The new experiment WAGASCI for water to hydrocarbon neutrino cross-section measurement using the J-PARC beam

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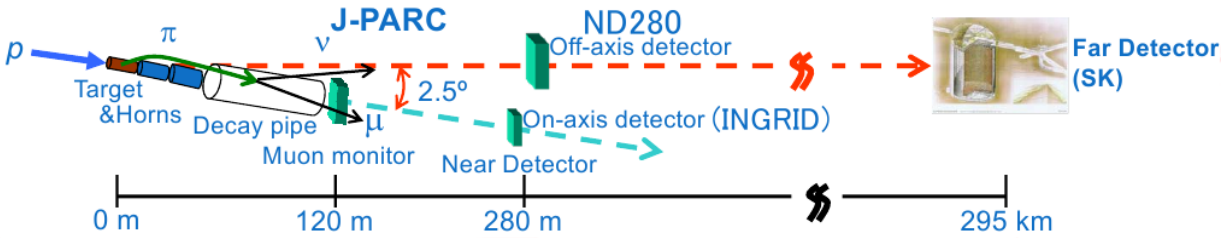
Motivation

- The T2K (Tokai-to-Kamioka) is a LBL experiment to study neutrino oscillations
- Complex of near detectors (ND280) and Super-Kamiokande as a far-detector
- ND280 data used to contstrain flux and XSec parameters for oscillation analysis



The largest systematic uncertainty due to:

- Difference in the target material between the far (H_2O) and near (CH) detectors
- Limited acceptance of the near detector w.r.t. to Super-Kamiokande ($= 4\pi$)

The uncertainties for predicted number of signal events for different oscillation modes (%)

Systematics	$\nu_\mu \rightarrow \nu_e$	$\nu_\mu \rightarrow \nu_\mu$	$\overline{\nu}_\mu \rightarrow \overline{\nu}_\mu$
Flux & XSEC	3.1	2.7	3.4
Non-canceling XSEC	4.7	5.0	10.0
Super-K detector etc.	2.4	3.0	2.1
FSI+SI	2.7	4.0	3.8
Total	6.8	7.7	11.6

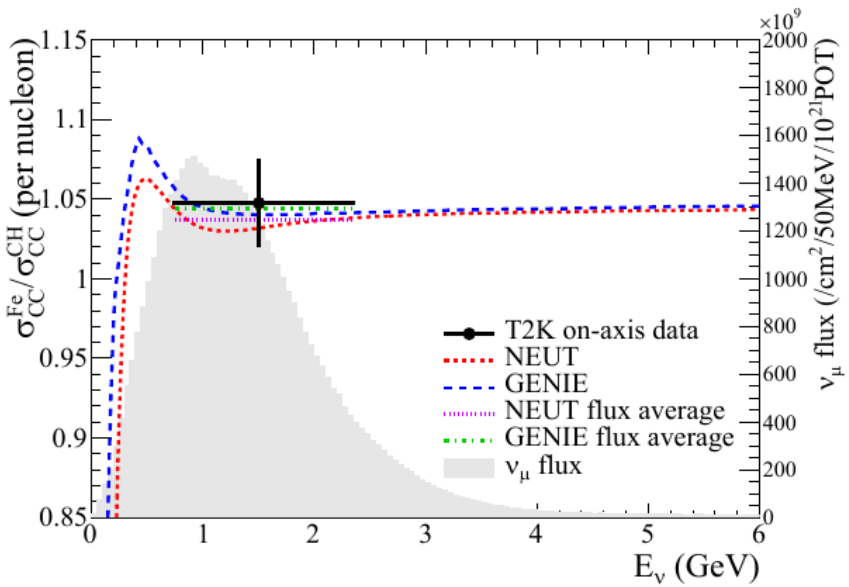
WAGASCI (WAter-Grid-SClintilator-Detector)

On-axis iron-scintillator detector INGRID + Proton Module(scintillator)

$\frac{\sigma_{Fe}}{\sigma_{CH}}$ cross section ratio (INGRID)

Main goals:

