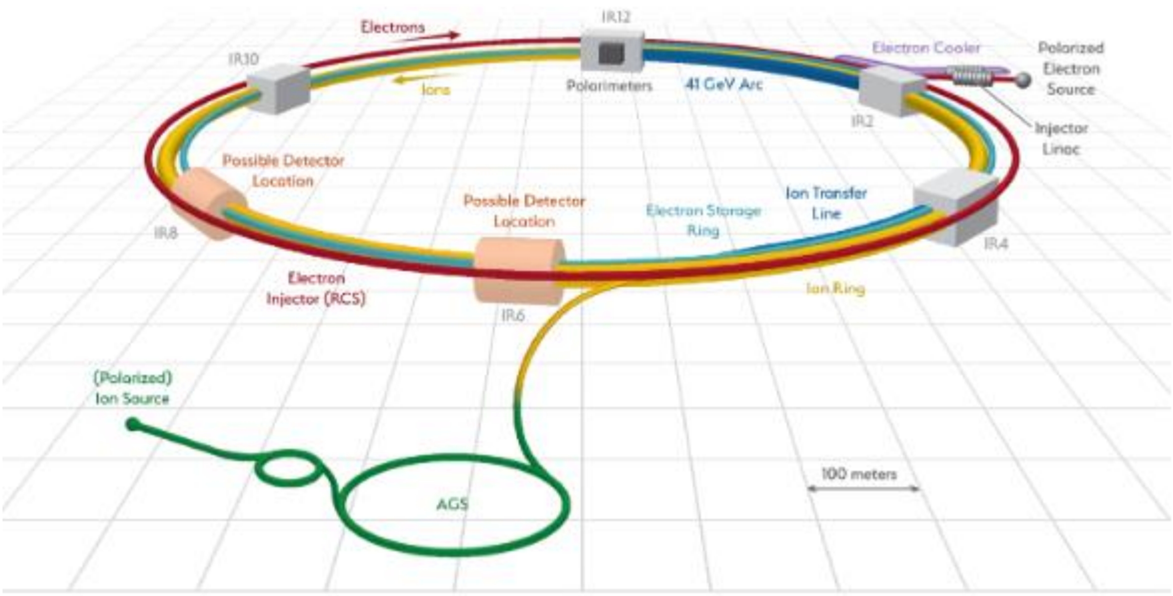

Compton polarimetry at the EIC

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e-Polarimetry requirements for the EIC

Fast

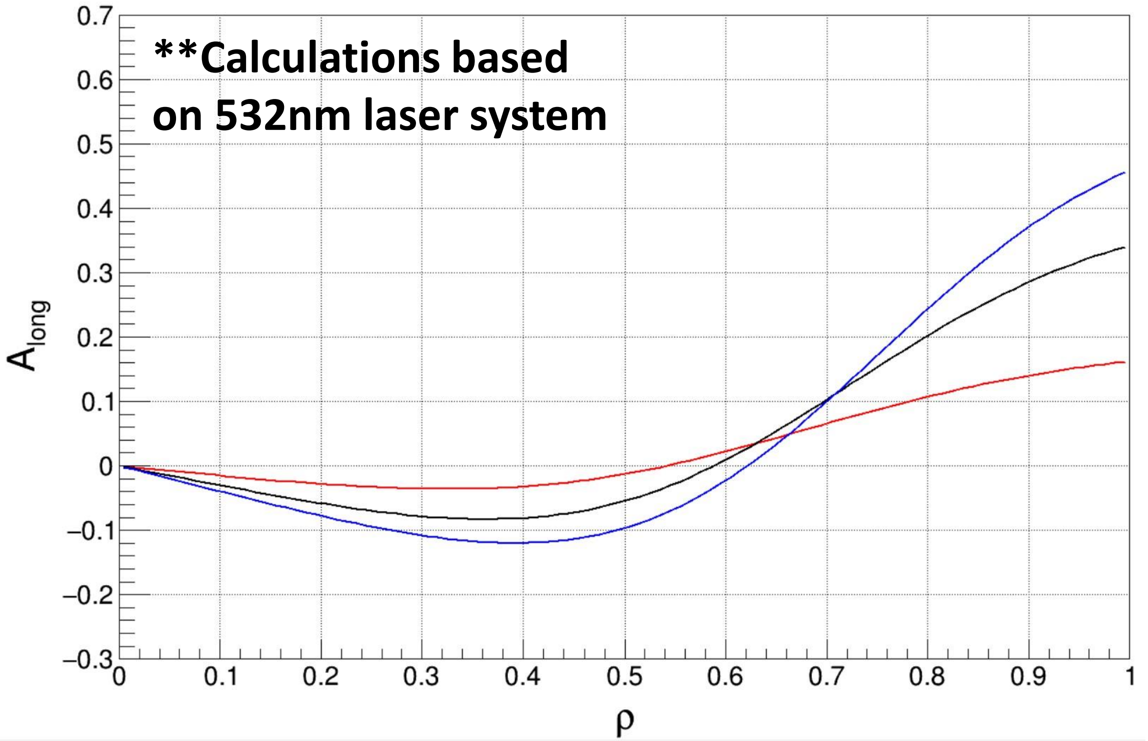
- At 18 GeV bunches will be replaced every 1-3 min
  - A full polarimetry measurement needs to happen in a shorter time span
- The amount of electrons per bunch is fairly small ~24 nC
  - will need bright laser beam to obtain needed luminosity
- A fast polarimeter will allow for faster machine setup

