

# Observations of Blazars Mkn421 and 1ES 2344+514 using the PACT and HAGAR telescope systems

V. R. Chitnis\*, B. S. Acharya\*, R. J. Britto\*, R. Cowsik<sup>†</sup>,  
 N. Dorji\*, S. K. Duhan\*, K. S. Gothe\*, P. U. Kamath<sup>†</sup>, M. K. Mahesh<sup>†</sup>,  
 B. K. Nagesh\*, A. Naidu\*, N. K. Parmar\*, T. P. Prabhu<sup>†</sup>, L. Saha<sup>‡</sup> F. Saleem<sup>†</sup>,  
 A. K. Saxena<sup>†</sup>, S. K. Rao\*, S. K. Sharma\*, A. Shukla<sup>†</sup>, B. B. Singh\*,  
 R. Srinivasan<sup>†</sup> G. Srinivasulu<sup>†</sup> P. V. Sudersanan\* S. S. Upadhya\* and P. R. Vishwanath<sup>†</sup>

\*Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai 400 005, India

<sup>†</sup>Indian Institute of Astrophysics, Sarjapur Road, 2nd Block, Koramangala, Bangalore 560034, India

<sup>‡</sup>Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Kolkata 700 064, India

**Abstract.** We have observed 2 blazars Mkn421 and 1ES 2344+514 recently. The BL Lac object Mkn421 was observed using the wave-front sampling PACT telescope array located at Pachmarhi in central India during January - May 2009 as well as the high altitude HAGAR telescope system during March - May 2009. The blazar 1ES2344+514 was observed using the high altitude HAGAR array during September - December 2008. We did not see any evidence for significant flares from both these blazars during our observation period in our preliminary analysis. The day to day variations in flux are compared with those measurements at other wavelengths.

**Keywords:** AGN VHE  $\gamma$ -ray astronomy  
 1ES2344+514 Mkn421 HAGAR PACT

## I. INTRODUCTION

Blazars are the active galaxies whose narrow radiation beams, generated in relativistic jets, are pointed directly to wards us. The blazar 1ES2344+514 ( $z=0.044$ ) was detected in TeV gamma rays in 1995 by Whipple collaboration. They had seen the source in flaring state. Later HEGRA and MAGIC collaborations confirmed the detection over 140 GeV up to several TeVs. This balzar is one of the brightest extra-galactic sources in the TeV gamma-ray catalog with 11% of the Crab flux at 350 GeV and accessible in the northern sky.

Markarian 421 is a well established near by ( $z=0.031$ ) HBL blazer. It was discovered as a source of TeV  $\gamma$ -rays by the Whipple group [1]. This object has been studied well in many wavelengths and several multi-wavelength campaigns were also performed in the past. This source is highly variable and many large outbursts were detected from this source since its discovery in 1992.

We have observed Mkn 421 using the PACT telescope system as well as HAGAR array and the blazar 1ES2344+514 was observed using only the HAGAR setup.

We did not see any significant flares from both these blazars during our observation period in our preliminary analysis of data. Comparison of day to day variations in

flux with those of other wavelengths wherever possible are presented in this paper.

## II. DATA COLLECTION AND ANALYSIS

The details of PACT [2] and HAGAR [3] experimental setups are given elsewhere. Only half the array (12 Telescopes) was used for Mkn 421 observations with PACT.

Regions having similar brightness and same declination as of source were selected for collecting OFF source data. Also, it was ensured that the OFF source data have the same zenith angle range as of source. The ON-OFF data pairs were subjected to quality cuts. The arrival direction of showers are estimated for each event. The distribution of space angle, the angle between the shower direction and the source, were constructed for ON-OFF pairs and compared after suitably normalizing the OFF source data. The  $\gamma$ -ray signal is extracted after subtracting the normalized OFF source data from the On-source data. The details of the selection cuts and analysis procedure is given in an accompanying paper [4].

## III. MKN 421

A total of 27 On-OFF pairs corresponding to 32.26 hrs of data were available from observations using PACT. The threshold energy of these observations corresponds to about 1.2 TeV. 19 pairs were retained after cuts. The total duration is 24.34 hrs. Regarding the HAGAR data 11 pairs were retained from 28 pairs. The total duration for this is 5.96 hrs. The difference in event count rate for these 11 pairs are shown in figure 1.

