# Background study : muons from the upstream rock

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Naho Tanimoto (Duke)

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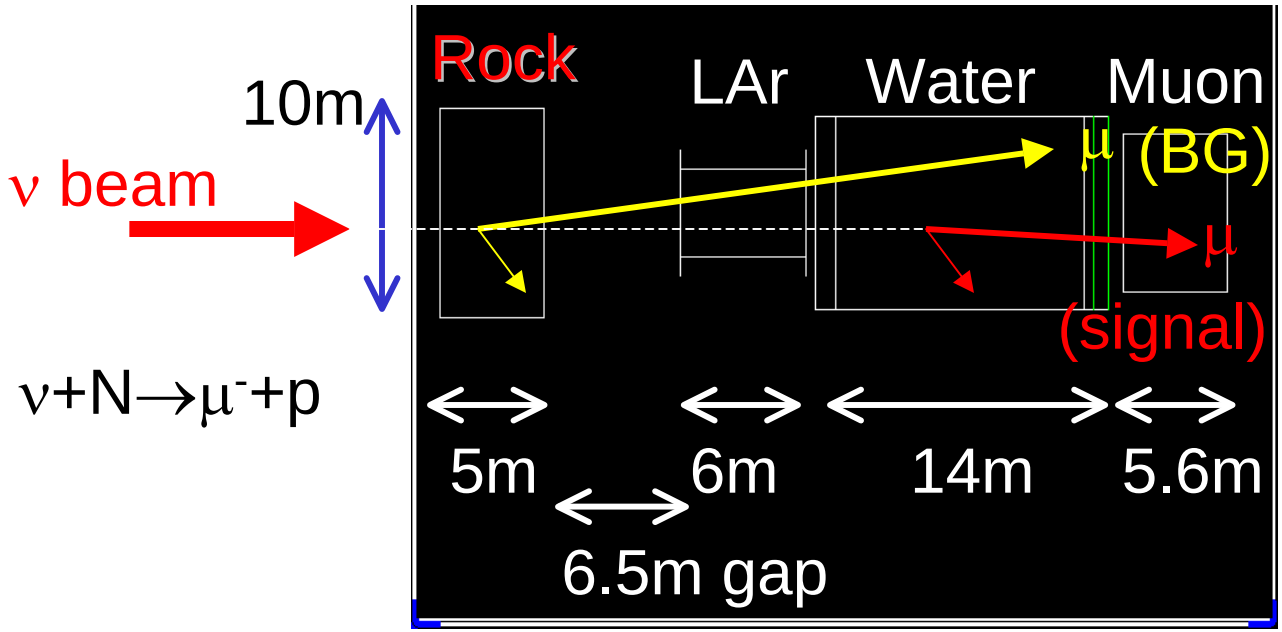
# Introduction

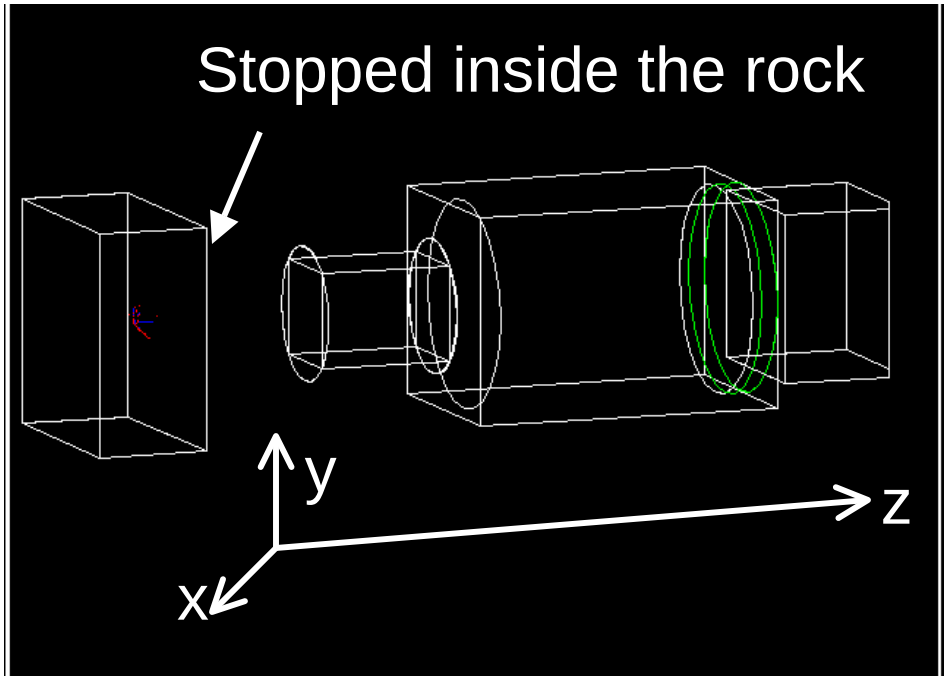
- Since Water Cerenkov detector can not detect more than one neutrino interaction per spill, it is important to make sure the fraction of muons coming from rock
  - SIGNAL : $\mu$ interaction in the WC
  - BG : $\mu$ from the rock hit the WC
- Add concrete block (10m×10m×5m) upstream side in experimental hall of T2K

