Design and Construction of the T2K Fine Grained Detector (FGD)

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On behalf of T2K FGD group:

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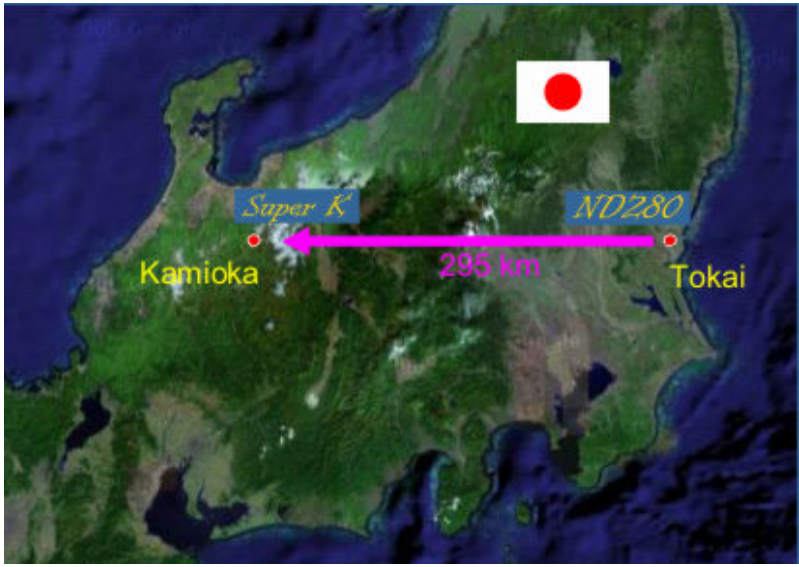
University of Regina,
TRIUMF, University of Victoria

