eRD15
Compton electron detector R&D

EIC R&D meeting

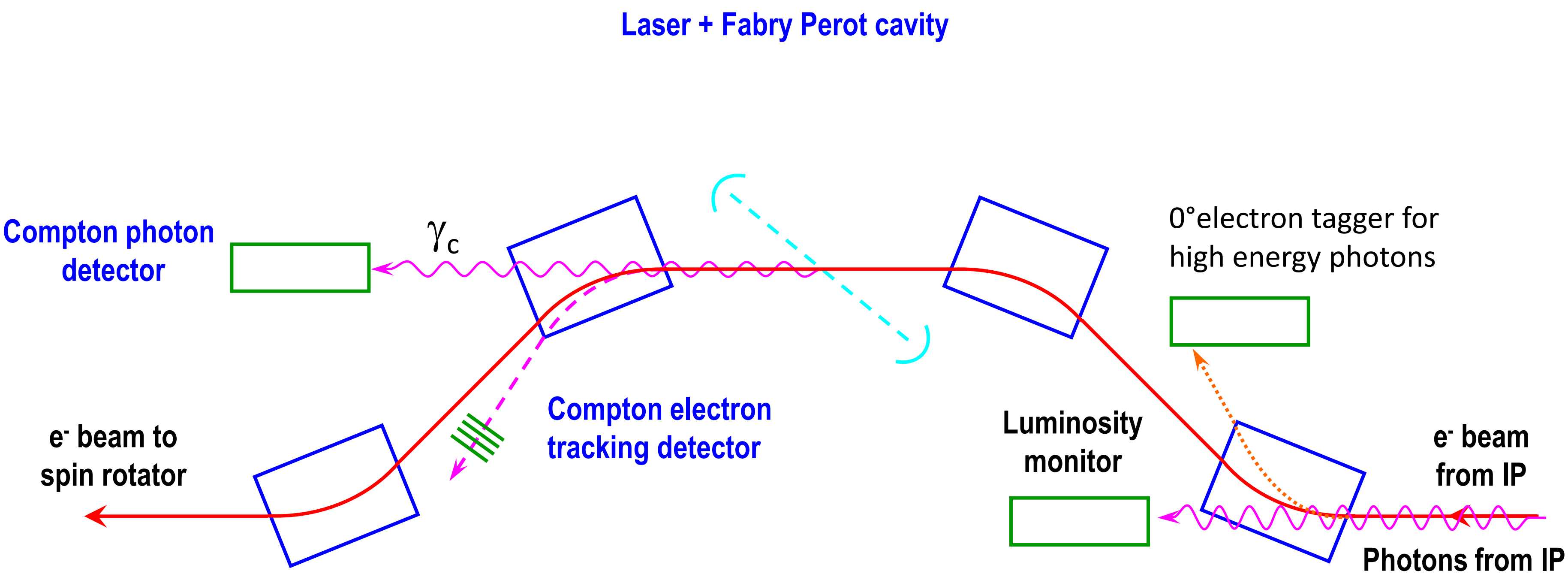
July 6-7th 2016

Alexandre Camsonne

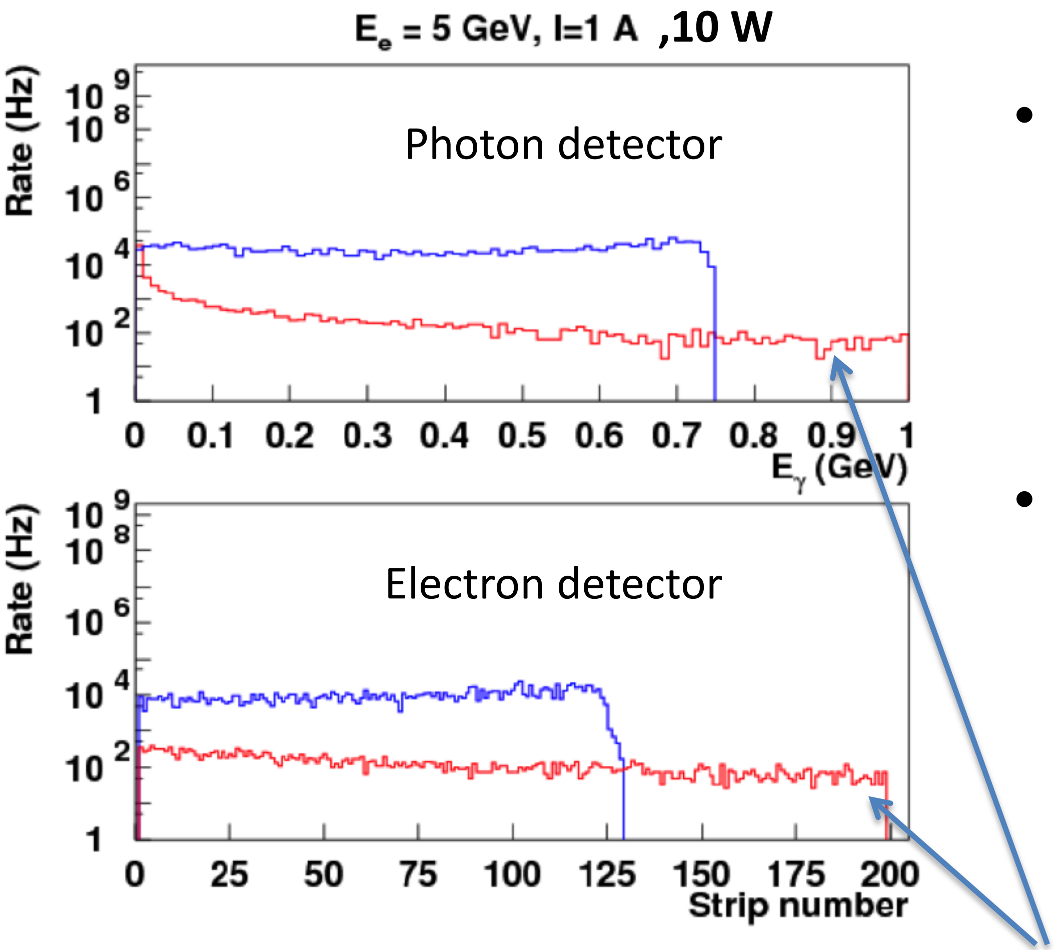
eRD15 : Compton electron detector R&D

- Requirement
  - 1% electron polarization measurement
  - Best measurement Compton electron detector at SLD (~0.5%)
- Deliverables
  - Simulation to determine signal to background for JLEIC baseline Roman Pot and expected accuracy
  - Detector R&D for faster detector (signal at least shorter than 100 ns for eRHIC design, improves rate capability for JLEIC)
  - Test stand at JLab to measure precision polarization with the foreseen detector for EIC

Compton polarimeter



Laser studies (Gaskell)

