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Cygnus X-3 and supernova remnants

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Abstract. Since 1994, the telescope SHALON at SHALON-ALATOO mountain observatory (altitude 3338m), has detected Very High Energy gamma-ray from Galactic objects Crab Nebula, Cygnus X-3, Geminga and Tycho Brage. Time analysis of the Cherenkov light outbursts shows that the contribution of protons of cosmic rays in observed gamma-quanta flux with energies higher than 0.8TeV from the point sources of gamma-quanta doesn't exceed 10% - 15%. The fluxes with energies above 0.8TeV observed for Crab Nebula are $(1.10\pm0.13)\bullet10^{-12}cm^{-2}s^{-1}$, for Cygnus X-3 are $(4.20\pm0.70)\bullet10^{-13}cm^{-2}s^{-1}$, for Geminga are $(4.8\pm1.7)\bullet10^{-13}cm^{-2}s^{-1}$ and for Tycho Brage are $(1.89\pm0.90)\bullet10^{-13}cm^{-2}s^{-1}$. The observable energy distribution of gamma quanta in an energy interval of 10^{12}–$5\bullet10^{13}$ from local sources in our Galaxy does not contradict to the spectrum for Crab Nebula $dF/dE_\gamma \sim E_\gamma^{-2.08\pm0.12}$, for 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 $dF/dE \sim E^{-2.35\pm0.12}$, for Cygnus X-3 $dF/dE \sim E^{-2.51\pm0.22}$. It also differs from energy spectrum of cosmic rays $dF/dE \sim E^{-2.70}$.

Basic directions of scientific researchers are nuclear physics and physics of elementary particles - high energy physics and connected with them astrophysics and cosmology investigation of a matter structure at extremely small and extremely large distances. More than seven years ago the project of the mirror Cherenkov telescope SHALON (Sinitsyna, 1987) was suggested and the first observations were started in 1991 at the ALATOO mountain observatory (Sinitsyna, 1992-2000). A distinctive property of the telescope is a large full angle due to a relatively large size of photomultipliers matrix. This allows to detect extensive air showers coming at to the distance up to 120 m from an optical axis of the telescope, that increases the statistics from the sources of very high energy gamma-quanta. In addition such a large full angle of an image matrix allows to research an isotropic background of extensive air showers from charged particles of cosmic rays simultaneously with the observation of gamma-quanta local sources at the same optical characteristics of atmosphere. It is particularly important because in our research of gamma-sources the extensive air showers generated by gamma-quanta are selected not only according to exceeding flux of showers in a small angle, but also according to the differences of the evaluation in the atmosphere depth of electron-photon cascades generated by protons and by nuclei of cosmic rays. Cherenkov imaging telescope SHALON - 1 equipped with a very high definition camera (144 pixels, full angle 8^o) obtains data since 1992 at the height 3338m. We will discuss some observations results on gamma-ray sources mentioned above and methods of gamma-rays and protons selections. Selection of gamma-quanta showers from a background of showers produced by protons (Fig. 1-2) is perfomed according to the following: 1) α <20; 2) length/width > 1.6 for γ; 3) relation of Cherenkov light intensity in pixel with max light to the light in eight pixels around it is int_0 >0.6; 4) relation of Cherenkov light intensity in pixel with max light to light intensity in all pixels except nine in the center is for int_1 >0.8; 5) distance is <3.5 pixels. On figure 1 experimental distribution of image parameters for proton and gamma showers data obtained with the SHALON telescope is shown. On the left gamma-quanta (250 events) from point sources observed by SHALON are represented. On the right -

