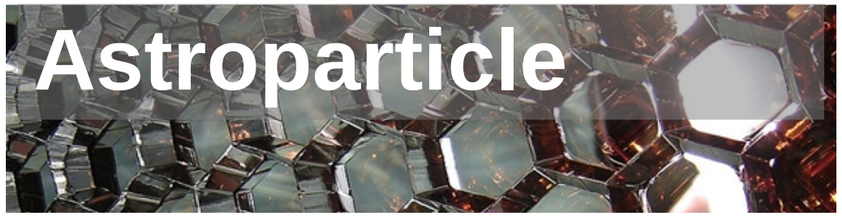


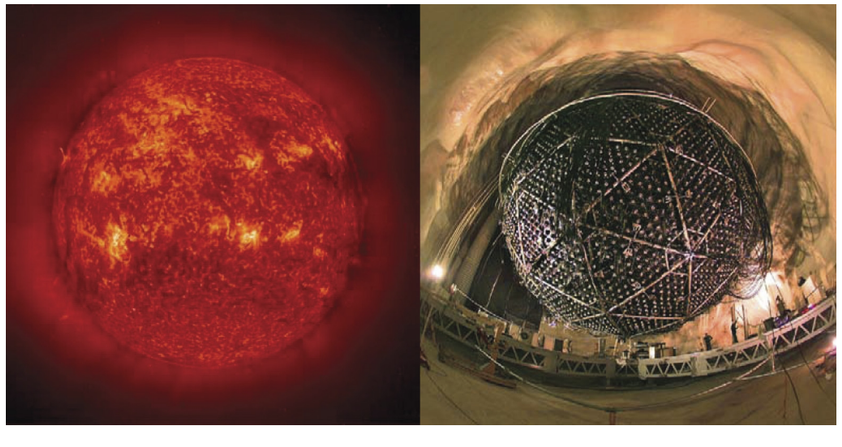
Astroparticle physics had a remarkable development in the last years. It is a research domain at the **border** between particle physics, **astrophysics** and **cosmology**. LIP organized, since 1996 and every two years, the international workshop "New Worlds in Astroparticle Physics", in partnership with theoretical and experimental groups in astrophysics and cosmology. Since then, LIP has been involved in some of the large projects in the field.

LIP is a member of the Pierre Auger Observatory, the world largest observatory for the study of the high energy **cosmic rays**, covering an area of 3000 km². These particles are extremely rate, and their origin remains a mystery. Auger is obtaining important results on the arrival direction of these particles and their interactions in the atmosphere at energies above the LHC.

Lower energy cosmic rays are studied with AMS. This complex particle detector installed in the International Space Station will collect information on the **anti-matter** in the Universe, amongst other fundamental questions. Since 2004, LIP has also worked with the European Space Agency in the study of **space** radiation environments in contracts involving the Portuguese industry.

LIP participates in the search for **dark matter**, which should constitute about 25% of the Universe. Several models predict the existence of weakly interacting particles which could explain this invisible mass and were never created at accelerators. LIP participated in the ZEPLIN projects and is now involved in LUX for the development of a detector with an about 100 times larger sensitivity. The long work of LIP in the development of Xenon detectors is one of the main ingredients of this participation.

LIP is also involved in **neutrino oscillation** experiments. SNO+, located in the world deepest underground laboratory, in Canada, should start taking solar neutrino data in 2013, improving both the solar models and the neutrino mass models.



LIP developed skills in **advanced computing**, which are of strategical interest for the research areas of the laboratory, while having a much wider field of application. In full operation, the LHC experiments will accumulate, and will have to process, about 8000 Terabytes of data per year. LIP has been participating in several grid computing projects for the development, implementation and operation of the computing infrastructures of the LHC experiments, and also for generic use.

Grid computing has the goal of integrating in a transparent way resources which may belong to independent organizations, hiding their specific features and presenting an homogeneous interface to users. In this way, large computing infrastructures can be created from spread resources, appearing to the users as a unique system. Grid computing in intensively used in **several scientific and technological domains**: meteorology, medical sciences, aerospace engineering and, of course, high energy physics!

LIP participates in some of the largest international projects in this field, both from CERN and from the European Union. In the context of the **National Grid initiative**, LIP operates the central grid computing node, the largest scientific computing center in Portugal. These computing resources are available to the research community in a large ensemble of scientific domains.

The development of strong bounds between research and **advanced training** is a priority for LIP. The research groups of the laboratory include a few tenths of students, from several universities, preparing master or PhD **theses**. During the last decade, hundreds of young engineers underwent **trainee programs** at CERN, ESA and ESO under the supervision of LIP.

