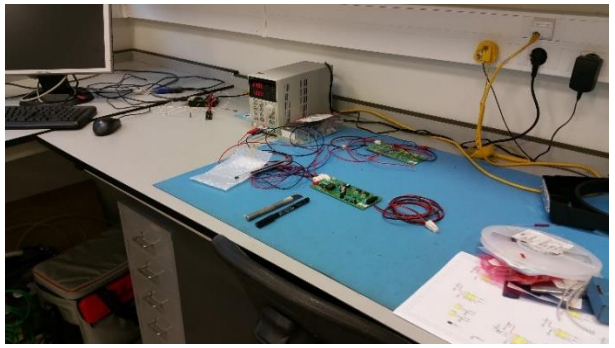
LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS

e-CRLab

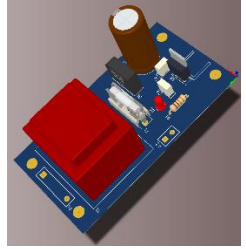
Cosmic
Rays
Electronics
Laboratory

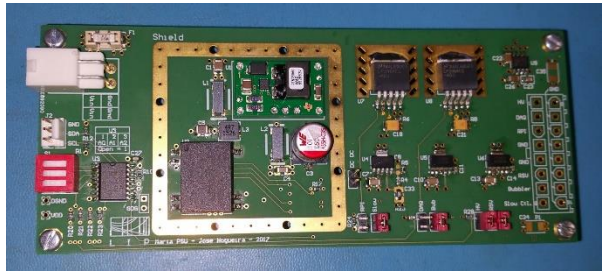


e-CRLab

Cosmic Rays Electronics Laboratory





Main focus: fast digital electronics implemented in FPGAs. Front-end

Capabilities:

- design complex printed circuit boards
- PCB prototyping and production (outsource)
- Assembly and rework in PCB boards (small series)
- Detector operation, optimization
- Test electronics response

Team: Miguel Ferreira (tech resp); José Carlos Nogueira (tech); Rui Fernandez (tech); Luis Mendes (tech)
Pedro Assis (res.); Ricardo Gonçalo (res.); José Venâncio (PhD student); Maria Miguel (MsC student); António Caramelo (MsC student)

MARTA

Rework done in Argentina
Hodoscope station working: Coincidence RPCs giving trigger to tanks
First Station on field coming online: RPCs receiving triggers
Need to assess next steps within Auger

MAROC DAQ board

Stable and being used in several setups (MARTA hodoscopes, MuTom, MicroDosimeter, …)
Explore and boost performance.
Next version: produce new boards; change FPGA, add functionality (Fenix) and connection interfacing

Fenix board:

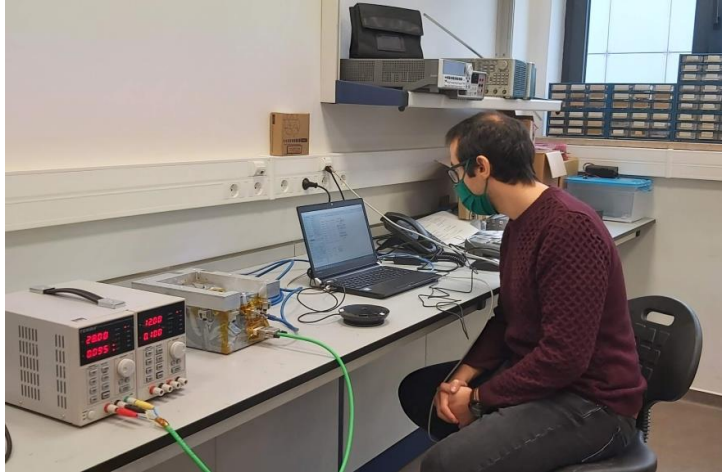
Solution to add computing power to any system. Allows an extended set of interfaces with low resources

