Far-Bwd Coincidence Program

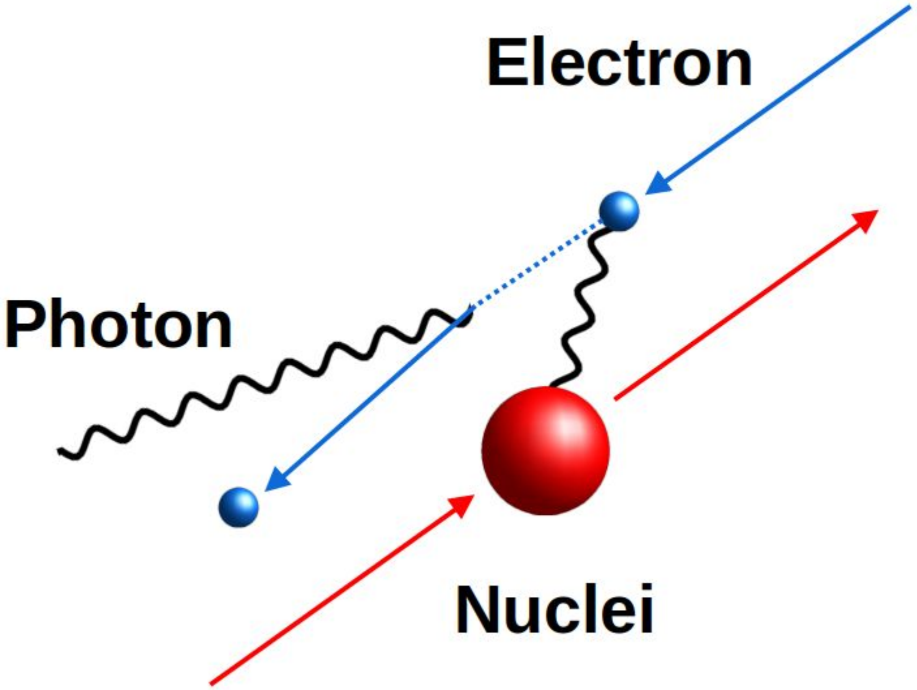
Low-Q2 Taggers — Pair Spectrometer / Direct-ɣ CAL

Jaroslav Adam, Ayanabha Das, Dhevan Gangadharan, Simon Gardner
Jan 2024 ePIC collaboration meeting

Measure the Entire Bremsstrahlung Process

1) Measure photon energy
   with Pair Spectrometer / direct-ɣ CAL
2) Measure scattered electron energy
   with low-Q2 taggers.

Powerful tool to empirically validate the acceptances and calibrations
→ reduce systematic uncertainties of
  lumi and low-Q2 measurements



$$E_{\text{scat electron}} = E_{\text{beam}} - E_{\text{brem}}$$

Considerations

1) Need low-lumi runs (e.g. start of EIC) to ensure 1-to-1 correspondence of scat electron in taggers and brem photon in PS / direct-ɣ CAL.

2) Need to lower the PS analyzer B field to ensure overlapping acceptances.

In-bunch pileup due to bremsstrahlung

- Multiple bremsstrahlung interactions in a single bunch xing (in-bunch pileup)
- Mean number of interactions in bunch xing (Poisson mu) depends on cross section and instantaneous luminosity L_inst
- Table shows 18x275 GeV, E_gamma > 1 GeV, evaluated with GETaLM generator
- We'll need steps in decreasing L_inst to map the in-bunch pileup

L_inst x 10^33 cm^-2s^-1	Poisson mu
1.54 (nominal)	8.31
1	5.4
0.1	0.54
0.001	0.005

- The L_inst must scale by decreasing bunch intensity (charge in each bunch), not by number of bunches around the ring

Considerations

Electron bunch intensity will need to be decreased in several steps until <= 1 track in taggers. Possibly need ~ x50 reduction in lumi: $\mathcal{L}_{coinc} = \mathcal{L} / 50$.

