

# A compact particle detector for Space-Based applications: Development of the Low Energy Module (LEM) for the NUSES space mission

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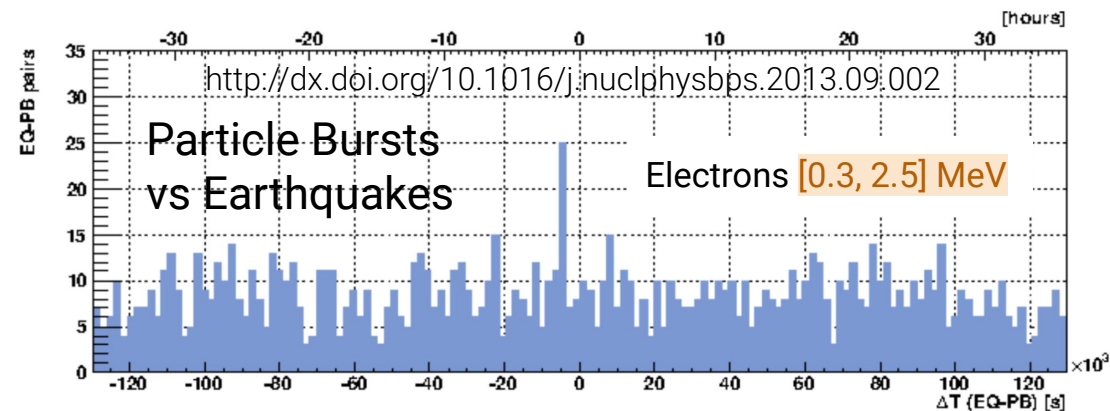
Preventivi INFN – 29/06/2023



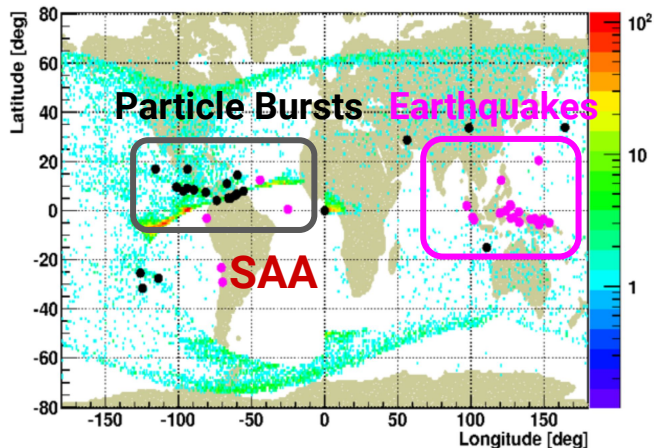
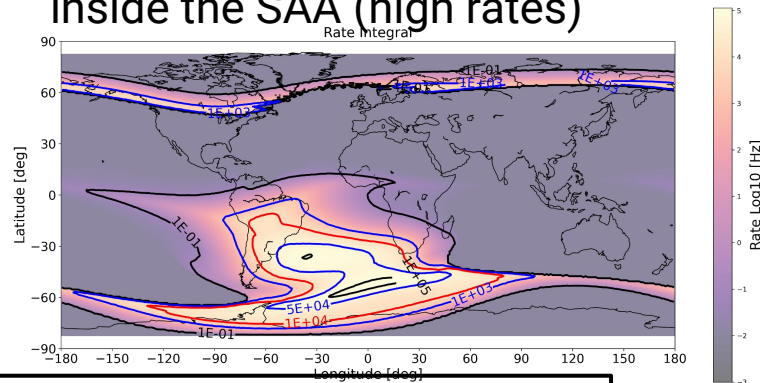
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# Physics of a spectrometer for low energy charged particles



study the trapped particles also inside the SAA (high rates)



