Group Meeting

Feb 6th 2020

MUPAGE tuning

- Change MUPAGE parameters
- Look at observables/parameters using *ana* tool in Aanet.
- MC - MC comparison

MUPAGE tuning

3. The multiplicity distribution of muons in bundles vs. depth and zenith angle

The multiplicity distribution of underground muons was experimentally studied with large statistics by the Frejus [21] and the MACRO [22] collaborations. The expected multiplicity distribution for a given primary mass and energy is known to be a negative binomial (NB) distribution. The observed distribution is a convolution of NB distributions, which can be described as a power law. Following the Frejus paper, the function:

$$\Phi(m; h, \theta) = \frac{K(h,\theta)}{m^{\nu(h,\theta)}} \quad \text{with } \nu = \frac{\nu_1}{(1 + \Lambda \cdot m)} \tag{2}$$

has been used as parametric formula for the flux of bundles with different number of muons m at a given depth h and zenith angle θ. Here K, ν_1 and Λ are free parameters, depending on h and θ. The phase space has been divided in seven values of vertical depth h (from 2.0 down to 5.0 km.w.e. in steps of 0.5 km.w.e.) and nine values of zenith angle θ (from 0° up to 80° in steps of 10°). Histograms have been filled with all the muons (single or in a bundle) reaching a given vertical depth h, and within $\Delta\theta = \pm 1°$ ($\pm 3°$ for the last bin, due to statistics reasons) centred with

equation:

$$\Phi(m = 1; h, \theta) = K(h, \theta) = K_0(h)\cos\theta \cdot e^{K_1(h)\cdot \sec\theta} \quad (\mathrm{m}^{-2}\,\mathrm{s}^{-1}\,\mathrm{sr}^{-1}) \tag{3}$$

At a given zenith angle, the flux decreases with depth and two simple expressions for $K_0(h)$ and $K_1(h)$ have been found (the values of fitted constants are reported in Table 3):

$$K_0(h) = K_{0a} \cdot h^{K_{0b}} \tag{4}$$

$$K_1(h) = K_{1a} \cdot h + K_{1b} \tag{5}$$

3.3. The parameter ν

The fraction of multiple muon flux with respect to the single muon flux depends on the parameter ν, which, for a given vertical depth h, is a function of $\sec\theta$:

$$\nu(h, \theta) = \nu_0(h) \cdot e^{\nu_1(h)\cdot \sec\theta} \tag{6}$$

For a fixed zenith angle θ, the parameter ν increases with increasing vertical depth h as

$$\nu_0(h) = \nu_{0a} \cdot h^2 + \nu_{0b} \cdot h + \nu_{0c} \tag{7}$$

$$\nu_1(h) = \nu_{1a} \cdot e^{\nu_{1b}\cdot h} \tag{8}$$

https://doi.org/10.1016/j.astropartphys.2005.10.005

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- K0a : seems to only scale livetime!

