1 GeV/c Proton-argon Inelastic Cross-section Update

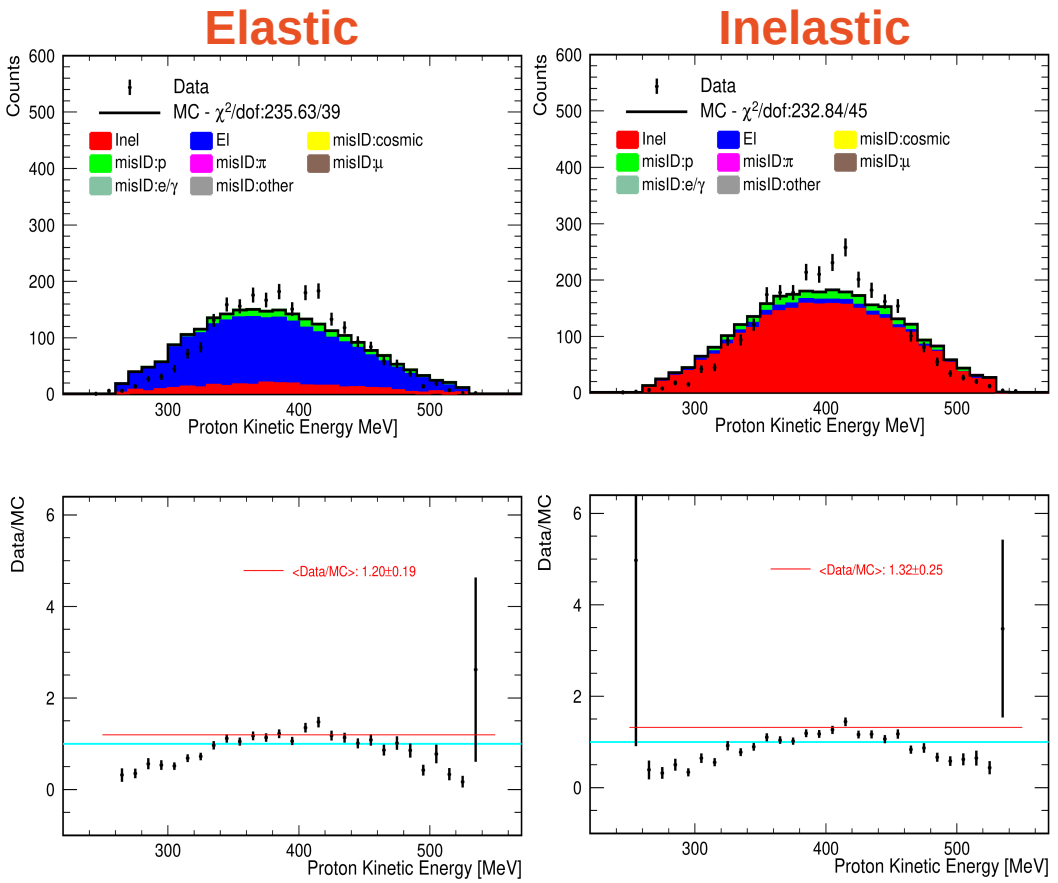
- Kinetic energy systematics

Heng-Ye Liao

Hadron Analysis meeting

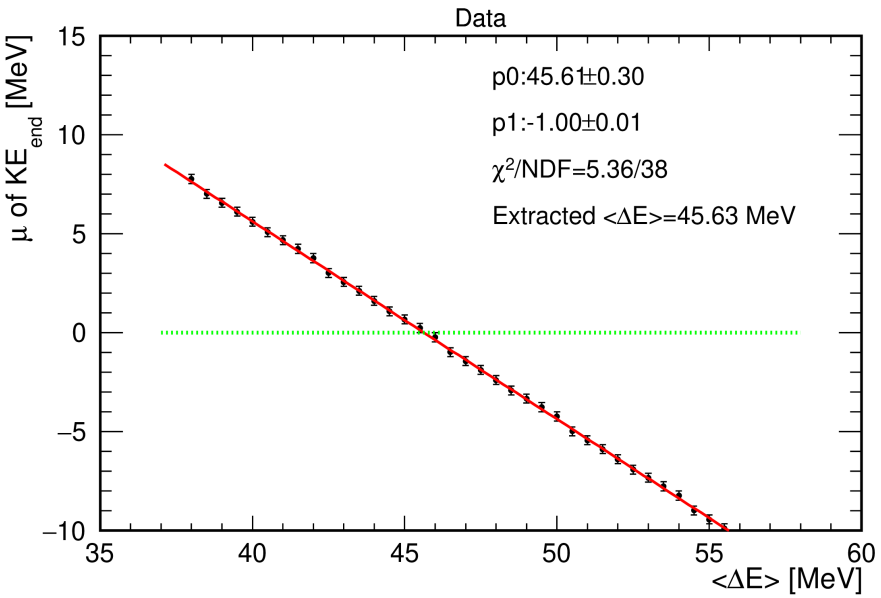
August 11, 2022

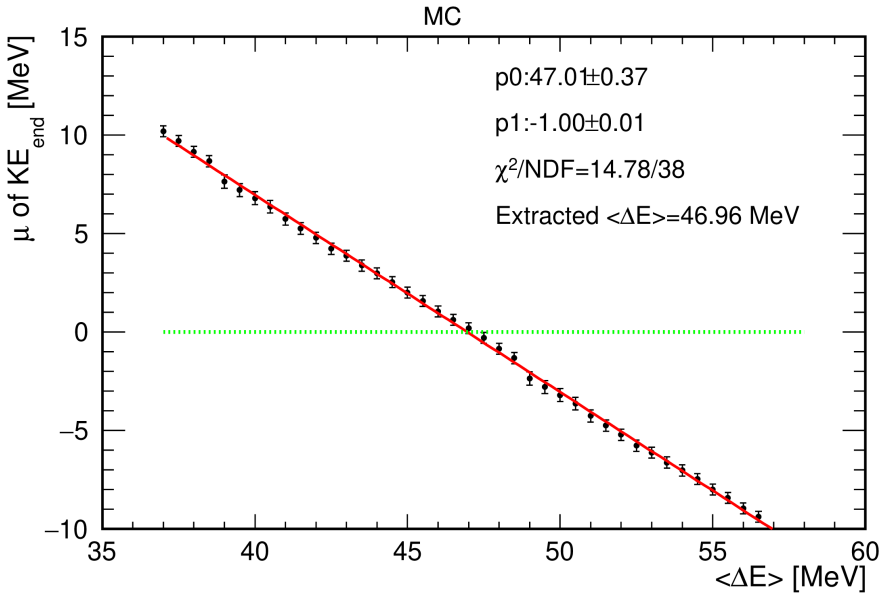
Issue: Data/MC Not Agree at KE_{ff}

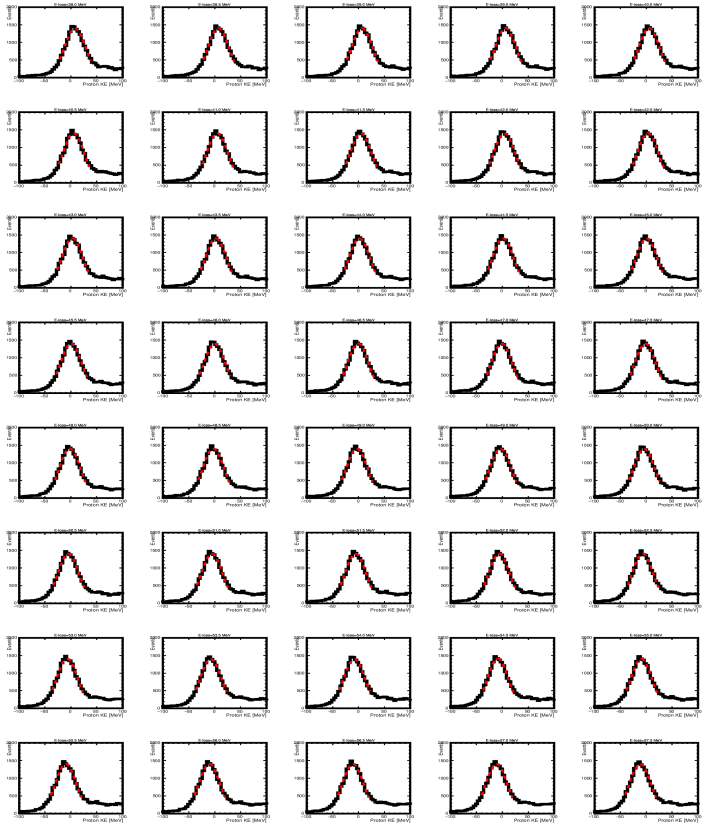


- Previous beam momentum reweighting:
  - Use range-based energy to build the weighting function
  - Assume constant energy loss at TPC FF
- MC **wider** than data after beam momentum reweighting
- This version of reweighting only guarantees that range-based energy deposition is the same for both data & MC
- To mitigate KE systematics at TPC FF, two key components need to be properly measured/handled:
  [1] Beam momentum
  (how well is energy measurement from beamline inst.)
  [2] Energy loss upstream
  (material budget)
  → Need new method to solve [1] & [2]

