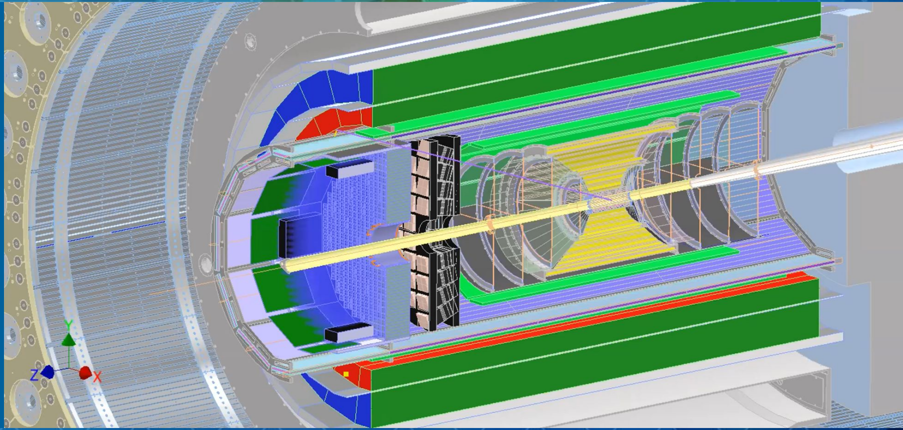
BIC Simulation Meeting

BIC SciFi/Pb Simulation Updates

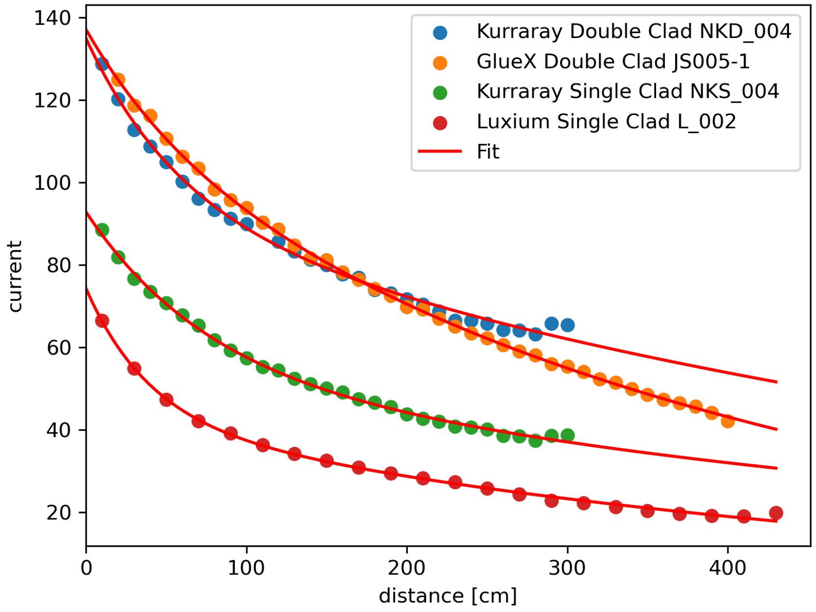


Maria Zurek

ePIC

Input: Attenuation Measurement

Measured attenuation dependencies for different naked fibers measured



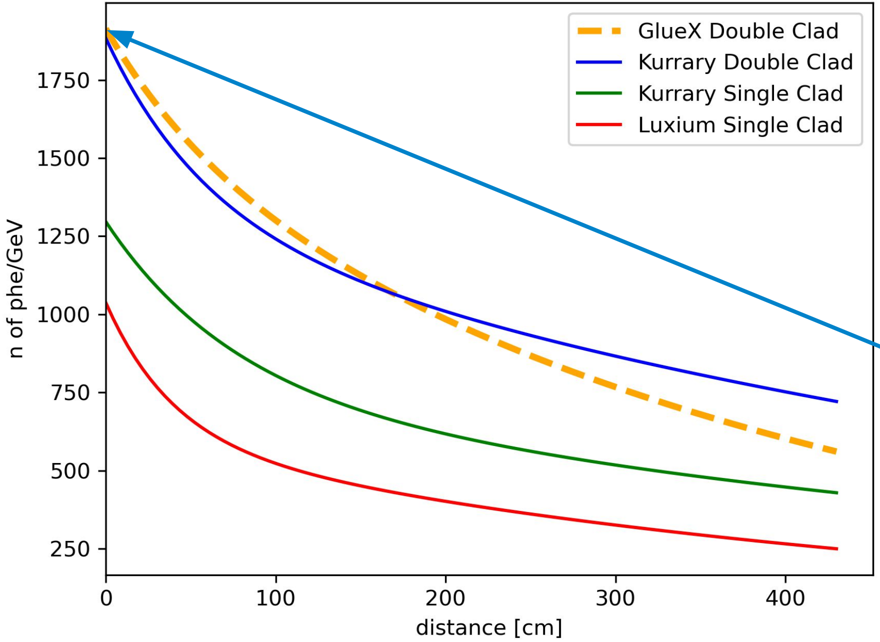
From measurements at Uni Regina

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

	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

Input: Flat (Old) Optical Connection Improvement

N of phe/GeV for different fiber types

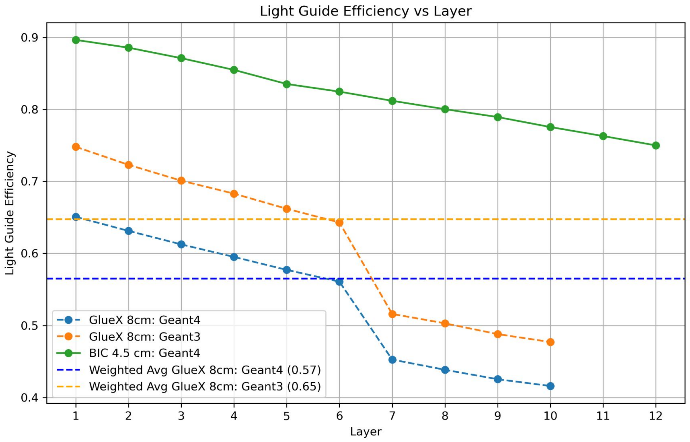


- Nb of photelectrons/GeV corrected for attenuation from Baby BCal Hall D measurement [phe/GeV]: **1100**
  - Improvement factor from new family SiPMs from improvement in PDE: **1.5**
  - **Improvement factor from optical connection: 1.16**
- Attenuation dependence from Old Kuraray Fiber (GlueX Double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

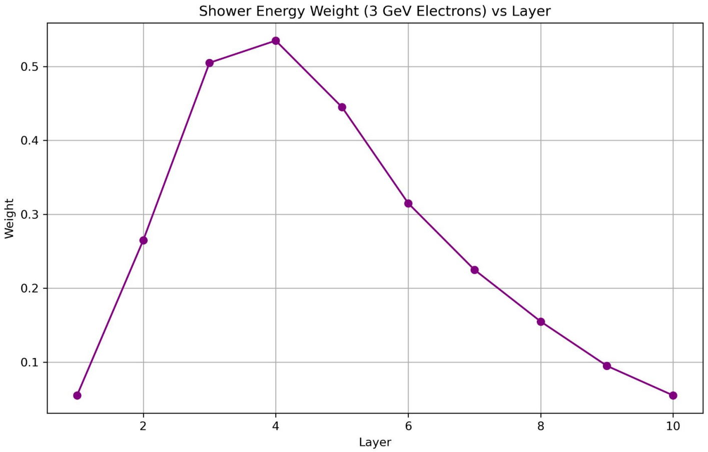
Input: Realistic (New) Optical Connection Improvement