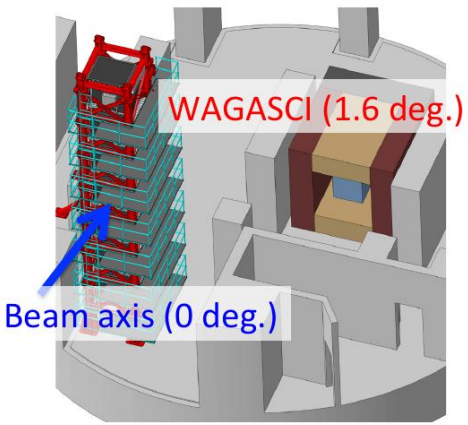
- measure the charge current cross section ratio between water and scintillator targets with 3% accuracy
- measure different charged current neutrino interaction channels with high-precision and large acceptance

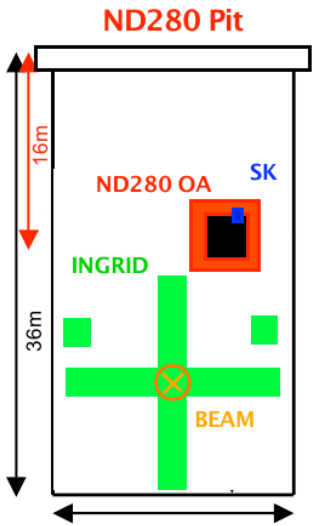


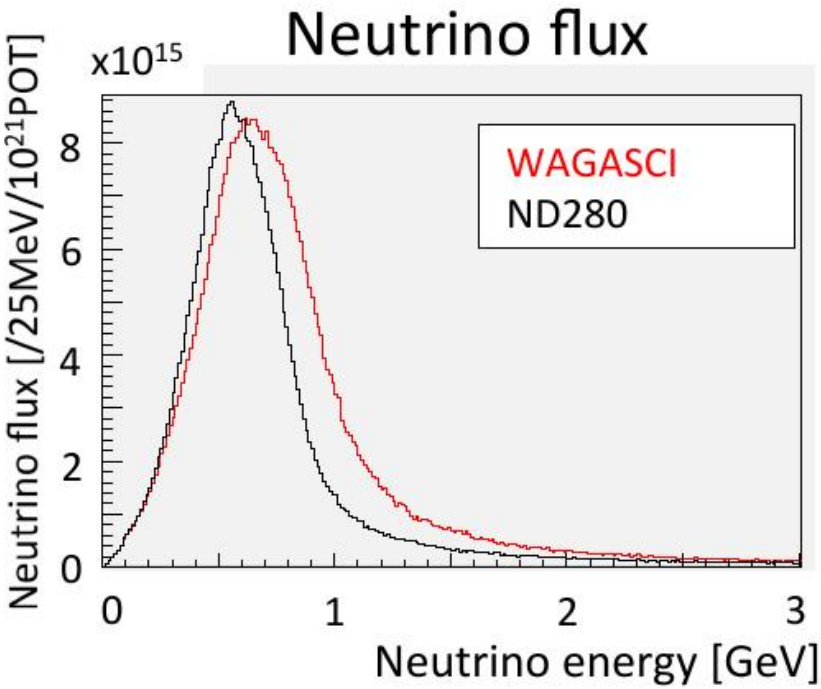
$\sigma^{Fe}_{CC}/\sigma^{CH}_{CC} = 1.047 \pm 0.007(stat.) \pm 0.035(syst.)$ *Phys. Rev.* D **90** 052010

Location

- T2K neutrino beam at J-PARC
- B2 floor of the near detector hall
- Off-axis angle 1.6° with respect to ν beam (E_ν=0.7 GeV) vs 2.5° at ND280 off-axis site and far detector

