SOME EVIDENCE FOR HIGH ENERGY GAMMA-RAY SOURCES AT LARGE GALACTIC LATITUDES

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ABSTRACT

The arrival directions of the gamma-quanta with energies of about 10^{15} eV which were registrated by Tien Shan experiment were compared with COS B observations.

On the basis of the Monte Carlo simulations it was shown with low probability that arrival directions of Tien Shan gamma-quanta initiated showers are not **uniformly distributed.**

We show that in the region not seen by COS B mission, the high energy gamma-ray sources should be located at position of $90^o < l^{II} < 130^o$ and $b^{II} \geqslant 50^o$. The integral intensity of these sources should be $I(>10^{15}\ eV) = (4.8 \pm 1.7) \cdot 10^{-13} \cdot cm^{-2} \cdot s^{-1} \cdot str^{-1}$.

There are no coincidence between the gamma-quanta registrated by Tien Shan experiment with Geminga intense COS B gamma source. So it is shown that the integral photon spectrum of Geminga $\left(I(>E) \sim E^{-\beta}\right.$, where $\beta = 0.8$ for $E < 1$ GeV) becomes steeper $(\beta > 1.2)$ in high energy region with probability 99.9%.

1. INTRODUCTION

The cross-section for photonuclear interactions is much smaller than the cross-section for nuclear interactions of hadrons, so the extensive air showers (EAS) initiated by high energy photons should be of muon poor showers (Maze and Zawadzki, 1960). The numerical estimations show that this type of EAS should content about 10-15% muons of that in the normal showers of the same size.

The succesfull obsevations of flux from discrete sources made by the ground base Cerenkov detectors and extensive air showers techniques have provided many speculations on the origin of ultra-high energy photons $(10^{15}$-$10^{16})$ eV from the Galactic point sources: Cyg X-3 (Samorski et al., 1983 : Lloyd-Evans et al., 1983), Crab (Dzikowski et **al.,1981,1983:** Kirov **et al.,1985**), **Vela** (**Protheroe et al.,** 1984). The observations of some excess of muons from the direction

Cyg X-3 by Mont Blanc Laboratory (Rubbia, 1985) can be of the fundamental importance for the problems of origin of cosmic rays and also for the problem of acceleration of particles in the astro - physical objects.

The Tien Shan experimental data shows that there exist EAS with anomalously small number of muons and hadrons (Stamenov, et al., 1983). The analysis of selected characteristics of muons and hadrons in EAS, aspecially the lateral energy structure in the shower core and the averaged cascades in the ionization calorimiter (Nikolsky et al., 1984) confirms the assumtion that there are EAS, generated by primary gamma-quanta in the energy range $E>4\cdot 10^{14}$eV. In the low energy interval (50 MeV - 5 GeV) the gamma emission from point sources has been observed by two satellite missions : SAS-2 (Fichtel et al., 1975) and COS B (Bignami et al., 1975 : Scarsi et al., 1977). The multiwire spark chamber spectrometer technique used in both experiments survived 3° of angular resolution. The second COS B catalog (Swanenburg et al., 1981) contain 25 gamma point sources, but only four of them were identified with known astrophysical objects (Crab, Vela, 3C 273, ρ Oph molecular cloud). The most intense source 2CG 195+04 (Geminga) is probably corelated with the nearest neutron star (Bignami et al., 1984).

In this paper we discuss the spatial distribution of eight of high energy photons registrated by Tien Shan experiment (Stamenov et al., 1983) and their's coincidence with COS B gamma sources.

2. METHOD AND RESULTS

From the experimental conditions for Tien Shan array (zenith angle $\theta \leqslant 30^{\circ}$) we have evaluated the daily exposition time for the source located at declination δ from the following expression: $\cos t = (\cos\theta - \sin\delta \sin\varphi)/\cos\delta \cos\varphi$, where $\theta=30^{\circ}$, $\varphi = 43.25^{\circ}$. The daily exposition time has a maximum at $\delta = 52.3^{\circ}$. We have analyzed the anisotropy of Tien Shan events in the galactic and celestial coordinates and calculated the following parameters: i) the sky area seen by Tien Shan EAS array for zenith angle $\theta \leqslant 30^{\circ}$, ii) the parallel $\delta = 43.25^{\circ}$ (Tien Shan zenith) in the galactic coordinates, iii) the parallel $\delta=52.3^{\circ}$ (for maximum time of exposition) in the galactic coordinates. Figure 1 shows also above parameters. Moreover Fig. 1 shows: the arrival directions of eight high energy photons events, points sources and area seen by COS B.