E-loss Calculation

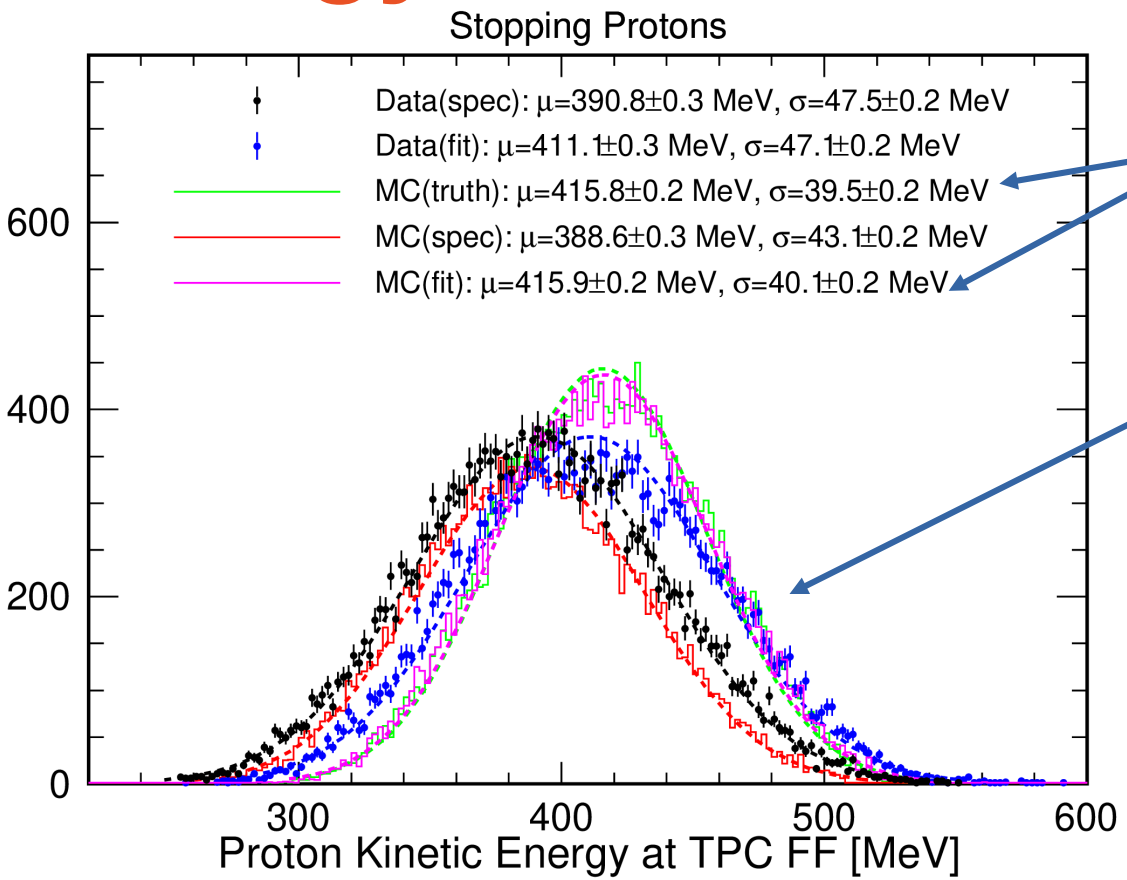






- $KE_{ff}:=KE_{beam}-\Delta E$
  - KE_{beam}: Energy measurement from beamline inst.
  - ΔE:constant energy loss
- $KE_{end}:=KE_{ff}-\Sigma(dE/dx*dx)$
- Tune ΔE such that peak at end point locates at zero MeV

Kinetic Energy at TPC Front Face

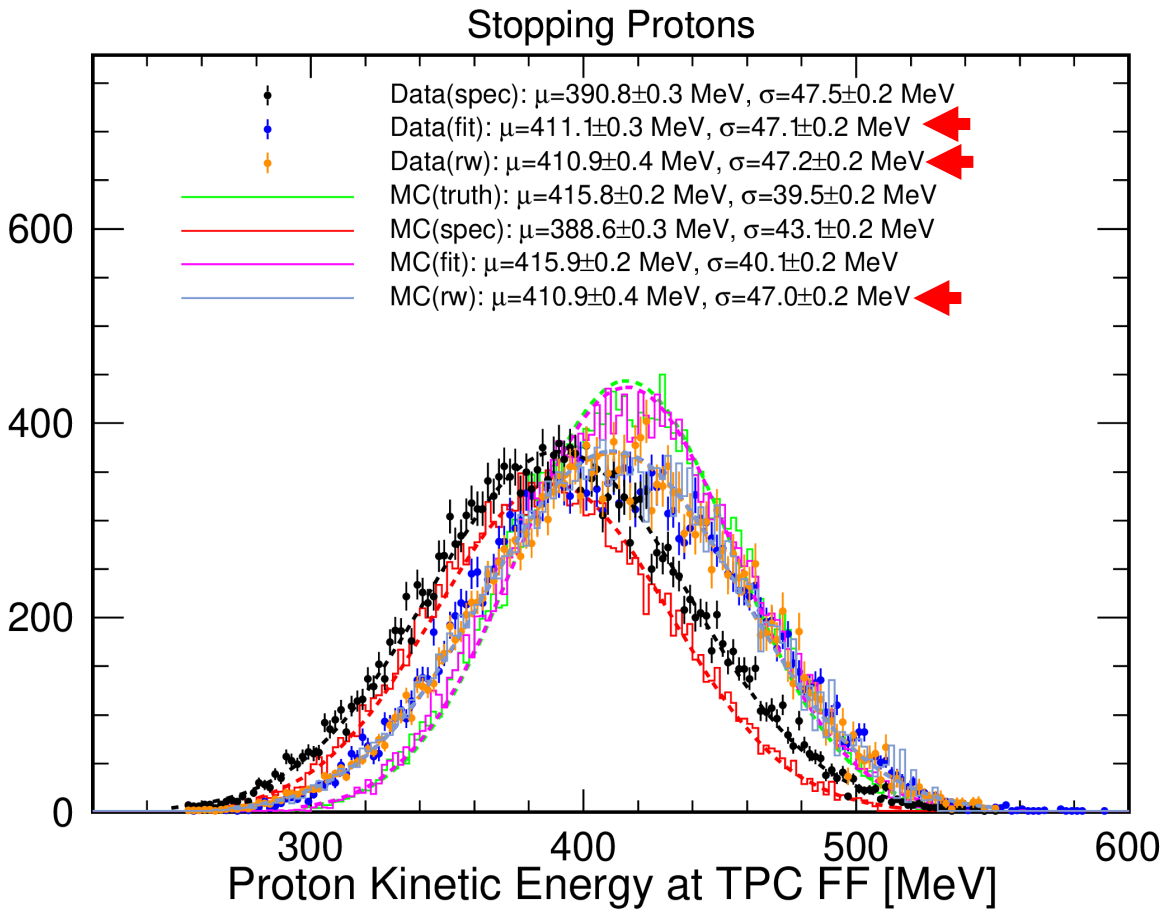


MC(truth)=MC(fit):
→ Proof that good energy reconstruction using fitting algorithm

Data(fit) is used as a reference to build the new weighting function

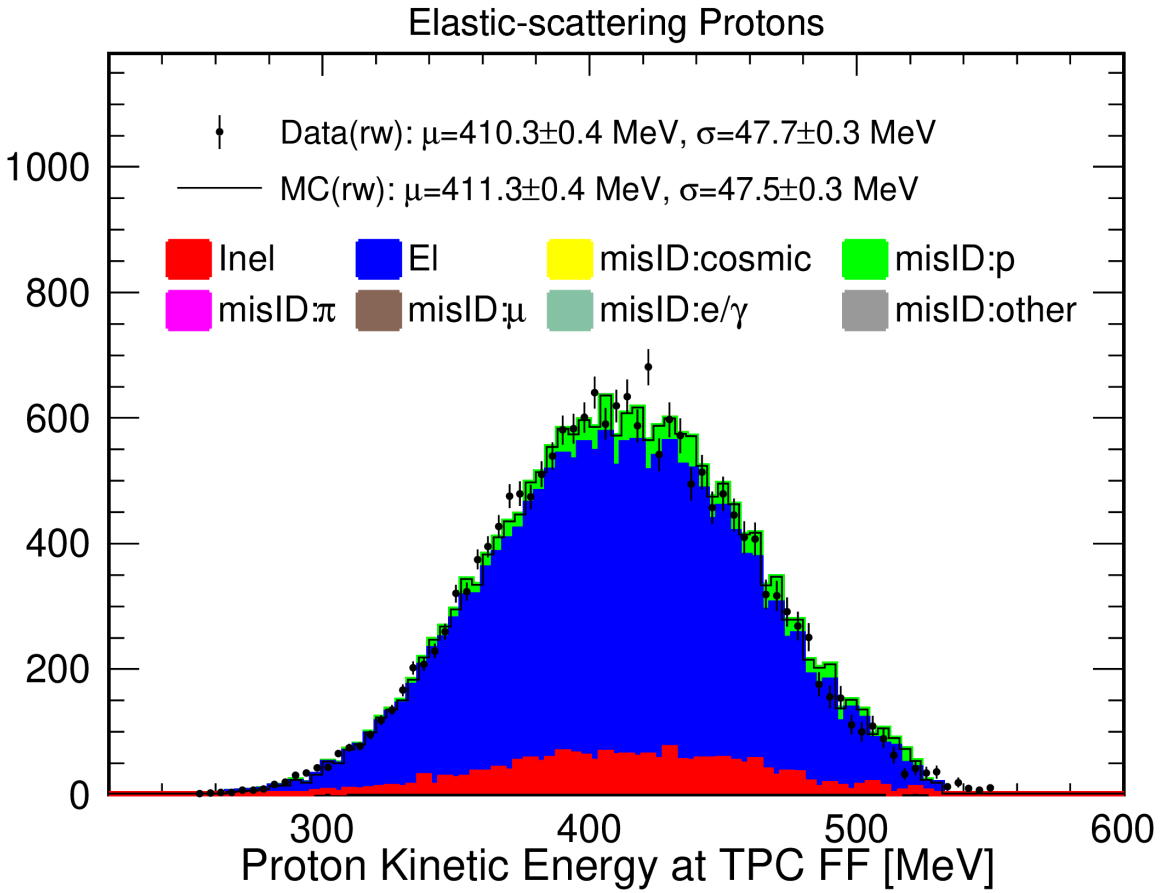
- Sungbin has demonstrated that energy can be well-reconstructed by fitting hypothetical residual ranges [link]
- MC KE_{ff} (fit)=KE_{ff} (truth) → Proof that fitting algorithm did great job on energy reconstruction
- Use data KE_{ff} (fit) as reference to build the new weighting function

