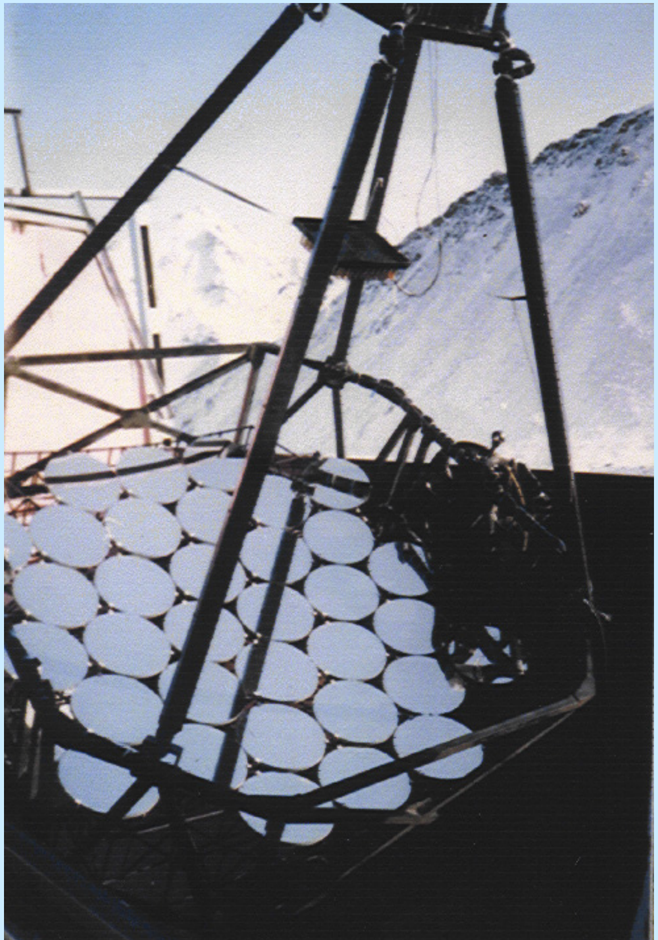

Integral spectra, spectral energy distributions and images of the close metagalactic sources SN2006gy, NGC 1275, Mkn 421, Mkn 501

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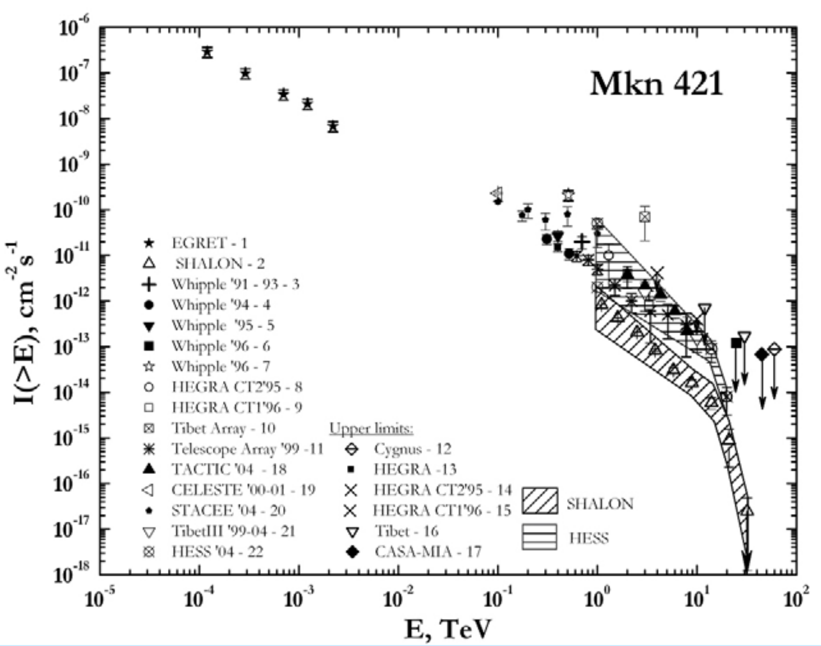
The distant VHE metagalactic sources 1739+522 (z=1.375) and 3c454.3 (z=0.859) the spectral energy distributions and images.

