Compton Detector Simulations R&D Update (ERD15)

Joshua Hoskins
University of Manitoba
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Outline

Project Goals

Software

Overview of Completed Work

Road map to Completion

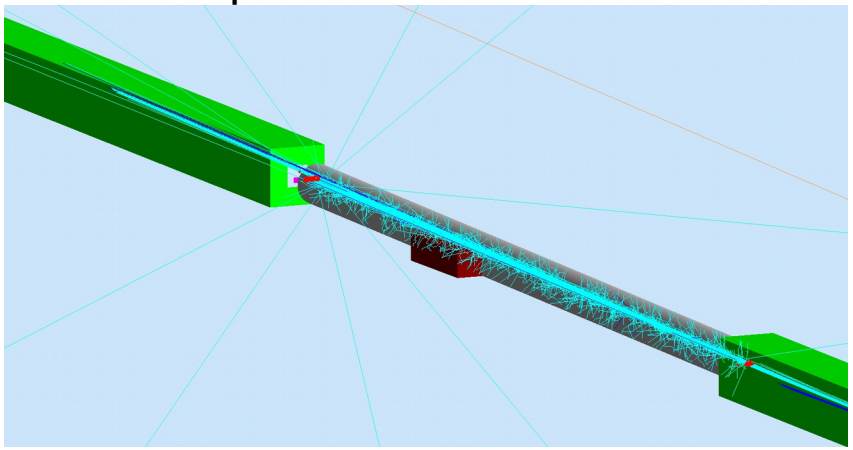
Compton Polarimetry R&D Simulations

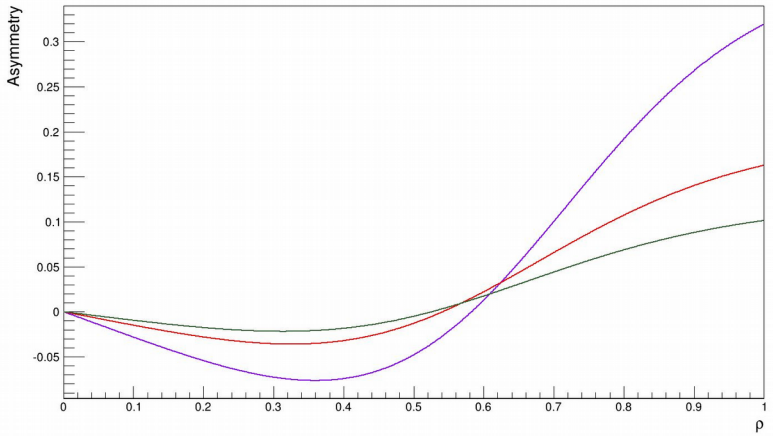
For the purposed of studying potential backgrounds and shielding, a model of Compton chicane and Silicon electron detector integrated into simulation.

Main sources of background:

- Bremsstrahlung from residual gas in beampipe and synchroton radiation (in-progress).
  Compton generator developed for estimating the compton rate in the detector.
- Beam halo interacting with detector and/or apertures in the interaction region.
  Halo generator, based on PEPII report, developed.

Main goals: Study of background contributions and systematics in order to provide estimates polarization extraction accuracy and recommendations of shielding and beam





Project Goals

- Expansion of rate and background estimations to all energies
- Optimization of strip size and spacing in electron detector
- Thin window optimization
- Estimate of experimental accuracy
- Beam induced background using Molflow/Synrad
- Realistic Roman Pot geometry

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Joshua Hoskins
Alexandre Camsonne

Project Goals

- Expansion of rate and background estimations (75%)
- Optimization of strip size and spacing (75%)
- Thin window optimization (50%)
- Estimate of experimental accuracy (25%)
- Beam induced background using Molflow/Synrad
- Realistic Roman Pot geometry

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Project Goals

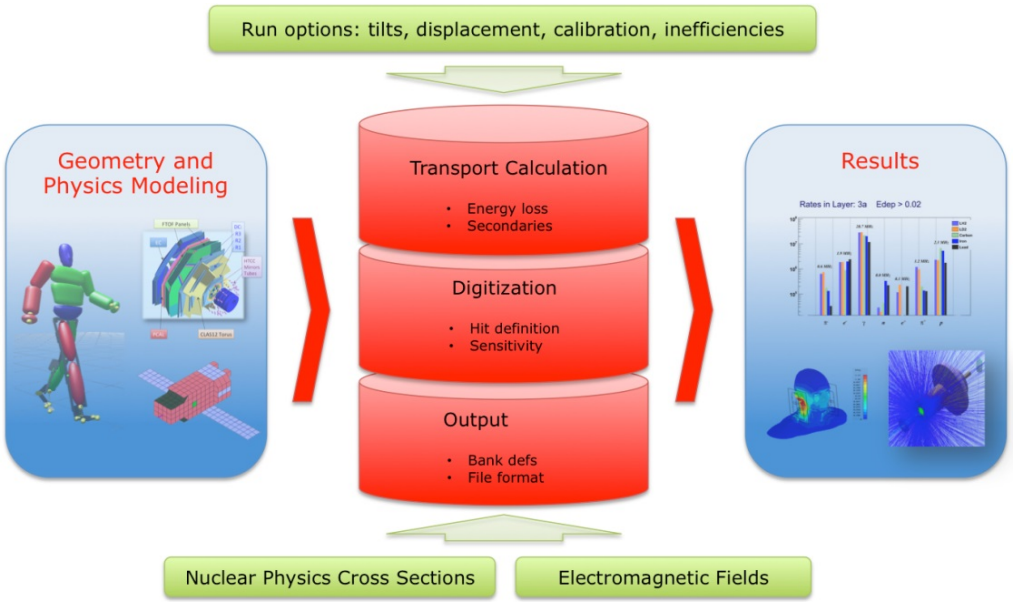
- Expansion of rate and background estimations (75%)
- Optimization of strip size and spacing (75%)
- Thin window optimization (50%)
- Estimate of experimental accuracy (25%)
- Beam induced background using Molflow/Synrad
- Realistic Roman Pot geometry

Need to develop integrated, modular software packages that can be used in the long term for studies even after the end of the project.

