Polarimeter update and preliminary chamber design

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GlueX polarimeter group

Arizona State University
and
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Outline

- Triplet production overview
- Preliminary vacuum chamber design
- Event generator developments
- Simulation results
- Moving forward

Triplet production

- Pair production off a nucleon: γ nucleon → nucleon $e^+ e^-$.

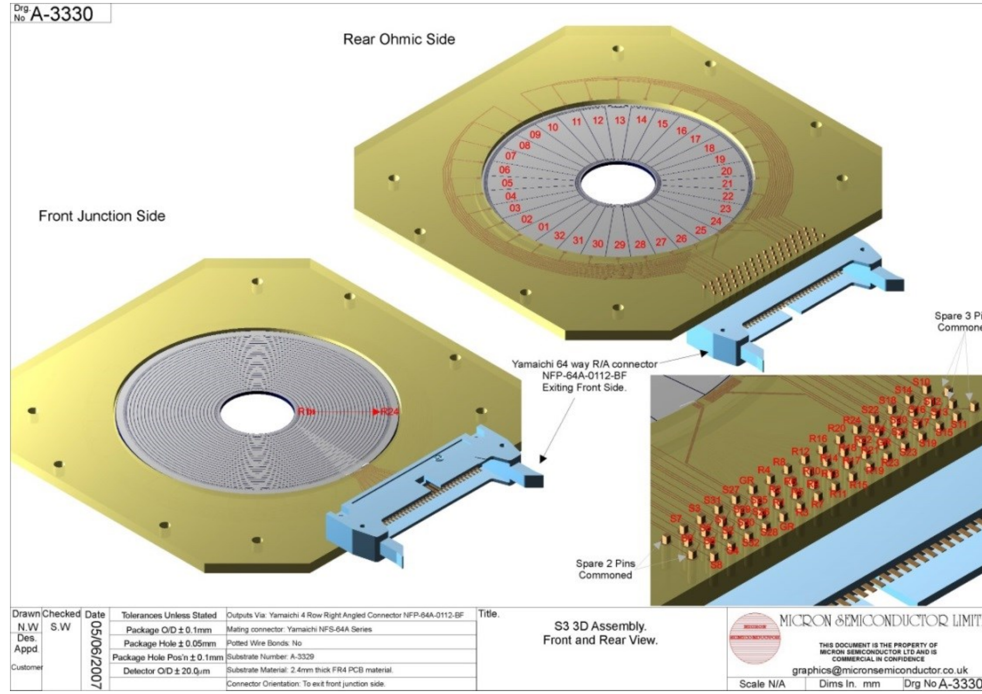
- For polarized photons $\sigma = \sigma_0[1 + P\Sigma \cos(2\varphi)]$, where σ_0 is the unpolarized cross section, P is the photon beam polarization and Σ is the beam asymmetry

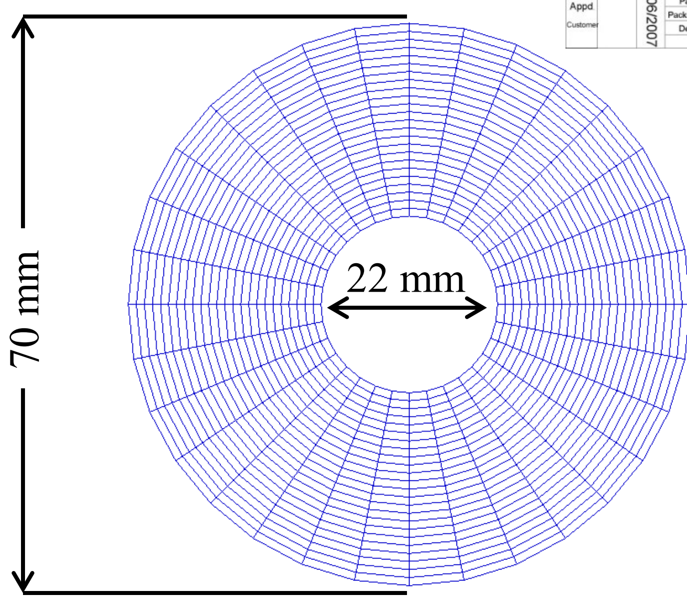
- Triplet production off an electron: $\gamma e^- \rightarrow e_R^- e^+ e^-$, where e_R represents the recoil electron

- Any residual momentum in the azimuthal direction of the $e^- e^+$ pair is compensated for by the slow moving recoil electron. This means that the recoil electron is moving perpendicular to the plane containing the produced pair and can attain large polar angles.

