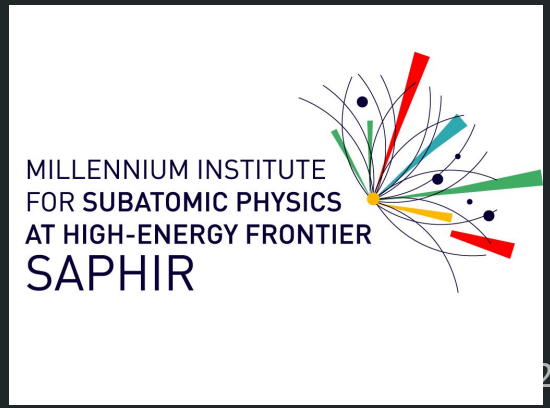
Experimental Physics at ULS

Orlando Soto



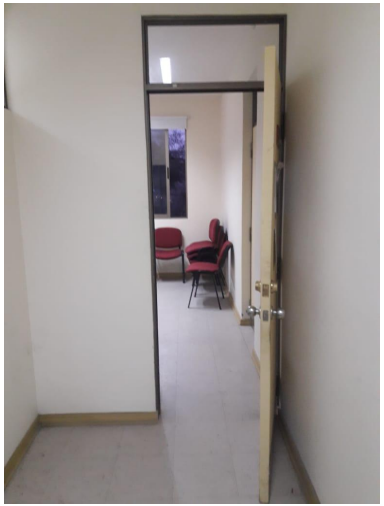
UNIVERSIDAD
DE LA SERENA
CHILE

2023

Outline

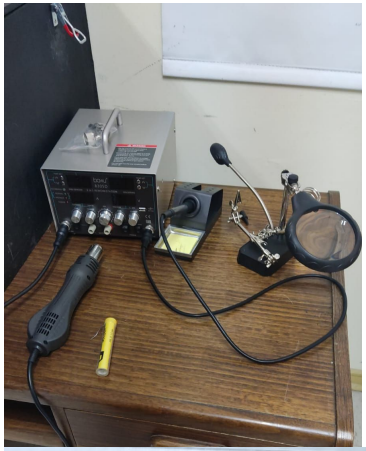
- Experimental physics at ULS
  - Infrastructure
  - Link with the university
- Astroparticle physics
  - Collaborations
  - R&D Water Cherenkov Detectors
    - LAGO
    - SWGO
- CERN related projects
  - ATLAS phase 2 upgrade
  - ATLAS phase 1 upgrade
  - NA64
- Future work

Experimental Physics infrastructure



About 1 year ago, the University of La Serena (ULS) give us space and resources to have a laboratory inside the physics department.

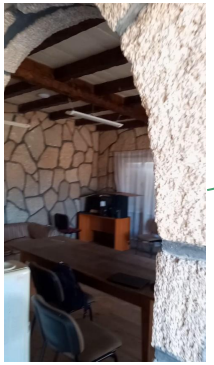
Experimental Physics infrastructure



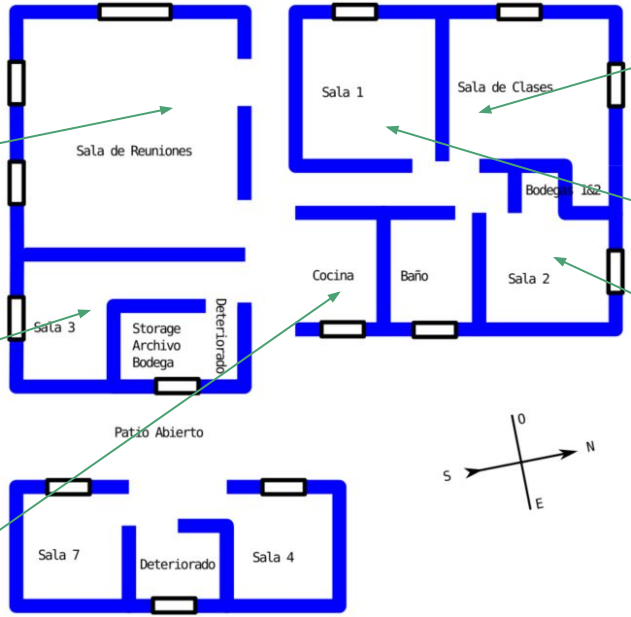
Currently, with the help of ULS and SAPHIR we have basic equipment that to do R&D of particle physics detectors.

