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uBooNE mtg

## Wire Pitch

- Physics motivation for wire pitch choice
- Practical considerations

Goal of this talk: Come to consensus on choice of wire pitch. This is a design parameter we must set as it drives other design issues

# MicroBooNE wire spacing physics case

with Monte Carlo truth studies

Joshua Spitz

# Wire spacing issues

- Money
- Signal-to-noise ratio
- Reconstruction
  - Calorimetric, spatial, and vertex resolution.

The above topics are not covered here.

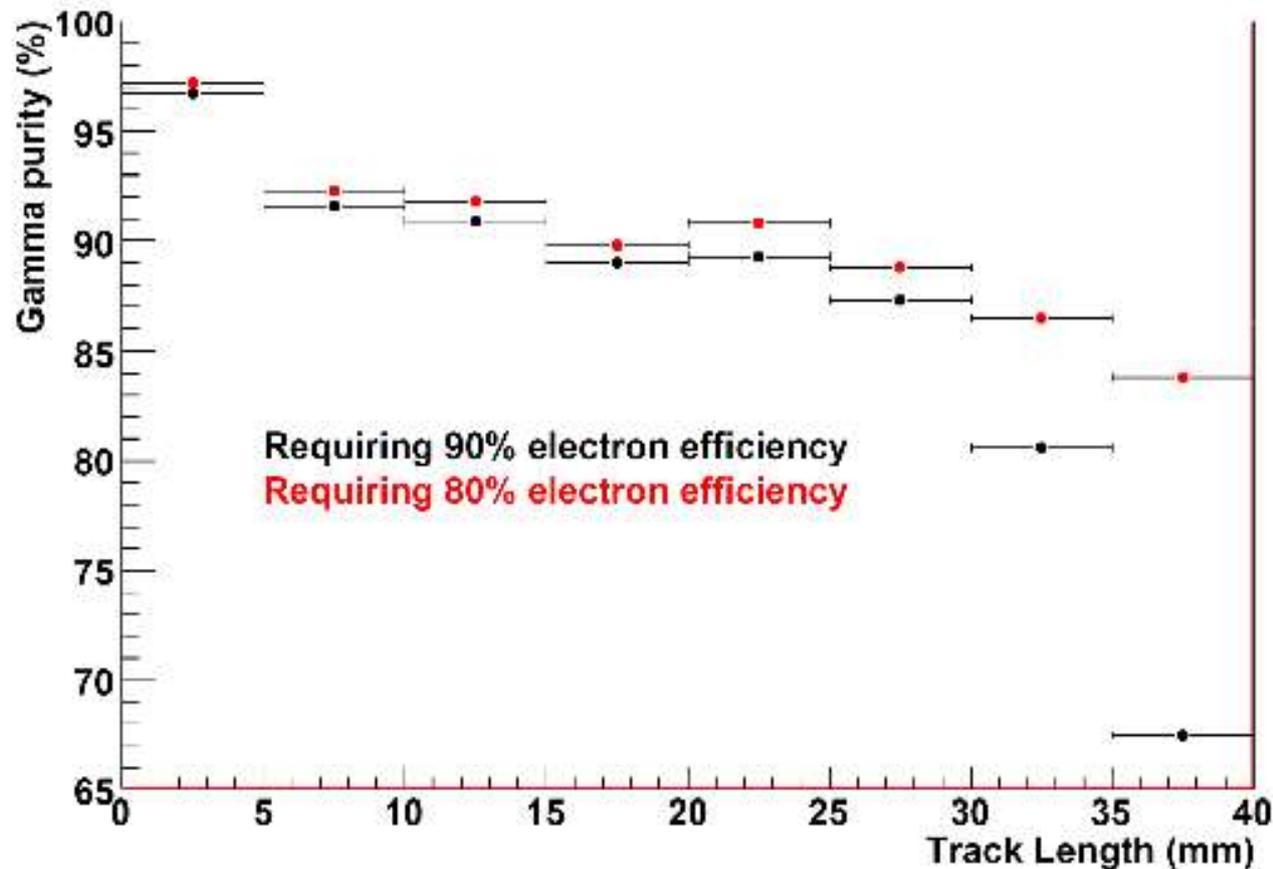
- Physics

# The physics case

- The  $dE/dx$  tag
  - Resolving the first 24mm of track.
  - Having enough wire hits after throwing away “bad” wires (due to Brem)
- Resolving short tracks
  - Neutron-induced protons
  - Nucleons in NC $\pi^0$  events
  - Primary nucleons
  - Nuclear fragmentation
- Resolving the gap between interaction vertex and pair production start in events involving a  $\pi^0$  (assuming the nucleon was resolved and a vertex defined).
- Resolving the angle between two overlapping gamma tracks.

# Is 24mm the correct track length to use for a dE/dx tag?

Gamma Purity (in a 5mm sub-track) vs. Track Length



Note that this plot shows gamma purity values in 5mm sub-tracks.

