

## HERCULES X-1 RESULTS FROM THE UTAH CHERENKOV ARRAY

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## Abstract

A search for excess showers from Hercules X-1 was done using the Utah Cherenkov Array. No significant excesses were observed when data were examined from 23 nights during March-June 1989.

Introduction Two UHE detections of Hercules X-1 have been reported. One was by the Fly's Eye (Baltrusaitis et al., 1985) from data taken during 1983 during a very rare 3 month long period of reduced X-ray emission. Enhanced emission above 500 TeV was observed during a 40 minute interval. The emission showed a narrow peak in the phase histogram at a frequency in precise agreement with X ray observations made 2 months earlier. A TeV experiment of the Durham group (Turver, 1985), observing from nearly the same location on the same night, failed to detect any signal. This suggests a quite flat emission spectrum or TeV beam steering effects if the Fly's Eye observation was truly due to a signal from Her X-1.

A second observation of Her X-1 was by the CYGNUS experiment at Los Alamos, N.M., U.S.A. (Dingus et al., 1989) The >50 TeV signal was observed during two approximately 30 minute intervals on one day of a 340, day exposure to Her X-1. A very interesting feature of the observation was that the observed period differed by about two parts per thousand from the X-ray period, but was in essential agreement with the period observed by two other groups operating in the TeV region. At the observed period events were observed to be concentrated in a small part of the total phase interval. Another remarkable feature was that muon measurements showed the muon content of the showers making up the signal was higher than expected for gamma ray primaries.

The present work reports a search for a signal using the Utah Cherenkov Telescope Array and the Michigan Muon Array located at Dugway Utah. These arrays are part of the cosmic ray complex under development by the Utah-Michigan-Chicago Collaboration. For 100 TeV showers, the

Cherenkov array has an effective area of  $45,000 \text{ m}^2$ , an angular resolution of about  $1^\circ$ , and energy resolution of 16%. The Michigan Muon Array has an actual detector area of  $1250 \text{ m}^2$  and detects about 5 muons in a 100 TeV shower. With these arrays it is possible to observe muon-poor showers with high sensitivity, but the results discussed here were obtained without selecting muon-poor showers. The Cherenkov array is described in more detail in paper OG 10.3-2 and the muon array is described in HE 3.4-1.

Analysis of Data As described in OG 10.3-2, a Monte Carlo simulation gave the Cherenkov array triggering efficiency as a function of energy. The triggering efficiency is the fraction of the showers falling within 120 m of the array center which trigger the array. The Monte Carlo results were very well approximated by 2 parameter fits to the integral of the Gaussian or normal distribution. For data taken before the May 1989 run, the mean value of the Gaussian,  $E_0$ , was 55 TeV, and the width parameter,  $\sigma$ , was 16 TeV. A small modification of the detector after May 1989 results in  $E_0 = 30 \text{ TeV}$  and  $\sigma = 9 \text{ TeV}$ . It can be seen that the efficiency (for showers within 120 m of the array center) goes from 0 to almost 100% in a reasonably narrow energy interval. In analyzing the data before and after May 1989, we accepted only data above 70 TeV and 40 TeV, respectively.

The shower directions were obtained by measuring the flash arrival times in the widely separated (170 m) mirror units. (See OG 10.3-2.) During operation, the mirror units tracked Her X-1, the "target". Showers within the  $1^\circ$  radius "inner circle" centered on the target were potential signal showers. Showers between  $1.5^\circ$  and  $2.5^\circ$  from the target were used to estimate the expected number of background showers within the inner circle. During each monthly run the ratio,  $\hat{a}$ , of the number of showers in the inner circle to the number in the outer ring was obtained. The number of showers in the outer ring, multiplied by  $\hat{a}$ , gave the number of showers expected in the inner ring during the night. The number of showers in the inner ring was then compared with the predicted number.

The method described above was used to search for sporadic signals which might occur during any night. The signals are assumed to be rare enough that  $\hat{a}$  is not affected greatly by the presence of the signals. The statistics were not high, typically about 50 showers were obtained per night in the inner circle. Consequently, the method does not require great stability of  $\hat{a}$  from night to night. The procedure was applied to the data from the 23 nights. No inner circle excess exceeded  $3\hat{a}$ .

Conclusion No signals were detected in the 23 nights of this search. Flux limits at the 90% confidence level were found from the March and April data (threshold = 70 TeV) and for the May and June data (threshold = 40 TeV). Nightly flux limits ranged from  $2.5 \times 10^{-13}$  to  $1.9 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1}$ .

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#### References

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