Update of electron beam Compton polarimetry

Jinlong Zhang (张金龙)
Shandong University
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Compton polarimetry

$$\left(\frac{d\sigma}{d\rho}\right)_{Compton} = \left(\frac{d\sigma}{d\rho}\right)_{Unpolarized}[1 + P_{\gamma}P_{e}A_{l}(\rho)] \qquad P_e = \frac{A_{measured}}{P_{\gamma}A_{l}}$$

- Quasi-head-on collision with high-power 100% circularly polarized laser
- Independent detectors for electron and photon of $\vec{e}\vec{\gamma} \rightarrow e\gamma$
- Noninvasive and continuous measurement of asymmetries between left and right handed laser polarization states

COMRAD generator

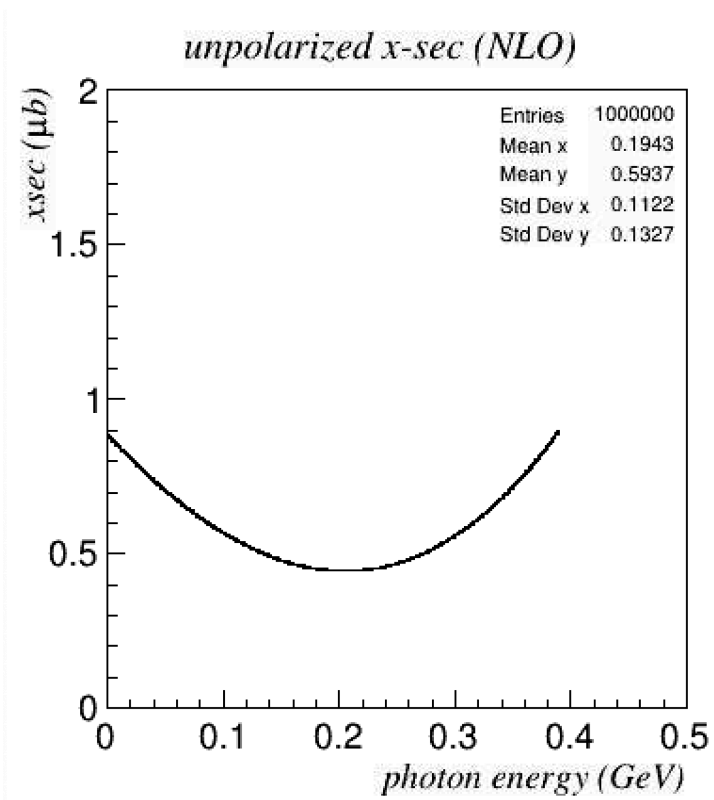
Reference: Morris L. Swart, Phys. Rev. D58, 014010 (1998)

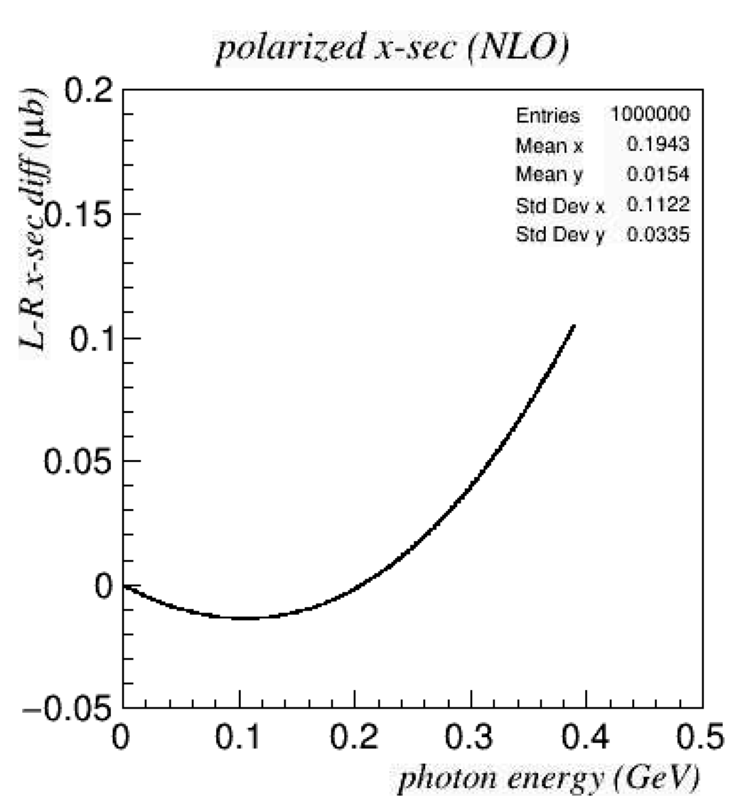
- Provides spin average and spin dependent cross sections for LO and NLO respectively
- Input:
  - electron beam polarization (x, y, z)
  - electron energy
  - photon energy
- Output:
  - 4-momentum for scattered electron and photon,
  - weights for spin average and spin dependent cross sections

