Status of NOvA Neutrino-Induced Neutral Current π^0 Production Cross-section Measurements

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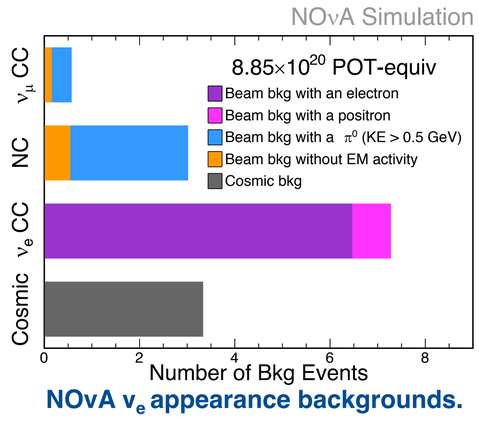
Introduction

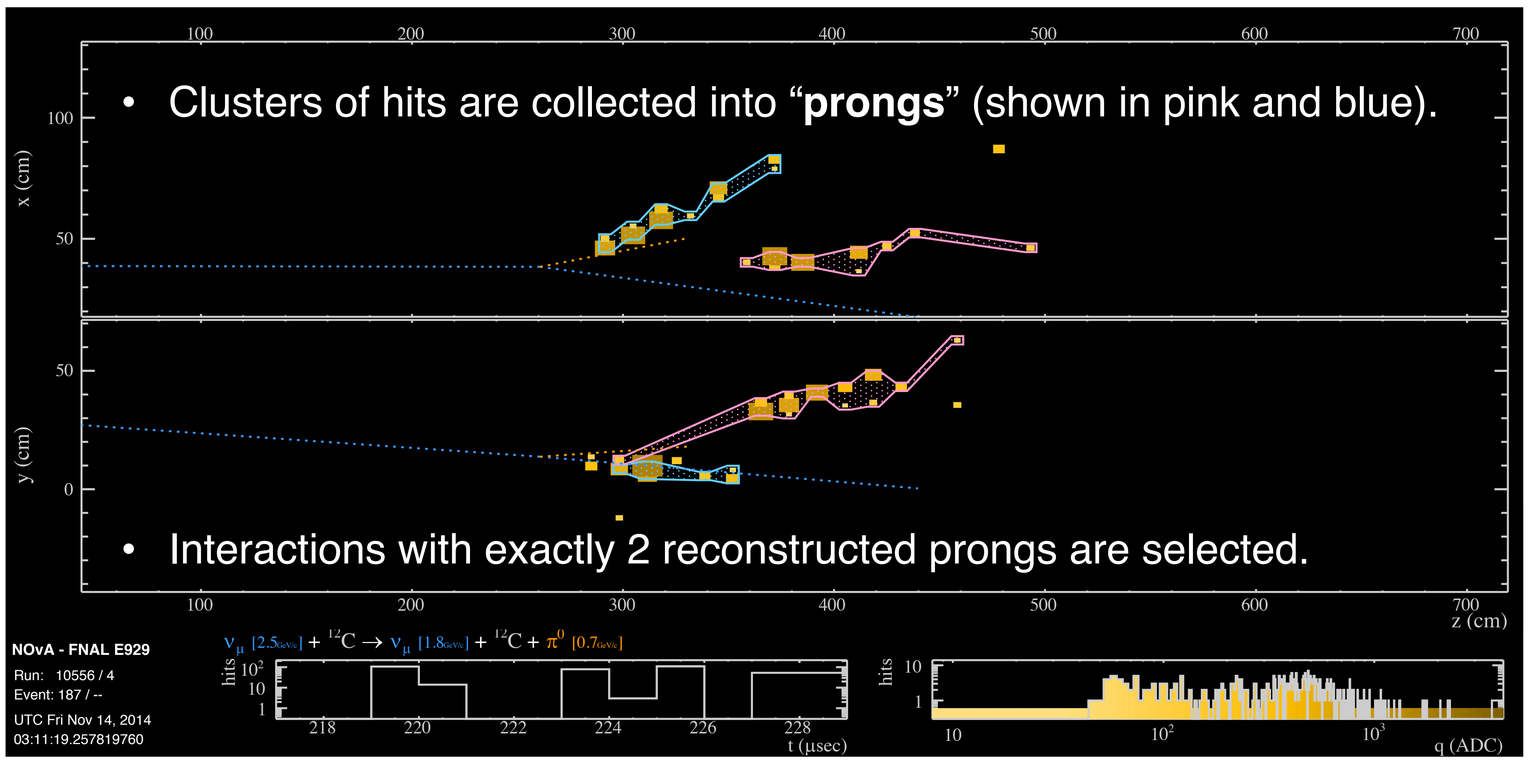
- Neutral current (NC) interactions with a final state π^0 are a background in $\nu_\mu \rightarrow \nu_e$ oscillation experiments.
- A ~10% uncertainty on the NC background for NOvA ν_e appearance is dominated by π^0 production.
- The NOvA Near Detector (ND) is exposed to a large flux of 1-3 GeV NuMI neutrinos.



