

# The SciBooNE Experiment Neutral Current Analysis

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- Neutral Current  $\pi^0$  production : My analysis
- Neutral Current Elastic Scattering : H. Takei

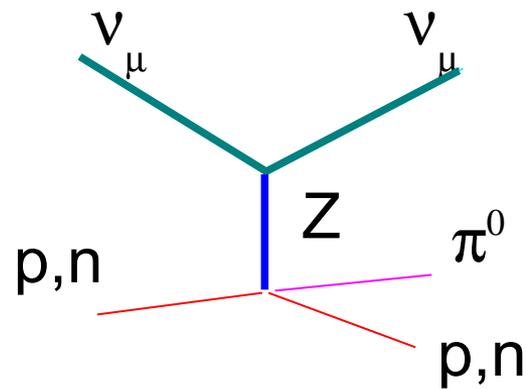
# NC $\pi^0$ Analysis

- Introduction
- Event selection
- Pi0 mass reconstruction

# Introduction

# Neutral Current $\pi^0$ Production

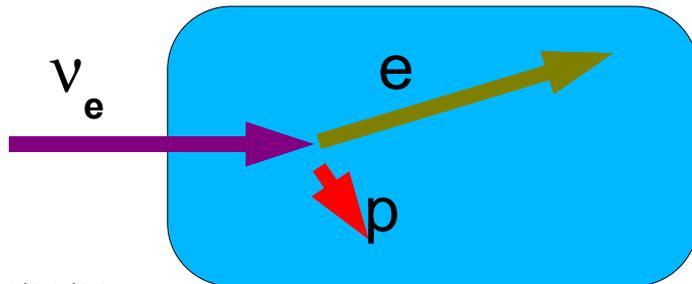
Neutral Current  $\pi^0$  (  $\text{NC}\pi^0$  )



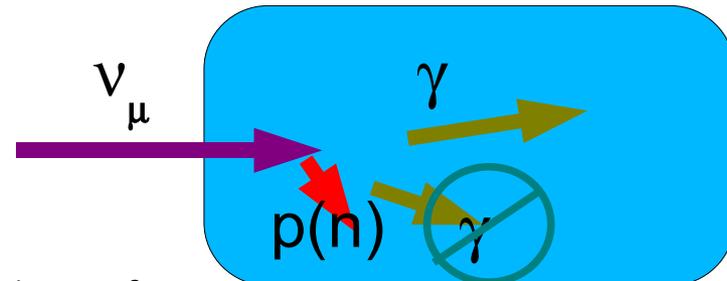
$\text{NC}\pi^0$  is the main background of the search for  $\nu_\mu$  to  $\nu_e$  oscillation

- $\gamma$  mimics  $e$  from  $\nu_e$

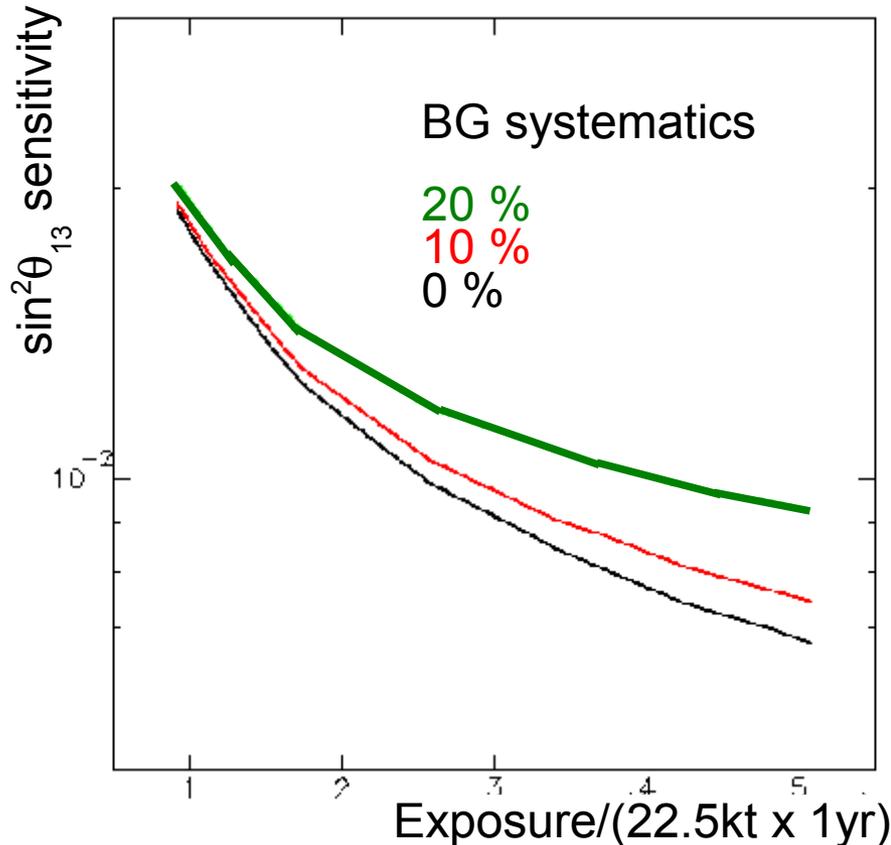
The  $\nu_e$  signal : electron



The background from  $\text{NC}\pi^0$   
: One  $\gamma$  from  $\pi^0$  , miss another  $\gamma$



# For T2K experiment



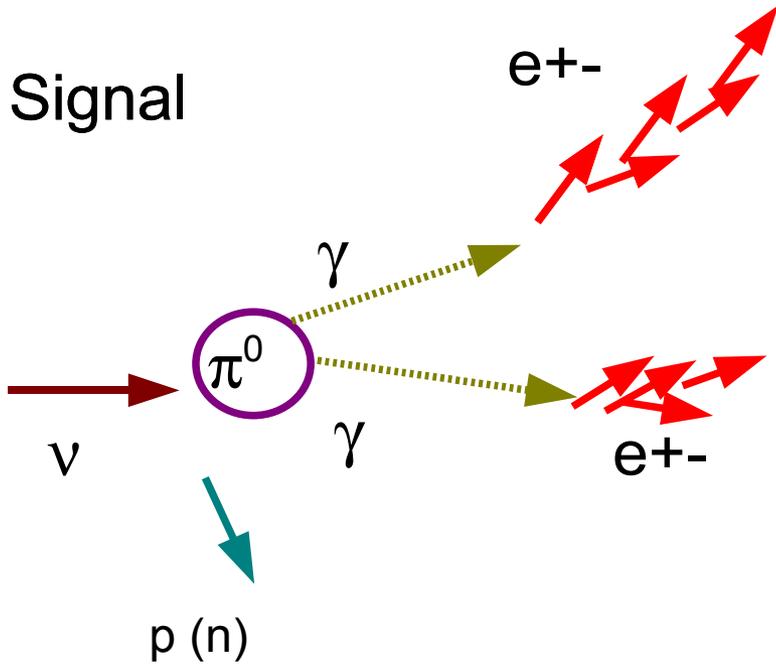
Oscillation probability

$$P(\nu_{\mu} \rightarrow \nu_e)$$

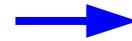
$$\sim \sin^2 2\theta_{13} \sin^2 \theta_{23} \times \sin^2(1.27 \Delta m_{13}^2 L(\text{km})/E(\text{GeV}))$$

- Want to reduce uncertainty in  $\sigma(\text{NC}\pi^0)$  from 20% to 10 %
- improvement of factor of 2 in ultimate T2K sensitivity to  $\theta_{13}$
- or 2.5 years vs. 4 years to  $10^{-2}$

# Signal and Background



$2\gamma$  from  $\pi^0$

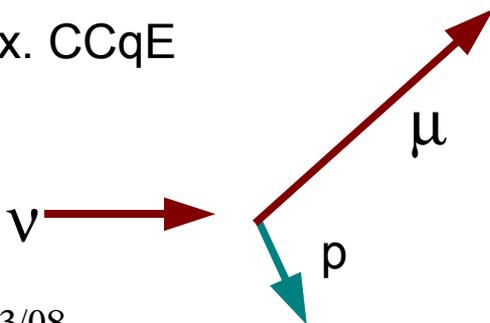


- 2 tracks isolated
- Both tracks are not  $\mu, p$

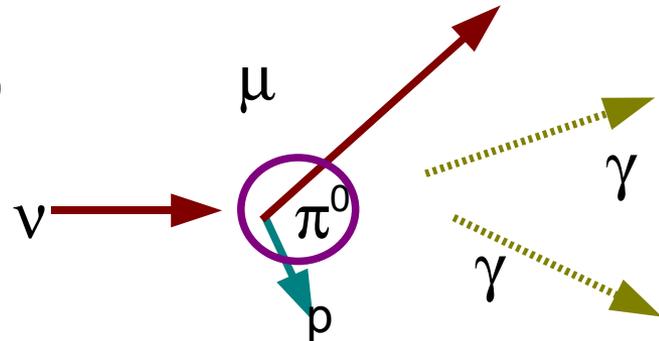
We don't have EM-Shower ID method so far.

