X-660-76-1

PREPRINT

NASA TM X- 71049

EVIDENCE FOR AN 11.2d PERIODICITY FROM Cyg X-2

S. S. HOLT
E. A. BOLDT
P. J. SERLEMITSOS
L. J. KALUZIENSKI

(NASA-TM-X-71049) EVIDENCE FOR AN 11.2d PERIODICITY FROM CYG X-2 (NASA) 11 p HC $3.50 CSCL 03A

N76-16989

Unclas
G3/89 13245

JANUARY 1976

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

Evidence for an 11.2d Periodicity from Cyg X-2

S. S. Holt, E. A. Boldt and
P. J. Serlemitsos
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

L. J. Kaluzienski
University of Maryland
College Park, Maryland 20742

ABSTRACT

Evidence for a persistent 11.17 ± .10d period from Cyg X-2 is presented from one year of accumulated data from the Ariel-5 All-Sky Monitor. The effect is not a simple sidereal alias of a true source period close to one day.

Subject headings: x-ray sources - binaries

I. INTRODUCTION

Cyg X-2 has been observed quasi-continuously for more than one year by the Ariel-5 All-Sky Monitor. As displayed in Figure 1, it differs significantly from the other strong sources which are discernable by the experiment with high duty cycle. The Crab Nebula is constant, and Cyg X-1 has relatively small daily excursions about its "low-state" intensity with the exception of well-defined flares. The source most similar in overall appearance to Cyg X-2 is Cyg X-3, with significant variations on timescales of several days or more. In particular, Sco X-1, to which Cyg X-2 has been likened in many respects (c.f. Peimbert, et al. 1968), exhibits considerable diurnal variability without any seemingly coherent structure on longer timescales.

In this paper, we report evidence for an 11.2d periodicity in the emission from Cyg X-2. This is comparable to the 13.6d reported by Chevalier, et al. (1975), but the latter period is inconsistent with the present data. This 11.2d timescale is more than an order of magnitude larger than the .787d binary period of Sco X-1 (Gottlieb, Wright and Liller, 1975; Cowley and Crampton, 1975), and is not a simple alias of a similarly short period.

II. EXPERIMENTAL DATA

All the data presented here are obtained with the Ariel-5 All-Sky Monitor, a scanning x-ray pinhole camera which has been described in detail elsewhere (Holt, 1975). It is obvious from Figure 1 that a variety of periods in excess of a few days will give relative χ^2 maxima when folded against the hypothesis of a constant source intensity. Figure 2 contains a sample of the χ^2 obtained with trial folds of the Cyg X-2 data, including the most pronounced peak (at ~11.17d) for periods less than ~3 weeks.

In the case of a similar candidate period of 16.9d for Cyg X-3, we were able to test the consistency of the effect with independent data taken with another experiment (Holt, et al. 1975). Here we suffer from a lack of independent verification, but we can exhibit that the effect is not the accidental coincidence of a few non-periodic intensity peaks. In Figure 3 we have plotted the entire year of data modulo multiples of 11.17d up to a factor of five. Each trace contains evidence for the number (and phase) of peaks expected from the 11.17d trace, so that the effect is clearly persistent.

As the data are taken in 100 min samples (with typical 60% on-time since the experiment is off during the night portion of each orbit and during radiation belt traversals), earth occultation of sources is routinely compensated for in the data analysis. Nevertheless, it is conceivable (but not likely) that the 11.17d effect could be an alias of a period near 100 minutes. It cannot, however, be a simple alias of a period near one day. No significant χ^2 peaks were obtained for any trial periods between .5d and ~ one week, where the significantly larger number of cycles for the shorter of these candidate periods allowed consistency with the expected χ^2 distribution (i.e. a mean χ^2 over all trial 10-bin folds of ~ 9).

