The status of neutrino experiment WAGASCI

International Session-Conference of Section of Nuclear Physics of PSD RAS

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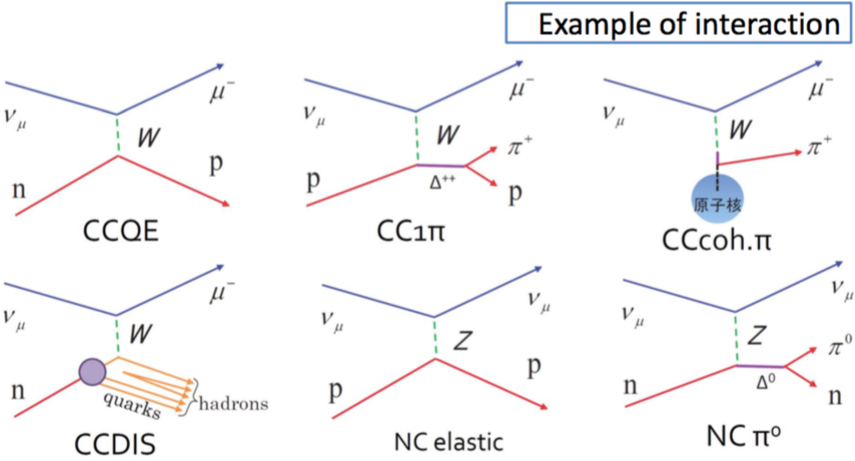
4 April 2016

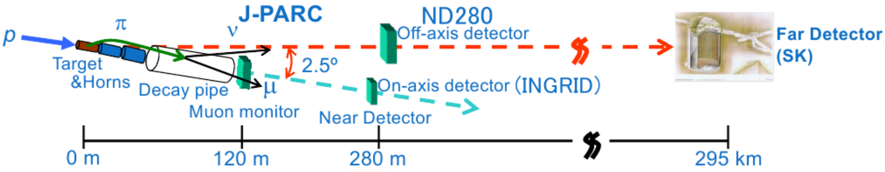
Neutrino Experiments

- Neutrino experiments have entered the stage of precision measurements
- Precision measurements require detailed knowledge of many factors including good understanding of neutrino interactions with matter



Motivation (T2K Experiment)

- LBL experiment to study neutrino oscillations with J-PARC ν beam
- 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 near detector w.r.t. to Super-Kamiokande ($= 4\pi$)

Systematics	$\nu_\mu \to \nu_e$	$\nu_\mu \to \nu_\mu$	$\overline{\nu}_\mu \to \overline{\nu}_\mu$
Flux & XSEC	3.1 %	2.7 %	3.4 %
Non-canceling XSEC	4.7 %	5.0 %	10.0 %
Super-K detector etc.	2.7 %	4.0 %	3.8 %
FSI+SI	2.5 %	3.0 %	2.1 %
Total	6.8 %	7.7 %	11.6 %

WAGASCI (WAter-Grid-SCIintilator-Detector)

Water scintillator detector WAGASCI to take data with J-PARC (ν_μ, anti-ν_μ) beam at $\tilde{1}$ GeV

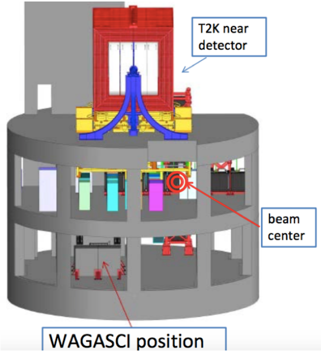
Main goals:

