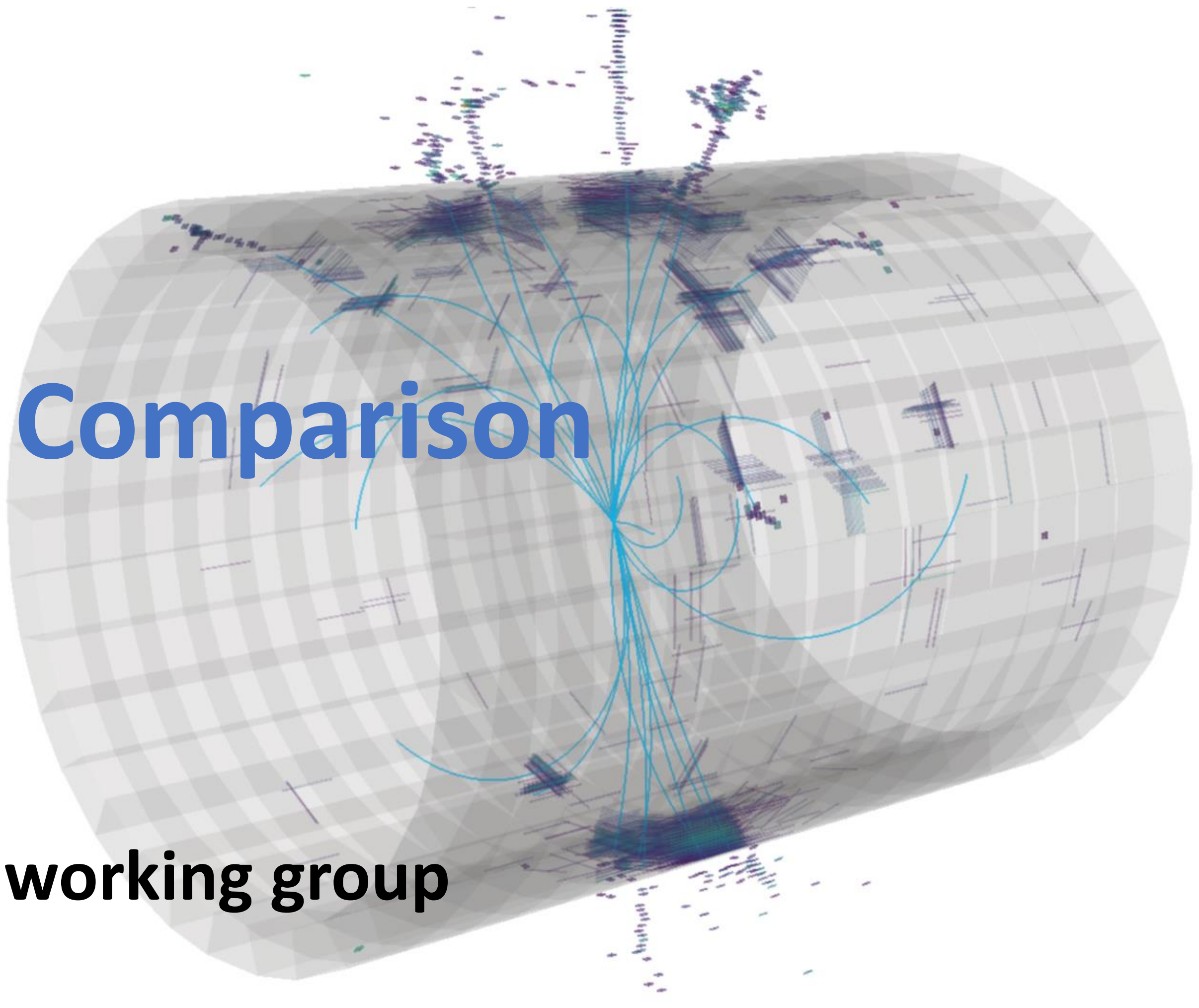
10mm vs. 15mm Crystal Comparison Using CyberFPA



