The mEIC electron low Q^2 chicane and Compton polarimeter

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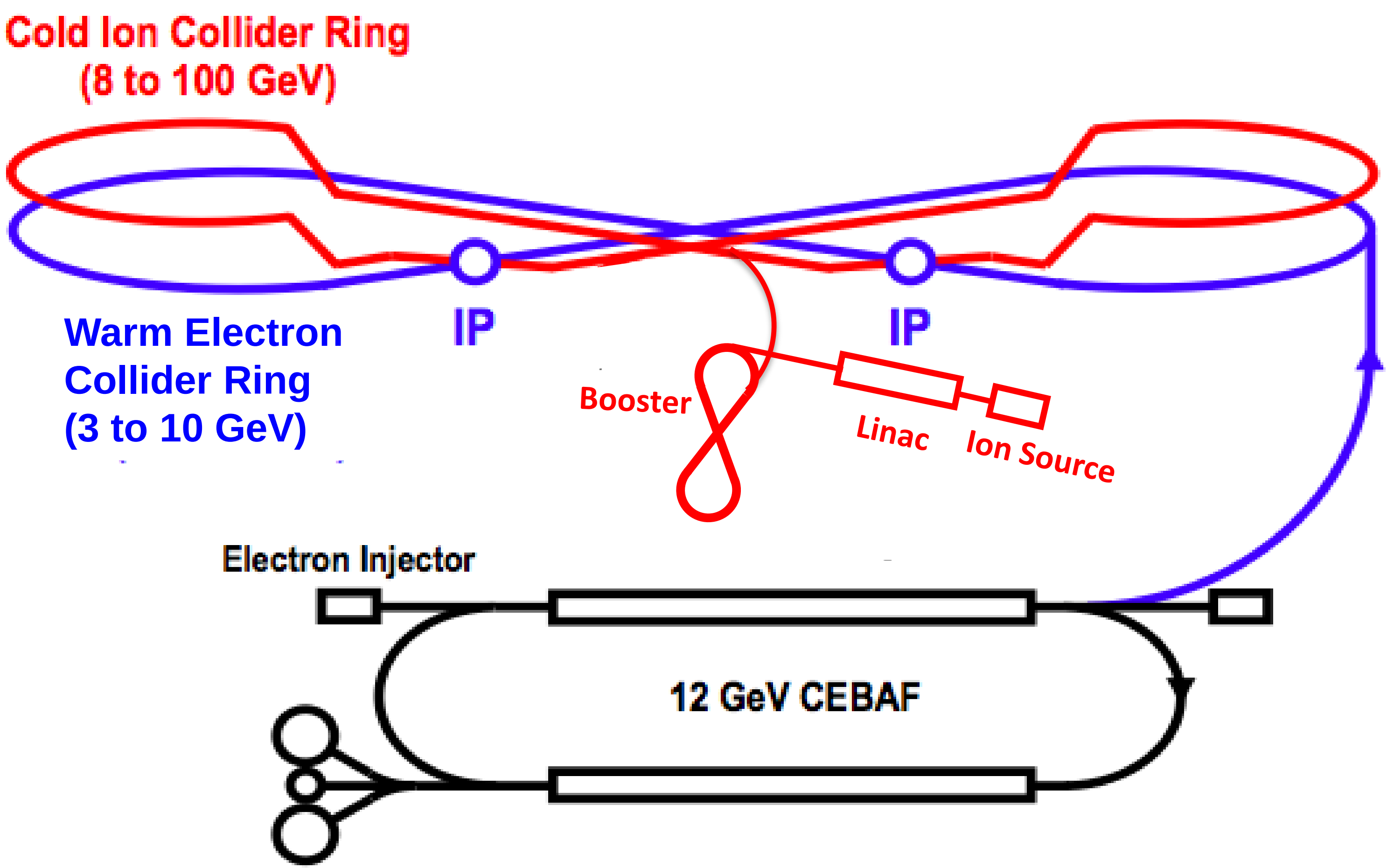
September 11th 2015
POETIC 2015
Ecole Polytechnique Paris, France