NOvA ν_e appearance backgrounds.

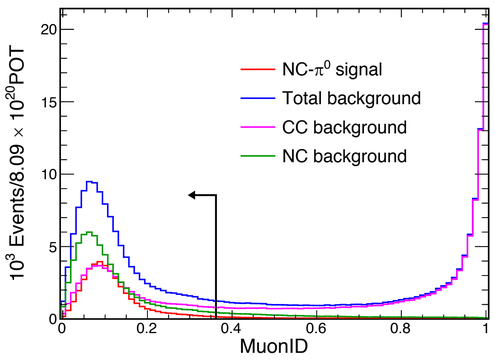
Neutral Current Neutral Pion Selection

- A selection for neutrino induced NC interactions with one or more final state π^0 with kinetic energy >0.1 GeV has been developed using NOvA ND simulation based on G4NUMI, GENIE, and GEANT.
- Selected events must be fully contained and interact in a fiducial volume.

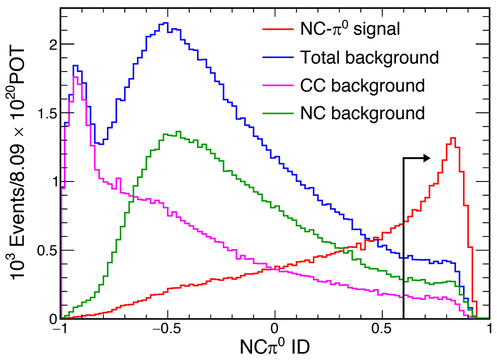


Simulated two prong NC π^0 interaction in the ND. In this example both prongs are showers from neutral pion decay gammas.

- Charged current events are rejected using a loose cut on the muon identifier developed for the NOvA oscillation analyses of > 0.36.



Charged-current rejection with muon identifier.



Boosted-decision tree based neutral pion selector.

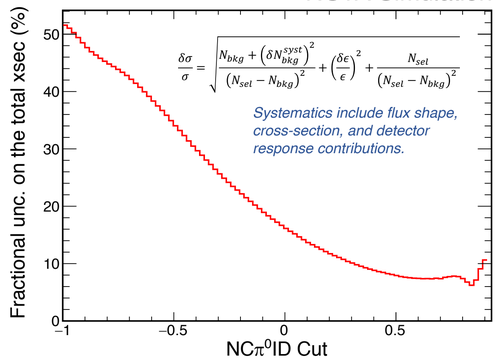
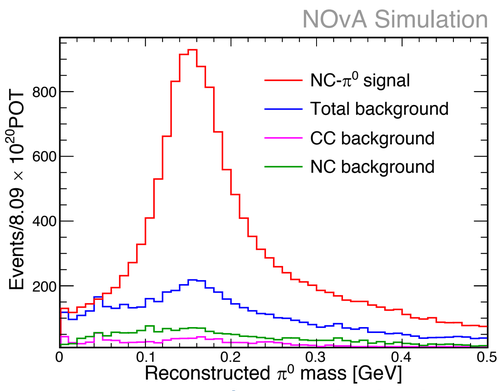


Figure-of-merit based on total cross-section uncertainty.

- A Booster Decision Tree (NCPi0ID) was trained on shower EM properties (e/pi LLL, dE/dx) and an interaction level convolutional visual network (CVN) muon id developed for oscillation analyses [1].
- The selection is optimized to minimize the estimated total cross section uncertainty at ~7%.
- 1.3% selection efficiency & 73% purity are obtained.