T2K Experiment

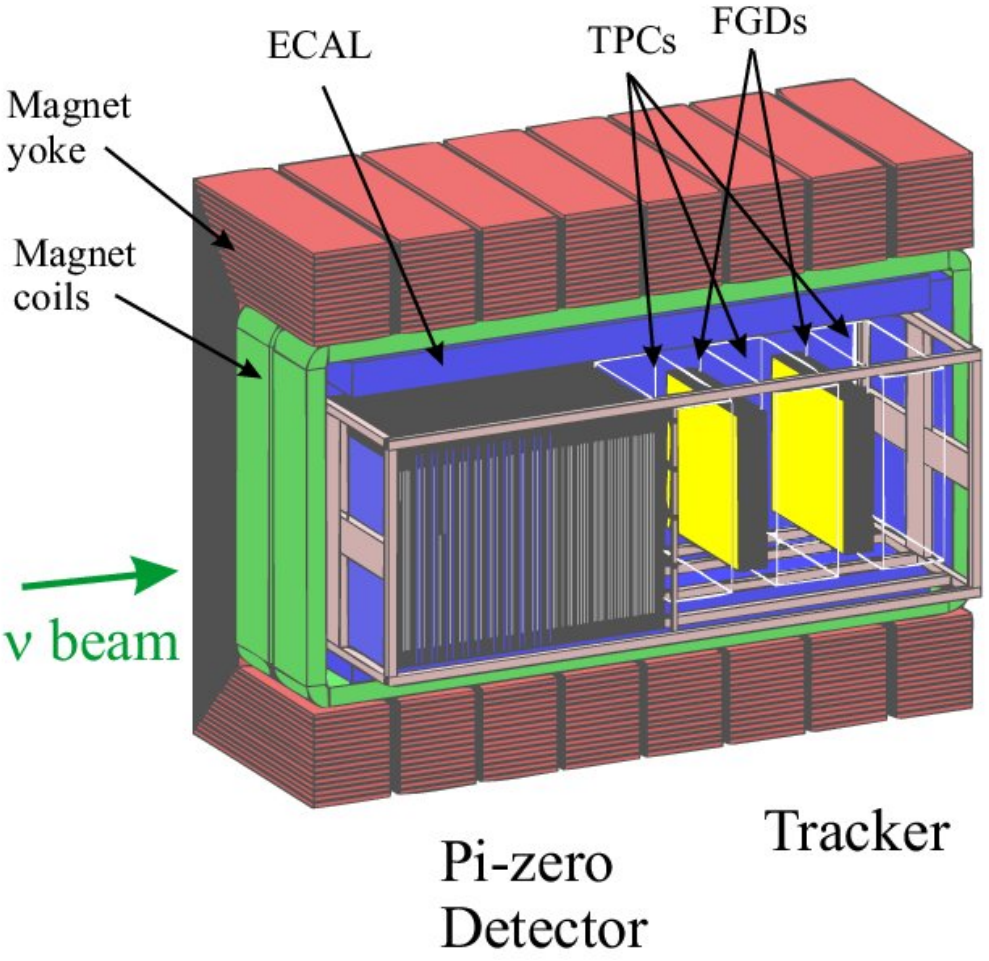


- Successor to K2K experiment.
- Technique: produce a ν_μ beam and observe effects of oscillation at far detector.
  - Neutrino production occurs at JPARC facility in Tokai.
  - Final detection at SuperKamiokande.
- High flux → precise ν_μ disappearance measurement.
- JPARC will begin neutrino production in 2009.

See I. Kato's talk for details about T2K science.

T2K Near Detector

- Near detector located 280m from hadron production target.
  - Goal of near detector is to characterize the neutrino beam before oscillation.
- Tracker is composed of three TPCs and two FGDs.
  - Primary goal of tracker is to measure charge current neutrino reaction rates.