Precise

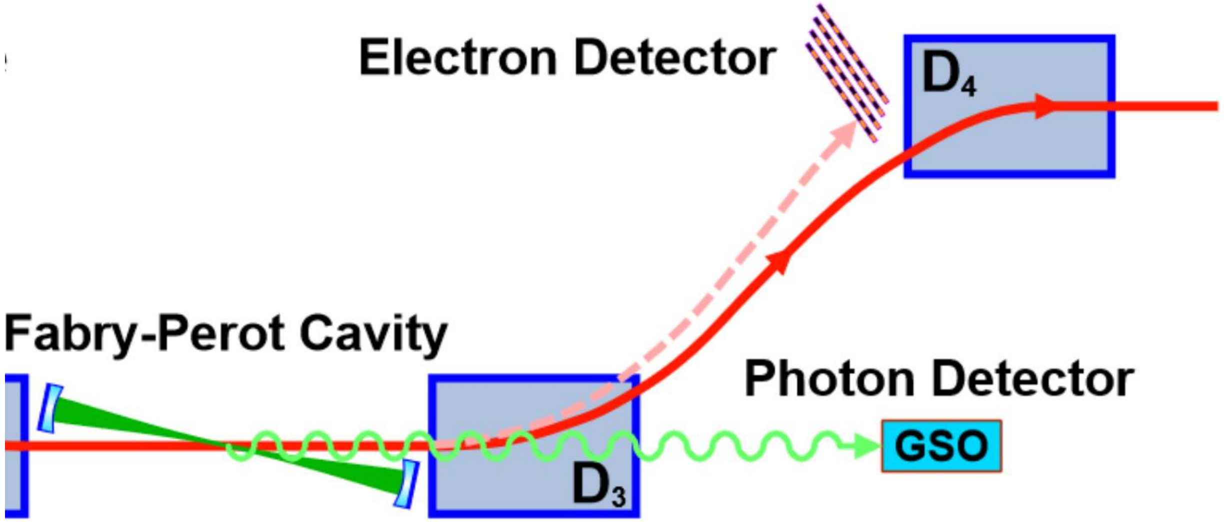
- Distance between buckets is ~10ns (@5,10 GeV)
  - bunch by bunch measurement cannot be done with a CW laser without very fast detectors
- For systematic studies we would like to have the ability to either measure a single bunch (~78kHz) or have interactions with all 1160 (260) bunches at 10 and 5 GeV (18GeV)
- Backgrounds need to be under control
- Laser polarization needs to be known to a high degree

Longitudinal polarization

$$A_{\rm long} = \frac{\sigma^{++} - \sigma{-+}}{\sigma^{++} + \sigma^{-+}} = \frac{2\pi r_o^2 a}{(d\sigma/d\rho)}(1-\rho(1+a))\left[1 - \frac{1}{(1-\rho(1-a))^2}\right]$$



