

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

- Update on KE systematics

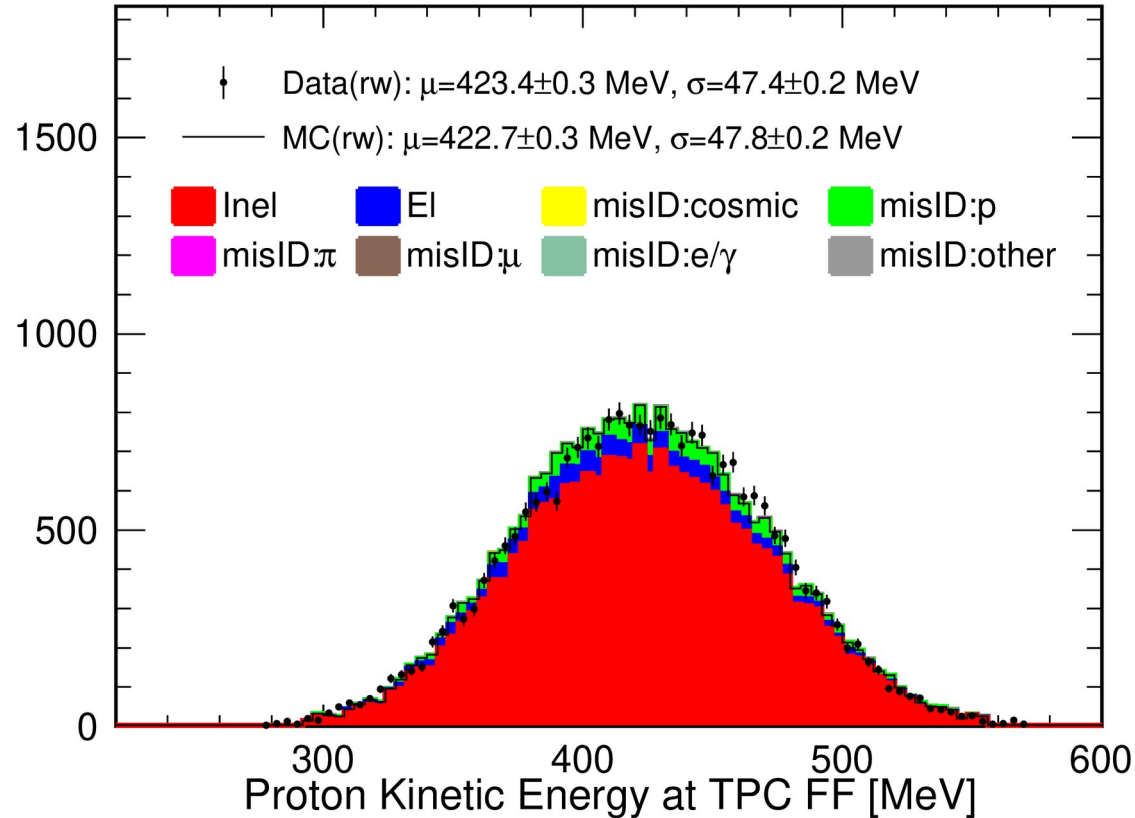
Heng-Ye Liao

ProtoDUNE hadron-argon XS measurements

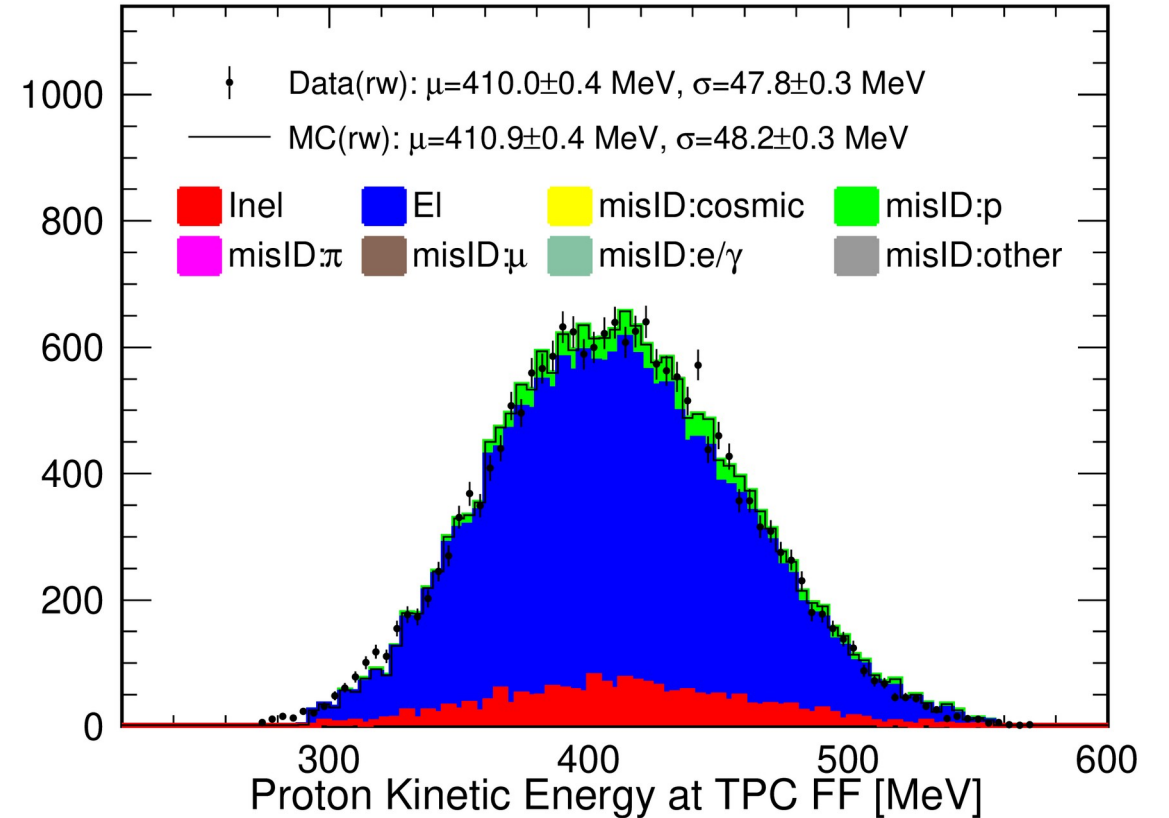
Sep 1, 2022

KE_{ff} with Const E-loss Assumption

