Nucl. Sci.* 49, NO.1, February 2002, pg.281- 284.

Dose imaging in radiotherapy with an Ar-CF₄ filled scintillating GEM, S.T.G. Fetal, C.W.E. van Eijk, F.A.F. Fraga, J. de Haas, R. Kreuger, T.L. van Vuure and J.M. Schippers, *submitted to Nucl. Instr. and Meth*

The GEM scintillation in He-CF₄, Ar-CF₄, Ar-TEA and Xe-TEA mixtures, *M. M. F. R. Fraga, F. A. F. Fraga, S. T. G. Fetal, L. M. S. Margato, R. Ferreira Marques and A. J. P. L. Policarpo*, submitted to Nucl. Instr. and Meth

Time analysis of the light pulses on gaseous active scintillators using GEMs with He/CF₄, *L.M.S. Margato, F.A.F. Fraga, S.T.G. Fetal, M.M.F.R. Fraga, R. Ferreira Marques, A.J.P.L Policarpo, B. Guerard and G. Manzin*, submitted to Nucl. Instr. and Meth

Luminescence and Imaging with Gas Electron Multipliers, *F.A.F. Fraga, L.M.S. Margato, S.T.G. Fetal, M.M.F.R. Fraga, R. Ferreira Marques and A.J.P.L Policarpo*, submitted to Nucl. Inst. and Meth.

Conferences after the 1st of January 2002

Imaging chambers in medicine, biology and astrophysics, *F. Fraga*, invited talk at the 8th Topical Seminar on Innovative Particle and Radiation Detectors, Siena, Italy, 21-24 October 2002

Luminescence and Imaging with Gas Electron Multipliers, *F.A.F. Fraga, L.M.S. Margato, S.T.G. Fetal, M.M.F.R. Fraga, R. Ferreira Marques and A.J.P.L Policarpo*, invited talk at the 6th Position Sensitive Detectors Conference, Leicester, United Kingdom, September, 9-13, 2002

Dose imaging in radiotherapy with an Ar-CF₄ filled scintillating GEM, *S.T.G. Fetal, C.W.E. van Eijk, F.A.F. Fraga, J. de Haas, R. Kreuger, T.L. van Vuure and J.M. Schippers*, oral presentation at the 6th Position Sensitive Detectors Conference, Leicester, United Kingdom, September, 9-13, 2002

The GEM scintillation in He-CF₄, Ar-CF₄, Ar-TEA and Xe-TEA mixtures, *M. M. F. R. Fraga, F. A. F. Fraga, S. T. G. Fetal, L. M. S. Margato, R. Ferreira Marques, A. J. P. L. Policarpo*, oral communication at the 3rd Conference "New Developments in Photodetection", Beaune, France, June, 17-21, 2002

Time analysis of the light pulses on gaseous active scintillators using GEMs with He/CF₄, *L. M. S. Margato, F. A. F. Fraga, S. T. G. Fetal, M. M. F. R. Fraga, R. Ferreira Marques, A. J. P. L. Policarpo, B. Guerard, G. Manzini*, poster presented at the 3rd Conference "New Developments in Photodetection", Beaune, France, June, 17-21, 2002

CCD readout of high pressure xenon-TMA GEM detectors for X-ray imaging, *L. M. S. Margato, F. A. F. Fraga, M. M. F. R. Fraga, S. T. G. Fetal, R. Ferreira Marques, A. J. P. L. Policarpo, T.L. van Vuure, R. Kreuger, C.W.E. van Eijk and R.W. Hollander*, presented at the Symposium on Applications of Particle Detectors in Medicine, Biology and Astrophysics II, Trieste, Italy, May, 27-29, 2002

Scintillation Neutron detectors with GEMs, *F. A. F. Fraga, L. M. S. Margato, M. M. F. R. Fraga, S. T. G. Fetal, R. Ferreira Marques, A. J. P. L. Policarpo, T.L. van Vuure, R. Kreuger, C.W.E. van Eijk, R.W. Hollander, B. Guerard, A. Oed, G. Manzini*, oral presentation at the European Conference ESS (European Spallation Source), Bonn, Germany, May, 16-17, 2002

GEM neutron detector development, *T.L. van Vuure, C.W.E. van Eijk, F. A. F. Fraga, R. Hollander, R. Kreuger, L. Margato* , oral presentation at the European Conference ESS (European Spallation Source), Bonn, Gemany, May, 16-17, 2002

PROGRESS REPORT

Project Title: Collaboration in the HERA-B experiment
CERN/FNU/43701/2001

Team

Project Coordinator: João Carlos Carvalho

PhD: Armando J.P.L.Policarpo, António Amorim, Helmut Wolters

Students: João A. Bastos, Vasco Amaral, António Oliveira, João Batista, Luis Silva

Technical Staff:

Summary of activities:

In the year 2002 the HERA proton accelerator had several problems and delays in its operation, which implied irregular data taking during most of the year, except for the last two months. The recently acquired data has higher quality and the detector performance is much better than in 2000, thanks to the repair and improvement of the different sub-detectors and the final installation of some pieces of equipment.

The Portuguese team is responsible for the experiment database system, which is now fully operational with the integration of information from all the sub detectors. The system is working as required and its performance and functionality are still being improved. For this task there is always a person in full time at the DESY laboratory. The database system was monitored and maintained, and new alignment constants were released whenever needed, to increase the data quality.

The group is also involved in the RICH detector. This system is working and its design parameters were already achieved. The group participated in the detector operation and in the test of the particle identification algorithms, using different types of likelihood probabilities.

In data simulation and analysis the Portuguese team is involved in the measurement of the branching ratio $\omega \rightarrow \mu^+ \mu^-$, that was published for the first time only in 2002, and for which the experiment has a clear signal. This is compared with the known branching ratios of $\omega \rightarrow \pi^+ \pi^- \pi^0$, implying the reconstruction of a neutral pion, and $\phi \rightarrow \mu^+ \mu^-$ where it is necessary to know the relative production cross sections ϕ/ω . Other important work was the measurement of the b-bbar cross section from double semileptonic B meson decays. The semileptonic channels (like $B^+ \rightarrow D l^+ \nu$) have a larger branching ratio than the J/ Ψ channels. There was a hint of signal in the 2000 data, both in the electron and the muon channel, but the new data allows to increase the statistics in a very significant way. Finally there was also work in the luminosity determination, fundamental for the

measurement of absolute cross sections, for which a new statistical method was developed and applied. This method counts the number of empty events in two independent sub-detectors, from which it fits the probability of an empty event. This is related with the interaction ratio by the Poisson statistics. One of us, J. Carvalho, is the convener of the luminosity working group.

Academic Training:

João Bastos - Ph.D. thesis finished in 2002.

Vasco Amaral - Ph.D. thesis conclusion foreseen in 2003.

António Oliveira - M.Sc. thesis conclusion foreseen in 2003.

João Batista - M.Sc. Thesis conclusion foreseen in 2004.

Luis Silva - M.Sc. Thesis conclusion foreseen in 2004.

Publications:

"Inclusive V^0 production cross-sections from 920 GeV fixed target proton-nucleus collisions" HERA-B Collaboration, DESY-02-213, DEC.2002, Submitted to Eur.J.Phys.C, hep-ex/0212040

" J/Ψ production via χ_C decays in 920 GeV pA interactions" HERA-B Collaboration, DESY-02-187, Nov. 2002, Submitted to Physics Letters B, hep-ex/0211033

"Measurement of the B anti-B production cross-section in 920-GeV fixed target proton nucleus collisions" HERA-B Collaboration, DESY-02-076, May 2002, Accepted for publication in Eur.J.Phys.C, hep-ex/0205106

PROGRESS REPORT

Project title: Applications of timing Resistive Plate Chambers
CERN/P/FIS/40111/2000

Project coordinator: Paulo J. R. Fonte.

PhD: Paulo Fonte, M. Isabel Lopes, Rui Ferreira Marques, and Armando Policarpo.

Students: Luís Lopes, Pedro Amado.

Technical: Alberto Blanco, José Pinhão, Rui Alves, Nuno Carolino.

Summary of activities

This report concerns the scientific activities developed during 2002.

Developments in RPC-PET

In the framework of a previous project we identified two possible applications for RPC-based PET counters: high accuracy PET for small animals and whole-body human TOF-PET.

A prototype for high-accuracy small-animal PET

Following the conclusions stated above an RPC-PET prototype for small animals, designed in 2001, was built and commissioned in 2002.

The system has 2 detector heads with 16 layers of RPCs each. The conversion point can be identified in one dimension by 32 strips (1 mm wide) with centroid calculation and the conversion layer will be also identified. The 96 channels readout system was custom-made, and equipped with special retriggerable discriminators which will deal with the large amount of interchannel crosstalk in the counter.

First experimental results indicate already a sub-millimetric resolution of 0.7 mm FWHM and further improvements are reasonable to be expected.

Developments for the HADES experiment (GSI)

Proposal for the Inner TOF Wall

A proposal for the construction of the HADES Inner TOF Wall was elaborated by LIP-Coimbra and GENP-Santiago de Compostela and presented to the collaboration by P. Fonte at the XI Collaboration Meeting, Smolenice Castle, Slovak Republic, 10-14 April 2002.

Following further discussions, a beam test will be held in April 2002 to clarify some technical aspects like the influence of the highly ionising background particles, the rate capability and possible crosstalk effects in high-multiplicity environment.

Preparations for the beam test

In view of the situation stated above, a beam test of a realistic prototype comprising at least 3 contiguous cells (60x2 cm² each), will be held in April 2002. A laboratory test of different cell shielding structures and strategies was made and the construction of a 3-cell counter was started.

Very high rate timing RPCs

Very high rate counters are of general interest for expanding the applicability of timing RPCs. A development in this direction was started by searching for adequate materials.

Aging in timing RPCs

Severe aging of glass RPCs operating in streamer mode has been observed and related to the presence of water vapour traces in the gas mixture. An unidentified deposit was found over the glass surface, severely increasing the dark count rates and reducing the counter efficiency.

Naturally it is of great practical importance the investigation of such effect in timing RPCs (operated in avalanche mode), often made with glass electrodes and working in somewhat similar gaseous mixtures. To this aim, we built a test set-up comprising six single-gap counters. After a charge transfer of ~250 mC, equivalent to 800 days of normal operation at 200 Hz/cm², no increase of dark current was detected. However a yet unidentified deposit was found over the glass cathodes.

First results were presented at the "6th International Conference on Position Sensitive Detectors", 9-13 September 2002, Leicester, UK.

Physics studies

Physics studies aiming to completely clarify the working mode of timing RPCs are being also pursued. Recent theoretical results were presented at the "6th International Conference on Position Sensitive Detectors", 9-13 September 2002, Leicester, UK.

Involvement in the CBM experiment at GSI

The Compressed Baryonic Matter experiment will be a prominent part of the experimental program at the future heavy-ion accelerator at GSI.

LIP Coimbra has been involved since the initial meetings and is expected to take active part already in the technical proposal.

Seminars, conferences, articles and reports

A RPC TOF Wall for the HADES Spectrometer, LIP-Coimbra, Univ. Santiago de Compostela, written proposal, April 2002.

H. Alvarez-Pol, J.J. Garzon, D. Gonzalez A.Blanco, R. Ferreira-Marques, P.Fonte, A.Policarpo, "Viability Analysis of a RPC TOF Wall for the Hades Small Angles Region", comunicação oral no "HADES Collaboration Meeting XI", April 11-14, 2002, Smolenice, Slovak Republic

P.Fonte, "Resistive Plate Chambers for Time-of-Flight Measurements" oral communication at "Compressed Barionic Matter Workshop 2002", 13-16 Maio 2002, GSI, Darmstadt, Alemanha.

