NuFACT2022
at Salt Lake City

WG6 : Detectors

Construction of a New Scintillation Tracker in T2K Experiment

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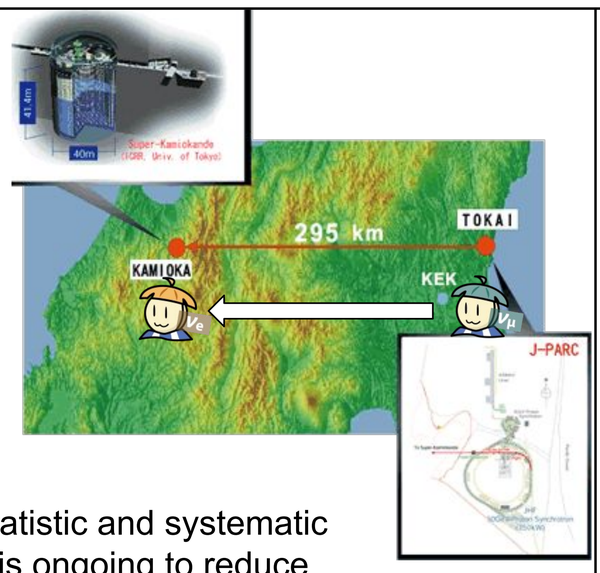
on behalf of the T2K experiment

T2K Experiment

T2K experiment is a long baseline neutrino oscillation experiment in Japan. Muon neutrino beam produced in J-PARC is measured by near detector at 280 m (ND280) and Super-Kamiokande (SK) at 295 km. T2K result so far indicates a signature of CP violation in lepton sector. Currently we are entering a precise measurement phase.

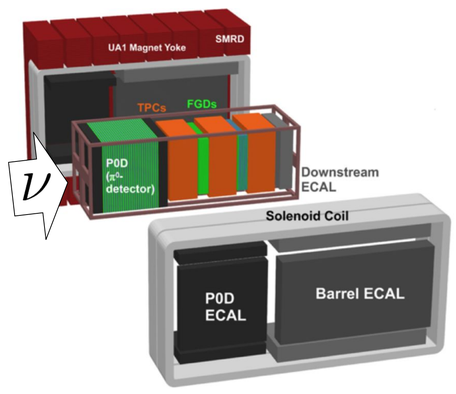


For more precise measurement, both of statistic and systematic errors have to be reduced. Beam upgrade is ongoing to reduce the former and we are working on upgrading the ND280 to reduce the latter.

ND280 Upgrade

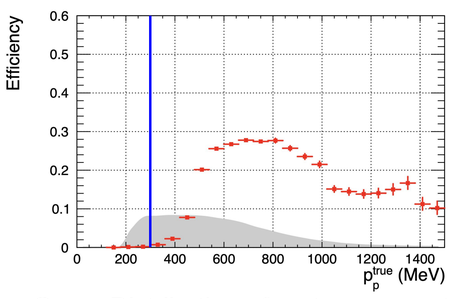
The ND280 gives a constraint to neutrino cross section and neutrino flux at SK.
The current detector has some issues.

- It is not sensitive to low momentum proton which is a key to understanding neutrino interaction with nucleus.
- It has good detection efficiency for particles going in beam direction but its efficiency gets worse for high angle scatter.

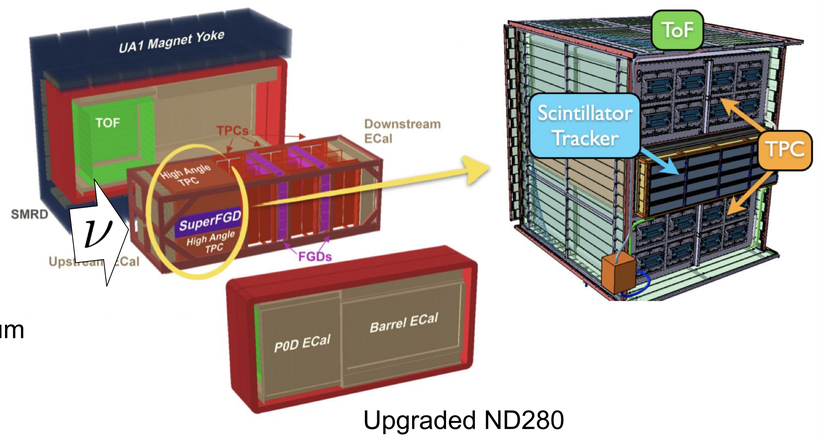


Current ND280

Then, new detectors are going to be installed into the ND280 to improve such performances.