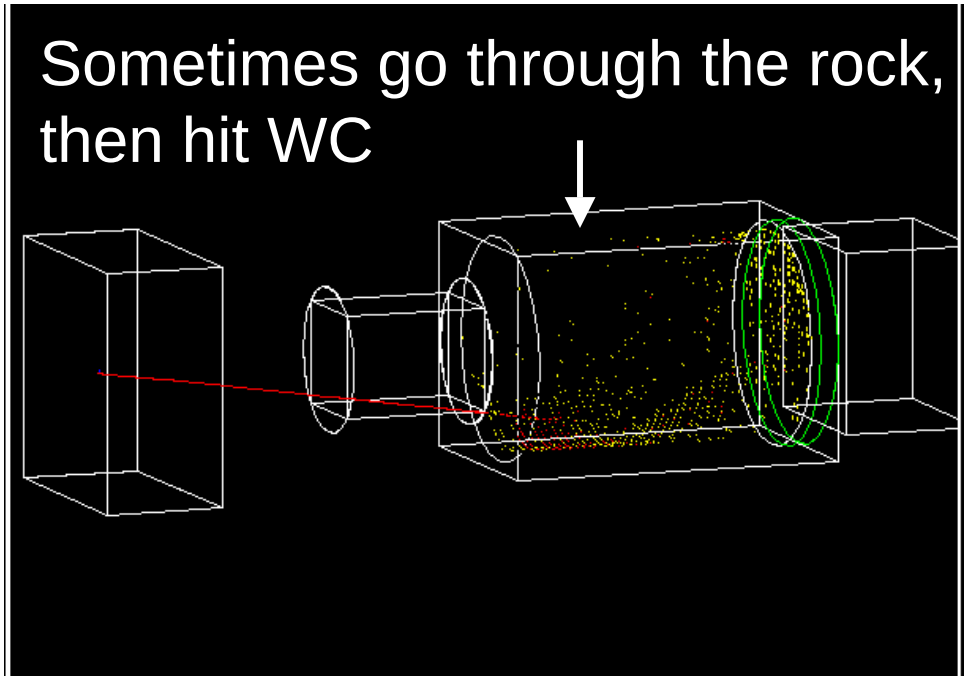


# Material of Rock

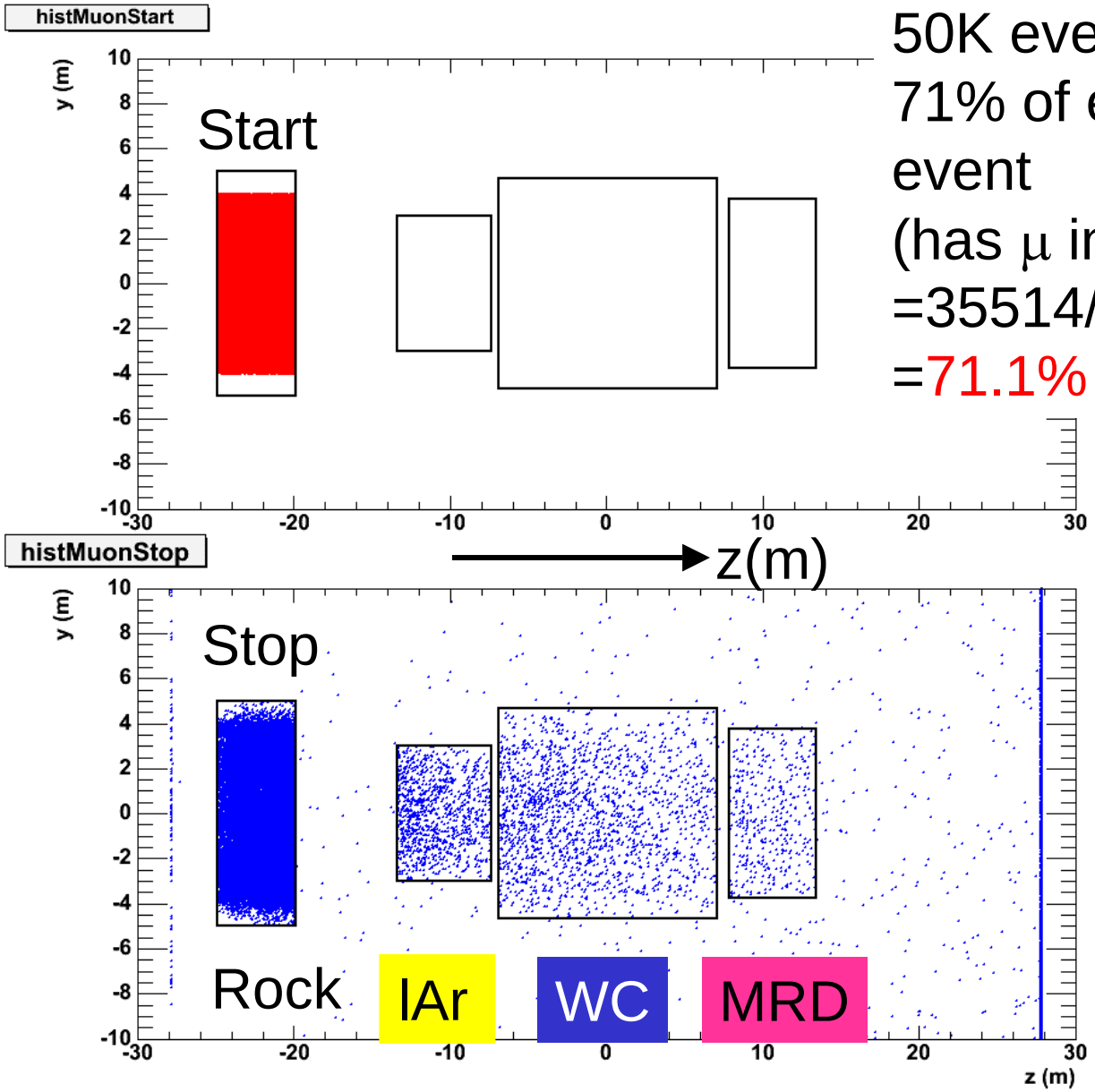
- Material of Rock is $SiO_2$, density = 2.7 g/cm$^3$, dE/dx=1.7 MeV*cm$^2$/g
- 2.7×1.7=4.59 MeV/cm=0.46 GeV/m

  Muon loose ~0.5GeV of energy per 1 m
- 5m thickness →2.5GeV muon can go through ~5 m, then stop
- Muon has proper momentum distribution (peak at ~0.4 GeV) and its vertex is set to inside the rock



