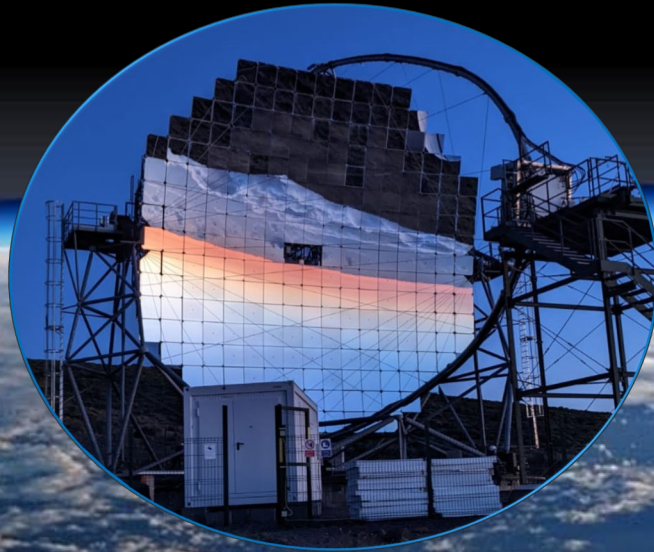# Gamma-ray identification with Imaging Atmospheric Cherenkov Telescopes

Di Venere Leonardo
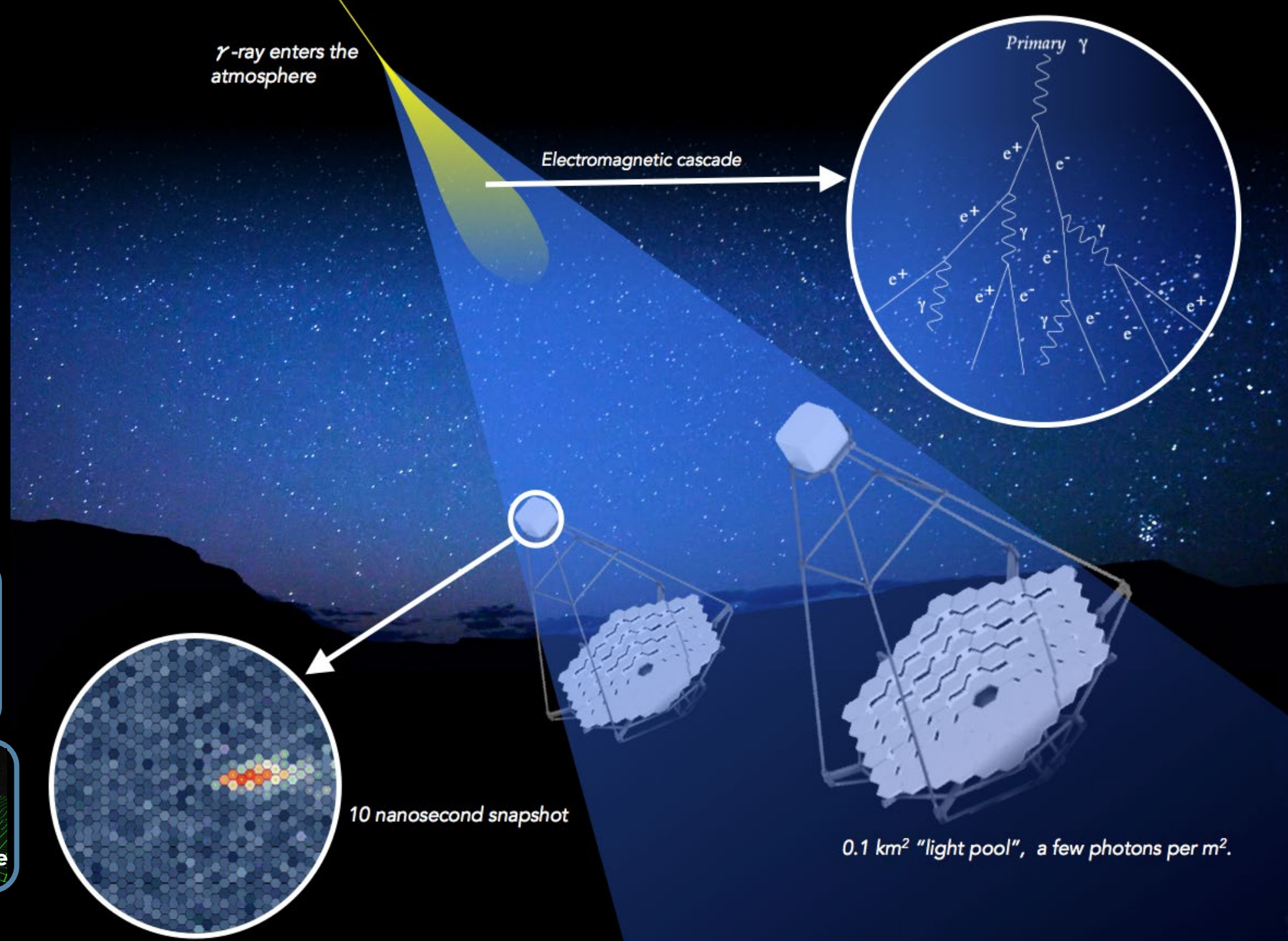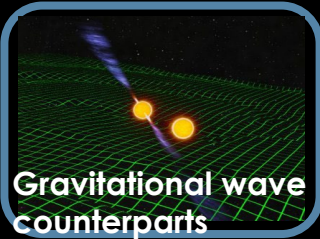
Università e INFN Bari
leonardo.divenere@ba.infn.it

