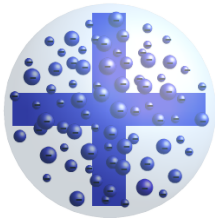


# Rutherford Scattering Detection through Gold Foil

Henry Shackleton

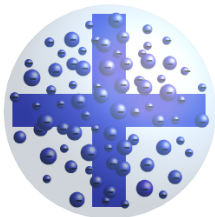
April 27, 2017

# Plum Pudding and Rutherford Models Predict Different Scattering Behavior



**Plum Pudding Model**

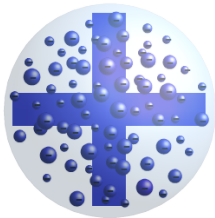
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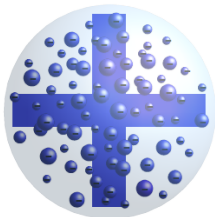
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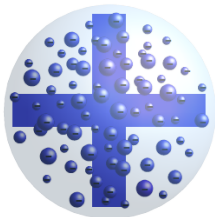
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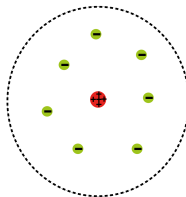
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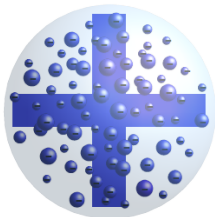
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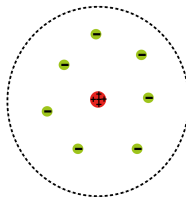
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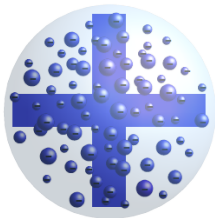
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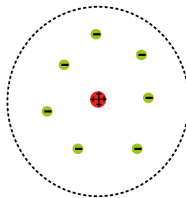
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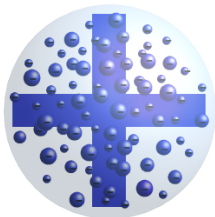


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- Electrons surround a concentrated positive charge
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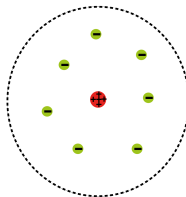


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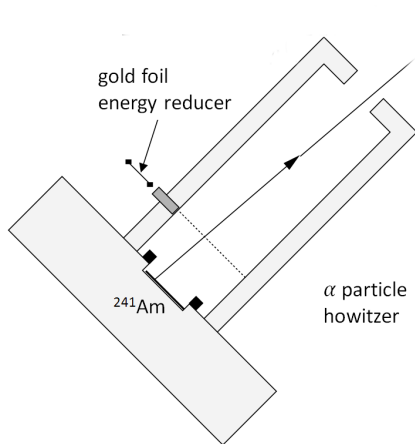
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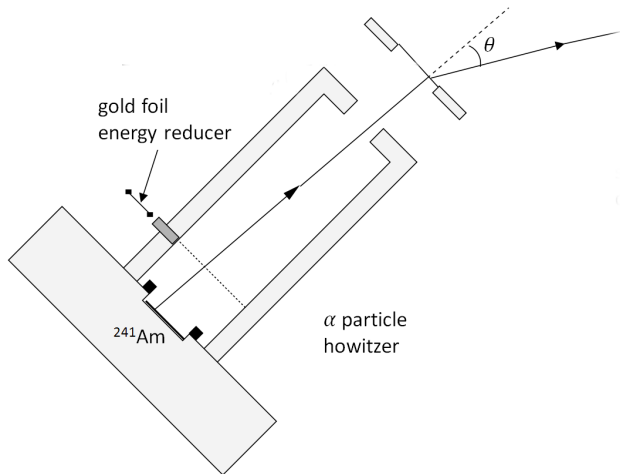
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- $F(\theta) \propto \frac{1}{\sin^4(\theta/2)}$

