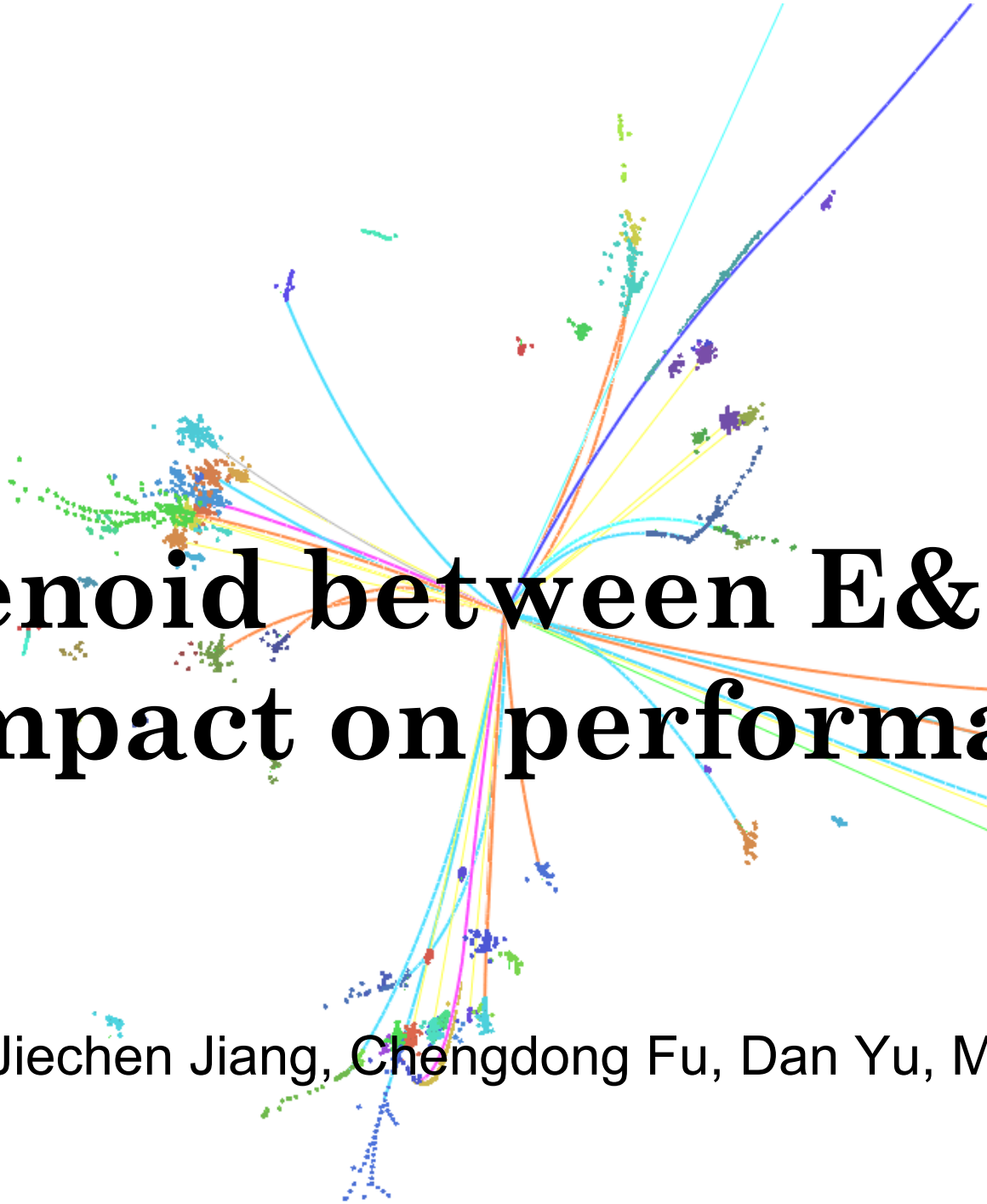
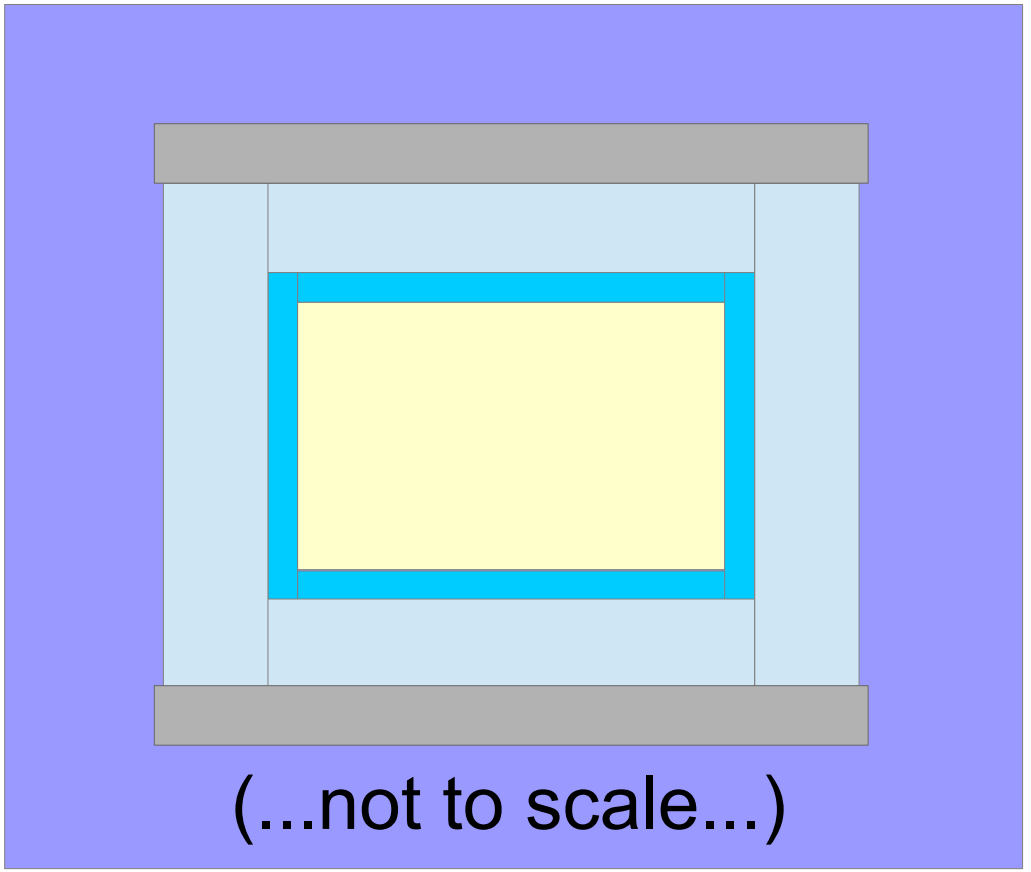
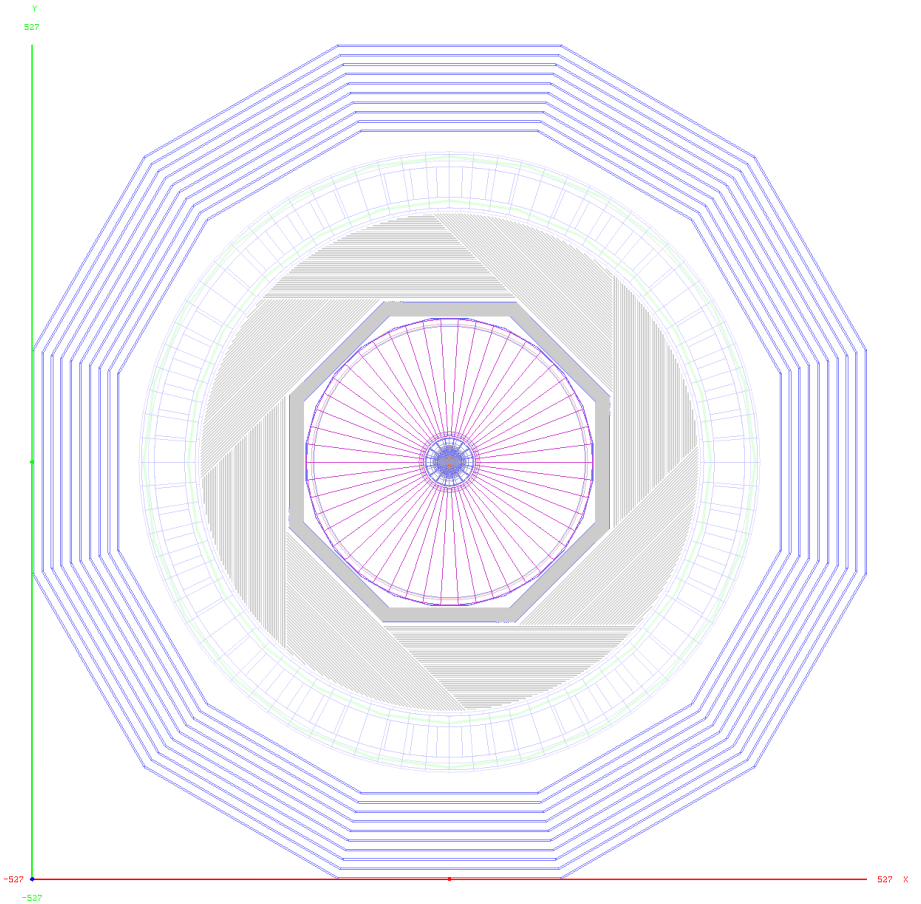


