Measurement of the νe component of the T2K beam in the ND280 Tracker

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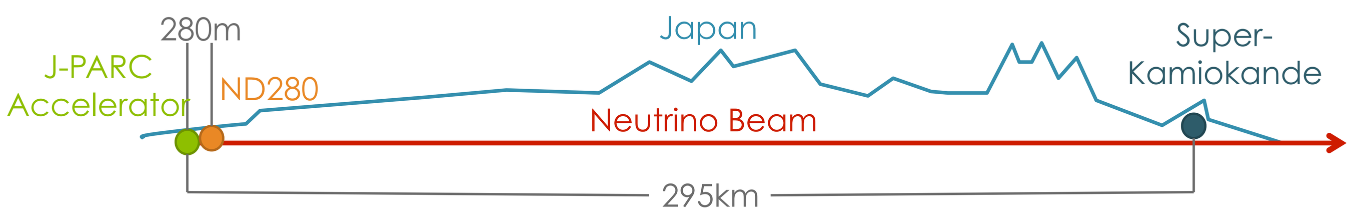
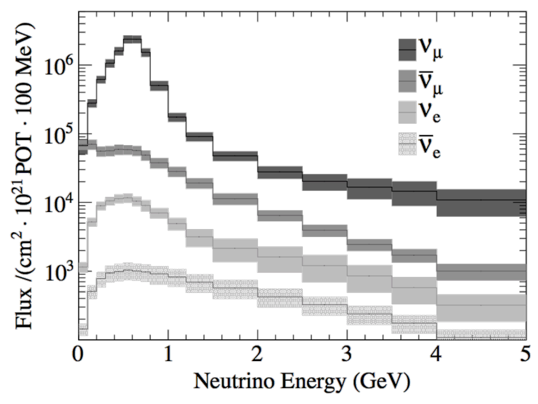
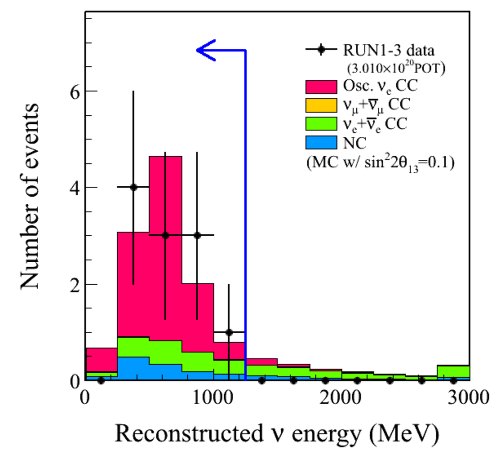
T2K

- ✓ Long baseline ν oscillation experiment, searching for $\nu_\mu \rightarrow \nu_e$.
- ✓ Measure neutrino spectrum at near detector (ND280) and far detector (Super-Kamiokande).
- ✓ Main background to ν_e appearance is the beam ν_e contamination → critical to measure it at the Near Detector





Expected fluxes at Super-K, assuming no oscillations → 0.8% of the beam is ν_e.



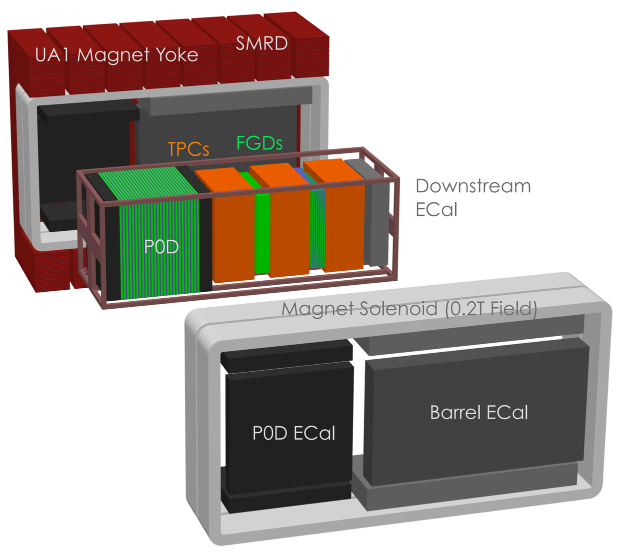
2012 ν_e appearance candidates at Super-K

