

Project Title: Computational and experimental studies for astrophysics

Name: Kenji Shinozaki

Laboratory at RIKEN: EUSO Team

Background: Joint Experiment Mission for Extreme Universe Space Observatory, JEM-EUSO program aims at space mission for the astrophysics about once-in-square-kilometer-area-per-century rare ultra-high energy cosmic rays (UHECRs). They are observed by imaging UHECR-initiated air shower phenomenon which emits faint fast-moving UV fluorescence light using a few-meter-scale telescope and ultra-fast readout "multi-pixel" photo-detectors.

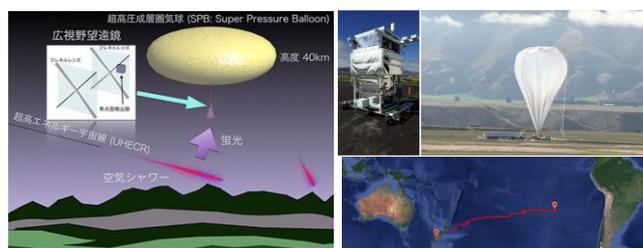
The international collaboration has been led by RIKEN. To develop and prove the key technologies for the JEM-EUSO program, we conducted "pathfinder missions". So far, two balloon-borne mission were complete and a ground-based EUSO-TA experiment is ongoing. "Mini-EUSO" mission is foreseen in FY2018. A compact prototype telescope will be carried to and operated in the International Space Station.

These pathfinder operate ~2300-pixel photo-detectors sampling at 400,000 samples per second at ~hertz trigger rate. Utilization of Hokusai mainly is for evaluating / estimating the science performance of operated / planned missions. Such a large amount of data from the performed pathfinders also needs to be analyzed and compared with simulations.

Status, Result, Conclusion and Prospect: In April 2017, we launched the EUSO-SPB pathfinder on NASA's SPB (Super Pressure Balloon) from Wanaka, New Zealand. The figure summarizes the concept, instrument and balloon (RIKEN Press Release, May 2017 and

http://jem-euso.roma2.infn.it/?page_id=1055).

SPB has a potential of ~100-day long flight. Although the instrument was successfully operated, the flight was terminated in 12 days due to gas leakage. This led to abandon EUSO-SPB before reaching South America where the whole data could



have been also retrieved.

We expected utilization of Hokusai for data analysis and relevant simulations linked to the real data. However, no job was executed as ~100GB data amount was processable by local resources. Within limited telemetry capacity to the ground, the data was largely reduced onboard but still not all data was transmitted to the ground before EUSO-SPB sank in Pacific.

If EUSO-SPB had flown longer as long as ~32-47-day previous SPB flights, more data would have been available and simulations surely required Hokusai at least "Quick Use". Such situations are foreseen in "Mini-EUSO" that will provide far larger amount of data in a few months operation by possibly flying above 3/4 of the Earth's area. We also started an R&D study of the "EUSO-SPB2" to realize in ~2020.

By this year, we optimize the software packages for our use: air shower simulation code, CONEX (<https://www.ikp.kit.edu/corsika/>), data analysis tool: ETOS (L. Piotrowski et al. 2015, Nucl. Instr. Meth. A 773, 164) and detector simulation tools: ESAF (C. Berat et al. 2010, Astropart. Phys. 221, 247) and OffLine (B. Panico et al. 2015, Proc. of 34th Int. Cosmic Ray Conf., 667). They are ready to be implemented and utilized in Hokusai for Mini-EUSO and other JEM-EUSO pathfinders.