Scintillator-based trackers

Masashi Yokoyama
Department of Physics, University of Tokyo

Important design choices: 2

- 6 scintillator-based detectors considered for the active target(s): FGD-like, 3D FGD, Super-FGD, Wagasci-like, Empty Wagasci, Scintillating fibers
- For the alternative configuration, the horizontal target could be totally active (Carbon only)
- Apart from the technology, other design choices for the target (granularity, bars geometry etc) need to be addressed
- Performances should include: efficiency for short hadronic tracks (includes high angle tracks), PID, gamma/nue, Michel electrons

Objectives of target detector(s)

- Provide target mass for neutrino interaction
  - Especially important for νe measurement
  - Water target necessary or not?
- Acceptance for large angle tracks
- Reconstruct tracks inside the target detector
- Background reduction/control for νe measurement

Need to be quantitively defined

in terms of physics requirements,

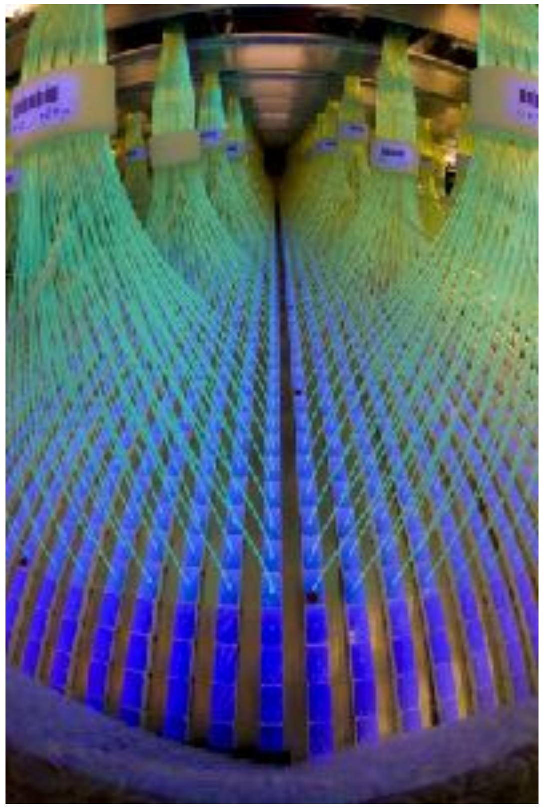
with consideration of the detector design

Extruded scintillator

- Can produce large amount with relatively low cost
- Ingredients are heated to be melt and extruded through a die
  - Co-extrusion with a reflector layer (w/ TiO_2) possible
  - Hole/groove for a fiber can be shaped at extrusion
- Mechanical dimension difficult to precisely control
  - Shrinkage during cooling after extrusion

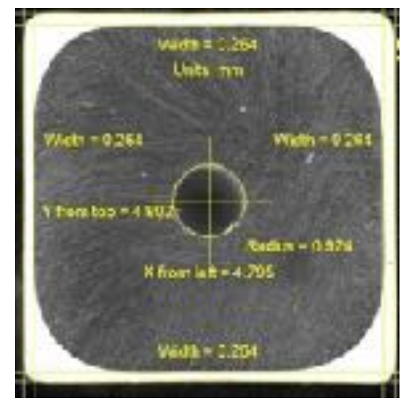
die for extrusion of WAGASCI scintillator

