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# **KLF beam simulation detector hit rates with variable W-plug**

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# Geant4 simulation of KLong beam

- new features in this update
  1. GlueX liquid hydrogen target filled
  2. start counter cone changed to cylindrical geometry, total length unchanged
- conditions unchanged from last simulation
  1. continuous variation in plug thickness in the range [10, 20] cm
  2. includes recording the z of particles in start counter, cdc straws
- same model of photon beam from CPS
  1. 5B bremsstrahlung photons from 12 GeV electrons
  2. only CPS flux in the range [2,12] GeV was included
  3. statistics equivalent to 1.2 ms of beamtime at 5uA
  4. with x1000 factor in phi(1020) photoproduction at KPT

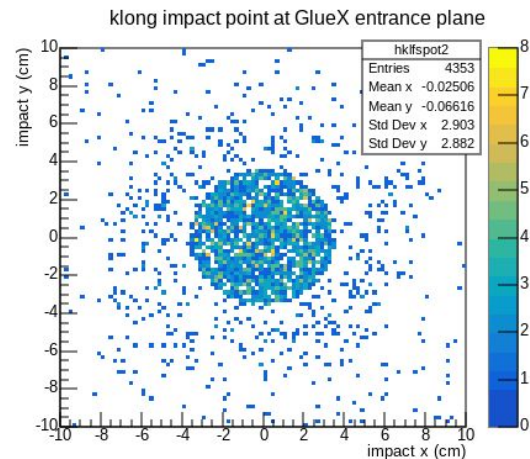
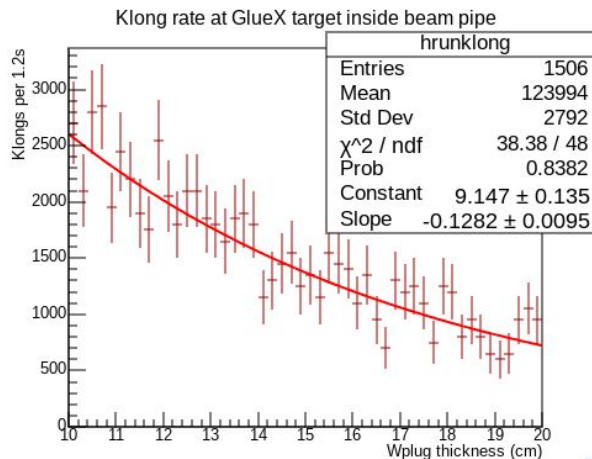
# Results from 1.2ms of beam

- total of 5B bremsstrahlung photons simulated in the range [2,12] GeV
  - 500k beam photons in range [2,12] GeV simulated per run
  - 10,000 runs, differ only in tungsten plug thickness, cavity around it
    - $W_{\text{plug\_length}} = (10 + n * 0.001)$  cm,  $n=\text{range}(1,10000)$
- when appropriate, vertical axes scaled to 1.2ms per bin in  $W_{\text{plug\_length}}$

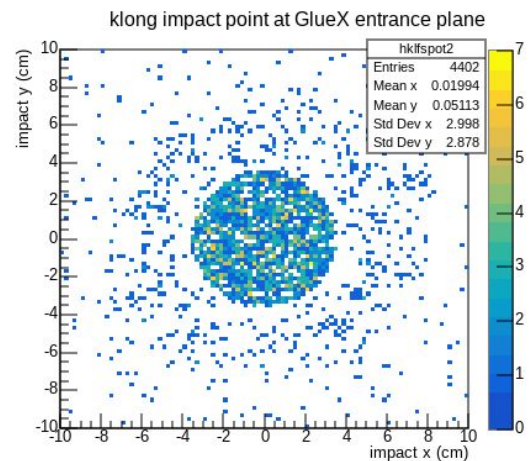
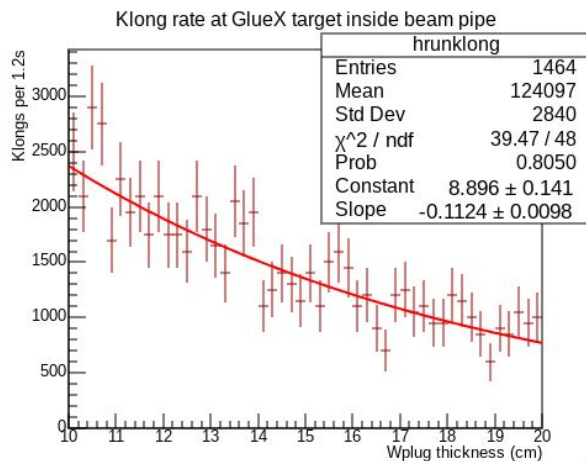
# Klong yield / 1.2s

(from  $\varphi(1020)$  decays only)

previous simulation  $\longrightarrow$   
(empty target, with cone)

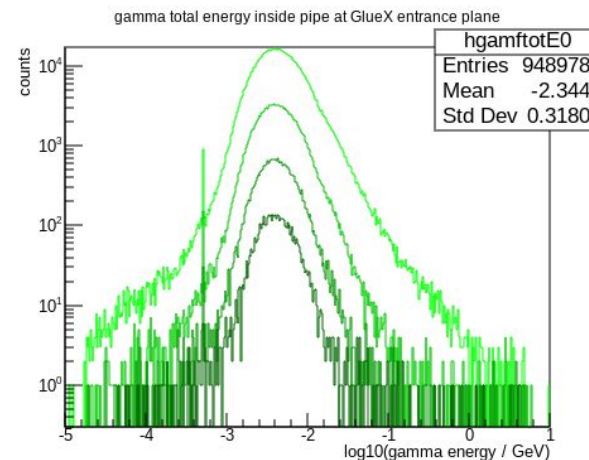
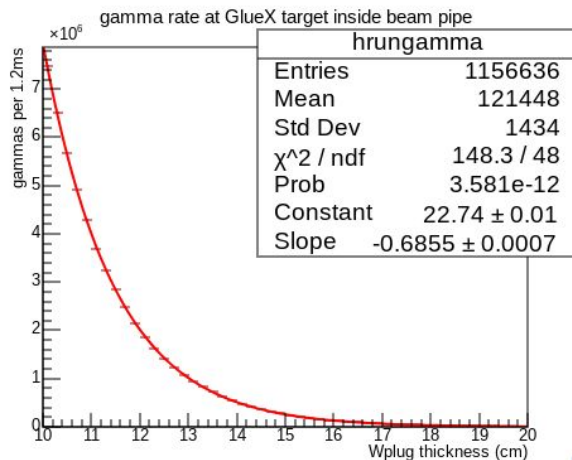
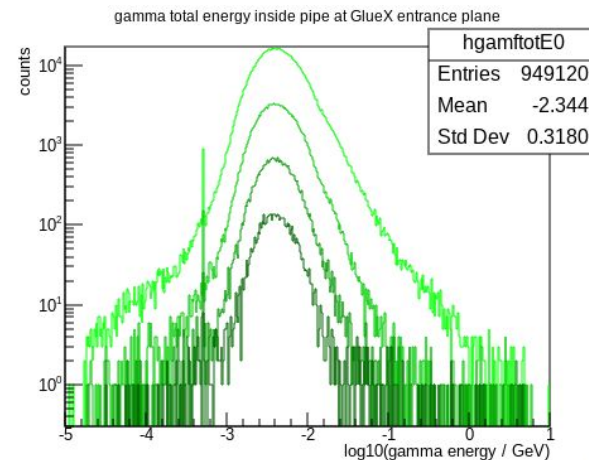
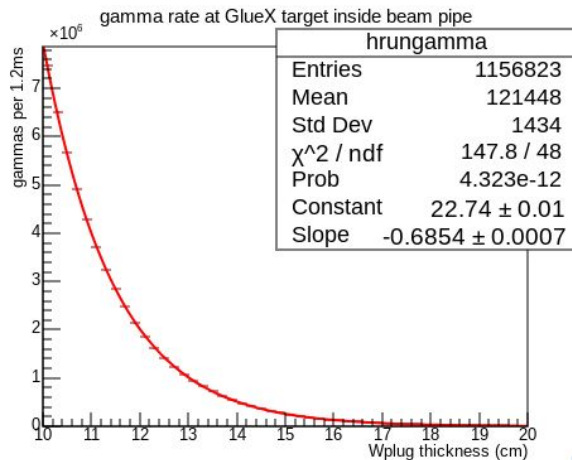


this simulation  $\longrightarrow$   
(full target, without cone)