Detector

- Decided to use Micron S3 design instead of the S2
- The S3 has 32 azimuthal sectors instead of 16 for the S2





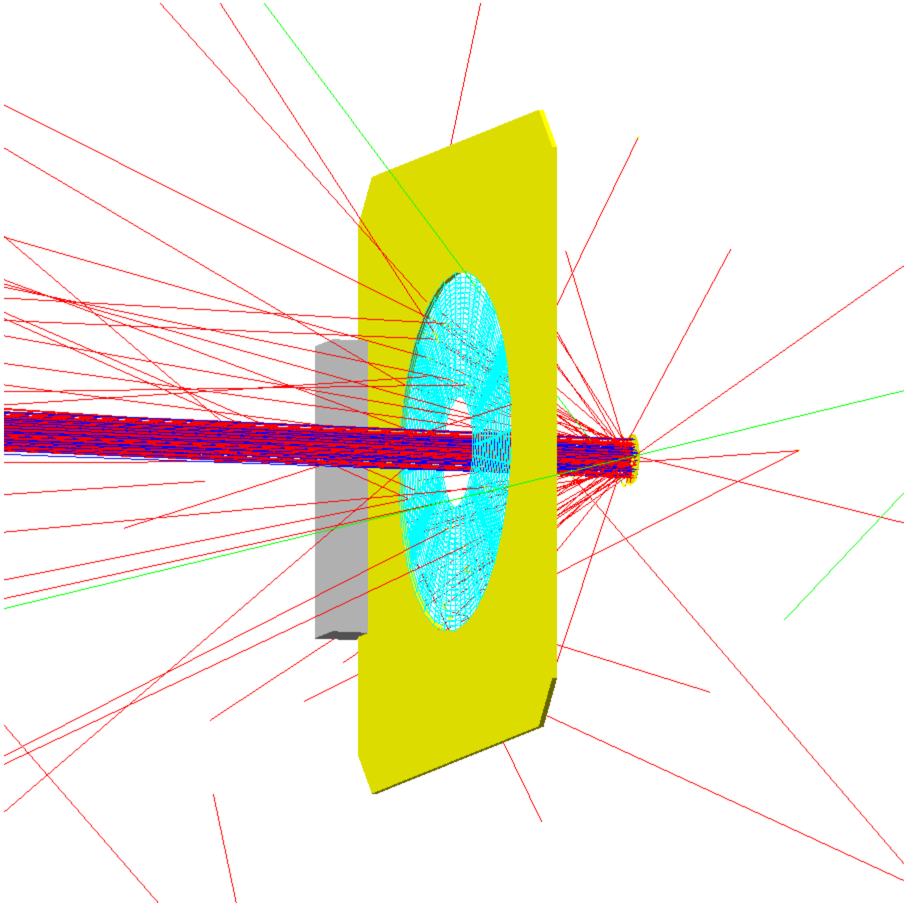
1 mm thick

Detector at ASU

- Obtained a Micron S3 detector over the holiday break

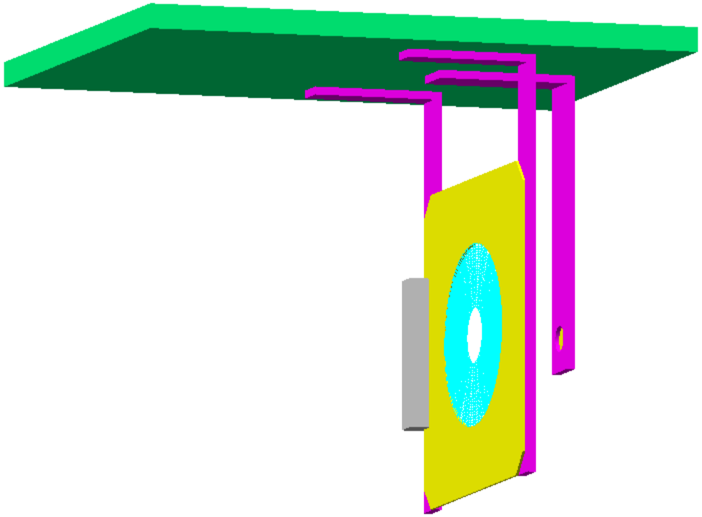
Design slide 1

- Micron S3
- Converter
- 200 events thrown



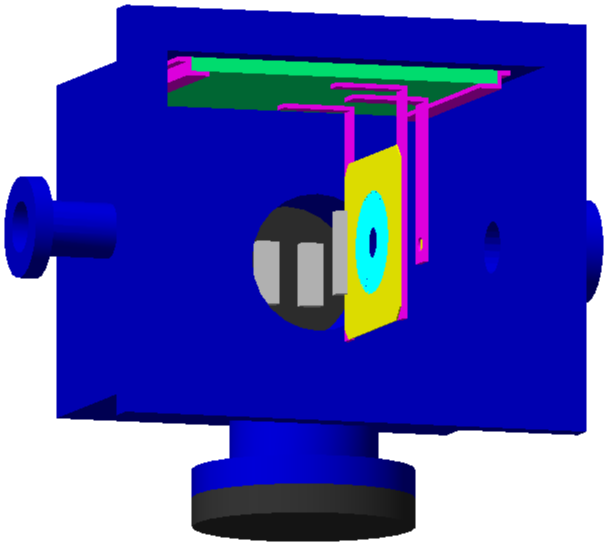
Design slide 2

- Micron S3
- Converter
- Mounting plate and brackets
- Having a removable plate will allow for easy modification of how the detector is mounted without having to modify the chamber
- Convertor stick is just a cartoon. Having ASU machine shop create preliminary design with four windows for different convertors



