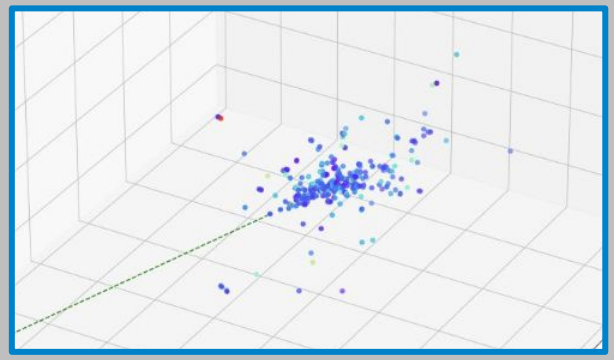
EIC Calorimetry WG Meeting

Argonne NATIONAL LABORATORY

Imaging Calorimetry for Central EM Barrel



Maria Żurek | ANL

ANL EIC Calorimetry Team
W. Armstrong, S. Joosten, J. Kim, J. Metcalfe, Z.E. Meziani, C. Peng, M. Scott, M. Żurek

06/21/2021

Imaging calorimeter based on monolithic silicon sensors

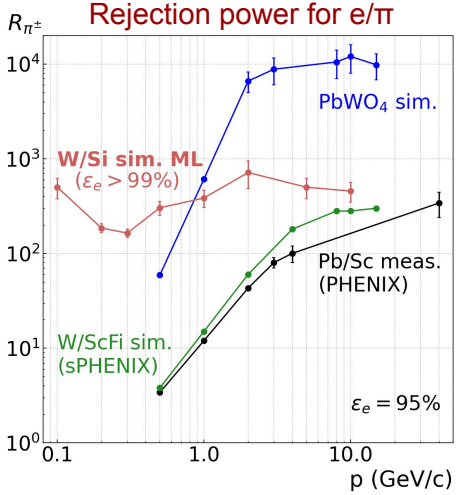
AstroPix (developed for NASA, off-the-shelf)

- Have no stringent power and cooling requirements (used in space)
- Energy resolution: 2% within dynamic range (20 keV ~ a few MeV)
- Time resolution: 50 ns

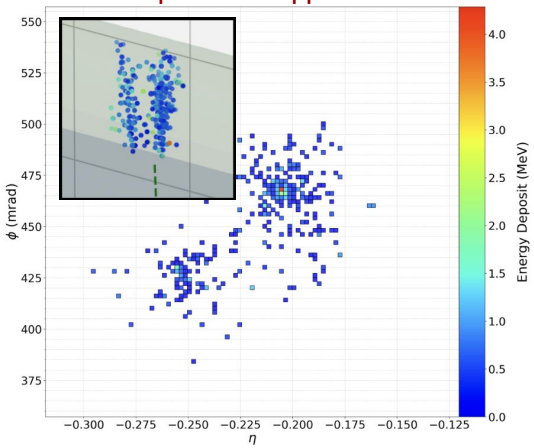
Ongoing design optimization using the simulation with IP6@EIC software framework with **AstroPix digitization, 3D clustering, ML algorithms,** …

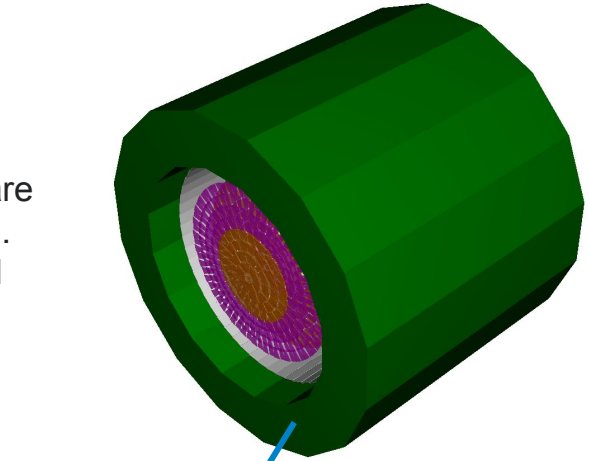
Tests against YR benchmarks: separation, shower separation, spatial and energy resolutions

