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

- Update on KE systematics
- Update on improving inelastic event selection

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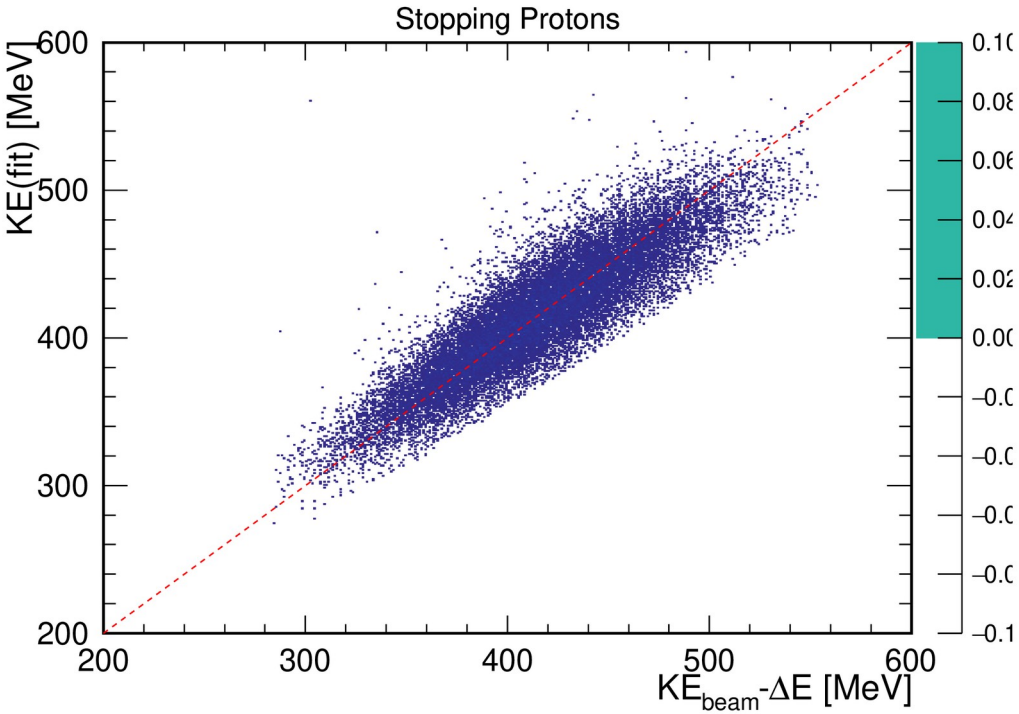
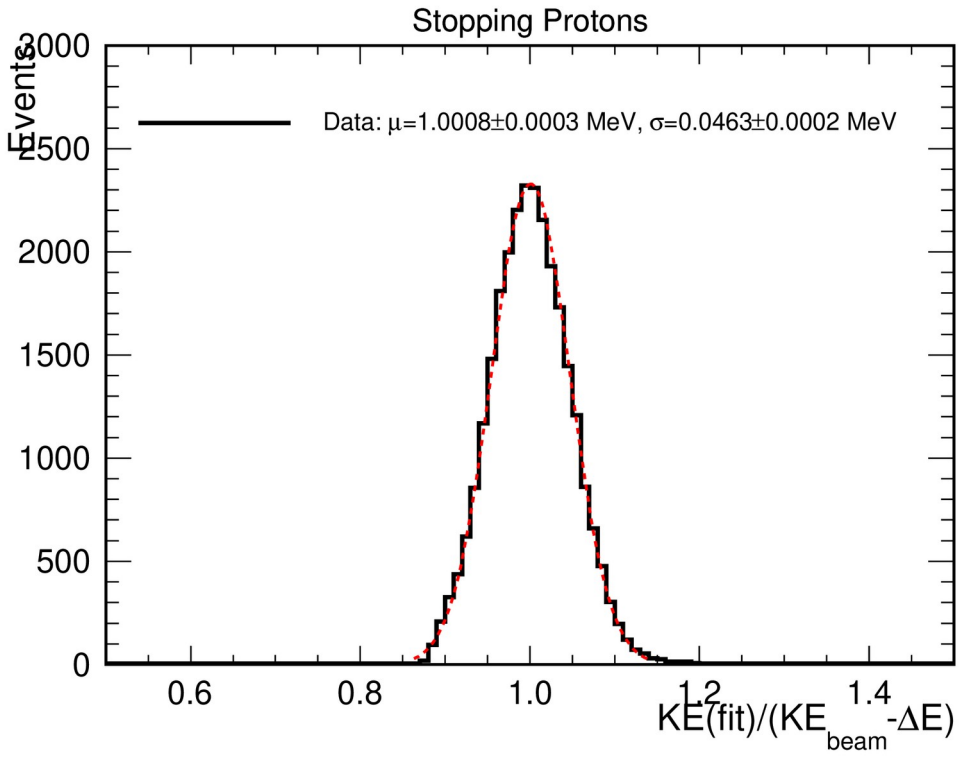
ProtoDUNE hadron-argon XS measurements

