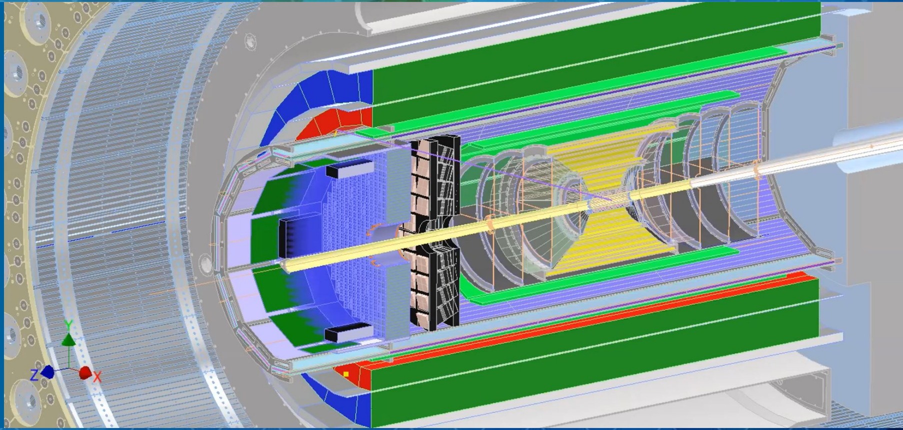
ePIC Barrel ECal Meeting

BIC SciFi/Pb Simulation Updates

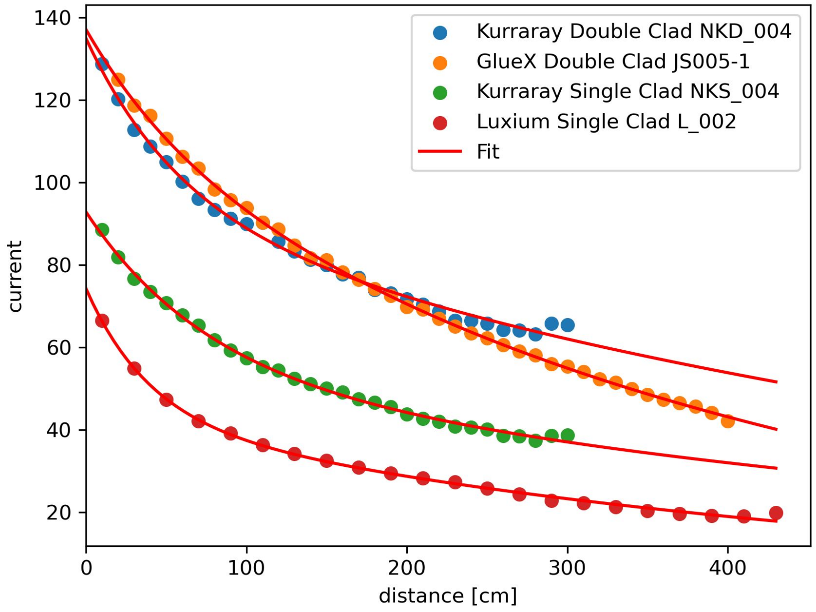


Maria Zurek, 11/21/2023, 11/28/2023

ePIC

SciFi studies - Input

Measured attenuation dependencies for different naked fibers measured



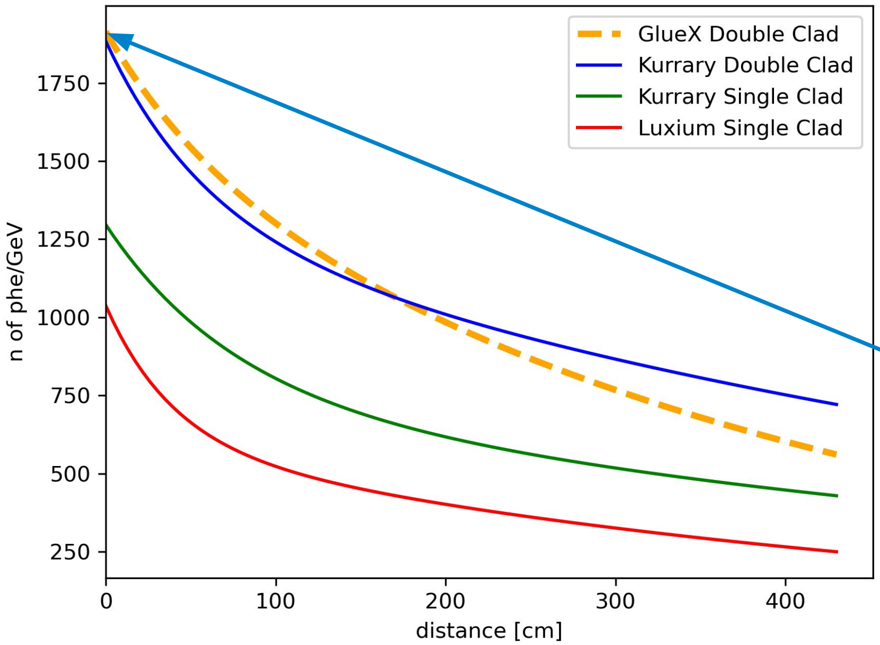
From measurements at Uni Regina

$$I(\Delta) = I_0(\alpha e^{\Delta/\lambda_1} + (1-\alpha)e^{\Delta/\lambda_2})$$

	I_0	α	λ_1 [cm]	λ_2 [cm]
Kuraray Single Clad	9.29E+01	4.16E-01	7.47E+01	7.52E+02
Kuraray Double Clad (New)	1.35E+02	3.06E-01	5.82E+01	7.23E+02
Luxium Single Clad	7.43E+01	4.23E-01	3.92E+01	4.91E+02
GlueX Kuraray Double Clad	1.37E+02	1.81E-01	6.09E+01	4.18E+02

SciFi studies - Input

N of phe/GeV for different fiber types



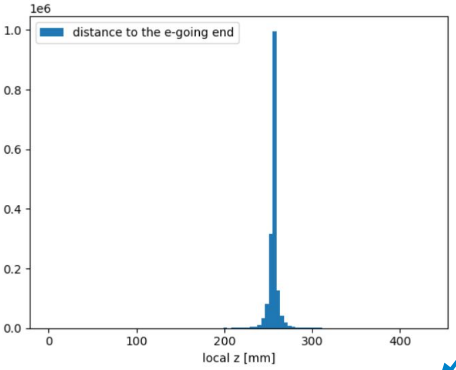
- Nb of photelectrons/GeV corrected for attenuation from Baby BCal Hall D measurement [phe/GeV]: **1100**
  - Improvement factor from new family SiPMs from improvement in PDE: **1.5**
  - Improvement factor from optical connection: **1.16**
- Attenuation dependence from Old Kuraray Fiber (GlueX Double Clad) anchored to 1914 phe/GeV at d = 0 cm

