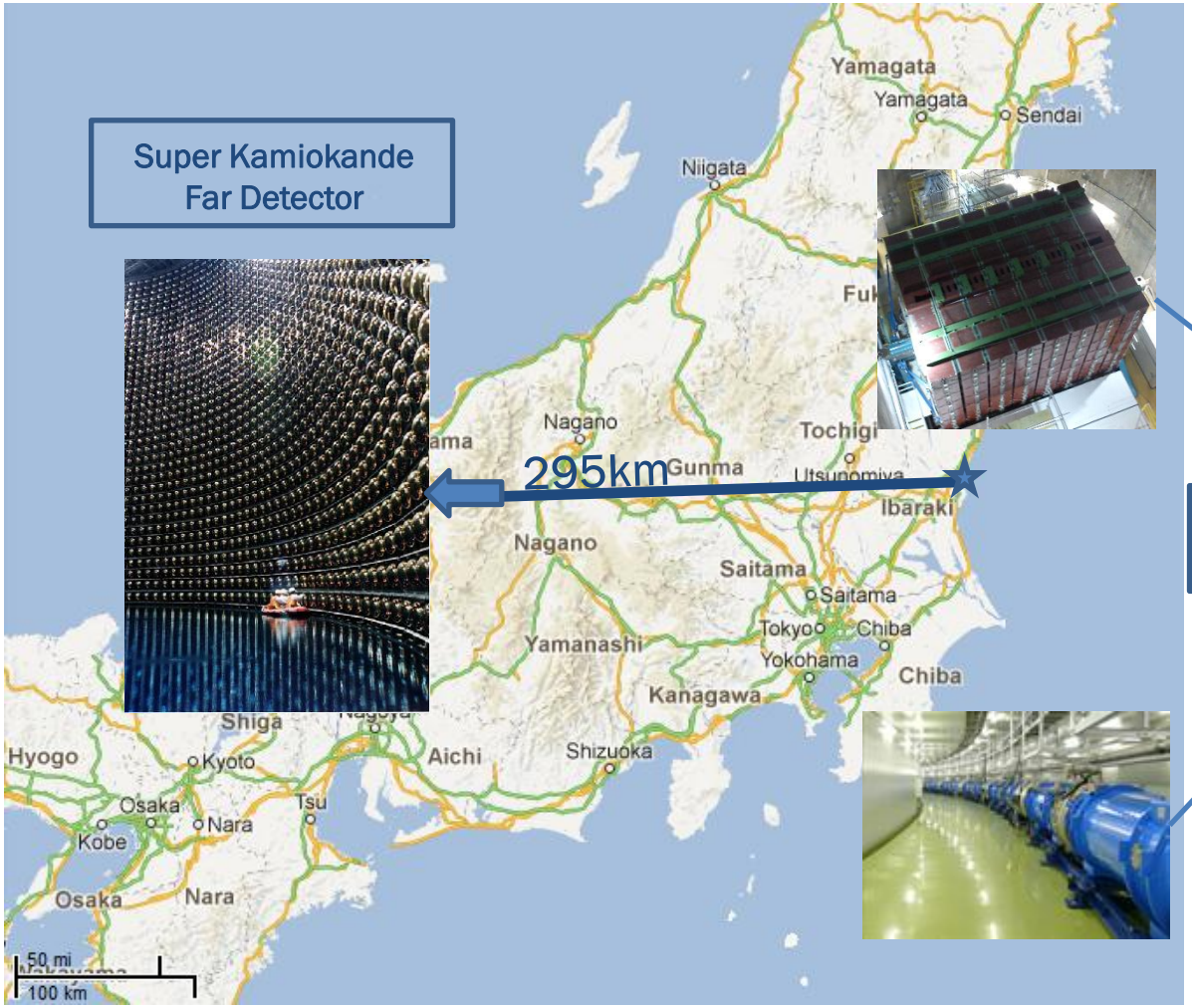
Leptonic topologies for the study of neutral current single π^0 events in the T2K near detector

