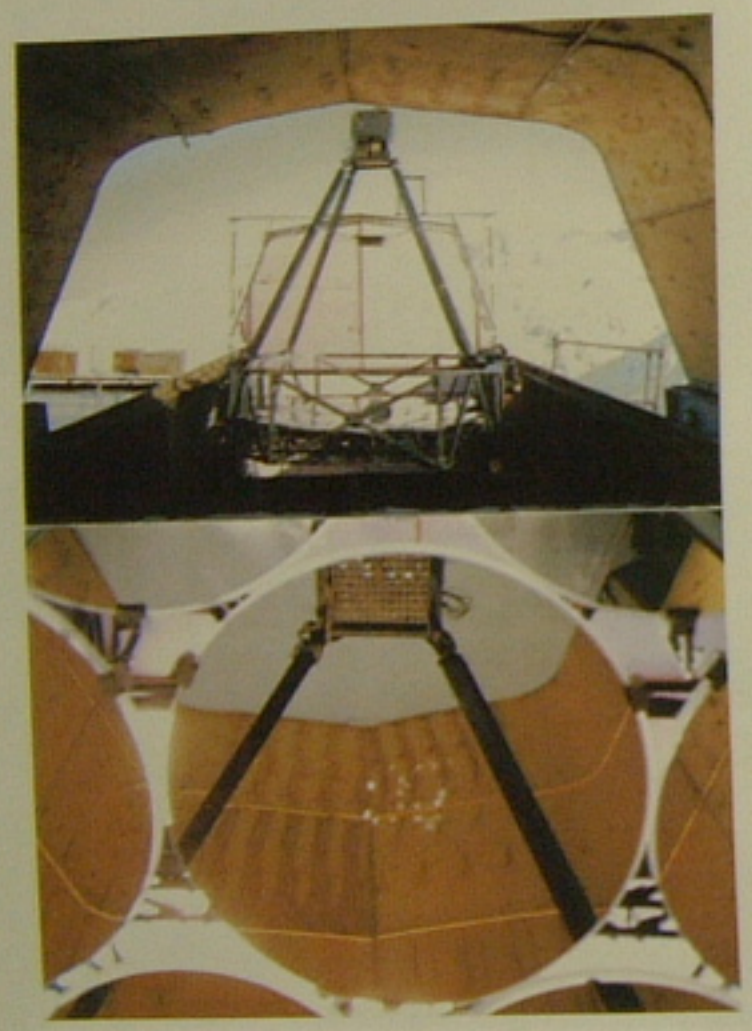

EFFICIENCY OF SELECTION OF GAMMA - QUANTA FROM A PROTON BACKGROUND IN EXPERIMENT SHALON ON OBSERVATION RESULTS OF EXTRAGALACTIC SOURCES NGC1275, 1739+522, 3C454.3 AND MKN501

G. Sinitsyna, A.Y. Alaverdian, T.P. Arsov, S.S. Borisov, F.I. Musin, S.I. Nikolsky, G.M. Kasparov, R.M. Mirzafatikhov, V.Y. Sinitsyna, G.F. Platonov

partment of Nuclear Physics, P.N. Lebedev Physical Institute, Russian Academy of Science, Leninsky pr. 53, Moscow 117924, Russia.

The active galactic nuclei NGC1275 and Mkn501 has been observed on gamma - telescope SHALON-1 since 1996. Using all obtained data the energy spectra are constructed. The observable energy distribution of gamma quanta from local sources of NGC1275 $dF/dE_\gamma \sim E_\gamma^{-2.09}$, but the observed spectra of the gamma-quanta including the 10%-15% contribution of the proton showers is of NGC1275 $dF/dE \sim E^{-2.36\pm0.16}$. It also differs from observed energy spectrum of cosmic rays $dF/dE \sim E^{-2.71\pm0.19}$. The carried out temporary analysis has shown that the contribution of proton events makes no more than-10 - 15 %. The observation of far extragalactic sources 1739+522 and 3c454.4 with z equal 1.375 and 0.859 recently are begun, the flux values received are equal $(9.43\pm0.17)\bullet10^{-12}cm^{-2}s^{-1}$ and $(0.47\pm0.18)\bullet10^{-12}cm\text{-}2s^{-1}$ accordingly.

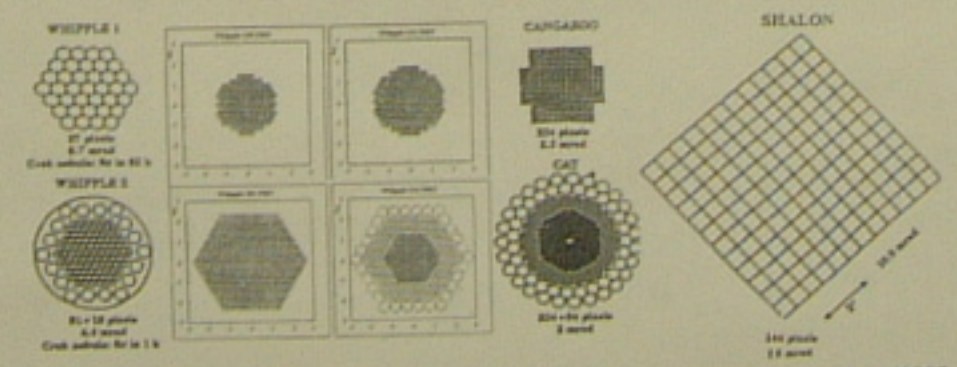

Fig.1 *Pixel distribution the focal plan of the 10m reflector: top left: 109 pixels (1993-1996); top right: 151 pixels (Dec.,1996); 331 pixels (Oct., 1997); 541 pixels).*

