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EIC Detector R&D Proposal and Progress Report

Project ID: eRD_X_

Project Name: _ A proposal for Compton polarimetry R&D for EIC

Period Reported: from_07/2014____ to_06/2015____

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Abstract

This proposal studies the issues related to Compton polarimetry by detecting Compton electrons. The concept of a Compton Polarimeter in the mEIC low Q2 chicane is presented. It is proposed to modify the existing Compton polarimeters at Jefferson Laboratory in order to be able to address issues about Compton Polarimetry at a future EIC such has effect of shielding, radiation hardness of the current detectors and improvement in detector timing with a goal in mind to reach electron polarimetry accuracy at 1% level.

A proposal for Compton electron polarimetry R&D for EIC

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1) Motivation for Compton polarimetry

As mentioned in the proposal RD 2013-6: R&D Proposal for an electron polarimeter, a luminosity monitor and a low Q2-tagger" . Precision electron polarimetry can have a significant impact on measurements at EIC for example in the measurement of luminosity which could be affected. In the white paper section 4.3 and 6.2.5, the accuracy on the polarization is aimed to be at 1%. The best Compton measurement was done at SLC which reached 0.5 % but at a higher energy of 46.2 GeV. However the condition at Stanford were quite different to an EIC machine : beam and laser were pulsed at a few hertz and the scattered electron displacement was of the order of several centimeters in addition to the high energy generating an asymmetry of the order of 75 %. At lower energy and with Continuous Wave beam at Jefferson Laboratory 1% level accuracy was achieved at 6 GeV where asymmetries are only a few percent. We anticipate accuracy at this level at 12 GeV, the higher background levels being counterbalanced by a larger analyzing power at higher energies.

2) Requirements for Compton polarimetry at EIC

In order to monitor the polarization of the electron, Compton Scattering is ideal. This process is an accurately computable QED process which allows a noninvasive and continuous monitoring of the polarization. The electron beam interacts with a source of circularly polarized photons: either a laser or using a cavity to amplify a seed laser. The cross section of the Compton process is dependent on the electron helicity and photon helicity, by measuring the asymmetry between two opposite longitudinal helicities states and computing the analyzing power of the Compton process one can extract the polarization. In order to detect both photons and electrons a dipole magnet is used after the interaction allowing catching the Compton photons in the zero degree line and the Compton electrons which are deflected more than the beam after giving energy to the photon during the Compton interaction. The EIC is a novel territory for Compton polarimetry since the energies are low to moderate from 3 GeV up to 21 GeV and currents range from 50 mA up to 3 A. In those conditions Compton asymmetry will range from a few percent to several tens of percent and contributions of bremsstrahlung and synchrotron radiation will be significant because of the higher energy and large current.

3) eRHIC

The electron beam of eRHIC will be a multipass Energy Recovery Linac with a repetition rate of 10.8 MHz. This design is very close to the Jefferson Laboratory design. Nominal current will be as high as 50 mA by using the "Gatling gun" scheme where up to 12 sources are used by switching from one to another source for each bunch. The helicity of the beam can be easily switched by using a pockell cell at the laser source. Since each source can have different polarization a logic signal for each source will be used to measure the average polarization of each one. The detectors should be optimized for a fast response less than 100 ns to be able to resolve each source.

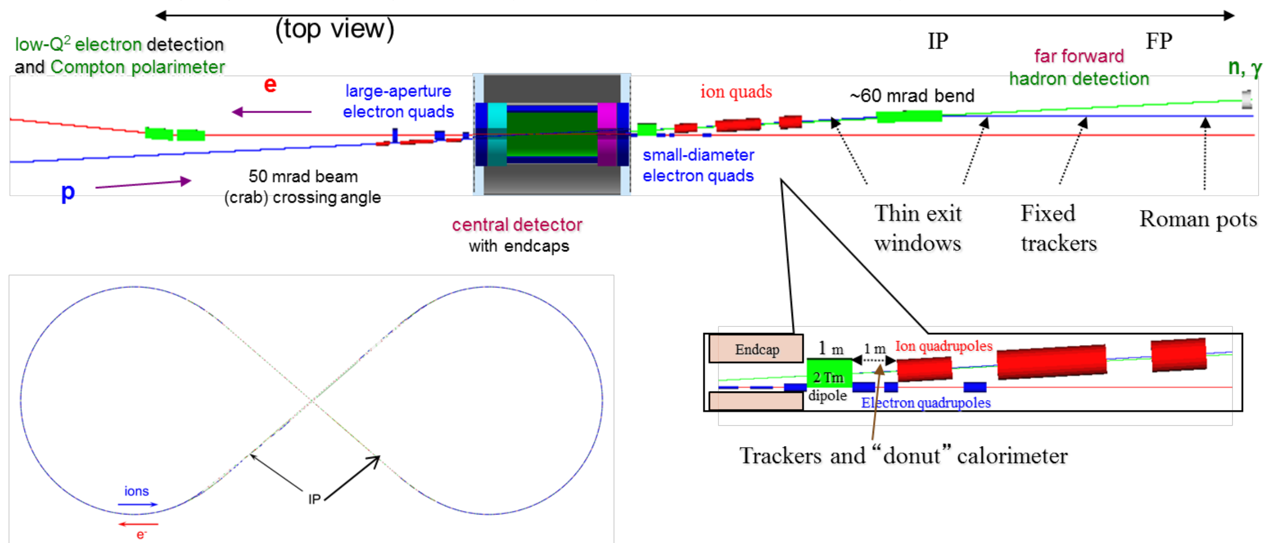
4) mEIC design parameters

a) mEIC new beam parameters

Several parameters were changed for the mEIC design in order to accommodate the reuse of SLAC PEPII component in order to save costs. This includes a change in the ring size and in bunch frequency. The mEIC will operate from 4 to 10 GeV with currents ranging from 3A to 720 mA.

