Polarization measurements with GRETINA

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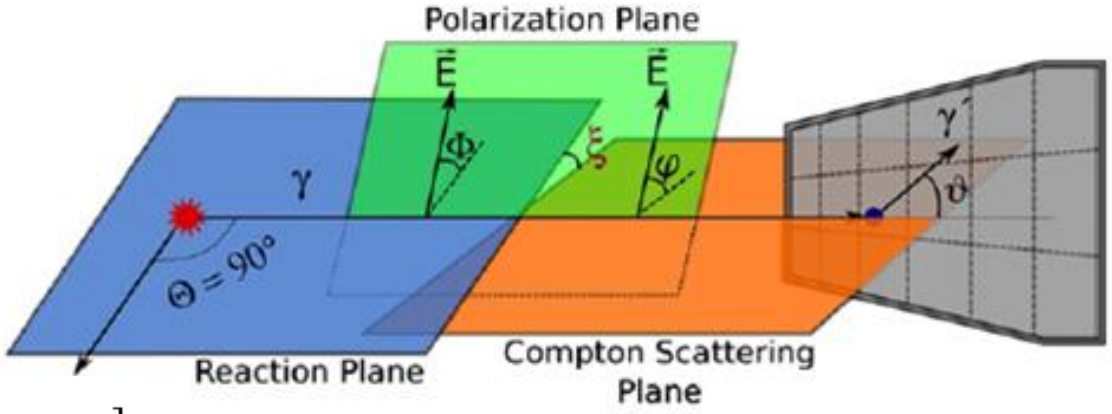
Introduction

Compton scattering is sensitive to polarization state of photons.



$$\frac{d\sigma}{d\Omega} = \frac{{r_0}^2}{2}\left(\frac{E'}{E}\right)^2\left[\frac{E'}{E} + \frac{E}{E'} + sin^2(\theta)(1 + P\,cos(2\varphi))\right]$$

B. Alikhani et al. NIM A 675 (2012) 144-154

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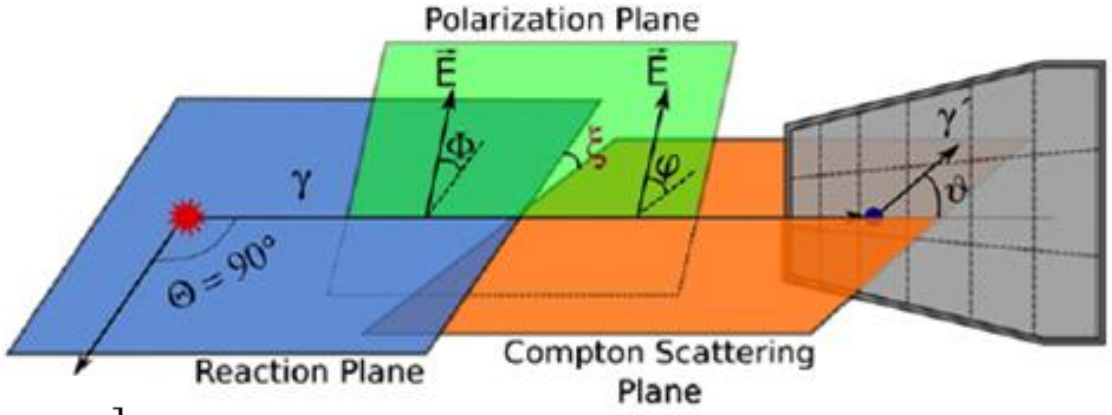

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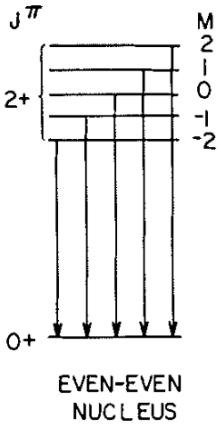
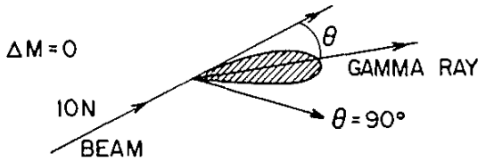
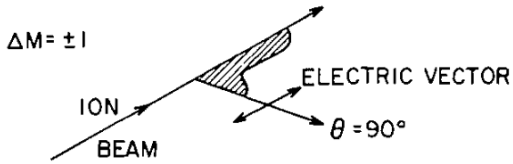
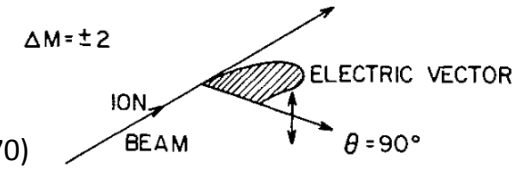
B. Alikhani et al. NIM A 675 (2012) 144-154

- Photons emitted from a given magnetic substate have a characteristic polarization
- If we can select which substates we populate, we can dictate the polarization state of the emitted photons





