FIGARO IV: 16 SQUARE METER BALLOON BORNE TELESCOPE TO STUDY RAPID VARIABILITIES AND TRANSIENT PHENOMENA AT ENERGIES ABOVE 50 MEV.

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ABSTRACT

We present the design of a balloon borne experiment based on the Limited Streamer Tube technology as a tracking telescope to detect gamma rays above 50 MeV. This technique allows to obtain very large sensitive areas (16 m^2 in our experiment). Because of the capability to collect a large signal in a short time and of its good angular resolution (about 2° above 200 MeV), the telescope is highly competitive to study both periodic and random rapid variabilities of gamma-ray sources as well as to detect high energy gamma-ray bursts.

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INTRODUCTION

The recent observations and discoveries of the Compton Observatory focus our attention on the role played by rapid variable (periodic and random) and transient phenomena in Gamma-ray Astronomy.
-The discovery of the 237 ms pulsation in Geminga[1] and the identification[6] of 2CG 342-02 with PSR1706-44 together with the previous, and well established, knowledge of Crab and Vela pulsars grant the hypothesis that the galactic gamma-ray sources, or at least a large subset of them, are young pulsars.

-The finding of 3C279 [(3)] and other blazars at gamma-ray energies shows that also in the extra-galactic emission are present compact objects in which the variability is one of the main characteristics.

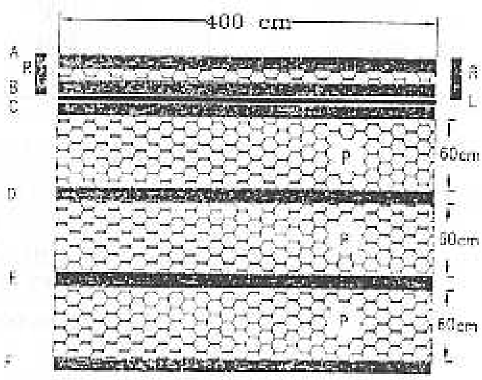
-The detection [5], on May 3,1991, of a burst by Egret at energy above 50 MeV urges the search for similar events.

The telescopes of the present generation, because of their limited collecting area and the long exposure time required to reach a significative signal, have difficulties to study these rapid phenomena. We propose a new gamma-ray telescope, operating at energies above 50 MeV, characterized for the very large collecting area. This telescope, called FIGARO IV, is based on the Limited Streamer Tube (LST) technology [4]. The present version (16 m^2 collecting area) is designed to fly on board of stratospheric balloons. The space qualification of the LST will allow their use in the future gamma-ray telescopes for satellites, space stations, and lunar observatories.

TELESCOPE LAYOUT

The gamma ray tracking detector proposed will use standard LST modified in order to assure the environmental working conditions of the balloon flights such as atmospheric pressure, temperature, and mechanical stresses.
Basically the telescope is composed of six planes of LST each one of dimensions 4m*4m with 4 units (4 tubes) forming a guard ring (R) around the first two planes; A, B and R constitute the anticoincidence system of the telescope to discriminate charged particles from photons (Fig. 1).

A lead converter (L), 2 mm thick, is placed between the B and C planes. C, D, E, and F, spaced 60 cm apart, track the electron-positron pair path.
The LST planes are supported by a honeycomb styrofoam structure (P) that assures the parallelism among the planes.
The read-out of LST is performed by two sets of strips with 1 cm pitch: one parallel to the tubes (X coordinate) and the other orthogonal to them (Y coordinate).



A chain of read-out electronics boards, placed on both X and Y sides of each plane, transfers the information on the track position into the data acquisition system.
Six separate H.V. channels (1 for each tube plane) will feed the LST, through a distribution bus.

Fig. 1 Telescope cross section: A, B and R are anticoincidence elements; L is a lead converter; C,D,E, and F are coincidence planes; P are styrofoam honeycomb boxes.

