T2K Time Projection Chambers

&

photoelectron calibration system

CAP Congress 2010.
Neutrino Physics

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On behalf of T2K-TPC Collaboration.

OutLine
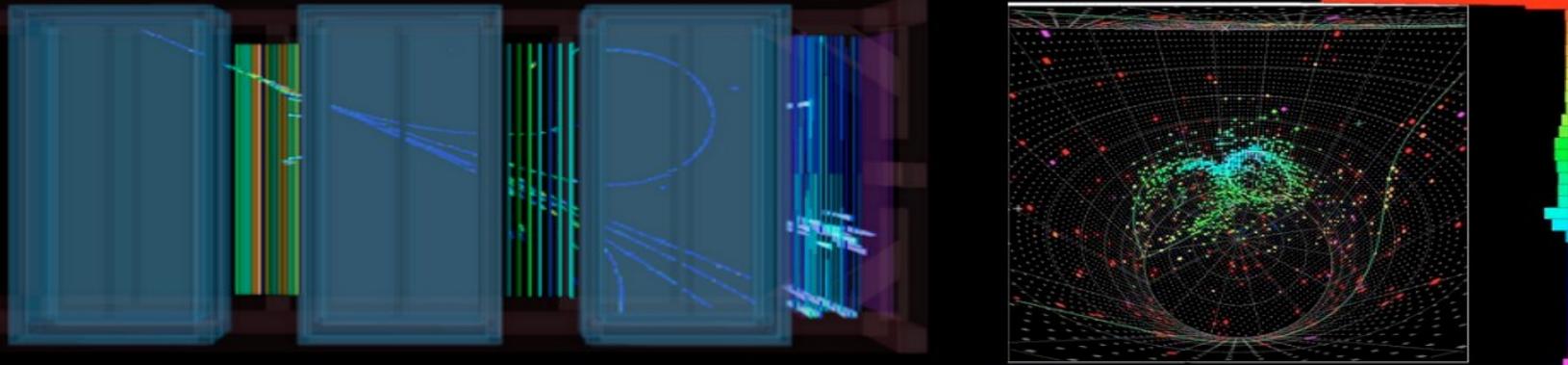
- Quick overview of T2K, ND280 detector complex

- Time Projection Chambers what, where, when, how, why?