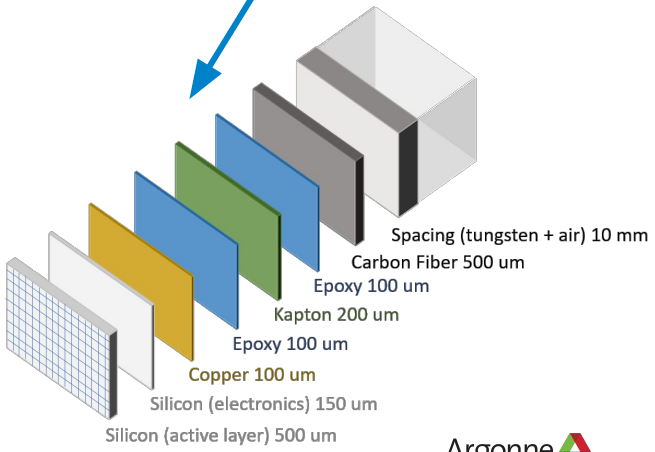
Rejection power for e/π



Example of π→γγ at 5 GeV

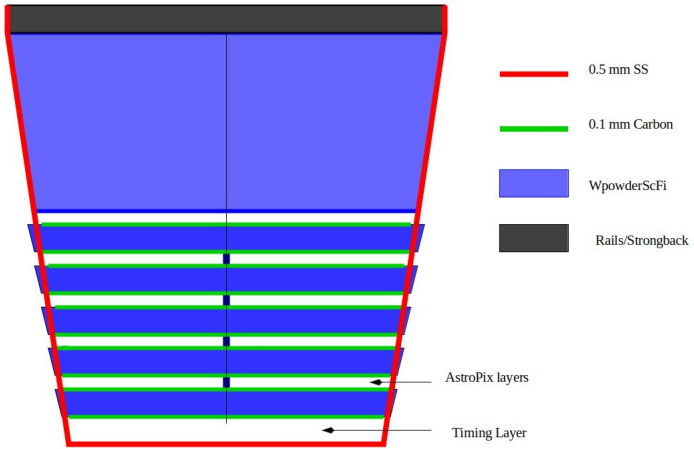


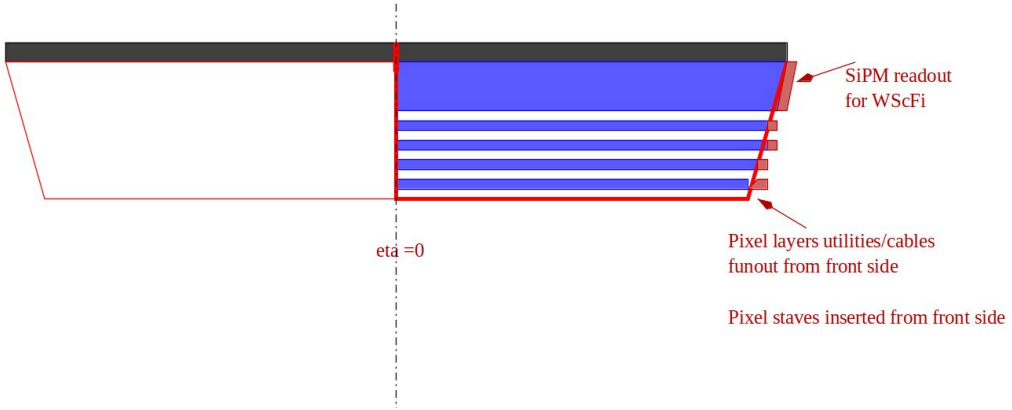




SiFi/W Calorimeter

Alternative to use instead of W layers





SiFi/W Calorimeter

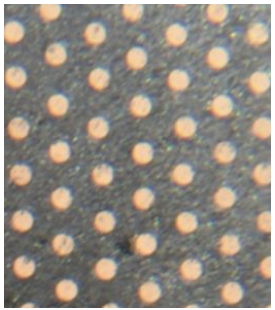
sPHENIX Calorimeter Parameters https://arxiv.org/pdf/1704.01461.pdf

Scintillating Fiber (Kuraray SCSF78) Diameter **0.47 mm**, spacing **1 mm** http://kuraraypsf.jp/psf/sf.html
Absorber Matrix of Tungsten powder and epoxy w/embedded scintillating fibers

- Whole SPACAL block ~10 g/cm^3
  (~ half density of metallic tungsten)
- Tungsten powder: **11.25 g/cm^3**
- Sampling fraction for EM-showers
  ~ 2.3%
- Radiation length **X_0 ≈ 0.7-0.8 cm**

TABLE I
EMCAL BLOCK COMPONENT MATERIALS

Material	Property	Value
Tungsten powder	THP Technon 100 mesh particle size	25-150 μm
	bulk density (solid)	$\geq$ 18.50 g/cm^3
	tap density (powder)	$\geq$ 11.25 g/cm^3
	purity	$\geq$ 95.4% W
	impurities ($\leq$ 5 percent)	Fe, Ni, O2, Co, Cr, Cu, Mo
Scintillating fiber	Kuraray SCSF78 (single cladding, blue)	
Epoxy	EPO-TEK 301	

