TeV gamma-ray Observations of the Supernova Remnant RCW86 with the CANGAROO-II telescope

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Abstract

The supernova remnant(SNR) RCW86(G315.4-2.3) has been observed as our third SNR in 2001 and 2002 with the CANGAROO-II 10 m telescope from Woomera, South Australia, to further test the hypothesis that SNR accelerate cosmic rays. RCW86 is a type II and shell-like supernova remnant, and *ASCA* detected non-thermal X-ray emission from the southwest shell of RCW86, which is brighter than that from SN1006. The multiwavelength spectrum of RCW86 derived from radio and X-ray data indicates that the emission is due to the synchrotron radiation, and it is argued that high energy electrons emitting the detected synchrotron radiation are expected to be accelerated up to 20 TeV.

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Therefore, the radiation due to inverse Compton scattering with photons of the 2.7 K cosmic microwave background is also expected to be detectable with the CANGAROO-II telescope if the magnetic field is as weak as that of SN1006. Here we report the preliminary results.

1. Introduction

The origin and acceleration mechanism of cosmic rays have been long-standing problems since the discovery of cosmic rays in 1911 [7,8]. The shock front of supernova remnants is believed to be the most promising candidate for the acceleration of cosmic rays up to 10^{15} eV. No other class of galactic object looks to have enough energy to satisfy the observed flux of cosmic rays.

We, CANGAROO group, have already detected TeV gamma-rays from two SNRs, SN1006 [12,13,6] and RX J1713.7−3946 [11,4], with the CANGAROO-II 10m telescope [10]. Needless to say, it is important to study other SNRs to see whether they are also acceleration sites of cosmic rays, and, if so, what mechanism dominates the TeV gamma-ray emission. We have therefore selected another SNR emitting synchrotron X-rays, RCW86 [1,2], for observations with the CANGAROO-II telescope.

RCW86, a type II [3] and shell-like SNR, has been observed in the radio and X-ray bands with the results suggesting that accelerated high energy electrons are emitting synchrotron radiation at these energies. In addition, from another observation, a molecular cloud is detected near the southwest(SW) shell of this SNR. The SW-shell may be interacting with the cloud. If the X-ray emission is due to the synchrotron radiation, there must be at least the emission of TeV gamma-rays by inverse Compton scattering. This emission should be at detectable levels if the strength of the magnetic field is less than $15\,\mu$G.

2. Observation

RCW86 was observed in 2001 (March, April and May) and 2002 (March and April). The tracking point of these observation was (R.A., Dec.)=(220.192°, −62.677°) in its SW-shell, where the strongest non-thermal X-ray emission was observed by *ASCA*. Total observation times were 79 hours and 72 hours for ON- and OFF-source runs, respectively.

3. Analysis

First, we selected the data taken under good sky conditions, and corrected the dead time of data acquisition system. The selected times after these processes are shown in Table 1. The data includes night sky background (NSB) photons and electronic noise, which deform the gamma-ray shower image. These effects were eliminated as follows; we required pixels to have more than ∼5 photoelectrons, be triggered within 35 nanoseconds from the center of the arrival timing distribution, and have at least 4 adjacent triggered pixels. The selected data includes any gamma-ray events, but also the huge cosmic ray background. In order to discrim-

Table 1. Observation time of RCW86.

	observed		selected	
	ON	OFF	ON	OFF
2001	38h 09m	33h 59m	18h 43m	17h 58m
2002	41h 11m	38h 37m	24h 57m	27h 34m

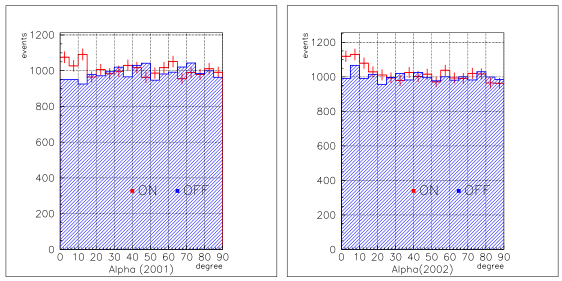

Fig. 1. Preliminary "alpha" distribution for ON-source (solid line) and OFF-source (hatched histogram) in 2001(left) and 2002(right). The number of OFF-source events is normalized to that of ON source events in the region of "alpha" $>$ 30 degrees, and the significance of the excess events is calculated for "alpha" $<$ 15 degrees.

inate gamma-ray–like events from cosmic-ray–like ones, we adopted the standard "Imaging Technique" [9,14]. In this analysis, conventional image parameters of "distance", "length", "width" and "alpha" were used. The energy threshold was estimated from simulations to be $\sim$1.0 TeV. This relatively high threshold is due to the observations at large zenith angles, $\sim 35°$, and the higher energy threshold requied to reduce the effects of background light from the township of Woomera.

4. Result and Discussion

In both years, a excess of $\sim 4\sigma$ was observed above 1 TeV (Fig. 1). Although this is not significant enough to establish RCW86 as a confirmed TeV gamma-ray source, the corresponding integral flux was estimated for 2001 and for 2002 as (2.7 $\pm$ 0.7)$\times$ 10^{-12} and (3.0 $\pm$ 0.7)$\times$ 10^{-12}, respectively, using these results and Monte Carlo simulations. Assuming the photon index to be -2.5, we constructed the multiwavelength spectrum (Fig. 2). In the figure, the error bars show statistical errors only, and the systematic error is estimated to be roughly 30%.

Peaks in the Alpha distributions are seen above 1 TeV both in 2001 and 2002, while there is no significant peak below 1 TeV. This may indicate that the TeV gamma-rays are due to inverse Compton scattering by high energy electrons, as in the case of SN1006. Figure 2 shows that the magnetic field in RCW86 is $\sim 10\,\mu$G, which is reasonable for a SNR.

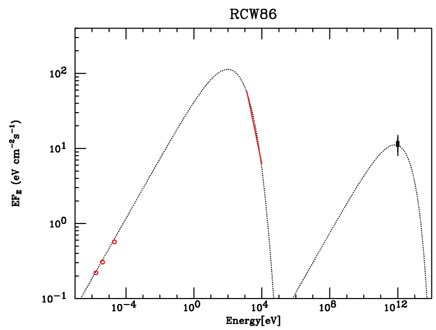

Fig. 2. Multiwavelength spectra of RCW86. The dots with error bars are based on our results for 2001 and 2002. The observation data of radio to X-ray band is explained by synchrotron model and as its counterpart, inverse Compton model is applied to our preliminary result of TeV gamma-ray band. The magnetic field is assumed to be 10 μG for spectrum of RCW86.

5. Conclusion

RCW86 has been observed with the CANGAROO-II 10 m telescope for about 44 hours (ON-source data after cuts). After the standard imaging cuts have been applied, peaks at low values of alpha appear at greater than the 3σ level both in 2001 and 2002. The corresponding integral flux was estimated above. Our present result suggests the possibility of gamma-ray emission derived from inverse Compton scattering in the SW shell of RCW86 from high energy electrons. However, it is premature to claim that this SNR is emitting TeV gamma-rays: further analysis of this data is being undertaken and new stereo observation [5] has been undertaken using the two 10 m telescopes.

6. References

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