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IHEP, CAS

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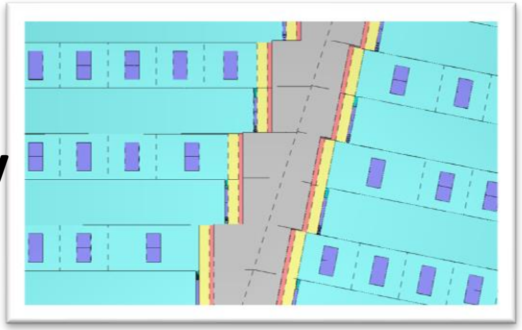
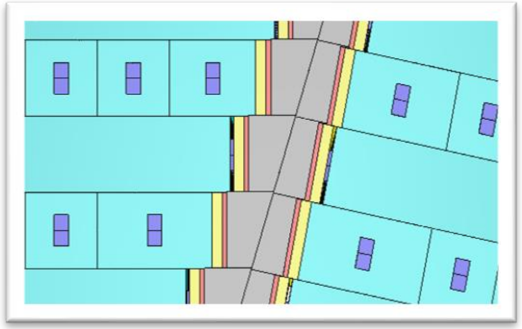
Introduction

- **10mm and 15mm granularity geometry display**


10mm×10mm

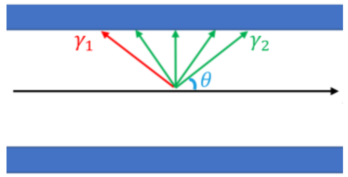

15mm×15mm

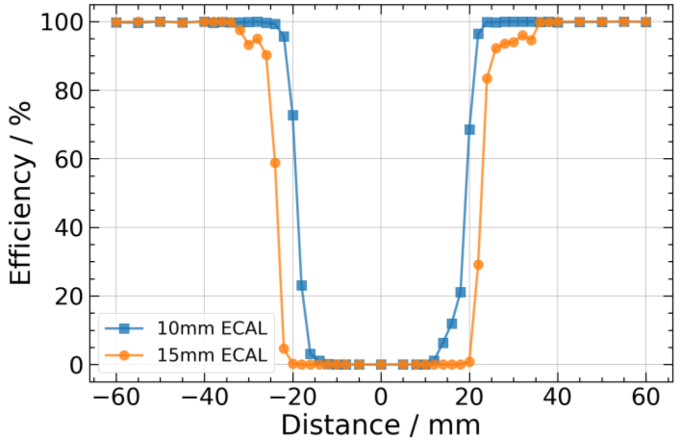
- **10mm ➔ 15 mm:**
  - Advantages:
    - Similar crystal volume, significant reduction in number of readout channels
    - Less dead area: one step per 2 layers for 10mm, one step per layer for 15mm
    - Reduce difficulty of production of crystal bars
    - Mechanics(cooling) and electronics benefit from larger granularity
  - Disadvantages:
    - Lager granularity deteriorate particle recognition
- **Physics performance study**
  - One step per 2 layers for 15mm: needs several days
  - Energy correction for cracks needs update

Granularity	Number of Readout Channels
10 mm	956,160
15 mm	405,120

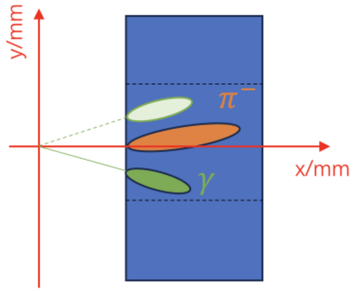
Separation Capability

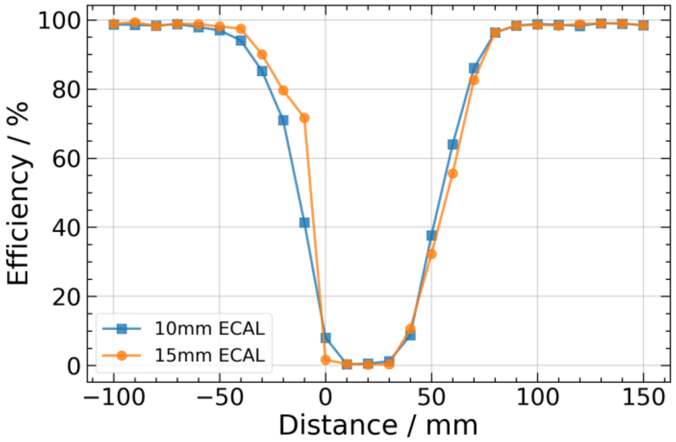
- $\gamma\gamma$
  - $E_{\gamma 1} = E_{\gamma 2} = 5GeV$
  - Success separation:
    - ≥2 PFO,
    - $|E_\gamma - E_{PFO}| < \frac{1}{3}E_\gamma$
    - $|\theta_\gamma - \theta_{PFO}| < 0.3$ for 10mm ECAL, <0.45 for 15mm ECAL





- $\gamma\pi$
  - $E_\gamma = E_{\pi^-} = 5GeV$
  - Success separation:
    - 1 charged PFO, ≥1 neutral PFO
    - $|E_\gamma - E_{neutral\ PFO}| < \frac{1}{3}E_\gamma$
    - $|y_{gamma} - y_{PFO}| < 30mm$



