Construction and Optimization of a Compton Polarimeter

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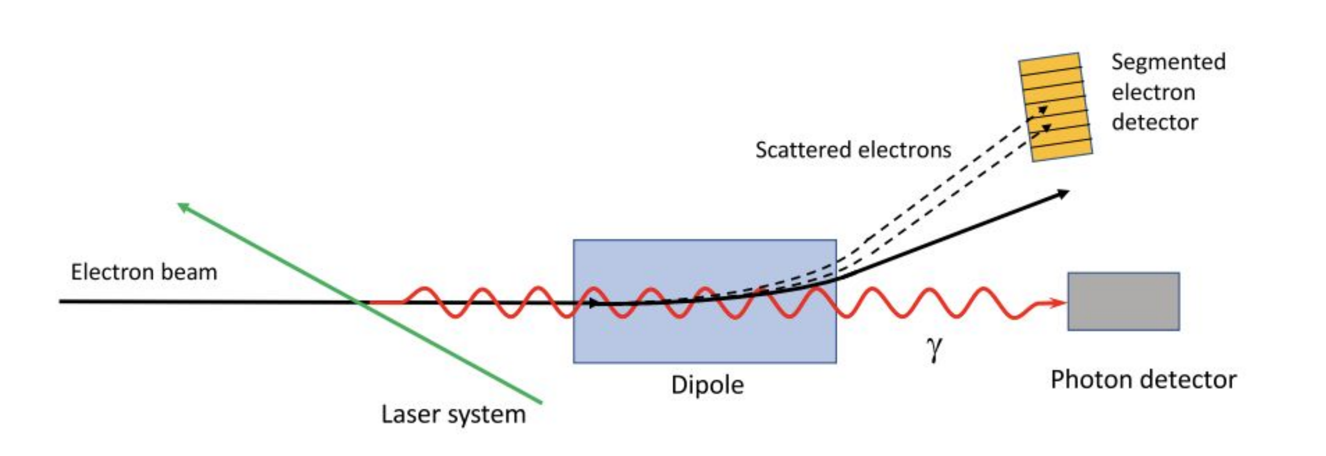
What is Compton Scattering?

- elastic scattering of an electron and a photon.
- Compton polarimeter uses a laser (photon) which collides nearly head-on with a high-energy electron beam
  - Photon is scattered and raised to high energy in opposite direction.
  - Polarimeter detects back-scattered photon, scattered electron, or both.



Calibration Considerations

- What energy range does a Compton polarimeter work best at?
- How to account for weighting in asymmetry computations
- What is the maximum length scale to detect asymmetry?