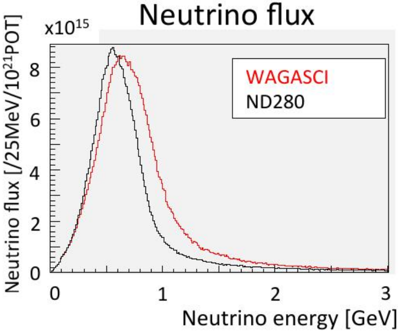
- Measure the CC cross section ratio between water and scintillator with 3% accuracy
  - High angular acceptance measurement
  - ND280 43 : 56 H_2O:CH fraction vs WAGASCI 79 : 21 H_2O:CH
- Measure different CC neutrino interaction channels with high-precision
  - Test models of nuclear target-dependence in neutrino interactions
- Strategy already proved with T2K on-axis INGRID detector

On-axis iron-scintillator detector INGRID + Proton Module(scintillator):
$\sigma_{CC}^{Fe}/\sigma_{CC}^{CH} = 1.047 \pm 0.007(stat.) \pm 0.035(syst.)$ *Phys. Rev.* D **90** 052010

Candidate site

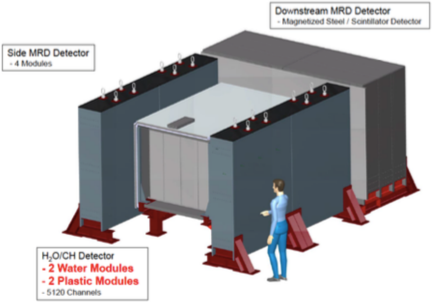
- T2K neutrino beam at J-PARC
- B2 floor of the near detector hall
- Off-axis angle 1.6° with respect to ν_μ beam (E_{ν_μ}=0.7 GeV) vs 2.5° at ND280 off-axis site and far detector

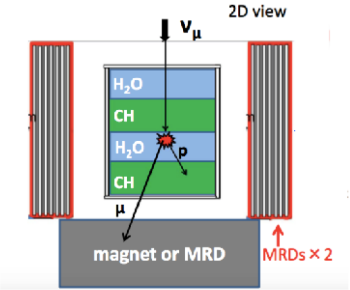




WAGASCI Design

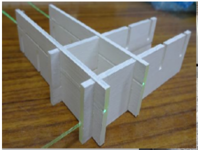
- Target: 3D grid structure filled with H_2O/CH
- Side muon range detectors MRDs : iron + scintillator
- Downstream detector:
  - Magnetized Iron detector MIND : (ν_μ/anti-ν_μ) event separation
  - MRD





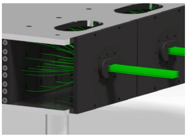
3D Grid Structure

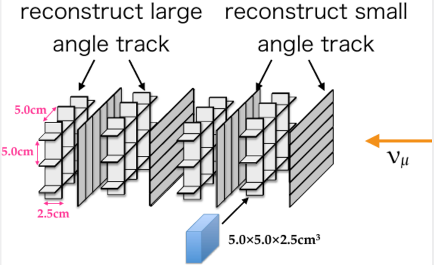
3 mm thin scintillator



Plastic scintillator prototype

WLS fibers connected to 32ch arrayed MPPCs





Cells filled with water or hydrocarbon

Fraction of target material 79 : 21

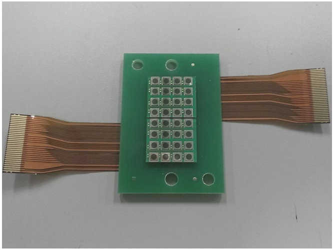
H_2O:CH

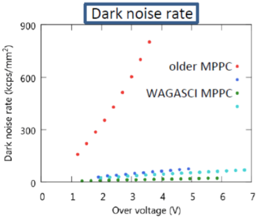
WAGASCI Photosensors

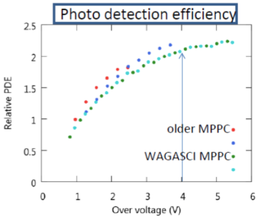
Thin scintillator in target→ need high light collection efficiency

