CEPC Calorimeter software status

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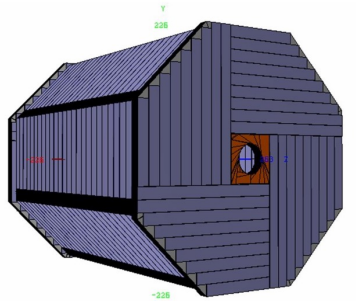
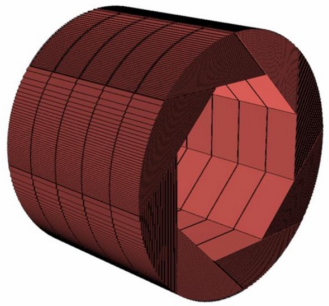
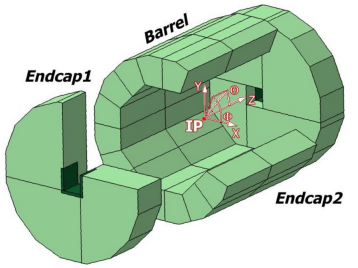
Software preparation in CEPCSW

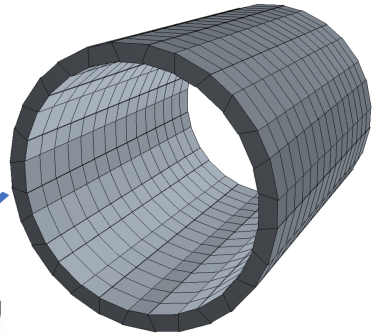
- **Geometry**
  - Full CEPC-v4 geometry: available, but need validation
    - Including Si-W ECAL, RPC and scintillator HCAL.
    - Octagonal arrangement for both ECAL and HCAL.
    - Missing: scintillator strip ECAL.
  - Long crystal bar ECAL:
    - Ideal octagonal ECAL: available.
      - No supporting, electronics, cooling, etc.
    - 32-side trapezoidal ECAL: developing by Weizheng
      - A relative ideal version is ready, with 3 cm carbon breaks between modules.
  - Short crystal bar (crystal cube) ECAL: developing
    - Ideal octagonal cubic ECAL: very preliminary version by Jiyuan.
    - 32-side: Missing
  - Stereo crystal ECAL: available.
    - Ideal case, no supporting, etc.
  - Glass HCAL: developing by Weizheng
    - Replace the sensitive material of CEPC-v4 scintillator HCAL to glass