P.Fonte, "Resistive Plate Chambers for PET", oral communication presented at the Workshop on Positron Emission Mammography, 1-2 Julho de 2002, Lisboa, Portugal.

A.Blanco, P.Fonte, L.Lopes, A.Mangiarotti, R. Ferreira-Marques, A. Policarpo "Resistive Plate Chambers For Time-Of-Flight Measurements" oral communication at "6th International Conference on Position Sensitive Detectors", 9-13 September 2002, Leicester, UK, accepted for publication in Nucl. Instr. and Meth.

PROGRESS REPORT

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

Project Coordinator: M. Isabel Lopes

PhD:

M. Isabel Lopes
Vitaly Chepel
José Pinto da Cunha
Paulo Mendes
Rui Ferreira Marques
Armando Policarpo

Students:

Vladimir Solovov
Francisco Neves
Alexandre Lindote
João Abrantes

Technical Staff:

José Pinhão
Américo Pereira

Summary of activities:

This report refers to the scientific activity developed during 2002 in the domain of liquid xenon detectors. The main activities and results can be summarised as follows:

Study of Large Area Avalanche Photodiodes

The study of Large Area Avalanche Photodiodes (LAAPD) has been continued in view of their application for the detection of liquid xenon scintillation in detectors, namely detectors for the direct search of WIMPs. The following topics were addressed:

- Measurement of the excess noise factor, F , of a LAAPD from Advanced Photonics as a function of gain and temperature from 0°C down to -80°C. In a detector with LAAPD readout, the noise and the fluctuations of the avalanche gain contribute to the energy resolution of the system. The later is expressed in terms of the excess noise factor which should be as low as possible. A linear dependence of F on the LAAPD gain was found for gains larger than 100, the slope being equal to 0.002 (the slope is the effective ionization rate ratio which is usually symbolised by k). As it was estimated in previous measurements of the energy resolution in liquid xenon of alpha-particles, the value of k measured was higher than that quoted by the manufacturer and usually reported in the literature for this type of photodiodes.

- Variation of the LAAPD gain with temperature. This aspect is of great relevance in view of a stable operation of the photodiode. For instance, a relative variation of the gain of 3% /°C at a gain of 50, rising to \approx 5% at a gain of 200, was observed. Hence, it is concluded that very good temperature stability is required to limit the gain variations, otherwise a correction mechanism has to be implemented.
- Detection of very low intensity light pulses. The amplitude distributions of the signals corresponding to an average number of primary electron-hole pairs (e-h) as small as 3 to 7 were measured, thus showing the possibility of detection of very low intensity light pulses. The pulse height spectra were compared with predictions based on McIntyre theory. Good agreement was found.
- On the basis of the McIntyre theory, the detection efficiency for single electron-hole pairs, ϵ_{ph} , was estimated for LAAPDs with different excess noise factor. It was found that the feasibility for detecting single e-h pairs strongly depends on that parameter. For LAAPDs with $k=0.002$, like that one from Advanced Photonics which was tested, ϵ_{ph} varies between 20% and 30% with the gain varying from 1000 to 2000.
- The dark count rate was measured as a function of the temperature and gain. A strong dependence on temperature was found, the dark count rate decreasing by a factor of about 17 per 10°C of temperature decrease. From measurements, a dark count rate of about 0.2/s was extrapolated for -100°C with 1 μ s shaping time, a gain of 1000 and a discrimination level of 1500 electrons. The results open good prospects for the use of LAAPD for low background applications.

Construction of a large test chamber

Final design of a large experimental chamber (~3 litres) for measurements of a liquid xenon/argon detector response to neutrons and gammas. The construction of the chamber was initiated in the workshop.

Vacuum tests and cleaning of a portable purification system for xenon and argon.

The portable purification system for xenon and argon was finished, the vacuum tests and the deep cleaning procedure carried out, and the outgassing process started.

Position determination and event reconstruction in liquid xenon detectors for WIMPs search and (n, γ) reactions

Large liquid xenon detectors based on scintillation are foreseen, both for WIMPs search and 4π γ -ray spectrometers. In these detectors, dependence of the collected light on the position of the interaction degrades the energy resolution. In order to correct for this position dependence in such a large volume, we developed an algorithm to reconstruct the interaction point from the analysis of the photo-detector amplitudes. For that, we carried out the full Monte-Carlo simulation of the test chamber that is being built to performing the measurements under neutron irradiation.

The results show that it is feasible to achieve energy resolutions of less than 50% for 20 keV γ -rays with a modest set of photo-multipliers, i.e. in an energy domain of interest for WIMPs search. The position resolution of such a device is about 8 mm in the x-y plane and better than 10 mm in z, for points at distance from the detector plane up to 5 cm. Besides improving the energy resolution, the position resolution achieved opens the possibility of improving the rejection of multiple scattering and other background events.

Participation in the n-TOF runs

We participated in n-TOF runs for the measurement of the cross section of the neutron capture in ^{204}Pb e ^{206}Pb . Two students involved in this project participated in the shifts and data taking.

Academic Training:

One student (Francisco Neves) is doing his Ph.D. work and another (Alexandre Lindote) is preparing his Master Thesis in the framework of this project.

João Abrantes finished his graduation project, in the framework of this project.

Publications:

“Low Temperature Performance of a Large Area Avalanche Photodiode”, V. Solovov, F. Neves, V. Chepel, M.I. Lopes, R. Ferreira Marques e A.J.P.L. Policarpo, accepted for publication in *Nucl. Instr. and Meth. A*.

"Liquid Rare Gas Detectors: recent developments and applications", M.I. Lopes e V. Chepel, submitted for publication in "*IEEE Trans. on Dielectrics and Electrical Insulation*".

“Liquid Xenon Scintillation: Light Propagation and Detection”, V. Chepel, V. Solovov, F. Neves, M.I. Lopes, A. Lindote and J. Pinto da Cunha, submitted for publication in "*The Identification of Dark Matter*, Word Scientific.

“Position determination in liquid Xe detectors”, J.Pinto da Cunha, A. Lindote, F. Neves, V. Chepel and M.I. Lopes, to be submitted to *Nucl. Instr. and Meth. A*.

Conferences:

“Liquid Xenon Scintillation: Light Propagation and Detection”, V. Chepel, V. Solovov, F. Neves, M.I. Lopes, R. Ferreira Marques and A.J.P.L. Policarpo, oral communication in "*4th International Workshop on the Identification of Dark Matter*", York, U.K., 2-6 September 2002.

"Liquid Rare Gas Detectors: recent developments and applications", M.I. Lopes e V. Chepel, oral communication as invited speaker in "*2002 IEEE, 14th International Conference on Dielectric Liquids (ICDL 2002)*", Graz, Austria, 7-14, July, 2002.

“Low Temperature Performance of a Large Area Avalanche Photodiode”,
V. Solovov, F. Neves, V. Chepel, M.I. Lopes, R. Ferreira Marques and
A.J.P.L. Policarpo, oral communication in “*3rd International Conference on New
Developments in Photodetection*“, Beaune, France 17-21 June, 2002.

LIP-LISBOA
and ALGARVE POLE

Introduction

During 2002, LIP-Lisboa has pursued its involvement in CERN experiments centred in the two major LHC collaborations, ATLAS and CMS.

Work was also continued in the framework of DELPHI and NA50 experiments where PhD candidates are still involved in data analysis and academic work.

An important milestone was achieved in the framework of the ATLAS collaboration, namely the fibre insertion in the Tilecal Calorimeter. In July 2002, ahead of schedule, 180.000 plastic profiles with inserted fibres were delivered to CERN. This project was a very successful collaboration of a number of institutions and industry, done closely with the LIP Mechanical Workshop in Coimbra where the mass production took place.

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.

Our involvement in Physics in Space was not only pursued in the framework of the AMS experiment but LIP has also joined a new International Space Station physics experiment, the Extreme Universe Space Observatory (EUSO), now approved for phase A by the European Space Agency.

Finally, the research in “Monte Carlo techniques and Detector Development applied to Medical Physics” was developed benefiting from a two-years funding grant and goes on in LIP Lisbon and its Algarve Pole. In Algarve Pole, the development of radiation hard silicon detectors in the framework of RD39 collaboration also continued.

Concerning Outreach activities, a project (funded by Ciência Viva) for developing an experimental set-up for collecting cosmic rays is now under development. The set-up will be installed in Secondary Schools, in 2003. The representation of Portugal in CERN Outreach group as well as in the Candidate Selection for the HST Programme (High School Teachers) at CERN must also be mentioned.

During 2002, LIP has organised or co-organised three major events:

“Workshop on Positron Emission Mammography”, July, 2002, Lisbon

“IV International Workshop on New Worlds in Astroparticle Physics”, September, 2002, Faro

“CERN Accelerator School – CAS”, September, 2002, Sesimbra

The funding granted to the above projects can be seen in the following table:

PROJECT	REFERENCE NUMBER	FUNDING
CALORIMETRY	CERN/FNU/43715/01	235.000€
CMS	CERN/FNU/43654/01	235.000€
DELPHI	CERN/FNU/43674/01	120.000€
NA50	CERN/FNU/43727/01	100.000€
ROBOTIZATION	CERN/FNU/43707/01	85.000€
PROC.&TRANS. TECHNOL	CERN/FNU/43668/01	75.000€
MEDICAL PHYSICS	CERN/FNU/43672/01	60.000€
CMS -DAS	CERN/FNU/43670/01	50.000€
SILICON DETECTORS	CERN/FNU/43681/01	25.000€
AMS	DIV 1179	149.600€
EUSO	POCTI/FNU/43515/01	80.000€
CIÊNCIA VIVA	PV-0124	55.300€
CROSSGRID	IST-2001-32243	55.900€
TOTAL		1.325.800€

The academic training program included in the projects can be summarized in the following table:

	PhD in progress	Master in progress	Master concluded	PhD concluded
ATLAS	2	3		
DELPHI	2	2		1
MEDICAL PHYSICS	3	1	2	
NA50	3			1
CMS	1			
AMS		3	1	
Total	11	9	3	2

The last months of 2002 were affected by delays in the payments due by our funding agencies (still pending in February 2003) and by the interruption (or suspension) of some new projects (LIP Lisbon new premises, GRID, hiring of new PhDs)

Human Resources

LIP 2002

	January 2002	December 2002
Administrative Staff	5	5
Technical Staff	5	5
Researchers	12	14
Post-doc Fellowships	6	8
PhD Students	12	12
BIC/BTI Fellowships and Master Students	19	17
TOTAL	59	61

This table includes LIP Lisbon and LIP Algarve staff

Administrative Staff:

Lina Barata, Claudia Delgado, Sandra Dias, João Vargas, Natália Antunes

Technical Staff:

José Carlos Nogueira, José Carlos Aparicio, João Paulo Conceição, José Carlos da Silva, Dário Passos*

Researchers:

Amélia Maio, Conceição Abreu*, Fernando Barão, Gaspar Barreira, João Cruz, João Varela, Jorge Gomes, José Mariano Gago (since April 2002), Luis Peralta, Mário Pimenta, Paula Bordalo, Pedro Abreu, Sérgio Ramos, Luis Bernardo (since July 2002)

Post-Doc Fellowships:

Agostinho Gomes, Bernardo Tomé, Catarina Quintans (since December 2002), Catarina E. Santo, Mário David, Patricia Gonçalves (since June 2002), Pedro Rato*, Reyes Alemany Fernandez.