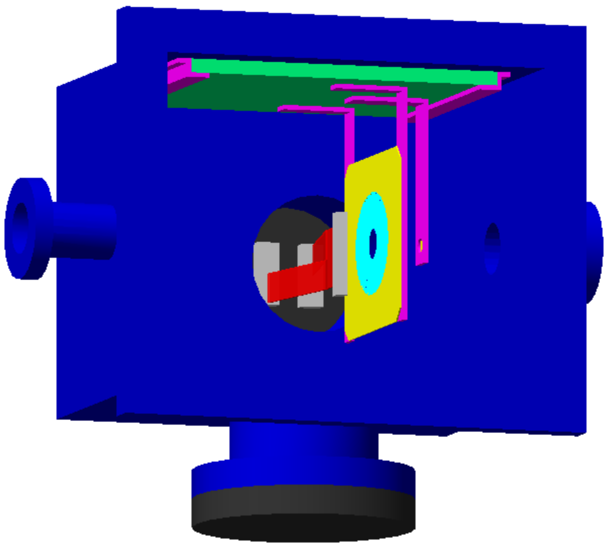
Design slide 3

- Micron S3
- Converter
- Mounting plate and brackets
- Chamber with electrical feed-through flange, and blank flange
- Inner dimensions: 11in by 9in by 9in



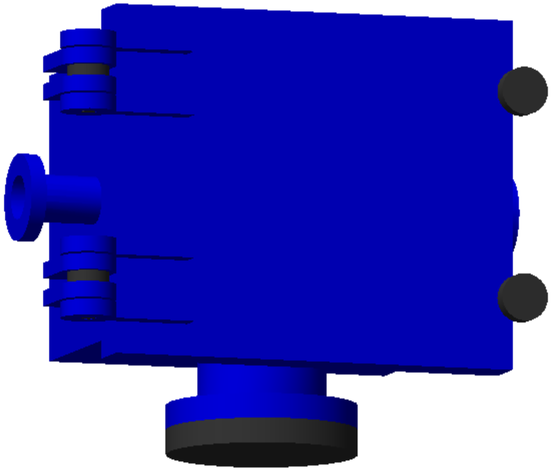
Design slide 4

- Includes ribbon cable from detector to electrical feed-through



Design slide 5

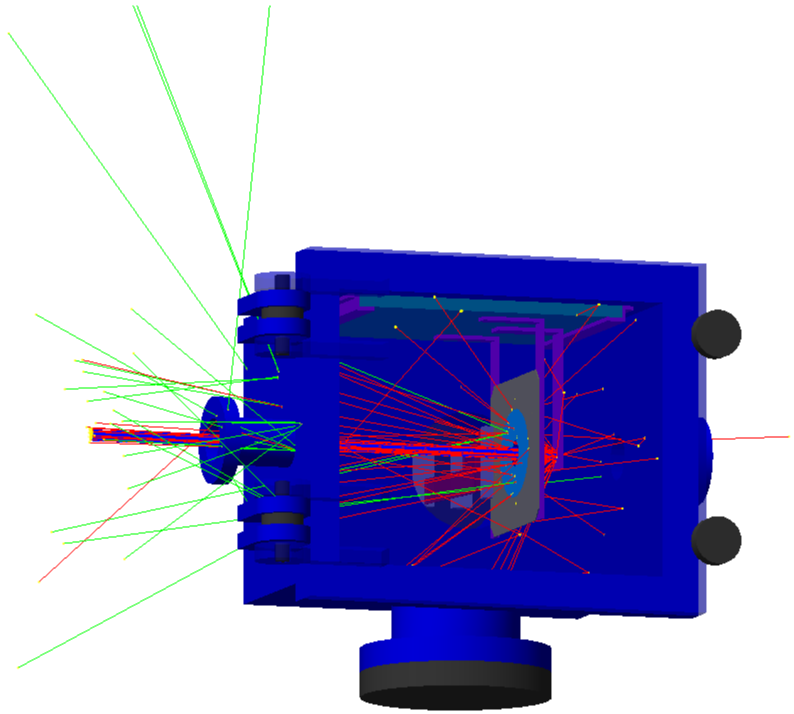
- With front door
- Current hinges and door latches shown are decorations, having ASU machine shop advise on design of such elements



