Resolving the Neutrino Ambiguity

By: Kelvin Mei (Rutgers University)

Advisors: Konstantinos Kousouris

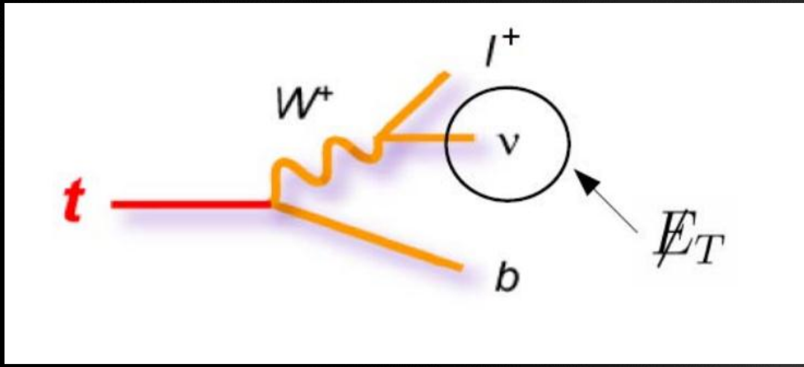
Andrea Giammanco

CMS

Compact Muon Solenoid

Reconstruction of Single Top

- Project: Using measurable variables such as missing transverse energy, lepton transverse momentum, etc…, reconstruct the single top from experimental data "with a maximal efficiency."
- Many difficulties ->
  - **Transverse momentum of the neutrino is not detectable.**
  - B-tagging uncertainties are large, thus making large error bars for the reconstructed t.
- Useful for:
  - Since the other t-decay channels are largely suppressed due to the configuration of the LHC (low correlation in the CKM matrix elements for the s-channel and decaying into down quark), this channel is a place to search for new physics.
  - The lower we can get the error bars and the uncertainties, the more sensitive this search will be.



Principle Equation:

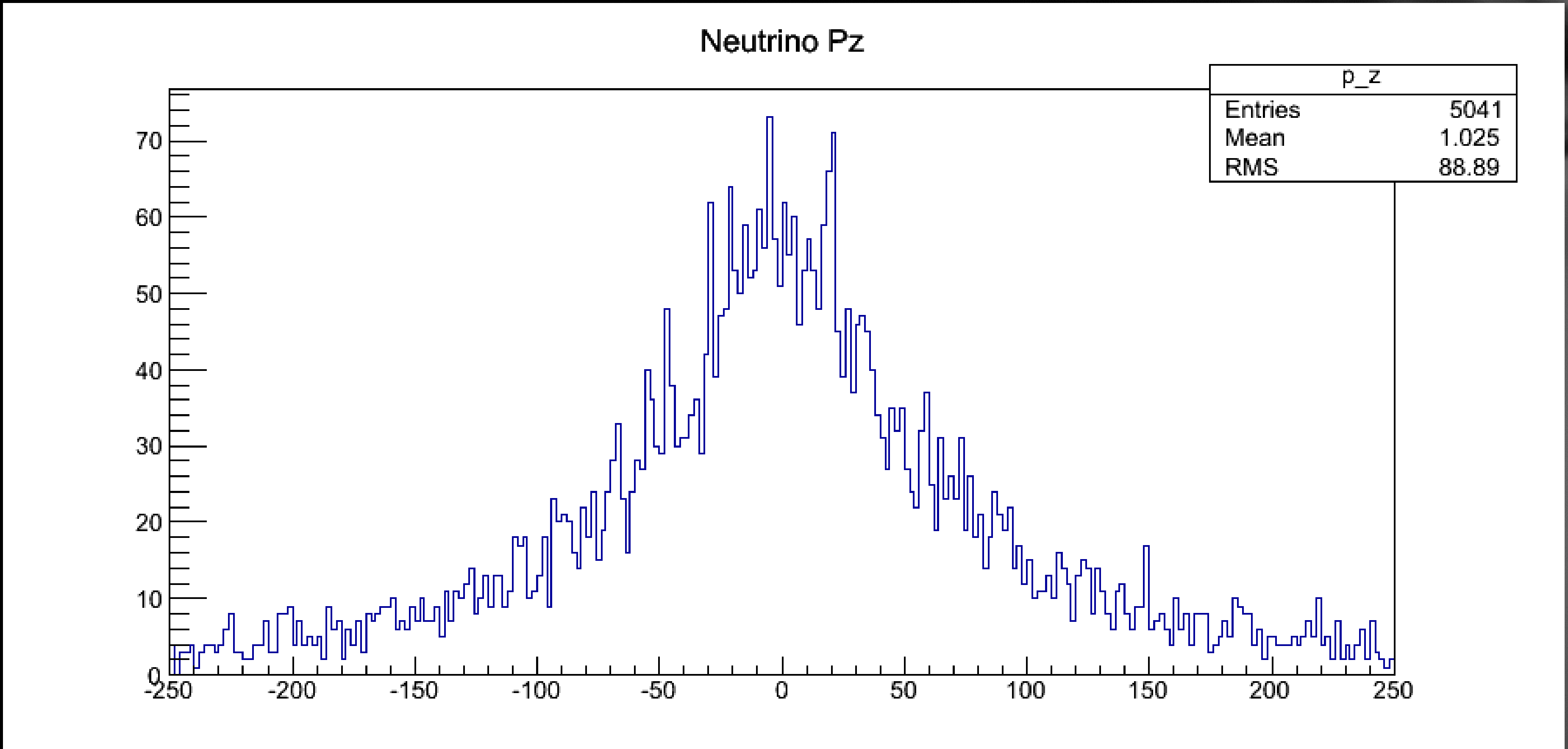
$$P_W = P_\nu + P_\mu$$

after lots of mathematics, and quite a few approximations:

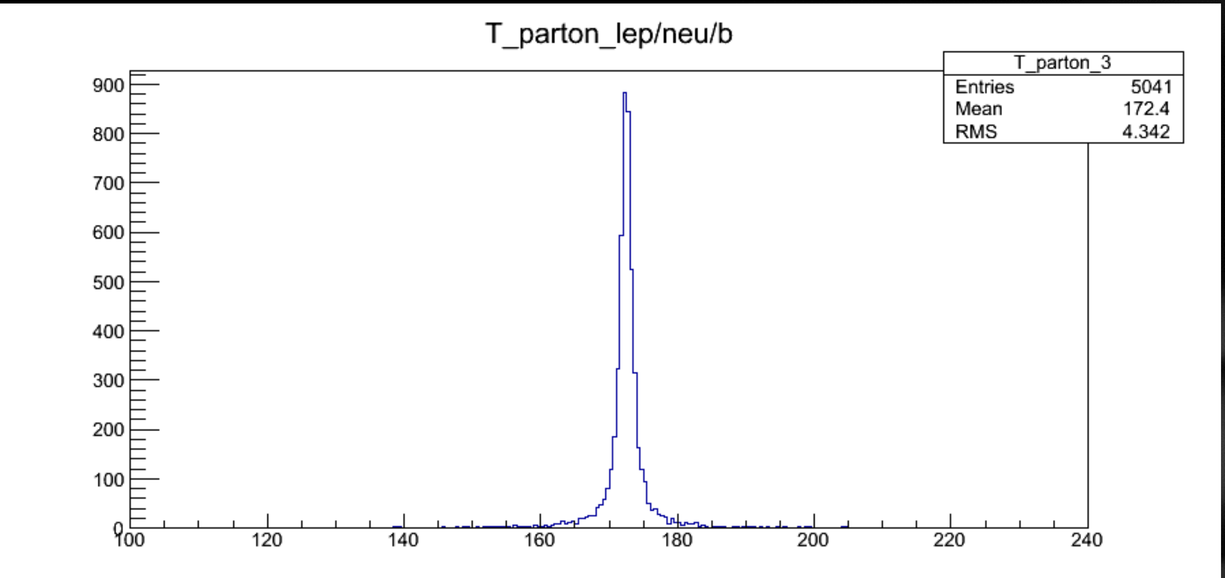
$$P_{z,\nu}^{A,B} = \frac{\mu \cdot P_{z,\mu}}{P_{\mathrm{T},\mu}^2} \pm \sqrt{\frac{\mu^2 \cdot P_{z,\mu}^2}{P_{\mathrm{T},\mu}^4} - \frac{E_\mu^2 \cdot {\mathbf{E}_\mathrm{T}^{\mathrm{miss}}}^2 - \mu^2}{P_{\mathrm{T},\mu}^2}} \,,$$