Background  $\mu, p$  common vertex

Ex. CCqE



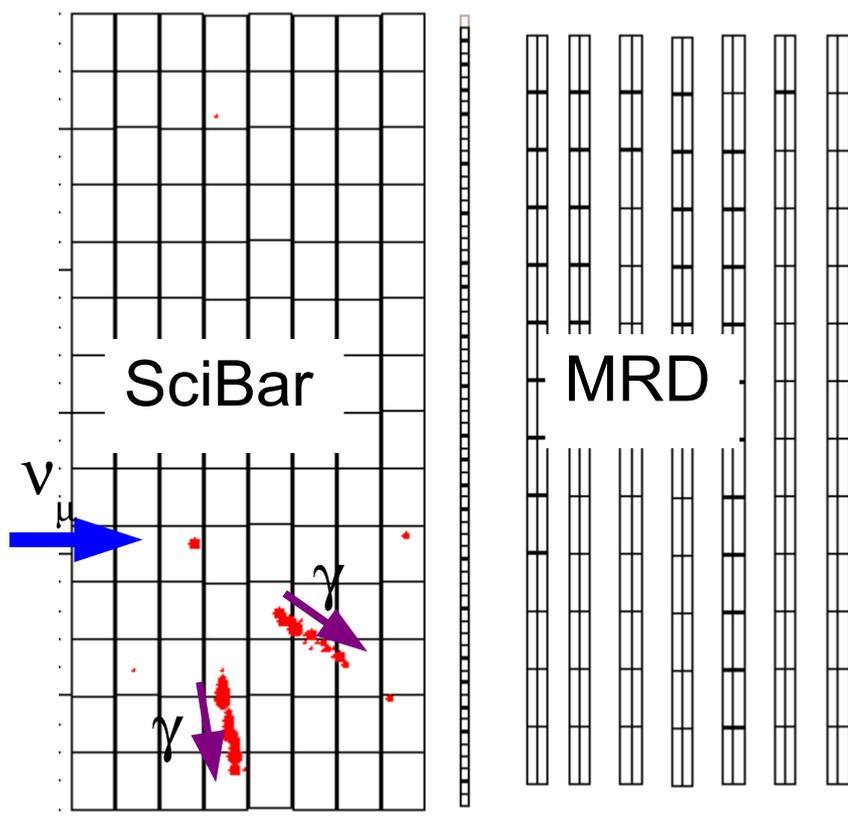
Ex. CC $\pi^0$



# Event Selection

# NC $\pi^0$ in the SciBar detector

NC $\pi^0$  Candidate



Event Selection

## 1. Pre-Selection

- At least two tracks
- Not reaching MRD

## 2. Using the track information

- Reject p using the  $dE/dX$
- Reject  $\mu$  using the decay e

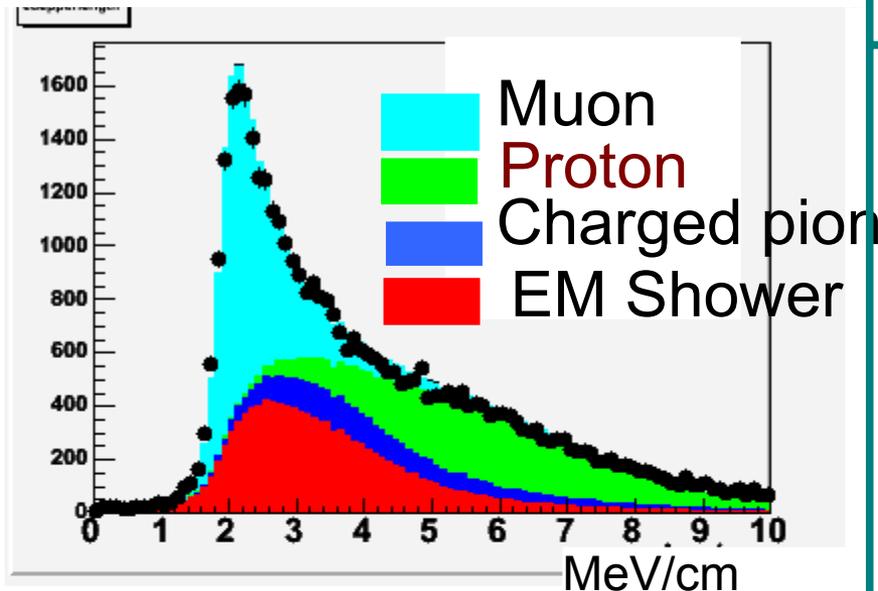
## 3. Using the event topology

Disconnection btw 2 tracks

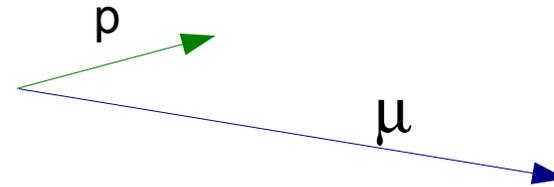
# The proton rejection using dE/dx

- Protons lose more energy than other particles do
- Reject events which have only track pairs including proton

dE/dx for each particle after pre-selection



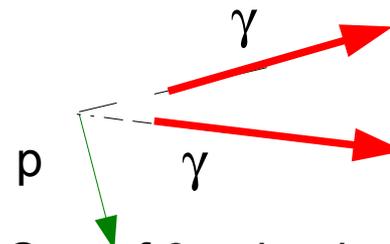
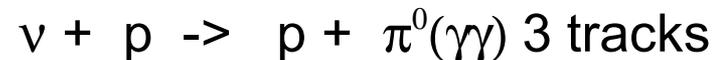
Ex.1