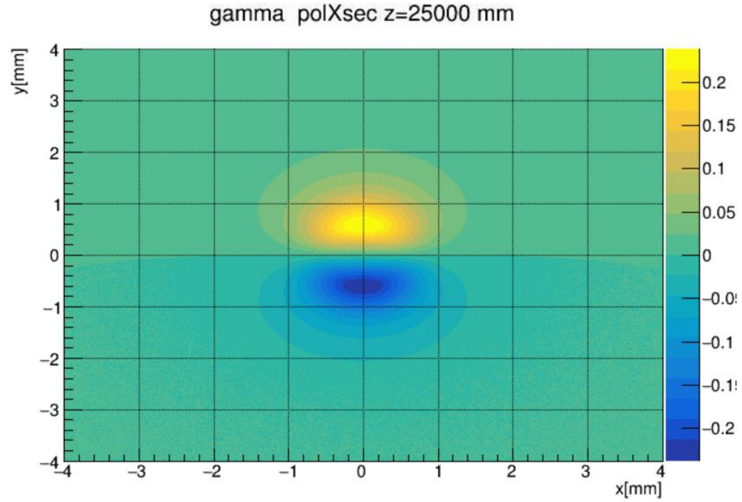
arXiv:1601:00251v2

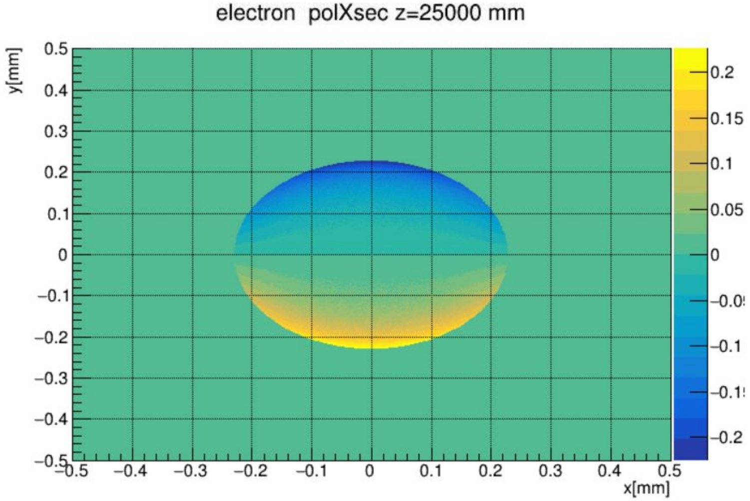


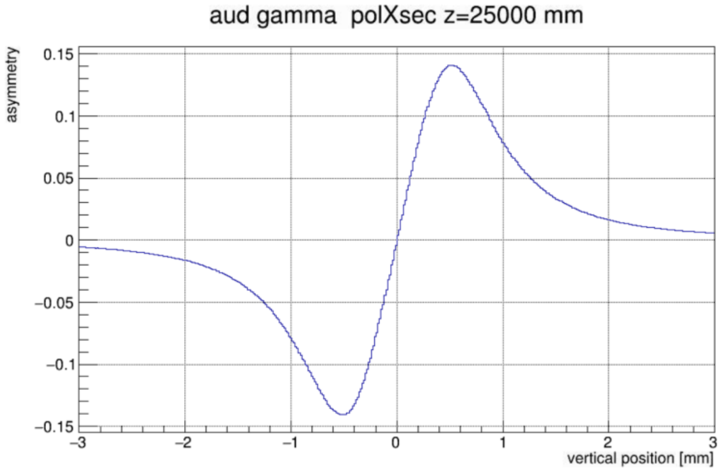
- The energy in the photon detector can measured with calorimetry while the electron is momentum-analyzed by a dipole after the interaction

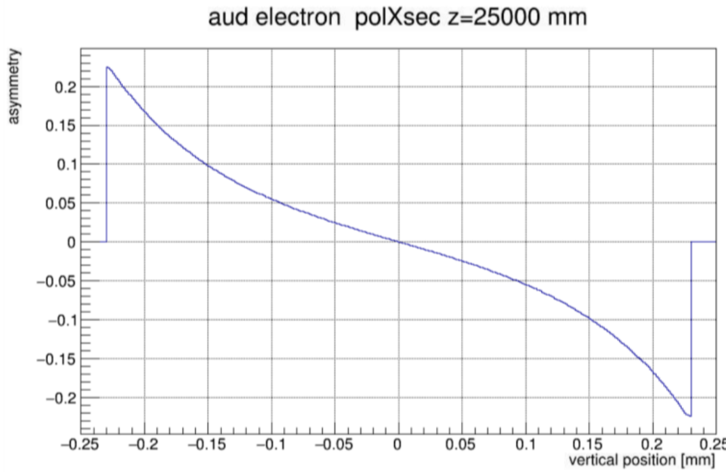
Transverse polarization

$$A_{\mathrm{tran}} = \frac{2\pi r_o^2 a}{(d\sigma/d\rho)} \cos\phi \left[\rho(1-a) \frac{\sqrt{4a\rho(1-\rho)}}{(1-\rho(1-a))} \right]$$