III. DISCUSSION

We find a persistent period of 11.17 $\pm$ .10 d in a quasi-continuous sample of Cyg X-2 data taken over more than one year. Chevalier, et al. (1975) have reported consistency in both x-ray and optical data with a Cyg X-2 period of the same order of magnitude, but we cannot sensibly reconcile the two reports. The Chevalier, et al. period is 13.6d (no error quoted), for which there is no significant modulation in Figure 2. The period difference (~20%) is apparently too large to suppose that the two effects are the same, and they cannot be obviously connected via aliasing.

Similarly, there is no evidence in our data for a shorter period giving rise to the 11.17d effect. Ulmer, et al. (1974) have set a 2σ upper limit of ~5% pulsed fraction for any sharply peaked periodic variation (i.e. ≤ 0.1 of the period) at energies above 7 keV in the range 10 hours to 2 days utilizing an analysis similar to ours. Applying the same "sharp disturbance" criterion, we find no pulsed fraction in excess of 1% for periods in the range .5 - 5d, although there are many longer period candidates above this level.

A binary period of 11.17d is not inordinately large for x-ray sources, although all others with periods in excess of ~2 days are associated with high-mass primaries. The Cyg X-2 candidate (Giacconi, et al. 1967) is assumed to have the low-mass primary typical of Sco X-1, Her X-1 and Cyg X-3, in which case a binary period this large would be rather unusual. It is conceivable that the 11.17d modulation is precessionally-induced, as in the case of the 35-day variation from Her X-1 and (perhaps) the 17-day variation from Cyg X-3.

References

Chevalier, C., Ilovaisky, S. A., Branduardi, G., and Sanford, P.W. 1975, IAU Circular No. 2859.

Cowley, A. P., and Crampton, D. 1975, *Ap. J. (Letters)*, **201**, L65

Giacconi, R., Gorenstein, P., Gursky, H., Usher, P. D., Waters, J. R. Sandage, A., Osmer, P., and Peach, J. V. 1967, *Ap. J. (Letters)*, **148**, L129.

Gottlieb, E. W., Wright, E. L. and Liller, W. 1975, *Ap. J. (Letters)*, **195**, L33.

Holt, S. S. 1975, *Proc. COSPAR Symp. Fast Transients X- and Gamma-Ray Astron.*, *Ap. and Space Sci.*, in press.

Holt, S. S., Boldt, E. A., Serlemitsos, P. J., Kaluzienski, L. J., Pravdo, S. H., Peacock, A., Elvis, M., Watson, M. G., and Po nds, K. A. 1975, submitted to *Nature*.

Peimbert, M., Spinrod, H., Taylor, B. J., and Johnson, H. M. 1968, *Ap. J. (Letters)*, **151**, L93.

Ulmer, M. P., Sammuli, A., Baity, W. A., Wheaton, W. A., and Peterson, L. E. 1974, *Ap. J.*, **189**, 339.

E. A. BOLDT, S. S. HOLT, L. J. KALUZIENSKI and P. J. SERLEMITSOS
Code 661, Goddard Space Flight Center, Greenbelt, Maryland 20771

Figure Captions:

1. One-year daily average intensities of five strong sources measured with the Ariel-5 All-Sky Monitor. The error bars are $\pm 1\sigma$, and statistical only. Data obtained near the edges of the experiment field-of-view have not been included in order to minimize the unrecoverable systematic error contribution.

2. Trial values of χ^2 against the hypothesis of a constant source intensity for one year of Cyg X-2 data folded in 10 bins.

3. One year of Cyg X-2 data folded modulo multiples of the candidate 11.17d period. The error bar shown is typical of each bin in that trace, and can be scaled to the other traces by the square root of the number of bins used. A sinusoid fit to the data has amplitude ~10% of the mean intensity and epoch JD 2,442,548 $\pm$ 1 at minimum near the midpoint of the data duration.