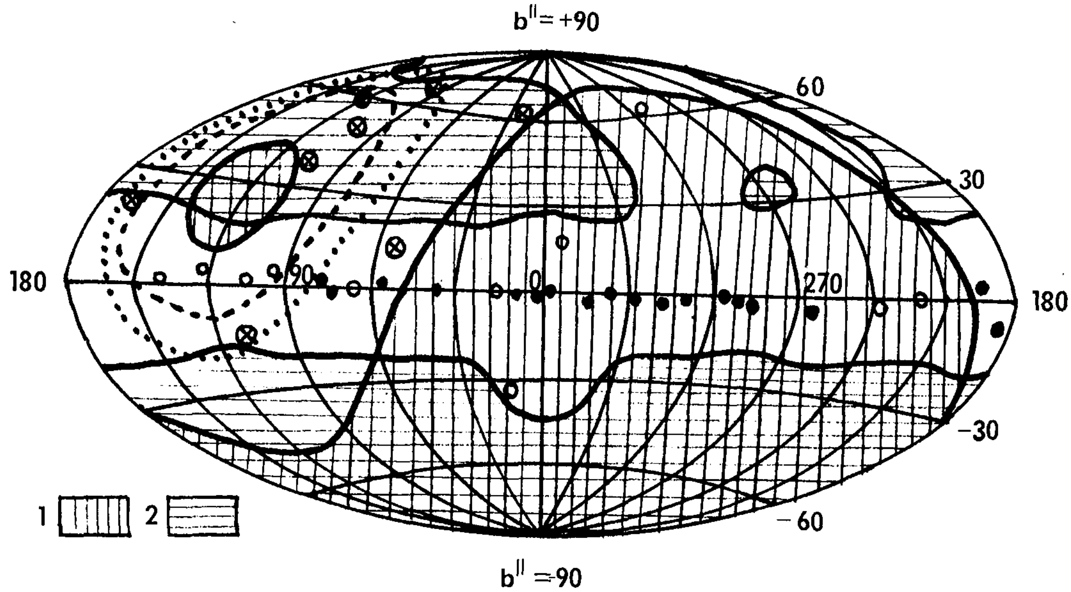

Fig. 1. The map of the sky area in the galactic coordinates:

1-region not seen by Tien Shan, 2-region not seen by COS B, + - Tien Shan experimental data, o,● - COS B sources, - - - Tien Shan **zenith** trajectory, ... - the trajectory of maximum time exposition.

The high energy gamma-ray events have some tendency to be located in the region not seen by COS B, $90^{o} < l^{II} < 130^{o}$, $b^{II} \geq 50^{o}$. From the experimental conditions for the Tien Shan array we have evaluated the probability distribution of registration of EAS, as the function of declination (in rectascention this distribution is uniform).Assuming that high energy gamma-rays sources are isotropically distributed on the sky we randomly simulate eight positions of the arrival directions of the EAS. From the large number (1000) of simulations we have evaluated: Q_1-the mean angular radius of eight events, Q_2 - the mean angular radius of four most collimated events. Table 1 shows above parameters for the Tien Shan eight events and from Monte Carlo calculations. We can notice that for both parameters the experimental data is lower than one standard deviation . It can be some indication that Tien Shan events are more

Table 1.

	Q_1^{o}	Q_2^{o}
Tien Shan	42.4	15.9
Monte Carlo	$56.1^{+10}_{-11.2}$	43.7^{+15}_{-21}

concentrated than we expect from isotropic distribution, aspecially four events are concentrated in the region $90^o < l^{II} < 130^o$ and $b^{II} > 50^o$. The integral intensity of this sources at energies $E > 4\cdot 10^{14}$eV should be greater than $(4.8 \pm 1.7)\cdot 10^{-13} cm^{-2}\ s^{-1}\ str^{-1}$ (Nikolsky et al., 1985). Now another question: what is the reason that there is no coincidence of Tien Shan events with Crab (2CG 184-05)? If we take the energy spectrum of Crab (Hermsen, 1980 : Masnou et al., 1981), $F(>E) = 1.67\cdot 10^{-7}(E/10^9)^{-1.2}\ cm^{-2}\ s^{-1}$, (E in eV) and extrapolate it up to energies of 10^{15} eV, the expected flux is $F(>10^{15}\ eV) = 1.06\cdot 10^{-14}\ cm^{-2}\ s^{-1}$. So the expected number of showers from the Crab is $n = 3.6\ 10^{-2}$ for the effective area Seff= 36 m^2 and corection for the exposition time ($t_{exp} = \varkappa t_{eff}$, where $\varkappa = t/24$). We should notice that as it was shown by Kirov et al., (1985) for much weaker criterions the Tien Shan data shows the detectable excess from the direction of the Crab. On the other hand the COS B source 2CG 195+04 (Geminga) has much harder energy spectrum (Hermsen, 1980 : Masnou et al., 1981), $F(>E) = 6.25\cdot 10^{-7}(E/10^9)^{-0.8}\ cm^{-2}\ s^{-1}$, (E in eV). The extrapolation of this spectrum to the high energy ($E > 10^{15}$ eV) provides that we should expect 23 gamma events on the Tien Shan array. Because there is no coincidence with this source we can conclude that the integral photon spectrum in high energy range of Geminga $F(>E) \sim E^{-\beta}$, where β = 0.8 for $E < 1$ GeV becomes steeper $\beta > 1.2$ with probability 99.9%.

3. DISCUSSION AND CONCLUSIONS

There is no coincidence between arrival directions of eight Tien Shan photons events and COS B gamma sources. Monte Carlo simulations indicated that this events are more concentrated than one could expect from the isotropic distribution, aspecially four events a concentrated in the region $90^o < l^{II} < 130^o$, $b^{II} > 50^o$: not seen by COS B. The spectrum of Geminga in high energy range should be much steeper than expected from COS B experiment.

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