SciFi studies - 2-side readout

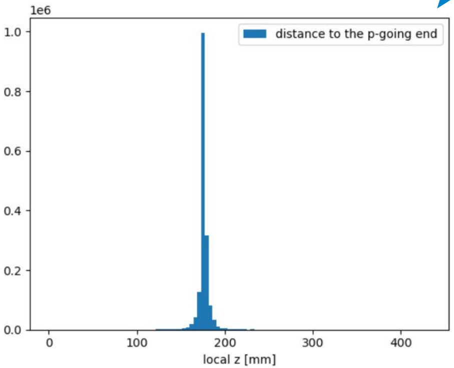
Use attenuation dependencies (nphe/GeV) to calculate energy and nphe per side of SciFi/Pb Calo

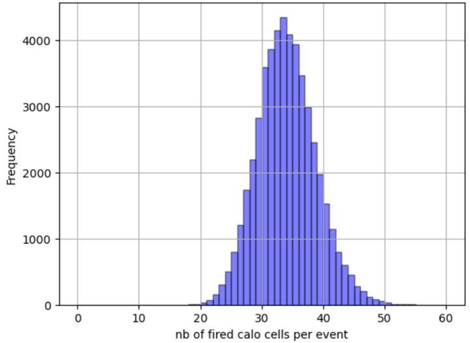
- From the simulation: energy per calorimeter cell: E^{cell}, and z position of the shower (that gives us *dist1* and *dist2*)
- **E^{cell} is translated to *nphe* per end** of the calorimeter (at *dist1*, and *dist2*) using attenuation dependencies
- *nphe* at each end of the calorimeter **rounded** to integer, and **smeared with Poissonian distribution**
- After smearing, ***nphe* are translated to energy** at each calo end, and energy **threshold cut (5 MeV) is applied**
- Energies of the cells that survived the cut are then **corrected back for attenuation and summed** → this gives us "calibrated for attenuation" energy per side of the calorimeter
  - Final absolute calibration requires adjustment of the sampling fraction/calibration constant to match the true particle energy

