BIC simulation studies at Korea

May 14th 2024 BIC In-Person Worhshop

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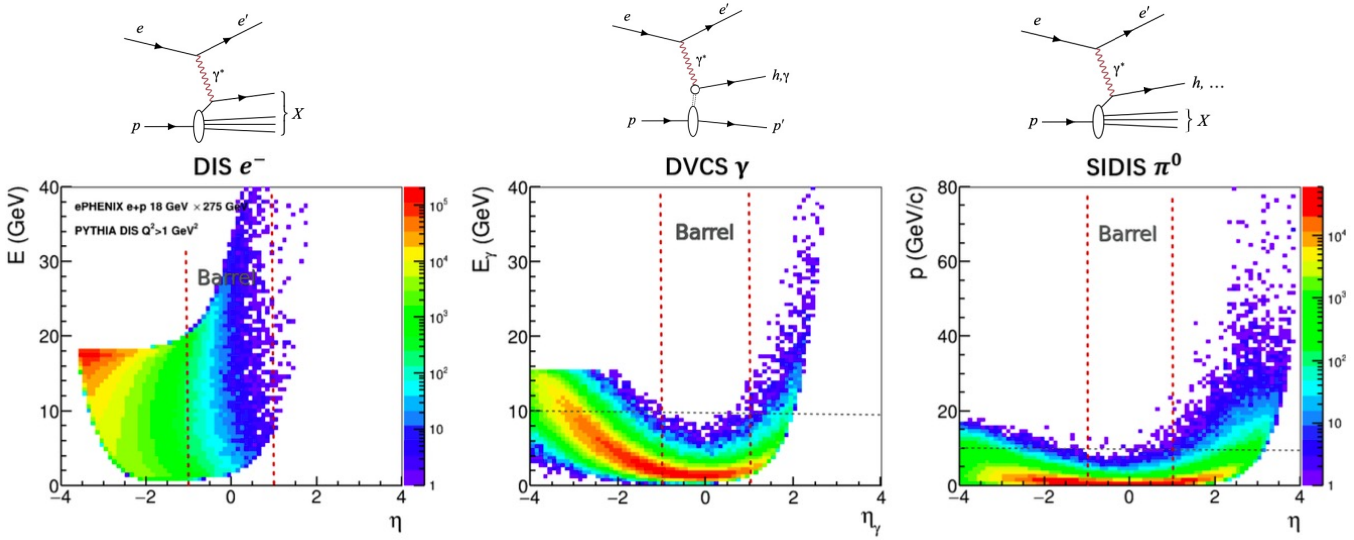
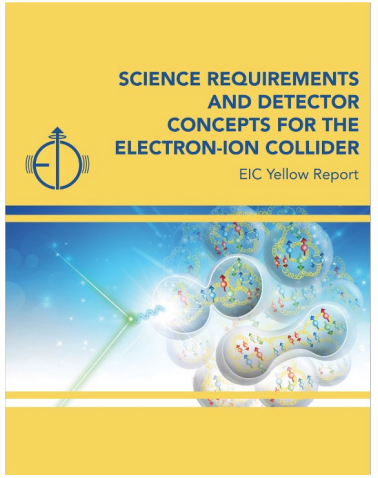
EIC Calorimeter requirements

- EIC Yellow Report requirements for Barrel EM Calorimeter
  - Detection of electrons/photons to measure energy and position
  - Require moderate energy resolution $(7-10)\%/\sqrt{E} \oplus (1-3)\%$
  - Require electron-pion separation up to 10^4 at low momenta in combination with other detectors
  - Discriminate between π^0 decays and single γ up to ~10 GeV
  - Low energy photon reconstruction ~100 MeV





