

# Development of a portable SiPM scintillator tracker for cosmic rays

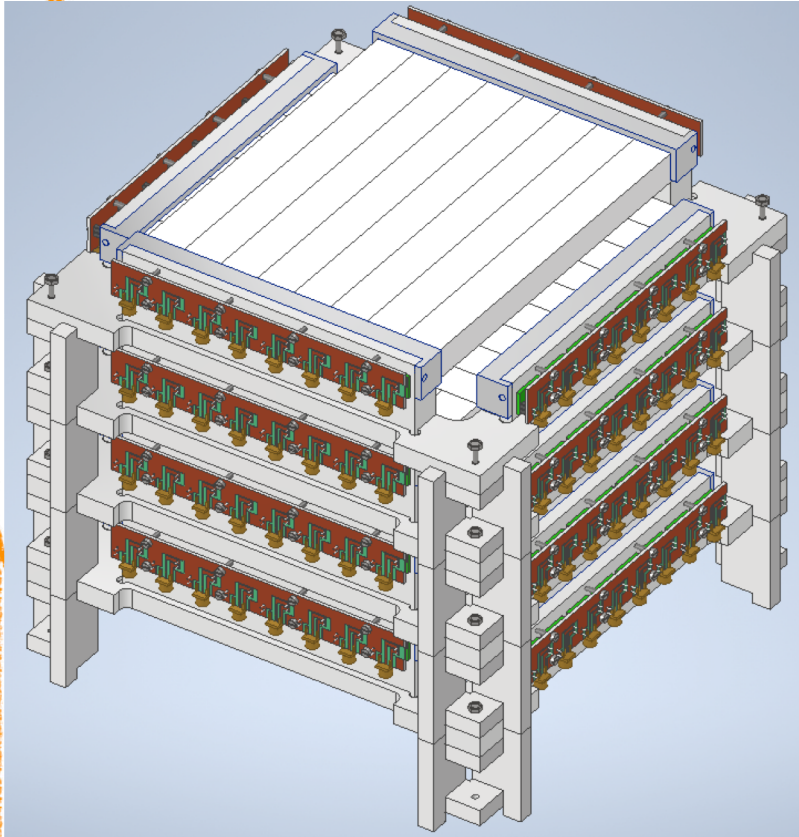
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# Tracker design and purpose



- Telescope layout:
  - Based on materials already available in our lab
  - Hodoscope consisting of 4 x-y planes (2 layers per plane)
    - 8 scintillator bars per layer with embedded WLS fibers
    - 2 SiPMs connected at both ends of each fiber
  - Readout with Caen DT5702 32 channel front end boards (FEB)
    - Each FEB can readout 2 layers
    - Implementation of new custom 128 channel FEB in progress
  - DAQ control with Raspberry Pi 4 B+ card through Ethernet connection
- Main purposes:
  - Outreach activities
  - Educational particle physics laboratories
  - Testbench for custom designed FEB
  - General purpose tracker

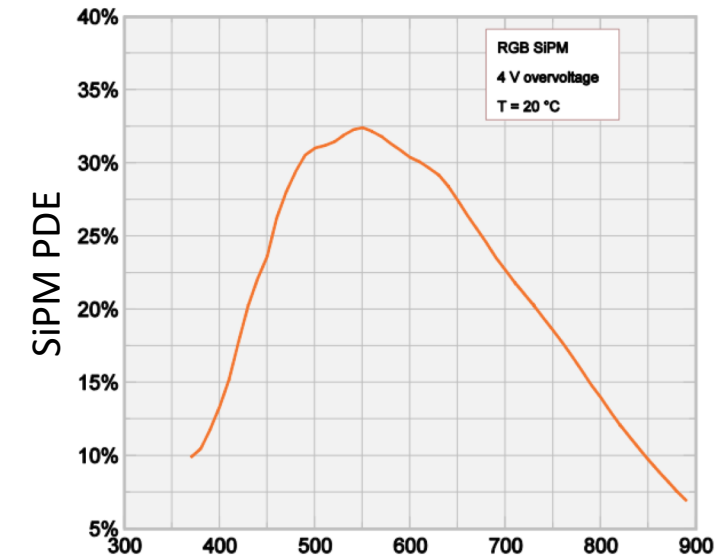
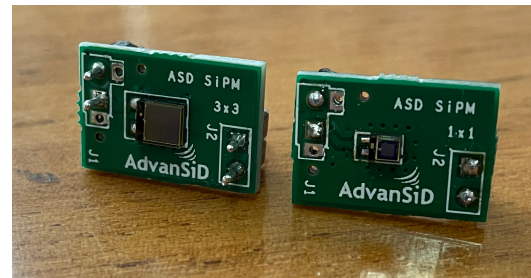
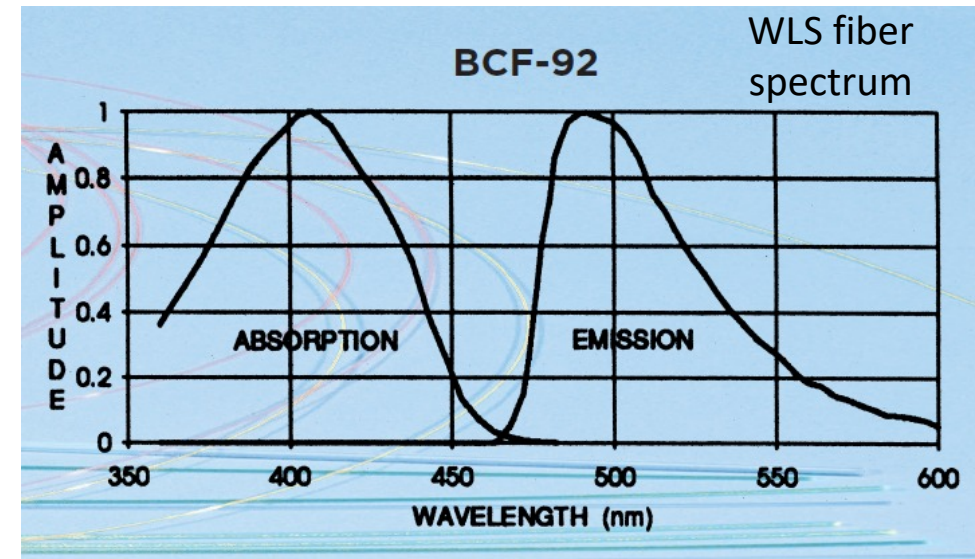
# Detector hardware



