Compton Polarimeters in EIC
— detector integration

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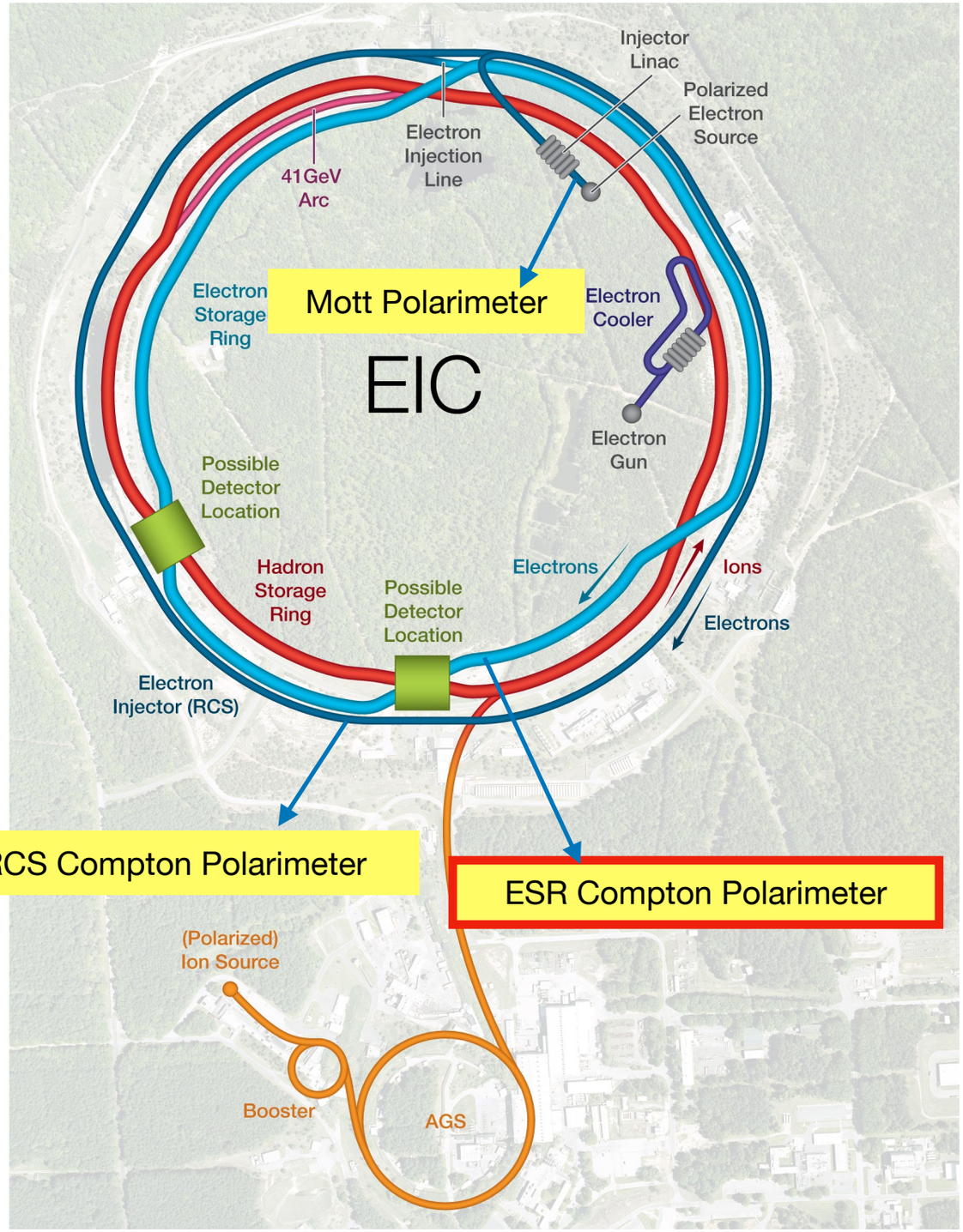
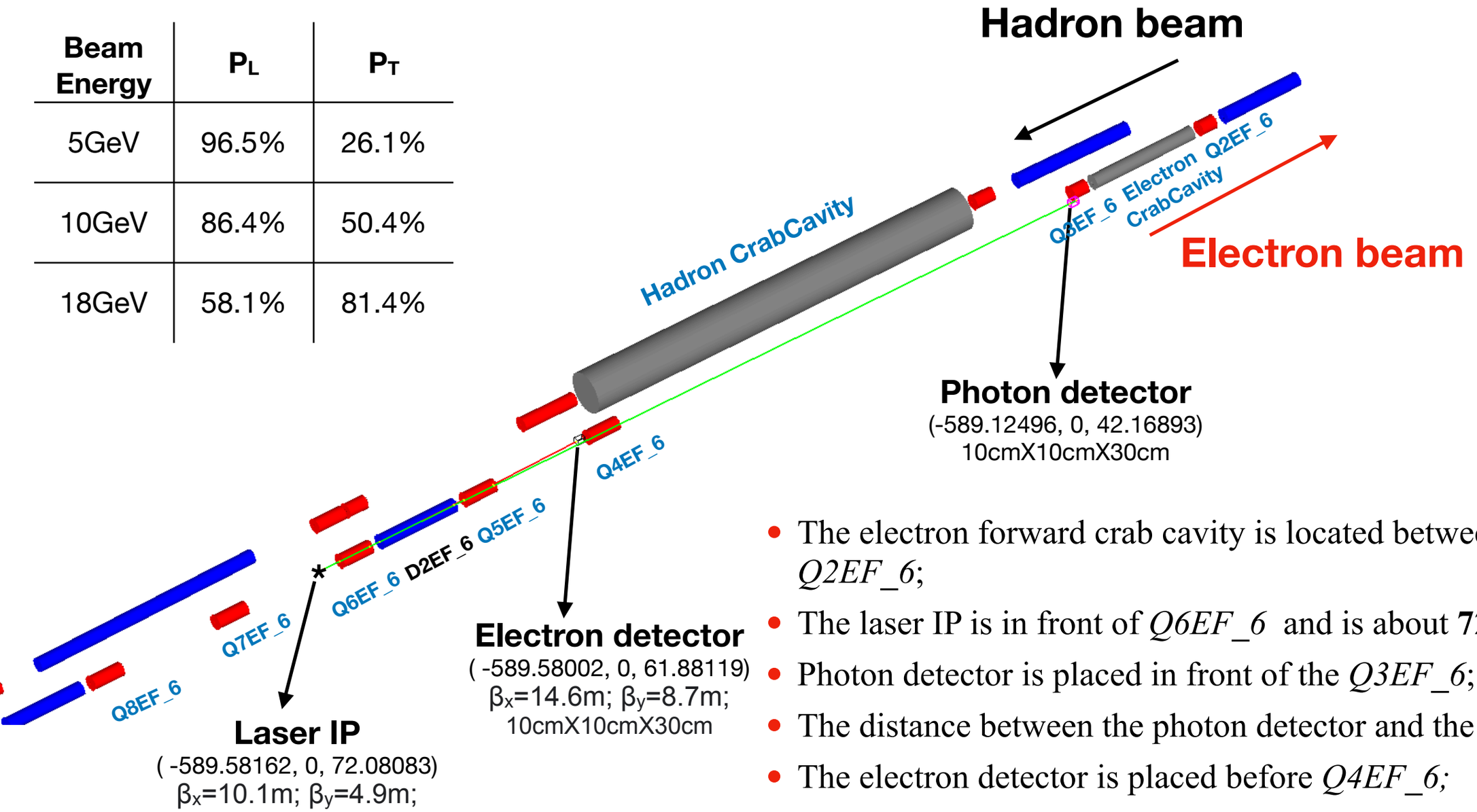
EIC polarimeters