The gamma-astronomical researches are carrying out with SHALON mirror telescope at the Tien-Shan high-mountain observatory. During the period 1992 - 2008, SHALON has been used for observations of the metagalactic sources Mkn421, Mkn501, NGC1275, SN2006 gy, 3c454.3, 1739+522 and galactic sources Crab Nebula, Cygnus X-3, Tycho's SNR, Geminga, 2129+47XR. The SHALON results for well known metagalactic gamma-sources (Mkn 421 amd Mkn 501) are consistent with the data telescopes of Whipple, TACTIC, HESS, Magic.

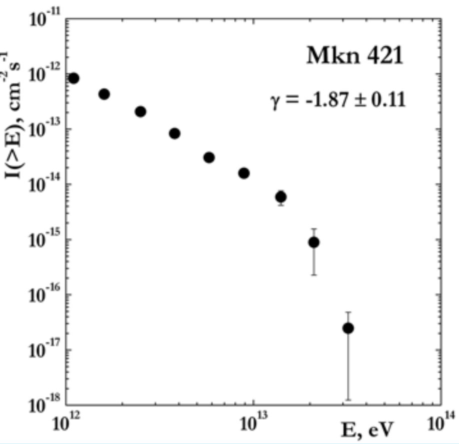
SHALON catalogue of metagalactic γ -quantum sources

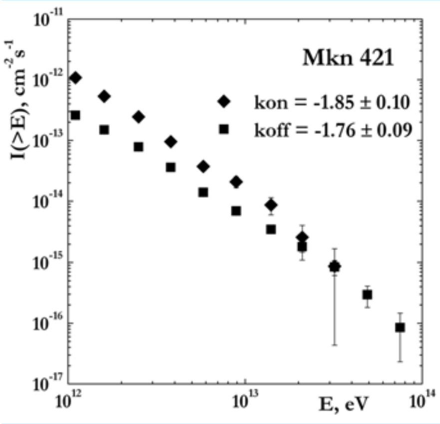
Source	Observable flux, $cm^{-2}s^{-1}$	z	Relative intensity of source (in Crab units)
Mkn 421	**$(0.63\pm0.14)\times10^{-12}$**	**0.031**	**3.8×10^{9}**
Mkn 501	**$(0.86\pm0.13)\times10^{-12}$**	**0.034**	**4.6×10^{9}**
Mkn 180	**$(0.65\pm0.23)\times10^{-12}$**	**0.046**	**6.2×10^{9}**
NGC 1275	**$(0.78\pm0.13)\times10^{-12}$**	**0.0178**	**1.2×10^{9}**
SN2006 gy	**$(3.71\pm0.65)\times10^{-12}$**	**0.019**	**4.2×10^{9}**
3c4543	**$(0.43\pm0.13)\times10^{-12}$**	**0.859**	**5.3×10^{12}**
1739+522	**$(0.53\pm0.10)\times10^{-12}$**	**1.375**	**1.4×10^{13}**

