Luminosity Study using H(e,e'p) elastic data

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Tritium Analysis meeting

August 21st, 2018

$$\frac{dN}{dt} = \sigma \mathscr{L}$$

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Integrating

$$N = \sigma \mathscr{L} t$$

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Integrating

$$N = \sigma\mathscr{L}t$$

protons/cm^2 electrons/s

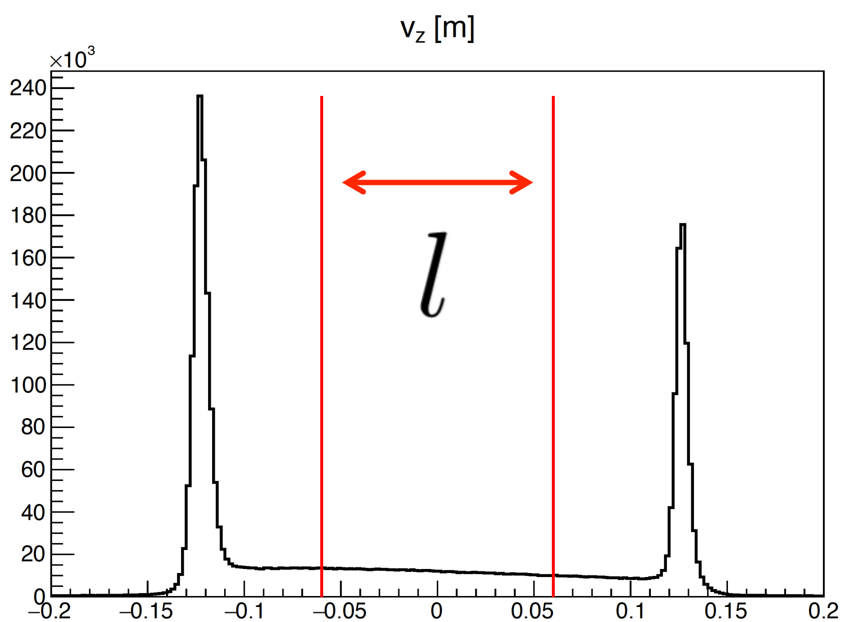
$$\mathscr{L} = T \cdot I$$

$$N = \sigma T \cdot \underbrace{It}_{\text{Number of ‘delivered’ electrons}} = \sigma T N_e$$

$$N = \sigma T N_e$$

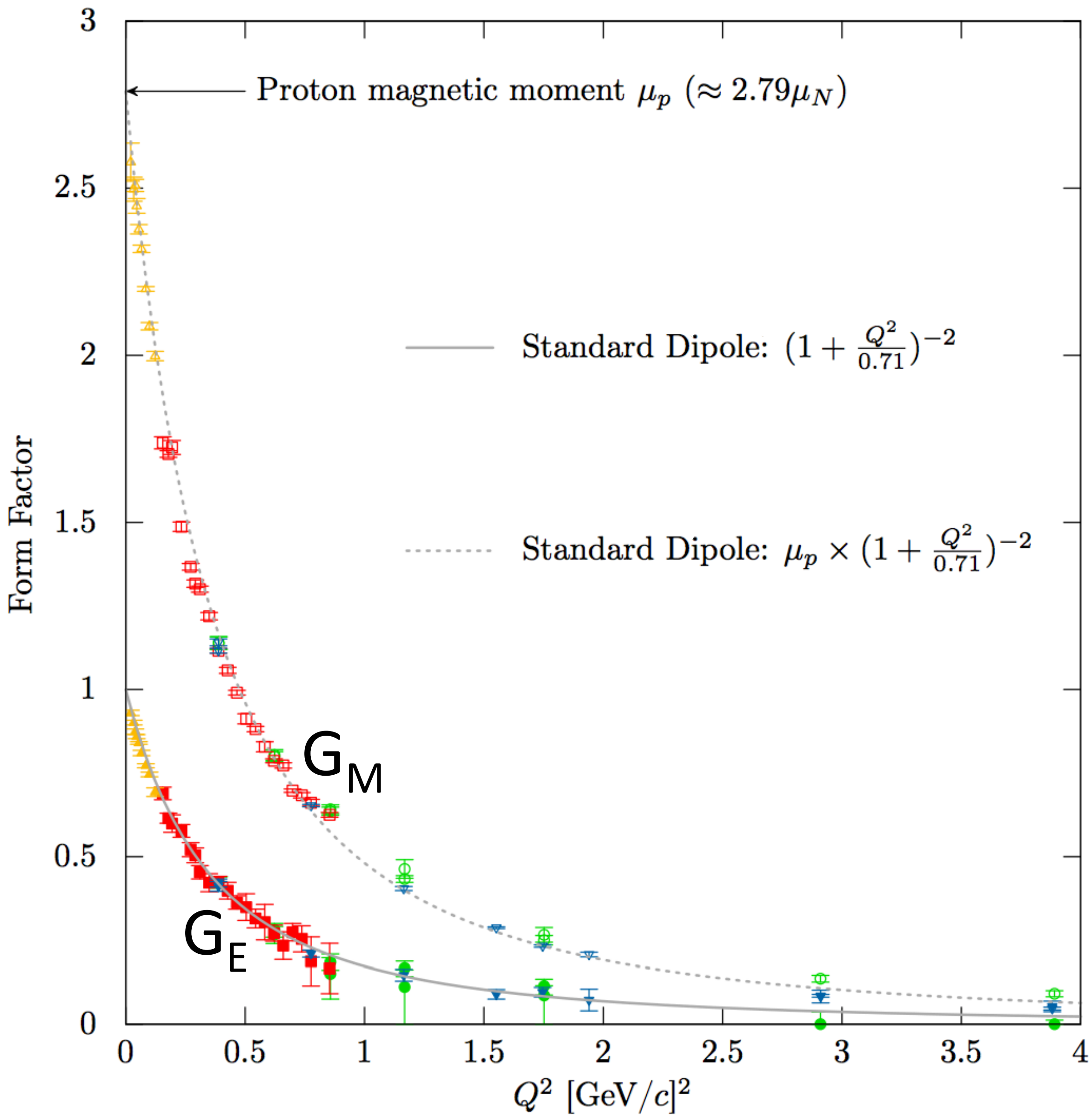
$$\boxed{\sigma = \sigma_{Mott}\left(\frac{1}{1+\tau}\right)\left[G_E^2 + \frac{\tau}{\epsilon}G_M^2\right]}$$