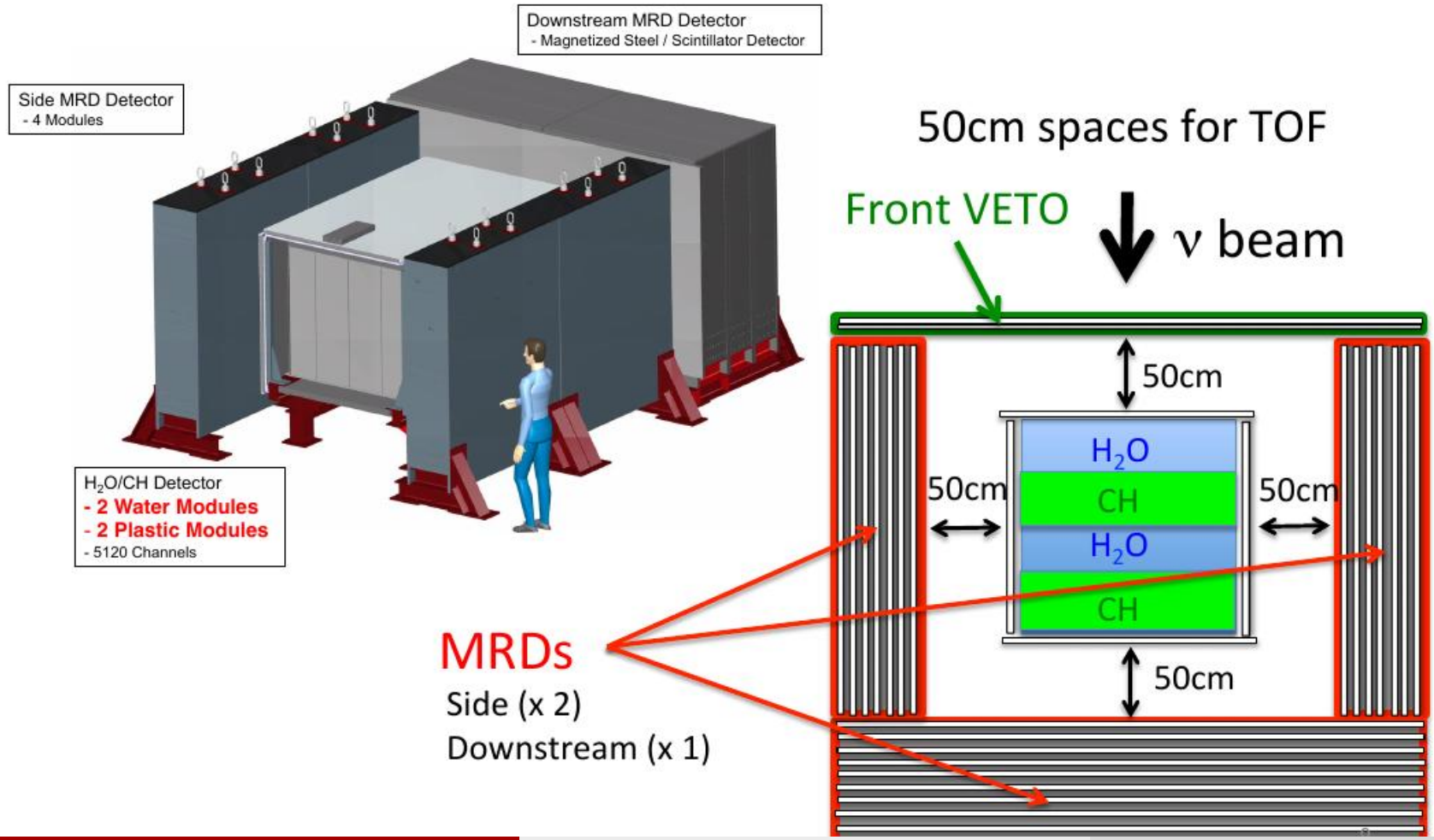






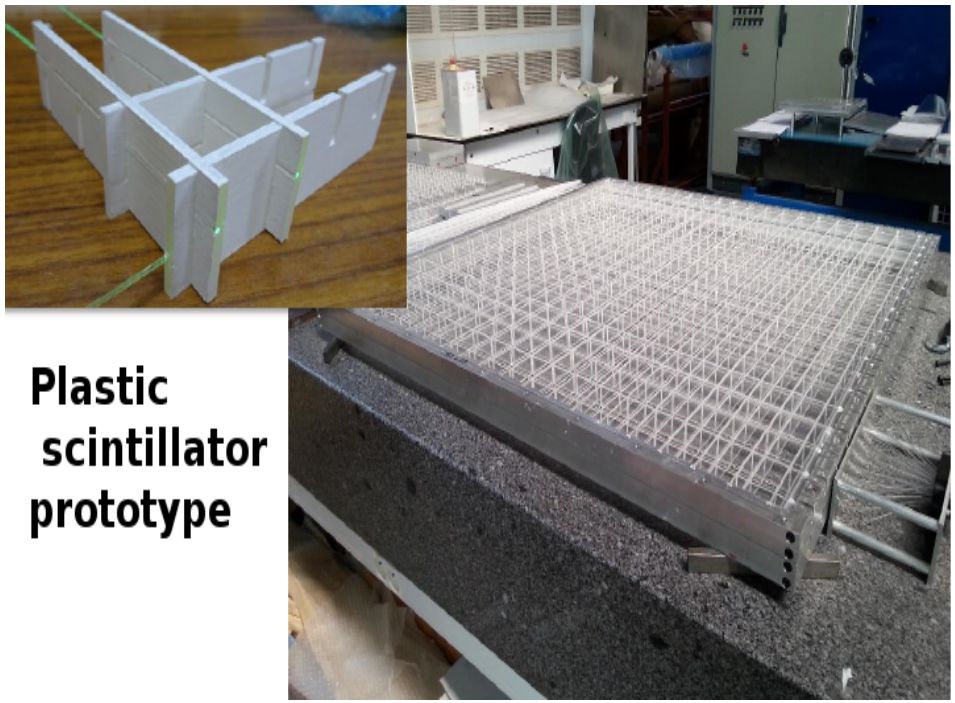
WAGASCI design

- central target: 3D like grid structure
- muon range detectors MRDs
- magnetized iron detector MIND as possible downstream MRD