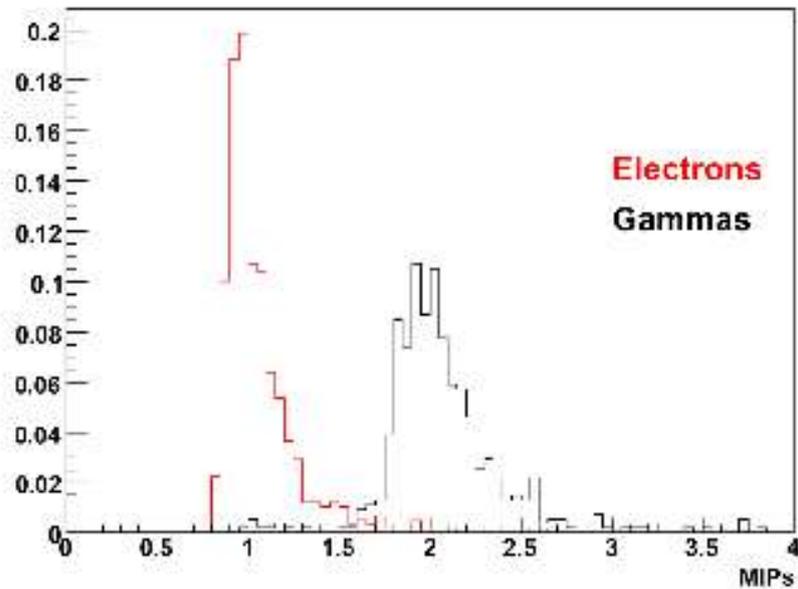
- For example, this means that the gamma purity in the 20-25mm bin is the gamma purity in that 5mm sub-track only and is not the purity from 0-25mm.

It appears 24mm is a reasonable length for the dE/dx tag.

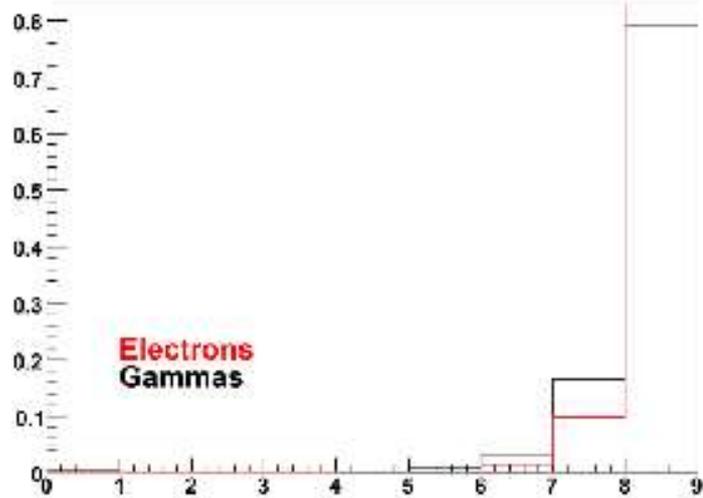
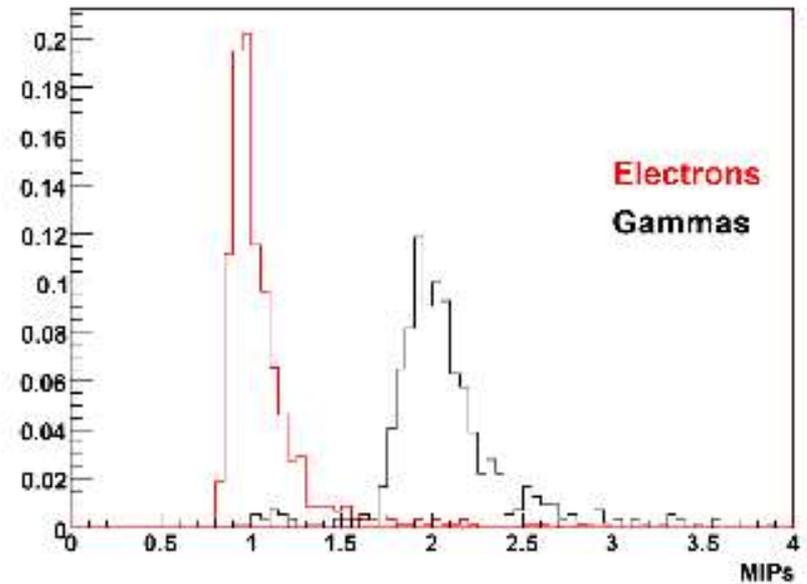
This value may be able to be pushed higher. More statistics are needed.

## The dE/dx tag (track orientation not considered)

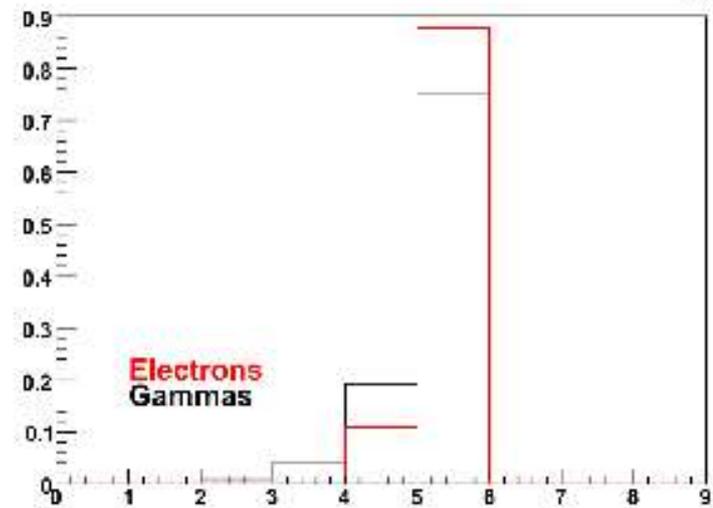
Energy loss in the first 24cm of track: 200 MeV electrons vs. 200 MeV gammas. Same wire spacing