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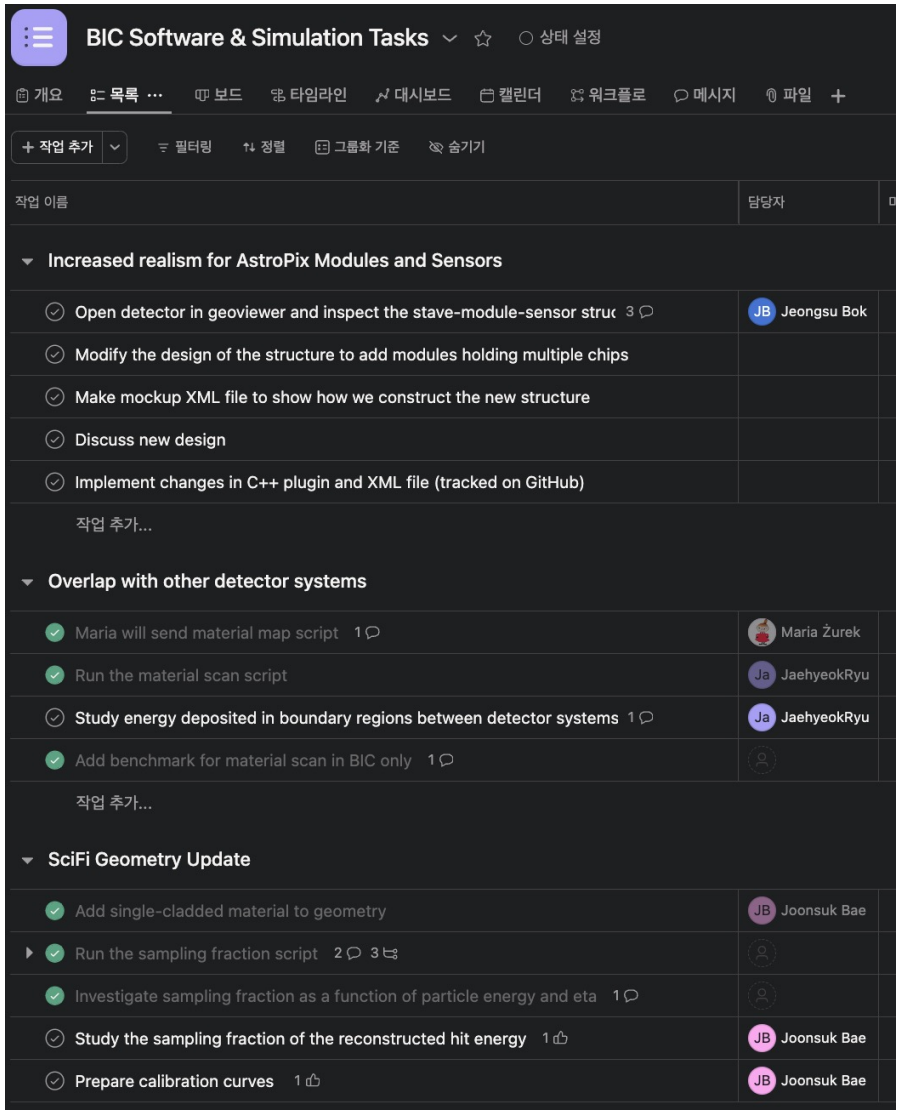
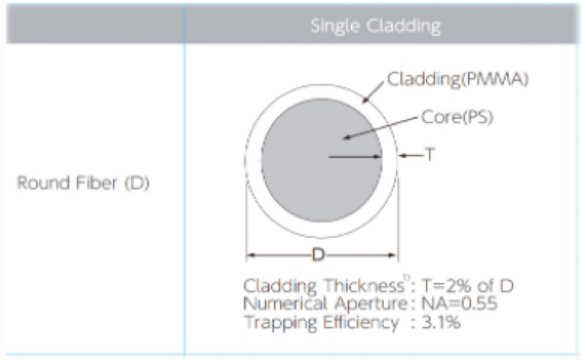
Recent contributions on BIC simulation in Korea



- We have formed group in Feb
  - PNU: Sanghoon Lim (faculty), Jeongsu Bok (postdoc), Jaehyuk Ryu(Ph.D student)
  - SKKU: Joonsuk Bae (Ph.D student), Harim Sung (Undergraduate, Computing)
- Goals
  - Contribution to TDR in short term
  - Continue significant contribution in BIC and future study
- Offline training session in Feb, Started working in March, presentation in KPS in April

SciFi Geometry



- SciFi geometry update
  - Clad thickness 0.04 to 0.02 mm
  - Confirmed updated thickness in the viewer

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472     <fraction n="0.001" ref="N"/>
473     <fraction n="0.001" ref="O"/>
474     <constant name="BirksConstant" value="0.126*mm/MeV"/>
475   </material>
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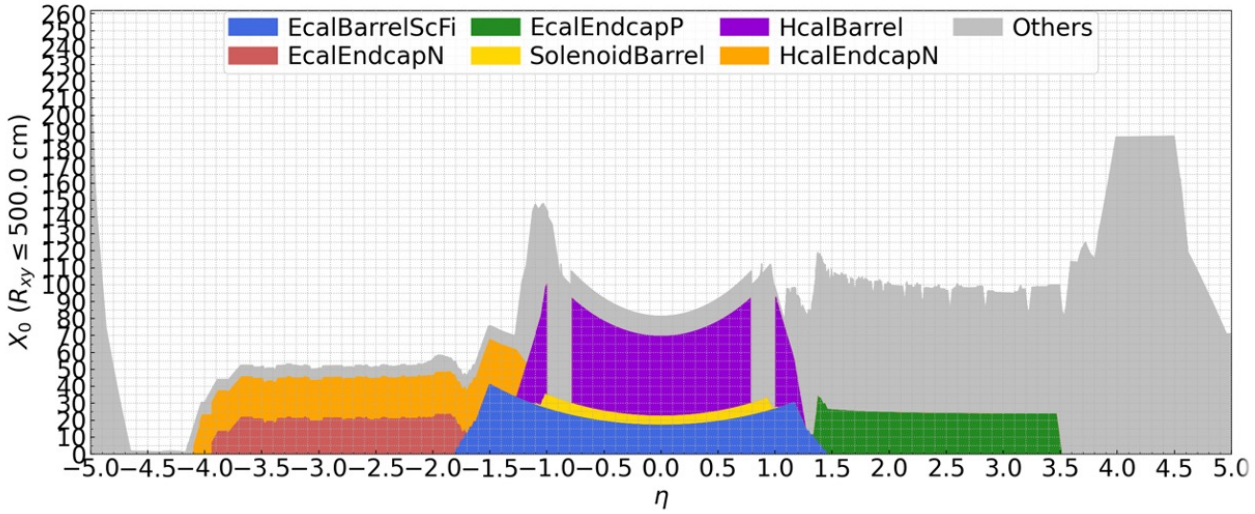
Material Scan

- Scanning detecter material concerning the eta and interaction length to check possible overlap with other detectors
- Material scan with most recent geometry
- Checked overlaps with a macro