Energy (GeV)	4	5	10
Current (A)	3	3	0.72
Rep rate (MHz)	476	476	159
Bunch length (cm)	1.2	1.2	1.6
Emittance (x/y) μm	74/74	144/72	1152/576
Polarization lifetime (hours)	66	5.2	0.8

The MEIC is a ring ring collider in a figure of 8 layout to preserve the deuterium ion polarization.



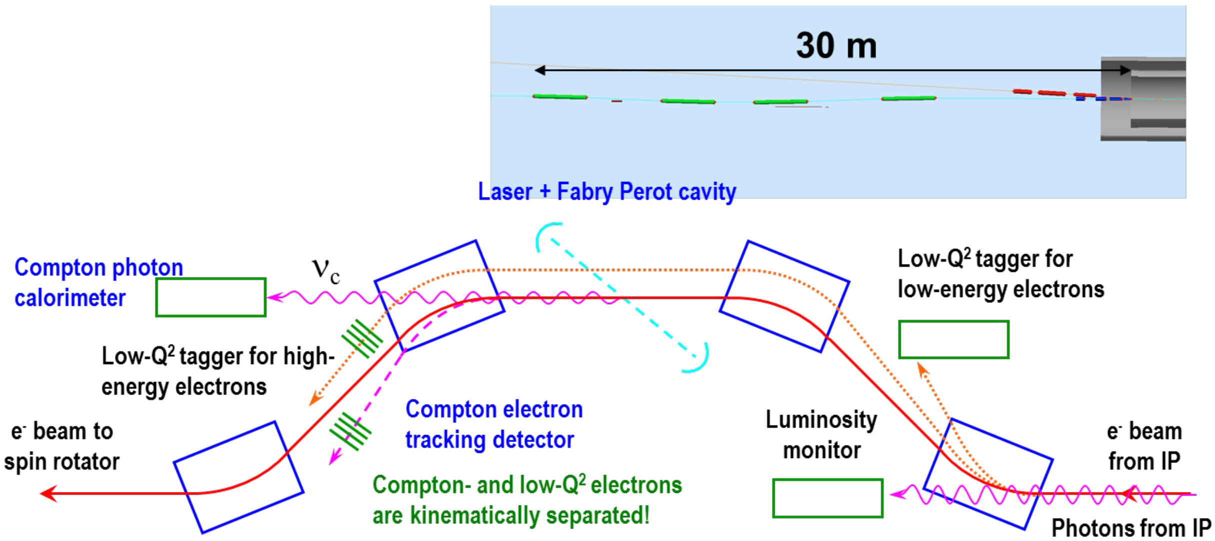
The electron beam is filled from the 12 GeV CEBAF. The beam bunch repetition rate will be 476 MHz at 4 GeV and 159 MHz at 10 GeV. 2 interaction points (IPs) are planned both followed by a low Q^2 chicane on the electron side.

b) Electron beam polarization structure

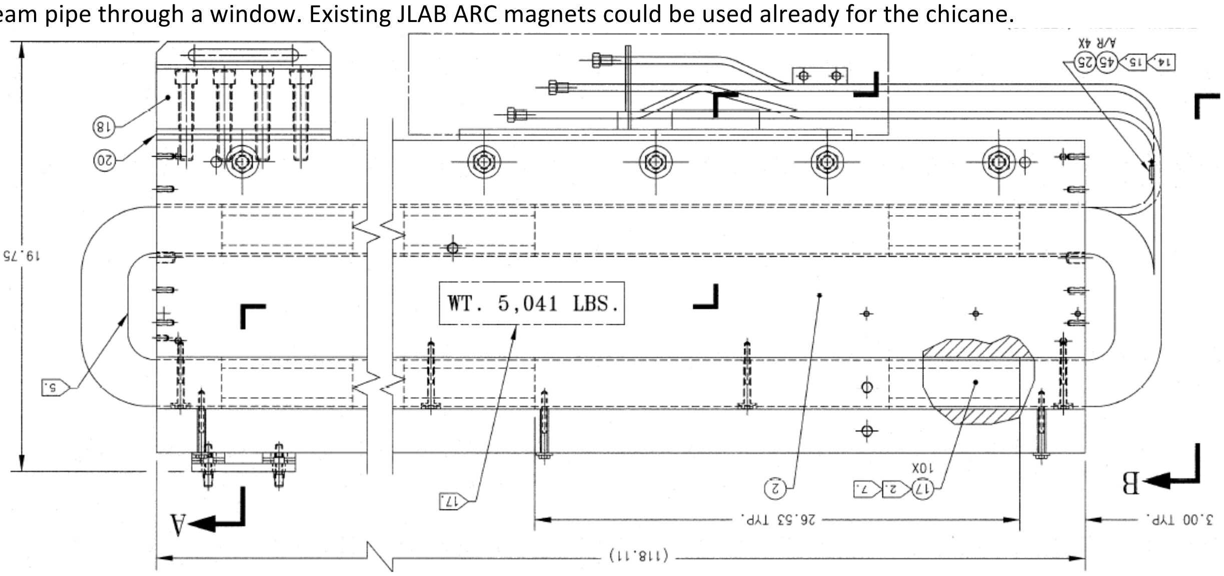
The beam will be divided in two helicity macro train of 1700 bunches each with blank bunches between the two. This will give two helicity bunches of 3.6 μs. The most straightforward signal to look at the asymmetry between the two helicity states bunch which will give the average polarization of the two bunches. The laser polarization will be flipped at a slower rate typically from a few hertz using mirror up to 1 KHz using a pockel cell. By accurately gating the detector signals with the bunch and laser polarization, the polarization of each of the state will also be determined by looking at the laser polarization asymmetry of each state.

c) The low Q^2 tagger chicane

The low Q^2 tagger chicane is designed to tag electrons associated with quasireal photons. It is placed after each interaction point. Those electrons are going out at small angle with the beam. A large dipole is placed after the IP to do the electron momentum analysis in order to bring the electrons which lost energy by emitting a photon to be bent out from the initial electron beam. In order to bring the main electron beam back into the ring three additional dipoles are added giving a chicane configuration as shown in the following chicane schematic.

