ProtoDUNE Measurements for NDK Physics

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NDK searches: where do ProtoDUNE measurements enter?

$$\tau/B = n_{p/n} \cdot \varepsilon \cdot Mt \,/\, (N_{obs} - N_{bgr})$$

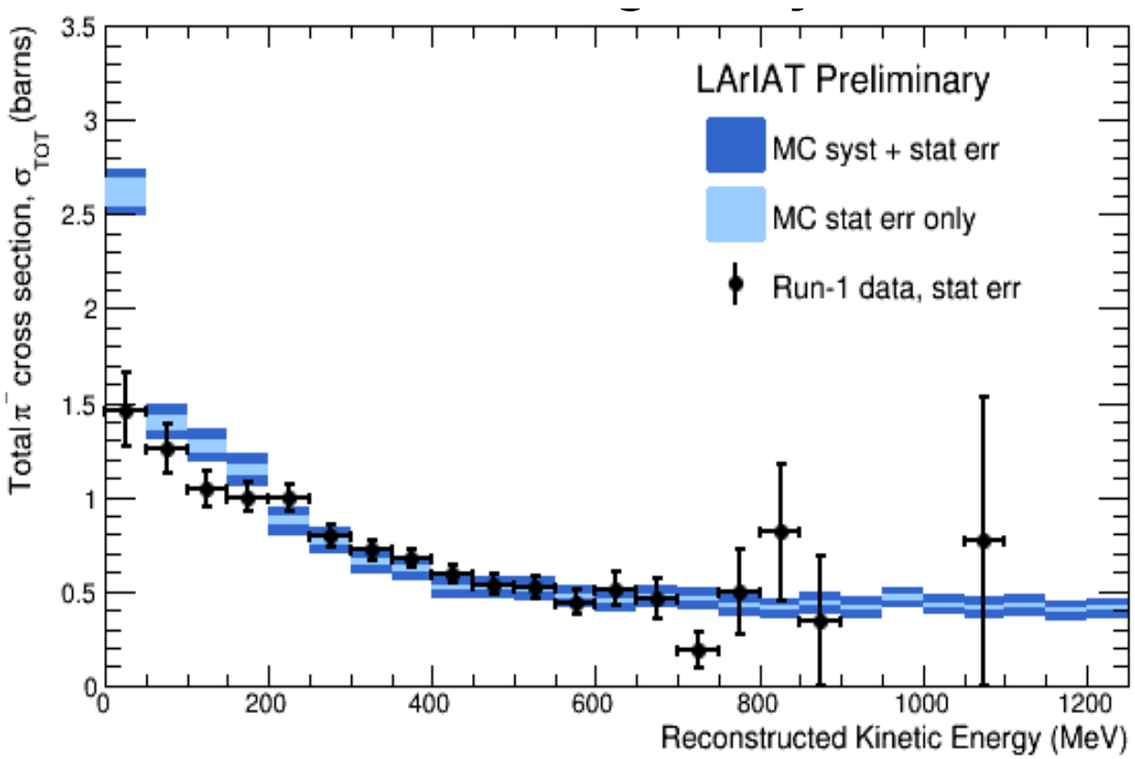
- $n_{p/n}$: number of p or n per unit mass [1 / kton]
- ε: signal detection efficiency [1]
- **Mt**: detector exposure [kton·yr]
- N_{obs}-N_{bgr}: (upper limit on) number of signal events [1]
- **τ/B**: partial lifetime sensitivity [yr]

- ProtoDUNE measurements that directly affect ε, N_{bgr} estimates:
  - π-Ar and K-Ar cross section measurements
  - Track/shower reconstruction performance
  - dE/dx-based particle ID performance

- ProtoDUNE data may also permit to refine NDK event selection in a LAr-TPC

K-Ar and π-Ar cross section measurements

- Tune hadron-nucleus interaction models in NDK generator (GENIE) and detector simulation (Geant4)
  - Understand irreducible signal efficiency losses, affect background rates
- Not just total cross sections, but exclusive measurements needed
  - absorption, charge exchange, inelastic, elastic
- Particularly interested in 0.1-0.5 GeV/c incident meson momenta
- LArIAT is a better match in momentum for this, but ProtoDUNE useful cross-check