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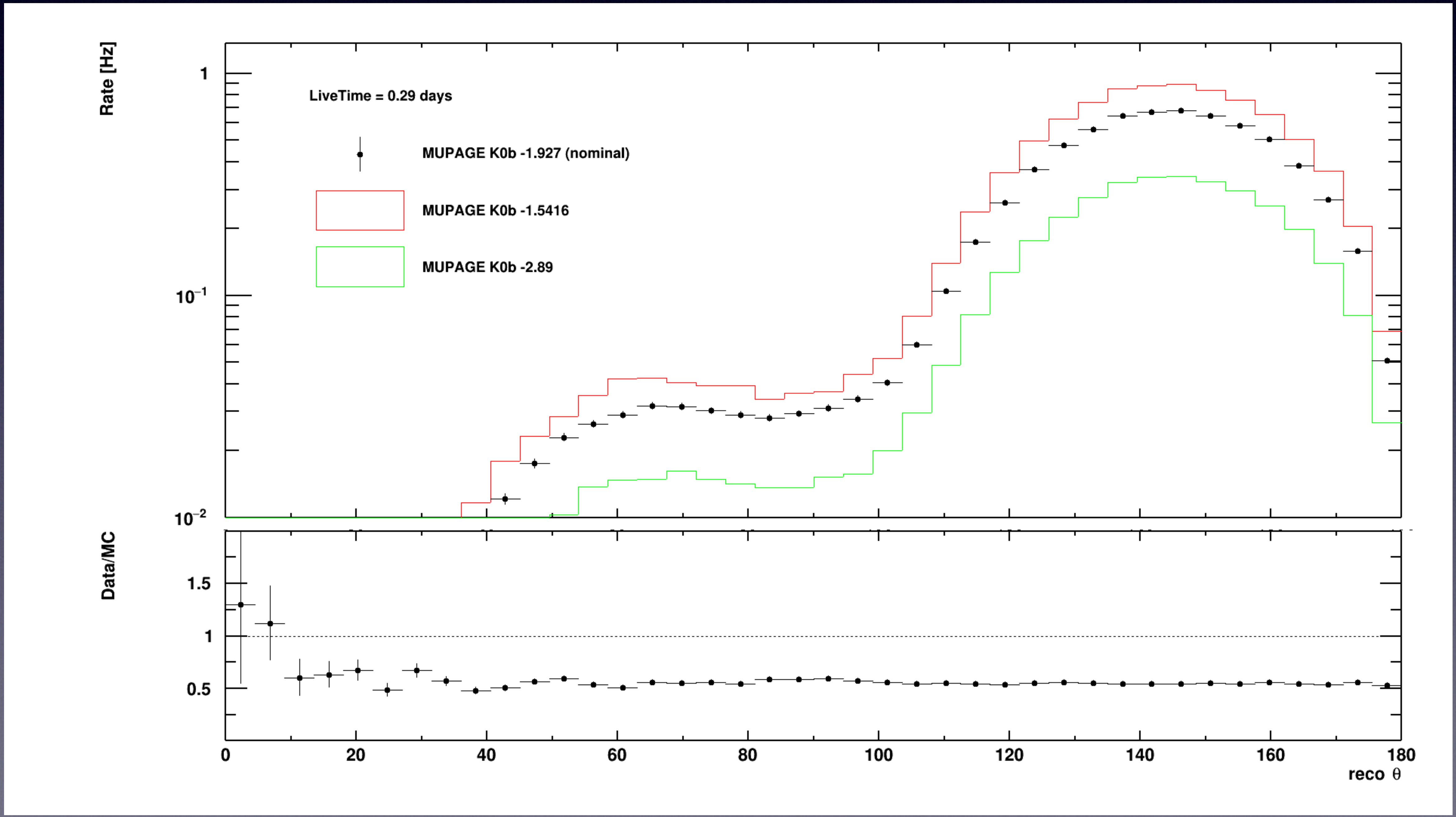
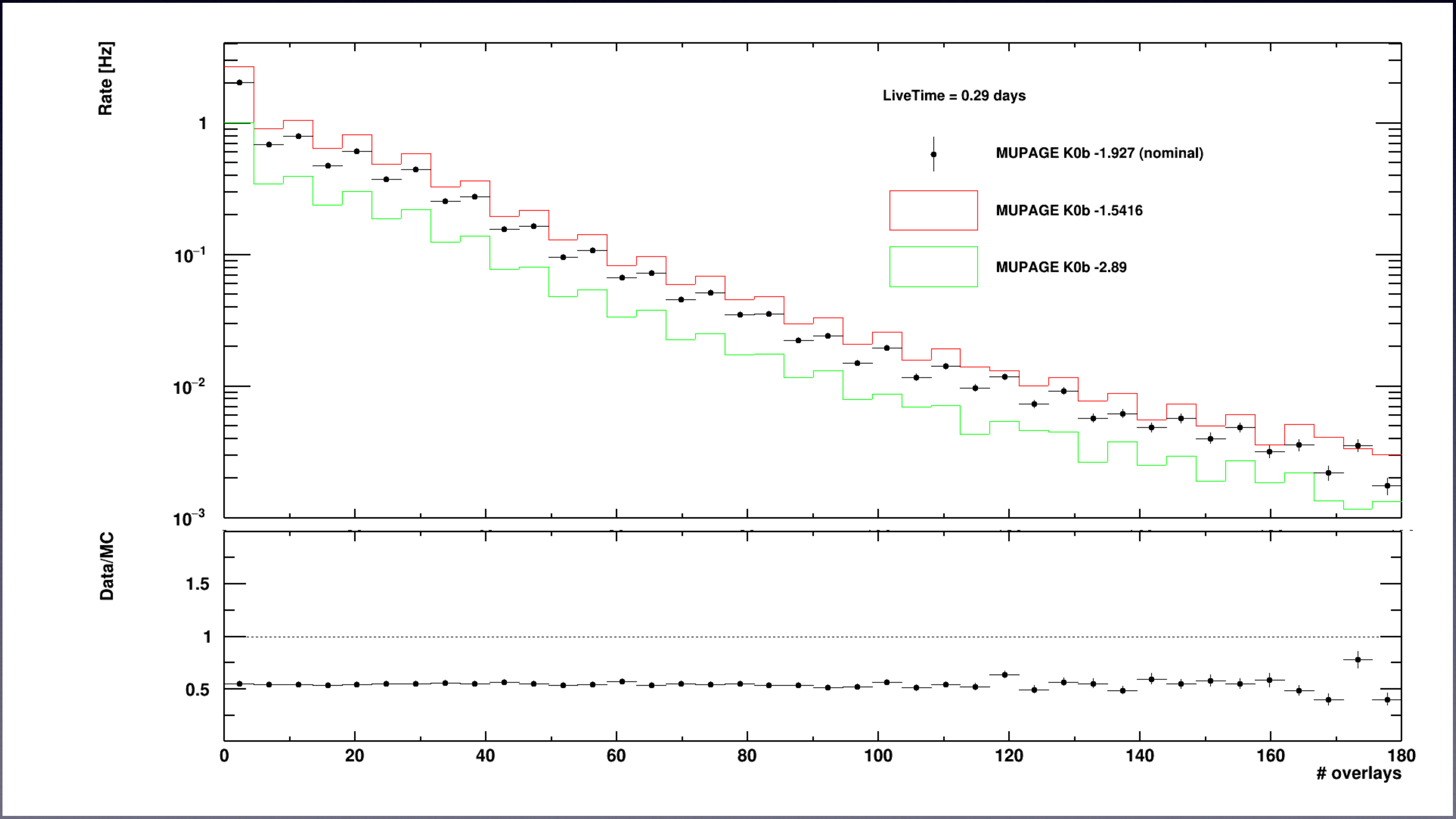
- K0b :



