LAr calorimeter R&D for FCC-ee

Sampling fraction

Brieuc François (CERN)

LAr Calo for FCC working meeting

Nov. 26th, 2020

Updated geometry in FCCSW

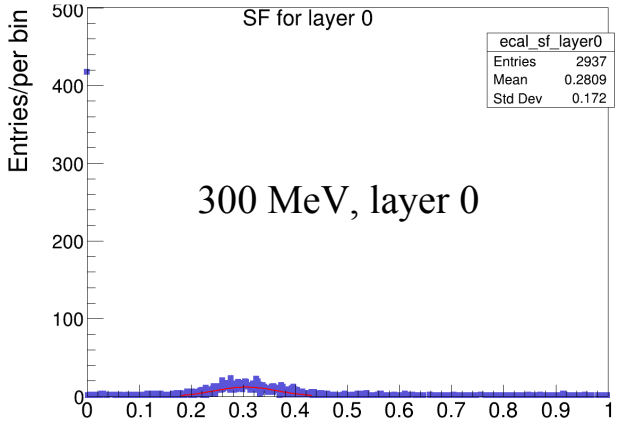
- Updated geometry implemented in FCCSW
  - Segmentation with fixed $\Delta\Theta$ (0.5625) instead of fixed $\Delta\eta$ (needed new segmentation factories in FCCSW)
  - 12 longitudinal layers (radial depth of 1.5 cm for pre-sampler, 3.5 cm for the others)
  - Updated calorimeter inner radius and absorber/gap thickness → 1536 Φ cells (divided by 2 for the readout)
  - Currently only in my FCCSW fork: BrieucF:geometry_change
    - Can open a pull request against FCCSW master later (validation needed)

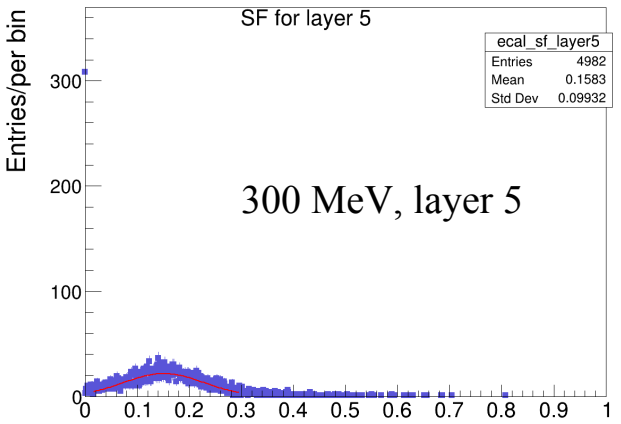
Sampling fraction

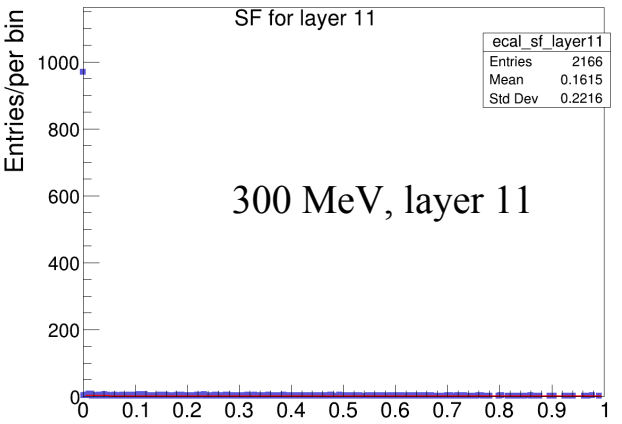
- Sampling fraction (SF) derived with a modified detector description: make the absorbers/readouts sensitive material and segment them to mimic the LAr segmentation
  - Event by event SF per longitudinal layer: energy deposited in active material / total energy in the given layer
  - Global SF: mean of a gaussian fit in a restricted range to prevent the tails to jeopardize the fit
- Study the energy dependence of sampling fraction
  - First MC generation: 5000 photon gun events with different energies (300 MeV, 1 GeV, 10 GeV, 50 GeV, 100 GeV), shot at 90^{o}

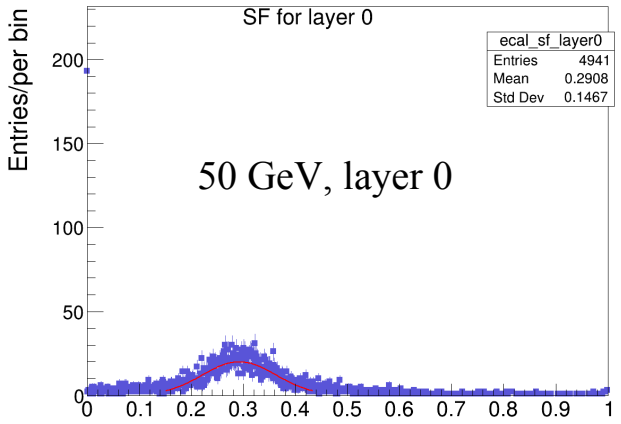
Sampling fraction

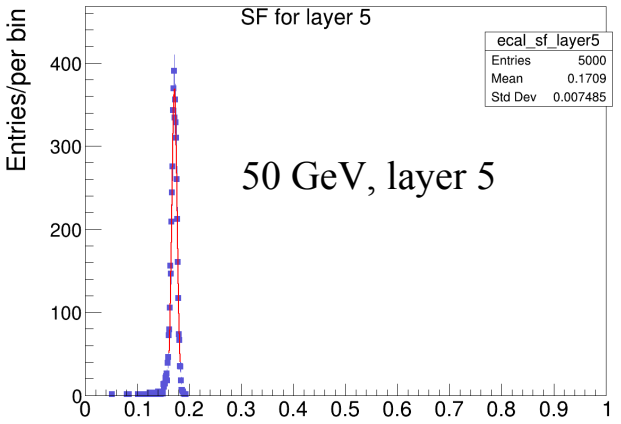
- 300 MeV photons have highly fluctuating sampling fractions, shower does not reach layer >~ 5 (benchmark not used in the rest of the talk)

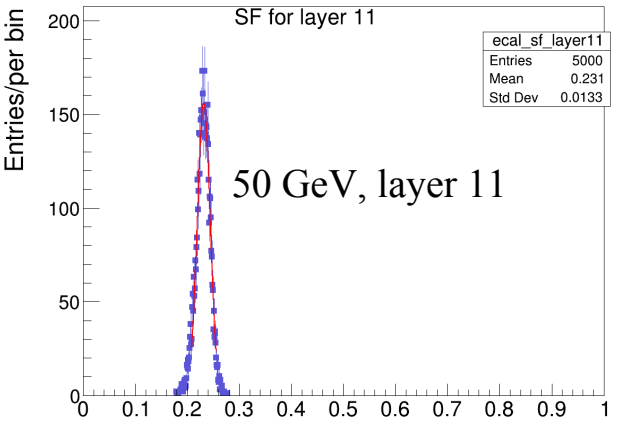






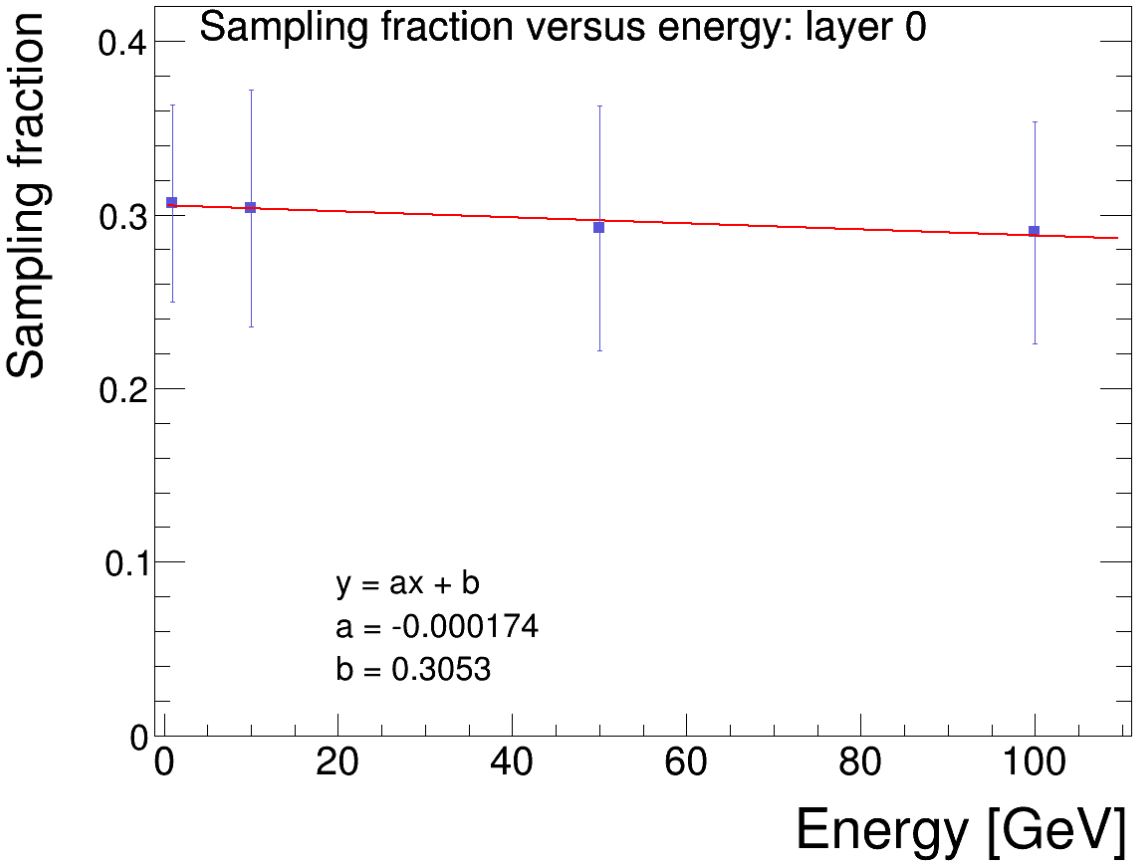






Sampling fraction VS energy

- Sampling fraction per layer as a function of energy: linear fit
  - ~constant w.r.t. to incoming particle energy
  - -10^{-4} to $+10^{-5}$ slope, trend inverting when going from layer 0 to layer 11



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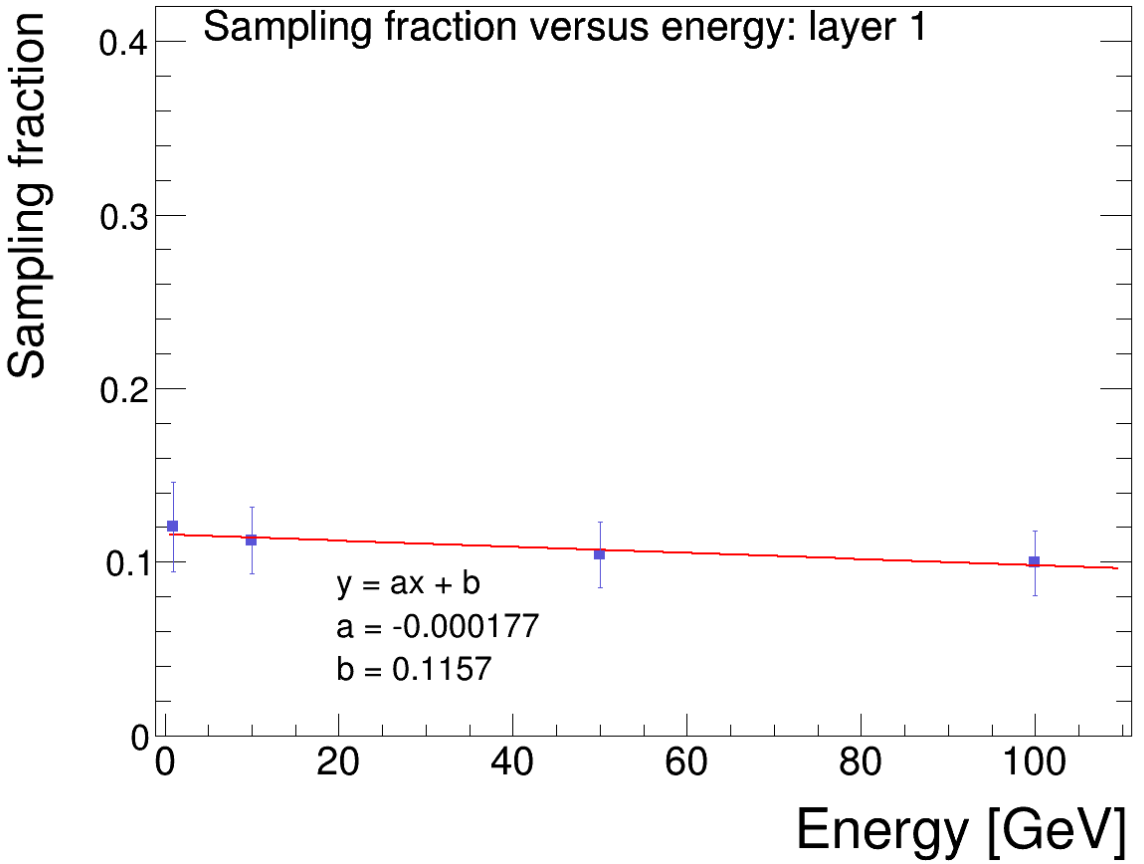

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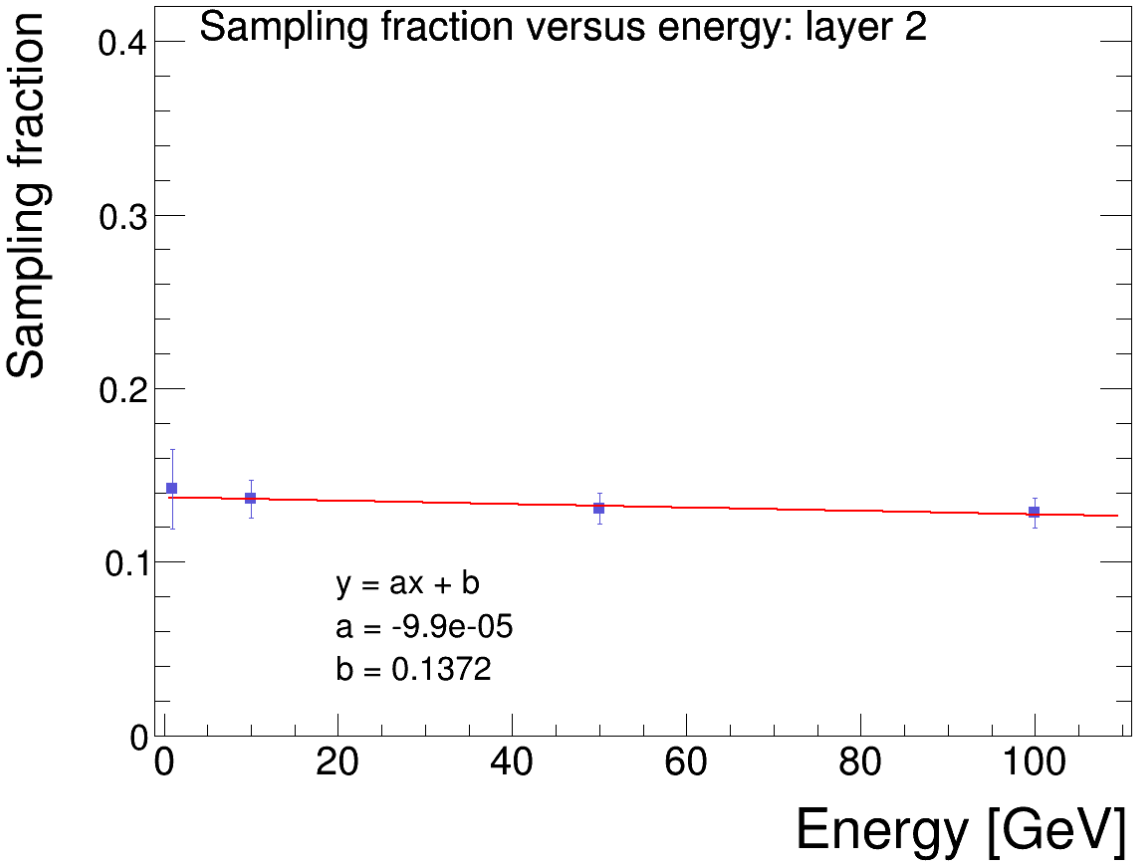

