Some homework and nominal configuration

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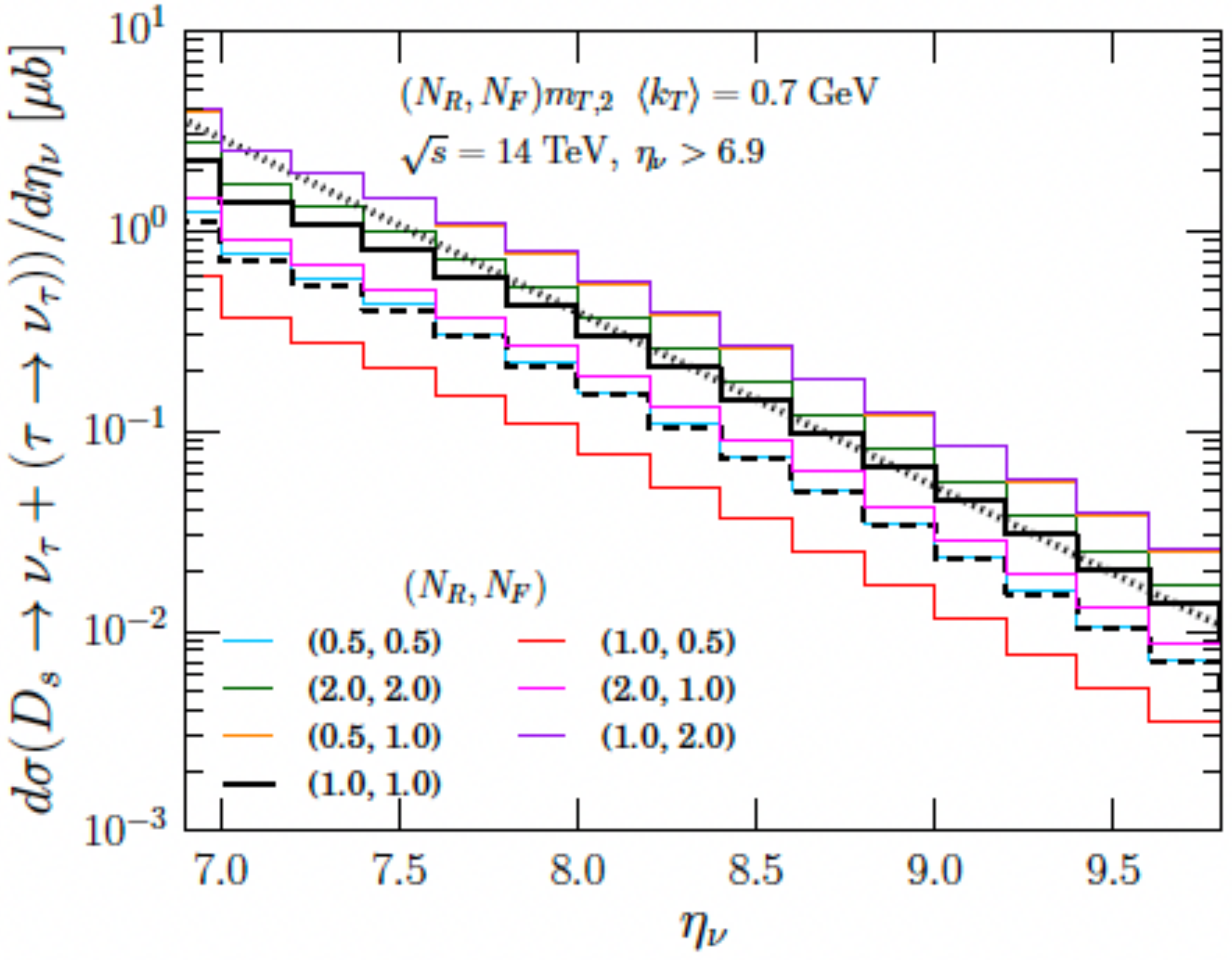
Section for NF10 Snowmass has been drafted and posted. Please send me comments. To be sent to Snowmass conveners by Monday



This is largely a geometrical issue.

At high rapidity, the lower right plot shows that the rapidity distributions for different scale combinations have a common behavior (i.e., the same shape) as a function of rapidity, and they only differ among each other for the normalization. The dotted line corresponds to the analytical formula

$$\frac{d\sigma}{d\eta_\nu} \simeq \Big(0.214\ \mu\text{b}\Big)\, e^{-2(\eta_\nu - 8.3)}\,. \tag{3.1}$$

This represents the central scale histogram values to within $\pm 5\%$ for $\eta_\nu > 8.3$ in Fig. 11, but eq. (3.1) lies above the histograms in the lower right panel for $\eta_\nu < 8.3$. The scaling behaviour at large η_ν appears to be a universal feature, independent of N_R and N_F for $(N_R, N_F) m_{T,2}$ scales when $\eta_\nu > 8.3$.

