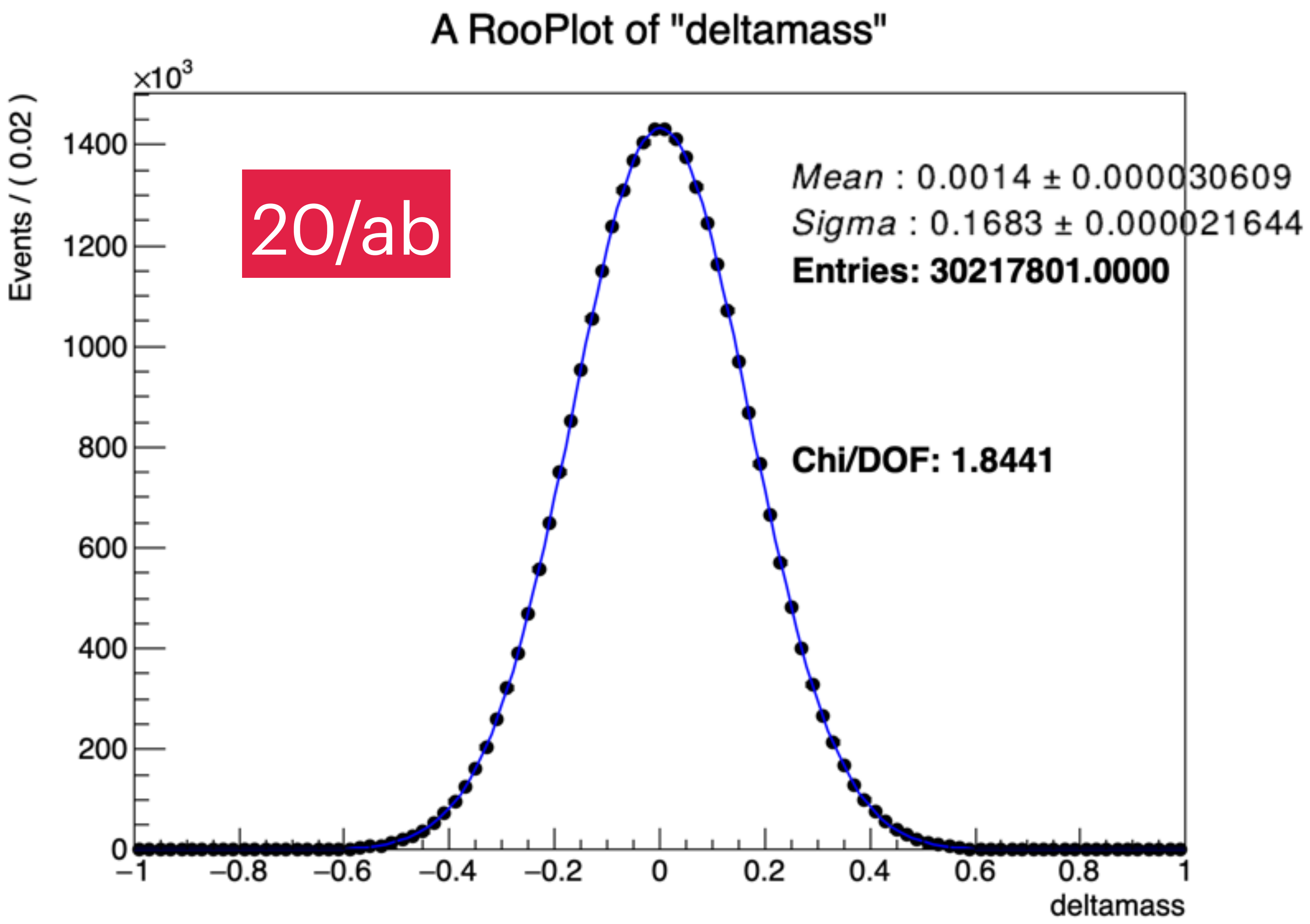
Status update on $ee \to \gamma\ Z \to \gamma\mu\mu$ study for recoil mass systematic

C.Zhang/21Apr2025

$ee \to \gamma\, Z \to \gamma\mu\mu$ @ 240 GeV

Generate 7.5M and 30M toys [5 and 20/ab] using the single Gaussian model



FCC-ee, 5/ab, IDEA,B=2T

3) Center-of-mass: +/- 2 MeV

- √s parameter in the recoil mass definition → uncertainty induces ~ linear shift the recoil distribution
- Precision estimated to be 2 MeV at 240 GeV using radiative return events Z → ll or Z → qq

4) Muon momentum scale: relative scale uncertainty variation of 1e-5

- Directly affects m(μμ), hence shift in recoil mass
- Statistical potential to measure muon scale ~ 1e-6, but NMR probes so far limited to yield 1e-5 unc

- **The expected precision ~ 60 and 30 KeV for 5/ab and 20/ab respectively.**
- **It agrees with a naive expectation, $\Delta\text{mean} = \dfrac{\sigma}{\sqrt{N}}$, and is also consistent with preliminary study from IDEA.**
- **It seems that the limitation of this standard candle comes from systematic errors**