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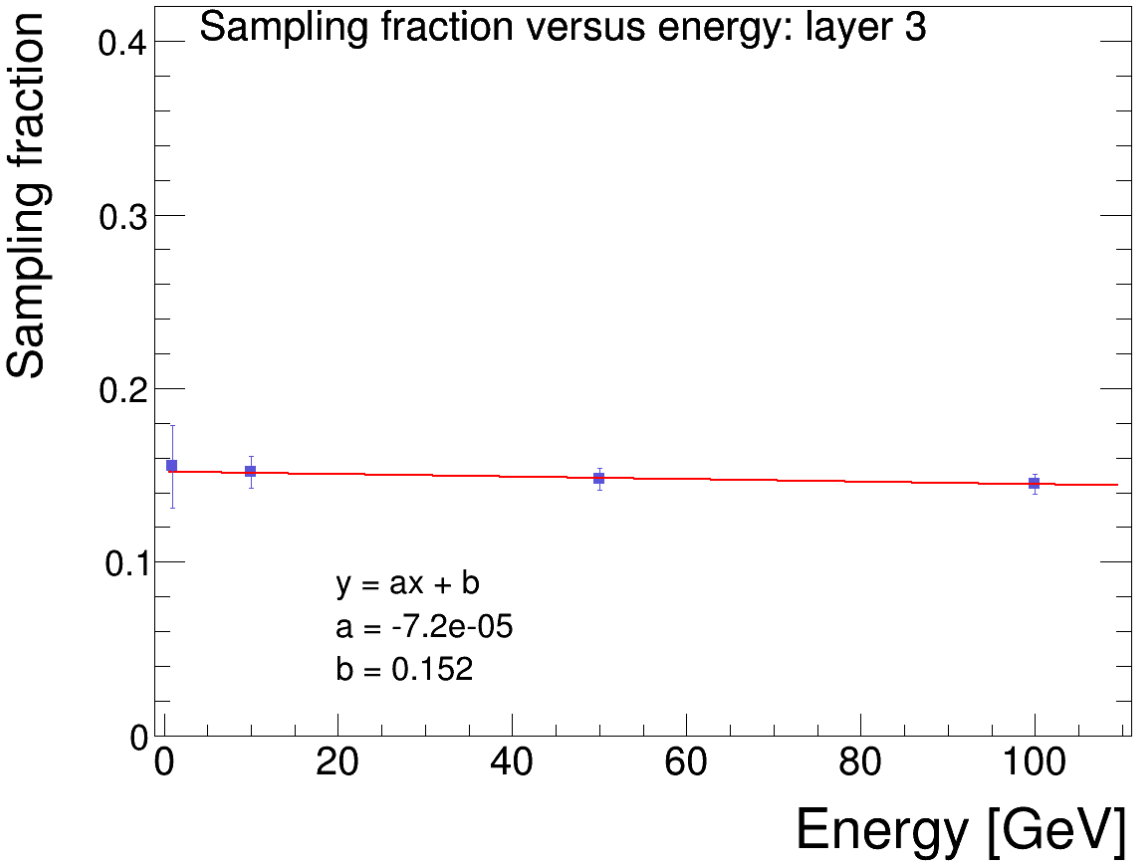

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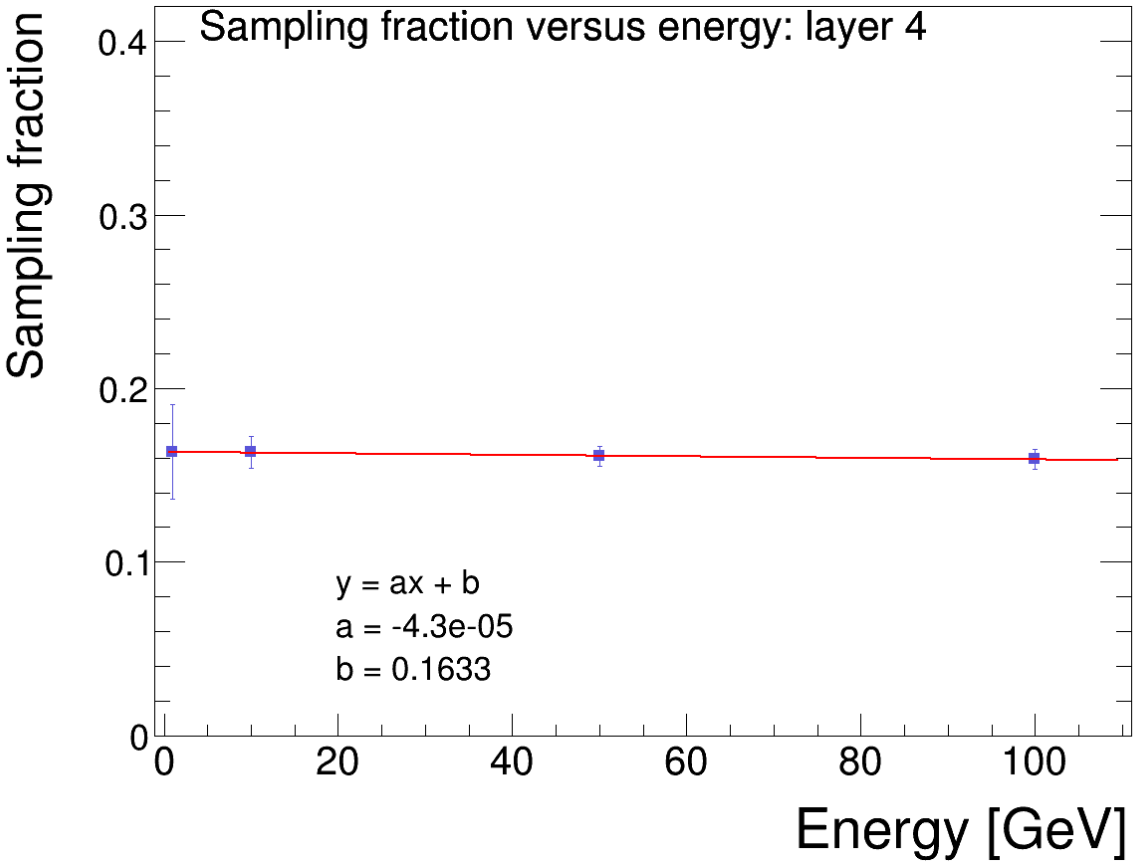

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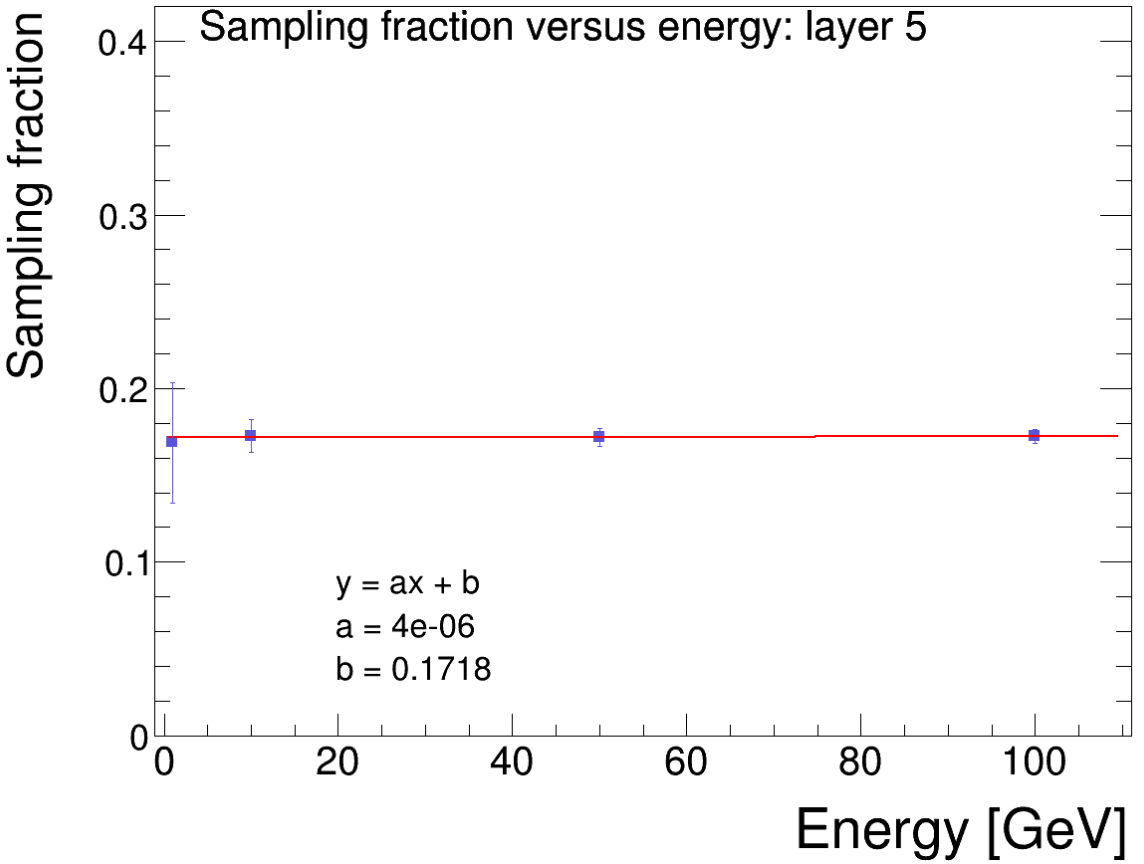

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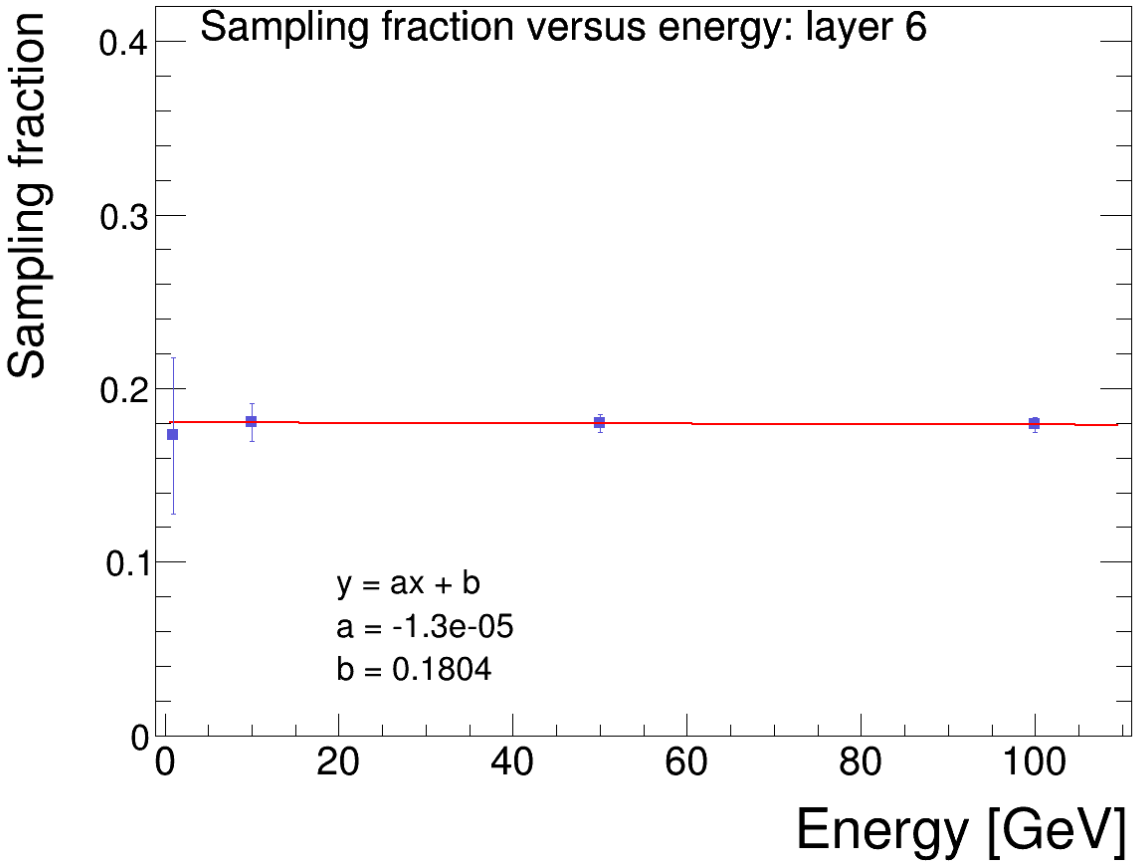

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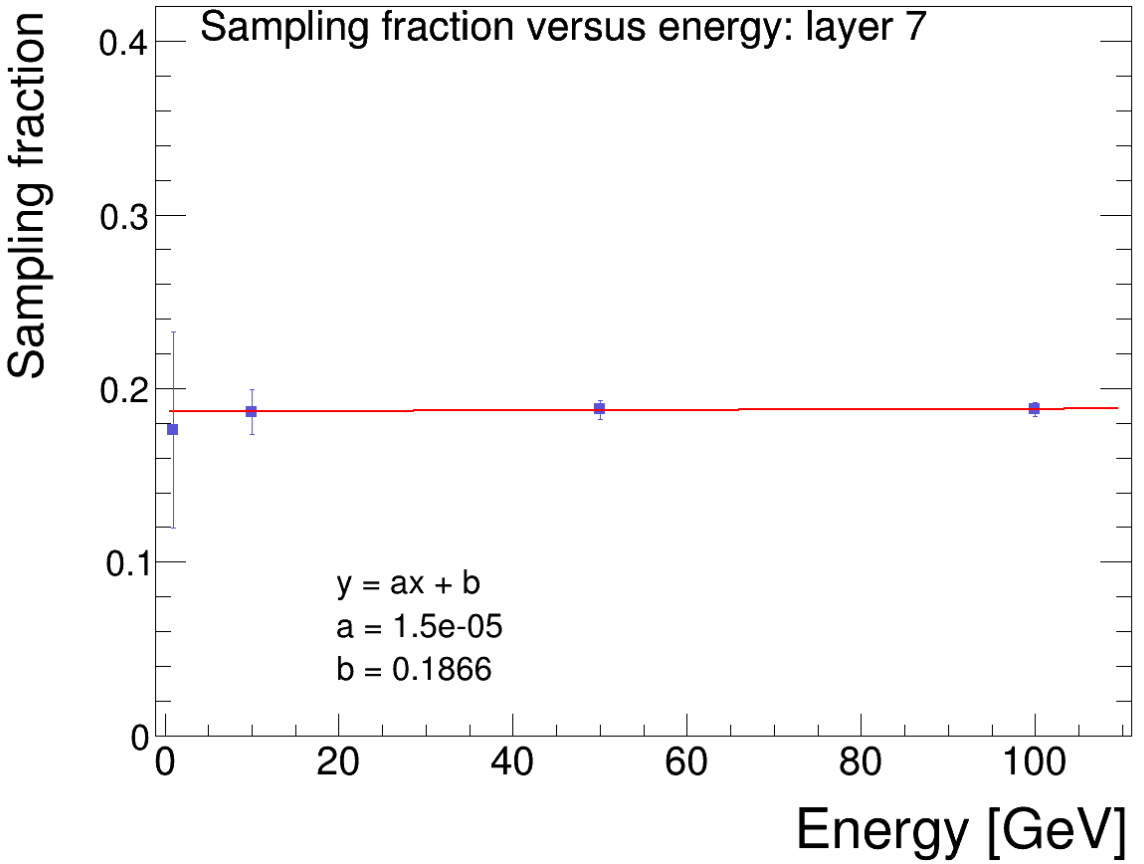