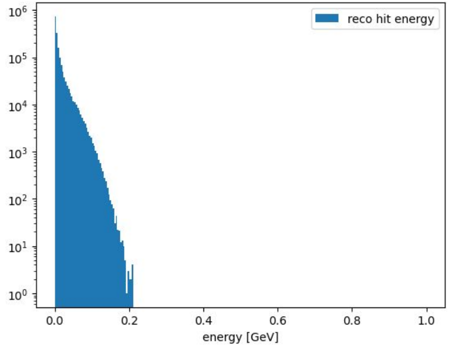
Proof-of-principle: 500 MeV electrons

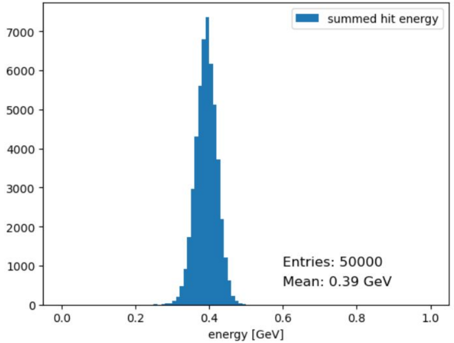


η = 0, different distance to p- and e-going end of sector



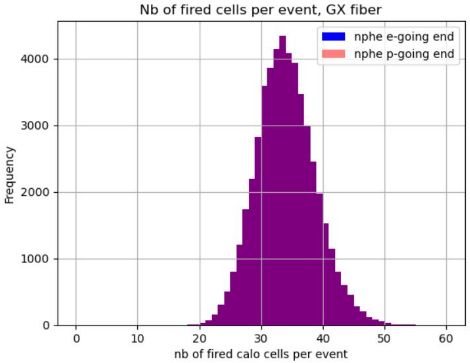


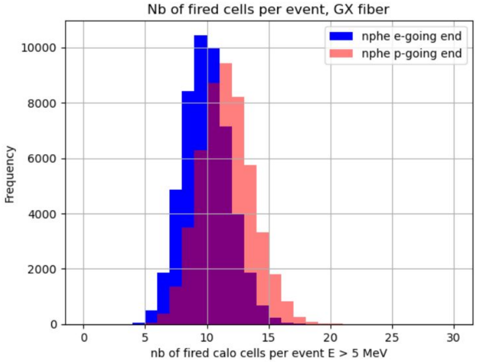


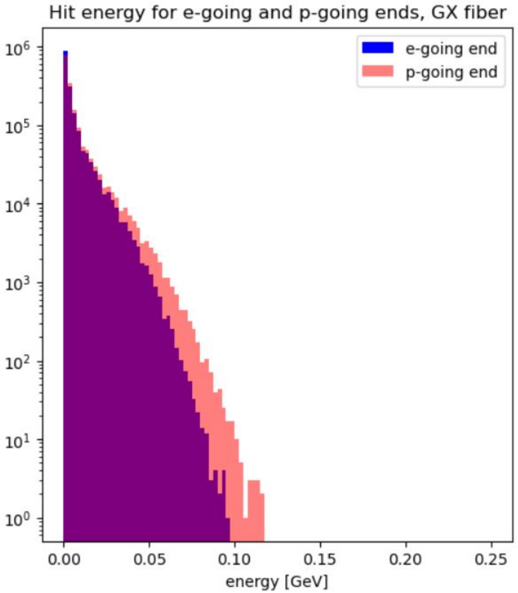


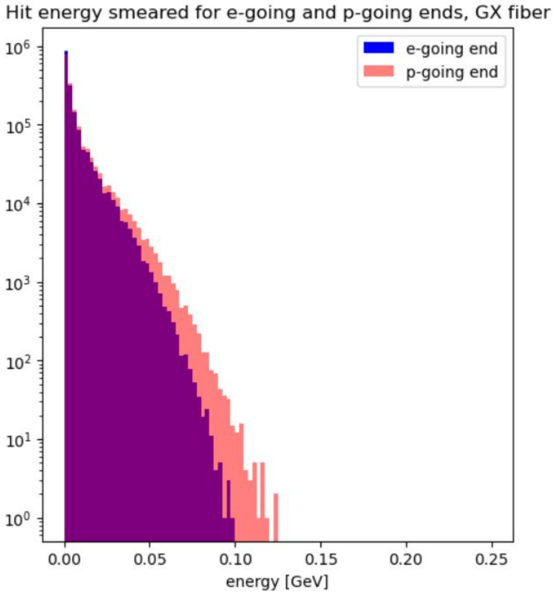
Proof-of-principle: 500 MeV electrons

Kuraray Old Double Clad (GlueX) fiber

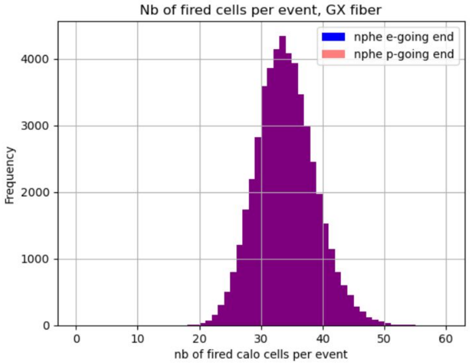


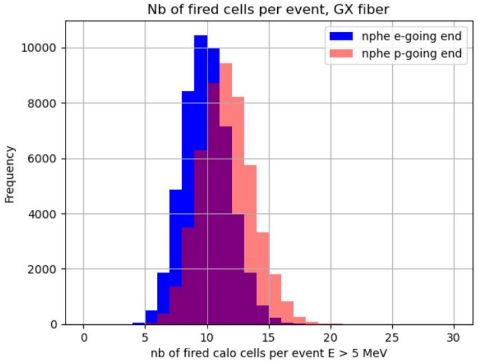




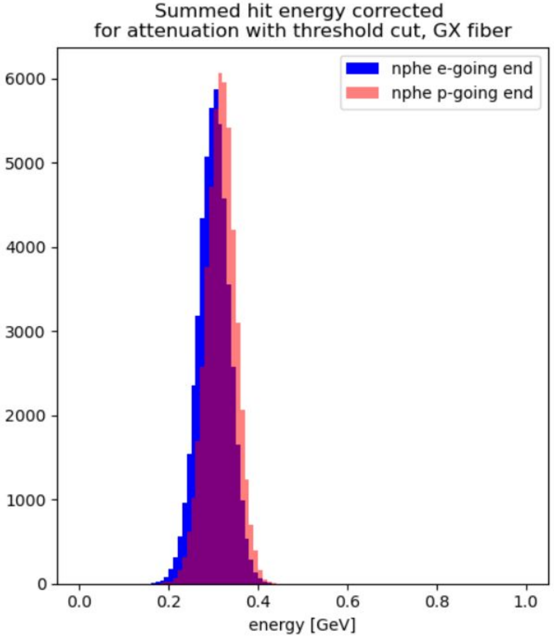


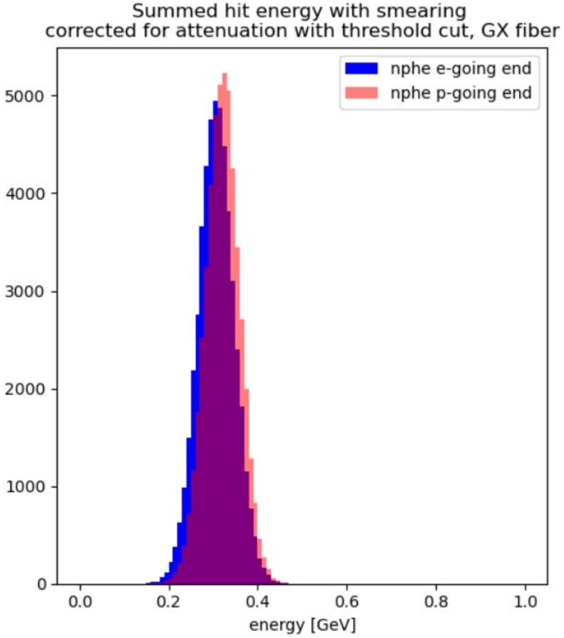
Proof-of-principle: 500 MeV electrons