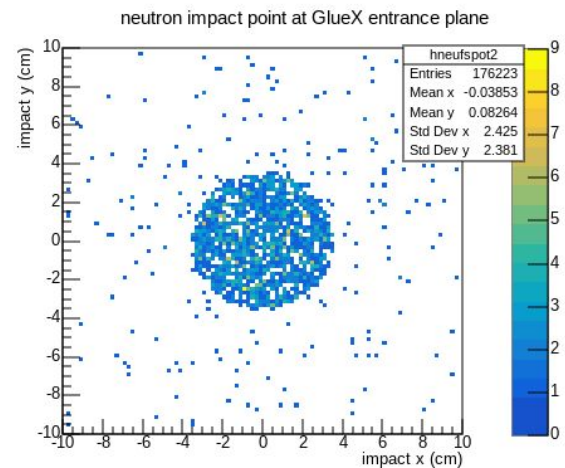
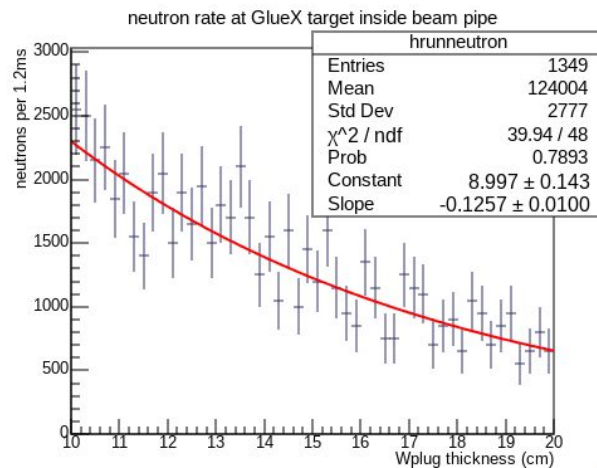
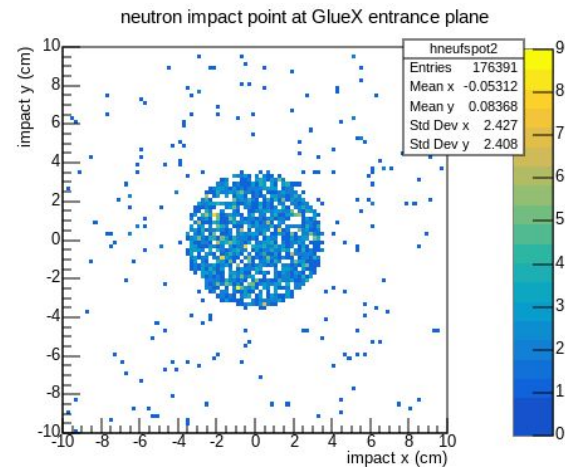
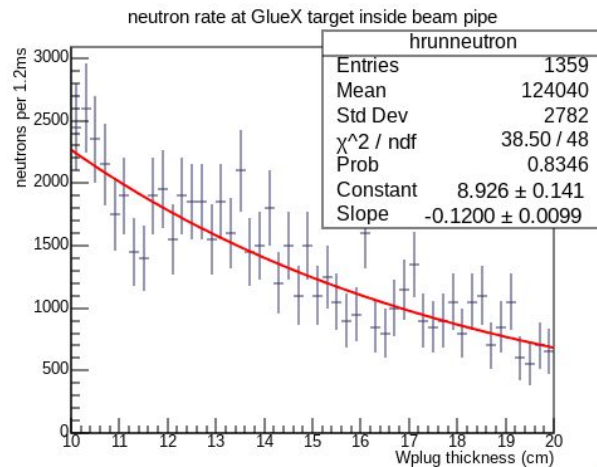
# gamma yield

$$\lambda = 1.459 \pm 0.001 \text{ cm}$$



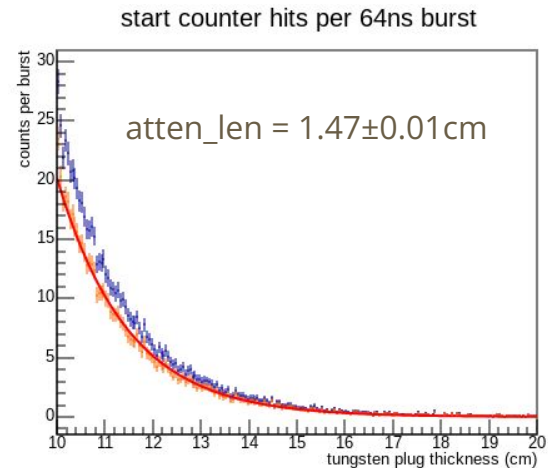
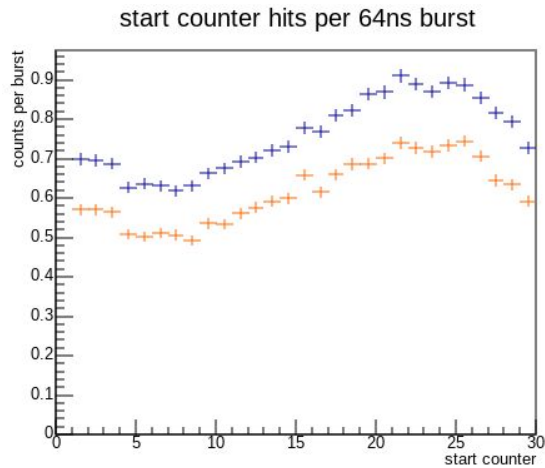
# neutron yield

$$\lambda = 8.3 \pm 0.7 \text{ cm}$$

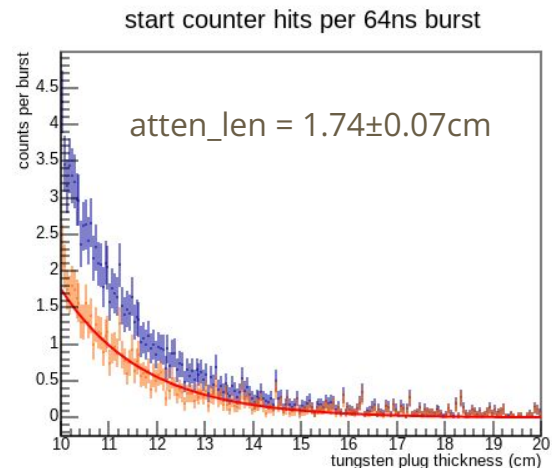
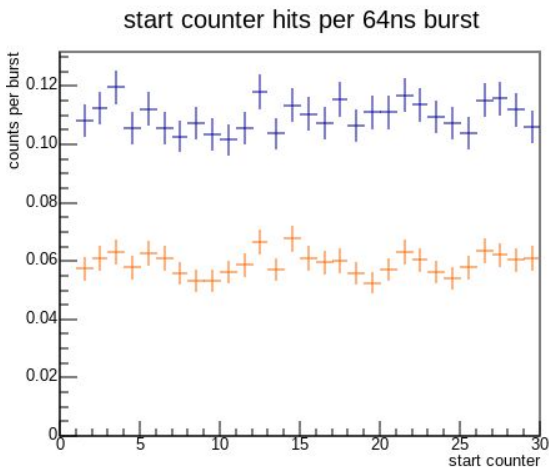


# Start counter hits

previous simulation  $\longrightarrow$   
(empty target, with cone)

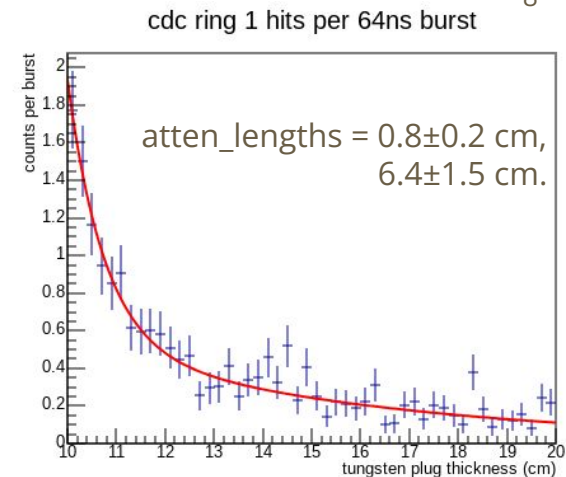
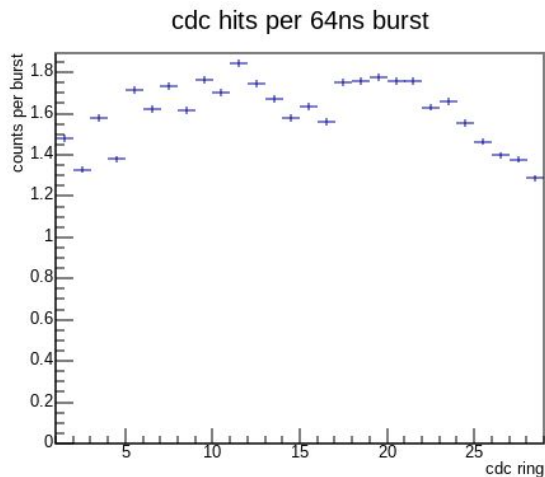


this simulation  $\longrightarrow$   
(full target, without cone)