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. Such additional selection of electron-photon showers among extensive air showers of cosmic rays can be

carried out by the analysis of a light image (generally of an elliptic spot in a lightreciever matrix) in comparison with developed characteristic parameters of distributions for both showers from gamma - quanta and showers from protons and nuclei. Selection of gamma-quanta showers from a background of showers produced by protons (Fig. 2) is performed 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_6 >0.6; 4) relation of Cherenkov light intensity in pixel with max light to light intensity in all pixels except nine in the centre is for int_9 >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. At the left is Monte Carlo distributions of particles both gammas and protones on selection criteria. And on the right the gamma-quanta (250 events) from point sources observed by SHALON and selected by criteria and far the cosmic ray protons (250 events) from zenith SHALON observations are represented. As the analysis of this particle distributions on five criteria of selection used in experiment SHALON has shown that 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. 2).

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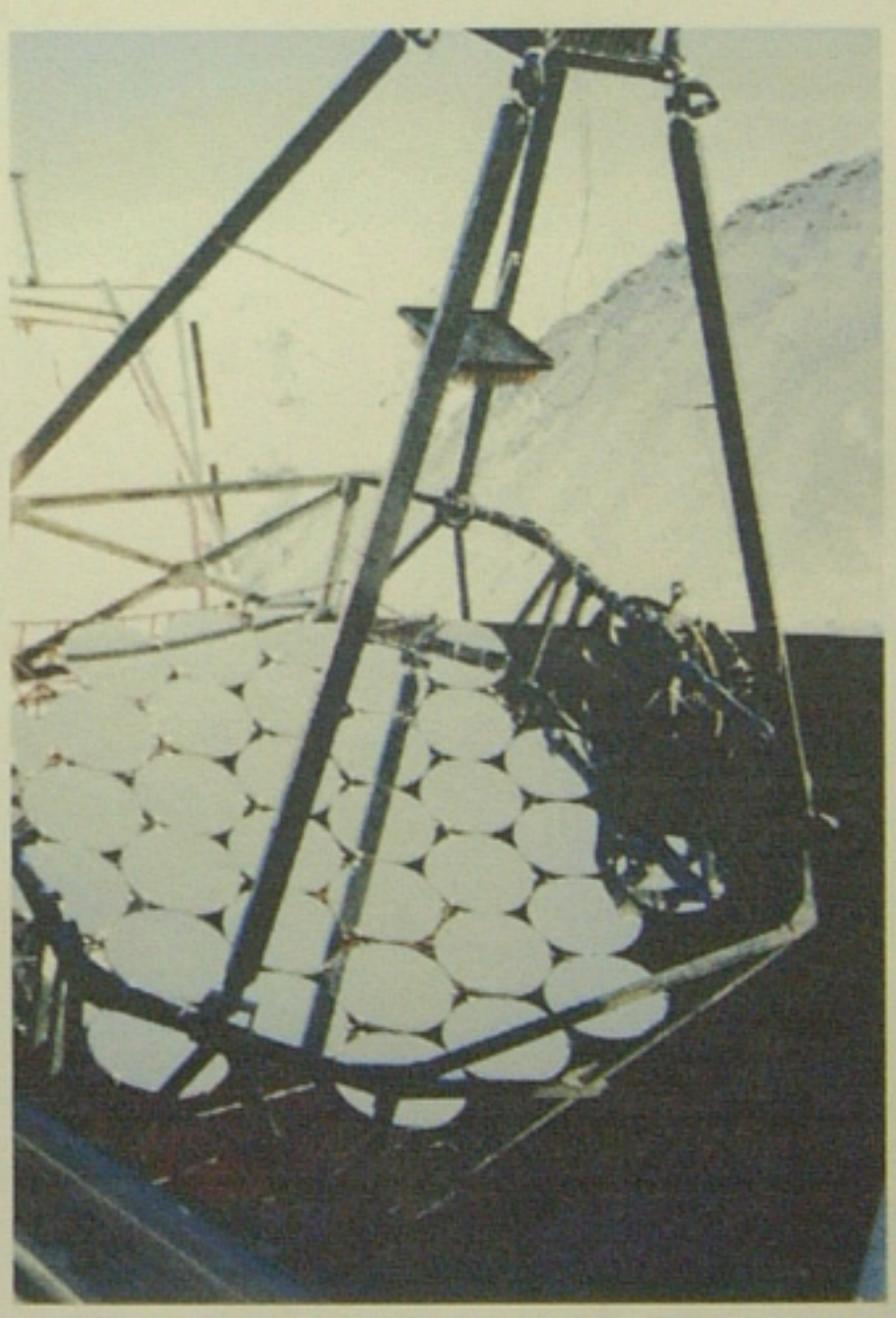
More than seven years ago the project of the mirror Cherenkov telescope SHALON (Sinitsyna, 1987) was suggested and the first observations were started in 1991 at the ALATOO mountain observatory at the height 3338m (Sinitsyna, 1992-2000). A distinctive property of the telescope is a large full angle due to a relatively large size of photomultipliers matrix (144 pixels, full angle 8^o). The comparison of SHALON PMT matrix with other experiments presented at fig. 1. 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 (OFF data) simultaneously with the observation of gamma-quanta local sources (ON data) at the same optical characteristics of atmosphere. It is particularly important because in our research of gamma-sources the extensive air showers



