LIP

Laboratório de Instrumentação e Física Experimental de Partículas

ACTIVITY PLAN

2004

LIP LISBOA
and ALGARVE POLE

WORKING PLAN

Project Title: AMS

Team

Gaspar Barreira	Senior scientist	10%
Mário Pimenta	Senior scientist	10%
Fernando Barão	Senior scientist, Coordinator	75%
Patrícia Gonçalves	Senior scientist (Post-Doc)	60%
Luísa Arruda	Student (Phd)	100%
Rui Pereira	Student (Phd)	100%
João Borges	Student (Master)	100%
Fernando Carmo	Student (Master)	35%

Activities Foreseen:

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

The capabilities of the AMS spectrometer, compared to the one which flew in the Discovery shuttle in 1998, were largely improved and extended through the inclusion of new detectors: a Ring Imaging Cerenkov Detector (RICH), an Electromagnetic Calorimeter (ECAL) and a Transition Radiation Detector (TRD). The RICH will provide both an independent measurement of the particle velocity and of the electric charge. A velocity goal resolution for singly charged particles of the order of 10^{-3} is envisaged. Such a resolution together with an improved measurement of the particle rigidity due to a higher magnetic field (0.9T), will allow to obtain a very good isotopic separation on a large kinetic range (up to 10 GeV per nucleon).

The RICH is a conical shaped detector with a dual radiator index configuration on the top made of aerogel (n=1.03) and sodium fluoride (n=1.33), a matrix of photodetectors on the bottom and an enveloping outer mirror of very large reflectivity.
The capabilities of the AMS spectrometer will be improved and extended through the inclusion of new detectors such as a RICH (Ring Imaging Cerenkov).

2003-2004	Test of the RICH electronics. Test of the different radiators (aerogels and sodium fluoride).
2004	Assembling and potting of the photomultipliers cells: photomultiplier, readout electronics, policarbonate housing and magnetic shielding. Functional test of the multipixel photomultipliers. Grouping of the photomultipliers by gain. Light guides glued to the photomultiplier. Thermal and vibration tests. Assembling of the phtomultiplier modules. Mechanical integration of the Rich detector. Cosmic runs tests.
2005	AMS integration of the different detectors.

For the year of 2004 the group intends to develop the following activities:

- Analysis of the test beam data taken at Cern on October 2003. Around 11 million events were accumulated on an one-week run corresponding to charges ranging from Z=1 to Z=45. Different aerogels samples from two different manufacturers and sodium fluoride were tested. A small piece of the rich reflector was also added to setup configuration in order to analyse the reflected patterns.
  The reconstruction algorithms (velocity and charge) will be tested, particularly taking into account the reflected photons on the mirror.
- Participation on the detector assembling and different test activities.
  The assembling of the RICH detector will be done at the CIEMAT institute, in Madrid (Spain). Functional tests of the overall detector must be realized after the assembling. Those tests will be done with cosmic events and eventually with ion beams.
- Simulation and analysis of some physics channels with the AMS full simulation.
  Among the physics channels to potentially explore are the helium and beryllium nuclei which can contribute to a better understanding of the cosmic ray confinement and propagation in the galaxy. The stay of AMS experiment in the International Space Station will hugely improve the current accumulated statistics.
- Characterization and simulation of the aerogel surface.
  The optical and surface quality of the aerogel radiator are a crucial issue for the radiator final selection. The 2002 test beam data revealed the existence of a cerenkov photon component forward scattered. For a full understanding of such a component, a detailed study of the aerogel surface with a AFM microscope is being done together with its simulation through the Geant4 package.

Training program:

Phd Thesis

Low charge nuclei identification with the AMS spectrometer
L. Arruda
(2004-2007)

Master Thesis

Development of a velocity reconstruction method for the RICH detector of the AMS experiment, João Borges
Instituto Superior Técnico
(presented on January 2004)

Study of the possibility of using the light guide signal for electric charge determination in RICH, F. Carmo
Instituto Superior Técnico

WORKING PLAN - 2004

Project Title: Collaboration in the ATLAS Experiment

Project Coordinator: Amélia Maio

PhD:

Amélia Maio	50%
João Carvalho	20%
Antonio Onofre	50%
Antonio Amorim	5%
Helmut Wolters	5%
Manuel Maneira	4%
Viriato Esteves	25%
Agostinho Gomes	95%

PhD Students:

F. Veloso	60%
Nuno Castro	60%
José Silva	90%

Master Students:

Joao Pina	100%
Joao Gentil	100%
Joao Santos	50%
Carlos Marques	100%

Technical Staff:

José Pinhão	5%
Rui Alves	10%
Luis Raposeiro	5%
José Carlos	5%
Carlos Silva	25%
Alexandre Moita	20%

Activities Foreseen:

1. Instrumentation of 1 Barrel and 1 Extended Barrel modules

Supply of extra WLS fibres for the production of the last Barrel module and of one of the 2 last Extended Barrel modules and participation on the Instrumentation at CERN.

2. Production of components for the laser calibration system

Production and QC of the patch pannels and adjustable connectors for the laser calibration system.

Preparation of 60m long clear fibers: cut to length, polishing and installation of the fibres that will connect the laser box in the electronics control room to the modules in the pit.

3. Scintillators, WLS fibres, PMTs and ageing

Adaptation of the setup used for the QC of the PMTs to monitor the ageing of PMTs. The software is being adapted.

Re-evaluation of the tile/fibre light budget. Study of the influence on the calibration and the nonuniformity observed in the Tilecal response to muons.

Construction of a dedicated setup for monitorization of the long term stability of the optical properties of WLS fibres, scintillators and PMTs. This setup will allow a study of natural ageing.Systematic tests of accelerated ageing are planned on several samples of WLS fibers and also on scintillating tiles, and combine these tests with the radiation damage tests.
Irradiation s of WLS fibres of all the batches received for the Tilecal calorimeter.. Irradiation of scintillators made of russian PSM-115 and western BASF polystyrene, both used in Tilecal. Evaluation of the radiation influence in the long term tilecal performance.

4. Testbeam

Preparation of the combined testbeam with all the ATLAS subdetectors. We are responsible for the software implementation and maintenance of Tilecal DCS.
Participation in the preparation of the run plan, in the simulation, in the data taking (8 weeks of shifts distributed from mid May to the end of September) and in the analysis that will be made using the Athena framework: performance of the combined calorimeter of ATLAS, intercalibration of the Tilecal and the electromagnetic Liquid Argon calorimeters for hadrons, study of the gap region between the central and extended barrel of Tilecal.

5. Installation of Tilecal in the pit

Participation in the installation of the Tilecal barrel in the pit, at the level of supervision by physicists and installation of connectors and patch pannels by technicians.

6. Tilecal DCS (detector control system) development, construction and coordination

Coordination of the Tilecal DCS.

Migration of systems to the new version of the SCADA software PVSS3, new OPCServer and new Framework.

Preparation of DCS system in building 185 for commissioning of 12 Extended Barrel modules using cosmic rays. Upgrade high voltage and low voltage systems when new prototypes are available. Maintenance of the system.

Definition and implementation of the Tilecal states for Finite State Machine operation using smi++ tool of new Framework, for the testbeam and for Atlas.
Development of Tilecal user interface for supervisor station for the testbeam and for Atlas.

Finalization of ELMB stability testbench in Lisbon, and stability monitoring.

Test new low voltage power supply and the respective control/monitoring using the ELMB.

Preparation of PVSS API managers or scripts to get the calorimeter table coordinates and SPS beam information data.

Installation of power crates and cabling for the CANbuses in the testbeam.
Installation of a distributed PVSS system using 3 PCs for Tilecal, and integrated with the other PCs of the combined testbeam.
Integration of the Tilecal DCS in an Atlas-like DCS during the Atlas combined testbeam run.
Interface the Tilecal DCS with the conditions database (Lisbon API) for the combined testbeam.
Maintenance and debugging of the Tilecal DCS during the combined testbeam.
Assembly and commissioning of the DCS of the Tilecal barrel cylinder in the Atlas pit.

Preparation of the Barrel commissioning in the pit using cosmic rays (cosmic ray test to start by mid 2005)

7. Software development and Physics simulation

Simulation of the physics that will be exploited at ATLAS/LHC, with focus on the top quark and W boson mass and width. Contribution to the calibration of ATLAS and certification of GEANT4.

Top quark physics
Top quark physics has been a subject of part of a PhD thesis of the portuguese group. In the same line, it is planned to continue the study of top physics. We plan to use the new software framework for ATLAS event simulation and data analysis, called ATHENA.
To study the double production of top quarks with anomalous couplings at LHC, a modified version of the PYTHIA generator was developed. The correct parametrization of the spin correlations of the top quarks was implemented and the forward-backward assymetries were studied at the generator level. The events were then passed through the Atlfast simulation program and stored in the ntuples used by the analysis program under development.Continuing the work done at LEP, the search for heavy quark production, the study of the tWb couplings and the spin correlations between the top quarks produced at the ATLAS/LHC experiment will be developed. This will imply the theoretical study of the tWb vertices structure within several models and the development of the corresponding signal generators. Software will be developed in the framework of ATHENA and for use of GRID.

W mass and width precision evaluation

The W mass and width of the W boson are precision measurements to be held at ATLAS/LHC collider. So it is very important to evaluate the achievable precisions on both measurements, comparing or combining different methods for the best possible result.

The work started with the statistical error study, for which, about 60 million events were generated with Pythia and processed with the ATLFAST simulation of the detector code. A study with a function that replicates the transverse mass spectrum was made with 10^9 events. The statistical error was 1.2 MeV.The present goal is the study of the systematics, so that the total uncertainty is achieved. This work will need a generation of a number of events significantly larger than the statistical study. The combination of both direct and indirect measurements will be considered, as most of the uncertainties are uncorrelated.

The possibility of new phenomena will be considered in the width study as the expected precision may be sensible to some new processes. An estimation of the Standard Model Higgs possible mass range will be made.