August 25, 2022

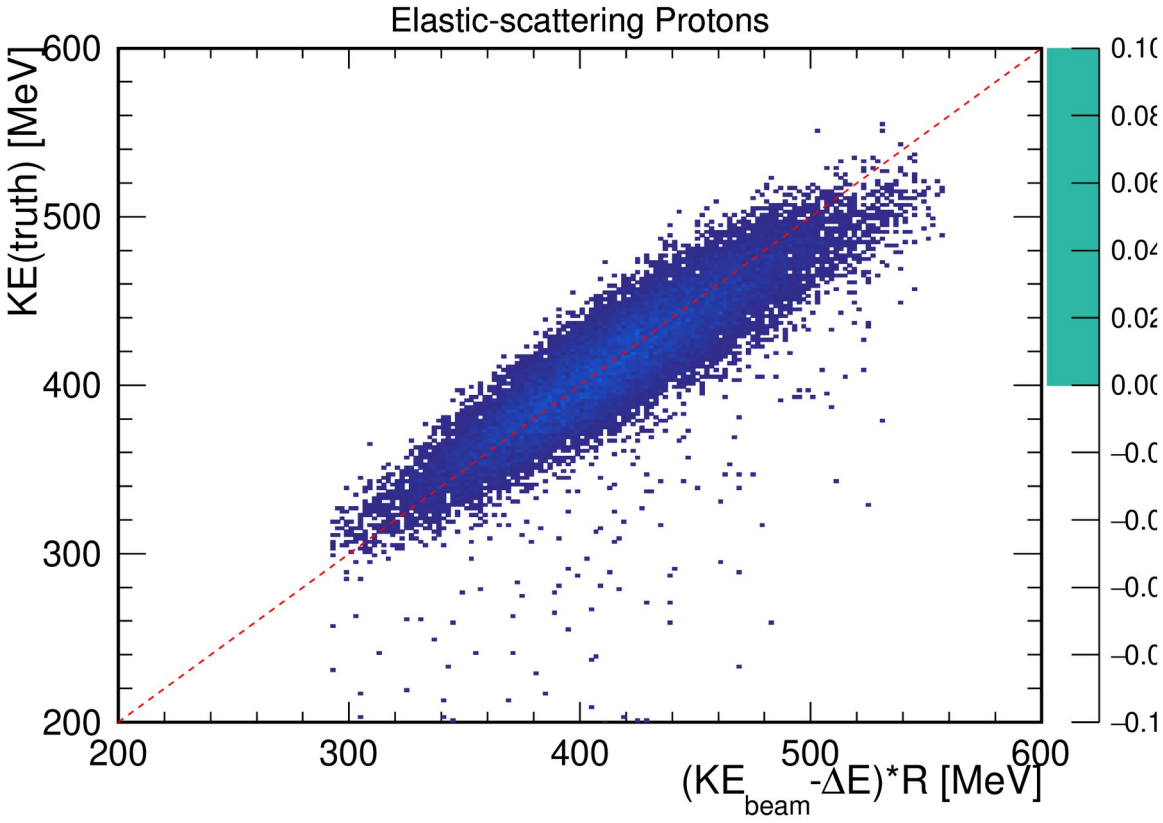
KE at TPC FF

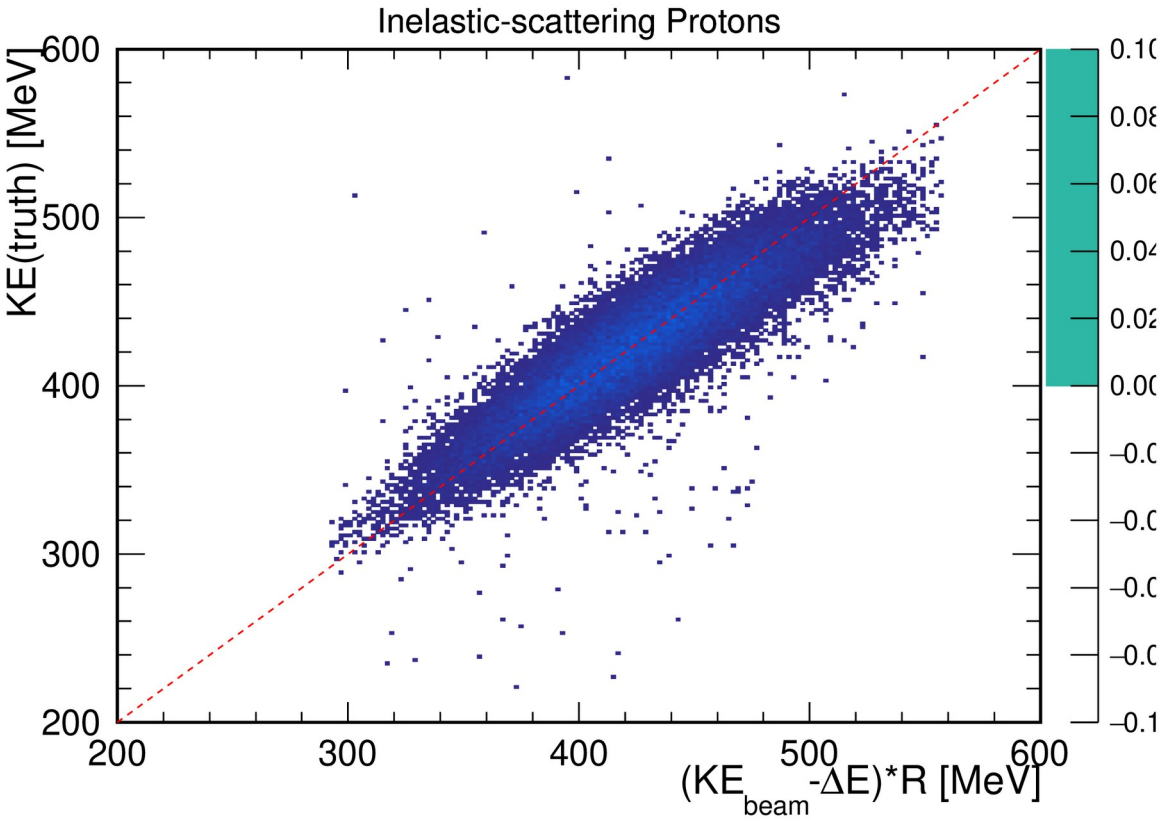




- Ratio between KE(fit) and KE$_{beam}$-ΔE around one showing that good assumption
  - ΔE is derived using the scanning method with KE(fit) on stopping protons

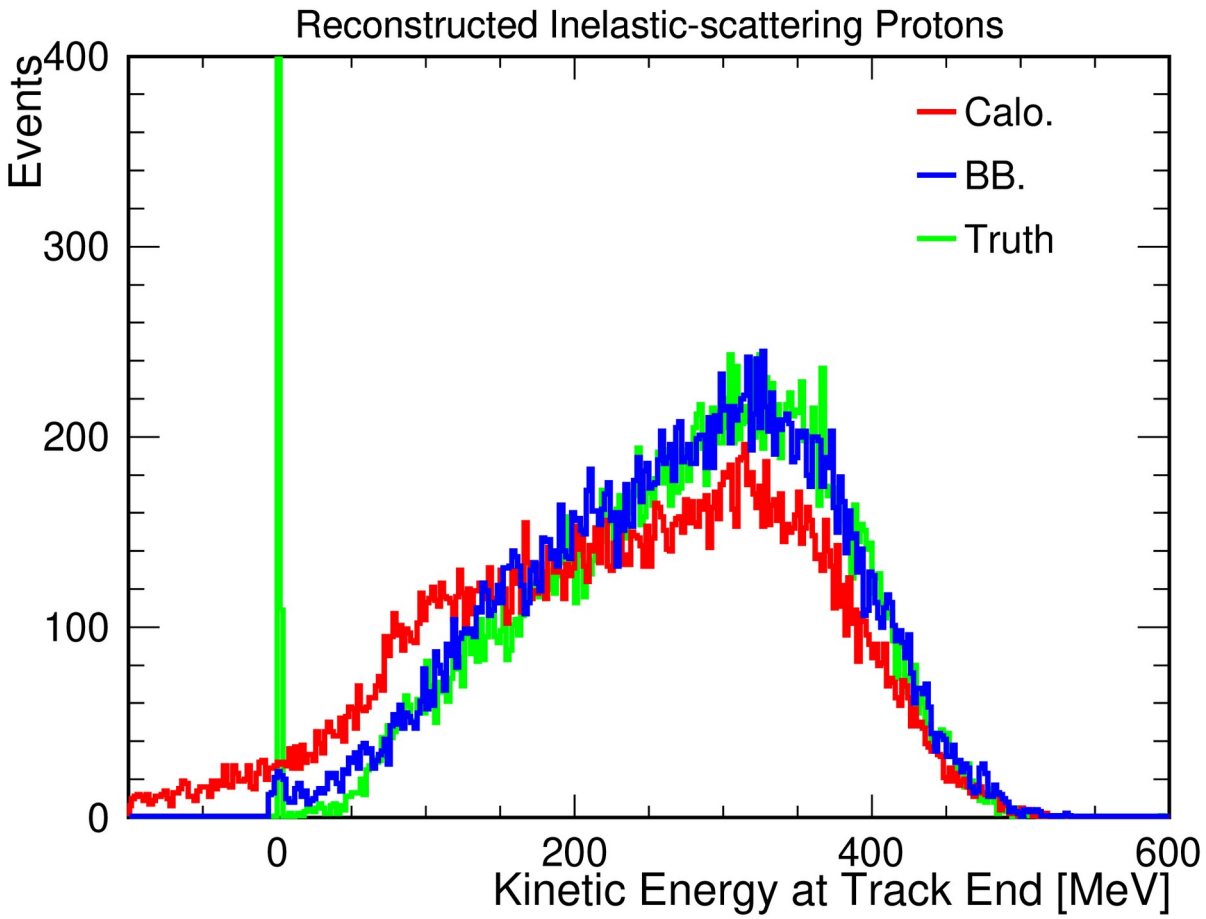
Reconstructed KE_{FF} after Ratio Correction

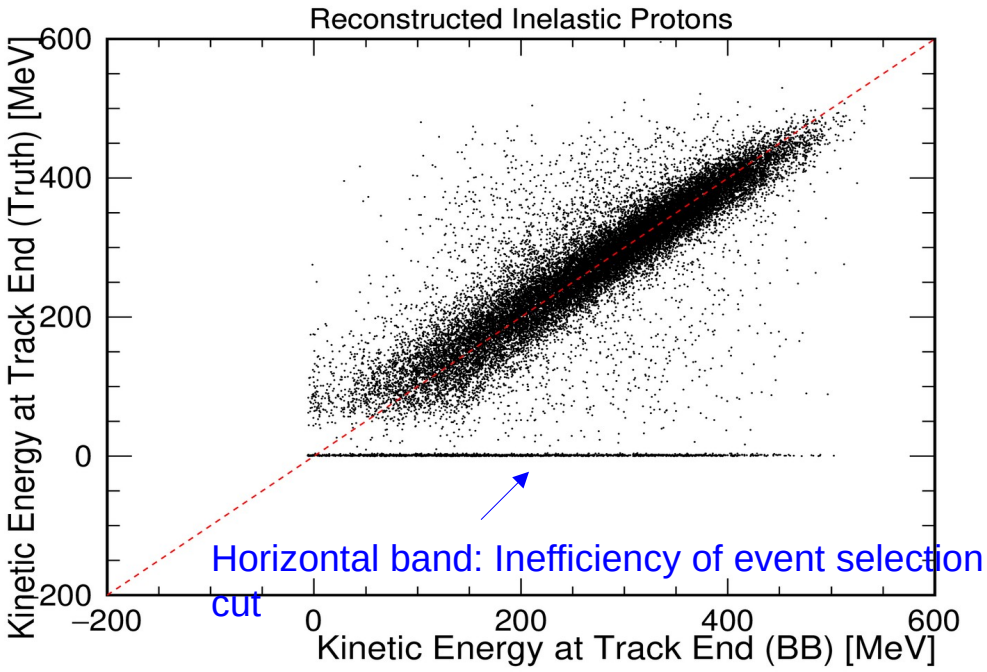


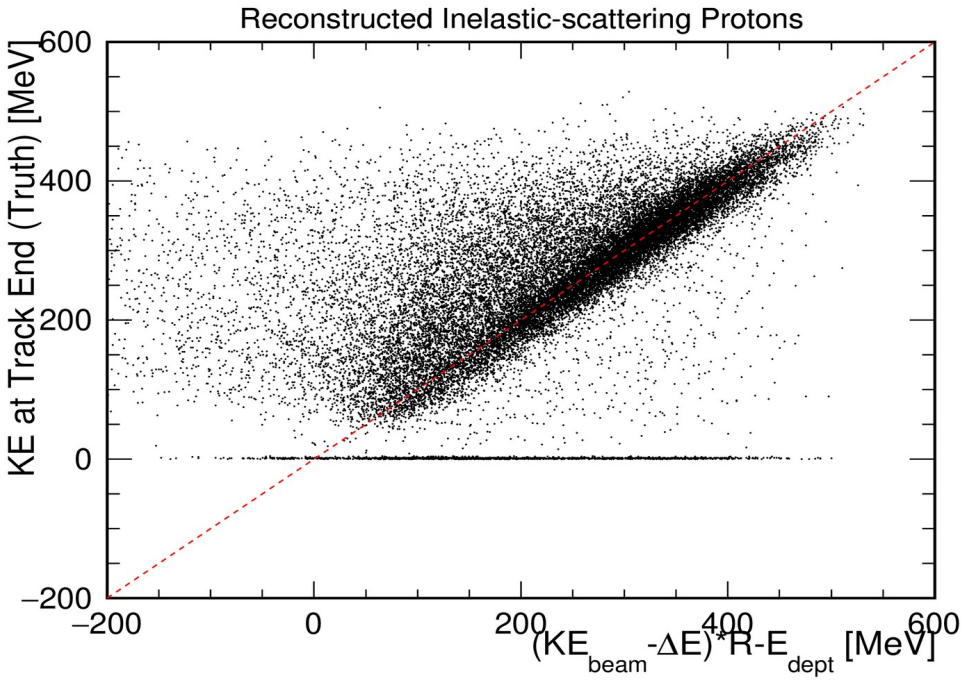


- Good KE_{FF}(reco) for both data and MC

KE at Track End (Reco. Inelastic Scatters)