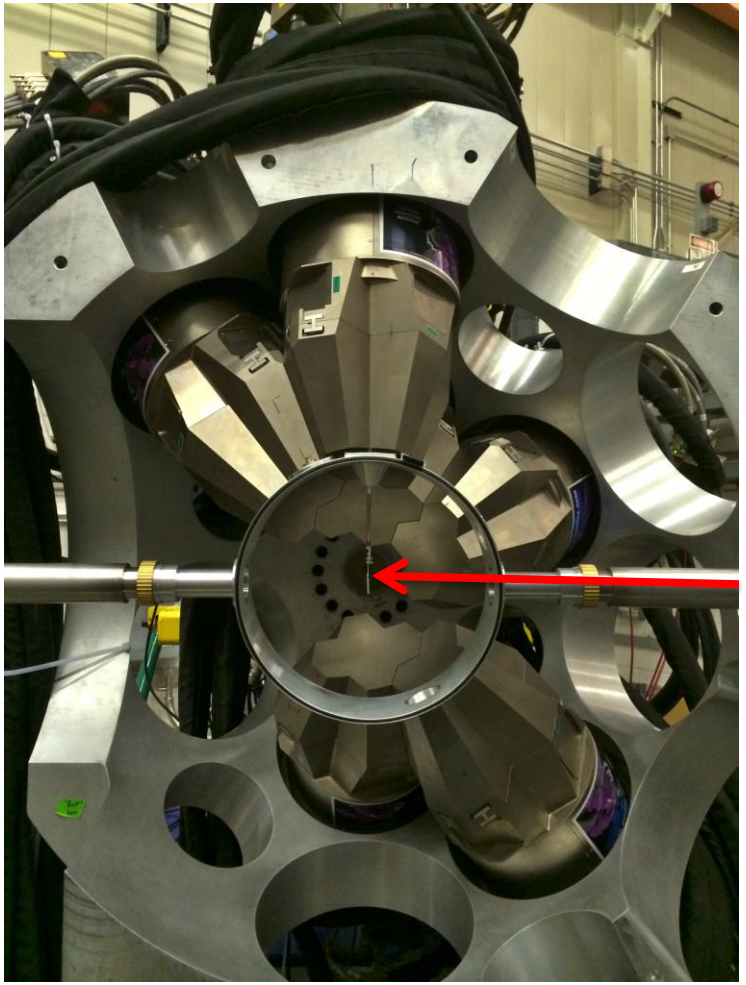




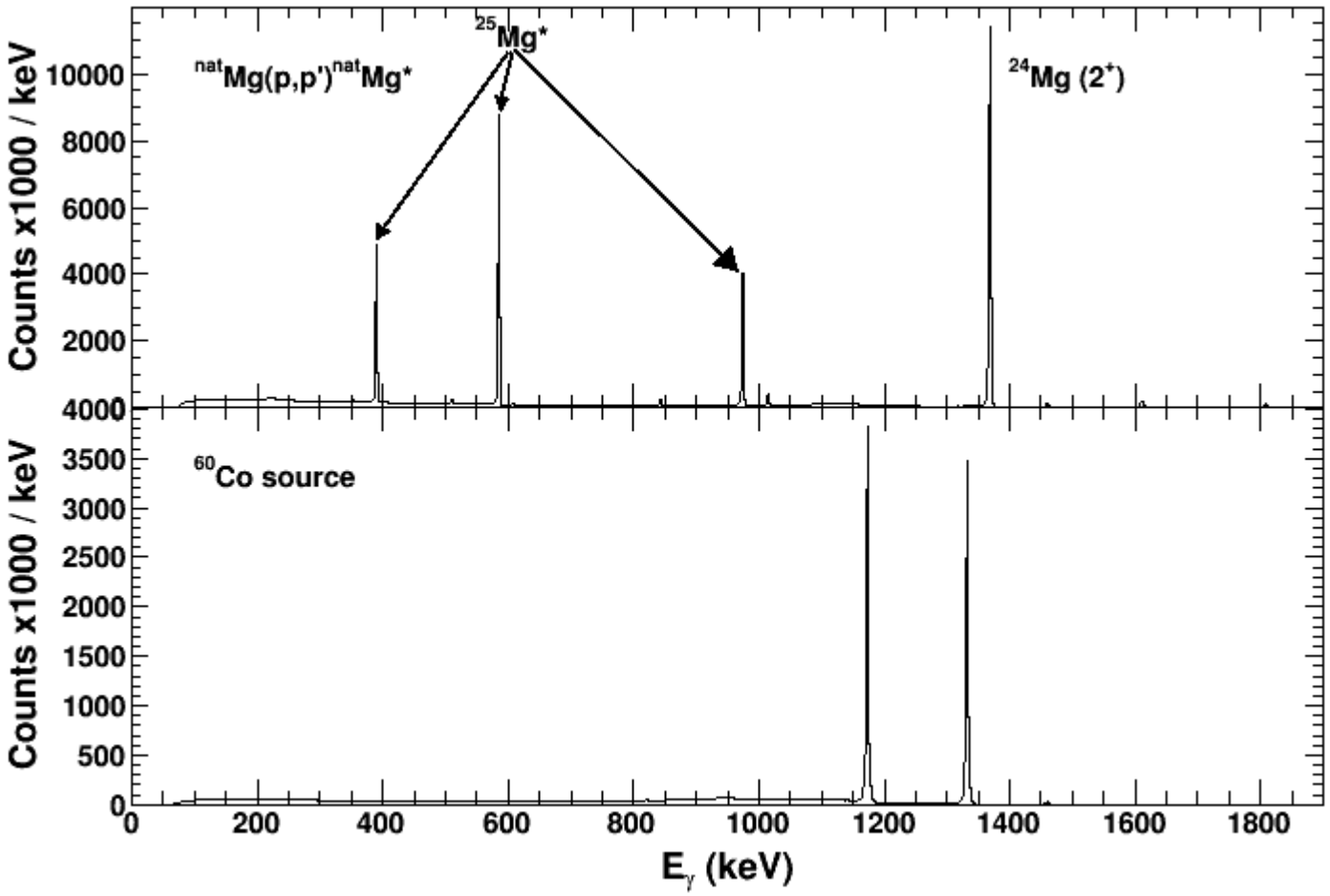
A.E. Litherland et al. Can. J. Phys 48, 2320 (1970)

Setup

- Commissioning experiment @ ANL
- 6 GRETINA modules
  - 1 module at 58 degrees
  - 3 modules at 90 degrees
  - 2 modules at 122 degrees
- Reaction: ^{24}Mg(p,p')^{24}Mg*
  - Proton energy: 2.45 MeV
  - Populates 2^+ state at 1.386 MeV
  - $L = |\vec{r} \times \vec{p}| \approx 1\hbar$
  - Selects only $M = 0, \pm 1$ substates
- Normalization: 1.332 MeV γ ray from ^{60}Co as source of unpolarized photons