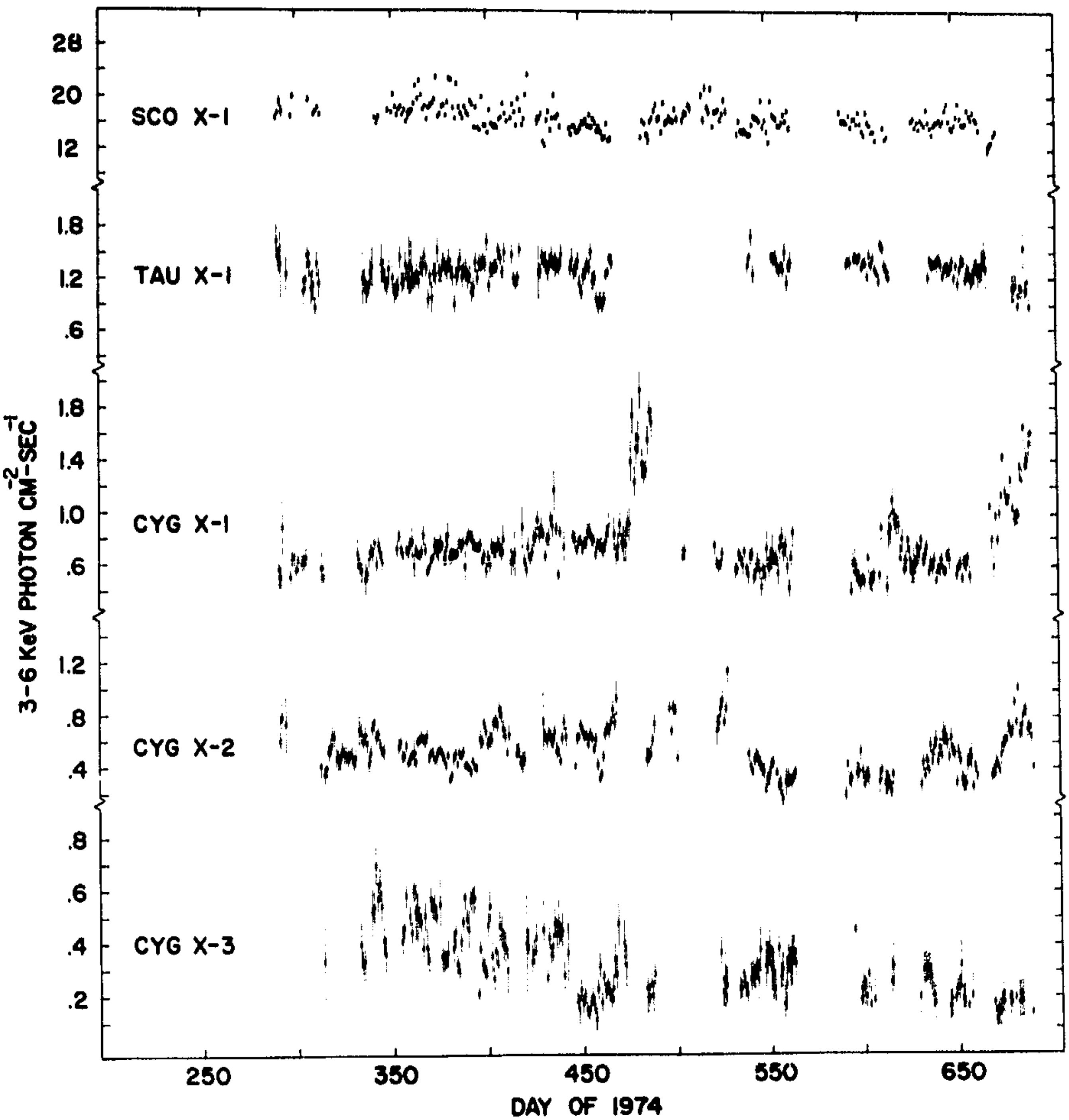
