Test and characterization of Multigap Resistive Plate Chambers for the EEE Project

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(**on behalf of the EEE collaboration**)

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The EEE project

The **Extreme Energy Events (EEE)** project is a special experiment of Centro Studi e Ricerche Enrico Fermi (Roma) in collaboration with CERN, INFN and MIUR, focused on the study of high energy cosmic rays, carried out with the **decisive contribution of students and teachers from high schools**.

A large network of cosmic ray telescopes is deployed on the Italian territory. **Students participate in the construction, maintenance and data analysis** of the telescopes.

Synchronization within stations is performed through GPS system. The network is able to identify and study high energy cosmic rays ($>10^{11}$ eV).

The telescope
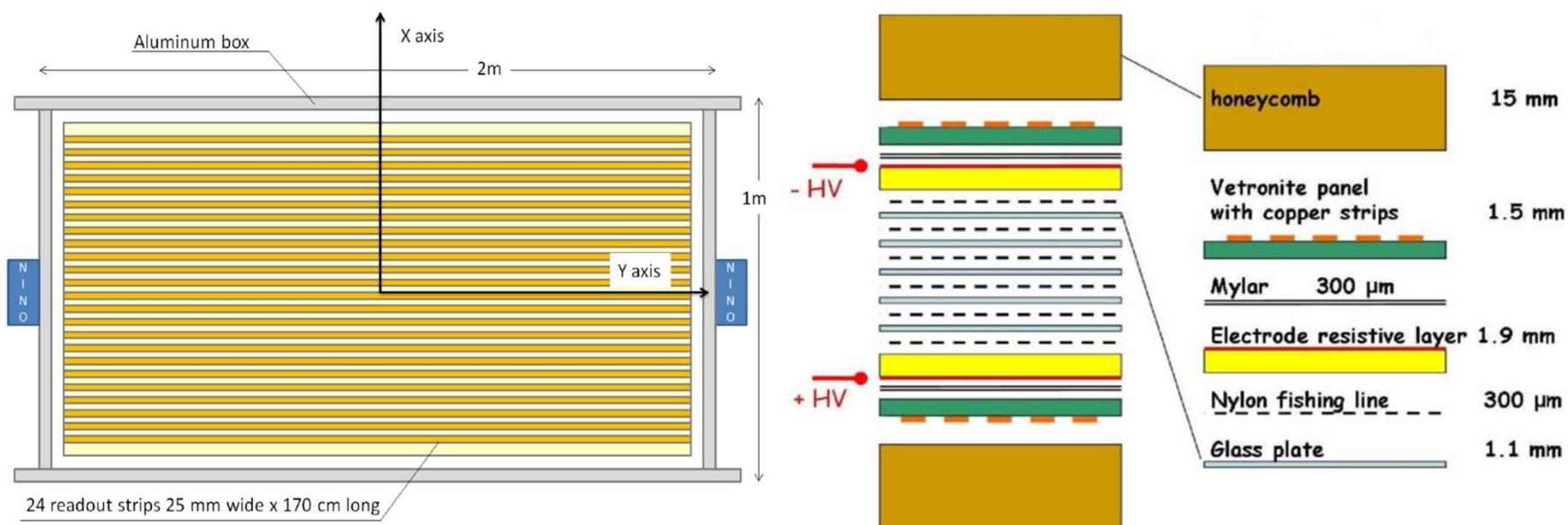
> ➢ 3 **Multi-Gap Resistive Plate Chambers** , with active surface of ~168x80 cm², readout by 24 longitudinal strips
> ➢ Each side of the chamber host two front-end card, for signals discrimination and digitization
> ➢ Particle longitudinal coordinate is extrapolated measuring the difference of the signal arrival time between the two edges, using Time to Digital Converter with <100 ps resolution
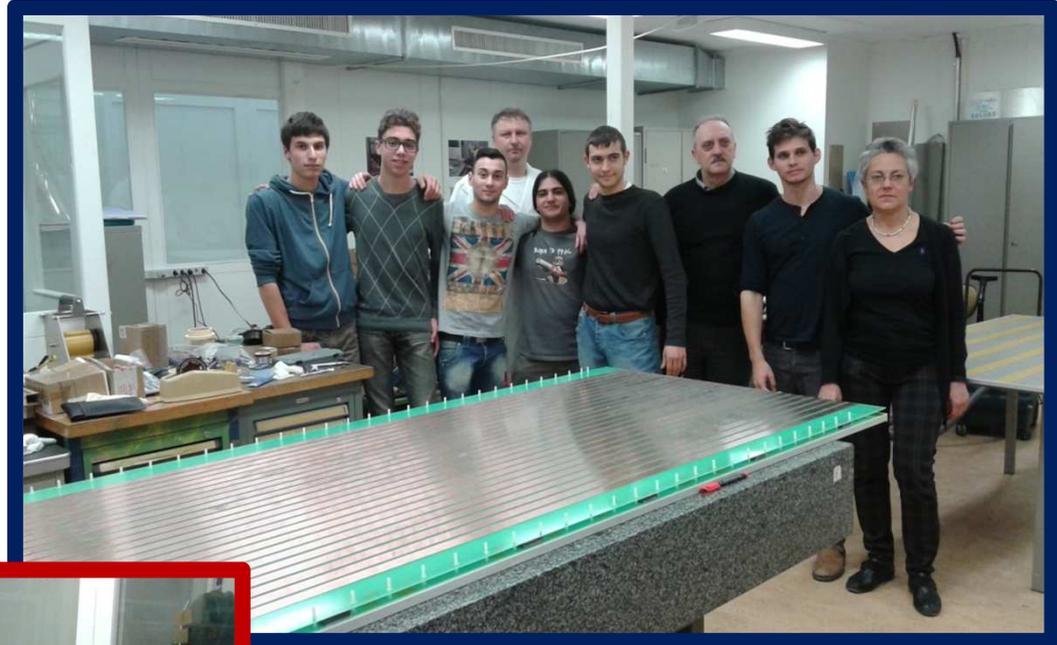
PISA-01 telescope
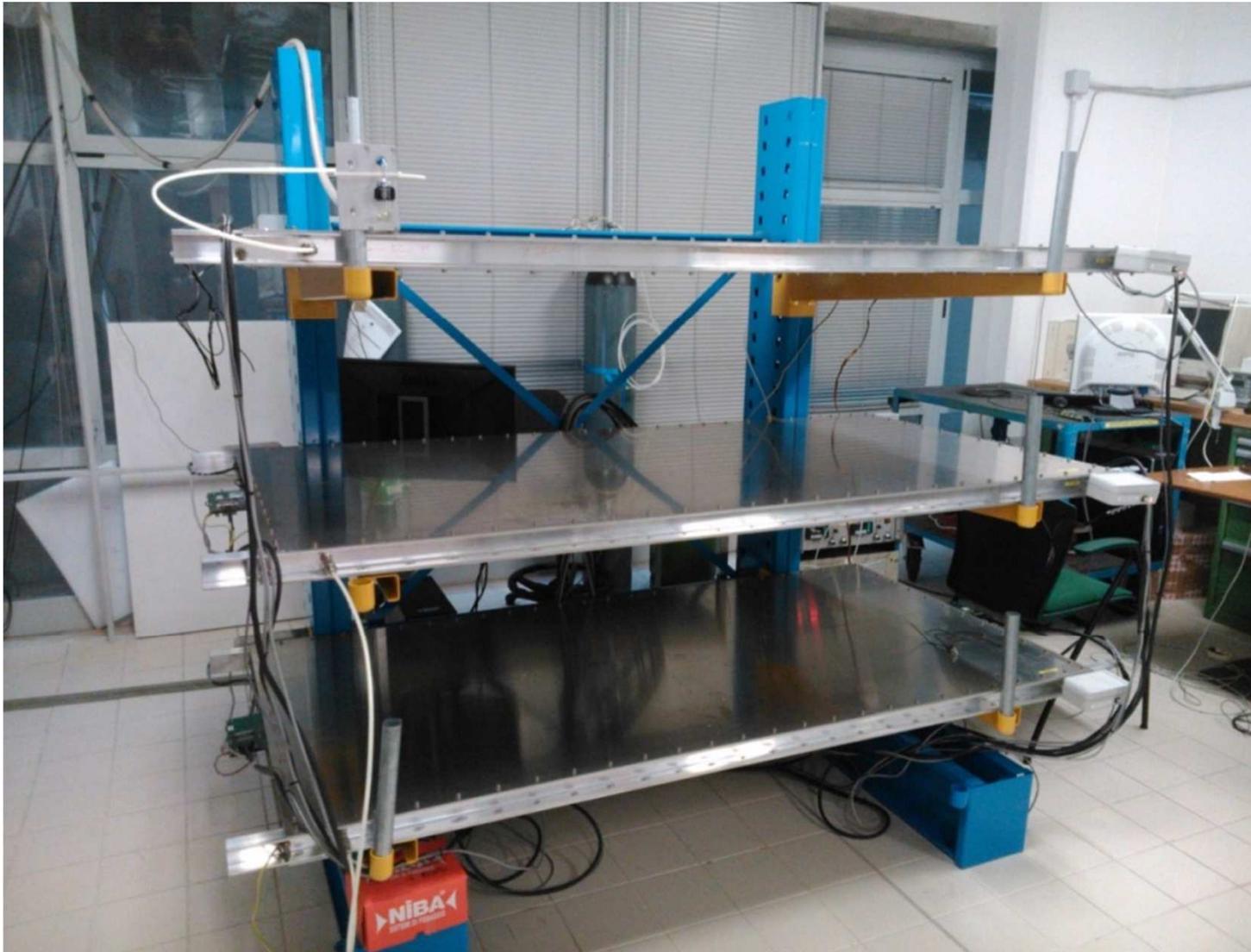
Network size

47 high schools are currently involved in the project, and 3 new schools will join the network in 2016.

