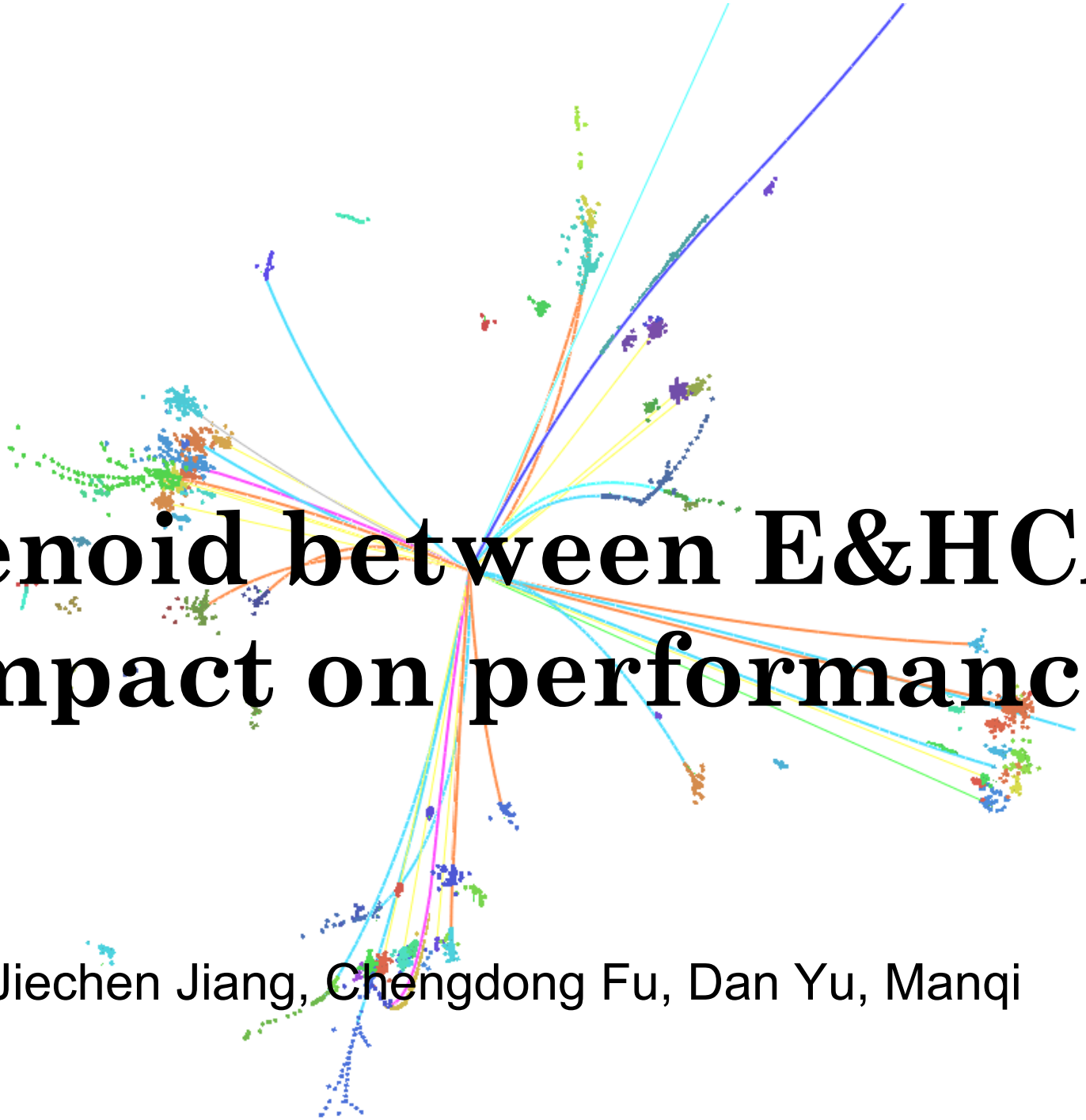
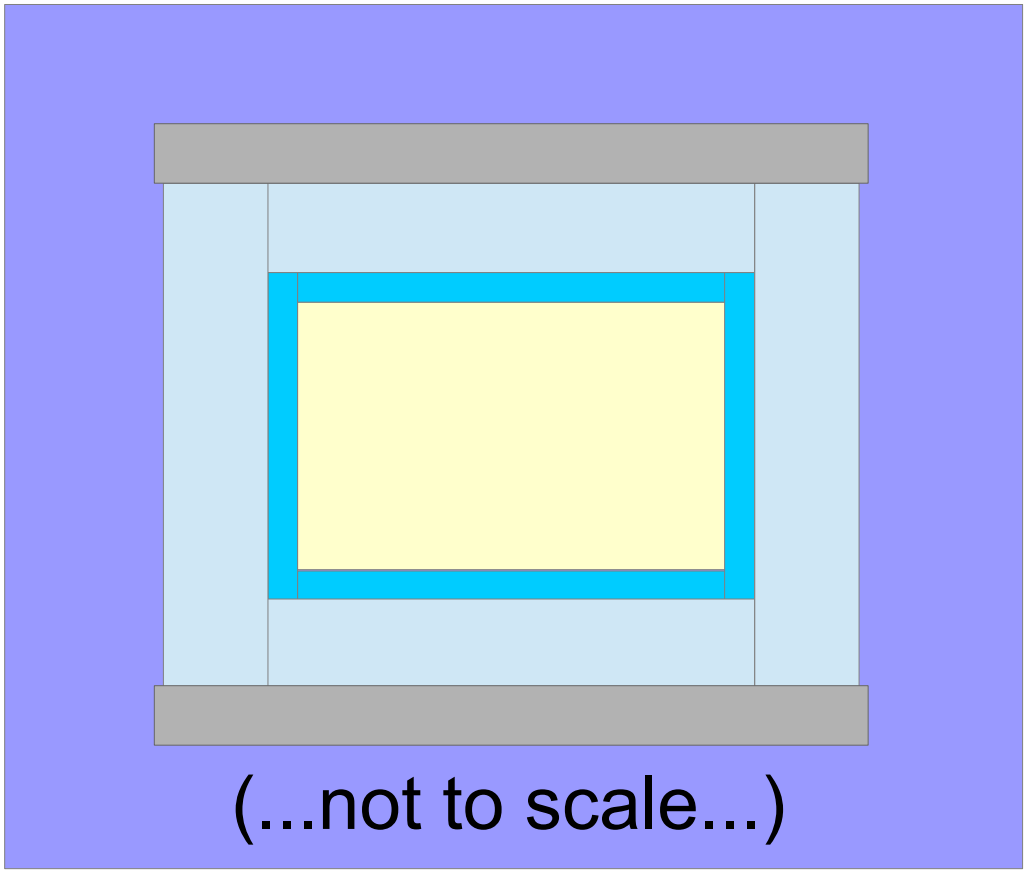
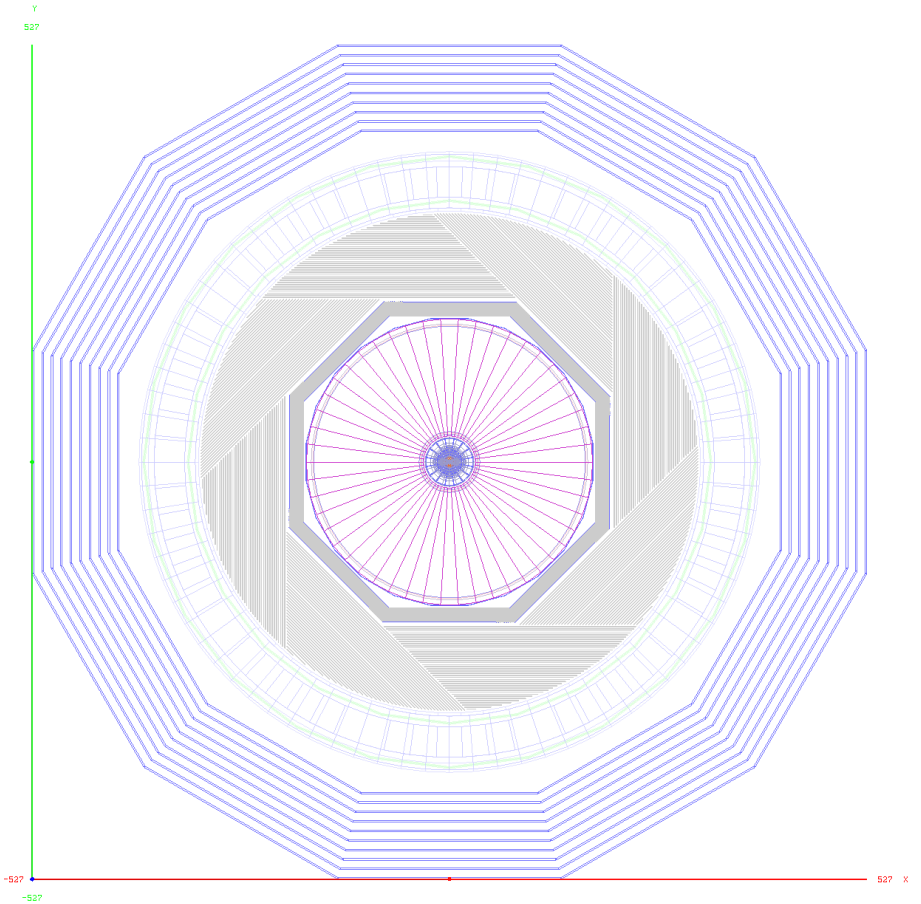