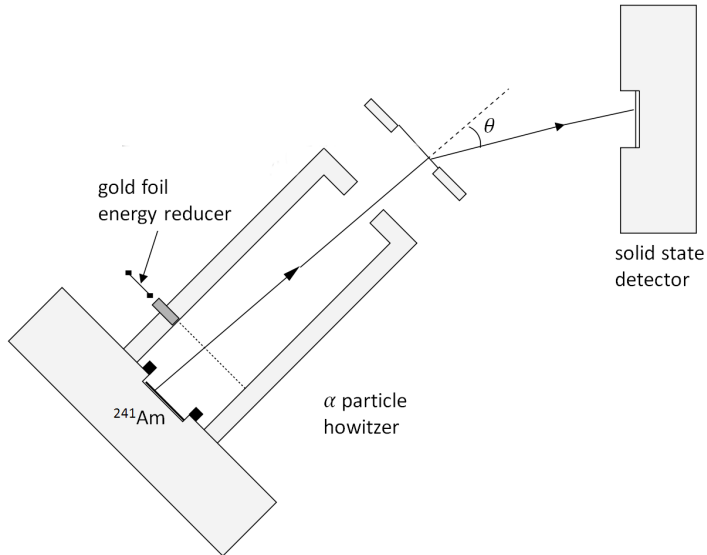
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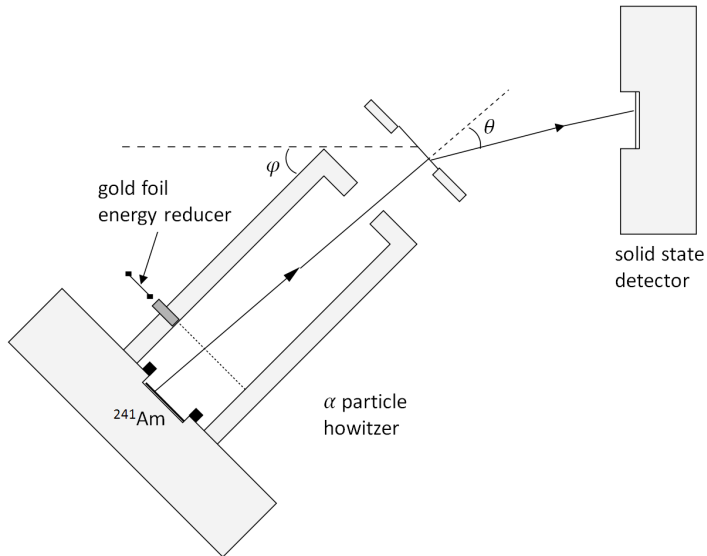
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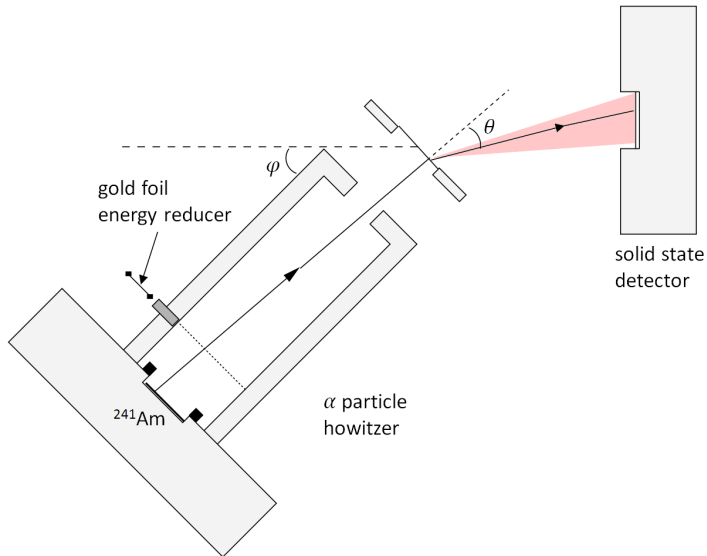
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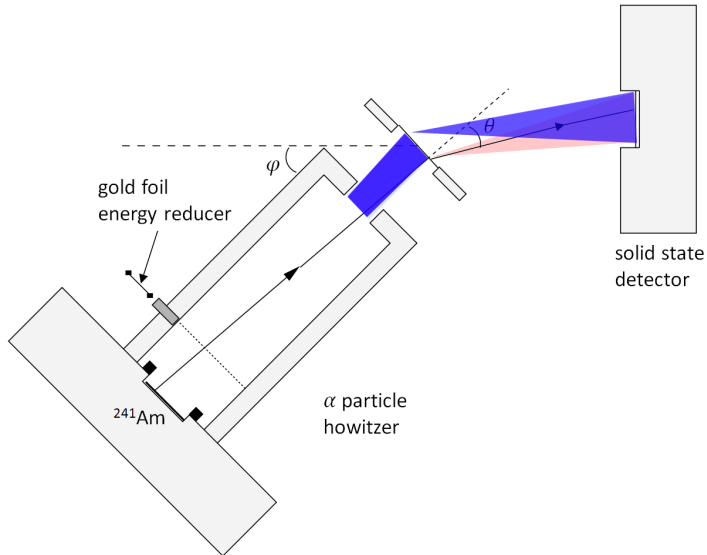
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# Geometry of Detector Leads to Deviations from Scattering Predictions