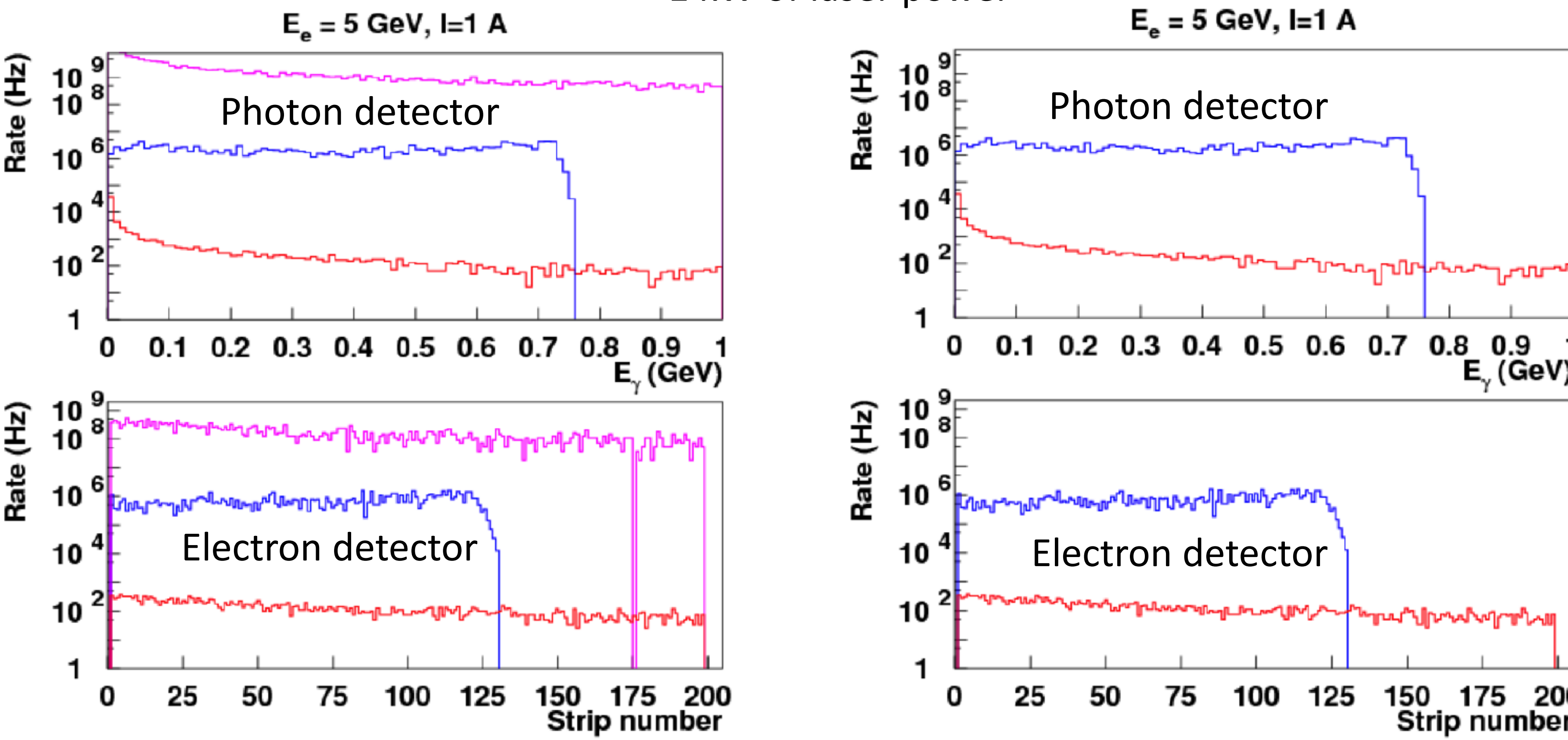


Bremstrahlung

- Compton signal in blue
- Reasonable signal to noise

Laser studies (Gaskell)

1 kW of laser power



Aperture +/- 1cm

Aperture +/- 2cm

Magenta = halo

Blue = Compton

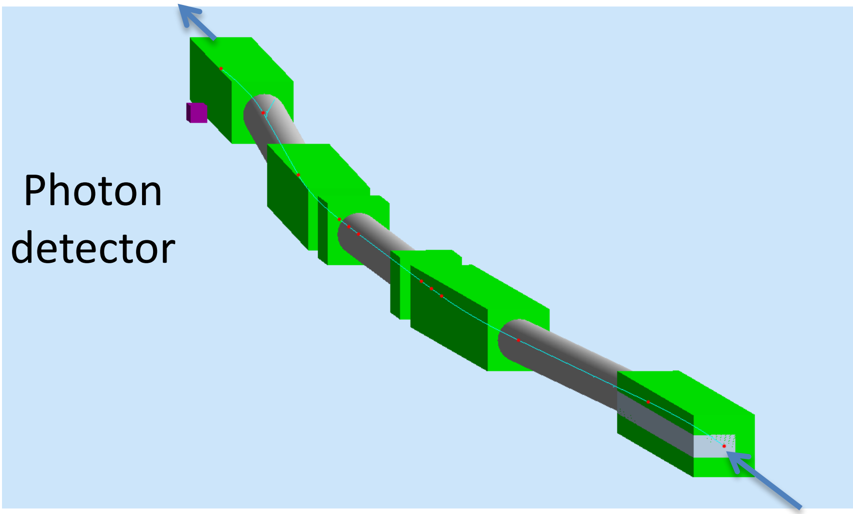
Red = beam-gas bremsstrahlung

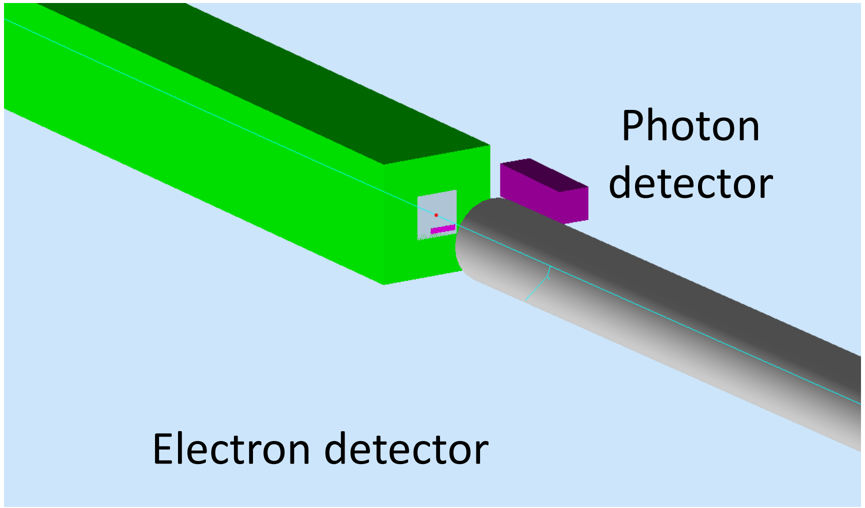
Measurement times for 1% statistics

Energy	Current	1 pass laser (10 W)		FP cavity (1kW)	
(GeV)	(A)	Rate (MHz)	Time for 1% uncertainty (ms)	Rate (MHz)	Time for 1% uncertainty (ms)
3	3	26.8	161	310	14
5	3	16.4	106	188	9
10	0.72	1.8	312	21	27

