Observation of sub-TeV gamma-rays from RX J0852.0-4622 with the CANGAROO-II telescope

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Abstract

RX J0852.0−4622 (G266.2−1.2) is a Type-II Supernova Remnant (SNR) located along the line of sight to the Vela SNR. The X-ray spectrum observed by *ASCA* was featureless, with the maximum of the X-ray emission detected from the northwest rim. We observed RX J0852.0−4622 with the CANGAROO-II telescope from December 2001 to February 2002 to search for sub-TeV gamma-ray emission. The detection of sub-TeV gamma rays, would be further evidence for the acceleration of cosmic rays via shocks, as observed for SN1006 and RX J1713.7−3946. The preliminary result of the analysis is reported.

1. Introduction

Supernova Remnants (SNRs) are believed to be the origin of cosmic rays up to 10^{15} eV. However, direct evidence is scarce. The CANGAROO group have detected gamma-rays from SN1006 (Tanimori et al. 1998, 2001; Hara et al. 2001) and RX J1713.7−3946 (Muraishi et al. 2000; Enomoto et al. 2002b).

RX J0852.0−4622 is a Type-II SNR (Chen, Gehrels 1999) located along the line of sight to the Vela SNR. It was discovered at X-ray energies during the *ROSAT* all-sky survey (Aschenbach 1998). Hard X-ray emission was also detected with the *ASCA* satellite, with a spectrum well described by a power law (Tsunemi et al. 2000; Slane et al. 2001). XMM-*Newton* observations have revealed the fine structure of this SNR (Iyudin et al. 2002). The radio emission was found with the Parkes radio-telescope to be very weak (Combi, Romero & Benaglia 1999; Duncan & Green 2000). CO observations showed the richness of large molecular clouds around this object in the Vela Molecular Ridge (May, Murphy & Thaddeus 1988). The detailed morphology has been mapped with the NANTEN 4 m milli-metre wave telescope (Moriguchi et al. 2001). COMPTEL detected the ^{44}Ti line and the distance and age were estimated to be less than 500 pc and ∼1000 yr respectively (Aschenbach et al. 1999). A line in the X-ray spectrum was also detected by

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ASCA which indicated the existence of the over-abundant Ca produced due to ^{44}Ti decay, again suggesting an age of around 1000 yr (Tsunemi et al. 2000).

2. Observation

RX J0852.0−4622 was observed with the CANGAROO-II telescope (Mori et al. 2001; Tanimori 2001) from December 2001 to February 2002. The pointing direction was $(\alpha, \delta) = (8h48m59s, -45^o39'00'')$ (J2000), where the X-ray emission was maximum. The maximum elevation angle was $\sim 75°$. In order to search for sub-TeV gamma-rays, background observations (OFF-source runs) were carried out and compared with the ON-source runs. The total observation time was 40h45m (ON-source runs) and 36h12m (OFF-source runs), respectively. The object is located on the Galactic Plane so that the sky background is bright due to stars near the object. This must be treated carefully during the analysis.

3. Analysis

The photons emitted from air showers generated by gamma-rays and cosmic rays are detected using the imaging air Cherenkov technique. These photons form a thin shower image which includes noise due to the night sky background (NSB). To minimize the effects of the NSB, we selected events that had clusters with 5 adjacent pixels with signals above a threshold of ∼3.3 photoelectrons. Signals with arrival times too far from the mean arrival time were also rejected as NSB photons. Events remaining after these cuts are predominantly caused by cosmic rays and so the event rate should be constant (with some zenith angle variation). Periods of low event rate due to clouds were eliminated . Data taken at elevation angles less than 60° were eliminated. To monitor the starlight, each pixel is equipped with a scaler circuit. Pixels with high scaler values were masked to remove the effect of stars. We also cut bad pixels due to electrical noise.

