

6<sup>th</sup> June 2016

## **LIP International Advisory Committee**

Meeting of 6<sup>th</sup> and 7<sup>th</sup> April 2016 in Coimbra

### **Executive Summary**

LIP Management met with the recently enlarged International Advisory Committee on April 6<sup>th</sup> and 7<sup>th</sup>, 2016.

In addition to summary reports distributed ahead of the meeting, detailed information was provided by project leaders about the full scope of LIP activities, covering three main areas: Experimental Particle and Astroparticle Physics, Development of new Instruments and Methods and Computing.

In Experimental Particle and Astroparticle Physics LIP researchers are addressing some of the most topical questions, such as new laws of fundamental physics, origin of dark matter, which represents approximately 80% of the matter content of the Universe, and studies of particle collisions at the highest energies ever recorded. The programme of Experimental Particle and Astroparticle physics is of world class quality and LIP researchers make significant contributions to the leading experiments in the field.

Over many years members of LIP have made major contributions in the area of 'Development of new Instruments and Methods'. Particularly noteworthy are recent developments in medical imaging. Efforts in Positron Emission Tomography (PET) instrumentation have led to instruments, presently evaluated in clinical trials and resulted in contacts with industries which have the potential of developing instrumentation with major impact in the field of medical imaging.

For a long time LIP has recognized the importance of scientific computing for science in Portugal. LIP has developed and is operating three major computer centres which are part of a world-wide computing network. They provide the computing infrastructure and are vital for science in the country.

One very positive development is the increasing strength of research outside the traditional sites at Coimbra and Lisbon. The development in Braga is particularly noteworthy, where in a few years a strong research activity was built up, including fruitful collaboration with other university departments and with local industry. In parallel, collaborations between the various LIP sites have been strengthening with a clear impact on the quality and efficiency of the research.

LIP is well aware of the importance of communicating their research activities to the general public. Their efforts are an inspiring example for many groups around the world. LIP, however, also recognizes that the (under)standing of fundamental particle physics within the universities needs further and continued exchange of information.

The Committee noted the impressively wide range of activities in the area of Development of new Instruments and Methods. It is recognized that further synergies and

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consolidations of activities should be encouraged with the aim to further strengthen the impact and visibility of these LIP activities in the medium term.

One concern expressed repeatedly and shared by the Committee is the lack of clear career prospects for scientists. Many researchers in their early forties are still employed on temporary contracts with no obvious perspectives of pursuing their scientific career. For a fruitful prospect of LIP research, the Committee considers it essential to establish mechanisms for the long term career development.

A related problem is the lack of a mechanism to provide a roadmap for the funding profiles needed for scientific research which extends frequently over ten to twenty years. This makes planning of experiments very hazardous and has prevented some of the LIP groups to accept major scientific responsibilities in international collaborations, with detrimental impact on the scientific output of the country.

The Committee understands that the last years have been quite difficult because of funding uncertainties, lack of support for students and lack of career prospects for young scientists. Nevertheless, LIP has managed to carry out their research program at the highest level with the potential to continue to be a major actor at the forefront of science. The Committee congratulates LIP to these achievements.

## **Introduction**

The LIP International Advisory Committee met in Coimbra on April 6<sup>th</sup> and 7<sup>th</sup>, 2016 to review the 2015 results and to discuss the 2016 and long-range programme of work.

Present: C. W. Fabjan, P. G. Innocenti, K. Parodi, L. Rolandi, M. Teshima

Apologies: S. Bertolucci

Prior to the meeting, Committee Members received written reports on the work carried out in 2015 and a plan of the activities planned for 2016. The reports consisted of a general description of the individual programmes and of a detailed account of each research project, covering scope, past achievements and plans for 2016 and beyond.

Committee Members had an introductory meeting with the LIP Management: M. Pimenta (Chairman), G. Barreira, N. Castro, P. Fonte, R. Marques and A. Onofre. The secretaries of the LIP Scientific Council, P. Gonçalves and F. Veloso also attended this meeting. M. Pimenta welcomed the new Committee members, outlined the terms of reference of the Committee and emphasised the importance of its advice. He then gave an overview of the Portuguese and international LIP activities.

Detailed presentations on the progress of each project were given by the project leaders, followed by questions and answers. The Committee appreciated the high quality of the presentations and the careful preparation of the meeting.

In a wrap-up session after the presentations, Committee Members had the opportunity of expressing comments of a general nature to the LIP Management and to the representatives of each project.

