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Recent HEGRA observations of Cygnus X-3

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Abstract. Cygnus X-3 has been observed during 1999-2000 by the HEGRA Cherenkov Telescopes, both the IACT system of five telescopes and the standalone CT1 telescope. The data have been analyzed to search for steady emission of TeV γ-rays, and 4.8 hr modulation of the γ-ray light curve. No evidence for TeV emission was found.

1 Introduction

The X-ray binary Cygnus X-3 has been object of several observations at all wavelengths. It is one of the most luminous X-ray sources in our Galaxy. The X-ray emission shows a 4.8 hr periodicity, which is believed to be associated with the orbital period of the binary, consisting of either a massive neutron star or a black hole, the companion being characterized by observations in the infrared as a Wolf-Rayet-star (Fender, 1999). Radio flares occur typically once per year, at which times Cyg X-3 is one of the loudest radio sources in the northern hemisphere. The VLA observations by Geldzahler (1983) confirm the picture of Cyg X-3 as an emitter of relativistic jets. Since Cyg X-3 lies in the galactic plane, at a distance of $\approx$ 8.4 kpc, its optical emission is largely obscured by interstellar matter. Evidence of unpulsed emission of γ-rays at $E > 50$MeV was found by the EGRET telescope aboard the CGRO satellite (Mori, 1997).

In higher energies, several claims of detection have been made since Nesphor (1979) in TeV resp. Samorski (1983) in PeV, see eg. Bonnet-Bidaud & Chardin (1988) and Weekes (1988) for reviews. All early detections at TeV energies made use of the 4.8 hr periodicity as seen in the X-rays, more recent observations fail to detect either a steady or a periodic emission of TeV γ-rays from Cygnus X-3 (O'Flaherty (1992), Protheroe (1994)).

In this paper the results of the HEGRA-IACT measurements in 1999 and 2000 are presented.

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2 Experimental Setup

The HEGRA experiment is located on the Canary Island of La Palma at the Observatorio Roque de los Muchachos of the Instituto de Astrofísica de Canarias at 2200 m above sea level, at 28.75°N, 17.89°W.

A total of six Cherenkov Telescopes is operated, five of them are operating as a stereoscopic system of Imaging Atmospheric Cherenkov Telescopes (IACT) (Daum, 1997), and one is operated as a standalone IACT (Rauterberg, 1995).

Each of the alt-azimuth mounted system telescopes is equipped with a 8.5 m^2 tesselated mirror, and a camera consisting of 271 photomultiplier tubes, which are arranged in a hexagonal tight packed structure with a field of view of 4.3° in diameter.

The stereoscopic observation of Cherenkov air showers provides us with an energy resolution of $\Delta E/E \leq 20\%$, an angular resolution of $\Delta\theta/\theta \leq 0.1°$, and small error $\Delta_{core} \leq 20$ m on the shower core position. The stereoscopic system has an energy threshold of 0.5 TeV at small zenith angles, which increases up to $\sim$5 TeV at 60° zenith angle (Konopelko, 1999).

3 Observations

The HEGRA observations of Cyg X-3 were made on five and six nights in Septemper 1999 and 2000, respectively. In order to find evidence for a 4.8 hr period in the emission, it was tried to cover 5 hours per night. Total observing time is 45 h, 20 h in September 99 and 25 h from 2000. The average zenith angle is $23.7°$, corresponding to an energy threshold of $E_{th} \approx 0.8$ TeV.

The observations have been carried out using the so called wobble mode, which is the standard data taking method of the HEGRA-IACT system. For pointlike sources the telescope is pointed $\pm 0.5°$ in declination aside the nominal source position. Thus we do not need to take seperate OFF-runs, but take OFF-data during the same time as the ON-data,

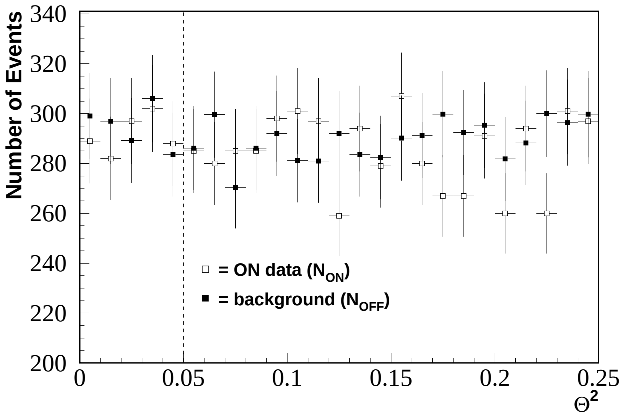

Fig. 1. Reconstructed source directions for Cygnus X-3. The region of interest is $\theta^2 < 0.05°$. ON-data (open symbols) show no excess above background (filled symbols).

minimizing effects caused by different athmospheric conditions. See Aharonian (1997) for details.

4 Results

The data have been subjected to our standard analysis technique. Only data with satisfying weather conditions and telescope performance was chosen.

4.1 Steady γ-ray emission

Figure 1 shows the reconstructed source direction θ for Cyg X-3. After cuts on the reconstructed source position ($\theta^2 \leq 0.05\,[°]^2$) and loose cuts on the *mean scaled witdh* ($\langle\tilde{w}\rangle \leq 1.2$) for gamma-hadron separation, the data contain 1458 ON and 1477 background events in the region of interest. No excess of ON-events, that means no evidence for steady γ-flux from Cygnus X-3 can be seen.

