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Very High Energy Gamma-ray and Near Infrared observations of 1ES2344+514 with TACTIC and MIRO Telescopes

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1ES2344+514 (z = 0.04) is one of the first BL Lac objects to be reported as an extreme synchrotron blazar with synchotron peak energy reaching up to 100keV and was discovered as a source of Very High Energy (VHE) gamma- rays by the Whipple group in 1995. Subsequently, it was observed by the HEGRA group in 1997/98 and 2002. We have recently (Oct.- Dec. 2004) observed the 1ES2344+514 using the imaging element of the TACTIC array and have collected data for 53 hours in on/off mode. The source was also observed in near infrared bands J, H and K, for some nights using NICMOS-3 array mounted on 1.2m MIRO infrared telescope. Such a study is expected to provide clues to the dominance or otherwise of the Compton component. After detailed analysis of the TACTIC data we have placed an upper limit of $\leq 4.2 \times 10^{-12}$ photons cm^{-2} s^{-1} at a 3σ confidence level on the gamma-ray flux from the source. In the near infrared band the source shows low level variations without any flaring activity.

1. Introduction

The availability of multi-wavelength data has shown that blazars follow a well defined sequence in terms of their broad band spectral properties. Combined with increasingly detailed emission models, this information has provided not only tools with which to identify potential sources of TeV emission but also made possible the predictions of their gamma-ray flux. All the blazars detected in VHE gamma-rays all of them are HBLs, where synchrotron peak falls in the region of UV to soft X-rays. They are the perfect targets of ground based observations with atmospheric Cherenkov telescopes since they have the second peak of their spectral energy distribution extending well into the TeV domain. In addition, these blazars show extreme variability in their flux in broad band spectrum ranging from radio to TeV gamma-rays. 1ES2344+514 was first reported by the Whipple group[1] in 1998 as a TeV gamma-ray source based on observations in 1995-97. Whipple detected a flare on December 20,1995 at a flux level of 0.63 Crab Units (E $\geq$300GeV) and the reported integral mean flux values of 0.11 and 0.08 Crab Units during the two observation spells. Although this source has been recently confirmed by the HEGRA telescope[2], its energy spectrum is still not available. In order to understand its broad energy spectrum, we have observed it in TeV energy range and in near infrared bands J, H and K for few nights with the TACTIC(TeV Atmospheric Cherenkov Telescope with Imaging Camera) and MIRO(Mt. Abu Infrared Observatory) telescopes.

2. Telescope Details

TACTIC array of atmospheric Cherenkov telescopes is located at Mt. Abu (24.6° N, 72.7° E, 1300 m asl), a hill station in Western India. Its Imaging Element (IE) uses a tessellated light-collector of 9.5 m^2 area which

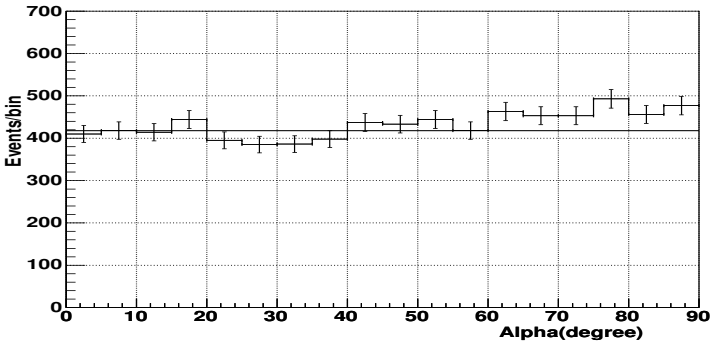

Figure 1. Distribution of image parameter ALPHA for the 2004 data set.

is configured as a quasi-parabolic surface, yielding a measured spot-size of 0.3° for on-axis parallel rays. The telescope is sensitive to gamma-rays with energies between approximately 2 TeV to 20 TeV and can detect the Crab Nebula at 5σ significance level in 25 hours of ON source observation[3]. The 1.2m MIRO telescope is located a few kms away from the TACTIC at an altitude of 1680m.

3. Observations and Data Analysis

3.1 TeV Gamma-rays: TACTIC

The VHE observations were made in tracking mode with the imaging element(IE) of TACTIC telescope during October to December 2004. Total duration of observations from on and off- source directions were 46.6 and 6.1 hours respectively. Data quality cuts have been applied to the raw data in order to reject bad quality data runs. After applying these cuts we have selected good quality data set of 43.4 hours. Details of the observations are given in the Table 1. Data analysis involves number of steps including filtering of light of night sky background and finding Cherenkov image boundaries. After this, clean images are parametrized using the Hillas method[4]. The gamma-ray selection cuts are applied to select signal like events from the background of cosmic-ray events. Various cuts values used in the analysis are given in the Table 2. The resulting distribution of orientation parameter alpha (in degree) for on source observation is shown in Figure 1. As is clear from the Figure , there is no evidence for a statistically significant gamma-ray signal from the source direction with in the range of system sensitivity. In addition, we have also searched for a gamma-ray signal from the source direction on nightly basis and Figure 2 shows these variations (TACTIC photons/hour) along with the RXTE ASM [5] data (counts/sec) in the energy range of 2-10 KeV. Again, we do not find any evidence for flaring episodes on nightly basis during our observations.