35 telescopes are already fully operational and took data during the Run 1 (February-April 2015)

2 Additional telescopes are installed at CERN and 3 in INFN structures → ~165 chambers

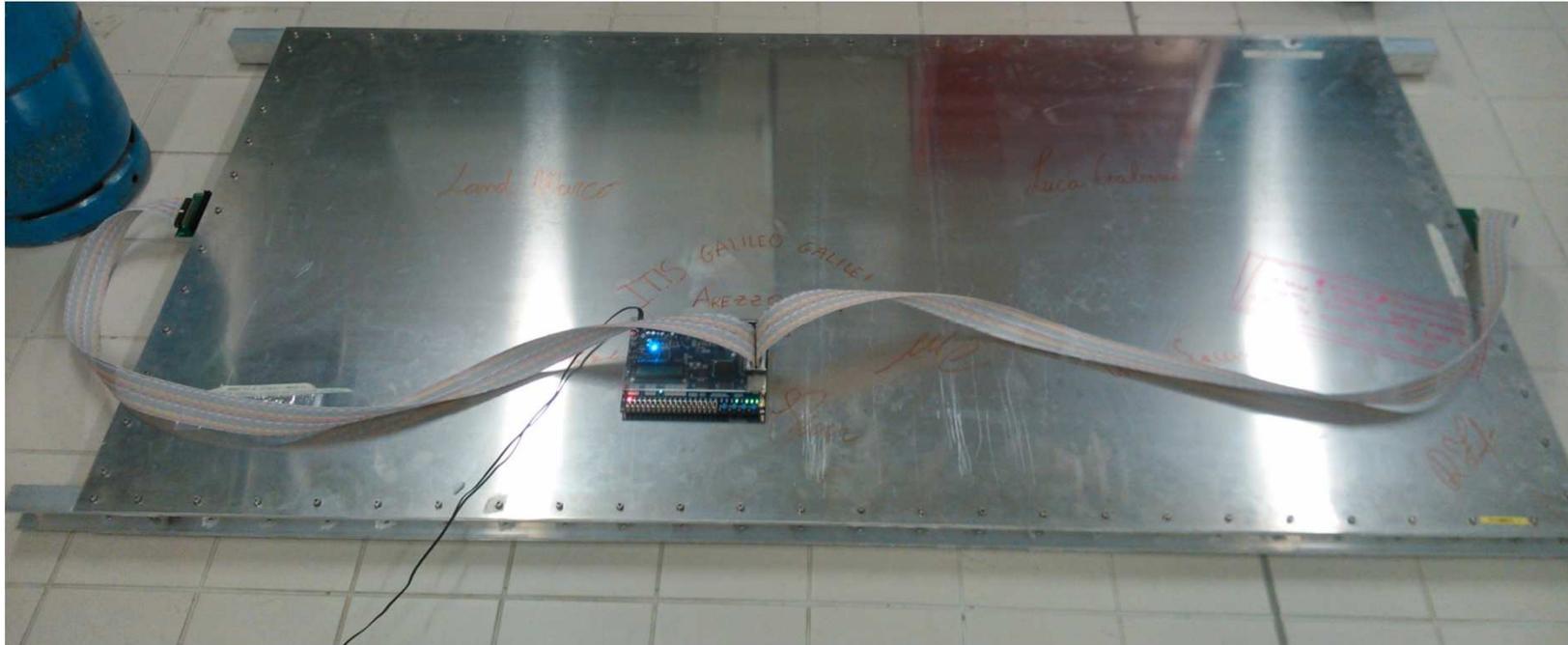Need for caracterization and testing tools, suitable also for students and teachers

Electrical test: Motherboard

TERASIC DE2 Development Board:

- Altera Cyclone II 2C35 FPGA
- 4 Push-button switches
- 16 x 2 LCD Module
- 50-MHz oscillator for clock sources
- 2 x 40-pin Expansion Headers

Electrical test: Setup

• Setup can be prepared in less than 5 minutes
• Test type selection through push button (instruction on display)
• Half chamber is tested at the same time
• Test result can be read on the LCD

No additional hardware/software required, not even a PC!

Electrical test

Once started the system performs a sequential scan:
TTL signal is injected from one side and read from the other side.

