OG 1.2.14

PRIMARY COSMIC RAY SPECTRA OBSERVED BY RUNJOB — proton and alpha spectra

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RUNJOB collaboration

Abstract

Primary cosmic ray absolute fluxes of proton and helium components are reported from RUssian Nippon JOint Balloon (RUNJOB) experiment. RUNJOB collaboration has been carrying out the balloon campaign since 1995. Total exposure so far becomes 342.4 m^2 hour at the average altitude of around 30 km.

Using the angular distribution of the secondary gamma rays and the darkness on X-ray films, the energy of the primary particle is estimated and the flux of proton components extends up to 10^{14} eV including an event with the primary energy of about 1 PeV. For helium, the flux up to 10^{14} eV/nucleon is obtained. The procedures of analysis and results of RUNJOB experiments are given here from campaigns in 1995 and 1996.

This paper becomes a complete paper with next OG 1.2.15. Some explanations are found in next paper and vice versa.

1 Introduction:

It is more reliable in the direct observations to determine energy and charge of the primary particles, though their exploring region are lower than that of the indirect methods. The chemical compositions and energy spectra thus obtained by the direct observation are vital to study the origin and propagation of the galactic cosmic rays.

To extend the observed energy region and put the different method of energy and charge determination, RUNJOB experiment started from 1995.

The preliminary results are reported in Ref. [1], [2], [3].

Proton and helium spectra are reported here based on the data from 1995 and 1996 campaigns.

2 Exposure:

2.1 balloon The balloons were launched from Kamchatka peninsula and flew to the Volga river region where they were recovered. Campaigns in last three years are summarized in Table 1.

Table 1: RUNJOB campaigns 1995 $\sim$ 1997 and plans in 1999

	1995		1996		1997			1999			
RUNJOB flight	1	2	3	4	5	6	7	8	9	10	11
duration [h]	129	165	134	148	140	140	-	planned			
chamber area [m^2]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
chamber weight [kg]	230	230	254	254	260	270	268	252	252	248	249
exposure [$h \cdot m^2$]	51.6	66.9	53.6	59.2	56.0	56.0	—				
total exposure	342.4 [$h \cdot m^2$]										

Fig.1 Trajectories

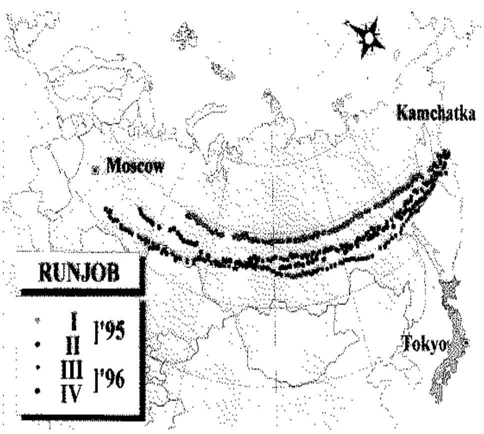
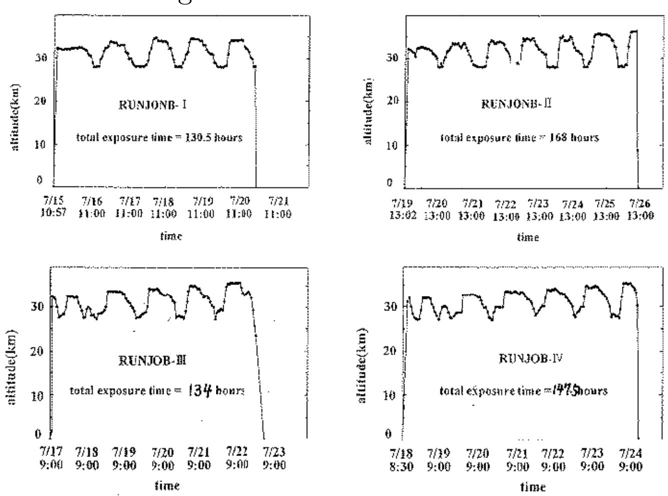


Fig.2 Altitudes



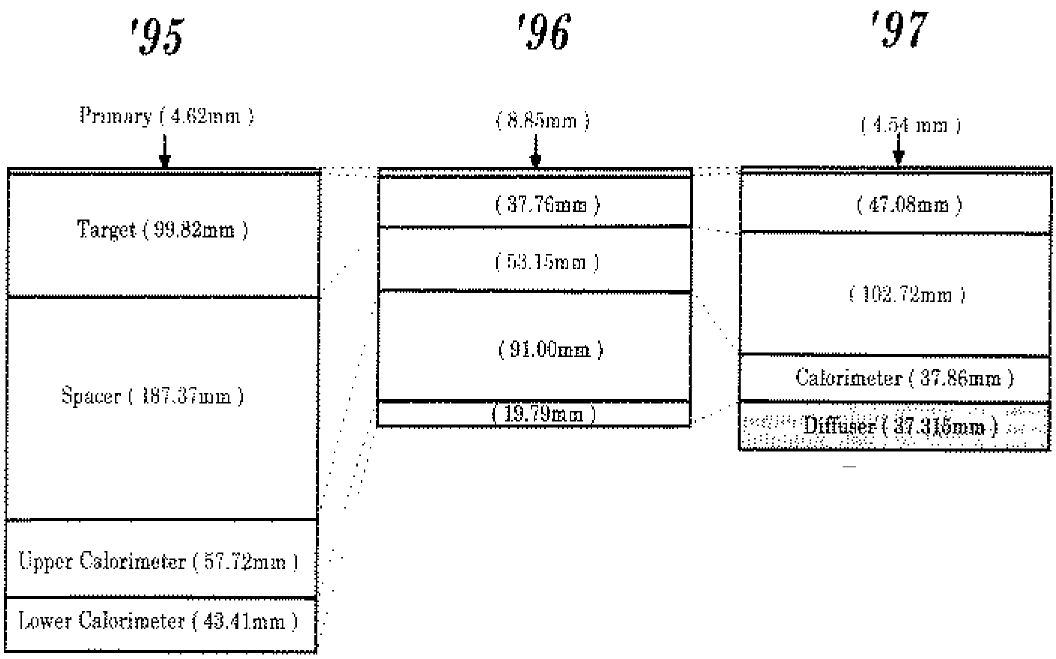
The trajectories of the balloons in 1995 and 1996 campaigns are shown in Fig.1. Trajectories in 1997 is not shown but very similar to those here. The trajectories are impressively stable. The altitude profile of the balloon flights are shown in Fig. . We can see the variation of altitude due to sun radiation.