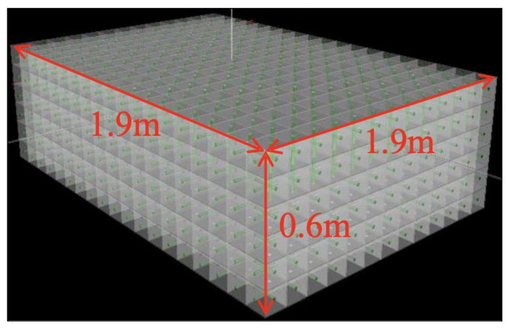
Gray : Distribution of proton momentum from neutrino interaction
Red : Current ND280 efficiency
Blue : SuperFGD threshold



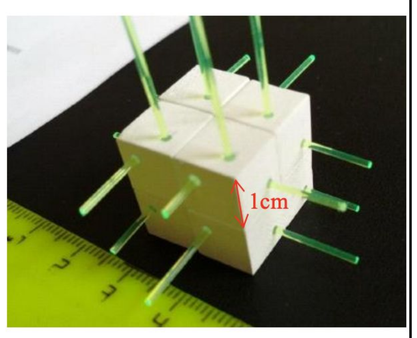
Upgraded ND280

SuperFGD

SuperFGD is a new main tracker and consists of 2 millions $1cm^3$ plastic scintillator cubes. Each cube is optically isolated by chemical treatment for its surface and has 3 holes to insert wavelength shifting fibers from 3 orthogonal directions. The 60 thousands fibers inserted in the cubes lead scintillation light and it is detected by Multi Pixel Photon Counter (MPPC) on a side of the fiber. SuperFGD enables us to observe full solid angle and short track particles.



Conceptual figure of SuperFGD



2 x 2 segment

Cubes assembled by fishing lines

Fiber Assembly

Now the cubes are assembled by fishing lines. Before installation into ND280, we have to replace them with the fibers.

After inserting the fibers, the extra length of them protruding from the cubes will be cut. Then, MPPCs are going to be attached and whole the detector is going to be covered for shading.

Our concern is fibers can be damaged during this work, for example, due to distortion of array of cubes.

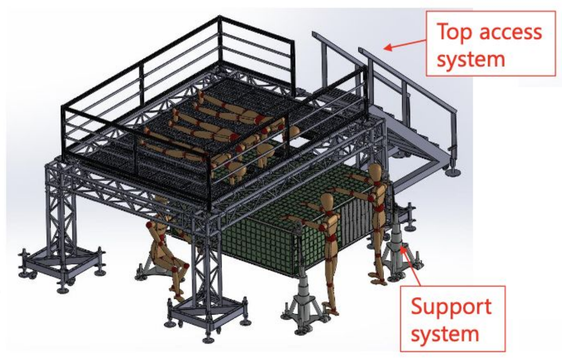
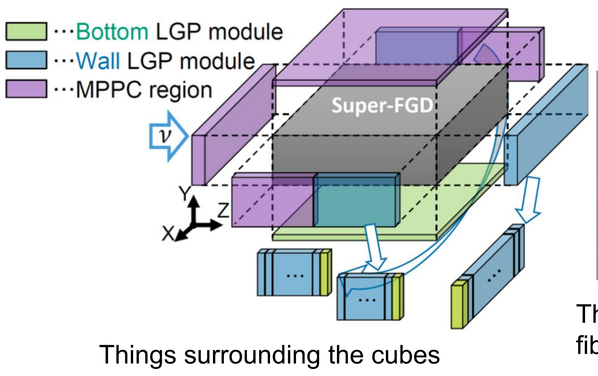
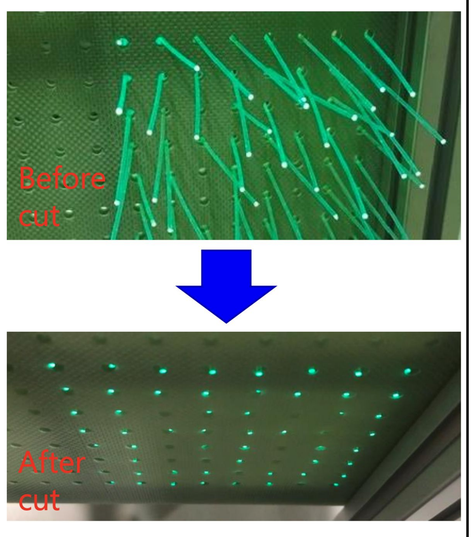