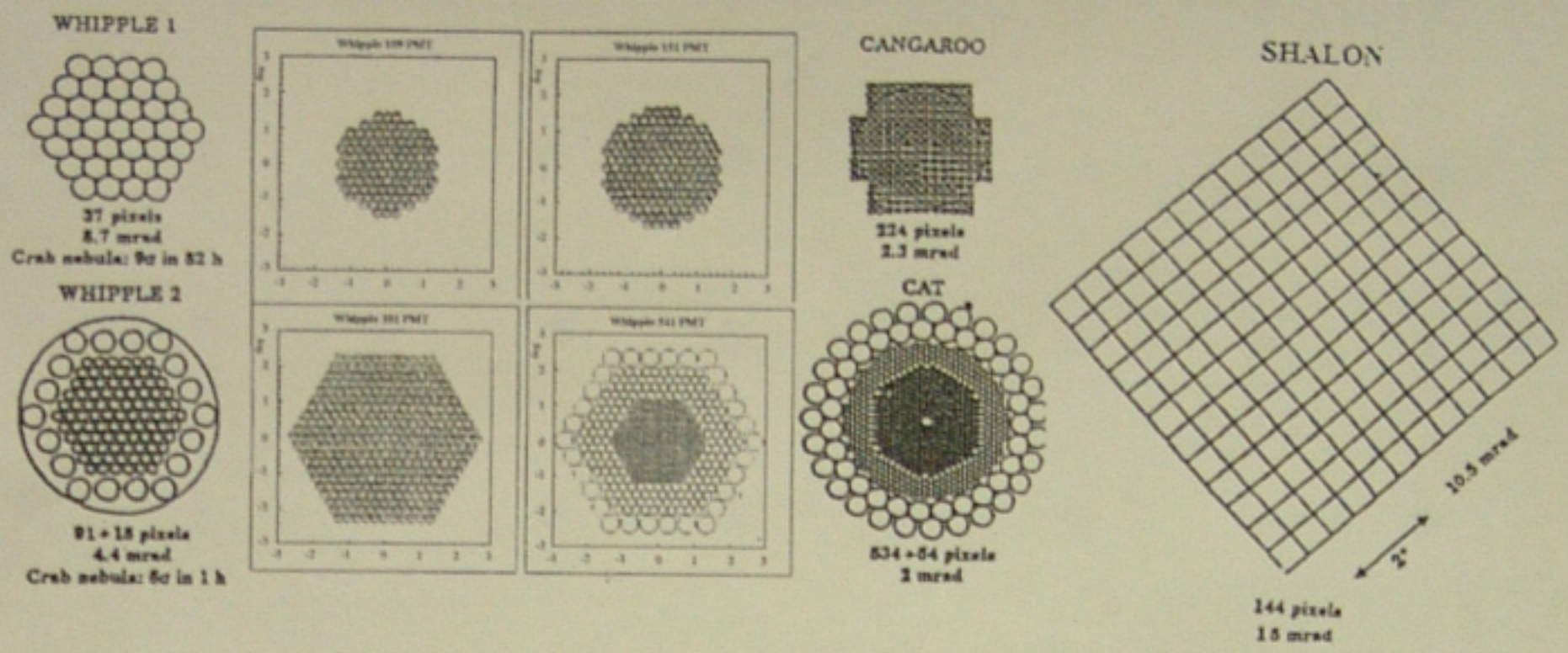


Fig.1 *Pixel distribution the focal plan of the 10m reflector: top left: 109 pixels (1993-1996); top right: 151 pixels (Dec.,1996); 331 pixels (Oct., 1997); 541 pixels).*

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. Such additional selection of electron-photon showers among extensive air showers of cosmic rays can be