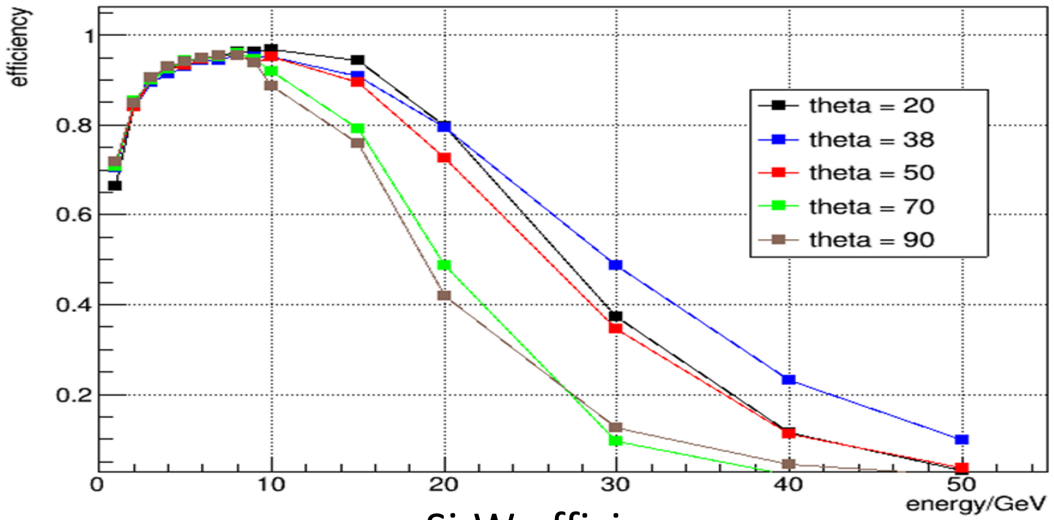


Veto events with interactions within ECAL

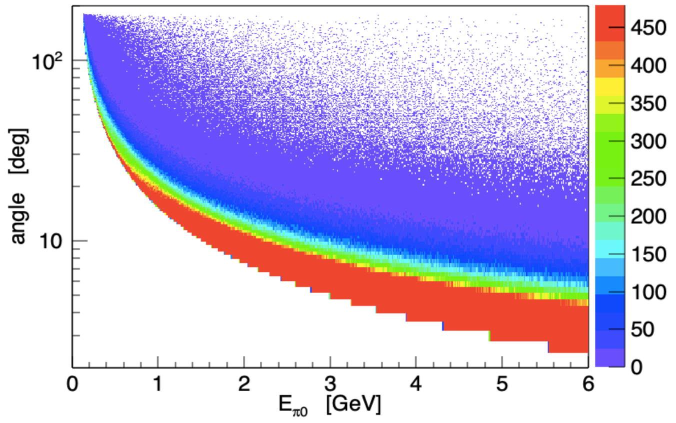
Mass Resolution and Efficiency of π^0

- $\boldsymbol{\pi^0}$
  - $E_{\pi^0}: 1, 2, .., 28$ GeV
  - $\theta: 50°\sim130°$
  - $\phi: 0°\sim360°$

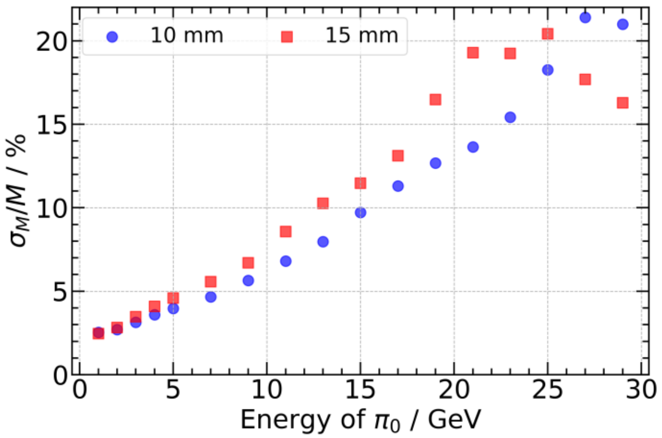
  Veto events with interactions within ECAL



