Energy reconstruction tuning for FD-VD

Wenjie Wu (UCI)

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Kinematics-based method

$$E_\nu = E_{\mathrm{lep}}^{\mathrm{cor}} + E_{\mathrm{had}}^{\mathrm{cor}}$$

- ν_e CC energy: divide event into reconstructed shower with highest charge and hadronic energy
- ν_μ CC energy: divide event into longest reconstructed track and hadronic energy
- Hadronic/Electron energy: electron lifetime (wire-by-wire) and recombination (constant) corrected calorimetric energy

Kinematics-based method

DUNE-doc-2278 by Nick Grant et al

Electron shower energy

Calorimetric energy calibrated with MC

Muon momentum (Longest track contained)

By track range, calibrated by MC

Muon momentum (Longest track exiting)

By multi-Coulomb scattering, calibrated by MC

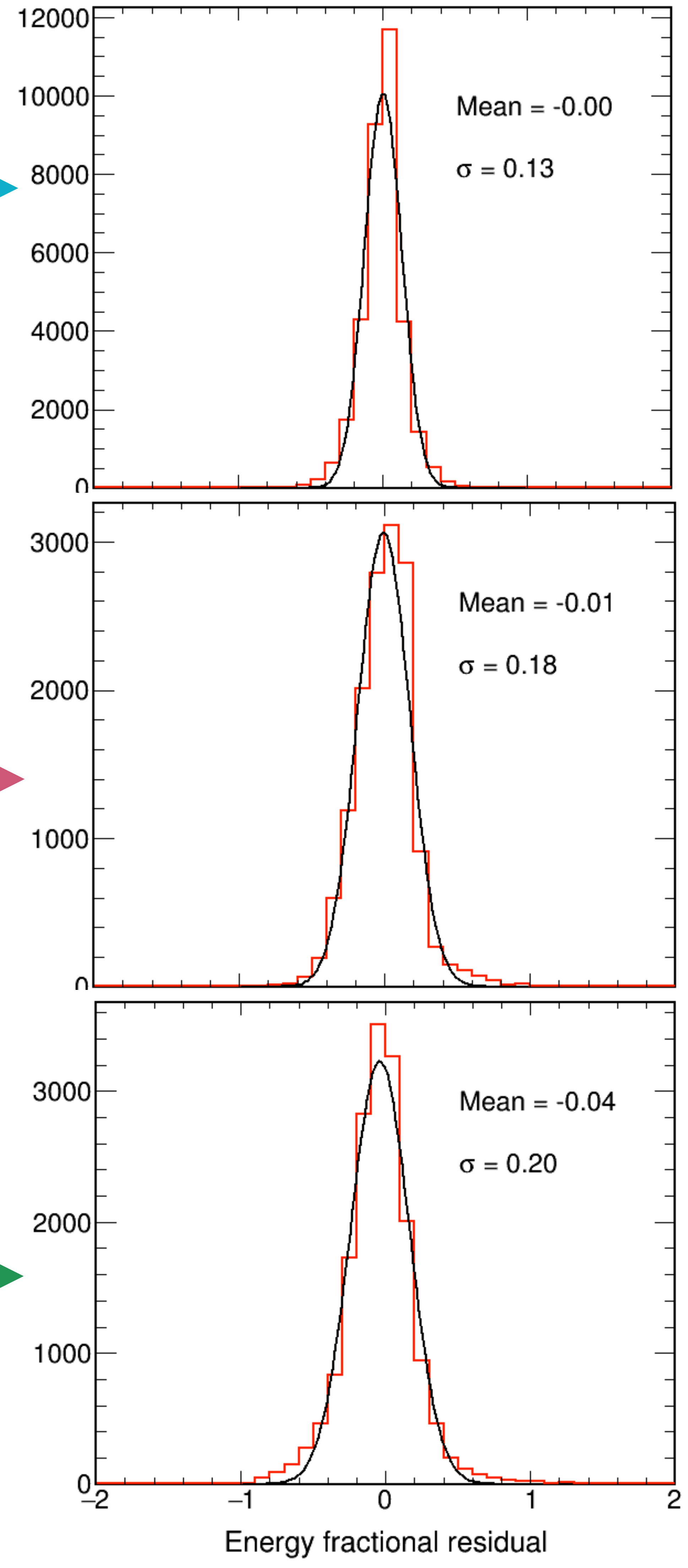
Hadronic energy

By reconstructed hits not in the muon track or electron shower, calibrated by MC

ν_e CC

Contained ν_μ CC

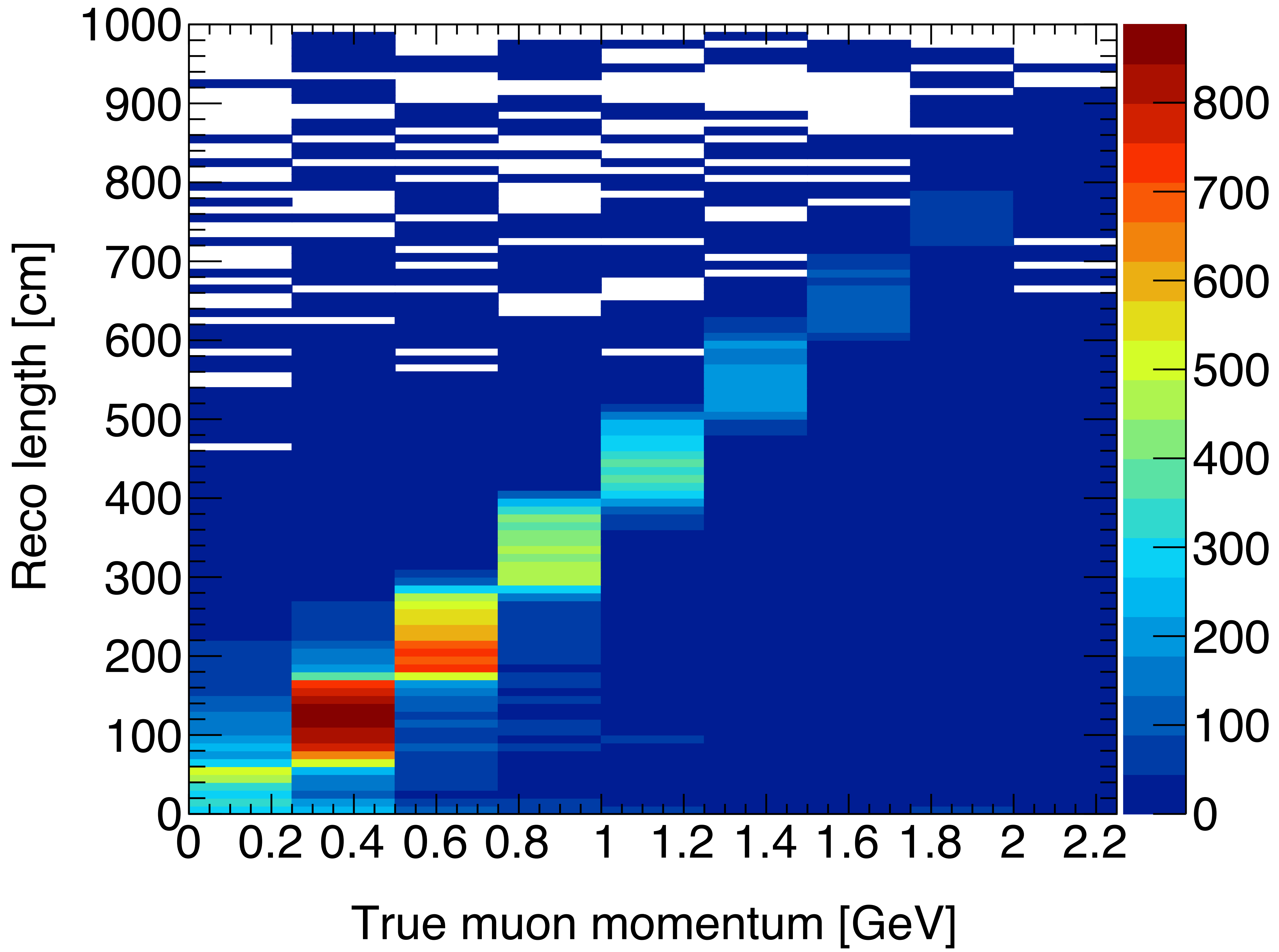
Exiting ν_μ CC



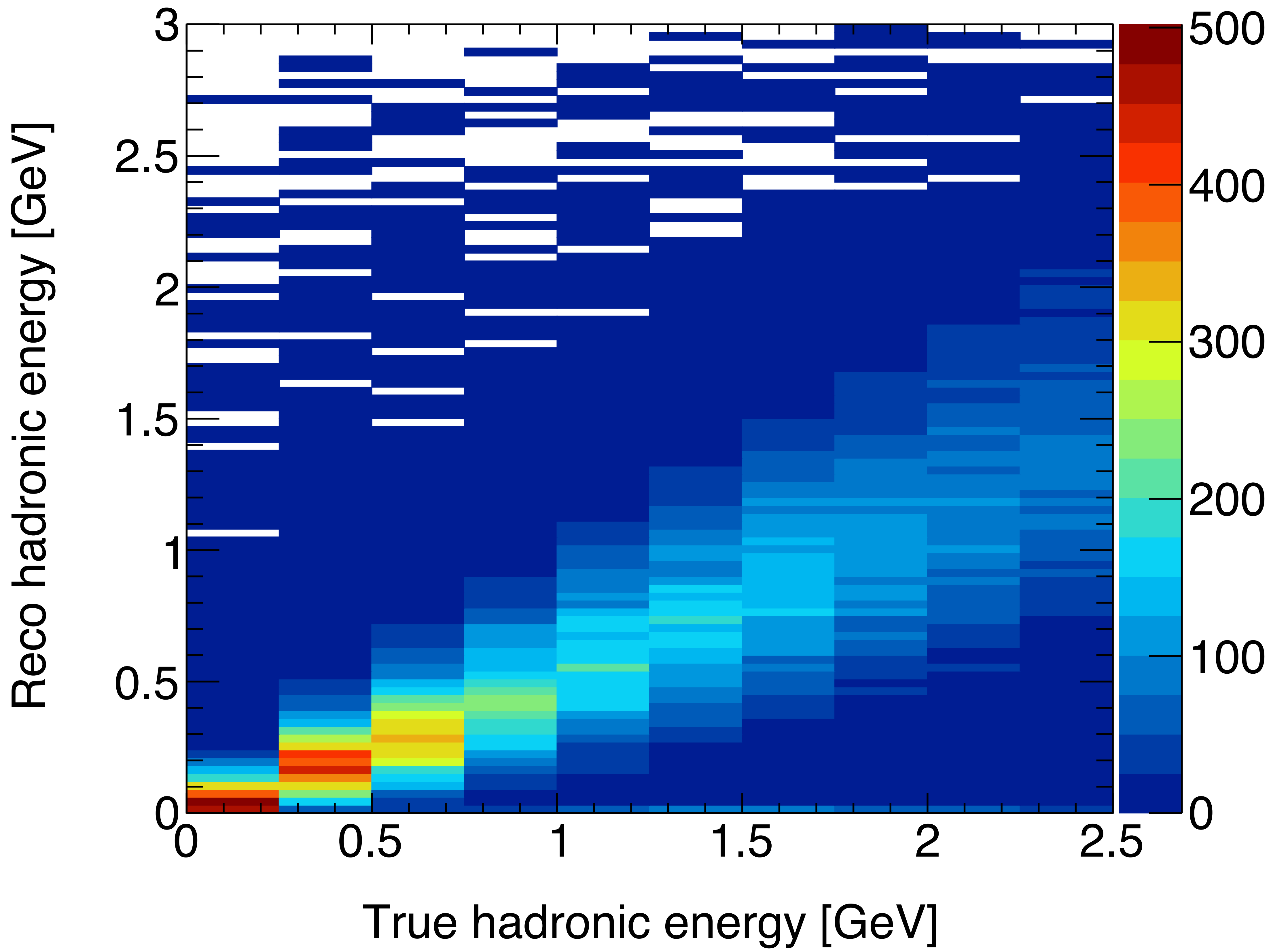
ν_μ CC events with contained track

Fid_Cut
abs(nuvtxx_truth) < 300.
abs(nuvtxy_truth) < 680.
nuvtxz_truth > 40.
nuvtxz_truth < 850.

Muon track length V.S. Muon momentum



Reco. Had. Energy V.S. True Had. Energy



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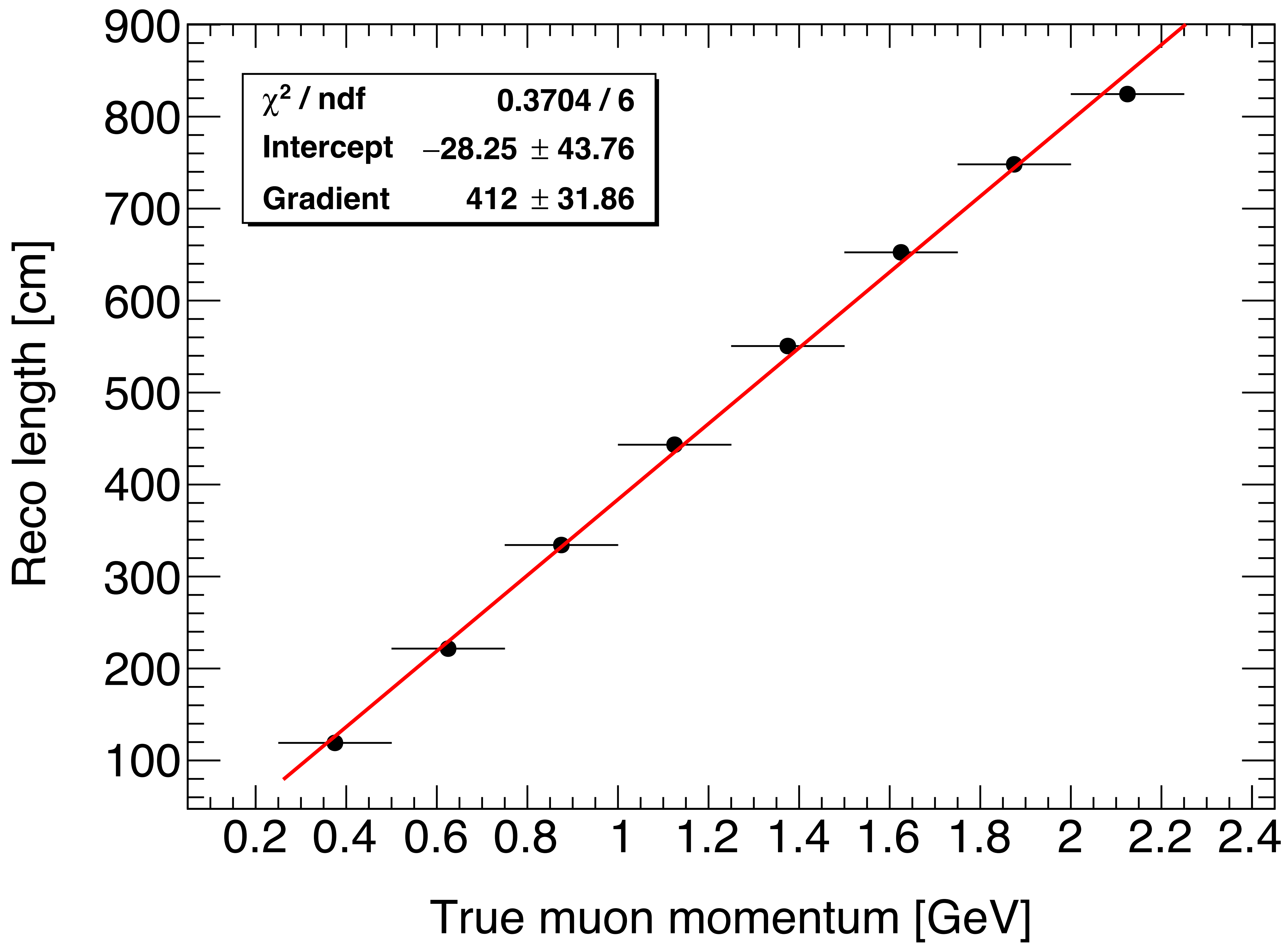

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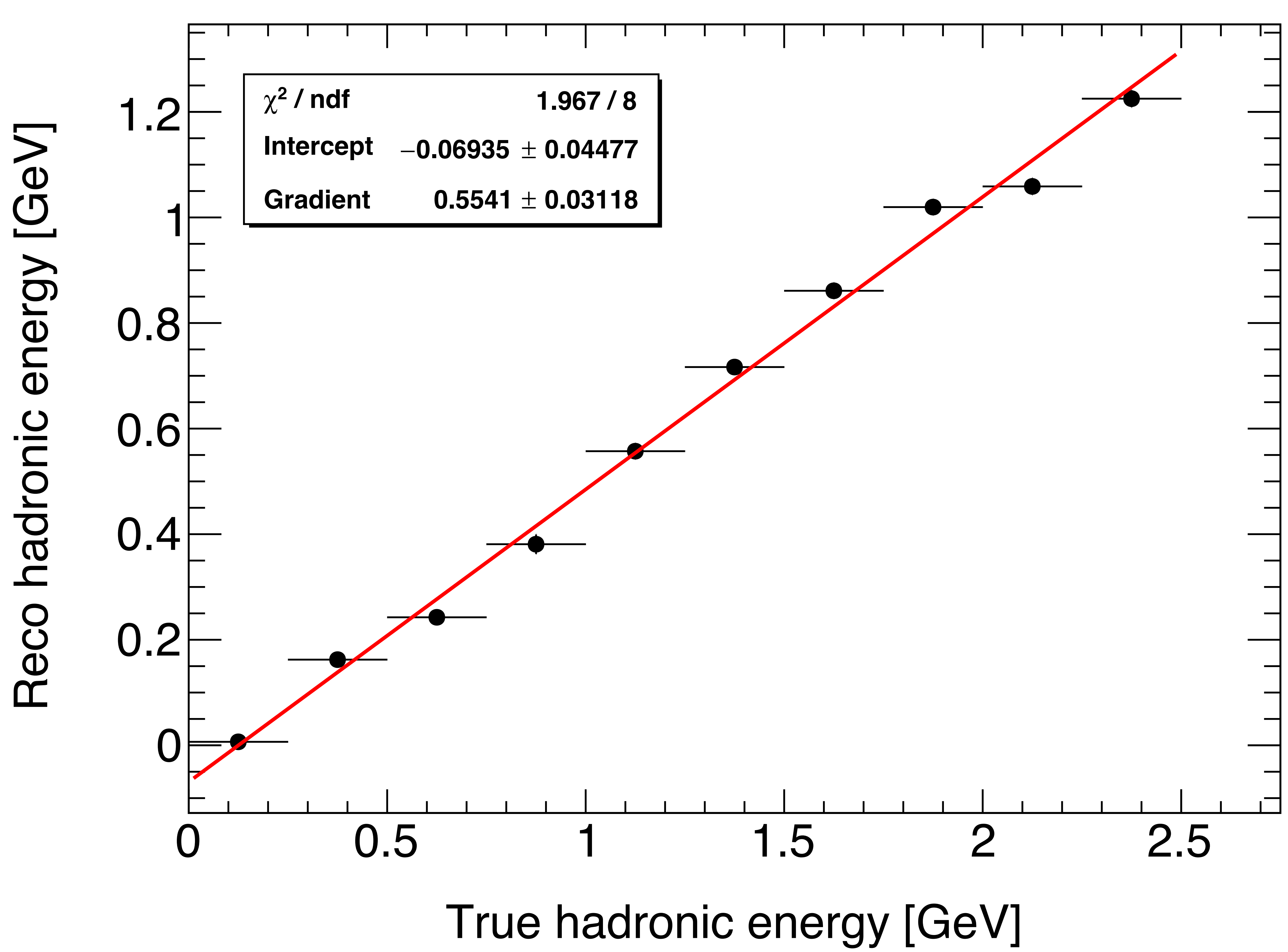