Outline

- EIC@Jlab overview
- Low Q^2 chicane
- Compton polarimeter
- Conclusion

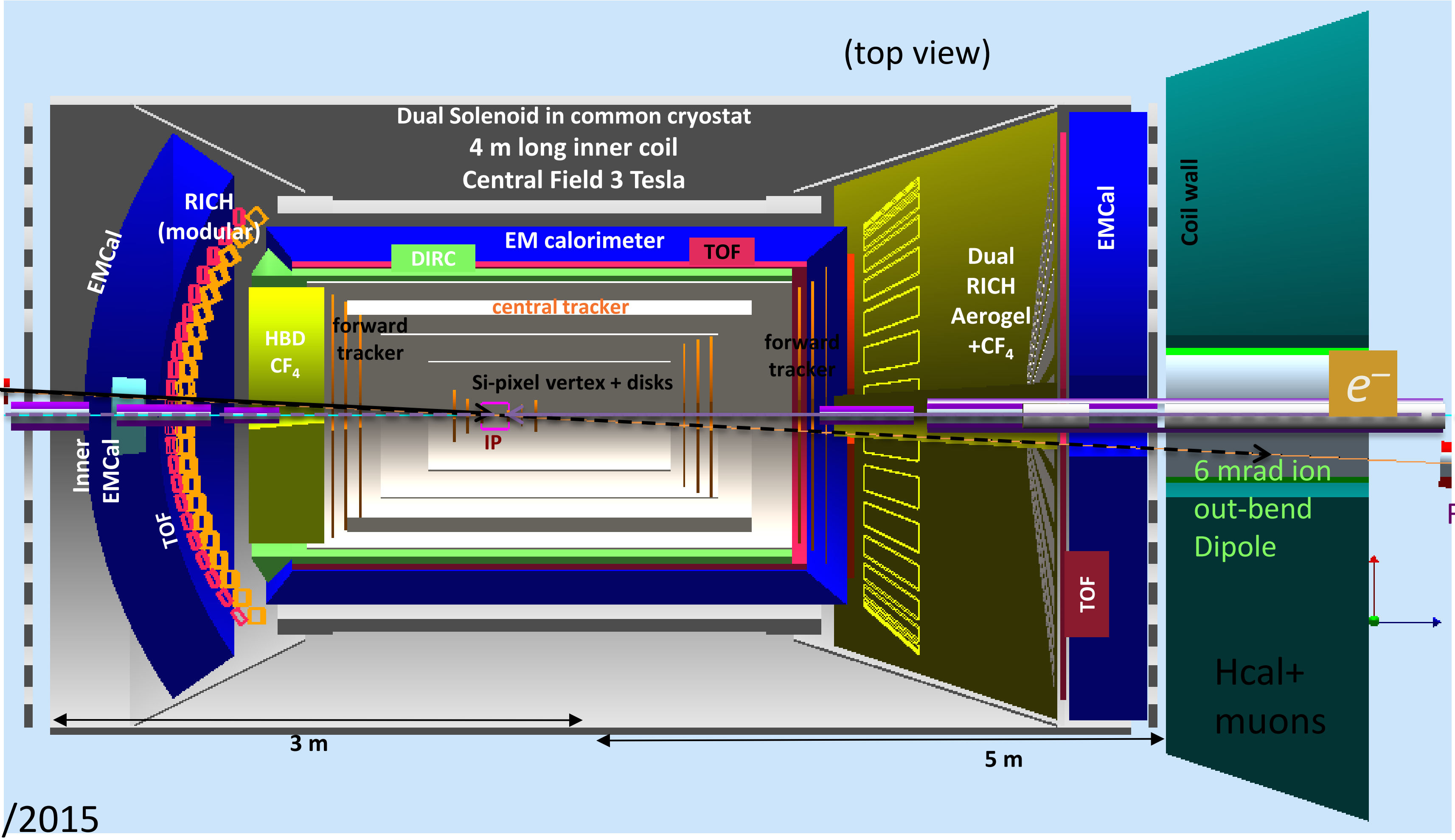
EIC@JLab Layout



MEIC Central Detector

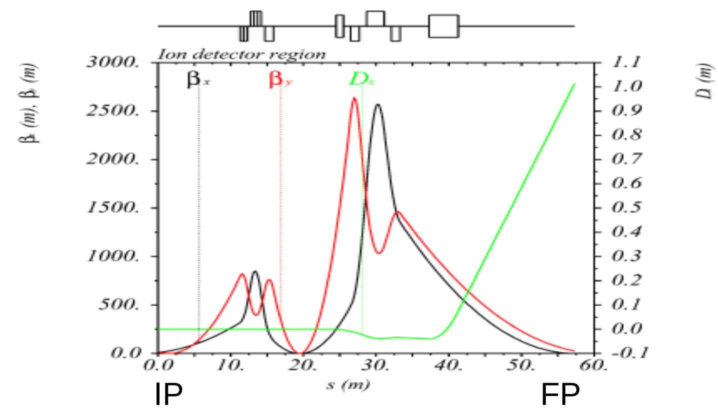
Electron End-Cap:

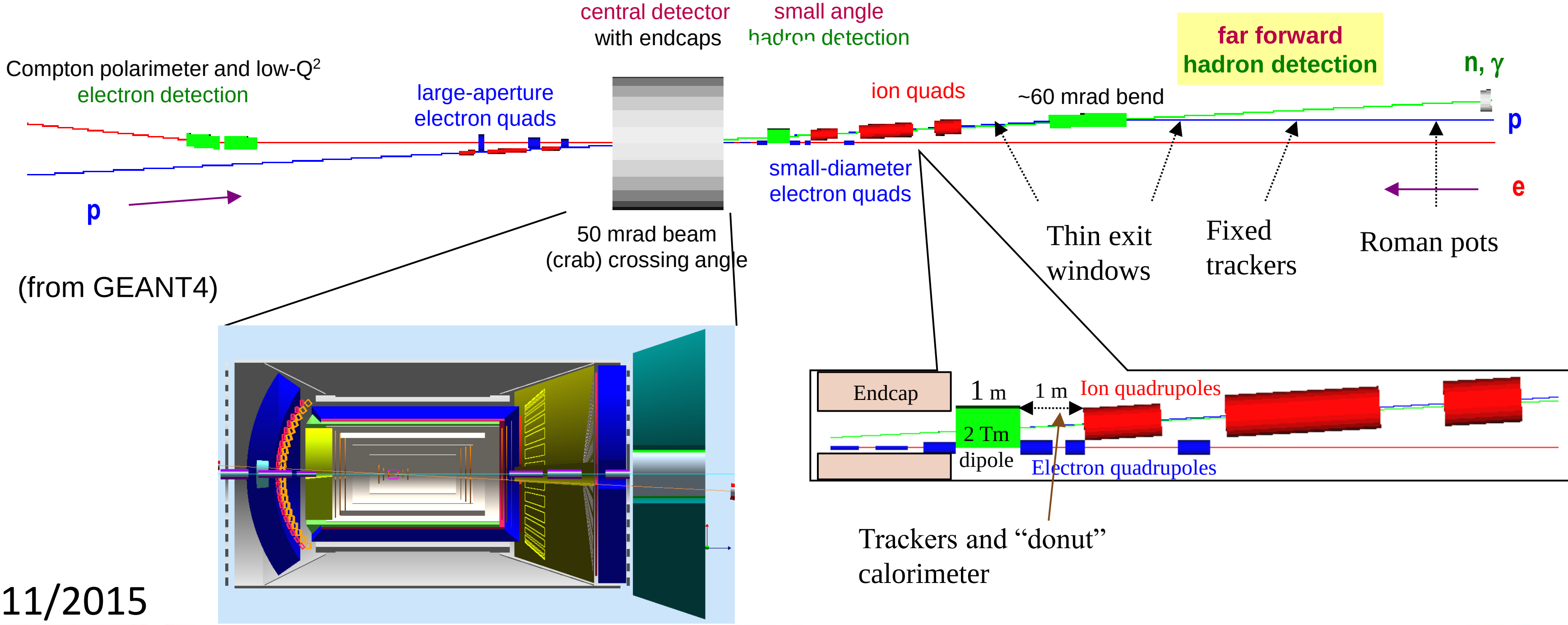
•HBD (CF_4+UV-GEM) or TRD, •Aerogel RICH (Modular), •TOF(MRPC), •EMCal (Shashlyk+ inner $PbWO_4$)