Half chambers can be tested in <2µs. When the test is over a complete error list can be read from the LCD panel
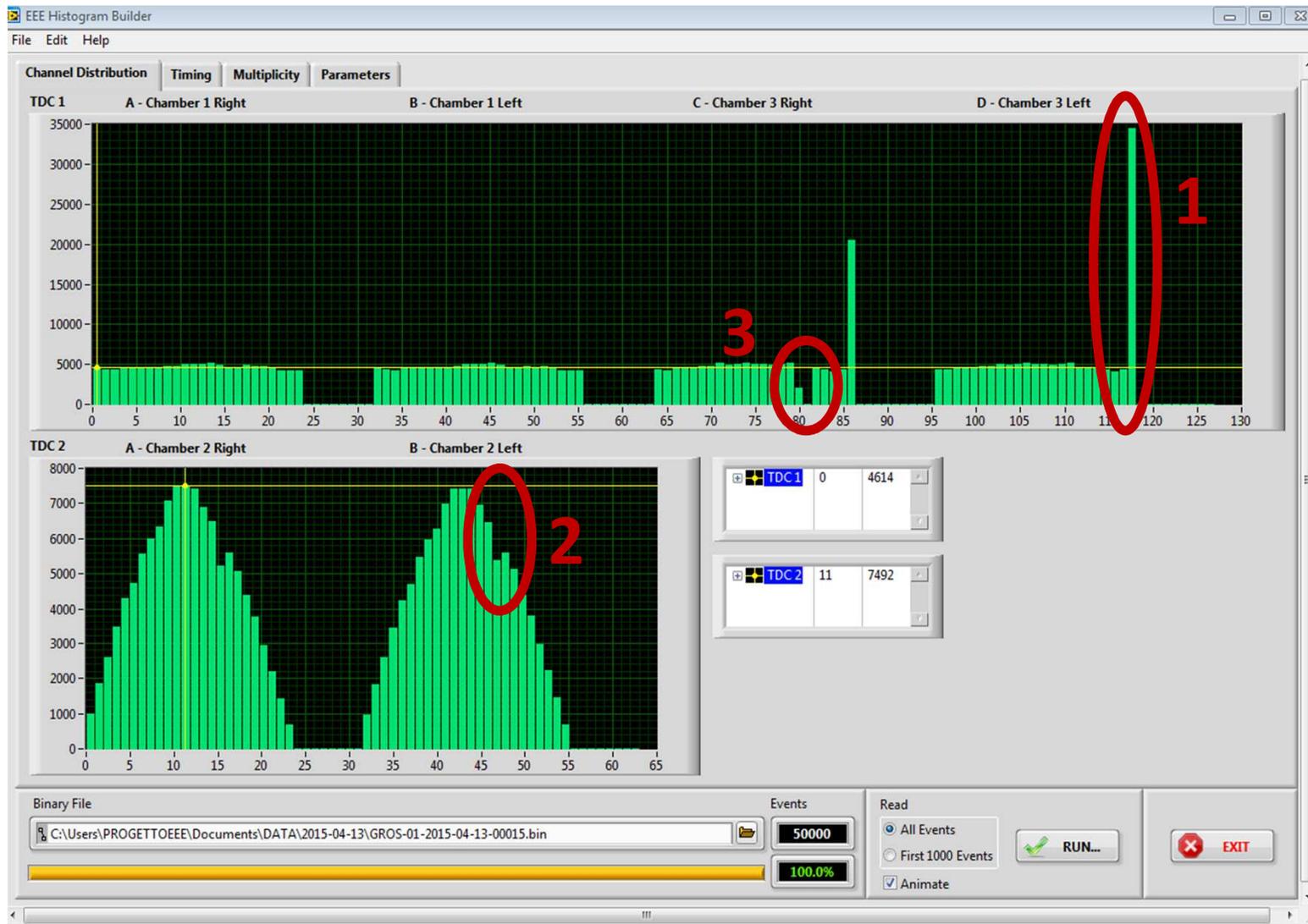
Output results:
1. Test OK
2. Short (signal back not only from the line under test, also hint of crosstalk)
3. Not connected (no signal back)
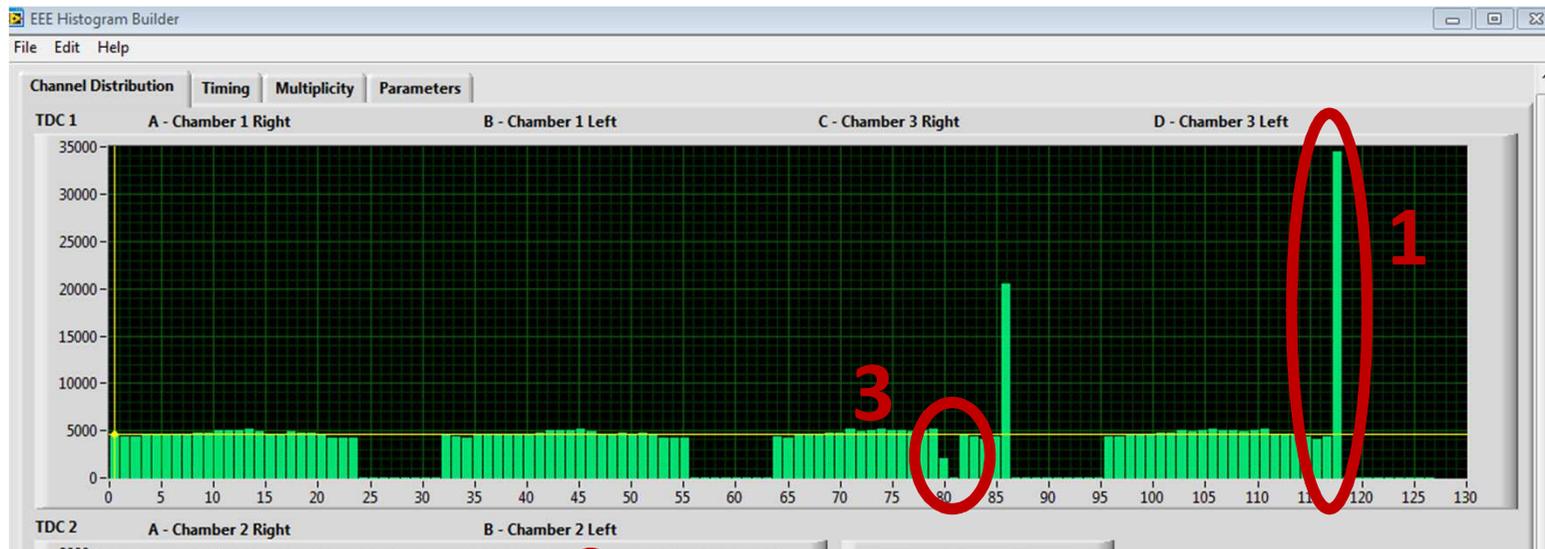4. Shift (signal back on other line)