Typical measurement takes less than 1 second even at 10 Watts of laser power

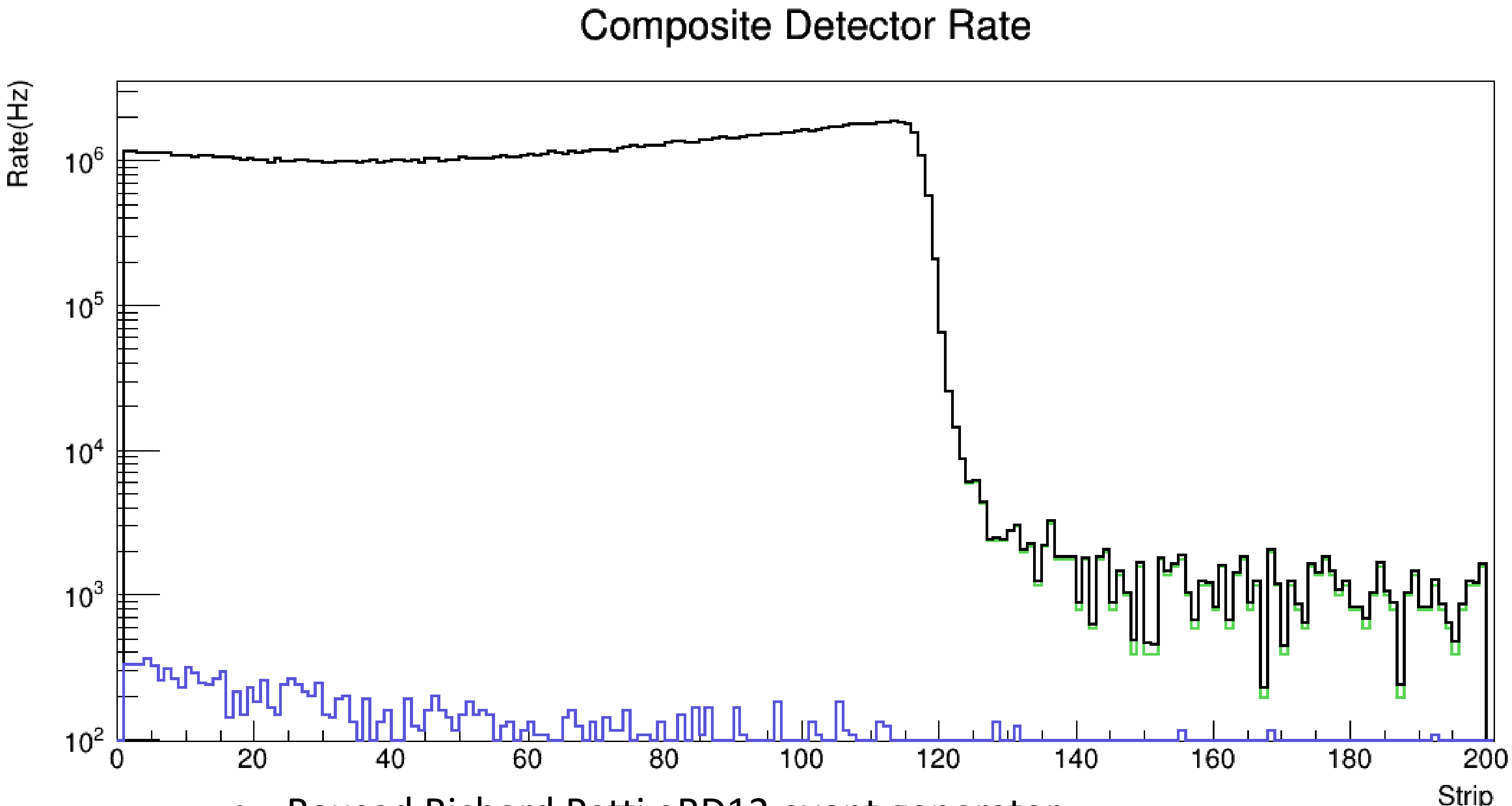
Beamline Geometry in GEMC





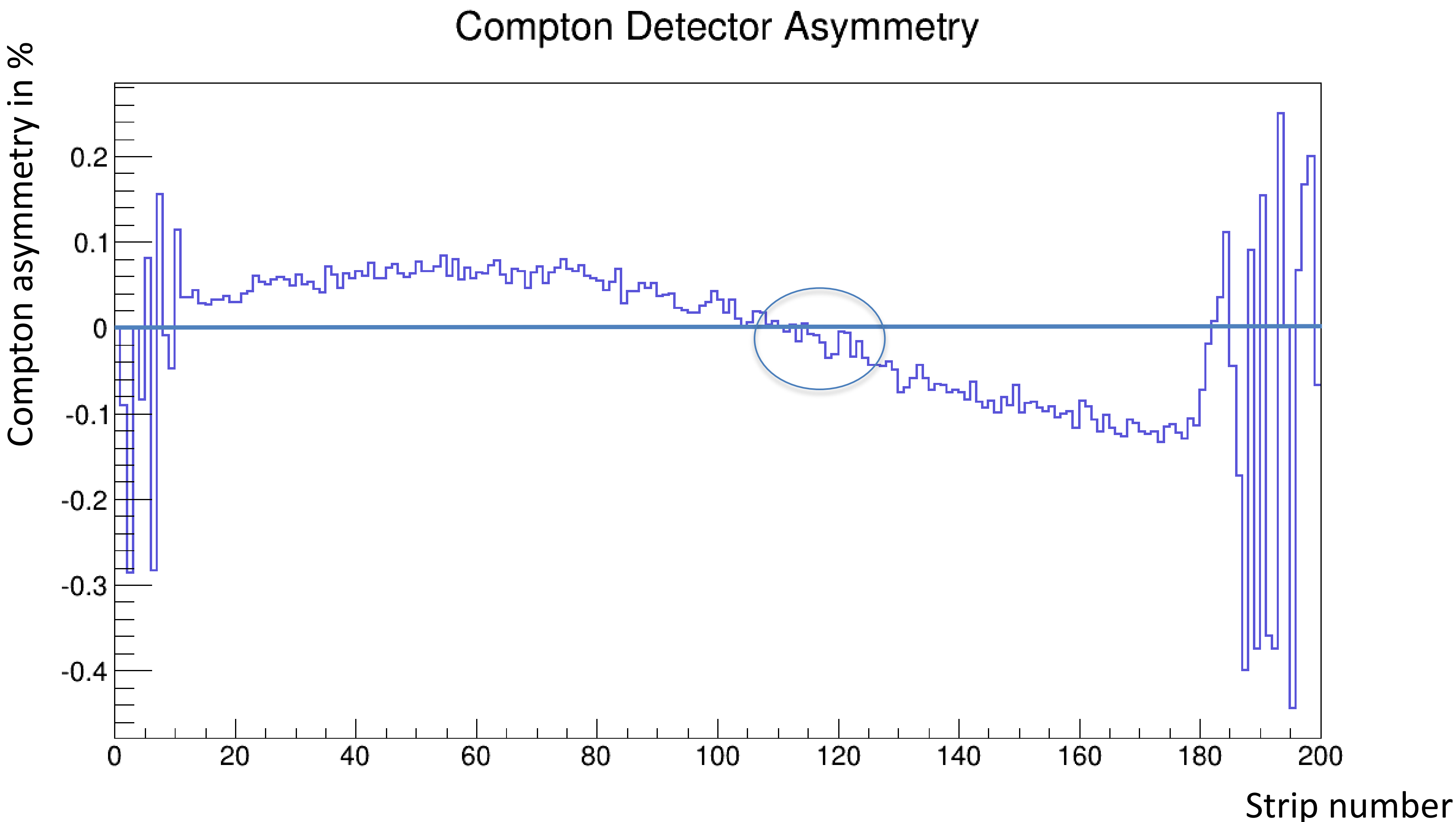
- Beam pipe implemented
- All presentation simulation results only done with the chicane to speed up the studies
- Will install on batch to run high statistics and full setup