We probe the functional behavior of $d\sigma/d\eta_\nu \sim e^{-2\eta_\nu}$ for $\eta_\nu > 8.3$ with the following considerations. We consider a cylindrical detector at a distance D_d from the interaction point, aligned and centered along the beam axis (z-axis), "on-axis," for which the minimum detectable η_ν is labelled as η_1. Given the relation between the pseudorapidity and angle θ relative to the z-axis, the cross sectional area of the detector is

$$A_d(\eta_1) \simeq 4\pi D_d^2 e^{-2\eta_1} \tag{3.2}$$
$$= D_d^2 \Omega_\nu(\eta_1)\,, \tag{3.3}$$

where $\Omega_\nu(\eta_1) \equiv 4\pi e^{-2\eta_1}$ is the approximate solid angle enclosed by a circle around the z-axis for which the angle θ relative to the z-axis corresponds to η_1 and is a distance D_d from the interaction point. The functional form of $d\sigma/d\eta_\nu$ in eq. (3.1) is therefore related to $\Omega_\nu(\eta_\nu)$. We will come back to this point in our evaluation of the number of events per ton of target (see Section 4.2), which depends on the transverse area and the depth of the target. The scaling of $d\sigma/d\eta_\nu$ with $A_d(\eta_\nu)$ for large η_ν has already been noted in Ref. [46].

Some issues to be settled for nominal configuration

Energy resolution requirement

HADCAL and Muon tagger requirements

How deep should be HADCAL and is there a strategy for muon momentum determination

Can the TPC be used for momentum determination for the muon ?

What is the benefit to muon charge determination ?

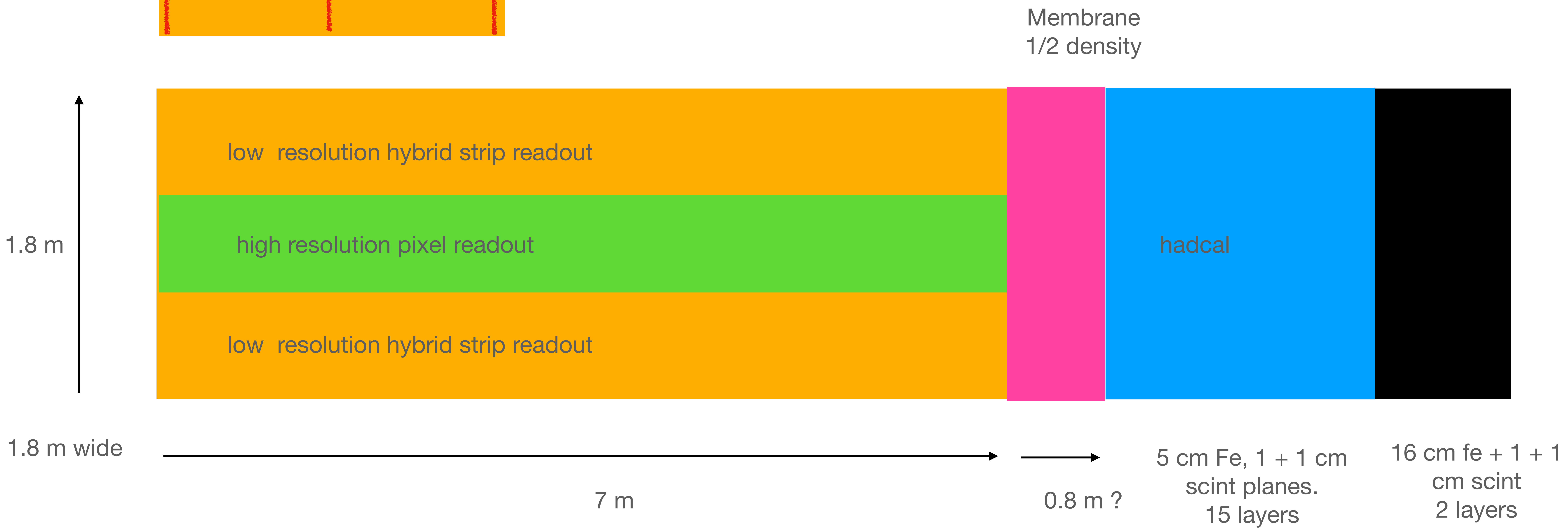
Acceptance of muons into FASER magnet

Technical issues: space above the cryostat ? - MVD+ Resnati.

Nominal configuration

To be detailed in a spread sheet and developed into a detail for a conceptual design.