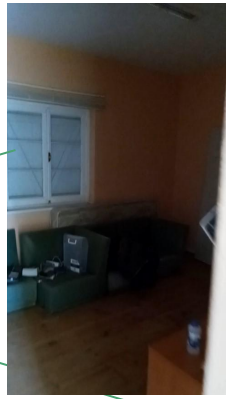
Available space, Juan soldado location

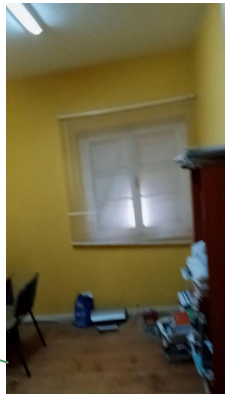
~2 years to be ready

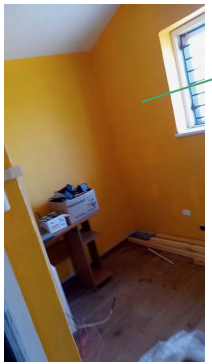


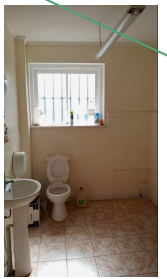
~100m2 built

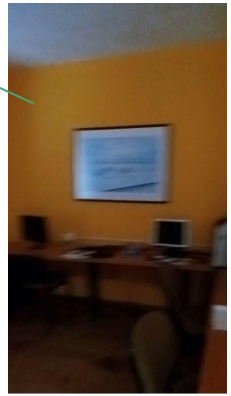






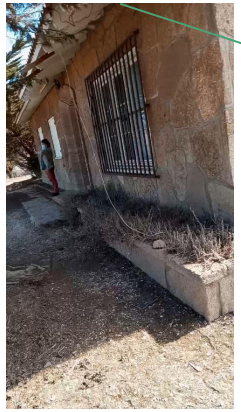




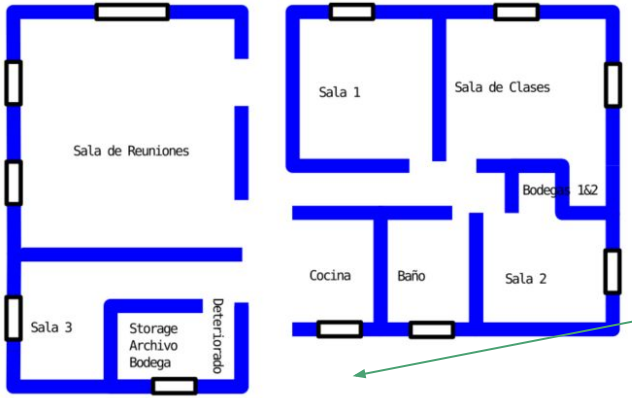


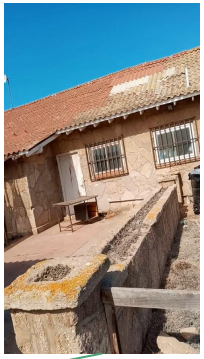
Available house in “Juan Soldado” for our group.
ULS has a grant for the refurbishment according to our needs.

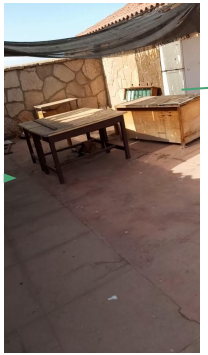
External view

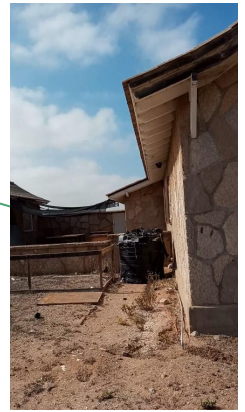


~60m2 in total









Sector “Patio Abierto” to add neighboring structures

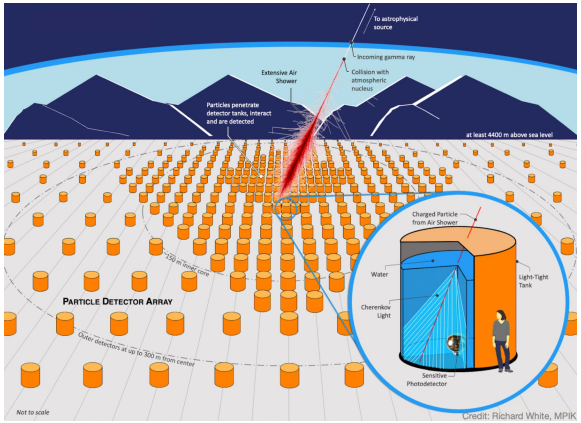
Links with the University

We have established links with the Mechanics Department through the professor Alexander Alvarez and also with the FABLAB from the Engineering faculty

Two CNC machines are available in the Mechanics department laboratory. FABLAB also have small cnc machines and 3D printers (filament and resin)

Astroparticle collaborations

Part of our development plan contemplates the collaboration with Astroparticle Physics. In this context we are member of two collaborations: The Southern Wide-field Gamma-ray Observatory (SWGO) and The Latin American Giant Observatory (LAGO)



SWGO concept

LAGO layout

Astroparticle collaborations

The concept for the future SWGO

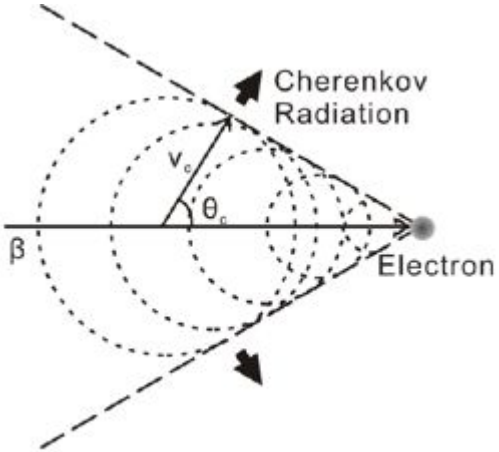
- Gamma-ray observatory based on ground-level particle detection (~100% duty cycle)
- Located in South America Chile, Argentina, Peru or Bolivia (latitude between 10 and 30 degrees south.
- Altitude of 4.4 km or higher.
- Energy range from O(100GeV) to O(100TeV)
- Based primarily on **Water Cherenkov Detector units**.
- High fill-factor core detector with area considerably larger than HAWC and significantly better sensitivity, and a low density outer array.