Examples

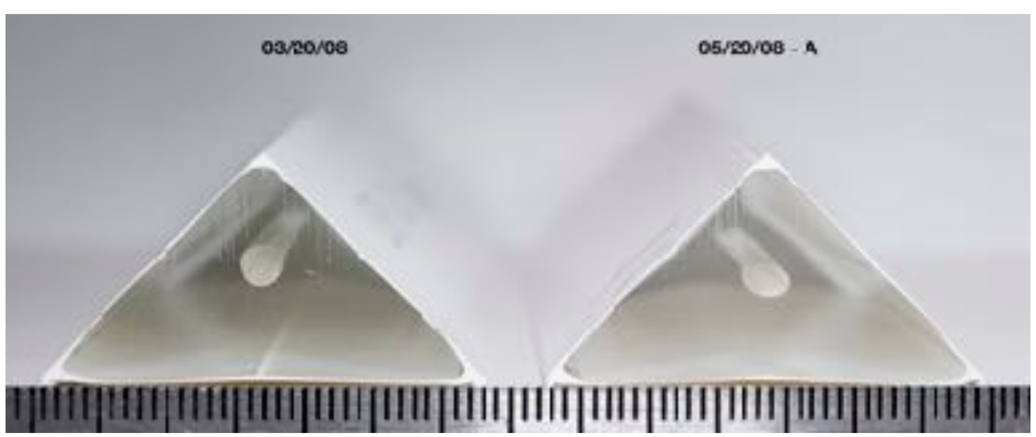


SciBar: $2.5\times1.3\text{cm}^2$
with a hole in center,
Fermilab

MINOS, $4\times1\text{cm}^2$
groove,
NICADD/Fermilab



FGD,
Made in Canada
based on Fermilab recepi



MINERvA, P0D
Fermilab

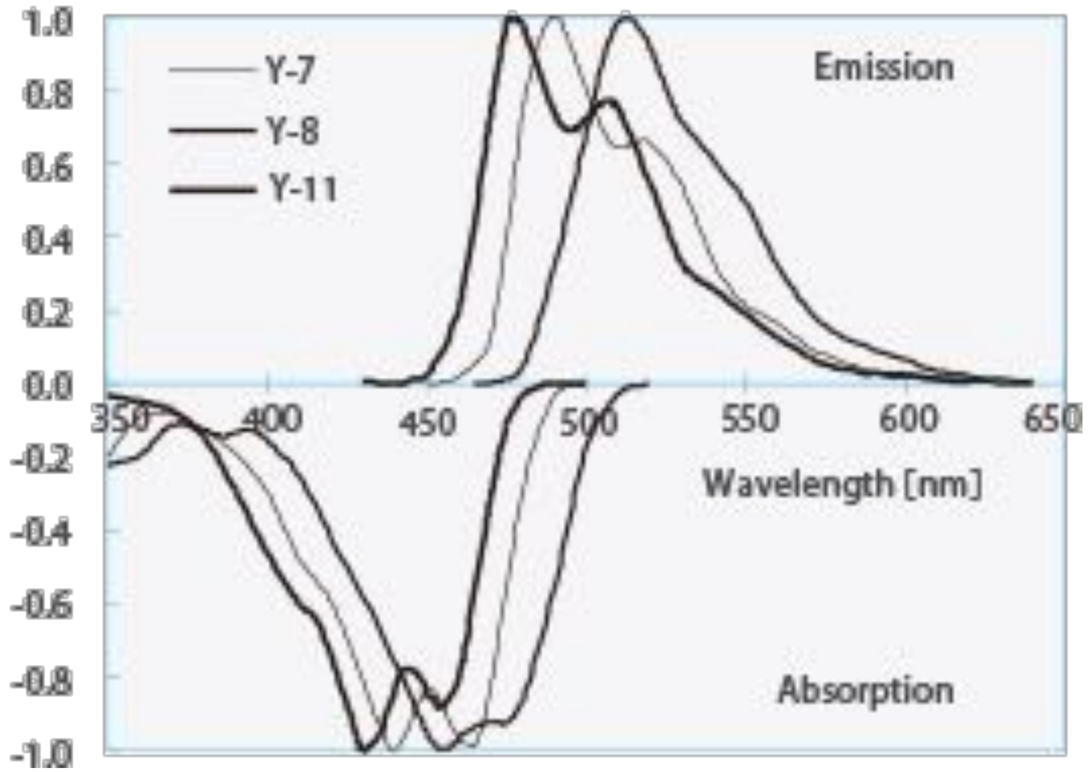
WAGASCI,
$2.5\times0.3\text{cm}^2$
Fermilab

