THE GAMMA-RAY TELESCOPE GAMMA-1

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ABSTRACT

French and Soviet specialists have designed and built the gamma-ray telescope GAMMA-1 to detect cosmic gamma rays above 50 MeV. The sensitive area of the detector is 1400 cm^2, energy resolution is 30% at 300 MeV, and angular resolution 1.2° at 300 MeV (and less than 20'arc when a coded aperture mask is used).Results on calibration of the qualification model and Monte-Carlo calculations are presented.

1. Introduction. SAS.II, then the long-lived COS-B, have shown the interest of high-energy gamma ray astronomy. Numerous point sources have been found, but identification with physical objects has been possible for only a few of them. The first objective of the GAMMA-1 experiment was to increase the sensitive area, and lower the angular resolution of a gamma ray detector. A wide gap spark chamber, tested at DESY in 1976 (1,2), showed that it was possible to obtain better than 2° angular resolution with this technique.

However, in order to still increase this resolution, a model of coded aperture mask was developped (3). In a spark chamber, image deconvolution is performed not only by position detectors,but also by taking into account the rough (<3°) arrival direction information. The addition of this mask, and the complexity of the experiment itself, resulted in some delay over the initial launch date.

2. The experiment. The Gamma-1 telescope is illustrated on Fig.1. The main detector is a 50X50 cm ,12-layered wide gap spark chamber. It is shielded with lateral and upper anticoincidence,inside and outside the satellite skin. A time of flight (SV + SN) can veto upgoing particles,

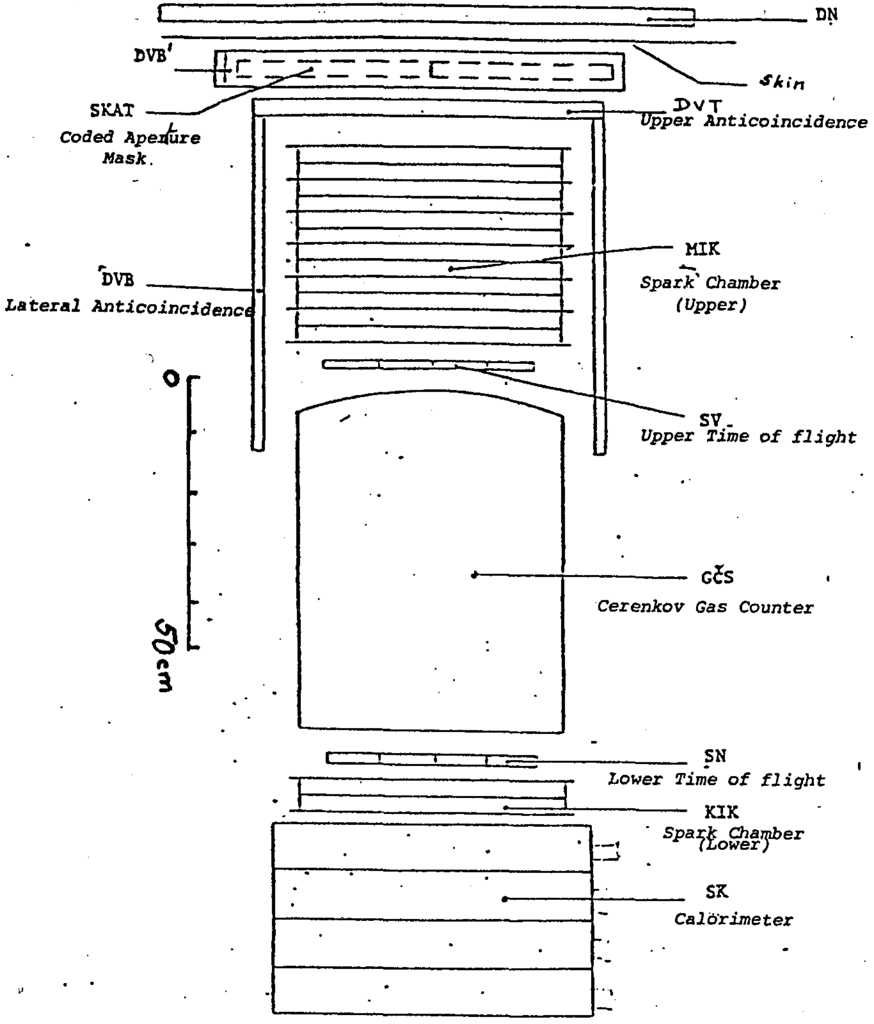


Fig. 1

THE GAMMA-1 EXPERIMENT

in reduddance with a Cerenkov gas counter. A two layered spark chamber below the SN counter is helpful when the very high energy electron-positron pair cannot be separated in the upper chamber.

