THE FIGARO EXPERIMENT FOR THE OBSERVATION OF TIME MARKED SOURCES IN THE LOW ENERGY GAMMA-RAY RANGE

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1. INTRODUCTION. The only two firmly identified galactic γ-ray sources in the second COS B catalogue (1) are the pulsars PSR 0531+21 (Crab) and PSR 0833-45 (Vela). Their spectra are rather similar in the medium energy γ-ray band, but differ drastically at lower frequencies. In the region between 100 keV and 10 MeV the detailed shape of the emission is particularly important, since one expects a turn-off which is related to the geometry of the source (2). A marginal evidence of such a turn-off just below 1 MeV has been reported for the Vela pulsar by Tümer et al. (3).

In order to study sources with a well marked time signature in this energy band, we have specifically designed the FIGARO - French Italian GAmma Ray Observatory - experiment (4), whose first version was launched in November 1983 from the Sao Manuel base (Brazil), and was destroyed in a free fall following a balloon burst at an altitude of 50 mbar. The available portion of the growth curve and the calibration data demonstrate that the effective area and the noise figure (extrapolated to the float altitude) were in accordance with the project goals, and indicate that the required level of sensitivity can indeed be reached (5).

In this contribution we give a brief description of the new improved version of the experiment, FIGARO II, which is nearly completed and whose launch is scheduled before summer 1986.

2. DESCRIPTION OF THE EXPERIMENT. FIGARO II is a wide angle γ-ray detector with a total geometric area of 3600 cm^2

of NaI(Tl), 50 mm thick. It is actively shielded from the atmospheric background by a lateral wall of NaI(Tl) tiles (25 cm high, 70 mm thick), and by a lower array of plastic scintillator blocks having a grammage of 50 g cm^{-2}. At variance with the first version, the main detector is square instead of rectangular, providing a more favourable ratio area vs weight; the lateral wall is higher by 5 cm; and the photomultiplier tubes of the nine detector elements are reversed, embedded within the bottom plastic, so as to have a field of view free of passive material, and to extend to lower energies the accessible spectral band.

The reduction of the geometrical area by about 13% does not affect appreciably the sensitivity of the experiment: in fact, it is very nearly compensated by the increased efficiency achieved with the PM's reversal, and by the lower noise contributed by the calibration source. In the new version, the gains of the individual detector elements are monitored with 511-keV photons from a very weak positron source (Na^{22} of about 40 nCi of activity), tagged by the companion photons emitted in the opposite direction, and detected on a small BGO crystal. An upper plastic shield 5 mm thick is used to anticoincide low energy charged particles. A schematic view of the complete payload (but not the BGO detector of the tagged source) is shown in Fig. 1.

Data from the nine detector elements are analyzed by a single 8 bit A/D converter, if there are no veto signals from the various anticoincidence sets. The anticoincidence window depends on the pulse height, and can be varied by telecommand. Qualified events are transmitted individually with a time resolution better than 0.05 ms; they are also cumulated onboard into 10 counters, and transmitted on a different telemetry channel every 2 ms. Signals which are tagged by a coincidence with the BGO crystal are sent separately, and analyzed in order to monitor continuously the gains of the individual amplifiers; these are corrected and equalized by telecommand, so that only one channel of A/D conversion is needed.

3. EFFECTIVE AREA AND SENSITIVITY. With respect to FIGARO I, this second version can be flown profitably at lower altitudes, with a safer heavy-load balloon, because of the improved performance at the lower end of the spectral window; furthermore, the spectral capabilities have been significantly increased with the adoption of the A/D converter. Both changes have been warranted by the low counting rate demonstrated by the Brazil flight.

On the other hand, the most critical experimental solutions have remained unchanged, so that we feel confident in modelling FIGARO II with the Monte Carlo code used successfully so far. Fig. 2 shows the total (▲) and photopeak (▼) effective area at a float altitude of 5 g cm^{-2} of residual pressure. The estimated sensitivity to a pulsed continuum, attainable in a five hour pass during a transmediterranean flight is reported in Fig. 3 for the same residual pressure; the numerical modelling of the γ-ray atmospheric background used in this computations has been described in detail elsewhere (6).

Apart pulsars, which remain our main target, all time-marked sources in this energy band such as hard-tail X-ray pulsators, solar flares and γ-ray bursts can be observed with a very high sensitivity by this experiment. For the γ-bursts, in particular, it will be very interesting the search for decaying periodicities during the event.