3.2 Near Infrared: MIRO

Observations in near infrared J, H & K bands were taken during November 18, 22-24 and December 5, 6, 2004 using NICMOS-3 256x256 pixel HgCdTe detector array camera mounted on the MIRO 1.2m IR telescope. by Physical Research Laboratory. Several sets of images were taken on each day with 280, 220 & 70 secs total

Table 1. Observation log for 1ES2344+514(ON Source)

Month	Dates Of Observations	Observation Time in hrs
October	18,19	3.1
November	3,4,5,6,7,8,9,10,15	24.4
December	2,3,4,5,6,8,9	19.1

Table 2. Cut Values used for Analysis

Parameters	Values
Length	$0.11° \leq L \leq (0.155 + 0.0260*\log(size))°$
Width	$0.06° \leq W \leq (0.080 + 0.01250*\log(size))°$
Distance	$0.4° \leq D \leq 1.3°$
Size	$S \geq 270$
Alpha	$\alpha \leq 15°$

integration times in J, H and K bands, respectively. Three comparison stars were also kept in the frames for magnitude calibration. Data reduction and analysis was performed using IRAF and locally developed scripts are given elsewhere[6]. The source, 1ES2344+514, and calibration stars were subjected to aperture photometry and the corrected magnitudes of the source in the J and H bands are plotted in Figure 3.

4. Results

As shown in the Figure 1, alpha distribution obtained, after applying cuts in the Hillas parameters space is flat, thereby indicating absence of statistically significant TeV gamma-ray signal from the source direction. Accordingly we have placed an upper limit of $\leq 4.2 \times 10^{-12}$ photons cm^{-2} s^{-1} at the 3σ confidence level on the gamma-ray flux from the source above 2 TeV. Further, day to day variations of gamma-ray signal (Figure 2) do not show any evidence for flaring activity.

It is clear from Figure 3 that 1ES2344+514 shows day-to-day low level (0.1 mag) variation in both, J & H

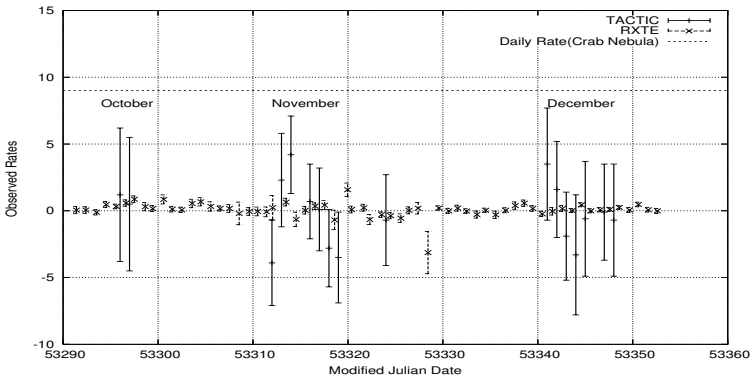

Figure 2. Light curve of 1ES2344+514 from Oct. to Dec. 2004 as observed by the TACTIC and the RXTE.

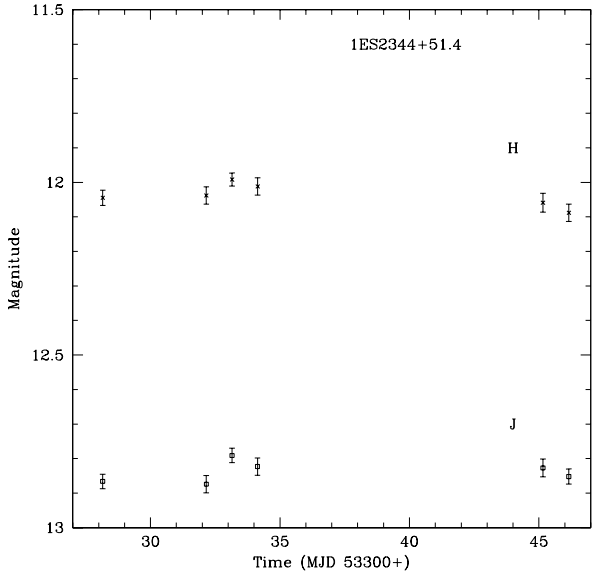

Figure 3. Near infrared J & H band light curve from Nov. 18 to Dec.6, 2004.

bands during the monitoring period. The J magnitude of the source is about 12.85 which is about the average value for source. The source, therefore, is not in flaring/outburst phase in this energy regime.

5. Discussion

Blazars show extreme variability in almost all wavelengths as one of their basic property. The object 1ES2344+ 514 has a redshift 0.044, implying it is a nearby object so the VHE emission may not be attenuated severely by interaction with the background of IR photons[7]. It prompted us to observe the source at VHE and near infrared regions of the electromagnetic spectrum. The results are shown with contemporary X-ray data from the All Sky Monitor of RXTE. We find that during TACTIC observations, source was in a quiescent phase which is also possibly supported by the fact that soft X-ray flux is also low. The source, however, shows low level (0.1 mag) variations in near IR bands during Nov. 18- Dec. 6, 2004. Though flux in the high energy regime is low, there is indication of a lag in the flickerings as seen in near IR vis-a-vis high energy- X and possibly γ-ray (Figure.2). Longer duration simultaneous monitoring is needed to understand the physical process of emission.

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