Terzina: A Space-Based Cherenkov Telescope

for Ultra-High-Energy Cosmic Rays and Earth-Skimming Neutrino Detection

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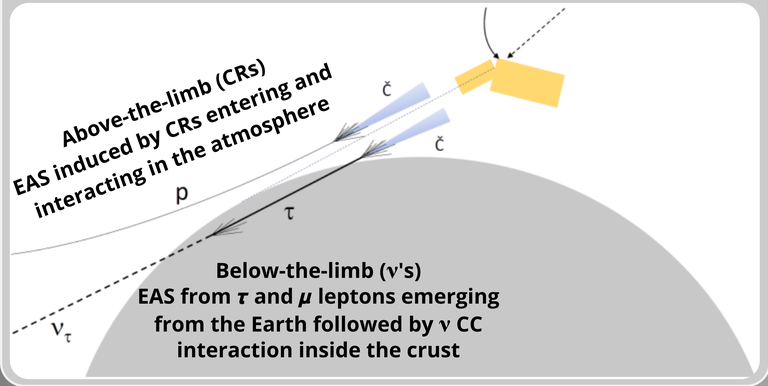
Orbital Mission for Observations of Cherenkov Emission from Cosmic Rays and Neutrinos Towards Earth-Limb

1. MOTIVATION

- PeV Cosmic Rays (CR) and Astrophysical Neutrinos (**ν**) are key to understanding: sources, acceleration mechanisms, galactic–extragalactic transitions.
- Above ~1-10 PeV, CRs detected via Extensive Air Showers (EAS) with ground-based detectors
- Ground experiments require huge detector arrays, which are difficult to scale for larger acceptance.

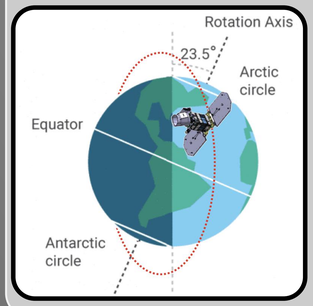
2. TERZINA

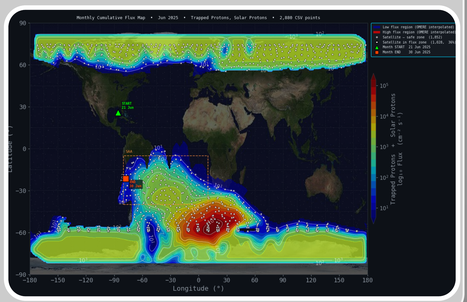
- Measure background conditions for UHE CRs and Earth-skimming upward **ν** detection from space.
- First measurement of showers with Cherenkov light from space for > 10 PeV UHE CRs
- Develop further SiPM technology for space
- Technological pathfinder for future orbital and sub-orbital missions (e.g., POEMMA).



3. MISSION CONCEPT

- LEO orbit (~550 km), Orbital period = 92 min and Speed = 7.59 km/s
- Points to Earth's night-side limb (viewing angle with respect to nadir 67.05°)
- Detects Cherenkov light from EAS in near-UV/optical
- Trapped radiation at LEO can increase the dark count rate, which can be mitigated by heating the tiles.

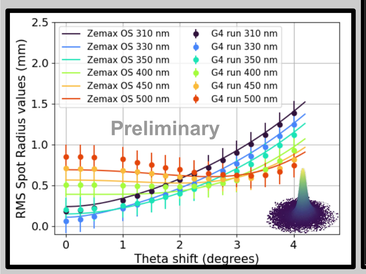




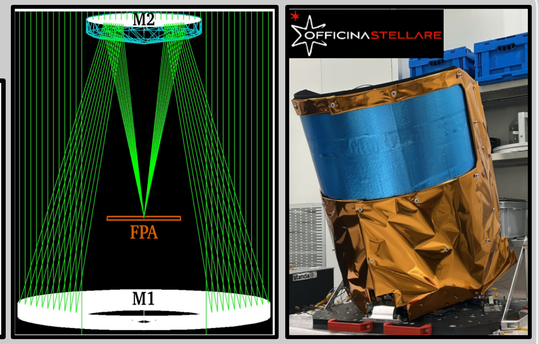
4. PAYLOAD & HARDWARE

OPTICAL HEAD UNIT

Schmidt-Cassegrain telescope



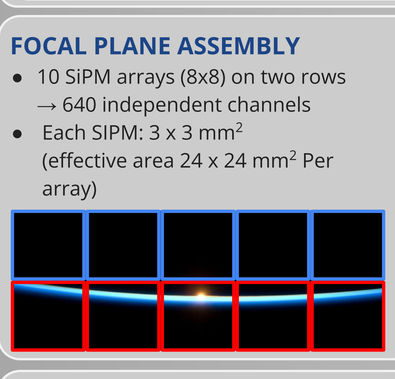
PSF vs offset angle: Zemax vs G4 comparison. PSF ~ 2 mm < pixel size

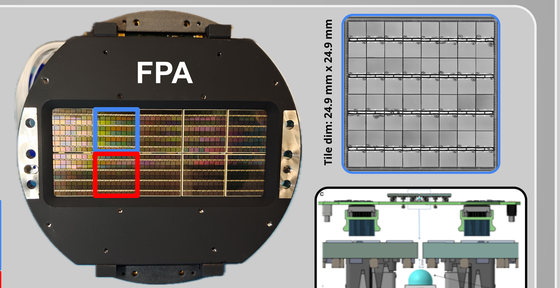


Parabolic primary mirror (M1) ✦ Correcting-lens acts as secondary (M2) ✦ Flat focal plane ✦ 7.2° FOV along the limb, 2.88° across

