Pedantic review of calculations in g4hrs

Tyler Kutz

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Topics

- Generator and sampling corrections
- Calculation of cross section and rate
- Some simulation results

Generator

Elastic generator chooses polar angle $\theta_{min} < \theta < \theta_{max}$ and aziumuthal angle $\phi_{min} < \phi < \phi_{max}$

- θ is chosen by sampling from non-uniform distribution:

$$S = \frac{1}{\text{RandFlat}\left[\frac{1}{1-\cos\theta_{max}},\ \frac{1}{1-\cos\theta_{min}}\right]} \Rightarrow \theta = \arccos(1-S)$$

- ϕ is chosen by sampling from a uniform distribution:

$$\phi = \text{RandFlat}[\phi_{min},\ \phi_{max}]$$

Phase space weight

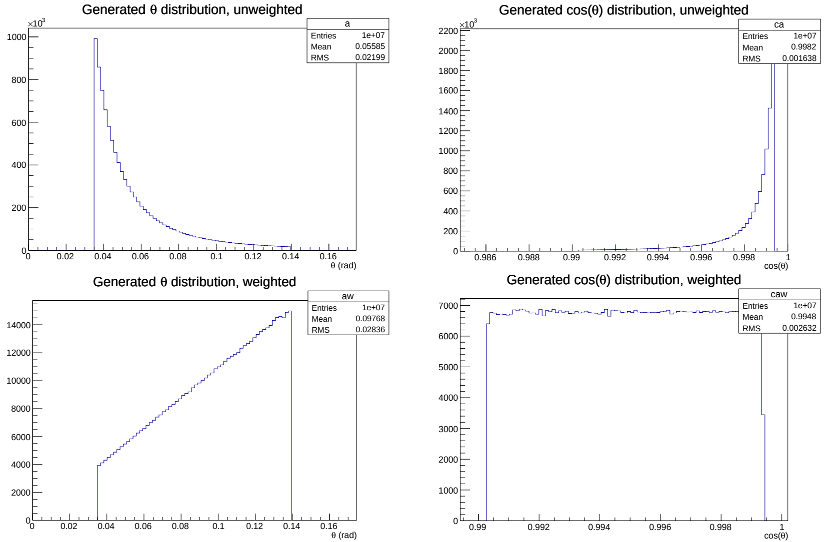
Need a weight to account for (i) sampling limited range, and (ii) non-uniform sampling

$$V = (\phi_{max} - \phi_{min})(\cos\theta_{min} - \cos\theta_{max}) \times S^2 \left(\frac{\frac{1}{1-\cos\theta_{min}} - \frac{1}{1-\cos\theta_{max}}}{\cos\theta_{min} - \cos\theta_{max}} \right)$$

The only factor that changes from event to event is $S = 1 - \cos\theta$

Tested this weighting on a "toy generator" outside of g4hrs, for $2^\circ < \theta < 8^\circ$ and $0 < \phi < 2\pi$...

Weight example



Integral of weighted $\cos\theta$ distribution yields sampled solid angle

Cross section

- Mott cross section calculated by:

$$\sigma_{Mott} = \left(\frac{Z\hbar c\alpha \cos(\theta/2)}{2E\sin^2(\theta/2)} \right)^2, \ [\sigma_{Mott}] = \mathrm{mm}^2$$

- Form factor squared F^2 looked up in database tables

- Effective cross section:

$$\sigma_{eff} = \sigma_{Mott} F^2 V$$

Material length, current, and luminosity

- Effective material length (density?):

$$M_{eff} = \rho t \left(\frac{N_A}{A} \right) \quad , \quad [M_{eff}] = \mathrm{mm}^{-2}$$

- Electron current:

$$I_{e^-} = \frac{I_{Amp}}{q_e} \quad , \quad [I_{e^-}] = (e^-)\ \mathrm{s}^{-1}$$

- Luminosity:

$$L = M_{eff} I_{e^-} \quad , \quad [L] = (e^-)\ \mathrm{s}^{-1}\ \mathrm{mm}^{-2}$$

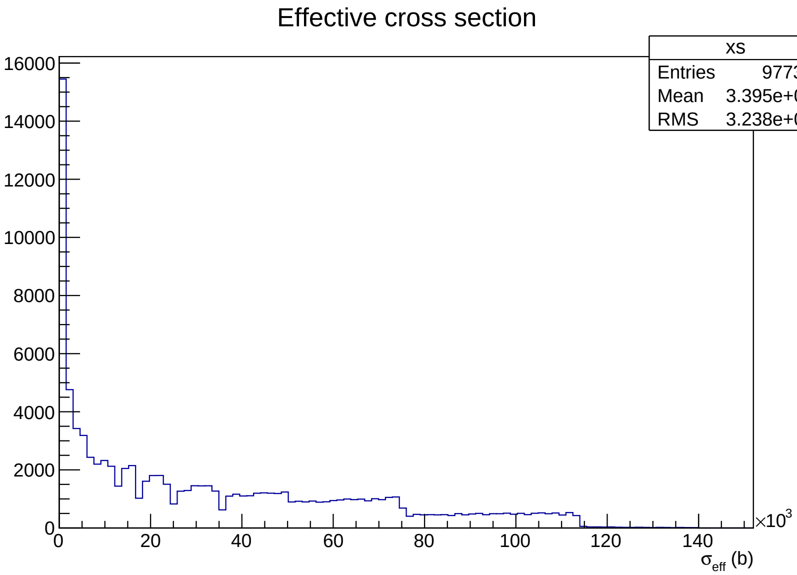
Rate

Rate is calculated by

$$R = \frac{\sigma_{eff} L}{N_{ev}}$$

where N_{ev} is the number of simulated events

Simulated cross section



Simulated rate