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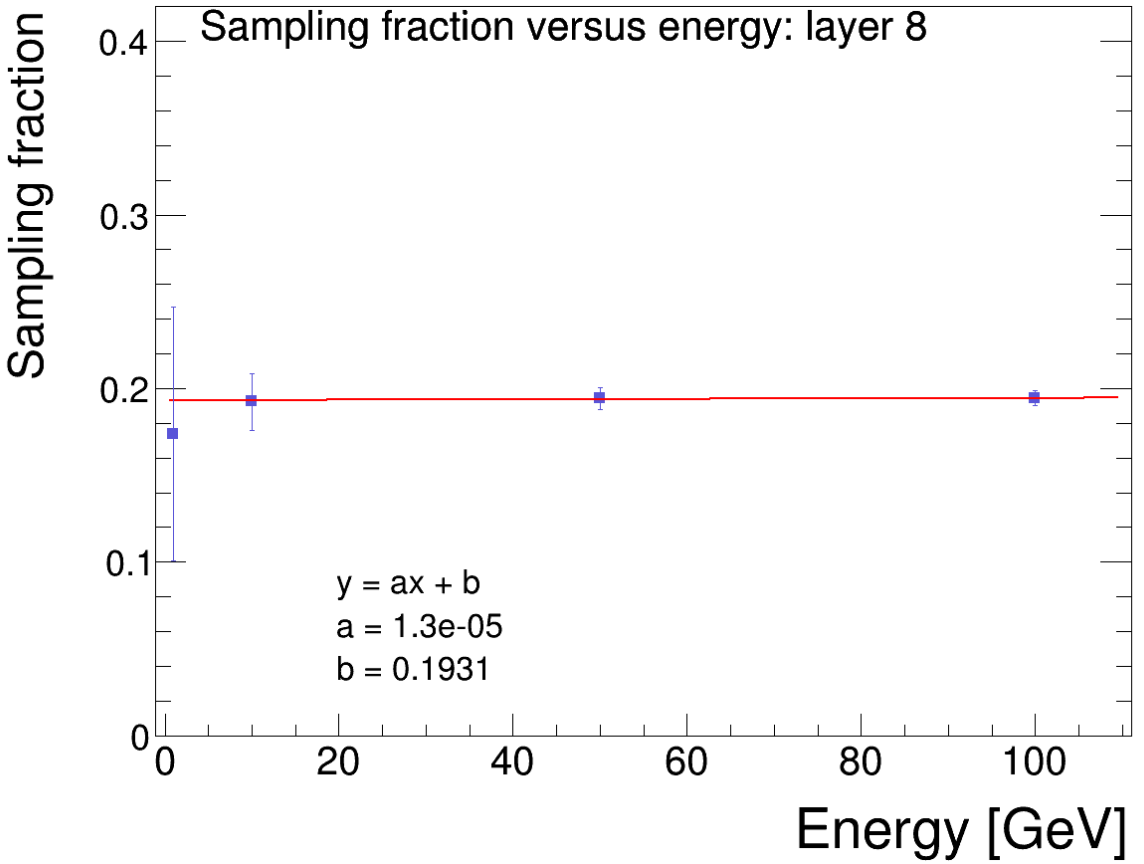

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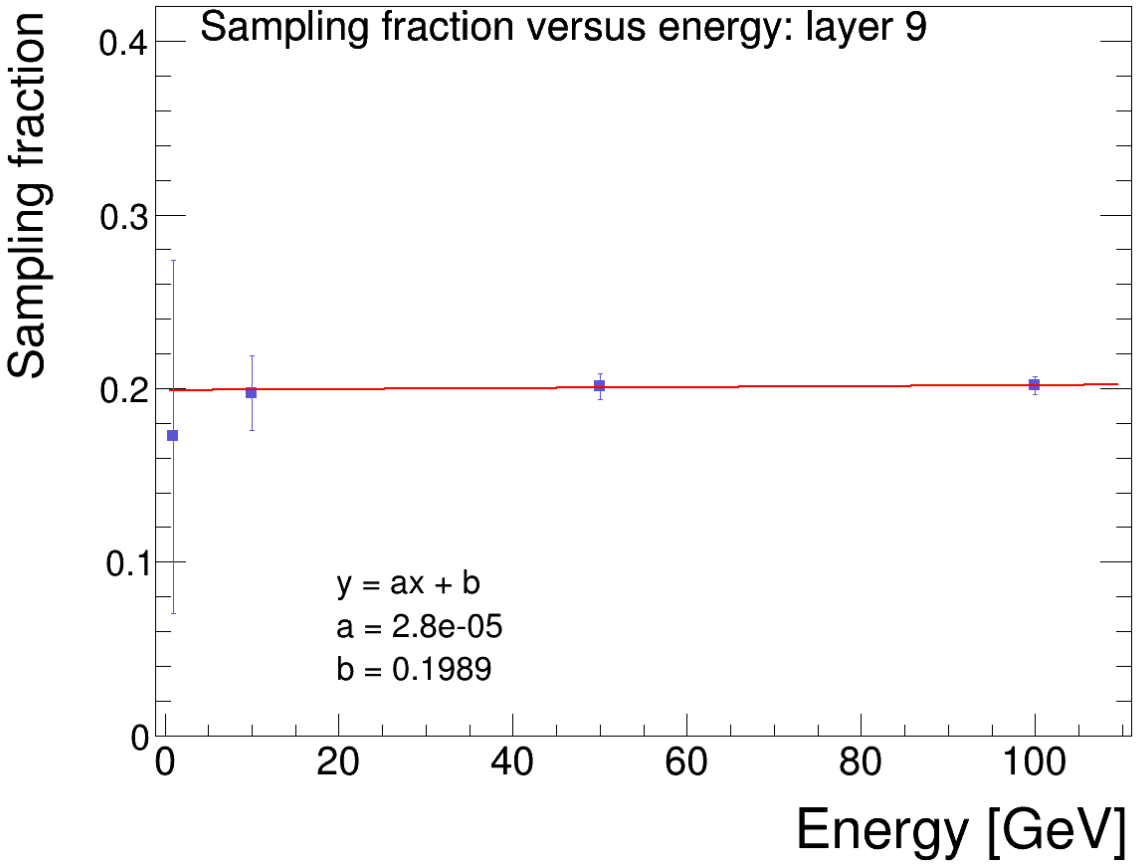

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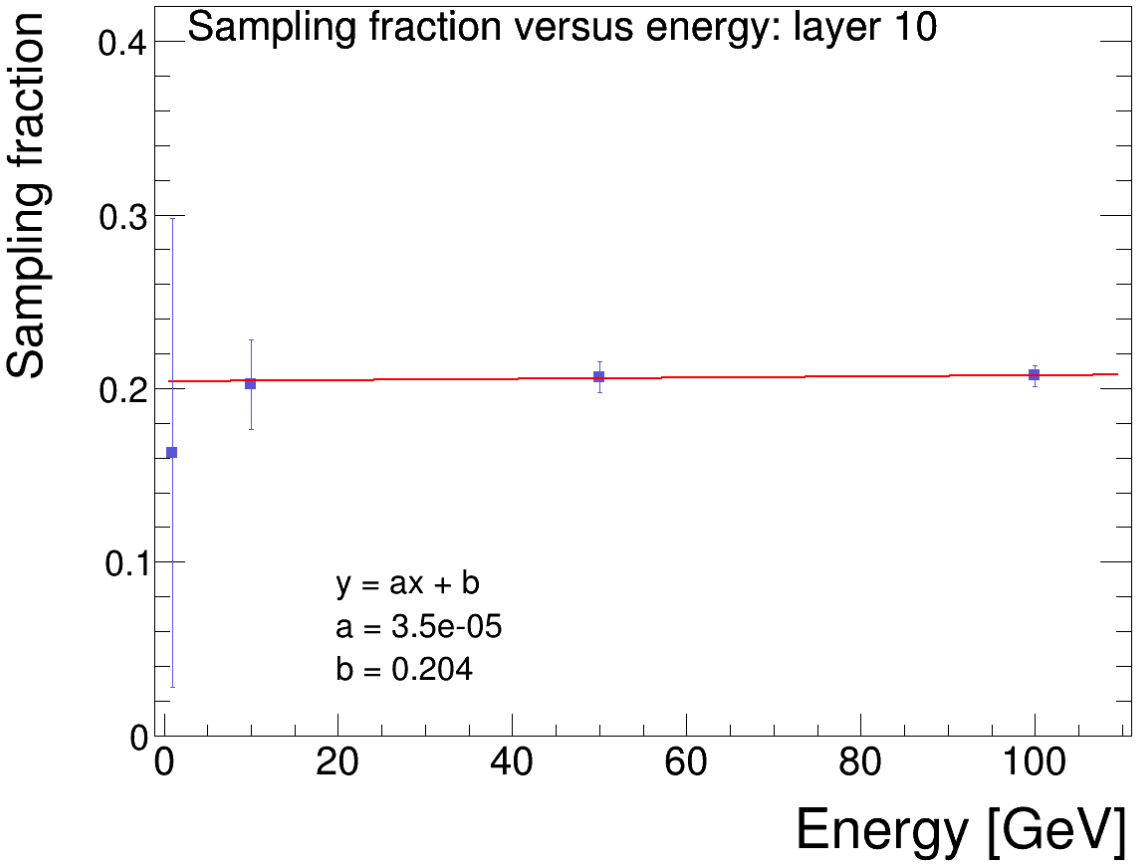

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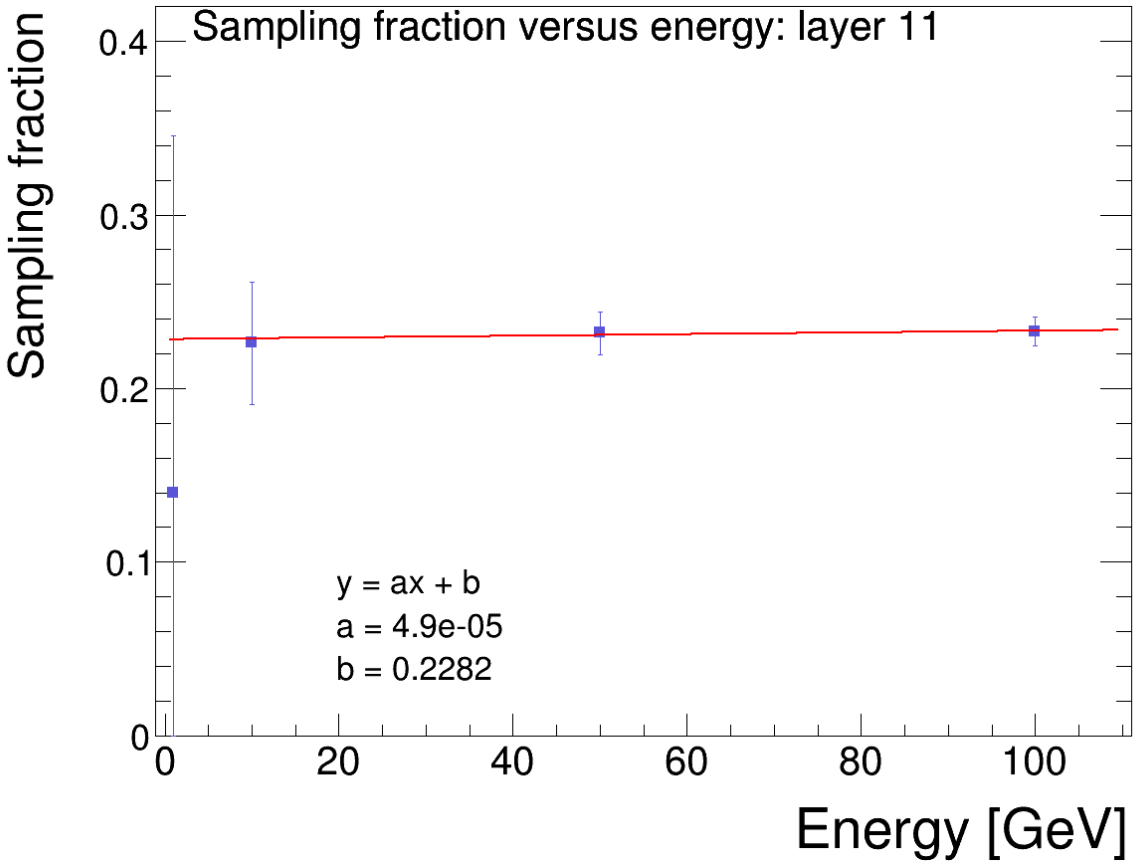
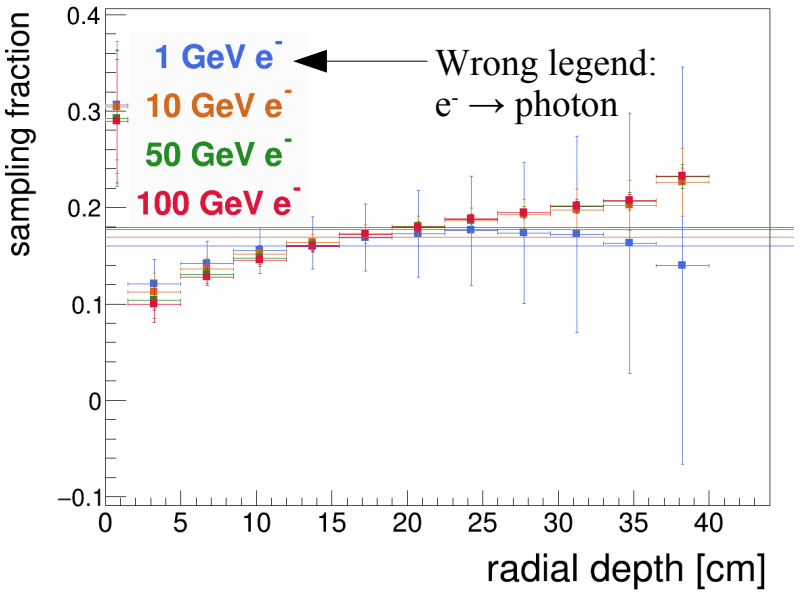
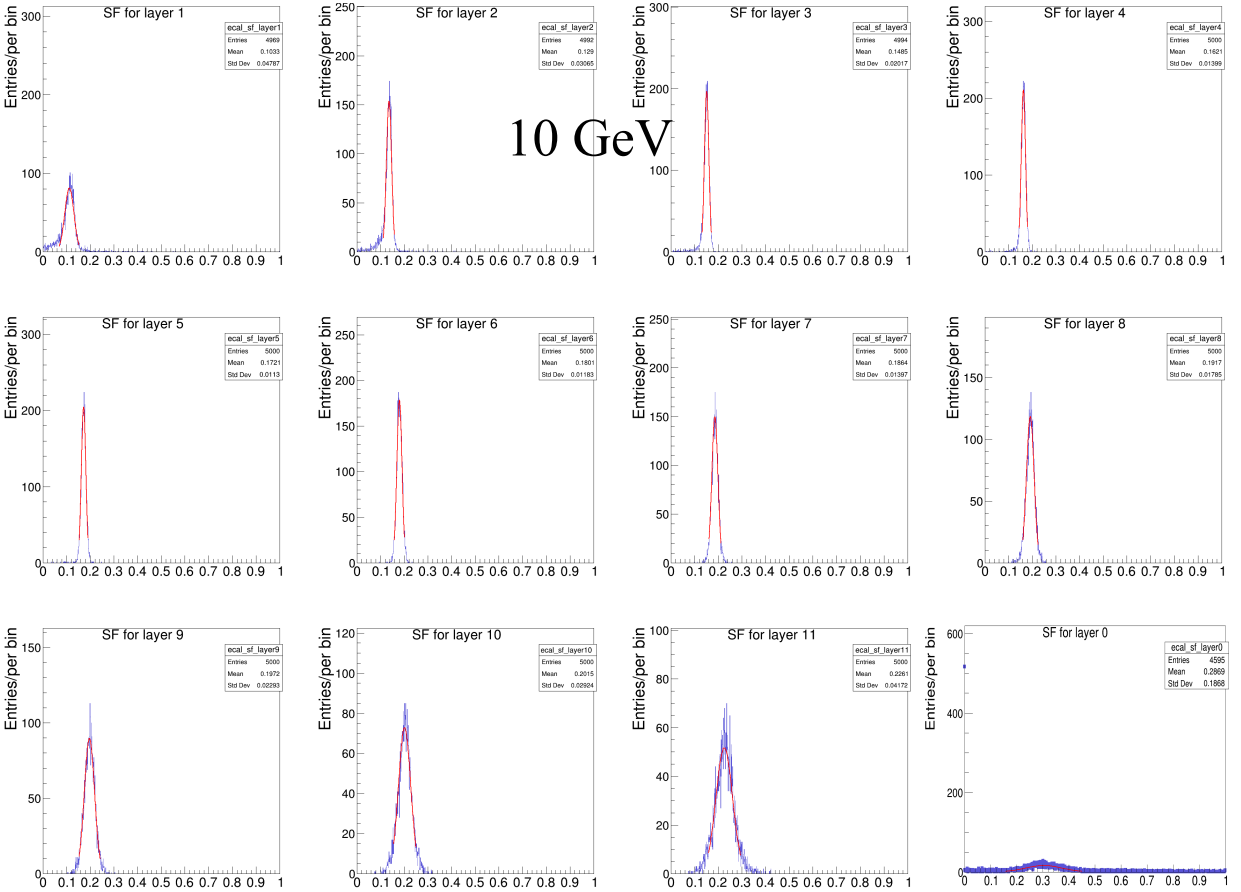


