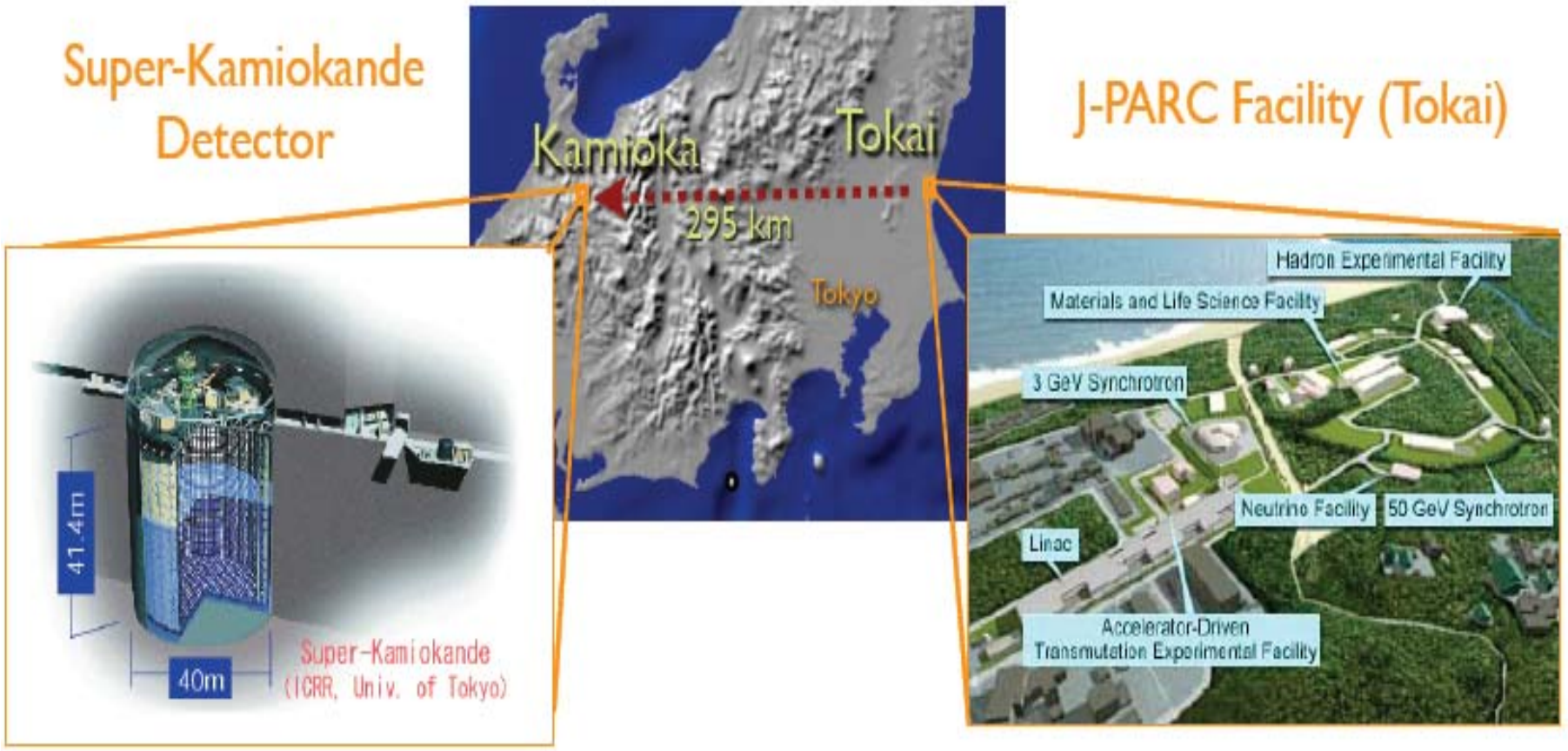
Status of the T2K Experiment

Gary Barker (Warwick)
for the T2K collaboration

THE UNIVERSITY OF WARWICK

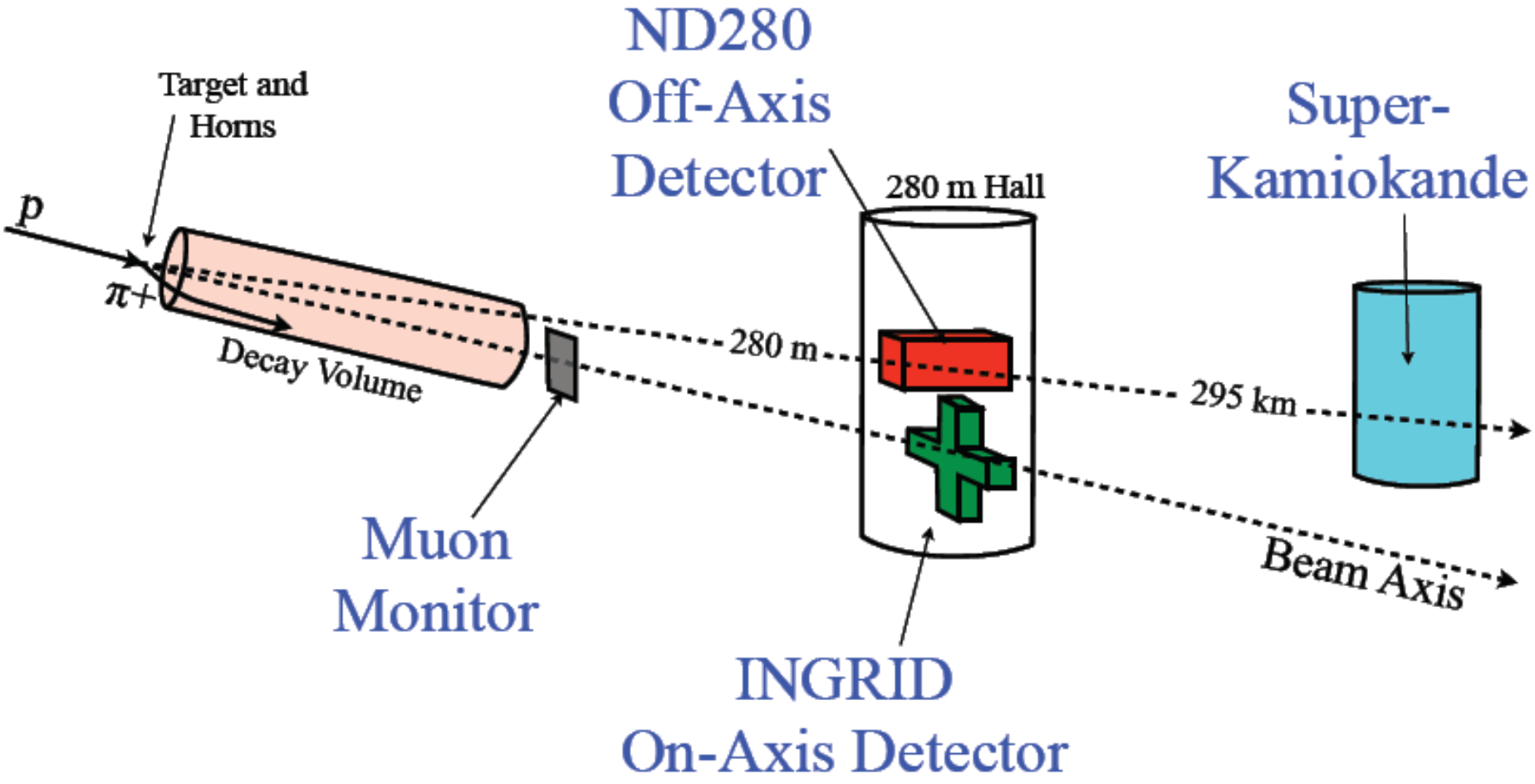
NNN09: 7-10 October 2009, Colorado

The T2K Project



- Long baseline (L=295km) ν_μ experiment
- Intense proton source (JPARC)
- SuperK as far detector

The T2K Project



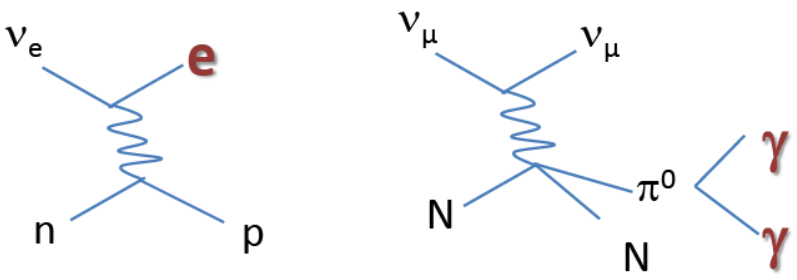
- Off-axis beam: 2.5 degrees
- Near (on and off-axis) and far detector (SuperK)