PhD Students:

Andreia Trindade (since July 2002), Gonçalo Borges, Helena Santos, José Manuel Silva, Maria de Jesus Varanda, Nuno Almeida, Nuno Anjos, Patrick Sousa*, Pedro Rodrigues (since July 2002), Sandra Moreno (till December 2002), Sofia Dias, Teresa Claudino, Patricia Gonçalves (till May 2002), Catarina Quintans (till November 2002)

BIC – BTI Fellowships and Master students:

Andreia Trindade (till May 2002), Carlos Marques, Catarina Ortigão, Fernando Esteves (till October 2002), Fernando Carmo (Master Student), Filipe Veloso, João Borges, João Pina, João Saraiva, Miguel Ferreira, Luisa Arruda, Nuno Cardoso, Nuno Castro (Master Student), Pedro Assis, Sandra Soares, Sónia Rodrigues* (since February 2002), Pedro Silva (till October 2002), Pedro Rodrigues (till May 2002), Marco Quintero (Master Student)*, Bruno Carriço*.

(*) LIP Algarve Staff

PROGRESS REPORT

Project Title: AMS

Team

Project Coordinator: Fernando Barão

PhD: Gaspar Barreira, Mário Pimenta, Patrícia Gonçalves, Jorge Dias Deus

Students: João Borges, Luísa Arruda, Fernando Carmo

Technical Staff:

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 improved and extended through the inclusion of new detectors such as a Ring Imaging Cerenkov Detector (RICH). The RICH will provide an independent measurement of the particle velocity with a goal resolution of the order of 10^{-3} . Such a resolution together with an improved measurement of the particle rigidity due to a higher magnetic field (0.9T), will allow to separate several isotopes on a large kinetic range.

The favored solution points to a conical shaped detector with a low radiator index (aerogel, $n=1.03$) on the top, photodetectors on the bottom and an enveloping outer mirror of very large reflectivity. The team is involved on the RICH setup simulation and 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 cerenkov photon ring, which differ from event to event due to the ring geometrical acceptance and event kinematics implied a charge reconstruction method based on an overall efficiency estimation on a event by event basis. A typical resolution on charge of the order of 20% is obtained for protons.

During the year of 2002 a RICH prototype made of a radiator and 96 photomultipliers, separated by an expansion volume similar to the final one, was built. The prototype,

together with a trigger system made of three scintillators and a tracking system made of three wire chambers, was submitted to cosmic muon runs at the ISN, Grenoble. Different aerogels radiators were compared and the monte carlo simulation was fine tuned. Both reconstruction methods developed at LIP were applied to data.

The radiator configuration was object of optimization in order to have in AMS the possibility of isotopes separation in a kinematic region as large as possible. The idea was to include in the central radiator region a larger refractive index radiator - dual radiator configuration. This will provide higher photon ring acceptances for events passing close to center of the radiator and consequently improves the reconstruction efficiency.

In the framework of one of the master thesis, we started studies on the possibility of using the light guide yield for charge reconstruction.

Academic Training:

Master Thesis:

Reconstrução da carga eléctrica com o detector RICH da experiência AMS, Ana Braga Keating. Supervisor: Fernando Barão. Maio, 2002 – Instituto Superior Técnico

Publications:

Cerenkov angle and charge reconstruction with the RICH detector of the AMS experiment, F. Barão et al. to be published in NIMA (2003)

The Alpha Magnetic Spectrometer (AMS) on the International Space Station, Part I, Results from the test flight on the Space Shuttle, AMS Collab., Physics Reports, 366/6 (2002) 331.

Conferences:

Cerenkov angle and charge reconstruction with the RICH detector of the AMS experiment, F. Barão, RICH 2002 Conference, June 2002, Pylos-Greece

Velocity reconstruction with the RICH detector of the AMS experiment, J. Borges. New Worlds In Astroparticle Physics, September 2002, Algarve. Proceedings to be published by World Scientific

Charge reconstruction with the RICH detector of the AMS experiment, L. Arruda. New Worlds In Astroparticle Physics, September 2002, Algarve. Proceedings to be published by World Scientific

PROGRESS REPORT

Project Title: Calorimetry for ATLAS/LHC

Team

Project Coordinator: Amélia Maio

PhD:

Amélia Maio	63%
António Amorim	4%
João Carvalho	25%
António Onofre	10%
Helmut Wolters	4%
Agostinho Gomes	95%
José Martins	10%
Manuel Maneira	4%
Carlos Cardeira	8%

Students:

Maria de Jesus Varanda	95%
José Silva	100%
João Santos	10%
João Gentil Saraiva	100%
João Pina	100%
Pedro Amado	50%
Fernando Esteves	30%
Carlos Marques	95%
Sandra Soares	95%

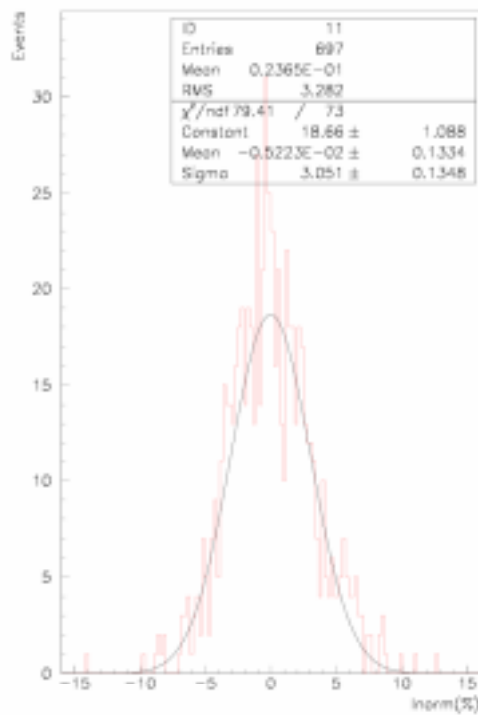
Technical Staff:

José Pinhão	5%
Rui Alves	10%
Fernando Moita Ribeiro	40%
Joaquim Oliveira	15%
Américo Pereira	25%
Jorge A. Moita	10%
Joaquim Patriarca	25%
Luís Raposeiro	15%

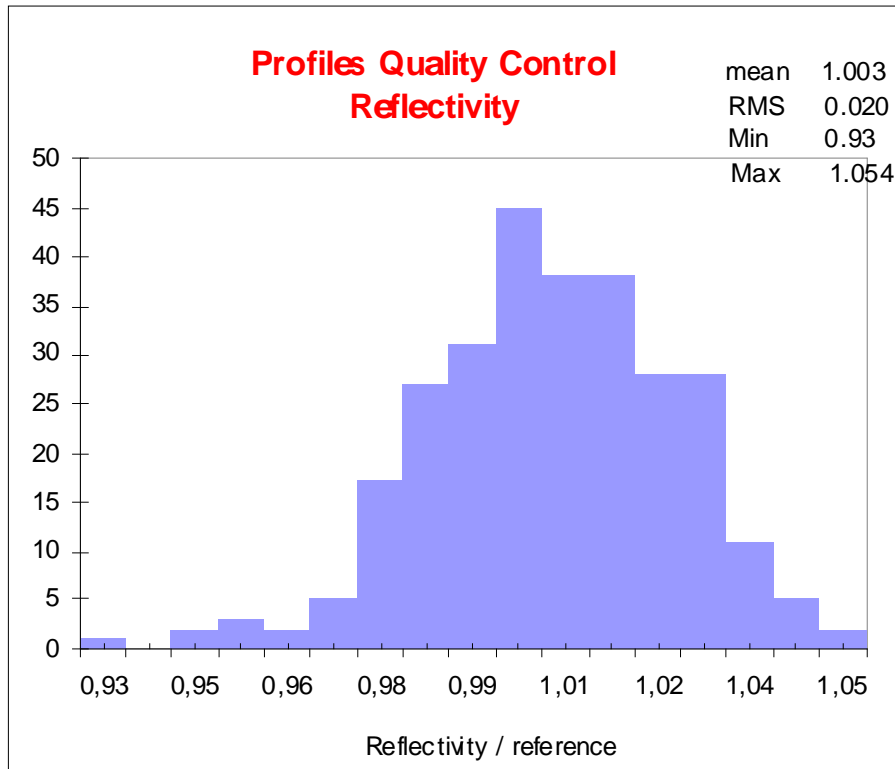
Summary of activities:

The activities related with the Tilecal calorimeter construction continued in 2002. Several activities of construction of optical components were finished. A total of about 5000 extra fibers were purchased to Kuraray in 2002 to complete the modules of the calorimeter. The preforms were received in Lisbon, controlled and accepted. The number of fibres that was aluminized was about 65000, more than 10% of the total production. The aluminium mirror quality was controlled and the fibres were delivered to LIP-Coimbra where they were inserted into profiles. The results of the relative light output of

the sets of fibres of each length for the whole production is shown in the next histogram. The acceptance limits were set at +/-10%.



After the mechanical and dimensional QC, the profiles are white painted and the respective holes are made by a drilling machine at the LIP workshop. The number of profiles that was painted and drilled in 2002 was about 35000, corresponding to 20% of the total production. The optical QC of the painted profiles has been done in the LOMAC laboratory at CFNUL in Lisbon, and the distribution of the relative reflectivity for a set of profiles is shown in the figure below. The production and quality control of plastic profiles is finished.



The production and quality control of distribution connectors and bundles of short clear fibres for the laser monitoring system was also finished in 2002.

A set of 250 photomultipliers produced by Hamamatsu for the Tilecal was controlled.

Simulation studies have been done to evaluate the possibility of tagging low p_T muons using the Tilecal. A new method was proposed, gaining robustness in the rejection of background. Studies to better determine the mass and width of the W using the Atlas detector started.

Modules of the Tilecal calorimeter equipped with the respective readout electronics were tested with beams of high energy particles at CERN. The data obtained is being analysed in order to establish better criteria for the calibration of the calorimeter and to get maps of the response of the modules.

During 2002, we started a participation in the Tilecal detector control system (DCS). Our participation involves the control of the cooling system, the setup of the distributed system and the coordination of the Tilecal DCS.

A viability study on a system to find persons inside the ATLAS area (FPIAA), in case of accident, or if someone is still inside when an experiment is about to begin was done. It included evaluation of hardware and software, and tests of sensors and fieldbus under magnetic field and irradiation. The irradiation tests took place at "Instituto Tecnológico Nuclear" in Sacavem. The sensors and fieldbus modules were irradiated with the doses and neutron fluxes expected in the areas of ATLAS where they will be located and the system still works without degradation. The system was submitted to a magnetic field at CERN and in Lisbon, for testing. The existence of some reed relays in the sensors lead to the need of changing these relays by solid state ones.

