FEE Rate Analysis

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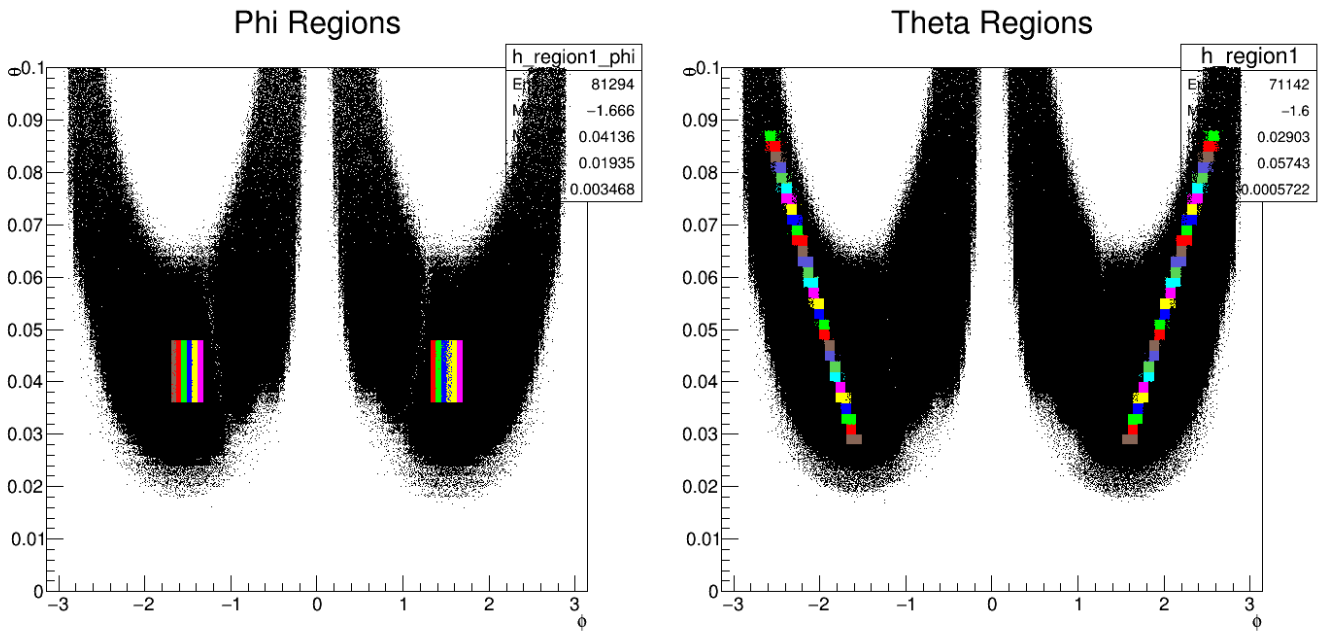
Introduction

- Pass3, V3 Detector, Singles1 Trigger
- FEE cuts - 10 ns timing window, 0.85-1.2 GeV energy cut, greater than 2 cluster size cut. All rates are matched
- FEE rates in different spherical (ϕ and θ) regions of detector. Comparison of data (tunsten and carbon targets) and MC.
- Measured differential cross section plots now included
- Data - 5771, and 5779 (Carbon); MC - 3.4.0 (Pass1)

