

**Project Title:**

**Generation of cosmic ray air showers at large statistics**

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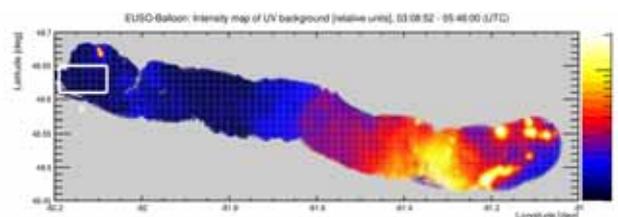
1. JEM-EUSO, Extreme Universe Space Observatory on Japanese Experiment Module, is the International Space Station (ISS)-based space mission for ultra-high cosmic rays (UHECRs) observations led by the EUSO Team (<http://jemeuso.riken.jp>).

By detecting air shower phenomenon, JEM-EUSO detects the incoming UHECRs to the atmosphere. The air shower phenomenon is based on the complex physics processes including electromagnetic and hadronic interactions. They produce in the end a huge amount of secondary particles starting by the single incident primary UHECR. These particles, mostly electrons and a few fraction of muons excite nitrogen molecules in the atmosphere. Resulting in emitting of ultra-violet (UV) photons, called fluorescence photons, the optical observations of such photons are used to detect UHECRs. The observation principle of UHECRs by JEM-EUSO is based on detection of such photons. Different from the existing observatories, JEM-EUSO will conduct the observations from Space. To realize this project, we started smaller-scale pathfinder missions on the ground and on the balloon. In this fiscal year, we in part use Hokusai system to make simulations to interpret the data from such pathfinders.

2. The detector simulations for JEM-EUSO and its pathfinders were carried out using the GEANT4 (<https://cern.ch/geant4>) together with ESAF code developed by the collaboration (C. Berat et al. 2010) and Offline package (S. Argio et al. 2007).

The essential design and parameter of the telescope have been developed and provided by EUSO Team.

3. In this year, we finalized the paper on to submit the scientific journal. The EUSO-Balloon is a pathfinder mission of the full-scale JEM-EUSO. We take part in the analysis of the UV light seen from the balloon at ~38 km altitude. Such light acts as background against detection of fluorescence light for air shower phenomena. The key results from the EUSO-Balloon pathfinder have been already obtained by FY2015 activities, cf. the figure shows the analyzed data of UV light along the trajectory of the EUSO-balloon (Mackovjak et al. 2015).



JEM-EUSO and EUSO-Balloon apply Fresnel lens into their telescopes that requires a large CPU power to characterize the performance of the detector. In this FY, Hokusai was utilized to simulate the detector response, mainly the optics simulations. These results are used in the final version of the journal paper.

4. 5. Utilization of Hokusai has been and will be essential for JEM-EUSO and its pathfinder mission that outputs three proceedings papers.

## Usage Report for Fiscal Year 2016

### References:

- C. Berat et al. 2010, *Astroparticle Physics*, 33, 21.
- S. Argio et al. 2007, *Nuclear Instruments and Methods*, A580, 1485
- S. Mackovjak et al. 2015, in *Proceedings of the 34th International Cosmic Ray Conferences*, Pos 685.
- S. Mackovjak et al. 2015, in *Proceedings of the 34th International Cosmic Ray Conferences*, Pos 685.