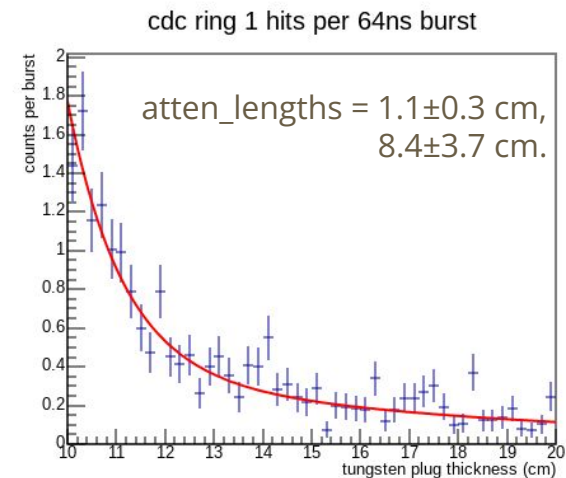
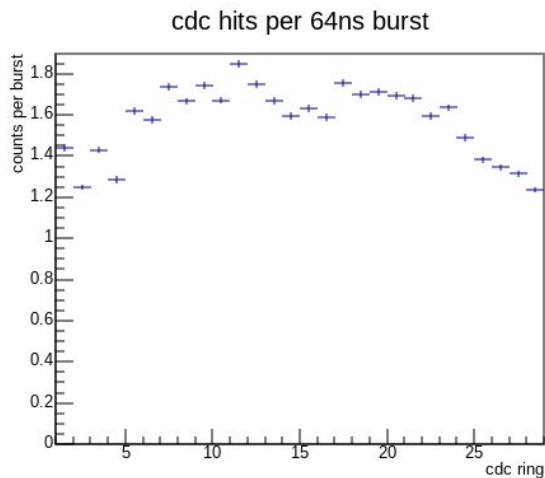


# CDC hits

previous simulation  $\longrightarrow$   
(empty target, with cone)



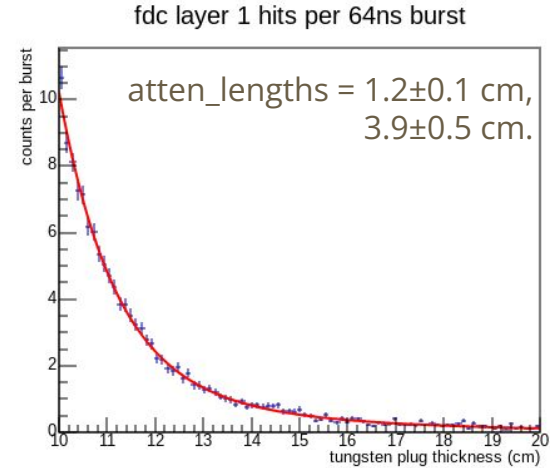
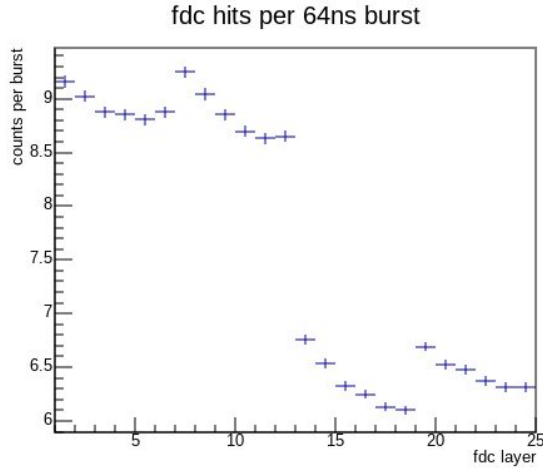
this simulation  $\longrightarrow$   
(full target, without cone)



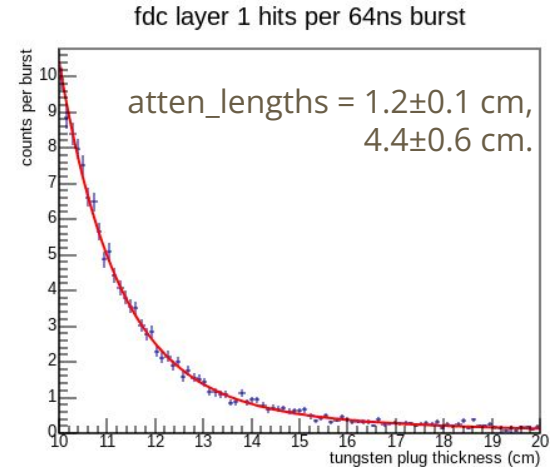
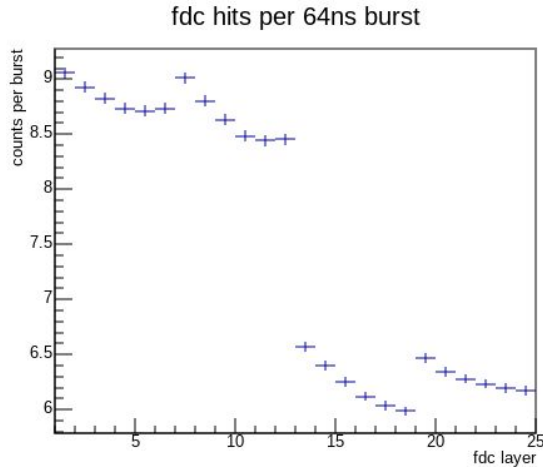


# FDC hits

previous simulation  $\longrightarrow$   
(empty target, with cone)

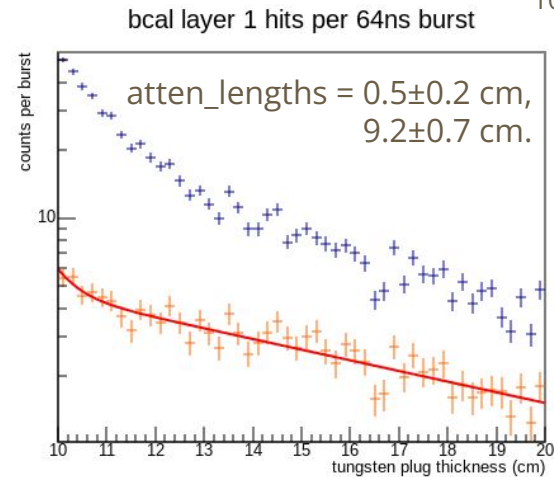
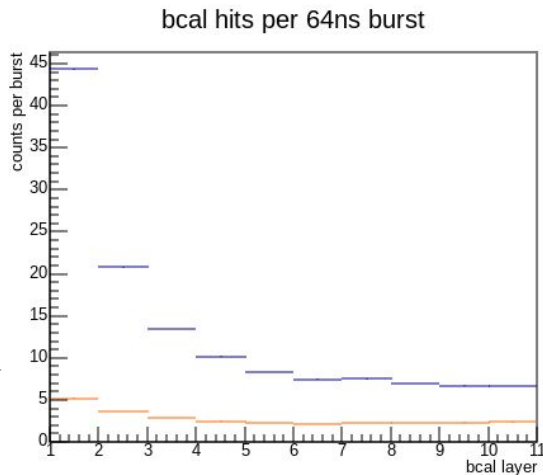


this simulation  $\longrightarrow$   
(full target, without cone)

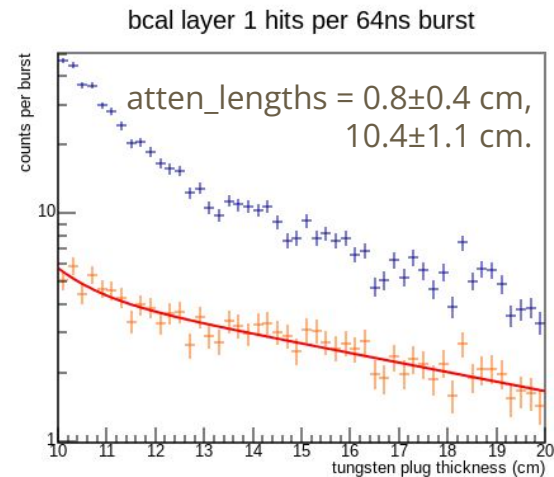
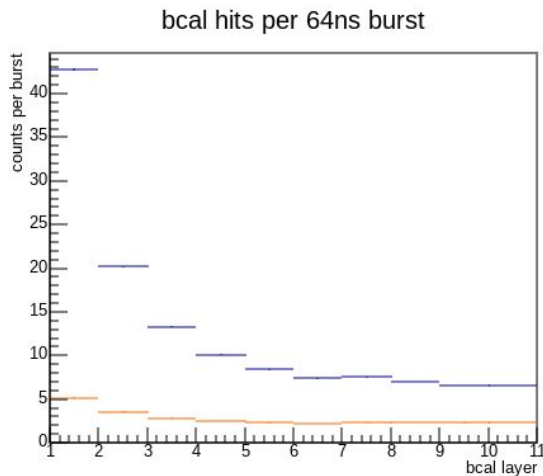