ν_μ CC events with exiting track

Fid_Cut
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nuvtxz_truth > 40.
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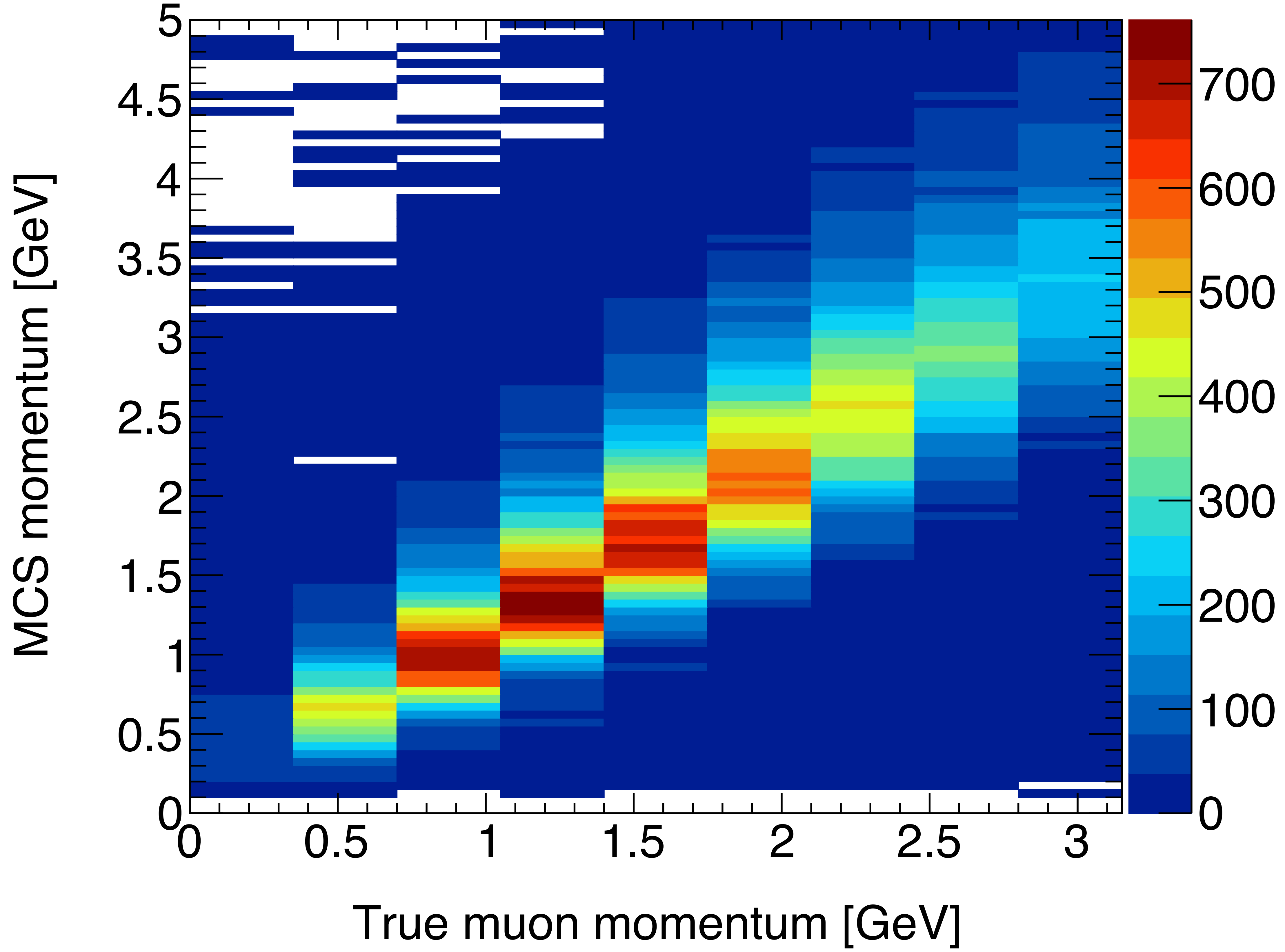
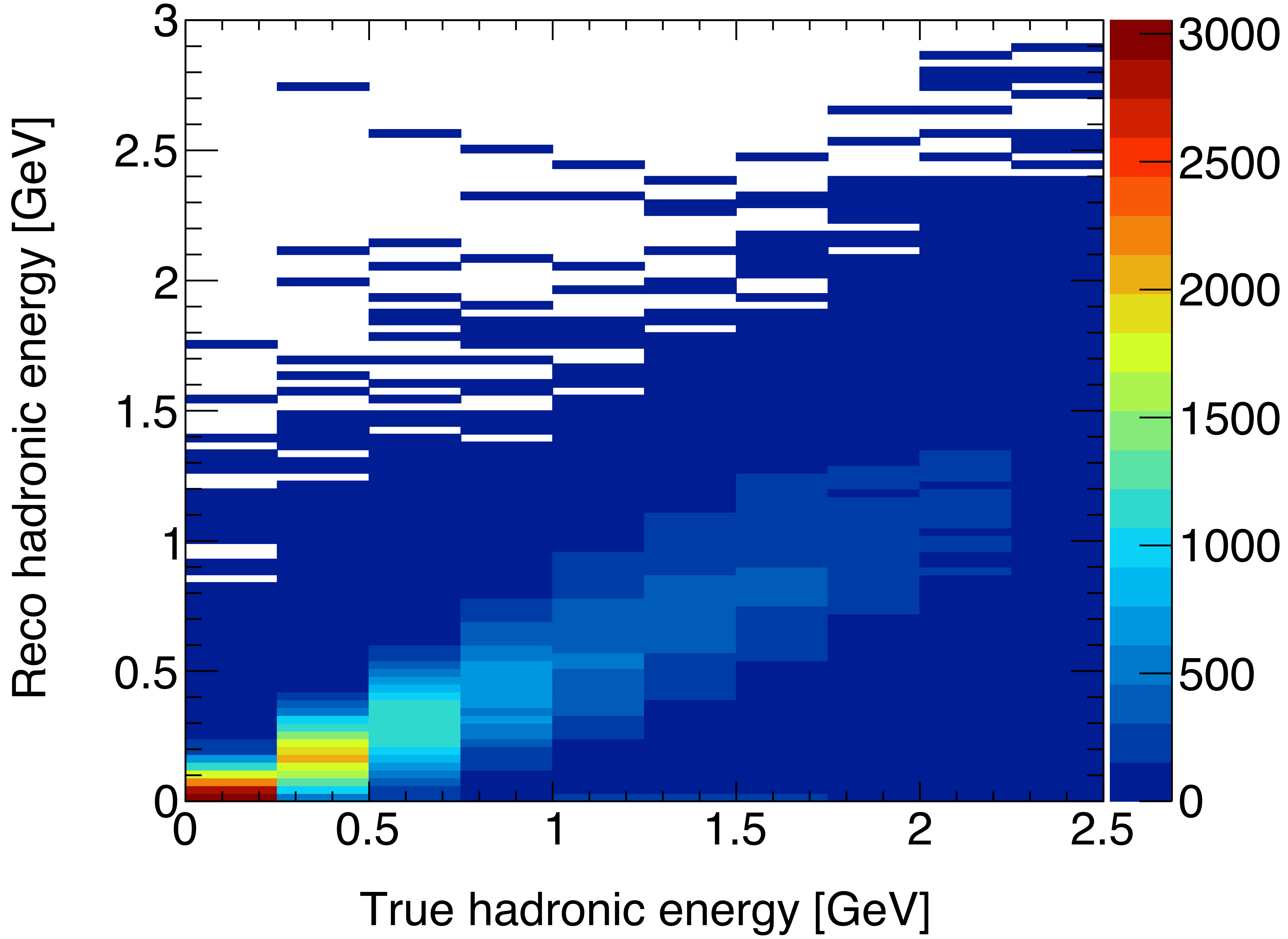
MCS momentum V.S. True momentum



Reco. Had. Energy V.S. True Had. Energy



ν_μ CC events with exiting track

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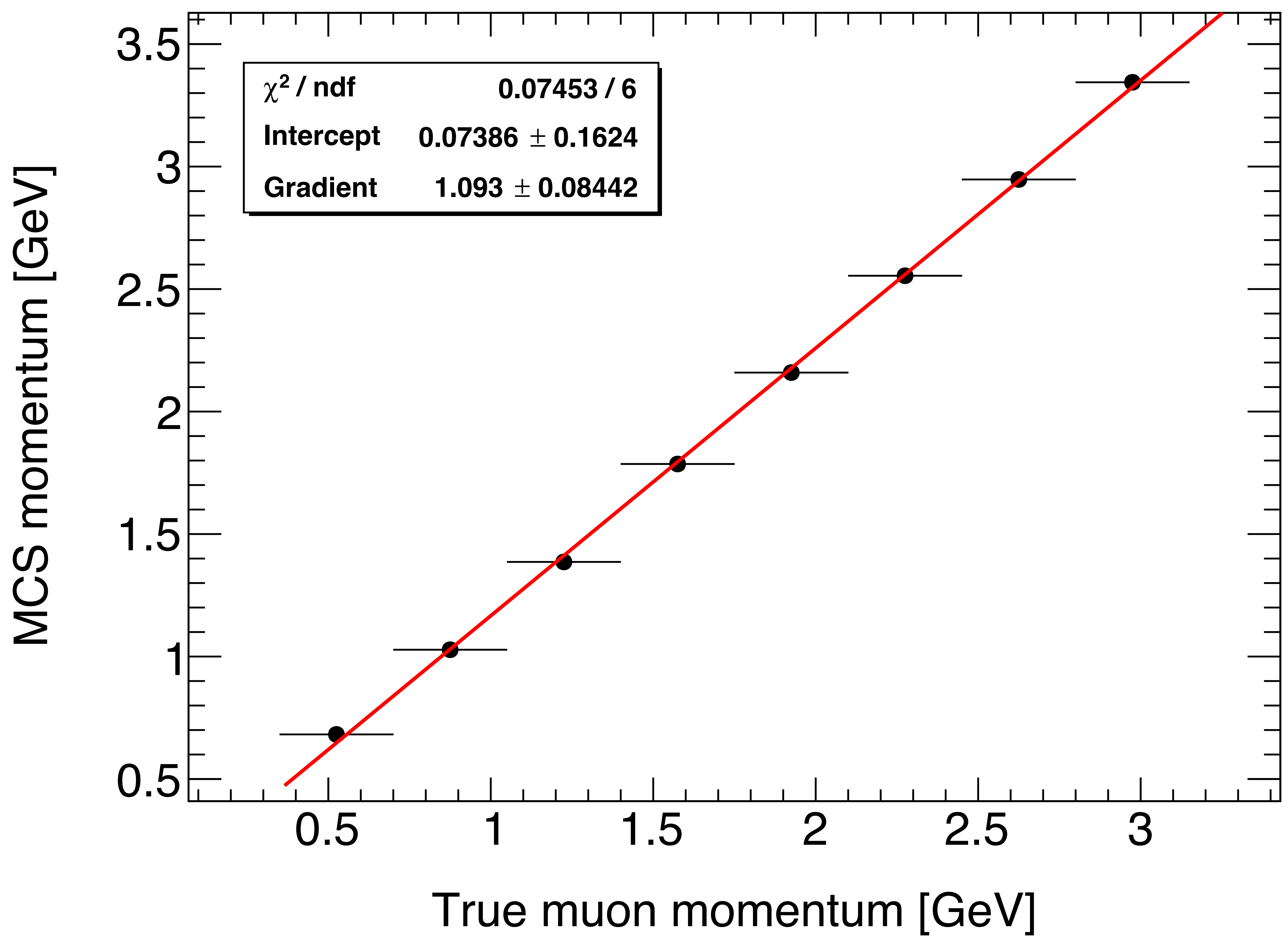
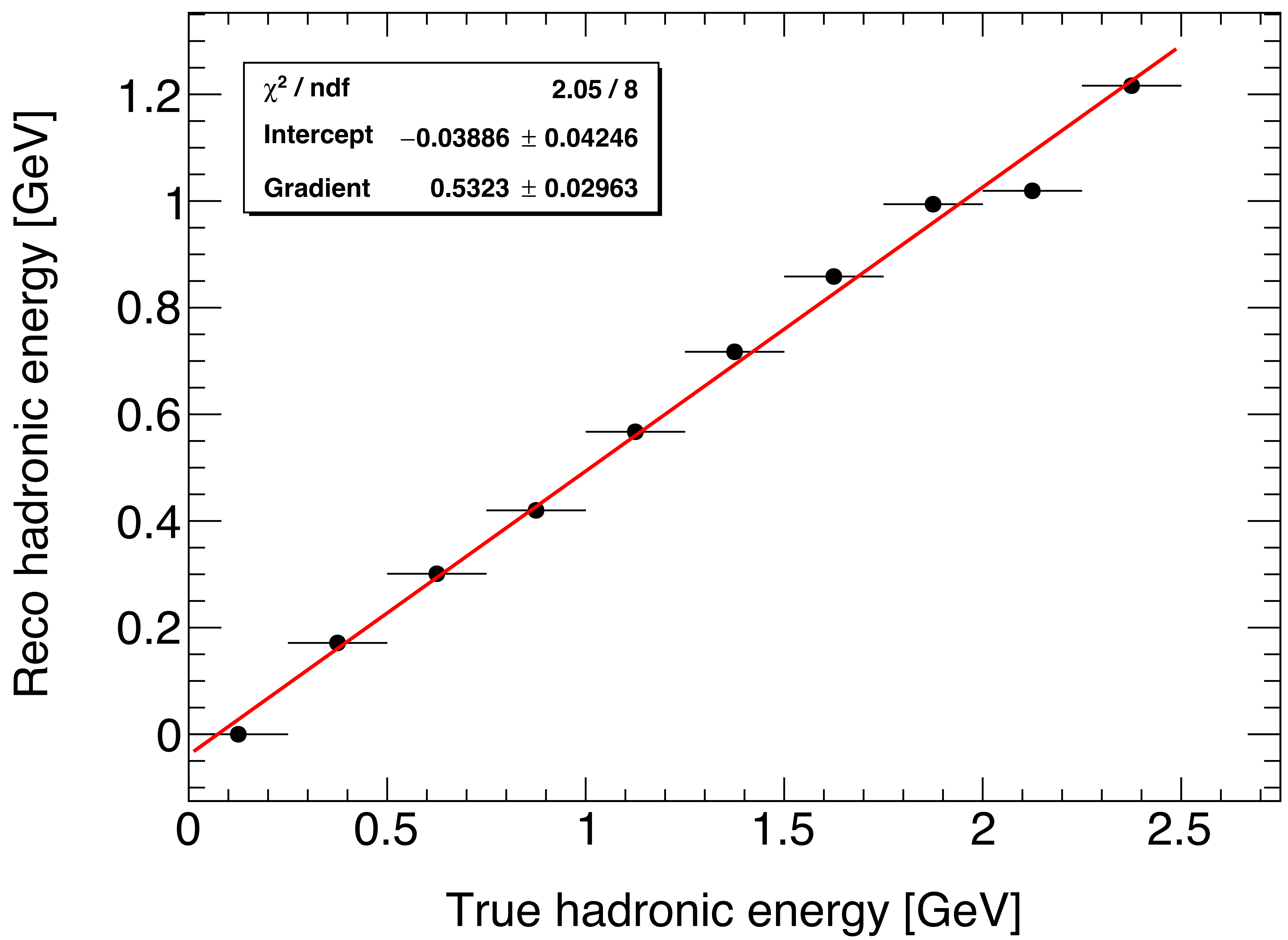
Muon MCS momentum V.S. Muon momentum



Reco. Had. Energy V.S. True Had. Energy



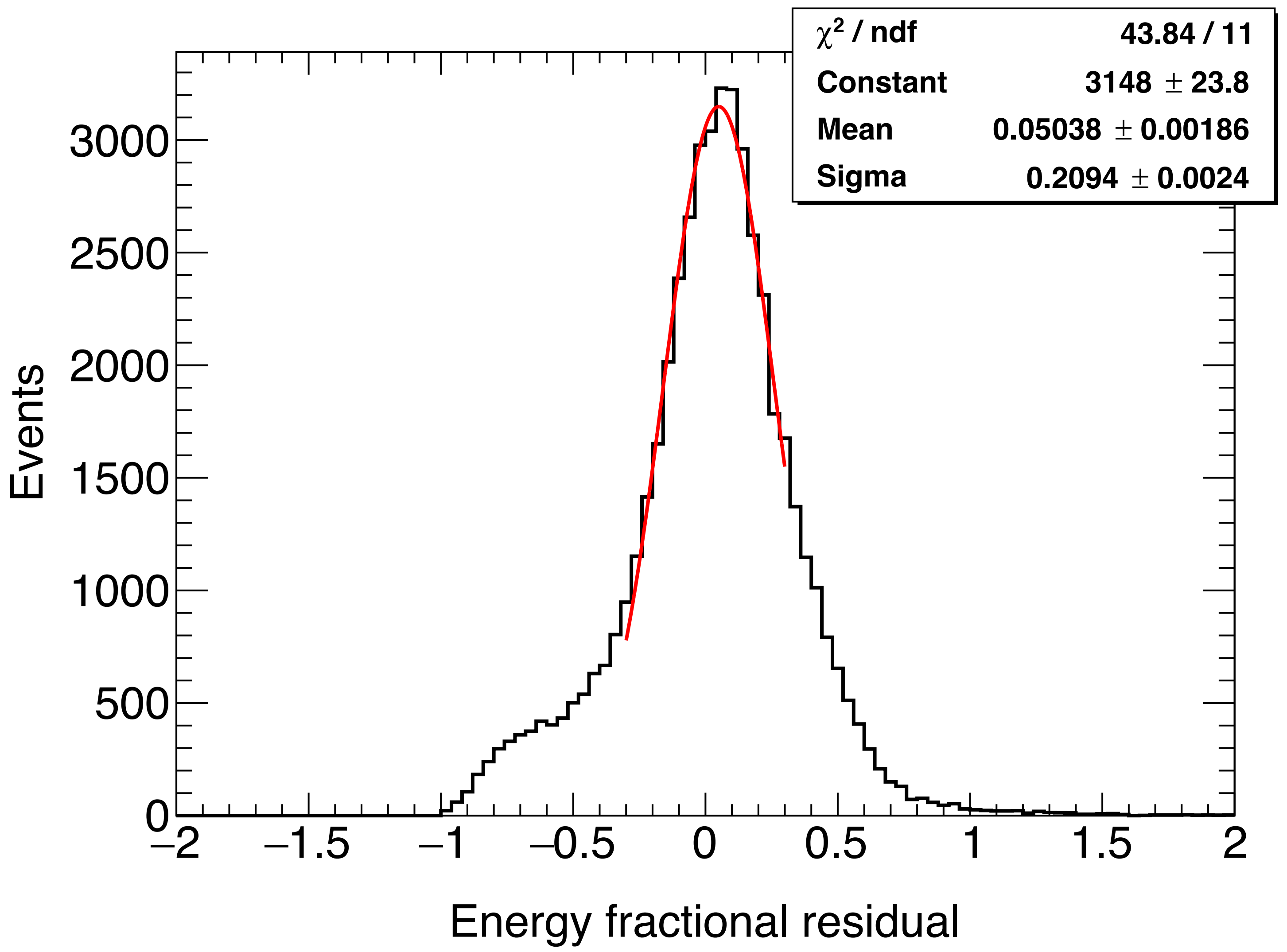
ν_μ CC events

Parameters	Current Value (for HD)	Tuned value
GradTrkMomRange	431.0	412.0
IntTrkMomRange	-40.7	-28.25
GradTrkMomMCS	0.89	1.093
IntTrkMomMCS	0.20	0.074
GradNuMuHadEnCont	0.76	0.554
IntNuMuHadEnCont	-0.07	-0.069
GradNuMuHadEnExit	0.86	0.532
IntNuMuHadEnExit	-0.08	-0.039