- Photoelectron Calibration System

- Oscillation parameter measurement goals

T2K (Tokai to Kamiokande)
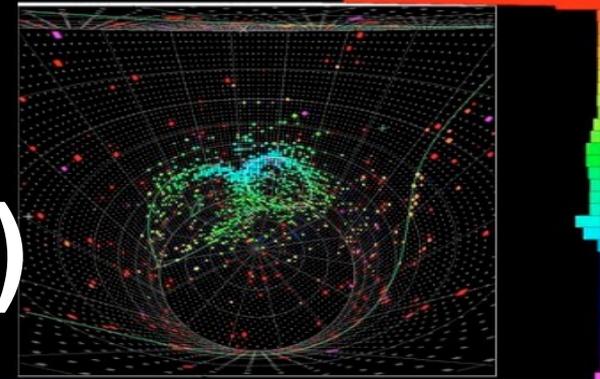
- Long baseline neutrino oscillation experiment.
  - Measurement of neutrino oscillation between near detector (J-PARC) and Super-K.
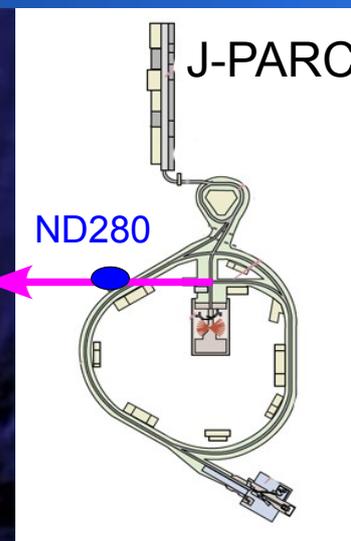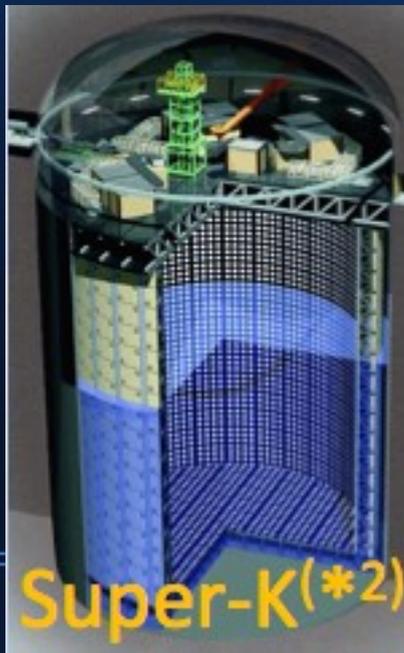
ν oscillations
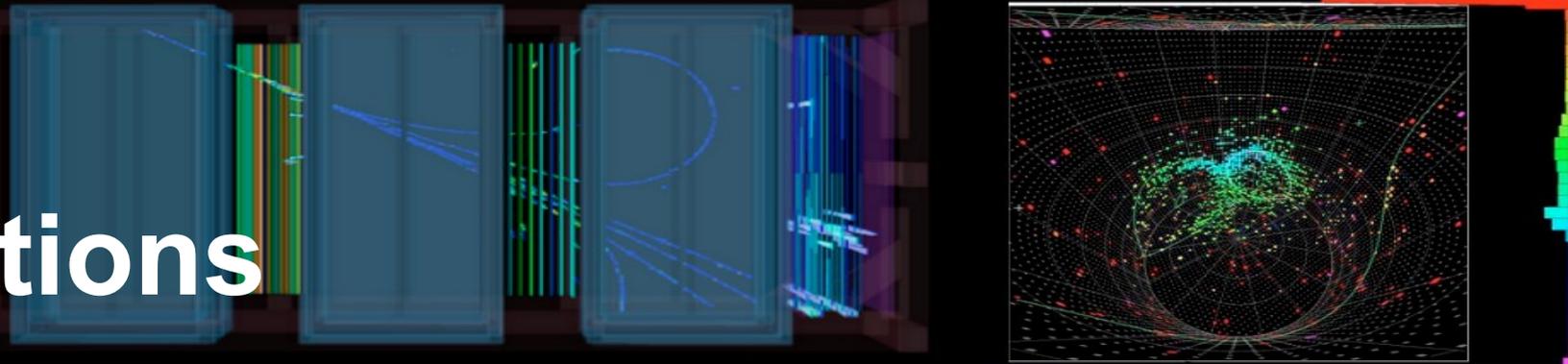
- Neutrino flavor eigenstates a mixture of mass eigenstates. Probability of measuring a given flavor varies with time. Neutrinos come in 3 flavors (e,μ,τ)

- T2K to measure

    – **ν_μ disappearance $\nu_\mu \rightarrow \nu_x$**

    – ν_e appearance $\nu_\mu \rightarrow \nu_e$

- ν disappearance is function of energy. Must understand ν energy spectrum before oscillation → One of the roles of ND280,TPC's

