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Telescope Array; Simulation and Data Analysis

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Telescope Array (TA) is a EAS detector which is now building in the western desert in Utah, USA. In order to estimate the performance of TA, a detailed detector simulation is being developed in Java. The number of particles produced during the development of the EAS shower with various inclinations is calculated by COSMOS code. The detection efficiency of each detector is evaluated by using the various calibration data and the results of GEANT4 simulation. And it is taken into account in estimating the signal. The analysis methods of the EAS data are also being developed using TA simulation. This report describes the structure of our simulation code, the analysis methods and the TA performance estimation based on our simulation.

1. Introduction

The AGASA observes 11 cosmic rays above 10^{20}eV in 12 years operation and shows the extension of the cosmic ray energy spectrum above the GZK cut-off.[1] Although the arrival direction distribution of EHECRs observed by AGASA is almost isotropic, some events shows an indication of point sources, from which 2 or more EHECRs arrived. High energy astronomical objects such as quasar remnants and BL Lac objects have been searched behind these events, but nothing have been found. There have been several hypothesis to explain these super-GZK events and point sources : super-heavy relics, Z-burst, the violation of Lorentz invariant at extremely high energy, and so on. Hires group have also studied the EHECRs and they reported that their energy spectrum is consistent with the existence of the GZK cut-off.[2] [3] From discussions of these two groups, it seems clear that a part of the inconsistency is due to the systematic error of both experiments in the determination of primary cosmic ray energy.

In order to dissolve the difference between AGASA and Hires, we are now constructing a hybrid detector which has an AGASA type ground array (SD) and 3 air fluorescence telescope stations like Hires detector (FD) as the first step of TA experiment.[4] The West Desert in Utah, USA is the experimental site. The Hybrid-TA consists of 576 plastic scintillation counters which cover the ground area of 760 km^2 in 1.2 km mesh and 3 telescope stations (FD stations) which surround the array and look inward. The field of view (FOV) of each FD station is $3^\circ \sim 34^\circ$ in elevation angle and 120° in azimuthal angle. There are $12 \sim 14$ telescopes in each FD station. The FOV of each telescope is 15.5° in elevation and 18.0° in azimuthal. Each telescope has spherical mirror of 3.3 m diameter and the shower image is recorded by a camera composed of 16×16 2-inch hexagonal PMTs placed on imaging plane. The separation of the FD station is $30 \sim 40$ km and stereo acceptance of FD is about 670 km^2 sr for EHECRs falling within 45 km of the FD station. Each particle detector of the SD is a plastic scintillator of 3m^2 area and 2 cm thickness. The scintillation photons are fed into PMT via wave length shifter fibers installed in grooves cut on the surface of the scintillator.

2. Simulation

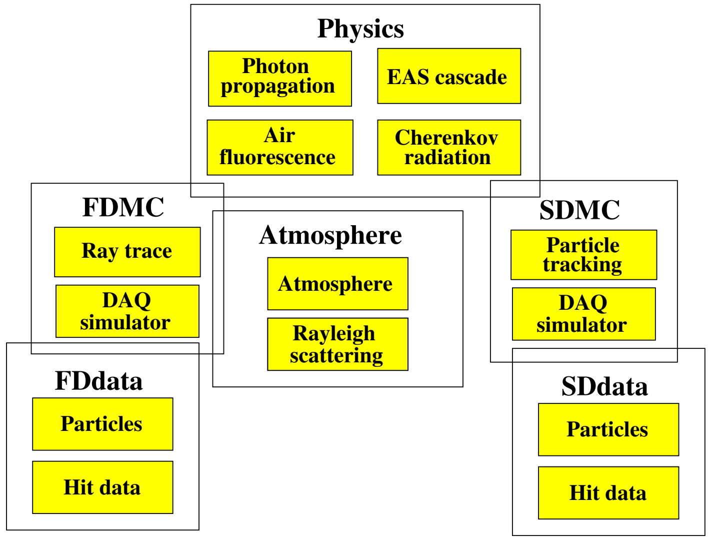

Figure 1. The schematic view of the TA simulation class

In this section, the components of the TA simulation are described. Simulation code is written in JAVA. It is said that the maintenance by a lot of people is comparatively easy for an object-oriented language as compared with languages, such as the C language and FORTRAN. This characteristic is indispensable when collaborators' activity place reaches far and wide. Figure 1 gives a schematic view of the TA simulation class.

Physics This class contains the classes which describe the physics processes. **EAS cascade** is the class to simulate the shower development. There are two methods to simulate the shower development: One method uses the Geisser-Hillas function for longitudenal development and the NKG function as the lateral distribution. But the correlation of the scale of these functions is unknown currently and it is one of the aim of our experiment. therefore, it is needed that the correlation of these functions is decided by a shower simulation when we adopt this method. The other is a method which uses the cascade shower data made by air shower simulation programs such as COSMOS, CORSIKA and some other full Monte Carlo code. Simulation program is designed so that it can cope with both methods. **Air fluorescence** and **Cherenckov radiation** are the class to simulate the emittion of photons by shower particles. In **Photo propagation**, the propagation of photons in the atmosphere is described.

Atmosphere This class describes the atmosphere. The density profile and temperature profiles are included. The elementary process of photon in atmosphere such as rayleigh scattering is also described.

FDMC,SDMC This class contains the classes to simulate the TA detectors. Reflection by telescope components is simulated in FDMC. In SDMC, the interactions of shower particles in the surface detector is simulated. Detection efficiency of the Surface detector is estimated by using of GEANT4. DAQ of each detectors is also described in this class.

FDdata,SDdata This class is for the simulation data.

3. Status and prospects

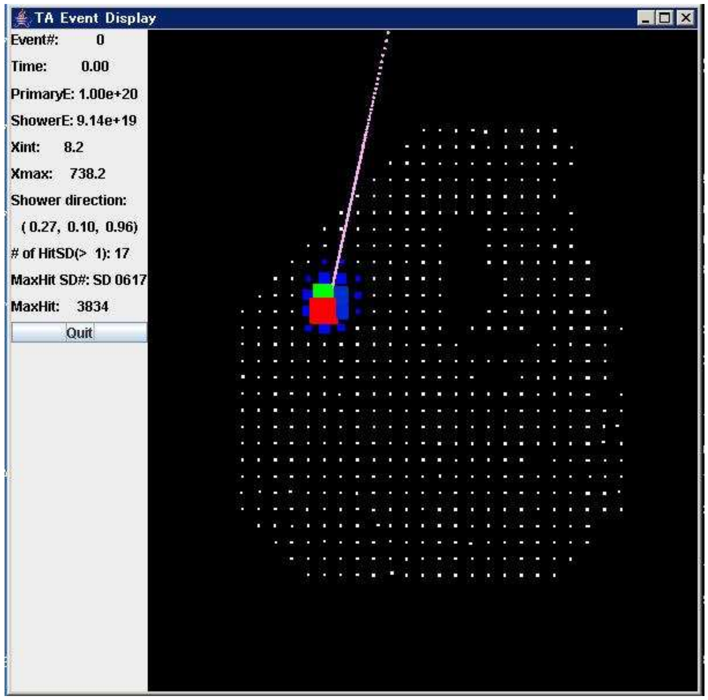

Figure 2. Event display of a typical Super-GZK event of the TA simulator.

The simulation code is develloping now. Figure 2 gives the event display of the TA simulation. In this simulation, the Geisser-Hillas function is used for the longitudial development of air shower and the NKG function modified by Linsley is used for the lateral distribution of shower particles. Muon component has not been included yet.

References

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