UNIVERSITÉ DE GENÈVE

FACULTÉ DES SCIENCES

Simulation of the target detector

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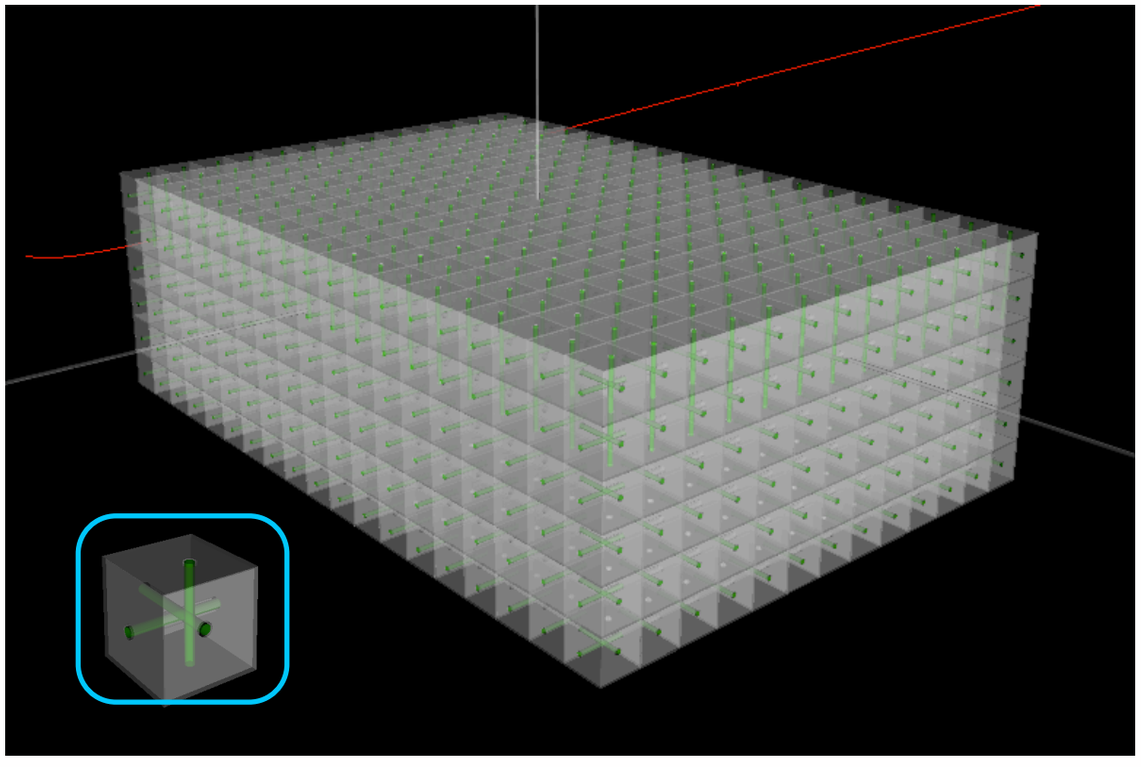
"Neutrino Near Detector" workshop, Tokai 21/5/17

Simulation of SuperFGD detector

- First implementation of the target simulation and reconstruction is done
- Available for SuperFGD, FGD-like, SciFi, WAGASCI, FGD3D
- See also Benjamin's talk

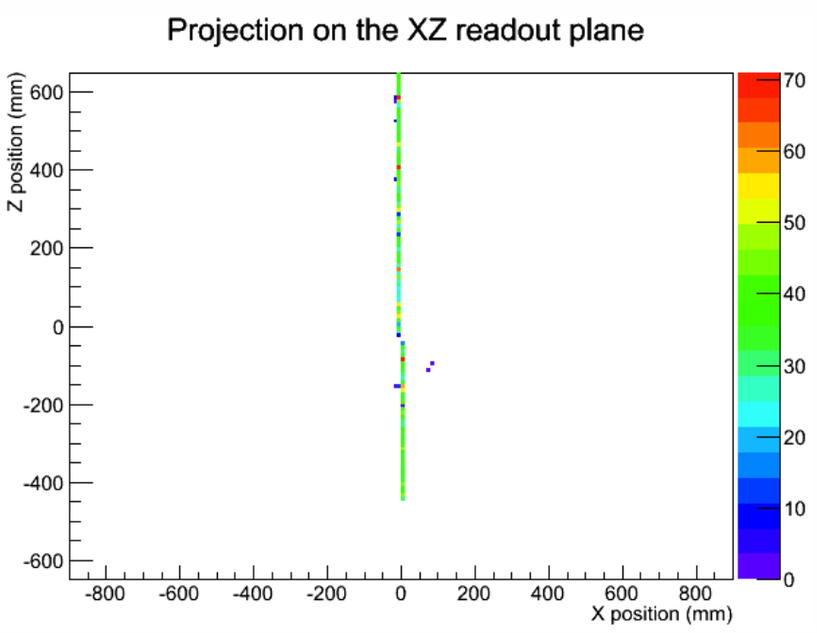


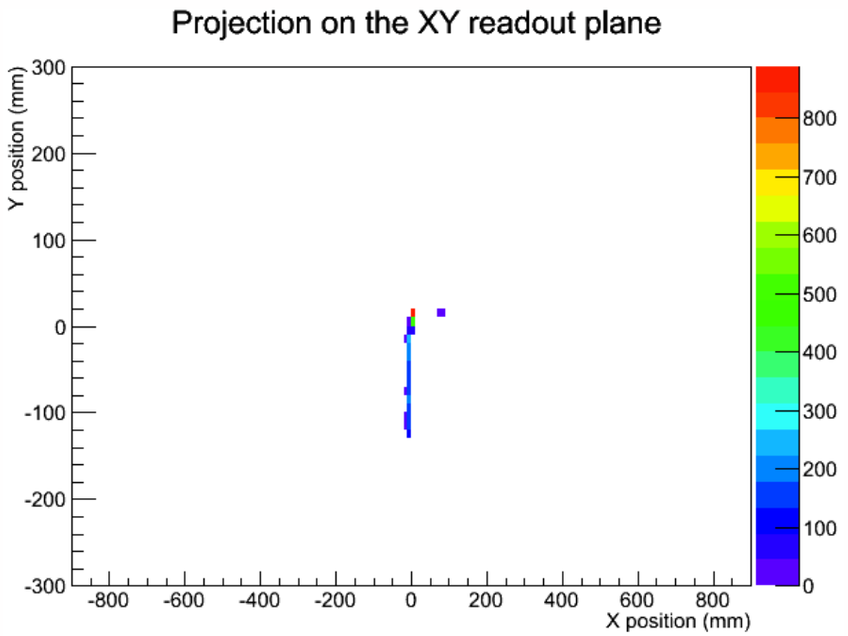
- Size of 1 cube: 1 cm^3
- Width = 180 cm
- Height = 60 cm
- Length = 130 cm
- Mass = 1.44 tons
- Example target size: it will be updated for each different geometry

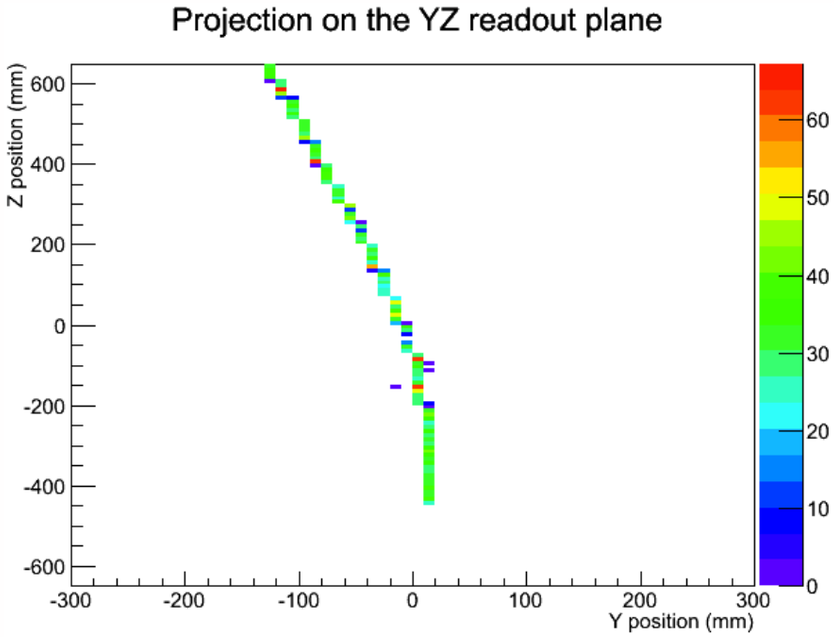
- Reconstructions Edep --> # of p.e. at MPPC is done (need double-check)
- FGD TN-103 and WAGASCI code taken as reference