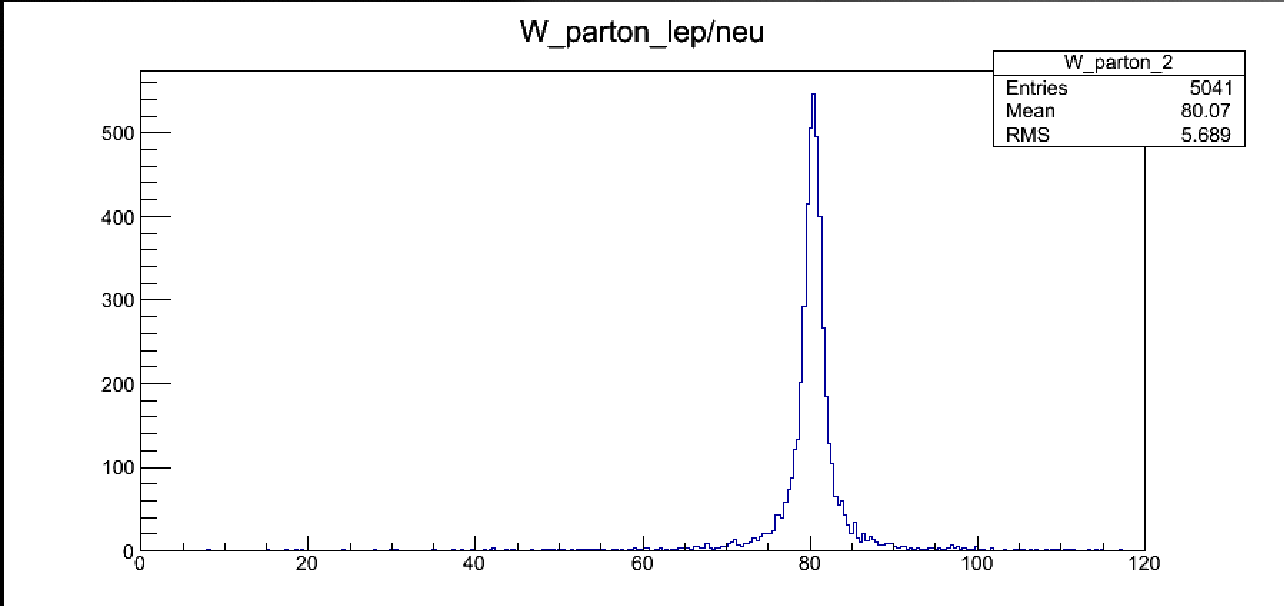
$$\mu = \frac{M_W^2}{2} + \mathbf{P}_{\mathrm{T},\mu} \cdot \mathbf{E}_\mathrm{T}^{\mathrm{miss}} \,.$$

