The NUSES space mission

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on behalf of the NUSES collaboration

NUSES in a nutshell

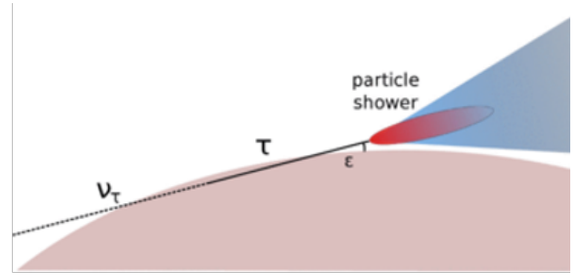
Mission Players:

- The NUSES initiative, a joint GSSI-Thales Alenia Space Italy (TAS-I) project, has been approved by the Italian government as a flagship initiative to relaunch the economy of the L'Aquila area.
- The scientific collaboration of >60 scientists from Italian Universities and INFN sites, together with the University of Geneva is already in place.

Mission Goals:

Payload 1 (Terzina)

- Pathfinder for future missions devoted to Ultra High Energy CR and neutrino studies through space-based atmospheric Cherenkov light detection.

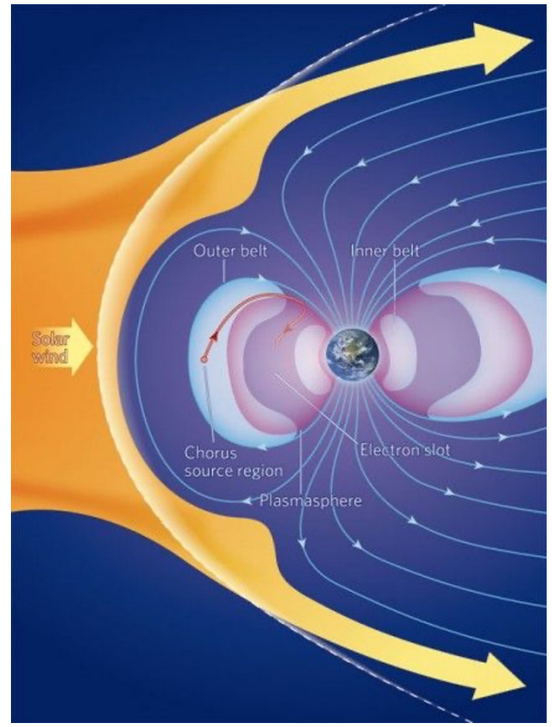


Payload 2 (Zirè)

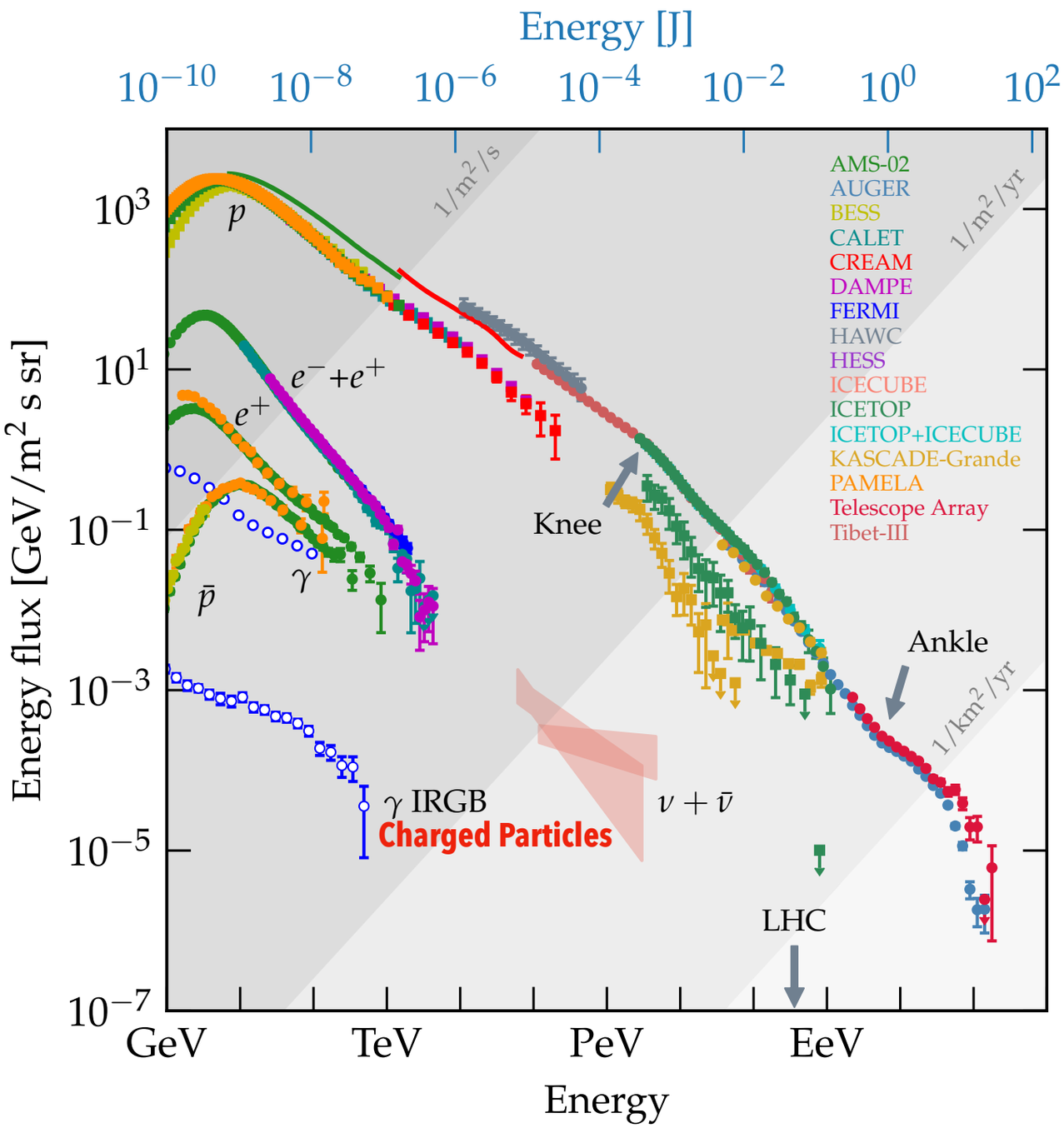
- Monitor the fluxes of low energy (<250 MeV) e, p, CR to study Van Allen belts, space weather and the magnetosphere-ionosphere-litosphere couplings (MILC) in case of seismic / vulcanic activities.
- Detect 0.1-10 MeV photons for the study of transient (GRB, e.m. follow up of GW events, SN emission lines,…) and steady gamma sources.