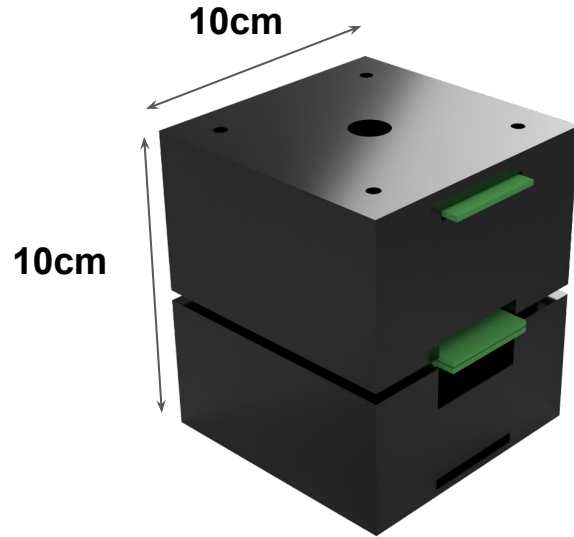
- + SPACE WEATHER  
(low energy protons/Helium)
- + Gamma Ray Burst

Multiple scattering: @ low energy is not possible to use “Traditional” particle tracking



# The (LEM) LOW ENERGY MODULE

A compact particle spectrometer for time resolved measurement of differential flux distribution of low-energy charged particles

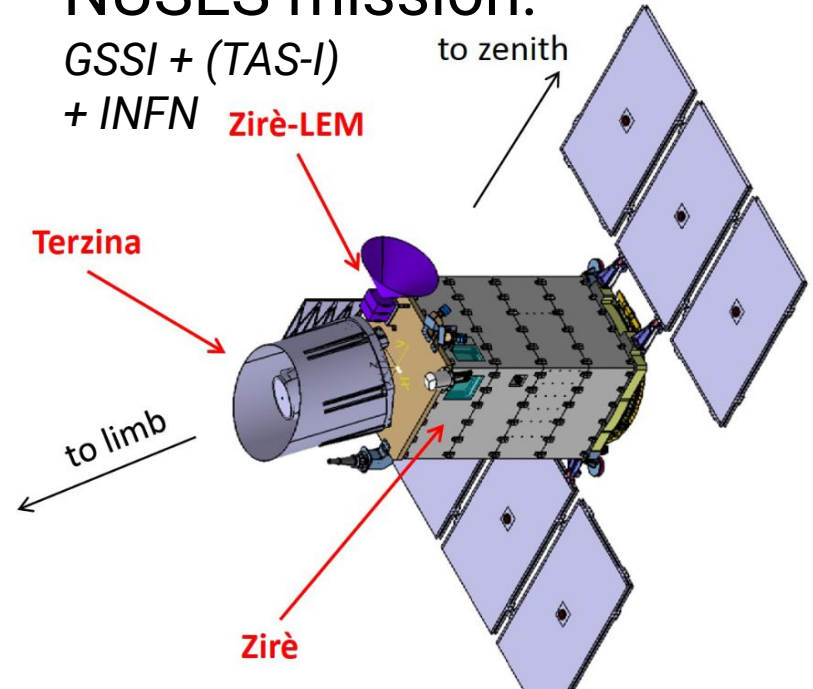


Future: launch a cubesat made in TN

2024-2025:

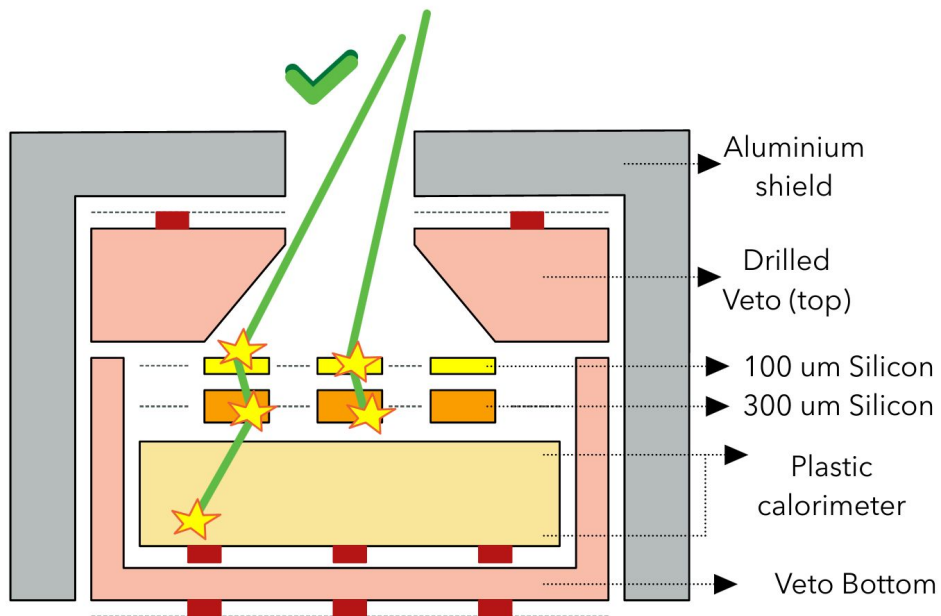
## NUSES mission:

GSSI + (TAS-I)  
+ INFN **Zirè-LEM**



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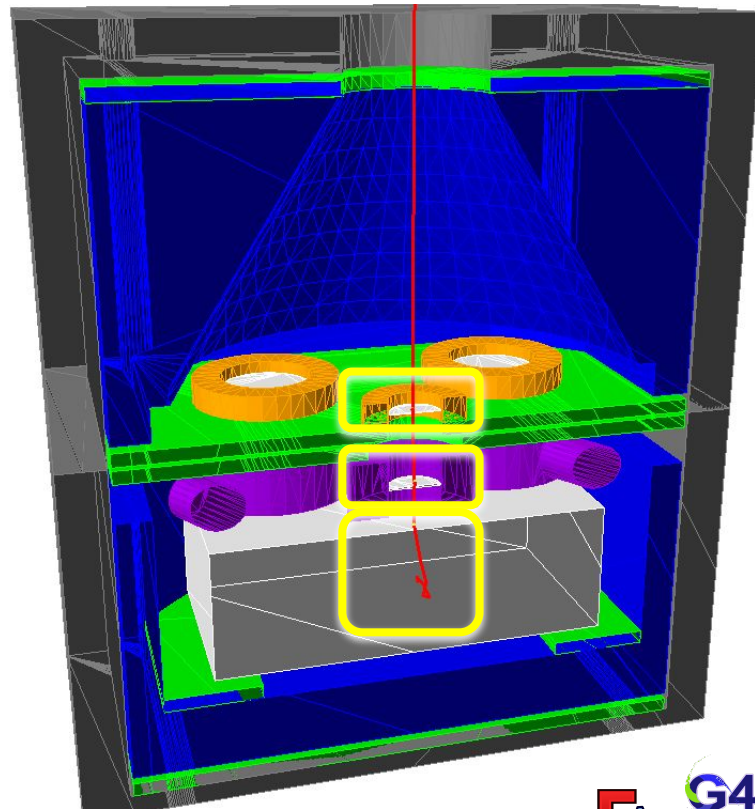
# The detection concept



- Particle **confined** within the thin detector and the veto
- **Event-based PID**



**Good events**



# Particle Identification

Some definitions:

$\Delta E$  Energy in 100  $\mu\text{m}$  Si (Thin)

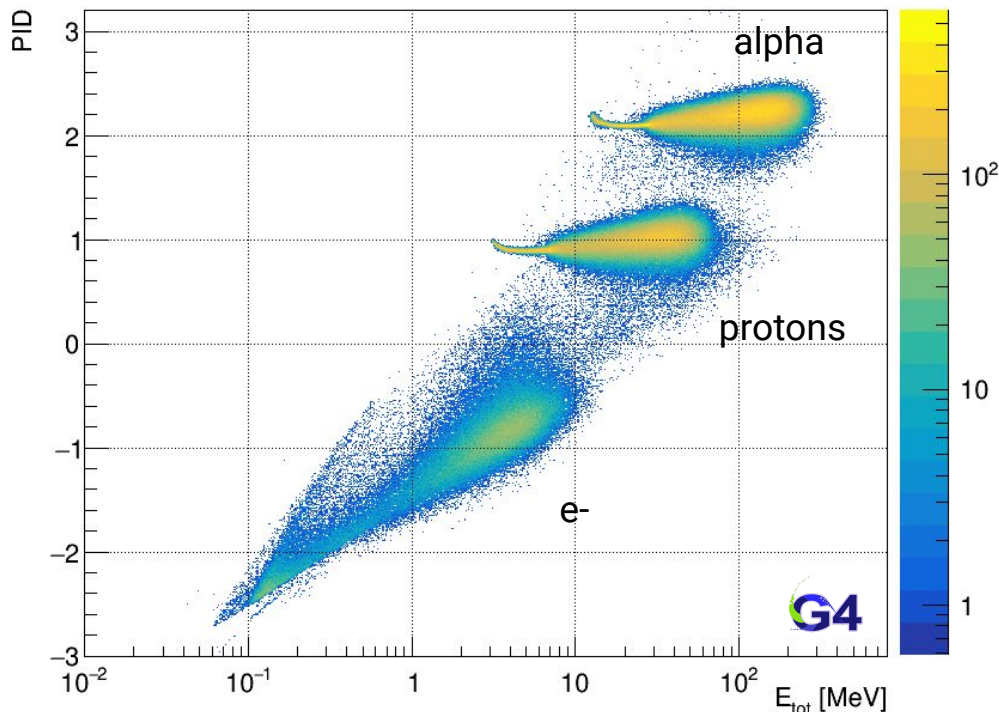
$E$  Energy in 500  $\mu\text{m}$  Si  
(or eventually in PS)

