Front-End electronics development for ToF measurements and its performance during the testbeam of ALICE-RICH

Testbeam, cosmogenic muons detection and light

Jaime Octavio Guerra-Pulido[1] Guy Paic[1]
on behalf of ALICE-RICH collaboration

[1]Instituto de Ciencias Nucleares,
Universidad Nacional Autónoma de México

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Objectives

- Develop a group of work capable to design and **construct high level electronics for high-energy particles detectors**, specifically, for the upgrade of the ALICE experiment.
- Acquire the experience and the tools required to design, manufacture and characterize **analog and digital microelectronics circuits** (ASICs).
- **Generate knowledge about the instrumentation techniques** used in the high energy particles experiments and their applications in other related fields.

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FEE design considerations

1. It should be economical and components should be easy to get.
2. PCB manufacturing must use standard process and must be inexpensive to be manufactured in 4 Cu layers.
3. Integrated circuits must be mounted without the necessity of a high cost equipment.
4. The noise level must be minimized and reduced as much as possible.
5. The bandwidth should be as wide as possible so that fast transitions of SiPMs are preserved after amplification.
6. FEE should be controlled using standard serial protocols.

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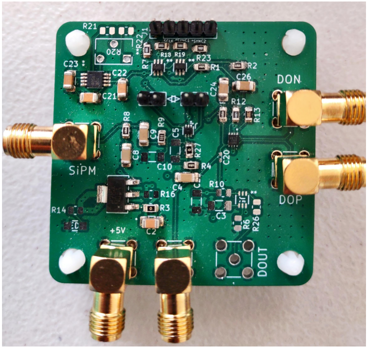
FEE components

FEE was designed using commercial components from Texas Instruments, mainly.

- Transconductance amplifier,
- LVDS output comparator,
- DACs,
- Accurate voltage reference,
- Linear voltage regulators,
- RF connectors,
- coaxial cables.



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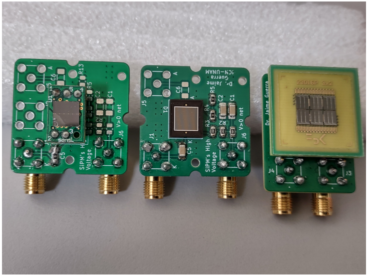
Set of SiPMs available

During all our test, we have been using any of these SiPMs:

- OnSemi MicroFJ-60035 mounted on MicroFJ-SMTPA-60035 board.
- Hamamatsu S13360-6075CS.
- FBK matrix with an epoxy window.
- During testbeam, we also tested another FBK matrix with a borosilicate window.



PCBs to mount SiPMs were designed to minimize noise and EMI.

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Output signals from the SiPMs and FEE

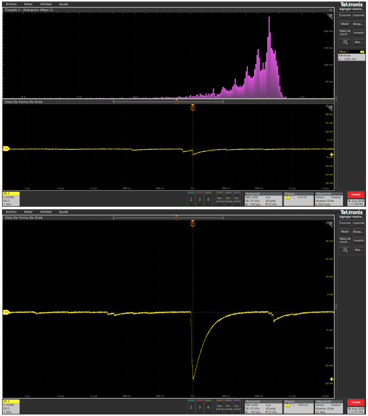

Figure: FBK SiPM

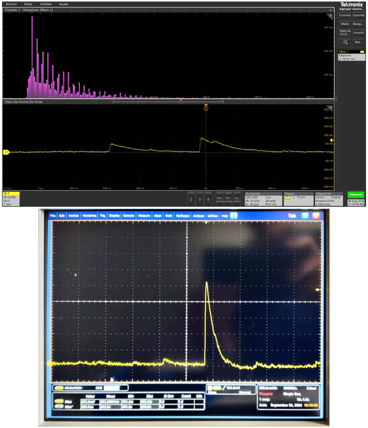

Figure: FBK SiPM and FEE

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Time-to-Digital Converters used during experimentation

We used two TDC: CAEN A5203 (picoTDC ASIC from CERN) and CAEN V1290N.

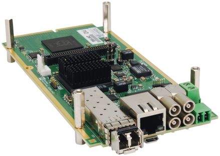

Figure: picoTDC with an LSB of up to 3.125ps.

Figure: TDC from CAEN with LSB of 25ps and time resolution of 35 ps.

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Experimental setup

We tried to measure the time resolution of our FEE using a SIPM with a CAEN SP5601 LED light source and our picoTDC board. However, the light source signal generator is not good enough to estimate the time resolution of the FEE with accuracy because the instant in which light emission occurs varies once the digital signal is high.

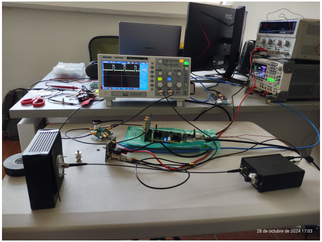

Figure: Experimental setup.