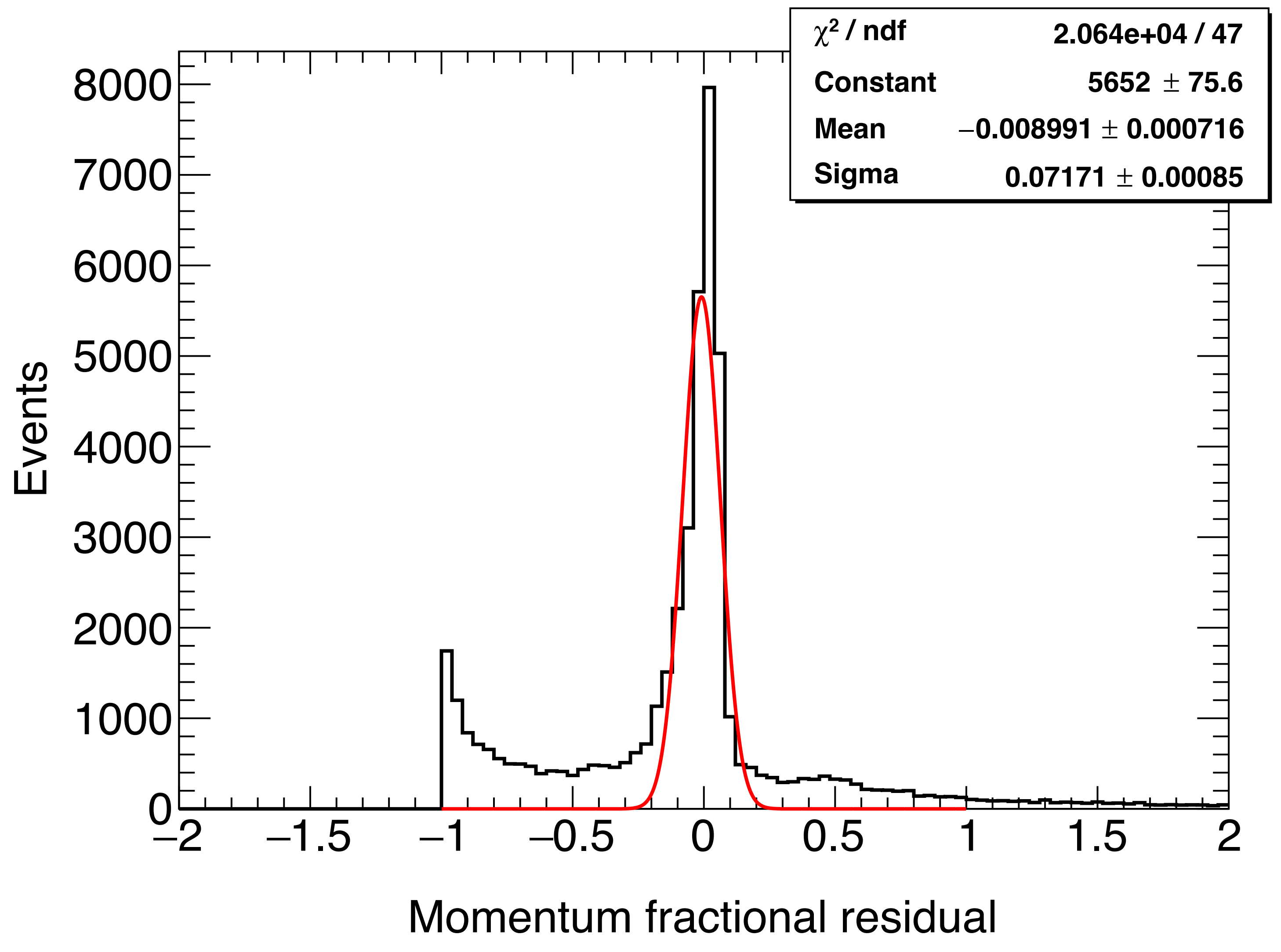
Energy resolution

ν_μ CC events with contained track

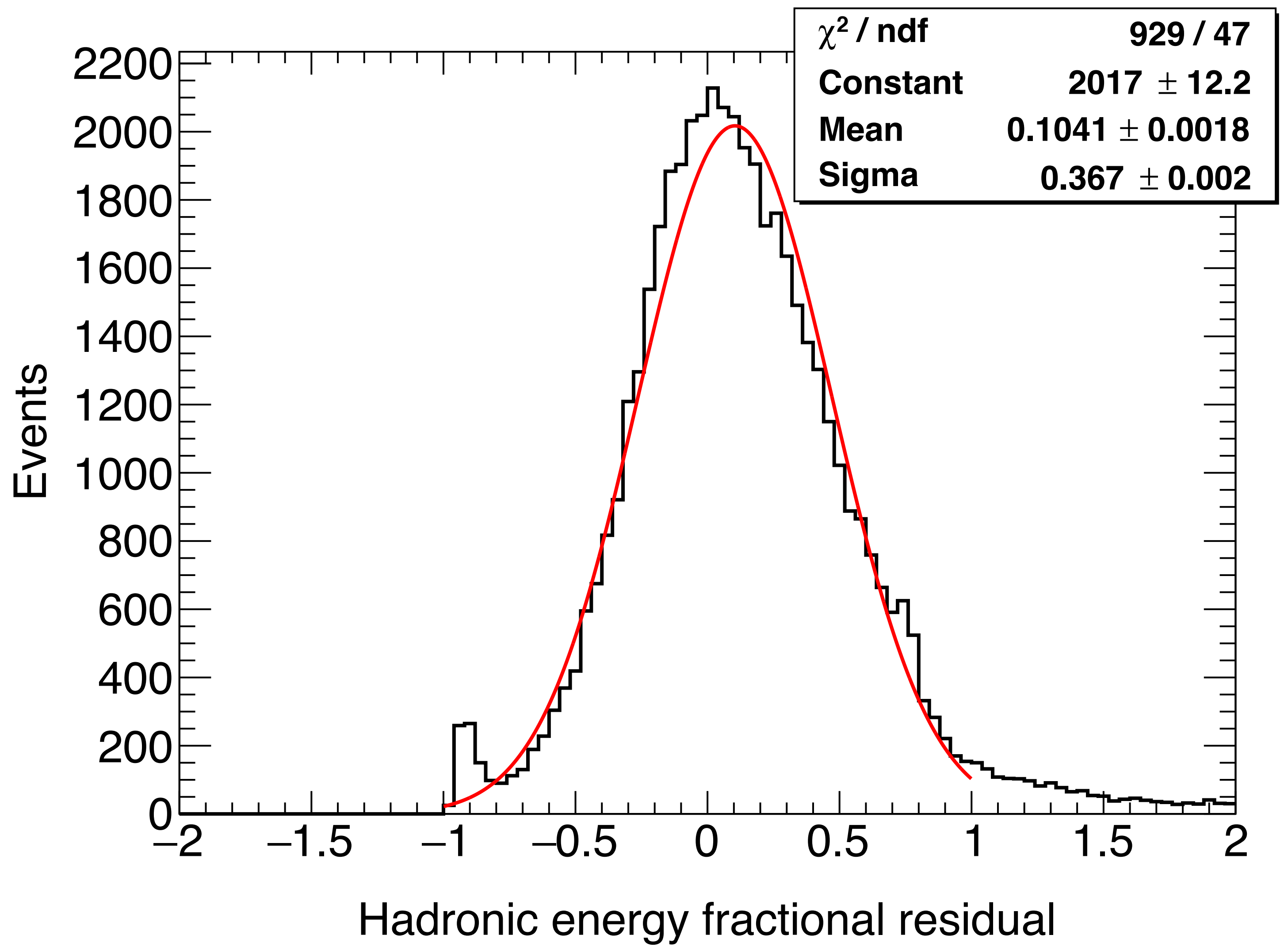
Neutrino energy



Lepton momentum

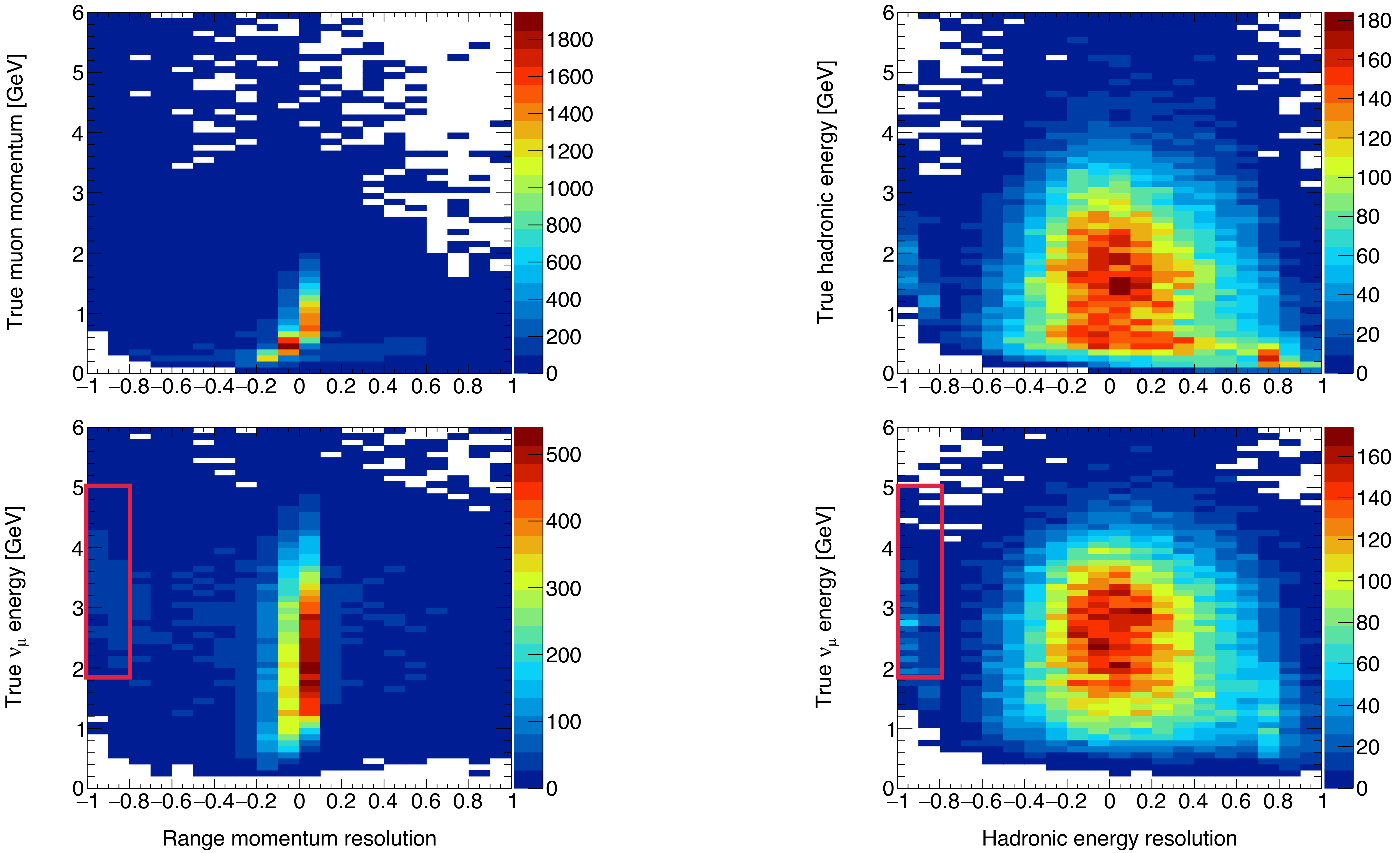


Hadronic energy



Energy resolution

ν_μ CC events with contained track



Energy resolution

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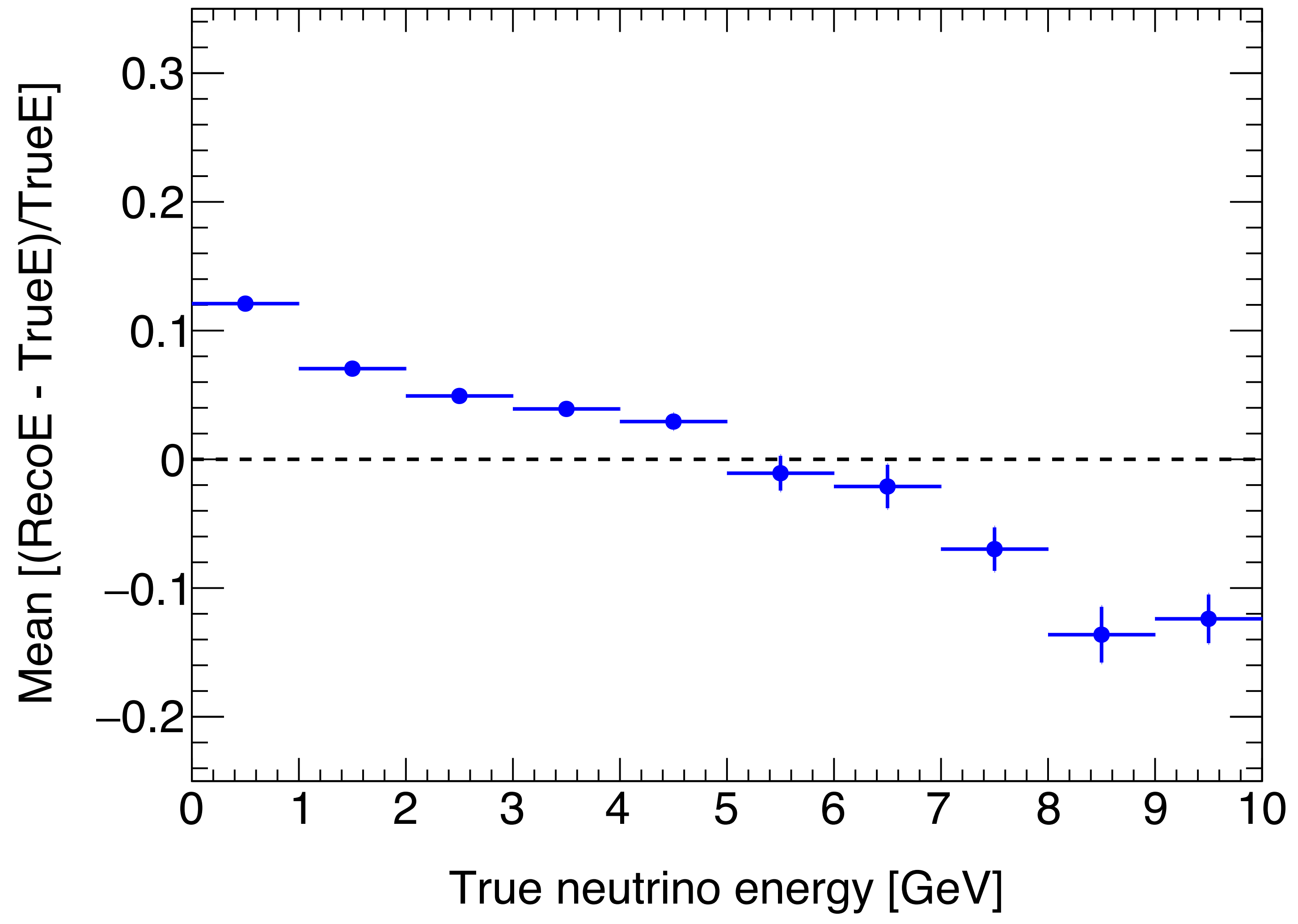
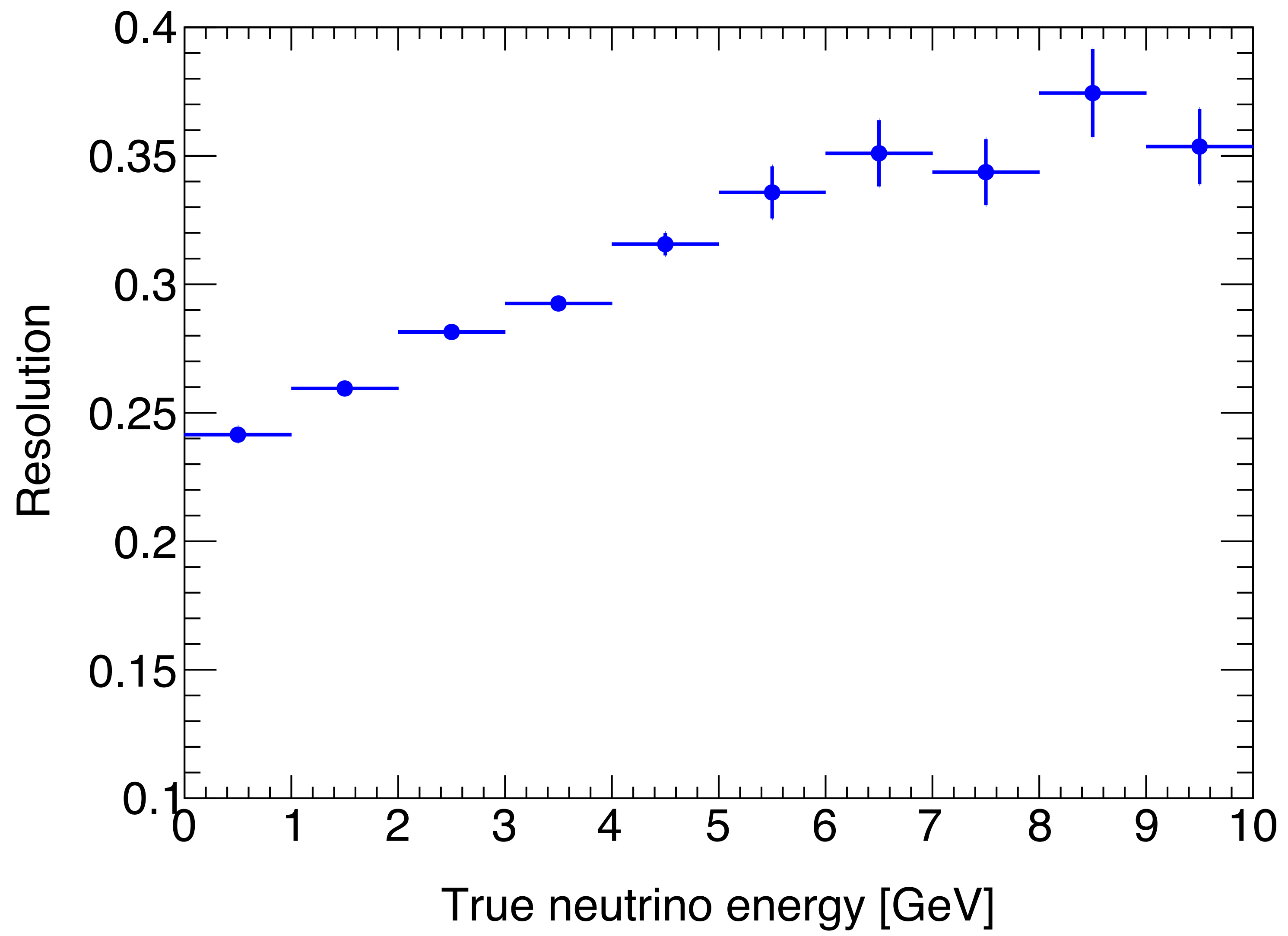
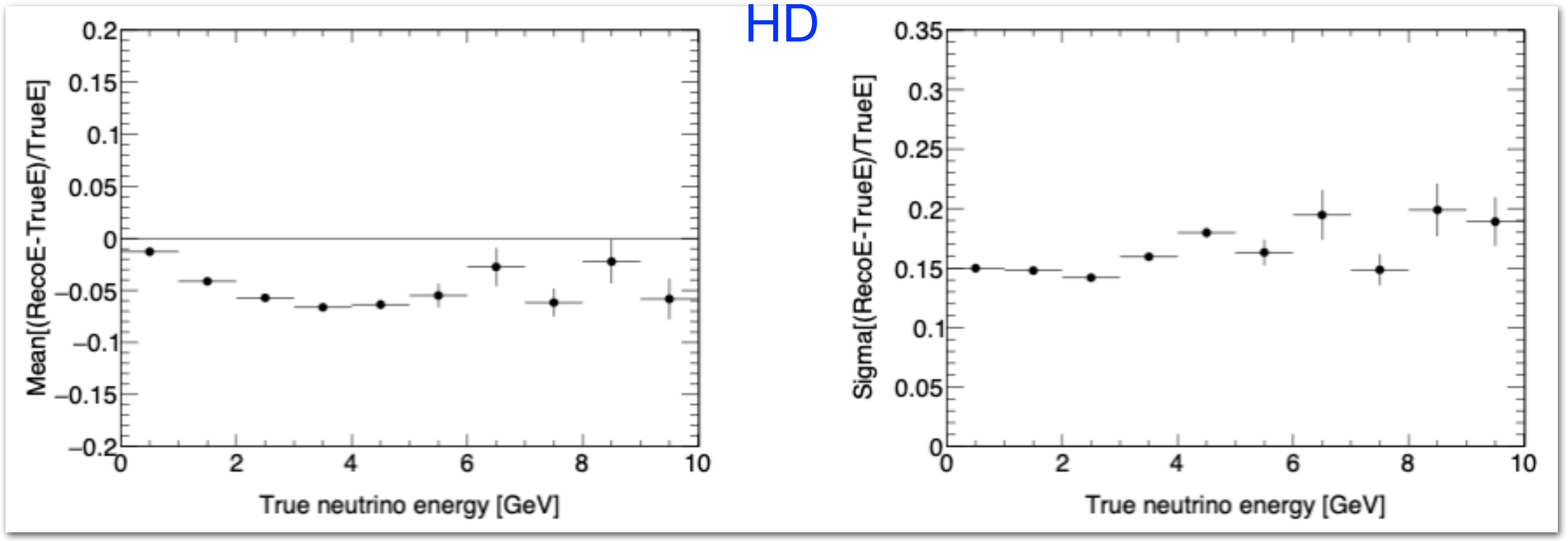


