All Particle Spectrum, Average Mass From RUNJOB Data

M. Furukawa[1], V.I. Galkin[5], M. Hareyama[1], Y. Hirakawa[2], M. Ichimura[2], N. Inoue[1], E. Kamioka[9], T. Kobayashi[1], V.V. Kopenkin[6], S. Kuramata[2], A.K. Managadze[6], H. Matsutani[3], N.P. Misnikova[4], R.A. Mukhamedshin[7], S. Nagasawa[1], R. Nakano[2], M. Namiki[8], H. Nanjo[2], S.N. Nazarov[5], S. Ohta[8],H. Ohtomo[2], D.S. Oshuev[6], P.A. Publichenko[6], I.V. Rakobolskaya[5],T.M. Roganova[6], G.P. Sazhina[6], H. Semba[11], T. Shibata[1], D. Shuto[2], H. Sugimoto[10], L.G. Sveshnikova[6], R. Tanaka[1], N. Yajima[8], T. Yamagami[8], I.V. Yashin[6], E.A. Zamchalova[6], G.T. Zatsepin[7], I.S. Zayarnaya[4]

(1) Faculty of Science and Technology, Aoyama Gakuin University, Tokyo, Japan
(2)Faculty of Science and Technology, Hirosaki University, Aomori, Japan
(3)School of Medicine, Hirosaki University, Aomori, Japan
(4)P.N.Lebedev Physical Institute of Russian Academy of Sciences, Moscow, Russia
(5)Physical Department, Moscow State University, Moscow, Russia
(6)D.V.Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia
(7)Institute for Nuclear Researches of Russian Academy of Sciences, Moscow, Russia
(8)Institute of Space and Astronautical Science, Sagamihara, Japan
(9)Research and Development Department, National Center for Science Information System, Tokyo, Japan
(10)Shonan Institute of Technology, Shonan, Japan
(11)Faculty of Comprehensive Welfare, Urawa University, Urawa, Japan

Abstract

Using the chemical composition and energy spectra observed by RUNJOB, here we will report all particle spectra up to 10^{15} eV/particle region, energy dependence of average mass and compare the results obtained by EAS experiments.

We do not see any drastic change from lower energy region.

1. Introduction

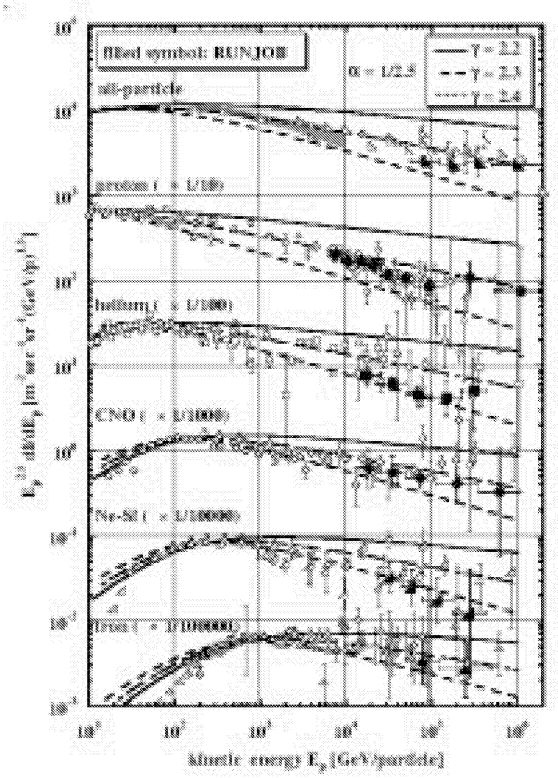
In the air shower experiment, it is not so easy to study the primary composition but observe the general tendency of the composition. So we convert the direct observation data to such that is comparable to air shower data.

pp. 1885–1888

2. Procedure

In Fig.1, each particle spectrum obtained by RUNJOB, from proton to iron, is shown with the results of other experiments. Here it should be noted that the energy scale is plotted as energy/particle to make the comparison with the air shower data. By summing up these, all particle spectrum is constructed. And the average mass number is calculated with the weight of the flux value.
In Fig. 1, γ is the spectral index at the source of cosmic rays and α is the parameter for the propagation, varying from 2 to 3, which is discussed elsewhere[1].

Fig.1 Each component for all particle spectrum



3. Results

All particle spectrum is shown in Fig.2, which covers the energy range from 50 to 1000 TeV/particle. We have no indication of the bend of spectrum in this energy region.

Our observation region is higher than the energy limit set by the most simple acceleration mechanism at the shock front of super nova remnant. So at least we need the modification of this mechanism though some attempts have been made.

The energy dependence of the average mass is also shown in Fig. 3 and no drastic change is not indicated here again. But in this presentation, subtle change of the each component does not show up, which may point out the difficulties of the indirect observation experiment.

