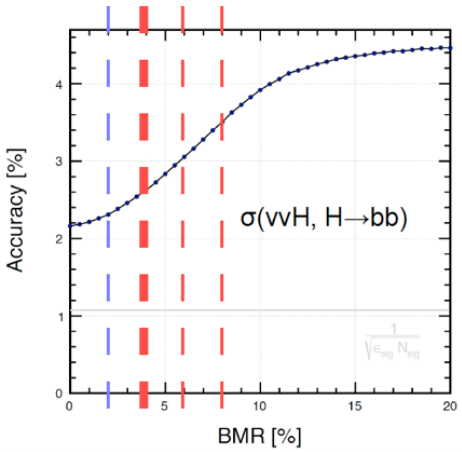
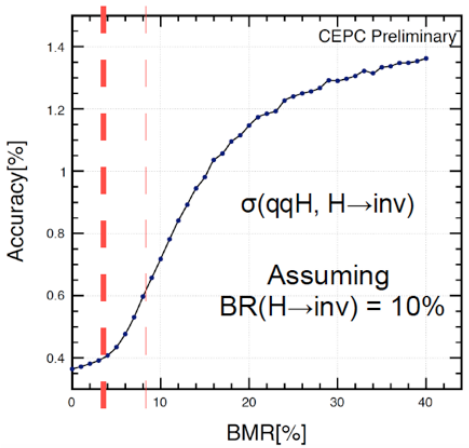
BMR Perspective & Feedback to 4th

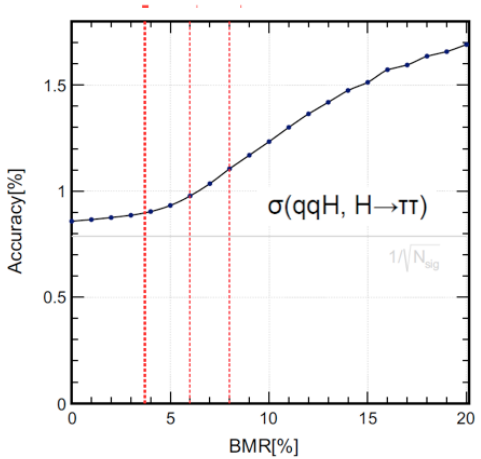
Manqi Ruan

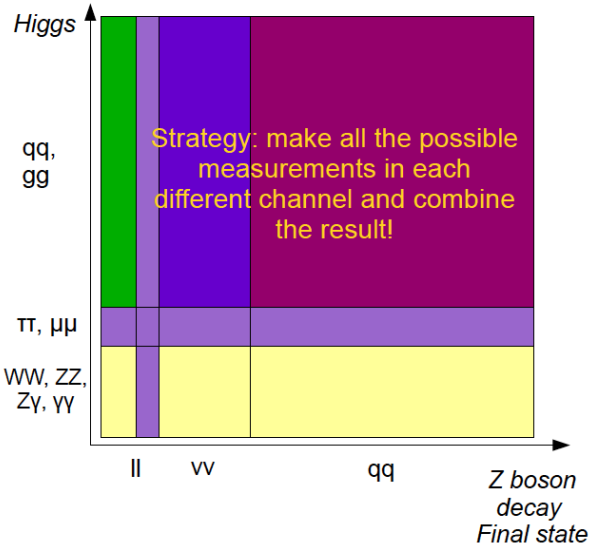
Hadronic event & BMR

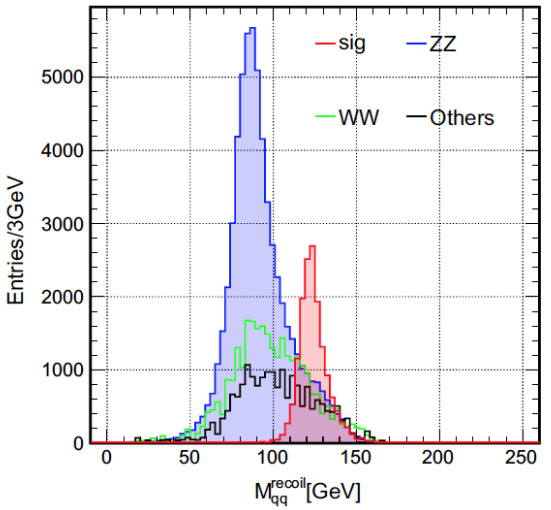
- Core of e+e- Higgs factory Physics measurements
  - 97% of CEPC Higgs events are hadronic/semi-leptonic
- Higgs measurement require BMR < 4%;
- Flavor & NP: much more demanding







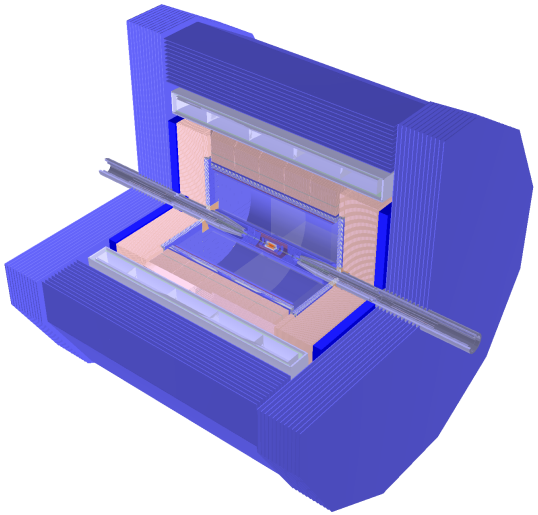




- Boson Mass Resolution: relative mass resolution of νν̄H, H→gg events
  - Free of Jet Clustering
  - Be applied directly to the Higgs analyses
- The CEPC baseline reaches 3.8%

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

@ Baseline



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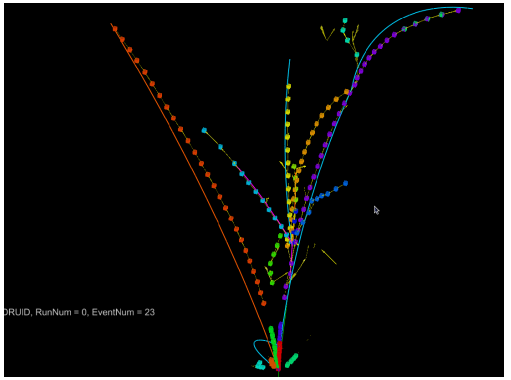

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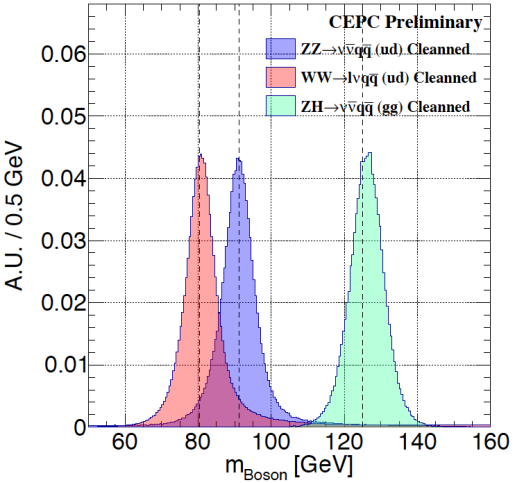
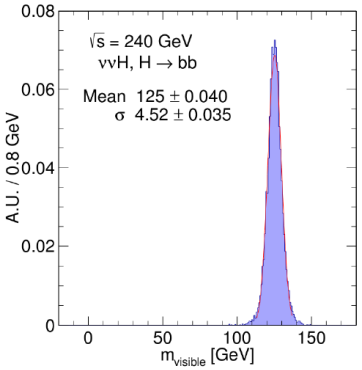
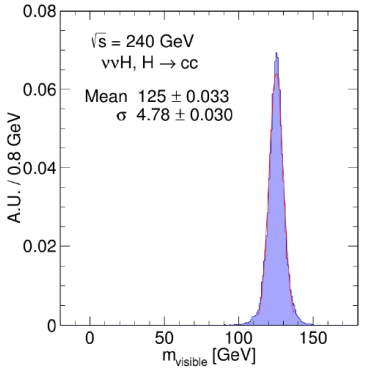
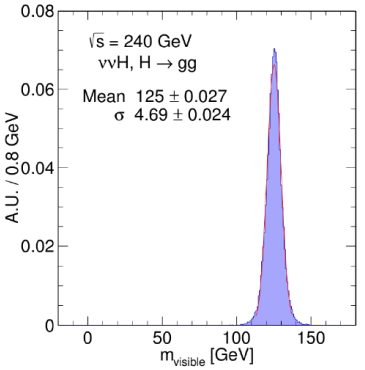
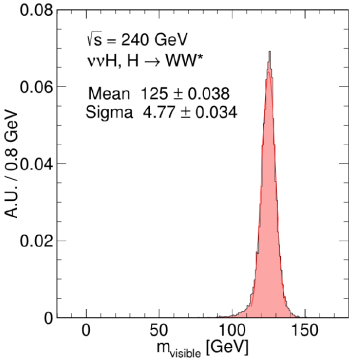