- Nphe/GeV has been **extracted from Baby BCAL measurement with electron shower**
  - It means that the effective number of phe/GeV = 1100 phe/GeV has **folded in the efficiencies of light guides (LG)** that the measurement has been done with
  - Since the number has been **extracted from electron showers**, **different layers (and LG efficiencies) contributed with different weights to this number** following the shower profile
  - **Effective number of phe/GeV** with folded LG efficiencies **depends on layer number** (because LG efficiencies differ with layers)
    - Optical Connection improvement factor also depends on the layer

LG efficiencies from Tegan and weighted average with electron shower weights



Electron shower profile weights

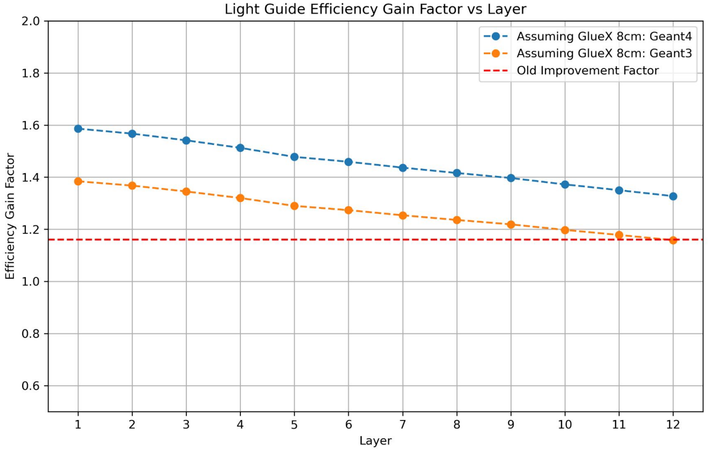


Input: Realistic (New) Optical Connection Improvement

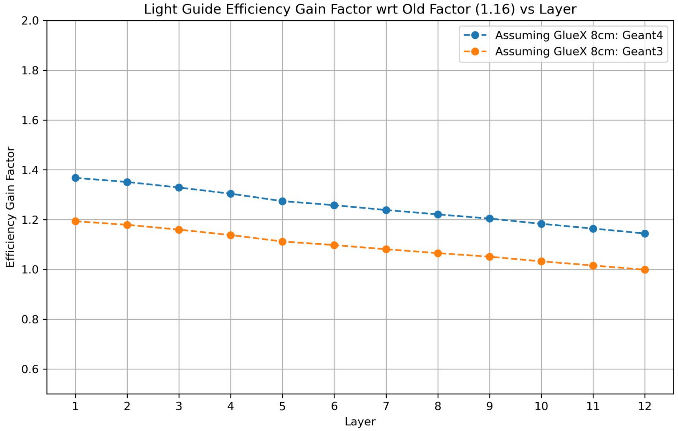
To calculate the layer-dependent improvement factors

- Take simulated LG efficiencies for Baby BCAL (2 scenarios: old (Geant3, Elton), new (Geant4, Tegan)
- Calculate weighted LG efficiency with electron shower weights that the 1100 phe/GeV has been effectively measured with
  - **new (Geant4, Tegan): 0.565, old (Geant3, Elton): 0.648**
- Calculate relative improvement factor for every BIC layer wrt the weighted average from the point above
  - This gives effective nphe/GeV dependence for each layer

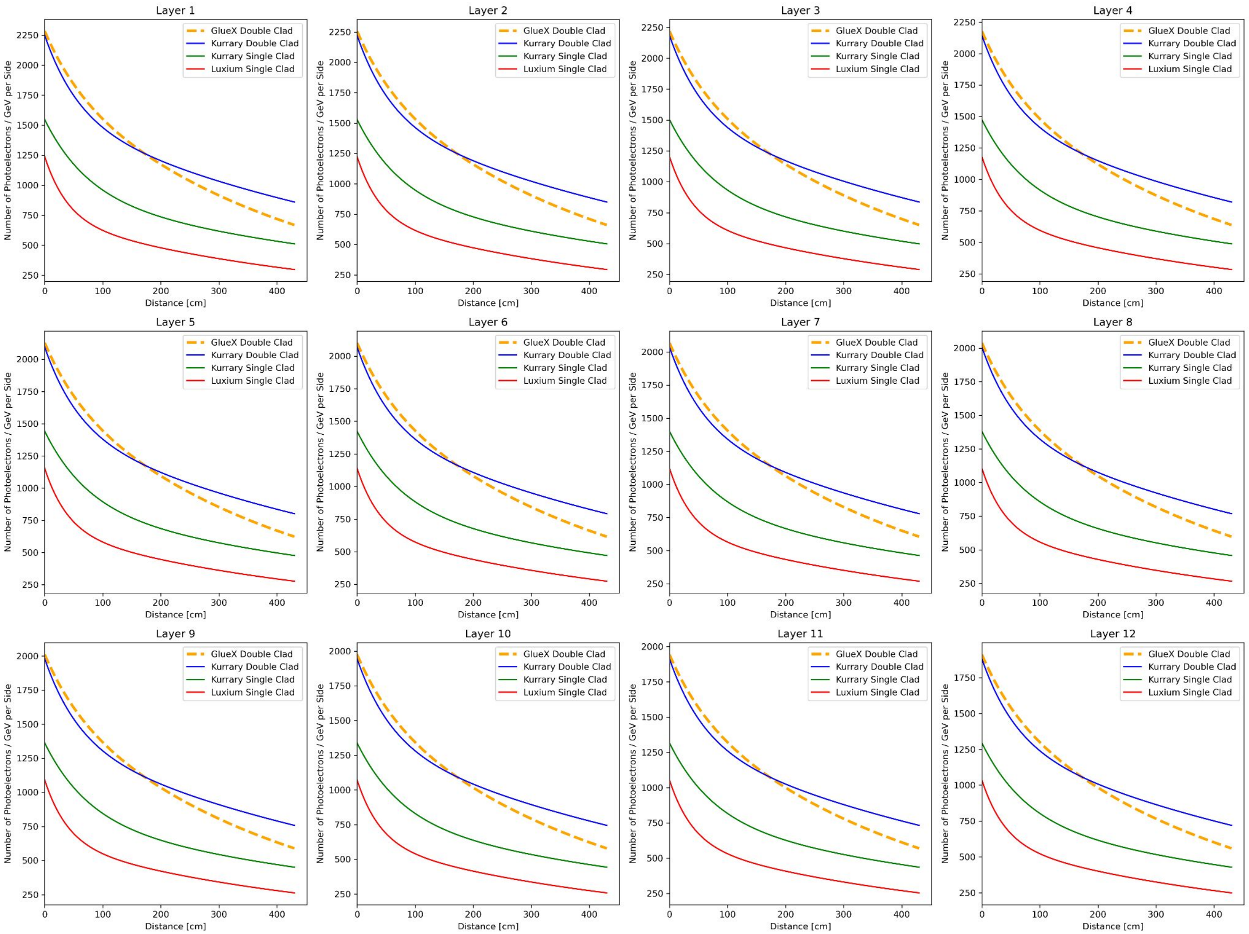
New Improvement factor



Relative Improvement factor to the old one (1.16)



