Gamma-ray identification with Imaging Atmospheric Cherenkov Telescopes

Di Venere Leonardo

INFN Bari
leonardo.divenere@ba.infn.it

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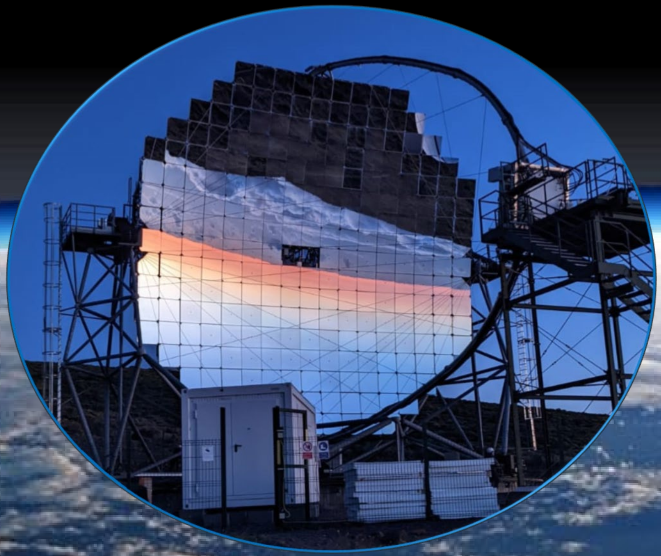
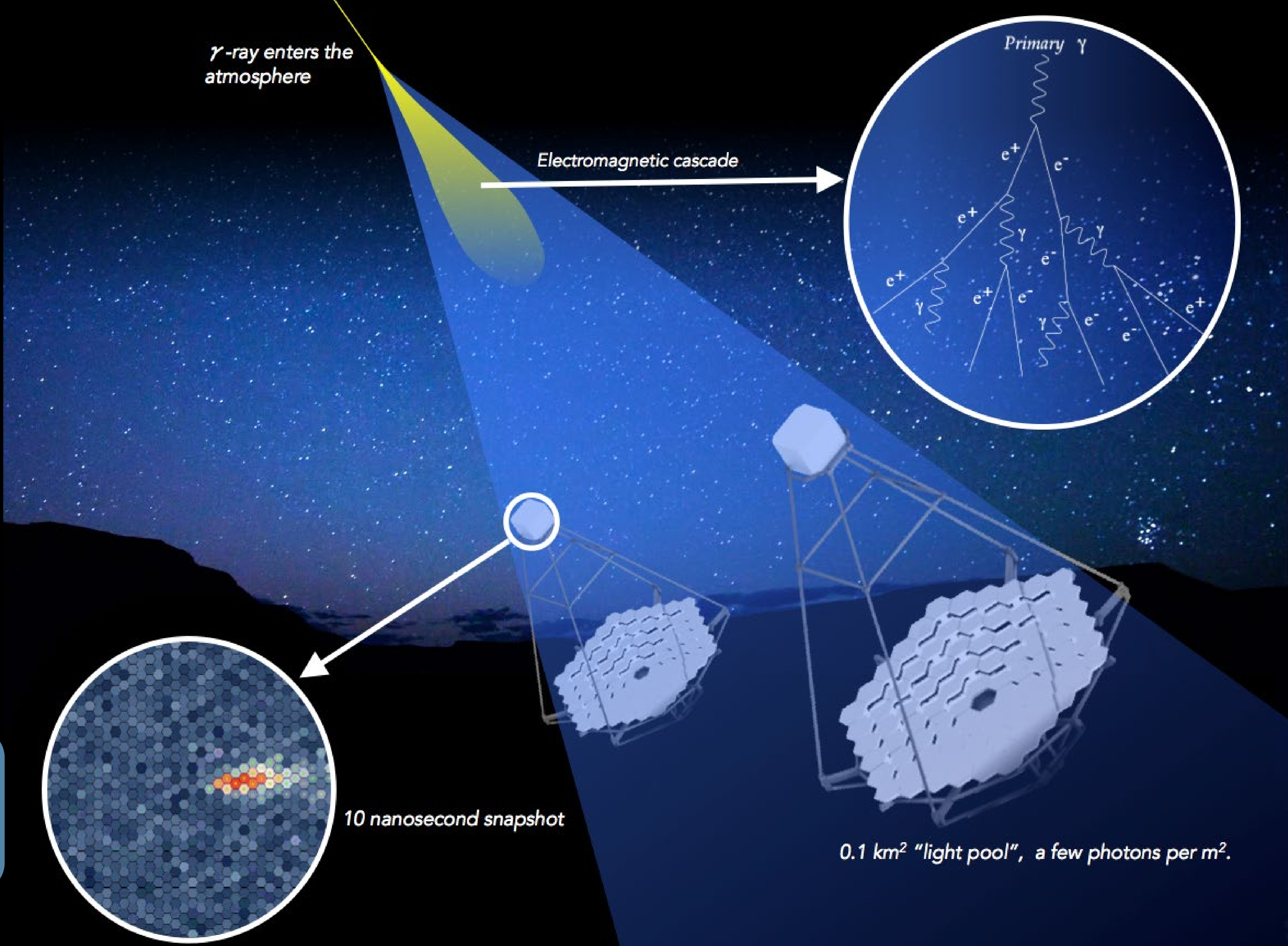