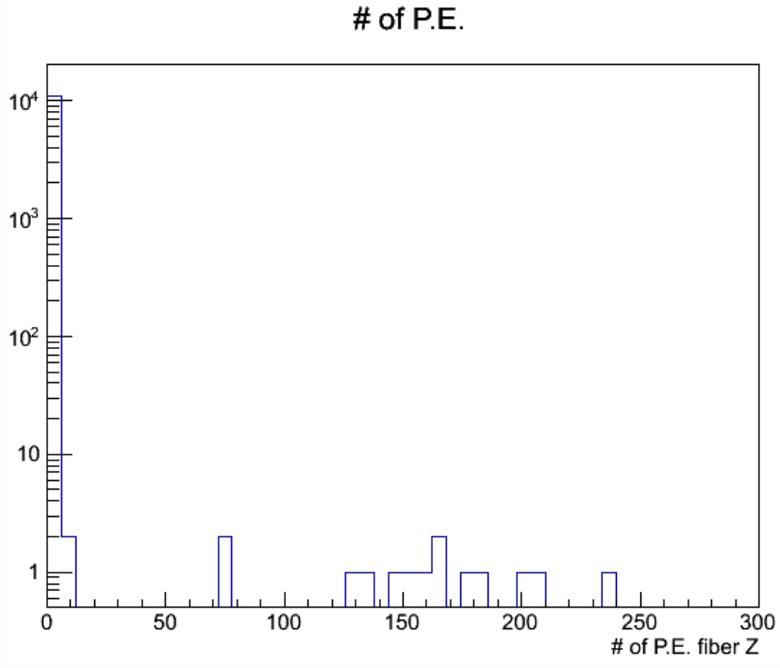
Particle gun: Muon

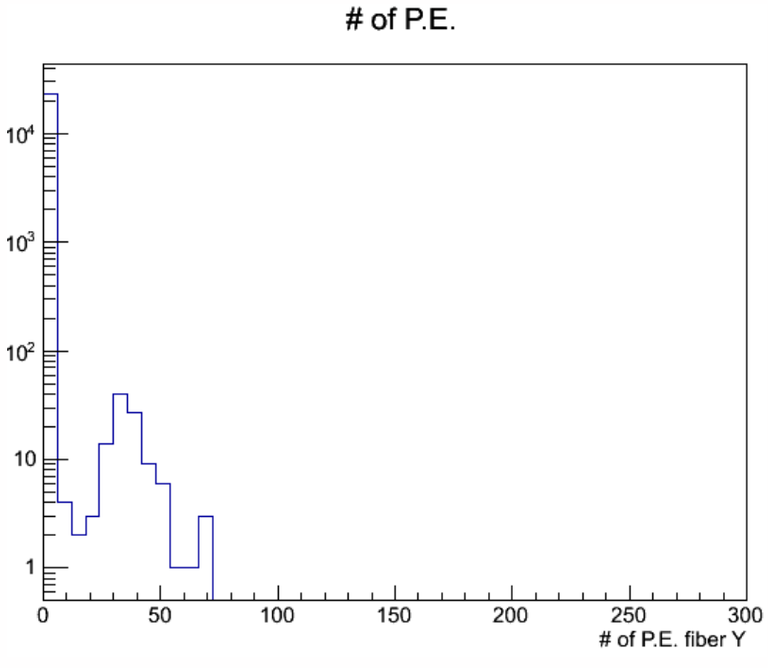
- Some particle guns used as validation and to look at basic performances

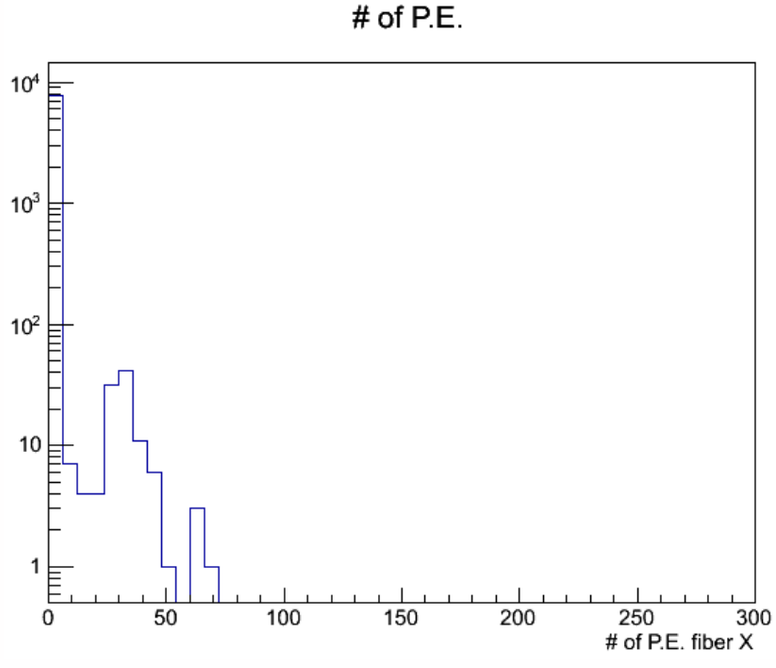












Simulation of the detector response

- Birks' equation is applied --> quenching in plastic scintillator $E_{vis} = \frac{E}{1 + k_B \frac{dE}{dx}}$
- Light collection in the fiber + Edep --> photon collected in the fiber

$< \text{elecSim.Scintillator.PhotPerMeV.fgd} = 70.8\ 1/\text{MeV} >$

Constants are taken from TN-103

- Account for 3 fibers in the same plastic scint. cube
  - light collected by a fiber is shaded by the other fibers
  - assume f_{Coll} = 10% (double-cladding, PDG2016)
  - Collection efficiency reduction ~ 8%
- # of photons: N_0 = Edep * PhotPerMeV.fgd * f_{shadow}
- Light attenuation in the fiber: # of photons at fiber end

$$N(x) = N_0 \left(a\, e^{(-x-d)/L} + (1-a)\, e^{(-x-d)/S} \right) \left(1 - \frac{1}{2}(e^{-mx} + e^{-m(L-x)}) \right)$$

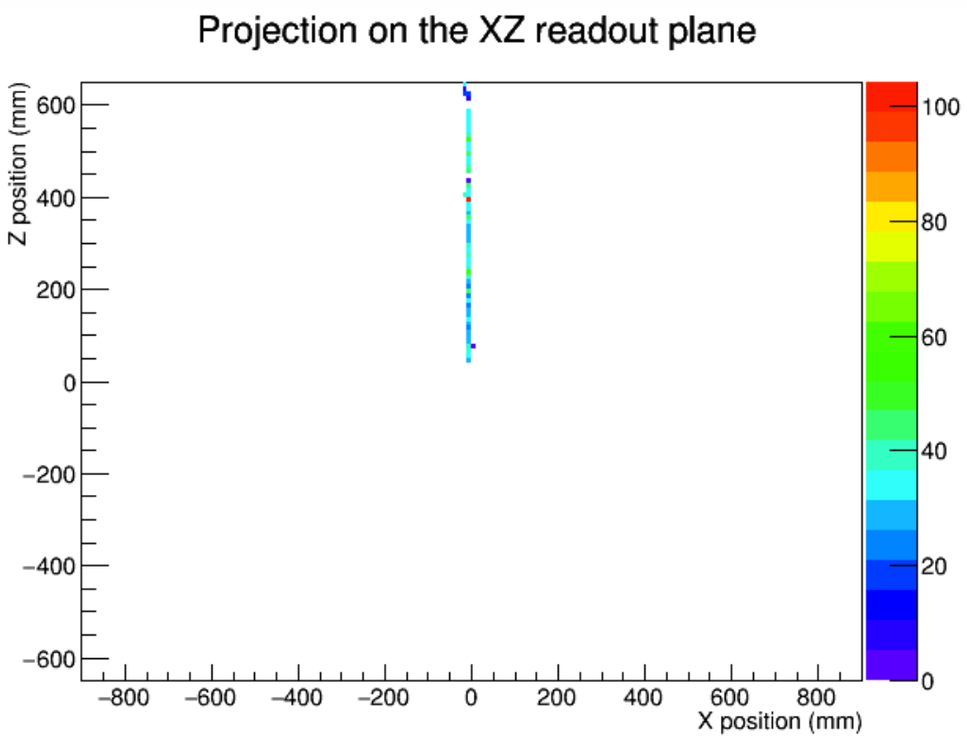
d=41mm (distance end-of-fiber - MPPC)

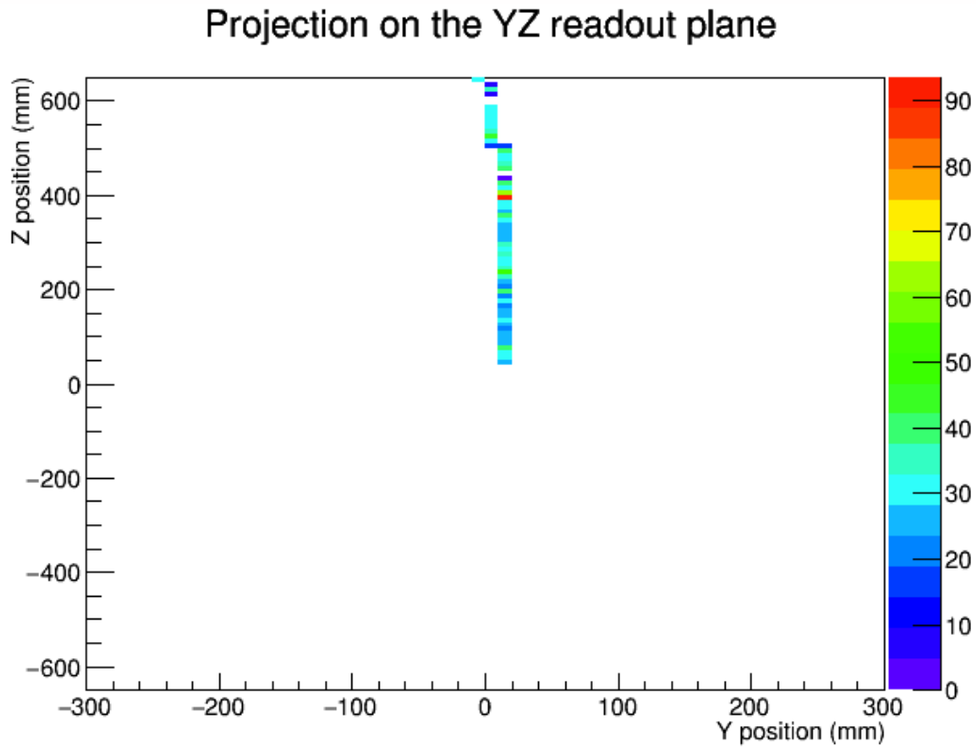
- Assume 38% photon --> p.e. efficiency of newest MPPC --> obtain # of p.e.
- The response is now applied on each single GEANT4 step: may need to apply on the sum of the energy released by the track

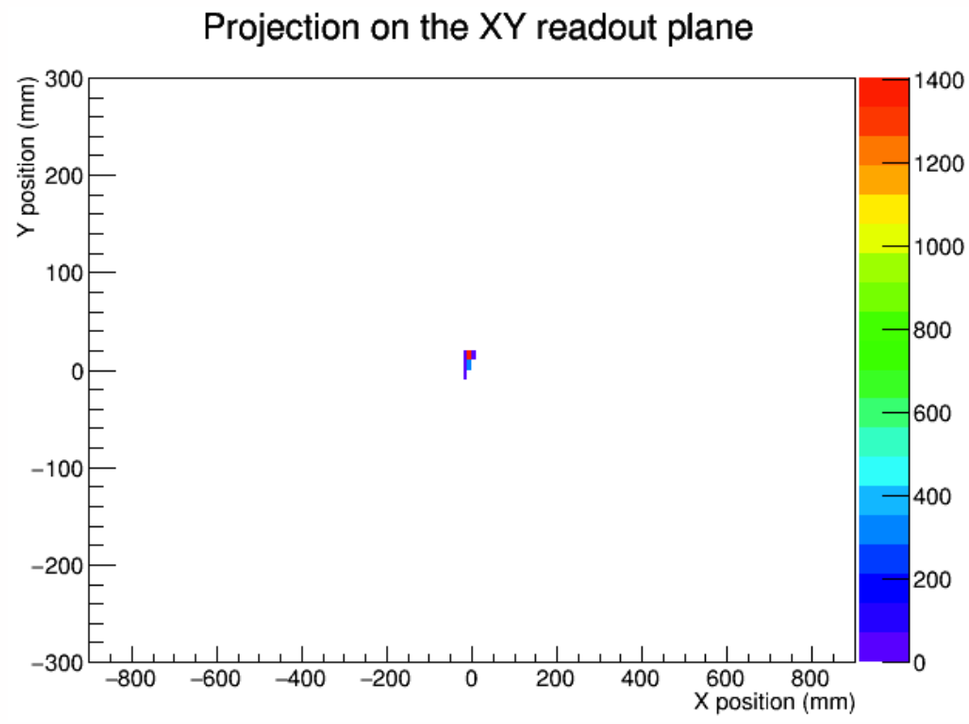
SuperFGD

Particle gun: Muon

Muon, E_{kin}=400MeV
Pos(0,0,0), Dir(0,0,1)