Sampling fraction

- Sampling fraction goes from 10% to 22% between layer 1 and layer 11
- SF energy dependence is extremely mild → propose to use SF from 10 GeV sample
  - Fast to simulate
  - Reasonable distributions

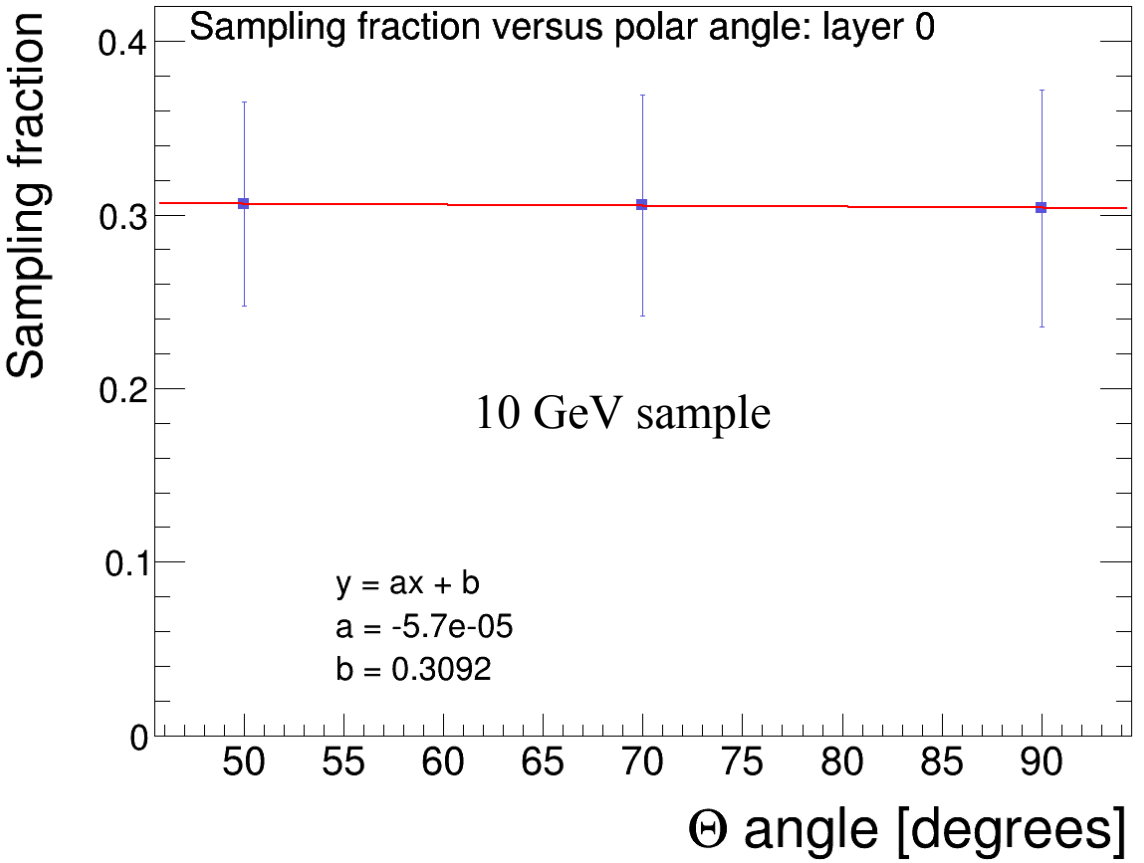


10 GeV



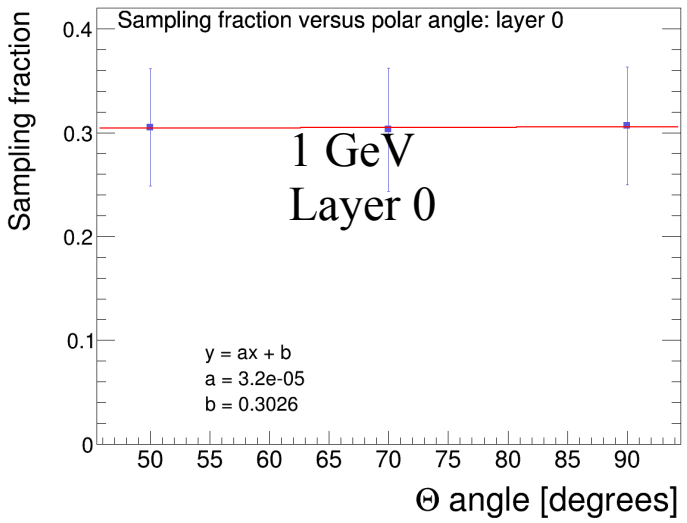
Sampling fraction VS polar angle

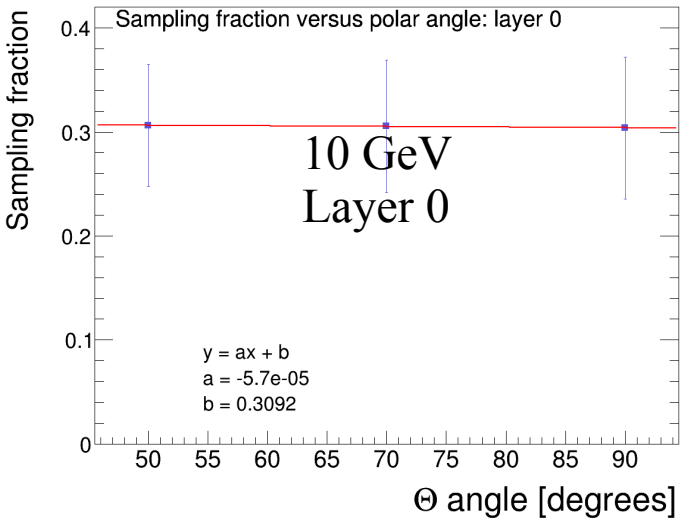
- Sampling fraction per layer as a function of polar angle: linear fit
  - Generated three angles (50°, 70° and 90°) for the 1, 10 and 50 GeV benchmarks
  - ~constant w.r.t. to incoming particle polar angle
  - -10^{-4} to $+10^{-4}$ slope, trend less clear when going from layer 0 to layer 11 (fit uncertainties)

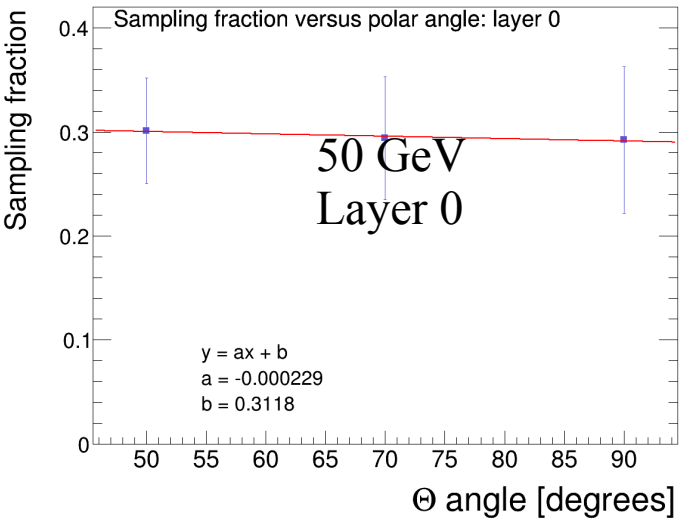


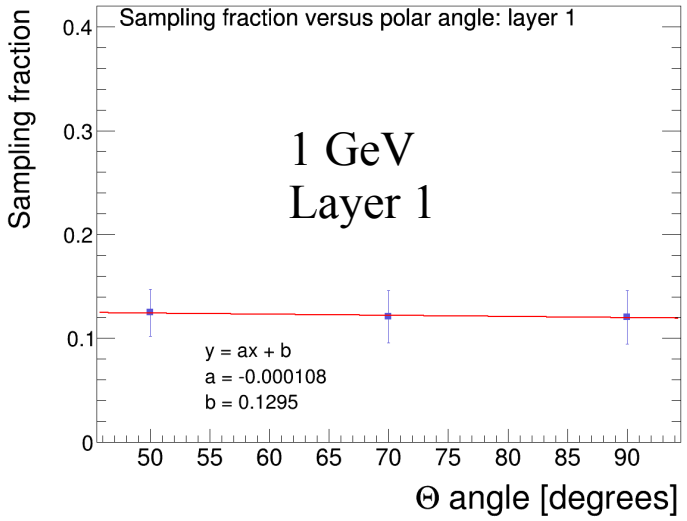
Sampling fraction

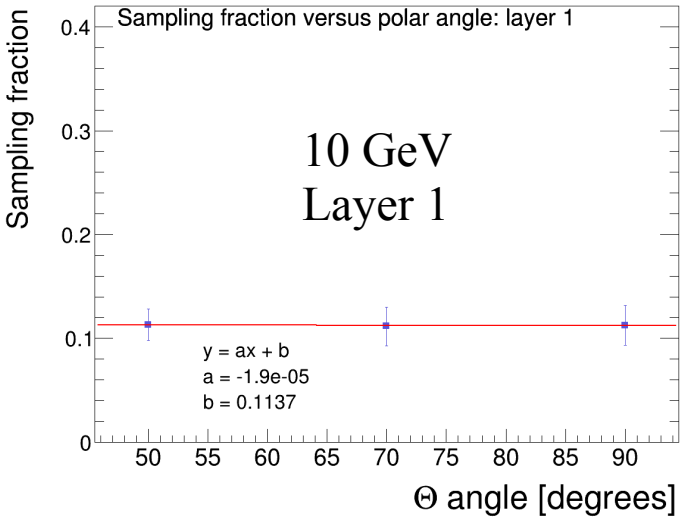
- Sampling fraction per layer for different polar angle: energy comparison

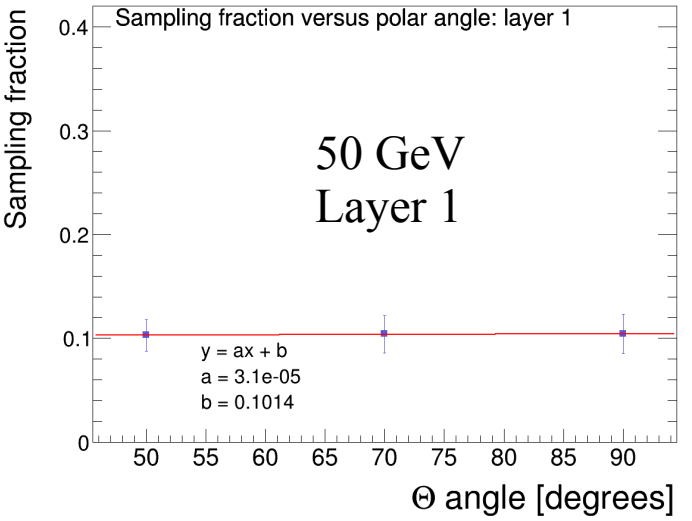












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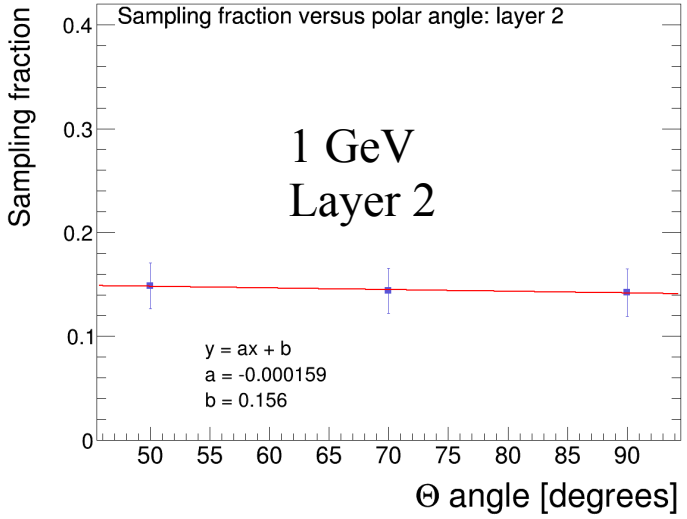

