Rate Comparison between Milagrito Data and Simulation II

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1 Background Rates

So far, we have only used proton showers to estimate the expected background rate in Milagrito. As shown recently, proton showers can account for $\sim \frac{2}{3}$ of the measured rate of showers in the Mrk 501 source bin. The simulation now includes Helium and Nitrogen and allows for a more accurate estimate of the background rate. The following sample of MC showers is used:

- 750 000 proton showers with core area $300 \times 300\,\mathrm{m}^2$, energy range 0.1-500 TeV,
- 750 000 helium showers with core area $400 \times 400\,\mathrm{m}^2$, energy range 0.4-500 TeV,
- 50 000 nitrogen showers with core area $500 \times 500\,\mathrm{m}^2$, energy range 1.4-500 TeV.

I chose a minimum energy of 100 GeV per nucleon (at least 80 GeV per nucleon is required by CORSIKA/VENUS). This leads to an underestimation of the expected contribution to the Milagrito rate by less than 1 % (He) and less than 5 % (CNO).

The zenith angle range for all showers is $0^\circ \leq \theta \leq 45^\circ$. The nitrogen showers are used to estimate the *combined* flux of C, N, and O. Figure 1 shows the effective area (reconstructed showers) for γ-, proton, helium, and nitrogen showers.

The MC prediction for the background rate depends on the cut on the number of hits we actually use. The analysis takes into account the "soft" trigger condition, *ie.* it simulates the soft rise as it is in the data. A certain fraction of tubes is lost in the calibration, and 20 tubes are considered "dead".

The following fluxes per particle are used [1, 2]:

- proton flux $(1.11^{+0.08}_{-0.06}) \times 10^{-1}\ E^{-2.80\pm0.04}\ \mathrm{m}^{-2}\,\mathrm{sr}^{-1}\,\mathrm{s}^{-1}\,\mathrm{TeV}^{-1}$
- helium flux $(7.19 \pm 0.20) \times 10^{-2}\ E^{-2.64\pm0.02}\ \mathrm{m}^{-2}\,\mathrm{sr}^{-1}\,\mathrm{s}^{-1}\,\mathrm{TeV}^{-1}$
- CNO flux $(2.86 \pm 0.06) \times 10^{-2}\ E^{-2.67\pm0.02}\ \mathrm{m}^{-2}\,\mathrm{sr}^{-1}\,\mathrm{s}^{-1}\,\mathrm{TeV}^{-1}$

After a full detector simulation with a waterlevel of 180 cm, *ie.* about 90 cm of water above the tubes, and the simulation of a source day, the following daily rates are expected for this detector setup:

- proton rate $2035^{+188}_{-104}\ \mathrm{day}^{-1}$
- helium rate $820^{+82}_{-33}\ \mathrm{day}^{-1}$
- CNO rate $129^{+8}_{-13}\ \mathrm{day}^{-1}$

The errors reflect the uncertainties in the measured flux for the different nuclei, both in total flux and spectral index. Neglecting other nuclei for the moment, the relative contributions of Helium and CNO to the total background flux are 27 % and 4 %, respectively.

Figure 2 (top) compares the sum of these individual fluxes with the measured daily rate. It shows the number of events per day in the Mrk 501 source bin as a function of the day of data taking (day 0 corresponds to day 487 in the data). The same cuts were used in data and MC, and the restriction to showers with $\theta \leq 45^{\circ}$ leads to a 5 % decrease in rate in the data (see Figure 2 (bottom)).

A preliminary study with a waterlevel of 280 cm, *ie.* about 190 cm of water above the tubes, shows an increase in the MC proton rate of $\sim 35\,\%$.

References

[1] K. Asakimori et al., Astrophys. J. 502 (1998) 278.

[2] B. Wiebel-Sooth, P.L. Biermann, H. Meyer, Astron. & Astrophys. 330 (1998) 389.