Inelastic-scattering Protons



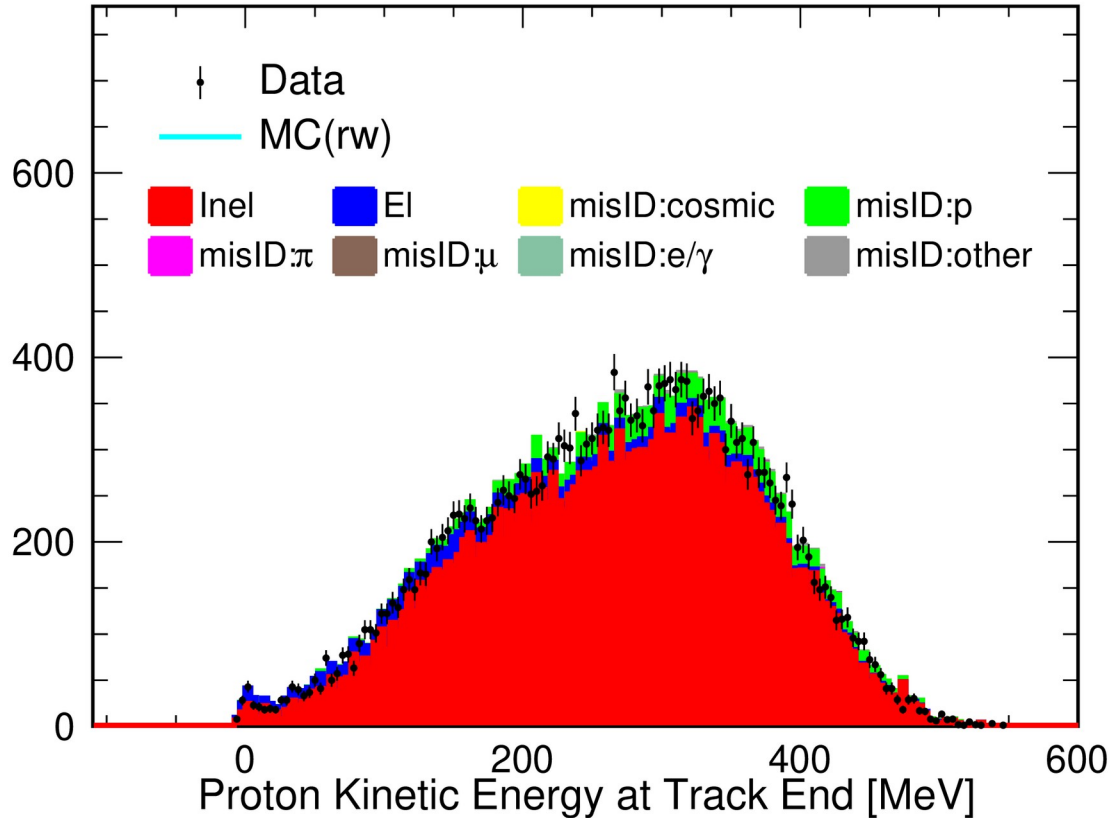
Elastic-scattering Protons



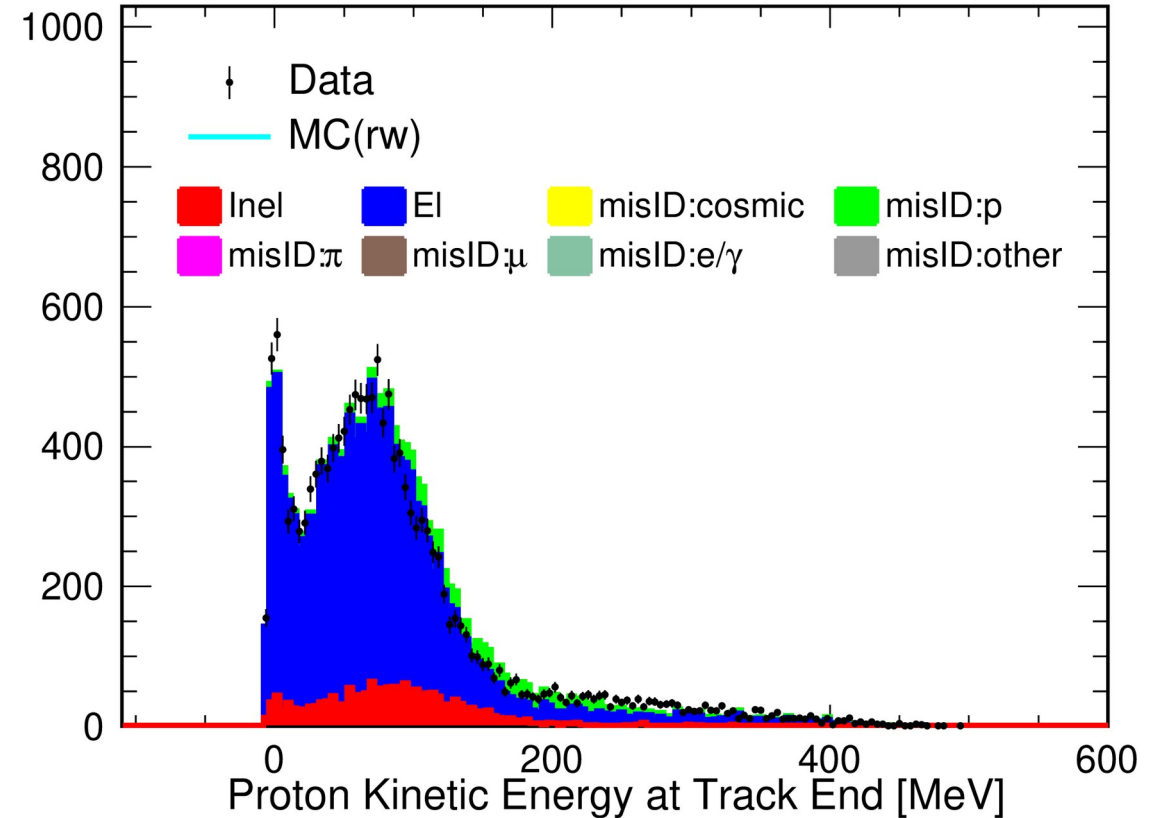
- ▶ $KE_{ff} = (KE_{beam} - \Delta E) * R$, $R \sim 1$
- ▶ Good reconstruction at KE_{ff} for both data and MC

KE at Track End (Bethe-Bloch)