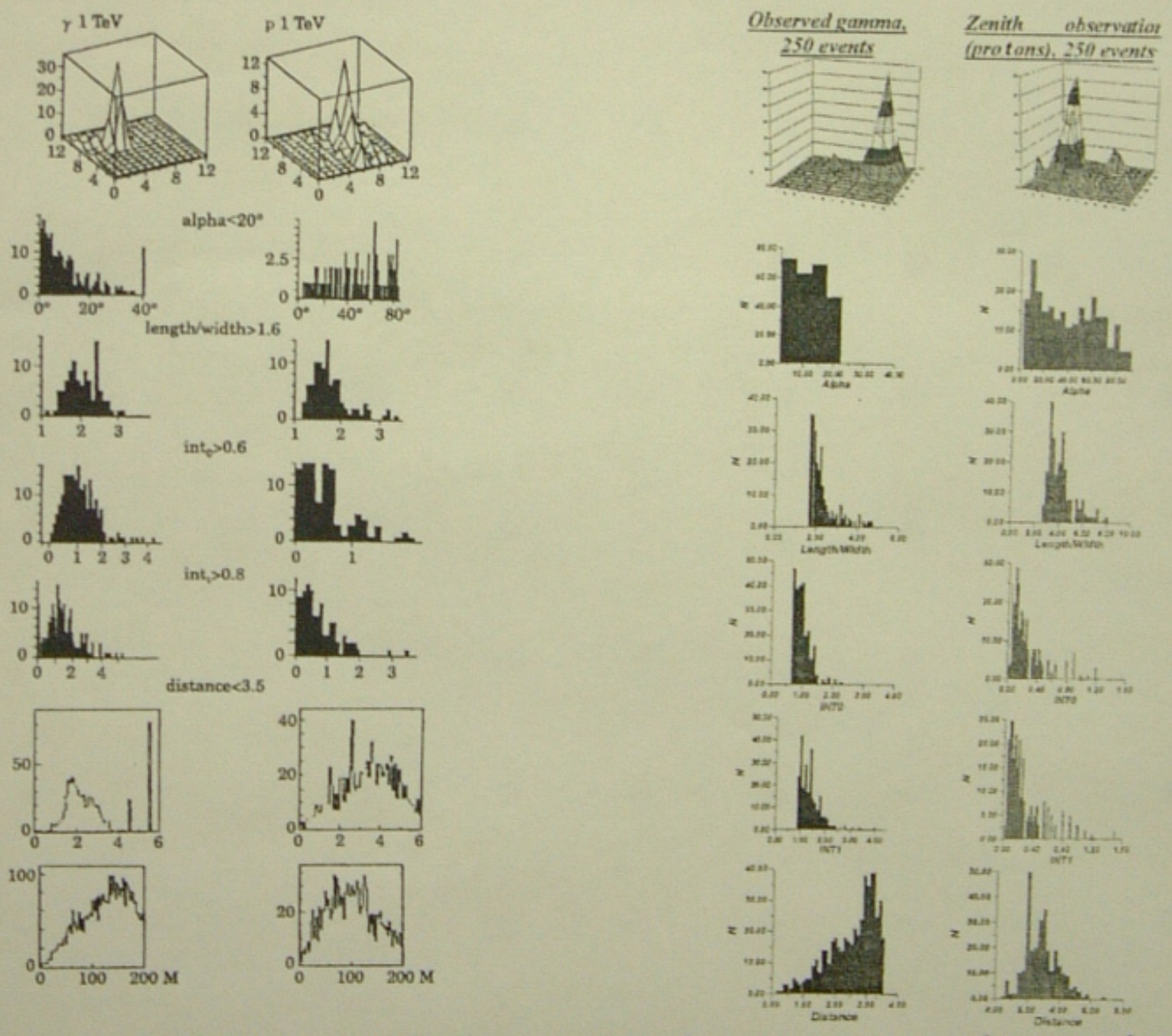


Fig. 2. *Monte Carlo distribution of image parameters for gamma-quanta and protons showers of 1 TeV and experimental SHALON distribution of image parameters for gamma-quanta and proton showers with energy more than 0.8 TeV*

carried out by the analysis of a light image (generally of an elliptic spot in a lightreciever matrix) in comparison with developed characteristic parameters of distributions for both showers from gamma - quanta and showers from protons and nuclei. Selection of gamma-quanta showers from a background of showers produced by protons (Fig. 2) is performed 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 centre 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. At the left is Monte Carlo distributions of particles both gammas and protones on selection criteria. And on the right the gamma-quanta (250 events) from point sources observed by SHALON and selected by criteria and far the cosmic ray protons (250 events) from zenith SHALON observations are represented. As the analysis of this particle distributions on five criteria of selection used in experiment SHALON has shown that 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. 2).