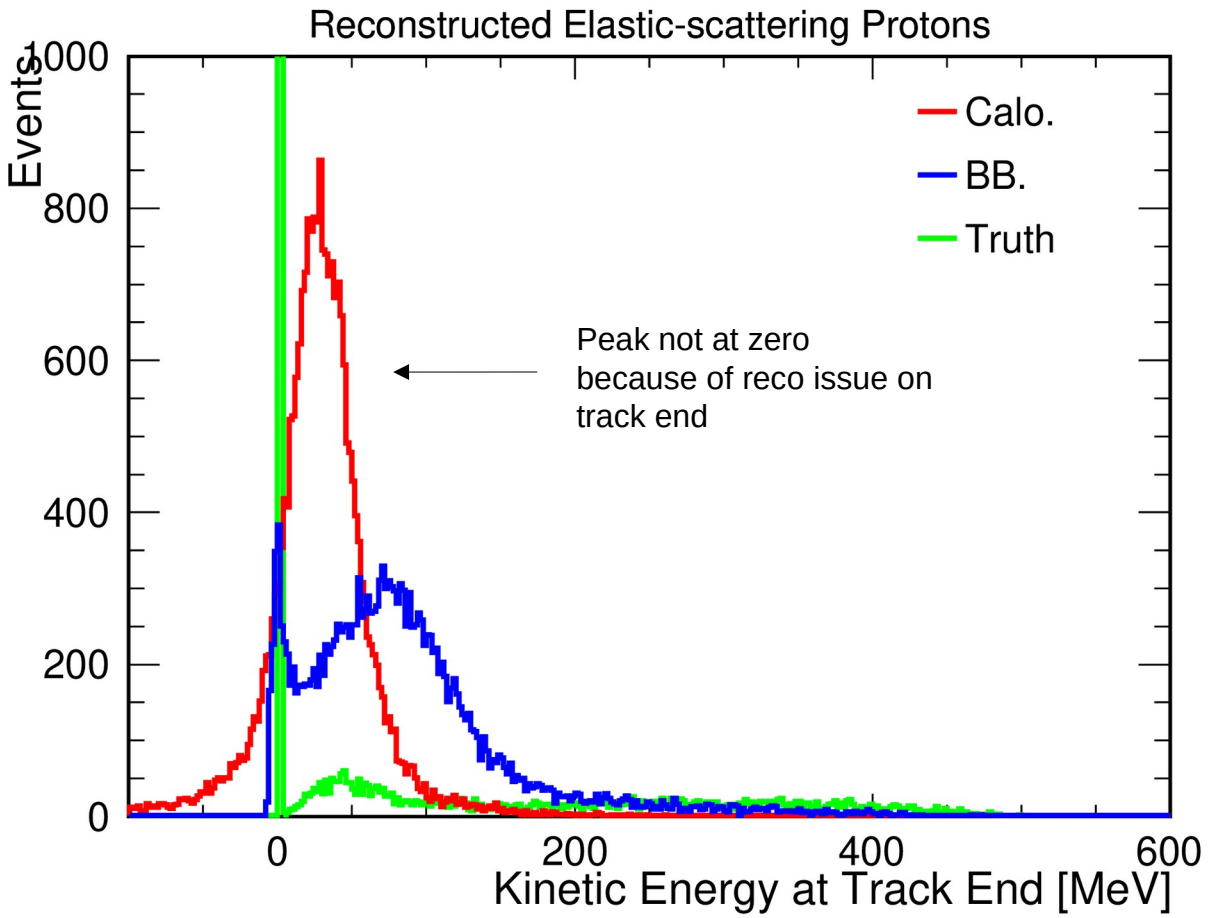




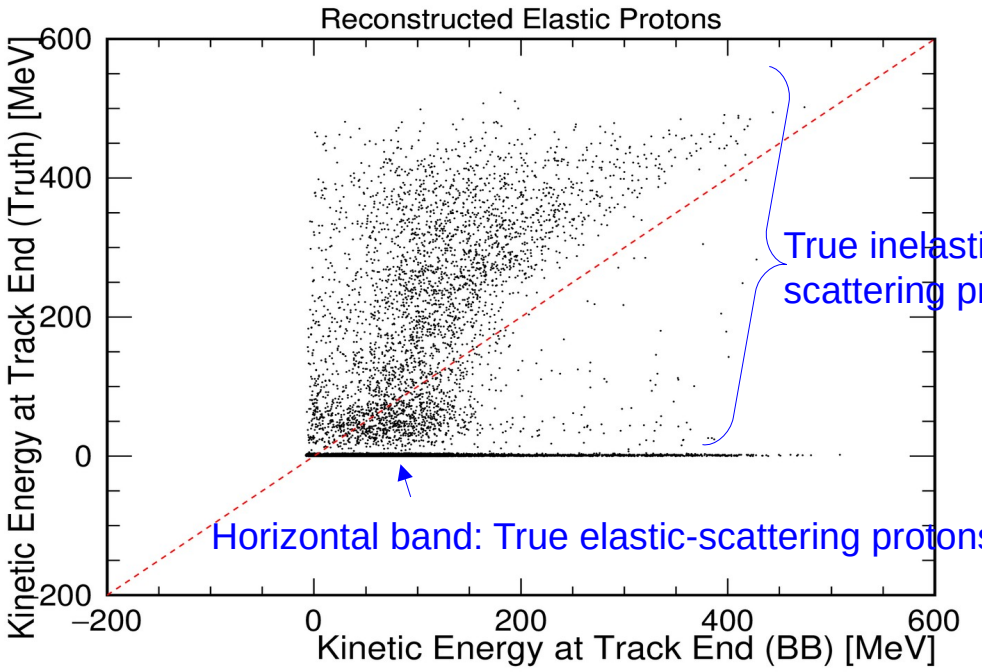


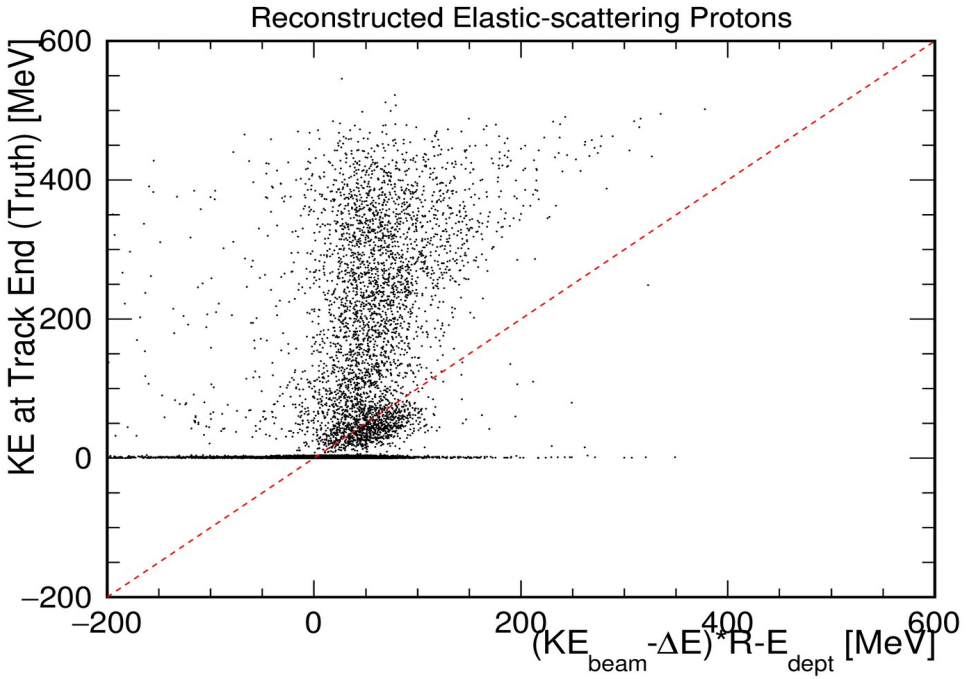
- Good KE(reco) at track end for inelastic-scattering protons
- KE_{bb} has a better reco performance