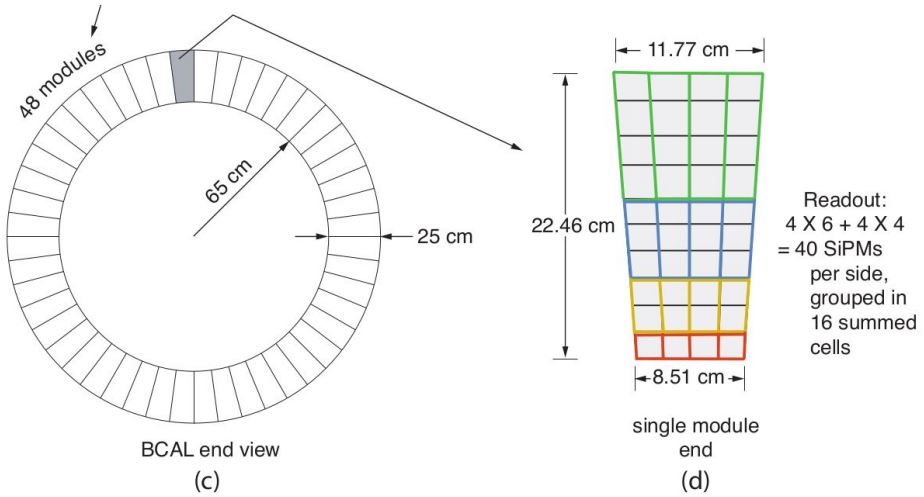


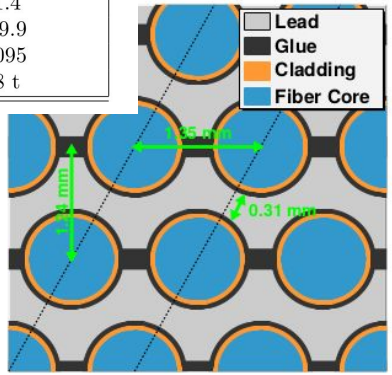
SiFi/Pb Calorimeter

GlueX Calorimeter Parameters

Table 1: Summary of BCAL properties.

Property	Value
Number of modules	48
Module length	390 cm
Module inner/outer widths	84.0 mm/118.3 mm
Lead-scintillator matrix thickness	221.9 mm
Inner/outer Al plates thickness	8 mm/31.75 mm
Module azimuthal bite	7.5°
Total number of fibers	685000
Lead sheet thickness	0.5 mm
Kuraray SCSF-78MJ multi-clad fiber	1.0 mm
Fiber pitch radial/lateral	1.22 mm/1.35 mm
Weight fractions (% Pb:SF:Glue)	86.1: 10.5: 3.4
Effective density	4.88 g/cm^3
Effective Radiation Length	1.45 cm
Effective Molière radius	3.63 cm
Effective Atomic Weight	71.4
Effective Atomic Number	179.9
Sampling fraction	0.095
Total weight	28 t





~14,300 fibres per module (48 modules)