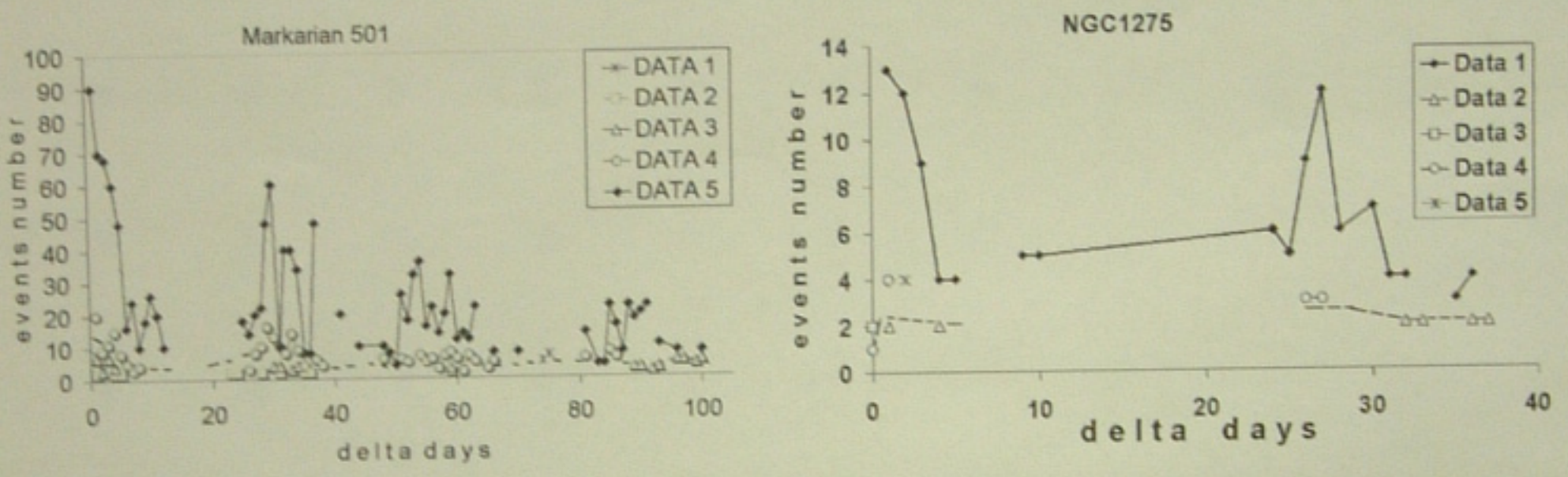


Fig. 3 left –*AGN Markarian 501 time diagram 1996-1999. DATA 5 - gamma-quanta events sum 1996, 1997, 1998 and 1999 SHALON; DATA 1,2,3,4 - background events of showers produced by cosmic ray protons (large full angle of observations gives an opportunity to carry out* ***ON*** *and* ***OFF*** *observations simultaneously) 1996, 1997, 1998 and 1999 accordingly* **right** –*NGC 1275 time diagram 1996-1999: DATA 1 - gamma-quanta events sum 1996, 1997, 1998 and 1999; DATA 2,3,4,5 - background events of showers produced by cosmic ray protons (large full angle of observations gives an opportunity to carry out* ***ON*** *and* ***OFF*** *observations simultaneously) 1996, 1997, 1998 and 1999 accordingly (see text).*

The Fig. 3 presents the results of the time analysis on Markarian 501 and NGC 1275. The time analysis shows number of event (gamma or background), coming with the certain time interval (delta days). At ON data in all sources groups of peaks with common average 5-10 days width were detected with the period to multiple 24-26 days. These peaks can be interpreted as periods connected with the fact that observations are being carried out only by moonless nights. As one can see from presented at Fig. 2 the contribution of cosmic rays background (dashed line) into observable gamma-quanta with energies > 0.8 TeV doesn't exceed 10% - 15%.

The SHALON-1 observations at Tien-Shan high-mountainous station were carried out since 1992 during this period 12 metagalactic and galactic sources were observed. Among them are galactic sources Crab Nebulae (the supernova remnant), Cygnus X-3 (binar), Ticho Brage

In accordance with accumulation of the observation data it is possible to build the source images on number of particles in the pixel and on energy (in TeV) coming in pixel of matrix. Such images for NGC 1275, Mkn 501, 1739+522 and 3c454.3 are presented at fig 7.

(supernova remnant), Geminga (radio-weak pulsar) and metagalactic ones Markarian 501 (blazar), Markarian 421(blazar), NGC1275 (Seyfert galaxy), 3c454.3 (quazar) and 1739+522 (quazar) (see tabl.1). The results of observation data analysis are integral spectrum, time analysis of events from the source (ON) and background ones (OFF) observed simultaneously and the sources images.