GEANT4 certification

Continue the work with the GEANT4 simulation package. The objective for the near future is the certification of this package through the comparison with events taken from test-beam data of the Tilecal modules, and with GEANT3 simulation. We intend to contribute in the inclusion of several detector effects in the Tilecal description: electronic noise and photostatistics, better description of scintillator light collection profiles, etc. This will be done for the combined testbeam simulation and/or for Atlas simulation.

In summary

Globally, our objectives fulfil two aims: the study of one of the first physics channel that will be studied in the first year of LHC running, and to learn how to use the new programming tools that are already being used in the ATLAS software framework.

WORKING PLAN - 2004

Project Title: A system to Find Persons Inside Atlas Area - FPIAA

Project Coordinator: Amélia Maio

PhD:

Amélia Maio	25%
Carlos Cardeira	30%
José Sá da Costa	5%
Agostinho Gomes	5%

Activities Foreseen:

Graphical interface for the FPIAA surveillance system

Retrieval of the relevant CAD models; software development using the CAD models delivered by CERN; delivery of a prototype interface; project delivery.

Pilot site with 20 sensors at IDMEC/IST

Test of the graphical interface in a smaller environment; installation of sensors, fieldbus and control, equipment in a large room (IDMEC systems laboratory); test the positionning of sensors in several positions to achieve a global perception of people movement; experimental validations of the time need to modify, install, test and place a sensor, to validate the man-power needed to install and maintain the FPIAA system; simulation of the actual behaviour of the final system.

Irradiation tests and electronics optimisation

Acquisition of sensors: irradiation of sensors and test of their functionality; modification of the sensors to replace the failing components; irradiation again, and test of their functionality; submission of modified sensor to magnetic field; modification of the sensors to replace the failing components; submission of modified sensor to magnetic field etc. repeat these operations until a steady state is reached. To achieve the steady state it may be necessary to build new sensors from scratch.

Planning

Plan the ATLAS FPIAA system construction and installation.

Project Title:
Collaboration in the CMS experiment at CERN

Project Coordinator:

João Varela	LIP/IST	

PhD:

João Varela	LIP/IST	50%
Paula Bordalo	LIP/IST	8%
Sérgio Ramos	LIP/IST	8%
Reyes Alemany	LIP	100%
Alexander Mishev	LIP	100%
Marcelino Santos	INESC/IST	20%
Carlos Almeida	INESC/IST	20%
João Paulo Teixeira	INESC/IST	25%
J. Augusto	INESC/IST	25%
F.M. Gonçalves	INESC	20%
Isabel Teixeira	INESC/IST	25%

Students:

Nuno Almeida	LIP	100%
Gustavo Ordonez	LIP	100%
Pedro Ribeiro	LIP	100%

Technical Staff:

José Carlos Silva	LIP	100%
Adarsh Jain	LIP	100%
Miguel Ferreira	LIP	50%
Jorge Semião	INESC	20%
Octávio Dias	INESC	10%

1. General Objectives

The main objective for the year 04 is the conclusion of our construction responsibilities in the CMS experiment. The SLB production and test should be concluded in Q3-04, and the DCC is foreseen in Q1-05. The online-software activities will continue, in particular related to the ECAL test beam in 04.

The activities on Physics Reconstruction and Analysis will be pursued following the boost in this area that occurred in 03 and the start of Extra-Dimensions models studies.

The responsibility of the overall Trigger Technical Coordination and DCS Coordination in the CMS experiment will continue to be assured.

2. Synchronization and Link Board (SLB)

A CMS Production Readiness Review (PRR) of the SLB is planned for May 04. The SLB documentation will be finalized for this event.
The SLB Test System will be installed at INESC, where the full SLB production will be tested.
In parallel, an international tender will be organized for the PCB production and assembly.
About 1000 modules will be tested. The test will include burn-in of the modules in the specialized ovens available at INESC. We estimate that this work can be concluded up to Q3-04.

3. Data Concentrator Card (DCC)

Firmware development and tests of the DCC will be pursued in the first quarter of 04. The capabilities of the test system now installed should allow a complete test of all board features.
The DCC module will be integrated in the ECAL test beam data acquisition system in 04. A major effort will be needed to guarantee a successful integration in the test beam. Software for the test beam is developed in task 4.
A final DCC review will be held in September 04 (ECAL Off-Detector Electronics System Review).
The requirements for DCC production will be defined. An international tender for PCB production and assembly will be organized. The test of 60 DCC boards should be concluded up to Q2-05.

4. Control and Monitoring Software

a) Integration of FEC and TCC in the Crate Controller Package:
In addition to the DCC boards, the ECAL trigger and readout crates include trigger concentrator cards (TCC) and front-end controller cards (FEC). Prototypes of these boards will become available in 04. In consequence, we plan to integrate the software drivers of these modules in the Crate Controller. The drivers will be based on the Generic Device Configurator we have developed in 02.

b) Monitoring software for the ECAL test beam:

The monitoring software we have developed for the ECAL test beam will have to be upgraded to take into account new DCC data formats and requirements.

c) ECAL Run Control software:
The Crate Controller Package will be integrated with the H4 test-beam DAQ. In parallel, it will be integrated with a prototype of the ECAL run control and local DAQ. Data will be read-out through both paths allowing the validation of the new software.

d) DCC and SLB production support:
Data management support for the production of the SLB and DCC boards has to be provided in the form of a production database.

5. Modeling and Simulation

The purpose of this task is to pursue the work on system-level modeling and simulation of the ECAL read-out and trigger chain.
In large systems, error detection and diagnosis is a major challenge. Using the system simulation tools we will perform a systematic study of error conditions and its effects on the system. The completeness of the diagnosis data defined in the design will be checked, studying in particular multi-error situations.

6. Physics Reconstruction and Selection

The major goal in 2004 is the study of physics channels predicted by the Universal Extra Dimensions (UED) model. Based on physics assumptions different from the ADD and RS models, the UED model predicts a rich phenomenology at LHC, with multi-lepton, multi-jet and missing Et final states.
Study of the detection efficiencies and backgrounds will be undertaken for the most important UED channels. This program of work requires previously to produce a suitable UED event generator. Work is now under way, in collaboration with the UED, COMHEP and PYTHIA authors, to produce the needed generation tools.
Since UED models present a phenomenology similar to SUSY, it is worth to investigate criteria to distinguish between the two. With this objective in mind, an effort will be made to introduce spin correlation in the decay chains of the channels involved. A correct description of the spin correlations is essentially to predict reliable angular distributions. These distributions may become important to distinguish among competing models. A collaboration with a HEP theoretical group should be established to achieve this goal.
The ability of the ECAL to measure very high energy electrons and photons is crucial for the detection of very high mass Kaluza-Klein excitations. In this respect we intend to study algorithms to recover electrons and photons that saturate the front-end electronics due to high signal amplitude.

7. Boundary Scan

We plan to organize in 2004 the production and test of the VME Boundary Scan Controller boards needed in the ECAL system (20 modules). A number of extra boards will be produced following the requests of other subdetectors in CMS.
This task is subject to the availability of manpower.

8. Study of the ECAL front-end digitization

The ECAL front-end electronics to be used in the test-beam in 04 will include the new Chipidea ADC. In the framework of our participation in the test-beam program, we intend to make a detailed study of the ECAL front-end digitization. The goal is to characterize the performance of the amplification and digitization electronics in a real beam environment. Having our physics goals in mind (task 5), we intend also to develop an algorithm to estimate the amplitude of saturated pulses.

WORKING PLAN

Project Title: **Collaboration in the COMPASS Experiment**

Team:

Project Coordinator

Paula Bordalo

PhD

Paula Bordalo	LIP Researcher / IST Professor	60%
Sérgio Ramos	LIP Researcher / IST Professor	60%
Catarina Quintans	LIP Researcher / Post Doc FCT grant	83%
Maria Varanda	LIP Researcher / Post Doc grant	100%
João Bastos	LIP Researcher / Post Doc grant	70%

Students

Student	PhD Student	100%
Student	PhD Student	100%

Technical Staff

David Sora	Software engineer	100%

Activities Foreseen

The main tasks the LIP-Lisbon group intends to carry on in 2004 are the following:

- to continue with the redesign the COMPASS Detector Control System, in order to meet the Collaboration requirements concerning reliabitily and speed;
- to develop code concerning new requirements of new or modified hardware;
- to integrate some missing detectors in the slow-control system;
- to take immediate actions and help detector people during the five months of data

taking;

- to participate in the shifts during the data taking periods;
- to participate in the offline effort, namely in the development of analysis tools (as the new algorithm to improve the reconstruction efficiency concerning slow tracks), in some technical studies (acceptances, efficiencies), and in the analysis effort.

The LIP-Lisbon group will participate in the COMPASS effort to build the second RICH detector, localized in the forward spectrometer, aimed for very high momentum hadron identification.

WORKING PLAN

Project Title: Collaboration in the DELPHI experiment at CERN

Team

Project Coordinator: Pedro Abreu

PhD:

Mário Pimenta,	20%
António Onofre,	15%
Pedro Abreu,	40%
Maria Catarina Espírito Santo,	10%
Bernardo Tomé,	10%
Patrícia Gonçalves,	10%

Students:

Nuno Anjos (PhD Student),	100%
Nuno Castro (Master Student),	100%
Filipe Veloso (Master Student),	100%

Technical Staff:

Resumo das Actividades previstas

O grupo DELPHI do LIP irá manter no ano de 2004 a análise dos dados de DELPHI e a preparação de artigos finais.

