Investigation of TeV Gamma-Ray Emission from Cygnus X-3

V.G. Sinitsyna, T.P. Arsov, A.Y. Alaverdian, S.S. Borisov, F.I. Musin, R.M. Mirzafatikhov, S.I. Nikolsky, G.M. Kasparov, V.Y. Sinitsyna, G.F. Platonov
P.N. Lebedev Physical Institute Russian Academy of Science, Leninsky pr. 53, 119991, Moscow, Russia

Abstract

Cherenkov mirror telescope SHALON-1 created at Lebedev Physical Institute and stated at 1991-1992 y. at Tien-Shan mountains 3338 m high above the sea level with 11,2 m^2 mirror area and image matrix consisting of 144 photomultipliers with total viewing angle of 8^o during 1992-2003 y. was used for observations of galactic sources: Crab Nebula, Cygnus X-3 Ticho Brage, Geminga and metagalactic sources: Markarian 421, Markarian 501, NGC 1275, 3C454.3, 1739+522. Timing analysis show that the contribution of protons of cosmic rays in observable gamma-quanta with energy more than 0.8TeV from the point sources of gamma-quanta very high energies do not exceed 10% - 15%. The fluxes at energy above 0.8TeV of observation Cygnus X-3 $(4.20 \pm 0.70) \bullet 10^{-13} cm^{-2} s^{-1}$ is and Crab Nebula - $(1.10 \pm 0.13) \bullet 10^{-12} cm^{-2} s^{-1}$. The observable energy distribution of gamma quanta in an interval of energy $10^{12} - 5 \bullet 10^{13}$ from the local sources in our Galaxy do not contradict with the spectrum of Cygnus X-3 - $dF/dE_\gamma \sim E_\gamma^{-2.20 \pm 0.14}$, of Crab Nebula -$dF/dE_\gamma \sim E_\gamma^{-2.45 \pm 0.04}$. The observed spectra of the gamma-quanta including the 10%-15% contribution of the proton showers is for Cygnus $dF/dE \sim E^{-2.51 \pm 0.22}$, for Crab Nebula $dF/dE \sim E^{-2.61 \pm 0.04}$. The images of Cygnus X-3 and Crab Nebula are also presented.

One of the basic science parts is nuclear physics, physics of elementary particles and connected with them astrophysics and cosmology, studied the matter structure on micro and macro scales. The gamma-astronomy is a unique experimental possibility of high-energy cosmic rays sources ($10^{12} - 10^{14}$ eV) location now. Only neutrino-astronomy will complete search and investigation of galactic and metagalactic objects where the protons and nuclei acceleration processes, accompanying with generation of non scattering by Universal magnetic fields gammas and neutrinos. The cosmological processes, connecting the physic of matter structure with its superdense quasistable state in active galactic nuclei will be observable on energy spectrum of electromagnetic radiation or, perhaps,

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on very high energy neutrino flux. The observation has been carried out at high mountainous Tien -Shan station (3338 m) with SHALON -1 gamma-telescope functioning since 1992 [1] and with coming into operation SHALON-2.

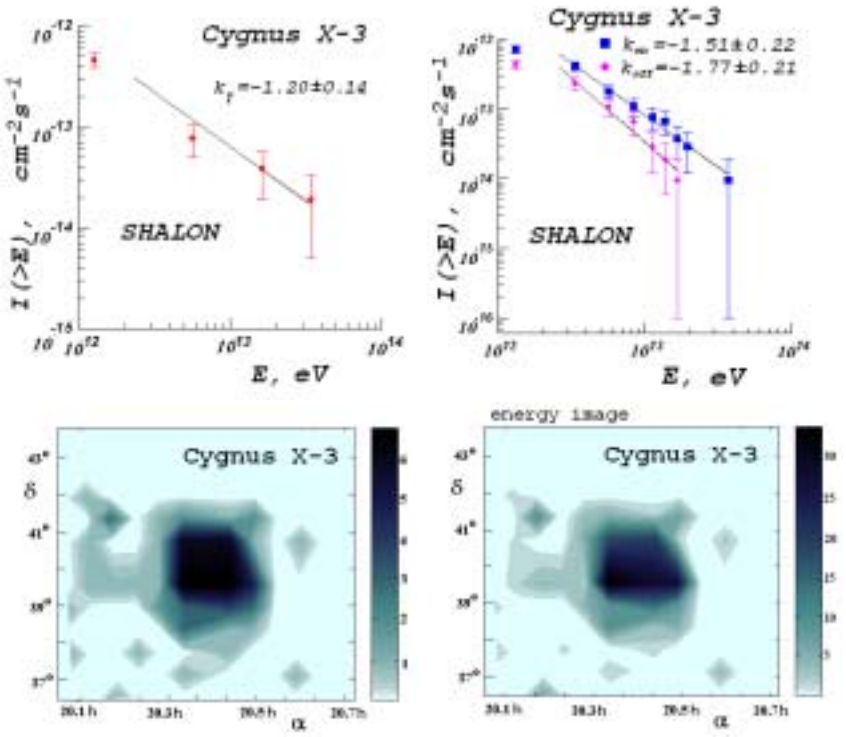

Fig. 1. Above: left–Spectra of the gamma radiation from Cygnus X-3. The observable energy distribution of gamma quanta from local sources Cygnus X-3 $dF/dE_\gamma \sim E_\gamma^{-2.20\pm0.14}$; Right– The observed spectra of the gamma-quanta including the 10%-15% contribution of the proton showers is $dF/dE \sim E^{-2.51\pm0.22}$. It also differs from observed energy spectrum for cosmic rays $dF/dE \sim E^{-2.77\pm0.21}$. Below: Image viewed by SHALON-1 at energy range of more than 0.8 TeV - left and energy image (in TeV)- right