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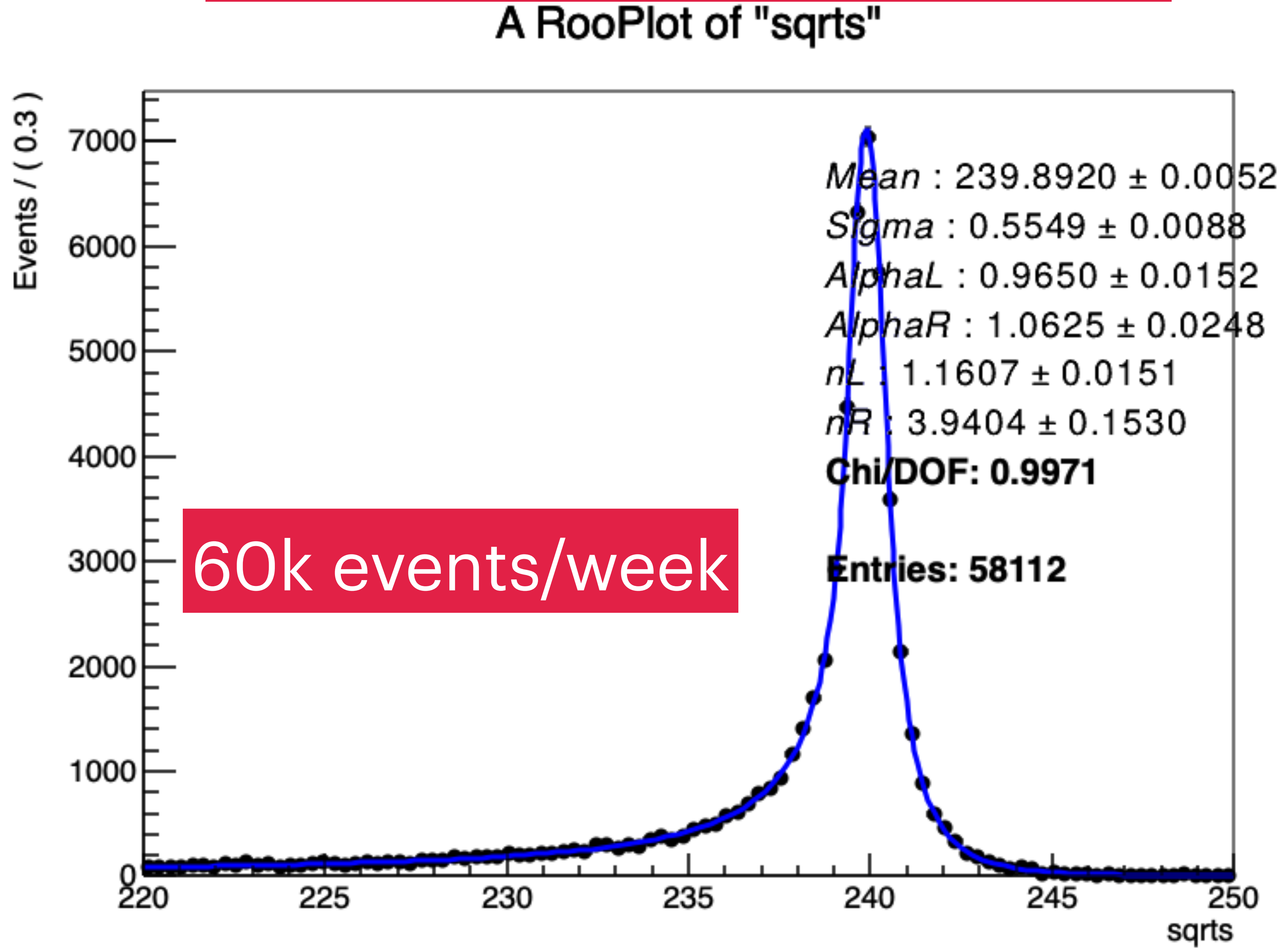
recoil mass method for sqrt(s)