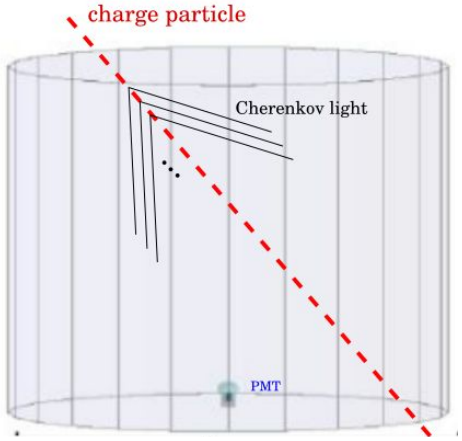
The LAGO detection network consists in single or small arrays of particle detectors (**Water Cherenkov Detector**) at ground level, spanning over different sites located at significantly different latitudes (currently from Mexico up to the Antarctic region) and different altitudes (from sea level up to more than 5000 meters over sea level), covering a huge range of geomagnetic rigidity cut-offs and atmospheric absorption/reaction levels. It is mainly oriented to basic research on three branches of Astroparticle physics:

- The Extreme Universe
- Space Weather phenomena
- Atmospheric Radiation at ground level.

Water Cherenkov Detectors

Our development plan contemplates the work with Water Cherenkov Detectors. These particle detectors are based on the Cherenkov radiation produced by a charged particle traveling on a medium at a speed bigger than the speed of light in the medium.





It is an effect that can be well described by classical electromagnetism

$$\cos(\theta) = \frac{1}{n\beta}$$

$$\frac{d^2N}{dxd\lambda} = 2\pi\alpha\left(1 - \frac{1}{n^2\beta^2}\right)\frac{1}{\lambda^2}$$

It is kind of blue!!

LAGO WCD at ULS

LAGO WCD at ULS is based on a 1000 liters plastic water tank (~200USD) with tyvek inside to reflect the Cherenkov photons, covered with few layers of plastic sheets to ensure very low light leakage and a lit to hold the PMT in the top which is sealed with black silicon.

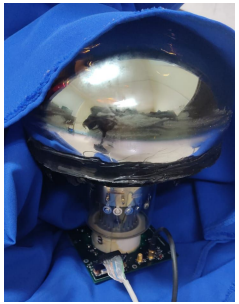
Tyvek inside

1000l vertical tank

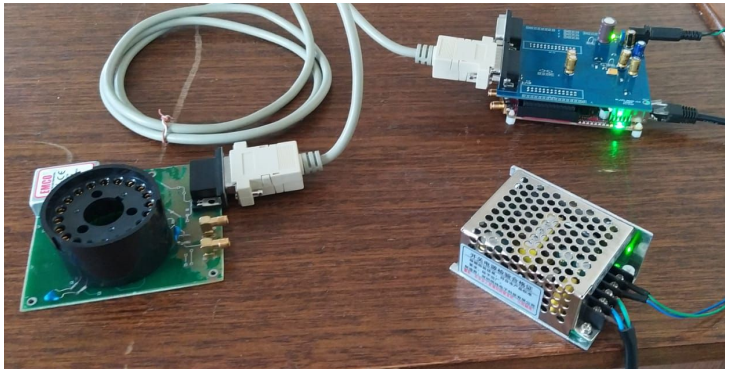
Completely covered to avoid light leakages

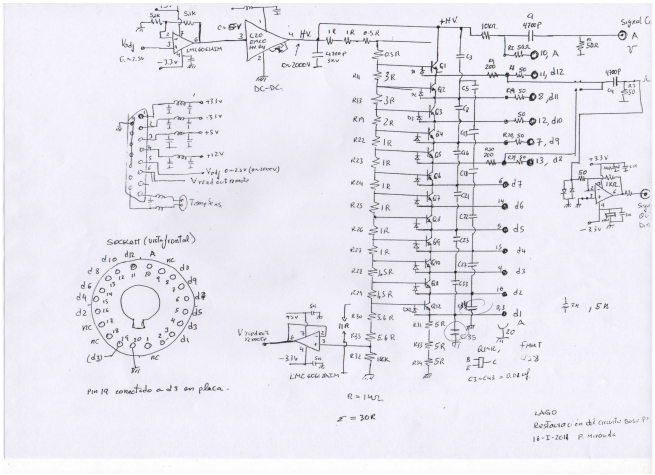
LAGO WCD at ULS

The PMT base comes from a design for Pier Auger, the HV is done with a DC-DC converter and includes the use of transistors in the dynodes.
The readout includes a control board and a Red Pitaya board (ARM Dual core Cortex A9 + zynq 7010 FPGA)