The electron chicane

- Dipole to tag electrons associated with quasireal photons



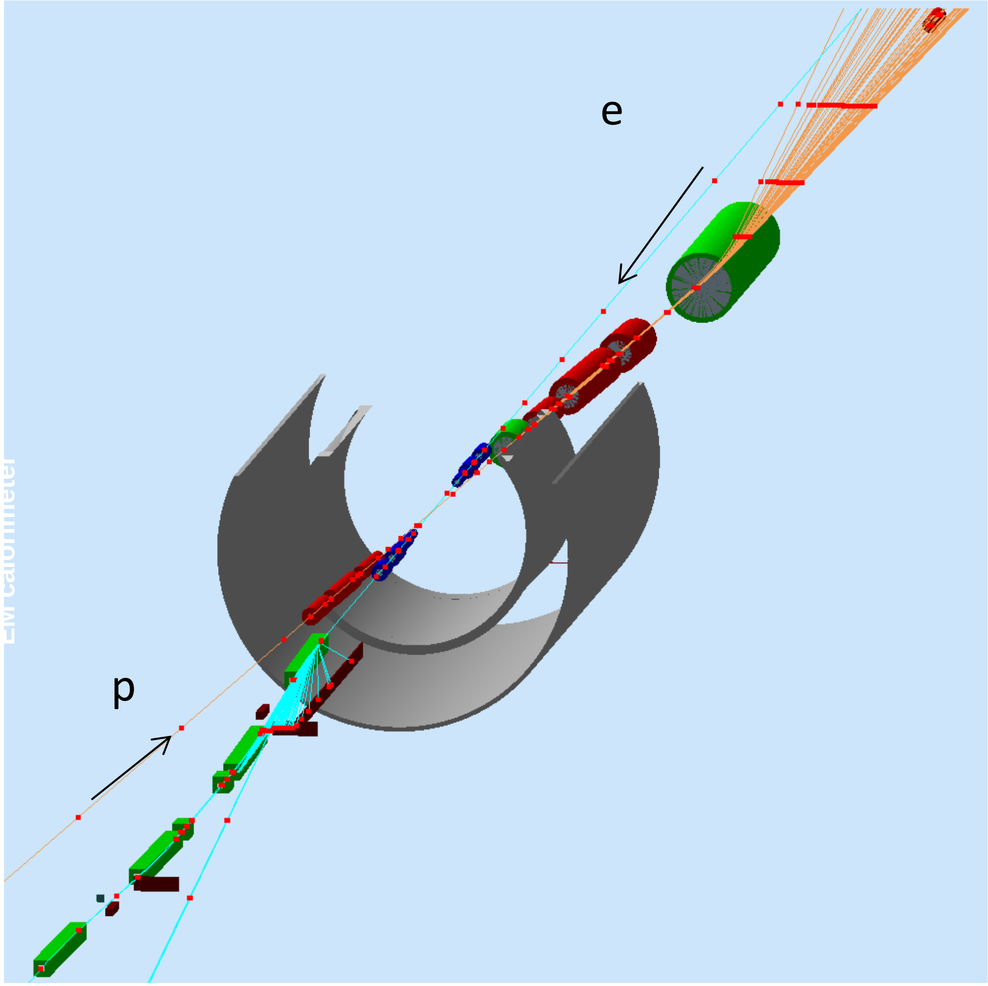


Quasi real photon physics

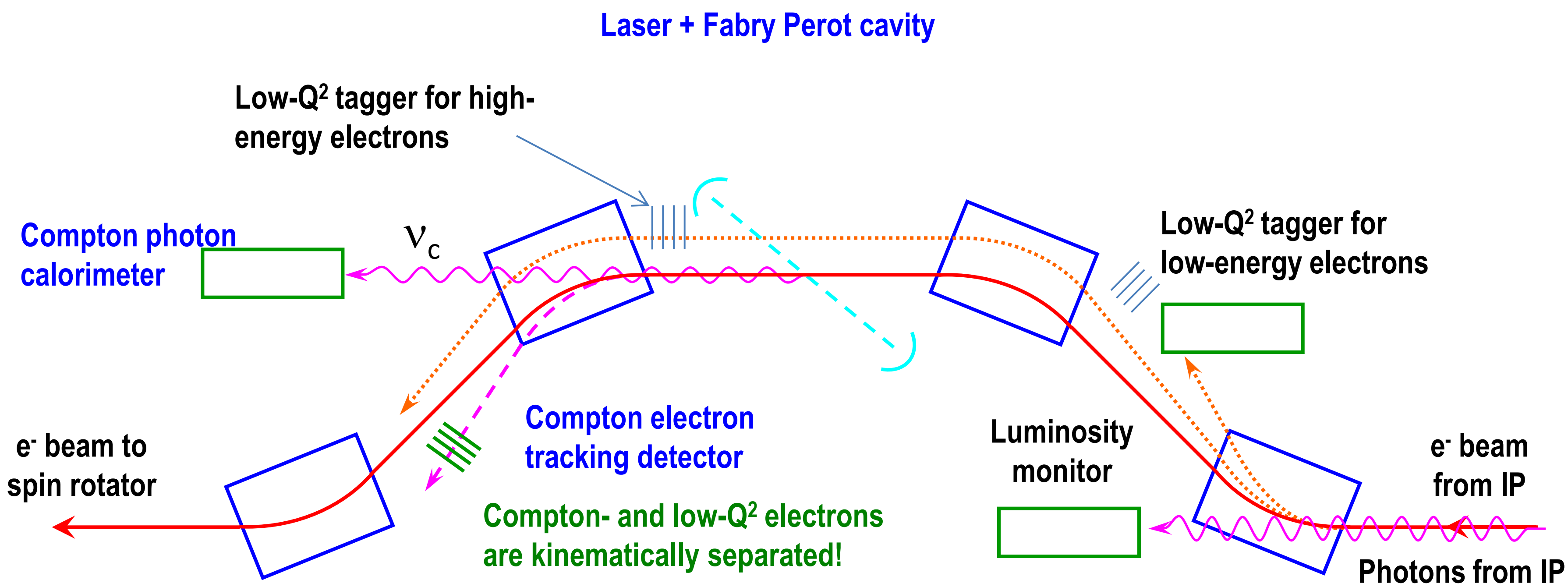
- Charm as direct probe of gluons
  - J/ψ, exclusive: spatial distribution of gluons
  - D, Λ_c, open charm (including quasi-real D^0 photoproduction for ΔG)
- Spectroscopy :
  - hybrids photoproduction
- Real and Time-like Compton Scattering

Low Q2 tagger

- **C magnet**
- **Side window with long tracker (scintillator array or scintillating fiber)**
- **Close detector : silicon or diamond strip detector in roman pot for very low Q^2 photon**
- **Design ~10^{-3} resolution on electron momentum**