The excess of source counts over the normalised background is shown as a function of Modified Julian Day (MJD) in figure ?? along with daily variations in the count rate from satellite observations for comparison. The X-ray ASM data is shown in top panel, the fermi-GLAST data in the second panel, PACT Data in the 3rd panel and HAGAR data in the fourth panel.

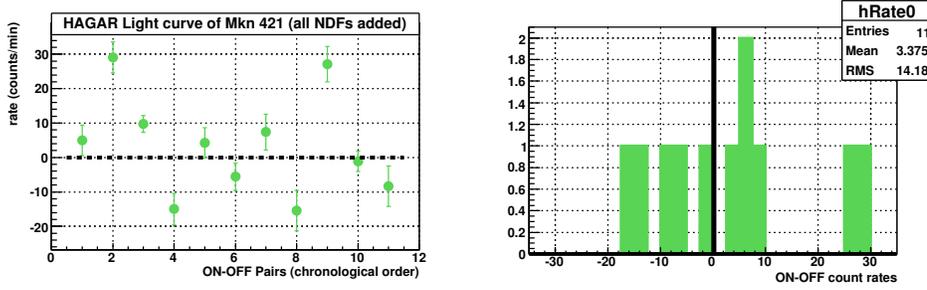


Fig. 1: ON-OFF data from HAGAR observations. The left figure is for difference in event rate for ON-OFF pairs in chronological order while the distribution of difference in event rate is shown in the right figure

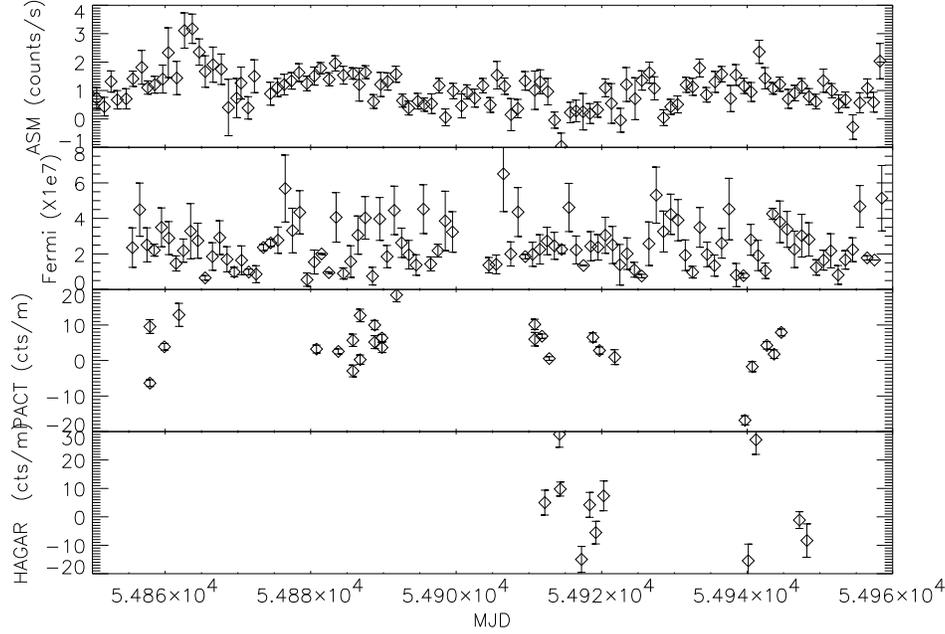


Fig. 2: Light curve of Mkn 421: ASM data (top panel); Fermi-GLAST (2nd panel); PACT data (3rd panel) and HAGAR data (bottom panel)

#### IV. 1ES 2344+514

We have observed this source using the recently commissioned high altitude (4270 m amsl) array, HAGAR, at Hanle in the Ladakh region of the Himalayas. HAGAR is an array of 7 non-imaging telescopes. The observations were made during September to December 2008 using ON and OFF-source mode for a total of 15.3 and 14.3 hours respectively. Each On-source/Off-source observation run typically lasted for about 40 m duration. The event trigger rate was  $\sim 10$  Hz. The zenith angle of the source during our observations was in the range of  $18^\circ$  to  $35^\circ$  and the corresponding threshold energy of gamma-rays works out to be about 250 GeV.

