The size spectrum of small Air Shower at Ooty GRAPES III ($800g/cm^2$).

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ABSTRACT
Our GRAPES III has started its Air Shower observation from the beginning of 1998 using around 100 detectors out of 217 located in position. So far about 10 months data have been collected. Total 1.6 million Air showers (about 4 months data) were used to derive the size spectrum between 10^4 to 10^6,
We derived the energy spectrum and chemical composition of primary cosmic rays (10^{14}eV<E_0<10^{16}eV) from the size spectrum of the Air Showers (10^4< Ne < 10^6) at Ooty ($800g/cm^2$) using the semi Monte Carlo simulation code GENAS (Kasahara and Torii). Though present work showed about 25% lower than the Proton Satellite's result in these energy range. Considering the amount of systematic error in observed data and analysis method to derive the energy spectrum in both experiment, we don't see serious discrepancy between those results.

INTRODUCTION

The main aim of our present work is to understand the reason of steepening in energy spectrum around 1--3 x 10^{15} eV, so called knee. One possible attempt is to explain it in terms of propagation effects of cosmic rays in the galactic disk and their leakage from the disk due to larger radii than galactic size and another is in terms of changes in the accelerating mechanism in cosmic ray sources at energy around 10^{15-16} eV. The better resolution is required to understand the real cause of existence of knee.

Also there are still different results among some observations about knee position and absolute flux of primary cosmic rays. We obtained the size spectrum of Air shower at Ooty from the observed data and compared with the simulation's results. To obtain the expected size spectrum with simulation we used the energy spectrum and the chemical composition of primary cosmic rays obtained by direct measurements and assumed the Leaky box model. Those results are presented here.

THE PRINCIPLE OF OUR METHOD

The significant discrepancies were often found even in a size spectrum of Air shower.

Though the derivation of the size spectrum from observed data looks to be rather straight forward process, some systematic errors are not so easy to correct. Each experiment has its own characteristics and systematic errors. This makes direct comparison of size spectrum of different Air shower observations very difficult.

So we proposed one method with that the comparison would become possible.

First we assume the size of Air shower (the total number of electro-magnetic components) and shower transition does not depend much on their interaction model. If this assumption is reasonably true, we can calculate the Standardized Size spectrums for various depth from one absolute primary energy spectrum. The comparison with such standard size spectrum will tell us the amount of relative systematic errors in each observations. Unless we follow this kind of method, reasonable error estimation among the observations is quite difficult. So the accuracy of the energy spectrum cannot be reduced.

EXPERIMENTAL CONDITIONS

The whole figure of our Ooty Air shower array is shown in fig.1. 217 scintillation counters (each 1m^2) are equally distributed with the distance of 8 m over the area of 128 x 128 m.

The triggering condition was 9 detectors out of 90 should have greater than 0.4 particles and triggering rate was 12Hz under this condition. In the analysis of observed data greater than 15 detectors are applied to select the proper Air shower.

So to accommodate this condition for simulation, >0.4 particles in >15 detectors out of 90 detectors are adopted as a condition for picking up the Air shower.

The accuracy of angle measurement is around 2 degrees.