References

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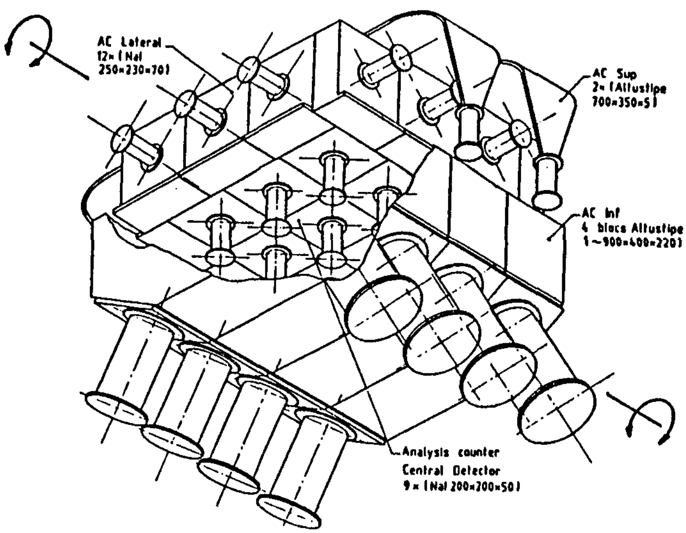

FIG.1

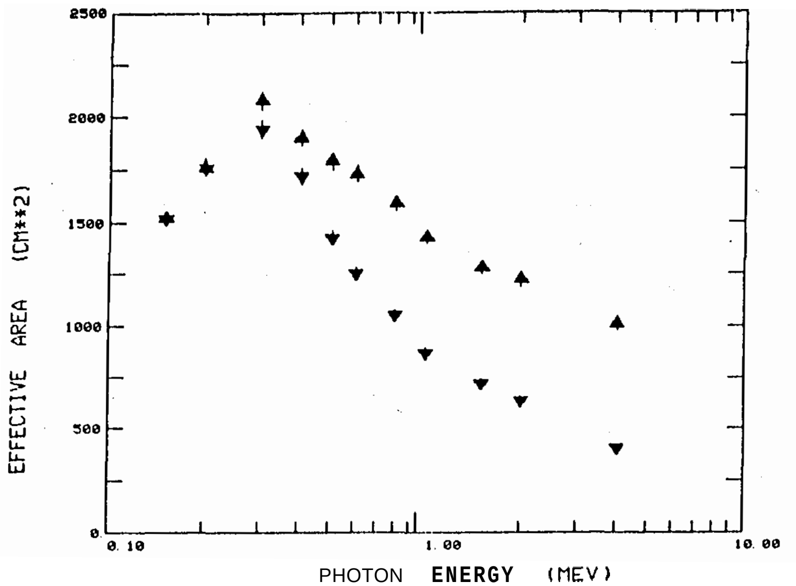
2500
2000
1500
1000
500
0
EFFECTIVE AREA (CM**2)
0.10
1.00
10.00
PHOTON ENERGY (MEV)

Fig. 2

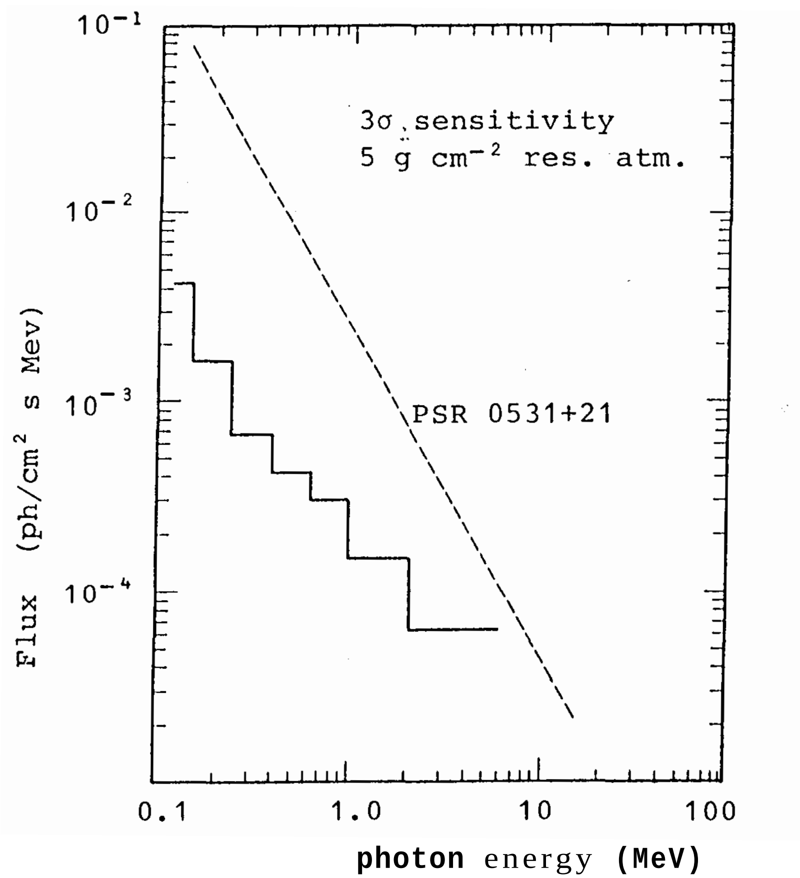
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Flux (ph/cm^2 s Mev)
3σ sensitivity
5 g cm^{-2} res. atm.
PSR 0531+21
0.1
1.0
10
100
photon energy (MeV)

Fig. 3