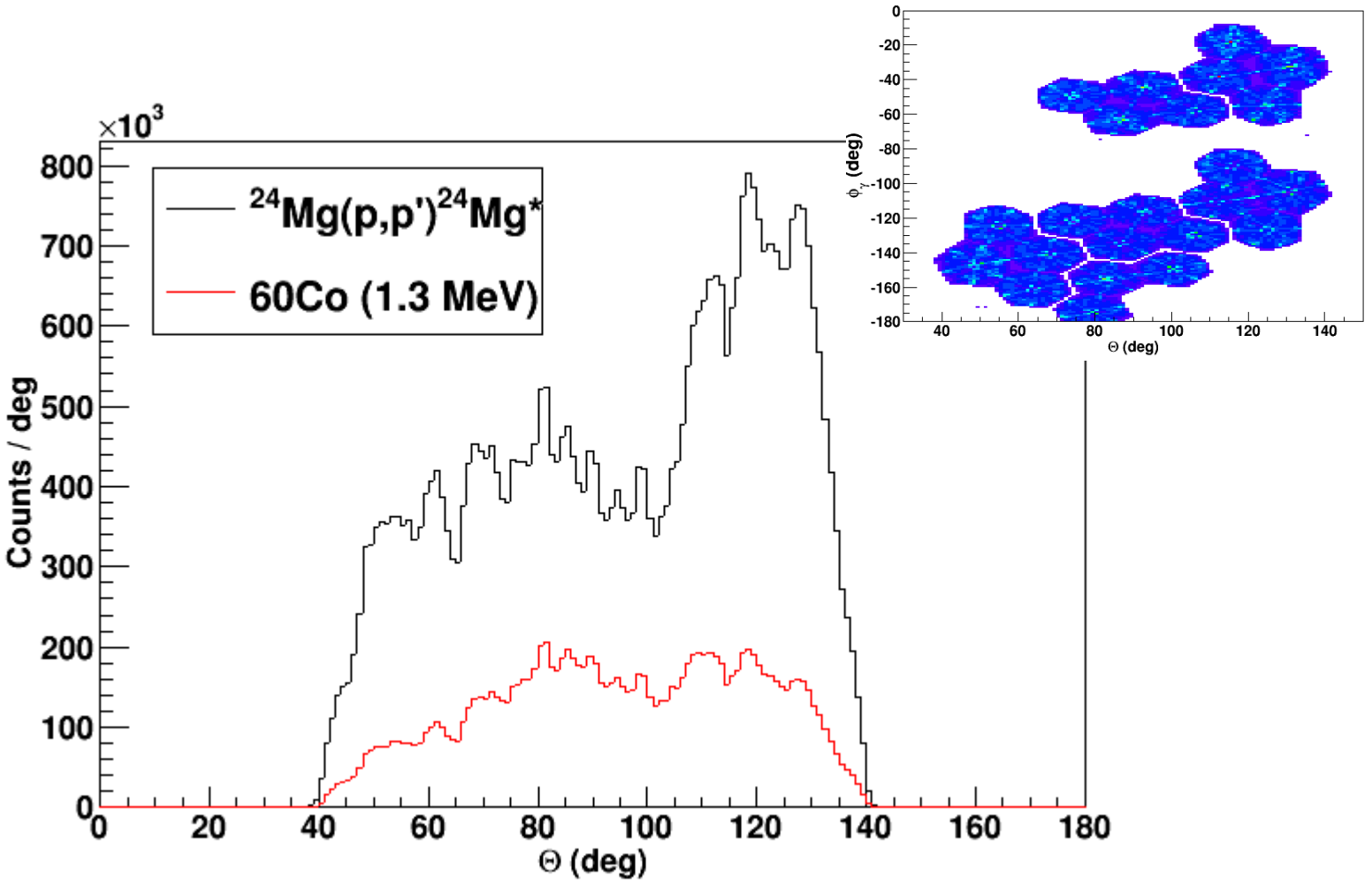


Data



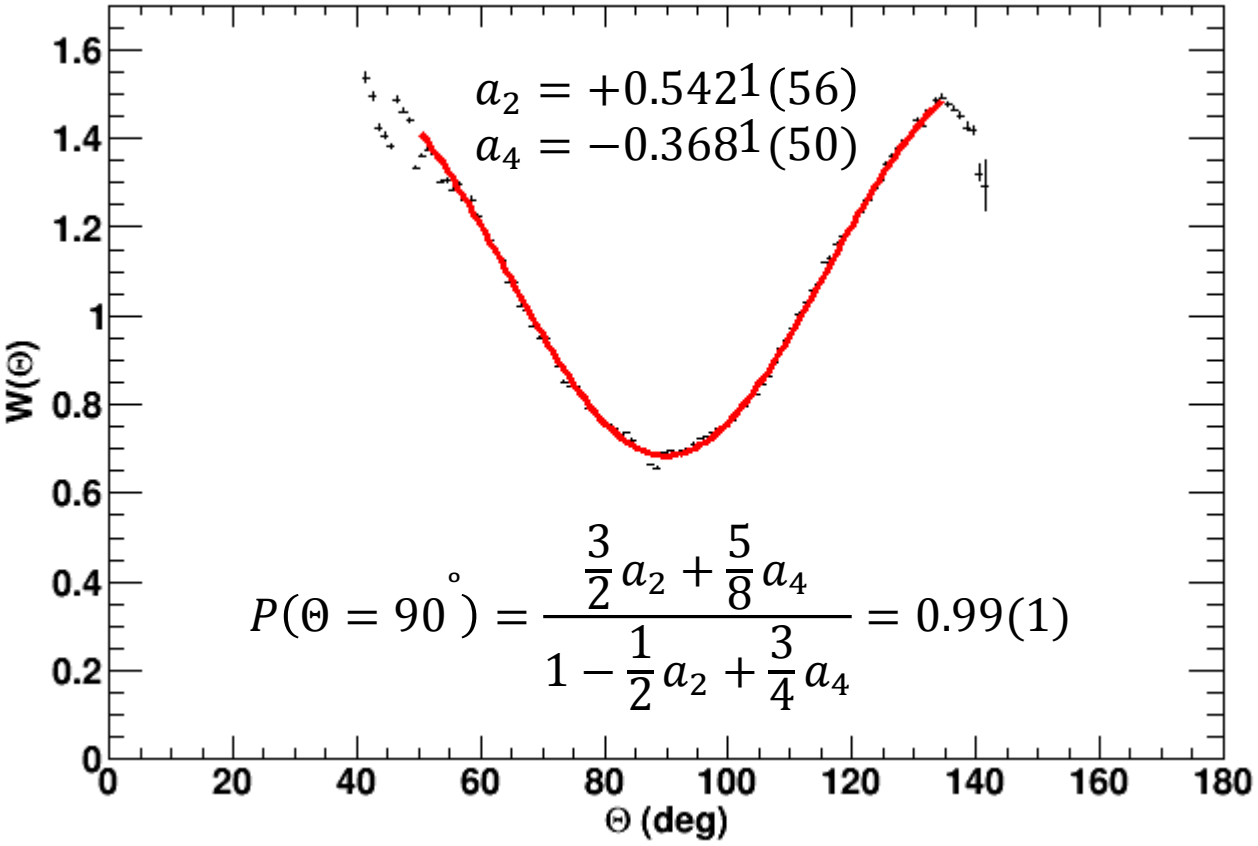
N.B. Tracked data

First interaction point



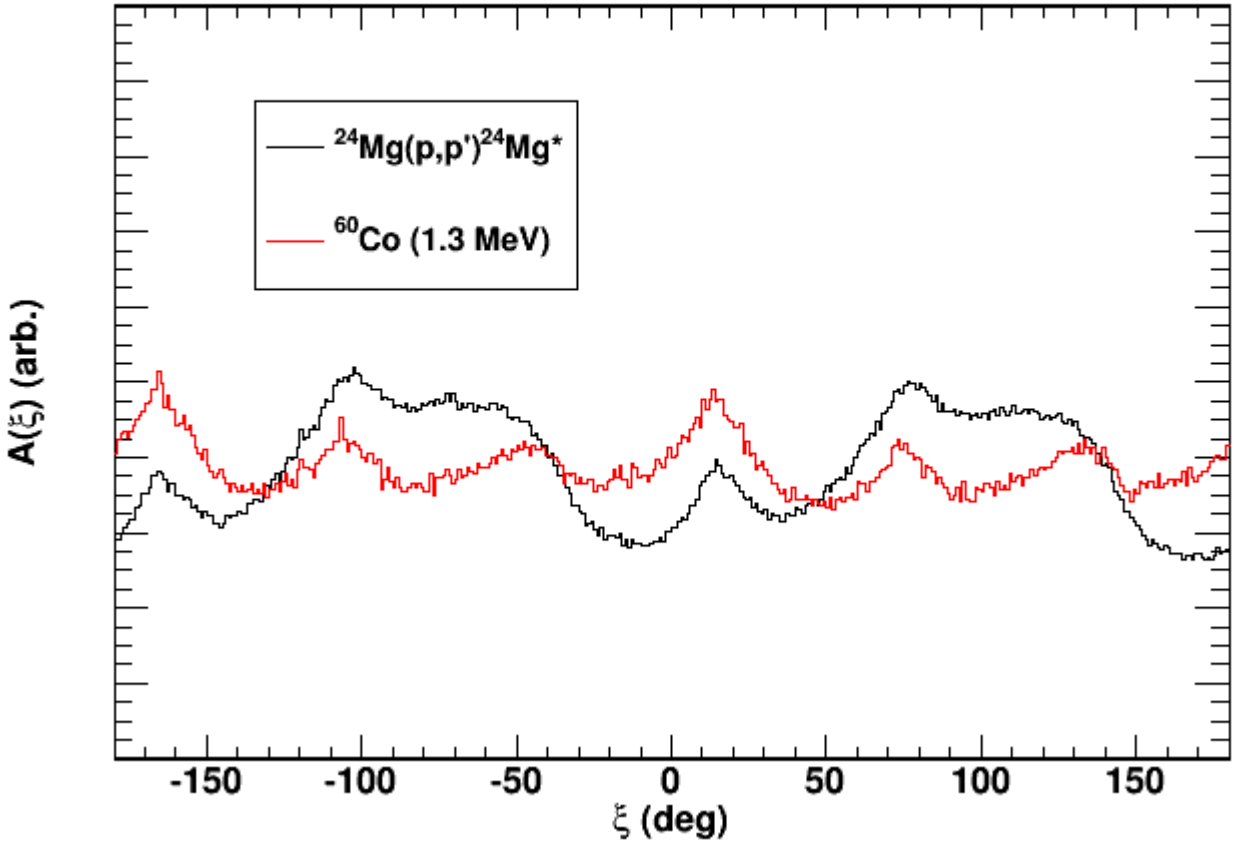
Angular distribution