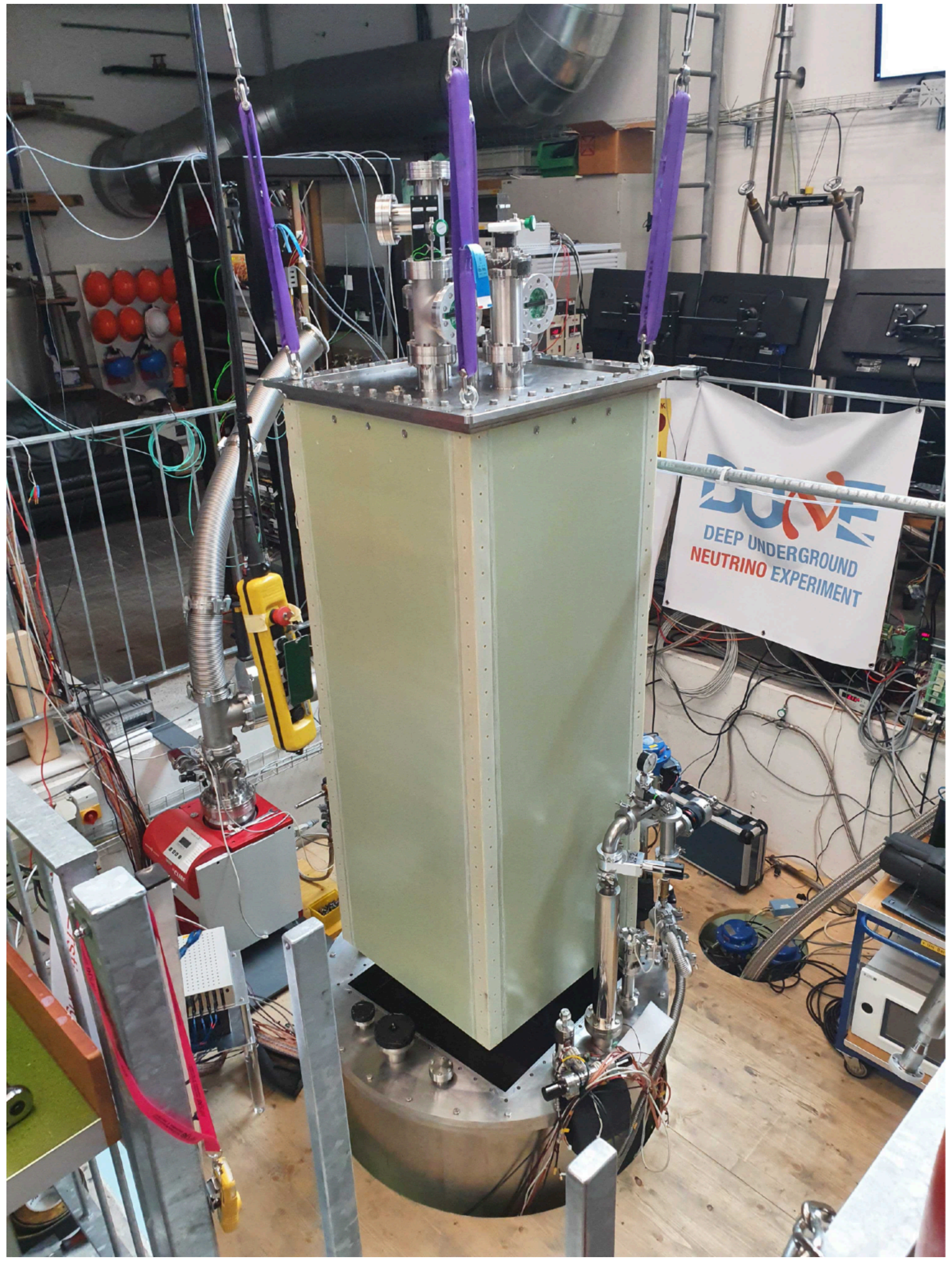
- Cryostat outer dimensions 3.5 m x 3.5 m x 9.6 m
- Insulation thickness 0.8 m (including corrugations)
- Detector dimensions: 1.8 m x 1.8 m x 7 m
  - confirmed that this size detector is good enough for containment.
- Fiducial volume: 1 m x 1 m x 7 m
  - Length might be adjusted based on further optimization
- Preference for a modular design based on DUNE near detector
  - Modular design allows flexibility regarding gap thickness given the muon rate might be poorly known or change during the HL-LHC running.
  - Two options: modules 2 X 7 array or 3 x 7 array
  - Module dimensions (0.9 m x 1 m with gap: 0.45 m) or (0.6 m x 1 m with gap: 0.3 m)
  - Anode design: pixellated in the fiducial region, same anode can be used for both modular options.
    - fiducial: 1 m x 1 m with 5 mm pitch => 80000 channels per module.
    - non fiducial: 2 x 0.4 m x 1 m with 10 mm pitch => 16000 channels per module.
  - Photo sensor design: either bare SiPM or use the x-ARAPUCA technology => ~ 50 channels per module.
  - The modular design leaves flexibility open for new designs for photo-sensors.
- DOWNstream cryostat wall ?   80 cm
- HADCAL: 2 m X 2 m x (5 cm Fe + 1+1 cm scint, 15 layers)   x   (1.05 m)
- MuRange: 2 m x 2 m x (16 cm Fe + 1 + 1 cm scint, 2 layers) x   (0.36 m)