MUPAGE tuning

- K0b :



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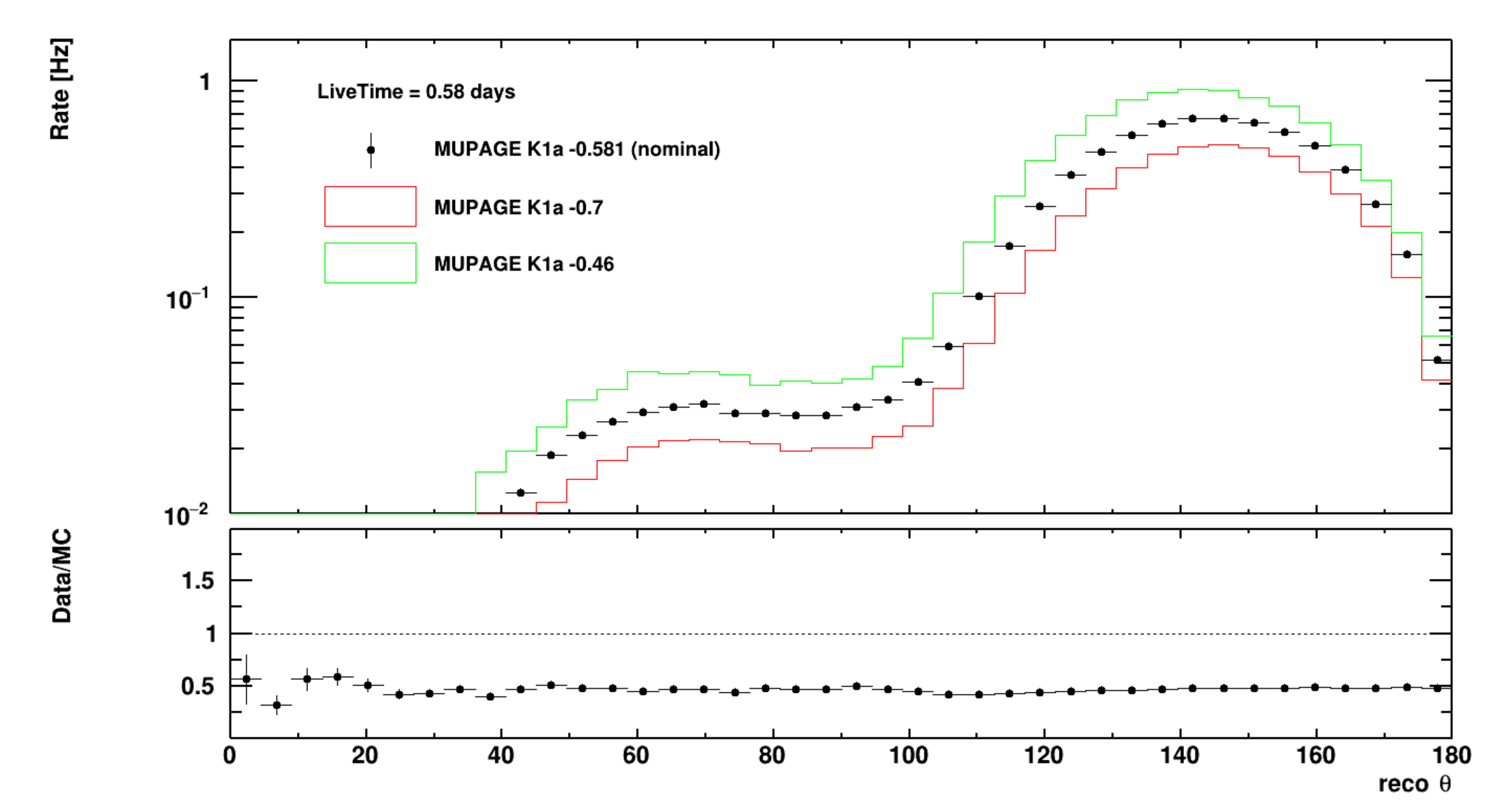
- K1a :



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- K1a :