TeV observations of Centaurus A

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Abstract

We have searched for TeV gamma-rays from Centaurus A and surrounding region out to $\pm 1.0^{\circ}$ using the CANGAROO 3.8m telescope. No evidence for TeV gamma-ray emission was observed from the search region, which includes a number of interesting features located away from the tracking centre of our data. The 3σ upper limit to the flux of gamma-rays above 1.5 TeV from the centre of Centaurus A as an extended source of radius $14'$ is 4.66×10^{-12} photons cm^{-2} s^{-1}.

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1 Introduction

Centaurus A (NGC 5128) is the closest known radio galaxy (∼3.5 Mpc), and is considered a misaligned BL Lac type AGN with a jet orientation angle of $\sim 70^\circ$ [9,15]. Variability in X-ray and low energy gamma-ray flux of up to an order of magnitude on time scales of days to years has been observed [2]. The EGRET source 2EGJ1326-43, is considered to be associated with Centaurus A [12,13]. A number of upper limits and marginal claims for detection at TeV and PeV energies have also been reported. See [1] and references therein.

We used the CANGAROO 3.8m telescope [4] in observations of Centaurus A taken from March to April 1995. An earlier analysis [14] assumed a single point source at the tracking centre. In the present work, we have subjected these data to a search for point-like and extended TeV emission over a $\pm 1^\circ$ region which includes a large fraction of the EGRET 95% error circle and the peak radio emission from the Northern Middle Lobe (NML). The NML is thought to be an end-point of the AGN jet interacting with the surrounding medium [11].

2 Analysis

A total of 45 hours of ON and OFF source data were considered for analysis. The spatial extent and number of interesting features of the Centaurus A region warranted an extended source analysis. We have based our analysis on the method of [3] in which location cuts, recalculated at every grid position of the search, are combined with shape cuts to form a skymap of the ON–OFF significance. We find that due to camera edge effects, some adjustment of image cuts as a function of source location is necessary to optimise the cosmic-ray background rejection over the search region. Location cuts used are *asymmetry* and the normalised distance between the assumed and calculated origins of the Čerenkov image. Shape cuts are the image *width* and *length*. This method will be described in a later paper. The actual values of each cut were selected *a priori* using Monte Carlo simulations. We found that the total cut combination provides a gamma ray acceptance of $\sim 40\%$ and cosmic ray acceptance of $\sim 1\%$ for point sources within $\pm 1^\circ$ of the camera centre.

Three sites were considered as potential gamma-ray sources within the search. The tracking centre of these data based on the radio VLBI core position [6], the unidentified EGRET source, and the NML. The tracking centre and EGRET source were considered as point-like and extended sources while the NML was considered as a point-like source only as it is close to the search boundary. In assuming an extended source, the point spread function (PSF) for gamma-

Table 1
Summary of ON–OFF excesses and 3σ upper limits for the Centaurus A region.

Feature	ON–OFF(σ)	Flux($\geq$ 1.5 TeV) ph cm^{-2} s^{-1}
Tracking[a] (point)	+1.6	$< 5.45 \times 10^{-12}$
Tracking[b] (extended, 0.45°)	+0.8	$< 4.66 \times 10^{-12}$
EGRET[c] (point, 0.9°)	+2.8	$< 1.14 \times 10^{-11}$
EGRET[d] (extended, 0.5°)	+0.9	$< 4.99 \times 10^{-12}$
NML[e] (point)	−0.7	$< 4.47 \times 10^{-12}$

a: Radio VLBI core position [6]. RA (J2000) $13^h\,25^m\,29^s$ Dec -43°$01^m\,12^s$

b: Radius $14'$(0.23°) covering ROSAT PSPC emission [16].

c: Highest significance within the error circle (0.68° [10]). RA $13^h\,23^m\,15^s$ Dec -43°$31^m\,12^s$.

d: Source radius limited by ±1° search. RA $13^h\,26^m\,02^s$ Dec -43°$31^m\,12^s$.

e: Northern Middle Lobe. Point source at max radio position [7]. RA $13^h\,26^m\,08^s$ Dec -42°$15^m\,35^s$

rays was taken into account by adding it to the extended source radius. The PSF increases slightly from 0.20° at the camera centre to 0.25° at the edges. To simplify the analysis, a single value of 0.22° for the PSF was assumed.

3 Results and Discussion

No significant excesses were found within our search region and 3σ upper limits were derived (table 1) for the features discussed earlier. The upper limits from this work are not in conflict with previous measurements, and lie at least an order of magnitude above the extrapolated EGRET flux (integral spectral index −1.5, [10]) at 1.5 TeV. We therefore cannot place constraints on gamma ray emission models concerning Centaurus A. The upper limit from the point source within the EGRET error box must be considered with a statistical penalty of ∼100 due to the non *a priori* nature of the search. We note that our observations were likely taken during a low state of X-ray emission, and might expect a greater chance of detectable TeV emission during a high state. Clearly, observations are required with more sensitive telescopes at energies below 1 TeV, for example, by CANGAROO II [8] and HESS [5], covering all states of emission.

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