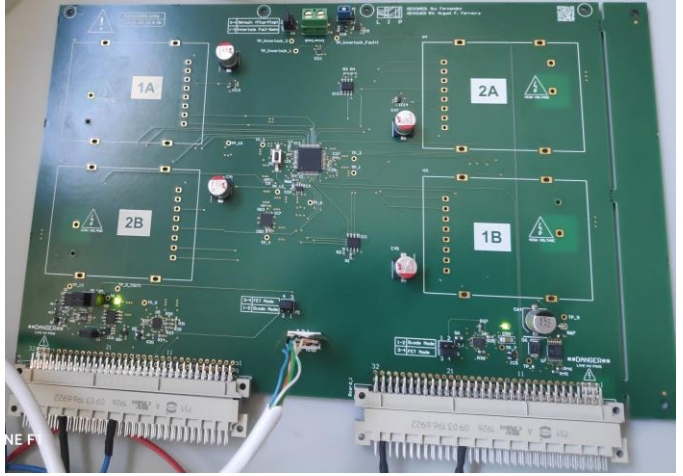
Support systems

Competence gained with the development of the MARTA control system (Control and monitoring)
Time series database + graphana

e-CRLab

Cosmic
Rays
Electronics
Laboratory





Atlas HV

Support for the team working. LOMAC leading the development of the system
HV Supplies performed as per specification (1 Temp. sensor w/wrong power)

ATLAS HGTD

ALTIROC testing: working with OMEGA for performance testing.
Responsibility for TID testing of version3
Enables the contribution in kind of the Portugal to the upgrade.
(small involvment in DCS, HVFilterTesting, Interlock)

SpaceRad

Supporting systems where LIP is involved; Planning to maintain the capability to test response of componentes to radiation. Several students doing project in the area.
BERM EQM setup in the lab.

Instrumentation

Implementation of acquisition in the context of medical and prototherapy, namely the MAROC DAQ system.
Ortho Prompt Gamma imaging, microdosimetry.
PhD student working on the instrumentation of SiPM with Crystals

Plan to develop the lab to increase timing resolution, bandwith and system density. Plan to develop competence on LGAD

RESEARCH INFRASTRUCTURES

E-CRLAB

Cosmic rays electronics laboratory

Coordinator:
Pedro Assis

4 Technician(s):
José Carlos Nogueira , Luís Mendes , Miguel Ferreira, Rui Fernandez

1 PhD Student(s):
José Patuleia Venâncio

3 External collaborator(s):
Marco Alves Pinto, Pedro Brogueira, Ricardo Luz

Executive summary

The e-CRLab is mainly dedicated to the development of electronics for particle and astroparticle physics experiments. The focus is put on fast digital electronics implemented in FPGAs and on front-end electronics. The laboratory has the capability to design complex printed circuit boards and to produce simple printed circuit board (PCB) prototypes. The production and assembly of complex PCB is outsourced. There is also the capability to do rework in PCB boards. A small set of mechanical tools allows the production of simple detector prototypes mainly for proofs of concept. In 2022 the e-CRLab had two main activities: the development, test and commissioning of the electronics for the MARTA detector and the development and test of electronics for the ATLAS upgrade.

MARTA is an RPC-based R&D project within the Portuguese participation in the Pierre Auger Observatory. The electronics were developed at the e-CRLab that has the responsibility of its operation. The systems are expected to become online during 2023. Hodoscopes were also developed and are crucial as calibration- and test-bench of the other detectors used in Auger.

The eCRLab is deeply involved in the HGTD electronics in the context of the ATLAS upgrade - namely testing the front-end electronics for fast timing and, and also in the development of auxiliary systems such as DCS and interlock.

The e-CRLab is also involved in outreach and teaching and gives support to several LIP groups (consulting and design review).

e-CRLab

Overview

The e-CRLab was created as a laboratory for the development of DAQ systems for cosmic ray experiments but has in the recent years diversified its activities. Nowadays, the e-CRLab is mainly dedicated to the development of electronics for particle and astroparticle physics experiments. The focus is put on fast digital electronics implemented in FPGAs and on front-end electronics. The laboratory has the capability to design complex printed circuit boards and to produce simple printed circuit board (PCB) prototypes. The production and assembly of complex PCB is outsourced. There is also capability to do rework in PCB boards. A small set of mechanical tools allows the production of simple detector prototypes mainly for proofs of concept. The laboratory facilities are located at LIP-Lisboa and are composed by an office room, one instrumentation room with state-of-the-art equipment, and instrumentation rooms dedicated to the development and testing of the different setups. A small mechanical workshop for detector prototypes development and a dark room are also available. The laboratory counts with four electronics technicians, has the support of several researchers and has PhD and Master students involved in its activities.

Assessment of the past year: objectives vs. achievements

During 2022, the laboratory has been involved mainly in the MARTA R&D project for the Pierre Auger Observatory, and in the development of electronics for the ATLAS upgrade. Support has been given to several groups at LIP.