Academic Training:

PhD thesis

Maria J. Varanda, "Muon detection in ATLAS and its relevance on semi-leptonic decays", finishing

José Silva, "Monitorization and intercalibration of the Tilecal/ATLAS calorimeter, and PMT qualification", in progress

Master thesis

João Pina, "Ageing effects in the optics of the Tilecal calorimeter", in progress

João G. Saraiva, "Improving the calibration of the Tilecal calorimeter", in progress

Carlos Marques, "Simulation of performance of the Tilecal detector", in progress

Publications:

"Hadron energy reconstruction for the ATLAS Calorimetry in the framework of the non-parametrical method", S. Akhmadalev et al, Nucl. Inst. and Meth. A480 (2002) 508-523

"Correlation between the optical properties of injection moulded polystyrene scintillators and the material thermophysical properties", J. A. Martins et al, accepted for publication in Polymer (2002)

"Correlation between the optical properties of injection moulded polystyrene scintillators and the processing conditions", J. A. Martins et al, accepted for publication in Polymer (2002)

"Choice of the WLS fibres for the Tilecal/ATLAS Calorimeter", M. David et al, ATLAS Internal Note, ATL – COM– TILECAL-2002-004

"Acceptance QC of the Tilecal WLS fibres performed in Lisbon", M. David et al, ATLAS Internal Note, ATL – TILECAL – 2002-004

"Cell Geometry and fiber lengths of Barrel and Extended Barrel modules", A. Gomes et al, ATLAS Internal Note, ATL – COM– TILECAL-2002-015

"Measurement of the Top Quark mass with the ATLAS detector at LHC", M. David et al, ATLAS Internal Note, ATL–PHYS–2002–007

Conferences:

"MC simulation of the ATLAS hadronic calorimeter performance", M. J. Varanda for the ATLAS/Tile coll., to be published in Proceedings of the 10th International Conference on Calorimetry in High Energy Physics, Pasadena, USA, 25-29 March 2002

PROGRESS REPORT

Project Title: Robotization of optical fiber insertion in the Tilecal calorimeter – mass production

Team

Project Coordinator: Amélia Maio

PhD:

Amélia Maio	25%
José M. Sá da Costa	5%
Carlos B. Cardeira	5%
Agostinho Gomes	5%

Students:

Maria de Jesus Varanda	5%
Carlos Marques	5%

Technical Staff:

José Pinhão	5%
Rui Alves	40%
Joaquim Patriarca	5%
Jorge A. Moita	90%
Américo Pereira	20%
Miguel Braga	100%
Marisa A. Santos	100%

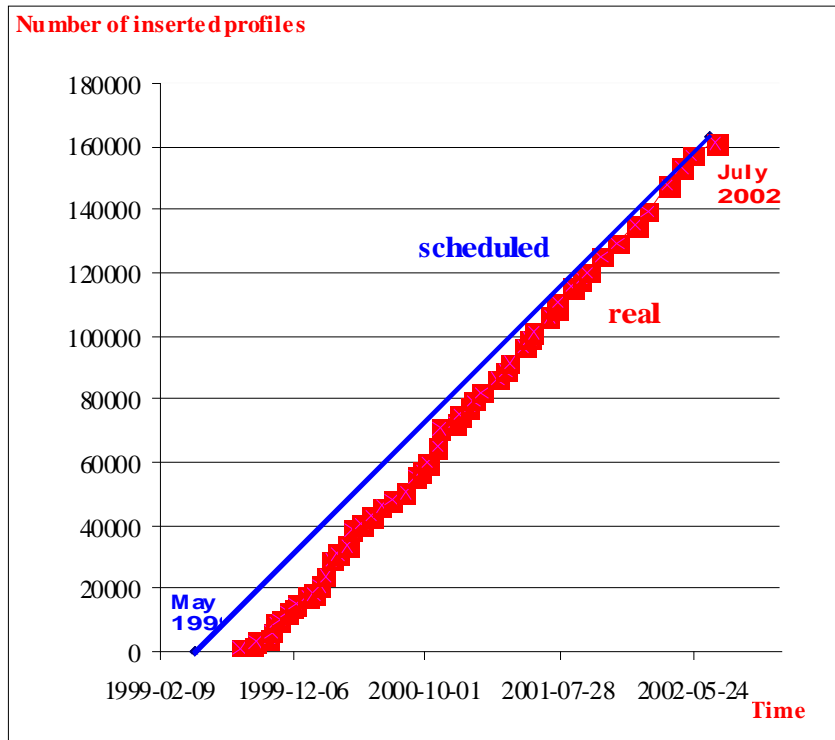
Summary of activities:

The main aim of this project was the mass production of the robotized insertion of the WLS fibres into the plastic profiles to instrument the Tilecal calorimeter, and the respective labelling, packing and distribution to the laboratories where the instrumentation took place. The portuguese group involved in these activities was responsible for all these tasks as well as for the quality control of the fibres inside the profiles. The group also participated in the instrumentation of the calorimeter barrel modules at CERN, and a first version of a 3D animation video describing the robot operations and its integration in the Atlas construction tasks was also produced.

The overall project of construction of the robotized system started in January 1996 and the robot construction was finished by May 1999. The overall work was divided in five main phases, namely design, construction, test and calibration, planning and mass production. Since July 1999 the project was in the phase of mass production.

The insertion of fibres into the profiles in 2002 was done at the scheduled rate, allowing to finish the production within less than 2 weeks of the revised date to finish the

production (30-06-2002), and only 2 months later than the original schedule defined 4 years before. This was quite remarkable, taking into account that the production started about 3 months after the scheduled date (1-05-1999), and there was a stop by mid September 1999 to transfer the machine from Lisbon (IDMEC/IST) to LIP-Coimbra. The evolution of the insertion of the fibres into the profiles is shown in the figure below.



The fibers were inserted into the profiles and the respective quality control was done. As an example, it is shown in the next figure the distribution of the minimum and maximum lengths of glue in the fibres per box of profiles.

The profiles with fibers were delivered to the instrumentation plants at CERN, Barcelona and United States (ANL and Michigan).

After the end of the regular production in July 2002, small productions of extra profiles were made in September and October to replace profiles damaged at the instrumentation plants. A table of the final production is shown below.

At this point we can state that we achieved the goals defined in 1995 (construction of the robot) and in 1999 (insertion of the fibres into the profiles using the robot), and that this project was a success. During 2002 it was also produced a 3D animation video of the robotized insertion of the fibres into the profiles. The video is almost finished and gives a nice report of this project.

Component	Total Quantity	Enterprise	Produced	Insertion Plant Destination

		<i>Name</i>	<i>Quantity</i>	<i>%</i>	
Table to cut the Profiles	2	SIRMAF	2	100	LIP-Coimbra
Plastic Profiles	187 000	IBEL - Cesar	187 000	100	LIP-Coimbra
Preparation of the Profiles	176 500	LIP-Coimbra	176 500	100	LIP-Coimbra
QC of the Profiles	1 765	LIP-Coimbra & LIP/CFNUL	1765	100	
Insertion of fibers into the Profiles (including damaged)	176 500 (profiles)	IDMEC-IST, Lisbon, until 09/1999, after moved to LIP - Coimbra	176 500	100	CERN, IFAE(SPAIN), ANL and MSU(USA)

PROGRESS REPORT

Project Title: Collaboration in the CMS experiment at CERN

Project Coordinator:

João Varela LIP/IST

PhD:

João Varela LIP/IST

Paula Bordalo LIP/IST

Sérgio Ramos LIP/IST

Reyes Alemany LIP

Marcelino Santos INESC/IST

Carlos Almeida INESC/IST

João Paulo Teixeira INESC/IST

J. Augusto INESC/IST

F.M. Gonçalves INESC

Isabel Teixeira INESC/IST

Students:

Nuno Almeida LIP

Nuno Cardoso LIP

Pedro Silva LIP

Jorge Semião INESC/IST

Octávio Dias INESC/IST

Technical Staff:

José Carlos Silva LIP

Jorge Gomes LIP

Miguel Ferreira LIP

1. Introduction

This project concerns the Portuguese participation in the CMS experiment. The LIP activity is centered on the development of hardware and software for the calorimeter trigger and for the readout system of the electromagnetic calorimeter. The project is carried on in collaboration with INESC-ID.

The calorimeter trigger system of the CMS/LHC experiment at CERN is a high performance electronics and computing system which processes on-line the detector data, about one hundred thousand calorimeter channels, to select electrons, photons, taus and missing energy events, as well as, samples of jet events. The trigger system performs the first selection step in the search for new physics reactions, in particular the search for the Higgs boson.

The Electromagnetic Calorimeter (ECAL) is an electron and photon detector composed by eighty thousand high purity PbWO₄ crystals. The extremely fine granularity and the excellent energy resolution makes this instrument very well suited for the measurement of electrons and photons at the LHC. The readout system is responsible for collecting data from 80000 channels.

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 integration scale required and the complexity of the on-line data selection and trigger algorithms is a real challenge for the electronics development. The dimension of the system requires the use of the most advanced quality control and testing techniques.

Due to cost limitations, a major re-design of the ECAL electronics took place in 2002 aiming at a substantial reduction of the number of optical links. This re-design does not affect our deliverables, but implies a new cycle of prototypes to adapt to the new functionality.

In this framework, we have pursued the development and prototyping work towards fulfillment of the Portuguese construction responsibilities in the CMS experiment. LIP was also involved in 2002 in the development of a 40 MHz, 12-bit ADC for CMS/ECAL sub-contracting a Portuguese company.

Finally, the responsibility of the CMS Trigger Technical Coordination continued to be assured.

Portuguese construction responsibilities in the CMS experiment:- Development and construction of the trigger synchronization circuits and the trigger high-speed links (construction of 850 ECAL Synchronization and Link Boards).- Development and construction of the ECAL Data Concentrator Card (construction of 60 DCC 9U VME boards).- Development and construction of the Calorimeter Trigger Readout and Control system.- Development of software for the ECAL readout modules.

In collaboration with Portuguese industry, Portugal is responsibly to deliver:

- Grease Pads for the magnet barrel wheels (concluded)
- Design of a high-performance 40 MHz 12-bit ADC (contracted)
- Muon Alignment Barrel carbon fiber structures (MABs) (in preparation)

This project is related to the following CMS sub-projects:

- Development of the ECAL Front-End boards, CERN and RAL
- Development of the ECAL off-detector electronics, LIP, Palaiseau, CERN, Saclay
- Development of the Calorimeter Regional Trigger, Wisconsin, USA
- Development of the Online Software framework, CERN
- Development of Physics Reconstruction and Selection software, CERN
- Pre-calibration of the Electromagnetic Calorimeter, CERN

Bibliographic references are available at: <http://cmsdoc.cern.ch/docnotes.shtml>

Sub-Project 1

Synchronization Circuit & Synchronization and Link Board

In the year 2002 we should have concluded a long term effort aiming at a circuit for synchronization of the calorimeter trigger primitive data. This circuit is the heart of a method developed and demonstrated by LIP to achieve 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). A prototype SLB was built and tested successfully.

The major re-design of the ECAL electronics decided in 2002 obliges to introduce a few modifications to the synchronization circuit. In the new ECAL electronics architecture, the SLB remains a well defined item, keeping the same functionality. However a new SLB implementation, with a more compact form factor, will be needed.

A new prototype was developed and the board layout is concluded. Six prototype boards will be produced produced in Q1 2003. Implementation of the revised version of BIST and final tests will be carried out in 2003.

Sub-Project 2

Data Concentrator Cards

The Data Concentrator Card is a 9U VME module responsible for collecting data from 68 sources, performing data selection and integrity checking, event formatting and transmission to the central Data Acquisition System. The final system will include 52 DCCs. A detailed document of specifications of the new DCC was produced.

Following the major redesign of the ECAL electronics system which occurred in 2002, the specifications and design of the DCC were reviewed. Relative to design developed by our group in 2001, the new module will receive 68 optical links (Gigabit links) from the detector front-end boards (instead of electrical input) and will include an additional input stage responsible for data reduction (zero suppression and selective readout). This board will be the major component of the ECAL data acquisition system.

The design of the new DCC card was concluded, following the parameters defined by the hardware simulation (task 4). In particular the internal bandwidth is kept at 528 Mbytes/s.

A prototype will be built with full performance and complete functionality. Prototype fabrication is scheduled in February 2003. The design will use large programmable FPGAs allowing small corrections to the functionality at a later stage. The software needed for the tests is developed in Task 3.

Sub-Project 3

Readout and Control Software

The development team of Readout and Control Software was re-built after the departure to industry of key members. Nevertheless, in 2002, our group succeeded to carry out important software developments, namely:

- Generic Device Configurator, used to the configuration of our hardware, and offered to the CMS collaboration as a generic tool (development concluded);
- Readout Crate Controller Package, to be used in the ECAL testbeam data acquisition system (partially implemented);
- Conclusion of the SLB test package;
- DCC Test Package, to be used in the tests of the DCC hardware (implemented).

This developments are done in the framework of the CMS Trigger Software Working Group, under our leadership.

Sub-Project 4

Modeling and Simulation

In order to guarantee that the entire functionality of the system under development, as well as the required performance, is taken into consideration at the specification phase, a model, at system level, of its constituting modules or units, 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.