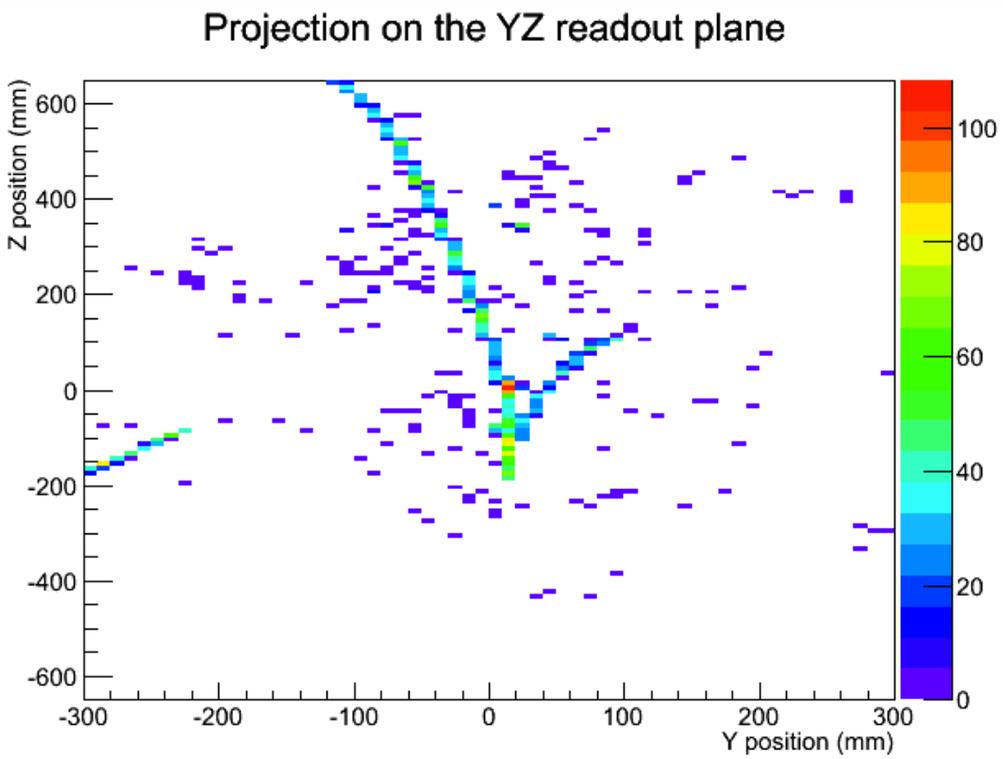


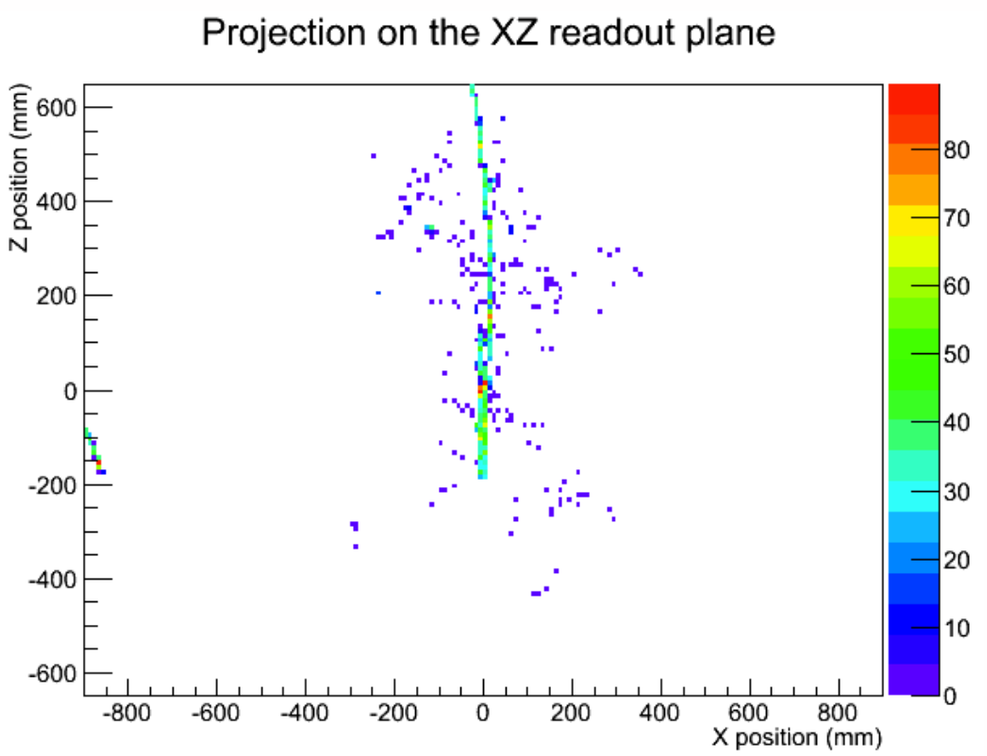
- Start of the track shifted by -16mm --> consistent with basket shift
- # of p.e. / cm (MIP) ~ 30-40 p.e. / fiber
- FGD: # of p.e. / cm (MIP) ~ 16-18 / fiber

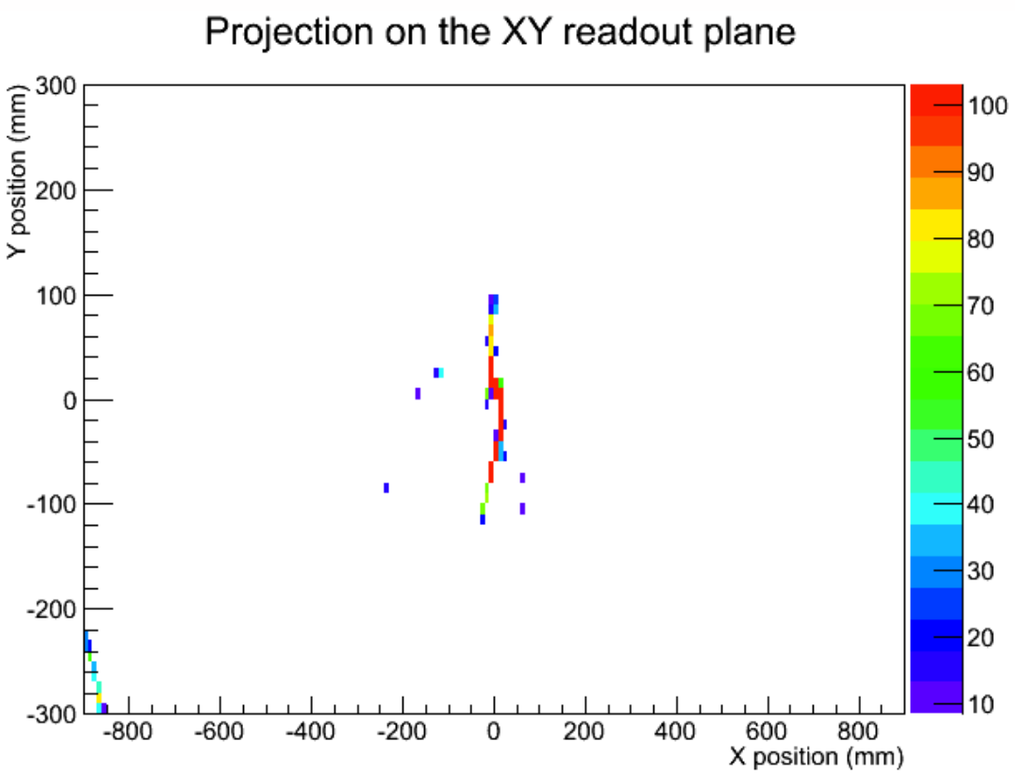
SuperFGD

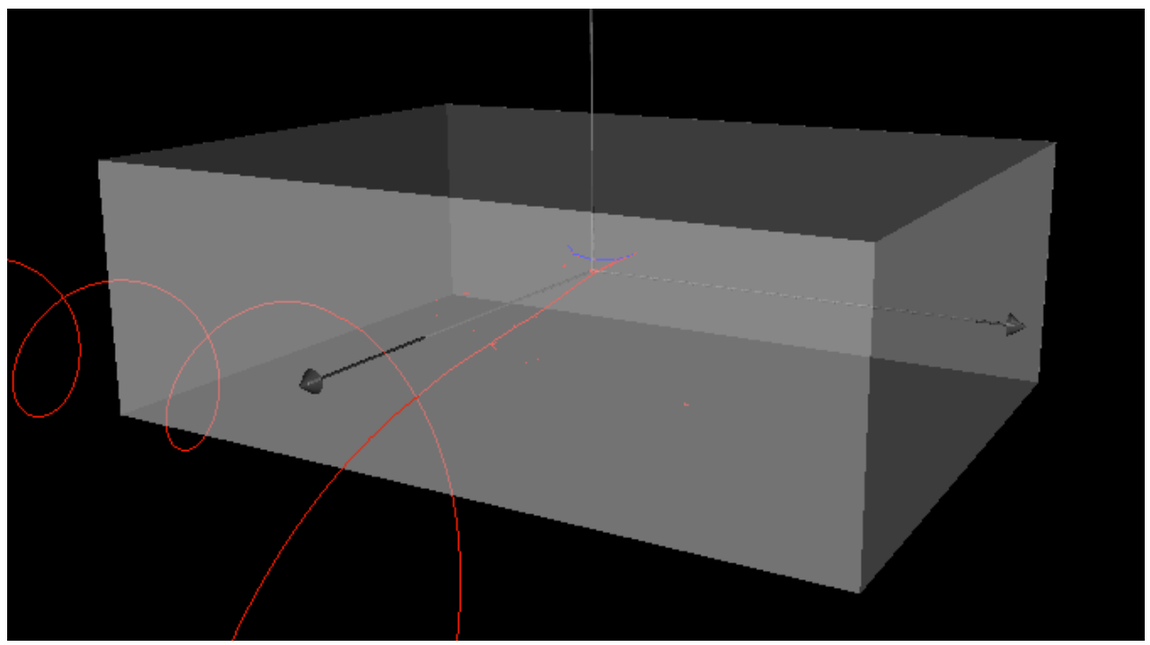
Particle gun: Gamma

Gamma, E_{kin}=400MeV
Pos(0,-600,-500), Dir(1,1,1)