Imaging Atmospheric Cherenkov Telescopes

TeV gamma-ray ideal to probe the most energetic Universe

Gamma-Ray Bursts

Supernova remnants

Active Galactic Nuclei

Pulsar wind nebulae

Dark matter

Gravitational wave counterparts

γ-ray enters the atmosphere

Electromagnetic cascade

Primary γ

e^+ e^-

10 nanosecond snapshot

0.1 km^2 "light pool", a few photons per m^2.

Particle identification

- Gamma rays and cosmic rays produce particle showers in atmosphere which emit Cherenkov light

- Shower images detected by fast high-resolution cameras

- ML algorithms used for the particle identification and the measurement of direction and energy of the primary particle
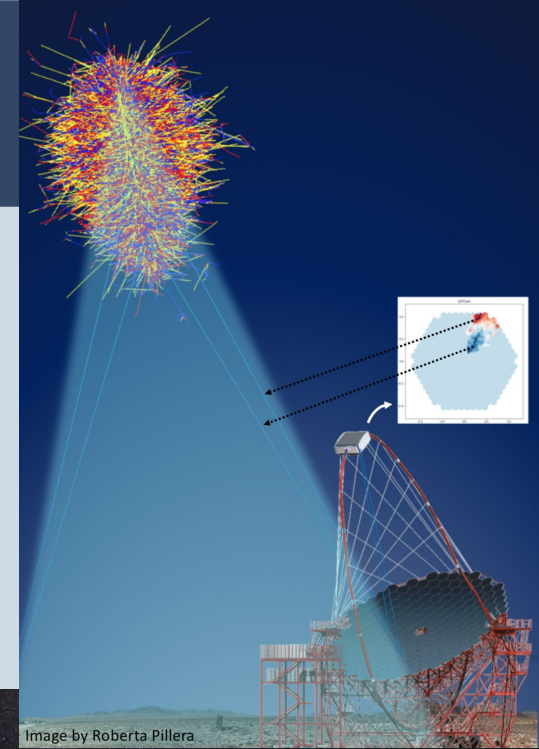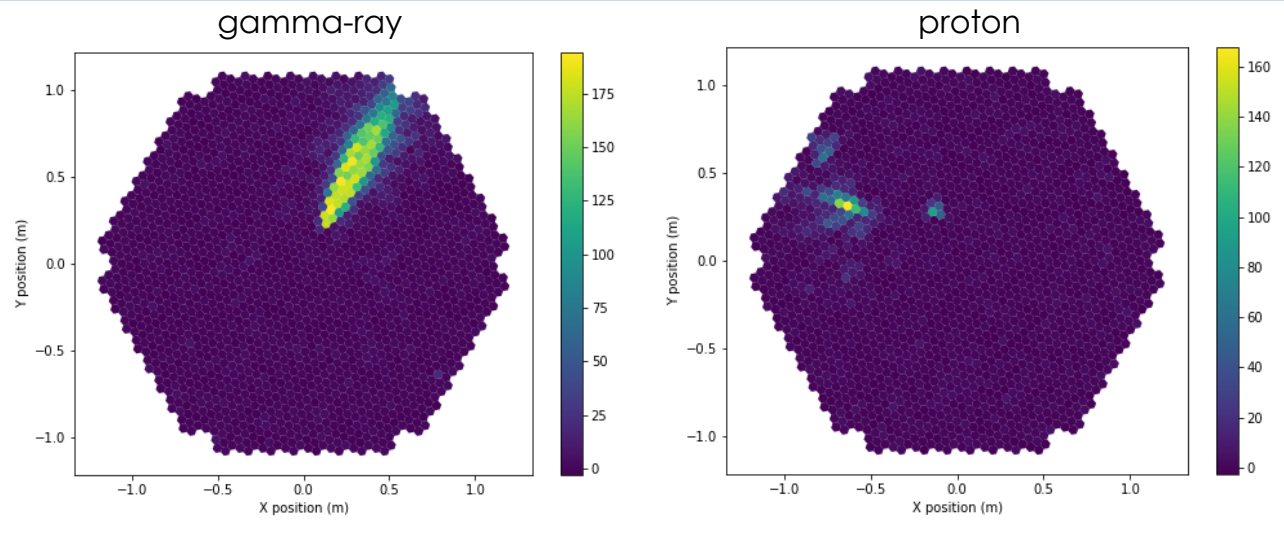
Image by Roberta Pillera

