A New Experiment at J-PARC to Measure the Neutrino Cross Section Ratio between Water and Plastic

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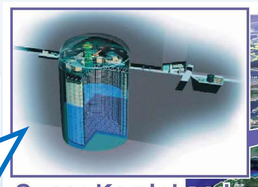
1. Physics Motivation

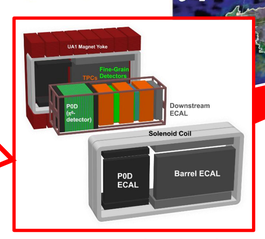
Far Detector (SK)
- Target : **Water(H_2O)**
- Acceptance : **4π**

Near Detector (ND)
- Target : **plastic(CH)**
- Acceptance : **forward scattering**

The differences in target & acceptance b/w SK and ND.



Super-Kamiokande (ICRR, Univ. Tokyo)



ND280 (Tokai)

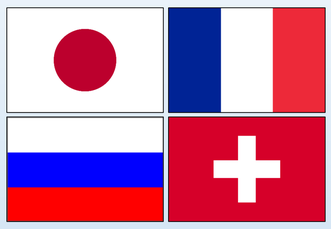
- ✓ ν_μ beam produced at J-PARC.
- ✓ Two modes of **neutrino oscillation**.
  - ν_e appearance : $\nu_\mu \rightarrow \nu_e$
  - ν_μ disappearance : $\nu_\mu \rightarrow \nu_{not\ \mu}$

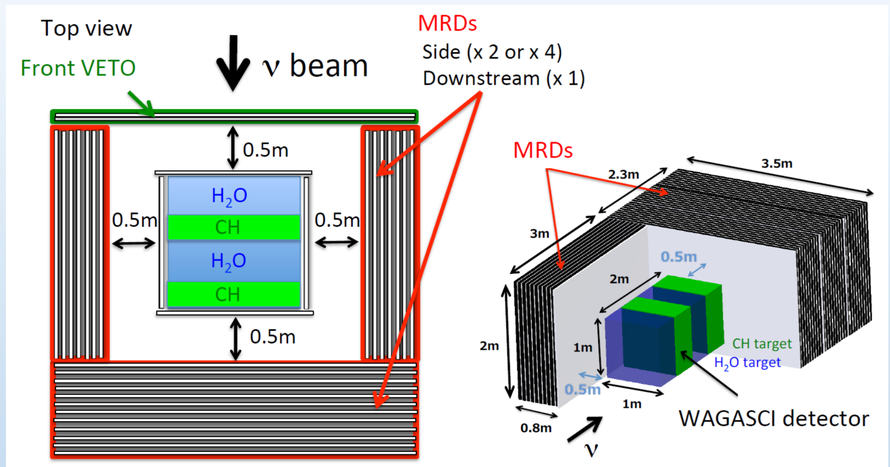
Systematic Error Sources	ν_e	ν_μ
ν flux & cross section (constrained by ND280)	3.2%	2.7%
ν flux & cross section (not constrained by ND280)	**4.7%**	**5.0%**
Super-K etc.	3.7%	5.0%
Total	6.8%	7.7%

The measurement of the H_2O/CH cross section ratio with large acceptance.

WAGASCI experiment.

2. WAGASCI experiment

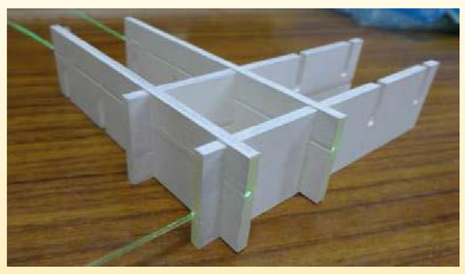


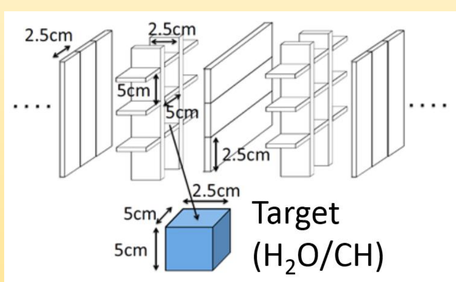


- Goal
  1. Measure the cross section ratio of charged current neutrino interaction on nucleus between H_2O/CH with 3% accuracy.
  2. Measure the differential cross section(T_μ, θ_μ) with large phase space acceptance.
- Location
  - J-Parc neutrino near detector hall. (at B2 floor)
  - Use the **similar off-axis angle to T2K ND280 and SK**. ($\sim 1.6°$)
- Design
  - Little difference in flux and detection efficiency between H2O/CH targets.
    ⇒ Taking cross section ratio **cancels systematic error in beam flux**.
  - Background is rejected by time information and veto planes.

3. WAGASCI Detector

- Target
  H_2O : *1ton*, CH : *1ton.*
- 3D grid-like scintillator detector.
  - ✓ Use **3-mm-thick plastic scintillator with slits**.
  - ✓ Each cell of 3D-grid is filled with target(H_2O/CH).



