The Cosmic Rays and Gamma-Quanta Local Sources Spectra Distinction and Formation of Uniform Cosmic Ray Spectrum

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Abstract

The obtained experimental data about local sources of gamma-quanta are characteristic by the following fact. Though the observed metagalactic sources (active galactic nuclei) are $10^6 - 10^7$ times more powerful, unlike the galactic one, the gamma-quanta energy spectra from both galactic and metagalactic sources can be averaged with spectrum index $F(> E_\gamma) \sim E_\gamma^{-1.3\pm0.15}$. This result puts under doubt the assumption about the galactic origin of observable cosmic ray flux. Uniform cosmic ray spectrum is forming in "infinite" number of elastic (or inelastic) collisions with relict photons in intergalactic space, where the cosmic rays are 0.999... part of their time as the common volume of extragalactic space exceeds more then thousand times the total galactic volume in Universe. Accordingly, the observable spectrum distribution has index of $(2.72 \pm 0.02) = 2.718...$, that is Napier's number.

The local sources of extra-high energy cosmic radiation search by the EAS flux excess at narrow angular interval at the direction on supposed sources did not give conformable results because of extremely low flux of showers generated by gamma-quanta, which is connected with the process of accumulation of charged particles in Metagalaxy, which includes intergalactic space. This was confirmed at experiments in the ionization calorimeter with Pb absorbent of total EAS formed by gamma-quanta which have no muons and hadrons flux determination. The analysis of such showers showed that between EAS on observation level of 3760 m high above sea level the "no hadron" showers flux is slight 0.005 ± 0.001 of full EAS flux; "no muons" showers showed the same result - at 0.004 ± 0.001 EAS with primary energy $> (3 - 4)10^{14}$ eV not a single muon was observed (Fig. 1).

As a consequence of small flux of EAS containing no hadrons and muons searching of high-energy gamma-quanta stellar sources it was advisable to concentrate on observations of probable high-energy gamma-quanta sources at narrow angular interval at the direction on supposed object. Presently the most prevalent became the observation of Cherenkov radiation using mirror telescopes whith

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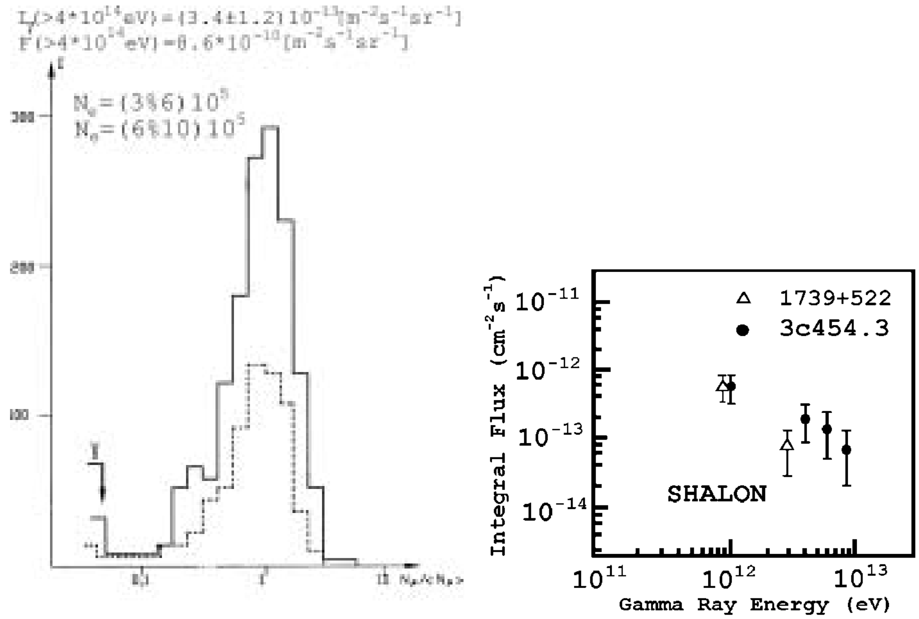