Signal to background with GEMC



- Reused Richard Petti eRD12 event generator
- 1A 1 kW 5 GeV
- All Geant4 processes
- Signal is consistent with Geant3 simulation

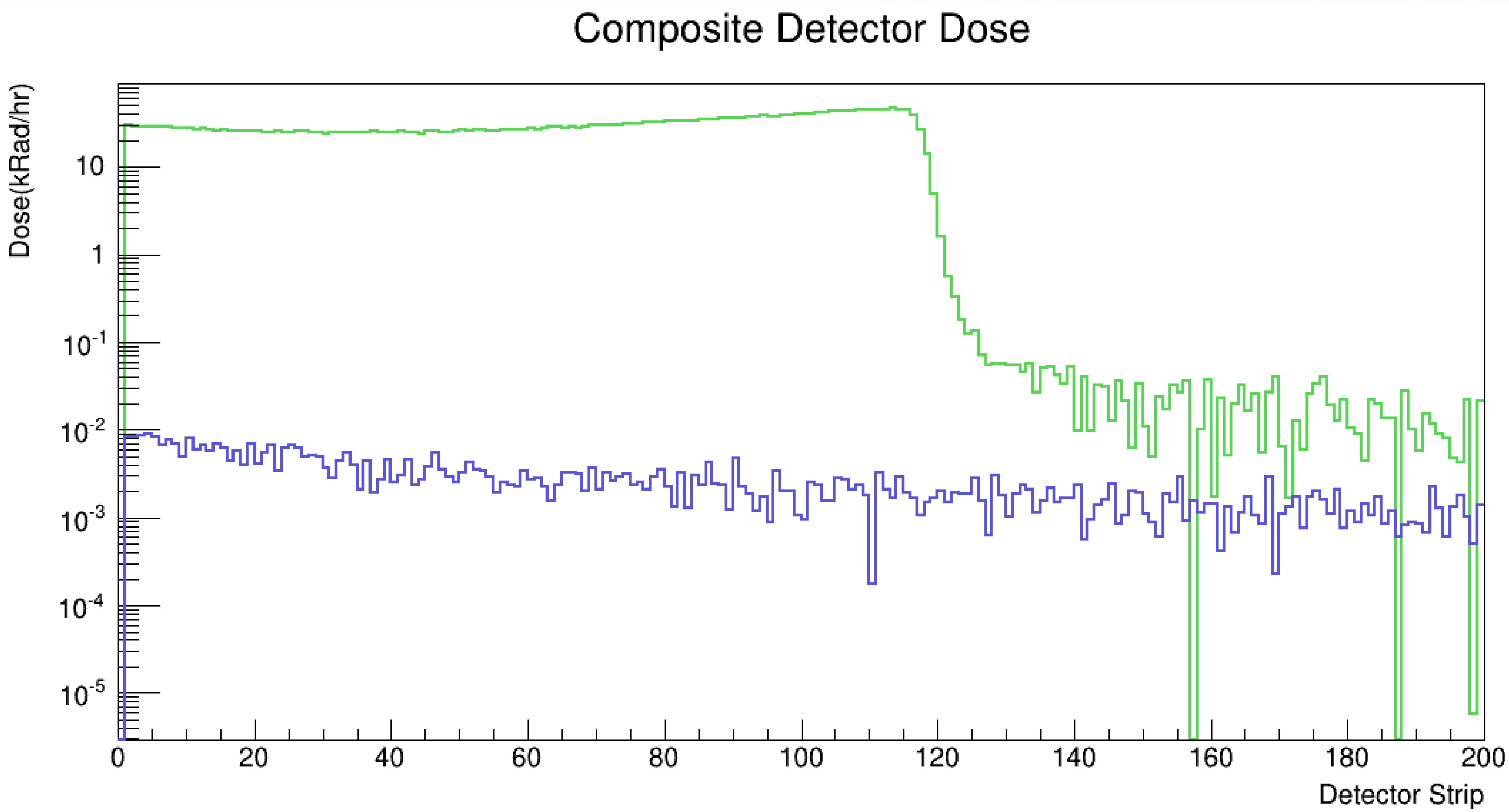
Compton Asymmetry



Asymmetry close to what is expected, being cross checked

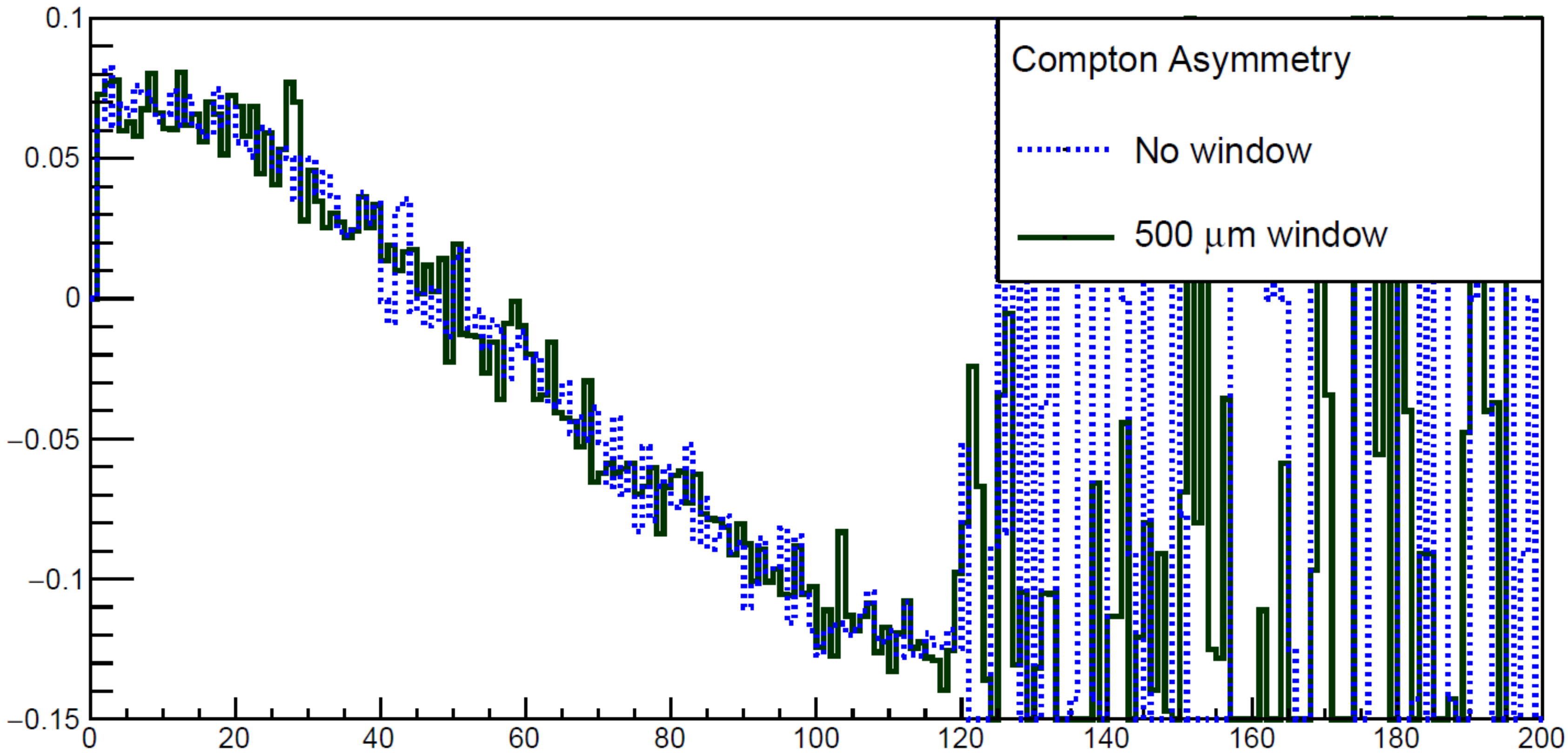
Use the zero crossing of the asymmetry to have a self calibrating detector

Radiation dose in the detector



- Consistent with estimation from a previous experiment in Hall C which showed no damages for the diamond detector after 10 Mrad (3 hours at JLEIC), regular silicon looses 50 % of amplitude after 10 Mrad
- Operate diamond detector at low duty cycle (1s/10 min) and lower laser power (10 W) to extend lifetime up to 3 years
- Radiation hard detector allows continuous monitoring of the polarization