- Scintillator bars
  - extruded plastic scintillator
  - 15x19x200mm<sup>3</sup>
  - 4mm  $\varnothing$  hole for WLS fiber accommodation
  - White coated lateral surface
  - peak emission in blue
- WLS fibers
  - blue-to-green Saint-Gobain BCF-92
  - 2mm  $\varnothing$  and 215mm length

# Silicon Photomultipliers (SiPMs)

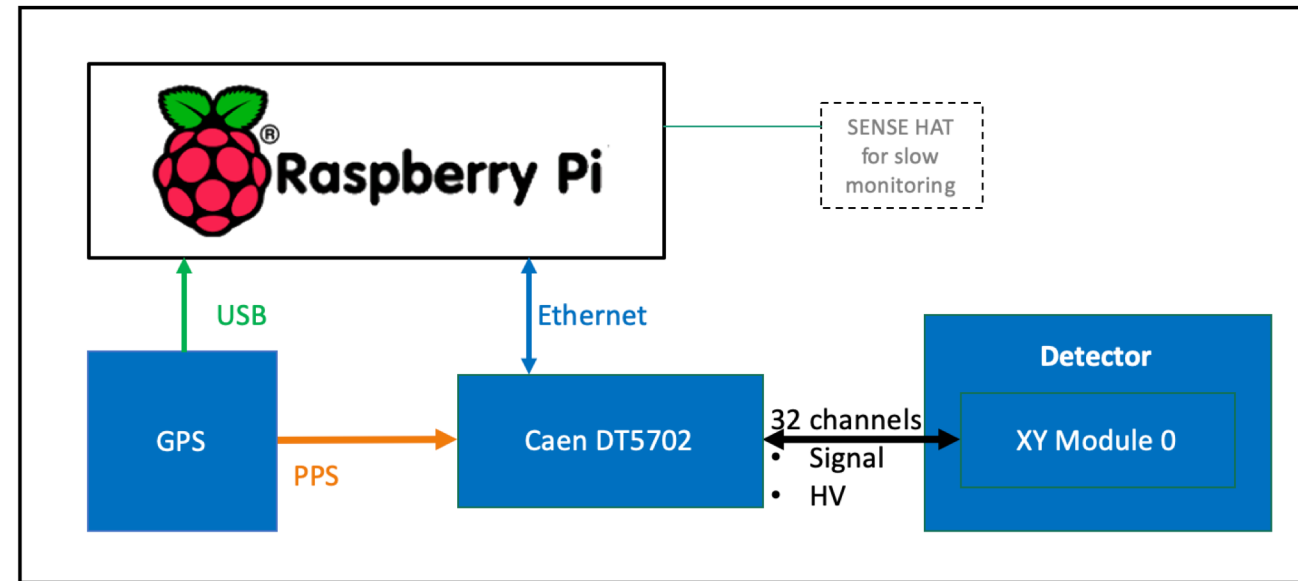
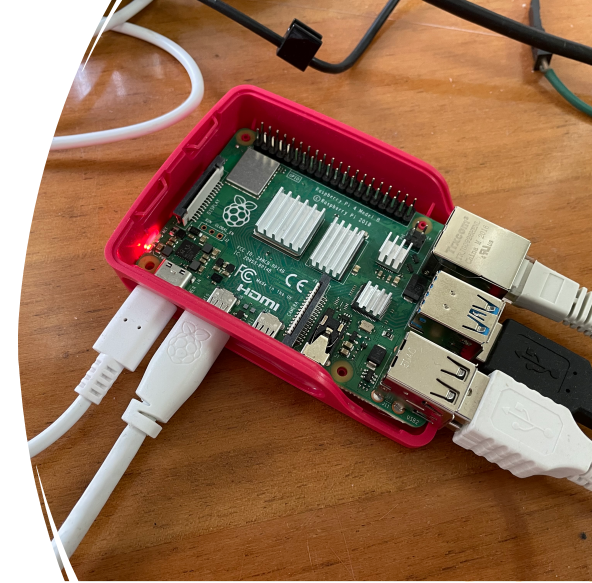
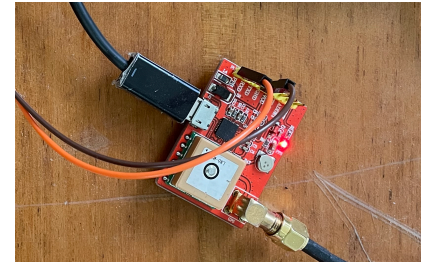
- Manufacturer: AdvanSiD
  - Sensitivity: RGB
  - Active area: 1x1mm<sup>2</sup> and 3x3mm<sup>2</sup>
  - 40 μm side micro-cells
  - $V_{bd} = 28 \text{ V}$
- WLS emission peak at 492 nm matches SiPM maximum PDE  $\approx 30\%$  @ 4V OV



[https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/sgc-scintillation-fiber\\_0.pdf](https://www.crystals.saint-gobain.com/sites/imdf.crystals.com/files/documents/sgc-scintillation-fiber_0.pdf)  
[https://advansid.com/attachment/get/up\\_54\\_1432741139.pdf](https://advansid.com/attachment/get/up_54_1432741139.pdf)