Figure of fiber assembly work



Things surrounding the cubes

The edges of the fibers (MPPC side)



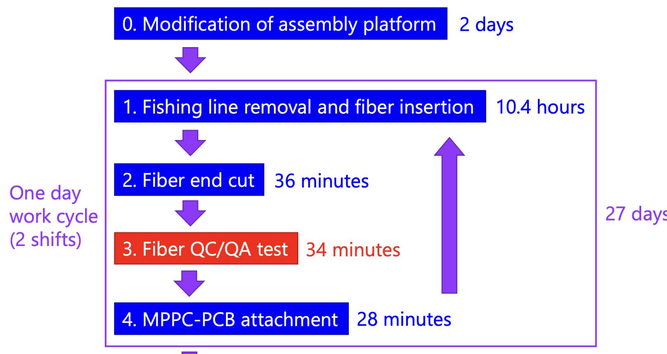
Cutting the fiber end

Fiber Quality Control (QC)

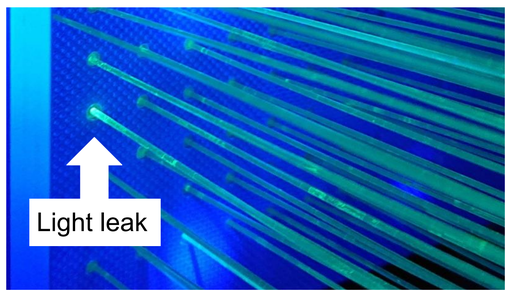
We are going to check whether fibers are damaged or not in parallel with assembly work. We will inject light from one side of fibers and measure the light intensity on the other side of the fibers.

Requirements to QC System

- The light source will be fixed by hand because it is a temporarily system during only construction.
  → The light has to have spacial uniformity for the fluctuation of its position.
- This test will be done in parallel with fiber insertion and there is not perfect light shielding.
  → This system has to work well in high background environment.
- Time for the fiber QC is limited.
  → The test has to be done quickly.
- This system has to be able to distinguish damaged fiber.
  A visible crack loses about 50% of the light.