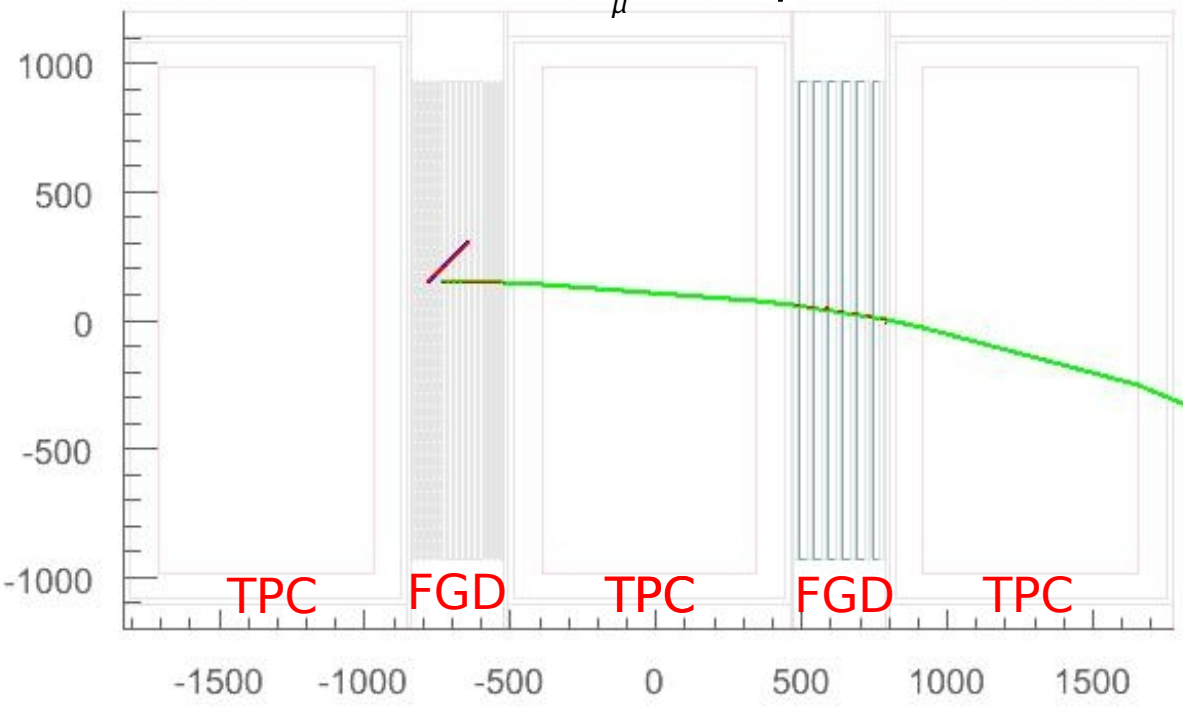


FGD Physics Requirements

- FGD provides the target mass for neutrino interactions in Tracker.
- FGD must also provide reconstruction and particle identification of short tracks that stop in FGD.
- In particular, must distinguish protons from pions; pion tagging will use Michel electrons, charge deposition.

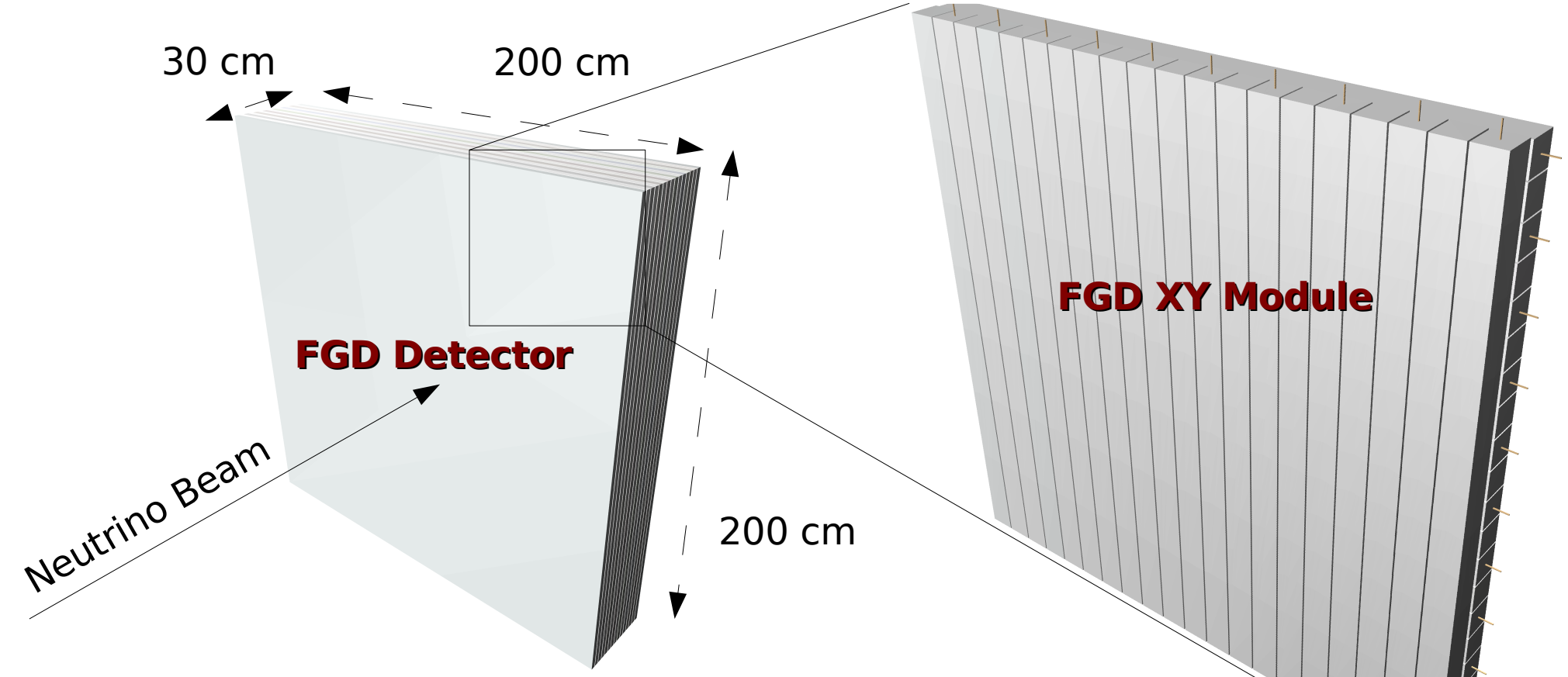
Simulated CCQE neutrino interaction:

$n + \nu_\mu \rightarrow p^+ + \mu^-$



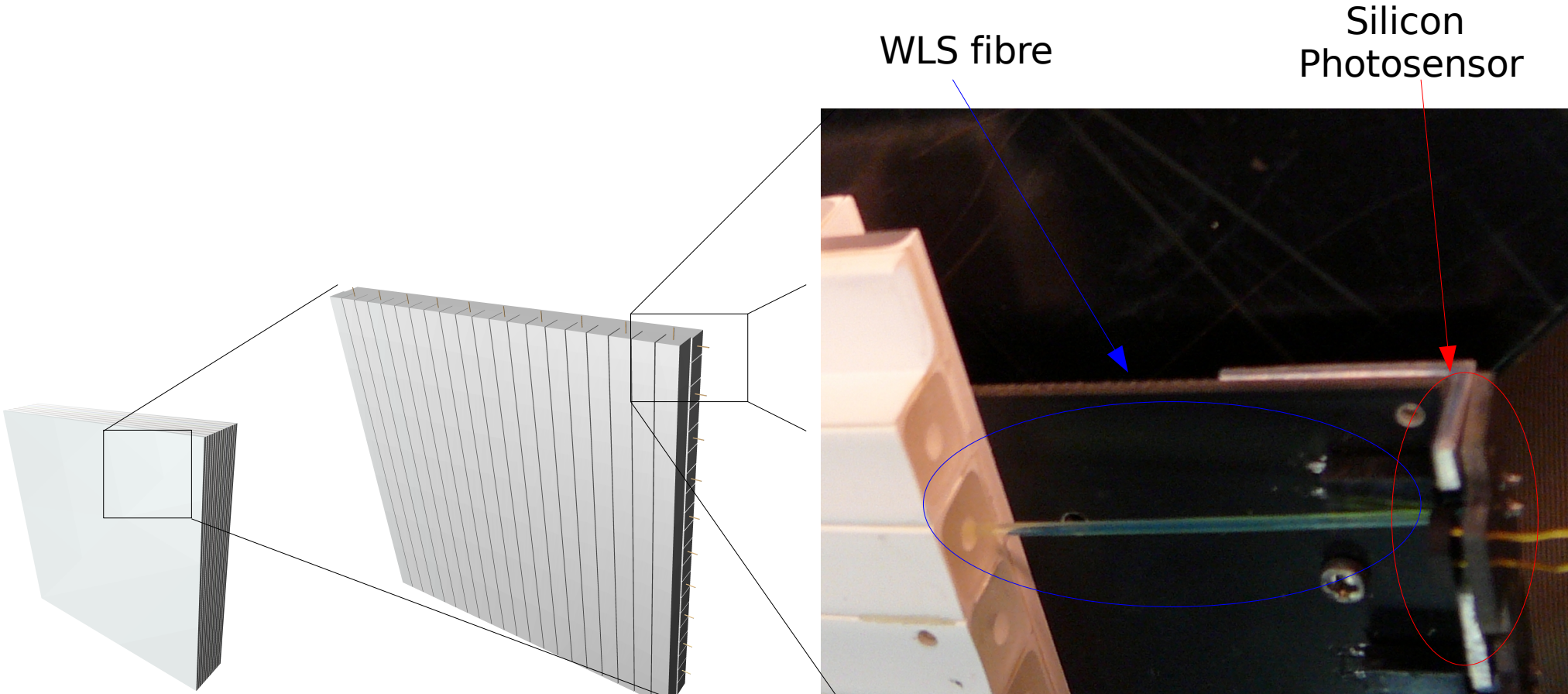
FGD Detector I

- FGD is composed of long, thin scintillator bars; bars organized into XY module.
- FGD is wide and thin: maximizes mass and probability that particles enter TPC.