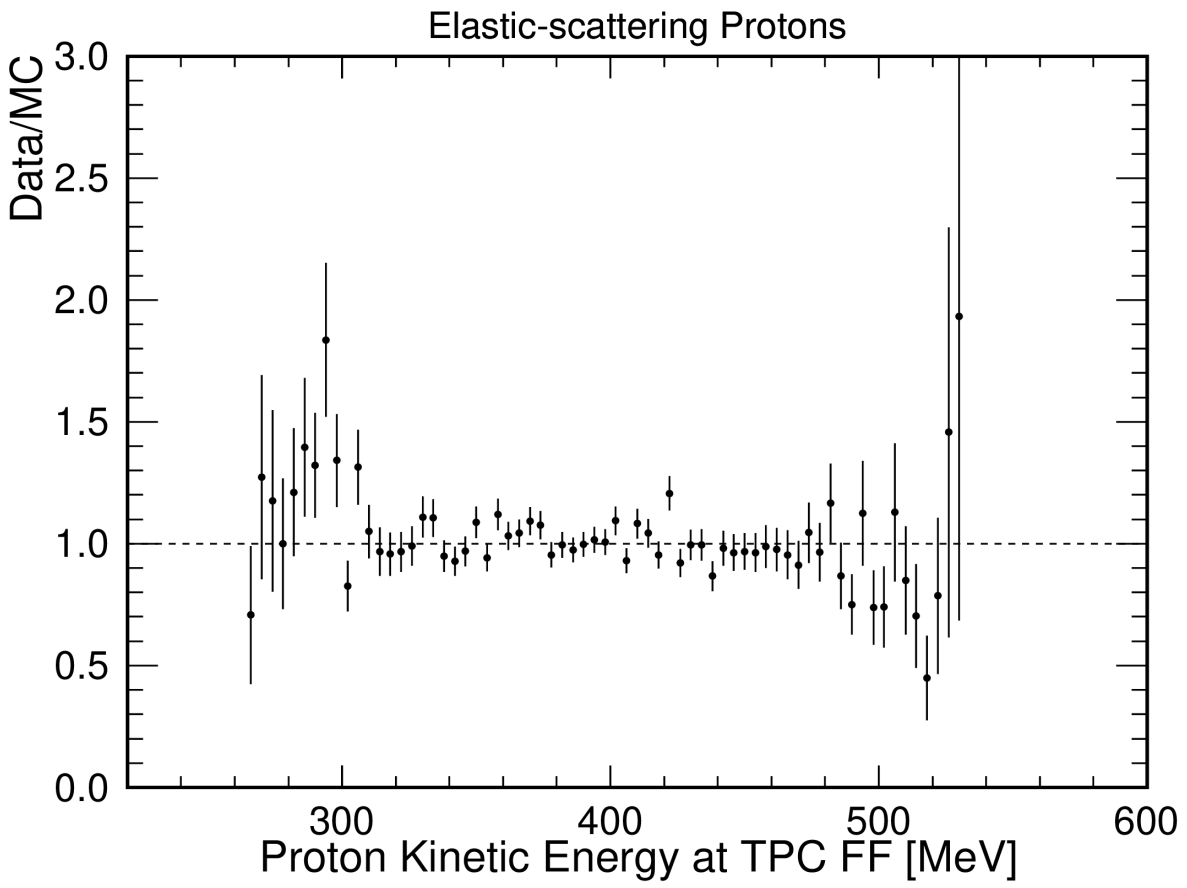
KE_{ff} with New Weighting Function



- Use KE_{fit} (data) as KE_{ff} (truth) since the energy can be well-reconstructed using fitting alg.
- New weighting functions:
  Data:KE_{fit} (data)/(KE_{beam}-ΔE) (data)
  MC: KE_{fit} (data)/(KE_{beam}-ΔE) (MC)
- Data/MC agree well after applying new weighting function (by definition)

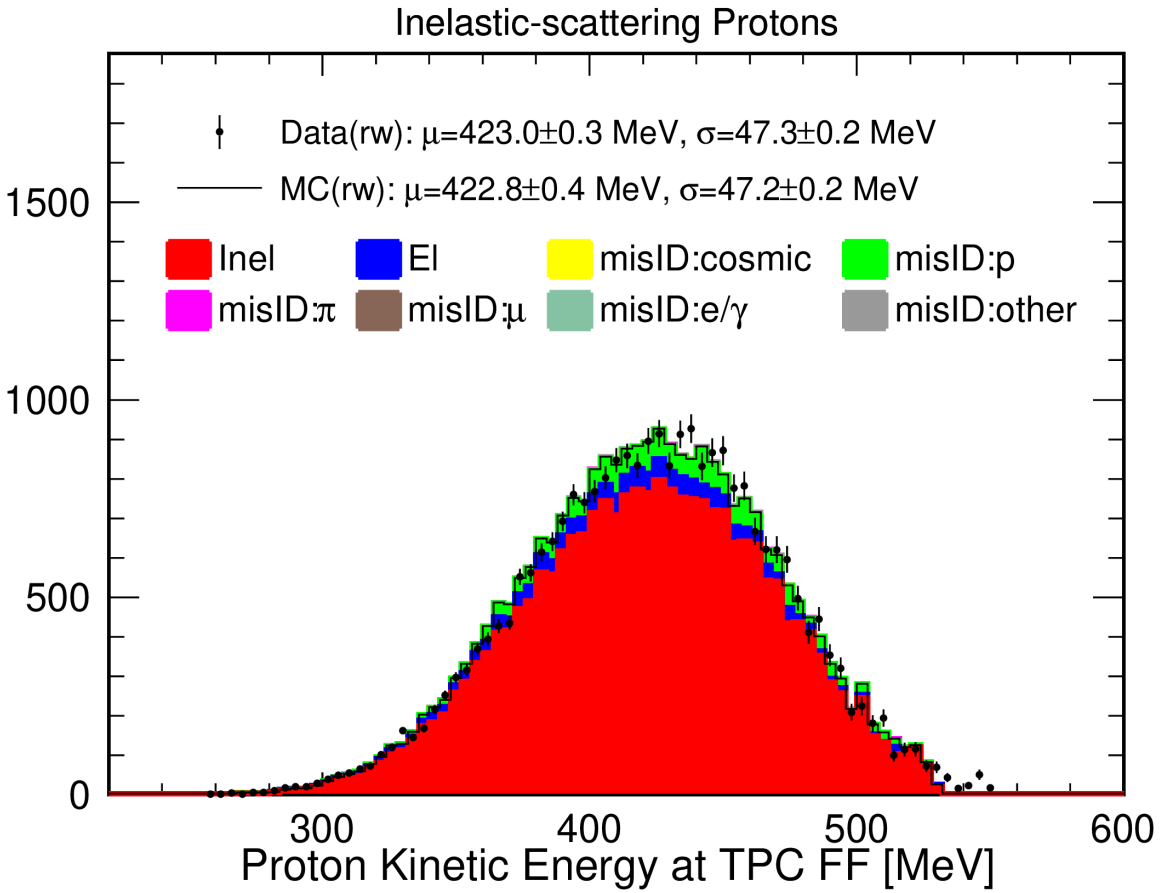
KE_{ff} (Elastic-scattering Protons)