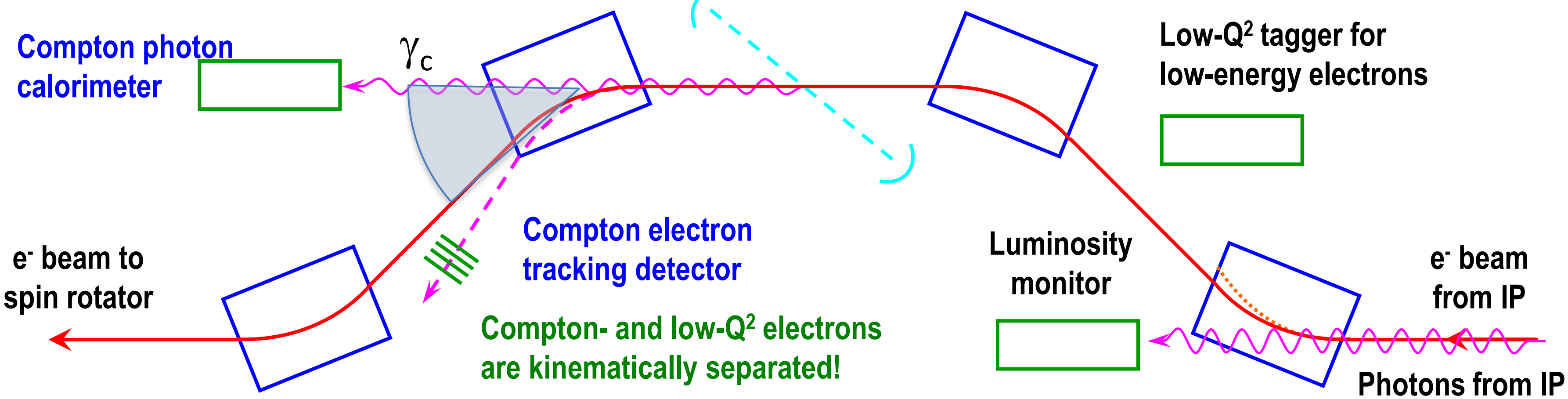
Compton asymmetry with window

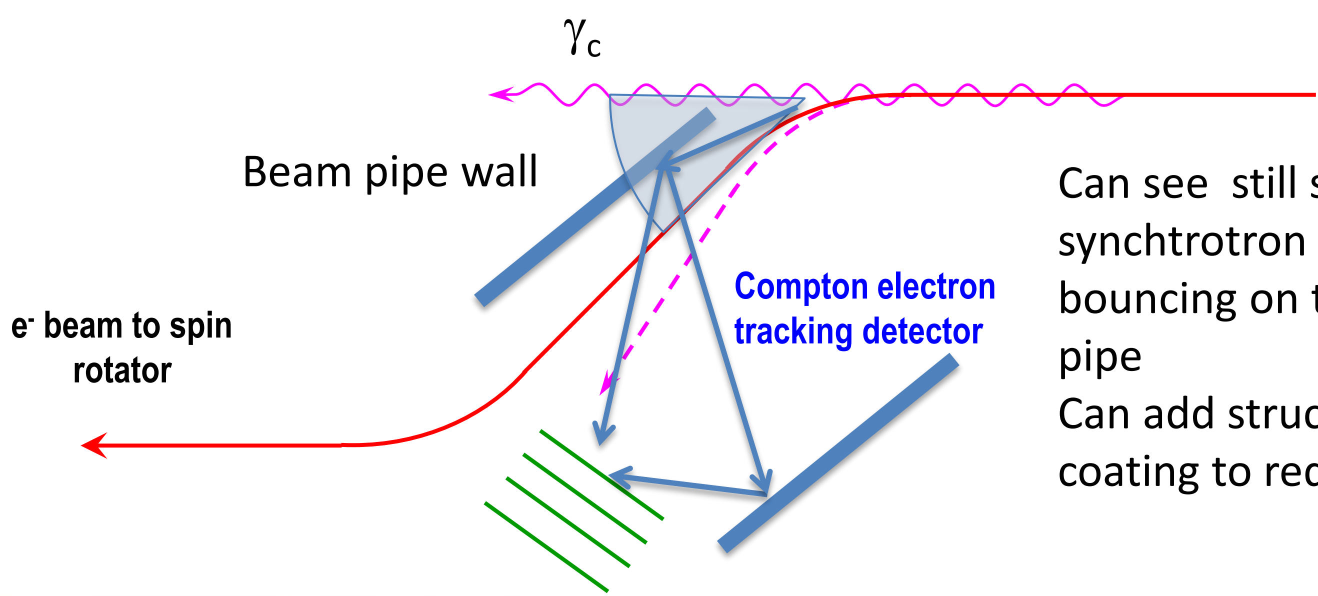


- Roman pot design introduces a 500 μm thin steel window in front of the detector. Preliminary results with low statistics seems to show that there is little change introduced by the window
- To be confirmed with high statistics and polarization extraction analysis

Synchrotron radiation

Not in direct view of synchrotron fan

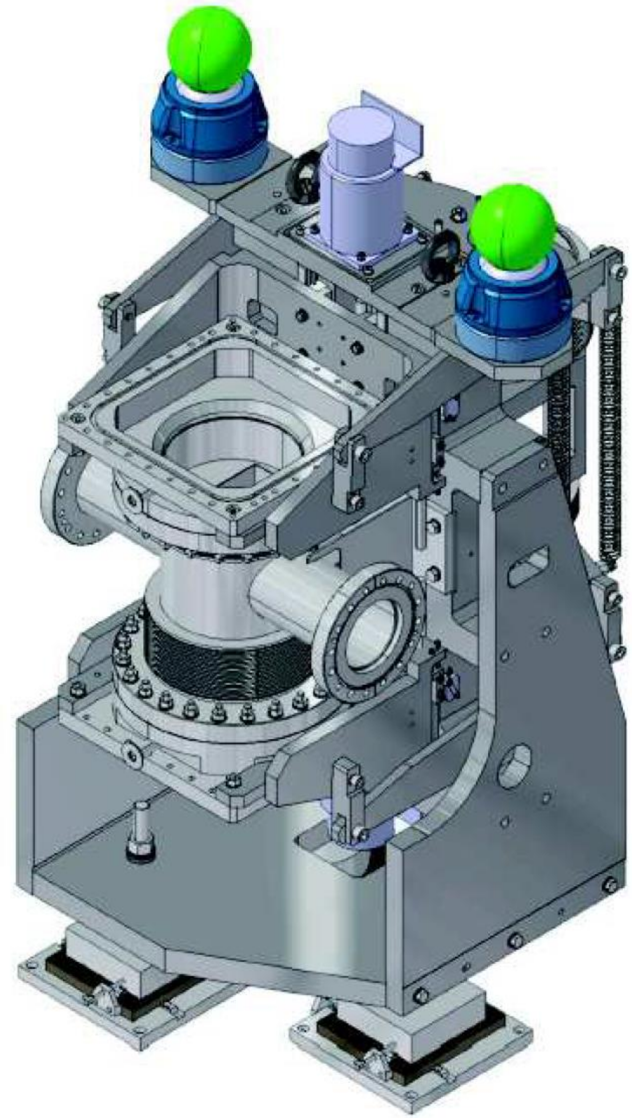




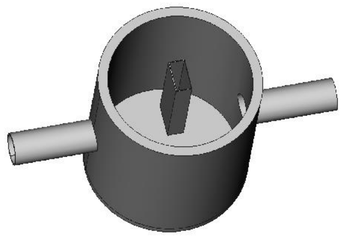
Can see still see synchtrotron bouncing on the beam pipe
