

# Exploring the Horizon from Near Space: The POEMMA-Balloon with Radio Mission for Ultra-High-Energy Cosmic Rays and Earth-Skimming Neutrino Detection

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The Probe of Extreme Multi-Messenger Astronomy on a Balloon with Radio (PBR) is a planned NASA Super Pressure Balloon mission as a prototype for the future space-based POEMMA mission, with an Ultra-Long Duration Balloon launch from Wanaka, New Zealand, targeted for 2028.

PBR will carry a multi-instrument payload including a Fluorescence and a Cherenkov cameras sharing a common focal plane, augmented by a low-frequency radio instrument, a gamma-ray/X-ray detector. This unique configuration enables the observation of extensive air showers (EAS) developing high in the atmosphere through four complementary detection channels, producing an unprecedented multi-messenger dataset.

The primary science objectives include the first observations of ultra-high-energy cosmic rays from above via fluorescence light, detailed measurements of high-altitude horizontal air showers across varying slant depths, and searches for Earth-skimming PeV tau neutrinos.

The payload is mounted on a Schmidt optical telescope with azimuthal rotation of 360° and elevation control from nadir to 13° above the horizon, representing a significant step toward a future space-based observatory.



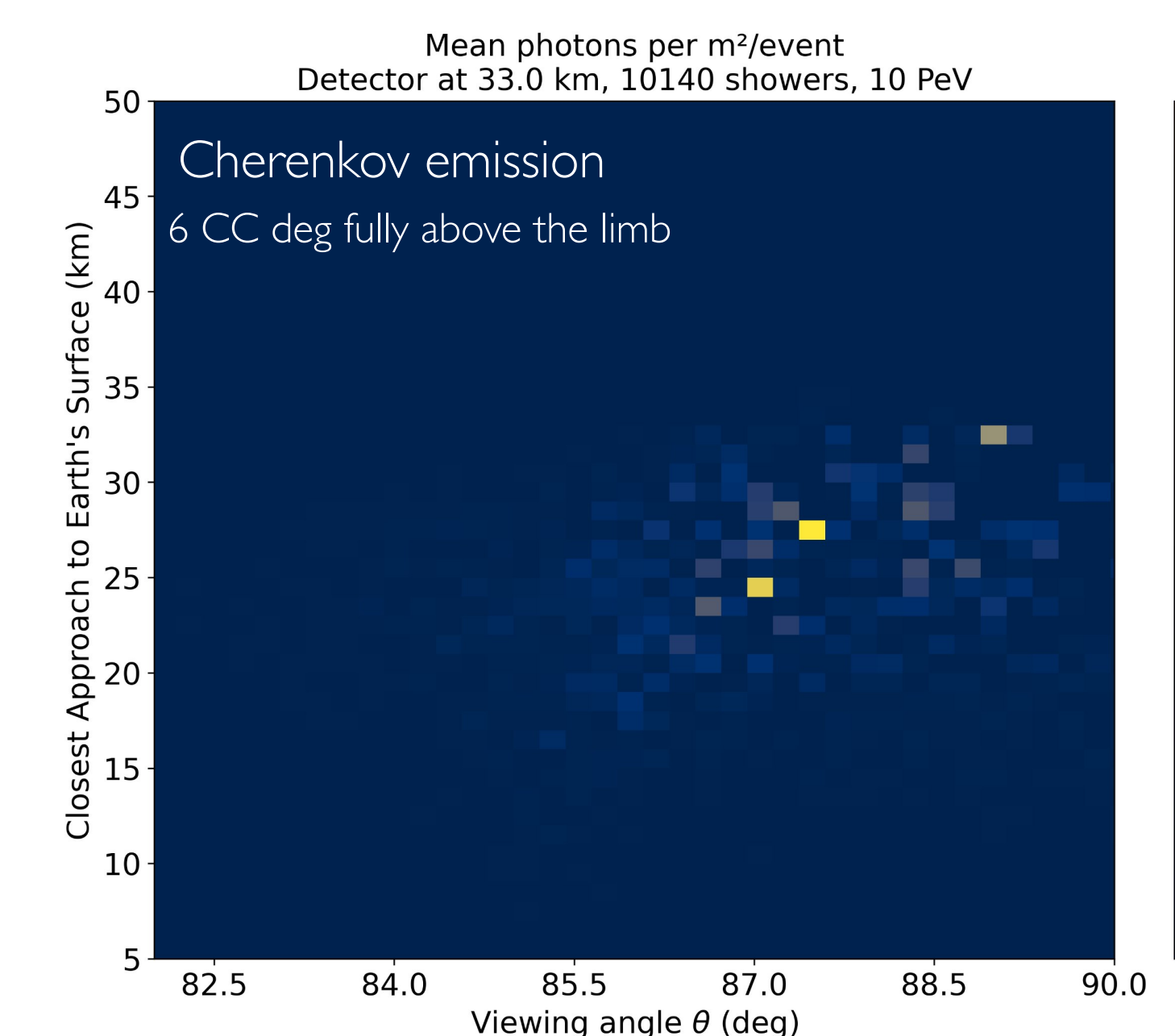
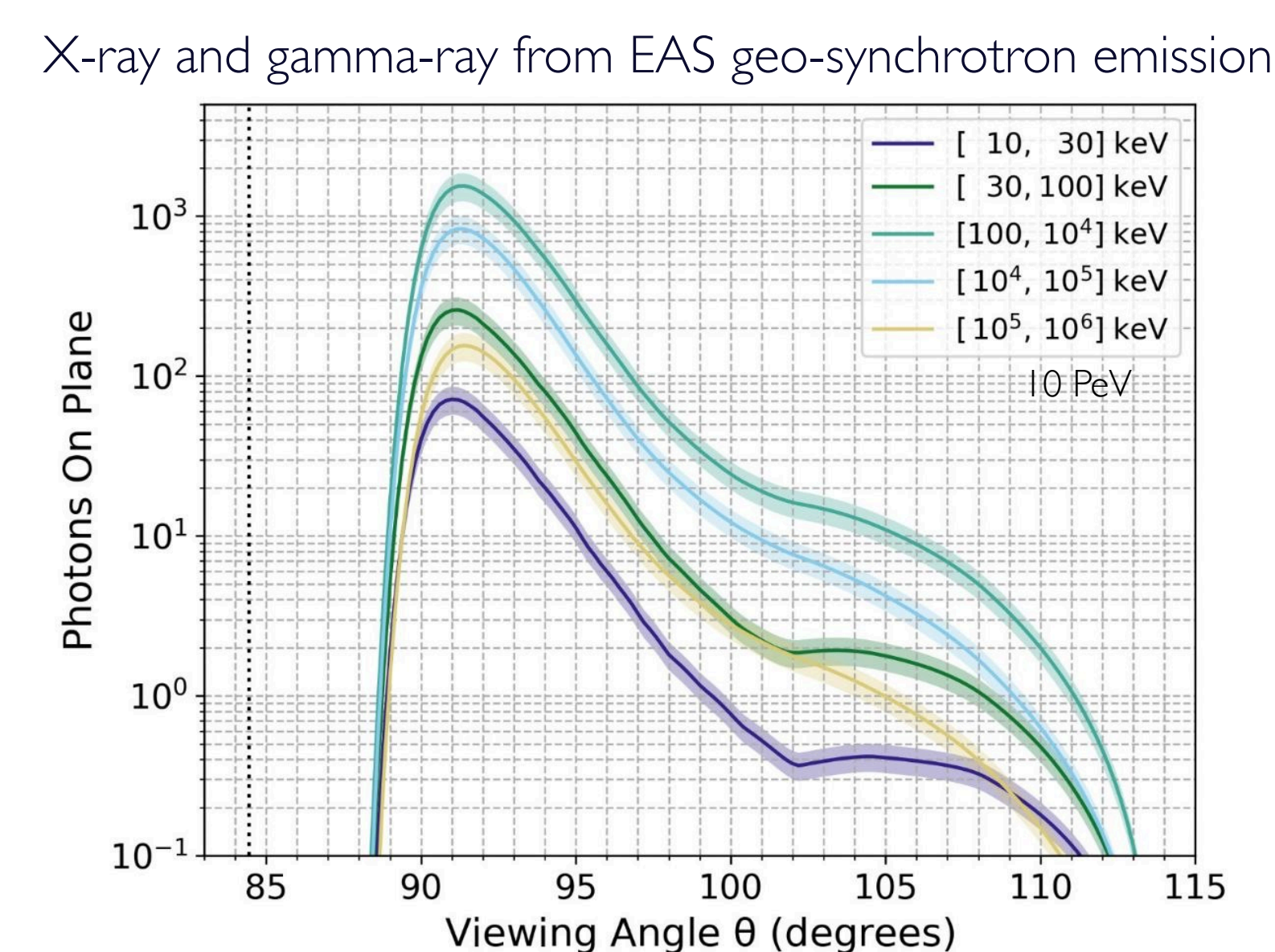
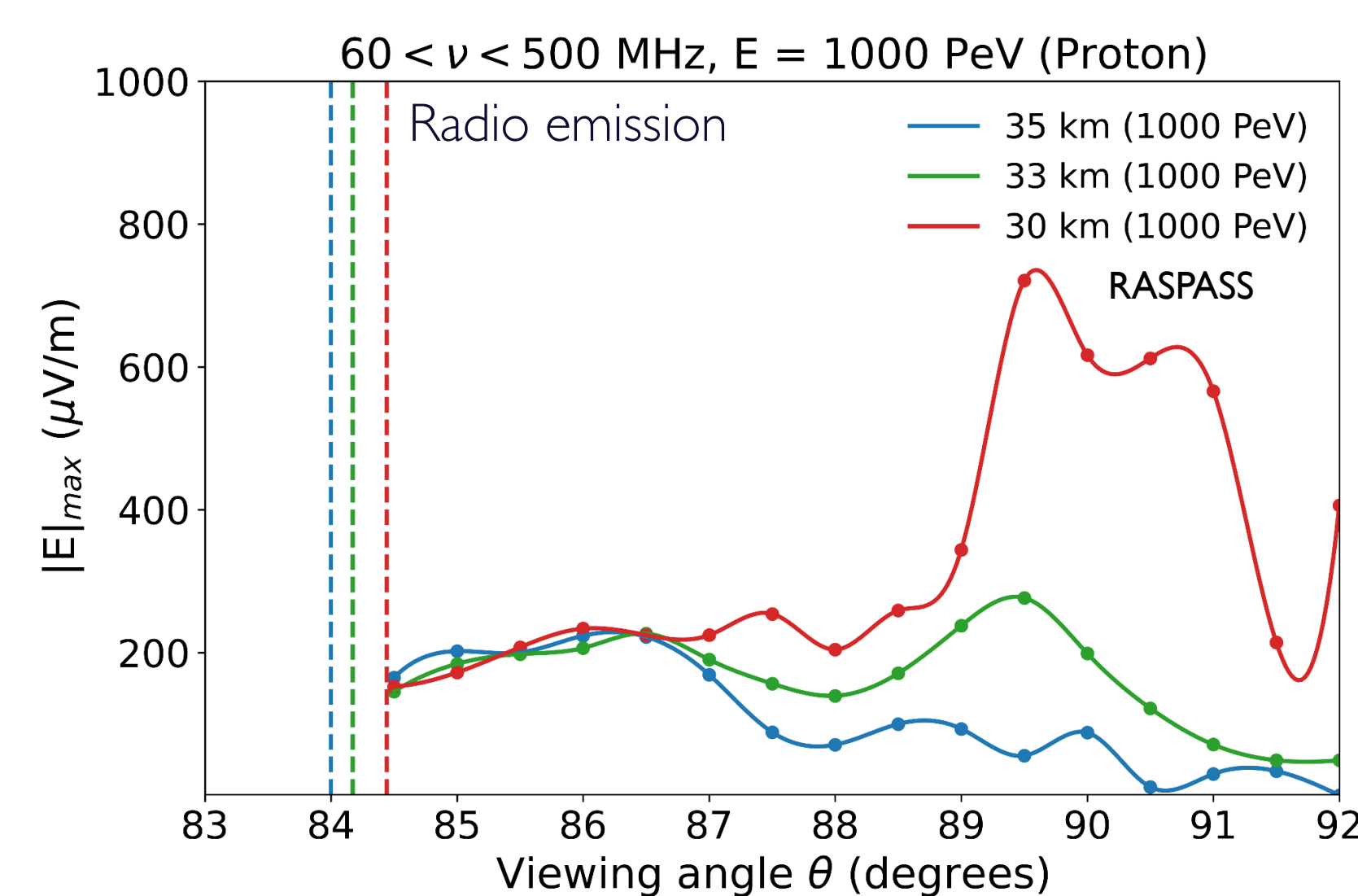
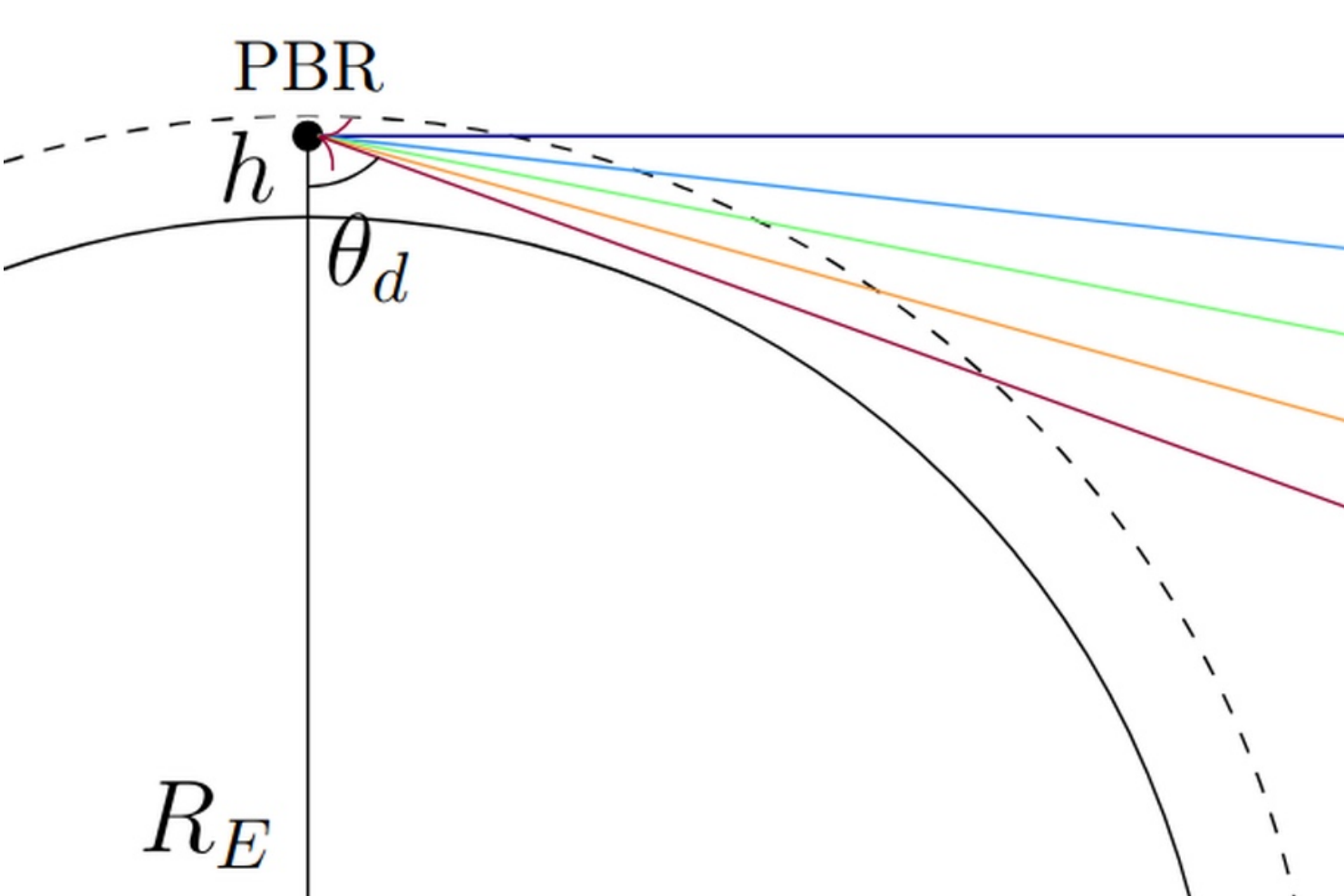
## Fluorescence Camera (FC)