Inelastic-scattering Protons

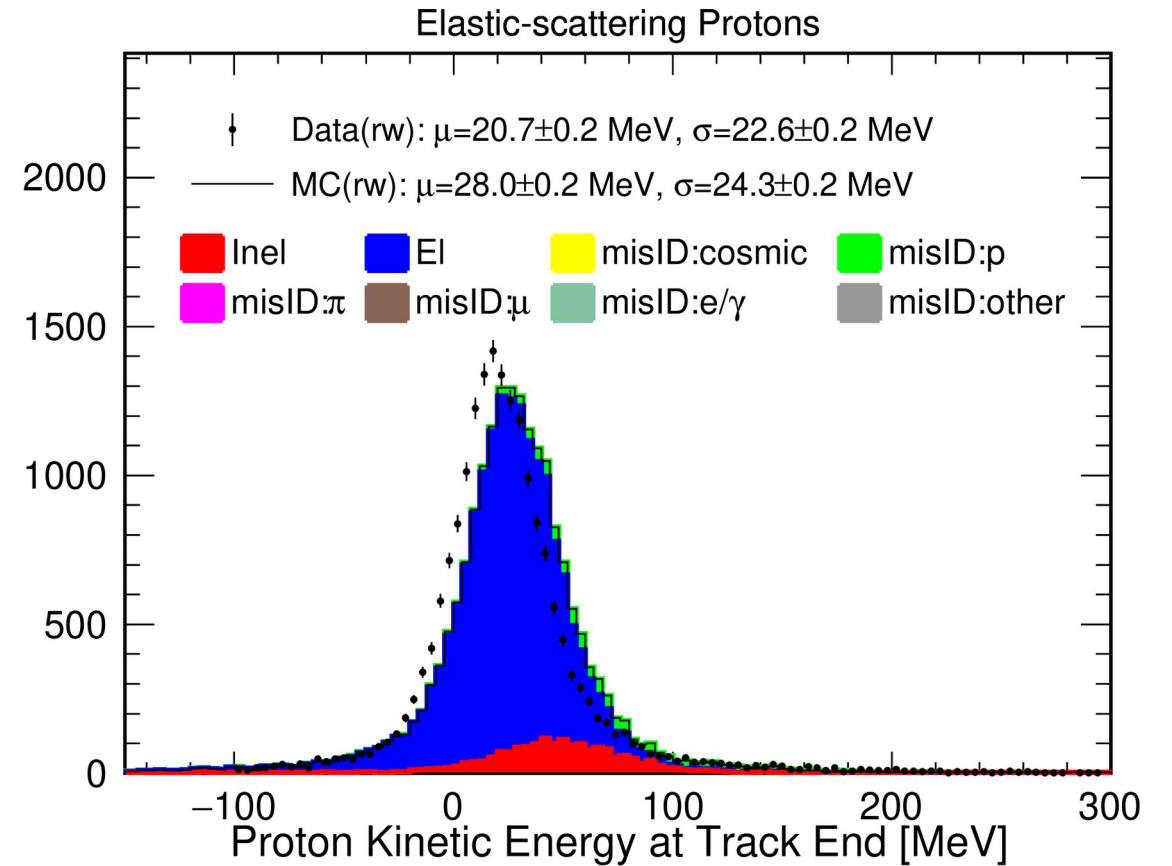
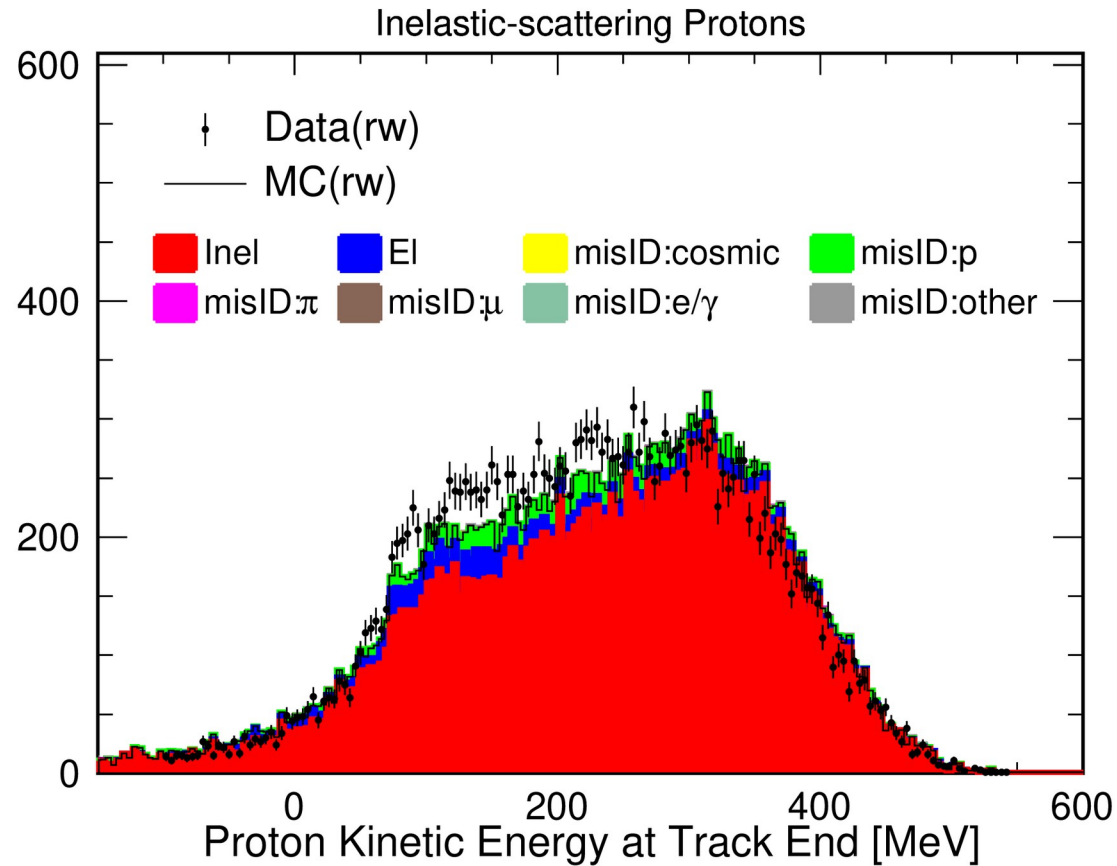