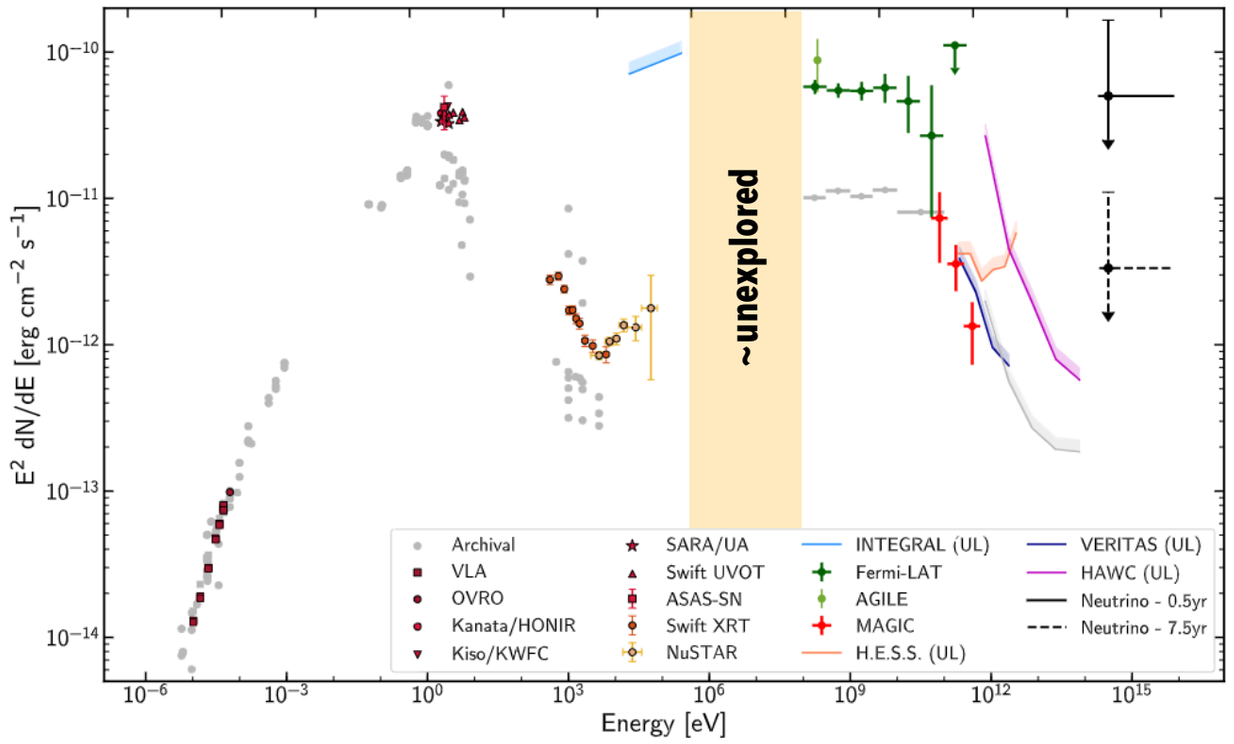
New technologies

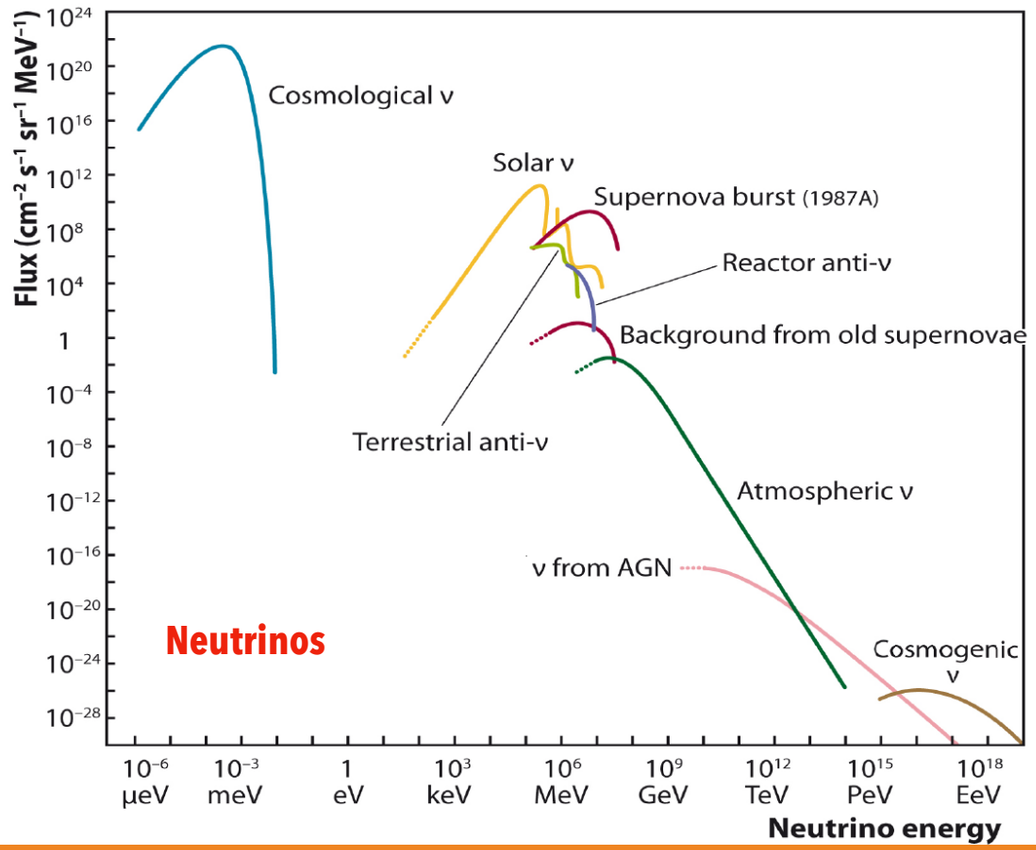
- Development of new observational techniques, testing new sensors (e.g. SiPM) and related electronics/DAQ for space missions.
- New solutions for the satellite platform.



The current (particle) landscape



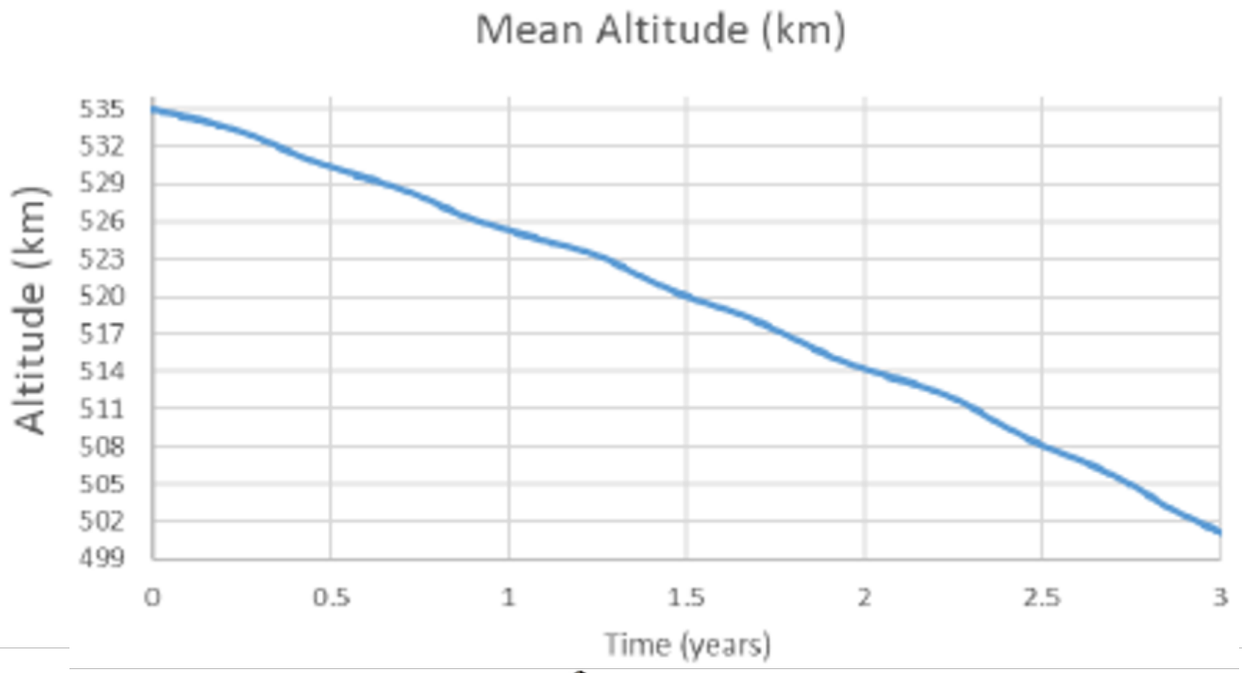




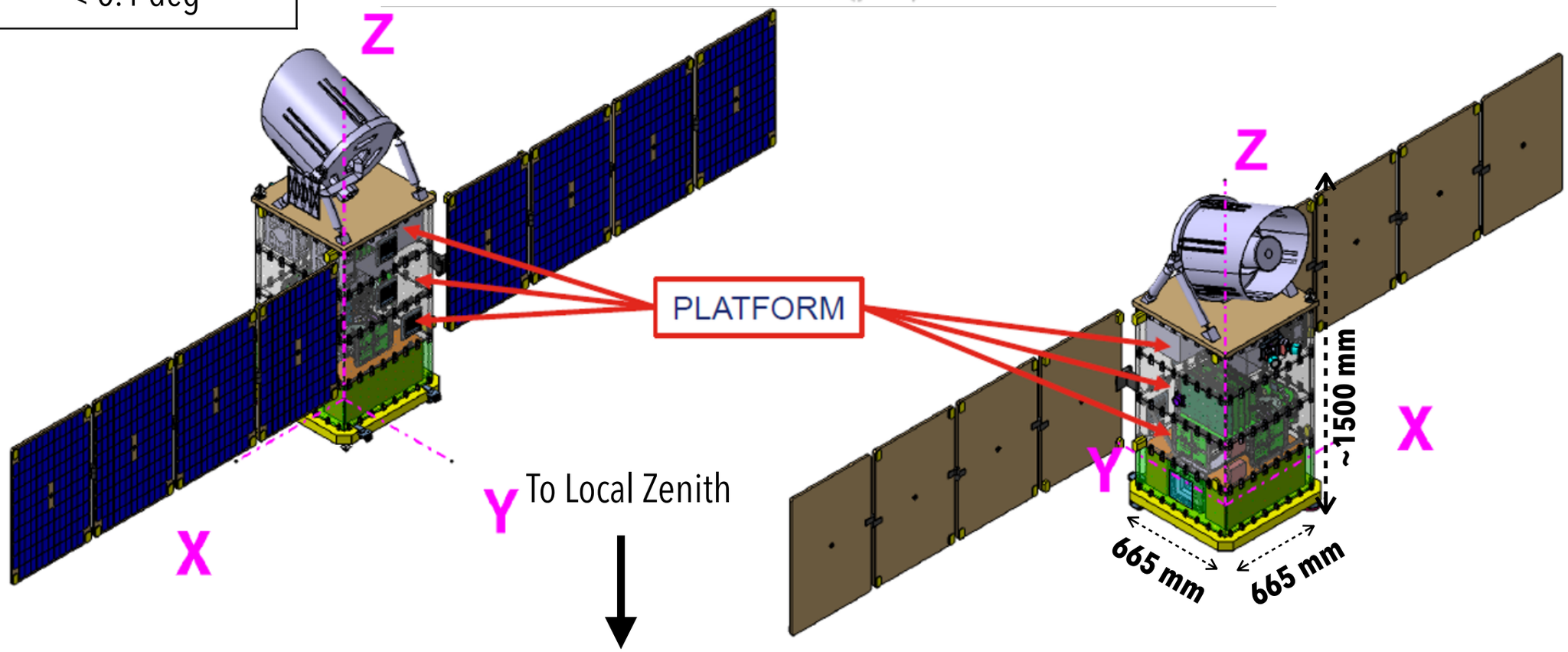
Mission parameters

ORBIT (ideal)

Mission Lifetime	3 y
Mean Altitude	550 km, LEO
Semi-major axis (km)	6928 km
Eccentricity	0
Inclination (deg)	97.6 deg, SunSync
LTAN	18:00:00
Pointing	< 0.1 deg