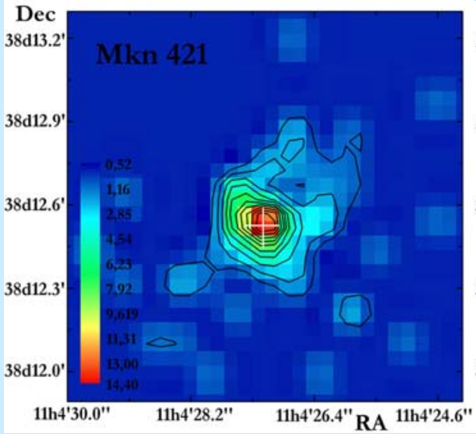
Markarian 421

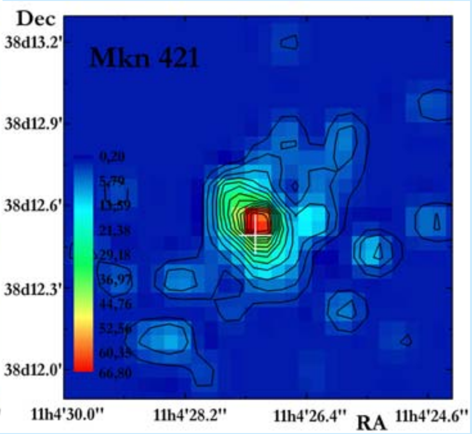


The Bl Lac Mkn 421 was detected as the first and the nearest (z = 0.031) metagalactic source of blazar type of TeV energy gamma-quanta in 1992 year using Whipple telescope. Presently this source is systematic studied by different experiments: VERITAS, SHALON, TACTIC, HESS, MAGIC. Mkn 421 is being intensively studied since 1994 by SHALON. As is seen from figure the SHALON results for this known gamma-source are consistent with the data by best world telescopes. An image of gamma-ray emission from Mkn 421 is also shown. The integral averaged for the period 1994 to 2006 gamma-ray flux above 0.8 TeV was estimated as $(0.63 \pm 0.14) \times 10^{-12}$ cm^{-2}s^{-1}. Within the range 1 - 10 TeV, the integral energy spectrum is well described by the power law $F(>E_O) \propto E^{k\gamma}$, with $k_\gamma = -1.53 \pm 0.14$. Extreme variability in different wavelengths including VHE gamma rays on the time-scales from minutes to years is the most distinctive feature of BL Lac objects. The increase of the flux over the average value was detected in 1997 and 2004 observations of Mkn 421 by SHALON and estimated to be $(1.01 \pm 0.25)\times10^{-12}$ cm^{-2}s^{-1} and $(0.96 \pm 0.2)\times10^{-12}$ cm^{-2}s^{-1}, respectively. The similar variations of the flux over the average value was also observed with the telescopes of Whipple, HEGRA, TACTIC, HESS (60^O – 67^O), MAGIC (45^O).

