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PROPOSAL ON THE OBSERVATION OF SUPER-HIGH ENERGY COSMIC-RAYS BY MEANS OF POLAR PATROL BALLOON (PPB) (EXTENDED ABSTRACT)

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We have performed an high energy cosmic-ray observation using huge balloon at Sanriku balloon-station (ICHIMURA *et al.*, 1993; SHIBATA, 1996; KAMIOKA *et al.*, 1997) (ISAS; Institute of Science and Astronautical Science) since 1987, and started last year further a new program (APANASENKO *et al.*, 1995), called RUNJOB (RUssia-Nippon JOint Balloon-program), in order to extend the energy region much higher than that covered by the Sanriku experiment.

Until now, we have launched four balloons with the volume of 30000–88000 m^3 from Sanriku, and also four ones with the volume of 180000 m^3 from Kamchatka, all of which were successfully performed and the payloads were recovered safely. The exposure time of each experiment was 10–30 hrs in the Sanriku experiment, while ~150 hrs everytime in the RUNJOB experiment.

The purpose of these programmes was to observe directly the composition and energy spectrum of high-energy cosmic rays, which give us key information on the origin and accceleration mechanism of galactic cosmic rays. It is well known that the model of diffusive shock acceleration by supernova blast waves describes quite well the observed data in the energy range of 10^8–10^{13} eV. The model faces, however, immediately a difficulty in the higher energy region, that is, because of limited life-time of shock waves, it is hard to accelerate cosmic-ray particles to the energy beyond a few tens of TeV. It leads naturally to some cutoff in cosmic-ray energy spectrum (AXFORD, 1991). On the other hand, various experimental data (NAGANO *et al.*, 1984; ASAKIMORI *et al.*, 1995), particularly the air shower data, show significant intensity with high energy beyond 10^{13} eV.

This puzzle has not yet been solved within the framework of current shock wave acceleration scenario, though many reasonable models are proposed nowadays. This is mainly due to poor data in the energy region of 10^{13}–10^{14} eV, particularly poor information on cosmic-ray composition. Though the air shower experiment gives us considerable data in the very high energy region of 10^{15}–10^{18} eV, no direct information is available on the composition. Figure 1 shows an example of all particle spectrum (rectangle symbols), and the spectra of proton and iron elements (circle and triangle sym-

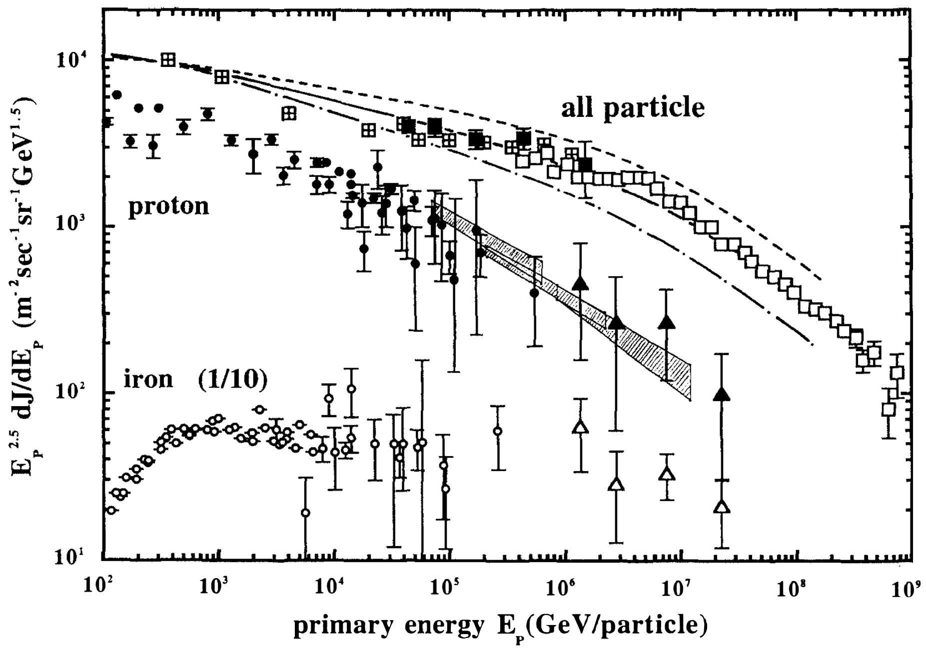

Fig. 1. All-particle spectrum (rectangle symbols), and proton (solid circle and solid triangle) and iron (open circle and open triangle) spectra. Solid and open circles are obtained by direct observation experiment, while the solid and open triangles are expected statistically by air shower experiment. Shadowed areas are expected by indirect emulsion chamber experiment. See ref. (SHIBATA, 1996) for more detail.

bols). One finds that the data (solid and open circles) obtained by direct observation are quite poor, and fluctuates considerably in the energy higher than 10^{13} eV/particle.

The cosmic-ray intensity I decreases drastically with the energy E_0, as is expressed by $I \propto E_0^{-2.0}$ in the integral form. The statistical intensity of observed cosmic-ray particles is of course proportional to $S \times T$ (S: chamber area, T: exposure time), so that we need long duration balloon flight to obtain more reliable experimental data, as the chamber size, both in weight and area, is limited in the case of using such vehicles as balloon, satellite and so forth.

Fortunately, RUNJOB-program started under the support of various organizations, ISAS, ICRR (Institute of Cosmic Ray Research, University of Tokyo), and with the Grant-in-Aids for Scientific Research from the Ministry of Education. The exposure factor $S \times T$ expected from RUNJOB is, however, still not enough to get a convincing solution to solve the above-mentioned puzzle.

In order to extend our data much more in the energy region of ~10^{14} eV, the observation of cosmic rays with PPB is quite attractive; for instance even one balloon experiment will bring us the exposure of ~ twenty days, approximately three times longer than the duration of RUNJOB campaign. As the cosmic ray observation using PPB has already been performed several times, we believe the present proposal is not a desk plan, but quite realistic. If two or three PPB-campaigns are performed, we shall obtain invaluable information for the cosmic-ray spectrum and composition, which might give us a definite solution for the problem of acceleration limit of galactic cosmic-rays.

Of course, in order to realize such observation using an emulsion chamber (sandwich of photographic plates and heavy absorbers), we must settle in advance the trouble of terrible background recorded on photographic materials. On this problem, we have learned a method to reduce it as much as possible by using low sensitive materials through the work of RUNJOB.

We hope the present proposal will be realized very soon, at least within the present century, and expect the support from NIPR.

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