Zachary Williamson
University of Oxford
IoP Conference, Liverpool
April 9, 2013

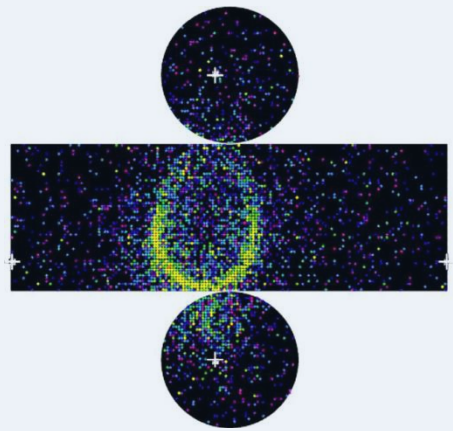
Tokai to Kamiokande Neutrino Experiment

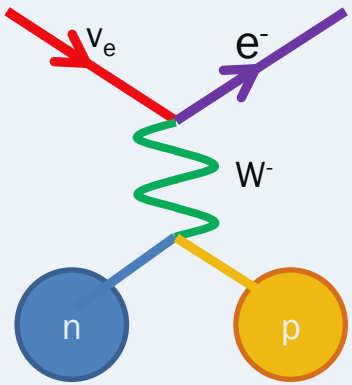


Introduction

- T2K aims to observe $\nu_\mu \rightarrow \nu_e$ oscillations, and use this result to fit for the oscillation parameter θ_{13}.
- A background to this measurement are neutral current π^0 interactions.
- Background can be constrained by measuring NC1π^0 interaction cross section at near detector, and extrapolating it to our far detector.
- Analysis uses Monte Carlo studies to measure background.

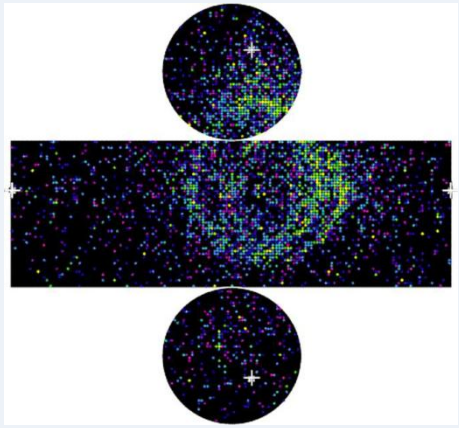
π^0 production & estimating SK backgrounds

