The search of primary particle tracks in nucleon-nucleus interactions with gamma ray energy $\Sigma E_\gamma \geq 3$TeV registered in stratospheric x-ray emulsion chambers (on data of the RUNJOB experiment)

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Abstract

On data of the RUNJOB experiment (RUssia-Nippon JOint Balloon) we here present the result of retreatment of nucleon-nucleus interactions registered in the stratospheric x-ray emulsion chambers (REC) with the use of new method of searching and tracing of galactic particles in nuclear emulsions. In about half of these interactions (~50) recorded in REC RUNJOB`96- 3B, RUNJOB`97-6A and RUNJOB`99-11A,B with energy released into electromagnetic component $\Sigma E_\gamma \geq 3$TeV and $\Sigma E_\gamma \geq 5$TeV respectively the single charged particle tracks are not found within the search area defined individually by the particle track location accuracy. The absence of primary proton tracks is consistent with original treatment of the RUNJOB experiment data.

There is a difference in the zenith angular distribution for two groups of events in which single charged particle track is observed or absent. The average penetration depth of the primary particles in REC to the interaction vertex at zenith angle range from 60^0 to 79^0 differs in two times for these groups.

Introduction

The Russian-Japanese balloon experiment RUNJOB have been conducted from 1995 to 1999 years for the purpose of studying the elemental composition and energy spectra of galactic cosmic rays at the energy range ~$10 \div 10^3$ TeV/particle with the use of stratospheric emulsion chambers exposed at the atmosphere depth ~ 10 g / cm^2 in the long duration flights (130÷170hr). The structure of REC RUNJOB`97 is shown in Fig. 1. As a result of the experimental data processing it was noted that the primary protons are identified in about half of the events related to the nucleon-nucleus interactions [1]. The single charged particle tracks are detected by nuclear emulsion with close to 100% efficiency (it is based on the tracing of secondary $\pi^{\pm}$ mesons as well as primary protons through the emulsion layers). To explain a large number of unfound primary particles in the events related to the nucleon-nucleus interactions, detailed investigation of methodical reasons of this experimental fact was conducted [2].

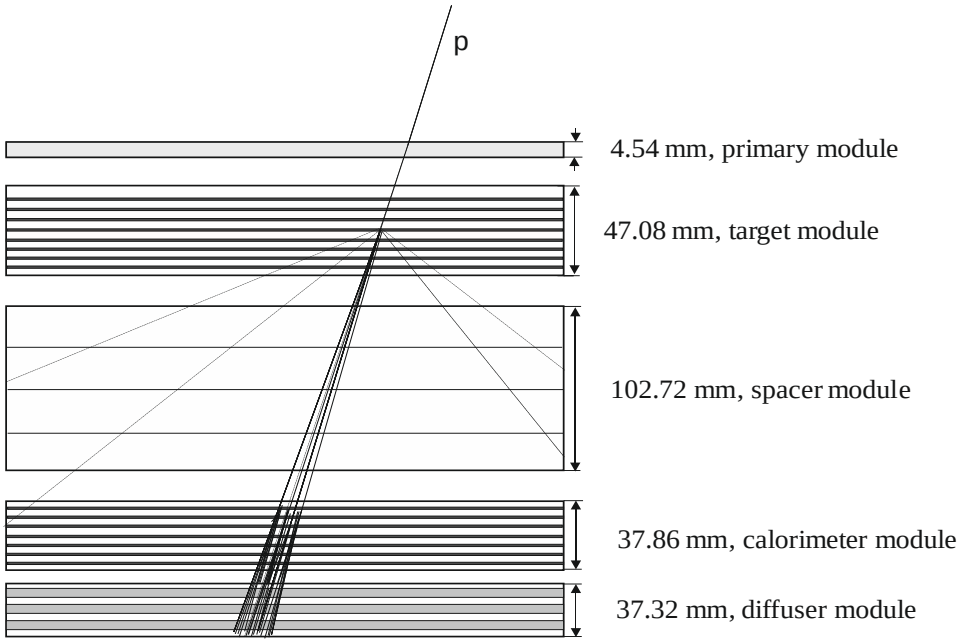

Fig.1 The structure of REC RUNJOB`97

As a result of this work we had not met with success to explain why there is a lot of unfound single charged particle tracks by the method of search and tracing of primary particles in emulsion layers. For the analysis it

was needed to increase the statistics of events on account of low-energy nucleon-nucleus interactions registered in the REC and not included in the final primary proton spectrum in RUNJOB experiment [3]. To be able to make retreatment of these events we proposed new method of searching and tracing of particles in nuclear emulsions of the REC [4].

