Triplet polarimeter study

Michael Dugger*
Arizona State University

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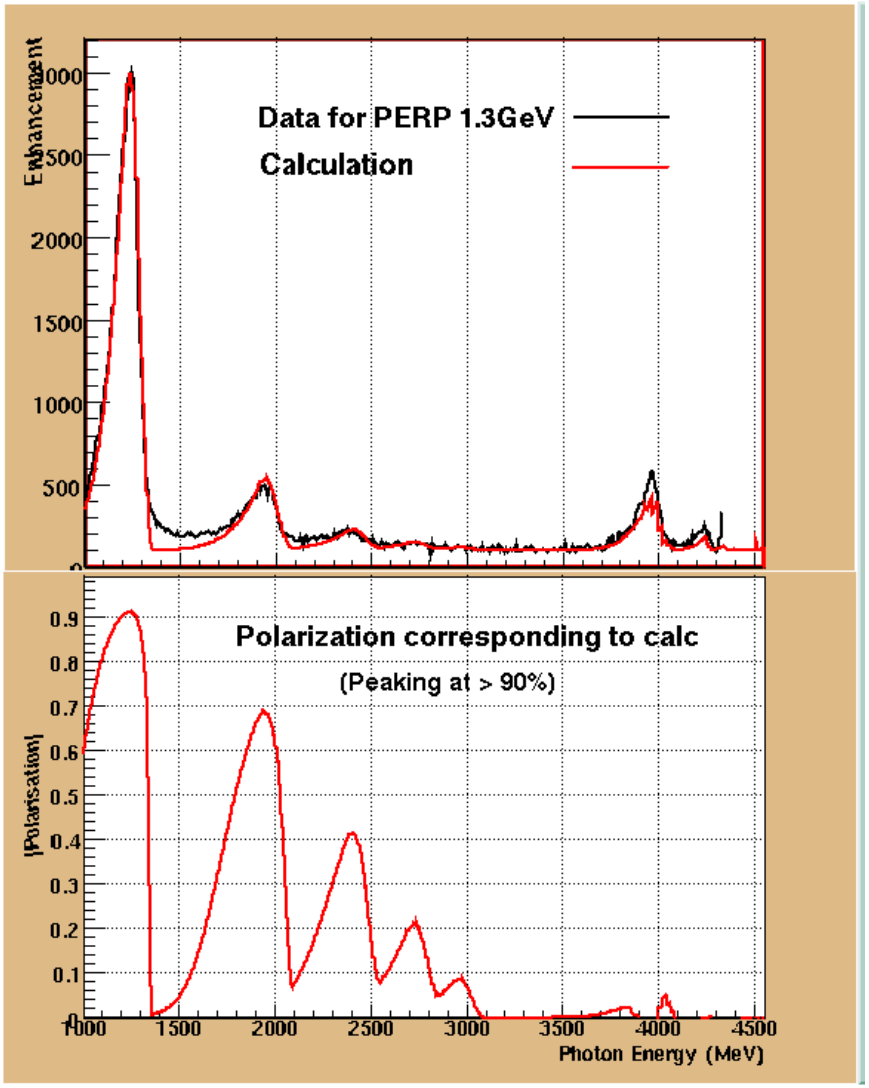
Outline

- Results of g8b consistency study of the polarization determined by CBSA
- Brief overview of triplet production
- Potential detector
- Event generator
- δ-rays
- Results of simulation
- Accidentals
- Stray magnetic fields
- Mainz test

Run period g8b (June 20- Sept 1, 2005)



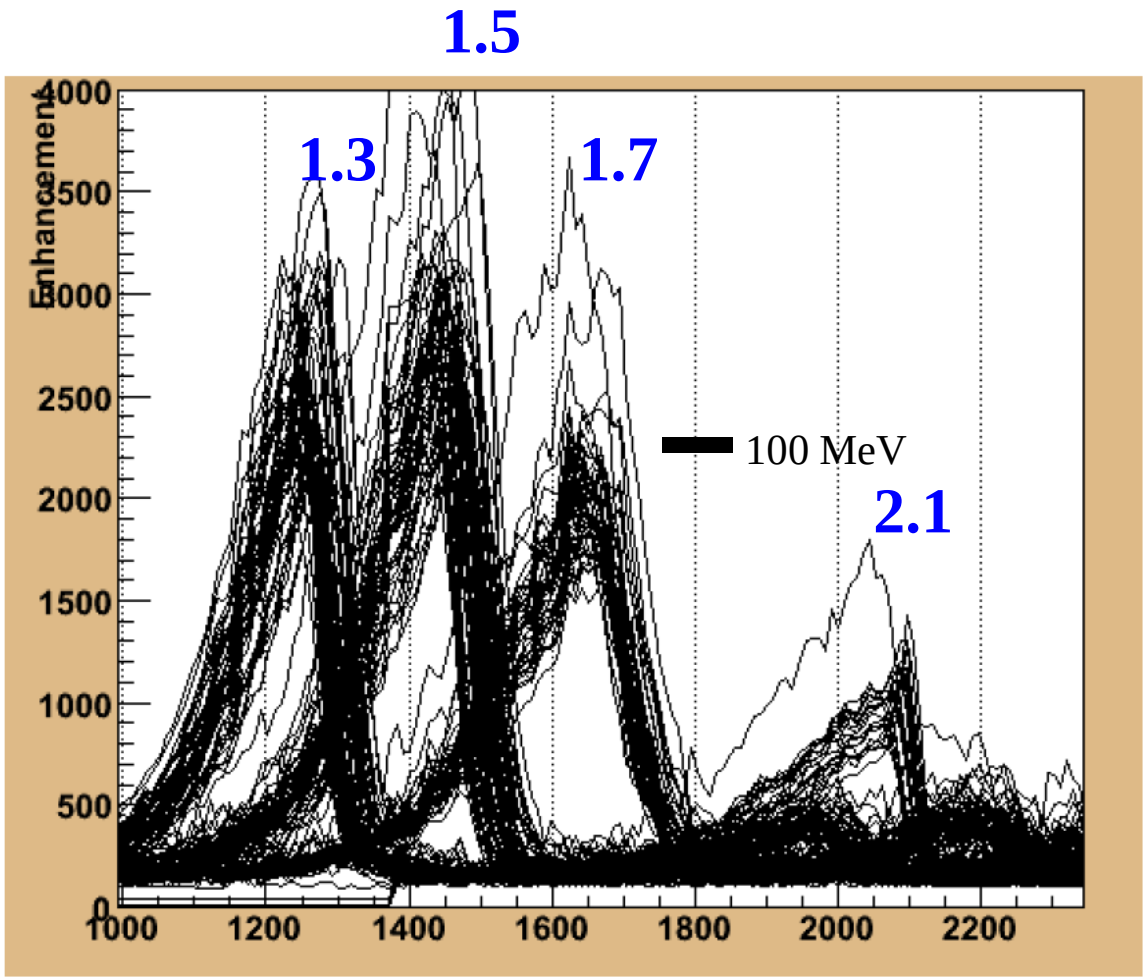
- Coherent bremsstrahlung in 50 μ diamond
- Two linear polarization states (vertical & horizontal)
- Incident electron energy of 4.55 GeV
- Analytical QED coherent bremsstrahlung calculation fit to actual spectrum:CBSA (Livingston/Glasgow)
- $\perp$ 1.3 GeV edge shown