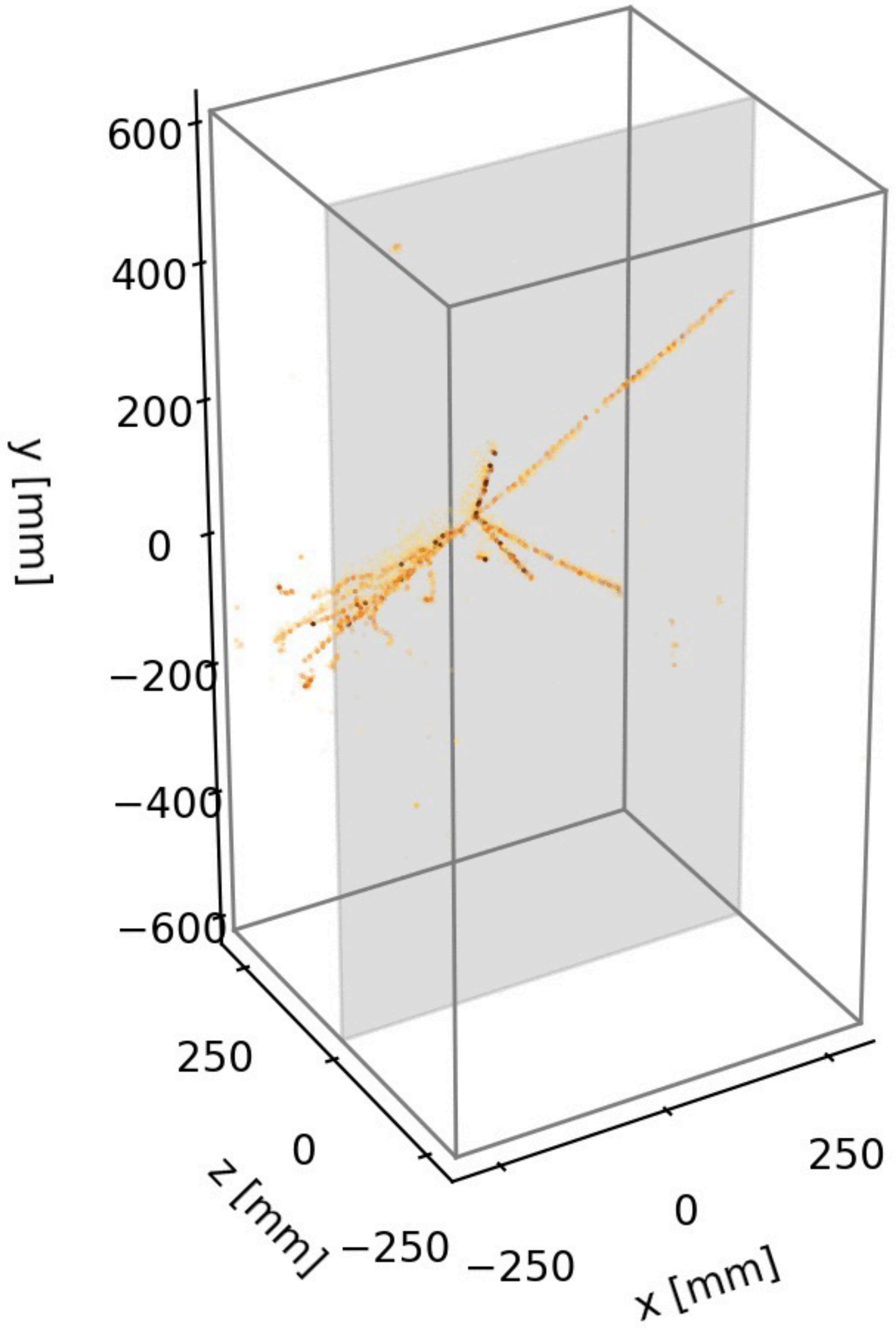


Carry two options into Conceptual Design

either 2 X 7 modules with 0.45 m gap
or 3 x 7 modules or with 0.3 m gap

Benefit from the DUNE near detector design
See Dan Dwyer talk from March 3, 2022





Facilities

There is now huge capacity at BNL for cryogenic detector R&D