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# Observation of shower excess from the discrete source of Cygn X-3 .

**A.A. Novalov**
*Institute of Physics, Georgian Academy of Sci., 380077 Tbilisi, Georgia*

**Abstract**

The results the observations of discrete Cygnus X-3 source are given in the work in the energy range of $E_0 > 0.5*10^{14}$ eV of the particles of initial cosmic radiation by extensive air showers (EAS) method. The analysis of the obtained materials has shown the presence of excess of shower numbers coming from Cygnus X-3 cell (RA = $20^h\ 31^m$ ). Phase analysis of showers from this cell proved the presence of significant peak on 0.4-0.6 phase at orbital period $P_0$ = 4.8 h.

The distribution of right ascension (RA) of cascades with anomalously large length of absorbtion observed by ionization calorimeter of the installation is also described in the work.

## 1 Introduction:

Radiation from the discrete X-ray Cygnus X-3 source, which is double system consisting of the neutron star and pulsar rotating round it was discovered for the first time in satellite measurements in 1966 [1].This source, being one of the most bright in the X-ray range, has 5 periods of 4.8 hours,19 days, 34.1 days , 328 days and 12.6 msec. In X-ray range Cygn. X-3 was observed practically in all satellite experiments in the energy range of 1 - 400 KeV. The most detailed data were obtained on satellite Ariel 5,HEAO1, orbital stations "Einstein" and Exosat.

$\gamma$ - radiation from Cygn X - 3 in the energy range $E_\gamma \geq 10^{12}$ eV was recorded in 1972 [2]. Photon flux in the energy region $E_\gamma > 40$ MeV was equal to $F_\gamma = (6.4\pm2.7)*10^{-5}$ photon/(cm$^2$ sec). Using radio- and $\gamma$-data it becomes possible to estimate the distance up to the source; it was equal to ~ 13 kps. From these data the source radiance in $\gamma$ - range was estimated as $L_\gamma = 10^{37}$-$10^{38}$ erg/sec, being the significant part of radiance of the whole Galaxy in $\gamma$ - rays. The following measurements on SAS-2 satellite have proved the existence of pulsed radiation with the period of 4.8 hours from Cygn X-3, however the measured flux turned out to be ~ 3 times less as compared to the above mentioned flux[3].

The use of terrestrial installations for investigation of EAS for the problem of 100 TeV $\gamma$ - astronomy was begun with the information on registration of $\gamma$ - radiation with $E \geq 10^3$ TeV energy from Cygn X-3 source of Kiel installation in 1983 [4]. Despite a great number of advantages of EAS method it has some disadvantages as well. For example, disadvantage of EAS installations was a small area of muon detectors not allowing to separate effectively pure electromagnetic showers from their total number. Nevertheless, the investigation of point sources by EAS method was carried out practically on all installations recording EAS.

## 2 Observation

The given work is carried out on Tskhra-Tskaro installation with geographic coordinates ($\varphi = 41^\circ 41'$ of n.l. and $\lambda = 43^{\circ\circ}\ 30'$ e.l.). The installation was located at 2500 m. altitude or 760 g/cm$^2$ of atmosphere. At the level of Tskra-Tskaro observations EAS of $E_0 \geq 10^{14}$ eV are most developed ($S \cong 1.$) facilitating the record registration and identification of showers. This fact stimulated the observation of discrete sources in 1986, 1987 and 1991. Three EAS components - electron-photon, hadron and muon - were recorded by the installation [5].

The installation consisted of the following detectors: ionization calorimeter (I.C) of 500 g/cm$^2$ depth, shower detector and trigger system of scintillation sensors with the hard selection of events (T.S) located above the geometric center of I.C. The level of trigger system discrimination haring area of $S_1$ = 0.75 m$^2$ corresponded to the passage of EAS core of $E_0 \geq 10^{14}$ eV through T.S. As calculations carried out by Monte-Carlo method have shown, the recording of EAS cores was made with the probability P = 0.95 and with the accuracy up to 1 m for determination of the core position.[5,6]. Trigger system was switched in coincidence with scintillators layer of I.C. with the area $S_2$ = 3.m$^2$. Thus, for EAS vertical flux the aperture of obtained detector set was:

$$S\Omega = S_1 * S_2/h^2 = 0.75*3/100 = 0.0075\ m^2*ster.$$

The level of discrimination of scintillators layer of calorimeter was chosen to be sufficiently low corresponding to passage of 1- 3 relativistic particles through the layer. At such geometry of sensors and under master conditions, detectors separate EAS cores falling at the solid angle $\vartheta$ =12$^\circ$, i.e the installation records predominantly the vertical showers. Under such conditions the frequency of shower recording was 3 event/hour.

Total number of particles in a shower was determined according to the data of shower detector and spark chambers. The ionization calorimeter recorded the absence and presence of hadrons in EAS composition, energy and shape of electron-nuclear cascade. In this paper the data obtained on the installation in 1975 and 1977 y. were also presented. The relative aperture of the installation (1975-1977) was $S\Omega$ = 0.5 m$^2$ster. The detailed description of the installation of those year can be found in [7,8]. The data of the material obtained on the installation are given in Table 1.

Table 1.

| Year | Exposure time (days). | Exposure time (hour) | Numb. of recorded showers. | Number (event/hour) |
|---|---|---|---|---|
| 1975 | 32 | 768 | 1477 | 1.923 |
| 1977 | 129 | 3096 | 4663 | 1.506 |
| 1986 | 17 | 408 | 927 | 2.272 |
| 1987 | 14 | 336 | 1170 | 3.482 |
| 1991 | 8 | 192 | 518 | 2.637 |
| Total | 200 | 4800 | 8755 | 1.824 |

At the same time the contribution of local events to the general statistics is ~ 20%.
The contribution of events with anomalous cascades to calorimeter is ~ 25%.
The contribution of events with normal cascades to calorimeter is ~25%.