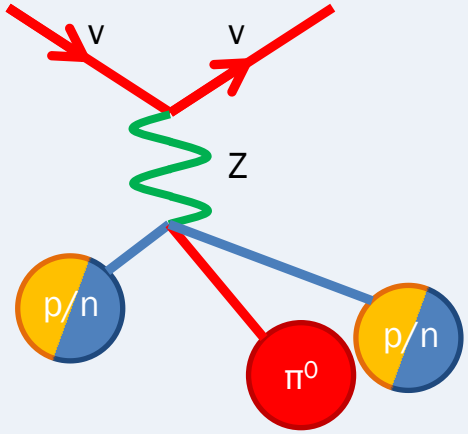




Signal

$$\nu_e + n \rightarrow p + e^-$$



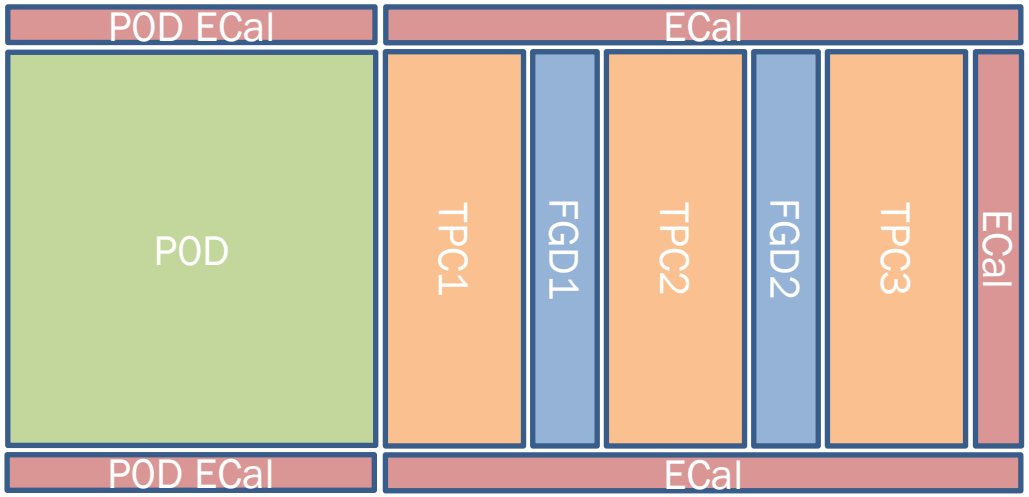


NC1π^0 Background

$$\nu + N \rightarrow \nu + N' + \pi^0$$
$$\searrow \gamma + \gamma$$

π^0's in ND280

- Analysis focuses on the Fine Grain Detectors (FGD) and Time Projection Chambers (TPC)
- Enables precision vertex reconstruction



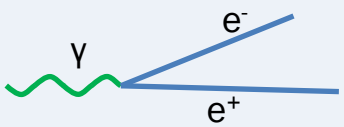
- π^0's detected by searching for two photons which converge to common vertex
  - Specifically, look for electrons and positrons from photon conversions

Topology Definitions

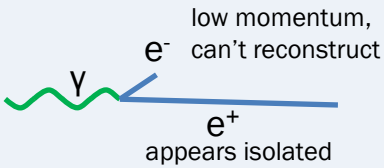
Main Topology

A neutral current π^0 interaction, produced in FGD1 or FGD2

$e^+ e^-$ pair



'Isolated' Leptons



conversion types
used to define

6 'Gold Plated' Topologies

'Gold Plated' = Subsets of main topology, each focuses on combination of photon conversion types

Photons must convert in vertex FGD, or adjacent downstream TPC

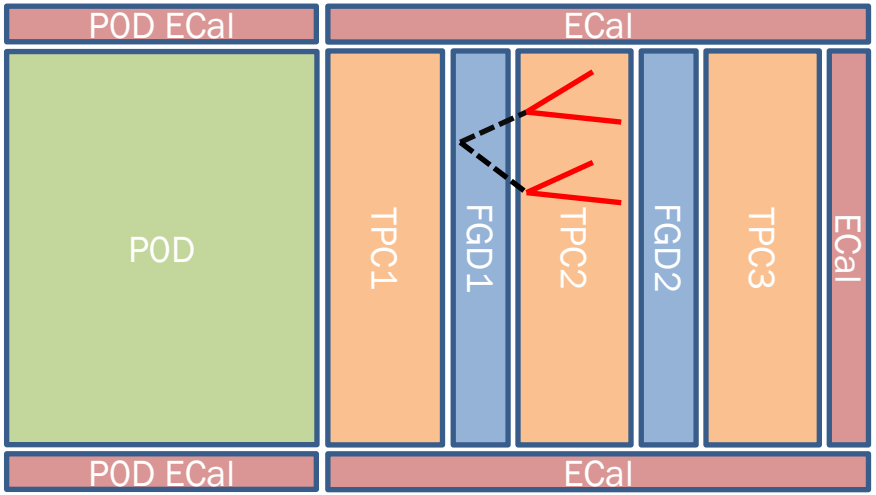
Other conversion locations covered by different analyses