Predicted number of events at Super-K for $\sin^2 2\theta_{13} = 0.1$	
Total	10.71
ν_e signal	7.79
ν_e background	**1.56**
Other background	1.37

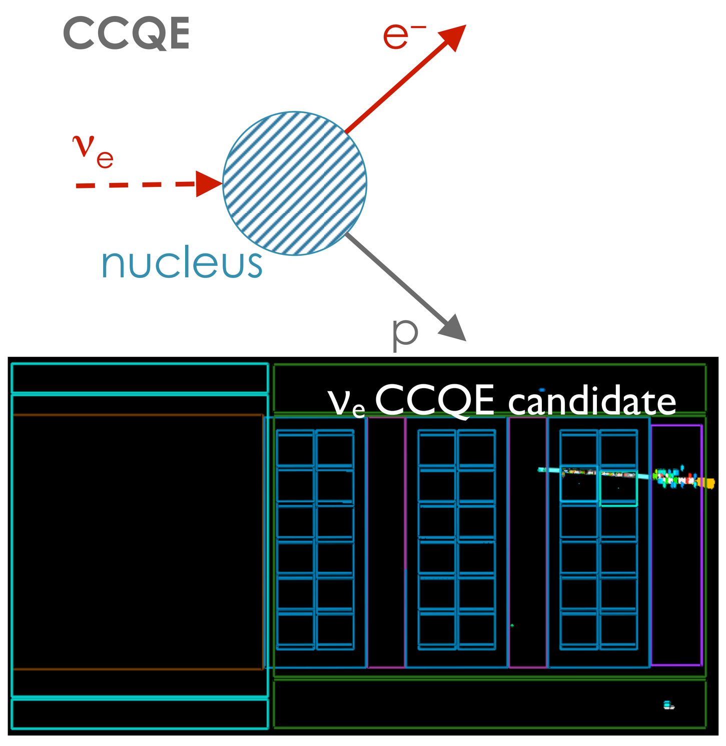
Intrinsic ν_e in the beam are the single biggest background in the $\nu_\mu \rightarrow \nu_e$ oscillation measurement.

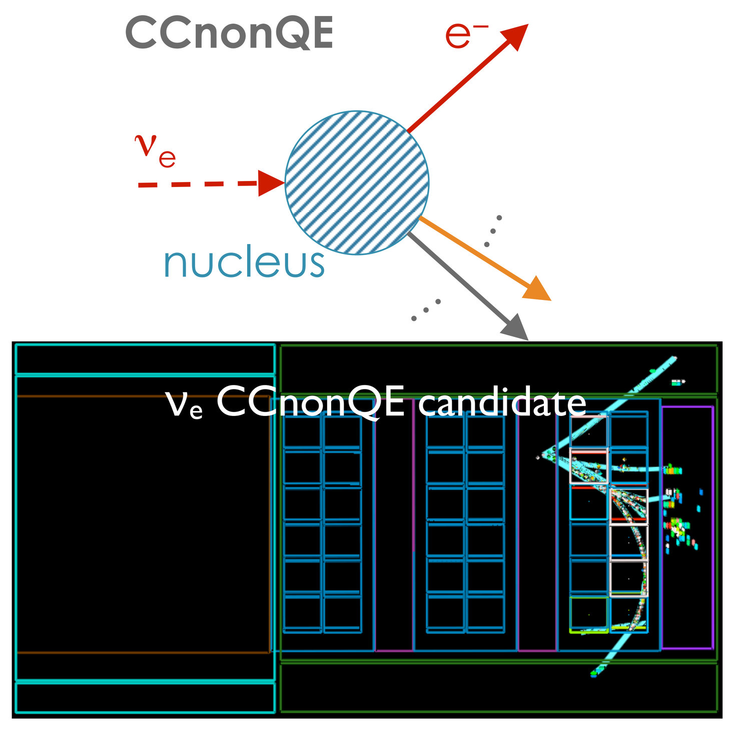
ND280

- ✓ Multiple scintillator and TPC detectors in a 0.2T magnetic field.
- ✓ Interaction targets for this analysis are FGDs (fully-active fine-grained scintillator detectors).
- ✓ Particle identification from energy loss in TPCs, and whether particle showers in the ECals.