The T2K Physics Programme

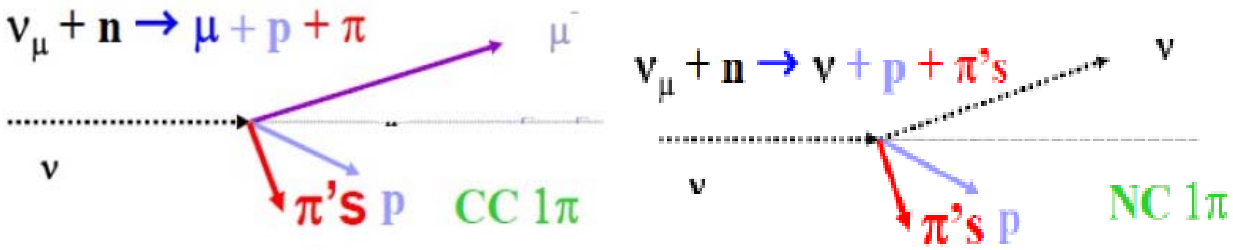
Use Charged Current Quasi Elastic (CCQE) interactions to precisely measure E_ν through kinematics (E_l, q_l):

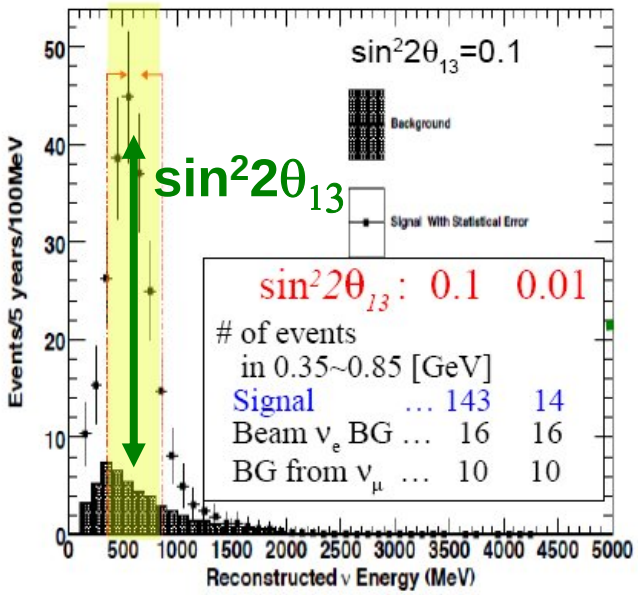
$$\nu_l + n \rightarrow p + l^-$$

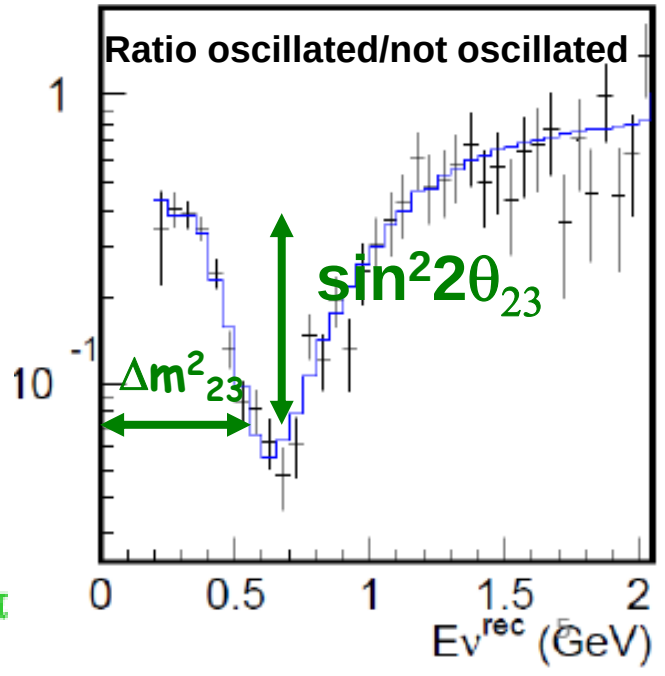
(1) Pin down θ_{13} through ν_μ –> ν_e appearance
Backgrounds: ν_e beam contamination, NC- $1\pi^0$



(2) Advance Δm^2_{23} , θ_{23} (esp. pin down whether θ_{23} is maximal) through ν_μ –> ν_μ disappearance
Backgrounds: single pion production

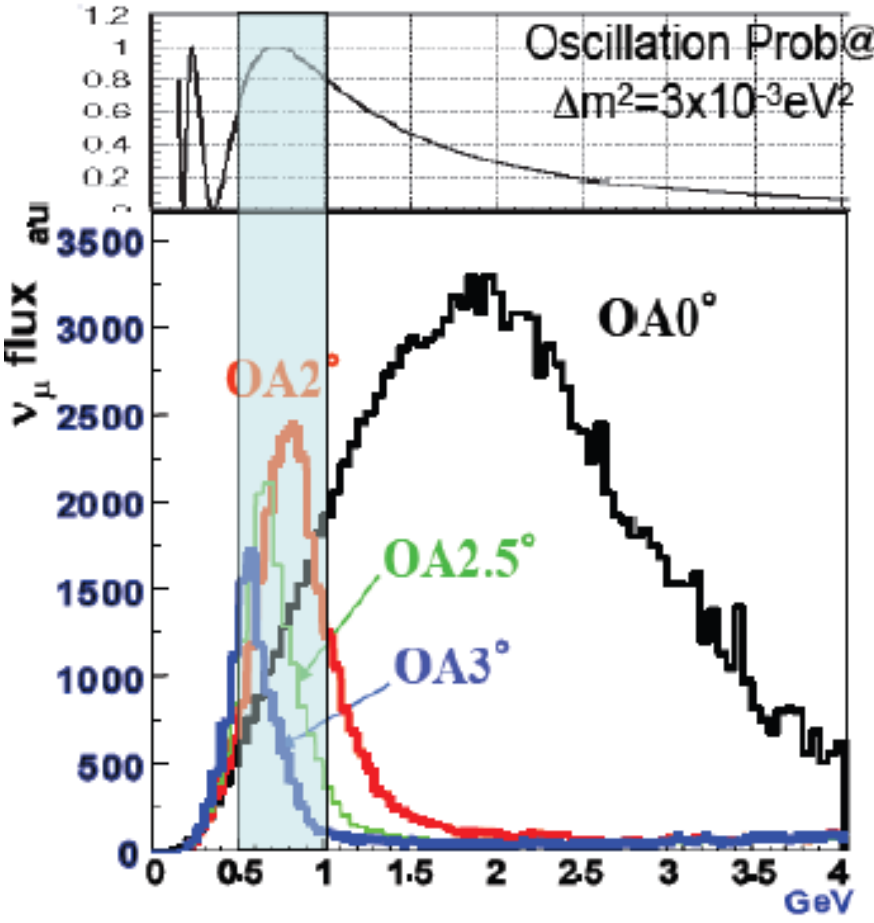






Off-Axis Beam

- Provides (quasi) mono-energetic beam tuned to first oscillation maximum
- Increases flux at maximum
- Drastically cuts high energy tail responsible for inelastic interactions that are background to the CCQE events
- T2K beam composition:
  95% ν_μ , 4% anti- ν_μ , <1% ν_e