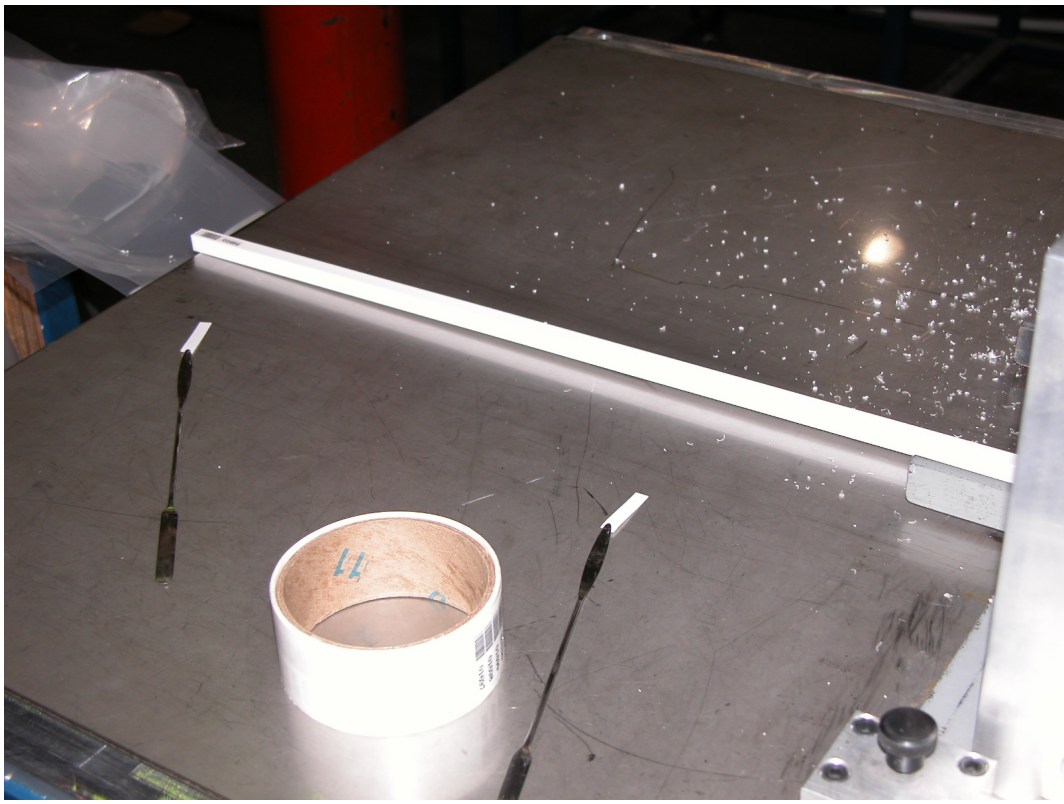
FGD Detector II

- Light produced in scintillator bar is readout using a WaveLength Shifting (WLS) fibre coupled to a pixellated APD (ie “SiPM”).
- FGD consists of 8448 channels.