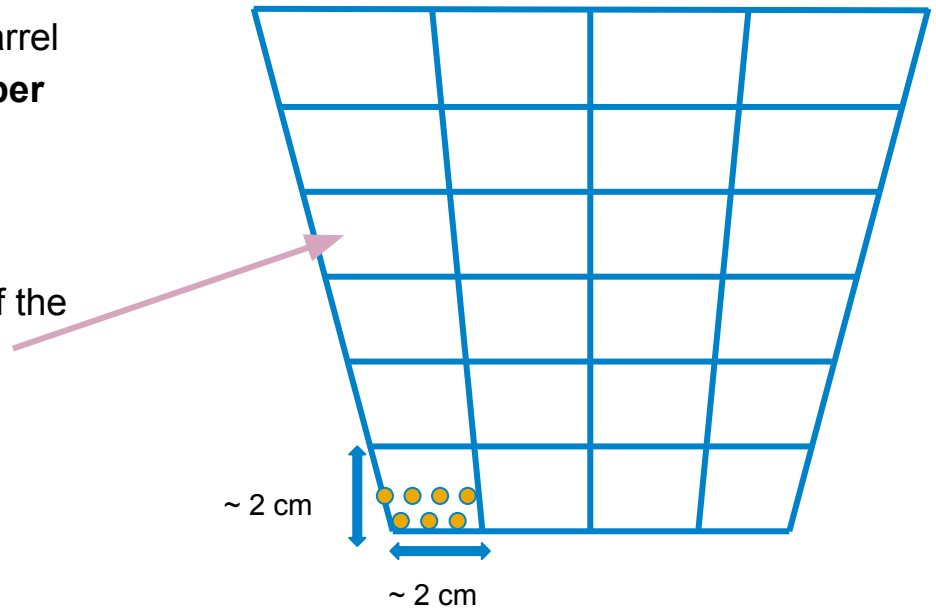
40 SiPMs x 4x4 x 3600 pixels per module

- Lightguides: from 21×21 mm^2 to 27×25 mm^2
- SiPM sensor area: 13×13 mm^2

SiFi Calorimeter

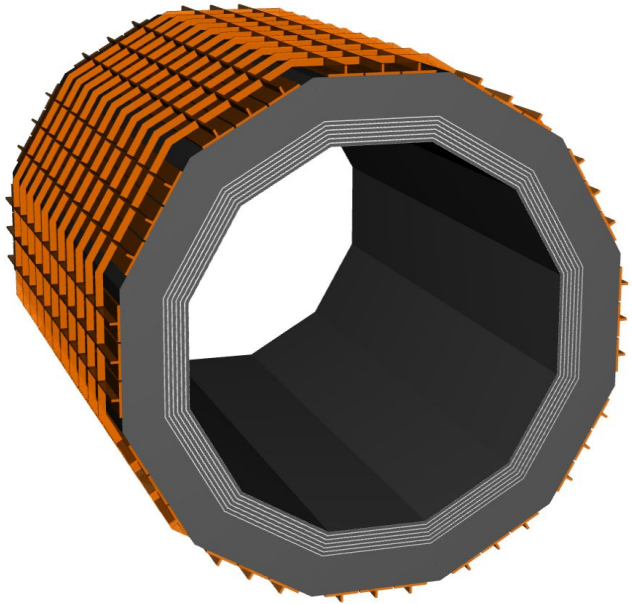
Implementation in dd4hep

- Layers of scintillating fibers embedded in absorber can be added to the current barrel calorimeter with **choice of absorber, fiber spacing, radius**, etc.
- Only fibers in absorber (no epoxy now)
- **Polygonal segmentation** on the side of the calorimeter staves (similar to GlueX)
- Currently 12 staves
- Digitization implementation in progress



SiFi Calorimeter

Implementation in dd4hep



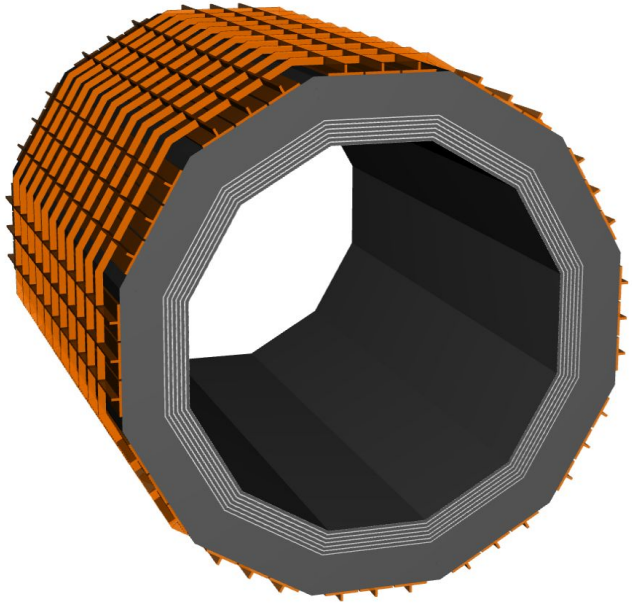
6 imaging layers with SiFi/Pb with 1.5 cm SiFi/Pb:
6 x 2.25 cm = 13.53 cm