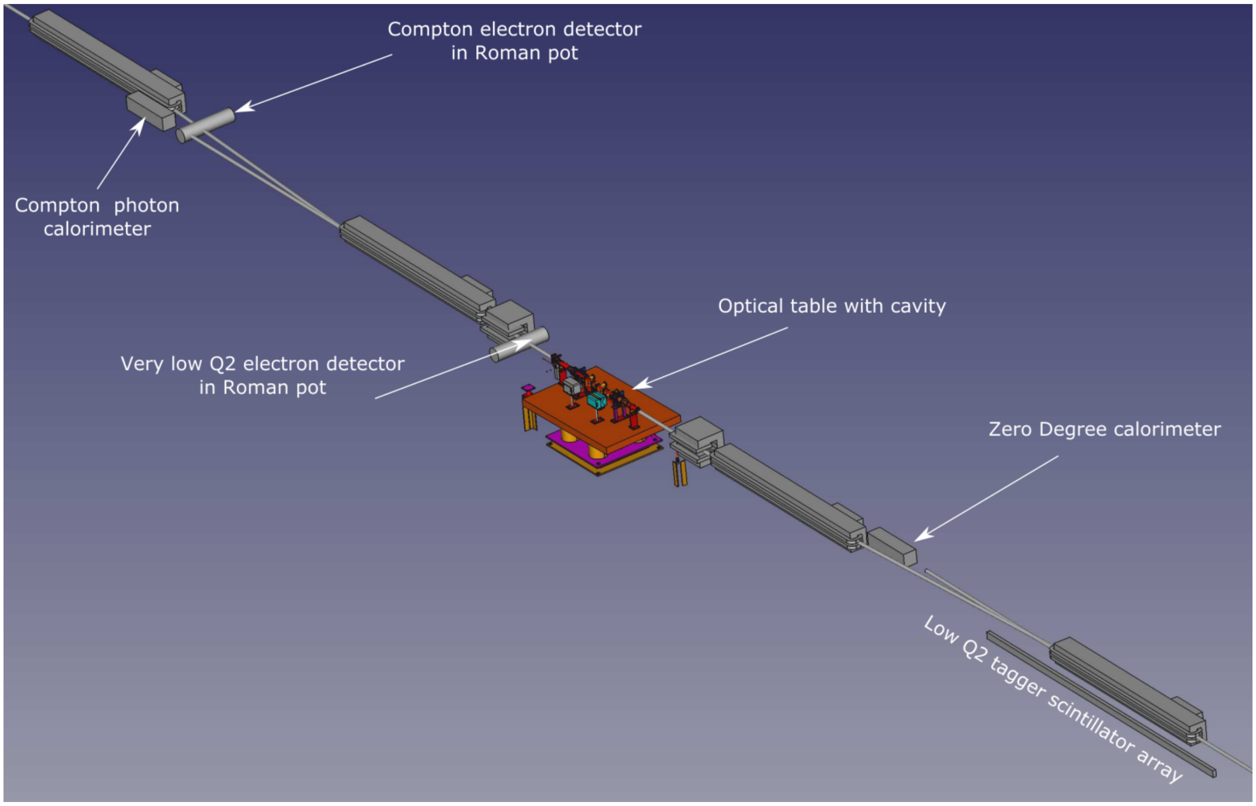


Such a chicane is a location suitable for Compton polarimetry. Indeed the beam in the middle of the chicane has the same polarization as the IP since the two first dipoles compensate each other. Also the third magnet of the chicane allows separating the Compton photon from the Compton electron also making the momentum analysis of the Compton electron by measuring the deflection of the Compton electron. The chicane will be constituted of 3 meters C magnets with opening toward the dispersion side to allow the low momentum electron to exit from the beam pipe through a window. Existing JLAB ARC magnets could be used already for the chicane.



While this location is not ideal as in Hall A because it is placed after interaction point giving a large energy spread, it is well integrated in the mEIC design. Background rates will have to be studied to optimize the signal and determine the photon source.

As an additional benefit the third dipole will generate synchrotron radiation that can be used to monitor the luminosity at the IP. Following is a design of the chicane using the JLAB ARC magnets.



5) Response to previous comments from reports

a) Comments from July 2015

i) Summary table

Comment 1: The time in which this accuracy has to be achieved, radiation dose
in the sensor, and last but not least the rate required to achieve these goals are missing.

Response:
some numbers were mentioned in section 8 for the lowest mEIC
current : 36 MHz of Compton signal rate which give statistical accuracy of 10000
events for 200 bins in less than a second, dose rates were estimated to be 27 krad
per hour for mEIC and 7.5 krad/hour for eRHIC. In case of continuous running
eRHIC would accumulate about 32.4 Mrad typical silicon have a signal to noise
ratio divided by two ofter 3 Mrad. In order to have a clear summary a table of the
dfferent parameters with parameters close to the current mEIC and eRHIC is following.

	Energy (GeV)	Rate(kHz/A/W)	Current	Rate kHz	Measurement 200 bins in s
MEIC	3	316	3	948	2.11E+00
	5	298	3	894	2.24E+00
	6	290	2	580	3.45E+00
	7	283	1.1	311.3	6.42E+00
	9	269	0.72	193.68	1.03E+01
	10	258	0.72	185.76	1.08E+01
eRHIC	3	316	0.05	15.8	1.27E+02
	5	298	0.05	14.9	1.34E+02
	6	290	0.05	14.5	1.38E+02
	7	283	0.05	14.15	1.41E+02
	9	269	0.05	13.45	1.49E+02
	11	258	0.05	12.9	1.55E+02

The 1 % statistical accuracy is reached in first approximation in a few seconds at mEIC and less than 3 minutes at eRHIC which will be sufficient for a monitoring of the polarization during the lifetime of the electron beam.