FOCAL PLANE ASSEMBLY

- 10 SiPM arrays (8x8) on two rows → 640 independent channels
- Each SIPM: 3 x 3 mm^2 (effective area 24 x 24 mm^2 Per array)

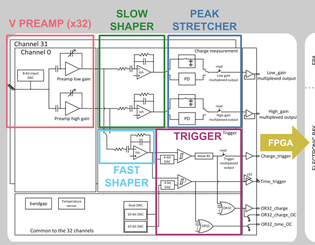


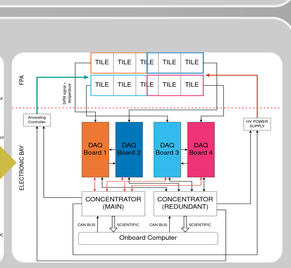


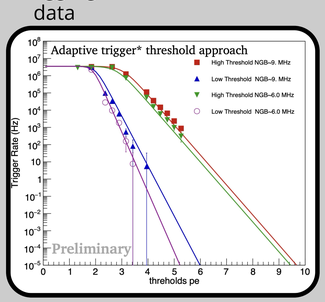
FoV_{Pixel} ~ 0.18° ✦ DCR(kHz/mm^2) ~ 100 ✦ CT (%) ~ 7 ✦ V_{BD}=32.6 V

FRONT-END ELECTRONICS

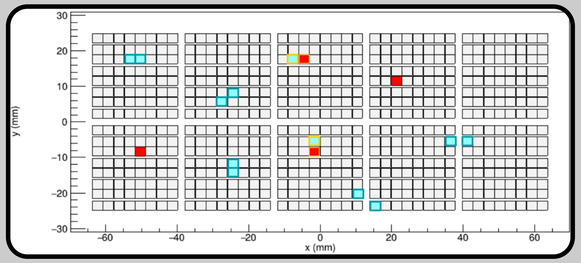
- SIPM signals → CITIROC front-end readout-chip (ASIC)
- Each ASIC reads half tile and has 32 input channels (one per SiPM)
- Slow shaper for charge readout, fast shaper for trigger
- Concentrator board aggregates and buffers the data







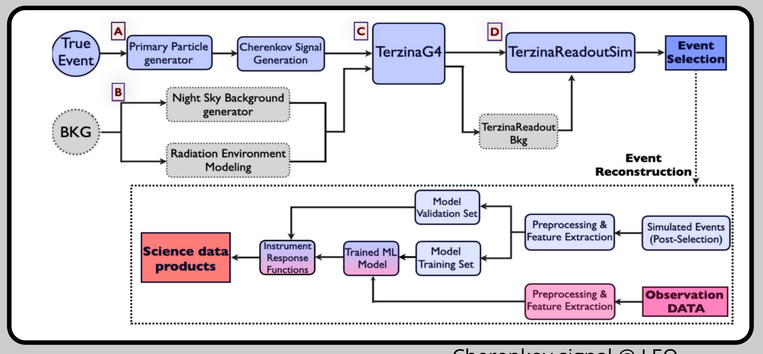
- Time window: 70 - 80 -100 ns
- Coincidence window: 15 - 18 - 20 - 30 ns
- Total deadtime between two events: 15 us



Trigger CITIROC

- At least one pixel exceeds the (trigType = 1 in data model)
- At least two adjacent pixels exceed the low threshold (trigType = 2 in data model)
- High/Low threshold value: [5, 30] mV / [5, 20] mV

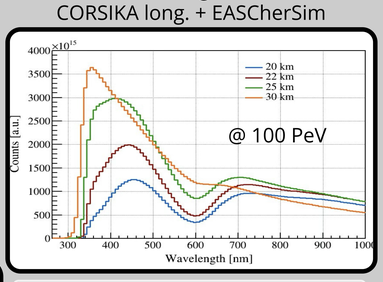
5. DETECTOR SIMULATION & PERFORMANCE

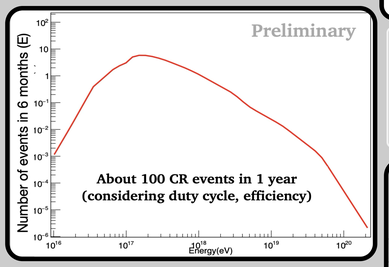


PERFORMANCE MODELING

- ☑ Background (city lights & moon)
- ☑ Trigger & electronics response
- ☑ Duty cycle, deadtime
- ☑ Radiation environment
- ☑ SiPM aging

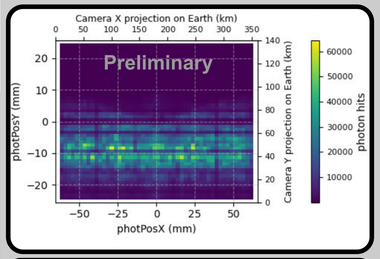
Cherenkov signal @ LEO
CORSIKA long. + EASCherSim

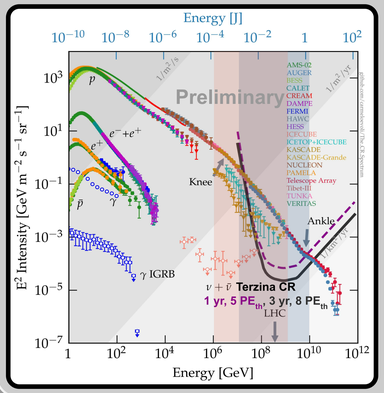


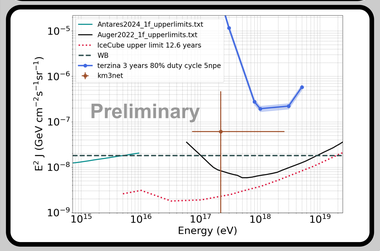


PRELIMINARY RESULTS

Cumulative photon hits
(3000 PeV proton showers)







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SCAN ME

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