After these cuts, clean shower images of gamma-rays and cosmic rays (mainly protons) were left. Figure 1 shows the distributions of the shape parameters (Hillas 1985; Weekes 1989). The left figure shows *width* and the right figure shows *length*. The contours show those from Monte Carlo simulations of gamma-rays. The points are the observed data (OFF-source runs) which can be used as background samples. These distributions were used as probability density functions (PDFs) for the inputs to the likelihood method (Enomoto et al. 2002). Here the energy dependences were taken into account. Before adapting this method, the events were selected with the criteria of $0.2° < distance < 1.2°$. This parameter is dependent on the object size so it should not be used as an input to the likelihood function. After this selection, the Likelihood ratio, L,

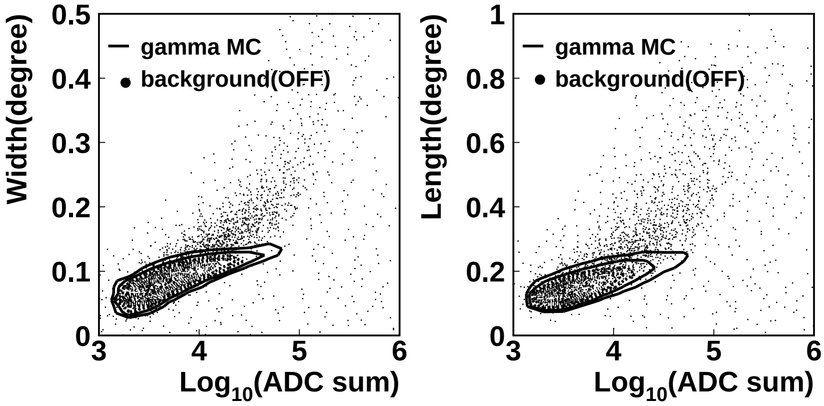

Fig. 1. ADC sum vs shape parameters. The left figure shows *width*. The right figure shows *length*. The Monte Carlo simulation of the gamma-rays is shown by the contours, and the OFF-source data as background samples are plotted as points. The ADC sum for each event is considered to be approximately proportional to the energy of the particle.

defined by

$$L \equiv \frac{Prob.(\gamma)}{Prob.(\gamma) + Prob.(p)}$$

was calculated. Figure 2 shows the distributions of L for the observed data (OFF-source runs) and for the Monte Carlo simulation of gamma-rays. The typical cut value of ~ 0.4 was adopted. If we adopt a higher value, the significance of the gamma-ray signal may increase, but the acceptance decreases significantly.

4. Result

The resulting *alpha* (orientation angle of image) (Punch et al. 1991) distribution after selecting the events by the likelihood cut is plotted in Figure 3. The points with error bars are obtained from the ON-source data. The hatched area is the data of the OFF-source runs which is normalized to the ON-source runs using the data with *alpha* greater than 30°. This preliminary result is encouraging, however a more detailed analysis is required. Further observations are planned in January 2003.

5. Discussion

Figure 4 is the multi-wavelength spectrum of RX J0852.0−4622. The thick solid line at the center of the figure is the X-ray spectrum observed by *ASCA*. It is described well by a power law with a photon index of ~ 2.6. The radio

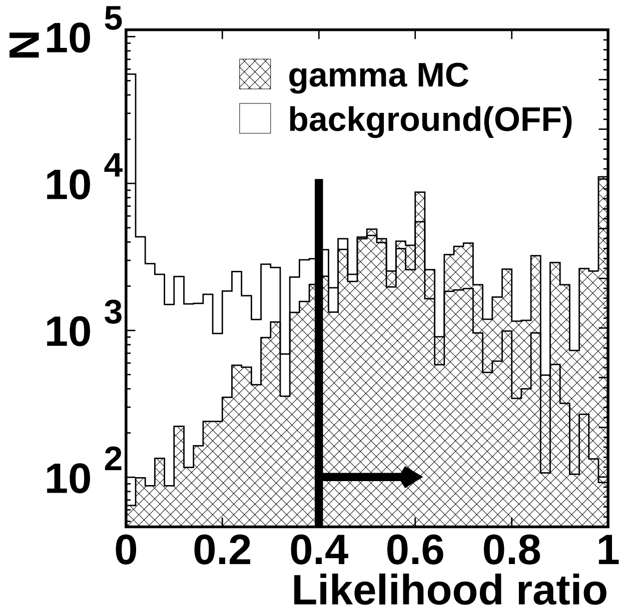

Fig. 2. Likelihood ratio. The Monte Carlo simulation of the gamma rays is shown by the hatched area, and the OFF-source data as a background sample is the unshaded area.