Statistics for g8b

Coherent Edge	Billions of events
• Non-polarized (amorphous)	2.3
• 1.3 GeV	1.4
• 1.5 GeV	2.6
• 1.7 GeV	2.2
• 1.9 GeV	1.2
• 2.1 GeV	0.9

Coherent edge is unstable

- Auto-flip data not shown
- All 1.9 GeV is auto-flip
- Coherent edge moves ~ ± 50 MeV or more



Results from the consistency study of the g8b polarization

Type of comparison		Distance of consistency from unity (%)	
		Unmodified polarization	Modified polarization
1.3 - 1.5 overlap region	PARA	5.9(7)	1.4(8)
	PERP	5.1(8)	0.6(9)
1.5 - 1.7 overlap region	PARA	5.0(9)	1.4(9)
	PERP	7(1)	1(1)
1.7(auto) - 1.9 overlap region	PARA	9(3)	4(3)
	PERP	4(2)	1(3)
1.7(manual) - 1.9 overlap region	PARA	10(2)	2(2)
	PERP	8(2)	1(2)
1.7 (manual) - 1.7 (auto) overlap region	PARA	1.8(7)	1.2(7)
	PERP	2.9(7)	0.5(7)
1.9 - 2.1 overlap region	**PARA**	**10(1)**	**5(2)**
	PERP	**17(4)**	**8(4)**
1.3 PARA to PERP ratio		1(3)	2.1(3)
1.5 PARA to PERP ratio		3.2(3)	2.7(3)
1.7 manual PARA to PERP ratio		0.6 (5)	0.7(5)
1.7 auto PARA to PERP ratio		0.4(6)	0.4(6)
1.9 PARA to PERP ratio		2.5(8)	0.4(8)
2.1 PARA to PERP ratio		**5(1)**	**17(1)**

- Neglecting the 2.1 GeV data set we can get consistency better than 5%

Why have a triplet polarimeter?

Having a polarization measurement independent of CBSA would

• Help in determining consistency corrections to CBSA

• Either confirm CBSA or substitute for CBSA if CBSA fails or has a larger systematic uncertainty

Brief overview of triplet production

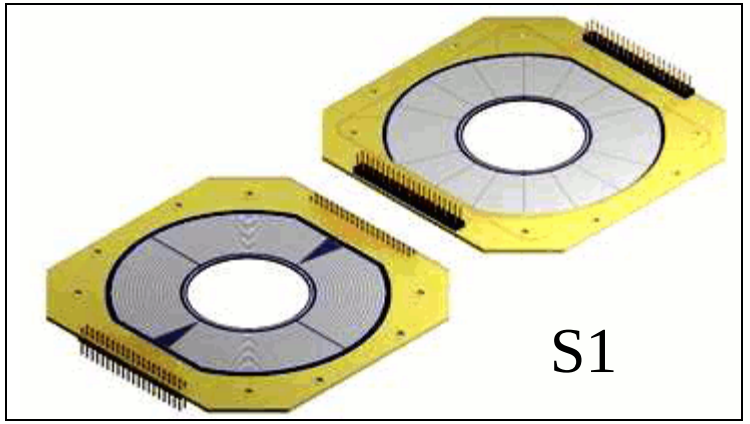
• Pair production **off a nucleon**: γ nucleon $\rightarrow$ nucleon e^+ e^-.

• 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 transverse direction of the e^- e^+ pair is compensated for by the slow moving recoil electron. This means that the recoil electron can attain large polar angles shifted about 90 degrees in the azimuthal direction relative to the plane containing the pair.

Potential detector

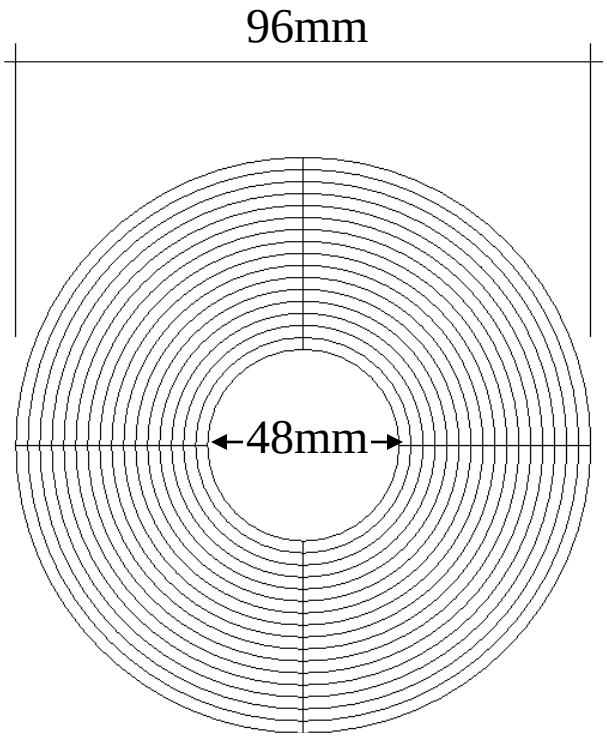


Front:
4 sectors
16 strips/sector

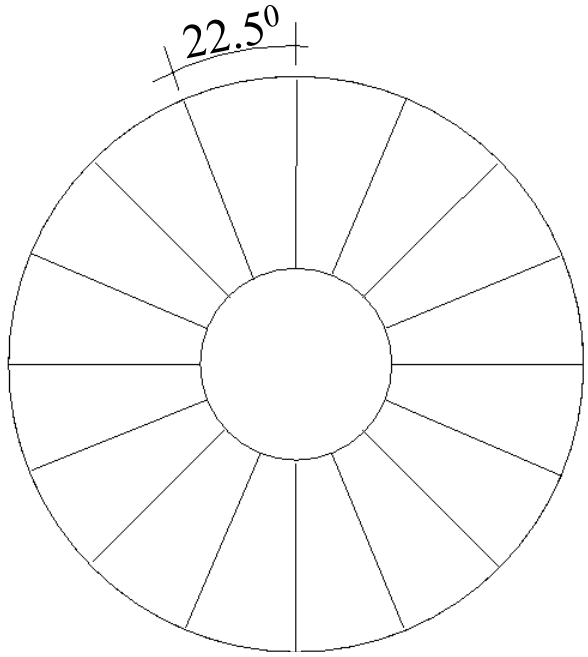
Back:
16 sectors

Cost: $7500
(back stock)