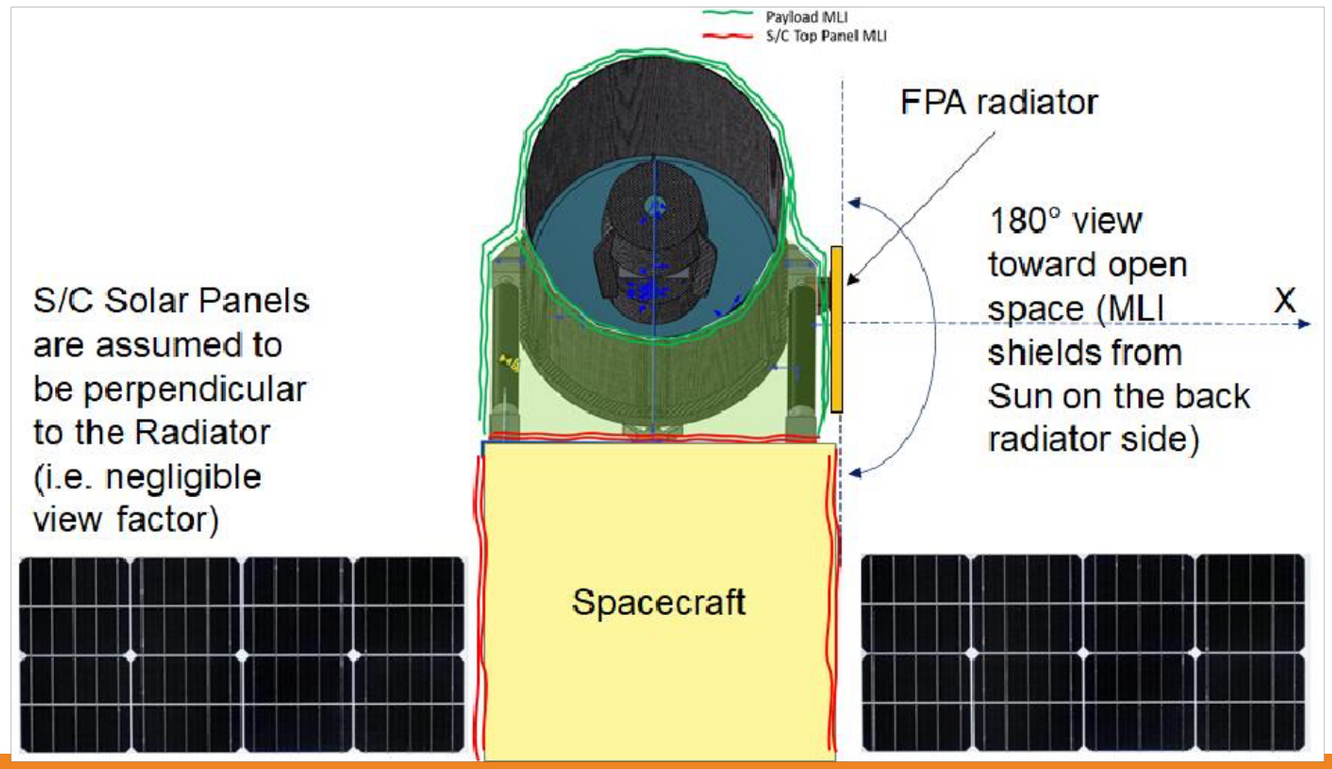


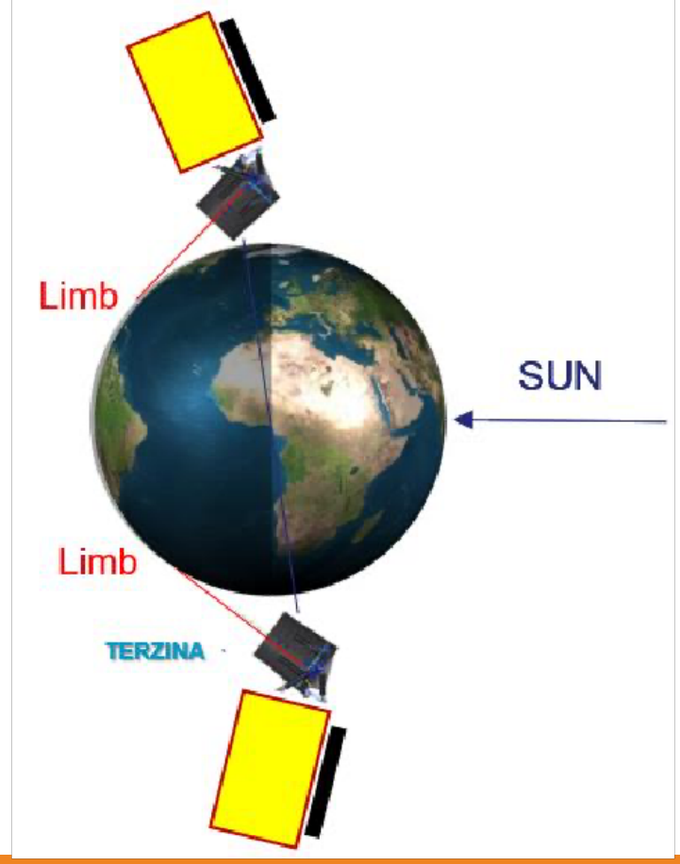
With Launcher "Injection in Orbit" Errors



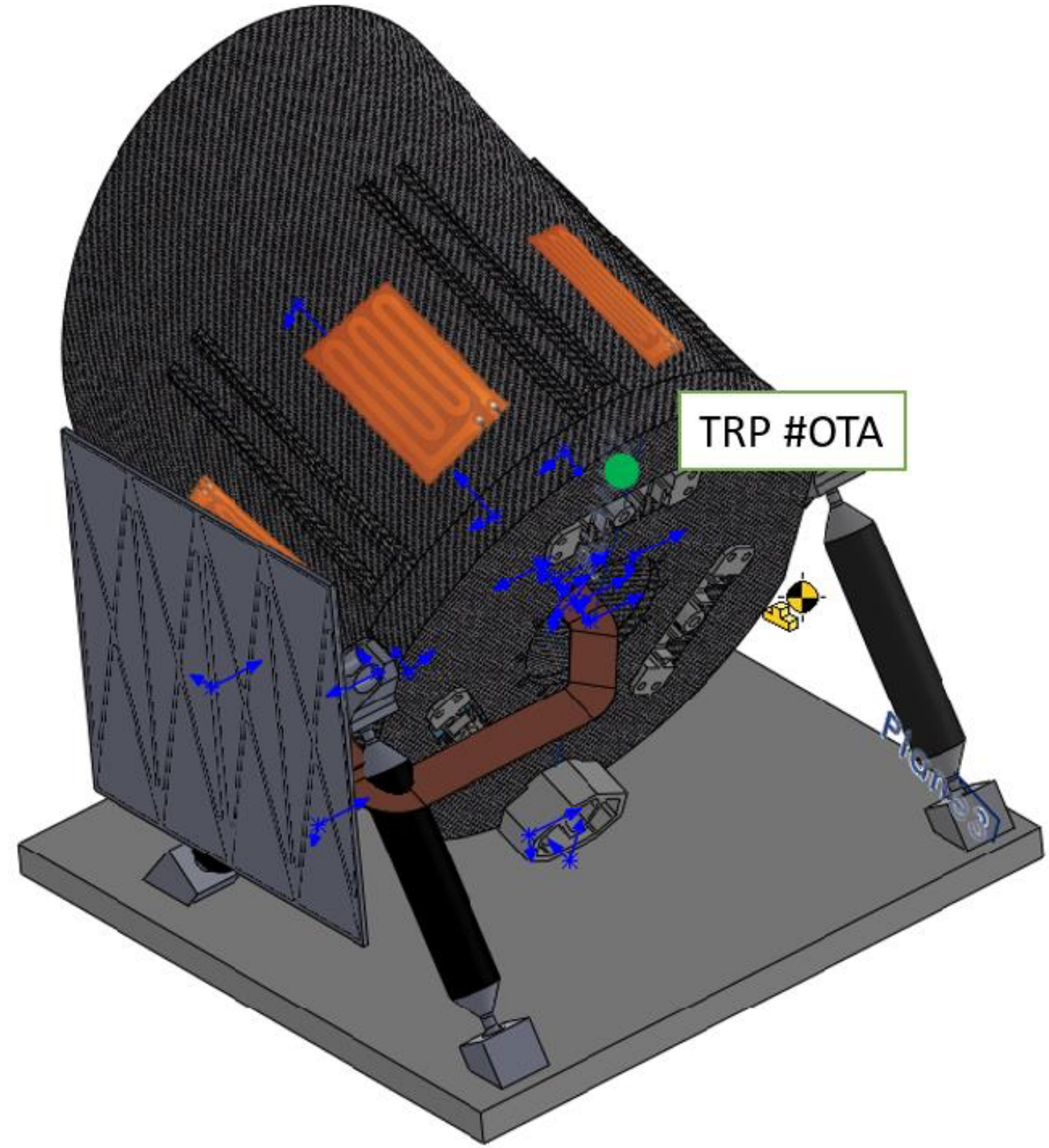
The two payloads: **TERZINA** and ZIRE

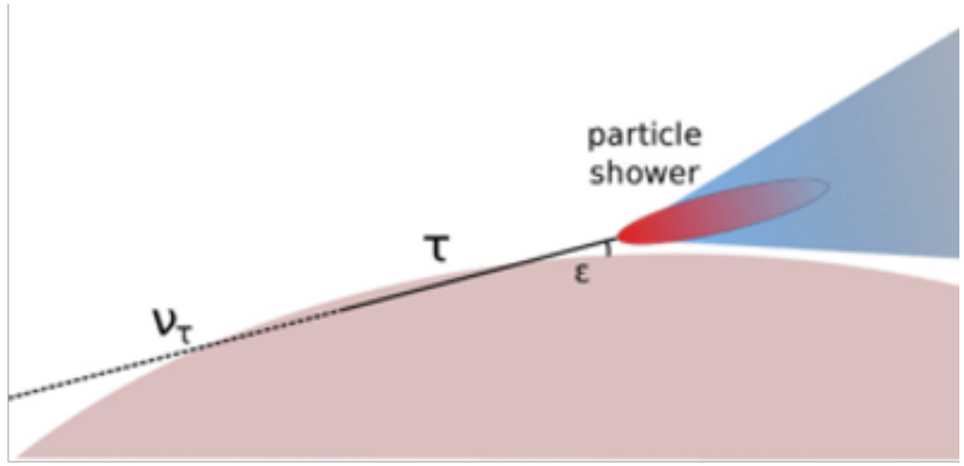
- Terzina is a demonstrator of Cherenkov light detection in space produced by Extensive Air Showers (EAS)
- It will measure the background conditions for the detection of UHECRs and earth skimming upward neutrinos with Cherenkov light emission
- First measurement of Cherenkov light from space for > 100 PeV showers
- Full enable SiPM technology for direct light detection in space
- A pathfinder for future missions (i.e. POEMMA) for the detection of Ultra High Energy Cosmic Rays (UHECRs, E > 1 EeV) via the fluorescence technique and of Very High Energy (VHE, E > 10 PeV) neutrinos via Cherenkov emission.