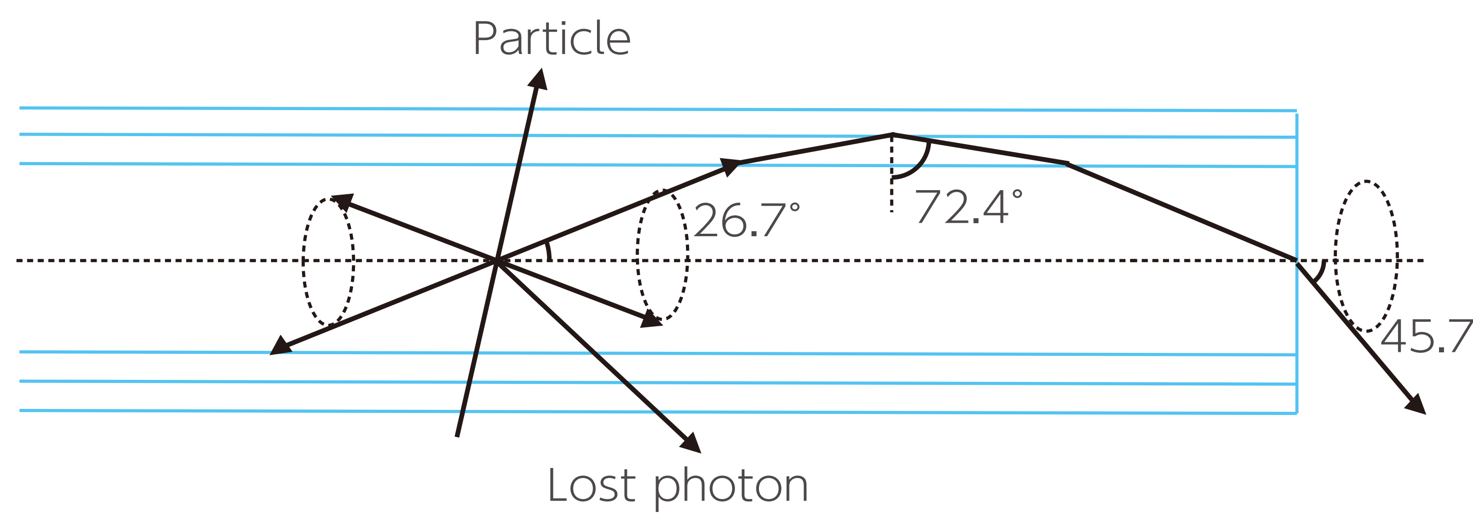
Example cost (Fermilab case)

- Cost estimate in Jan. 2015
  - \$56k for $\underline{0.3\times2.5\text{cm}^2}$, (WAGASCI type) 6,000m
    - \$21k material, \$35k labor
  - \$79k for $\underline{1.0\times5.0\text{cm}^2}$, (INGRID type) 3,000m
    - \$44k material, \$35k labor
- New die for WAGASCI costed ~\$55k including test production