One pair including protons

→ Reject

Ex.2



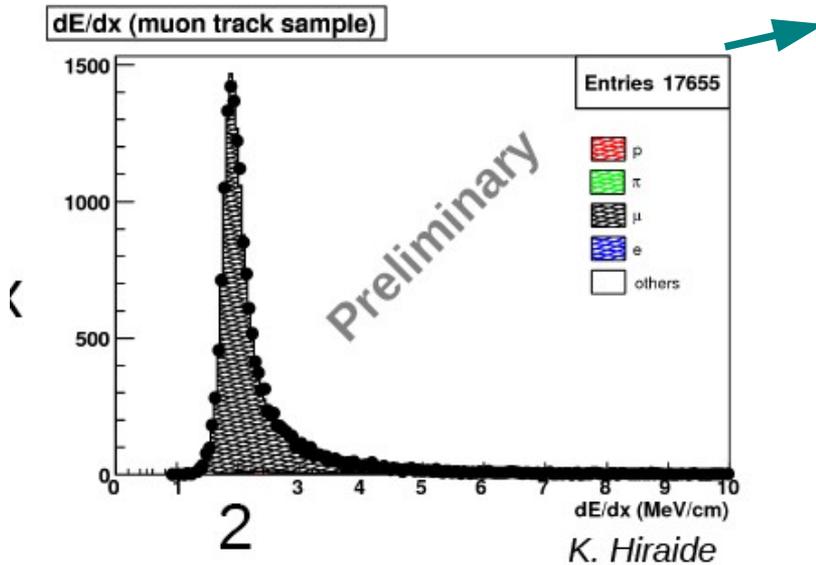
One of 3 pairs doesn't have proton

→ Accept

# The Proton Identification

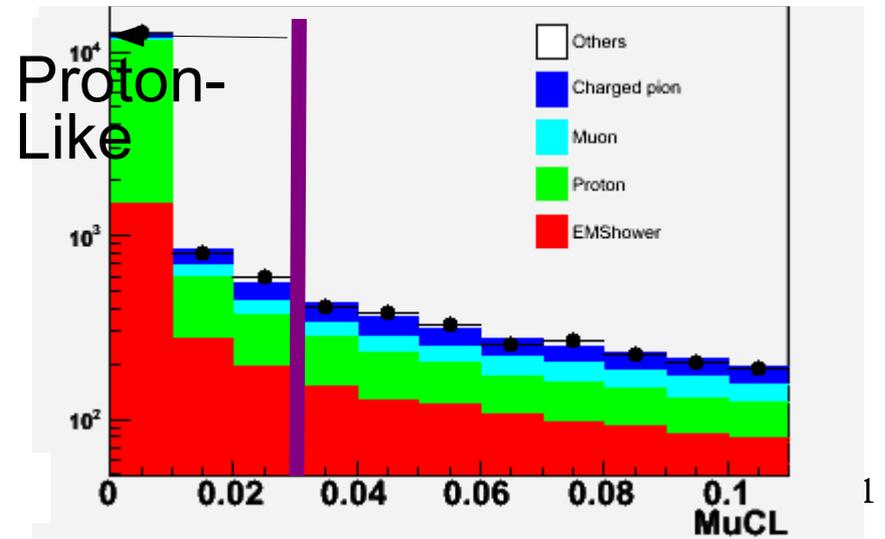
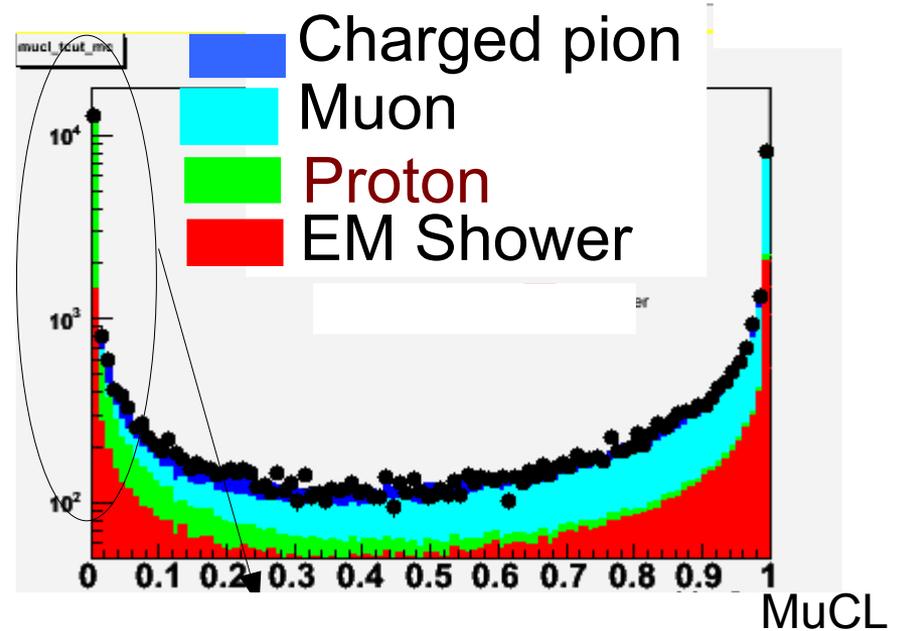
Using muon  $dE/dx$ , make likelihood called muon confidence level.

$dE/dx$ : Muons



$MuCL < 0.03$

Proton-Like

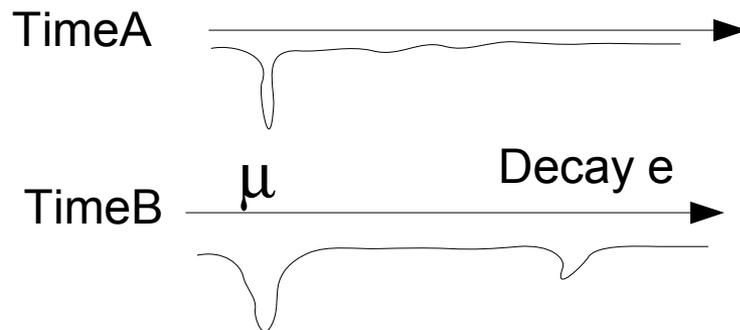
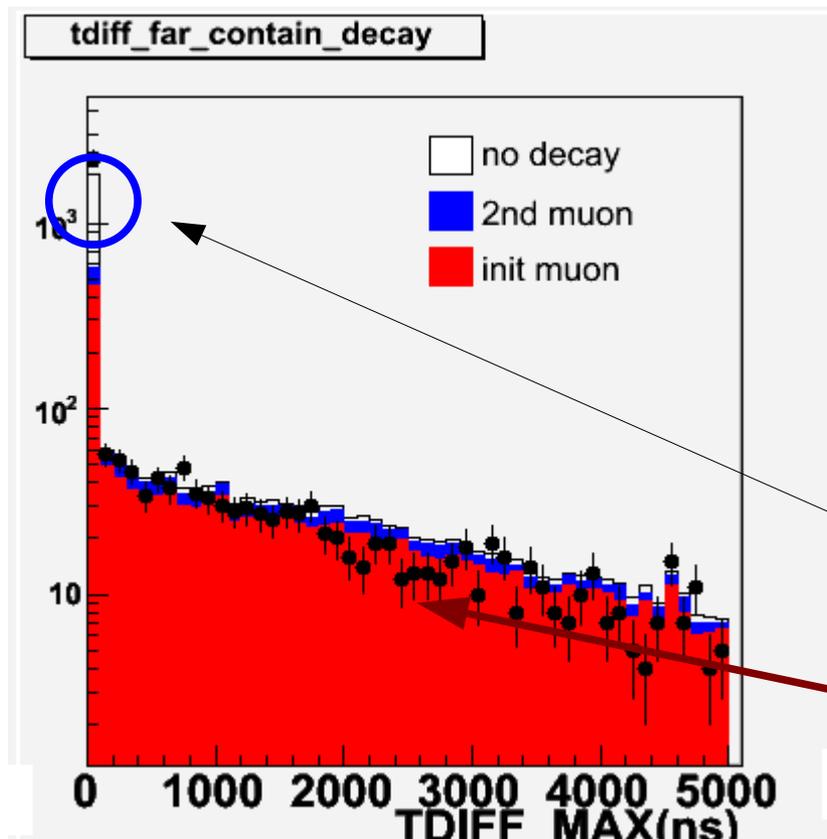


# Muon Rejection with the decay e

There are  $\mu$ s stopping in SciBar ( not reaching MRD )