$$\Delta E \propto \frac{z^2}{\beta^2} \quad \Downarrow \quad E_{tot} \simeq \frac{1}{2} m \beta^2$$

$$E_{tot} = E + \Delta E$$

$$PID_{\text{proxy}} = \log_{10} \left( \frac{\Delta E}{1 \text{ MeV}} \frac{E_{tot}}{1 \text{ MeV}} \right)$$

$$\simeq \log_{10} \frac{z^2 \cancel{\beta^2} m}{\cancel{\beta^2} 2} = \boxed{\log_{10} z^2 m} + \text{const.}$$



- $\Delta PID (e^-, p^+) \sim \text{Log}_{10}(938/0.511) \sim \mathbf{3}$
- $\Delta PID (p^+, \text{alpha}) \sim \text{Log}_{10}(2^2 * 4) \sim \mathbf{1.2}$



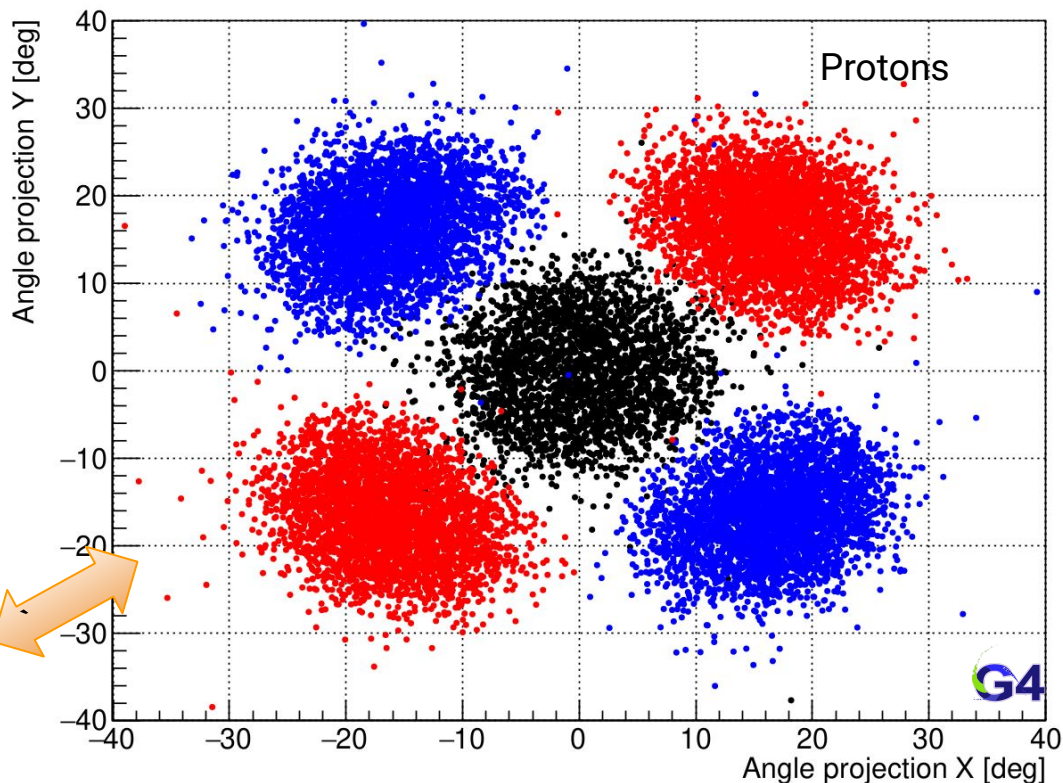
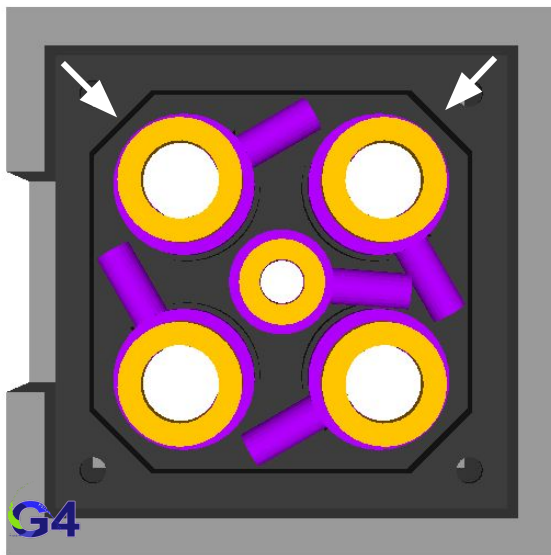
# Angular resolution