Ambiguity of Neutrino Pz



Instead look at…

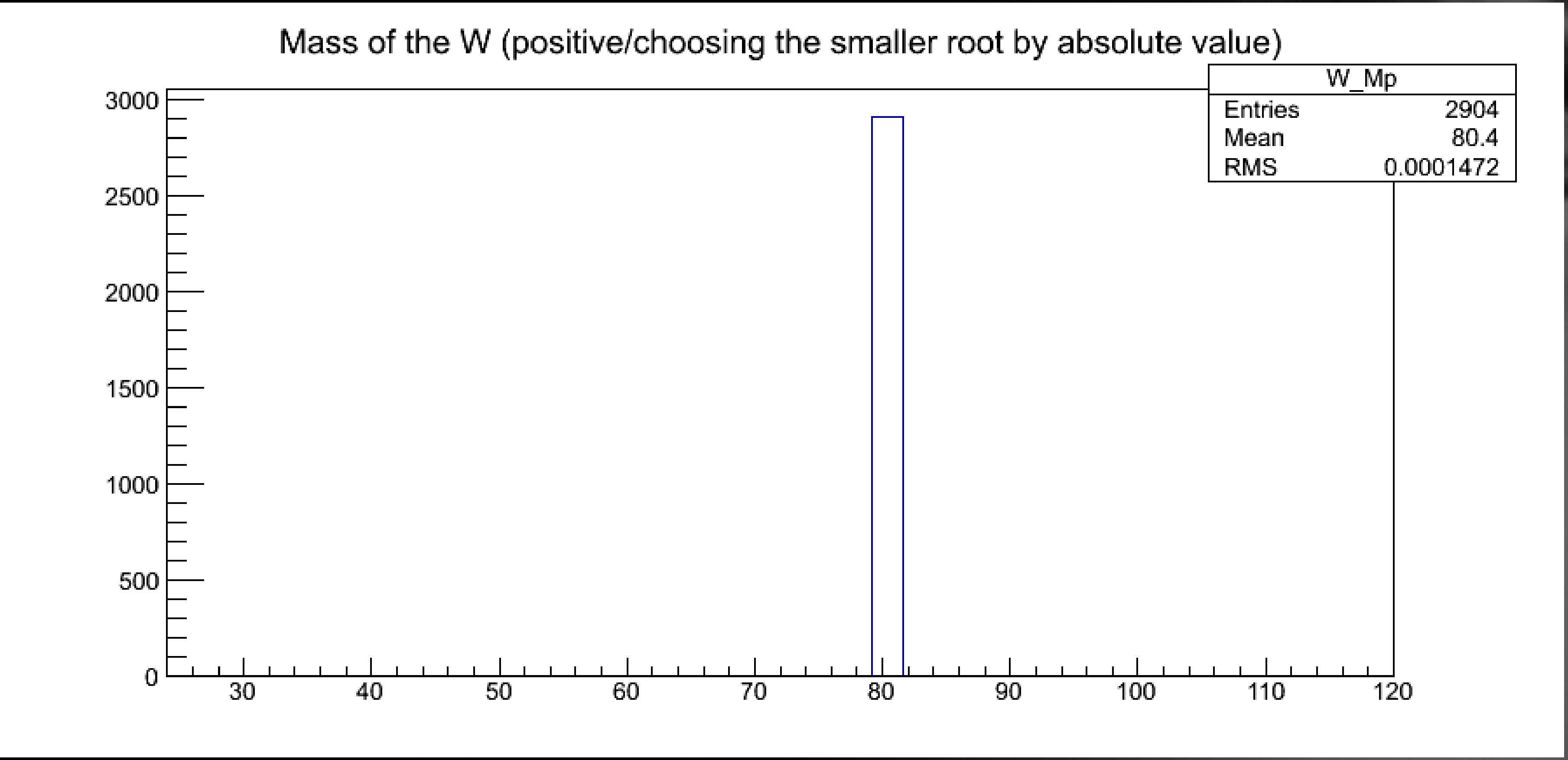




Positive Discriminants

Two Real Roots

Method 1: Choosing the Smaller Root By Absolute Value



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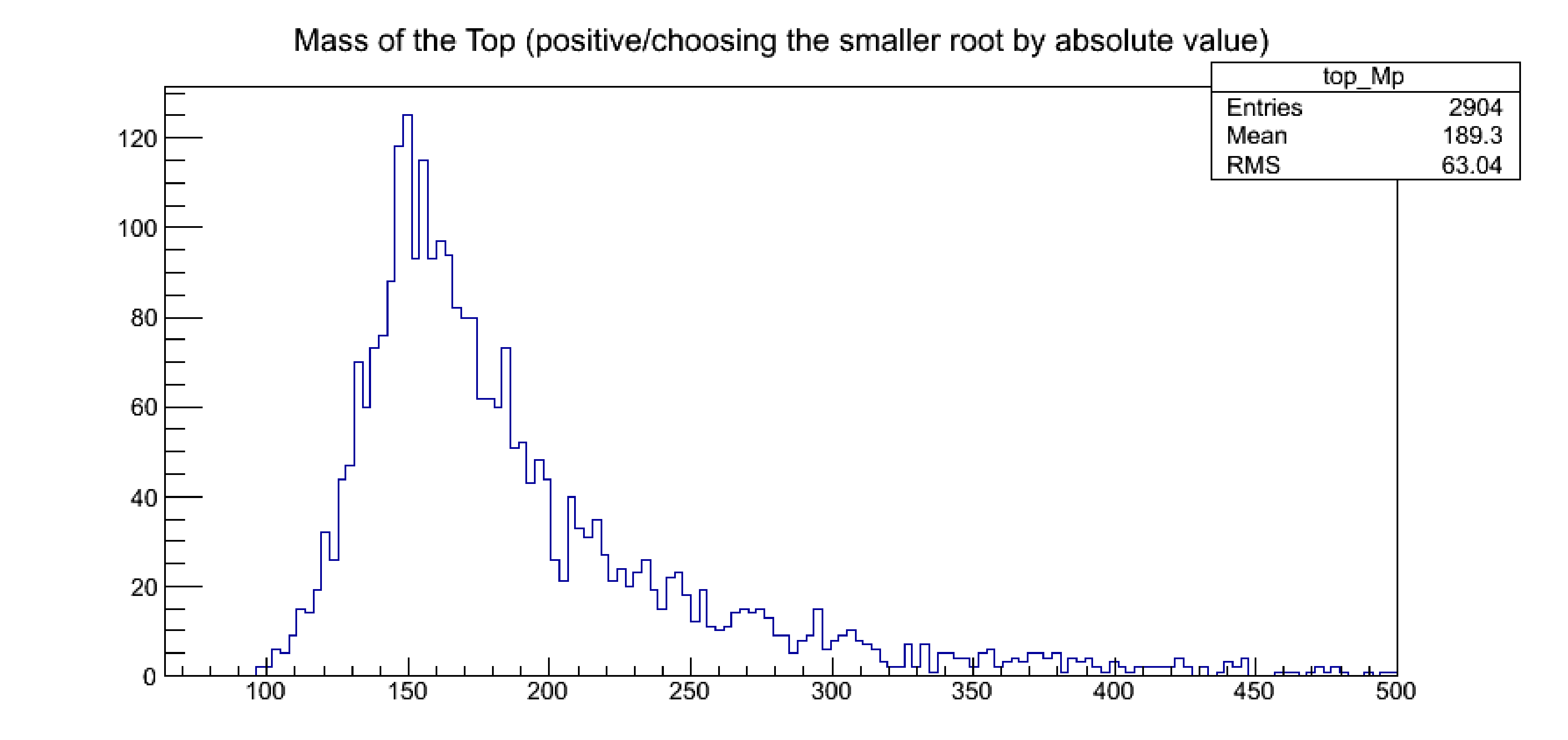
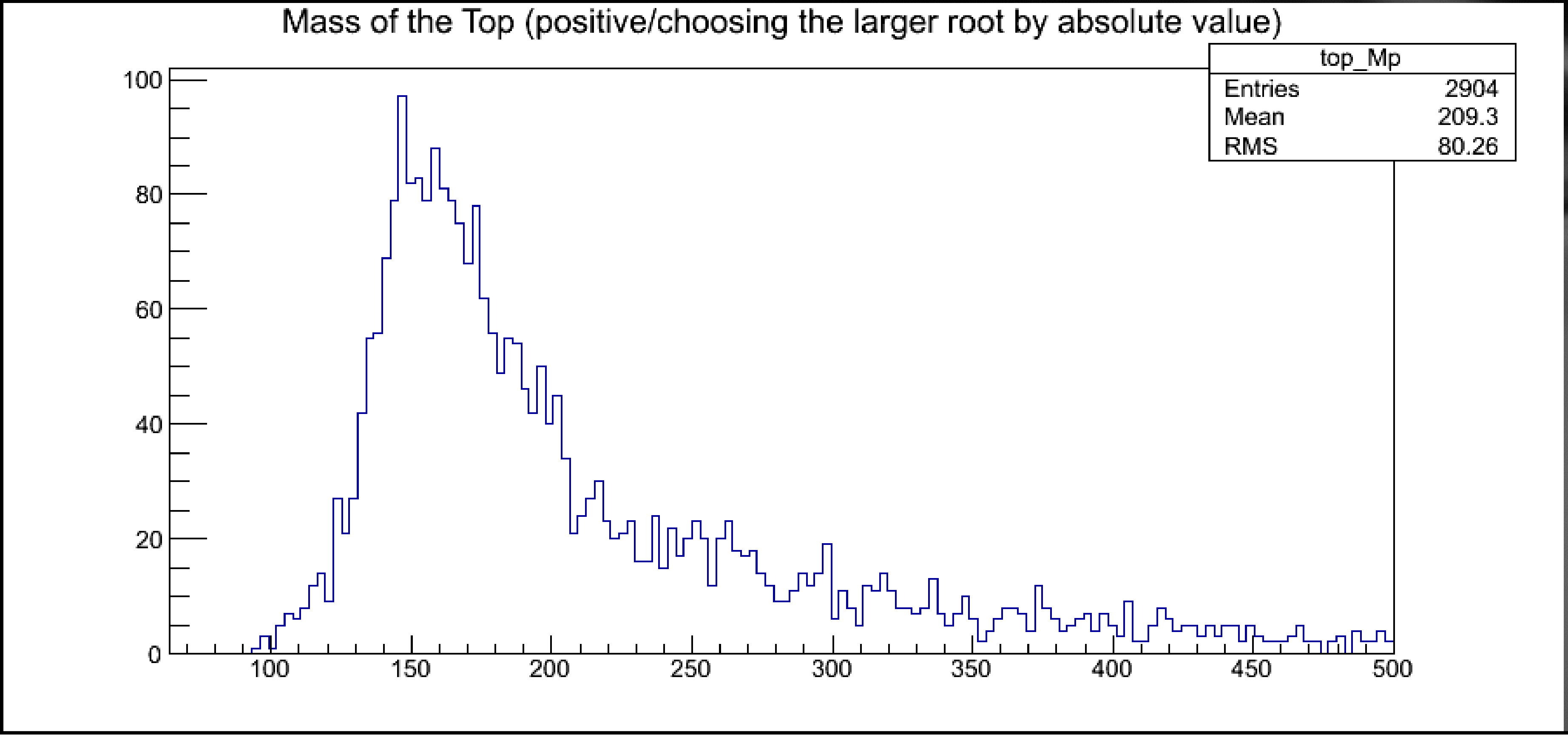


