

SmartPhantom: Simulations Update

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1) Including Araldite between Fibres

From PubChem, a chemical composition of Epoxy Resin is: $C_{21}H_{25}ClO_5$ with a density of about 1.2 g/cm^3 .

Summary of Observations

- Little to no impact compared to no glue (i.e. water between fibres) at least in terms of energy deposition

2) Light Yield

- Used the MAUS conversion of energy deposition to photoelectron number.
- I simulated with a few ions and then scaled in order to get to the rate expected from a full spill.

Summary of Observations

- Proton

- Average Spill Rate: $\frac{1.6 \times 10^9 \text{ proton}}{\text{s}}$

- Light Yield: $\frac{5 \times 10^{10} \text{ photons}}{\text{s}} \leq \text{Light Yield} \leq \frac{5 \times 10^{11} \text{ photons}}{\text{s}}$

- Carbon

- Average Spill Rate: $\frac{2 \times 10^8 \text{ carbon}}{\text{s}}$

- Light Yield: $\frac{1 \times 10^{11} \text{ photons}}{\text{s}} \leq \text{Light Yield} \leq \frac{8 \times 10^{11} \text{ photons}}{\text{s}}$

3) MedAustron Beam/Spill Parameters

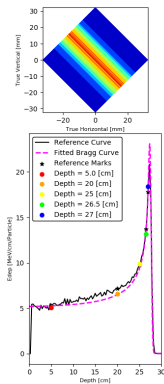
Average Beam Parameters:

- Typical beam spill for protons: 5 seconds
- Typical beam spill for carbon: 4 seconds
- Dead Time between Spills: 1 second \leq Dead Time \leq 2 seconds

0.5 Hz \leq Repetition Rate \leq 1.0 Hz

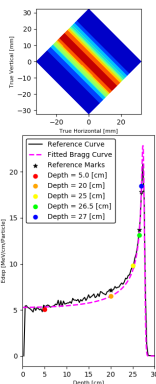
Simulation Slides

1) Including Araldite between Fibres – p207 (noglu | glue)



Particle	Proton
Energy	207.0 [MeV]
# Particles	100000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	0.948
Film	Mylar
Glue	None

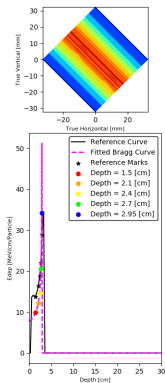
	Delta FWHM	Delta Edep
Depth = 5.0 [cm]	-0.110	-0.219
Depth = 20 [cm]	-0.360	-0.597
Depth = 25 [cm]	+0.430	+0.157
Depth = 26.5 [cm]	+0.210	-0.543
Depth = 27 [cm]	+0.600	+0.585
Absolute Error	+1.710	+2.100



Particle	Proton
Energy	207.0 [MeV]
# Particles	100000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	0.942
Film	Mylar
Glue	Epoxy Resin

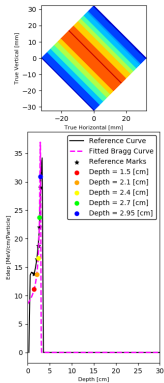
	Delta FWHM	Delta Edep
Depth = 5.0 [cm]	-1.050	-0.253
Depth = 20 [cm]	+0.910	-0.626
Depth = 25 [cm]	+0.120	+0.082
Depth = 26.5 [cm]	+0.580	-0.584
Depth = 27 [cm]	+0.300	+0.655
Absolute Error	+2.960	+2.200

1) Including Araldite between Fibres – p62.4 (noglue | glue)



Particle	Proton
Energy	62.4 [MeV]
# Particles	100000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	0.714
Film	Mylar
Glue	None

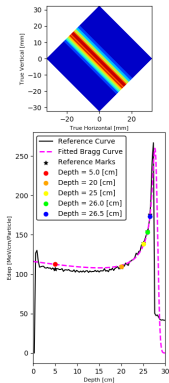
	Delta FWHM	Delta Edep
Depth = 1.5 [cm]	+2.240	-3.900
Depth = 2.1 [cm]	+0.800	-4.186
Depth = 2.4 [cm]	+0.330	-4.111
Depth = 2.7 [cm]	+1.350	-1.401
Depth = 2.95 [cm]	+1.620	+5.185
Absolute Error	+6.340	+18.773



