Measurement of neutrino interactions on water and hydrocarbon with a 3D-grid detector in the WAGASCI experiment

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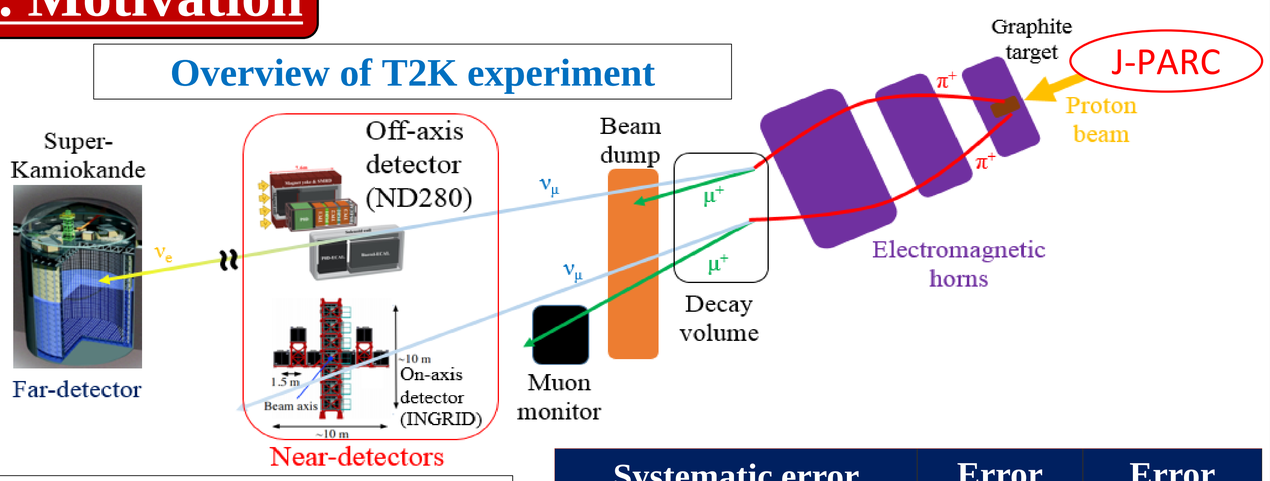
1. Motivation



Two types of off-axis detectors
- ND280 (CH target + H_2O target)
  Acceptance : forward scattering
- Super-Kamiokande (H_2O target)
  Acceptance : 4π

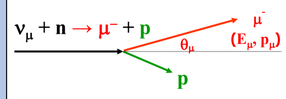
Systematic error source	Error (ν_μ -> ν_μ)	Error (ν_μ -> ν_e)
ν flux & cross-section (Non-cancelled)	2.9%	4.2%
Total	5.0%	5.4%

Reduce this uncertainty by measuring H_2O/CH neutrino cross-section ratio within a 3% accuracy using a detector with a large angular acceptance
→ **WAGASCI experiment (J-PARC T59)**