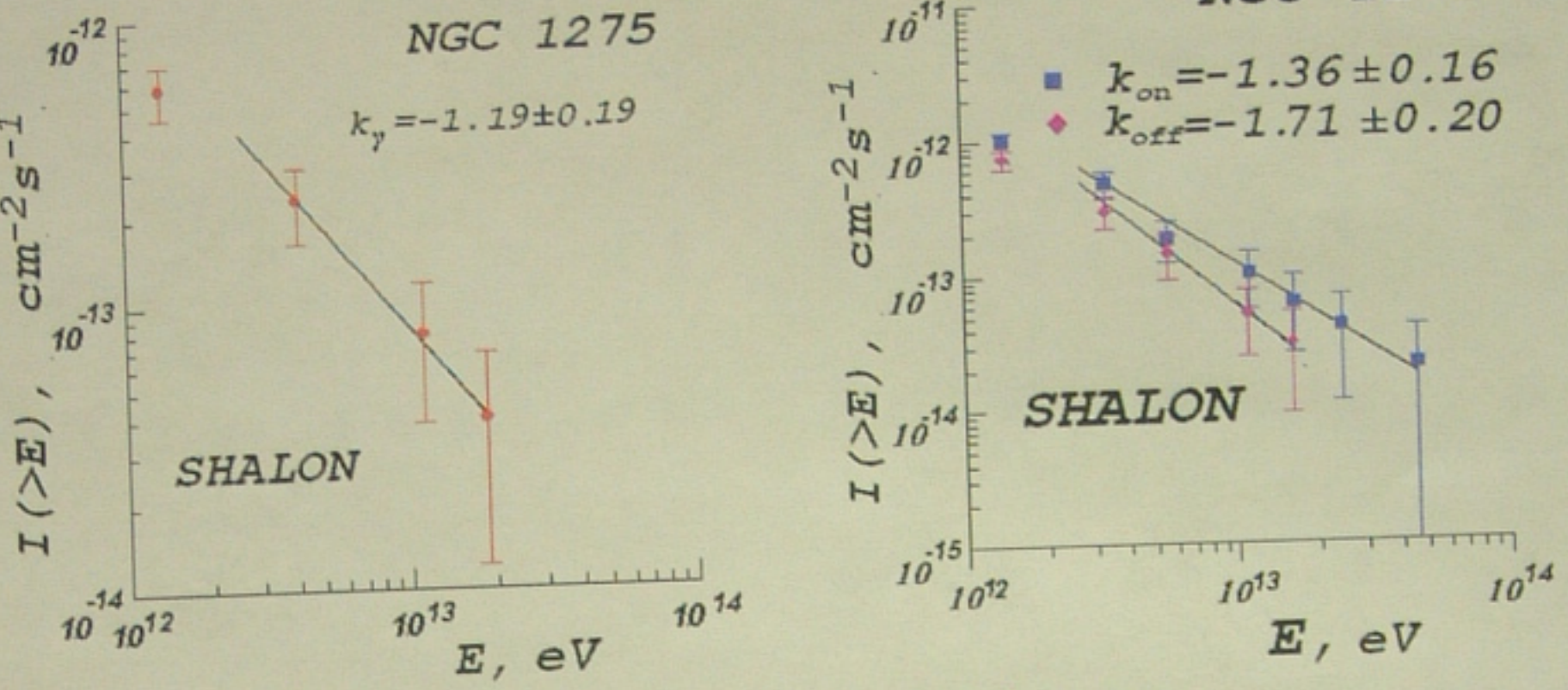


Fig.4 *Spectra of the gamma radiation from Seyfert AGN NGC 1275.*

At 1998 at SHALON observation there was a new metagalactic gamma-quanta with energies >0.8 TeV source with flux (0.78±0.13)•10^{-12} detected. This source coincides by its coordinates with the active nucleus galaxy NGC 1275. The energy spectrum of active galactic nuclei NGC 1275 was measured at energy interval of 0.8 to 30 TeV, k_γ=-1.19±0.19 (fig.4), time analysis was performed. The observable energy distribution of gamma-quanta from local sources of NGC 1275 is $dF/dE_\gamma \sim E^{-2.19\pm0.19}$. The observed spectrum of the gamma-quanta including the 10%-15% contribution of the proton showers is for NGC 1275 $dF/dE_\gamma \sim E^{-2.36\pm0.16}$ fig.4. It is different from observed simultaneously spectrum for cosmic rays $dF/dE_\gamma \sim E^{-2.71\pm0.19}$.