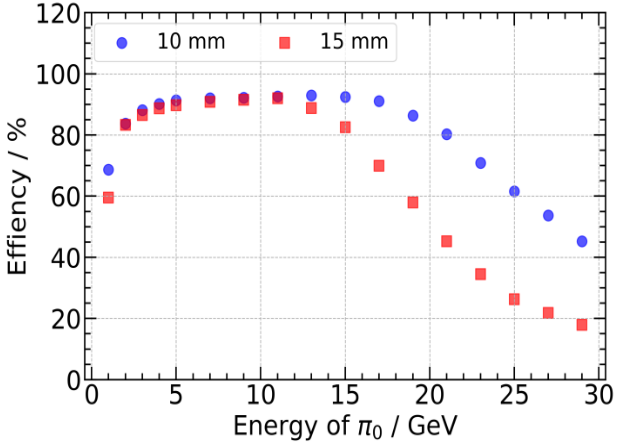
Si-W efficiency



Angles of 2γ vs Energy of pi0



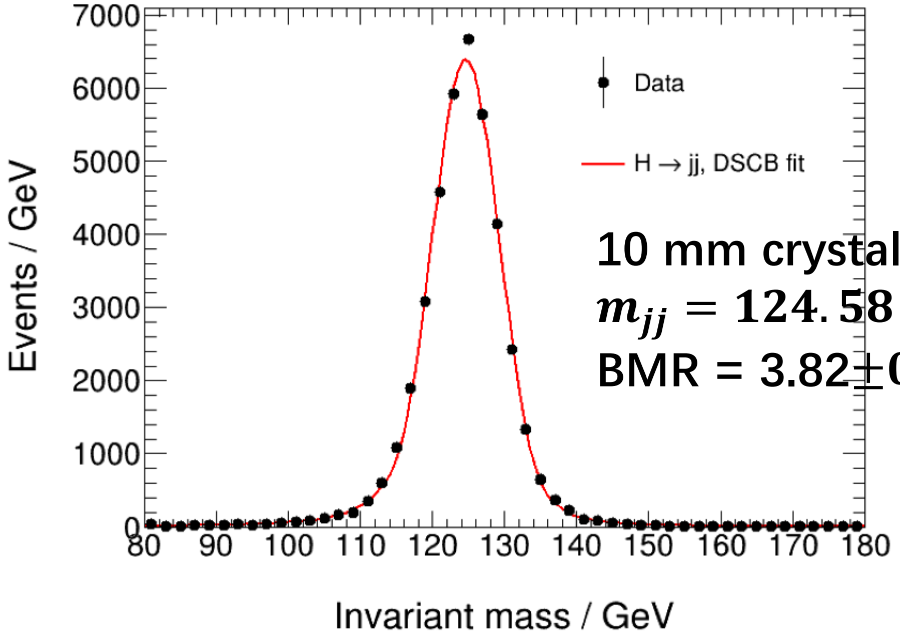
Crystal resolution



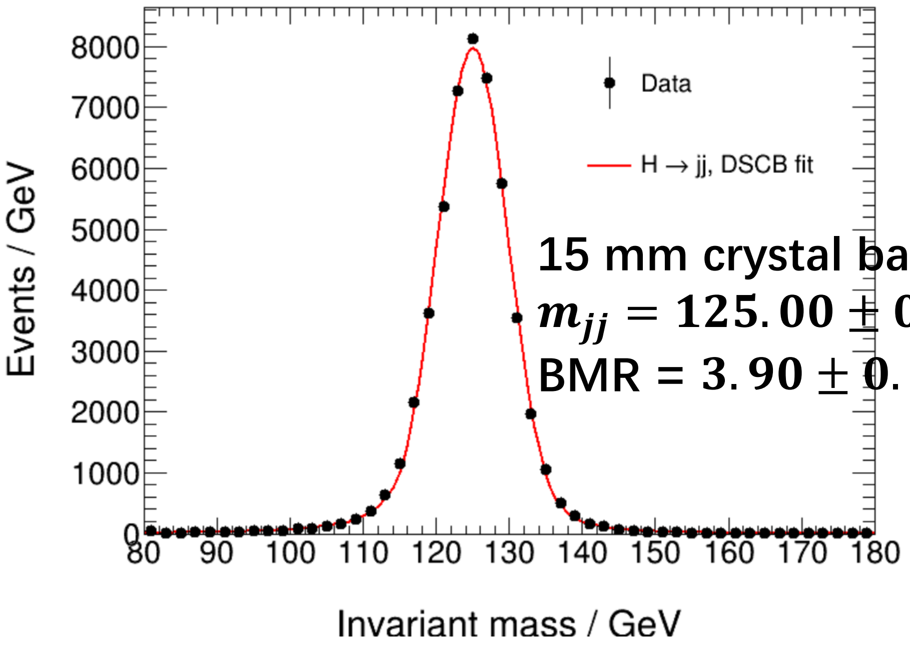
Crystal efficiency

Preliminary BMR performance

- **Full detector reconstruction: track + ECAL (10 mm / 15 mm) + GS-HCAL**
  - Track selection: a BDTG-based selection.
  - ECAL and HCAL digitization are the same for 10 mm and 15 mm.
  - CyberPFA reconstruction: tuned granularity related parameters.
  - ~200k events generated, ~ 50k selected for barrel only.