In MARTA it was finally possible to organize campaigns in Argentina to commission the setups: a hodoscope for precision studies of the response of the Auger main detectors to isolated muons, whose firmware and software are being finalized and tested; and the "Peter Mazur" station, a regular detector station of the Auger array equipped with RPCs underneath. Recent changes to the setup allow for the estimation of the stability of the RPC efficiency. Most hardware has been deployed and the interface between MARTA and the water Cherenkov detector is being set up in coordination with the AMIGA team (owner of support infrastructure). Both setups are being tested and finalized and are expected to become online in the first quarter of 2023.

The second main activity is related to the ATLAS upgrade and to the in-kind contribution to this program. The laboratory is performing work for the HGTD detector, with the testing program of the ALTIROC ASIC. A technician hired by ATLAS is in the e-CRLab to give support to these activities. During the last year it was possible to acquire expertise in the testing of the ASIC with impressive progress. Moreover, the laboratory has given support to the design of auxiliary systems such as the high voltage power supply for the TileCal, the DCS of the HGTD system and the Interlock system.

Activities within medical applications are being pursued by giving support and adapting solution for the readout of sensors, leaning on the acquired expertise.

It has not yet been possible to dedicate resources to the instrumentation of silicon-based sensors. However, support is being given to the operation of such sensors installed on space radiation monitors. This activity is developed within the Space Radiation group.

Important developments were also made in the slow control and monitoring of the MARTA project. This development comprises the automation of the data filling mechanism into a database, coupled to an off-the-shelf tool for visualization of the data with web interface. Such system has also been deployed in the tomography system at the Lousal mine.

The laboratory has also given support to different groups developing electronics. Most activity has taken the form of consulting, design review or development of small projects. Support has also been given to outreach activities.

Lines of work and objectives for next year

During this year, it is expected that the setups within the Pierre Auger Observatory reach a maturity level and start acquiring data in a stable way. Once the nominal operation at low gas flux is achieved on the field and the performance of the setups is assessed, upgrades to the setup can be considered. Such upgrades are to be driven by the Auger group exploiting the installed setups.

Within the ATLAS activities, the main development is related to the testing of the ALTIROC ASIC. We plan to participate on the tests of the new version (V3). We are currently negotiating our contribution. It is expected that a significant contribution related to the radiation hardness assurance can be achieved. Moreover, we would like to be able to perform tests with the sensor coupled to the ASIC. We will also try to establish synergies with groups using the same type of sensors. The development of auxiliary systems for the ATLAS upgrade will continue. Contributions are expected to be given in the DCS and Interlock subsystems. These activities are done in close cooperation with the LIP ATLAS group.

In terms of DAQ development, we plan to finalize the first parts of the MARTA DAQ upgrade: The development of the multipurpose intelligent module. This will allow the acquisition systems to be more reliable and autonomous. This part can also be deployed in other DAQ or slow control/monitoring systems.

We also plan to increase the support of the laboratory to the LIP community. Such support is expected to be given in consulting or through the development of small electronics projects. One of the novelties is the creation of the first mini-school in electronics to give training in basic electronics design to the community. One important aspect is the training of the new students that are involved in such activities.

Finally we will pursue the development of instrumentation for medical devices taking advantage of the know-how existing in the laboratory. We expect to be able to produce data acquisition systems for SiPM sensors and also for Si-based detectors.

Medium-term (3-5 years) prospects

The infrastructure plans to secure the acquired competence in front-end DAQ and in digital electronics as well as in the system integration. The systems developed will be brought to a mature level and we will exploit possible uses, seeking internal and external partnerships.

We will continue pursuing synergies with research groups at LIP to apply and develop the competences acquired and to support the activities whenever necessary. One of the main lines of development of the infrastructure is based on the capability to develop faster systems with better time resolutions and higher bandwidths. The collaboration with the ATLAS group will be reinforced with the test and developments on the front-end electronics for fast systems.

SWOT Analysis

Strengths

Competences acquired in digital logic design as well as the competence in the design of complex electronic systems. Competence in handling several types of detectors such as RPCs, scintillators coupled to photomultipliers and silicon photomultipliers. Activities developed in the context of research projects. Capability to develop characterization systems. Possibility to plan and perform irradiation campaigns.

Weaknesses

The current level of funding is not compatible with the full development of detectors. Up to now it was not possible to attract direct funding for detector development. Independetly publishing the work developed has been systematically delayed and must be pursued.