Elastic-scattering Protons



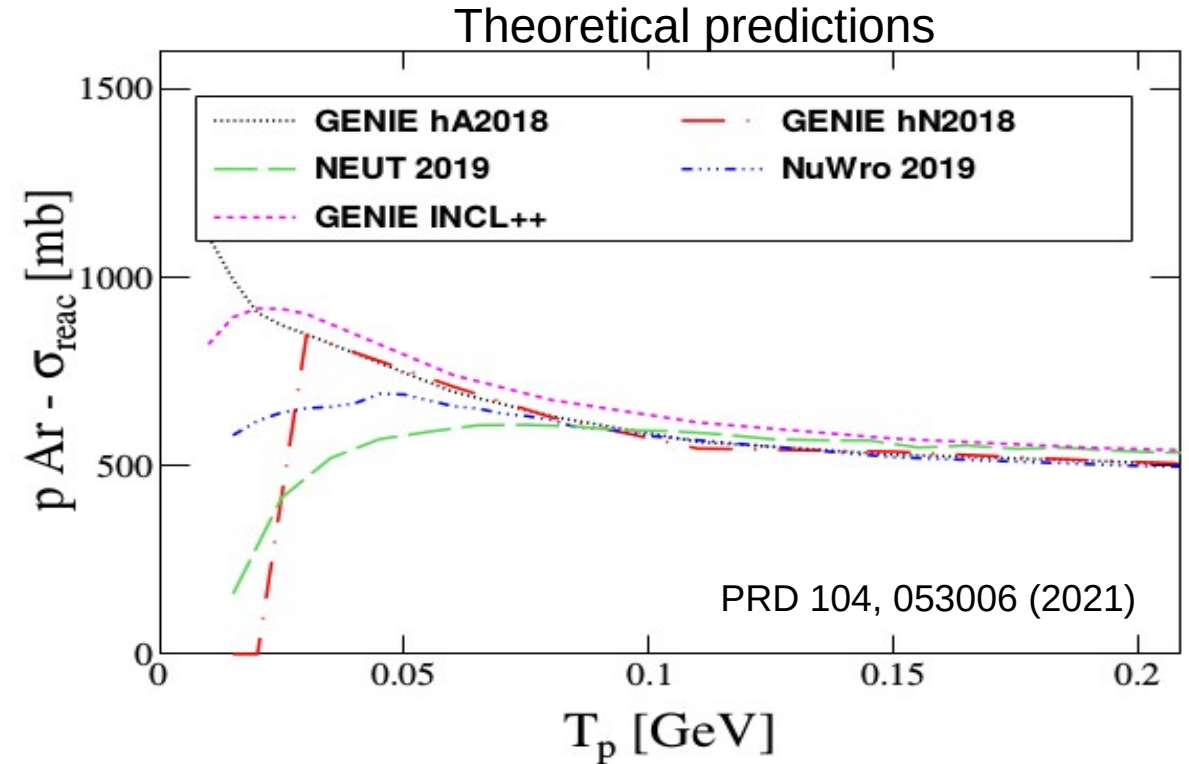
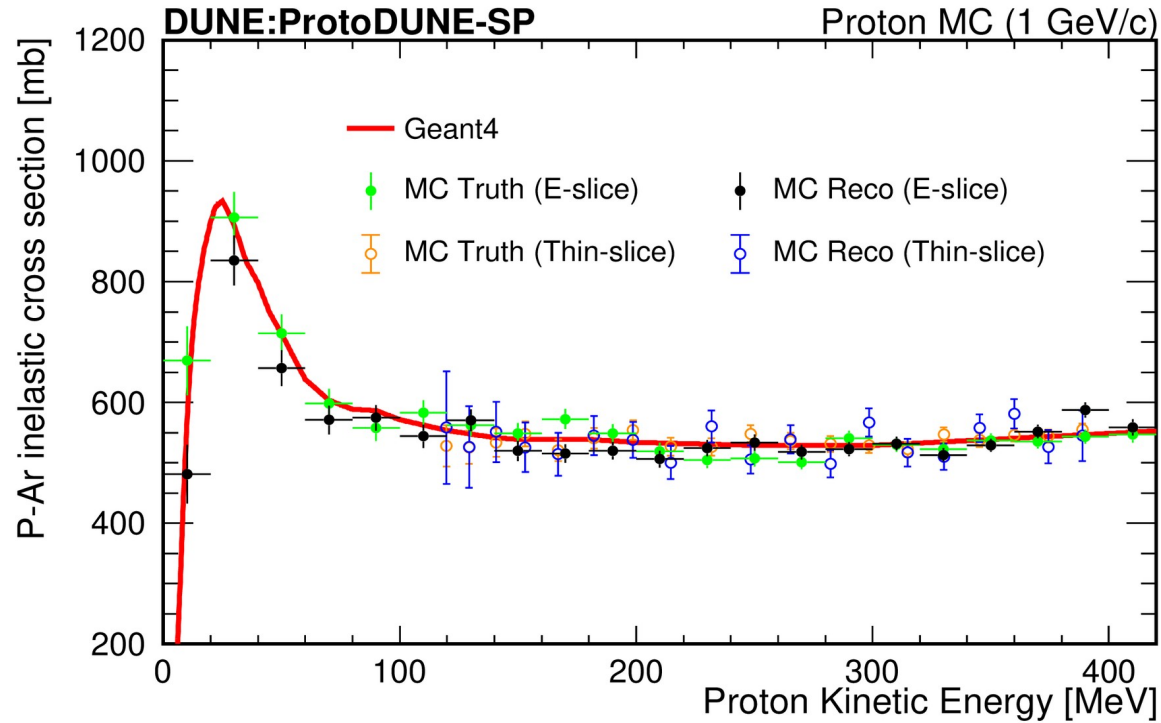
► Good reconstruction at KE_{end} for both data and MC!

KE at Track End (Calo)



► Systematics between data and MC

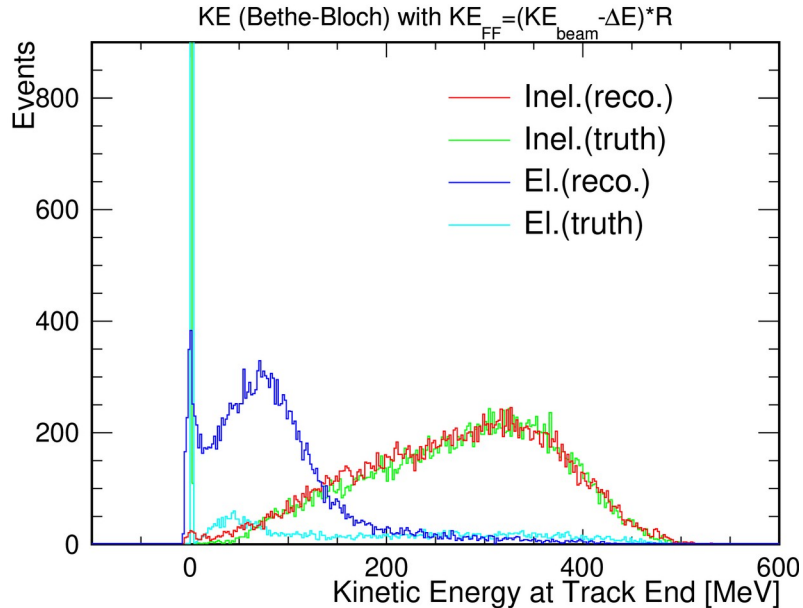
Proton-Ar Inelastic Cross-section



► Exciting Physics at low energy (KE<100 MeV)