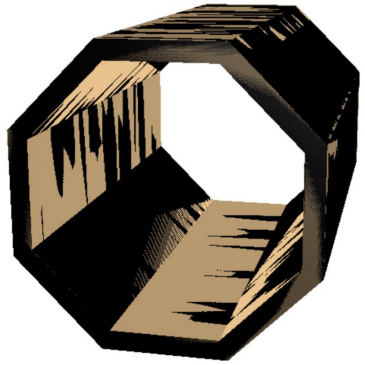






Barrel only

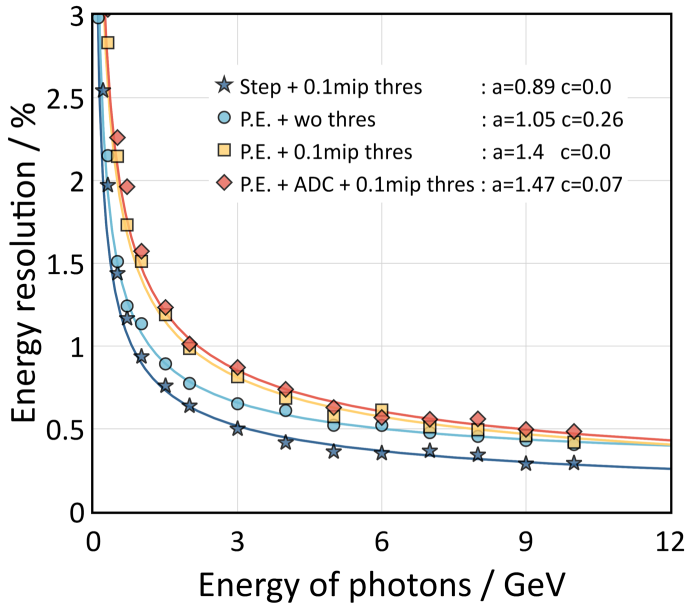




Software preparation in CEPCSW

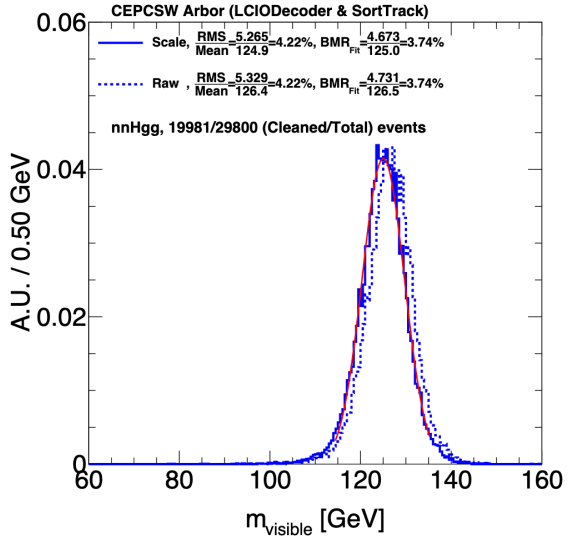
- **Digitization:**
  - G2CD: available.
    - For CEPC-v4 ECAL and HCAL, only include simple calibration constant.
    - Support transverse cell merge.
  - CRD Digi: available.
    - For crystal bar ECAL: energy + time info, but in an ideal digitization model.
  - Realistic model: developing by Zhiyu, Weizheng & Baohua.
    - Including: crystal scintillation, SiPM, ADC.
    - Timing response development is missing.

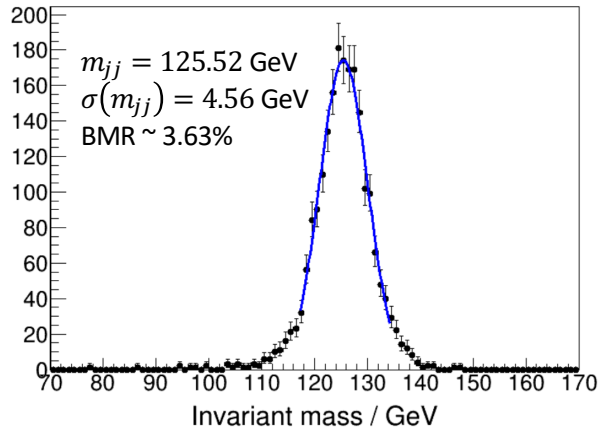
		24MeV		594MeV						
	Energy (MeV)	5	10	50	100	500	1000	5000	10000	15000
Scintillation	σ/<E> (%)	13.18	9.35	4.20	2.96	1.32	0.94	0.42	0.30	0.24
SiPM	σ/<E> (%)	15.28	10.84	4.88	3.47	1.55	1.09	0.49	0.35	0.28
ADC	σ/<E> (%)	0.98	0.68	0.97	0.53	0.24	1.14	0.30	0.23	0.21
1⊕2⊕3	σ/<E> (%)	20.20	14.33	6.51	4.59	2.05	1.84	0.71	0.52	0.42
Total	σ/<E> (%)	19.74	14.15	6.51	4.60	2.05	1.83	0.71	0.51	0.44



