Measuring the Proton-argon Cross Section at ProtoDUNE-SP

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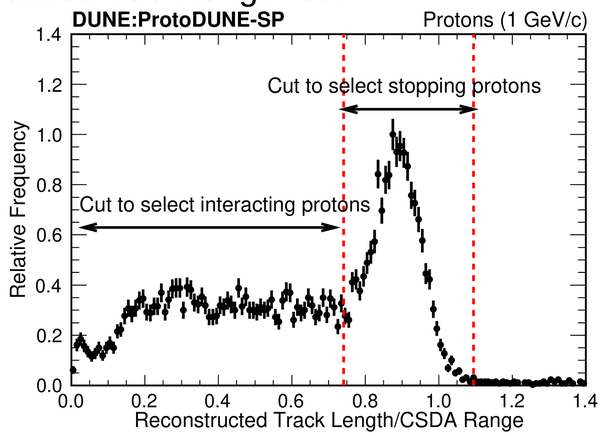
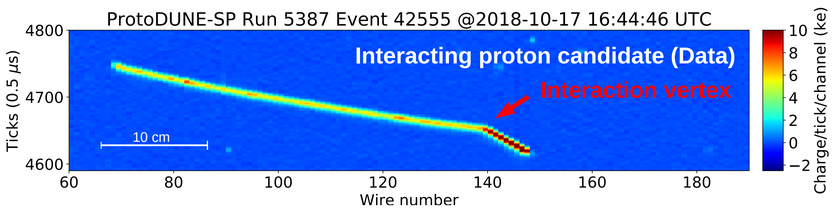
I. Introduction

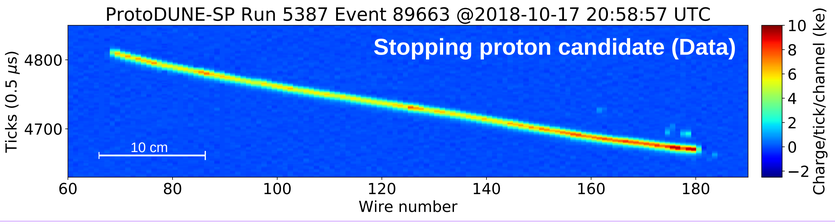
- Precise cross section measurements of proton interactions with Ar: An important step to realize the physics goals for DUNE
- ProtoDUNE-SP: Use CERN H4 beam line with known particle type & incident energy → Controlled environment for better understanding of particle interactions happening within LArTPC

II. Proton Selection & Calorimetric Reco.

- Selection of beam protons using information from beam line instrumentation (ToF & Cherenkov counters)
- Calorimetric reconstruction using stopping muons
- Selections of stopping & interacting protons using normalized track length cut

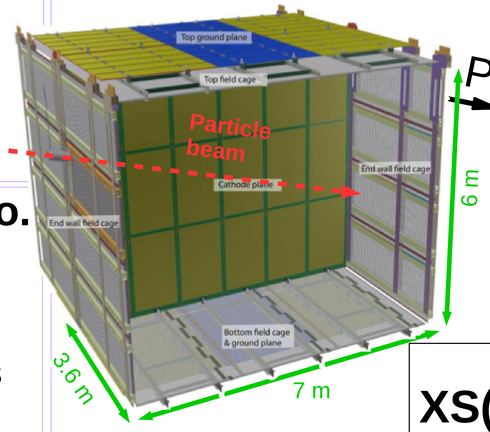






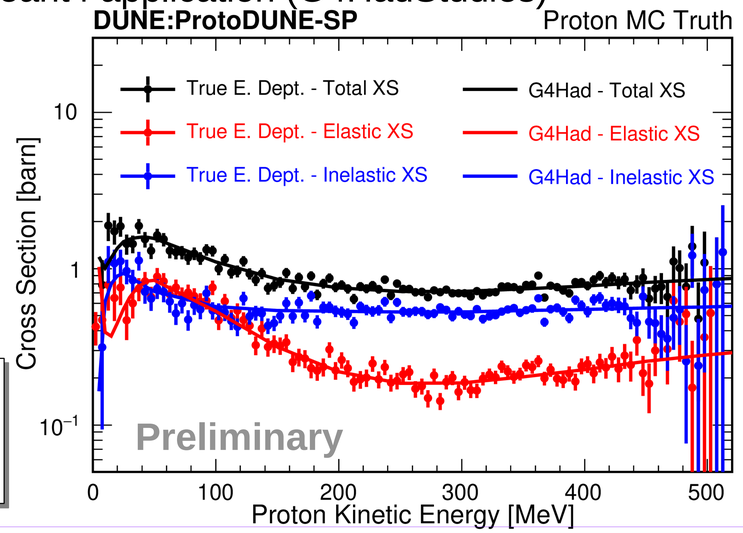
III. Proton-argon Cross Section

- MC truth study using the "thin-slice method"
  - Proof-of-principle of the method using a stand-alone Geant4 application (G4HadStudies)



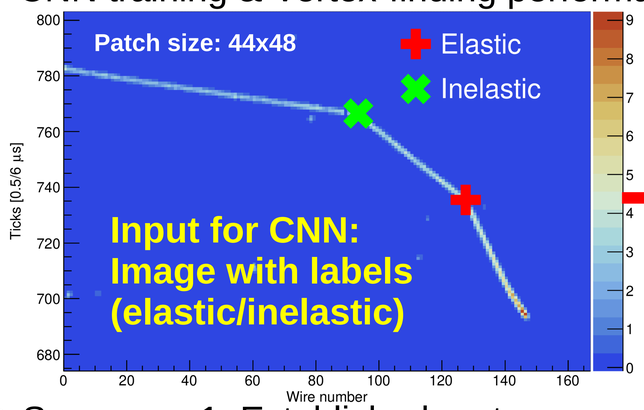
$$XS(KE) = S_f \cdot \frac{N(KE)^{interacting}}{N(KE)^{incident}}$$

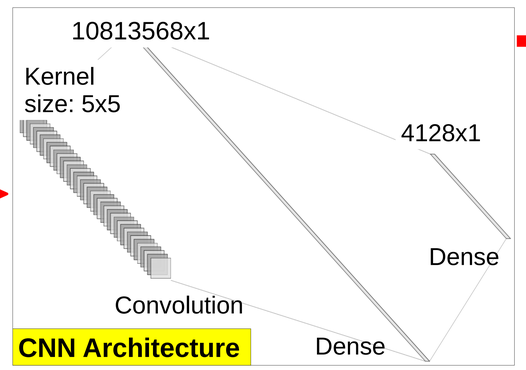
S_f~100 barn for ProtoDUNE-SP



IV. Vertex Reconstruction

- Key to the success of cross section measurement using the thin-slice method
- Use Pandora multi-algorithm reconstruction & Convolutional Neural Network (CNN)
  - Look at the 1st interaction vertex and see how well we can identify it
    * Good reconstruction: distance between truth and reconstructed vertex less than 5 cm
- CNN training & Vertex-finding performance:





Output: Elastic/Inelastic score [0-1] per pixel

Interaction	Efficiency [%]	
	Pandora	CNN
Elastic	13.7	30.5
Inelastic	66.5	74.7

- Summary: 1. Established proton-argon cross section in truth level 2. Interaction vertex identification: More efficient in recognizing inelastic scattering interaction vertex, further improvement in elastic ones
- Outlook: 1. Improve vertex identification 2. Efficiency correction of vertex identification 3. Understand background sources for the measurement 4. Study cross section systematics using reweight method