Energy loss in the first 25cm of track: 200 MeV electrons vs. 200 MeV gammas. Same wire spacing



Number of 3mm segments along track used after statistical cuts  
~97% gamma purity, requiring 80% electron efficiency



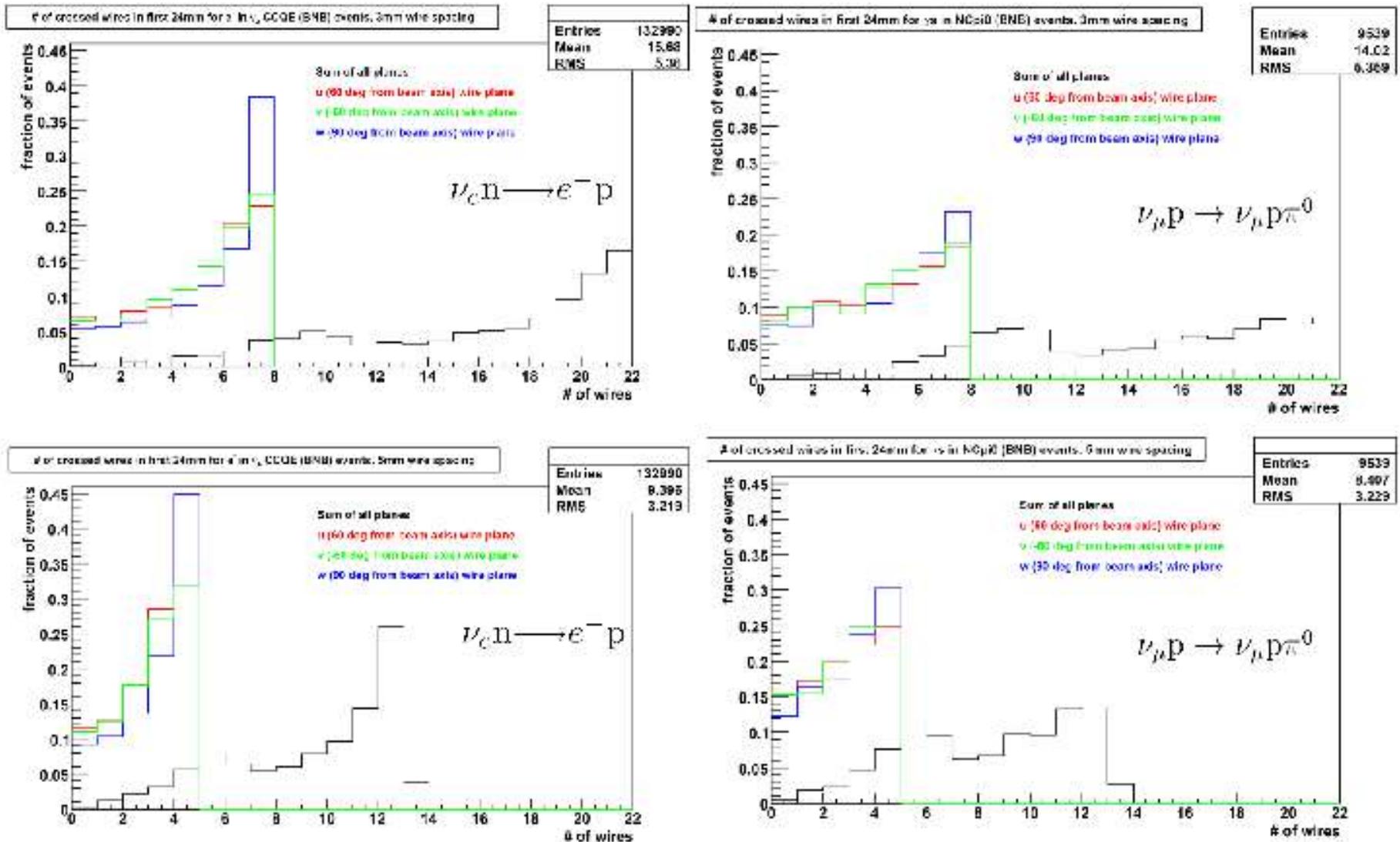
Number of 5mm segments along track used after statistical cuts  
~96% gamma purity, requiring 80% electron efficiency

# Resolving short tracks

- Along with track length, the number of wires that a track crosses (depending on track orientation) is the figure of merit in these studies.
  - A “crossed wire” is defined after projecting a track onto the wire planes.
- Obviously the more wires a track crosses, the “better” the track is reconstructed and the “better” the track is resolved.
  - “Better” can only be defined after a reconstruction and track-finding algorithm is developed.

Note that studying the # of wire crossings in a given track neglects the drift coordinate. Also, a track may be able to be detected even if it does not cross any wires.