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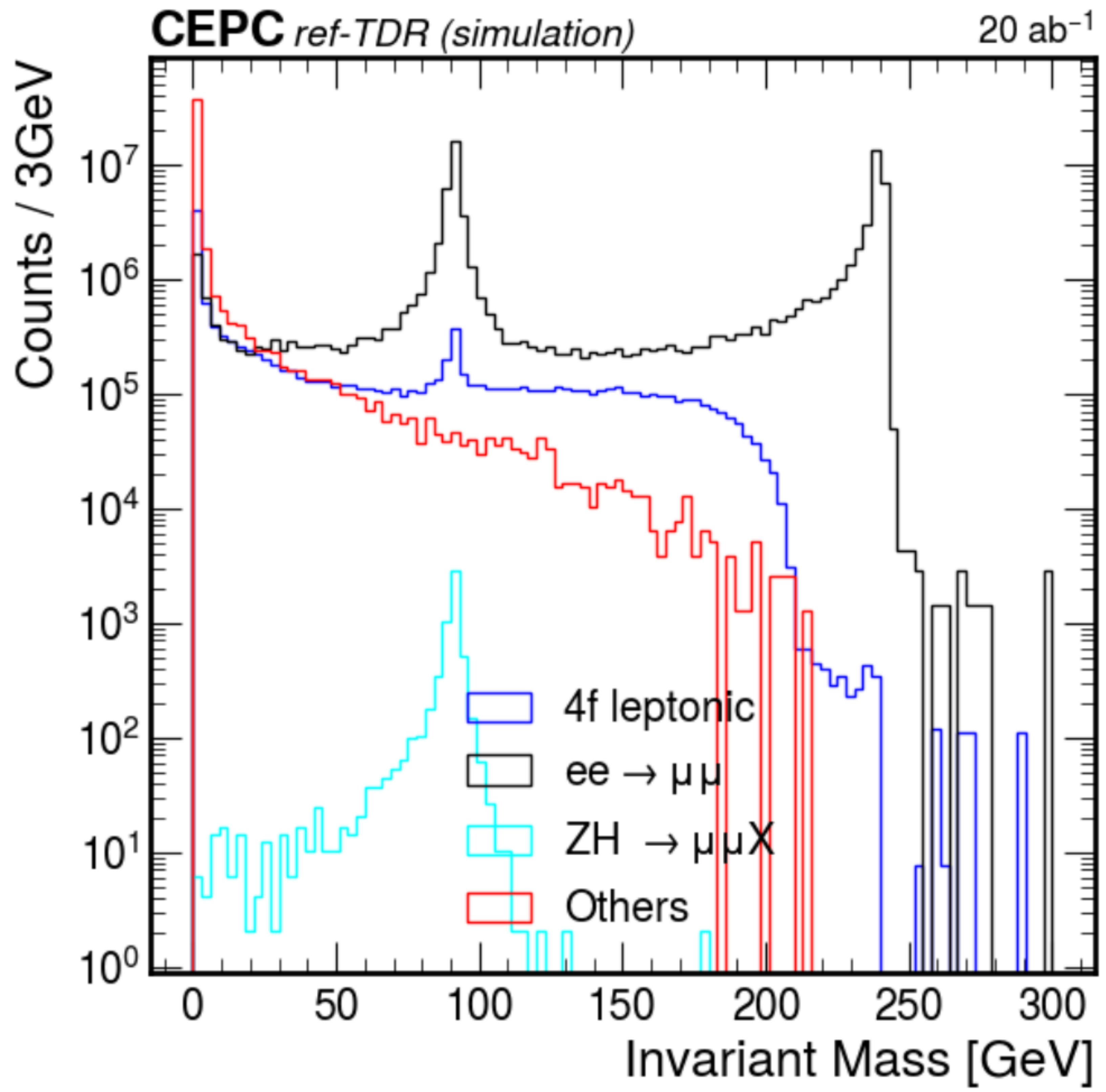
- **Assume undetected photon**
- **muon pair recoils against photon**
- **MeV level reachable**