Since 2010, LIP supports the coordination of the **international doctorate network** IDPASC, which groups universities from several European countries and research institutions in particle physics, astrophysics and cosmology, including CERN. This network aims at promoting common training programs and reinforcing the mobility of students, professors and researches of the different institutions.

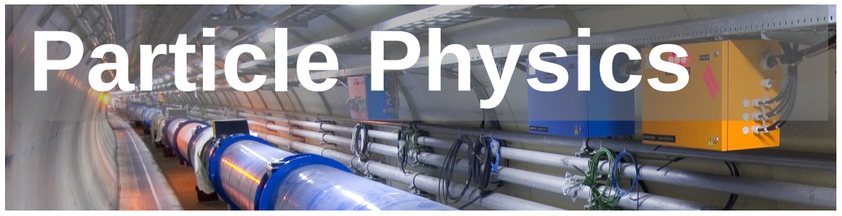
LIP promotes a large number of science outreach activities, in particular for **high school** students and teachers, with the support of *Ciência Viva*. The Radiation Environment project involves 55 schools and the particle physics masterclasses reach more than one thousand students per year. Hundreds of teachers already attended the CERN physics schools in Portuguese language.

The Laboratory for Instrumentation and Experimental Particle Physics celebrates its 25th anniversary!

LIP was created on the 9th of May of 1986, simultaneously in Lisboa and Coimbra, in the context of Portugal joining CERN. The birth of LIP has merged and boosted the efforts of an embryonic community of experimental particle physicists. CERN was the first international scientific organization Portugal has joined. The history of LIP is thus an unavoidable element of the history of scientific research in Portugal. In particular, it appears with high relevance in the chapters devoted to the internationalization and to the large increase of advanced training that Portuguese science met in the last decades.

In these 25 years LIP has grown and changed. Today, it counts about 170 researchers, including 70 PhDs, in its Lisboa, Coimbra and Minho sections. In 2001, LIP became an Associate Laboratory of the Ministry of Science, Technology and Higher Education. Through LIP, Portugal has been in the first row of the great particle physics projects of the last decades. Its research domains include today experimental particle and astroparticle physics, detector development and the associated instrumentation, applications to medical physics and advanced computing. The activities of LIP are now developed in relation with several national and international organizations, in addition to CERN.

Particle Physics



The participation in the main CERN research lines is at the core of the activities of LIP. In the first years, the two great pillars were the systematic studies of particle physics at the **electroweak scale**, in the DELPHI experiment of the LEP accelerator, and a series of heavy ion experiments, which culminated with the observation at CERN of the **quark gluon plasma.** NA50, in particular, contributed in a decisive way for the observation of this state of matter which takes us back to primitive phases of the Universe evolution.

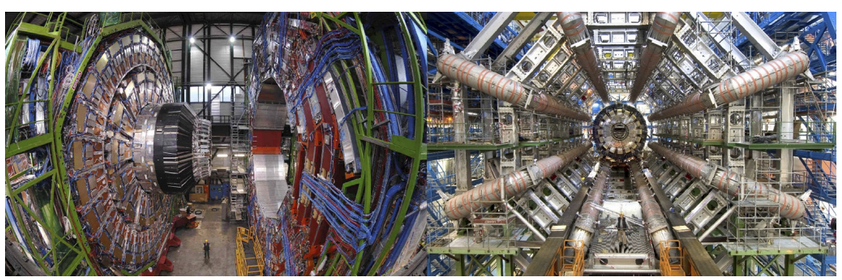
Presently, LIP is involved in the COMPASS experiment at CERN, devoted to the study of the **structure of matter** and in particular to the contribution of quarks and gluons for the nucleon spin, being responsible for the detector control system. LIP also participates in HADES, at the GSI, where it is responsible for the RPC-based time-of-flight detector. Both experiments are presently taking data.

The participation on the LHC, the large proton-proton collider of CERN, is a central aspect of the present activities at LIP. It is the largest particle accelerator ever built, and LIP collaborates in the **ATLAS and CMS** experiments. Both teams had large responsibilities in the construction, test and installation of detectors – the hadron calorimeter TileCal, in particular its optical components, in the case of ATLAS-LIP; and the electromagnetic calorimeter ECAL, in particular its electronics, in the case of CMS-LIP.

