HCAL Design

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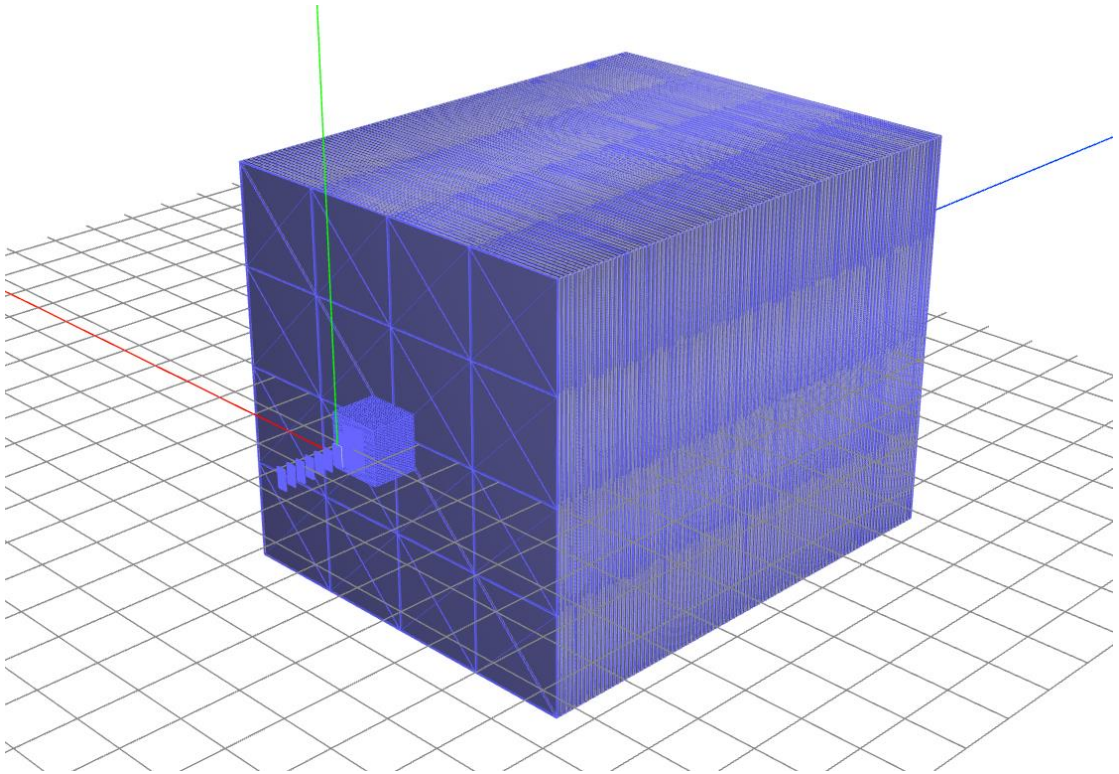
Target of DarkShine HCAL

- Most charged decay products could be detected by ECAL
- Neutral hadrons could be missed and fake signals
- Muons could only be fractionally reconstructed and fake signals
- Conclusion: Veto **neutrons** and **muon** tracks

DarkSHINE HCAL Annals

- 2019-2021 4mx4mx4m HCAL



Absorber thickness: 30mm per layer

Total layers: 100

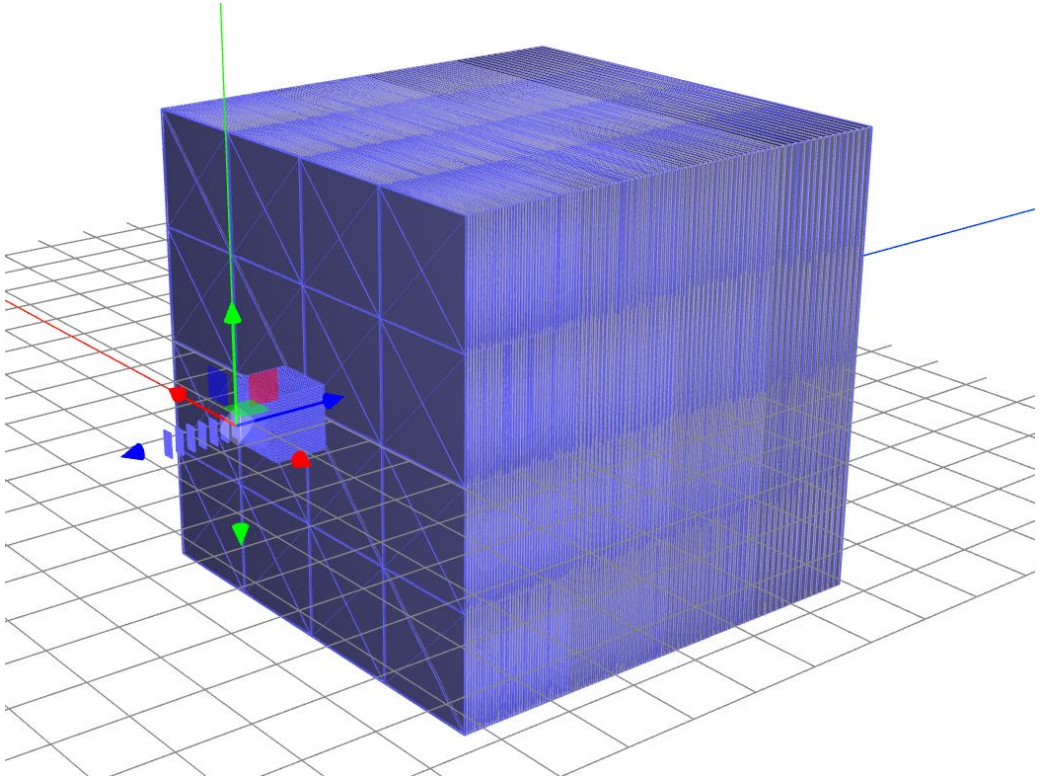
Total Fe length: 100*30 = 300 [cm]