# BCal hits

previous simulation  
(empty target, with cone) →

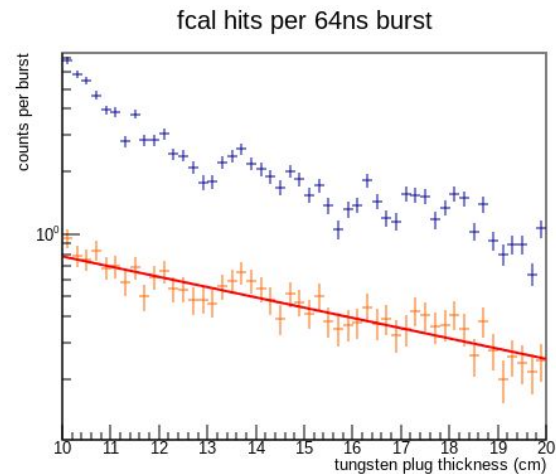
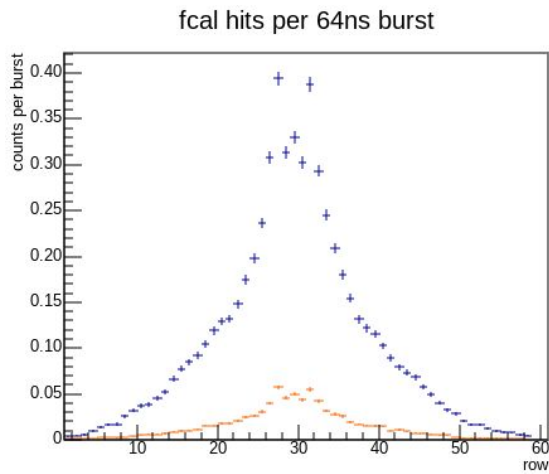


this simulation →  
(full target, without cone)

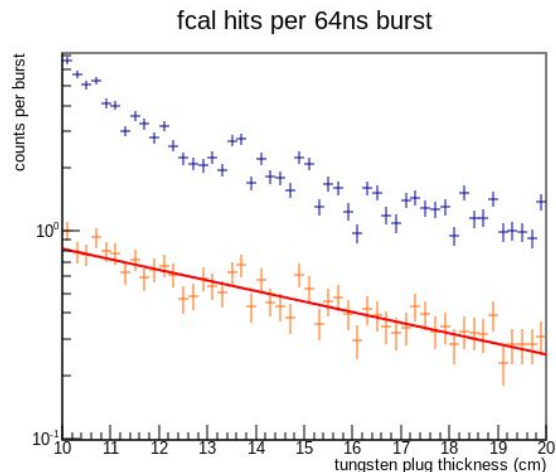
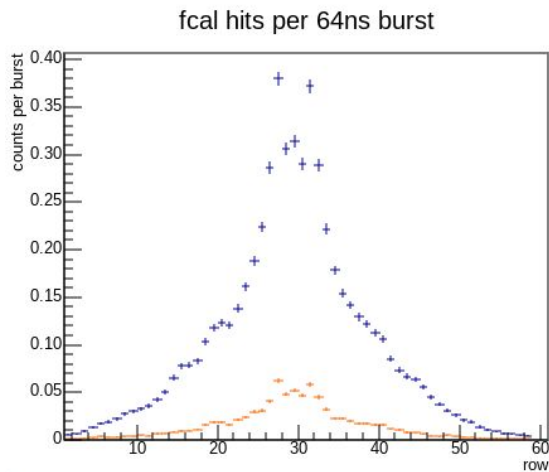


# Fcal hits

previous simulation  
(empty target, with cone) →

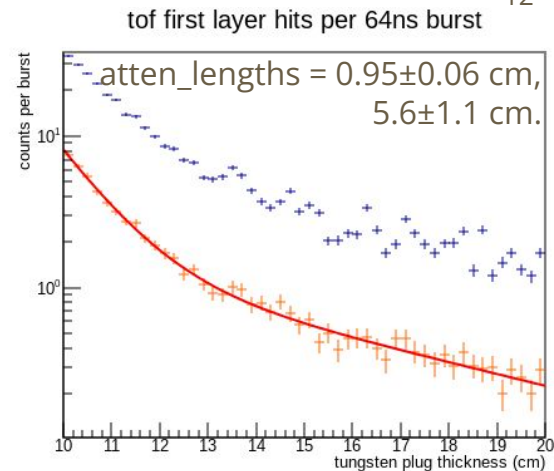
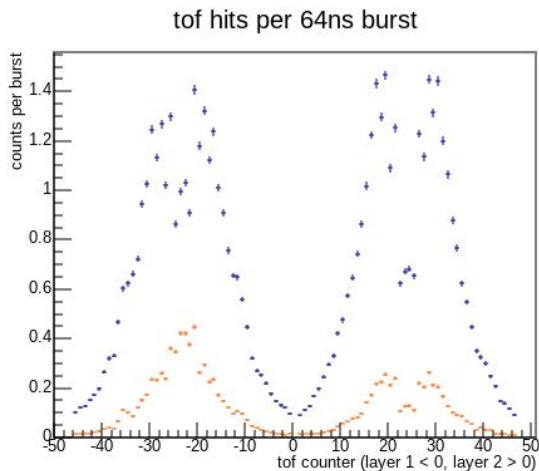


this simulation  
(full target, without cone) →

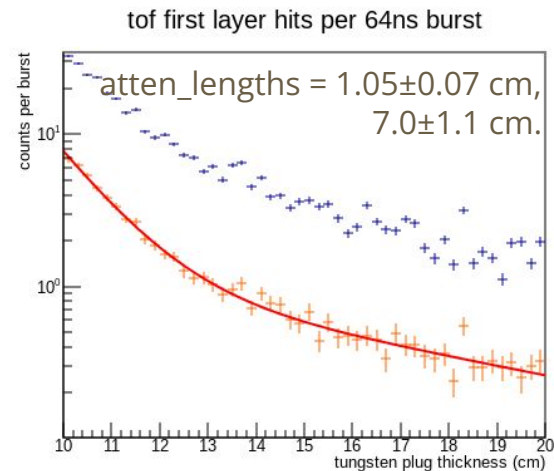
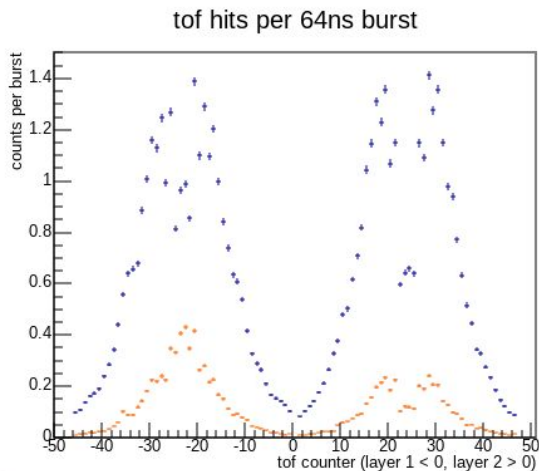


# FTOF hits

previous simulation  
(empty target, with cone) →

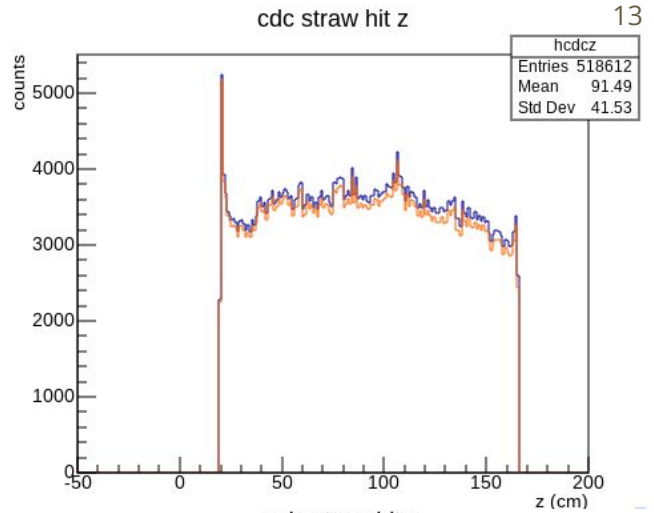
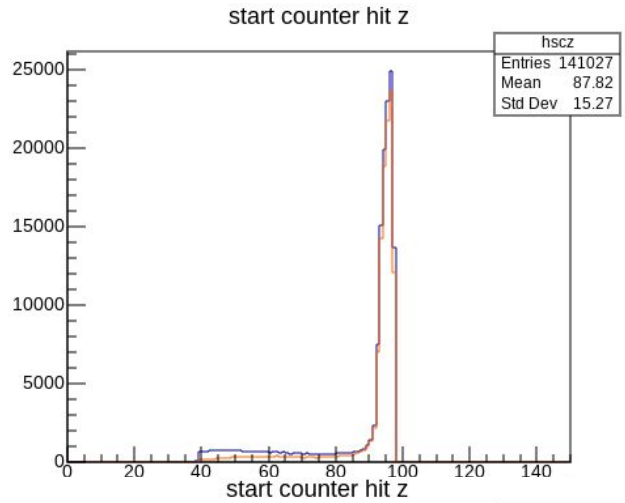