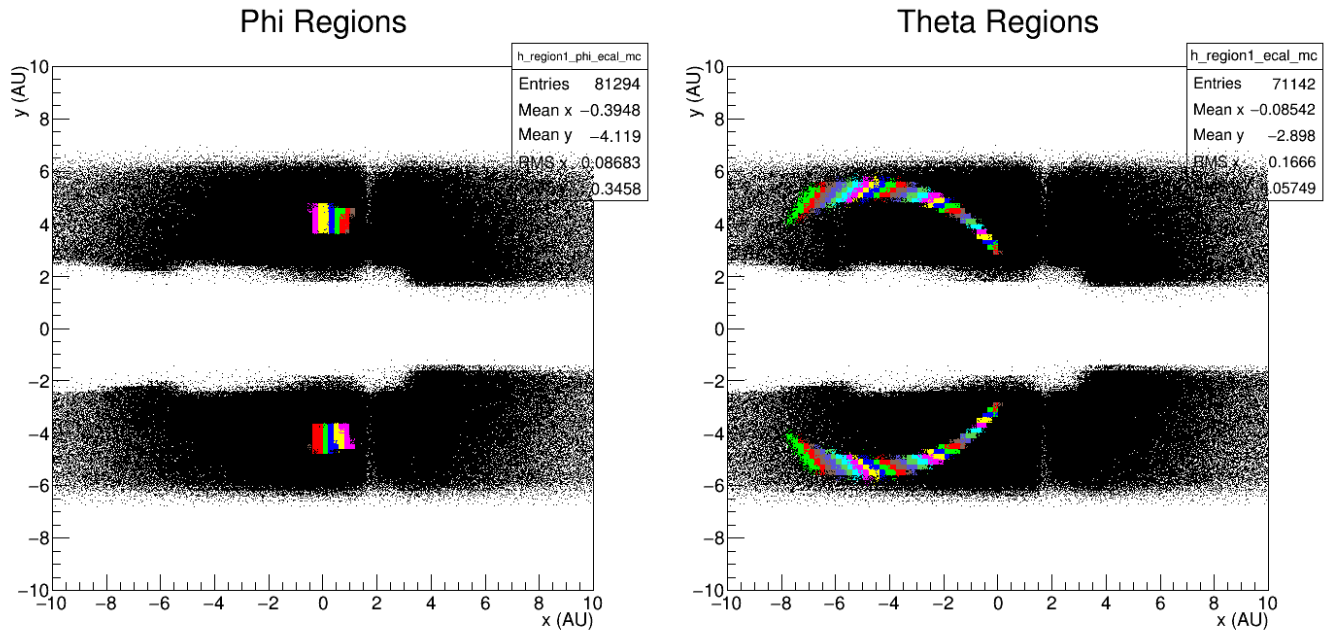
Region Definitions

- Definition of regions shown in the different colors. Black is not a part of any region
- ϕ regions (left): $\Delta\phi = 0.0666$, $0.036 < \theta < 0.048$. **This has changed!**
- θ regions (right): $\Delta\phi = 0.2$, $\Delta\theta = 0.02$



Region Definitions (Cont.)

- Definition of regions shown from previous slide in x-y coordinates
- ϕ regions (left) and θ regions (right)



Normalization

- Data normalized based on time (7200 s), current (50 nA), blind (0.1), prescale (2^{11}) and deadtime (0.85)
- Carbon run normalized based on (1800 s), current (30 nA), prescale (2^{7}), and deadtime (0.85).**Carbon is NOT blinded.**
- MC normalized based on time (calculated from file size), and current (50 nA)

Calculations

- Mott cross section with form factor

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{Z^2 e^4}{(4\pi\epsilon_0)^2 4E^2 \sin^4\frac{\theta}{2}} \left(1 - \beta^2 \sin^2\frac{\theta}{2}\right) |F(Q)|^2$$

- where $F(Q)$ is the electric form factor. For Tungsten it is

$$F(Q) = \frac{3\hbar}{(QR)^3} \left(\sin\frac{QR}{\hbar} - \frac{QR}{\hbar}\cos\frac{QR}{\hbar}\right)$$

- where R is the nuclear radius and Q is the positive transferred 4-momentum which is given in the high energy limit

$$Q^2 = 4EE' \sin^2\frac{\theta}{2}$$

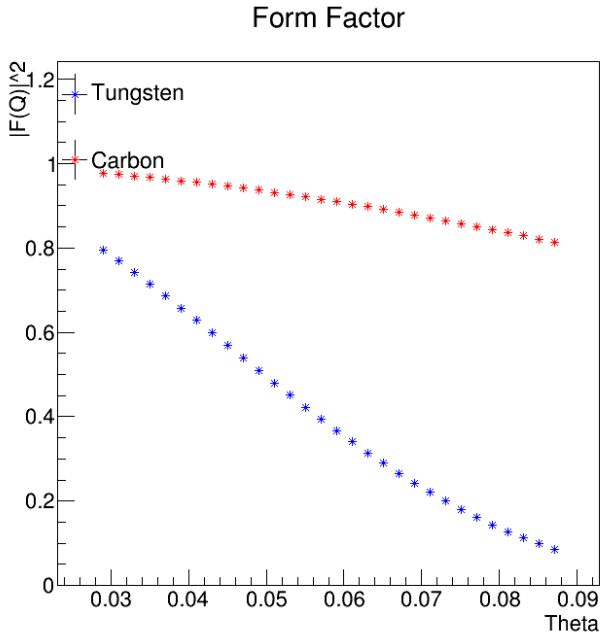
- where E' is the scattered electron energy

$$E' = \frac{E}{1 + \frac{2E}{M}\sin^2\frac{\theta}{2}}$$

Form Factor

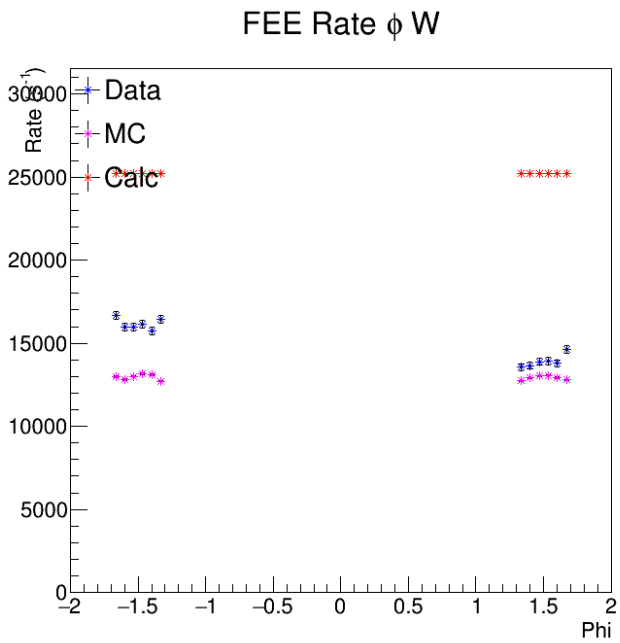
- Form factor for tungsten does not take into account nuclear surface affects.
  - This could be the reason for discrepancy for large θ
- New form factor for carbon. Valid for $4 < Z < 12$

