POEMMA-Balloon with Radio: Mission Overview

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Abstract

The Probe of Extreme Multi-Messenger Astronomy (POEMMA) on a super-pressure balloon with radio (PBR) is a planned instrument designed as a successor mission of EUSO-SPB2 and a prototype for a space-based POEMMA mission. The three primary science objectives are to make the first observations of Ultra-High-Energy Cosmic Rays (UHECR) from above using fluorescence light measurements, to measure high-altitude horizontal air-showers (HAHAs), and to search for Earth-skimming astrophysical neutrinos with PeV energies. To accomplish these goals, PBR will fly three main instruments. The Fluorescence Camera (FC) will measure the fluorescence light emission of UHECR induced air-showers of $\gtrsim$ EeV range energies from above. The Cherenkov Camera (CC) will observe Cherenkov light produced by above-the-limb cosmic rays with energies of $\sim$0.5 PeV and search for Earth-skimming neutrino signatures below the limb. Finally, PBR will fly a Radio Instrument (RI) consisting of two low-frequency sinuous radio antennas to measure radio signatures of HAHAs and Earth-skimming neutrino candidates both in individual trigger mode as well as utilizing the external triggers from the FC and CC.

The FC and CC will be placed on a combined focal surface in a 1.1 m diameter aperture Schmidt optics telescope comprised of a 1.9 m$\times$2 m primary mirror with a radius of curvature of 1.66 m. This telescope and the RI will be able to rotate in elevation angle from nadir to $\sim 12^\circ$ above horizontal and 360° in azimuth to enable follow-up measurements of transient astrophysical sources of interest using the Target of Opportunity methodology. The predicted sensitivity is expected to achieve instantaneous single source sensitivities similar to or exceeding current ground-based experiments at energies above $\sim$ 10 PeV. PBR will also fly an infrared camera to monitor cloud coverage and a gamma/x-ray particle detector to search for signals from cosmic ray air-showers or other gamma-ray sources. The combination of these instruments makes PBR a unique experiment, which is able to probe the physics of extensive airshowers in ways currently inaccessible to ground-based detectors.