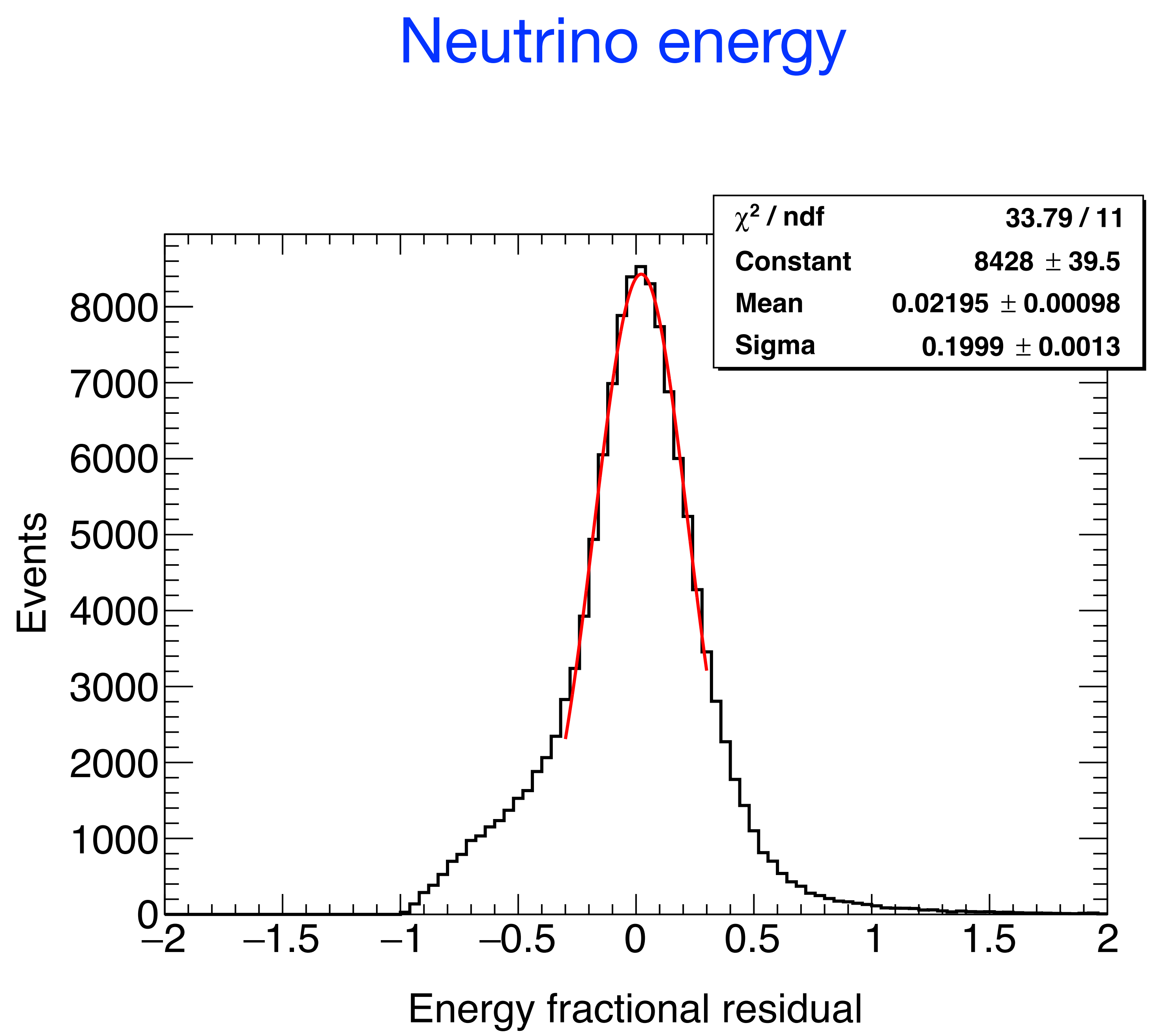


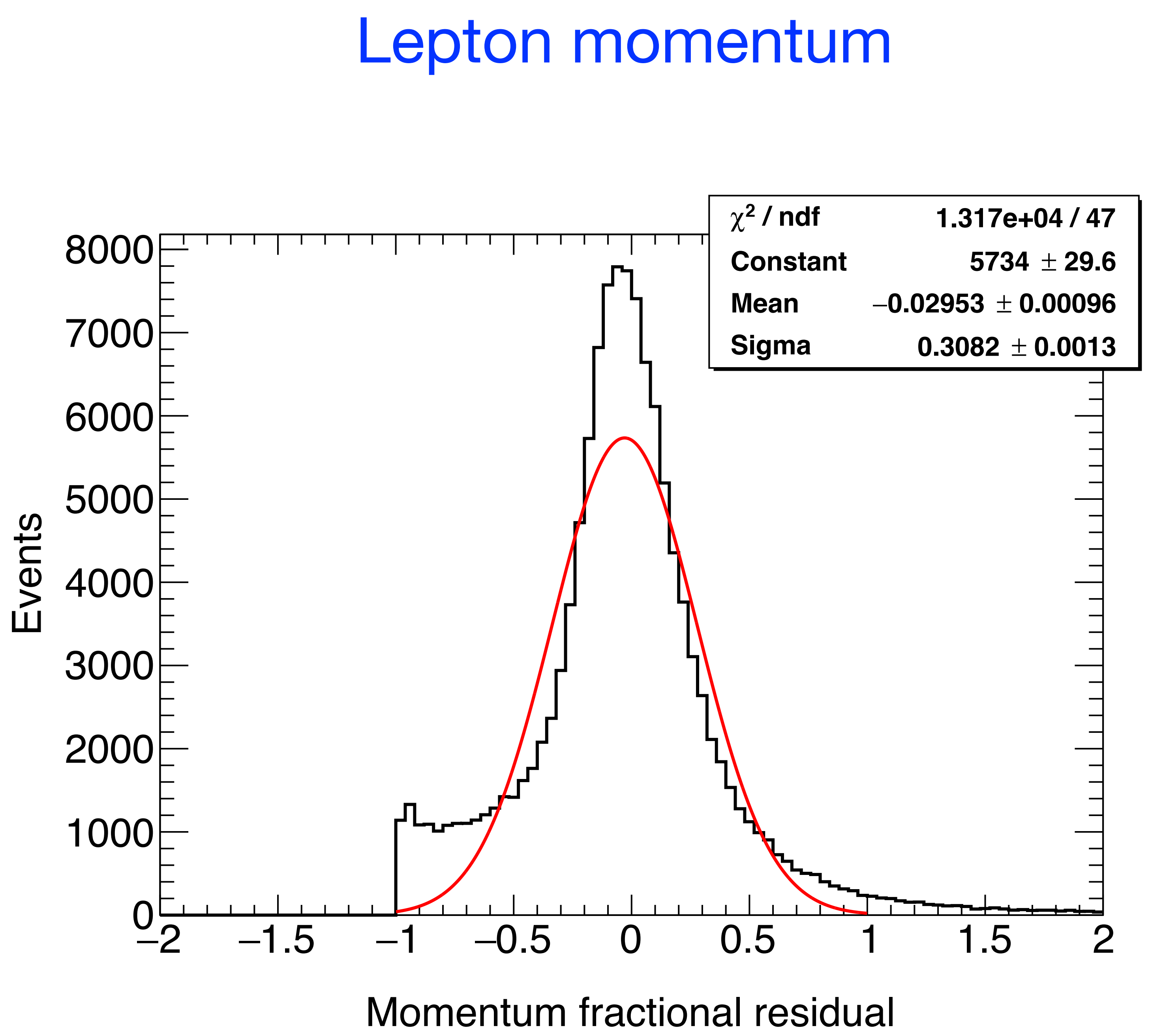
HD

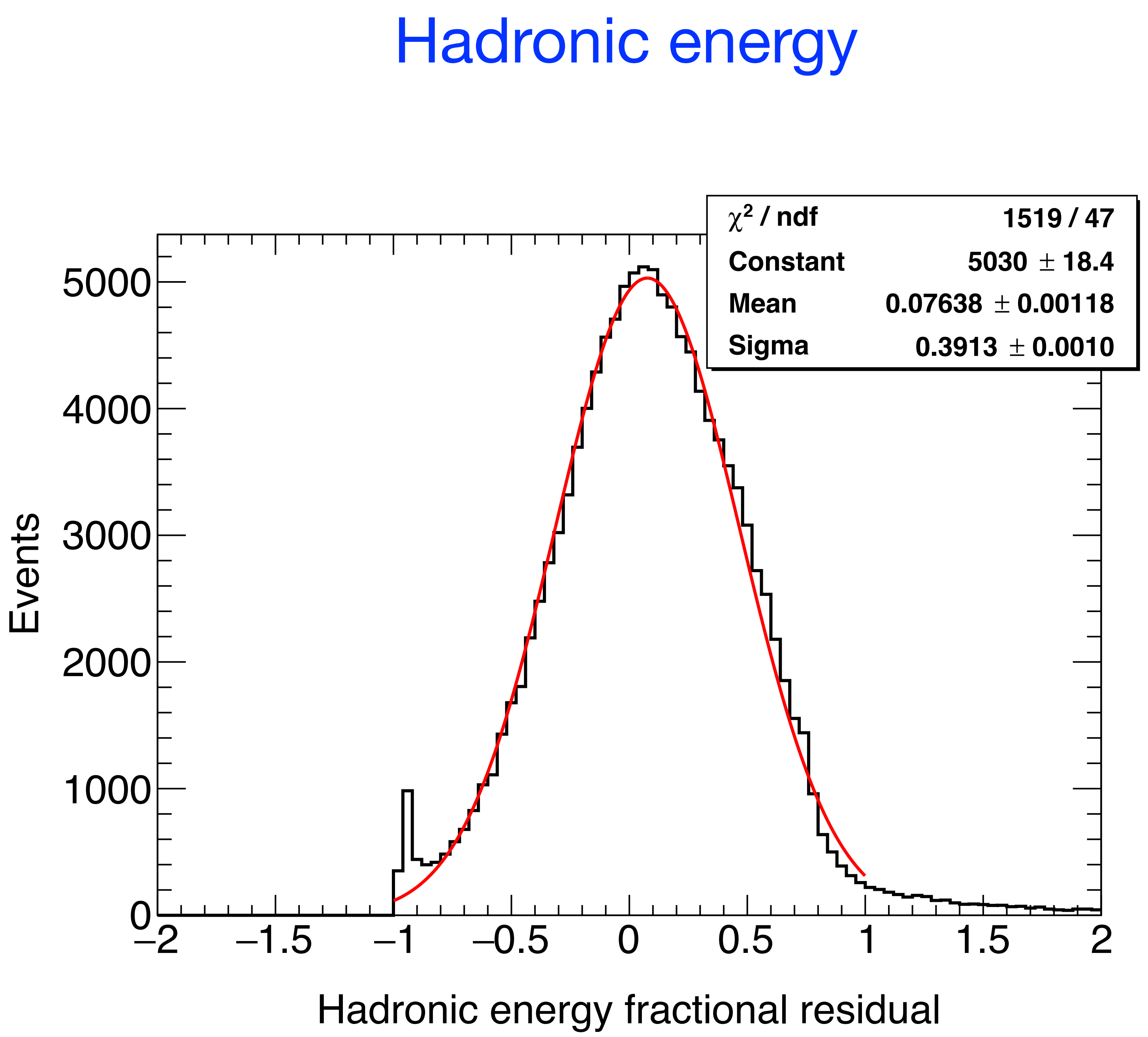


Energy resolution

ν_μ CC events with exiting track

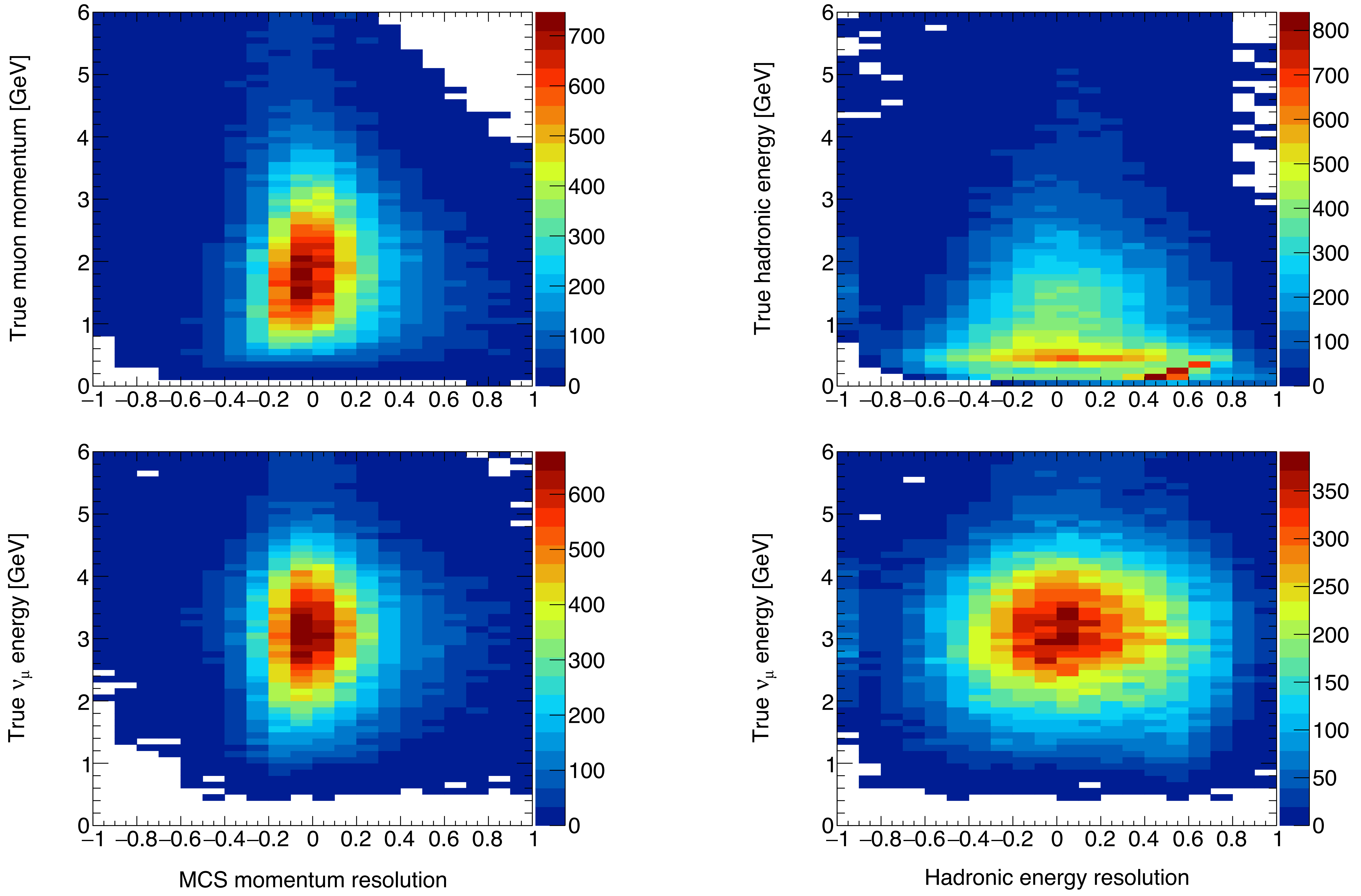






Energy resolution

ν_μ CC events with exiting track



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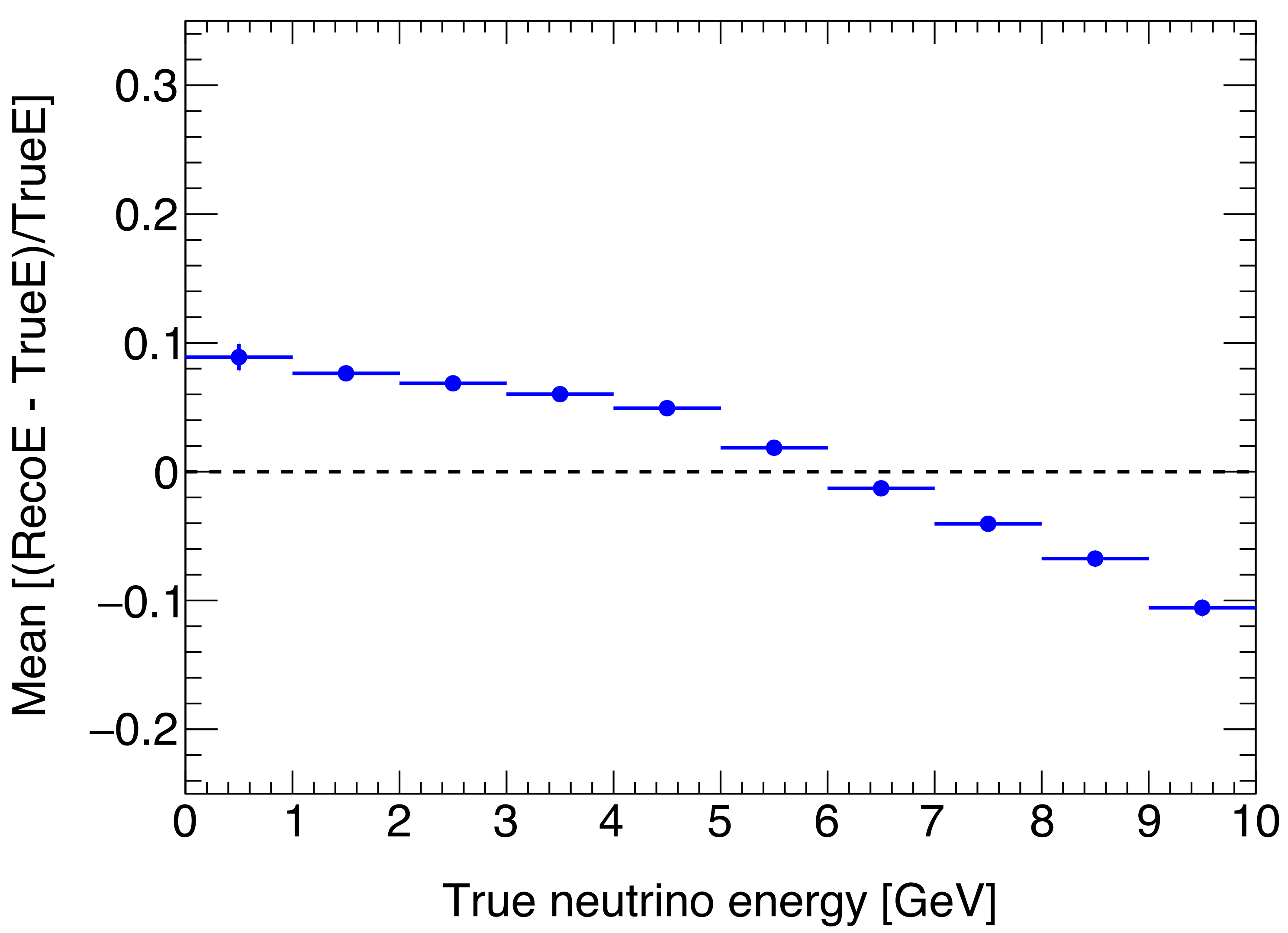
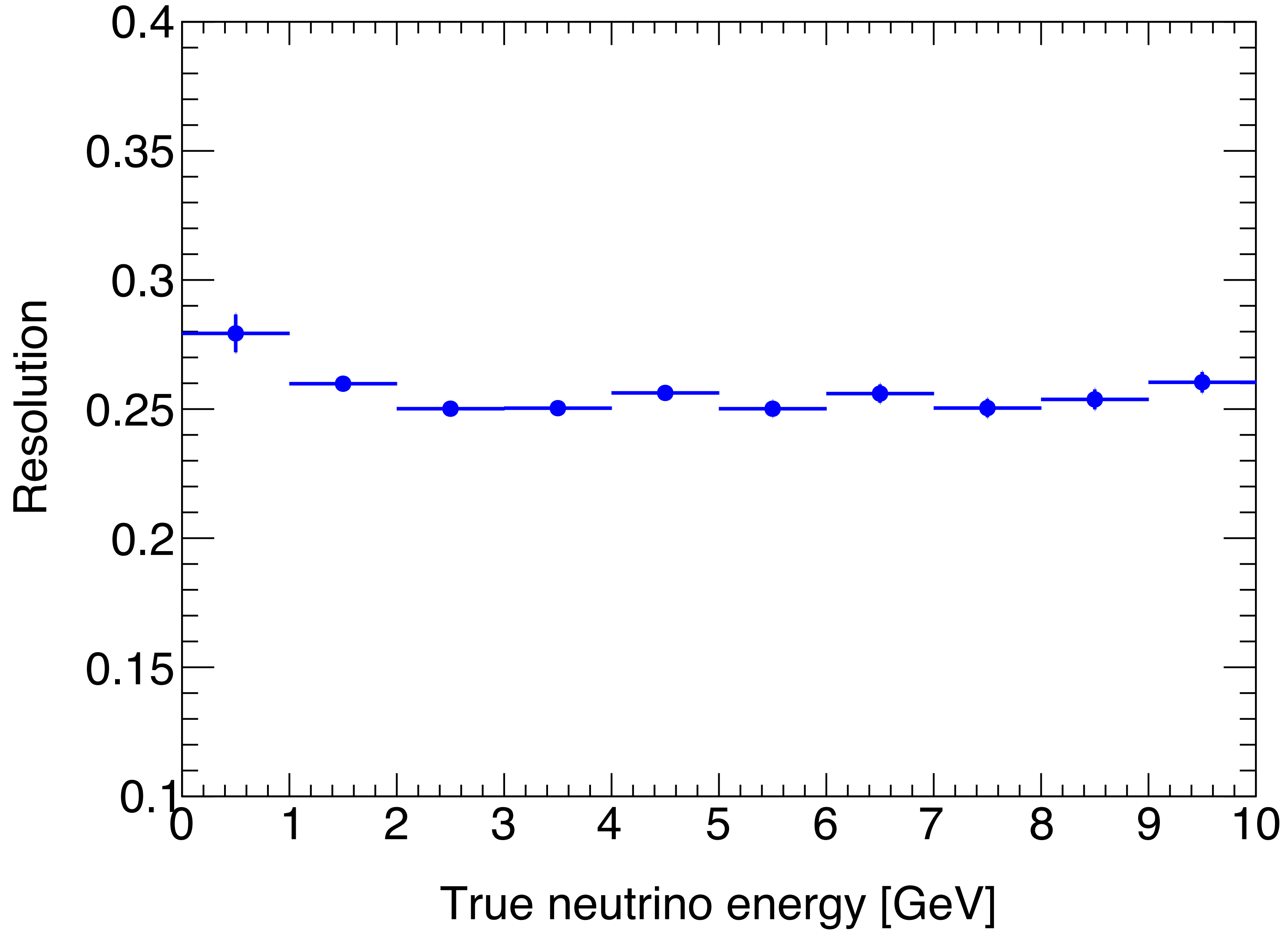
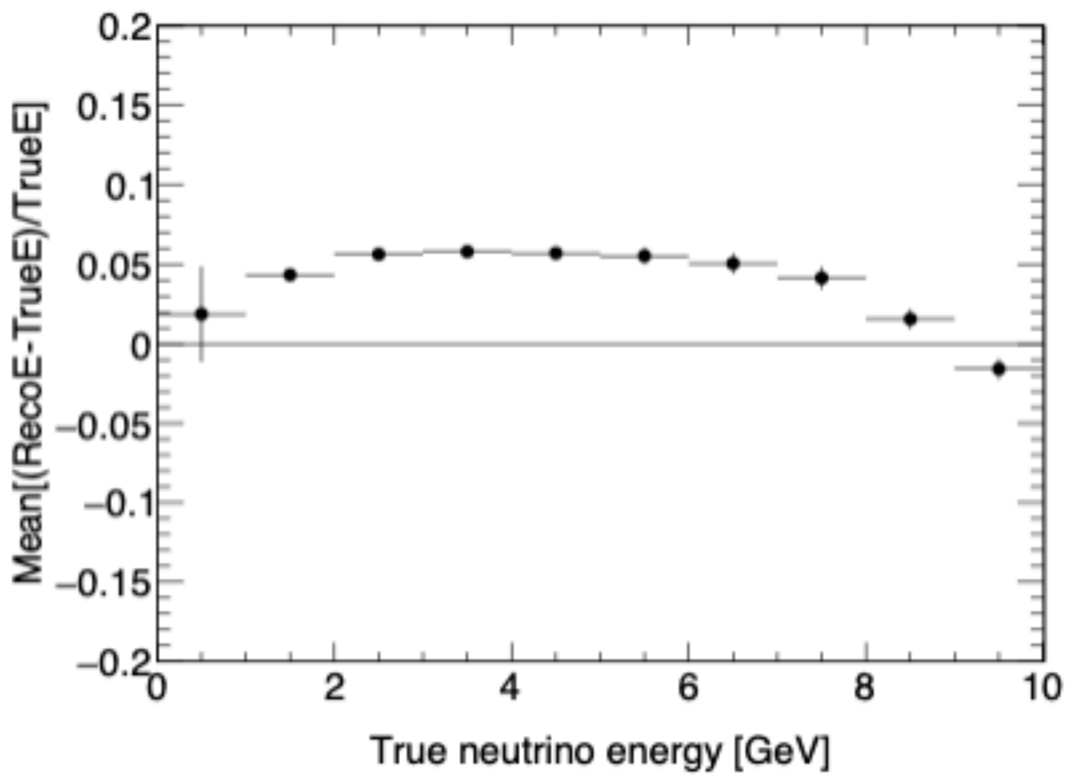
Energy resolution