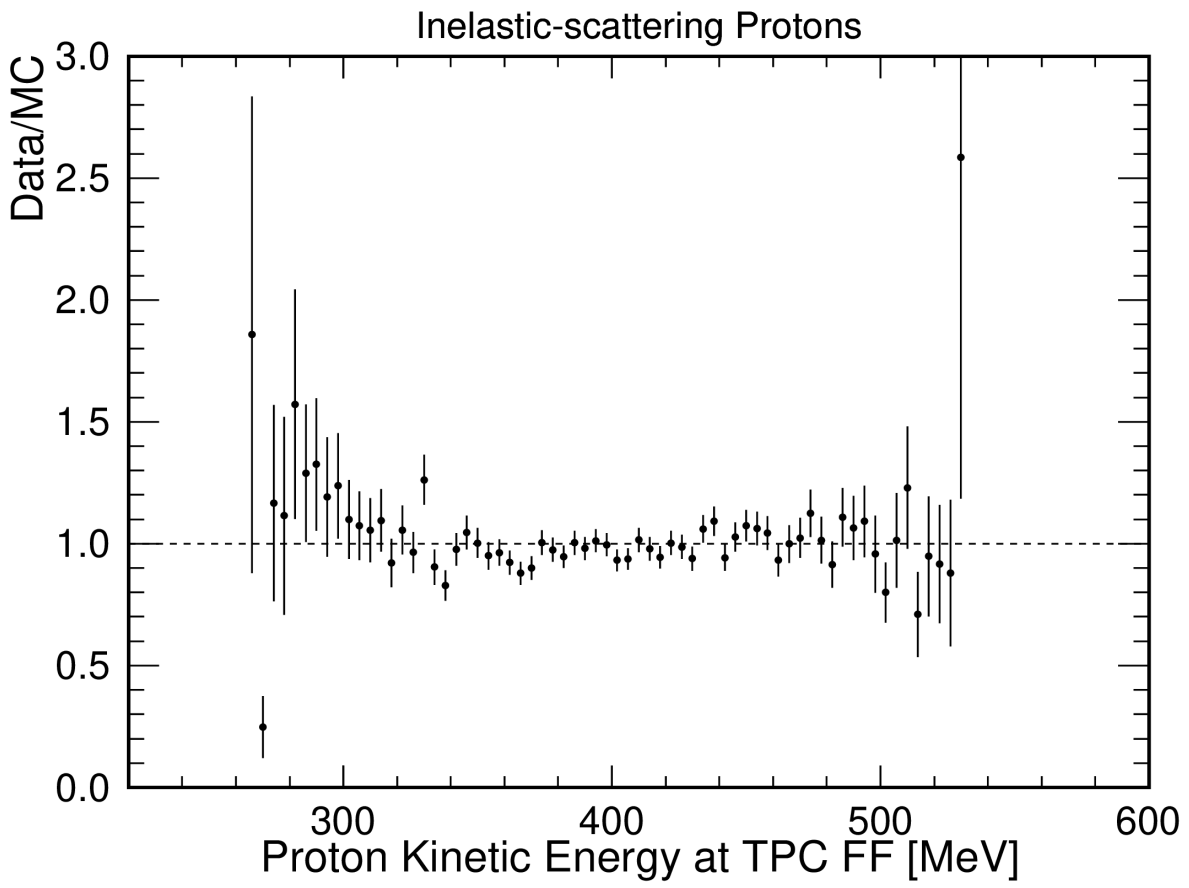




- Good data/MC agreement for elastic-scattering protons

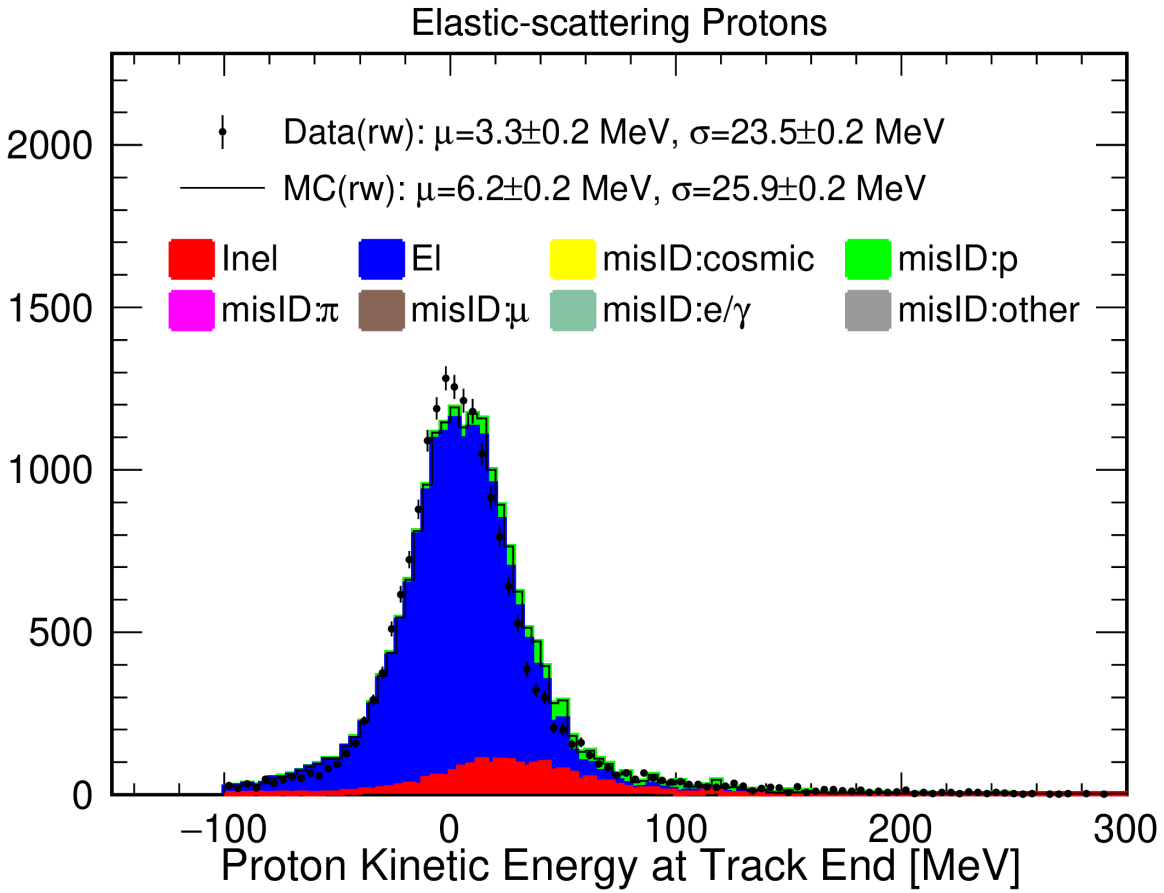
KE_{ff} (Inelastic-scattering Protons)