Radiation damage

The radiation damage just coming from the Compton signal was evaluated assuming a 250 μm thick Si detector of 5 cm length and a width of 1 cm and a laser power of 1 W. The Compton signal was approximated to be a narrow stripe along the dispersion plane of the third dipole of width of 350 μm which is a typical beam size.

	Energy	Current	Rate kHz	Dose per hour	Dose / day	N days for 3 Mrad
MEIC	3	3	948	2.07E+04	4.98E+05	6.03E+00
	5	3	894	1.96E+04	4.69E+05	6.39E+00
	6	2	580	1.27E+04	3.05E+05	9.85E+00
	7	1.1	311.3	6.81E+03	1.63E+05	1.84E+01
	9	0.72	193.68	4.24E+03	1.02E+05	2.95E+01
	10	0.72	185.76	4.06E+03	9.75E+04	3.08E+01
eRHIC	3	0.05	15.8	3.46E+02	8.30E+03	3.62E+02
	5	0.05	14.9	3.26E+02	7.82E+03	3.83E+02
	6	0.05	14.5	3.17E+02	7.61E+03	3.94E+02
	7	0.05	14.15	3.10E+02	7.43E+03	4.04E+02
	9	0.05	13.45	2.94E+02	7.06E+03	4.25E+02
	11	0.05	12.9	2.82E+02	6.77E+03	4.43E+02

Since the signal is focused on a small volume of detector the accumulated dose can be significant. The last column shows the number of days of continuous running to accumulate a dose of 3 Mrad where the detector signal to noise ratio of a Si detector is divided by 2. One can see that radiation from could be an issue for the mEIC and in case 1000 W of laser power is needed to see the Compton signal it would be an issue for both mEIC and eRHIC. It is thus advised to take Compton at a low duty cycle to limit the damage coming from the Compton signal and to seek radiation hard detectors. Contributions of others background will be evaluated when they will be accurately modeled in the simulation.

ii) Bunch to bunch differences

Comment 2:
The committee notes that colliders are repetitive machines and the fate of different bunches is not obviously guaranteed to be the same, due to bunch interactions with the machine structure and dependencies of emittance growth and instabilities on bunch charge. Some study is warranted here, even if the bunch crossing pattern allows all combinations as in MEIC.

Response:
We still think that the effect of individual bunch polarization and charge variations is less important if all electron bunches crosses each ion bunches by making the measurement sensitive to the average charge and polarization. A simple simulation was carried out by David Gaskell and preliminary results seem to show that. Though we agree that a more complete simulation needs to be carry out and reported to confirm this preliminary result.

iii) Background

Comment 3:
The background, as shown in Fig.1, which does not yet include synchrotron radiation, is alarming, and demands a detailed study and efforts to find ways how to reduce it. The requirements for bunch-to-bunch accuracy of the polarization measurement are essential, but have not been specified. An evaluation of rates and the development of a scheme, which satisfies the requirements for bunch-to-bunch accuracy of the polarization measurement, are essential. A further study of the backgrounds and efforts to find ways how to reduce it, have a high priority.

Response:
The background was evaluated in a simplified simulation of the chicane reusing the Hall C simulation code with parameters adapted to mEIC configuration. The aim of the plots was to show the sensitivity to aperture due the halo background and comparison with the Bremsstrahlung background to motivate the choice of the laser source. The plots shown were extreme cases showing the care should be taken to optimize any aperture in the beam line. More realistic simulation are being implemented to take into account a more detailed description of the beam line and detectors and the designs will be optimized to reduce backgrounds. A preliminary study of synchrotron radiation was carried out and will be redone for the updated mEIC design. This work is critical since one expect to see increased background in the mEIC design due to the location after the IP. The background rates are also the driver for the photon source right now the photon source planned are pulsed laser or pulsed laser with Perot Fabry cavity. Such a system is attractive since it could improve signal to noise background. In case a pulsed Perot Fabry cavity is used with 1000 W of power, the laser frequency could be matched to a lower duty cycle to select a single bunch and laser polarization recorded accurately single bunch polarization could be foreseen if needed but this would require a significant R&D similar to the effort from [1].

iv) Detector studies

Comment 4:
For 2015 the study of different sensor types (diamond, quartz and micromegas) is proposed. For all these detectors plenty of information is available in the community, beyond the one given in the proposal. Once the detailed requirements are known, and additional information on the different sensor types is acquired, the proponents should decide which one to pursue if any.

Response:
We agree that the choice of detector was premature given the degree advancement of the background studies and that some information are available on most of the detectors. More simulations will be carried out to determine the signal to background ratio. For now the detector study will mostly focus on improving existing silicon and diamond detector. Nevertheless it will be comforting to prove the detector technology chosen is able to reach the Compton accuracy needed.

v) Test stand

Comment 5:
The committee considers a high-quality polarization-measurement program essential for EIC and supports the idea of a Compton polarimeter test bed. It recommends that the detailed requirements on polarization knowledge be worked out and the resulting detector specifications evaluated, for both EIC machine designs.

Response:
This proposal will focus mainly on the implementation of the test stand and planning for measurements to address Compton issues. Several tests relevant to eRHIC and mEIC will be able to be carried out at JLab at lower current. Possibility of moving the test stand to a storage ring later could be interesting to validate the RF and synchrotron simulations and shielding

vi) Collaboration

Comment 6:

A close contact between the other groups working on EIC polarization and the machine experts from both EIC machine designs is strongly encouraged.