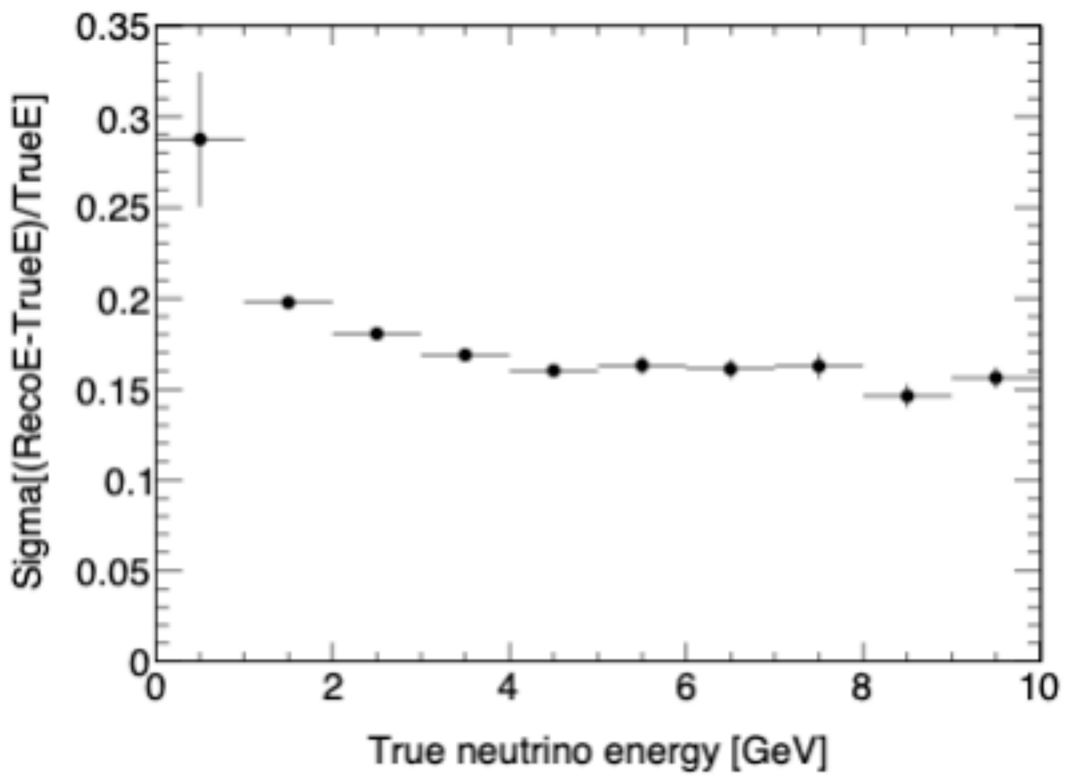
ν_μ CC events with exiting track





HD





ν_e CC events

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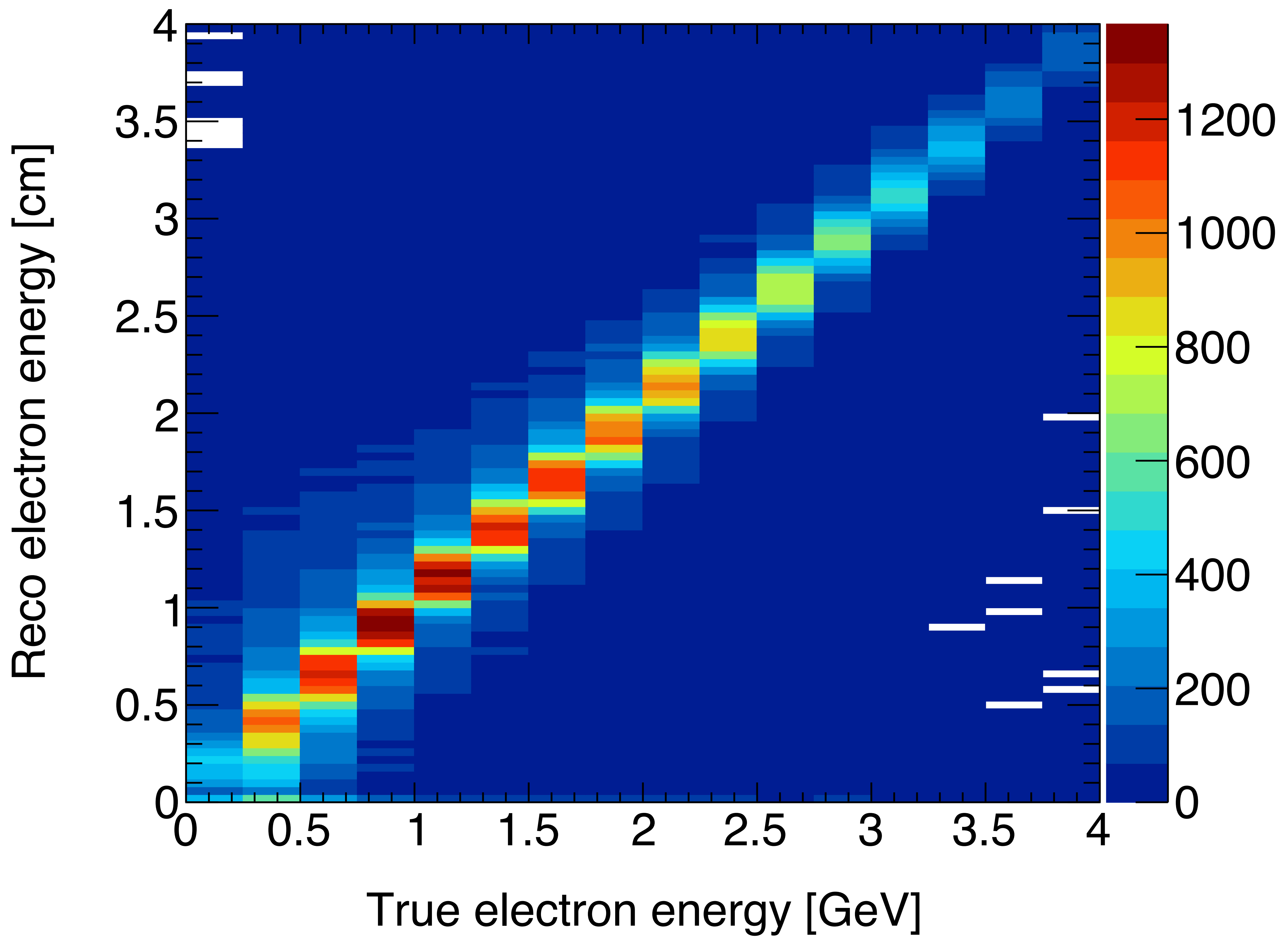
Reco shower energy V.S. True shower energy



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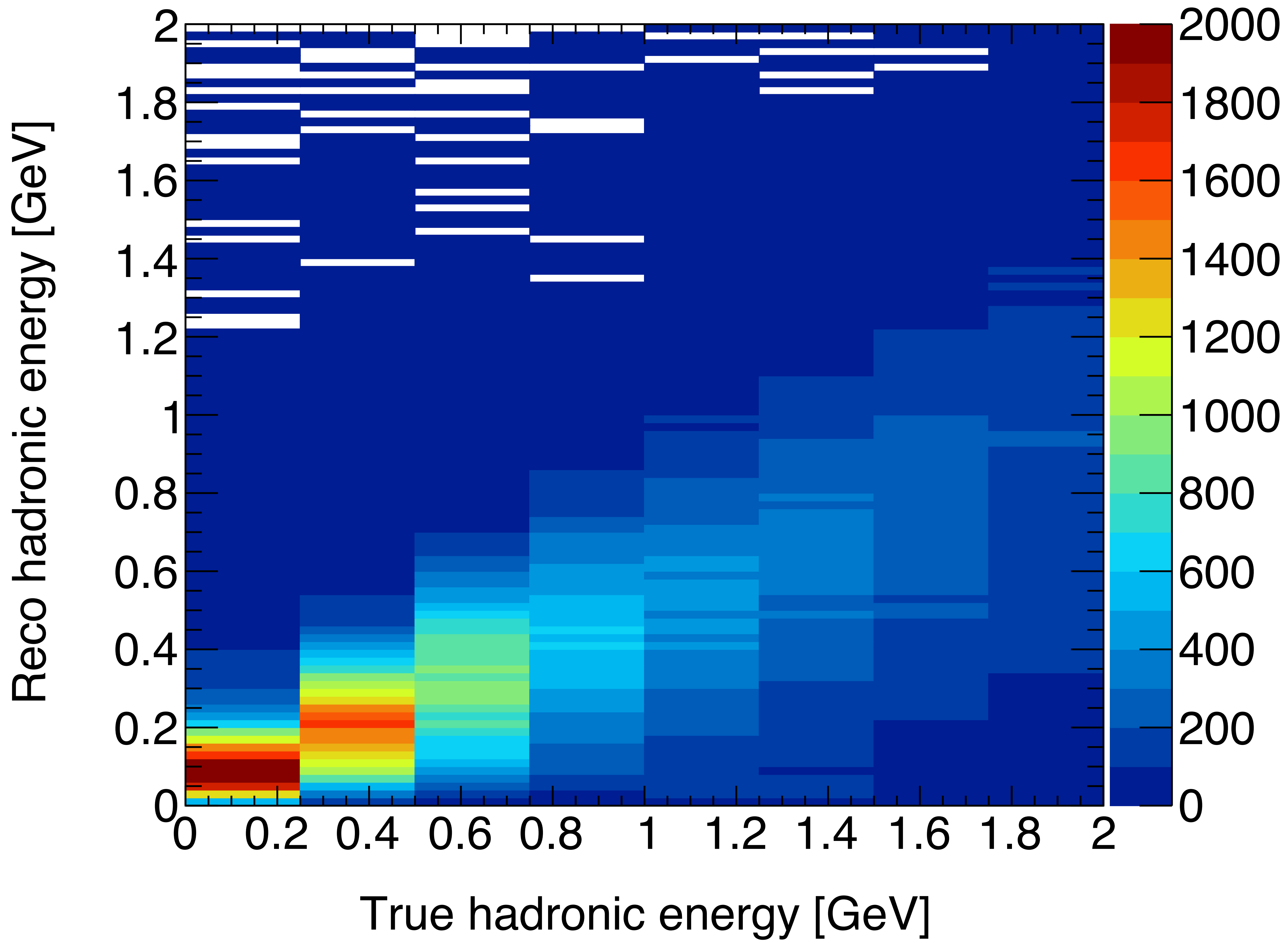

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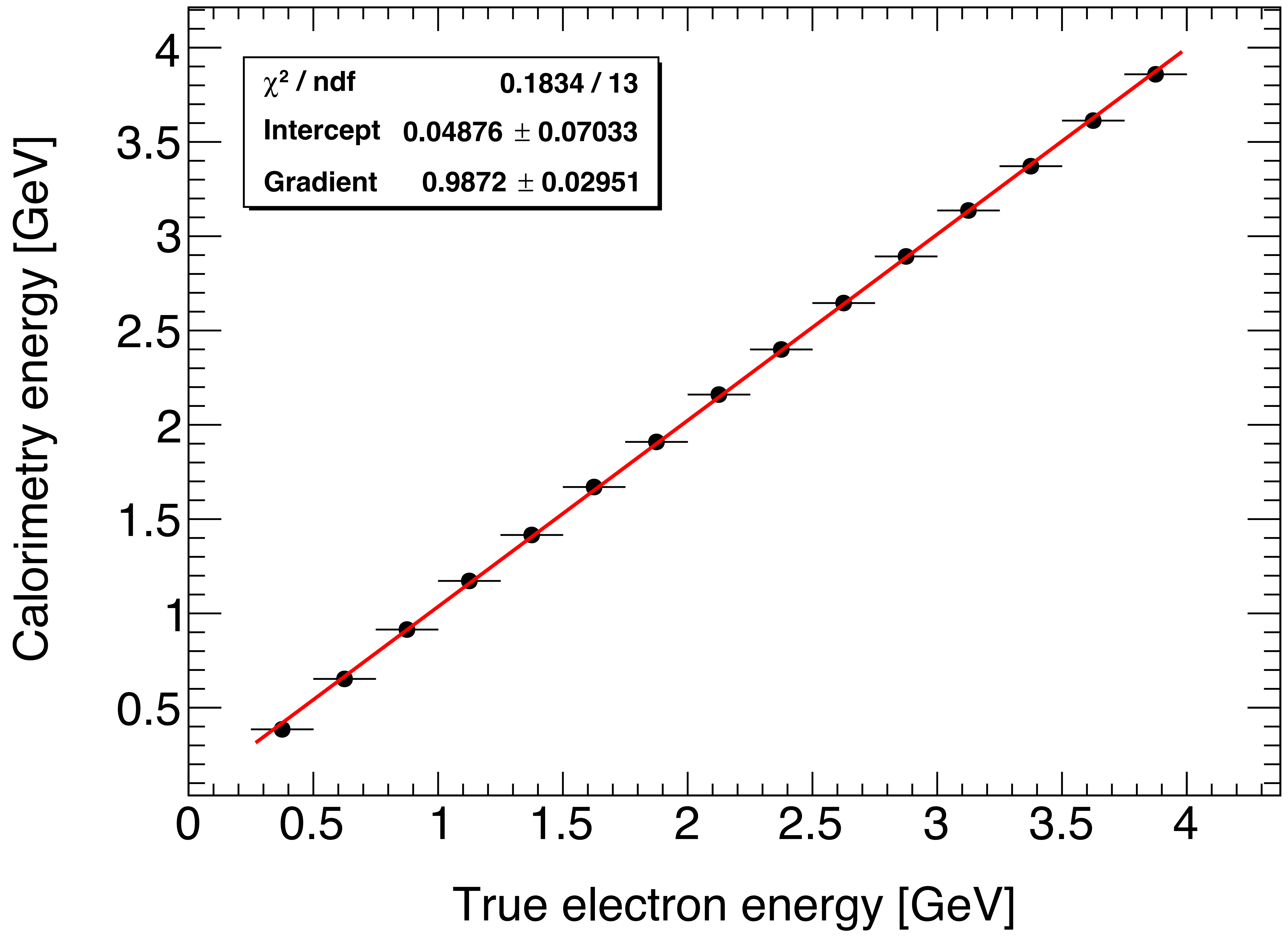

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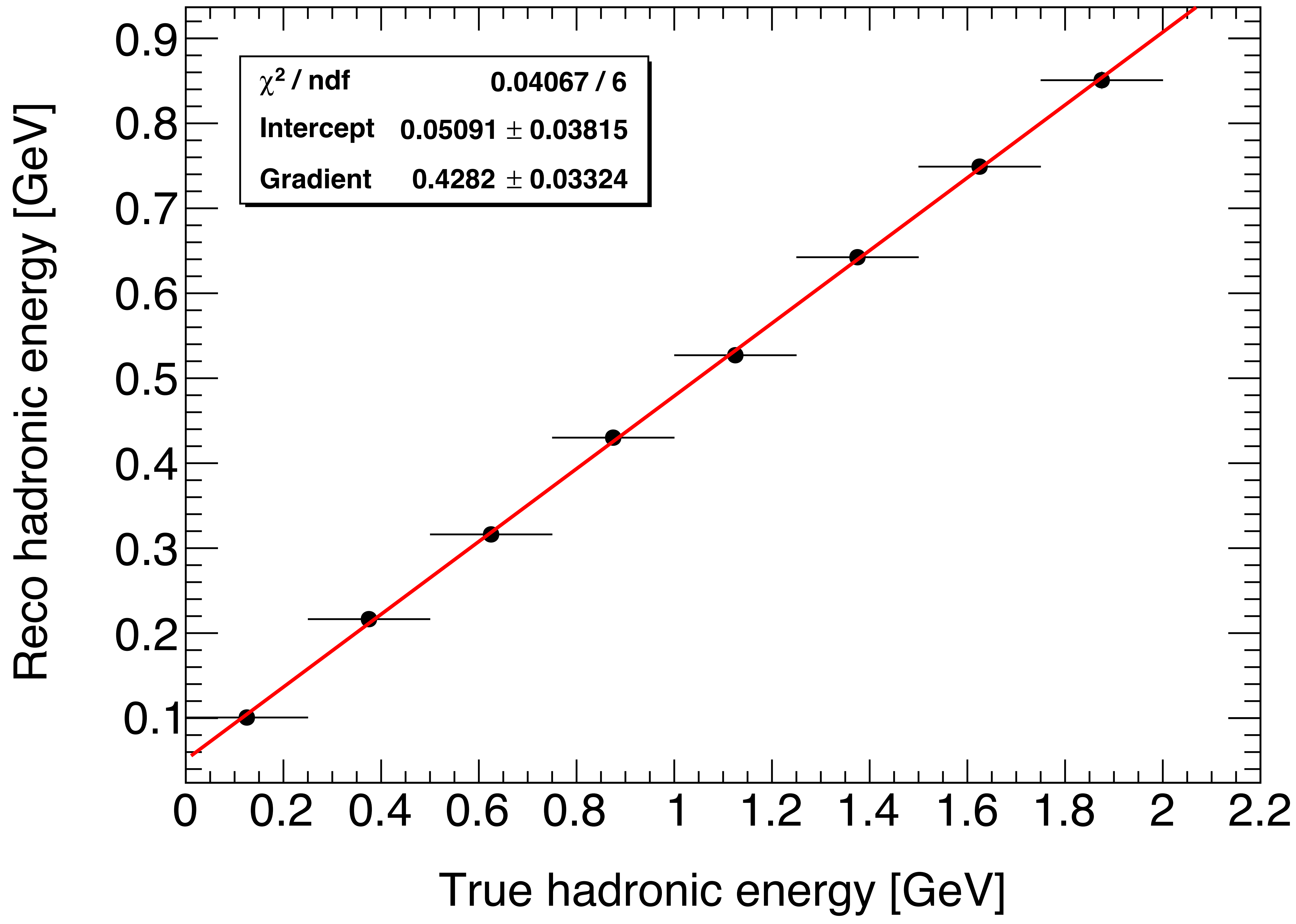
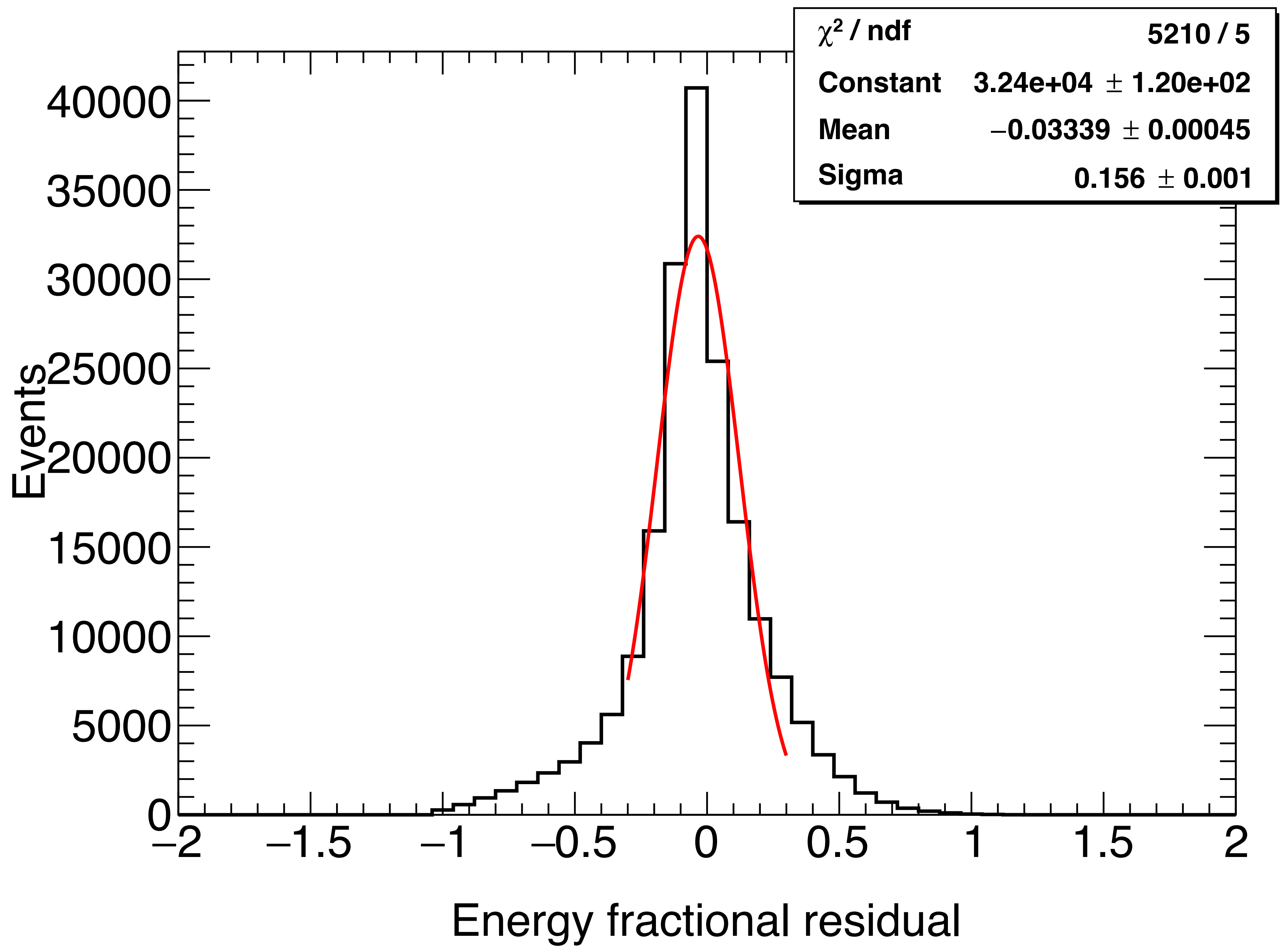
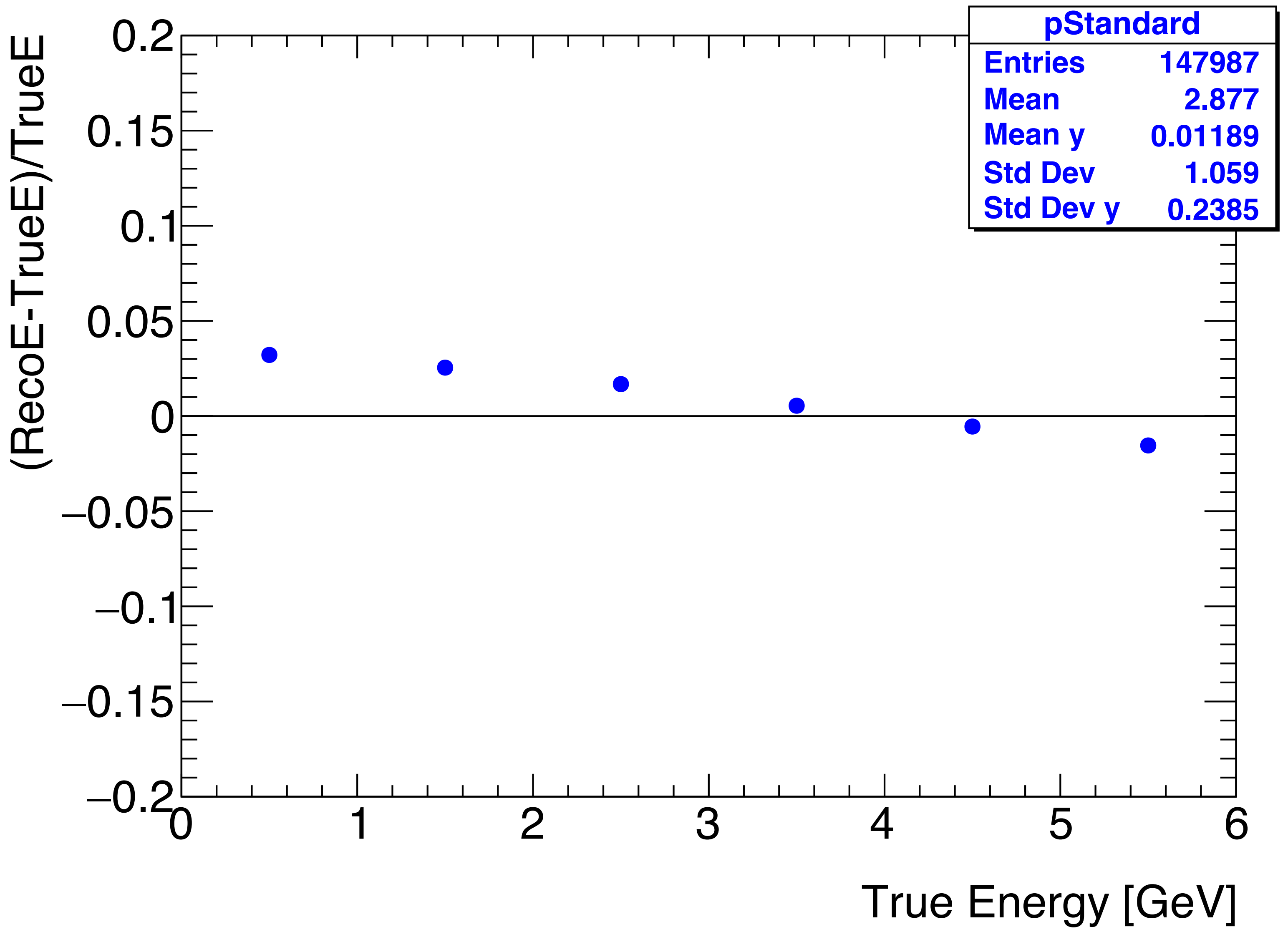