Joshua Hoskins
Alexandre Camsonne

Software Development

Software



The architecture of gemc

GEMC: Application built on GEANT4. used to simulate particles through matter.

Intended to make simulations available without the requirement of GEANT4 or C++ knowledge.

Allows for real-time changes in experimental parameters without the need to recompile

GEant Monte Carlo (GEMC) is the primary simulation framework for the JLEIC detector design including the Compton polarimetry R&D effort.

Detector and beamline geometries added via simple perl API.

Software

Initially, software and analysis piecemeal combination of macros and standalone code.

- Generator: Compton and Halo
- Analysis: Compton rate, halo rate, background rates, asymmetry, polarization extraction, systematics.

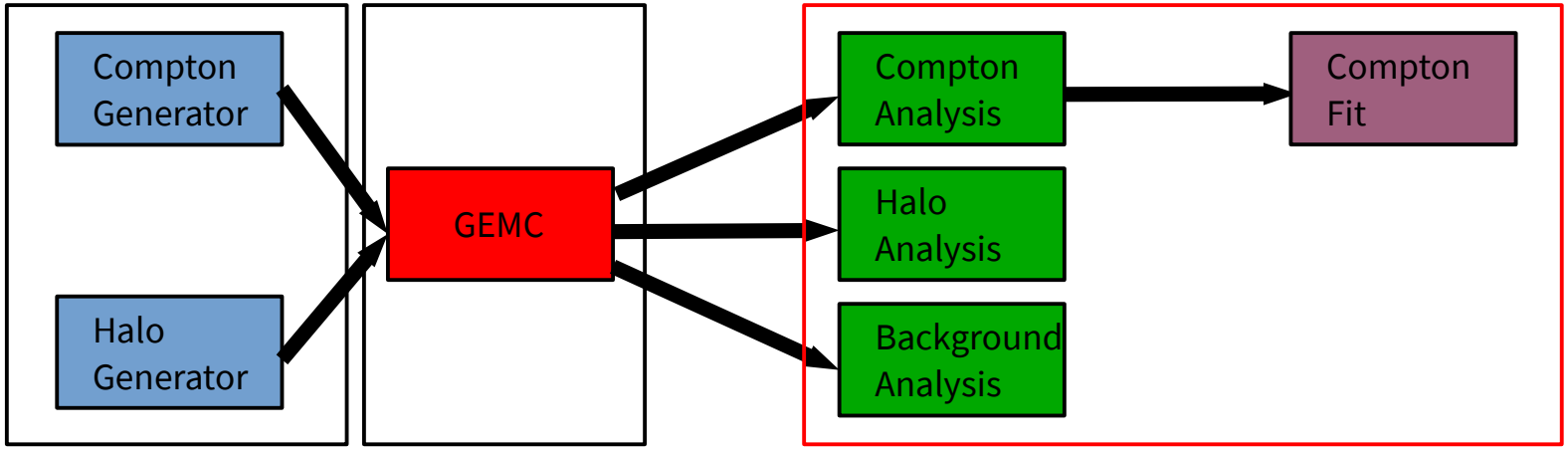
As software needs evolved → need comprehensive, integrated, software suite.

For complete analysis:

- Need high statistics to study systematics and estimate final accuracy → must run on scientific cluster
- Eliminate hard coding and ROOT macros.
- Expand analysis to all energies and make configurable externally.

Complete analysis: generator → GEMC → analysis

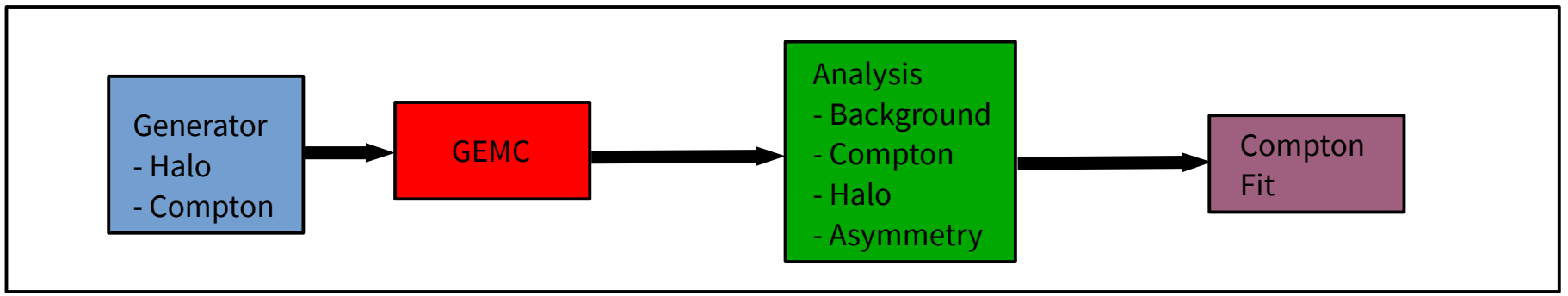
Software



Consolidating in this way make analysis, faster, more workable with cluster, configurable, easier to evolve in future analysis.