Hamamatsu
R5912-100

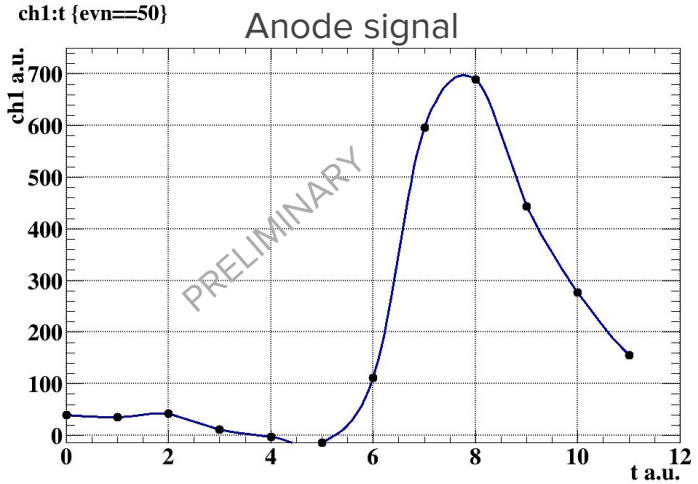


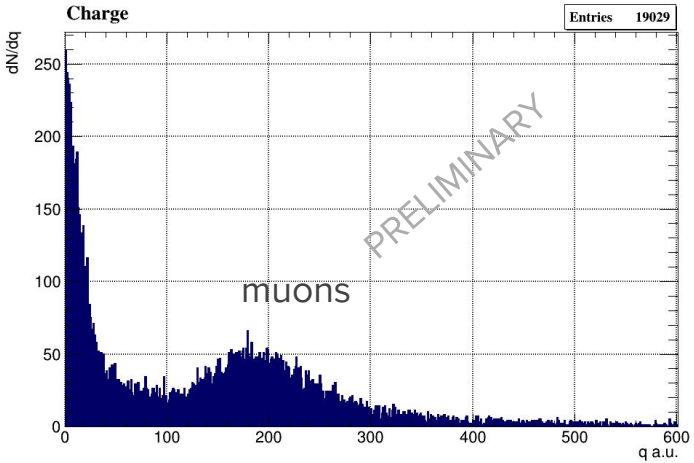


Red Pitaya

LAGO WCD at ULS

The data is stored in the Red Pitaya and is regularly upload to a cloud storage through a script done by Sebastián Infante (ULS M.Sc. student). The mounting of the detector was mainly done by Vicente Agosin and Sebastián infante. Preliminary data show the peak corresponding to the path of the muons crossing the WCD, possible light leakages need to be studied yet.





WCD Detector R&D at ULS

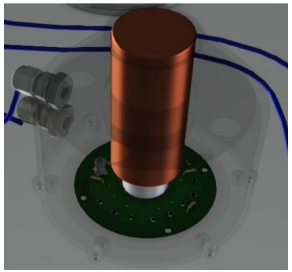
We are developing a small WCD with the PMTs inside. The objective is make systematic studies about the WCDs like the effect of water purity in the light collection together with different configuration options like the reflective material and PMTs array configuration.

This project has been carried out with a joint effort of SAPHIR members from UNAB and ULS together with the institute staff.

The building of the mechanical designs is being done in the ULS mechanical department.

WCD prototype based on an oil barrel

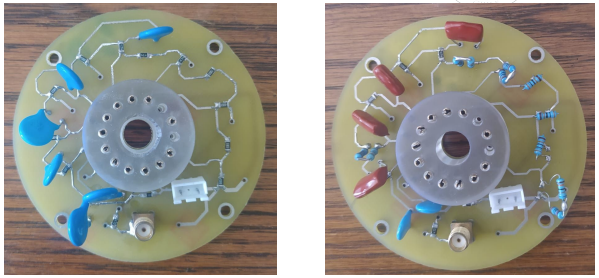
PMT socket produced in FABLAB ULS



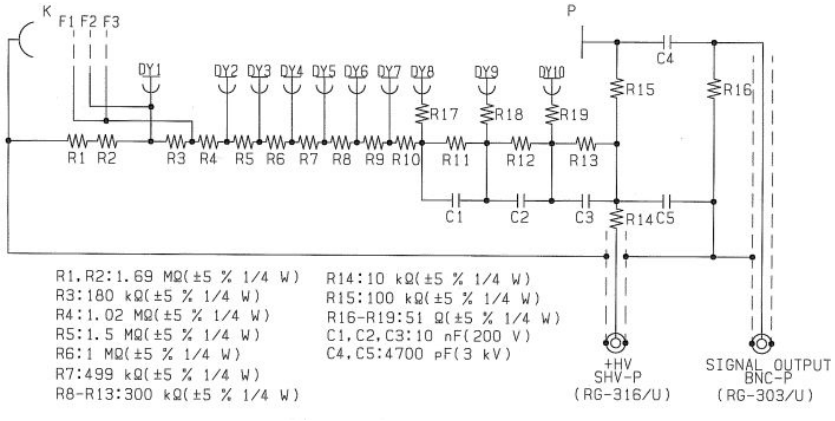
Design of waterproof assembly for small pmt

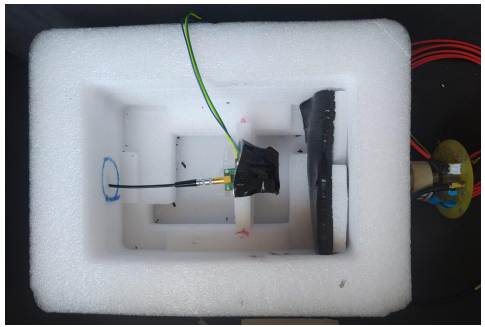
WCD Detector R&D at ULS

Several versions of the PMT voltage divider have been developed in ULS and tested using LED driver and Pulse generator developed by SAPHIR engineers.