How long to gather enough stats?

Say we need 1 M coincidences:

1 M = (rec photons in PS/bunch-Xing) * (bunch-Xing frequency) * Time

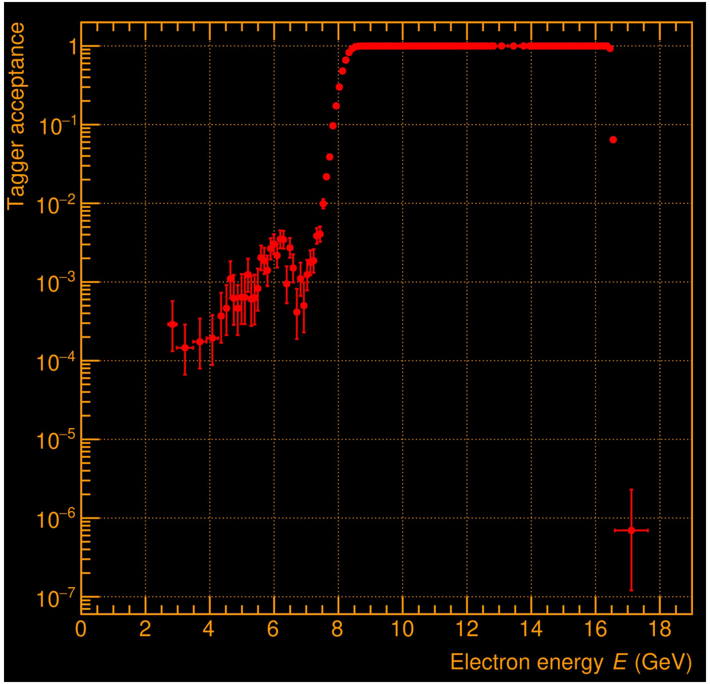
1 M = (f_{conv} * $\mathcal{L}_{coinc}$ * σ_{eff} * time/bunch) * (1/ (10 nsec)) * Time