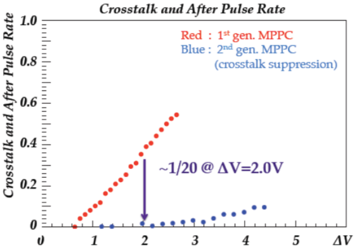
New generation Hamamatsu MPPCs as photodetectors

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





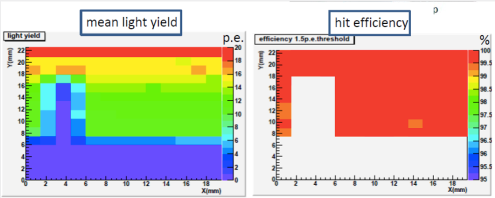




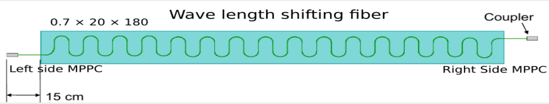
WAGASCI Scintillator Performance

WAGASCI

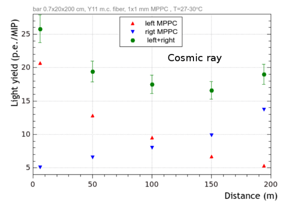
- 600 MeV positron beam test at Tohoku Uni.
- Light yield 10-18 p.e.
- Detection efficiency > 99%
- New generation MPPCs

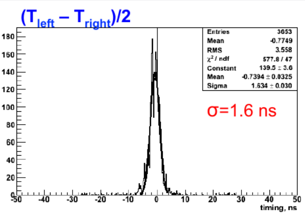


MRD



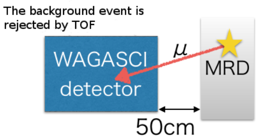
- Light yield > 17p.e./MIP
- Detection efficiency > 99%
- Timing resolution 1.6 ns (=> 50cm resolution)
- Old generation MPPCs

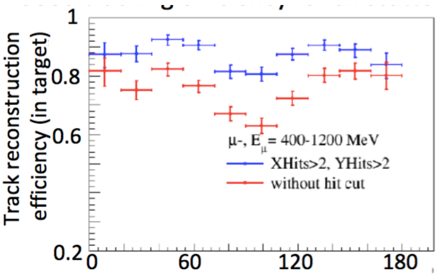


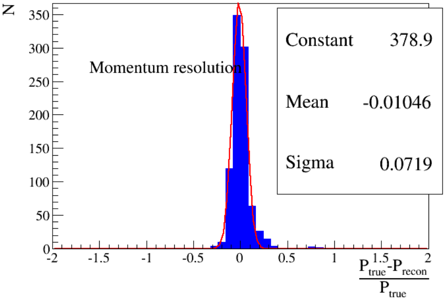


Expected Performance

- 2D tracks reconstruction (Radon transform/ SBCAt)
- 2D tracks → then combined into final 3D
- Target tracks → MRD matching
- Time Of Flight
- Fiducial volume

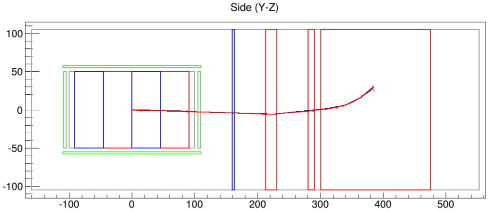


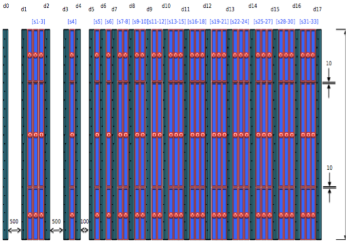


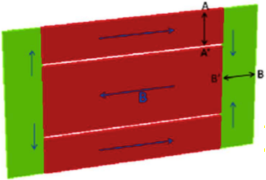


Magnetized IroN Detector

- Steel plates covered with aluminium coils
- 1.5T, B_x in central region
- Beam test at CERN in June - Jule 2016