Compton polarimeter

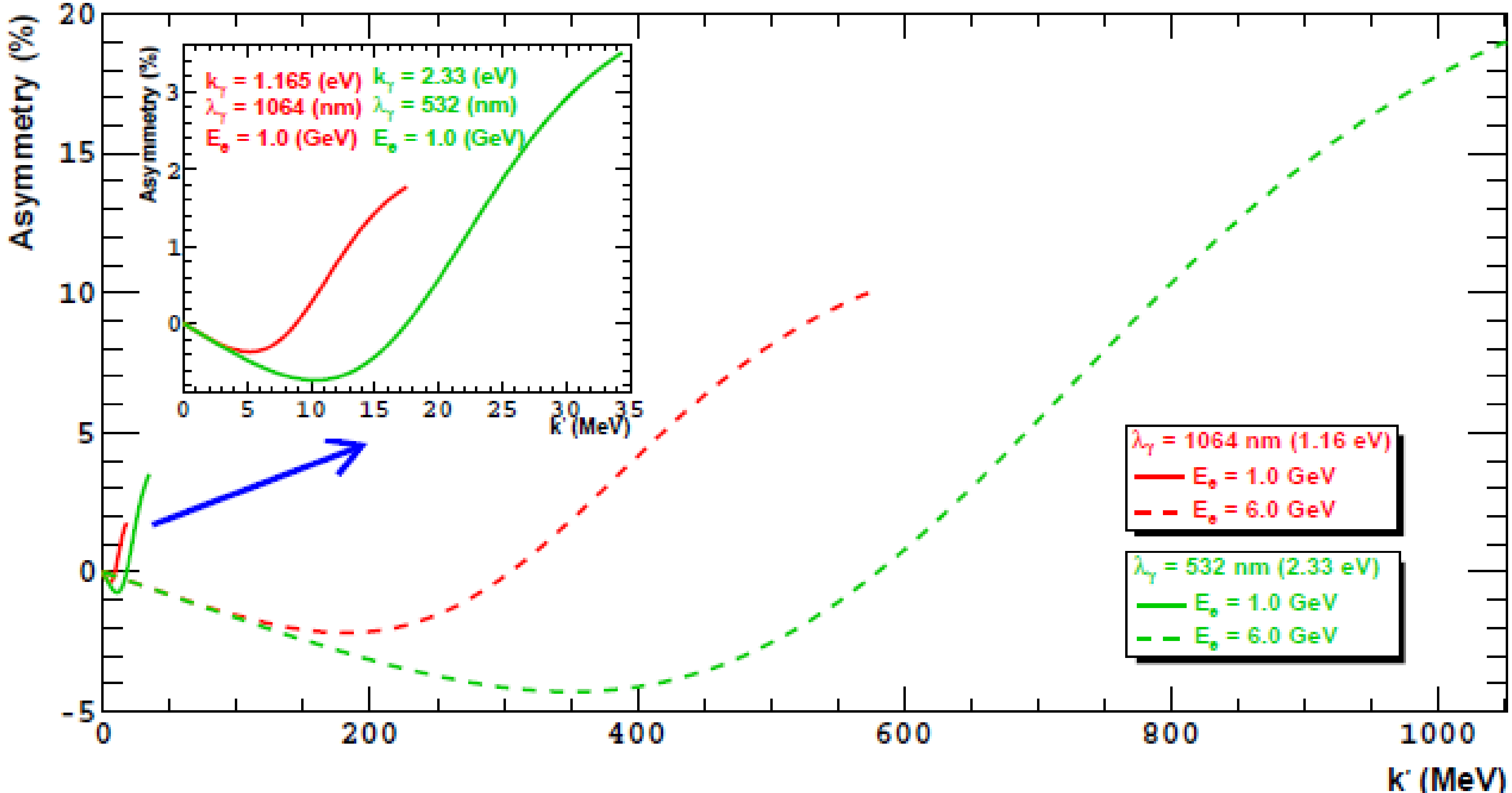


- Second IP will have a similar chicane optimized for electron detection
  - Goal is to push the uncertainty of the polarimeter towards 0.5 -1 %

Compton asymmetry

σ(e + γ ⟶ e’ + γ’) ≠ σ(e + γ ⟶ e’ + γ’)

$$\frac{N^{+}-N^{-}}{N^{+}+N^{-}}(E_e, k_\gamma, k_{\gamma'}) = P_e * A(E_e, k_\gamma, k_{\gamma'})$$



Photon vs electron

EIC ≤ 1% polarimetry accuracy requires electron detection

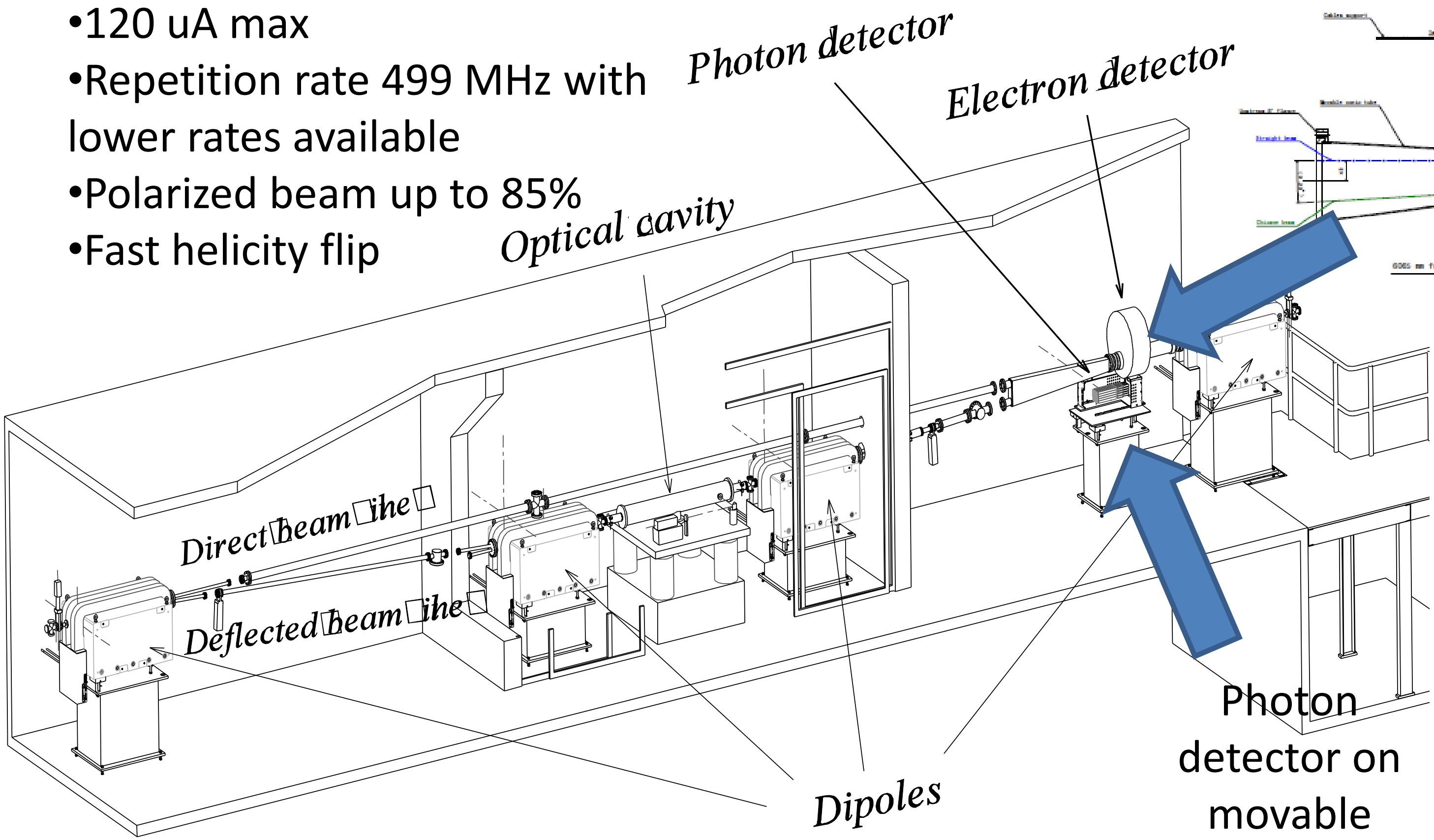
- Photon
- **Counting differential**
  - Response function of calorimeter
  - Low energy resolution
  - Threshold
  - Calibration
  - Dead time
  - **Example:** Hera 1.6 % @ 27.5 GeV
- **Integrated (best accuracy but might be difficult at high energy)**
  - No dead time
  - No threshold
  - Sensitive to background
  - Asymmetry smaller
  - Need good linearity
  - **Example:** Hall A: 1% @ 3 GeV