Total radiation length = 17.86 λ

DarkSHINE HCAL Annals

https://www.overleaf.com/project/627b8abcd36dae4ae051d787

- 2021-2023.2 Baseline 1.5 HCAL



Absorber thickness:

- -40(layer)*0.5(cm)
- -25(layer)*2(cm)
- -20(layer)*3(cm)
- -15(layer)*5(cm)

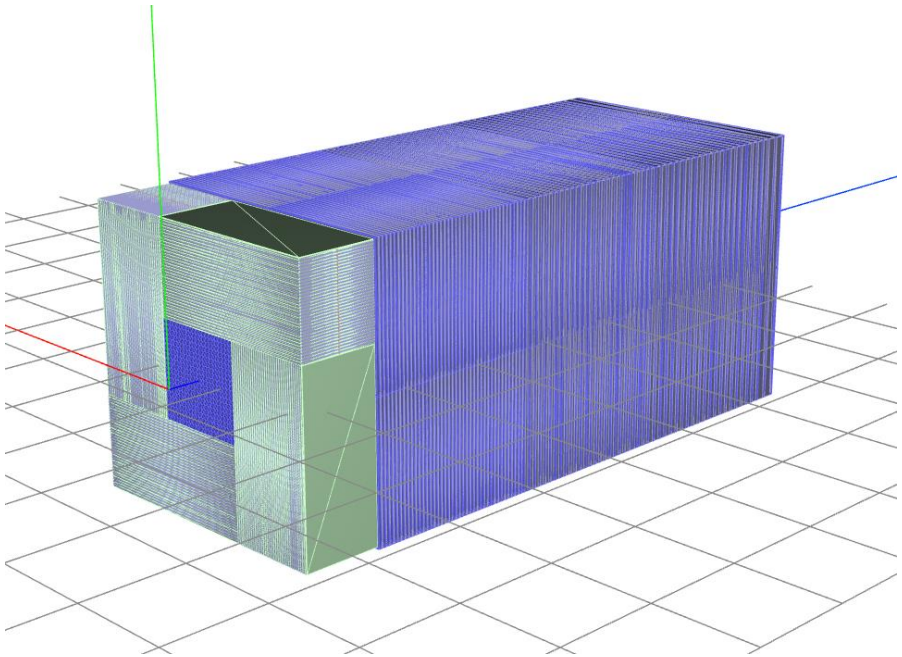
Total layers: 100

Total Fe length: 100*30 = 205 [cm]

Total radiation length = 12.2 λ

DarkSHINE HCAL Annals

- 2023.2-now Baseline 1.6 HCAL



Main Body:

Absorber: (40*0.5 + 25*2 + 20*3 + 1*5)*150*150*7.86 = **23.87** ton

Sensitive: 86*150*150*1*1.03 = **1.99** ton

Side :