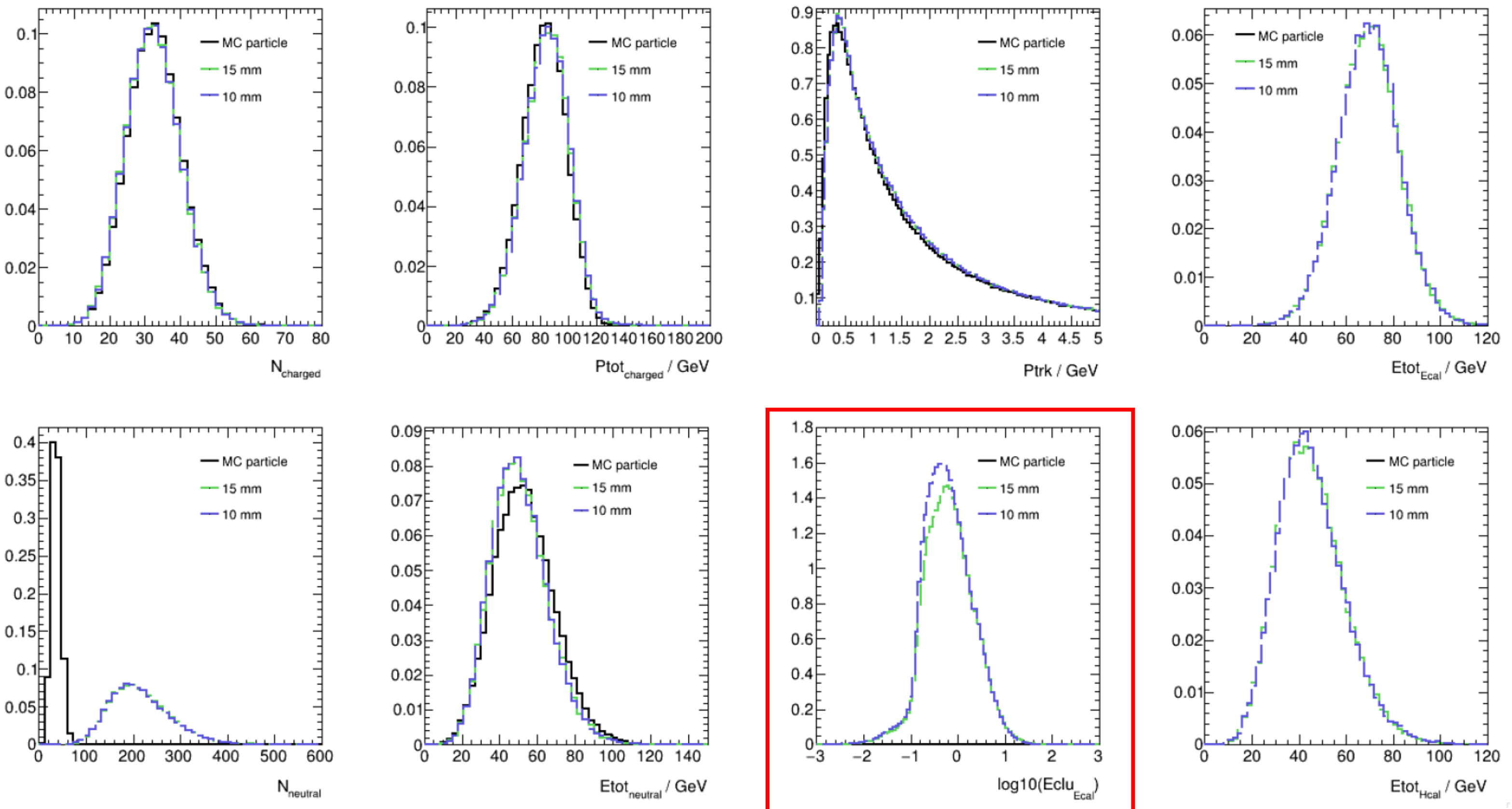
10 mm crystal bar ECAL
$m_{jj} = 124.58 \pm 0.03$ GeV
BMR = 3.82$\pm 0.03\%$