Solenoid between E&HCAL: impact on performance

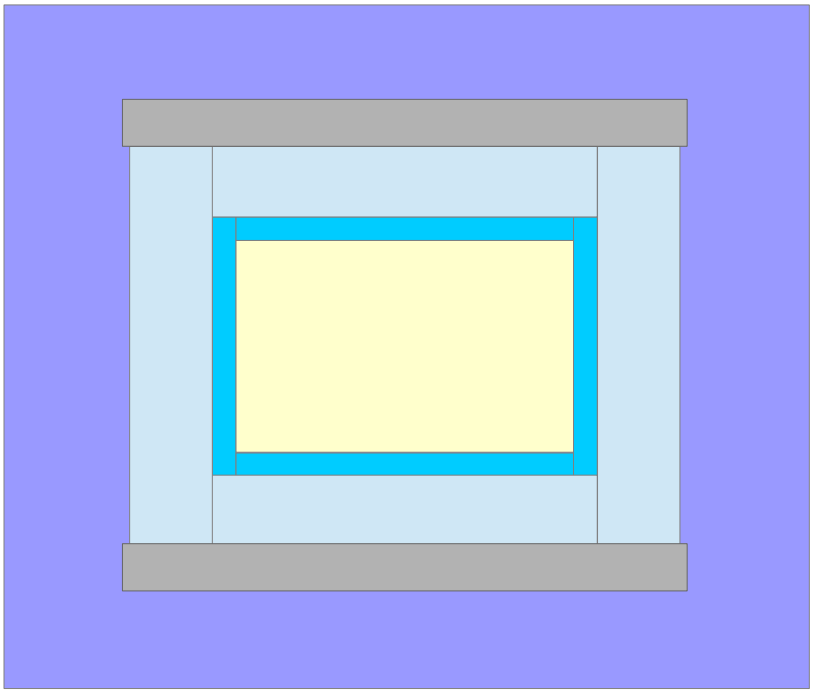
Jiechen Jiang, Chengdong Fu, Dan Yu, Manqi