# DAQ system

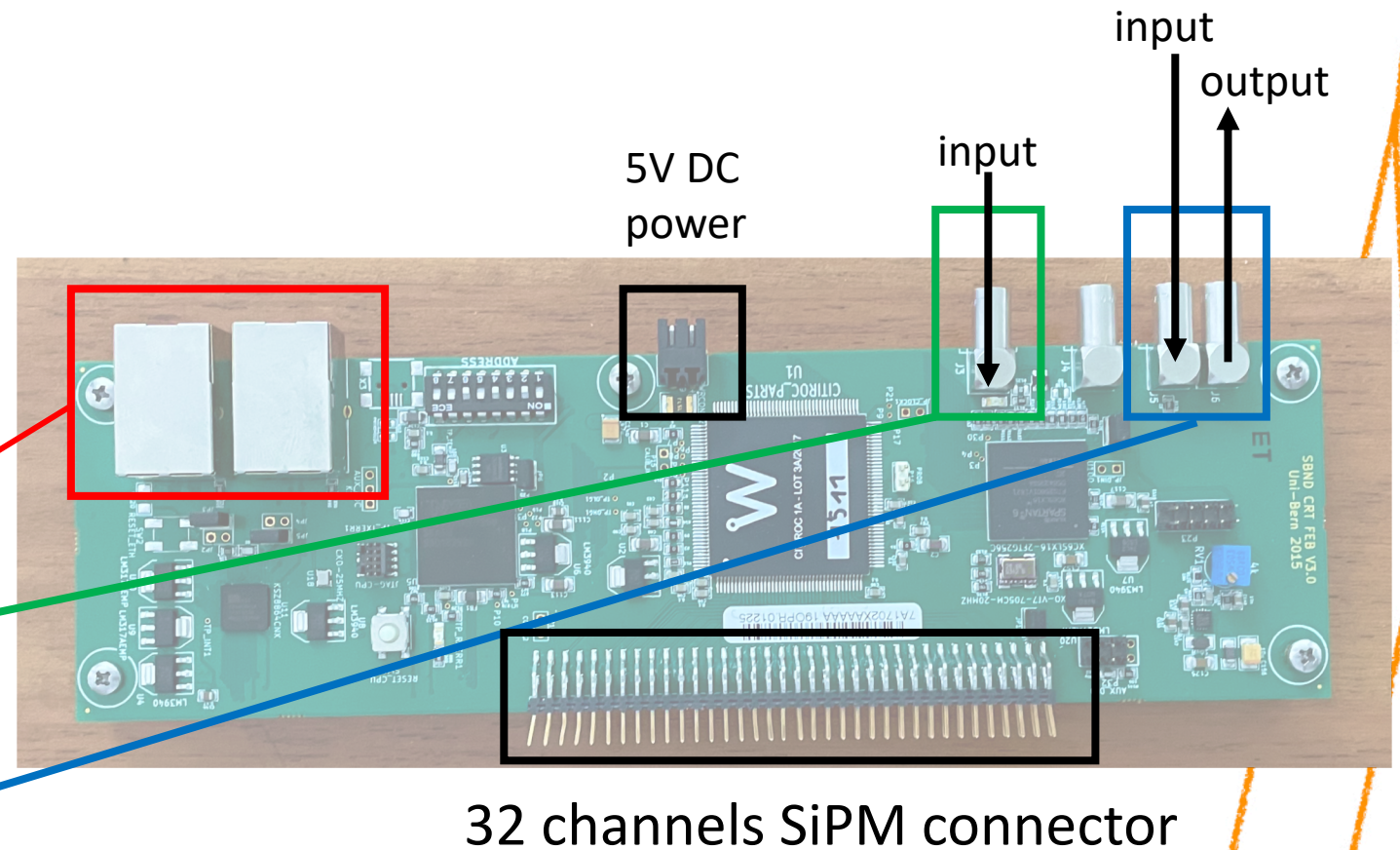
- Raspberry Pi 4 B+ card
  - 8 GB RAM, 128 GB SD memory card for data storage
  - Ethernet connection to the board
- GPS
  - GPS L80-M39
  - USB connection to Raspberry Pi
  - PPS signal to board
  - Run timestamp generation



<https://www.raspberrypi.org/products/raspberry-pi-4-model-b/?variant=raspberry-pi-4-model-b-8gb>