- EIC requires 3 electron polarimeters;
  - Compton Polarimeter in ESR
  - Polarimeter for RCS (A Compton Polarimeter is proposed)
  - Polarimeter at source (Mott Polarimeter)
- Compton polarimeters for RCS and ESR have similarities but will operate in different modes —> ESR single photon/counting mode; RCS multi-photon/integrating mode.

Layout of polarimeter in ESR

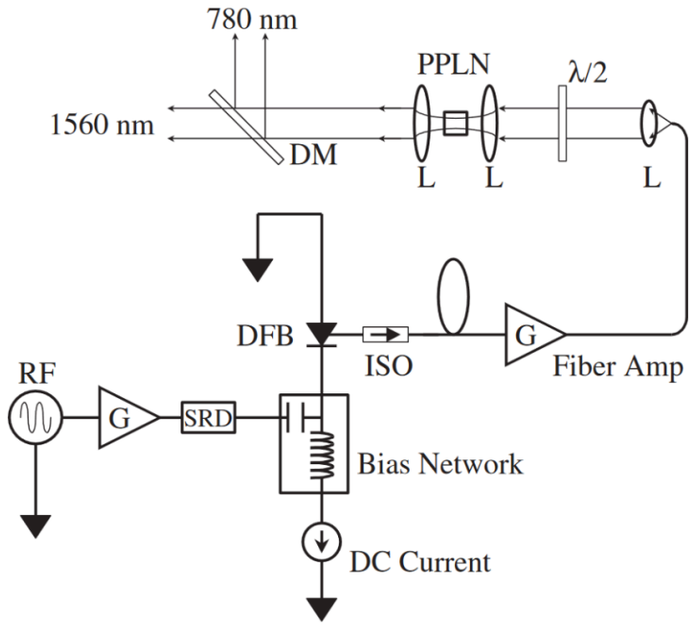
Beam Energy	P_L	P_T
5GeV	96.5%	26.1%
10GeV	86.4%	50.4%
18GeV	58.1%	81.4%