Baseline Design

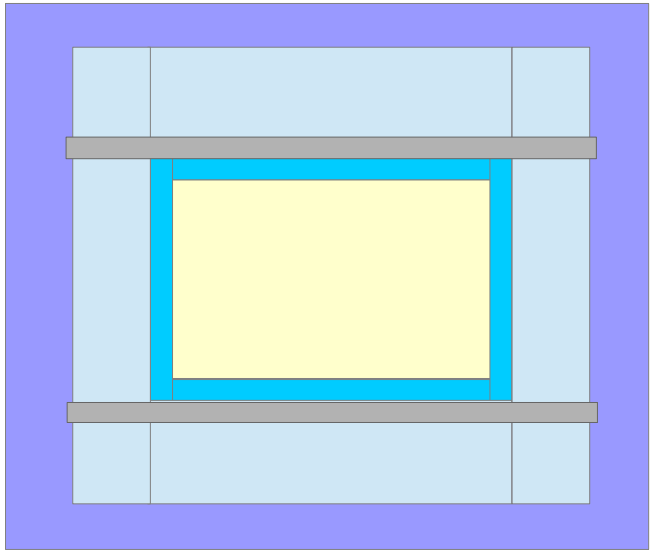




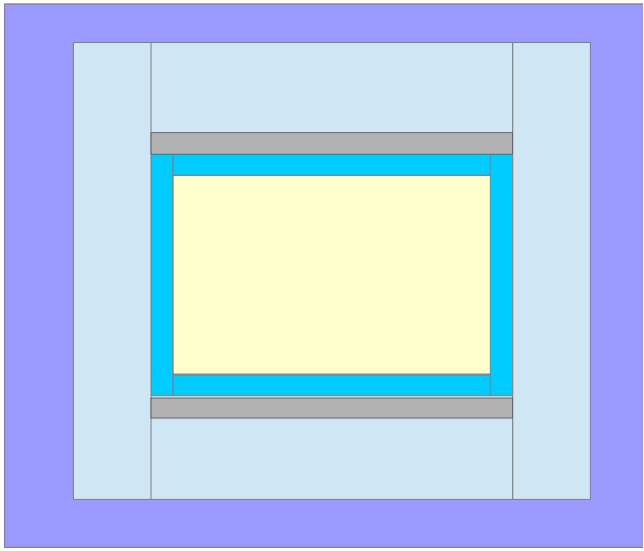
New designs



A: long solenoid



B: short solenoid

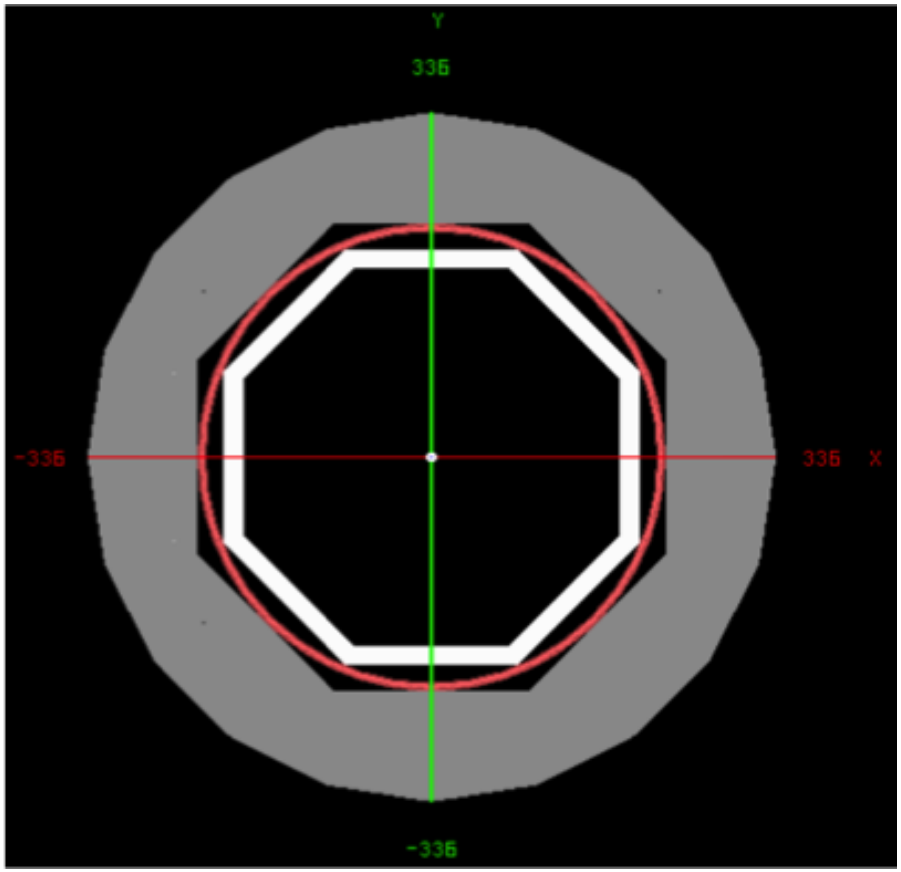


- Long/short solenoid between E/HCAL: saving cost on reduced solenoid & Yoke, while the HCAL cost increases (once ECAL/Tracker fixed)
- Performance comparison between long/short solenoid
  - Short solenoid has less dead materials & worse B-Field homogeneity