KE at Track End (Reco. Elastic Scatters)

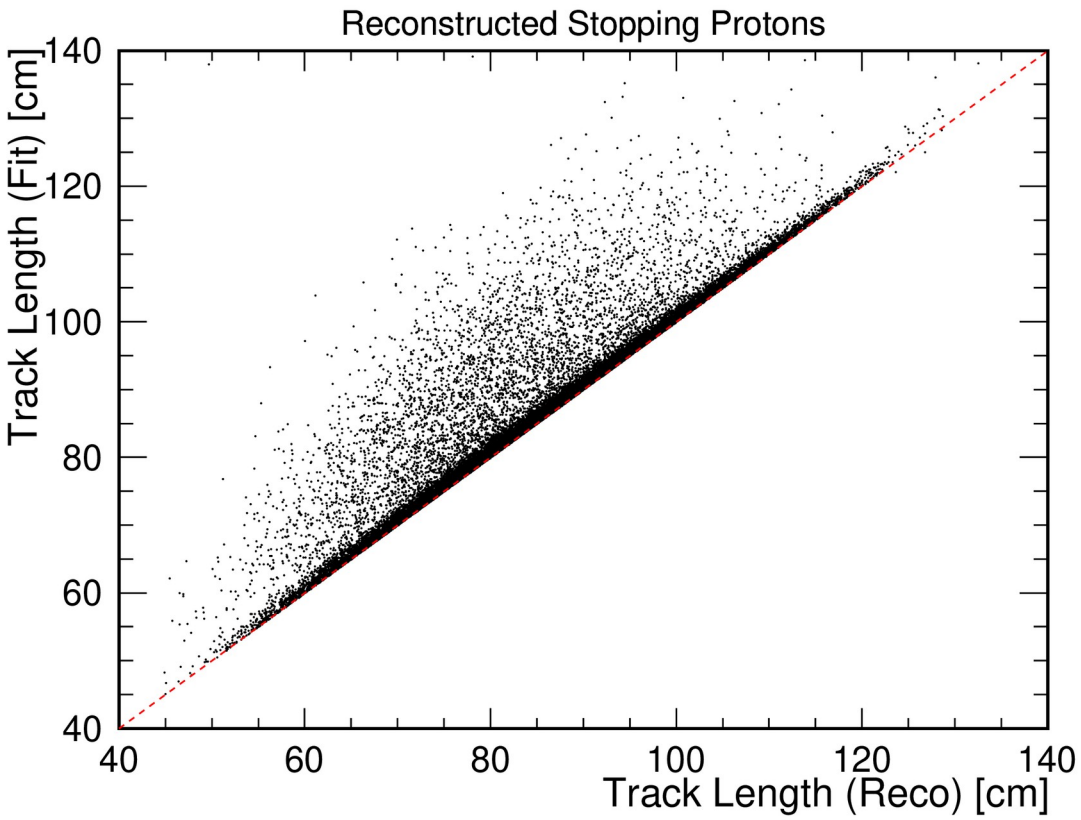


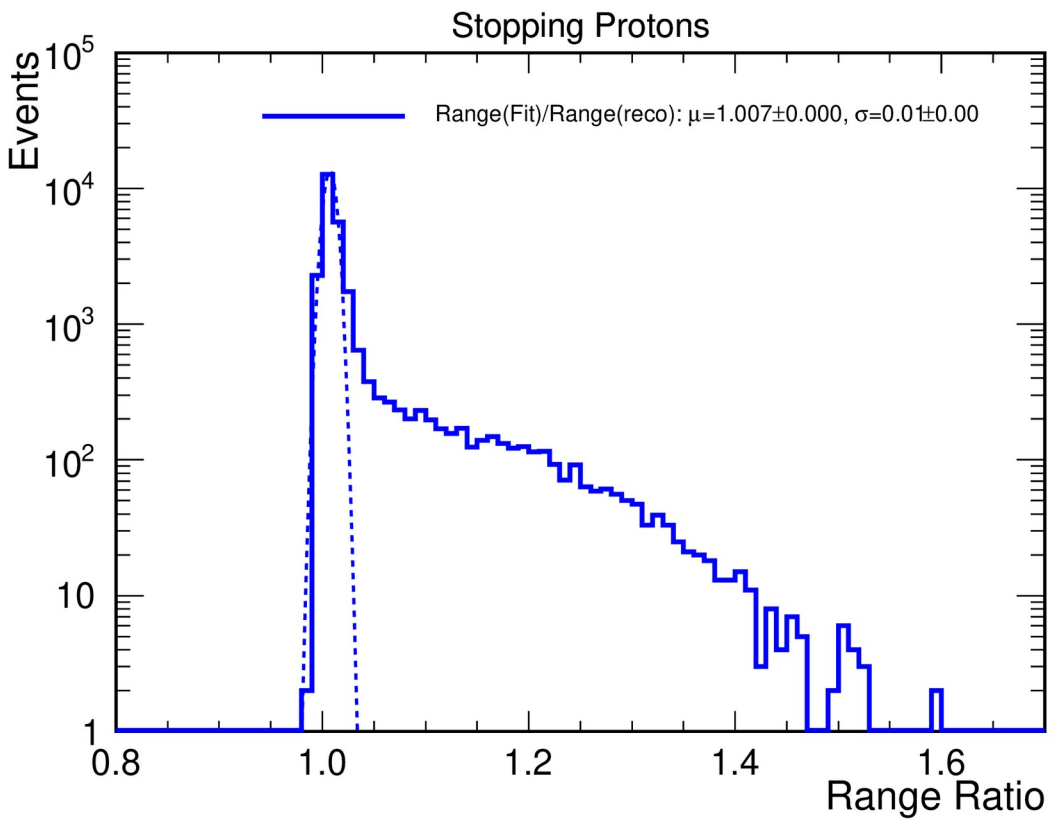
- KE_{calo} has a better resolution than KE_{bb}
- Bad KE_{bb} implied that reco track length has room for improvement (since KE_{ff} is well-reconstructed)





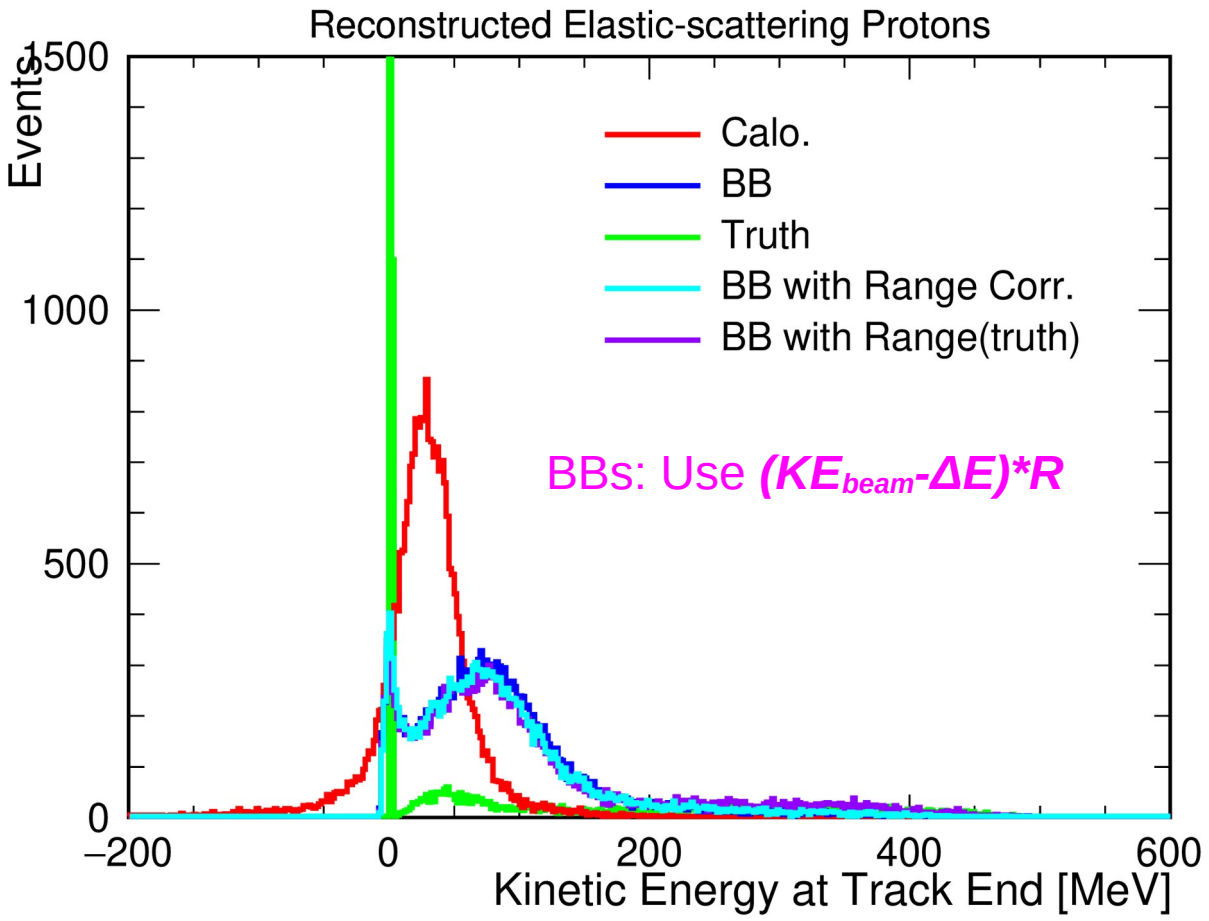
Range: Reco vs Fit (Stopping Protons)



