Measuring neutral current single π^0 event rate on water at T2K

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Introduction

Why Study NC1π^0 on Water?

- π^0 decays to two photons which behave similar to an electron in a Water-Cherenkov detector.
- This forms an important background for detecting $\nu_e/\bar{\nu}_e$ appearance at Super-Kamiokande.
- Cross section of NC1π^0 on water at T2K energy range has not been measured previously.

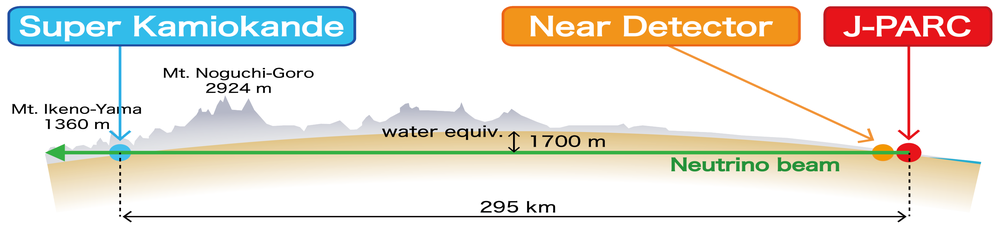


Figure 1: T2K Experiment

- The T2K Experiment is a long-baseline neutrino oscillation experiment.[1]
- The pi0 detector - P0D is one of the near detectors of T2K located at the near detector complex 280 m downstream of the ν source.
- It has 50 alternating layers of water and scintillator interspersed with brass and lead.
- The water can be filled and drained out of the P0D periodically, enabling measurements completely on-water.

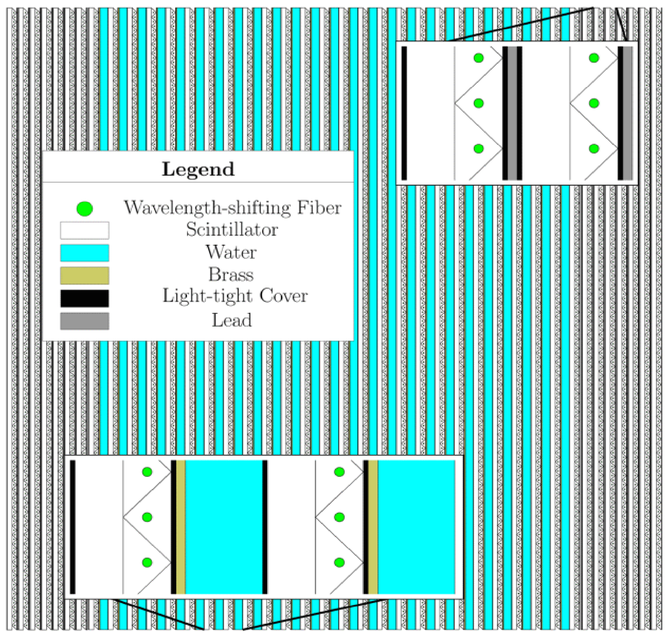
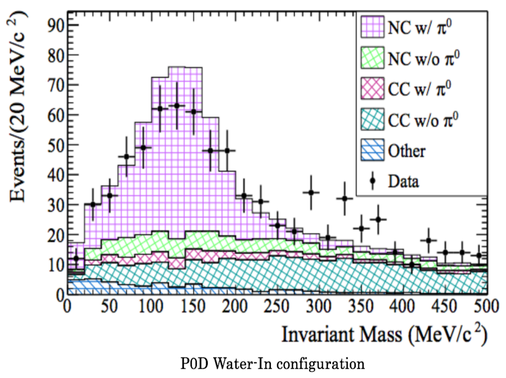


Figure 2: P0D at near detector complex, T2K

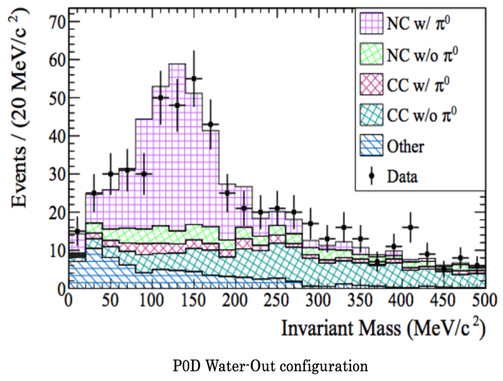
Measuring Event Rate

Selection Strategy

- Detector Cuts: Within P0D fiducial volume, containment in P0D, π^0 direction < 60^0
- Muon Decay Cluster Tag: Removes events with a μ decay cluster
- Particle ID: All particles are tagged EM like
- Charge-in-Shower: > 90% charge in event is contained in two showers from π^0 decay
- Object Separation: the two showers are separated in space for better reconstruction



P0D Water-In configuration



P0D Water-Out configuration

Major Source of Systematics	Water-In	Water-Out
Track Particle ID Efficiency	5.4%	5.1%
Shower Particle ID Efficiency	6.6%	2.6%
Object Separation	9.1 %	11.6%
Charge-In-Shower	6.6%	3.0%
Correlated Systematic due to Background Shape	19.8%	

RESULTS[2]

MC : NEUT v5.1.4.2.

