# AN IMPROVED TIME OF FLIGHT GAMMA-RAY TELESCOPE TO MONITOR DIFFUSE GAMMA-RAY IN THE ENERGY RANGE 5 MeV - 50 MeV

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Abstract

A time of flight measuring device is the basic triggering system of most of the medium and high energy gamma-ray telescopes. A simple gamma-ray telescope has been built in order to check in flight conditions the functionning of an advanced time of flight system. The technical ratings of the system will be described. This telescope has been flown twice with stratospheric balloons, its axis being oriented at various zenital directions. The results of these flights for what concern : diffuse gamma-rays, atmospheric secondaries, and various causes of noise in the 5 MeV-50 MeV energy range will be presented.

1. Introduction and motivation. Gamma ray telescopes for energies in excess of 10 MeV are mostly built around a track chamber in which photons are materialized by pair effect. Coordinates of track of an event is read if the veto counter above and on the sides of the chamber have not been triggered and if downward moving particles (supposed to be electrons) issuing from the bottom trigger a set of thin counters in coïncidence see (1) (2). This last set of two counters is usually named "time of flight" measurement since its purpose is to measure sense and duration of travel of the electrons across it and also to give a limit to the angular aperture of the telescope.

Nevertheless once looking at the tracks visually or with the help of some track identifying software one is left with only a few percent of "good events" among the initial trigger rate of the chamber. This fact leading to a waste of telemetry bit rate.

A second fact is the large number of upward moving events giving tracks stopping in the chamber or reflected backward and simulating pairs /1/. These events if not properly removed by the time of flight counters (T.O.F.) can plague the data. In order to improve the characteristics of a gamma-ray telescope designed for the energy range 5 MeV-50 MeV (3) (AGATHE experiment) we have undertaken to built a T.O.F. telescope with the double objective to improve its capabilities on a short T.O.F. path (57.5cm) but with realistic lateral dimensions (80x40cm) keeping in view to reduce the total dimensions of the telescope. In a second step we included this T.O.F. in a very simple gamma ray telescope and had it flown with a stratospheric balloon in order to monitor and try to explain various counting rate observed in balloon borne gamma ray experiments.

2. Description. The experimental set-up used in flight is shown fig. 1. It includes from the top :

1. An anticoïncidence counter plastic scintillator NE 102A with dimensions 85x45x1 cm.

2. A Tantalum target 0.03 cm thick the same thickness used in the Agathe telescope spark-chamber.
3. T.O.F. counters made of two sheets of NE 102A plastic scintillators with dimensions 80x40x0.5 cm placed at 57.5 cm separation.
4. We had at the bottom a 10 cm thick plastic scintillator calorimeter (85x45x10cm) made of Altustipe blue 155 manufactured by Altutor. This scintillator was used in various electrons beam for other purposes and proved to be linear far electrons up to 24 MeV for the 10 cm thickness. Photomultipliers were XP2020 for the AC and T.O.F., and XP 2041 for the calorimeter.

NIM electronic units were used for the fast electronics and ADC, and home made electronic circuits for housekeeping informations and interfacing with telemetry . The whole telescope could be rotated in flight at various zenit angles and stabilized in azimut. Basic events were defined by $\overline{AC}$+S1+S2 and T.O.F. value in a 50nsec window. The functionning of the T.O.F. measurement is based on the comparison with a Time to Amplitude Converter of the mean arrival time in S1 (upper T.O.F. counter) and S2 (lower T.O.F. counter). These mean arrival times on each counter were obtained by sending left and right signals in a very performing "Time Pick-off"circuit made by Schlumberger-Enertec and then both signals from the T.P.O. output in a "mean-timer" Lecroy.
The informations sent by telemetry were
- T.O.F. observed in the 50 nsec window, with 256 channels accuracy. The width of the window and the delay in S2 allowing to display upward and downward moving particles.
- Amplitudes in T.O.F. counter S1 and S2 obtained by mixing dynodes signal from left and right PM tubes and digitized in 256 channel ADC.
- Amplitude read in the calorimeter digitized in 256 channel the muon peak beeing in the channel 118.

3. Results. Fig.2 shows the T.O.F. spectra obtained at ceiling ( 4mb) for 0° zenit direction in AC ON and AC OFF configuration.
- T.O.F. spectrum : The first and second peak being respectively upward and downward moving events are very clearly separated when using particles see AC OFF at celing Fig. 2 a small displacement of the peaks toward greater time difference at ceiling can be explained by a much larger isotropy of arrival direction. When looking at gamma-ray T.O.F. (AC ON configuration) the separation is not so good and is probably due to the fact that pair of particles are reaching the lower T.O.F. counter at spatial distances not so negligible for the mean-timer compensation to be efficient. Nevertheless distinction between the two senses of travel is still very good and can be made of the order of $10^{-3}$ at the expense of a small loss of good events. Another noticeable fact that can be observed on the T.O.F. distribution AC ON is the great number of upward moving events a fact also noted with Double Compton Telescope although using very different thickness of material and neutral events selection. (5)
- Calorimeter. The spectra obtained for gamma-ray events (AC ON) at various zenit angle have been used with the efficiency curve for gamma-ray obtained by Monte Carlo computation to derive the atmospheric gamma-ray spectrum above 5MeV in these directions.

Preliminary result at 180° inclination which are useful in particular for satellite experiments (fig. 3) agree well with other experiment at same latitude but higher energies (4).