Input: Flat (Old) Optical Connection Improvement



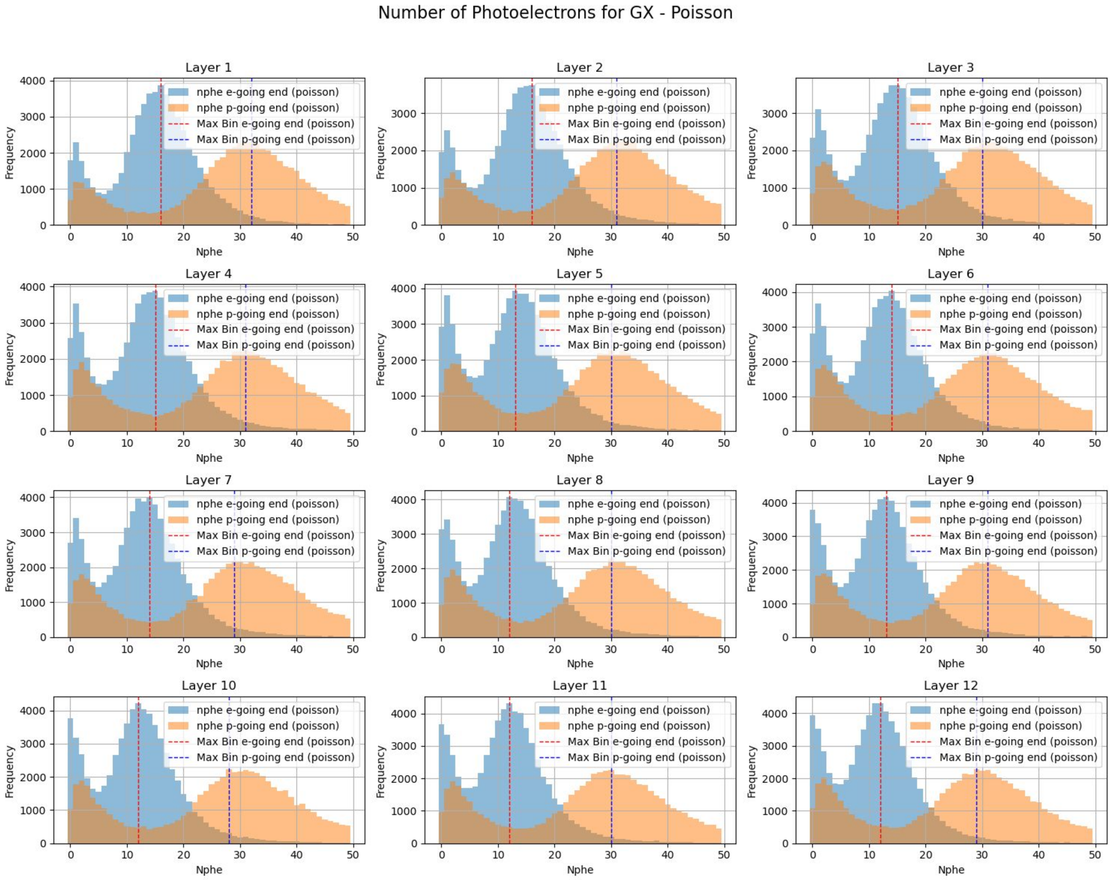
Nb of photelectrons/GeV corrected for attenuation from Baby BCal Hall D measurement [phe/GeV]: **1100**

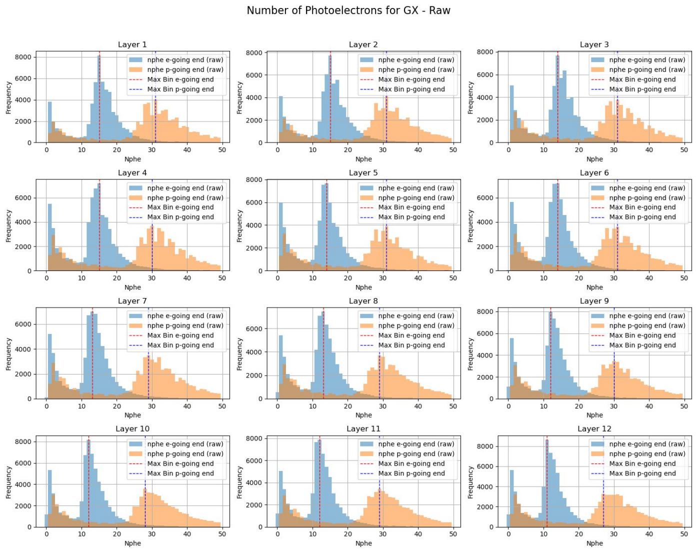
improvement factor for LG efficiency for every layer

- Geant3 LG efficiencies used (conservative choice)

Improvement factor from new family SiPMs from improvement in PDE: **1.5**

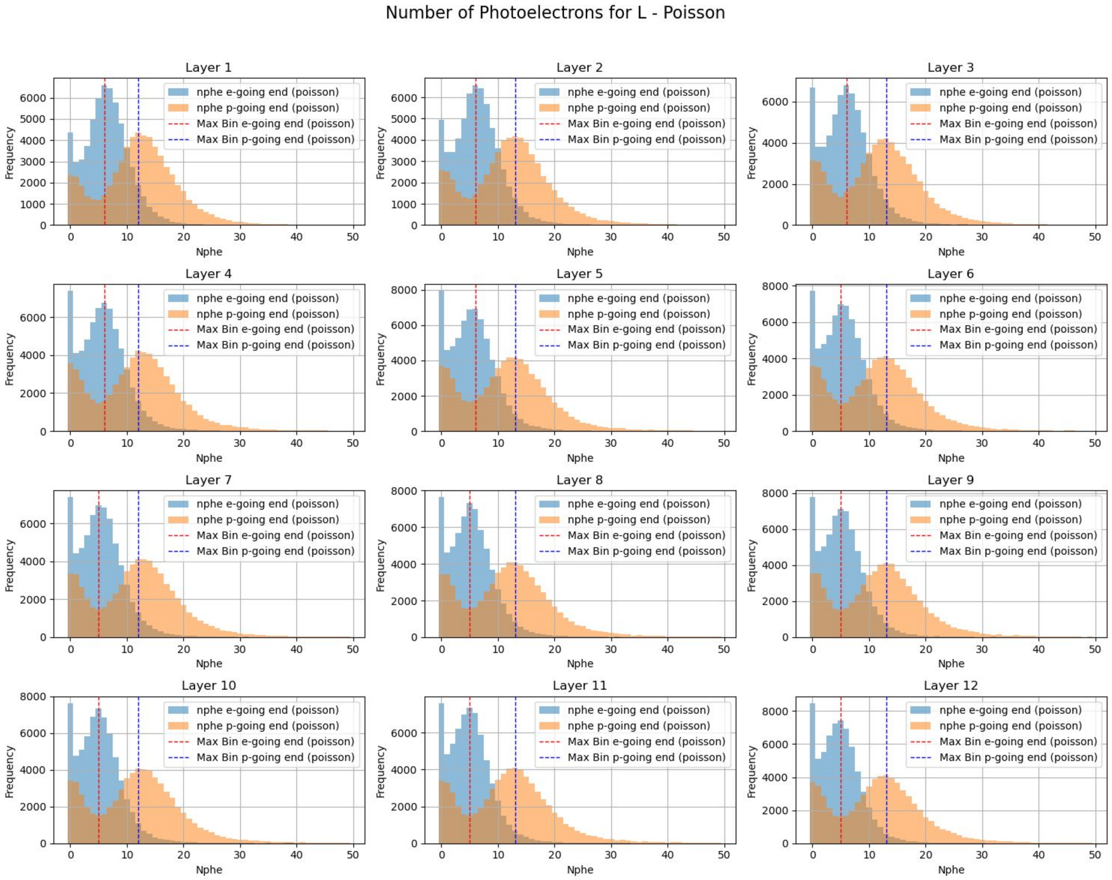
Simulated response to MIP (5 GeV muon eta: +1)