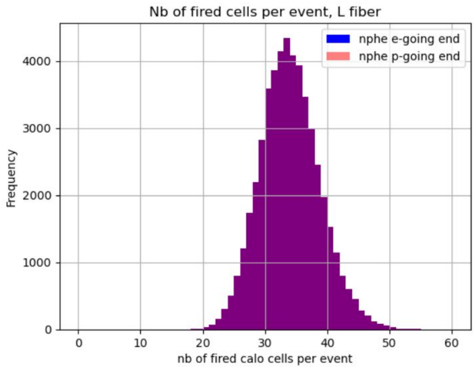


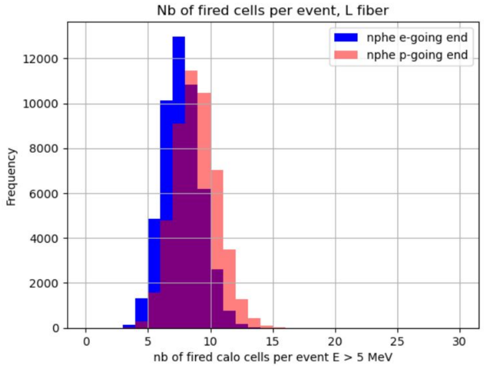
Kuraray Old Double Clad (GlueX) fiber



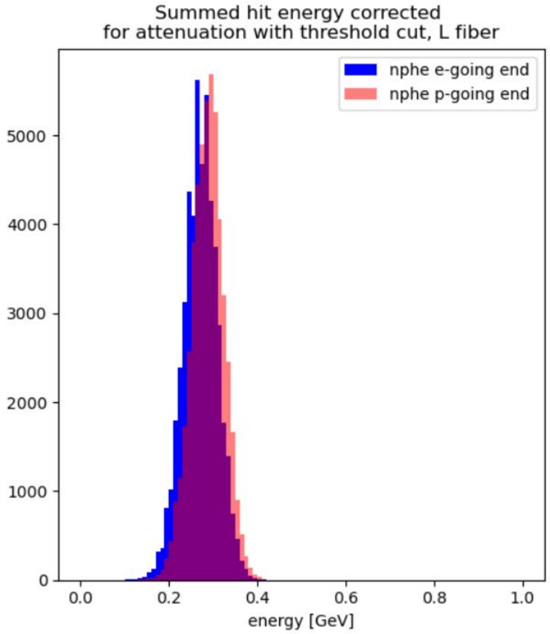


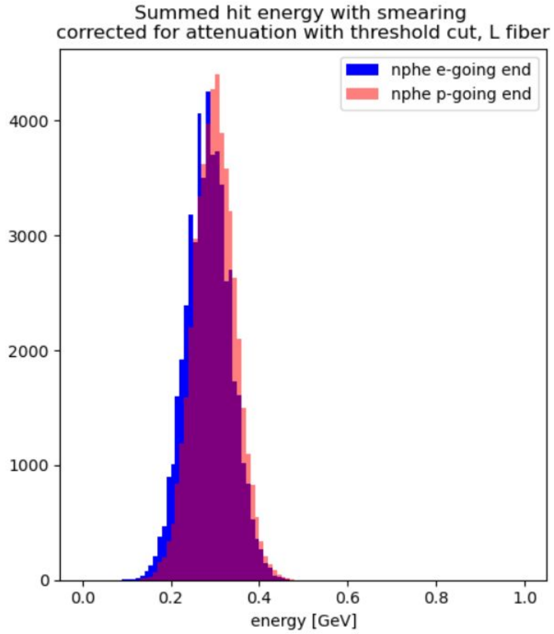
Proof-of-principle: 500 MeV electrons



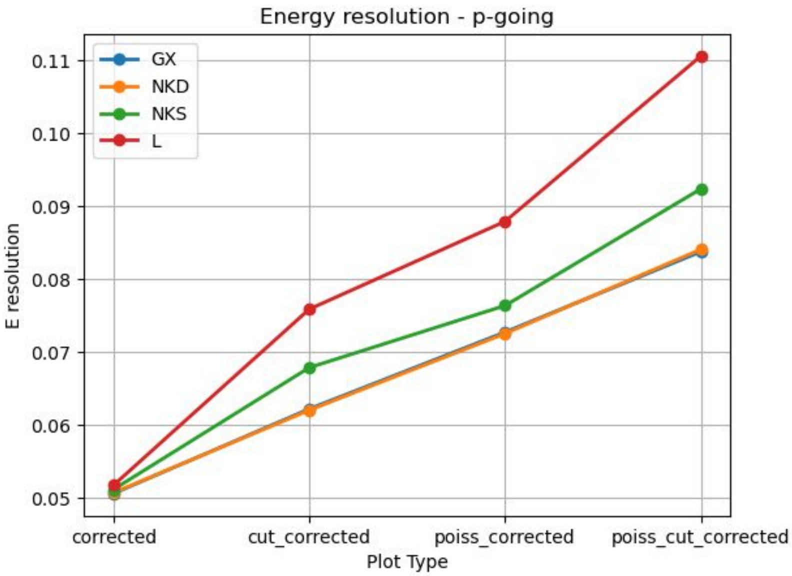


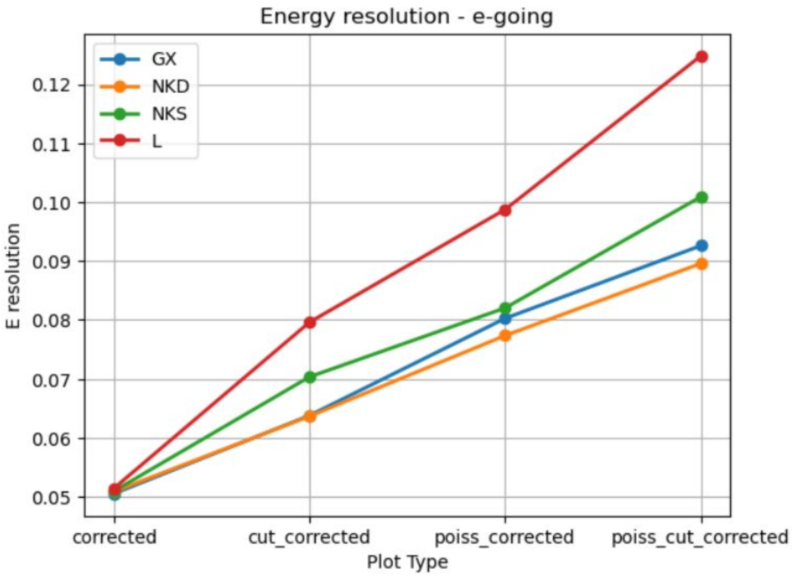
Luxium fiber



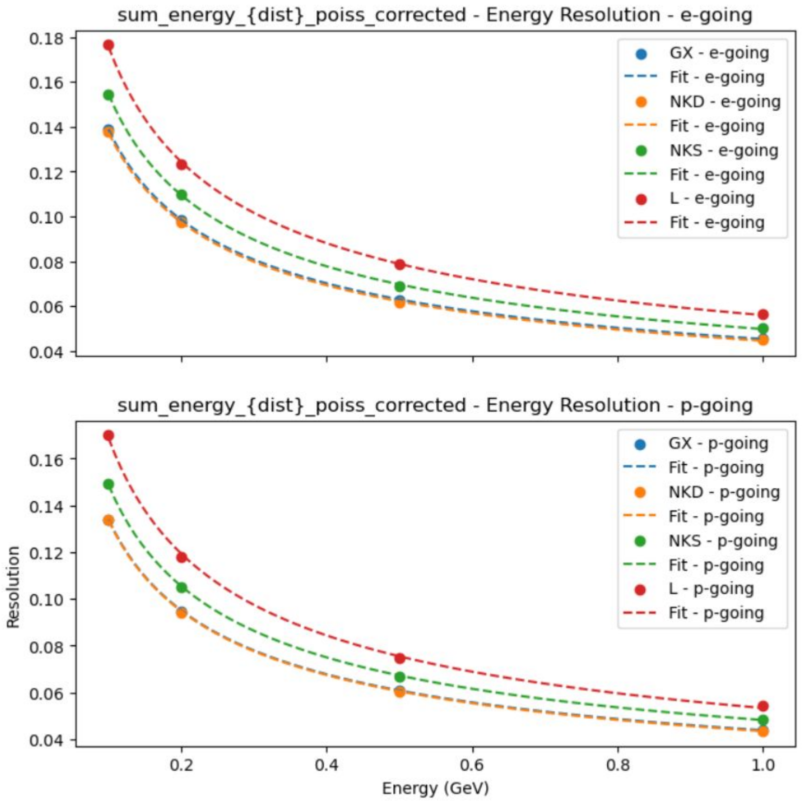


500 MeV electrons - energy resolution





Low Energy Gammas - Energy Resolution



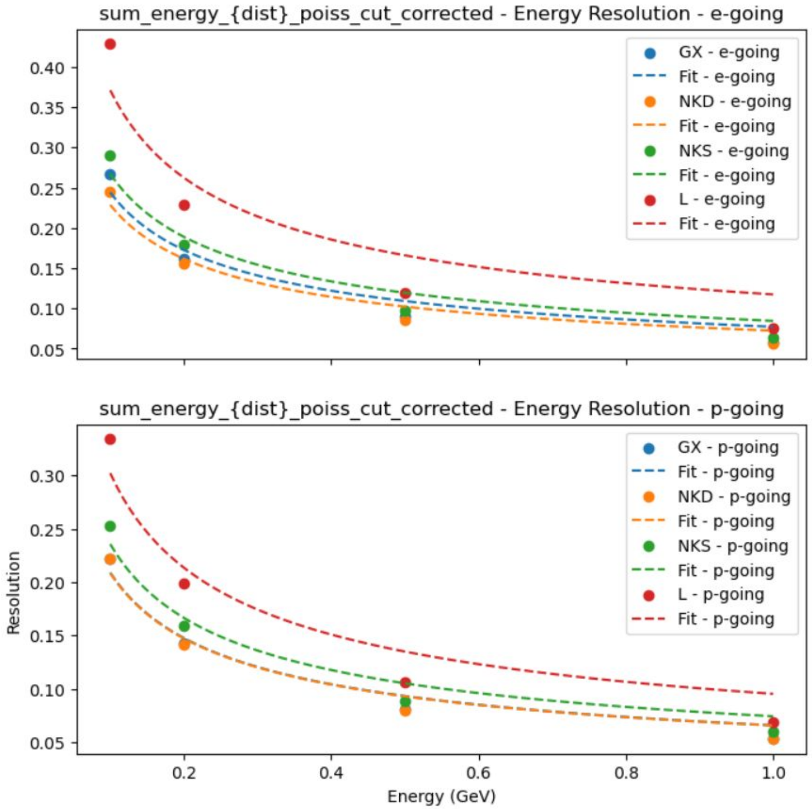
Fitted parameters for GX - e-going: a = 0.044, b = 0.012
Fitted parameters for GX - p-going: a = 0.042, b = 0.012