Response:
We initially planned to try to meet in March but JLAB 12 GeV commissioning and Long Range Plan work.
Having a postdoc and travel money would allow keeping better contact. Meeting will be planned this summer. We acknowledge that a large EIC polarimetry working group will be fruitful for both EIC and electron polarimetry in general.

b) Comments from January 2014 report

Comment :

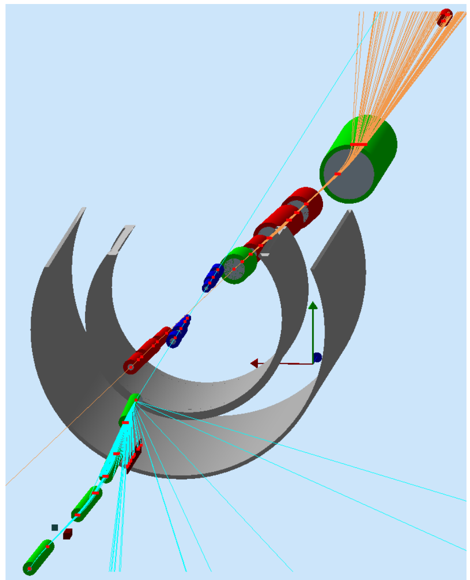
There has been considerable progress in the understanding of the different requirements of eRHIC and MEIC for a Compton polarimeter. This includes noting eRHIC has a given ion bunch always colliding with the same electron bunch, whereas MEIC has each ion bunch colliding in succession with all electron bunches. The different RF structures of the machines were taken into account. An evaluation was given of the expected rate of electrons as a function of electron kinetic energy per Watt of laser power and per Ampere of beam. It was shown that acquiring adequate counting statistics can be done in a few seconds for the various cases. The group has studied a particular magnetic chicane layout (Hall A at Jefferson Lab) and a particular layout for laser, crossing angle and detector location. There are possibilities for preparing a chamber to allow testing of various detector ideas. The chicane can operate any time the Hall is operating, giving regular possibilities for scheduling tests. The group has recognized that relevant rates dictate detectors with good time response and may require detectors and perhaps electronics with a good degree of radiation hardness. Options for detectors were discussed; the Committee encourages further contact with colleagues with experience with fast radiation hard devices and development of specific concepts for trials.

Response:
We agree that silicon detectors can have better timing properties than the current Hall A setup which is limited to 1 MHz because of the amplifying electronics shaping. The way to improve the detector speed is to place the electronics as close as possible to the detector. Provision for low voltage and cooling will be planned so that ASIC electronics could be implemented. Performance of on detector electronics and radiation hardness will be evaluated in the test stand.

6) Progress summary

a) Simulation

All the magnets of the chicane are in the GEMC model. Acceptance of the Compton detector and Low Q2 chicane were studied.



The beamline and shielding can now be implemented and studied for the photon and electron detector. Simulation will be crosschecked with measurement from the test stand.

b) Evaluation of background and beam pipe window design

A study of the synchrotron radiation was carried out by Mike Sullivan[3]. It shows that the exit window of the beam pipe should have a slope of 25 mrad to be able to handle to power synchrotron radiation power density. It has to be less than 10 W/mm for aluminum.

Beam parameters			E (GeV)	5.0			
			I (A)	3.0			
Magnet segment	SR pwr (W)	Bend angle (mrad)	Crit. energy (k_c) keV	Beam pipe W/mm perp.	Beam pipe W/mm sloped	Surface of perp. pipe hit (mm)	Surface of sloped pipe hit (mm)
Before (#1)	1761	5.007	3.7	176	4.4	10	400
After (#2)	1761	5.007	3.7	176	4.4	10	400
Det. SA	4396	12.5	3.7				
Beam parameters			E (GeV)	11.0			
			I (A)	0.18			
Before (#1)	2475	5.007	39.4	248	6.2	10	400
After (#2)	2475	5.007	39.4	248	6.2	10	400
Det. SA	6179	12.5	39.4				

Reduction of the energy radiated out from the beam pipe was studied for several beam pipe configurations.

Beam pipe options	1 mm Be, 2 mm H_2O, 1 mm Be		10 µm Au, 1 mm Be, 2 mm H_2O, 1 mm Be		25 µm Au, 1 mm Be, 2 mm H_2O, 1 mm Be	
5 GeV e- beam 25 mrad inc. angle 4.830×10^{13} γs/bun. inc. 5.498×10^{13} keV/bun. inc.		Fraction with solid ang. cut applied (3.46×10^{-4})		Fraction with solid ang. cut applied (3.46×10^{-4})		
Frac. of inc. γs through bp	0.003715	1.285×10^{-6}	1.184×10^{-5}	4.097×10^{-9}		
Frac. of inc. enr. through bp	0.01626	5.626×10^{-6}	5.764×10^{-5}	1.994×10^{-8}		
11 GeV e- beam 25 mrad inc. angle 6.371×10^{12} γs/bun. inc. 7.729×10^{13} keV/bun. inc.				Fraction with solid ang. cut applied (2.103×10^{-2})		Fraction with solid ang. cut applied (2.254×10^{-3})
Frac. of inc. γs through bp			0.0103	2.166×10^{-4}	4.467×10^{-3}	1.007×10^{-5}
Frac. of inc. enr. through bp			0.0267	5.615×10^{-4}	0.0116	2.615×10^{-5}

The best configuration reduces the number of photons exiting the beam pipe significantly.

Nevertheless a still very large amount of energy is still deposited in the photon detector.

11 GeV beam with soft bend magnets (critical energy = 18.45 keV)				
	Frac. of inc. γs thru sheet	γs thru to the detector/bunch	Fraction of inc. energy thru sheet	Energy/bunch on the detector (GeV)
1.71×10^{8} γ/bunch 4.06×10^{9} keV/bun.	Beam pipe: 10 µm Au, 1 mm Be, 2 mm H_2O and 1 mm Be			
2 mm Cu sheet	0.245	4.19×10^{7}	0.287	1.16×10^{3}
1 mm Cu sheet	0.470	5.50×10^{7}	0.509	2.06×10^{3}
6.36×10^{6} γ/bunch 1.60×10^{8} keV/bun.	Beam pipe: 25 µm Au, 1 mm Be, 2 mm H_2O and 1 mm Be			
2 mm Cu sheet	0.291	1.85×10^{6}	0.327	52.2
1 mm Cu sheet	0.527	3.35×10^{6}	0.556	88.9
2 mm Ag sheet	3.00×10^{-2}	1.91×10^{5}	4.92×10^{-2}	7.87
2 mm Pb sheet	4.22×10^{-3}	2.68×10^{4}	4.48×10^{-3}	0.716
3 mm Pb sheet	3.25×10^{-4}	2.07×10^{3}	3.49×10^{-4}	0.0558

An additional lead sheet in front of the detector reduces the energy deposit to an acceptable level.