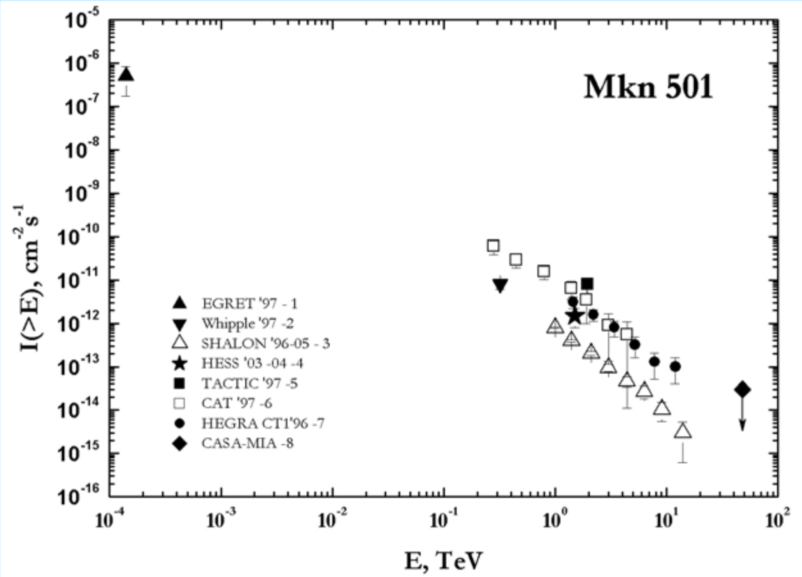




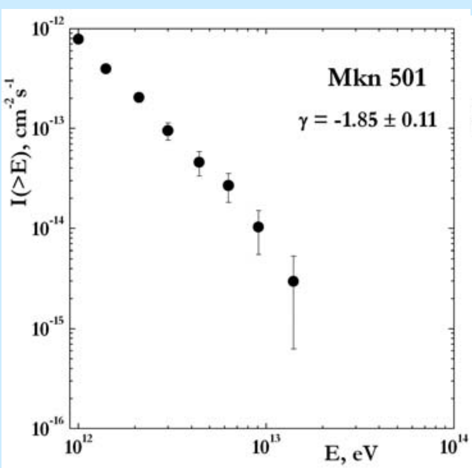


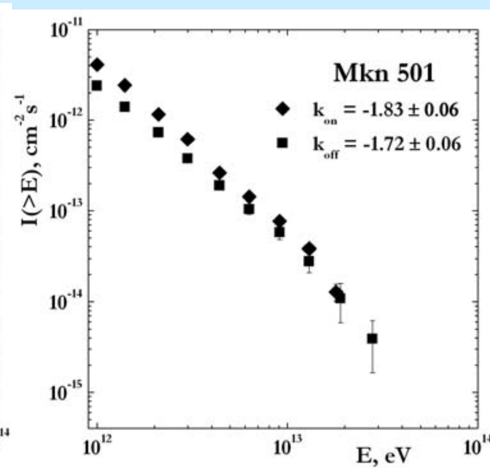


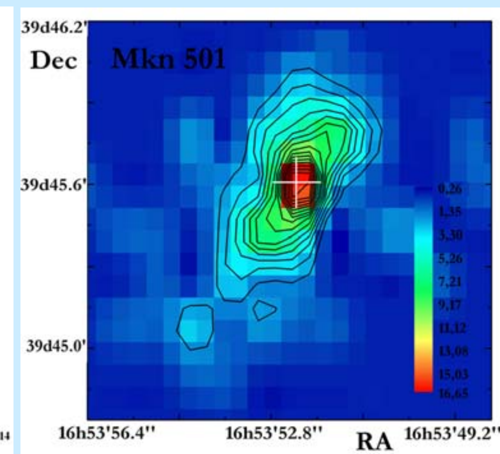
Markarian 501

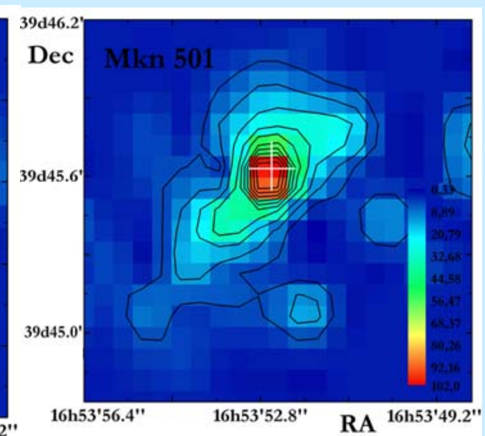


The detection of Mkn 421 as metagalactic VHE gamma-ray source initiated a search for VHE emission from several other active galactic nuclear of blazar type. This led to the detection of BL Lac object Mkn 501 (z = 0.034) by Whipple in 1995. In contrast to Mkn 421, EGRET had not detected this source, as significant source of gamma rays. So Mkn 501 was the first object to be discovered by as gamma-ray source from the ground. As is seen from figure the SHALON results for this gamma-source are consistent with the data telescopes of Whipple, TACTIC, HESS, MAGIC. An image of gamma-ray emission from Mkn 501 by SHALON telescope is also shown. The integral average gamma-ray flux above 0.8 TeV was estimated as $(0.86 \pm 0.13)\times10^{-12}$ cm^{-2}s^{-1} and the power index of the integral spectrum is $k_\gamma = -1.85 \pm 0.11$. The significant increase of Mkn 501 flux was detected in 1997 with the VHE ground telescopes all over the world. The integral gamma-ray flux in 1997 and 2006 by by SHALON telescope was estimated as $(1.21\pm0.13)\times10^{-12}$ cm^{-2}s^{-1} and $(2.05\pm0.23)\times10^{-12}$ cm^{-2}s^{-1}, respectively that is comparable with flux of powerful galactic source Crab Nebula.