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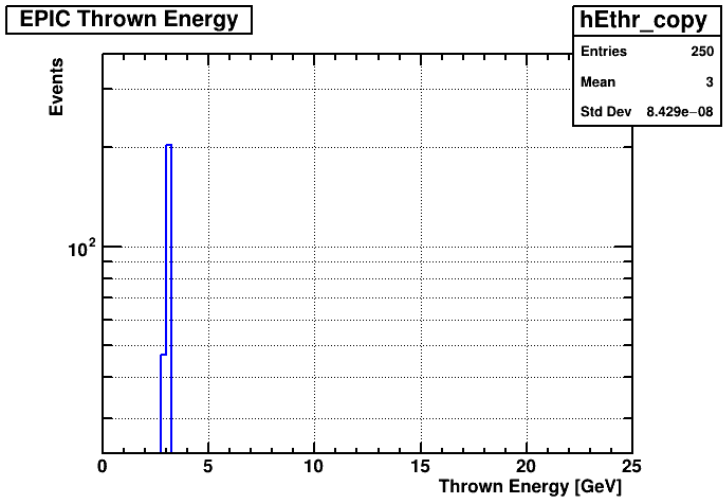
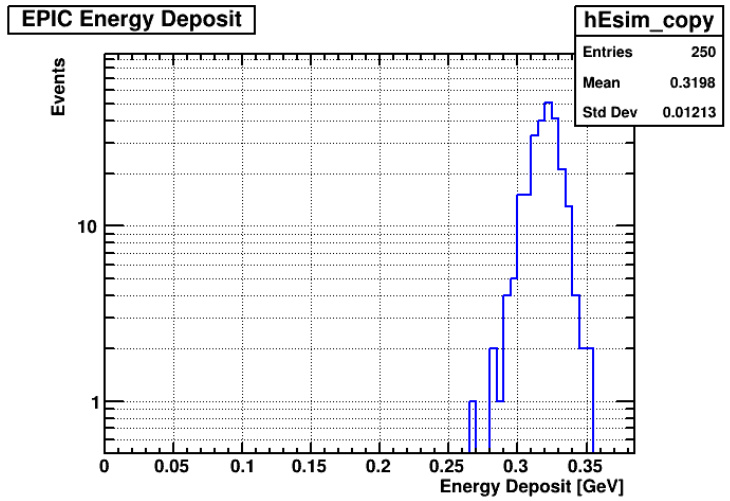
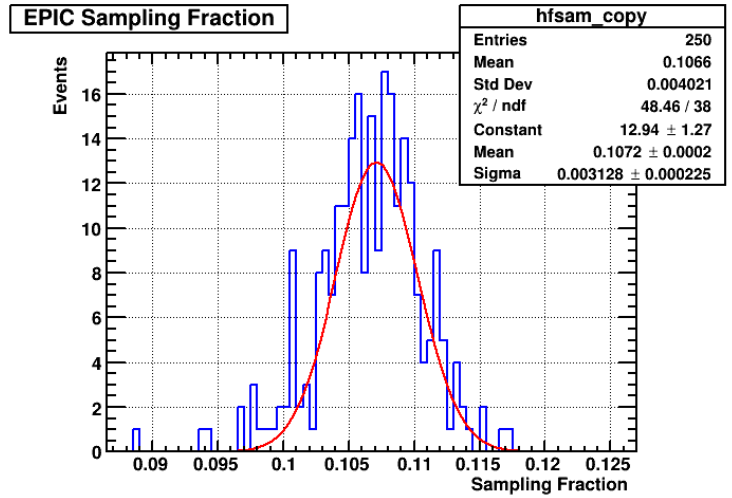
Sampling Fraction for 250 e-, 3GeV, $0<\eta<0.5$



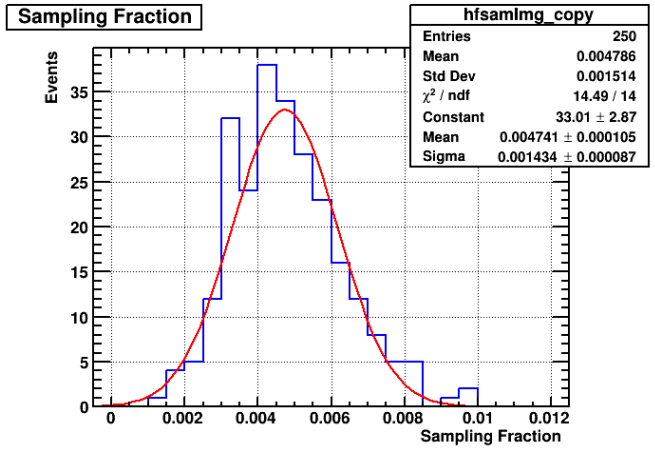
Thrown energy



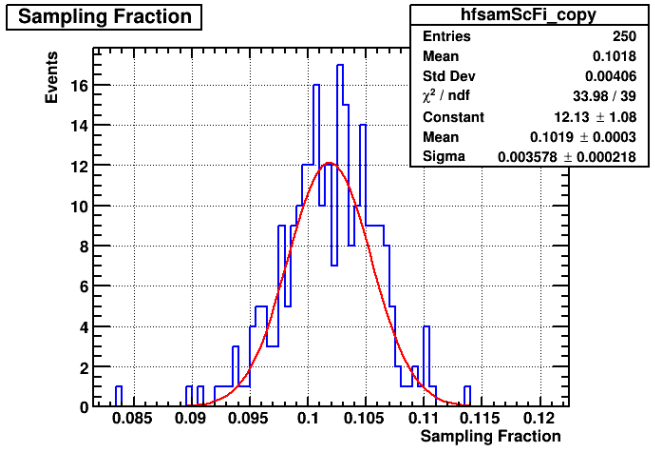
Energy deposit



Sampling fraction



Sampling fraction (Imaging)