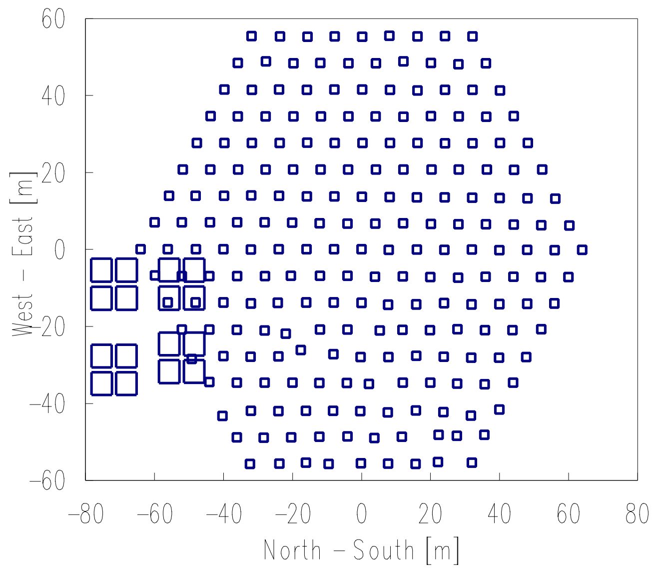

Figure 1: Air Shower Array at Ooty

PROCESS OF ANALYSIS

1. We took the absolute primary cosmic rays (greater than 5 TeV) = 8.4 x 10^{-3} (/m^2/sec/str) (Ichimura et. al.)

The powers of energy spectrum is -2.7 < 2 x 10^{15}eV and -3.15 > 2 x 10^{15} eV

Ratio of each nuclear group is Pr:He:CNO:SiMg:Fe = 0.4:0.3:0.1:0.05:0.15

2. We generate the Air shower from the minimum energy of 5 TeV. Since maximum shower size generated from primary energy of 5 TeV is well under 10^4, the size spectrum derived from this condition is free from distortion above 10^4.
3. The change of index of energy spectrum for proton is assumed at 2000 TeV

For other nuclei the change of index is proportional to atomic number (2000 x A)

4. Air shower is selected only θ smaller than sec θ <1.1 (θ :zenith angle of AS.)

DISCUSSIONS AND CONCLUSIONS

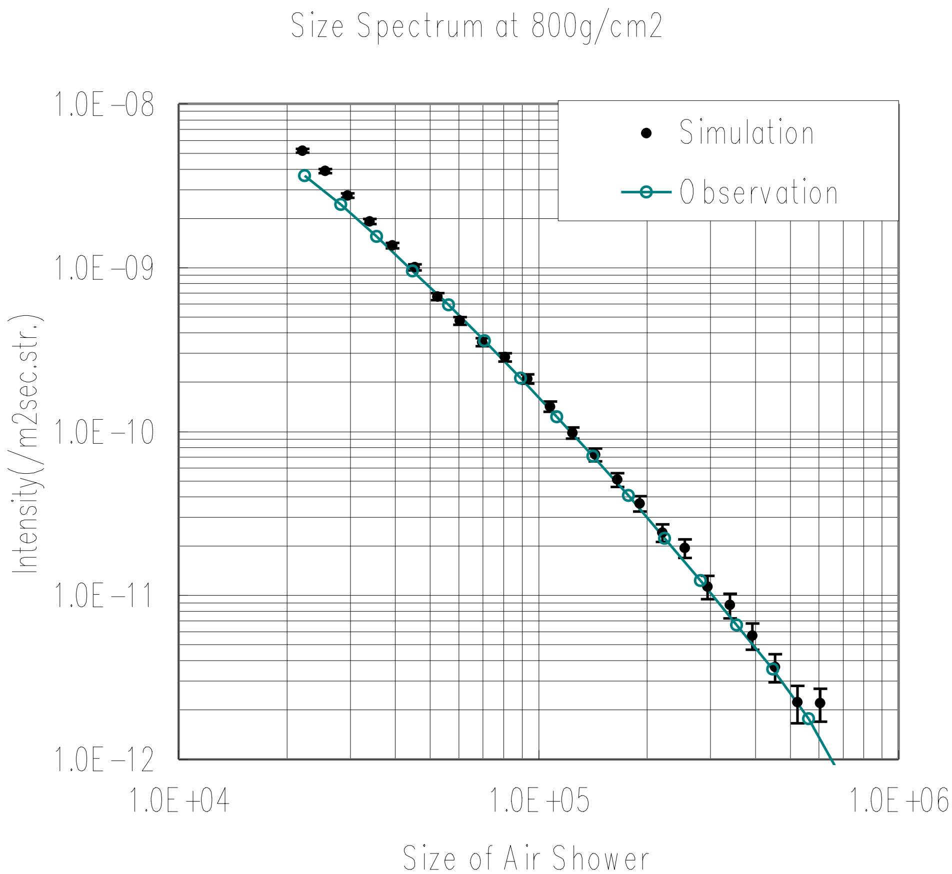

Figure 2: Comparison between Observed Size spectrum and simulation

As you can see from our results in figure 2, observed data and simulation showed excellent agreement in the size region between 3 x 10^4 to 6 x 10^5 where our size estimation of observed data is reliable.

Above 6 x 10^5 we found the systematic discrepancy in size estimation of observed data. Below 4 x 10^4 there might be some rejection of Air shower due to strict selection criteria in our data analysis program. Since we have adopted the same energy spectrum as for Norikura experiment (N.Ito et. Al.) to derive the size spectrum, I think validity of our present method and the energy spectrum of primary cosmic rays are rather established.

For the next step we are planning to improve the analysis method in size estimation and accommodate the all conditions which are adopted in data analysis into simulation. Then direct comparison between experiment and simulation can be performed.

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