Fitted parameters for NKD - e-going: a = 0.043, b = 0.01
Fitted parameters for NKD - p-going: a = 0.042, b = 0.011

Fitted parameters for NKS - e-going: a = 0.049, b = 0.0095
Fitted parameters for NKS - p-going: a = 0.047, b = 0.011

Fitted parameters for L - e-going: a = 0.056, b = 0.0067
Fitted parameters for L - p-going: a = 0.053, b = 1.4e-08

Low Energy Gammas - Energy Resolution



Low energy points with minimum energy cuts (5 MeV corrected for sampling fraction, ~0.5 MeV for non-corrected energy)

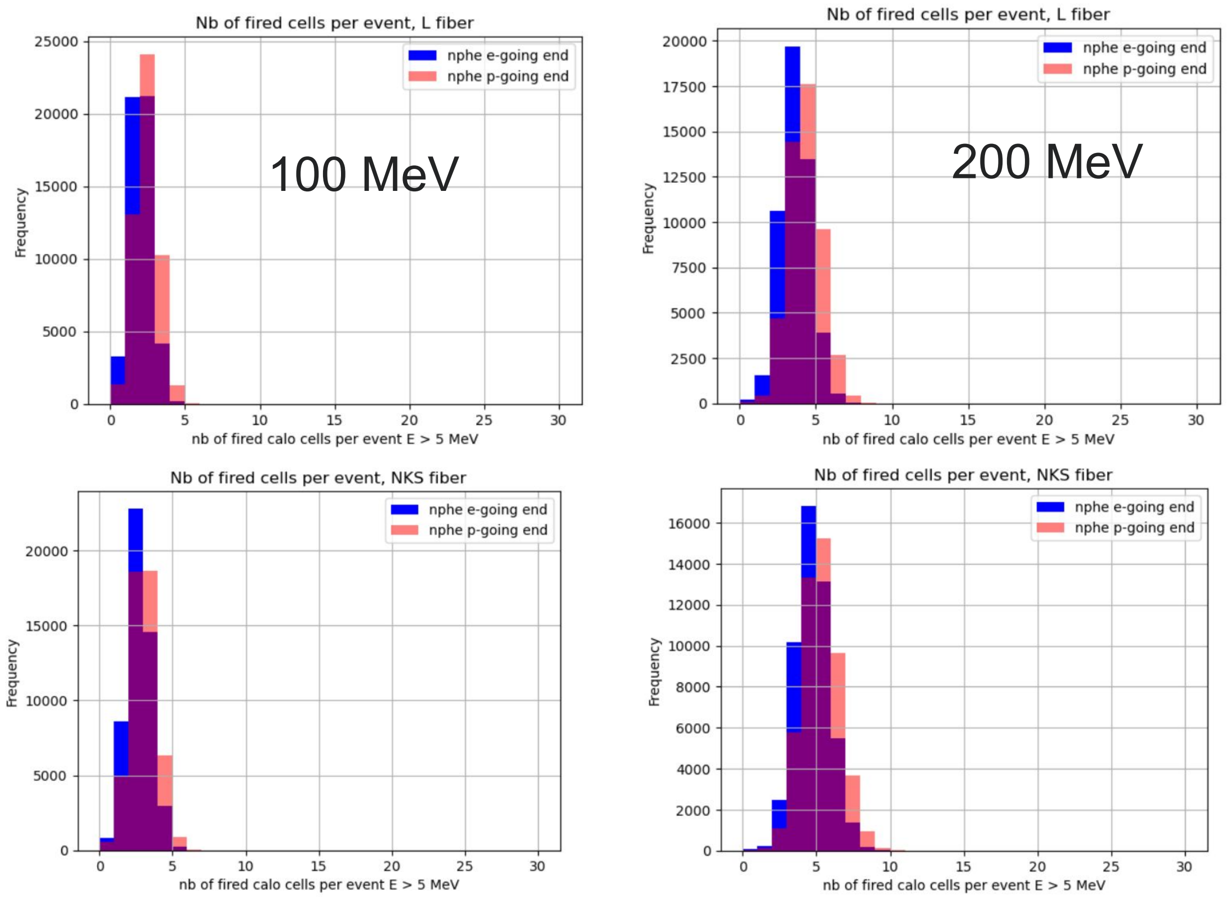
Fitted parameters for GX - e-going: a = 0.077, b = 3.5e-12
Fitted parameters for GX - p-going: a = 0.066, b = 2.4e-11