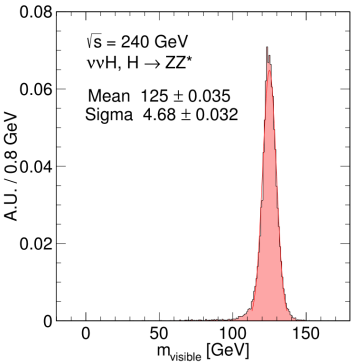
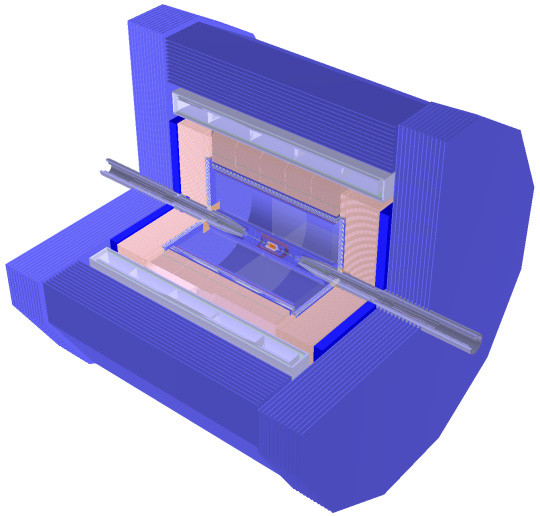
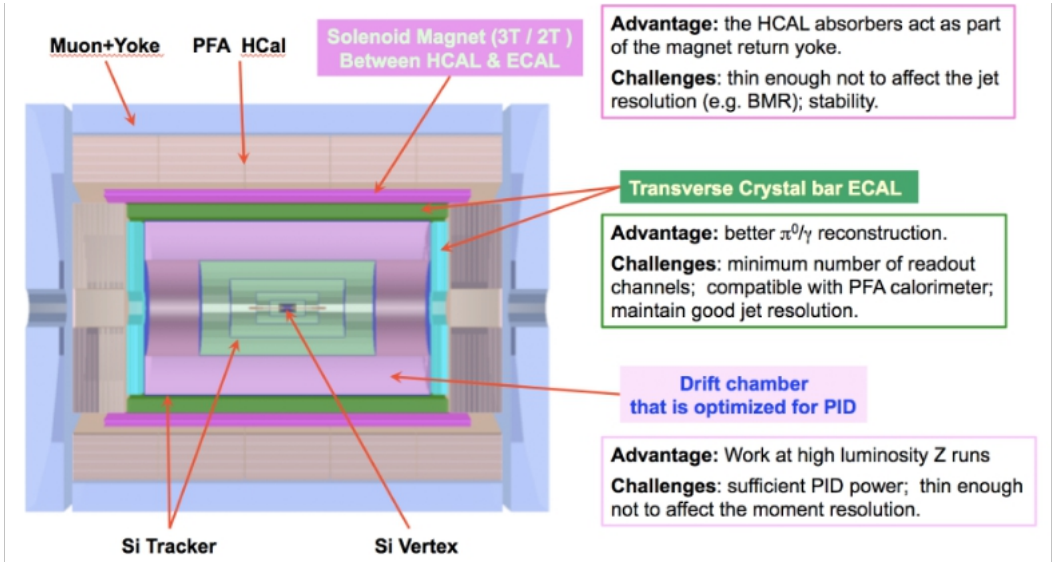


Table 3. Higgs boson mass resolution ($\sigma/Mean$) at different decay modes with jets as final state particles, after the event cleaning.

Higgs→bb	Higgs→cc	Higgs→gg	Higgs→ WW*	Higgs→ ZZ*
3.63%	3.82%	3.75%	3.81%	3.74%

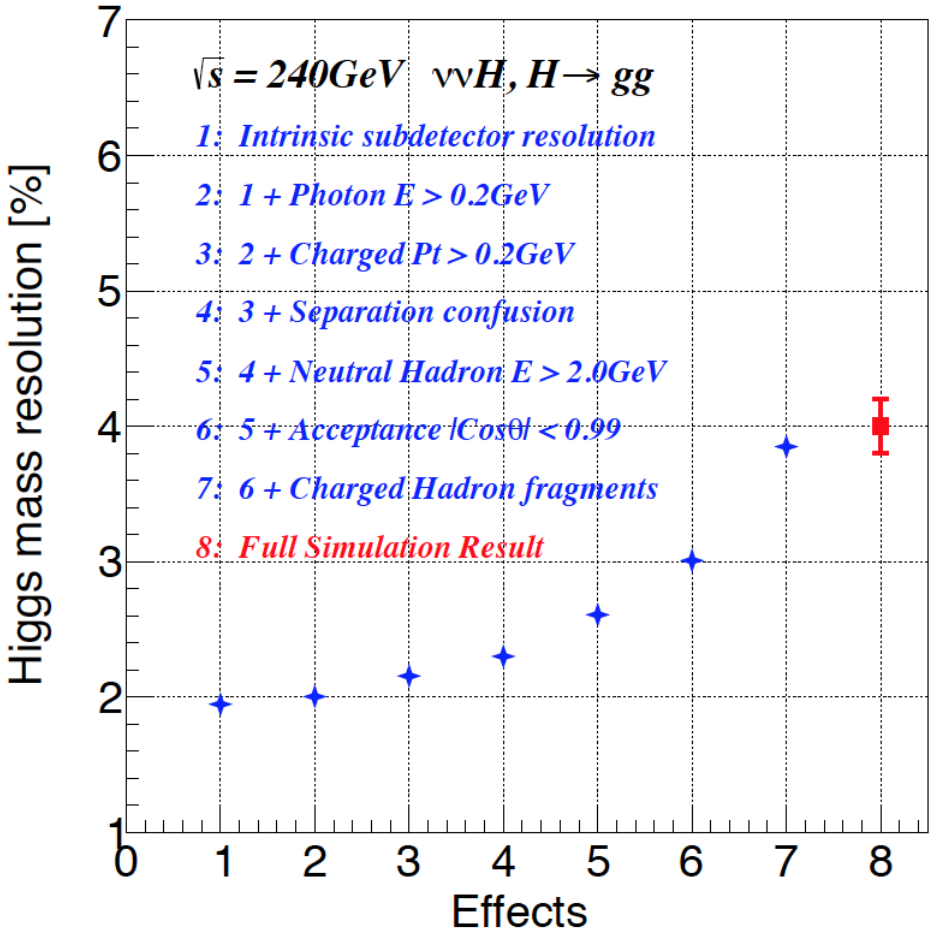
From Baseline to 4th

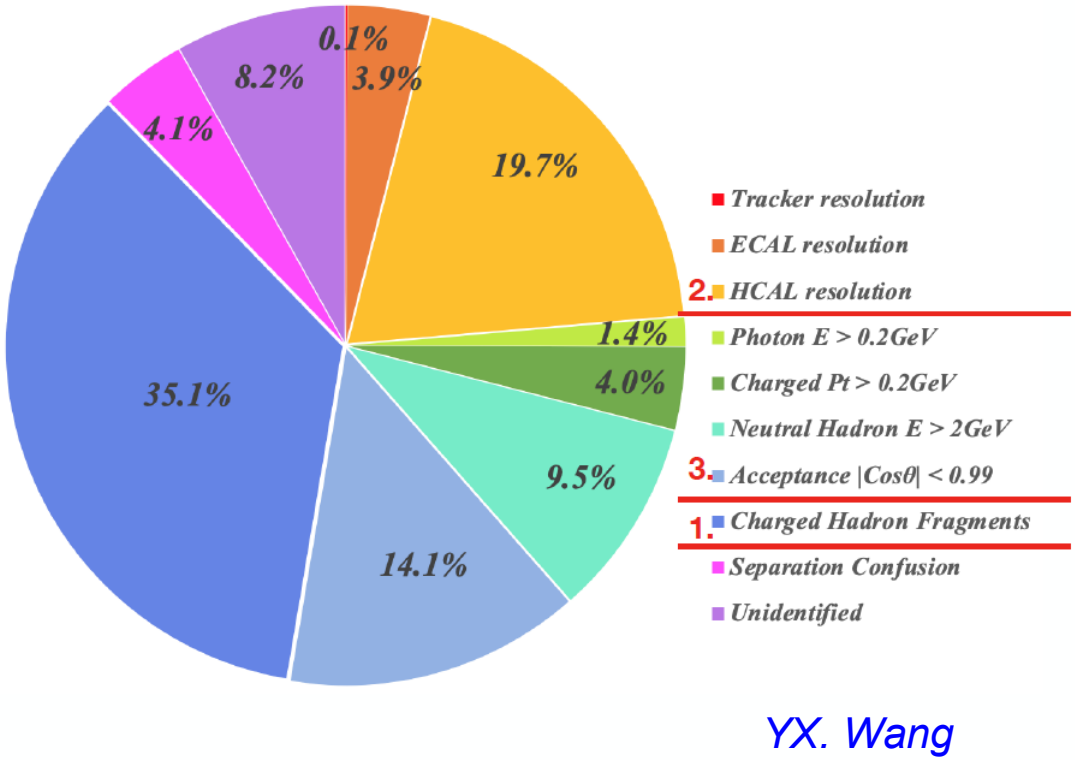




- Tracker: TPC + Silicon → Drift Chamber + Silicon
- ECAL: Si+W → Xstal
- HCAL: GRPC + Iron → Glass + Iron
- Solenoid: Outside HCAL → Between ECAL & HCAL