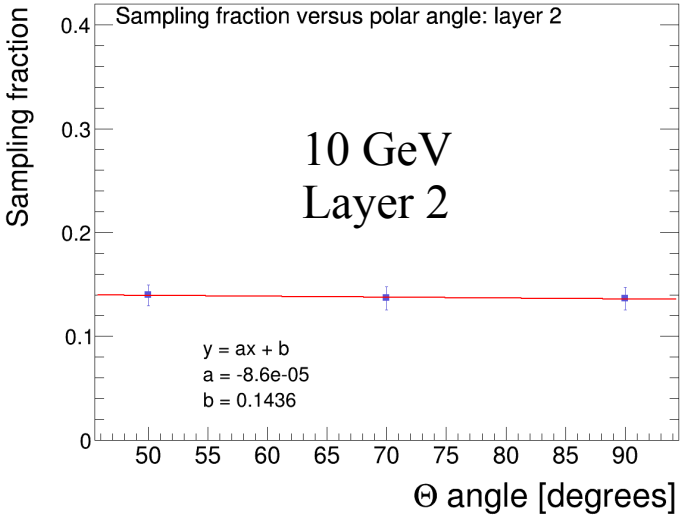

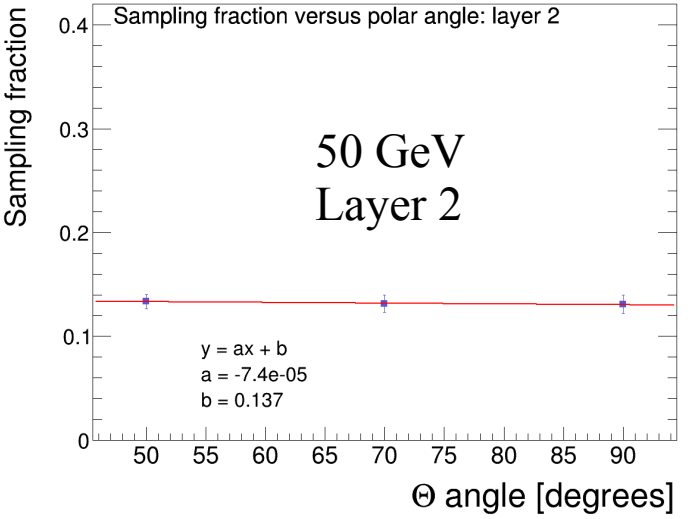

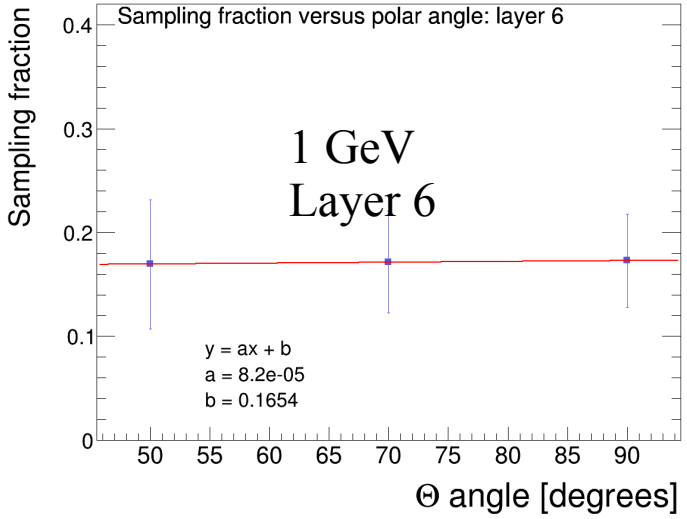

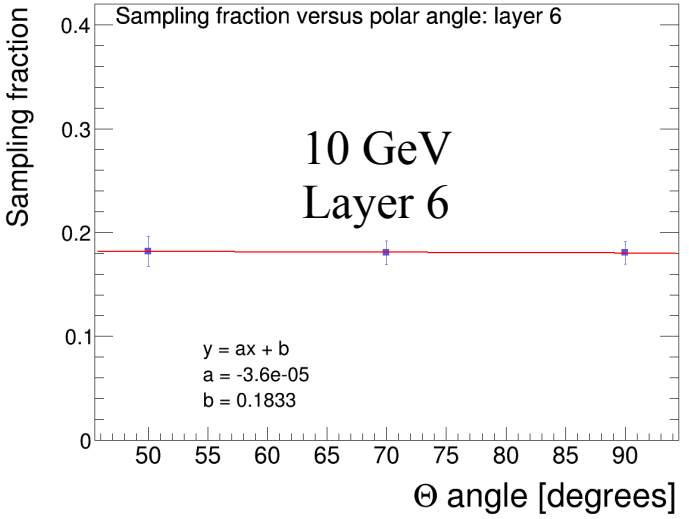

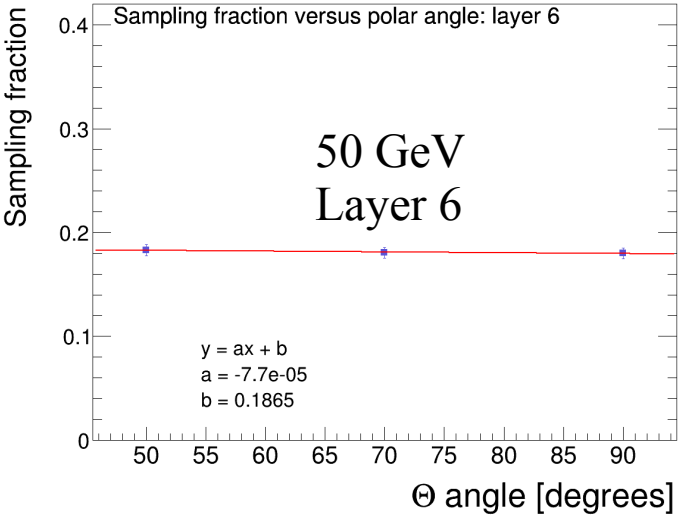

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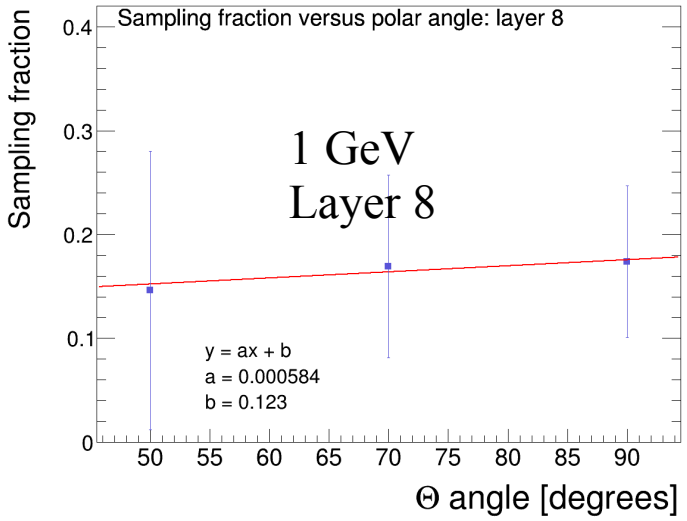
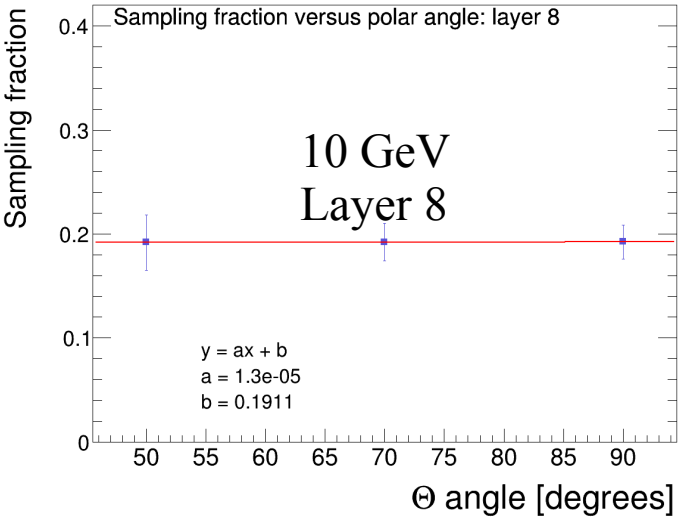
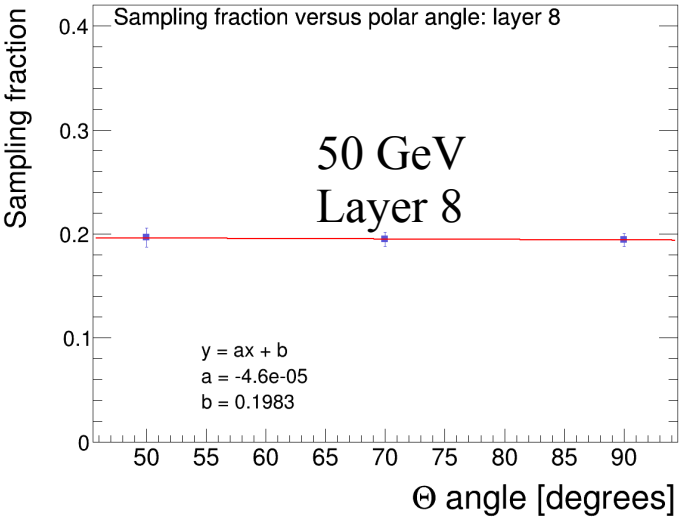
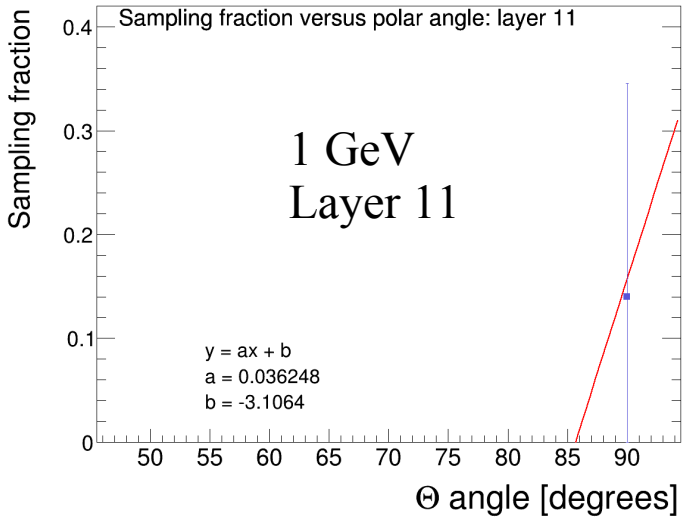
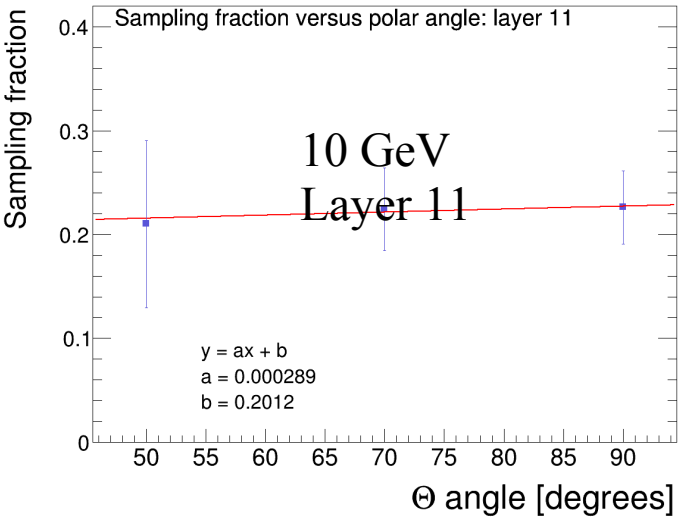
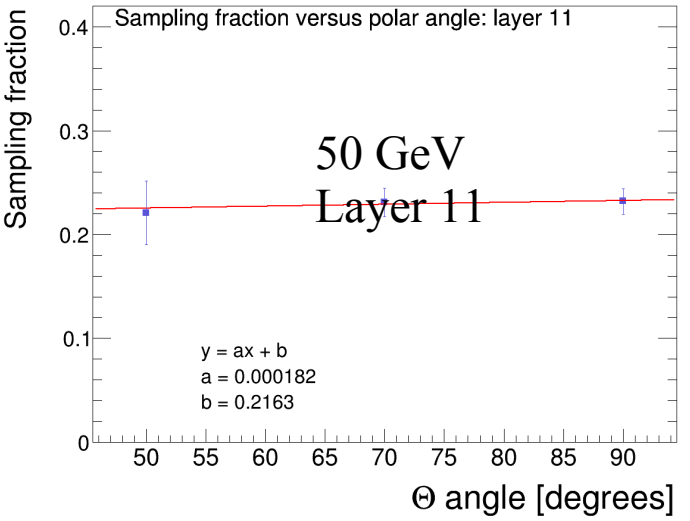






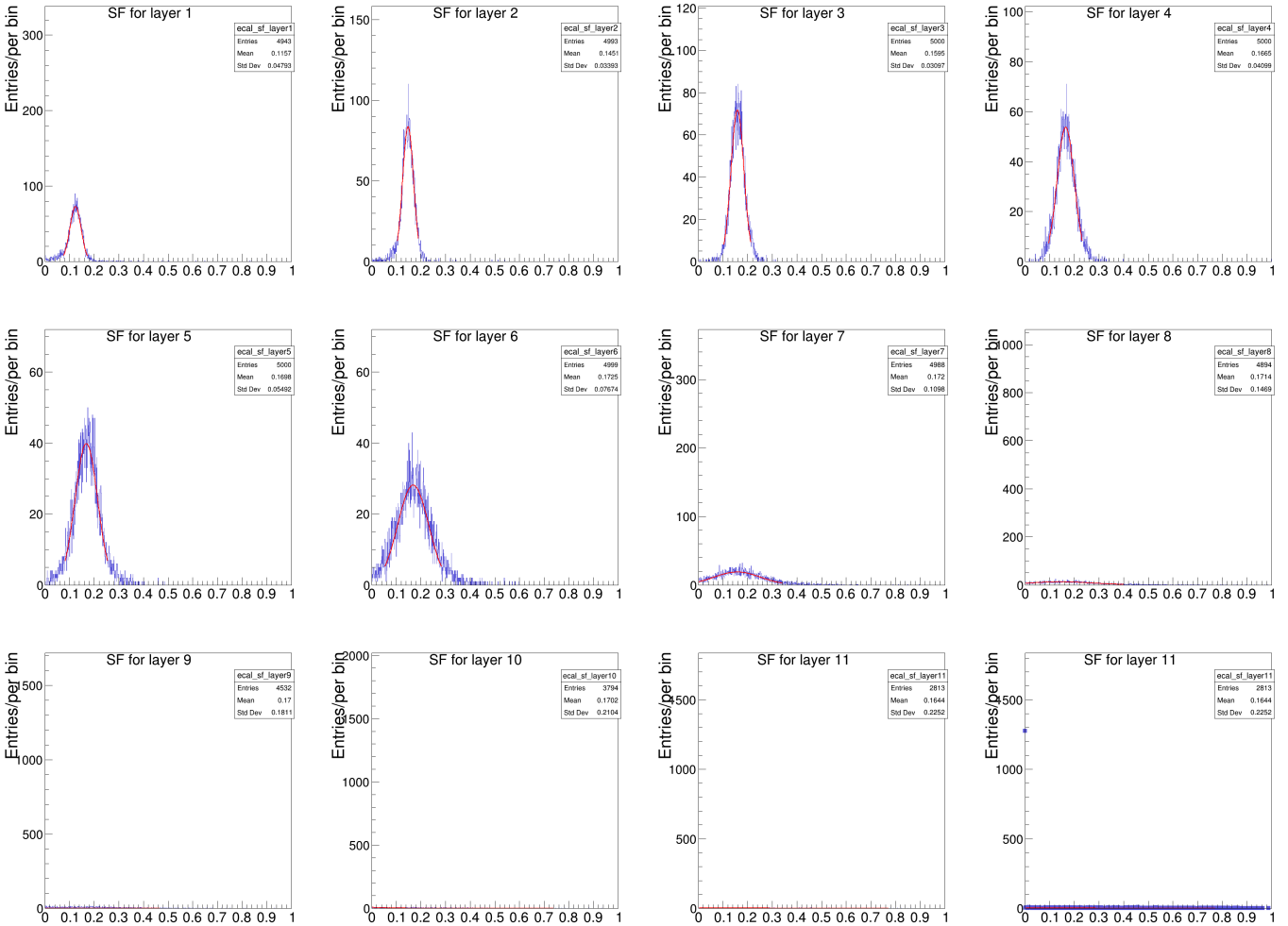






Sampling fraction

- 1 GeV photon at 50° do not reach the end of the calorimeter

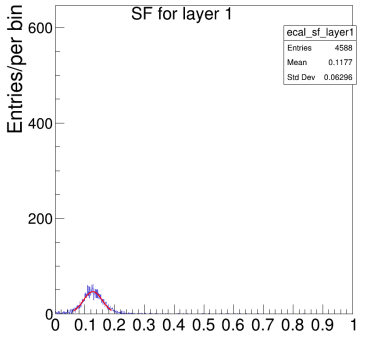


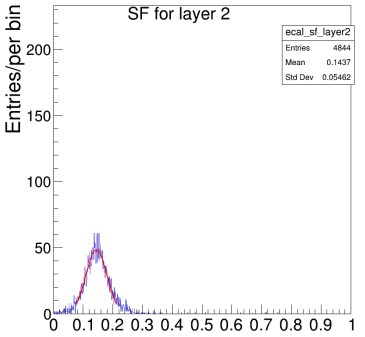
Summary

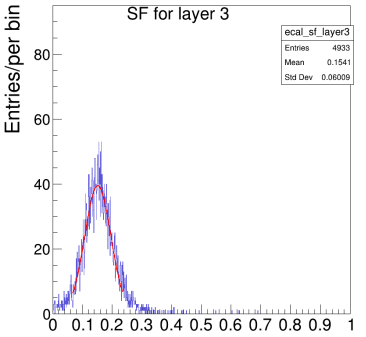
- SF mean does not vary significantly with
  - Energy
  - Polar angle
- Propose to use 10 GeV sample at 90 degrees SF for all the benchmarks, at least for now
- Not much to gain in energy resolution by deriving SF as a function of energy or polar angle
  - Potential further improvement on energy resolution by a calibration method could come from a correction based on the shower depth
  - Will be studied later
- Moving now to the upstream material correction...

