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Possible bursts of TeV gamma rays in PACT from MKN 421 in April 2004

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Out of the four runs taken on MKN 421 with the PACT array in April 2004, the data of April 18th show possible bursts of TeV gamma rays. On comparison of the space angle distribution of events from the source and the background directions, the run clearly shows more events coming from nearer the source direction with the the excess amounting to a ∼9 σ effect. A clear indication of intra-run variability is seen with no excess in the initial part of the run and most excess coming in the last half an hour.

1. Introduction

Since its detection in the early' 90s, MKN 421 has played an important role in the progress of VHE γ ray astronomy. It was the first extragalactic source to be detected. It has also been seen to burst often by several groups [1, 2]. With the observations on this source, limits to the infra red flux have also been set up which highlight the connection between different bands of the electromagnetic spectrum. The correlation between x-ray variability and TeV γ ray variability of MKN 421 has also underlined the importance of multi-wavelength studies in astrophysics. This source has been observed for the past few years with the PACT array and the overall results are being presented elsewhere in this conference [3]. The present paper focuses on only the runs taken in April 2004 with an analysis undertaken in a slightly different manner from that in reference [3].

2. The Analysis

4 runs were taken on MKN 421 in the second half of April 2004 with the PACT experiment. These runs, taken on 16th,17th,18th and 19th had exposures of, 2.6, 2.4, 2.1 and 2.5 hours respectively. Background runs of similar duration were also taken on the same days. 3 sectors (2,3,and 4) out of 4 sectors were functional on all the nights. Standard analysis was done to get the arrival direction of the events [4]. At least 8 telescopes were demanded for further analysis. This ensured that telescopes from at least 2 sectors were present and also that no chance events were present in the selected data. The number of events on the source with data from at least 8 telescopes corresponded to $\sim$ 1.8 Hz.

The health of the runs was checked by comparing the number of events on source to that on background for the same hour angle interval (each 8 minute (2°) duration) for the 4 runs. The mean ratios were 1.01±0.1, 1.02±0.2, 1.00±0.03 and 1.00±0.03. Since the runs on April 16th and 17th showed larger fluctuation, they were not used or further analysis.

The space angle distribution becomes narrower with more degrees of freedom (NDF). There is also an increase of lever arm as the number of telescope increases. Unless the NDF distribution is quite similar, comparing the total space angle distribution (combined from all NDF) of source and background regions may not be advisable. Also the space angle distribution is a function of hour angle. Therefore, to treat data from all NDF in a similar manner, the 67 percentile point was found for space angle distribution for each NDF for events combined from both source and background runs. For example, for run on April 18th, for events within 0° and 10° hour angle the 67 percentile point for NDF of 8,12 and 15 was found to be 2.3°, 2.1° and 1.9° respectively. For binning purpose, 1/4 of this value was used and events in 8 bins were obtained for each space angle distribution. The normalization was done considering the number of events beyond the 67 percentile, Computing the differences between the number on source and background seperately for each NDF and adding them, we get a total excess of 1580±163 events for the run which is about 127 minutes long. This excess amounts to ∼9 σ and ∼11 per minute. The breakup of this excess in NDF groups is as follows : NDF (8-10)= 770±92 ; NDF (11-13)= 476±94; NDF (14-15)= 314±89 and NDF> 15= 20±51. It is seen that there is a decrease of excess with energy since NDF is proportional to energy. The left part of table 1 shows the number of events in different space angle bins (in above mentioned units) after adding the difference distribution from different NDFs. It is seen that the excess is present wholly within 67% of the total number of events.

However, the middle part of the table shows that the excess is not uniform in time. The data was split into 16 minute intervals and for each interval the source and background space angle distribution was compared for NDF $\leq$ 12 and $>$ 12 separately and the differences were added. There seems to be little or no excess in the beginning of the run and the excess builds up with time. Thus there seems to be intra-run variation in the number of the excess events. This is also borne out by the last column which shows the ratio of total number of ON source events/ OFF source with time. Similar analysis of the data of the run on 19th April will be presented later.

Table 1. No of excess events as a function of various parameters (for April 18th run)

Space Angle	Total No. of excess evts	Time (UTC) Hr:Min	No. of excess evts (per minute)	total ON source events /total OFF source events
0.125 ± 0.125	184 ± 52	16:15	-1 ± 6	0.85 ± 0.04
0.375 ± 0.125	558 ± 83	16:21	2 ± 4	0.87 ± 0.02
0.625 ± 0.125	562 ± 91	16:37	18 ± 4	0.89 ± 0.02
0.875 ± 0.125	258 ± 86	16:53	21 ± 4	0.90 ± 0.02
1.125 ± 0.125	-35 ± 72	17:08	9 ± 4	0.86 ± 0.02
1.375 ± 0.125	15 ± 56	17:25	8 ± 4	0.88 ± 0.02
1.625 ± 0.125	-108 ± 40	17:41	10 ± 5	0.93 ± 0.03
>1.75	128 ± 58	17:57	27 ± 4	0.93 ± 0.03
		18:13	17 ± 3	0.93 ± 0.04

3. Discussion

Aharonian et al [5] have reported a high flux period for the source from the HESS experiment for months of April and May 2004. They also report signal from the Whipple data of that night. A significant level burst seems to start off at ∼ 19h 30m in their data of April 18th. It is interesting to note that the present preliminary analysis of the PACT data also shows significant activity on that night. There is considerable excess of events from the source direction from ∼ 17h 40 m - 18h 22m when the run ended. A more detailed analysis could possibly reveal the energy spectrum during the burst.

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