PFA Fast simulation



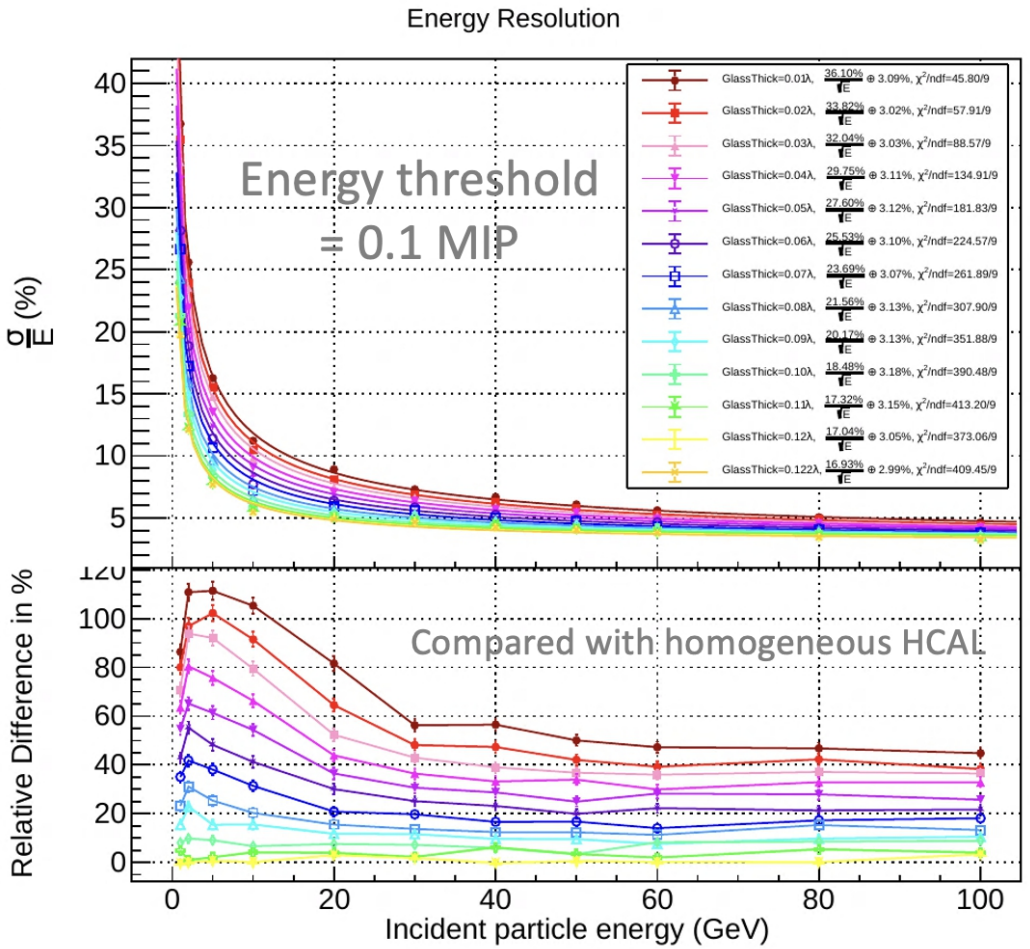


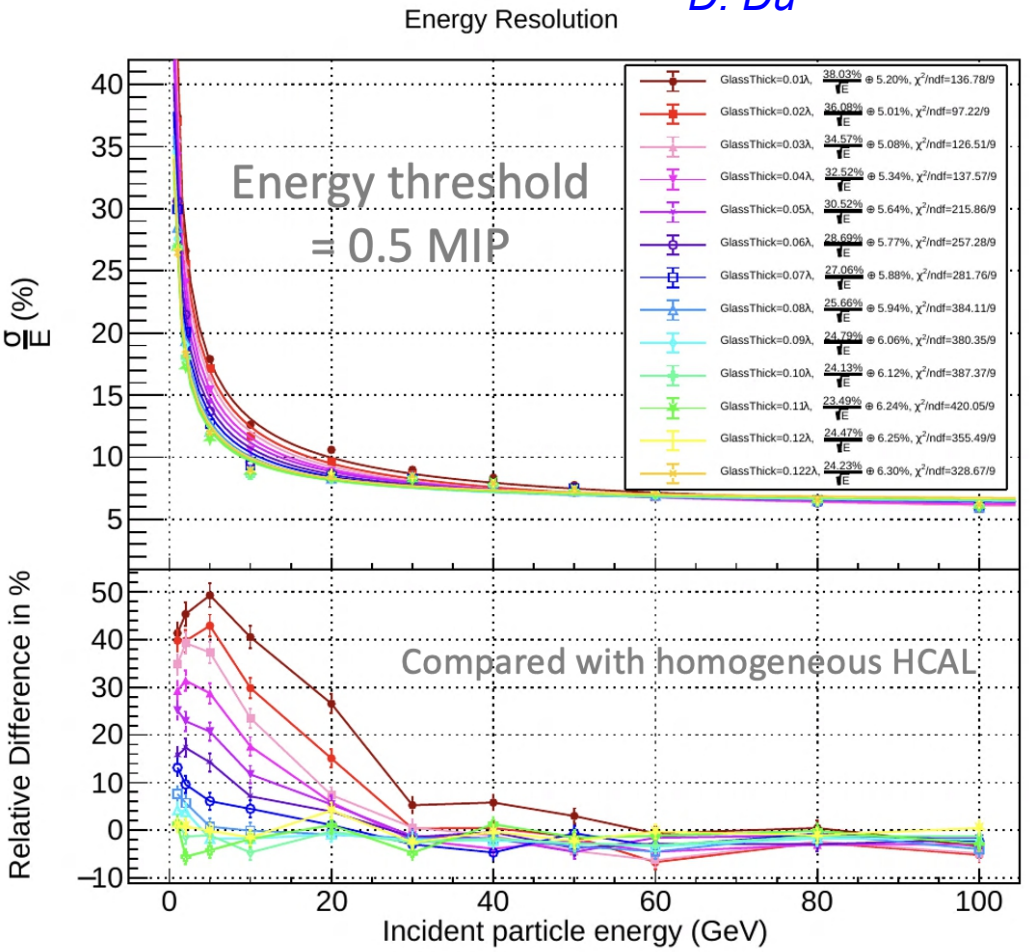
YX. Wang

Fast simulation reproduces the full simulation results, factorize/quantifies different impacts