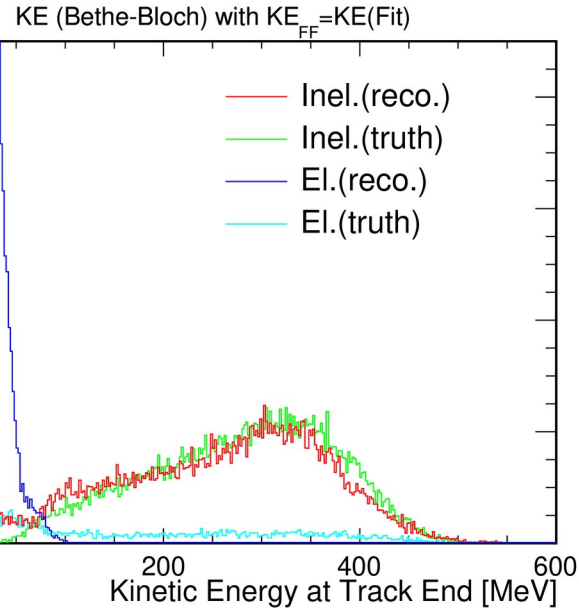
KE at Track End: Method Comparison

Bethe-Bloch



Threshold=**140 MeV**

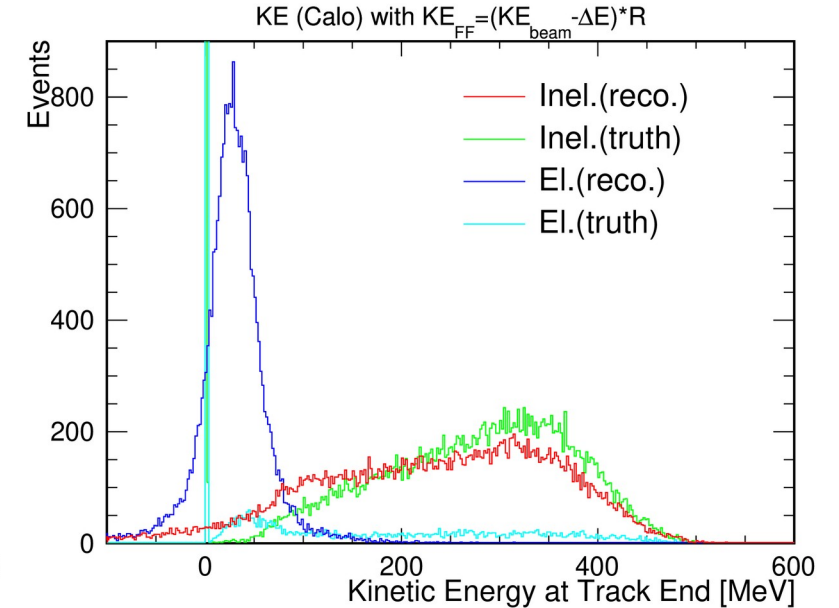
Best energy reco for inelastic-scattering protons.
(reco shape=truth shape)



Threshold=**70 MeV**

Better energy threshold
Distorted energy spectrum
for inelastic-scattering
protons

Calorimetry



Threshold=**70 MeV**

Better energy threshold
Distorted energy spectrum
for inelastic-scattering
protons

KE_{bb} Calibration: Discussion

$$KE = \frac{1}{2} \cdot \left(\frac{KE_1}{\varepsilon_1} + \frac{KE_2}{\varepsilon_2} \right) \quad \text{OR} \quad KE = \frac{KE_1}{\varepsilon_1} = \frac{KE_2}{\varepsilon_2}$$

