T2K experiment : Neutrino Detectors

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T2K Neutrino Detectors

- 280m Near Detectors
 - On-axis Neutrino Monitor
 - Off-axis Detector
- 295km Far Detector

Super-Kamiokande



280m Near Detectors



Characterize the neutrino beam at the origin

Photosensor of Near Detectors

We have developed a special Multi Pixel Photon Counter for ND with Hamamatsu Photonics

□ Active area : 1.3 x 1.3 mm

 \Box Num. of pixels : 667 (50 x 50 μm^2 each)

□ Operation voltage : 70 V (typical)

□ PDE @ 550nm : > 15 %



- □ Dark count : < 1.35 MHz @ 25 deg. (Gain = 7.5 x 10⁵)
- □ Operational in magnetic field (0.2 T)
- Delivery of 63500 MPPCs for ND was completed in Feb. 2009!

Testing of T2K MPPCs

- 17500 MPPCs have been tested at Kyoto
 Installed in INGRID (On-axis) and FGD (Off-axis)
- Also at other testing stations (France, UK, Russia, USA, Poland)





- INGIRD : 7 (Hori.) + 7 (Vert.) + 2 (Off-axis) modules
- Module : 9 Iron targets + 11 Scinti. planes + Veto planes
- Scintillator plane : 24 ch x 2 layers
 Scintillator + WLS Fiber + MPPC

v beam profile @ INGRID





- Cover a wide range near the beam center (±5 m)
 Measure v beam direction with 1 mrad accuracy
 - \rightarrow 1 mrad = 28cm @ INGRID (E_µ peak shift : 13 MeV) ,

Mechanical assembly of all the scintillator planes (x 228) was completed in Dec. 2009.







All the channels (9592 ch) were tested using cosmic events. All OK.
cracked







- Assembly of 1st module was completed on Feb. 2009!
- One module (out of 16) will be operated in the NM pit during the beam commissioning in Apr. 2009.
- The other modules will be installed in the NM pit before summer, to be ready for v beam from the end of 2009.





Off-axis Detector

- Flux and E spectrum of Off-axis v_{μ}
 - □ Measured through CC-QE : v_{μ} + n → μ^{-} + p
 - □ Extrapolated to SK
- Estimation of background
 BG for v_μ disappearance
 → CC-1π : v_μ + N → μ⁻ + N' + π (Cross section)
 BG for v_ρ appearance
 - \rightarrow NC-1 π^0 : ν_{μ} + N \rightarrow ν_{μ} + N + π^0 (Cross section) $\rightarrow \nu_e$ in the beam (Flux and E spectrum)

Off-axis Detector

P0D

 \Box High static π^0 measurem ent

UA1 Magnet Yoke

(πºdetector) Fine-Grai

P0D

ECAL

Solenoid Coil

Barrel ECAL

Tracker (FGD+TPC)

 \Box Charged current measur ment (μ , p, π ,

 \Box FGD : π^0 measurement

SMRD

- \Box Large angle CC μ detection
- Veto from outside

ECAL

 $\Box \pi^0$ measurement with FGD and P0D

Photon Veto

FGD (Fine-Grained Detector)

1cm

- Target Mass for tracker
 Short track reconstruction
 p/π separation
- Plastic layer + Plastic/Water layer
 Upstream : 15XY scinti. Layers
 Downstream : 7XY scinti. Layers
 + 6 water panels



□ Scinti. bar
 → 1cm x 1cm x 185cm

Scinti. Layer

□ Scinti. + WLS + MPPC

TPC (Time Projection Chamber)

Gas amplification device

- □ Micromegas used to amplify electron signals
- □ 24 Modules on each TPC (Module: 34x36 cm)



Construction of TPC1 and TPC2 is going well.