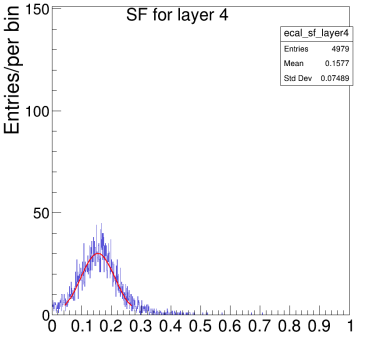
Additional material

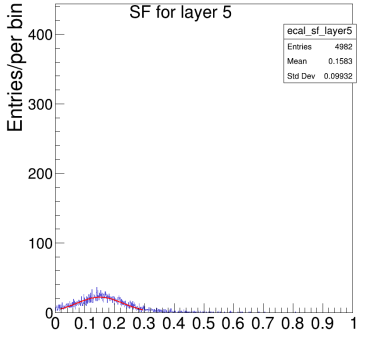
Sampling fraction 300 MeV

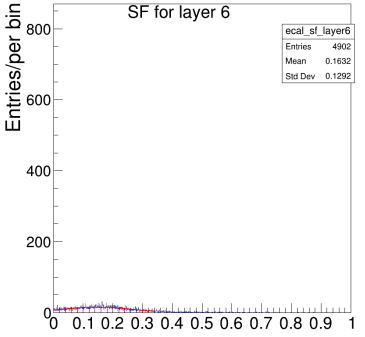


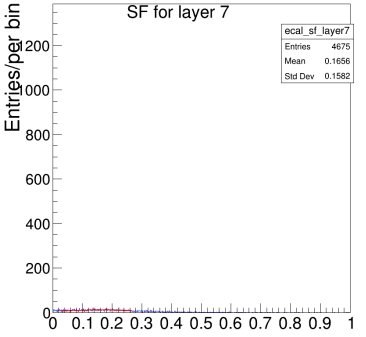


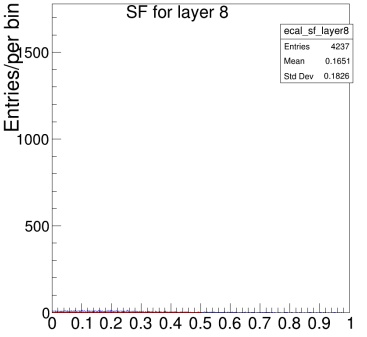


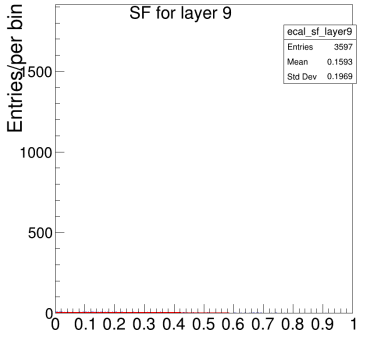


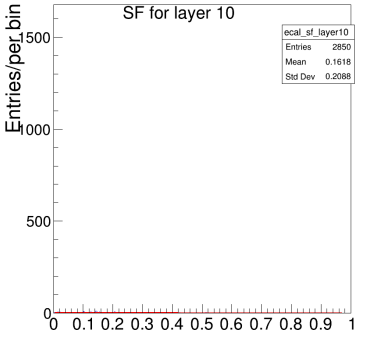


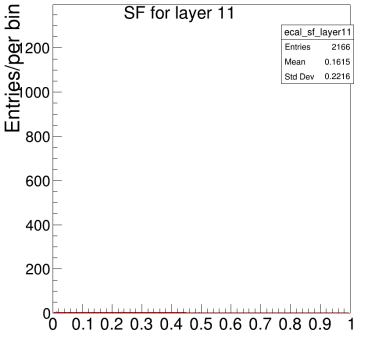


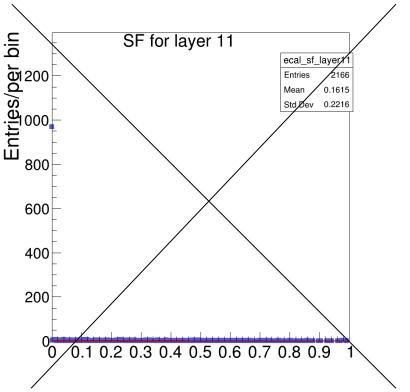




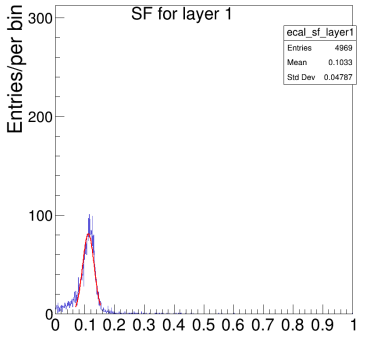


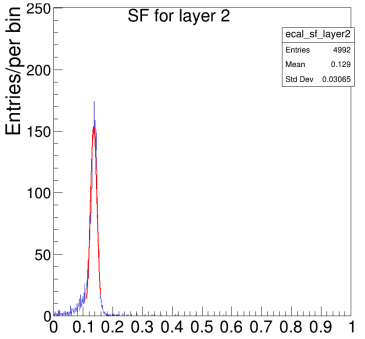


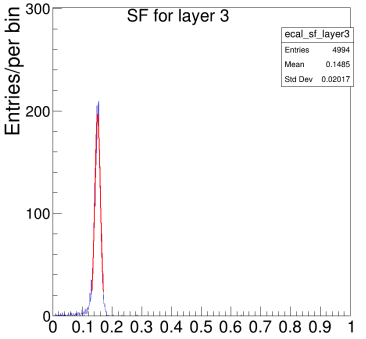


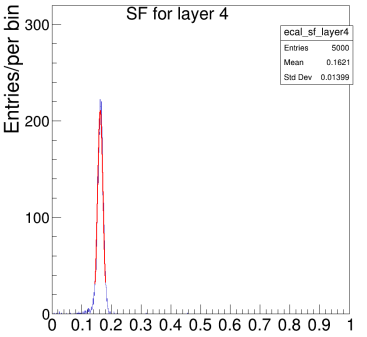


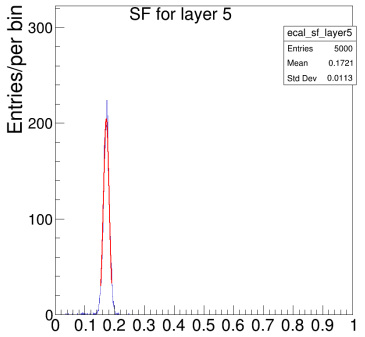
Sampling fraction 10 GeV

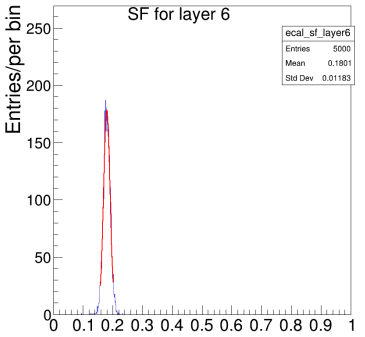


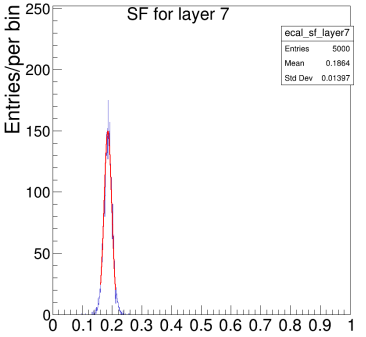


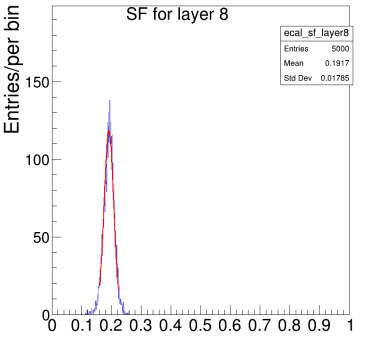


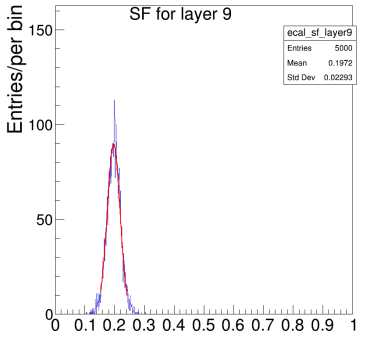


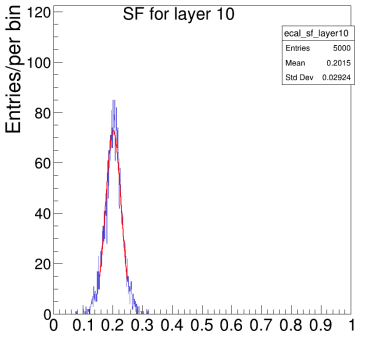


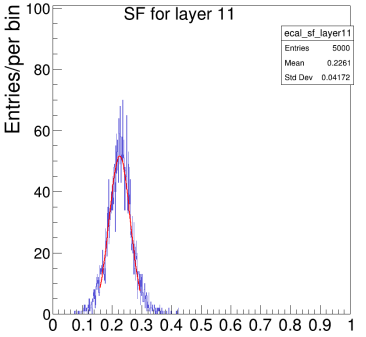


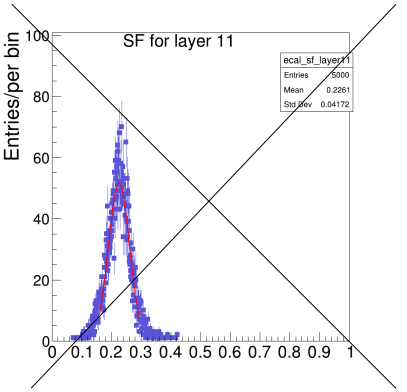




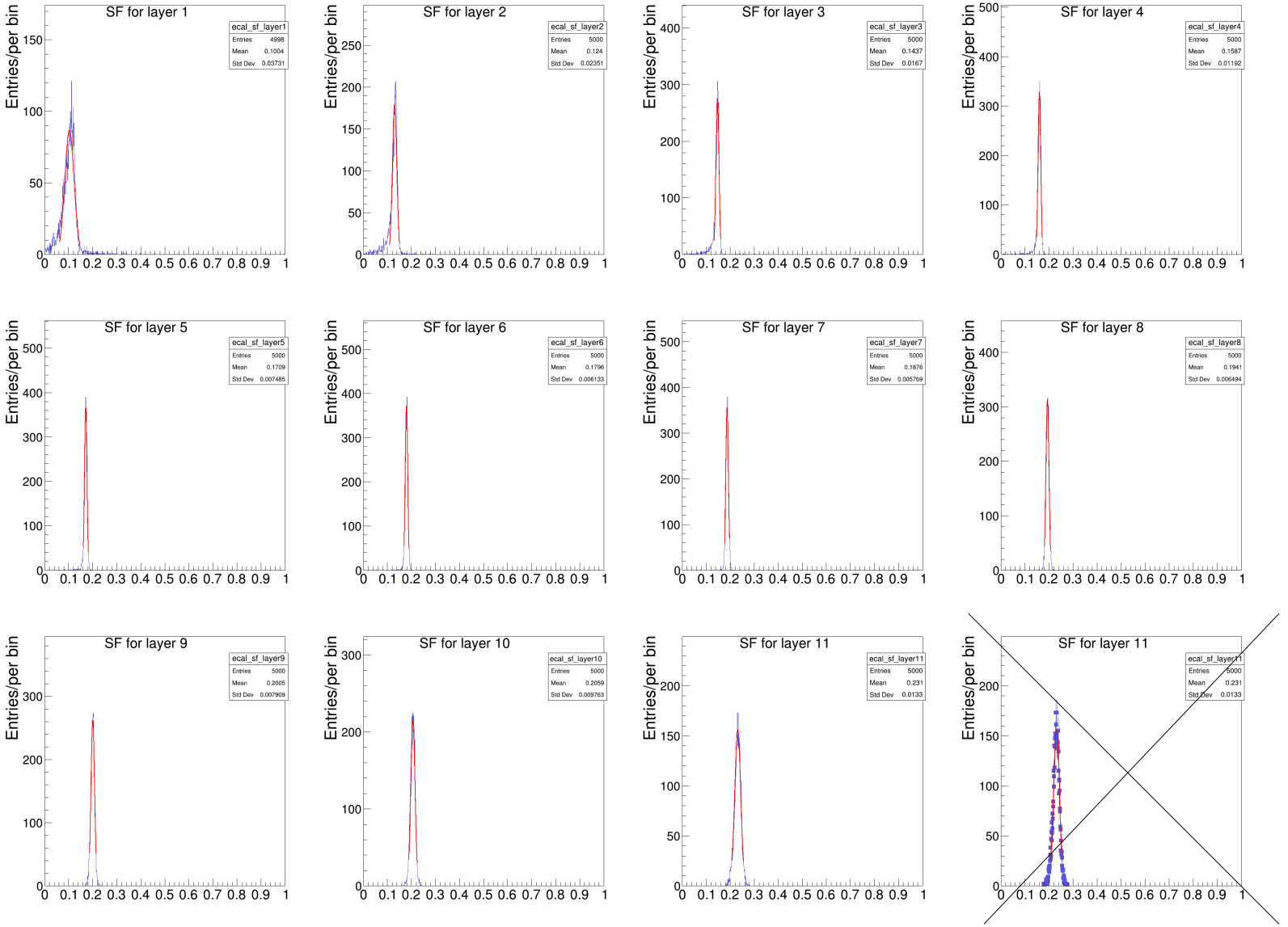




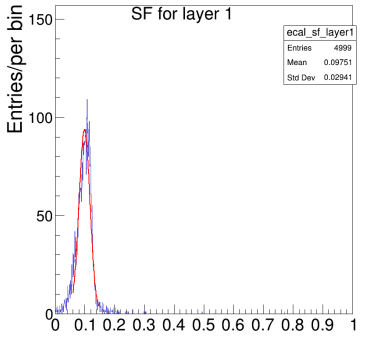


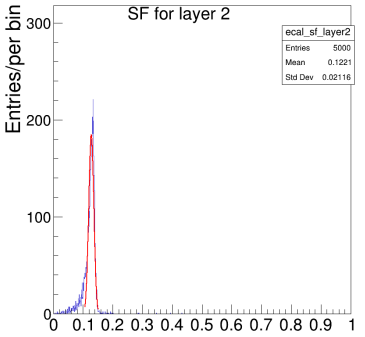


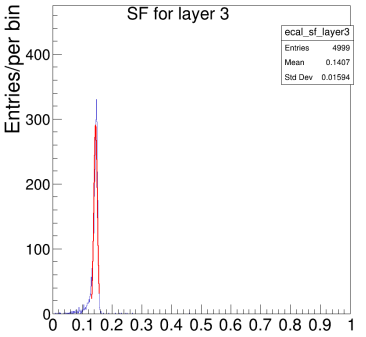
Sampling fraction 50 GeV