1 M = (0.0001) * (1/(10 nsec) * Time

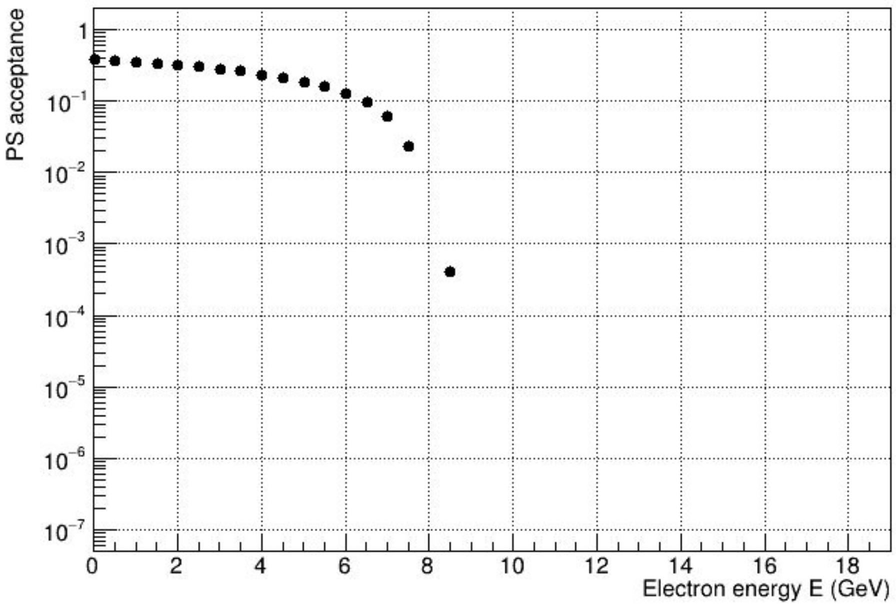
Time = 100 sec

Acceptances

Low-Q2 Taggers



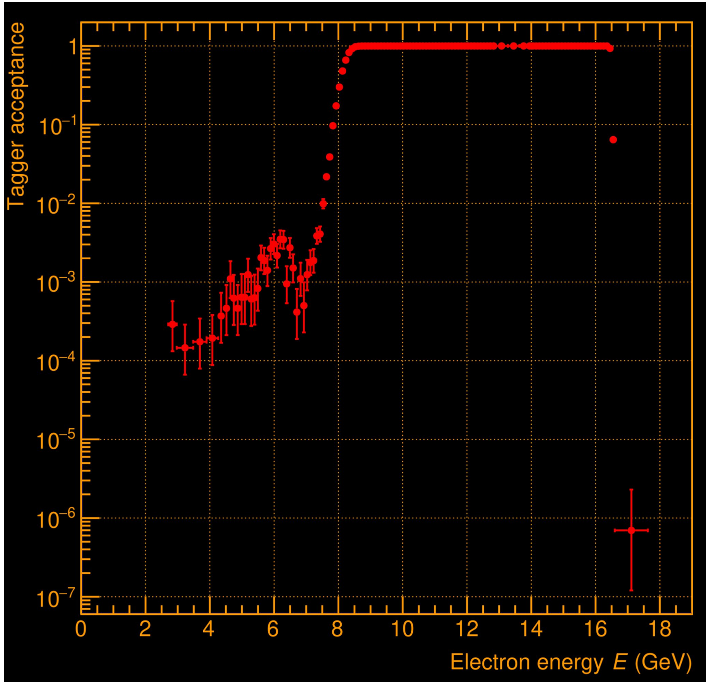
Pair Spectrometer (Full Field:nominal)



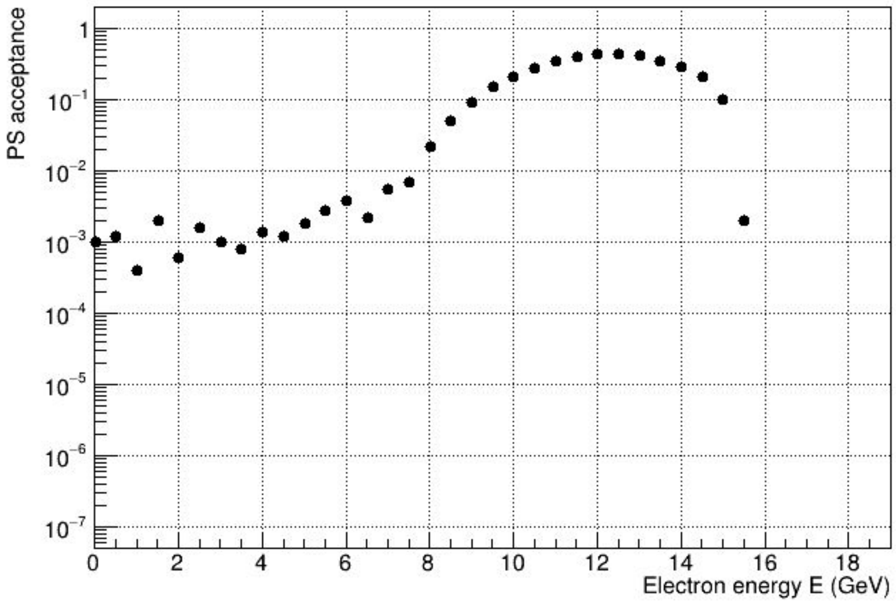
❌ Practically no overlap with the PS analyzer magnet at full field.