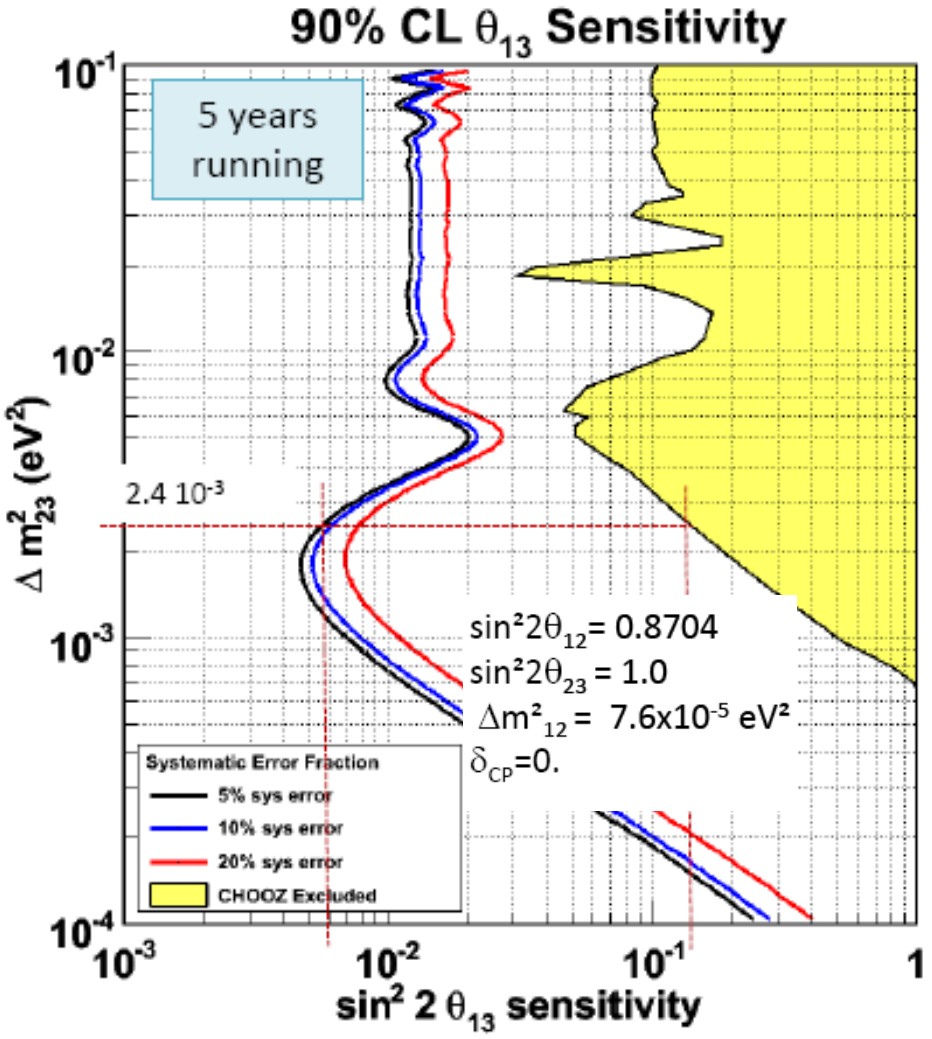


T2K: Sensitivity

- Sensitivity on $\sin^2 2\theta_{13}$ down to ~6×10^{-3} given:
  - 5 years running at 0.75MW
  - $\Delta m^2_{23}=2.4 \times 10^{-3}$ eV^2
  - 10% systematic error (ν_e and π^0 background)

- Assuming $\sin^2 2\theta_{13}=0.1$:

# of events
in 0.35~0.85 [GeV]
Signal … 143
Beam ν_e BG … 16
BG from ν_μ … 10



T2K collaboration

Canada
TRIUMF
U. of Alberta
U.of British Columbia
U. of Regina
U. of Toronto
U. of Victoria
York U.

France
CEA Saclay
IPN Lyon
LLR E. Poly
LPNHE-Paris

Germany
RWTH Aachen U.

Italy
INFN Bari
INFN Roma
Napoli U.
Padova U.
Rome U.

Japan
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ICRR Kamioka
ICRR RCCN
KEK
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Kyoto U.
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Osaka City U.
U. of Tokyo

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Sejong U.
Seoul Nat'l U.
Sungkyunkwan U.

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H.Niewodniczansk
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Wroclaw U.

Russia
INR

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STFC/RAL
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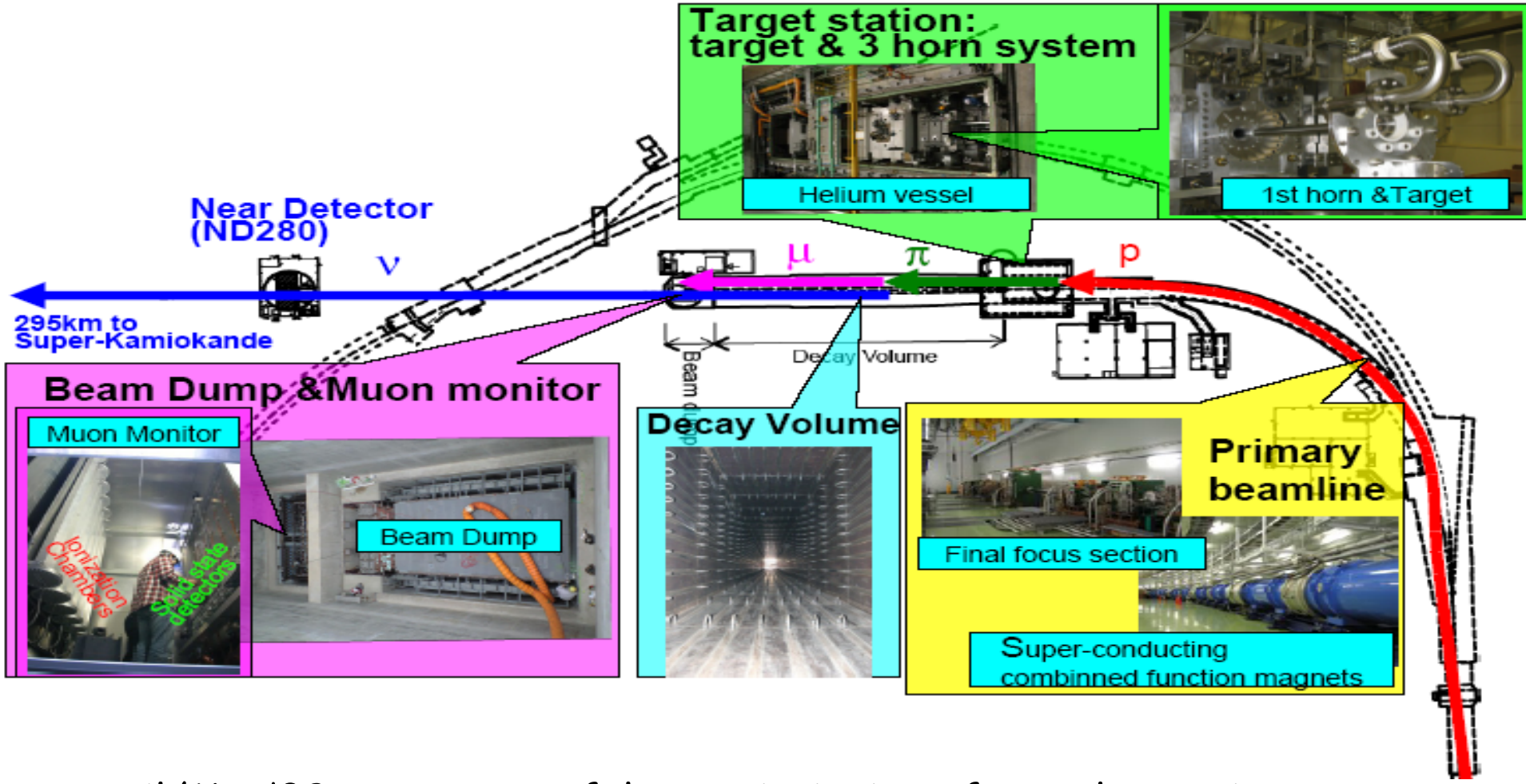
BNL
Colorado State U.
Duke U.
Louisiana State U.
Stony Brook U.
U. of California, Irvine
U. of Colorado
U. of Pittsburgh
U. of Rochester
U. of Washington