The SHALON telescopes feature is large full angle that enlarges the observation area, increases the statistical accuracy and allows to control the background of EAS, generated by protons and cosmic ray nuclei, during observation. The SHALON mirror telescopic system consists of composed mirror with area of 11.2 m^2. It is equipped with 144 photomultipliers lightreceiver with 0.6^o angular resolution, that has the most in the world angular size more than 8^o [1, 21 - 27]. It allows to control the background of cosmic ray particle emission and the atmospheric transparency continuously with observation that means the increasing of observation efficiency. So it is the telescope characteristics that permit to start, after the coming into operation SHALON-2 gamma-telescope, the search of local

neutrino sources with energy $10^{12} - 10^{15}$ eV on Extensive Air Showers generating in mountain-range located at some 5 and more kilometers from gamma-telescope (in Russian the abbreviation SHALON means - the Extensive Air Showers from Neutrino). The observed gamma-quanta energy spectra of four galactic and five metagalactic sources doesn't contradict with average energy spectra of this sources in energy rage 1 - 50 TeV - $f(E_\gamma)dE_\gamma \sim E_\gamma^{-2.3\pm0.1}dE_\gamma$ [21 - 27].

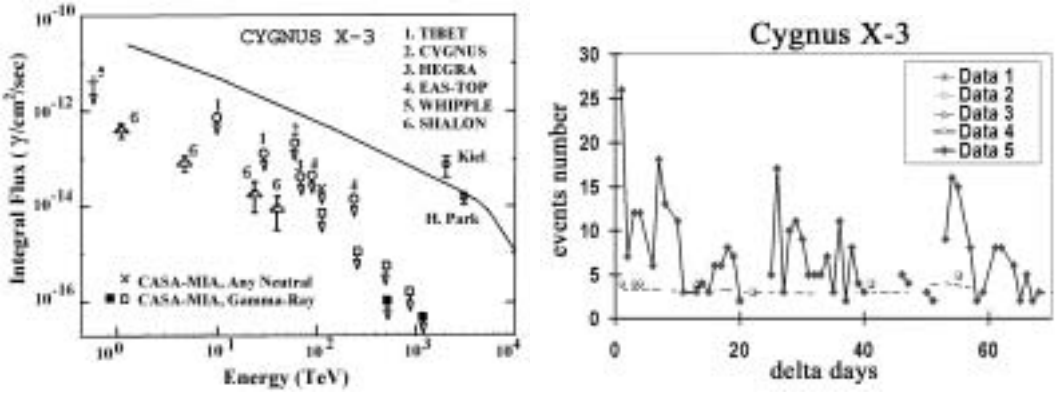

Fig. 2. Left: Flux limits on the γ-ray emission from Cygnus X-3 (see references). The curve is from model of Hillas. And gamma-quanta integral spectra of Cygnus X-3 by SHALON-1; Right: Cygnus X-3 time diagram 1996-2000 SHALON: Line 5 - gamma-quanta events sum 1996, 1997, 1998, 1999 and 2000; (large full angle of observations gives an opportunity to carry out ON and OFF observations simultaneously) Lines 1,2,3,4 - background events 1996, 1997, 1998 and 1999 accordingly.

The galactic source Cygnus X-3 known more the for 10 years as a variable intensity $\leq 10^{-11} - 5 \bullet 10^{-12} cm^{-2} s^{-1}$ source was observed with gamma-quanta flux $F(E_o > 0.8TeV) = (4.2 \pm 0.7) \bullet 10^{-13} cm^{-2} s^{-1}$ (Fig. 1). For the first time the energy spectrum of this source was measured energy range 0.8-40 TeV with flux by order of magnitude smaller than the upper limits published before (Fig.2) [2 -27]. For Cygnus X-3 the integral spectrum indexes are accordingly: $k_\gamma = -1.20 \pm 0.14$ (fig. 3), $k_{on} = -1.51 \pm 0.22$, $k_{off} = -1.77 \pm 0.21$, where k_γ is the index of source spectrum; the k_{on} is index of observed spectrum of the gamma-quanta including the 10%-15% contribution of the proton showers; and k_{off} - index of observed simultaneously spectrum for cosmic rays (Fig. 1). Time analysis of the events observed by SHALON telescope showed that the OFF events (dashed line) number none more than 10%-15% of ON events, this means that the cosmic rays protons contribution into the observed gamma-quanta with energies >0.8 TeV from local extra-high energy gamma-quanta sources is no more than 10%-15% (Fig. 2). The creation of stereo pair of two gamma-telescopes SHALON-l and SHALON-2 [21 - 27], located on a distance of 260 m, is at the final stage. The observation by telescopic stereo pair will allow to research more weak sources than Cygnus X-3.

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