Topology Definitions

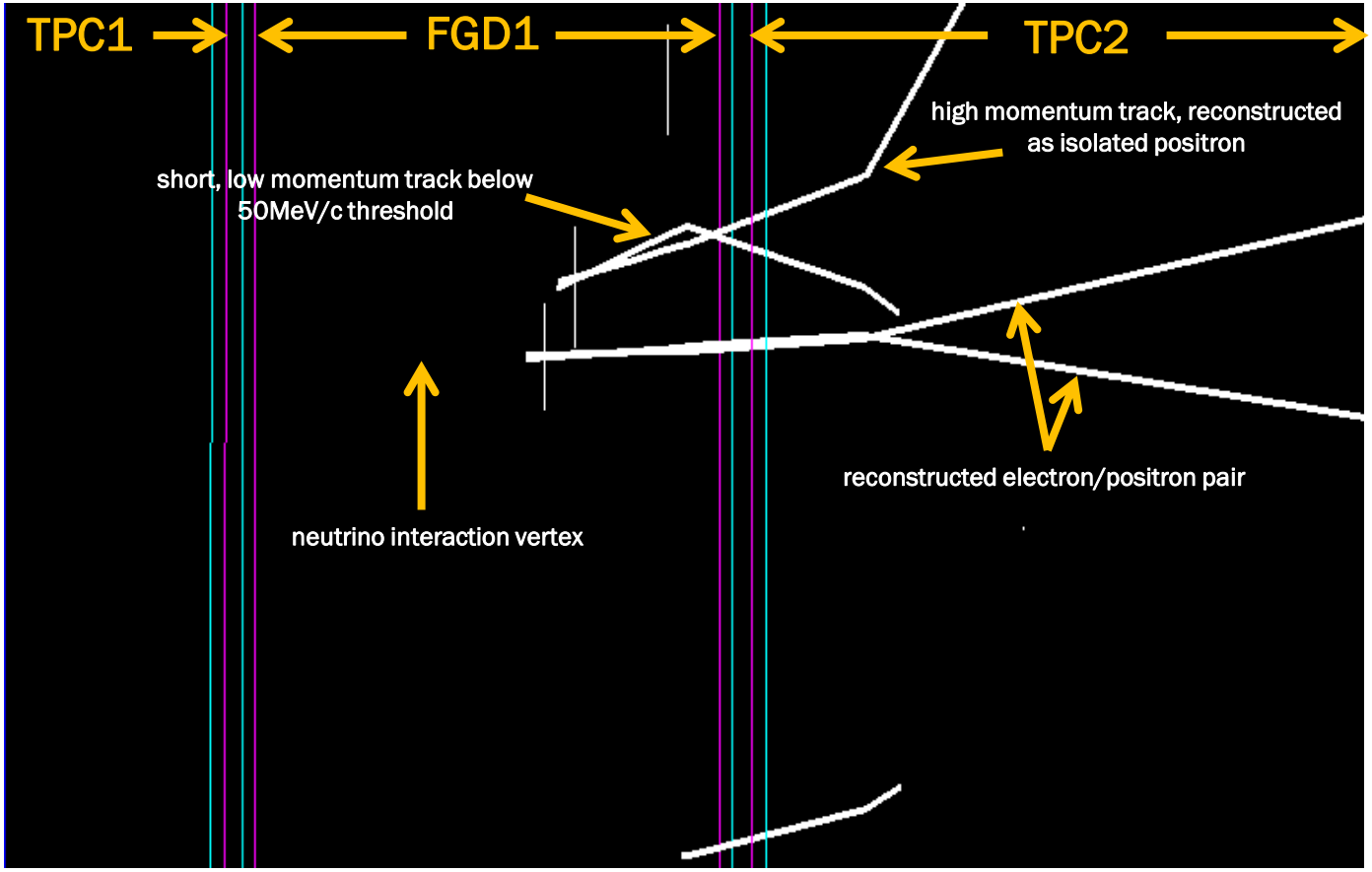
What do the π^0 decay photons produce?

Topology Type	Topology #	$e^+ + e^-$	Isolated e^-	Isolated e^+
Twin Pair	1	2	0	0
Twin Isolated e^-	2	0	2	0
Twin Isolated e^+	3	0	0	2
Pair + Isolated e^-	4	1	1	0
Pair + Isolated e^+	5	1	0	1
Isolated e^- + Isolated e^+	6	0	1	1