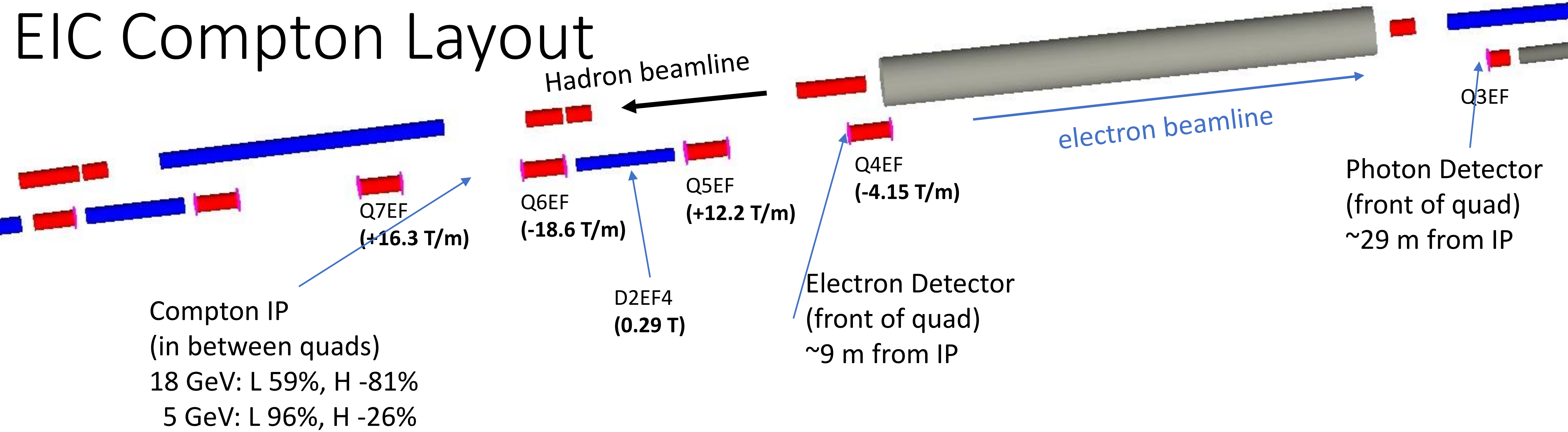






- Asymmetry is usually measured with respect to the vertical axis
  - The scattered electron reaches the largest analyzing power at large scattering angles
- The higher the energy the tighter the collimation for the scattered photons will be
  - This can lead to significant constraints on detector segmentation