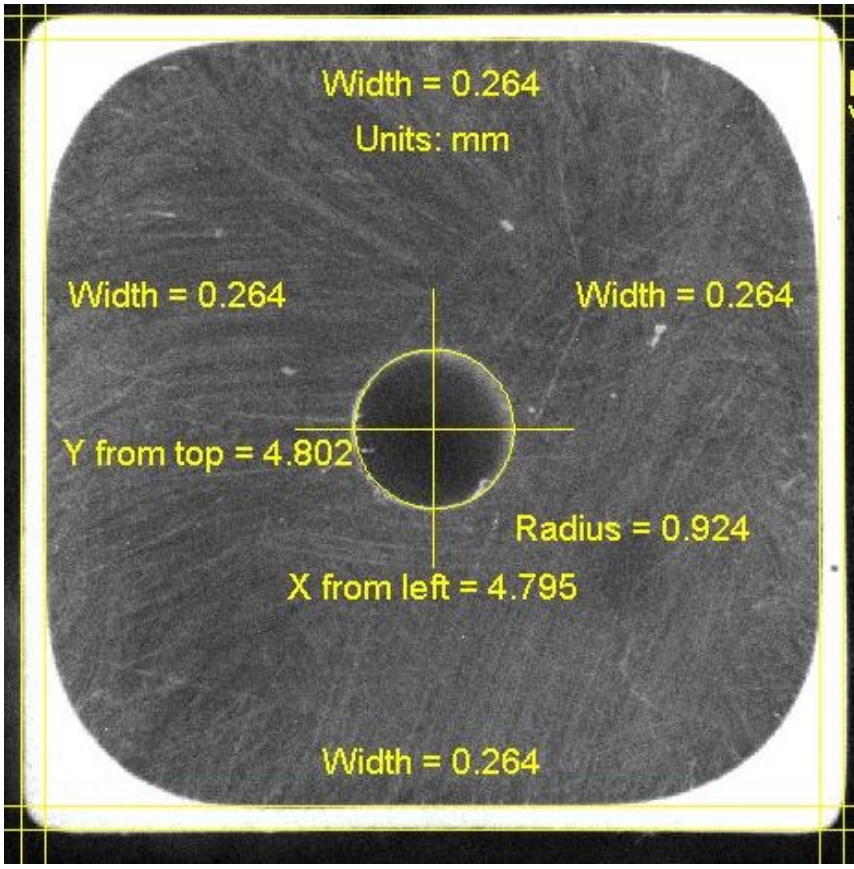
Scintillator Production

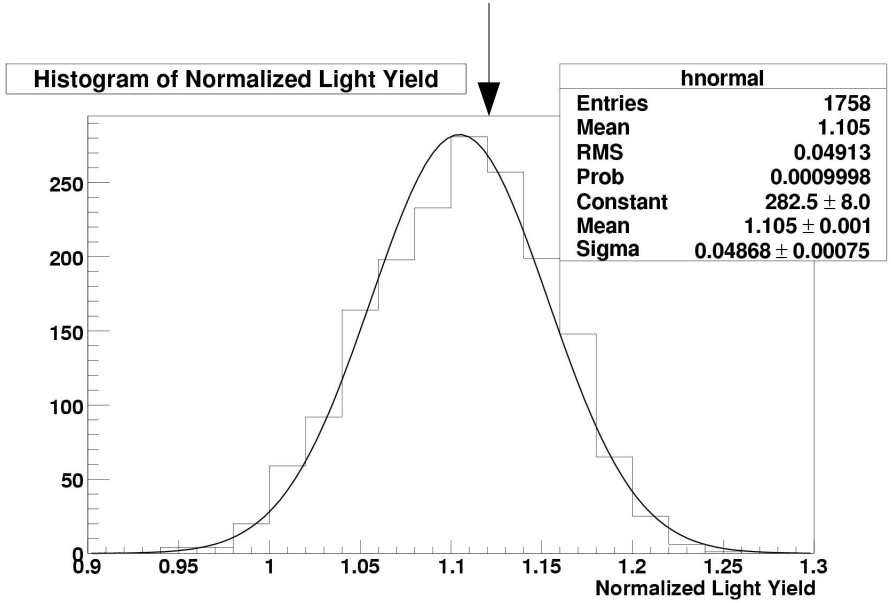
- Production of scintillator bars done at Celco Plastics in Surrey, BC in late 2006.
  - Required 24-hr-a-day work for several weeks.
- Scintillator co-extruded with a TiO2 coating and a 2mm central hole (for WLS fibre).



Scintillator Quality Control

- Periodically checked Ti02 coating width and size/position of WLS fibre hole.
- Used automated scanner check light output from bars using Ru-106 source; found that bar-to-bar light yield was constant to 5%.