Near Detector
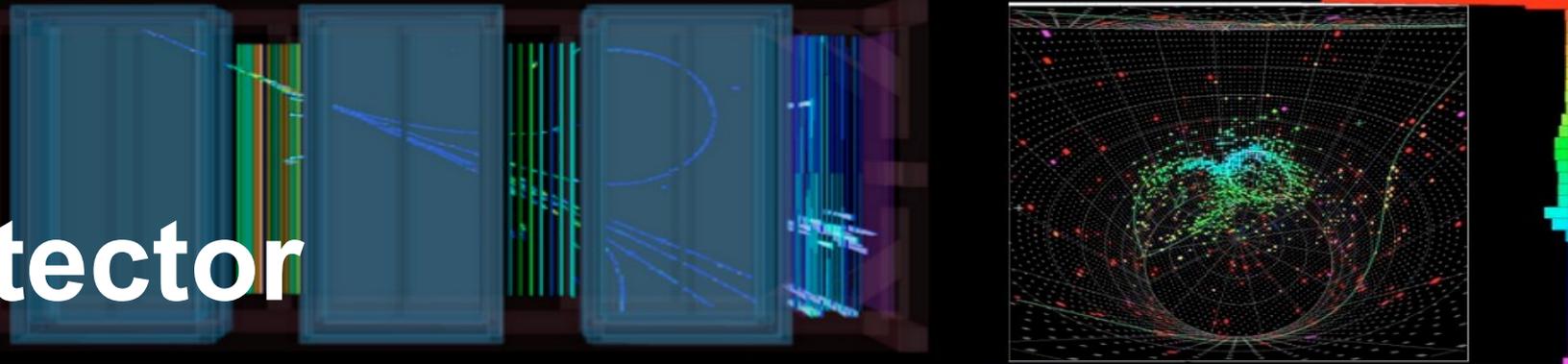
- ND(Near Detector) located 280m from proton target.

- Multi-Detector Complex. Basket structure holds many sub detectors inside magnet coils.

  – 3 Time projection chambers and various scintillator detectors.

Scintillator Detectors
- Fine Grained Detector (FGD)
- Down Stream Electromagnetic Calorimeter. (DS ECAL)
- π^0 Detector (P0D)

P0D   TPC   FGD   TPC   FGD   TPC   DS ECAL
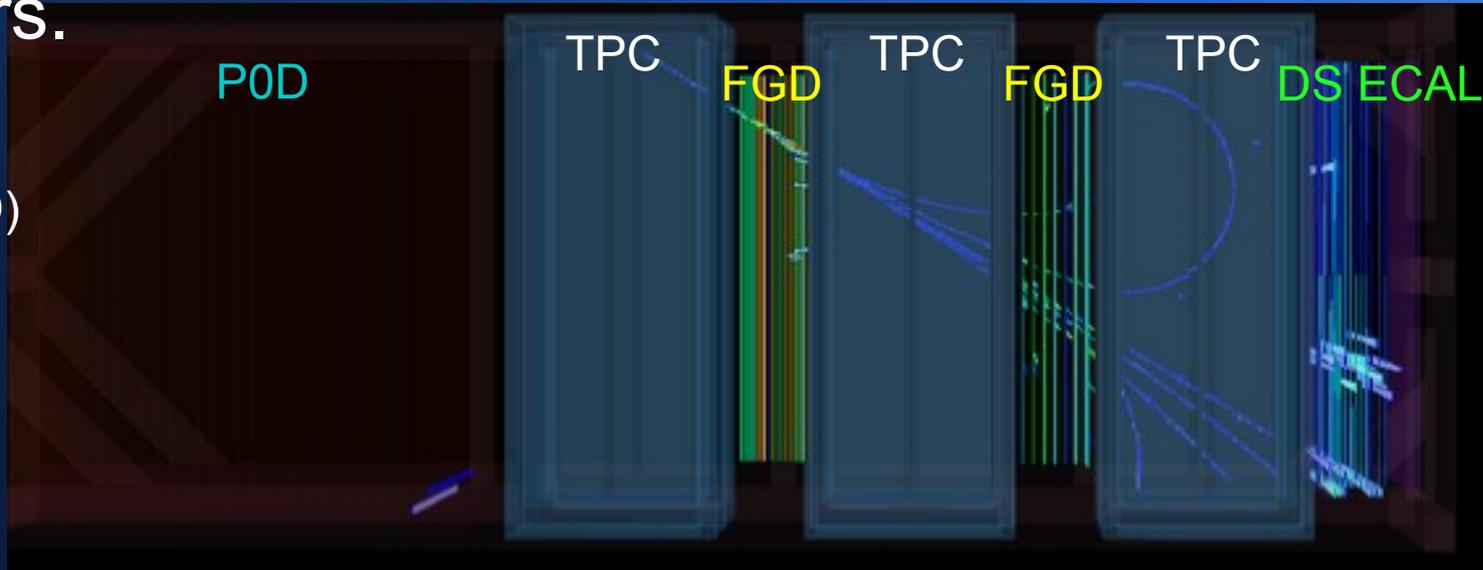
Time Projection Chambers

