The Focal Surface of the JEM-EUSO Instrument

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Abstract: The Extreme Universe Space Observatory on JEM/EF (JEM-EUSO) is a space mission to study extremely high-energy cosmic rays. The JEM-EUSO instrument is a wide-angle refractive telescope in the near-ultraviolet wavelength region which will be mounted to the International Space Station. Its goal is to measure time-resolved fluorescence images of extensive air showers in the atmosphere. In this paper we describe in detail the main features and technological aspects of the focal surface of the instrument. The JEM-EUSO focal surface is a spherically curved surface, with an area of about 4.5 m^2. The focal surface detector is made of more than 5,000 multi-anode photomultipliers (MAPMTs). Current baseline is Hamamatsu R11265-03-M64.

Keywords: Ultra High Energy Cosmic rays, Instrumentation.

1 Introduction

The Extreme Universe Space Observatory on JEM/EF (JEM-EUSO) is a space mission to study extremely high-energy cosmic rays [1,2,3,4]. The JEM-EUSO instrument is a wide-angle refractive telescope in the near-ultraviolet wavelength region which will be mounted to the International Space Station. Its goal is to measure time-resolved fluorescence images of extensive air showers in the atmosphere. The focal surface is a spherically curved surface, and its area amounts to about 4.5 m^2.

2 JEM-EUSO Focal Surface

The Focal Surface (FS) of JEM-EUSO has a curved surface of about 2.35 m in diameter, and it is covered with about 5,000 Multi-Anode Photomultipliers Tubes, MAPMTs, (Hamamatsu R11265-M64). It makes ±30º FOV and 0.07º angular resolution.
The FS detector consists of Photo-Detector Modules (PDM), each of which consists of 9 Elementary Cells (EC) arranged in an array of 3 × 3. About 1,233 ECs, corresponding to about 137 PDMs, are arranged on the whole FS (Figure 1).

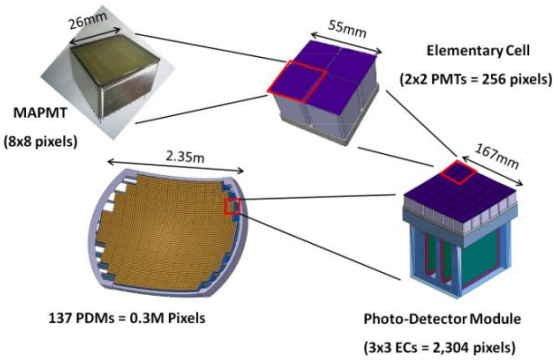

Figure 1. JEM-EUSO Focal Surface

3 Photo-detector

JEM-EUSO is a photon-hungry experiment; its expected photon ratio is <100 photons/μsec/pixel around shower maximum. And its FS detector should have high detection efficiency. The FS detector should have single photon counting capability in the near-ultraviolet wavelength region to avoid the systematic errors, which may be introduced through the gain drift. It should be reliably and stably operational in Space environment for at least 3 or 5 years mission period. For the above reason, MAPMTs with UV-glass entrance window are employed as sensors of the FS detector.

Present baseline choice is the Hamamatsu R11265-03-M64 (see Fig. 2, Fig. 3), which was developed by RIKEN in collaboration with Hamamatsu Photonics K.K.
It has an ultra-bialkali photo-cathode, which transforms photons into electrons, and amplifies photo-electrons by means of a stack of metal channel dynodes. The signals are taken from the anode which is formatted as an array of 8 × 8. The photon detection efficiency of this is about 0.3 in the near-ultraviolet wavelength region.

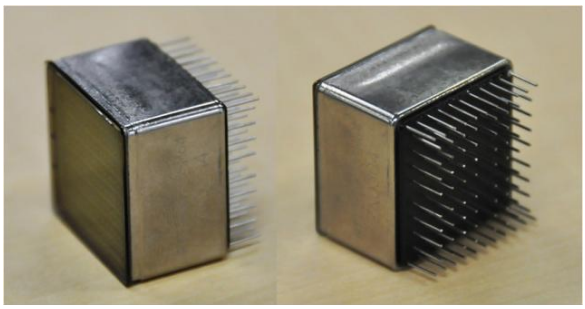

Figure 2. The MAPMT for the JEM-EUSO photo-detector (R11265-03-M64)

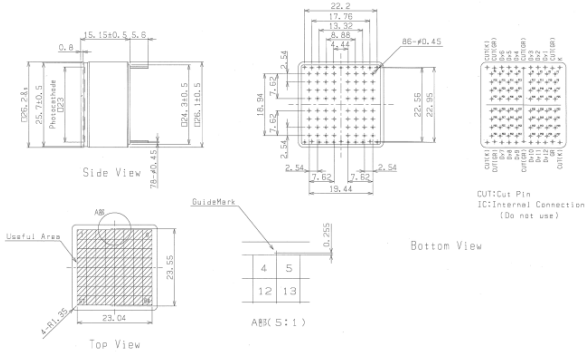

Figure 3. The Dimensional drawing of the MAPMT(R11265-03-M64)

Figure 4 shows single photo-electron spectra measured for the R11265-03-M64. Each single photo-electron peak is enough distinguished above the pedestal to use the single photon counting measurement.