Software preparation in CEPCSW

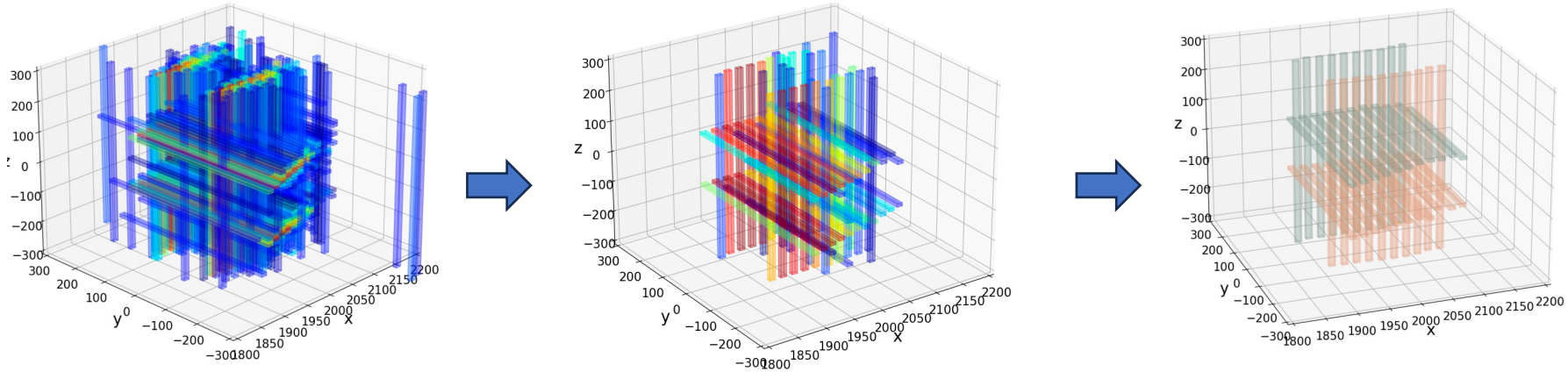
- **Reconstruction:**
  - PandoraPFA: migrated by Wenxing but obsolete. [indico]
  - ArborPFA: migrated by Dan
    - Algorithm validation(Yuexin): BMR=3.74%, with all info read from CEPCSoft.
    - Full sim+rec in CEPCSW: developing.
    - For other options want to use Arbor: need uniform edm4hep input.
      - Track.
      - Calorimeter clusters (x, y, z, E). Ecal cluster and Hcal cluster can be separated.
      - CalorimeterHit in high granularity to define the shape and boundary of clusters. (x, y, z, E, layer, module. time as option.)
      - Time and personpower.
  - Crystal bar ECAL PFA: developing.
    - With truth track and truth HCAL: BMR=3.6%.
      - Truth track: track extrapolated from charged MCParticles (100% eff).
      - Truth HCAL: clustering HCAL hits with MC info. (intrinsic resolution included).
    - Connection with Arbor is undergoing.

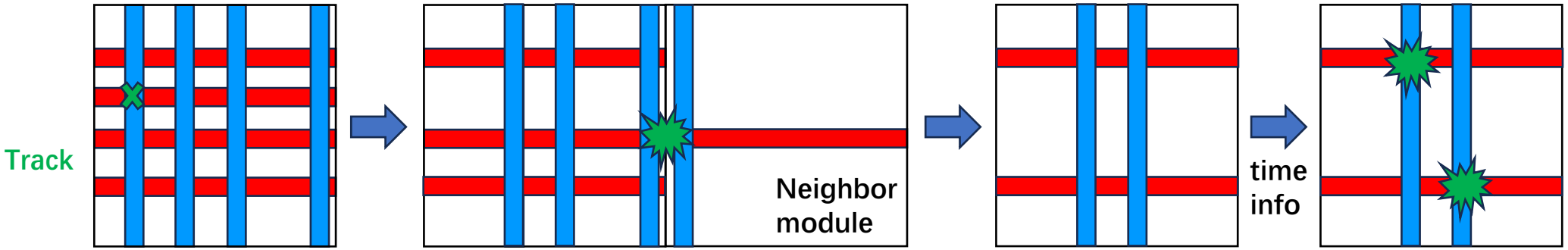




Crystal bar ECAL reconstruction

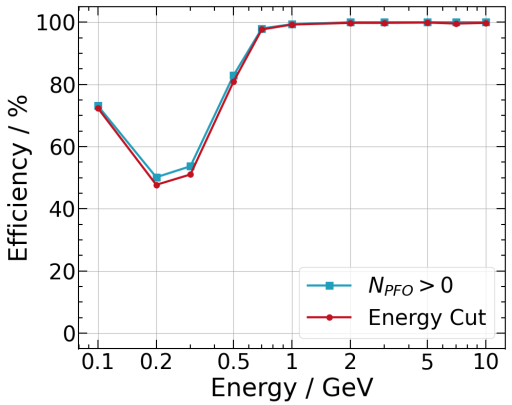
- **Pattern recognition + energy matching**