This year (2002) we are adapting our simulation to the new design of the ECAL electronics.

Sub-Project 5

Physics Reconstruction and Selection

Due to lack of resources this year, our activity in this important area was reduced to a minimum. We have been using the CMS simulation and reconstruction tools to study the effect of ECAL selective readout on the data content, in connection with the activities in task 4.

Depending on the availability of new resources, we plan to extend this activity and to integrate more deeply the efforts of the CMS Physics, Reconstruction and Selection

(PRS) group. This activity should be done in collaboration with the Portuguese GRID project.

Sub-Project 6

Boundary Scan Test System

The development of boundary scan tools, that we have been consistently pursuing in the last years, was concluded. The set of hardware and software boundary scan tools produced in this sub-project will be extremely valuable for testing and diagnosing hundreds of electronics modules under our responsibility, in the production phase and latter when installed in the experiment.

In the past two years we have built a VME based boundary scan controller board, developed the software implementing the bi-directional link between the SVF format and the VME BS controller and installed the commercial BS software adopted by CERN. Special attention was paid to the application of boundary scan to in-situ re-programming of FPGAs. Two VME test boards, emulating real readout/trigger boards, were built and used to validate our boundary scan test system.

A formal final review of the Boundary Scan test system will be conducted, before the production of modules in 2003.

Sub-Project 7

Test Beam ECAL Monitoring

The LIP/CMS group is participating in the ECAL test beam pre-calibration program. A large experimental infrastructure, including readout electronics, data acquisition, trigger, cooling, test systems, etc. is being installed in the CERN North Area to allow the completion of this program. The size of this experimental setup is typical of any fixed target experiment. Many experimental aspects related to the physics behavior of the CMS electromagnetic calorimeter will be studied in this environment. Our group is mainly involved in the development of the JAVA-based monitoring system of the ECAL test beam setup. In 2002 the software was adapted to the new requirements set by the test of a new ECAL module in testbeam.

Sub-project 8

CMS Trigger Technical Coordination

The CMS Trigger Control System designates the set of interfaces, protocols and dedicated central control hardware and software modules, which aims the integration in a coherent system of the various trigger components and subdetector readout systems in the overall CMS experiment.

This integration activity is coordinated by the CMS Trigger Technical Coordinator in the framework of working groups with representatives of the various sub-detectors. A final specification of the CMS Trigger Control System was achieved in 2002. Design of key

components in the central system, undertaken by several CMS groups, was started in 2002 under the direction of the CMS Trigger Technical Coordinator.

Sub-project 9

ADC 40 MHz 12-bit for CMS/ECAL

In the framework of the major re-design of the ECAL electronics system under way, the ECAL community has decided to sub-contract the design of IP block with a 40 MHz 12-bit ADC in 0.25 micron radhard technology. This IP block is intended to integrate an analog-digital ASIC with 4 ADCs and a dynamic digital range selector. This component will match a new 4-fold preamplifier with different gains under development at RAL, replacing the present FPPA (Floating-Point PreAmplifier) which is facing serious problems of bandwidth and noise.

LIP is participating in this new program contracting the design work to the Portuguese company Chipidea. The contract between LIP and Chipidea was established in September 2002. LIP and CERN will follow the design work. The production of the test samples as well as the final production will be organized by CERN, under a special agreement to be established between LIP and CERN.

Publications, Conferences and Technical Documents:

ECAL Data Volume and Selective Readout, N. Almeida, J. Varela, CMS IN 2002-009

CMS LI Trigger Control System, J. Varela and CMS Trigger/DAQ group, CMS NOTE 2002-033.

Data Concentrator Card, Specification V1.1, LIP-CMS Group, CMS/ECAL Technical Document.

(http://cmsdoc.cern.ch/~jlfaure/OD_Web_Folder/Page_web.html)

DCC Tester Boards, Preliminary Specifications, V0.2, N. Cardoso, CMS/ECAL Technical Document. (http://cmsdoc.cern.ch/~jlfaure/OD_Web_Folder/Page_web.html)

PROGRESS REPORT

Project Title: Cosmic Rays Telescope - Ciência Viva

Team

Project Coordinator: João Varela LIP/IST

PhD:

Fernando Barão LIP/IST

Technical Staff:

Miguel Ferreira LIP

José Carlos da Silva LIP

José Carlos Nogueira LIP

Summary:

The objective of the project is the construction, installation and operation of a cosmic rays detector network, interconnected by the internet, covering a number of secondary schools. The detector network allows the measurement of the characteristics of high-energy particles impinging our planet, looking for correlations between data collected by the network stations.

Project Goals:

- To reinforce experimental physics teaching in secondary schools, using relatively simple research equipment;
- To introduce front-line research topics in particle physics, astrophysics and cosmology to secondary school students, based on an experimental approach;
- To promote a practice of collaboration between researchers and secondary school professors;
- To give secondary school students an opportunity of participation in a scientific project.

Scientific Motivation:

The observation and measurement of high energy particles impinging the Earth is a recent research topic, which has motivations both from cosmology and particle physics. The origin of very high energy cosmic rays ($>10^{18}$ eV) is unknown and mysterious. Gigantic cosmologic events, like collisions of galaxies, relics of ultra-heavy particles created in the first moments of the Universe expansion or large scale topologic structures in the universe have been proposed to explain its origin. However, none of these models fully account for the observations.

Several large scale scientific projects (Auger, Euso) are now in construction or in preparation to study the phenomenon in more detail. Our project fits in this context,

mimicking in a smaller scale these large research enterprises. Very high energy cosmic rays can be detected by the Cosmic Ray Telescope providing an opportunity for confrontation of results.

Participating Institutes:

Escola Secundária D. Pedro V

Escola Secundária Gomes Ferreira (Benfica)

Escola Secundária Gil Vicente

Escola Secundária Maria Amália Vaz de Carvalho

Escola Secundária da Amadora

Escola Secundária Herculano de Carvalho

Escola Secundária Paço de Arcos

Escola Secundária Mem Martins

Escola Secundária Diogo de Gouveia (Beja)

Escola D.Manuel I (Beja)

IST- Instituto Superior Técnico

LIP- Laboratório de Instrumentação e Física Experimental de Partículas

PROGRESS REPORT

Project Title: Collaboration in the DELPHI experiment at CERN

Team

Project Coordinator: Mário Pimenta

PhD:

Mário Pimenta,	50%
Amélia Maio,	10%
Luís Peralta,	40%
António Onofre,	35%
Pedro Abreu,	60%
Fernando Barão,	10%
Maria Catarina Espírito Santo,	40%
Bernardo Tomé,	90%

Students:

Patrícia Gonçalves,	40%
Sofia Andringa,	100%
Nuno Anjos,	100%
Sandra Moreno,	100%
Nuno Castro,	100%
Filipe Veloso,	100%

Technical Staff:

Summary of activities:

Analysis of DELPHI data

The group DELPHI of LIP has proceeded along the lines defined in the previous plan of activities which, after the end of operation of the LEP machine, consist mainly in the extraction of the best results possible from the DELPHI data. The activities can be divided in two subgroups: Searches for New Physics and Hadronic Physics. In both subgroups, the participation of the LIP-DELPHI team has taken place in the DELPHI physics analysis concerned, as well as in the coordination of the corresponding physics teams and physics research lines. Members of the portuguese team are also representatives of the DELPHI Collaboration in the LEP Working Groups.

There are 8 final papers in different stages of preparation, under our responsibility or with important contributions from the LIP-DELPHI team, to be published along the years 2003/2004.

In 2002 LIP members wrote also many communications for international conferences with proceedings, and presented the DELPHI or LEP results in International Conferences, as listed below. During this period, one PhD thesis was concluded and

defended with great success, by Patrícia Gonçalves, in the Physics Department of Instituto Superior Técnico / Universidade Técnica de Lisboa.

Searches for New Physics (*contact person: Mário Pimenta*)

- A Topology-based analysis of the collected data
- Search for non-fermionic neutral Higgs couplings
- Search for composite and exotic fermions
- Search for $\gamma\gamma(\gamma)$ events
- Search for Leptoquarks
- Search for Flavour Changing Neutral Currents
- Search for 4th Generation b'-quark
- Search for Contact Interactions
- Search for anomalous Quartic Gauge Couplings

Hadronic Physics (*contact person: Pedro Abreu*)

- Average multiplicities, dispersions and inclusive distributions
- Differences in the multiplicities in b-quark events to light-quark events, or the Dead Cone effect in QCD
- Interconnection effects in WW events

Academic Training:

Thesis concluded in 2001/2002

- Study of $\gamma\gamma(\gamma)$ events at LEP II – PhD thesis – Patrícia Gonçalves

Thesis in progress

Title	type	Student	Conclusion foreseen
Exotic Higgs and Anomalous Couplings	PhD	Sofia Andringa	2003
Hadronic Final States at LEP-II	PhD	Nuno Anjos	2003/04
Search for 4th Generation b' quarks	Master	Nuno Castro	2003
Search for top quarks with F.C.N.C.	Master	Filipe Veloso	2003

Publications: (LIP authors are underlined)

Reports

- DELPHI note 2002-003 PHYS 915, 9 January 2002
P. Abreu, N. Anjos, N. Neufeld

- Charged and identified particle distributions in the hadronic decay of the W Boson and in $e^+e^- \rightarrow q\bar{q}$ at 183 and 189 GeV*
- DELPHI note 2002-027 CONF 561, 5 July 2002
J. Abdallah, ..., M. Espírito Santo, ..., A. Washbrook
Searches for supersymmetric particles in e^+e^- collisions up to 208 GeV, and interpretation of the results within the MSSM
 - DELPHI note 2002-047 CONF 581, 11 July 2002
P. Abreu, N. Anjos
Update on the investigation of Colour Reconnection in WW Pairs using Particle Flow
 - DELPHI note 2002-051 CONF 585, 11 June 2002
P. Abreu, N. Anjos
Charged Particle Multiplicity in e^+e^- Annihilations into qq at $\sqrt{s}=206$ GeV
 - DELPHI note 2002-052 CONF 586, 30 June 2002
P. Abreu, A. De Angelis
Hadronization properties of b quarks compared to light quarks in e^+e^- Annihilations into qq at $\sqrt{s}=206$ GeV
 - DELPHI note 2002-059 CONF 593, 6 June 2002
S. Andringa, P. Gonçalves, D. Jeans, U. Mueller, A. Onofre, M. Pimenta, B. Tomé
Measurement of the $WW\gamma$ Cross-section and Limits on Anomalous Quartic Gauge Couplings with DELPHI
 - DELPHI note 2002-063 CONF 597, 10 July 2002
S. Andringa, N. Castro, M. Espírito Santo, P. Gonçalves, O. Oliveira, A. Onofre, M. Pimenta, B. Tomé, F. Veloso
Search for a fourth generation b' -quark at LEP-II at $\sqrt{s} = 200-209$ GeV
 - DELPHI note 2002-064 CONF 598, 11 July 2002
V. Obraztsov, S. Slabospitsky, O. Yushchenko, S. Andringa, P. Gonçalves, A. Onofre, M. Pimenta, B. Tomé
Search for Single Top Production at LEP via F.C.N.C. at $\sqrt{s} = 189-208$ GeV
 - DELPHI note 2002-086 PHYS 921, 8 June 2002
S. Andringa, P. Gonçalves, A. Onofre, L. Peralta, M. Pimenta, B. Tomé
Search for a fermiophobic Higgs at LEP2 (update)
 - DELPHI note 2002-087 CONF 620, 12 July 2002
The LEP Collaborations (... , P. Gonçalves, ...)
Searches for Higgs Bosons Decaying into Photons: Combined results from the LEP experiments
 - DELPHI note 2002-089 CONF 622, 16 July 2002
The LEP Collaborations and the LEP-II Diphoton Working Group (... , P. Gonçalves, ...)
Combination of LEP-II results for the reaction $e^+e^- \rightarrow \gamma\gamma(\gamma)$ and interpretations
 - DELPHI note 2002-090 CONF 623, 17 July 2002
The LEP Collaborations and the LEP W Working Group (P. Abreu, N. Anjos, ...)
Combined Preliminary Results on Colour Reconnection using the Particle Flow in $e^+e^- \rightarrow WW$
 - DELPHI note 2002-095 PHYS 925, 26 November 2002
The LEP Collaborations and the LEP WW Working Group (S. Andringa, ...)