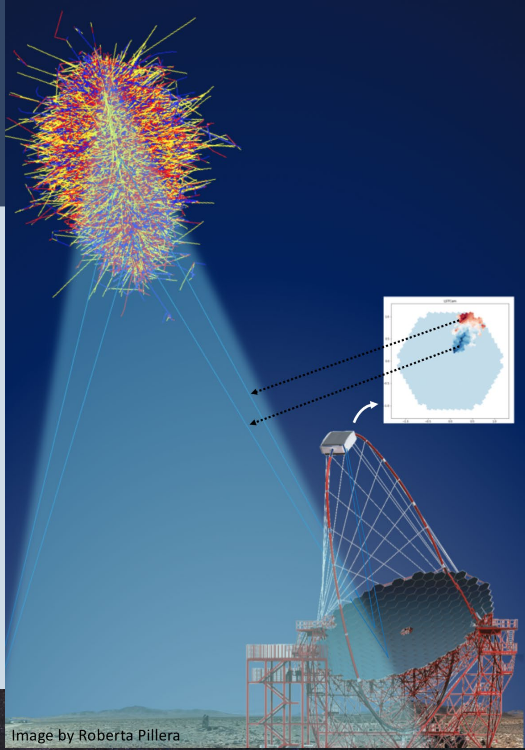
Imaging Atmospheric Cherenkov Telescopes

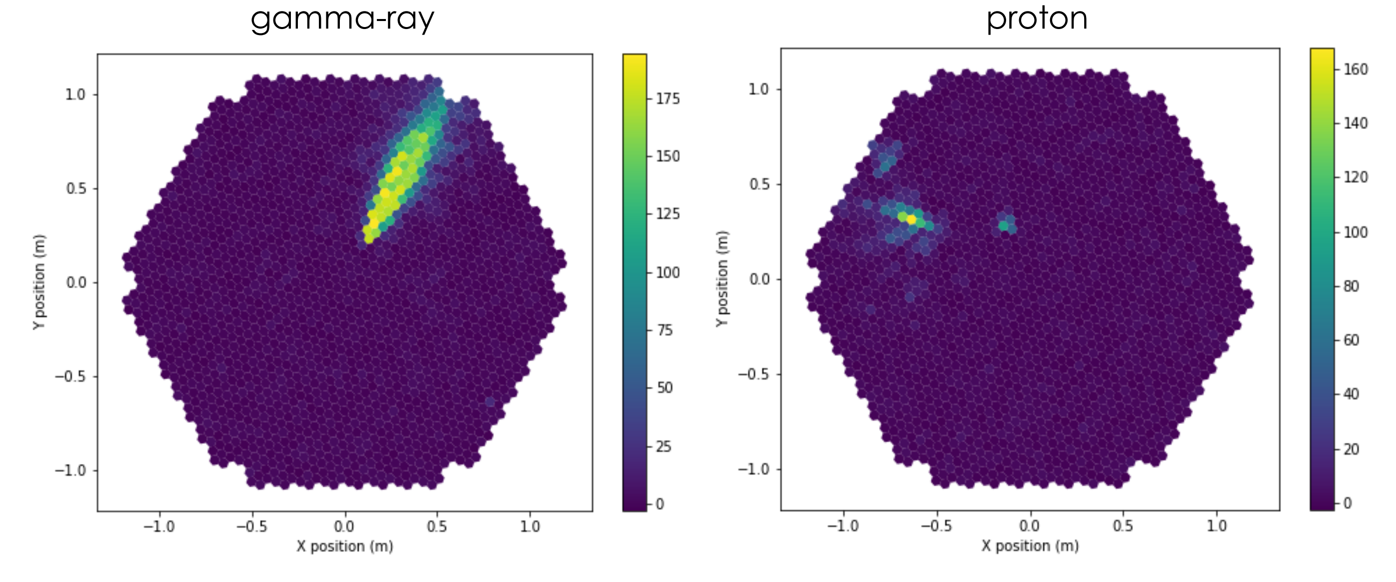
TeV gamma-ray ideal to probe the most energetic Universe