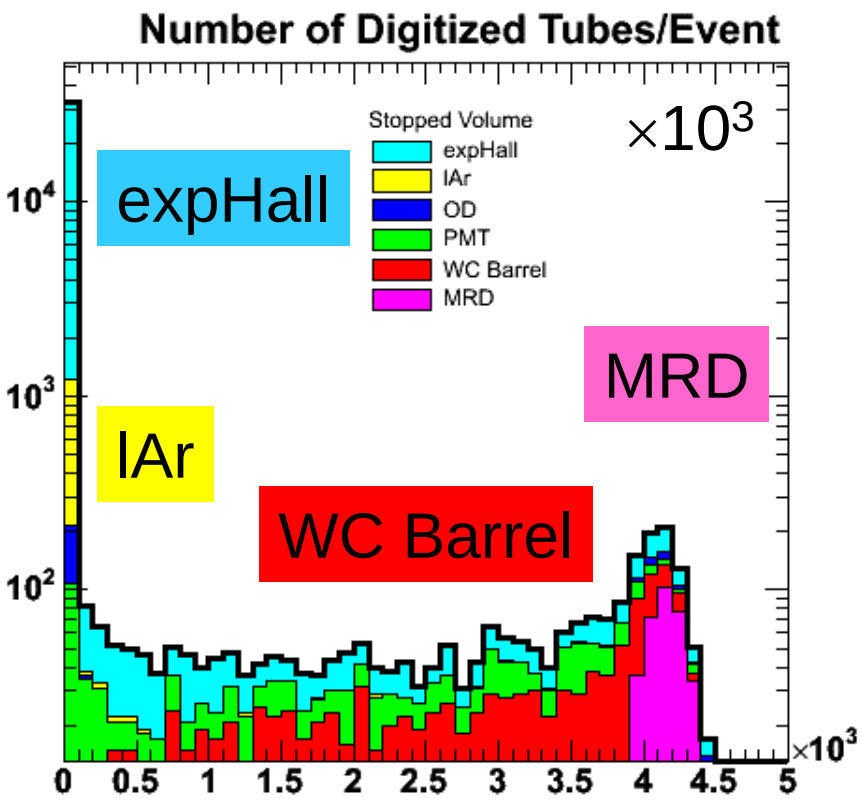



# Start and Stop positions of muon

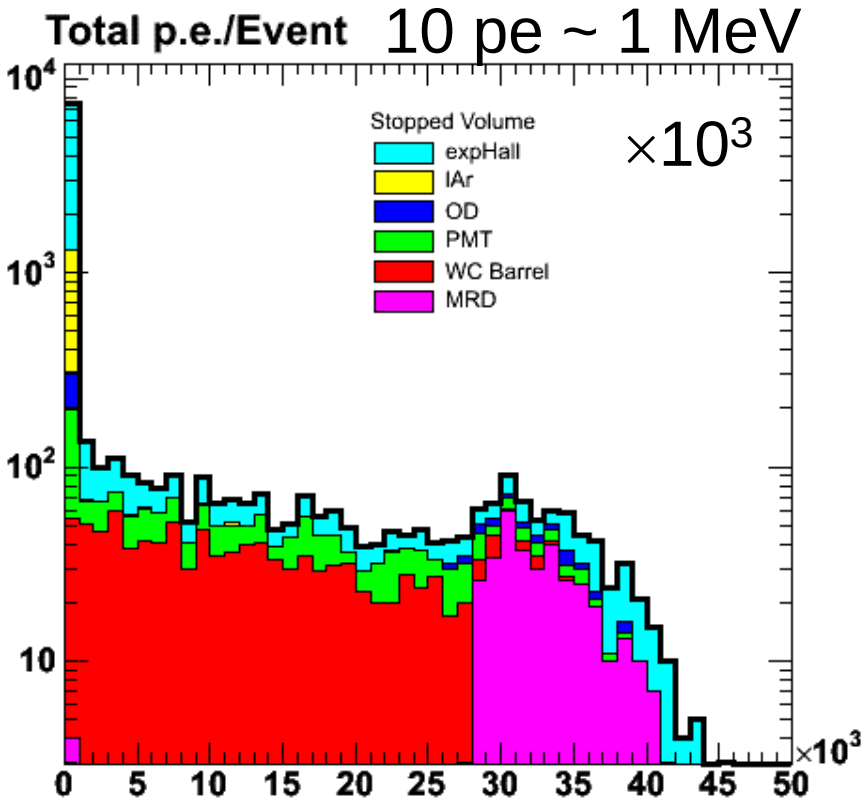



50K events are generated
71% of events has muons in event
(has μ in event)/(generated)
=35514/49970
=71.1%

# Digitized tubes




# of digitized tubes in event




p.e. in tubes

✓ (Has digitized tubes at least one in event) / (generated)
= 2917/49970 = 5.8%

✓ # of tube or p.e. cut probably <u>won't work</u> to reduce BG of μ from rock. May need OD to identify incoming muons

# Overlapping rate of μ from rock in WC

- Interaction rate : 1 interaction/ spill / 1000 tons of water
- For rock :

  10m×10m×5m = 500 $m^3$ rock = 500×2.7~1400 tons of water
- In rock :