Can add structure and coating to reduce it

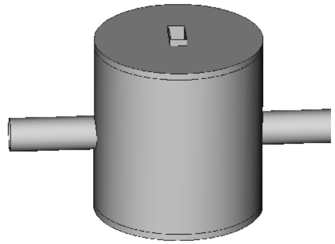
Roman pots from TOTEM

- For small angle detection
- Two chambers
- Thin window
- Can be moved in and out from beam
- Typical 10 to 15 sigma
- Up to 4-5 sigma in optimal places
- Might work for electron side at both JLEIC and eRHIC to be studied



Wakefield progress





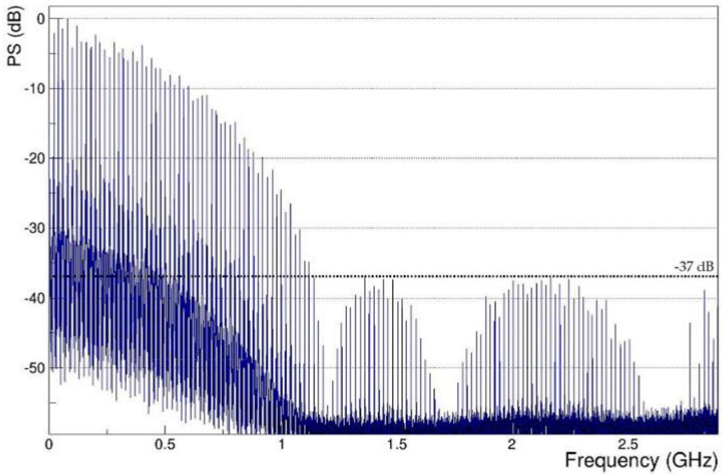
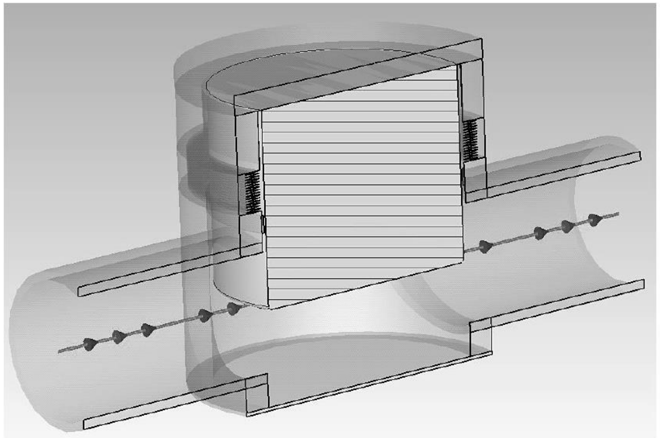


Figure 2.1: *LHC Power spectrum, measured before LS1 [33]. The power spectrum is more than* 37 dB *attenuated above* ∼ 1.2 GHz.