Fig. 1. left: Relative EAS flux, generated by primary gamma-quanta (0.004) and selected on muons absence in showers. **right:** Gamma-quanta integral spectra by SHALON-1 of 3c454.3 and 1739+522 (quasars with z=0.859 and z=1.357)

good angular resolution. At table 1 the results of metagalactic (Fig. 1, 2) and our Galaxy's (Fig. 2) [1] gamma-sources observations are showed in units of relative source power, power of gamma-quanta radiation of Crab Nebula was set as 1. The most far from us metagalactic source 1739+522 with red shift z = 1.357 at the optic wave band is the most powerful (Fig. 1). But, the spectral distribution of gamma-quanta emitted by him does not differs from the one averaged by all other currently detected metagalactic and two galactic (Cygnus X-3 and Crab Nebula): $F(>E_o) \sim E_\gamma^{-1.36}$ As the last column of table shows the gamma-radiation powers of local sources in our Galaxy are incomparably smaller then the ones of metagalactic sources.

In common the difference of observing metagalactic and our galaxy sources power corresponds with scale and energy of observing sources. In Metagalaxy they are quasars and active galactic nuclei, in our galaxy - the supernova remnants and binary objects. As it was discussed above, the averaged energy gamma-quanta spectrum of local sources $F(>E_o) \sim E_\gamma^{-1.36}$ which does not coincides with the energy spectra of cosmic radiation with spectrum index $F(>E) \sim E^{-1.72}$. So the development of gamma-astronomy pulled out two questions as the most actual:1)is there any ground to divide the cosmic radiation into two parts - the radiation of galactic and metagalactic origin and 2) in which processes the uniformed cosmic rays spectrum is formed as a uniformed spectrum in wide energy band $10^{11} - 10^{19}$

Table 1. The metagalactic gamma-quanta sources with energy $> 0,8$ TeV

Sources	**Flux,** $cm^{-2}sec^{-1}$	**Distance**	**Relative source power**
Extragalactic		***mpc***	
Markarian 421	$(0.63 \pm 0.14)10^{-12}$	124	$3.8 \bullet 10^{9}$
Markarian 501	$(0.86 \pm 0.13)10^{-12}$	135	$4.6 \bullet 10^{9}$
NGC 1275	$(0.78 \pm 0.13)10^{-12}$	71	$1.2 \bullet 10^{9}$
3c4543	$(0.43 \pm 0.17)10^{-12}$	4685	$5.3 \bullet 10^{12}$
1739+522	$(0.47 \pm 0.18)10^{-12}$	7500	$1.4 \bullet 10^{13}$
Galactic		***kpc***	
Crab Nebula	$(1.00 \pm 0.17)10^{-12}$	2.0	1
Cygnus X-3	$(0.42 \pm 0.07)10^{-12}$	1.1	0.12
Geminga	$(0.48 \pm 0.17)10^{-12}$	0.25	0.11
Tycho' SNR	$(0.19 \pm 0.06)10^{-12}$	2.0-3.1	0.3