$$KE_1 = KE_{bb}(R \cdot (KE_{beam} - \Delta E), x)$$

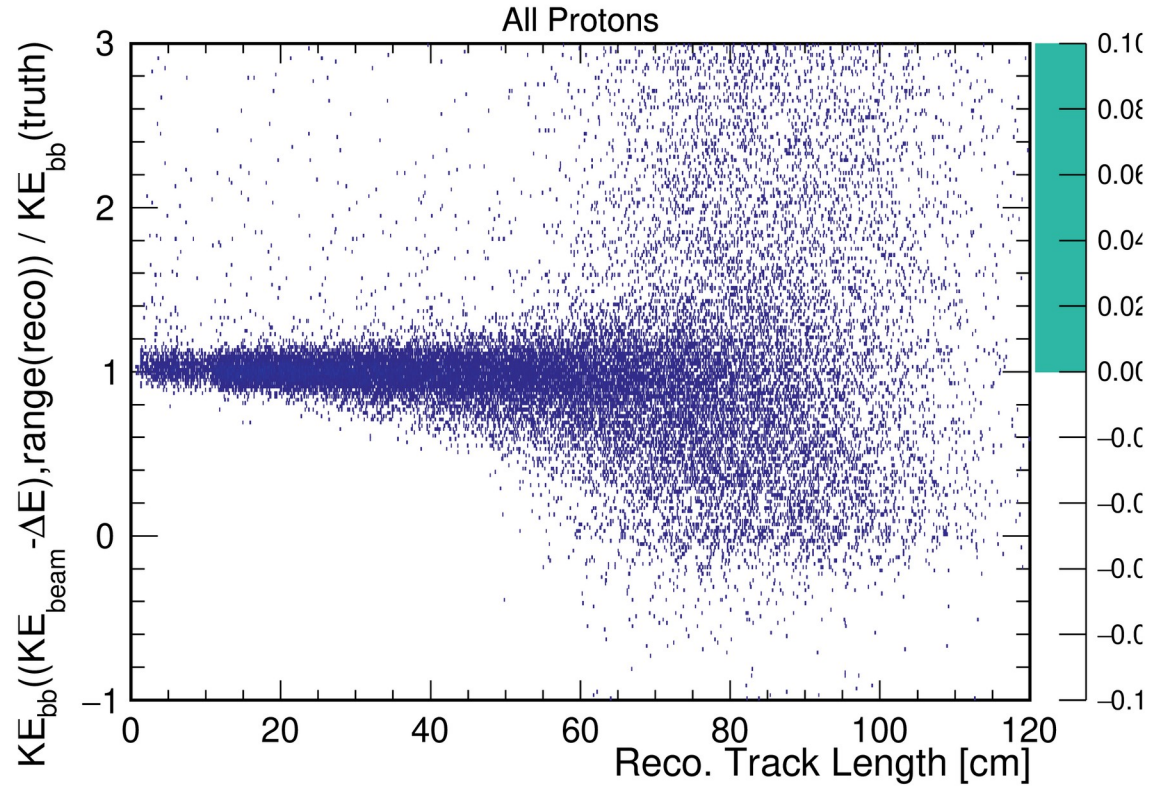
$$KE_2 = KE_{bb}(KE_{fit}, x)$$

$x : Range(reco)$

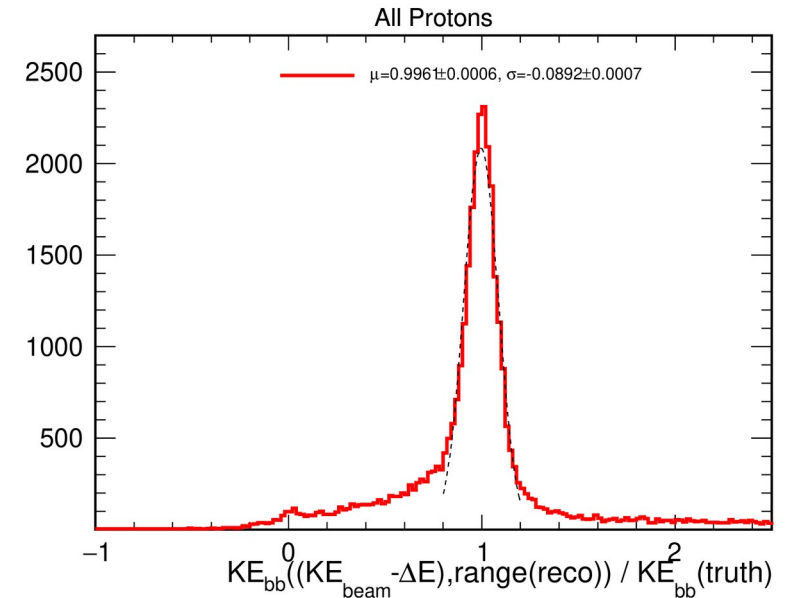
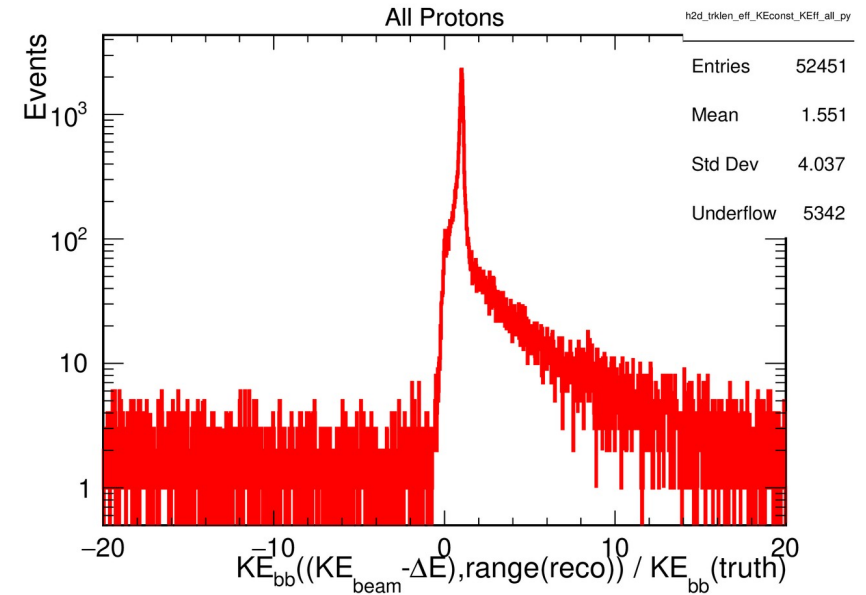
$$\left. \begin{aligned} \varepsilon_1 &= \frac{KE_1}{KE(truth)} \\ \varepsilon_2 &= \frac{KE_2}{KE(truth)} \end{aligned} \right\}$$

In pure sample to provide KE(truth):
→ Stopping protons & inelastic-scattering protons

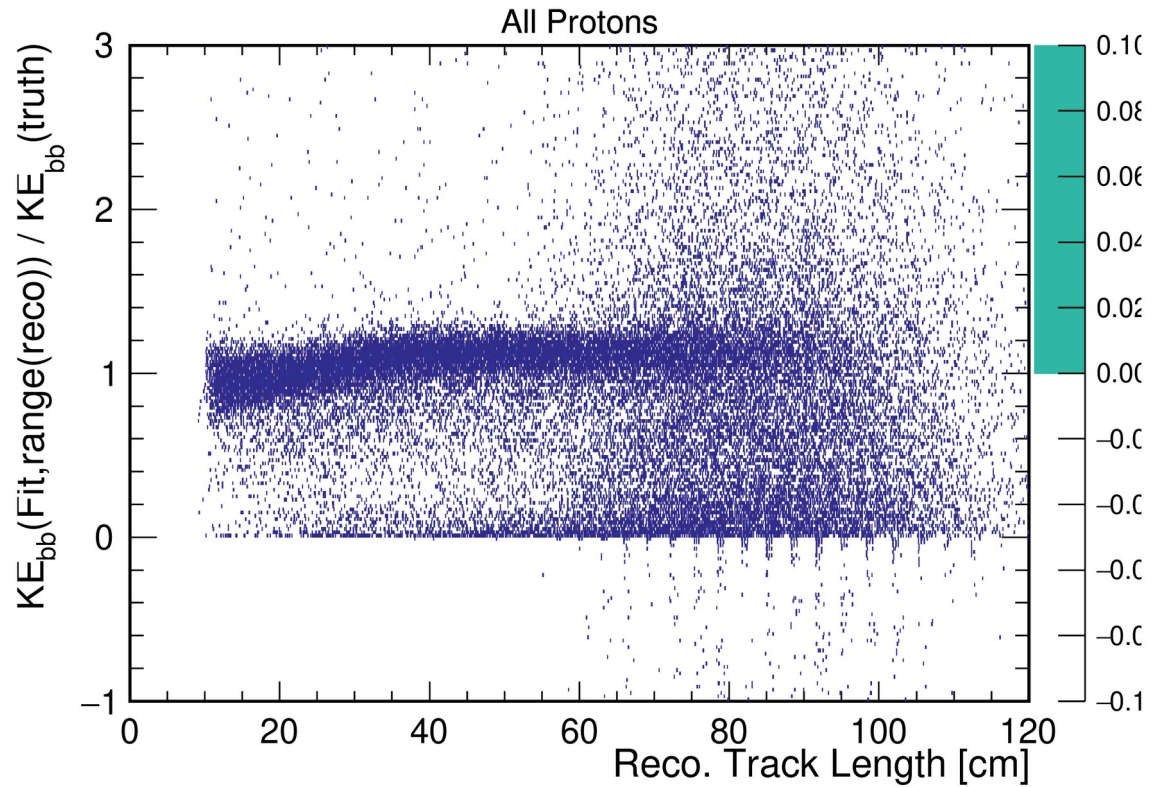
KE_{bb} Ratio v.s. Track Length: Constant E-loss Assumption