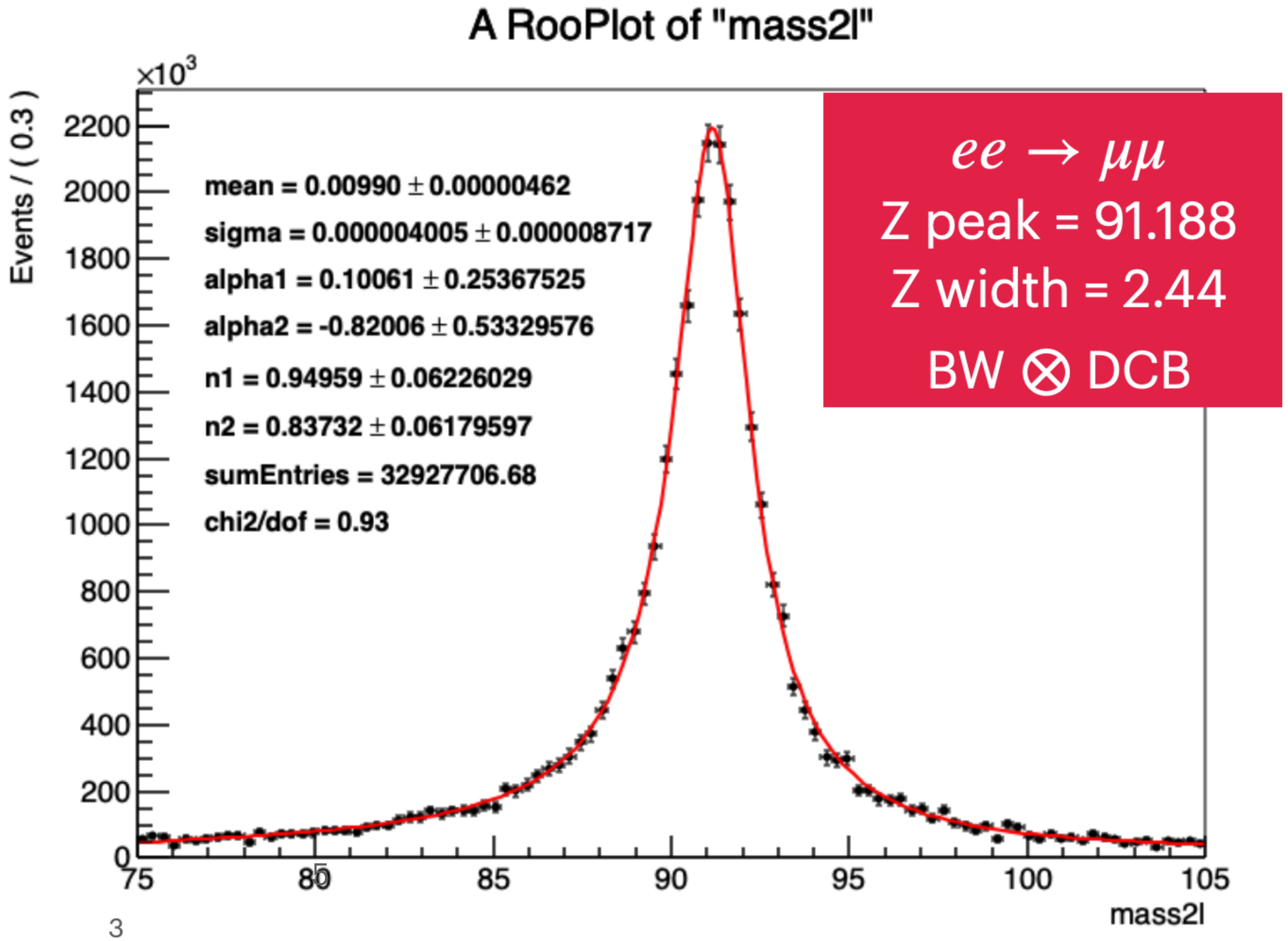
Back up

$ee \to \gamma Z \to \gamma\mu\mu$ @ 240 GeV

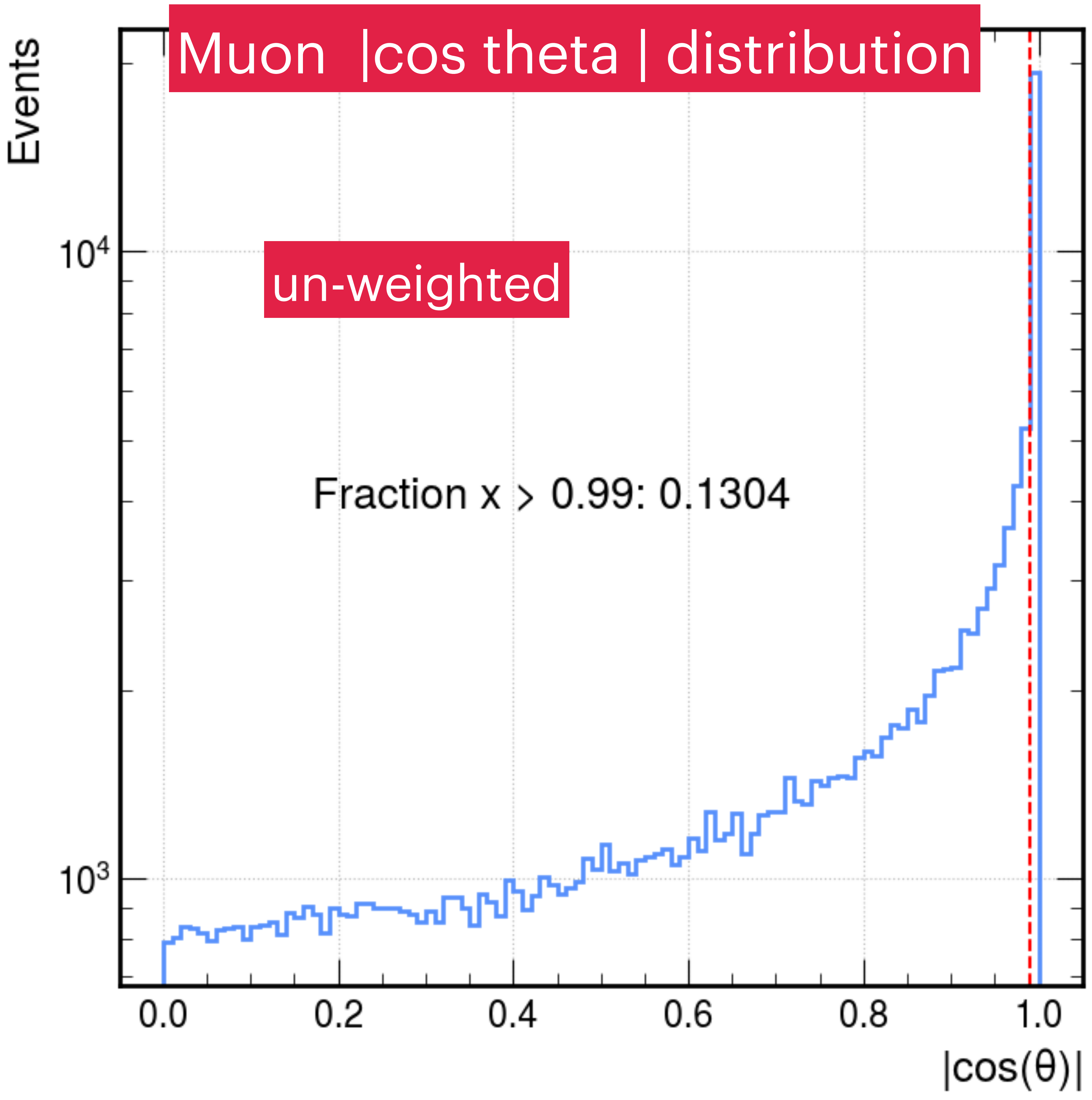
- **Previous status**
  - **98 muID working point results 0.77 efficiency of muon pair**
  - **Difficult handle Z line-shape; Sigma is too small**