- Largest FC FoV flown at high altitude:  $25^\circ \times 25^\circ$
- 4 photodetection modules (PDMs)
  - 48 × 48 pixels per PDM
  - 36 multianode photomultiplier tubes per PDM
- **9,216 total pixels**, pixel size  $3 \times 3 \text{ mm}^2$
- Narrow-band UV filter + field-flattening lens
- SPACIROC3 ASIC

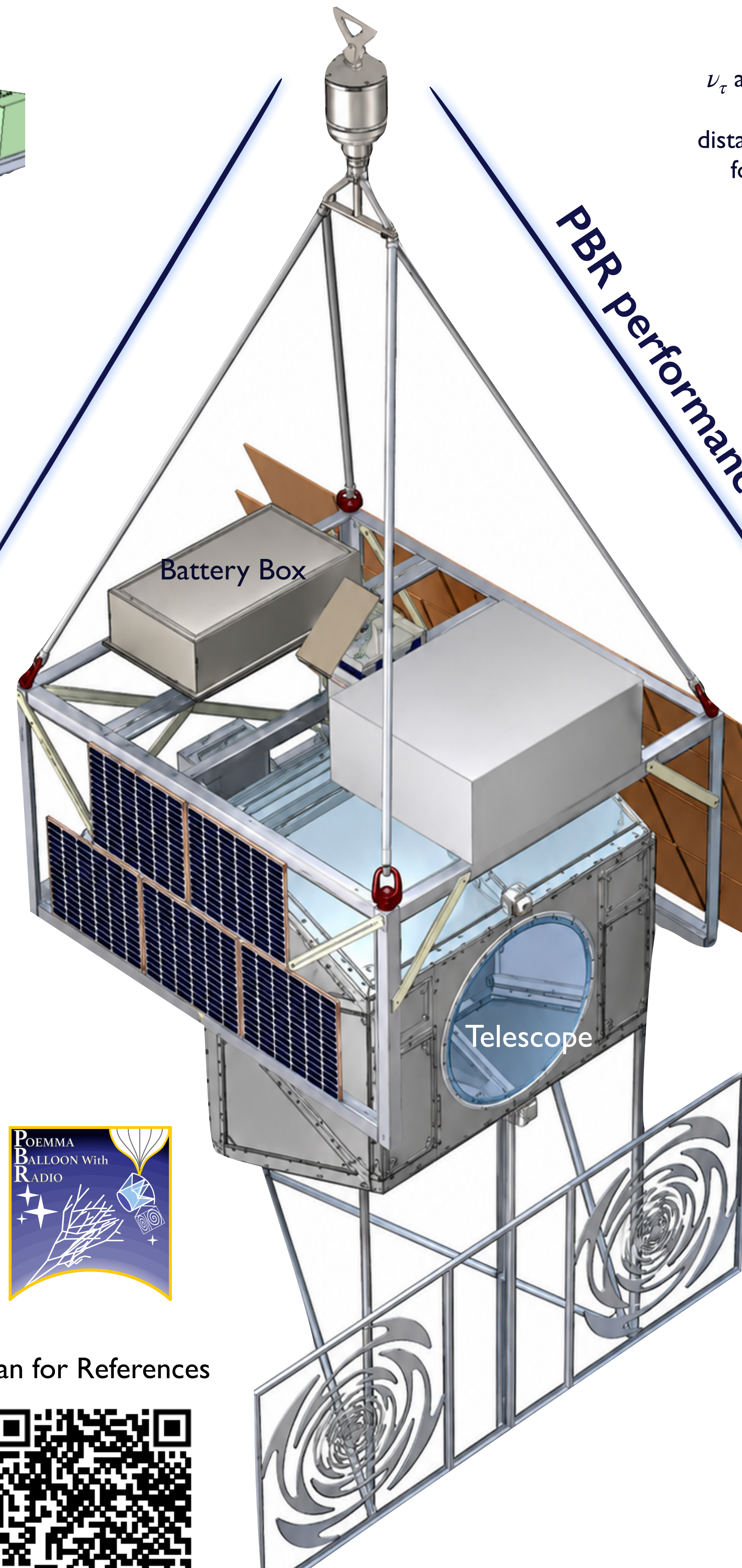
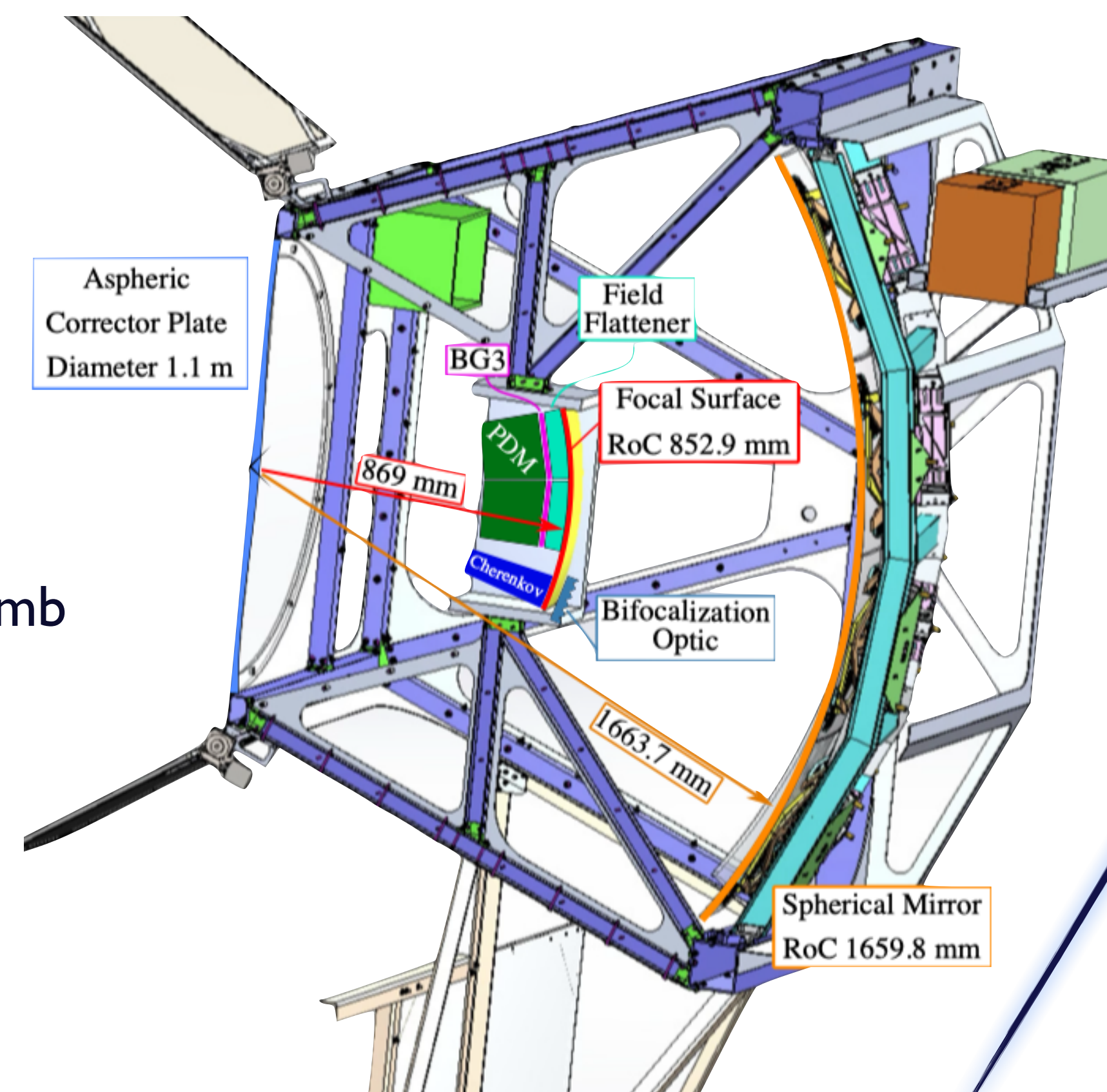
## Cherenkov Camera (CC)

