Evidence of TeV Gamma-Ray Radiation in Binary CYGNUS X-3

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Abstract

Since 1992, the telescope SHALON, operating on SHALON-ALATOO mountain observatory (altitude 3338m), has been collecting Very High Energy gamma-ray data from Galactic objects Crab Nebula and Cygnus X-3. 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 Crab Nebula is $(1.00\pm0.17)\bullet10^{-12}cm^{-2}s^{-1}$ and Cygnus X-3 $(4.20\pm0.70)\bullet10^{-13}cm^{-2}s^{-1}$. The observable energy distribution of gamma quanta in an interval of energy $10^{12} - 5 \bullet 10^{13}$ eV from the local sources in our Galaxy do not contradict with the spectrum of Crab Nebula – $dF/dE_\gamma \sim E_\gamma^{-2.08\pm0.12}$ and of Cygnus X-3 - $dF/dE_\gamma \sim E_\gamma^{-2.20\pm0.14}$. The observed spectra of the gamma-quanta including the 10%-15% contribution of the proton showers is for Crab Nebula $dF/dE \sim E^{-2.35\pm0.12}$ and for Cygnus $dF/dE \sim E^{-2.51\pm0.22}$.

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, 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

pp. 1–8

functioning since 1992 [1, 2] and with coming into operation SHALON-2.

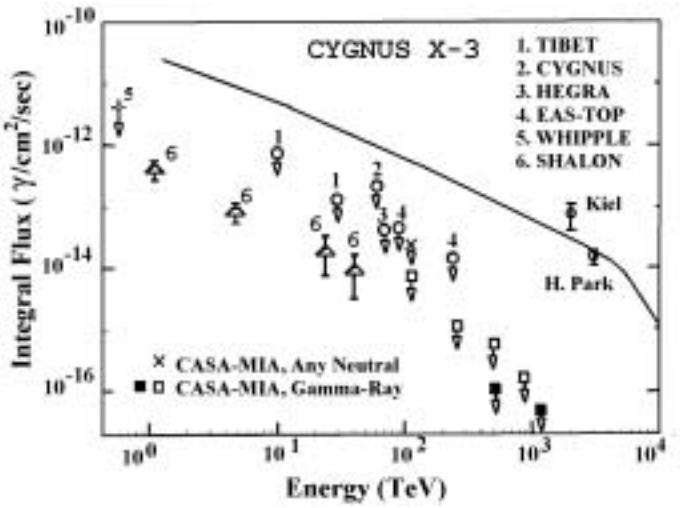

Fig. 1. Flux limits on the γ-ray emission from Cygnus X-3 (see references). The curve is from model of Hillas. And gamma-quanta integral spectra of Cygnus X-3 by SHALON-1;

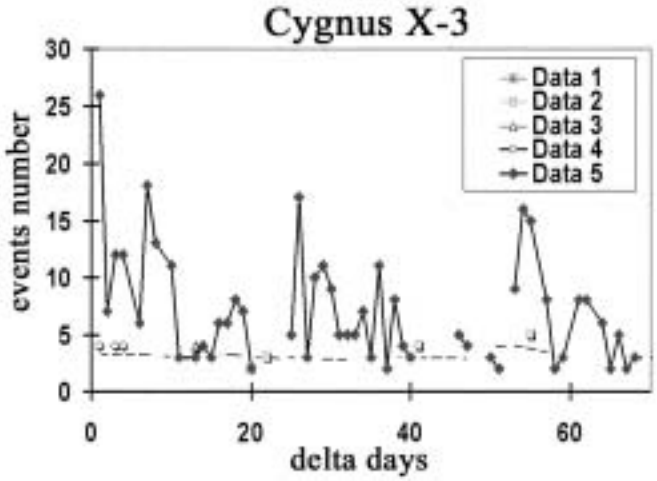

Fig. 2. Cygnus X-3 time diagram 1996-2000 SHALON: Line 5 - gamma-quanta events sum 1996, 1997, 1998, 1999 and 2000; (large full angle of observations gives an opportunity to carry out ON and OFF observations simultaneously) Lines 1,2,3,4 - background events 1996, 1997, 1998 and 1999 accordingly.

