X-611-69-245
PREPRINT

NASA TM X-63582

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JUNE 1969

GSFC

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In this Letter, we report a measurement of the pulsed x-ray emission associated with the Pulsar NP 0532 in the Crab Nebula. This information was obtained with a six element detector flown on-board an aerobee 150 rocket from White Sands N. M., which was launched on March 16, 1968 at 03:15 UT. Our results in connection with the overall 2-20 kev spectrum from the Crab Nebula and the diffuse x-ray background, as well as a payload description, have been published elsewhere.[1]

NP 0532 is the only known pulsar to have detectable emission extending from the radio band to energies exceeding 30 kev.[2] Our measurement is one of the two existing that can provide information concerning the history of NP 0532 prior to its discovery in the radio and optical bands. Since the energy output of this object is generally accepted to have as its origin the dissipation of rotational energy, knowledge of the period of pulsation as a function of time is of special interest.

The data were digitized on-board and were subsequently transmitted in a PCM telemetry format constructed of 16-bit words. The telemetry word was approximately constant at 322 μ sec, and provided our means for timing the occurrence of an event. A small but detectable drift was experienced in the telemetry clock during the 130 sec duration of data collection. A correction for the drift was applied utilizing time markers from a Cesium atomic clock which were recorded, in real time, on the same tape. Overall time uncertainty was of the order of one part in 10^{+5}, corresponding to an uncertainty of about 300 n sec in the observed period.

As discussed in Ref. 1, RF interference was experienced during the flight, which resulted in the loss of about 84% of all data. The interference was confined to one of the six counters only, and was, therefore, unambiguously separable from events in the other five counters. We have shown[1] that the sole effect of the RF interference is a reduction in the effective live time for the other five counters.

Our method for extracting a period for the pulsed x-ray emission was as follows: We used the 322 μ sec telemetry word length to label each event from an arbitrary reference time. We then superposed events in 40 phased channels, based on a time interval near the expected pulsar period. In the absence of pulsar characteristics, or if a test period is not near coincidence with the actual period of pulsation, the resulting 40 channel distribution should be flat (structureless). Thus, if χ^2 is computed for a fit to a random distribution, its largest values (worst fit) should be near the actual period. In Fig. 1 we show the value of χ^2 for a range of test periods which includes the period we would expect to observe real-time if we apply a linear interpolation (for the barycentric period) between recent radio and optical data and the 1967 measurement of Fishman et al., properly corrected for the earth's orbital motion. We note that our best estimate is in good agreement with such an interpolation. In Fig. 2 we have plotted the data, superposed in phase, for the expected period of 33.0855 m sec. The "light curve" exhibits the same double maximum observed in the radio and optical.[3,4] As observed in more recently obtained x-ray rocket observations[5,6], the area under the broader interpulse appears to be about the same as the area under the primary pulse.

We estimate that the pulsed x-ray emission is 15 $\pm$ 3% of the total x-ray flux from the nebula. This determination is based upon our understanding of the large contribution of the diffuse background in our instrument due to its large field of view (see Ref. 1) and the subjectively chosen time interval used for background determination (see Fig. 2). Fritz, et al. estimate the pulsed contribution to the x-ray emission in, essentially, the same energy band as 5%, while Bradt, et al. obtain 9% (no errors quoted in either case, but both of these 1969 measurements have much better statistics than does our own). We note that there are slight differences in the definition of this fraction, i.e. Bradt, et al. define their fraction as the ratio of pulsed emission to steady Crab contribution (rather than total Crab contribution, as we have done), but a redefinition of our fraction will only enhance the disagreement (by an amount much smaller than our estimated error, however).

It is possible that both our results and those of Fritz, et al. can be reconciled with those of Bradt, et al. Alternatively, we suggest that the pulsed component of the x-ray emission may be variable in amplitude. Taken together, the three results indicate the possibility of a long-term (i.e. one year) decrease in the pulsed x-ray emission and/or shorter term variability if the difference between the two 1969 measurements is real.

We wish to acknowledge valuable discussions with Drs. S. Maran, H. Ogelman and E. Roelof.

Figure Captions

Fig. 1: The value of χ^2 for the hypothesis of a random distribution of events for 40 degrees of freedom as a function of assumed period.