- The electron forward crab cavity is located between *Q3EF_6* and *Q2EF_6*;
- The laser IP is in front of *Q6EF_6* and is about **72m** away from IP6;
- Photon detector is placed in front of the *Q3EF_6*;
- The distance between the photon detector and the laser IP is **29m**;
- The electron detector is placed before *Q4EF_6;*
- The distance between the electron detector and the laser IP is **9.7m**;
- Open midplane is required for *Q4EF* to allow the photons to go through and the hole through the yoke is cleared by the magnet expert;

Compton Laser System

Average of 1 backscattered photon/bunch crossing will allow Compton measurements on the ~1 minute time scale —> can be achieved with a pulsed laser system that provides about 5W average power at 532nm;

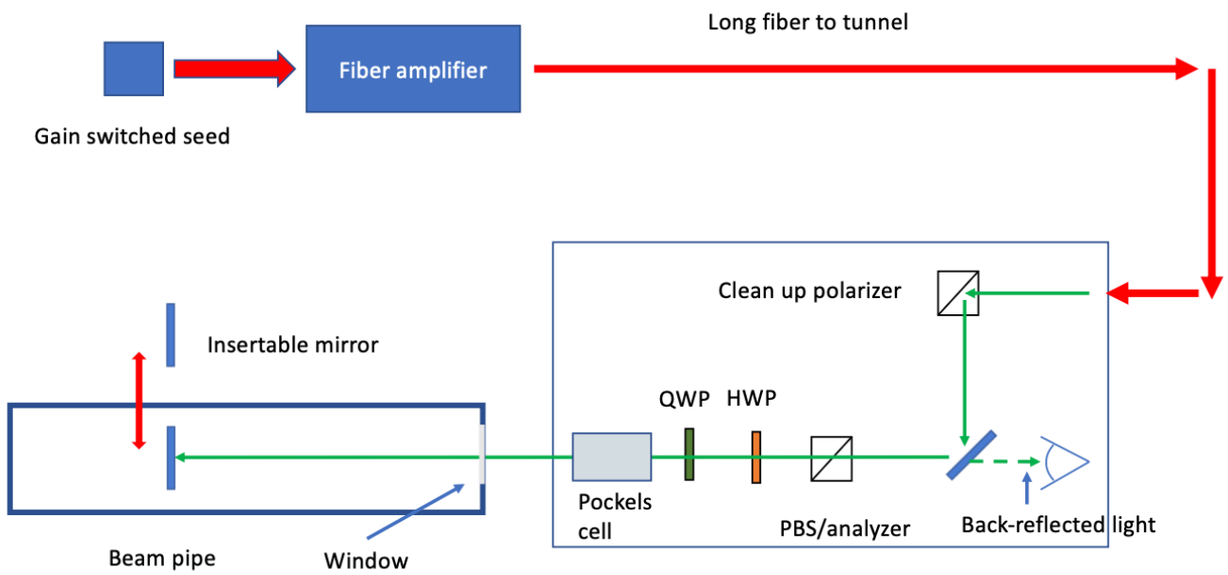


JLAB injector laser system

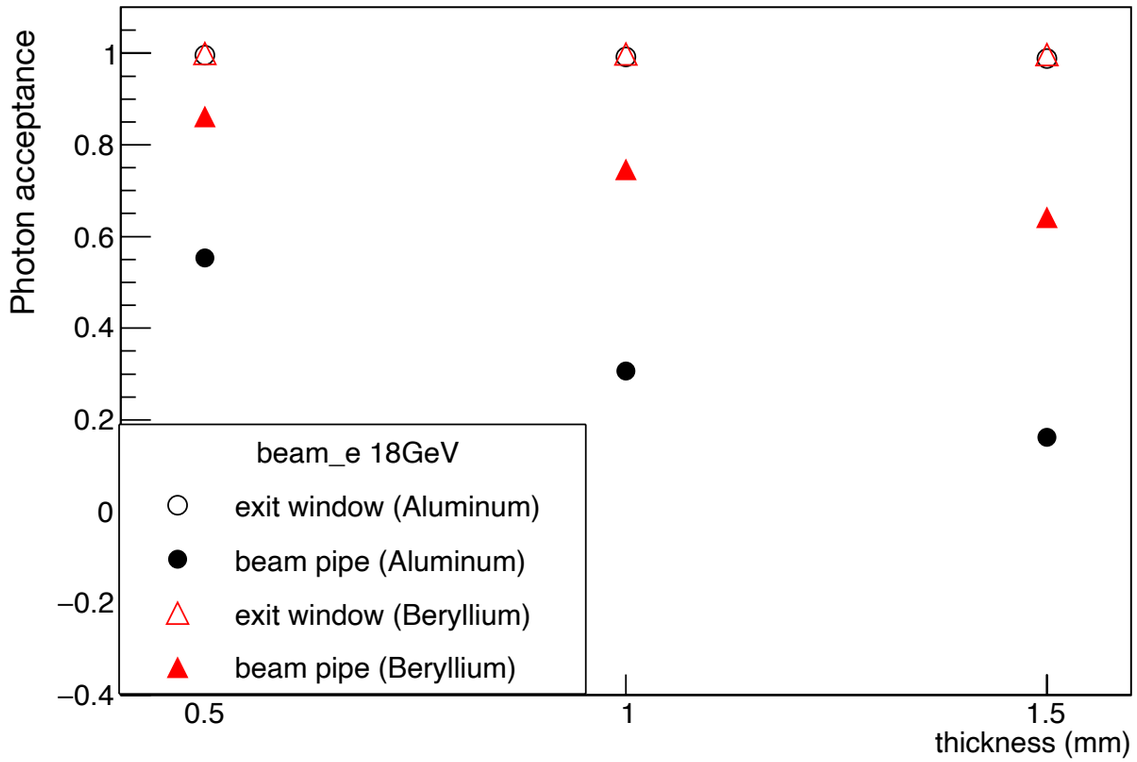
Polarization in vacuum set using "back-reflection" technique —> Required remotely insertable mirror (in vacuum)

