Observation of sub-TeV gamma rays from SS433/W50 with the CANGAROO-II telescope

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Abstract

Observations of the western X-ray lobe region of SS433/W50 system were performed by the CANGAROO-II telescope in August and September, 2001, and July and September, 2002. Total observation times were 85 hours for ON source, and 80 hours for OFF source, respectively. We present analysis results of 2001 and 2002 data at the position where the hardest X-ray spectrum has been observed by *ASCA*.

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1. Introduction

W50 is a galactic SNR, and is also a strong non-thermal radio source. Radio maps of W50 show a $2^\circ \times 1^\circ$ ellipsoidal-like shape with limb-brightened "ears" elongated in the east-west direction [4, 5, 6, 8]. SS433 at R.A. (J2000) = $19^h11^m49^s$, Dec. (J2000) = +04°58'48" is a unique object located at the center of W50. It is a close proximity binary star system which consists of a compact star and a normal star. Jets of material are directed outwards from the vicinity of the compact star symmetrically to the east and west at the speed about 0.26 c [1, 7, 10]. The radiation of non-thermal X-rays considered to be formed by the jets is detected at both of X-ray lobes by *Einstein* observatory [18], and confirmed by *ROSAT* and *ASCA* [3, 15], respectively. The X-ray spectrum of each lobe has no apparent emission lines, and is well described by power-law models. According to the results of *ASCA* [17], it was found that the spectrum of each X-ray lobe becomes harder as distance from SS433 decreases, and the spectrum of the western region has a harder spectrum than that of the eastern region. The spectra of the western lobe have been reported by the latest analysis of *ASCA* [12, 13]. In 1998 and 1999 observing seasons, the HEGRA CT-System searched for TeV gamma rays from the eastern lobe [14]. Their tracking position was the X-ray brightest region of the eastern lobe at about 35' east of SS433. They concentrated their effort of analysis on the jet termination region where the eastern radio "ear" was seen. They showed no evidence for TeV emission at photon energies above 1 TeV, with resulting 99 % upper limits in the range 8 - 10 % of the Crab flux.

2. Observations

The CANGAROO-II 10m telescope (S31°06', E136°, 160m a.s.l.) is equipped with the imaging camera which consists of 552 PMTs and its field of view is about 3 degrees. Details of the telescope are described elsewhere [2, 11, 16]. The western X-ray lobe of SS433/W50 was observed in August and September, 2001, and in July and September, 2002. In contrast to the previous observation of HEGRA [14], our tracking position was the jet shock region of the western X-ray lobe at R.A. (J2000) = $19^h10^m17^s$, Dec. (J2000) = +04°57'46". This position is about 23' west of SS433, and has the hardest X-ray spectrum in the western X-ray lobe. Whole western X-ray lobe was in the field of view of our imaging camera. Total observation times were about 85 hours for ON source, and 80 hours for OFF source. After pre-selection with a good sky condition, 60 % of observed data were accepted for the analysis (Table 1.).

Table 1. Observation time $t_{\rm obs}$ and selectd time $t_{\rm sel}$ in 2001 and 2002.

	2001	2002	TOTAL
$t_{\rm sel}$[hr] / $t_{\rm obs}$[hr] (ON)	36 / 51	16 / 34	52 / 85
$t_{\rm sel}$[hr] / $t_{\rm obs}$[hr] (OFF)	30 / 49	17 / 31	47 / 80

3. Analysis

The analysis of the data was performed based on the imaging atmospheric Cherenkov technique [9, 19]. The gamma-ray like events are selected by using the shape parameters as *distance*, *length*, *width* and *alpha*. We determined ranges of these parameters by comparing distributions between gamma ray events generated by the Monte-Carlo simulation and the OFF source data (Fig. 1.). To obtain the maximum acceptance of gamma rays, the ranges of cut values were determined as $0.5 < distance < 1.0$, $0.03 < length < 0.25$ and $0.02 < width < 0.13$, respectively.

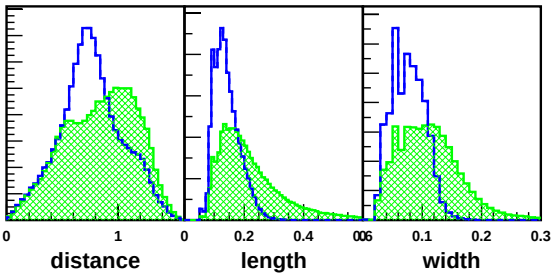

Fig. 1. Distributions of the shape parameters for *distance*, *length*, *width*. Hatched histograms show OFF source data, and solid lines show gamma rays. The number of gamma rays are normalized to the number of OFF source events.

4. Results

Figure 2 shows preliminary results of *alpha* distributions for the observation data of SS433/W50 in 2001, 2002 and 2001+2002, respectively. Number of ON source events are normalized to the number of OFF source events in the range of $alpha > 30$ degrees. Mean zenith angle of the analyzed data was 51 degrees, and the energy threshold for this source was estimated to be about 650 GeV by the Monte-Carlo simulation.

5. Summary

We have searched for sub-TeV gamma rays from the western X-ray lobe of SS433/W50 system using 85 hours of observation data. We found no significant

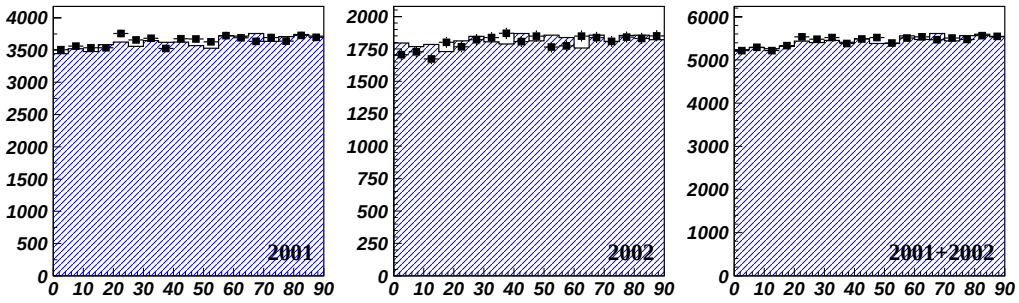

Fig. 2. *Alpha* distributions for 2001, 2002 and 2001+2002 data. Solid squares show ON source data and hatched histograms show OFF source data.

excess of sub-TeV gamma rays at the position where the hardest X-ray spectrum of the western lobe from these data. We can discuss the strength of magnetic field, material density, and acceleration efficiency of the jet shock, by comparing our estimation for the upper limit of sub-TeV gamma rays with the flux density of X rays. We are analyzing the data by considering energy dependence, and in other regions of the western X-ray lobe.

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