EXPERIMENTAL RESULTS ON GAMMA-RAY SOURCES AT $E_0 = 10^{13} - 10^{14}$ eV

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1.Introduction. The detection of very high energy gamma ray sources has been reported in the last few years by means of extensive air shower observations (Cerenkov light and EAS particle arrays); as reviews see (1) and (2).
The Plateau Rosa array for the registration of the arrival directions of extensive air showers is operating since 1980 and first results on Cygnus X3 have been reported (3,4). In this note we want to present the status of observations of Cygnus X3 ($\sim$4y) and of the Crab Pulsar ($\sim$ 2y, for which the ephemeris from radio observations are available).

2.The experiment. The experimental equipment (5) consists of four liquid scintillator detectors 1 m^2 each, positioned at the corners of a rhombus (7x14 m diagonals, 8 m side). The array operates at an altitude of 3500 m a.s.l.; the most probable detected primary energy is $E_0=3\cdot 10^{13}$ eV. The accurancy in the determination of the arrival direction of individual EAS is $\Delta\psi$=5.5 degrees at the zenith (timing error δt=4.2 ns, mainly due to the thickness of the shower disk).
Since Dec.'81 for all events the relative delays (t) between different scintillators (Δt=1 nsec step) together with the absolute time (T) of the event (ΔT=1 msec) are recorded.
In order to avoid corrections due to the atmospheric absorption, pressure and temperature variations, the data are analyzed in ON/OFF mode, i.e.: the number of source events is normalized to the counting rates from two "OFF" sources located $\pm$ 2.5^h around the candidate, at the same declination. An event is assigned to a source if the deviation of relative delays between different scintillators with respect to the theoretical one is $|\delta t| < 5.9$ ns for which the best signal/noise ratio is expected. The arrival times of the events from the OFF sources are shifted $\mp$ 2.5 h in order that to equal arrival times correspond equal atmospheric absorptions. Data are analyzed around the source culmination, up to 30° from the zenith, and only complete days of measurement are considered.

3.Results. Cygnus X3. The arrival times (corrected to the center of mass of the solar system) are folded following the ephemeris obtained from X-ray observations (6). The results are shown in Fig.1 for the whole epoch '81-'85, and split into $\sim$1 year intervals (also the epoch Nov'80-Dec'81 is shown, but, due to the insufficient recording system, the data are analyzed in a different way (4) , and therefore not

TAB.1

Epoch	hours meas.	Nev ON $[\times 10^6]$	(ON/OFF-1) $[\times 10^{-3}]$	χ^2 [19 d.f.]	A_1 $[\times 10^{-2}]$	Phase
11/80-12/81	1078	1.0		35.9	1.42 ± 0.46	0.32 ± 0.05
12/81- 1/83	1177	5.1	3.59 ± 1.71	38.4	0.62 ± 0.24	0.69 ± 0.06
1/83- 3/84	1265	5.8	1.99 ± 1.6	8.0	0.16 ± 0.23	0.59 ± 0.22
3/84- 3/85	990	4.6	-0.65 ± 1.8	25.8	0.85 ± 0.26	0.39 ± 0.05
12/81- 3/85	3432	15.5	1.74 ± 0.98	34.3	0.33 ± 0.14	0.53 ± 0.07

included in the sum). The absolute excesses, the values of χ^2 obtained by checking for uniformity the phase histograms and the amplitudes and phases of the first harmonics are shown in Tab.1 (in order to check phase histograms similar to the X-ray light curve).
We notice:

a) the significance of the possible signal in '81-'82 (c.l. 10^{-2} from the phase analysis and 2 10^{-2} from the absolute excess) is decreased when the data from '83-'84 are added;

b) this might be partly due to different phases of the signal in different epochs (in (4) we tried to analyze such phases in terms of a 34 days modulation, that we cannot confirm);

c) the possibility for the signal to be variable on year's and month's time scale has been suggested by other experiments (see e.g. 7,8);

d) while the excesses seem to be located between phases 0.5 and 0.7 there is an indication, before 1982, of a signal at phase 0.2-0.3 as reported in (7,9,10);

e) the overall effect would correspond to a flux (with primary proton spectrum $S(E)=2\cdot E^{-2.75}\ cm^{-2}s^{-1}sr^{-1}GeV^{-1}$):

$$\Phi(E > 3\cdot 10^{13}eV) \sim 5\cdot 10^{-12}\ cm^{-2}s^{-1}$$

<u>Crab Pulsar.</u> For obtaining a msec accuracy in the determination of the arrival times we use a quartz thermostabilized oscillator (stability $\sim 10^{-9}$) and the detection of radio network signals for absolute timing and calibration of the oscillator (r.m.s. error including the 1 msec step $\delta T_1 < 0.4$ ms, the maximum systematic shift being $\delta T_2 = 1$ ms). The arrival times corrected to the center of mass of the solar system ($\delta T_3 < 0.7$ ms) are folded following the Pulsar ephemeris obtained from radio observations (11) (max. error of our interpolation δT_4=0.2 ms).
The analysis concerns the data collected between Feb'82 and March'84 corresponding to 1268 h of effective observation, for a total of $4.36\cdot10^5$ events within the source angular bin. No excess arises both from the absolute counting rate (ON/OFF=1+(0.04$\pm$2)10^{-3}) and the phase