Manufacturer:
Micron
Semiconductor



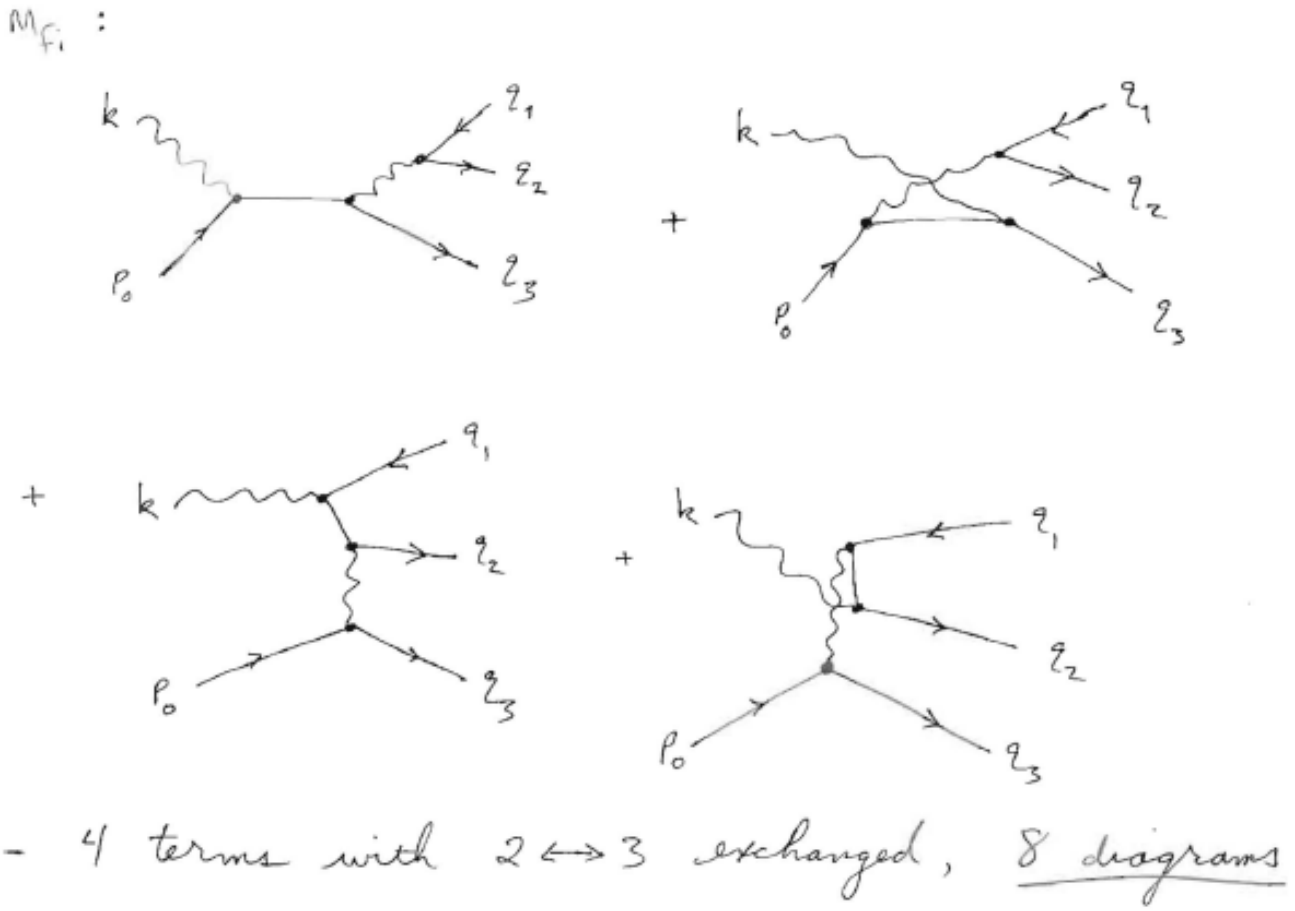
Front



Back

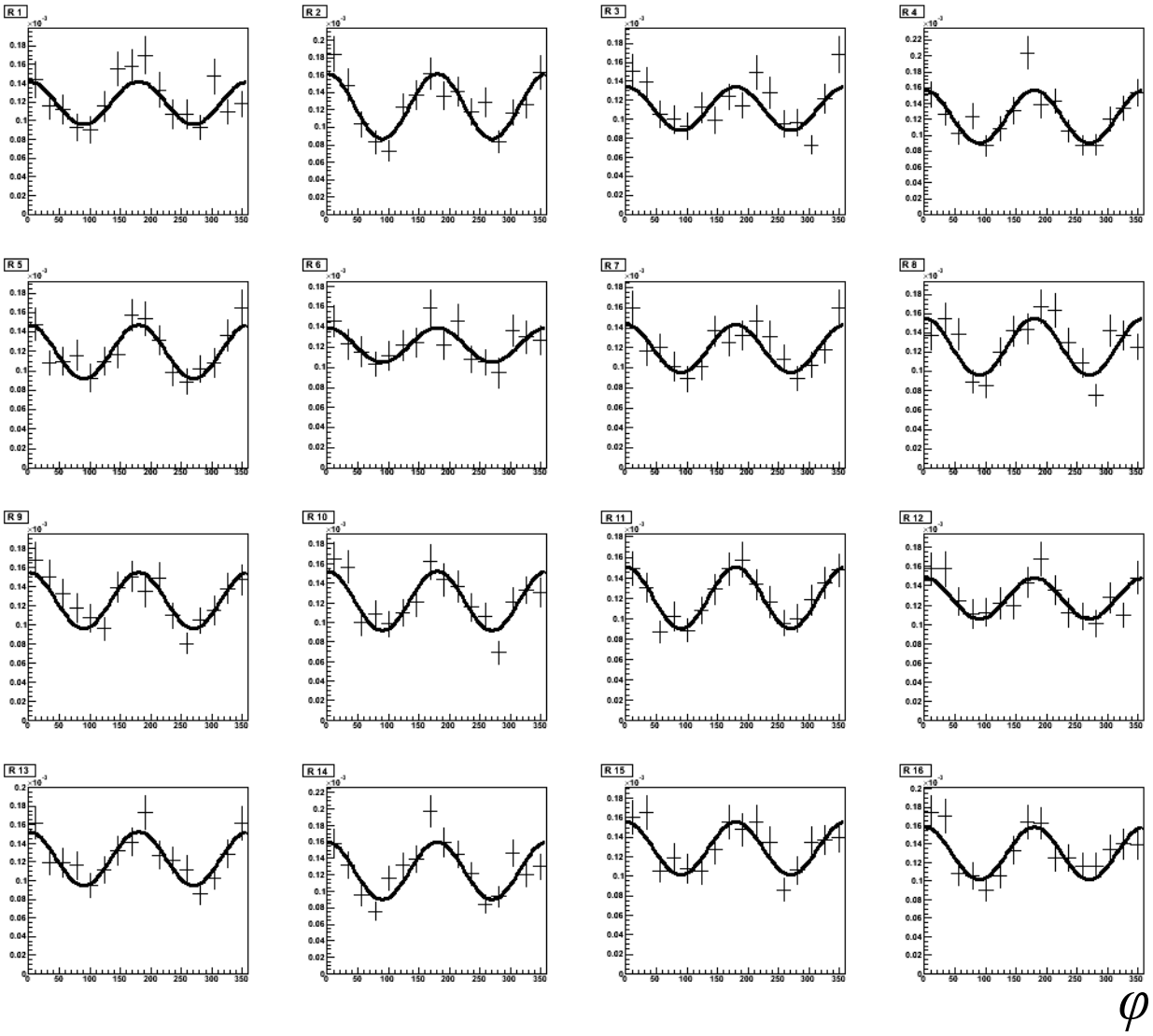
Event generator

• Richard Jones provided an event generator that calculates QED tree level Feynman diagrams:



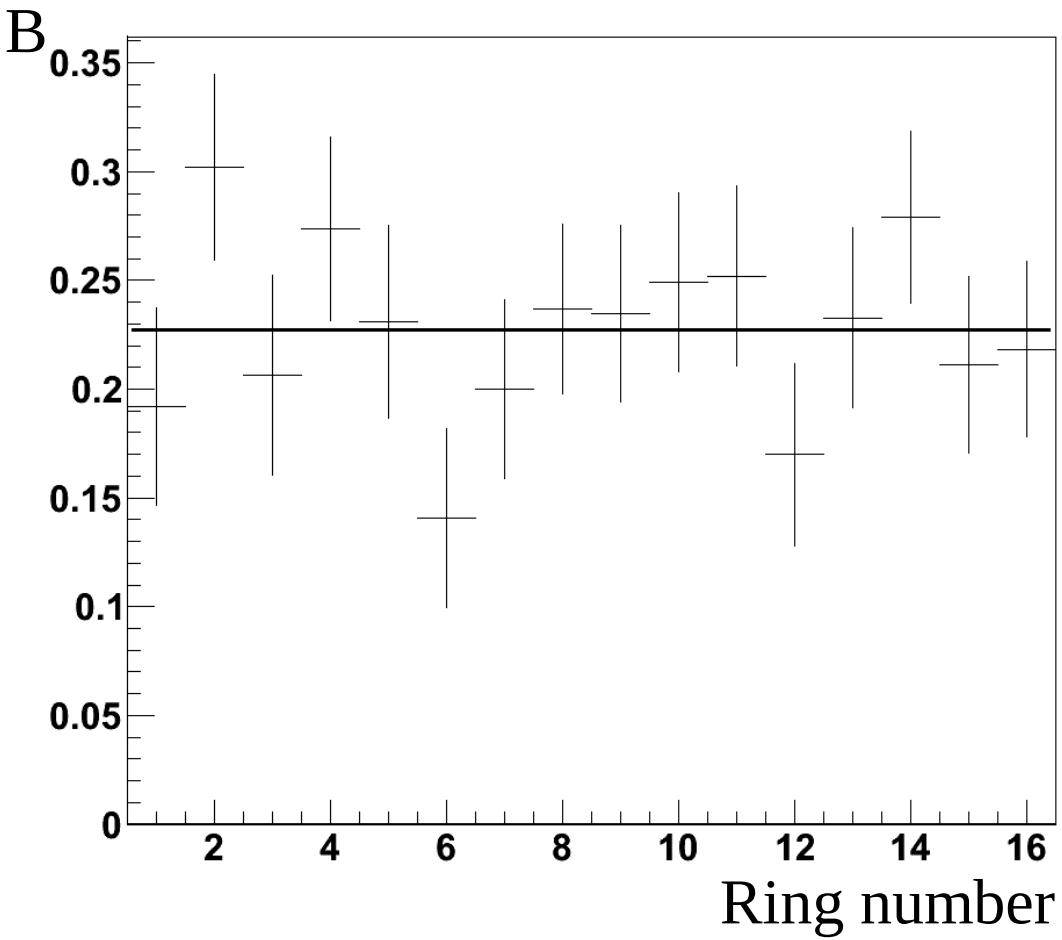
Triplet asymmetry fits

- 10 million generated events using Richard's code
- E_γ = 9.0 GeV
- Fit each ring separately
- Fit function: $A[1 + B\cos(2\varphi)]$



Triplet asymmetry fit results
$A[1 + B\cos(2\varphi)]$

- Parameter B from fit
- Results fairly consistent over ring number (inner most ring number = 1)
- Zero order fit:
22.7 ± 0.1



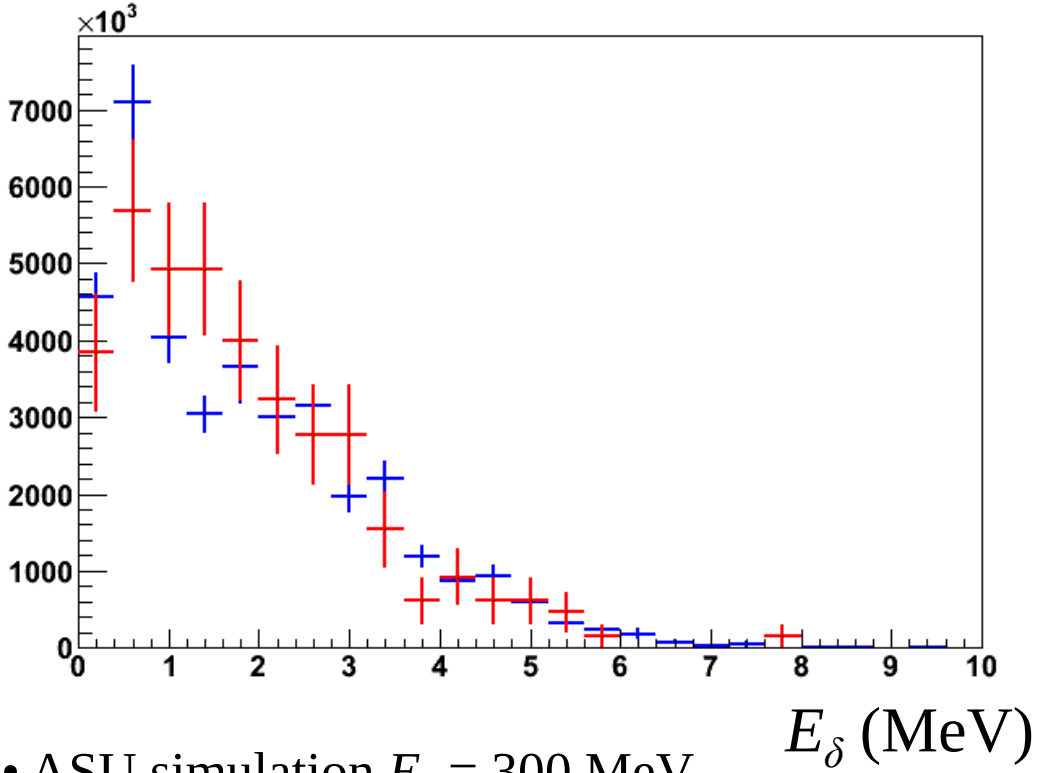
δ-ray comparison with Iwata 1993 simulation

- E_δ is δ-ray kinetic energy after traveling through 1 mm of scintillator using Iwata's polar geometry and scintillator widths

- **BLUE**: Current ASU GEANT4 results

- **RED**: Iwata GEANT3 (scaled to GEANT4 results by ratio of signal integration)