- Search for Earth-skimming neutrinos below the limb
- **4 × 8 SiPM arrays**
- **2,048 total pixels**, pixel size  $3 \times 3 \text{ mm}^2$
- Sampling time: **5 ns**
- FoV:  $12^\circ \times 6^\circ$
- SiPM **Hamamatsu S13361-3050**
- **MIZAR** ASICs

## High Altitude Horizontal air showers signatures at ~30 km

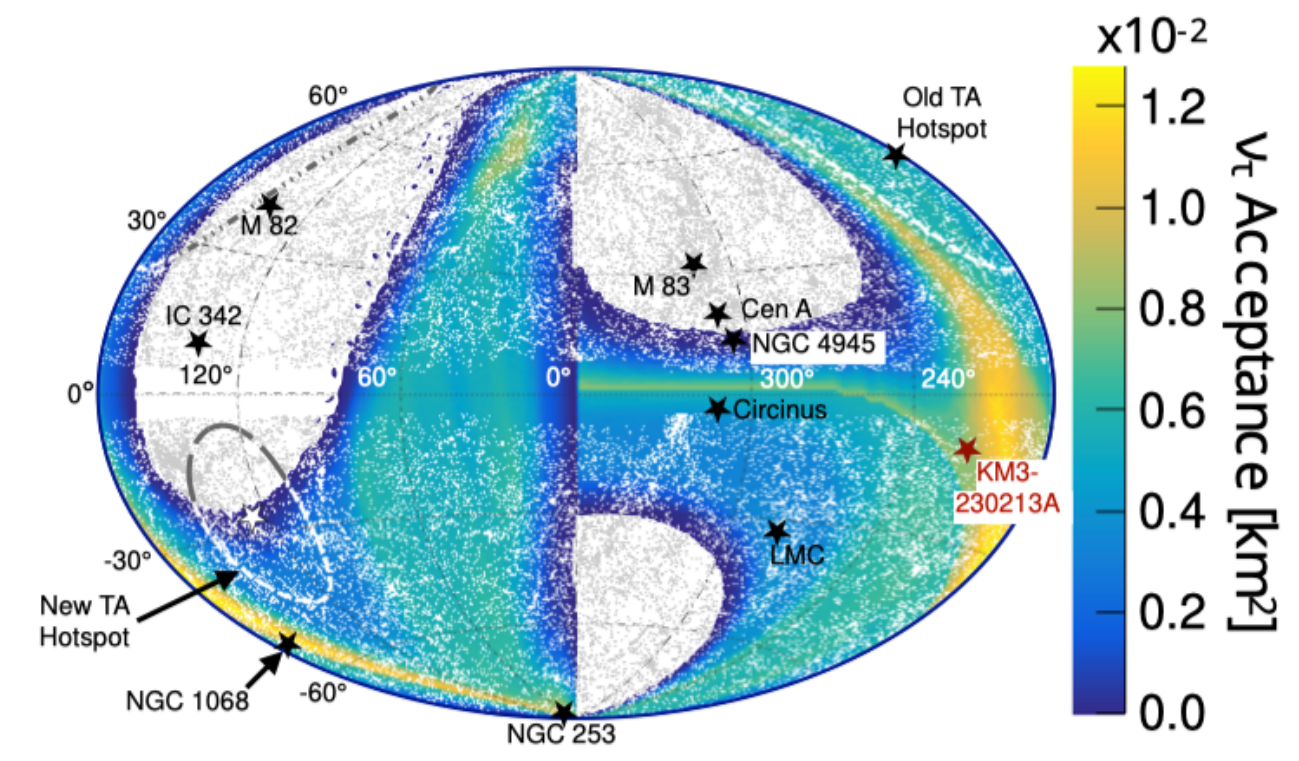


## Mission Overview and Science Goals

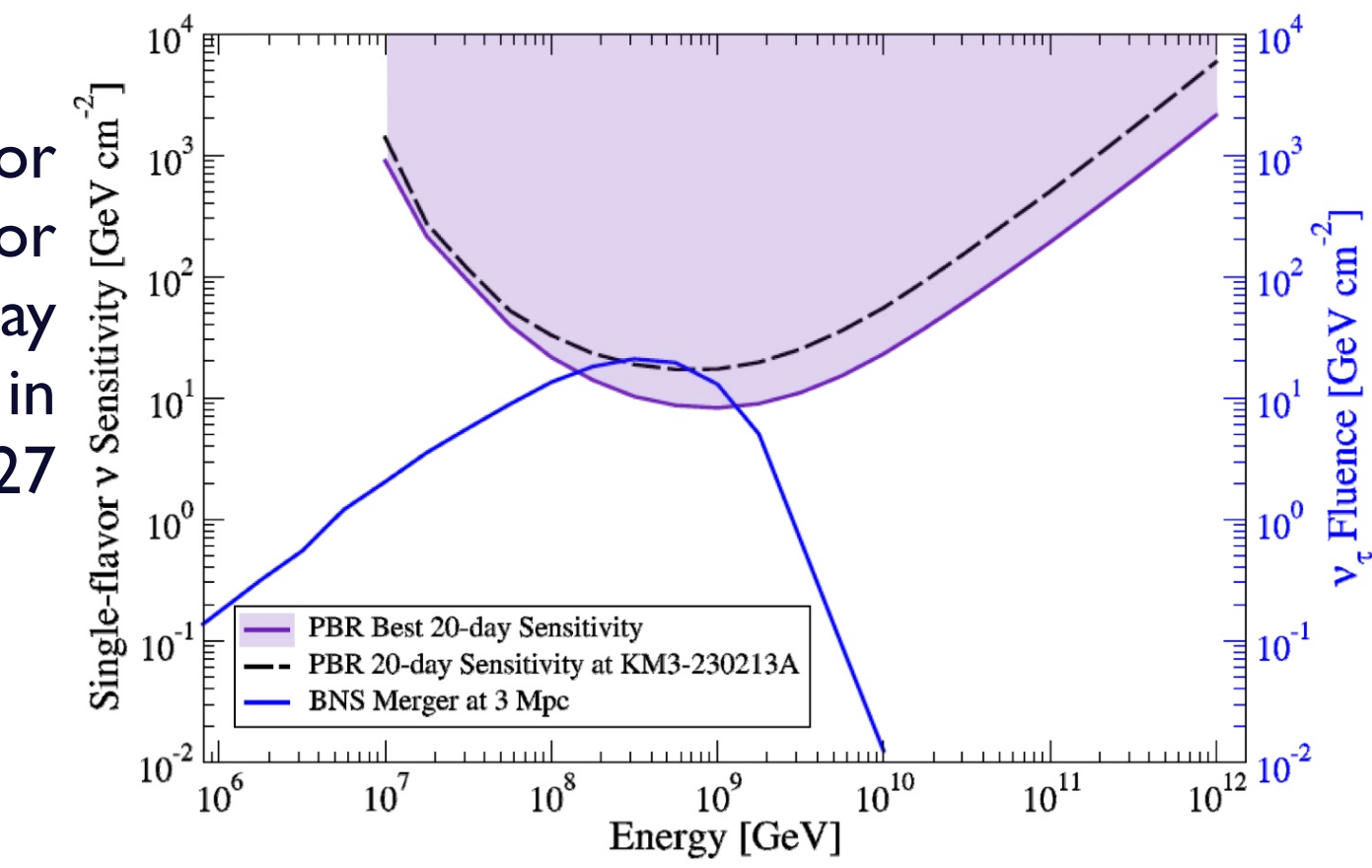