ν_e interactions at ND280



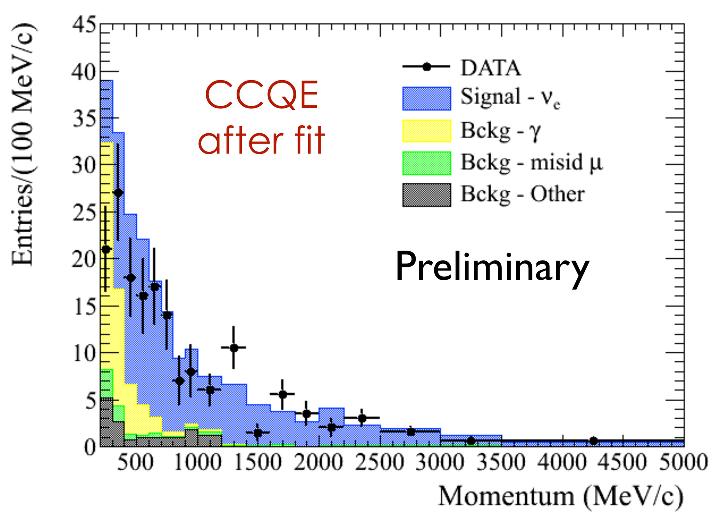


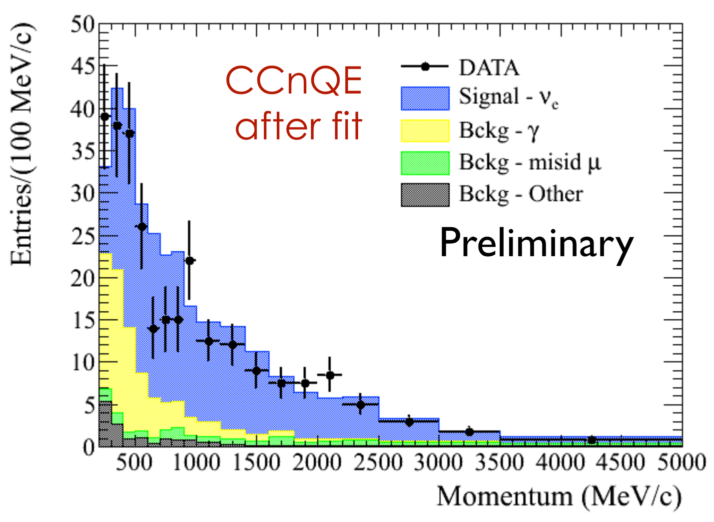
Measurement of the ν_e component

- ✓ Perform a likelihood fit to extract data/MC ratio including QE, nonQE and γ selections

Data/MC ratio = 1.055 ± 0.058 (stat.) ± 0.074 (syst.)

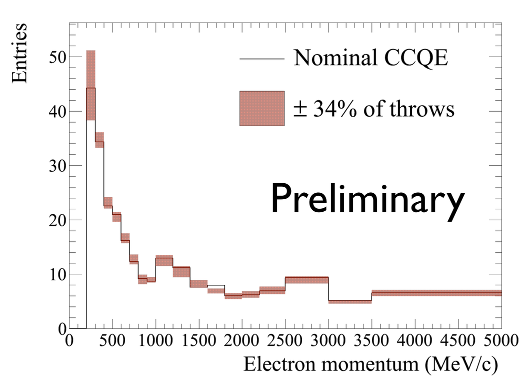
- ✓ Include contribution from the detector systematics (5.0%) and from the flux and cross-section systematics (6.1%) → using same uncertainties used in T2K νe appearance analysis
- ✓ Very important confirmation that the beam νe component is well understood