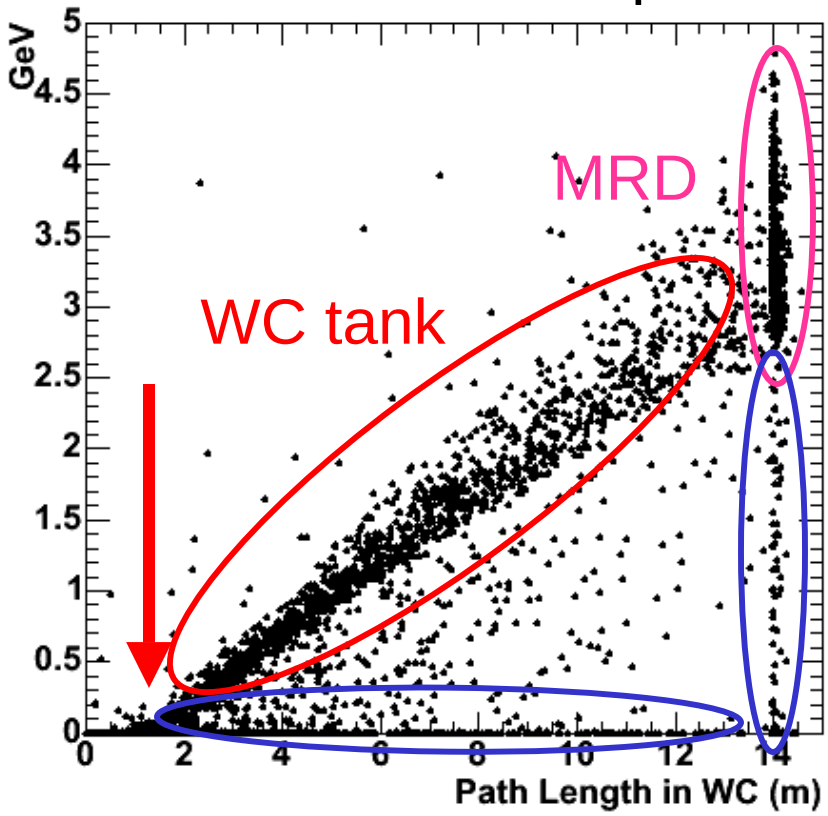
  1400 tons of water × 1 interaction/ spill / 1000 tons
  = 1.4 interaction/ spill

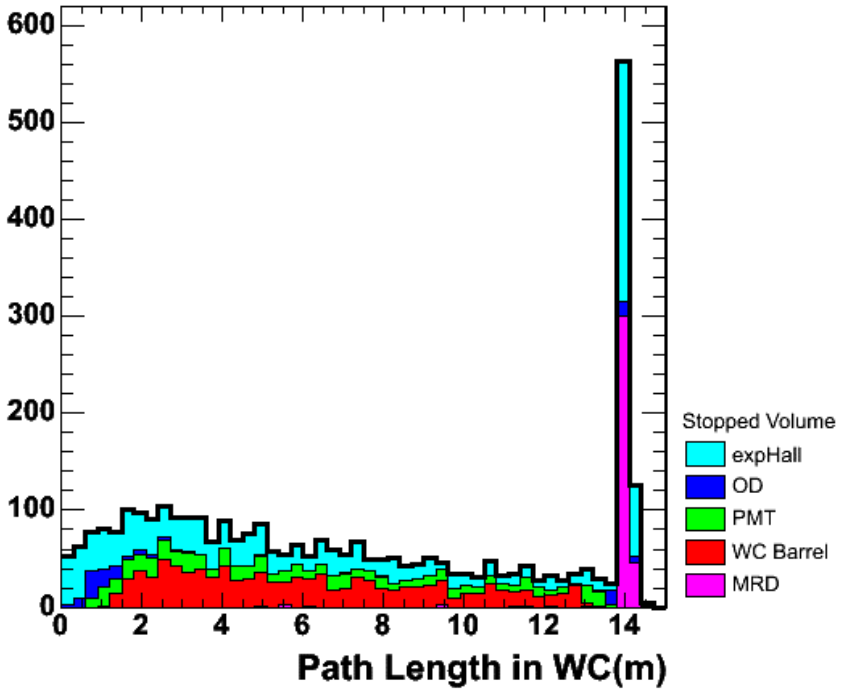
  (1.4 int/ spill) (0.058 WC events/ int)

  = 0.08 events/ spill muons come from the rock and make digitized hits in WC
- No beam structure are taken into account. Timing information may help to reduce the BG