Proposed laser system based on the similar system used in JLab injector and LERF

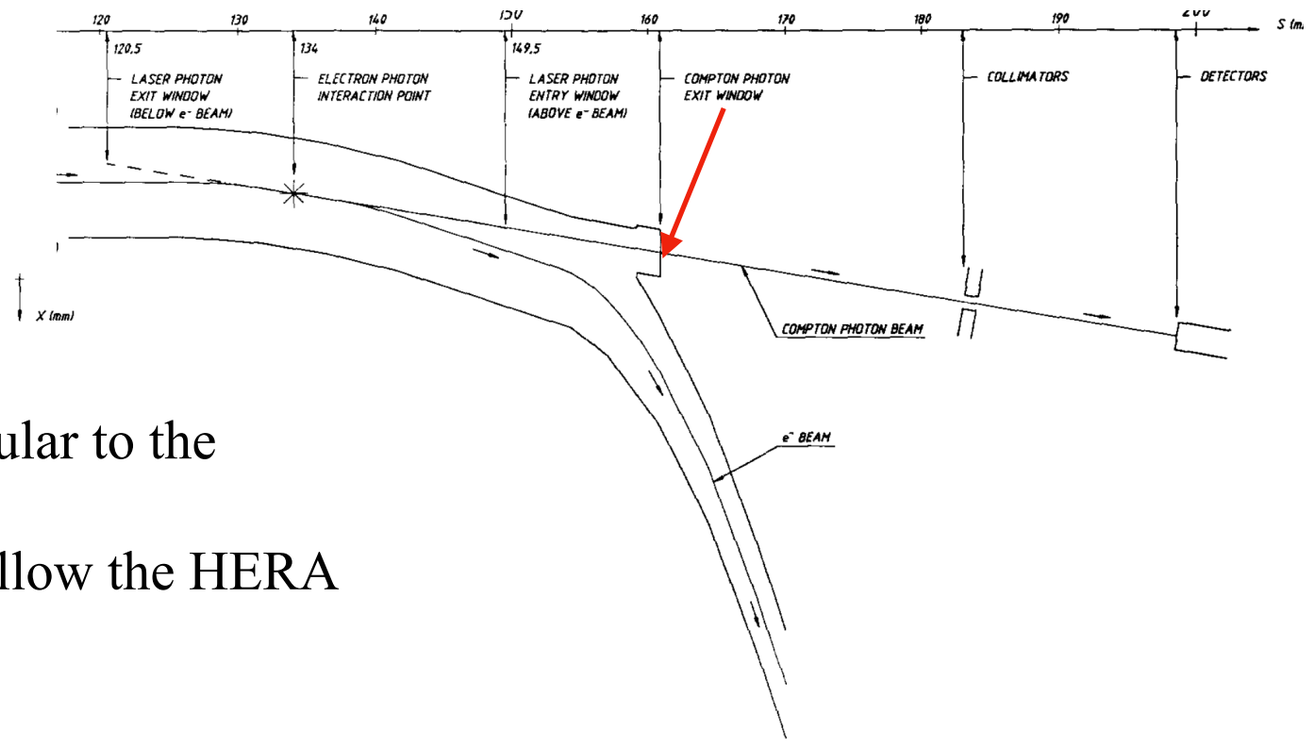
- Gain-switched diode seed laser -variable frequency, few to 10 ps pulses @ 1064 nm —> Variable frequency allows optimal use at different bunch frequencies (100 MHz vs 25 MHz)
- Fiber amplifier —> average power 10-20 W
- Optional: Frequency doubling system (LBO or PPLN)
- Insertable in-vacuum mirror for laser polarization setup



Exit Window



- Geant4 simulation shows the acceptance for scattered photon (18GeV beam energy) with/without exit window;
- The exit window can significantly improve acceptance;
- Similar results for 10GeV and 5GeV electron beam energy;

