POEMMA-Balloon with Radio: Mission Overview

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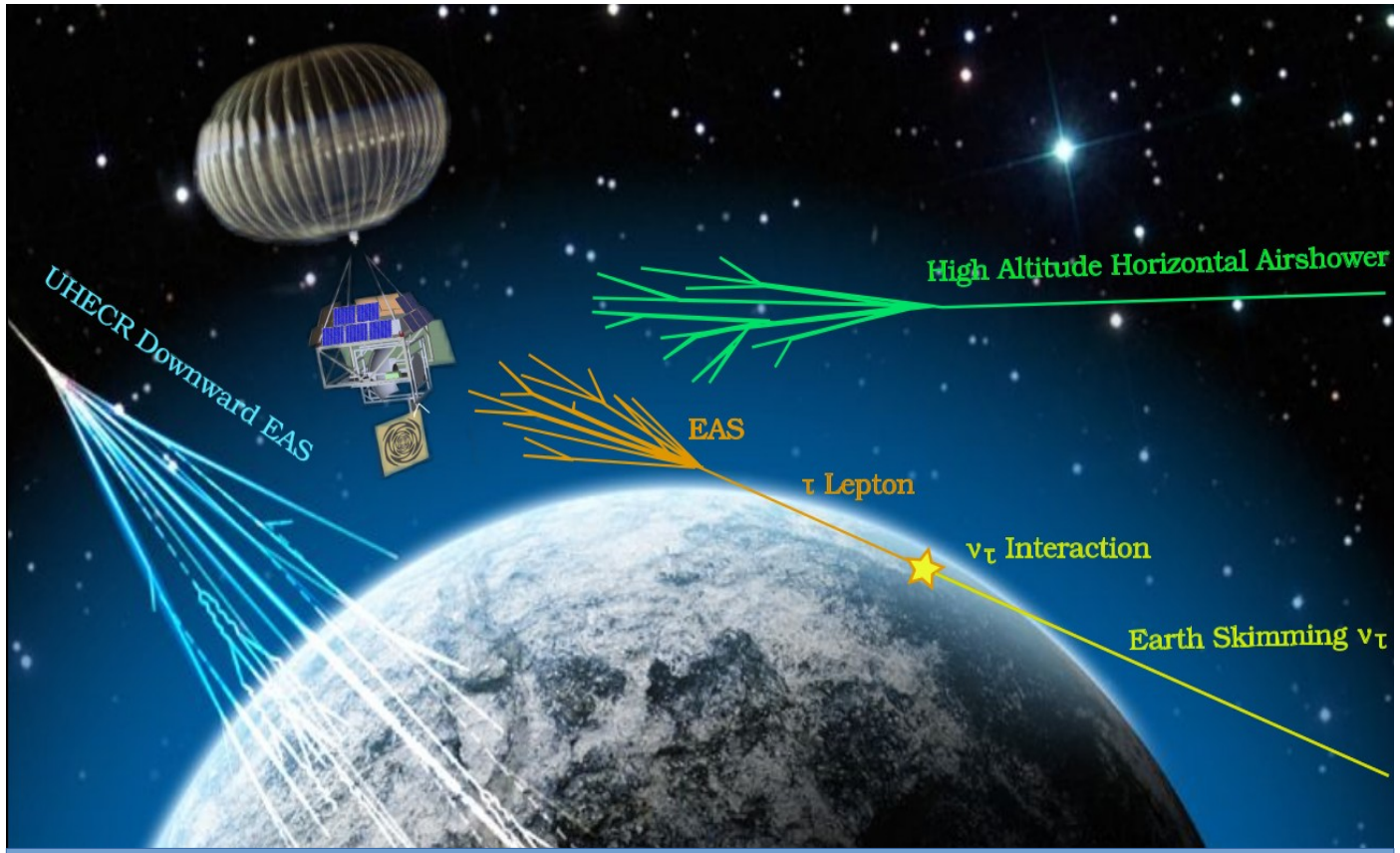
Mission Overview:

- Planned Super Pressure Balloon Mission anticipating a 2027 launch from Wanaka, NZ
- Successor Mission of Extreme Universe Space Observatory 2 (EUSO-SPB2)
- Predecessor to Probe of Extreme Multi-Messenger Astrophysics (POEMMA)