$$W(\Theta) = \sum_{\substack{k=0 \\ \text{even}}}^{4} a_k \, P_k(\cos\Theta)$$



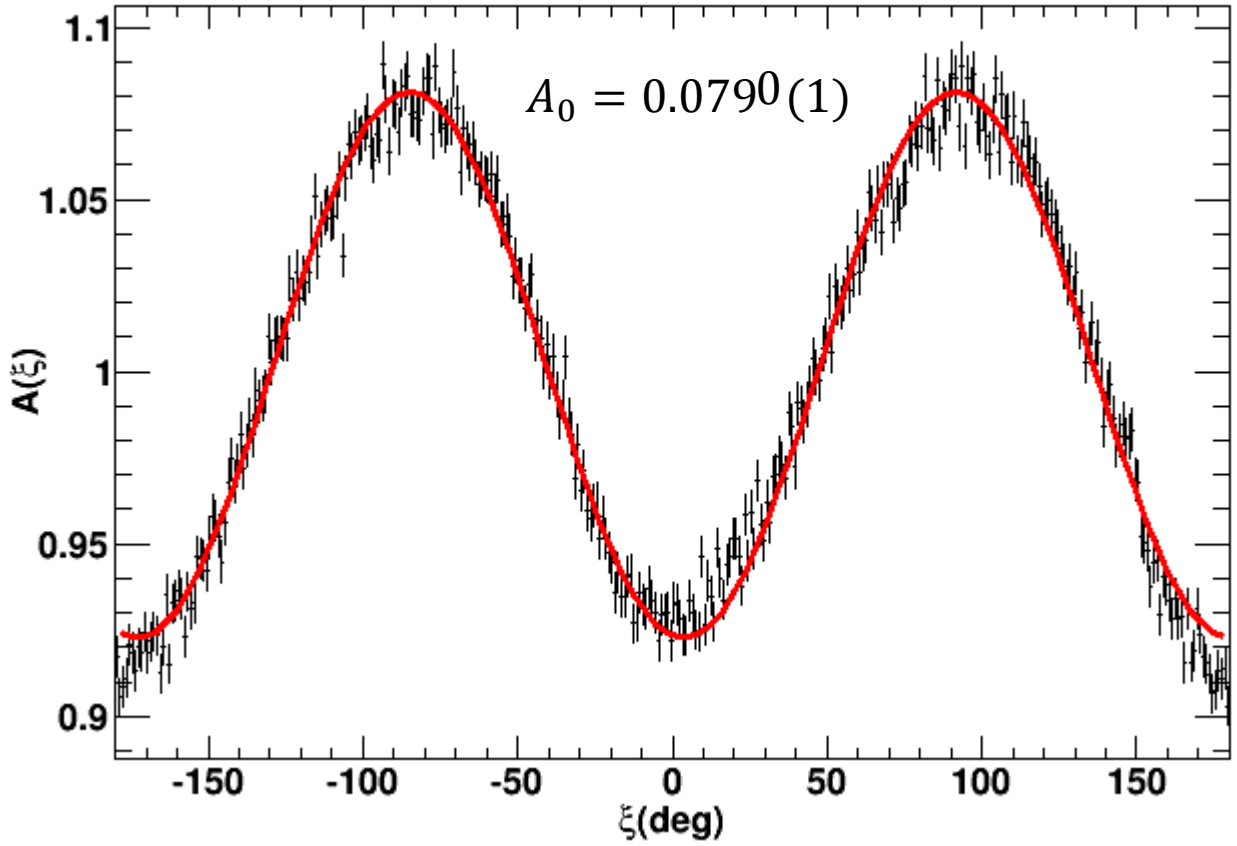
B. Schlitt et al. NIM A337 (1994) 416

Compton scattering asymmetry



Compton scattering asymmetry