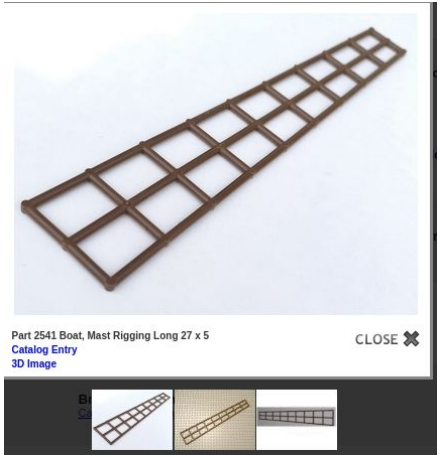
Layer of SiFi/Pb:
20.0 cm

Total:
33.53 cm

SiFi Calorimeter

Implementation in dd4hep





SiFi Calorimeter

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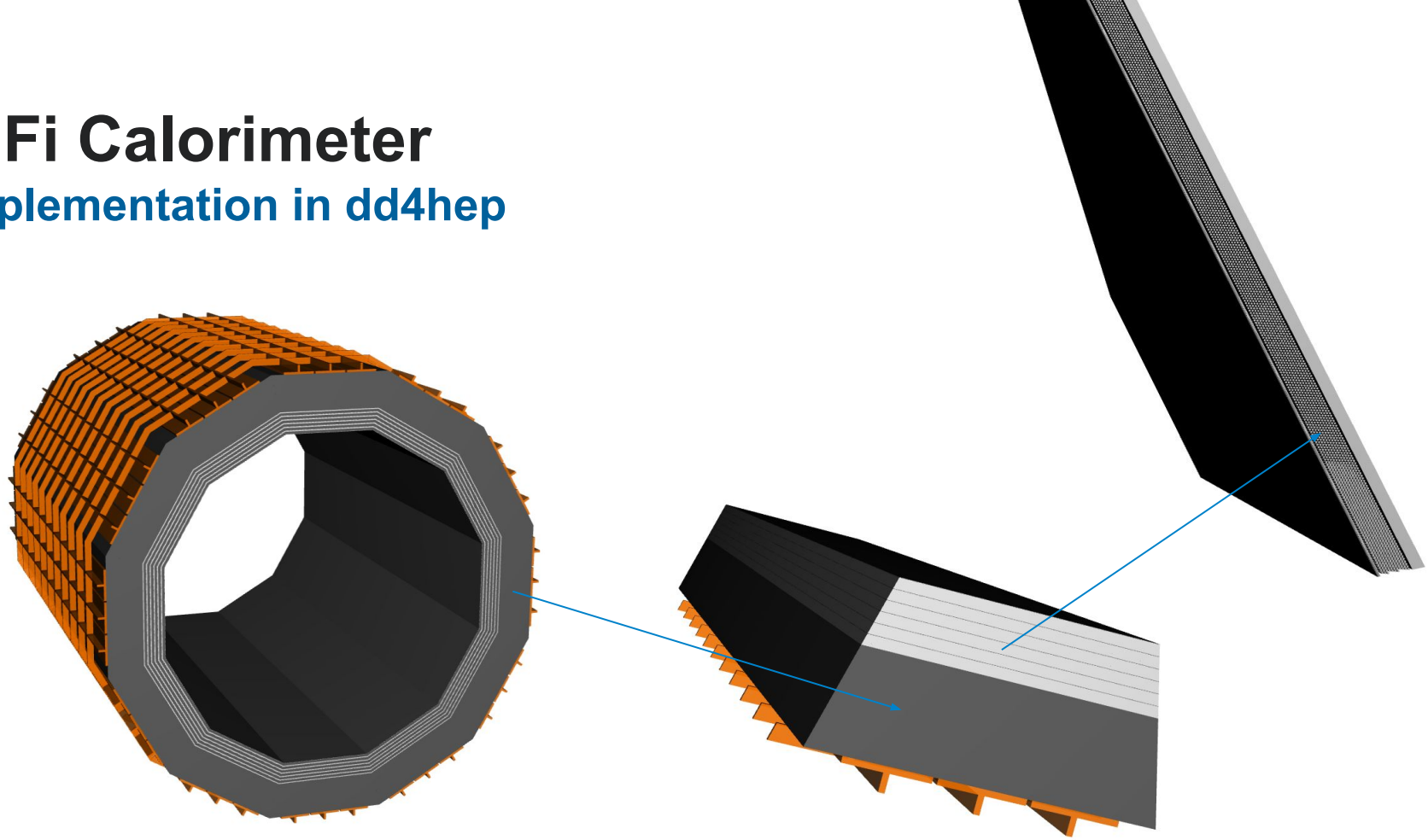