Acceptances

Low-Q2 Taggers



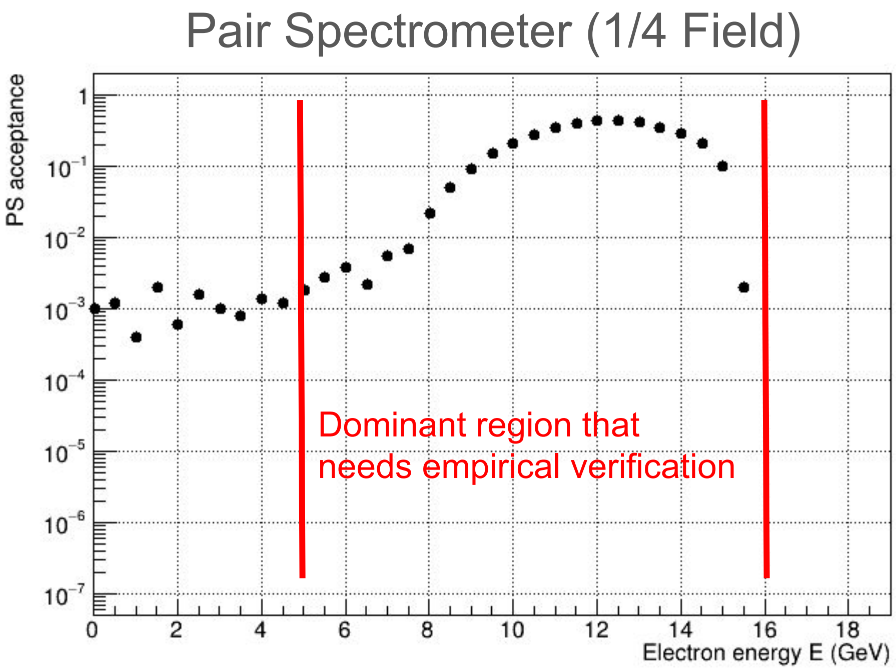
Pair Spectrometer (1/4 Field)



✅ Overlap between about 8 and 15 GeV.

However, still desirable to shift PS acceptance more to right (lower current).

Acceptance Verification



Goal for PS

- **Empirically verify this MC-produced acceptance function.**
- Can be measured “directly” with tagger-PS coincidences:
  Get $E_{scat\ electron}$ from taggers and look for coincidence signal in PS, or vice-versa.

Acceptance was the main uncertainty for ZEUS luminosity.
There was no coincidence program at ZEUS.

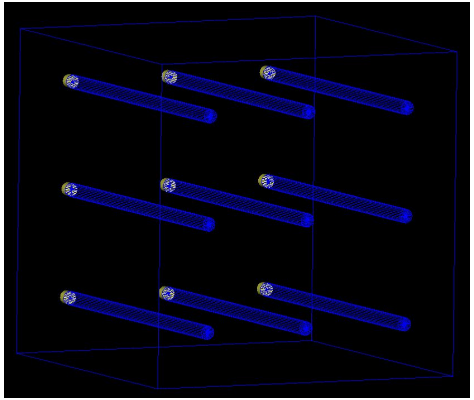
$$E_{scat\ electron} = E_{beam} - E_{brem}$$

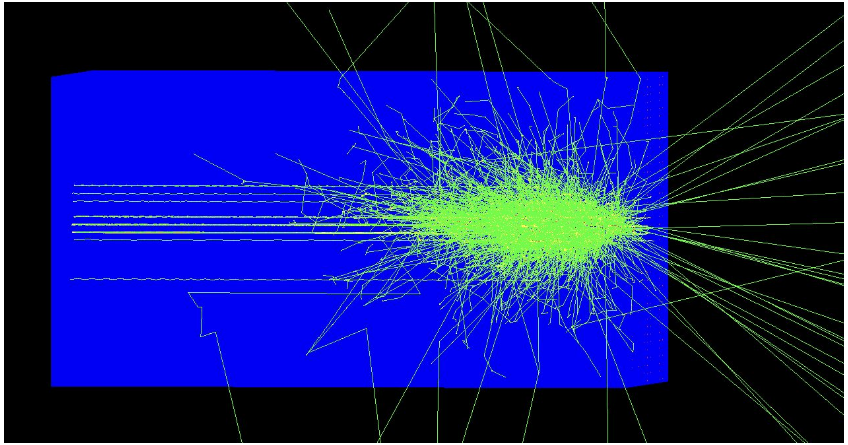
Direct Photon Calorimeter

- **One possibility:** $PbWO_4$ homogeneous calorimeter (PWO)