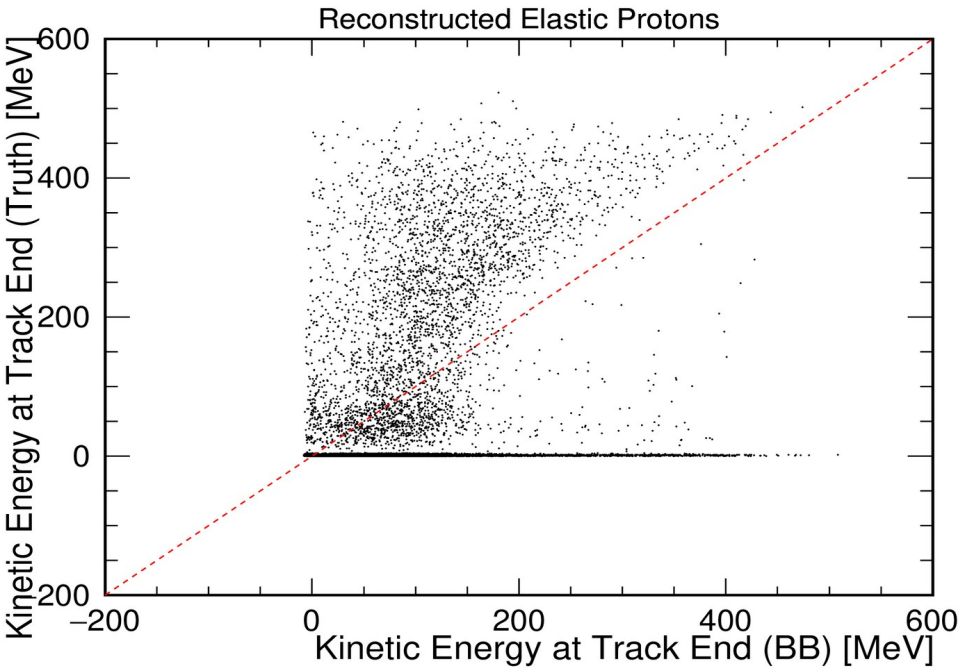


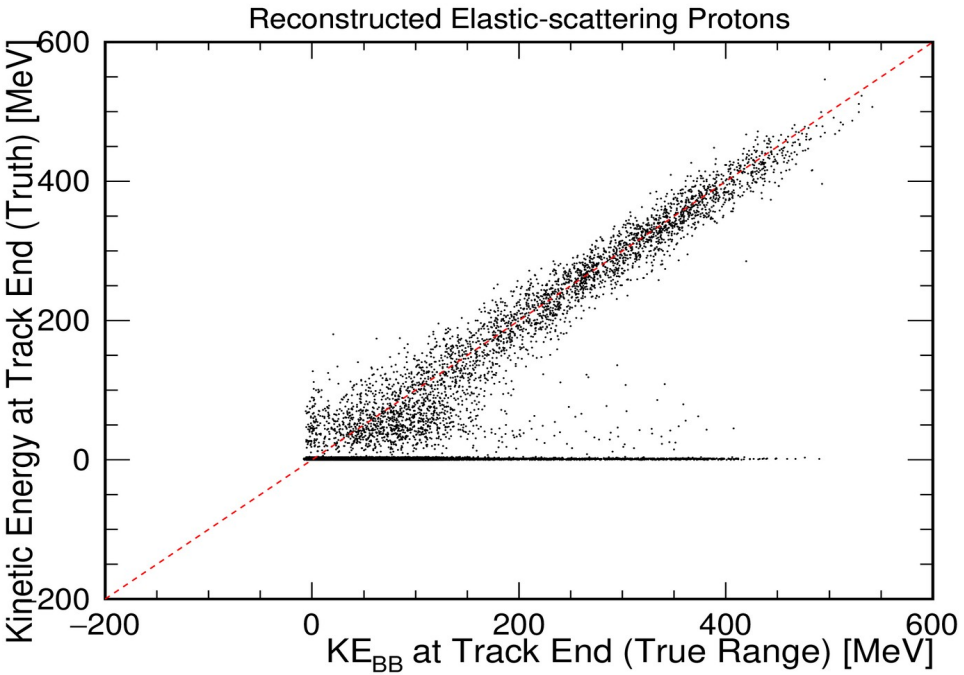
- Minor correction on reconstructed range