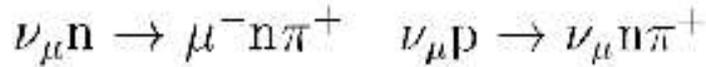
## Resolving the first 24mm of track (considering track orientation)



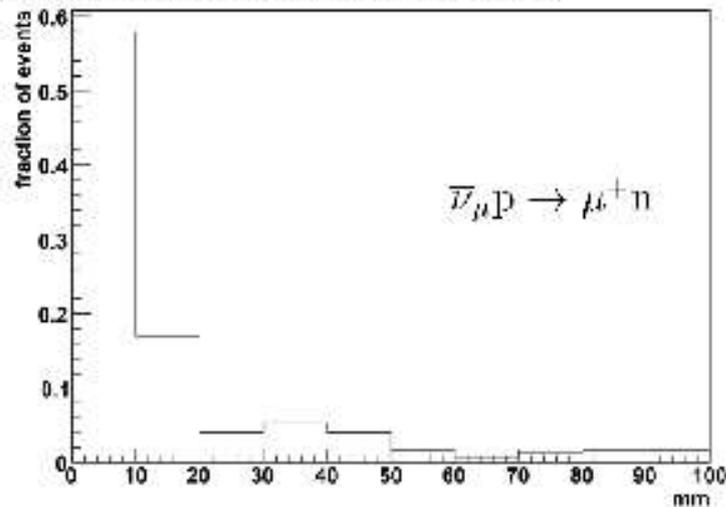
Redundancy will be very important in making the dE/dx tag. Entire track segments will need to be statistically eliminated to reduce mis-IDs due to Bremsstrahlung.

# Resolving neutron-induced proton tracks

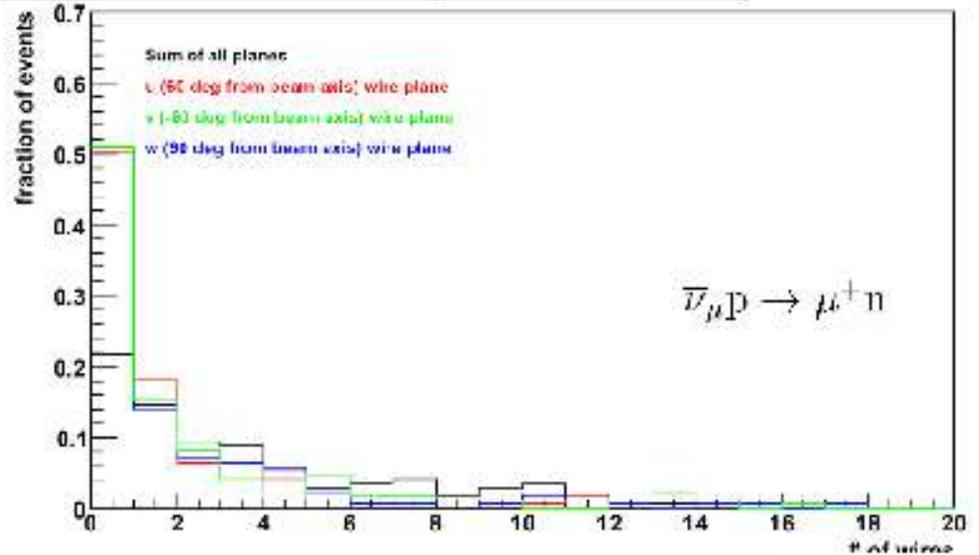
$\bar{\nu}_\mu p \rightarrow \mu^+ n$  is taken as an example of events involving a neutron.  
 Other common channels involving a neutron:



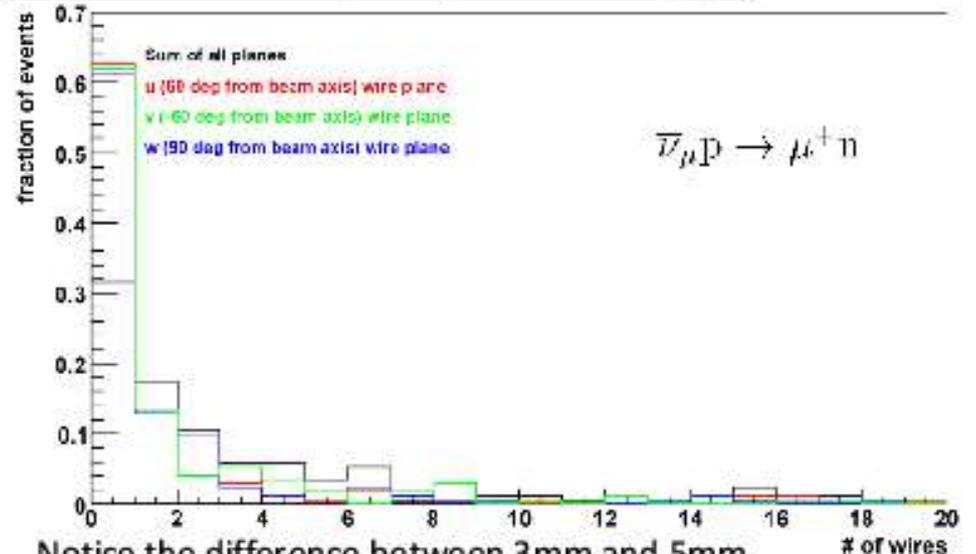
Neutron-induced proton track length in  $\bar{\nu}_\mu$  CCQE events