Significant amount of RF power and synchrotron radiation will be dumped in the detector requiring cooling, a careful layout of the exit windows and shielding of the Compton photon and electron detectors. We expect to further improve signal to noise ratio by using collimation and shielding since the Compton photons are in a very small forward angle.

c) Photon detector

A 4 blocks lead tungstate was put together by Carnegie Mellon University. First data taking with integrating DAQ was taken so far at low energy.

d) Electron detector

By looking at the position of the Compton Edge and Zero Crossing, one can determine how close the detector needs to be from the electron beam.

E (GeV)	k' Compton edge (MeV)	k' 0-Xing (MeV)	dp/p edge %	dp/p Xing %	Positition edge (cm)	Position 0 xing (cm)	Width (cm)	Nstrips
3	290.1609	152.4531	0.0967	0.0508	3.7141	1.9514	1.7627	70.5064
4	499.7302	266.5132	0.1249	0.0666	4.7974	2.5585	2.2389	89.5553
5	757.1794	409.6041	0.1514	0.0819	5.8151	3.1458	2.6694	106.7751
6	1058.2858	580.3218	0.1764	0.0967	6.7730	3.7141	3.0590	122.3588
7	1399.3094	777.3515	0.1999	0.1111	7.6762	4.2643	3.4119	136.4753
8	1776.9251	999.4605	0.2221	0.1249	8.5292	4.7974	3.7318	149.2732
9	2188.1676	1245.4918	0.2431	0.1384	9.3362	5.3141	4.0221	160.8833
10	2630.3832	1514.3588	0.2630	0.1514	10.1007	5.8151	4.2855	171.4213
11	3101.1905	1805.0394	0.2819	0.1641	10.8260	6.3012	4.5247	180.9898
12	3598.4460	2116.5717	0.2999	0.1764	11.5150	6.7730	4.7420	189.6799
13	4120.2152	2448.0496	0.3169	0.1883	12.1705	7.2312	4.9393	197.5728
14	4664.7480	2798.6187	0.3332	0.1999	12.7947	7.6762	5.1185	204.7410
15	5230.4569	3167.4728	0.3487	0.2112	13.3900	8.1087	5.2812	211.2496
16	5815.8985	3553.8502	0.3635	0.2221	13.9582	8.5292	5.4289	217.1566
17	6419.7578	3957.0313	0.3776	0.2328	14.5011	8.9382	5.5629	222.5146
18	7040.8342	4376.3351	0.3912	0.2431	15.0204	9.3362	5.6843	227.3706
19	7678.0290	4811.1171	0.4041	0.2532	15.5177	9.7235	5.7942	231.7672
20	8330.3353	5260.7664	0.4165	0.2630	15.9942	10.1007	5.8936	235.7429
21	8996.8282	5724.7041	0.4284	0.2726	16.4513	10.4680	5.9833	239.3325
22	9676.6568	6202.3809	0.4398	0.2819	16.8902	10.8260	6.0642	242.5676

The detector will have to be the closest from the beam at the lowest energy, in the mEIC case it is 1.9 cm with a 4 meters drift. At this position the beam size is at most 500 μm, leaving the detector cleared at more than 15 sigmas from the beam.

Considering requirements for RF and synchrotron radiation shielding, need for cooling and motion of the electron detector depending on the electron beam energy. A roman pot design is planned to be used similar to the ion side.

7) Issues to be addressed by R&D

From the previous studies and previous R&D meeting, several issues concerning the Compton Electron Detector should be addressed for both the mEIC and eRHIC design.

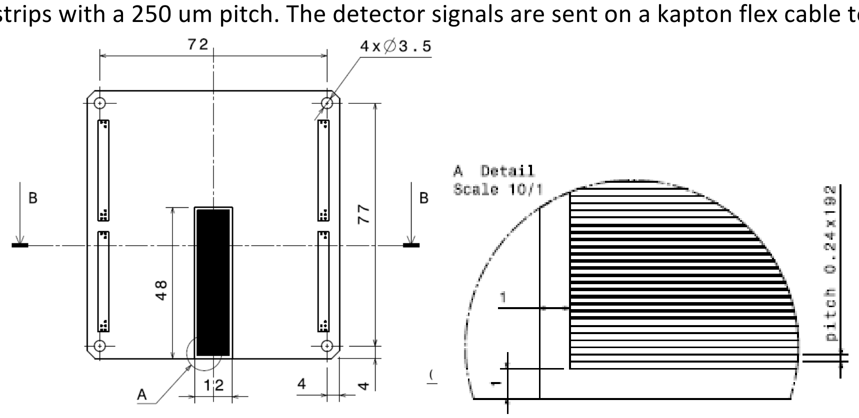
- Improvement in timing for silicon detector by using on board ASIC, test of effect of shaping time on timing resolution and asymmetry due to pile-up in real Compton measurement
- Influence of the material window for the Compton electron polarimetry
- Radiation hardness of silicon detector
- Possibility of measuring each separate source at eRHIC
- Study of diamond detector : timing, readout electronics and radiation hardness