LEP Four-Fermion Cross Section Results for the Summer 2002 Conferences

Conferences:

- Lake Louise Winter Institute, February 2002, Lake Louise, Alberta, Canada
Patrícia Gonçalves,
Measurements with photons at LEP
- DPF'2002, May 2002, Williamsburg, Va., USA
Nuno Anjos
Colour Reconnection at LEP 2
- QCD'02, July 2002, Montpellier, France
Pedro Abreu,
Colour Reconnection in DELPHI at LEP
- LEP Jamboree, July 2002, CERN, Geneva, Switzerland
Maria Catarina Espírito Santo
DELPHI Results at the LEP Jamboree
- Lake Louise Winter Institute, February 2003, Lake Louise, Alberta, Canada
Nuno Castro,
Search for a 4th Generation b'-quark at LEP

PROGRESS REPORT

Project Title: Collaboration in the EUSO experiment

Team

Project Coordinator: Mário Pimenta

PhD:

Mário Pimenta,	35%
Maria Catarina Espírito Santo,	60%
Pedro Abreu,	30%
António Onofre,	10%
Bernardo Tomé,	10%
Luís Melo,	10%
Pedro Brogueira,	10%
Jorge Gomes,	10%

Students:

Pedro Assis,	100%
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Technical Staff:

Summary of activities:

EUSO, the Extreme Universe Space Observatory, is a mission devoted to the exploration from space of the highest energy processes present and accessible in the Universe. Using the atmosphere as a *calorimeter* for particles with energies in excess of 5×10^{19} eV, the EUSO instrument will detect Extreme Energy Cosmic Rays (EECR) and neutrinos, indicative of unknown particle production and acceleration mechanisms in the Universe. When a high energy cosmic ray enters the Earth atmosphere, it induces a shower of billions of relativistic particles (Extended Air Showers or EAS), which interact with the atmosphere to produce UV fluorescence light, as well as a *Cherenkov* signal that is diffused in the Earth surface or in the top of clouds. EUSO will look downwards to the Earth atmosphere, detecting the faint ultraviolet traces and the *Cherenkov* signal produced by these EAS. The main detector consists of a pair of Fresnel lens, 2.5 m in diameter with a pupil diameter of 2 m, and a full angle coverage of 60°, that focuses the light on a focal surface containing multipixel photomultipliers, for a total of about 300 000 pixels.

EUSO was approved by the European Space Agency (ESA) for phase A accommodation study in the International Space Station (ISS). The phase A study started in March 2002 and will end in September 2003.

During phase A, LIP is responsible for the coordination of the EUSO Science and Operations Data Centre subsystem (SODC), and also participates in a program of experimental support activities, performing various studies of critical parameters for EUSO, namely the BABY experiment and the ULTRA project.

SODC – Science Operations and Data Centre

LIP is, at present, responsible for the coordination of the EUSO Science Operations and Data Centre (SODC). The SODC constitutes the EUSO scientific Ground Segment. It ensures the scientific mission control and planning and addresses the issues of data collection, monitoring, distribution and archiving.

The SODC life cycle will accompany the mission life cycle and can be generically divided into the following phases: definition, design, implementation, validation, commissioning, in-flight operations and post-operation. The SODC should in all phases provide adequate support to the user community. During the mission definition phase, the constraints, concepts and requirements should be defined and the feasibility should be assessed. The preliminary design, detailed design to the element level and implementation should follow. The validation phase includes the technical verification and validation of each SODC element and the operational validation of the full system (including training of the people and data validation). The commissioning of the SODC, corresponding to the installation and first orbits of EUSO on board of the ISS, will precede the routine operations phase, when the scientific data will be acquired. During the operations execution phase, the SODC will receive telemetry data (from the mission operation centre), generate EUSO specific commands, monitor the instrument health, functional status, performance and trend, and notify any relevant scientific/monitoring events. The SODC will also be responsible for the scientific operations planning, software maintenance and calibration of the EUSO instrument. Furthermore, it will establish the EUSO archive and provide the mission products to the users (data, analysis tools, documentation).

The main topics for the EUSO SODC phase-A study are:

1. identification of the Columbus/ISS operation context;
2. preliminary evaluation of data volumes;
3. identification of the operation modes and procedures;
4. conceptual design of the ground data handling facilities;
5. archive and database preliminary planning;
6. preliminary evaluation of costs and manpower.

The studies corresponding to these topics have been addressed and three reports have been produced. The first report, “*The EUSO Scientific Operations and Data Centre EUSO-SODC Subsystem*”, defines the SODC subsystem and discusses the objectives of its phase A study; the second report, “*Preliminary evaluation of the EUSO telemetry and operational requirements*”, addresses the EUSO needs in terms of telemetry resources and telecommand procedures, describes the basic system, and discusses ground mission planning, instrument control, and data handling; the third report, “*EUSO operations: flight and ground*”, describes the EUSO operations concept, covering both the flight and the ground segments, with an overview of the end-to-end communication scheme, the general scenario and space/ground interplay.

ULTRA – Ultraviolet Light Transmission and Reflection in the Atmosphere

The ULTRA experiment has been designed to provide quantitative measurements of the reflection/diffusion signal produced by an Extended Air Shower (EAS) impacting on the

Earth surface, overcoming the lack of information in this specific field. A scintillator array and UV light detectors will operate simultaneously to detect EAS in coincidence with the UV light reflected/diffused from its impact on Earth. The atmospheric transmission properties will also be studied using the UV light detectors and a laser emitter. Moreover, measurements of light from meteors are feasible with the same instrumentation.

The LIP team is responsible for the synchronization and for the data acquisition systems of the experiment. A prototype PCI-based board to time-tag the arrival of the EAS on the cells of the array, was produced, using GPS receivers. In the board it was also implemented a basic Data Acquisition system, which has successfully acquired and pre-processed the collected data, in an engineering run that took place in the Autumn of 2002, in Mont-Cenis in the French Alps.

BABY – Balloon experiment for background experiments

BABY was set up by members of I.A.S.F./Palermo as a calibration experiment to measure the background light in the UV band emitted by the Earth and structures in the Earth surface. It consists of a simple detector installed in a balloon, that collects data while the balloon is flying. In 2001, LIP members have joined this small collaboration, and in 2002 have assisted in the launch of a second balloon, with eight photomultipliers and different wavelength filters installed, which flown successfully over the Mediterranean Sea. The data of the first run was analysed, with collaboration of LIP members, and its results were presented and discussed in the group.

Academic Training:

“Sincronização de detectores de Raios Cósmicos através de GPS” – Graduation thesis – Pedro Assis, October 2002.

Publications:

(members of LIP are underlined)

Reports

- EUSO-SODC/SP-001/1.C
M. C. Espírito Santo, J. Gomes, M. Pimenta
The EUSO Scientific Operations and Data Centre EUSO-SODC Subsystem
- EUSO-SODC/SP-002/Draft in preparation
M. C. Espírito Santo, M. Pimenta
Preliminary evaluation of the EUSO telemetry and operational requirements
- EUSO-SODC/SP-003/1
M. C. Espírito Santo, M. Pimenta
EUSO Operations: flight and ground
- EUSO-Scientific Support Activities
O. Catalano, P. Vallania, D. Lebrun, P. Stassi, M. C. Espírito Santo, M. Pimenta
ULTRA Technical Report
- EUSO-IDD-001-3

O. Catalano *et al.*

EUSO-IDD: Instrument Definition Document (Phase A study)

Conferences:

- IVth New Worlds in Astroparticle Physics, September 2002, Faro, Portugal
M. C. Espírito Santo,
EUSO – Basic Parameters
- IVth New Worlds in Astroparticle Physics, September 2002, Faro, Portugal
P. Assis,
GPS Synchronization in Cosmic Ray Experiments

PROGRESS REPORT

Project Title: Processing and transmission technologies for LHC experiments (LHC Computing Grid)

Team

Project Coordinator: Jorge Gomes

PhD: Mario David, Luis Bernardo

Students:

Technical Staff: João Martins, José Aparicio

Summary of activities:

The LIP Computer Centre team is involved in three International Grid projects, CrossGrid, DataGrid and LHC Computing Grid (LCG).

LCG is the CERN long term Grid initiative for LHC. LCG is centred in providing a global production-quality computing infrastructure for the LHC experiments. The main goal of LCG is to coordinate the deployment of such infrastructures and services. It is also the contact point for the experiments and acts as an umbrella for other grid development projects. LIP is involved in LCG through its participation in the “grid deployment board” and “LCG resources review board”. The activities of LCG have been followed closely.

LCG relies on other grid development and deployment projects to provide the actual resources. In Europe the most relevant projects for LCG are the EU funded DataGrid and CrossGrid.

LIP is a non-funded member of DataGrid has contributed to the project in the following areas:

- **Grid deployment:**
 - LIP has maintained a grid “site” integrated into the DataGrid testbed.
 - CA authentication and coordination:
 - LIP is an active member of the Certification Authorities task force.
 - LIP has participated in the evaluation and acceptance process of new CAs.
 - LIP has participated in the review of the minimum CA requirements.
- **Monitoring:**
 - Collaboration was established on the improvement and customization of the Mapcenter monitoring tool.
- **Test and validation:**
 - LIP has established collaboration with the DataGrid test group.
 - Several middleware evaluations were performed including: LCFGng, EDG WMS, gsi file transfer, replica catalogue and replica manager.

The main efforts of LIP have been centered on the participation in the CrossGrid project where LIP is a funded member and has assumed responsibilities in the “International Testbed Organization”. LIP is involved in the testbed deployment coordination, user and system administration support, integration with DataGrid and has assumed the coordination of the project task 4.4 “Testbed quality assurance”.

The LIP contributions to CrossGrid were the following:

Task 4.1 Testbed set-up and incremental evolution

- Deployment of the CrossGrid central services:
 - Deployment of the CrossGrid production testbed central services. All production central services are hosted at LIP.
 - Deployment of the CrossGrid validation testbed central services at LIP. All production services are hosted at LIP.
- Participation in the Certification Authorities (CAs) work group:
 - Review of the Certification Policies (CP/CPS) of the new CrossGrid CAs.
 - Participation in the specification of the requirements for the CrossGrid CAs.
 - Participation in the coordination of the CAs.
- Participation in the testbed coordination activities.
 - LIP participated actively in the site deployment coordination effort.
- Integration team activities.
 - LIP is a member of the CrossGrid software integration team.
 - LIP worked in the integration of network tools and applications.
- Elaboration of the minimum hardware requirements for the CrossGrid testbed sites.
- Elaboration of two documents about the experience with the testbed deployment and usage.
- Deployment of a CrossGrid testbed site in Lisbon. The site is being used in the context of the Production and Test and Validation testbeds.
 - Deployment and maintenance of the LIP grid systems and services.
 - Development of web pages with information about the site configuration and status.
- Improvement of the LIP certification authority (CA) infrastructure.
 - Improvement of the LIP CA/RA web site.
 - Improvement of tools for the management of the CA/RA.
 - Improvement of the CA CPS and operation rules.