$$T = \frac{\rho \cdot l \cdot N_A \cdot n_{ppm}}{M}$$



- $\rho = 0.002832\ \mathrm{g/cm^3}$ is the target density
- l is the effective target length
- $N_A = 6.0221409 \times 10^{23}$ particles/mol
- $M = 2.016$ g/mol is the molar mass
- $n_{ppm} = 2$ is the number of protons per H_2 molecule

$$\sigma = \sigma_{Mott}\left(\frac{1}{1+\tau}\right)\left[G_E^2 + \frac{\tau}{\epsilon}G_M^2\right]$$

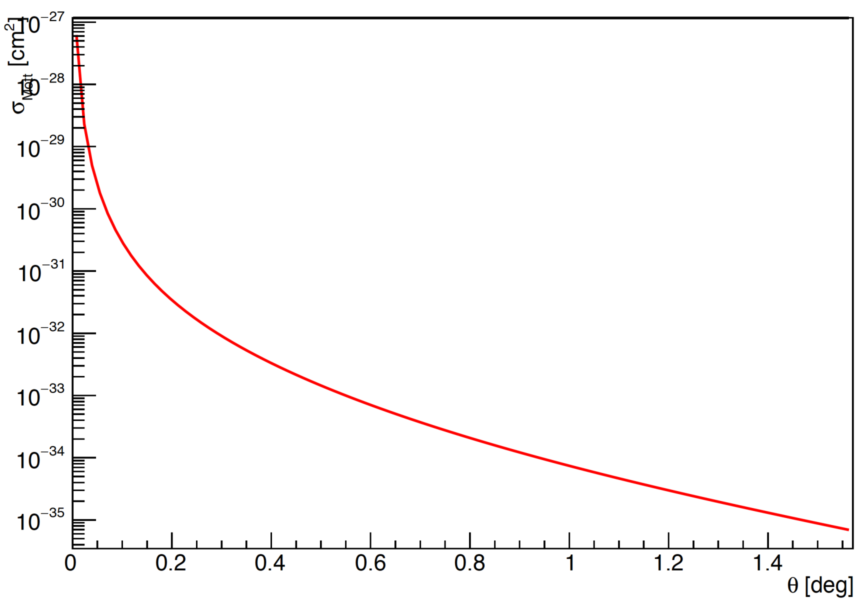