Solenoid between E&HCAL: impact on performance

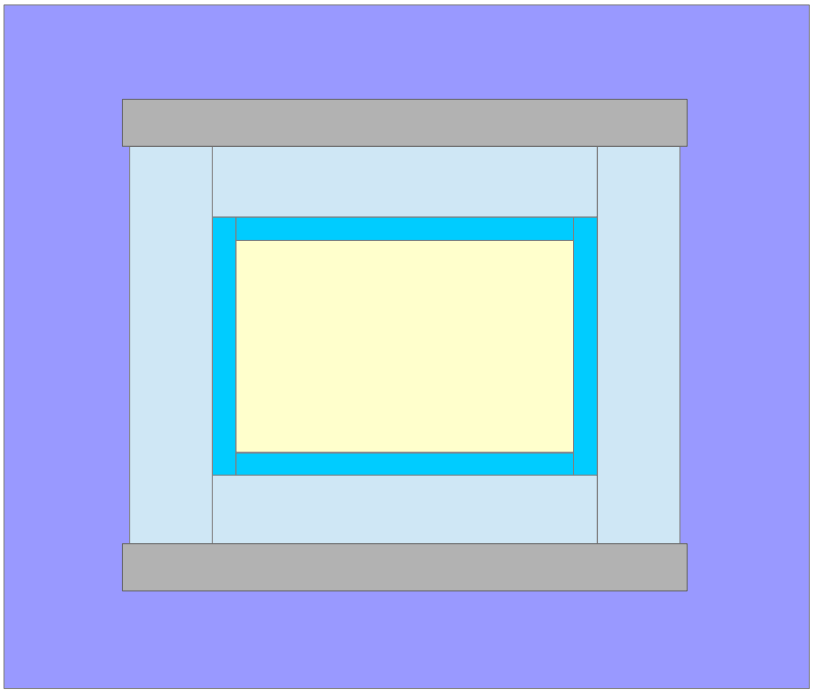
Jiechen Jiang, Chengdong Fu, Dan Yu, Manqi