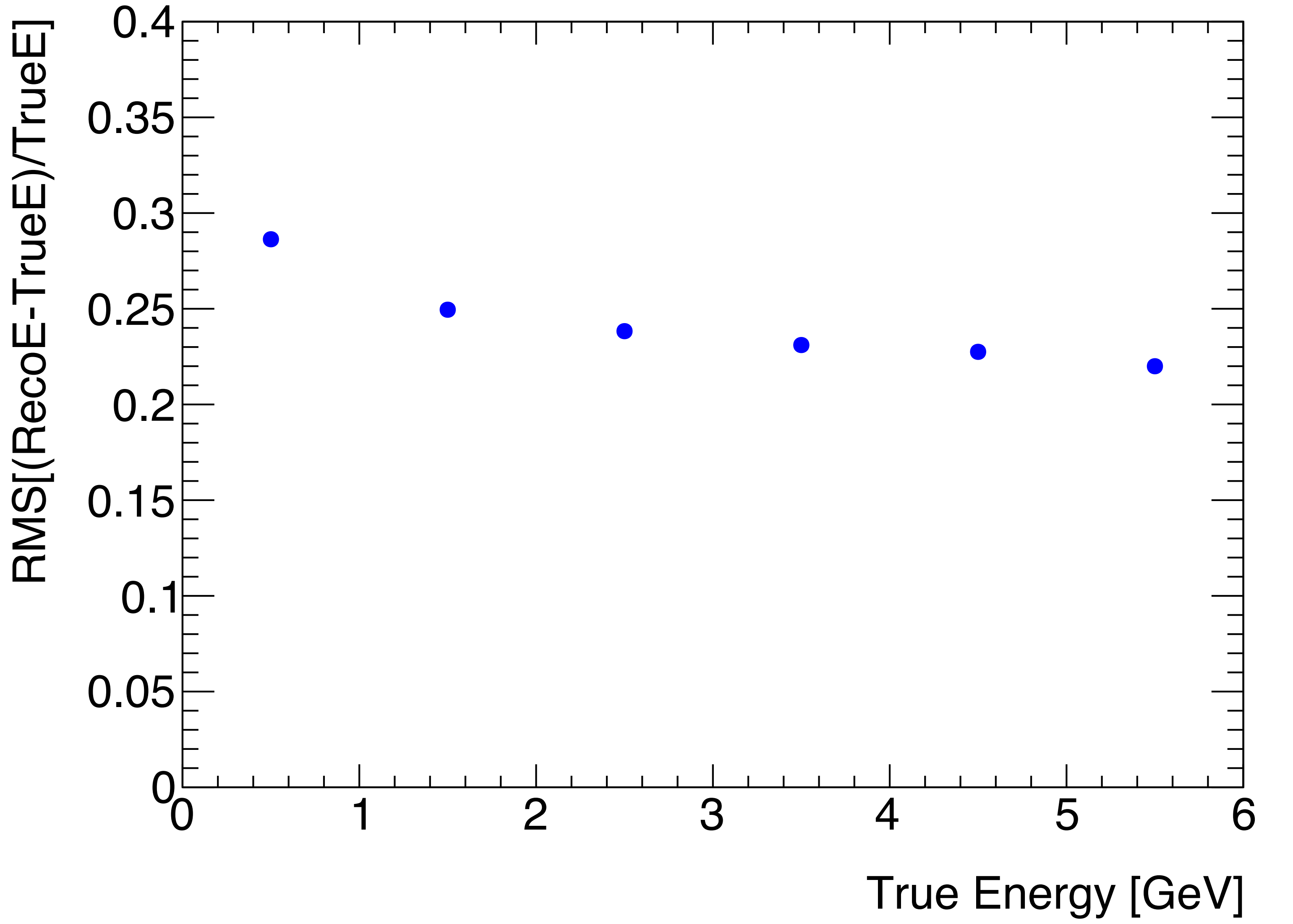
ν_e CC events

Parameters	Current Value (for HD)	Tuned value
GradShwEnergy	0.985	0.987
IntShwEnergy	-0.02	0.049
GradNuEHadEn	0.62	0.428
IntNuEHadEn	0.02	0.051

Energy resolution







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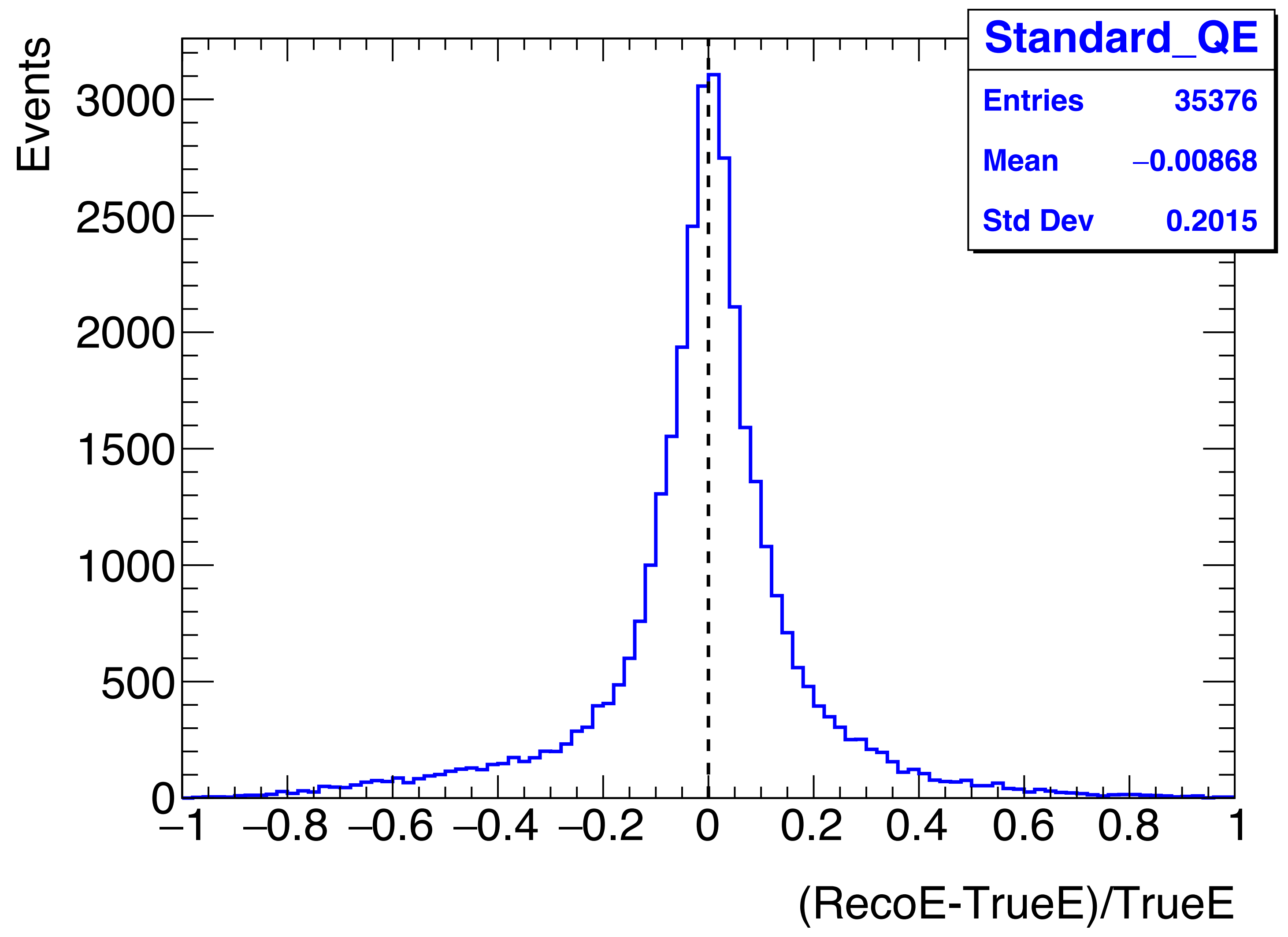
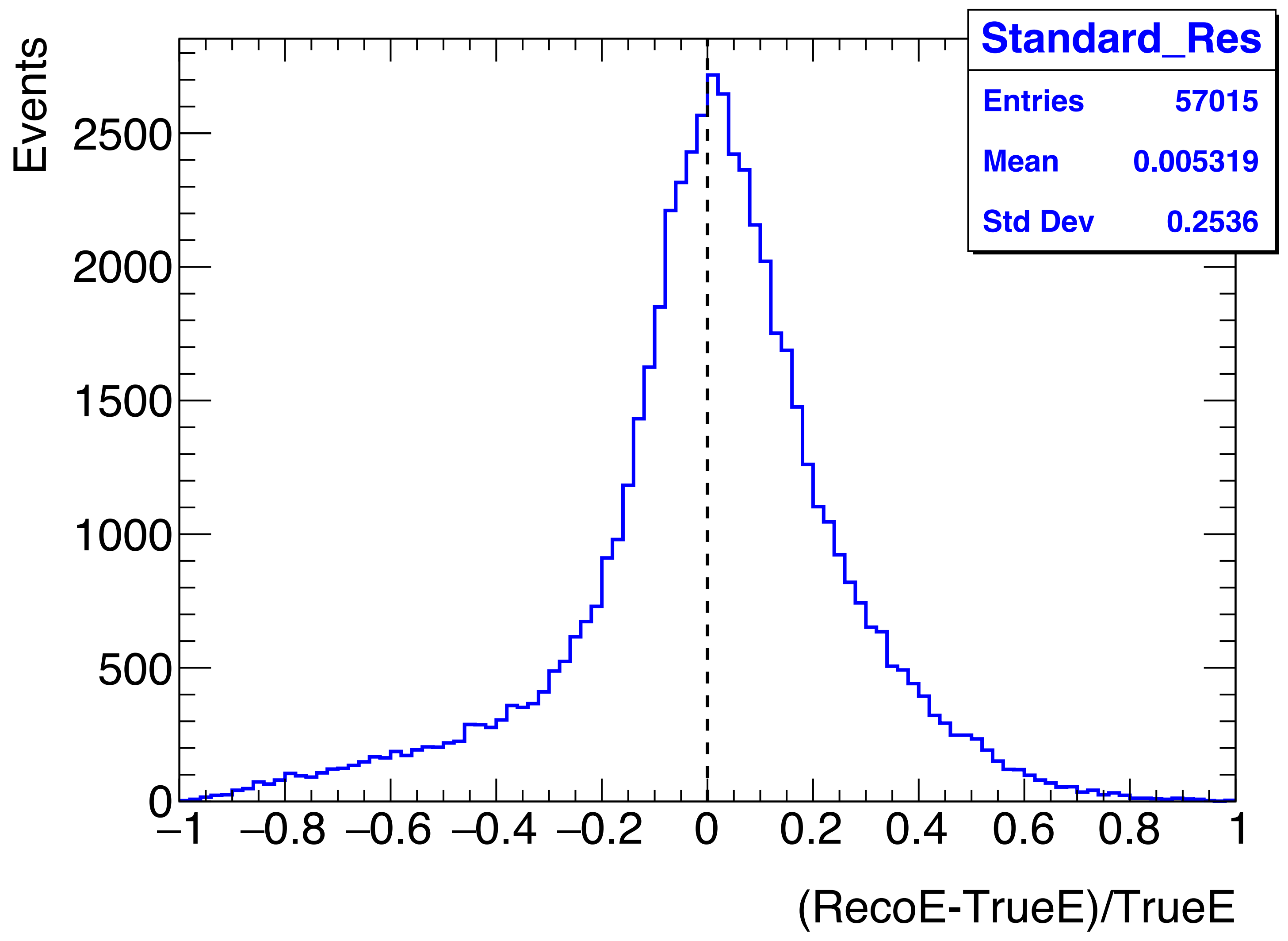
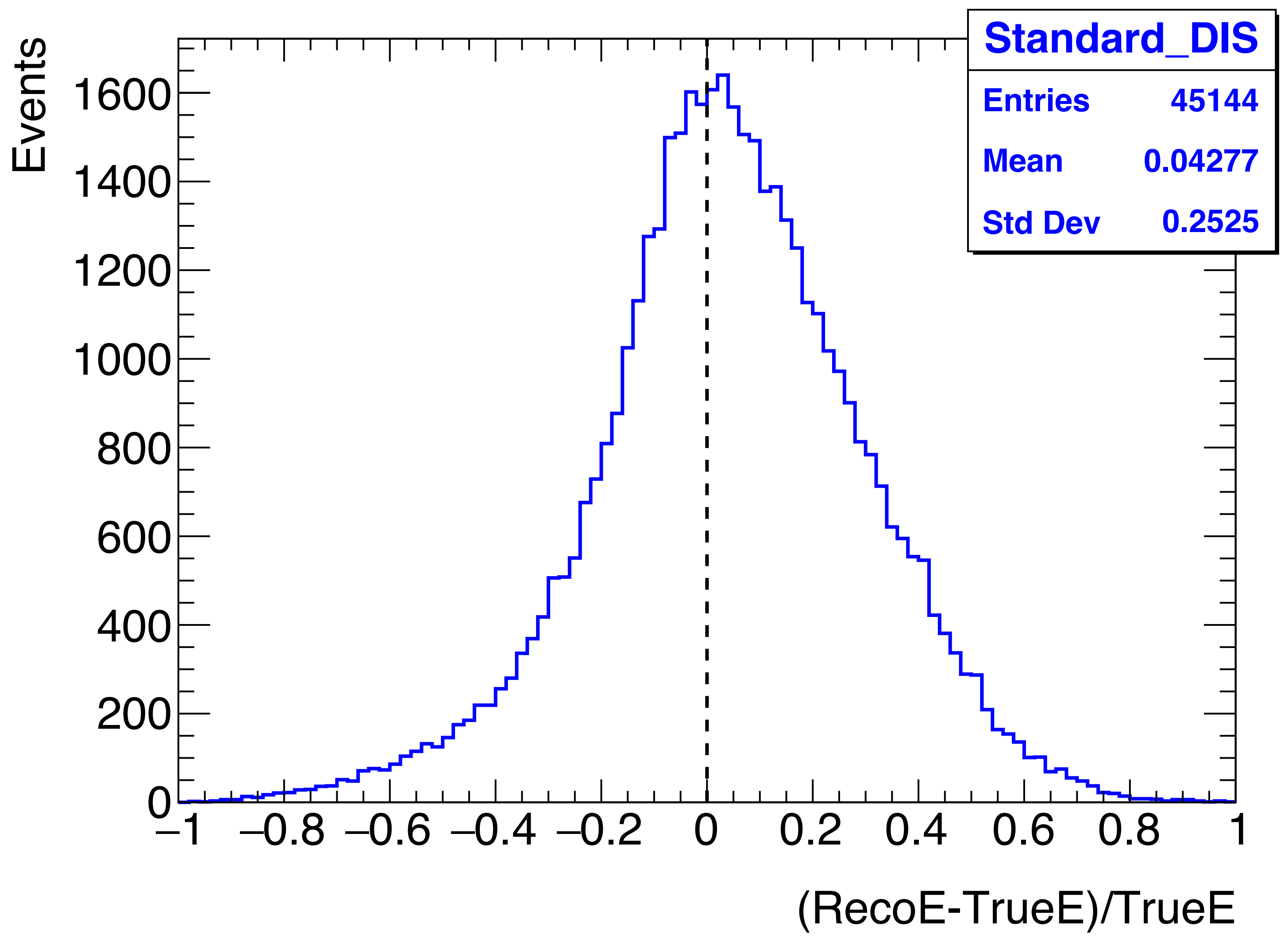