- Gaseos ionization detectors (Box of Gas)

- Gas mixture within a large potential difference.
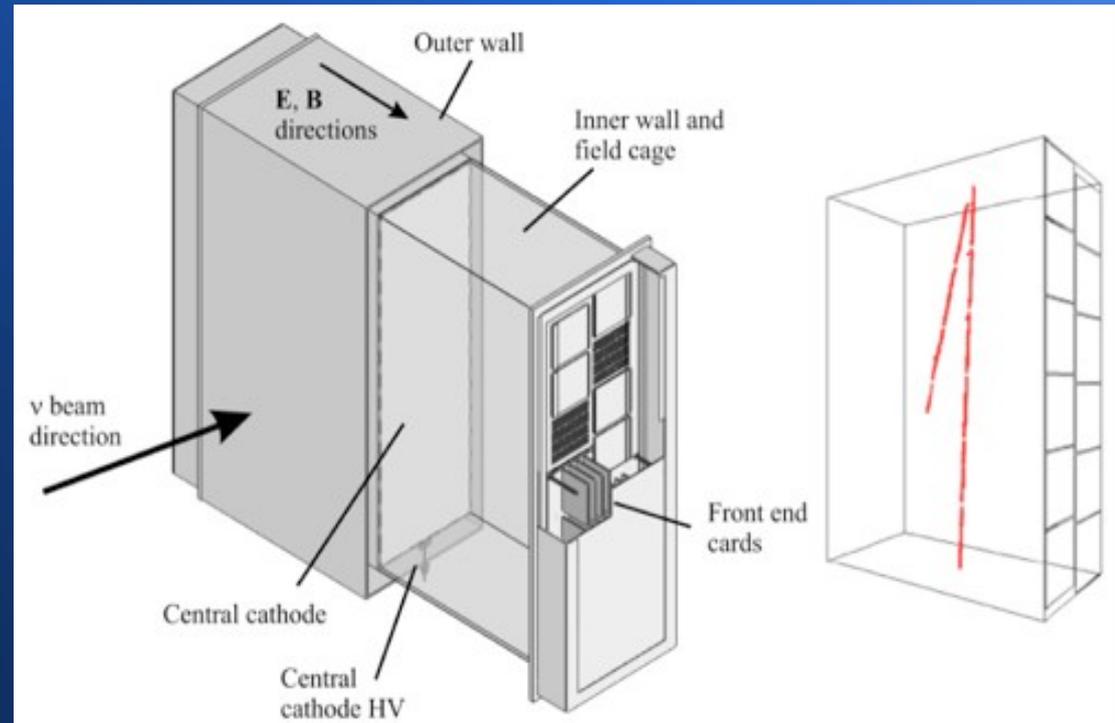
- Electrons/ion pairs created in gas. Electrons drift towards MicroMegas (amplification & readout)

Time Projection Chambers
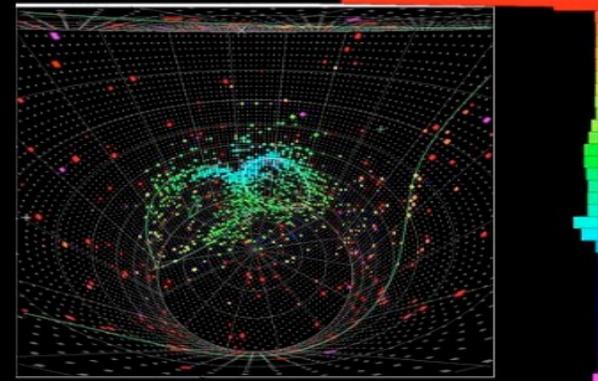
- Mechanical Construction done at TRIUMF.

- Double box design.

    - Insulation of central cathode. Reduction of contamination of Gas Mixture.