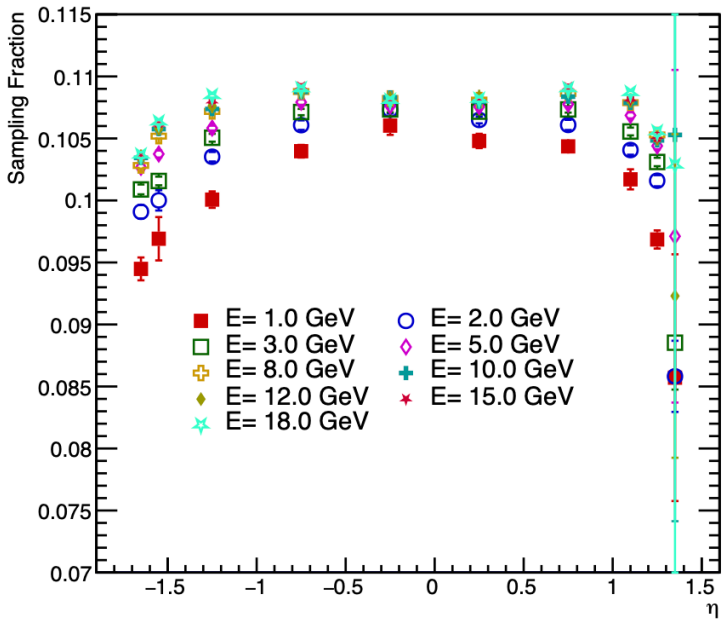


Sampling fraction (SciFi)

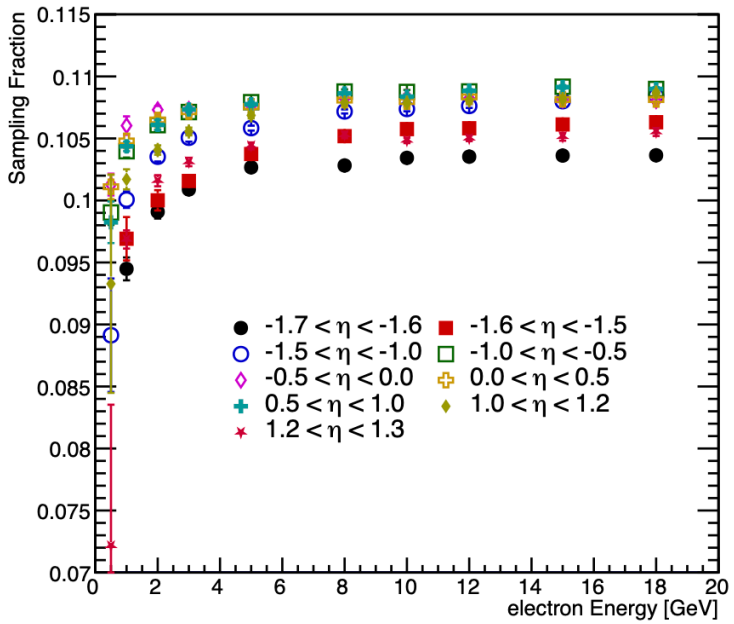
- Energy deposit / thrown energy → sampling fraction
- Simulated energy. → changing it to reconstructed energy