4. Conclusion. These preliminary results will be refined by making use of the full informations from the amplitudes and T.O.F.; and also given for other zenital direction monitored during the flights. A first explanation for what concern the discrepancy between trigger-rate and acceptable pictures from track chamber seems to be the large acceptance angle of the counter telescope for low energy gamma-ray. A way to improve this situation could be to locate the particles in the two T.O.F. counters in order to derive an estimate of the incoming direction. More or less sophisticated use of the amplitudes from left and right PM tube on each T.O.F. counter can bring very sensitive improvement (6), it could be used on our telescope at a very moderate cost.

References

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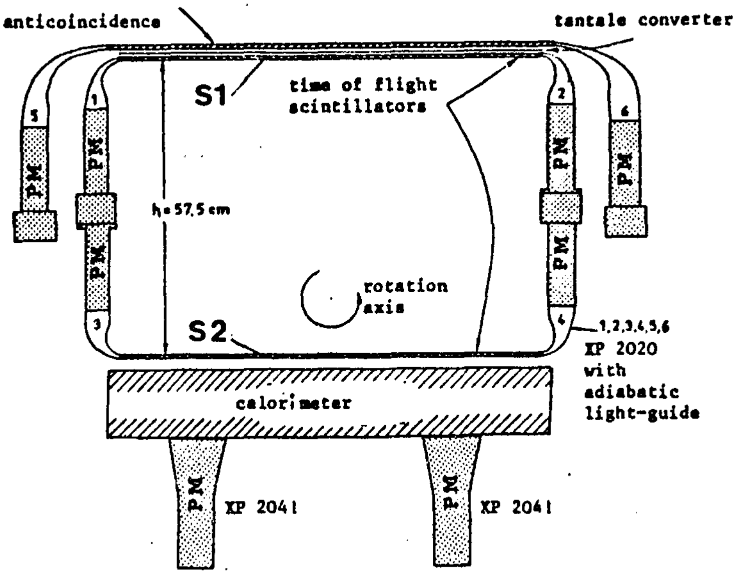


FIG 1

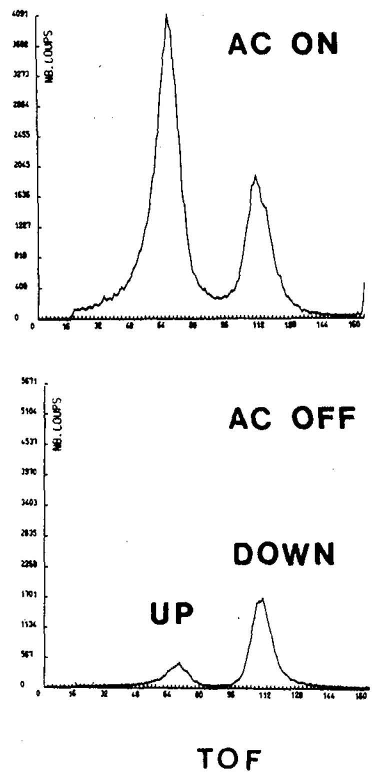


FIG 2

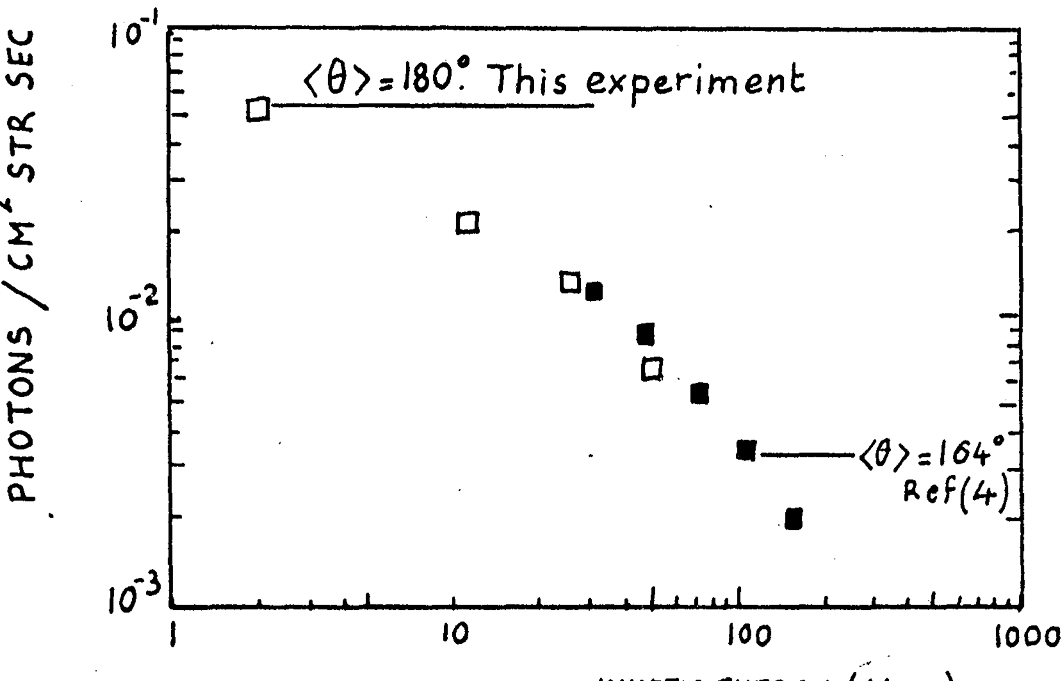


FIG 3