Absorber: 33 * 0.5 * 45.511 * 105 * 7.86 * 4 = **2.48** ton

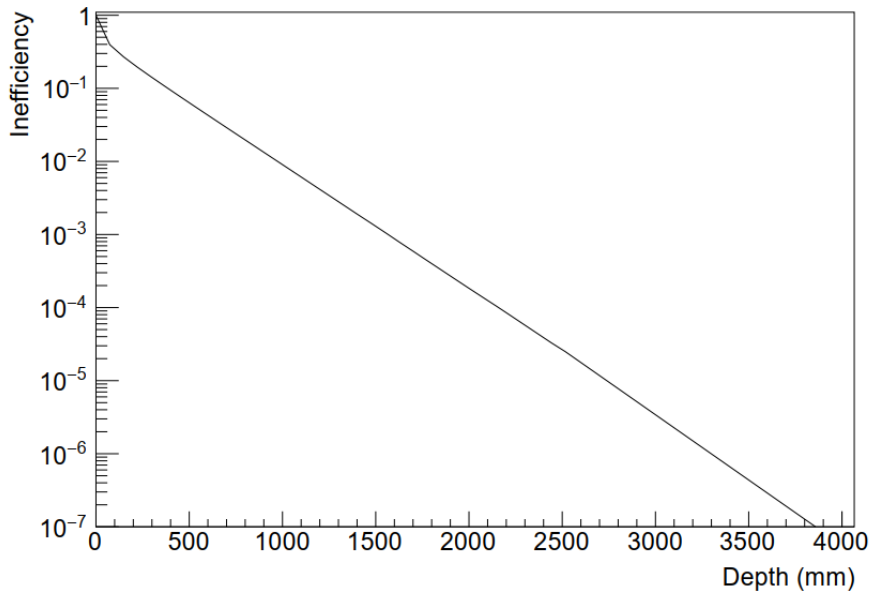
Sensitive: 33 * 1 * 45.511 * 105 * 1.03 * 4 = **0.65** ton

Total: 23.87 + 1.99 + 2.48 + 0.65 = **28.99** ton

Total Abs Thickness: 135 cm (~8λ)

Goal

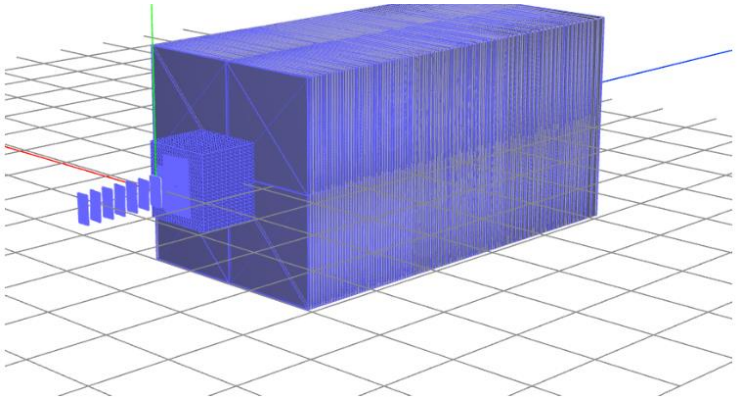
https://arxiv.org/abs/1808.05219



- How many neutron could be detected ?
- How many neutron would be missed ?
- Veto inefficiency : $\frac{N_{miss}}{N_{all}}$ (# of events missed divided by # of events all) (0.1 MeV max_cell energy, 9.52 MeV total energy)

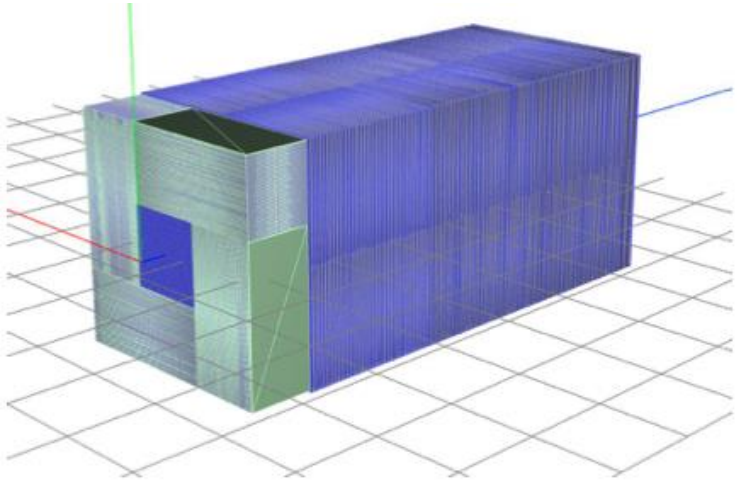
Performance Study

Reference:
Baseline 1.5 HCAL (4m * 4m * 3m)



1.5m*1.5m HCAL

Total Abs Thickness: 160 cm (~9.5λ)



Add Side HCAL the green part

Total Abs Thickness: 135 cm (~8λ)

Veto Ineff of neutron events

1e7 EOT

EN_Target	Total	Missed	Veto Ineff
w/ Side	1.73E-15	9.36E-17	**5.40%**
w/o Side	4.14E-15	5.30E-17	**1.28%**
EN_ECAL			
w/ Side	1.46E-15	6.59E-17	**4.50%**
w/o Side	1.90E-15	1.04E-16	**5.49%**
PN_Target			
w/ Side	4.12E-15	5.87E-18	**0.14%**
w/o Side	4.31E-15	3.41E-16	**7.92%**
PN_ECAL			
w/ Side	2.00E-14	4.09E-16	**2.04%**
w/o Side	1.74E-14	1.60E-15	**9.17%**
PN+EN			
w/ Side	2.73E-14	5.74E-16	**2.10%**
w/o Side	2.78E-14	2.10E-15	**7.55%**