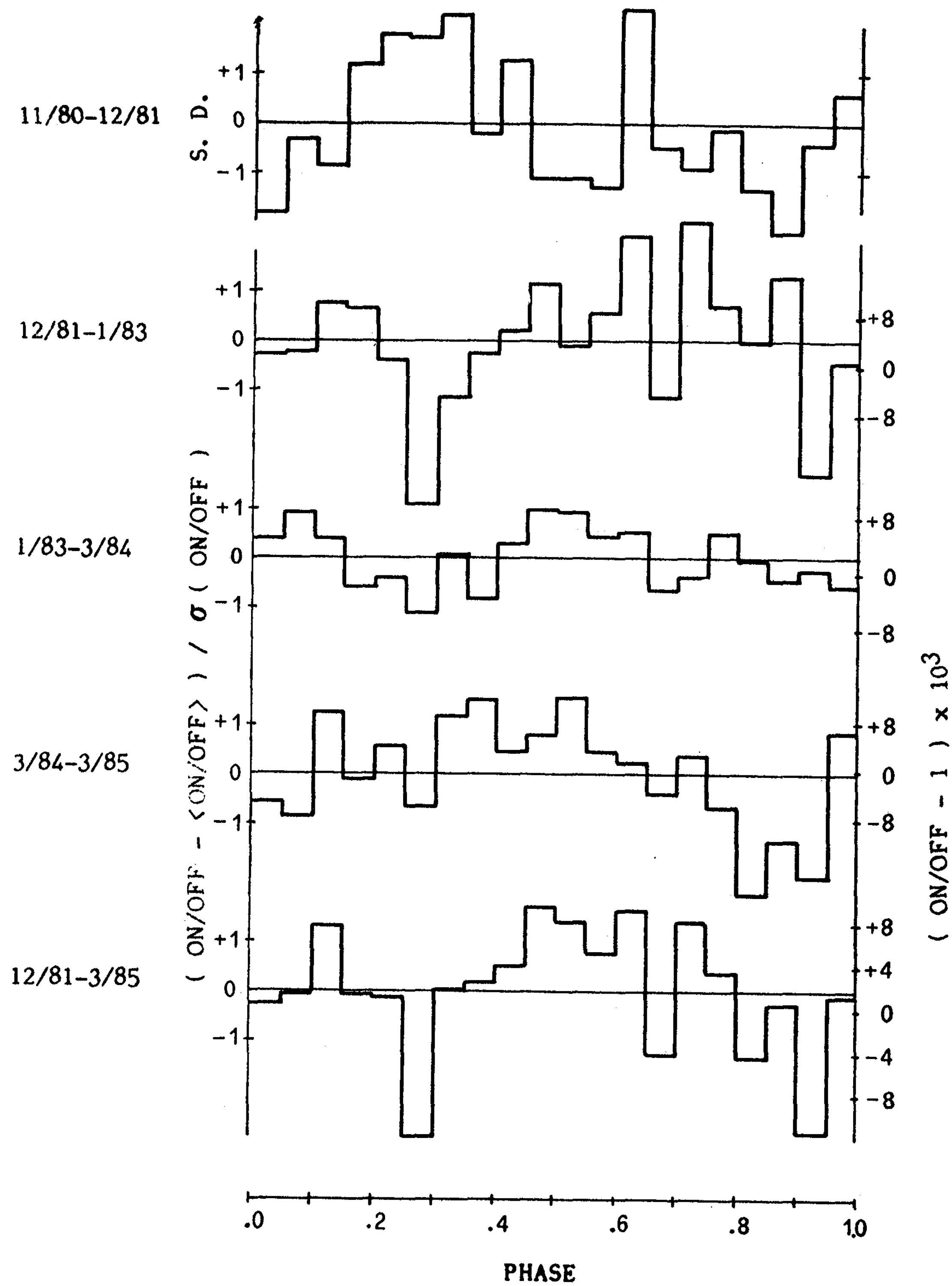

Fig. 1 Phase histograms of the Extensive Air Showers from the direction of Cygnus X3.

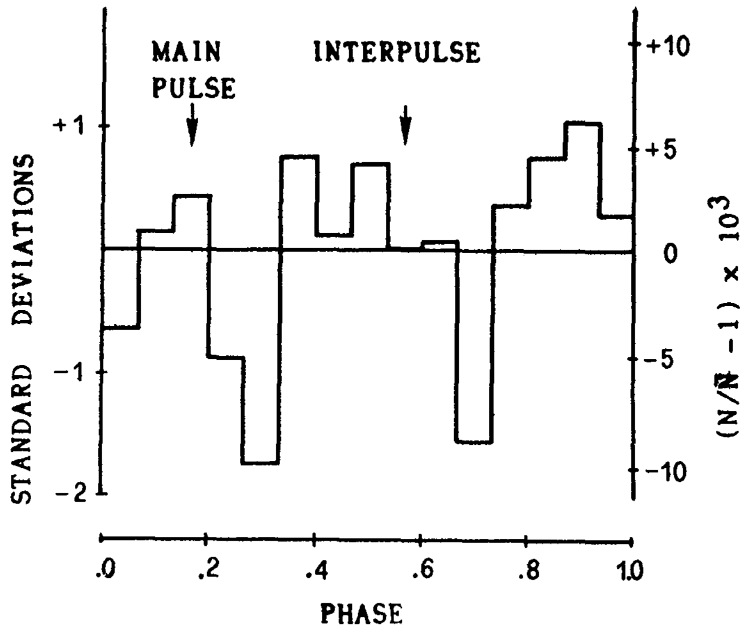

Fig. 2

Phase histograms of the Extensive Air Showers from the direction of the Crab Pulsar ("ON events", deviations from the mean).

analysis (χ^2=9.8 / 14 d.f., see fig.2). The upper limits to the continuous and to the pulsed flux in phase with the main pulse observed at other wavelenghts, and of duration $\Delta T<2$ ms, are (at 90% c.l., $E_{th}=3\cdot10^{13}$ eV):

$$\Phi_{cont}= 10^{-11}\ cm^{-2}sec^{-1};$$

$$\Phi_{puls}= 3\ 10^{-12}\ cm^{-2}sec^{-1}.$$

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