- **477 members, 62 Institutes, 12 countries**

JPARC Accelerator Complex

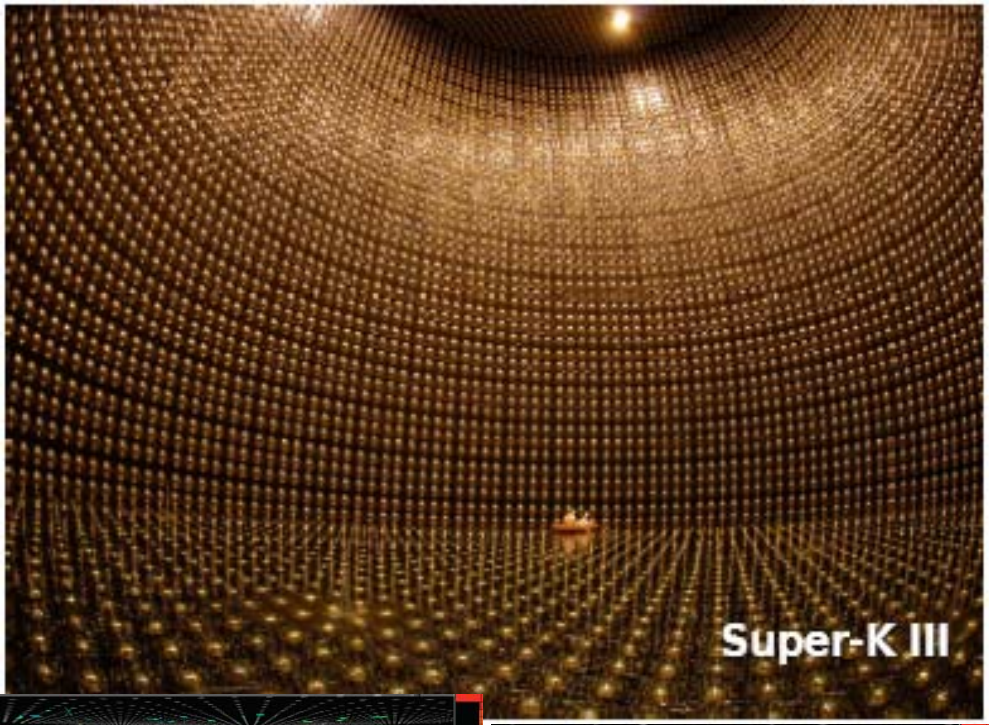
T2K Beamline

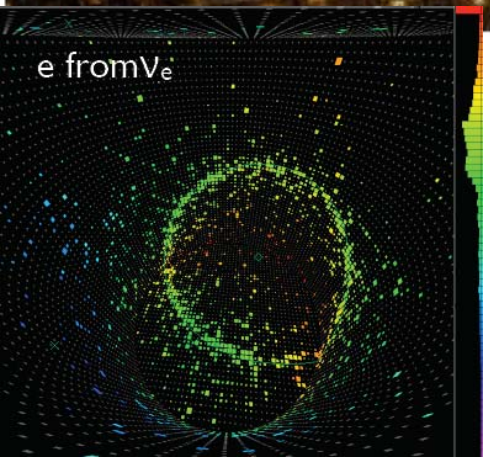


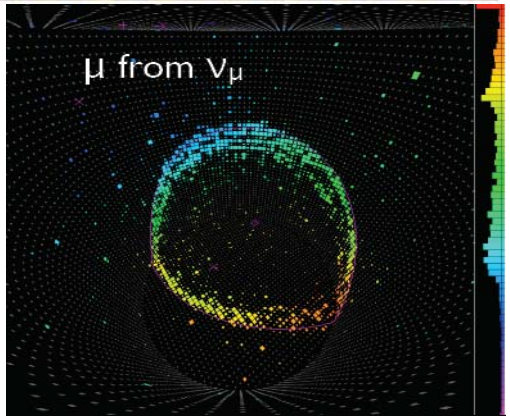
- April/May'09 saw successful commissioning of complete primary beam line + first horn

(for more details see talk by Takashi Kobayashi tomorrow)

Far Detector SuperK

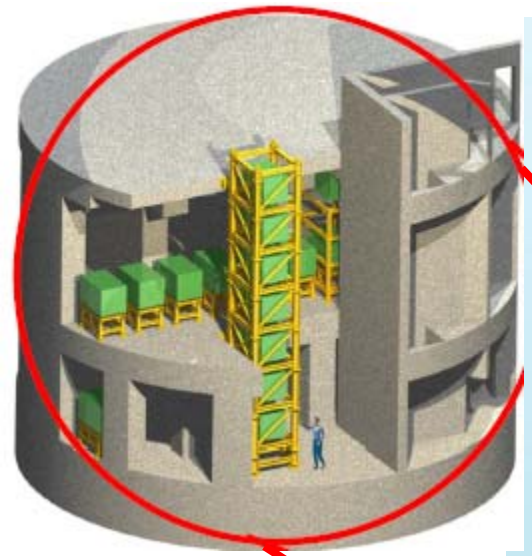


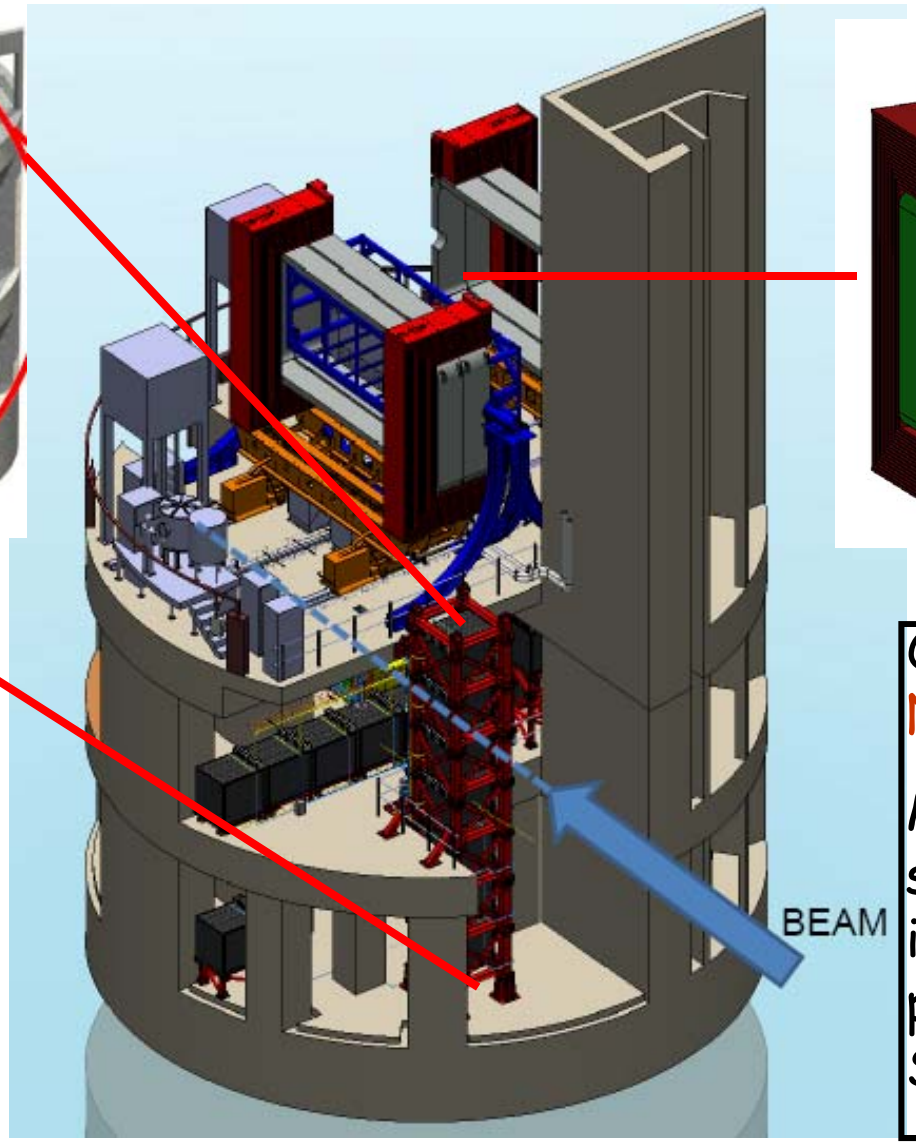


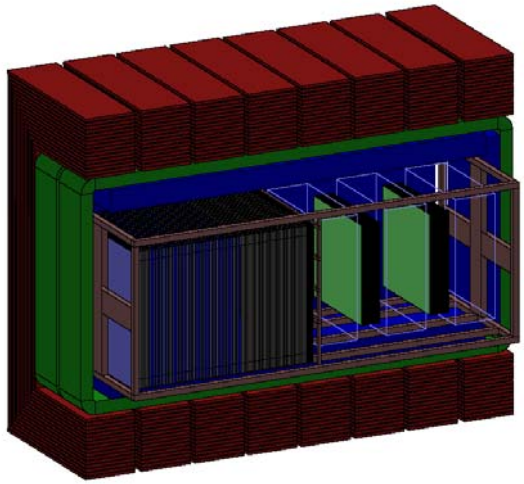


- 50kT pure H_20 Cherenkov detector
- Excellent E-resolution and e/μ discrimination at low energy
- Synchronised to T2K beam via GPS
- Expect 10 ν_μ events/day at full power
- SK IV: New dead-timeless FE electronics and DAQ installed 2008 => improved decay electron tagging
- Lots of work carried out to improve recon. software performance and simulation detail