Fig. 2: Observed light curve in the energy band 2-10 keV on March 16 1968 during the time 03:17 - 03:19 UT. We have used temporal bins which are twice as wide as those in Fig. 1.

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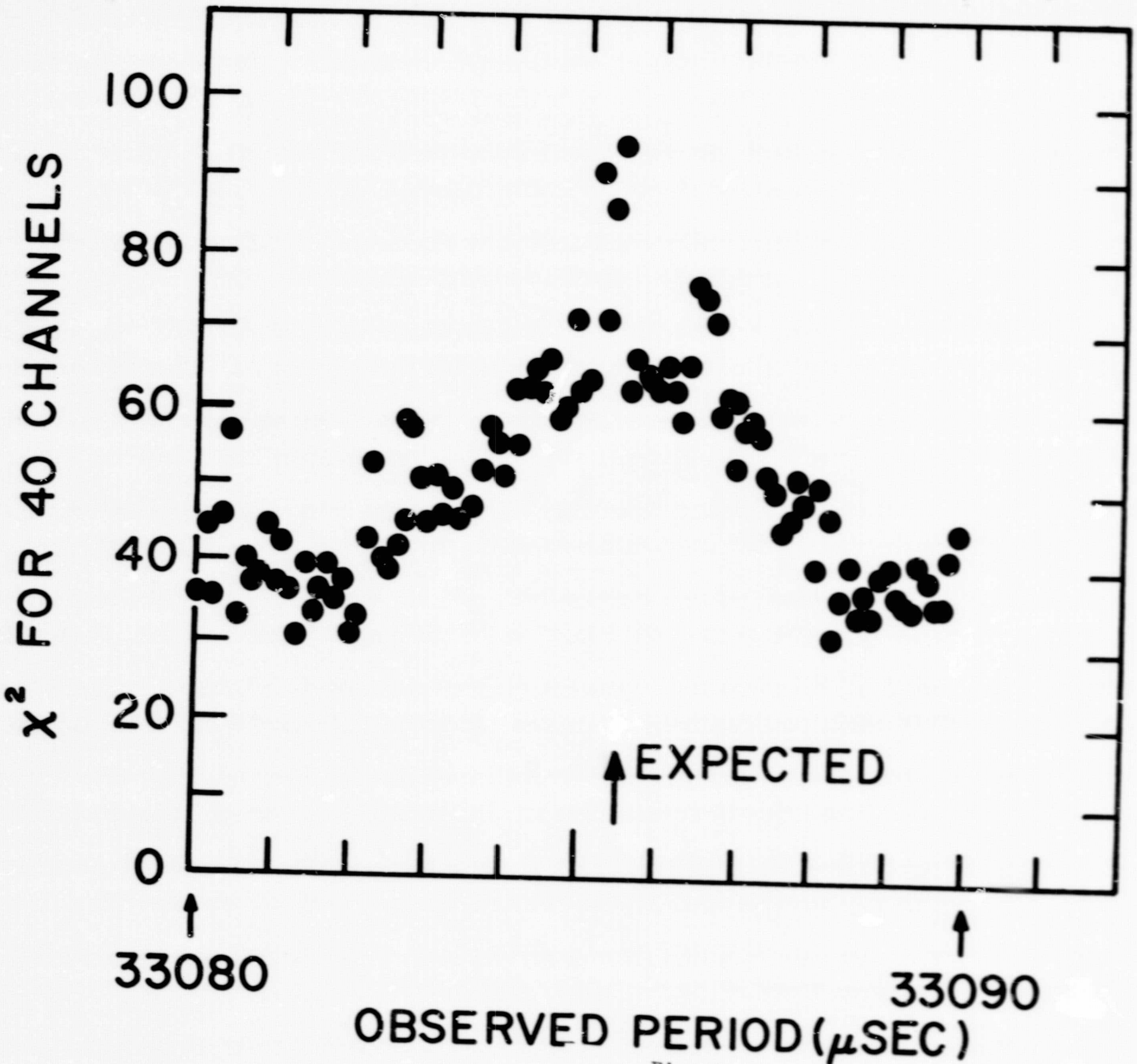

X² FOR 40 CHANNELS
100
80
60
40
20
0
EXPECTED
33080
33090
OBSERVED PERIOD (μSEC)

