

## Absolute calibration of the photodetection modules for the JEM-EUSO missions

The JEM-EUSO (Joint Experiment Missions for Extreme Universe Space Observatory) collaboration constructs a series of balloon and orbital telescopes to detect fluorescent UV emission from the Earth atmosphere, with the primary aim to study ultrahigh energy cosmic rays (UHECRs) from space.

The detectors have wide field-of-view (more than 20 degrees FOV), high temporal resolution (1-2.5  $\mu$ s) and sensitivity provided by a large aperture. Currently one of these detectors is operating onboard the ISS (Mini-EUSO). The next one is planned to be launched in the spring of 2023 (EUSO-SPB2) and the other one is in preparation stage (K-EUSO). These projects use the same photo-detection modules (PDMs) composed of 36 multi-anode photomultiplier tubes (MAPMTs) with 2304 channels in total. Mini-EUSO uses one PDM, EUSO-SPB2 uses three and K-EUSO will use more than 40 PDMs.

In the process of preparing and testing of PDMs, a unique technique for absolute calibration was developed, a comprehensive study of the efficiency of the multi-anode PMTs used in the projects, including the structure of the photocathode of both the MAPMT as a whole and individual pixels, was carried out. Efficiency measurements were carried out at different supply voltages and input near UV photon flux intensity.

The methods of absolute calibration and its application to EUSO-SPB2 PDMs in different modes of operation and internal PDM structure studies will be presented.

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