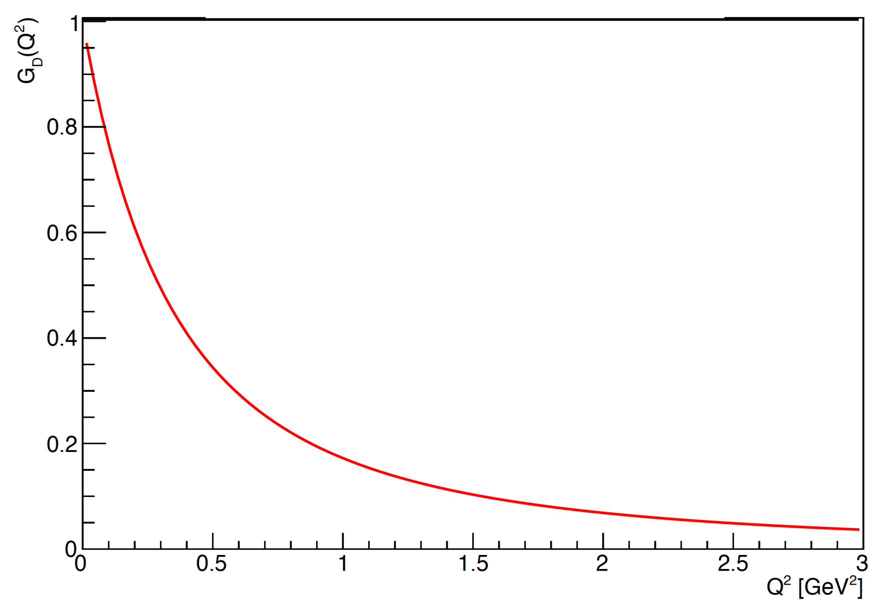
$$\sigma = \sigma_{Mott}\left(\frac{1}{1+\tau}\right)\left[G_E^2 + \frac{\tau}{\epsilon}G_M^2\right]$$

$$\sigma = \sigma_{Mott}\left(\frac{1}{1+\tau}\right)\left[1 + \frac{\tau}{\epsilon}\mu_p^2\right]G_D^2$$

$$\frac{d\sigma_{Mott}}{\sin\theta d\theta} = \int \frac{\alpha^2 E'}{4E^3 \sin^4\theta/2}\cos^2\frac{\theta}{2}d\phi$$

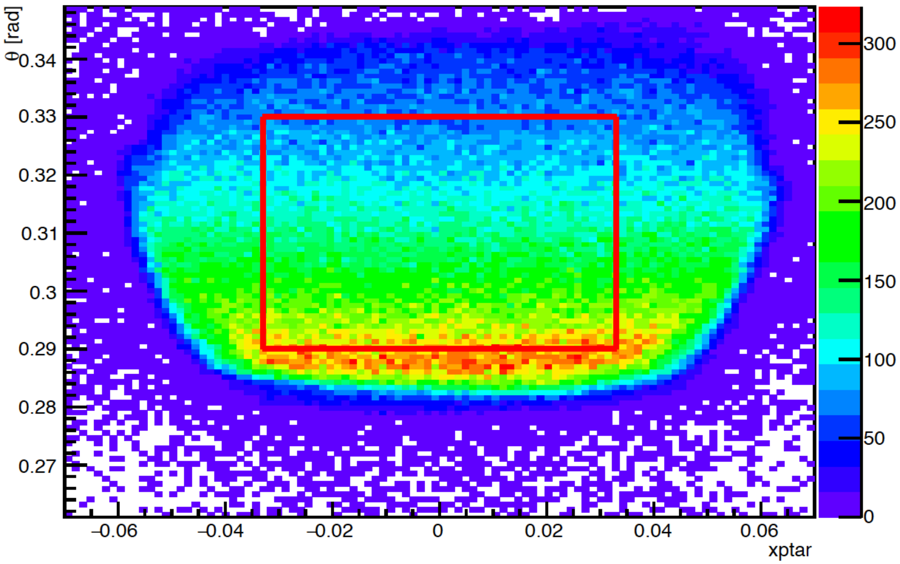
$$G_D(Q^2) = \frac{1}{(1+\frac{Q^2}{0.71GeV^2})^2}$$