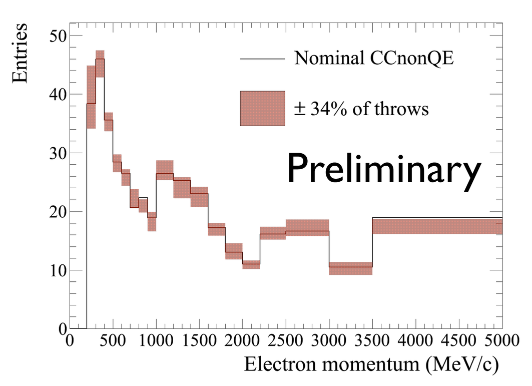


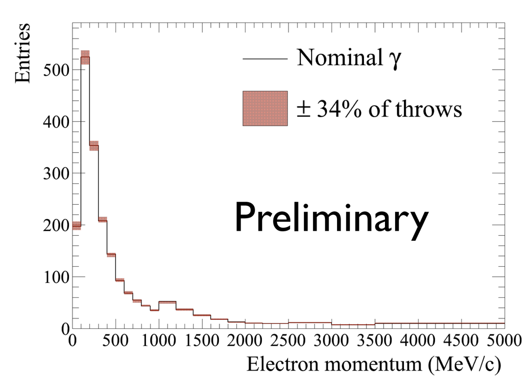


Detector Systematics

- ✓ Systematics from detector response, flux prediction and cross-section models.
- ✓ Flux and cross-section systematics come from output of the fit to the ND280 ν_μ data
- ✓ Plots show effect of detector systematics on CCQE, CCnonQE and photon samples.







Future prospects

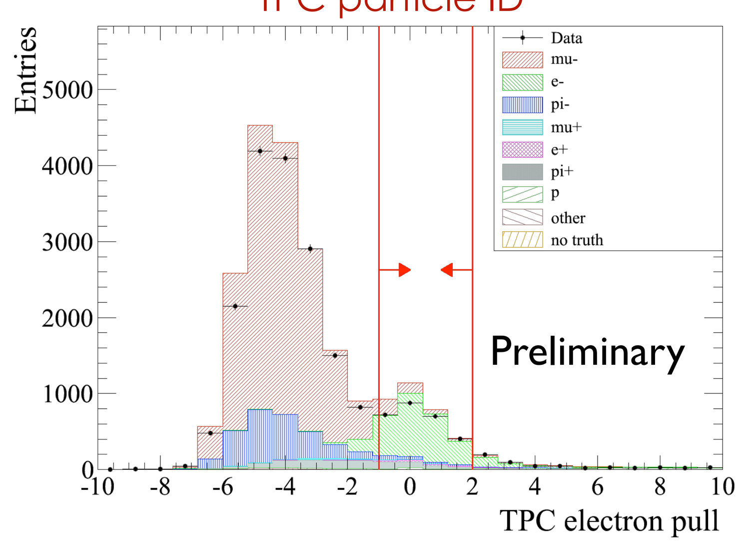
- ✓ Jointly fit the ν_μ and ν_e samples to further constrain flux and cross-section parameters for the T2K oscillation analyses.
- ✓ We already selected a pure sample of ν_e with enough statistics to do a measurement of ν_e cross-section → never been done at these energies before.