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

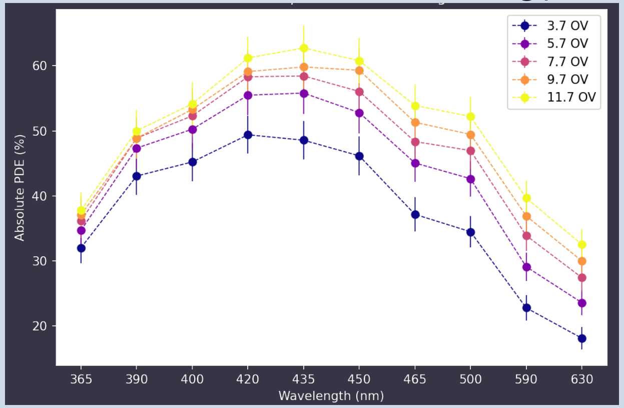


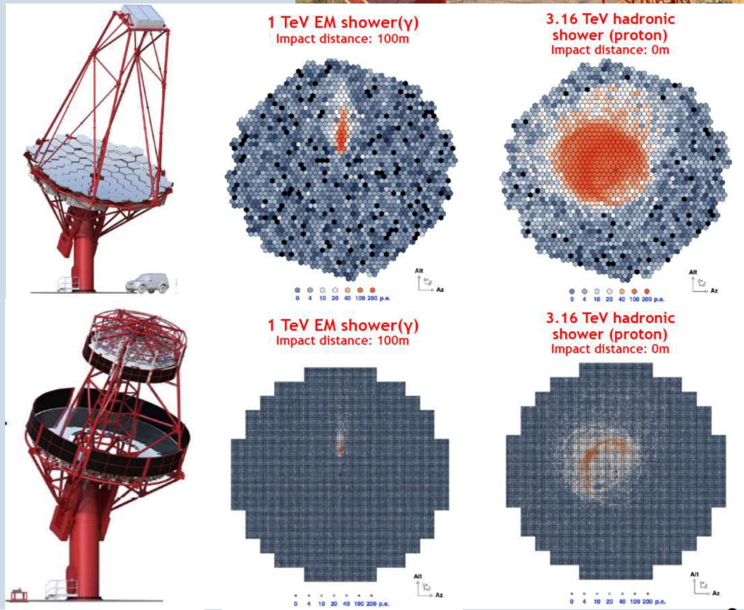


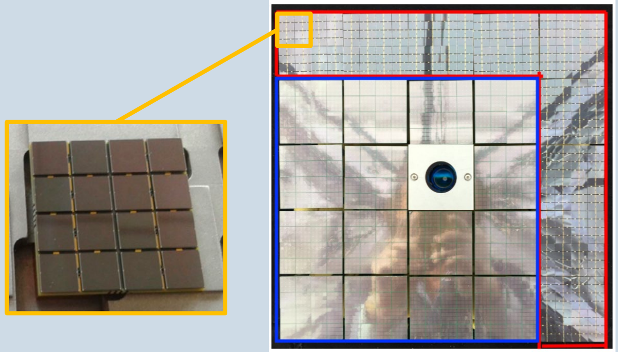
IACT camera

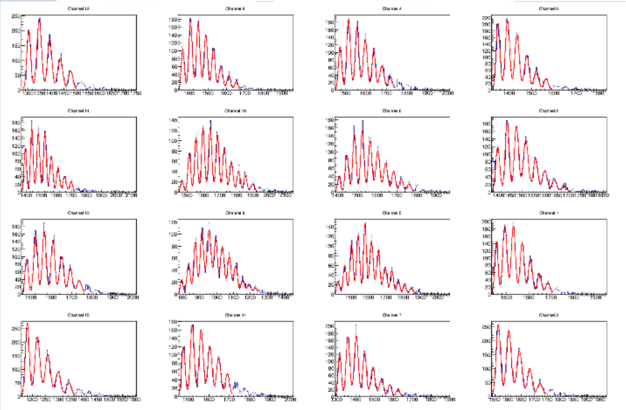
- Need to detect faint (down to few p.e.) and fast (~tens of ns) Cherekov light
- Need to deal with night sky background (NSB) light
- Photon detectors:
  Photomultiplier Tubes (PMT) → Silicon Photomultipliers (SiPM)
- Pros:
  - Single p.e. resolution
  - NSB tolerant → Operable under full moon
  - High 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-MT technology









Di Venere L.

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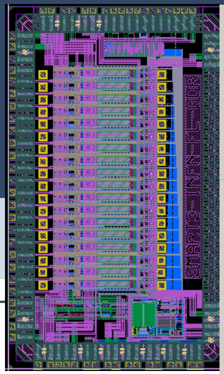