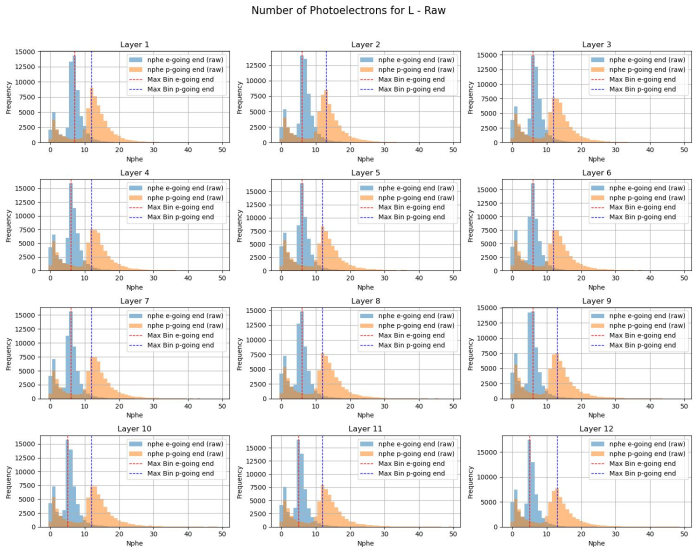




Old GlueX fiber

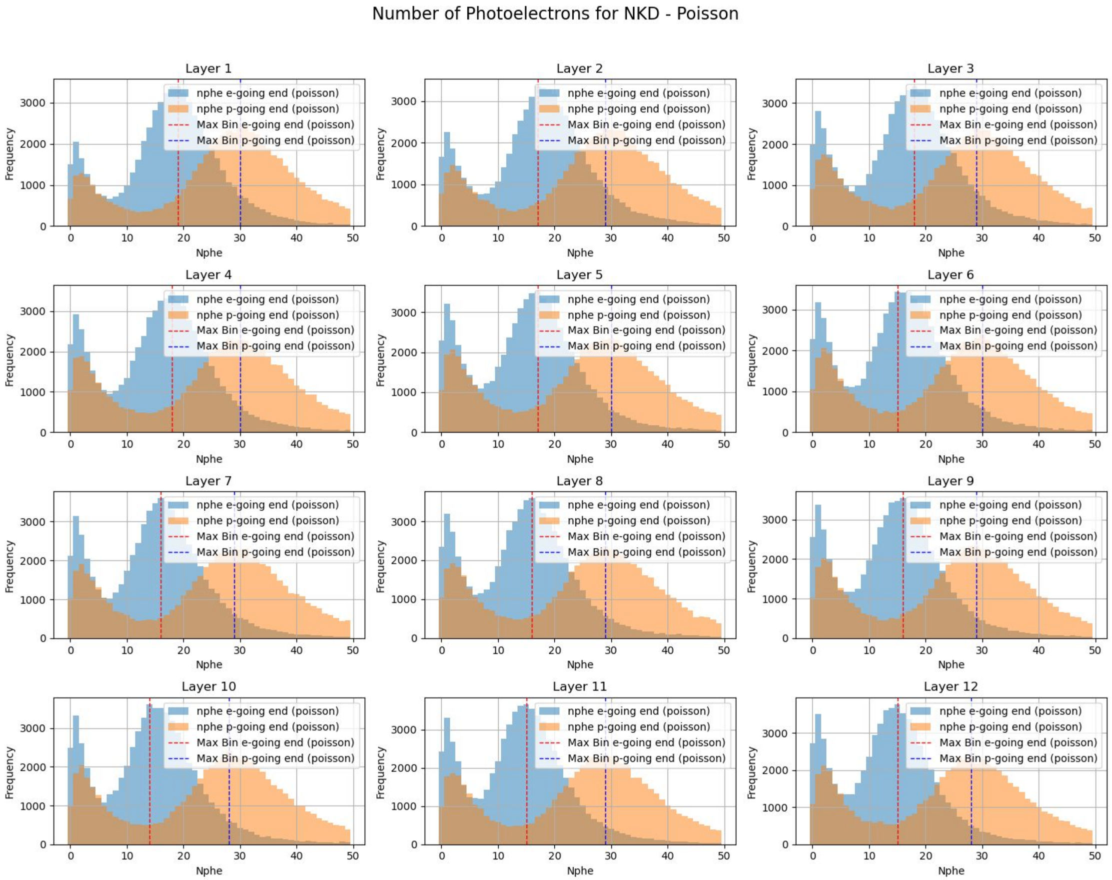
Simulated response to MIP (5 GeV muon eta: +1)

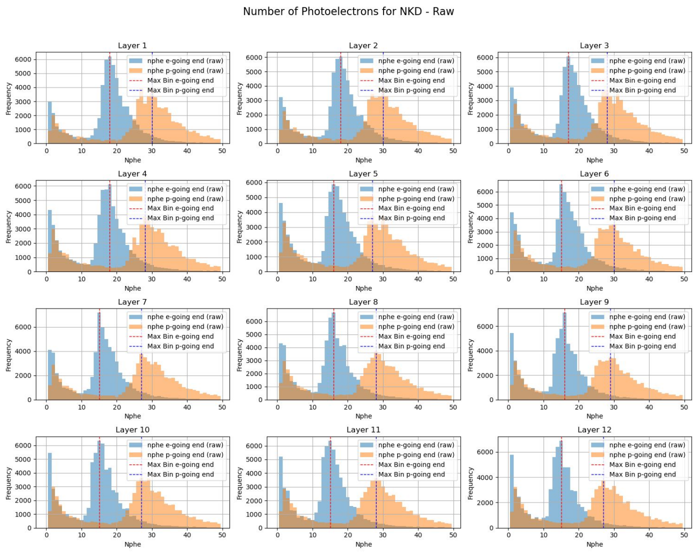




Luxium fiber

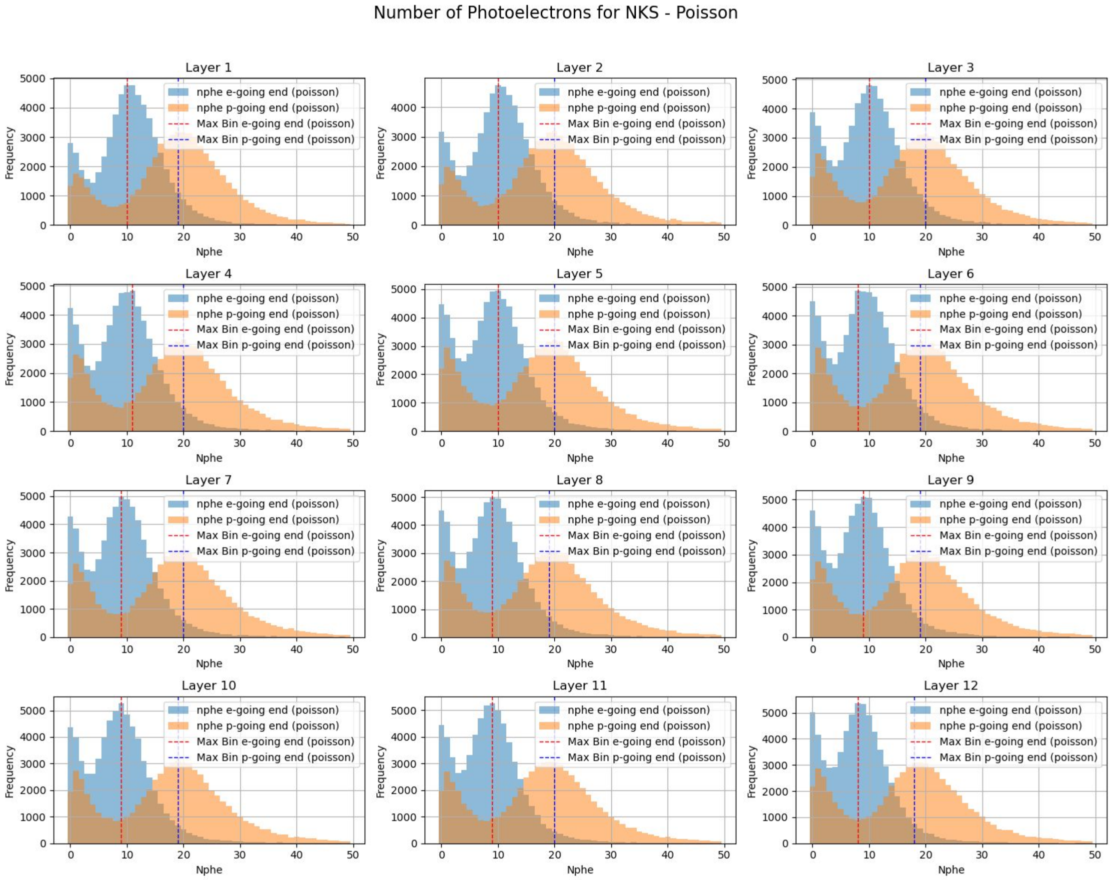
Simulated response to MIP (5 GeV muon eta: +1)

