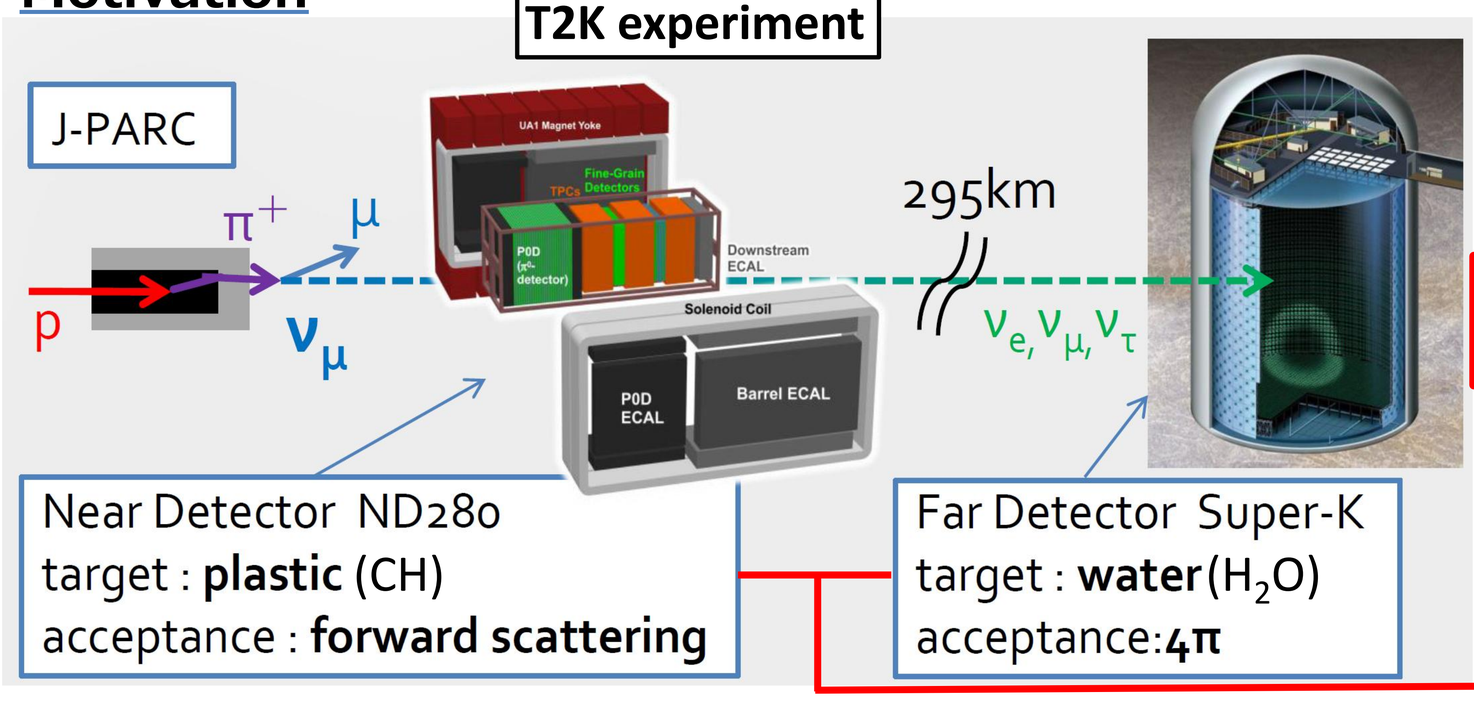
Detector design and R&D for Water/CH Neutrino Cross Section Measurement , WAGASCI

Taichiro.Koga[5] ,A.Bonnemaison[1], O.Drapier[1], O. Ferreira[1], M.Gonin[1], Th.A.Mueller[1], B.Quilain[1] , I.Ayzenberg[2], A. Izmaylov[2], I.Karpikov[2], M.Khabibullin[2], A.Khotjantsev[2], Y.Kudenko[2], S.Martynenko[2], A.Mefodiev[2], O.Mineev[2], T.Ovsjannikova[2],S. Suvorov[2],N.Yershov[2] ,T.Hayashino[3], A.K. Ichikawa[3], A.Minamino[3], K.Nakamura[3], T.Nakaya[3], K.Yoshida[3] ,Y. Seiya[4], K.Wakamatsu[4], K.Yamamoto[4] , H.Hosomi[5], N.Chikuma[5], M.Yokoyama[5], Y.Hayato[6]
1.Ecole Polytechnique 2. Institute for Nuclear Research of the Russian Academy of Sciences 3. Kyoto University 4.Osaka City University 5. University of Tokyo, Department of Physics 6.University of Tokyo, Institute for Cosmic Ray Research