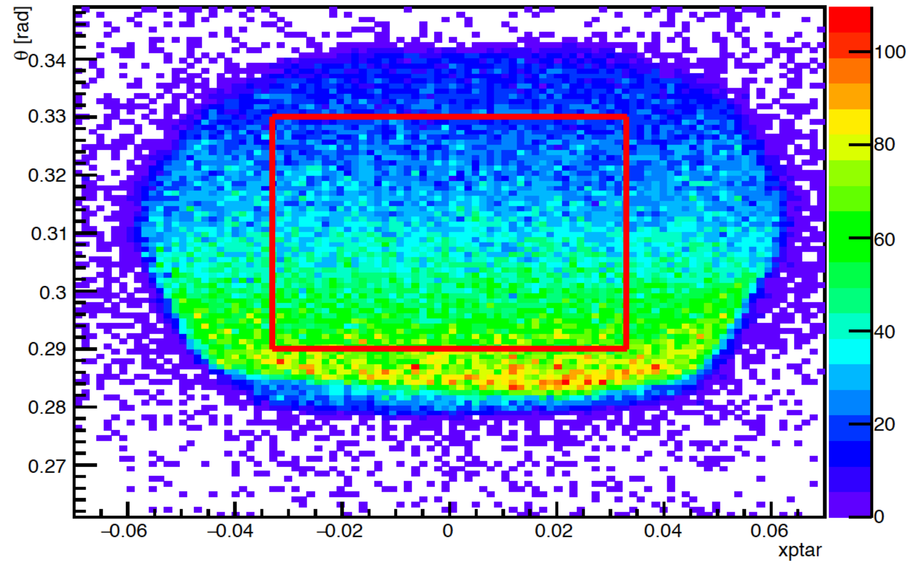


yptar vs. xptar distributions

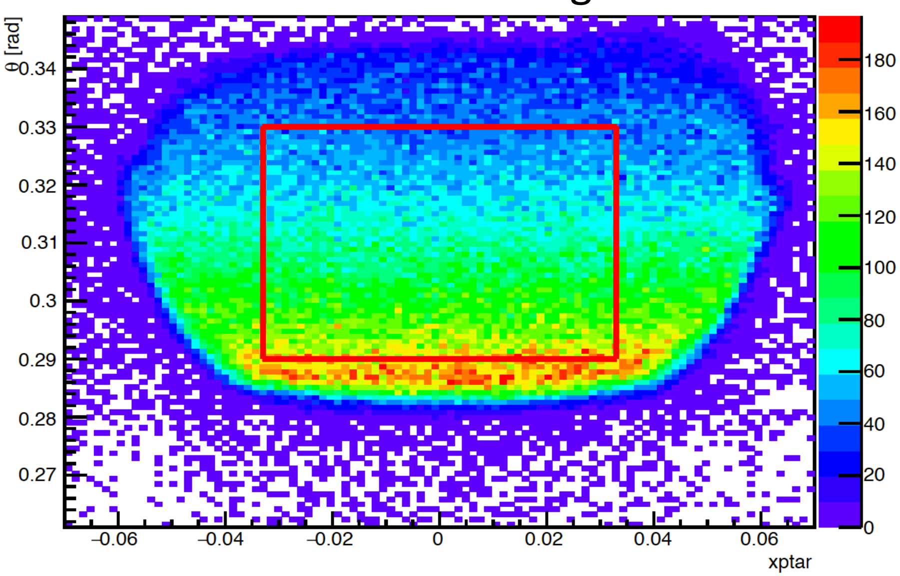
overall distribution



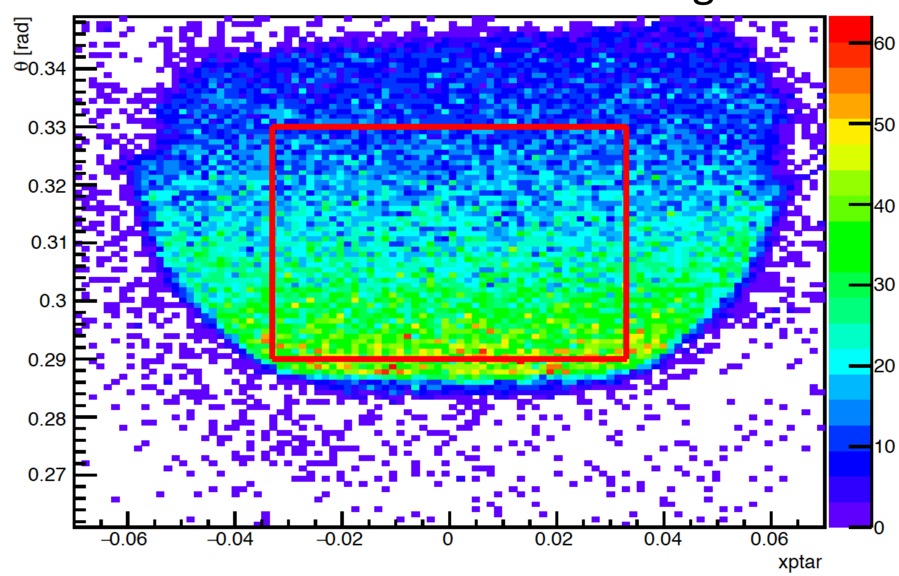
‘upstream end’ of the target



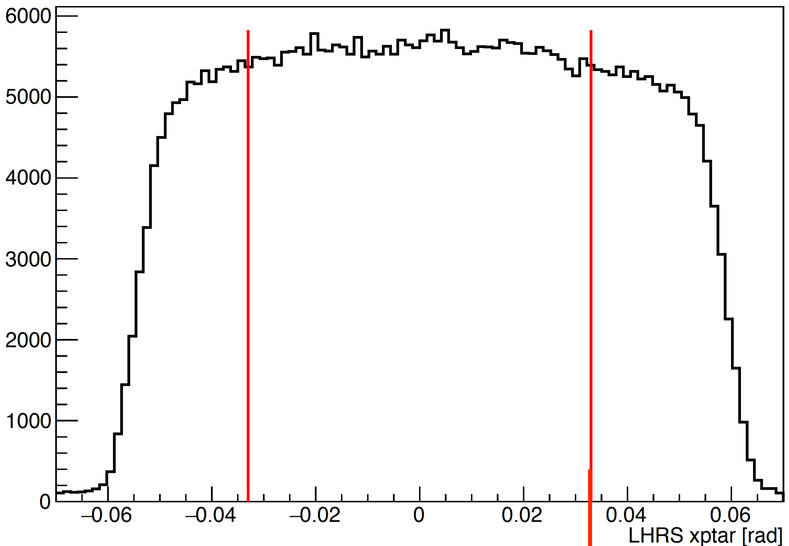
‘middle’ of the target