Range: Reco vs Truth

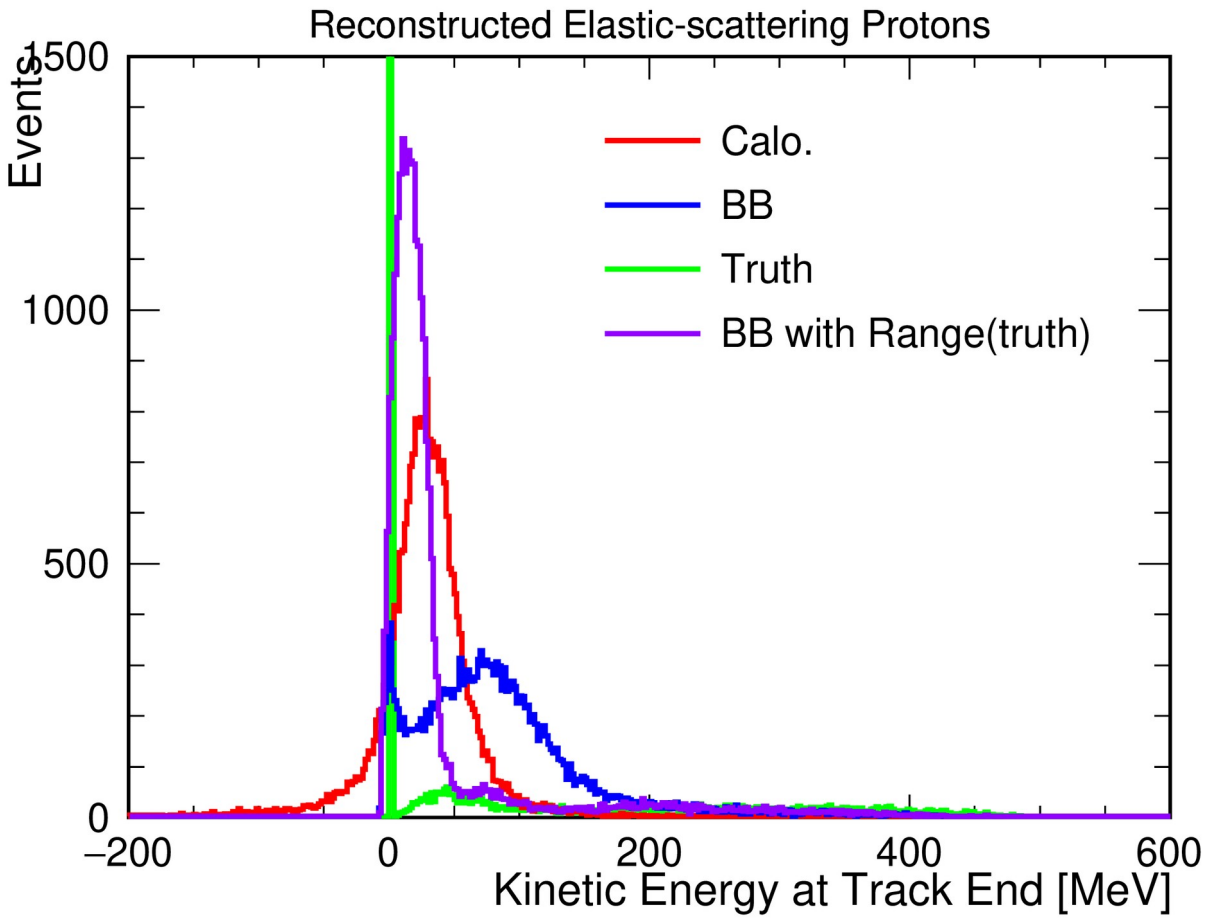


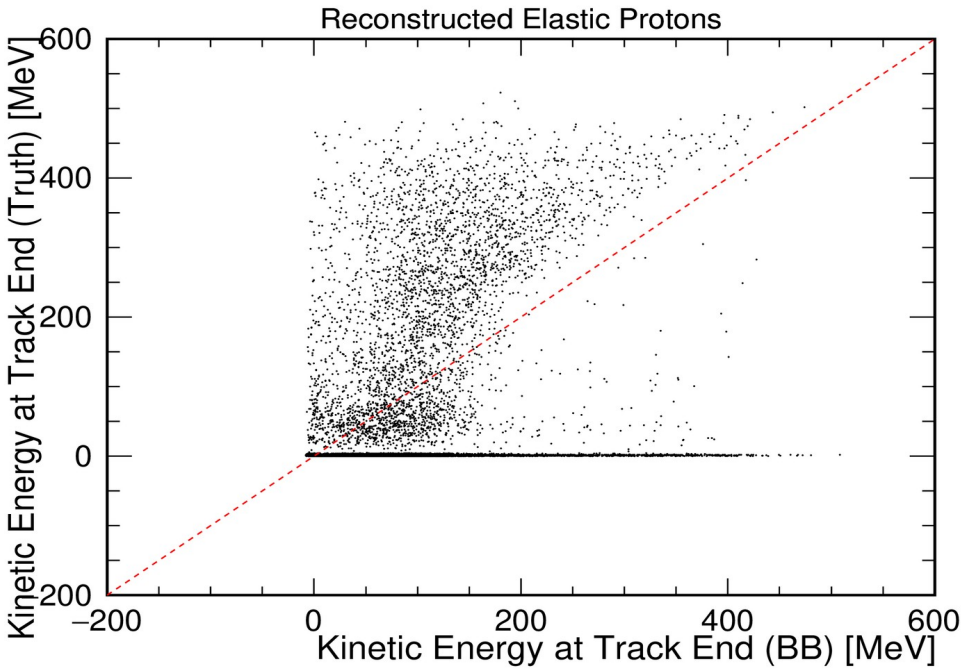
- A bit surprise to see no improvement on KE_{bb} with range-correction

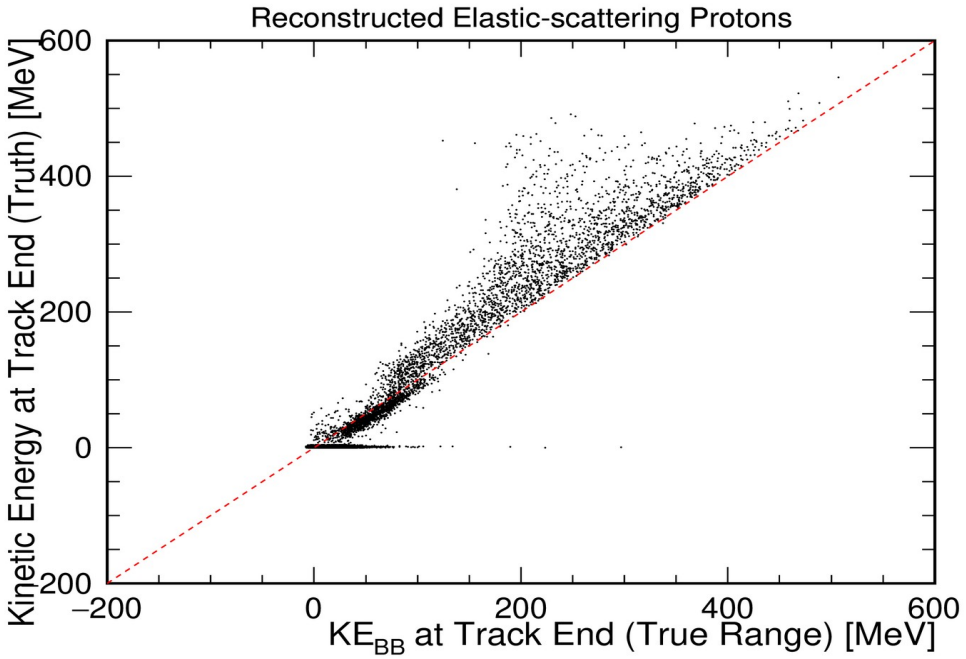




Range: Reco vs Truth

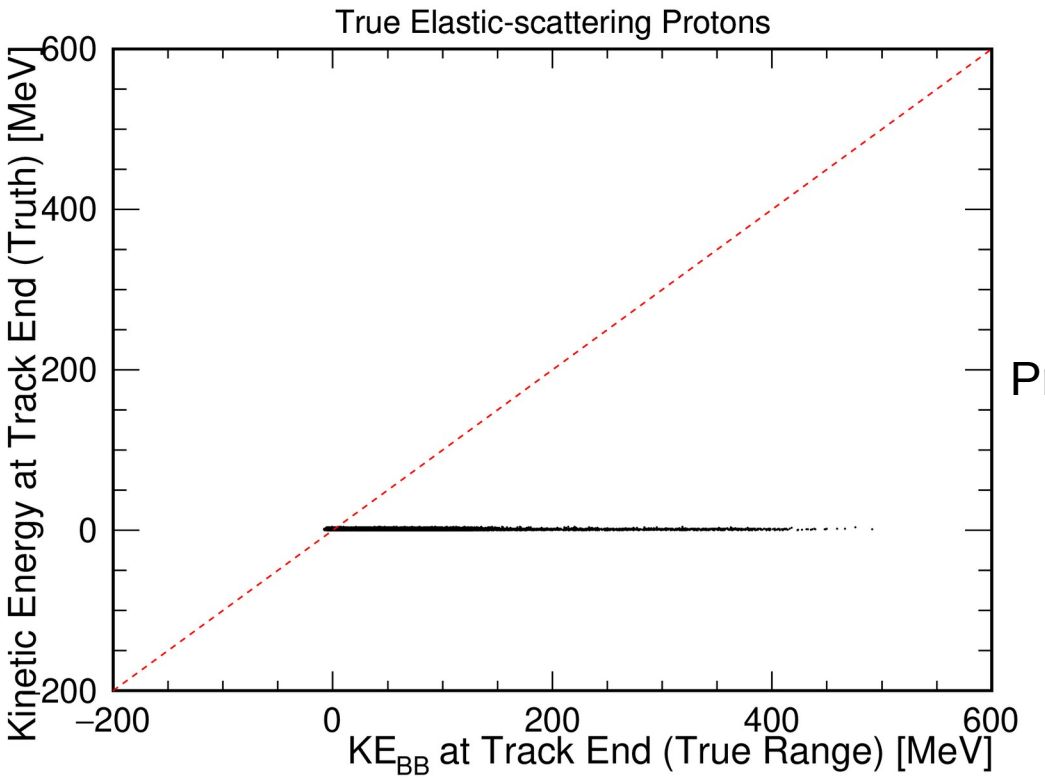




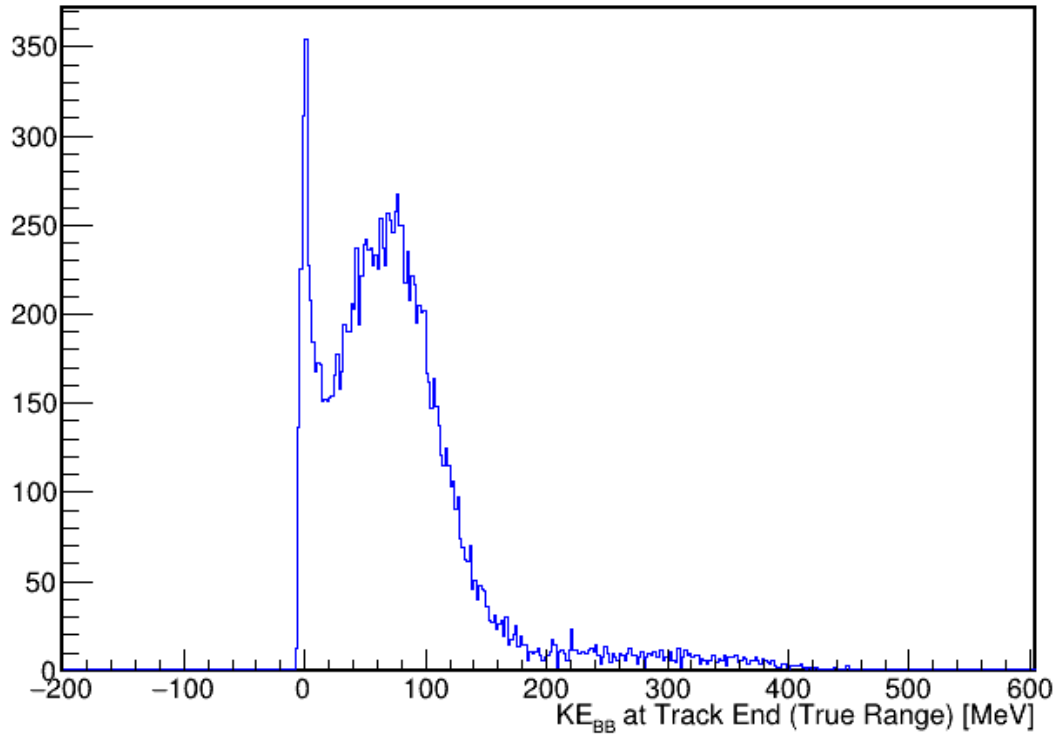


- KE_{bb} has improved resolution using KE_{FF}(truth) & Range(truth)