In this method as well as original one the background nuclei as fiducials are used for locating of the primary particle track. The results of search of primary particle tracks in all nucleon-nucleus interactions registered in the chambers RUNJOB`96-3B, RUNJOB`97-6A and RUNJOB`99-11A,B with total electromagnetic energy $\Sigma E_\gamma \geq 3$TeV and $\Sigma E_\gamma \geq 5$TeV respectively by two methods is fully coincide, i.e. in about half of the events related to proton ones the primary particle tracks are not found within the search area determined by the primary track location accuracy [5]. Figure 2 shows the deviation distribution of measured coordinates of primary particle from respective predicted ones for nucleon-nucleus and nucleus-nucleus interactions registered in the x-ray emulsion chambers by using of new method. The measurement accuracy

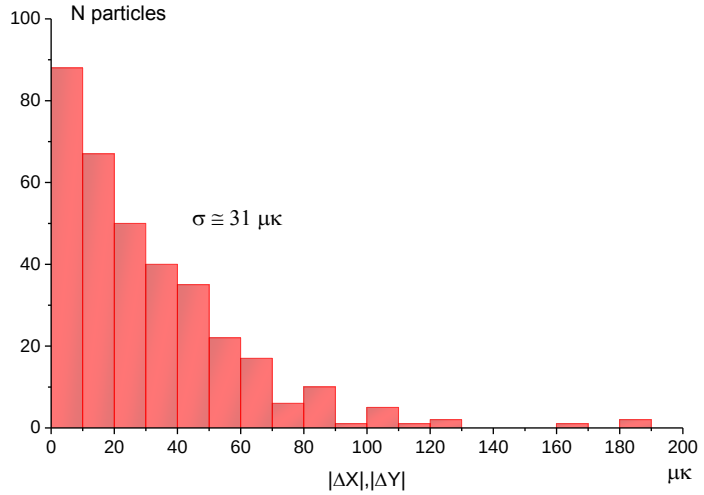

Fig.2. Deviation distribution of the measured coordinates of primary particles from respective predicted ones.

σ for the primary particle track location is near 31 microns.

The angular analysis of nucleon-nucleus interactions with found and absent primary particle tracks.

In this work we analyzed 50 events registered in REC RUNJOB`96- 3B, RUNJOB`97-6A and RUNJOB`99-11A,B with gamma ray energy $\Sigma E_\gamma \geq 3$TeV and $\Sigma E_\gamma \geq 5$TeV respectively at the zenith angle θ cut $\tan\theta \leq 5$ and related to the nucleon-nucleus interactions in RUNJOB experiment. In each X-ray emulsion chamber the primary single charged particle track is not found in about half of the interactions. Figure 3 shows the zenith angle distribution for two groups of events in which the primary particle is observed or is not found. The graphs show that the zenith angle distribution for the group with observed proton track is nearly isotropic, that is not contrary to the expected zenith angle distribution of proton at the chamber exposure level

(~10 g/cm^2). At the same time, increased amount of events with unfound primary single

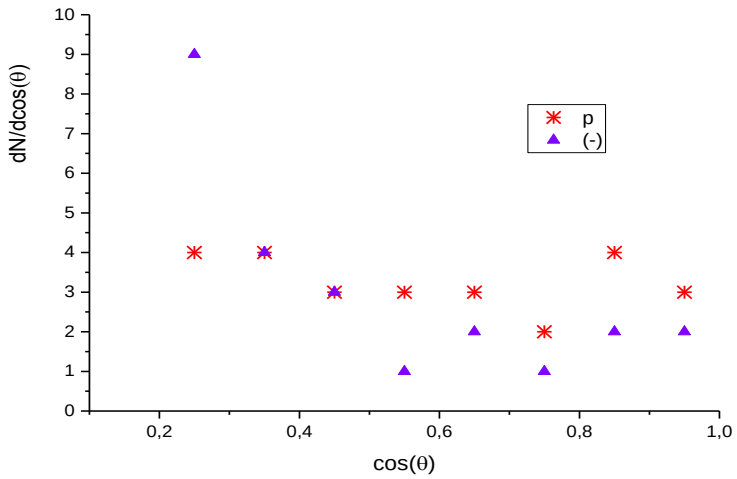

Fig.3. Zenith angle (θ) distribution for two groups of events: with observed primary proton track (*) and unfound one (▲).

charged particle track are observed in range of zenith angles θ> 60 °. It is interesting to note that the mean penetration depth (Λ) of primary particles within the REC from the first emulsion layer to the layer above the interaction vertex differs in two times at range of zenith angles from 60 ° to 79^0 for these groups. In units of mean free path length for a proton in the group with observed proton track <Λ (p)>= 0.18± 0.12, and with the absent one charged particle track <Λ (–)> = 0.37 ± 0.16. Since statistics of studied interactions is low, we can only talk about a possible indication of a distinction in the nature of the primary particles in the group of events with absent single charged particle track from protons.

Conclusion

According to the reprocessing of galactic particle interactions detected by nuclear emulsions of REC RUNJOB`96- 3B, RUNJOB`97-6A and RUNJOB`99-11A,B with gamma ray energy $\Sigma E_\gamma \geq 3$TeV and $\Sigma E_\gamma \geq 5$TeV respectively and related to the nucleon-nucleus interactions in RUNJOB experiment the primary proton tracks are not observed in about half of the events by using of new method of searching and tracing of the cosmic ray particles in emulsion plates. The absence of the single charged particle tracks within the search area is consistent with the original processing of RUNJOB experiment data. The nucleon flux incident on REC may include the secondary neutrons from the interaction of the primary cosmic rays with the residual atmosphere above the exposed installation (~10 g / cm^2). According to calculations [6], their proportion in the flux of secondary particles is about 4% that is much smaller than the experimental relative number of the events with absent proton track within the search area. To clarify the nature of the primary particle in the events related to nucleon-nucleus interactions in the RUNJOB experiment it is required further processing and analysis of experimental data.

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