The 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, 2, 24 - 35]. 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 - $f(E_\gamma)dE_\gamma \sim E_\gamma^{-2.3\pm0.1}dE_\gamma$ [24 - 35].

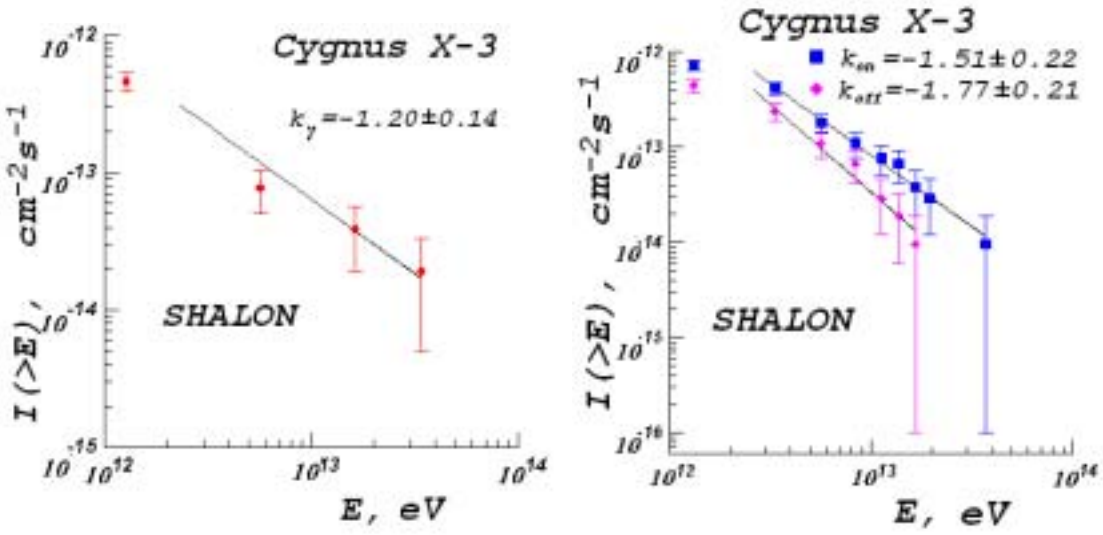

Fig. 3. left–Spectra of the gamma radiation from Cygnus X-3. The observable energy distribution of gamma quanta from local sources Cygnus X-3 $dF/dE_\gamma \sim E_\gamma^{-2.20\pm0.14}$. The observed spectra of the gamma-quanta including the 10%-15% contribution of the proton showers is $dF/dE \sim E^{-2.51\pm0.22}$. It also differs from observed energy spectrum for cosmic rays $dF/dE \sim E^{-2.77\pm0.21}$.

Among them are galactic sources Crab Nebula (the supernova remnant), Cygnus X-3 (binary), Tycho Brage (supernova remnant), Geminga (radio-weak pulsar) and metagalactic ones Markarian 501 (blazar), Markarian 421(blazar), NGC1275 (Seyfert galaxy), 3c454.3 (quasar) and 1739+522 (quazar) (see table 1, these Proc.)[3 – 35]. The observation data of previously known gamma-quanta source Crab Nebula observed by both SHALON and other experiments are ap-

proximately equal (these Proc.). The energy spectrum agrees with the extrapolation of spectra observed using EGRET at the energy region $10^2 - 10^3$ MeV. The Crab Nebula observation results are compared with the other experiment's data including the data from space at energy region $10^8 - 10^9$ eV. As it's follows from the picture the experimental data can be described by the unified law $F(> E) \sim E^{\gamma}$ at the energy region of $10^8 - 10^{13}$ eV with $\gamma = -2.08 \pm 0.12$.