SiFi Calorimeter

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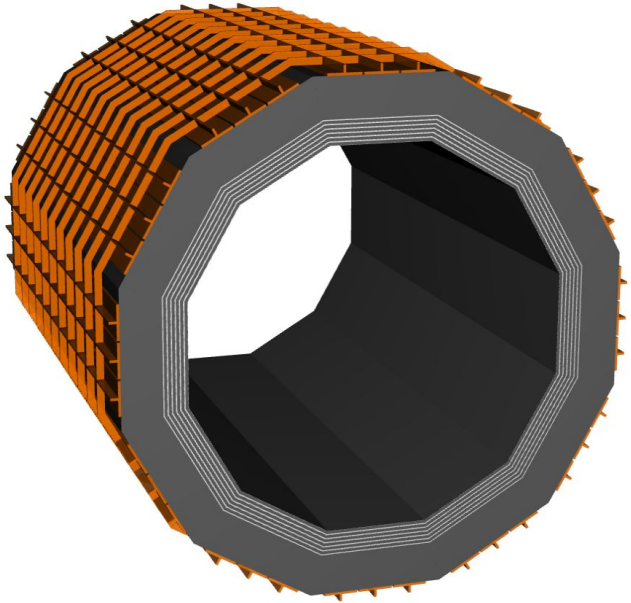
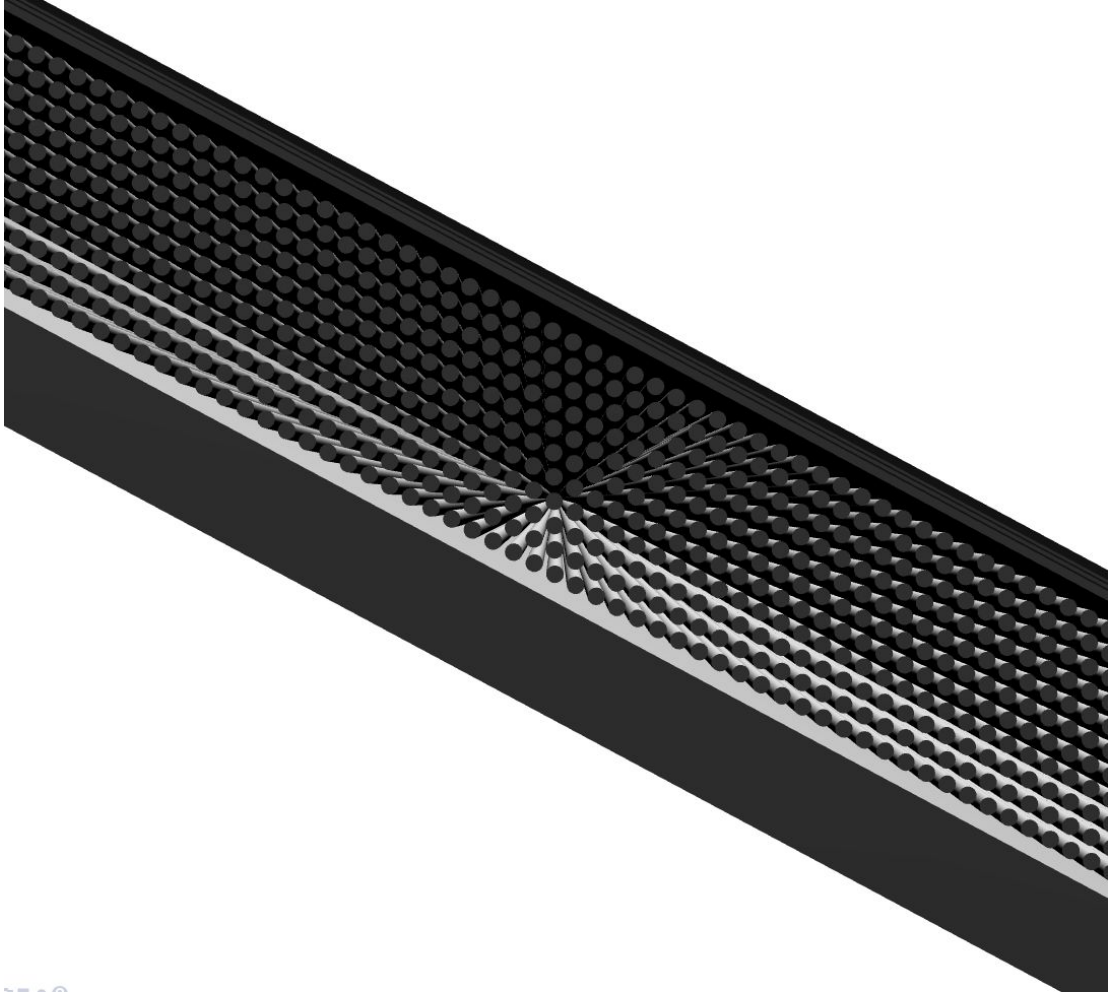
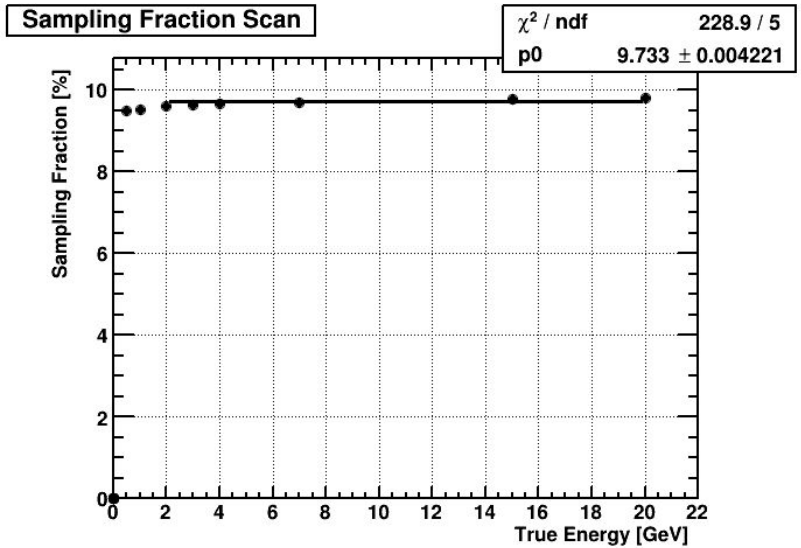


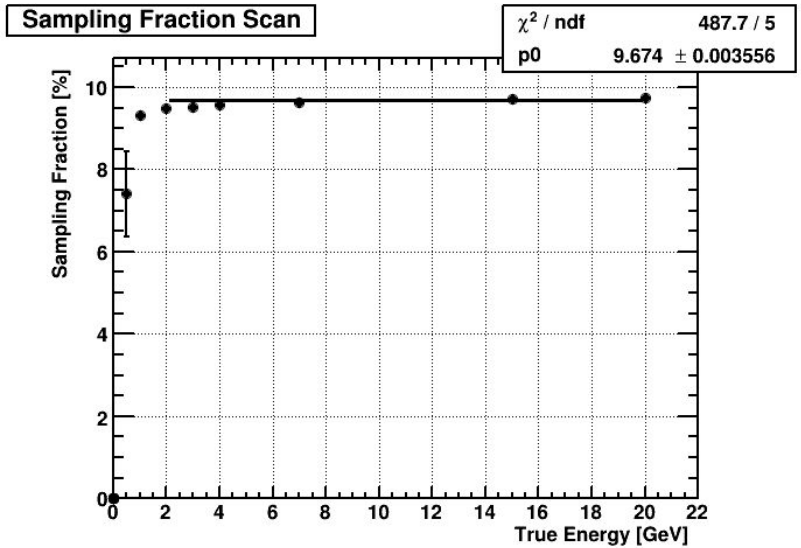


Sampling fraction

electrons and photons

p0: fit to the sampling fraction (constant)