‘downstream end’ of the target



Integrating over the out-of-plane angle



$d\Omega = \sin\theta \cdot d\theta \cdot d\phi = 6$ mstr (constant)

$d\theta = 3.5^{o}$ (constant)

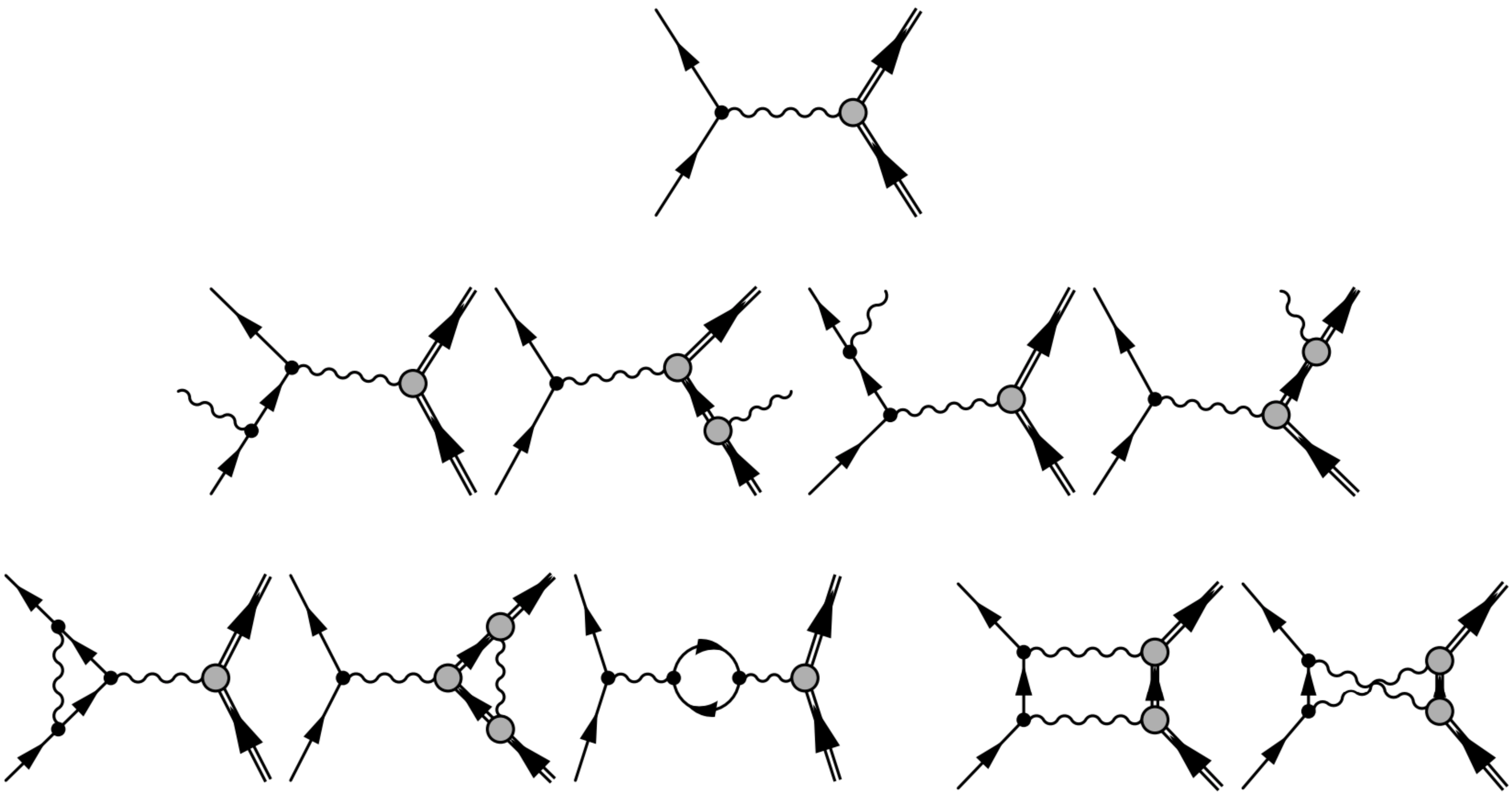
$\sin\theta \cdot d\phi =$ (constant)

