RosenbluthPXSec fix

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1 Introduction

An issue has been noticed in the implementation of the Rosenbluth differential cross section. Here we report the fix and the impact.

2 Correction

The error is in the evaluation of the Jacobian. The model is giving $\frac{d\sigma}{d\Omega}$ but the default cross section is supposed to be $\frac{d\sigma}{dQ^2}$ hence a jacobian is supposed to be evaluated.

The implemented Jacobian factor is

$$\frac{d\sigma}{dQ^2} = \frac{\pi}{E'^2}\frac{d\sigma}{d\Omega} \tag{1}$$

A little bit of math suggests otherwise

$$\begin{aligned}
\int d\Omega &= \int d\phi\, d\cos\theta && (2)\\
&= 2\pi \int d\cos\theta && (3)\\
&= 2\pi \int dQ^2 \left|\frac{d\cos\theta}{dQ^2}\right| && (4)\\
&= 2\pi \int dQ^2 \frac{1}{\left|\frac{dQ^2}{d\cos\theta}\right|} && (5)
\end{aligned}$$

Now

$$\begin{aligned}
Q^2 &= 2EE' - 2|\boldsymbol{p}||\boldsymbol{p}'|\cos\theta - 2m_\ell^2 && (6)\\
\frac{dQ^2}{d\cos\theta} &= -2|\boldsymbol{p}||\boldsymbol{p}'| && (7)\\
&\sim -2EE' && (8)\\
& && (9)
\end{aligned}$$

Therefore

$$\int d\Omega = 2\pi \int dQ^2 \frac{1}{\left| \frac{dQ^2}{d\cos\theta} \right|} \tag{10}$$

$$= \frac{\pi}{EE'} \int dQ^2 \tag{11}$$

So it seems the jacobian should be

$$\frac{d\sigma}{dQ^2} = \frac{\pi}{EE'} \frac{d\sigma}{d\Omega} \tag{12}$$

Smilar results have been repoerted here: `http://www.int.washington.edu/NNPSS/2013/lectures/Badelek2.pdf` - page 33.

3 Impact

The effect of our proposed change can be seen in the figures below for EMQE interactions on ^{1}H and ^{12}C.