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Observations of Mrk 421 with the CELESTE Heliostat Array

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Abstract. Since CELESTE first began routine observations in November 1999 in the 50 GeV range Mrk 421 has been a prime target. Here we report the preliminary average integral flux measurement obtained with 31.5 hours of ON-source time of $(7 \pm 3) \times 10^{-10}$ cm^{-2} s^{-1}.

Key words: Mrk 421, Atmospheric Cherenkov technique

1. Introduction

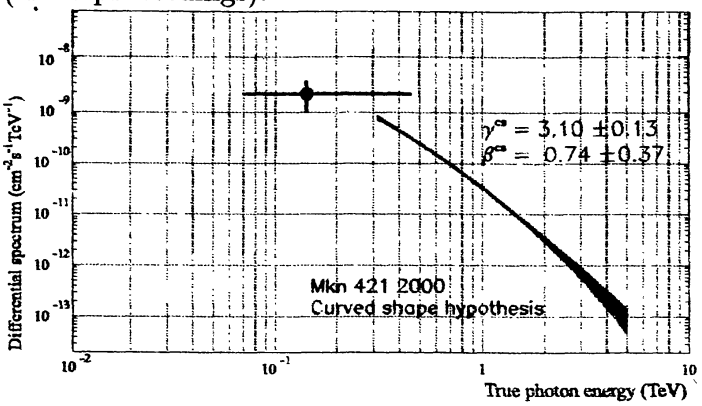
CELESTE was described in these proceedings in a separate review, and a preliminary light curve was shown (Smith, these proceedings). Since the conference, work has proceeded and in particular we now have a preliminary determination of the absolute flux from this blazar, averaged over the epoch of the light curve (Le Gallou 2001a, Le Gallou2001b). Previous results on Mrk421 were presented in (Holder 2001).

The analysis used here is independant of the one used to establish our Crab signal, now submitted to the Astrophysical Journal (de Naurois et al,astro-ph/0107301). While the results of the two analyses are quite consistent with each other, a number of differences exist, yielding a slightly different gamma ray rate after cuts, and different acceptance curves. One key difference is that the present analysis uses a cut on the apparent width of the Cherenkov pulses to improve the photon-hadron signal-to-noise ratio.

2. Data Sample

Different heliostat pointing strategies have been studied with CELESTE. The strategies used during the observations presented here are convergent viewing, mainly at 11 km but with some data at 17 km altitude, and the double pointing method where half of the heliostats point at 11 km and the other half at 25 km altitude. In convergent viewing, the heliostats point at the shower rather than at the source itself.

Figure 1: Differential spectrum for Mrk 421 showing the preliminary flux determination by CELESTE, along with the results from CAT described by Fleury (these proceedings).



Observation period	Runs	Obs. time (h)
12/1999 - 02/2001	107	31.5

11 km runs	17 km runs	11/25 km runs
67	8	32

ON	OFF	ON-OFF	σ	S/B (%)
197541	190254	7287	11.7	3.8

A selection using quality criteria has been applied to the data before including it in the analysis dataset. These criteria are based on the stability of the PMT anode currents and on the trigger group counting rates. The analysis dataset is summarized in the table.

The mean number of ON-OFF run pairs per night is 3.5, that is 1 hour per ON source. The excess rate after analysis is 3.9 $\gamma/minute$. The integrated flux above 60 GeV is calculated by normalizing an E^{-2} differential spectrum to give the observed number of events once multiplied by the acceptance and integrated. The resulting mean flux is $0.7 \pm 0.3.10^{-9}\ \gamma.cm^{-2}.s^{-1}$. For comparison, the excess rate on the Crab Nebula is 4.4 $\gamma/minute$ and the corresponding flux is $0.6 \pm 0.3.10^{-9}\ \gamma.cm^{-2}.s^{-1}$ with the same analysis.

We insist upon the delicacy of expressing an integral measurement such as ours on a differential plot as is shown in Figure 1, taken from CAT and described by Fleury in his contribution to the special session. The result is sensitive to the spectral shape assumed in the calculation. Furthermore, the energy where the point is placed needs to be clearly explained. For the integral flux we define our threshold as the maximum in the convolution of the assumed energy spectrum with the detector acceptance, as is common practice in the field. For the differential plot on the other hand, the point is placed at the median energy deduced from the Monte Carlo, and the bin size, represented by the horizontal "error bar" shows the range expected to contain 68% of the events (70 to 450 GeV). The vertical error bar includes the systematic uncertainties on the acceptance. This délicate translation is handled differently in the Crab Ap J.

3. Discussion and Conclusion

CELESTE is now taking data regularly on AGNs. The detector and analysis acceptance versus pointing direction has been established, allowing variability studies. Mrk421 data might be rich in information concerning variability and wide wavelength range spectroscopy, mainly through CAT-CELESTE simultaneous analysis, which is ongoing. There is some indication for a signal on Mrk501 but there is also a strong seasonal bias in the raw trigger rate, which decreases from 20 Hz in Winter to 10 Hz by late Spring. At present we don't know how the gamma ray acceptance is affected by this and thus we do not express the Mrk 501 results as an absolute flux.

References

Le Gallou, R., doctoral thesis, 2001a, http://infodan.in2p3.fr/themis/CELESTE/PUB/papers.html

Le Gallou, R., in proc. 27th ICRC, Hamburg, Germany, 2001b

Holder, J., in proc. High Energy Gamma-Ray Astronomy, Heidelberg, AIP 558, edited by F. Aharonian and H.J. Völk, 2001