Simulation framework of STM code for development of JEM-EUSO instrument

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Abstract: The Extreme Universe Space Observatory installed on the Japanese Experimental Module at ISS(JEM-EUSO) is a science mission to investigate the nature and origin of Ultra-High-Energy Cosmic-Rays (UHECRs). The Saitama simulation is covering the End-to-End procedure for the JEM-EUSO mission to study the telescope performance, therefore it has been used as a tool especially for the development of the optics and focal surface devices. This implementation can contribute to the hardware development for seeking the best performance of the telescope. The code offers the data analysis routine for the simulated shower events, as well. In this report, the framework of this simulation code will be introduced and discussed.

Keywords: JEM-EUSO,Simulation,Ultra High Energy Cosmic Rays

1 Introduction

The Extreme Universe Space Observatory installed on the Japanese Experimental Module at ISS(JEM-EUSO) is a science mission to investigate the nature and origin of Ultra-High-Energy Cosmic-Rays(UHECRs)[1]. An UHECR interacts with an atmospheric nucleus and then produces an Extensive Air Shower (EAS). JEM-EUSO on board of the ISS at the altitude of about $430km$, captures the moving track of the fluorescent UV photons along EAS development.

JEM-EUSO telescope records EAS track with a time resolution of $2.5\mu s$ and a spatial resolution of $0.5km$ at ground. These timesegmented EAS images allow us determining EAS energies, their arrival directions and longitudinal profiles.

The End-to-End simulation code has been developed considering hardware characteristics of the JEM-EUSO optical system, the focal surface detector and the output signal control circuit.

The accuracies of cosmic ray energy, arrival direction and longitudinal development can be estimated by reconstructing EAS profiles with the most suitable algorithm; the End-to-End simulation code is also used for successive improvements of the hardware system to upgrade their accuracies.

2 STM code

The Shower and Telemetry Module(STM) code is End-to-End simulation code for JEM-EUSO. The STM code have three components(fig1): EAS generation, detector simulation and EAS event reconstruction part.This code was written by C language. Each parts of STM code are independent and joined by Perl.

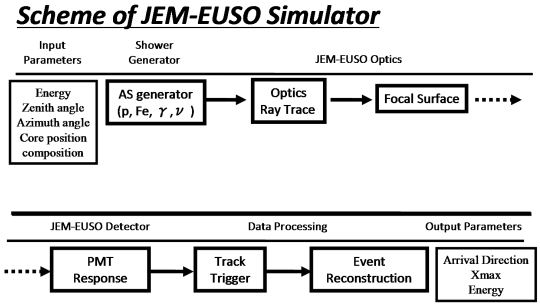

Figure 1: Scheme of STM code

2.1 EAS generation part

EAS generation code generates EAS longitudinal profile in atmosphere initiated by cosmic ray assumed chemical compositions, injected angle and energy. EAS has been generated by executing the code for various EAS longitudinal de-

velopments pooled in the EAS database made by AIRES or CONEX. Air fluorescence and Cherenkov light emissions are calculated taking into account their yields [2].they have wavelength 300-500nm. Absorption and scattering in atmosphere(rayliegh scattering, mie scattering and ozone absorption) are also calculated. And then the characteristics of the photons (wavelength, arrival time and spatial position of emission) on the optical lens of the telescope are evaluated. Figure 2 is sample of arrival time profile of photons on the optical lens.