ND280 ν_e selection

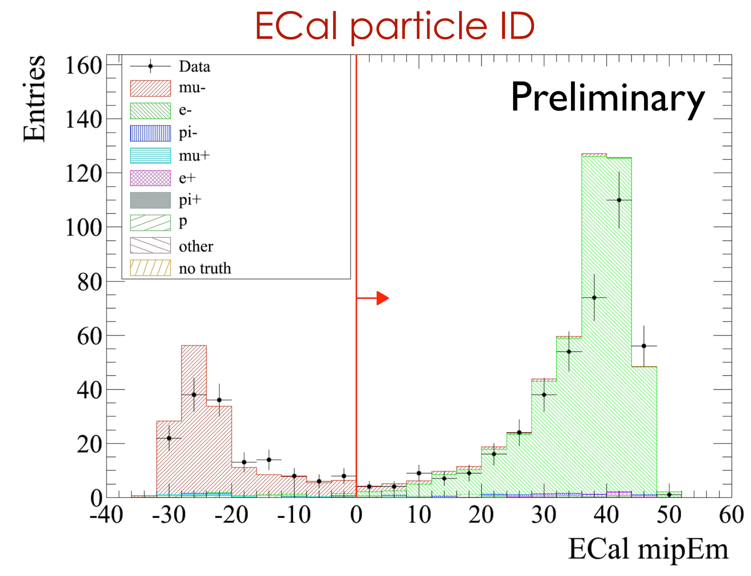
Step 1 – select e-like tracks with TPC/ECAL PID

- ✓ Look for tracks starting in FGD1 or FGD2.
- ✓ Require energy loss in TPC is compatible with electron.
- ✓ Require an EM shower in the ECal.