To measure the energy, scattering is used from 50 to 200 MeV, and a four-layered-calorimeter is used above 100 MeV.

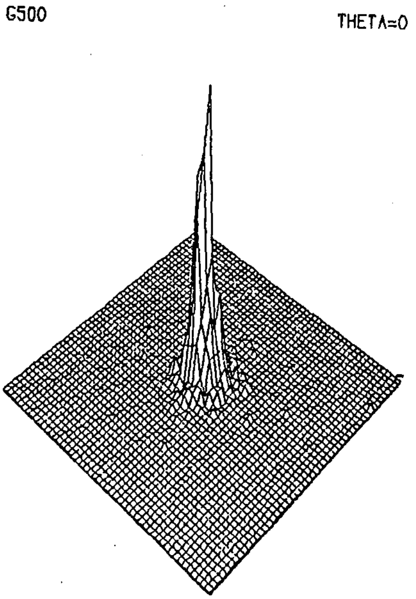
The spark images are viewed through an optical system by two orthogonal vidicon cameras and digitised before storage on a recorder. The 50 cm width of the chamber is divided in4096 points (localisation accuracy 0.125 mm). For each spark, there are three lines of sweep, separated by 17 mm; the width of each digitised spark is also recorded.

The dead time of the high voltage (24 KV) generator is less than 0.5 sec. Data from the vidicons, and from all counters, along with housekeeping informations, are dumped to the telemetry station twice a day.

The coded mask is made of two orthogonal one-dimensionnal arrays of 1cm-thick tungsten bar,each one covering half of the field of view, which can slide on or off the field of view of the experiment. The experiment can be put in many different modes by telecommands(for instance, recording of proton tracks to check linearity of the imaging system.) while the satellite is above the station.

3. Calibration. The qualification model has been extensively calibrated in the tagged gamma ray beam of the accelerator "Pakhra", near Moscow. The set-up of the beam has been described elsewhere (4), but Fig. 2 shows arrival directions of 1000 gamma rays on top of the chamber, on axis (bin size 1cm). FWHM is about 4cm.The energy resolution, from 30 to 700 MeV, is about 30 MeV, and the openning of the beam 2.5 mrad.

Fig.2

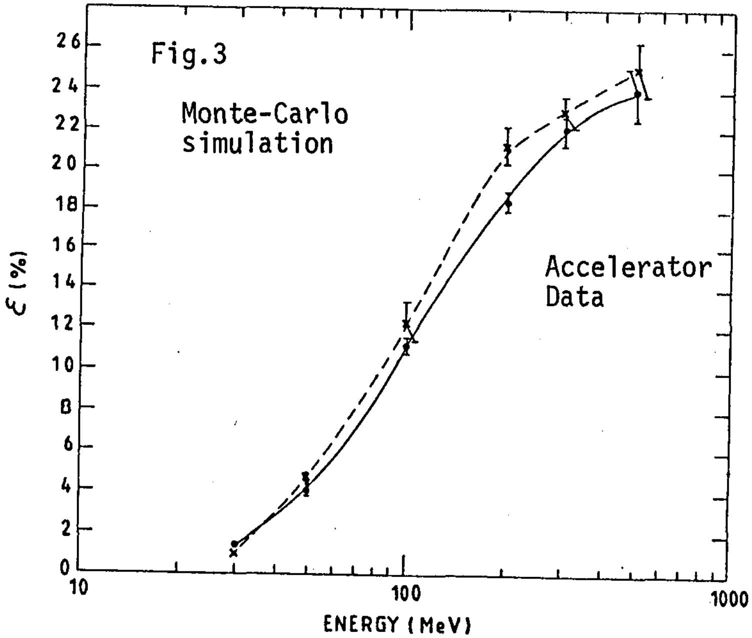


In parallel, Monte-Carlo calculations were performed, to check the actual response up to 700 MeV, and to be used as calibration above.

Figures 3 and 4 show the efficiency and angular resolution of the detector,without the coded mask. Energy resolution (as measured by the calorimeter), decreases from 95% at 50 MeV to 30% at 500 MeV.