2. Neutrino interaction

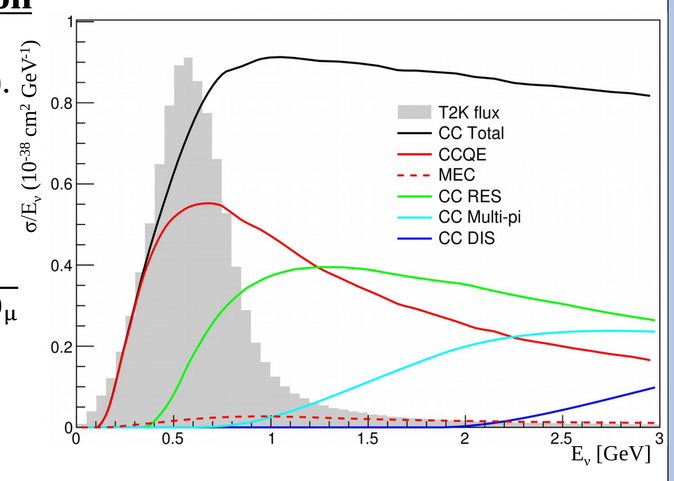
Charged Current (CC) interaction

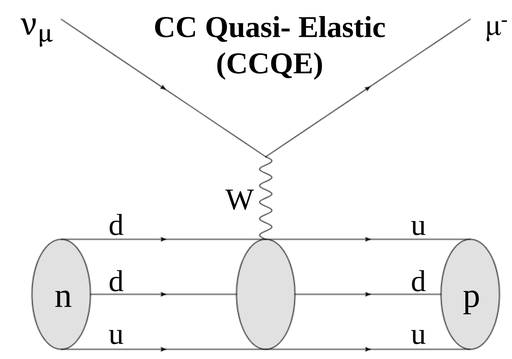
- Dominant neutrino interaction at T2K/WAGASCI energy (~0.6 GeV).
- Easily reconstruct neutrino energy from information of charged lepton. (CC Quasi- Elastic)

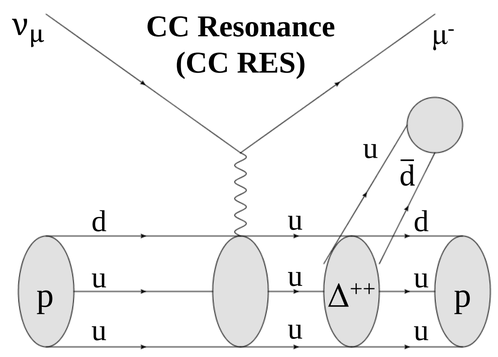


$$E_\nu = \frac{m_N E_\mu - m_\mu^2/2}{m_N - E_\mu + p_\mu \cos\theta_\mu}$$

- **Signal interaction in our analysis for WAGASCI experiment.**

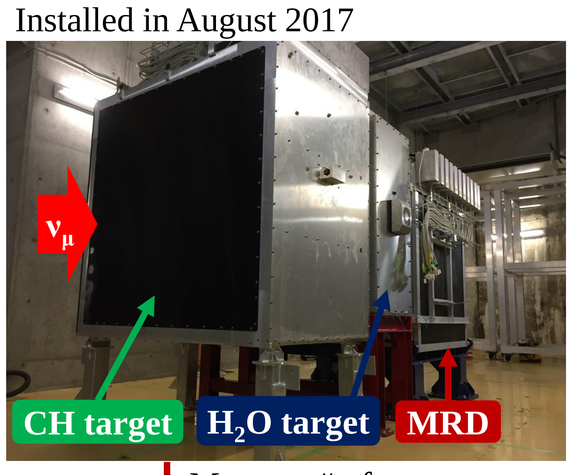




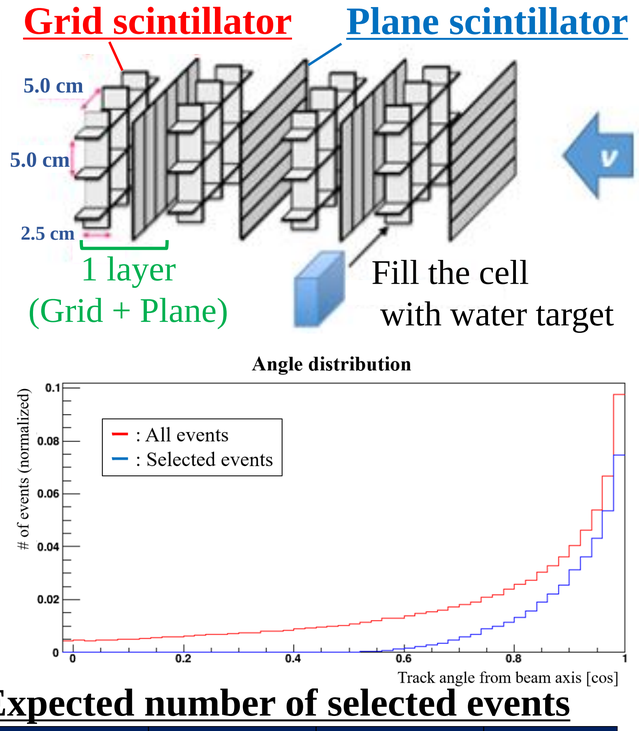


3. Detector

Installed in August 2017



Measure # of events



ν Xsec measurement

$$X_{H_2O} = \frac{N_{obs} - N_{BG}}{\Phi \cdot T_{H_2O} \cdot \varepsilon}$$

- N_{obs} : # of observed events
- N_{BG} : # of background events
- ϕ : Neutrino flux
- T_{H_2O} : # of nucleons (H_2O)
- ε : Detection efficiency