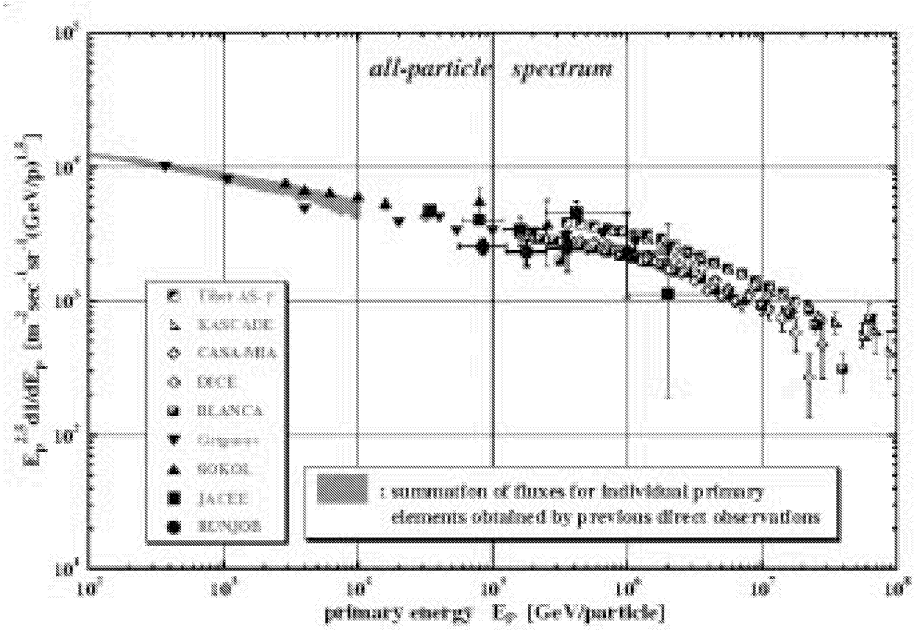


Fig. 2 All particle spectrum

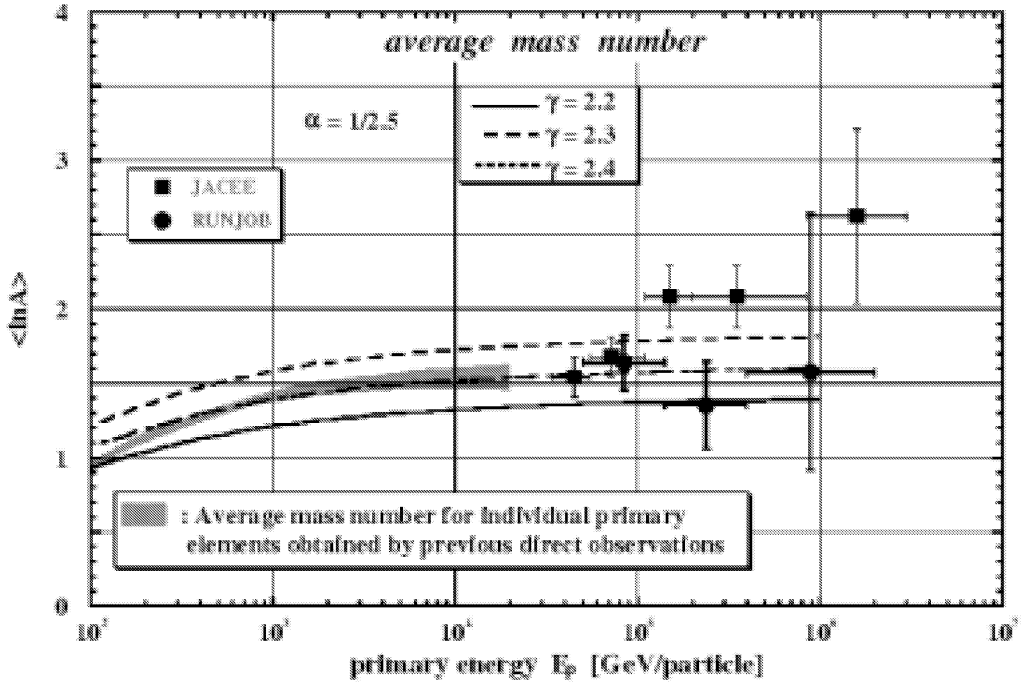


Fig.3 average mass number

4. Discussions

Discussions and conclusions are summarized here for all RUNJOB results.[2],[3]

- Proton spectra has no indications of steepening where we observe from 10 to 1000 TeV/nucleon. The power-type spectral index turns out to be about 2.8.
- He spectrum observed from 5 to 100 TeV/nucleon is almost parallel to that of proton though absolute flux value is lower than that of most other direct observation experiments by about 40 %.
- The spectra of the heavier nuclei get more stiff.
- The secondary to primary nuclei ratios do not decrease in such a way that the simple leaky box model predicts.
- In all particle spectrum and the average mass, our results are consistent with smooth extrapolation from the lower energy region.

5. References

1. Shibata T. et al. 2003, In this Proceedings
2. Furukawa M. et al. 2003, In this Proceedings:
Primary Proton and Helium Spectra Observed by RUNJOB Collaboration
3. Furukawa M. et al. 2003, In this Proceedings:
Primary Heavy Components Spectra and 2-ry/1-ry Ratio Observed by RUNJOB Collaboration