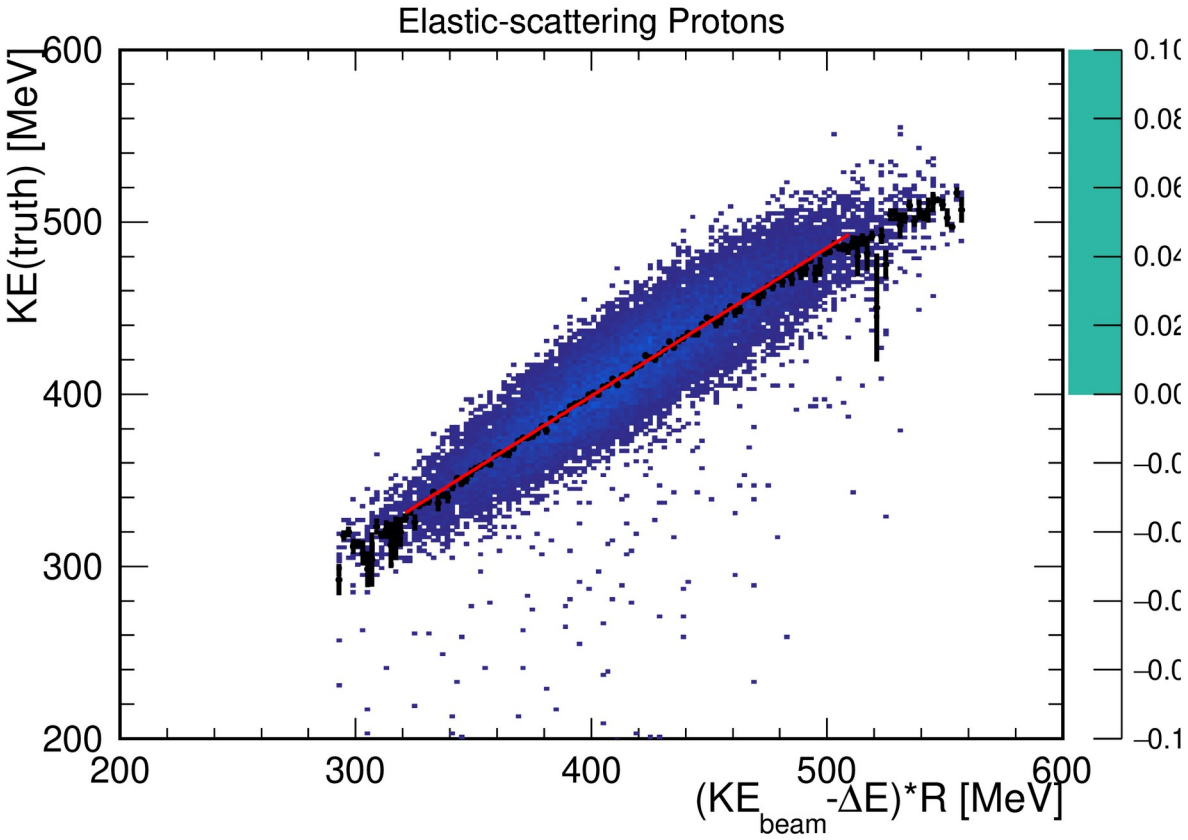
True Elastic-Scattering Protons

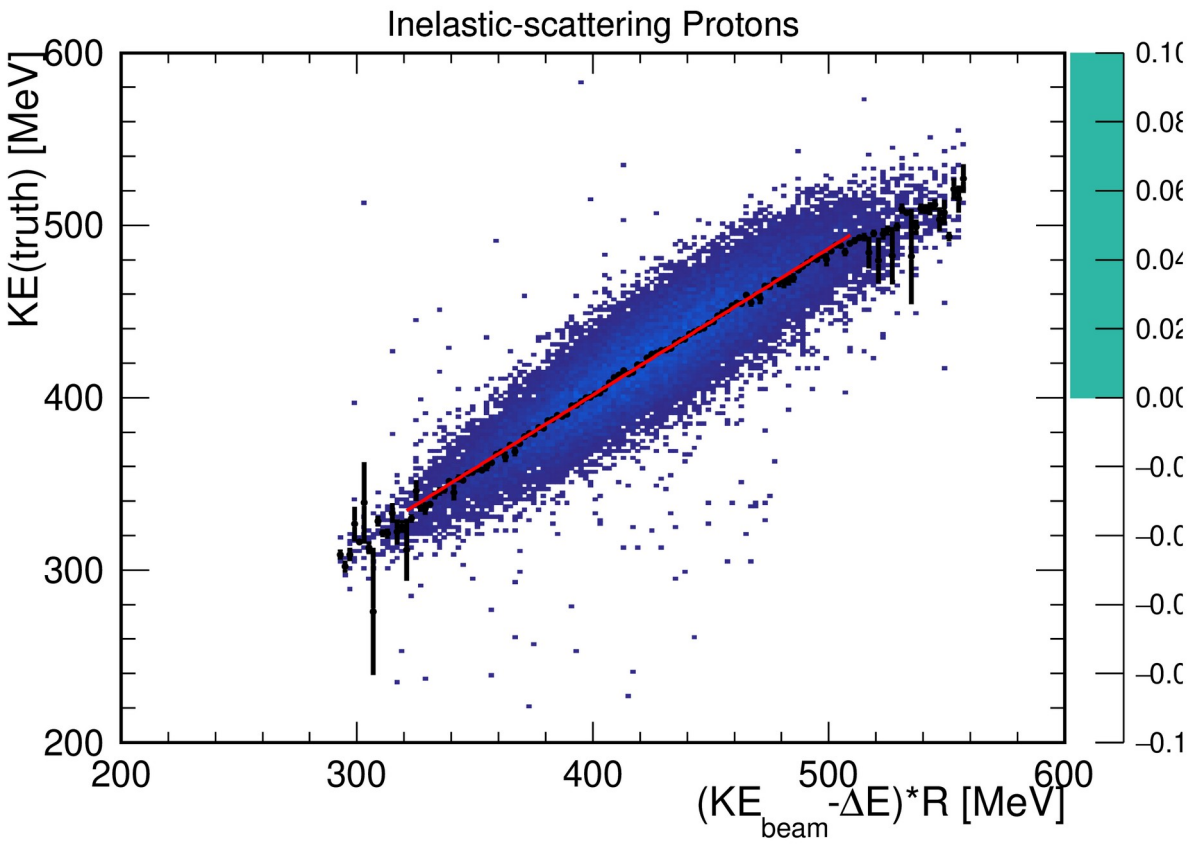


Projection on X



Reconstructed KE_{FF} vs KE_{FF} (Truth):