Particle	Proton
Energy	62.4 [MeV]
# Particles	100000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	0.804
Film	Mylar
Glue	Epoxy Resin

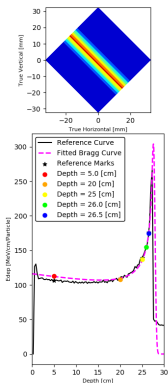
	Delta FWHM	Delta Edep
Depth = 1.5 [cm]	+2.460	-2.631
Depth = 2.1 [cm]	+1.490	-2.621
Depth = 2.4 [cm]	+1.840	-2.144
Depth = 2.7 [cm]	+1.060	+1.759
Depth = 2.95 [cm]	+1.720	+1.923
Absolute Error	+8.570	+11.078

1) Including Araldite between Fibres – c402.8 (noglue | glue)



Particle	Carbon
Energy	402.8 [MeV]
# Particles	10000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	1.026
Film	Mylar
Glue	None

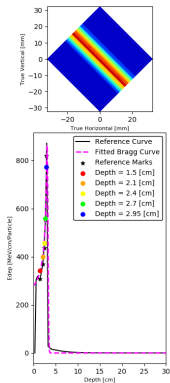
	Delta FWHM	Delta Edep
Depth = 5.0 [cm]	-1.490	+6.550
Depth = 20 [cm]	-2.300	+0.304
Depth = 25 [cm]	-3.960	-0.915
Depth = 26.0 [cm]	-1.670	-1.218
Depth = 26.5 [cm]	-1.430	-2.535
Absolute Error	+10.850	+11.522



Particle	Carbon
Energy	402.8 [MeV]
# Particles	10000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	1.018
Film	Mylar
Glue	Epoxy Resin

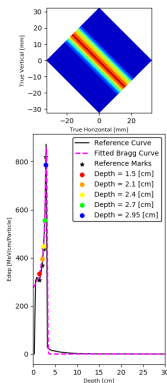
	Delta FWHM	Delta Edep
Depth = 5.0 [cm]	-1.650	+6.516
Depth = 20 [cm]	-2.770	-1.666
Depth = 25 [cm]	-4.760	-2.155
Depth = 26.0 [cm]	-1.660	-0.215
Depth = 26.5 [cm]	-0.990	-1.150
Absolute Error	+11.830	+11.703

1) Including Araldite between Fibres – c120 (noglu | glue)



Particle	Carbon
Energy	120.0 [MeV]
# Particles	100000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	10.976
Film	Mylar
Glue	None

	Delta FWHM	Delta Edep
Depth = 1.5 [cm]	-1.450	+33.956
Depth = 2.1 [cm]	-1.310	+32.346
Depth = 2.4 [cm]	-1.630	+19.564
Depth = 2.7 [cm]	-2.430	+4.717
Depth = 2.95 [cm]	-2.610	-46.720
Absolute Error	+9.430	+137.303

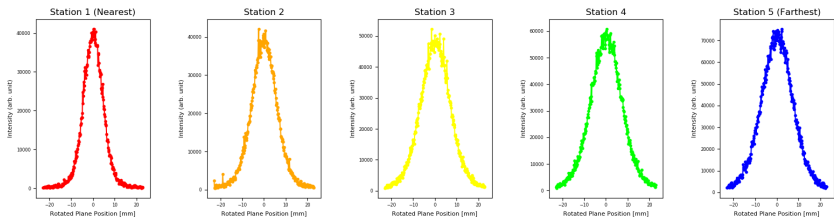


Particle	Carbon
Energy	120.0 [MeV]
# Particles	100000
Pitch	0.1525 [mm]
Plane Config	Stacked Planes
Station Depth	0.318 [mm]
Film Thickness	0.30 [mm]
Correction Factor	10.734
Film	Mylar
Glue	Epoxy Resin

	Delta FWHM	Delta Edep
Depth = 1.5 [cm]	-1.170	+27.560
Depth = 2.1 [cm]	-1.600	+26.930
Depth = 2.4 [cm]	-1.960	+11.549
Depth = 2.7 [cm]	-2.030	+1.414
Depth = 2.95 [cm]	-2.150	-32.888
Absolute Error	+8.910	+100.341

