Direct Photon Calorimeter

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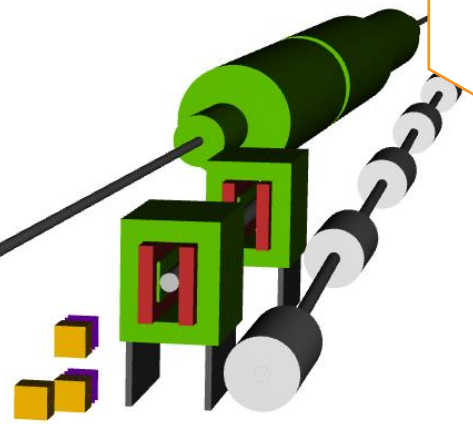
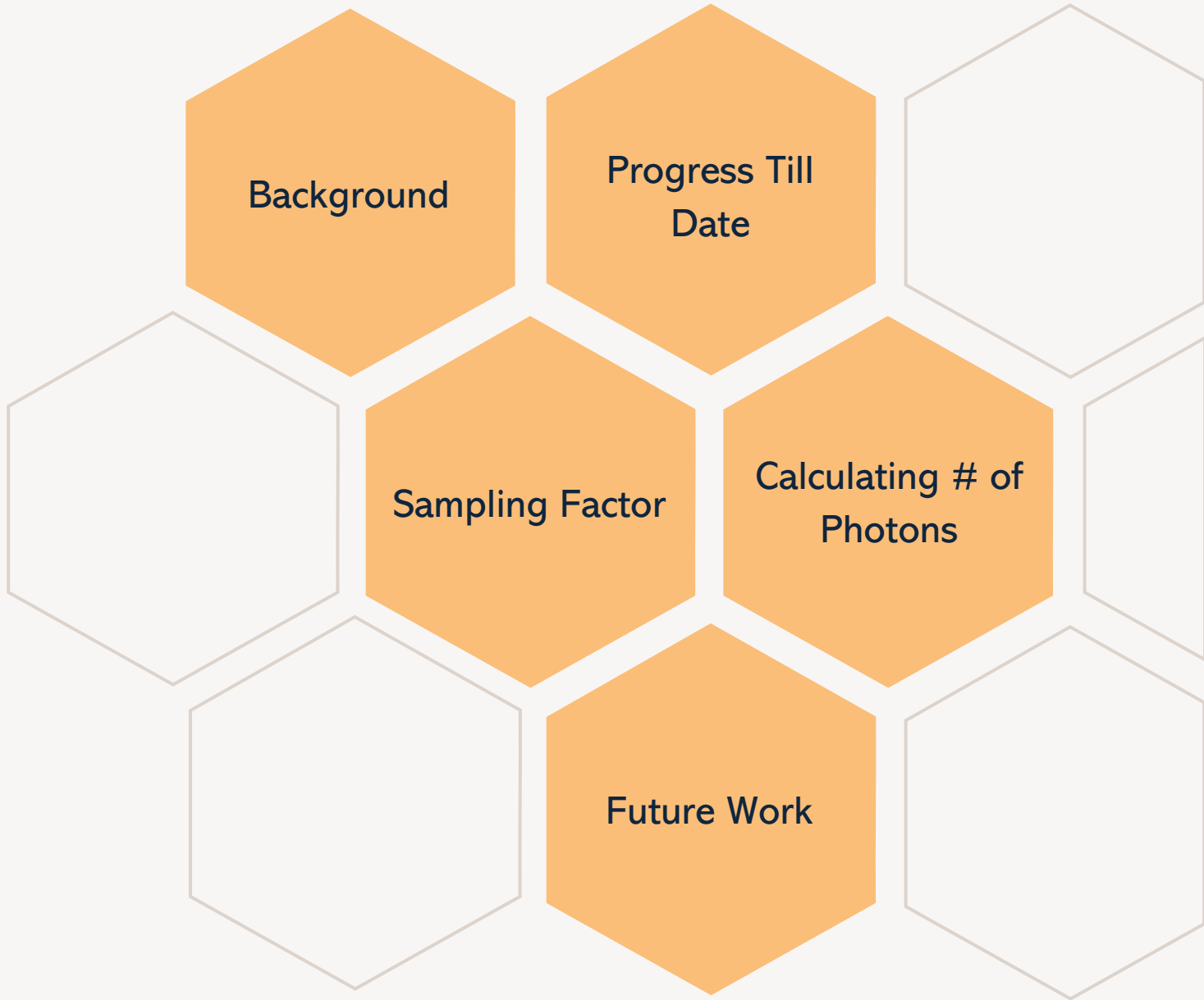