# Readout board

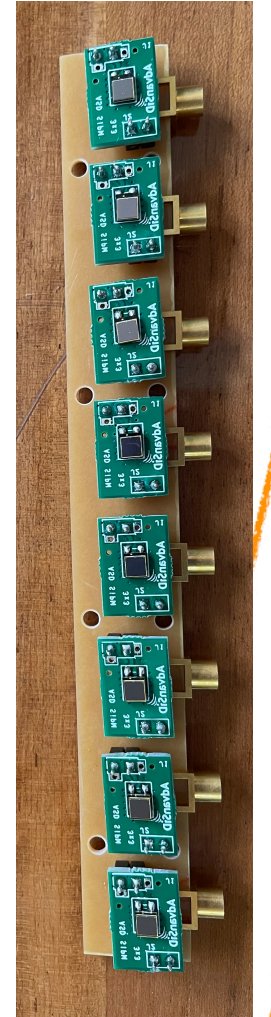
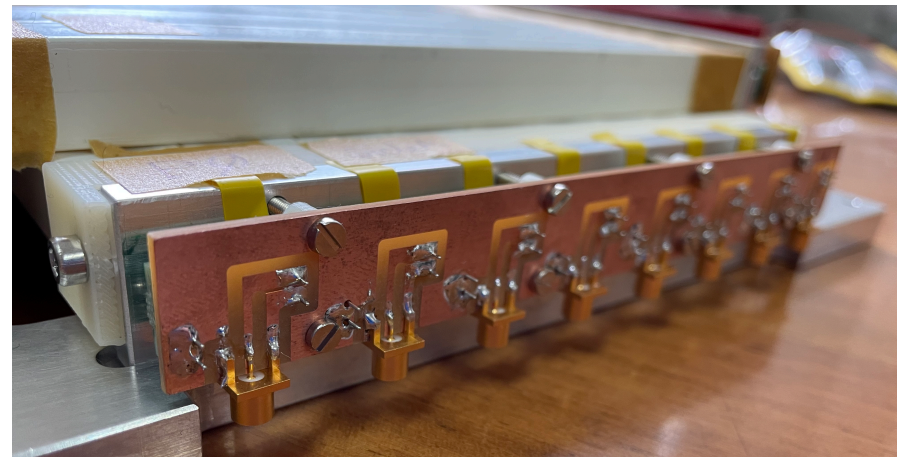
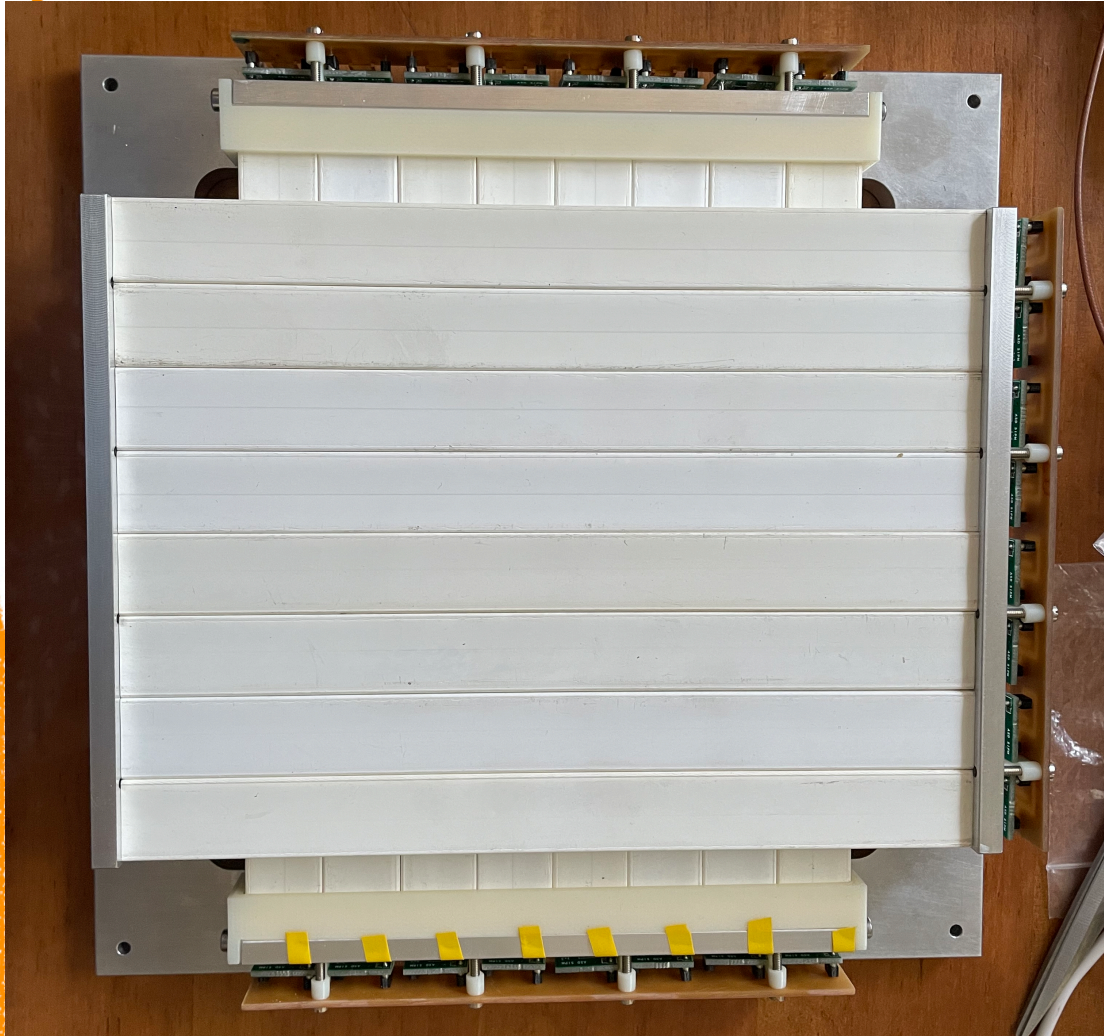
- Caen DT5702 32 channels FEB
- CITIROC front-end ASIC
- Trigger logic:
  1. Individual bar left-right SiPM coincidence
  2. single channel for pedestal calibration runs
- Ethernet connection for DAQ
- GPS PPS signal input for relative timing
- XY plane trigger enable signal for multiple board operation