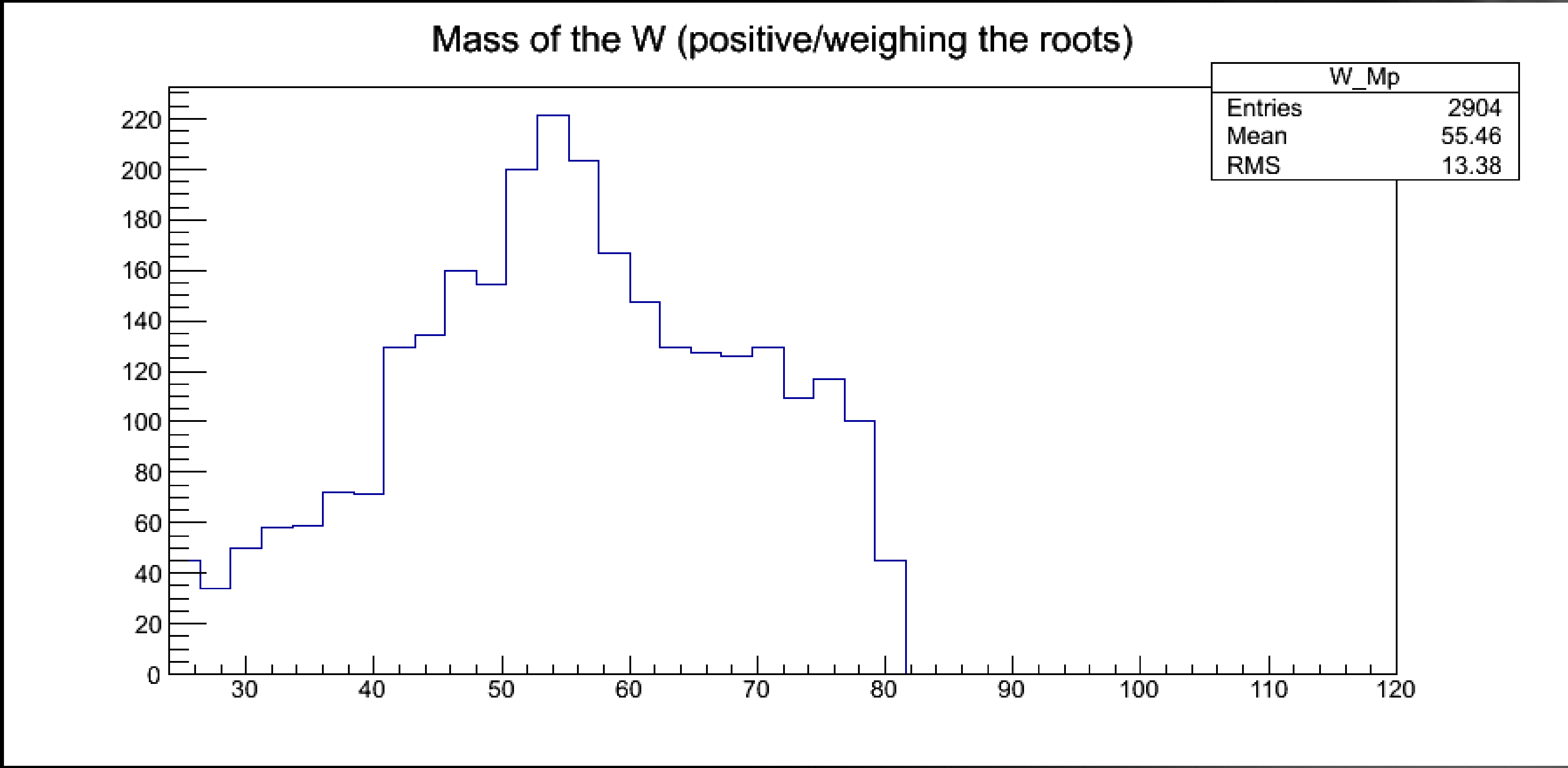
Mean Mass: 189.3 GeV/c²

Comparing with the Larger Root…

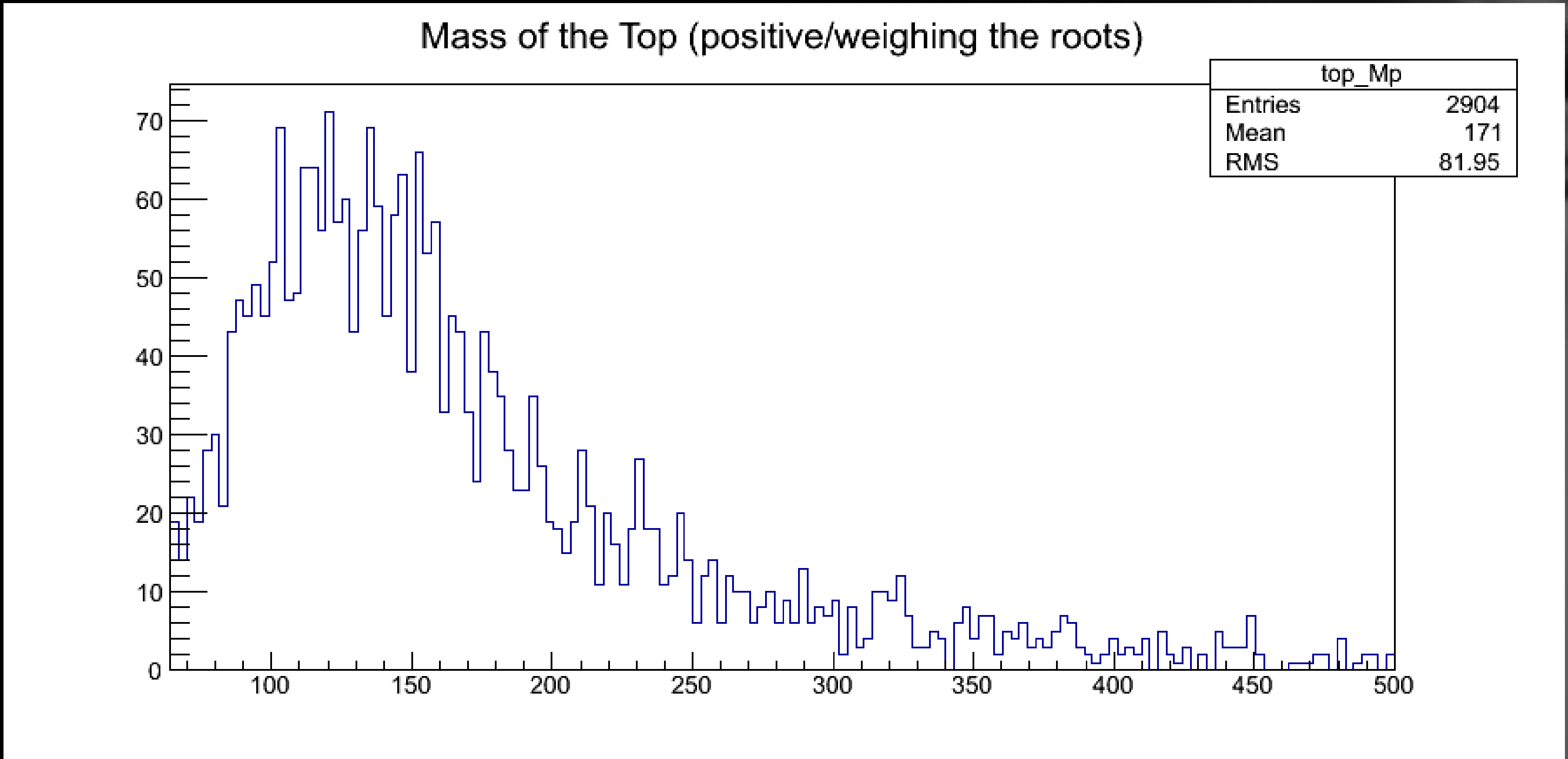


Mean Mass: 209.3 GeV/c²

Method 2: Scaling the Two Roots



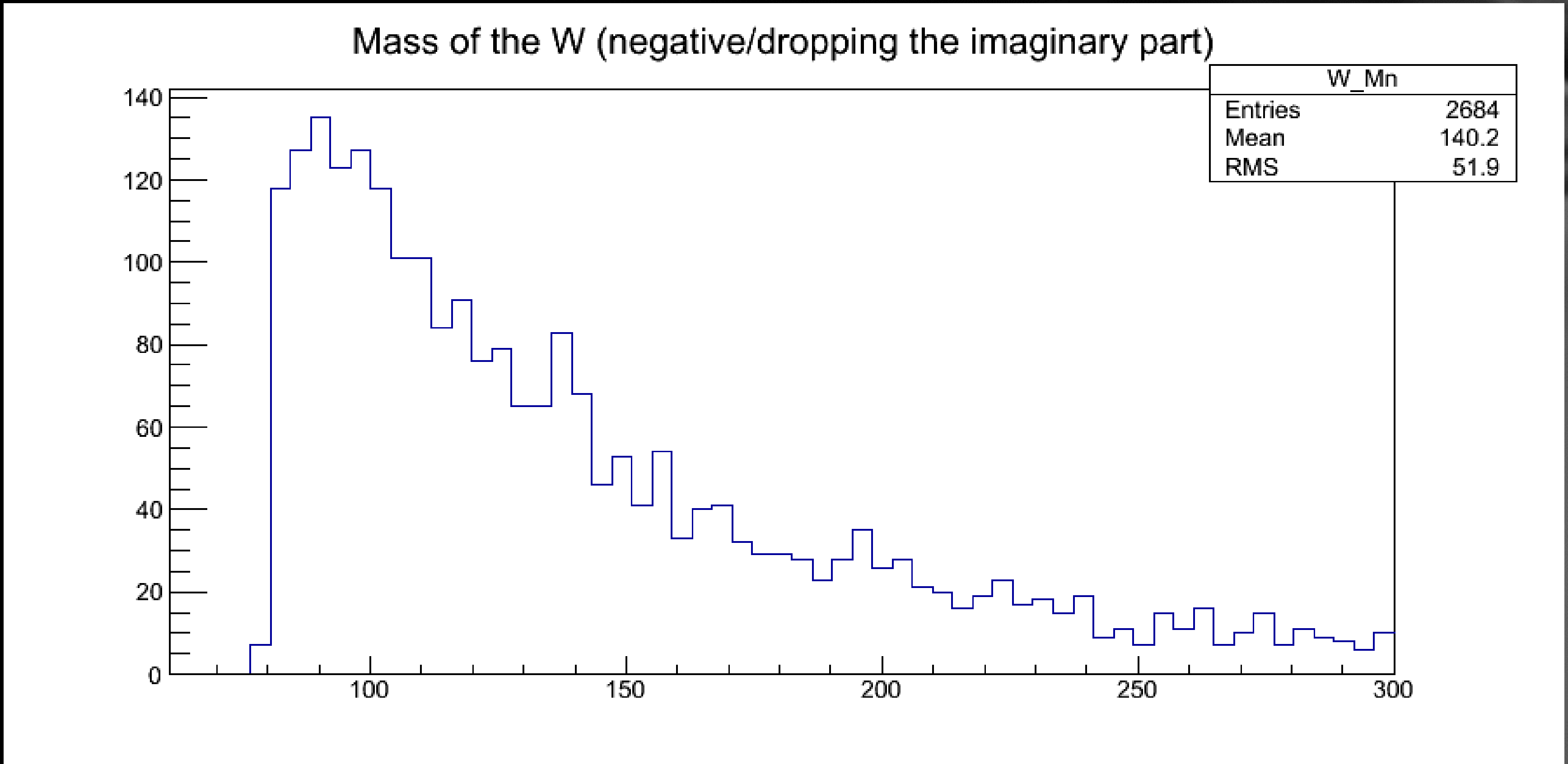
Method 2: Scaling the Two Roots



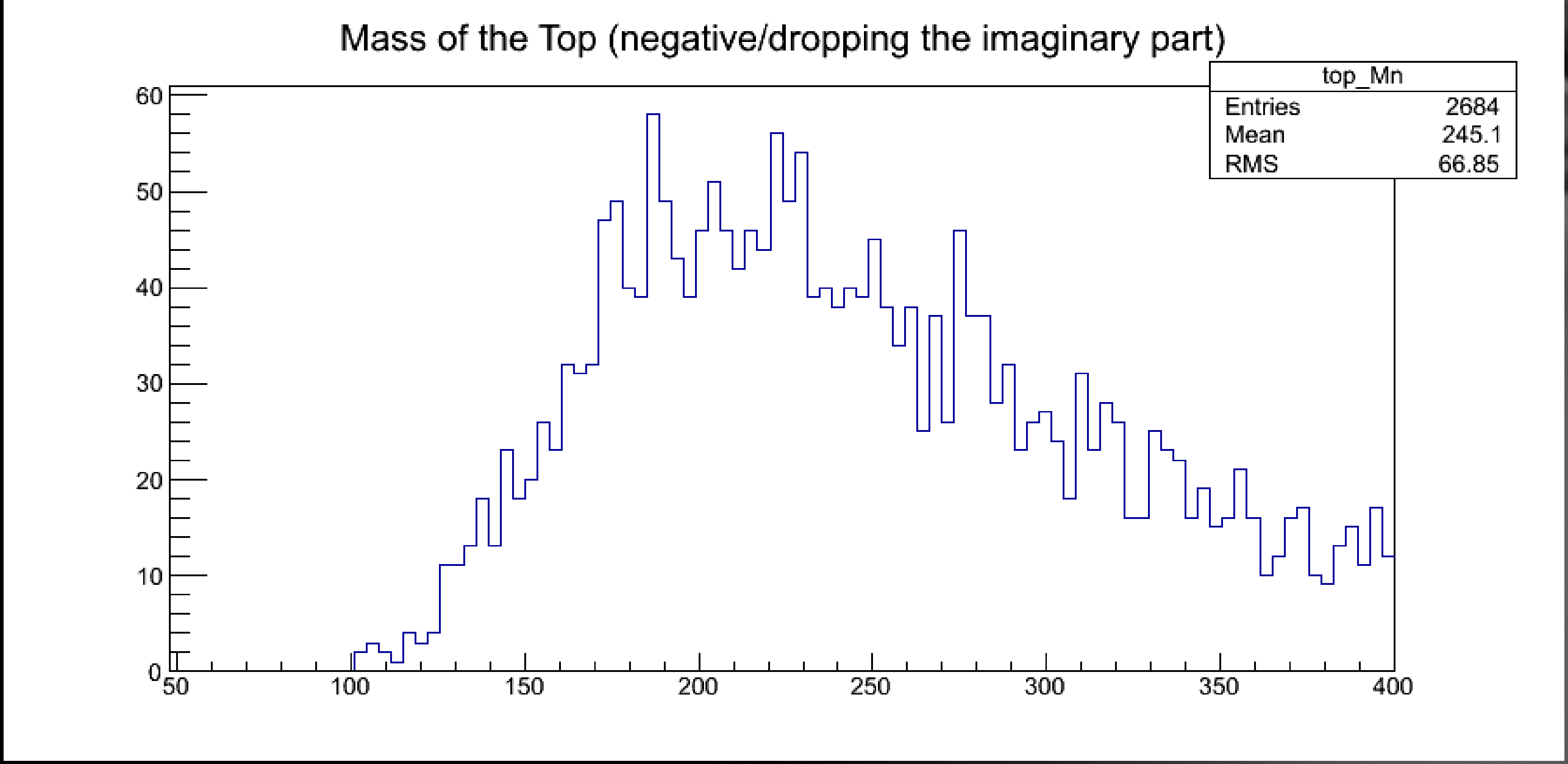
Negative Discriminants

Two Imaginary Roots