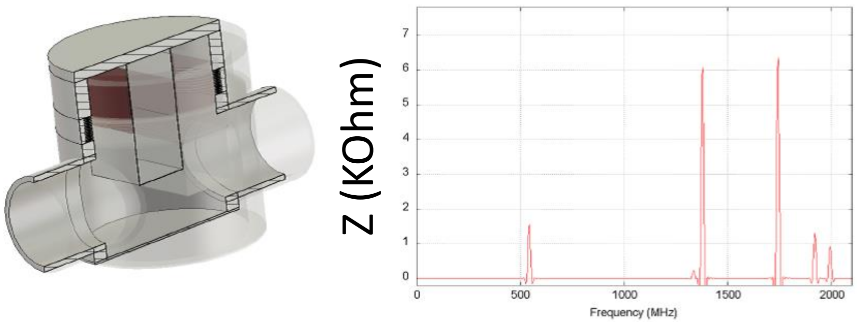
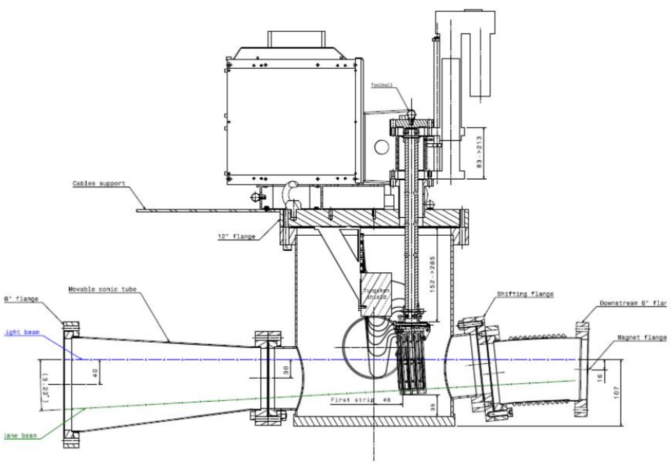
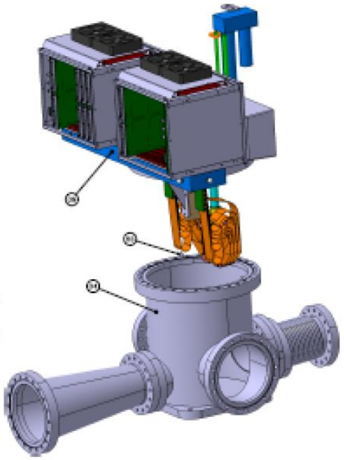
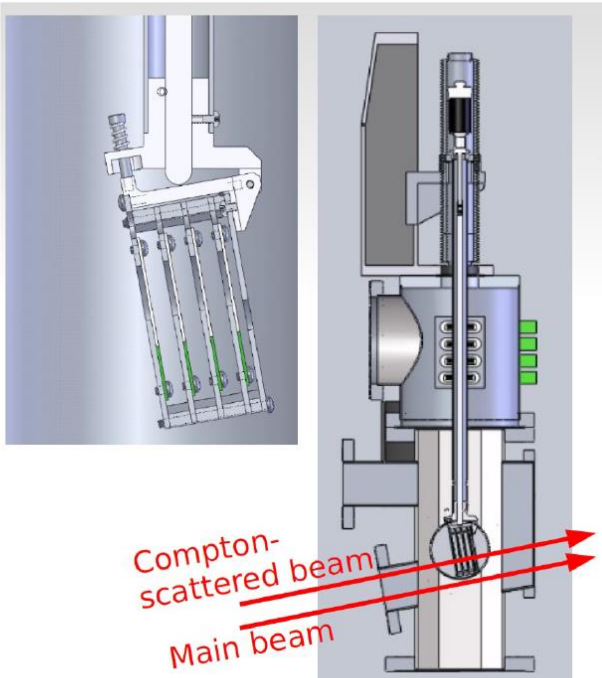


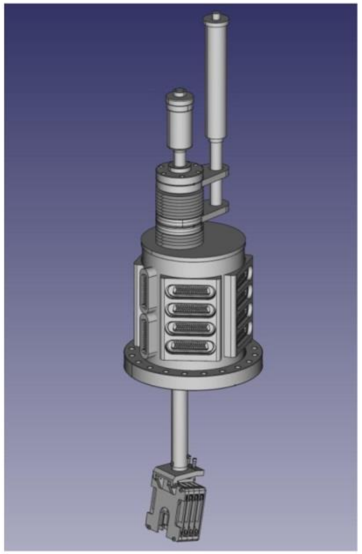
Figure 2.2: *Before LS1 all Totem Roman Pots were box shaped (left). The empty space between the RP and the flange resonate at low frequency (*∼ 500 MHz*) as visible in the simulated longitudinal impedance without ferrites (right).*

Test stand









- Compton polarimeter was demonstrated to achieve 1 % systematic with photon at 1 to 3 GeV
- Prove detector technology with pulses shorter than 100 ns eRHIC beam structure
- Crosscheck accuracy of electron detector for EIC
- Could consider Roman Pot but more expensive

Electronics

- Available electronics
  - 768 A/D for silicon
  - spare 192 channels
  - 32 channels analog for silicon
  - 256 A/D for diamond
  - 96 spares channels

- Would like to acquire
  - 1 channel of CIVIDEC amplifier
  - SAMPIC
  - 32 channels sampling
  - Up to 8.2 GHz
  - Low cost 4.2 K$
  - Allow study of several channels and record very fast pulses