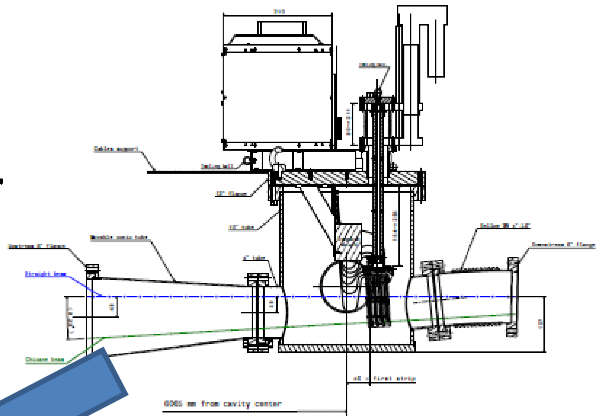
- **Electron**
- **Counting differential**
  - Response function
  - Resolution
  - Threshold due to detector at distance
  - Dead time correction
  - Self calibration by using the zero crossing and Compton edge
  - Compute asymmetry at each strip
  - Global fit
  - **Example:** Hall C: 0.6% @ 1 GeV

Best polarization measurement: SLC SLD Compton polarimeter using electron detection: 0.52 % @ 21 GeV

Hall A Compton chicane

- 2.2 GeV to 11 GeV
- 120 uA max
- Repetition rate 499 MHz with lower rates available
- Polarized beam up to 85%
- Fast helicity flip

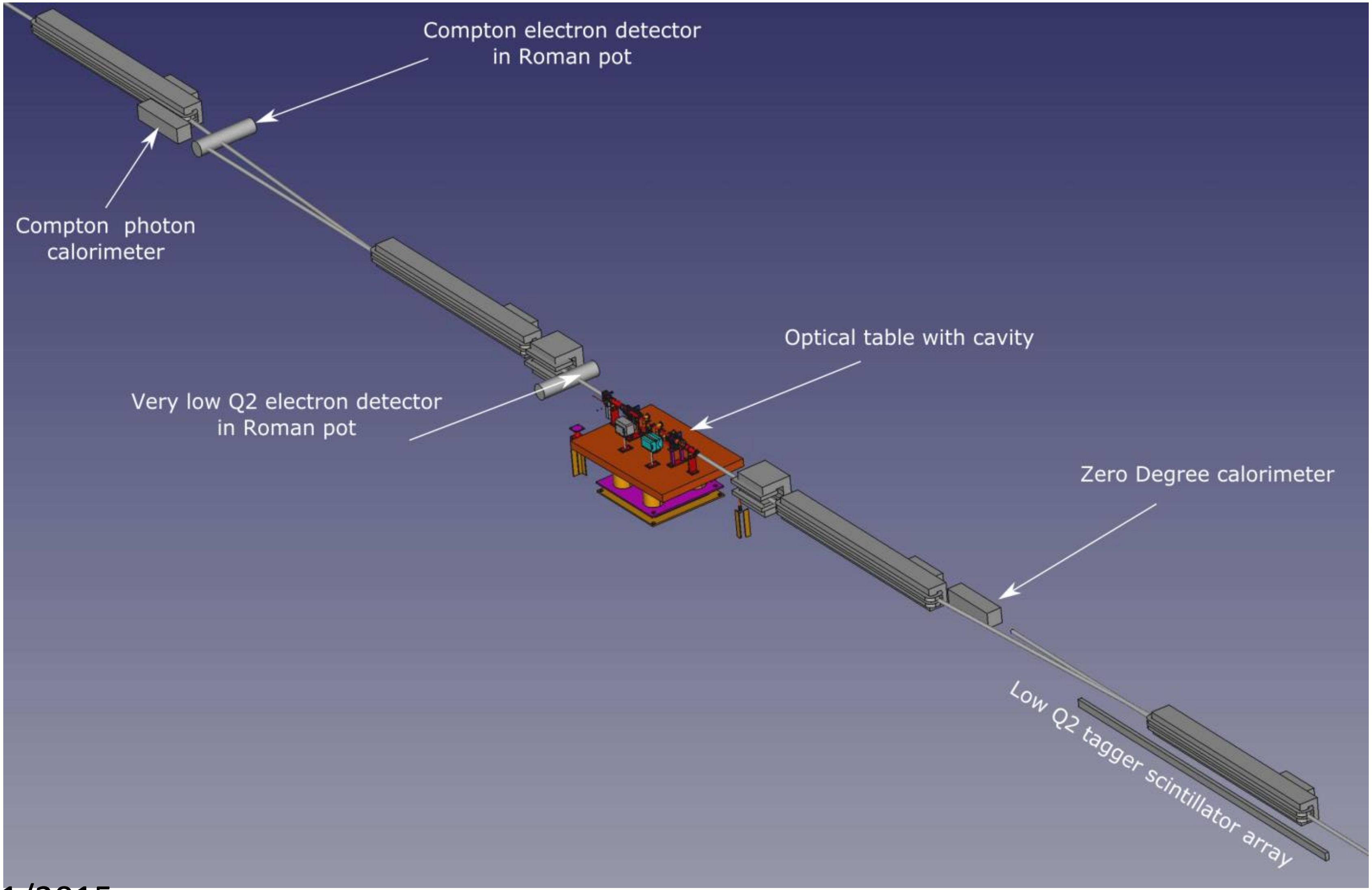




Vertical motion of electron detector to move detector close to the beam (up to 5 mm)