gamma-ray

proton

Di Venere L.

https://www.cta-observatory.org

IACT camera

pSCT @FLWO

- Need to detect faint (down to few p.e.) and fast (~tens of ns) Cherekov light

- Need to deal with night sky background (NSB) light

- Photon detectors:
  Photomultiplier Tubes (PMT) → Silicon Photomultipliers (SiPM)

- Pros:
  - Single p.e. resolution
  - NSB tolerant → Operable under full moon
  - High PDE (> 50% peak)
  - Small pixels → easy to make arrays
  - Low bias voltage (<100V)

- Cons:
  - High sensitivity to NSB in > 550 nm range
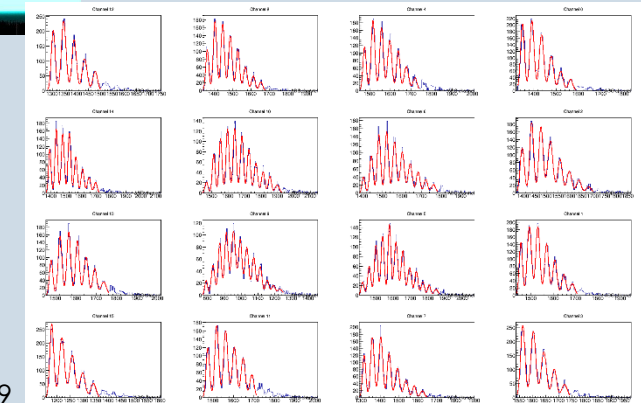 - Correlated noise
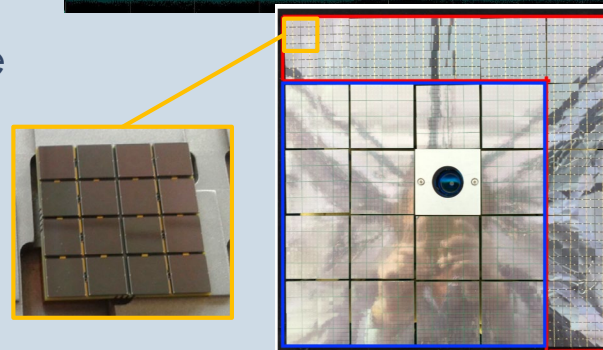 - high dark count rate →
    usually below the NSB rate

FBK NUV-HD technology
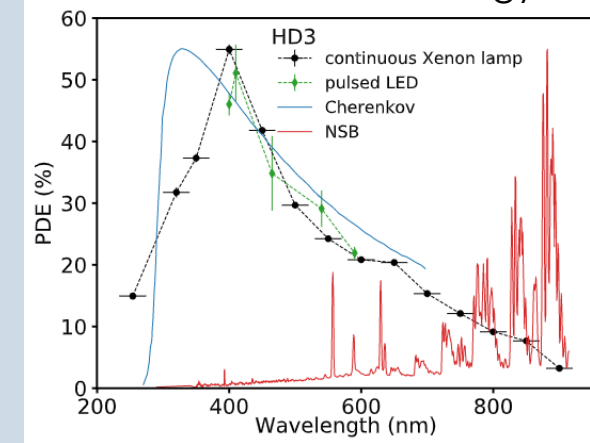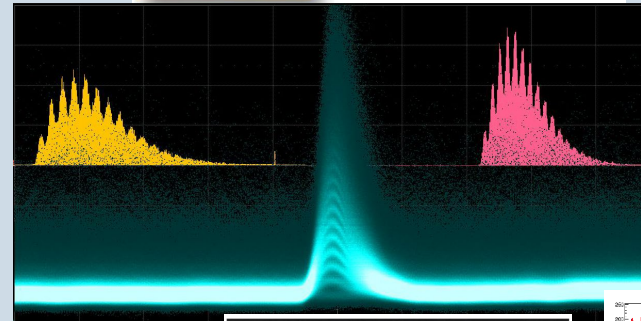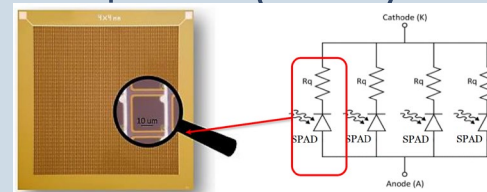
Ambrosi+2022 Submitted to NIMA

