JMuonEnergy M-estimators

Track energy fits

JMuonEnergy based on a MLE of the track energy

- Likelihood = product of hit probabilities

Hit/no-hit probability

$$\chi^2(E) \equiv -\ln\left(L(E)\right) = -\sum_{i=1}^{N} \ln\left[\left(1 - 2e^{-\mu_i(E)}\right)\mathbb{1}_{n>0} + e^{-\mu_i(E)}\right]$$

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For ARCA the likelihood is modified using a Lorentzian M-estimator

$$\chi^2(E) = \sum_{i=1}^{N} \ln\left[1 + \frac{1}{2}\ln^2\left[\left(1 - 2e^{-\mu_i(E)}\right)\mathbb{1}_{n>0} + e^{-\mu_i(E)}\right]\right]$$

Hit/no-hit probability

Why? Is this the best?

M-estimators

Jpp implements different M-estimators (cost functions):

- Modify the relative weights contributed to the likelihood by each hit

$$\chi^2(E) \equiv -\sum_{i=1}^{N} f(\ln[p_i(E)]),$$

$$p_i(E) = \left(1 - 2e^{-\mu_i(E)}\right) 1_{n>0} + e^{-\mu_i(E)}.$$

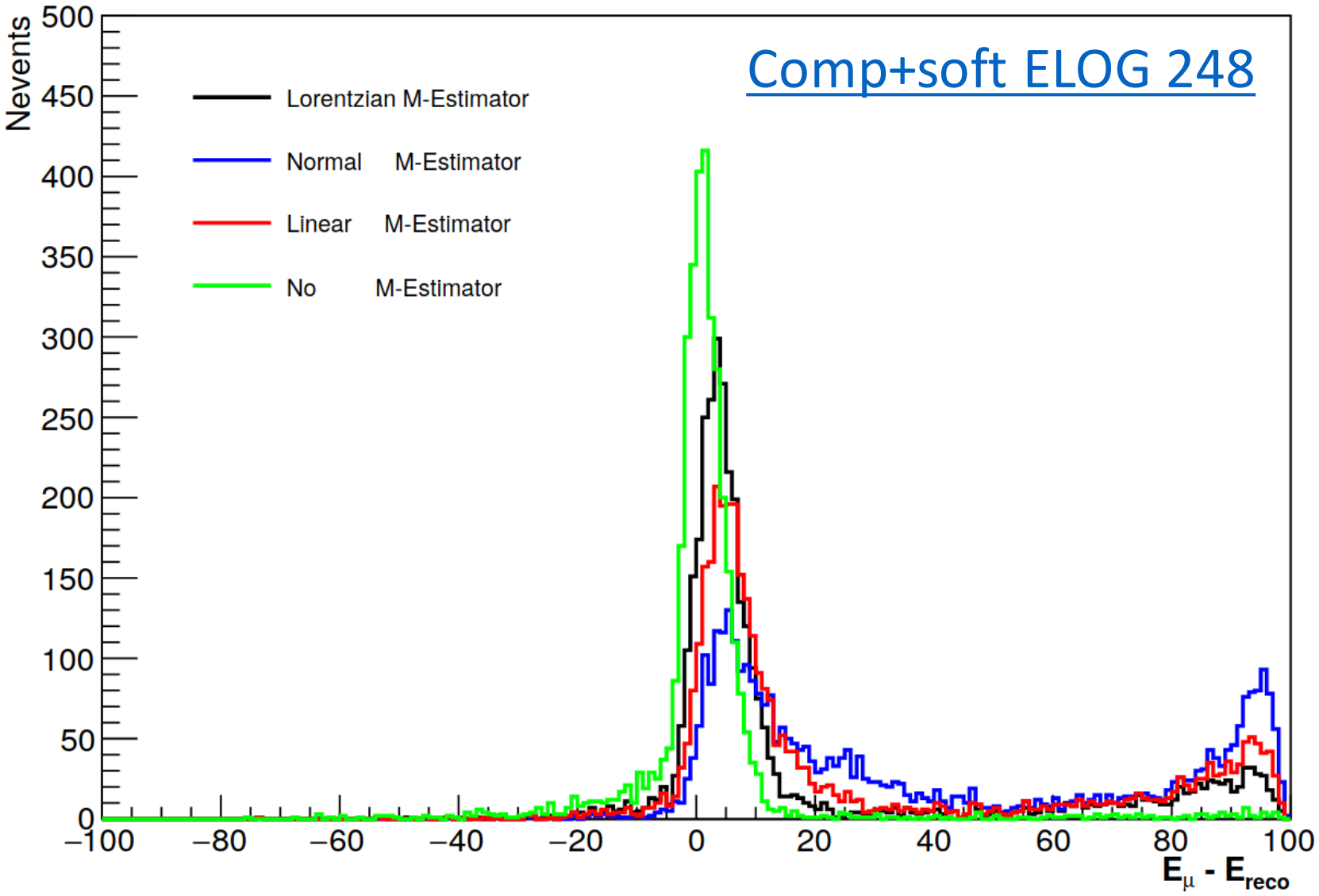
$$f_0(z) = \frac{1}{2}z^2$$

$$f_1(z) = \ln\left[1 + \frac{1}{2}z^2\right]$$

$$f_2(z) = \sqrt{1 + \frac{1}{2}z^2} - 1$$

$$f_3(z) = z$$

Previous studies for ORCA



Comp+soft ELOG 248

For ORCA
raw likelihood
truly seems best