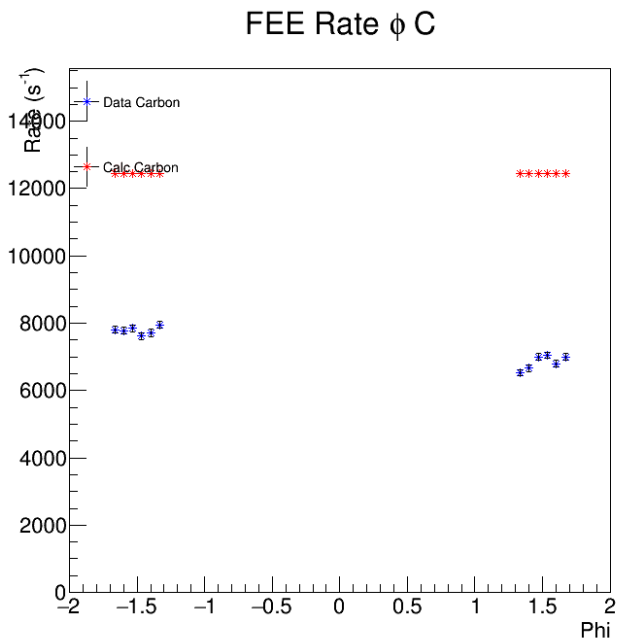
$$F(Q) = (1 - \frac{Z-2}{6Z} a^2 Q^2)\ e^{-\frac{1}{4} b^2 Q^2}$$



FEE Rate of ϕ Regions

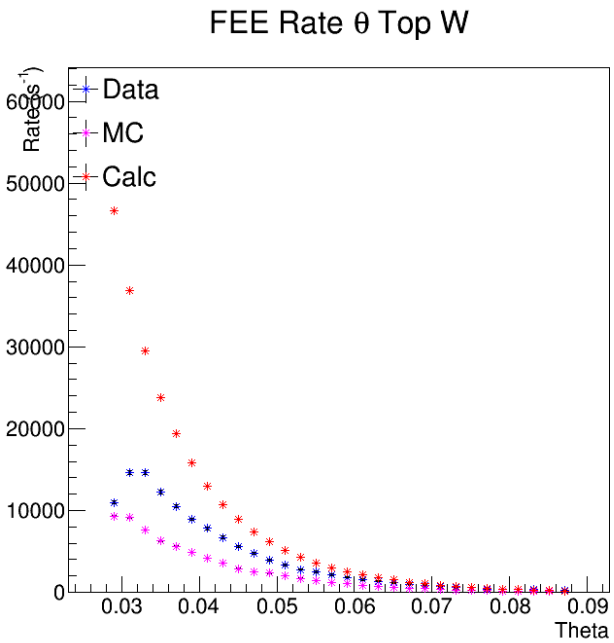
- Comparison of ϕ regions, should be constant
- Tungesten on the left and carbon on the right