## Particle and Astroparticle Physics

The topics addressed by LIP researchers in Experimental Particle and Astroparticle Physics cover some of the most fundamental questions, such as new laws of physics (e. g. supersymmetry), origin of dark matter and studies of particle collisions at the highest energies.

The LIP groups of ATLAS and CMS are major partners with high visibility and impact in these two experiments taking data at the highest energy ever reached by an accelerator. The ATLAS group has important responsibilities in the operation and upgrade of the hadronic Tile Calorimeter and related triggers, including many aspects of hardware and data control system. They participate also to the forward detector ALPHA and forward proton tagger. The CMS group contributes to the electromagnetic calorimeter (ECAL) maintenance and upgrade and has a leading involvement and management responsibility of the CMS Totem Precision Proton Spectrometer project where they contribute to the crucial timing detectors and to the development of the CT-PPS data acquisition system.

Both groups have a large presence in the research programme of the experiments including studies of proton-proton, proton-lead and lead-lead collisions. The CMS group participated to the  $B_s \rightarrow \mu \mu$  discovery, searches with tau leptons in the final state and studies of “onia” polarization. One member of the team is the coordinator of the B-physics group. The ATLAS team contributed to studies of Higgs production and decays, especially in the  $b\bar{b}$  final state and studies of rare top quark decays.

The group “LHC phenomenology” has a significant collaboration with the experimental groups, especially ATLAS. They concentrate on top physics including top quark anomalous couplings and single top production via Flavor Changing Neutral Currents (FCNC) at the LHC.

The LIP group in COMPASS has been fully engaged in the 2015 run and has given important contributions to the physics analysis of the Drell-Yan data. The experimental program is now centred on Generalized Parton Distributions through measurements of exclusive channels. For this, COMPASS has been upgraded by adding new detectors; these detectors have required sizeable modifications to the Detector Control System, DCS, which is a continuing responsibility of the LIP team in the Collaboration. The experiment has started a new campaign of data taking in 2016.

The HADES group maintained the TOF-wall in flawless operation during last run and is contributing to physics analysis. The plan is to keep the TOF-wall in stand-by during the current shutdown. The Committee is concerned by this long term hardware commitment, given the uncertainties in the schedule of the FAIR project at GSI.

The Auger experiment is studying Cosmic Ray collisions at the highest accessible energies, yielding unexpected results. This points to the need to improve muon identification by direct muon measurements. The LIP-initiated pilot project (MATRA) to install RPCs under the water Cherenkov tanks for muon identification has produced encouraging results, both on reliability of the hardware and on its performance. The project will be continued and strengthened in collaboration with a Brazilian team, also in view of its use in other possible experiments. However, this will be a relatively small effort. The Auger Collaboration had decided to improve muon identification by using scintillators and not RPCs as proposed by the LIP team.

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The extension of the Auger operation for another 10 years, approved in 2015, is recognized as an extremely important and wise decision, which acknowledges the results obtained so far and the large discovery potential of Auger.

The AMS experiment on the ISS had a full year of data taking. The LIP team, in addition to the continuing tasks of maintaining and improving the RICH reconstruction algorithms and participating in the operation of the AMS in the mission control centre at CERN, is developing advanced analysis techniques, as for instance Boosted Decision Tree (BDT) algorithms to distinguish antiprotons from electrons in their large data set. The LIP team is also participating in the study of particle fluxes modulated by solar activity.

The LUX experiment continues data taking. Analysis of the total data set collected so far, with a refined calibration, has improved by a factor 2 to 3 the world's limits on dark matter candidates. The LIP group is very active in the next generation Dark Matter search, LZ; it has given a substantial contribution to the Conceptual CD-1 review, approved by DOE, and to the Technical Design Report, thanks to its experience in data analysis and in detector control systems.

The commissioning of the SNO+ detector was delayed by a water leak which was finally repaired at the end of 2015. Commissioning of the detector should be finished in 2016. LIP has delivered and will continue testing the photomultiplier calibration system and has designed and constructed the source insertion mechanism. The LIP team has been working on a set of analysis and monitoring tools.

### **Detector Developments and Medical Physics**

Confirming a tradition of excellence of Portuguese Universities in the area of particle detectors and instrumentation, LIP produced excellent results in many areas.

Recent developments in medical imaging have been very encouraging. The Clear-PEM project has produced instruments for Positron Emission Tomography (PET) which are being thoroughly evaluated in clinical trials. These developments have permitted a close collaboration with industries, such as PETSys, which have the potential of developing instrumentation with major impact in the field of medical imaging. Further research aims to improve time resolution, by using silicon photomultipliers and a more performant readout chip.