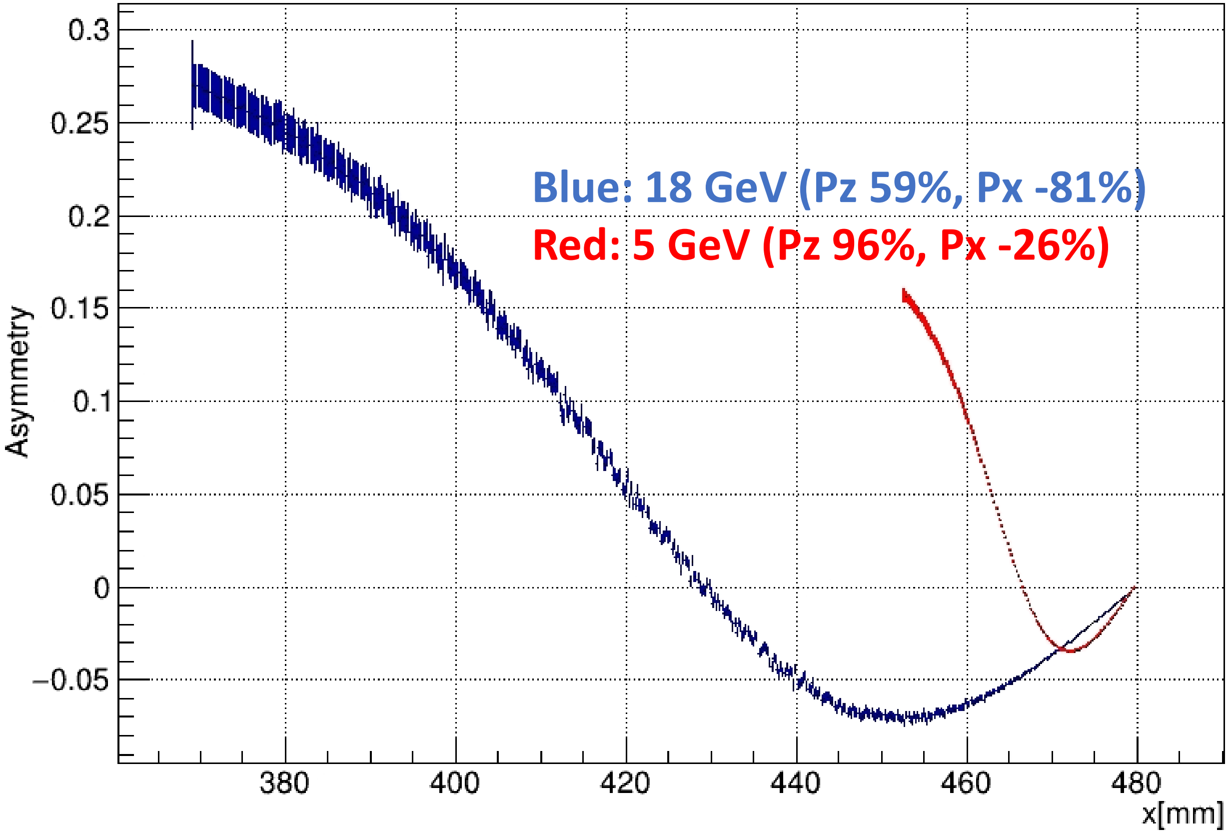
EIC Compton Layout



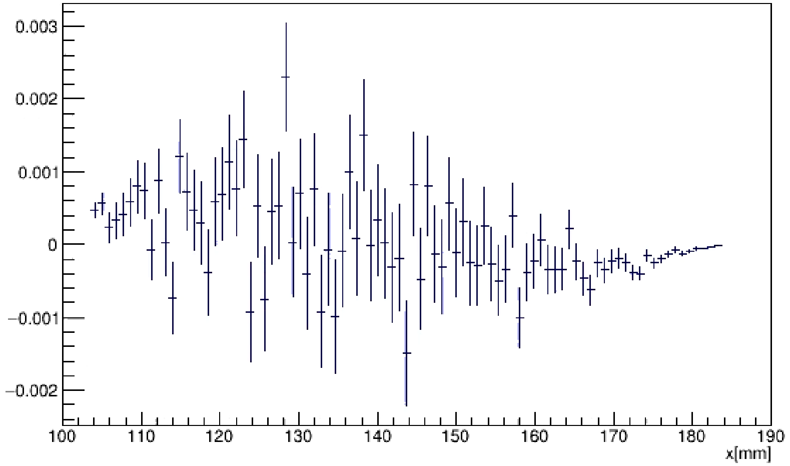
- The current configuration allows for the interaction point to be in a magnetic field free region reducing the complexity at the interaction point and allows for relatively access to insert the laser beam
- The electron detector is placed after a dipole which has enough power to energy analyze the scattered electrons at all energy set points
  - The Quad after the dipole is horizontally defocusing increasing the effectiveness of the dipole
- One downside of this configuration is that the dipole upstream of the interaction region may produce significant synchrotron radiation that may reach the electron detector

Scattered electrons

- The scattered electrons produce significantly different positional distributions at the detector location in the different configurations
- The analyzing power here probes only the longitudinal components of the electron beam polarization
- Because of the magnetic configuration the transverse component is actually washed out by the dipole so the electron detector will be blind to it
  - Horizontal polarization going into a horizontal bend dipole resulting in a spread of the L-R asymmetry that is on the level of microns making it not measurable