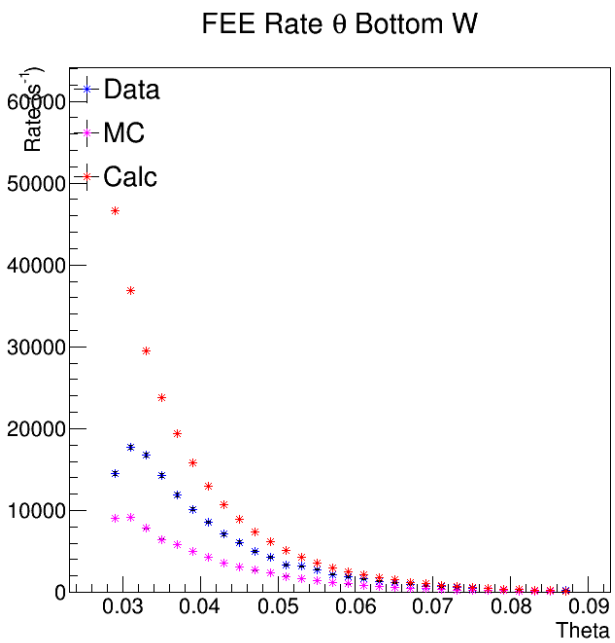




FEE Rate of θ Regions Tungsten

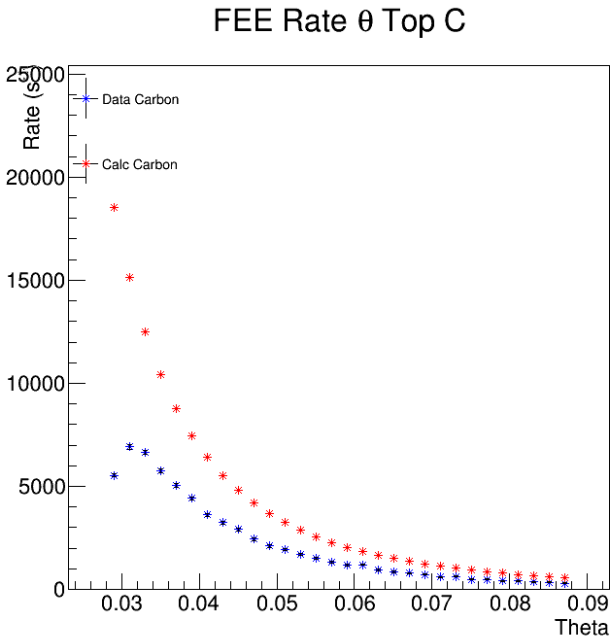
- Data matches calculation up to a factor of about 2
- All MC is re-scaled from here on:
  $Rate_{MC} \rightarrow Rate_{MC}|F(Q,\theta)|^2$
  - MC still not "uncorrected" for Thomas-Fermi Form Factor

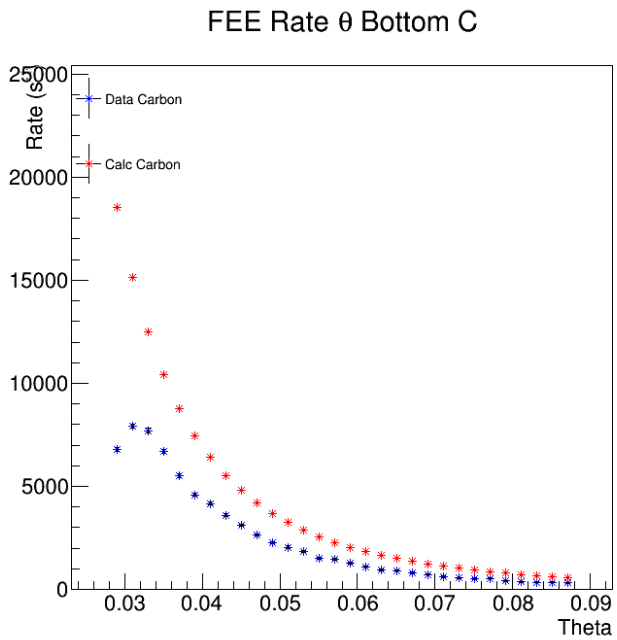




FEE Rate of θ Regions

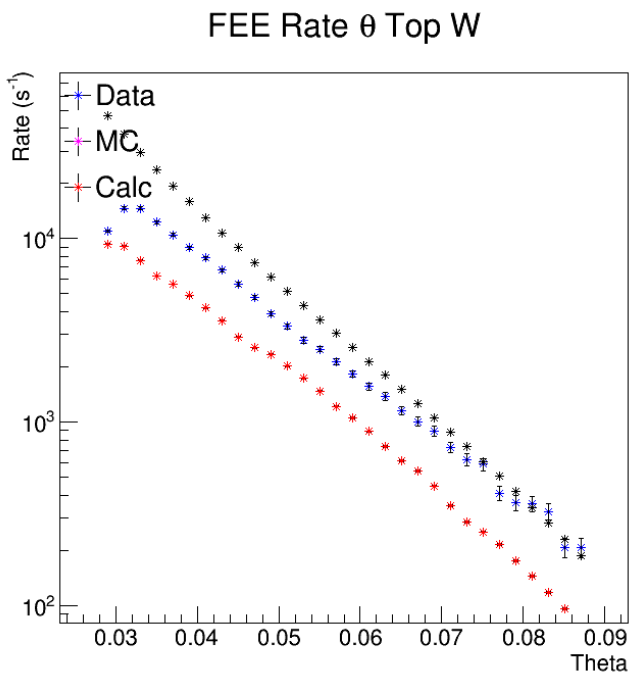
- Carbon data also matches calculation up to a factor of about 2
- **There is a decrease in rate at small θ. Why?**