$$A(\xi) = A_0 \cos^S(2\xi) = \frac{1}{2} QP(\Theta)\cos^S(2\xi)$$



B. Alikhani et al. NIM A675 (2012) 144

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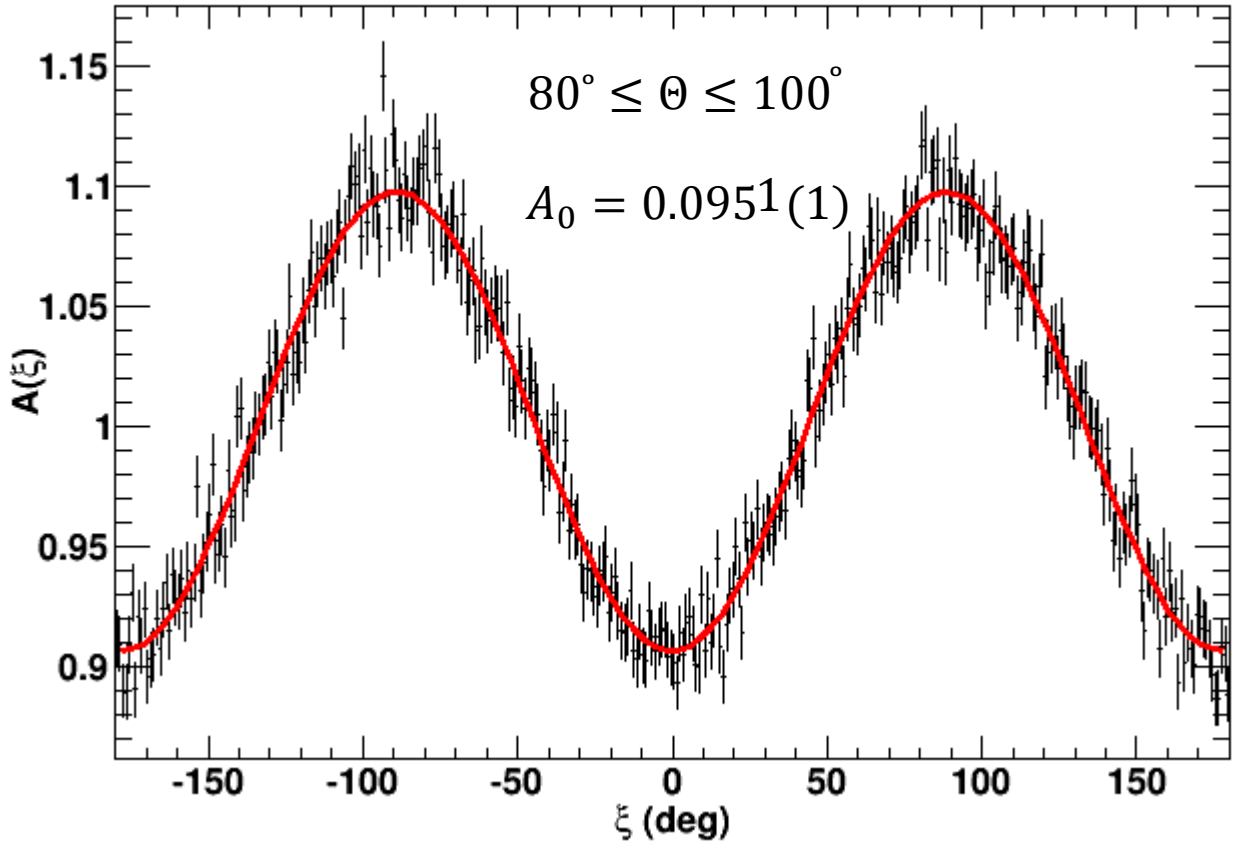
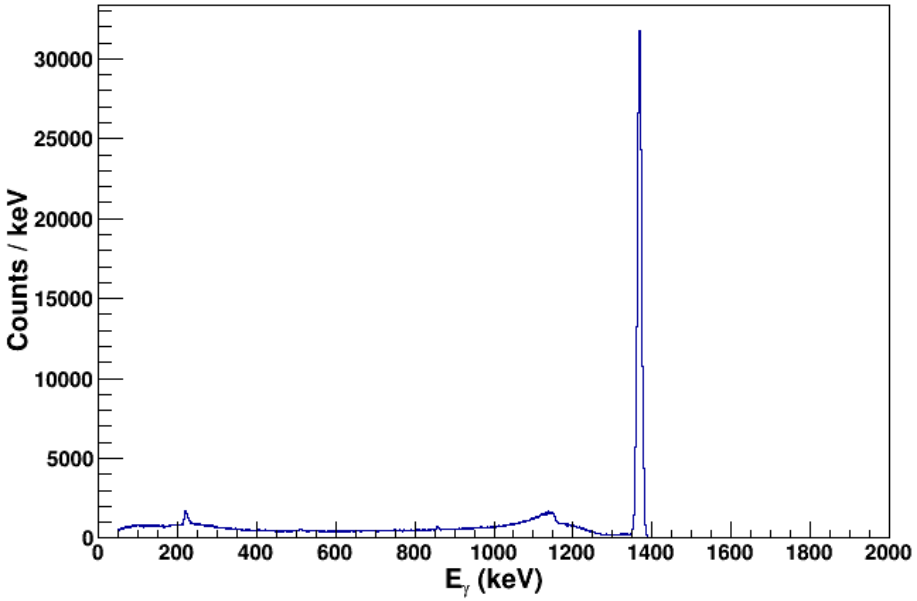