When an error is found the line number is also shown

Electrical test: GROS-01

Electrical test: GROS-01

Test output chamber 1:

- Test OK

Test output chamber 3:

- Strip 23- not connected
- Strip 23+ Shifted (probably on strip 22-)

➤ No error related to **3**. Problem should be elsewhere.

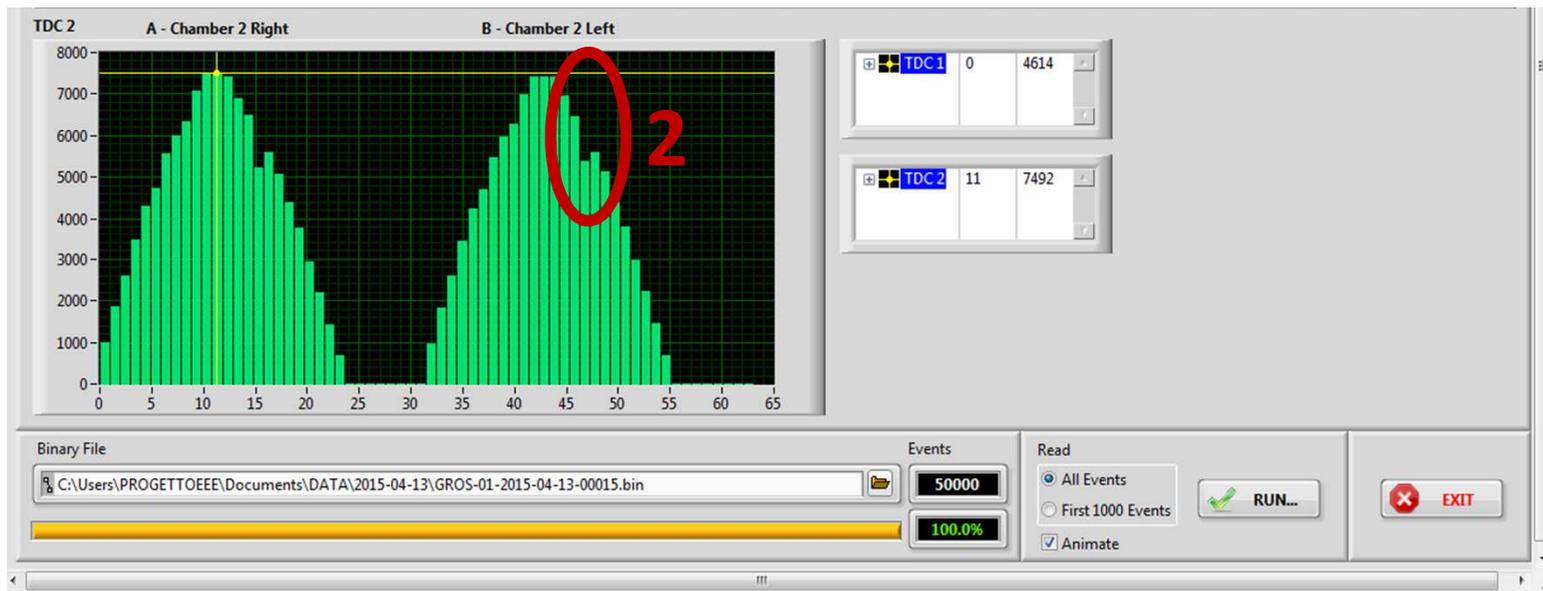➤ Strips (24-23) removed. No more noise (**1**) on chamber 3.