  - Assume B-Field difficulties can be solved, short solenoid has better performance, and implemented in Full sim (Thanks to ChengDong!)

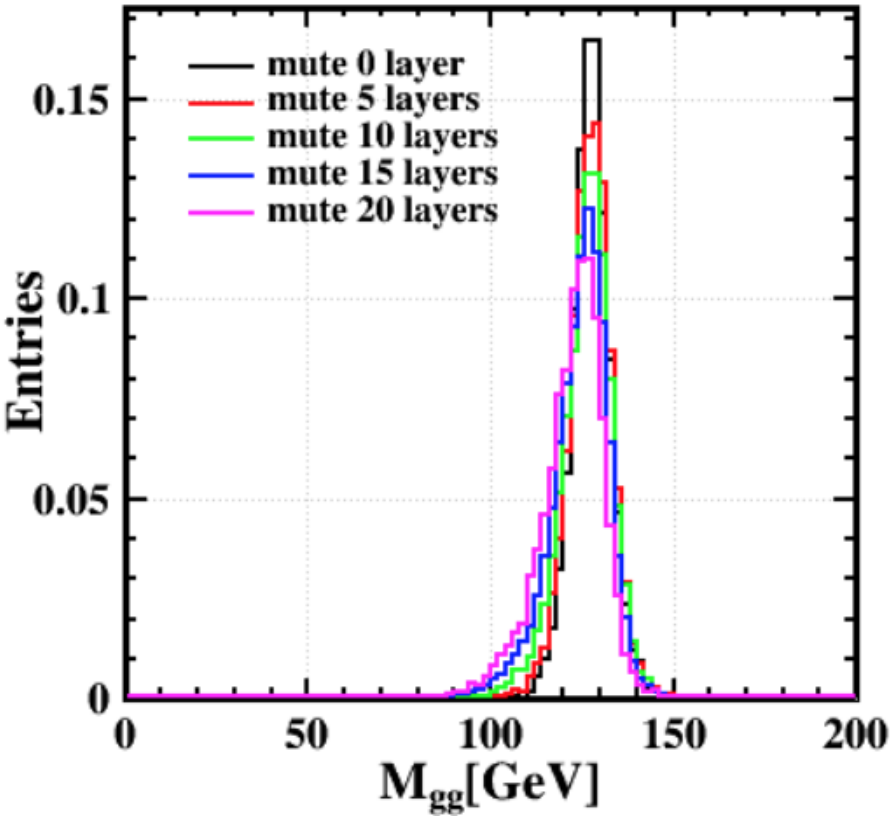
Performance & Geometry effect

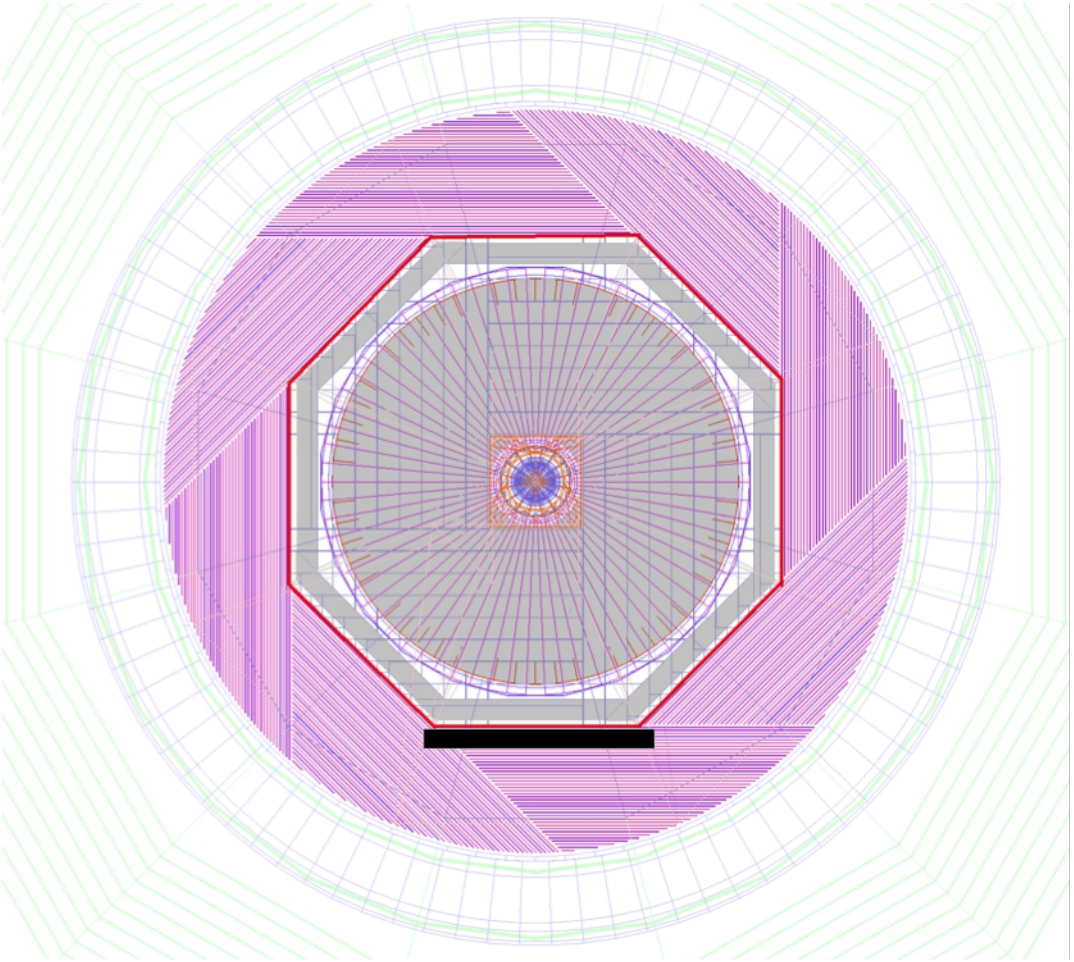
- Short solenoid w.r.t Baseline
  - No change in Track & Photon
  - No change in forward region
  - Degrade the Jet Performance (Quantified with BMR) and Pid in barrel