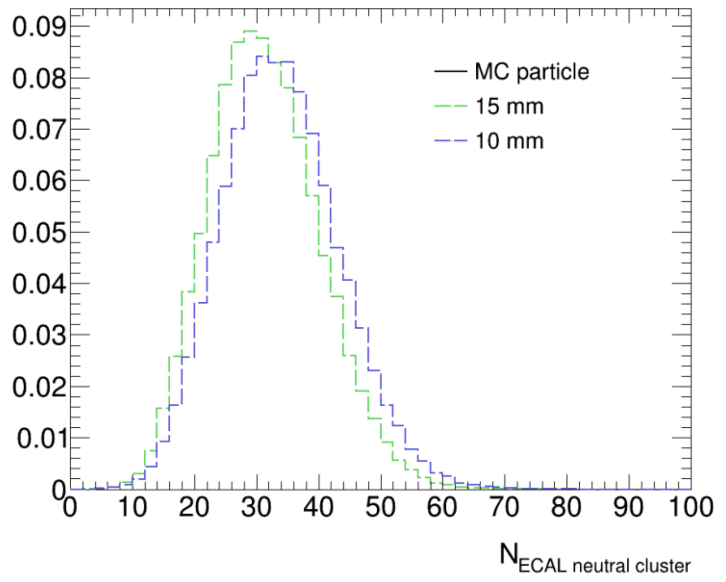


15 mm crystal bar ECAL
$m_{jj} = 125.00 \pm 0.03$ GeV
BMR = $3.90 \pm 0.02\%$

BMR performance

- **Major difference: ECAL cluster number and energy.**
  - Less clusters in 15 mm ECAL, but larger energy for each cluster -> more confusion.





BMR performance

- **Previous studies about ECAL granularity:**
  - PandoraPFA: *"For 45 GeV jets, the dependence is relatively weak since the confusion term is not the dominant contribution to the resolution. For higher energy jets, a significant degradation in performance is observed with increasing pixel size."*
  - ArborPFA: *"with the ECAL cell size is at 10 mm, the overlapping chance is 1.7% only. However, once the ECAL cell size increases to 20 mm, this overlapping chance rapidly increases by one order of magnitude."*

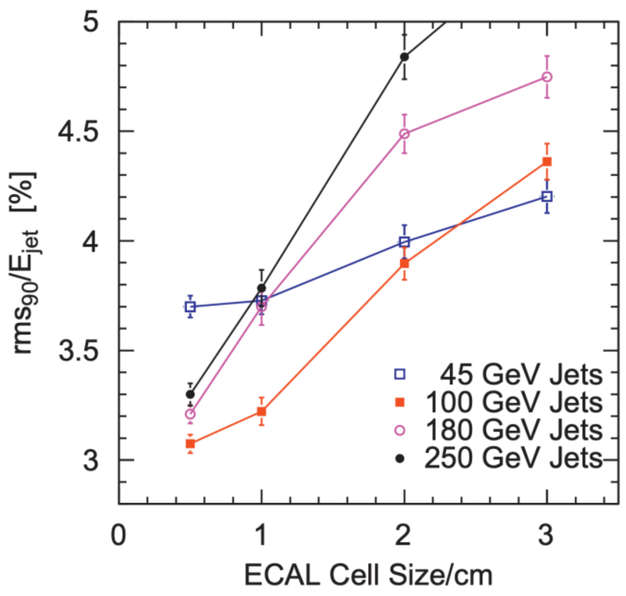


Table 2. Percentages of photons that would be polluted by neighbor particles

Cell Size	Critical Separation Distance with Arbor	Percentage of $Z \rightarrow \tau^+\tau^-$
1 mm	4 mm	0.07%
5 mm	8 mm	0.30%
10 mm	16 mm	1.70%
20 mm	38 mm	19.6%