Primary Science Objectives

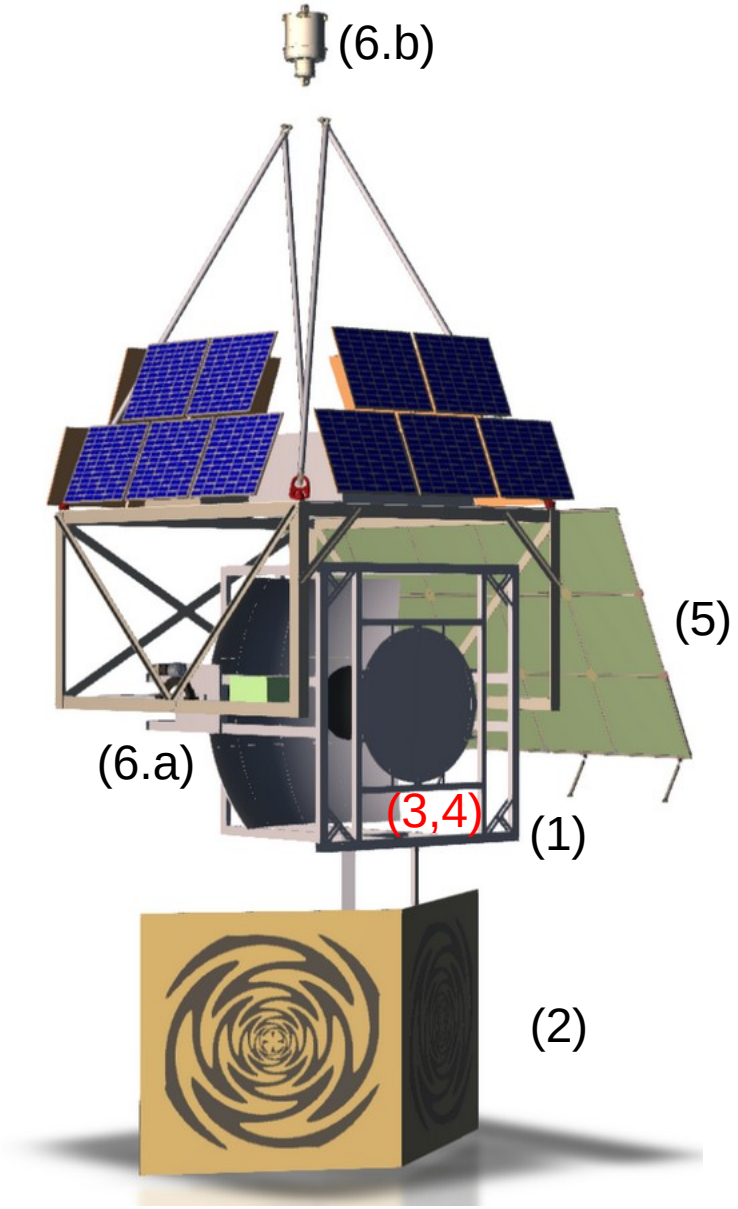
- Make first measurements of UHECR from above using fluorescence light emission.
- Make measurements of high-altitude horizontal air-showers (HAHAs) at various shower development stages.
- Search for Earth-skimming PeV astrophysical neutrinos.



adatped from https://icecube.wisc.edu/news/research/2012/04/cosmic-rays-100-years-of-mystery/

Payload Description

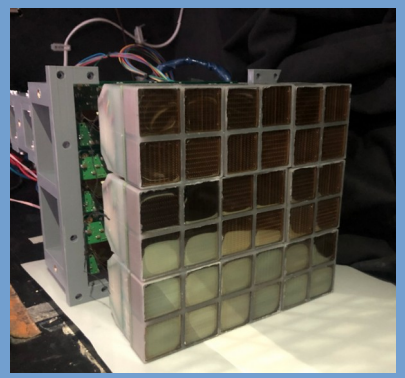
1) Schmidt Optics telescope with combined focal surface:
    - Fluorescence Camera
    - Cherenkov Camera
2) Low Frequency Radio Instrument
3) Infrared Camera
4) Gamma-ray/X-ray/Particle Detector
5) Solar Power System
6) Rotation Mechanism:
    - a) Elevation: Nadir to +13 degrees above horizontal
    - b) Azimuth: 360 degrees