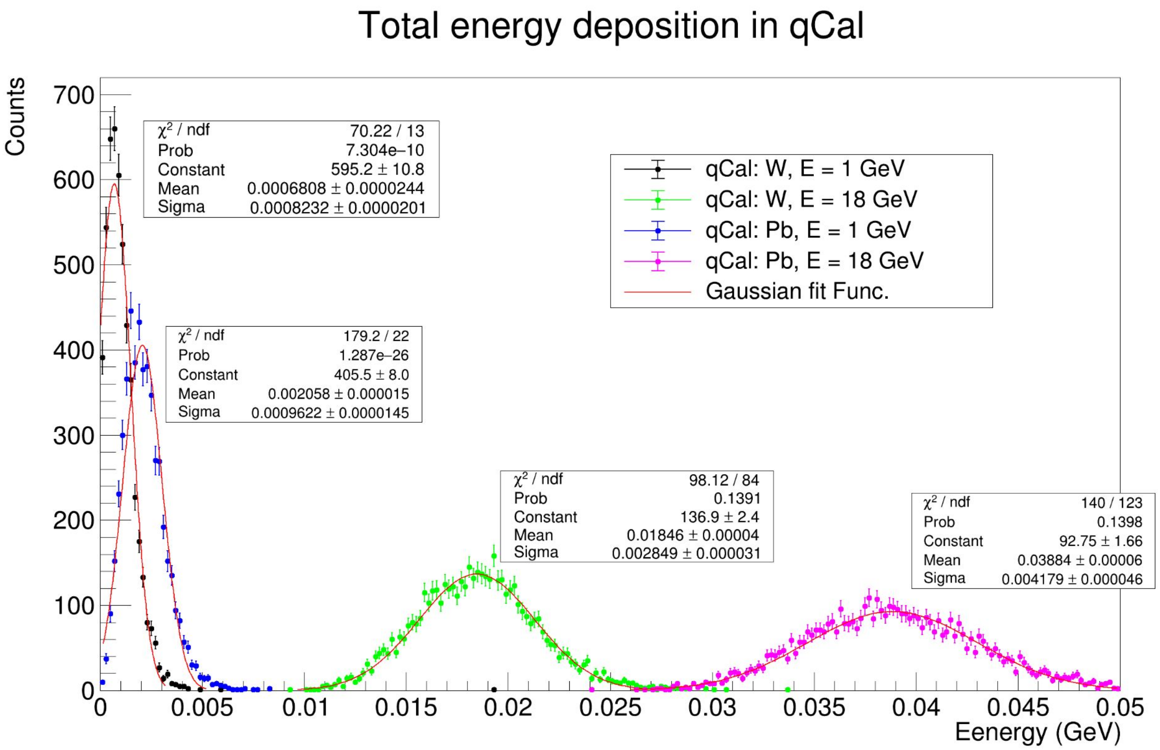
  (Conclusion: Efficiency of the scintillation light yield fluctuates with the temperature variation)

- **Second possibility:** Quartz (SiO_2) fiber calorimeter (QCAL)
  - Size-xy: 16 cm, Size-z: 30 cm
  - Fiber details: r_{core} = 500 μm, r_{clad} = 540 μm, and dx = 4 mm
  - Absorber material: W or Pb