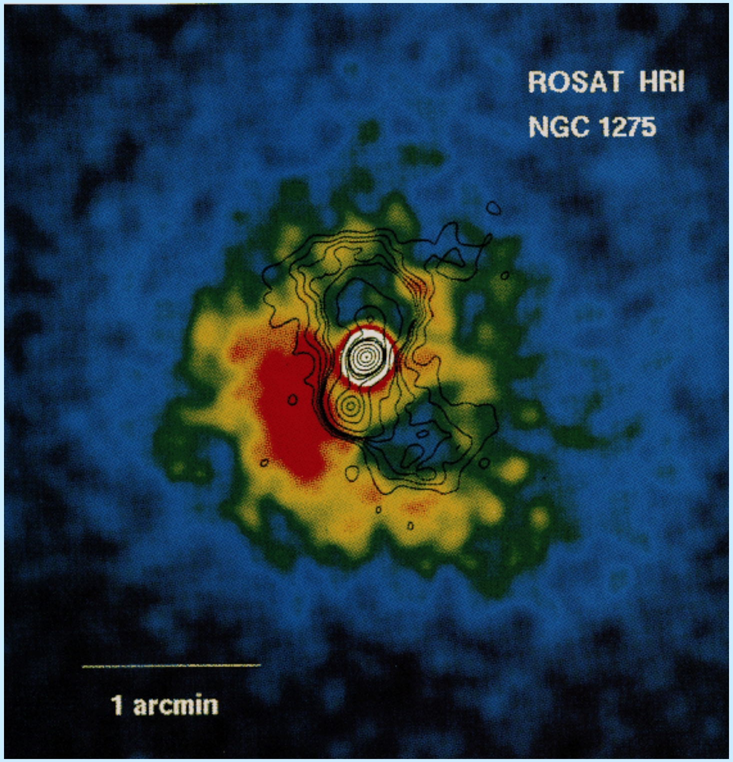




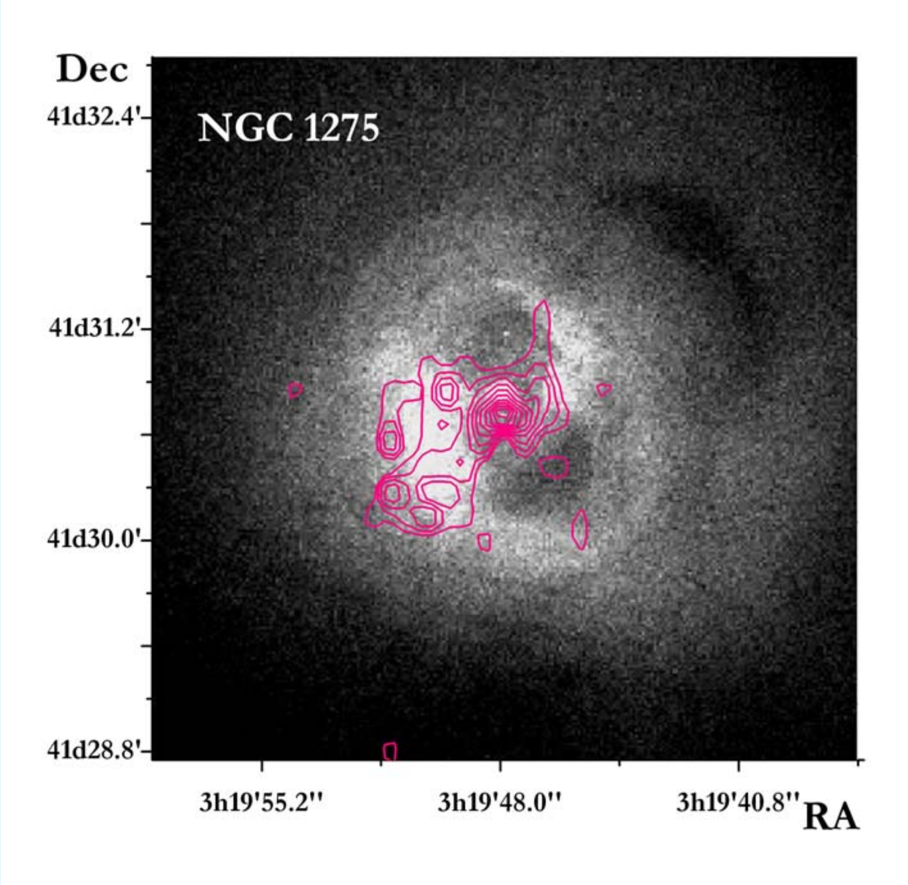




NGC 1275

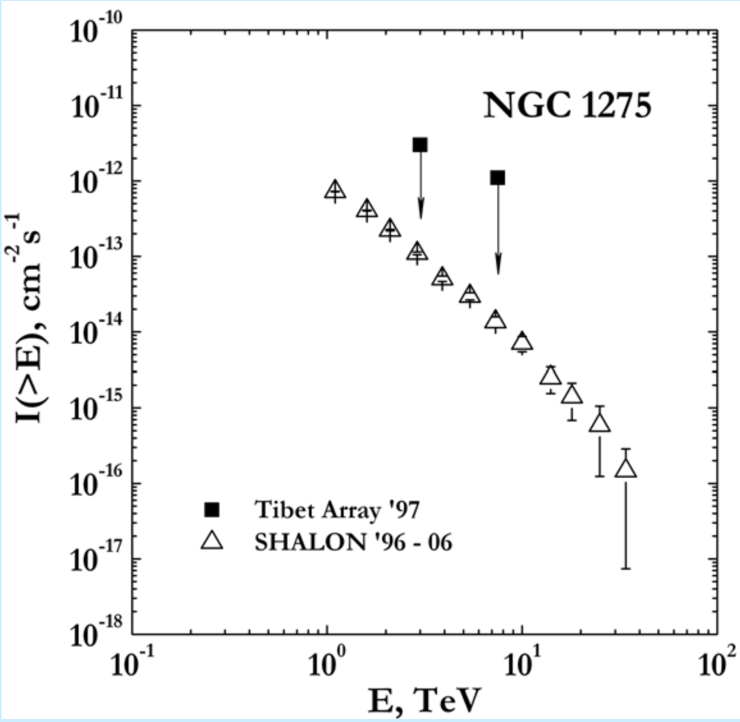


A ROSAT HRI image of the region around the galaxy NGC 1275 at the centre of the Perseus galaxy cluster. The contour lines show the radio structure as given by VLA observations. The maxima of the X-ray and radio emission coincide