These  $\mu$ s can be removed using the decay e

Time difference btw track edges



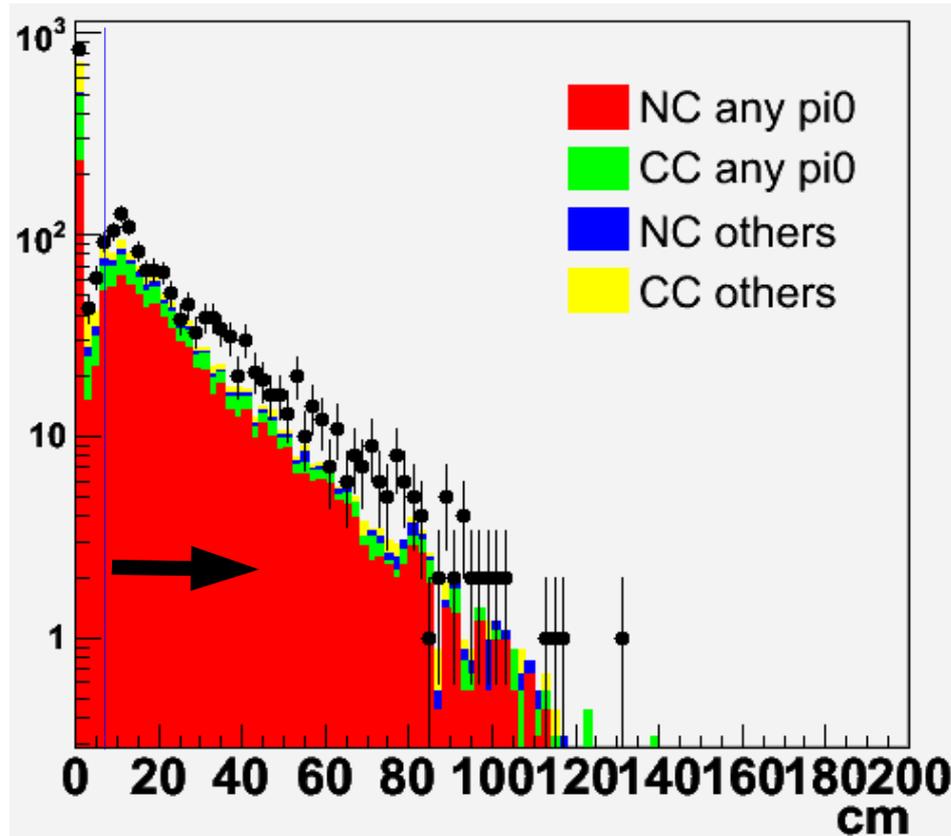
(The latest) TimeB - TimeA

Most "no decay" events is in the region  $< 100$  ns (first bin)

➔ Reject " $> 100$  ns "

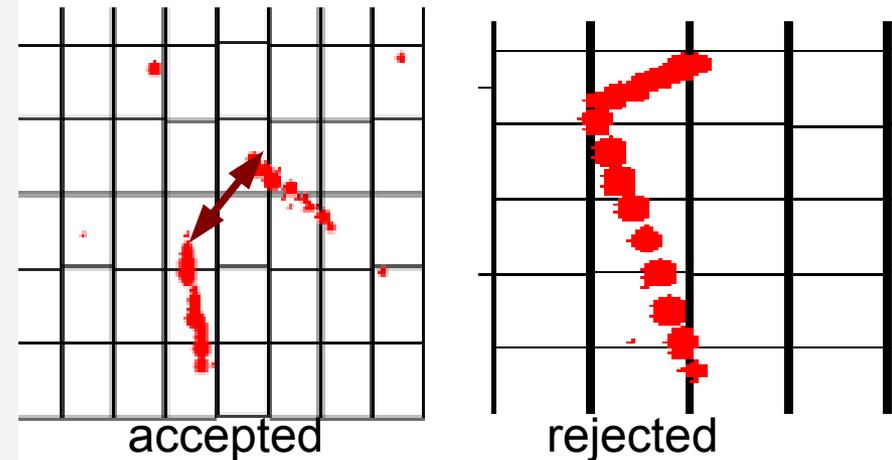
# The disconnection btw tracks

The distance btw tracks (after all events selection)