- Shapes of the distributions look similar



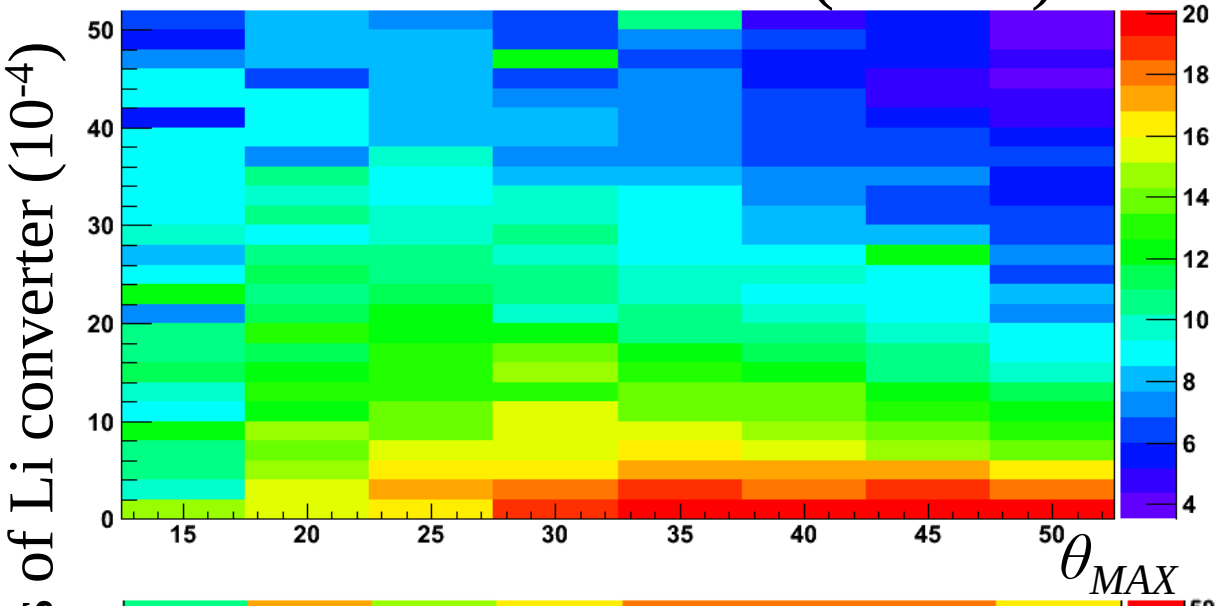
- ASU simulation E_γ = 300 MeV

- Iwata simulation E_γ = 250, 365, 450 MeV

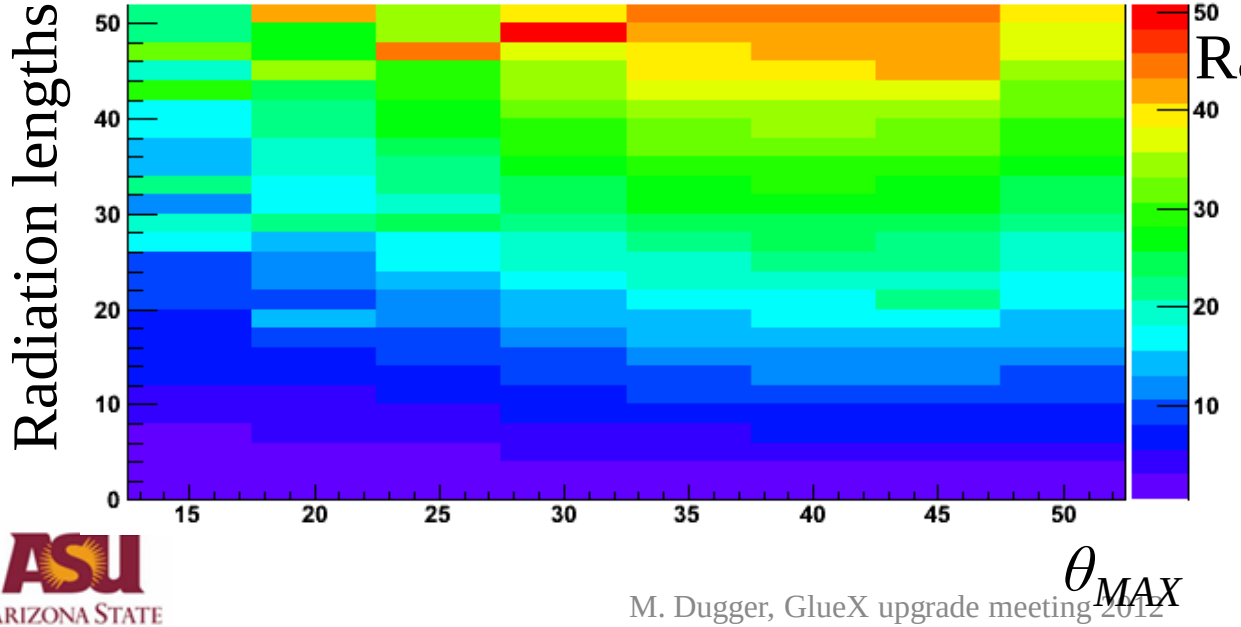
Note: ASU simulation did not wrap scintillators

Results of simulation

Converter thickness and polarimeter placement study (slide 1)

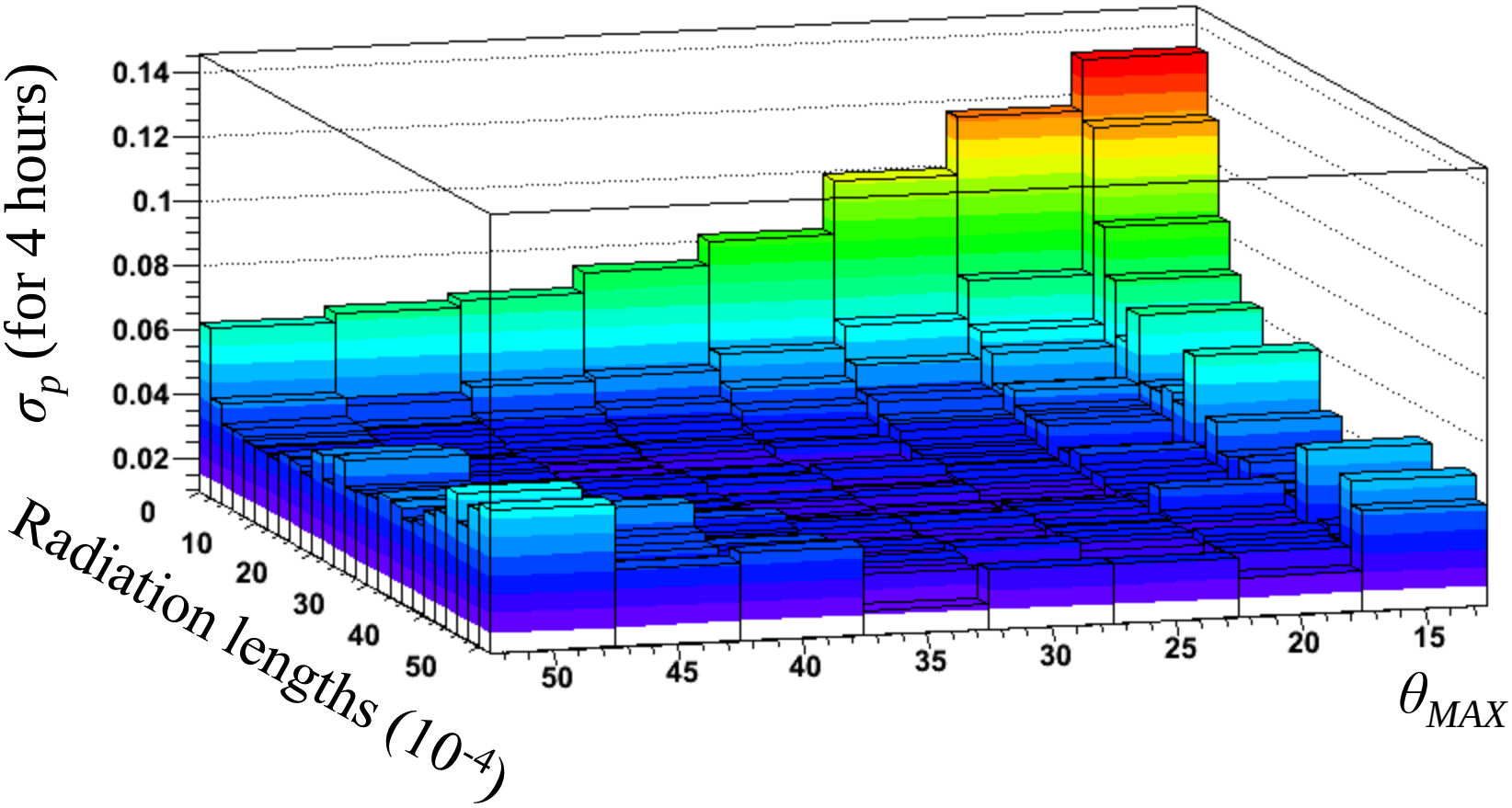


Analyzing power (%)