HCAL

D. Du

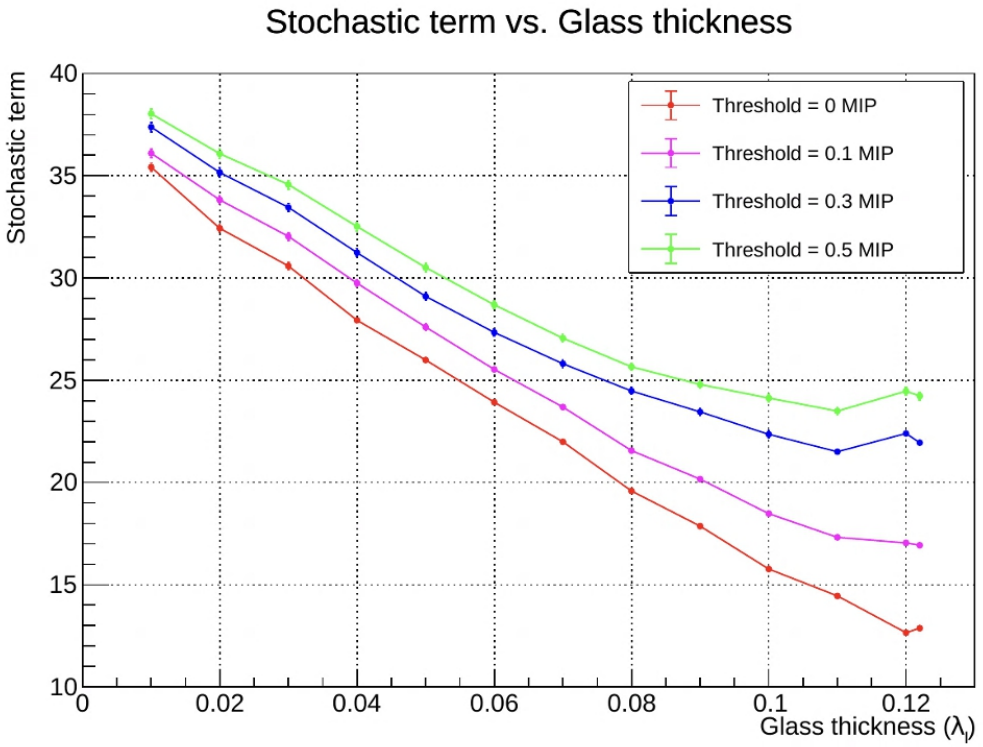


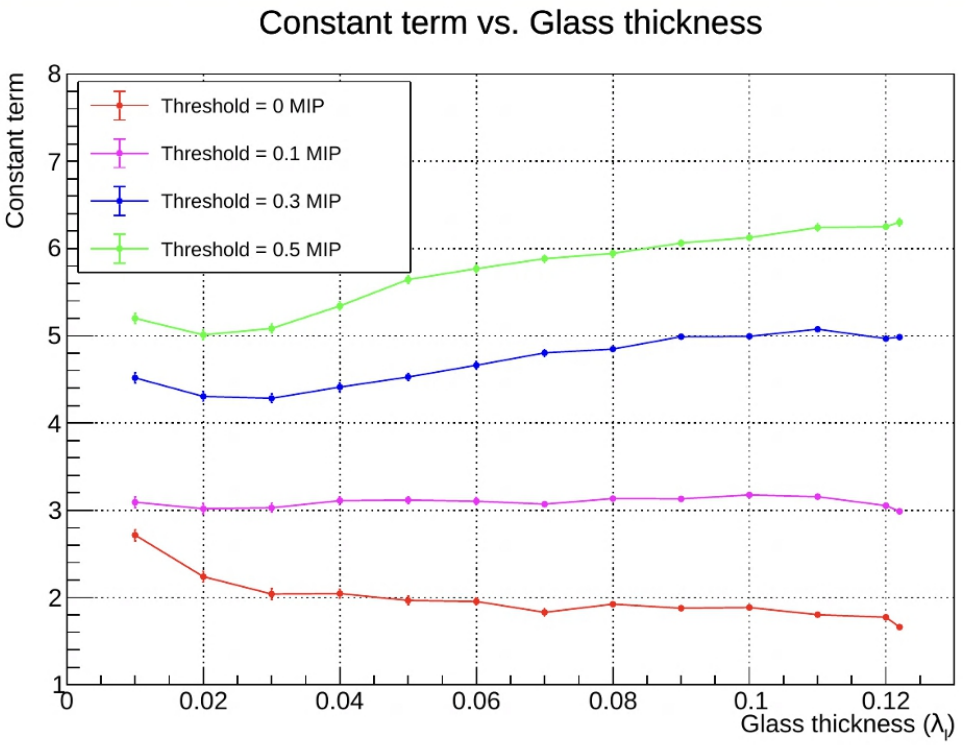


- In an ideal case - ideal Geometry ~ semi infinite...
- HCAL resolution significantly w.r.t. Baseline, at single particle level

Single Particle @ GS HCAL

D. Du

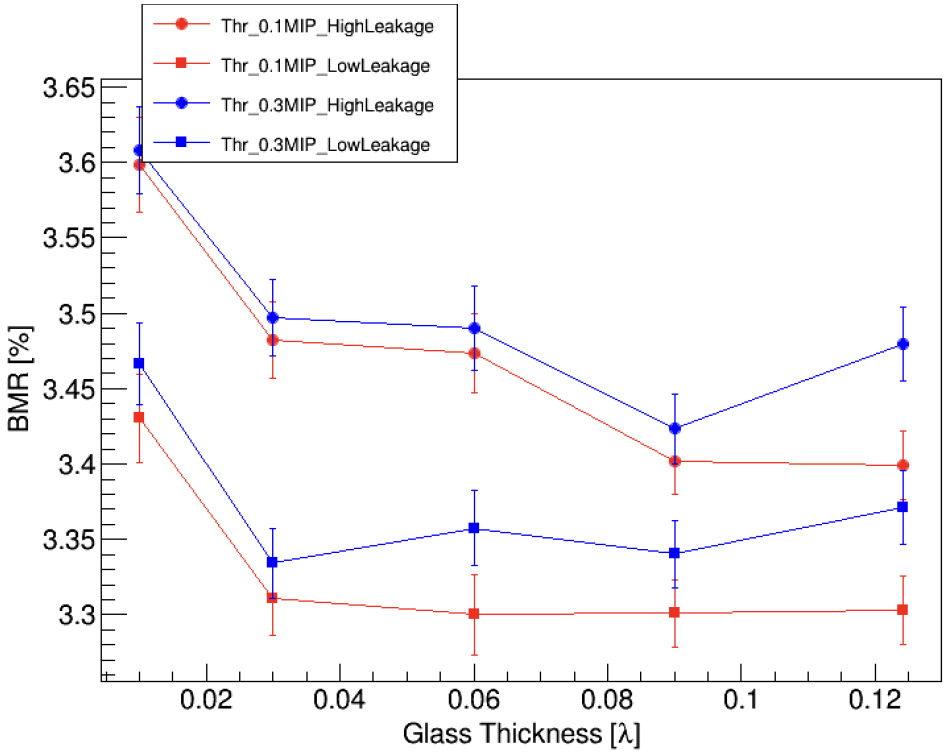


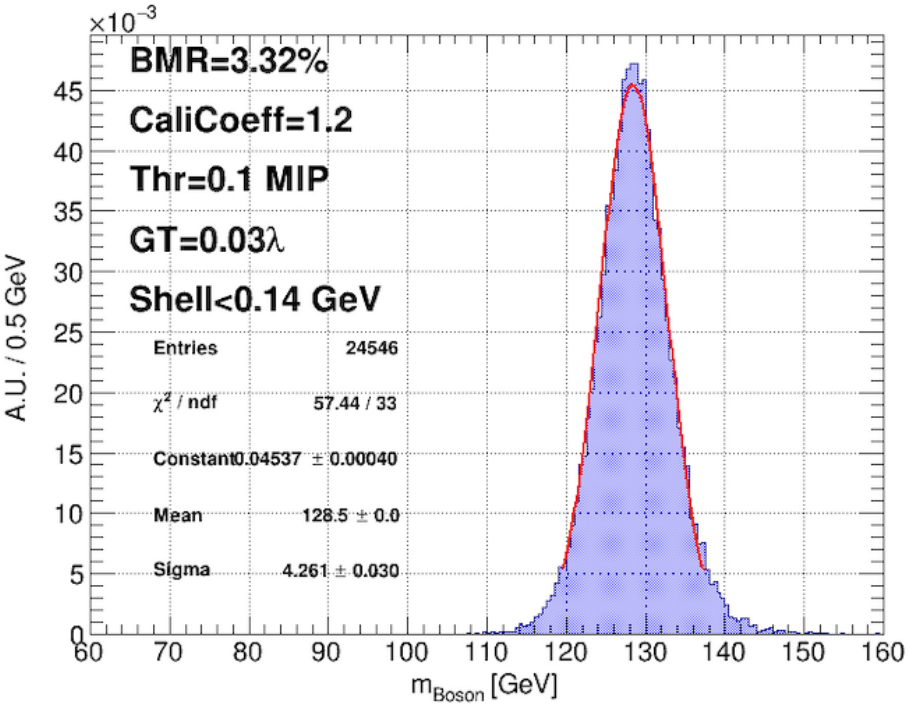


- Performance improves almost linearly at lower energy threshold, and larger sampling fraction