x'_{tar} cut in spectrometer acceptance → $\phi/\sin\theta$ limit when integrating the cross section

$$\frac{d\sigma_{Mott}}{\sin\theta d\theta} = \int \frac{\alpha^2 E'}{4E^3 \sin^4\theta/2} \cos^2\frac{\theta}{2} d\phi$$

Radiative corrections

$$d\sigma_{meas.} = d\sigma_{1\gamma} \times (1 + \delta(\theta, \Delta E)).$$

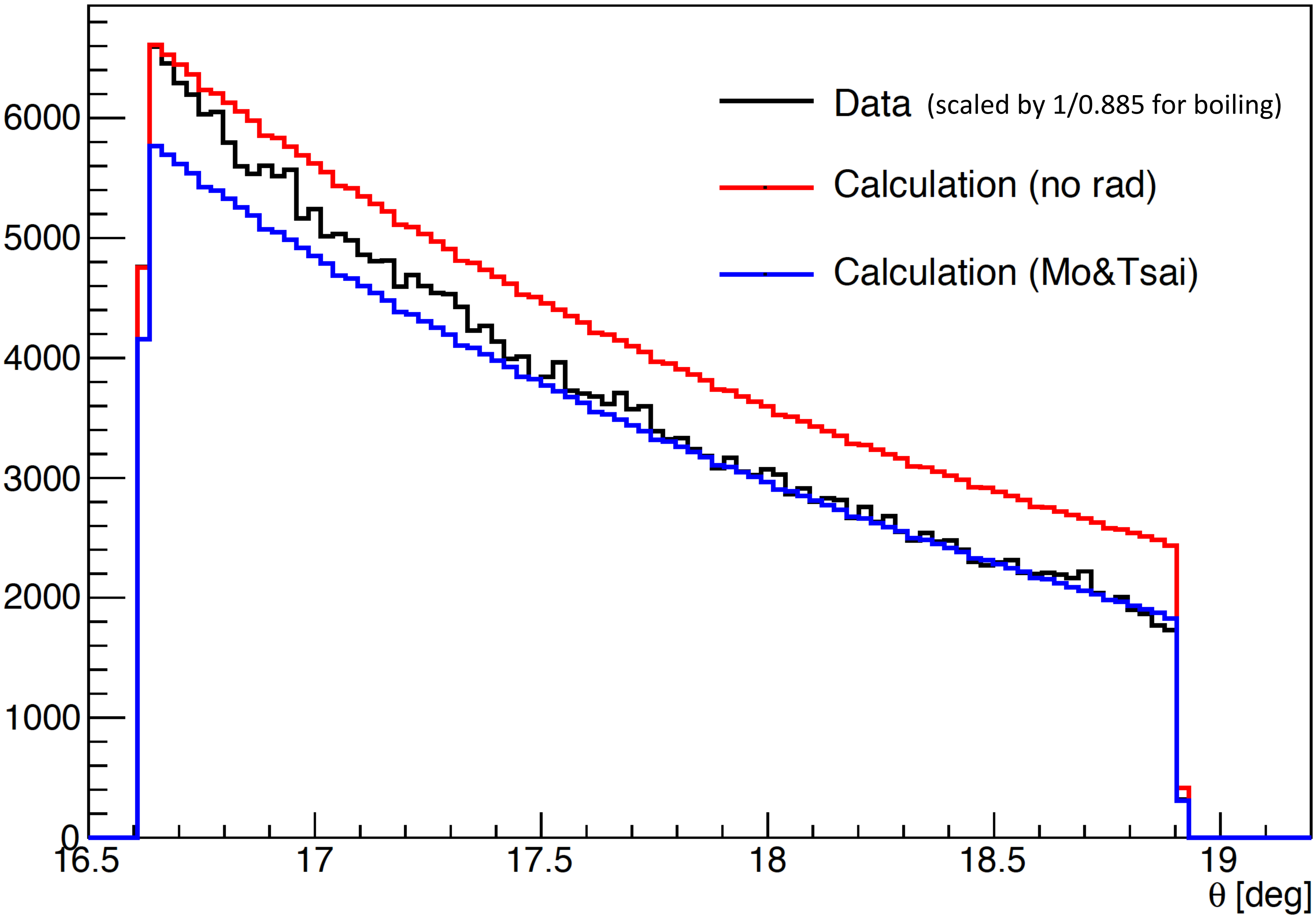


Radiative corrections

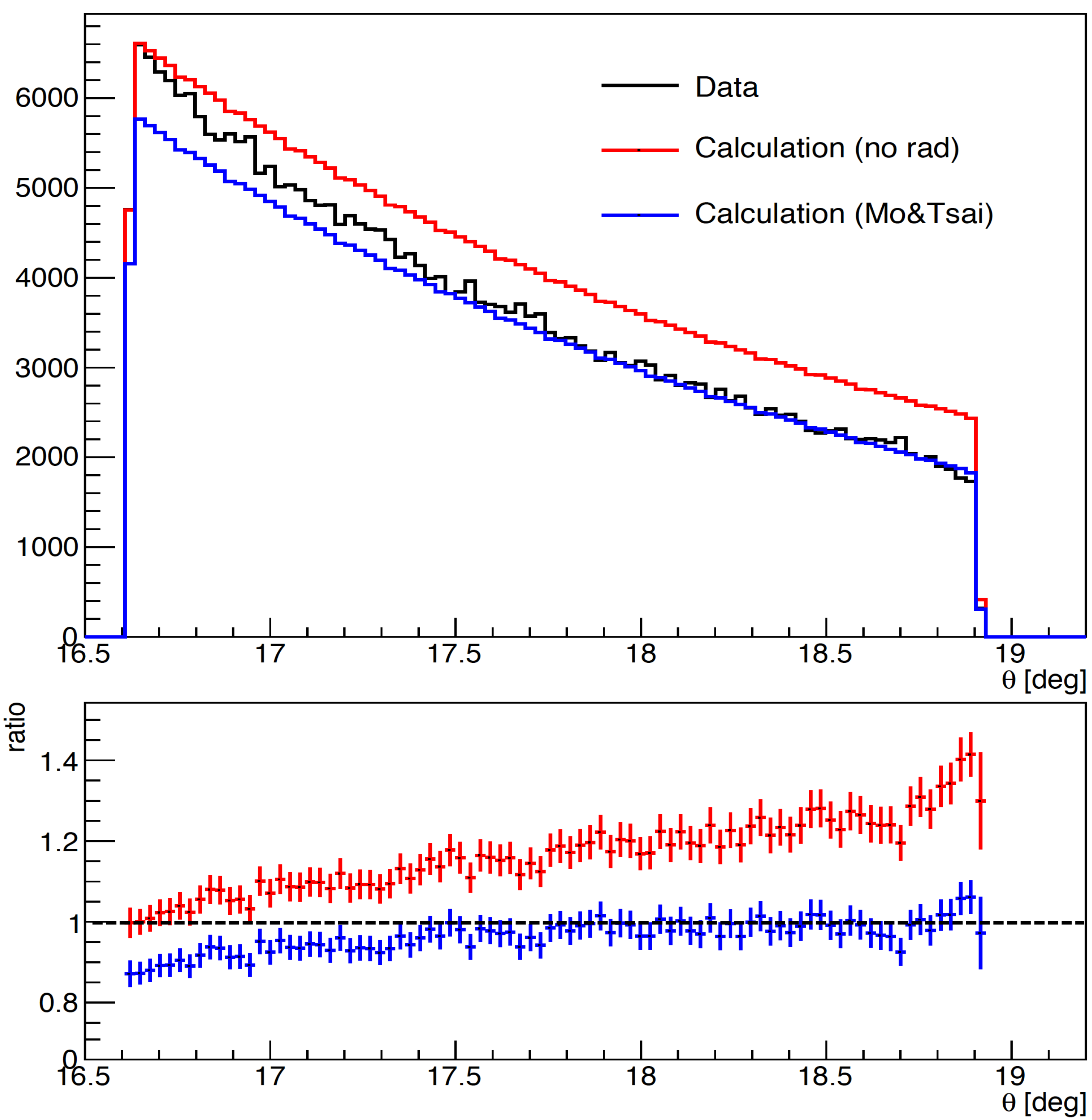
$$d\sigma_{meas.} = d\sigma_{1\gamma} \times (1 + \delta(\theta, \Delta E)).$$