Near Detector at 280m







On-axis neutrino monitor: INGRID

Off-axis detector: ND280

Must measure all significant neutrino interactions to predict response at SuperK

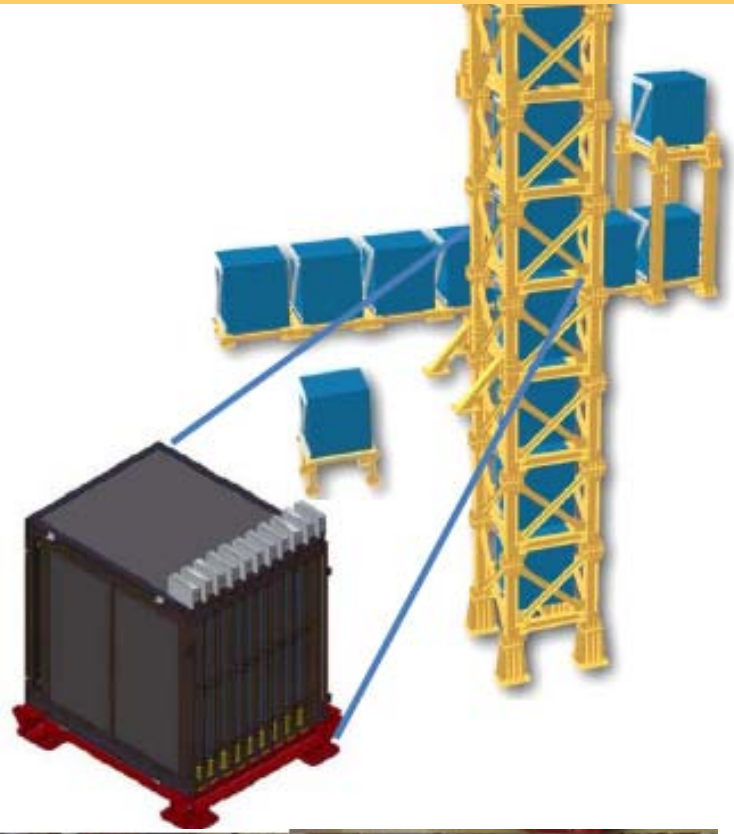
Beam Monitoring:INGRID

- P-beam monitors in beamline, optical transition radiation monitor at target, muon monitors in the beam dump
- Direction of horn-focused ν-beam monitored by INGRID

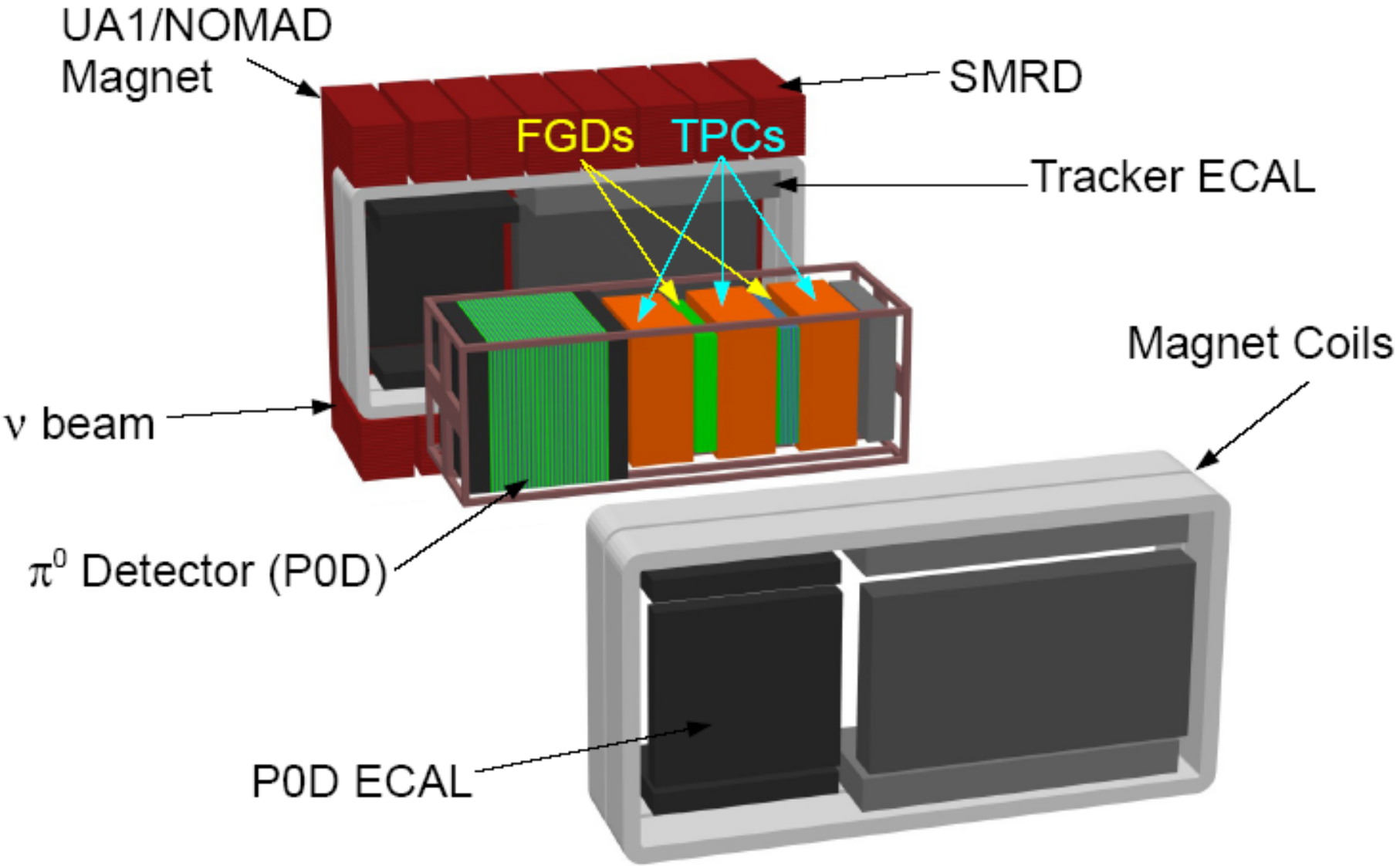
  –16 modules

  -11 layers scintillator interleaved with Fe

  - sufficient statistics for a daily measurement
- Off-axis angle must be monitored to <1mrad (i.e. 2% shift in the ν peak energy)
- Complete INGRID system was installed this Summer

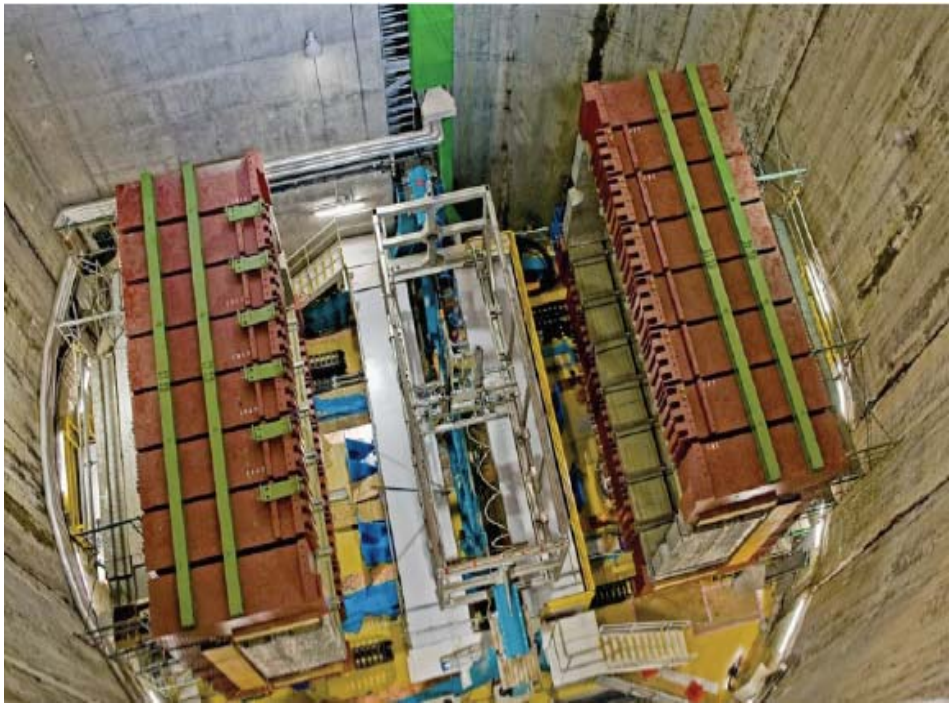


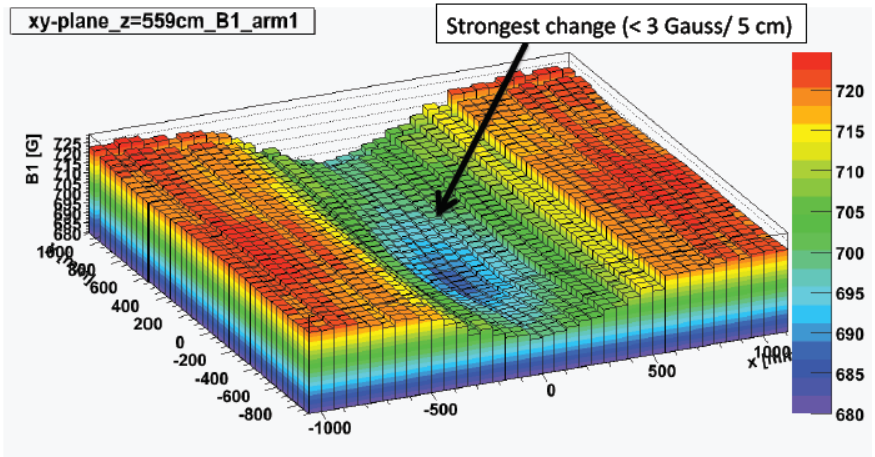
ND280


UA1/NOMAD
Magnet
SMRD
FGDs
TPCs
Tracker ECAL
Magnet Coils
ν beam
π0 Detector (P0D)
P0D ECAL