As análises com participação dos membros de DELPHI do LIP (membros do LIP/DELPHI) podem-se dividir em duas grandes áreas: *Pesquisa de sinais de nova física*, e *Física Hadrónica*, que correspondem a linhas de investigação da Colaboração DELPHI coordenadas também por membros do LIP/DELPHI. Na primeira área, são pesquisados sinais de vários modelos extendendo o Modelo Padrão da Física das Partículas, desde supersimetria aos Leptoquarks, tendo duas análises sido iniciadas após o fim da operação da máquina LEP (a pesquisa de uma 4ª família de quarks b', e a pesquisa de quarks top via interacções de contacto). Ainda no quadro desta área são realizadas medidas da secção eficaz dos processos $e^+e^- \rightarrow WW\gamma$ e $e^+e^- \rightarrow \gamma\gamma(\gamma)$. Na segunda área são investigados os efeitos de reconexão de côr entre quarks e gluões nos estados finais de acontecimentos WW, coordena-se o capítulo 'Soft QCD' de um grande artigo de revisão da QCD em DELPHI, actualmente em preparação, e elabora-se uma pesquisa de pentaquarks em acontecimentos hadrónicos do Z^0, em parceria com o grupo DELPHI da Univ. Udine e INFN, Udine, Itália.

Em ambas as áreas há um total de 8 artigos nas diferentes fases de preparação para publicação, sob nossa responsabilidade ou com contribuições importantes dos membros LIP/DELPHI.

Alguns membros LIP/DELPHI representam a colaboração nos grupos de trabalho de LEP para a combinação de resultados entre as experiências LEP.

Ao nível da formação académica avançada espera-se a conclusão de duas teses de mestrado e uma tese de doutoramento.

Activities Foreseen: *Analysis of DELPHI data*

In 2004, the analysis and extraction of the best results from the DELPHI data will proceed, after the last reprocessing of the complete datasets in 2002/03, towards the final publications.
In most of the channels and analyses the final papers are already in advanced stage of preparation, and review papers have started. Nevertheless there is room and opportunities for new ideas to pop up and new analyses to be launched. DELPHI is still one of the most active LEP Collaborations, and the data collected in the eleven years of LEP operation are still the best clean sample needed in many analyses, for many years to come. DELPHI has also started to develop methods to save the data and analyses programs in a format easily accessible in the future.

LIP members of the DELPHI Collaboration have taken important responsibilities in the Collaboration, namely the coordination of two main areas of research ("Research Lines"), "*Searches for New Exotic Physics* " and "*QCD/*$\gamma\gamma$ ". While the former addresses the searches in non-standard topics (not standard model Higgs and not Supersymmetric models, but basically all other possible extensions to the Standard Model), the later aims at the very precise measurements of standard and/or exquisite properties of Quantum ChromoDynamics and of hadronic physics in photon-photon collisions. The discussion of physics analysis in DELPHI proceeds in Physics Teams (within Research Lines), of which several are coordinated by LIP members. The combination of the DELPHI results with the other LEP experiments takes place in special groups, the LEP Working Groups, aiming at extracting the most precise results from the bulk of the LEP data. Several LIP members are representing the DELPHI Collaboration in these LEP Working Groups.

The status of analysis and papers of the responsibility of LIP members is given in the following table. The status can be 'on going analysis/text preparation' [ana], 'draft0 of paper produced and under discussion in the relevant physics team' [dr.0], 'draft1 of paper produced and circulated in the Collaboration' [dr.1], 'draft2 of paper released, with almost final results, and circulated in the Collaboration' [dr.2], 'draft final being refereed by a senior DELPHI member' [final], 'draft of paper sent to CERN-EP division, and in discussion with CERN-EP referee' [EP], 'paper submitted to the journal' [sub], 'paper accepted by the journal' [acc], or 'paper published in the journal' [pub].

Physics Channel		Month in 2004				
		January	March	June	September	December
Searches	Supersymmetry	acc	pub			
	FCNC	sub	acc	pub		
	Fermiophobic Higgs boson	EP	sub	acc	Pub	
	Compositeness	dr.1	dr.2	final	EP	sub
	$e^+e^- \rightarrow \gamma\gamma(\gamma)$	dr.1	dr.2	final	EP	sub
	Leptoquarks	ana	dr.0	dr.1	dr.2	final
	Contact Interactions	ana	dr.0	dr.1	dr.2	final
	b'	ana	dr.0	dr.1	dr.2	final
QCD	Colour Reconnection	ana	ana	dr.0	dr.1	dr.2
	Search for Pentaquarks	ana	ana	dr.0	dr.1	dr.2
	Big review paper	ana	ana	ana	ana	dr.0

Table: Status of analyses and preparation of drafts and papers by members of the LIP/DELPHI group. Legend is described in the text above.

In the following, the plan of activities is detailed by Physics Channel.

Searches:

The LIP DELPHI members are convenors of 6 Physics Teams – SUSY/LSP, Flavour Changing Neutral Currents, Fermiophobic Higgs bosons, Heavy and Excited fermions, Leptoquarks and Collinear photon-photon – and one Research Line – Exotica. They also participate in the LEP Higgs, LEP Exotica and LEP Electroweak Working Groups.

Search for Supersymmetric (SUSY) particles

In the framework of the Minimal Supersymmetric extension to the Standard Model (SUSY), assuming R-Parity conservation, the lightest supersymmetric particle is stable, and the selection criteria employed depends primarily on the masses of the particles probed, and the mass differences with respect to the lightest supersymmetric particle.

Search for Flavour Changing Neutral Currents

Flavour Changing Neutral Currents (FCNC) are absent at tree level and severely suppressed at one loop level in the Standard Model, but present in many of its extensions. Single Top quark production at LEP would be an indication of such anomalous FCNC couplings.

Search for non fermionic neutral Higgs boson

Many of the proposed extensions of the Standard Model change the properties of the Higgs bosons, either by the effect of higher energy interactions or directly assuming a non-minimal sector. Two of these extensions are explored; the introduction of anomalous couplings between the Higgs and the gauge bosons, due to the presence of higher order corrections, and the introduction of a second Higgs doublet in a scenario where a light Higgs boson with suppressed couplings to fermions arises (fermiophobic Higgs).

Search for Heavy and Excited Leptons (Compositeness)

Sequential, non-canonical excited leptons could be produced singly or in pairs, and would decay promptly by radiating a photon, a Z or a W boson, giving rise to different topologies. Limits are derived as functions of its masses and couplings.

Search for $\gamma\gamma(\gamma)$ events

Final states with two photons are mainly produced by the standard process $e^+e^- \rightarrow \gamma\gamma(\gamma)$. This reaction is an almost QED process and therefore any significant deviation between the measured and the very precise QED cross-section could unambiguously be interpreted as the result of non-standard physics.

Search for Leptoquarks

Leptoquarks are coloured spin 0 or spin 1 particles, which carry both baryon and lepton quantum numbers. A search for singly produced leptoquarks decaying both in charged and neutral modes is performed within two distinct frameworks: the direct mechanism and the resolved photon mechanism.

Search for top quark via Contact Interactions

The top quark is the heaviest and the least studied quark in the Standard Model. Due to its high mass, it can only be produced at LEP via Flavour Changing Neutral Currents, as discusses in many extensions of the Standard Model. Among these extensions, the production of a top quark associated with a charm quark via Contact Interactions is searched by DELPHI at LEP.

Search for 4th Generation b'-quarks

Data collected at LEP 1 has excluded the possibility of an extra family of particles with mass less than half of the Z boson mass and coupling to the Z boson. However, for masses above $M_Z/2$, the regions excluded become strongly model and analysis dependent. A natural and simple general extension is an extra family of particles, and a quark of bottom type, *b'*, is searched for in this new analysis.

QCD:

The LIP DELPHI members are co-responsible of the QCD Research Line and participate in the LEP QCD and W Physics Working Groups.

Colour Reconnection effects in events containing a pair of W bosons

The W bosons are produced in pairs at LEP2, and may both decay hadronically, in the very short lifetime of 3.1×10^{-25}s, travelling no more than about 0.1 fm. This time and

distances are much smaller than the typical hadronisation time and distance scales of about 1 fm, thus allowing for both evolving hadronic systems to interact with each other, at the parton or at the hadron level. Begin a challenging probe to understand the properties of QCD, this effect needs also careful study in order to assess the modifications to the reconstructed W boson mass in the fully hadronic channel. We are working in this area in tight cooperation with the other LEP experiments.

Search for Pentaquark states in Z^0 decays at LEP

Following recent reports on a new state of hadronic matter, a search was started for pentaquark states in hadronic Z^0 decays at LEP. Although the statistics collected is very limited for this decay, it gives a very distinctive signal that can pinpointed. If no candidates are found, limits on the production cross-section will be set.

Review of DELPHI QCD results

One of the ambitious projects launched recently in DELPHI, is the preparation for publication of a review of all the results in the QCD area of research, that enables for a reader to find in one paper the most important results in this area. Sometimes, a result in some analysis was superseded in a more recent published paper, but without an obvious relating title, and thus difficult to be found by the unaware reader. In this final publication, it is expected to have also the latest results, collected at the highest centre of mass energies, that in themselves do not constitute material original enough to make a standalone publication. A LIP member is co-responsible of the QCD/Softer section.

Training program:

Within the LIP/DELPHI group, there were already presented and defended with success a total of 3 graduation thesis, 9 Master thesis or equivalent reports and 10 PhD thesis.
We still have in progress one PhD thesis and two Master thesis:

"Hadronic final states at LEP II" – PhD thesis – Nuno Anjos, conclusion foreseen in 2004.

"Search for 4th Generation *b'*-quarks in the DELPHI experiment" – Master thesis - Nuno Castro, conclusion foreseen in 2004.

"Search for single top quark production at LEP via four-fermion contact interaction at $\sqrt{s}$=189-209 GeV" – Master thesis – Filipe Veloso, conclusion foreseen in 2004.

