

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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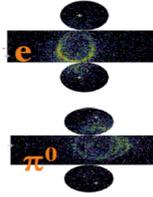
1. The T2K experiment



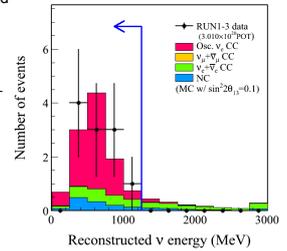
- Second generation long-baseline neutrino experiment for precision measurements of oscillation parameters:
 - $\nu_\mu \rightarrow \nu_e$ appearance: θ_{13}
 - $\nu_\mu \rightarrow \nu_\tau$ disappearance: $\theta_{23}, \Delta m_{23}^2$
- Intense ν_μ beam at 2.5° off-axis resulting in narrow band beam 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 ν_e appearance measurement at T2K.

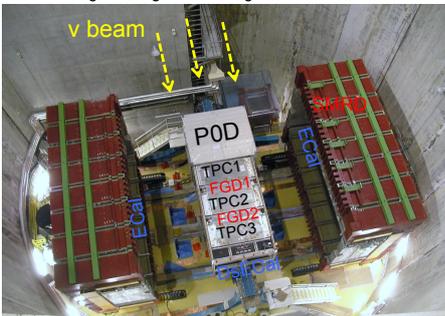


- ν_e signal identified by reconstructing electron-like rings
- NC- $1\pi^0$ interaction can mimic ν_e signal when second γ showering ring is low energy and not reconstructed



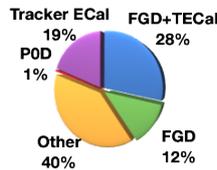
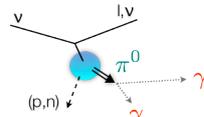
3. Off-axis near detector at 280m : ND280

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

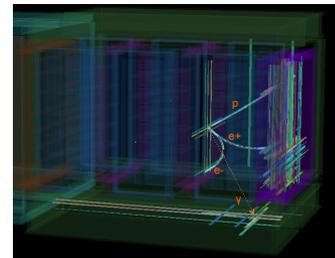


4. NC $1\pi^0$ signal definition & topology in tracker

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



γ from π^0 decay in FGD target convert in different sub-detectors

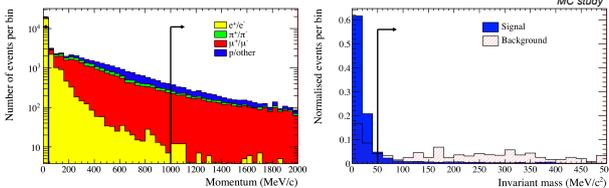


Topology of interest for this work is one γ conversion in Ecal and e^+e^- pair from second γ conversion in the FGD/TPC.

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/c²

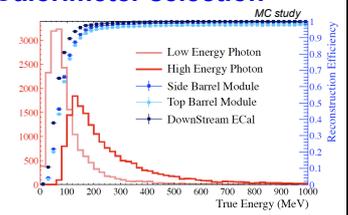
Efficiency = 20%
Purity ~ 80%



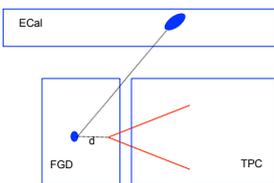
7. Electromagnetic Calorimeter selection

- 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

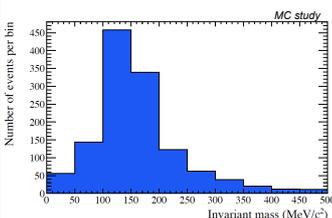
Efficiency = 45%
Purity ~ 60%



6. Vertex reconstruction



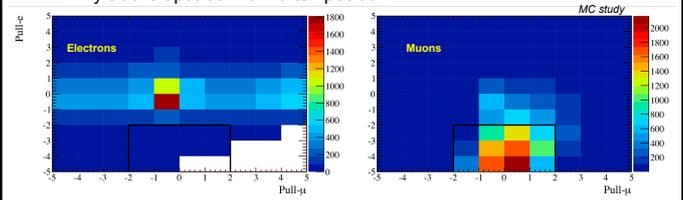
- Pair production point obtained from point of closest approach of e^+ and e^-
- Pair is typically created a few cm from the vertex
- Estimate most probable vertex position from pair start position using γ mean free path
- Direction of other photon is determined from point of entrance in ECal and vertex



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 π^0 invariant mass < 500 MeV/c²
- Present π^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 π^0 decay reconstruction demonstrated with FGD/TPC e^+e^- pair + Ecal cluster
 - Topology with one γ converting close to vertex and second in ECal covers large acceptance
 - ECal provides good energy measurement of the second, low energy γ
 - TPC pair reconstruction has high purity and enables accurate π^0 invariant mass reconstruction
- Work in progress to optimise selection and minimise CC and external backgrounds