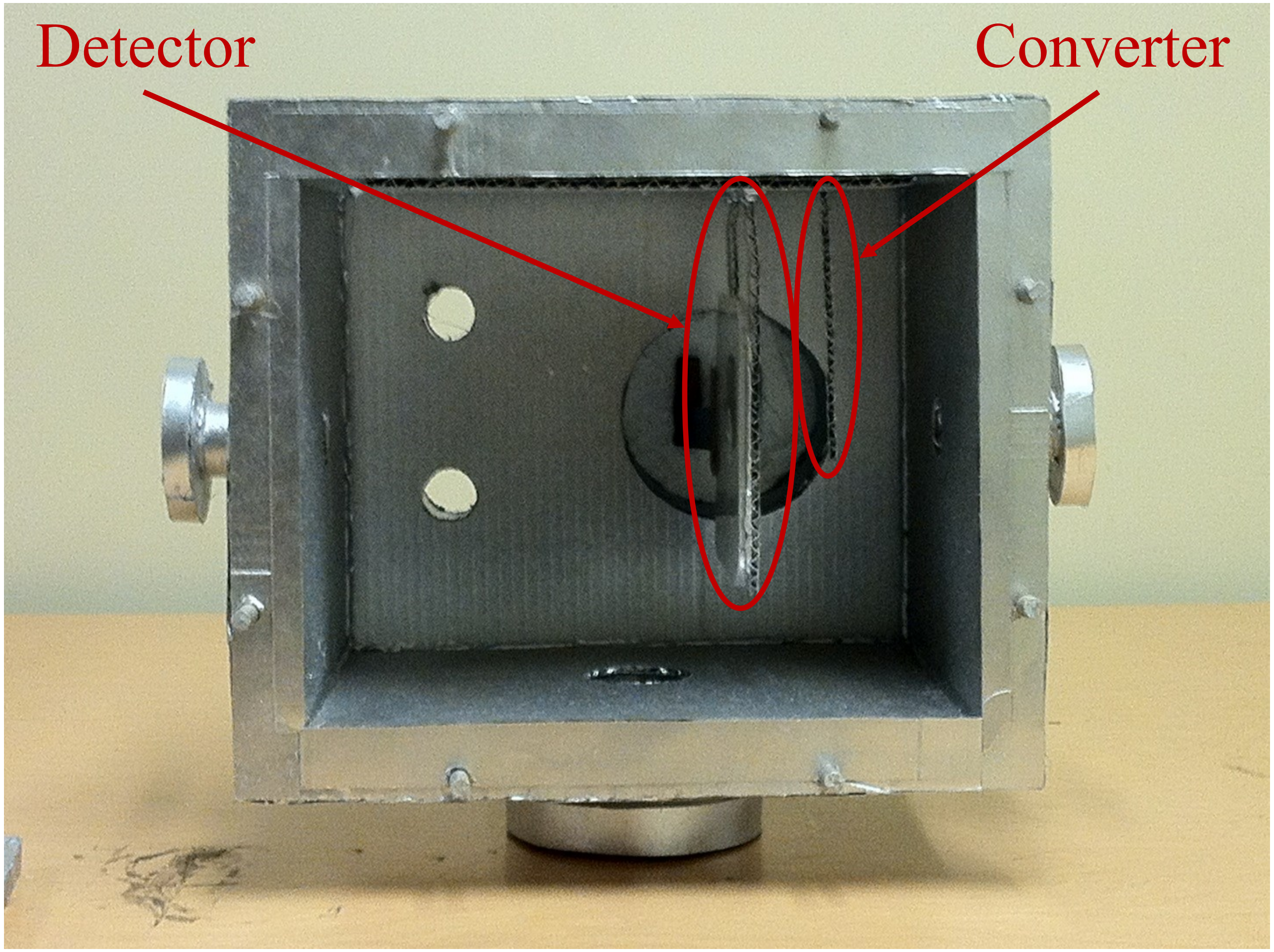
Design slide 5

- With front door in see through mode

- 200 events thrown



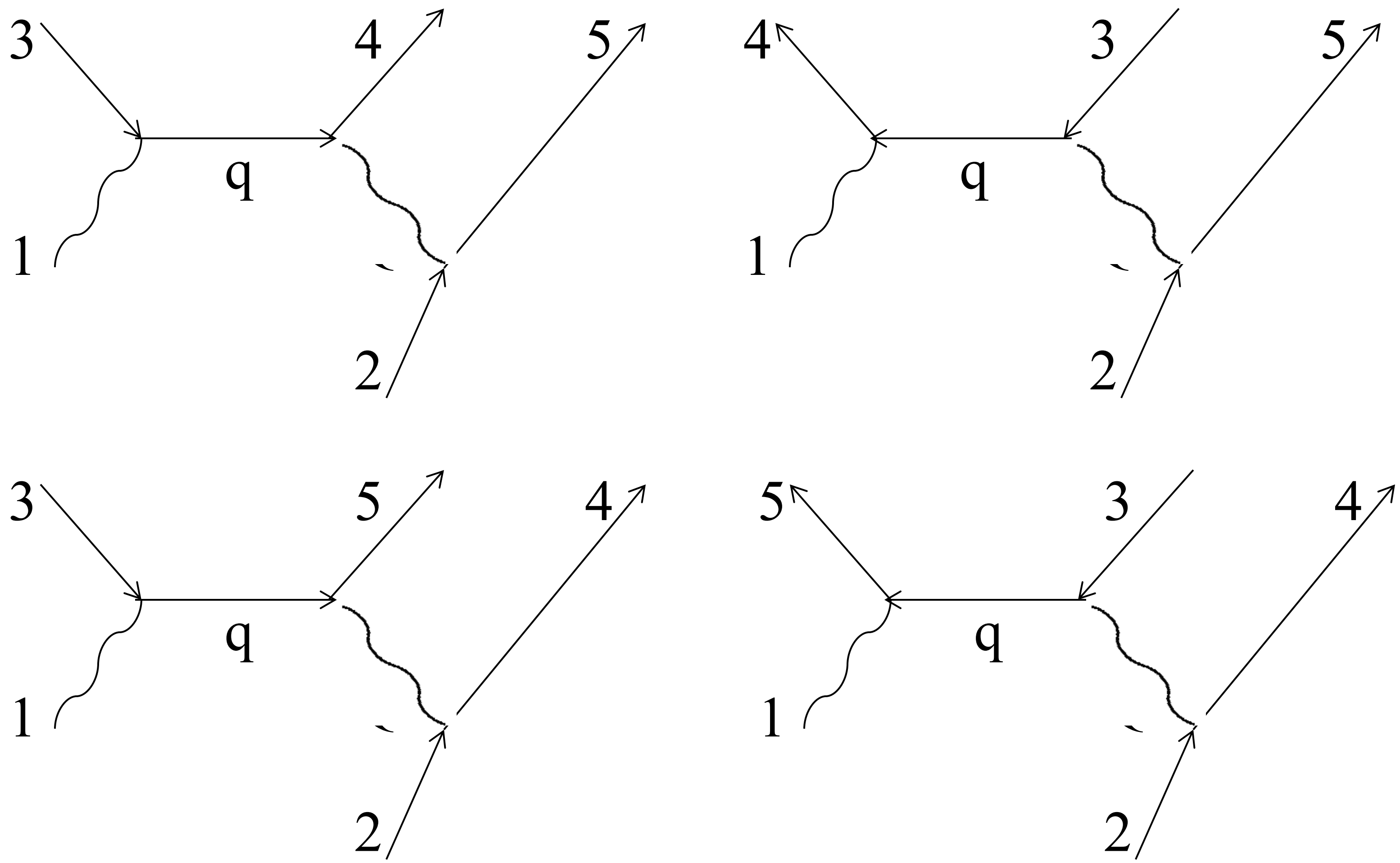
Cardboard mockup