8) Test stand

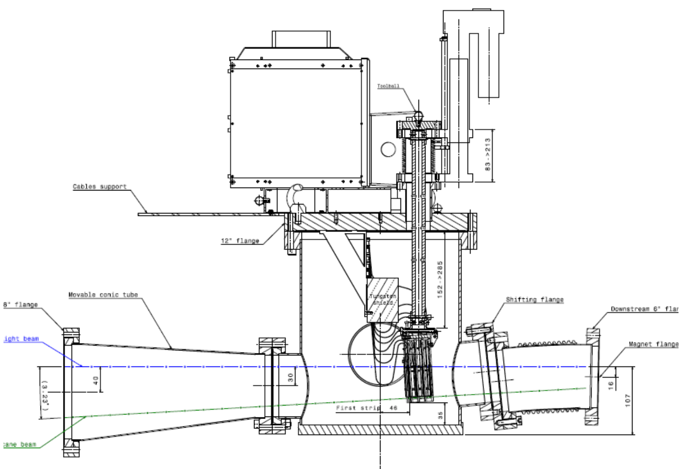
a) The Jefferson Laboratory Compton polarimeters

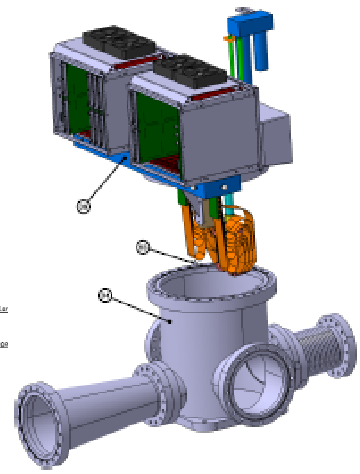
i) Hall A Compton

The Hall A Compton electron detector has 4 planes of silicon detector of 192
strips with a 250 um pitch. The detector signals are sent on a kapton flex cable to a PCB board



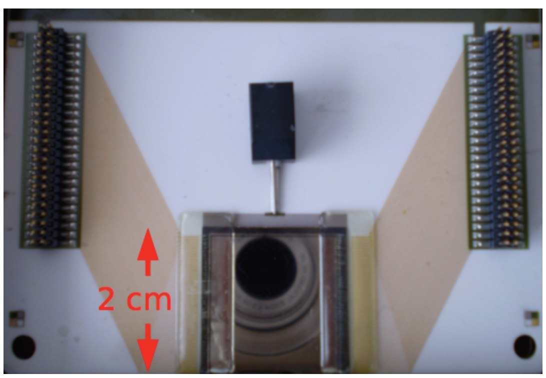
which goes through the vacuum flange and take the signal to amplifier discriminator modules.
The detector was designed to be movable in order to accommodate the different positions of the Compton edge and zero crossing of the asymmetry as a function of the beam energy up to 11 GeV.

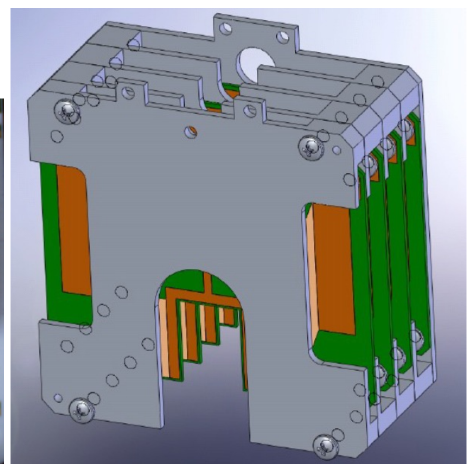


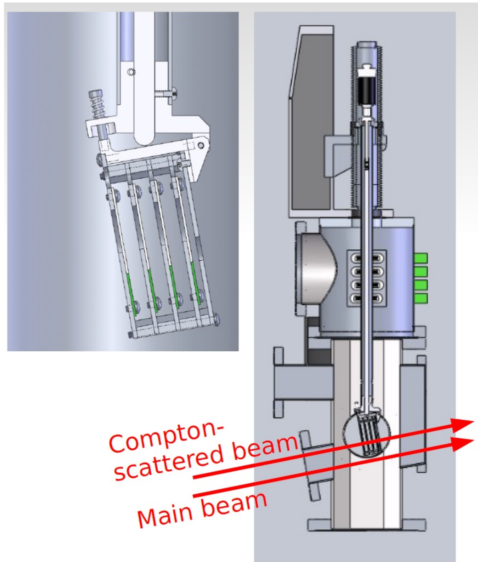


ii) Hall C Compton

The Hall C Compton electron detector is a 96 strips diamond detector of 200 μm pitch which covers a length of 2 cm. It was designed for low energy running for the QWeak experiment at 1 GeV.



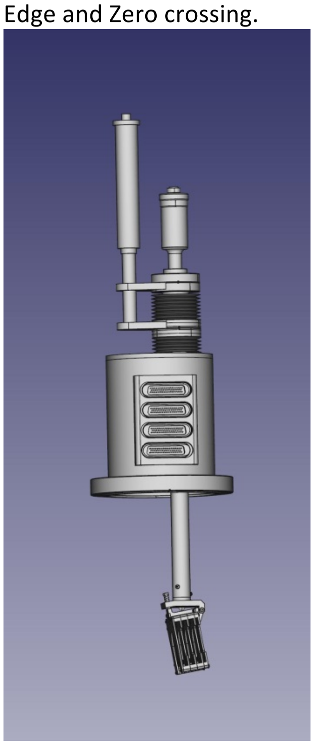


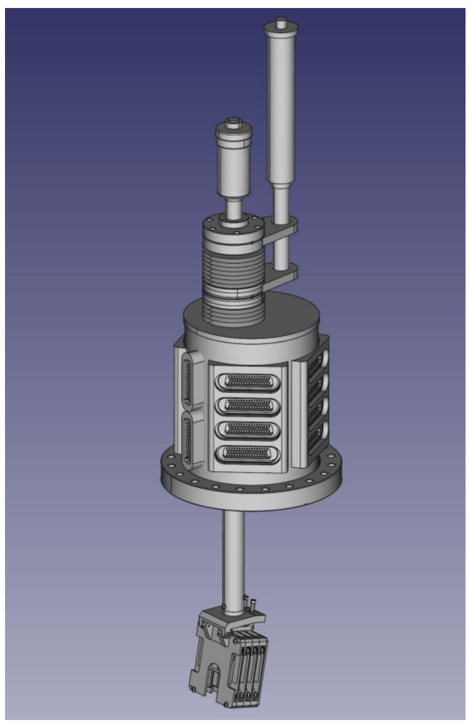


After a second iteration of the Amplifier Discriminator card the detector performed well even though the signal is at least 3 times smaller than for silicon detector.

b) Proposed test stand

We propose to replace the Hall A chamber by the same design as the Hall C chamber since direct connection through flex and feedthrough seems less noisy that through the current PCB.
A new top flange will be designed as test flange which will include 768
channels instead of the current 384 channels of the current Hall C detector order to be able to equip the whole silicon detector or accommodate current the diamond detector. R&D for larger detector or a detector using 8 planes of diamond will be carried out in order to have a diamond detector capable of registering the Compton Edge and Zero crossing.