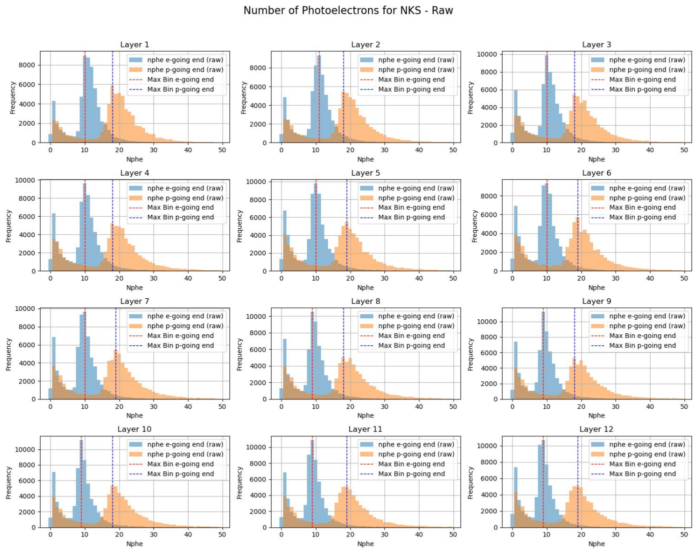




Double Clad Kuraray fiber

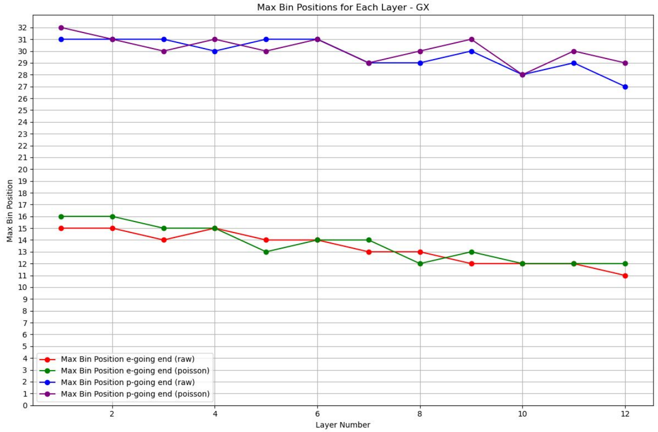
Simulated response to MIP (5 GeV muon eta: +1)

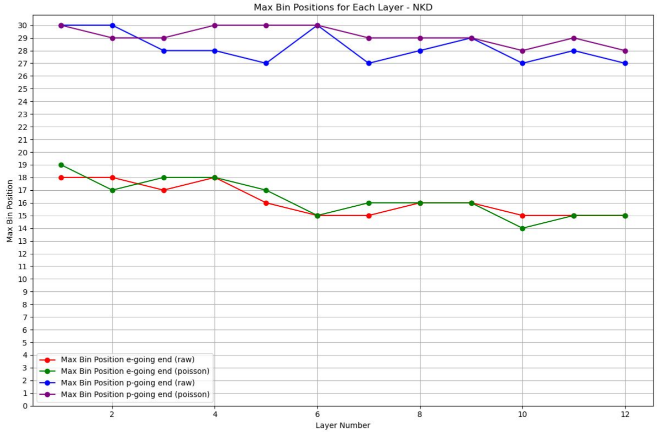


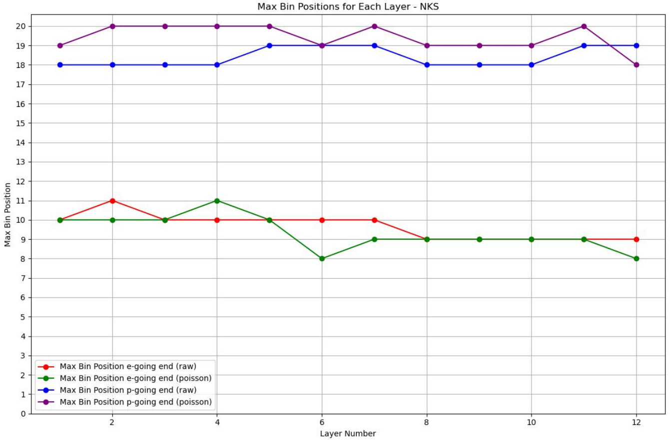


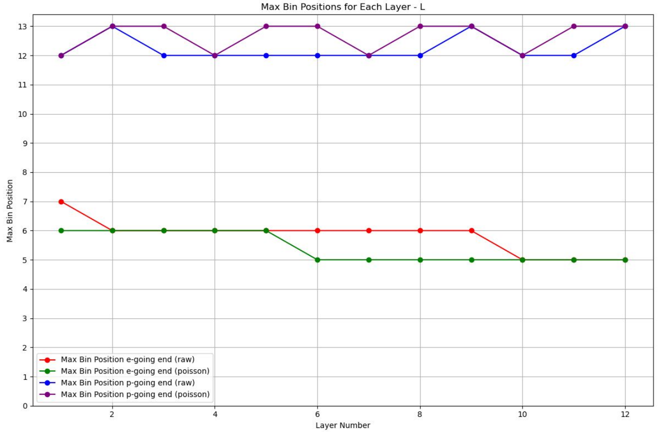
Single Clad Kuraray fiber

Simulated response to MIP (5 GeV muon eta: +1)