Fitted parameters for NKD - e-going: a = 0.072, b = 8e-12
Fitted parameters for NKD - p-going: a = 0.066, b = 2.3e-11

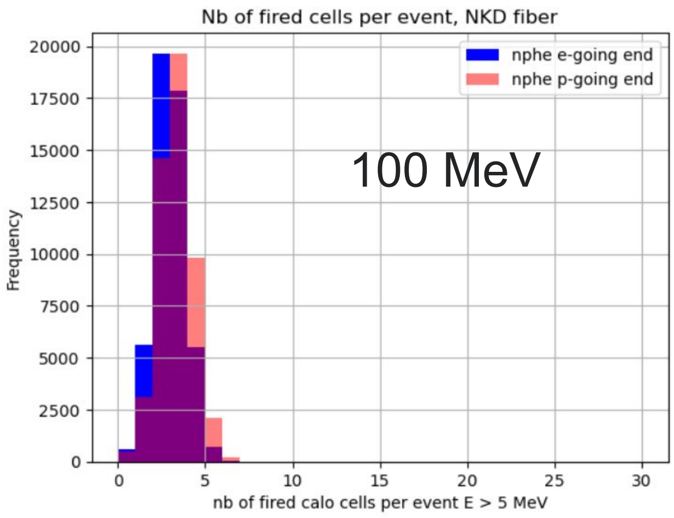
Fitted parameters for NKS - e-going: a = 0.084, b = 2.3e-12
Fitted parameters for NKS - p-going: a = 0.074, b = 8.6e-12

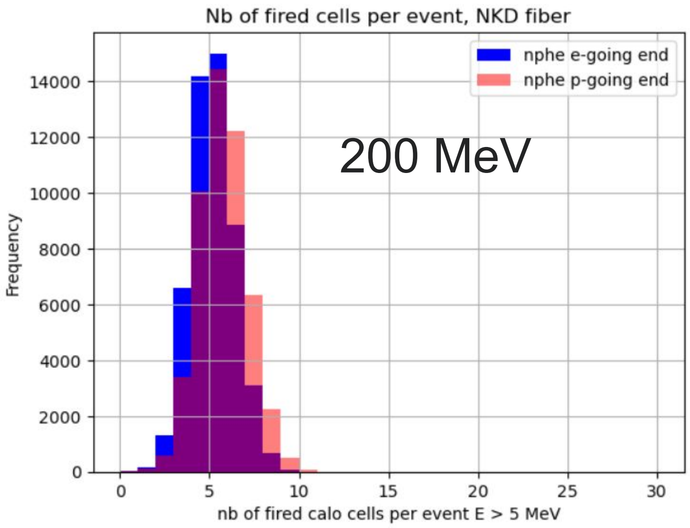
Fitted parameters for L - e-going: a = 0.12, b = 4.4e-18
Fitted parameters for L - p-going: a = 0.096, b = 8.7e-13