To get  $2\gamma$  from  $\pi^0$  and remove CC events

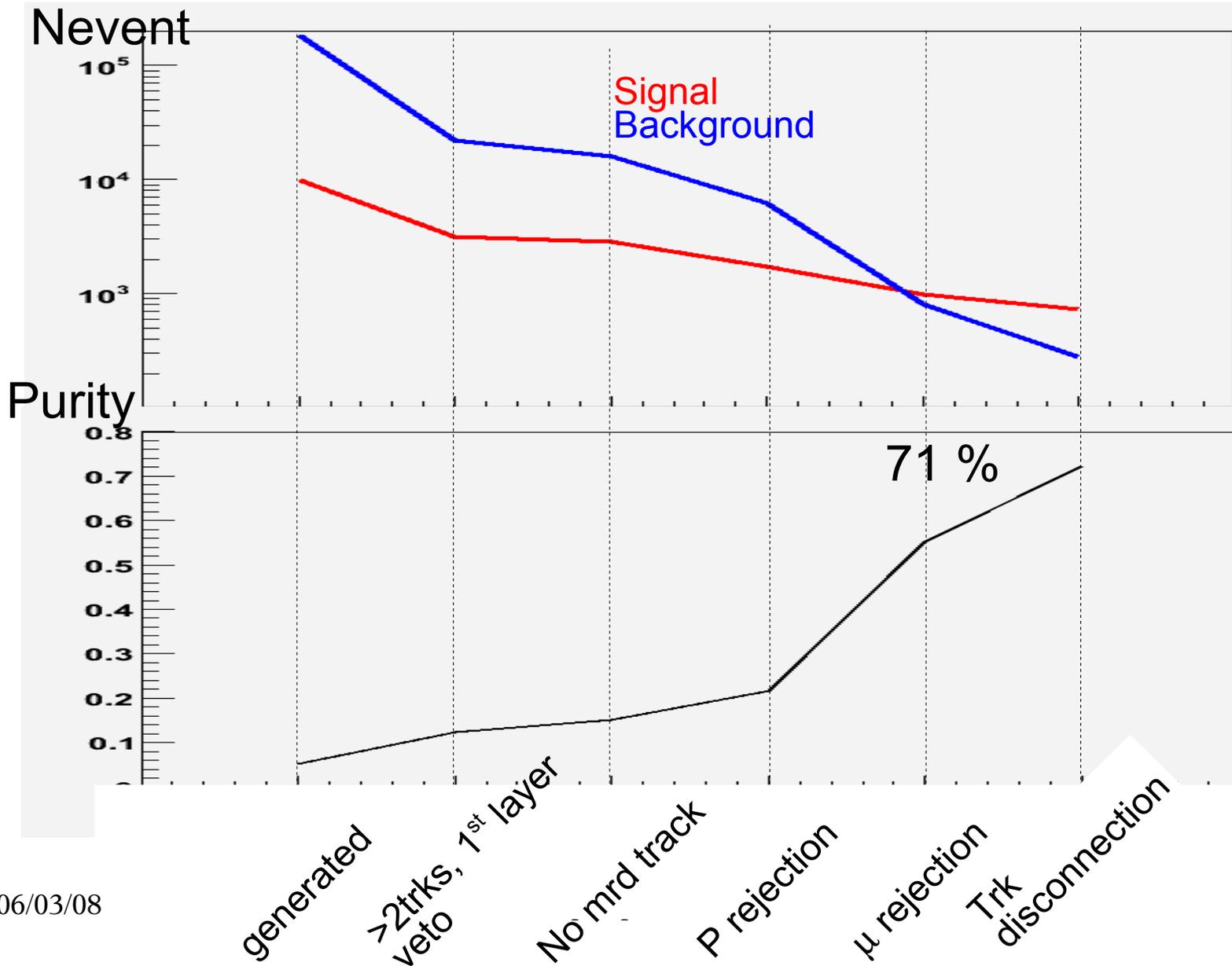
Threshold = 6cm



1300 events are selected

The purity of the signal = 71 %

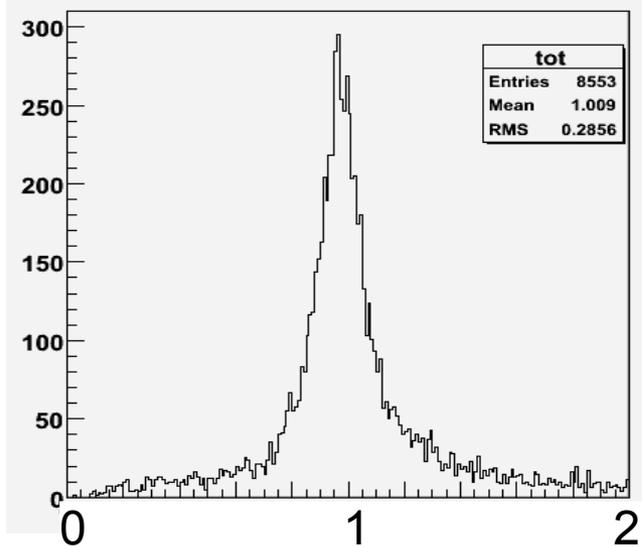
# Efficiency and Purity



# $\pi^0$ mass reconstruction

# $\gamma$ Reconstruction Performance

## (1) Energy Collection Efficiency

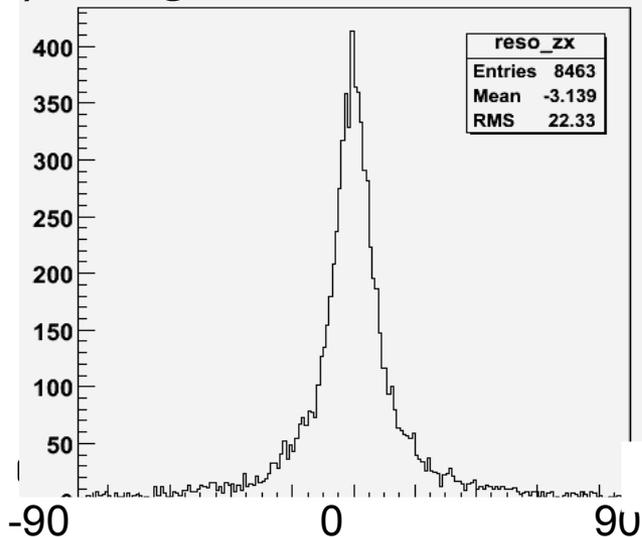


Energy Collection Efficiency =

$$\frac{\text{Reconstructed Energy of the Track}}{\text{Energy Deposit in SciBar (True)}}$$

$$= 1.01 \text{ (RMS} = 0.29)$$

## (2) Angular Resolution

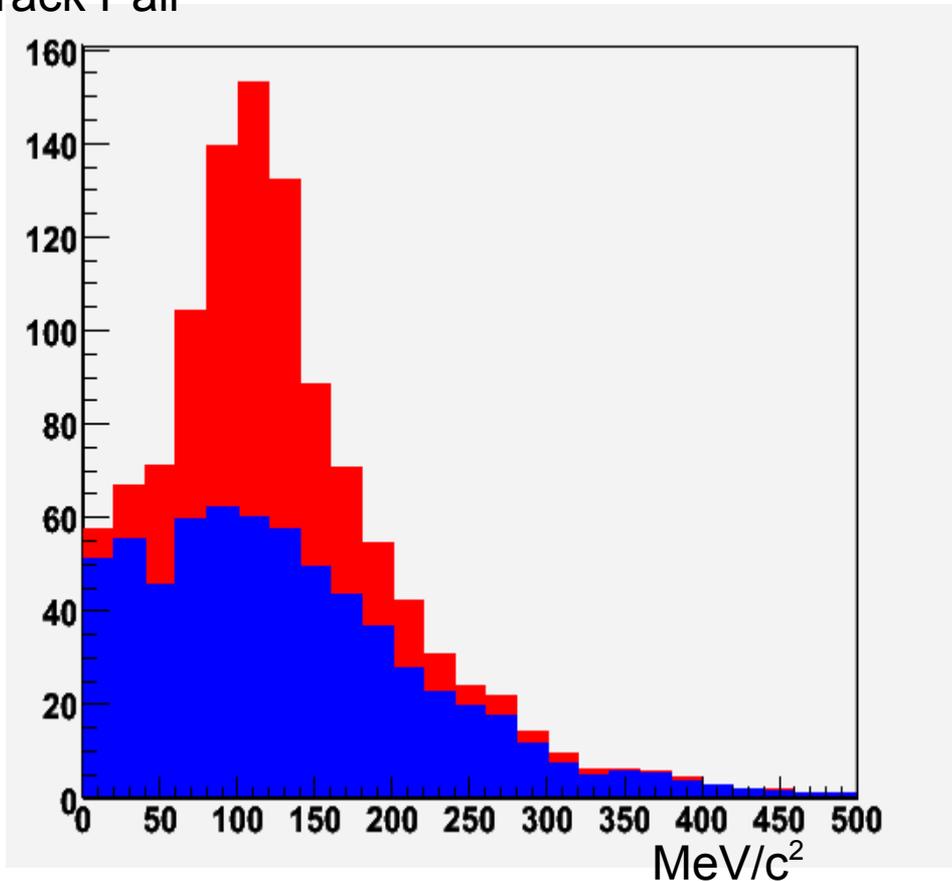


$$\theta_{xz}^{\text{rec}} - \theta_{xz}^{\text{true}}$$

$$\text{Angular Resolution} = 22^\circ$$

# $\pi^0$ Mass Reconstruction (MC only)

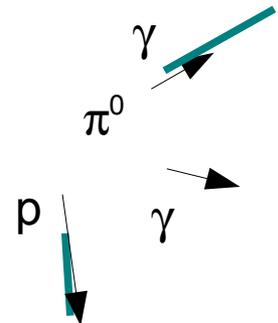
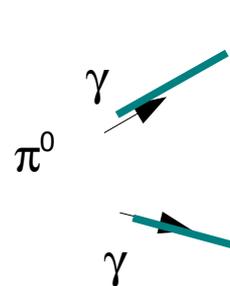
#Track Pair



- Calculate  $\pi^0$  mass for all track combinations in the sample

Red : 2  $\gamma$  from  $\pi^0$

Blue : wrong combination



Clear difference btw signal and background !

SciBar can reconstruct  $\pi^0$  mass

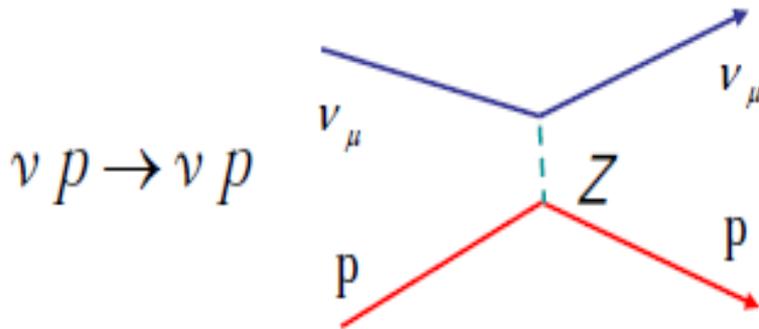
# Summary for NC $\pi^0$ Analysis

- NC $\pi^0$  cross section is important for  $\nu_e$  appearance search
- 1300 events are selected
- 71% purity for the signal in this sample
- SciBar can reconstruct  $\pi^0$  mass
- Systematic error should be estimated (Next Step)

# NC Elastic Analysis

# Motivation

Neutral Current elastic scattering

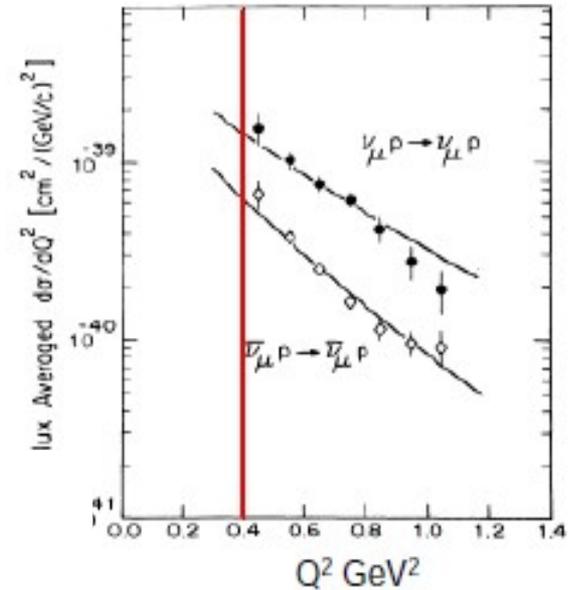


- Access to axial vector form factor

→ Strange component using  $\nu p \rightarrow \nu p$  at low  $Q^2$  region

- No data of  $\sigma(\nu p \rightarrow \nu p)$  at  $Q^2 < 0.4 \text{ GeV}^2$  published

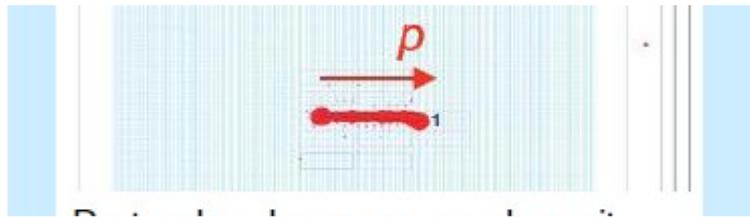
We aim at a measurement at smaller  $Q^2$