# of crossed wires for neutron-induced protons in  $\bar{\nu}_\mu$  CCQE events, 3mm wire spacing

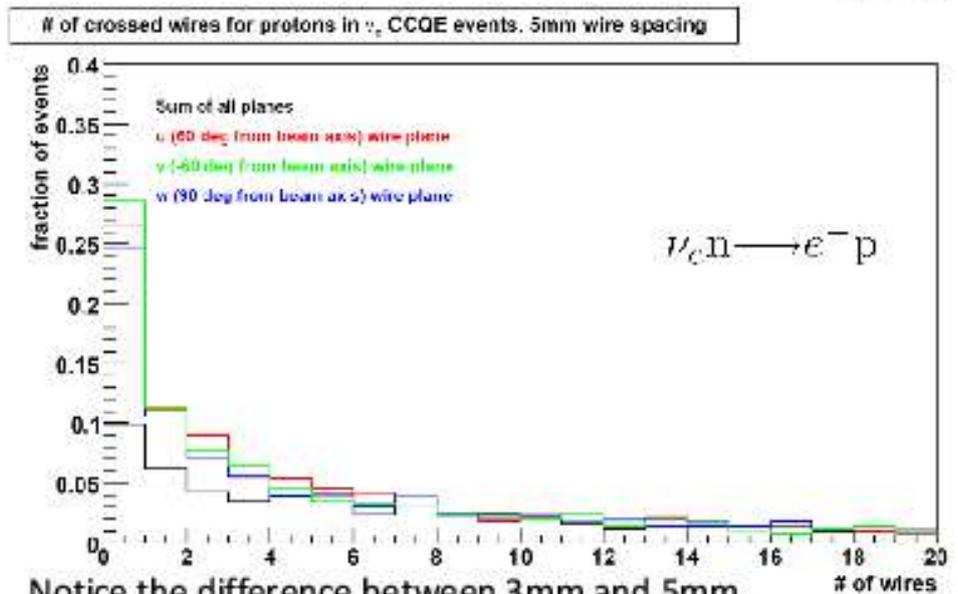
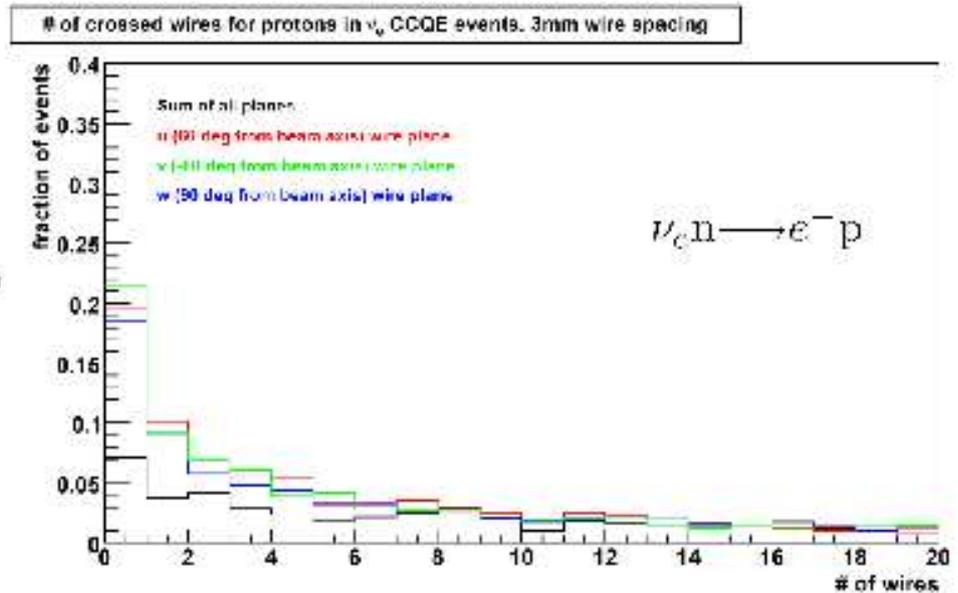
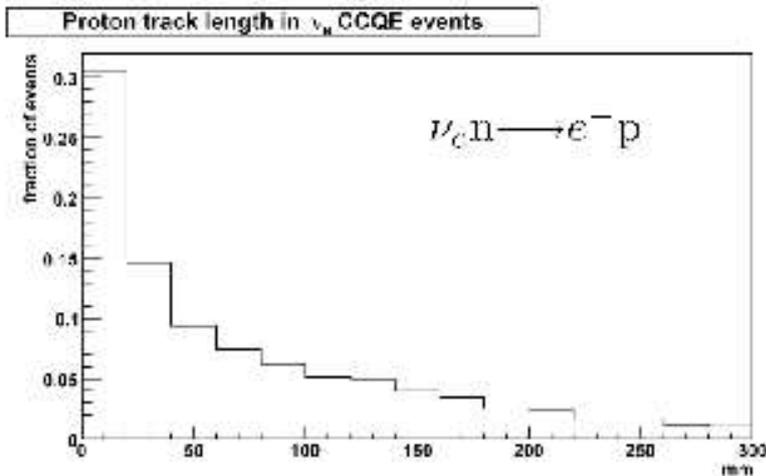
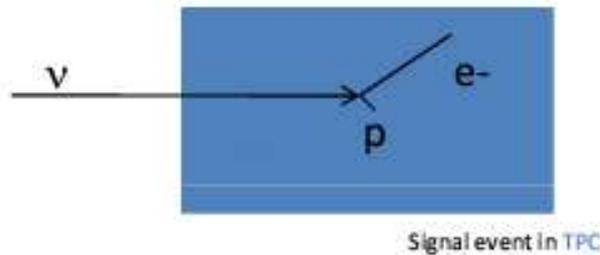
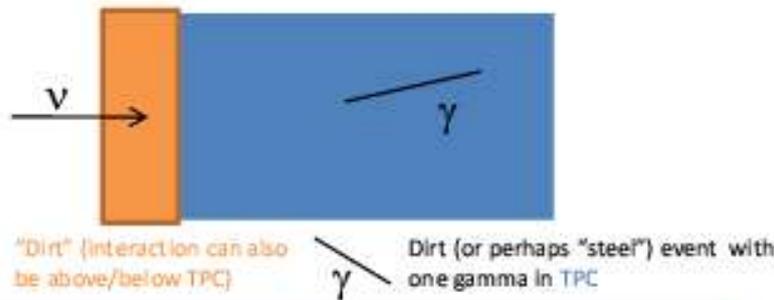