2) Light Yield – p207

Proton 207.0 MeV -- 100,000 Protons Simulated (62.5 us spill)



Depth in Water	5 [cm]
Max # Photon in a Single Fibre	4.100E+04
Total Energy Deposited	1.682E+04 [MeV]
Sum Photons from Simulation	2.940E+06 [Photons/62.5 us]
Rate of Photons Over Layer	4.703E+10 [Photons/s]

Depth in Water	20 [cm]
Max # Photon in a Single Fibre	4.201E+04
Total Energy Deposited	2.169E+04 [MeV]
Sum Photons from Simulation	3.790E+06 [Photons/62.5 us]
Rate of Photons Over Layer	6.064E+10 [Photons/s]

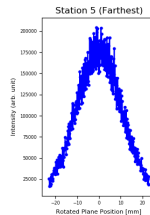
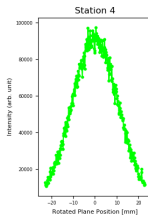
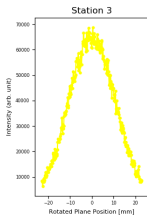
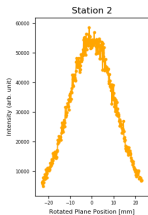
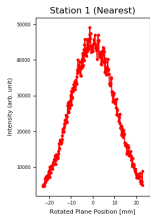
Depth in Water	25 [cm]
Max # Photon in a Single Fibre	5.219E+04
Total Energy Deposited	3.146E+04 [MeV]
Sum Photons from Simulation	5.498E+06 [Photons/62.5 us]
Rate of Photons Over Layer	8.796E+10 [Photons/s]

Depth in Water	26 [cm]
Max # Photon in a Single Fibre	6.074E+04
Total Energy Deposited	3.943E+04 [MeV]
Sum Photons from Simulation	6.889E+06 [Photons/62.5 us]
Rate of Photons Over Layer	1.102E+11 [Photons/s]

Depth in Water	26.5 [cm]
Max # Photon in a Single Fibre	7.519E+04
Total Energy Deposited	5.017E+04 [MeV]
Sum Photons from Simulation	8.766E+06 [Photons/62.5 us]
Rate of Photons Over Layer	1.403E+11 [Photons/s]

2) Light Yield – p62

Proton 62.4 MeV -- 100,000 Protons Simulated (62.5 us spill)



Depth in Water	1.5 [cm]
Max # Photon in a Single Fibre	4.906E+04
Total Energy Deposited	4.392E+04 [MeV]
Sum Photons from Simulation	7.674E+06 [Photons/62.5 us]
Rate of Photons Over Layer	1.228E+11 [Photons/s]

Depth in Water	2.1 [cm]
Max # Photon in a Single Fibre	5.853E+04
Total Energy Deposited	5.367E+04 [MeV]
Sum Photons from Simulation	9.379E+06 [Photons/62.5 us]
Rate of Photons Over Layer	1.501E+11 [Photons/s]

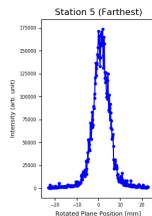
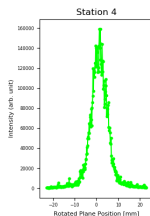
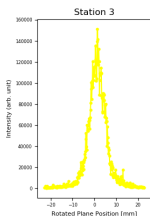
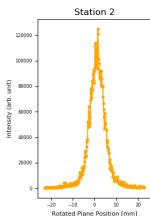
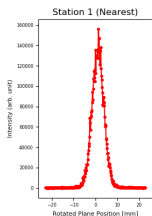
Depth in Water	2.4 [cm]
Max # Photon in a Single Fibre	6.866E+04
Total Energy Deposited	6.444E+04 [MeV]
Sum Photons from Simulation	1.126E+07 [Photons/62.5 us]
Rate of Photons Over Layer	1.802E+11 [Photons/s]

Depth in Water	2.7 [cm]
Max # Photon in a Single Fibre	9.731E+04
Total Energy Deposited	9.023E+04 [MeV]
Sum Photons from Simulation	1.577E+07 [Photons/62.5 us]
Rate of Photons Over Layer	2.523E+11 [Photons/s]