Tracker (TPC + FGD)

3 TPCs + 2 FGDs

- Measure Charged particle
- \Box Reconstruction (FGD \rightarrow TPC)

Beam test @ TRIUMF



50-400MeV/c e/ μ / π /p



TPC 0, 1, 2

1 10

2.5 m



PC MODULES, 1TH TWO FOR

ECAL

ECAL modules

□ Measure the EM component (e,γ) from FGD and p0D, and Veto background particles coming from outside.

Measure the EM cluster position and energy

Component

Scinti. bar + WLS fiber + MPPC +"1.75 or 5 mm lead"







SMRD (Side Muon Range Detector)

Muon Range Detector

Catch the muon going out of the TPC acceptance
 Momentum measurement by the range of muon

Hori. : 768 counters Vert. : 1060 counters





SMRD counter installed into yoke



295km Far Detector (Super-K)





New electronics installed in the summer of 2008.

DAQ has been quite stable since then.

Detailed electronics check with calibration data has been finished.

Super-K is ready for T2K.

Summary

- Near detector construction is in its highest peak.
- Super-K is ready for the beam.
- INGRID will be ready for the beam commissioning with one module in Apr. 2009.
- Full INGRID and Off-axis detector will be ready to accept beam from the end of 2009.
- Publish first physics results with 100kW x 10⁷s data in 2010.



Off-axis beam method

Direction of Super-K is out of phase with the beam center by 2.5 deg. to select sub-GeV v for oscillation maximum.



Requirements on INGRID

Measure the direction of v beam to an accuracy of 1 mrad

 \rightarrow 1 mrad = 28cm @ NM pit (13 MeV peak shift)

 \Box Cover $\pm 5m$ around the beam center.

 \rightarrow v beam profile has a wide distribution at NM pit.

□ Detect v (< 3 GeV) decayed from π (< 6 GeV)

 \rightarrow 93% of ν flying to Super-K

□ Tens of ton of the target mass

 \rightarrow 1 mrad accuracy during the beam commissioning

ECAL

ECAL modules

□ Measure the EM component (e, γ) from p0D and FGD, and Veto background particles coming from outside.

Barrel-ECAL 10.5X_o

- 31 layers, 1.75mm Pb

 34 layers, (4cm x 1cm) scintillator bars

- 33 layers, 1.75mm Pb

 6 layers, (17cm x 1cm) scintillator slabs

DS-ECAL 11X

POD-ECAL 4.5X₀

5 layers, 5mm Pb

Basket

- 32 layers, (4cm x 1cm) scintillator bars

Measure the EM cluster position and energy

Perform Particle ID

Component

- Scintillator bar
- WLS fiber

"1.75 or 5 mm lead"

ECAL

DS-ECAL (Completed!)

- □ Will be moved to CERN in April for a beam test.
- Then to J-PARC at the end of June.



1st cosmic muon seen in the DS-ECAL module at RAL 19 February 2009



Barrel ECAL (+ POD ECAL)

- Construction will start in April.
- □ Two module is aiming to install before Dec. 2009.
- □ Full ECAL is completed in late summer 2010.

SMRD (Side Muon Range Detector)

Muon Range Detector

- Catch the muon going out of the TPC acceptance
- □ Momentum measurement by the range of muon

Horizontal : 768 counters Vertical : 1060 counters



SMRD (Side Muon Range Detector)

- Half of counters are at J-PARC and tested.
 - □ Remaining will arrive in Mar/Apr.
- Installation work has started in Feb.

□ It will continue till Aug from bottom part.



Light yield with cosmic at center of (870mm) counter



SMRD counter installed into yoke

P0D

Forward part of Off-axis detector

• π^0 detector

- NC interaction on water
- \Box CC π^0 production on water



Scinti. + WLS + MPPC



P0D

Side : ECAL & SMRD, Back : TPC/FGD

10040 channels

- Measure the EM cluster position and energy
- □ Veto coming from outside
- Muon momentum
- → Perform Particle ID

Upstream The PØD Central ECAL Image: Contral Ec

Water target