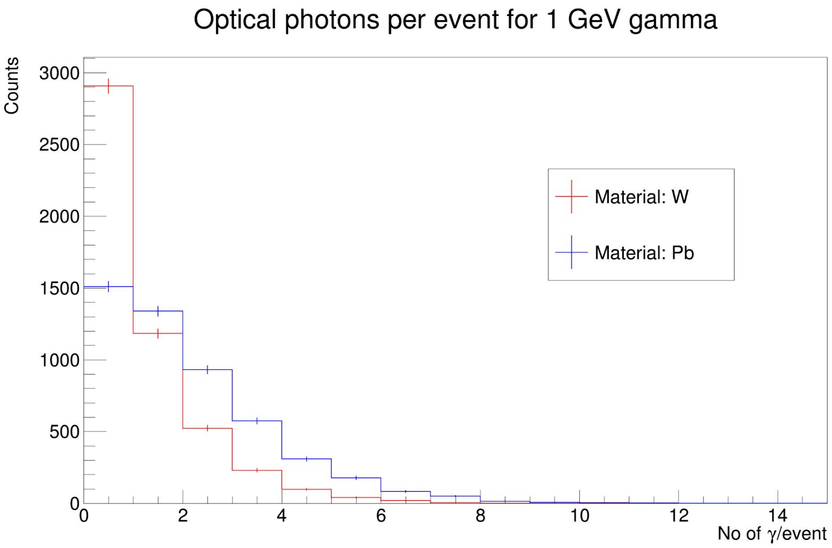
Energy Deposition

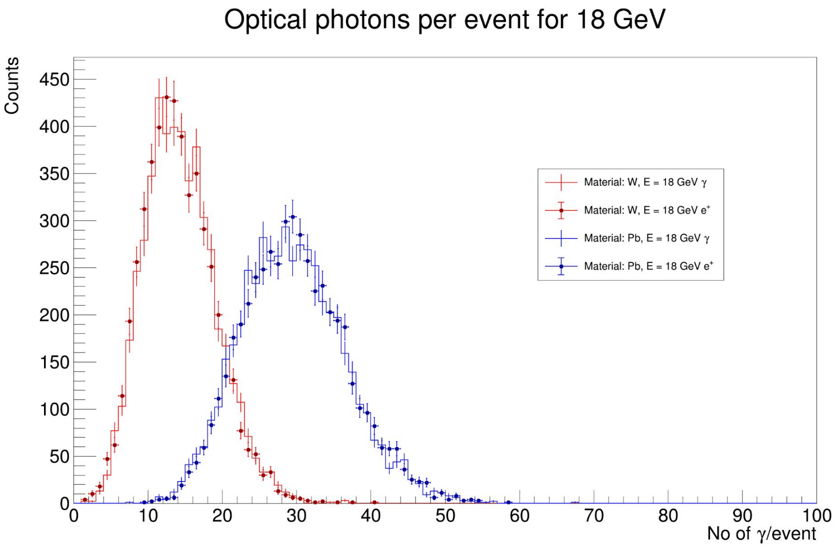


Gaussian fitting of E_{tot} for 1 and 18 GeV photon with different absorber material

