True $\pi^{\pm}$ KE limit

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Intro

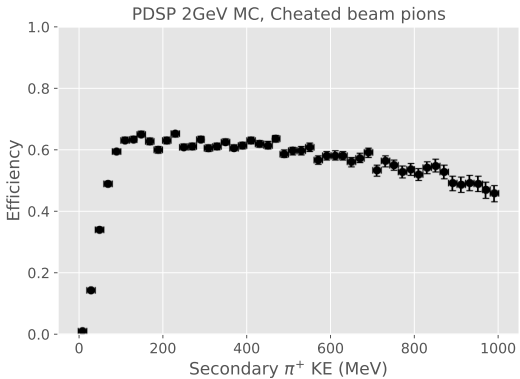
- Cross sections measured with PDSP 2GeV Data and MC.
- Single pion production measurement has a clear discrepancy
- One recommendation was to investigate a $\pi^{\pm}$ KE limit when defining the exclusive processes

Secondary $\pi^{\pm}$ reconstruction efficiency

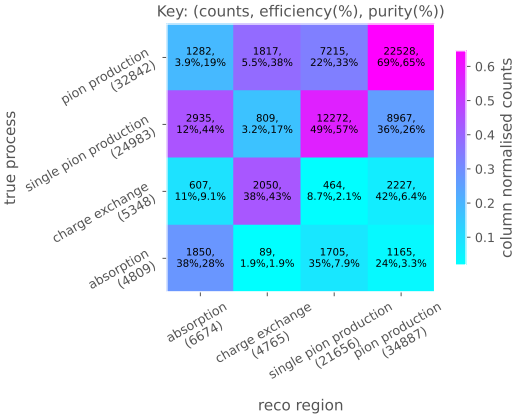
- Pandora struggles to reconstruct low energy $\pi^{\pm}$ in ProtoDUNE

$$\text{efficiency} = \frac{\text{number of true } \pi^{\pm} \text{ reconstructed}}{\text{number of true } \pi^{\pm}} \quad (1)$$

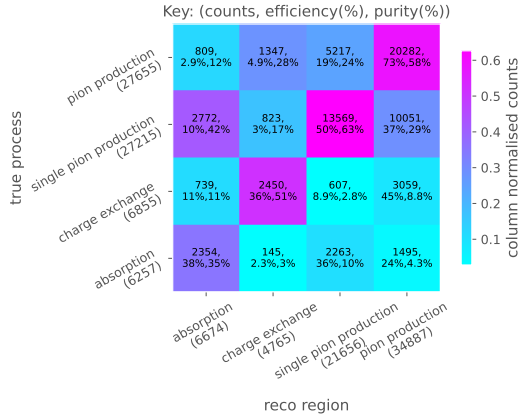
- study only includes secondary pions from the beam interaction
- number of true $\pi^{\pm}$ calculated using truth information
- number of true $\pi^{\pm}$ reconstructed is number of reconstructed PFOs backtracked to a $\pi^{\pm}$
- Jake observed similar effect in 1GeV pions, selected true $\pi^{\pm}$ only if starting $KE > 65$ MeV.



Without true $\pi^{\pm}$ KE limit



With true $\pi^{\pm}$ KE limit



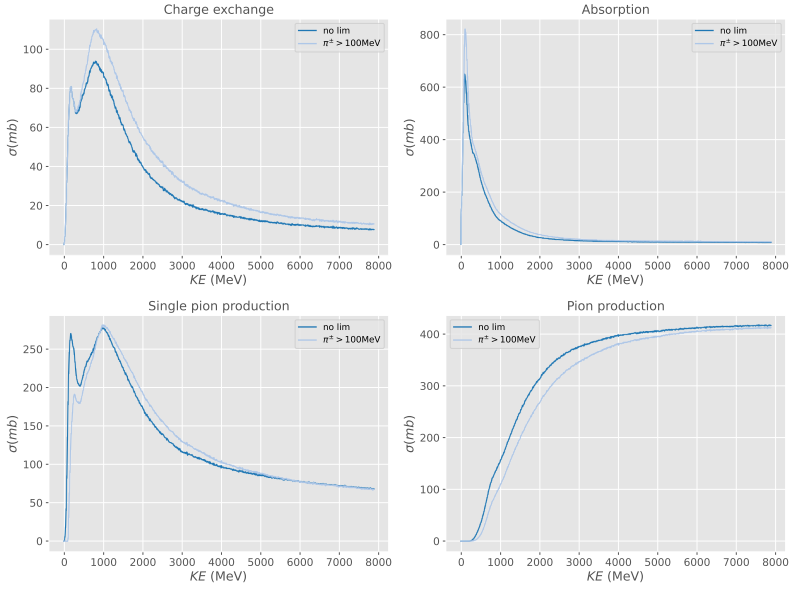
μ_{abs}	μ_{cex}	μ_{spip}	μ_{pip}
0.8 ± 0.1	1.0 ± 0.09	0.7 ± 0.05	1.21 ± 0.03

μ_{abs}	μ_{cex}	μ_{spip}	μ_{pip}
0.8 ± 0.1	1.02 ± 0.08	0.76 ± 0.04	1.22 ± 0.04

Secondary $\pi^{\pm}$ KE lim only enforced in MC truth.
Same KE limit must be enforced in MC reco and Data to appropriately implement

Modifying Geant4 cross sections

- Instead, we can compare measured cross sections to Geant4 cross sections using the KE limit.
- Geant4 cross sections generated using Geant4 reweight, software allows defining energy thresholds when defining exclusive interactions
- pion production cross section decreases, while the others increase
- single pion production decreases below 1000MeV



Comparing geant cross sections to measurement

- In every case, agreement is worse.
- If reconstructing low energy $\pi^{\pm}$ was biasing the measurement, measured pip xs should be *lower*, and spip xs should be *higher*.
- other forms of mis-reconstruction are causing the discrepancy in the spip measurement.

χ^2/ndf	Abs	Cex	Spip	Pip
no KE lim	2.13	4.72	16.8	3.97
KE lim	5.79	9.22	24.9	21.3