Magnet

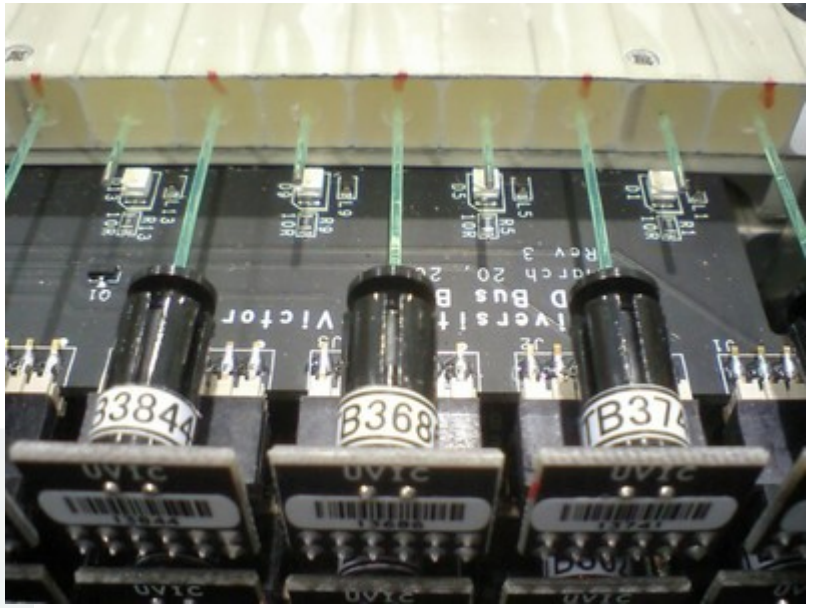
- Installed complete in July and commissioned in August
- Reached field of 0.07T and full field 0.2T should be attained after power upgrade- ready for neutrino running
- Preliminary I vs B curve agrees with the UA1 measurements to ~3%!
- B-field has been precisely mapped throughout the volume on a 5cmx5cm to 1cm x 1cm grid

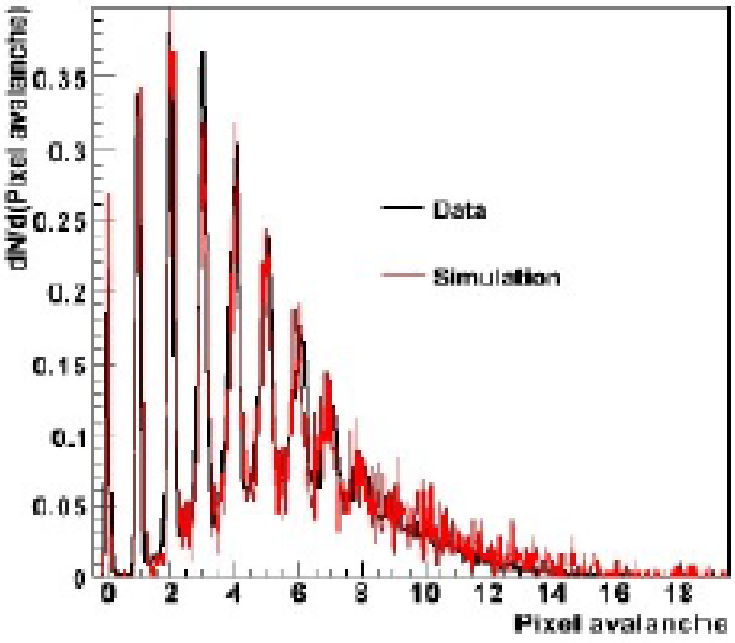


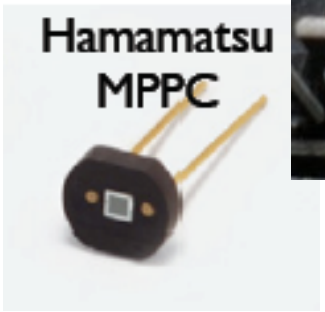


Photosensors: MPPC

- All detectors (except TPC's) use WLS fibres coupled to MPPC's as photo sensors
- Pixel counters in Geiger mode
- Developed jointly with Hamamatsu - largest scale implementation to date (x70K) with < 0.5% QA rejection rate







- Small, cheap and operate in B-fields
- Superb single p.e. discrimination
- Gain: 0.7 x 10^6 at room temp
- Dark rate: typically < 1 MHz at room temp
- PDE = QE x ε(Geiger) x ε(size)~25% (green)

ND280: Tracker

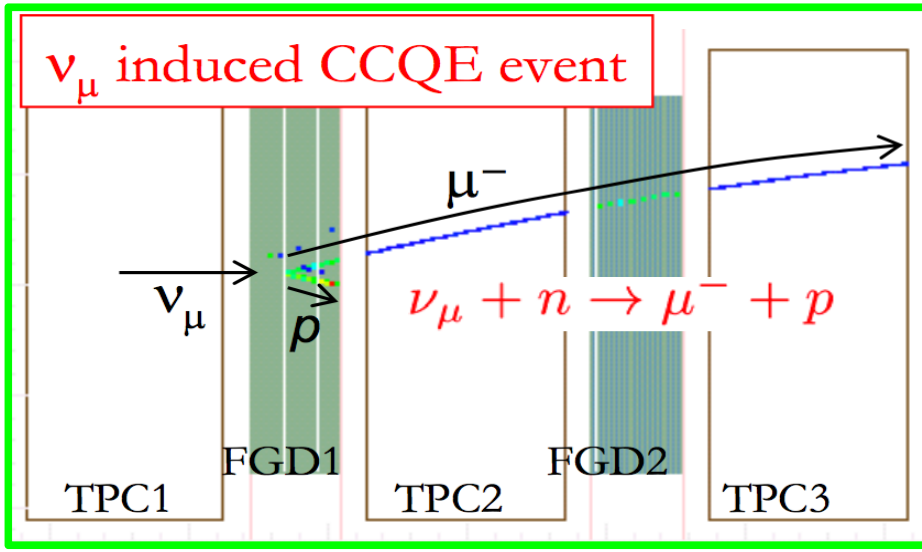
Tracker Optimised to measure momenta and to provide PID of charged particles especially muons and pions

FGD's target mass of tracker (1.3T per module):

- alternating x-y scintillator bars (1cmx 1cm) fine enough to measure recoil protons
- 2nd module contains scintillator and water (for cross section measurements at SuperK)