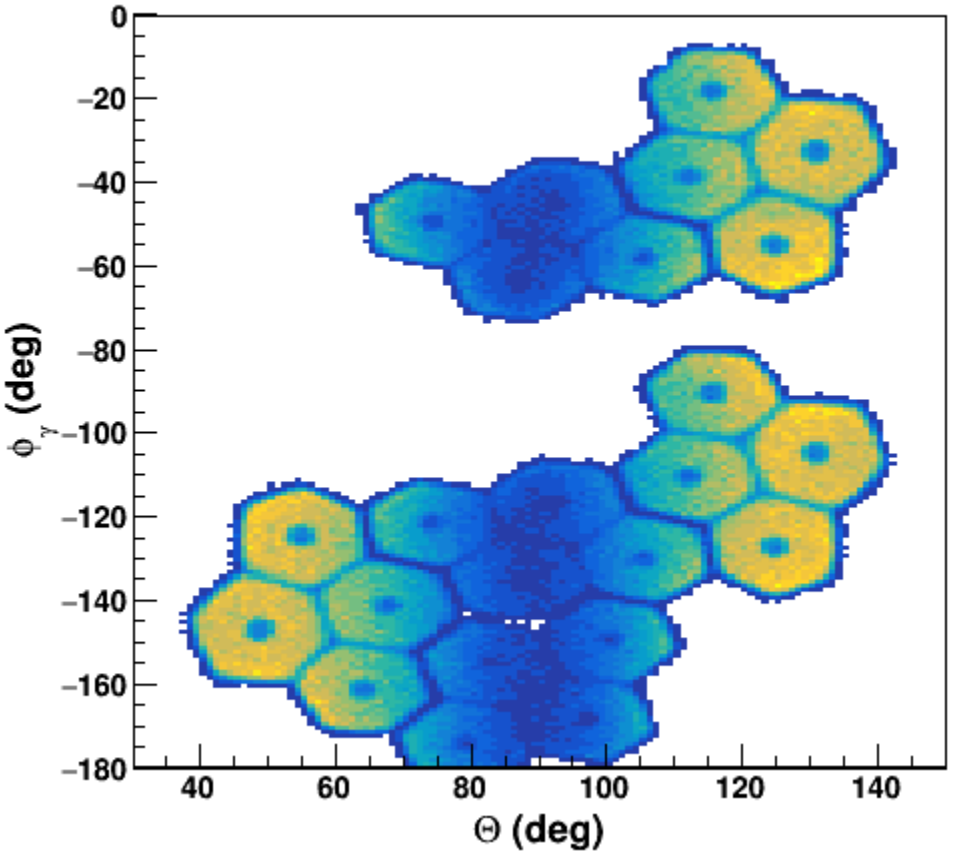
$$P(\Theta = 90^\circ) = 1 \;\rightarrow\; Q = 0.19^2(2)$$

B. Alikhani et al. NIM A675 (2012) 144

Geant4 simulations

- Extension of UCGretina package
- Now includes polarized photons





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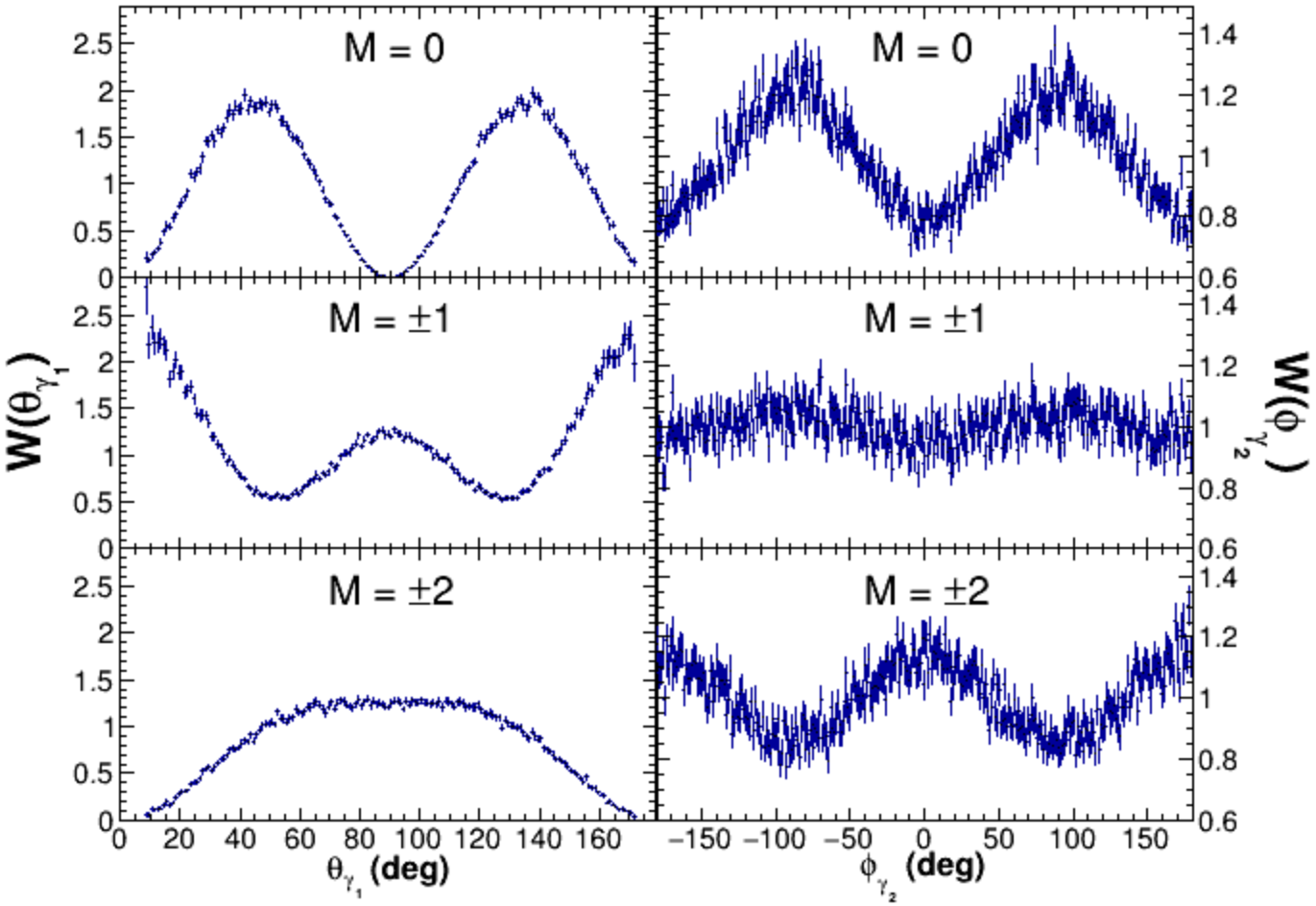