2.2 Chamber: Our chamber consists of 4 parts: Primary layer, Target layer, Spacer layer, and calorimeter layer. The thickness of each layer is optimized basing on the experience of our analysis. In '95 chamber the spacer layer, the thickness of the spacer layer is larger than that of later chambers, because we thought opening angle of fragments is essential to determine the primary energy of heavy

cosmic nuclei. But for the analysis the thinner spacer is better. So the thickness of the spacer is reduced. The change of the chamber structure is shown in Fig. 3.

In 1997 chamber we have the Diffuser layer at the bottom. This is for the energy determination using the shower structure. The details of this energy determination is discussed in another our paper.

Fig. 3 Chamber structure



3 Data analysis:

3.1 scanning: X-ray films in the calorimeter layer are scanned and the dark spots on the films are traced up till we can find the origin of the cascade showers. The scan results are shown in Table 2.

Table 2 Scan Results total of 1995 and pat of 1996

vertex	target		spacer		U.C.		L.C.		total	
primary	'95	'96 IIIA	'95	'96 IIIA	'95	'96 IIIA	'95	'96 IIIA	'95	'96 IIIA
proton	10	32	5	2	57	35	45	31	117	100
helium	2	15	2	0	12	10	10	2	26	27

Only quarter of 1996 exposure is listed here but this is almost comparable with the result of 1995. This is due to the lower threshold which is caused both by reducing of spacing factor in the calorimeter layer and usage of fresh X-ray films.

3.2 charge determination: It is not easy to separate helium tracks from proton tracks in nuclear emulsion specially when the tracks are nearly perpendicular to the emulsion surface. ET6B, which is insensitive to the minimum ionizing track, proton, are installed for this separation.

4 Results:

The absolute flux of protons and heliums thus obtained are shown here with other experiments. Our results are consistent with others within statistical errors. But our proton spectrum seems to have no break over the range we observed.

Our Helium spectrum with other experiments is also shown here. Our spectrum is slightly lower and steeper, which is too soon to take as the final conclusion.

Fig.4 Proton

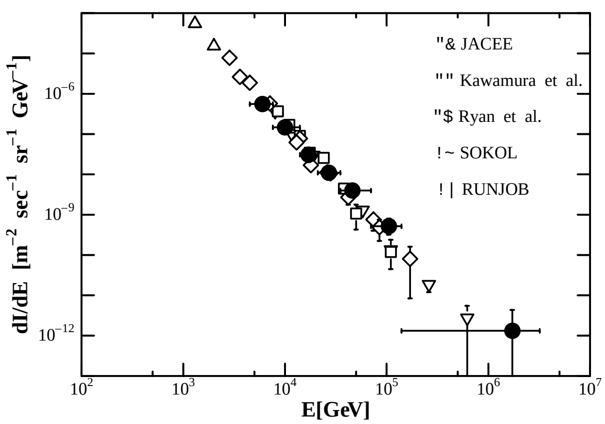
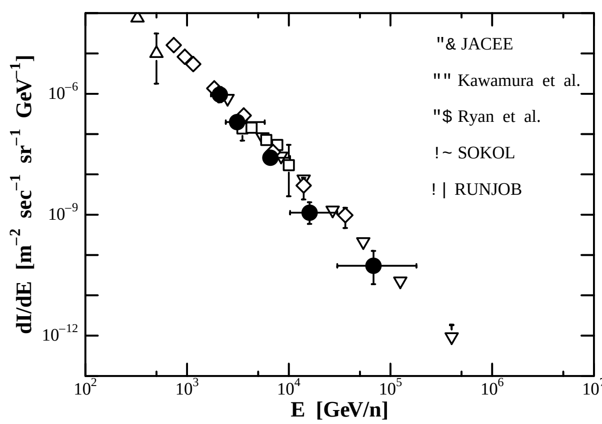


Fig.5 Helium



This work is supported in Japan by the grant in aid for scientific research of Monbusho (08045019 and 08404012), ICRR, Univ. of Tokyo and ISAS and in Russia by Russian Foundation of Basic Research N 99-02-17772 and Foundation "Universities of Russia — Fundamental Research" N 5374.

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