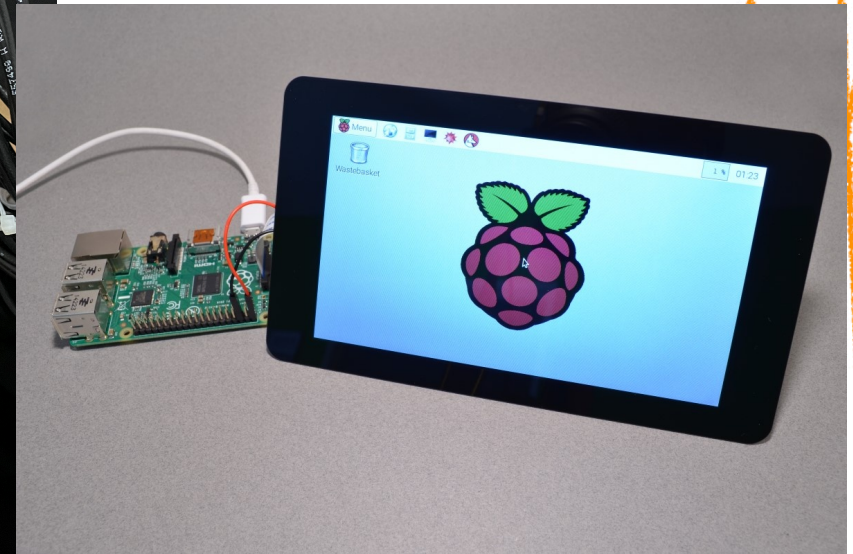
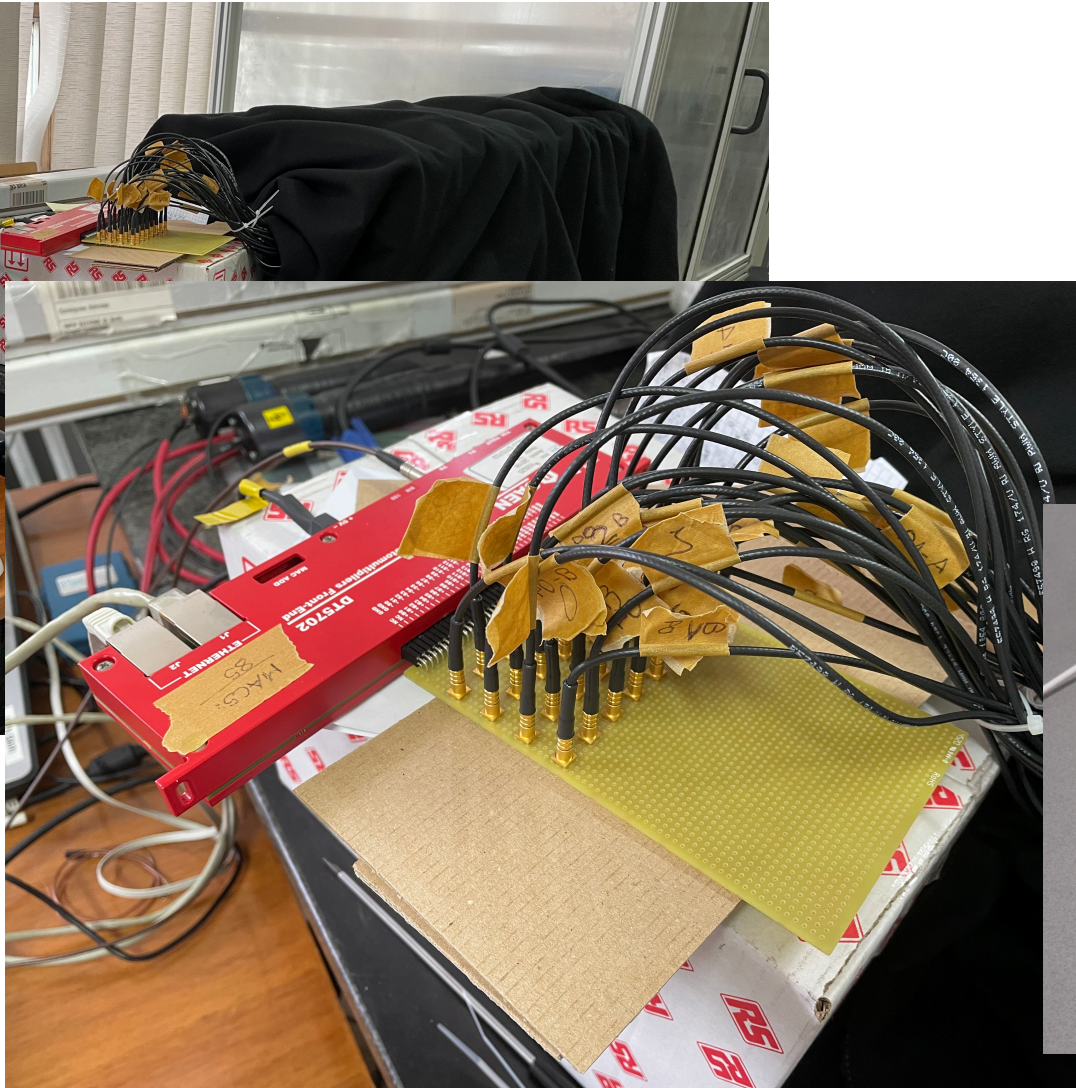
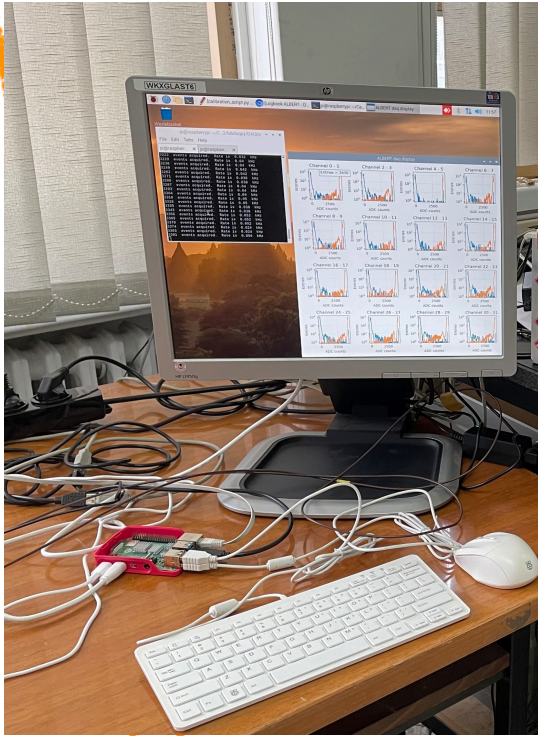
<https://www.caen.it/products/dt5702/>

<https://www.weero.com/products/sipm-read-out/citiroc-1a>

# View of a X-Y plane



# Setup





# DAQ software

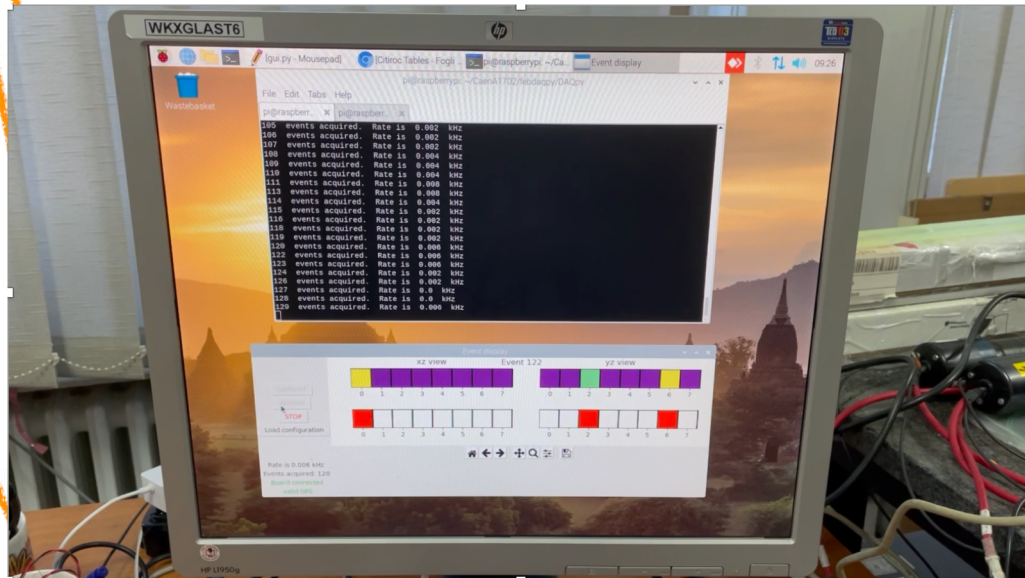
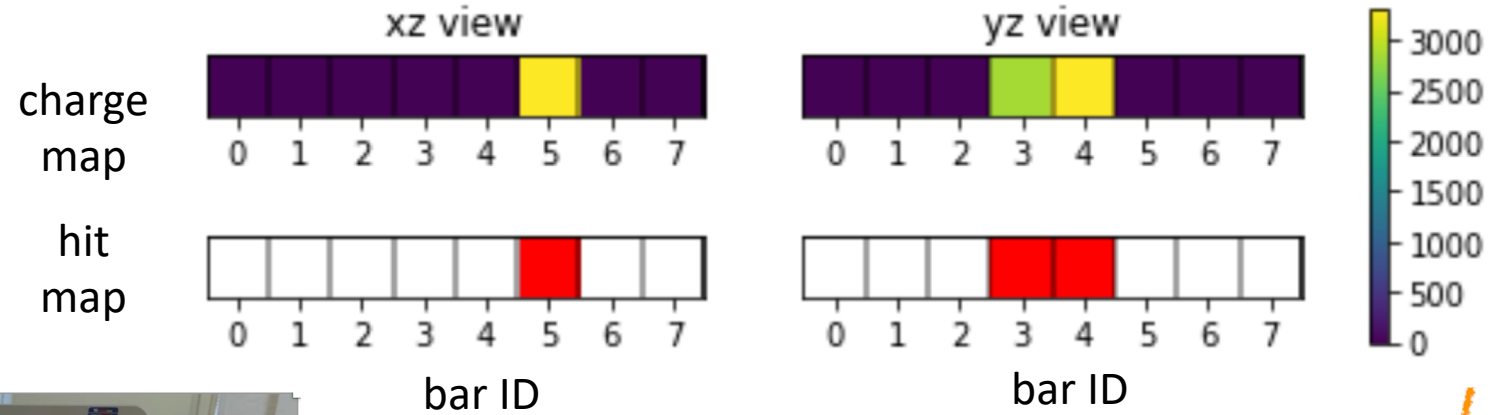
- Custom version of the CAEN FEBDTP C++ library for DT5702
  - DT5702 readout software: <https://www.caen.it/download/?filter=DT5702>
- Python wrapper using SWIG
  - Interface generator: <http://www.swig.org/index.php>