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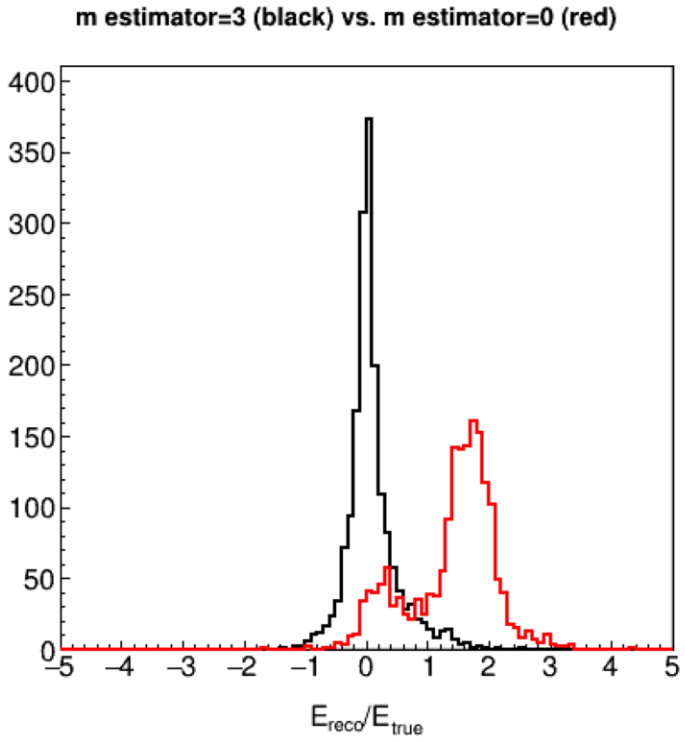
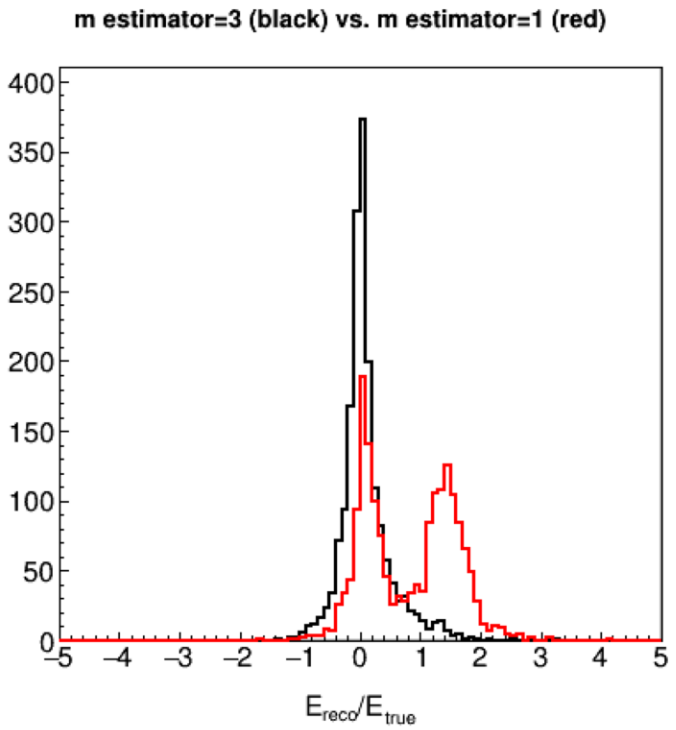
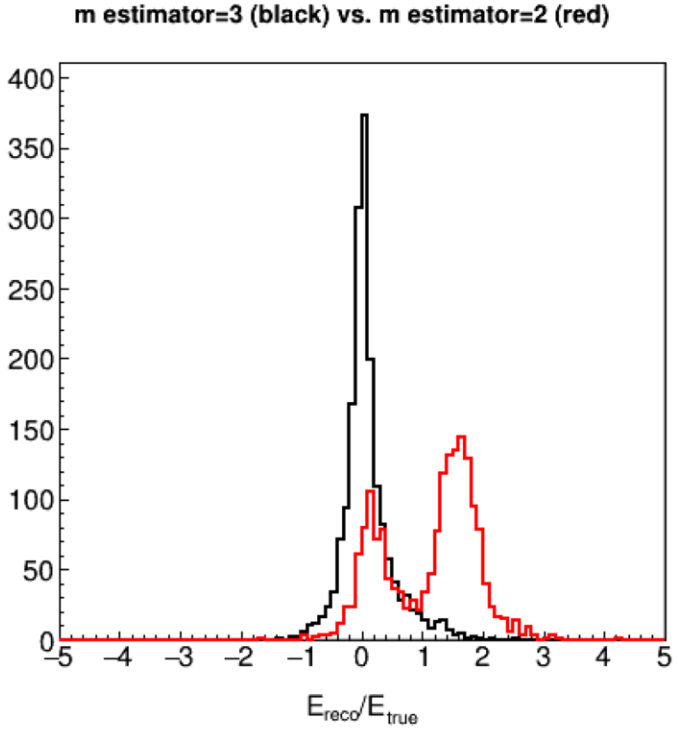
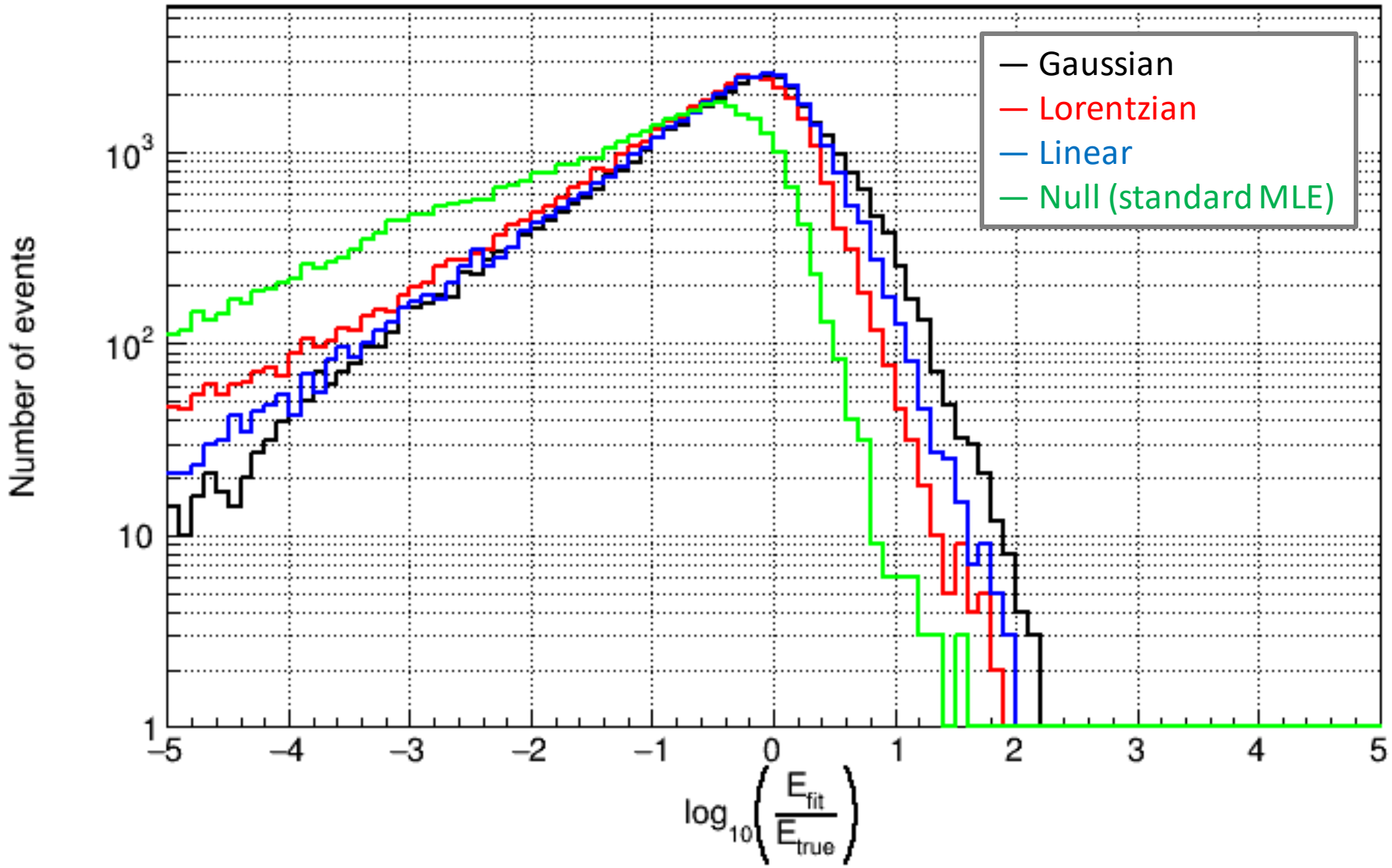
[Comp+Soft ELOG 489]







Comparison of M-estimators for ARCA



M-est.	Mean	RMS
Gauss	-0.52	0.97
Lorentz	-0.78	1.0
Linear	-0.61	0.98
Null	-1.4	1.2

9 numu-CC files (~ 40.000 events)
Full ARCA building block
1E2 GeV < E < 1E8 GeV
Jpp v14.4.2

Summary

Currently:

- Raw likelihood for ORCA
- Lorentzian cost function for ARCA

Raw likelihood indeed seems best for ORCA

Gaussian M-estimator might be better for ARCA