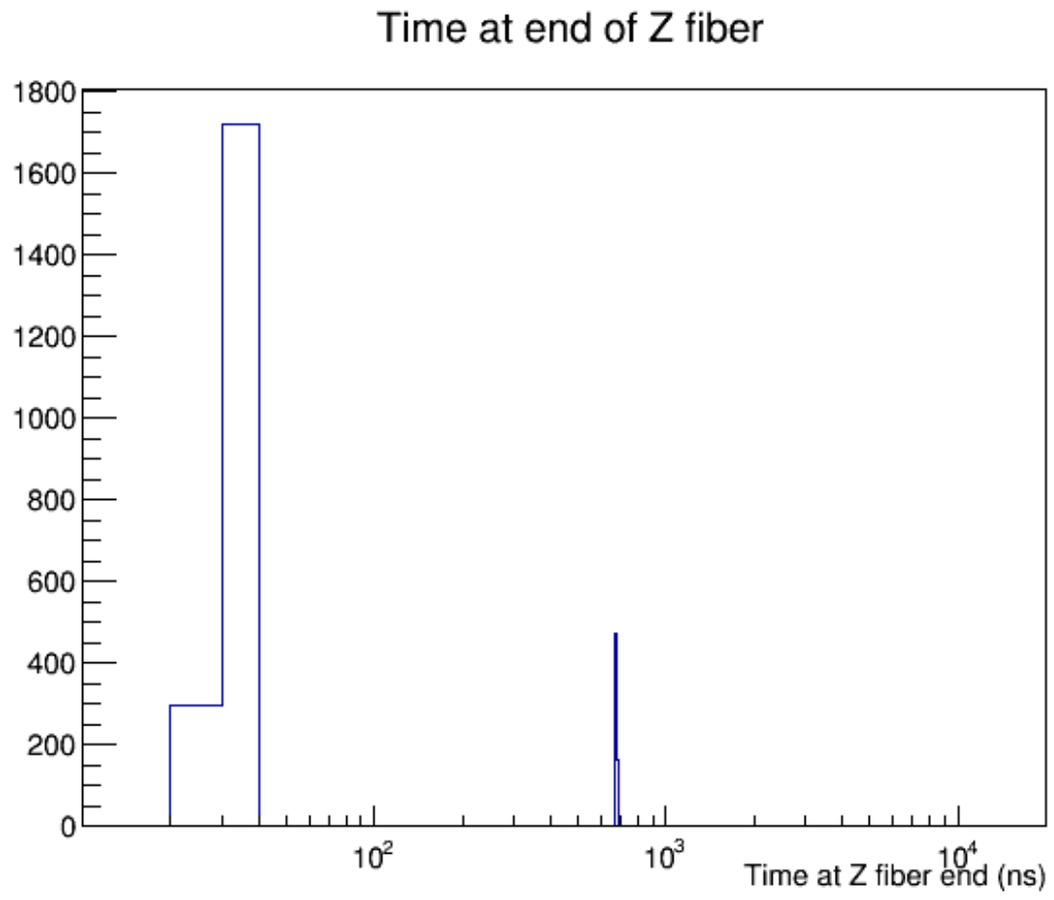




Particle gun: pi+ --> Michel e+

- Detect pi-, muon, e- as a function of X and time

pi+, E_{kin}=200MeV
Pos(0,0,0), Dir(0,0,1)

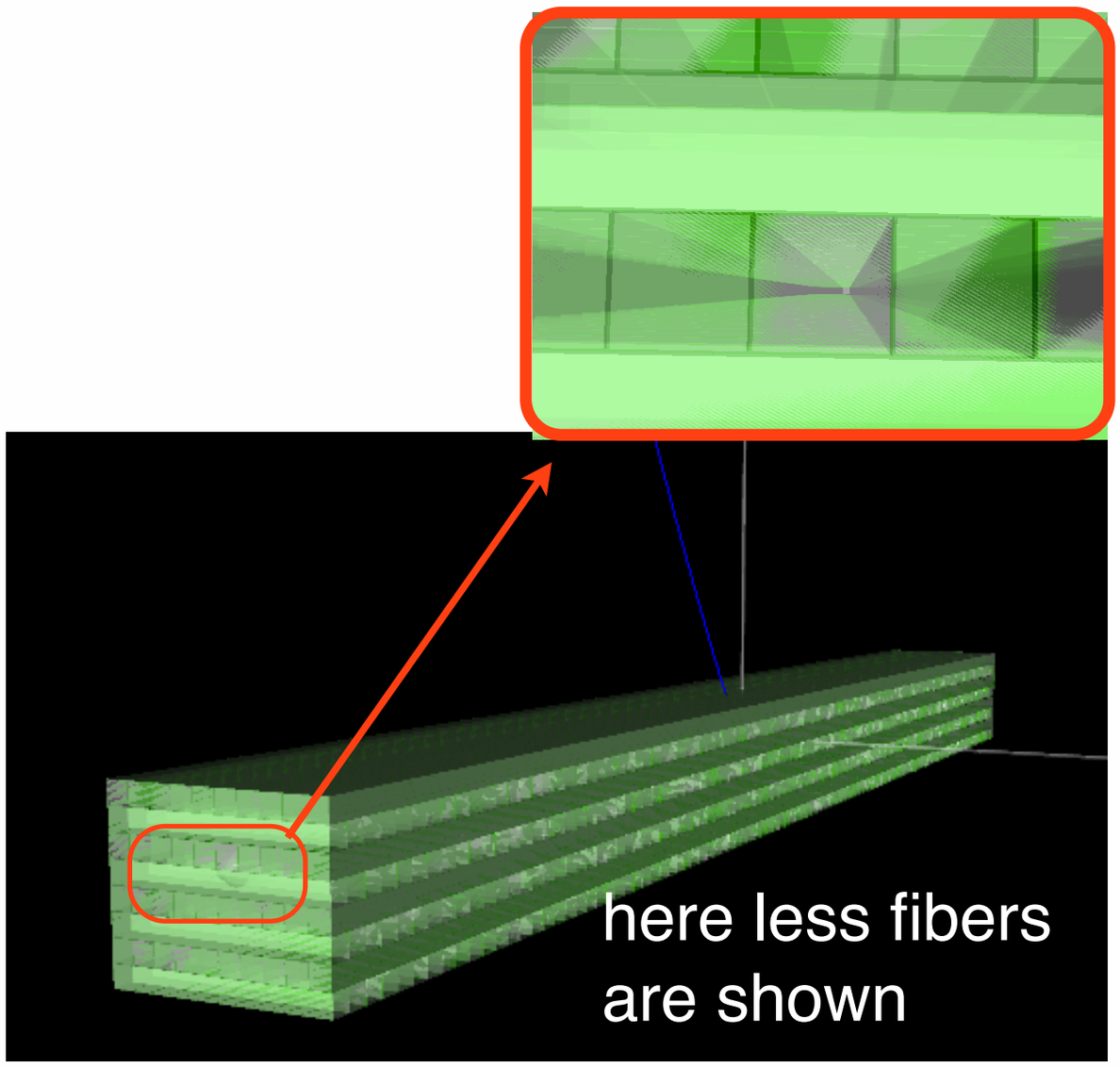


- Analogous for other targets (using same time calibration due to fiber)

- SuperFGD has 3 fibers that tag the Michel-e+ while the other detectors have 1 fiber (if electron releasing energy only to 1 fiber)

Simulation of Tracking Fiber detector

- First implementation of the SciFi detector and response is done
- Scint fibers alog X and Z to measure tracks going upward
- Single-cladding, square, 2mm edge scint fibers
- 3% of cladding on both edge as in Kurakay catalog
- Perfect SciFi: no gap, no glue, etc...



- Total size (mm^3):
  1300 x 600 x 1800
- Fiber edge: 2 mm
- # of fibers:
  900 horizontal (along X)
  650 vertical (along Z)
- # of layers (XZ each): 150
- mass=1489.61 kg

- Reconstructions Edep --> # of p.e. at MPPC is done

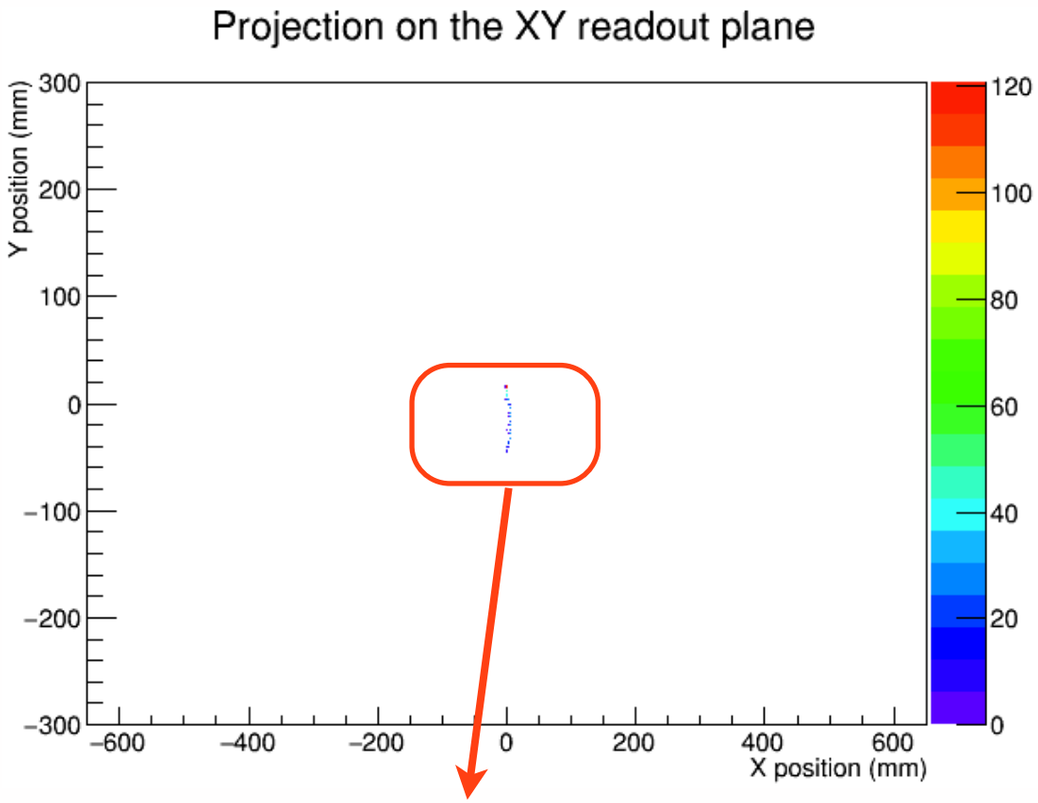
From deposited energy to # of p.e.