# Path length of muons in water tank

## Correlation between path length and charge(p.e.) in water tank



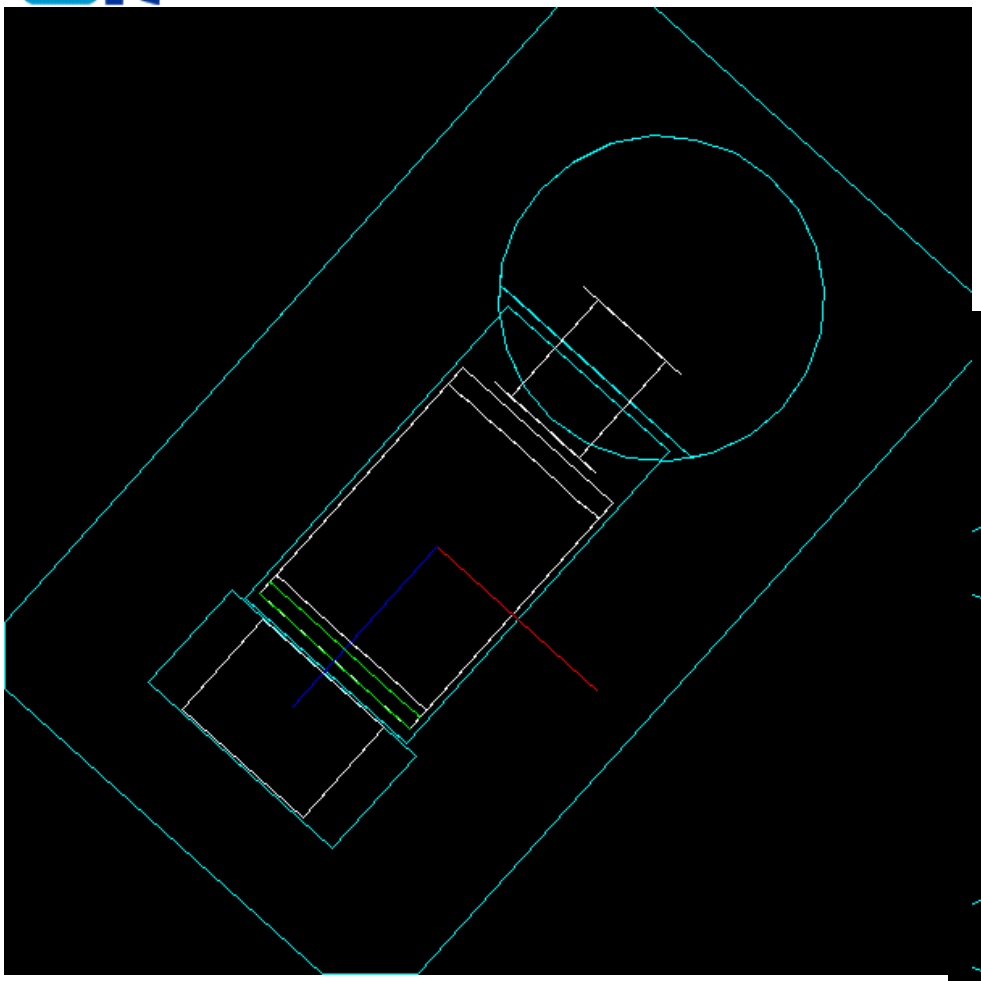




Experimental hall