Wavelength shifting fibers

- Kuraray Y11 is commonly used





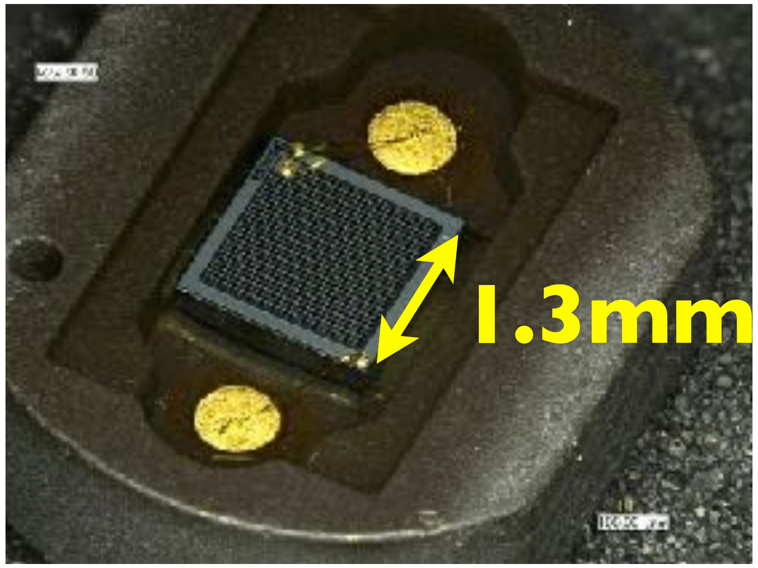
Trapping efficiency is a few %

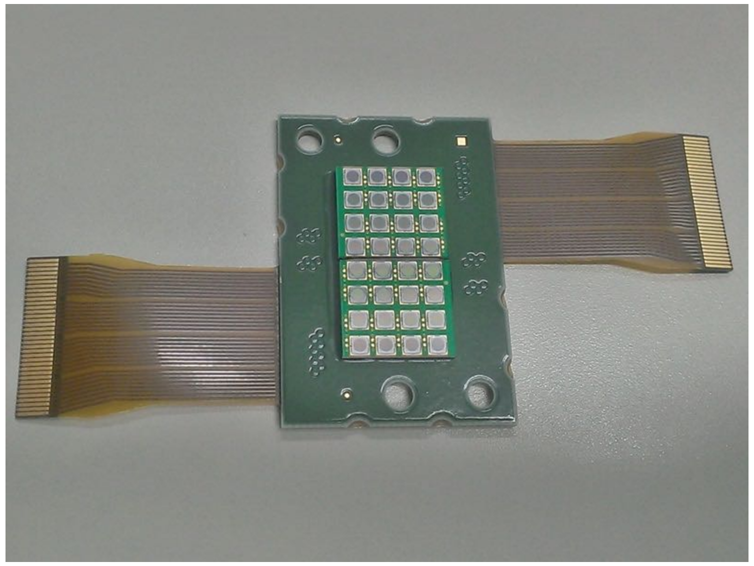
Dimensions available
0.2mm - 2.0mm
(0.2, 0.5, 1.0, 1.5, 2.0 typ.)

http://kuraraypsf.jp/psf/ws.html

Photo-sensors

- Assume to use MPPCs
  - Excellent performance in the current ND280
  - Improved version available
- Need to define package and optical connection
- Typical cost ~2,000JPY/channel





Electronics

- Current FGD uses the same electronics with TPC
  - Independent system or identical to HTPC?
- Important to have decay-e tagging capability
  - Consideration on dead time requirement
- Timing synchronization with other detectors

Sub-WorkPackages (preliminary)

- Definition of detector configuration [with simulation/physics]
  - Water target necessary?
  - WAGASCI-like? FGD-like? Else?
- Plastic scintillator
- WLS fibers
- Photosensors (MPPC)
- Mechanical structure [with WP1]
- [Water system (if necessary)]
- Electronics (frontend, backend)
- Monitoring system

WP6 group status

- Currently Japanese institutes + possibly LLR
- We need more people to cover all items
- More groups are necessary! your contribution is welcome, for any of items

Detector options

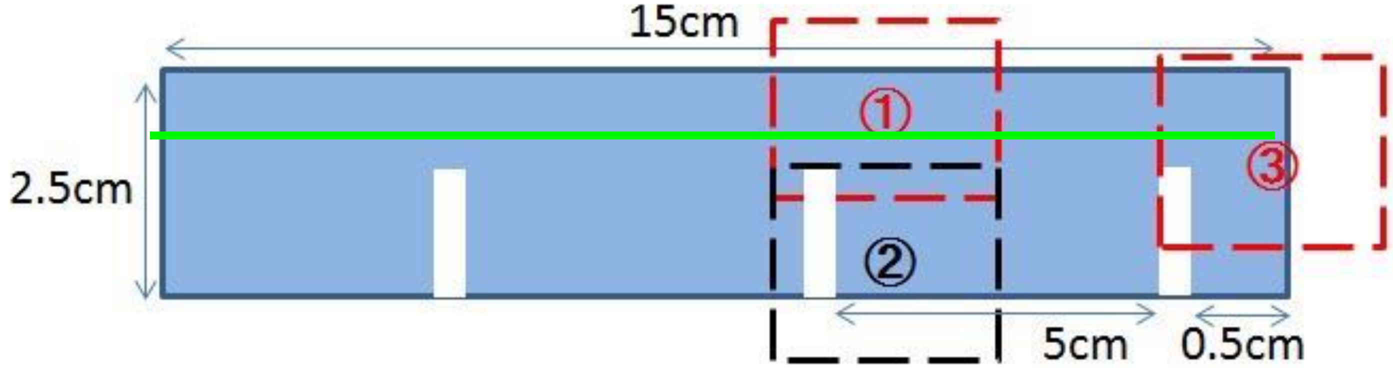
- Considering the timeline to write the proposal within by October, we need to define a “baseline” with robust and feasible design
  - With “alternative” options that need to be studied

- In my opinion, 3D-FGD (and FGD-like) seems one of feasible options from construction view point, but not much studied so far
  - Can we have a performance study?