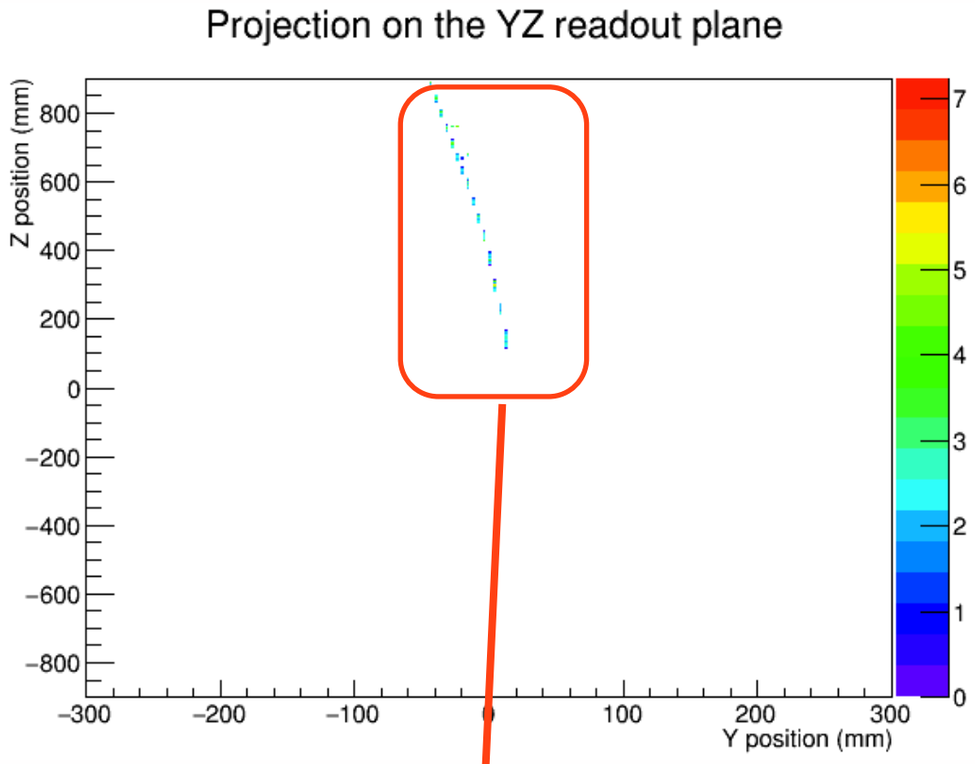
- Birks' equation is applied --> quenching in plastic scintillator $E_{vis} = \frac{E}{1 + k_B \frac{dE}{dx}}$
- Light collection in the fiber + Edep --> photon conversion
- From Minamino-san slides: # p.e. (MIP) / mm = 23.7 (@15cm)
- Convert from MIP to MeV: Edep(MIP) ~ 2 MeV/cm
- Convert from mm to 1 fiber (edge=2mm)

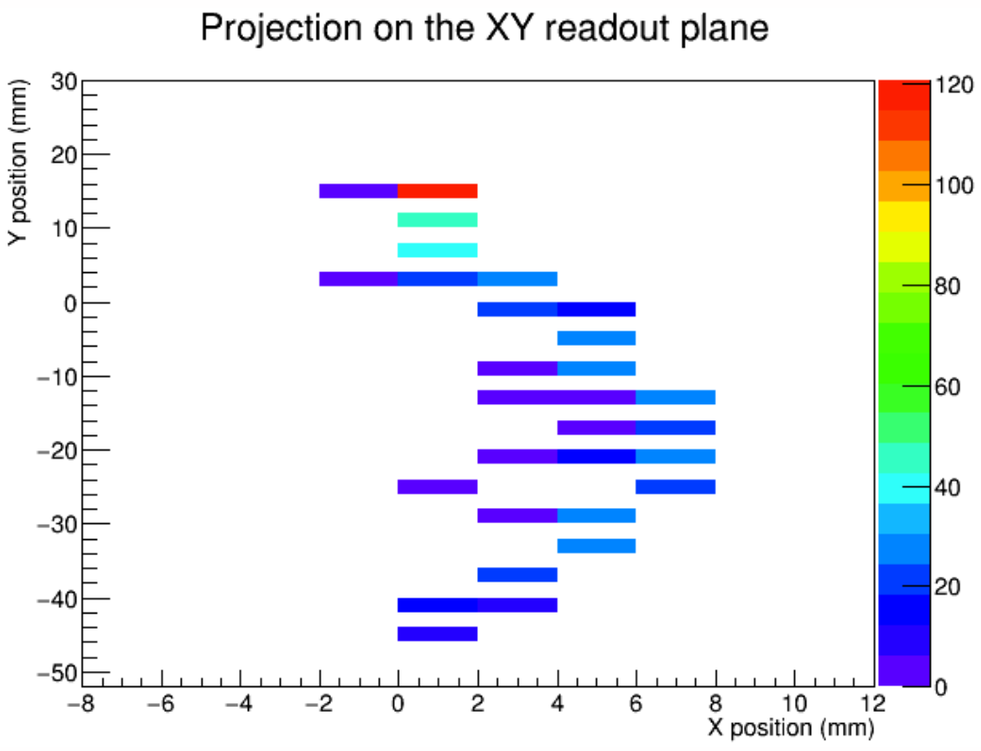
- # p.e. collected in fiber = 23.7/MeV
- # of photons: N_0 = Edep * PhotPerMeV.fgd
- The rest is the same as for SuperFGD:
  - attenuation of light in the fiber same as in FGD (TN-103)
  - time propagation of light in the fiber same as in WAGASCI
  - MPPC with 38% photon-->p.e. efficiency

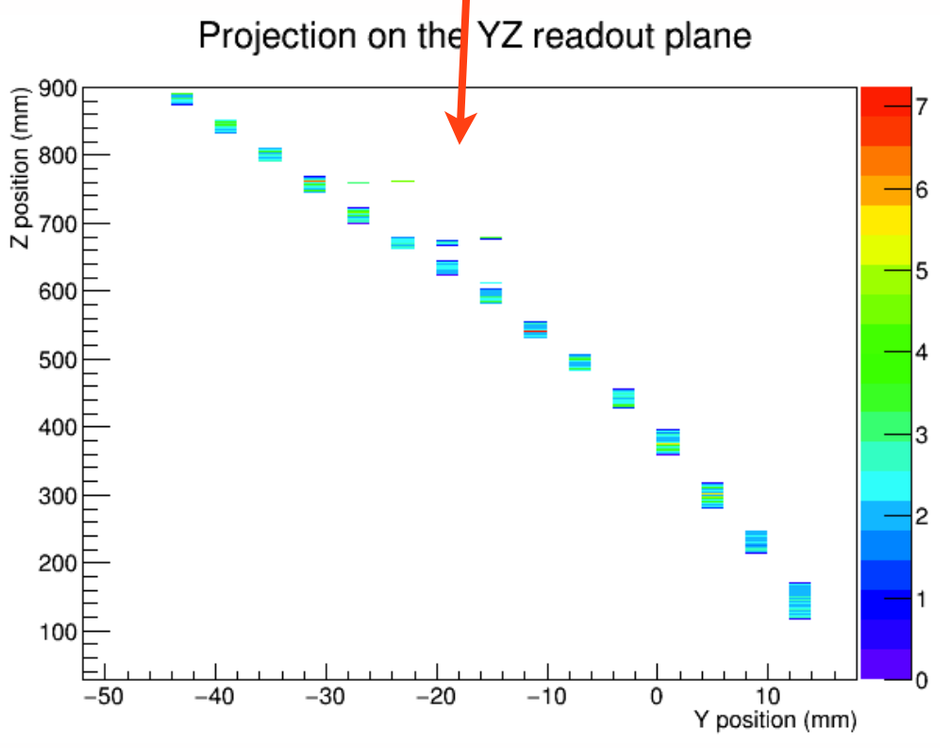
Particle gun: Muon

Muon, E_{kin}=400MeV
Pos(0,0,0), Dir(0,0,1)