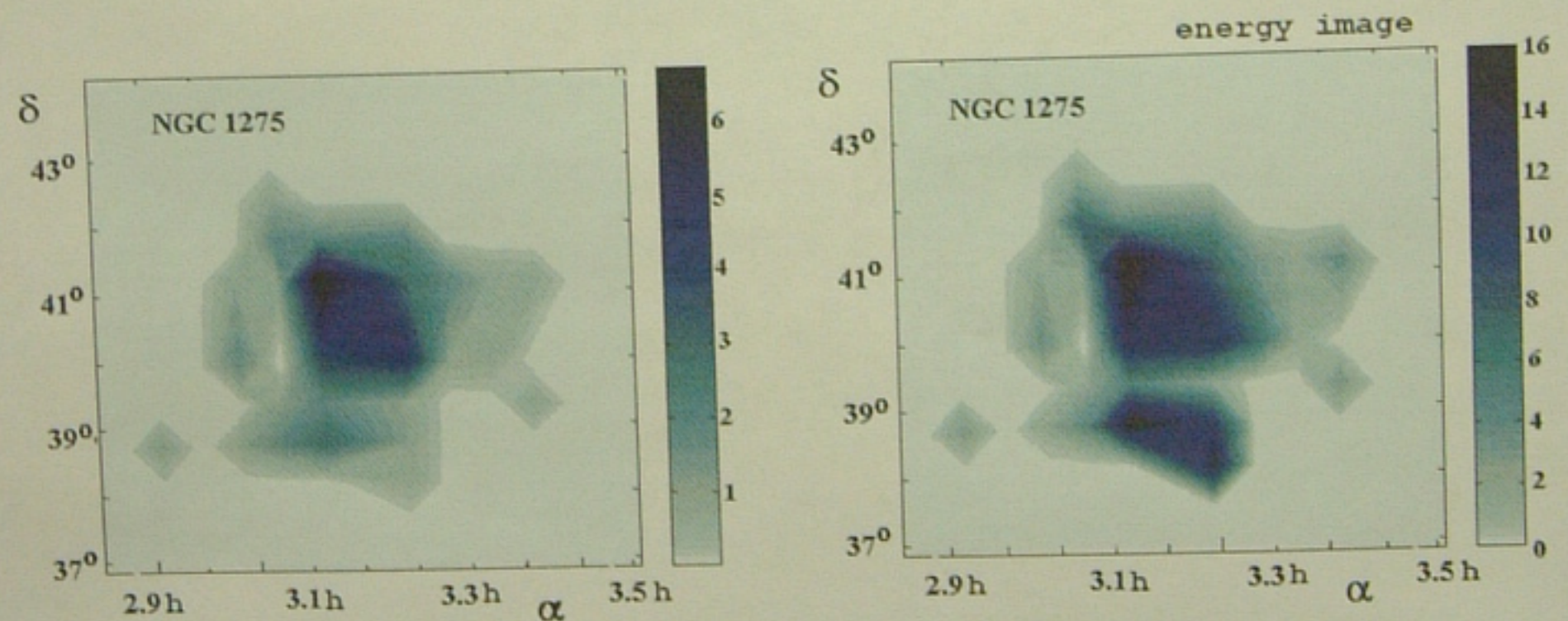


Fig.5 *Images of NGC 1275 (see text)*

Firstly detected by SHALON telescope extragalactic source NGC1275 also was observed at Tibet installation. The NGC 1275 image at energy range >0.8 TeV is presented at fig. 5. At the

proton showers with energy more than 0.8 TeV

left is the image on number of events satisfying to selection criteria. And at the right – energy image of source on the particle energy (in TeV) coming to the pixel.

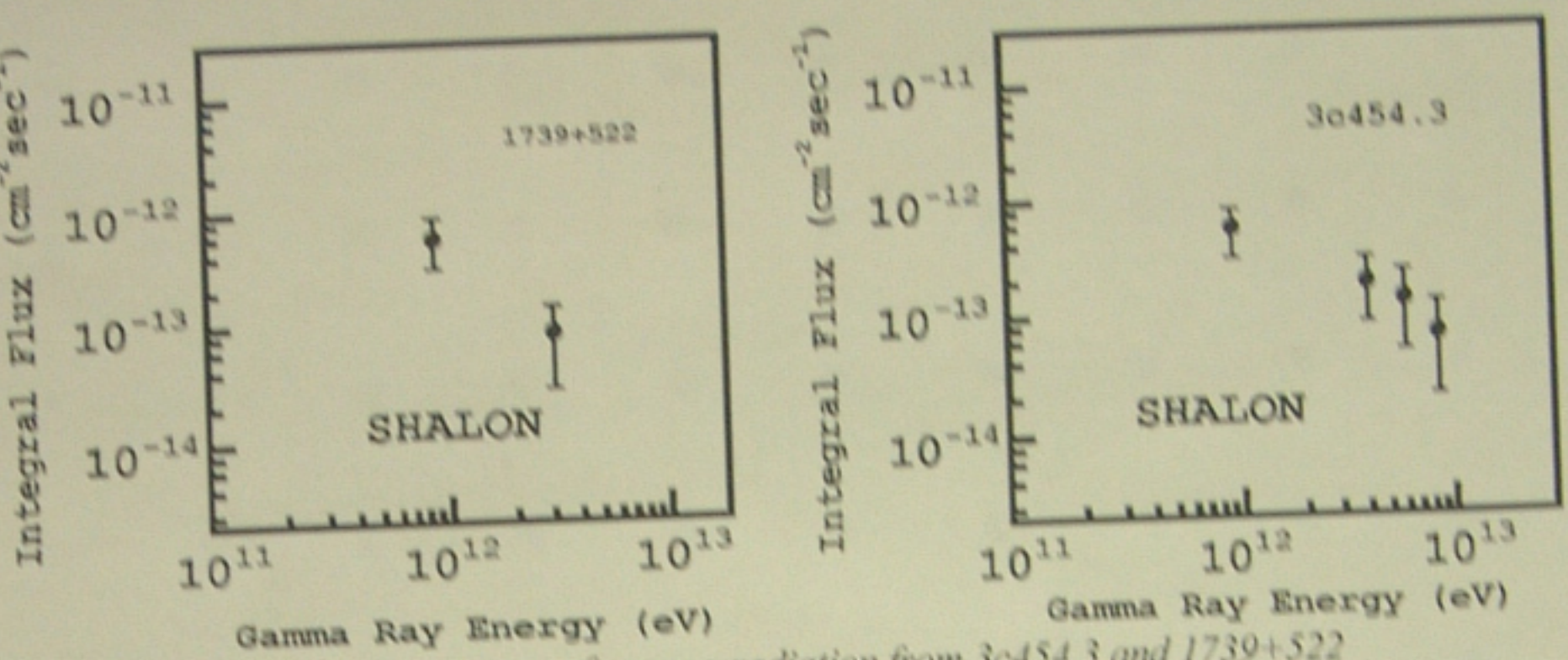


Fig. 6 *The spectra of gamma-radiation from 3c454.3 and 1739+522*

At the energy region from 0.8 to 10 TeV there were detected new metagalactic sources 1739+522, z=1.375 and 3c454.3, z=0.859 with fluxes $(0.43\pm0.17)\bullet10^{-12}$ and $(0.47\pm0.18)\bullet10^{-12}$ accordingly. The energy spectra at energy region from 0.8 to 10 TeV were measured (fig 6).