this simulation  
(full target, without cone) →

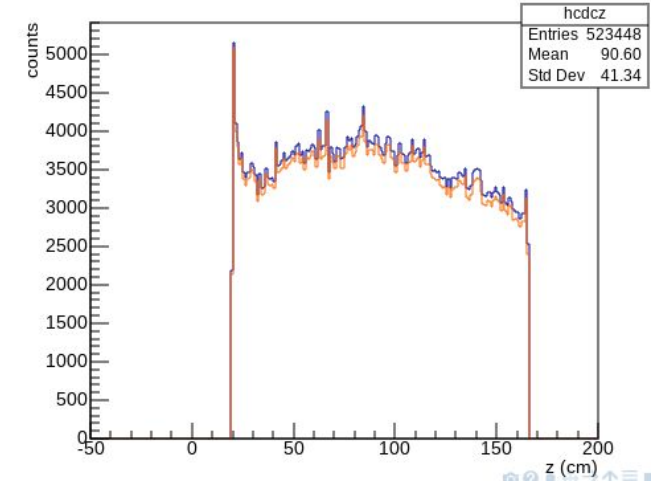
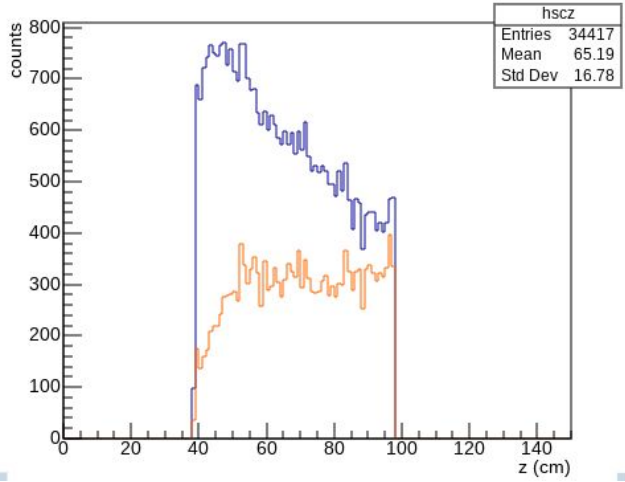


# z-profiles

previous simulation →  
(empty target, with cone)



this simulation →  
(full target, without cone)



## Part II: Comparison with GlueX photon beam

- GlueX also has beam background from soft gammas
  - bremsstrahlung includes incoherent component  $\sim 1/E_\gamma$
  - behavior of detectors in the GlueX beam is well-known empirically
  - **what does the G4 simulation of the GlueX beam predict for inner detector rates?**
- This comparison requires a different beam from what was used for KLF
  - 350nA electron beam at 12 GeV
  - 50um diamond radiator at the goniometer position
  - 5mm collimator in place of the KPT in the alcove
  - GlueX alcove shielding + pair spectrometer configuration
  - (2, 12) GeV copper spectrum replaced with (0.0001, 12) GeV diamond spectrum