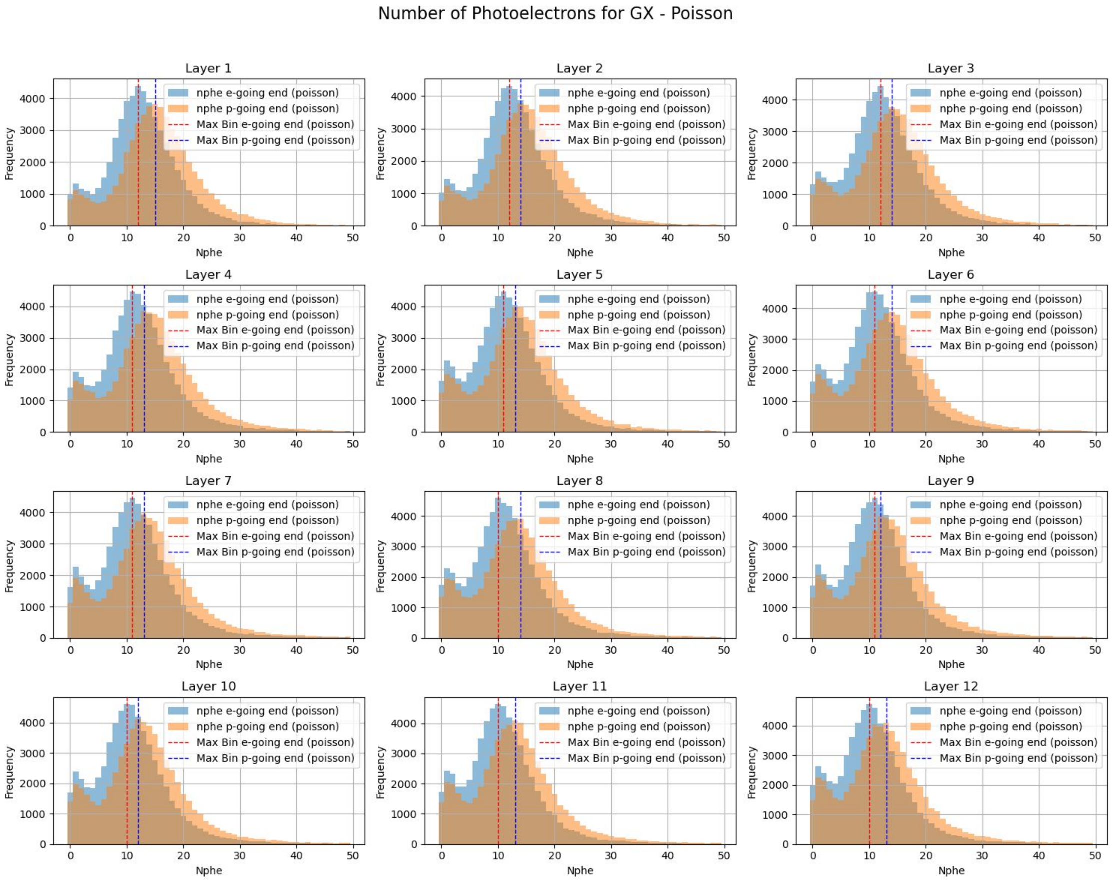


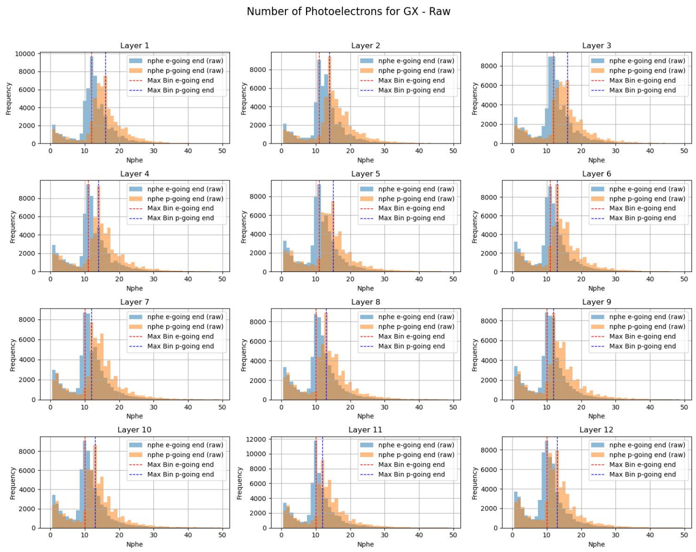


Note: This is MPV position (we need to cut below to register the whole MIP peak)

- L - Luxium
- GX - Old GlueX
- NKS - Kuraray Single
- NKD - Kuraray Double

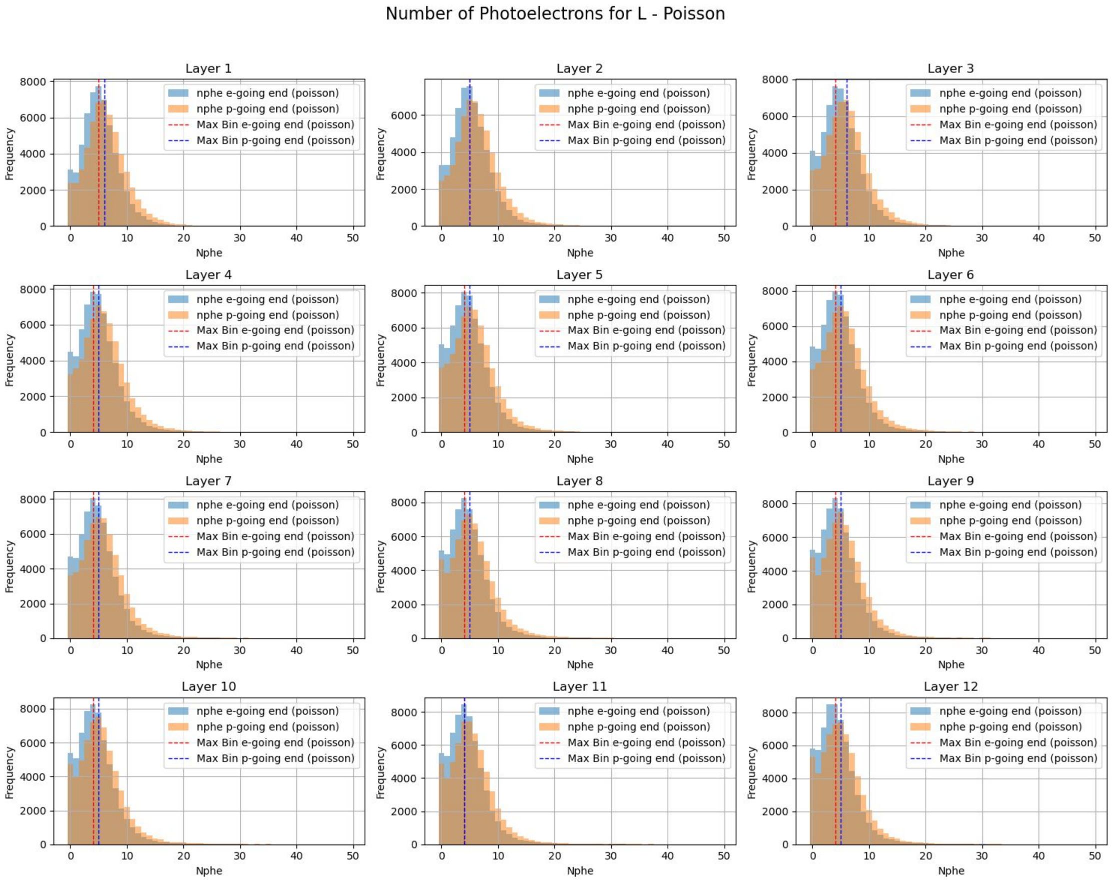
Simulated response to MIP (5 GeV muon eta: 0)