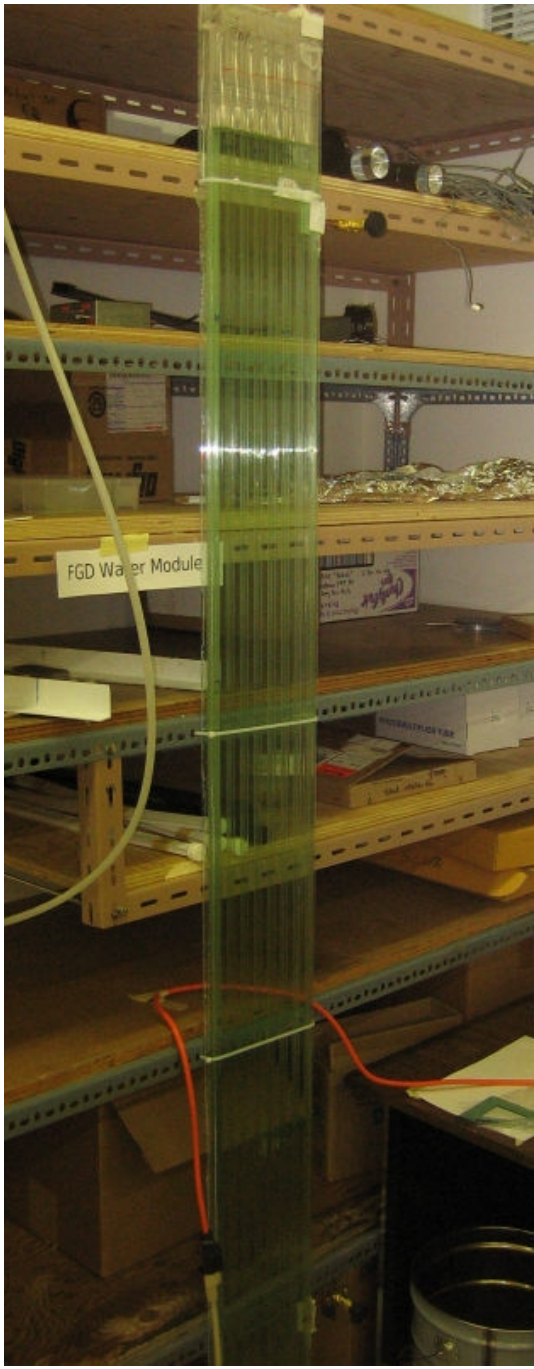


XY Module Construction

- Each module consists of an X layer, a Y layer and two G10 skins.
- Considerable R/D was done for module glueing procedure.
- Metal jig was constructed to ensure that X and Y layers were aligned and perpendicular.

Water Module Testing

- Second FGD is composed of water layers interleaved with scintillator.
  - Must measure CCQE cross-section on water, since SuperK is water-based detector.
- Using commercial polycarbonate water panels.
- Water panels will be connected to a sub-atmospheric pressure water circulation system (to mitigate the effects of any leak).