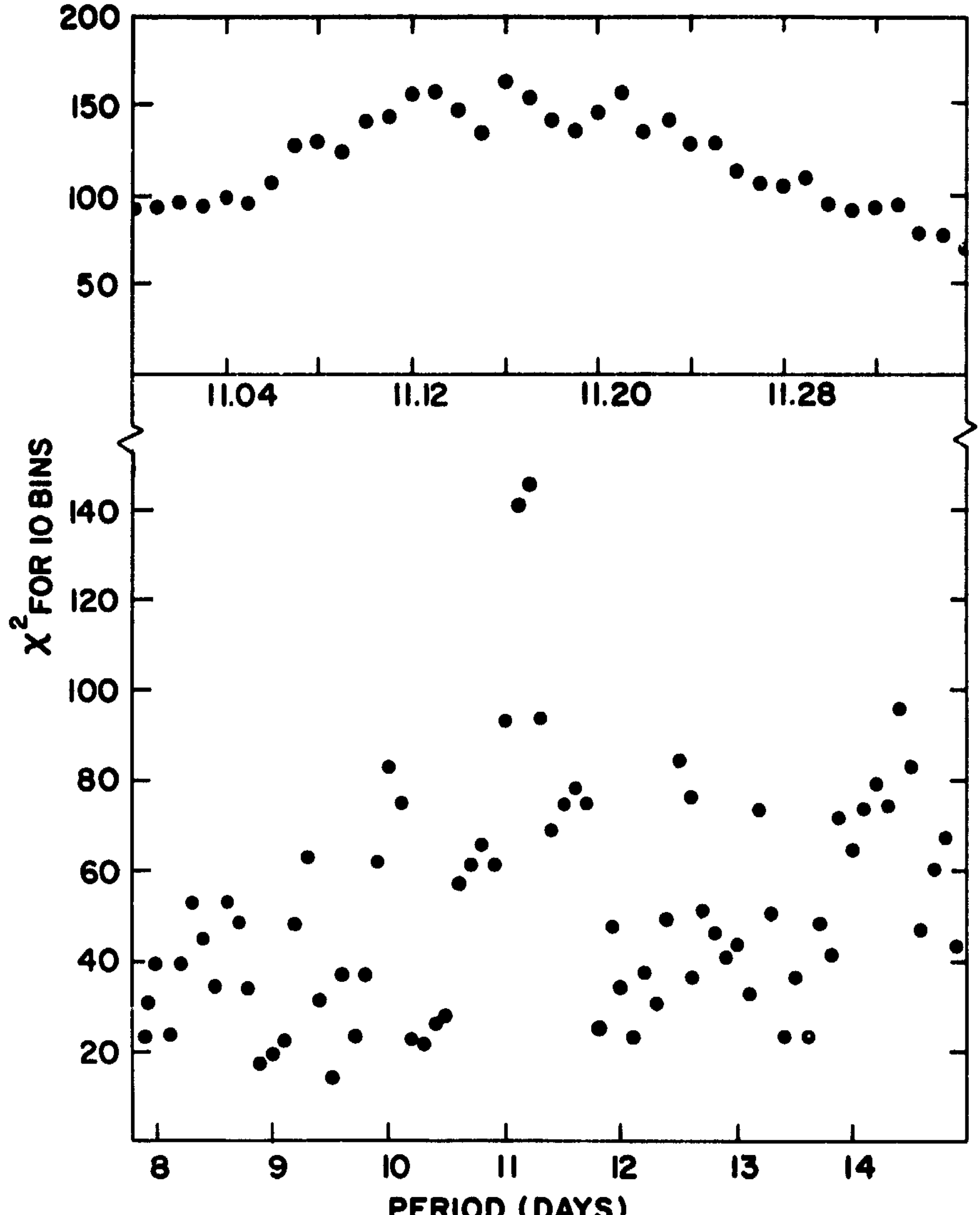