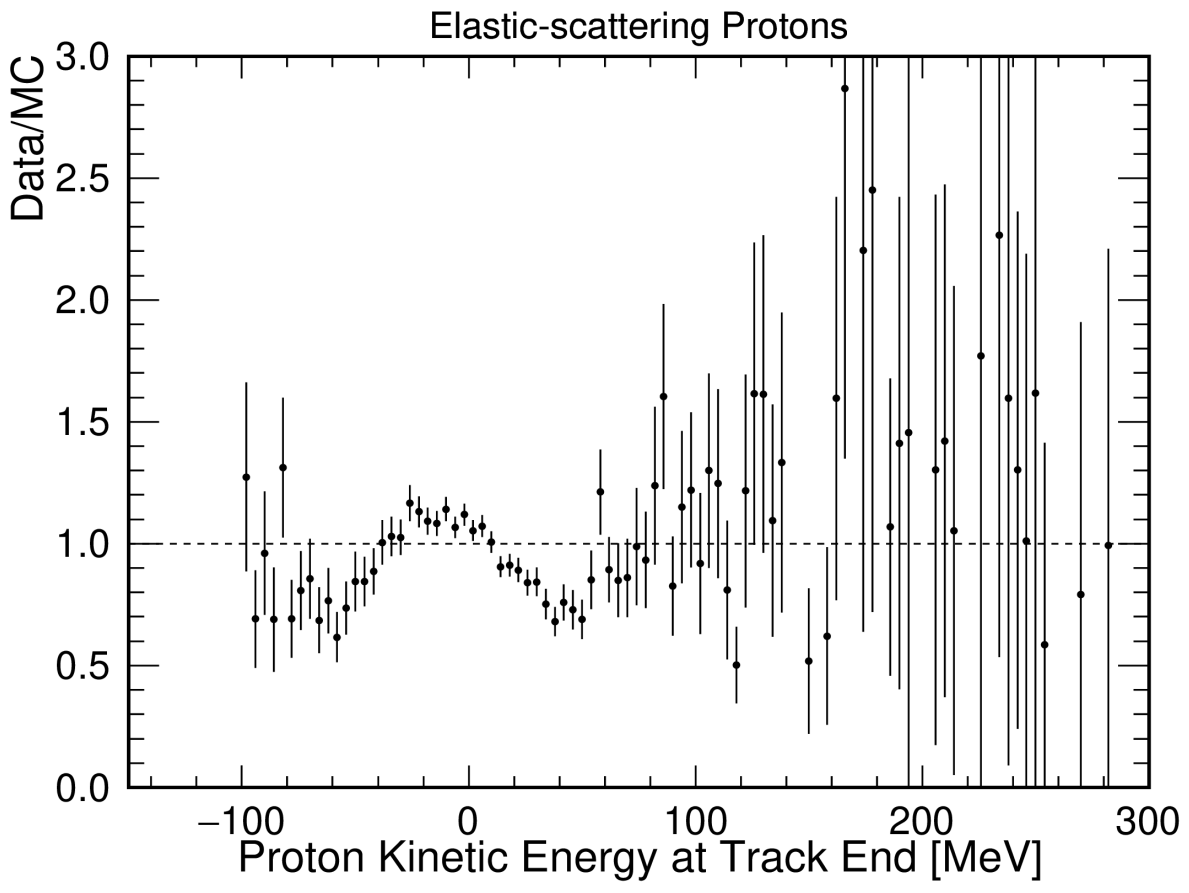




- Good data/MC agreement for elastic-scattering protons

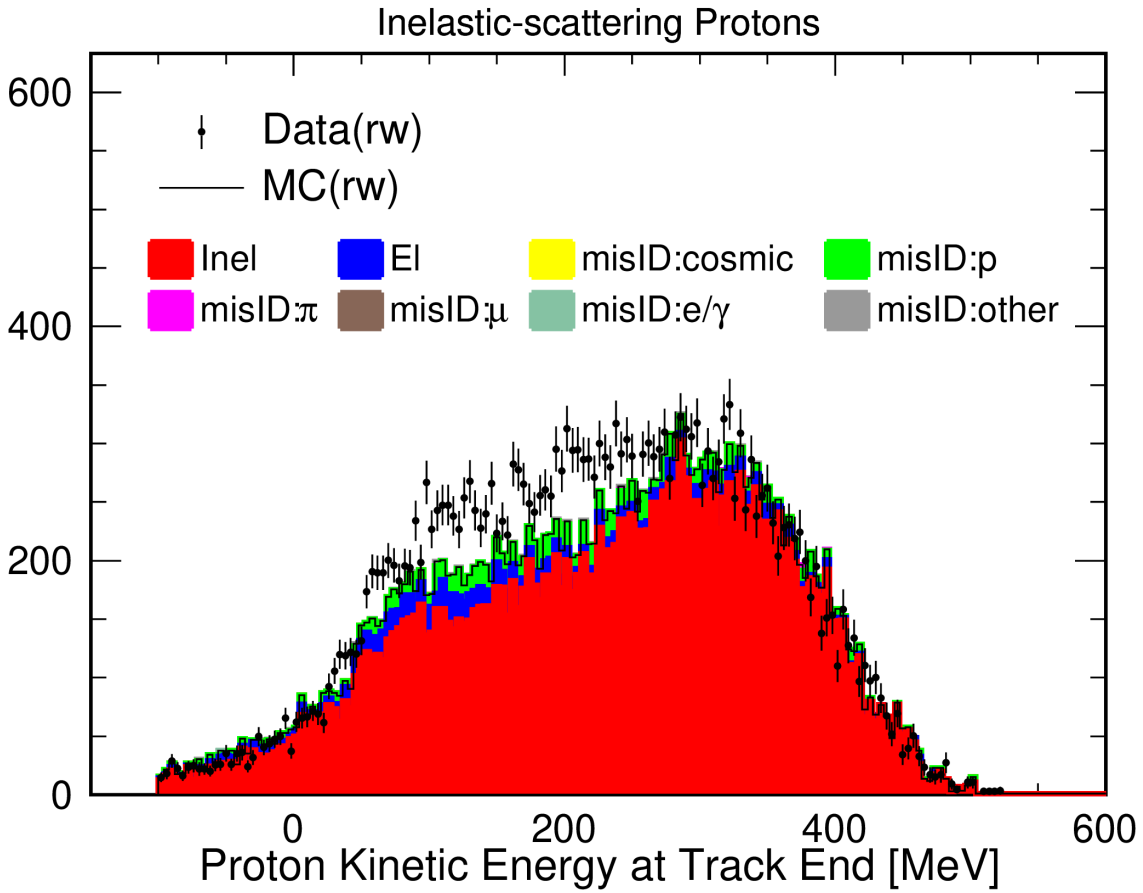
KE_{end} (Elastic-scattering Protons)

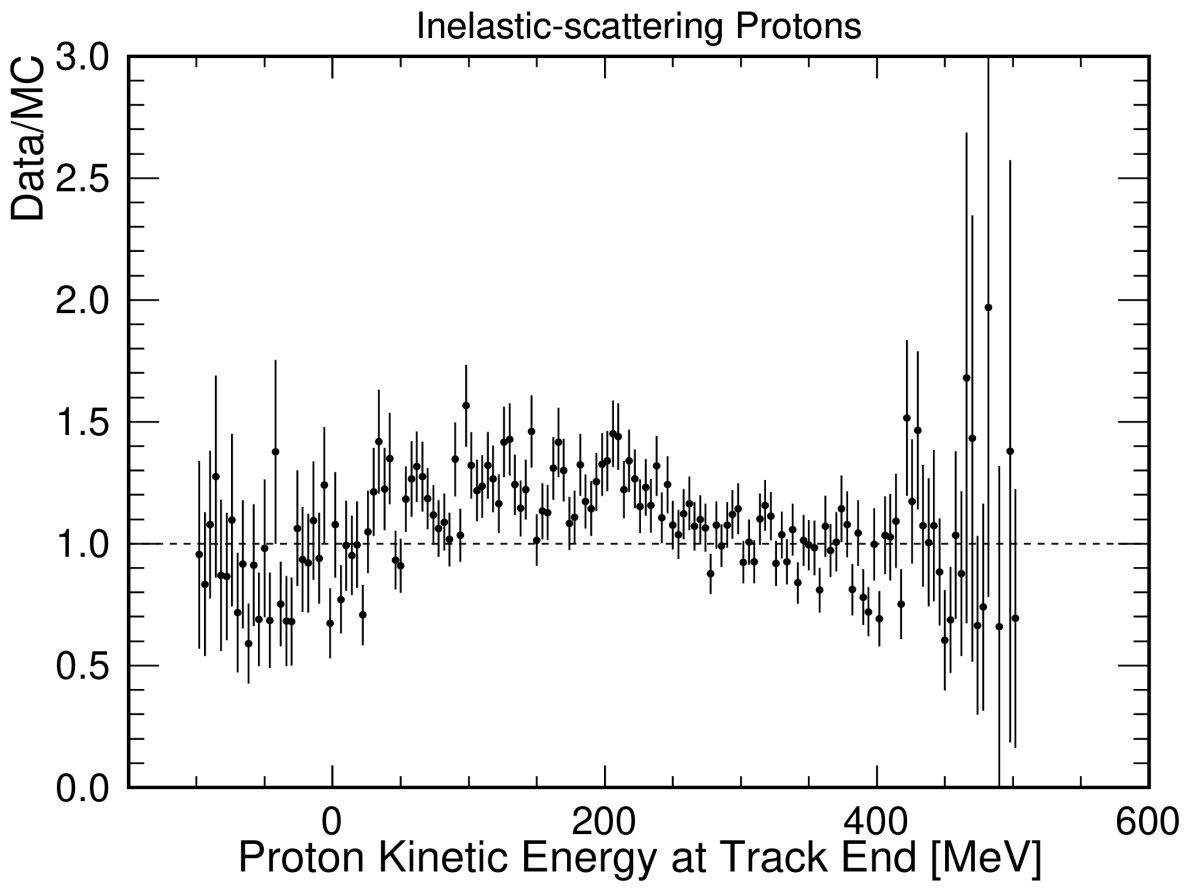




- MC is 10% wider than data

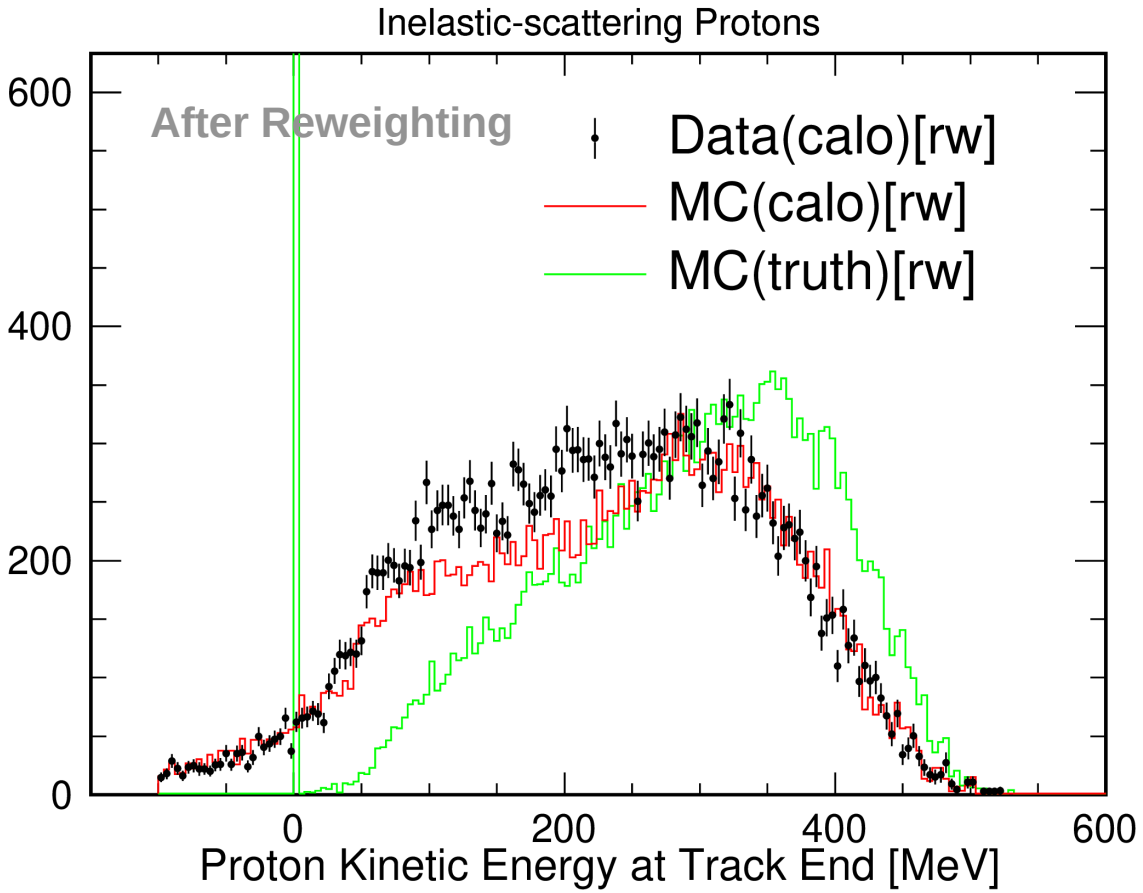
KE_{end} (Inelastic-scattering Protons)