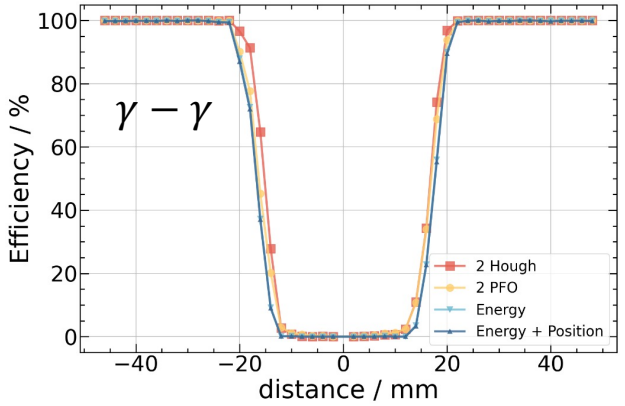


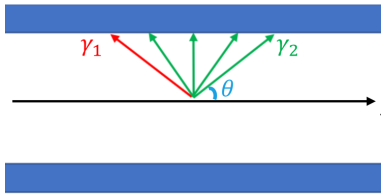


Crystal bar ECAL reconstruction

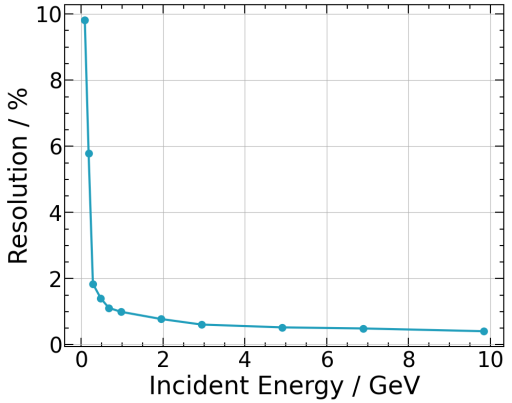
- **Performance:**
  - Single photon: efficiency >50% for O(100) MeV photons, ideal energy resolution
  - $\gamma-\gamma$ and $\gamma-\pi$ separation: 2.2 cm @ 100% eff. for $\gamma-\gamma$, 10 cm @ 100% eff. for $\gamma-\pi$.

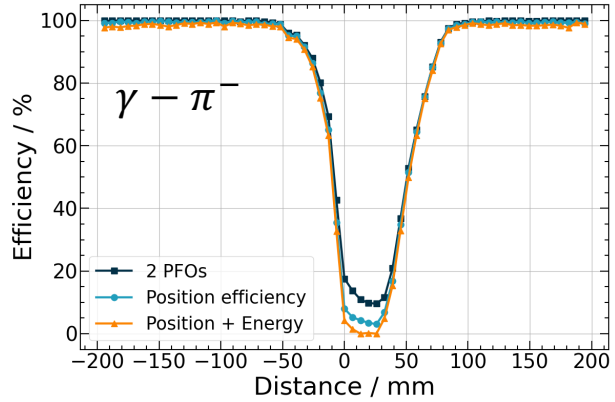


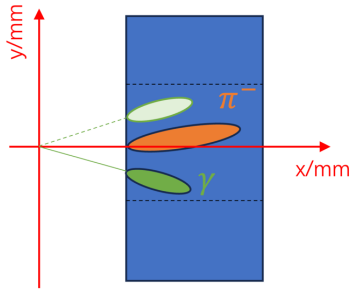




$\gamma-\gamma$: scan in θ direction.
Should be symmetry in θ and ϕ.