Di Venere L.

Ambrosi+2022 https://doi.org/10.1016/j.nima.2022.167359

Fast and single p.e. resolution frontend electronics

**SMART:** a **S**iPM **M**ultichannel **A**sic for high **R**esolution Cherenkov **T**elescopes

Features:

- 16-channel trans-impedance amplifier
- Fast path gain: 1-3 mV/ph
- Tail suppression: pulse duration ~ 10ns
- Power consumption: 20mW/channel
- SiPM bias fine tuning: LSB = 12.5mV
- Slow path output & 10 bit ADC: LSB = 2MHz
- Output dynamic range:
  - 900 mV without external PZ
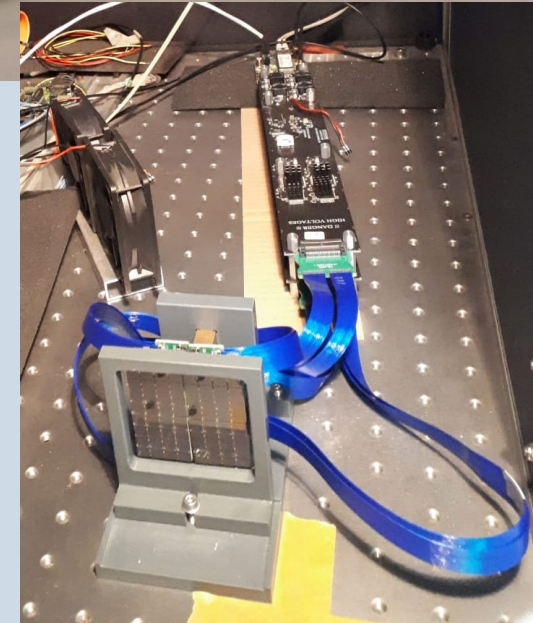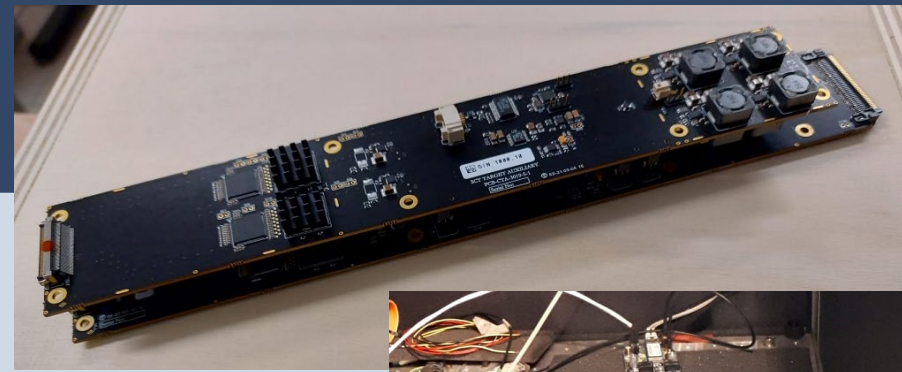 - 600 mV with external PZ