# of crossed wires for neutron-induced protons in  $\bar{\nu}_\mu$  CCQE events, 5mm wire spacing



Notice the difference between 3mm and 5mm wire spacing in the first few bins

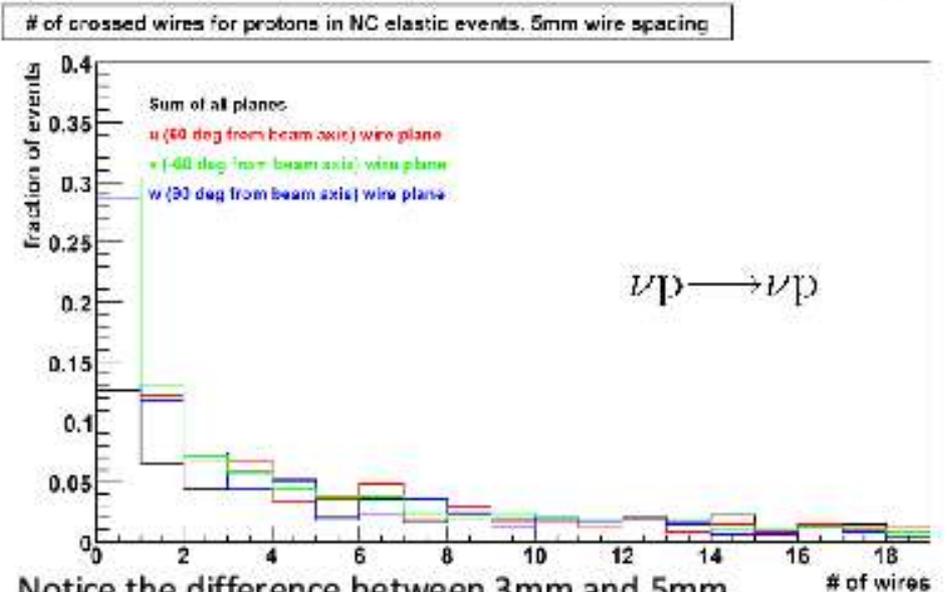
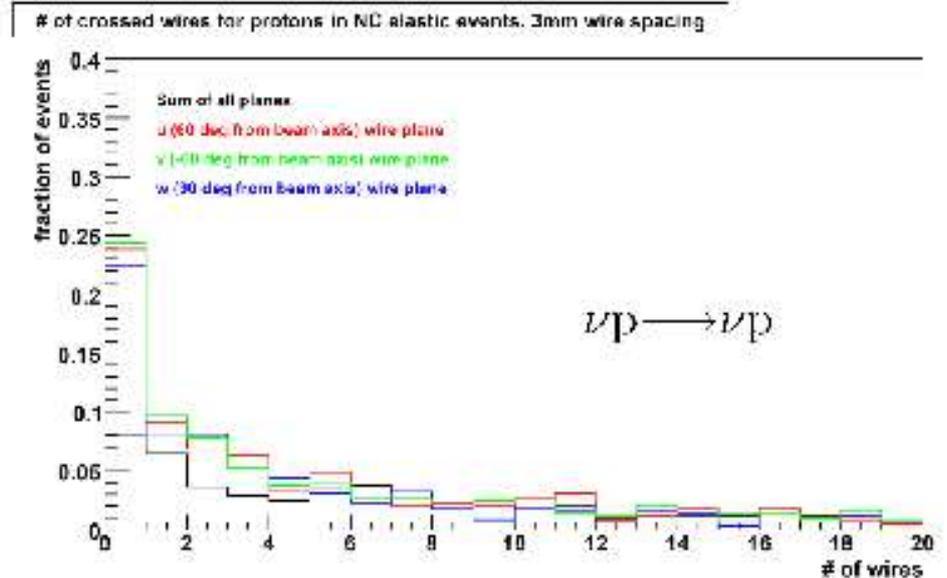
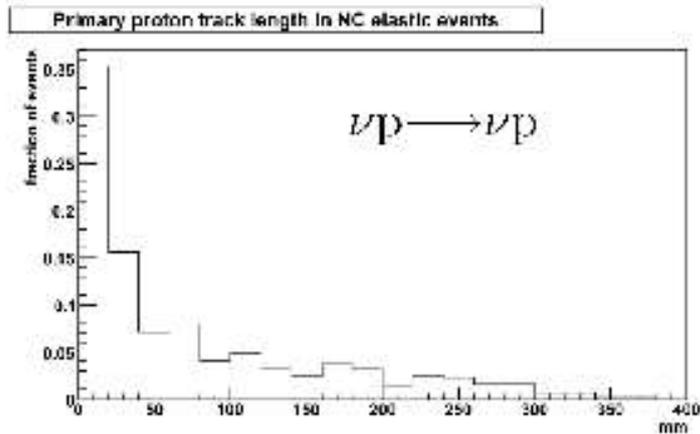
# Resolving the nucleon to differentiate between dirt background and signal