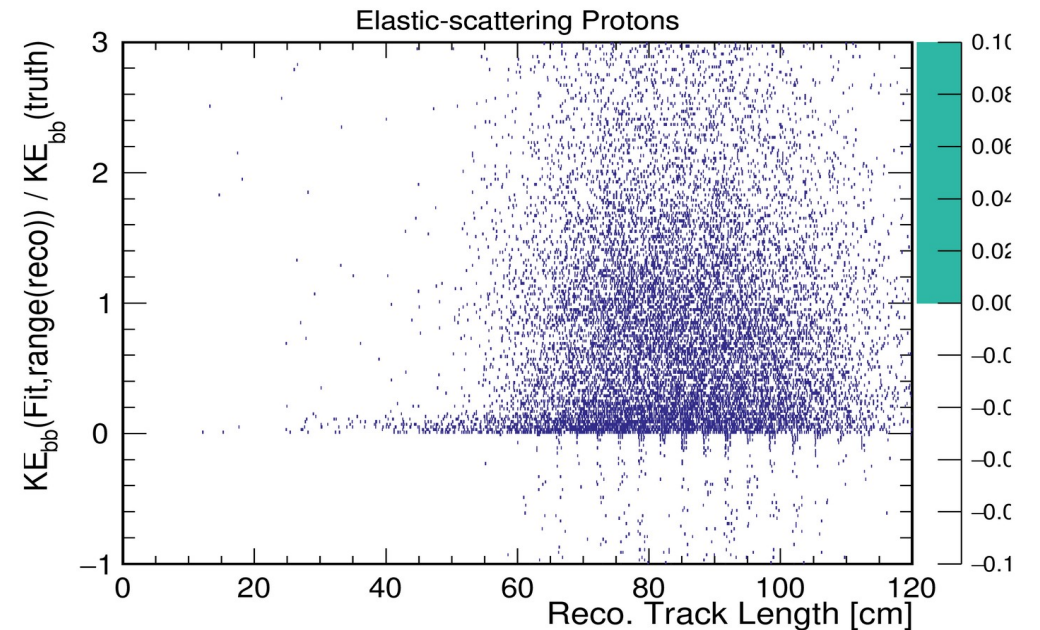
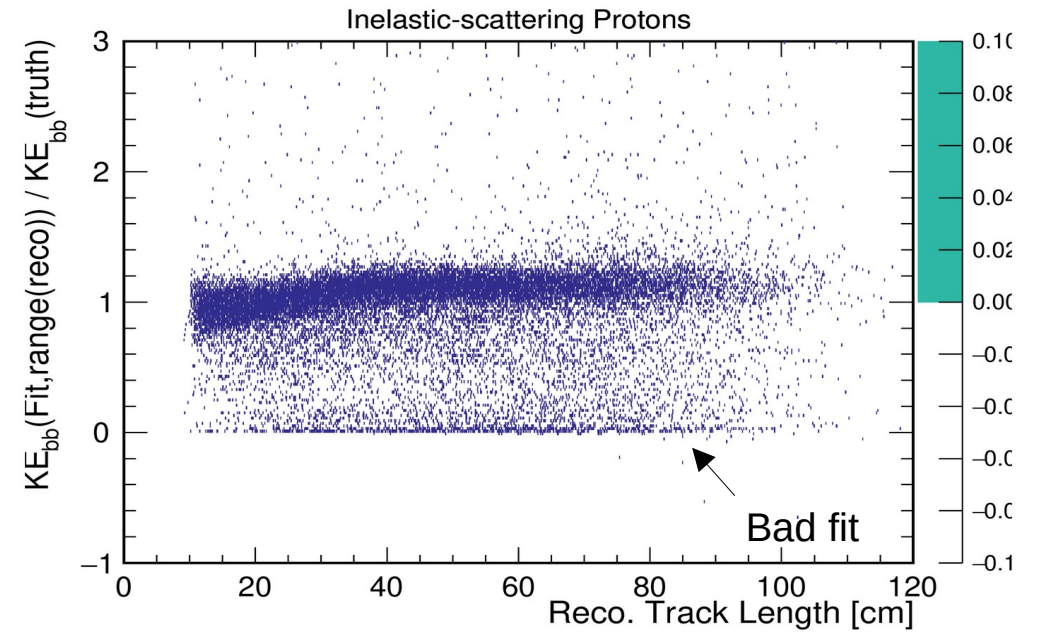
- Const. E-loss assumption shows good reco at short track length; bad at long track length (smearing)