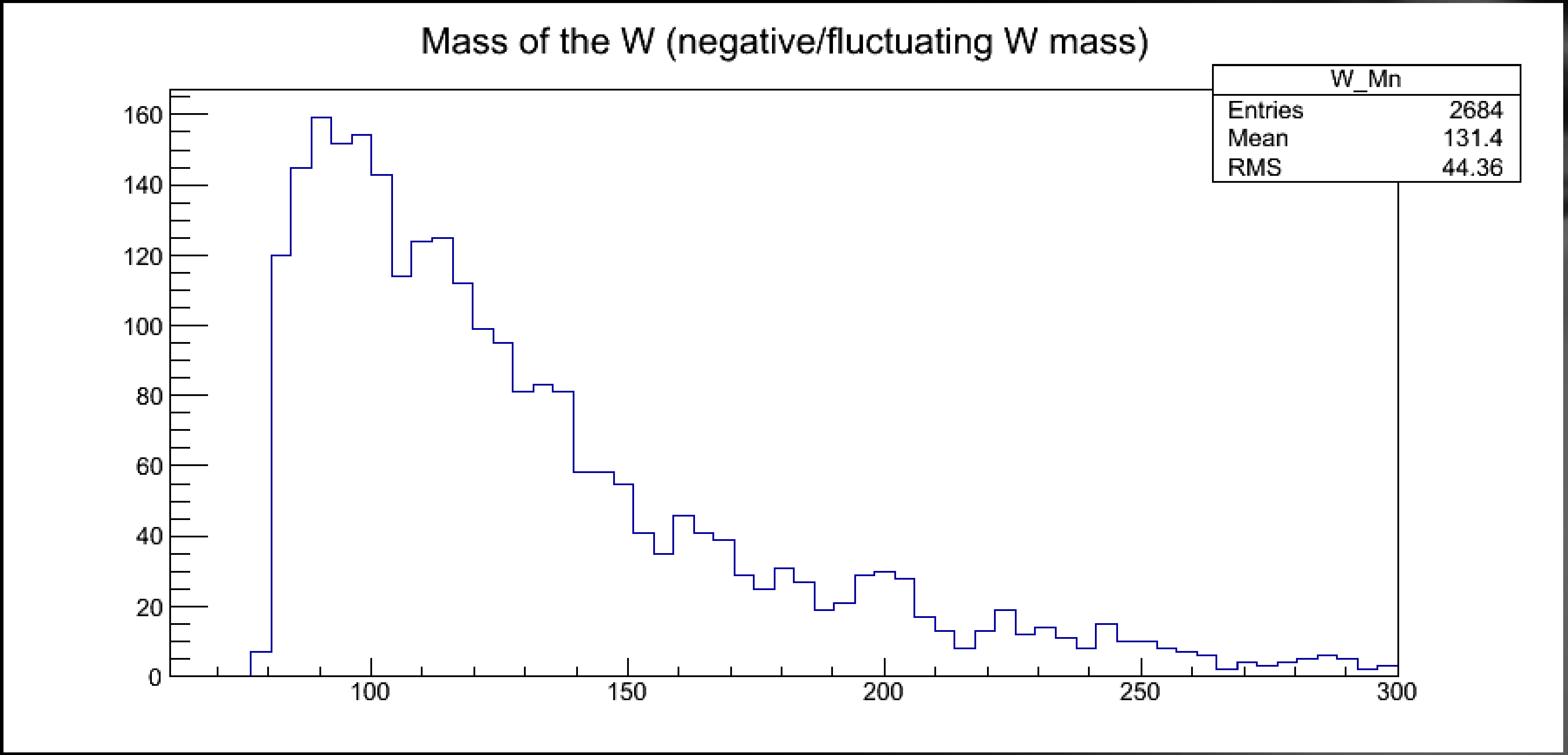
Method 1: Dropping the Imaginary Root



Method 1: Dropping the Imaginary Root



Method 2: Letting the Mass of the W Boson Fluctuate



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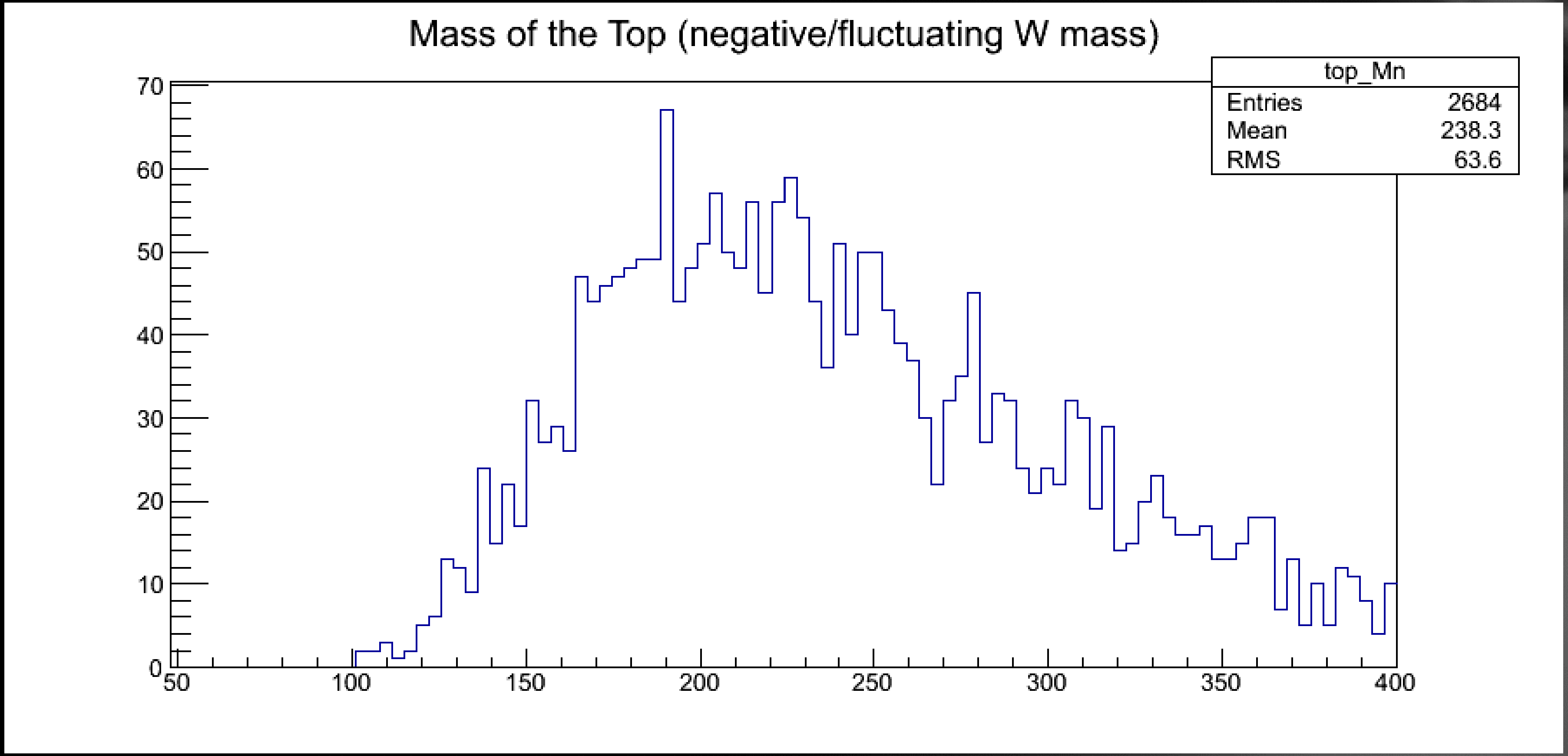
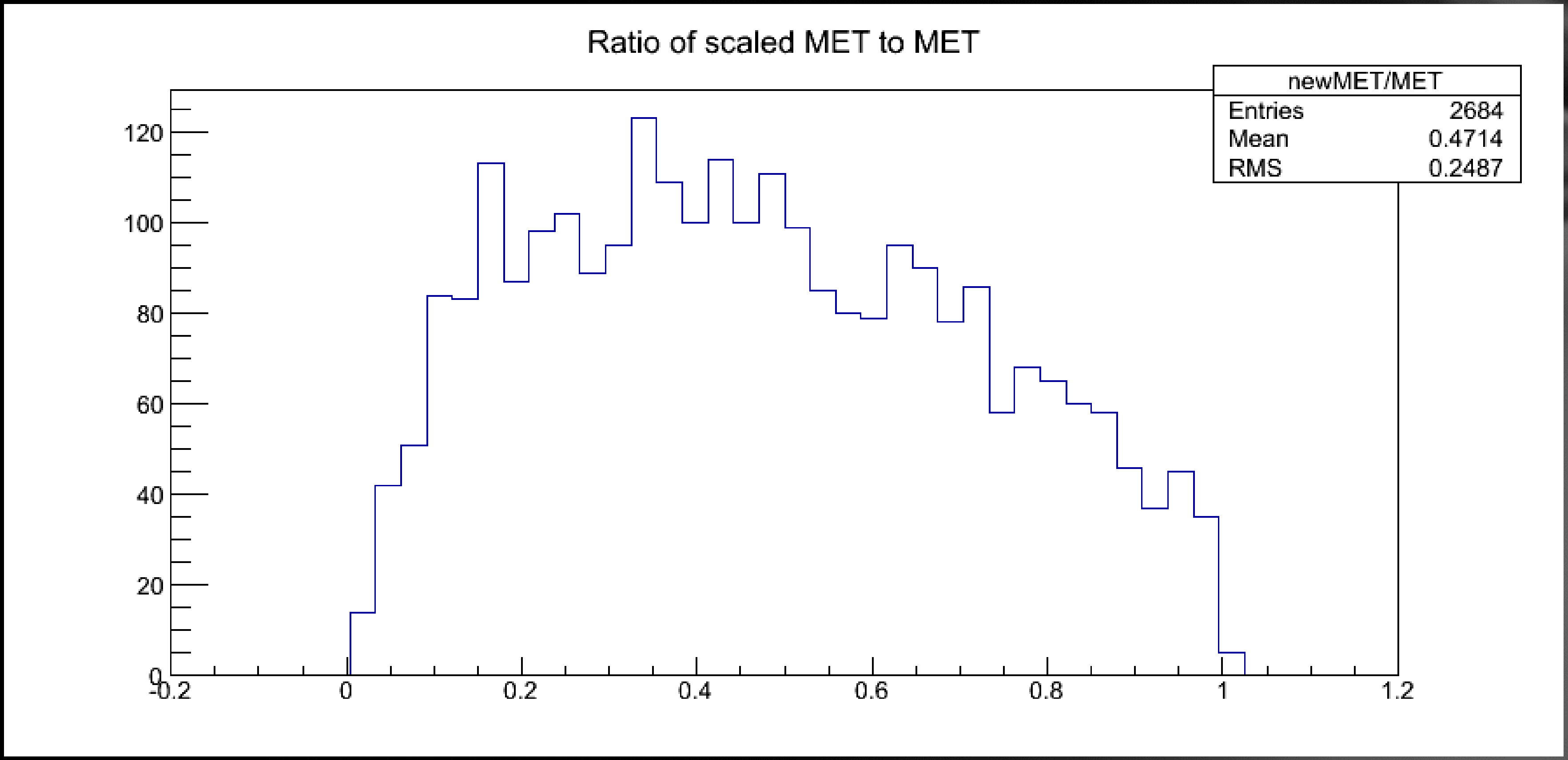


The Equation Again:

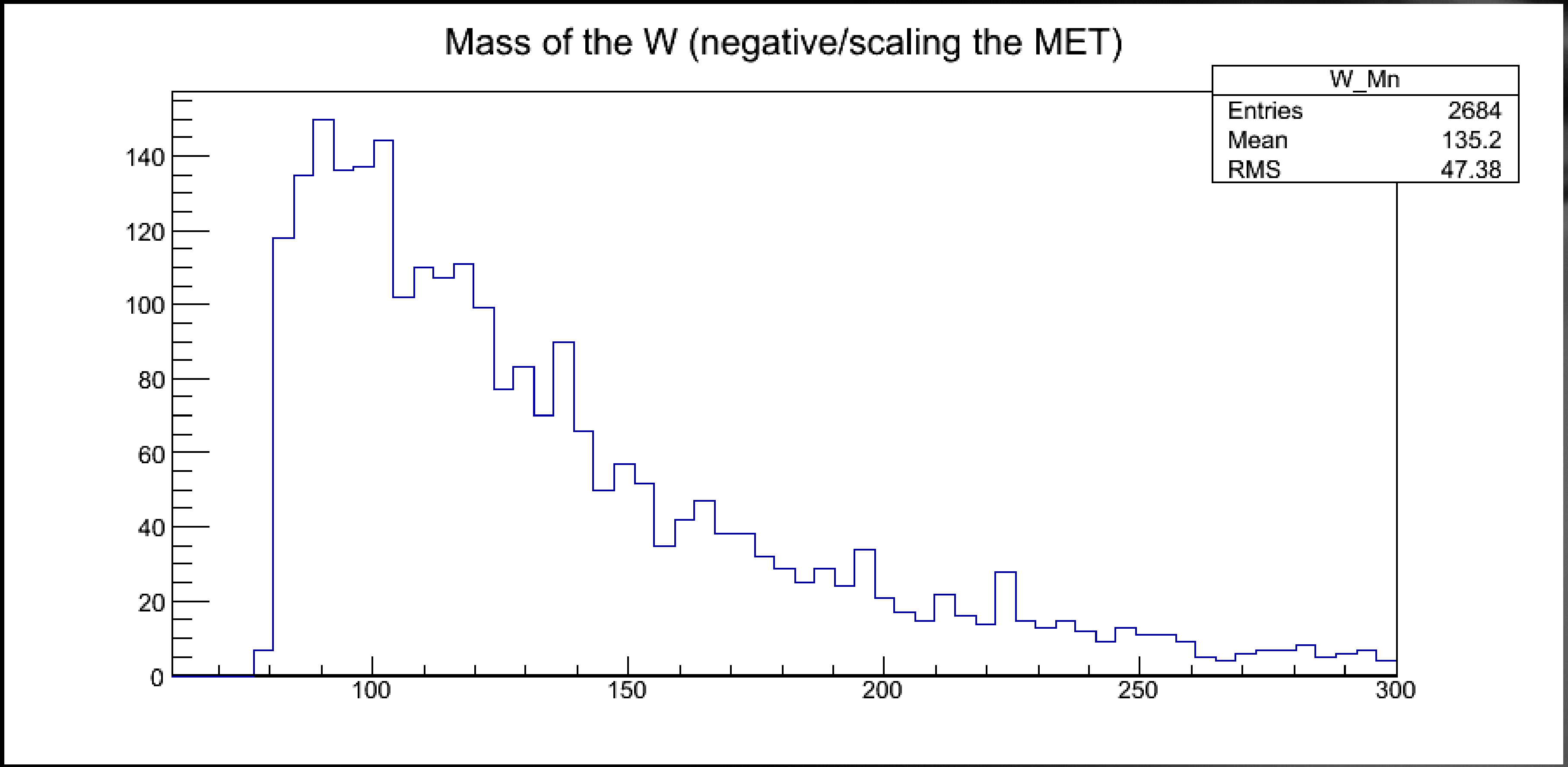
$$P_{z,\nu}^{A,B} = \frac{\mu \cdot P_{z,\mu}}{P_{\mathrm{T},\mu}^2} \pm \sqrt{\frac{\mu^2 \cdot P_{z,\mu}^2}{P_{\mathrm{T},\mu}^4} - \frac{E_\mu^2 \cdot \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}^2} - \mu^2}{P_{\mathrm{T},\mu}^2}} \ ,$$

$$\mu = \frac{M_W^2}{2} + \mathbf{P}_{\mathrm{T},\mu} \cdot \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}} \ .$$