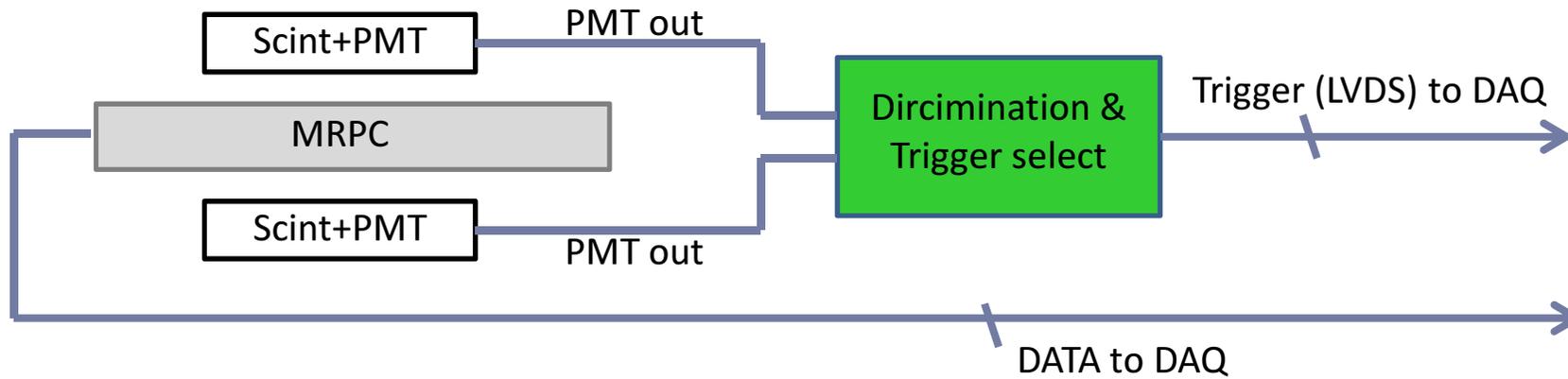# Electrical test: GROS-01

Test output chamber 2:
- Short Strip 15+
- Short Strip 15-

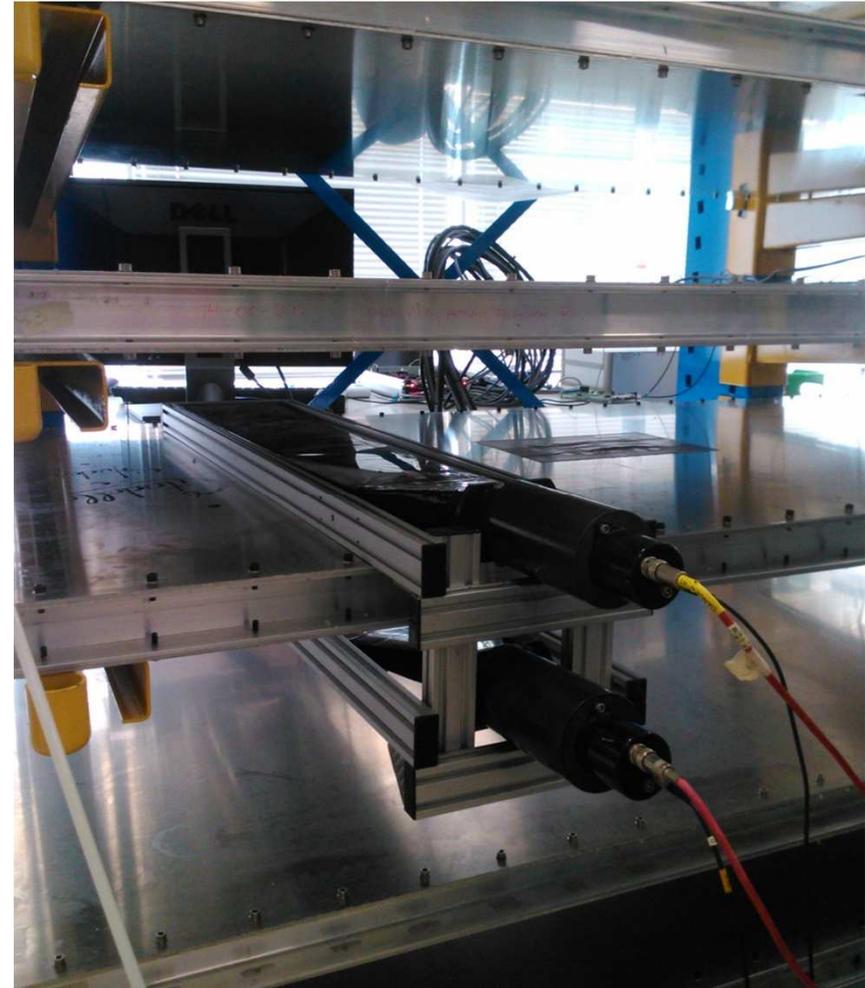Probably due to a crosstalk which lowers the strip efficiency.