π⁻ - Ar total cross section
LArIAT FNAL W&C, April 2016

Track/shower reconstruction performance

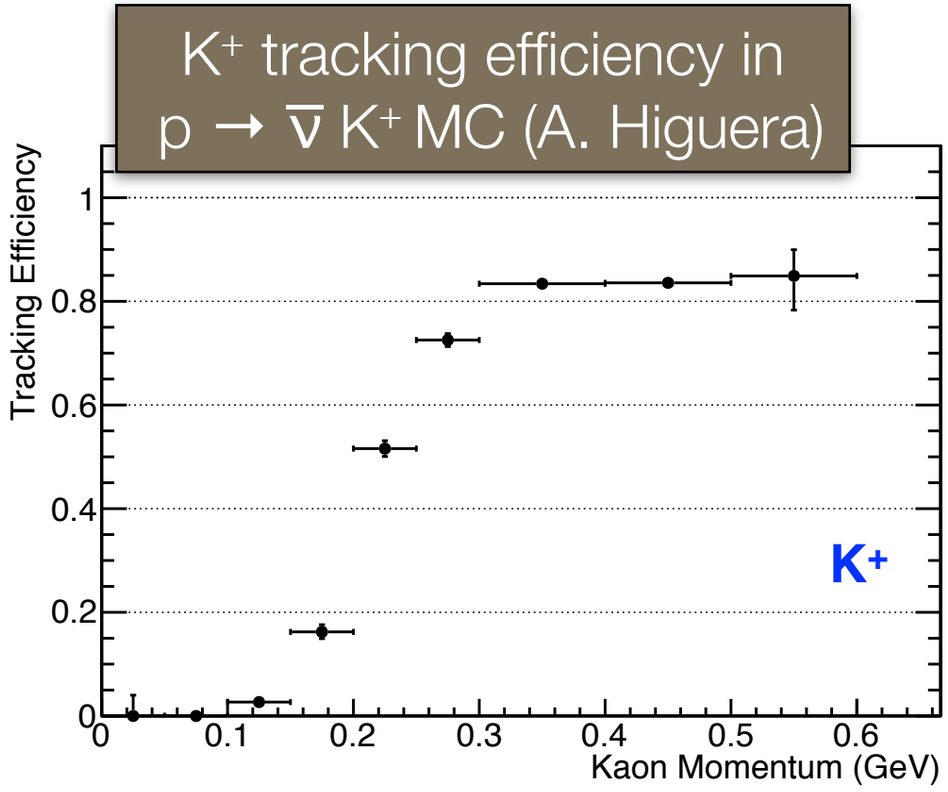
Reconstruction efficiency, resolutions

- ProtoDUNE data important to cross-check MC reconstruction efficiencies

- Single-track momentum/angular resolution not so important, considering nuclear Fermi smearing

- Invariant mass and vertex resolutions more important, since many NDK searches involve reconstructing 2-body (or many-body) decays of neutral particles

- Need LAr-TPC as similar as possible as FD for this → ProtoDUNEs



Examples:

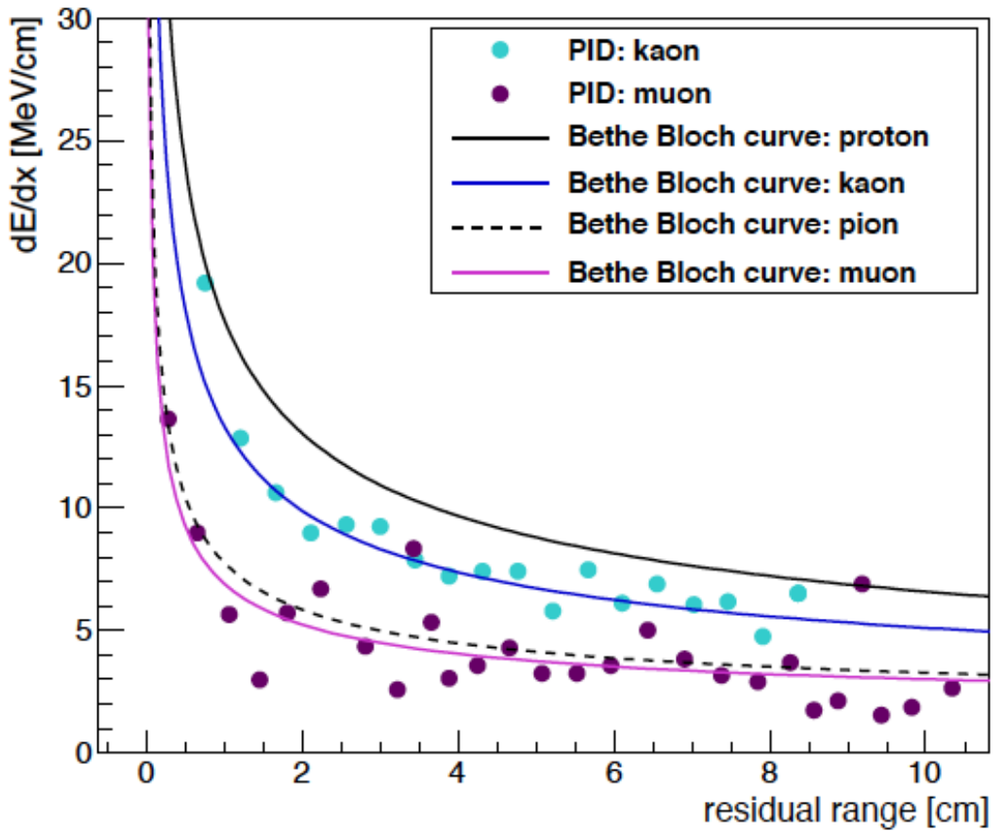
- $K^0_S \rightarrow \pi^+\pi^-$ in $p \rightarrow \mu^+ K^0$
- $\pi^0 \rightarrow \gamma\gamma$ in $p \rightarrow e^+ \pi^0$
- $\eta \rightarrow \gamma\gamma$, $3\pi^0$ in $p \rightarrow e^+ \eta$

dE/dx-based particle ID performance

ID efficiencies, mis-ID rates

- Understand **PID** performance based on **dE/dx of stopping particles**
  - Several separations needed: K/π, K/p, etc.
  - To better define our requirements, need better understanding of NDK backgrounds from mis-reconstruction (6 months away?)
  - Exact match in momentum between PDUNE data and NDK final states not needed?

K/μ separation in ICARUS



- **e/γ separation** (from dE/dx at shower beginning) also important, since many NDK searches involve electrons and gammas simultaneously
  - Example: $p \rightarrow e^+ \eta$, $\eta \rightarrow \gamma\gamma$

- Need LAr-TPC as similar as possible as FD for this → ProtoDUNEs

NDK priorities related to ProtoDUNE measurements

For discussion

1.dE/dx-based particle ID performance

2.Track/shower reconstruction performance

3.π-Ar and K-Ar cross section measurements

Comments?