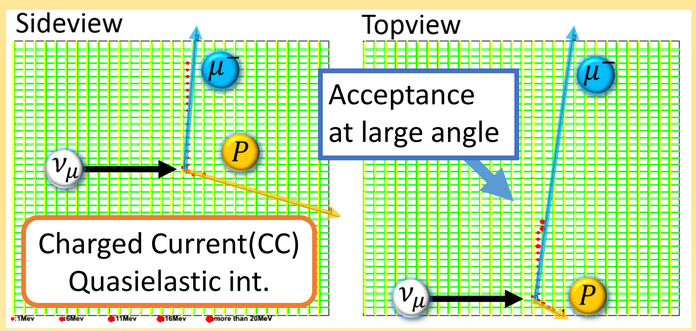


○***Merit***
1. **80% target region** in the detector.
   ⇒ Reduce the ν interaction on scintillators.
2. Almost **4π acceptance**.
   ⇒ Improve neutrino interaction model.

- Expected Performance

	CC	*NC*	*Ext. BG*	*All*
Events	**31466**	1608	1832	43440
Ratio	**90.1%**	4.7%	5.2%	100%

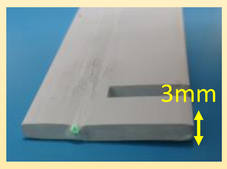
*Expected number of event with 10^{21} POT.
- ➢ **High Statistics.**
- ➢ **Low Background.**
- ➢ **High purity of CC interaction.**

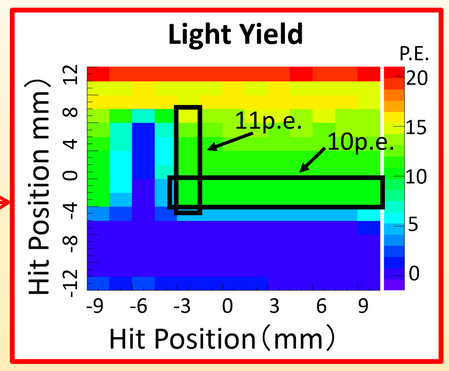


4. Components

Performance test of 3mm thin plastic scintillator

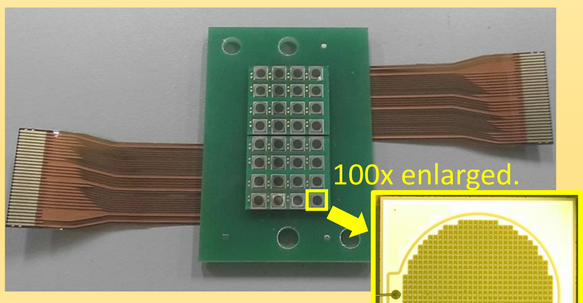
- ✓ Positron beam produced by the accelerator at Tohoku Univ.
- ✓ Readout : WLS fiber ⇒ MPPC.
- ✓ 1.5mm segmentation hodoscope.





Result: (1.5p.e. threshold)
99% detection efficiency

32ch arrayed MPPC



- 716 pixels.
- Diameter : 1.5mm

Performance of new MPPCs developed by Hamamatsu
- ✓ Low noise(~1/10 compared to T2K ver.)
- ✓ Much less after pulse
- ✓ Wider operation voltage
- ✓ Low cross-talk

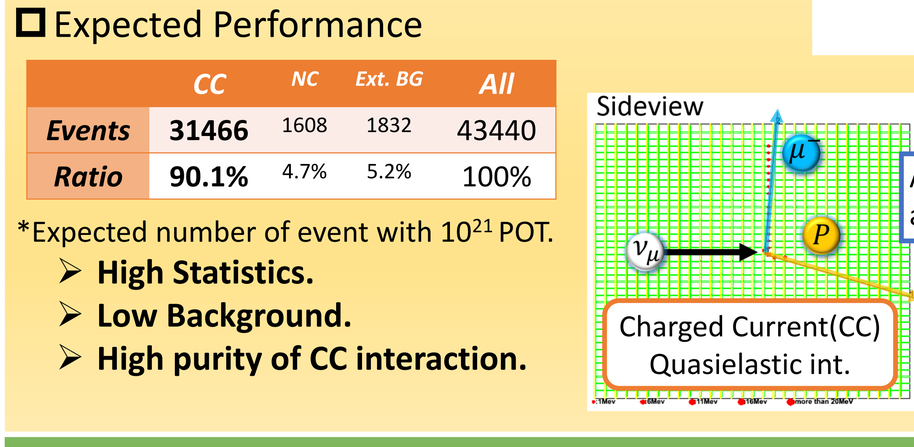
- Performance test of MPPC
- Development of electronics

On going

5. Magnetized Downstream MRD

- **An option** for improving the performance to measure anti-neutrino cross section.
- **Large BG from ν_μ interaction**.
  1. Large fraction of ν_μ in anti-nu mode beam.
  2. Smaller cross section of $\bar{\nu}_\mu$ than ν_μ.

- Remove this BG by **magnetic field**.
  - ➢ The charge of particle from ν int. is reconstructed by the variation of direction.



Expected Performance
- ➢ Charge recon. eff. : 91%
- ➢ ν_μ BG Contamination : decreased down to 7%

Measurement of anti-neutrino cross section ratio with 3% accuracy.

Optimization of the detector configuration. is still going on.

6. Schedule & Summary

- ✓ We plan to construct a new detector, named WAGASCI, for precise neutrino oscillation measurement.
- ✓ Measure **the charged current neutrino cross section ratio** on H_2O to CH with 3% accuracy.
- ✓ **3D grid-like scintillator** will be used for large acceptance.
- ✓ MC studies and R&D of components have almost been done.
- ✓ An Option to install **magnet module at downstream**.
- ✓ Start operation at Oct. 2016.

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