N.B. This is the full GRETA complement of detectors

Simulated angular distribution

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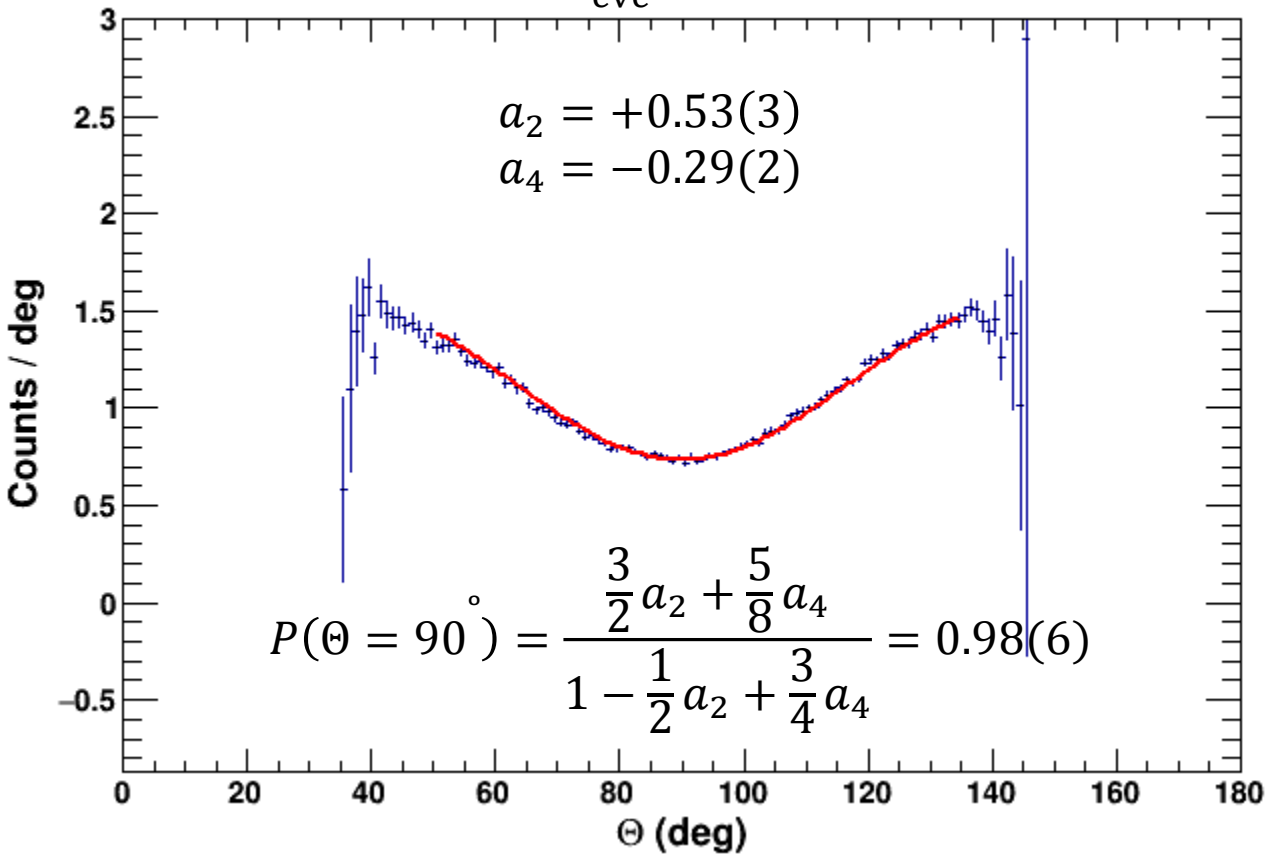

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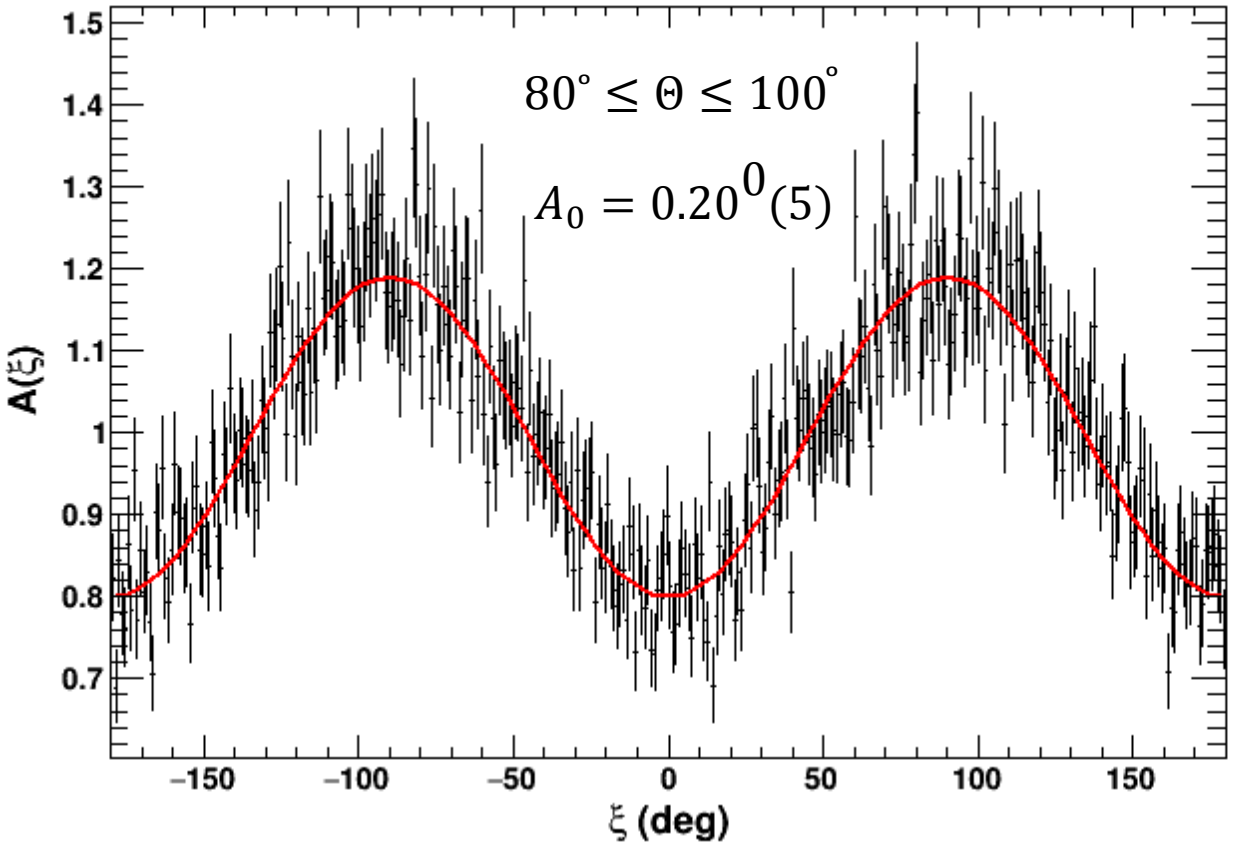