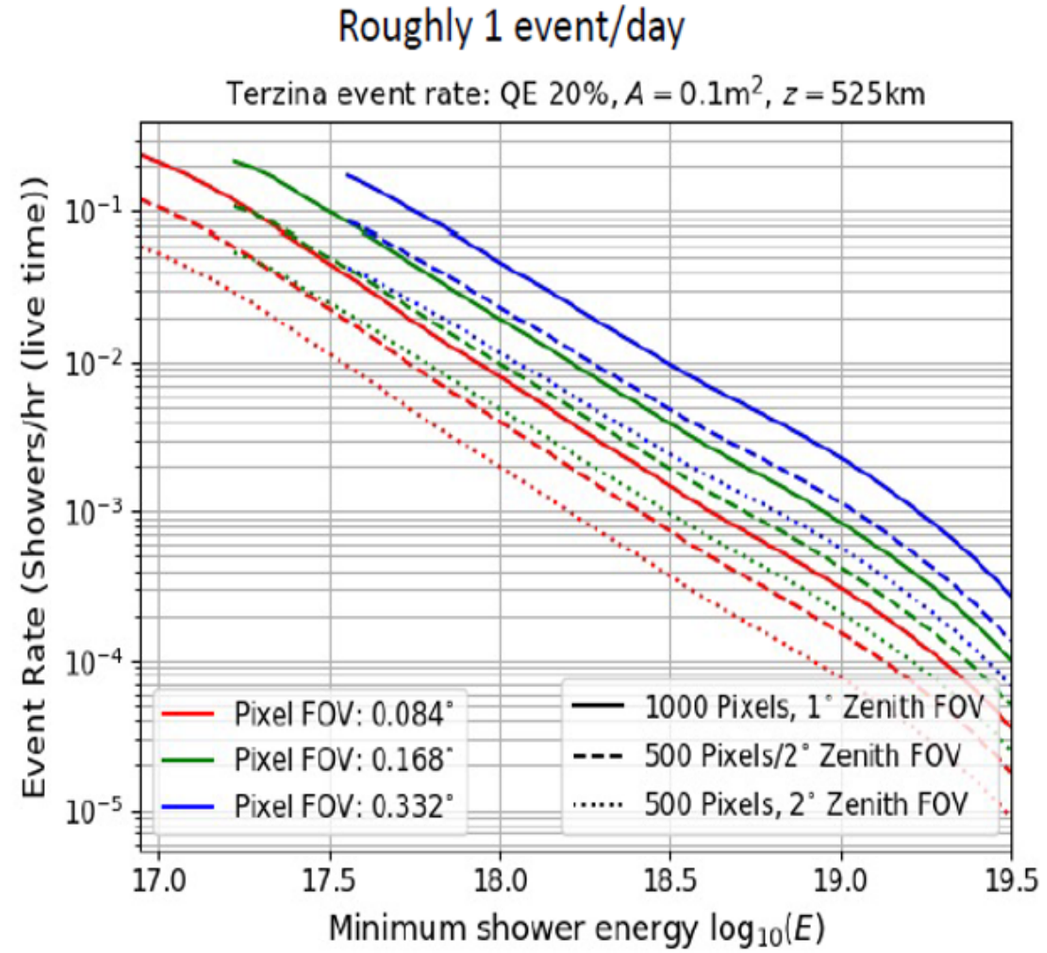




TERZINA: the optical instrument







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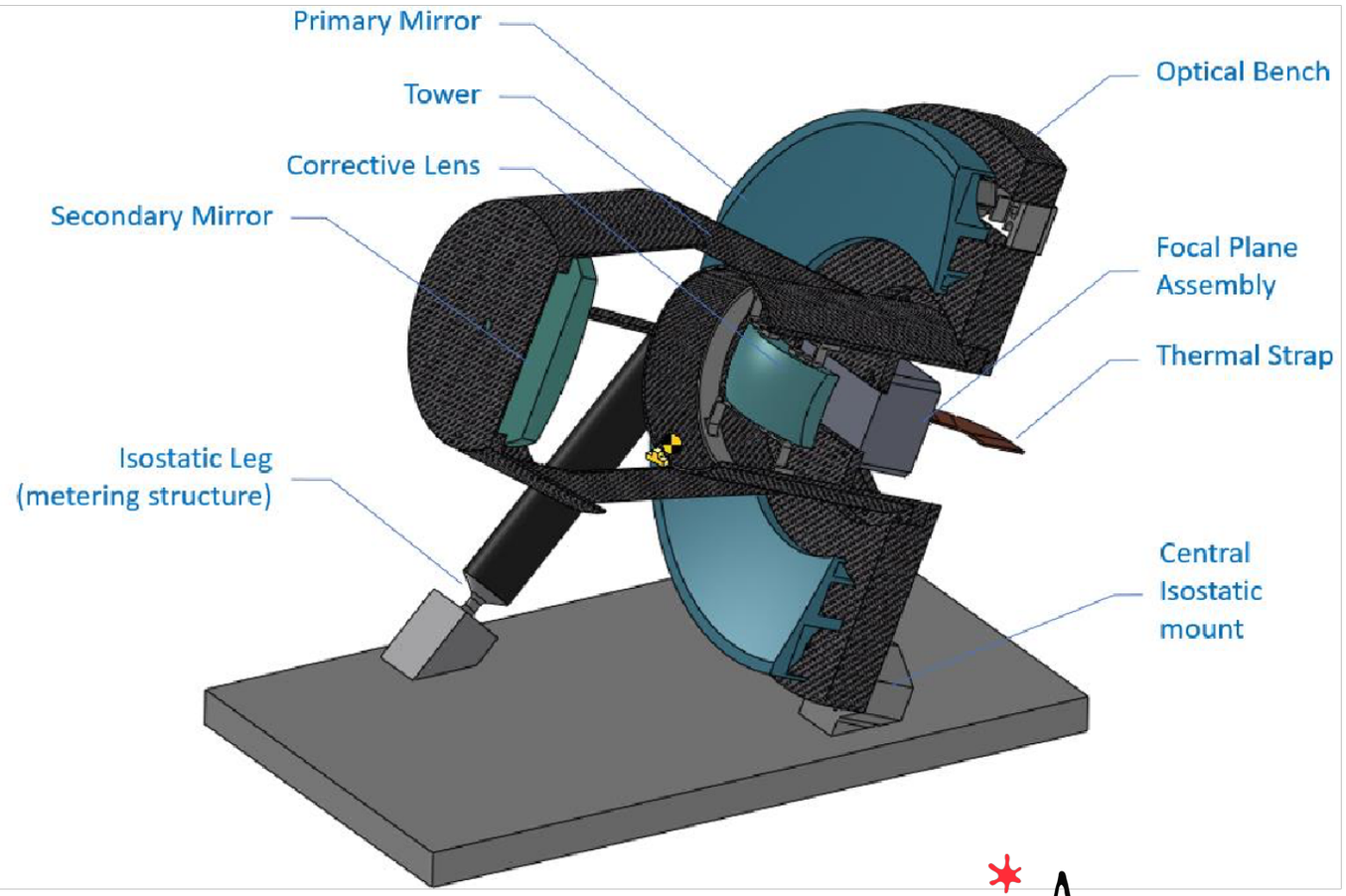
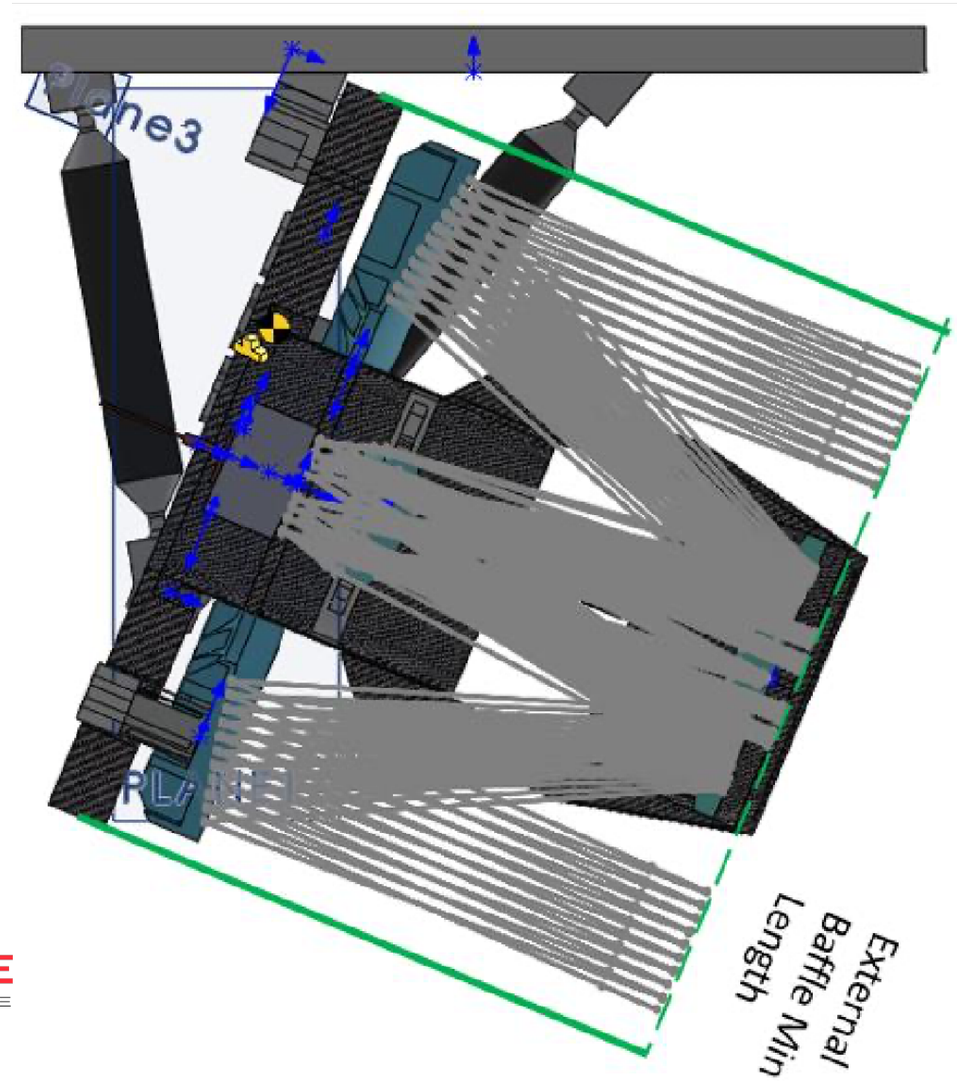