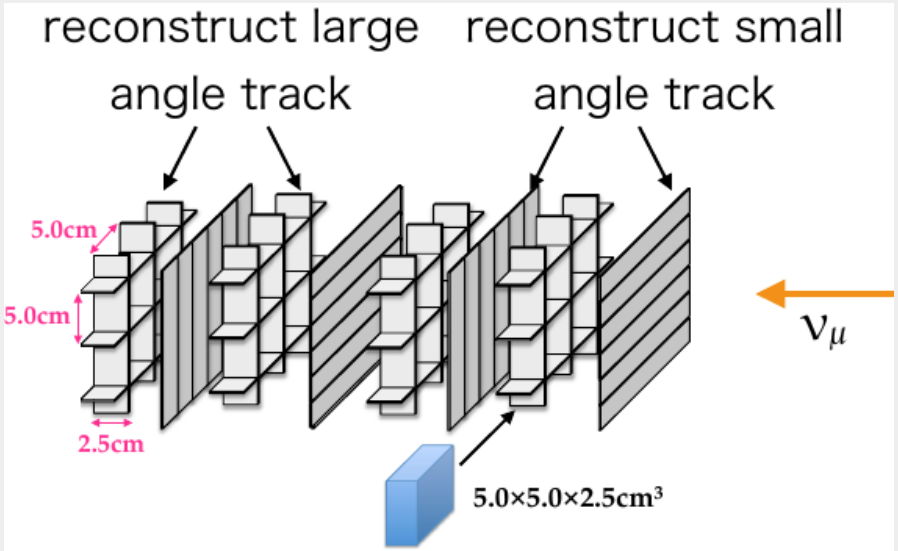
3D like grid structure

3 mm thin scintillator



Plastic scintillator prototype

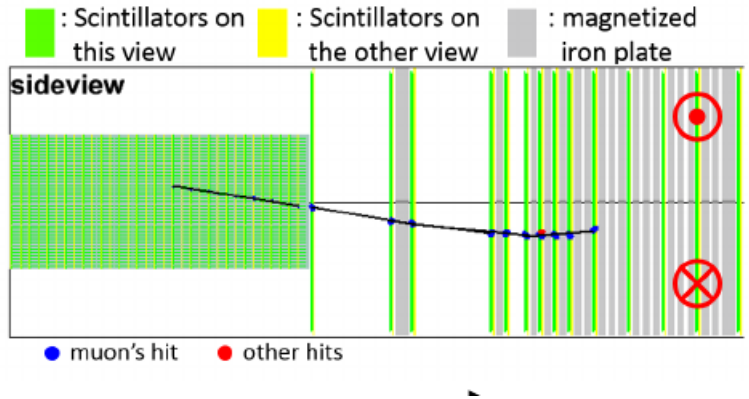
fibers are connected to the 32ch arrayed MPPC