Fig. 1

PRECEDING PAGE BLANK NOT FILMED



200
150
100
50
11.04
11.12
11.20
11.28
140
120
100
80
60
40
20
X^2 FOR 10 BINS
8
9
10
11
12
13
14
PERIOD (DAYS)

Fig. 2

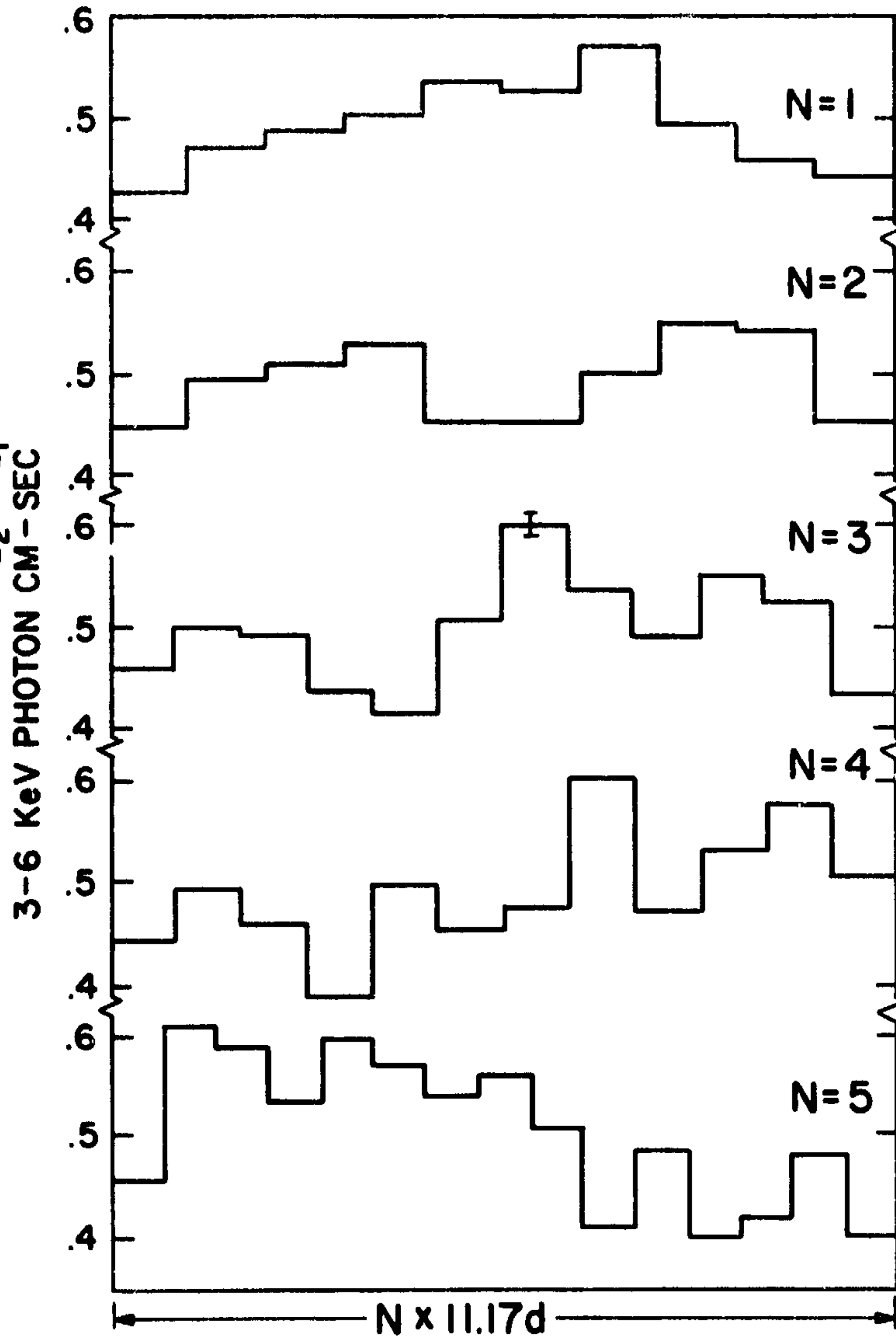


Fig. 3