Notice the difference between 3mm and 5mm wire spacing in the first few bins

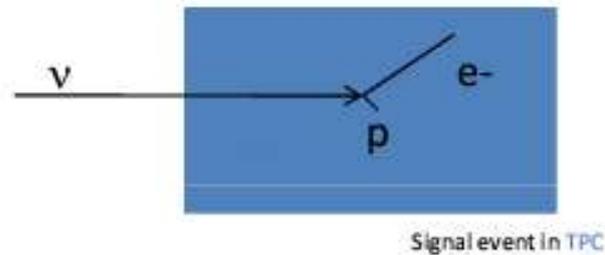
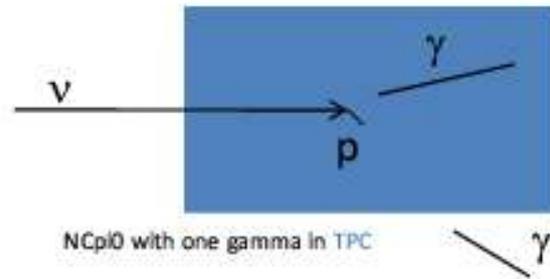
## Resolving the nucleon to measure cross sections

- The neutral current elastic channel is taken as an example.
- Separating neutron events from proton events may be possible with an LArTPC.
  - Measuring  $\Delta_s$  ?

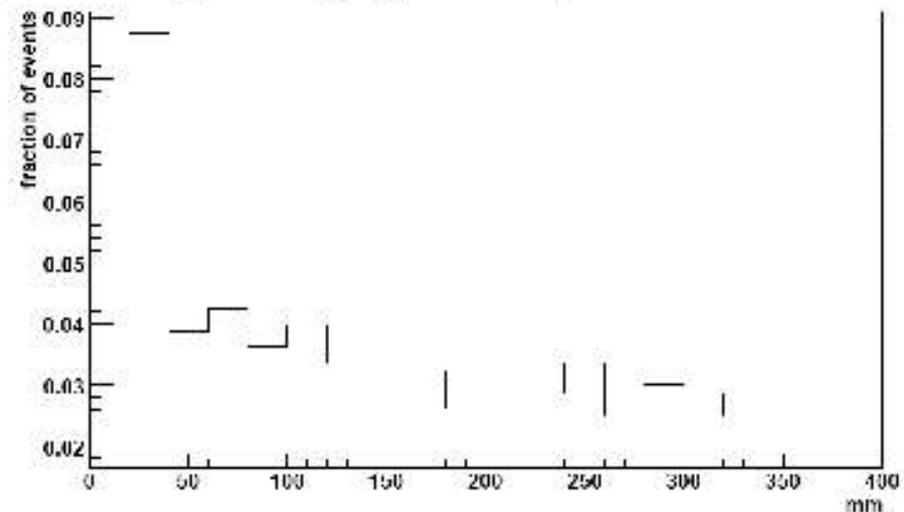


Notice the difference between 3mm and 5mm wire spacing in the first few bins

## Resolving the nucleon to define a vertex (and then gap between vertex and conversion point) in NCpi0 events

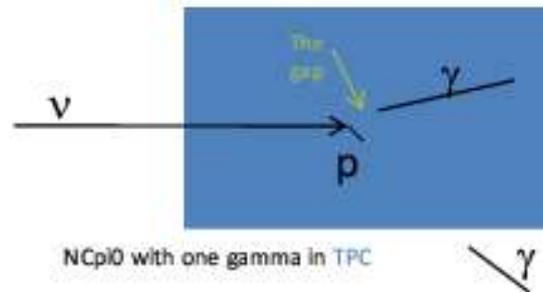


Total track length of all outgoing protons in NCpi0 events



Track orientation is not considered here because there is sometimes more than just a single proton at the vertex. "Track length" is the length of all outgoing proton tracks in a single event added together.

