

# Reconstruction of neutrino induced NC- $1\pi^0$ using the T2K-ND280 tracker

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On behalf of the T2K collaboration

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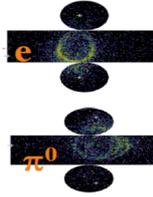
## 1. The T2K experiment



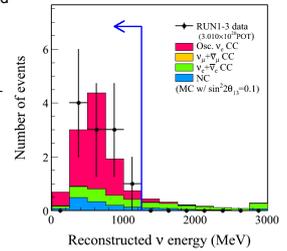
- Second generation long-baseline neutrino experiment for precision measurements of oscillation parameters:
  - $\nu_\mu \rightarrow \nu_e$  appearance:  $\theta_{13}$
  - $\nu_\mu \rightarrow \nu_\tau$  disappearance:  $\theta_{23}, \Delta m_{23}^2$
- Intense  $\nu_\mu$  beam at 2.5° off-axis resulting in narrow band beam peaked at  $E \sim 0.6$  GeV

## 2. Backgrounds to appearance measurement

NC- $1\pi^0$  is one of the largest background and systematic error to  $\nu_e$  appearance measurement at T2K.

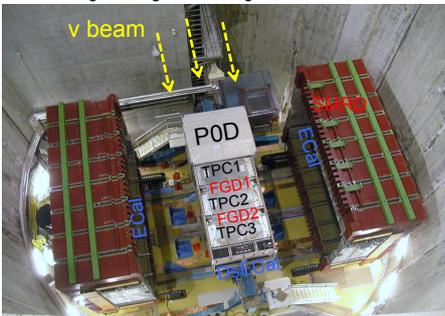


- $\nu_e$  signal identified by reconstructing electron-like rings
- NC- $1\pi^0$  interaction can mimic  $\nu_e$  signal when second  $\gamma$  showering ring is low energy and not reconstructed



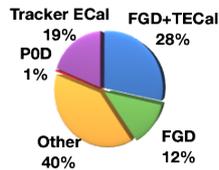
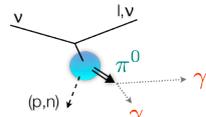
## 3. Off-axis near detector at 280m : ND280

- Embedded in UA1 dipole magnet to measure beam and neutrino interactions before oscillation
  - POD : Highly segmented tracking calorimeter dedicated to NC- $\pi^0$  measurement
  - Tracker region designed for charged current interaction

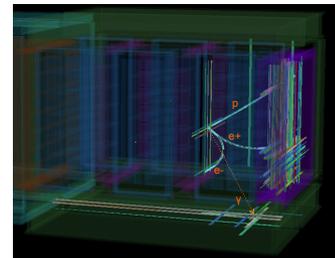


## 4. NC $1\pi^0$ signal definition & topology in tracker

NC- $1\pi^0$  definition is one  $\pi^0$  decay and any proton or neutron but no muon or other meson



$\gamma$  from  $\pi^0$  decay in FGD target convert in different sub-detectors

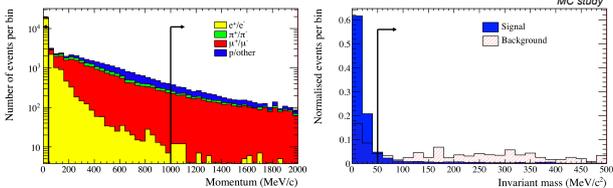


Topology of interest for this work is one  $\gamma$  conversion in Ecal and  $e^+e^-$  pair from second  $\gamma$  conversion in the FGD/TPC.

## 5. $e^+e^-$ pair selection

- Select two TPC tracks starting in tracker region that have
  - opposite charges
  - $40 < \text{Momentum} < 1000$  MeV/c
  - front separation  $< 15$  mm
  - pair invariant mass  $< 50$  MeV/c<sup>2</sup>

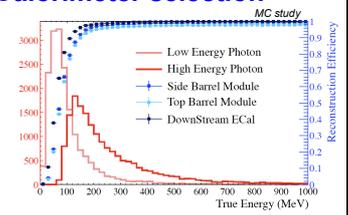
Efficiency = 20%  
Purity ~ 80%



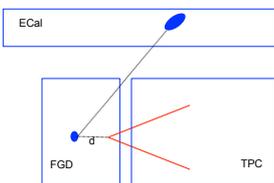
## 7. Electromagnetic Calorimeter selection

- For events with a pair, require at least one ECal cluster that is
  - Not matched to a track
  - Energy  $> 50$  MeV
  - No Michel electrons
  - Within 100 ns of pair start time

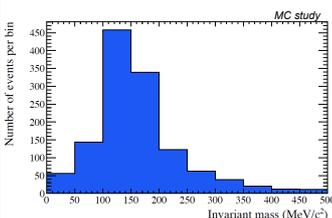
Efficiency = 45%  
Purity ~ 60%



## 6. Vertex reconstruction



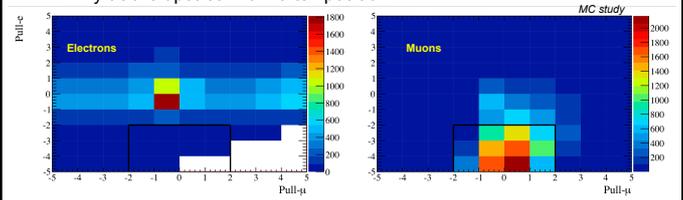
- Pair production point obtained from point of closest approach of  $e^+$  and  $e^-$
- Pair is typically created a few cm from the vertex
- Estimate most probable vertex position from pair start position using  $\gamma$  mean free path
- Direction of other photon is determined from point of entrance in ECal and vertex



Method gives precise invariant mass reconstruction for signal event (using  $d = 5$ cm)

## 8. Background rejection cuts

- Reject beam bunches with
  - Any tracks upstream in the POD
  - Any muon candidates
  - Ecal objects  $> 4$
  - Tracker tracks  $> 9$
  - Any tracks upstream of vertex position



## 9. Final selection & summary

- Requires  $\pi^0$  invariant mass  $< 500$  MeV/c<sup>2</sup>
- Present  $\pi^0$  reconstruction efficiency is 5% and purity is 20%
- Preliminary estimation of number of selected signal events for Run I+II+III p.o.t is 25 events
- Accurate  $\pi^0$  decay reconstruction demonstrated with FGD/TPC  $e^+e^-$  pair + Ecal cluster
  - Topology with one  $\gamma$  converting close to vertex and second in ECal covers large acceptance
  - ECal provides good energy measurement of the second, low energy  $\gamma$
  - TPC pair reconstruction has high purity and enables accurate  $\pi^0$  invariant mass reconstruction
- Work in progress to optimise selection and minimise CC and external backgrounds