Low Energy Gammas - 100 MeV and 200 MeV



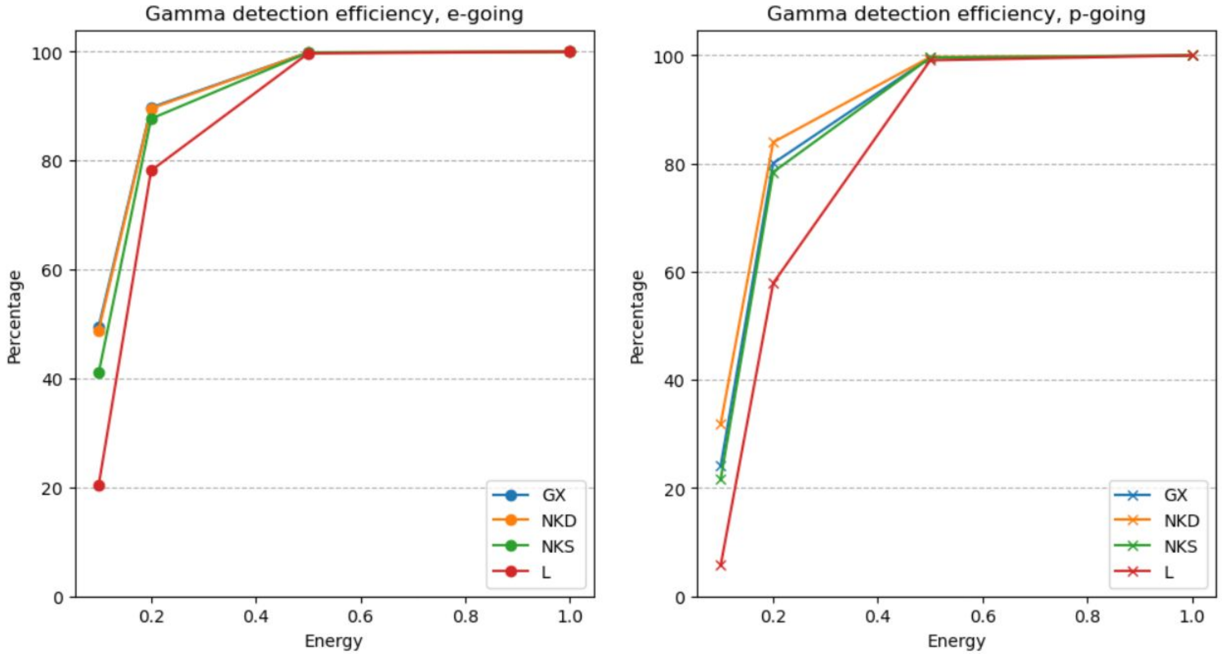
Low Energy Gammas - 100 MeV and 200 MeV





Low Energy Gamma - Efficiency

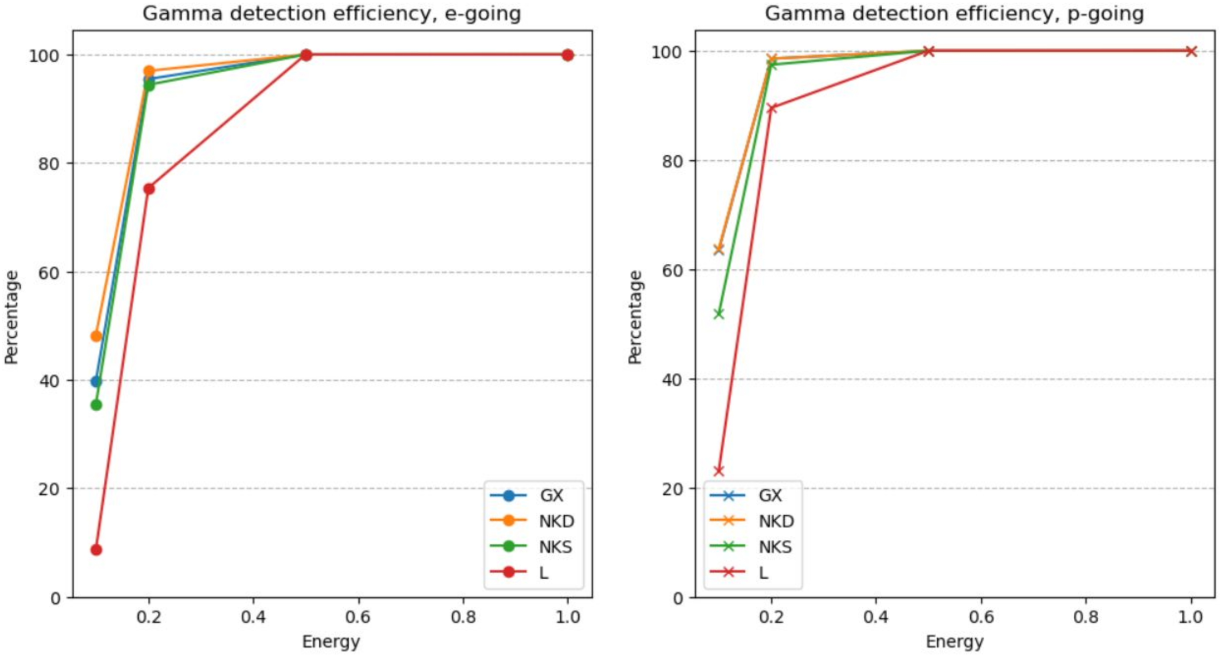
Assumed here: at least 3 cells required per sector end



η = -1

Low Energy Gamma - Efficiency

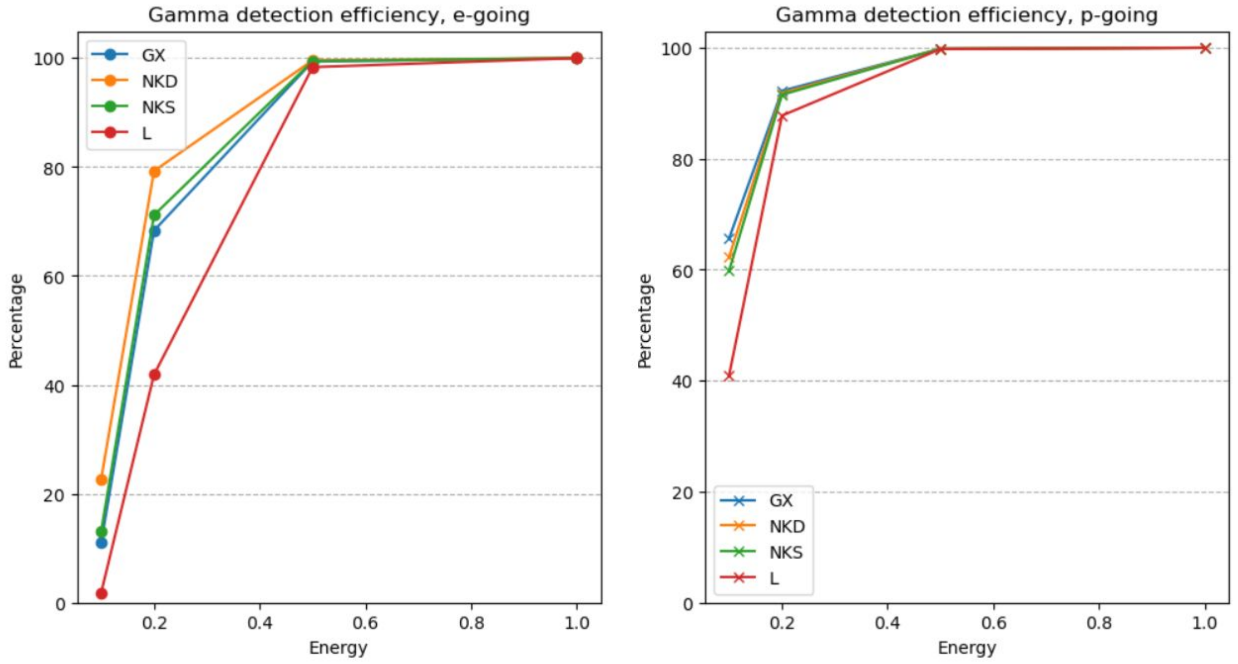
Assumed here: at least 3 cells required per sector end