- Visible Z peaks
  - $ee \to \mu\mu$ efficiency : $83M/106M \approx 0.77$





$ee \to \gamma\, Z \to \gamma\mu\mu$ @ 240 GeV



Statistics = 140 k muons with 98-muID		**|cos theta| < 0.99**
MCParticle links to a track	87.1773%	99.9410%
Track links to a PFO	87.1739%	99.9386%
PID gives a response	87.1739%	99.9386%
PID performance (normalised to tot. stat.)		
PID = e	0.61%	0.69%
PID = mu	83.4%	95.62%
Pion	2.35%	2.68%
Kaon	0.39%	0.45%
Proton	0.42%	0.48%

$$.77 \approx .95 \times\ .95 \times .87$$

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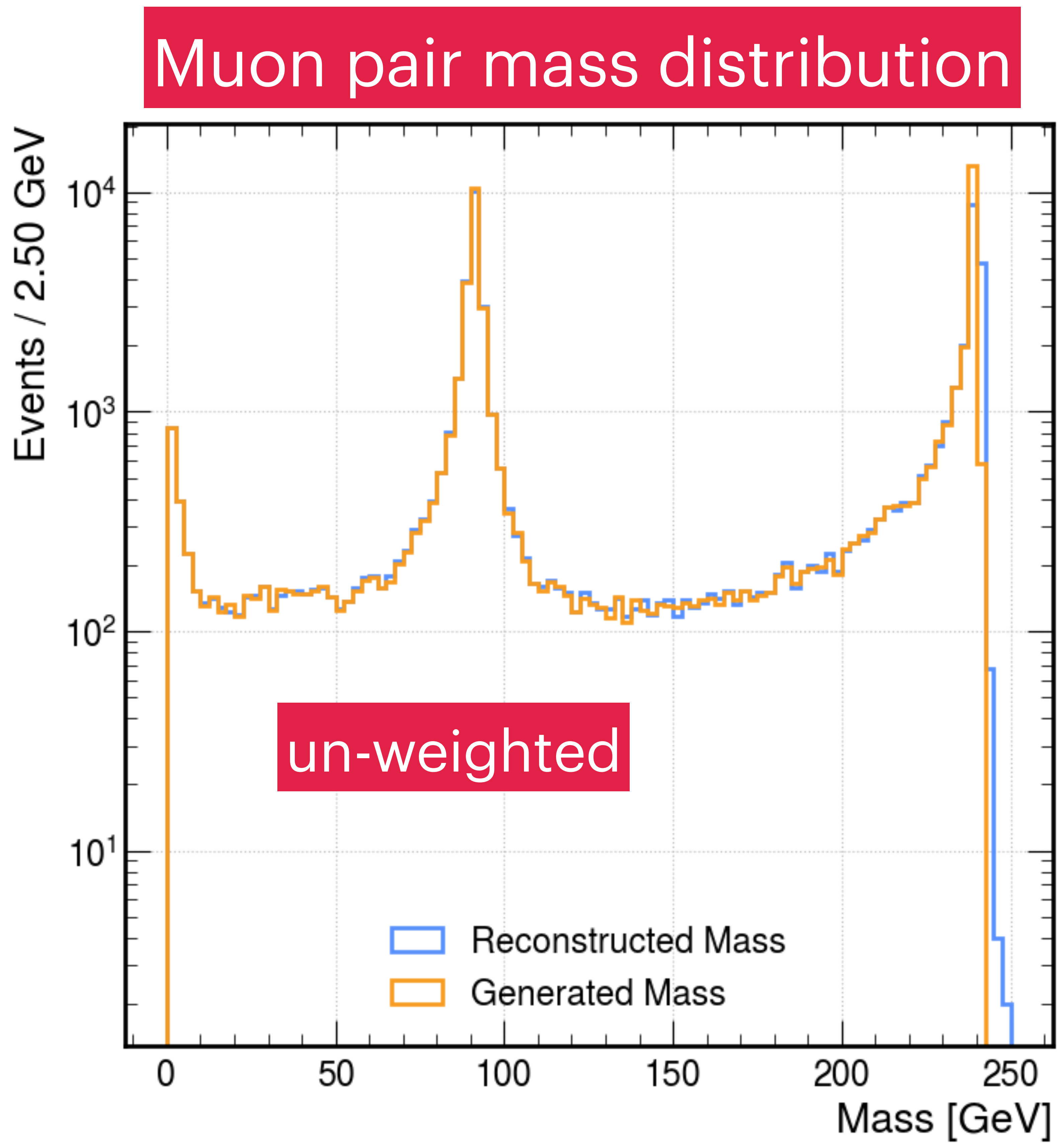