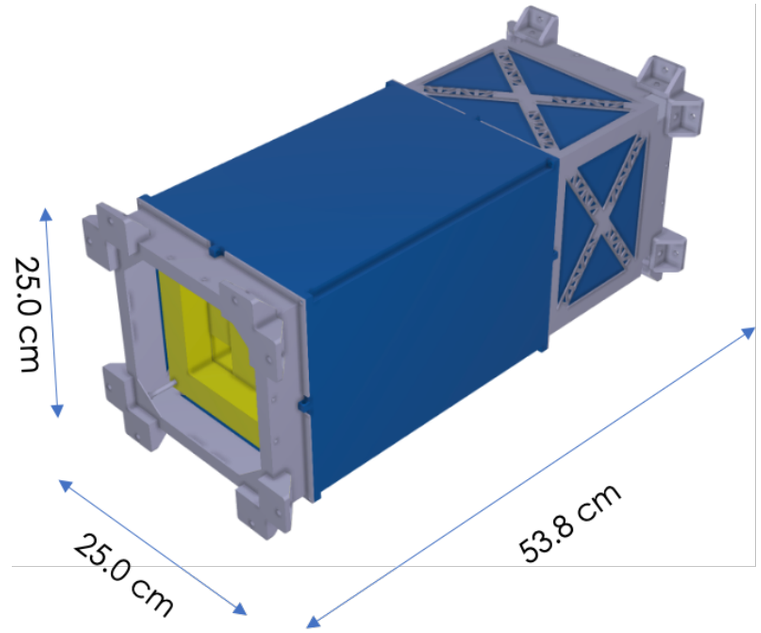


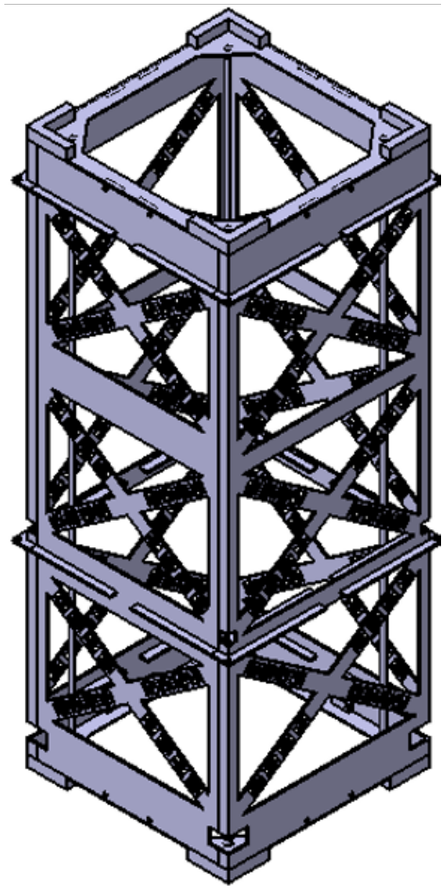
- The Terzina optical system is based on the use of mirrors and corrective lenses.
- The photons are focused toward the focal plane consisting of a matrix of photosensors capable of single photon counting (SiPM).

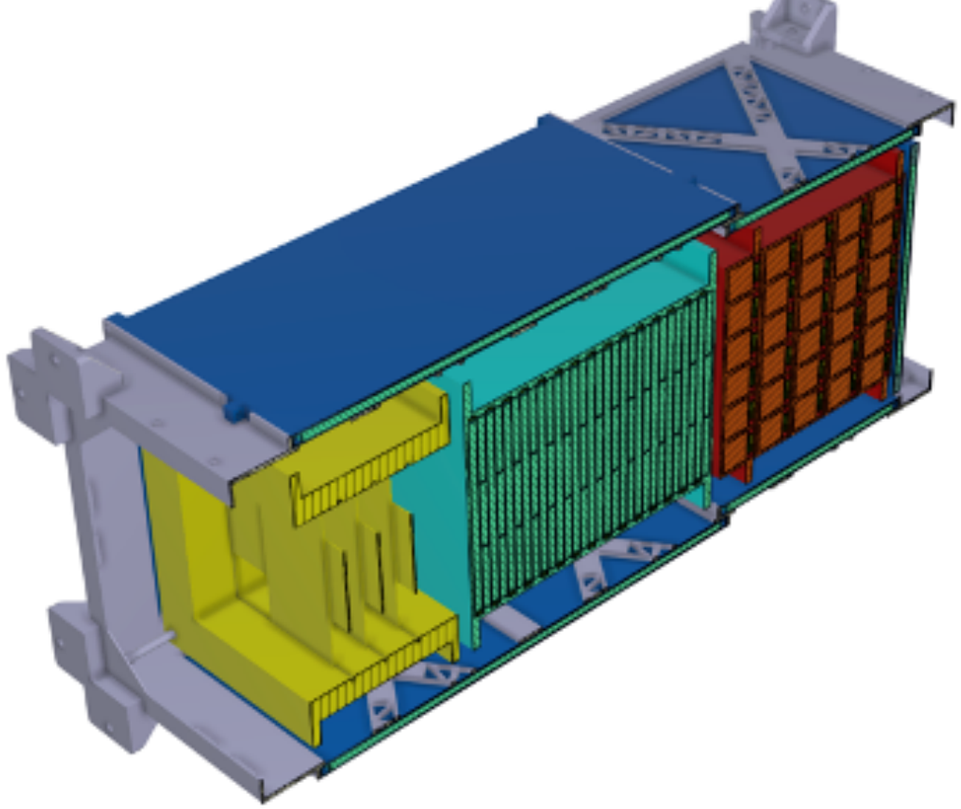
The two payloads: TERZINA and ZIRE'

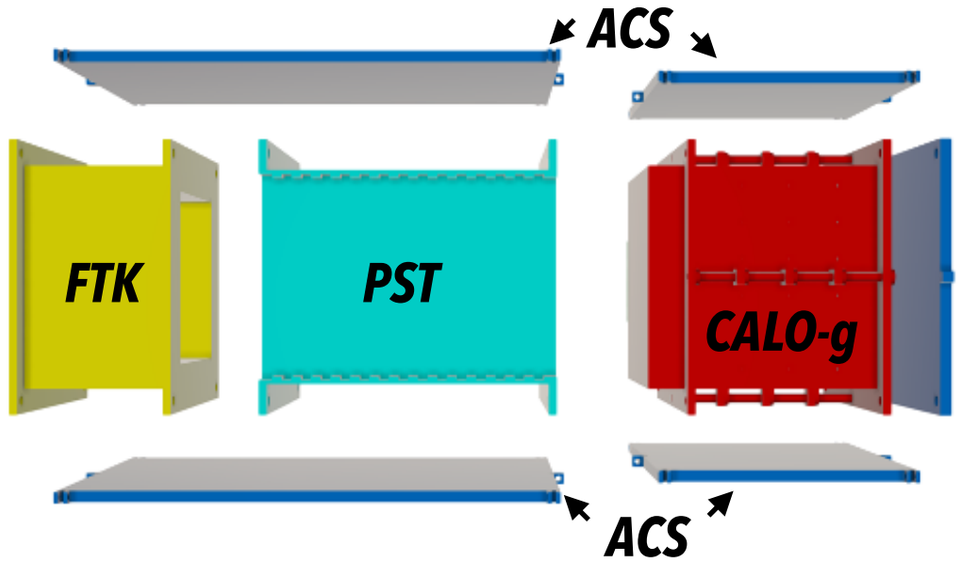
Monitor the fluxes of low energy (<250 MeV) CR, mainly electrons and protons, to study Van Allen belts, space weather and the lithosphere-ionosphere-magnetosphere couplings.

Detect 0.1-10 MeV photons for the study of transient (GRB, e.m. follow up of GW events, SN emission lines, …) and steady gamma sources.









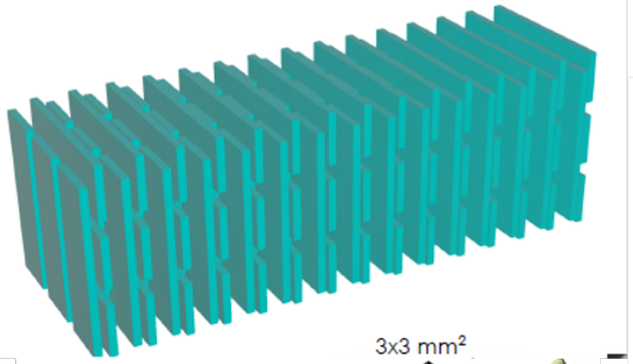
FTK - Fibre Tracking

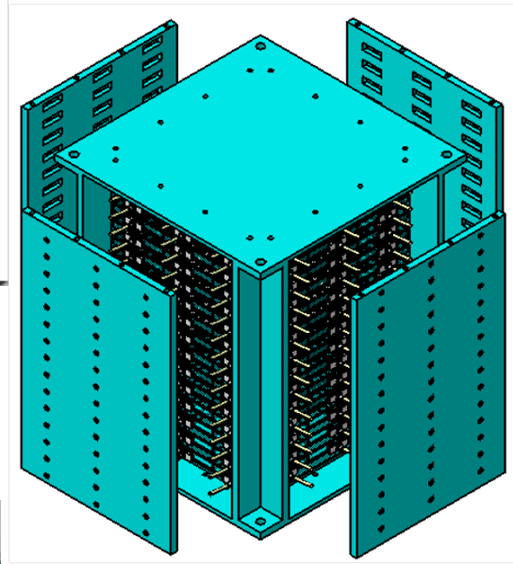
PST - Plastic Scintillating Tower

CALOg - Gamma Calorimeter

ACS - AntiCoincidence System

The two payloads: TERZINA and ZIRE'