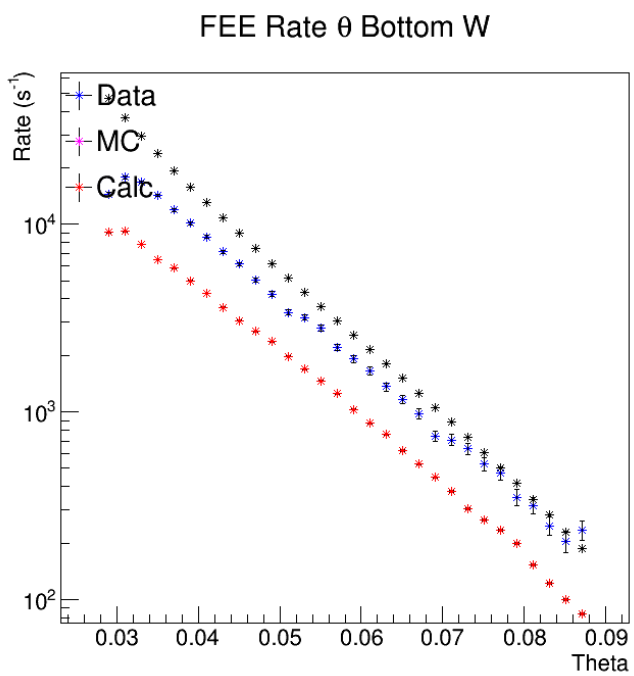




FEE Rates of Calculation Compared to Data or MC in θ

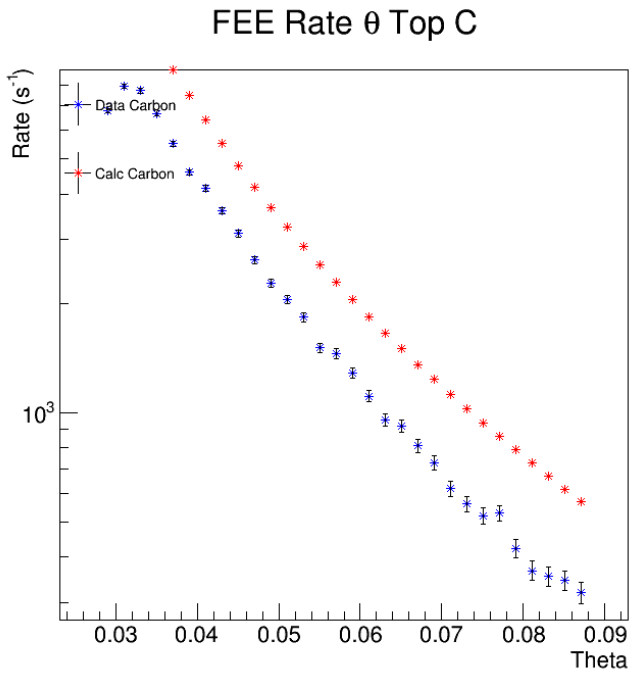
- Comparison of Calculation (Mott Scattering) Rates to Data and MC log scale for tungsten

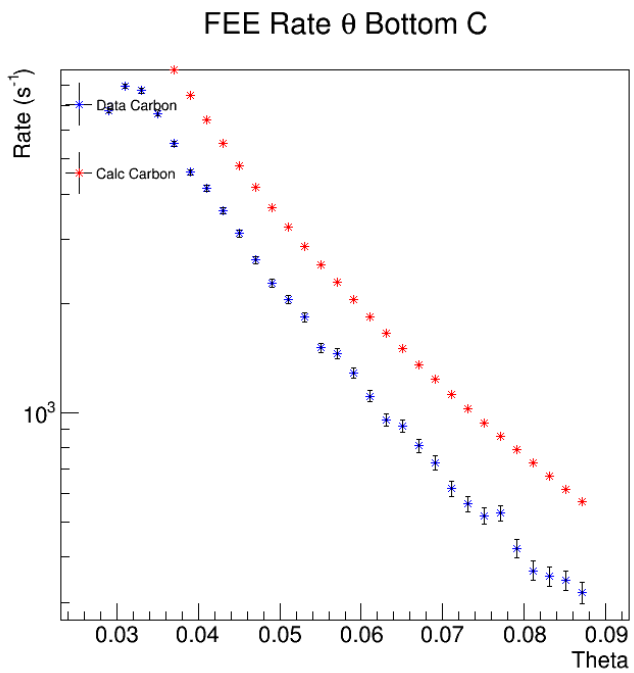




FEE Rates of Calculation Compared to Data or MC in θ

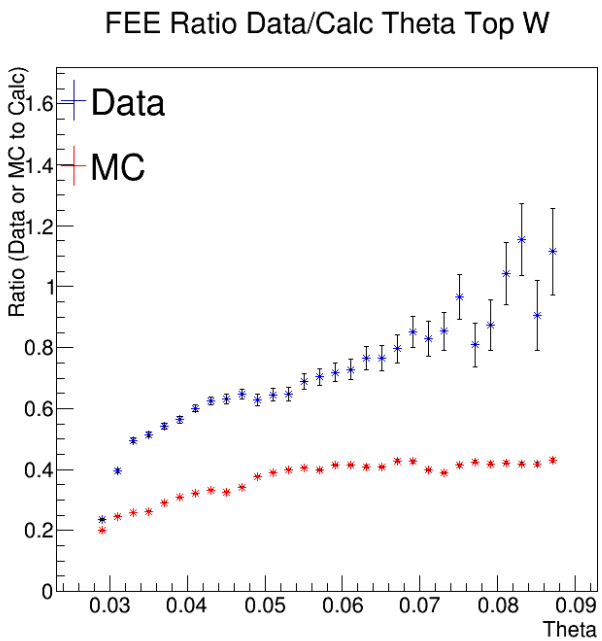
- Comparison of Calculation (Mott Scattering) Rates to Data and MC log scale for carbon