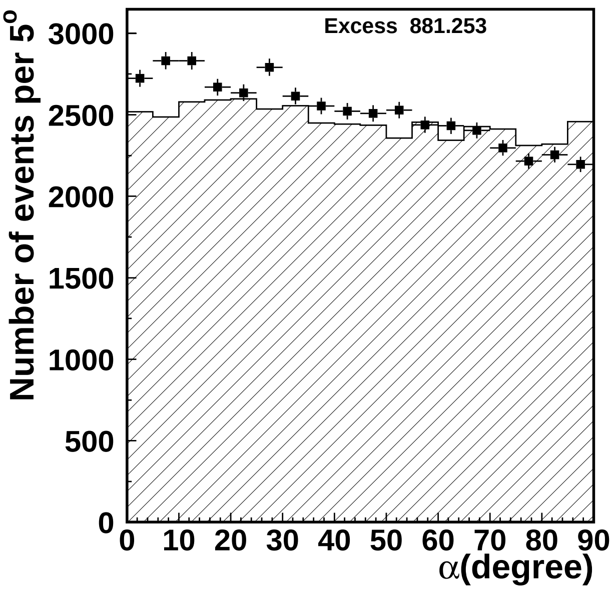

Fig. 3. Alpha distribution. The data of the OFF-source runs is normalized by the ON-source runs using the data greater than 30 degrees.

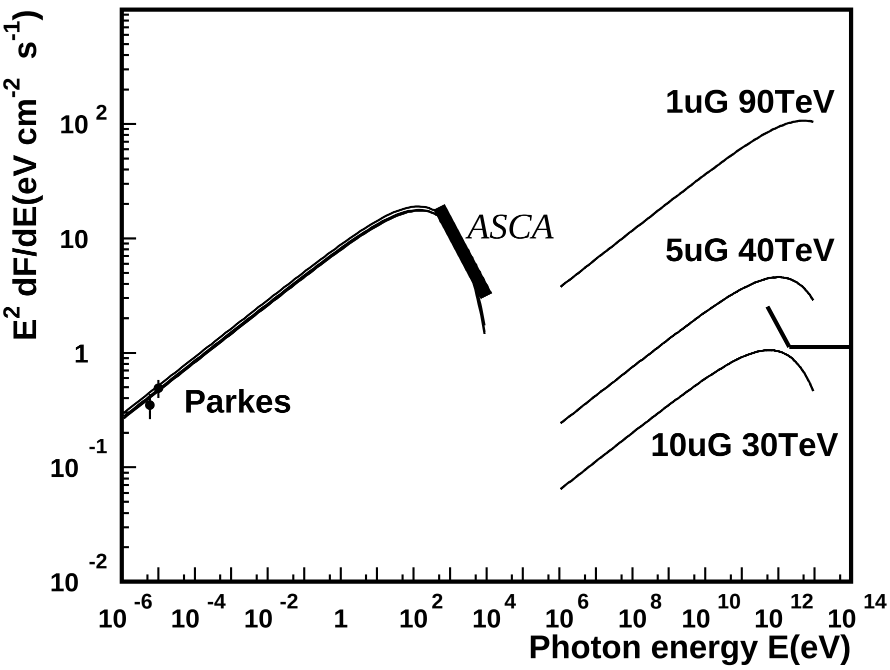

Fig. 4. Multi-wavelength spectrum of RX J0852.0−4622. The X-ray data taken by *ASCA* satellite are plotted by the thick solid line at the center. The radio data taken by Parkes observatory are plotted by the points. The sensitivity of the CANGAROO-II telescope is shown by the solid line at the right. The models based on the inverse Compton scattering of CMB by high energy electrons are shown by the the curved solid lines, for several values of the magnetic field.

points are from Parkes 64 m telescope observations. These emissions seem to be synchrotron radiation, indicating the existence of high energy electrons. The solid line at the right of the figure is the sensitivity of the CANGAROO-II telescope. The curved solid lines are estimated by the models based on the inverse Compton scattering of cosmic microwave background (CMB) by high energy electrons emitting synchrotron radiation. Within a reasonable range of magnetic field strengths, emission of detectable levels of sub-TeV gamma-rays for the CANGAROO-II telescope seems quite feasible.

6. Conclusion

We have analyzed CANGAROO-II data from RX J0852.0−4622 and derived a preliminary alpha distribution. A more detailed analysis is underway. If a significant gamma-ray flux is confirmed, arising from accelerated electrons, we can estimate or limit the strength of the magnetic field of this SNR. Further observations must be carried out to confirm the excess events.

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