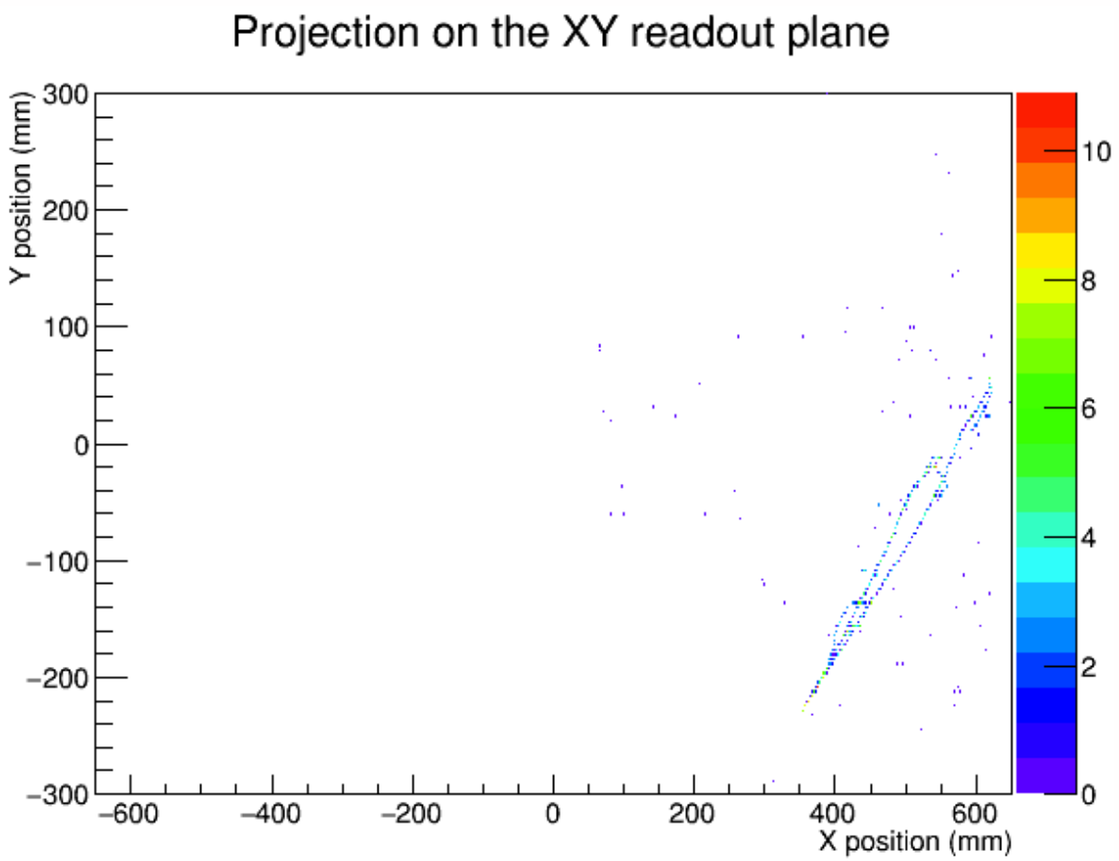


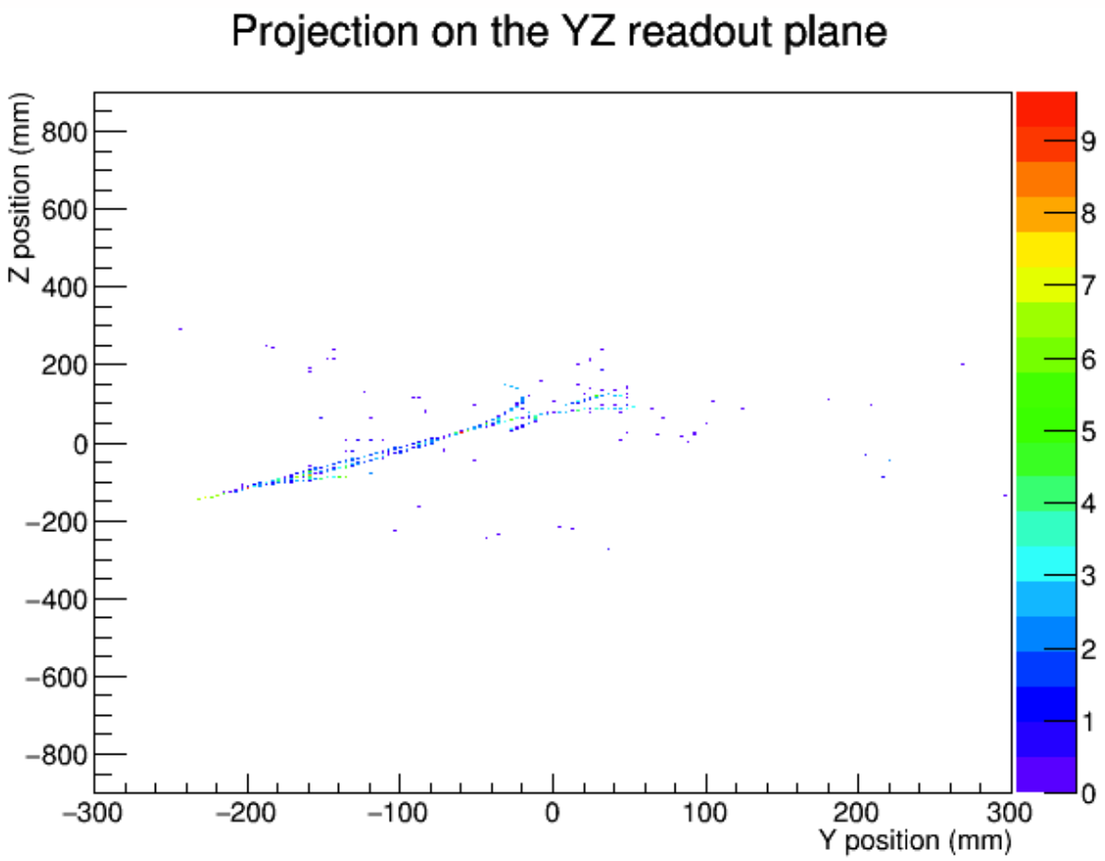


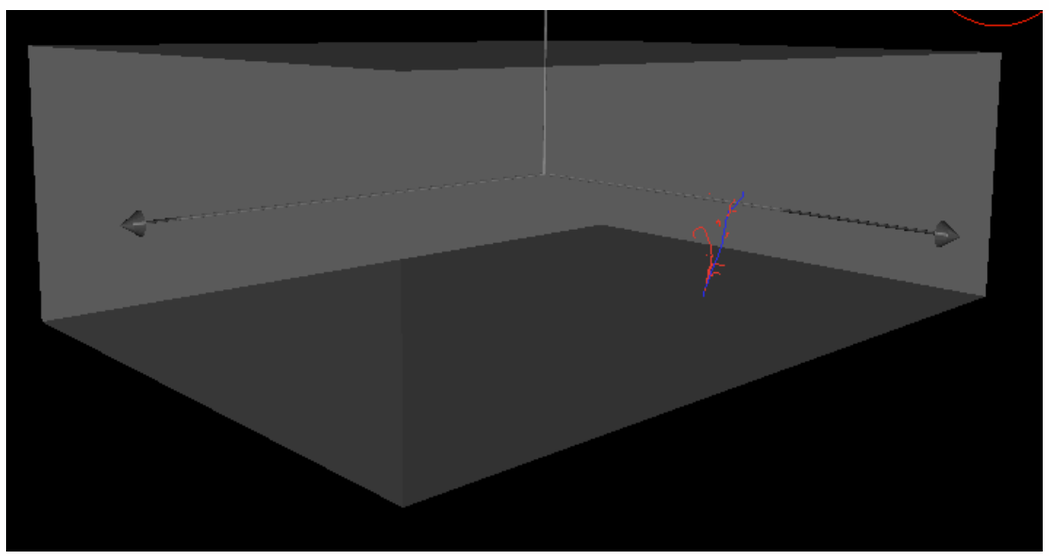


Particle gun: gamma

- Hit position (MPPC) Vs # p.e.







Gamma, E_{kin}=400MeV
Pos(0,-600,-500), Dir(1,1,1)

- The gamma conversion is well visible

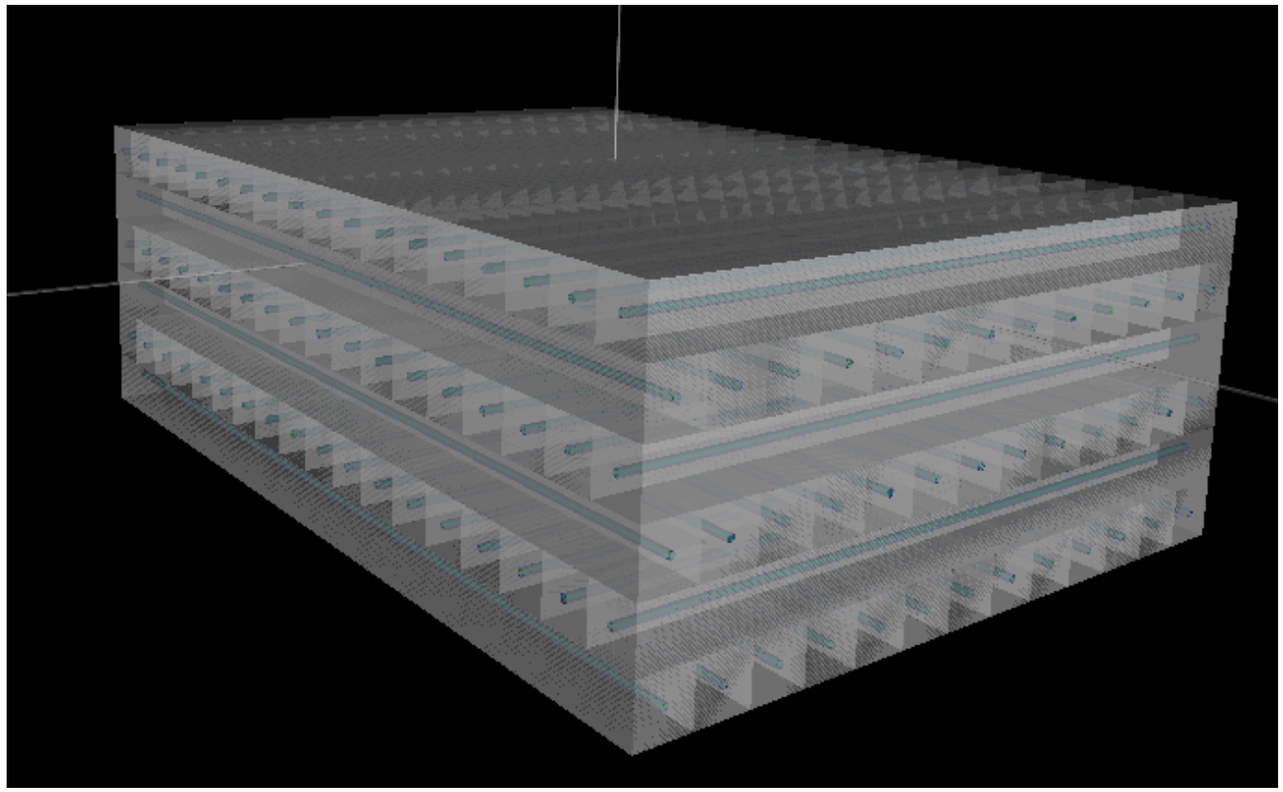
Simulation of horizontal FGD

• Long plastic scintillator bars with WLS along the hole (same as FGD)