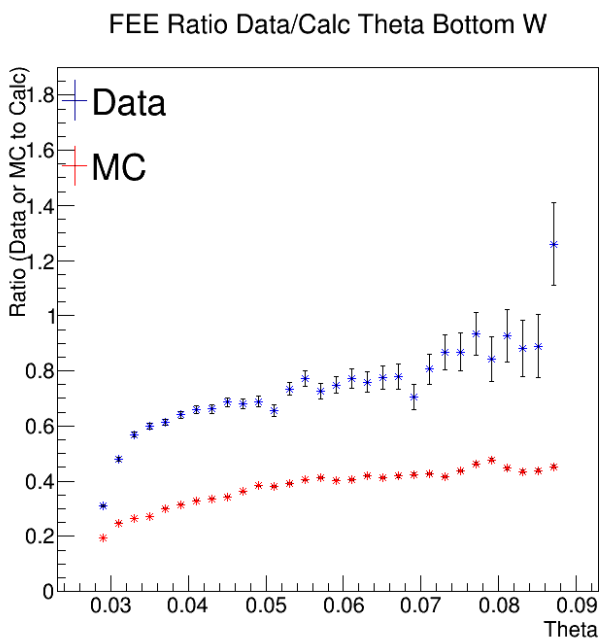




FEE Ratio of Calculation to Data or MC in θ for Tungsten

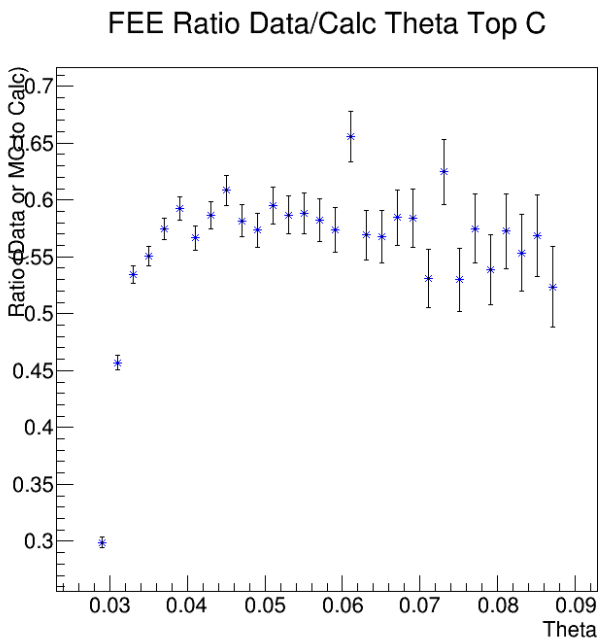
- Comparison of the ratios of Data and MC to Calculation (Mott Scattering): $\frac{\text{MC or Data Rate}}{\text{Calc Rate}}$
- The data, MC, and calculations are off by about a constant factor
- The data and MC both show a decrease in rates at small θ

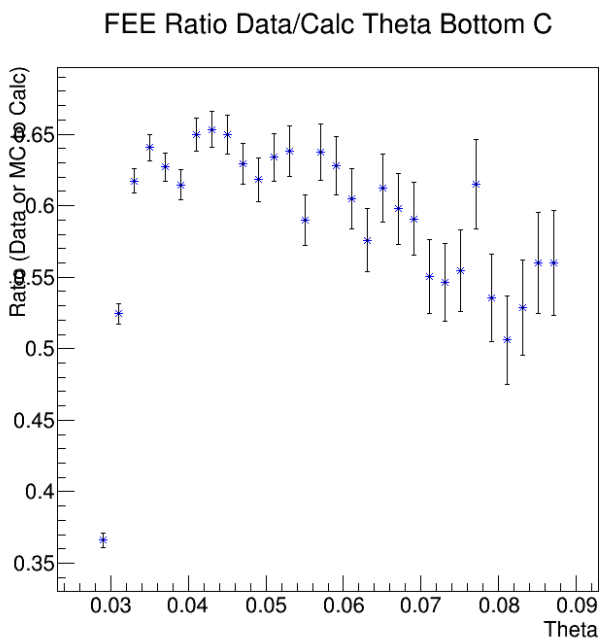




FEE Ratio of Calculation to Data or MC in θ for Carbon

- Comparison of the ratios of Data and MC to Calculation (Mott Scattering): $\frac{\text{Data Rate}}{\text{Calc Rate}}$
- The data and calculations are off by about a constant factor - very similar to tungsten
- The carbon data shows a decrease in rates at small θ