Table 1: Technical characteristics of FIGARO IV

Detector type	L.S.T. (1cm^2 cell)
Number of L.S.T. plane	6
Gamma-ray converter	Lead (2mm thick)
Geometric area	160,000 cm^2
Pick-up	Strips (1cm pitch)
Read-out channels	4800
Spatial resolution	0.5 cm
Telescope height	2 m

TELESCOPE SCIENTIFIC PERFORMANCE

The effective area and the resolution of the telescope as a function of the energy, as computed by a Montecarlo procedure for on-axis sources, are given in table 2). The decay of the effective area versus the off-axis angle is slow, for a source located at 20° off-axis the loss is about the 12% at 250 MeV.

Table 2: Effective area and angular resolution of the FIGARO IV telescope for on-axis sources.

Energy (Mev)	Effective Area (cm^2)	Resolution (degree)
100	23,000	3.5
200	29,000	2.2
300	32,000	1.6
500	32,000	1.2

We evaluated the sensitivity of the experiment by means of Montecarlo simulations taking in to account the cosmic and atmospheric background[2]. For a source transit of $2*10^4$ s, at a 4 mbar ceiling and a cut-off rigidity of 8 Gv we obtained the results of table 3). The minimum detectable flux at 3 σ ($0.75*10^{-6}$ ph cm^{-2} s^{-1}) corresponds to 0.2 of the Crab flux above 100 MeV .

Table 3: Visibility of gamma ray sources during a balloon flight of $2*10^4$ s , at a ceiling of 4 mbar and a cut-off rigidity of 8 Gv.

Source	Number of standard deviations
Vela	48
Geminga	20
Crab	14
$\Phi = 0.75*10^{-6}$ ph cm^{-2} s^{-1}	3

Figure 2 shows the capability of FIGARO IV to detect pulsed signals. The figure reports the number of standard deviations of the power (sum of the first four harmonics) for Geminga, Crab and 2CG342-02 The figure shows, also, the white noise power spectrum distribution obtained between 0 and 50 Hz. Other eight 2CG sources, if they are pulsars, have power values greater than the white noise fluctuations, and FIGARO IV is able to detect them without the need of any external input.

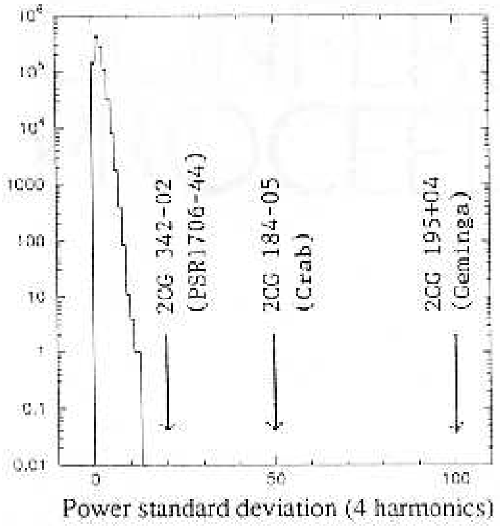


Figure 2: Comparison between the expected pulsed signal from the gamma-ray pulsar Crab, Geminga, and 2CG 342-02 and the white noise spectrum distribution expected for the sum of the first four harmonics between 0 and 50 Hz, in $2*10^4$s observation time of FIGARO IV.

GAMMA-RAY BURSTS

It is difficult to make extimates of GRB visibility because we know only the single event detected by EGRET. However, because of the high instantaneous sensitivity and wide field of view, a single day exposure of the FIGARO IV telescope may correspond to many EGRET observation days.

FUTURE PERSPECTIVES

Because of the large collecting area of the telescope it is impossible to provide it with a calorimeter system; photon energy can be derived by the pair opening angle and by the electron scattering. This technique is limited by the spatial resolution of the LST (1 cm). We are studying the possibility to improve the spatial resolution close to the converter plane up to a few mm.

REFERENCES

1. Bertsh D. L. et al., 1992, Nature, **357**, p. 306 .
2. Beuermann K.P., 1971, J. Geophys. Res.,**76**, 4291.
3. Hartman R.C. et al., 1992 , Ap. J. , **385**, L1.
4. Iarocci F. et al., 1983, N.I.M., **217**, 30-42.
5. Schneid E.J. et al.,1992, A. & A., **255**, L13.
6. Thompson D.J. et al.,1992, Nature, in press.