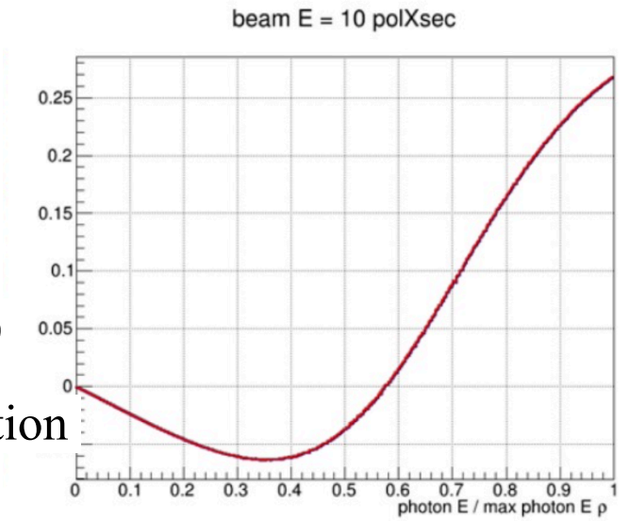


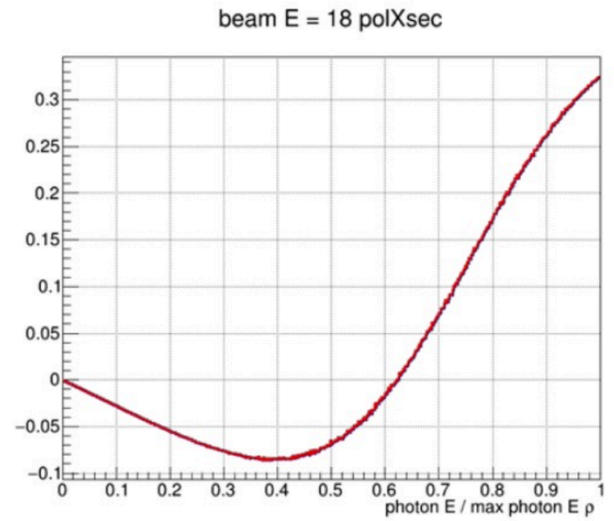
- The exit window is near the dipole. It is perpendicular to the scattered photons;
- The exact geometry is not decided yet. It would follow the HERA design;

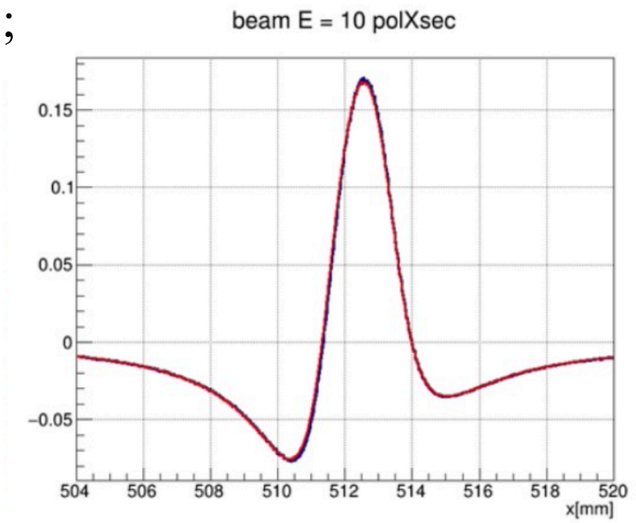
Barber, D. P., et al. "The HERA polarimeter and the first observation of electron spin polarization at HERA." *NIMA,* 329.1-2 (1993): 79-111.

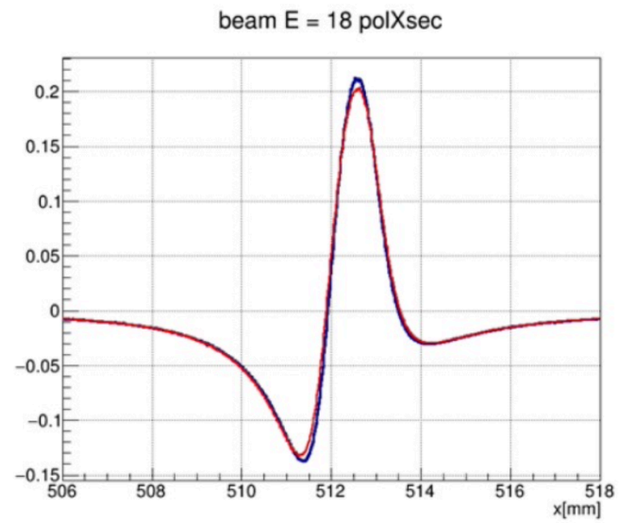
Photon Detector

- Photon detector needs 2 components to measure both longitudinal and transverse polarization;
  - Calorimeter —> photon energy asymmetry (P_L)
  - Position sensitive detector —>left-right asymmetry (P_T)
- Longitudinal measurement requires good energy resolution from ~0 (as low as possible) to 7 GeV;
- Fast time response is also needed (10 ns bunch spacing);
- Position sensitive detector segmentation determined by highest energy, more investigation is needed, but segmentation on the order of 100-400 μm should work;
- Radiation hardness: 80Gy/h;