Rate surviving cuts (Hz)

Absolute polarization uncertainty in 4 hours of running



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

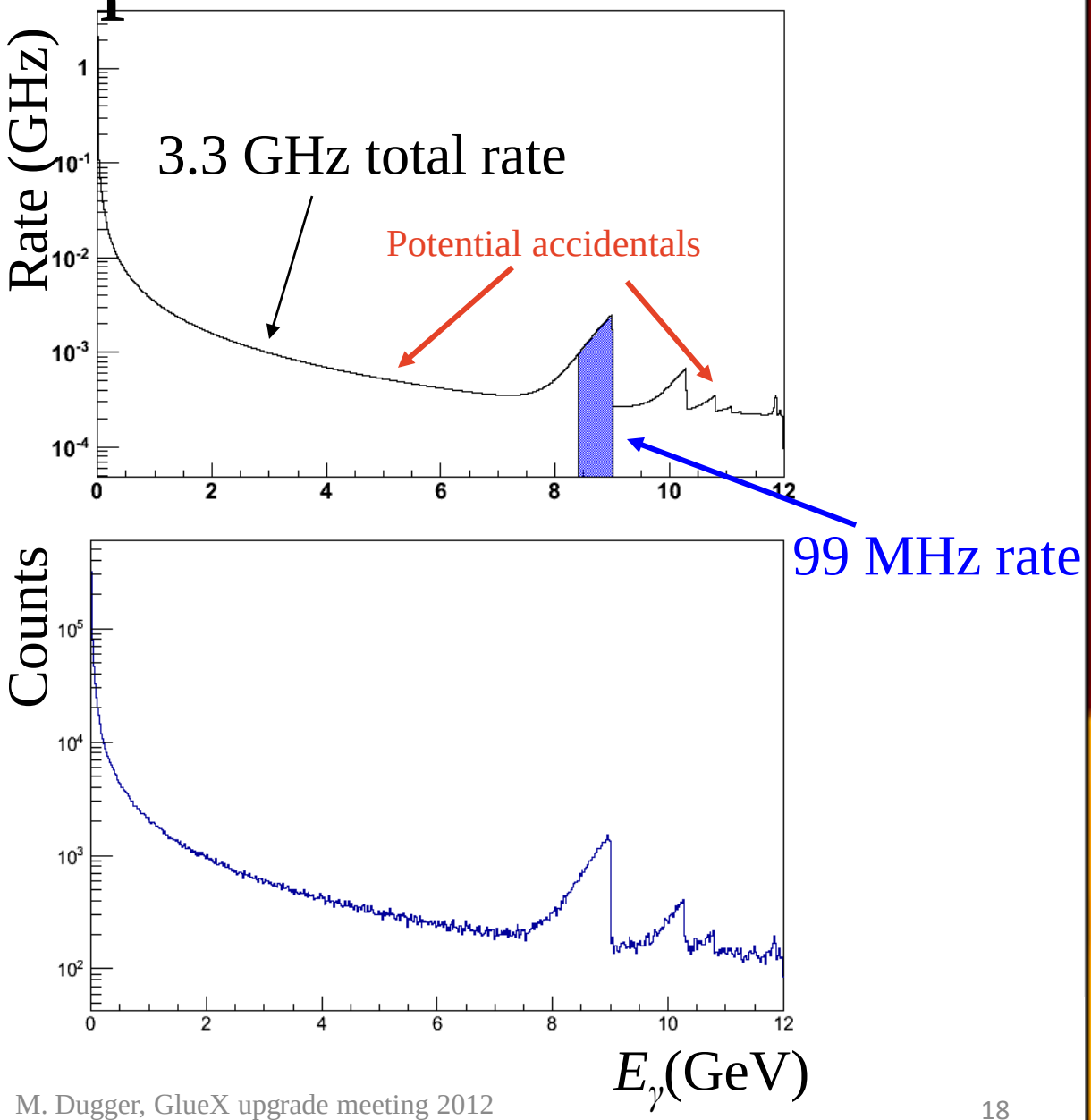
where N ≡ Rate * 4 hour,
P ≡ Polarization = 0.4, and
α ≡ analyzing power

Estimate of accidentals for the triplet polarimeter

Collimated photon distribution

- Used Richard's cobrems_root code to create shape of E_γ distribution (top panel)

- Used shape of E_γ to generate 1 million events (bottom panel) that were fed into the triplet-polarimeter Monte Carlo



Accidental estimate

• For 1 million events thrown (N_T) there were 177 events seen (N_S) on the polarimeter

• Assumed a lithium converter of 10^{-3} radiation lengths

• Total expected photon rate: R_γ = 3.3 GHz

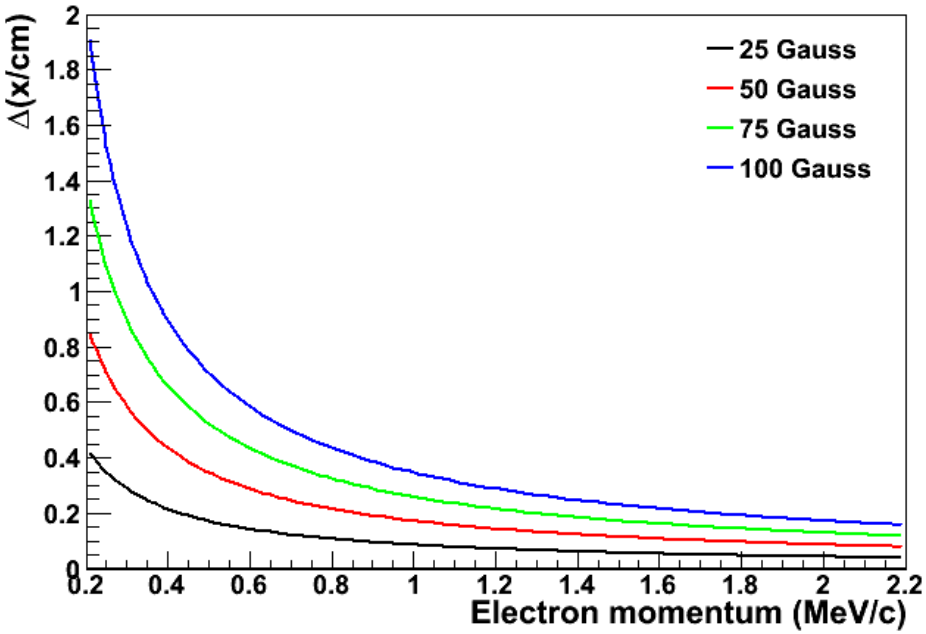
• Expected total photon rate seen on device:
$R_S = R_\gamma * (N_S/N_T)$ = 3.3GHz*(177/1million) = 584 kHz