The development of RPCs for a time-of-flight PET (TOF-PET) has continued with tests of a small animal PET system, yielding excellent position resolution. Simulation of a full body human PET and tests on a simple prototype also predict good performance.

Other innovating ideas have been pursued and have materialized with encouraging results, such as orthogonal imaging and auto-calibration of a gamma camera, to name a few.

Studies of a high pressure gaseous xenon mixture for the TPC of NEXT, a  $^{136}\text{Xe}$  neutrinoless double beta decay experiment have continued with encouraging results. These investigations could be particularly valuable, if found application in a neutrinoless double beta decay experiment.

Detector developments have been supported by the project Rad\_for\_Life, which ended in the second half of 2015. It covered a broad spectrum of studies on gaseous detectors, neutron detectors, and investigations related to medical imaging. It was a vital source of funding

during a period of financial hardship. The final report of the project documents the success in all areas.

### **Computing**

LIP research relies very heavily on scientific computing. The group responsible has been very successful in attracting EU funds, in consolidating the various IT projects and in developing the Portuguese GRID infrastructure. LIP initiated and developed three computer centres and is operating them. Availability and performance have been excellent throughout. In addition to LIP research, all Portuguese science is profiting from the world-wide communication infrastructure and the large computer power installed.

The collaboration with computer scientists from the University of Minho has brought to the LIP computing environment a set of competencies that are important for adapting the HEP programs, which are very CPU power intensive, to the new computer architectures. Code optimization is essential! Another area of growing interest is handling of large data sets, with links to data mining and machine learning.

### **Outreach**

LIP outreach effort has been excellent in the past and continues to be so.

On top of the traditional activities, such as master classes, training for Portuguese speaking physics teachers etc., a recent achievement is the exhibition "Particles: from the Higgs boson to dark matter" for the LIP 30th anniversary.

The Committee had the occasion of visiting the exhibition which, after opening in Braga, had just moved to Coimbra, before going to Lisbon. The posters are scientifically precise and informative for the general public; the brochures with its appealing graphics are very attractive.

The LIP annual report has been issued in a new format, which represent a major improvement. A first volume summarises the activities and the management structure, while the second volume provides detailed information on the research program, including scope, past achievements and future plans.

### **Remarks and Suggestions by the Committee**

The Committee notes the increase of LIP research in Braga, involving collaborations with other University departments and technology transfer to industry. More generally, having LIP involved in research of groups in regions outside Lisbon and Coimbra is very desirable as it increases the efficiency and coherence of Portuguese research. The Committee encourages the LIP Management to continue the action aimed at enhancing the collaboration between LIP sites and to explore new areas of possible collaboration. Along this line, the association to LIP of nuclear physicists from the Centro de Física Nuclear da Universidade de Lisboa, which took



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place in 2015, is a positive step in this direction: research interests common with those at GSI, CERN ISOLDE and in nuclear astrophysics will generate productive synergies.

The range of activities in the area of "Development of new instruments and Methods" is wide and the results obtained are valuable. The Committee shares the view with the LIP Management that further synergies and consolidations of activities could and should be considered to further sharpen the focus and to strengthen the impact and visibility of this research and development in the medium term.

Simulation, and in particular GEANT4, are assuming an increasingly important role in all areas of research. Expertise with simulation tools resides naturally in some groups, e.g the team involved in Radiation Environment Studies for Space Applications. Other research projects, new to simulation, could profit from a "LIP simulation competence centre" where newcomers, in- and outside particle physics, could be given (initial) guidance.

One concern expressed repeatedly and shared by the Committee is the lack of clear career prospects for scientists. Many researchers in their early forties are still employed on temporary contracts with no obvious perspectives of pursuing their scientific career. For a fruitful prospect of the LIP research, the Committee considers it essential to establish mechanisms for the long term career development.

A related problem is the lack of a mechanism to provide a roadmap for the funding profiles needed for scientific research which extends frequently over ten to twenty years. This makes planning difficult and hazardous. It has prevented some of the LIP groups to accept major scientific responsibilities in international collaborations with detrimental impact on the scientific output of the country.

The very high quality of research has been maintained at LIP during the past years despite financial restrictions, lack of support for students and lack of career prospects for young scientists.

LIP, as a laboratory, has maintained its prominent position at the forefront of the international scene and its researchers are valued as essential members of Collaborations.

The message to Society through the training and outreach programmes has been attractive, professional and is well received.

The Committee congratulates LIP for these remarkable achievements.

  
C. W. Fabjan      P. G. Innocenti      K. Parodi      L. Rolandi      M. Teshima