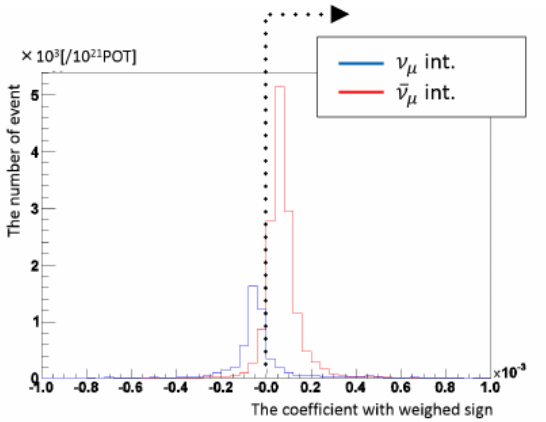


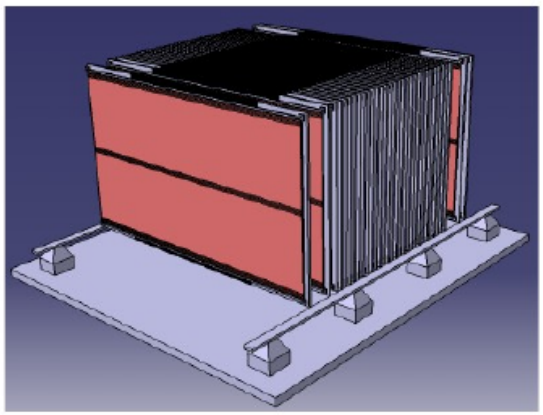
Cells filled with water or hydrocarbon
Fraction of target material 79 : 21
H_2O:CH

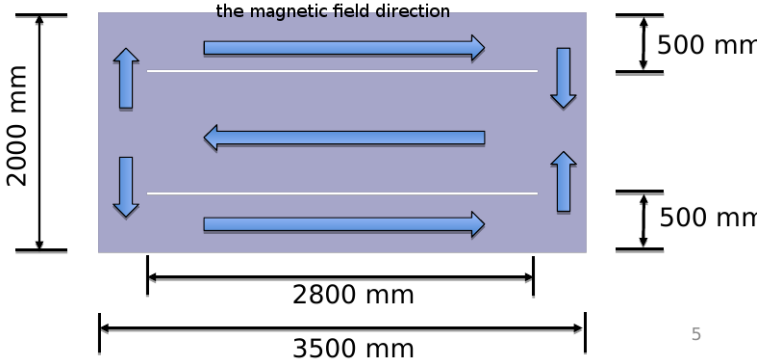
Magnetized IroN Detector

- low carbon steel plates
- Aluminum coils around single plate
- 1.5T, B_x in central region
- Expected charge identification efficiency 88.9%
- Contamination of ν_μ would decrease to 2.9 %