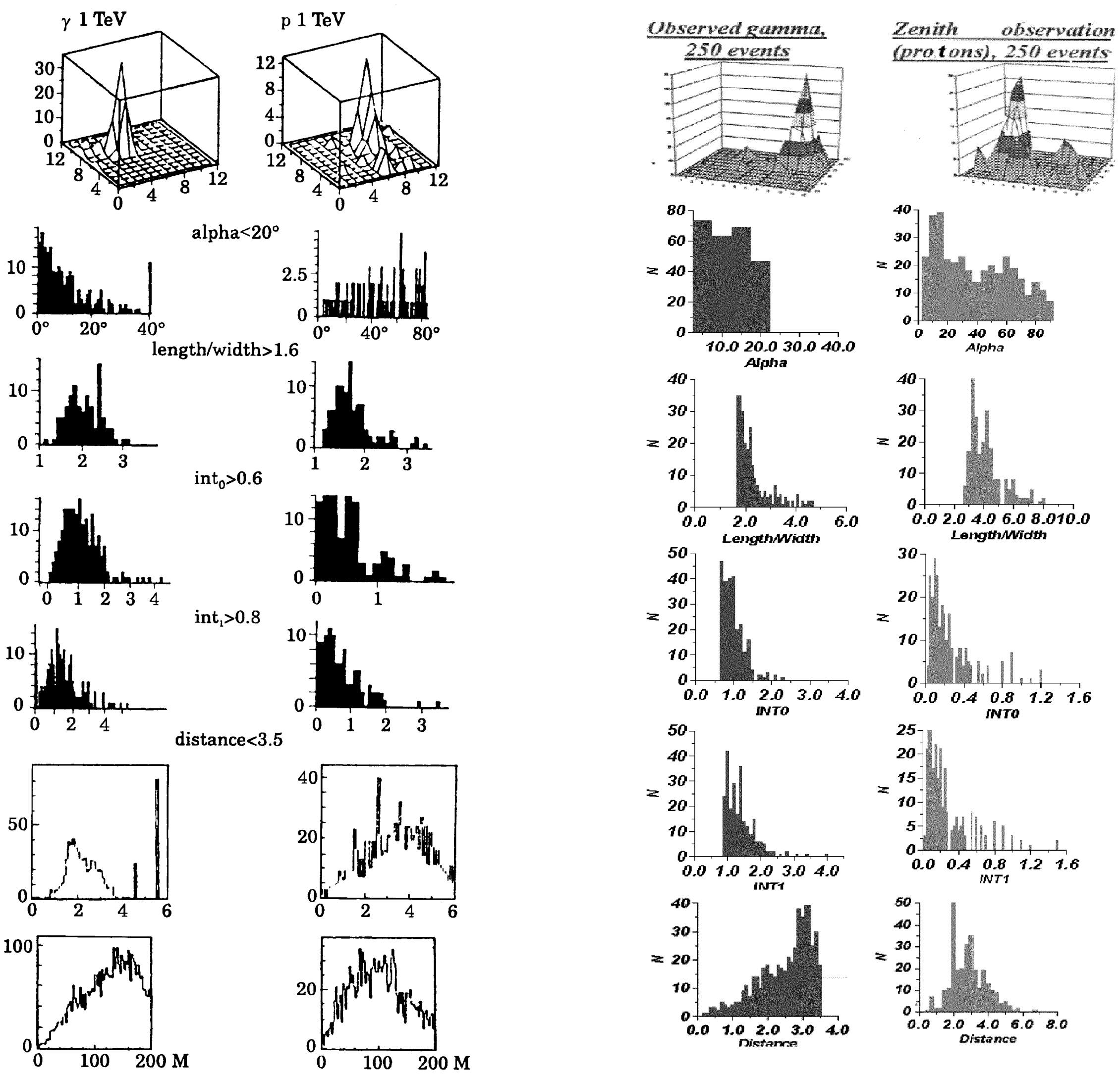

Fig. 1. *Monte Carlo distribution of image parameters for gamma-quanta and protons showers of 1 TeV and experimental SHALON distribution of image parameters for gamma-quanta and proton showers with energy more than 0.8 TeV*

cosmic ray protons (250 events) from zenith SHALON observations. As one see following criteria of selection (Fig.2) shows calculations for protons showers carried out by means of CORSIKA, using a special program allowing to take into considerations the geometry of the SHALON telescope (height, Bx, By are equal 3338m and 27.5μT, 44.9μT accordingly). Minimal threshold energy, till which the history of cascade particles can be followed, is equal for hadrons and muons - 0.3GeV, for electrons and photons - 0.15GeV. Primary particles fall vertically. In figure 4 the results of calculations by means of the CORSIKA program for protons with energies 2TeV and 5TeV of parameters int_0 and int_1 distributions are presented. Taking into consideration earlier carried out calculations (Fig. 1), experimental distribution of gamma-quanta from point sources and from protons (Fig. 1), criteria int_0 > 0.6 and int_1 > 0.8 based on CORSIKA calculations (figure 2), one can see, that

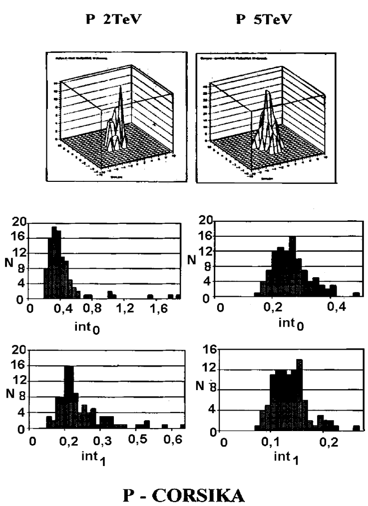

Figure 2. *INT_0 and INT_1, simulated by CORSIKA program for protons with energies 2TeV and 5TeV)*