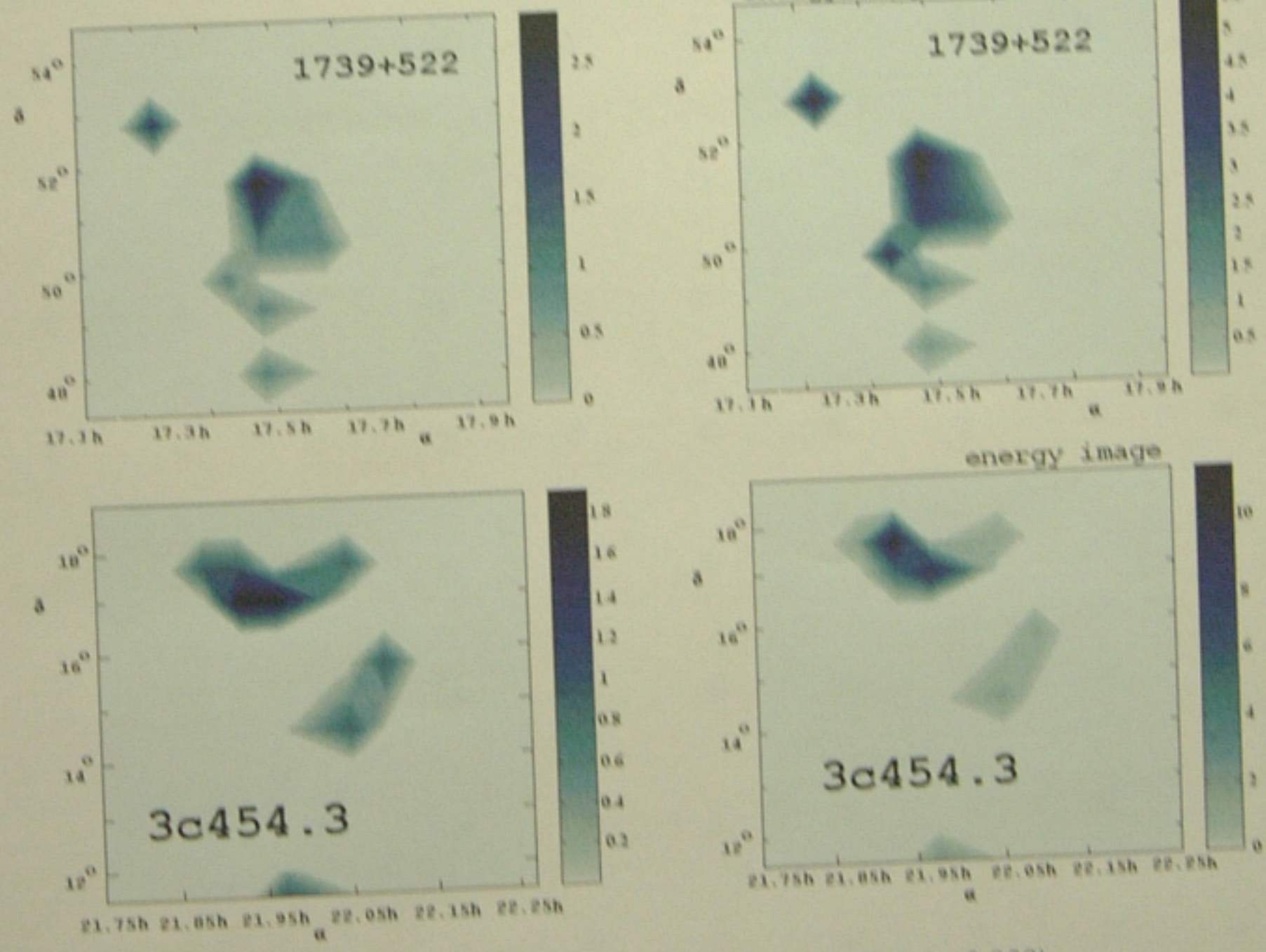


Fig. 7 *Images of far qusars 1739+522 (z=1.375) and 3c454.3 (z=0.859)*

In accordance with accumulation of the observation data it is possible to build the source images on number of particles in the pixel and on energy (in TeV) coming in pixel of matrix. Such images for NGC 1275, Mkn 501, 1739+522 and 3c454.3 are presented at fig 7.

Now the creation of SHALON-1 SHALON-2 stereo pair comes to the end. The observations of Cherenkov light by this method will essentially improve distinction of gamma-quanta on a background of cosmic rays, down to the analysis of individual events.

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