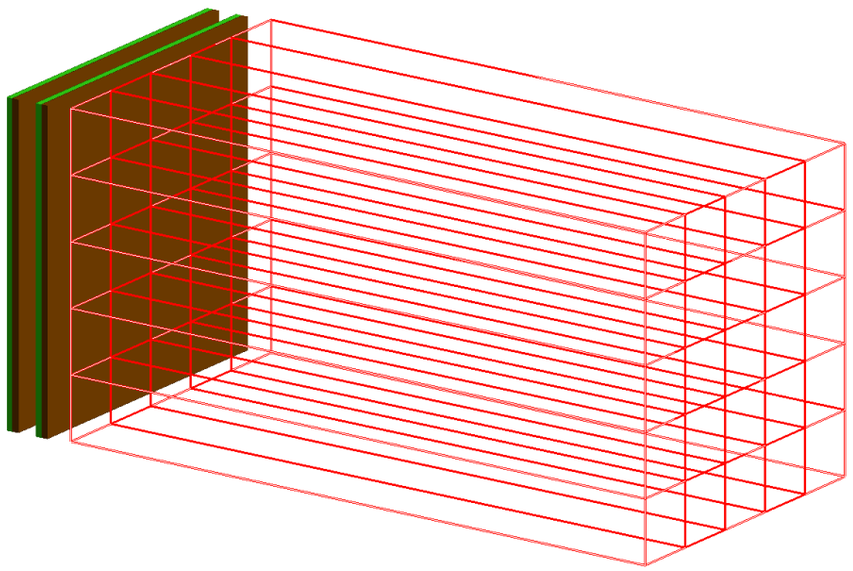






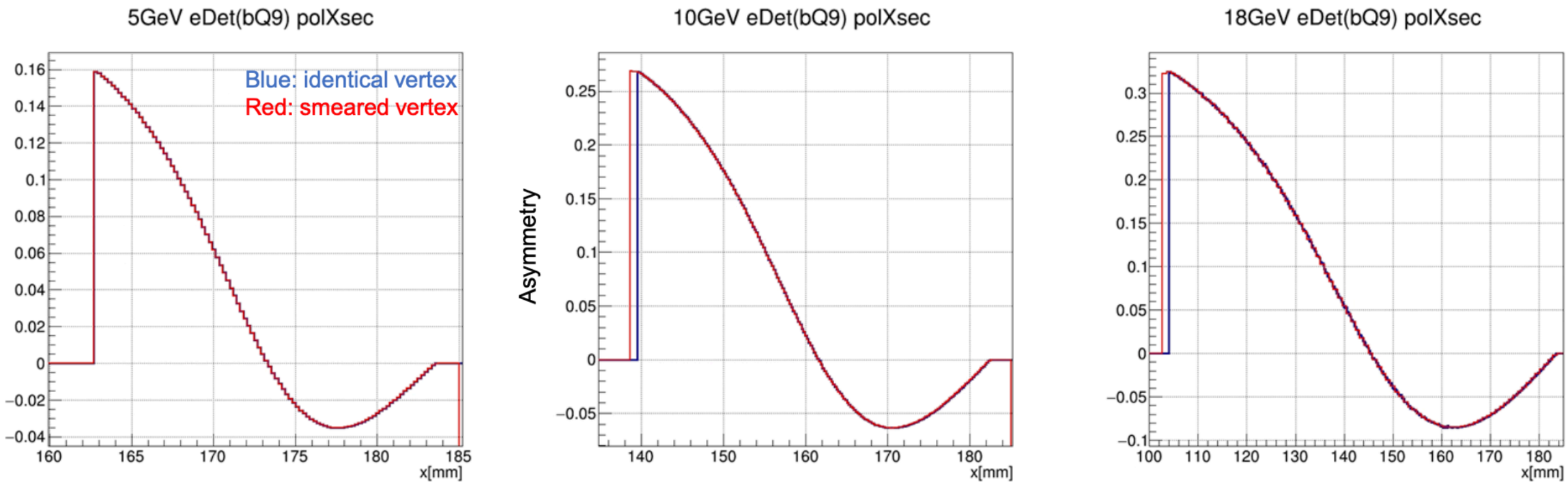
Photon Detector

Homogeneous Calorimeter with Preshower detector



- A homogeneous Calorimeter with Preshower detector is being considered;
- The preshower is made of two planes of lead followed by silicon sensors;
- The segmentation of the silicon sensor on the order of 100-400 μm is required;
- Good energy resolution from ~0 (as low as possible) to 7 GeV;
- PbWO4 is a possible candidate, but the slow component may be an issue;
- A fiber-tungsten or lead sampling calorimeter is another (perhaps safer) option, but would likely result in reduced precision for P_L on the photon side;
- Detailed simulations of detector response are needed;
- Background studies are also needed for the photon detector;