$$P(\Theta = 90^\circ) = 1 \;\rightarrow\; Q = 0.40(1)$$

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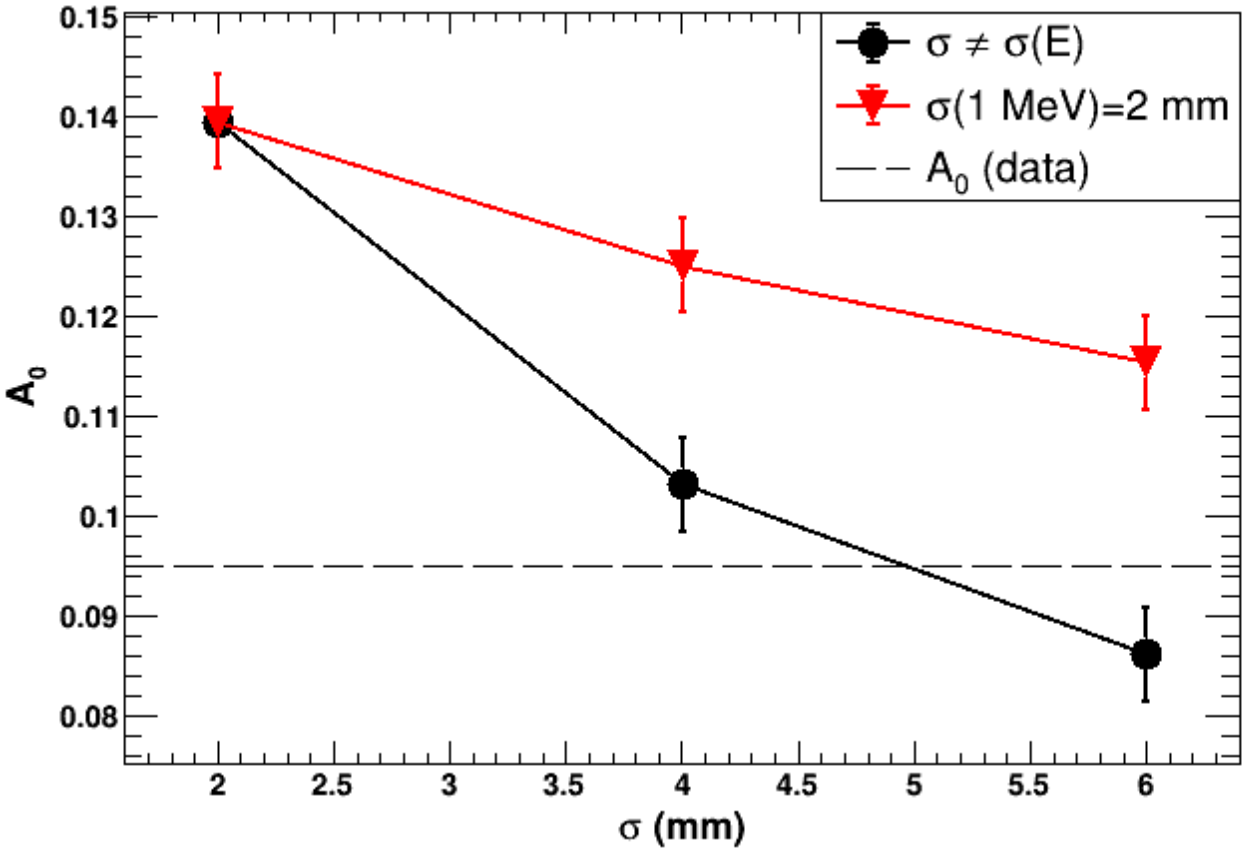
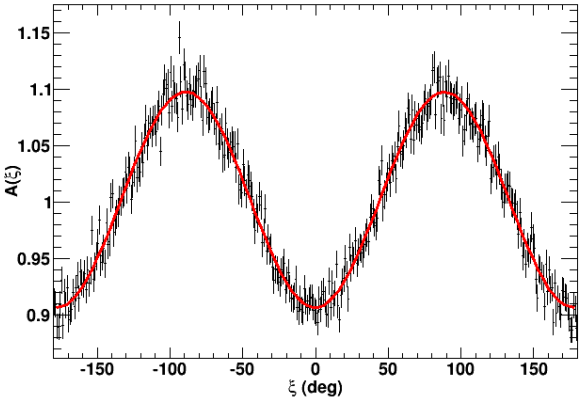
Position resolution

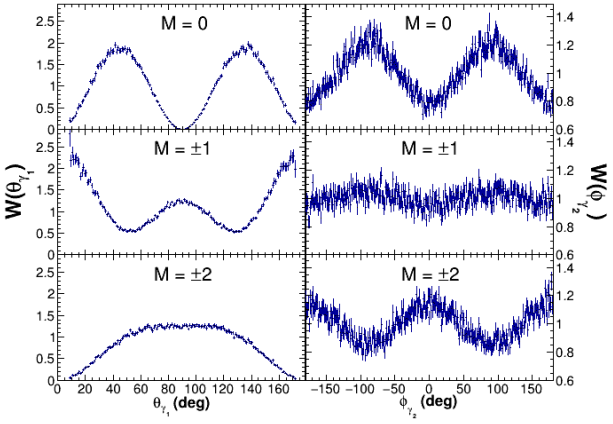


Summary

Determined polarization sensitivity of GRETINA

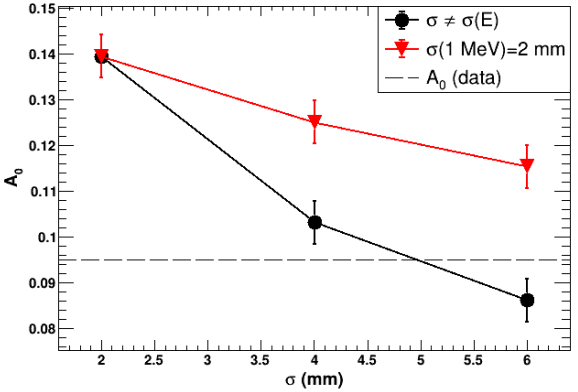
$$Q = 0.19^2(2)$$





Geant4 simulation now exists with full treatment of polarized photons

Can use simulation to understand performance of tracking and signal decomposition



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