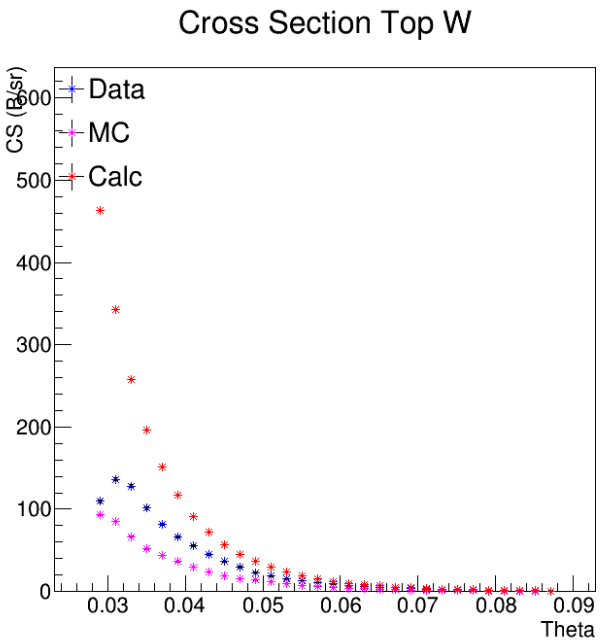


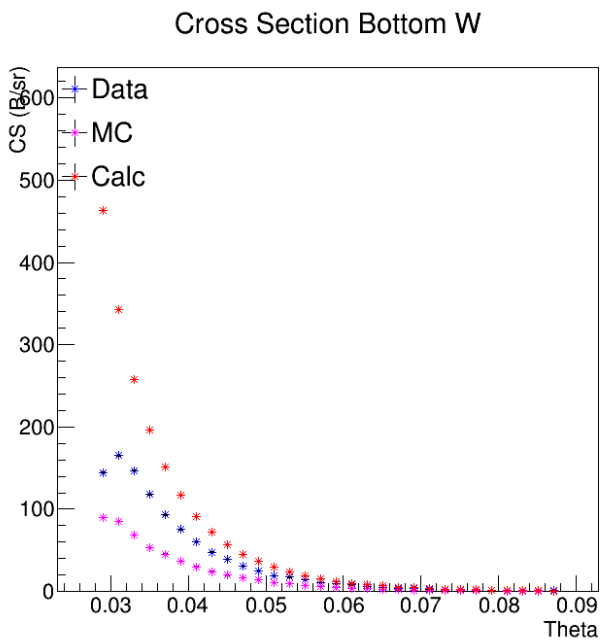


FEE Differential Cross Sections Tungsten

$$\frac{d\sigma}{d\Omega} = \frac{1}{L\Delta\Omega}\frac{dN}{dt}$$

- Differential cross section $\frac{d\sigma}{d\Omega}(\theta)$ for tungsten in both top and bottom compared to calculations

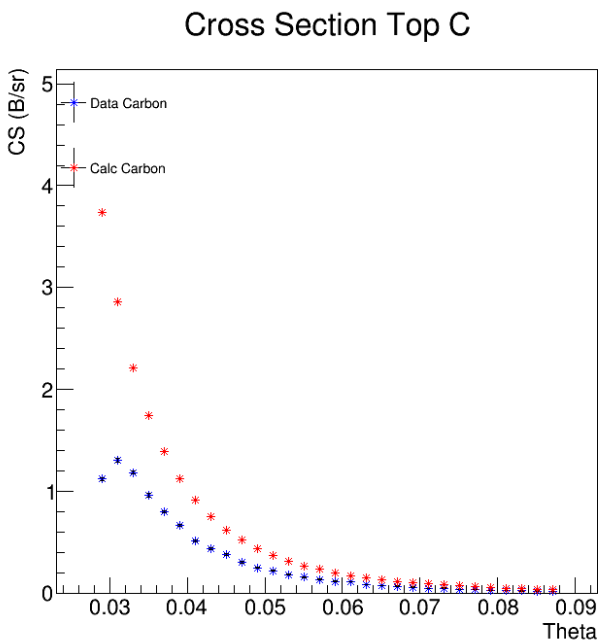


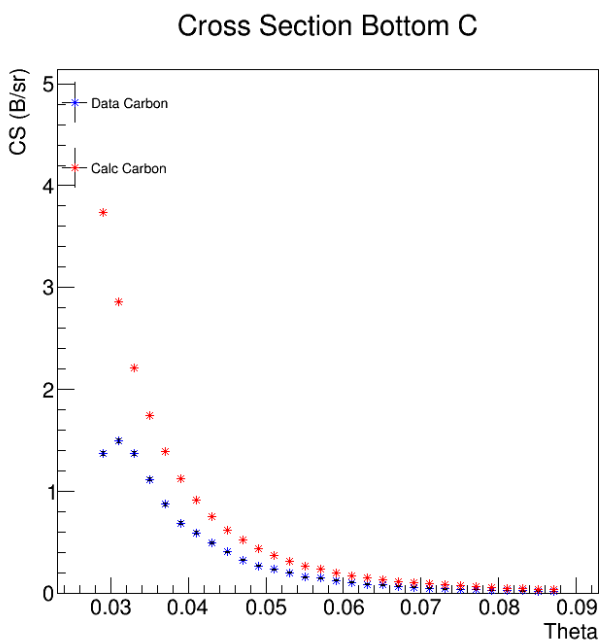


FEE Differential Cross Sections Carbon

$$\frac{d\sigma}{d\Omega} = \frac{1}{L\Delta\Omega}\frac{dN}{dt}$$

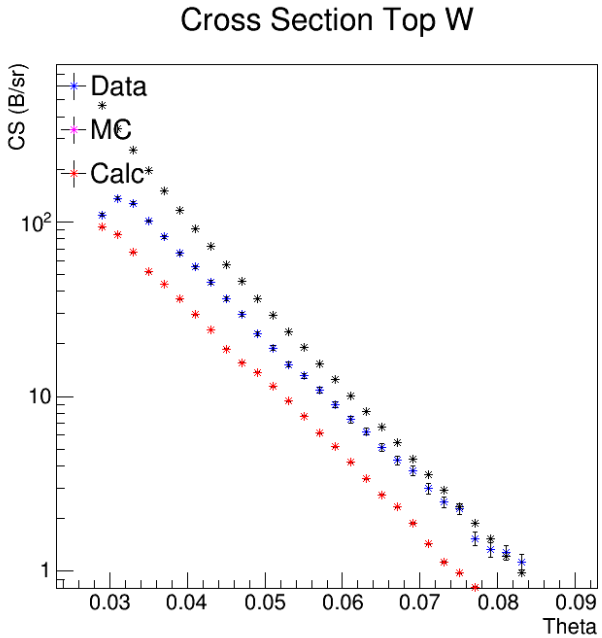
- Differential cross section $\frac{d\sigma}{d\Omega}(\theta)$ for carbon in both top and bottom compared to calculations