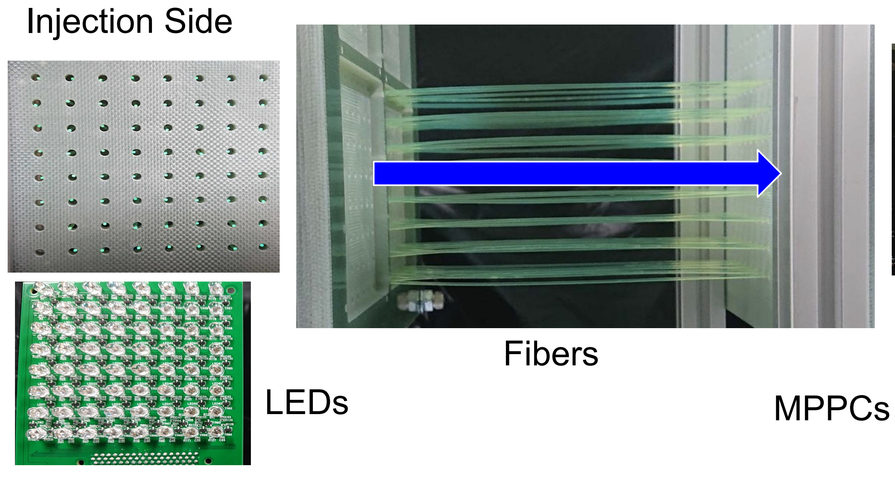


Flow of construction of SuperFGD

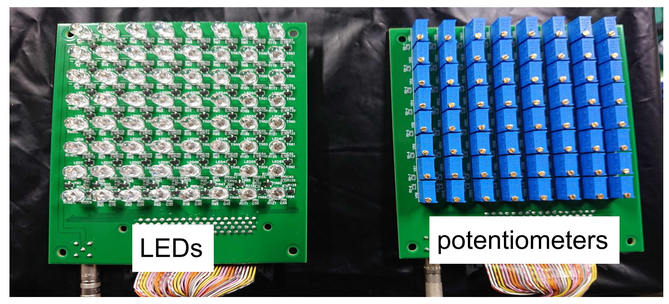


Light leak from a crack of a fiber

Concept of the System

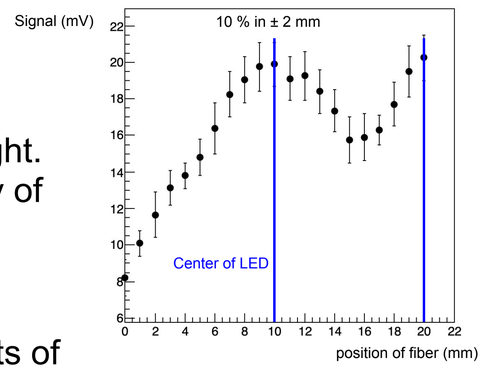


Injection Side



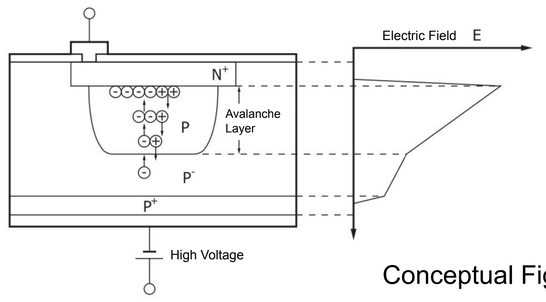
We have adopted an array of high-brightness LEDs as the light source. The blue light is absorbed by the fibers and they emit green light and transmit it. The dedicated PCB on which LED is mounted has potentiometers and we can tune the intensity of the light.

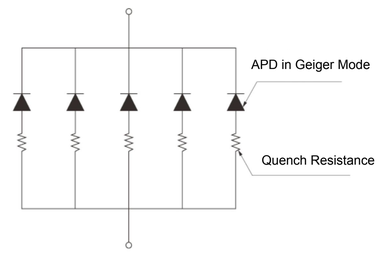
We have confirmed that the LED light can be observed in environment exposed by the room light. The fluctuation which comes from the uncertainty of the position of LED is about 10%.



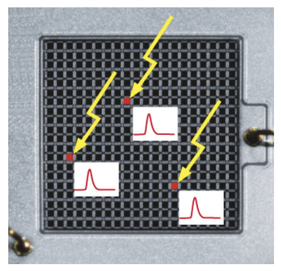
Detection Side

MPPC is a semiconductor photosensor. It consists of some thousands pixeled Avalanche Photo Diode (APD).
In normal use called Geiger mode, applied voltage is large to saturate the avalanche on each pixel. This detector can measure even one photon but its linearity gets worse for intense light.



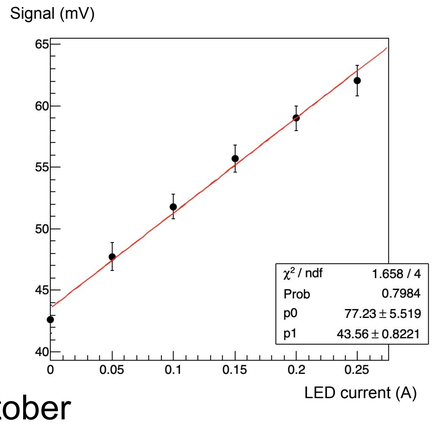


Conceptual Figure of MPPC



For this system, MPPCs are operated in lower voltage than Geiger mode. In this region, each pixel responses linearly and this operation is called linear mode.

We have confirmed good linearity (~ 2%) of the photosensor.



Plans

- Construction of SuperFGD is going to be start in October and whole of upgraded ND280 will be ready in 2023.
- Mock-up test of the QC system will be done in August.
- The criteria will be determined considering the efficiency of the event reconstruction.