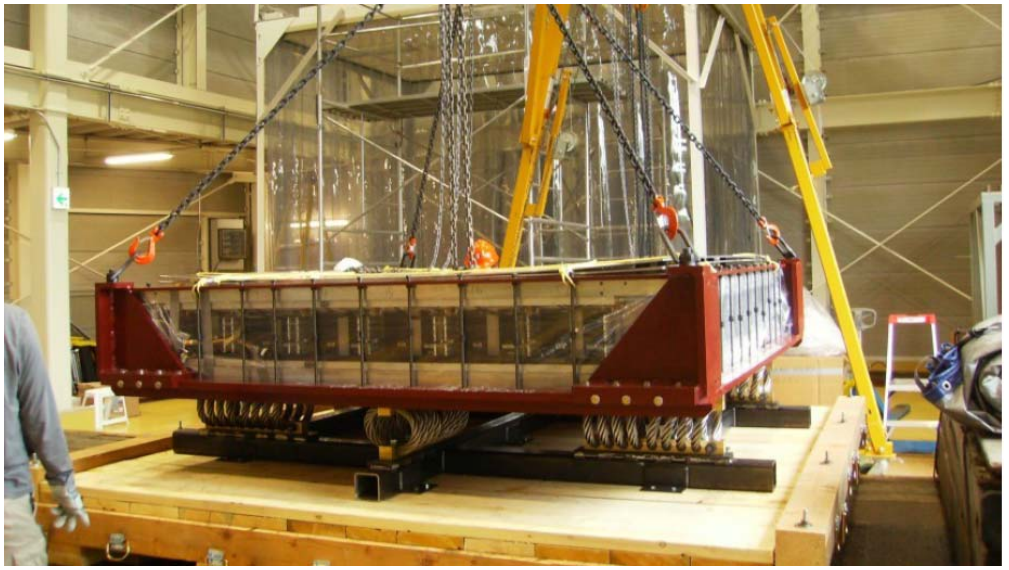
TPC high resolution tracking

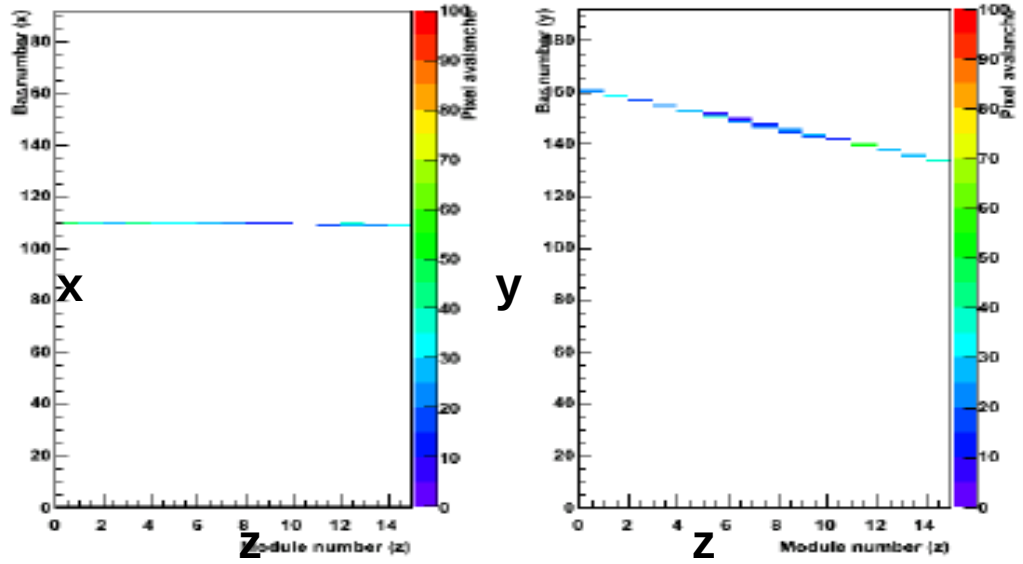
- charge/momentum measurement: $\sigma p/p \sim 10\%$
- 5σ e/μ discrimination

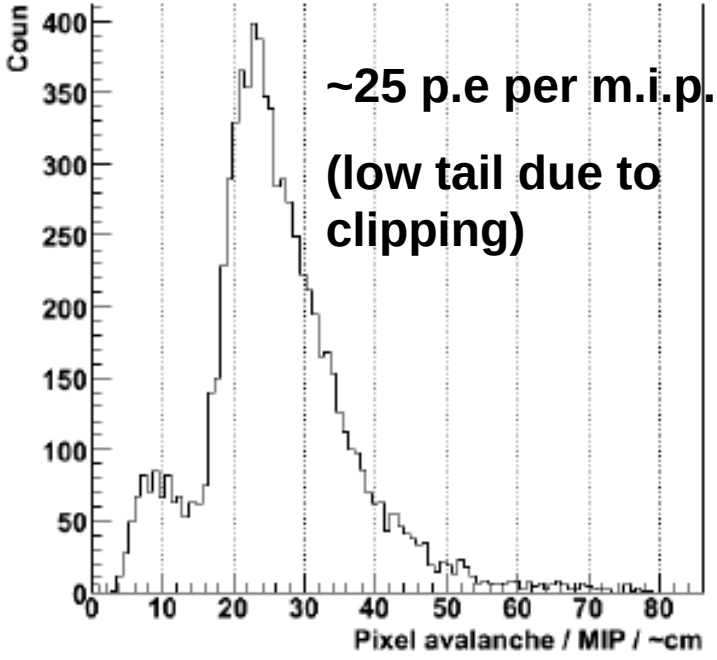


Status: Fine-grained Detectors

- Both modules have travelled well: commissioned on surface with cosmics and less than 0.1% dead channels
- Installation of both modules was completed this week
- Currently integrating readout with T2K DAQ

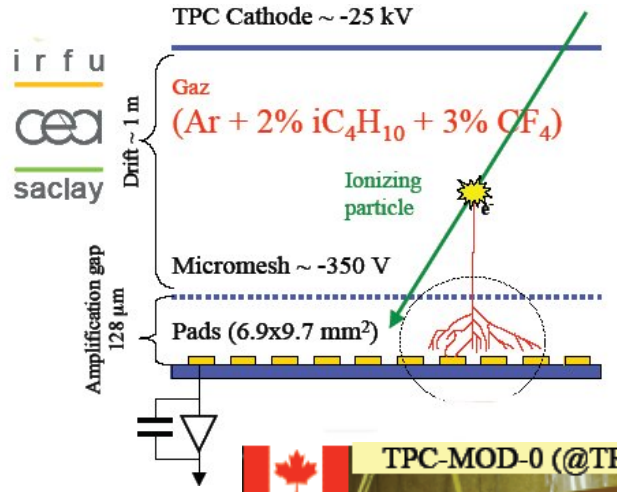


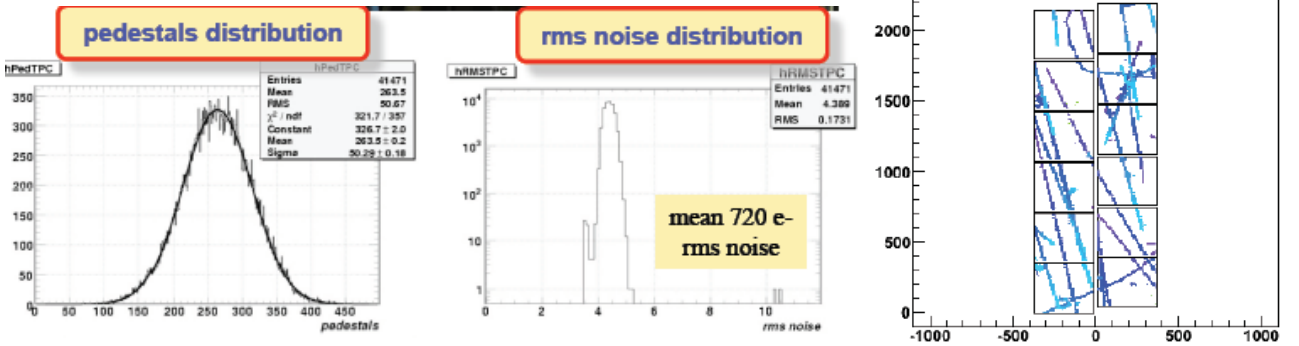




Status: Time Projection Chambers

- First large-scale implementation of bulk micromegas (32 modules, 124K channels)
- TPC0 and TPC1 extensively tested with cosmic and particle-beam running at TRIUMF
- Uniform/low-noise channel performance confirmed in Tokai recently



