Comparison of GEANT4 study of triplet polarimeter to previous studies

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Iwata's polarimeter

- E_γ = 250, 365, and 450 MeV studied. Polarization peak was at 365 MeV
- 1.2 mm polyethylene converter
- Polarimeter located 5 cm downstream of converter
- Each polarimeter arm had 1 mm thick scintillator backed by a 5 cm thick scintillator
- Recoil θ = 24.3 to 35.7 degrees
- Eight recoil φ counters, each having a width of 23 degrees
- Analyzing powers from GEANT3 (1993) with opening angle less than 0.7^o:
  22 6% @ 250 MeV; 11 3% @ 365 MeV, and 15 5% @ 450 MeV
- Analyzing power from GEANT3 with opening angle less than 3.5^o: 8 2 @ 365 MeV
- Experiment (opening angle less than 3.5^o) was consistent with simulation

The GW SAL detector

- E_γ = 220 to 330 MeV
- 2 mm scintillator converter
- Polarimeter located ~39 cm downstream of converter
- Recoil θ = 15 to 35 degrees
- Recoil φ = 0, 90, 180, 270 degrees with $\Delta\varphi$ = 44 degrees
- Analyzing power at the event generator level = 12%
- Analyzing power from simulation 3-4%
- Measured analyzing power = 2.66%
- Device was essentially useless as a polarimeter

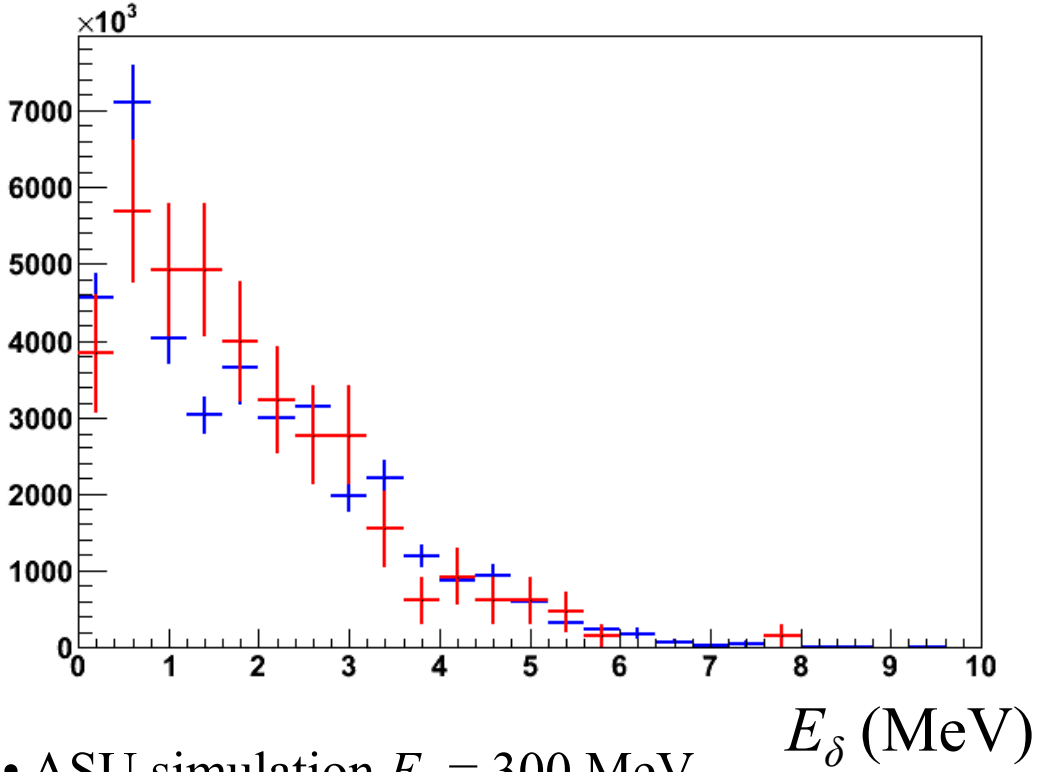
δ-ray comparison with Iwata 1993 simulation