- Inner box require precise alignment. Electric field cage as uniform as possible.

    - Made from machining strips from solid copper panel.

Time Projection Chambers

- MicroMegas micropattern gas detectors.

    - Micromesh 120 μm from readout planes create large field gradient for amplification.

    - 'bulk' micromegas large area of readout made of a single piece

- 1728 channels per MM x 72. Over 120,000 channels

- Energy resolution tested with Iron source.

TPC Cathode ~ -25 kV

Gas
$(Ar + 2\% iC_4H_{10} + 3\% CF_4)$

Drift ~ 1 m

Ionizing particle

Micromesh ~ -350 V

Amplification gap 128 μm

Pads (6.9x9.7 mm²)
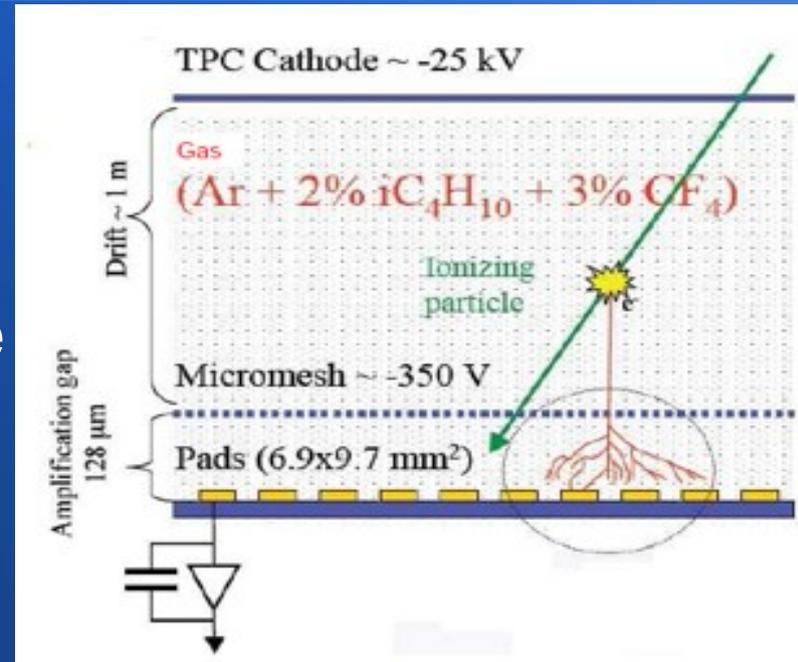
Time Projection Chambers
Why?

- TPC within a 0.2T B field
  - Particle charge and momentum
    (dp/p < 0.1 p 1GeV)
- Energy Deposited (dE/E < 10% for MIP)
  - Particle Identification. Muon and electron separation. Separation at 1GeV is 40-50%.
- Measure Energy Spectrum of particle produced from neutrino interactions in fine grained detectors other detectors.
  - Energy scale uncertainty < 2%

Time Projection Chambers
Where and When?
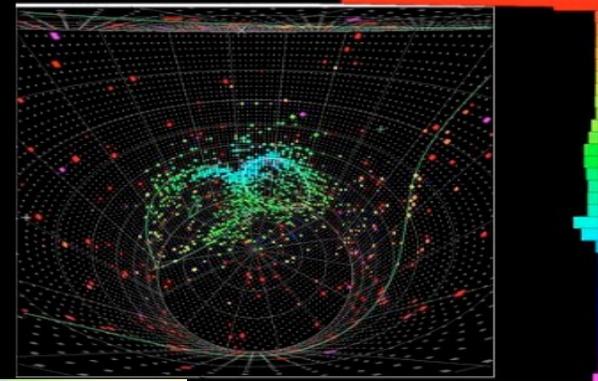
- TPC's Placed 'dropped' into ND280 basket in winter 09.

- Commissioning of subsystems early 2010

- Now up and running stably, collecting neutrino data.