Motivation



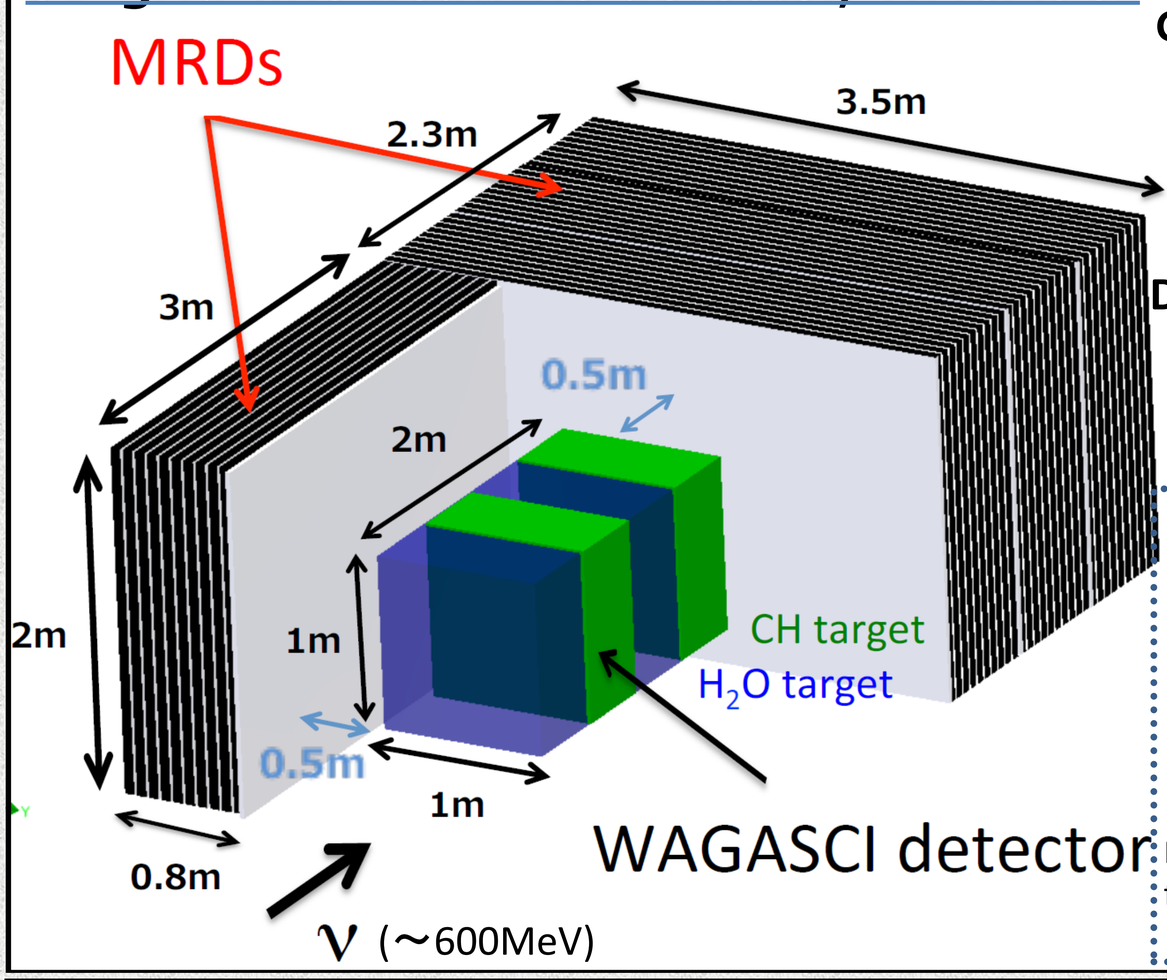
T2K oscillation analysis systematic error