Cluster

Terminal



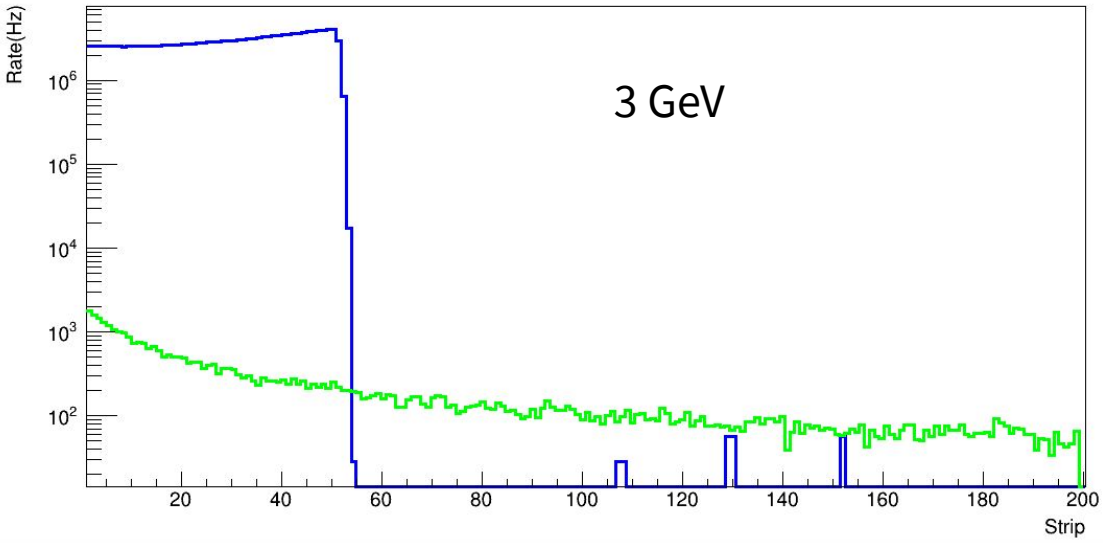
Detector Rates and Backgrounds

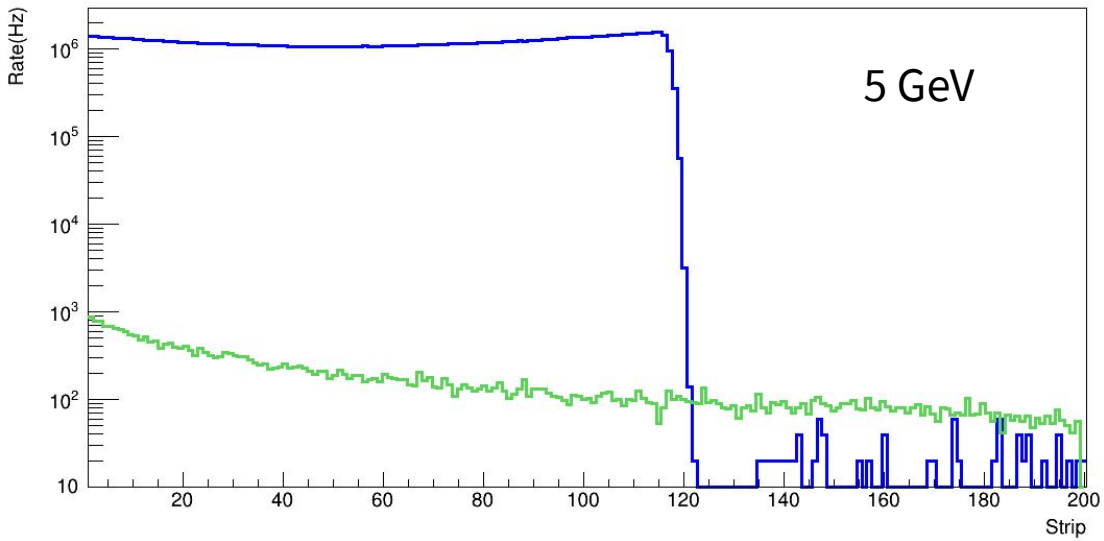
Detector Rates and Backgrounds

Previous analysis can now be easily redone to look at other energies.

Currently 3 GeV and 5 GeV.

Rates for higher energies will also be provided in short term.

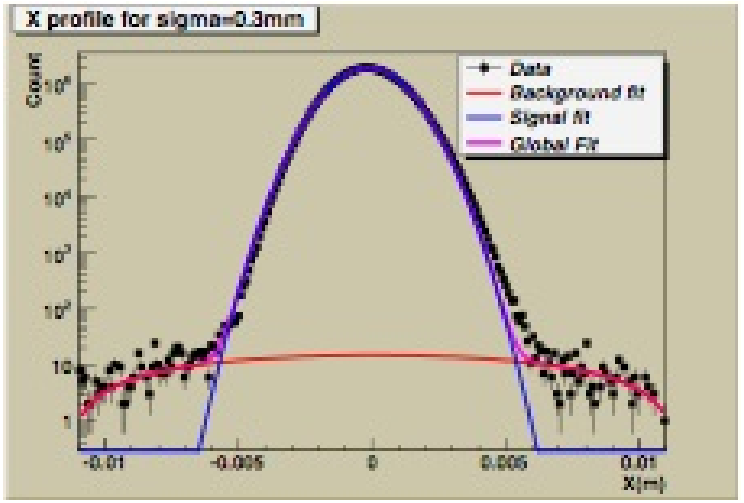




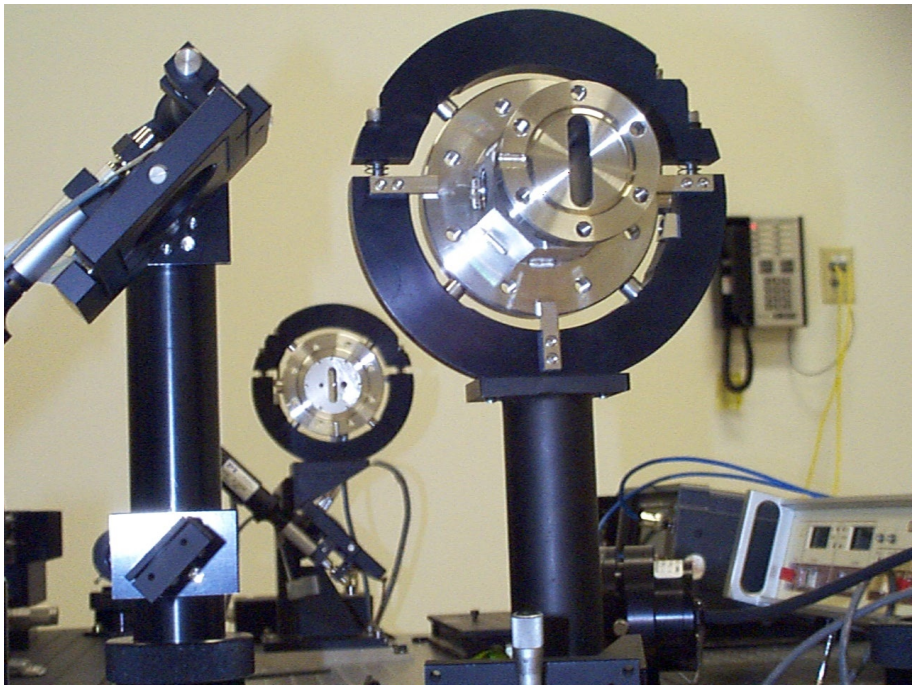
Halo Background: Apertures

Experimental halls A and C at Jefferson Lab use CW, Fabry-Perot cavities.