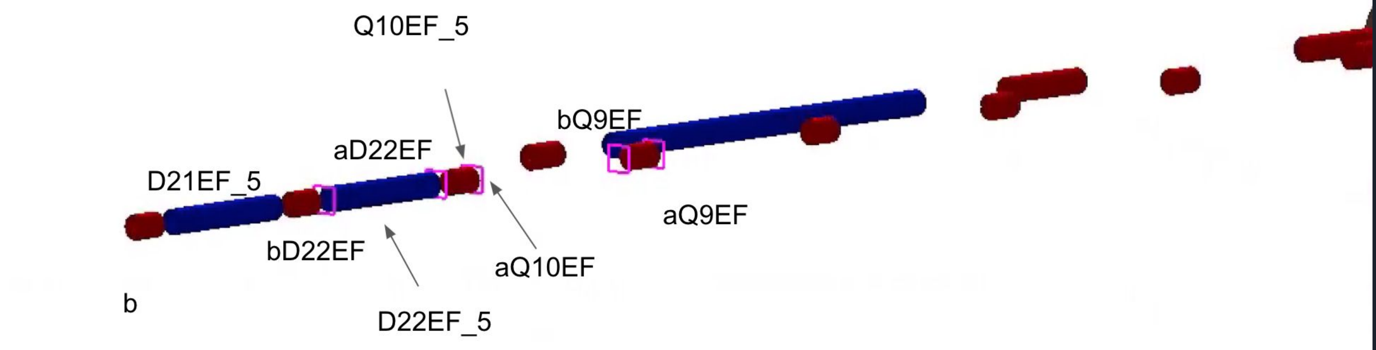
Energy Range

- Energy can be calculated using $E=hc/\lambda$ or $\lambda'-\lambda = (h/mc)(1-\cos\phi)$
- Given
  - λ = 532 nm = 5.32*10^-7 m
  - $E = hc/\lambda$
  - h= 4.1357*10^-15 eV*s
  - c = 3.0*10^8 m/s
- E = 2.332161654 eV
- EIC and Compton polarimeters work best at large energies ~5-20 GeV
- This is much greater than calculated, by a magnitude of <9.
- If the photon energy is to the order of eV, an electron beam with a range of 5-20GeV will transfer a large amount of energy to the photon during collision.

Asymmetry

- Idea: If an experiment were to be flipped across an axis, the results would be exactly the same
- Asymmetry occurs when this does not happen
- For an accelerator/polarimeter:
  - Particles become polarized as they pass through the experiment. A left-right asymmetry is found by considering the number of events that are left-polarized compared to the number of events that are right-polarized.

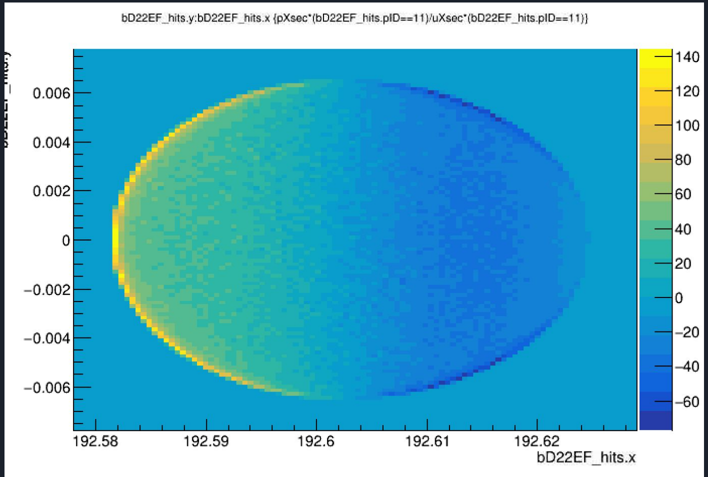
- In this experim $A_{LR}=(N_L-N_R)/(N_L+N_R)$ y polarized electron beam will create an asymmetry between the positive and negative helicities.