Fig. 1

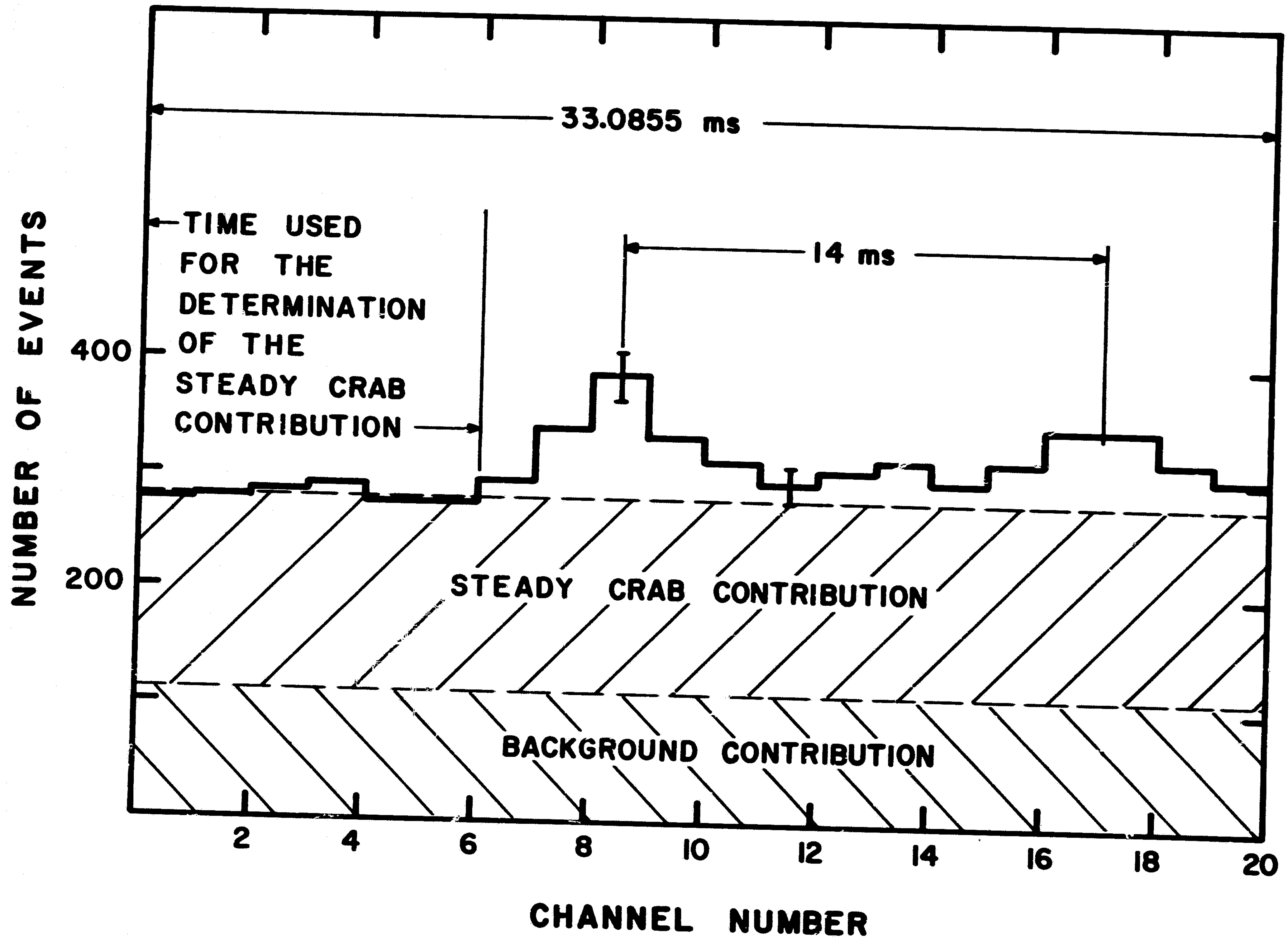
33.0855 ms
TIME USED FOR THE DETERMINATION OF THE STEADY CRAB CONTRIBUTION
14 ms
400
200
NUMBER OF EVENTS
STEADY CRAB CONTRIBUTION
BACKGROUND CONTRIBUTION
2
4
6
8
10
12
14
16
18
20
CHANNEL NUMBER

Fig. 2