HCAL @ BMR

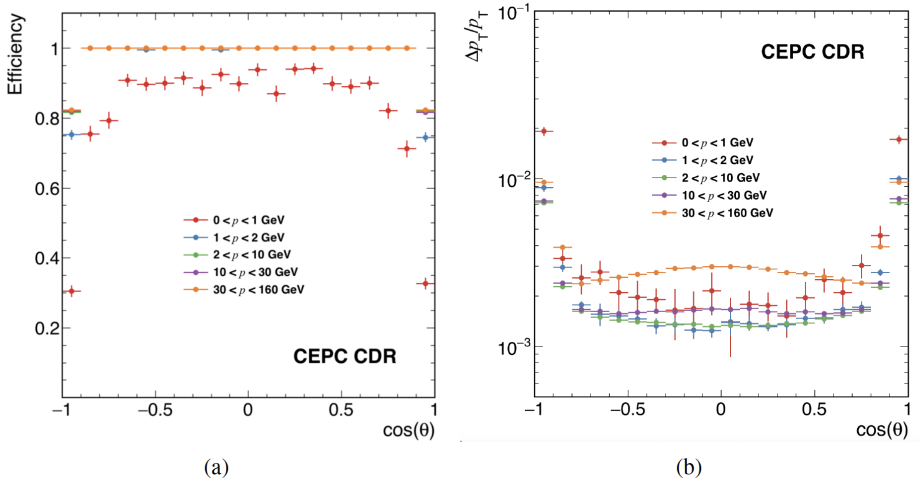
P. Hu & YX. Wang

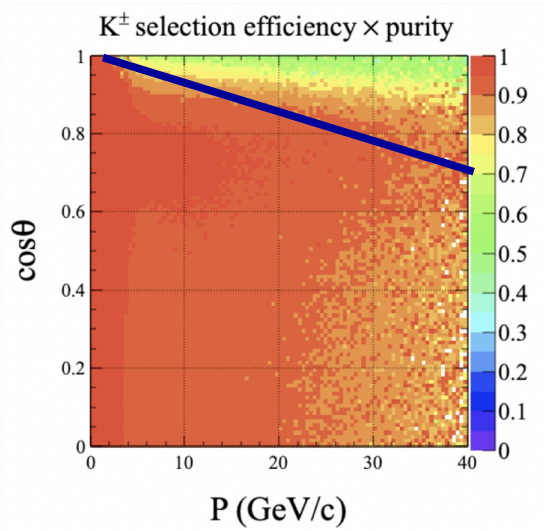


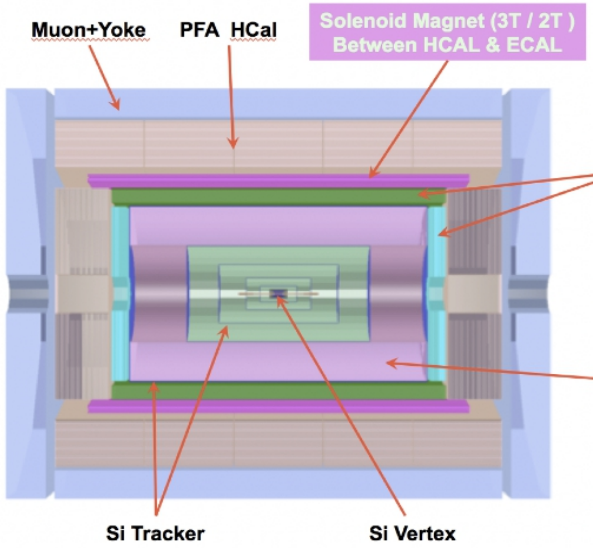


- Fits well with the model...
- Yet, a lot more to be understood

Tracker: tracking & Pid



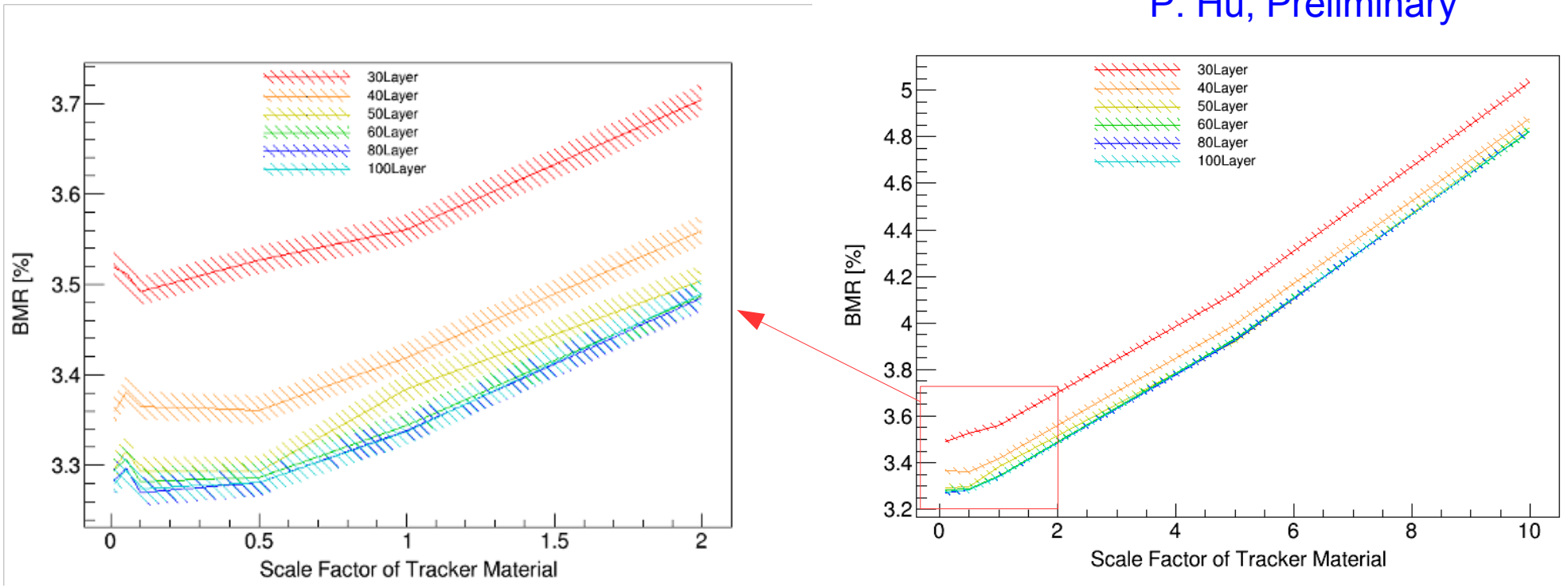




- BMR insensitive to Tracker unless tracker is bad
  - Pid & Lower the threshold shall leads to small improve, by correcting hadron mass
- Baseline set a good reference. Move toward better realizability & performance
- Performance – show the differential one!
  - Momentum resolution ~ 0.1%
  - Threshold ~ 0.1 MeV or lower & Larger Solid Angle Coverage!
  - dEdx or dNdx, if provided, better than 3% in barrel region for GeV level hadron (PS, very doubt for an DC inner radius of 600 mm... or larger)

BMR VS upstream material

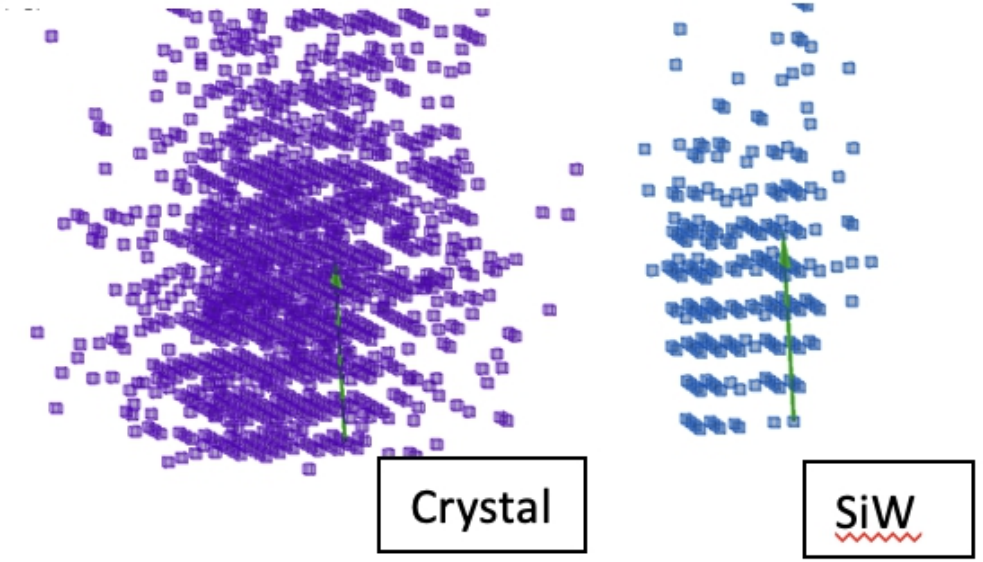
P. Hu, Preliminary

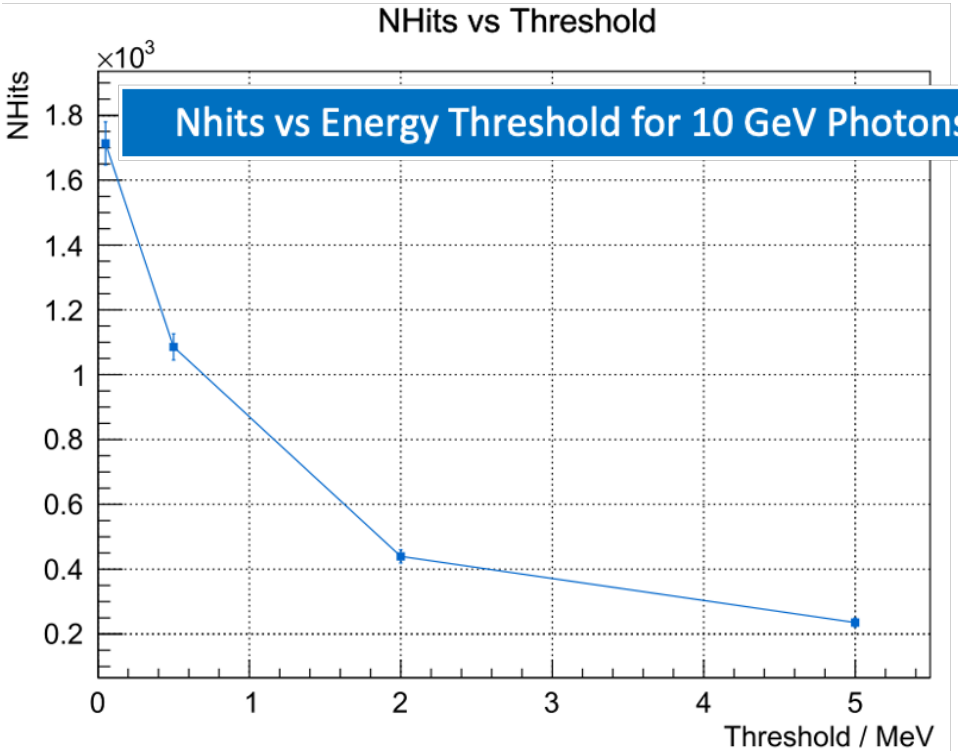


- Baseline: 10% X0 material in the barrel region.
- Would be great to half the upstream material.