eV with the differential index $\sim E_k^{-2.72 \pm 0.01}$ from the set of metagalactic cosmic radiation sources with more hard energy spectrum $\sim E_\gamma^{-2.36 \pm 0.10}$. The answer to the first problem is suggested by currently known gamma-astronomical data. Our Solar system became one of chosen for biological life so one should not complain, that its contribution into the generation of cosmic radiation is insignificant, and the core of our galaxy is not in the group of active ones and besides separated from the Solar system by the space dust and gas. Before the answering to the second question, it is important to underline, that the core of our galaxy is not between the active ones and note that the acceleration of cosmic protons and nuclei process is not effective enough: the probability of proton and nuclei turn to the opposite direction without particle capture by the magnetic field is very small. It's important to note that the observing break of EAS spectrum with the electrons number in shower $\sim 10^6$ cannot be treated as the break in the primary protons of cosmic radiation spectrum, so the spectrum of EAS generated by the primary protons at the atmosphere depth has no break [2]. This means that the break in spectrum of EAS with electrons number $\sim 10^6$ connected with the changing of process of multiple generation in the first interaction of cosmic ray proton with a nuclei of the air. Such suggestion is confirmed by the changing of EAS absorption length near the spectrum break energy from $\lambda < 90 g/cm^2$ to $\lambda > 150 g/cm^2$. The absorption length $\lambda > 150 g/cm^2$ representative for the hadrons cascades having no leading hadron. In this case the maximum of EAS formed by the interaction with the high multiplicity development essentially moves to the upper atmosphere and the EAS electrons number index increases from 1.7-1.72 up to 3.0 - 3.6 which reflects increasing faster with the growing of primary protons energy multiplicity of hadrons at the first act of shower generation. This leads to predominance in the total showers flux at the observation level of the EAS generated by primary

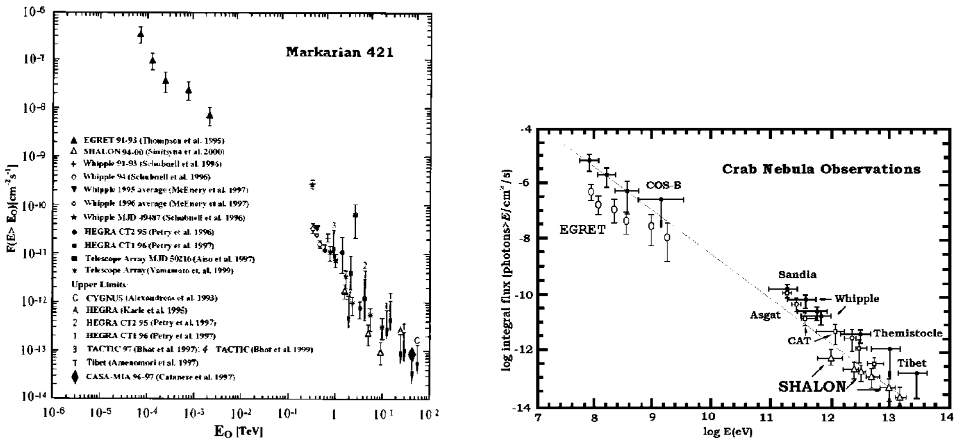

Fig. 2. Gamma-quanta integral spectra by SHALON-1 of Mkn 421 and Crab

protons at the atmosphere depth which save the spectrum index of EAS by electron number unchanged. This is displayed at the EAS with electrons number $N_e > 3 \bullet 10^7$ spectrum index restoration, observing before the EAS spectrum break at $N_e \sim 10^6$. It was experimentally discovered by G.B. Cristiansen [3] and confirmed in [4]. Unfortunately many of modern installations with widely separate detectors underestimate the electrons number in EAS, generated by protons in atmosphere depth, which is equal to their lose. Showers from primary protons becomes apparent as the only observing component of primary cosmic radiation in experiments investigating the energy range of relict primary protons flux "cutoff" [5]. As for the answer to the second question formulated by the results of gamma-astronomical observations one can consider that uncomparably larger amounts of time protons and nuclei accelerated by active galactic nucleus and having energy spectrum $F(> E_o) \sim E_\gamma^{-1.36}$ is in metagalactic space. The total volume of intergalactic space is some thousand times bigger than the total volume of all galaxies of Metagalaxy. Unlimited number of small energy losses by protons and nuclei of cosmic rays in elastic collisions with relict radiation compose in sum the Nippers number that is to say 2.718... - the number more than close to the observing energy spectrum index of primary protons at the energy ranges of $10^{12} - 10^{16}$ eV and $3 \bullet 10^{17} - 10^{20}$ eV and reconstructed from the EAS spectrum. Weak staining of relict "cutoff" of protons and hard fission of primary nuclei can be treated as the confirmation of stated suggestion.

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