Photon detector on movable table

Low Q^2 chicane layout

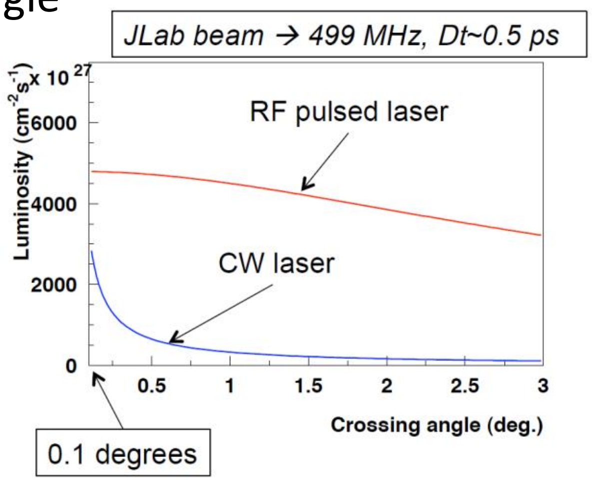


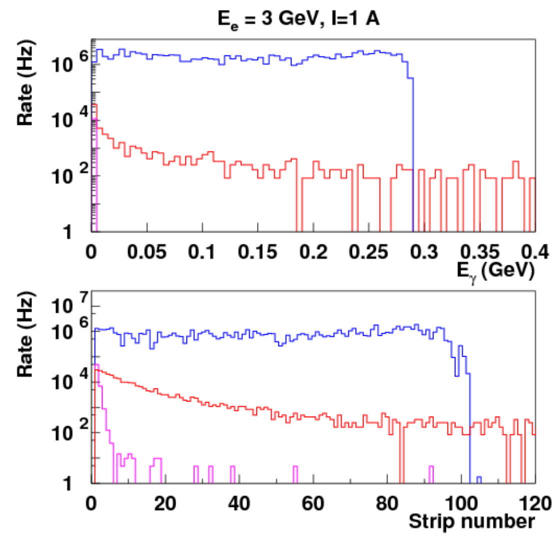
Laser options

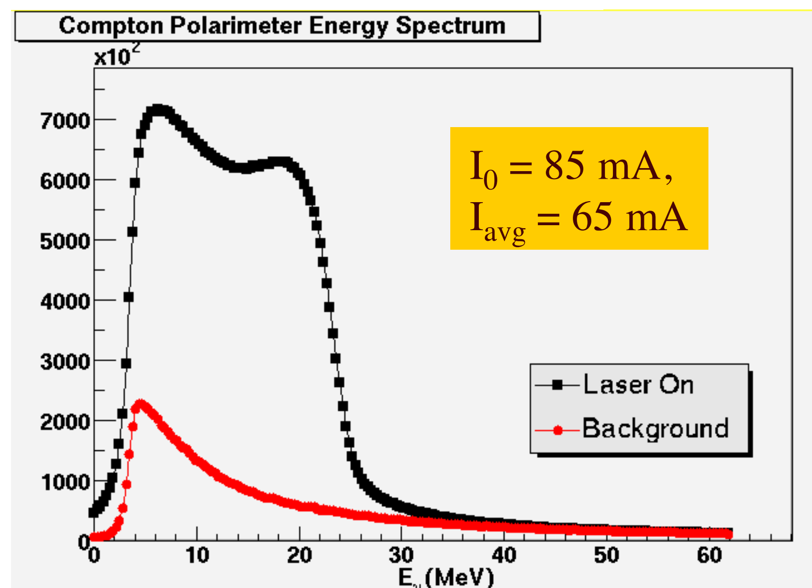
In order of power

- Single pass CW laser (few Watts)
- CW cavity (around 10 kW)
- RF pulsed laser and RF pulsed cavity help with

Crossing angle



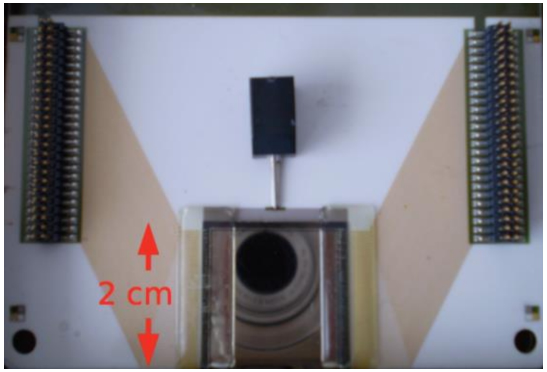


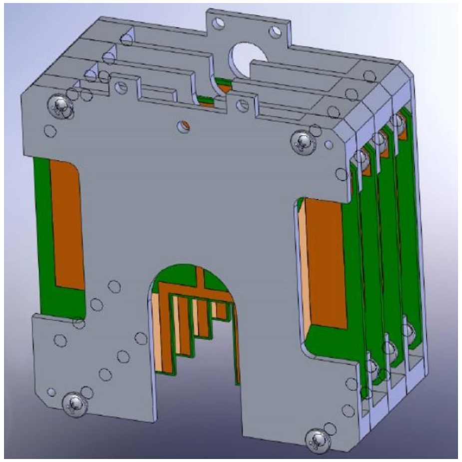


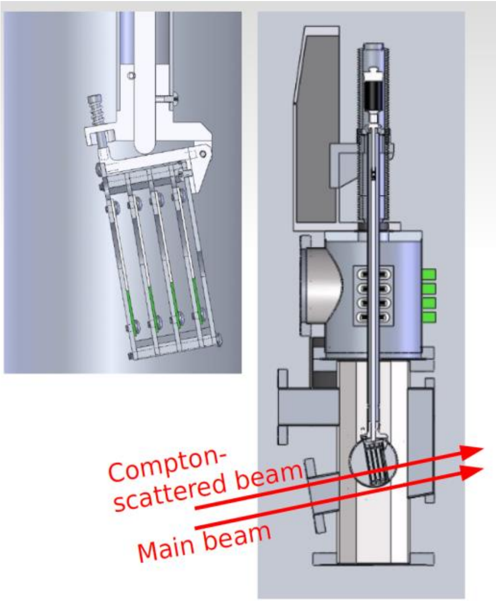
Choice of laser solution highly dependent on background considerations. Baseline CW cavity similar to JLab

