29th International Cosmic Ray Conference Pune (2005) **7**, 163-166

On primary mass composition of giant air showers

Julie Saikia[a] and Pranayee Datta[b]
(a) Department of Physics, Pub Kamrup College, Baihata Chariali, Assam, India
(b) Department of Electronics Science, Gauhati University,Guwahati, Assam, India
Presenter: Julie Saikia (jsaikia2000@yahoo.co.in) , ind-saikia-J-abs1-he14-oral

Primary cosmic ray particles, which are nuclear messengers from cosmic ray source to the earth, carry information of the physical processes going on in the source. Although the problem of primary mass composition is solved to some extent in the lower energy region, for higher energy it is still remaining as an unsolved problem. In this paper, an attempt is made to throw some light into our understanding of this problem. For this, experimental data available from the Giant Air Shower Laboratories are analysed on the basis of lateral distribution function of charged particles of EAS developed for different primaries.

1. Introduction

The picture of mass composition of primary CR for Giant Air Shower (GAS) is still not clear. Capdevielle et al., put forward a lateral distribution function (LDF) of electron component of Giant Air Shower for proton primary as well as iron primary [1]. In this paper, available data of GAS laboratories viz. Yakutsk, Russia [2] & Volcano Ranch, USA [3] are analysed with the help of Capdevielle LDF to throw some light into our understanding of the mass composition of the observed GAS.

2. Method

Capdevielle et al. performed simulations of shower development using CORSIKA code for proton and iron nuclei with energies 10^{11} GeV/ nucleon. They obtained mean distribution of several EAS components for distances from core up to 10^4 metre. Then they fitted the lateral distributions with the function which has one more free parameter allowing to achieve consistency with simulations.

The Capdevielle LDF [1] for GAS is given by,

$$\rho\,(r) = N_e.C.\ x^{-\alpha}\,(1+x)^{(\alpha-\eta)}.(1+d.x)^{-\beta}$$

Experimental lateral distribution is compared with the theoretical distribution for proton as well as iron primaries by statistical method.

An approach has been adopted by the authoresses to identify the primary particle for GAS with the help of modification of the Fenyves model [4] developed for determining age parameter (s) for different primary particles (photon, proton and iron nuclei) for E_p up-to ~ 10^{16} eV. Details of these are given elsewhere [5].

3. Results

χ^2- E_p graph (for proton as well as iron primary) is given in Figure 1 for all charged particle densities and for zenith angles 10^0. Corresponding graph for electron-positron densities and zenith angle 10^0 is given in Figure 2. Similar graphs for other zenith angles viz 20^0, 40^0 & 60^0 will be presented at the conference.

Again (s- E_p) curves for different primary particles of vertical showers obtained from the modified Fenyves model are given in Figure 3. Experimental observation for vertical showers are compared with these theoretical curves.

4. Discussion

From the Figure 1& 2 it is seen that χ^2 for proton primary is less than that for iron primary for all the GAS under investigation. Thus out of these two primaries, observations are in favour of protons. Moreover, for all the events investigated, E_p is in the range 1.02×10^{19} - 4.23×10^{19} eV i.e. $E_p<$ GZK cut off (5×10^{19} eV). It is seen from Figure 3 that the experimental values of s for E_p in the range ~ 10^{18} eV- ~10^{20} eV cannot be explained with any one of the theoretical curves for proton, iron and photon. The comparison with experimental data shows that the experimental s values is in complete disagreement with the theory.

The different observed characteristics of s [5] for $E_p>10^{19}$ eV are found to be of similar nature to those for E_p~10^{15} - ~10^{16} eV. But for E_p in the range E_p~10^{15} - ~10^{16} eV showers are known to be non- LPM [6] having the normal characteristics of s. In other words, the observed showers with E_p>~10^{19} eV may be taken to be non- LPM. This may rule out any possibility of the primary particle to be proton or iron nuclei for showers with E_p>~10^{19} eV, because for such showers initiated by proton or iron nuclei, there may be some deviations from normal nature in the age parameter characteristics due to LPM effect [7]. But for photon initiated air shower with E_p>~10^{19} eV, due to interaction of the high energy photon in the earth's magnetosphere [8], energy of the particles of the electron photon cascade as they enter the earth's atmosphere will be ~ 10^{15}-10^{16} eV or less and hence LPM effect will not be effective in case of photon-initiated showers having E_p>~10^{19} eV. Thus, for E_p>~10^{19} eV air showers having normal characteristics of age parameter may be photon-initiated. Hence, to arrive at a definite conclusion for primary mass composition, it is essential to develop a LDF for photon, with 'pre shower' development for energy >10^{19} eV

5. Conclusion

Out of the two primaries proton and iron, available Giant Air Shower data analysed adopting Capdevielle LDF are in favour of proton primary. But result of investigation of characteristics of s for GAS is in favour of photon primary. Hence, it is essential to develop LDF of GAS with 'pre shower' formation for photon primary to have a clear picture of mass composition.