ECAL → Crystal

- Let's simply assume crystal has same separation power as Si/Sci HGC.
- Changing Si-W Cell from Baseline to crystal
  - Better intrinsic EM resolution
  - #Hits increased by 1 order of magnitude - with 0.1 MIP cut

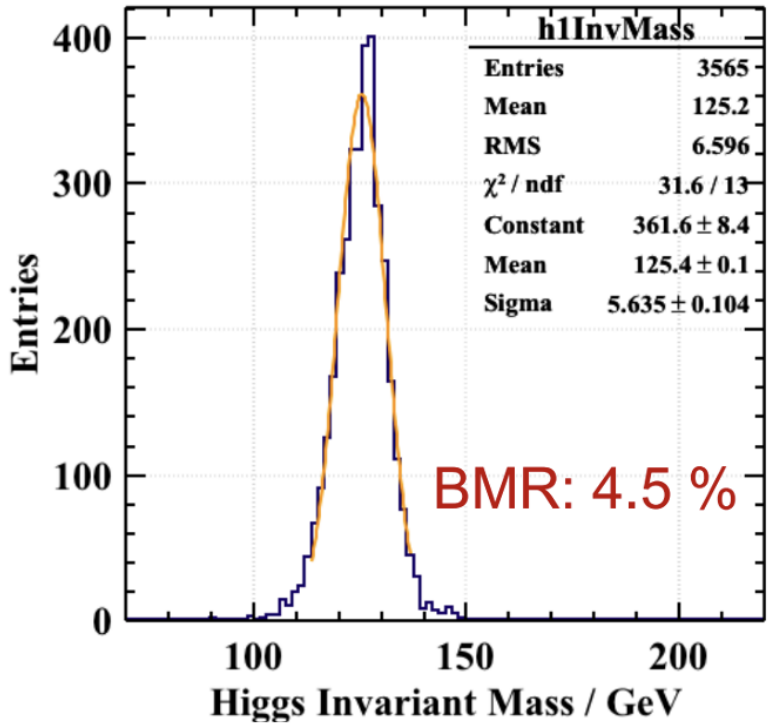


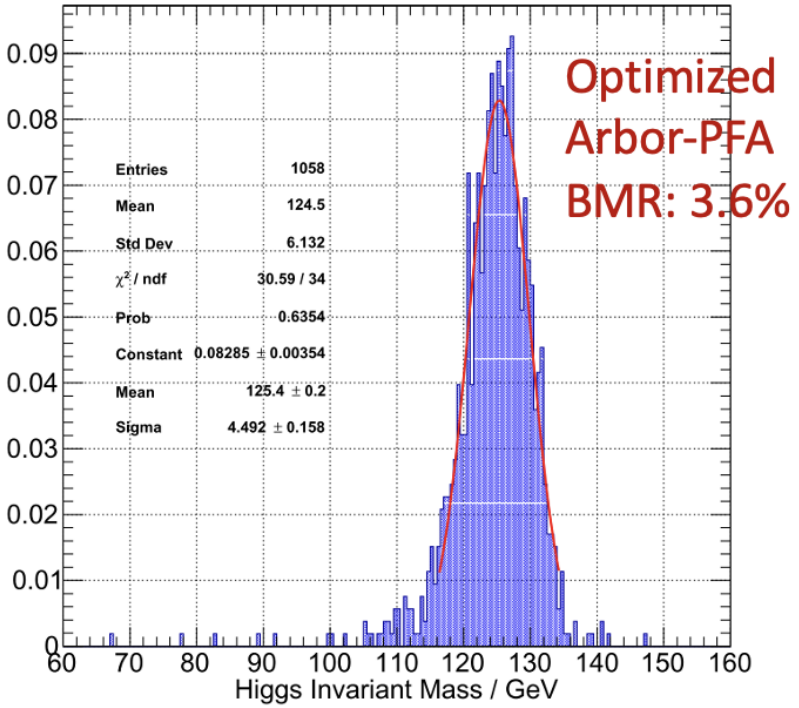


BMR @ Crystal ECAL Cell

B. Qi Preliminary

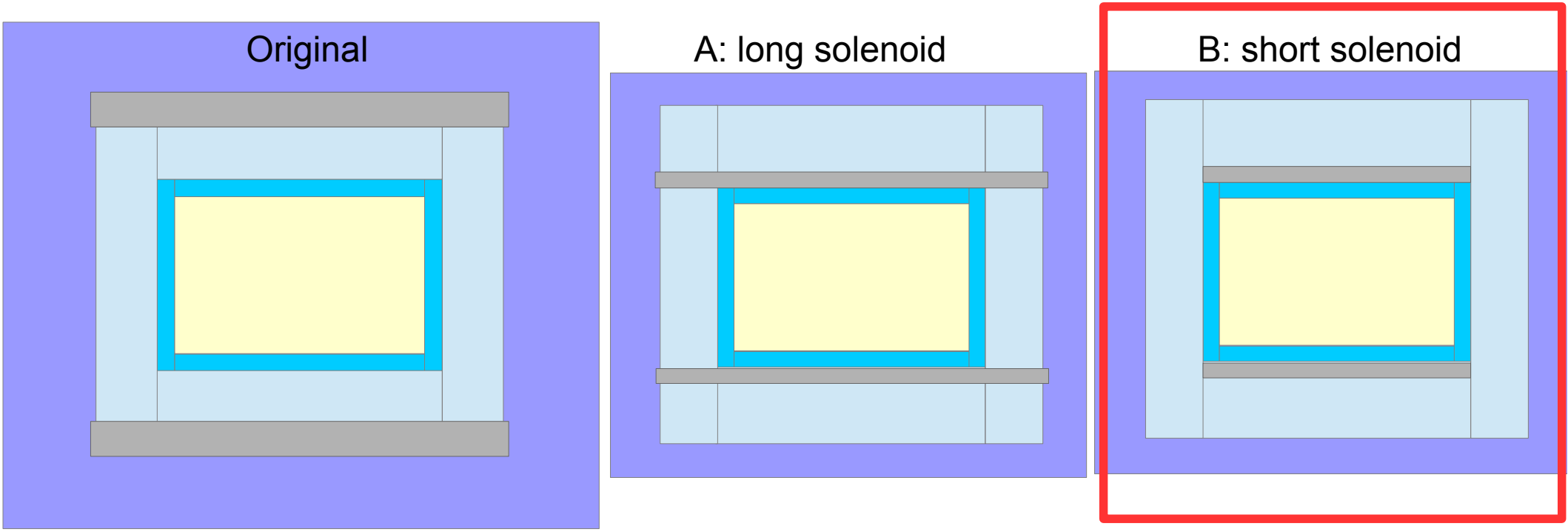
BMR ($H \to gg$)





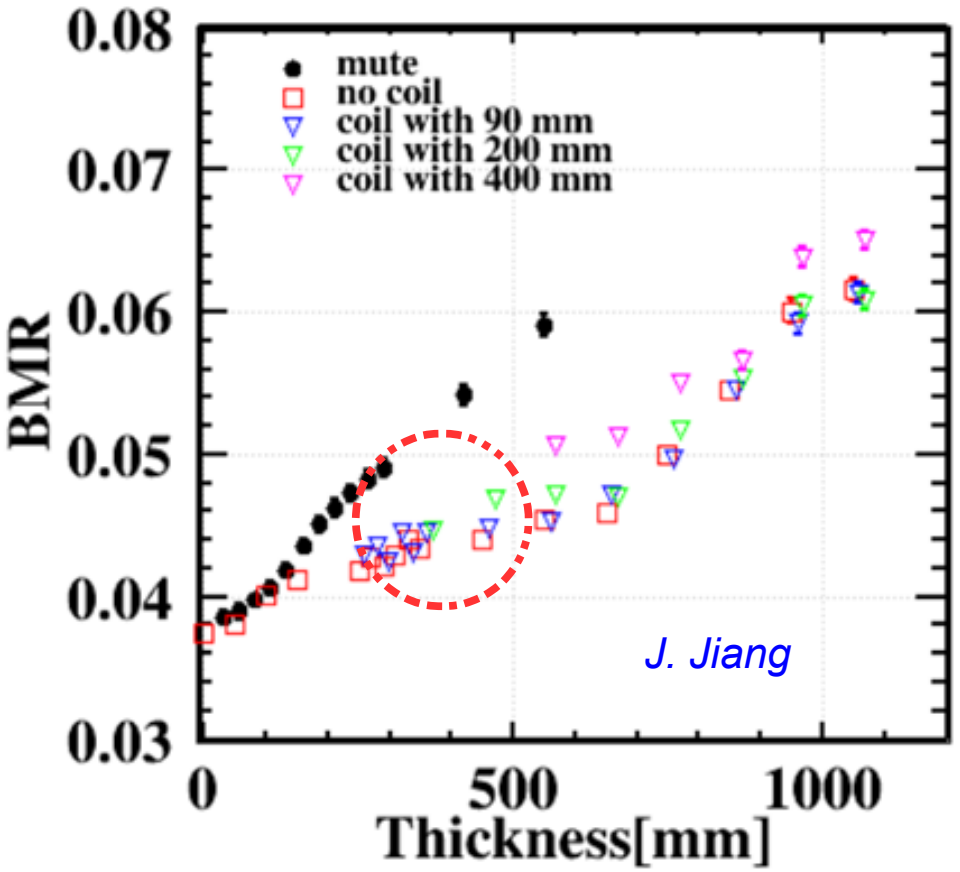
- A two-staged Arbor has been developed, which seems capable to overcome the difficulties of massive #Nhits in ECAL
- No significant improvement in BMR observed. 2% improvement anticipated from Fast simulation.