Baseline Design

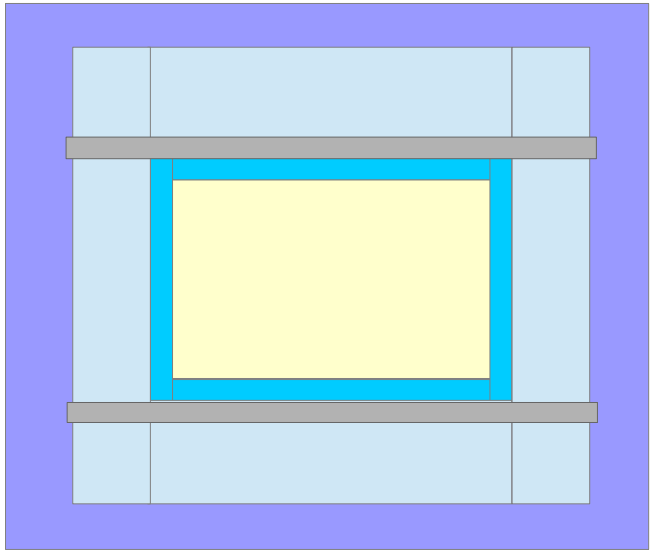




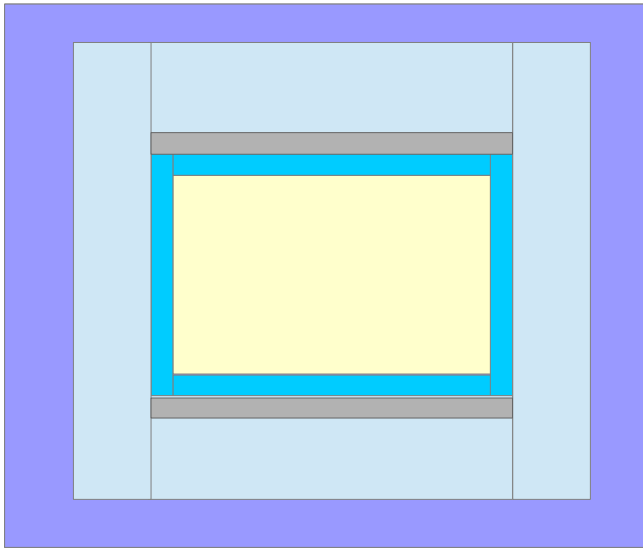
New designs



A: long solenoid



B: short solenoid

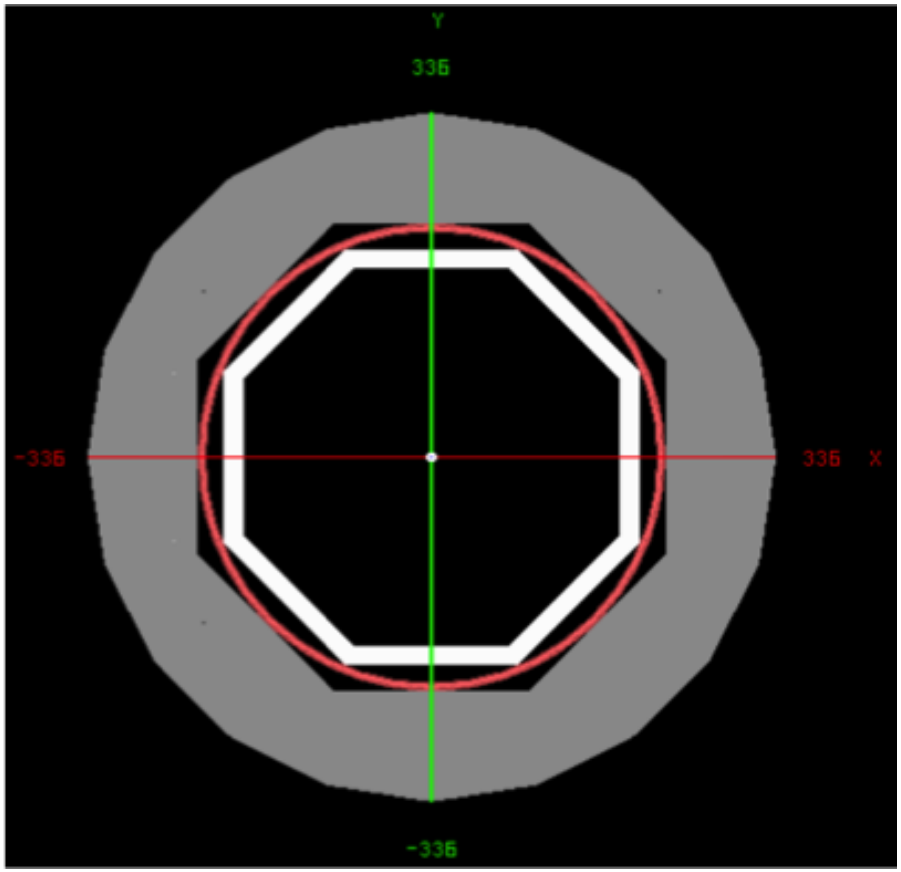


- Either long/short solenoid: saving cost on reduced solenoid & Yoke, while the HCAL cost increases (once ECAL/Tracker fixed)
- Performance comparison between long/short solenoid
  - Short solenoid has less dead materials, and worse B-Field homogeneity
  - Assume B-Field difficulties can be solved, short solenoid scenario has better performance -> optimistic one.
  - Short solenoid implemented for performance comparison