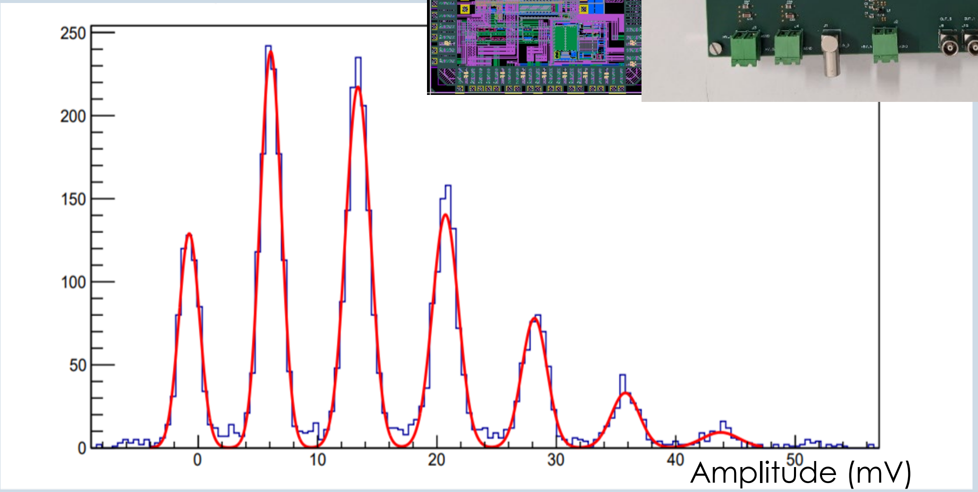
Fast and single p.e. resolution frontend electronics

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

Features:

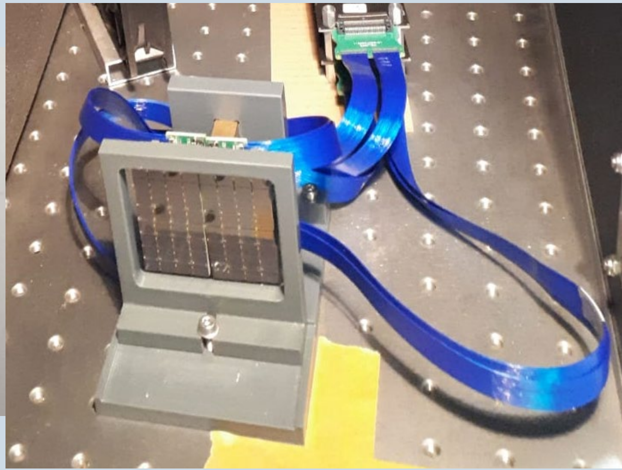
- 3.3 V & 1.2 V power supply
- SiPM fine bias adjust range: 1.7 V
- Channel current consumption 3.6 mA
- Fast-path output dynamic range: up to 1.7 V on 50 Ohm load (AC coupled)
- Slow-path input dynamic range: up to 2 mA of mean SiPM current (1 pC/pe at 2 GHz)
- Programmable gain (R), bandwidth (C) and tail suppression (PZ)
    - Gain is adjustable for each channel to be combined with SiPM bias fine adjustment to improve gain equalization



