# Mott Rates

November 3, 2016

# Expected Rate at KE=5.0 MeV

$$Rate = \rho_{Au} d_{foil} \frac{N_A}{M_{Au}} \frac{I_{beam}}{e} \frac{d\sigma}{d\Omega} \Delta\Omega = L \frac{d\sigma}{d\Omega} \Delta\Omega$$

Beam Current ($I_{beam}$) = 1.0 µA
Solid Angle ($\Delta\Omega$) = 0.18 msr
Foil Thickness ($d_{foil}$) = 1.0 nm
Gold Density ($\rho_{Au}$) = 19.32 g/cm$^3$
Avogadro's Number ($N_A$) = 6.022*10$^{23}$ /mol
Atomic Mass ($M_{Au}$) = 196.97 g/mol
Electron Charge (e) = 1.602*10$^{-19}$ C

Luminosity (*L*) = $\rho_{Au}$ * $d_{foil}$ *1.0e-7 * $N_A$ / $M_{Au}$* $I_{beam}$* 1.0e-6 / e
= 3.69*10$^{28}$ cm$^{-2}$ s$^{-1}$

Differential Cross Section at 172.6° ($d\sigma/d\Omega$) = 5.12*10$^{-26}$ cm$^2$/sr (our Mott code)
Differential Cross Section at 172.6° ($d\sigma/d\Omega$) = 5.12*10$^{-26}$ cm$^2$/sr (Xavier)

**Calculated single rate per detector = *L* * dσ/dΩ * ΔΩ = 0.340 Hz/(µA nm)**

# Measured Rates vs Expected

- **Calculated single rate per detector = 0.340 Hz/(μA nm)**

- **Marty's GEANT4 prediction is 0.198±0.001 Hz/(μA nm) – equation (20) in Tech Note (no energy cut)**

- For 50 nm foil, calculated rate = 17.0 Hz/μA. Measured rate (mostly single) with an energy cut (±5 sigma) and ToF cut (±2 sigma) is:

  1. RUN I: Run 8083, Rate = 12.8 Hz/μA
  2. RUN II: Run 8539, Rate = 12.6 Hz/μA

We measured 75% of calculated rate (0.255 Hz/(μA nm))

- For 1000 nm foil, calculated rate = 340 Hz/μA. Measured rate (single and double scattering) with an energy cut (±5 sigma) and ToF cut (±2 sigma) is:

  1. RUN I: Run 8187, Rate = 319.1 Hz/μA
  2. RUN II: Run 8546, Rate = 313.3 Hz/μA

# RUN I: Foil 1 μm Rate

| Run | Rate (Hz) |
|---|---|
| 8000 | 204.7 |
| 8004 | 204.9 |
| 8030 | 205.9 |
| 8039 | 207.7 |
| 8046 | 208.5 |
| 8059 | 208.5 |
| 8065 | 208.5 |
| 8073 | 209.3 |
| 8094 | 207.4 |
| 8095 | 208.5 |
| 8120 | 196.8 |
| 8123 | 197.9 |
| 8130 | 197.7 |
| 8131 | 199.5 |
| 8187 | 196.9 |

E: -0.5 sigma → 2 sigma
ToF: ±2 sigma

# RUN II: Foil 1 μm Rate

| Run | Rate (Hz) |
| --- | --- |
| 8424 | 163.7 |
| 8432 | 161.3 |
| 8433 | 192.4 |
| 8436 | 190.7 |
| 8441 | 189.3 |
| 8485 | 185.3 |
| 8495 | 187.2 |
| 8503 | 191.1 |
| 8510 | 190.7 |
| 8534 | 192.6 |
| 8540 | 191.5 |
| 8546 | 192.2 |
| 8547 | 192.1 |
| 8548 | 192.7 |
| 8549 | 193.1 |

After beam re-steering

E: -0.5 sigma → 2 sigma
ToF: ±2 sigma

# What Changed between Runs 8432 and 8433

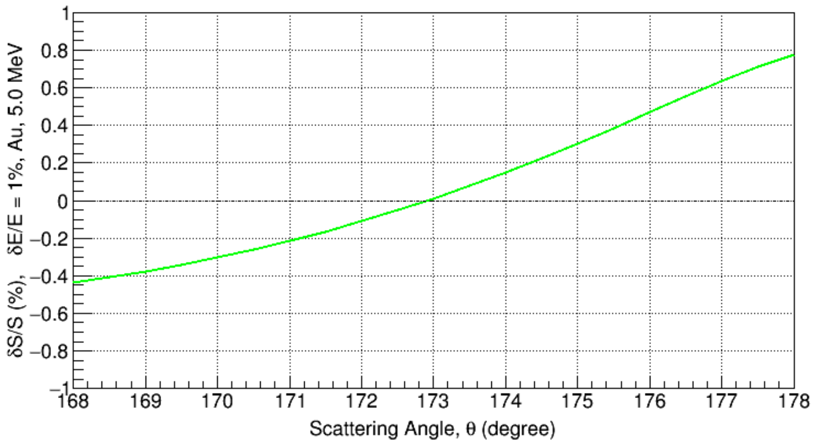
I. Run 8432 was taken on end of first owl shift – might have been scraping – same for all rate scan runs with Pockels Cell off and constant beam current of 1 µA (8413-8424)