with the active nucleus of NGC 1275. In contrast, the X-ray emission disappears almost completely in the vicinity of the radio lobes.

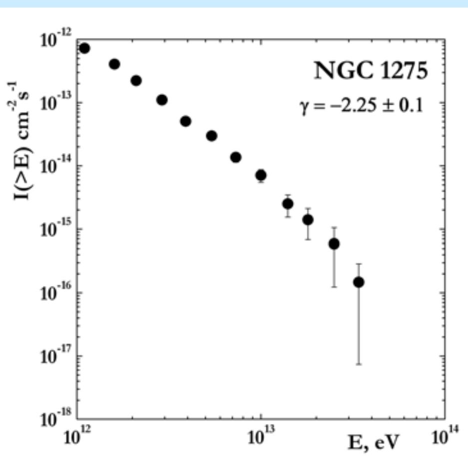


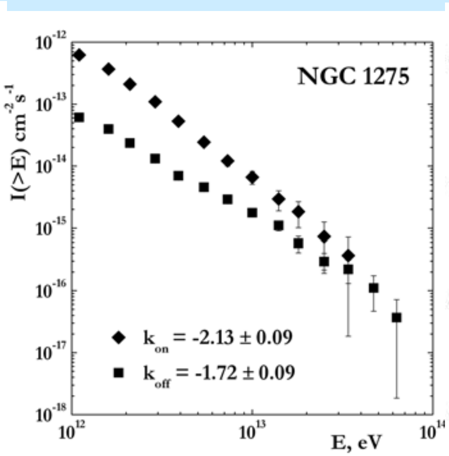
A Chandra X-ray image of NGC 1275 at the centre of the Perseus galaxy cluster. The contour lines show the TeV - structure by SHALON observations.