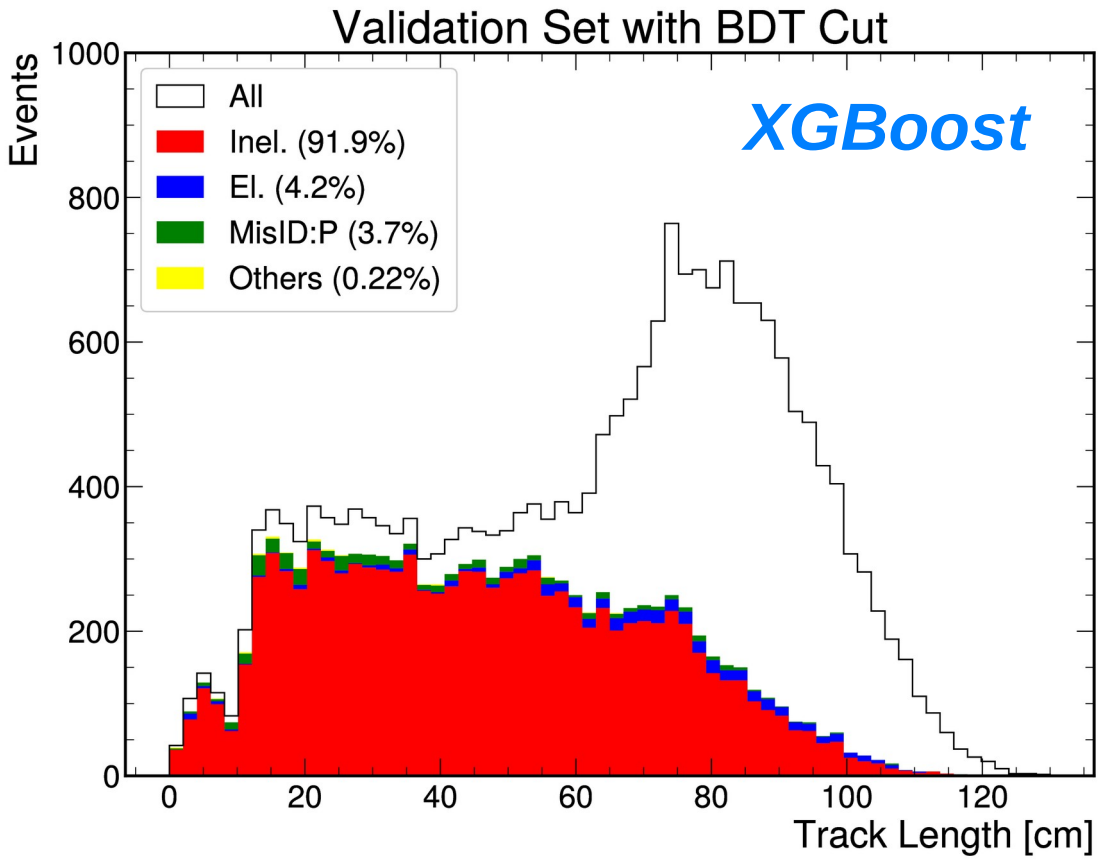


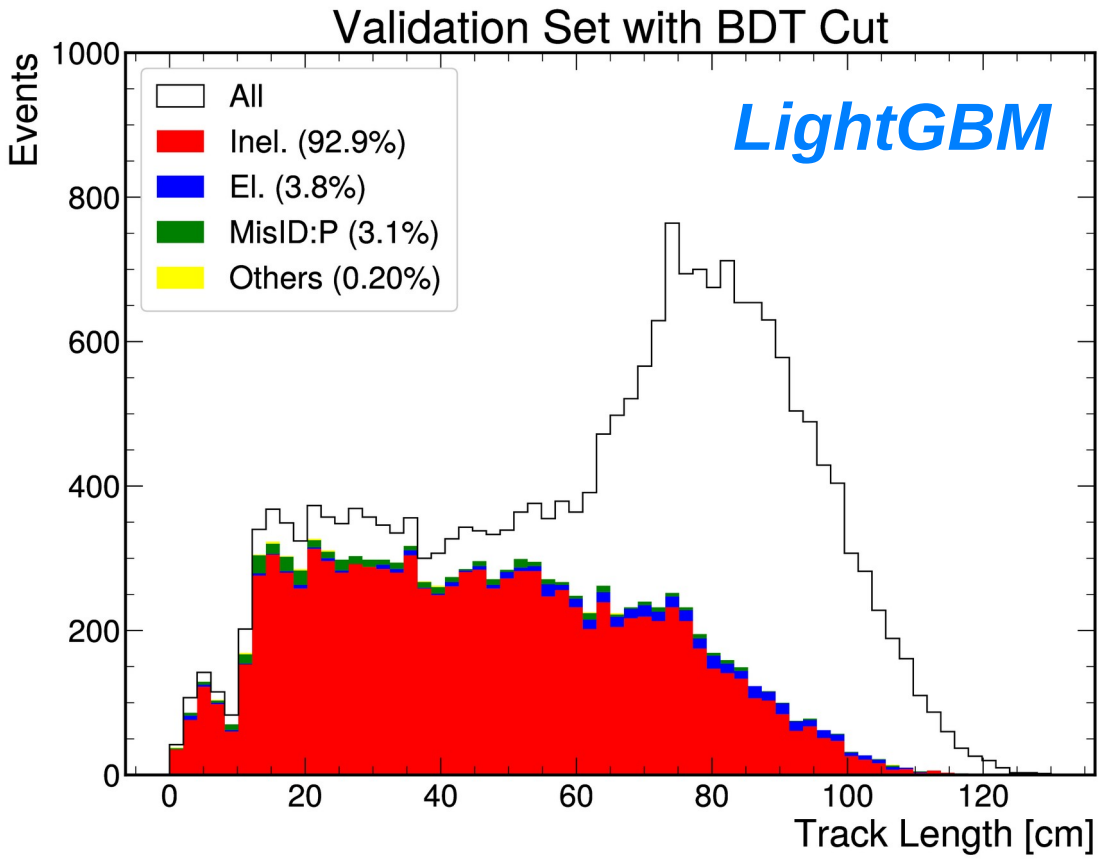

```
Minimizer is Linear / Migrad
Chi2                      =      139.588
NDf                       =           93
p0                        =      55.1626   +/-   1.52162
p1                        =     0.859605   +/-   0.00372839
```

```
Minimizer is Linear / Migrad
Chi2                      =      163.871
NDf                       =           93
p0                        =      61.6651   +/-   1.28207
p1                        =     0.849729   +/-   0.00306889
```

- Additional correction needed?

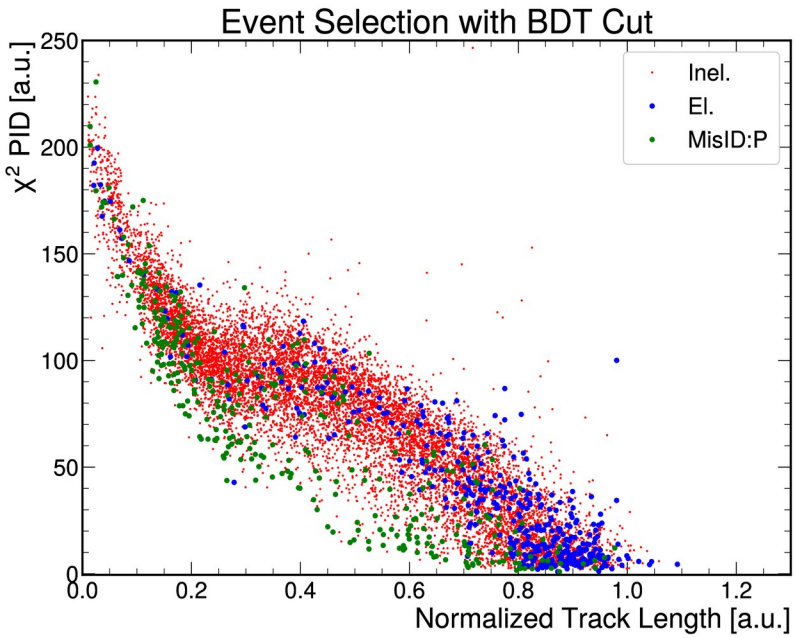
Decision Tree using LightGBM

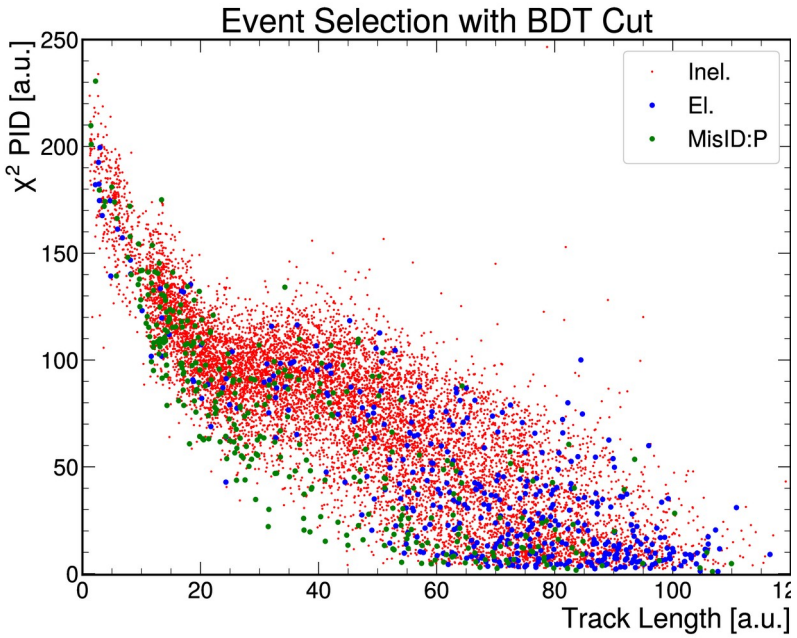


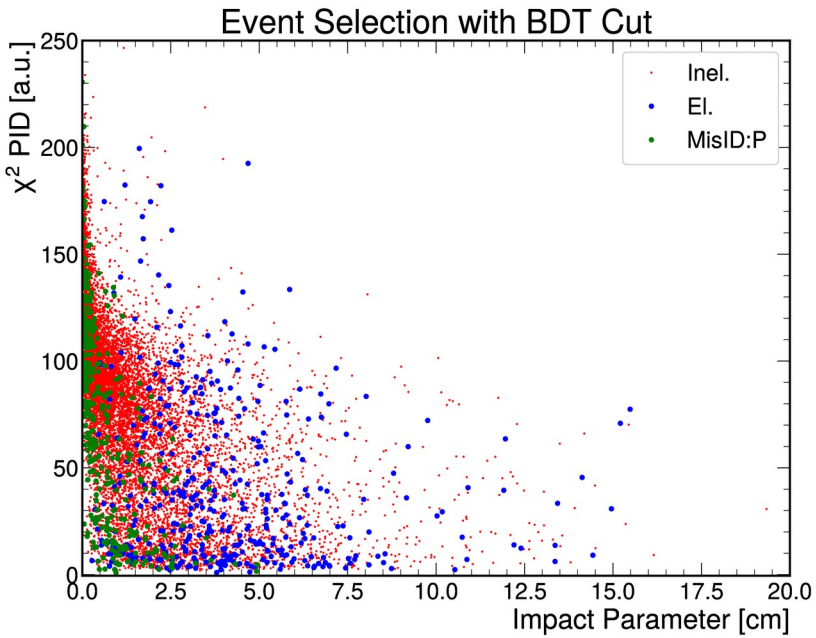


- LightGBM always have a better performance that XGBoost but with much slower training time (~16 min.)

Selected Inelastic Events: Signal & Background







- Will be hard to cut out remaining backgrounds using current observables
- We do have change to remove more backgrounds by adding more energy-related observables (i.e. KE_{bb}, KE_{ff}, KE_{calo}, ...)