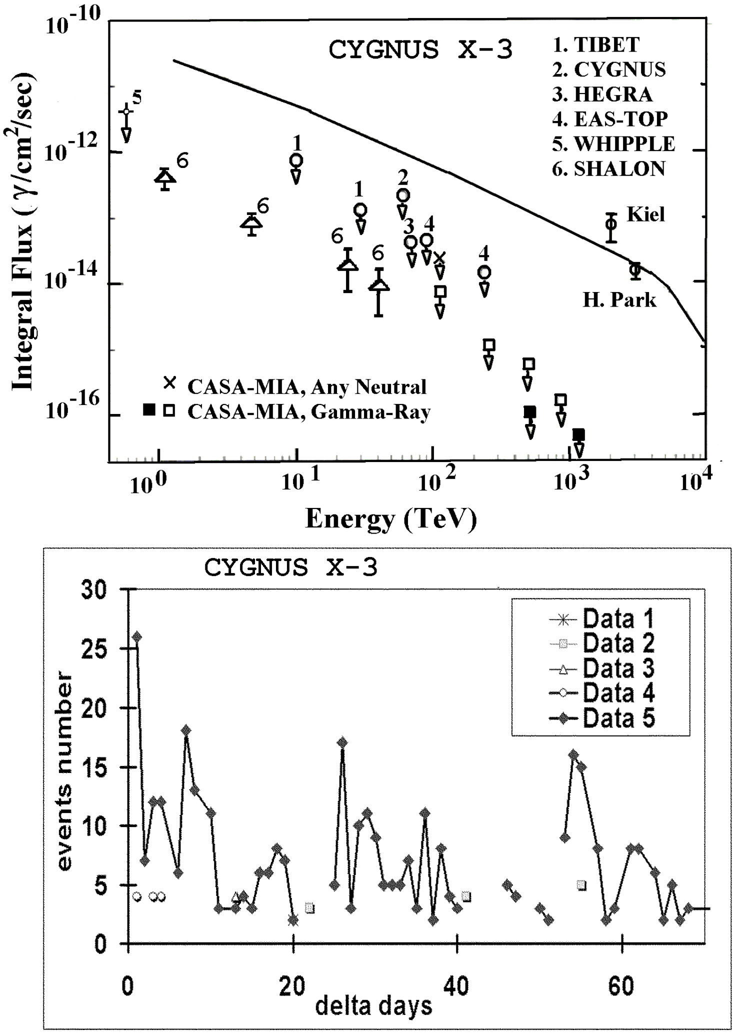

Fig 3. *The spectrum of the gamma- radiation of extra-high energies from Cygnus X-3 and Cygnus X-3 time diagram 1996-1999 SHALON: Line 5 - gamma-quanta events sum 1996, 1997, 1998 and 1999; (large full angle of observations gives an opportunity to carry out* ***ON*** *and* ***OFF*** *observations simultaneously)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

the contribution of background proton events into gamma events is not more than 10%, i.e. 90% of a background is cut, whereas the separation of gamma - quanta according to carried out estimations is not more than 6% (Fig. 1).

Time analysis of the Cherenkov light outbursts shows that the contribution of cosmic ray protons in observed gamma-quanta flux with energies higher than 0.8TeV from the point sources of gamma-quanta doesn't exceed 10% - 15%. The fluxes of energies above 0.8TeV observed for Crab Nebula are $(1.10\pm0.13)\bullet10^{-12}cm^{-2}s^{-1}$, for Cygnus X-3 are $(4.20\pm0.70)\bullet10^{-13}cm^{-2}s^{-1}$, for Geminga are $(4.8\pm1.7)\bullet10^{-13}cm^{-2}s^{-1}$ and for Tycho Brage are $(1.89\pm0.90)\bullet10^{-13}cm^{-2}s^{-1}$. The observable energy distribution of gamma quanta in an interval of energy 10^{12} – $5\bullet10^{13}$ from local sources in our Galaxy does not contradict with the spectrum of Crab Nebula $dF/dE_\gamma\sim E_\gamma^{-2.08\pm0.12}$, in 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 $dF/dE\sim E^{-2.35\pm0.12}$, for Cygnus X-3 $dF/dE \sim E^{-2.51\pm0.22}$. It also differs from energy spectrum of cosmic rays $dF/dE\sim E^{-2.70}$. Crab Nebula may be a typical source of galactic cosmic rays and NGC 1275, Markarian 421 and Markarian 501 are a typical sources of extragalactic cosmic rays. Among different methods of gamma-quanta local sources search the most important is observation from Cherenkov radiation of electron - photon cascades generated in atmosphere by very high energy gamma - quanta, because a direction on the source can be derived from direction of Cherenkov radiation. The approximate equality of observable intensity of sources is connected with a limited time of a observation of a proposed point source. The distance from Earth to galactic and extragalactic sources differs about 10^4 times which means that extragalactic sources 10^8 higher radiation ability in comparison with the galactic sources. An efficient mechanism of cosmic rays