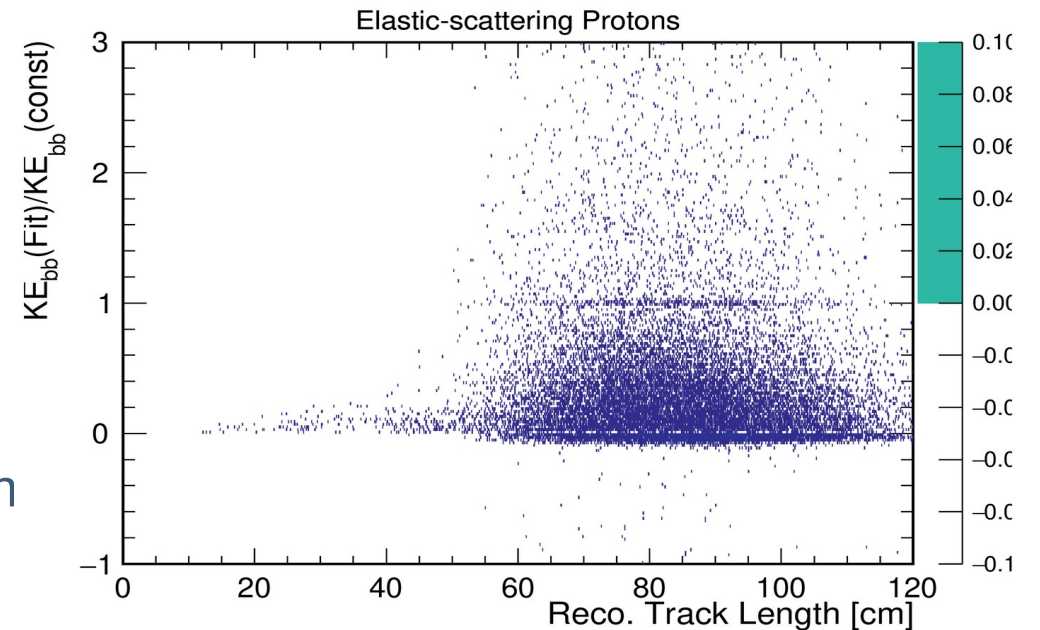
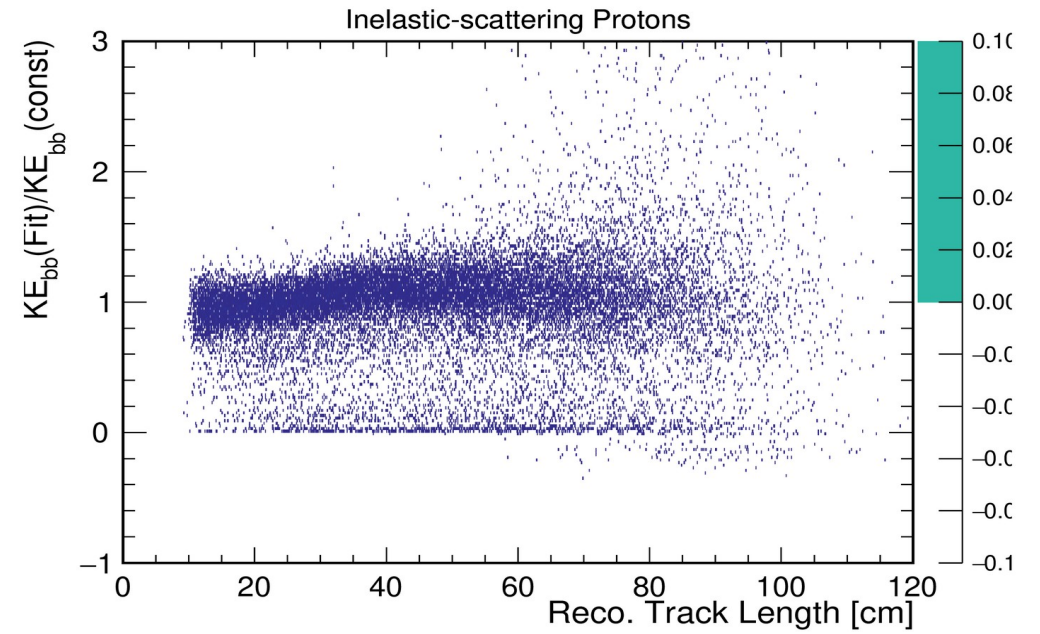
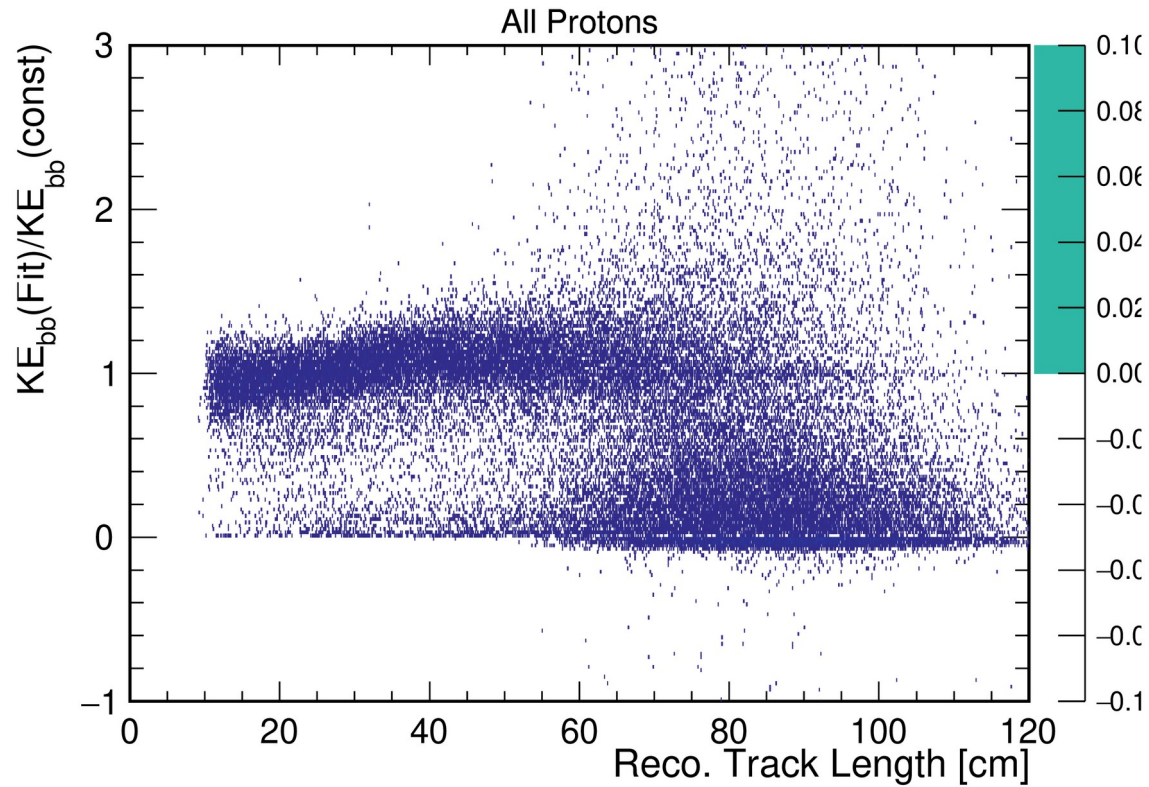
KE_{bb} Ratio v.s. Track Length: KE_{FIT}



- KE_{bb} (Fit) for inelastic-scattering protons can be corrected



KE_{bb} ratio: KE_{bb}(Fit)/KE_{bb}(const E-loss)



- Use KE(fit) to calculate energy and apply correction on inelastic-scattering protons, i.e, use KE_{bb}(const E-loss) to calibrate KE_{bb}(Fit)