η = 0

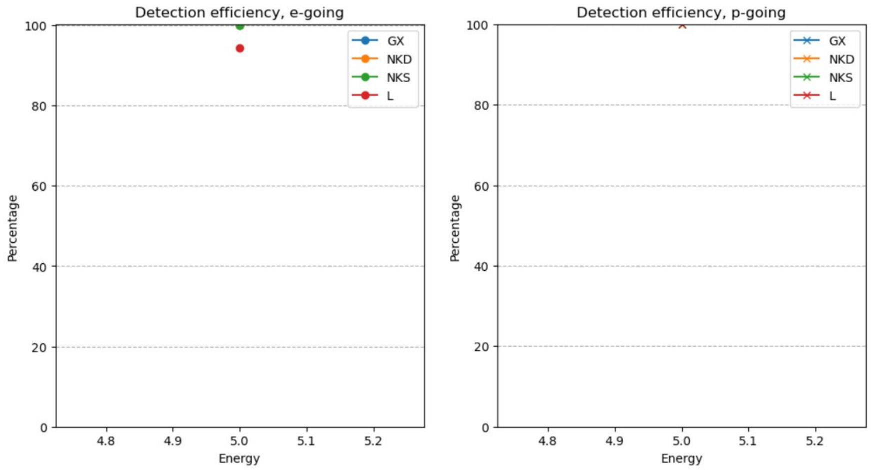
Low Energy Gamma - Efficiency

Assumed here: at least 3 cells required per sector end

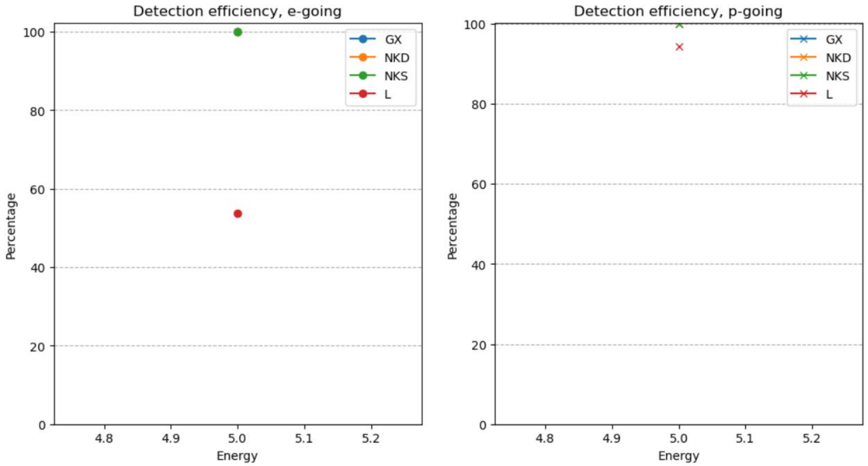


$\eta = +1$

Muons at 5 GeV (eta = 0)

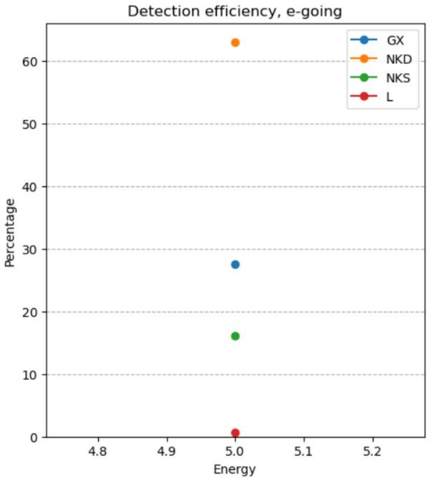


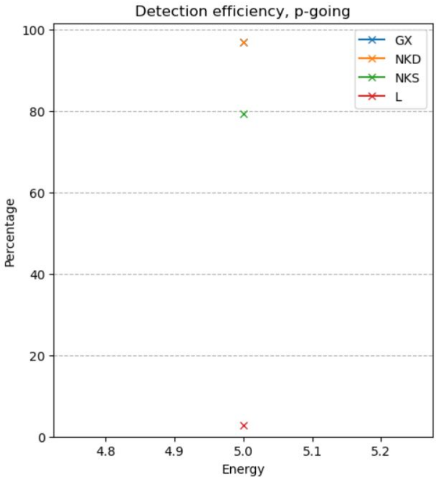
nb of cells >= 1



nb of cells >= 5

Muons at 5 GeV (eta = 0)





nb of cells >= 10

Backup

Photoelectron statistics

From our 2023 Hall D tests using GlueX SiPMs and double-clad Kuraray fibers: **1000 phe/GeV** per side for showers at the center of the Baby BCAL prototype

- Corrected for attenuation: **1100 phe/GeV*** per side

We can scale these results for the **ePIC Barrel ECal*:**

- x 1.5 factor improvement in **SiPM photon detection efficiency**
- x 1.16 factor to account for **better optical coupling**
- x 0.69 reduction accounting for **single-clad** Kuraray fibers

This gives ~ **1239 phe/GeV** per side (fully corrected for attenuation)

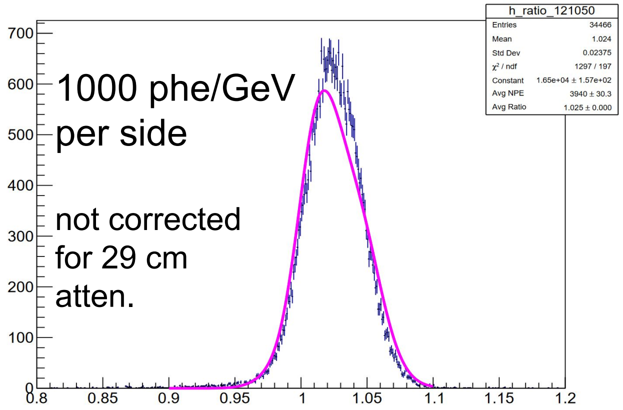
- **10 GeV ɣ at η ~ -1.7:** 5560 phe → **9.8 % max SiPM occupancy**
- **19 GeV e⁻ at η ~ -1.7:** 9181 phe → **16.1 % max SiPM occupancy**
- **50 GeV e⁻ at η ~ 1.4 (most extreme case):** 17456 phe → **30.1% max SiPM occupancy**

Well below the region where large nonlinearities in the SiPM response are expected in almost all cases.

Small non-linear effects possible for some ultra-high energy electrons, which is acceptable (e-π separation straightforward).

* See backup slide for the attenuation length measurement and extraction of those factors

2023 Hall D, Baby BCal, 3.9 GeV e⁺



2008 Hall B beam test, photons

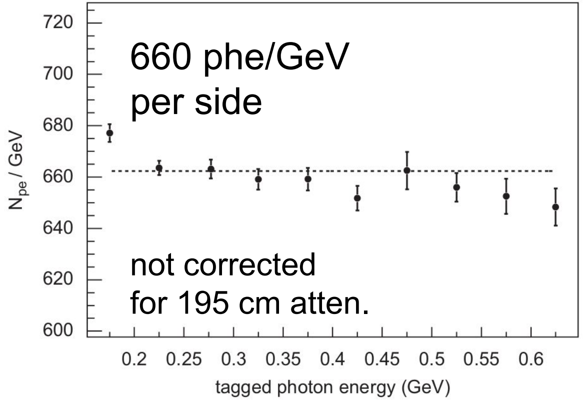


Fig. 16. The number of photoelectrons per GeV per end of the BCAL module is shown as a function of energy. A one parameter fit is plotted (dashed line). For more details see the text.