- BMR Degrading due to
  - Dead Material
  - Space



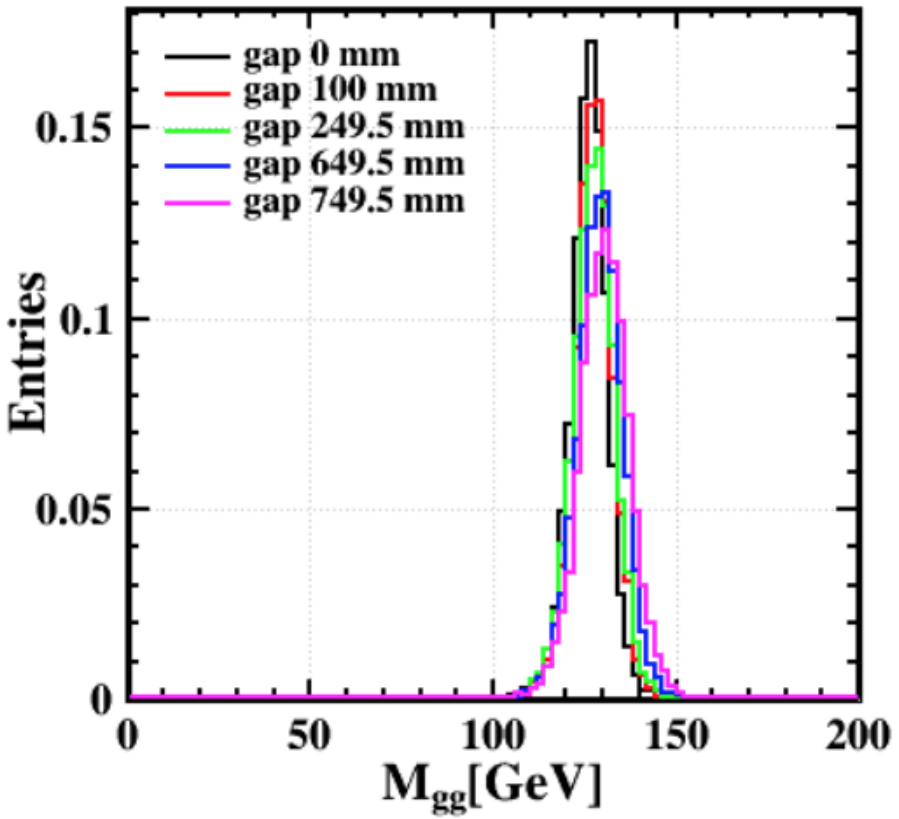
Impact of dead material

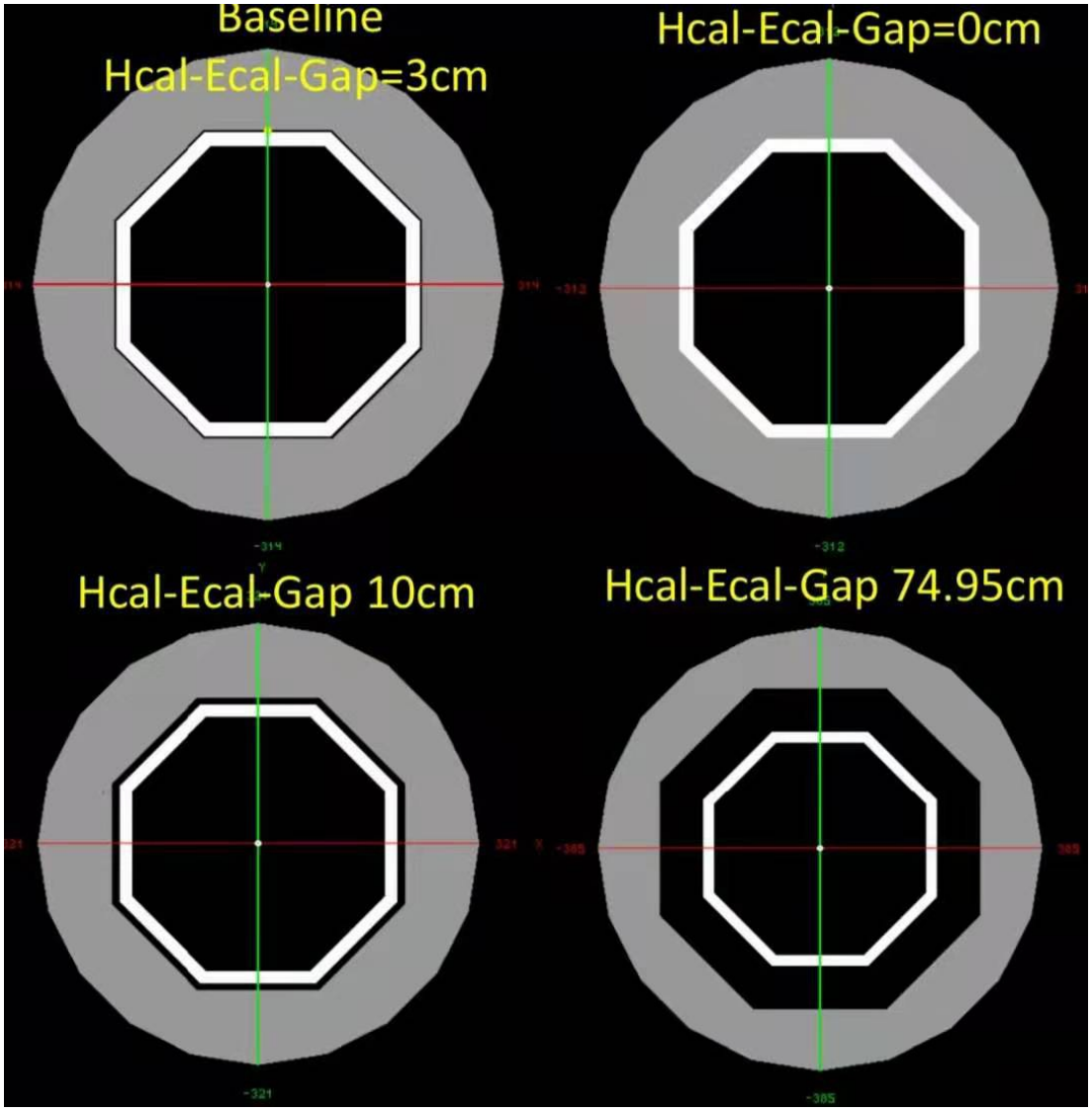




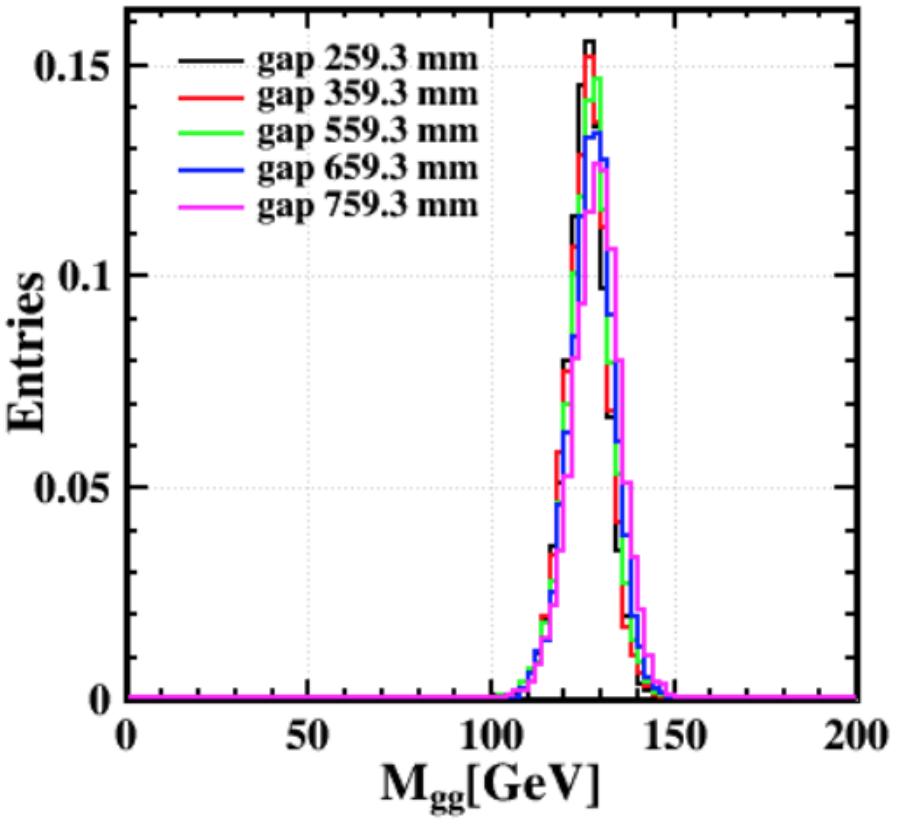
- Mimic by muting HCAL Volume (layer)
- 1 layer ~ 2.65 cm of Iron ~ 1 X0