Phys.Rev.D35,3(1987)

# Signal and Background

Signal : One proton ,no other tracks



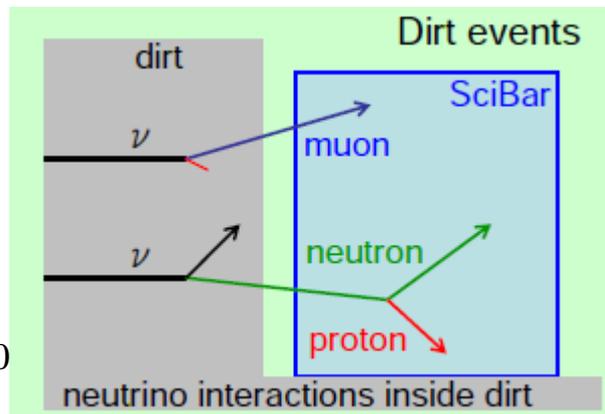
- Short Tracks
- Large Energy Deposit

The key for this analysis is

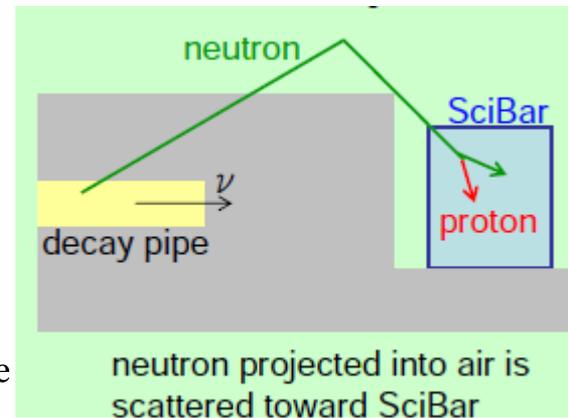
reducing or estimating these background

Background

ex1. Dirt events



ex2. Other beam related background

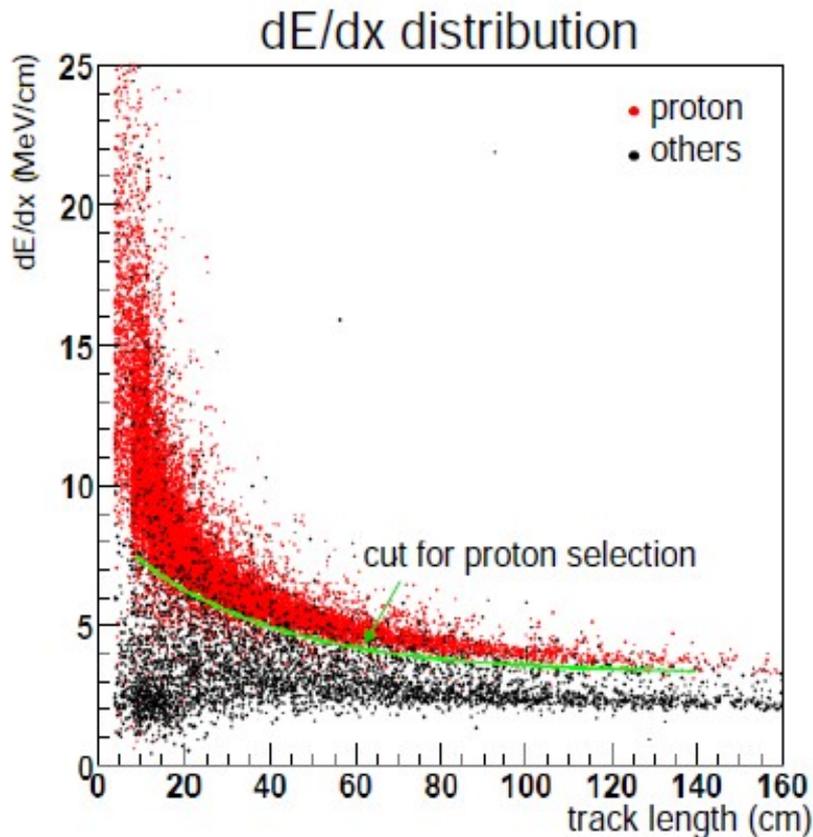


perspective

# Basic Selection Criteria

- Only one track stopped in SciBar
  - to get signal and remove CC events since many muon go through SciBar
- Reject events with hits outside the fiducial volume
  - to reject background from outside
- Remove events with the decay electron
  - to reject charged current events where muon stops in SciBar
- Select events which have a track with large energy deposit
  - to select proton tracks (more...)