Energy Scale

4 mm
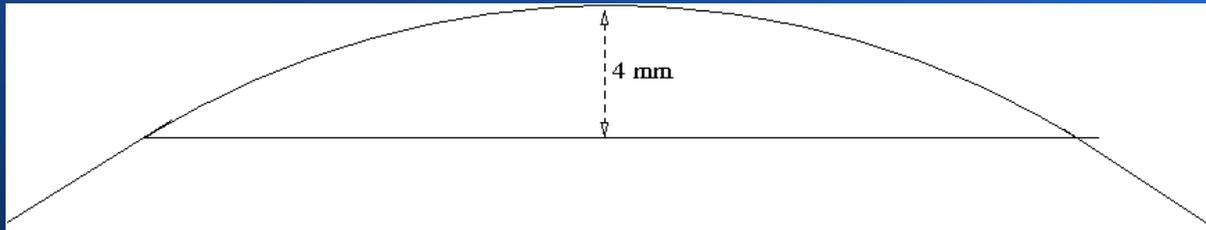
- Possible bias in momentum due to E and B field distortions causing not perfect drifts.

  – Shape of curved track distorted at readout plane
  → biased momentum reconstruction

- T2K energies ~ 1GeV. Sagitta is 4mm.

  – Energy Scale uncertainty < 2%

  ->Spatial distortions of 4x0.02 = 0.08mm

PhotoElectron Calibration
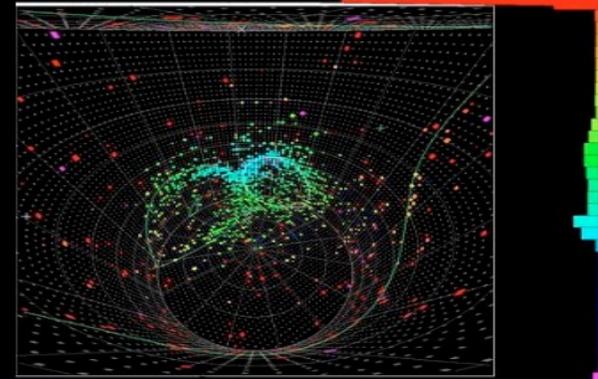
- Array of calibration targets placed on central cathode.

  – Aluminum targets emit photo electrons when flashed by UV light.

- Survey of targets and readout plane performed to measure any transverse movement of photoelectrons during drift.

- Distortions of track shape for photoelectrons moving through full drift (~900mm) can be measured.