Q10EF_5
bQ9EF
aD22EF
D21EF_5
aQ9EF
bD22EF
aQ10EF
b
D22EF_5


Gdet_ecal
gDet

Asymmetry Predictions

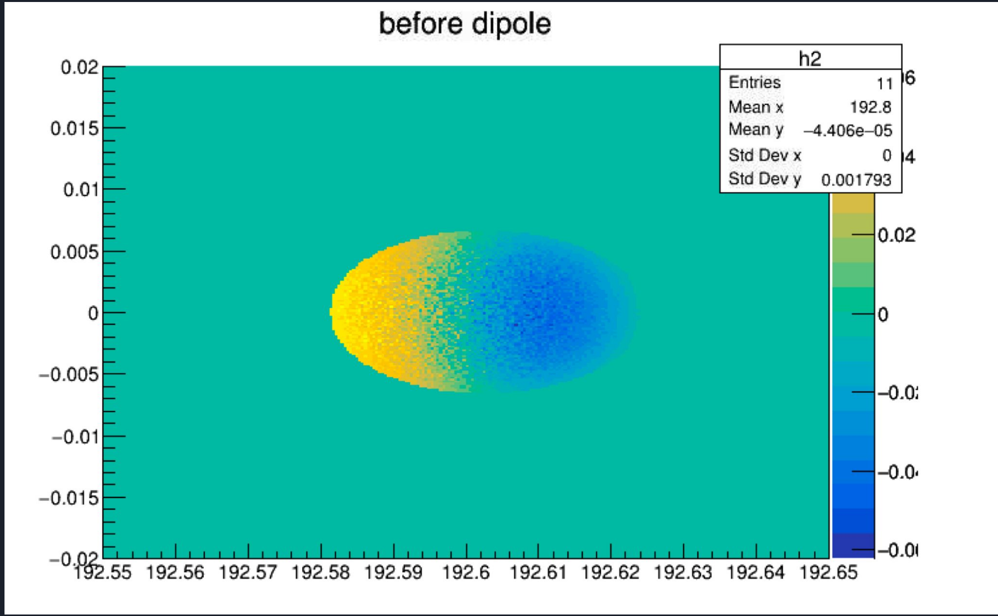
- By running programs and macros through ROOT, we can predict asymmetry measurements in a theoretical Compton Polarimeter
- By considering one detector (bD22EF) within the polarimeter, operating at 18GeV, we can map the projected asymmetry
- Here, asymmetry is found by dividing the polarized cross-section by the unpolarized cross-section. (A = pXsec/uXsec)
  - This is derived from the left-right asymmetry formula seen before, where the polarized cross-section is N+ - N- (denoting direction of photon polarization) and the unpolarized cross-section is N+ + N-
- This graph does not reliably plot asymmetry as a probability (-1.0<A<1.0)



Weighting in Asymmetry Calculations

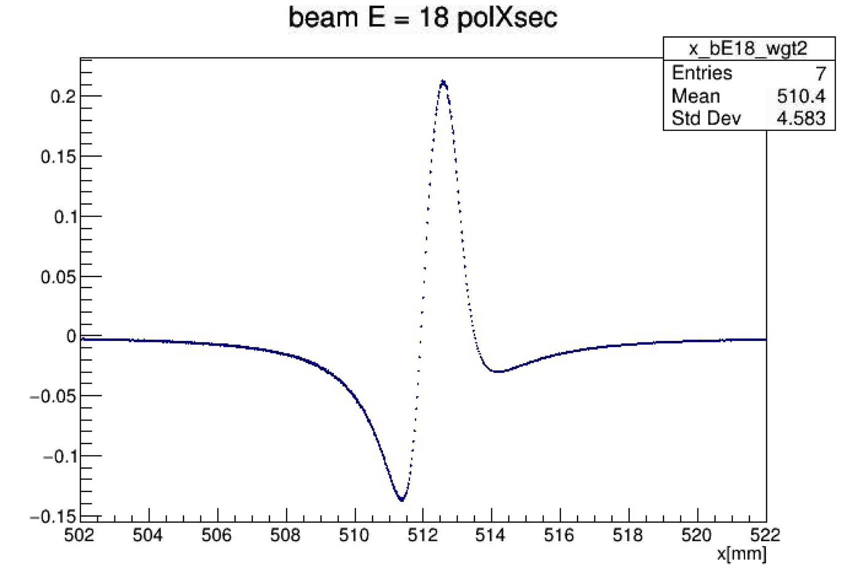
- To attain a proper probability distribution for asymmetry measurements, we must account for weighting in the polarimeter
- Certain events are more likely to occur than others
- This is done in ROOT through the histogram function:

```
TH2D *h1=new TH2D("h1","polX",300,192.55,192.65,300,-0.02,0.02);
TH2D *h2=new TH2D("h2","polX",300,192.55,192.65,300,-0.02,0.02);

t-
>Project("h2","bD22EF_hits.y:bD22EF_hits.x","pXsec*(bD22EF_hits.pID=
=11)");

 t-
>Project("h1","bD22EF_hits.y:bD22EF_hits.x","uXsec*(bD22EF_hits.pID=
=11)");
```



Next Step: Size Limitations

- When designing the Compton Polarimeter, there are size limitations that must be considered
- When plotting photon asymmetry as a function of segmentation size, a wave is produced



- If the segmentation size is too large, this wave disappears or is too small to properly interpret.
- Therefore, we must consider the maximum segmentation size possible before the wave disappears.