A SEARCH IN THE COS-B DATA BASE FOR CORRELATED TIME VARIABILITY IN REGIONS CONTAINING OBJECTS OF INTEREST.

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1.Introduction

The information on COS-B >100 MeV gamma-ray sources is contained in the second catalogue (Swanenburg et al. 1981) and its first amendment (Pollock et al.1985, and this conference), based now on the totality of the COS-B data base (Mayer-Hasselwander et al.1985 , and this conference).

As is well known, association of the gamma-ray sources with celestial objects is, in general, difficult on a pure positional basis, while correlated time variability could obviously provide such proof. This technique can be employed on regions of the gamma-ray sky containing interesting objects of known variability at some wavelength,even in the absence of a recognized gamma-ray excess ,with the aim to extract a weak but predictable signal from the surrounding noise.

Such an idea was used for the unsuccessful search for gamma-ray emission from radio pulsars in the SAS-2 and COS-B databases (see Thompson et al.1983 and Buccheri et al.1983).

Here it will be applied on a longer variability time scale, generally of the order of days : this is technically easier than the case of the rapid, sub-second pulsar search, but requires a more detailed treatement of the background.

It should be borne in mind that the $\sim$158,000 celestial photons (>100 MeV) collected by the COS-B mission in the 6 1/2 years of operation come with an average frequency of 5-6/hour. For a given direction in the galactic plane, in general only few hundreds photons (sometime less) are collected within the area covered by the instrument's point spread function for each $\geq$ 1 month-long observation. Most galactic regions have been observed repeatedly during the mission, at typically yearly intervals, thus allowing the analysis of several months of data in each case.

The celestial objects considered here have been chosen because they are either located in regions of enhanced gamma-ray emission (LSI 61.303, Cyg X3, Cir X1), or have been reported as UHE gamma-ray sources (Vela X1, Cyg X3 ; Her X1

and LMC X4 were unaccessible throughout the COS-B mission). All have some time variability law which was exploited here.
For the case of Cyg X3 only the long term (i.e. days to months) time profile was considered, the 4.8 hour periodicity search being the subject of separate work(Hermsen et al., this conference)