Detectors

Fluorescence Camera

- Measures fluorescence light emission
- ≳ EeV energies from above
- Comprised of 4 Photo Detection Modules

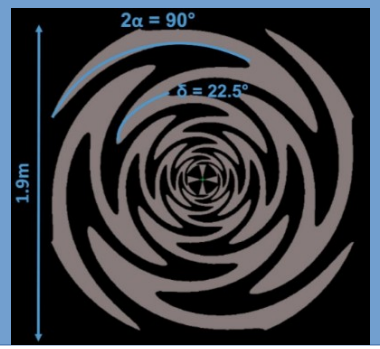


Cherenkov Camera

- Measures Cherenkov light produced by above-the-limb cosmic rays with energies of ~0.5 PeV
- Searches for PeV scale Earth-skimming neutrino signatures below the limb.
- 8x8 Silicon Photo-Multiplier array

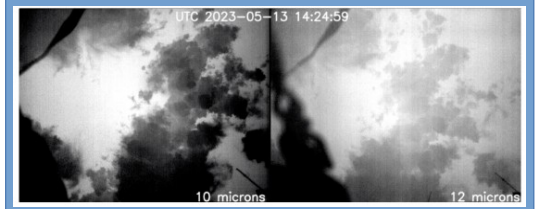
LF Radio Instrument

- Measures radio emissions from extensive air showers
- broadband 5 dBi gain from 50 MHz to 500 MHz in both V & H polarizations
- FoV: 60° x 120°



Infrared Camera

Quantifies cloud coverage within the telescope's FoV



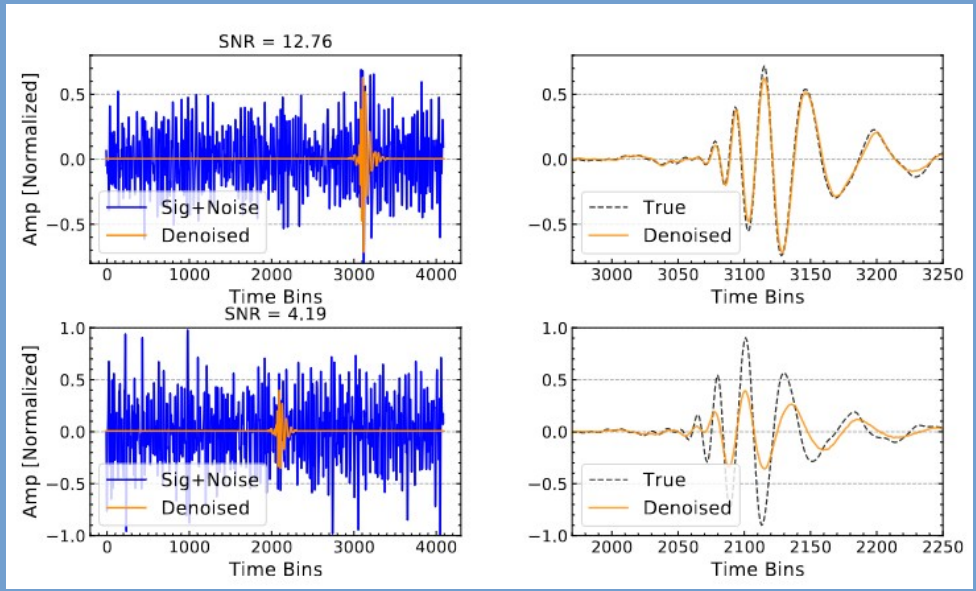
Gamma/X-ray/Particle

Measures the charged particle flux during flight and search for TLEs, TGFs, ToO events, and GRBs

Machine Learning Studies

ML with Radio

Radio signals of airshowers is very challenging due to only small signals compared to the background. **Uses CNNs to Denoise and Classify EAS emission signals from background noise**



A. Rehman, A. Coleman, F. G. Schröder, and D. Kostunin. Classification and Denoising of Cosmic-Ray Radio Signals using Deep Learning. PoS ICRC2021, 417, 2021.

Early Study EAS Reconstruction from Above using ML

Focuses on utilizing CNNs to reconstruct key parameters of EAS, such as geometry, energy, and X-max of EAS events by convolving a 4D (x pixel, y pixel, time, and photon count) into 3D (x pixel, y pixel, functional attributes.