Illustrated Twin Pair Topology



Topology Examples: Pair + Isolated Positron



Event display plot of a simulated Monte Carlo NC1π^0 interaction

Reconstructing Event Topologies

Reconstructing photons: e^+ e^- pairs

Identify lepton-like tracks

Combine track pairs with origin points < 10 cm

Pairs must have invariant mass < 50 MeV/c^2

Reconstructing photons: Isolated e^+/e^-

Identify lepton-like tracks

Return tracks whose origin points > 10 cm from any other track origins

Particle de/dx must be consistent with an electron

Reconstructing π^0 interaction vertices

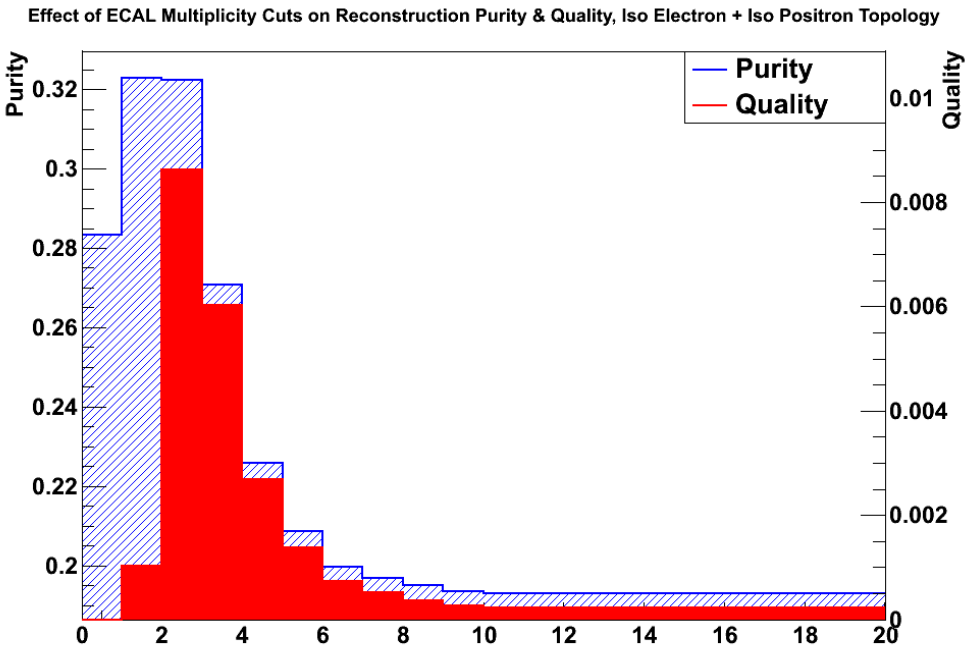
Combine reconstructed photons, use lepton kinematics to project photon trajectory

Search for combinations where projected photon's converge to vertex

Vertex must be in an FGD, distance between projected photons <10cm

Apply tracker multiplicity selection cuts

ECAL Multiplicity Cut: Efficiency/Purity/Quality



An ECAL multiplicity cut of 2 significantly reduces background, minimally reduces signal

$$\text{Efficiency} = \frac{\text{reconstructed signal}}{\text{all events that pass topology criteria in truth}}$$

$$\text{Purity} = \frac{\text{reconstructed signal}}{\text{reconstructed signal + reconstructed background}}$$

Quality = Efficiency x Purity

Overall Results

Topology Type	Topology #	Reconstructed Signal (# events)	Efficiency (% of topology-matched events)	Purity (%)
Twin Pair	1	3.0	7.6	44
Twin Isolated e^+	2	5.9	8.6	34
Twin Isolated e^-	3	8.6	22	24
Isolated e^- + Isolated e^+	4	13	13	34
Pair + Isolated e^+	5	2.6	3.5	48
Pair + Isolated e^-	6	3.1	3.1	62
Total	All	35	8	33

With data up to June 2012, projected…

35 reconstructed events

8% efficiency

33% purity

Conclusions

- Analysis reconstructs NC1π^0 interactions with good efficiency & purity.
- 8% of events which match topology criteria are reconstructed.
- 1% of all NC1π^0 FGD interactions are reconstructed.
- Statistics are doubled by combining other NC1π^0 FGD analyses in progress
- Using Monte Carlo information, transitioning to real data.
- Aim to eventually measure NC1π^0 production cross section.