➔ Event statistics: 5000

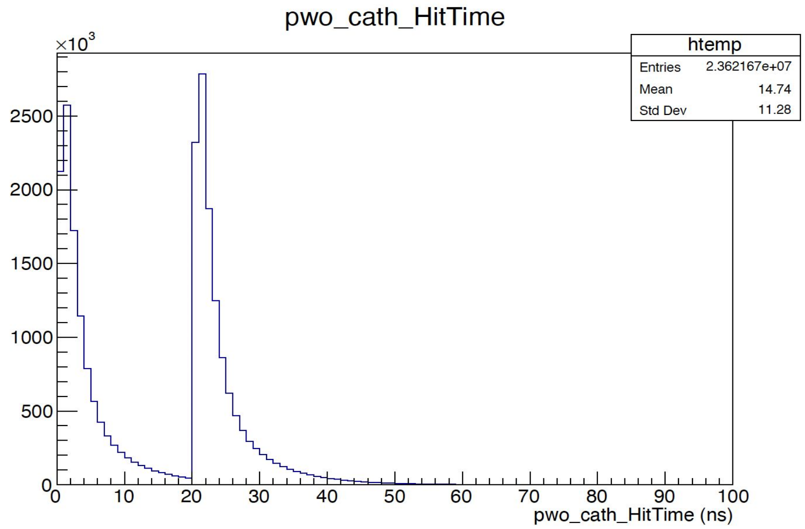
Optical photon production

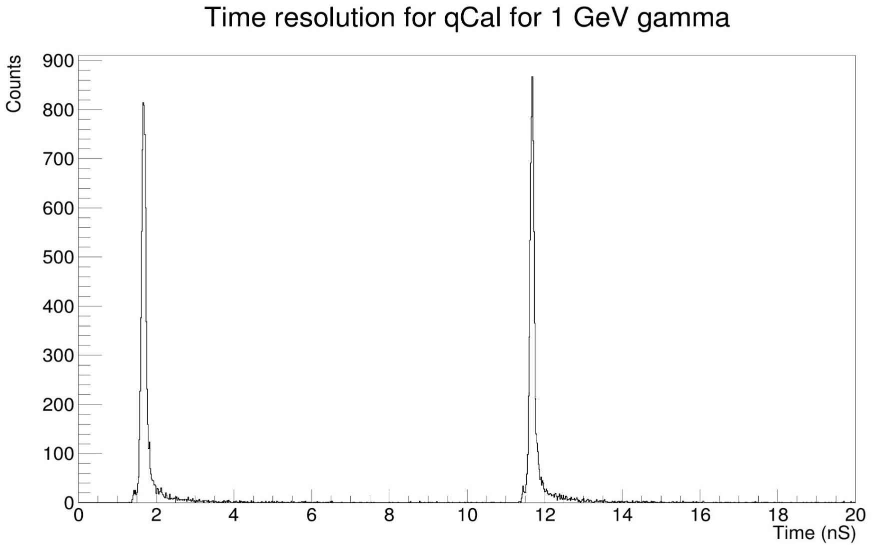




- Event statistics: 5000
- Comparison of optical photon counts reaching at the end of fiber for different energies, particle gun and absorber material