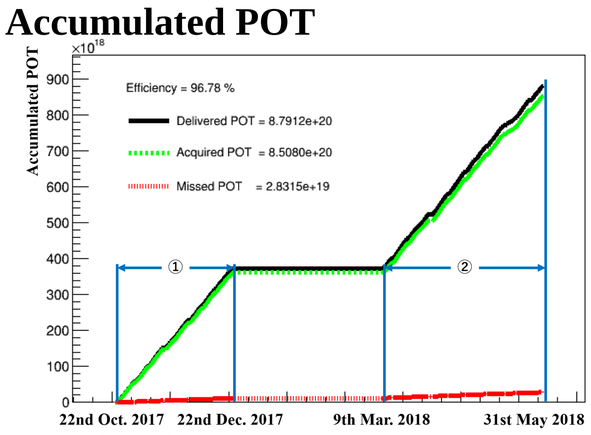
Expected number of selected events

	Signal	BG	Total
# of events	**2024**	**810**	**2834**
Fraction	**71.4%**	**28.6%**	**100%**

※ 9.0×10^{20} POT w/ anti-neutrino mode

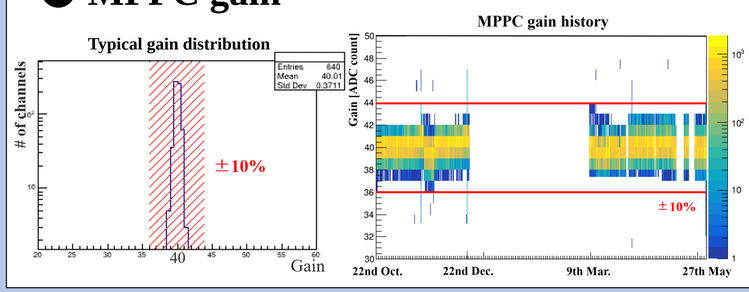
4. Detector operation status

- **Accumulated POT**



- POT: Proton n Target
- w/ Anti-neutrino mode
- Data acquisition period
  ① 2017/10/22 - 2017/12/22
  ② 2018/03/09 - 2018/05/31
- Data taking efficiency is 96.8%
  : No serious issue
- Total 8.51×10^{20} POT
  : 95% statistics of our estimate