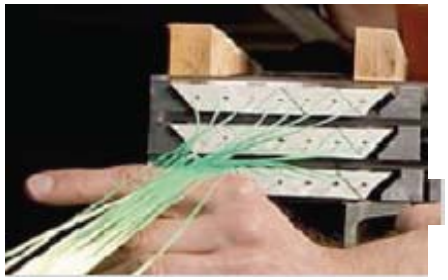


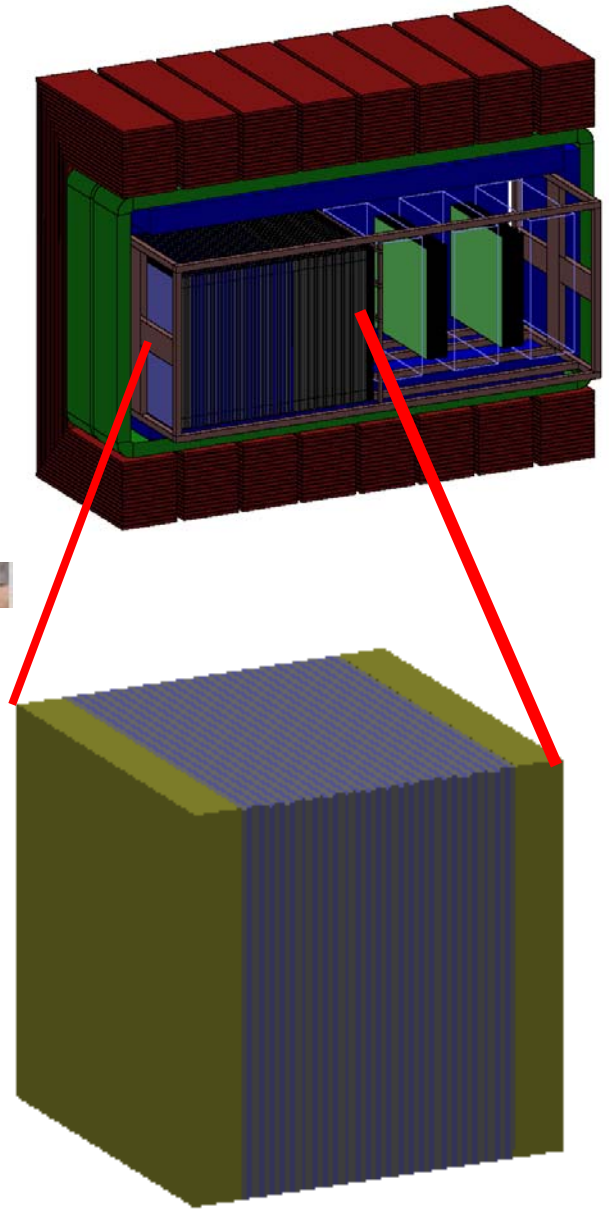
- TPC0 and TPC1 are ready for installation **this week**
- Majority of cabling, gas systems and laser calibration complete

ND280: π^0 Measurement

POD detector

- 40 x-y brass+scintillator tracking planes interspersed with water volumes (Carbon:Oxyg. 1.8ton:0.9ton)
- 5.7 X_0 upstream/downstream γ-stops
- WLS fibre readout
- All 4 POD modules now installed, utilities installation and commissioning is underway
- Surrounded by a coarse Pb/scintillator calorimeter PODECAL (5 X_0 thick) to collect escaping γ/mip's





ND280:ECAL+SMRD

- Detectors surround entire inner region to catch high angle e,μ,γ
  - boost CCQE efficiency and Eν resolution
  - veto for cosmic, magnet or cavern wall interactions

ECAL

- Scint.+Pb sampling calorimeter (Tracker+POD)
- Downstream module installed this week
- 5/12 modules installed by Dec.'09-Jan'10

SMRD

- Scint. planes in UA1 calorimeter gaps in yolk
- All installed, commissioning underway

Cross-Section Measurements

- Cross section measurements in ND280 needed to measure backgrounds at SuperK i.e.

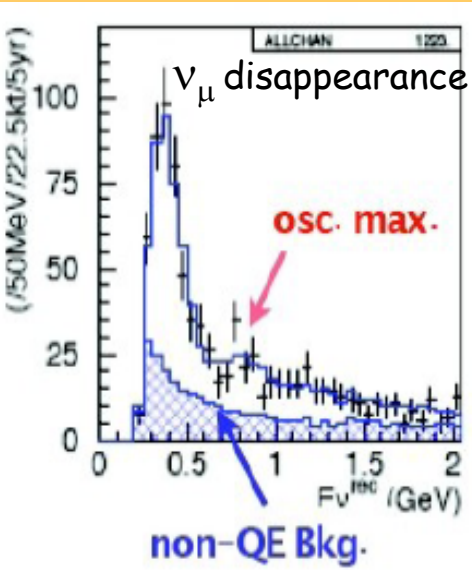
  - NC-1π, CC-1π for ν_μ disappearance

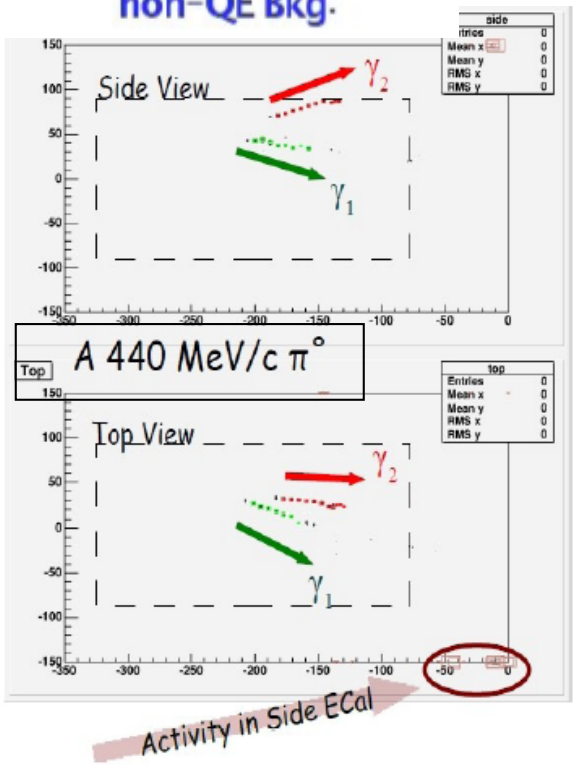
  - NC-1π^0 for ν_e appearance

- To achieve design precision on θ_{23}, Δm_{23} demands: non-QE/QE ratio known to < 10%

e.g. From 5 years running (5x10^{21} POT) expect following numbers of NC-1π^0 events in POD: C/Pb/brass=20k, water=8k ($\varepsilon(\pi^0)$=55%, purity=60%)

- ND280 will provide the most extensive measurements of sub-GeV neutrino cross-sections on oxygen to date





T2K: Schedule

Beamline

- Beam commissioning to recommence from mid October:
  - Full horn system in place
  - Increased intensity (with up to 6 bunches)
- Plan is for physics running to start from December collecting 100kW x 10^7s (2 x 10^{20} POT) in the first year
- Subsequent power increases will come from increasing the rep. rate at E=30GeV and LINAC energy upgrade from 181MeV to 400MeV

ND280

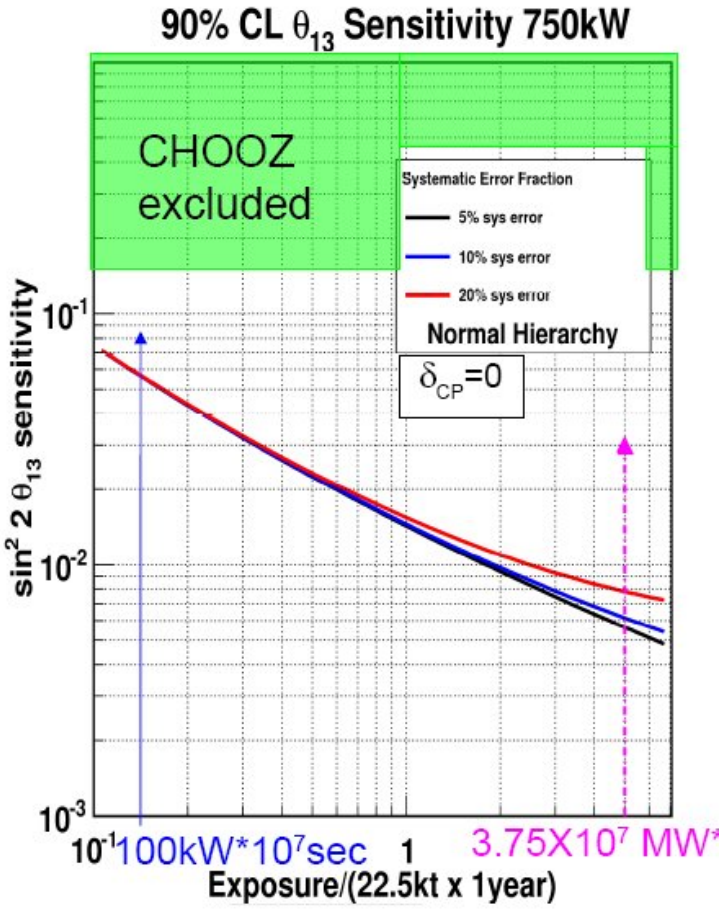
- FGD1 + FGD2, DSECAL were installed this week
- TPC0+TPC1 to be installed in next days
- What remains: TPC2 installed December/Jan.'10, remainder of ECAL in place by Summer 2010

Conclude

- T2K experiment close to being ready for first physics
- All beamline elements installed and are currently being commissioned
- SuperK improved and ready to run
- Almost all ND280 components are ready and currently being installed/commissioned
- First neutrino data beginning in 2010 aiming for 100kWx10^7 sec in first year:
  - expect 1-sigma sensitivities:

    $\delta(\sin^2 2\theta_{23}) = 0.03,\ \delta(\Delta m^2_{23}) = 1.6 \times 10^{-4}$

    (statistics limited)
  - begin extending the Chooz θ_{13} limit



Extra slides

T2K Discovery Potential on $\nu_\mu \rightarrow \nu_e$ as a Function of Integrated Power