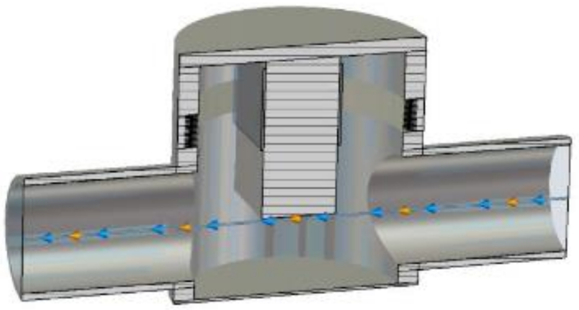


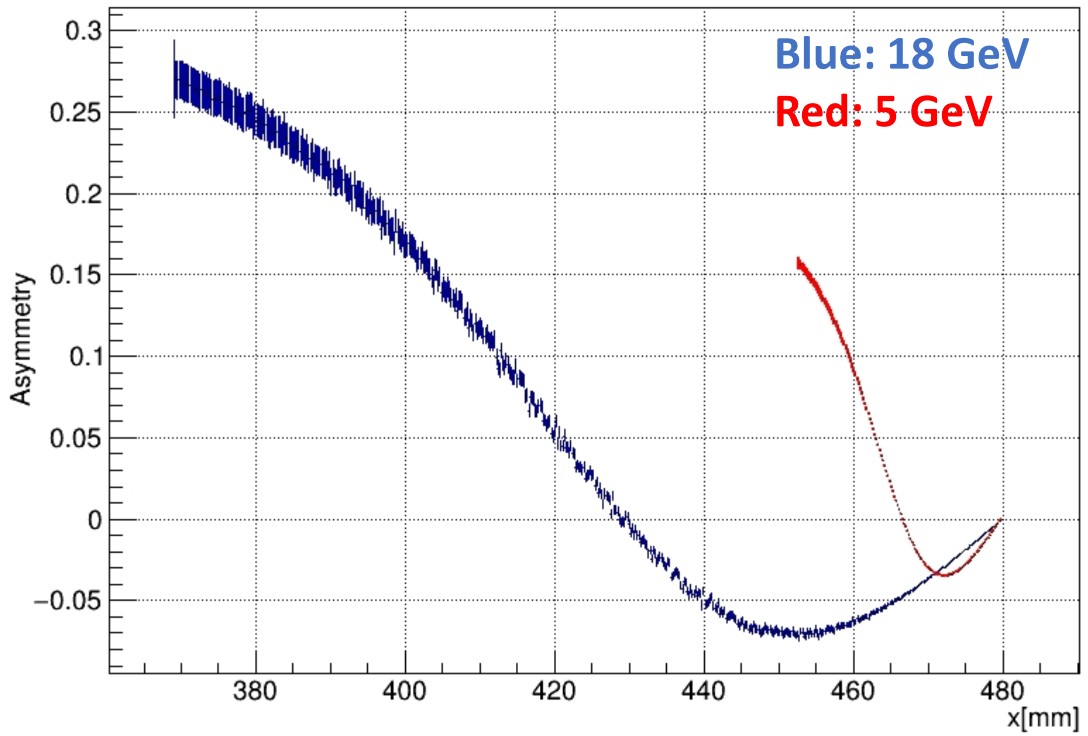
18GeV eDet(bQ9) polXsec



Electron detector challenges

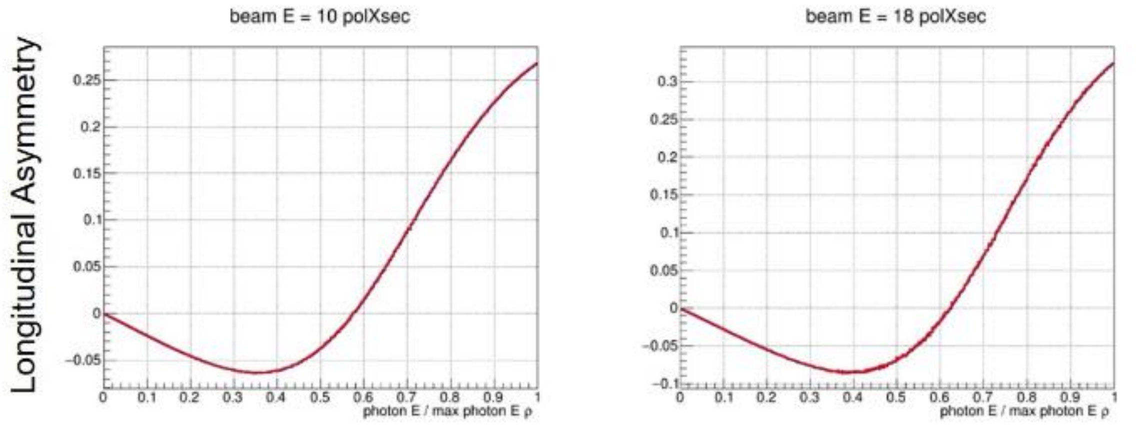
- Getting close enough to the beam to capture the 0-crossing is going to be the biggest challenge
- The vacuum vessel for the detector and moving mechanism (similar to a Roman Pot) will need to be carefully designed to take into account power depositions
- Only horizontal segmentation is going to be required with only modest requirements (5 GeV configuration will set the pitch while the overall size will be given by the 18 GeV configuration)
  - At JLab we obtained very good results with approximately 30 bins from the Compton edge to the 0-crossing leading to about 0.5mm pitch