- Both systems have mirrors ~5 mm from the beam.
- Small apertures protect mirrors from beam excursions and bad beam properties.



Yves Roblin and Arne Freyberger
JLAB-TN-06-048



The protective apertures can lead to backgrounds due to interactions with beam halo.

Use of FP cavity at JLEIC depends on understanding halo.

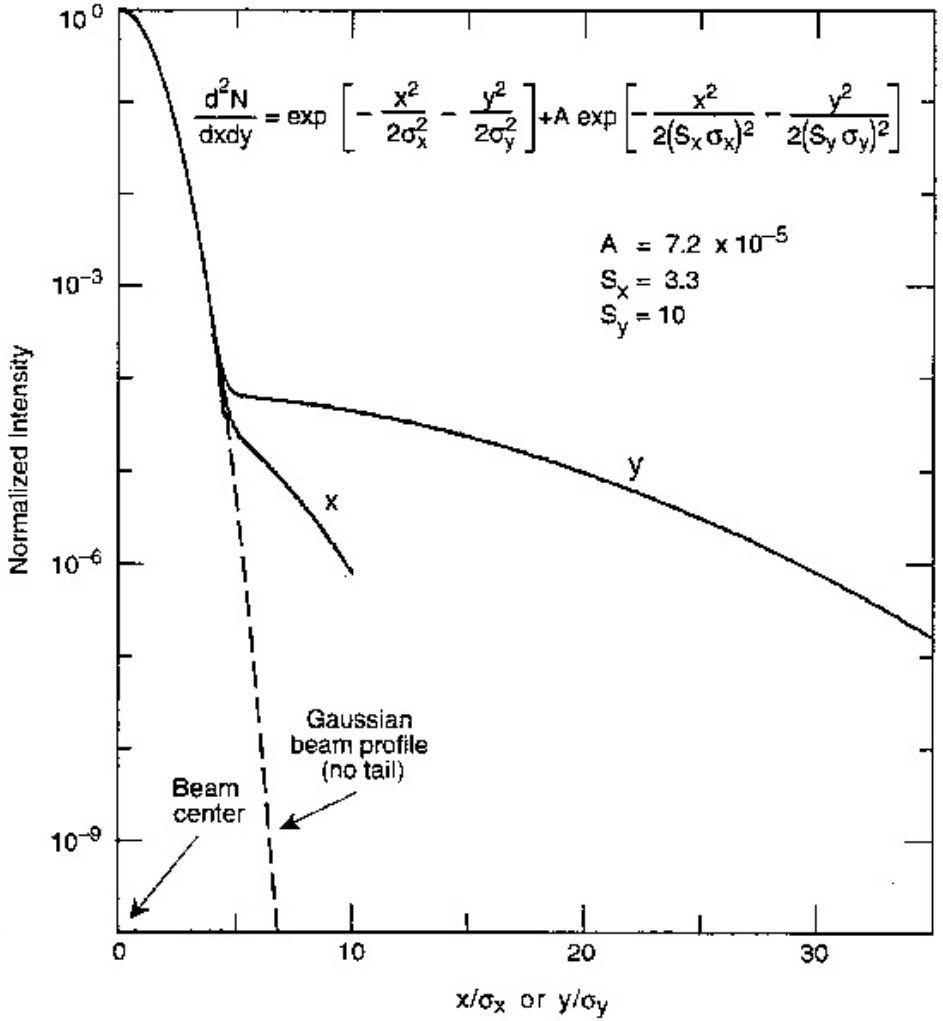
Halo Background: Apertures

Both GEANT3 and GEANT4 simulations uses description of beam halo from PEPII design report[1].