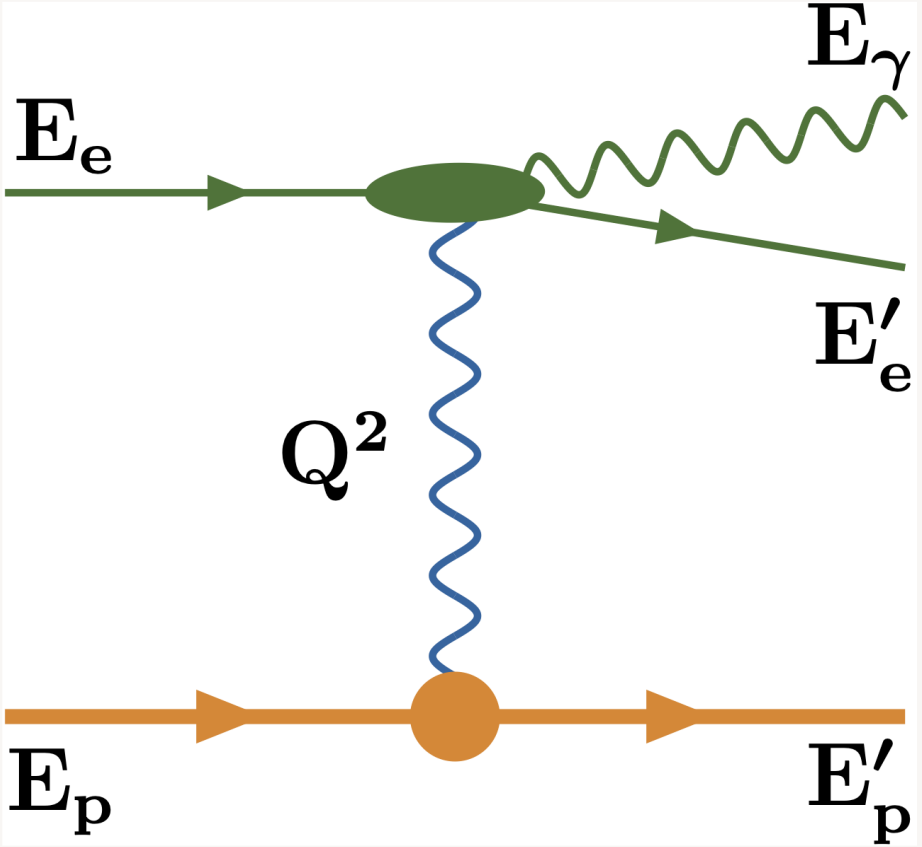
Agenda


Background
Progress Till Date
Sampling Factor
Calculating # of Photons
Future Work

Background

EIC requires a precise calculation of Luminosity using the bremsstrahlung process. Which poses 3 challenges:

- Bremsstrahlung rate suppression due to Bean-Size Effect
- Huge synchrotron radiation fluxes
- Enormous Bremsstrahlung event rate



Piotrzkowski, K. (2021). *Challenging luminosity measurements at the Electron-Ion Collider.* https://doi.org/10.1088/1748-0221/16/09/P09023, accessed 11/10/2023