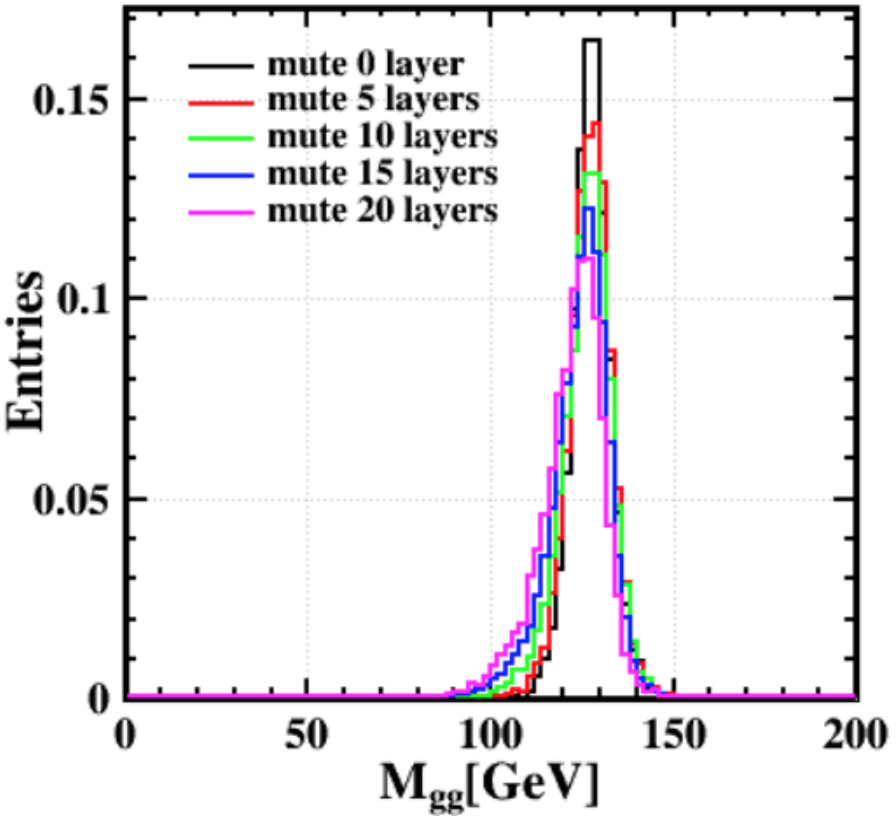
Performance & Geometry effect

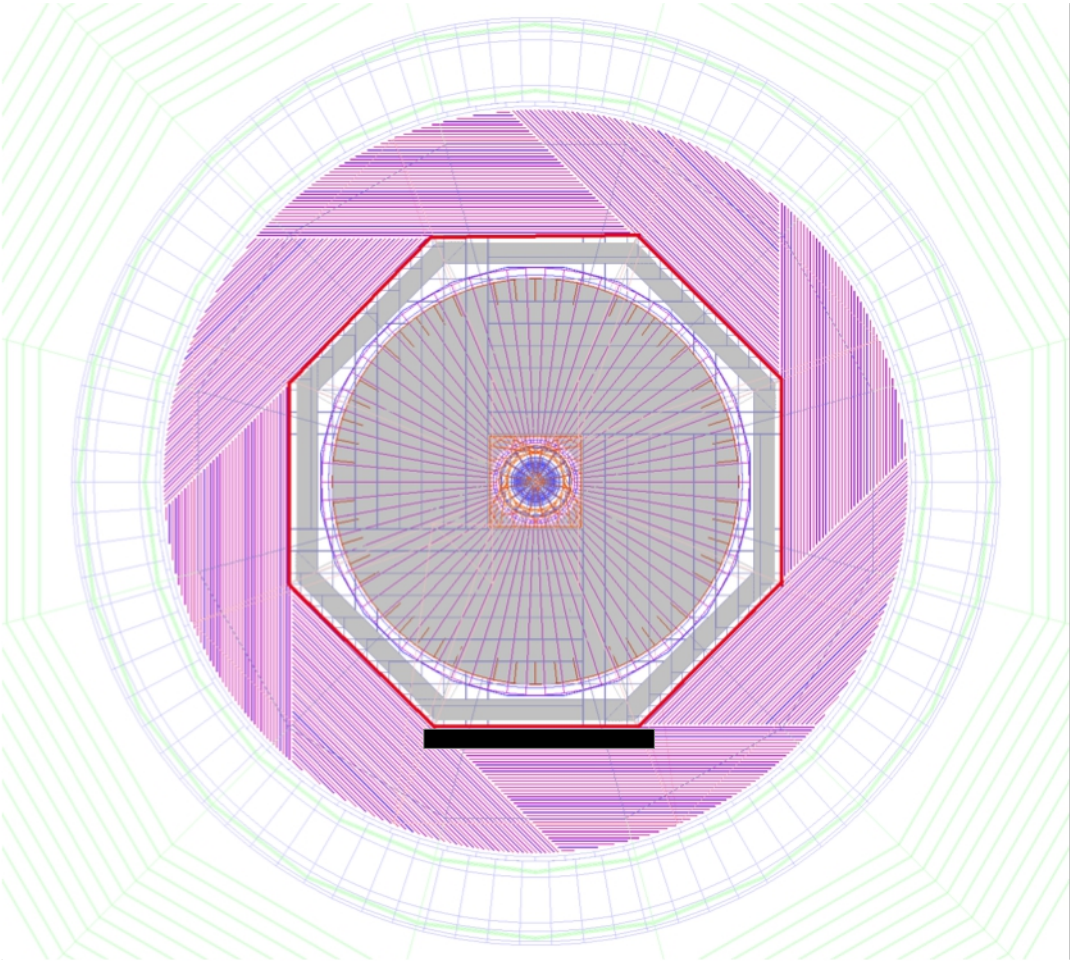
- Short solenoid w.r.t Baseline
  - No change in Track & Photon
  - No change in forward region
  - Degrade the Jet Performance (Quantified with BMR) and Pid in barrel