• No other materials (e.g. glue) but coating (0.25 mm) is implemented

• Not using the FGD-nd280mc code for the time being because this detector may be slightly different

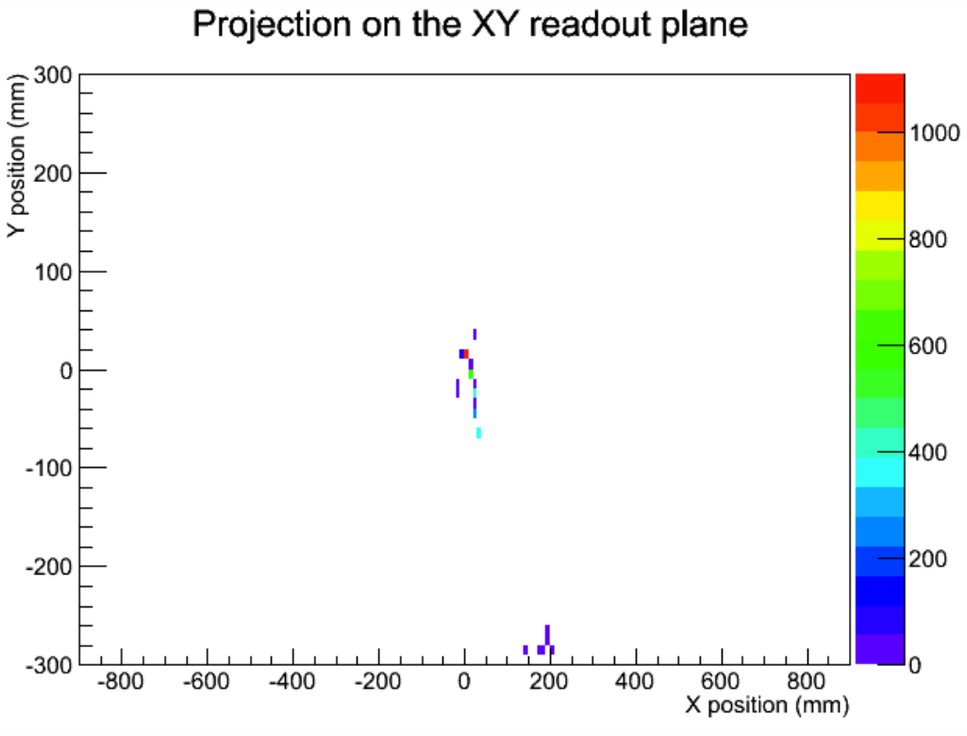
• Can take nd280mc code and use both for vertical and horizontal FGDs

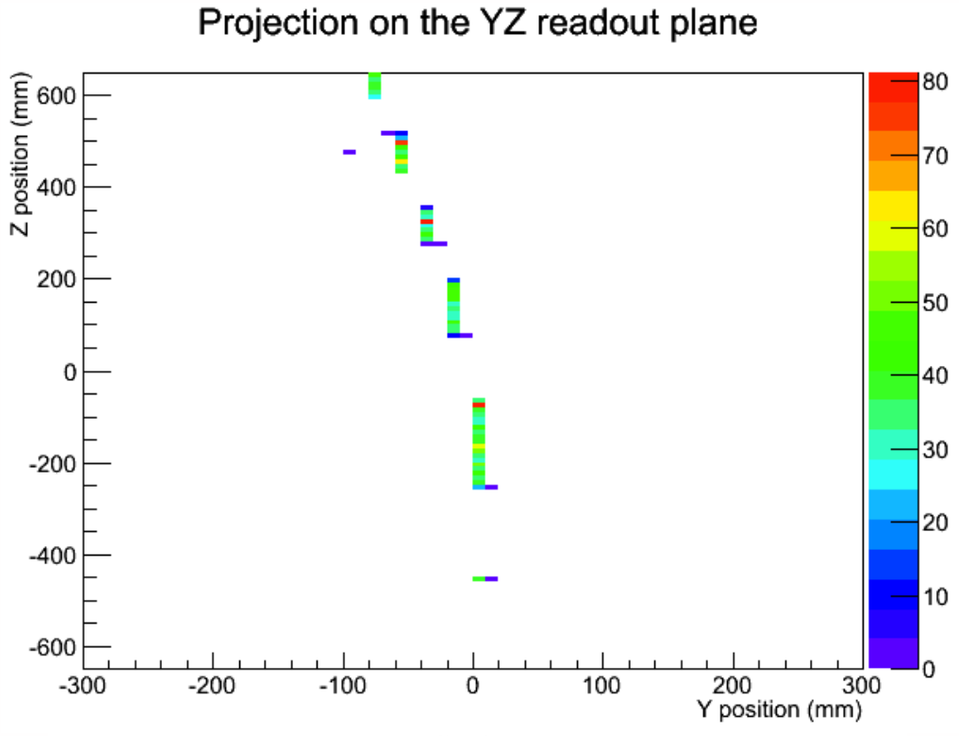


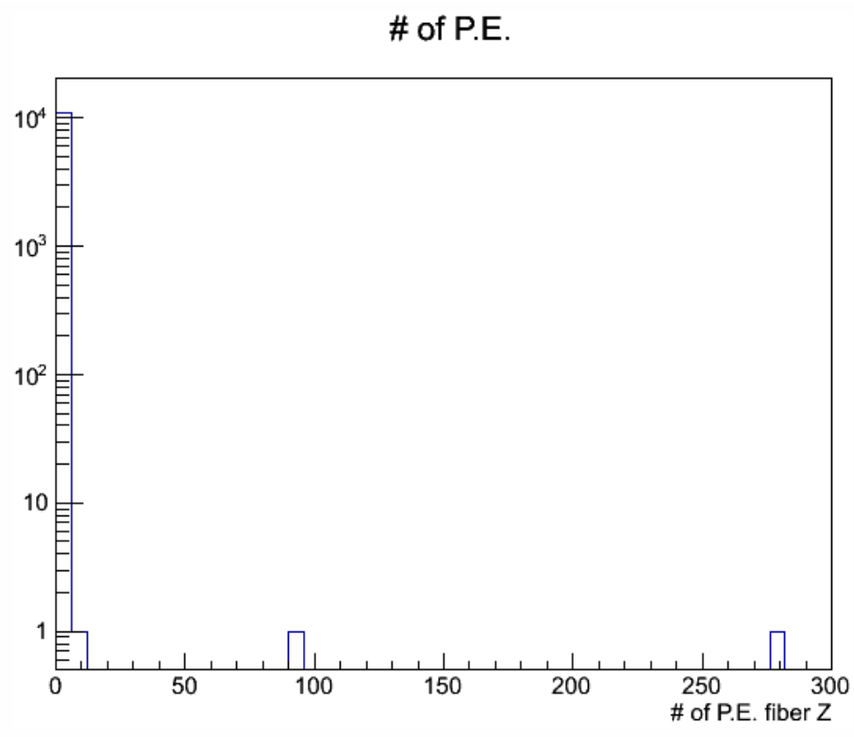
- Total size (mm^3): 1800 x 600 x 1300
- Bar edge: 10 mm
- mass=1438.22 kg

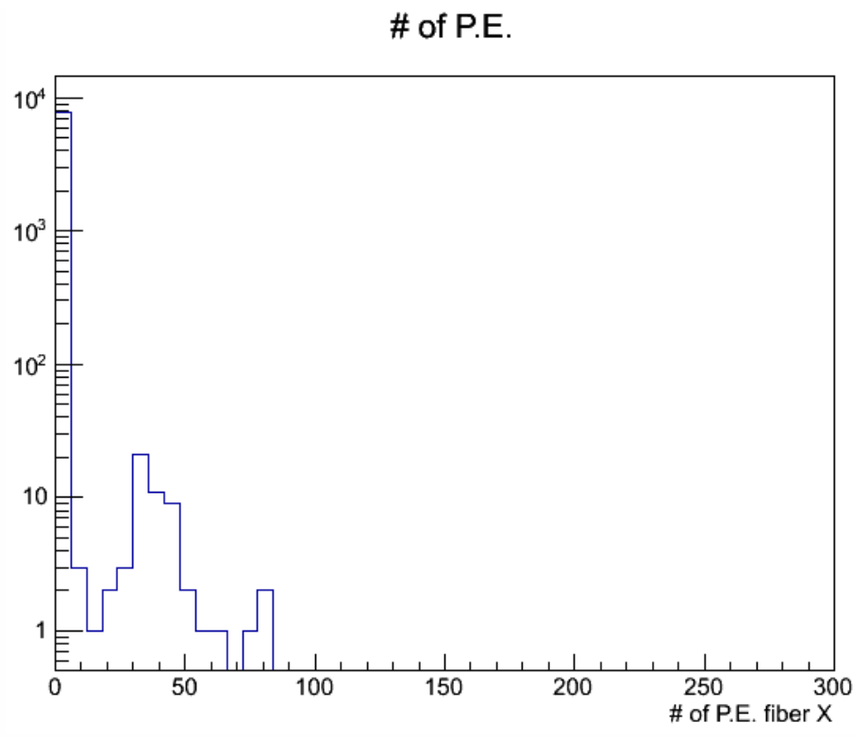
Particle gun: Muon

Muon, E_{kin}=400MeV
Pos(0,0,0), Dir(1,1,1)









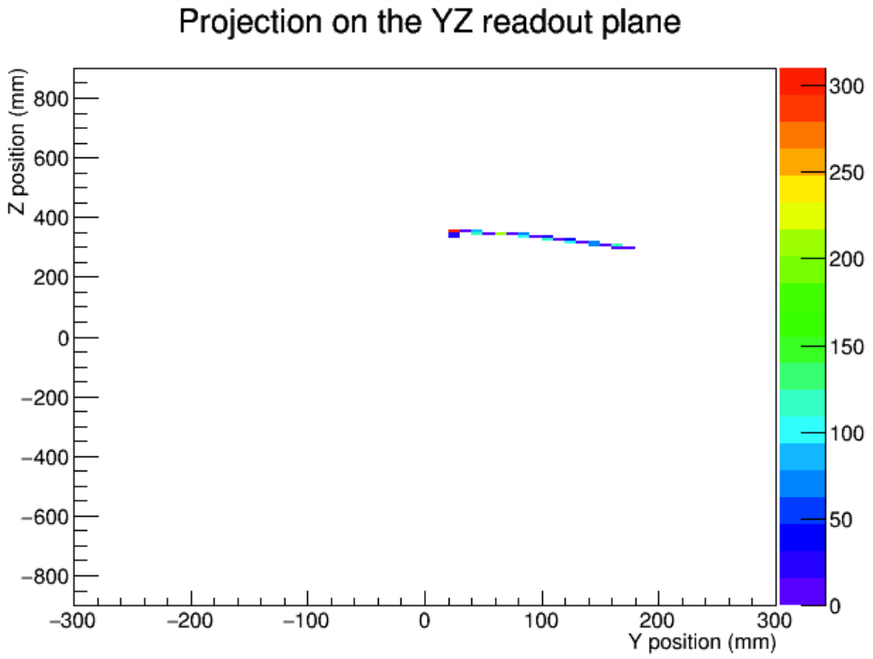
- Work is ongoing to fix some migrations among MPPCs
- GEANT4 steps at volume borders