TPC particle ID



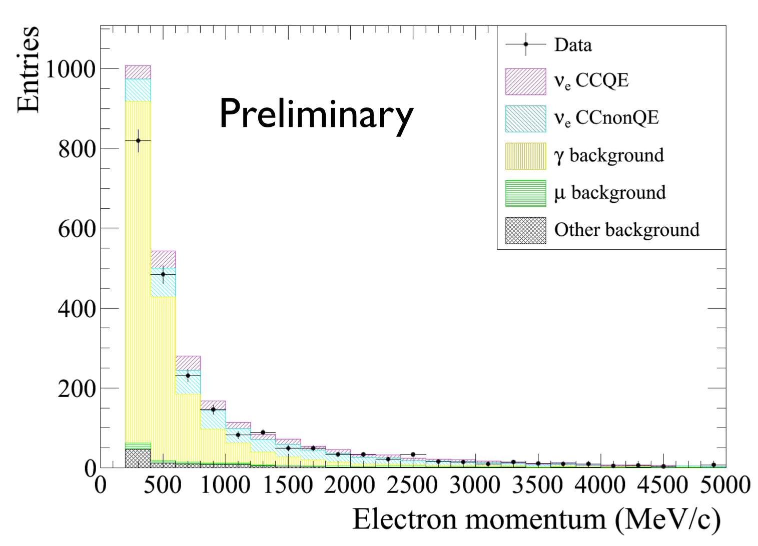
ECal particle ID



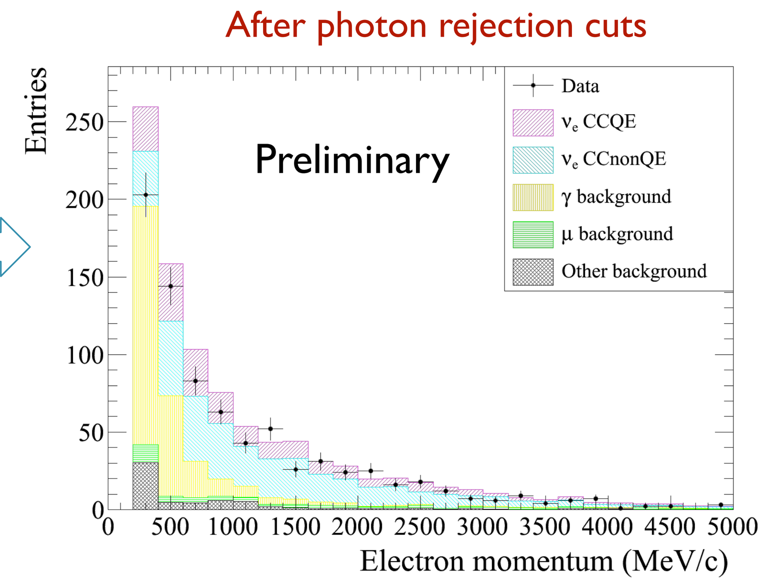
Step 2 – reduce photon backgrounds

- ✓ With the PID we select a pure sample of electrons (muon rejection factor ~99.8%)
- ✓ Most of the electrons do not come from νe interactions but from γ conversions in the FGD → can be rejected by a combination of vetoes on other detectors and invariant mass cut if also the e+ reach the TPC

After PID cuts

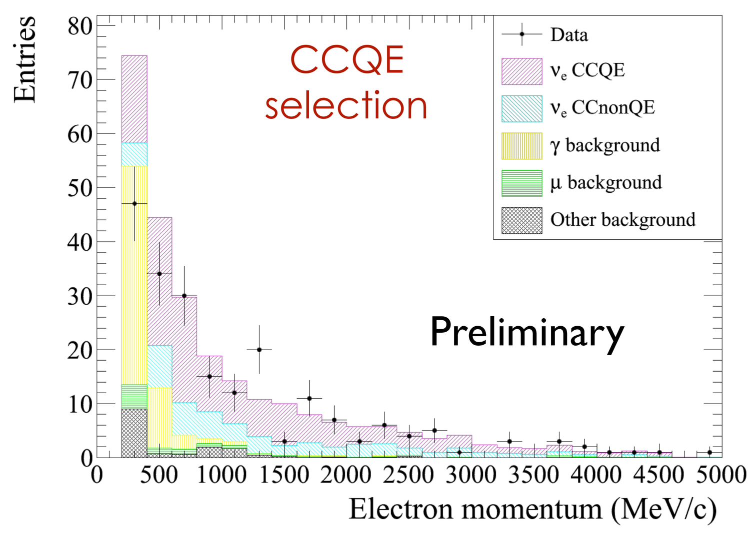


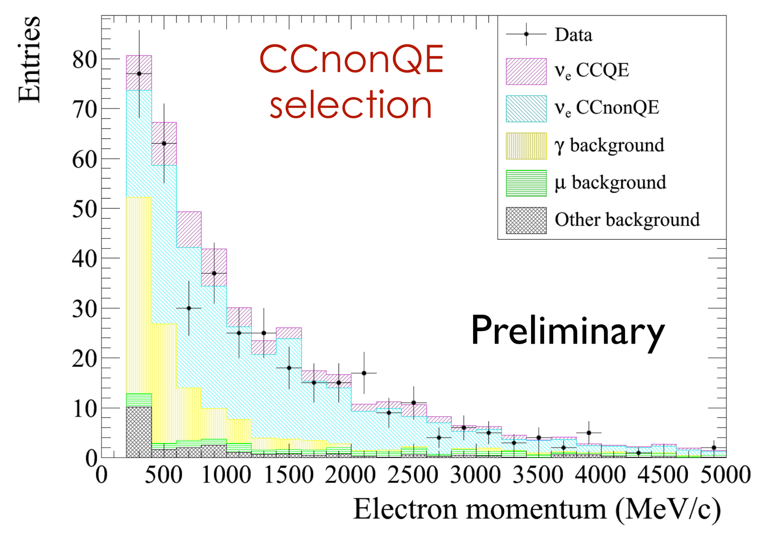
After photon rejection cuts



Step 3 – split into CCQE and CCnonQE

- ✓ Look at other tracks in the event to split into CCQE-like and CCnonQE-like topologies.
- ✓ Overall ν_e purity is 67%.
- ✓ Main background is from low-momentum photon conversion.





Photon control sample

- ✓ Main background is from photon conversions.
- ✓ Can constrain it from the data by developing a selection of a photon conversion sample.
- ✓ Look for e^+e^- pair entering the TPC by reconstructing their invariant mass