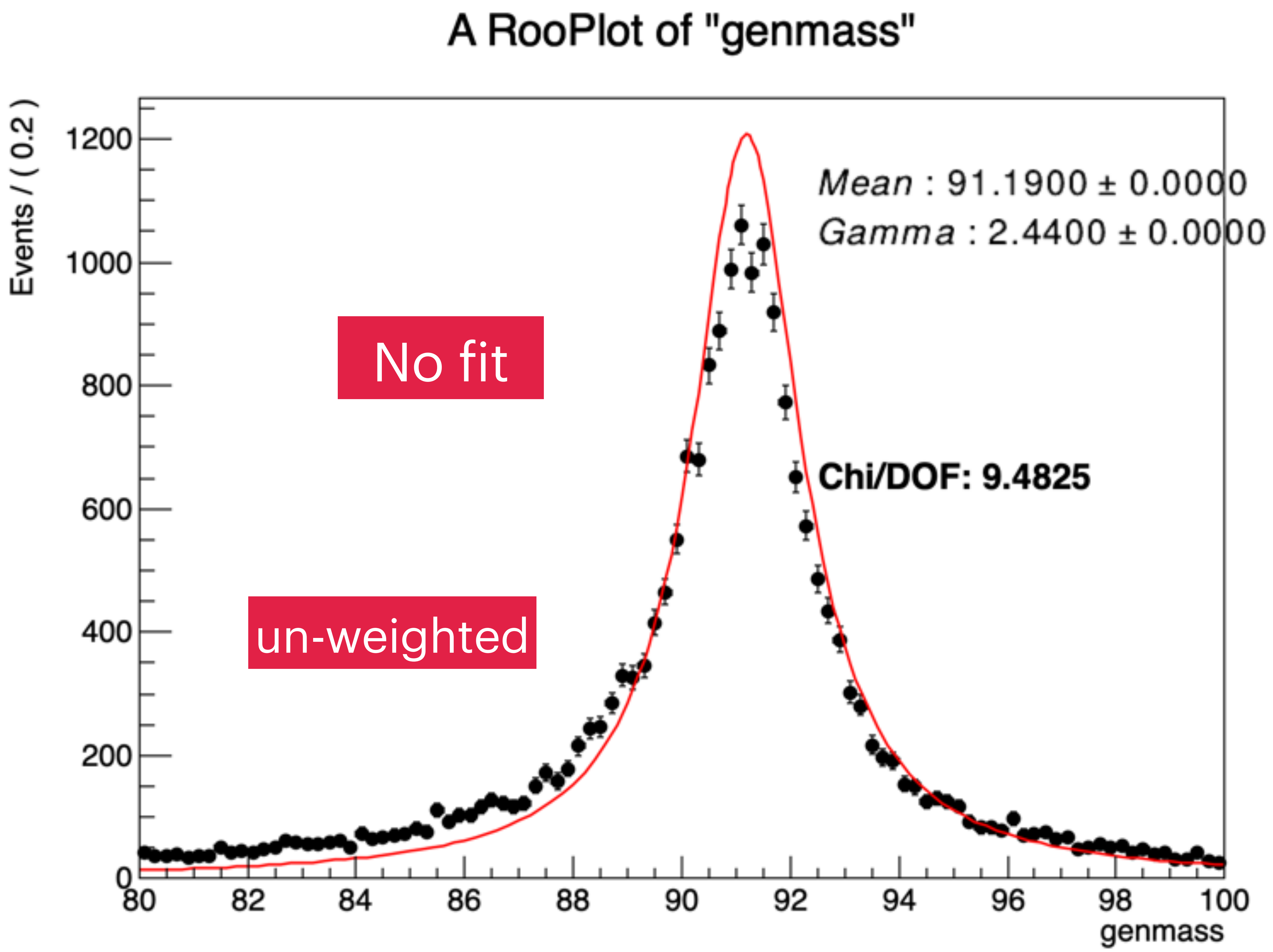

- **As already confirmed, other processes may contribute to the Z peak, but this process dominates it. Therefore, only this process is considered.**
- **The GEN peak can not be described by a Breit-Wigner function.**

