# Rate Comparison between Milagrito Data and Simulation

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March 26, 1999

## 1 Mrk 501 and Crab Rates

**Important:** For all MC predictions, the Mrk 501 spectrum (as measured by Whipple)

$$J_\gamma(E) = (8.6 \pm 0.3 \pm 0.7) \times 10^{-7} E_{\mathrm{TeV}}^{-2.20 \pm 0.04 \pm 0.05 - (0.45 \pm 0.07) \log_{10} E} \; \mathrm{m}^{-2}\,\mathrm{s}^{-1}\,\mathrm{TeV}^{-1}, \tag{1}$$

is used. Numbers are therefore no longer in "Crabs" and do not have to be multiplied by $x$ Crab, which, as Cy pointed out, is incorrect anyway as these numbers depend on the energy threshold of the instrument.

David Williams suggested a while ago to have a closer look at the rates (background and excess) we see from Mrk 501 and the Crab rather than significances.

In the data, the following rates are measured on Mrk501 for a 1.1° circular source bin, $\theta < 45^\circ$, and $nFit \geq 40$, *ie.* more than 40 tubes used in the angle fit:

- excess: $8.7 \pm 3.0$
- background: $2866 \pm 1$

(here and in the following sections, all rates are *per day*).

Note that this is the average rate we observed when the water level was 90 cm above the tubes, which is the value used in the simulation. Figure 1 shows the rate in the Mrk 501 source bin as a function of the day of data taking.

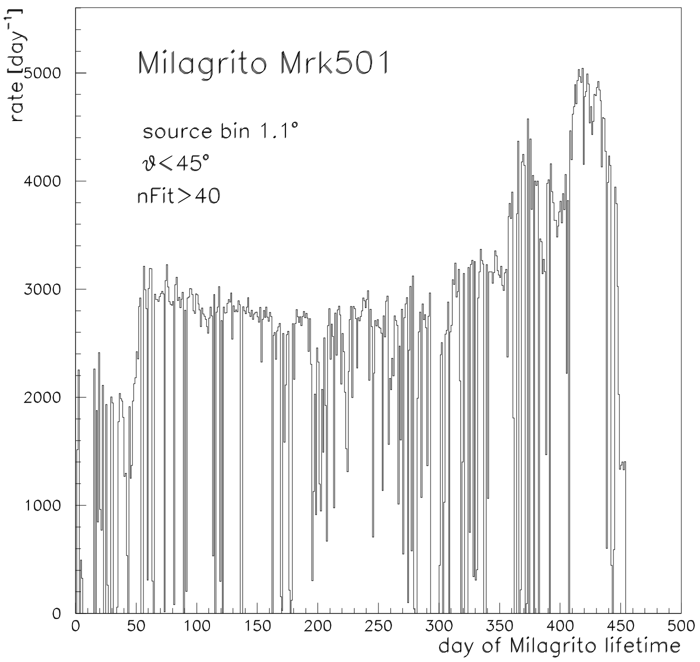


Figure 1: Number of events in the Mrk 501 source bin as a function of the day of Milagrito's lifetime.

The MC prediction for the background rate depends on the cut on the number of hits we actually use. It's 3305 for a trigger requiring more than 80 tubes in the event, and 3115 for more than 100 tubes. This raises the question why we overestimate the background rate where we should actually underestimate it, as higher nuclei are not taken into account. One of the most important differences between the MC and the data at this point is that the MC assumes that we have a sharp trigger and that all tubes survive the calibration, which definitely does not describe Milagrito as we know it. In the data, the number of tube distribution *before* the calibration starts at 95 tubes, rises rather quickly and has a maximum around 105 tubes. However, only about 90 % of the tubes survive the calibration. The predicted rates drop as we add these effects to the simulation.

