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EAS Core Structure above 10^{16}eV

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We have observed the extensive air shower core above 10^{16}eV using the 100 small .scintillation detectors at Taro Cosmic Ray Laboratory from 2002. The fluctuation of the density and the lateral distribution near the EAS core was obtained. Comparison between the small scintillation detector and the 0.25m^2 scintillation detector were also discussed. The calculation results of the fluctuation of the density using CORSIKA code seem not to be corresponding to the experimental result.

1. Introduction

Measurement of the density near the EAS core correctly with the ordinary scintillation detector was difficult, because of its dynamic range of the number of particles. So we used the thin plastic scintillator (t=2.5cm), the detection area was reduced, and PMT that excelled about the linearity characteristic. The structure of the EAS core seems to reflect the primary composition or the high energy interaction. We used the fluctuation of the density and the lateral distribution of the core as a core structure parameter.

2. Experimental Procedure

The core detector array called TASC1 consists of 169 0.25m^2 (t=2.5cm) scintillation detectors that arranged in a 13×13 lattice with 1.5m separation was installed at Taro Cosmic Ray Laboratory (Iwate, Japan) [1, 6]. At the center of TASC1, TASC2 consists of 100 0.0225m^2 (t=2.5cm) scintillation detectors arranged in 10×10 lattice with 0.4m separation was installed. The dynamic range of the PMT used in TASC2 was 4.5, and the diameter of PMT cathode is 1.5”. PMT output was converted to the number of particles carefully.

3. Analysis

The EAS core hit inside TASC1 was collected, and the fluctuation of the density (RD) and the lateral distribution were examined. We determined the fluctuation to ratio of average density and standard deviation each of r-bin [3,4]. The CORSIKA code with QGS Jet model [5] is used to calculate the number of the particles that hitted inside the core detector, and GEANT4 is used to conversion from the number of particles to the number of scintillation photons. The case of the shower particle strikes PMT is not take into account in this calculation.

4. Results and Discussion

Simulation results of the primary energy (E_0) vs. shower size(Ne) at Taro is shown in figure 1. RD vs. shower size was shown in the left side of figure 2. The tendency of RD is simply decrease with shower size, but larger than 10^6 , the tendency was different. The difference of RD obtained from TASC-1 and TASC2 , it is influenced by the low particle number for its detection area of the core detector, and distribution of shower particles. Simulation results of RD, each of primary particle and energy, are shown in the right side of figure 2. The tendency is different in the calculation result and the experiment one. When see the value, the case of iron seems to be nearer the data. The comparison with the interaction model is progressing now.

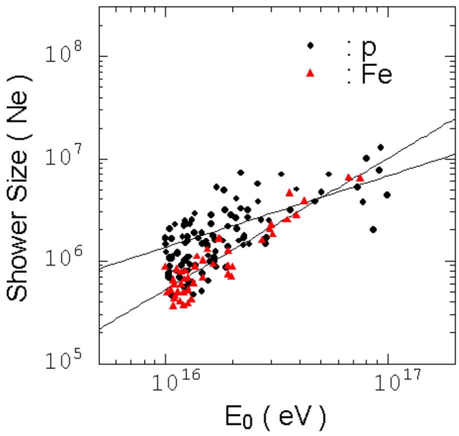

Figure 1. Scatter plot of the primary energy E_0(eV) vs. shower size Ne. The solid line indicates the fitting function using the least square method. Log(Ne)=0.69×Log(E0)-4.95 : proton, Log(Ne)=1.28×Log(E0)-14.8 : iron