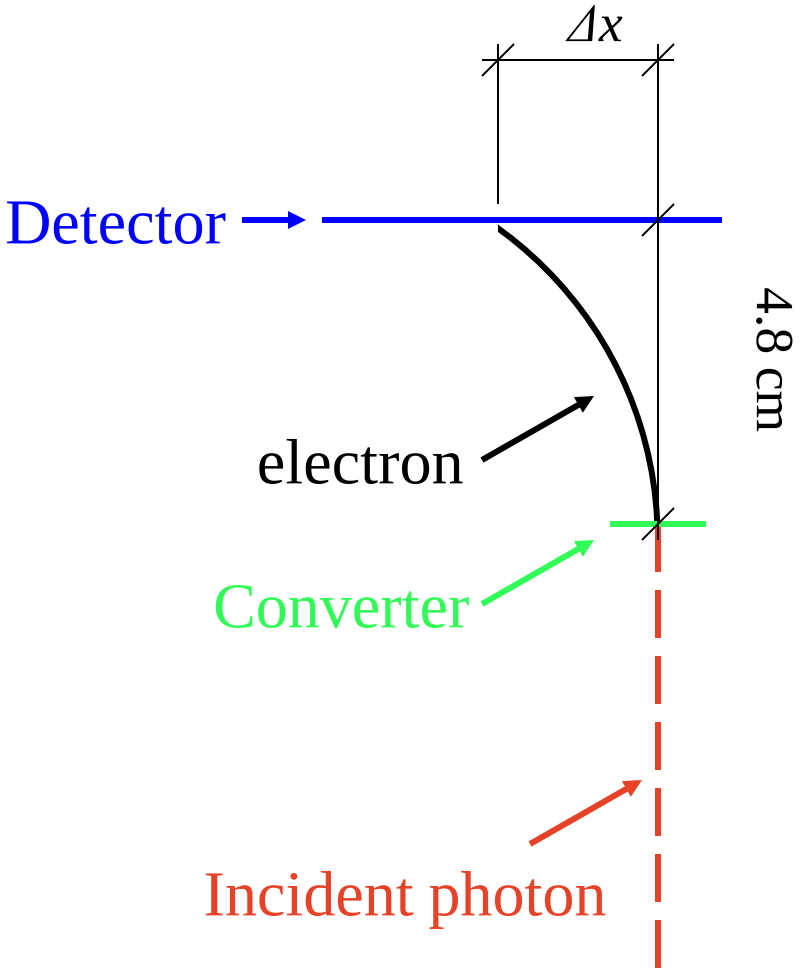
• Expected number of polarimeter hits for a 20 ns window:
$\langle n_{5ns} \rangle = R_S$*20ns = 0.012

• Probability of accidental coincidence between pair spectrometer and polarimeter: $P_{acc} = 1 - P_0(\langle n_{5ns} \rangle)$ = 1.2 %