- ~800 ASICs tested @INFN Bari
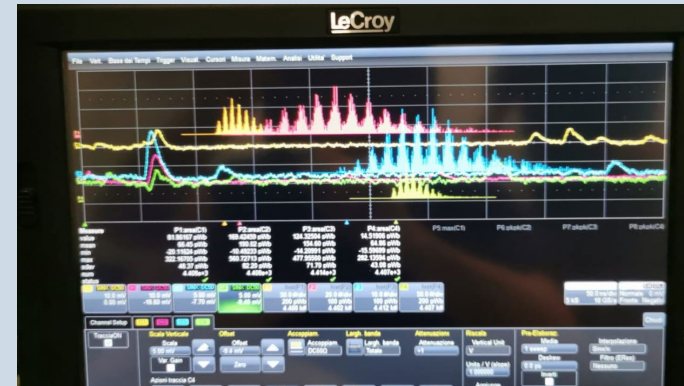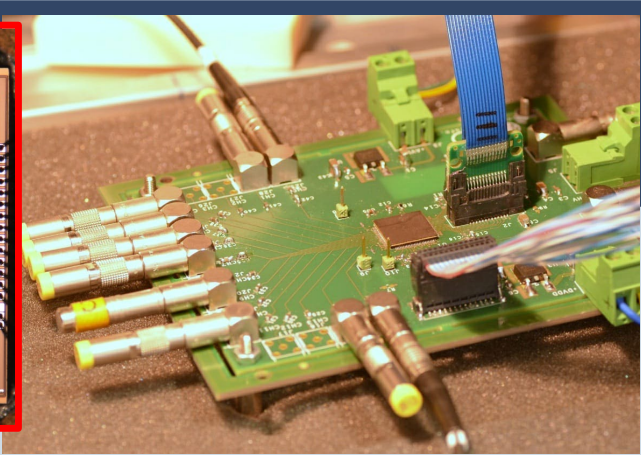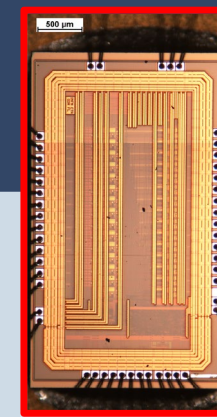
Designed by F. Licciulli & G. De Robertis at the Electronics CAD INFN Bari

Contact: francesco.licciulli@ba.infn.it
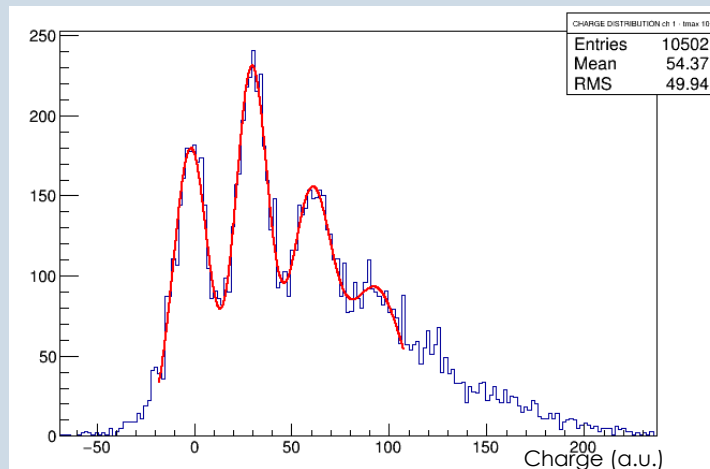

Di Venere L.
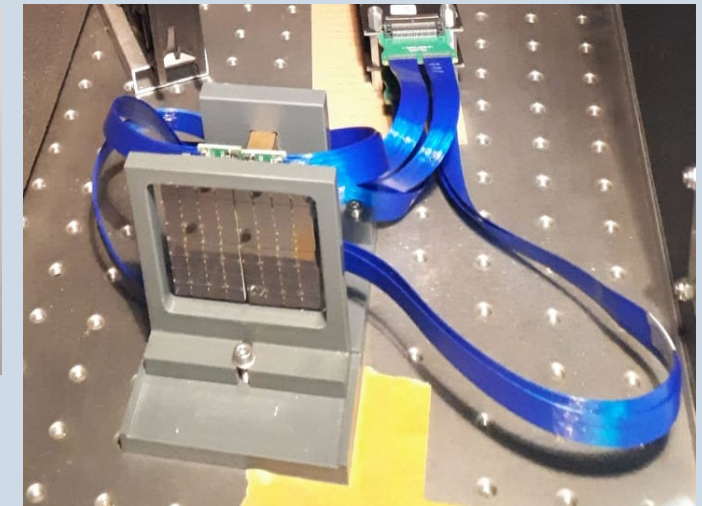
Readout electronics

- Readout electronics to digitize fast signals and generate trigger signals at pixel level →
TARGET ASICs

  o CTC ASIC: 16-channel 1GSa/s digitizer

    • Analog buffer with 16k cells per channel →16 us storage depth

  o CT5TEA ASIC: 16-channel trigger ASIC

    • Channels are summed in groups of 4 to obtain 4 trigger pixels per ASIC

Single p.e. spectrum

Rate scan

Di Venere L.