# GlueX photon flux at the primary collimator

Electron beam energy  GeV

Electron beam current   $\mu\text{A}$

Electron beam emittance  m

Electron beam circular polarization

Radiator thickness  m

Radiator secondary tilt  rad

Photon spectrum peak energy  GeV

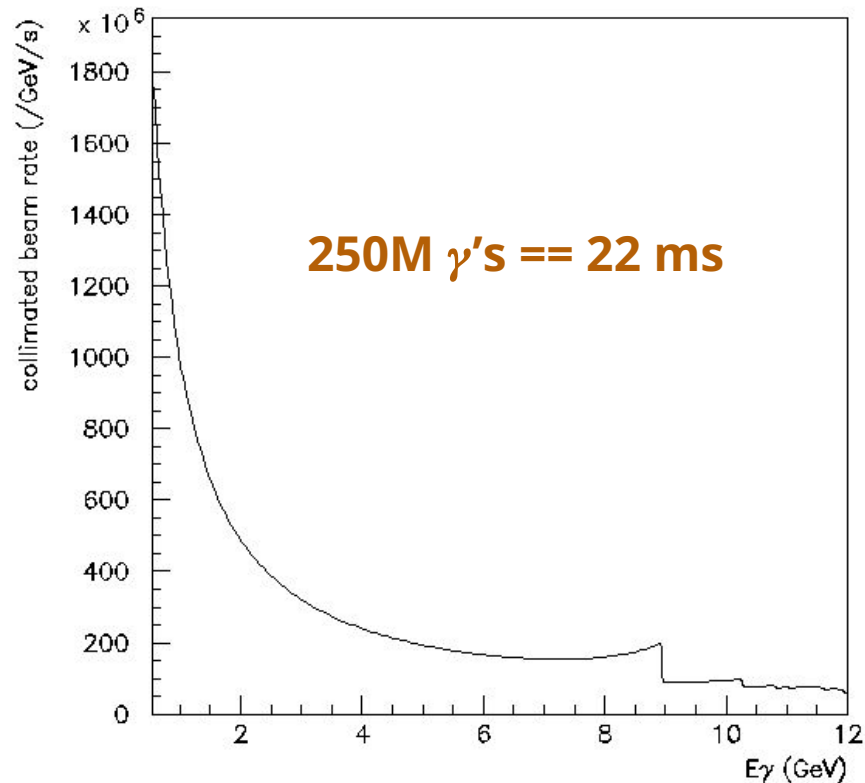
Number of bins in photon spectrum

Photon spectrum energy maximum  GeV

Photon spectrum energy minimum  GeV

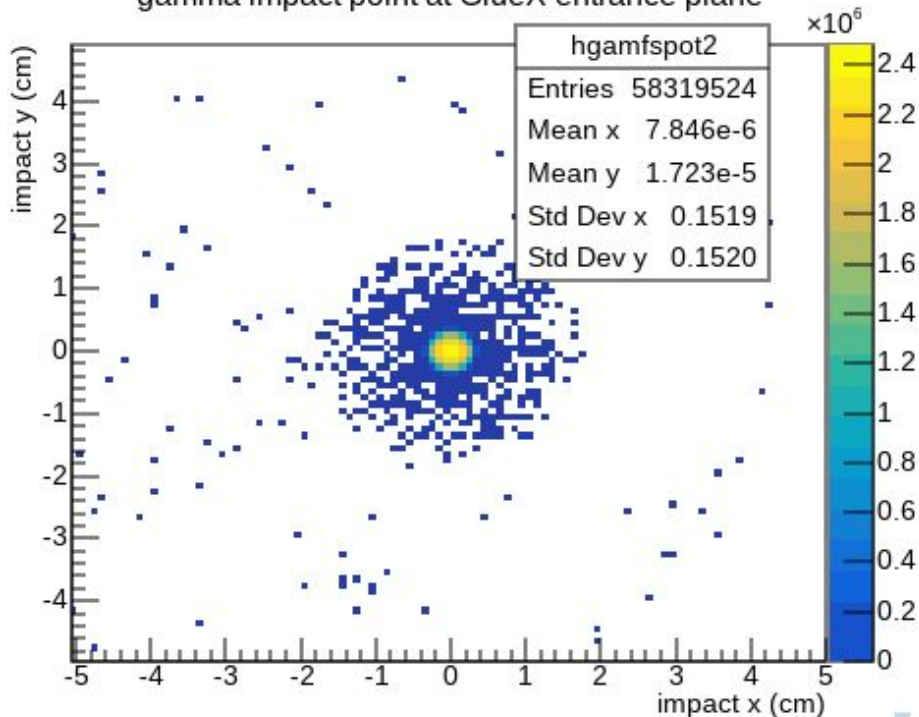
Radiator-collimator distance  m

Collimator diameter  m

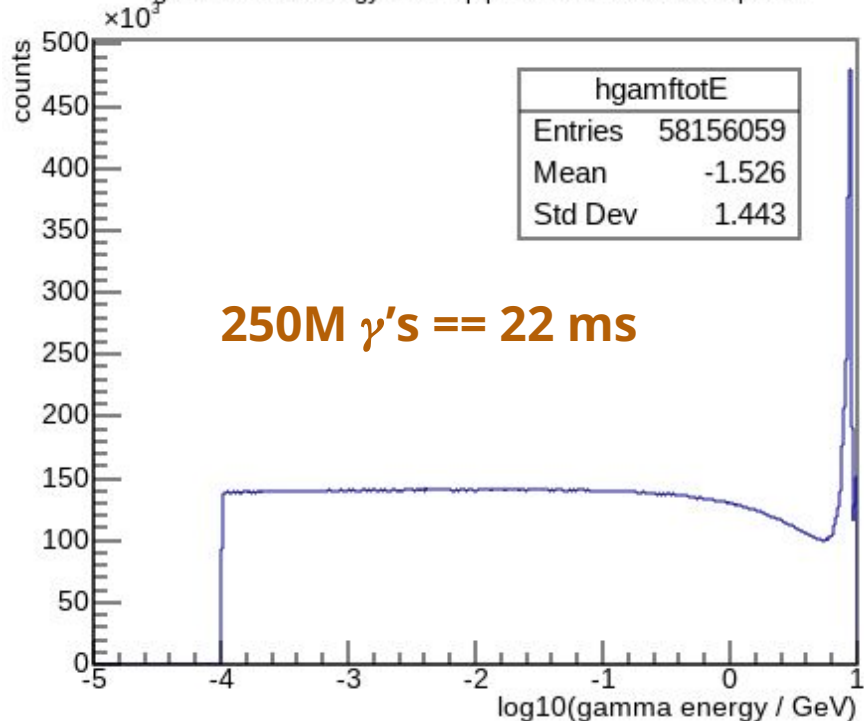


# GlueX photon flux at the primary collimator

gamma impact point at GlueX entrance plane



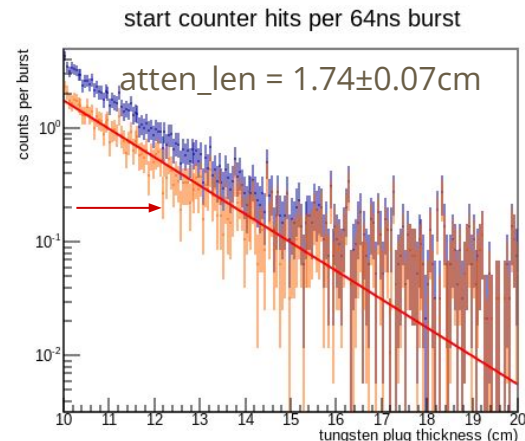
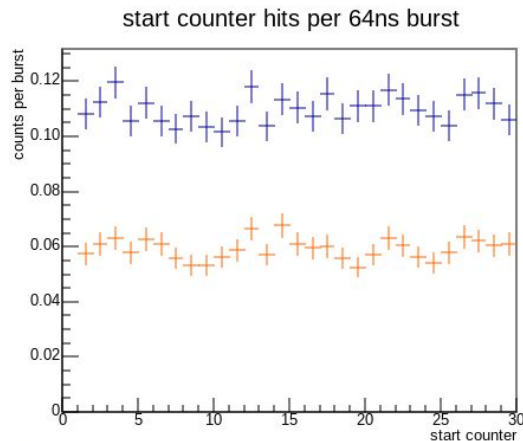
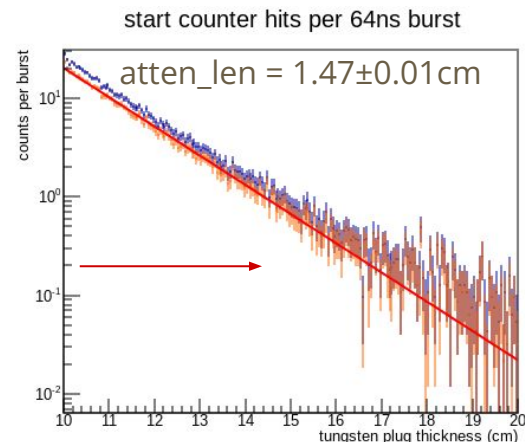
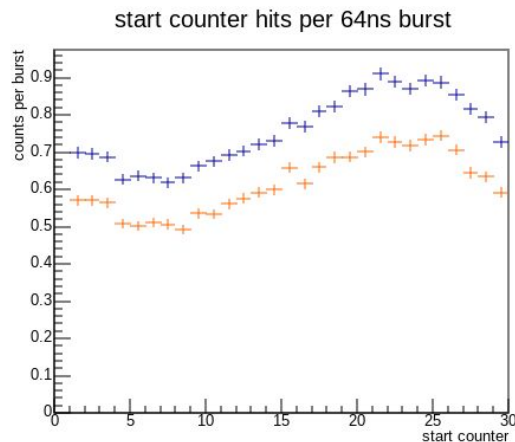
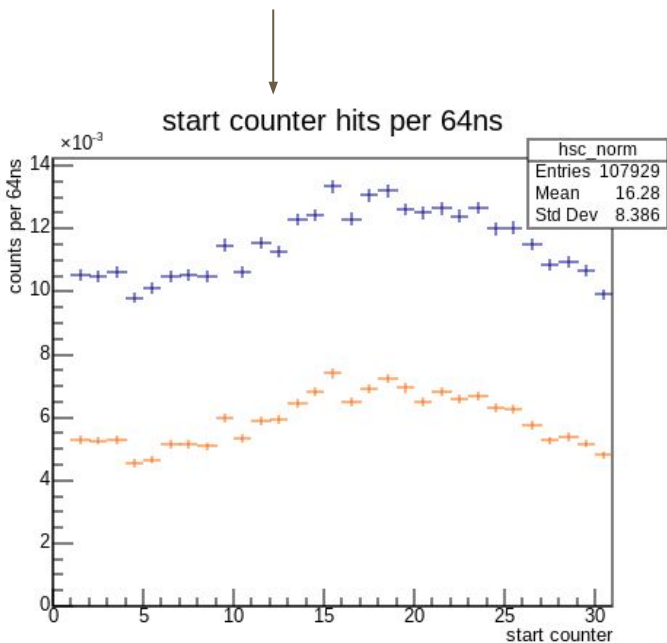
gamma total energy inside pipe at GlueX entrance plane