- BMR Degrading due to
  - Dead Material
  - Space



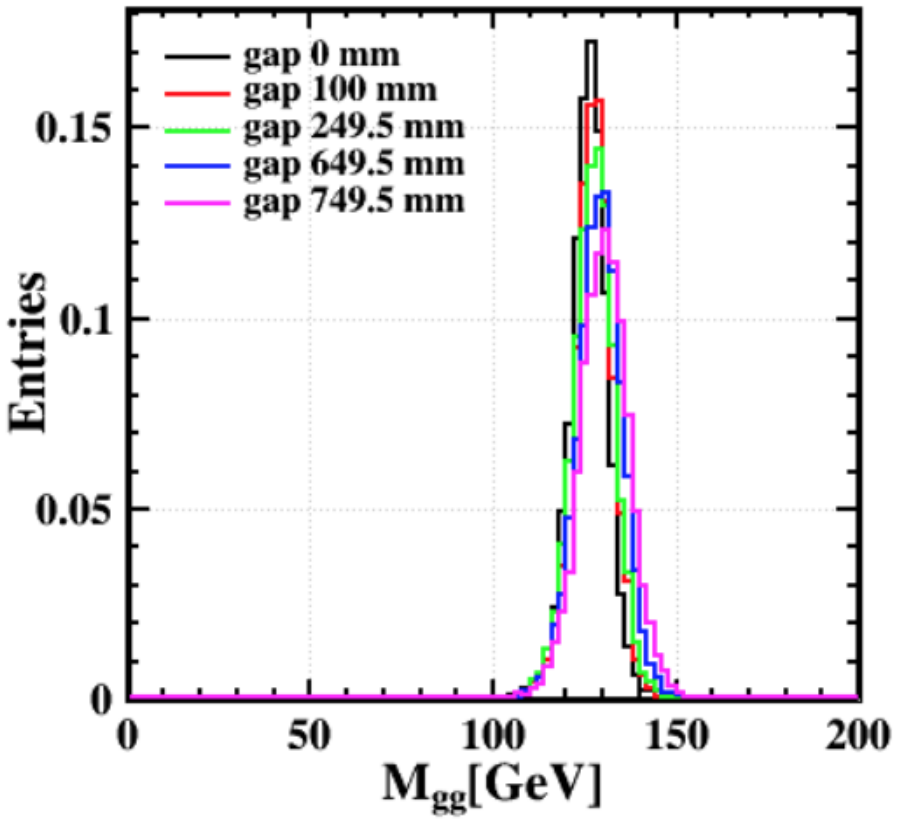
Impact of dead material

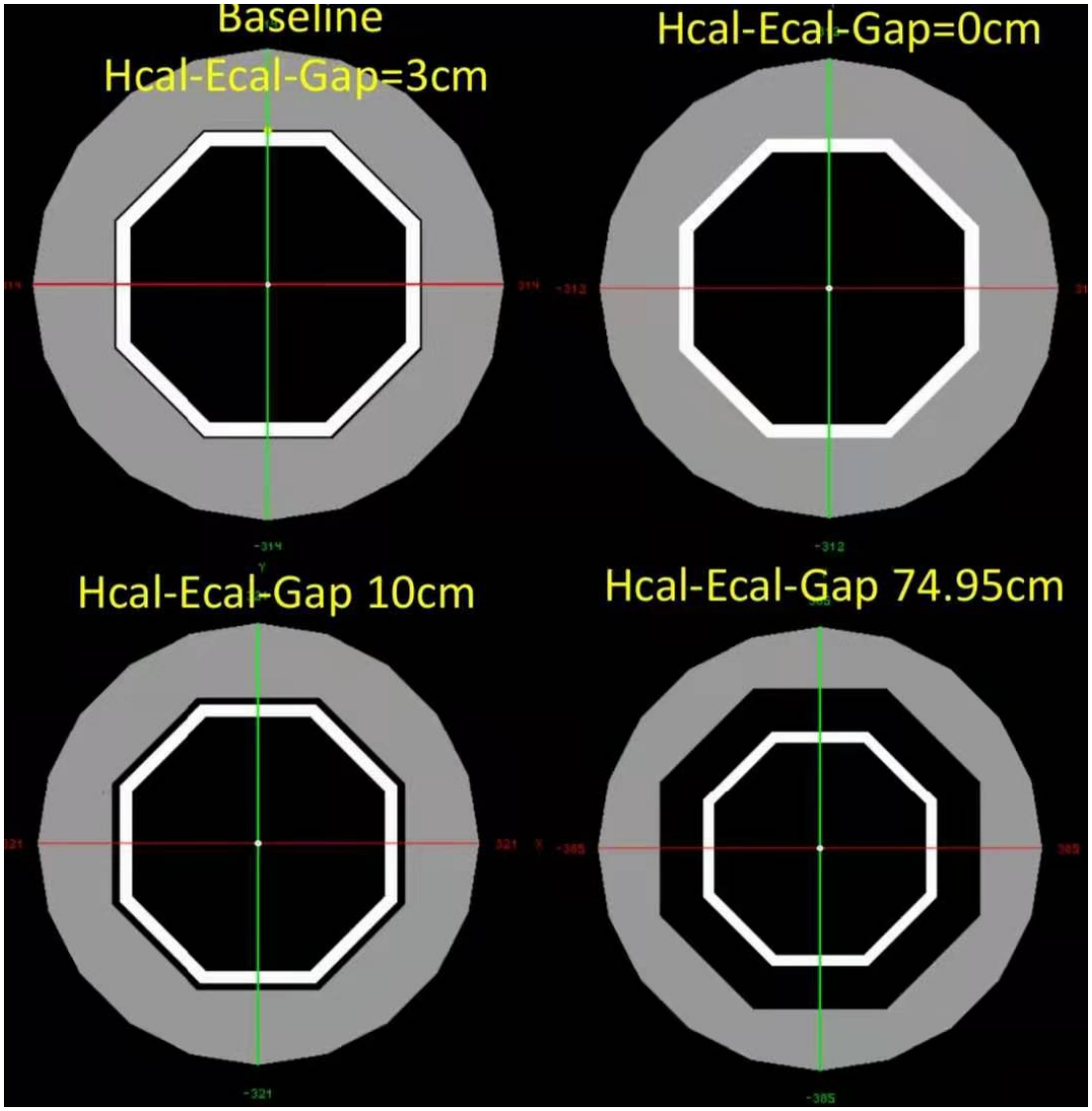




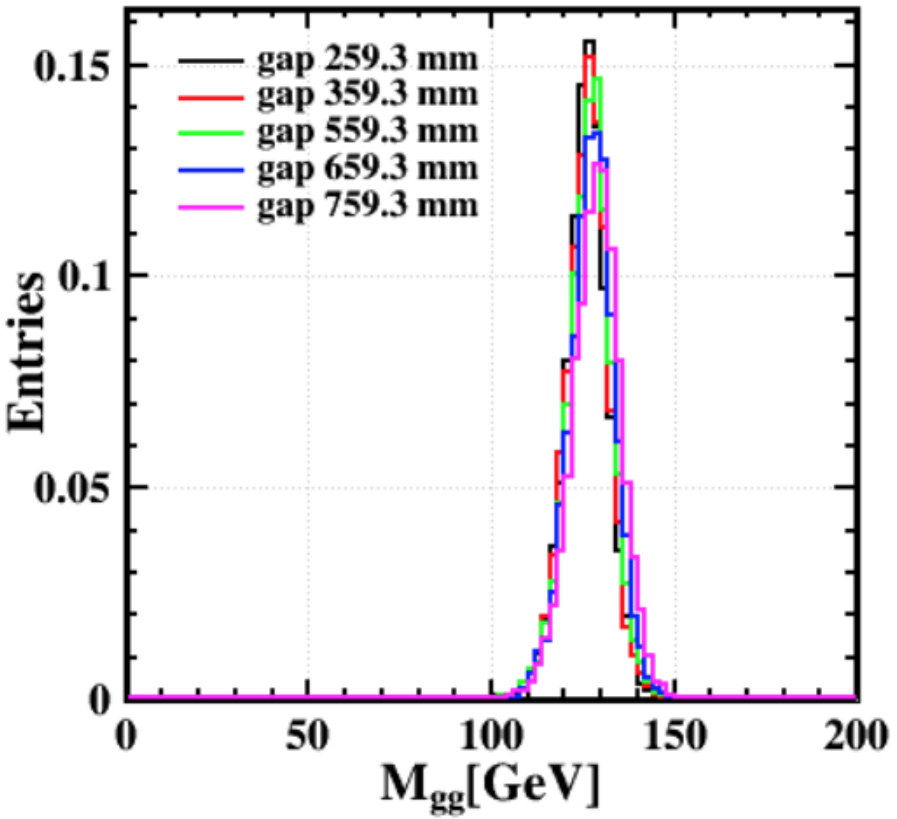
- Mimic by muting HCAL Volume (layer)
- 1 layer ~ 2.65 cm of Iron ~ 1 X0