Additional feedthrough will be added in order to provide low voltage and control signal to test potential ASIC which would provide integrated analog discrimination. The CLAS12 DREAM Micromegas chip or the 32 channel NINO (IRPICS), VMM2 or FPHX [2] are good candidates and are likely to work with silicon. It is not clear if they would work for diamond which produces a signal of about 9000 electrons for 250 microns of thickness. Liquid feedthrough will also be added to evacuate the heat from electronics and investigate the possibility of cooling down the silicon detectors to reduce their noise.

c) Test first year

The first year would be spent building the lower chamber for Hall A so the diamond detector could be tested either in Hall A or Hall C. A simpler top flange will be designed with a limited amount of channels to test the effect of cooling and ASICs placed close from the detector, efficiency and timing resolution will be determined on the bench with pulser signals, radioactive sources and cosmics rays using the spare silicon detector planes of Hall A. Major work to model the beam line and shielding as well as Compton process in the simulation will be done so they can be crosschecked with beam data taken later.

d) Second year

During the second year the full 768 channel top flange will be manufactured and equipped with the current silicon detector spare. After full testing of the system on the bench, it will replace the current Hall A chamber allowing testing the silicon detector with and without analog discriminator ASICs, the effect of cooling of the detector and the effect of the window thickness of the future roman pot by varying the materials and thickness in front of the detector.

Efficiency, timing resolution and effect of shielding will be testing using Compton signal validating the accuracy reachable on the polarization during parasitic data taking.

Depending on the energies available, the same tests will be carried out using the current Hall C diamond detector. If funds allow in the first year, year one and two could be merged which would allow saving on the low density test flange by bench testing on the final high density flange.

A dedicated run will be discussed to simulate the Gatling gun system and several sources, it would involve reducing the JLAB laser frequency to a sub harmonic of 499 MHz to be close from 10 MHz and send beams of Hall C and/or B in Hall A, each laser will be set with different polarization. This will allow measuring the effect of timing of the detector signal and of sources with different polarization and make sure one can measure polarization of each source reliably.

e) Third year (depending on year 2 results)

Four additional planes of diamond detectors will be procured to have a detector covering the full range of energy from 2 to 11 GeV. This will be a check of the scalability of diamond detectors. Other detector technologies might be investigated.

9) Budget

Budget includes 54.5% overhead and 3% inflation

Half a postdoc is requested to carry out bench test of the setup, develop the simulation model to include realistic beamline and optimize locations and shielding to reduce the background and determine what laser source is needed. The postdoc would be located at JLab and supervised by Alexandre Camsonne and David Gaskell.

2016			
Electronics	5.00	4.00	20.00
Front end	10.00	1.00	10.00
Lower chamber	10.00	1.00	10.00
Detector holder	2.50	1.00	2.50
Test flange	10.00	1.00	10.00
Post doc	25.00	1.00	25.00
Travel	5.00	1.00	5.00
Design	5.00	1.00	5.00
		Total	including overhead
		87.50 K$	135.19 K$

2017			
Motion system	8.00	1.00	8.00
Feed through	2.25	18.00	40.50
Flange	10.00	1.00	10.00
Postdoc	25.00	1.00	25.00
Travel	5.00	1.00	5.00
		Total	including overhead
		91.16 K$	140.83 K$

If budget in first year allows: procuring the expensive signal feedthrough could be moved to first year allowing using the final test flange on bench and in beam.

2018			
Detector holder	2.50	1.00	2.50
Diamond	12.80	4.00	51.20
Flex	4.00	1.00	4.00
Postdoc	25.00	1.00	25.00
Travel	5.00	1.00	5.00
Electronics	20.00	1.00	20.00
		Total	including overhead
		114.26 K$	176.53 K$

10) Conclusion

The location of the low Q2 chicane and Compton polarimeter are final for mEIC. Final location of magnets, detectors, and shielding and beam element will be optimized from the background studies.

Currently the laser system favored is a RF pulsed laser, if background level are estimated to be too high a pulsed or CW Perot-Fabry cavity will be chosen.

A roman pot configuration was chosen since the Compton electrons are far enough from the beam to allow material on the beam side. The roman pot configuration allows easy access to the detector and shields the detector from RF power from the beam also permitting cooling of the detector.

Systematic effect of the window material and shielding on the polarization will be evaluated using simulation and validated with the test stand data.

A test stand will be developed to test ASIC on silicon detector as amplifier discriminator in order to improve timing resolution as well as effect of temperature. The chamber will be compatible with the current Hall C diamond detector allowing performing the same tests on diamond as on silicon.

A dedicated test will be done to test the eRHIC beam structure and effect of the pulse width on measurement of polarization.

References

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beam Compton scattering off GeV-electrons
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[2]Technical Design Report of the Forward Silicon Vertex Tracker (FVTX)
http://www.phenix.bnl.gov/WWW/fvtx/home/Documents/fvtx-proposal_11-1-07.pdf

[3]Study of Synchrotron Radiation for the Electron Beam Polarimeter for the MEIC
Mike Sullivan
Private communication August 22nd 2014