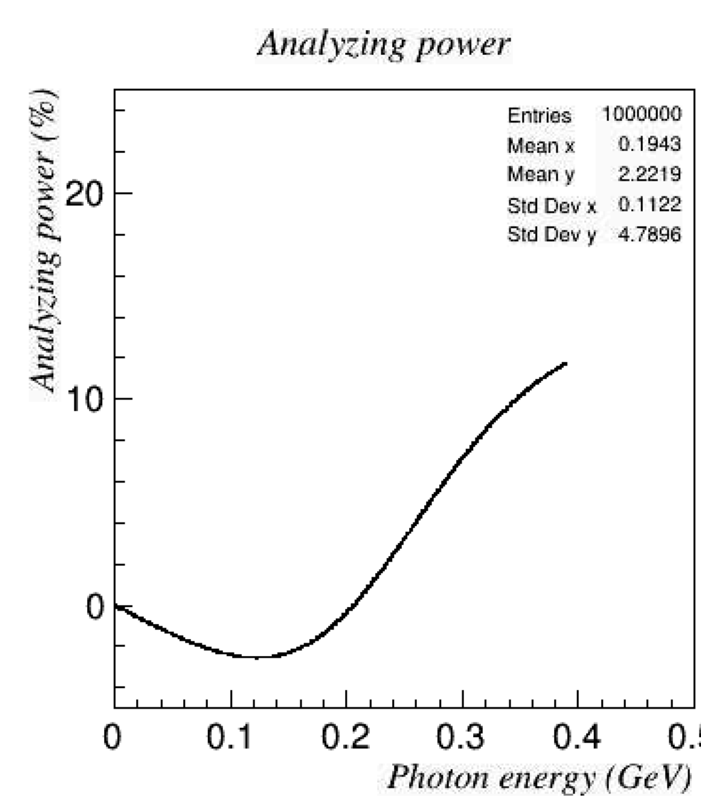
```
C
      PROGRAM COMRAD
C
C ***********************************************************************
C * Author: M. Swartz                                 Date: November 1997 *
C * Reference:                                                           *
C *   SLAC-PUB-7701; hep-ph/9711447; Phys. Rev. D58, 014010 (1998)       *
C *                                                                      *
C * Monte Carlo for e-gamma=>e-gamma(gamma) and e-gamma=>e-e+e-          *
C * to full order-alpha**3 including initial state polarization          *
C * (circular polarization for gamma, general spin direction for e-).    *
C * Uses Stuart and Gongora, Z.Phys. C42,617 (1989) for e+2gam final     *
C * state; Tsai, DeRaad, and Milton, Phys Rev D6, 1411 (1972) for        *
C * virtual and soft-photon corrections; and home-grown calculation      *
C * (based upon the Gongora-Stuart spinor technique) for the 3e final    *
C * state.  Includes explicit unpol xsection calcs as diagnostics.       *
C * Consists of three weighted-generators: COMTN2 which the does the     *
C * e-gamma final state, COMEGG which does the e-2gamma final state,     *
C * and COMEEE which does the 3e final state.  The user interface to     *
C * all 3 generators is via the routine WGTHST (see comments there).     *
C *                                                                      *
C * Requires two external CERNLIB routines:                              *
C *   RANMAR random number generator from MATHLIB (V113)                 *
C *   DDILOG double precision dilogarithm from MATHLIB (C332)            *
C ***********************************************************************
C
      IMPLICIT REAL*8 (A-H,O-Z)
C
C  The block /CONTRL/ contains the adjustable parameters needed for the
C  calculation and some useful physical constants: EB - e- beam energy in
C  GeV, EPHOT - photon energy in GeV, XME - electron mass (in GeV),
C  XMG - the fictitious photon mass (GeV), KGMIN - the minimum resolvable
C  photon energy (GeV), ALPHA - the fine structure constant, PI - 3.1416...
C  ROOT2 - SQRT(2), BARN - (hbar*c)**2 in units of mb-GeV**(-2),
C  SPIN(3) - the initial state electron spin (in the me rest frame),
C  LDIAG - logical flag to turn on diagnostic T-DR-M unpol xsection,
C  LBF - logical flag to turn on diagnostic Brown+Feynman unpol xsection,
C  NTRY - the number of event trials to generate with COMTN2,COMEGG,COMEEE
C         (COMEEE generates NTRY/20)
C
      COMMON /CONTRL/ EB,EPHOT,XME,XMG,KGMIN,ALPHA,PI,ROOT2,BARN,
     >                SPIN(3),LDIAG,LBF,NTRY,WGT(4)
      LOGICAL LDIAG,LBF
      REAL*8 KGMIN
C
C  Define a bunch of physical constants
C
      XME=0.511D-3
      ALPHA=1.d0/137.0359895D0
      PI=ACOS(-1.d0)
      ROOT2=SQRT(2.d0)
C
C  XMG is a small mass for the photon to regulate the infrared divergence
C
      XMG=0.00001D0*XME
C
C  KGMIN is the minimum detectable energy of the photons in the electron
C  rest frame (not the cm frame)
C
      KGMIN=0.002D0*XME
```