Working Plan

Project Title: Development of Positron Emission Mammography

Project Coordinator:

João Varela	PhD Physicist, Professor IST, Lisbon

Members LIP-Lisboa:

João Varela	PhD Physicist, Professor IST, Lisbon
Rui Ribeiro	PhD Physicist, Professor FEUP, Porto
Luís Peralta	PhD Physicist, Professor FCUL, Lisbon
António Soares	PhD Physicist
Sérgio Ramos	PhD Physicist, Professor IST, Lisbon
Paula Bordalo	PhD Physicist, Professor IST, Lisbon
Pedro Rodrigues	PhD Student Physicist
Andreia Trindade	PhD Student Physicist
Rui Moura	PhD Student Physicist
Catarina Ortigão	PhD Student Physicist

Members LIP-Algarve:

Conceição Abreu	PhD Physicist, Professor Univ. Algarve
Pedro Rato Mendes	PhD Physicist
Bruno Carriço	Master Student Physicist
Patrick Sousa	Physicist

Members LIP-Coimbra:

Francisco Fraga	PhD Physicist, Professor Univ. Coimbra
Susete Fetal	Master Physicist
Filipa Balau	Master Student Physicist

Working Program

The development of PET (Positron Emission Tomography) technology applied to the detection of breast cancer is the objective of a project carried out by the Consortium PET-Mammography. The project answers this need by developing new equipment with higher sensitivity for beast cancer detection (see Report 2003).

In the year 2004, the project's second year, we aim to develop the necessary technologies and to build the detector components. The main developments planed for the year 2004 are:

- Test of a small scale prototype (mini-PEM) integrating the final detector modules in coincidence (LIP-Lisbon).
- Detailed characterization of detector modules and setting-up of the quality control system from module production (LIP-Algarve).
- Simulation studies: studies of detector performance; studies of trigger and data acquisition performance; studies of the axila region (LIP-Lisbon).
- Study of sensitivity to breast cancer detection using a detailed simulation of anthropomorphic phantom and PEM detector together with image reconstruction software (LIP-Lisbon/IBEB/HGO).
- Production and test of the front-end chip. Design of the front-end electronics system (INESC-ID/ INOV).
- Production and test of the trigger and data acquisition system (INESC-ID/ INOV /LIP-Lisbon).
- Design of the high-voltage and temperature monitoring systems (LIP-Lisbon/INOV).
- Development of the data acquisition, control and image visualization software (IBILI / IBEB/ HGO).
- Mechanical design of the PEM detector plates (INEGI).
- Study and design of the detector cooling system (INEGI/LIP-Algarve).
- Design and construction of the mechanical systems (INEGI).
- Preliminary design of the protocol of the clinical trials (HGO).

WORKING PLAN

Project Title: Installation of the Laboratory TagusLIP

Project Coordinator:

João Varela	PhD Physicist, Professor IST, Lisbon

Members LIP-Lisboa:

João Varela	PhD Physicist, Professor IST, Lisbon
Rui Ribeiro	PhD Physicist, Professor FEUP, Porto
Luís Peralta	PhD Physicist, Professor FCUL, Lisbon
António Soares	PhD Physicist
Sérgio Ramos	PhD Physicist, Professor IST, Lisbon
Paula Bordalo	PhD Physicist, Professor IST, Lisbon
Pedro Rodrigues	PhD Student Physicist
Andreia Trindade	PhD Student Physicist
Rui Moura	PhD Student Physicist
Catarina Ortigão	PhD Student Physicist
Miguel Ferreira	Technician

Working Program

In 2003 LIP and Tagusparque SA obtained funds from the program LisAction for the installation of a laboratory (TagusLIP) dedicated to the development of medical equipment. The laboratory will be located at Taguspark.

TagusLIP is intended to be an infrastructure available for R&D projects, equipped for the development of nuclear medicine equipment. The project PET-Mammography will be the first user of the infrastructure.

The architectural project for the adaptation of the installations and the construction of a protected hot zone will be concluded in February 04. A dossier requesting licensing for work with radio isotopes was submitted to Direcção Geral de Saúde beginning of January 04. The civil engineering and final adaptation work is expected to be finished by end April 04. Equipment installation will follow during May and June 04.

WORKING PLAN

Project Title: Development of radiation hard silicon detectors

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Team

Project Coordinator: Pedro F. P. Rato Mendes

PhD: Maria da Conceição Abreu (25%), Pedro Rato Mendes (40%)

Ph. D. Student: Patrick Sousa (25%)

M.Sc. Student: Sónia Rodrigues (50%)

Technical Staff: José Mariano (25%)

Sumário:

O projecto "Desenvolvimento de detectores de silício resistentes à radiação - Participação na Colaboração RD39 do CERN" é da responsabilidade do LIP - Laboratório de Instrumentação e Física Experimental de Partículas - no âmbito das actividades do laboratório do LIP sito na Universidade do Algarve, em Faro.

O objectivo do projecto é prosseguir os esforços do laboratório iniciados em 1999 no desenvolvimento dos detectores de silício resistentes à radiação que irão ser utilizados no futuro acelerador do CERN, o grande colisionador de hadrões (LHC). O actual programa de RD39, aprovado até 2005, pretende caracterizar detectores irradiados até 10**16 neutrões de 1 MeV por cm2, o limite previsto para a segunda fase de operação de LHC (denominada Super LHC).

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

Activities Foreseen:

During year 2004 it is foreseen to continue the work program started back in 1999, namely the study of heavily irradiated silicon diodes through the measurement of the charge collection efficiency (CCE) and other device characteristics. Also, a new goal has been set within RD39 this year: the low temperature characterization of silicon samples irradiated at or above 10^{16} n/cm^2, the fluence expected at the SuperLHC.

The set of samples under study includes oxygenated, edgeless, Float-Zone (FZ) and Czochraslki (CZ) grown devices, with the objectives of better understanding the radiation damage processes in silicon, and of devising the best radiation-hard material for tracking detectors in future high-luminosity colliders. The CCE of the extremely irradiated samples that will be studied this year will be dominated by severe trapping, which could set the optimal operating point at a temperature below that of liquid nitrogen. A new setup for CCE measurements down to liquid helium temperatures is being developed at CERN in collaboration between RD39 and the Cryogenics Laboratory of CERN, with the LIP coordinator of this project being responsible for the CCE measurement equipment to be installed.

The data collected are analysed and discussed within the RD39 Collaboration, adding to further development and refinement of the Lazarus Effect [1] and its theoretical modelling [2], validating CCE measurements at low temperatures also as a precise technique for deep level spectroscopy of defects in silicon. The main goal of this year's research program is the demonstration of the detection capabilities of silicon detectors irradiated up to SuperLHC fluences when operated at cryogenic temperatures.

Cited references

[1] V. G. Palmieri et al., "Evidence for charge collection efficiency recovery in heavily irradiated silicon detectors operated at cryogenic temperatures", Nucl. Instr. and Meth. in Phys. Res. A 413 (1998) 475-478

[2] E. Verbitskaya et al. (RD39 Collaboration), "The effect of charge collection recovery in silicon p-n junctions irradiated by different particles", Nucl. Instr. and Meth. in Phys. Res. A 514 (2003) 47

Training program:

- one Ph.D. student
- one Master student

WORKING PLAN

Project Title: MONTE CARLO TECHNIQUES AND DETECTOR DEVELOPMENT APPLIED TO MEDICAL PHYSICS

Team

PhD: Luis Peralta 40% (team leader)**,** Maria do Carmo Lopes[1] 50%, Maria Conceição Abreu 25%**,** Pedro Rato 30%, Margarida Fragoso[1] 50%, Maria dos Anjos Neves[3] 10%,

Students: Adérito Chaves[1] 70%, Carla Alves Oliveira[1] 70%, Patrick Sousa 50%, Florbela Rego 20%, Ana Pinto 20%, Sandra Moreno 100%, José Coucello Martins[2] 10%, Marília Pedrosa[2] 10%, Sandra Brás 100%, Sónia Rodrigues 50%, Marco Paulo Quinteiro[4] 50%.

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[1] CROC-IPOFG, [2] Hospital do Alvor, [3] ITN, [4]Biologia Molecular – Genética Ambiental e Farmacogética

Resumo:

A presente proposta é referente às actividades do Laboratório no domínio da Física aplicada à Medicina, em colaboração com especialistas de medicina nuclear da UIC do Hospital do Alvor. Juntamente com as simulações MC, este projecto propõe-se participar no desenvolvimento e construção de um protótipo de um detector híbrido para radiação gama para ser utilizado em aplicações médicas. Esta participação será possível com recurso ao know-how da tecnologia de detectores existente no âmbito da colaboração ISPA do CERN. Nos últimos anos tem existido um aumento continuo do desenvolvimento de detectores para aplicações médicas usando técnicas nascidas no seio da Física de Altas Energias. Um exemplo, são os detectores de silício e de determinados tipos especiais de cintiladores em imagiologia com base em raios-X ou gama. Este tipo de materiais usados correntemente em Física de Altas Energias, podem melhorar significativamente o contraste e resolução das imagens obtidas. Permitem também, de uma forma simples, a obtenção e tratamento de imagens digitais.No decurso deste projecto serão consolidados os conhecimentos adquiridos com o protótipo actualmente em construção e será feita uma iteração sucessiva com o desenvolvimento e a implementação de um sistema baseado em detectores ISPA, que será testado na imagem funcional de pequenos animais.