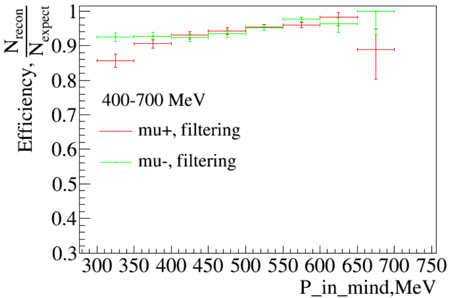


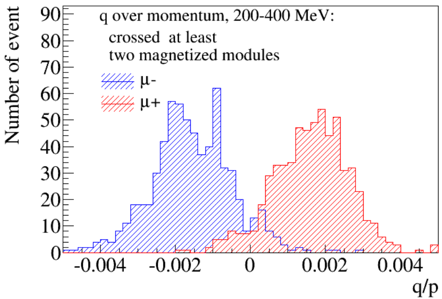




MIND Perfomance

- Charge discrimination investigation
- Study reconstruction algorithm with RECPACK (Kalman filter based)
- Monte-Carlo test : charge ID efficiency > 90%



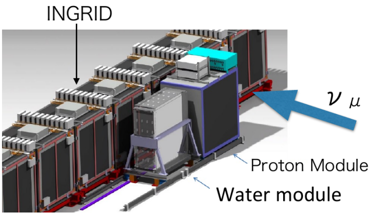


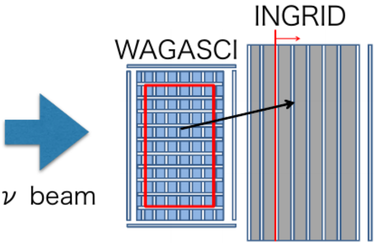
RECPACK webpage: http://ific.uv.es/recpack

WAGASCI Prototype

WAGASCI prototype for basic performance tests

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

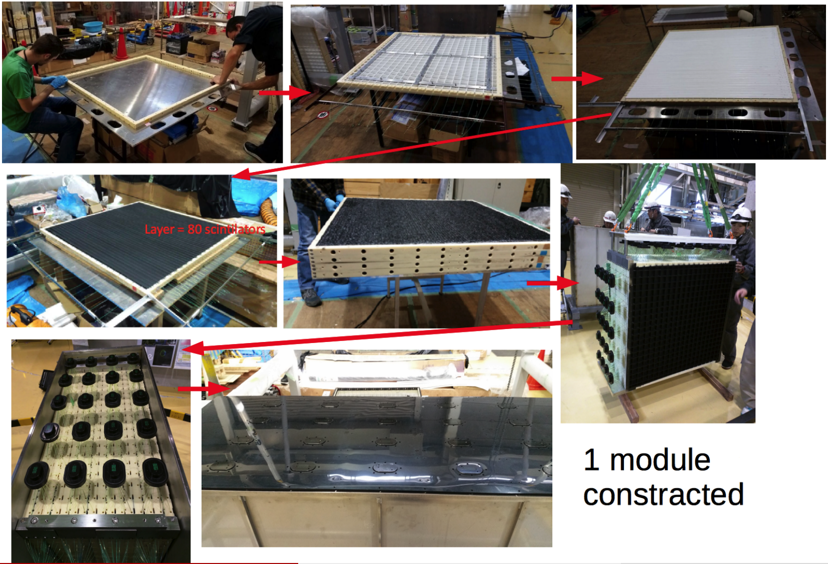




- Measure H_2O and CH cross section

WAGASCI Prototype Status

Detector will be ready to take beam in August.



1 module constracted

WAGASCI Collaboration

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Summary

- Water scintillator experiment WAGASCI proposed to take data with J-PARC neutrino beam
- Primary goal: measurement of neutrino CC cross-section ratio H_2O:CH with 3% accuracy
- Further study of CC neutrino interaction channels
- Pilot detector soon will be ready to take ν_μ beam
- Planned to have full WAGASCI in place by the end of 2016