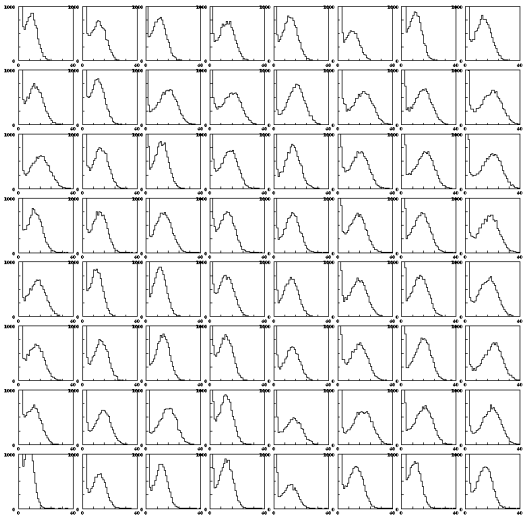

Figure 4. Sample of the single photo-electron spectra of R11265-03-M64.

Figure 5 shows the sensitivity map of the MAPMT for each pixel. The sensitivities of each pixel are clearly separated and it has almost no crosstalk.

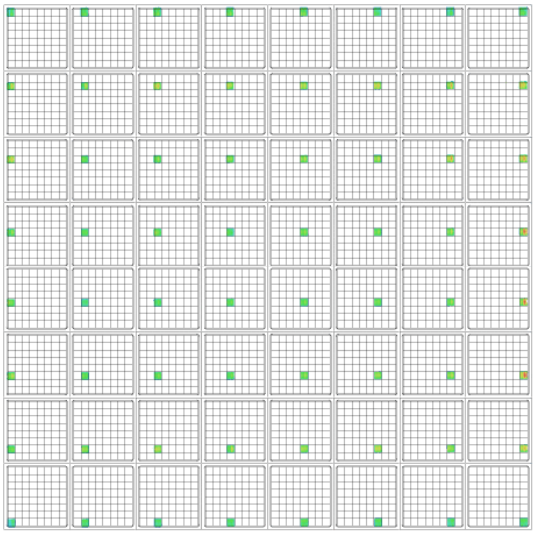

Figure 5. Sample of the pixel sensitivity map of R11265-03-M64.

4 Photo-Detector Module

PDM is the basic unit of the data acquisition of the JEM-EUSO telescope. PDM consists of the following components.

- 36 MAPMTs
- Front-End readout ASIC boards [5]
- 1st trigger board [6]
- Power Supply board
- High Voltage Supply boards [7]
- PDM Mechanical Structure [8]

Figure 6 shows Prototype of the PDM Mechanical Structure with 12 MAPMTs.

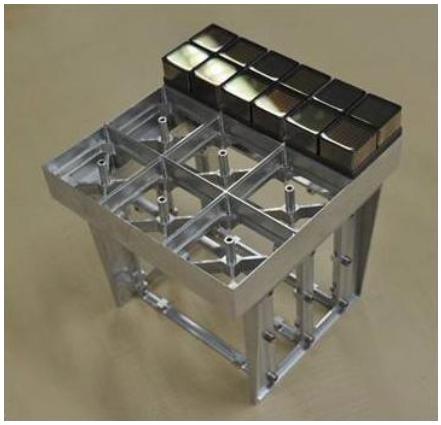

Figure 6. Prototype of the PDM Mechanical Structure with 12 MAPMTS

5 Focal Surface Mechanical Structure

The FS of JEM-EUSO is composed of a grid of ~5,000 MAPMTs arranged in modular support structures, that cover all the surface to collect the light of the optical system.

The FS is a portion of a sphere of radius 2785 mm, inserted within an in-plane section 2650 mm × 1900 mm (allowed by the HTV Exposed Pallet dimensions). We have studied the FS geometry and analyzed different PDMs distributions in order to maximize their number within the allocated space. The adopted configuration consists of a total of 137 PDMs lying in 11 rows along the parallels of the mentioned sphere, with one PDM located at the center of the FS geometry as shown in Figure 7.

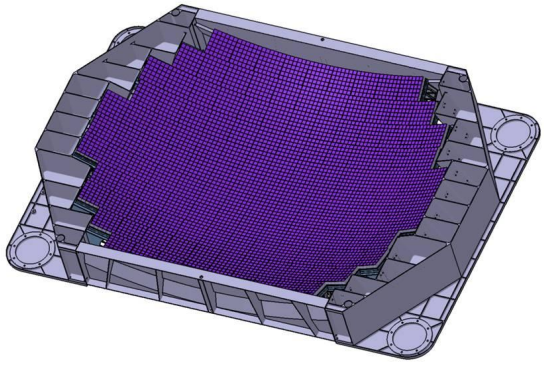

Figure 7. Focal Surface Assembly

6 Conclusion

We have developed a very large area photo-detector system for the JEM-EUSO focal surface, based on the Photo-Detector Module. We will start to build the full system when the JEM-EUSO mission is started.

Acknowledgements

These works are parts of the JEM-EUSO study of each country.

Reference

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