New baseline HCAL

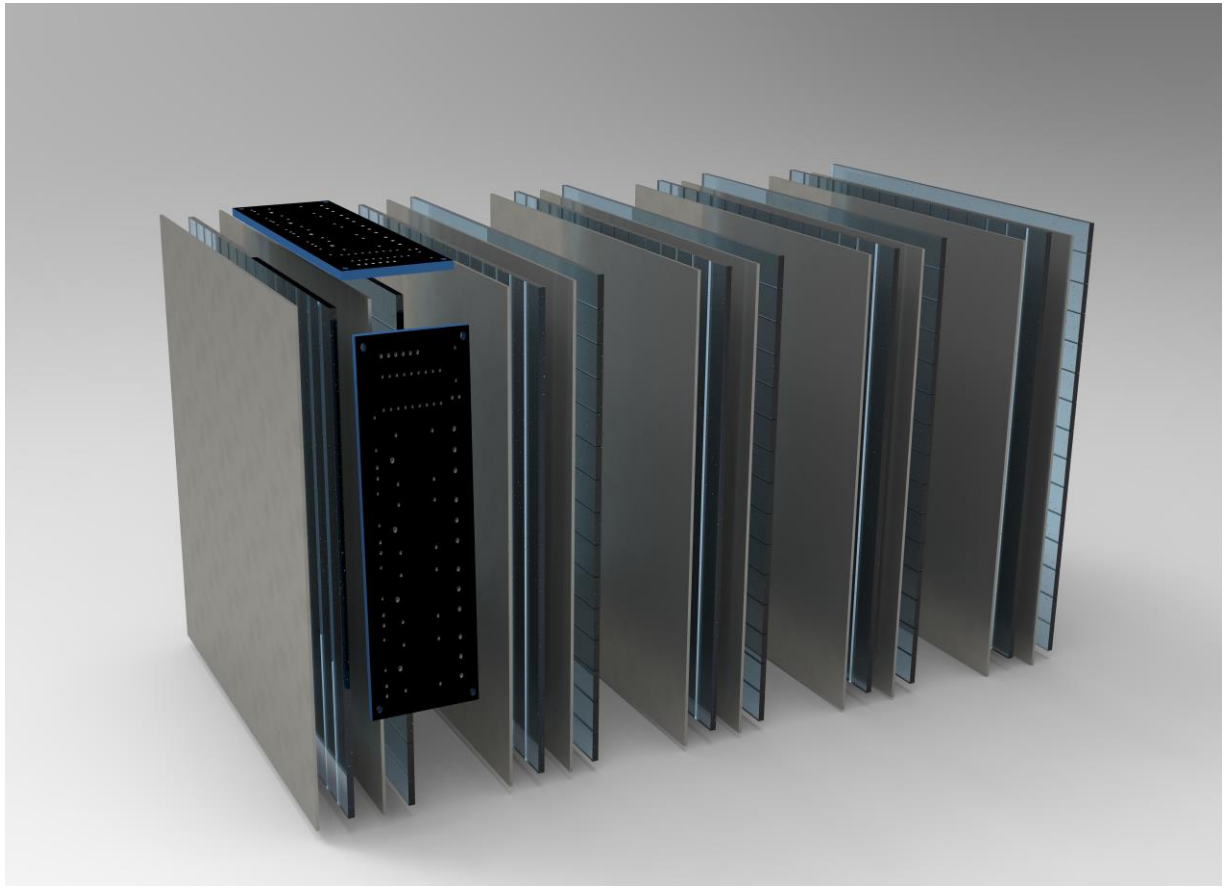
	Total	Miss	Veto ineff
EN target	1.21E-17	2.38E-19	1.97%
EN ECAL	9.74E-18	4.63E-19	4.76%
PN target	1.19E-14	1.00E-17	0.08%
PN ECAL	4.09E-14	2.34E-15	5.72%

Baseline 1.5 HCAL

Weighted veto inefficiency of different rare process with neutrons

Can achieve better veto inefficiency with side HCAL built

HCAL Module Study



10 layers in total:

Each layer:
75*75*0.5 [cm] Absorber
+ 75*75*1 [cm] Scintillator (XY crossing)

Scintillator layer:
75*5*1 [cm] * 15 per layer
XY crossing

Summary & Plans

- We stick to design of 1.5m x 1.5m HCAL with side under 30t at most.
- Feasibility of HCAL module is studied simulation framework is built.
- Unit test purchase contract is ready
- Plans:
  - Finish unit test at lab by the end of 2023
  - Build HCAL module in next 3 years