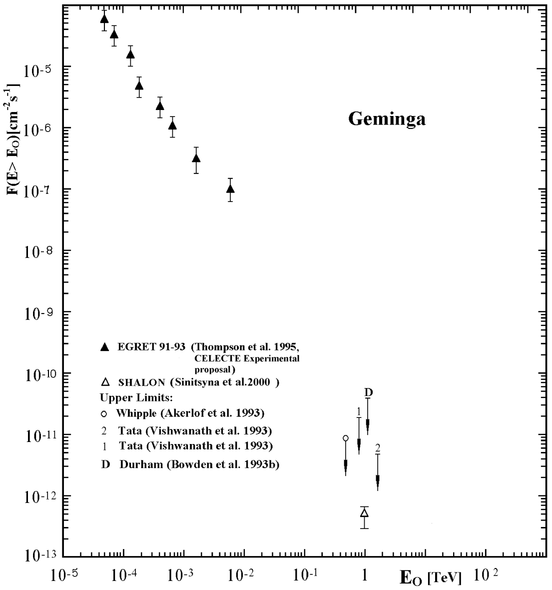

Fig. 4. *The spectrum of the gamma- radiation of extra-high energies from Geminga*

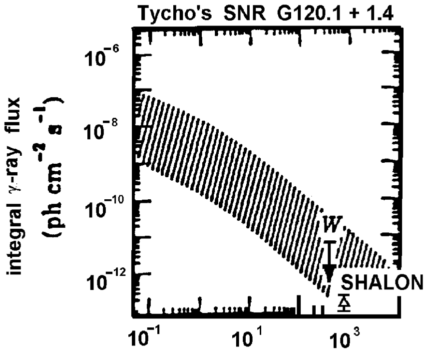

Fig. 5. *The spectrum of the gamma- radiation of extra-high energies from Tyho Brahe*

acceleration by means of which a necessary supernova energy part radiating during the explosion can be transferred to cosmic rays was proposed. High rate of acceleration and the energy spectrum form of accelerated particles ~γ, is the arguments of the prevailing role of the regular acceleration process in the supernova remnants.

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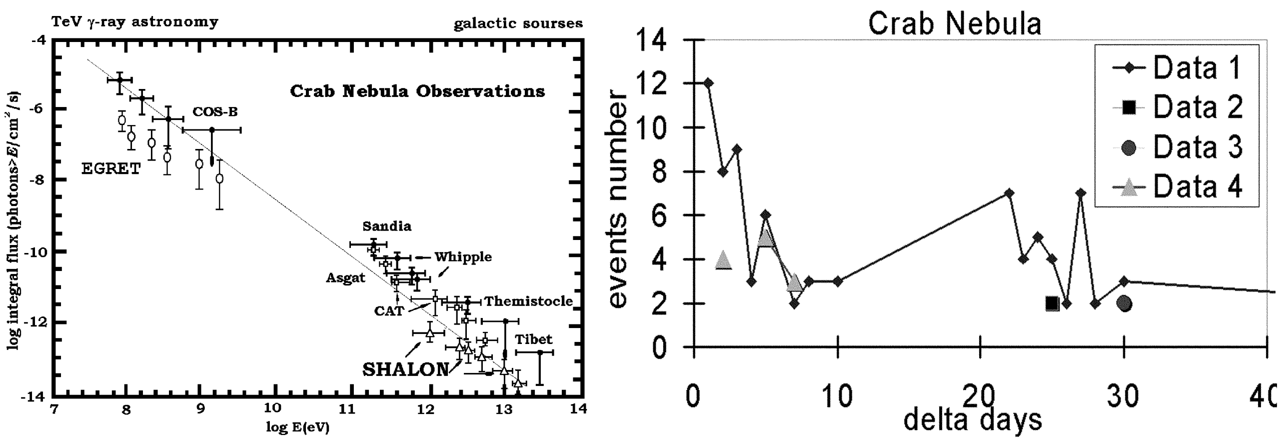

Fig 6. *The spectrum of gamma- radiation of extra-high energies from Crab Nebula and Crab Nebula time diagram 1994-1999 SHALON: Line 1 - gamma-quanta events sum 1994, 1996, 1998 and 1999; (large full angle of observations gives an opportunity to carry out* ***ON*** *and* ***OFF*** *observations simultaneously) Lines 2,3,4 - background events 1994, 1998 and 1999 accordingly*