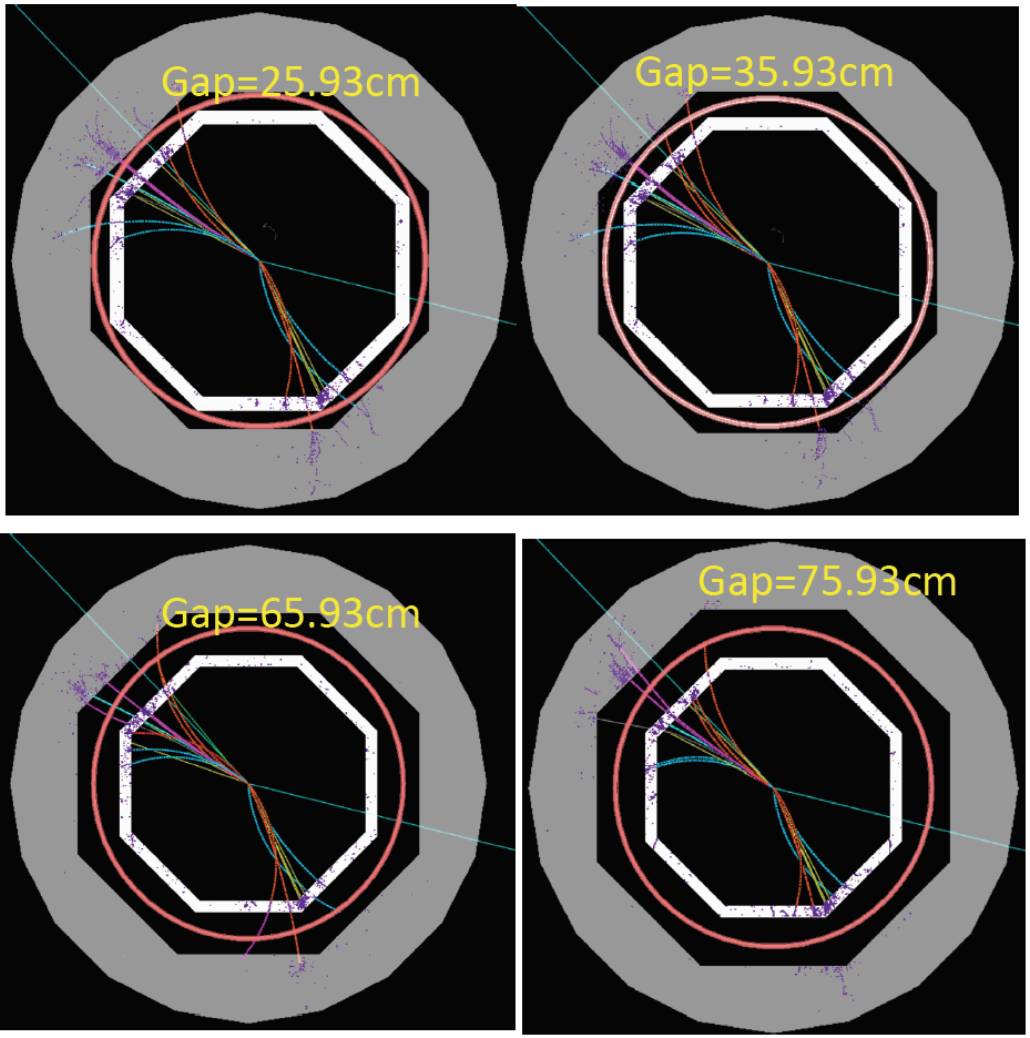
Impact of Space





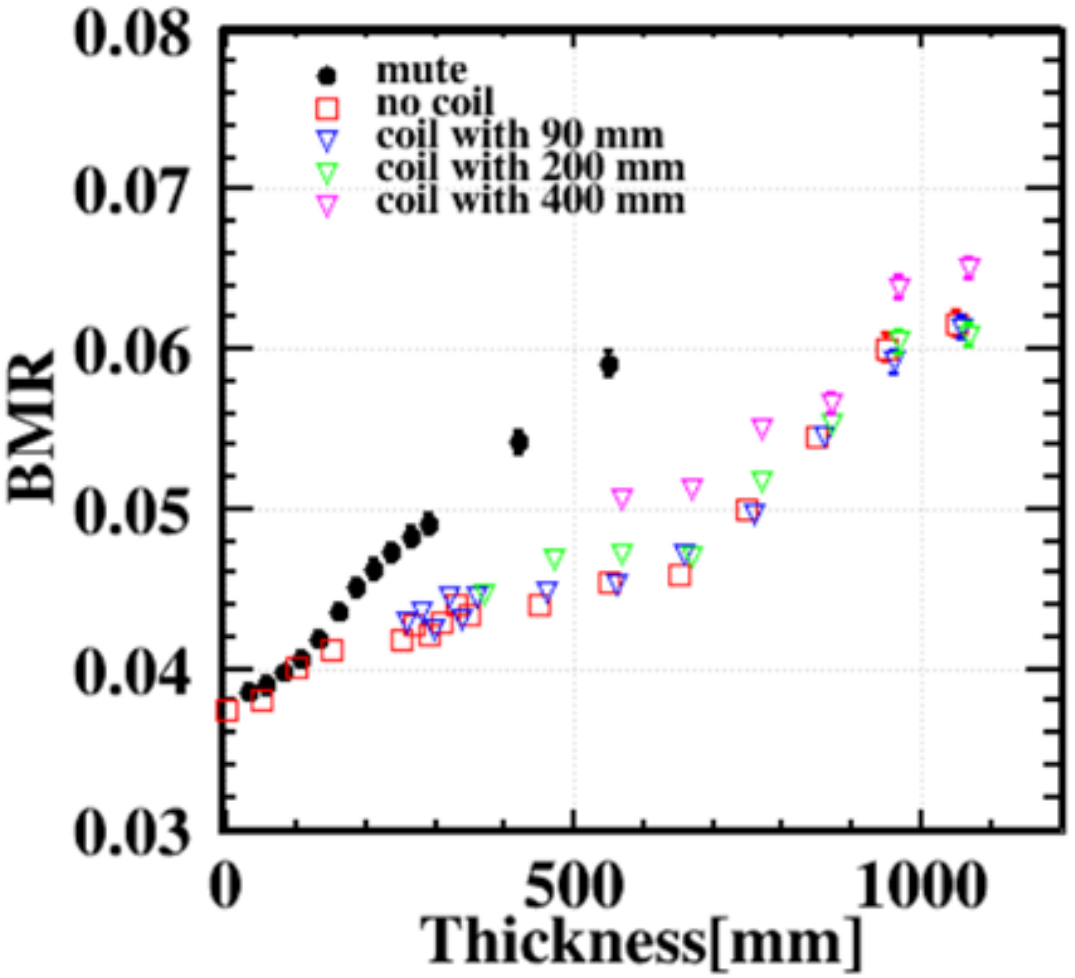
Impact of both





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

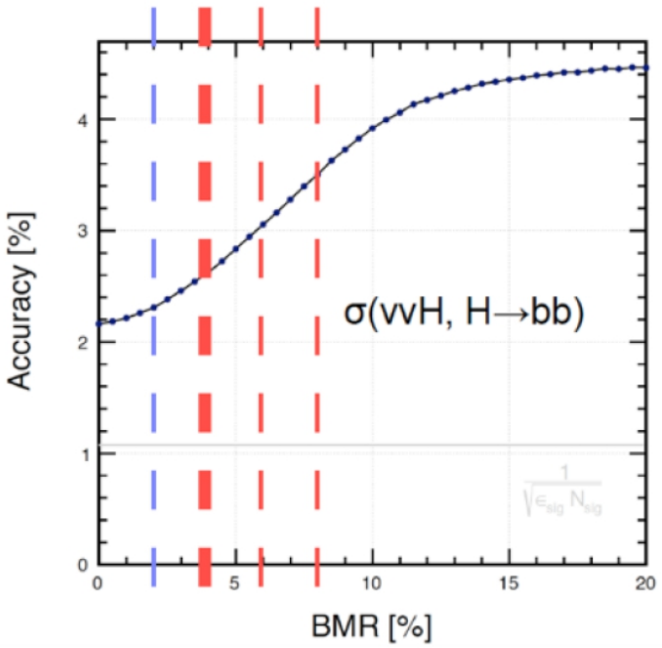