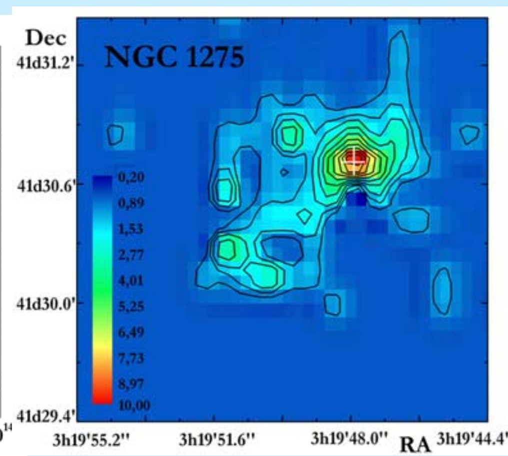
NGC 1275

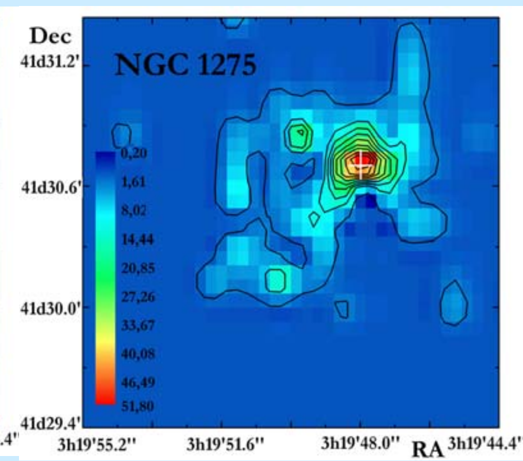


In 1996 year a new metagalactic source are detected by SHALON in TeV energies. This object was identified with Seyfert galaxy NGC 1275 (with redshift z=0.0179); its image is presented. The integral gamma-ray flux for this source is found to be $(0.78\pm0.13)\times10^{-12}$ cm^{-2}s^{-1} at energies of > 0.8 TeV. The energy spectrum of NGC 1275 at 0.8 to 20 TeV can be approximated by the power law $F(>E_O) \propto E^{k\gamma}$, with $k_\gamma = -2.26 \pm 0.10$. The spectra of events satisfying the selection criteria (spectral index $k_{ON} = -2.05 \pm 0.09$) and of the background events observed simultaneously with the source (spectral index $k_{OFF} = -1.75\pm0.08$) are both shown in Figure below for comparison. The Seyfert galaxy NGC 1275 has been also observed with the Tibet Array. The flux increase was detected from the region NGC 1275 in autumn 2006. The detailed analysis of gamma-shower direction turned out the detection of metagalactic object. This object was identified with the supernova SN 2006gy that is about 10 minutes away from NGC 1275. The integral gamma-ray flux for SN 2006gy is found to be $(3.71\pm0.65)\times10^{-12}$ cm^{-2}s^{-1} at energies of > 0.8 TeV.









Source	z	k_γ	k_{ON}	k_{OFF}
NGC 1275	0.0179	-2.25±0.10	-2.13±0.09	-1.72±0.09
SN2006 gy	0.019	-3.13±0.27	-2.54±0.16	-1.73±0.11
Mkn 421	0.031	-1.87±0.11	-1.85±0.10	-1.76±0.09
Mkn 501	0.034	-1.85±0.11	-1.83±0.06	-1.72±0.06
3c454.3	0.859	-0.99±0.10	-1.13±0.08	-1.71±0.08
1739+522	1.375	-0.93±0.09	-1.10±0.08	-1.71±0.08

- According to our analysis, the energy spectra of distant quasars 3c454.3 and 1739+522 differ from those of the known blasars Mkn 421, Mkn 501 and Seyfert Galaxy NGC 1275. Hence, the average energy spectrum of these nearest metagalactic sources differs from spectra of remote objects 1739+522 and 3c454.3 within the energy range 10^{12}-10^{13} eV. This observation does not contradict to unified energy spectrum $F(>E_\gamma) \propto E_\gamma^{-1.2\pm0.1}$.
- Another problem arises when one collates the gamma-ray energy releases of the galactic and metagalactic sources. The power of metagalactic sources exceeds that of the gamma-sources from our Galaxy by 10^8. The most distant currently known source 1739+522 is about 10^{11} times more powerful than the full gamma-emission from all known sources of our Galaxy! Thus, the modern gamma-astronomical observations put forward the two key questions: (1) what mechanisms might be responsible for the currently observed gamma-ray fluxes from the remote metagalactic sources? (2) which processes compose the uniform cosmic – ray spectrum close to the power law $dF/dE \propto E^{-2.72\pm0.01}$ over the wide energy range from ~10^{11} to 10^{19} eV and distinctly different from the harder energy spectrum of the powerful metagalactic gamma-emitters?
- Unlike a spectrum of cosmic protons and nuclei, the energy spectrum of gamma-quanta is hard, $F_\gamma(E_\gamma)dE_\gamma \propto E_\gamma^{-2.2}dE_\gamma$. This lead to a rather small contribution of gamma-quanta to the total flux of cosmic ray with energies ≥6 ×10^5GeV. But in the energy range of GZK cutoff, the contribution of gamma-quanta grows up to 20% of the total cosmic-ray flux. It is possible that the gamma-spectrum is not changed up to super-high energies and thus it carries a unique information on super-high-energy processes in the Metagalaxy. All the above-mentioned put a further development in experimental gamma-astronomical researches and in observational methods for gamma-quanta of energies 10^3 - 10^9 GeV to the list of the most important physical problems.