## Neutrino search from Targets of Opportunity

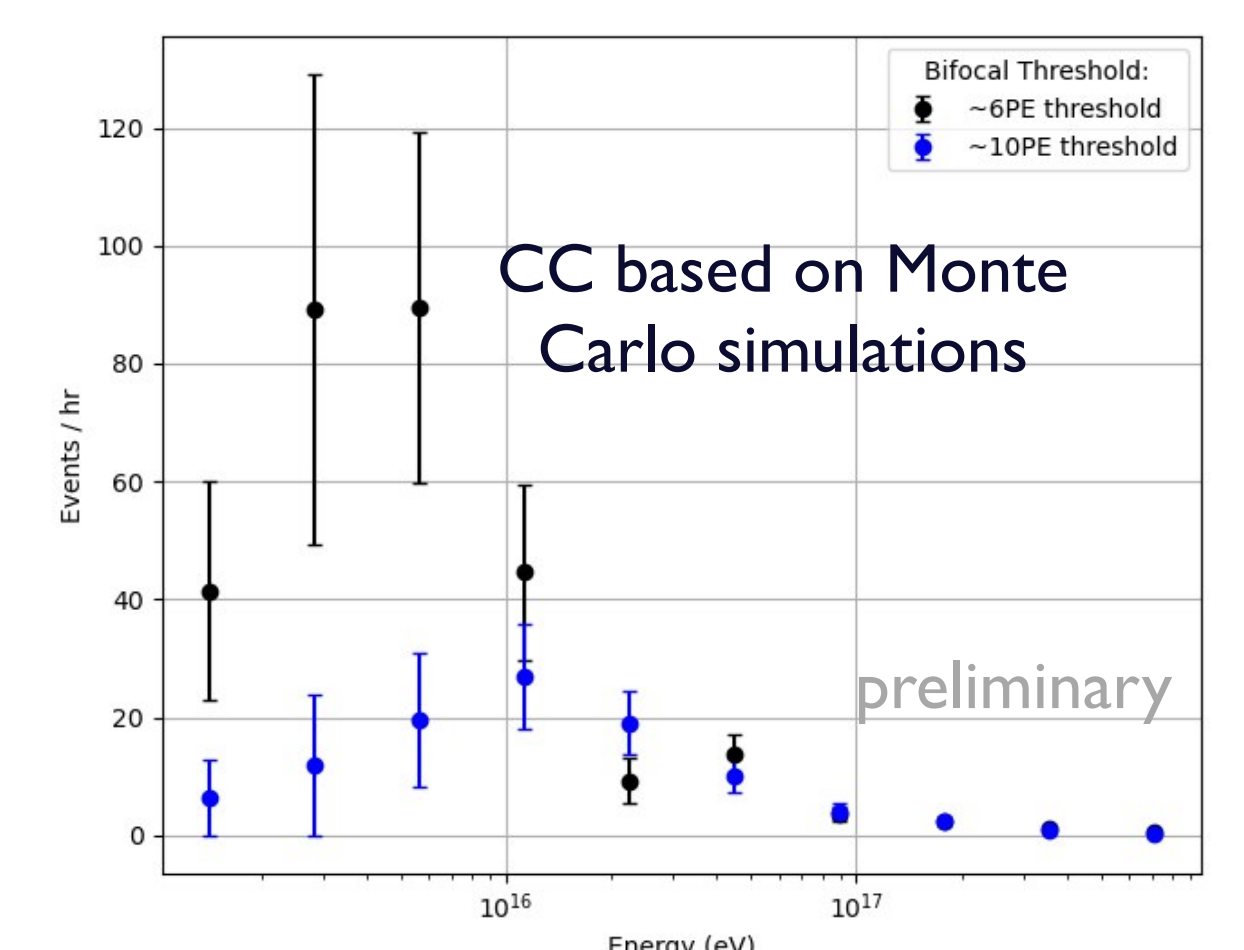
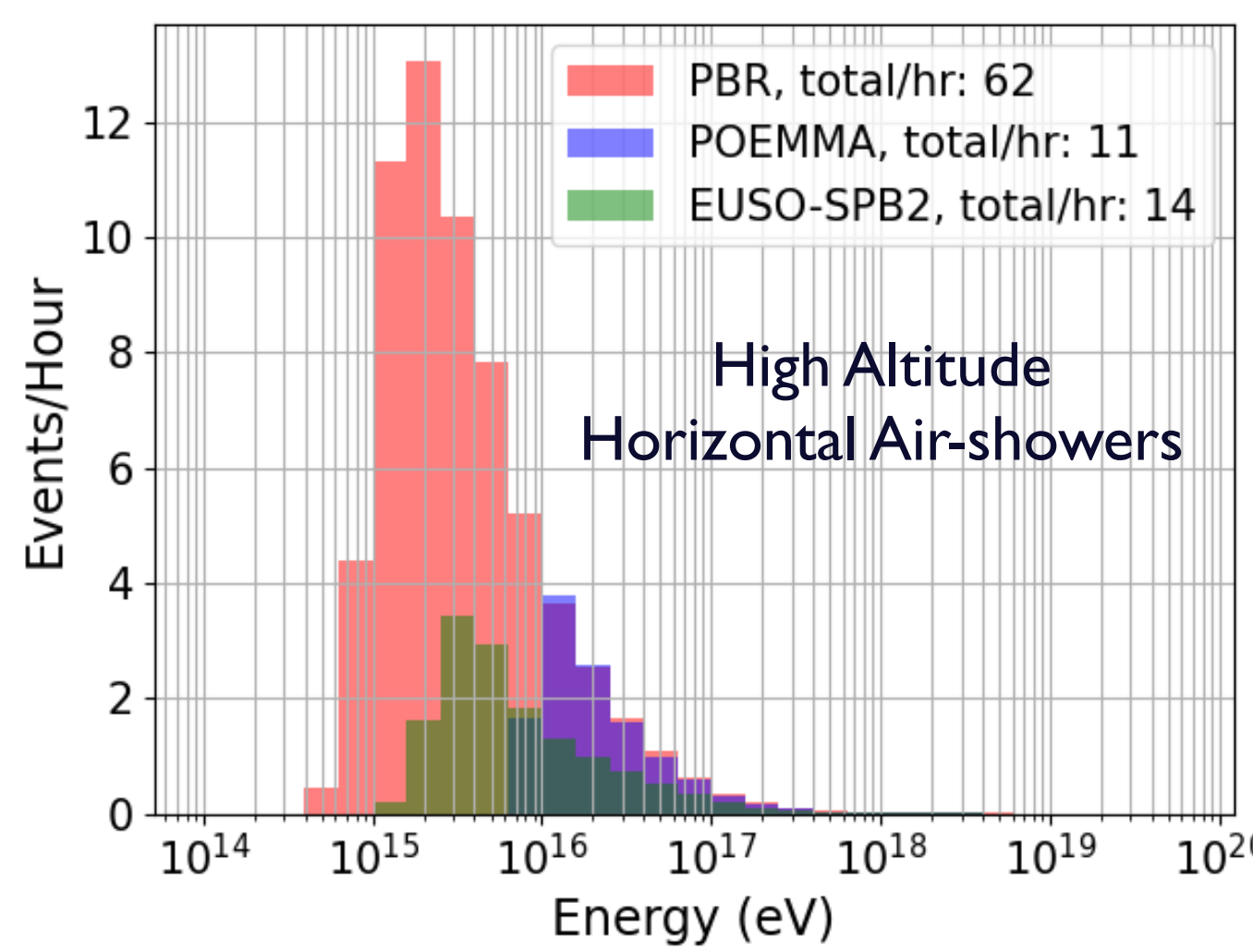
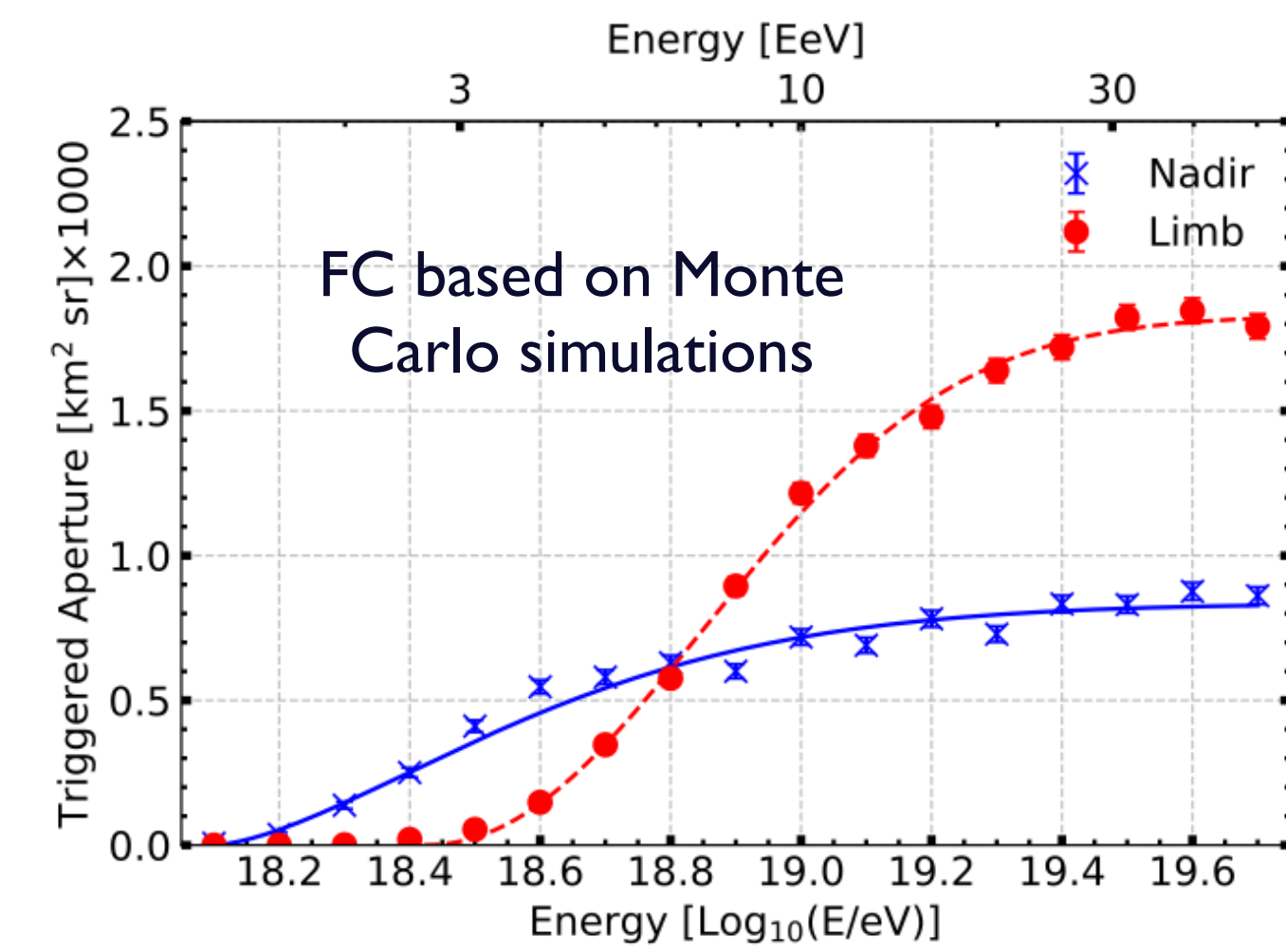
$\nu_\tau$  acceptance assuming a BNS merger model at 3 Mpc distance in galactic coordinates for a mission lasting 50 days



The single-flavor sensitivity range for PBR for a 20-day flight launched in early April 2027



Within the Planetary Neutrino Monitoring network (PLEvM) framework, PBR-like detector is envisioned as a core element of a future PLEvM- $\tau$  extension for  $\tau$ -neutrino astronomy



## Gamma-ray / X-ray detector

It monitors high-energy photon emission starting from 15 keV, probing the early stage of shower development.

On the front of the telescope it will point in the direction of the CC and FC.



## Radio Instrument

Based on PUEO LF design and used to characterize cosmic ray air-showers and tau lepton decay induced air-showers.

- 2 m wide, dual polarized sinuous antennas
- broadband 5 dBi gain from 60 MHz to 500 MHz
- Field of view of  $60^\circ \times 120^\circ$

It will be triggered by CC which gives the opportunity for hybrid measurements.



Scan for References