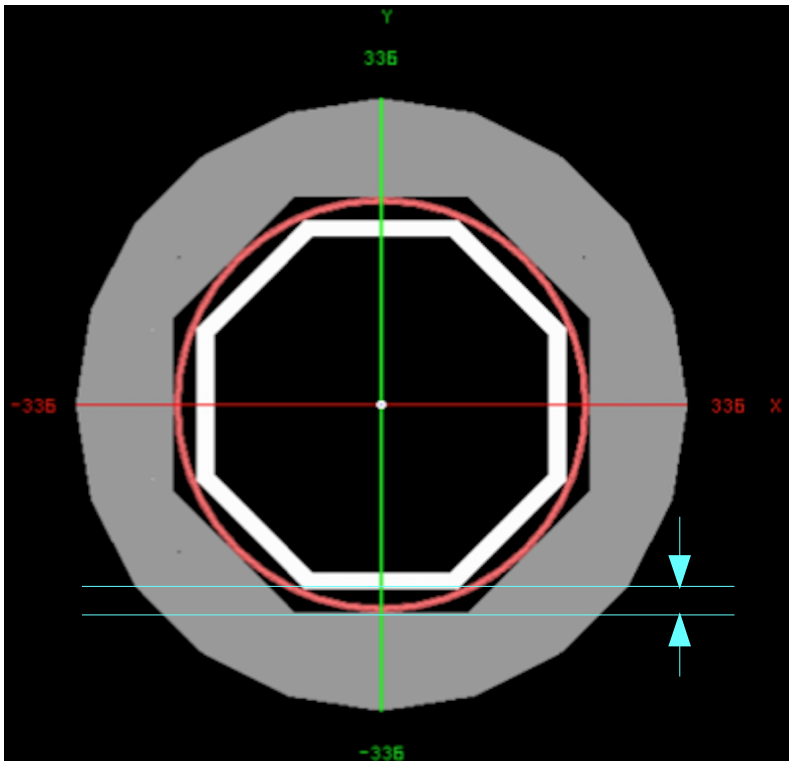
Solenoid between E&HCAL



- 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!)

Smaller Solenoid Impact on BMR



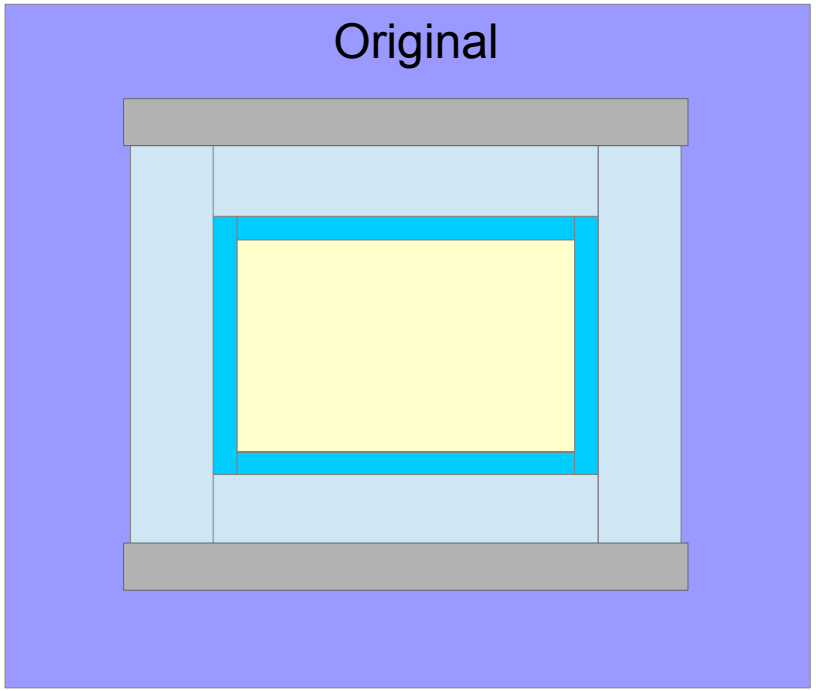


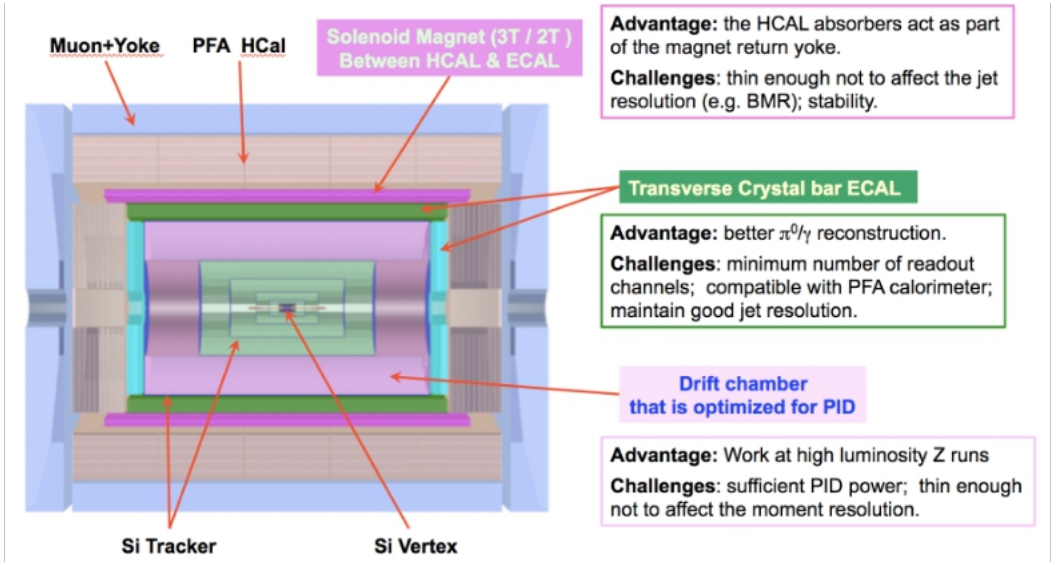
150 mm thick Cylinder Solenoid require at least 300 mm distances between ECAL/HCAL, Solenoid has Material Budget of at least 1 - 2 X_0

BMR Degrades from 3.8% to 4.3 – 4.4%.

Valve, Dead-zone, etc, will induce further inhomogeneity and degrades the performances.

Difference in cost





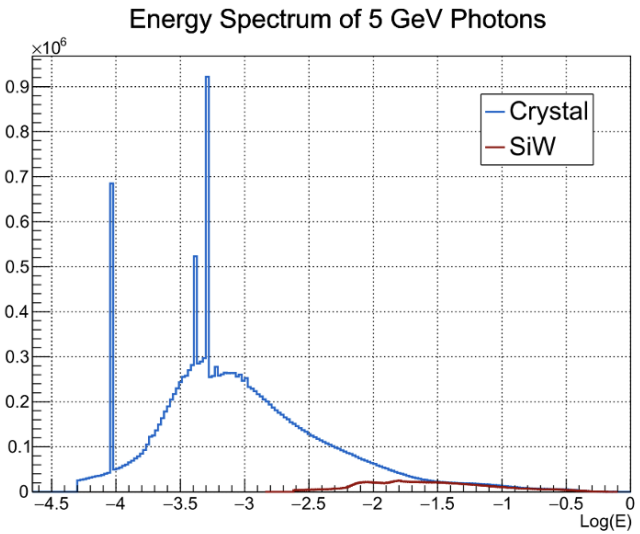
	Inside	Outside
Solenoid (LTS)	10900 w	14706 w
Yoke	? (~ 1000 w)	~ 6000 w
Solenoid (HTS)	14500 – 15400 w	22000 – 23800 w

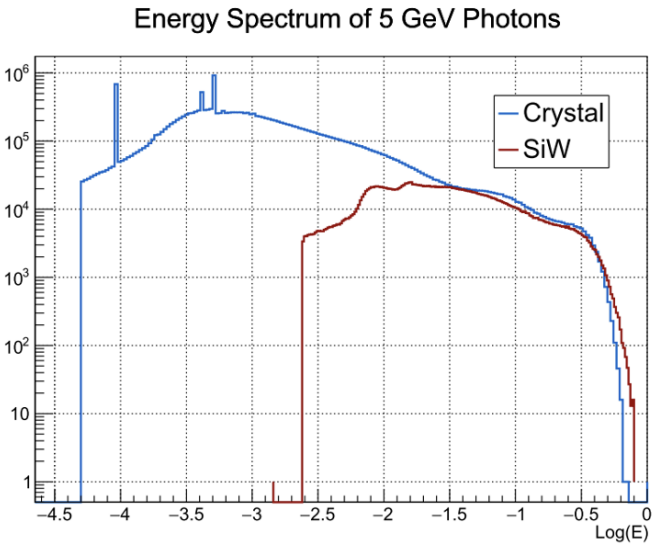
LTS (NiTi): Cost difference ~ 100 M.
HTS(YBCO): Cost difference < 150 M.