Activities Foreseen:

Introduction

The proposal aims are the development of Monte Carlo (MC) simulation programs in the computation of doses delivered by radiation ionisation sources and the development of solid state detectors for digital gamma-ray imaging in nuclear medicine, within the scope

of the ISPA Collaboration. This is an important technological transfer from the High-Energy domain to the Medical Physics Sciences, in strict collaboration with nuclear medicine medical doctors from UIC in Alvor Hospital.Monte Carlo techniques are now recognised as being an important tool in the computation of absorbed radiation doses in several medical problems. Our group have now a considerable background in this field due to the work done in the past years. The present project continues this successful work, and extends it to new applications. Conceming the Monte Carlo applications to radiotherapy, several topics are going to be developed. The study of the radiosurgery beams is going to be carried on, now with the comparison of the results obtained with the developed Monte Carlo model with results of commercial treatment planning systems. A considerable effort was undertaken in the past few years to develop Monte Carlo models that accurately simulate the radiation fields produced by clinic linear accelerators. Now we want to develop a user-friendly interface to these packages, so they can be used in a clinical environment. The study of the beams produced by the dynamic wedges of the Varian Clinac 600C existing in the Coimbra Hospital is starting. With this study it is intended to understand the physical aspects of radiation field when modulated by a dynamic wedge. A new topic on the simulation of braquitherapy applications is going to be started. This work will profit from the recent renewal of the braquitherapy service in the Coimbra Hospital.Together with MC simulations, this project proposes to develop and build 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. In recent years there has been a significant and continuously growing development of detectors for medical applications using technologies and techniques matured in experimental high energy physics. An example of this is the use of silicon detectors and special scintillators for X-ray and gamma-ray imaging. These materials, extensively used and applied in high energy physics environments, can provide a significant improvement in both contrast (better energy resolution) and sharpness (better spatial resolution) compared to standard medical imaging sensors, with the additional improvement of requiring lower radiation doses and the benefit of allowing an easy and straightforward digital treatment of the images, with all its inherent advantages.During this project the know-how from a prototype currently under construction will be used for the development and implementation of a compact gamma camera system based on ISPA detectors, which will be tested in the functional imaging of small animals.

Objectives

The project objectives are: Monte Carlo developments for radiotherapy: 1) MC study of the narrow beams used in Radiosurgery. 2) MC simulation of the photon field produced by the linear accelerator Varian Clinac 600C, using dynamic wedges. 3) Development of a user-friendly interface for the use of the simulation package in clinical environment. 4) Simulation of braquitherapy cases.MC development for Nuclear Medicine: 1) MC simulations of gamma images obtained in cardiological and kidney imaging with 99mTc-Sestamibi; 2) comparison MC - experimental imaging results from anatomical phantoms of cardiological, kidney and thyroid examinations; 3) study of dose delivered to the patient, comparison with standard dose measuring equipment. All medical tests will be done with a Siemens ECAM dual head SPECT system. The results will be used in

quality control procedures of nuclear medicine diagnosis.Detectors: The objectives are the assembly of the final prototype with integration of detectors and electronics, followed by laboratory tests with sources and phantoms, and in vivo imaging tests with radiological phantoms and small animals. Monte Carlo simulations for quality control and characterization will be done.

Academic training program:

Adérito Chaves, PhD thesis - Conclusion foreseen in 2004
Patrick Sousa, PhD thesis – Conclusion foreseen in 2005
Sandra Moreno, PhD thesis – Conclusion foreseen in 2006
Florbela Rego, Master thesis – conclusion foreseen in 2004
Ana Pinto, Master thesis – conclusion foreseen in 2004
Sónia Rodrigues, Master thesis – conclusion foreseen in 2004
Sandra Brás, Master thesis – conclusion foreseen in 2004

WORKING PLAN

Project Title: Particle Physics Education and Public Outreach

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Team

Project Coordinator: Pedro Abreu

PhD:

Pedro Abreu,LIP/IST,	30%
João Varela,LIP/IST,	20%
Maria Abreu,LIP/Ualg.,	10%
Amélia Maio,LIP/FCUL,	10%
Luís Peralta,LIP/FCUL,	10%
Fernando Barão, LIP/IST,	10%

Students:

José Silva,LIP,	10%
João Pires,LIP,	100%
Dário Passos, LIP,	50%
Catarina Pereira, LIP/IST,	100%

Technical Staff:

José Carlos Silva, LIP,	10%
Miguel Ferreira, LIP,	50%
José Carlos Nogueira, LIP,	10%

Activities Foreseen:

The next years will be crucial concerning Particle Physics Education and Public Outreach. In particular to potentiate the most of the public awareness from the UNESCO announcement of '2005 – World Year of Physics' and to prepare parallel activities associated to the international event with the importance of the 'European Physical Society High Energy Physics conference'.

The problem of getting the public's attention towards Particle Physics, and in particular end-years high-schools teachers and students (along with their families), is being tackled by two different roads: the maintenance and development of traditional education and public outreach activities, and the project of "Measurement of Time Correlations in Cosmic Rays" profiting from the equipment installed in the schools.

In both cases, these activities were in the past split in the projects "Cosmic Rays Telescope – Ciência Viva" and "Experimental Particle Physics Outreach". In this project it is described the plan to integrate all the different activities, and maintain and operate the equipment installed in the high-schools.

Education and Public Outreach

The activities proposed concerning education and public outreach are briefly described in the following.

LIP members have prepared seminars to be given at schools, universities and other sites, and collaborate in the preparation of public exhibitions associated with the Open Days at Research Centres and Universities, Forum "Ciência Viva", "Semana de Ciência e Tecnologia", and a proposed "Dia do CERN" similar to the successful past event of "Dia do Espaço".

CERN invites one teacher per country to participate in the program "High-School Teachers at CERN", in which the selected candidates participate, during three weeks in the summer, in an intense update course in Particle Physics and the carry out of activities with the help of CERN experts, in several working groups. In the past two portuguese candidates were selected, and in both cases CERN accepted to pay an extra teacher from Portugal. We shall coordinate the portuguese part of this program.

We plan to develop several tools for the promotion of Particle Physics in Portugal, in particular tools for the Web. We shall renew the outreach page of the LIP public Web site, and prepare it for a 'Particle Physics portal', including:

- updates of LIP activities, projects and experiments, links and main news of interest for people motivated by Particle Physics;
- developed films depicting details of the world of particle physics (as for example the film of the experiment "The muon lifetime");
- a page in the style of "Ask an expert", where a visitor to that page can put up a question pertaining to the world of high-energy physics, and the question will be routed to an expert that will provide an answer. In that page there will be an archive of relevant questions and their answers, and after some experience we shall be able to provide a 'Particle Physics FAQ' (a file with Frequently Asked Questions and their answers);
- tools developed at CERN and elsewhere, translated to portuguese, in particular the famous site of "Hands on CERN" (part already included);
- a page of seminars given to public at large and in schools, with the possibility of "Call a seminar", in which a school or other organization can ask for a particular seminar to be taught in their installations, and then we will put the selected speaker in contact with the school/organization to get down to the details.

Finally, we propose to maintain the active participation in the EPOG working group, in particular the participation of the portuguese representative in its semi-annual meetings, the contribution with ideas and solutions, and the translation to portuguese, subject to budget availabilities, of the brochures, posters, films and booklets, produced at CERN and other sites. In particular we shall study the possibility to organize in Portugal the EPOG event of the masterclasses, which gathers high-school students in high-energy physics institutes to spend one morning with lessons about particle physics, and one

afternoon for hands-on sessions (classification of high-energy real data events collected at LEP, using the web-based "Hands On CERN" program in the computers of the institute).

Measurement of Correlations in Cosmic Rays with the High-schools

In the follow-up of the project "Cosmic Ray Telescope", it is planned to profit from the equipment installed in the high-schools to measure, with the help of the teachers and motivated students, correlations in time between measurements of showers in two or more separated schools. After some experience with the present set-up, it is planned to consider the installation in other high-schools of the same basic system, to increase the possibility to observe these long-range time correlations. If the need for the duration of some runs becomes large (say, more than one weekend continuously taking data), this can be planned for the periods of the students holidays, in order not to interfere with the normal laboratory introduction to those students.

This subject is very interesting, since these correlations were observed in a work of O. Carrell and M. Martin in1994, in Switzerland (reference [1]), and were never repeated. The running of cosmic ray experiments in the high-school is a wonderful opportunity to motivate students (and teachers) for Particle Physics.

Training program

At this moment, there is a student of Physics Engineering in Instituto Superior Técnico preparing the graduation thesis in the Cosmic Ray Telescope project (simulation of cosmic rays in the set-up of a typical school installation, and comparison with the data collected there). If this project is approved, it is expected the engagement of other students in the measurements of cosmic rays in the high-schools.

[1] O. Carrell and M. Martin, "Observation of Time Correlations in Cosmic Rays", Départment de physique nucléaire et corpusculaire, University of Geneva, preprint UGVA-DPNC-1994/1-162, January 1994;

O. Carrell, "Recherche de Gerbes Cosmiques Extraterrestres", Ph. D. Thesis presented to the Department de physique nucléaire et corpusculaire of the Geneva University, 1994, *unpublished.*

WORKING PLAN

Project Title: Collaboration in the EUSO experiment

Team

Project Coordinator: Mário Pimenta

PhD:

Mário Pimenta,	50%
Maria Catarina Espírito Santo,	70%
Bernardo Tomé,	70%
Pedro Abreu,	30%
António Onofre,	10%
Luís Melo,	10%
Pedro Brogueira,	10%
Jorge Gomes,	10%

Students:

Pedro Assis (PhD Student),	100%
Filipe Cardoso (undergraduate)	50%
Miguel Paulos (undergraduate)	50%

Activities Foreseen:

The participation of Portugal in EUSO is a responsibility of LIP – Laboratory for Instrumentation and Particle Physics. EUSO is concluding (Spring 2004) the phase A of ESA, which established the requirements and feasibility of the project, addressing aspects ranging from the detailed instrument design to its installation and operation on the ISS. According to the schedule, phase A will be followed by a Phase B of approximately 1.5 years, dedicated to the detector design and to the conception and testing of prototypes. Phase B is foreseen to start in mid 2005. A Phase C/D of approximately 3.5 years will follow, dedicated to the final detector design, construction, test and calibration. The EUSO experiment will be accommodated on the ISS in 2009/2010, for a nominal period of three years.

The main activities of the LIP/EUSO team are:

- Coordination of the EUSO Science Operations and Data Centre Subsystem (SODC), addressing the issues of data collection, monitoring, certification, distribution and archiving. The main topics for the SODC phase A study were: identification of the Columbus/ISS operation context; preliminary evaluation of data volumes; identification of the operation modes and procedures; conceptual design of the ground data handling facilities; preliminary planning of archives and databases; preliminary

evaluation of costs and manpower. Portugal has at present the support of the collaboration to be the host country of the SODC.