Event generator

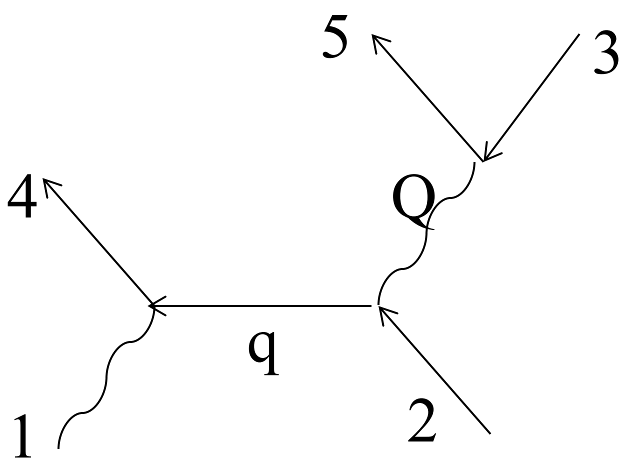
- Diagrams used
- Screening correction
- Most important diagrams

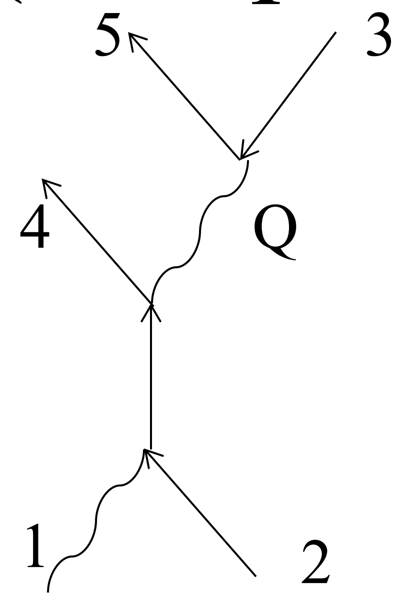
Triplet production (pair like)