Sampling Fraction for -1.7<η<1.4 , 0.5~18 GeV

Sampling Fraction



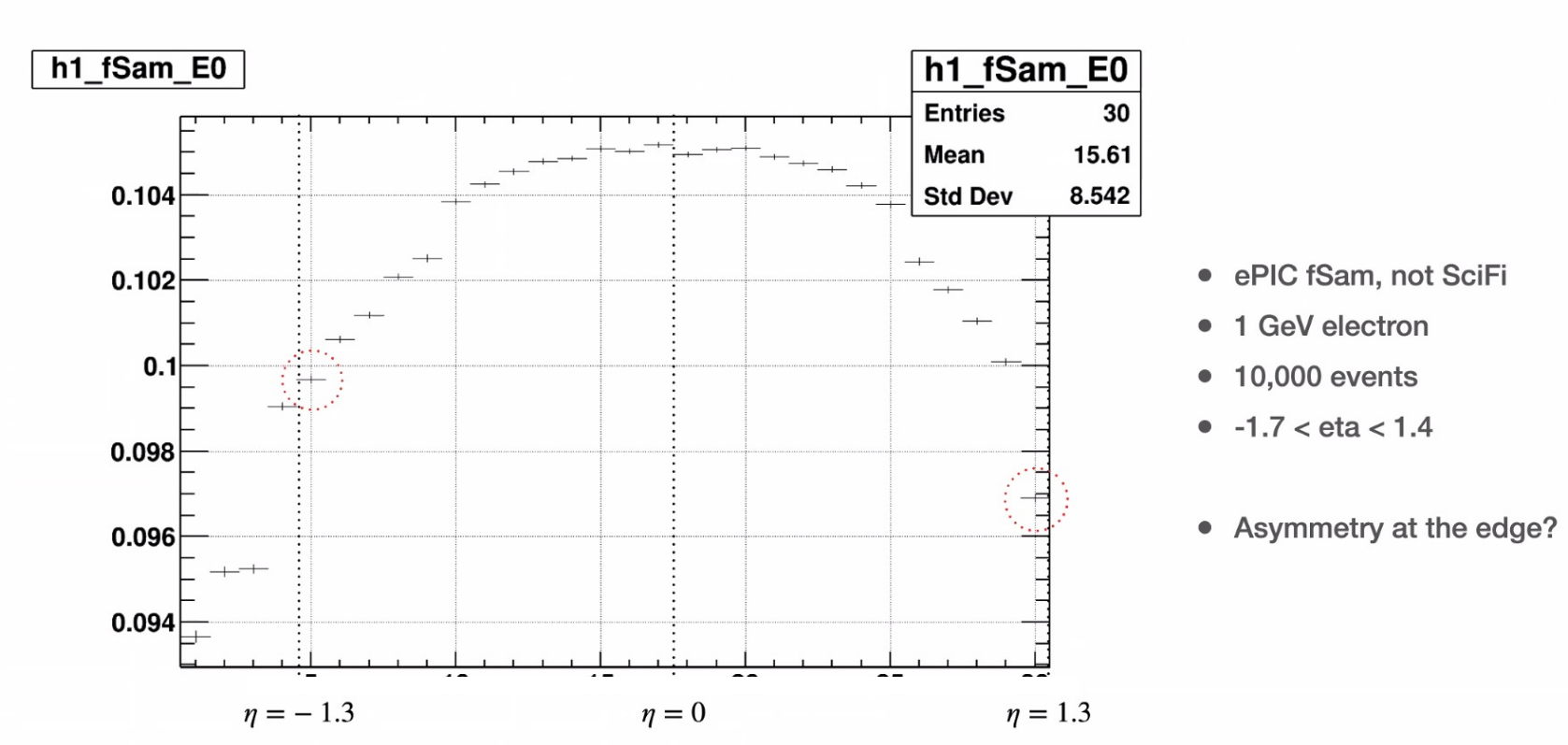
η



Electron energy [GeV]

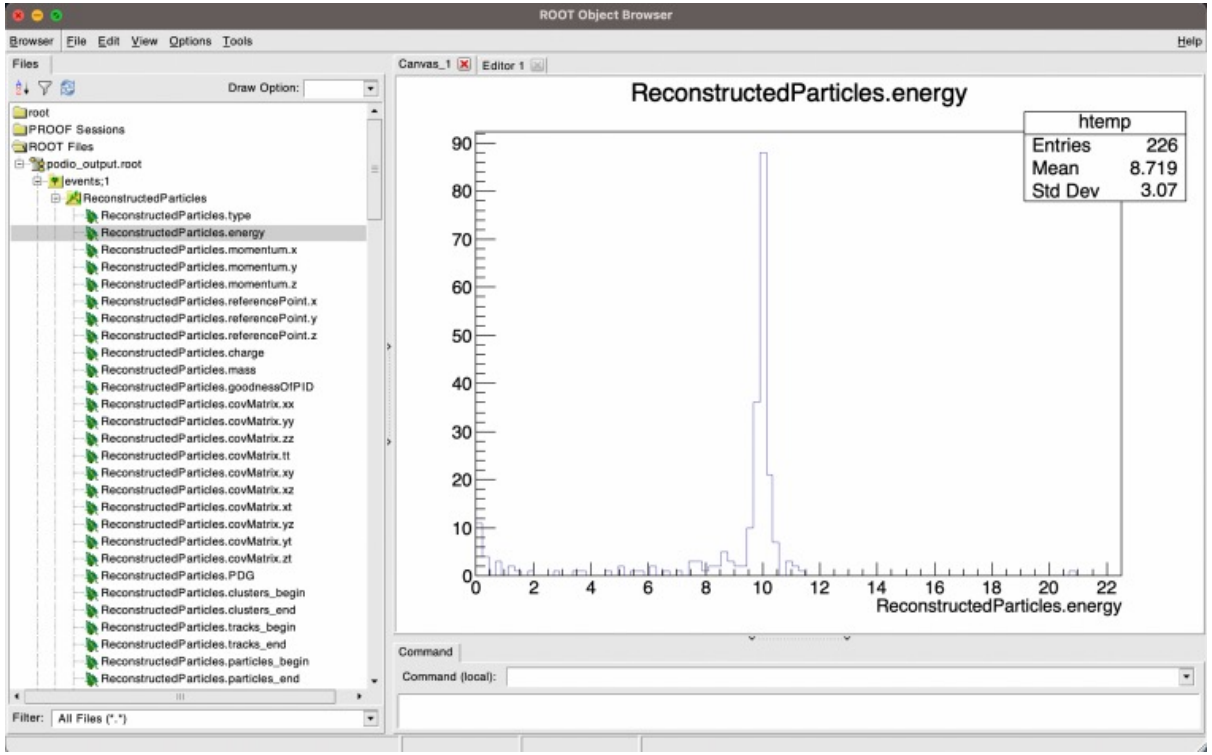
- 250 electrons for 0.5~18GeV, -1.7<η<1.4
  - Using script https://eicweb.phy.anl.gov/EIC/benchmarks/detector_benchmarks/-/blob/master/benchmarks/barrel_ecal/scripts/emcal_barrel_particles_analysis.cxx
- Value is from Gaussian fit. Error is error of fit mean.
- To do : change to reconstructed hit energy from reco + photons

Asymmetic in eta?