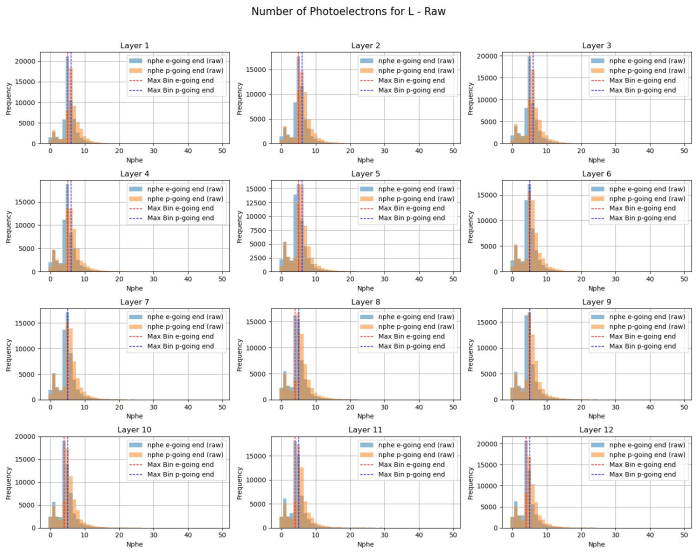




Old GlueX fiber

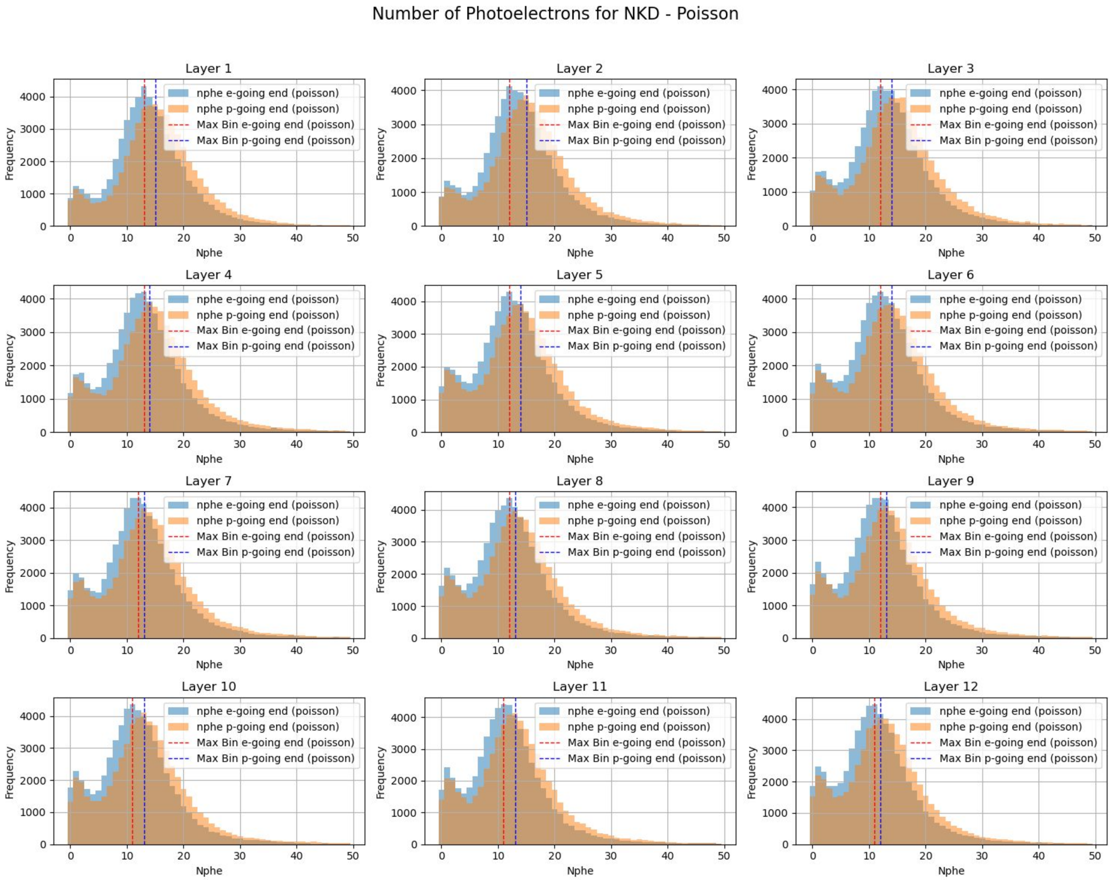
Simulated response to MIP (5 GeV muon eta: 0)

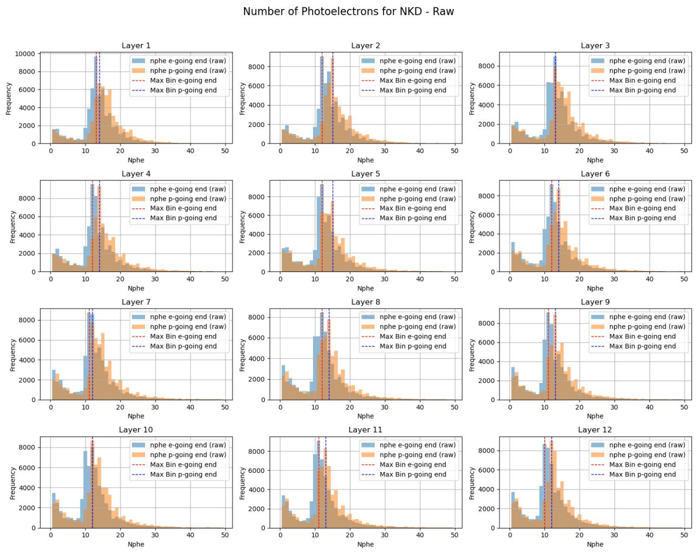




Luxium fiber

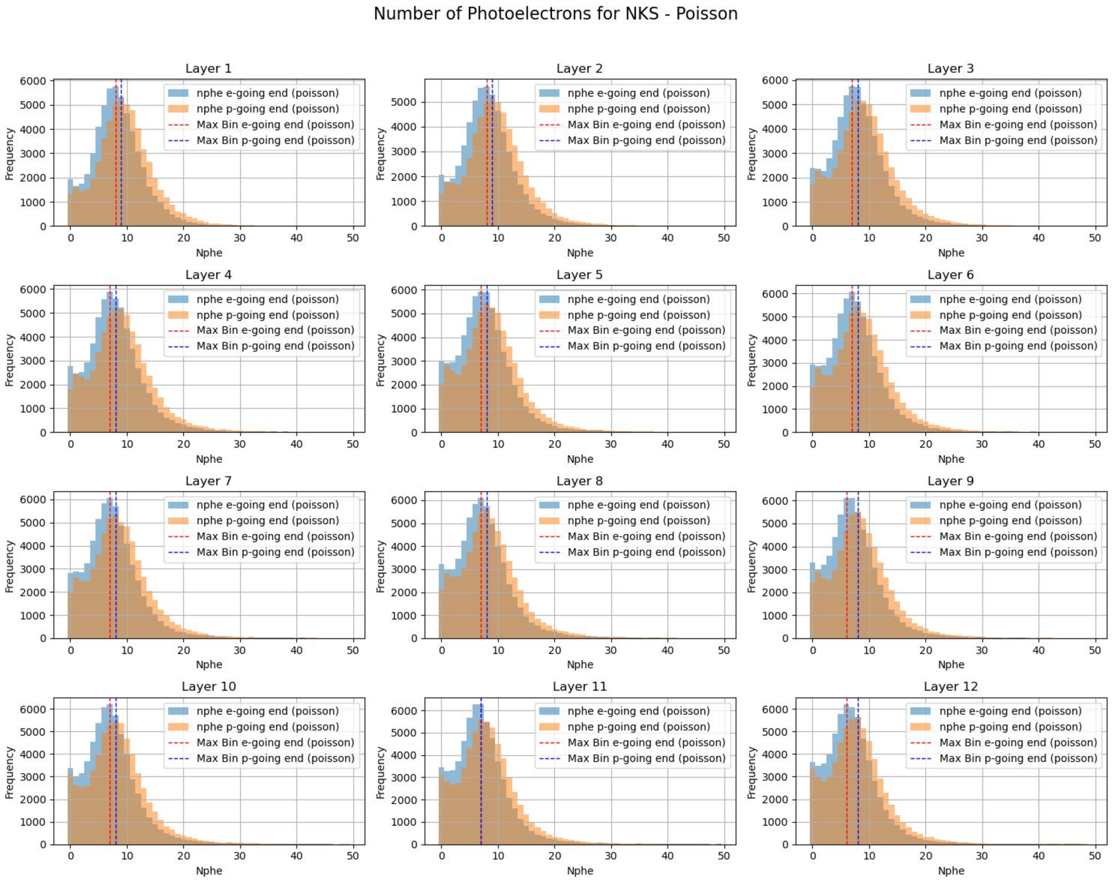
Simulated response to MIP (5 GeV muon eta: 0)