# Proton Selection



Proton

Other

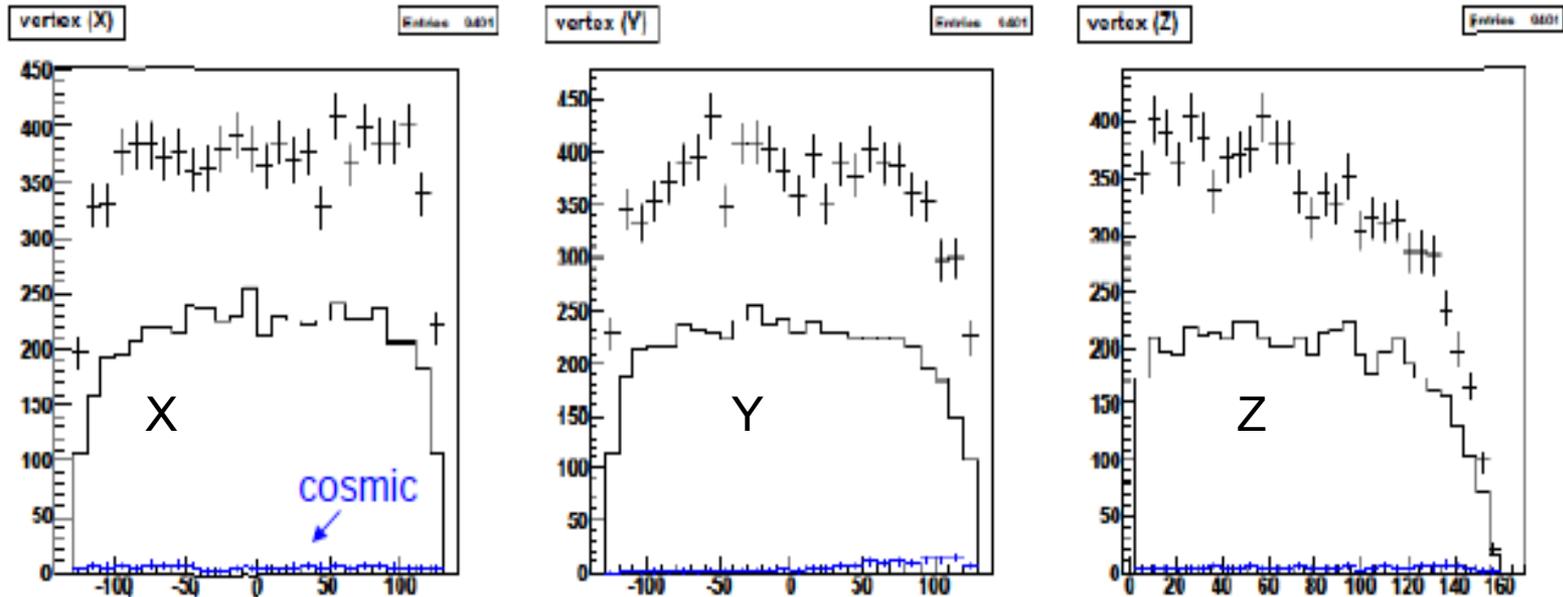
Select events above  
green Line

→ Proton efficiency 95 %  
mis-ID rate 5.3%

Efficiency for NCEL (proton)  
~ 22 %

Expected #events ~ 10000  
events

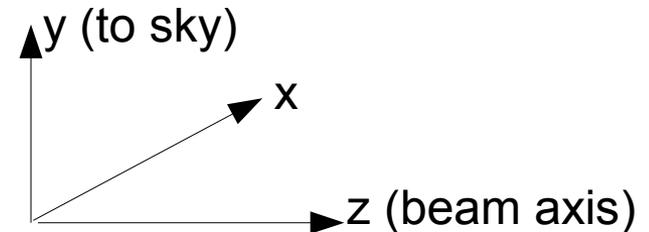
# Vertex Distribution after selection



— Date normalized by #MRD -  
matched events

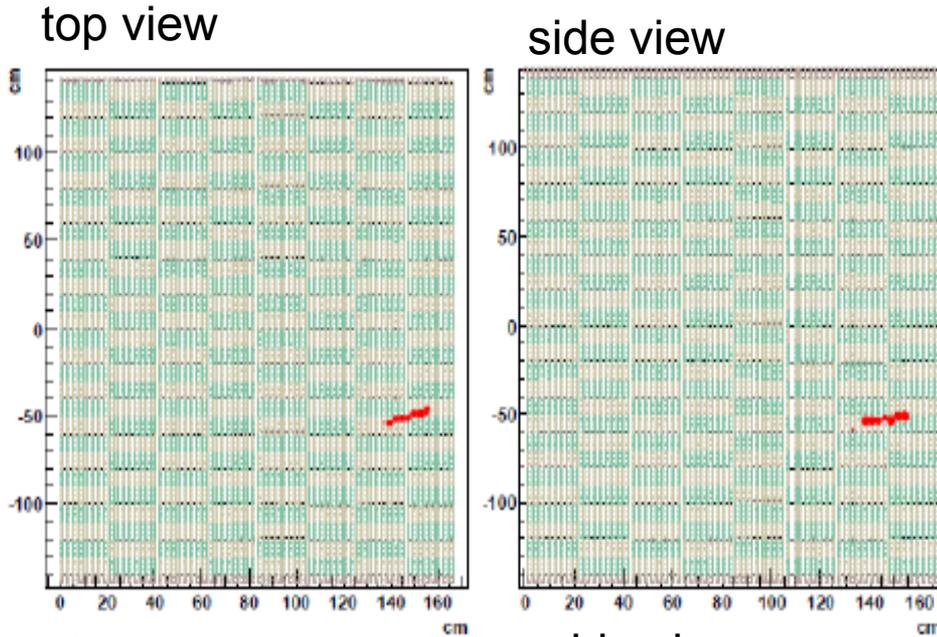
Still a lot of backgrounds

but not coming from cosmic ray  $\longrightarrow$  Dirt ?

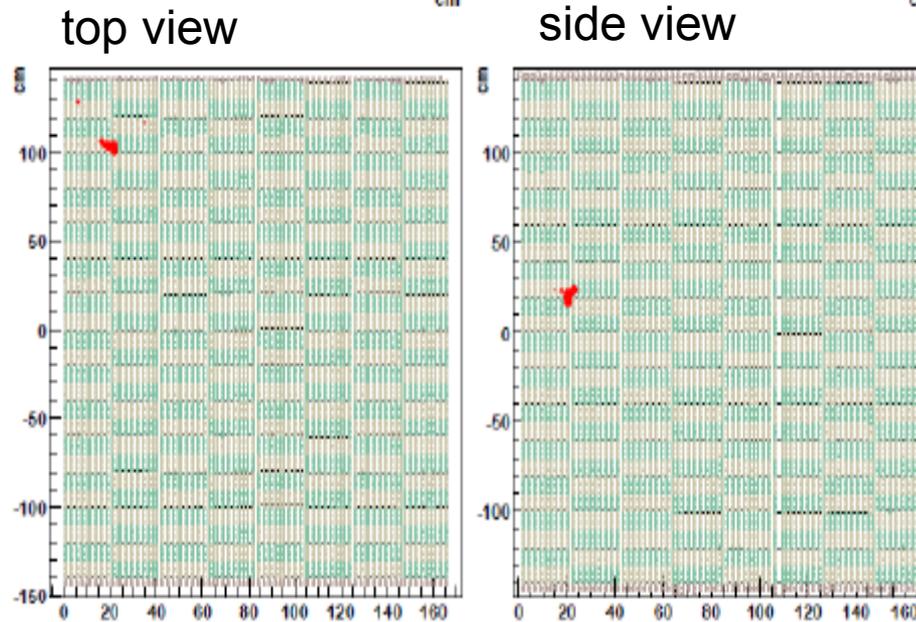


# Event Display after selection

Ex.1



Ex.2



# Summary for NCEL analysis

- The efficiency for NCEL (p)  $\sim 22\%$
- Expected events for NCEL(p)  $\sim 10000$
- Still a lot of background



need to simulate events from  
Dirt (Next Step)

# Summary

## NC $\pi^0$

- 1300 events selected after event selection
- 71 % purity
- systematic error needs to be estimated

## NC elastic

- ~ 10000 events selected with event selection
- Still a lot of background
- Neutrino events from dirt should be estimated

The Result will come up at Nuint 2009

# Thank you very much !

Business : casual day



SciBooNE : formal day

On every Friday

or

Any conference (APS)