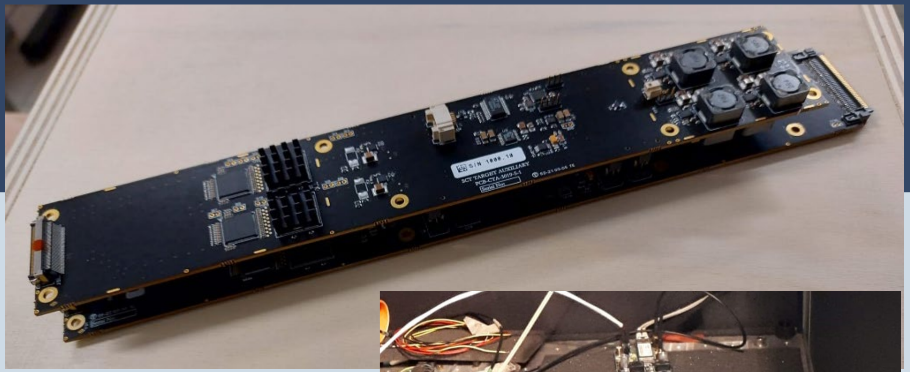


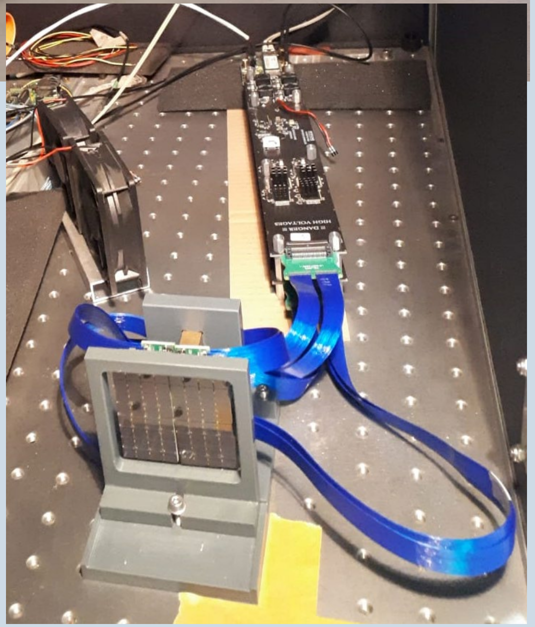
Designed by F. Licciulli & G. De Robertis at the Electronics CAD INFN Bari

Contact: francesco.licciulli@ba.infn.it



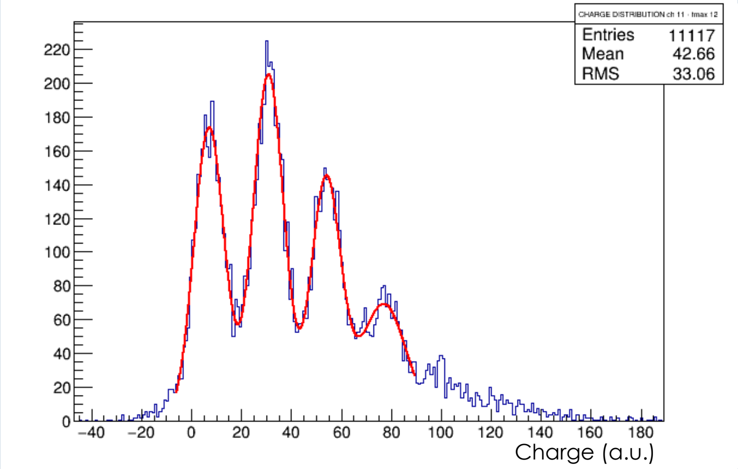
Readout electronics





- Readout electronics to digitize fast signals and generate trigger signals at pixel level → TARGET ASICs
  - CTC ASIC: 16-channel 1GSa/s digitizer
    - Analog buffer with 16k cells per channel →16 us storage depth
  - CT5TEA ASIC: 16-channel trigger ASIC
    - Channels are summed in groups of 4 to obtain 4 trigger pixels per ASIC

Single p.e. spectrum



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