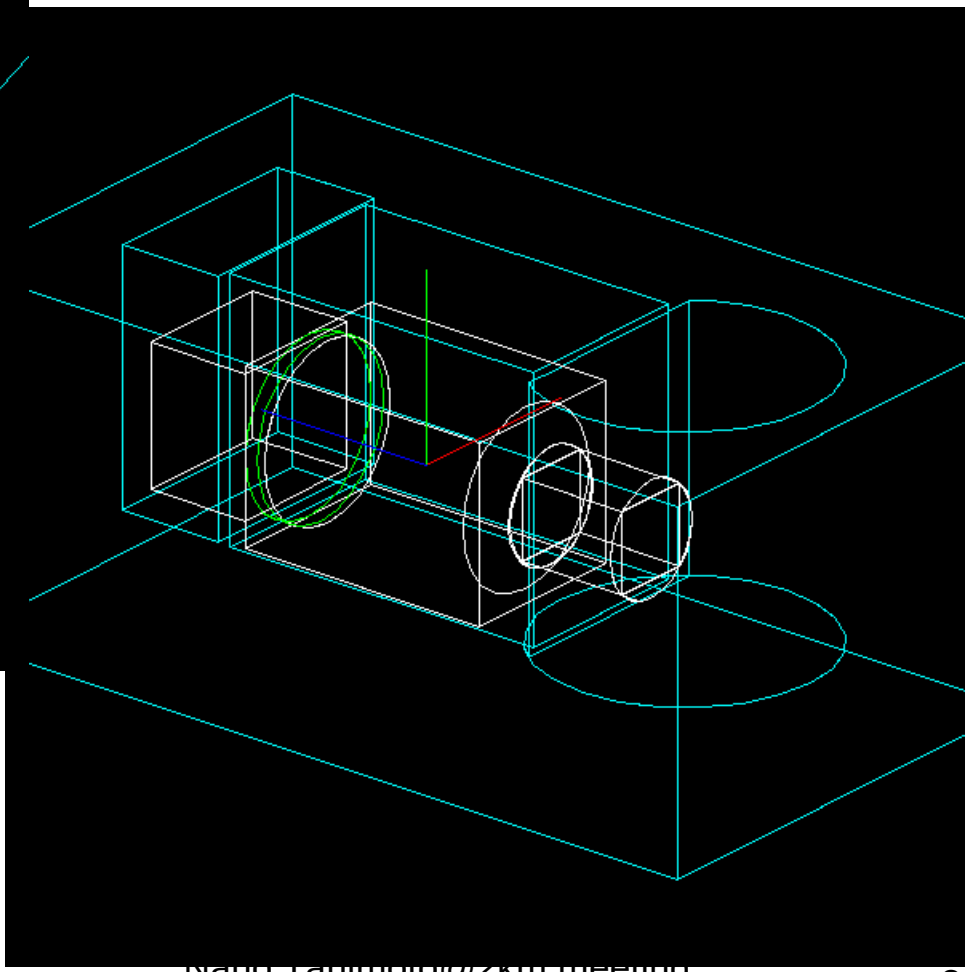
✓Charge ∝ path length (x) : can measure E(μ) with dE/dx

✓Need at least ~1.5 m to make a Cerenkov light. It may get worse the energy resolution