- 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

NIST cross sections for triplet and pair production off Carbon

$\sigma_{pair}/\sigma_{triplet}$:
5.75 @ 300 MeV
5.16 @ 9.0 GeV

Edge	(required) Photon Energy	Scattering		Photoelectric Absorption	Pair Production		Total Attenuation	
		Coherent	Incoherent		In Nuclear Field	In Electron Field	With Coherent Scattering	Without Coherent Scattering
	MeV	barns/atom	barns/atom	barns/atom	barns/atom	barns/atom	barns/atom	barns/atom
	3.000E+02	8.537E-09	1.965E-02	3.030E-08	2.528E-01	4.397E-02	3.164E-01	3.164E-01
	4.000E+02	4.802E-09	1.539E-02	2.270E-08	2.613E-01	4.630E-02	3.230E-01	3.230E-01
	5.000E+02	3.073E-09	1.274E-02	1.815E-08	2.670E-01	4.792E-02	3.277E-01	3.277E-01
	6.000E+02	2.134E-09	1.091E-02	1.512E-08	2.712E-01	4.914E-02	3.313E-01	3.313E-01
	8.000E+02	1.201E-09	8.520E-03	1.133E-08	2.768E-01	5.084E-02	3.362E-01	3.362E-01
	1.000E+03	7.684E-10	7.009E-03	9.065E-09	2.805E-01	5.198E-02	3.395E-01	3.395E-01
	1.500E+03	3.415E-10	4.895E-03	6.041E-09	2.859E-01	5.372E-02	3.445E-01	3.445E-01
	2.000E+03	1.921E-10	3.789E-03	4.530E-09	2.889E-01	5.471E-02	3.474E-01	3.474E-01
	3.000E+03	8.537E-11	2.634E-03	3.019E-09	2.922E-01	5.580E-02	3.506E-01	3.506E-01
	4.000E+03	4.802E-11	2.033E-03	2.264E-09	2.939E-01	5.644E-02	3.524E-01	3.524E-01
	5.000E+03	3.073E-11	1.663E-03	1.811E-09	2.951E-01	5.684E-02	3.536E-01	3.536E-01
	6.000E+03	2.134E-11	1.410E-03	1.509E-09	2.958E-01	5.712E-02	3.543E-01	3.543E-01
	8.000E+03	1.201E-11	1.086E-03	1.132E-09	2.969E-01	5.749E-02	3.555E-01	3.555E-01
	1.000E+04	7.684E-12	8.868E-04	9.056E-10	2.975E-01	5.773E-02	3.561E-01	3.561E-01

Comparison of ASU MC of SAL detector to GW results

Note: ASU results are for E_γ = 300 MeV and GW is of E_γ = 220 to 330 MeV

Analyzing power:

- At event generator level: 12.6 0.1 % ASU; ~12% GW (no error reported)
- ASU simulation: 2.65 0.05%
- ASU simulation (30 μm Al wrapped scintillators): 2.83 0.05 %
- ASU simulation (wrapped and 50 keV threshold): 3.17 0.06 %
- ASU simulation (wrapped and 100 keV threshold): 3.54 0.07 %
- ASU simulation (wrapped and 200 keV threshold): 3.55 0.07 %

- GW experiment: 2.66% (no error reported)
- GW simulation: 3-4% (range given with no error reported)

Given that we don't know what kind of threshold cuts were placed on the GW simulations, or what kind of material they used to wrap the scintillators, it is very possible that the ASU results are in agreement with the GW simulations for the SAL detector.

Analyzing power of SAL type detector when some parameters are changed

- No change to SAL parameters: 2.83 0.5 %

Notation for parameter changes:
A: Air → Vacuum
B: Converter → 10^-4 radiation length carbon
C: E_γ → 9 GeV
D: ΔE_{pair} < 1500 MeV

- SAL with condition A: 6.9 0.1 %
- SAL with conditions A & B: 12.5 0.2%
- SAL with conditions A, B & C: 10.6 0.2 %
- SAL with conditions A, B, C & D (generated 10X previous for stats): 17.5 0.3 %

Dependence of analyzing power on ΔE_{pair} for 16 sector detector

- Same parameters as previous ABC configuration but now with 16 sectors instead of 4 paddle SAL design

- Analyzing power fairly constant for $\Delta E_{pair} < 1750$ MeV

- The 16 sector design increases the analyzing power to 19.1 0.7 % from 17.5 0.3 % of the 4 paddle design ($\Delta E_{pair} < 1500$ MeV)