Halo flux is about 0.25% of total beam flux

Backgrounds due to halo can contribute in two locations

1. Interactions with cavity apertures
2. Direct strike of electron detector



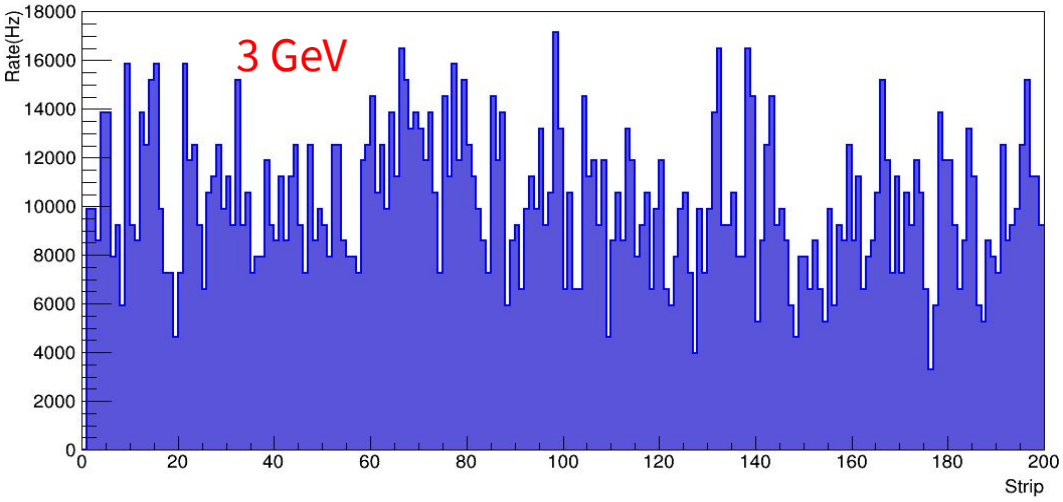
[1] SLAC-R-418 p. 113

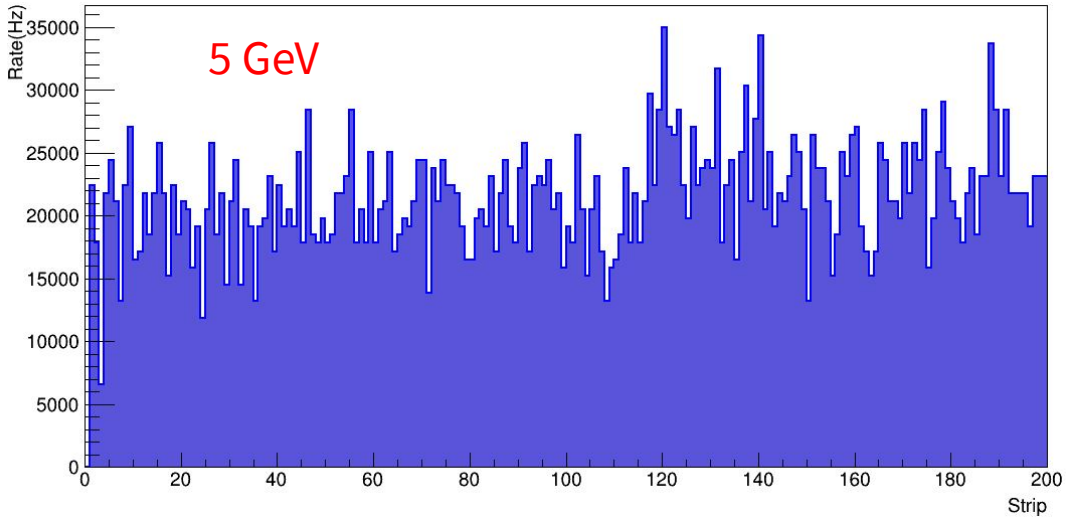
Halo Backgrounds

Halo contributions from center of chicane will be studied over a range of energies

Rates have been shown previously for 5 GeV to be easily controllable be varying the aperture size.

The more pertinent problem is halo interacting with the detector directly.





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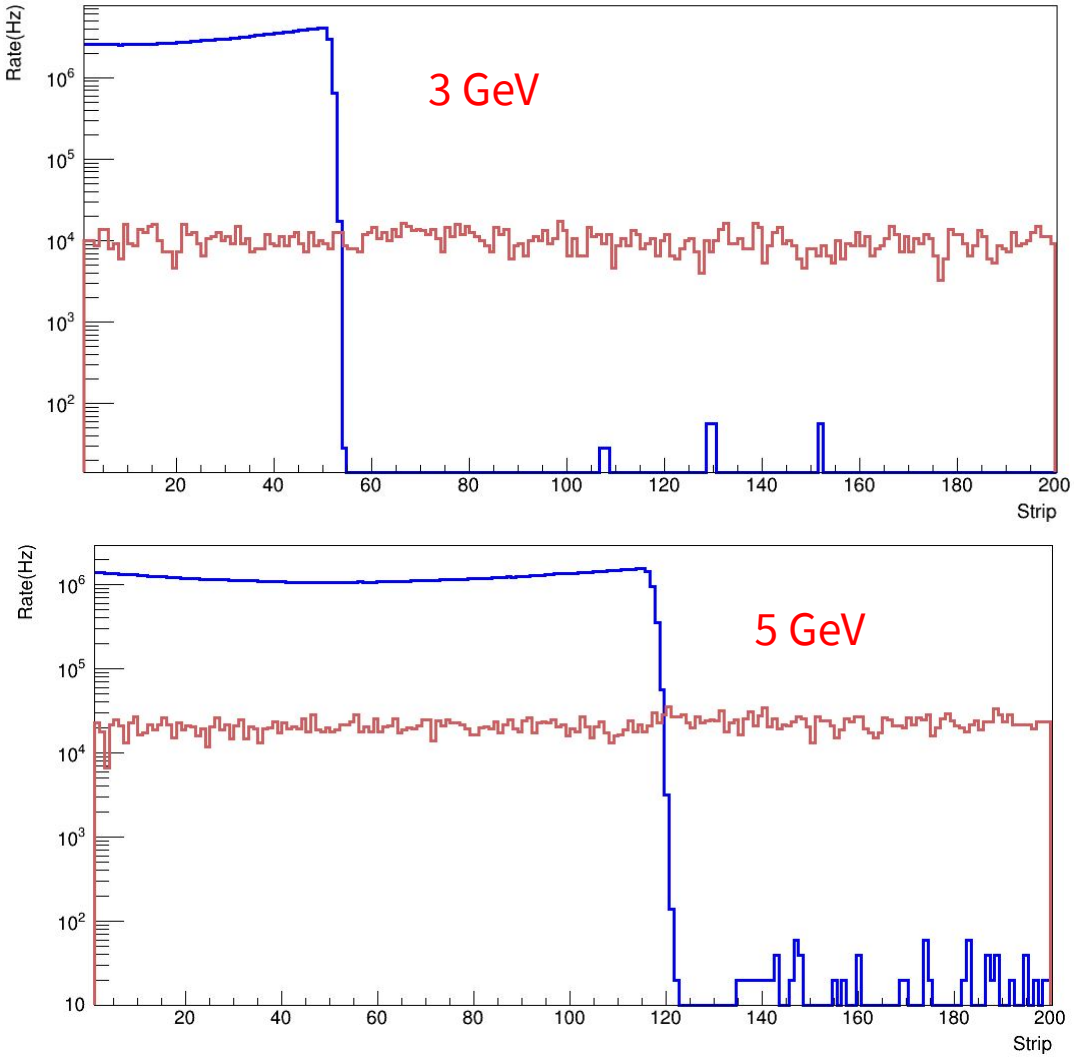


Detector Systematics

Detector Systematics

Want to successfully extract polarization from asymmetries of each beam energy.