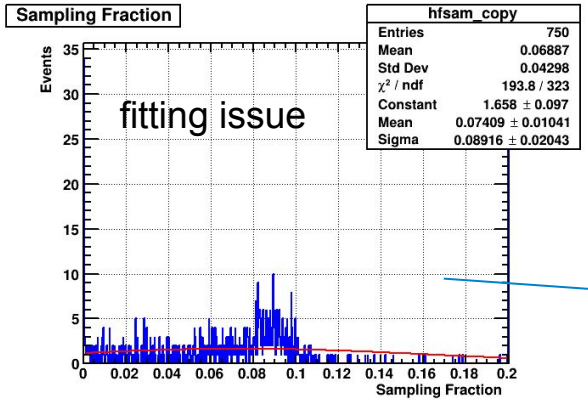


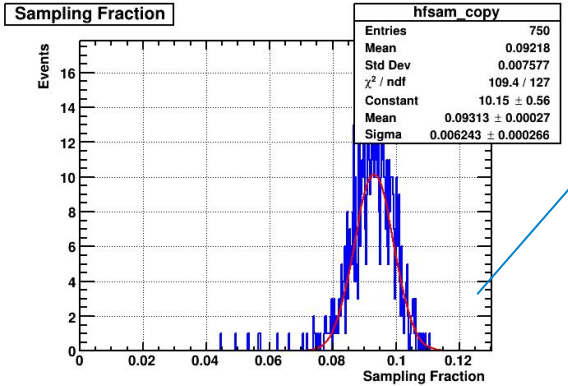
Photons

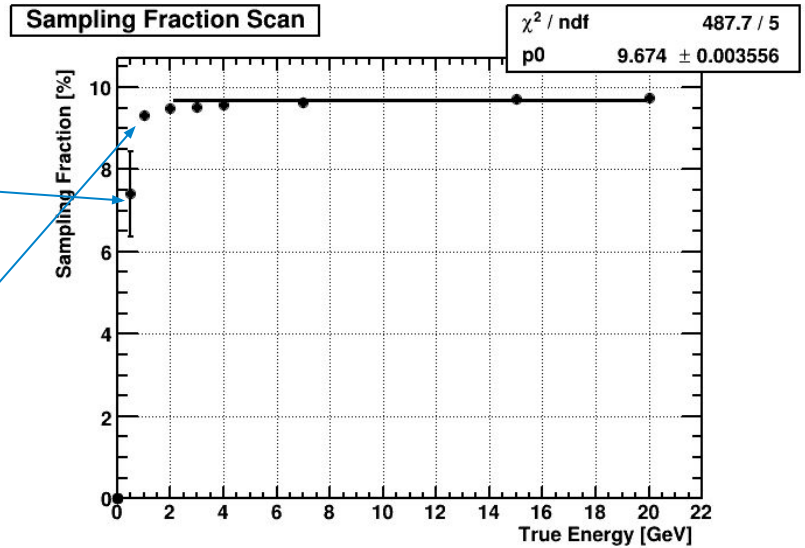
Electrons

Sampling fraction

electrons and photons



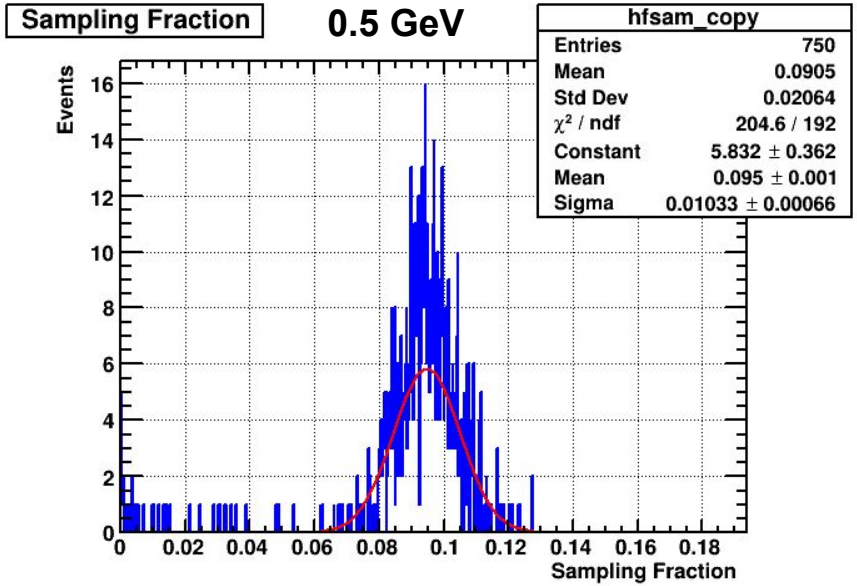


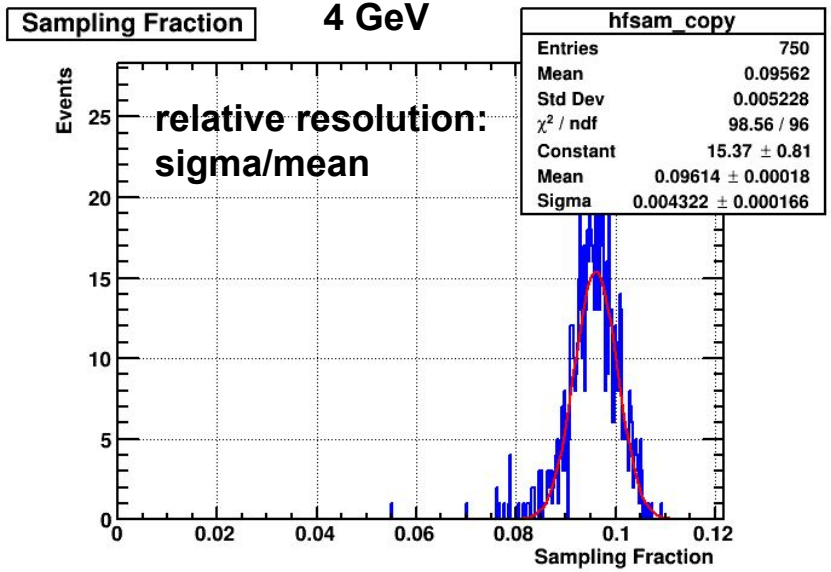


Electrons

Limit of the energy resolution

Only Geant4 simulation information