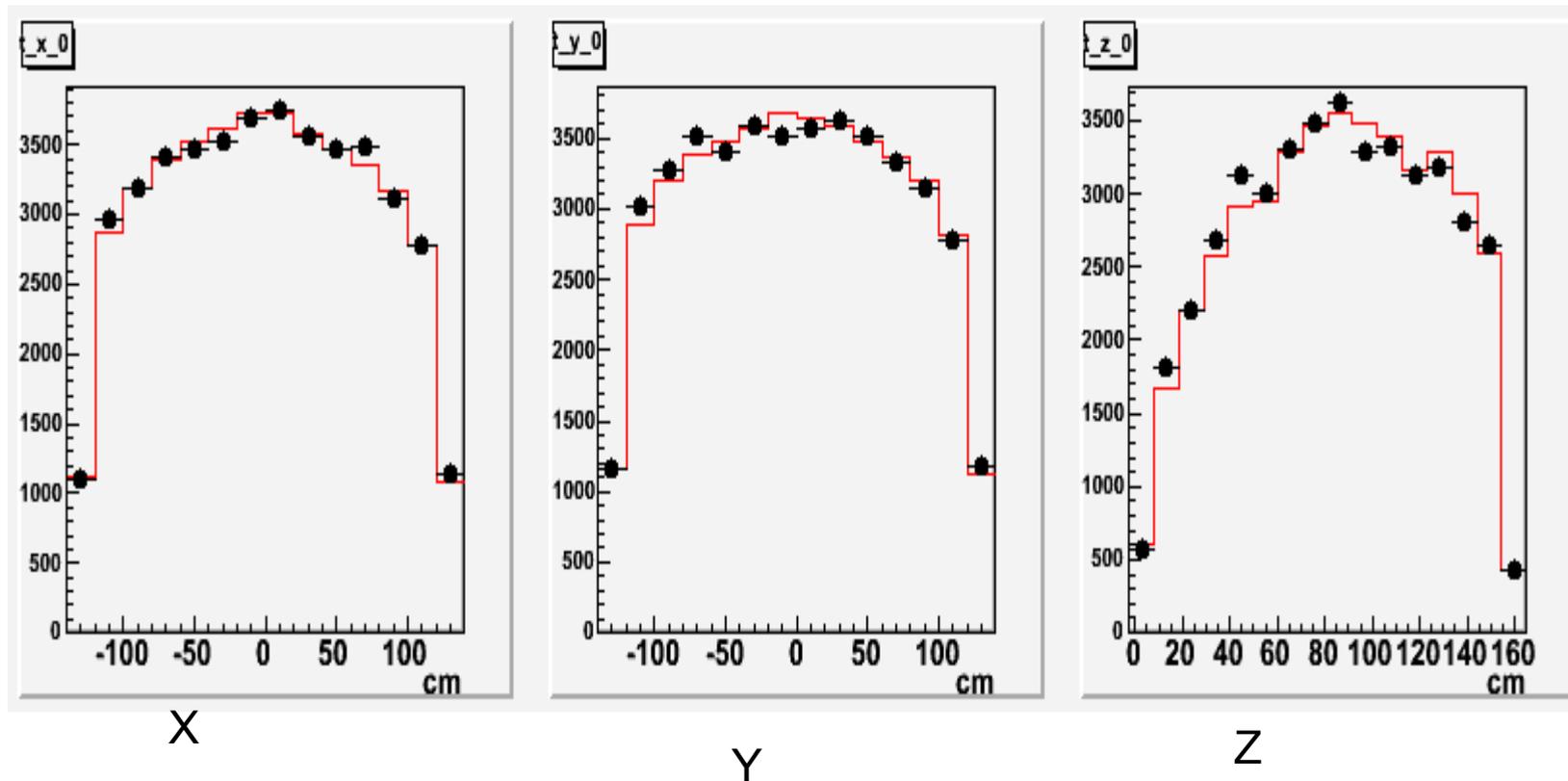


ectiv



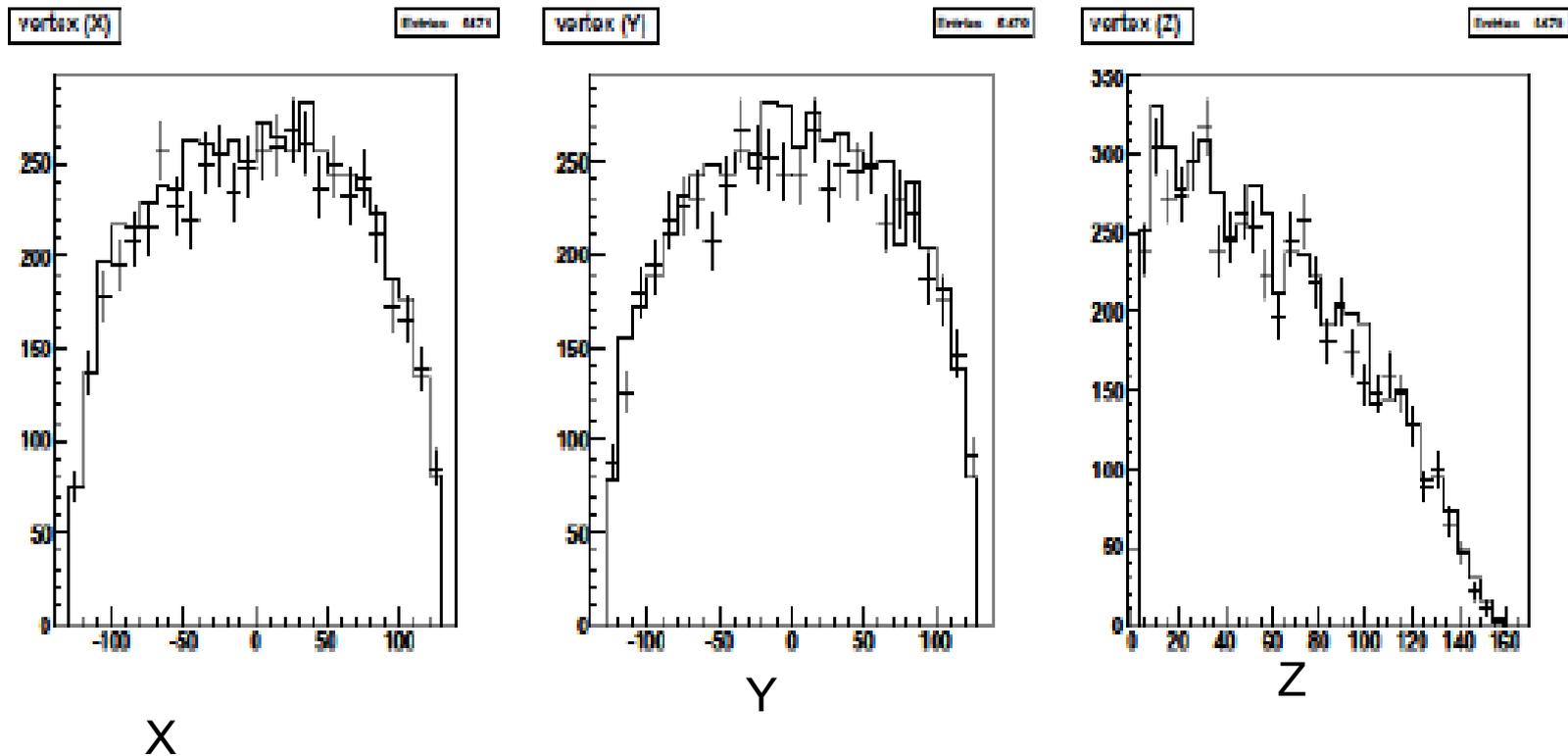
# Backup

# Vertex Distribution after pre-selection



Normalized by #MRD Matched events  
new perspective conference

# Vertex Distribution of Rejected Events w Michel Decay Filter

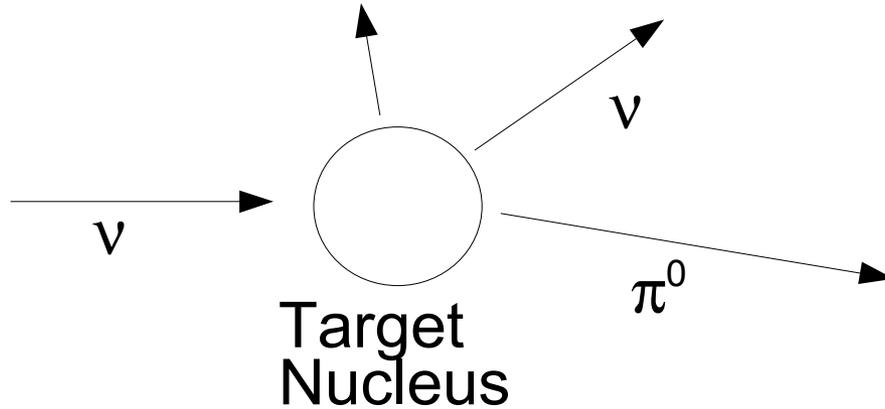


Normalized by #MRD Matched events  
new perspective conference

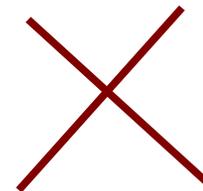
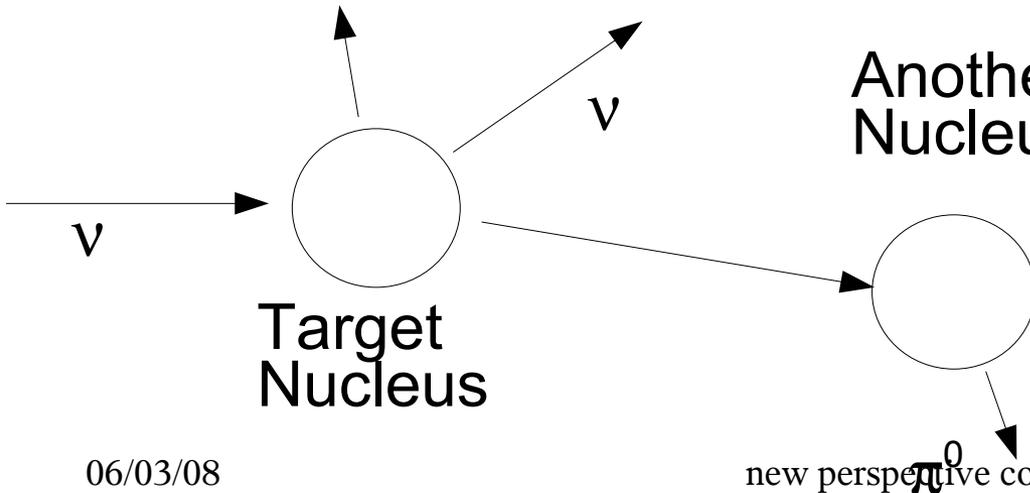
# Signal Definition

NC $\pi^0$

NC&any $\pi^0$



Another Nucleus



# Data and MC comparison

	NCany $\pi^0$	BG	TOTAL	Data
$\geq 2$ trks, 1 <sup>st</sup> layer veto	3121	22111	25353	25261
Not reaching MRD	2850	15915	18746	19099
P rejection	1718	6191	7924	8117
$\mu$ rejection	990	806	1796	2253
Disconnection	726	277	1004	1327