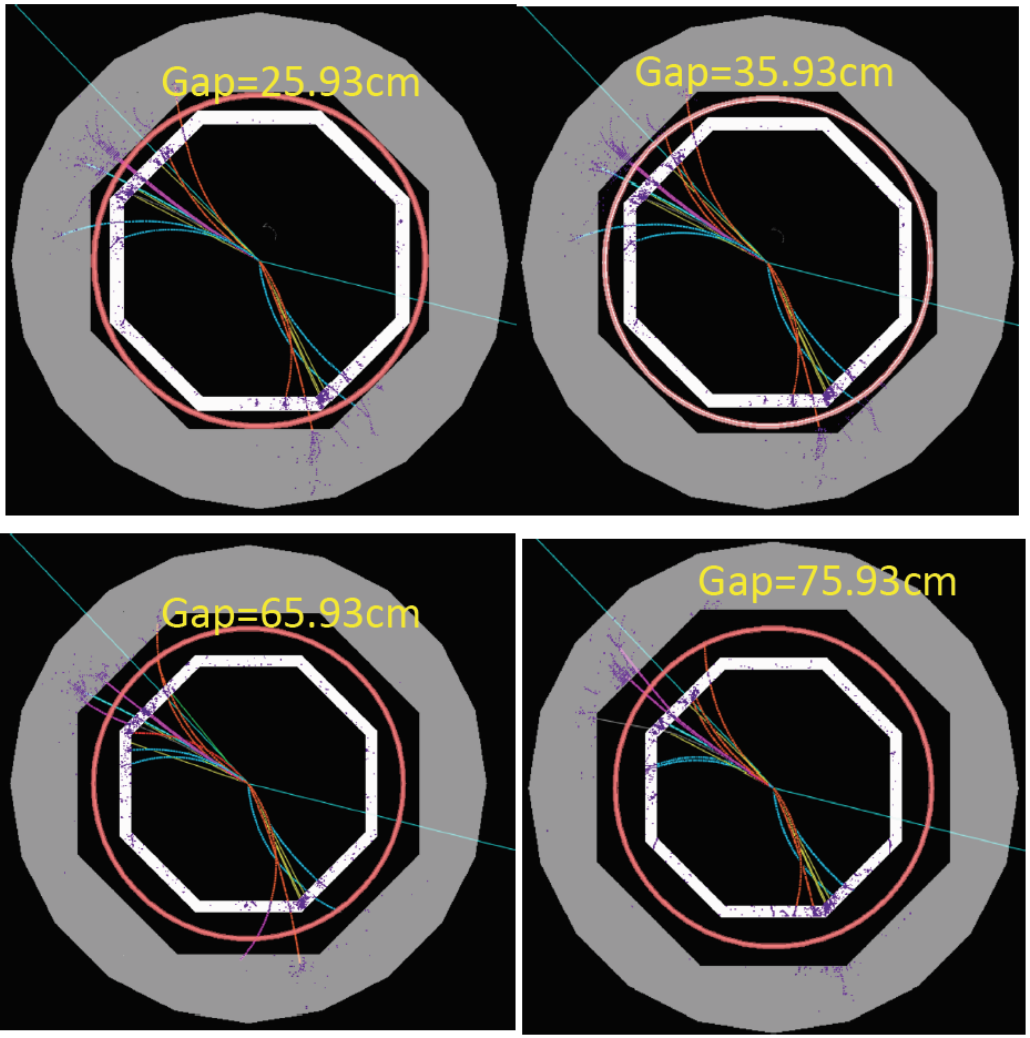
Impact of Space





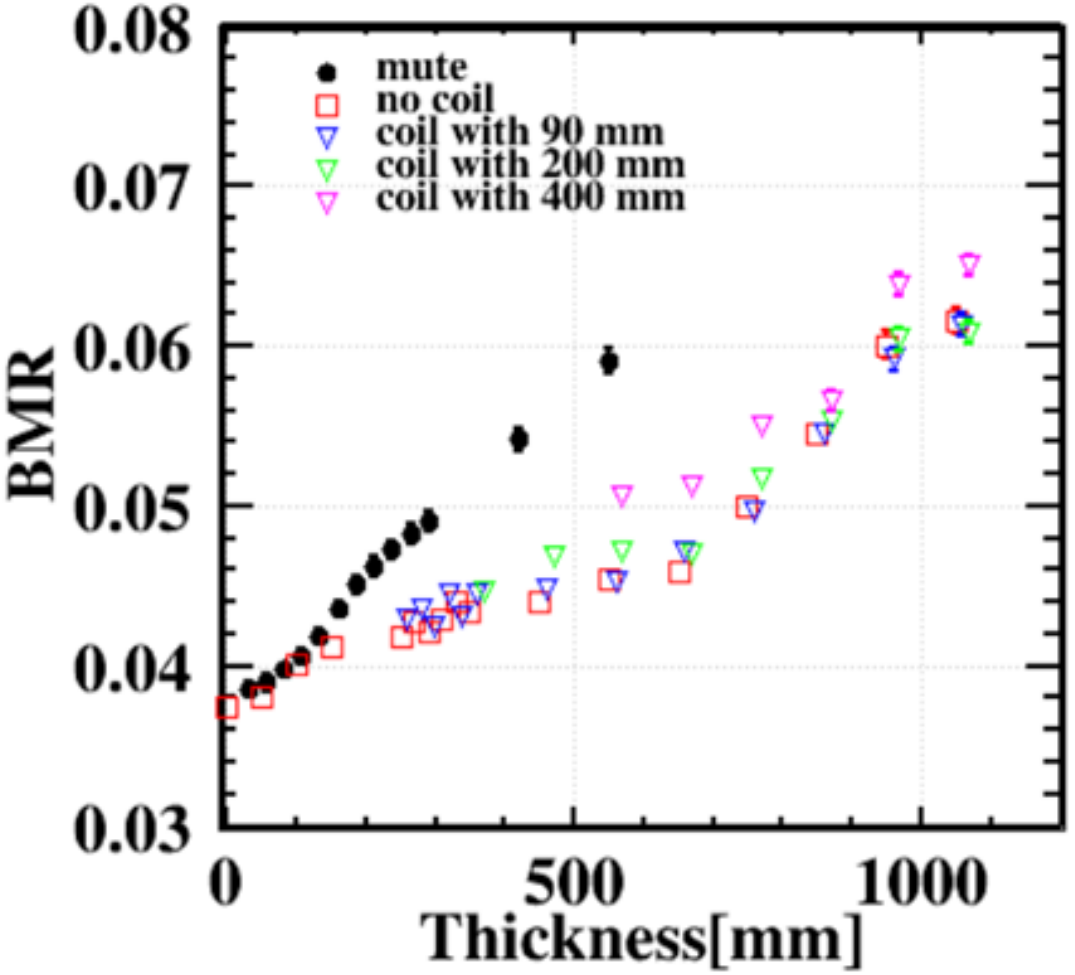
Impact of both

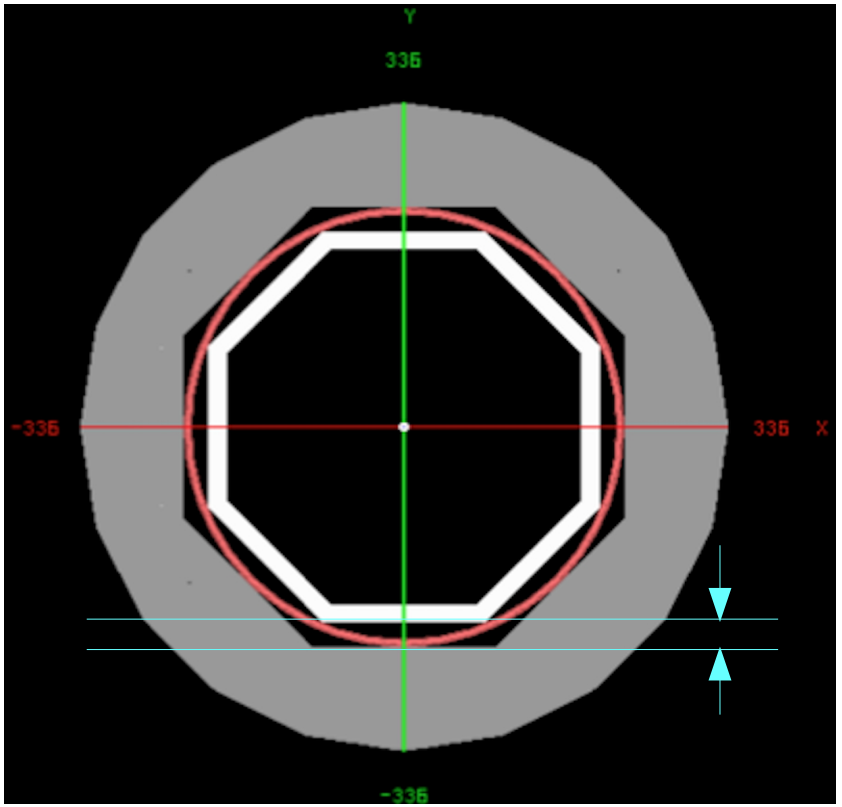




- 90 mm Al (mimic Solenoid with material ~ 1 X0)
- Space varies from 260 mm to ...