- With the howitzer at an angle  $\phi$ , what is the probability of detecting a particle scattered between  $\theta$  and  $\theta + d\theta$ ?



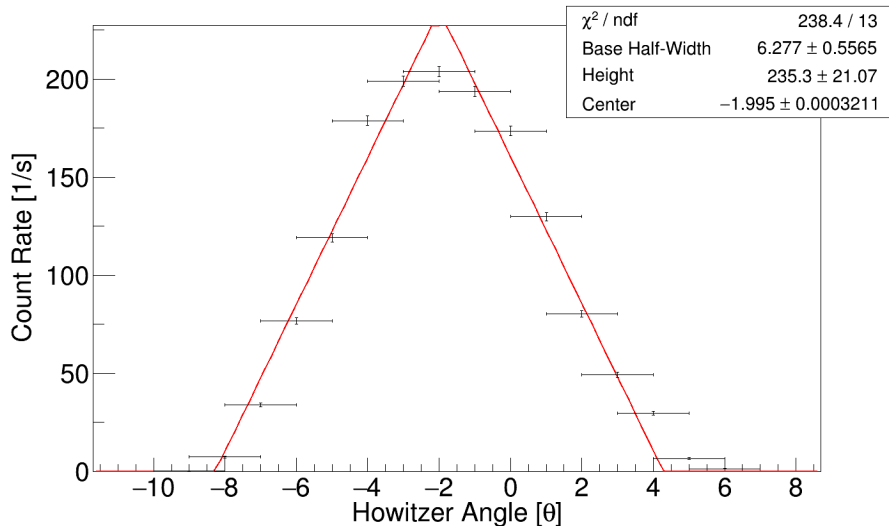
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- Ideally,  $P(\theta) = \delta(\theta - \phi)$ .
- Realistically, we expect roughly a triangle-shaped distribution.