Method 3: Scaling the MET



Method 3: Scaling the MET



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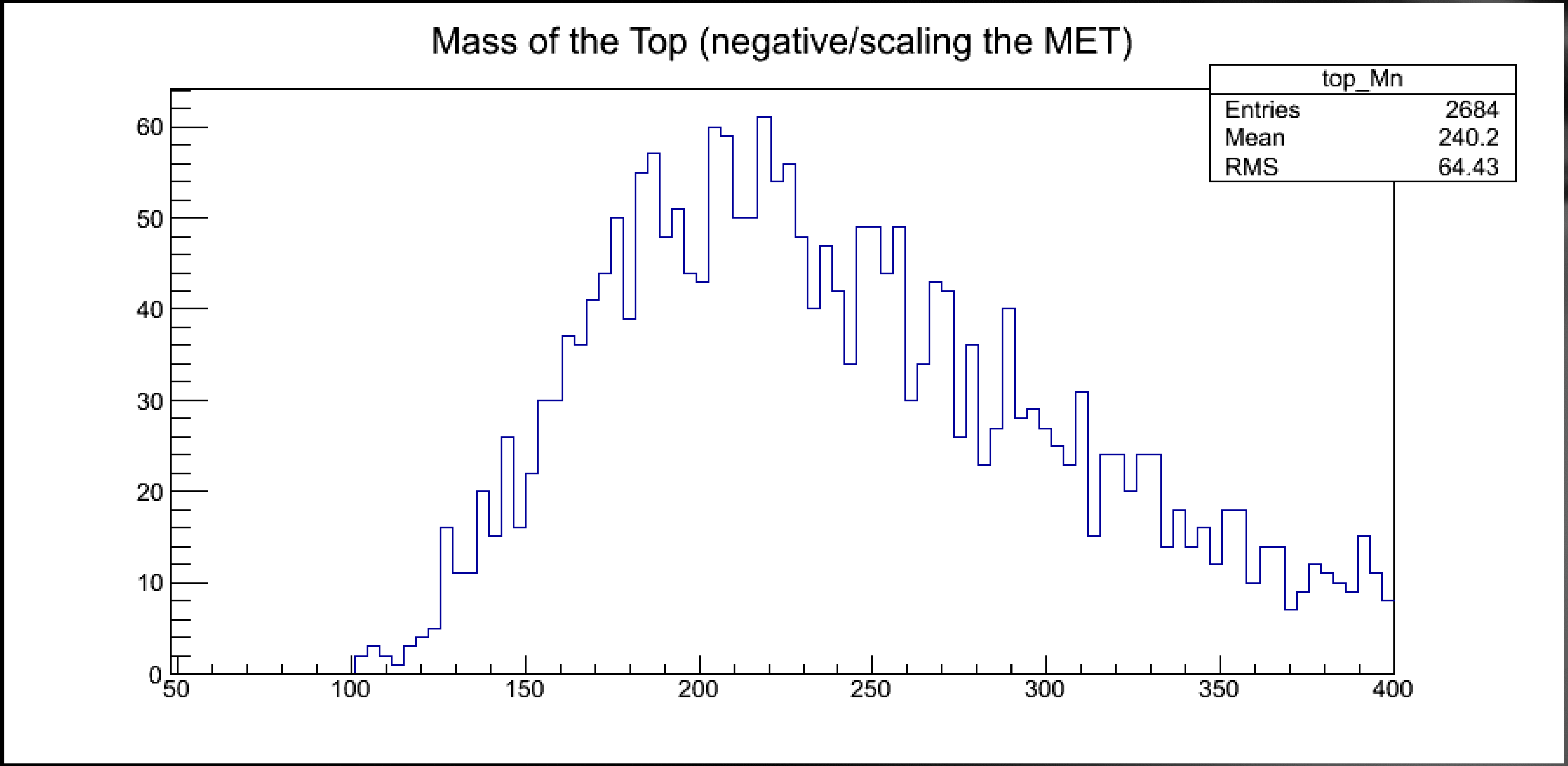
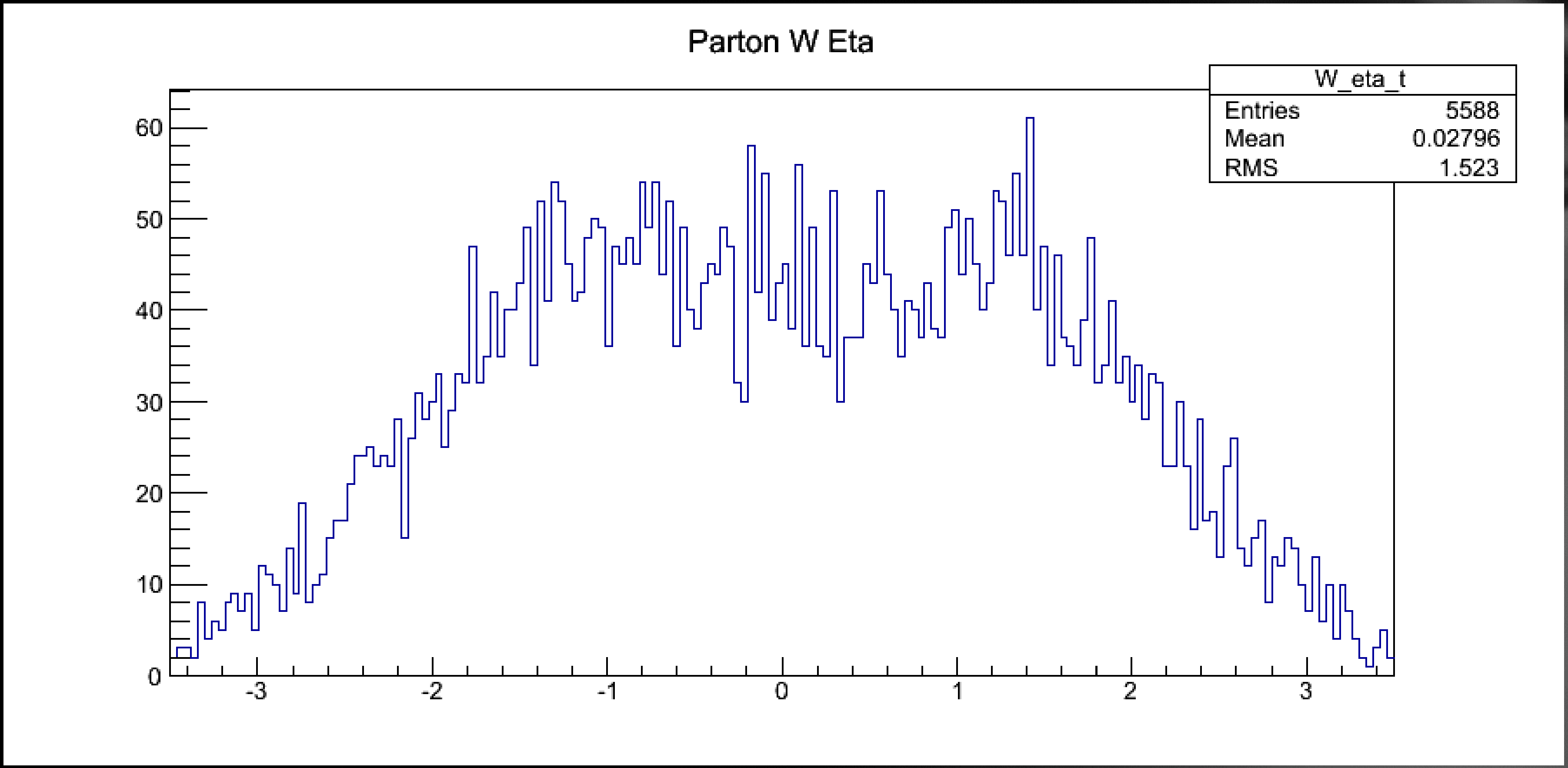
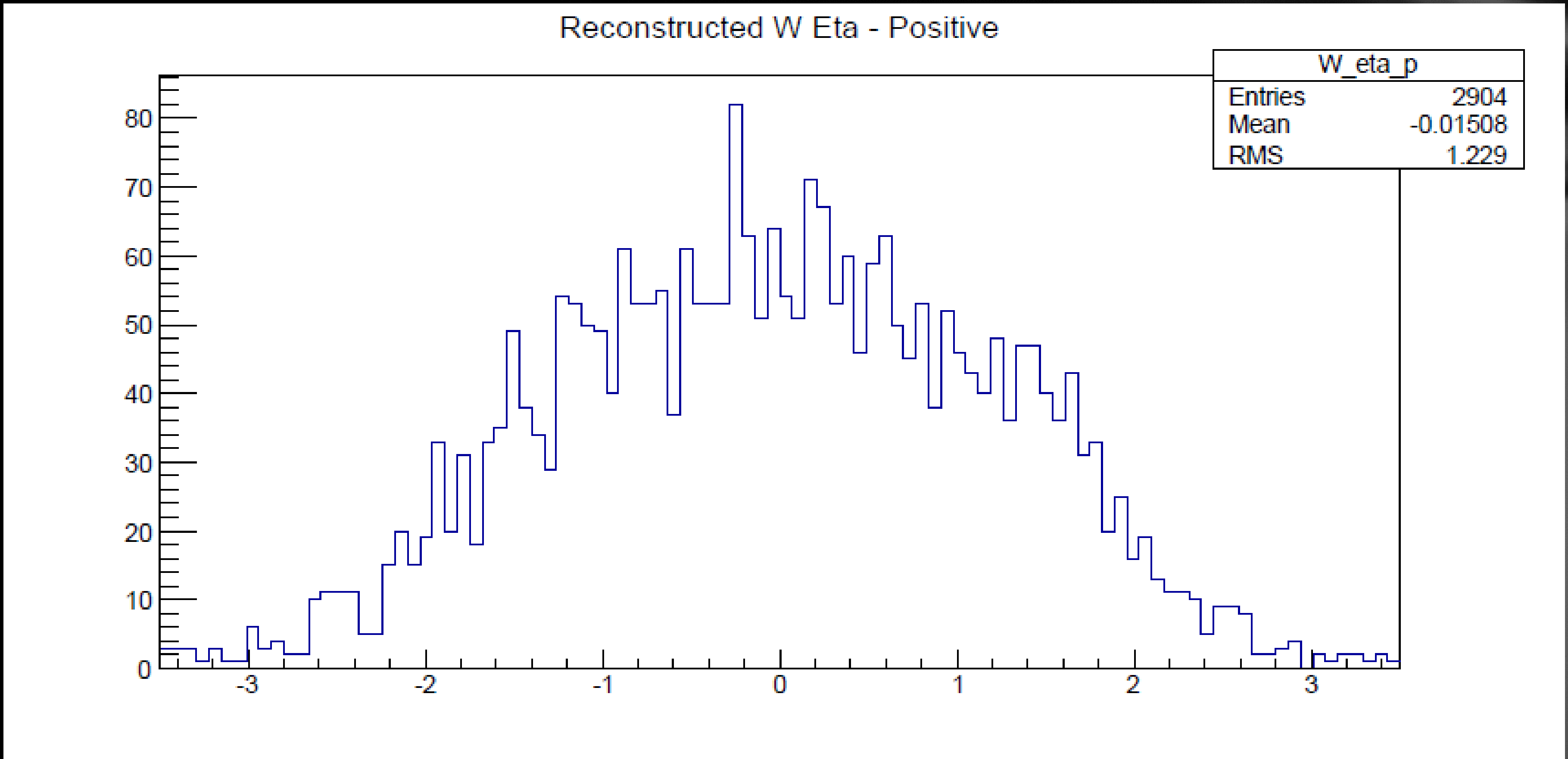