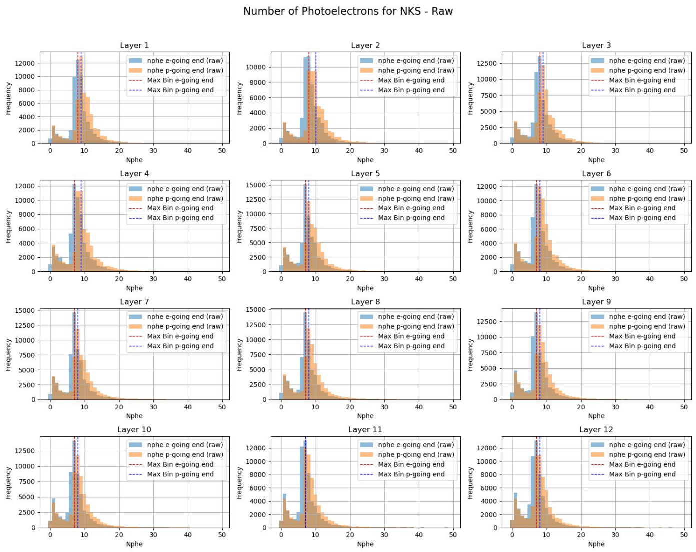




Double Clad Kuraray fiber

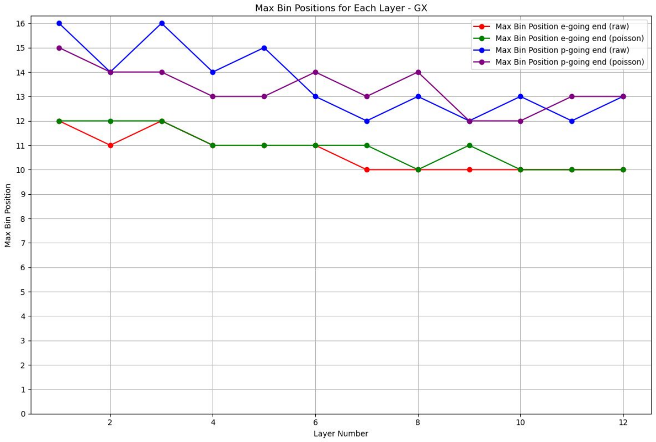
Simulated response to MIP (5 GeV muon eta: 0)

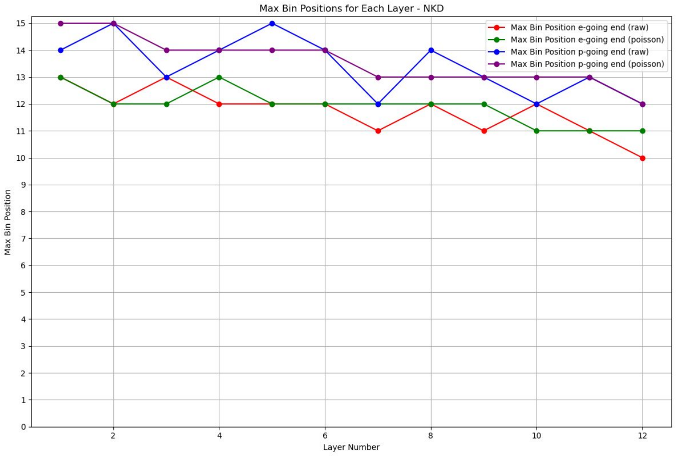


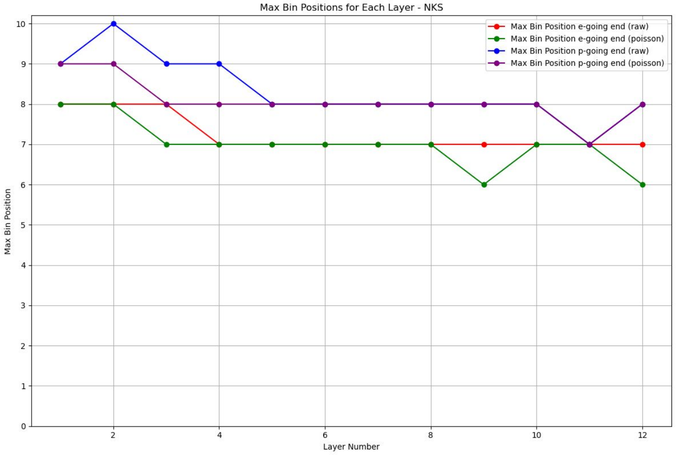


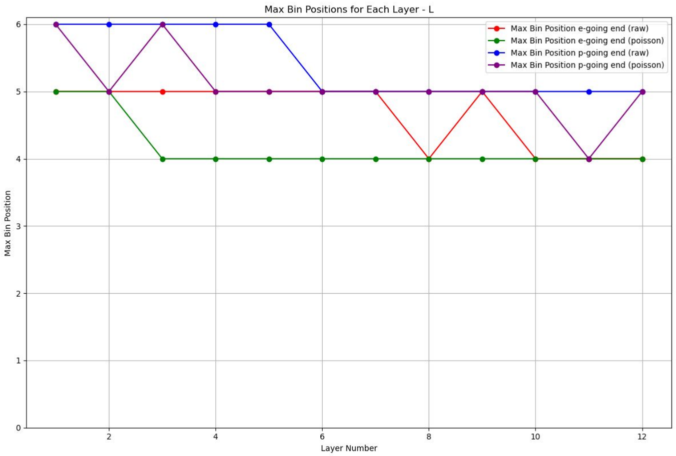
Single Clad Kuraray fiber

Simulated response to MIP (5 GeV muon eta: 0)









Note: This is MPV position (we need to cut below to whole MIP peak)

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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)

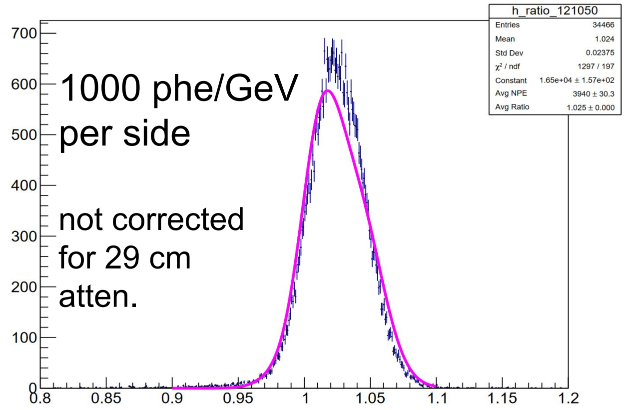
- **10 GeV ɣ at η ~ -1.7:** 5560 phe → **9.8 % max SiPM occupancy**
- **19 GeV e^- at η ~ -1.7:** 9181 phe → **16.1 % max SiPM occupancy**
- **50 GeV e^- at η ~ 1.4 (most extreme case):** 17456 phe → **30.1% max SiPM occupancy**

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

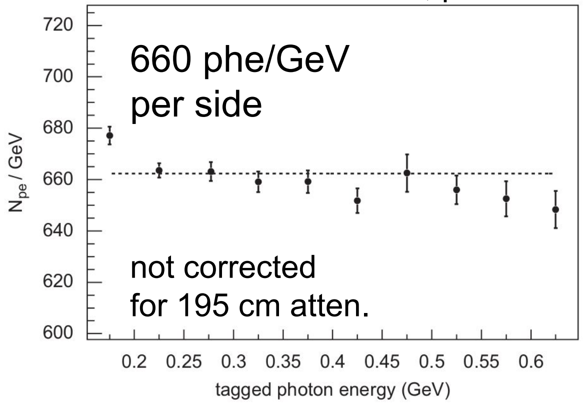


Fig. 16. The number of photoelectrons per GeV per end of the BCAL module is shown as a function of energy. A one parameter fit is plotted (dashed line). For more details see the text.