Study of magnetic field on polarimeter

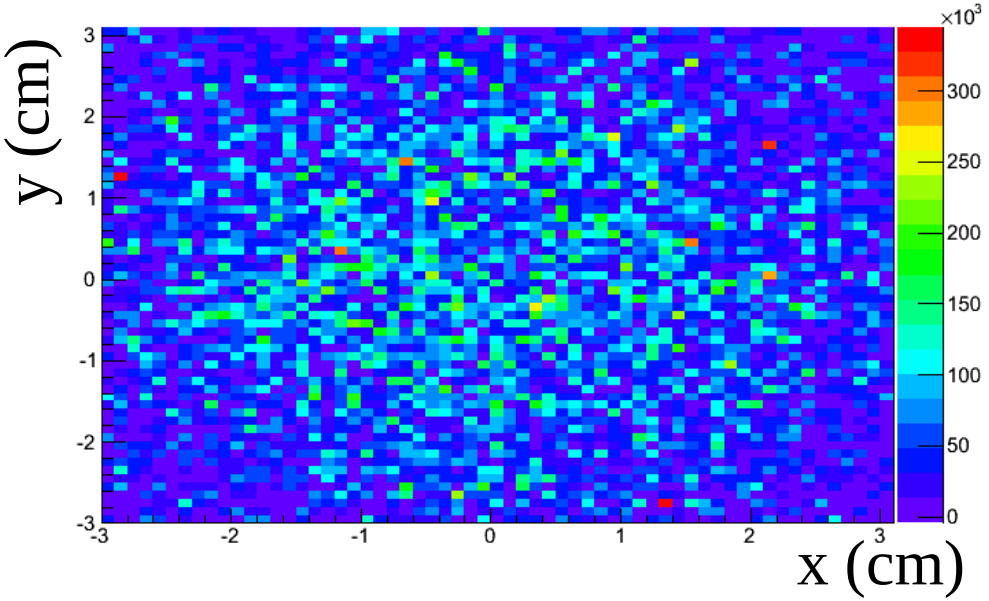
Effect of magnetic field on electron



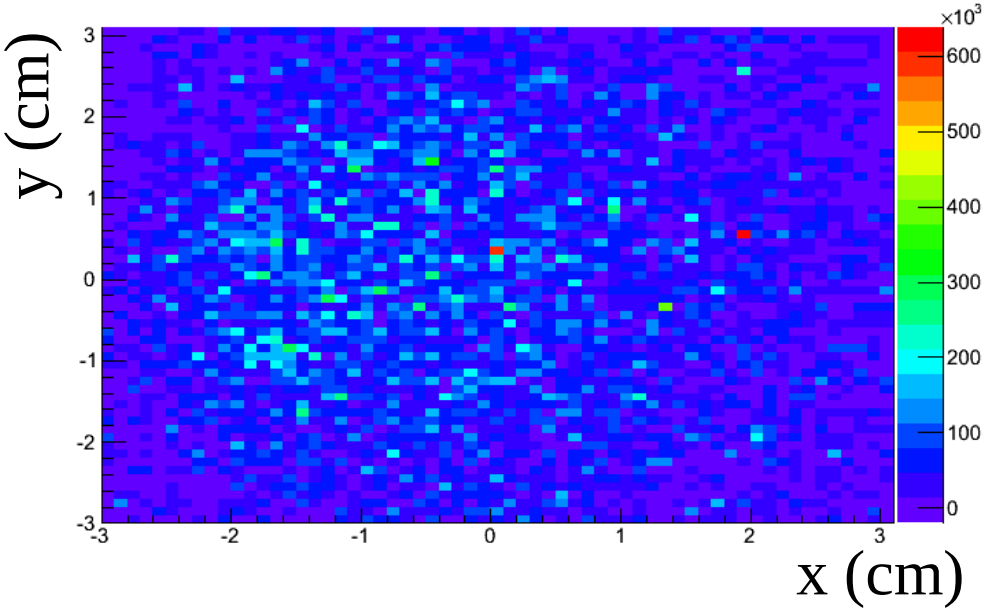


Effect of B-field on δ-rays

No field →



350 gauss field →



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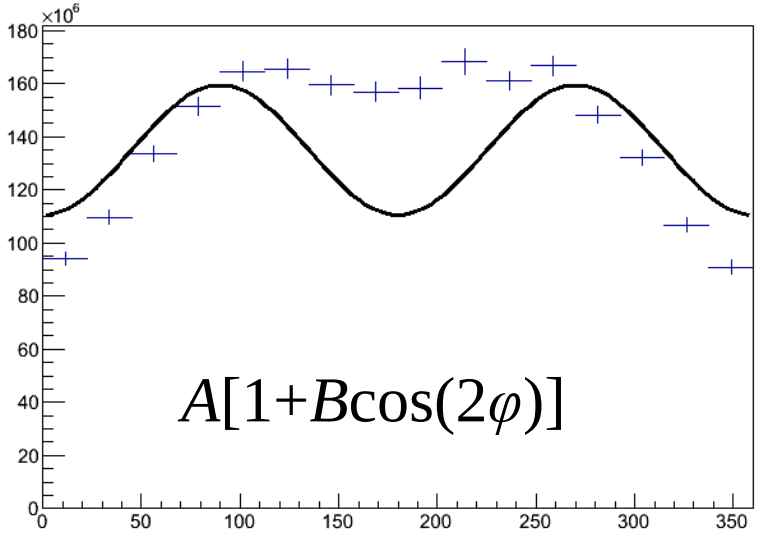
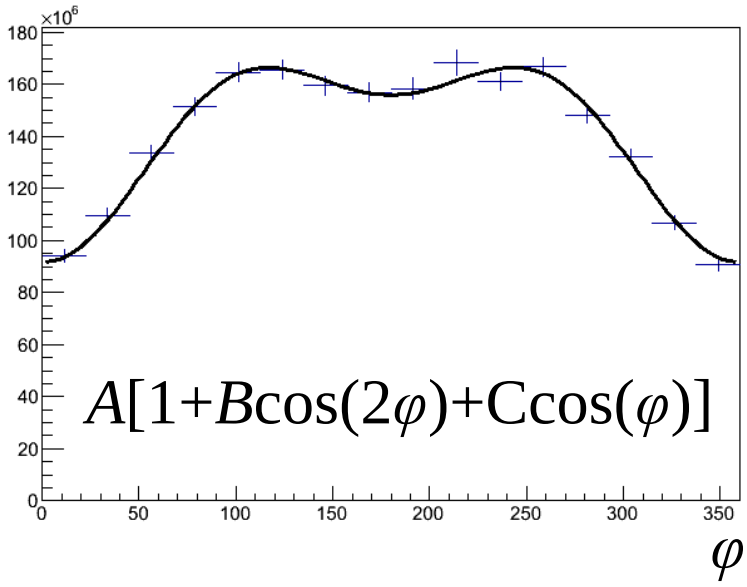
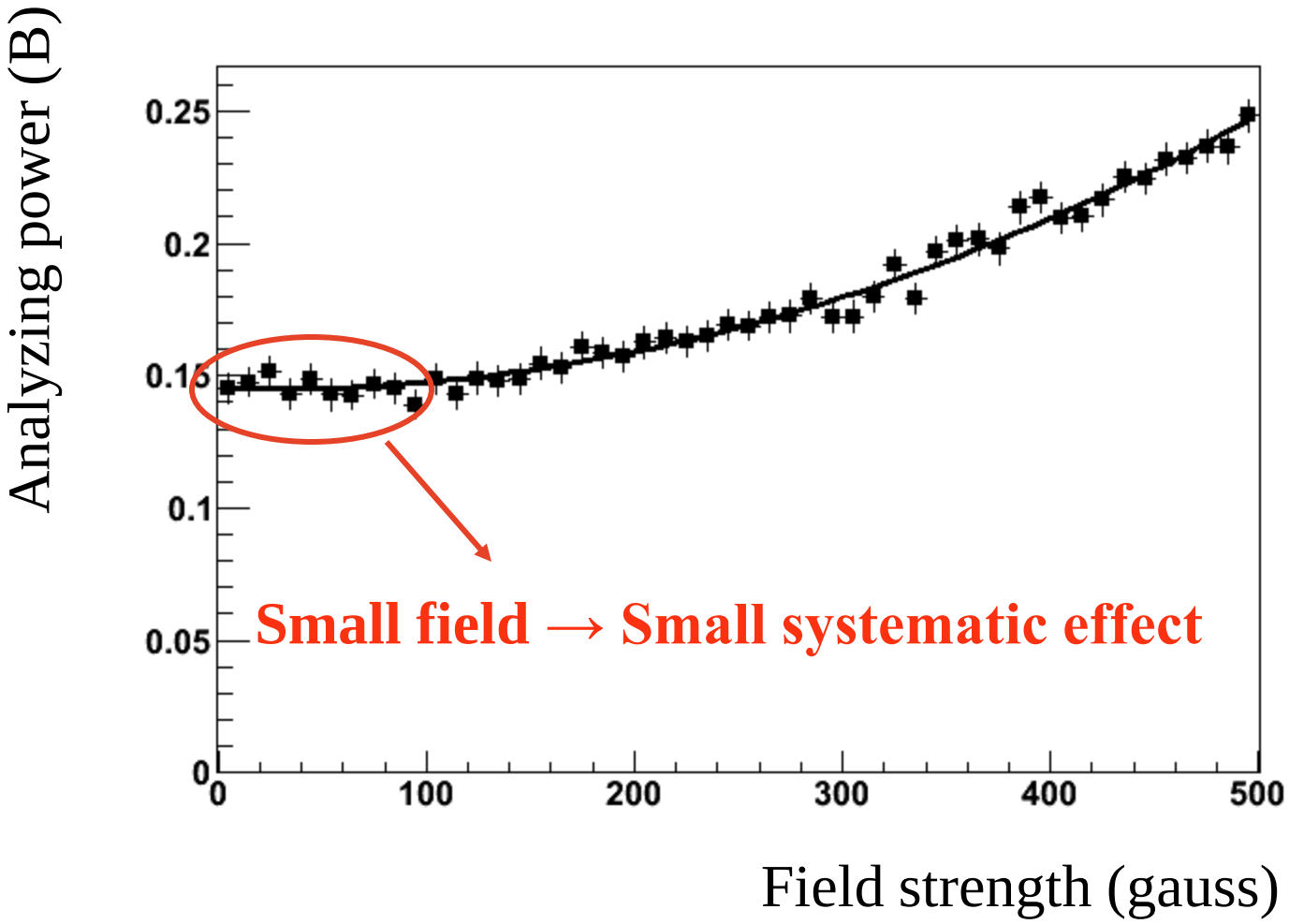
Azimuthal distribution with applied B-field

- 350 gauss field applied





Analyzing power vs. B-field



Potential material for magnetic shielding

High Permeability (AD-MU-80)
Initial Permeability at 40 gauss: 55,000 - 75,000
Permeability at 100 - 200 gauss: 70,000 - 100,000

- If we wrap the polarimeter with a couple layers of AD-MU-80 we should be able to get the stray fields inside to be below a Gauss

The cost is likely not high. They advertise an engineering kit:

- Four (4) feet of AD-MU-80 .004 in. Thick x 15 in. Wide
- Four (4) feet of AD-MU-80 .006 in. Thick x 4 in. Wide
- Four (4) feet of AD-MU-00 .004 in. Thick x 15 in. Wide

Cost: $183.50

Testing a device at Mainz

• In the next presentation, Ken Livingston will talk about testing a triplet polarimeter at Mainz ☺