6. Acknowledgements

The computational works of the present paper are done in the DST -FIST sponsored computer laboratory of the Department of Electronics Science, Gauhati University. The authoresses are, therefore, thankful to the Department of Science and Technology (DST), Government of India for the FIST grant to the department.

References

[1] Capdevielle J. N. et al., proc. 27th ICRC, Hamburg, (2001)
[2] Efimov N. N. et al., Catalogue of HECR ed World Data Centre-C2 for Cosmic Rays (1988).
[3] Linsley J., Catalogue of HECR, Ed. M. Wada, World Data Centre C2 for Cosmic Rays, (1980)
[4] Fenyves E. J.et al. Phys. Rev. D, 37, number 3, p. 649 (1988)

[5] Saikia J., Ph. D thesis, Gauhati University, Assam, India, (2003)
[6] Kawaguchi S. et al. proc. 27th ICRC , 718, (2001)
[7] Misaki A. et al., 25th ICRC, 7, 145, (1997)
[8] Karakula S. et al., Proc. 24th ICRC, Rome, Italy, 1, p. 266, (1995)

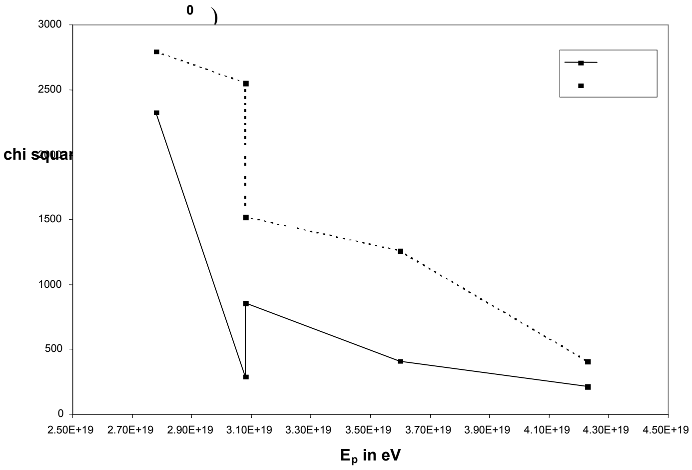

Figure1. Energy vs chi square values for all particle density (theta= 10

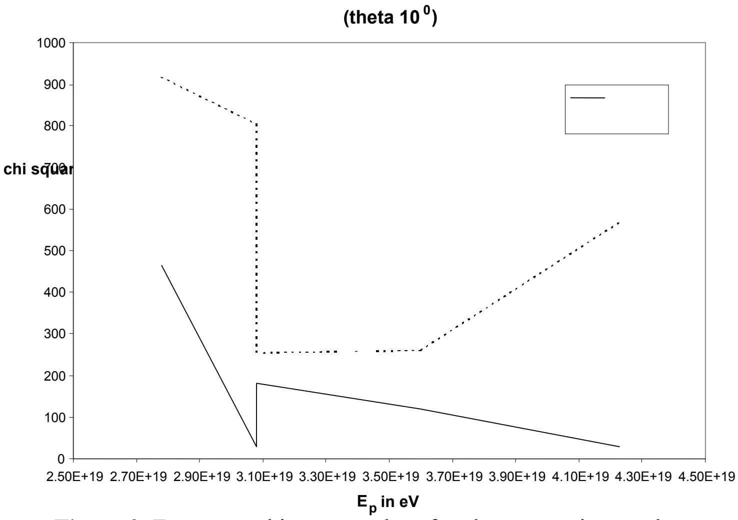

Figure 2. Energy vs chi square values for electron positron only

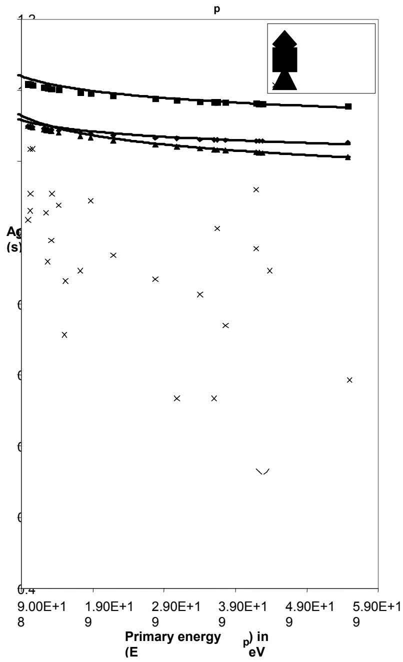

Figure3. (s – E) curve