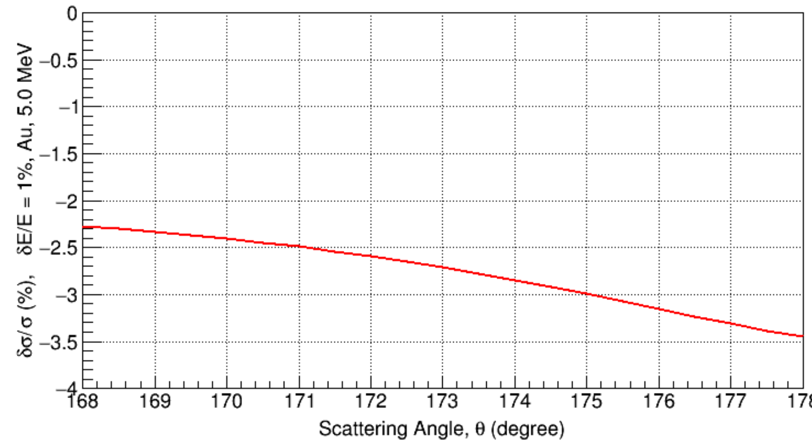
II. Run 8433 was taken at start of day shift after re-steering (adjusting MAD3D00H)

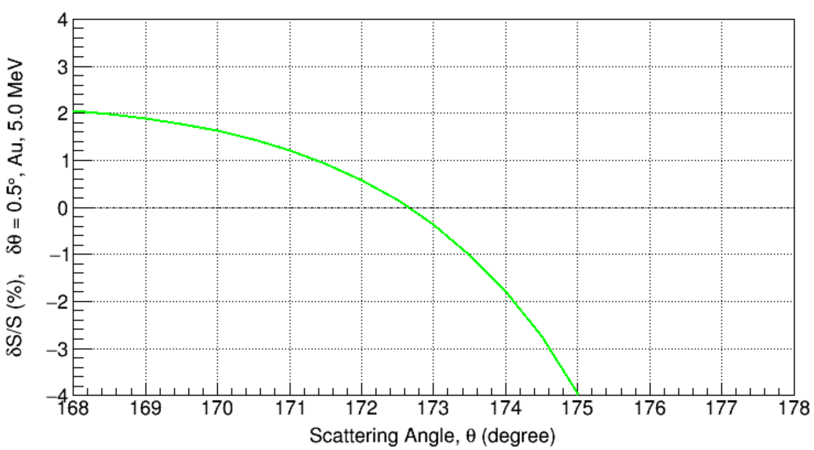
# Sensitivity to Energy and Angle

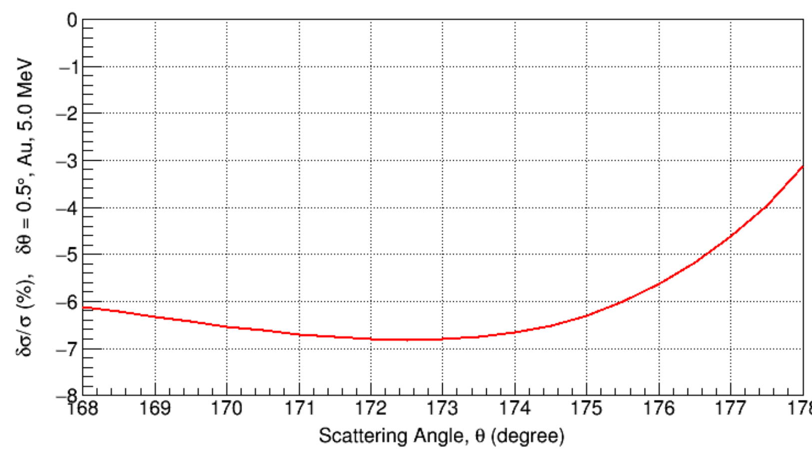
Sherman Function

Elastic Differential Cross Section



# Summary

I. Calculated single scattering rate per detector is 0.340 Hz/(µA nm)
II. We measured 75% of calculated single rate (0.255 Hz/(µA nm))with energy cut of ±5 sigma and Tof cut of ±2 sigma

III. Marty's prediction is 0.198±0.001 Hz/(µA nm) – with no energy cut

IV. Rates are independent of NIM Discriminator thresholds (Low/High) because of analysis energy cut; difference in rate found earlier is due to inconsistent fit to find mean and sigma of energy spectra
V. Rates are independent of Timing Veto (ON/OFF) because of analysis ToF cut
VI. Rates are very sensitive to beam position on foil (angle and acceptance, *i.e.* beam steering) unlike Mott asymmetries

VII. RUN II rate scan runs with Pockels Cell OFF were taken at start of RUN II with initial beam steering

# Recommendations

I. For each Mott Run, we should have: Time, I_beam, N_ave, N_trig, N_acc, R, and dR. Daniel's work is fine.

II. Not recommended to use RUN II rate scan completed at start of data taking (first owl shift) and all runs before 8433

III. Beam systematics studies should show large rate sensitivity to beam properties

IV. For target thickness extrapolation versus rate, add a systematic error to each rate measurement. This systematic error is equal to relative variation of rates of 1 μm stability runs. This reflects rate dependence on beam steerings done over data taking period.