Calibrations have also been performed using the mask. An exemple of correlation function at 300 M eV is given in Fig. 5. Bin size is 5' arc. The actual position of the beam was at -15'. Reconstructed direction is (-10 ± 5)' arc, with a FWHM of 28'.

Such a figure may seem high, but when one takes into account the angular width of the beam itself, the FWHM is less than 15' of arc.



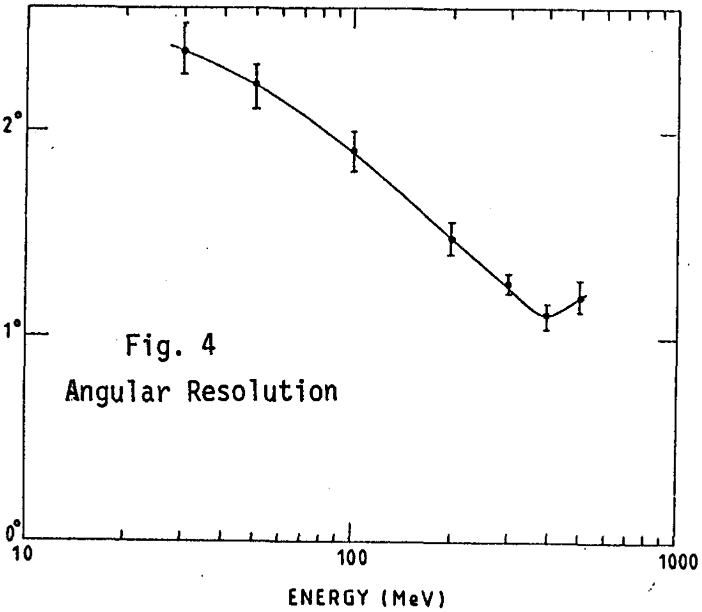


Fig. 4
Angular Resolution

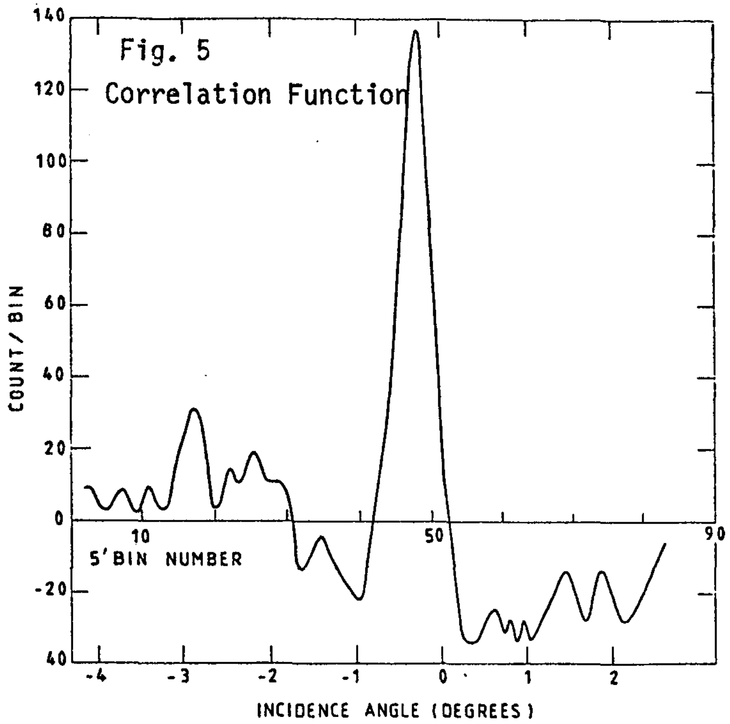


Fig. 5
Correlation Function

4. Conclusions. The calibrations performed on the qualification model of the Gamma-1 experiment , as well as calculations, have shown its potential in reconstructing gamma-rays directions. The use of a coded mask can give images with 15' arc resolution. Absolute celestial coordinates are obtained with the help of a stellar sensor with 5' arc accuracy.

Without the mask, upper flux limits of 10^{-7} should be detected within two weeks of exposure, using a sensitive area of 1400 CM^2 , and gamma rays within 10° of the axis.

Calibration of the flight model will be performed at the end of 1985, on a reduced program. Then, it will be integrated in a Salyut-type, 3-axes stabilised, satellite, to be launched in late 86 on a low-altitude orbit.

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