

Observation of Southern High Energy Peaked BL Lac Object PKS 2155-304 with the CANGAROO-II Telescope

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Abstract

In spite of its distance ($z=0.116$), high energy peaked BL Lac object (HBL) PKS 2155-304 had been considered as promising TeV gamma-ray emitter which can be observed only from southern hemisphere.

We observed PKS 2155-304 in Aug-Sep 2000 and Jul-Sep 2001. Exposure time for this HBL object is ON/OFF = 35.6 hours/35.1 hours (2000) and 28.7 hours/26.2 hours(2001). Analysis shows that no significant gamma-ray excess is found for 2000 and 2001 observation period and flux upper limit is derived.

Estimated energy threshold is ~ 400 GeV (2000) and ~ 500 GeV (2001). Derived flux upper limit (2 sigma) above these threshold is $F(>400 \text{ GeV}) < 1.2 \times 10^{-11} \text{ cm}^2 \text{ sec}^{-1}$ (2000) and $F(>500 \text{ GeV}) < 8.2 \times 10^{-12} \text{ cm}^2 \text{ sec}^{-1}$ (2001), respectively.

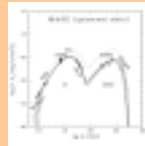
Introduction

The Spectrum Energy Distribution (SED) of BL Lac object is known to have "double humped" shape from northern BL Lac object, Mkn 421 ($z=0.030$) and Mkn 501 ($z=0.034$). TeV gamma-ray emission from these sources was discovered by Whipple group.

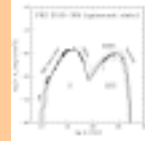
Southern BL Lac object PKS 2155-304 ($z=0.116$) is bright at optical and hard X-ray band. This object not only have double humped SED but also has highly variable hard X-ray spectrum. Durham group observed this promising object in November 1997 and claimed detection of TeV gamma-ray (Chadwick *et al.* 1999a).

It is pointed out by Stecker *et al.* (1992) that these TeV gamma-ray emitting BL Lac objects can be used as a probe of extragalactic infrared back-ground (EIRB) from these nature of long distance (typically $z \sim 0.1$). Recently, Whipple, HEGRA, and CAT group detected TeV gamma-ray from BL Lac object H 1426+428 ($z=0.129$). This detection is encouraging to observe PKS 2155-304.

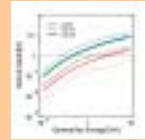
If we do detect TeV gamma-ray and spectrum cut-off from PKS 2155-304, spectrum information will pose severe constraint on poorly known EIRB spectrum.



SED of Mkn 421 (adopted from Kino *et al.* 2002)



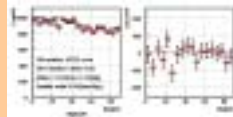
SED of PKS 2155-304 (adopted from Kino *et al.* 2002)



Optical depth for TeV gamma-ray

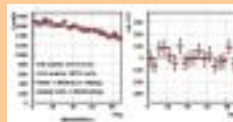
Preliminary Results

2000

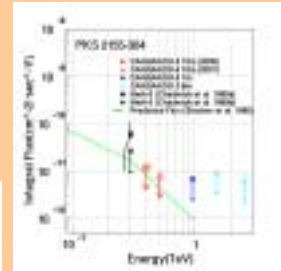


Distribution of ALPHA parameter for observation epoch of 2000.

2001



Distribution of ALPHA parameter for observation epoch of 2001.

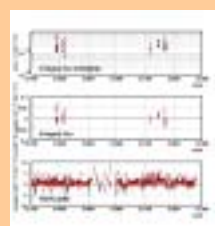


Derived integral flux limit (2 sigma) from CANGAROO-II and others.

Left figures shows distribution of ALPHA parameter, which is one of so-called "Hillas parameter". If sufficient number of TeV gamma-ray is detected, an excess of events will appear between 0 and 15 degree. It can be seen from these ALPHA plots that no significant event excess is found from each observation epoch (2000 and 2001).

Right figure shows integral flux upper limit (2 sigma) derived from the CANGAROO-II telescope and other observatory. If the statistical confidence interval of flux upper limit derived in the respective literature was other than 2 sigma, data was converted into 2 sigma confidence interval. Energy threshold estimated from simulation is ~ 400 GeV for 2000 and ~ 500 GeV for 2001. The calculated Integral flux limit is $F(>400 \text{ GeV}) < 1.2 \times 10^{-11} \text{ cm}^2 \text{ sec}^{-1}$ for 2000 and $F(>500 \text{ GeV}) < 8.2 \times 10^{-12} \text{ cm}^2 \text{ sec}^{-1}$ for 2001, respectively.

Multiwavelength Observation



This figure shows daily integral flux limit (2 sigma) of TeV gamma-ray (upper panel), integral flux (middle panel), and light curve from RXTE-ASM (lower panel) which is consisted from the one-day averaged count which is taken from NASA/SOF light curve generator. Simultaneous observation was conducted with RXTE (from 51783 MJD to 51788 MJD) but not indicated.

According to the synchrotron self-Compton model, TeV gamma-ray flux variation correlate to hard X-ray variation. But, during our TeV gamma-ray observation epoch, no hard X-ray activity is seen.

Observation



	Epoch	ON	OFF
	2000 August	11.6 hours	10.8 hours
	September	24.0 hours	24.3 hours
	2001 July	8.1 hours	7.4 hours
	August	9.4 hours	8.9 hours
	September	11.3 hours	9.7 hours
	Total	64.4 hours	61.1 hours
	Eff. Exposure	37.6 hours	29.3 hours

CANGAROO-II Telescope (RA, Dec) = (21^h58^m52.0^s, -30^o13' 32") (J2000)

References

- Chadwick *et al.*, 1999a, ApJ, **513**, 161
Chadwick *et al.*, 1999b, Proc. 26th ICRC (Salt Lake City), **3**, 338
Kino *et al.*, 2002, ApJ, **564**, 97
Stecker *et al.*, 1992, ApJ, **390**, L49
Stecker *et al.*, 1996, ApJ, **473**, L75