The Fine-Grained Detectors and Michel electron tagging for T2K

Jiae Kim for the T2K collaboration (University of British Columbia)

NEUTRINOS

subatomic fundamental particles

WERE		*ARE*
NO MASS	➡	**YES MASS**
NO CHARGE		NO CHARGE
NO COLOR		NO COLOR

We can define them in two ways :

three flavors $(\nu_e, \nu_\mu, \nu_\tau)$

three masses (ν_1, ν_2, ν_3)

BUT they are not identical $(\nu_e, \nu_\mu, \nu_\tau) \neq (\nu_1, \nu_2, \nu_3)$

THAT IS the flavor eigenstates can be expressed as $\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix} = U \begin{pmatrix}\nu_1\\ \nu_2\\ \nu_3\end{pmatrix}$

This is the **NEUTRINO OSCILLATION**

The oscillation parameters are

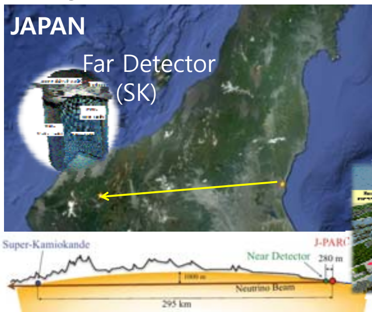
- three mixing angles θ_{12} θ_{23} θ_{13}
- one CP phase δ
- two mass differences Δm^2_{21} Δm^2_{32}

DO KNOW $|\Delta m^2_{32}|$ Δm^2_{21} θ_{12} θ_{23}

DO NOT KNOW sign? Δm^2_{32} non-zero? θ_{13} δ

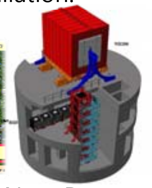
T2K

T2K is one of long baseline experiments and designed to measure θ_{13}

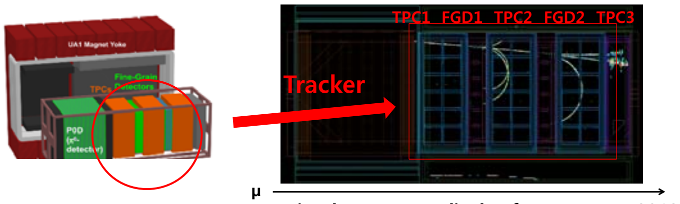


We have two detectors, ND280 and SK, so that we can measure neutrino interactions before/after oscillation.

Accelerator (J-PARC)



Near Detector (ND280)

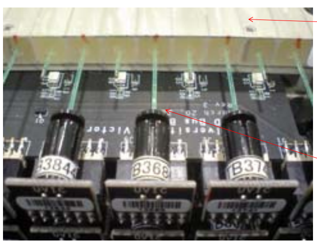


Neutrino beam event display from January 2012

The Tracker consists of 3 Time Projection Chambers (TPCs) + 2 Fine-Grained Detectors (FGDs) and tracks charged particles to determine charge and momentum of them

FGDs

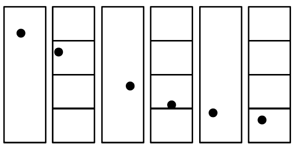
FGDs are scintillating ***tracking*** detectors with a tone of ***target mass***.



When a neutrino comes in interacts with the target mass produces charged particles

They produce scintillate light

The light travels through fibers is measured by multi-pixel photon counters (MPPCs)



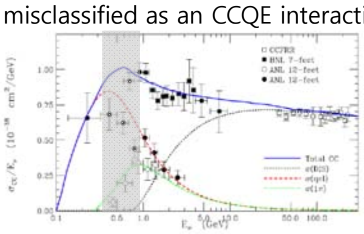
In FGDs, XZ layers and YZ layers are aligned alternatively. It allows us to do ***3D tracking***.

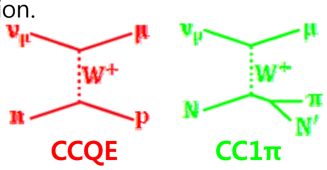
Charged-Current Quasi-Elastic(CCQE)

a dominant channel

the neutrino energy can be well reconstructed

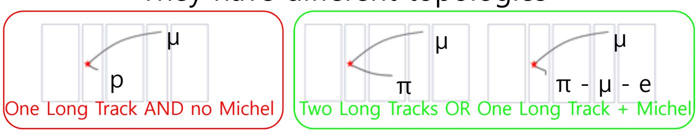
A subdominant channel is **Charged-Current Single Pion (CC1π)** production. If we miss a recoil nucleon, it can be misclassified as an CCQE interaction.



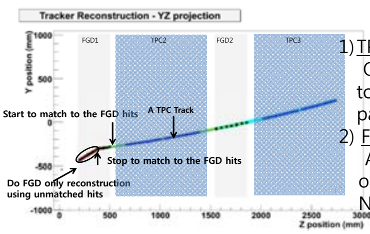


MISSION : **reject CC1π**

They have different topologies

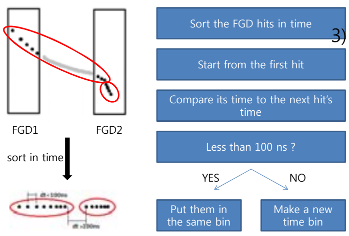


Three STRATEGIES of the FGDs (The FGD Reconstruction)



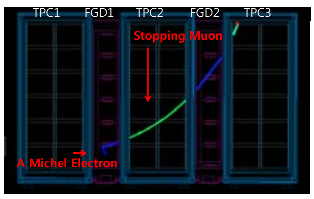
1) <u>TPC-FGD Matching</u> for finding long tracks
Once we have TPC objects, we match them to all FGD hits to identify corresponding FGD parts of the tracks

2) <u>FGD only Reconstruction</u> for finding short tracks
After TPC-FGD matching, we find short tracks only belong to an FGD using all unmatched hits
NOTE : not currently used very much



3) <u>FGD Time Binning</u> for identifying Michel electrons
Clustering all FGD hits based on their time
If the time gap between a primary interactions and any delayed activity is long enough, we could separate them into more than one time bin

THE MICHEL DETECTION EFFICIENCY



We studied using cosmics

Cosmic rays

- produce many muons in flight
- provide a large sample of stopping muons

$$\text{Efficiency} = \frac{\text{Number of Stopping Muons with a Michel Electron}}{\text{Number of Stopping Muons}}$$

Simulation	Real Data
64.2 +/- 2.0 %	59.3 +/- 0.4 %

The measured muon lifetime with the selection is **2.05 +/- 0.03 μs**