No digitization, light collection, calibration corrections



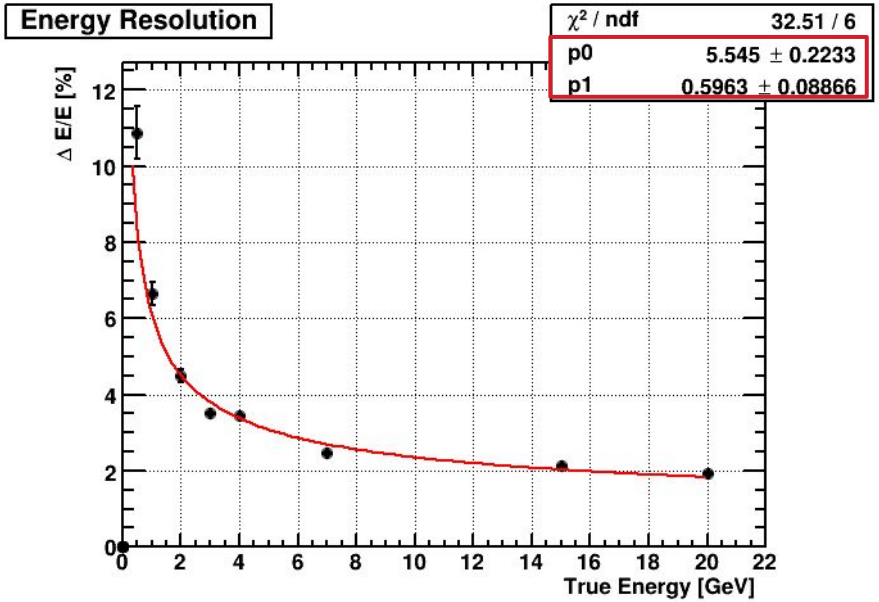


Photons

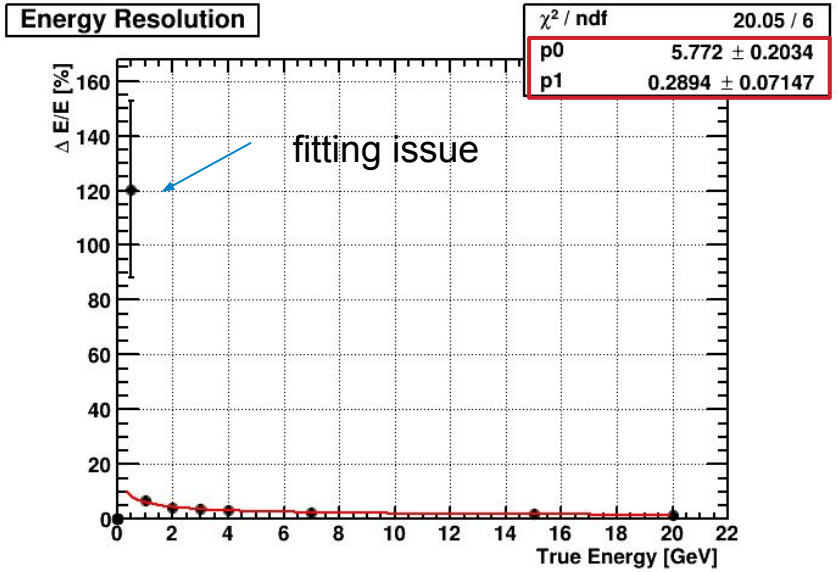
Limit of the energy resolution

p0: stochastic term
p1: constant term

Only Geant4 simulation information
No digitization, light collection, calibration corrections



Photons



Electrons