Depth in Water	2.95 [cm]
Max # Photon in a Single Fibre	2.041E+05
Total Energy Deposited	1.750E+05 [MeV]
Sum Photons from Simulation	3.057E+07 [Photons/62.5 us]
Rate of Photons Over Layer	4.892E+11 [Photons/s]

2) Light Yield – c402

Carbon 402.8 MeV -- 10,000 Carbon Simulated (50.0 us spill)



Depth in Water	5 [cm]
Max # Photon in a Single Fibre	1.560E+05
Total Energy Deposited	3.530E+04 [MeV]
Sum Photons from Simulation	6.168E+06 [Photons/50.0 us]
Rate of Photons Over Layer	1.234E+11 [Photons/s]

Depth in Water	20 [cm]
Max # Photon in a Single Fibre	1.246E+05
Total Energy Deposited	3.368E+04 [MeV]
Sum Photons from Simulation	5.886E+06 [Photons/50.0 us]
Rate of Photons Over Layer	1.177E+11 [Photons/s]

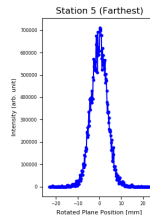
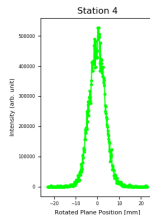
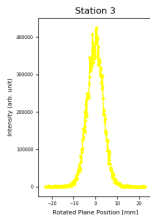
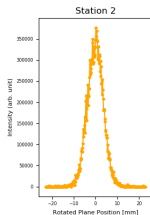
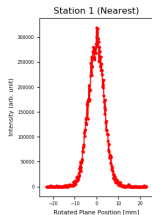
Depth in Water	25 [cm]
Max # Photon in a Single Fibre	1.511E+05
Total Energy Deposited	4.270E+04 [MeV]
Sum Photons from Simulation	7.462E+06 [Photons/50.0 us]
Rate of Photons Over Layer	1.492E+11 [Photons/s]

Depth in Water	26 [cm]
Max # Photon in a Single Fibre	1.589E+05
Total Energy Deposited	4.795E+04 [MeV]
Sum Photons from Simulation	8.379E+06 [Photons/50.0 us]
Rate of Photons Over Layer	1.676E+11 [Photons/s]

Depth in Water	26.5 [cm]
Max # Photon in a Single Fibre	1.735E+05
Total Energy Deposited	5.428E+04 [MeV]
Sum Photons from Simulation	9.484E+06 [Photons/50.0 us]
Rate of Photons Over Layer	1.897E+11 [Photons/s]

2) Light Yield – c120

Carbon 120.0 MeV -- 10,000 Carbon Simulated (50.0 us spill)



Depth in Water	1.5 [cm]
Max # Photon in a Single Fibre	3.189E+05
Total Energy Deposited	9.871E+04 [MeV]
Sum Photons from Simulation	1.725E+07 [Photons/50.0 us]
Rate of Photons Over Layer	3.450E+11 [Photons/s]

Depth in Water	2.1 [cm]
Max # Photon in a Single Fibre	3.759E+05
Total Energy Deposited	1.163E+05 [MeV]
Sum Photons from Simulation	2.032E+07 [Photons/50.0 us]
Rate of Photons Over Layer	4.064E+11 [Photons/s]

Depth in Water	2.4 [cm]
Max # Photon in a Single Fibre	4.246E+05
Total Energy Deposited	1.314E+05 [MeV]
Sum Photons from Simulation	2.297E+07 [Photons/50.0 us]
Rate of Photons Over Layer	4.593E+11 [Photons/s]

Depth in Water	2.7 [cm]
Max # Photon in a Single Fibre	5.264E+05
Total Energy Deposited	1.618E+05 [MeV]
Sum Photons from Simulation	2.827E+07 [Photons/50.0 us]
Rate of Photons Over Layer	5.654E+11 [Photons/s]

Depth in Water	2.95 [cm]
Max # Photon in a Single Fibre	7.105E+05
Total Energy Deposited	2.225E+05 [MeV]
Sum Photons from Simulation	3.889E+07 [Photons/50.0 us]
Rate of Photons Over Layer	7.777E+11 [Photons/s]