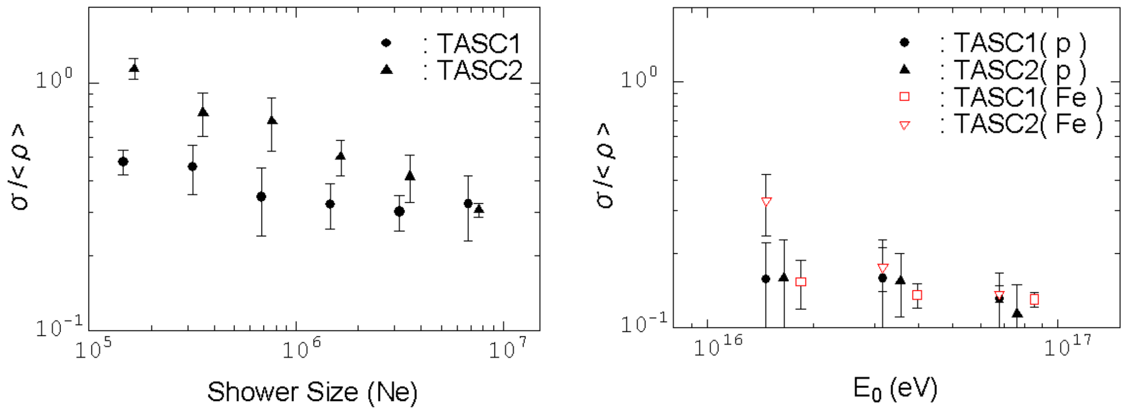

Figure 2. The distribution of the fluctuation parameter (RD) vs. shower size. The left side shows the data, and the right side shows the calculation. The value was calculated each of size bin and energy bin.

Lateral distribution of near the EAS core (R< 10m) was examined. For investigate only its form, ρ/Ne was calculated and example of the lateral distribution are plotted in figure 3. From comparison between the NKG function, the average lateral distribution is approximately like electromagnetic cascade near the core(1 m < R < 10m). The s parameter is about 1.1 in this size region for the average distribution. Simulation results are shows in figure 4. The average distribution expressed by one s parameter, s=1.2 for proton, s=1.3 – 1.4 for iron. Distribution of Age parameter was not compared in this time and further analysis is progressing now.

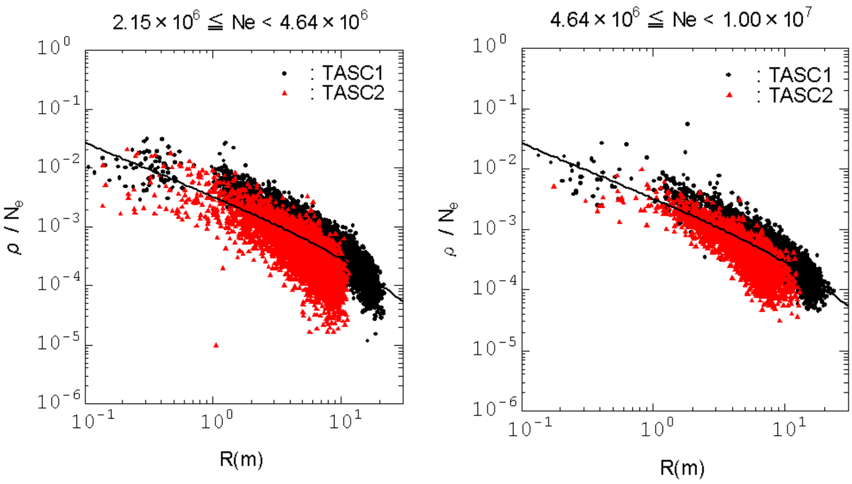

Figure 3. Samples of the lateral distribution near the EAS core obtained from the experiment. The solid line indicates NKG function and both age parameter is 1.1.

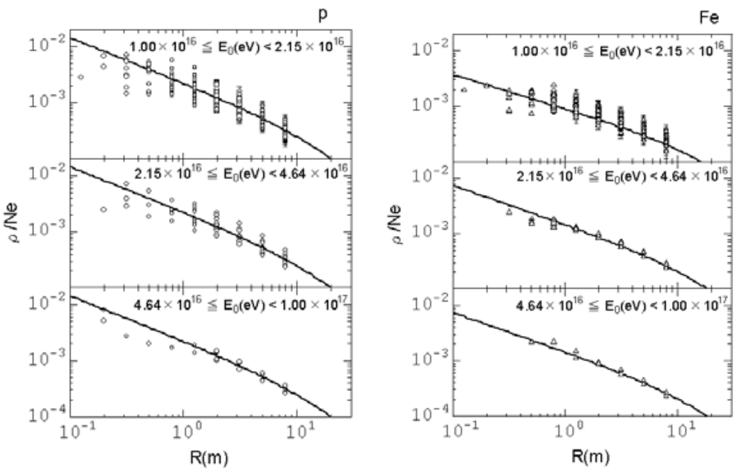

Figure 4. Simulation results of the lateral distribution. The left side shows proton shower, and the right side shows iron shower. The average value of each r-bin per event are plotted. The solid line indicates NKG function. S parameter is 1.2 for proton, 1.4 (energy range Log(E_0) : 16.0 – 16.3), 1.3 (energy range Log(E_0) : 16.3 – 17.0) for iron.

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