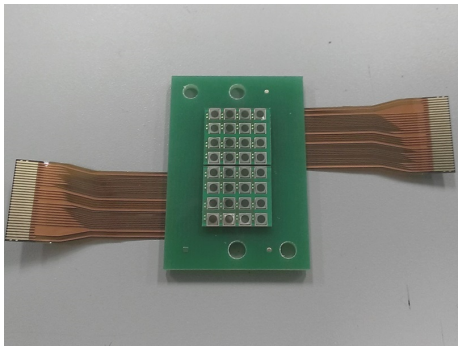


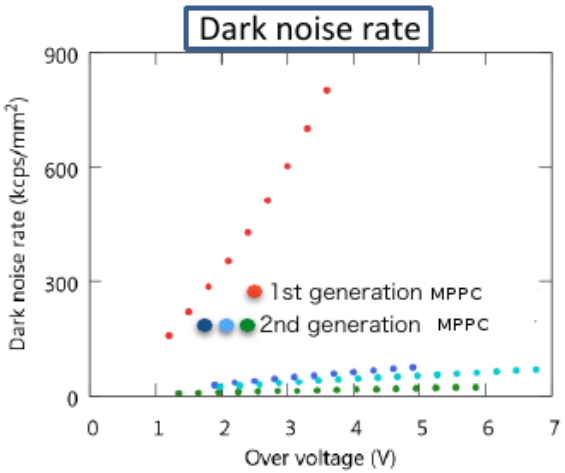
2 gap magnetized plate

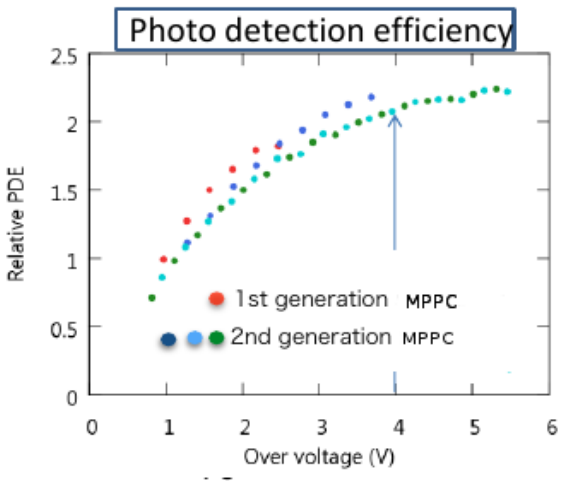
WAGASCI photosensors

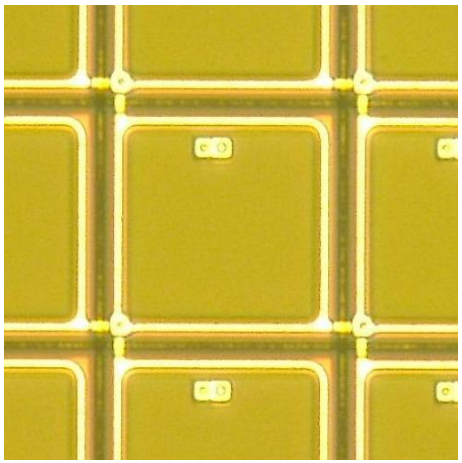
New generation Hamamatsu MPPC as photodetectors

- Low noise and crosstalk
- High photon detection efficiency
- Wide range of over voltage (4V)





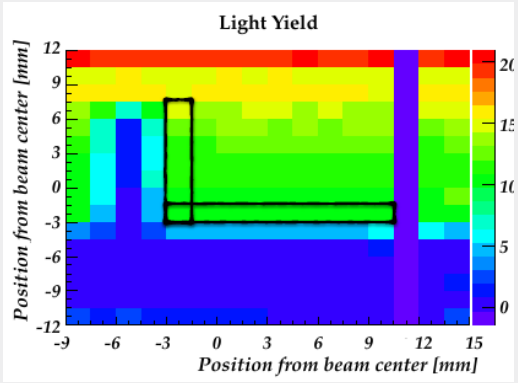


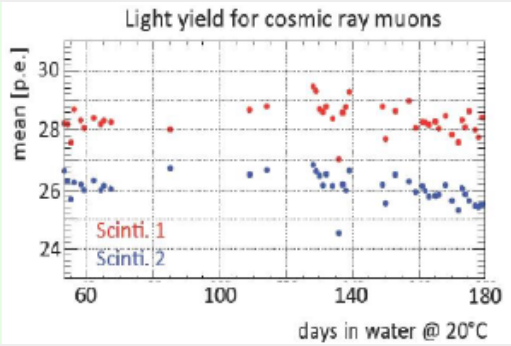


WAGASCI scintillator performance

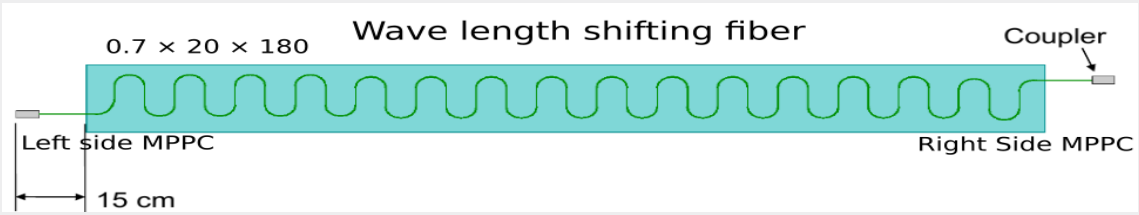
WAGASCI

- 600 MeV positron beam test at Tohoku Uni.
- Light yield 10-18 p.e.
- detection efficiency > 99%
- new generation of MPPC