Determine the sensitivity of extracted polarization to detector strip size and spacing.

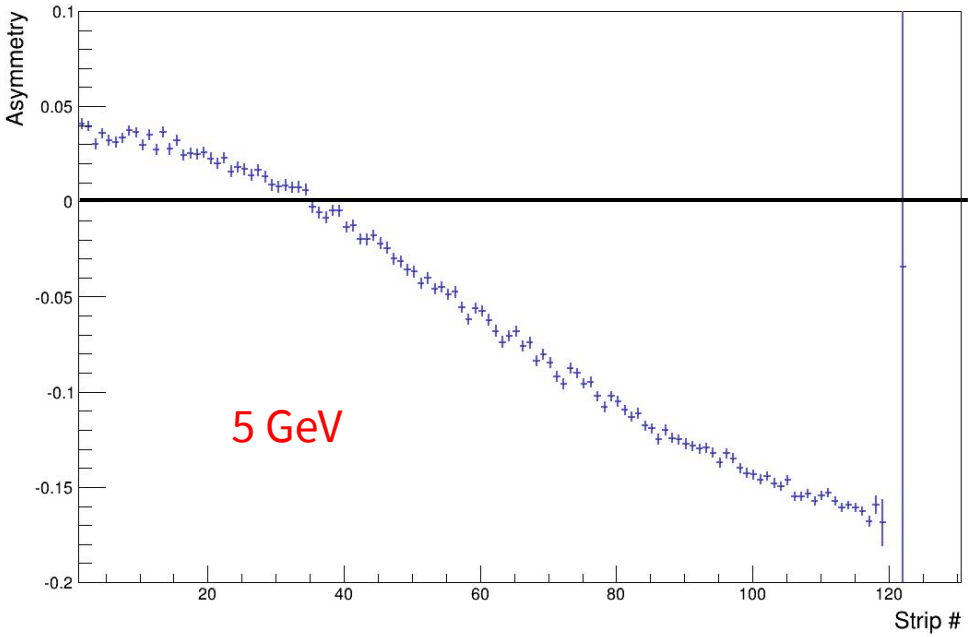
Systematics due to other parameters can be extracted.

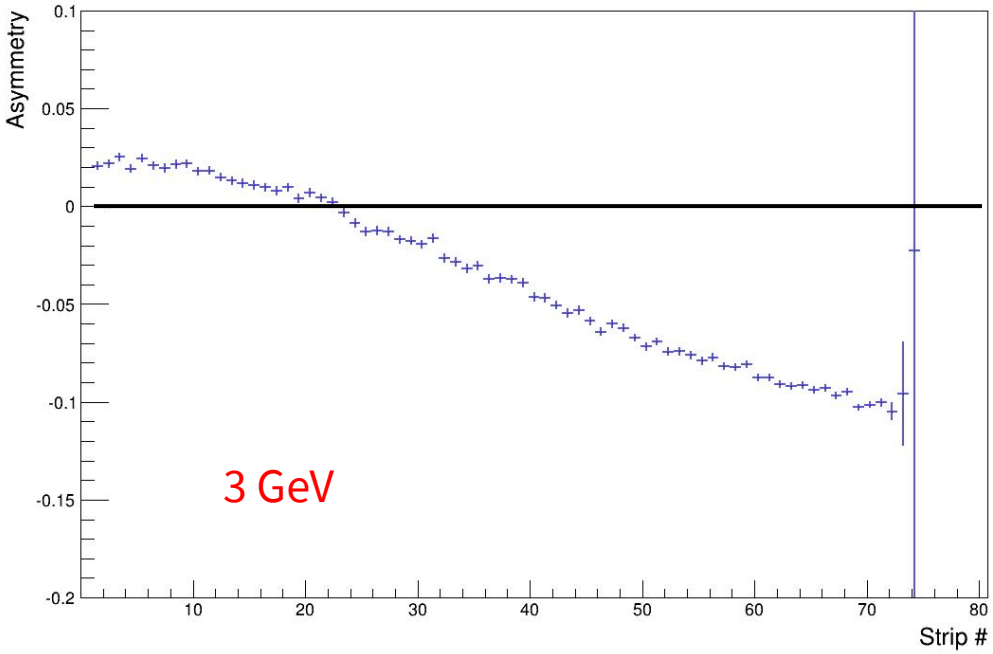
- dipole placement
- dipole field
- detector position

Detector Systematics

The asymmetry in the electron detector is produced for both 3 GeV and 5 GeV.

Once the asymmetry data is produced systematic studies can be done.



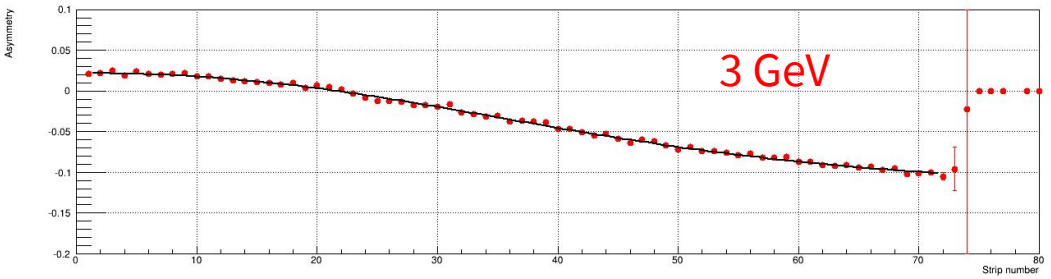


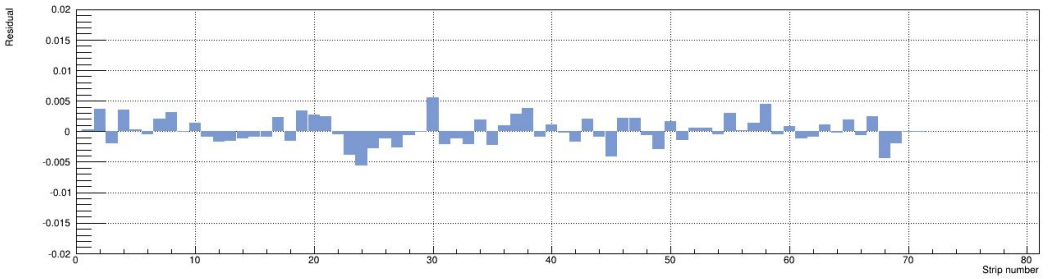
Higher beam energy (11 GeV) can also be added in the next week.