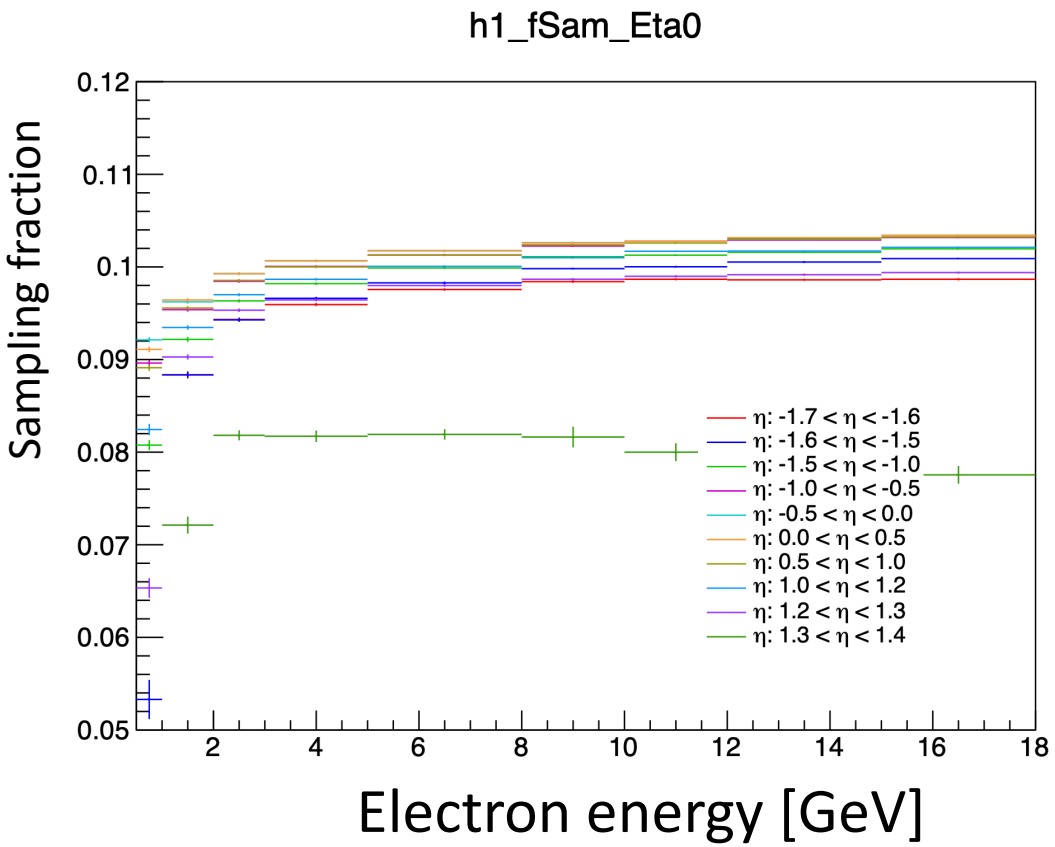
- It looks symmetric for 10,000 electrons with 1GeV for each 0.1 eta bin width

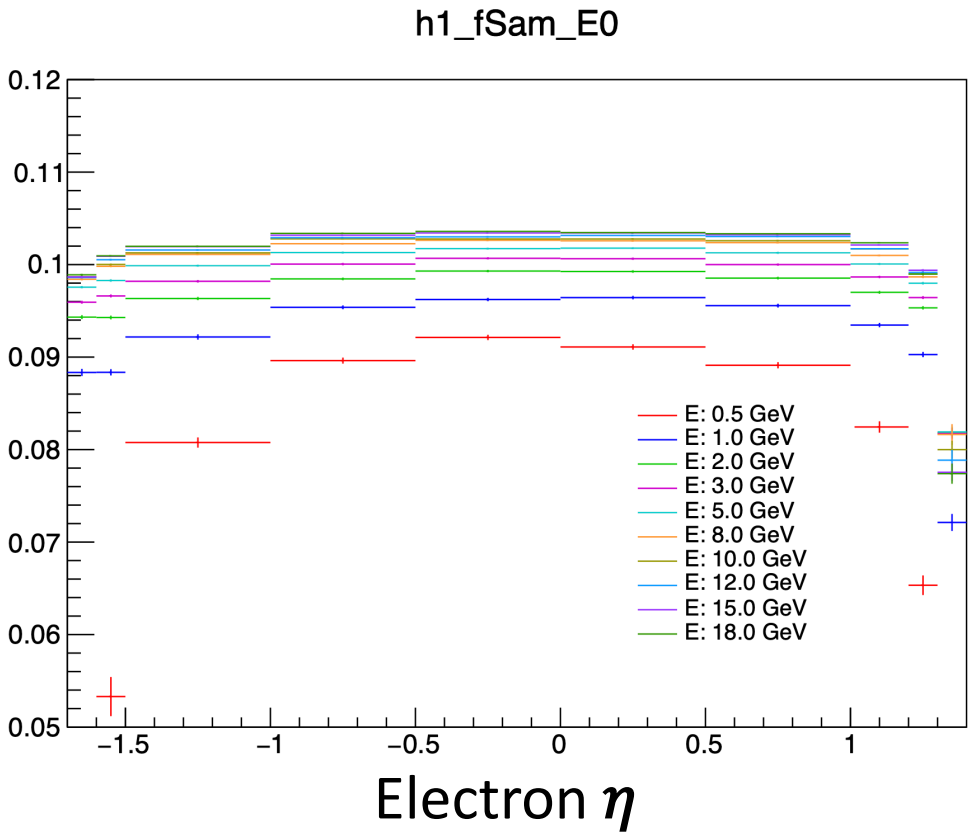
Changing to Reconstructed Energy



- 200 electrons of 10 GeV
- Script for various eta, energy is ready
- Plan for sampling fraction
  - Use reconstructed energy
  - Various eta, energy
  - Same for photons