Systematic Error sources	Error($\nu_\mu \to \nu_e$)	Error($\nu_\mu \to \nu_\mu$)
ν flux & cross section (constrained by ND280)	2.9%	2.7%
ν flux & cross section (not constrained by ND280)	7.5%	5.0%
Super-K etc.	3.5%	5.6%
Total	8.8%	8.0%

The differences of target and acceptance cause systematic error

- T2K have non-canceling systematic errors on neutrino cross sections because of different target material and acceptance.
- **We plan to construct a new detector measuring H_2O/CH CC cross section ratio with large acceptance.**
  Validate the target–dependence in the neutrino interaction models and **reduce the T2K systematic error.**

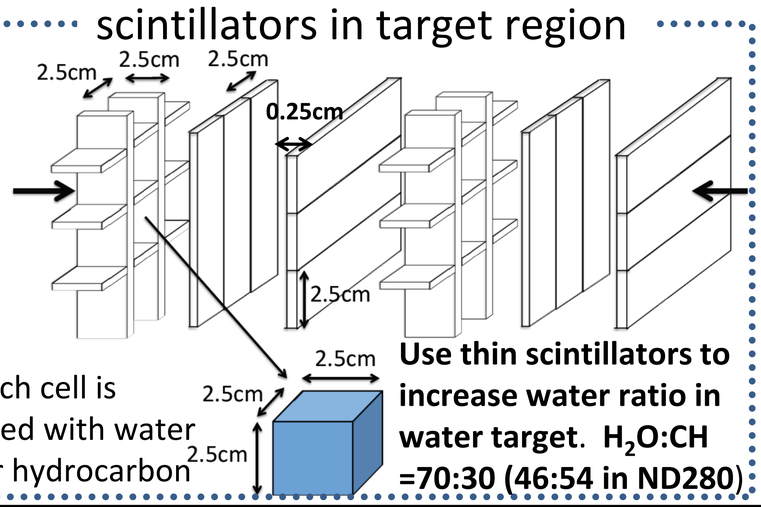
3D grid-like neutrino detector, WAGASCI



Goals
- **Measure H_2O to CH cross section ratio with 3% accuracy :CC-inclusive and exclusive channels.**
- **Differential cross-section(T_μ ,θ_μ) with large phase space acceptance.**

Design
- Use J-PARC ν beam with the similar off-axis angle as T2K ND280.
- 3D grid structure of plastic scintillators in target for large acceptance.
- Little differences of flux and detection efficiency between targets. Systematic errors are cancelled when taking ratio.
- Background rejection with time information and veto planes around target.

scintillators in target region



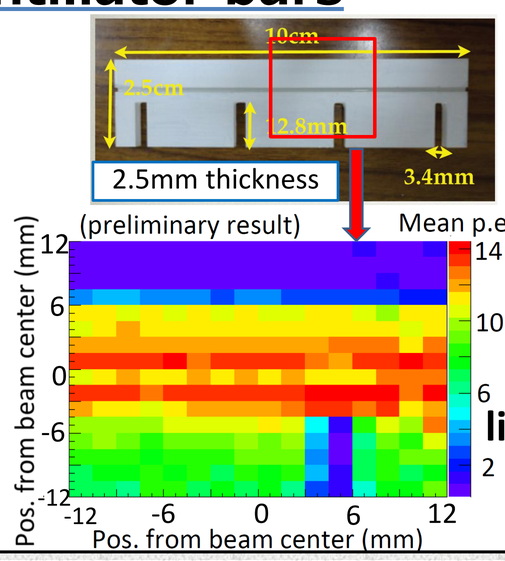
Use thin scintillators to increase water ratio in water target. H_2O:CH =70:30 (46:54 in ND280)

- Two options for downstream detectors
  - muon range detectors(MRDs): iron + scintillators bars
  - magnetized detector: permanent magnets + scintillator tracking plane
  → Good for over 1GeV μ and anti-nu data