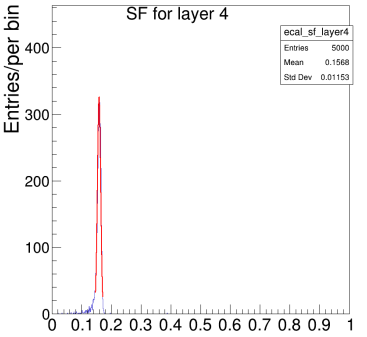


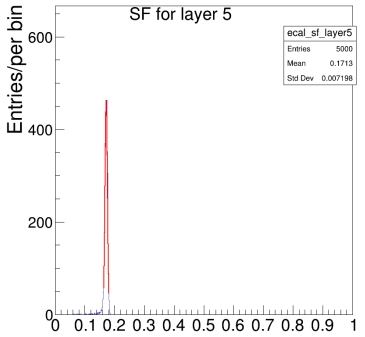
Sampling fraction 100 GeV

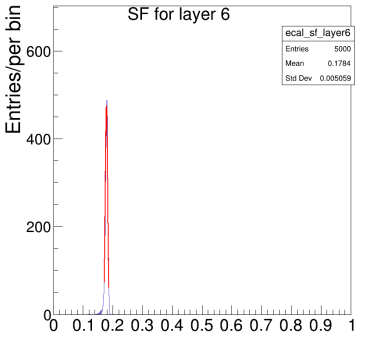


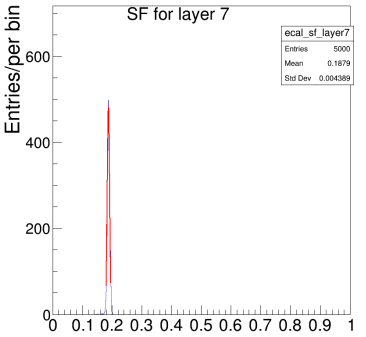


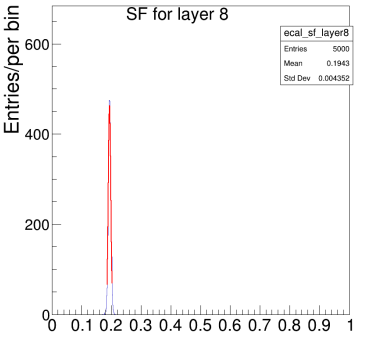


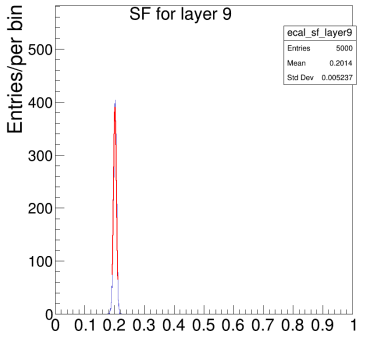


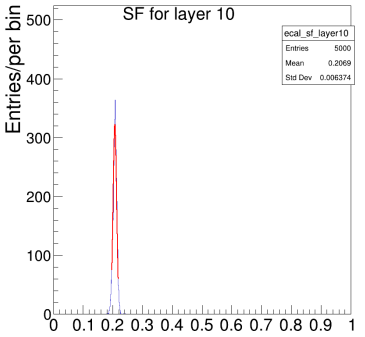


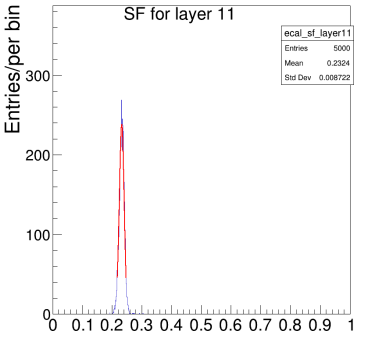


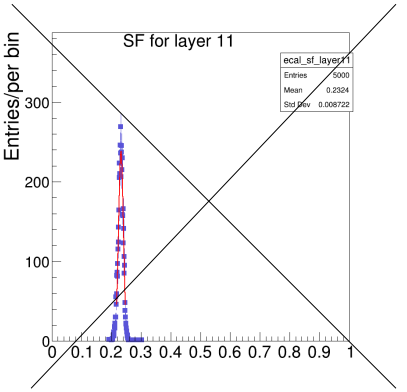




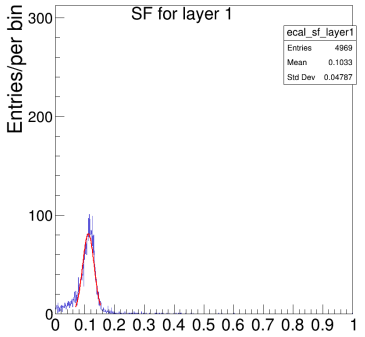


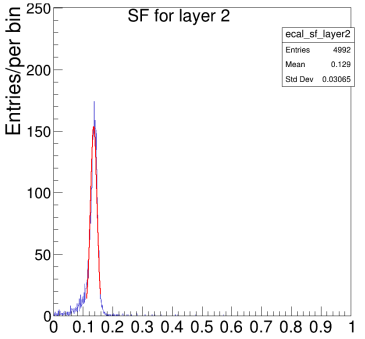


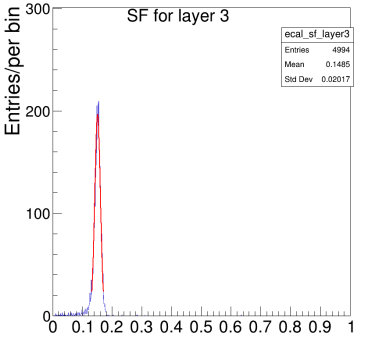


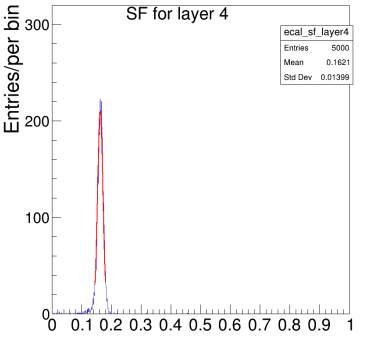


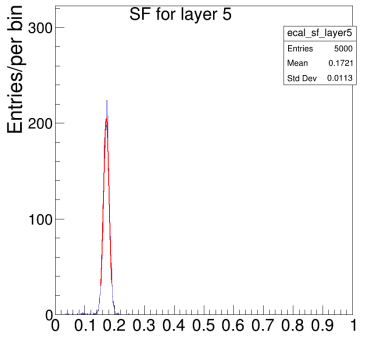
Sampling fraction 10 GeV, 90°

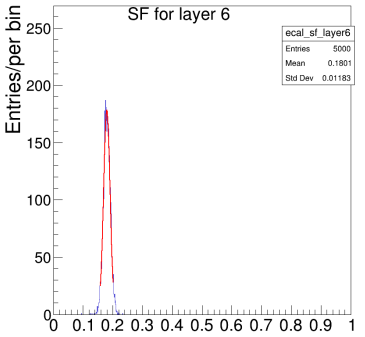


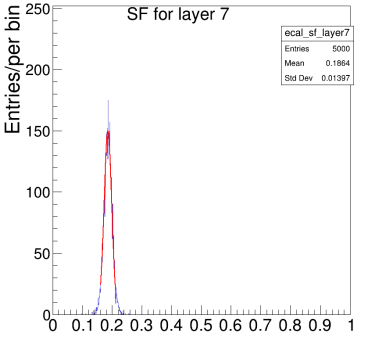


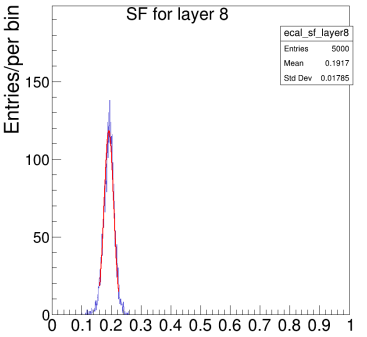


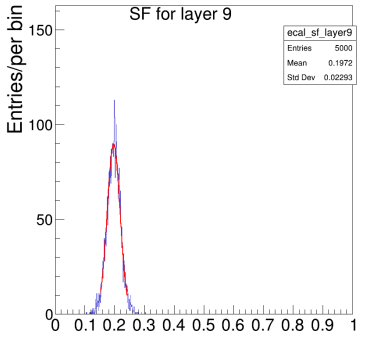


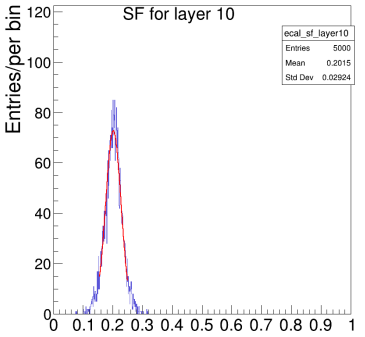


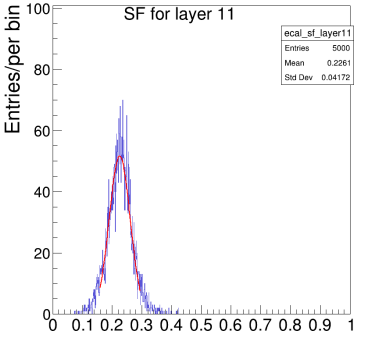


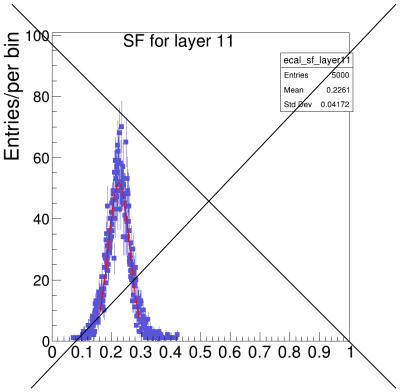




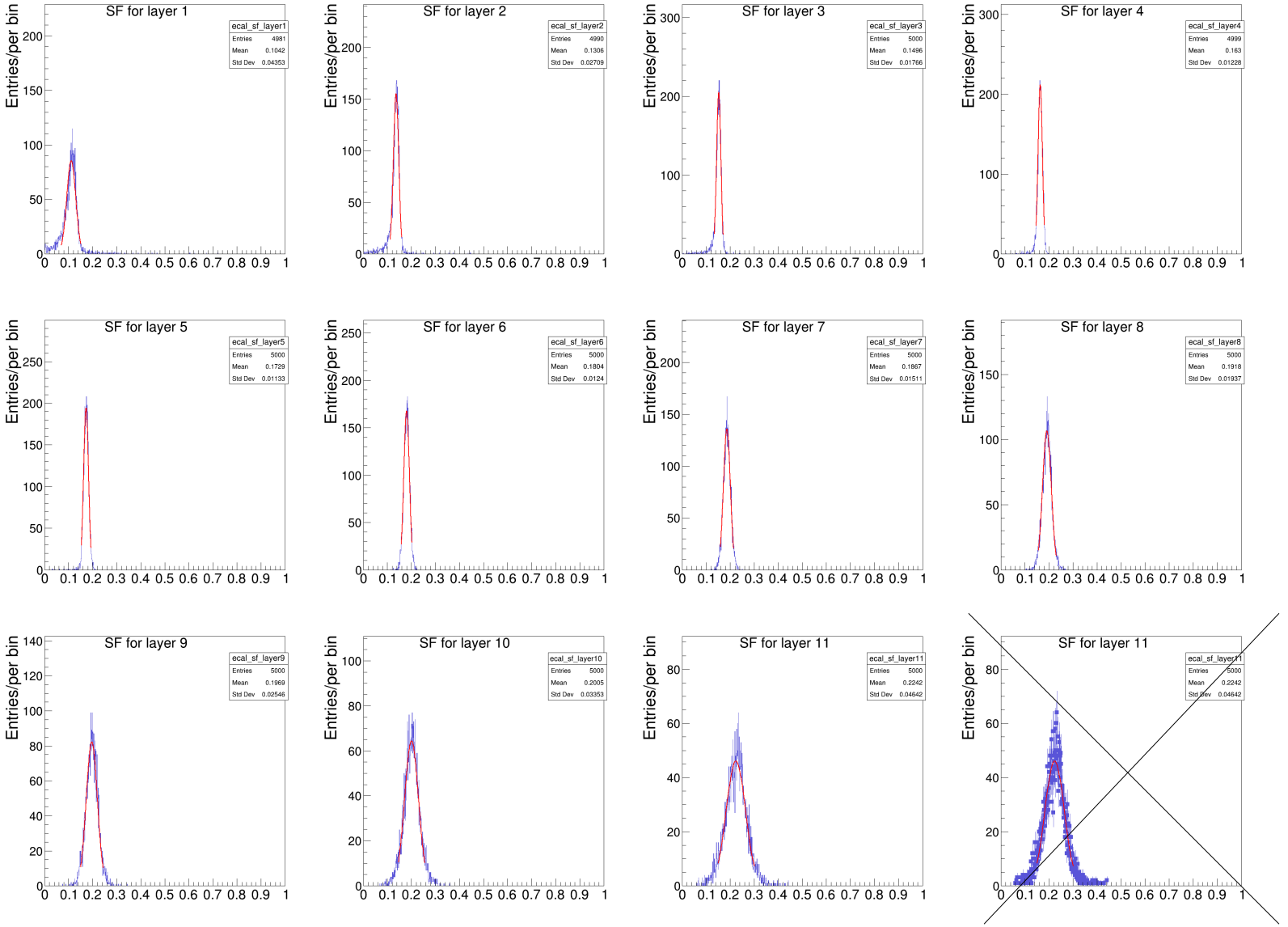




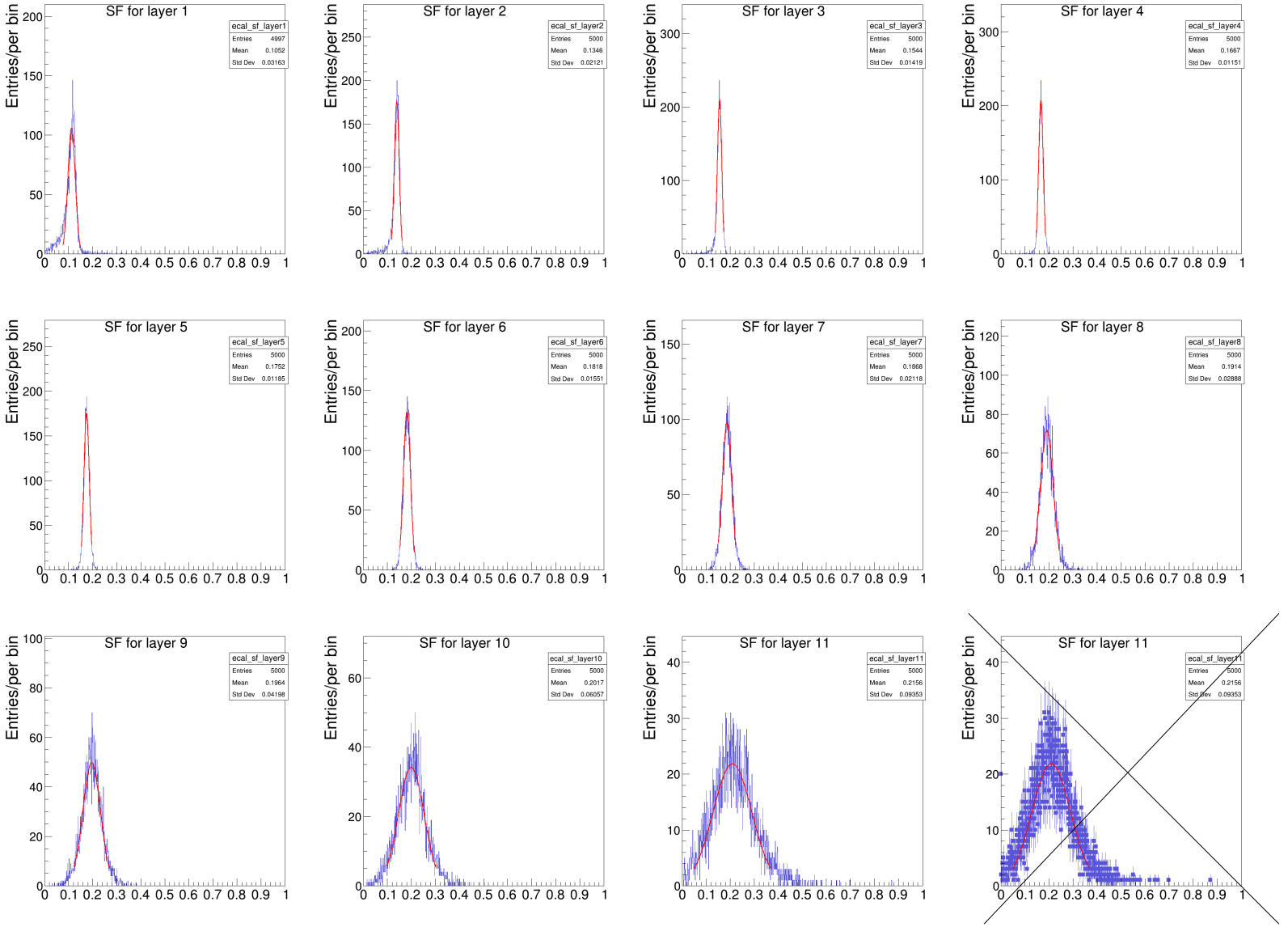




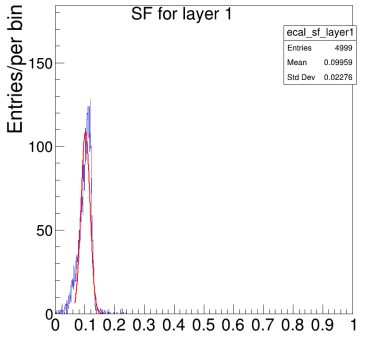
Sampling fraction 10 GeV, 70°

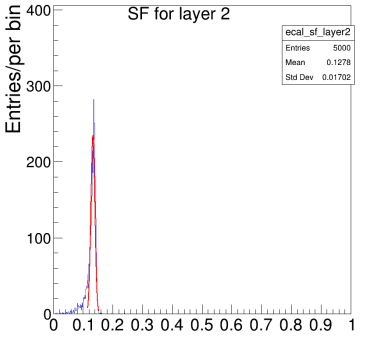