Motivation for TMVA

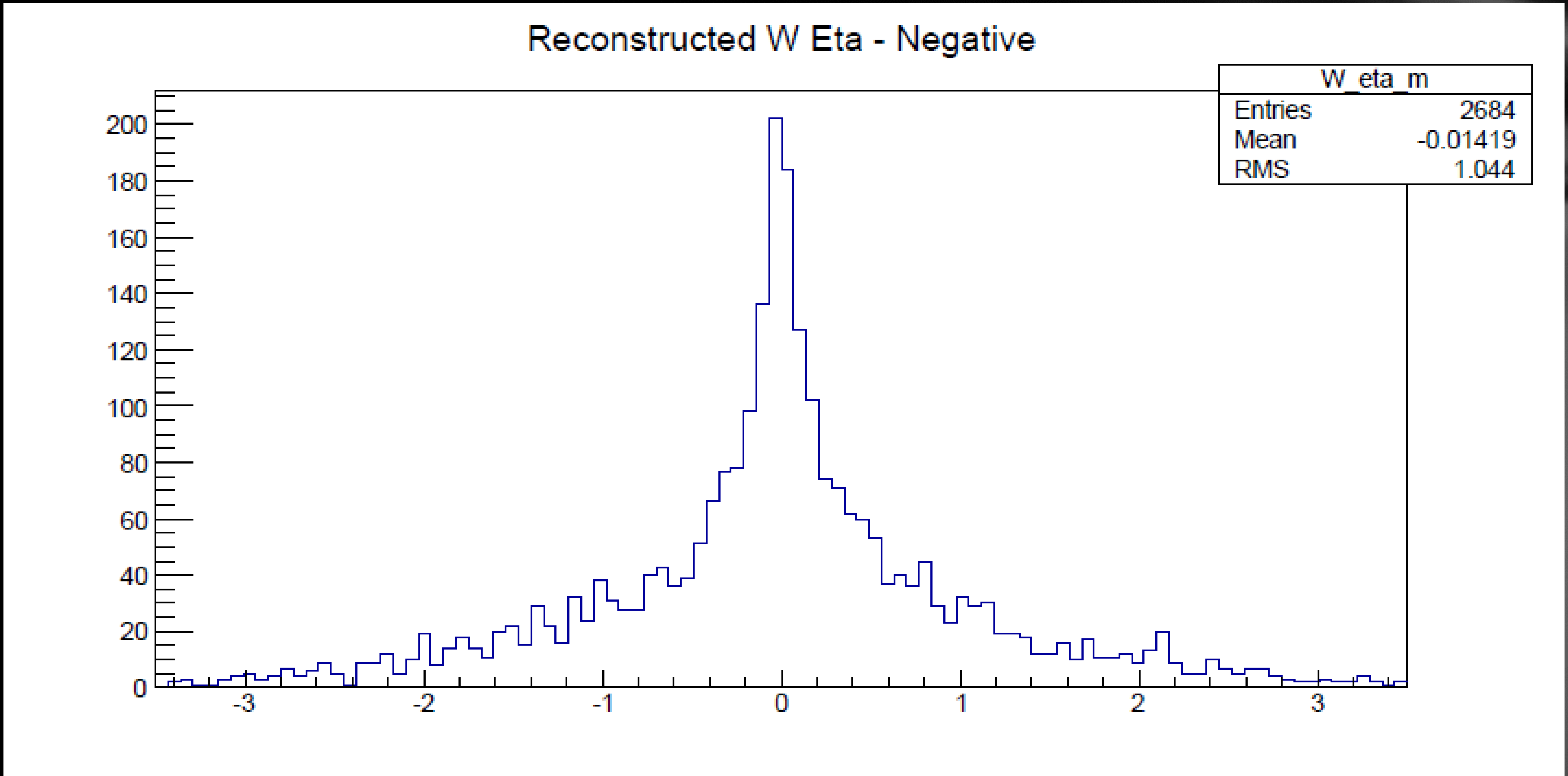
More Detailed Look Into the Problem: Modeling Pseudorapidity of W



η of Positive Discriminants



η of Negative Discriminants



Conclusions

- Current method of dealing with the neutrino ambiguity is very inefficient.
- Simple methods that have been used, such as scaling the MET, letting the mass of the W boson fluctuate, and weighing the roots by the probabilities do not significantly improve on the selection of the right value for the neutrino longitudinal momentum nor the reconstruction of the top.
- A quick look at other variables show that within the imaginary part of the roots may lie information about the pseudorapidity and motivates a multivariate analysis.
- Other difficulties lie in the reconstructions still, such as b-tagged jets and other particles that may be undetected and contributing to the MET.

Works Cited

- CMS Logo: http://www.physics.rutgers.edu/hex/
- Feynman Diagram and Equations: D. Klingebiel. Prospects for a Measurement of the t-Channel Single Top Quark Cross Section with the CMS Experiment. April 2010.