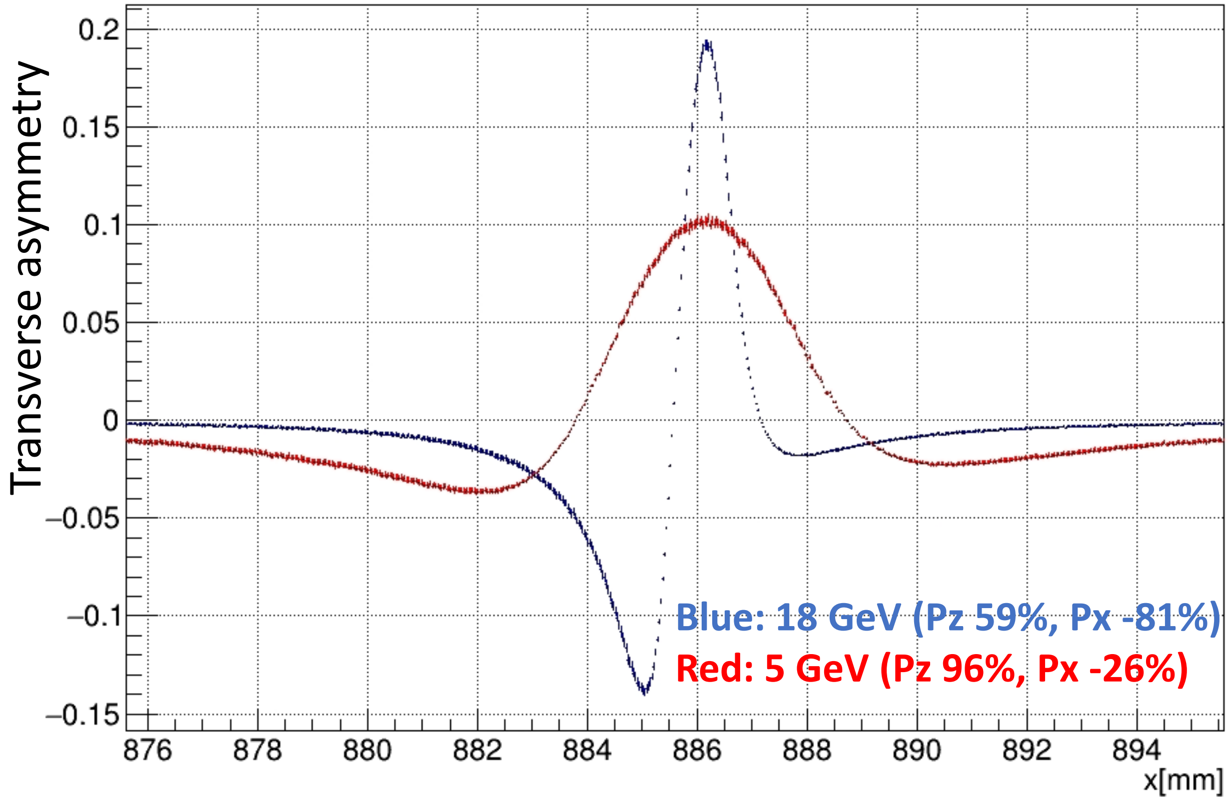




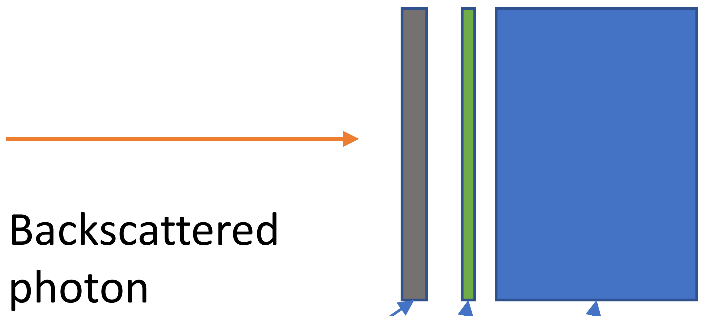
Scattered photons

- The scattered photons will carry information about both the longitudinal and transverse electron beam polarization
  - The longer travel distance from the IP makes the transverse measurement manageable
- To extract this information a combination of position and energy information for each photon is required