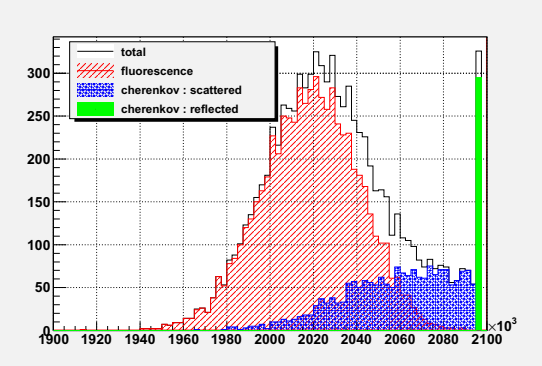

Figure 2: arivall time profile of photons on the optical lens of the telescope

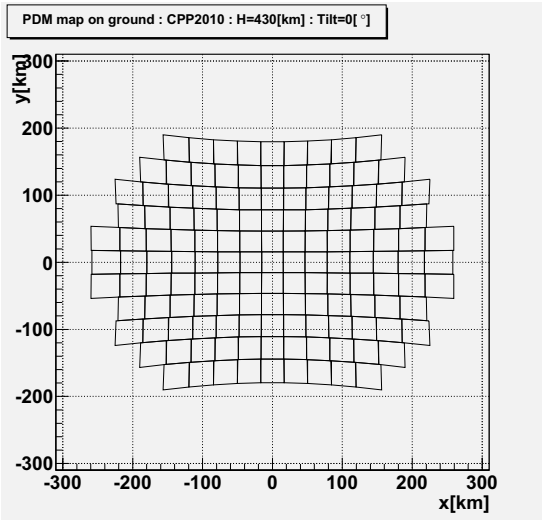

Figure 3: PDM layout thrown on earth

2.2 Detector simulation part

In the detector simulation code, characteristics of hardware responses to incident photons, photoelectrons and analogue/digital signals have been taken into account. The detector simulation have optical raytrece, PDM layout on focal surface, PMT performance(QE, CE and etc.) and trigger algorithm for JEM-EUSO.

In optical raytrace simulation, main part of raytrace made by Y.Takizawa and N,Sakaki. We converted for STM code. Optical raytrace simulation has several lens design(old, baseline and advance design).

PDM layout on focal surface exists each lens design. It has gap of each PDM and PMT. Figure3 is PDM layout thrown on earth.

PMT simulation calculate number of photoelectron changed from photon with quantum efficiency and collection efficiency of PMT and absorption of BG3 filter. Figure4 is photon counting efficiency on pixel calculated by STM code.

Trigger scheme have two step. First step of trigger was called progressive tracking trigger(PTT). Second step of trigger was called linear tracking trigger(LTT). Detail of PTT and LTT can be found in [3].

Finally pseudo-observational data including overall hardware responses will be generated.

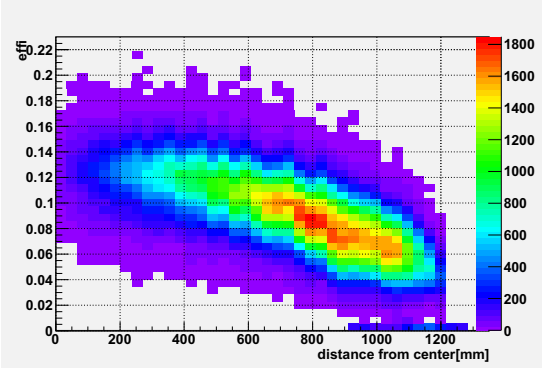

Figure 4: photon counting efficiency on pixel

2.3 EAS event reconstruction part

In addition, EAS event reconstruction code determines EAS energy, arrival direction and longitudinal development from simulated pseudo-observational data, and is used for evaluating their accuracies. This part also contributes as a feedback for the studies related to the development of analytical algorithms and hardware improvements aiming at the excellent telescopes capability with the best accuracies. Figure5 is a sample of reconstructed shower image calculated by STM code.

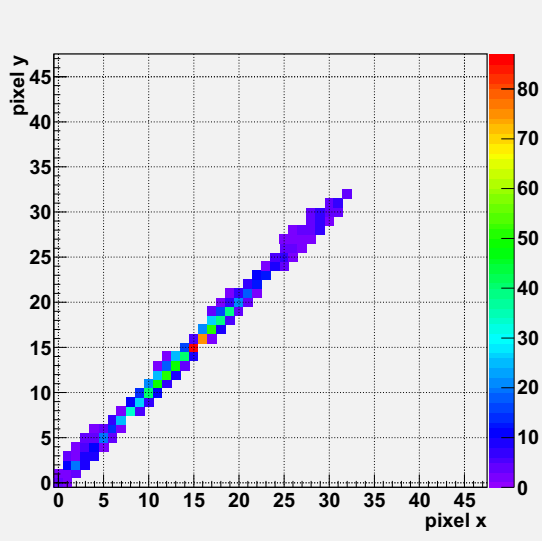

Figure 5: sample of reconstructed shower image calculated by STM code. energy=$10^{20}[eV]$. zenith angle=60[degree]]

3 Conclusions

The STM code is End-to-End simulation code for JEM-EUSO mission. In this paper we described the STM code framework and did not describe performance. If you know expected performance of the JEM-EUSO, please show [4].

References

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