- **MPPC gain**

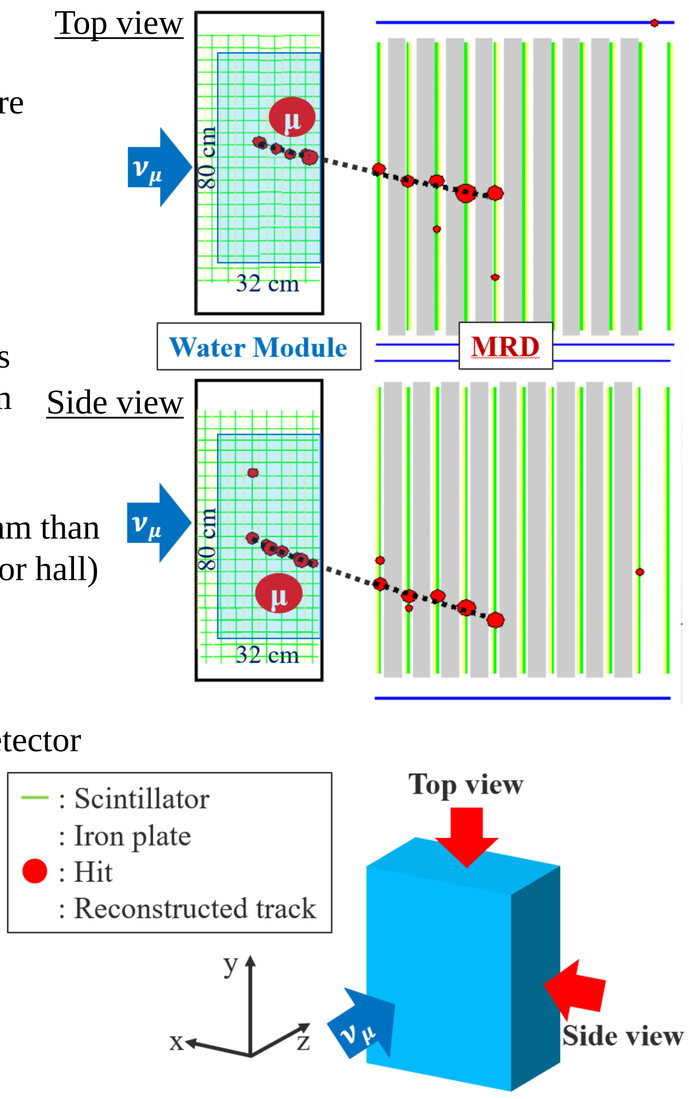


- MPPC: Multi-Pixel Photon Counter
  :Total 1280 MPPCs are used
- Calibrated to 40 ADC counts
- Basically stable (~10% deviation)

5. Event selection

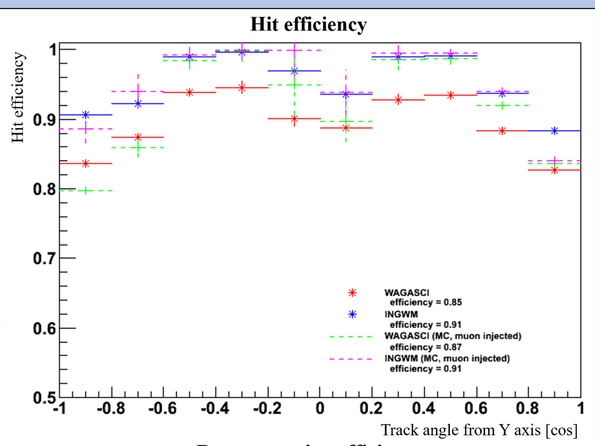
- **Track reconstruction (2D)**
  - Track in side-view and side-view are reconstructed independently
- **Track matching with MRD**
  - Conditions are not optimized yet
  - The number of hit in MRD > 2
  - Track angle difference < 35 degrees
  - Track position difference < 150 mm
- **Upstream veto cut**
  To reject neutrino events more upstream than water module (ex. from wall of detector hall)
  - Two upstream planes (10 cm)
- **Fiducial volume cut**
  To select neutrino events inside the detector
  - 80×32 cm^2
  - Mass in Fiducial volume: 200 kg

To be added...
- Track reconstruction (3D)
- The number of tracks
- Particle ID
- Track angle cut



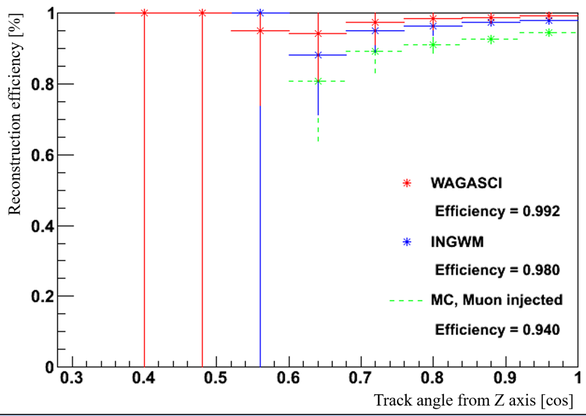
6. Work in progress

- **Hit efficiency**
  - After 2D-track reconstruction (Cosmic-muon events)
  - Comparison between real data and MC prediction shows good agreement
  - ~5% lower than prototype detector (IWM)
    : To be checked



- **Reconstruction efficiency**
  - For 2D-track reconstruction (Sand-muon events)
  - Good agreement between data and MC

To be checked...
- Cross-talk rate
- Event rate
- Beam MC predictions
- Systematic errors



Summary

WAGASCI experiment at J-PARC

- We aim to reduce T2K systematic errors in the oscillation analysis.
- Total 8.51×10^{20} POT collected with 96.8% efficiency so far.
- ~2000 signal events are expected to be observed.
- Hit efficiency and reconstruction efficiency are in good agreement between data and MC.
- Further MC studies are in progress.