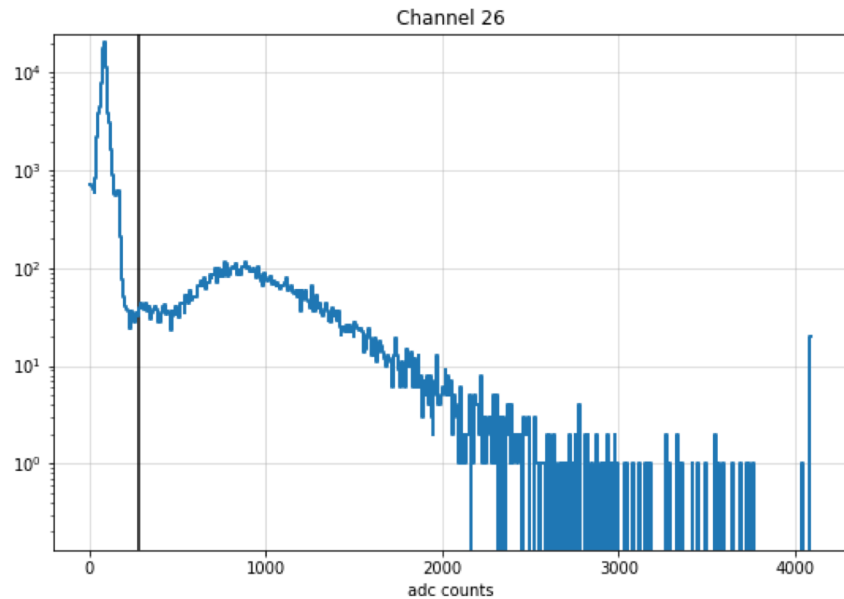
## ➤ Easy-to-use DAQ handling class:

- Command line tool
- GUI for portable device setup
- Online event display

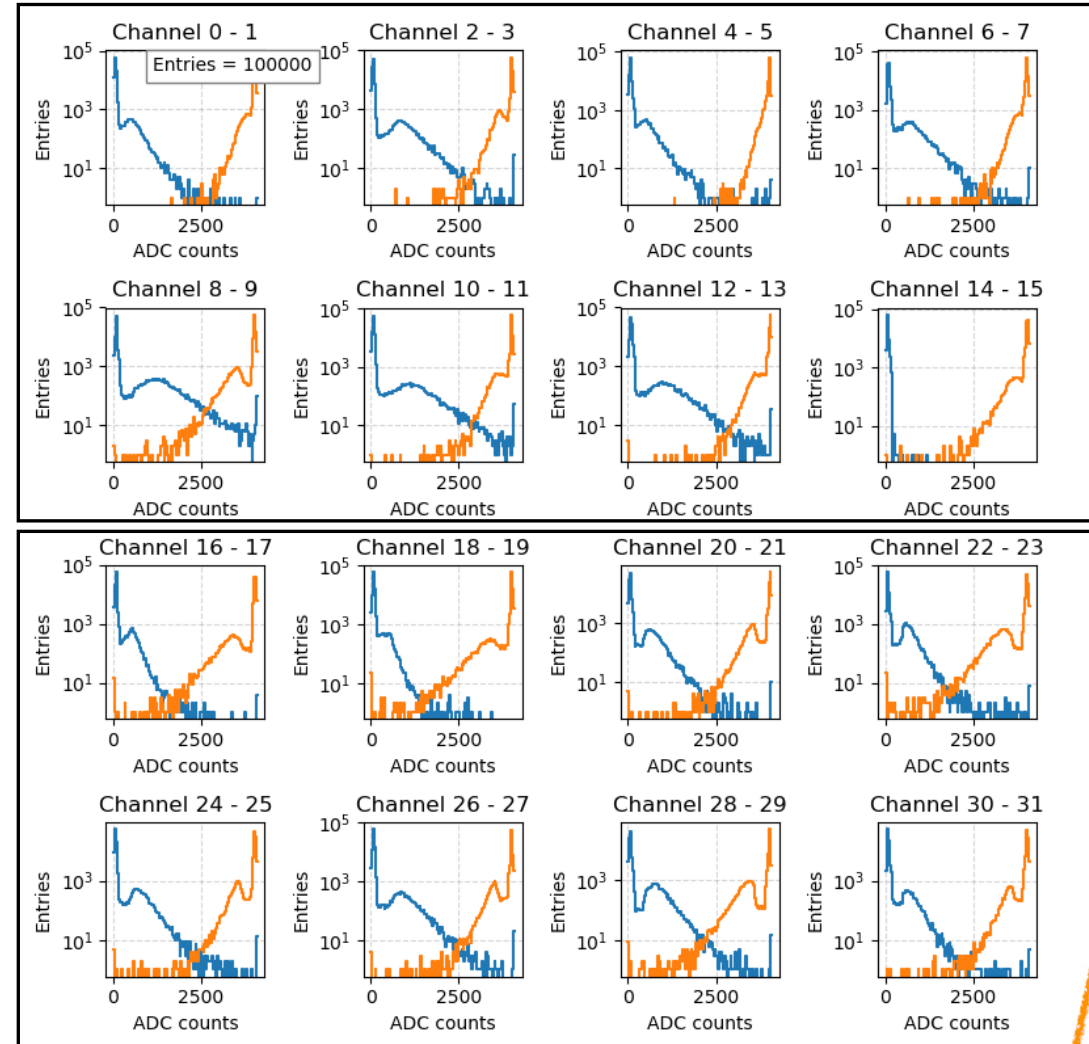
# Event display



# ADC count distributions

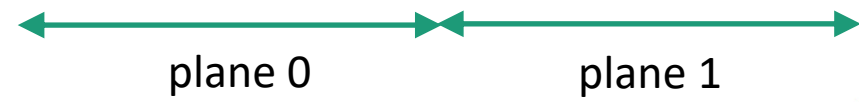
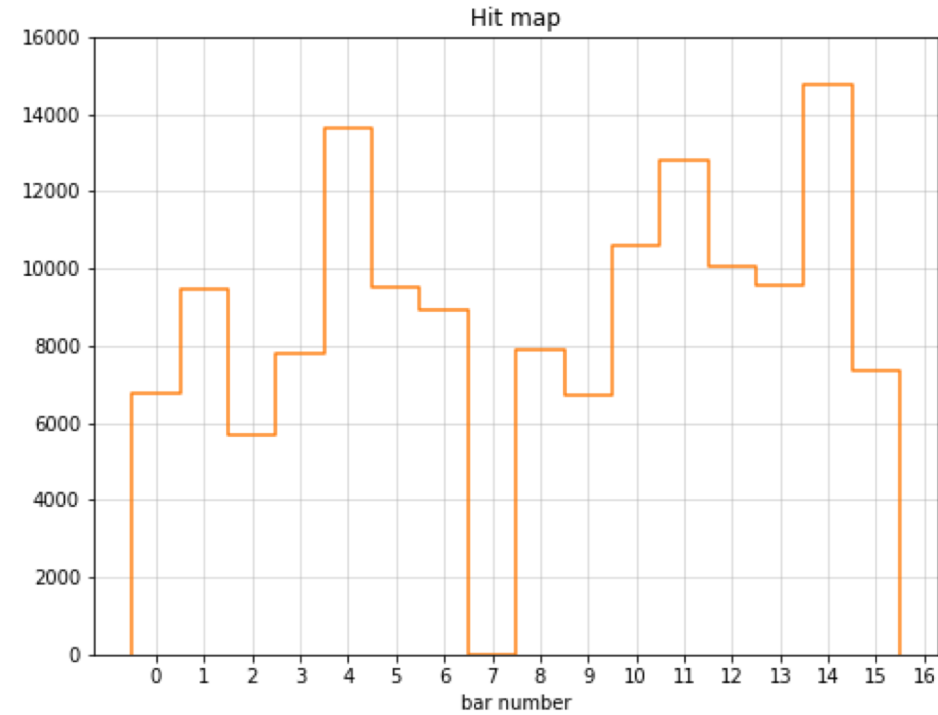
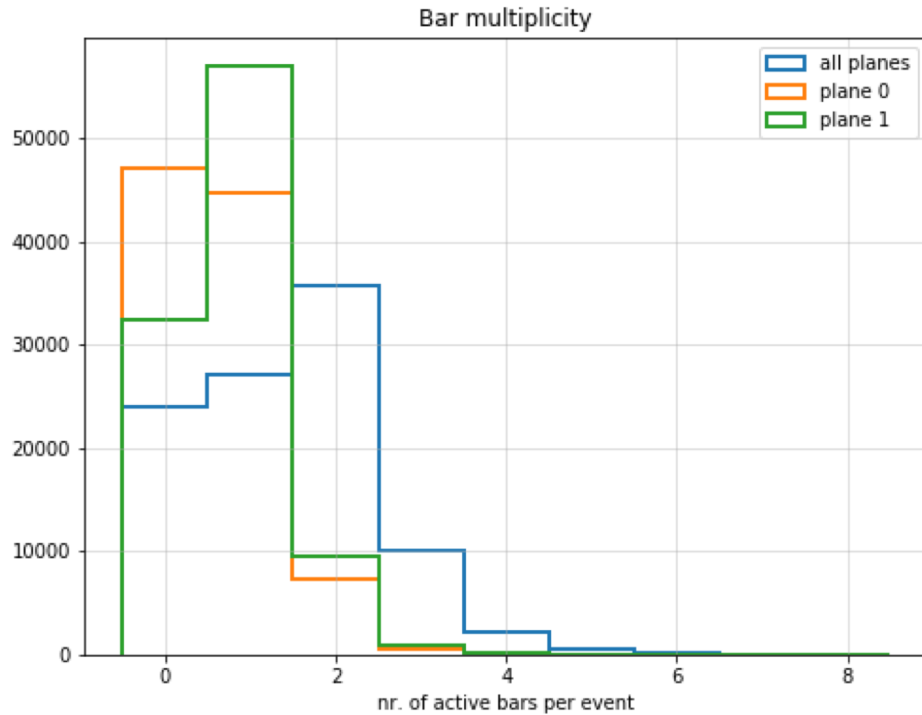


- Pedestal threshold:  $\text{SNR} \approx 5\sigma$
- Channel equalization to be optimized!