# Start counter hits

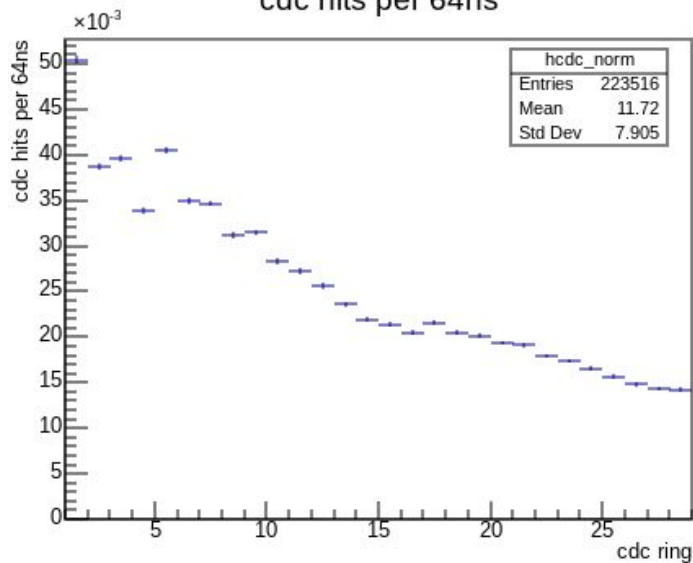
GlueX phase 2



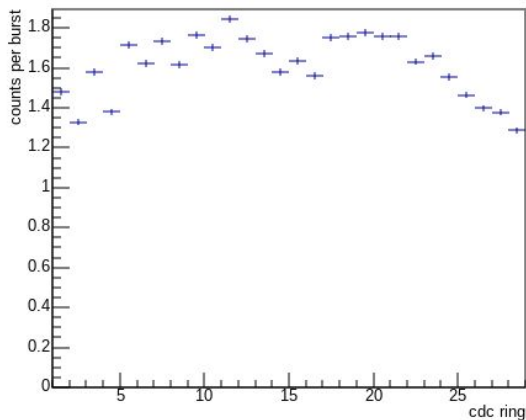
# CDC hits

GlueX phase 2

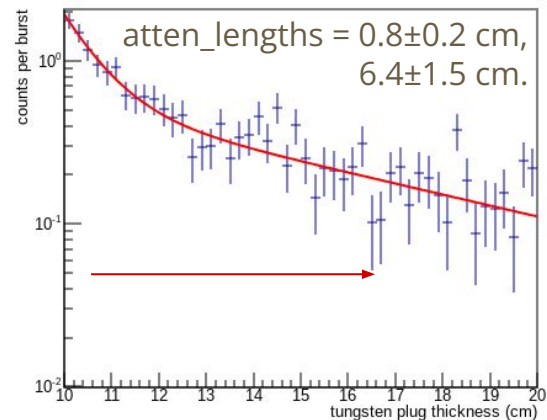
cdc hits per 64ns



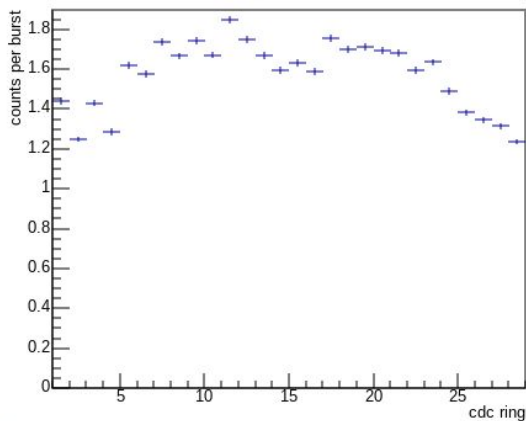
cdc hits per 64ns burst



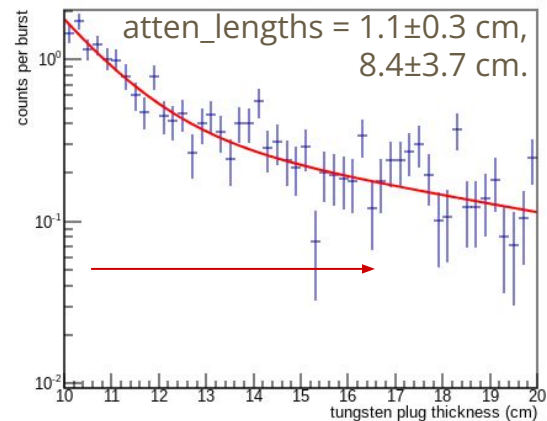
cdc ring 1 hits per 64ns burst



cdc hits per 64ns burst



cdc ring 1 hits per 64ns burst

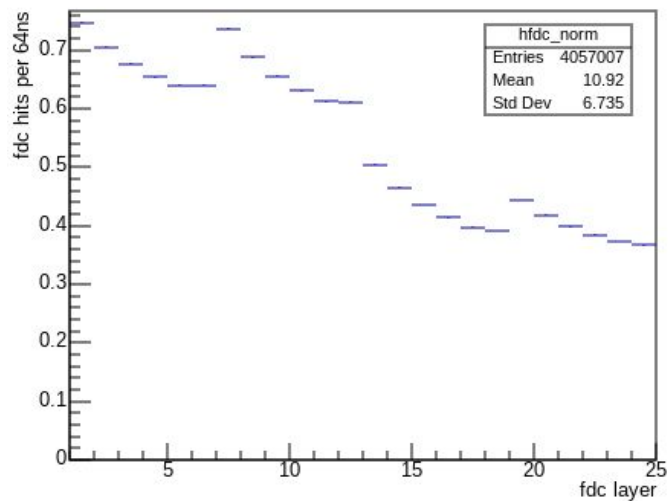


# FDC hits

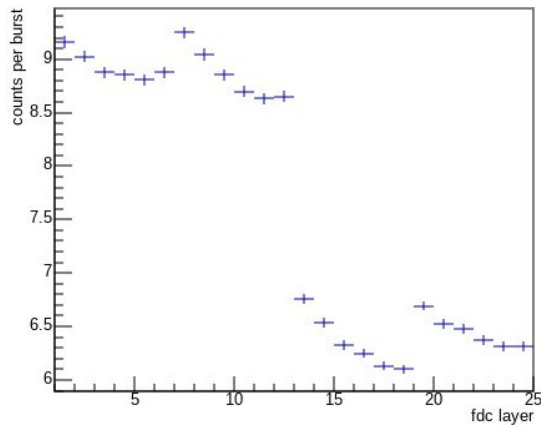
GlueX phase 2



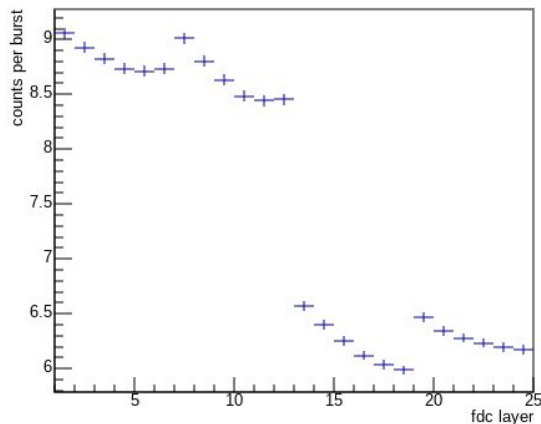
fdc hits per 64ns



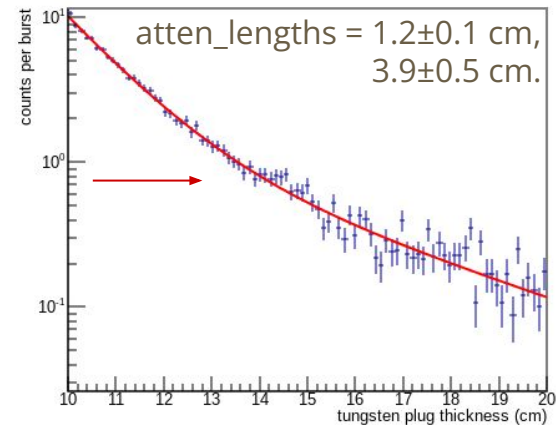
fdc hits per 64ns burst



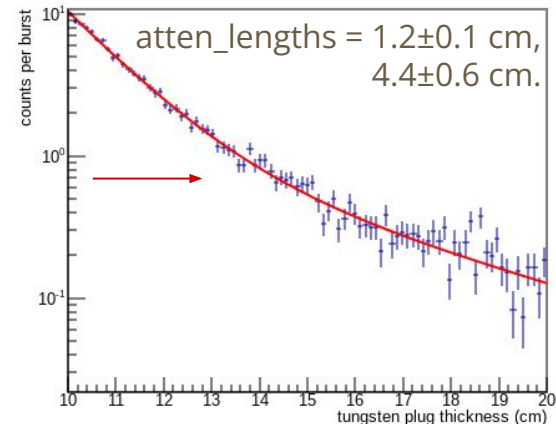
fdc hits per 64ns burst



fdc layer 1 hits per 64ns burst



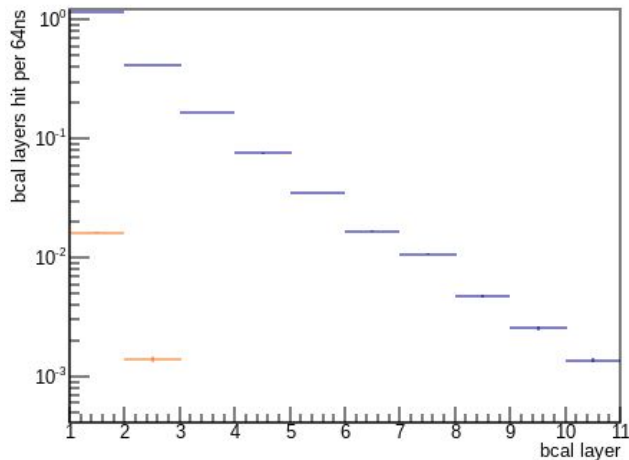
fdc layer 1 hits per 64ns burst



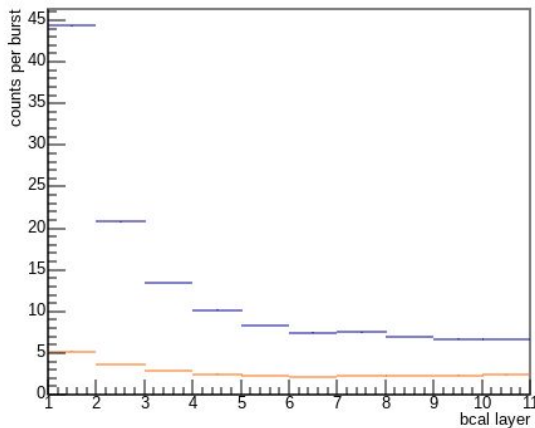
# BCal hits

GlueX phase 2

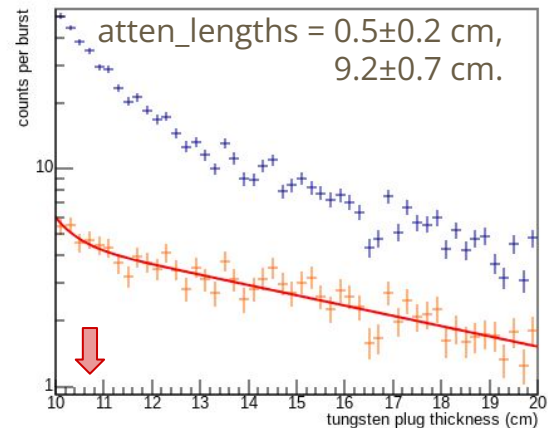
bcal hits per 64ns



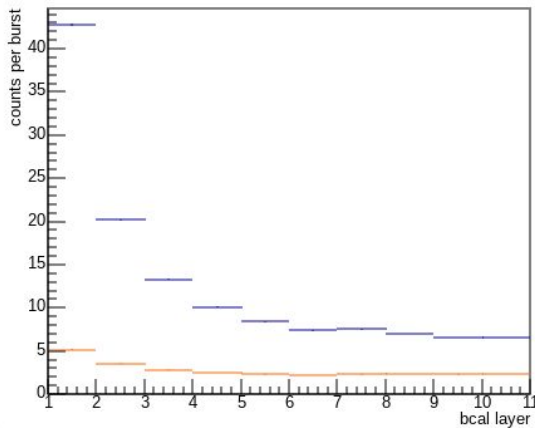
bcal hits per 64ns burst



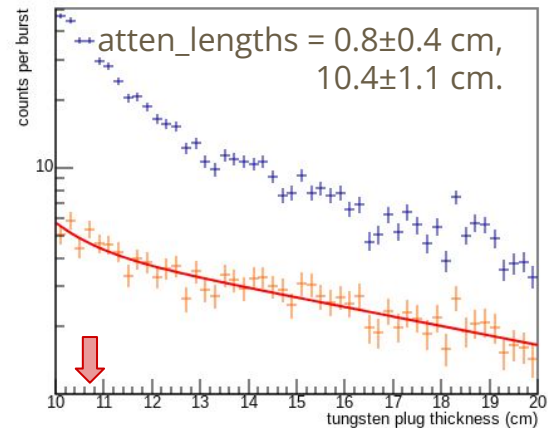
bcal layer 1 hits per 64ns burst



bcal hits per 64ns burst



bcal layer 1 hits per 64ns burst

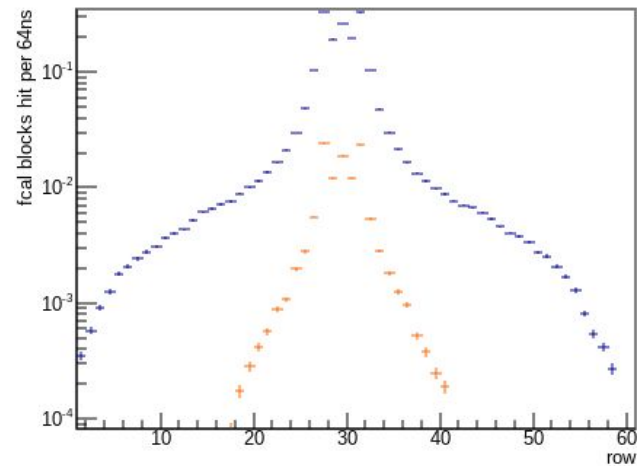


# Fcal hits

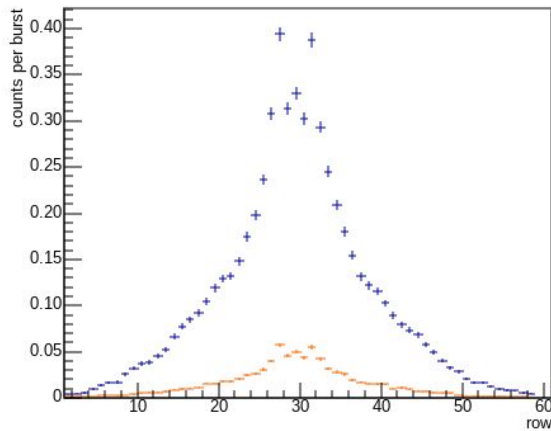
GlueX phase 2