8 mm
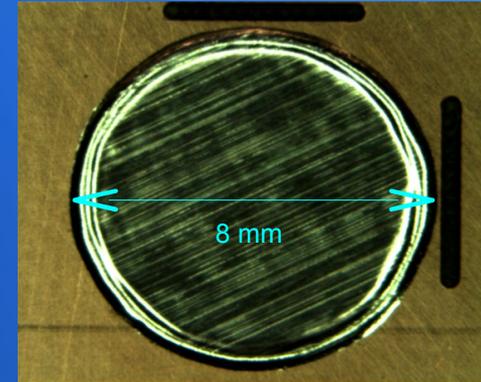
PhotoElectron Calibration
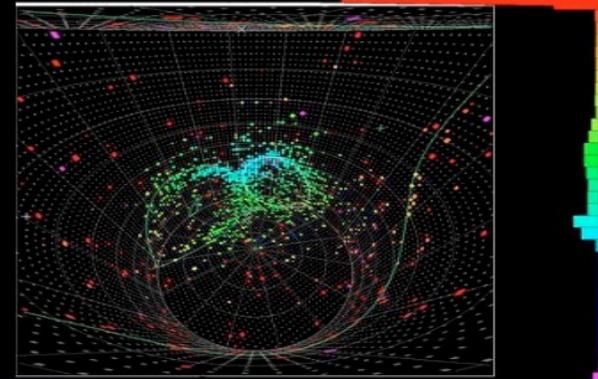
- Multiple fiber optic cables direct UV laser light onto central cathode TPC. 18 fibers required to cover 3 TPC's. Mulitplexor system to flash laser light on one fiber at a time.
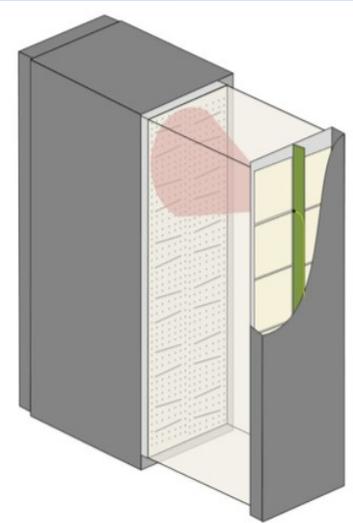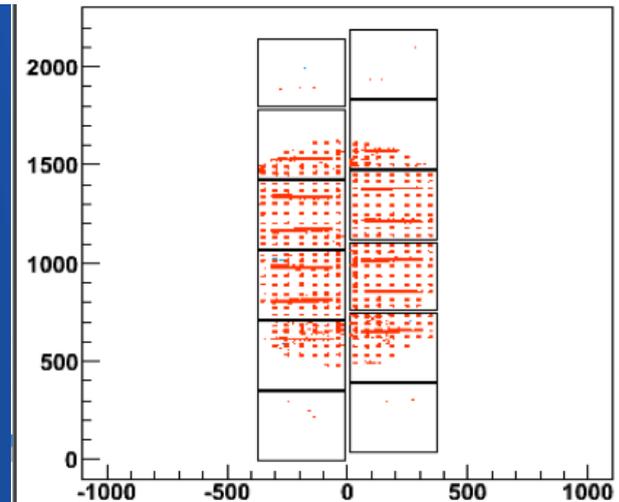
PhotoElectron Calibration
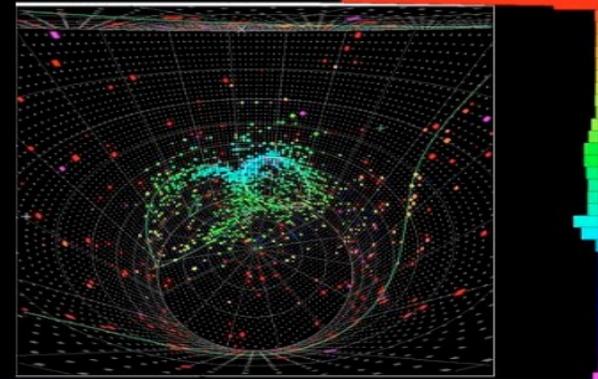
- Displacement of target centroid measured from distribution on 4 MM pads

- Studies show spatial resolution can be met

- Additional errors in absolute position error in surveyed location.
- Knowledge of dot displacements → Mapping of E/B field distortions.
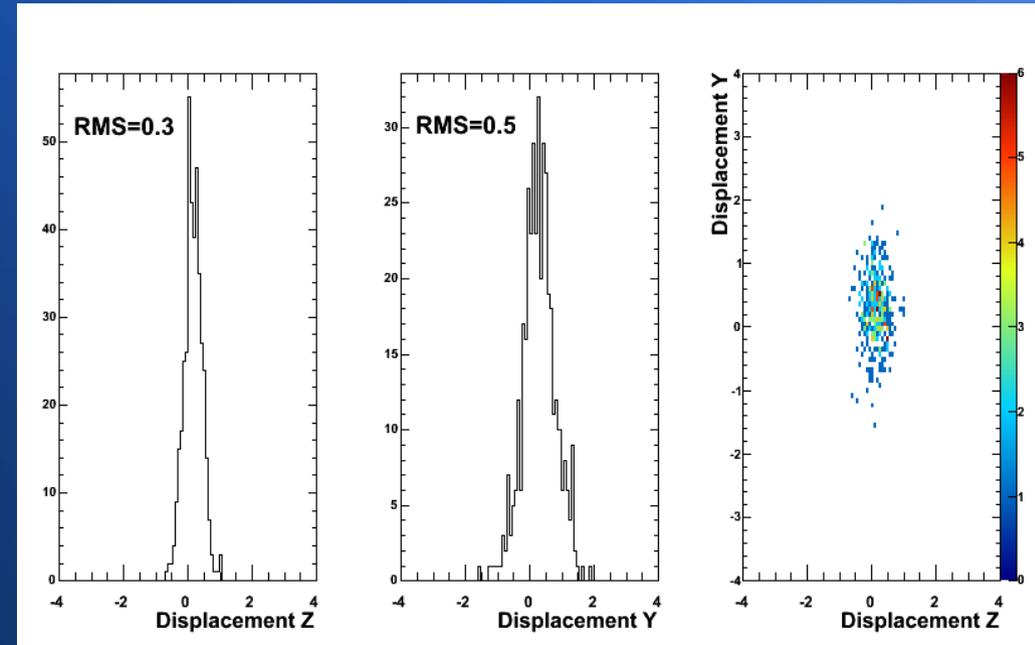
Sensitivity