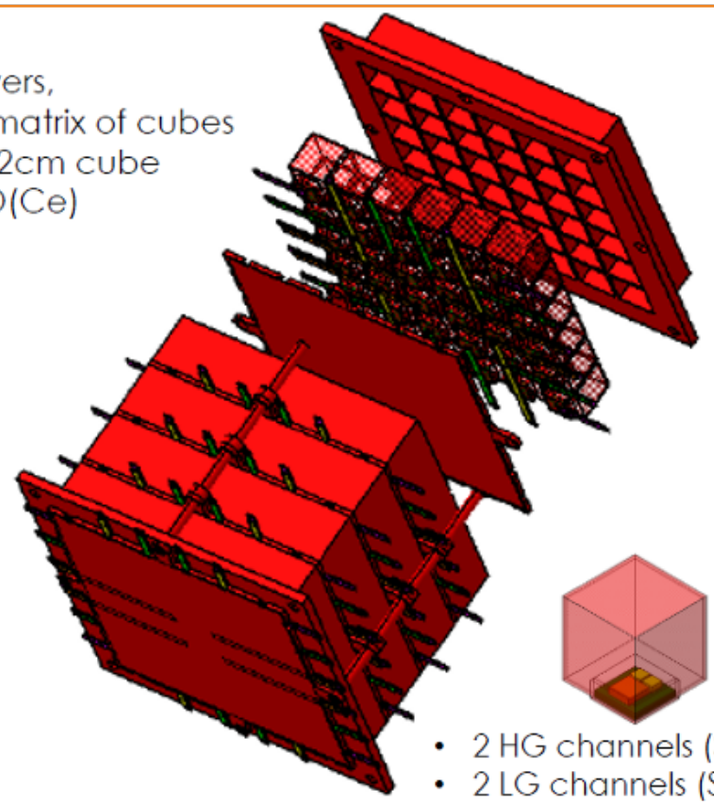




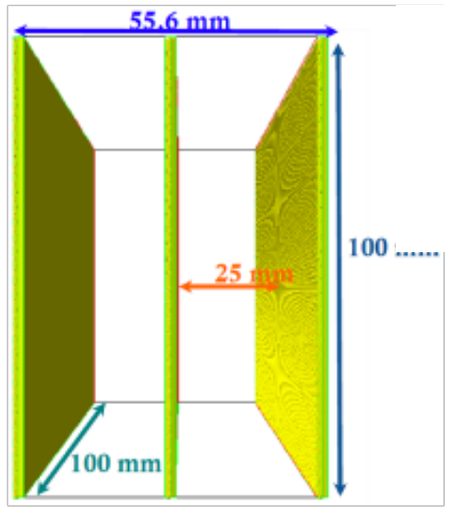
PST

- 5 layers,
- 6x6 matrix of cubes
- 2x2x2cm cube
- LYSO(Ce)

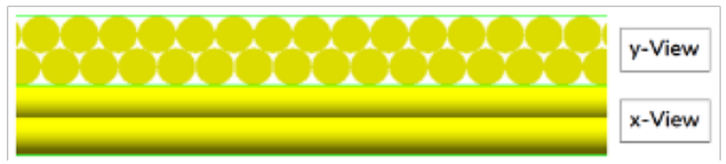
CALO-g



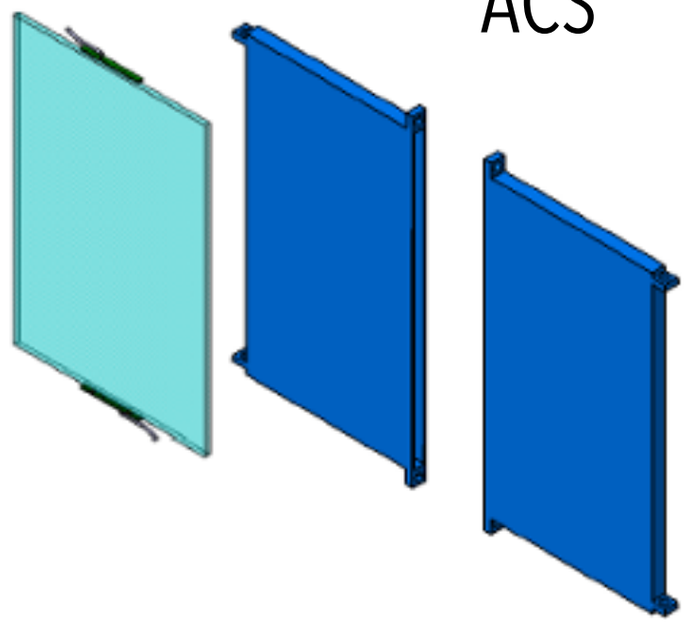
- 2 HG channels (SiPM 6x6 mm)
- 2 LG channels (SiPM 1x1 mm)