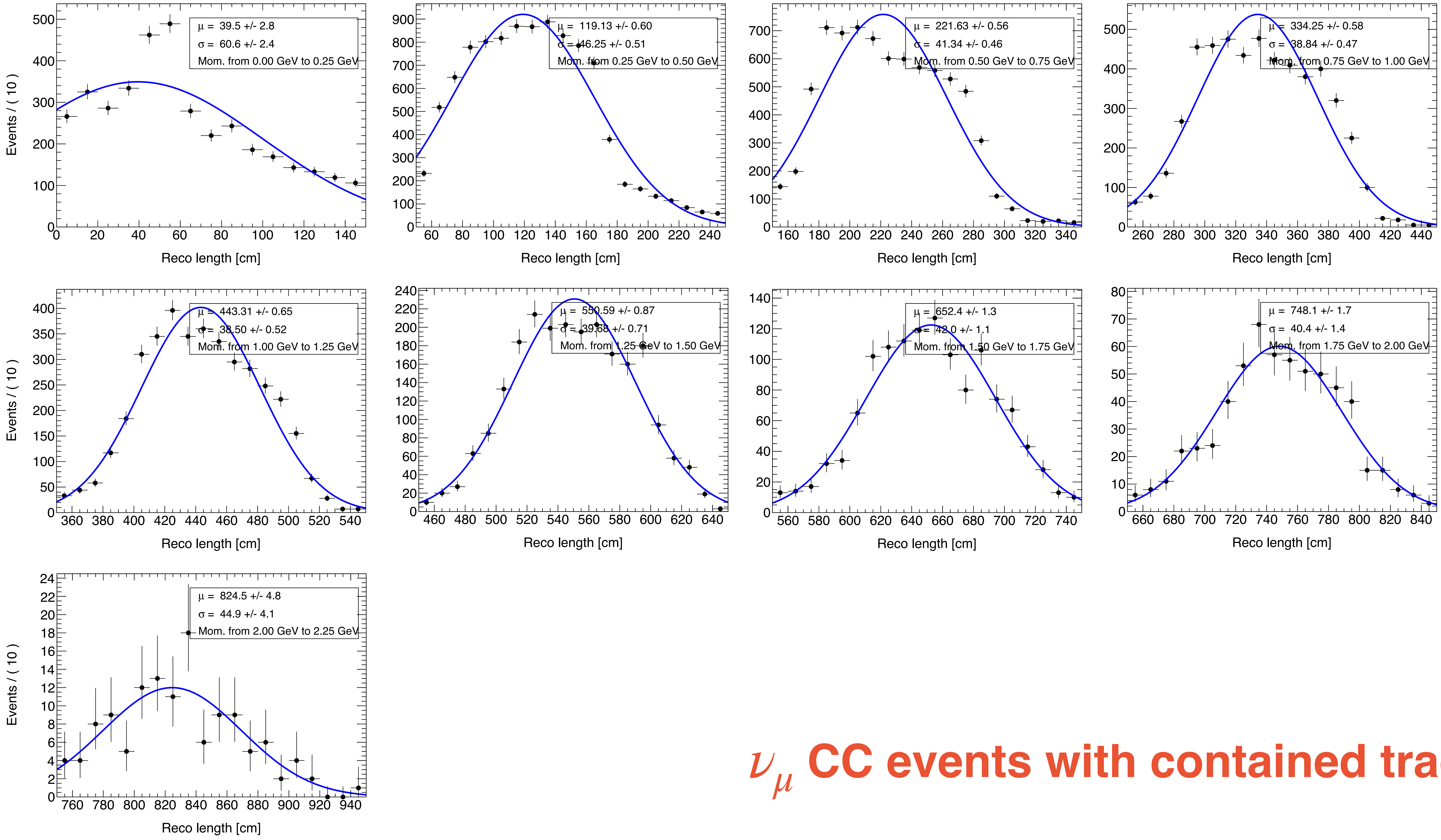


Next steps

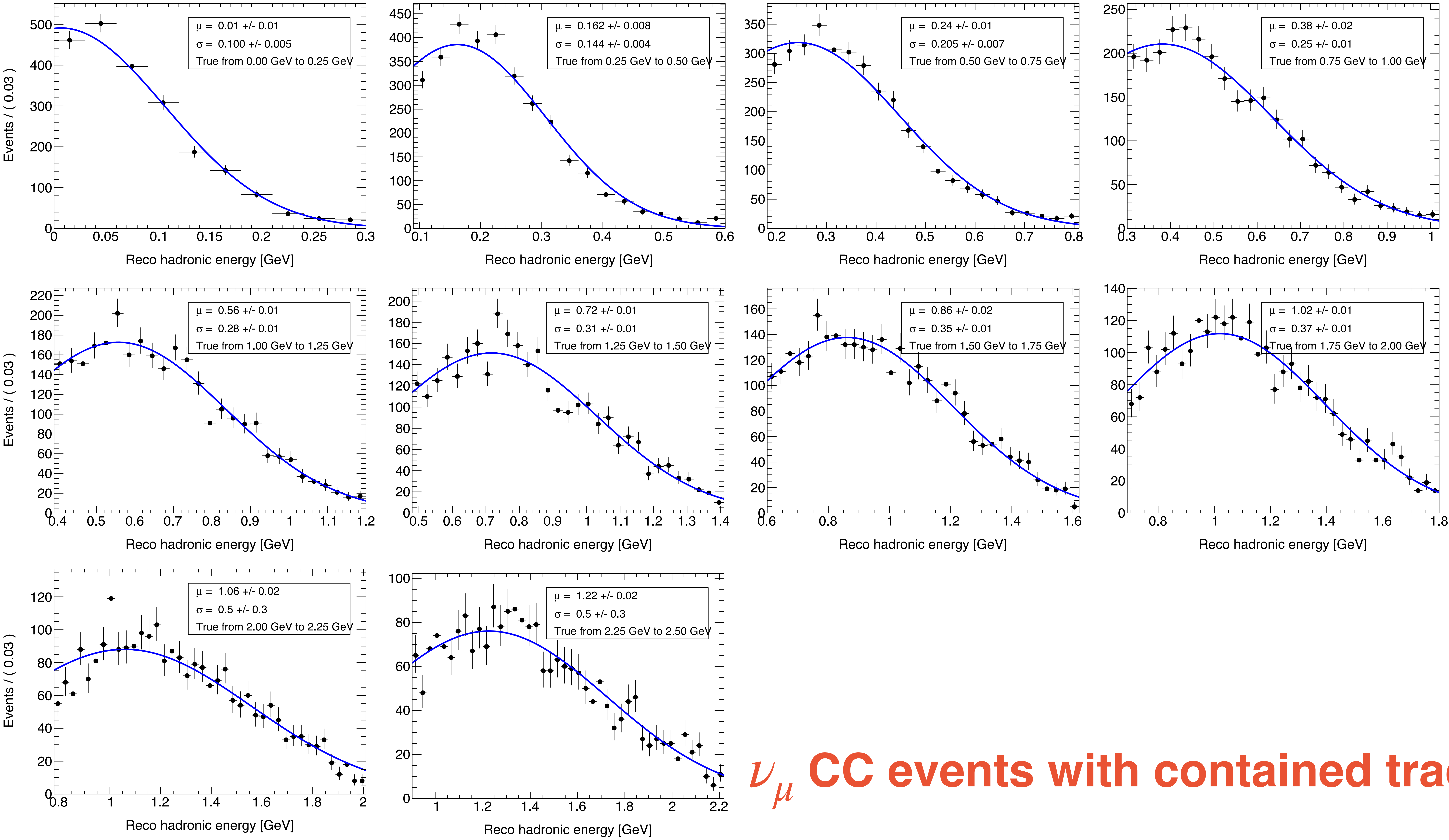
- The energy dependence of resolution for ν_e CC is similar to HD
- Contained ν_μ CC has larger resolution w.r.t higher energy
  - Large bias/residual for both lepton and hadronic energy reconstruction
- Exiting ν_μ CC has better uniformity than contained events

- Will study the correlation with lepton directions

Backup



ν_μ CC events with contained track



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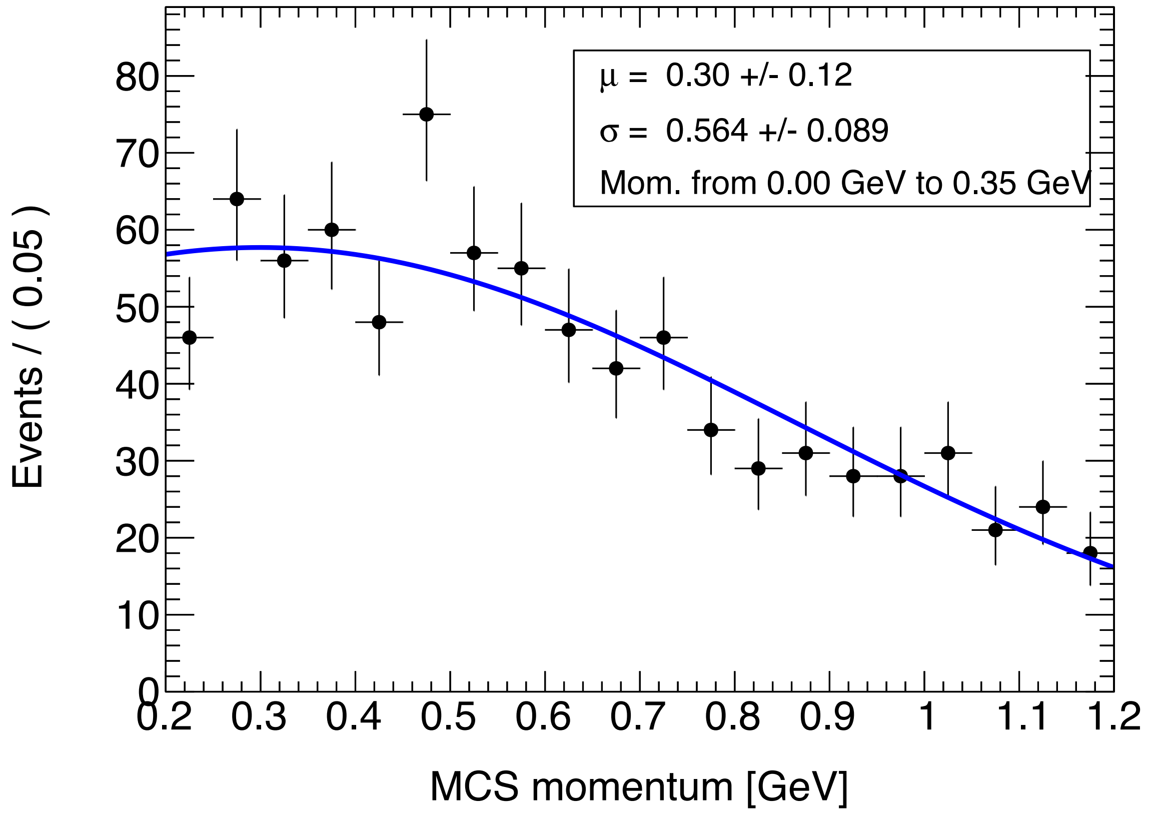
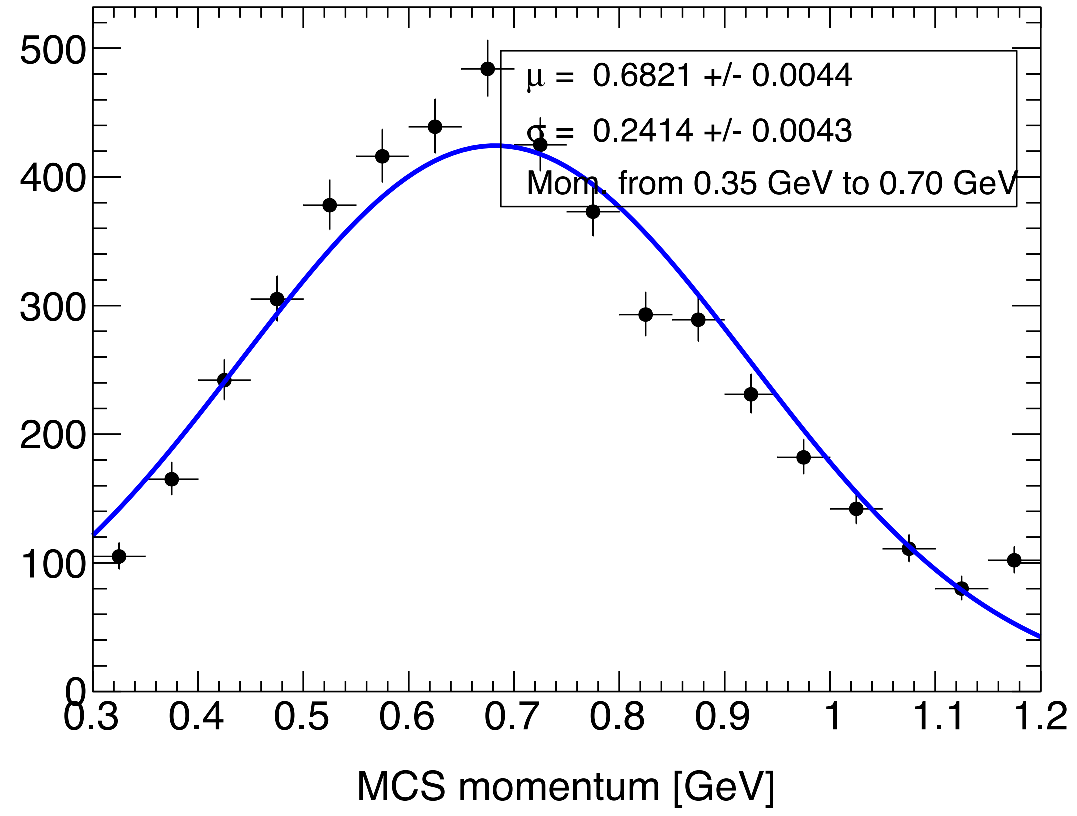
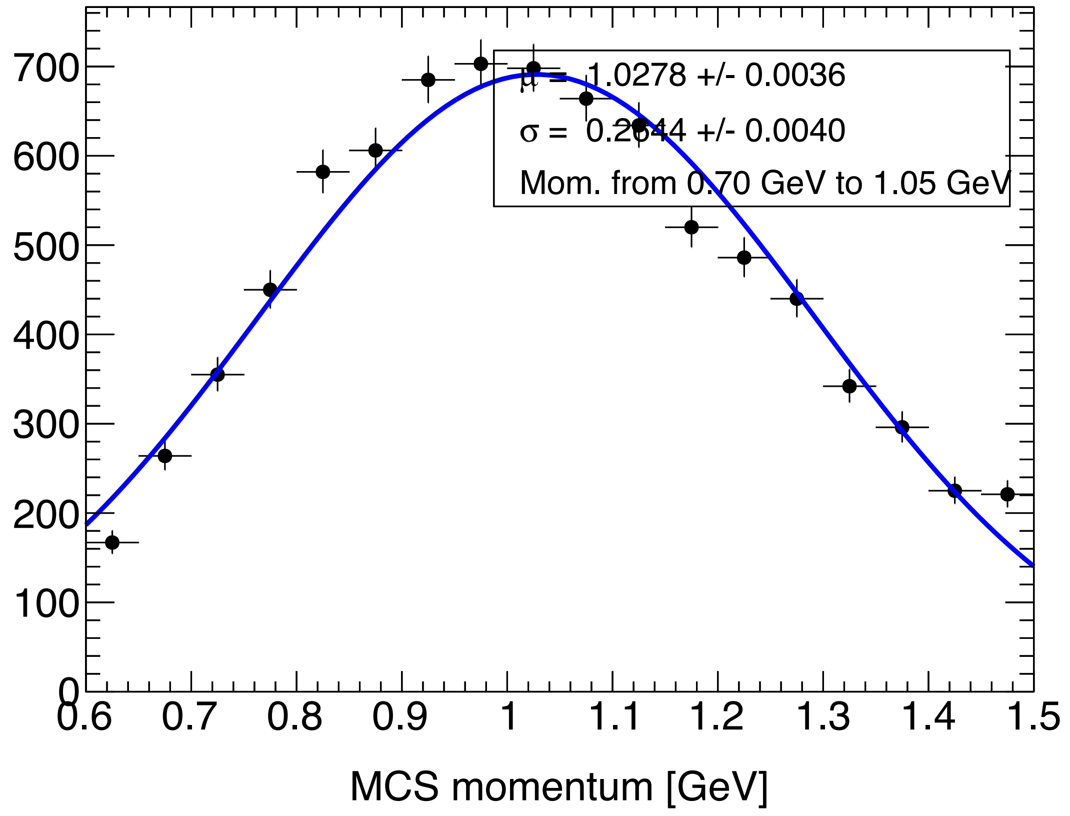
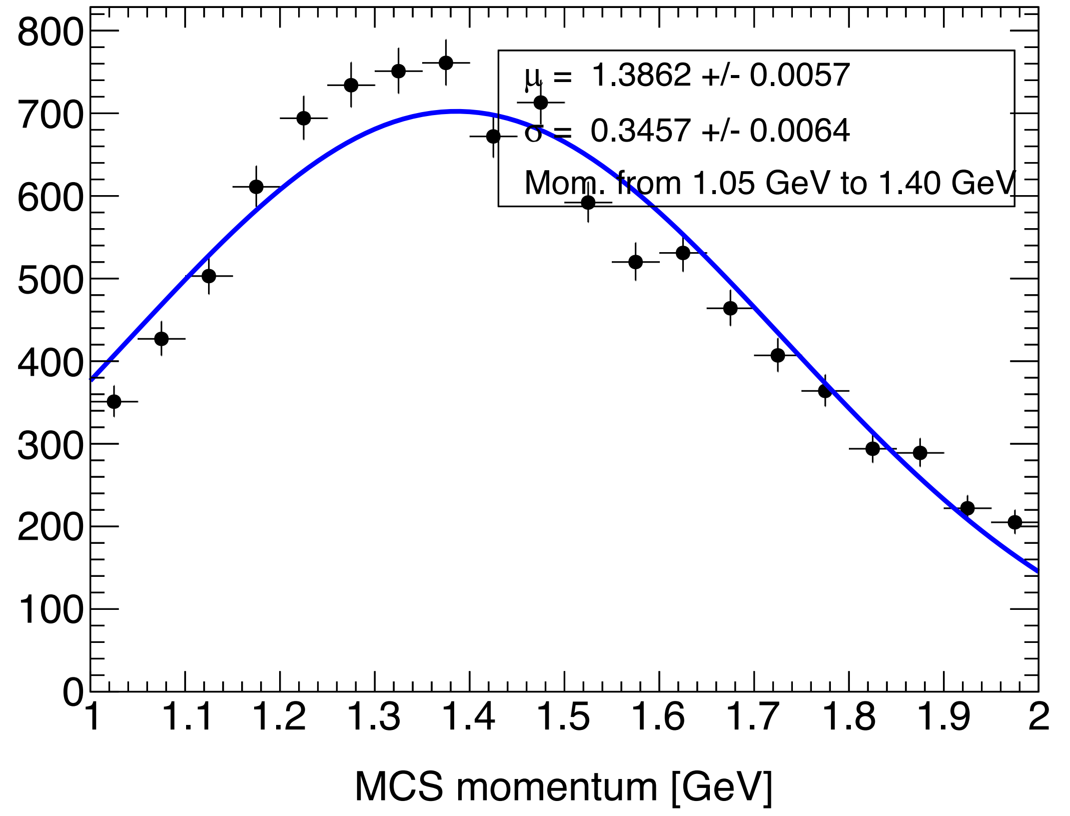
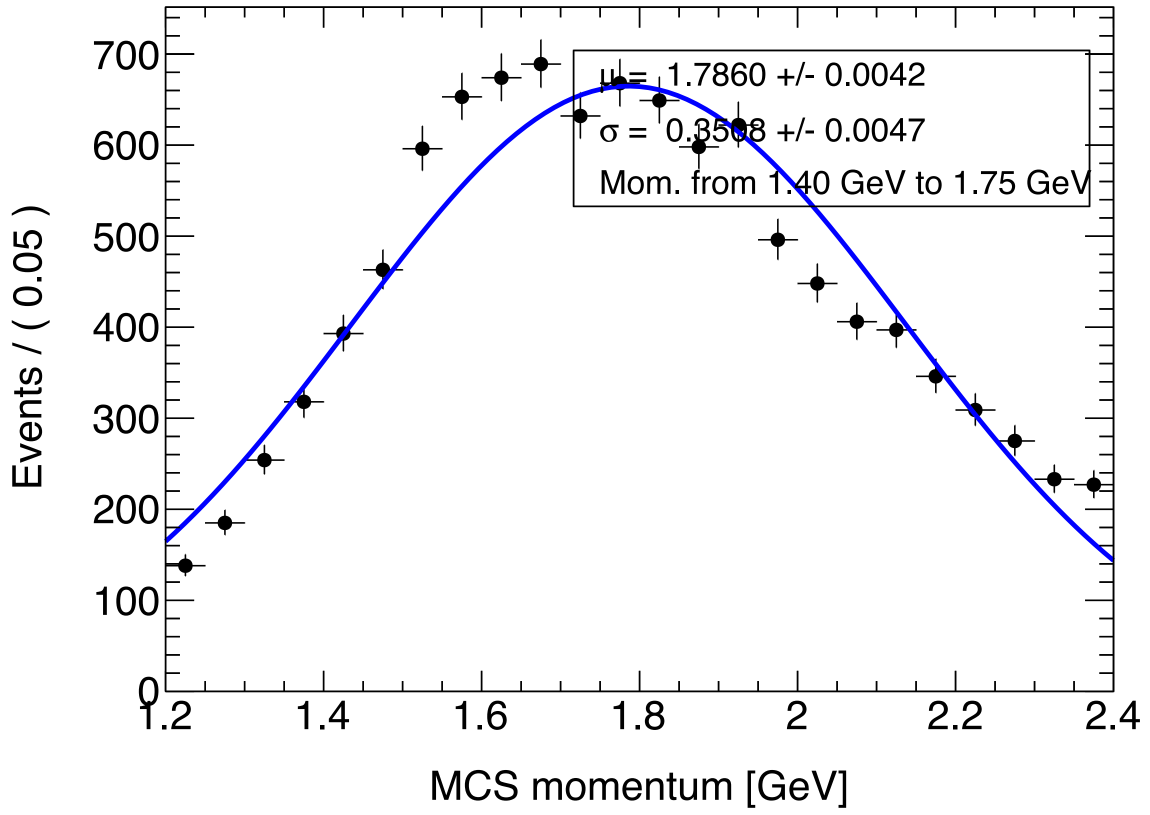
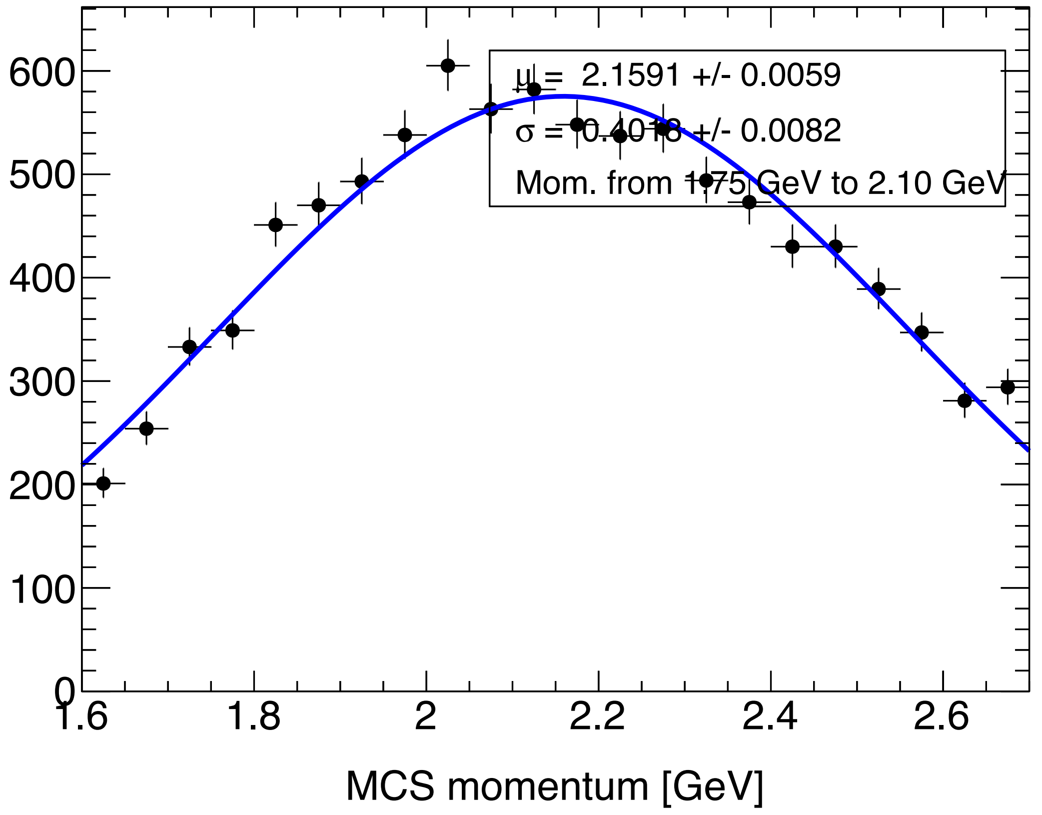