- Energy scale requirement will give an order of magnitude improvement on Δm_{23}^2
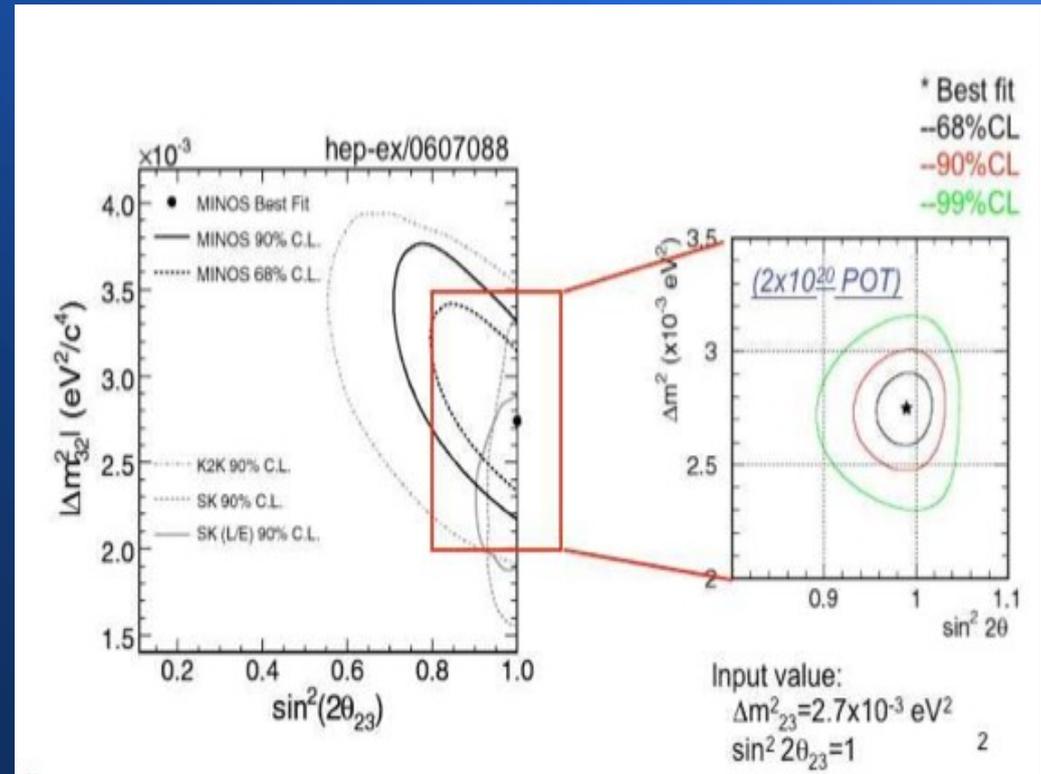
Conclusion

- TPC integral part of T2K near detector. To measure neutrino energy spectrum before oscillation.

- Installation and commissioning complete. Now taking neutrino data.

- Photoelectron calibration will be used to determine E/B distortions, energy scale uncertainty < %2.

- T2K will improve ν_μ disappearance measurements