Resolving the gap between interaction vertex and pair production in events involving a pi0 (e.g.  $\nu_\mu p \rightarrow \nu_\mu p \pi^0$ )



$$P(x) = \frac{1}{\lambda_{pair}} \exp\left[-\frac{x}{\lambda_{pair}}\right] \quad \lambda_{pair} = 18\text{cm} \longrightarrow \text{Conversion length of photon in LAr}$$

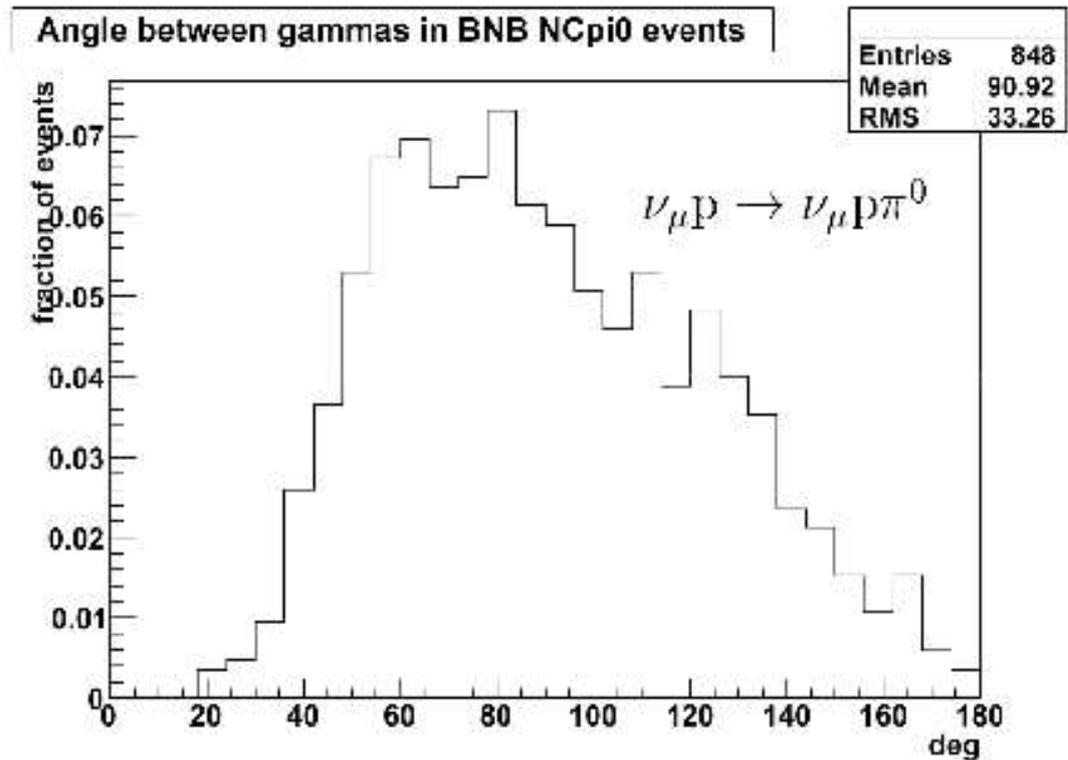
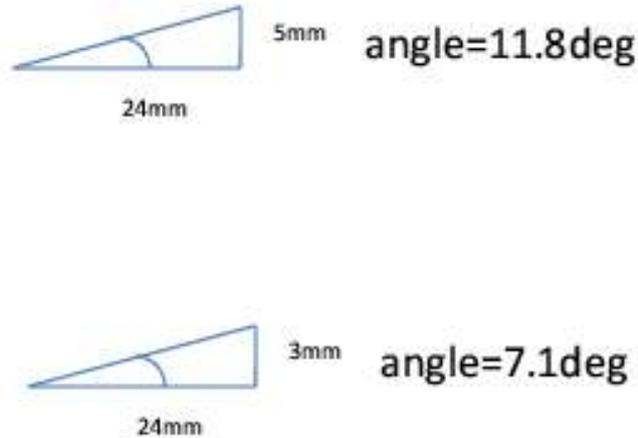
$$\int_0^{5\text{cm}} \frac{1}{18\text{cm}} \exp\left[-\frac{x}{18\text{cm}}\right] dx = 2.7\%$$

$$\int_0^{3\text{cm}} \frac{1}{18\text{cm}} \exp\left[-\frac{x}{18\text{cm}}\right] dx = 1.7\%$$

2.7% of gammas convert in the first 5mm of track and 1.7% of gammas convert in the first 3mm of track.

Note that the nucleon needs to be resolved for the gap to be defined in the first place (see previous slide)!

# Resolving the angle between two overlapping gamma tracks



Cost savings: Lets say you save the cost of  $\frac{1}{2}$  of the wire planes. The biggest cost savings here is in channel count. Save  $\sim 4,000$  channels at \$142 per channel =  $\sim 570k$ . Scale this as we did for estimating how much you really save considering you still have to pay for design work and folding in pedestal costs.

For PAC, we told them the electronics savings would only be 40%. So we'd still have the cost of 60% of this number: Save 350k.

Discussion....