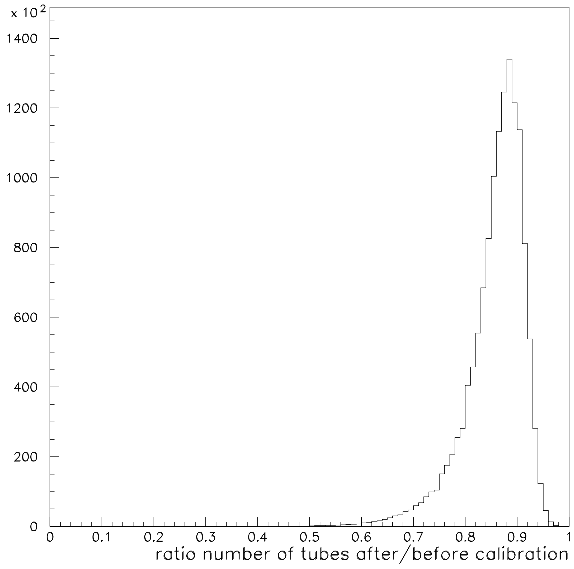


Figure 2: Ratio of the numbers of tubes after and before the calibration routine.

We have to include

1. a "soft" trigger condition simulating the soft rise as it is in the data,
2. $\sim 20$ "dead" tubes,
3. a calibration loss as in the data (see Figure 2 for the distribution used).

Simulating (1) and (2) lowers the rate to 2670 per day, including (3) brings us to 2010.

Going down by 25 % applying the calibration loss seems too high at first glance, but don't forget that a 40 tube cut on the number of tubes used in the angle fitter is applied. At this point, further fine tuning of the background rate requires knowledge of the contribution of heavier nuclei which we have not simulated (yet) – more on that in the future.

What does this mean for the $\gamma$-rate from Mrk 501 ? From the excess seen from Mrk501, we observe a rate of $8.7 \pm 3.0$ where $12.9 \pm 0.4$ is the prediction (this is the statistical error only - there is an additional larger error from the uncertainty in the measured flux and spectral index, probably not much less than 30 %). We don't know whether the Whipple flux measured for the first half of the year is also the average flux for the time when the Cherenkov telescopes didn't monitor Mrk 501 (after October 1997), but in any case, this is not in disagreement with what we see. If we use the predicted $\gamma$-rate from the MC and the background rate from the data (because the MC background rate does not include heavier nuclei), the expected significance in 370 days of data taking is $4.7\,\sigma$ (just for comparison: for a fully working detector with a 100 tube trigger and 100 calibrated tubes, the expected significance is almost $5.5\,\sigma$).

Here are the corresponding numbers for the Crab: The predicted gamma-rate is $3.6 \pm 0.2$, the predicted background rate is $1740 \pm 40$, the measured background rate is $2367 \pm 1$, the Crab excess rate is $2.1 \pm 2.8$, corresponding to an $0.6\,\sigma$ excess. Again, using MC $\gamma$-rate and data background rate, the expected significance in 350 days (our total "on time" for the Crab is slightly less than for Mrk 501) is about $1.4\,\sigma$, as compared to more than $2\,\sigma$ for a fully working detector).

The expected gamma rate from Mrk 501 for Milagrito is thus 3.6 times the rate from the Crab.

The main uncertainites at this point are:

- the contribution of heavier nuclei (I started the simulation of He showers and will add them to the background once I have sufficient statistics).
- How did our sensitivity change when we had water *on* the cover and how did it change when we had more water *under* the cover ? Right now, all MC predictions refer to a detector with 90 cm of water above the tubes.
- Was Mrk 501 still "on" after October 1997 ?

The problem with the last two items combined is that for the months where we had a different water level, Whipple and HEGRA were not observing. Trying to learn anything from this period will be hard.

The main conclusion is, however, that it is not true to state that what we see falls below expectations. In the paper for the Texas Symposium Proceedings, I decided to use effective area plots that describe a detector with *no* dead tubes and *no* calibration losses. The fuzzy trigger threshold is, however, taken into account (thus the slight change in what is now Figure 1 and Figure 2 (c) in the paper). The paper no longer quotes expected significances apart from a rather vague statement on the Crab. I did, however, quote the ratio of gamma rates we expect from Mrk 501 and the Crab, and I quote the expected gamma rate for Mrk 501. These numbers are not inconsistent with the data and they are not affected by whatever is the result of the study of Helium showers. I had the feeling that we have to touch base with the simulation at some point in the paper.