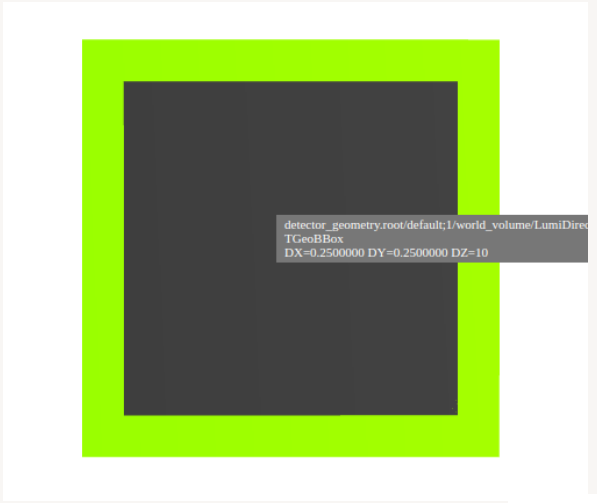
The Design is identical to one of the older Spectrometer design.

Position: $(0,0,-71.70)\ m$

Dimension: $(0.2,0.2,0.2)\ m$

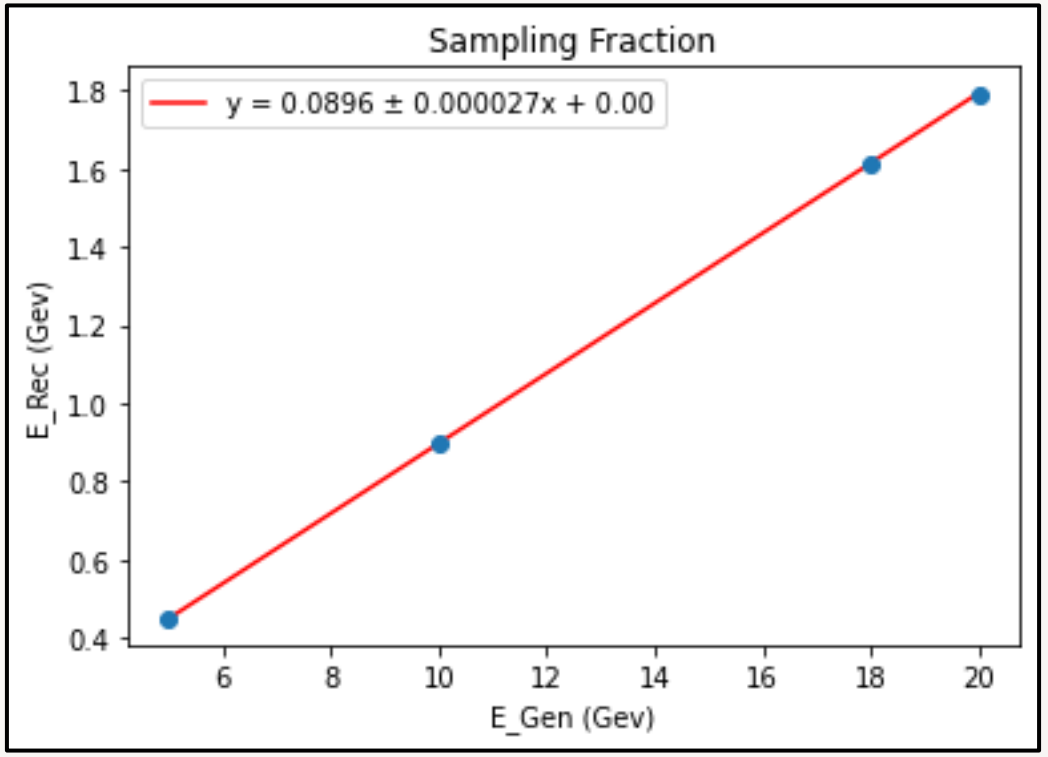
($5.0\ mm^2$ * Length) Tungsten 1600 Modules alternating in x and y directions

($4.0\ mm^2$ * Length) Plastic Scintillating Fiber within them



Sampling Fraction

- DPCAL is a Sampling Scintillation calorimeter
- It does not have a 1 to 1 conversion factor.
  - That is, if we receives a 1 GeV photon, the number of entries and the energy measured from each entry that results from scintillation does not add up to 1 GeV.
- Our simulations show the sampling factor to be $S_f = 8.96 \pm 0.0027$ %



Data from the simulations

# of Events	Energy (GeV)	Multiplicity	$G4_{Hits}$	Mean Energy Per Hit
500	5	1	112490	0.001995
500	5	2	170133	0.002635
500	5	3	211649	0.003138
500	10	1	170648	0.002631
500	10	2	247032	0.003632
500	10	3	299849	0.004484
500	18	1	233894	0.003449
500	18	2	326950	0.004938
500	18	3	388577	0.006235
500	20	1	247348	0.003618
500	20	2	343146	0.005223
500	20	3	405833	0.006634

Goal: To Calculate the Multiplicity of an event

Question: How would we get the number of Photons per bunch crossing (or per event in our simulations) from the Total Energy deposited by the event.