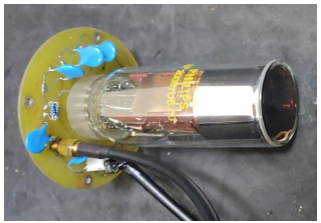


4 voltage divider versions has been done





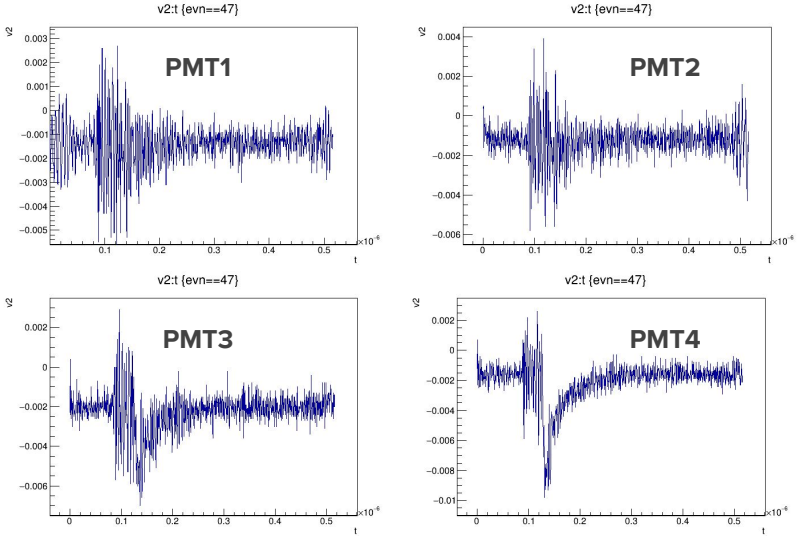
Setup to test PMTs and readout versions



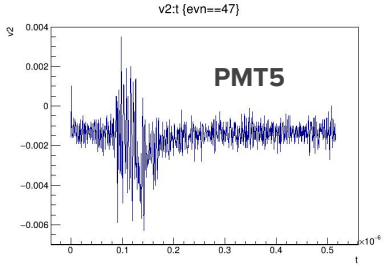
5 different PMTs (Philips XP2017B)

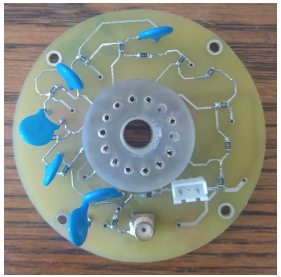
WCD Detector R&D at ULS

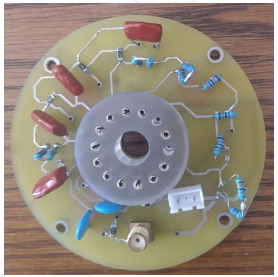
Several versions of the PMT voltage divider have been developed in ULS and tested using LED driver and Pulse generator developed by SAPHIR engineers.



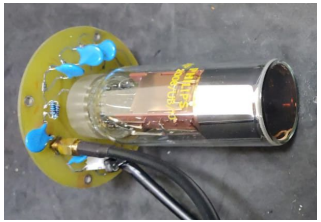
Not all the PMTs shows good signal







4 voltage divider versions has been done



5 different PMTs (Philips XP2017B)

WCD at Atacama Astronomical Park

In the context of SWGO, we have earn a QUIMAL Grant (200 MCLP) for the study of Water Cherenkov Detectors in extreme weather conditions. The SWGO site candidates share similar extreme, desert-like climate conditions, thus the study of the WCD in Chile will have a valuable impact for the SWGO WCD R&D.

Team

ULS: Orlando Soto (Proj. Manager), Pablo Ulloa, Alexander Alvarez

UTFSM: Claudio Dib, Taisiya Mineeva

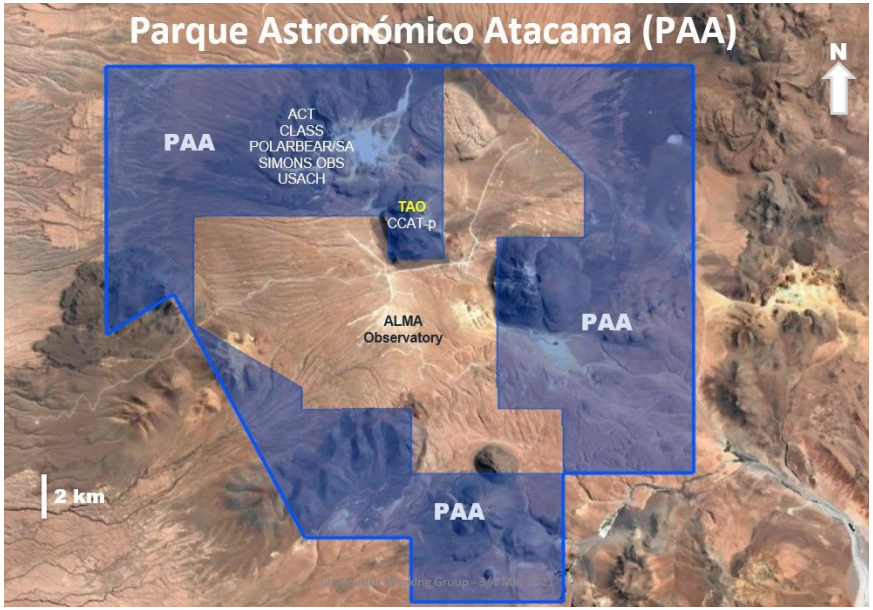
UNAB: Renato Galleguillos, Giuliano Pignata