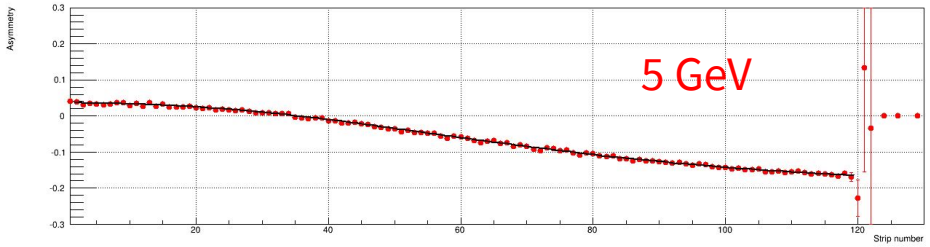
Detector Systematics

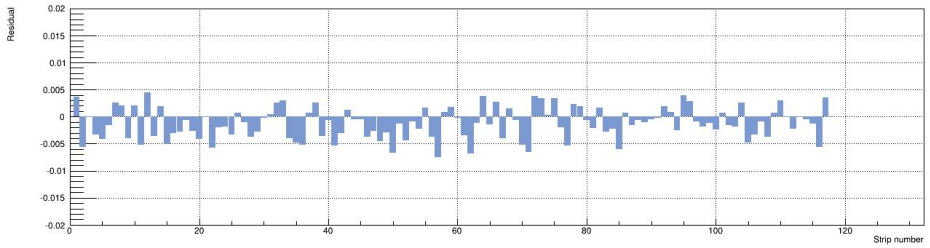
The polarization can be extracted by fitting the asymmetry with respect to parameters of the Beam, dipoles, and detector properties.

The fitting algorithm is based on the original Qweak poalrimetry extraction; it has now been expanded to new energies and the ability to study systematics.









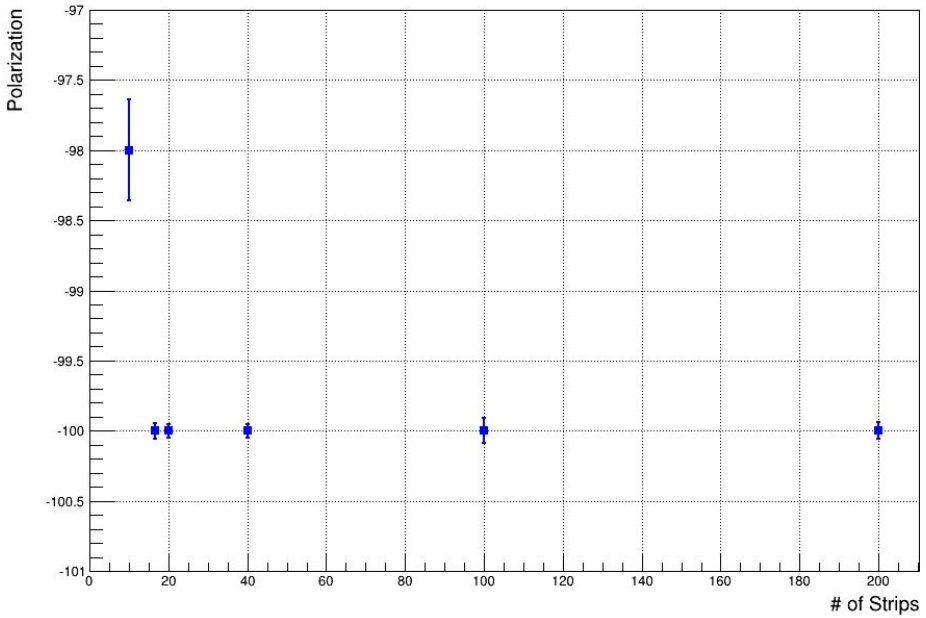
Polarization: 100.0 ±- 0.04
X^2/NDF: 0.87

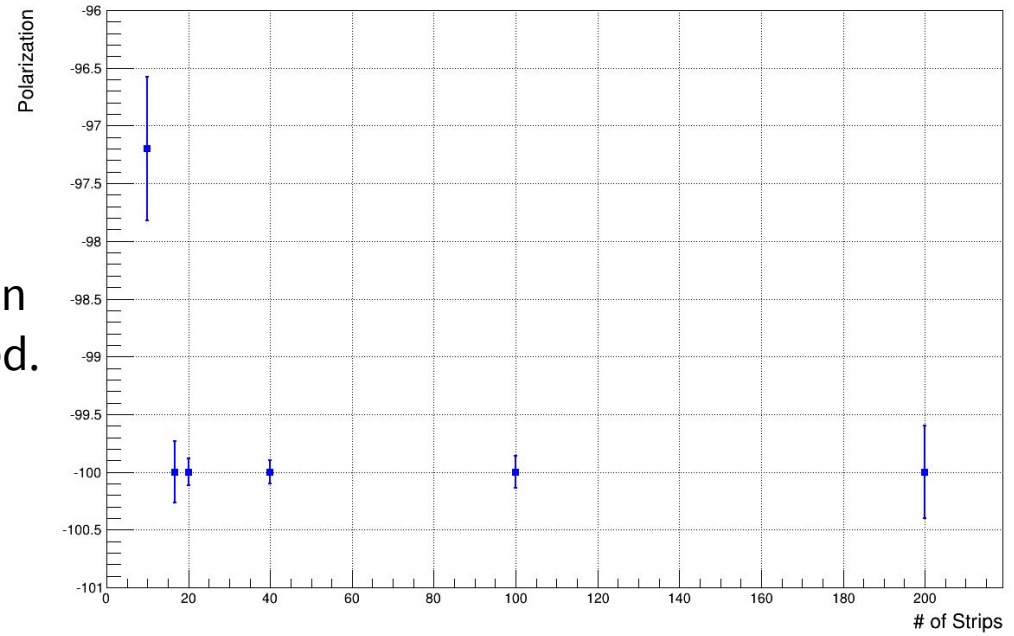
Polarization: 100.0 ±- 0.06
X^2/NDF: 1.18

Detector Systematics

The first systematic study was to determine the minimum strip number needed to properly extract polarization.