Impact on BMR

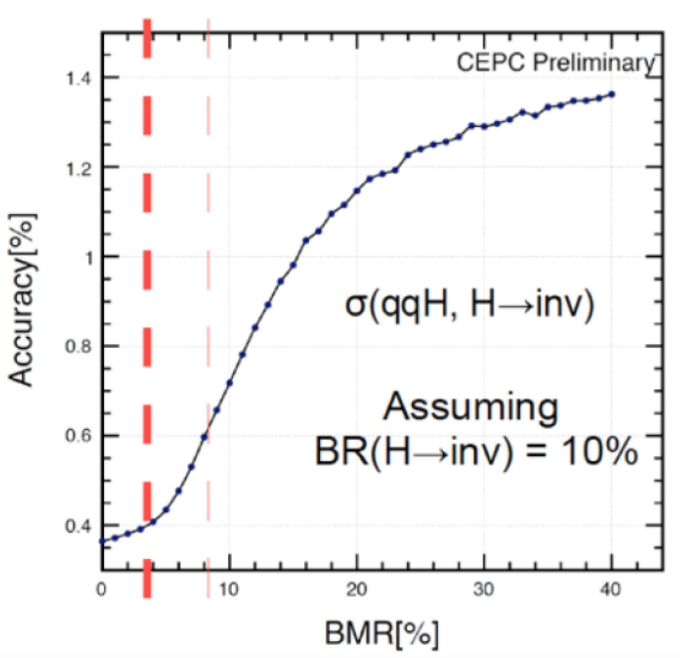


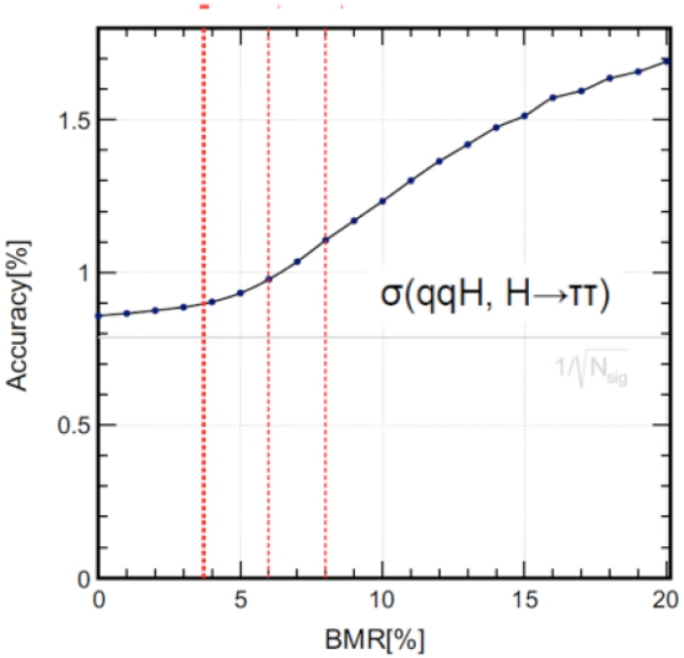
- BMR is sensitive to Both space & material
- The polygon structure requires a minimal space of
  - R*(1(cos(pi/n)) – 1)