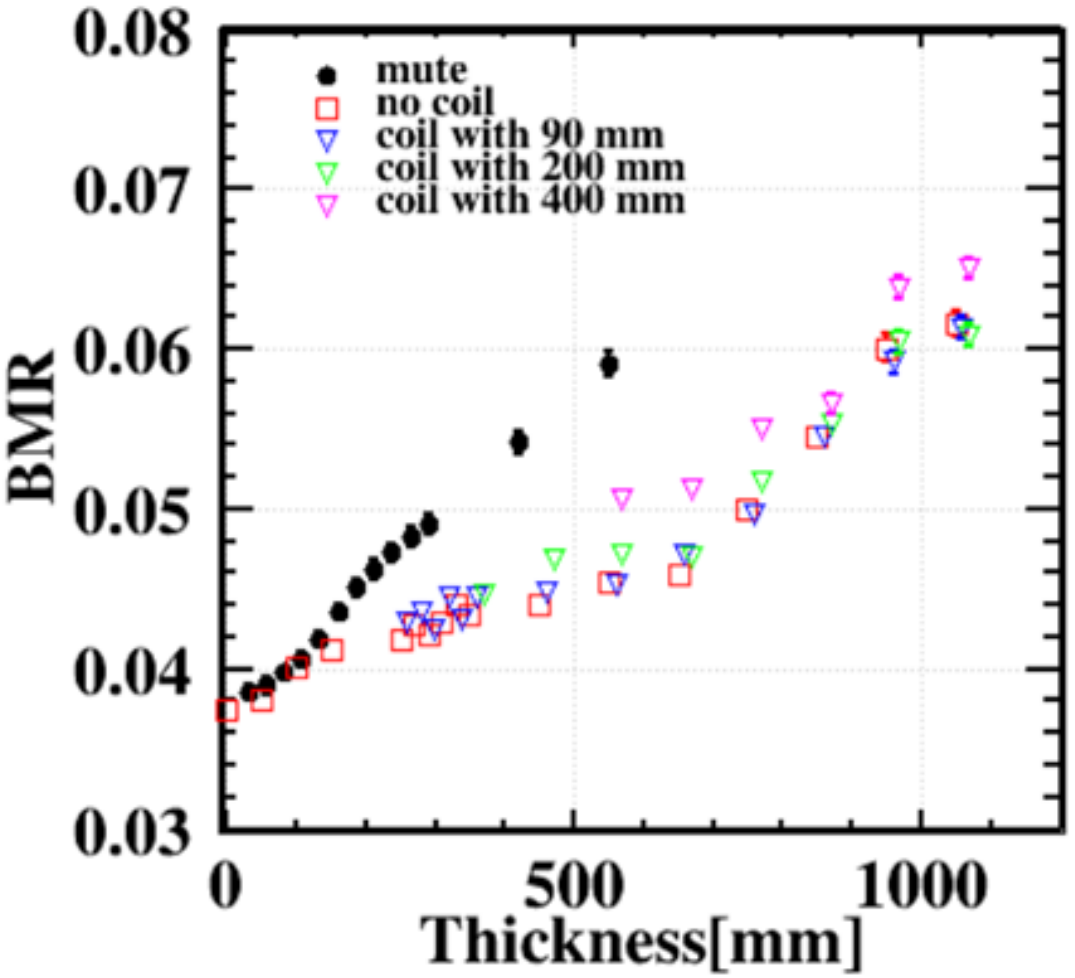
Impact on BMR





X axis: distance between parallel ECAL/HCAL active Layers

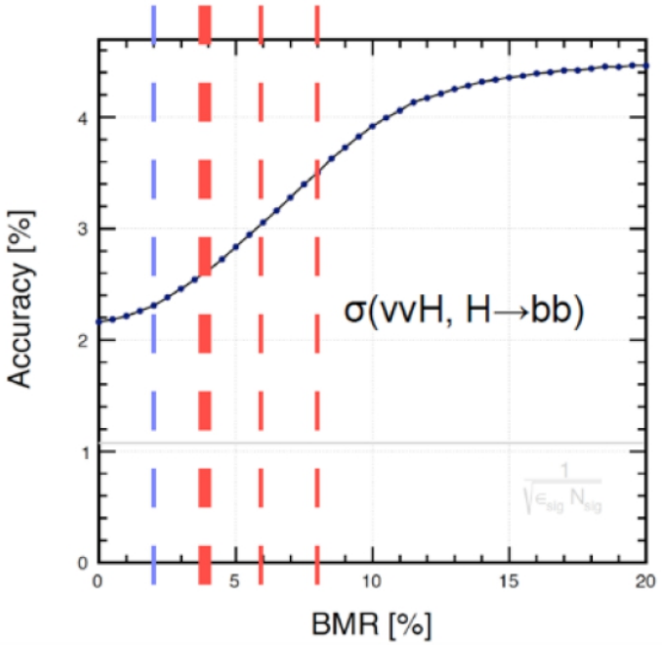
Impact on BMR

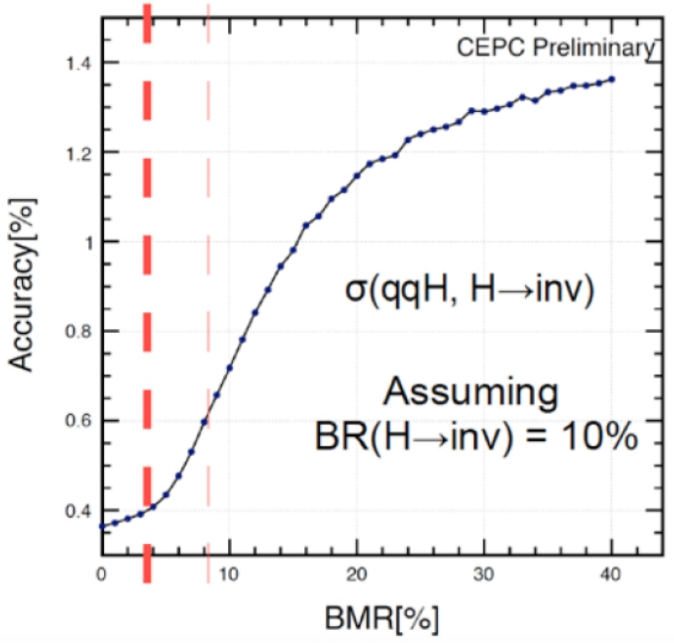


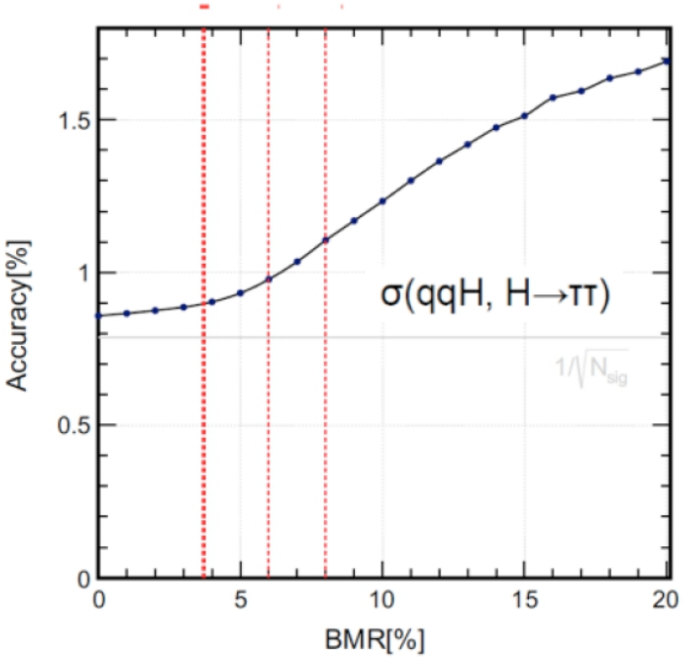
- BMR is sensitive to Both space & material
- The polygon structure requires a minimal space of
  - R*(1(cos(pi/n)) – 1)

  A 169 mm gap is required at baseline octagon structure, leads to a BMR degrading of 8% (3.8% -> 4.1%).
- Solenoid material, BMR degrades for
  - 1X0 (of Al) & 260 mm Gap: 10%
  - 2.2X0 & 370 mm Gap: 15%.
  - 4.4X0 & 570 mm Gap: 32%.

Impact on Physics







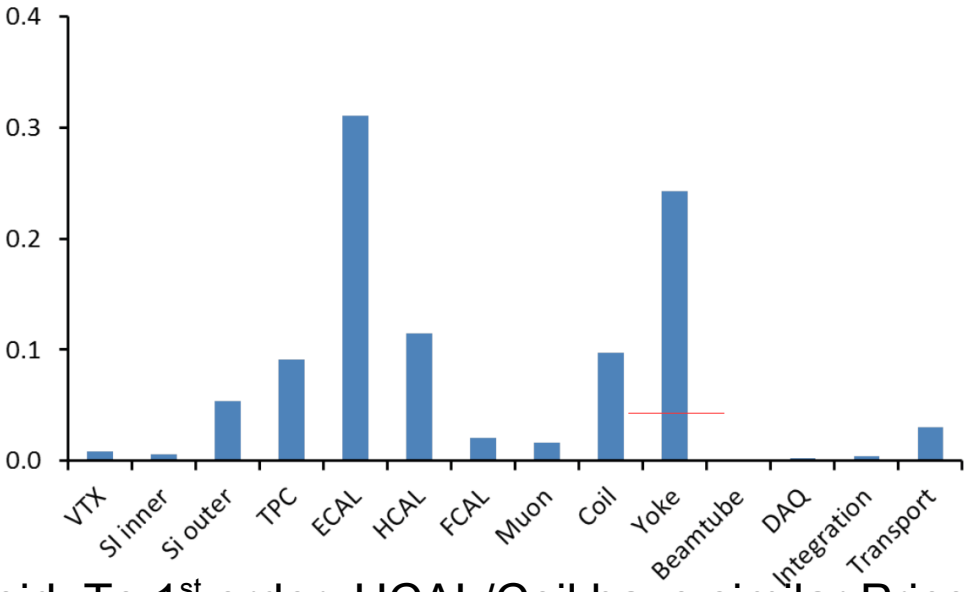
- Boson Mass Resolution: relative mass resolution of vvH, H→gg events
  - Free of Jet Clustering
  - Be applied directly to the Higgs analyses
- The CEPC baseline reaches 3.8%

	BMR = 2%	4%	6%	8%
σ(vvH, H→bb)	2.3%	2.6%	3.0%	3.4%
σ(qqH, H→inv)	0.38%	0.4%	0.5%	0.6%
σ(qqH, H→ττ)	0.85%	0.9%	1.0%	1.1%

10% of BMR degrading need to be compromised by 6%/10%/5% of Luminosity increase,
For physics benchmark with Higgs width (W fusion), Higgs invisible & Higgs to tautau

How much can we save in total?