- We ran a simple uniform distribution of Photon energies.
  - 500 events
  - Each event had a multiplicity of 10
  - With a uniform distribution of energies between 4 and 18 GeV
- Results

# of Events (n)	Mean Energy (GeV)	Multiplicity	$G4_{Hits}$	Mean Energy Per Hit
500	$\langle 11 \rangle$	x_m	496726	0.009871

- Calculations

$$E_{TotalGen} = n * x_m * \langle Mean\ Energy \rangle * S_f = E_{TotalRec}$$
$$x = 9.93$$

Future works

Bethe-Heitler Curve

- Calculate Multiplicity of an event with a Bethe-Heitler distribution of energies.

Calculating Luminosity

- $f\langle E_\gamma \rangle = LA_\gamma(1 - C_\gamma^*) \int_{E_\gamma,min} E_\gamma \, d\sigma$
- Here $f \cong 100$ MHz is the bunch crossing rate, $\langle E_\gamma \rangle$ is the measured average sum of photon energies, in a single bunch crossing, of $e\text{-}ion$ bremsstrahlung (i.e. after subtracting contributions from the $e\text{-}gas$ bremsstrahlung, and the SR), L is the EIC luminosity, the geometrical acceptance $A_\gamma > 0.99$ is the probability of a bremsstrahlung photon to reach the exit window, and $C_\gamma^* = C_\gamma - \epsilon$ where C_γ is the photon conversion factor and $\epsilon \cong \frac{9C_\gamma^2}{14}$ is an average fraction of the incident photon energy detected via the "secondary" bremsstrahlung of e^+e^- in the exit window; for a 5(10) mm thick aluminum exit window $1 - C_\gamma^* = 0.961(0.924)$.

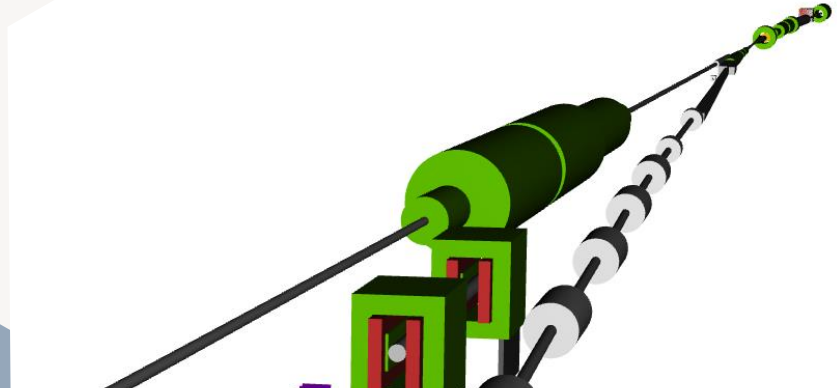
Material Changes

- Incorporating Quartz fiber instead of Tungsten Scintillating Fiber.

Summary

We have made some good progress in terms of positioning the detector and working out if the simulations work or not.

We still have much more progress to make in terms of Bethe-Heitler Curve integration and ultimately calculating the Luminosity.



Thank you

Yug

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Refrences

- Fabjan, C. W., & Gianotti, F. (2003). *Calorimetry for Particle Physics*. https://cds.cern.ch/record/692252/files/ep-2003-075.pdf, accessed 11/11/2023

- Piotrzkowski, K. (2021). *Challenging luminosity measurements at the Electron-Ion Collider*. https://doi.org/10.1088/1748-0221/16/09/P09023, accessed 11/10/2023