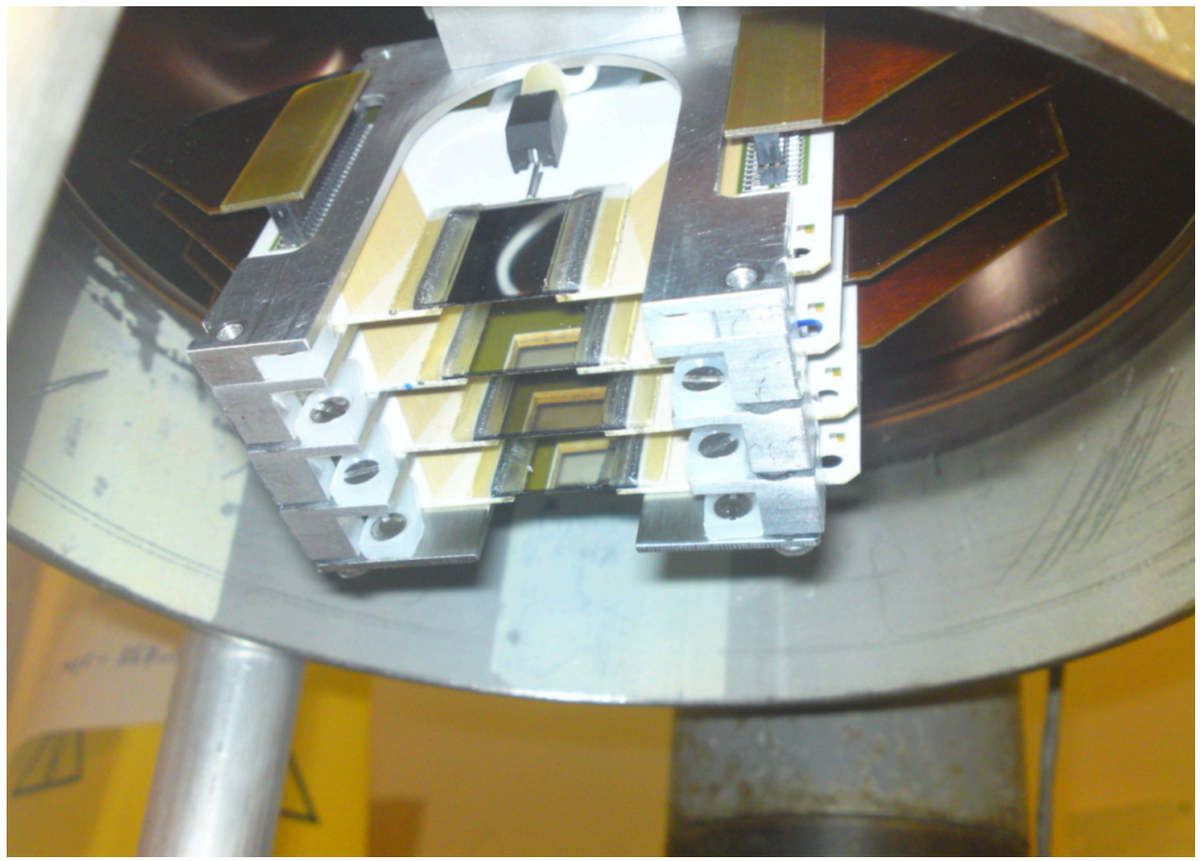
Electron Detector



- Electron detector (horizontal) size determined by spectrum at 18 GeV (which has the largest horizontal spread);
  - Need to capture zero-crossing to the endpoint —> detector should cover at least 60 mm;
- Segmentation is dictated by the spectrum at 5 GeV (smallest spread);
  - Need at least 30 bins, so a strip pitch of about 550 μm would be sufficient;
- At 18GeV, zero-crossing is about 3 cm from the beam; at 5GeV it is 8-10 mm, this might be challenging (beam size in horizontal is about 0.55 mm);
- Electron detector can only be used for the measurements of P_L due to the large dispersion induced by the dipole;