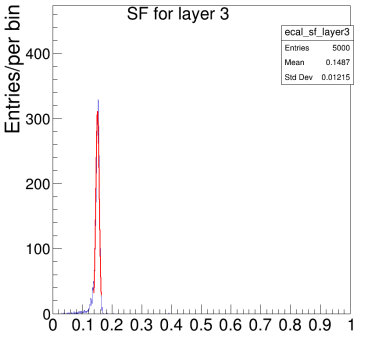
Sampling fraction 10 GeV, 50°

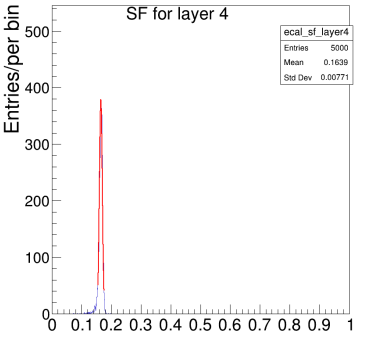


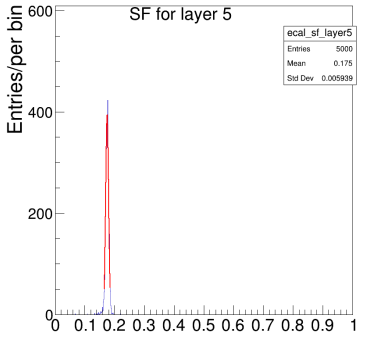
Sampling fraction 50 GeV, 50°

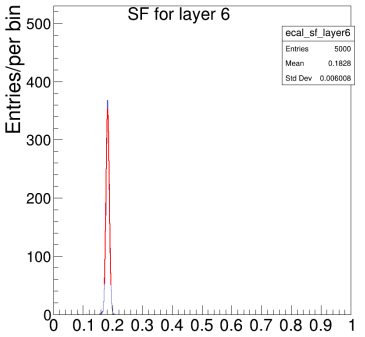


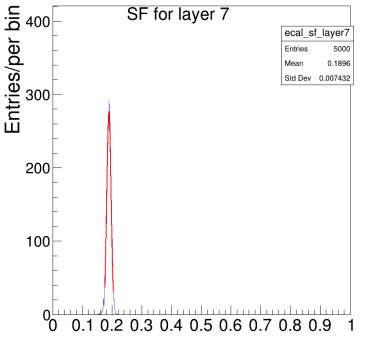


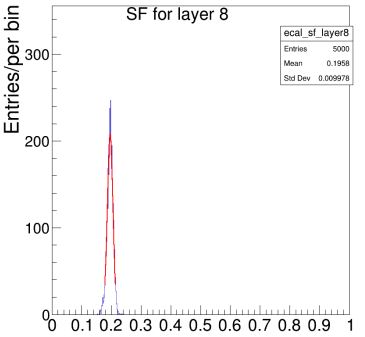


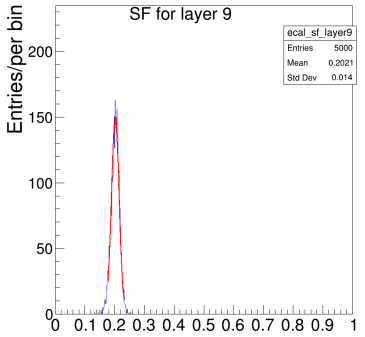


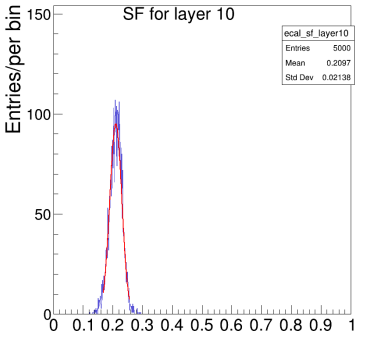


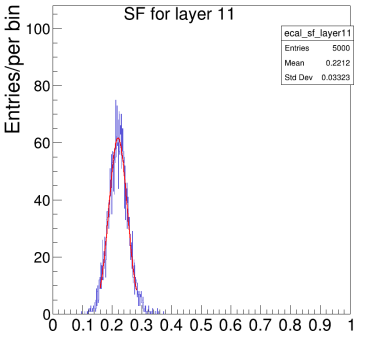


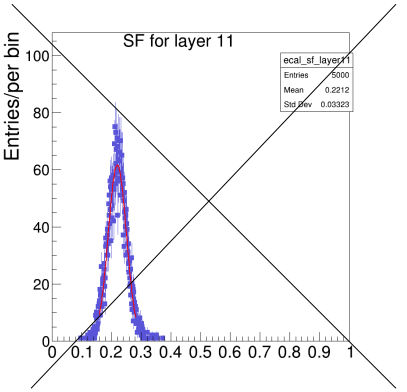






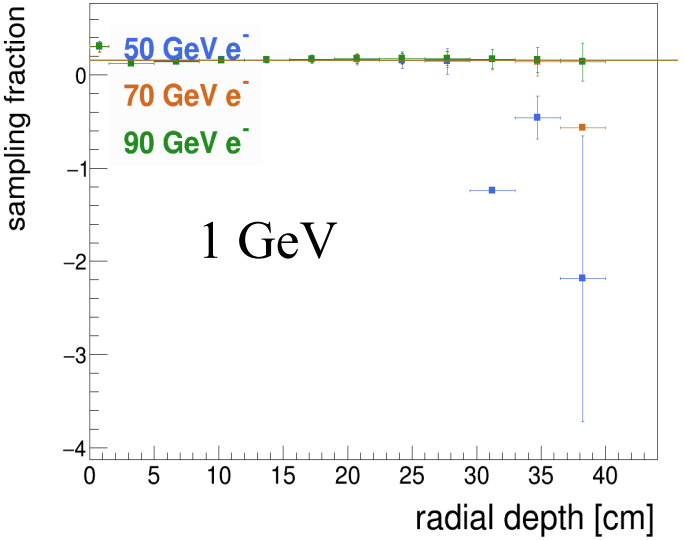


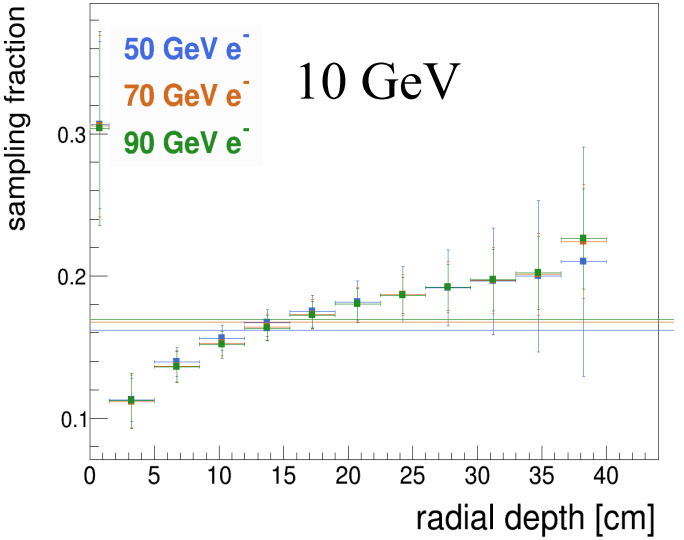


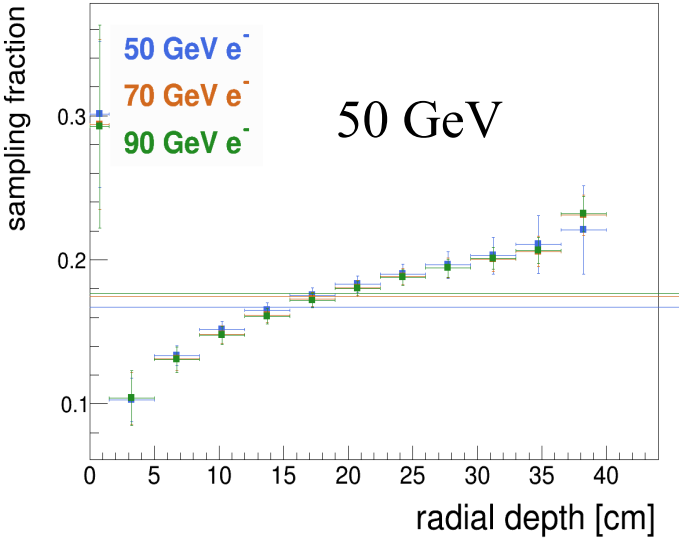


Sampling fraction

- Sampling fraction per layer for different polar angle and energies

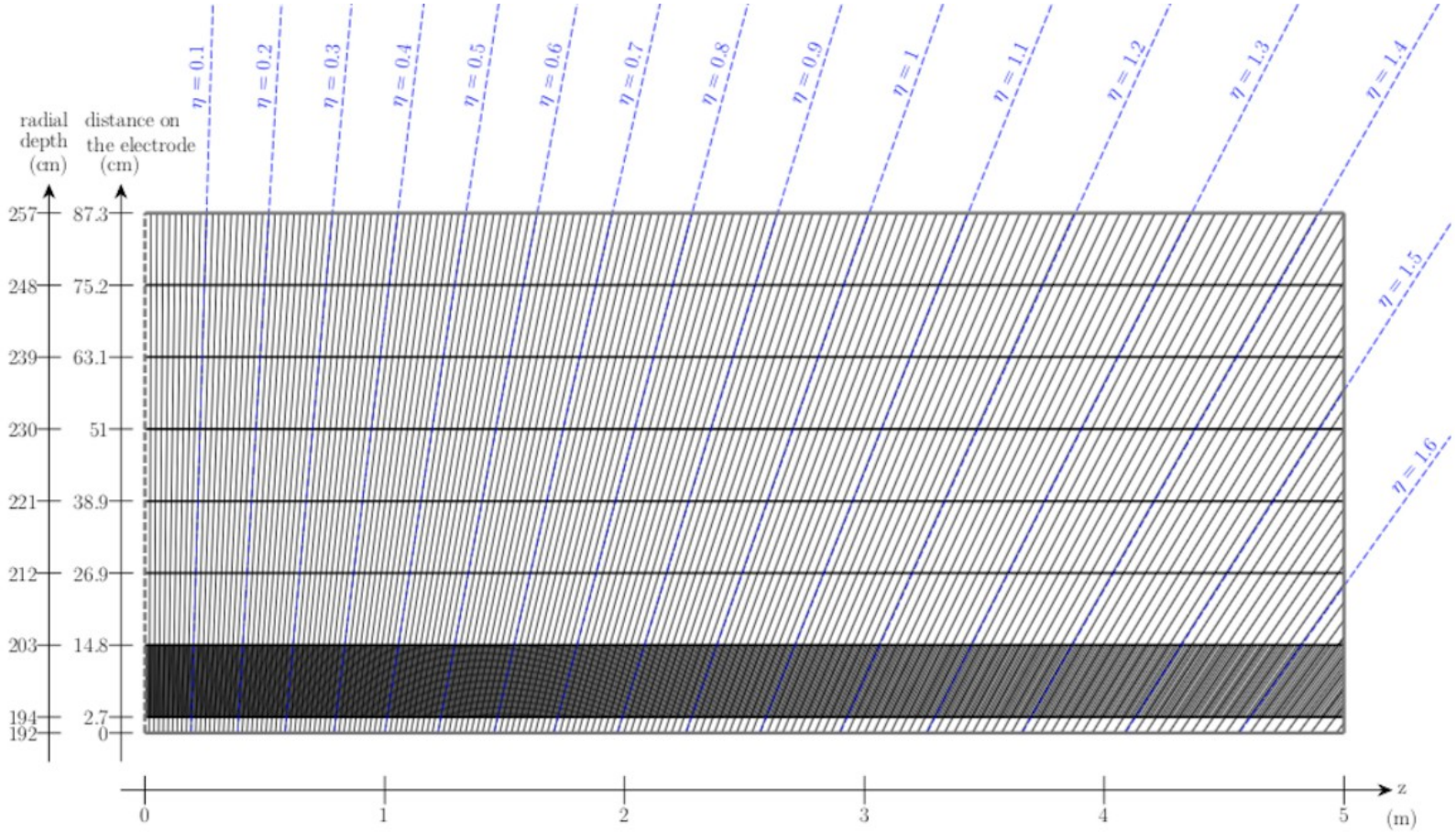






Wrong legends:
GeV → polar angle
e^- → photon

Full readout theta view



FCC-hh sampling fractions

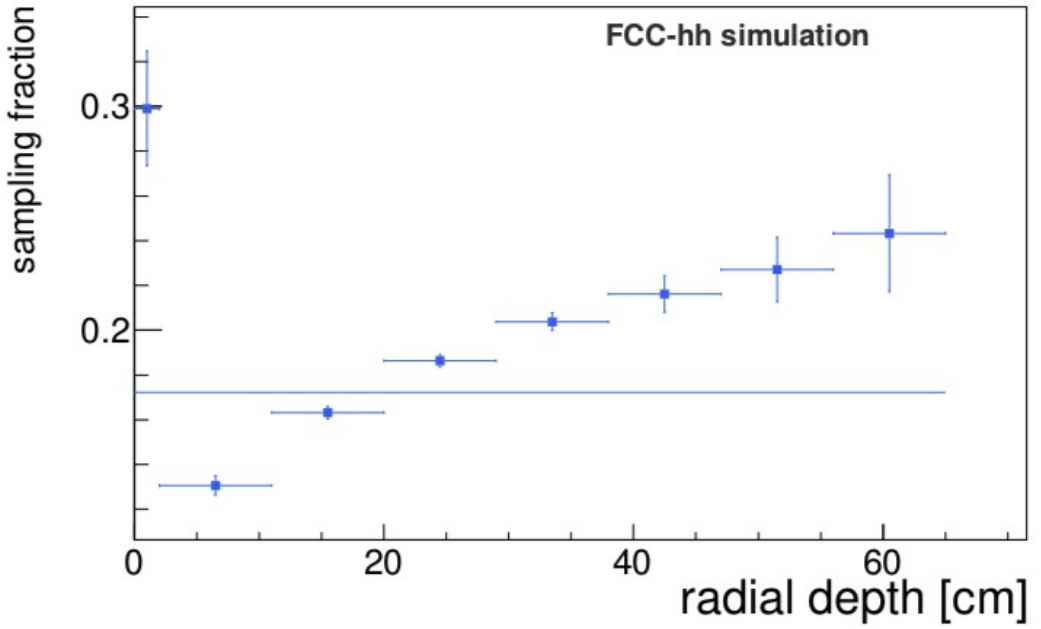


Figure 14: Average sampling fraction (E = 50-200 GeV) calculated from the energy deposited by electrons in each of the 8 layers of the detector. Horizontal line represents the average sampling fraction, obtained without longitudinal segmentation.