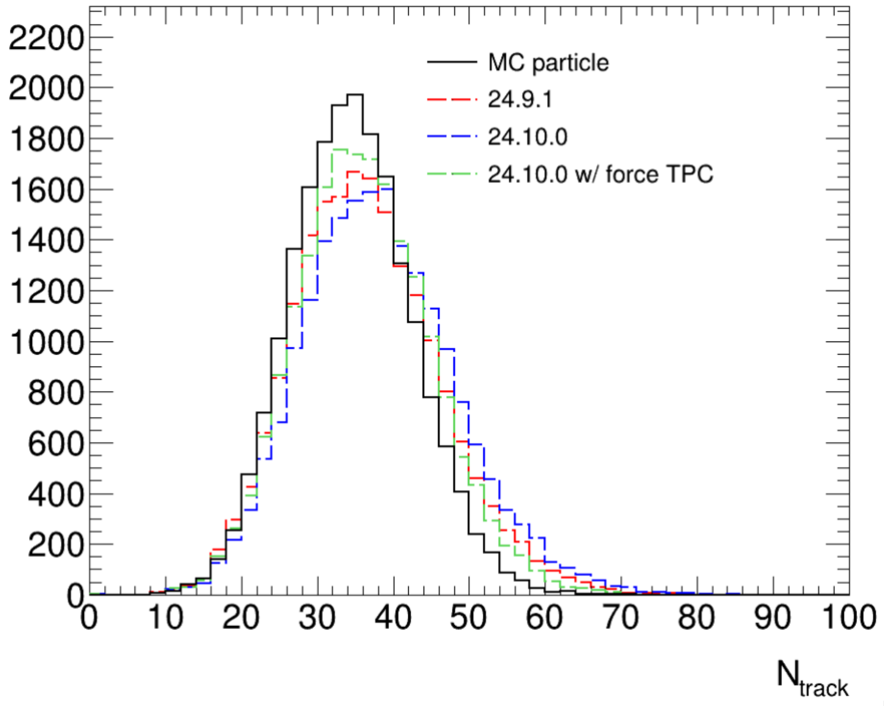
Table 3. Resolution of reconstructed Higgs boson mass through $\nu\nu Higgs, Higgs \rightarrow gluons$ events with different cell size at CEPC_v1 geometry.

Silicon sensor cell size	Higgs boson mass resolution (Statistic error only)
5 mm	3.74 ± 0.02 %
10 mm	3.75 ± 0.02 %
20 mm	3.93 ± 0.02 %

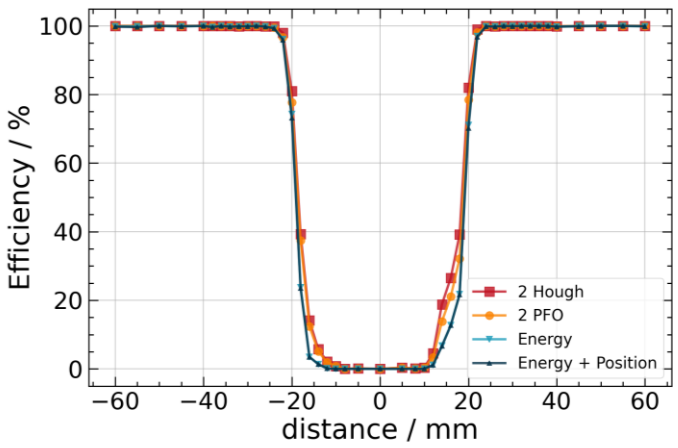
Backup

Track update

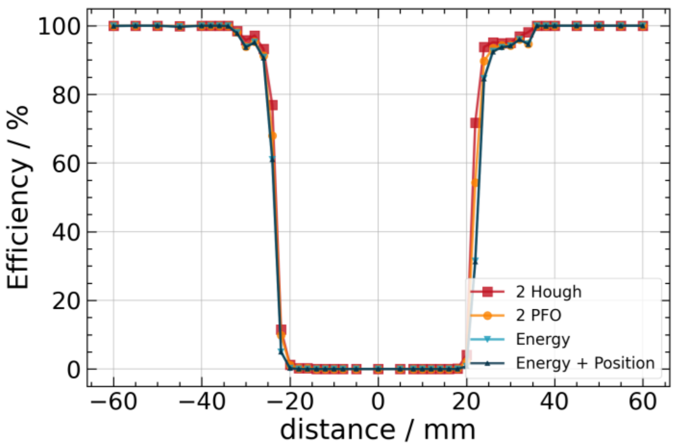
- **Track performance update in CEPCSW tdr24.10.0 by Chengdong Fu:**
  - Fix the low efficiency issue for P<1 GeV
  - Reduced the fake tracks in TPC.