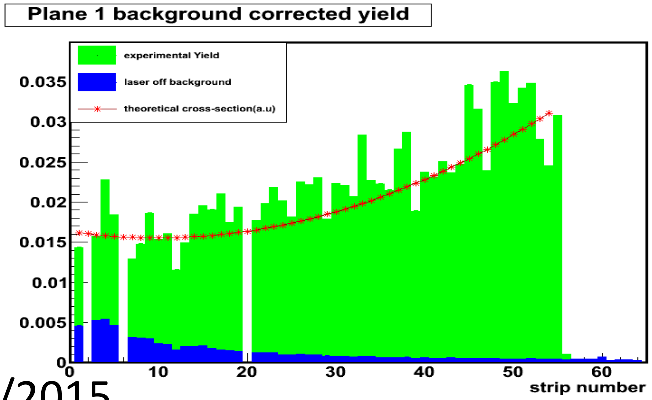
Compton polarimeter electron detector

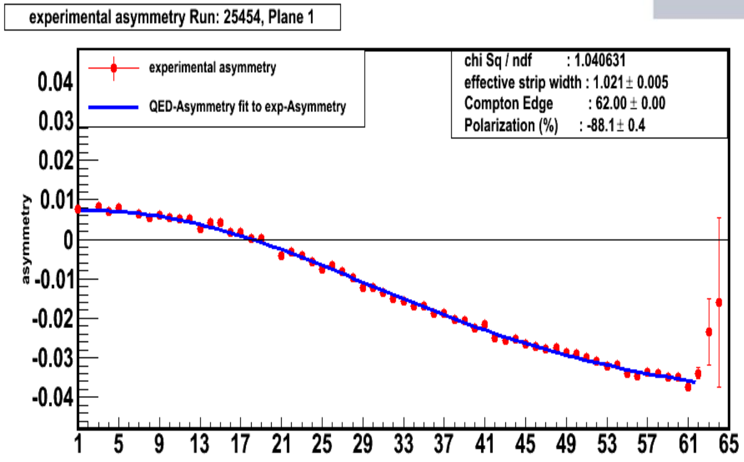
- Silcon or diamond strip option
- About 200 to 250 strips 250 μm width
- 5 cm length to catch zero crossing





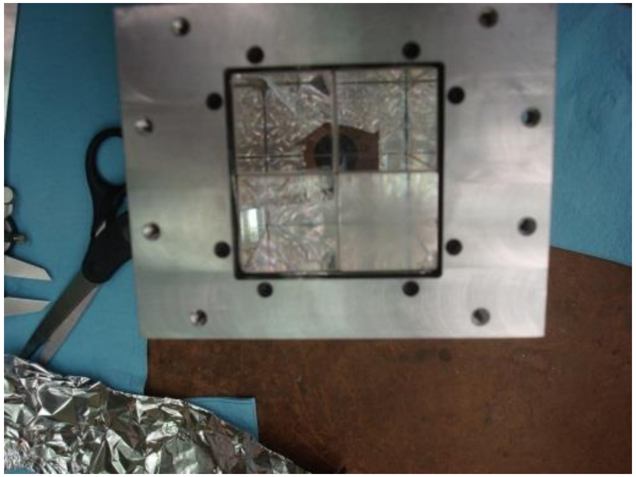


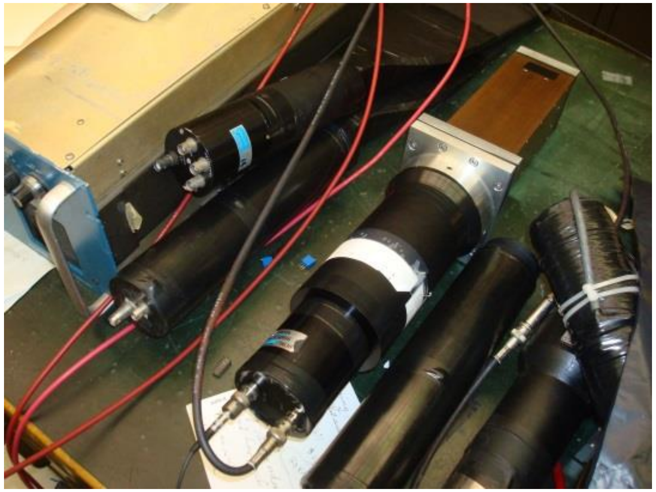




Compton polarimeter photon detector

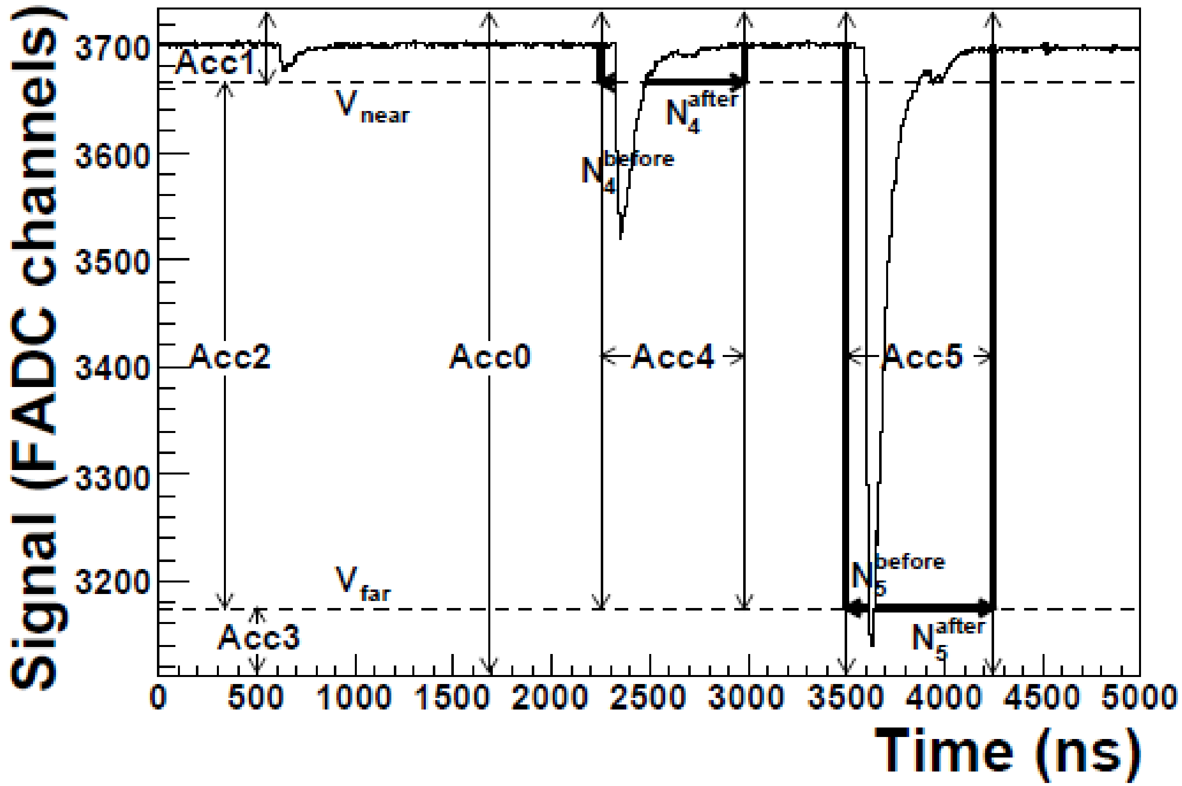
- Lead tungstate calorimeter instead of GSO
- 2x2 matrix couple to one PMT
- FADC Integrating method to be tested at high energy