Task 4.2 Integration with DataGrid

- Participation in the DataGrid CAs task force.
- Participation in the DataGrid WP6 (Testbed) and WP7 (Network) meetings.
- Participation in the DataGrid workshops and conferences.
- Participation in DataGrid/CrossGrid coordination meetings.
- Participation in the DataGrid test team activities.
- Participation in DataGrid integration team meetings.
- Follow DataGrid WP6 and WP7 developments.
- Provide solutions for to the integration of CrossGrid sites into the DataGrid testbed.

Task 4.3 Infrastructure Support

- Participation in the CrossGrid QoS work group.
- Participation in activities related with the test and deployment of the helpdesk service.
- Work on the development of a CrossGrid infrastructure monitoring system.
- Provide support to system administrators and users in the context of the CrossGrid helpdesk service.
- Development of a support page on the usage of the CrossGrid central services.

Task 4.4 Verification and Quality Control

- Elaboration of a document establishing the CrossGrid middleware test procedure.
 - Elaboration of a draft document on the monitoring requirements for the test and validation activities.
 - Elaboration of a document on the “Test and Validation testbed architecture”.
 - Elaboration of two internal notes on the development of test software.
 - Development of middleware test programs.
 - Development of testbed usage statistics.
 - Participation in middleware test activities in coordination with the DataGrid
 - Test of the CrossGrid initial, production and validation testbeds.
 - Test the usage of MPI parallel applications across the testbed.
 - Deployment and coordination of the CrossGrid Test and Validation testbed.
- Other activities:
- Team members have been participating actively in the CrossGrid internal review board activities.
 - LIP is member of the recently created CrossGrid security work group.
 - A draft document about the testbed security procedures was been written.

The site grid site in Lisbon:

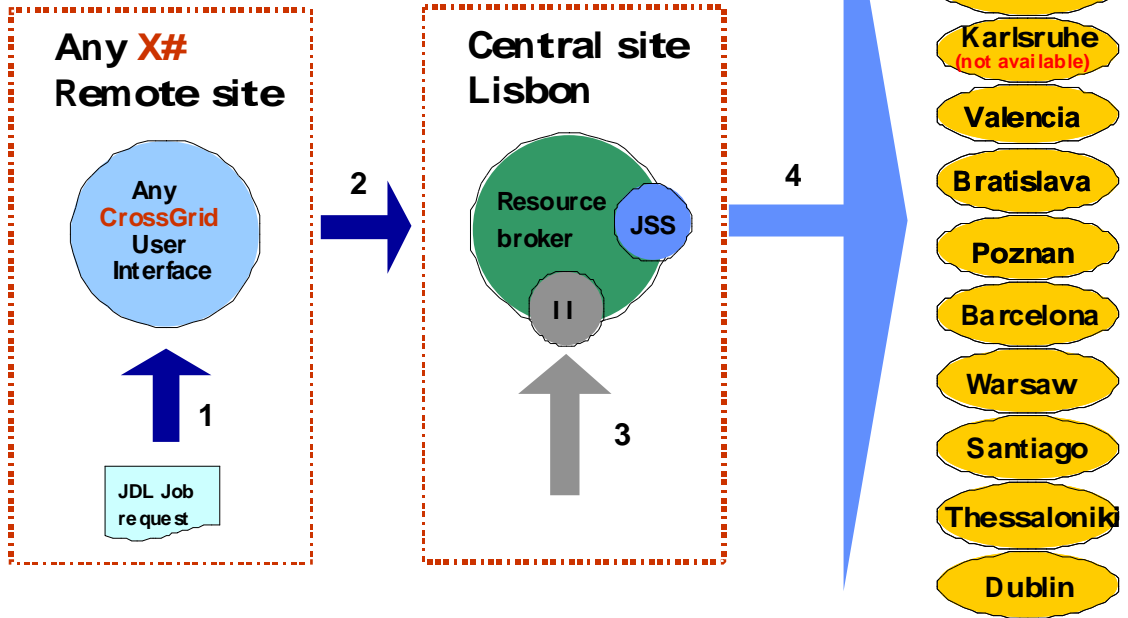
The LIP testbed site infrastructure is being maintained as a shared facility used by all Grid activities in the Laboratory.

The LIP testbed site is also the main site for the CrossGrid “Test and Validation” testbed. The main site provides computing resources, scheduling services, replica file location services, root MDS services and central services required for authentication and authorization such as the virtual organization server and the credentials proxy server.

LIP was appointed as the central services host for the initial testbed supporting all CrossGrid sites across Europe. **Due to the success obtained in the deployment and maintenance of these services LIP has now the full responsibility over the central services for both CrossGrid production and validation testbeds.**

The next diagram shows the central CrossGrid production Resource Broker at LIP:

1. Job requests are submitted from remote UIs
2. Jobs are sent to the RB located in LISB
3. The RB uses site information in the matchmaking
3. The RB submits the job to a CE using GRAM



Academic Training:**Publications:**

First Prototype of the CrossGrid Testbed; J. Gomes et al. (draft to be published).

CrossGrid D4.1: Middleware Test Procedure; Jorge Gomes

<http://www.eu-crossgrid.org/Deliverables/M3pdf/CG-4-D4.1-004-TEST.pdf>

CrossGrid D4.2: Test and Validation Testbed Architecture; Jorge Gomes, Mario David

<http://www.eu-crossgrid.org/Deliverables/M6pdf/CG4.4-D4.2-v1.1-LIP011>

[ValidationOfTestbedArchitecture.pdf](#)

CrossGrid D4.3: Experience with the CrossGrid Initial Testbed; Jorge Gomes, Mario David (INTERNAL)

CrossGrid D4.4: Testbed Extension and Site Status; Jorge Gomes (DRAFT)

Conferences:

First Prototype of the CrossGrid Testbed; Jorge Gomes; AcrossGrids Conference, Santiago Compostela 13-14 February 2003

CrossGrid Testbed Status; Jorge Gomes; 1st CrossGrid Workshop, Linz September 2002

CrossGrid Testbed Status; Mario David, Jorge Gomes; DataGrid Workshop; CERN October 2002

CrossGrid Testbed Status; Jorge Gomes; 2nd CrossGrid Workshop; Santiago Compostela, February 2003

PROGRESS REPORT

Project Title: Monte Carlo techniques and detector development applied to medical physics

Team

Project Coordinator: Luis Peralta

PhD:

Luis Peralta	40%
Maria do Carmo Lopes ¹	50%
Maria Conceição Abreu	25%
Pedro Rato	20%

Students:

Adérito Chaves ¹	70%
Carla Alves Oliveira ¹	70%
Andreia Trindade	100%
Pedro Rodrigues	100%
Catarina Ortigão	100%
Patrick Sousa	50%

¹ CROC-IPOFG

Summary of activities:

The project aims are the development of Monte Carlo simulation programs in the computation of radiation transport problems applied to medicine, and the development of solid-state detectors for digital gamma ray imaging in nuclear medicine.

Several projects goals have already been obtained in what concerns the Monte Carlo simulation of physics applications to medicine. Photon and electron phase space have been computed for several clinical energies and fields for the Siemens KD2 linear accelerator, existing at the Coimbra hospital. A treatment planning verification system based in GEANT4 is operational for photons. Thin photons beams for radiosurgery have been simulated. The dose computation engine for radiosurgery is underway. A fast simulation engine to obtain electrons phase space has been developed. This simulation coupled with a dedicated fast simulation (DPM [1]) for dose calculation in the phantom, proved to be a better alternative to commercial Treatment Planning Systems (TPS). Collaboration with the GEANT4 group is underway aiming the development of one of the physics modules of the code. The covered subjects in this project part are:

1. Application of GEANT4 radiation transport toolkit to dose calculations on homogeneous and anthropomorphic phantoms
2. Fast Electron Beam Phase Space-Data Generation

3. A fast electron simulation based on DPM
4. Basic dosimetry of radiosurgery narrow beams using Monte Carlo simulations – a detailed study of depth of dose maximum
5. Electron beam adjustment in PLATO RTS 2 including the effect of air gaps

Together with MC simulations, this project develops and builds a prototype hybrid gamma-ray detector for use in medical diagnosis, profiting from the know-how in detector technology acquired by the members of the research team and the opportunity given by the ISPA Collaboration at CERN. During this year experimental tests of the prototype were done at CERN, and the detector simulation was developed. This simulation is now being used to optimise the detector final layout. The electronic acquisition charts development is underway. The covered subjects in this project part are:

1. Test, characterization and simulation of radiation sensors (ISPA tubes)
2. Design of electronics cards for detector front-end and data readout
3. Development of software for control and presentation

Academic Training:

On going Thesis

Catarina Ortigão, Master thesis – Conclusion in 2003

Adérito Chaves, PhD thesis - Conclusion foreseen in 2003

Carla Alves, PhD thesis - Conclusion foreseen in 2005

Patrick Sousa, PhD thesis – Conclusion foreseen 2005

Pedro Rodrigues, PhD thesis – Conclusion foreseen 2006

Andreia Trindade, PhD thesis – Conclusion foreseen 2006

Concluded Thesis

Pedro Rodrigues, Master Thesis, “Verificação de Cálculo de Dose em Radioterapia Externa por Simulação Monte Carlo”, University of Lisbon, May 2002

Andreia Trindade, Master Thesis, “Optimização do Cálculo de Dose por Simulação Monte Carlo em Radioterapia Externa com Feixes de Electrões”, University of Lisbon, May 2002.

Publications:

Gamma Spectroscopy and Optoelectronic Imaging with Hybrid Photon Detector, C. D’Ambrosio, M. Abreu, V. Cencelli, F. Cindolo, F. De Notaristefani, H. Leutz, J. Mares, M. Nikl, D. Piedigrossi, D. Puertolas, P. Rato Mendes, E. Rosso, P. Sousa, accepted for publication in Nucl. Instr. Meth. in Phys. Res. A

Treatment planning verification by means of a monte carlo dose calculation engine, P. Rodrigues, C. Alves, A.Chaves, M.C. Lopes, C. Oliveira, L. Peralta, A. Trindade, Proceedings of the 6th Biennial ESTRO Meeting on Physics for Clinical Rad. & Onc. 2001; 61 (Suppl. 1) S27.

Influence of air gaps on electron dose calculations, A.Trindade, C.Alves, A.Chaves, M.C.Lopes, C.Oliveira, L.Peralta, P.Rodrigues, Proceedings of the 6th Biennial ESTRO Meeting on Physics for Clinical Radiotherapy. Rad. & Onc. 2001; 61 (Suppl. 1) S39.

Design and simulation of irregular frames for electron radiotherapy treatment, J. Ambrósio, A. Trindade, C. Alves, A. Chaves, M. C. Lopes, C. Oliveira, L. Peralta, P. Rodrigues, 6th Biennial ESTRO Meeting on Physics for Clinical and Radiotherapy, Rad. & Onc. 2001; 61 (Suppl. 1) S102

Conferences:

Basic dosimetry of radiosurgery narrow beams using monte carlo simulations – a detailed study of depth of dose maximum, A. Chaves, M.C.Lopes and C. Oliveira, Accepted Poster communication to the International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry, 25-28 November 2002 Vienna- Austria.