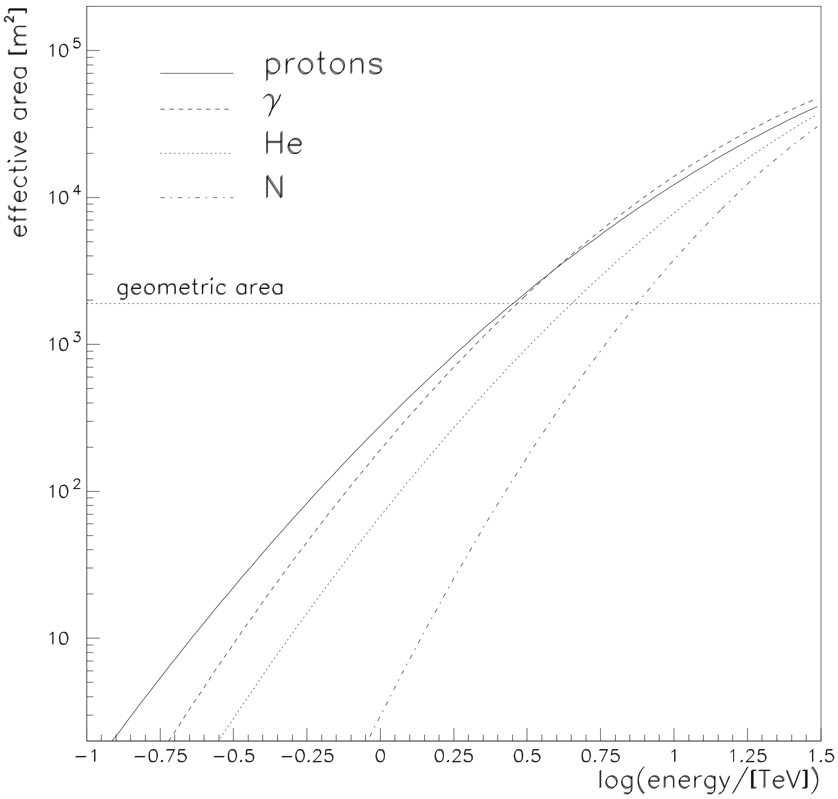

Figure 1: Effective area for γ-showers, protons, helium, and nitrogen.

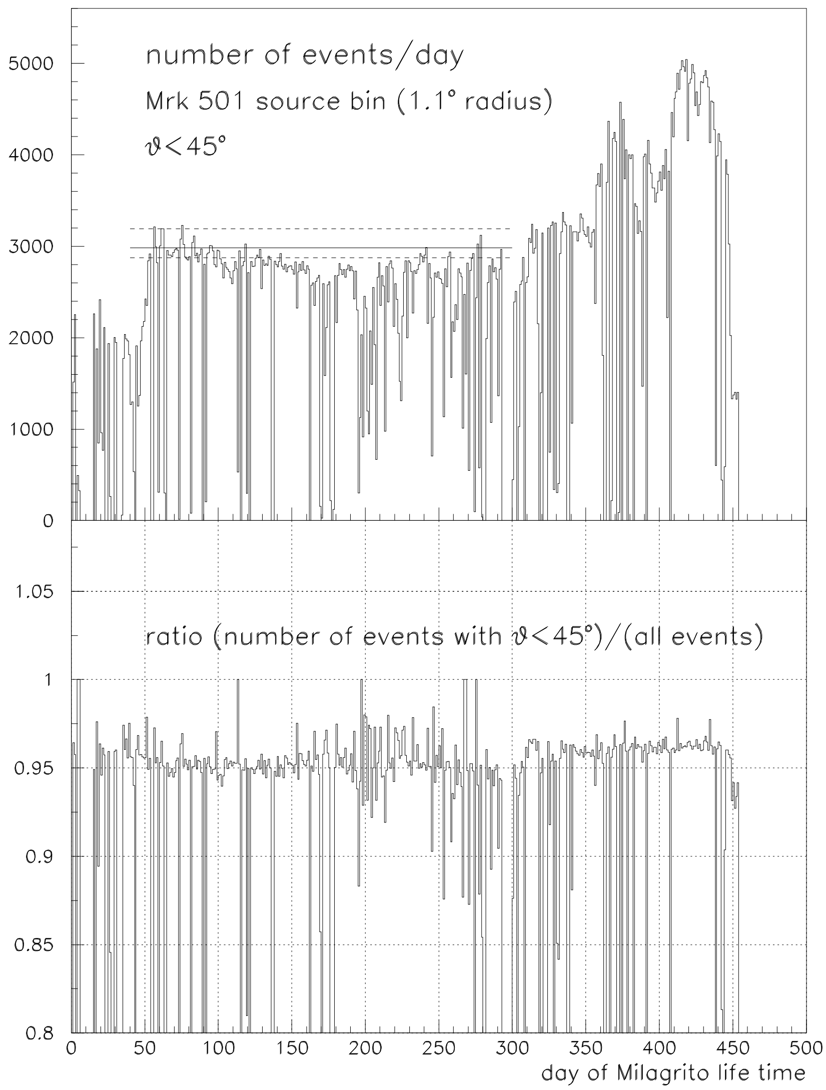

Figure 2: Number of events in the Mrk 501 source bin as a function of the day of Milagrito's lifetime (top). The zenith angle cut $\theta \leq 45^{o}$ reduces the event rate by about 5%.