Water Module Test Setup

WLS Fibres and Silicon Photon Counters

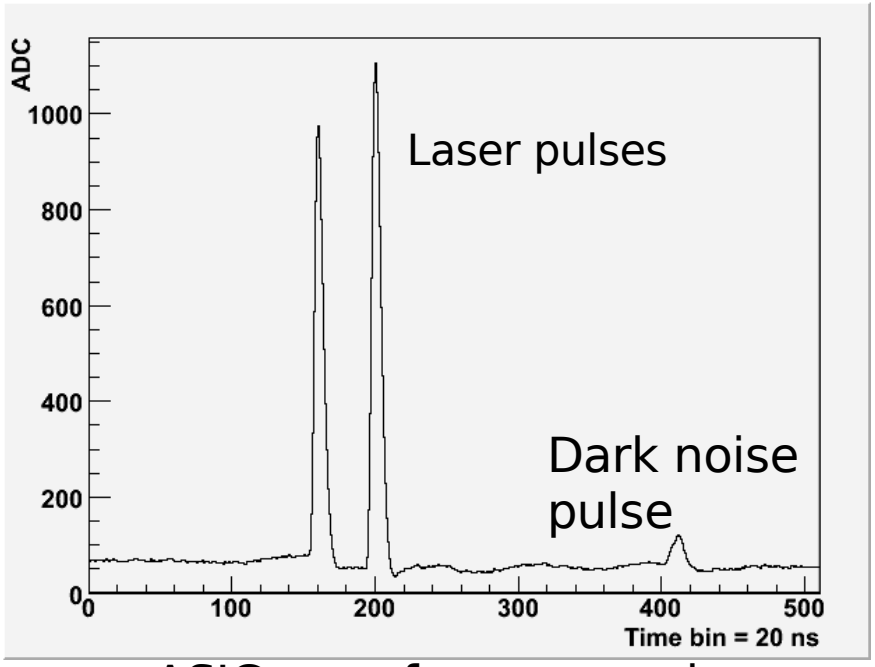
- Procurement and testing of WLS fibres being done at University of Regina.
- Fibres are presently at Fermilab being mirrored at one end.

Photo from product catalogue

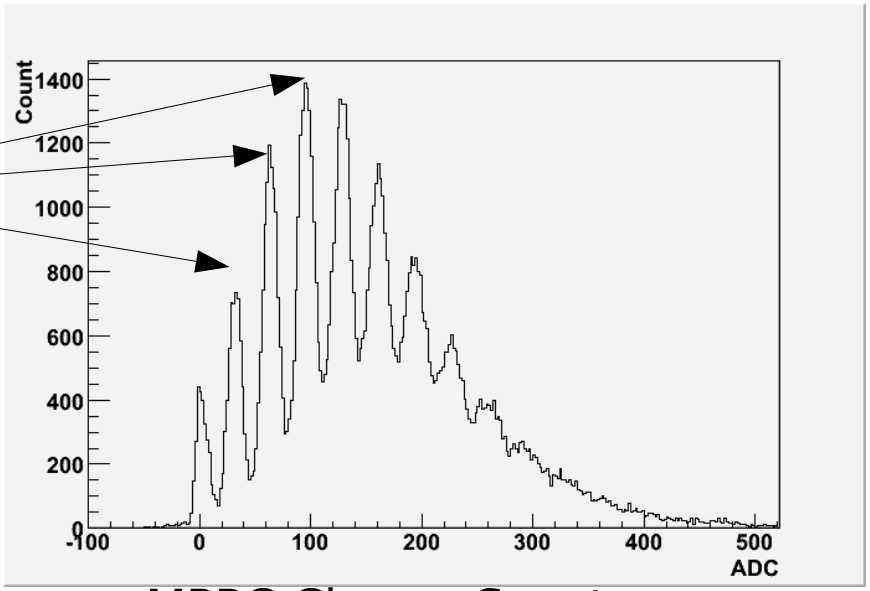
- Kyoto University handling purchase of silicon photon counters.
- T2K is the first large experiment to use this type of sensor.
- Results of our tests have been very positive; devices such as Hamamatsu MPPC will satisfy all our requirements.

FGD Electronics

- MPPC signal is shaped and digitized by ASIC designed by TPC/Saclay collaborators.
- Currently testing ASIC prototype. Signal to noise of electronics is excellent; can easily distinguish single photoelectrons.



ASIC waveform example



MPPC Charge Spectrum

Conclusion

- FGD provides a significant portion of target mass for neutrino interactions at T2K near detector.
- Also provides capability to track and identify short-range charged particles that stop in FGD.
- Construction of FGD is proceeding well.
  - All components are meeting or exceeding required specifications.
  - On schedule to finish construction this time next year.
  - The rest of 2008 will be spend testing detector before shipment to Japan in 2009.