Errors in Asymmetry Calculation

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Assume independent errors for the different helicities, prompt vs random, and data vs dummy, and then follow the general formula for error propagation:

$$\sigma(f(x,y,...)) = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 \sigma(x)^2 + \left(\frac{\partial f}{\partial y}\right)^2 \sigma(y) + ...}$$

The initial error in each bin of the ϕ distribution follows counting statistics

$$\sigma = \sqrt{N}$$

These errors are first propagated through the prompt random subtraction, where in each bin we now have

$$\sigma = \sqrt{\sigma_{PROMPT}^2 + (\sigma_{RANDOM}/6)^2}$$

where the factor of 6 comes from the averaging of six random windows in the subtraction.

Then in the dummy target subtraction we take

$$\sigma = \sqrt{(\sigma_{LH2}/Q_{LH2})^2 + (\sigma_{DUMMY}/(Q_{DUMMY} * t))^2},$$

where Q is the normalized charge of both data and dummy, and t is the thickness of the dummy target compared to the LH_2 target.

Finally, at the asymmetry calculation, the asymmetry equation:

$$BSA = \frac{Y^+ - Y^-}{Y^+ + Y^-}$$

leads to the error being calculated as

$$\sigma(BSA) = \sqrt{\left(\frac{\sqrt{\sigma_+^2 + \sigma_-^2}}{N_+ + N_-}\right)^2 + \left(\frac{\sqrt{\sigma_+^2 + \sigma_-^2}(N_+ - N_-)}{(N_+ + N_-)^2}\right)^2}$$

Note that this does not yet consider the error on the effective charge or polarization, and in fact the polarization is not yet included in the calculation of the BSA. This will be included at a later point in the analysis.