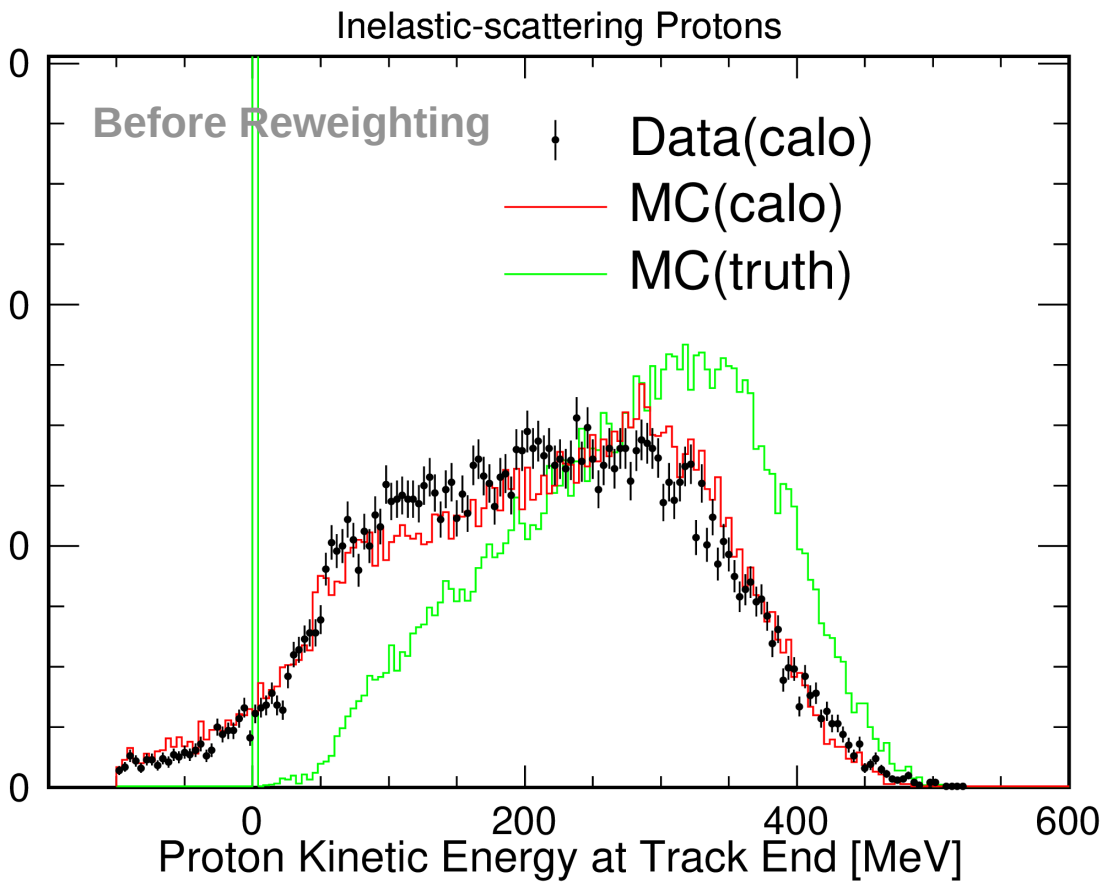




- Data>MC at 100-300 MeV: Same pattern has seen before, need investigation

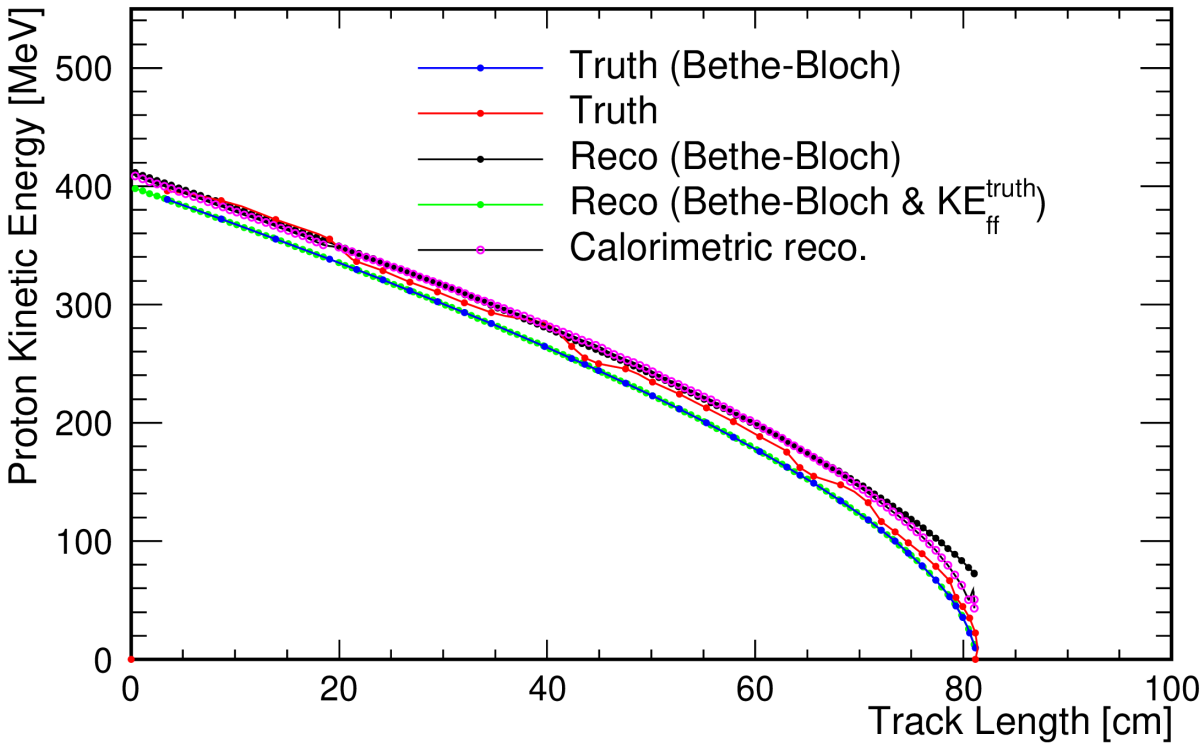
KE_{end} (Inelastic-scattering Protons)