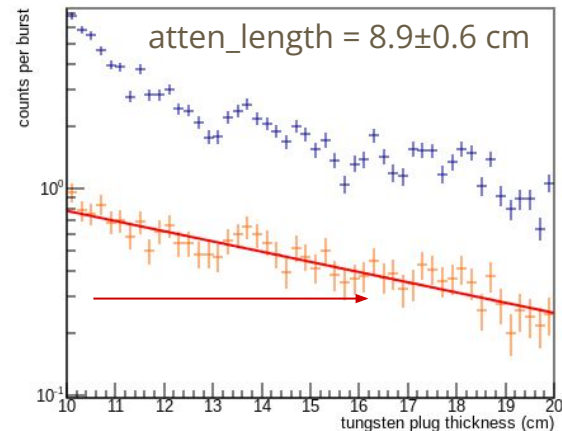
fcal hits per 64ns



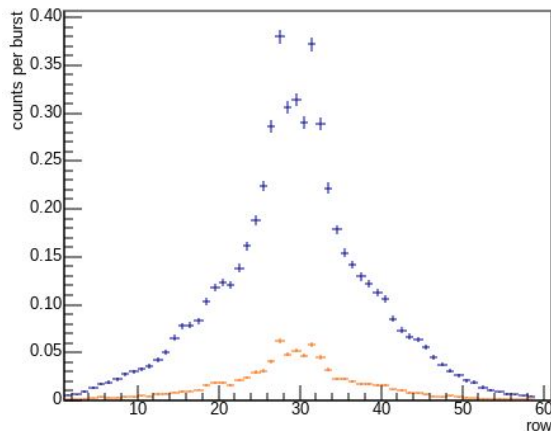
fcal hits per 64ns burst



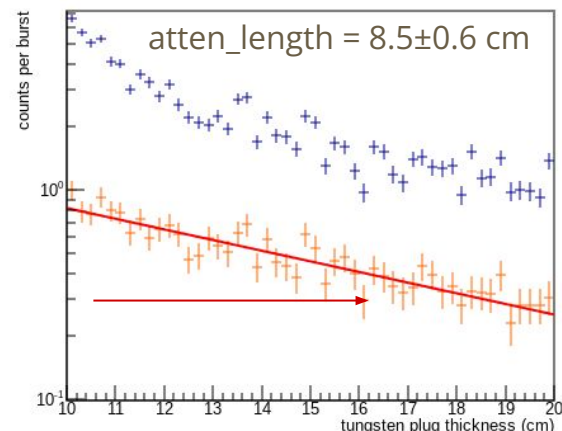
fcal hits per 64ns burst



fcal hits per 64ns burst



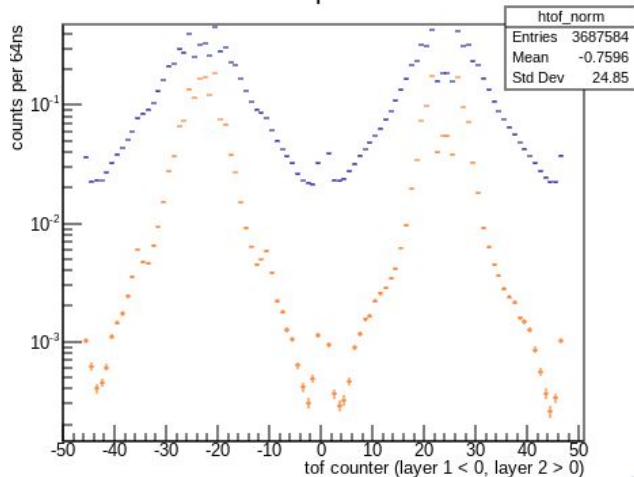
fcal hits per 64ns burst



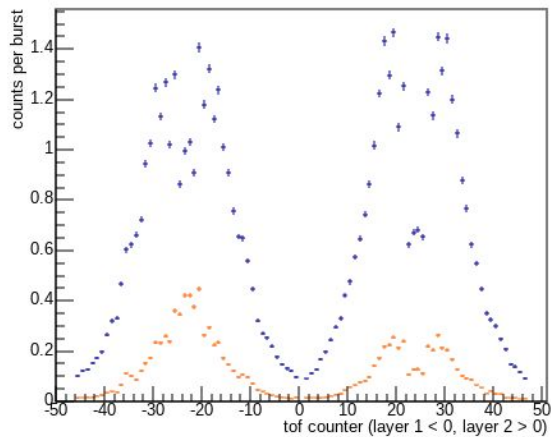
# FTOF hits

GlueX phase 2

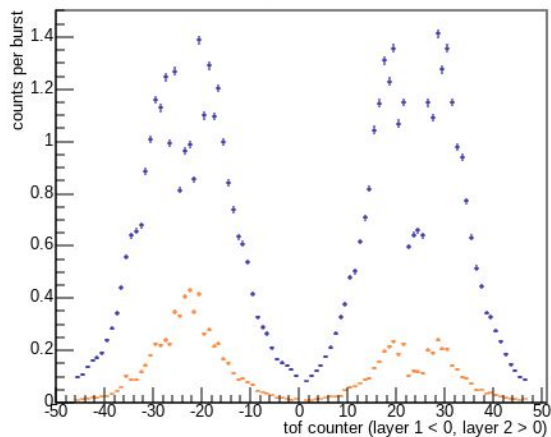
↓  
tof hits per 64ns



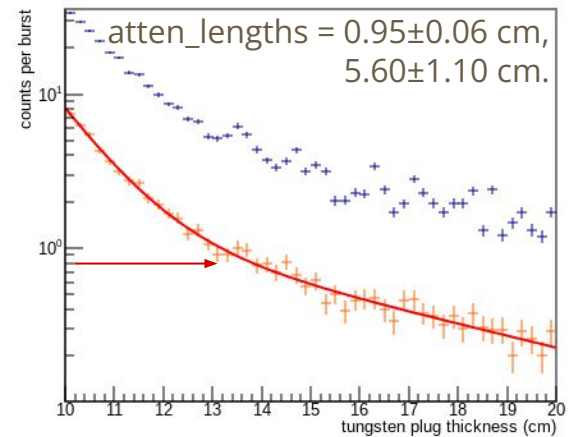
tof hits per 64ns burst



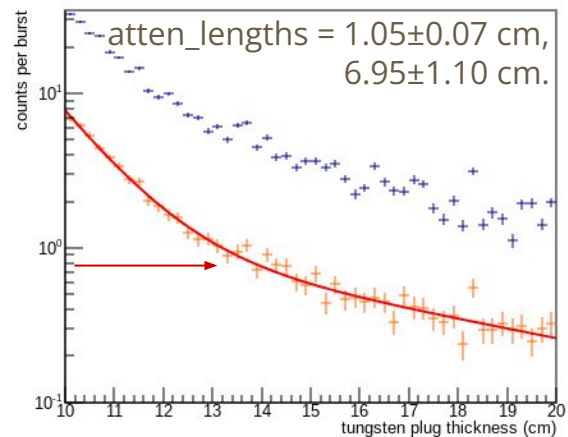
tof hits per 64ns burst



tof first layer hits per 64ns burst



tof first layer hits per 64ns burst



# Preliminary conclusions

1. Choice of Wplug\_thickness = 14cm looks like it works.
  - a. Most of the inner detectors are close to GlueX Phase 2 background rates
  - b. CDC looks like the one exception, **rate is of order x5 over GlueX II**
  - c. **BCal rates in GlueX Phase II simulation look too low, compared with reality**
    - i. probably related to incomplete high-energy photonuclear physics in G4
    - ii. will also affect the high-energy tail of the neutron distribution in KLF
    - iii. *should be investigated...*
2. Muon pair conversion in the KPT is not currently included in G4
3. These conclusions should be revisited once these issues are resolved.