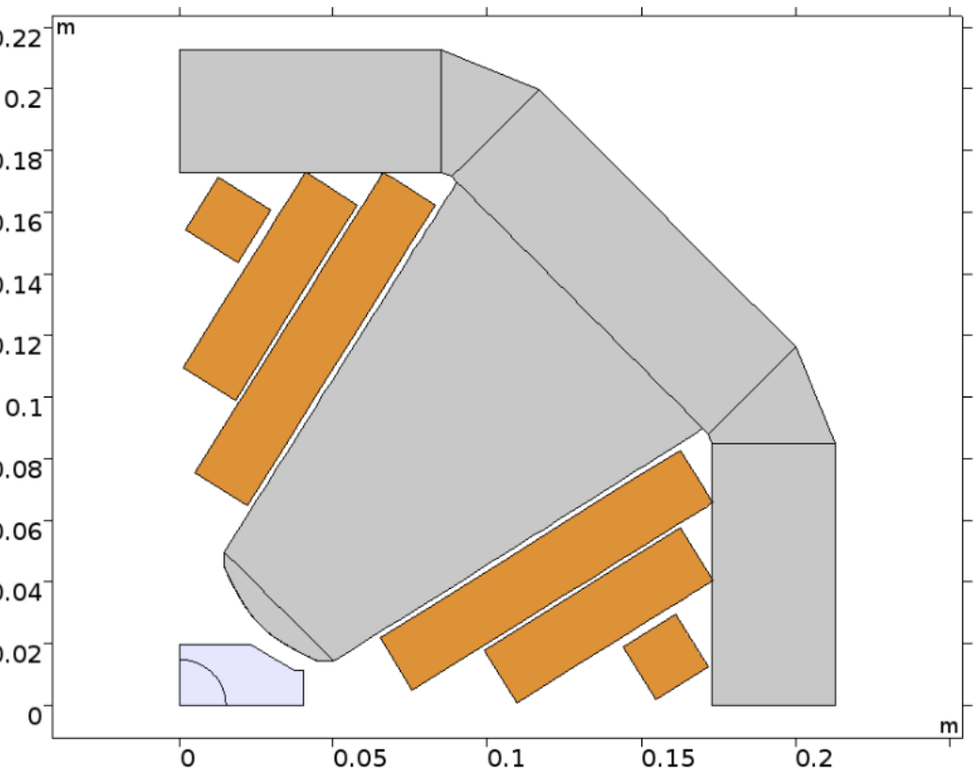
Electron Detector

Hall C diamond detector

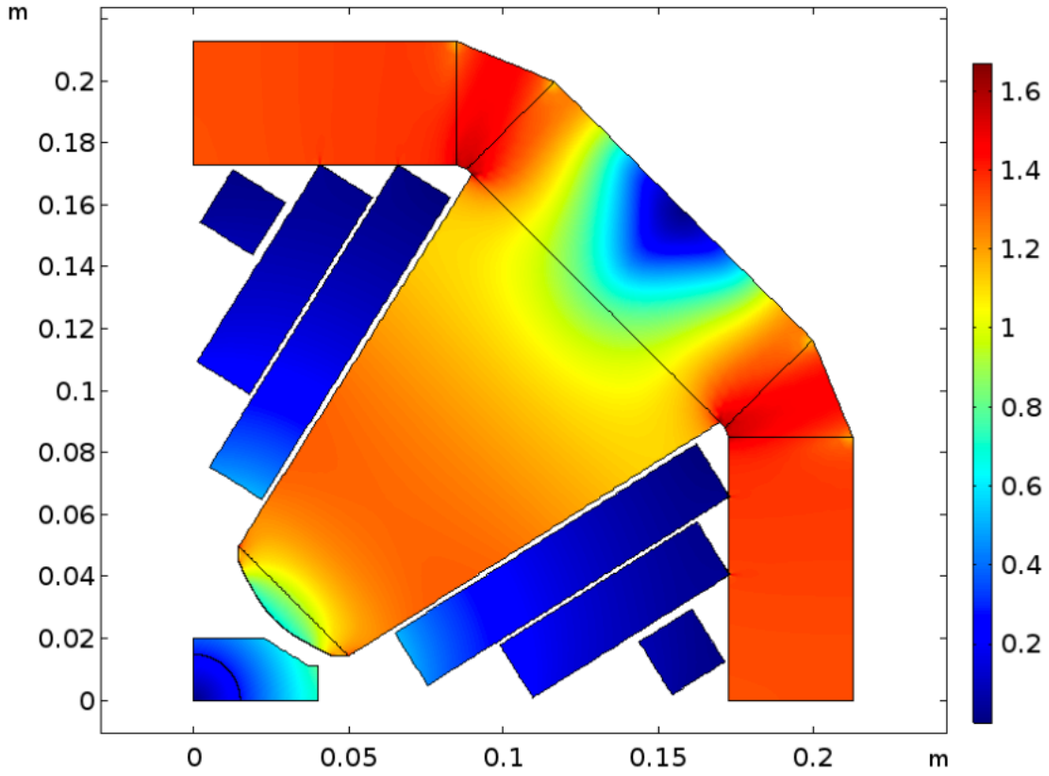


- Several choices feasible for position sensitive detectors;
- Diamond strip detector similar with JLab Hall C diamond detector is being considered;
  - Radiation hard;
  - Fast time response;
  - Compatible with segmentation requirements;
  - ASIC under development for LHC diamond detectors compatible with EIC timing requirements;

Arc Quadrupole Design



(a) Geometry of the arc quadrupole magnet



(b) Magnetization

"EIC Conceptual Design Report", BNL, Up- ton, NY, USA, Rep. **EIC CDR, 2021**

- A quadrupole design is required which delivers about 18.4 T/m over a length of 0.6 m. A relatively large inscribed radius of 37 mm is necessary to clear the beam pipe;
- Open midplane or a hole in the return yoke (hole radius ~ 2cm) is required for Q4EF to allow the clearance for "photon cone";
- By carefully designing the coils, we can make the space for this requirement;

Summary

- A Compton Polarimeter is placed at IR6 in ESR;
- The Compton laser system is being developed;
- The requirements for the exit window and detectors are studied;
- Detailed simulations of detector response are needed;
- The design of the arc quadrupole is discussed;
- More work to be done for the success of EIC polarimetry;

Thanks.