  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







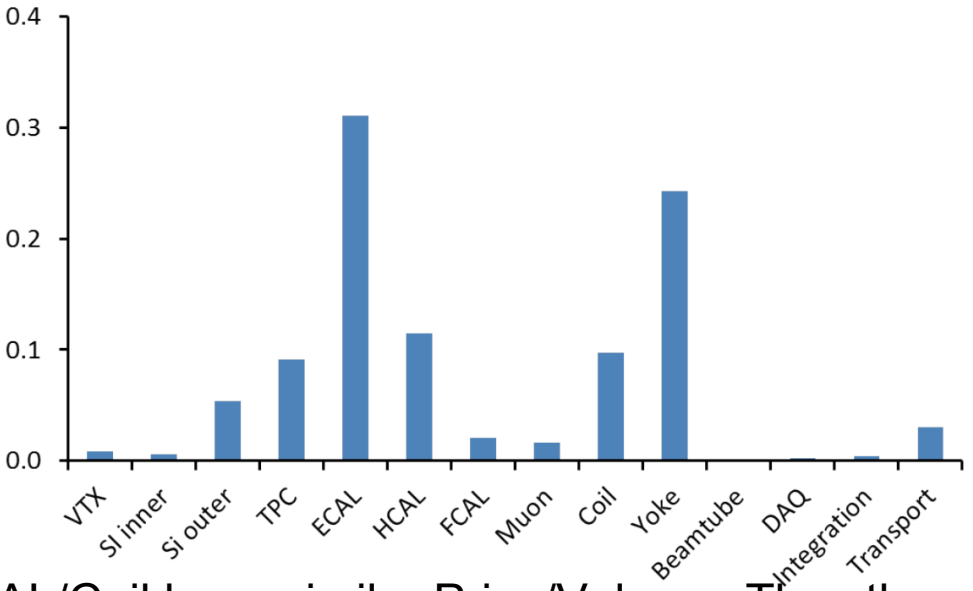
- Boson Mass Resolution: relative mass resolution of vvH, H→gg events
  - Free of Jet Clustering
  - Be applied directly to the Higgs analyses
- The CEPC baseline reaches 3.8%

	BMR = 2%	4%	6%	8%
σ(vvH, H→bb)	2.3%	2.6%	3.0%	3.4%
σ(vvH, 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, 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.



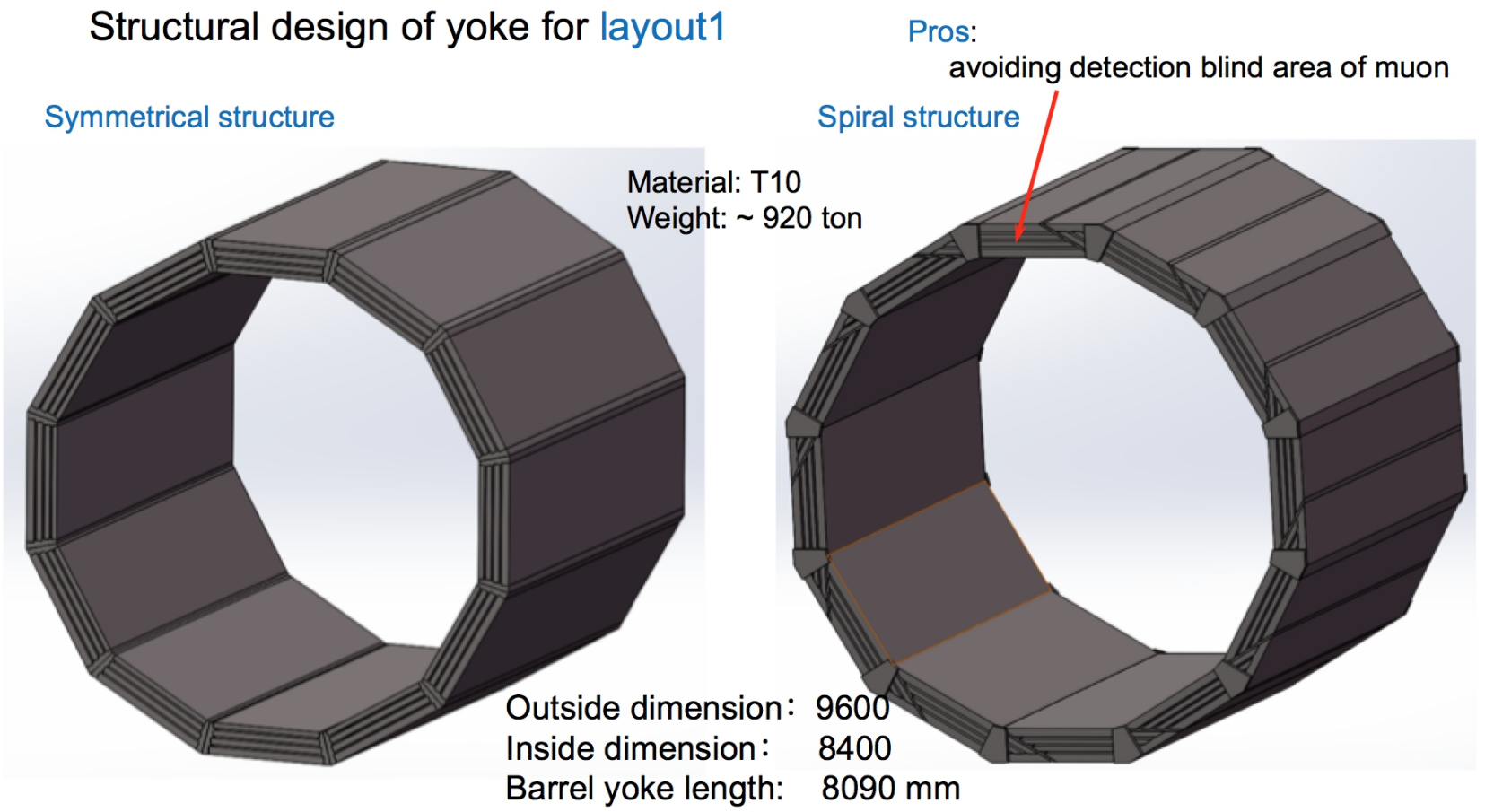
At the baseline & to 1st order, HCAL/Coil have similar Price/Volume. Thus the saving occurs mainly at reduced Yoke Size.

Thin Solenoid (~ 10 cm)... leads to percentage level saving
Solenoid cost reduced by 30%; HCAL cost increases by 15%.

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

50 M CNY saved if a kilo-ton level Yoke is implemented (The entire HCAL at baseline weights 910 ton. Therefore, probably need a kilo-ton level Yoke to form sufficient shielding...)

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.
  - *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 how thin the solenoid goes: should be less significant then Yoke
  - *The 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)...