UMCE: Andreas Reisenegger

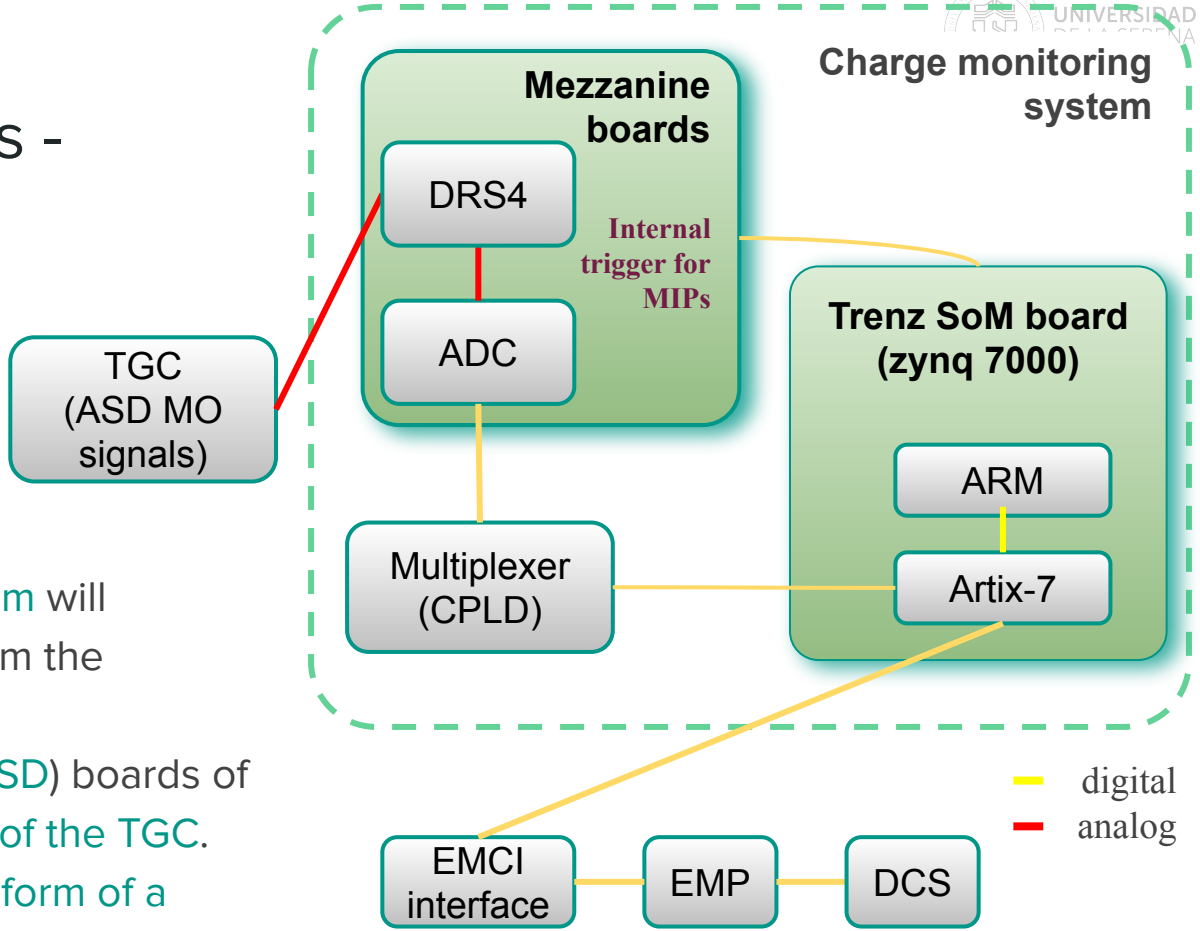
SAPHIR is also an associated institution

WCD at Atacama Astronomical Park

- Design and build one WCD prototype to be placed at one of the Chilean candidate sites at the Atacama Astronomical Park (AAP).
- Study the WCD behavior under extreme weather conditions.
- Develop detailed simulations of WCDs and use the results to optimize the design of the individual detector components and the whole detector assembly.
- Create educational activities and materials on Astroparticle Physics for high-school students and train science teachers in their implementation.

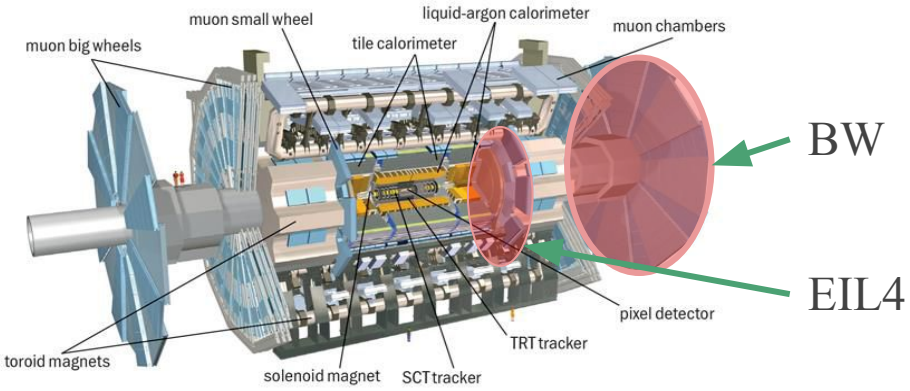


CERN related projects - ATLAS: TGC Charge monitoring system



The TGC charge monitoring system will measure the charge extracted from the monitoring output (MO) of the Amplifier-Shaper-Discriminator (ASD) boards of the TGC, allowing the monitoring of the TGC. The CMS will also provide a waveform of a channel upon request.

CERN related projects - ATLAS: TGC Charge monitoring system

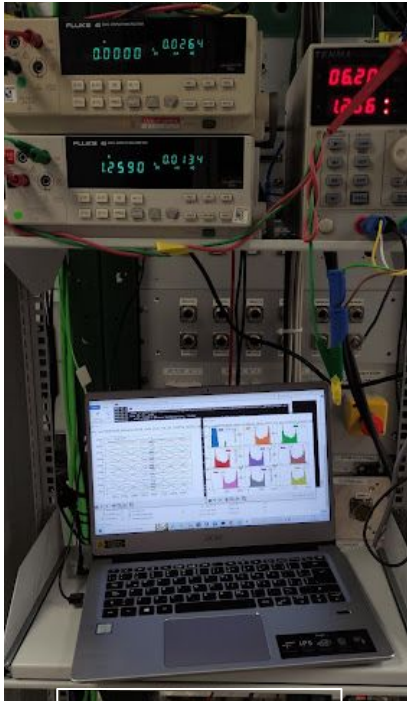


40 channel charge monitoring boards. 4 board + EMCI per rack:
3408 channels (BW)

40 channel charge monitoring boards. 2 board + EMCI per rack:
132 channels (EIL4)