## 3 Data analysis

Treatment of obtained data reduces to the following for each recorded shower during its registration the local sidereal time LST was determined. Further, using the strip method the shower distribution according to LST or RA was plotted. The data obtained by years of observation are given in Table 2.

For 1987 the background was determined in the whole strip of RA. The data of 1986 did not show the direct excess of shower number in Sign X-3 cell. Obtained distribution is shown in Fig 1. Histogram 1 is the shower distribution according to RA on the basis of the whole statistics by all years of observation. Histogram 2 is the distribution according the whole statistics of 1987 and histogram 3 is the distribution of anomalous events according to RA. As Fig 1 shows histogram 2 has several peaks with the excess above the background (17 events) not more than 1.5 $\sigma$ for the intervals 17 - 18 RA (direction to the center of Galaxy RA = $17^h\ 50^m$). Further, the phase analysis of 4.8-hour orbital period was carried out by the well-known method for all showers fell in the Cygn X-3 cell using ephemerides $T_0$ = 2 440 949.8965 JD, P = 0.199 683 d, taken from [9].

Table 2.

| Year | The interval of continuos observation (LST). | Shower number in Cygn X-3 cell. | Background by interval. | Excess above background in ($\sigma$ - unit). |
|---|---|---|---|---|
| 1975,1977 | 18 - 23 | 134 | 120 | 2.1 |
| 1987 | 0 - 24 | 58 | 50 | 1.2 |
| 1991 | 18 - 23 | 34 | 24 | 3.1 |

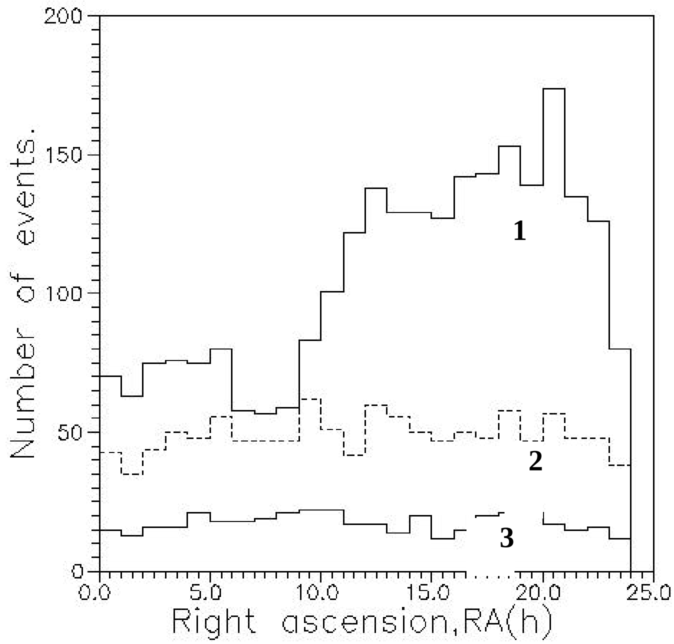


**Figure 1:** Analysis of showers by the angle of right ascension

## 4 Results

The results of phase analysis of 4.8 hour period are given in Fig 2. (curve 1 ). It shows that particularly pronounced peak on 0.4 - 0.6 phase is observed on phase diagram. Curve 2 is the results obtained on satellite Exosat [10]. As the Fig 2 shows the histogram of event numbers in phase and the curve of the rate of photon counting in satellite experiment are in good agreement with each other.

In ionization calorimeter we observed the "normal" cascades, i.e cascades not falling outside the lower limit of the calorimeter and "anomalous" cascades, in which ionization increase is observed in the lower third part of the ionization calorimeter. These cascades fall outside the limit of calorimeter.

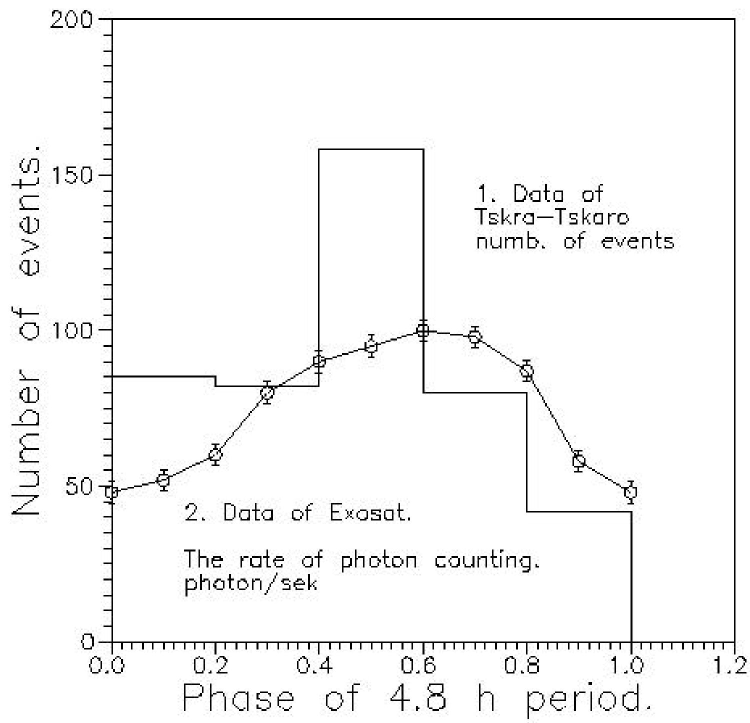


**Figure 2:** Phase analysis of showers from Cygn. X-3 cell.

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