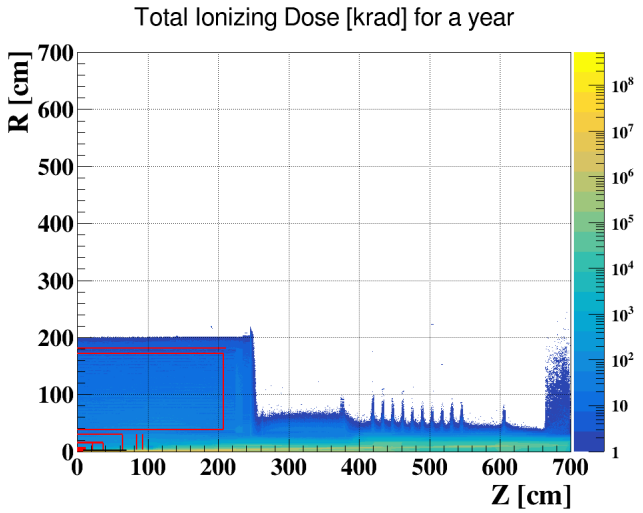


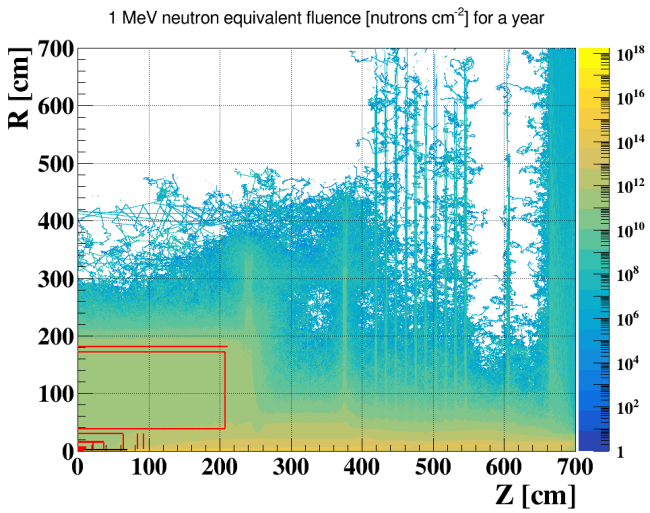
$\gamma-\pi$: scan in ϕ direction

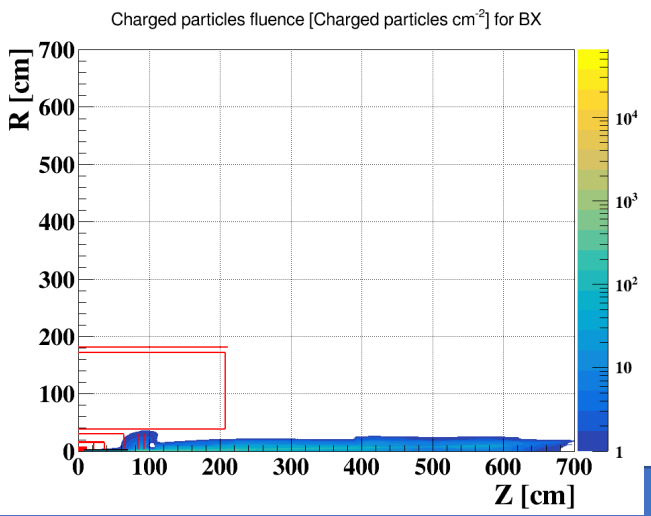
Beam background

- **Beam background processes [1][2]:**
  - Synchrotron radiation(todo), Pair production, Beam-thermal photon (BTH), Beam-gas coulomb (BGC), Beam-Gas Bremsstrahlung (BGB), Touschek (TSC, for Z only)
  - Simulated in CEPCSoft, with TDR accelerator + CDR detector. Not reliable in forward region
  - Each process considers:
    - TID in krad/year.
    - 1 MeV Silicon neutron eq. flux in number/cm^{-2} /year
    - Hit density in number/cm^{-2}/BX.
  - 1st version only considered Z<100 cm, R<40 cm. 2nd version is updating. Now only pair is available.

Higgs mode, pair production background







Beam background

- **Beam background simulation:**

  - For barrel ECAL: preliminary estimation can be done with old results.
    - For beam background impacts on physics event: generator info + new detector simulation.
    - Generator is available, software is developing.
  - For endcap ECAL and HCAL: need geometry.
    - In CEPCSoft: TDR accelerator + CDR detector.
    - In CEPCSW: accelerator and forward detectors are all missing.