Backup

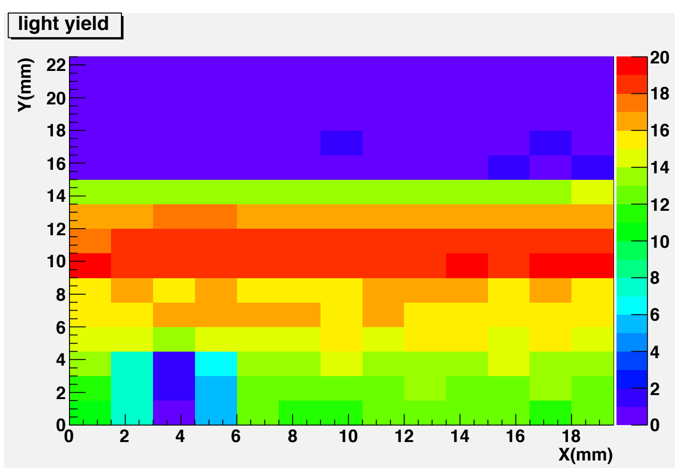
Scintillator performance

Light yield measurement with WAGASCI scintillator (2014)

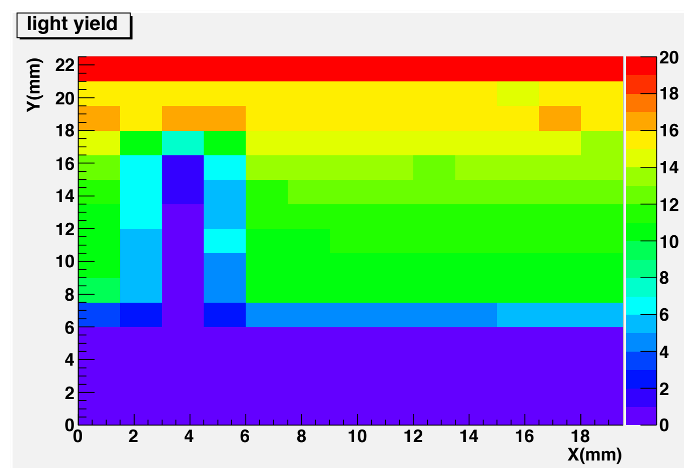


From Master thesis of T.Koga

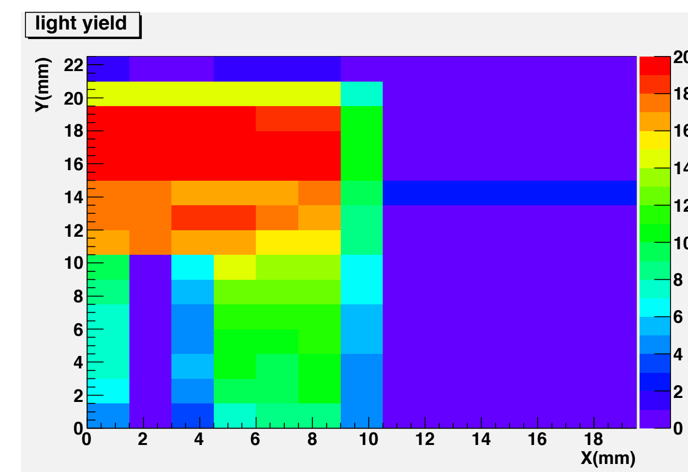
Position 1



Position 2



Position 3



Position dependence

- Also observed significant cross-talk:
  - Improved version (fraction of TiO_2 increased) just delivered. To be tested soon