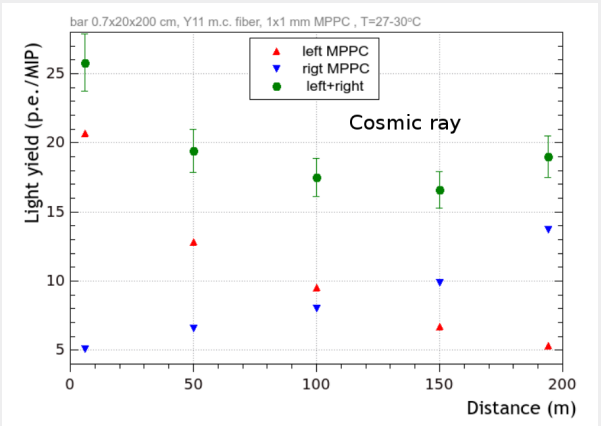


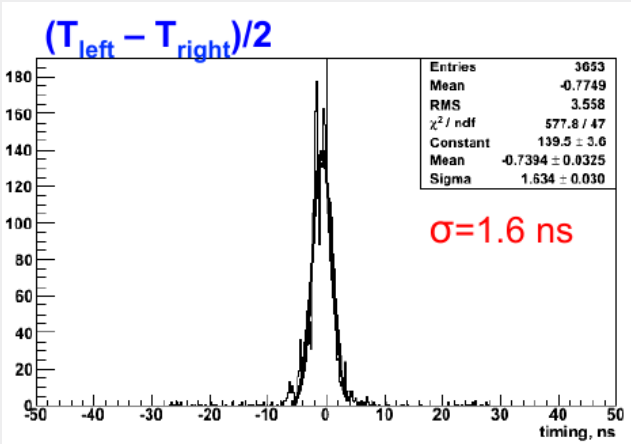


MRD



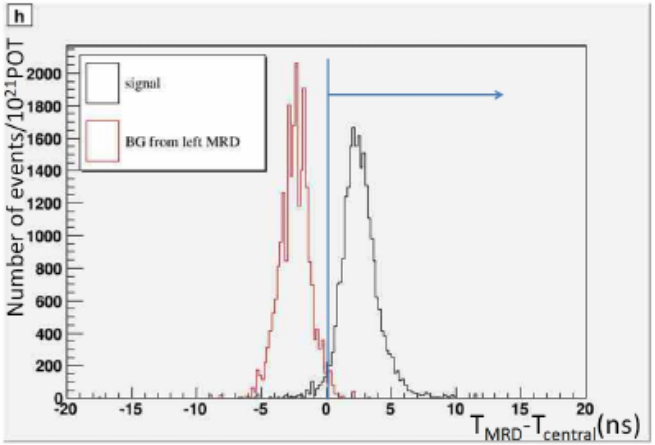
- light yield > 17p.e./MIP
- detection efficiency > 99.5%
- Timing resolution 1.6 ns (=> 50cm resolution)
- old generation of MPPC



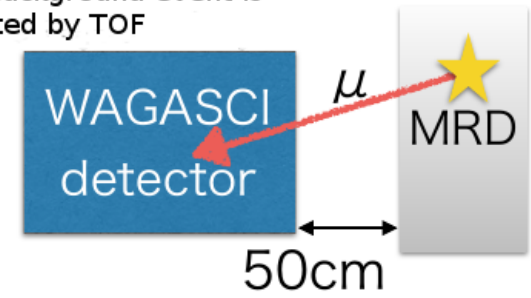


The expected performance

- 2D tracks → then combined into final 3D
- Target tracks → MRD matching
- Time Of Flight
- Fiducial volume