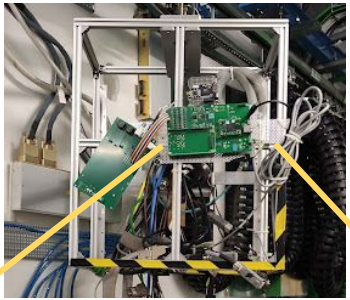
CERN related projects - ATLAS: TGC Charge monitoring system

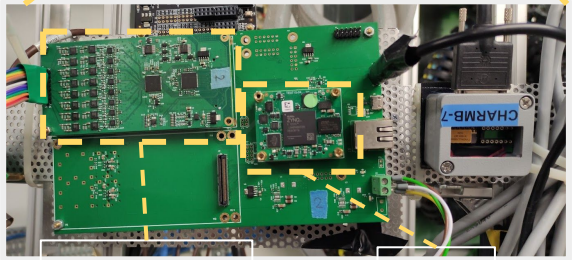
We have perform 3 irradiation campaigns at CERN CHARM facility. This facility provide a mixed field (particles mixture) similar to the one obtained in ATLAS



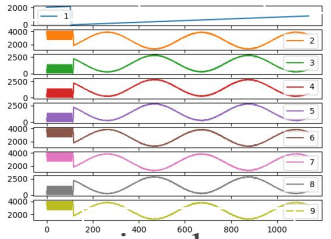
Control Room

CHARM overhead conveyor





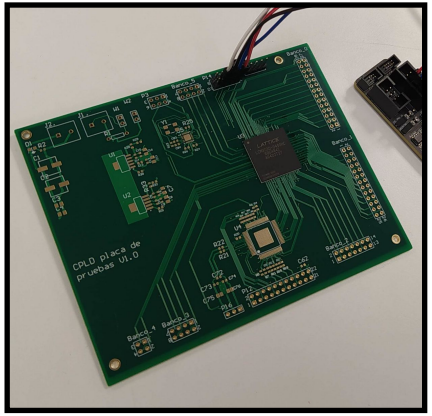
Mezzanine SoM

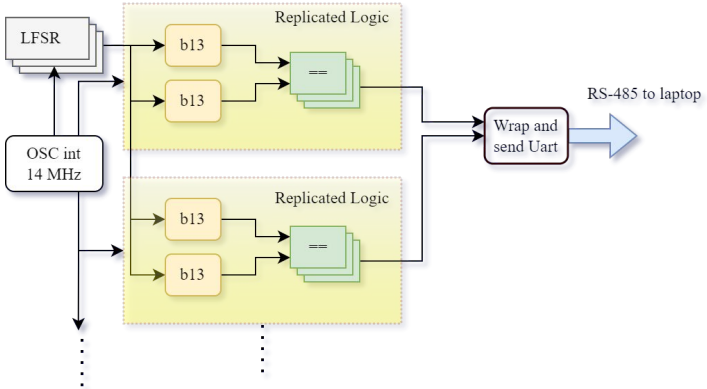


signals

CERN related projects - ATLAS Charge monitoring system

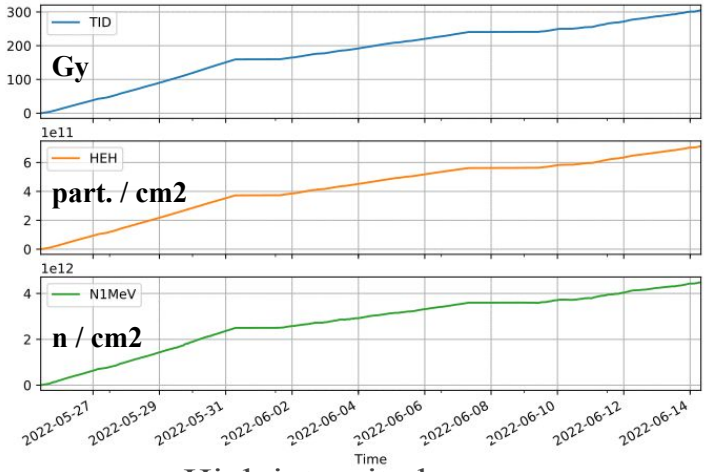
This project is currently carried out by ULS, UNAB, PUC and SAPHIR staff.
ULS has participated in the development of boards and firmware for the Radiation tests





CERN related projects - ATLAS Charge monitoring system

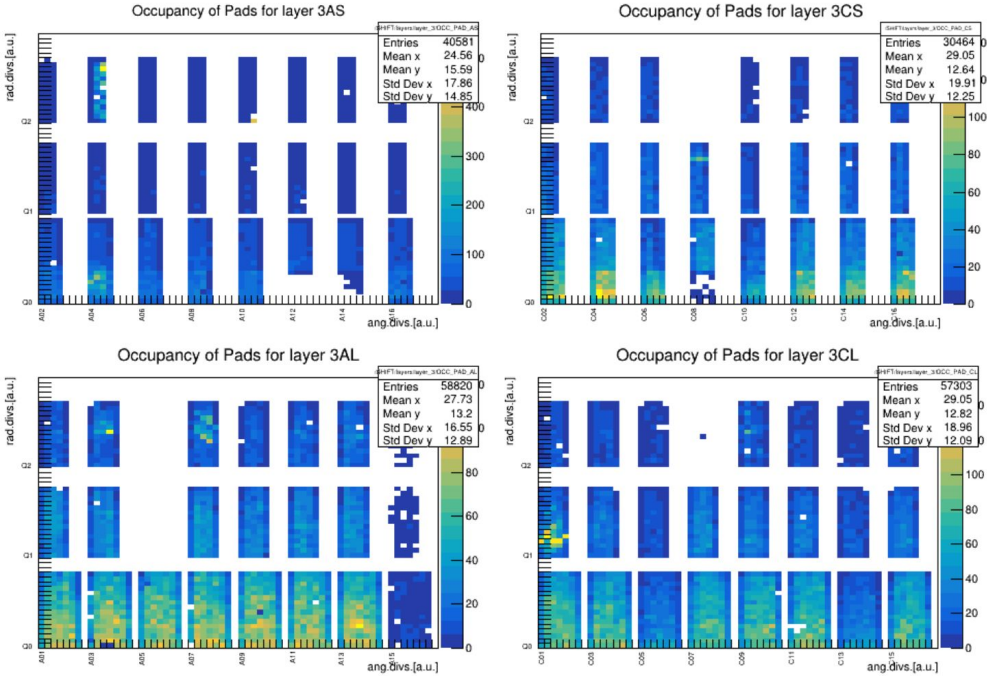
We aim to test the irradiation levels equal to 10 years of operation (3000fb^{-1}).
The prototype passed the irradiation levels required.