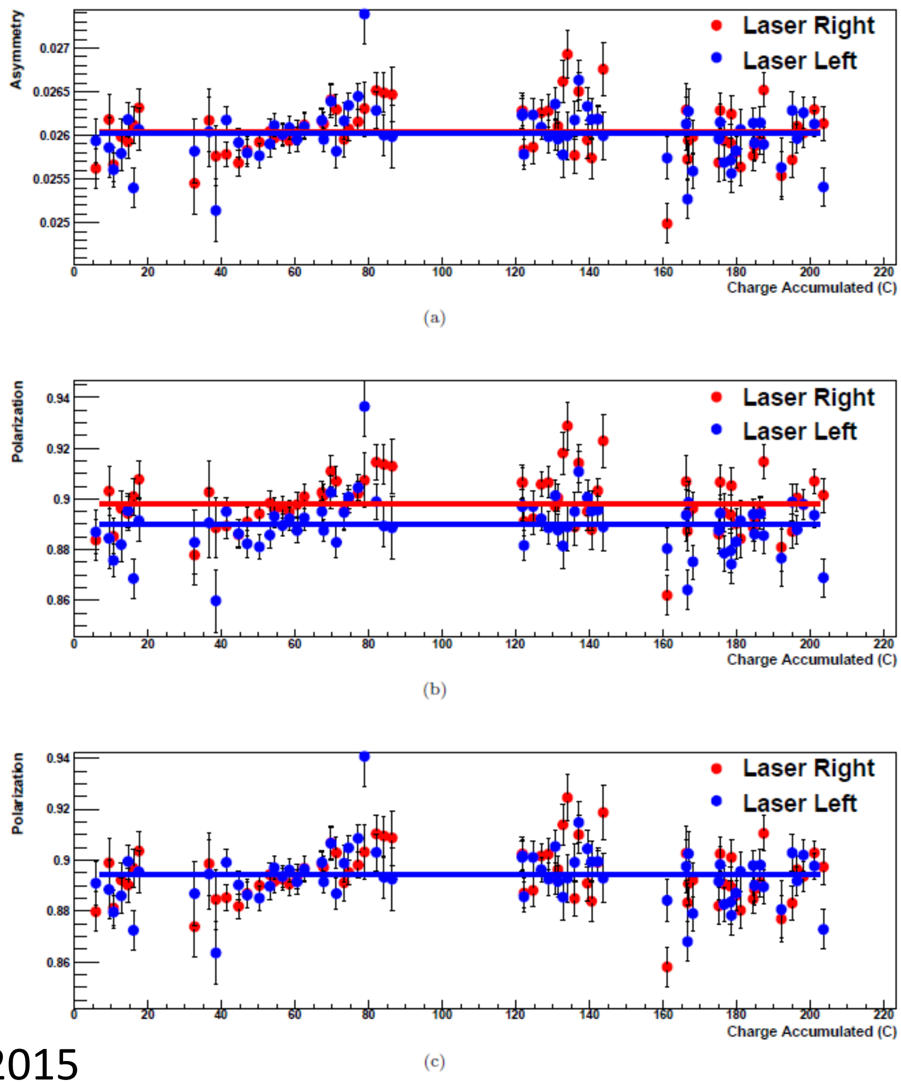


Hall A Photon detector

- FADC readout SIS3320 250 MHz FADC
- Digital integration with 240 Hz helicity flip
- Record all the signal for a given helicity
- Compute integrated asymmetry for a pair



Happex III results



Friend
Nucl.Instrum.Meth. A676 (2012) 96-105

Friend PhD Thesis CMU 2012

Systematic Errors	
Laser Polarization	0.80%
Analyzing Power:	
Non-linearity	0.3%
Electron Energy Uncertainty	0.1%
Collimator Position	0.05%
MC Statistics	0.07%
Total on Analyzing Power	0.33%
Gain Shift:	
Background Uncertainty	0.31%
Pedestal Uncertainty	0.20%
Total on Gain Shift	0.37%
Total	0.94%

Pe =89.41%

Compton polarimetry R&D

- 1 % Compton polarimetry reached at Jlab with current up to 200 μA during 6 GeV
- Main challenge is to scale to large current :
    - 50 mA at eRHIC
    - 3 A at Jlab
  - Hit capabilities
  - RF from beam in detector
  - Evaluate background : Bremstrahlung, Synchrotron
  - Photon source power
  - Design and shielding of detector
  - Impact of shielding on measurement
- Simulation effort and plan to use Jlab as EIC Compton electron polarimetry test stand during 12 GeV

EIC@JLab Compton working group

- Accelerator and detector
- Compton polarimetry
  - David Gaskell, Alexandre Camsonne Jlab
  - Juliette Mammei,Joshua Hoskins (U. Manitoba)
  - Dipangkar Dutta (Missisipu U)
  - Gregg Franklin, Brian Quinn (Carnegie Mellon U)
- eicRD15 : postdoc and design support by R&D EIC fund for electron detector
- Collaboration with BNL on common tools for polarimetry (Compton event generator …)

Conclusion

- The low Q^2 chicane location was integrated in the initial JLab EIC design
- A Compton polarimeter naturally find its place in the Low Q^2 chicane with detection of photon and electron
- Simulation work and detector R&D on going to optimize the design and background aiming at 1% level electron polarimetry