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# PERFORMANCE OF "GAMMA-1" TELESCOPE IN FLIGHT

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The "Gamma" satellite [1] was launched by "Soyuz" rocket on July 11 of 1990 to the circular orbit with an altitude about 450 km, inclination 51.6$^{o}$ and period 92 minutes. The satellite was specially designed to carry "Gamma-1" telescope [2,3] intended for the investigation of cosmic gamma radiation with energies higher than 50 MeV. The very first turn on of the telescope on July showed an absence of high voltage power supply on the spark chambers, caused by a failure of primary 27 V tension circuit at the input of spark chamber electronics. There were no ways of restoration and as a result instead of the gamma-telescope we found in our disposal a gamma-spectrometer with large sensitive area and 25$^{o}$wide field of view. All the detectors and electronics of the spectrometer performed normally except the second strip of the counter SN which decreased its efficiency causing a reduction of the spectrometer sensitive area by ≈ 10%.

At these conditions one could use two methods to distinguish cosmic gamma-radiation: "on-off the source" method or time analyses for the sources with known time behavior. The former one hardly could give good sensitivity because of different rigidity conditions during "on" and "off" pointings. Therefore a program of observations was concentrated on variable sources like Vela pulsar, Crab pulsar, Cyg X3, Her X1, Geminga and so on. The Sun in periods of high flare activity was considered as potential target and special procedure of urgent pointing to the Sun was added to the onboard computer program. It was also decided to pay more attention to the investigation of cosmic ray electrons in the magnetosphere and the experiment data bank was modified for this purpose.

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Regular observations began in the middle of August. All the observation procedure was driven by the onboard computer. According to the loaded from the Earth coordinates of the targets to be observed it calculated periods of visibility and proper attitude of the satellite. The computer commanded the reaction wheels to perform necessary rotations of the satellite and at calculated moments it was turning on and off the scientific equipment. Twice a day it conducted special calibration sessions for the scientific equipment.

Limitations on the source visibility were the following: the telescope longitudinal axis was to be more than $25^{o}$ apart of the Earth horizon, more than $60^{o}$ from the Sun and more than $20^{o}$ from the Moon. The last two limitations were necessary for normal performance of the stellar sensor "Telezvezda" which allowed to restore an actual position of the telescope axes at the instant of the event (the telescope triggering) with an accuracy about 3 angular minutes. The first limitation led to maximal source visibility time 42 minutes per orbit that is 45% of the flight time. To increase the efficiency of the flight time utilization a mode of two targets observation was worked out. In this mode after the end of the "main" target observation the satellite was being slewed in 10 minutes to the "secondary target". Time to time the "secondary target" observation had to be omitted for a gravitational compensation of the torque accumulated by the reaction wheels. This mode allowed to have 65÷75% of useful time depending on relative position of the targets, the Sun and the orbit plane. The viewing program for the first year of flight is given in fig. 1.

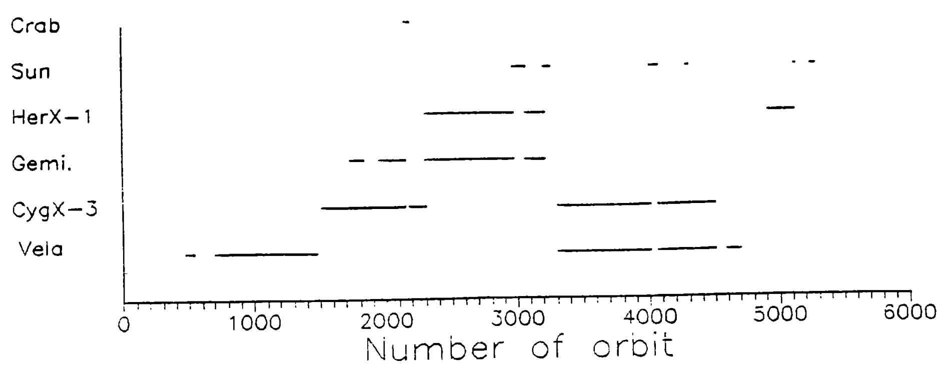


**fig.1**

A year of flight showed high reliability and stability of the performance of all the telescope detectors and electronics. No spare electronics was used. Fig.2 shows results of inflight calibration of four sections of the energy detector - scintillation calorimeter. In fig. *a*, *b*, *c* and *d* mean amplitudes from the relativistic protons are depicted, and fig. *e*, *f*, *g* and *h* display time variations of ADC response to two standard probe pulses. It is seen that during 4300 orbits that is 9 months of flight only the third section noticeably, by 20%, decreased its mean amplitude. This can be easily taken into account in data treatment.

One of the most important characteristics of any gamma-telescope is its ability to select gamma-events from all the events induced by the cosmic ray charged particles. An absence of the spark chambers



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information made it impossible to use the most powerful selection criteria - an appearance of a "picture" in the spark chamber corresponding to the photon conversion into electron-positron pair in one of the chamber electrodes. Nevertheless the composition of the telescope detectors and logic of gamma-trigger allowed to provide sufficiently high fraction of cosmic gamma-quanta among all the registered events.