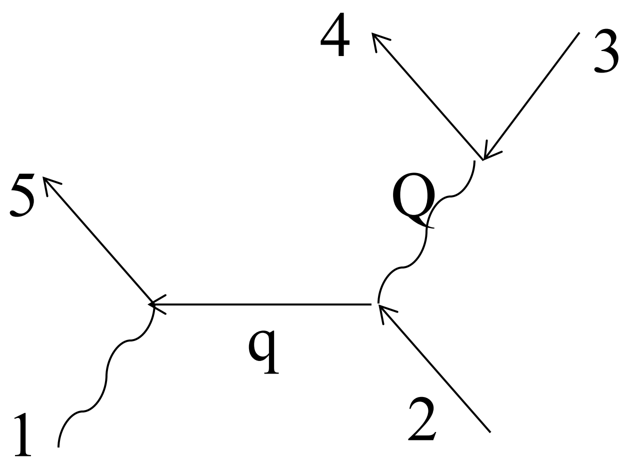


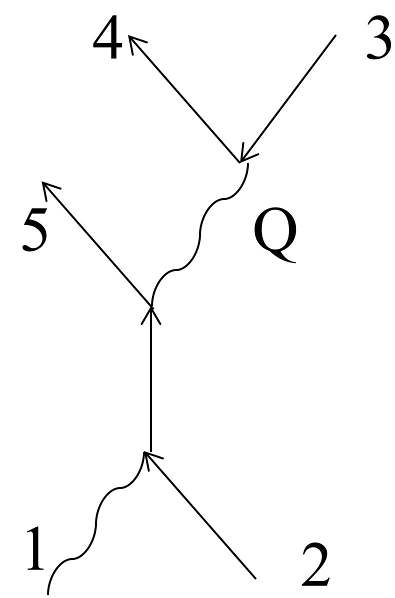
- Here we have two electrons in final state and must include diagrams that have $4 \leftrightarrow 5$ interchange

Triplet production (Compton like)









- Includes $4 \leftrightarrow 5$ exchange

Screening correction

Screening correction

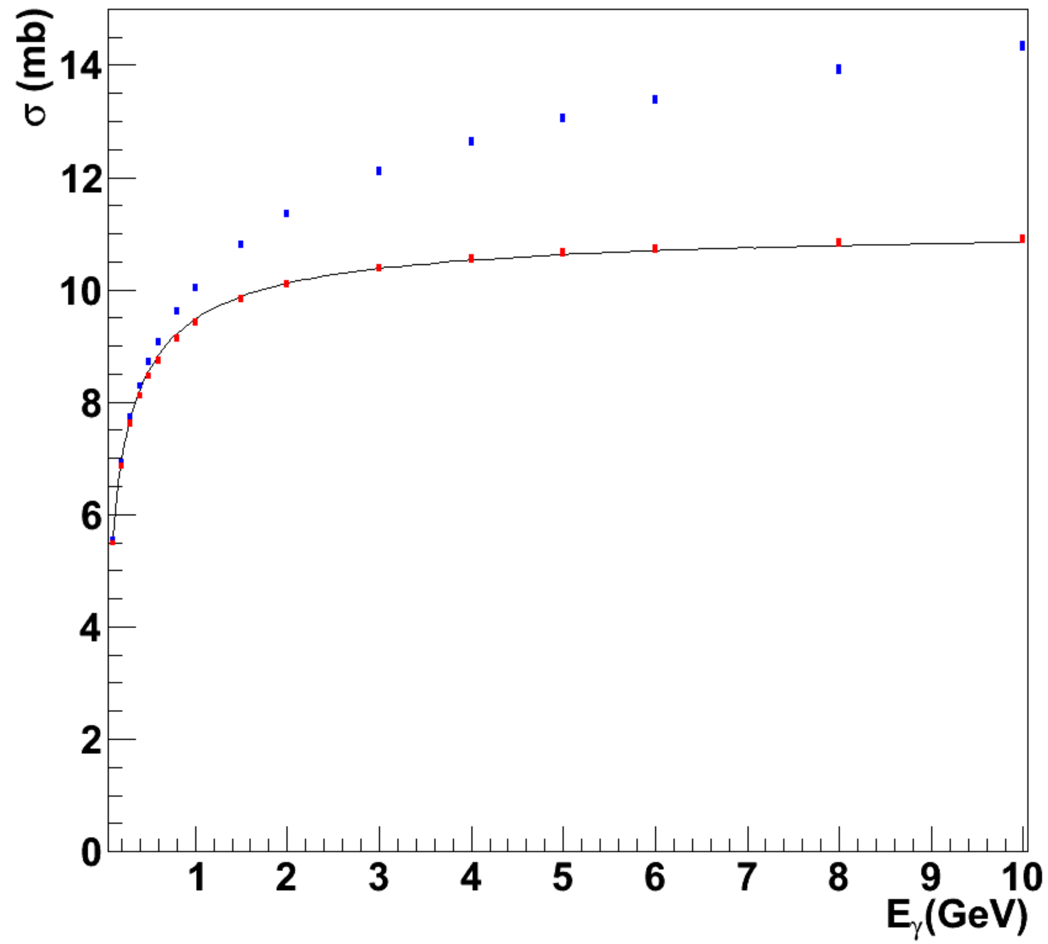
- Leonard Maximon informed me that the screening correction for triplet production should not be important for the beam asymmetry but was very important for the cross section