Backup

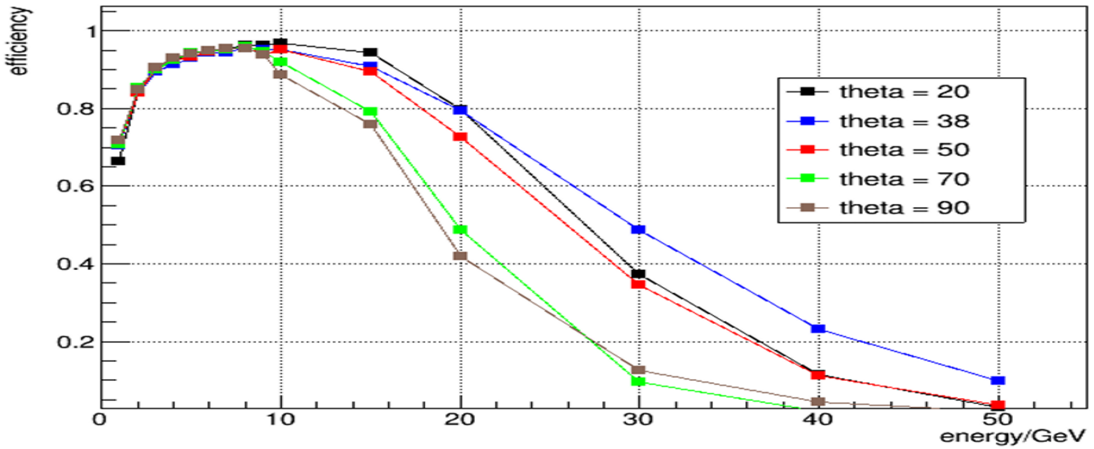


$\gamma\gamma$， 10mm ECAL

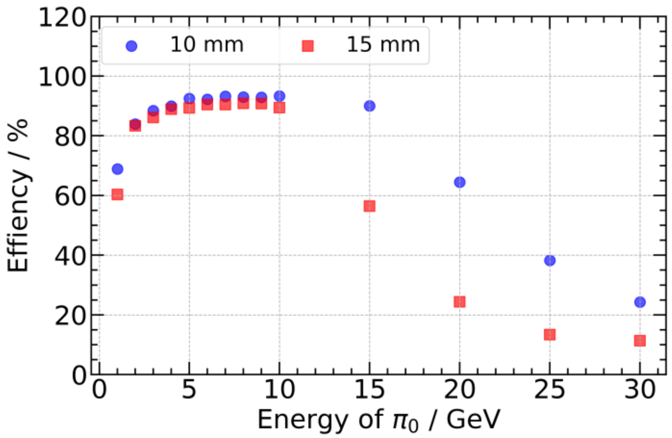


$\gamma\gamma$ ， 15mm ECAL

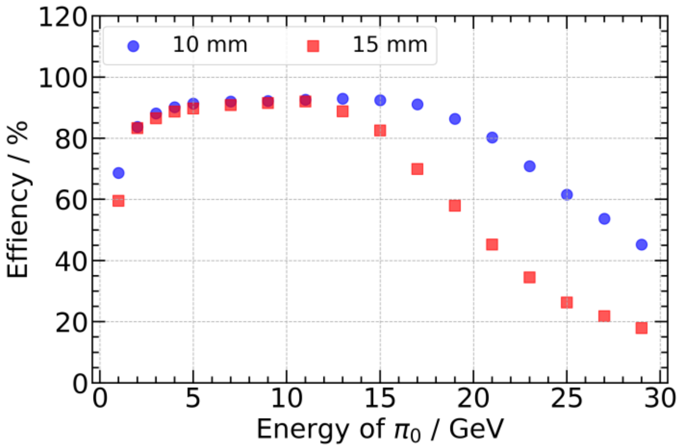
Si-W



晶体ECAL更新前

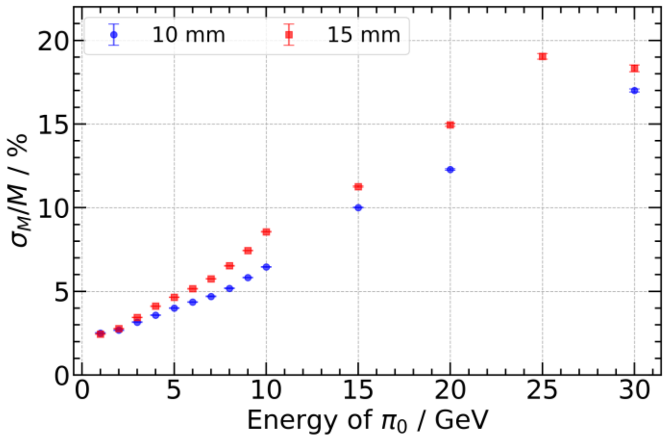


晶体ECAL更新后



π^0
theta 50 - 130
phi 0 - 360

晶体ECAL更新前



晶体ECAL更新后