The figure 3 shows the difference in count rate between 18 ON-OFF pairs. Six pairs remain after imposing selection cuts. The difference in count rate for these pairs is shown in figure 4. The top left panel in the figure is for  $\geq 5$  telescopes with valid TDCs, top right panel for just 5, bottom left panel for just 6 (bottom left) and

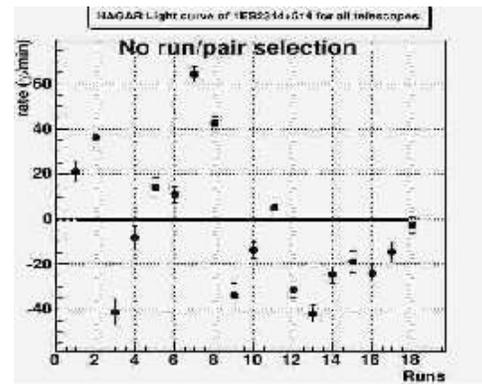


Fig. 3: Excess/deficit count rates from 18 ON/OFF pairs

bottom right panel for all 7 telescopes with valid TDCs. There is no significant evidence for flare and the data are consistent with background. The  $3\sigma$  upper limit on

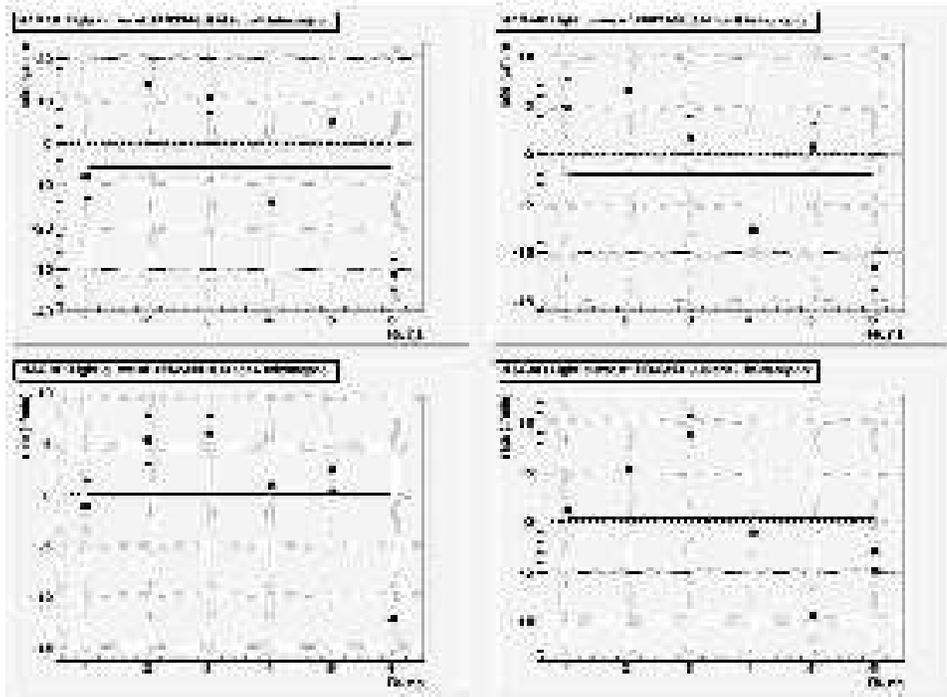


Fig. 4: Excess/Deficit count rate after data selection (a)  $NDF \geq 5$ , (b)  $NDF=5$

the flux of  $\gamma$ -rays from 1ES 2344+544 is estimated to be  $2 \times 10^{-11} \text{ photons cm}^{-2} \text{ s}^{-1}$  above a threshold energy of 250 GeV.

## V. CONCLUSIONS

We did not see any evidence for significant flares from both Mkn421 and 1ES 2344+514 during our observation period in our preliminary analysis. The quoted errors are only statistical and the estimation of systematic uncertainties are awaited. The analysis on the correlation of MKn 421 light curve at different wavelengths are going on.

## VI. ACKNOWLEDGEMENTS

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