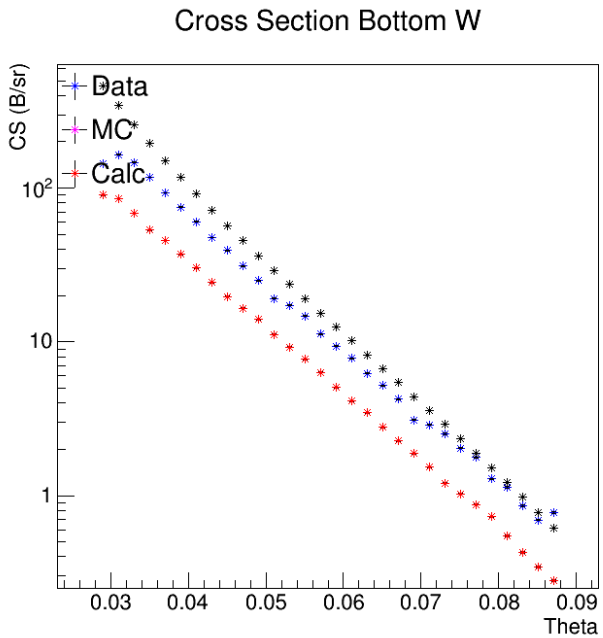




FEE Differential Cross Sections Tungsten Log

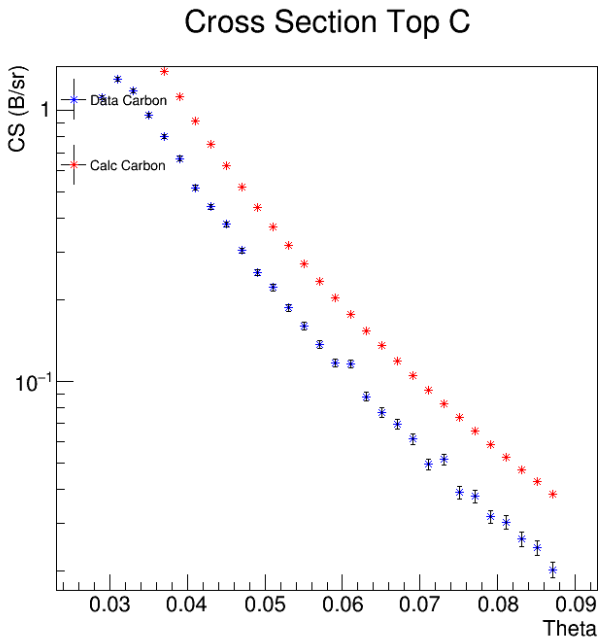
- Differential cross section $\frac{d\sigma}{d\Omega}(\theta)$ for tungsten in both top and bottom compared to calculations

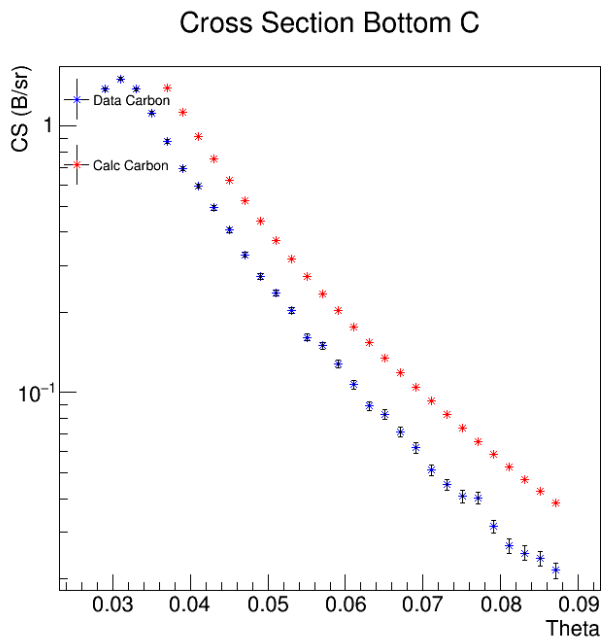




FEE Differential Cross Sections Carbon Log

- Differential cross section $\frac{d\sigma}{d\Omega}(\theta)$ for carbon in both top and bottom compared to calculations





Conclusions

- Trends in data and corrected MC are matching calculation in both tungsten and carbon
- Differential cross section successfully measured?
- There are still unanswered questions
  - A factor of 1.5 between calculation and both tungsten and carbon data. A larger discrepancy between calculations and MC
  - A decrease in rates at small θ in both data and MC for tungsten and carbon