# Current status of Rock Walls

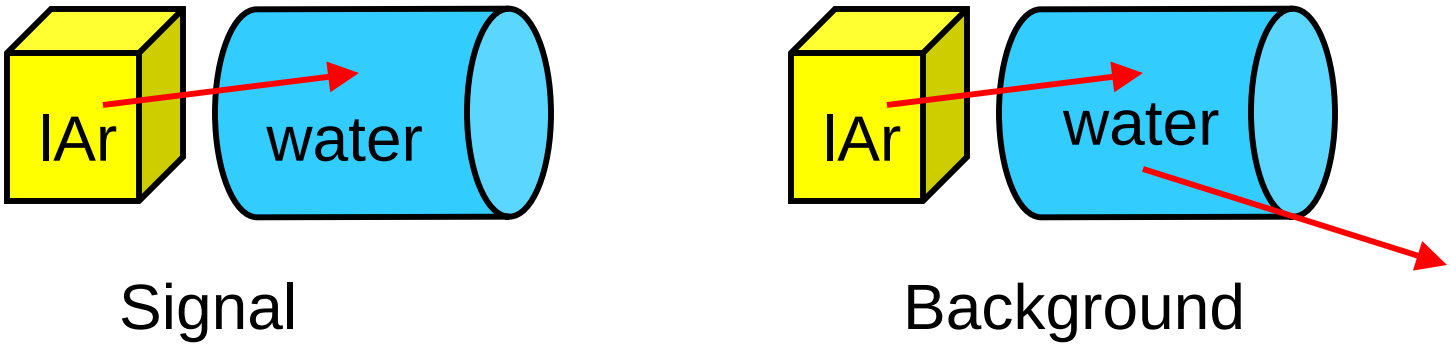


Still need to work…



# Muons from the lAr

- Muons from the lAr are also the BG




Signal Background

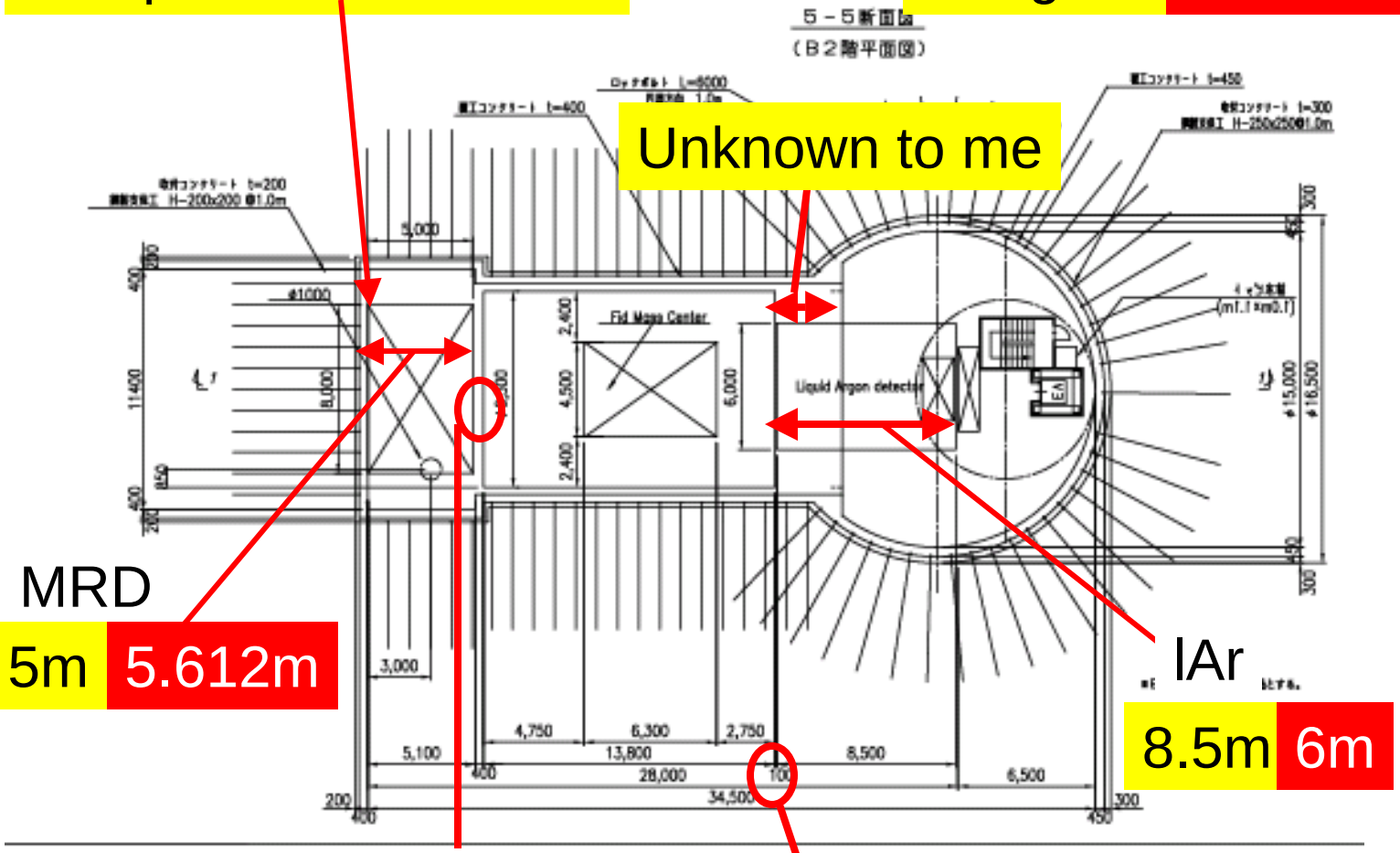
lAr : vertex + track info→ path length(x)→ $E(\mu)_{lAr}$

$E(\mu)_{total}=E(\mu)_{lAr} + E(\mu)_{water\ tank}$

# Differences between construction diagram and G4

No space behind MRD

designed Current in G4




MRD

5m 5.612m

lAr

8.5m 6m

Gap between MRD & WC

50cm 74cm

Gap between WC & lAr

10cm 50cm

# Conclusion and plan

- I calculated the event rate which muon coming from the upstream rock hit the water tank, 0.08 events/ spill
- The number of minimum tube or p.e. cut probably won't work to reduce BG of $\mu$ from rock
- Calculated the path length of muon in the water tank. This becomes a good cross-check tool of E($\mu$)
- Constructing Rock walls around the detectors, I found some discrepancies between the first proposal and current G4 constructed ones
- I will finish to construct walls soon and estimate the background from the muons from lAr detector as well