The study was achieved by extracting the polarization and then combining strip and refitting till the fit failed.





The 11 GeV study will be important and likely be the limiting factor.

Detector Systematics

Multiplier	Energy	Polarization	X^2/NDF
1	3	-100.00 ± 0.06	1.17
2	3	-100.00 ± 0.08	1.12
5	3	-100.00 ± 0.04	1.23
10	3	-100.00 ± 0.05	2.12
12	3	-100.00 ± 0.05	2.62
20	3	-98.00 ± 0.36	24.75

Multiplier	Energy	Polarization	X^2/NDF
1	5	-100.00 ± 0.40	0.87
2	5	-100.00 ± 0.13	1.09
5	5	-100.00 ± 0.10	1.87
10	5	-100.00 ± 0.11	2.98
12	5	-100.00 ± 0.26	2.74
20	5	-97.20 ± 0.62	17.16

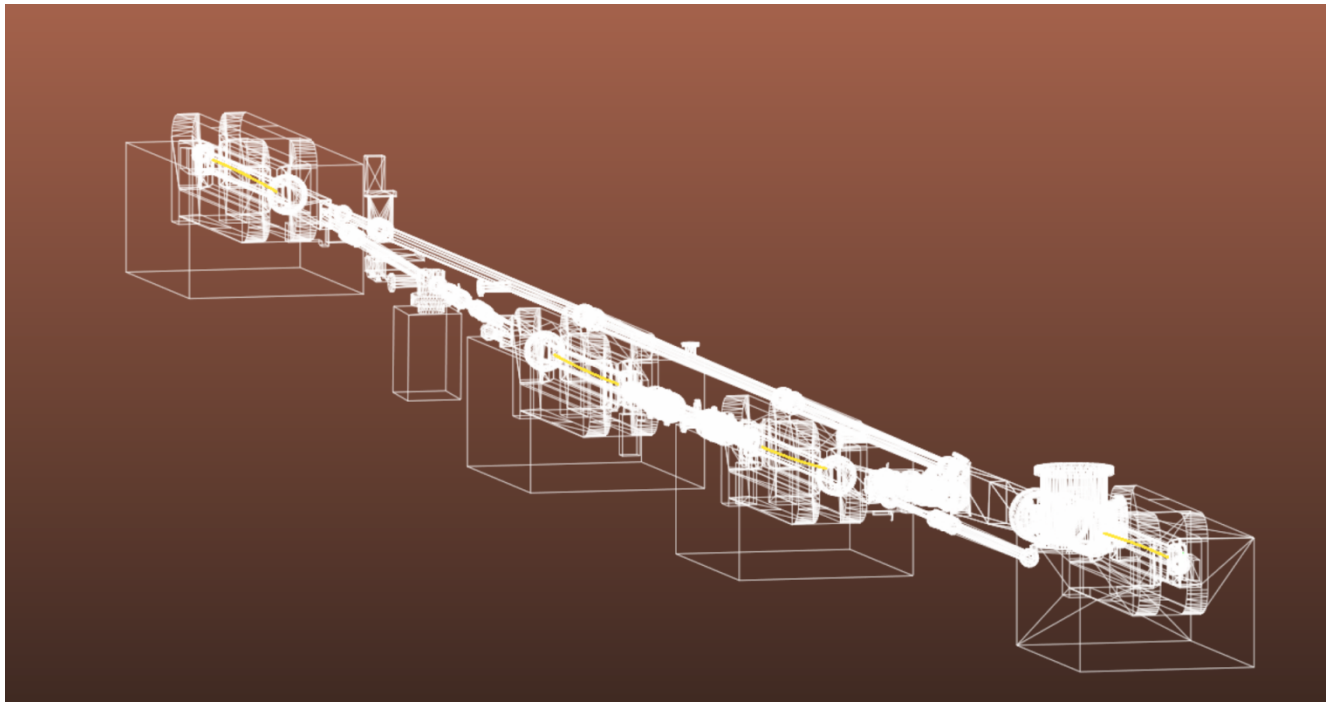
Relatively modest number of strips required(<40 from zero-crossing to endpoint) to adequately fit asymmetry distribution.

It is now possible to study the systematic effect of other parameters such as:

- Dipole placement
- Detector placement
- Dipole field

With these studies we will be able to provide an estimate of the accuracy of the polarization measurement.

SynRad Testing



- Geometry import from CAD successful from existing chicane.
- But need simplified geometry to have better speed and control on node collapsing

SynRad and Moflow Testing

- Molflow take a photon flux as input.

- Most likely will use Synchrotron information by Mike Sullivan, transport in GEMC and feed flux to Molflow+ to evaluate outgassing

Roadmap

Produce 11 GeV rates/backgrounds/asymmetries

The tools to complete this are ready with the exception of a few minor tweaks so 2-3 week should be fine.

Mapping halo @detector background phase space

Depending on how in-depth we got this is expected to take 4 weeks

Systematics and polarization accuracy estimate

This is expected to take 5-6 weeks.

Roman Pot Geometry and Beam Induced Background

New Geometry should be straightforward if we can import it. Need to rerun plots in parallel.

4 weeks Geometry plus analysis plots

4 weeks for Synchrotron studies.

Software documentation

So that the software can be used to further studies in the future, I will write up a users manual 1-2 weeks

Final paper

Our final report presenting the results of our studies thus far, 2 weeks.

Thank you