TOTEM detectors

- Diamond detector

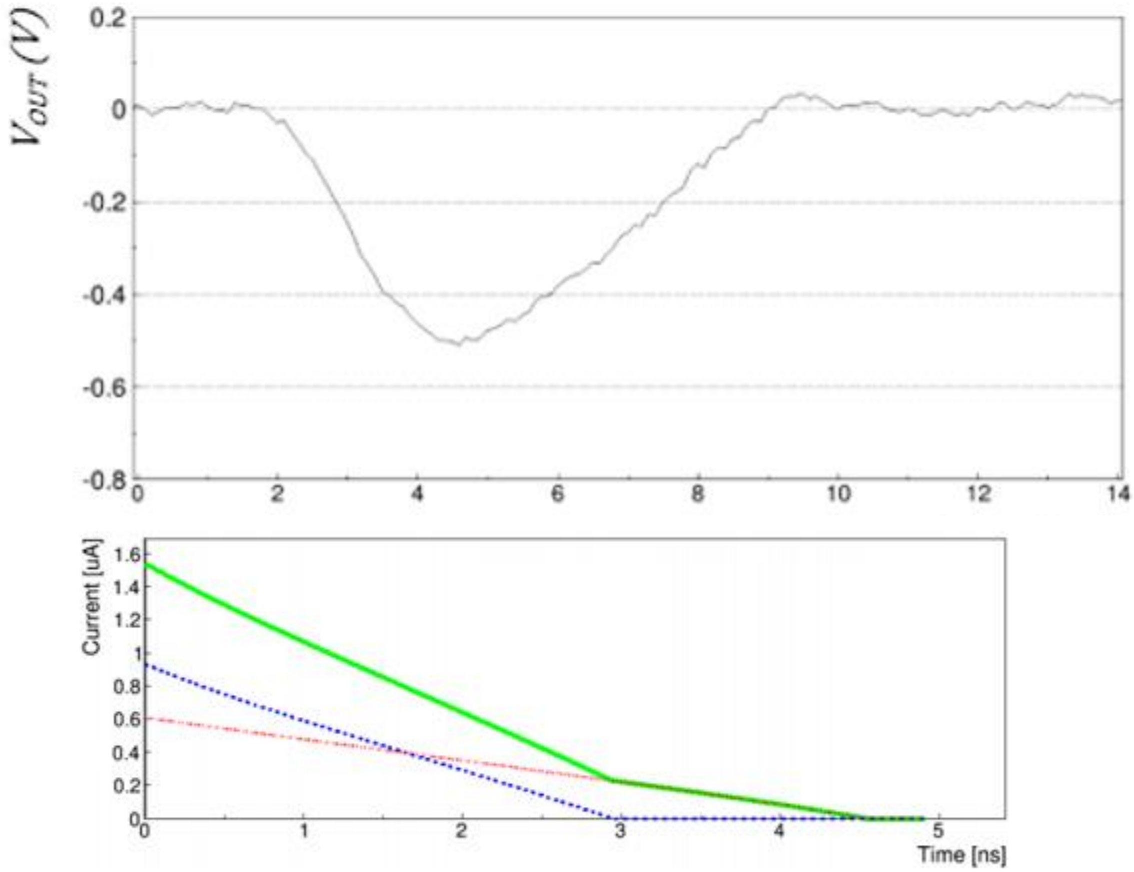
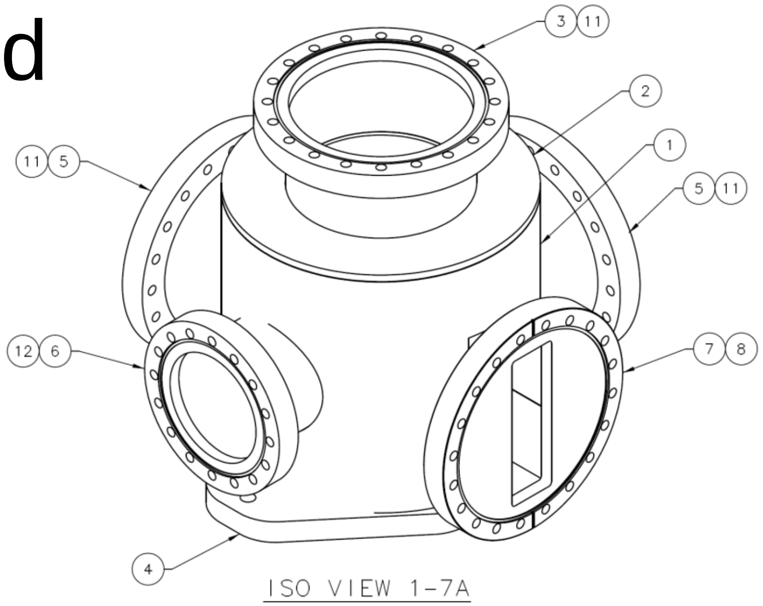


Figure 4.4: *Signal produced by a MIP passing through a 500 μm diamond simulated using Weightfield2 [67]. The red dotted line represents electrons, the blue dashed line is for holes and the green solid line is the sum of the two contributions.*

- Current TOTEM detector and electronics should accommodate eRHIC need to separate the different source
- Polarimetry only needs moderate timing resolution : will test with amplifier discriminator

Lower chamber designed

- Lower chamber designed and costed
- Compatible with Hall C diamond detector
- Integrated in Hall A beamline



Jefferson Lab

Proposal for 2017

- Continue postdoc funding to complete simulation work
- Increase travel money for collaboration with KU on Wakefield, electronics and detector
- Procure amplifier and readout for bench test at Jlab before beam test
- Build lower chamber for beam test

Deliverable for 2017

- Simulation
  - Fix beam pipe in magnet
  - More cross check with old simulation
  - Full simulation with Interaction Region and beam pipe
  - Run simulation large scale on batch farm will full setup
  - Halo modelling
  - Model beam laser interaction
  - Implement polarization extraction analysis
  - Study of systematics and optimization of the setup
  - Synchrotron radiation study, detector response to synchrotron photons
- Wakefield Higher Order Mode
  - Run first pass simulation and determine if Roman Pot is doable for Compton Electron detector
- Test stand
  - Procure Amplifier and SAMPIC and setup bench
  - Multichannel amplifier design and multichannel discriminator board design
  - Complete design of the chamber, delayed because of designer time and change in design of connectors for the Amplifier Discriminator boards
  - Measure detector pulse width on the bench

In boxes, completion expected for next R&D meeting

Manpower

Individual	Institution	Percentage in %	Task
Alexandre Camsonne	Jefferson Lab	20	Wakefield, general,postdoc supervision
David Gaskell	Jefferson Lab	5	Geant3, laser system,postodoc supervision
Joshua Hoskins	U. Manitoba	50	GEMC full simulation
Michael Sullivan	SLAC	advisory	Synchrotron
Haipeng Wang	Jlab SRF	advisory	Wakefield
Robert Rimmer	JLAB SRF	advisory	Wakefield
Christophe Royon	Kansas U.	5	Detector, electronics, Wakefield
Nicola Minafra	Kansas U.	5	Detector, electronics, Wakefield
Michael Murray	Kansas U.	5	Detector, electronics, Wakefield

Budget

		K$ direct	Cumulative Direct K$	Total Cost K$	Cumulative Total (K$)
Post doc		22	22	33.99	33.99
Travel		15	37	23.175	57.165
CIVIDEC Amp		3.6	40.6	5.562	62.727
SAMPIC cost		4.2	44.8	6.489	69.216
Amplifier		20	64.8	30.9	100.116
Detector Si		2	66.8	3.09	103.206
Detector Diamond		3	69.8	4.635	107.841
Wirebonding		5	74.8	7.725	115.566
Discriminator		20	94.8	30.9	146.466
Lower chamber		10	104.8	15.45	161.916
Detector holder		7.5	112.3	11.5875	173.5035
Test flange		5	117.3	7.725	181.2285
				Total	181.23 K$

Summary

- First signal to background plots
  - 10 W laser seems sufficient but need full background
- Wakefield
  - Tools and collaboration to make the study in place
- Simulation in place
  - Run in batch for full background and high statistics
  - Need implement background and analysis to study effect of background and shielding

Backup slides

TOTEM CIVIDEC amplifier

- Fast amplifier used with TOTEM diamond detector
- About 3 K$ per channel
- Plan to procure one
- Multichannel amplifier development planned (need 768 channels)

C6 Gaussian pulse shape