- Used the screening correction provided in the paper by Maximon and Gimm [1] to compare cross section results of the event generator to values from the NIST

[1] L. C. Maximon, H. A. Gimm Phys. Rev. A. 23, 1, (1981).

Comparison plot of total cross section for triplet production

- **Black line**: Total cross section from NIST
- **Blue points**: Total cross section from event generator without screening correction
- **Red points**: Total cross section from event generator with screening corrections included



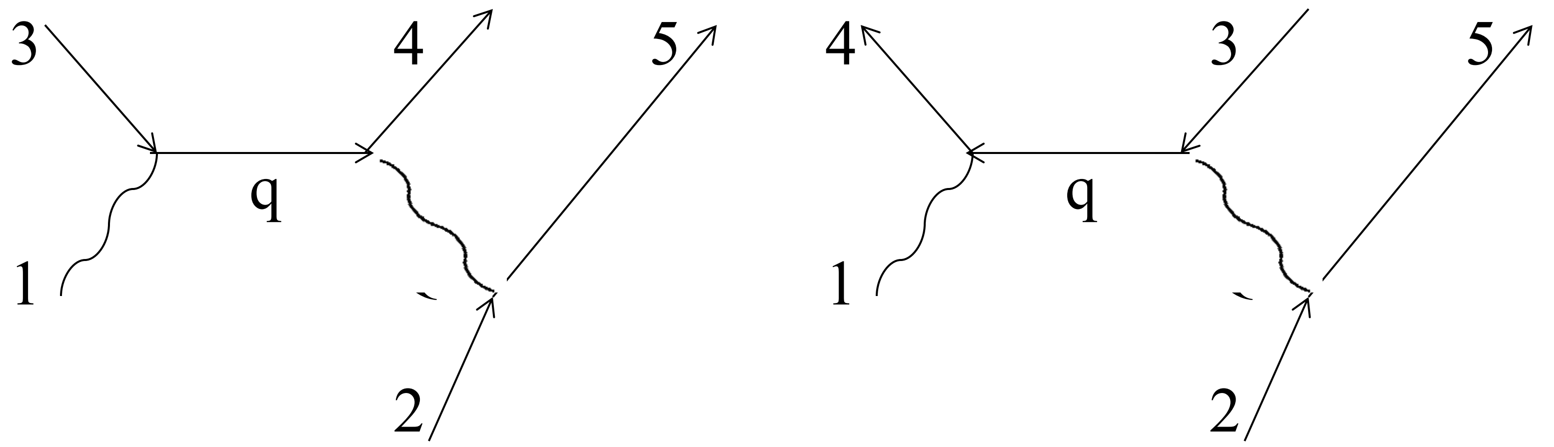
- Very nice agreement once screening is included ☺

Most important diagrams

- The Mork paper [2] says that the Compton-like diagrams and the switched electron leg diagrams should be negligible at high photon energy

[2] K. J. Mork Phys. Rev. 160, 5, (1967).