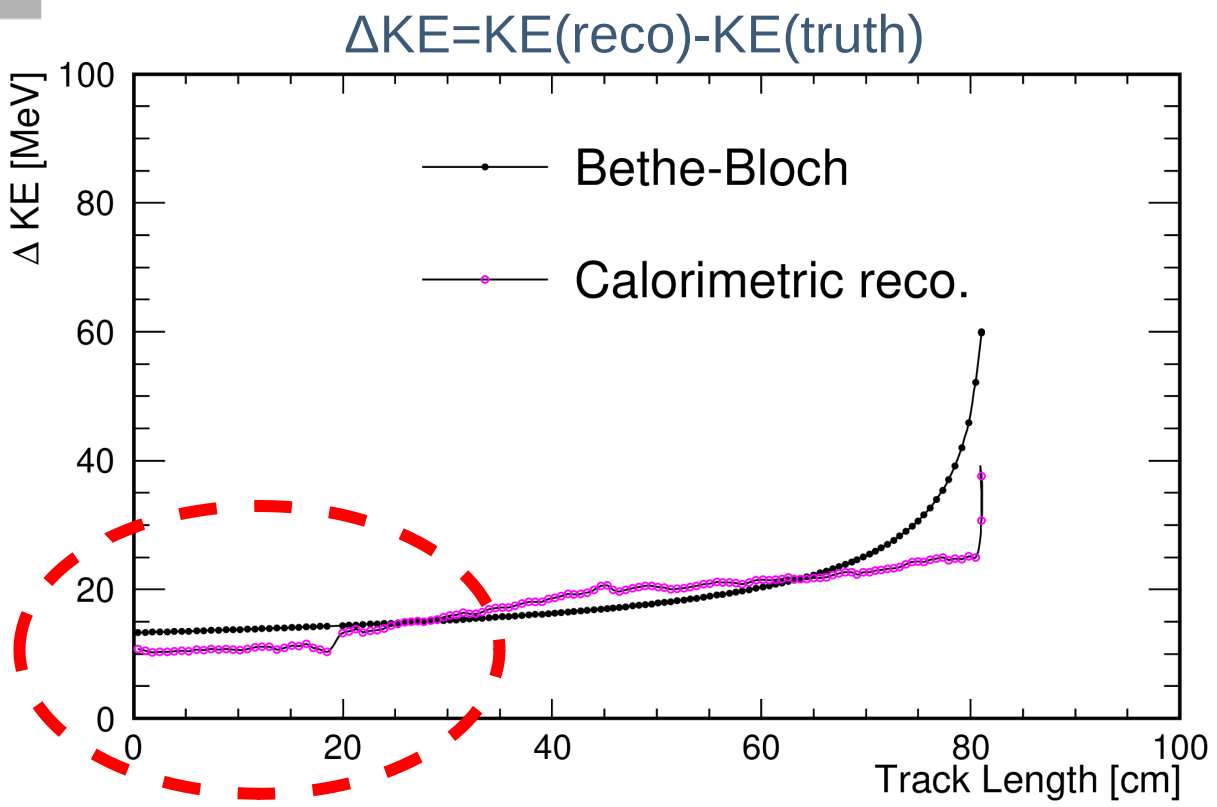




Calorimetric KE

Run: 21644123	Subrun: 406	Event: 1286	ID: 34





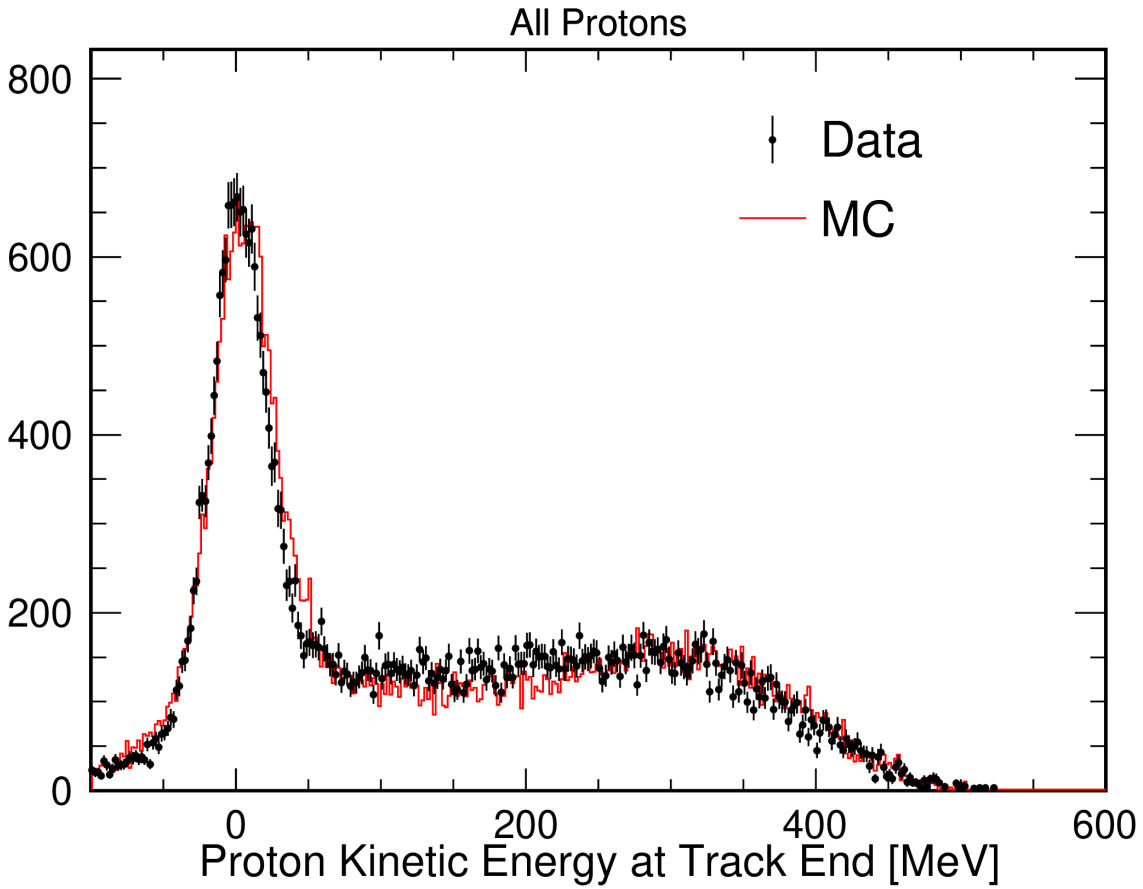
- Single event display for KEs
- Inspection on KE(calo):
  - → Gap in the short track area
  - → Data/MC might have different KE(calo) in short track length

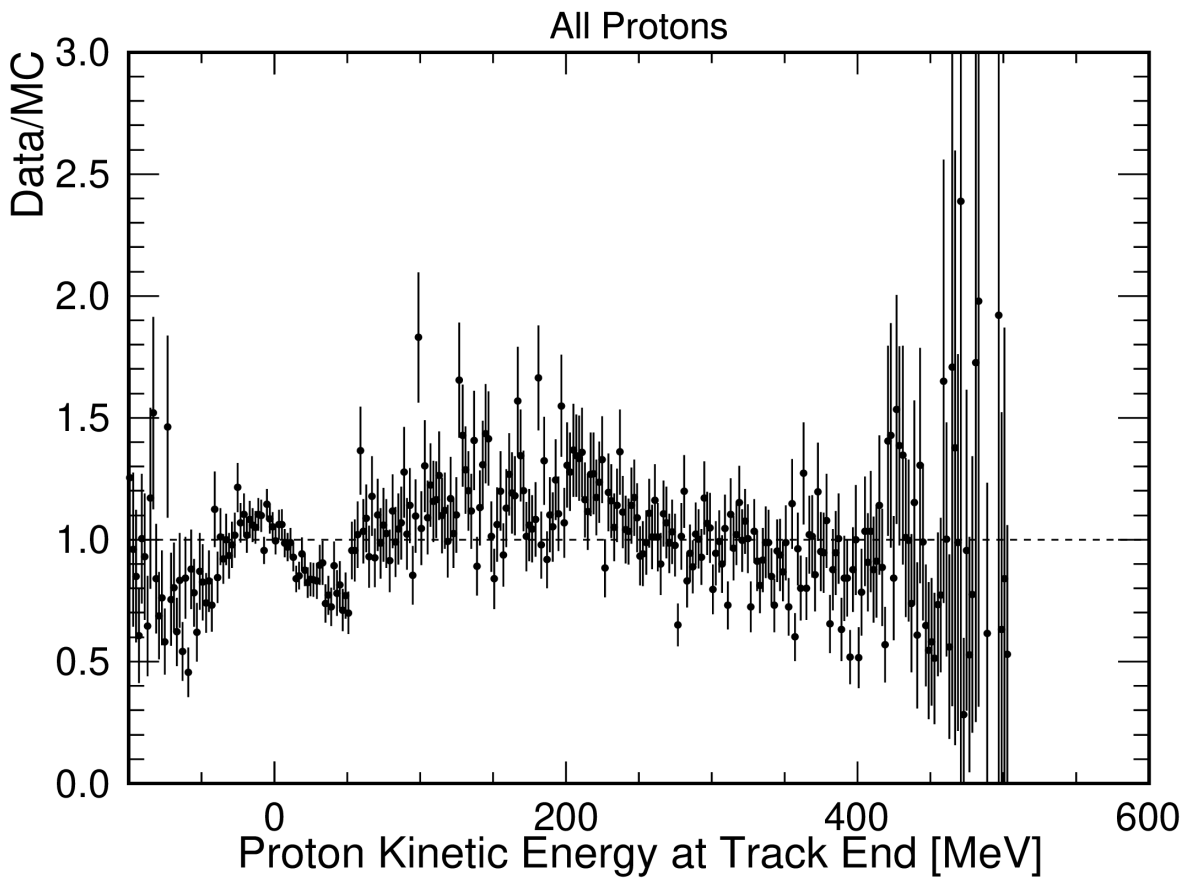
Summary

- Main issue on KE_{ff} systematics has been solved using data KE_{fit}
- Remaining KE issue:
  - Data/MC KE_{end} difference for inelastic- & elastic-scattering protons
- To do:
  -Investigate data/MC difference on KE_{end}(calo)
  -KE(Bethe-Bloch) as an alternative way for energy calculation

Backup

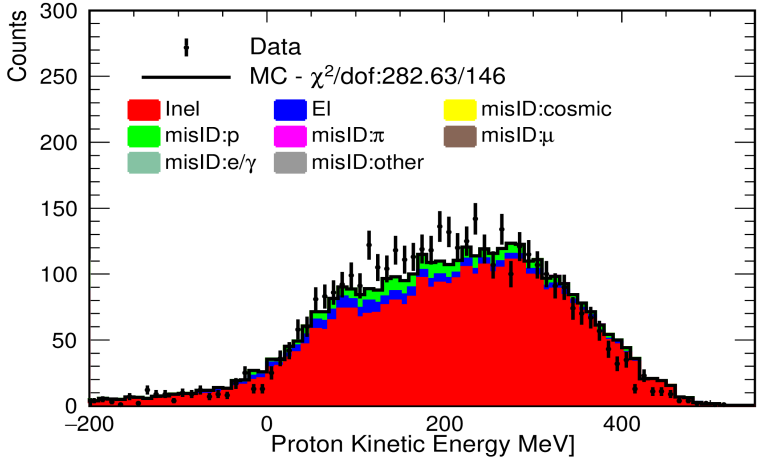
KE_{end} (All Protons)