# Beam Profile Indicates Both Angular Spread and Systematic Angular Offset



# Convolving Beam Profile Corrects for Beam/Detector Width

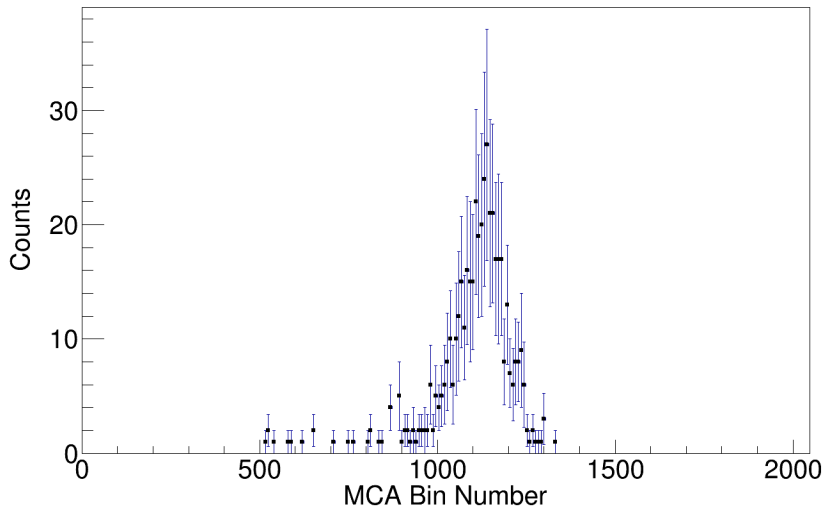
## Rutherford

$$C_r(\phi) = C_{r,0} \int_0^{\pi} g(\phi, \theta) \sin^{-4}(\theta/2) d\theta$$

## Thomson

$$C_t(\phi) = C_{t,0} \int_0^{\pi} g(\phi, \theta) e^{-\frac{\theta^2}{\theta_m^2}} d\theta$$

# MCA Readout Centered Around Energy Range



# Uncertainty in Angles and Counting Rates Contribute to Overall Uncertainty

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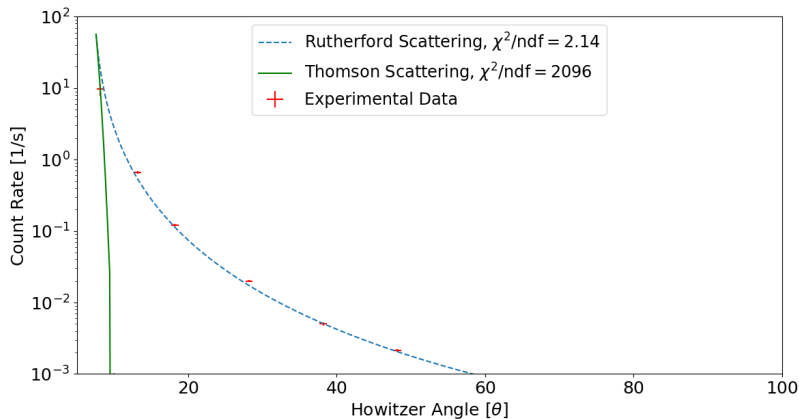
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## Angular Uncertainty

- Protractor read by eye contributes  $\pm 1$  degree uncertainty to angular measurements

# Rutherford Scattering Effectively Predicts High-Angle Scattering



# Uncertainty in Convolution Contributes Small Uncertainty in $\chi^2/\text{ndf}$

Model	$\chi^2/\text{ndf}$
Rutherford	$2.14 \pm 0.11$
Thomson	$2096 \pm 24$

# Rutherford Model Predicts High-Angle Scattering



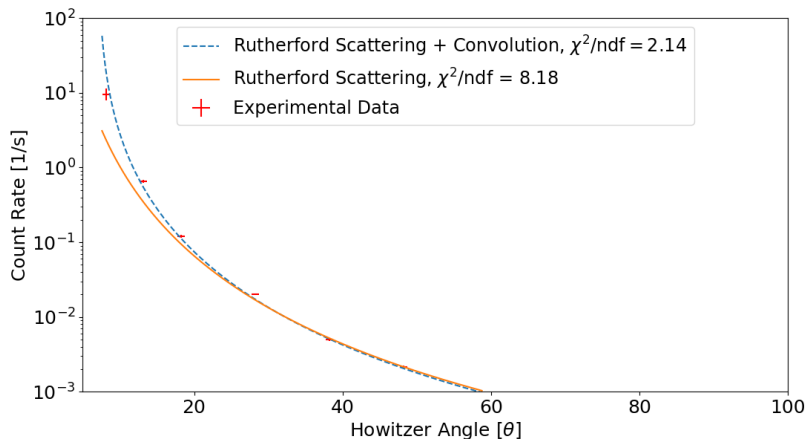
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- Rutherford model predicts these trends more accurately, leading one to suspect a Rutherford-like atomic model

# Convolution Improves Results from Raw Rutherford Fit



# Thomson with Free $\theta_m$ Unable to Capture Data