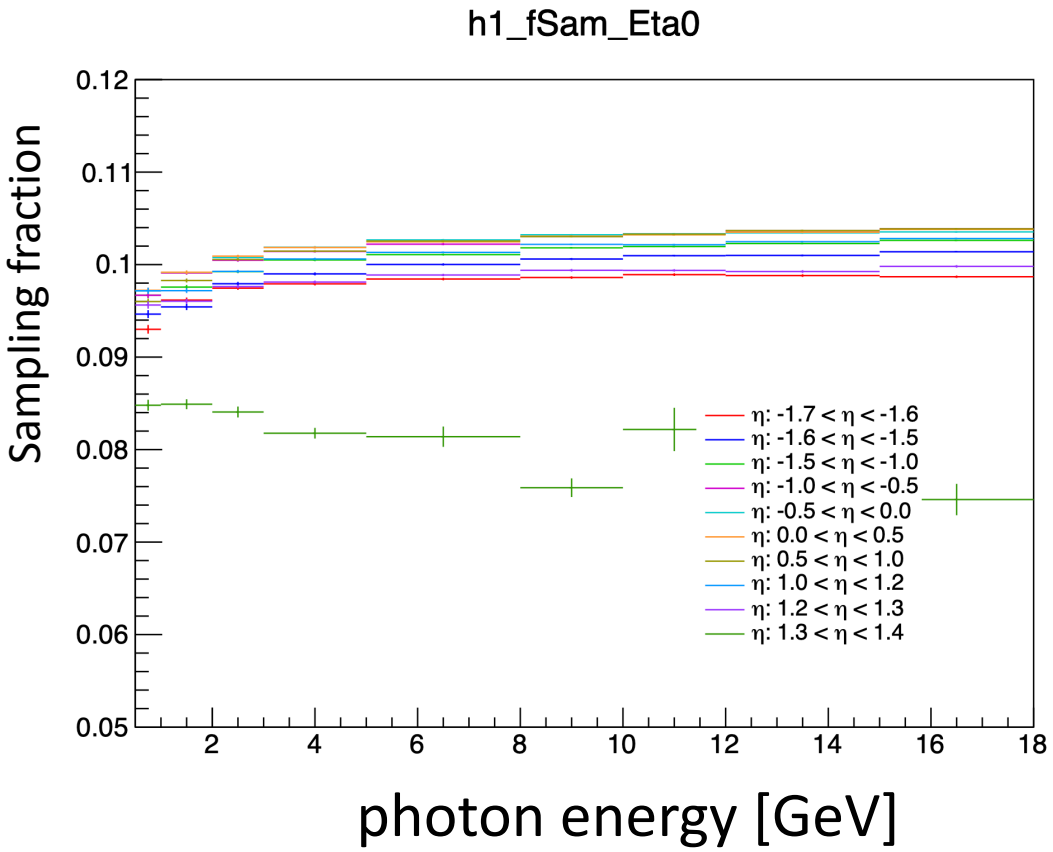
Recent update : electron sampling fraction

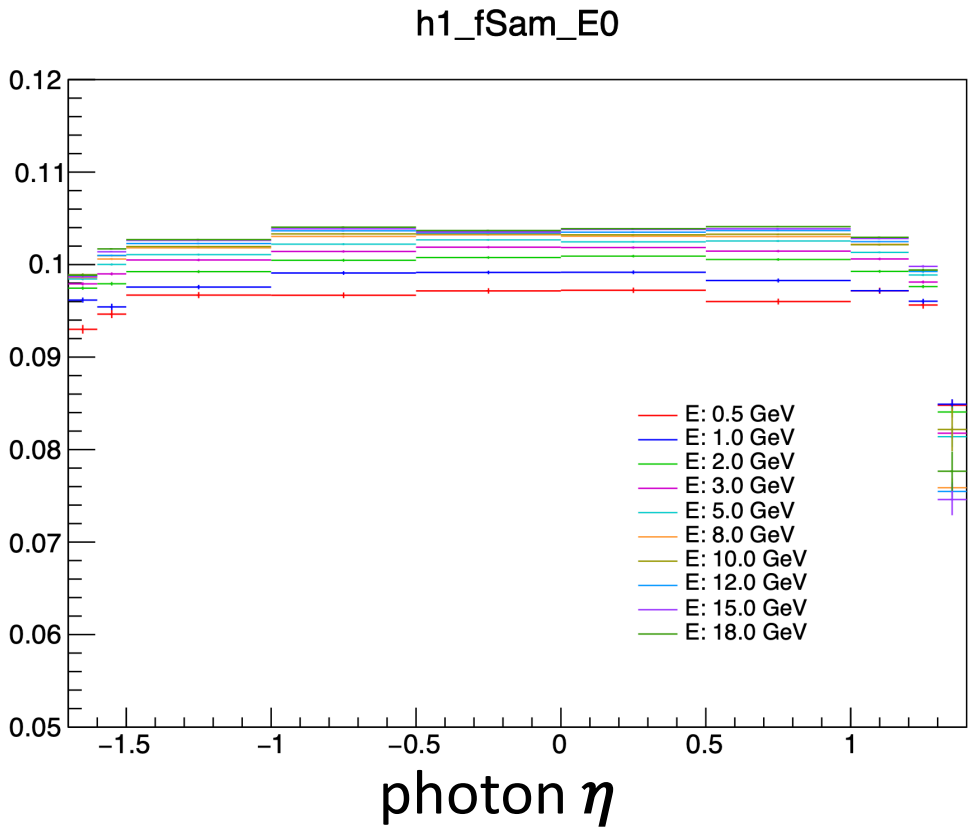




- 1000 electrons.
  - E: 0.5, 1, 2, 3, 5, 8, 10, 12, 15, 18
  - η: -1.7, -1.6, -1.5, -1, -0.5, 0, 0.5, 1, 1.2, 1.3, 1.4