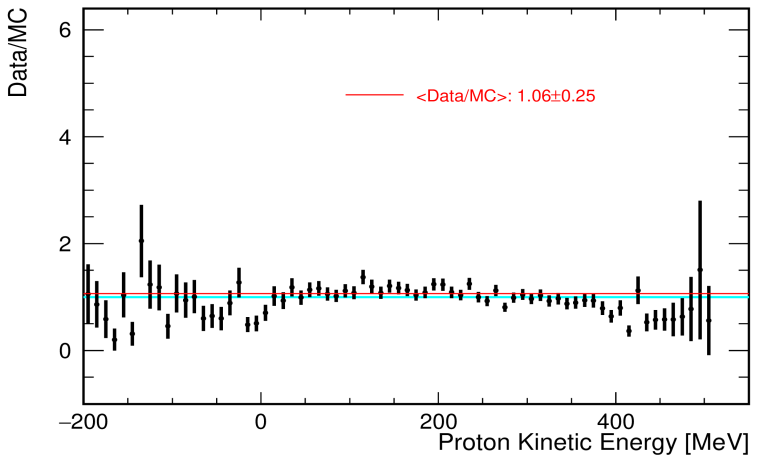




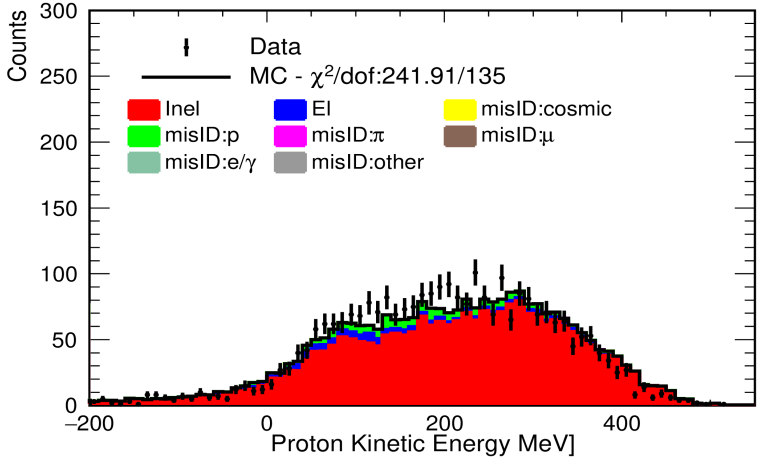
Inelastic Channel: Before/After Beam XY Cut

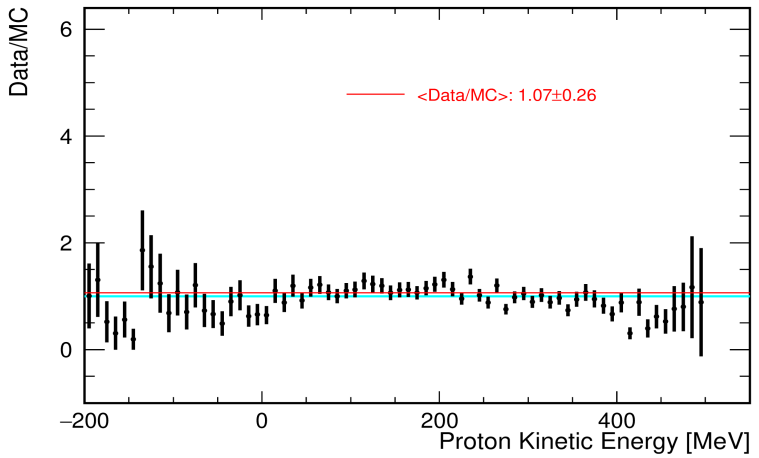
Before XY Cut





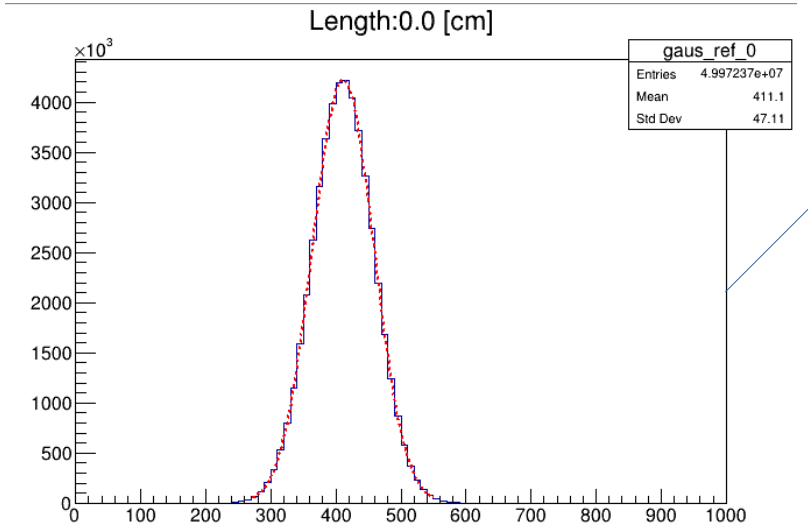
After XY Cut

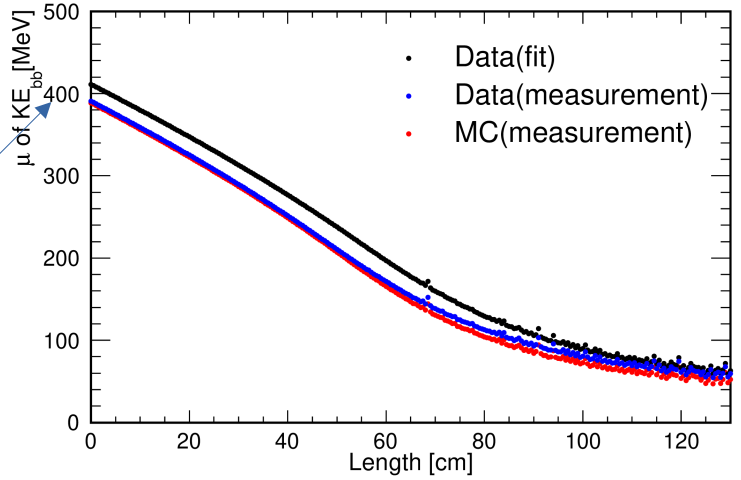


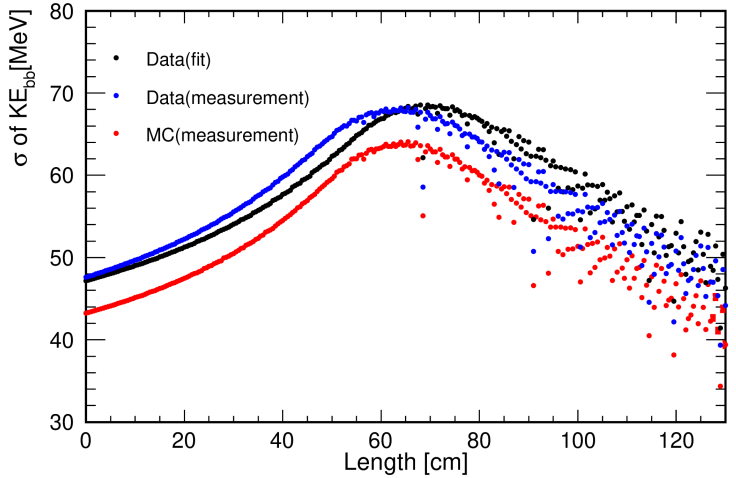


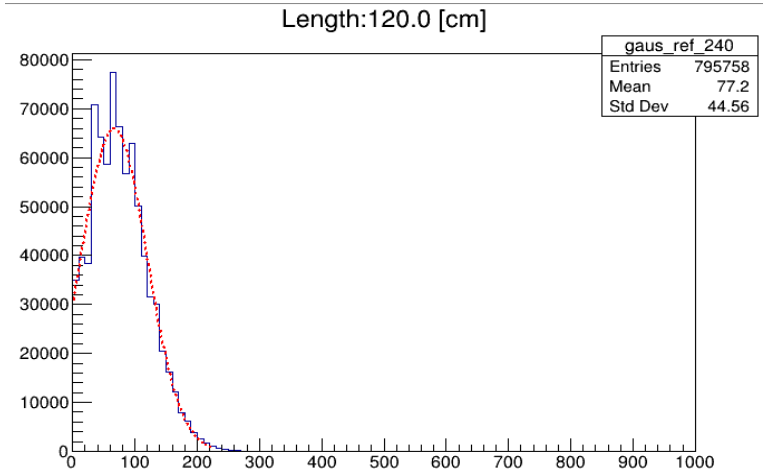
- Similar data/MC agreement after Beam XY cut

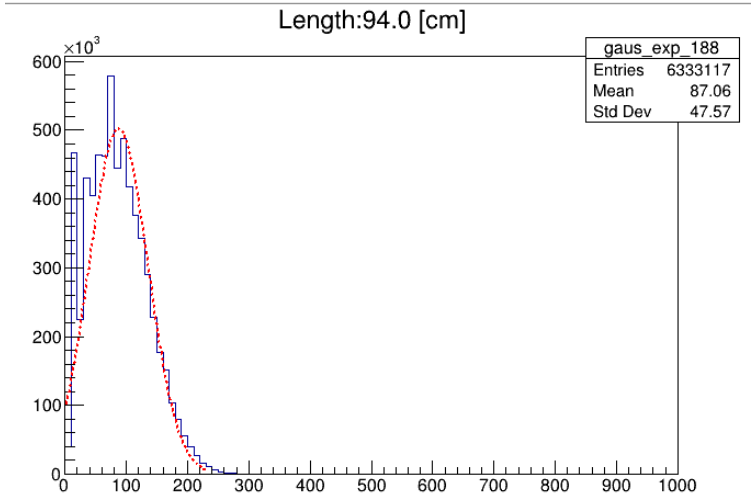
Weighting Function for KE_{bb}











- Build a weighting function for Bethe-Bloch based energy calculation