Very usefull to understand the sensitivity of the test!

Commissioning @ PISA: Efficiency

Efficiency: Setup

➢ Scan of one chamber can be done easily, also for non expert (i.e. students and teachers)
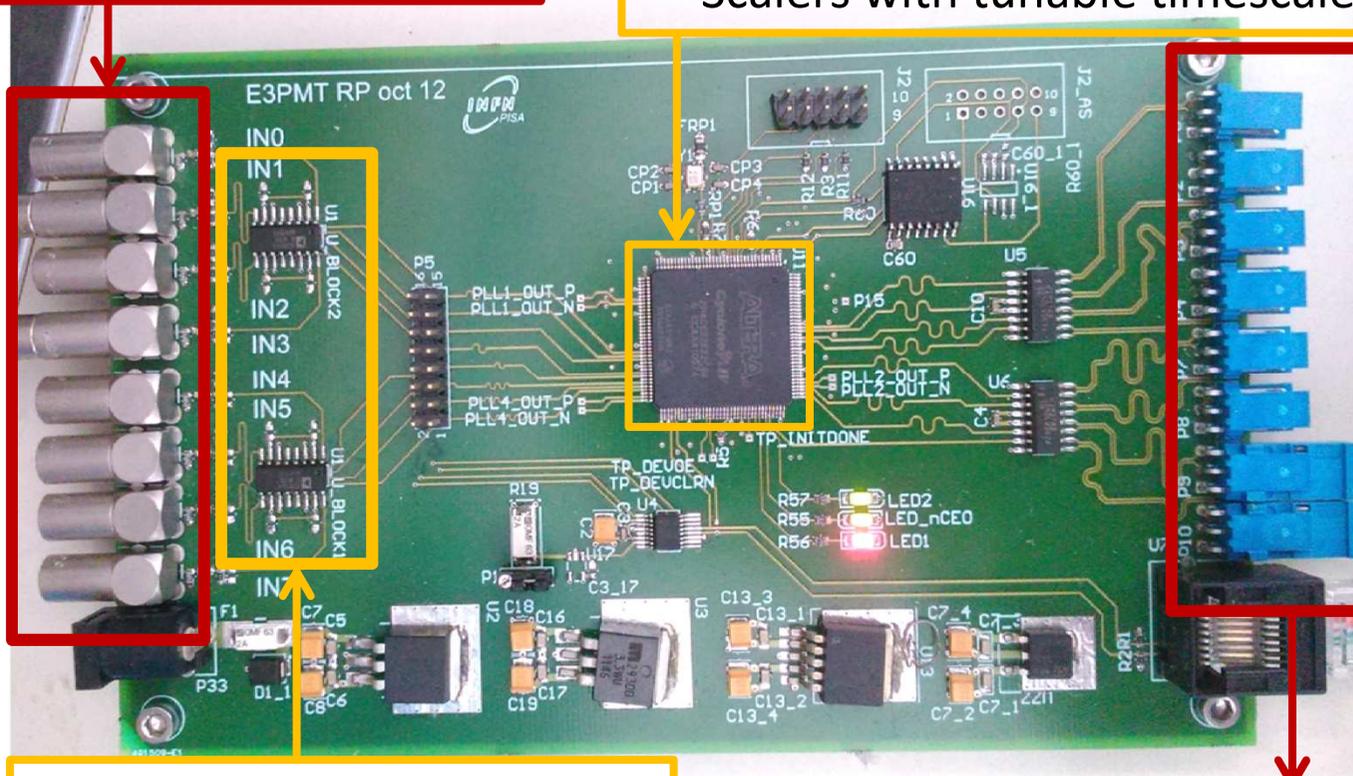
Efficiency: Trigger Board