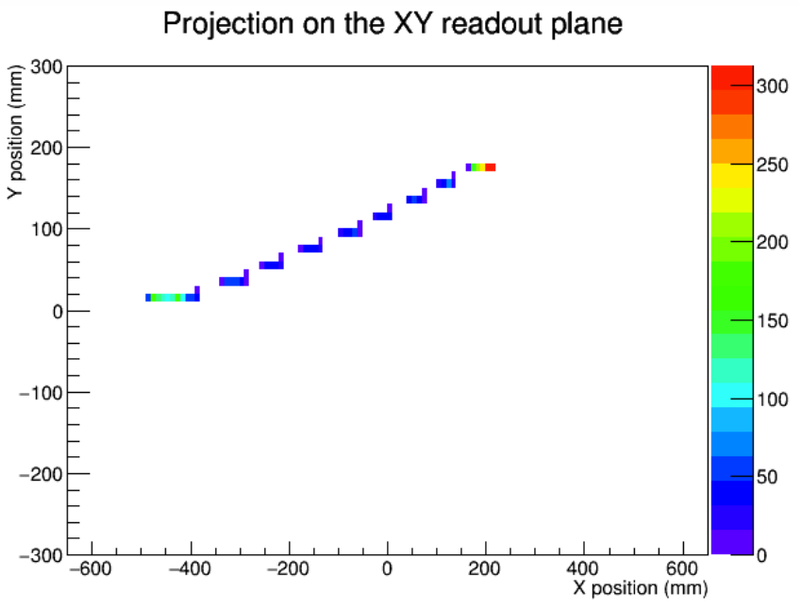
Event displays from neutrino interactions

Example of GENIE event

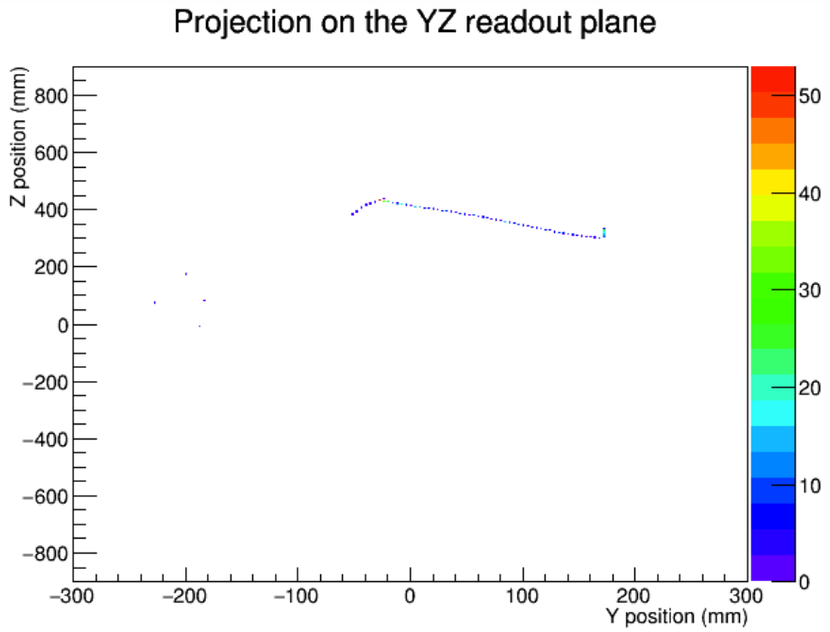
CCQE event: muon + proton

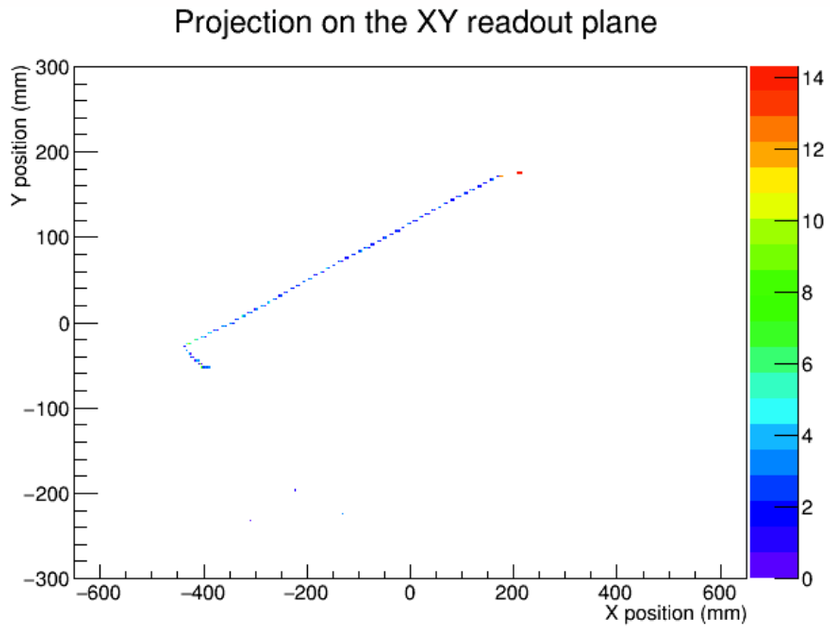
FGD-horizontal



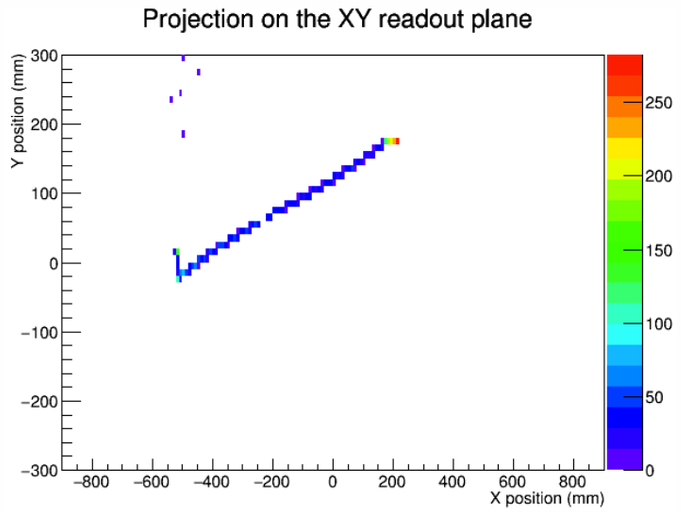


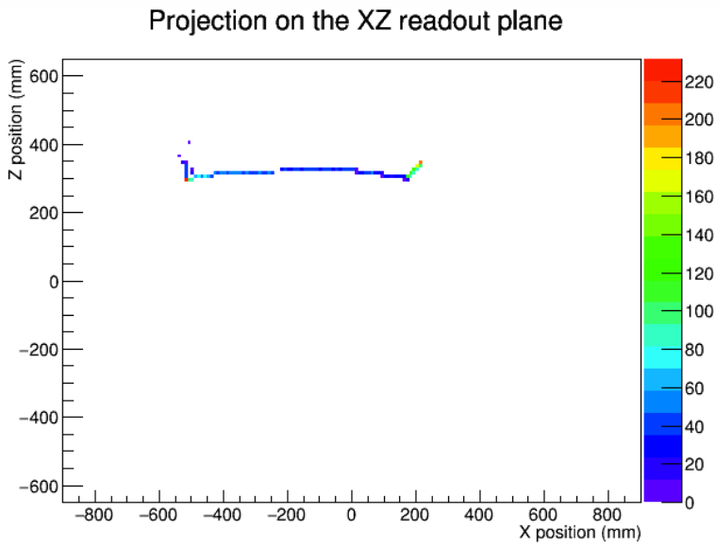
SciFi

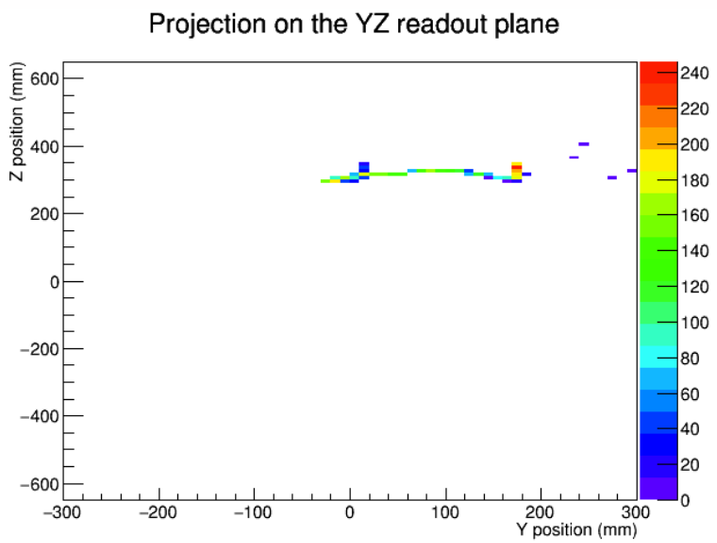




SuperFGD







- Next step: reconstruct real events (PID, momentum)

Conclusion and plans

• A full simulation of several target detectors is available in the ND280 upgrade simulation framework

• Detector response is fully implemented

• Available for all the target detectors proposed so far

• See next talk for simulation of WAGASCI and FGD3D

• Working on additional debugging and validation

• Will start working on the simplified event reconstruction: PID, momentum resolution but no pattern recognition (at least at the beginning)

• Simplified reconstruction should be rather simple: can use code used for WAGASCI stand-alone studies, but also implementation would require a limited amount of time

• First direct comparison of different target detectors

• Plan to perform the first ND280 upgrade + real target simulation (could be done in parallel) and use the reconstructed event in selection --> BANFF --> OA

BACKUP