- Participation in the program of experimental activities studying different parameters that are critical for EUSO. The project ULTRA – UV Light Transmission and Reflection in the Atmosphere – is based on a hybrid system consisting of an UV optical detector (UVscope) and an array of scintillators (ETscope). The development of the data acquisition system and the GPS-based position determination and synchronisation system are a responsibility of the LIP group. The group also participated in the analysis of the data collected by the BABY balloon and is interested in recently started fluorescence yield measurements.

- Participation in the Atmosphere Sounding, namely on the evaluation of the feasibility and performance of infrared cameras in the EUSO context, to monitor and characterise the cloud coverage in the field of view.

- Participation in simulation and reconstruction software development. The LIP group has recently started a line of activity concerning both the development of energy reconstruction methods and the participation in the development of ESAF, the EUSO simulation and analysis framework.

- Participation in education and public outreach program.

In the following the planned activities will be described by subject.

SODC – Scientific Operations and Data Centre

As part of the EUSO Phase A study, EUSO operations were addressed by the SODC team, considering the flight and the ground segment in an integrated way. This led to the definition of a preliminary operations concept, and made possible the estimation of the EUSO telemetry needs and the definition of the generic requirements and structure of the SODC. From now to the start of phase B (mid 2005), it is important to concentrate on the internal architecture of the SODC, which was up to now addressed only at a rather generic level. The basic functional blocks of the SODC can be divided in three basic units:

- Telecommand generation, mission planning and system maintenance (Unit 1);
- Telemetry reception, processing and monitoring (Unit 2);
- Mission archive and database, external database handling, user support (Unit 3).

Each of these units includes a number of different modules and functionalities, which were outlined during Phase A and should now be converted into a detailed requirement statement and architecture definition.

As Unit 1 includes all the aspects related to telecommand uplink, its detailed definition is highly dependent on aspects external to the SODC, such as the definition of the role of the ESA part of the ground segment (Columbus control centre) and of any aspects related to the ISS communications (data links, bandwidths, protocols and formats). The more detailed definition of such aspects amplies further information and discussion with ESA, not expected before to final decision to proceed to Phase B.

Units 2 and 3 are reasonably well constrained provided the expected data rates and types are defined. These will, thus, be the addressed in priority. In particular, Unit 3 focus on

aspects that should be addressed relatively early in the lifetime of the mission. In fact, much before operations, the organisation of mission related data and the communication between users start to become relevant issues. This is particularly true with the development of end-to-end simulation and reconstruction tools, which will soon produce large amounts of data and require the access to auxiliary atmospheric and (simulated) detector condition data.
Furthermore, the possible participation of industry (Portuguese software companies) in the development of the SODC during Phase B should be addressed and defined during this period. In view of this, a small and self-contained collaboration with the company Edisoft was initiated, aiming at a better definition of the requirements and at the outline of the architecture of Unit 3 of the SODC. Edisoft is at present developing work in the same area for Land SAF, one of the elements of the EUMETSAT ground segment hosted by the Portuguese Institute of Meteorology. While the data volumes are, in the case of EUSO, much lower, specific needs and characteristics arise: EUSO calibration is a complex process and involves different types of collected calibration data and software tools; large volumes of atmospheric data, both collected by EUSO and belonging to external databases, have to be used in reconstruction; a processing and monitoring environment compatible with the EUSO simulation and analysis environment would be desirable.
In short, important preparatory work for Phase B should be carried out during this period, making it possible during the relatively short Phase B to achieve the required level of detail in the definition of the system.

ULTRA – UV Light Transmission and Reflection in the Atmosphere

After the engineering run of ULTRA in the French Alps in the summer of 2003, this is a crucial year for the ULTRA experiment. In early March, an integration test will be carried out in Grenoble. This test will involve 5 ETscope units and the data acquisition system based in the LIP-PAD board developed by the LIP group. The LIP-PAD is a PCI based board with an analog acquisition subsystem, with six 8-bit channels, and a time measuring subsystem, with a dynamic range wider than 1 second and a resolution of a few nanoseconds. The associated digital logics is implemented in a ALTERA PLD. A GPS signal is used to synchronise the device.
The UVscope detector, re-designed after the engineering run, is at present under construction in Palermo. The Lisbon group is contributing with detailed simulation work (based on GEANT4) of the instrument (in particular of the Fresnel lens), crucial for the validation of the instrument design and for the understanding of its performance.
A run of ULTRA including both the ETscope and the UVscope, as well as the LIP-PAD data acquisition system, is expected to take place in Sicily still during the first half of the year. The main goal of this run is the observation of a clear signal corresponding to the reflected Cherenkov light.
A master thesis on the ULTRA data acquisition and synchronisation system will be completed in Spring 2004. An *Initiation to Research* grant has been given in the context of the testing of the new generation of Motorola GPS receivers.

Measurement of the Fluorescence Yield in Air

Air fluorescence yield measurements have recently been started at LIP-Coimbra. The system consists of a chamber with controlled conditions of pressure and temperature (namely refrigeration possibility) and a UV light collection system. Fluorescence spectra by excitation with alpha particles have been obtained and present at the 2nd International Workshop on Air Fluorescence Yeild IWAFY (Germany, December 2003). Measurements with a beta source and in different temperature and pressure conditions will be carried out. The participation in possible accelerator beam measurements at CERN within a project led by the EUSO Annecy group (MacFly) is also envisaged.

Atmosphere Sounding – Studying the Atmosphere properties as an active medium

The knowledge of the atmosphere properties, in particular of the presence and height of clouds, which may obscure part of the fluorescence signal and of the _erenkov signal, are crucial for the accurate measurements of the cosmic ray energy and arrival direction.
In 2004, the studies related to a complementary system for cloud detection based on infrared cameras will be pursued, with emphasis on the simulation and image reconstruction software development.

Simulation and Reconstruction

The LIP group has recently initiated studies on energy reconstruction algorithms. Energy reconstruction in EUSO depends on the characteristics of the atmosphere at the time the event occurs, which affect both the shower development and the production and propagation of the fluorescence light detected by EUSO. The baseline methods used for performance evaluation during Phase A were based on the integral of the detected fluorescence light. More sophisticated methods, taking into account the shape of the signal, are currently being developed by different groups. At LIP, methods performing a simultaneous fit to the energy and to a reduced number of parameters able to reasonably describe the atmospheric profiles are being investigated. An *Initiation to Research* grant has been given in this context.
Furthermore, additional effort will be put into the understanding of the reconstruction methods, data analysis and physics potential of the Auger experiment, which is the next step forward in ultra high energy cosmic rays and has obvious and important synergies with EUSO.
The EUSO end-to-end simulation and reconstruction chain has been stressed at the final Phase A review as one of the aspects to be pushed further in the near future. ESAF – EUSO Simulation and Analysis Framework, is a C++, object oriented framework, based on ROOT. The LIP group is initiating its participation in the development of ESAF, in particular in its reconstruction modules. This participation should be considerably boosted during 2004.

Education and Public Outreach

The education and public outreach potential of EUSO is very high, covering both science (cosmic rays, EUSO), general aspects related to space (ISS, ground operations) and technologies (electronics, software and detectors). These activities will play an important role and will be carried out in the framework of the general outreach activities of LIP.

Training program

- "Data Acquisition system of the Ultra experiment", P. Assis, master thesis, conclusion foreseen in Spring 2004.

- "Data Acquisition and Control systems in Cosmic Ray Experiments", P. Assis, PhD Thesis.

- Energy reconstruction in EUSO, M. Paulos, *Initiation to Research* grant.

- Test of the new generation of GPS receivers, F. Cardoso, *Initiation to Research* grant.

WORKING PLAN

Project Title: COLLABORATION WITH GEANT4

Team

Project Coordinator: Luis Peralta

PhD: Luis Peralta 35% (Team Leader), Patrícia Gonçalves 10%, Bernardo Tomé 10% Maria Espírito Santo 10%, **Students:** Andreia Trindade 50%, Pedro Rodrigues 50%, Rui Moura 25%

Resumo:
O objectivo deste projecto é a colaboração com o projecto GEANT4, de que este grupo faz parte como colaborador oficial. O código GEANT4 é desenvolvido por uma colaboração internacional de que o CERN é um parceiro. O primeiro trabalho desenvolvido no âmbito desta colaboração, foi o desenvolvimento dum gerador angular de fotões de radiação de travagem que fosse mais preciso na zona de baixas energias que o então implementado. Esse gerador é baseado na função 2BN de Koch e Motz (1959). As responsabilidades do nosso grupo dentro da colaboração GEANT4 aumentaram desde o ano passado, e abrangem agora um maior número de tópicos. *Desenvolvimento de uma gerador para a distribuição angular de fotoelectrões*: Os electrões emitidos após uma absorção por efeito fotoeléctrico, apresentam uma distribuição angular fortemente correlacionada com a polarização do fotão incidente. O primeiro tratamento relativista do problema (Sauter 1930), só é válido para elementos leves, fotões não polarizados e fotoelectrões da camada K. Um tratamento mais geral foi feito por Gavrila (1958 e 1960), sendo aplicável a todos elementos e fotoelectrões das camadas K e L. Esta nova distribuição incorpora também a dependência na polarização do fotão. A descrição correcta da dependência angular da emissão de fotoelectrões é importante na simulação de experiências de medida de polarização de raios-X, como a reportada por Costa (2001), que estuda a luz proveniente de buracos negros ou estrelas de neutrões.*Transporte de fotões ópticos*: Para o transporte de fotões ópticos o GEANT4 fornece um modelo para as superfícies de separação entre meios. Este modelo designado por UNIFIED, não toma em consideração a natureza tridimensional das superfícies de separação, devido à sua rugosidade. Neste projecto propomos rever a classe G4OpBoundaryProcess, incluindo um modelo tridimensional das superfícies ópticas.*Aplicações espaciais*: No quadro das aplicações ao espaço, serão construídos exemplos avançados relativos à utilização de detectores de RICH com radiadores de aerogel ou NaF