Side A 3x3 SiPM for both planes  
Side B 1x1 SiPM for plane 0, 3x3 for plane 1

# Bar multiplicity and hit map

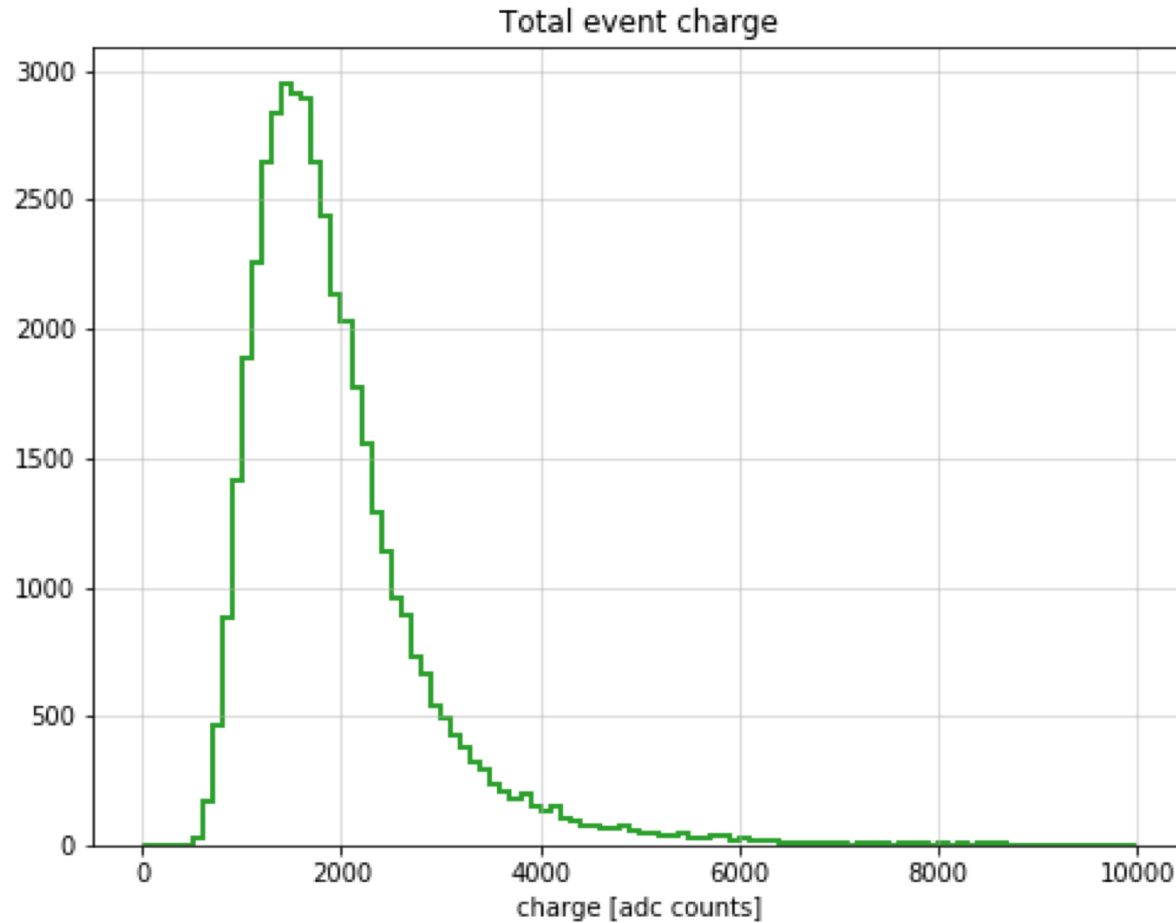


Lower efficiency of plane 0:

- a dead channel (bar #7)
- bars from one side are readout with  $1 \times 1 \text{mm}^2$  SiPMs

➤ Channel equalization to be optimized!

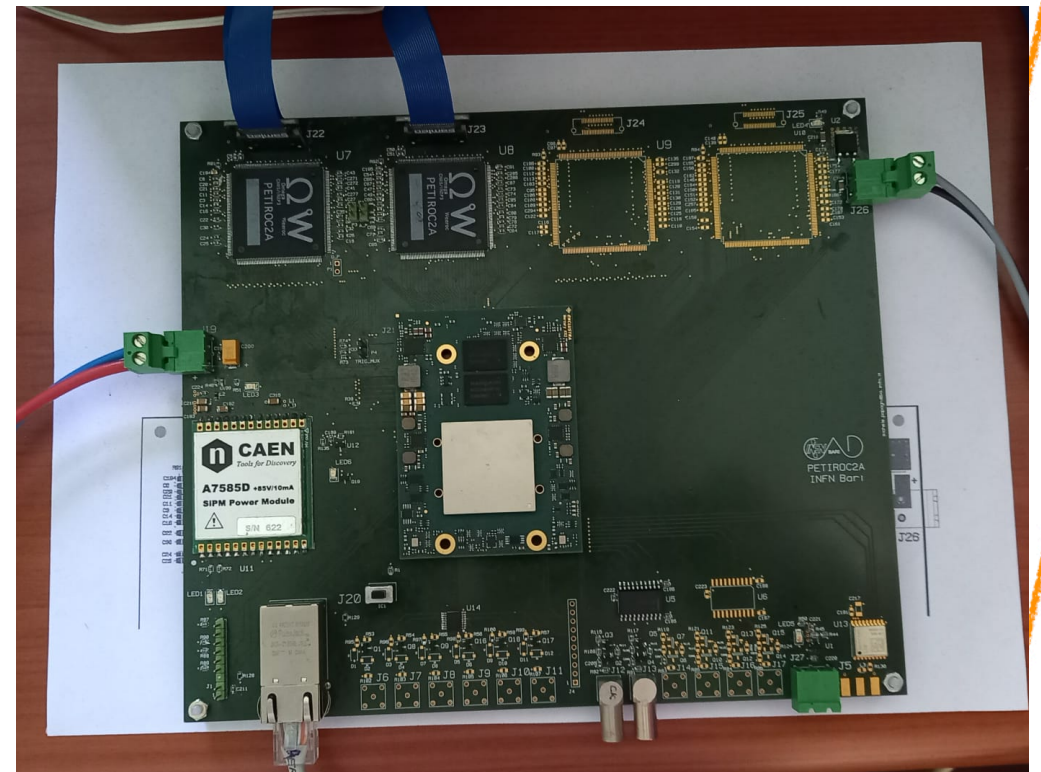
# ADC Charge distribution



The ADC charge looks as a Landau distribution as expected

# Conclusions and outlook

- Complete setup with more planes
- Release of full software and documentation
- Upgrade with custom DAQ board using PETIROC front-end ASIC
  - 128 channels
  - GPS for single event timing
  - flexible trigger logic



**Thanks for  
your attention!**