T2K data :

$2.64 * 10^{20}$ protons-on-target P0D Water-In

$3.49 * 10^{20}$ protons-on-target P0D Water-Out

NC1π^0 events on water:

MC prediction = 157 events

Data = $106 \pm 41(stat.) \pm 69(sys.)$

Target	Ratio (Data/MC)	
Water-In	0.790 ± 0.076(stat.)	± 0.143(sys.)
Water-Out	0.850 ± 0.091(stat.)	± 0.137(sys.)
On-Water	0.677 ± 0.261(stat.)	± 0.462(sys.)

Updates & Improvements

A new iteration of this analysis is underway with:

- Latest production of reconstruction with better Particle ID algorithm and new T2K data runs.
- Object separation was redefined for a more accurate selection and to reduce the effect of systematic uncertainty from this cut.
- Aim to better understand and calculate the correlated background shape systematics.
- Developed a Markov Chain Monte Carlo likelihood fitter to fit the Invariant Mass of π^0.

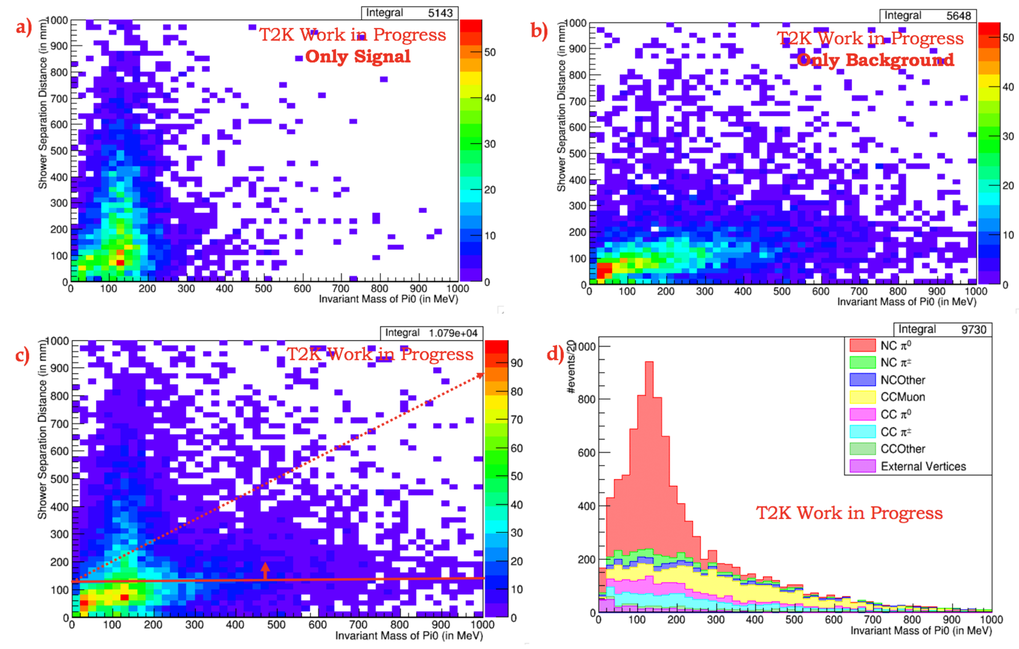


Figure 3: a) Only Signal; b) Only Background; for the new Object Separation definition Vs Invariant Mass of π^0 c) solid red line represents a cut on object separation which gives a better Invariant Mass peak of π^0 in part d), while the dotted line presents an option to divide the 2D phase space in two samples which can be fit simultaneously with constraints.

Conclusion

- A measurement of NC1π^0 production rate on water was made in P0D at T2K [2].The observed event rates are consistent with the expectation and indicate that the NC1π^0 event rate is not underestimated in the MC.
- This result has a large systematic uncertainty. New update aims to make a more accurate estimation of systematics for ν mode and produce a first result for $\bar{\nu}$ mode.

References

[1] K. Abe et al., Nuclear Instruments and Methods, vol. A 569, (106)2011

[2] K. Abe et al. arXiv:1704.07467 [hep-ex]

I would like to acknowledge Dr. Karin Gilje for her thesis work on this analysis before me.