Opportunities

R&D activities in the framework of MARTA, SWGO and muon tomography projects create opportunities to lead R&D project and to consolidate the existing core lab activities.In the long term, ATLAS offer the opportunity to consolidate activities on fast and digital electronics. The radiation damage studies present the possibility to attract students and financing through the SpaceRad group. Training activities and master theses developed in e-CRLab may allow to increase manpower and to pursue different projects. The know-how acquired can also boost the participation in new projects related with fast timing and the development of instrumentation for medical physics. The investment plan resulting from the FCT evaluation allows for the increase the capability in test-and-measure.

Threats

Financing is always a key issue when developing hardware. Lack of human resources could be an issue in the mid-term.

SWOT analysis

Strengths Competences acquired in digital logic design as well as thecompetence in the design of complex electronic systems.Competence in handling several types of detectors such asRPCs, scintillators coupled to photomultipliers and siliconphotomultipliers. Activities developed in the context ofresearch projects. Capability to develop characterizationsystems. Possibility to plan and perform irradiation campaigns.

Weaknesses

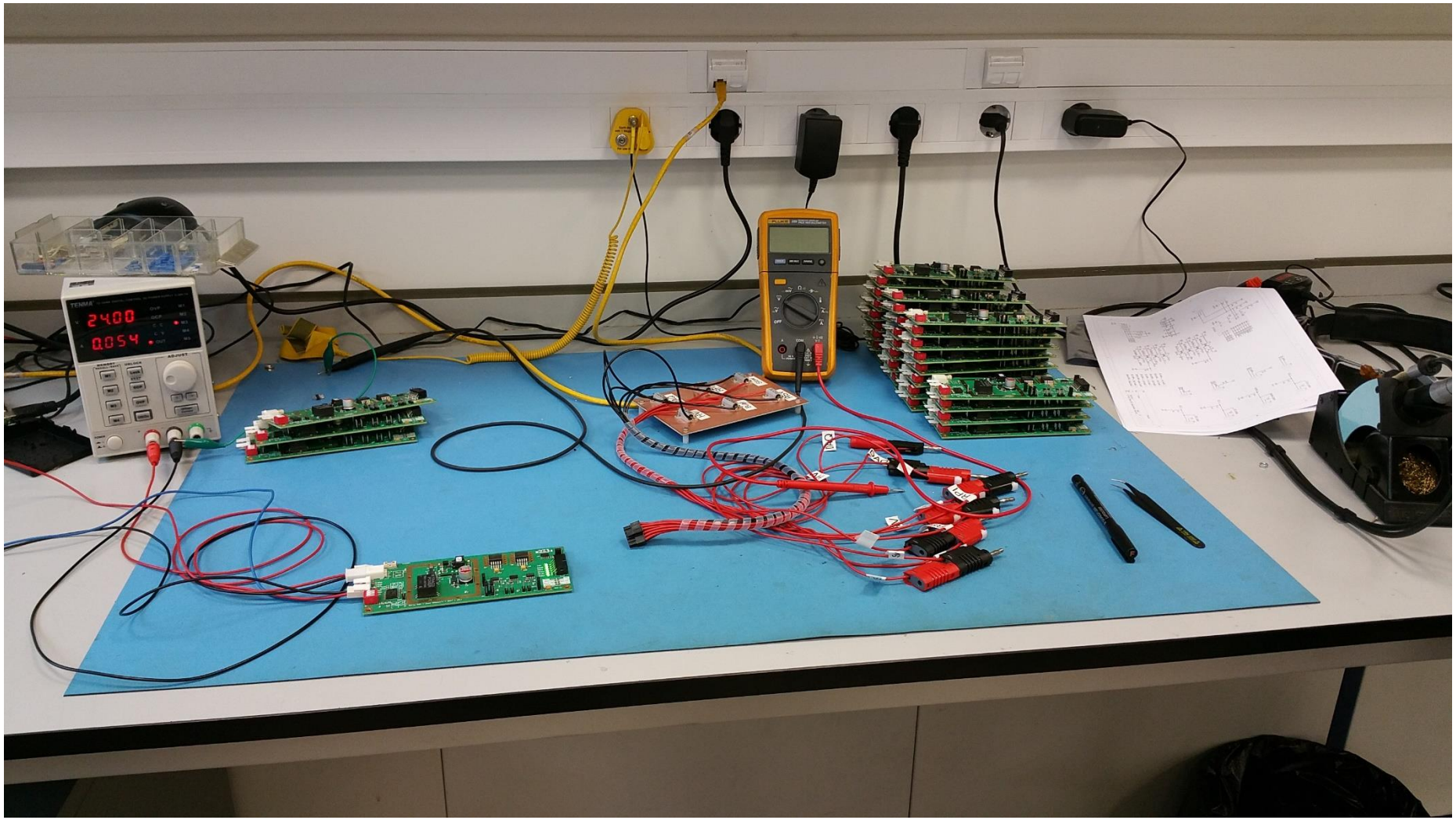
The current level of funding is not compatible with the fulldevelopment of detectors. Up to now it was not possible toattract direct funding for detector development. Independetlypublishing the work developed has been systematically delayedand must be pursued.

