Compton Scattering

Investigating electron rest-mass

Dominik Szablonski and Nicholas Smith

February 18, 2025

Aims and Goals of the Experiment

- Find the rest mass of the electron by observing Compton scattering at various angles
- To understand the nature of Compton scattering of the γ rays of a Cs-137 source, as observed by a Sodium-Iodine scintillation detector.
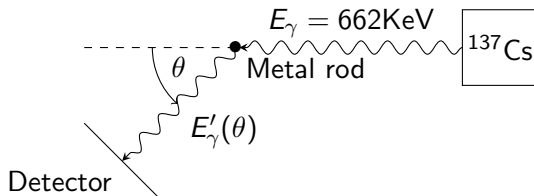
Apparatus

Figure 1: The setup for the experiment – θ is variable from -10 to 120 degrees
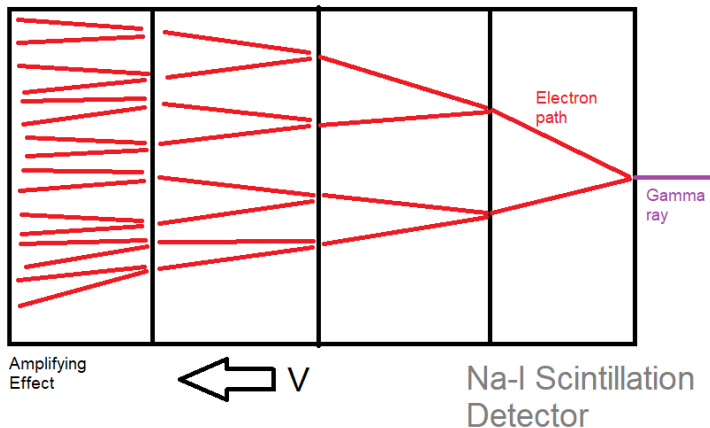
Detector

Figure 2: A mockup of how the Sodium-Iodine detector amplifies the initial incident γ ray.

Compton Scattering
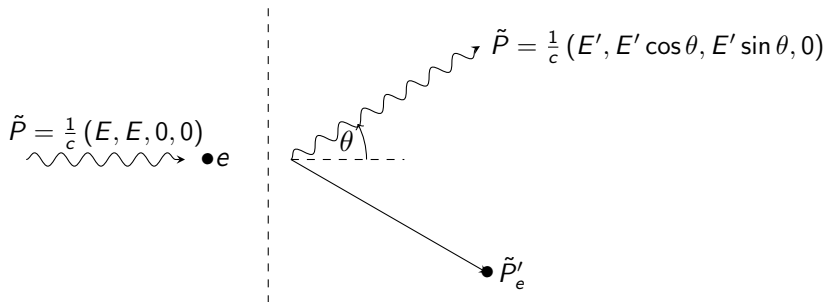

Figure 3: The setup for the experiment – θ is variable from -10 to 120 degrees

$$\frac{1}{E'} = \frac{1}{E} + \frac{1 - \cos\theta}{m_e c^2} \tag{1}$$
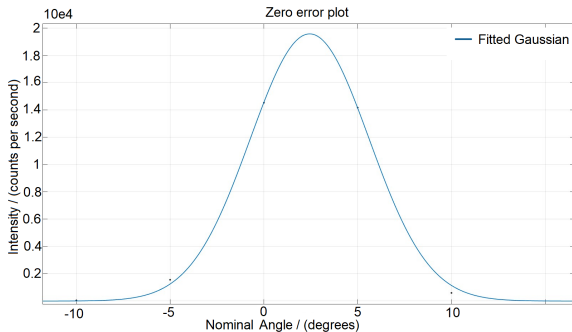
Experimental History

Figure 4: The plot for zero error of the apparatus

The angle of the detector was varied from -10 to 10 degrees as marked by the apparatus. A Gaussian was fitted to the intensity, whose peak was noted to be the zero angle, $(2.2337 \pm 0.0924)°$.
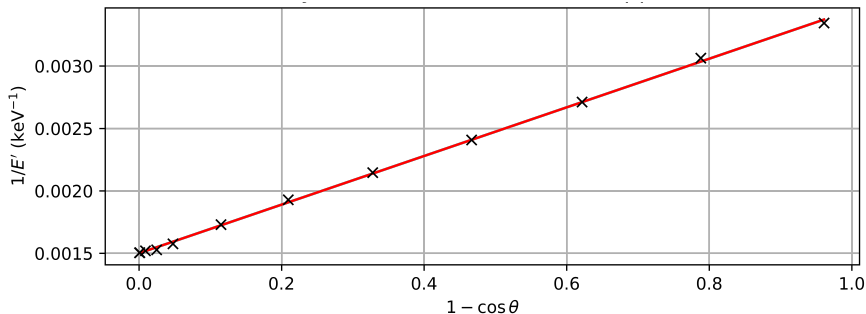
Results

Figure 5: $\chi^2_R = 189.57$

$$E_\gamma = (666.67 \pm 2.89)\,\text{keV} \qquad m_e = (513.29 \pm 3.03)\text{keV}/c^2$$

Discussion of Errors

Random Error

- The main source of random error was in detecting peak energy.
    - Attempted to reduce by allowing apparatus to collect data for as long as possible.

Systematic Error

- Zero offset error of $(2.2337 \pm 0.0924)°$, corrected for.
- Slight offset in incoming energy due to earth's magnetic field, corrected for by scaling energies at each angle.
- Despite this, we still found the y-intercept (which should be ≈ 661.7 keV) to be higher than expected.

Conclusions

- The value for the electron mass was calculated to be (513.29 ± 3.77) keV/c^2, this value compares well to literature.
- A lot of care was taken to minimise systematic error, but some may still remain given the y-intercept of Figure 5 was only accurate within 2σ