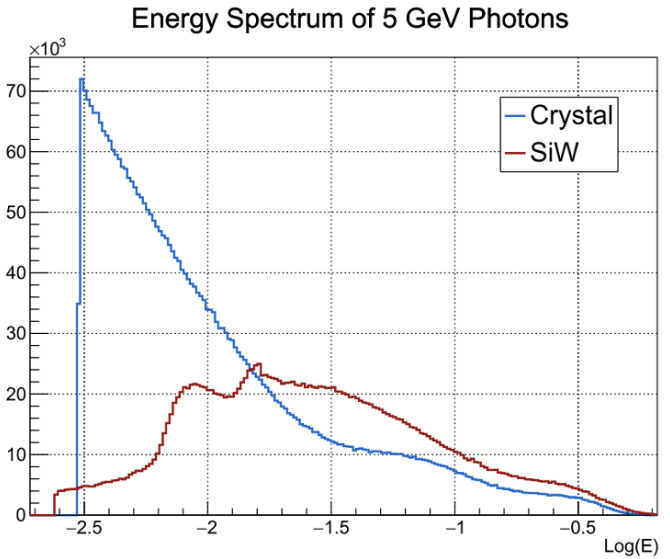
Summary

- Tracker: TPC + Silicon → Drift Chamber + Silicon:
  - Almost irrelevant if the Tracker is good enough;
  - BMR: Small margin from Pid, require upstream material in the barrel < 10%, if possible, 5%.
- ECAL: Si+W → Xstal
  - Crystal improves EM resolution, and induces much more hits
  - Small impact on BMR if separation power can be ensured.
- HCAL: GRPC + Iron → Glass + Iron
  - Promising
    - Single Particle level improved up to 2 times
    - 10% improvement on BMR (3.3%)
- Solenoid: Outside HCAL → Between ECAL & HCAL
  - Leads to a degrading more than 15%! Strongly disfavor
- Vertex, or VTX + MDI: Lots of margin & need intensive effort

Backup



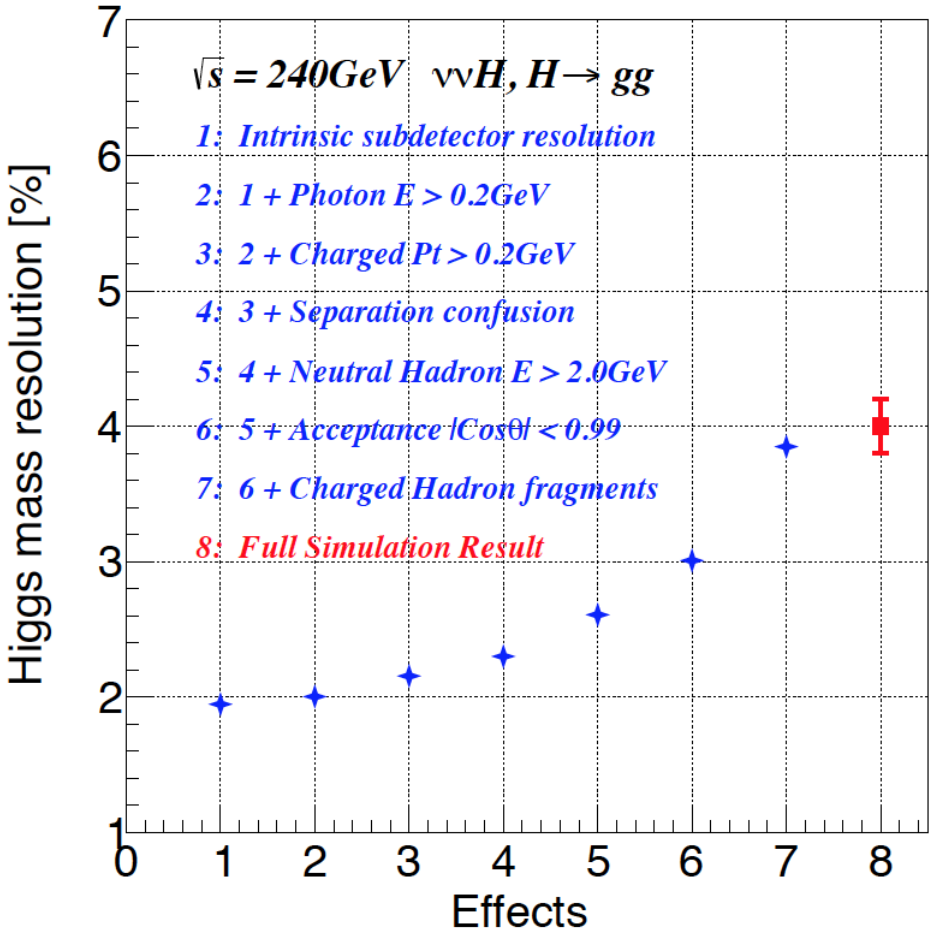


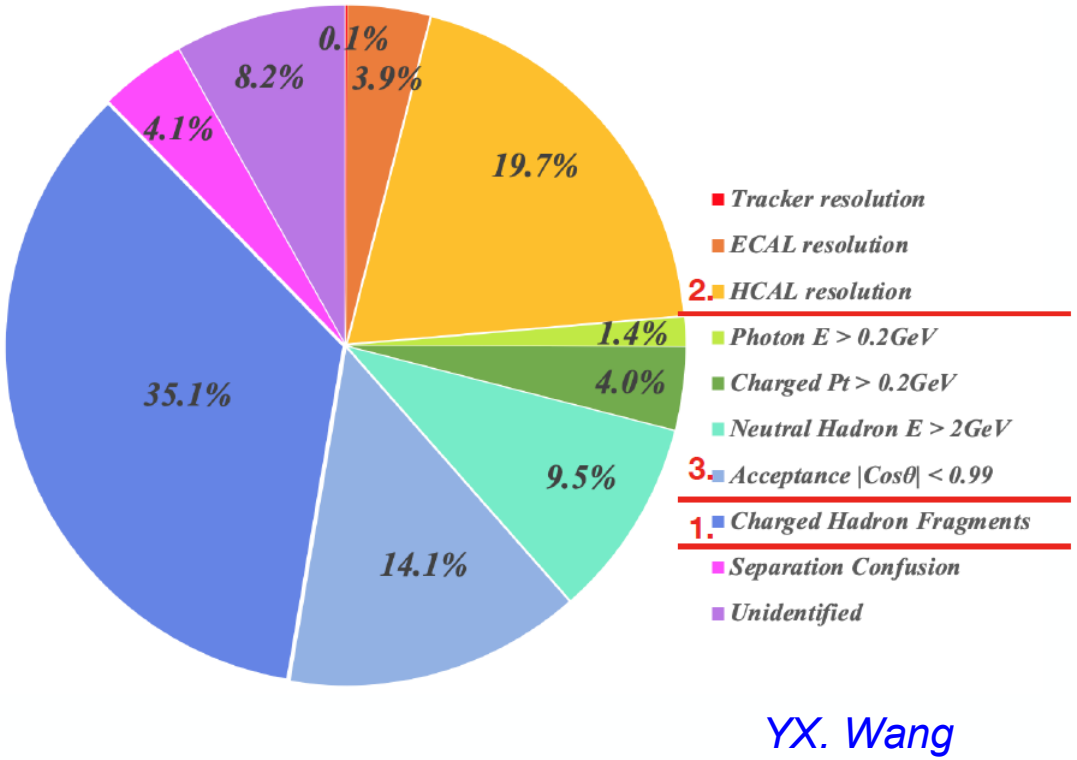


- Original energy spectrum, 10k events, threshold 50 keV
- A large number of low energy hits in crystal ECAL

- Threshold (0.3 MIP): SiW 50 keV, crystal 3 MeV

PFA Fast simulation





YX. Wang

Exercise so far fits well with the model...

低温超导方案（不包括轭铁）

		Inside（万元）	Outside（万元）
超导线圈	超导电缆	3050	5760
	线圈加工测试	1500	1885
磁体内部低温	阀箱、吊挂、冷却结构、恒温器	1500	2215
制冷系统	低温系统，管道及支架、低温控制	2000	2000
真空系统	机械泵、分子泵、质谱仪等	310	310
电源及失超保护	电源、失超保护系统、母排	2000	2000
控制系统	检测及联锁控制	160	160
磁测系统	测磁机安装设计制造	376	376
总额		10,896	14,706

高温超导方案（不包括轭铁）

	Inside		Outside	
超导电缆	电缆长 9 km，其中有带材 35 层，共 315 km，目前市场价 350 元/米，1.1 亿元，电缆覆铝加工 1 千万元。	12,000 万元	电缆长 21 km，其中有带材 30 层，共 630 km，目前市场价 350 元/米，2.2 亿元，电缆覆铝加工 2 千万元。	24,000 万元
	考虑 5 年后电缆性能的提升，带材用量的减少，以及大批量采购带来的价格降低，170-200 元/米	6,355 ~ 7,300 万元	考虑 5 年后电缆性能的提升，带材用量的减少，以及大批量采购带来的价格降低，170-200 元/米	12,710~ 14,600 万元
线圈加工	比低温超导多电缆接头制作	1,800 万元		2,200 万元
其他部分与低温方案相同	1500+2000+310+2000+160+376	6,346 万元	2215+2000+310+2000+160+376	7,061 万元
总额		18,729 万元		33,261 万元
		14,501 ~ 15,446 万元		21,971 ~ 23,861 万元

轭铁费用

CDR 中轭铁用量 12573 吨

	CDR	
重量	12573 吨	2000 吨
费用（包含底座、移动机构、组装）	35,000 万元	6,000 万元