Test of light yield of scintillator bars

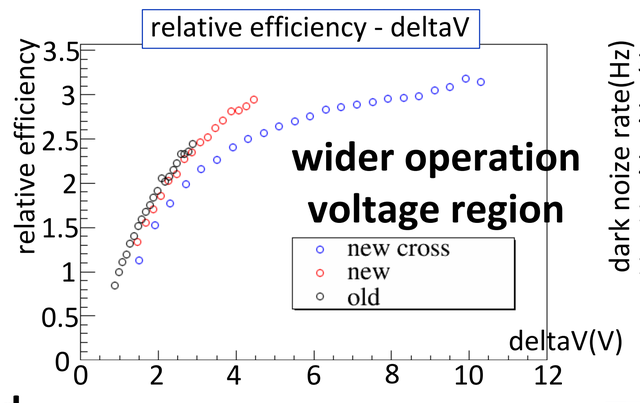
3D grid scintillators are required to have High light yield.
Tested 2.5mm thickness specific shape prototypes with 500MeV e^+ beam.
- Used 1.5mm resolution hodoscope.
- Used T2K MPPC and wavelength shifting fiber put in a groove of the scintillators for Readout.

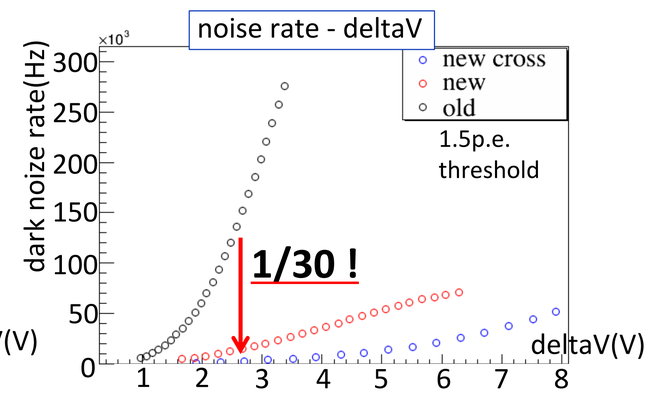
As a result, light yield is not enough high at the lower position in the right picture.
→ plan to use new high PDE MPPC



light yield is low

Test of New Low noise and Low crosstalk MPPCs



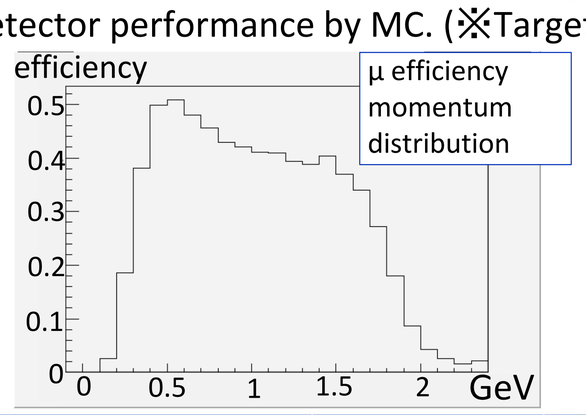


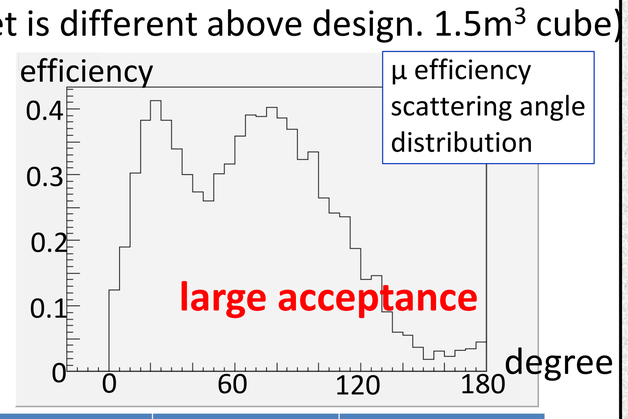
We tested new MPPCs developed by Hamamatsu Photonics. It has
- **high quantum efficiency**
- **low noise**

kind	ΔV	dark noise rate	relative efficiency
old	1.5V	**3.6E4** Hz	1.5
new	3.0V	**5.0E3** Hz	**2.0**

Monte Carlo simulation

- We developed track reconstruction algorithm for WAGASCI and evaluated detector performance by MC. (※Target is different above design. 1.5m^3 cube)





	CC inclusive	NC	Outer BG	All
event rate/10^{21}POT	82600	7200	4000	93800
ratio	88.0%	7.7%	4.3%	100%

high statics

Summary

- We plan to construct a new detector for precise neutrino oscillation measurement.
- Measure the H_2O to CH charged current cross section ratio with 3% precision with large acceptance.
- MC studies test of the detector components are on-going
- Start operation on Dec., 2015.