Um sistema de cálculo de dose com base em GEANT4, Luis Peralta, Oral presentation to the National Physics Conference, Física2002, Évora 6-10 Sep. 2002

Uma Câmara Gama De Alta Resolução Para Medicina Nuclear, M. Conceição Abreu, Oral presentation to the National Physics Conference, Física2002, Évora 6-10 Sep. 2002

A compact, high resolution camera for nuclear medicine, P. Sousa, M. C. Abreu, C. D'Ambrosio, F. Cindolo, C. Ortigão, L. Peralta, P. Rato Mendes, E. Rosso, poster presentation to the 12th General Conference of the European Physical Society, EPS12: Trends in Physics, 26 - 30 August 2002, Budapest (Hungary)

Detectores de semiconductor para imagiologia, P. Rato Mendes, M. C. Abreu, S. Rodrigues, P. Sousa, oral presentation to the IV Radiology Workshop – IV Jornadas de Radiologia, 7-9 June 2002, Faro (Portugal)

Internal Notes

Electron beam adjustment in PLATO RTS 2 including the effect of air gaps, LIP/02-03

PROGRESS REPORT

Project Title: Collaboration in the NA50 experiment

Team

Project Coordinator: Paula Bordalo

PhD: Paula Bordalo	LIP Researcher / IST Professor	75%
Sérgio Ramos	LIP Researcher / IST Professor	75%
Pedro Rato	LIP Researcher	17%
Ruben Shahoyan	LIP Researcher	17%

Students:

Catarina Quintans	PhD Student	100%
Teresa Claudino	PhD Student	100%
Helena Santos	PhD Student	100%
Gonçalo Borges	PhD Student	100%
João Cruz	LIP Research Assistant	25%

Technical Staff:

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 Ultrarelativistic 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 reported.

Here, we just concentrate on the tasks of our responsibility concerning the year 2002:

- Participation in the Collaboration and Steering Committee meetings
- Participation in specific technical analysis meetings
- Contribution to lead and proton induced data analyses:

- Comparative study of Ψ and Ψ' production and of the ratio Ψ'/Ψ , in p-A, using different targets, and S-U interactions (in order to establish the Ψ baseline production)
- Study of charmonia suppression in lead-lead collisions
- Study of the dimuon continuum production, namely its Drell-Yan and charm components, in lead-lead collisions
- Study of ϕ production compared with $\rho+\omega$ in lead-lead interactions, as a function of centrality and of p_T .

A main task force was organized in order to obtain new results for the 2002 Quark Matter Conference (the most important one in our field). All LIP members participated in this huge effort, which was twofold: to elaborate new analysis methods and to reanalyse data concerning previous periods in order to merge all data in the same conditions. The effort was major but, due to lack of fund, special travels to discuss and explain new methodologies and results to other members of the Collaboration were very restricted and, as a consequence, it was very difficult to our foreigner collaborators to assimilate and mature our new ideas.

Academic Training:

Catarina Quintans, "Study of dimuon production in ion-nucleus ultra-relativistic collisions, as a function of energy density and impact parameter", PhD Thesis, concluded.

Helena Santos, "Study of high-mass vector-meson production in lead-lead collisions at ultra-relativistic energies", PhD Thesis, in progress.

Teresa Claudino, "Study of muon pairs in proton-nucleus and nucleus-nucleus collisions at high energies", PhD Thesis, in progress.

Gonçalo Borges, "Study of Ψ production in collisions of protons with different targets", PhD Thesis, in progress.

Publications:

"Pseudorapidity distributions of charged particles as a function of centrality in Pb-Pb collisions at 158 and 40 GeV per nucleon incident energy", Physics Letters B530 (2002) 33.

"Scaling of charged particle multiplicity in Pb-Pb collisions at SPS energies", Physics Letters B530 (2002) 43.

" ϕ production in Pb-Pb collisions at 158 GeV/c per nucleon incident momentum", submitted to publication in Phys. Lett. B

"Fission cross section of lead projectiles in Pb-nucleus interactions at 40 and 158 AGeV", submitted to publication in Phys. Lett. B

"Charmonia and Drell-Yan production in proton-nucleus collisions at the CERN SPS", submitted to publication in Phys. Lett. B

Conferences

"J/Ψ production in proton-nucleus and nucleus-nucleus interactions at the CERN SPS", a ser publicado em Proc. of Ultra-relativistic Heavy Ion Collisions Workshop, Janeiro 2002, Hirschegg, Áustria.

"J/Ψ and Ψ' production in 450 GeV p-A interactions", a ser publicado em Proc. of XXVII Rencontres de Moriond, Março 2002, Les Arcs, França.

"Transverse momentum distributions of J/Ψ produced in Pb-Pb and p-A interactions at the CERN SPS", a ser publicado em Proc. of Quark Matter 02 Conference, Julho 2002, Nantes, França.

"Charmonia absorption in p-A collisions at the CERN SPS: results and implications on Pb-Pb interactions", a ser publicado em Proc. Of Quark Matter 02 Conference, Julho 2002, Nantes, França.

"Results on leptonic probes from NA50", a ser publicado em Proc. of Quark Matter 02 Conference, Julho 2002, Nantes, França.

"New results on J/Ψ from the NA50 experiments", a ser publicado em 31st Int. Conf. on High Energy Physics, ICHEP02, Julho 2002, Amsterdão, Holanda.

"Transverse momentum and transverse mass distributions of J/Ψ mesons produced in p-A and Pb-Pb interactions at the CERN SPS", a ser publicado em XVI International Conference on Particles and Nuclei, PANIC02, September 2002, Osaka, Japão.

PROGRESS REPORT

Project Title: Development of radiation hard silicon detectors

Team

Project Coordinator: Pedro F. P. Rato Mendes

PhD: Maria da Conceição Abreu, Pedro Rato Mendes

Students: Patrick Sousa, Sónia Rodrigues, Bruno Carriço

Technical Staff: Dário Passos

Summary of activities:

1. Introduction

The main objective of the project “Development of radiation hard silicon detectors” is the characterization of sensors for tracking detectors capable of operating in extremely harsh radiation environments as those expected at future high-luminosity collider experiments like ATLAS and CMS at the CERN LHC.

This project is part of the RD39 Collaboration effort, whose approach to the development of radiation-hard detectors is based on the so-called “Lazarus effect” and the operation of silicon devices at cryogenic temperatures, typically 130 K.

The LIP group contribution to the RD39 Collaboration programme, made through this project, consists on the following: characterization of new sensor samples, understanding of polarization effects (time dependence of the charge collection efficiency in heavily irradiated silicon) and development of edgeless detectors (that is, detectors without guard-ring structures on one side). These latter detectors will be used for charged particle tracking very close to the beam line, in collaboration with the TOTEM experiment at CERN.

Together with RD39 activities, and profiting from the existing instrumentation, a simple system for two-dimensional soft x-ray imaging, featuring silicon microstrip detectors and integrated electronics, was implemented and tested.

2. Development of radiation hard silicon detectors

Task 1 – Instrumentation upgrade

Task 2 – Measurement and characterization of irradiated detectors

a) CCE temperature dependence of irradiated samples

The collected data, together with other data by the RD39 Collaboration, demonstrated the existence of a general temperature dependence of the CCE of irradiated detectors. The theoretical modelling of the Lazarus effect was further developed, leading to a successful explanation of the observed data. The local maximum observed at about 130 K is believed to be due to the contribution of two processes in the silicon bulk as the temperatures decreases from room temperature to cryogenic values: a reduction in the charged fraction of radiation-induced deep levels and an increase in carrier trapping. The first process leads to a decrease of the absolute value of the effective charge density N_{eff} , with a consequent widening of the depletion layer up to full depletion – increasing CCE – while the second traps more and more carriers generated by ionisation as the temperature is lowered – thus decreasing CCE. The competition of both processes leads to the observed maximum of CCE at about 130 K.

b) CCE time dependence of irradiated samples

The detailed analysis of the data taken will be used in order to further understand the mechanism of CCE degradation observed for charged particle detection and to find ways of minimising this effect, such as injecting minority carriers with light thus compensating the non-homogeneous electric field in the bulk. A clearer understanding is expected at the end of this project.

c) Edgeless silicon detectors

In order to have a quantitative estimate of the CCE at different distances from the edge, a test with beam was performed at CERN at the end of this summer using tracking detectors before and after a cryostat with two edgeless detectors operating at low temperatures. We expect to have a clearer understanding of the problem as the data are analysed. The results will show if it is possible or not to have segmented edgeless detectors sensitive all the way to edge, featuring no dead areas.

3. Silicon strip detectors for two-dimensional soft x-ray imaging

Although not directly related to the development of radiation-hard silicon detectors, a small contribution was made by the group responsible for this project in the implementation and characterization of a small prototype for two-dimensional x-ray imaging using silicon strip detectors, as a graduation project for a student at the University of Algarve.

The prototype consisted of single-sided silicon detectors made from 300 μm thick wafers, read by RX64 ASICs, mounted on a multi-layer printed circuit board. Data acquisition and control was performed by a Windows PC workstation running dedicated LabVIEW 6i routines, connected to the sensors through a PCI-DIO-96 interface.

Two-dimensional images were obtained by scanning, along the whole detector size, a lead collimator with a thin slit perpendicular to the strip axis; the several strip profiles (slices) taken at each position, put together, form a planar image. The imaging capabilities of the system were tested with soft x-rays from ^{57}Co and ^{109}Cd radioactive sources with good results.

This work was made in collaboration with INFN Torino (Italy), which provided both detector boards and dedicated software.

Academic Training:

Graduation Thesis

Bruno Clímaco H. C. C. Carriço (Physical Engineering) – “ *LAAPD (Large Area Avalanche Photodiode) Characterization*” for the PEM Project.

Sónia Isabel E. S. Rodrigues (Physics and Chemistry) – “ *Microstrip Silicon Detectors for Bi-dimentional Imaging with low energy X Rays*”.

Publications:

- “Radiation hardness of cryogenic silicon detectors”, T. Niinikoski, M. C. Abreu, P. Rato Mendes, P. Sousa et al. (RD39 Collaboration), Nucl. Instr. and Meth. in Phys. Res. A 476 (2002) 569-582
- “Silicon detectors irradiated “in situ” at cryogenic temperatures”, G. Ruggiero, M. C. Abreu, P. Rato Mendes, P. Sousa et al. (RD39 Collaboration), Nucl. Instr. and Meth. in Phys. Res. A 476 (2002) 583-587
- “A new ultra radiation hard cryogenic silicon tracker for heavy ion beams”, L. Casagrande, M. C. Abreu, K. Borer, A. De Falco, B. Dezillie, V. Granata, E. Heijne, M. Hess, Z. Li, C. Lourenço, A. Neves, T. O. Niinikoski, V. G. Palmieri, B. Pes, P. Ramalhete, P. Rato Mendes, P. Rosinsky, G. Ruggiero, J. Seixas, P. Sonderegger, P. Sousa, G. Usai, G. Vandoni, Nucl. Instr. and Meth. in Phys. Res. A 478 (2002) 325-329
- “Electrical and transient current characterization of edgeless silicon detectors diced with different methods”, Z. Li, M. Abreu, V. Eremin, V. Granata, J. Mariano, P. R. Mendes, T. O. Niinikoski, P. Sousa, E. Verbitskaya, W. Zhang, accepted for publication in IEEE Trans. Nucl. Sci.
- “RD39 Status Report”, K. Borer, M. C. Abreu, P. Rato Mendes, P. Sousa et al. (RD39 Collaboration), CERN/LHCC/2002-04 (2002) 86 pp.
- “Summary, plan and resources of RD39 projects”, K. Borer, M. C. Abreu, P. Rato Mendes, P. Sousa et al. (RD39 Collaboration), CERN/LHCC/2002-15 (2002) 10 pp.

Conferences:

Presentations to conferences by LIP group members:

- “Recent progress in the CERN RD39 Collaboration”, Pedro Rato Mendes for the RD39 Collaboration, invited talk at the 4th International Conference on Radiation Effects on Semiconductor Materials, Detectors and Devices – RESMDD’02, Firenze, Italy, July 10-12, 2002 (proceedings to be published in Nucl. Instr. and Meth. in Phys. Res. A)

- “Silicon strip detectors for two-dimensional soft x-ray imaging at normal incidence”, Pedro Rato Mendes et al., oral presentation at the 4th International Workshop on Radiation Imaging Detectors (IWORID’2002), Amsterdam, The Netherlands, September 8-12, 2002, (proceedings to be published in Nucl. Instr. and Meth. in Phys. Res. A)