COMRAD for EicC

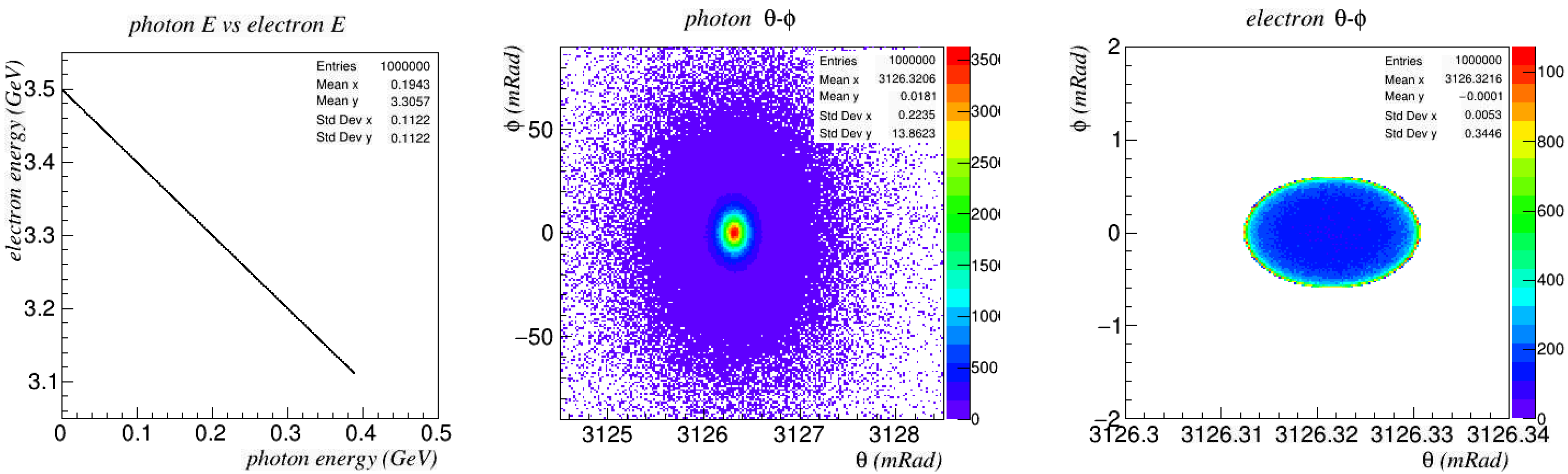
- Electron beam energy: 3.5 GeV
- Photon energy: 2.33 eV
- Electron beam 100% longitudinally polarized