Light collection time





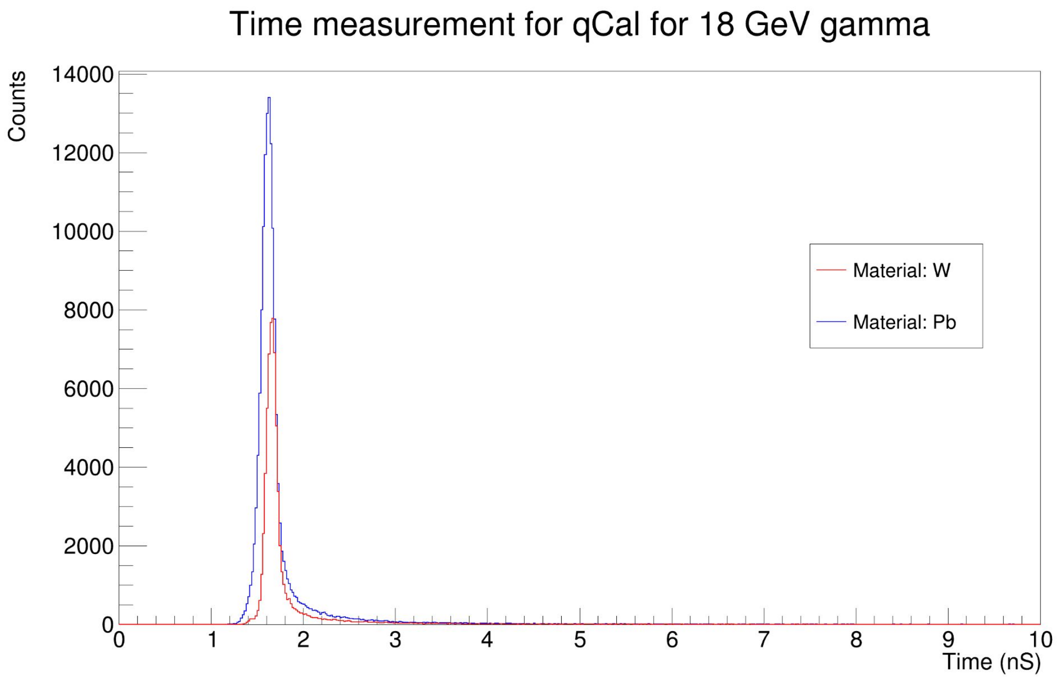
PWO hit time

- ➔ Event statistics: 1000
- ➔ E_γ = 1 GeV
- ➔ Scintillation light yield
- ➔ Time difference: 20 ns

QCAL hit time

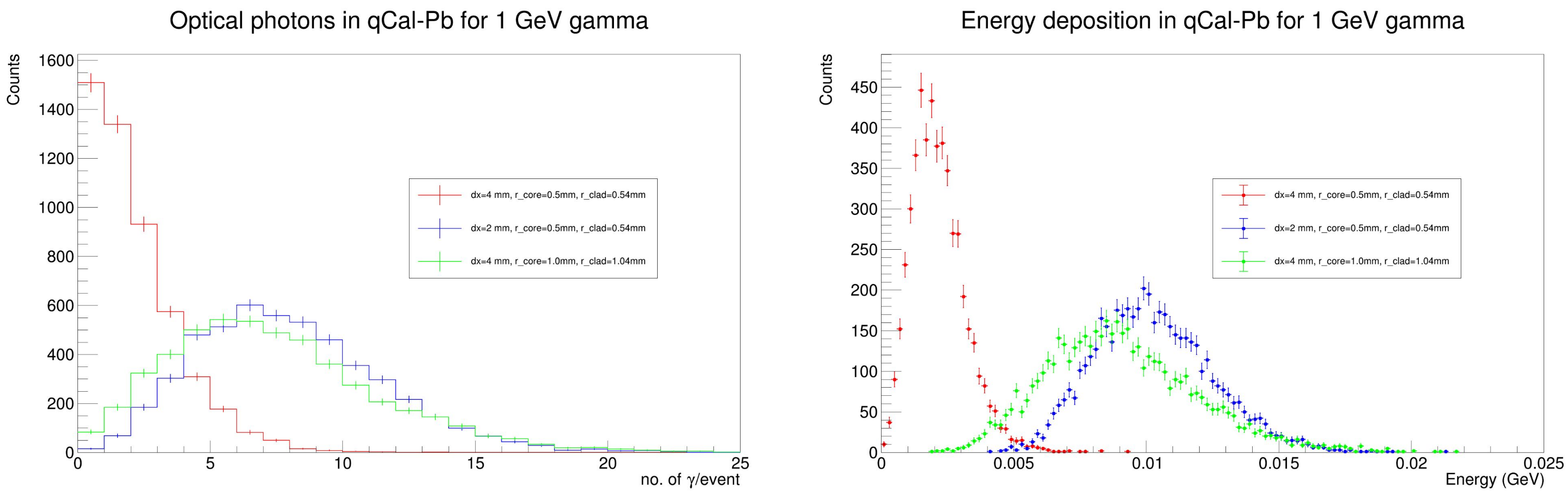
- ➔ Event statistics: 5000
- ➔ E_γ = 1 GeV
- ➔ Cherenkov light yield
- ➔ Time difference: 10 ns

Light collection time



- Event statistics: 5000
- Comparison of optical photon production for different absorber material

Fiber configuration



- Material: Pb
- Event statistics: 5000
- E_γ = 1 GeV

➔ Checks on fiber spacing and core, clad radius

Future steps

- ❖ Study of detailed quartz fiber configuration for better light collection yield
- ❖ Finalize absorber material for optimal shower formation from bremsstrahlung
- ❖ Include SiPMs into the lmon simulation
- ❖ Measurements of energy and time resolution in EIC regime