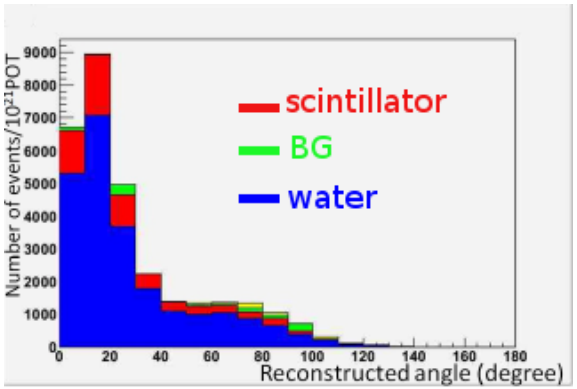


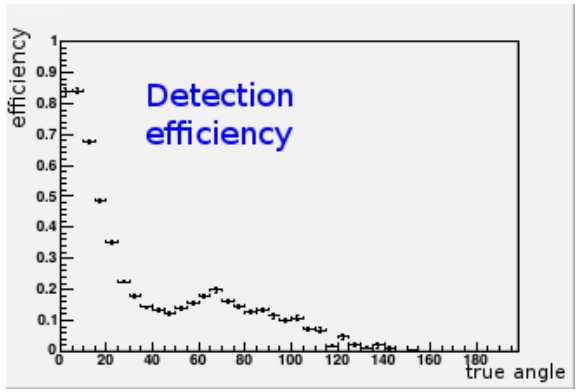
The background event is rejected by TOF

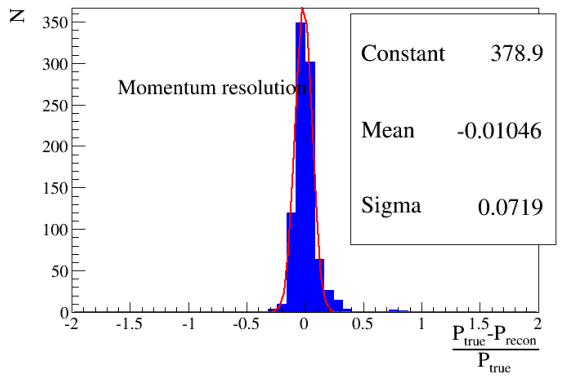


The selected events for 10^{21} POT statistics

Water module	CC	NC	BG from scintillator	BG from outside	All
Number of events	2.41×10^4	8.65×10^2	6.19×10^3	1.64×10^3	3.19×10^4
Fraction	75.5%	2.71%	19.4%	5.14%	100%



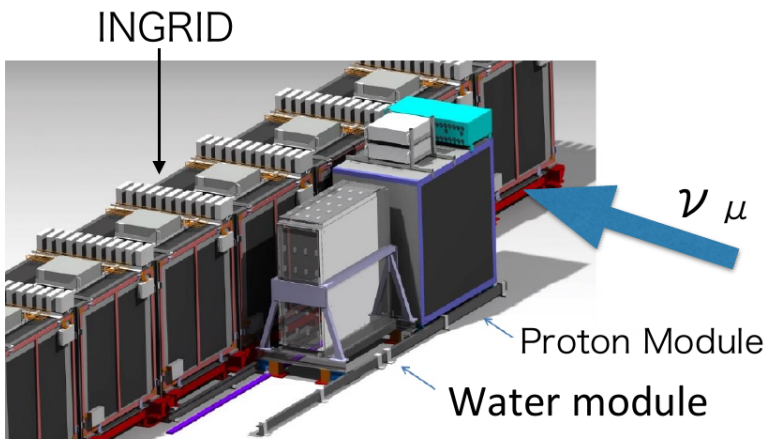


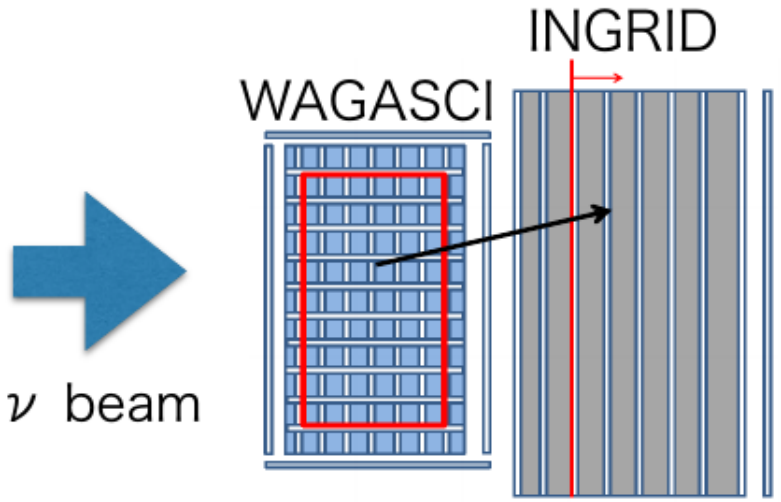


The WAGASCI prototype

WAGASCI prototype for basic performance tests

- WAGASCI water target in front of the INGRID module
- on-axis beam
- identify muon by the INGRID module (Fe/CH)





- measure H_2O and CH cross section
- will be constructed in October-December 2015

WAGASCI Collaboration

- Institute for Nuclear Research of the Russian Academy of Sciences, Russia

  M. Antonova, A. Izmaylov, M. Khabibullin, A. Khotjantsev, Y. Kudenko, A. Mefodiev, O. Mineev, T. Ovsiannikova, S. Suvorow, N. Yershov

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Summary

- 3D grid water scintillator experiment WAGASCI proposed to take data with J-PARC neutrino beam.
- Measurement of the neutrino cross-section ratio H_2O:CH with 3% accuracy
- Exact design of the detector and its components is still being finalized
- WAGASCI scheduled to take beam from late fall 2016