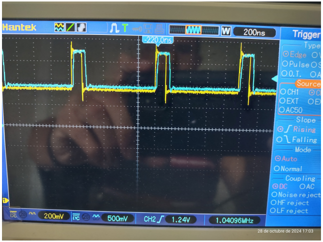

Figure: Output signals.

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Ligth test results

The time resolution was $\approx$ 100 ps but what we actually measured was the timing of radiation of the light source.

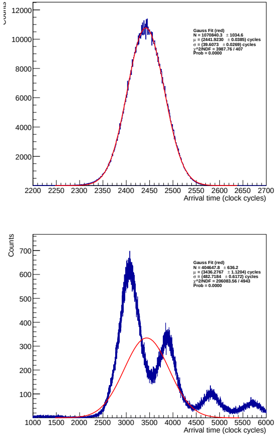

Figure: Light test with TDC A5203

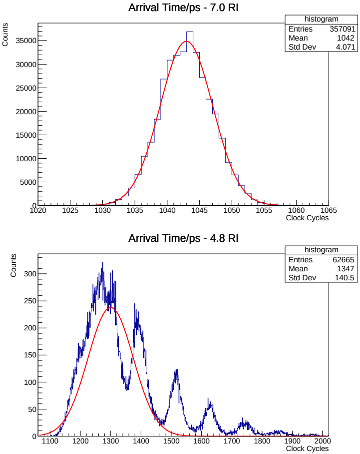

Figure: Light test with TDC V1290N

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Cosmogenic muon detector

Prior to the test beam we tried our setup to detect muons coming from the sky.

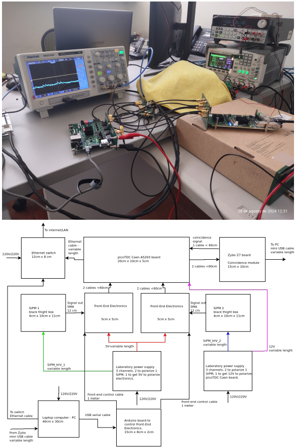
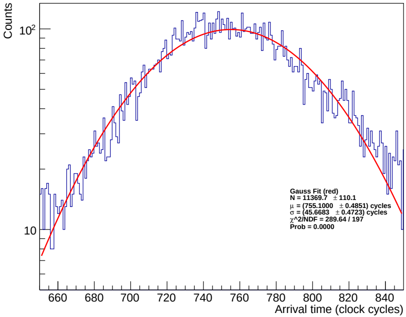


Figure: Light test with TDC A5203



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Testbeam setup

The experimental setup for the test beam is composed of two SiPMs placed one in front of another, each uses our FEE and coincidences are detected using a FPGA board. Times were measeured using picoTDC (CAEN A5203 board). We have tested for different combinations of sensors and threshold voltages and even the sensor position (pointing backwards of pointing forward).

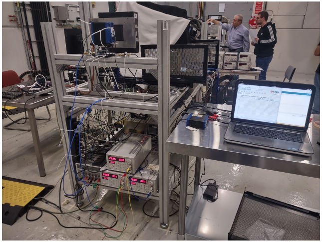

Figure: Test beam setup.

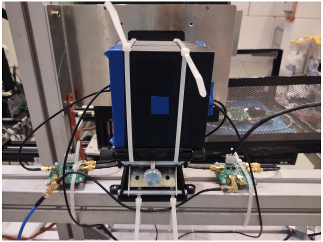

Figure: Close up of the boxes and FEE.

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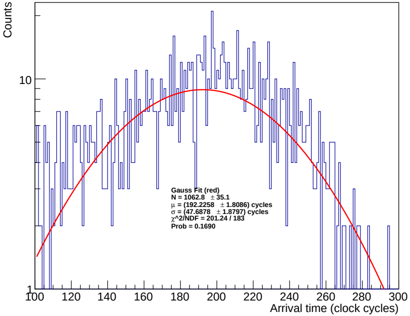
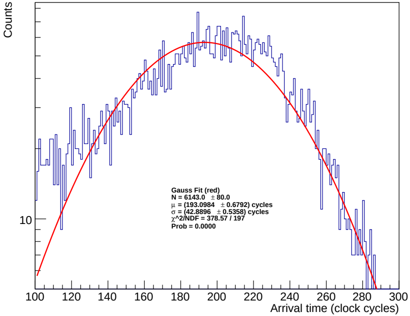
Test beam results

The **time resolution** was $\approx 120/\sqrt{2}$ ps $= 80$ ps. The main difference of two histograms shown below is the threshold voltage.





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Conclusions

- We have gained relevant experience to start growing a group of work capable of designing electronics and detectors from the ground.
- These results can be used in many applications that do not demand a large number of SiPMs, and are valuable for the design of ASICs under consideration for ALICE3.
- This work aims to design and produce electronics that contribute to the upgrade of the ALICE-RICH detector.
- We have developed electronics that are applied to the detection of high-energy particles.
- We have designed, implemented, and tested our FEE electronics in real conditions such as the ALICE-RICH test beam this year, achieving a time resolution of about ≈ 80 ps.

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