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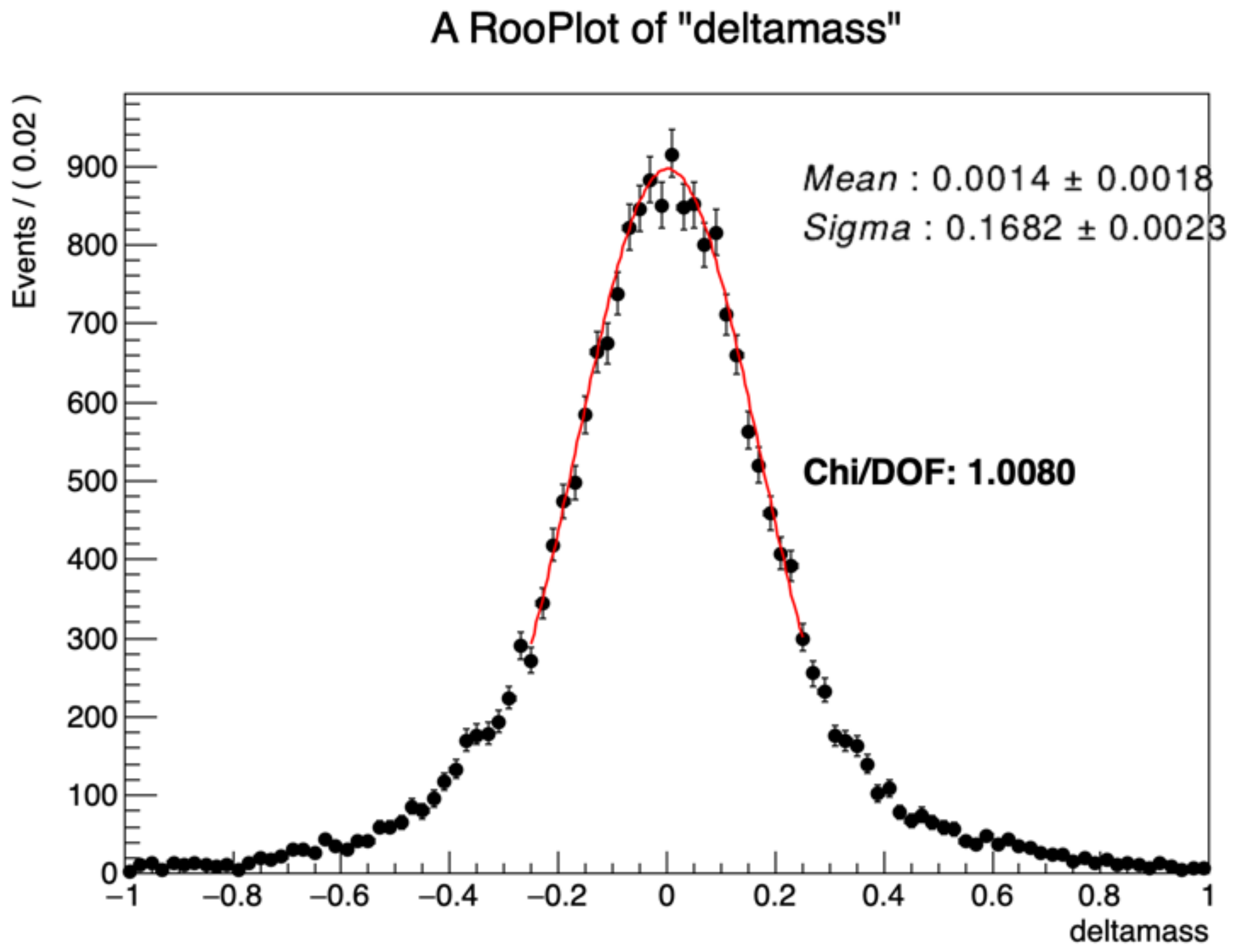
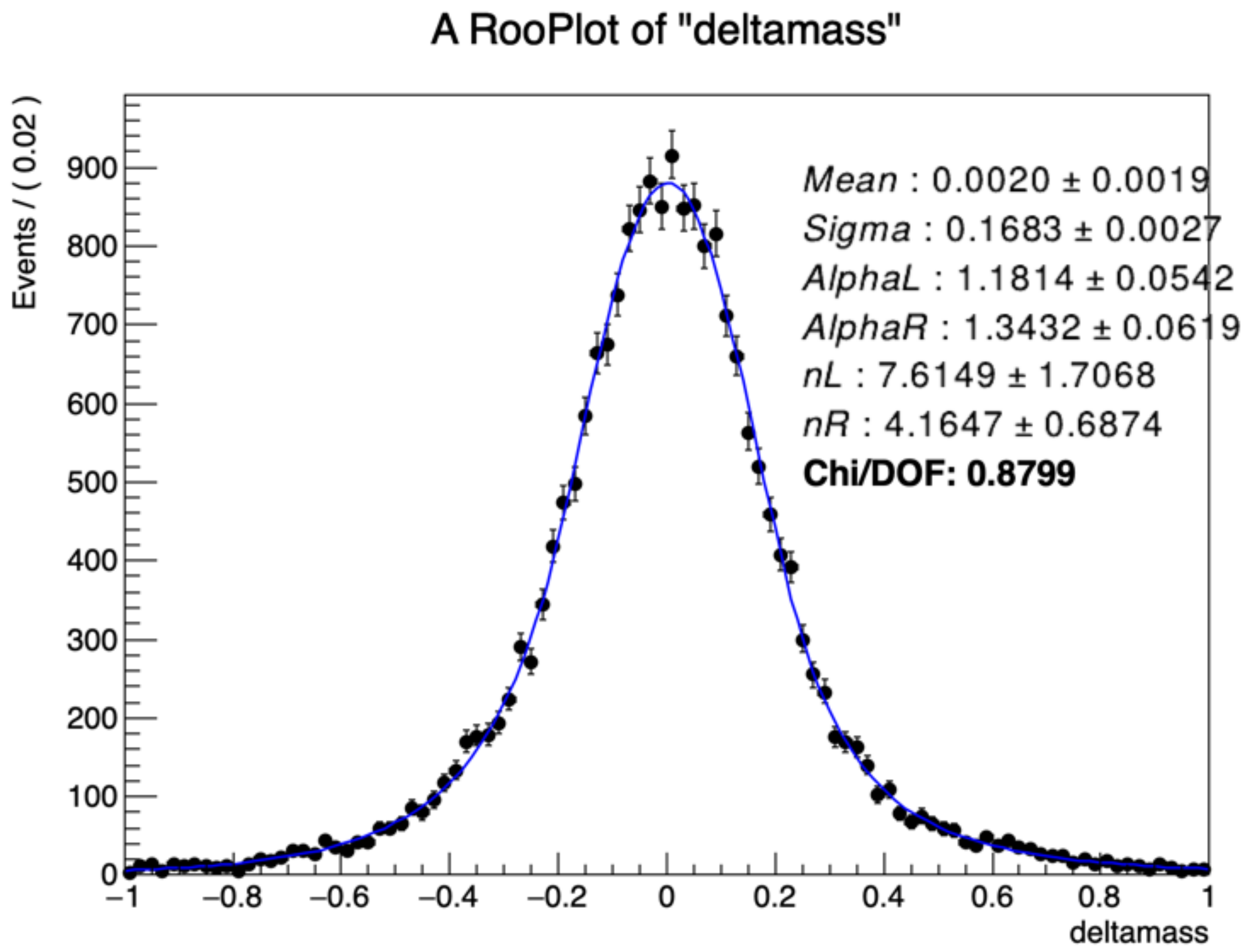
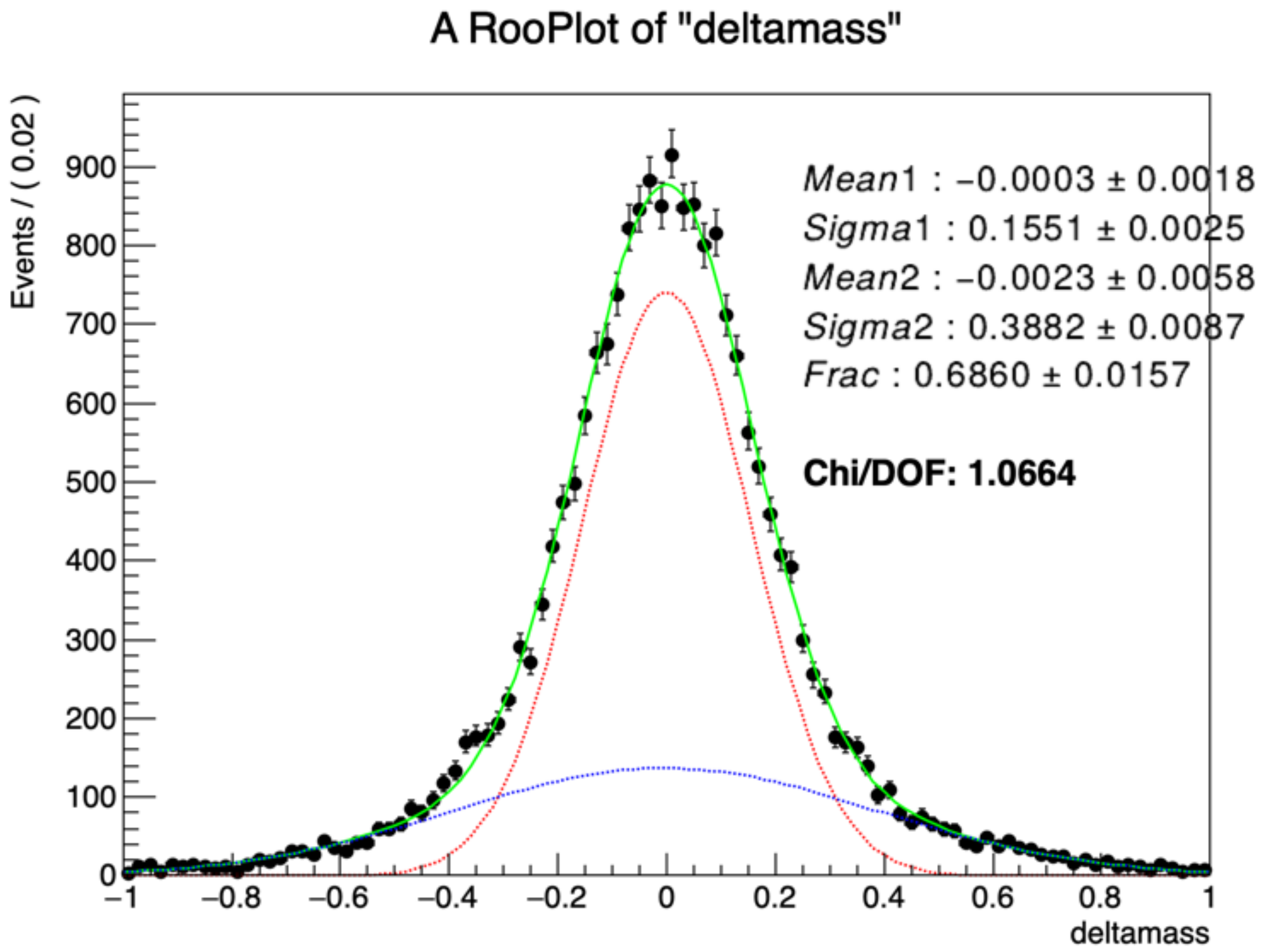
(Rec_mass - Gen_mass) distribution (un-weighted)







- **Fit the Delta mass (Rec-Gen), three functions tested.**
  - **Single Gaussian, sub-range**
  - **Double-side-crystal-ball, full-range**
  - **Double Gaussian, full-range**
- **Similar scale precision, 1.8 MeV with un-weighted events [50k]**
- **Relative resolution [Sigma] ≈ 0.17%, agree with the observation in tracking performance study.**