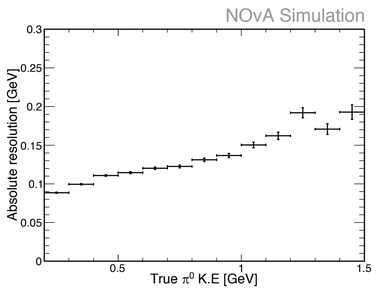
Uncorrected π^0 mass of selection.

Outlook

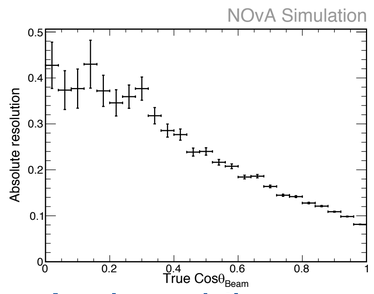
- Studies of background constraints, resolutions and unfolding are in progress.
- NOvA aims to produce a world-class differential cross-section measurement.

Pion Kinematic Resolutions

- Energy and angular resolutions for selected events with a 80-220 MeV invariant mass are shown.

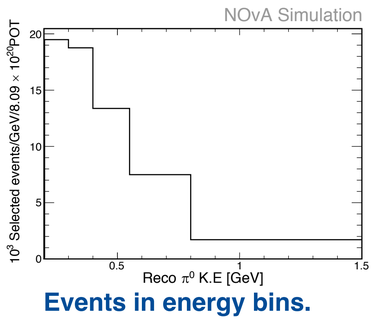


Energy resolution.

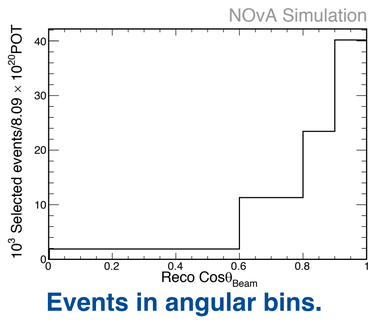


Angular resolution.

- These resolutions and expected statistics suggest a differential cross section w.r.t. the π^0 kinetic energy and angle are viable.



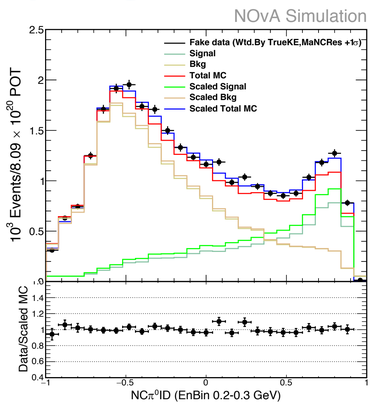
Events in energy bins.



Events in angular bins.

Background constraints

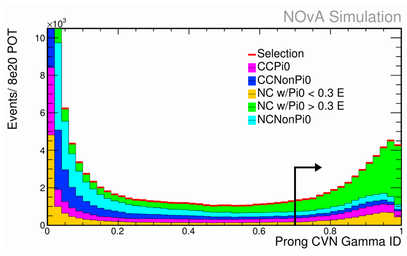
- Background and signal are determined by fitting NCPi0ID templates in energy and angle bins.
- This method has been demonstrated using modified simulated datasets.



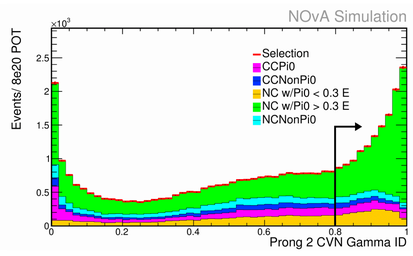
NCPi0ID distribution for single energy bin.

Additional Selections

- A selector which identifies photon prongs via a CVN in a 2 prong sample is shown.

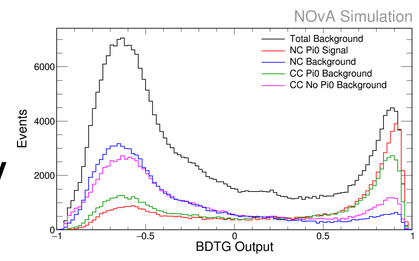


Most energetic prong CVN ID.



Second prong CVN ID.

- This selector has a 2% efficiency & 67% purity with energy and angular resolutions comparable to the BDT selector.
- A BDT single prong selection has a 4% efficiency, 40% purity, and 250 MeV K.E. resolution.



One prong event selector

[1] A. Aurisano et al., *A convolutional neural network neutrino event classifier*, JINST, Vol. 11, Sept. 2016

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