Opportunities

R&D activities in the framework of MARTA, SWGO and muontomography projects create opportunities to lead R&D projectand to consolidate the existing core lab activities.In the longterm, ATLAS offer the opportunity to consolidate activities onfast and digital electronics. The radiation damage studiespresent the possibility to attract students and financingthrough the SpaceRad group. Training activities and mastertheses developed in e-CRLab may allow to increase manpowerand to pursue different projects. The know-how acquired canalso boost the participation in new projects related with fasttiming and the development of instrumentation for medicalphysics. The investment plan resulting from the FCT evaluationallows for the increase the capability in test-and-measure.

Threats Financing is always a key issue when developing hardware. Lackof human resources could be an issue in the mid-term.

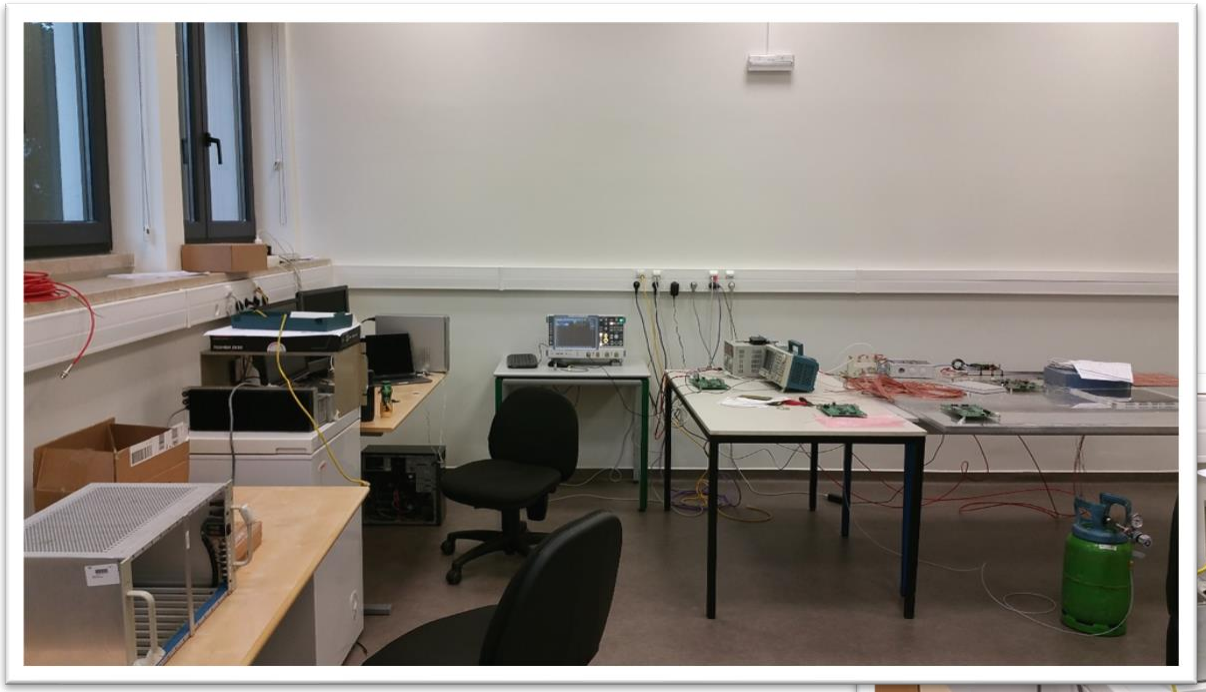
Thank you



Office

electronics

Detector integration and testing



Detector prototyping workshop

Detector prototypes room