Activities Foreseen:

The project objective is the collaboration with the GEANT4 project. The GEANT4 code is developed by an international collaboration where CERN is one of the main partners. Our group is an associate member of the Low Energy Physics Working Group of the GEANT4 collaboration. The first work done inside the GEANT4 collaboration was the development of a more accurate bremsstrahlung angular distribution generator based on the 2BN Koch and Motz (1959) function, and the improvement of other bremsstrahlung distributions. Our duties inside the collaboration have increased since last year and now our responsibilities span over several topics. Development of a generator for the angular distribution of the photoelectron:Electrons emitted after a photoelectric absorption of a photon present a definite angular distribution. The relativistic treatment of the problem for light elements has been worked out long time ago by Sauter (1931), using K-shell hydrogen-like electron wave functions. Later on a generalized solution to the problem has been found by Gavrila (1958 and 1961), which can be used for all elements, K and L-shells electrons and lower electron velocities. This generalization also allows for the introduction of the photon polarization. The correct description of the photoelectron emission has an impact in the simulation of some experiments like the one reported by Costa (2001) (the operation of a photoelectric X-ray polarimeter for the study of black holes and neutron stars) where the photoelectron angular distribution is used to determine the photon polarization.Our aim is to introduce the Gavrila photoelectron angular distribution in GEANT4, allowing for one of the most general descriptions available. The implementation of this generator inside GEANT4 will require a study of the Gavrila photoelectron angular distribution properties, since this is a complex function which can not be sampled using the inverse-transform method (James 1980).For optical photon transport, GEANT4 provides physics and interface models. Physics models include light production (in scintillators and Cherenkov radiators) and light attenuation (Rayleigh scattering and bulk absorption). Interface models simulate the effect of medium boundaries in optical photon tracking. Realistic boundary effects are simulated with the UNIFIED model. The UNIFIED model however does not take into account the true three-dimensional nature of a rough surface. In the work we propose for the next year, a revision of the G4OpBoundaryProcess class will be undertaken. The new revisited class will allow the user to use the distribution that describe the surface or in alternative to provide a three-dimensional map of the optical medium surface.Within the framework of space applications, advanced examples will be constructed, concerning the use of Rich detectors with aerogel and NaF radiators.

WORKING PLAN

Project Title: **Collaboration in the NA50 Experiment**

Team:

Project Coordinator

Paula Bordalo

PhD

Paula Bordalo	LIP Researcher / IST Professor	25%
Sérgio Ramos	LIP Researcher / IST Professor	25%
Catarina Quintans	LIP Researcher	17%
Ruben Shahoyan	LIP Researcher	17%

Students

Helena Santos	PhD Student	100%
Gonçalo Borges	PhD Student	100%

Activities Foreseen

The LIP-Lisbon group working program concerning its participation in NA50 Collaboration will continue to focus on carefull analyses of the different physics aspects of the data, namely :

- Comparative study of ψ and ψ' production and of the ratio ψ'/ ψ, in p-A and S-U interactions

- Study of charmonia suppression in lead-lead collisions

- Study of low-mass vector-meson multiplicities in ion induced reactions and final results merging the three data taking periods.

LIP-COIMBRA

WORKING PLAN

Project Title: Active gaseous scintillators for detecting neutron and other radiations

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Project Coordinator: Francisco Amaral Fortes Fraga (40%)
PhD Researchers : Armando José Ponce de Leão Policarpo (10%), Rui Ferreira Marques (10%), Ermelinda Pedroso de Lima (10%), Maria Margarida Feteira Ribeirete de Fraga (10%), Paulo Jorge Baeta Mendes (20%)
PhD Students: Luís Manuel Silva Margato (100%)**,** Susete Fetal (100%)
MsC Student: Filipa Balau (100%)
Technical Staff: Americo Pereira (20%), Nuno Carolino (20%) , João Silva (20%)

Activities Foreseen:

Development of applied detectors using active gas scintillators using microstuctures (GEMs) operating in the UV, visible and NIR and state of the art optical readout techniques. Due the good results obtained in the studies of the individual light pulses, we focused our efforts on pulse counting mode applications using PMTs.

1. X-ray polarimetry detector : the main objective of this task it now to develop a prototype pulse counting imaging detector with a readout using four PMTs, with possible to microdosimetry. A preliminary simulation was made to check of its feasibility and determine the optimum geometry and, effects such as avalanche diffusion, noise and PMT non uniformity will now be introduced. The experimental system using 4 PMTs will be completed until end of June and a computer controlled sweeping system will be used for the first tests. We envisage to carry the first tests with polarized X-rays at the end of 2004.
2. Large area (32x 32 cm) gaseous detector 3He capable of high background rejection using photon counting devices for thermal neutron imaging. This project is being carried in the Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy - EU 6th Framework Progamme JRA2 - Millimeter Resolution Large

Area Neutron Detector (MILAND), and our group is responsible for task 4 related to option#2 : GSPC (Gas Scintillating Proportional Chamber) with light readout.

3. Recoil detector for fast neutron (1-20 MeV) spectroscopy with single event energy resolution. The energy of the recoil target will be measured from the amount of scintillation and the direction of emission will be computed from the estimated real length of the track and the length of the projection. We have now determined that the energy resolution of the recoil interaction is 2% and the accuracy of determination of track angle is typically 2 degree, using only the PMT readout. We will now build a detector that can be operated at 6 bar using 4He and helium camera and the tests with neutrons will be carried at the Democritos Institute neutron accelerator (Nuclear Physics Laboratory of the University of Ioannina, Greece).

4. Basic GEM scintillation studies will focus mainly on the He mixtures, as we had several requests from groups working in Astrophysics concerning the possibility of GEM optical readout with this gas. We will go on testing the prototype GEMs supplied by 3M.

5. Depth of interaction studies in crystals for a mamography PET scanner. These tests will be continued in our laboratory, as the most recent results using 2x2x20mm crystals have shown a resolution of 2 mm. The effects of crystal wrapping and painting will be studied.

6. Scintillation (30x30cm) screen for 2D-dosimetry in proton radiation therapy free of quenching effects at the Bragg peak. The collaboration with the Technical University of Delft will be continued.

Training program:

Luís Manuel Silva Margato : PhD. Conclusion foreseen in 2004

Susete Fetal : PhD started in 2003 MSc.

Filipa Balau : PhD studies started in 2004

WORKING PLAN

Project Title: Applications of timing Resistive Plate Chambers

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Team

Project Coordinator: Paulo J. R. Fonte

PhD: Carlos Capela, Nuno Chichorro, Paulo Fonte, Rui Ferreira Marques, Carlos Neves, and Armando Policarpo

Students: Carlos Sousa, Milena Vieira, Luís Lopes, Luís Fazendeiro, Patrícia Maduro, Miguel Couceiro

Technical Staff: Alberto Blanco, José Pinhão, Américo Pereira, Rui Alves, Nuno Carolino, João Silva

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Activities Foreseen:
This plan concerns the activities foreseen for 2004.

Developments in RPC-PET
The existing small animal PET prototype will be fully exploited. It is expected that position resolutions lower than 0.5 mm FWHM will be possible. A radioactive phantom will be built and imaged.

Design efforts towards both a human full-body field of view TOF-PET detector and a small-animal high accuracy PET will be initiated. The simultaneous design will allow us to pursue as much as possible a single line of development, instead of doing two, eventually mutually exclusive, developments.

When the opportunity arises an independent project for the construction of a small animal PET will be submitted to the funding authorities. Several other research groups, with expertise complementary to ours, have already expressed their interest in the project.

Developments within the HADES collaboration at GSI
A medium-size prototype of the RPC TOF Wall comprising 20 counters and necessary electronics will be built and tested. The front-end electronics is the responsibility of the University of Santiago de Compostela and CIEMAT Madrid. The preparation of mechanical parts will be the responsibility of the Department of Mechanical Engineering of the Escola Superior de Tecnologia e Gestão do Instituto Politécnico de Leiria. LIP Coimbra will assist the preparation of mechanical parts, assemble the counters and do laboratory tests. A beam test with full integration on the HADES detector is foreseen for early 2005.

A project for the construction of the full HADES RPC-TOF was submitted to the FP6 initiative on “Design of Facilities”.

Developments within the CBM collaboration at GSI

The timing RPC-related R&D studies necessary for the CBM experiment are for the moment concentrated around an approved FP6 JRP and on a complementary approved INTAS project (see below).

Developments within the FP6 and INTAS initiatives

The timing RPC-related R&D studies necessary for the CBM experiment are for the moment concentrated around an approved FP6 JRP named *Advanced TOF* and on a complementary approved INTAS project Ref.Nr. 03-54-3891 named *Development of the high rate RPC TOF detector for particle identification in the CBM experiment*. The first meeting of these working groups has taken place the 12/2/2004.

These approved complementary projects aim at clarifying the necessary issues required for the next generation of very large RPC TOF detectors. Major topics are the counter readout structures, counting rate capability, aging and readout electronics.

We will pursue the already partially successful developments in high-rate timing RPCs. A beam test may take place late 2004 or early 2005.

The ongoing RPC aging studies will be continued and extended.

The continuous effort to understand the detector physics of timing RPCs will be continued in the framework of the FP6 project, in close collaboration with the University of Heidelberg. A dedicated setup will be installed there for the measurement of electron swarm parameters for the gases of interest, while accurate measurements on specially-made timing RPCs will take place in Coimbra this year.

Training program:

Luis Lopes is expected to initiate a masters program and Miguel Couceiro and Luís Fazendeiro a PhD program.