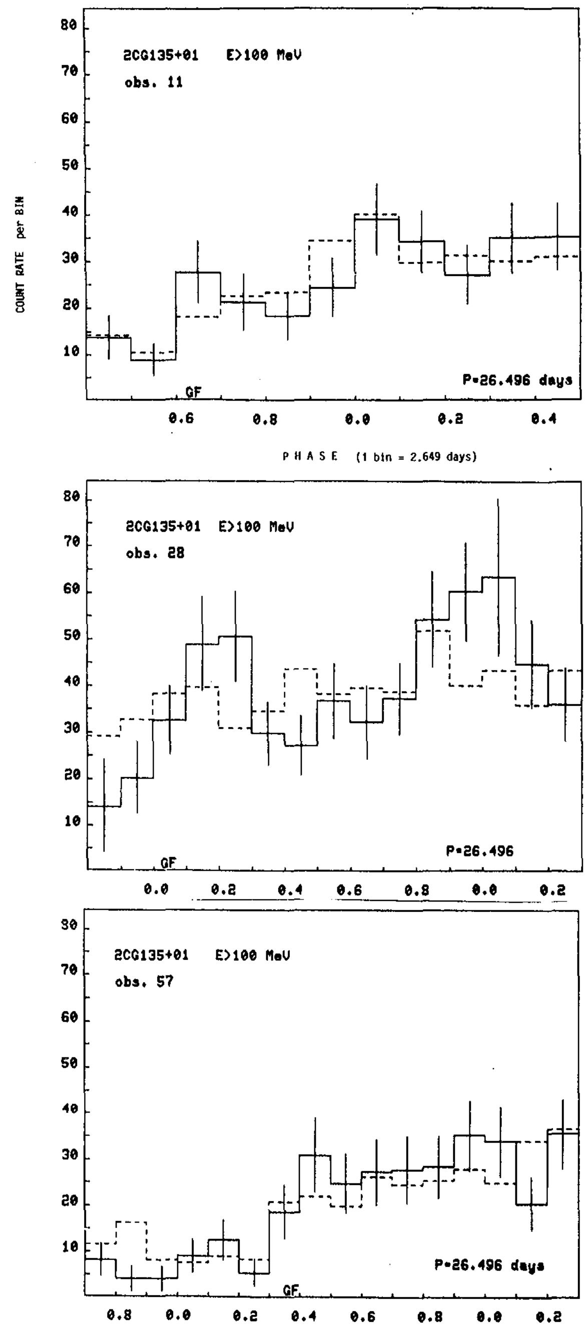
2. The Method

Photons coming from the sky regions centered on the various celestial objects considered were selected with energies > 100 MeV and with arrival directions within an energy-dependent area (see Buccheri et al., 1983), of radius $\simeq 6$ deg. at 100 MeV.
In order to construct a time profile of such photons , their arrival times were grouped in bins of dimensions defined by the available photons number and by the value of the period searched for. The binning process corrects for the experiment dead time, arising from various causes throughtout the mission.
To assess the significance of any apparent count variation in the "source" profiles, a comparison with the background data has been performed. This was done by constructing a profile for all the counts within the observing period ,minus the "source" photons, thus obtaining a measurement of the variations of the total background. In most cases this was seen to vary, sometimes significantly, responding possibly both to external causes (cosmic ray variations) or to internal ones (e.g. spark chamber gas flushing). The background count profile was then normalized to the source counts, and used as a reference distribution in performing a X^2 test of the source profile, to search for possible true time variability.
In order to obtain the evaluation of the method's sensitivity, simulations were performed by adding photons in given "source" profile bin(s) until a deviation judged significant by the statistical test was reached. The amount of flux thus introduced represents the minimum detectable flux variation for a given source and background conditions. However, the assumption on the duty cycle of the hypothetical gamma-ray emission is of critical importance: clearly a narrow pulse would render the detection much easier than the case were the same number of photons is spread over a large fraction of the phase.
Moreover, owing to fluctuations of source and background,the simulation results depend on the particular bin(s) where the increase is put. This aspect is taken into account by cycling the bin number(s). A simple example is given below.

3. Results

The data base used was the final COS-B Data Base, and Table 1 gives the relevant parameters for all the source directions investigated, including the results of the test. Fig.1 a,b and c illustrate the case of LSI 61.303 ,a periodic radio and optical star, and also an X-ray source, spatially compatible with 2CG 135+01.

The variability laws investigated have been observed at either radio, optical or X-ray wavelengths, and the search was triggered by the assumption that it was reasonable to expect them also in gamma-rays.



None of the objects listed in Table 1 can be identified as a gamma ray source on the basis of temporal variation.

The evaluation of the method's sensitivity through simulations could in principle lead to upper limits to the gamma ray flux which should be lower than those obtainable from the pure spatial analysis. However, the variable background conditions and the unknown duty cycles prevent the setting of firm upper limits. Taking Fig.1a as an example, increasing the count rate in only one bin (10% duty cycle) one has to add a count rate of 20 to obtain at least one $\chi^2 > 3$, and over 40 to have $\chi^2 > 3$ for every possible position of the increased bin. The situation is considerably worse for a 20% duty cycle, where the corresponding increase in count rate goes to 28 and 50 respectively. Of course , this does not take into account any prediction based on the radio phase nor a recurrence of the same "duty cycle" over several periods.

However, it is apparent that very big source variations (of over a factor of two, at least) are required to be detectable by COS-B.

Fig.1 COS-B count rates (>100 MeV) for the observation periods including the variable radio/X-ray star LSI 61.303. "Source" counts (full line) are seen to follow closely the background distribution (broken line). Abscissa in fraction of the orbital period. GF indicates a gas flushing of the spark chamber.

References

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T A B L E 1

SOURCE PARAMETERS Name l^0,b^0 Distance Period	COS-B OBSERVATION PARAMETERS #	Pointing Direction l^0	b^0	Offset ^{0}	"source" photons	bkg photons	N_{bin}	Red.χ^2
LSI+61°303	11	125.8	1.1	10	206	1954	11	0.56
135.67,1.08	28	140.9	0.1	5.3	311	2180	15	1.17
2.5 kpc	57	130.0	2.4	5.8	203	1380	16	0.79
26.496±0.008 day								
CIR X1 (*)	7	321.5	0.3	0	683	3333	29	1.04
322.18,0.037	33	310.2	0.4	10	255	2621	36	1.05
8-10 kpc	61	330.5	0.3	10	136	968	44	1.20
∿16.6 day								
VELA X1 (ф)	3	262.7	3.5	0.6	189	2046	22	0.83
263.06,3.93	12	262.5	3.5	0.9	190	2433	34	0.80
1.4 kpc	45	263.0	3.0	0.1	203	1706	40	0.99
8.9643 day								
CYG X3 (*)	4	73.9	0.3	6	397	1794	25	0.74
78.85,0.70	22	84.1	0.5	4.3	773	3163	36	2.03
10 kpc	36	84.7	0.5	4.9	529	2314	37	1.21
∿34.1 day (?)	51	80.0	-0.2	0.9	454	1651	40	1.77
	55	71.2	0.4	8.6	120	488	17	1.20
	60	85.6	-7.8	10.3	324	1661	50	0.65
	63	80.3	-1.2	3.7	836	3444	103	1.10

(*) Owing to the uncertainty of the reported long term X-ray periodicities, the time profiles were constructed for bins of one day.

(ф) Prior to the analysis of this object the pulsed gamma-ray photons of PSR 0833-45 (∿7° away) were substracted from the data base.