Recent update : photon sampling fraction



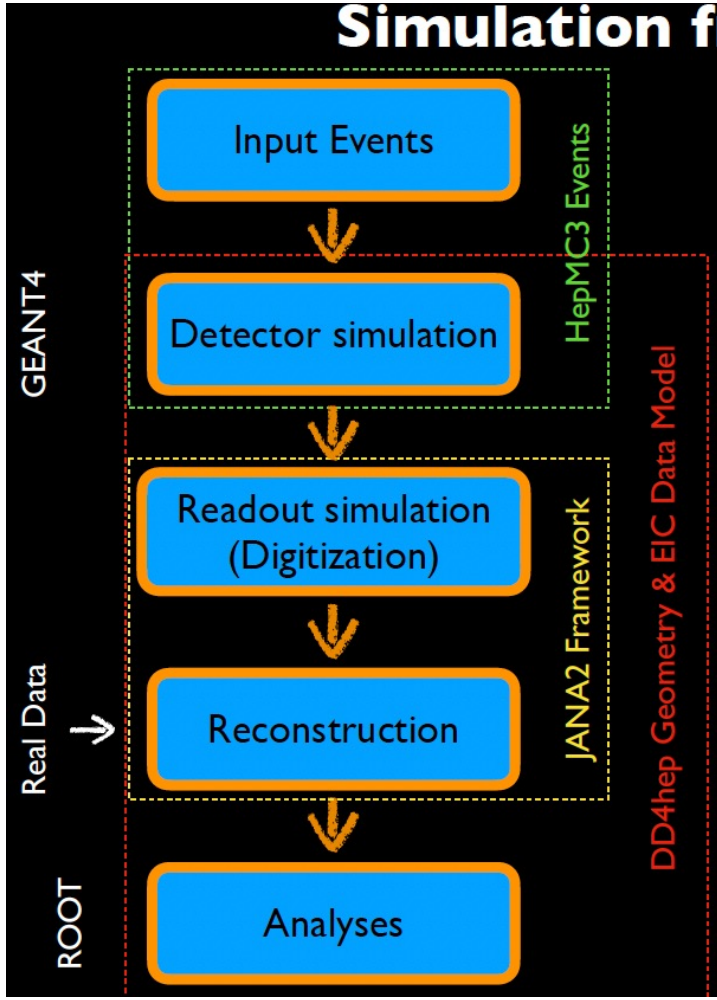


- 1000 photons.
  - E: 0.5, 1, 2, 3, 5, 8, 10, 12, 15, 18
  - η: -1.7, -1.6, -1.5, -1, -0.5, 0, 0.5, 1, 1.2, 1.3, 1.4

Status and Outlook

- Status in Korea
  - Students are trained, ready to boost.
  - Sampling fraction is on track
  - Overlap checking is ok.
  - Geometry is ongoing
- More interests and capacity in Korea
  - PNU group is leading ALICE Run3 flavor tagging using ML.
  - Yonsei group made significant contribution in building Dual Readout Calorimeter simulation.
  - Need related topics to ask them to join.

backup



- Input events from **MC event generators** or particle guns, with optional physics background merging
- **Geant4** simulations with **DD4hep** for geometry description and exchange, output data in the **EIC Data Model** (EDM4hep + EDM4eic)
- Algorithms to transform the GEANT4 hits to mimic real detector readout, including background stacking, "pileup", DAQ frames
- **Realistic reconstruction algorithms** starting from raw detector output (from digitization or real data)
- **User analyses** in plain C++/ROOT or Python/uproot, facilitated by using a flat data model

Backup: Tasks

	Task	Priority	Difficulty	comment
1	realistic sensor dead areas	high	medium	geometry update, benchmark e-pi resolution and position and energy resolution gamma
2	realistic CF frames	low	medium	geometry update, redo benchmarks, can potentially wait until later when we are preparing the preliminary design
3	First AstroPix layer in tracking	medium	hard	check if really needed for DIRC reconstruction (needs to be added to ACTS geometry)
4	Impact of incomplete coverage AstroPix	medium	medium	evaluate metrics on edge calorimeter
5	Study impact of lowering weight by removing Pb/ScFi	very low	easy	key performance metrics, revisit after benchmarks are up (not an entry-point)
6	Move first AstroPix layer to second slot	low	easy	
7	Incorporate attenuation length and NPE in digitization	medium	hard	effective light model in reconstruction
8	Add single-cladded material to geometry	medium	easy	simple geometry update
9	Improved clustering for imaging layers	medium	medium	Tune to 4 layers
10	Basic clustering with splitting (proof of concept)	medium	hard	
11	Implement clustering with proper splitting in EICrecon	medium	medium	
12	Automized benchmark setup to evaluate geometry changes	medium	hard	
13	Better energy "calibration"	medium	easy-medium	now using constant sampling fraction, does not work for all cases
14	Revisit overlap with other detector systems	high	easy	
15	Stand-alone optical simulation for light guides	medium	hard	
16	Realistic noise model for readout components	medium	hard	

backup

<2024 봄 학술논문발표회 우수발표상 수상명단>

(구두발표 부문)

H3.06*

Detailed Simulation Study of Barrel Imaging Calorimeter for ePIC at Electron-Ion Collider / LIM SangHoon[*1], BOK Jeongsu[1], RYU Jaehyeok[1], YOO Hwidong[2], KIM Beom Kyu[3], LEE Hyungjun[3], BAE Joonsuk[3], PARK Sangwoo[3], BAE Yunseul[3], JO Hyon-Suk[4], LEE Changhui[4], KIM Minsuk[5] ([1]Physics Department, Pusan National University, [2]Department of Physics, Yonsei University, [3]Department of Physics, Sungkyunkwan University, [4]Department of Physics, Kyungpook National University, [5]Department of Mathematics and Physics, Gangneung Wonju National University)

- First award with BIC presentation in Korean Physical Society meeting: Jaehyuk Ryu (PNU) – Simulation Study of BIC