Scattered electrons and photons



- E’(e) + E’(γ) = 3.5 GeV
- Back scattered photon energy: 0~0.4 GeV
  - Electromagnetic calorimeter
- Recoil electron separated from the beam by bending/analyzing Dipole
  - Position sensitive electron tagger

Polarimetry Position selection

Linear and/or semi-circular ?

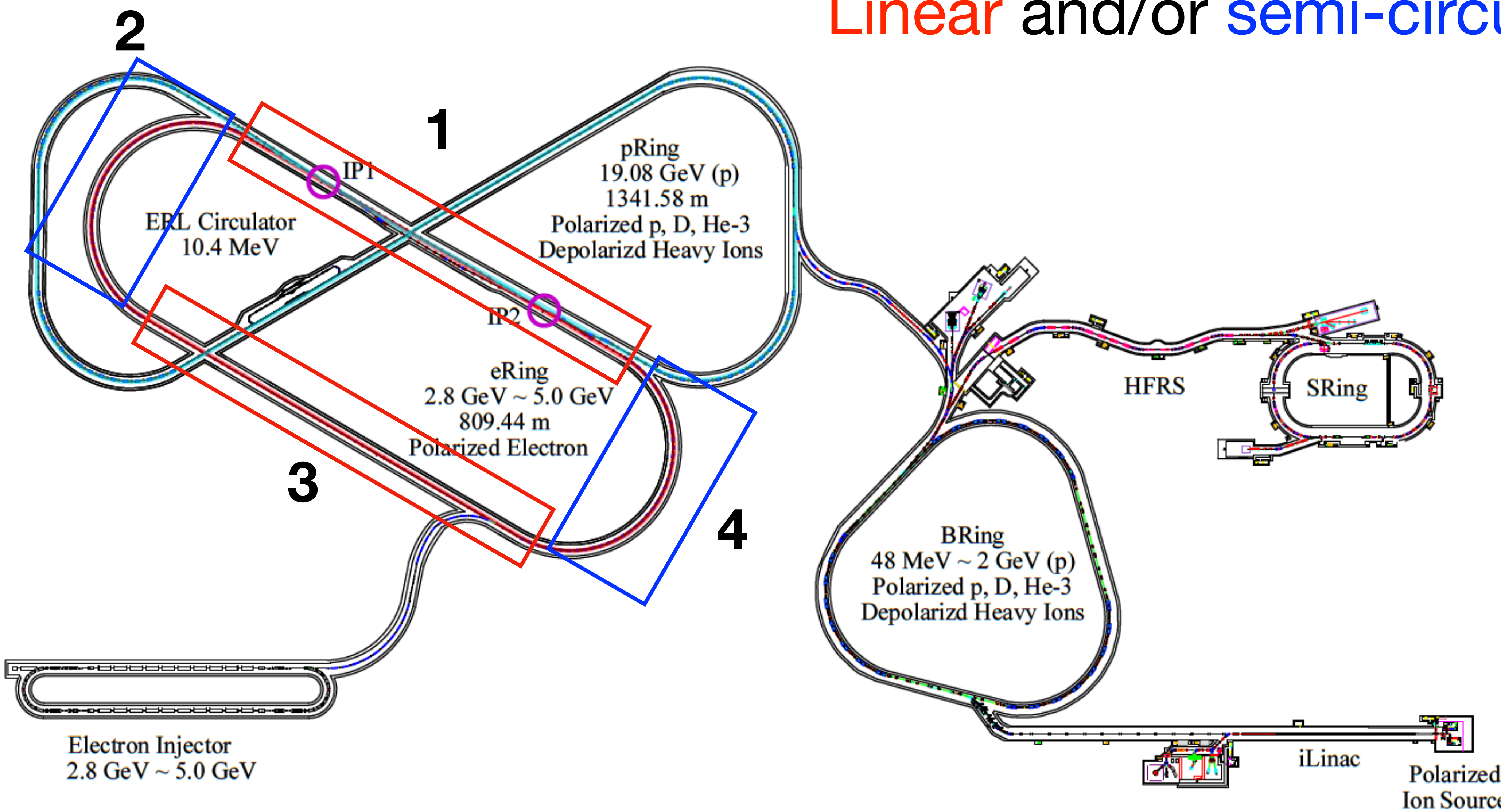
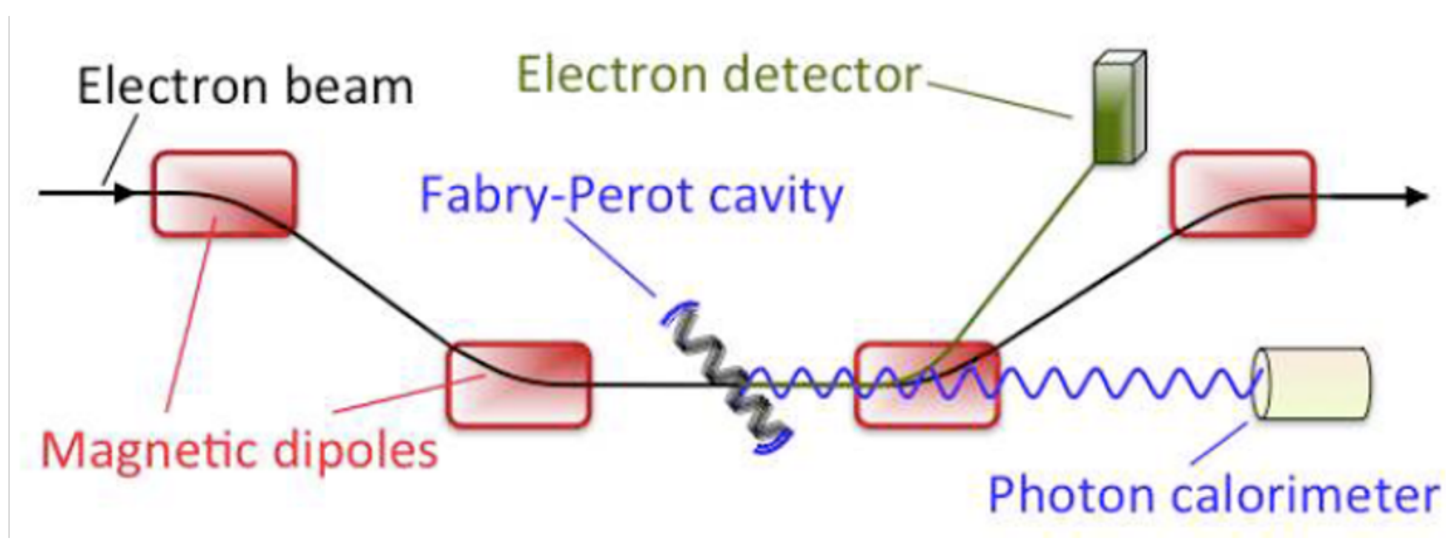


Figure 3.1: The layout of EicC accelerator facility.