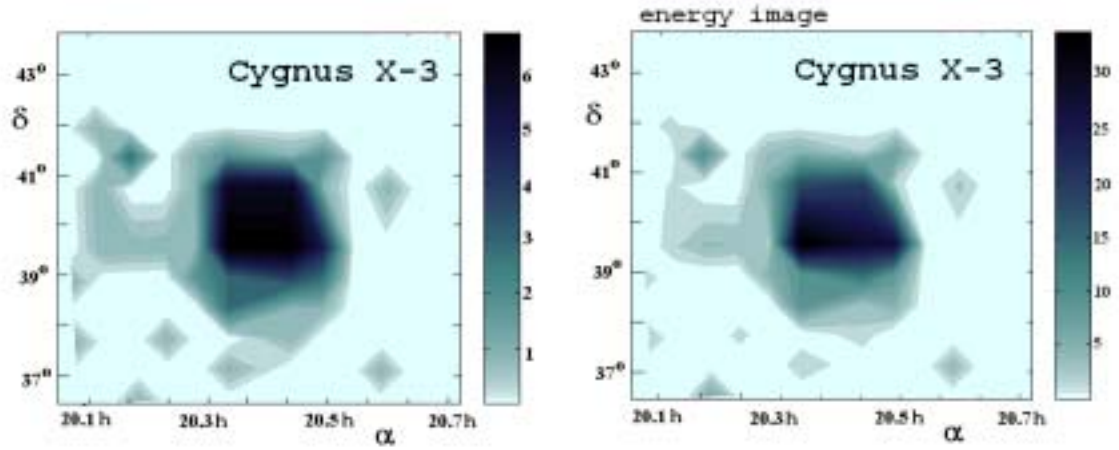

Fig. 4. Image viewed by SHALON-1 at energy range of more than 0.8 TeV - left and energy image (in TeV)- right

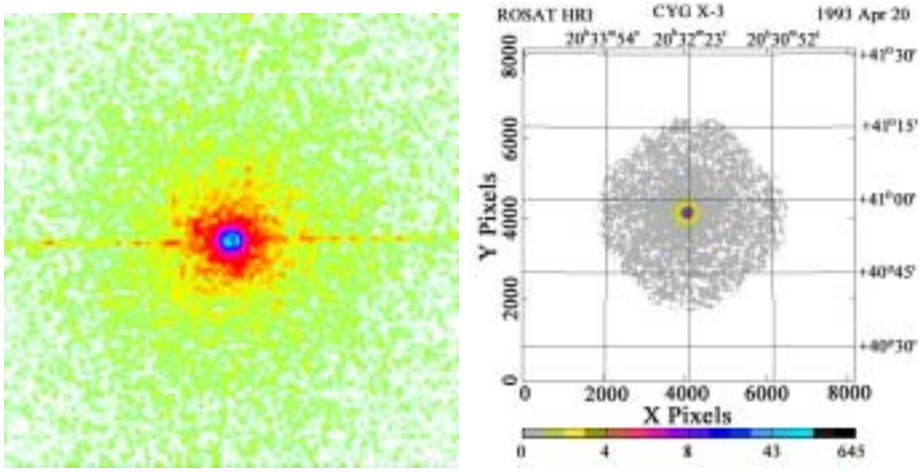

Fig. 5. left – Cygnus X-3 image by Chandra; right – Cygnus X-3 image by ROSAT

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 $F(E_o > 0.8 TeV) = (4.2 \pm 0.8) \bullet 10^{-13} cm^{-2} s^{-1}$. 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.1). 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. 2, 3). 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). Presently it is possible to build the source images on number of particles in the pixel and on energy (in eV) coming in pixel of matrix. Such images for Cygnus X-3 are presented at fig. 4. Cygnus X-3 is know as the binary system consisting of massive star (Wolf-Rayet) with compact companion. The X-ray emission from Cygnus X-3 is due to matter falling from a normal star onto a nearby neutron star or black hole. The Cygnus X-3 viewed by Chandra and ROSAT present at fig.5. The creation of stereo pair of two gamma-telescopes SHALON-l and SHALON-2 [24 - 35], 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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