High intensity beam

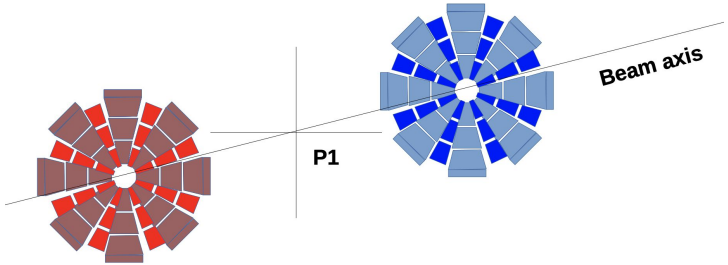
	Target Dose	Reached Dose Trenz board TE0715	Reached Dose Mezzanine	Reached Dose Mezzanine (DACs)	Reached Dose CPLD
TID [Gy]	123	271 (**220%**)	191 (**155%**)	137 (**111%**)	133 (**108%**)
HEH	1.3E+11	6.34E+11 (**488%**)	4.55E+11 (**350%**)	3.28E+11(**252%**)	2.89e+11 (**222%**)
N1MeV	8.8E+11	4.03E+12 (**457%**)	2.79E+12 (**317%**)	2.07E+12(**235%**)	1.57e+12 (**178%**)

CERN related projects - ATLAS sTGC Monitoring



2D Occupancy maps done by Pablo Ulloa helps to determine where are the problems.

Small raw data set representation, coming from the NSW during 13,6 TeV pp collisions in 2022.

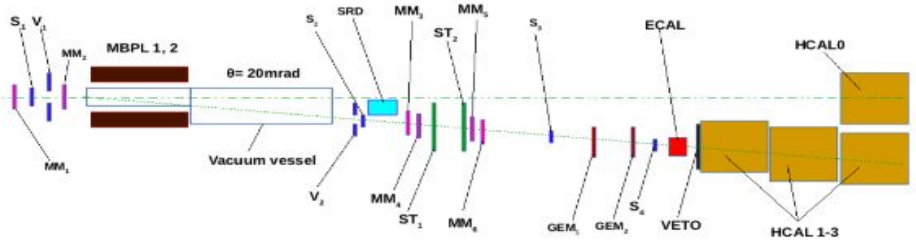


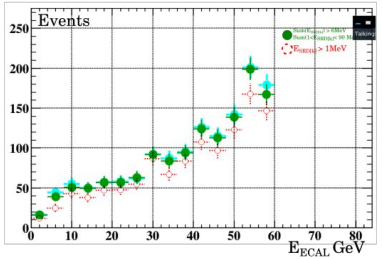
CERN related projects - NA64

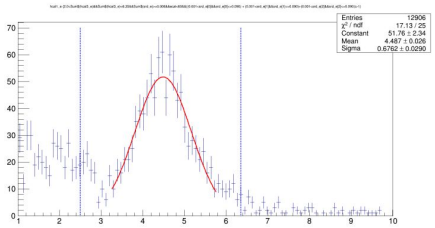
Our group is also working with the data of NA64 experiment. A Thesis from Rocío Carrera related with the production of di-muons in Lead is being carried out (eZ➔ e'Z'γ➔ e'Z'μμ).

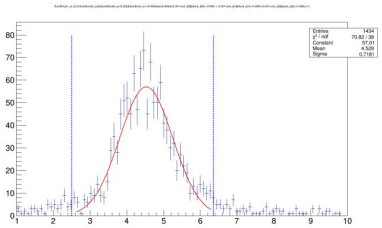
To start, previous preliminary data analysis has been verified

This data analysis is being done between UNAB and ULS, in the frame of SAPHIR institute.









Future Work

- We will continue with the charge monitoring system development. Soon PDR and FDR.
- Participation on the monitoring of pixel system readout (mops-hub) ITK
- We will start working with the ATLAS Heavy Ion group.
- We are developing a plan to get local technicians to work in the laboratory.
- We are considering a call for electronic engineer post-doc to help us in our activities.
- We will move the laboratory to a new and bigger room that is being prepared during students vacation

Thank you

Appendix

QUIMAL schedule

		Year 1				Year 2				Year 3			
Tasks	**Name**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
T1	Acquisitions												
T2	Electronic R&D												
T3	DAQ R&D												
T4	sWCD												
T5	PMT selection												
T6	Final setup												
T7	WCD at AAP												
T8	SWT at AAP												
T9	SWT study												
T10	Data Taking												
T11	Data Analysis												
T12	Mecanical R&D												
T13	Simulations												
T14	Outreach Audience												
T15	Community activities												
T16	Audiovisual Material												