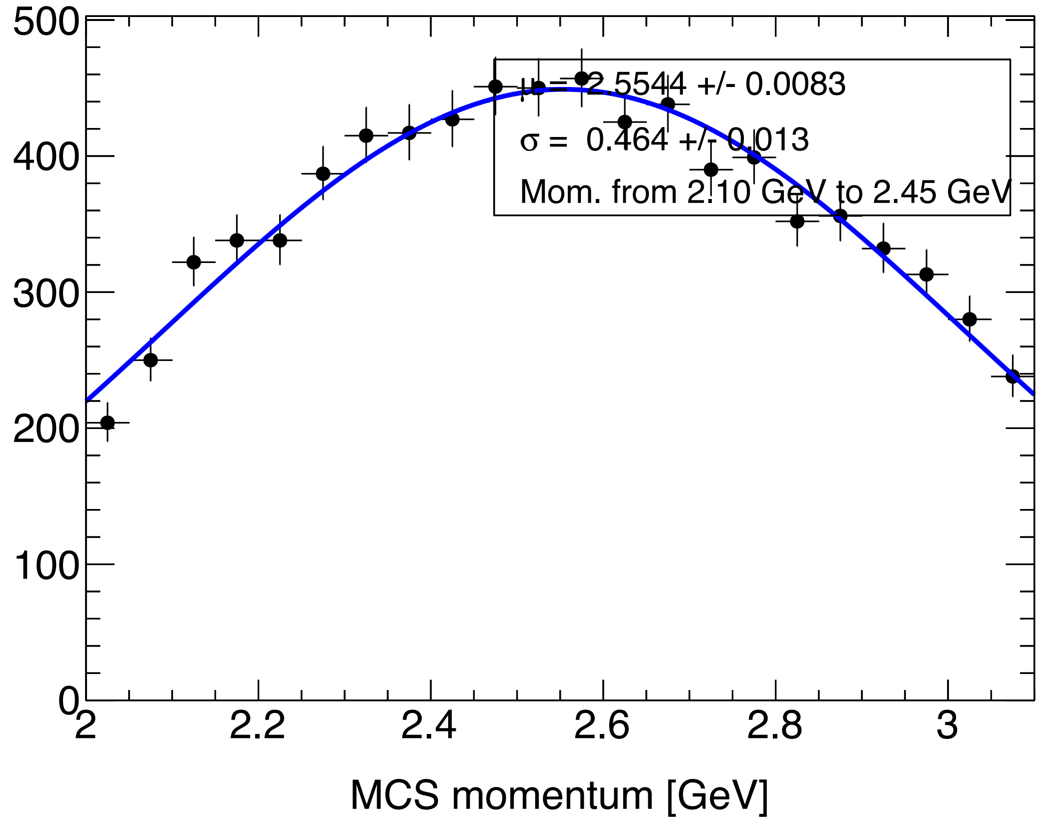


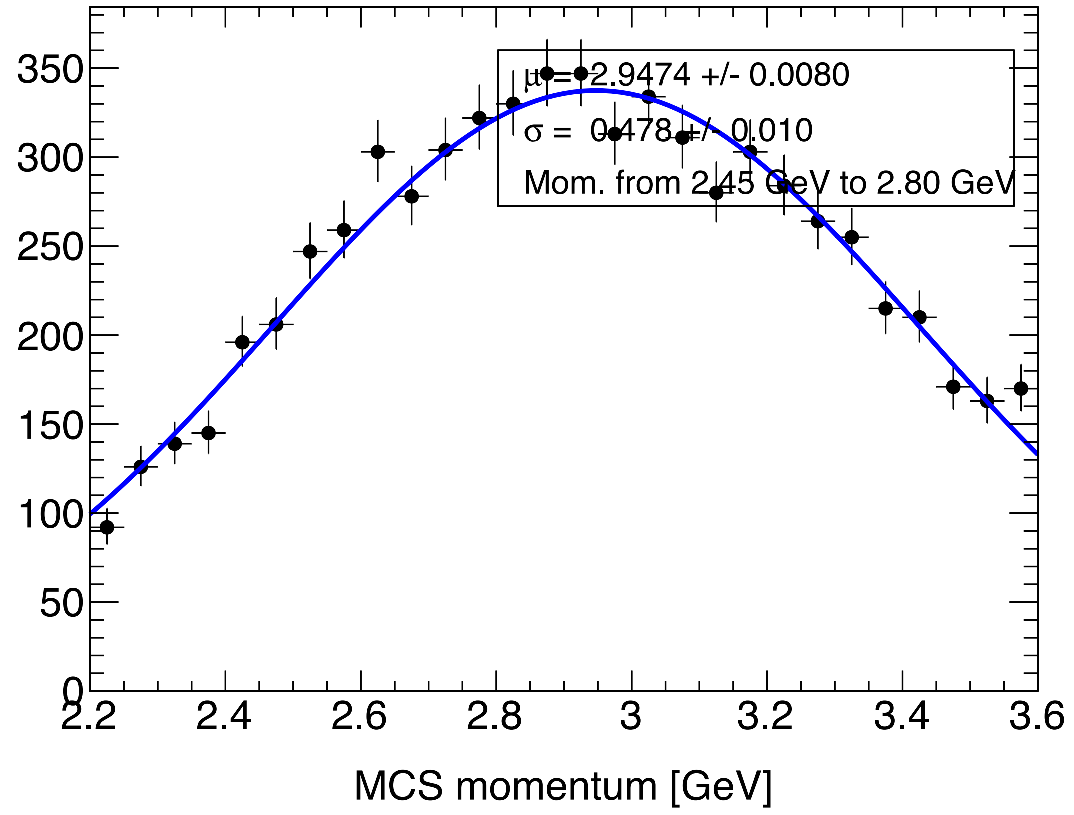


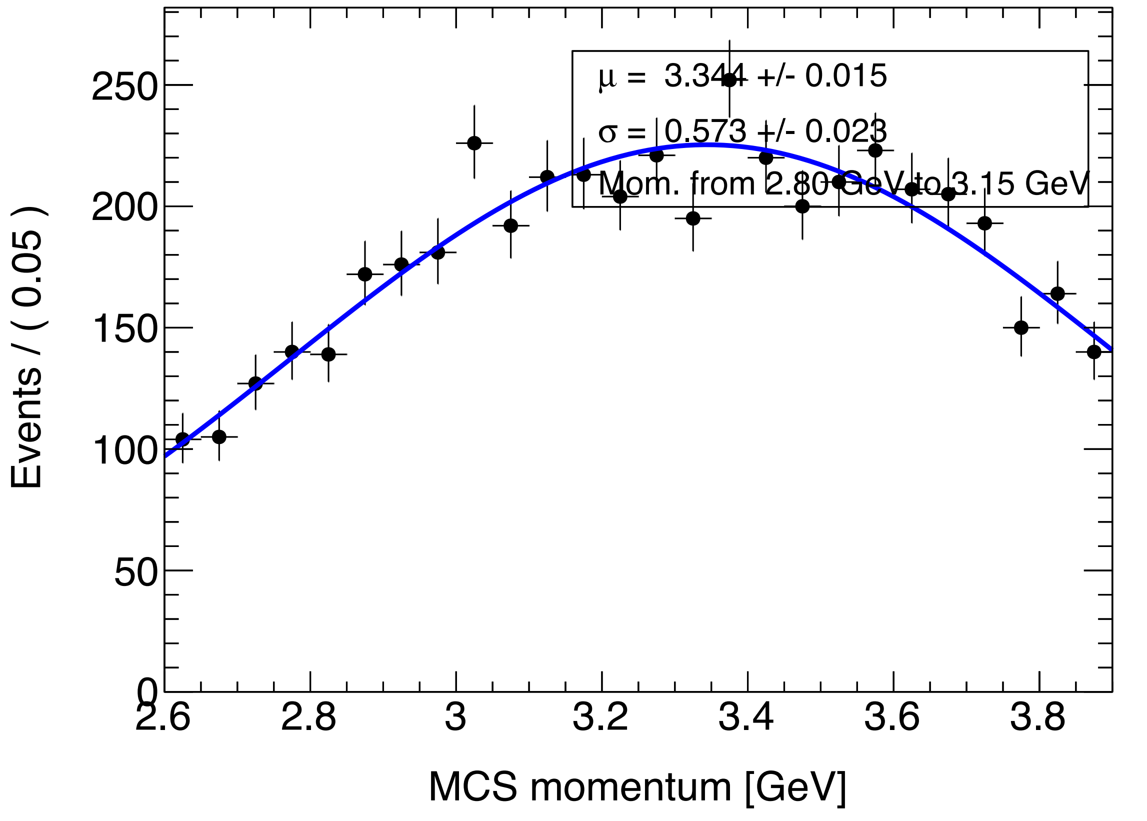




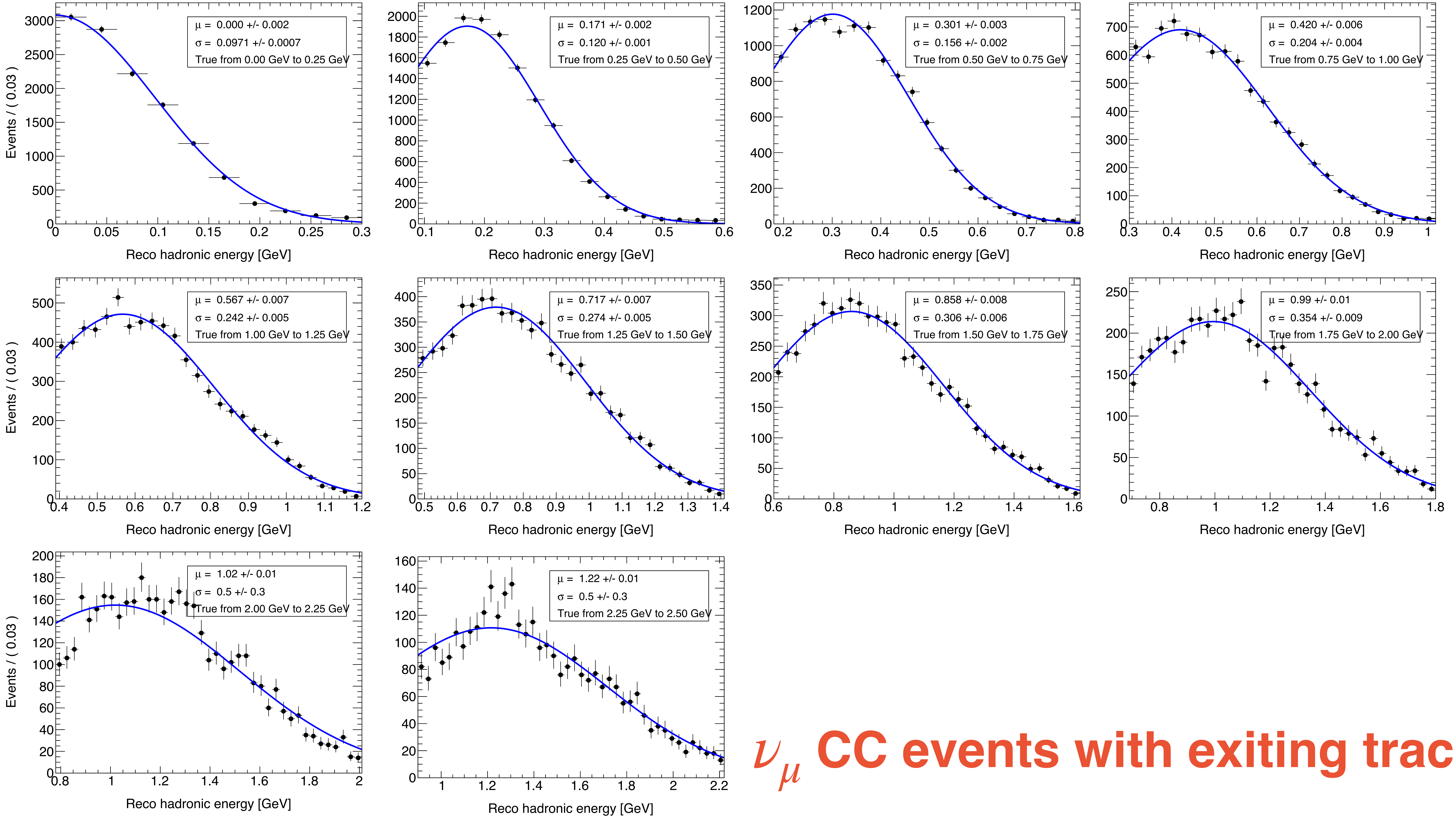






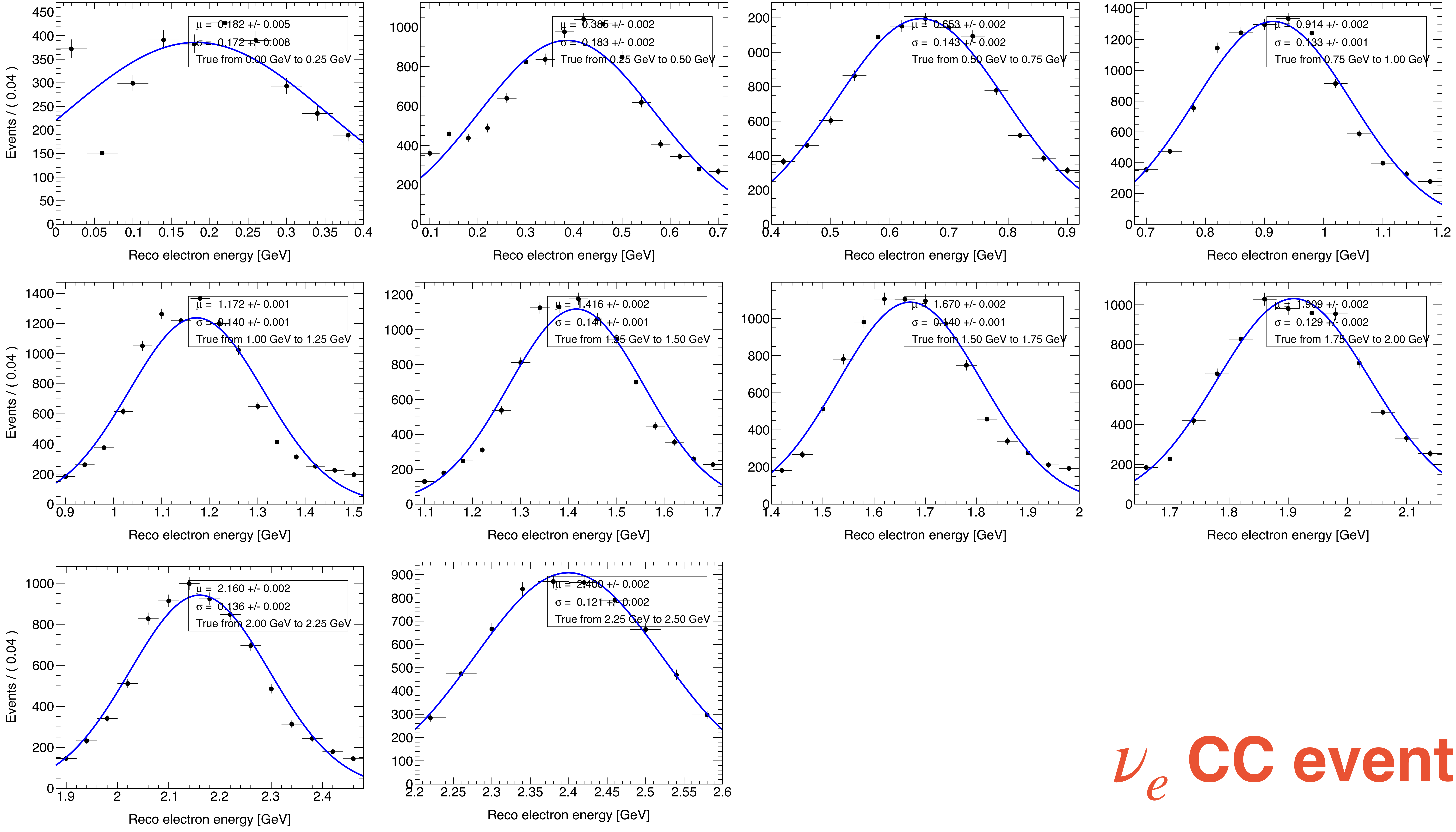


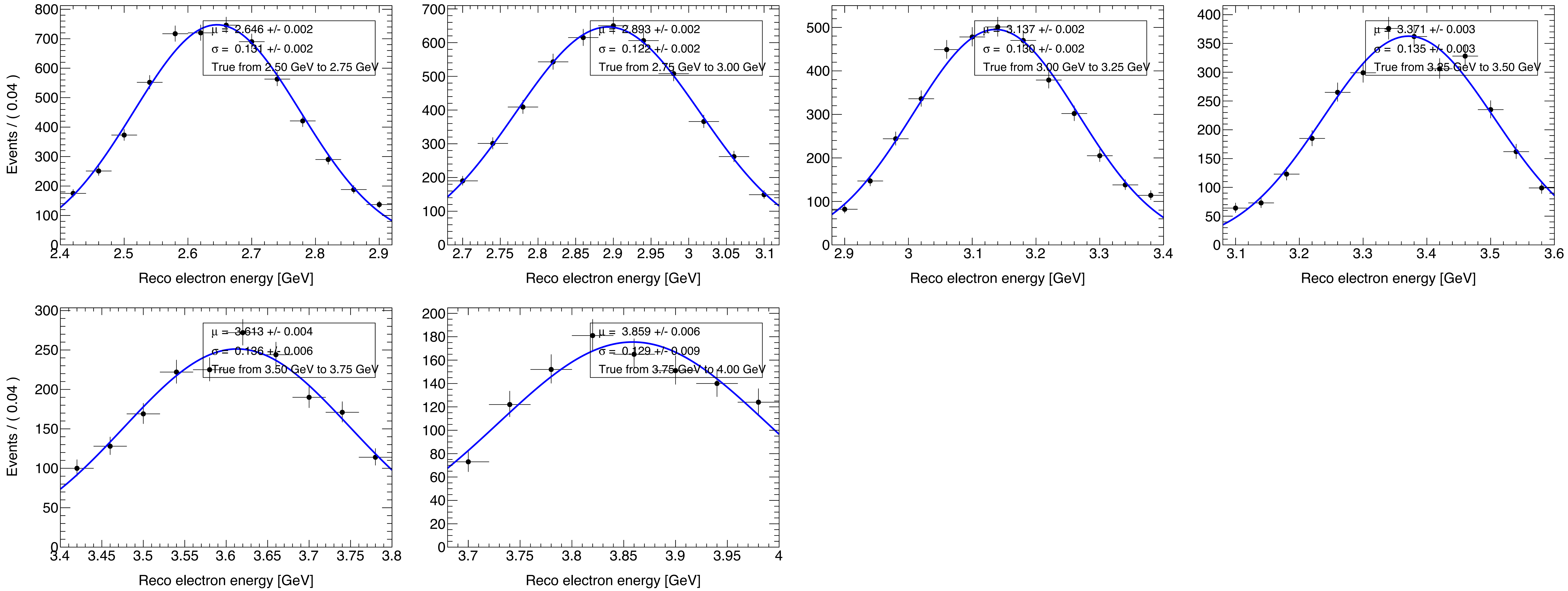
ν_μ CC events with exiting track



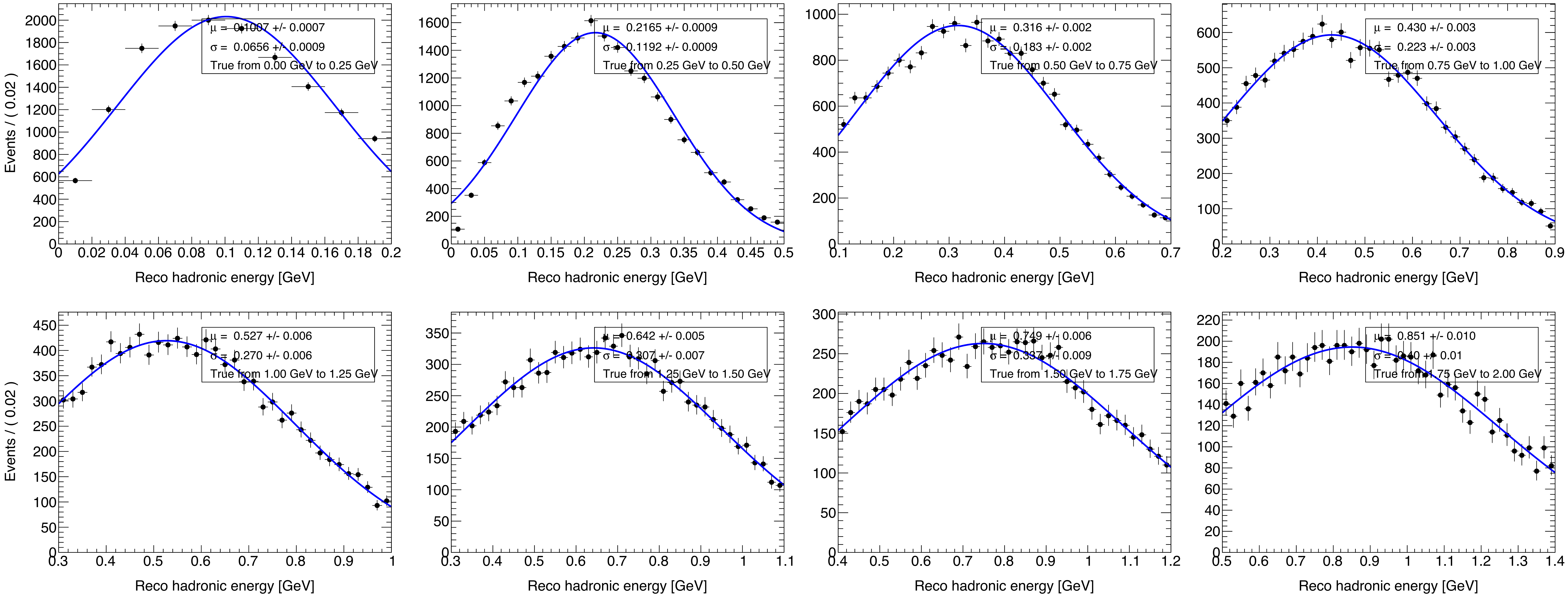
ν_μ CC events with exiting track

ν_e CC events





ν_e CC events



ν_e CC events