WORKING PLAN

Project Title: Collaboration in the HERA-B experiment

Team

Project Coordinator: João Carlos Carvalho (40%)

PhD: Armando Policarpo (5%), António Amorim (10%), Helmut Wolters (40%)

Students: Vasco Amaral (100%), João Batista (75%), Luis Silva (100%), Rui Matos (100%), Matilde Castanheira (70%)

Activities Foreseen:
The HERA-B collaboration finished data taking in 2003, and in 2004 it will be concentrated in finalizing the data analysis, publish the physics papers and complete the thesis in progress. The "priority measurements" are: the b-bbar cross section, the A dependence of the charmonium production, and charm physics.

The main tasks of the portuguese team for 2004 are:

Database system. The database is a crucial system for the experiment, now in particular for the data analysis. It must be always working as required so it would not compromise the data analysis activities. Its operation must be monitored by experts to detect any possible problem.

Data Analysis. HERA-B collected a very large data sample during the 2002-3 run. The data analysis will be focused in the priority physics measurements. The portuguese group will concentrate its efforts in three tasks. The first is the measurement of the b-bbar cross section at the HERA center of massa energy. This is poorly known, as the results from previous experiments are not consistent. The measurement will be done using the B meson semileptonic decays. Even if this decay is not fully reconstructed, its branching ratio is higher than the other channels and it contains at least one high momentum lepton track, and then it is selected by the HERA-B trigger system. The backgrounds to this channel will be estimated using Monte Carlo data. The second task involves the measurement of the acquired luminosity as it is essential for the determination of absolute cross sections. One of the team members is the convener of this analysis sub-group. The determination of the acquired data luminosity will be done using different methods, with information from independent sets of sub-detectors, searching for the variables with best linear behavior with the number of simultaneous interactions, and estimating the efficiency and systematic errors associated with the different detector and reconstruction quantities. The last task deals with the implementation and test of a new paradigm of data analysis, with the use of databasing technology and data query

languages, which can be used in future particle physics experiments, with a prototype being developed and tested with the HERA-B data sample.

Training program:
Vasco Amaral - Ph.D. thesis conclusion foreseen in 2004.
João Batista - M.Sc. Thesis conclusion foreseen in 2004.
Luis Silva - M.Sc. thesis conclusion foreseen in 2004.
Matilde Castanheira - graduation thesis foreseen in 2004.

WORKING PLAN

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

Project Coordinator: M. Isabel Lopes

PhD:

Armando Policarpo
José Pinto da Cunha
Paulo Mendes
Rui Ferreira Marques
Vitaly Chepel
Vladimir Solovov (PosDoc)

Students:

Alexandre Lindote
Ana Catarina Fonseca
Cláudio Pascoal da Silva
Francisco Neves
Rui Miguel Meleiro

Technical Staff:

José Pinhão
Américo Pereira

Activities Foreseen:

1. To carry out the study of the liquid xenon scintillation chamber to nuclear recoils of energy between 20 and 200 keV produced by neutron elastic scattering . The measurements will be performed at the neutron beam of Demokritos Laboratory, Athens, Greece. Namely,
    a) the linearity of the detector response with nuclear recoil energy and gamma-energy;
    b) the light collection uniformity;
    c) the ratio of scintillation yields due to nuclear recoils and to electrons (i.e. the so called *quenching factor*);
    d) the neutron/gamma scintillation pulse shape discrimination;

e) test of the position reconstruction algorithm developed.

2. To measure the intensity of secondary scintillation in xenon gas as a function of electric field and gas temperature down to the temperature of liquid xenon (-110ºC). The absolute number of VUV photons per electron emitted in the secondary scintillation process will be measured at different electric field strengths and temperatures, in the xenon saturated vapour and in gas at different pressures. These results are relevant for detection of the ionisation events resulting in a few electrons in double-phase liquid xenon detectors being developed for WIMPs.
3. Detection of low energy signals in a double-phase liquid xenon detector, like ZEPLIN-3 of UKDMC, requires amplification of the signal in the detector. A feasible alternative to secondary scintillation seems to be the electron multiplication in the gas phase with novel microstructures that have been proven to operate at the standard conditions. However, they performance in ultra-pure saturated xenon gas at low temperature is not studied. We plan to study the electron multiplication in xenon gas above the liquid with a gaseous electron multiplier (GEM). If it works, the multiplication gain will be measured as a function of applied voltage.
4. The reflectivity of the materials at xenon wavelength (175 nm) is poorly known. Both absolute reflectivity coefficient and the profile of the reflected light are necessary for optimisation of the light collection. We plan to measure the angular distribution of the reflected VUV light from such materials as PTFE, aluminium and stainless steel. Two options for spatially resolved VUV detection are considered one being with a position sensitive photomultiplier, movable around the irradiated sample. The other solution could be a VUV sensitive photographic film totally surrounding the region of interest. A possibility of parametrisation of the measured profiles for further use in Monte Carlo simulation of a real detector will be studied.

Training program:

Ana Catarina Fonseca, Cláudio Pascoal da Silva and Rui Miguel Meleiro will do their graduation project (graduation in Physical Engineering) in the framework of this project Alexandre Lindote will start his Ph.D. work programme**.**

Francisco Neves is expected to conclude his work programme in view of getting the PhD degree.

WORKING PLAN

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

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Team:

Name	Position	% of full time in project
Maria Margarida Feteira Ribeirete de Fraga	Project Coordinator	30%
António Joaquim Onofre de Abreu Ribeiro Gonçalves	PhD Researcher	25%
Mário João Martins Pimenta	PhD Researcher	10%
Armando José Ponce de Leão Policarpo	PhD Researcher	20%
Rui Ferreira Marques	PhD Researcher	10%
Francisco Amaral Fortes de Fraga	PhD Researcher	5%
Susete Fetal	PhD Student	5%
Nuno Filipe da Silva Fernandes de Castro	PhD Student	10%
Filipe Manuel Almeida Veloso	PhD Student	10%
Americo Pereira	Technician	20%
Nuno Carolino	Technician	15%

Resumo:

A detecção de radiação de fluorescência produzida na atmosfera por raios cósmicos incidentes de muito alta energia, é uma técnica que tem vindo a ser utilizada pela nova geração de experiências como Hires, Auger e, no futuro, por EUSO. Este método baseia-se na excitação das moléculas de azoto pelas partículas carregadas do chuveiro produzido no ar (electrões e positrões) seguido da emissão de fotões num comprimento de onda na região entre 300 e 400nm. A emissão de radiação de fluorescência produzida pelas partículas carregadas é considerada isotrópica e proporcional à energia perdida por unidade de comprimento no ar. Este plano de trabalhos pretende combinar o know-how dos vários membros que constituem a equipa de trabalho, tanto na área da física das astropartículas como na dos processo fundamentais de física da radiação, e assim contribuir para uma melhor compreensão dos processos físicos envolvidos na cintilação

do ar e para uma redução dos erros sistemáticos associados à medida da eficiência de emissão por fluorescência.
O principal objectivo deste projecto é medir de forma sistemática a quantidade total de luz emitida no azoto e ar seco em função da pressão e temperatura, em determinadas regiões de comprimentos de onda, utilizando electrões energéticos como fonte de excitação. O estudo da influência do vapor de água e possívelmente de outros gases presentes na atmosfera como gases minoritários, é um aspecto importante que será tomado em consideração. Este estudo inclui a medida da luz total emitida em função da concentração do gás minoritário e a análise dos espectros de emissão de forma a verificar se as emissões características desses gases na região de sensibilidade dos fotomultiplicadores são ou não importantes. As medidas da luz total emitida têm de ser efectuadas com elevada precisão em pequenos volumes de gás, de forma a contribuir com informação relevante para a modelização das energias dos raios cósmicos de muito alta energia. A calibração do sistema óptico de detecção e de outras unidades de medida é, por isso, de primordial importância. Um detector de electrões (cintilador plástico acoplado a um fotomultiplicador ou detector semicondutor) colocado face à janela de entrada da radiação, permitirá a medida da energia dos electrões. Os sinais deste contador são ainda utilizados no sistema de trigger. Prevê-se ainda o teste de um dispositivo experimental no feixe SPS do CERN, para o qual foi submetido um projecto (Ref:MacFly-MEMO-01 de 11/24/2003).

Activities Foreseen:

Measurements will consist of spectral analyses and total light yield measurements of the primary scintillation of nitrogen and dry air, using α and/or β particles as excitation sources.

1. Spectral analyses: the main purpose of this study is to investigate and quantify the quenching of the main emissions of N_2 and dry air by the parent gas(es) or by small concentrations of the minority gases present in the atmosphere. Characteristic emissions of these gases may also be present. Spectral studies will allow us to check if these emissions are present and, if so, to identify them. Due to the relative low number of primary photons emitted per MeV of deposited energy, it is necessary to maximize the throughput of the optical system. An experimental system for energy resolved measurements will, thus, be developed in order to enable measurements of very low levels of light yields. The absolute calibration of the detection system will also be performed with a tungsten ribbon lamp.

2. Total light yields: we will measure total light yields in given wavelength regions, as defined by adequate filters, as a function of pressure and temperature for nitrogen and dry air. Time resolved measurements will also be performed for the main molecular bands and/or atomic lines, as a function of pressure and temperature. Since precise light yield measurements (uncertainties should be less than 10%) are essential for the modelling of the cosmic air showers, calibration of all the measurement devices will be an essential part of these measurements.

Up to now, most measurements neglect the effect of water vapor on total light yields. We will study this effect by measuring the ligth intensity in given wavelength bands as a function of the water vapor concentration.
The experimental set-up will consist of chamber coupled to two photomultipliers working in the photon counting mode. An electron detector will be mounted, opposite to the radiation window. As electron detector we will consider the use of either a plastic scintillator coupled to a fast photomultiplier or a silicon detector.

3. Total light yield measurements in the CERN-SPS beam: An experimental set-up will be tested at CERN in the SPS beam facility for which a dedicated proposal has been submitted (Ref:MacFly-MEMO-01 of 11/24/2003). The tests will focus: i) on the total light yield dependence on pressure and temperature; ii) on the fluorescence light produced in a shower device by the electrons of the beam.