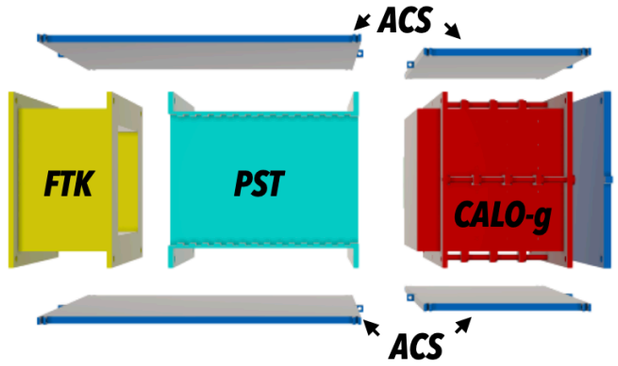


FTK



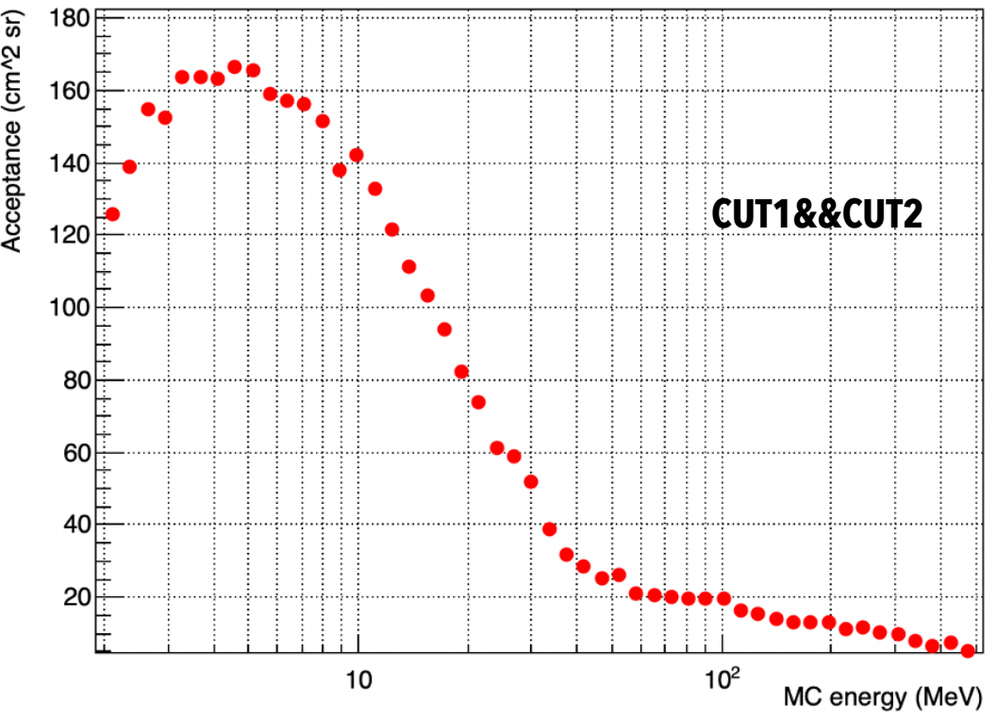
ACS



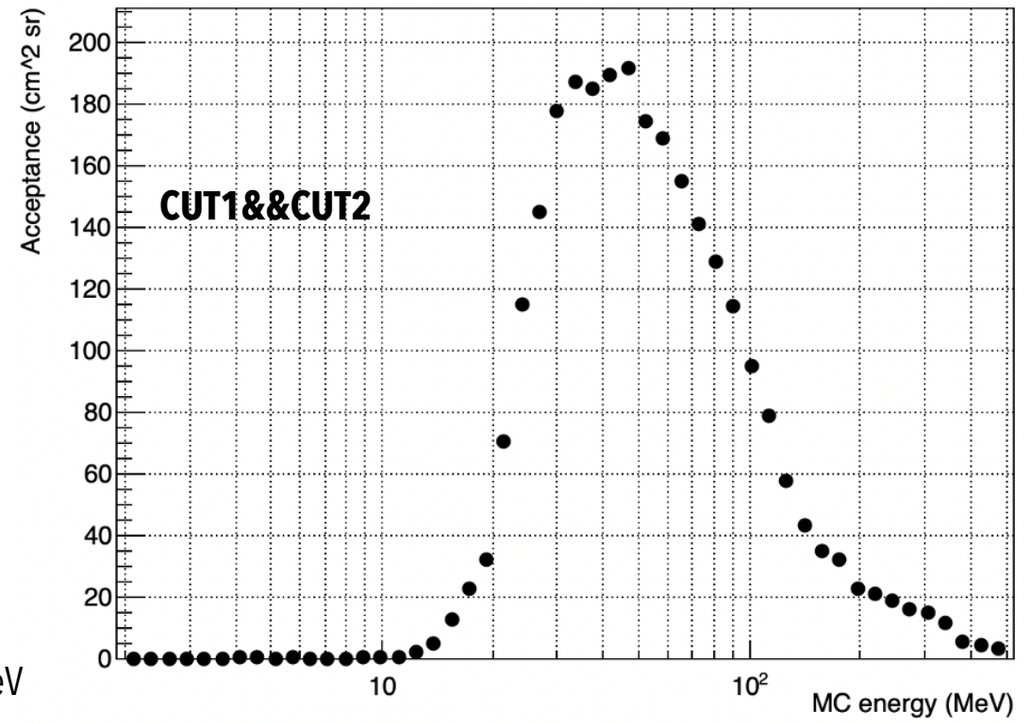


ZIRE': Acceptance

Electrons, full contained



Protons, full contained

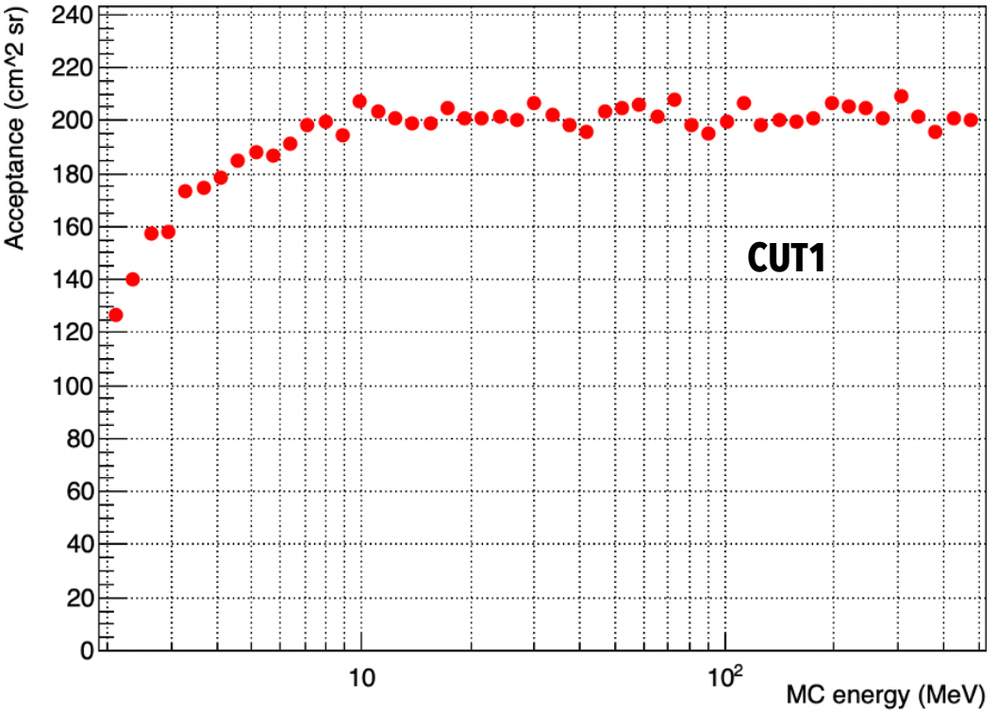


CUT1 (Trigger activation):
$\Delta E_{FTK_0} > 0.1$ MeV & $\Delta E_{PST_0} > 0.3$ MeV

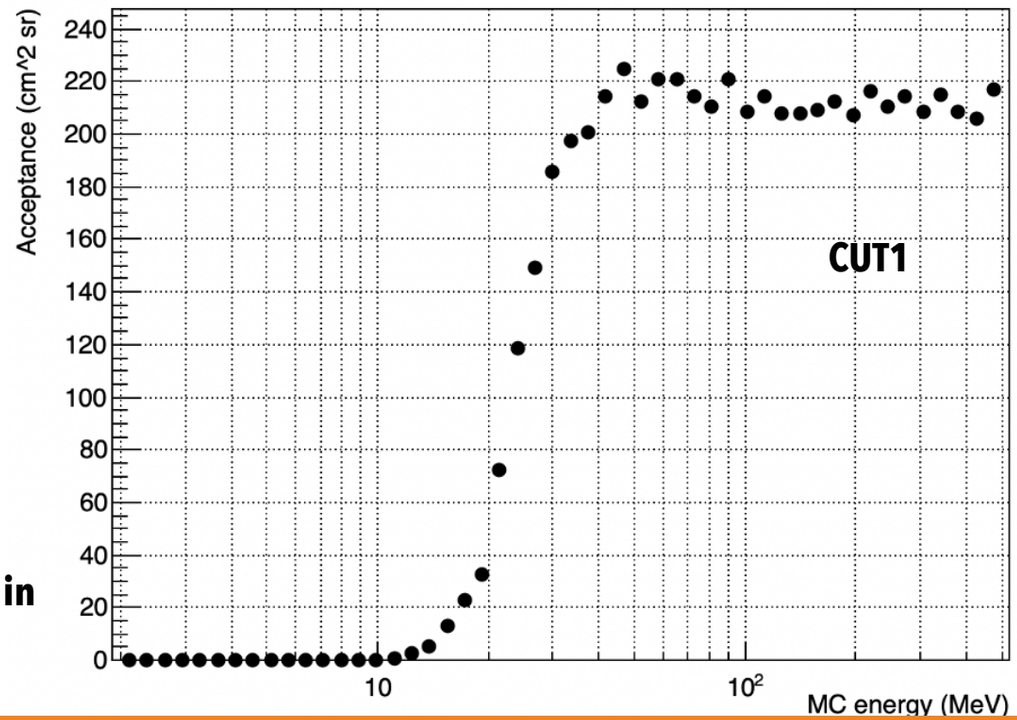
CUT2 (Containment):
$\Delta E_{ACS_{side}} < 1$ MeV & $\Delta E_{ACS_{bottom}} < 1$ MeV