If one uses all the events with no additional selection to evaluate the Vela pulsar light curve the pulsed fraction contains 6% of all the events. Taking into account that in the wide field of view of the telescope there is a part of Galaxy disk adjacent to the pulsar it is easy to find that at least 10% of all the events correspond to real cosmic quanta. Application of additional selection criteria in data treatment like demands of "two particles" signal in SV counter, signals in opposite strips of SV and SN counters and latitude limitation by 40° allows to increase the pulsed fraction to 25% at the expense of exposure reduction by factor of 2.3.

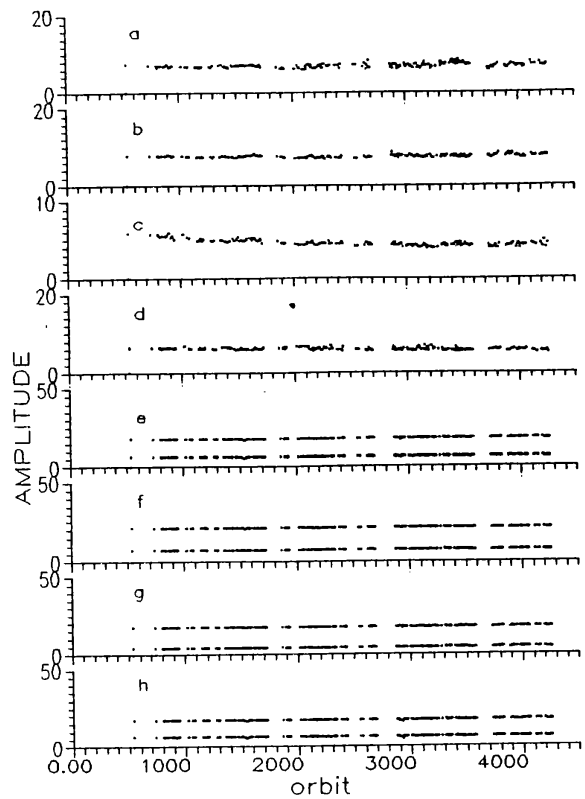


**fig.2**

The fact that demand of two particles in SV counter significantly improves signal to noise ratio gives a hint that important part of the background events are born by charged particles missed by anticoincidence counters. Another part of the background arises obviously from the gamma radiation locally produced by charged particles in the material of the satellite and the telescope itself. But for low energy events there is a specific source of background which is worth to be discussed: a decay of muons stopped in the material inside the anticoincidence dome. If a delay between an entrance of the muon into the spark chamber volume and the decay is longer than veto signal the decay electron can mimic a gamma-event. To avoid significant dead time the veto signals in the telescope were made quite short (150 ns that is much shorter than muon decay time), but special delayed coincidence system was introduced to investigate this effect. Any signal in surrounding the spark chambers counters initiated a sequence of pulses $\tau_1 \div \tau_5$ of which $\tau_1 \div \tau_3$ were 1 $\mu$s long and $\tau_4$ and $\tau_5$ were 2 $\mu$s long. Every trigger M was checked for coincidence with the pulses $\tau_i$ and tags $M x \tau_i$ ($i = 1 \div 5$) could be read in the format describing the event.

Fig. 3*a* shows a dependence of a fraction of the events with any tag $M x \tau_i$ on apparent energy. Fig. 3*b* shows probability of different delays



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normalized to 1 $\mu$s for apparent energies less than 100 MeV and more than 200 MeV. All the data in fig. 3 can be explained by 60% of muon born events at low energies and 6 KHz counting rate of the detectors surrounding the spark chambers. (It is worth to mention that without the spark chamber data an energy resolution at low energies is very poor, it is why one dose not see sharp high energy cutoff in fig. 3a). So important role of muon decay in the background formation at low energies should be taken into account in the future gamma-telescopes design and data analysis.

A year of flight showed that "Gamma"-type satellite can be efficiently used for astrophysical experiments and "Gamma-1" telescope can (in spite of the absence of spark chamber data) give new information about variable gamma sources and the Sun, some of which is presented at this Conference.

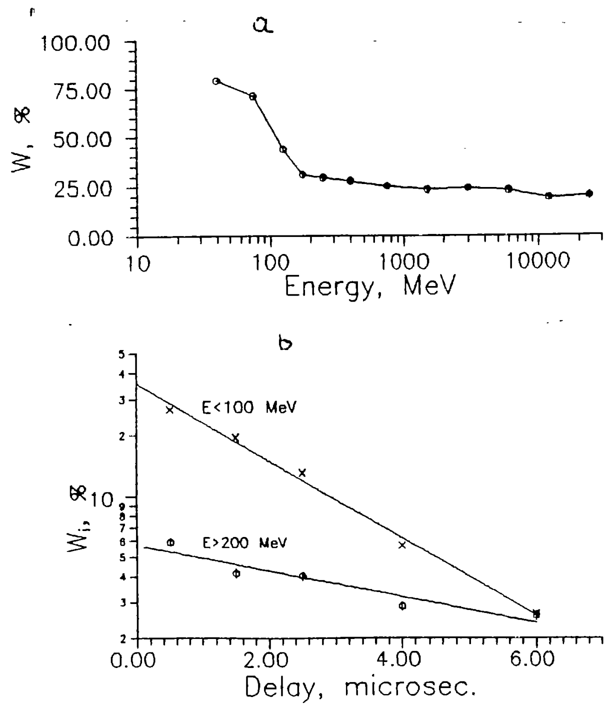


fig.3


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