Photon detector concept



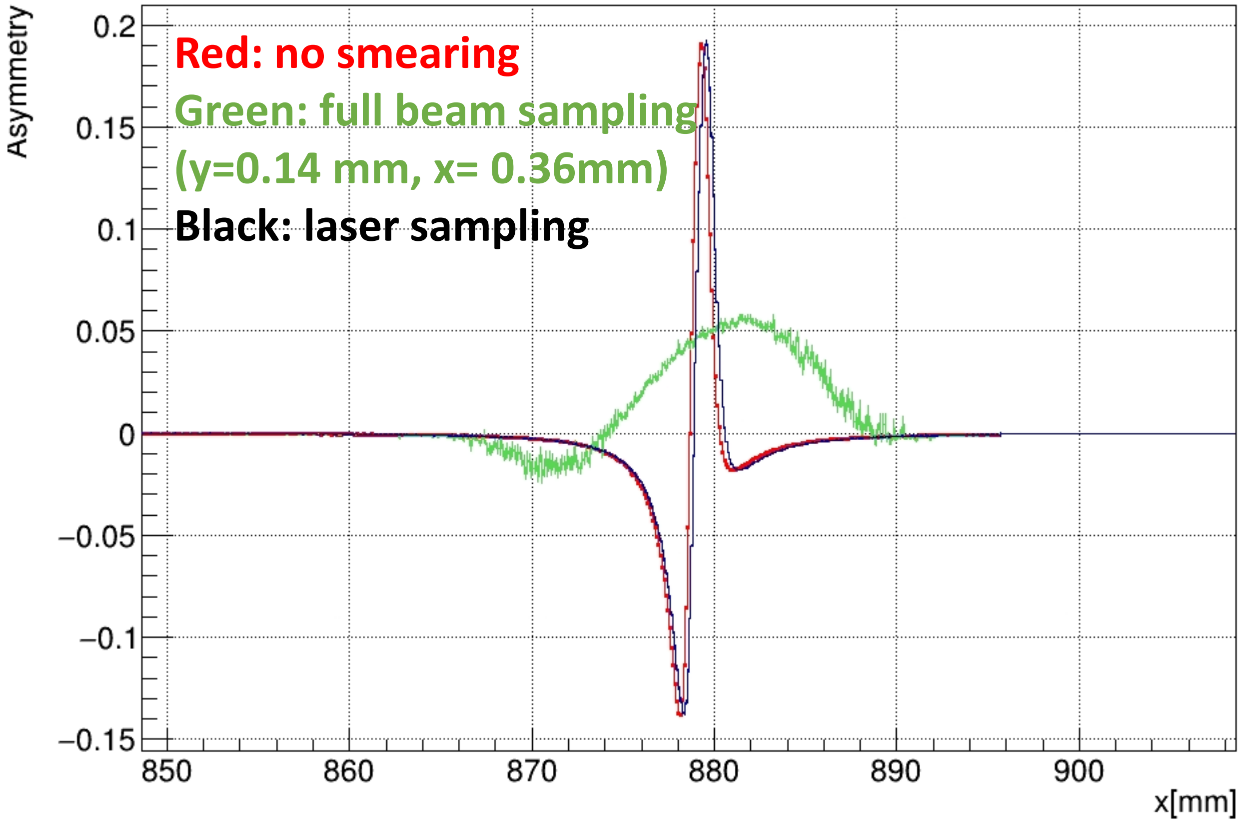
Pre-radiator:
- Convert back-scattered photons
- Protect against Synchrotron radiation

Pixel detector:
- Make a position measurement possible to access the transverse analyzing power

Calorimeter:
- We need a relatively fast response time and good resolution up to 3 GeV
- Redundant measurement of the longitudinal component

- The photon detector will be necessarily be the workhorse of the EIC Compton measurement
  - The only location where we can determine the transverse component
- The large distance from the IP allows for photons to occupy a large transverse area which can be cleanly measured even at 18 GeV
- Lead tungstate crystals are a good candidate (although the slow component of the response is significantly larger than the minimum spacing of 10 ns)
- Initial studies on the position resolution requirements show that something on the order of 100-400 microns should be sufficient with a transverse size of approximately >1cm to be able to capture most of the cone

Discussion and further analysis



- Including full beam smearing at the IP we see that the transverse asymmetry sees a suppression by a factor of 4
- Sampling only from the width of the laser beam (0.1mm) allows for an almost complete recovery of the initial analyzing power

- The EIC high precision needs (1%) will make this Compton polarimeter one of the most difficult to implement (to date)
- Both the electron and the photon detectors are going to be needed to be able to reach the stated precision
- We expect the electron measurement to reach the highest precision for the longitudinal component (based on JLab experience 0.5% is very much possible)
- The transverse component precision with the photon detector will be worse (optimistically on the level of 1%) getting us to bellow 1% overall

Backup