Similar studies on He, C–> Fe are in progress

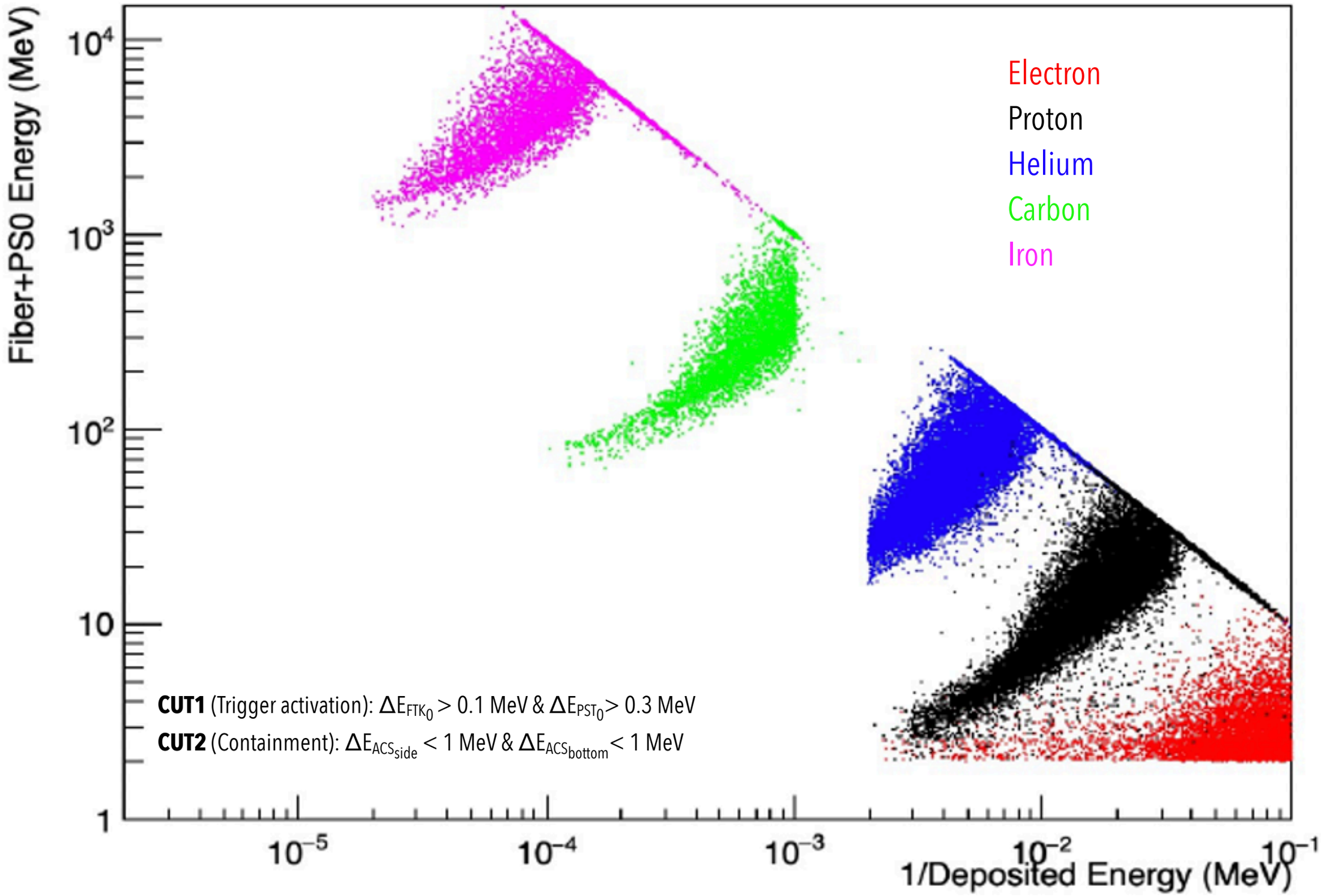
Electrons, non-contained



Protons, non-contained

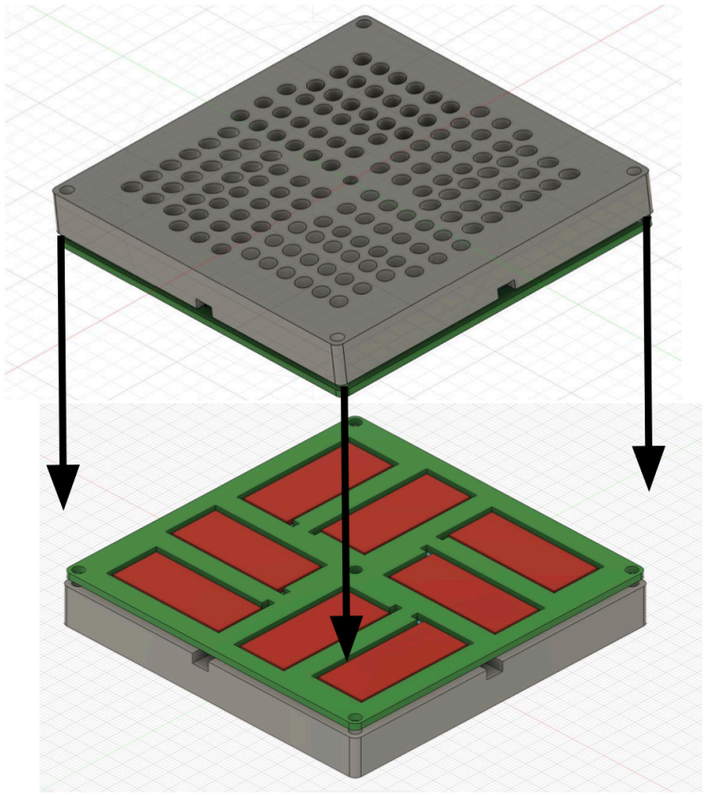


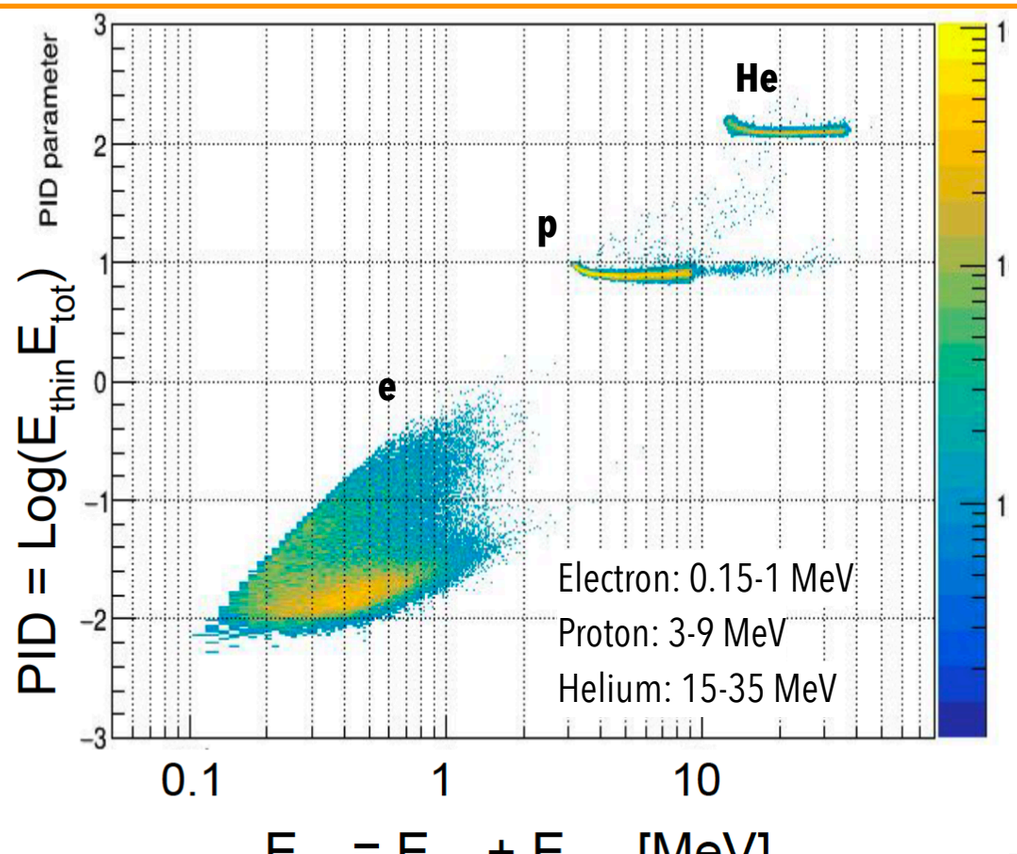
ZIRE': particle ID

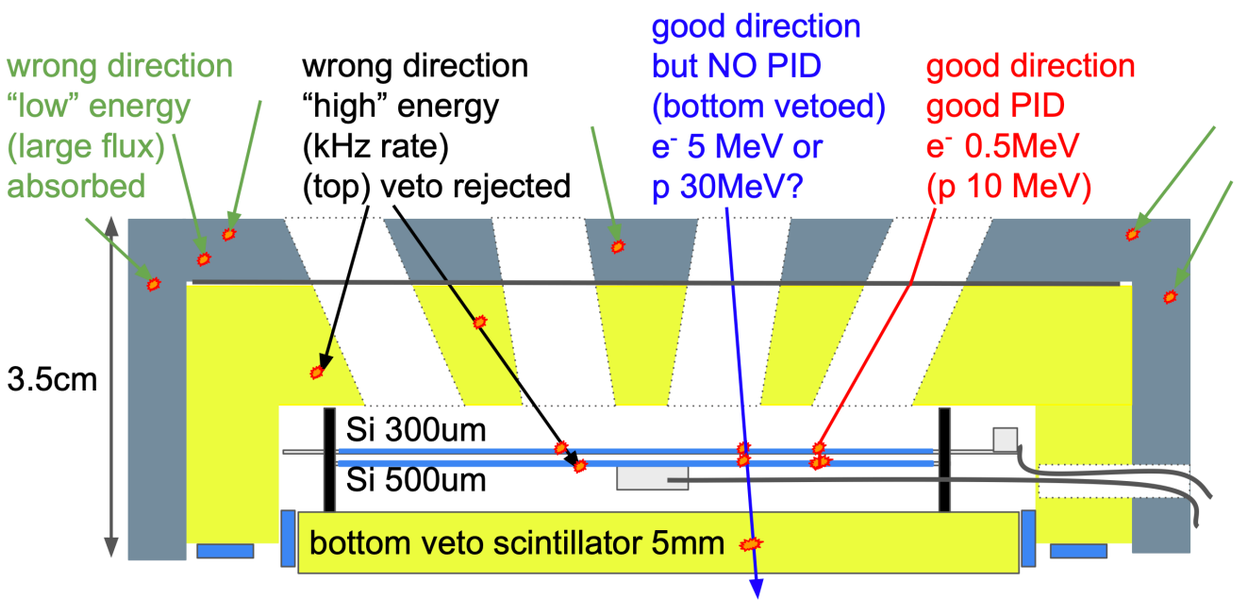


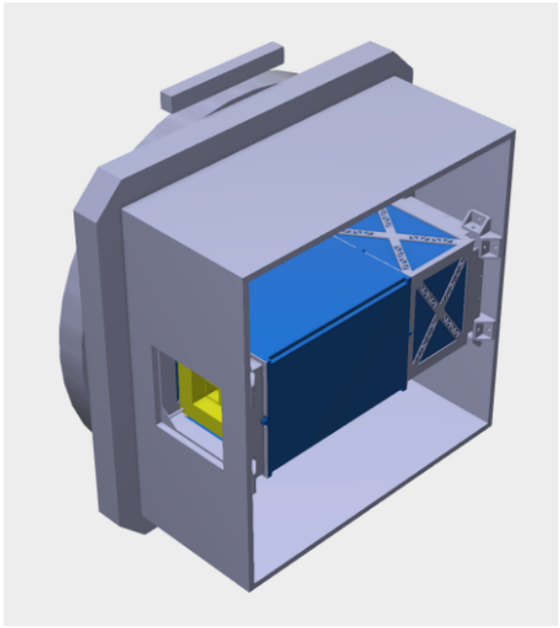
The two payloads: TERZINA and ZIRE'

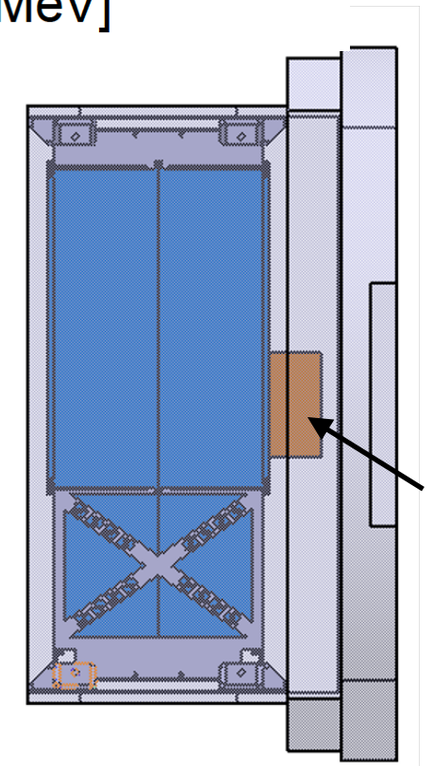
LEM - Low Energy Module











Summary of science and technological goals

SCIENCE:

- First Observation of High Energy cosmic ray showers from space through Cherenkov signal
- Test HE neutrino detection feasibility using the Earth skimming geometry and Č light
- (UV - near visible) background characterization from the Earth limb
- Measure electrons , protons and nuclei up to hundreds of MeV
- Study particle flux correlation with seismic activity and space weather phenomena
- Monitor very low energy (< 10 MeV) electron flux
- Measure 0.1-10 MeV photons for transient and steady gamma source detection (Earth Observation, TGF, etc …)

TECHNOLOGY:

- Space qualification of new technologies (Photosensors, onboard data reduction, 3D printing,…)
- Setup a Č telescope based on a SiPM focal plane
- Design/qualification/use of low power/COTS electronics (~few mW/ch)

MISSION PATHFINDER:

- New observational methods: Cherenkov light from the limb
- Networking with other missions: GRB, space weather, MILC effects,
- Precursor for larger missions: Crystal Eye, POEMMA like, ….