- 12 degs std. resolution for electrons (multiple scattering)
- 5-6 degs std. resolution for protons and alpha particles

5 Distinct channels



5 different sold angles



Central channel is smaller to limit its geometric factor

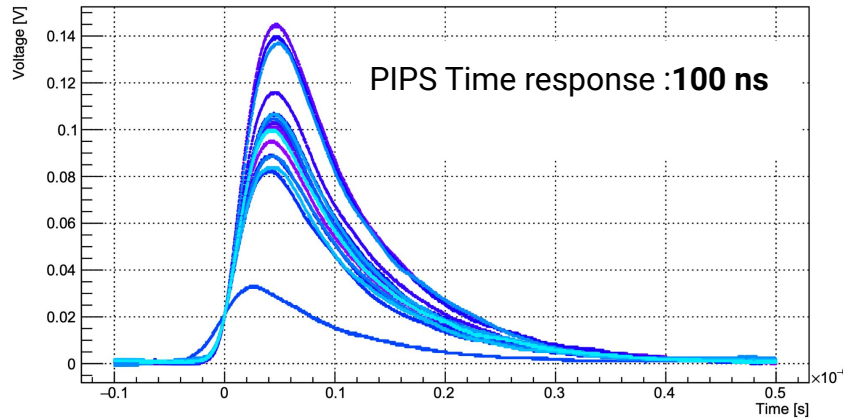


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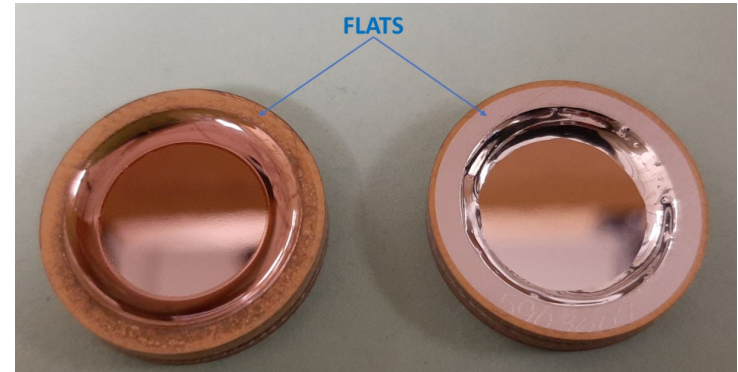
# Preventivi 2024:

## Requirements for INFN-TIFPA

- laboratory space for integration & TESTS
- Proton beam time
- technical support (Mechanics & Electronics)  
(sempre più urgente un tecnico TIFPA)
- amministration support  
(ordini per 120keuro già avviati altri in arrivo)



100 um thick fully depleted Silicon AMETEK



300 um thick  
Silicon MIRION

Induced  
waveform  
 $^{241}\text{Am}$  alpha  
particle