Polarimetry at Linear Part(s)

- Closer to main interaction region
- Fewer beam line component
- Need specific dipole magnet(s) to bend/analyze beam

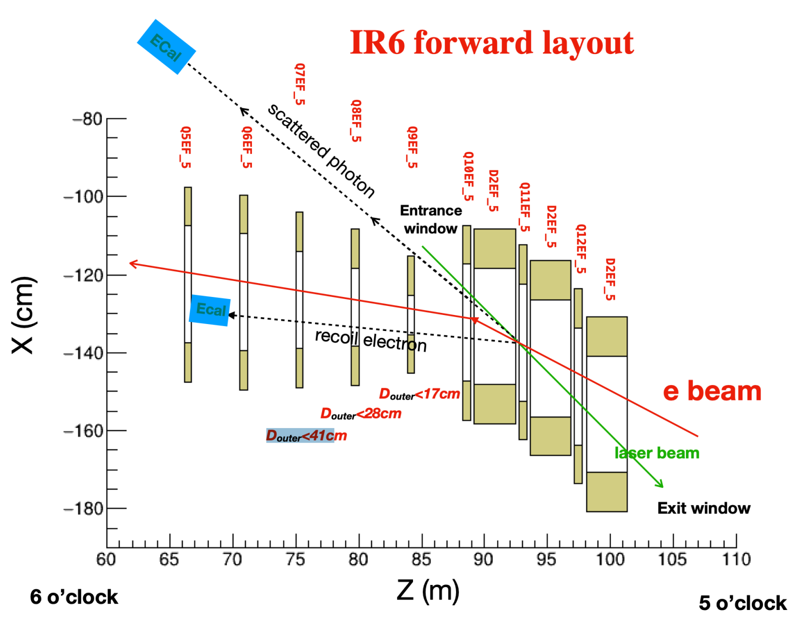
JLab Hall-A Compton polarimetry

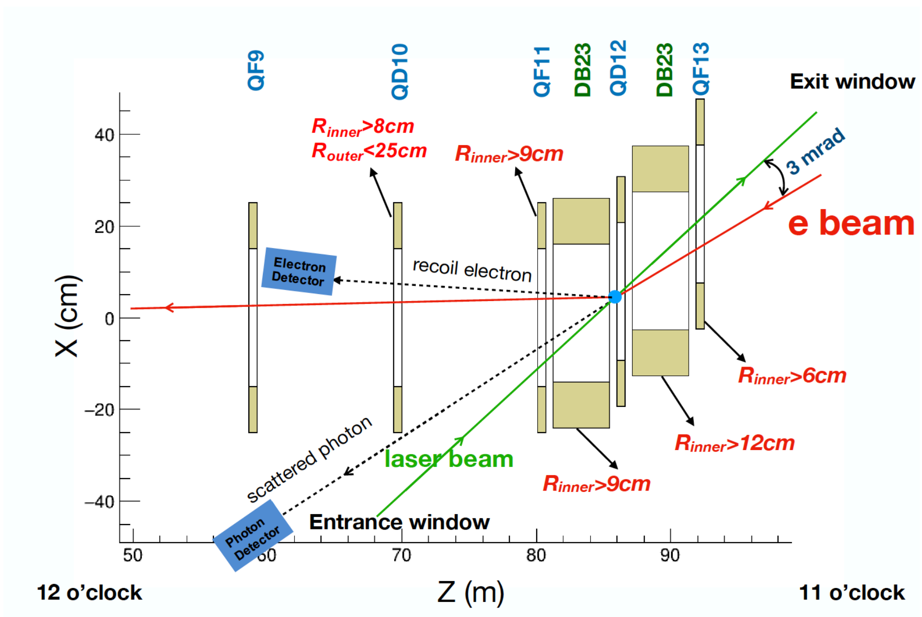


Polarimetry at Semi-Circular Part(s)

- Take usage of beam line bending dipole
- Limited by beam line magnets setup: apertures, spacing, alignment, etc.

