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Recent Results from the CANGAROO Project

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1. The CANGAROO Project

The Collaboration of Australia and Nippon for a GAmma Ray Observatory in the Outback operates two large telescopes at Woomera (South Australia), which detect the Čerenkov light images produced in the atmosphere by electron-positron cascades initiated by very high energy (~1 TeV or 10^{12} eV) gamma rays. These gamma rays arise from a different mechanism than at EGRET energies: inverse Compton (IC) emission from relativistic electrons.

The spoke-like images are recorded by a multi-pixel camera which facilitates the rejection of the large numbers of oblique and ragged cosmic ray images. A field of view ~3.5° is required. The Australian team operates a triple 4 m diameter mirror telescope, BIGRAT, with a 37 photomultiplier tube camera and energy threshold 600 GeV. The Japanese operate a single, highly accurate 3.8 m diameter f/1 telescope and high resolution 256 photomultipler tube camera. In 1998 a new 7 m telescope is planned for Woomera with a design threshold ~200 GeV.

2. Egret pulsars

2.1. The Crab

The Crab, a synchrotron nebula and pulsar at a distance of 1.5 kpc, is a standard candle for TeV work. We have observed it from Woomera, where it reaches a maximum elevation of 38°. At an energy threshold of 7 TeV, a 4σ excess of gamma-ray events was found (Tanimori et al. 1994). More recent observations have confirmed this result.

2.2. PSR B1706−44

This isolated southern 102 ms pulsar is only the second pulsar known to emit ∼1 TeV photons so its confirmation and further study are important. Our observations were made in 1992–1993 and show steady non-periodic emission in both years with a combined statistical significance of 12σ (Kifune et al. 1995). The measured flux of 1×10^{-11} photons cm^{-2} s^{-1} above 1 TeV is approximately 2 orders of magnitude below the extrapolated EGRET spectrum. Using BIGRAT data alone, the upper limit is 4.6×10^{-11} photons cm^{-2} s^{-1} above 600 GeV.

2.3. The Vela pulsar

The Vela pulsar is young (11,000 y) and relatively close (∼500 pc). It is by far the brightest GeV gamma ray source observed by EGRET. The GeV emission is almost 100% pulsed. Recently Rosat observations below 2 keV have revealed a relativistic jet extending SSW from the pulsar along the magnetic axis out to 0.4° (Markwardt and Ogelman, 1995). emission. The TeV data show unpulsed gamma-ray emission from a position offset by ∼0.05° from the pulsar, near the jet. An excess was detected each year over the three year period 1993–1995. The jet may cause shock acceleration of energetic particles which could result in the emission of TeV gamma rays. Further work is needed to confirm this important result.

2.4. PSR B1055-52

PSR 1055-52 is a 197 ms EGRET pulsar at a distance of 1.5 kpc. It is notable as a very efficient converter of rotational energy into GeV gamma rays. However, no TeV emission has so far been observed in 2 years of CANGAROO observations.

3. Other pulsars

PSR 1259-63 is a binary pulsar. At periastron in January 1994, it passed very close to its companion. During these 4 days observation a 3σ excess was observed by Cangaroo. Further observations are needed at the next periastron in 1997.

PSR J0437−4715 is a binary 5.757 ms pulsar. The system is only 140 parsecs away. The spin down energy flux density, $\dot{E}/4\pi D^2$ is the same order of magnitude as PSR B1706−44. It has not been detected by EGRET. Our search for emission from PSR 0437−47 at the radio period yielded no evidence for TeV gamma ray emission. An upper limit for a pulsed flux above ∼1 TeV of 5×10^{-11} photons cm^{-2} s^{-1} was obtained by BIGRAT.

References

Kifune, T. et al., 1995, ApJ, 438, L91.

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