Input signals from scintillators:
- Up to 8

FPGA:
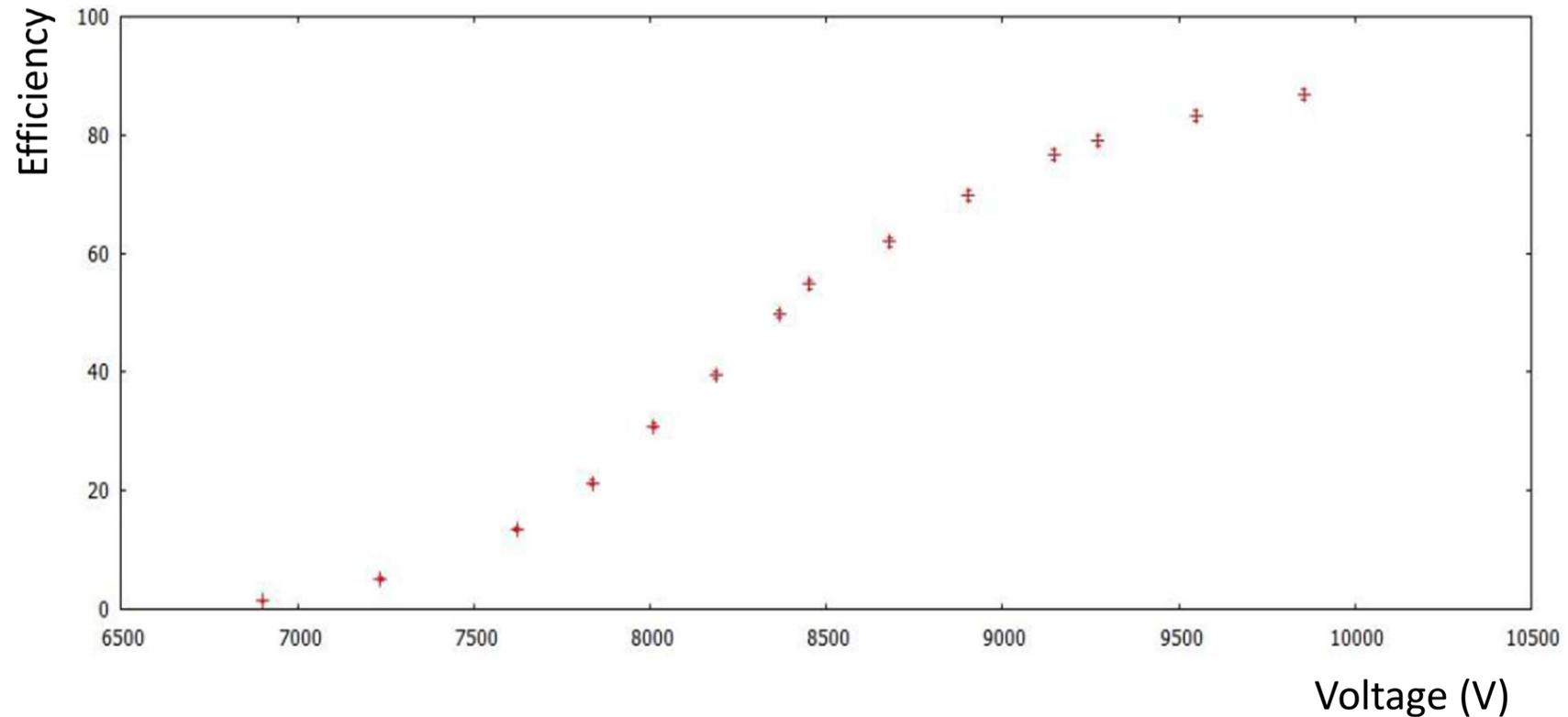- Can select any combination of inputs
- Scalers with tunable timescale

Discriminators:
- 4 independent thresholds
- Software controlled

LVDS Output . Can be directly sent to DAQ

Efficiency: Example

Example of chamber efficiency wrt applied voltage for one of the PISA-01 chambers. **This result has been obtained by students!!**

Conclusion

➢ The EEE project is designed to combine scientific research and outreach

➢ Students actively construct, maintain and perform data analysis of the detectors with outstanding enthusiasm

➢ They can also take part in detector test and caracterization, having a deeper overview of the research process

➢ The tools described are both professional and user friendly

More details about the project and the ongoing analysis at SIF 2015:
- M.Abbrescia «First Results from the Run-1 of the Extreme Energy Events experiment»
- M.P.Panetta «Distribuzioni angolari di muoni cosmici osservati dai telescopi del progetto EEE»