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 photon calorimeter

Laser + Fabry Perot cavity

Compton electron tracking detector

Low-Q^2 tagger for low-energy electrons

Compton- and low-Q^2 electrons are kinematically separated!

Luminosity monitor

Photons from IP

e^{-} beam from IP

e^{-} beam to spin rotator
Laser studies (Gaskell)

- Compton signal in blue
- 10 W laser power is marginal for the photon detector
- Reasonable signal to noise for the electron detector

Photon detector

Electron detector

Bremstrahlung
Laser studies ( Gaskell )

1 kW of laser power

Halo contribution for small and large apertures, 2 cm aperture
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 can be produced, amplitude close to what is expected.

Some issue in the first and last bin to be checked.
Radiation dose in the detector

- About 30 kRad/hr at 1 A and 1 kW laser power per strip, 3 Mrad/hr for whole detector
- Consistent with estimation from a previous experiment in Hall C which showed no damaged after 10 Mrad (3 hours at JLEIC)
- Most radiation damage comes from signal, lower duty cycle (measurement every 10 minutes) and lower laser power at 10 W ensure detector operating for several years
- Radiation hard detector allows more continuous measurement
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

Compton photon calorimeter

$\gamma_c$

Compton electron tracking detector

Low-$Q^2$ tagger for low-energy electrons

Luminosity monitor

$\gamma_c$

Beam pipe wall

Can see still see synchrotron 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 eRHIC but solution of exit window with calorimeter is planned for now (easier solution if optics permits)
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).
Compton polarimeter was demonstrated to achieve 1% systematic with photon at 1 to 3 GeV
Prove detector technology with pulses shorter than 100 ns in beam
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

• 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

Figure 4.4: Signal produced by a MIP passing through a 500 \( \mu \)m 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.
Lower chamber designed

- Lower chamber designed and costed
- Compatible with Hall C diamond detector
- Integrated in Hall A beamline
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.
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<th>Individual</th>
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<td>Wakefield, general, postdoc supervision</td>
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<td>David Gaskell</td>
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<td>Geant3, laser system, postdoc supervision</td>
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<td>Joshua Hoskins</td>
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<td>GEMC full simulation</td>
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Conclusion

• 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
• Fast amplifier used with TOTEM diamond detector
  
• About 3 K$ per channel

• Plan to procure one

• Multichannel amplifier development planned ( need 768 channels )