Figure III-7.2
Summary plot of the relative contribution by the different sub-components to the total cost of the ILD detector.

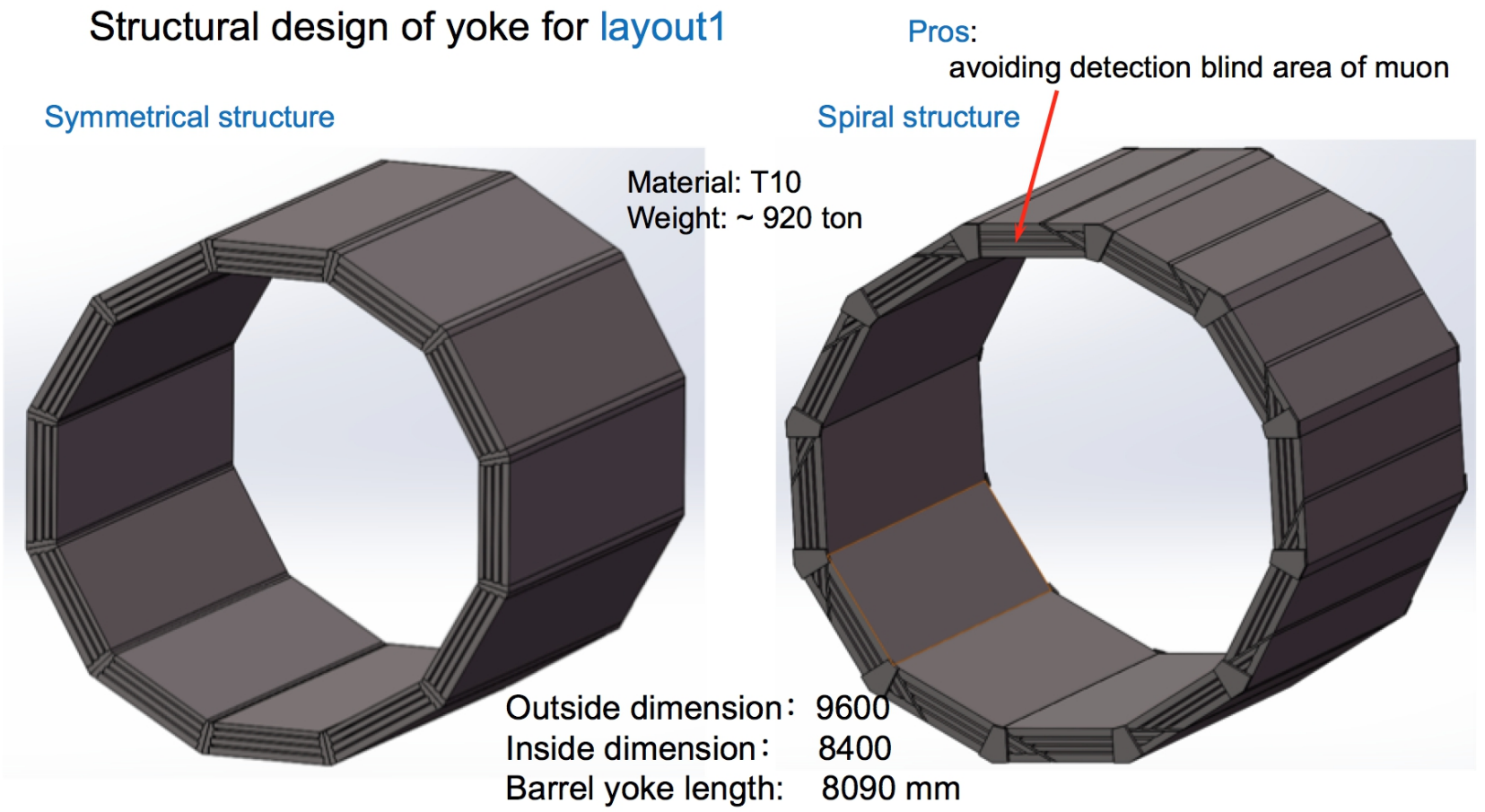


At the baseline uses Thick Solenoid. To 1st order, HCAL/Coil have similar Price/Volume. Thus the saving occurs mainly at reduced Yoke Size. *Thin Solenoid (~ 10 cm) leads to 1-2% level saving (Solenoid cost reduced by 30%; HCAL cost increases by 15%).*

ILD have an enormous Yoke (~ 13000 ton, equipped with ~ 10 sensor layers), takes up to 1/4 of the construction cost.
At CEPC, the Yoke can be reduced to ~ 2000 ton, corresponding to 100 M CNY cost (5%)

The entire HCAL at baseline weights 910 ton. For the solenoid inside HCAL, probably an Additional ~ 1000 ton Yoke is needed to enhance the B-Field flux flow, providing mechanic support & install additional sensor for LLP... cost 50 M CNY.

Construction cost on Reduced Yoke



- Discuss with Prof. Ji: Material & Mechanic (MM) for Yoke ~ 2k ton: 20 M CNY (10k/ton; T10 Iron: Price – 6k/ton, without transportation fee)
- With detector/transportation & installation: MM cost * 3 times **~ 60** M CNY

Conclusion

- The short solenoid scenario (SSS) is relative optimistic among the Solenoid between E/HCAL options: relies on good B-Field stability-monitoring & homogenous control.
- BMR strongly relies on gap & material. Compared to original design, The BMR of SSS degrades by at least **10%**, requiring **5-10%** more luminosity to compensate for corresponding benchmarks.
  - *Polygons with more side is helpful, but marginal (Gap -> 70 mm at dodecagon).*
- Saving on Yoke: **30 – 100 M** CNY
  - No Yoke (highly unlikely – LLP search complains...)
    - **~ 100 M CNY** (5%) @ ILD costing
    - **~ 60 M CNY** with our estimation (3 times the material + mechanic cost)
  - 1000 ton Extra Yoke: **30 ~ 50 M** CNY
  - Matter/Mechanical: 10 k CNY/ton: according to Prof. Ji
- Saving on solenoid – HCAL:
  - Depends on the solenoid thickness: at most percentage level (**~20 M** CNY if the solenoid thickness reduced to 10 cm & the construction cost/weight of solenoid remains the same...)
- *To overcome technical difficulties might consume a significant amount of the saving.*

Back up

Mass

	mass (kg)	mass (ton)
MDI	11,909.85	11.91
LumiCal	118.46	0.12
VXD	0.85	0.00
SIT	15.70	0.02
SET	259.62	0.26
FTD	3.21	0.00
TPC	1,750.47	1.75
Ecal	161,489.50	161.49
Hcal	906,668.80	906.67
Yoke	12,685,708.80	12,685.71
Magnet	262,841.11	262.84

Yoke Cost/Weight

- Yoke - 2500 Kilo ton ~ 1 亿 RMB
- 40 CNY/kg, ~ 1 order of magnitude higher than iron market price?...

New design(Not to scale)...