  - Two positions, IP6 and IP12 are considered at US-EIC

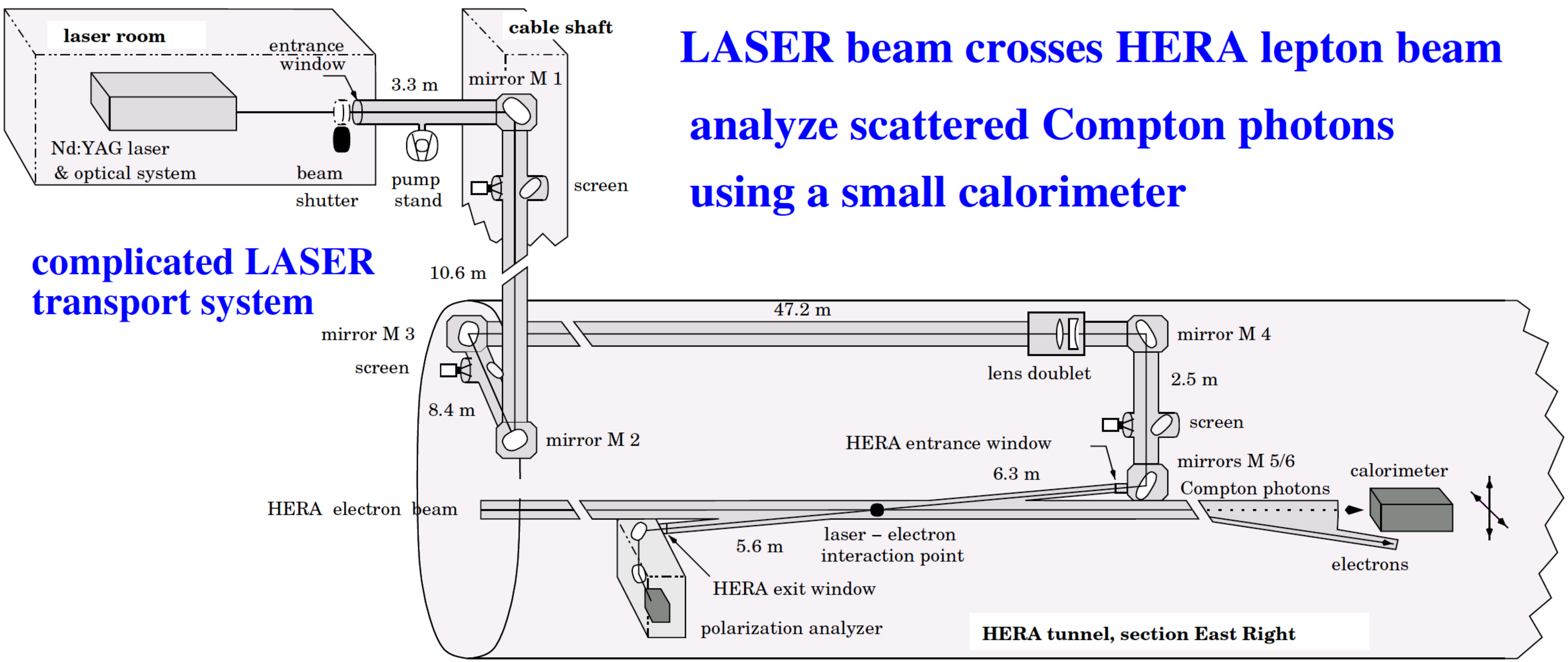




Summary

- Tested NLO Compton generator COMRAD for EicC setup
- Position options: linear and/or semi-circular parts
  - **Need inputs from accelerator experts**
- Next step: Geant4 simulation for detector design

COMPTON at HERA



complicated LASER transport system

LASER beam crosses HERA lepton beam

analyze scattered Compton photons

using a small calorimeter

COMPTON at SLC