Calculations



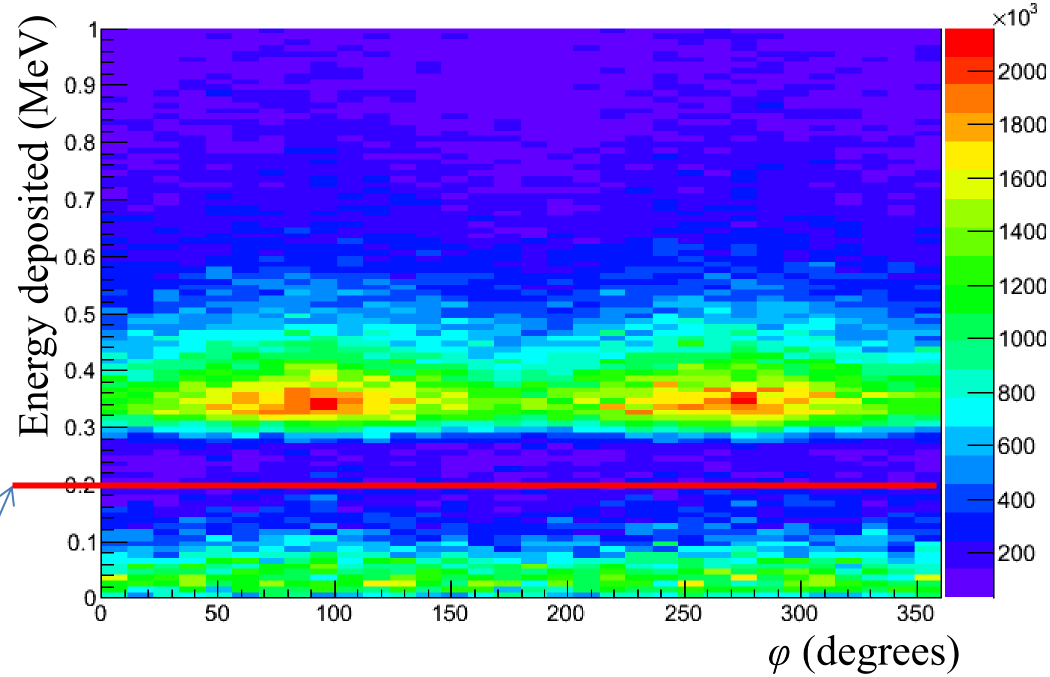
- Ran 100,000 events at $E_\gamma = 9.0$ GeV using:
  - Full calculation: $\sigma = 10.856$ mb
  - Reduced calculation: $\sigma = 10.855$ mb

- Reduced calculation neglects Compton-like and crossed electron-line diagrams

- Reduced calculations are well within 0.1% of full calculations

Simulation

- Generated pairs and triplets with $E_\gamma = 9$ GeV
- Required energy of $e^+ e^-$ pair to be within 1.75 GeV of each other
- Required energy deposition in detector to be greater than 200 keV



- Converter: 35 μm beryllium
- Used full calculation (all diagrams included)

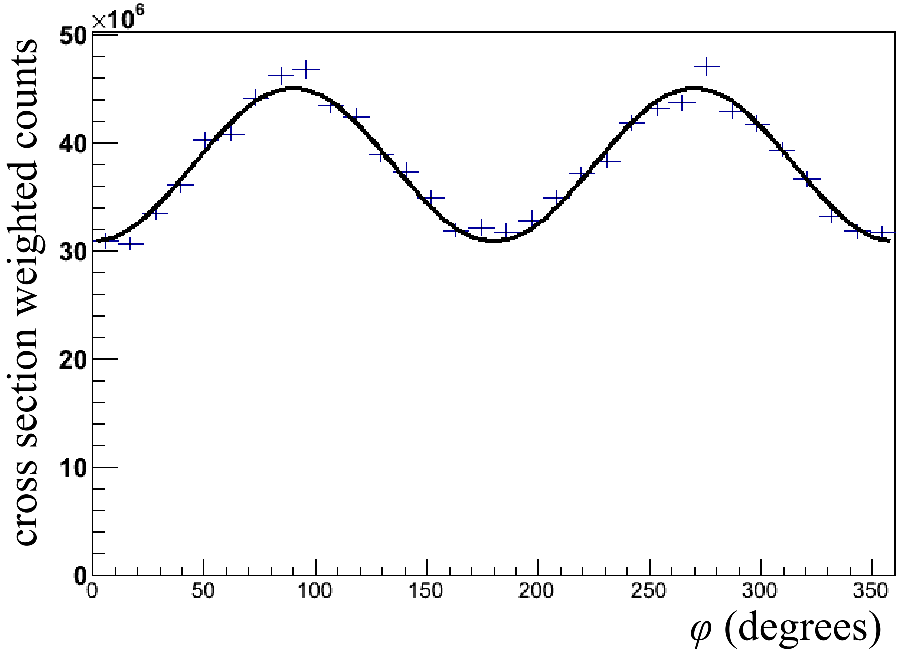
Simulation results

- Assumed collimated photon rate in coherent peak : 99 MHz
- Δt = 4 hours

- Analyzing power: 0.186
- Polarization uncertainty: 0.01

Assumed $$\frac{\sigma_P}{P} = \sqrt{\frac{1}{N}}\sqrt{\frac{2}{\alpha^2 P^2} - 1}$$

where N ≡ Rate surviving cuts * 4 hour,
P ≡ Polarization = 0.4, and
α ≡ analyzing power



Rates:

- Total rate on device = 955 Hz
- Rate surviving software and trigger cuts = 64 Hz

Moving forward

- Once ASU machine shop finishes the preliminary chamber design we will consult with JLab collaborators and machine shop
- Ken Livingston (Glasgow) is consulting with Tom Davinson in Edinburgh for the design of preamp motherboards.
- Once motherboard design is finalized, Glasgow will produce and populate the preamp motherboards
- Hope to have test bench up and running in the Spring

Backup