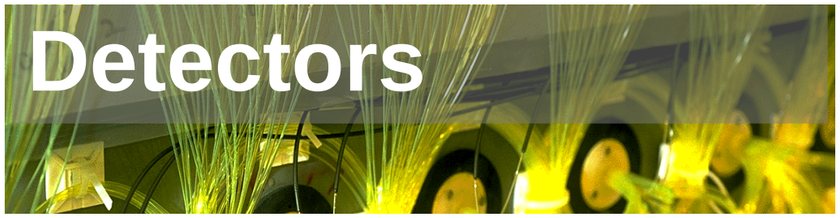
The first **proton collisions** at the **LHC**, at half the nominal energy but still the highest ever reached in laboratory, happened in March 2010, starting a stable data taking period which surpassed all expectations. Near the end of 2010, and for about 3 weeks, the LHC delivered data from **lead ion collisions**.

For the LIP teams that worked for more than **15 years in the preparation** of these experiments, this 25th anniversary of LIP happens at the real turning point. With the start of data taking, the focus of the activities has naturally moved to the physics analysis.

For both LIP-LHC groups, top quark physics appears in the priority list, as well as heavy ion physics. The search for the **Higgs boson**, the only missing “piece” in the elementary particle puzzle, is an unavoidable goal!



Detectors



Profiting from the experience of a group dedicated to the study of gaseous detector since the 1970s, LIP has a long history in **radiation detectors**. The activities of the last 25 years include the development and upgrading of new detector types of different technologies, but also the design, construction and operation of complex detectors for international projects.

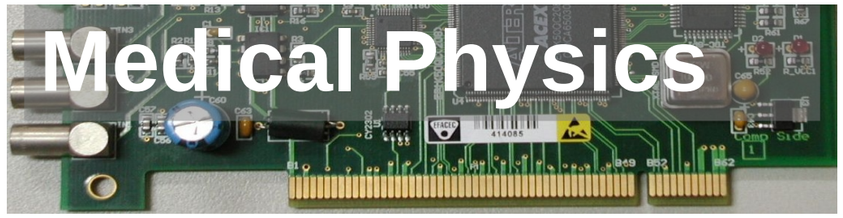
The role of LIP in the development of Resistive Plate Chambers is internationally recognized. These are robust detectors which provide extremely precise timing measurements. **RPCs** are increasingly used has they allow the instrumentation of large areas at moderate costs. The first large project was the construction of a Time Of Flight detector for HADES. Studies on the application for medical imaging are now on-going, and questions on “open-field” operation are being addressed to prepare for use in cosmic rays experiments.

The development and characterization of **gaseous detectors** equipped with **micro-structures** is another of the fields LIP works on. These developments are done in the framework of international collaborations, with dedicated optimization for different applications.

Characterization of **photo-sensors** and **gaseous cintillators** for use in different detector types and applications are also being pursued. Applications for particle and nuclear physics are on-going within international collaborations: NEULAND, for high energy neutron detection, MILAND for thermal neutrons, and the RD51 Collaboration based at CERN, for segmented electrode detectors, including double phase (liquid and gas) detectors.

LIP has also a long tradition in **calorimetry**, with several research and development projects, namely in optical fiber readouts. As a direct result, LIP had important responsibilities in the construction and tests of STIC, the forward electromagnetic calorimeter of DELPHI, at LEP and, mainly, of Tilecal, the hadronic calorimeter of ATLAS, at the LHC. Both projects involved the tests of many thousands of optical fibers and scintillating tiles in Portugal.

Medical Physics



From its beginning, LIP has tried to maintain and develop know-how on **advanced technologies** of direct interest for particle physics research, many being also of useful application in other fields. LIP had responsibilities in the design, implementation and/or operation of data acquisition, trigger or control systems in many projects. Applications to medical physics had special impact in the last years.

LIP has two large **medical imaging** projects, dedicated to positron emission tomography (PET). They focus on developments that increase the position resolution of the obtained images, with reduced acquisition times and lower doses for the patient. The LIP groups developed **prototypes** based on two completely different technologies: scintillating crystals and RPCs. In both cases, these projects started from the experience with the same kind of detectors in particle physics projects.

A **mammography** dedicated PET scanner based on scintillating crystals is being tested in ICNAS, at the Coimbra University. An RPC based scanner for small animals is already acquiring data, while a **full human body** exam prototype is being designed.

Other projects on radio-protection, radiology, radio-biology, radio-therapy and environmental radiation are also underway. In these medical physics projects, LIP collaborates with a large **bio-medical** and health-technologies community, including several national and international partners in research and industry. In these activities, university hospitals and laboratories are used, together with own LIP dedicated **infrastructures**.

LIP's **mechanical workshop**, in Coimbra, was created in 1987. The available equipment, together with a highly qualified staff, provide high quality precision mechanics works. Although closely linked to the research needs of LIP, the workshop is opened and has been used by other research groups and institutions. It has specialized in cryogenics, vacuum equipment and several kinds of detectors. LIP has also a **fast electronics laboratory**, which supports the several projects in these field, putting together the expertise of the different research groups.