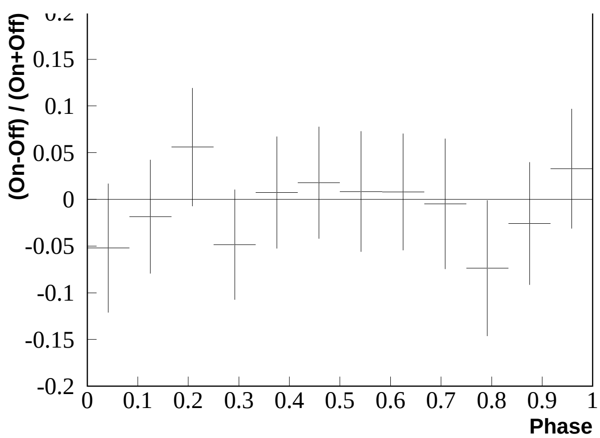

Fig. 2. 4.8 hr phase diagram for Cygnus X-3 data after all cuts.

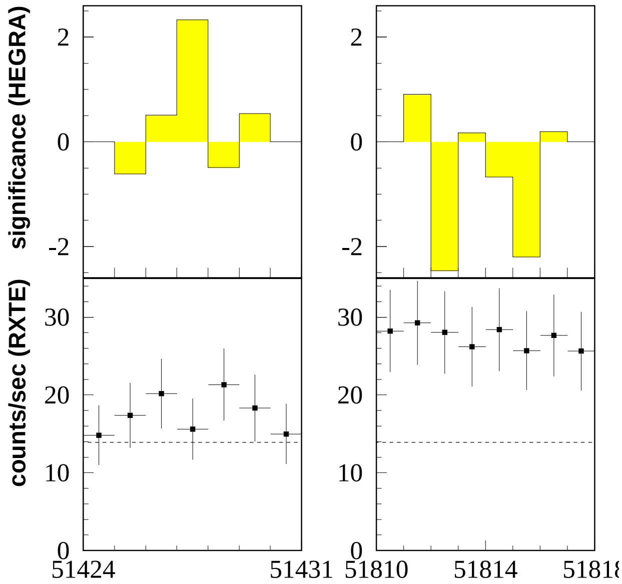

Fig. 3. Significance of Excess for the single Nights. The upper panels show the HEGRA-IACT results, the lower panels the averaged daily flux as from the RXTE-ASM, the dotted line denotes the average flux. There is no significant TeV γ-ray excess, also no correlation between X- and γ-rays is observed.

The significane

$$S = \frac{N_{ON} - N_{OFF}}{\sqrt{N_{ON} + N_{OFF}}}$$

is $S = -0.4$. The 99% upper limit for the steady emission is 5% Crab.

4.2 Periodic emission

Since we were not able to detect steady γ-flux from Cygnus X-3, the data have been searched for evidence of the 4.8 hr modulation. Figure 2 shows the phase diagram for the accumulated 1999 and 2000 data. Admittedly the statistics of eleven nights (i.e. eleven phase transitions) is rather poor. There is no evidence for any statistically significant excess in any phase bin. This is in agreement with other recent Cygnus X-3 TeV observations (Protheroe, 1994).

4.3 Single nights

As Cygnus X-3 flares occur on relatively short timescales in other wavelenghts, the significance of the excess have been calculated for each single night, see Figure 3. Though Cyg X-3 is above the X-ray average of the years 1999/2000, no night with a significant TeV γ-ray excess has been observed. Also no correlation between X-rays and γ-rays can be seen.

5 Conclusion

Cyg X-3 has been observed by the HEGRA-IACT system for 45 hours in the last two years. No evidence for TeV γ-ray emission, neither steady nor periodic emission, has been found.

Because of the long observing time per night, the zenith angle changes over an interval of up to $30°$, thus increasing the threshold of the IACT-system. If we consider a crab-like spectrum, the flux intensity drops dramatically towards higher energies. So it might be possible, that we do not detect a signal because of the high energy threshold during parts of the night. Another 52 hours on the source are planned this year. This year's observing time will be spread more along the months, covering more of the phase of the binary at smaller zenith angles.

CT1 observed Cyguns X-3 for 29 hours in 2000. These data are not yet analyzed and will be presented at the ICRC.

The average TeV flux from Cyg X-3 seems to have decreased since its first discoveries in the 1970s, and is still in a state of low activity.

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References

Aharonian et al., 1997, A&A **327**, L5.
Bonnet-Bidaud, J.-M. and Chardin, G., 1988, Phys. Rep. **170**, 325.
Daum, A. et al., 1997, Astropart. Physics, 8, 1.
Fender, R.P., Hanson, M.M., and Pooley, G.G., 1999, MNRAS **308**, 473.
O'Flaherty, K.S. et al., 1992, ApJ **396**, 674
Geldzahler, A.M. et al. 1983, ApJ **273**, L65.
Konopelko, A., 1999, J.Phys.G **25**, 1989.
Mori, M. et al., 1997, ApJ **476**, 842.
Nesphor Yu.I. et al., 1979, ApSS **61**, 349.
Protheroe, R.J., 1994, ApJS **90**, 883.
Rauterberg, G., et al., 1995, *Proc 24th ICRC*, Rome, **3**, 460.
RXTE/ASM Team `http://xte.mit.edu/asmlc/srcs/cygx3.html`
Samorski, M. and Stamm, W., 1983, ApJ **268**, L17.
Weekes, T.C., 1988, Phys. Rep. **160**, 1.