$$\begin{aligned}
\delta = \frac{-\alpha}{\pi}\Bigg(& \tfrac{28}{9} - \tfrac{13}{6}\ln\left(\frac{-q^2}{m^2}\right) + \left(\ln\frac{-q^2}{m^2} - 1 + 2Z\ln\eta\right)\left(2\ln\frac{E_1}{\Delta E} - 3\ln\eta\right) - \Phi\left(\frac{E_3 - E_1}{E_3}\right) - Z^2\ln\frac{E_4}{M} \\
& + Z^2\ln\frac{M}{\eta\Delta E}\left(\frac{1}{\beta_4}\ln\frac{1+\beta_4}{1-\beta_4} - 2\right) + \frac{Z^2}{\beta_4}\left\{\tfrac{1}{2}\ln\frac{1+\beta_4}{1-\beta_4}\ln\frac{E_4+M}{2M} - \Phi\left[-\left(\frac{E_4-M}{E_4+M}\right)^{1/2}\left(\frac{1+\beta_4}{1-\beta_4}\right)^{1/2}\right]\right\} \\
& + Z\left[\Phi\left(-\frac{M-E_3}{E_1}\right) - \Phi\left(\frac{M(M-E_3)}{2E_3E_4 - ME_1}\right) + \Phi\left(\frac{2E_3(M-E_3)}{2E_3E_4 - ME_1}\right) + \ln\left|\frac{2E_3E_4 - ME_1}{E_1(M-2E_3)}\right|\ln\left(\frac{M}{2E_3}\right)\right] \\
& - Z\left[\Phi\left(-\frac{E_4-E_3}{E_3}\right) - \Phi\left(\frac{M(E_4-E_3)}{2E_1E_4 - ME_3}\right) + \Phi\left(\frac{2E_1(E_4-E_3)}{2E_1E_4 - ME_3}\right) + \ln\left|\frac{2E_1E_4 - ME_3}{E_3(M-2E_1)}\right|\ln\left(\frac{M}{2E_1}\right)\right] \\
& - Z\left[\Phi\left(-\frac{M-E_1}{E_1}\right) - \Phi\left(\frac{M-E_1}{E_1}\right) + \Phi\left(\frac{2(M-E_1)}{M}\right) + \ln\left|\frac{M}{2E_1 - M}\right|\ln\left(\frac{M}{2E_1}\right)\right] \\
& + Z\left[\Phi\left(-\frac{M-E_3}{E_3}\right) - \Phi\left(\frac{M-E_3}{E_3}\right) + \Phi\left(\frac{2(M-E_3)}{M}\right) + \ln\left|\frac{M}{2E_3 - M}\right|\ln\left(\frac{M}{2E_3}\right)\right]\Bigg) \\
& - \frac{\alpha}{\pi}\left(-\Phi\left(\frac{E_1-E_3}{E_1}\right) + \frac{Z^2}{\beta_4}\left\{\Phi\left[\left(\frac{E_4-M}{E_4+M}\right)^{1/2}\left(\frac{1-\beta_4}{1+\beta_4}\right)^{1/2}\right] - \Phi\left[\left(\frac{E_4-M}{E_4+M}\right)^{1/2}\right] + \Phi\left[-\left(\frac{E_4-M}{E_4+M}\right)^{1/2}\right]\right\}\right).
\end{aligned}$$

L.W.Mo, Y.S.Tsai, Reviews of Modern Physics vol 41, number 1 (1969)



Data (scaled by 1/0.885 for boiling)
Calculation (no rad)
Calculation (Mo&Tsai)
6000
5000
4000
3000
2000
1000
0
16.5
17
17.5
18
18.5
19
θ [deg]



Data
Calculation (no rad)
Calculation (Mo&Tsai)
6000
5000
4000
3000
2000
1000
0
16.5
17
17.5
18
18.5
19
θ [deg]
ratio
1.4
1.2
1
0.8
0
16.5
17
17.5
18
18.5
19
θ [deg]