Compton Scattering I:

Compton Kinematics and the Determination of mc^2

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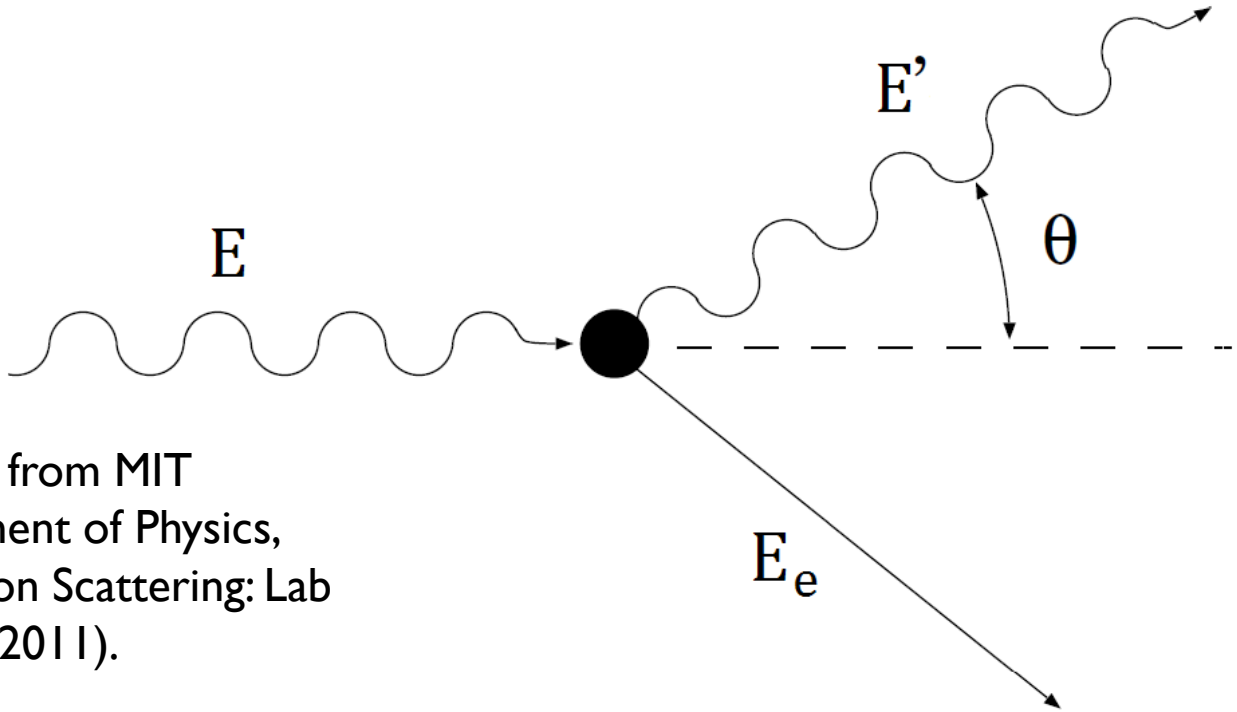
Theory: Compton Kinematics



Adapted from MIT Department of Physics, "Compton Scattering: Lab Guide" (2011).

- Wavelength shift is unexplained by classical theory of Thomson scattering

Theory: Compton Kinematics

- Compton scattering relation:

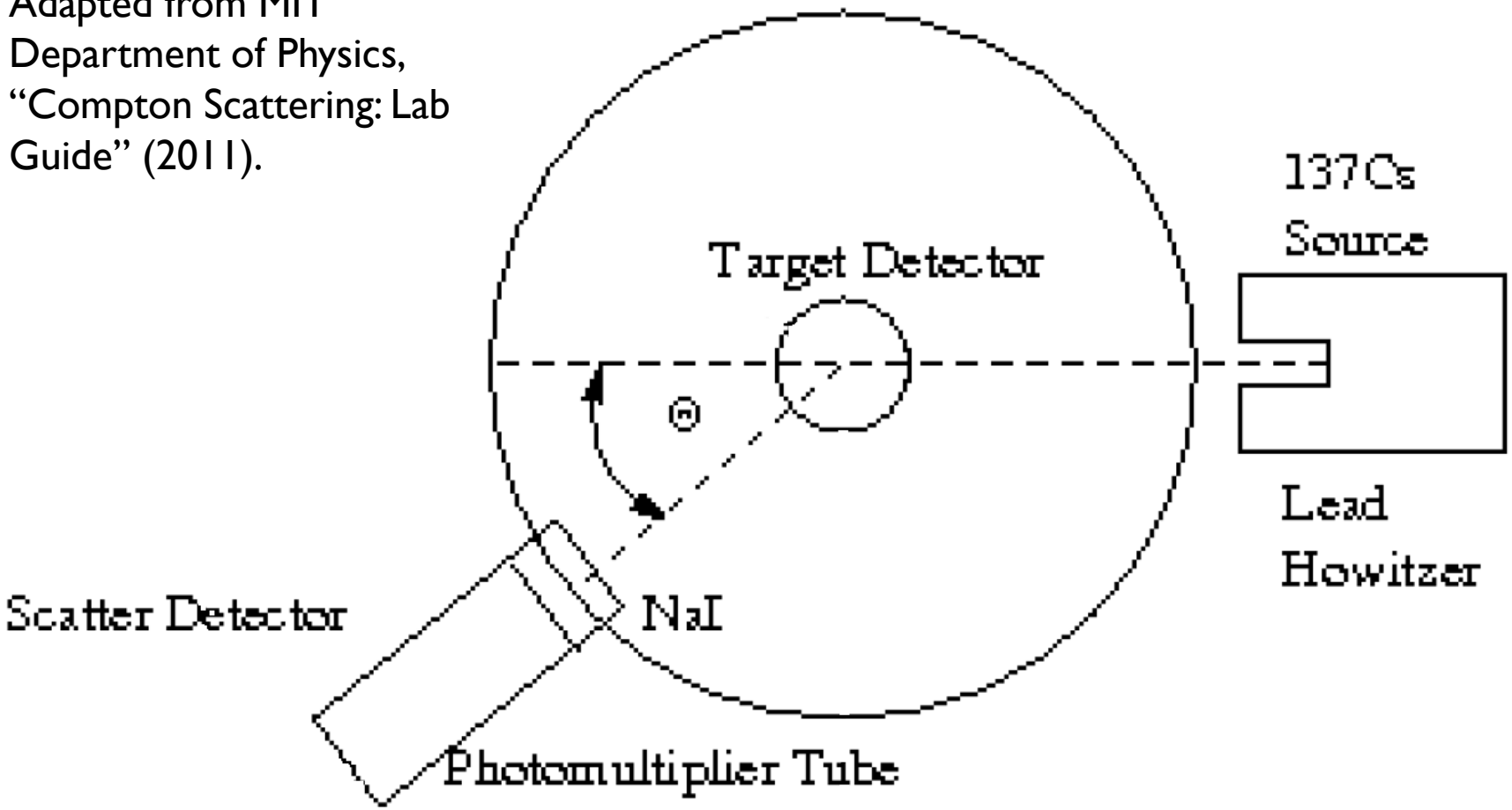
$$\frac{1}{E'} - \frac{1}{E} = \frac{1}{mc^2}(1 - \cos\theta)$$

- Recoil electron energy: $E_e = E - E'$

$$\frac{1}{E_e} - \frac{1}{E} = \frac{mc^2}{E^2}\frac{1}{1 - \cos\theta}$$

Experimental Setup

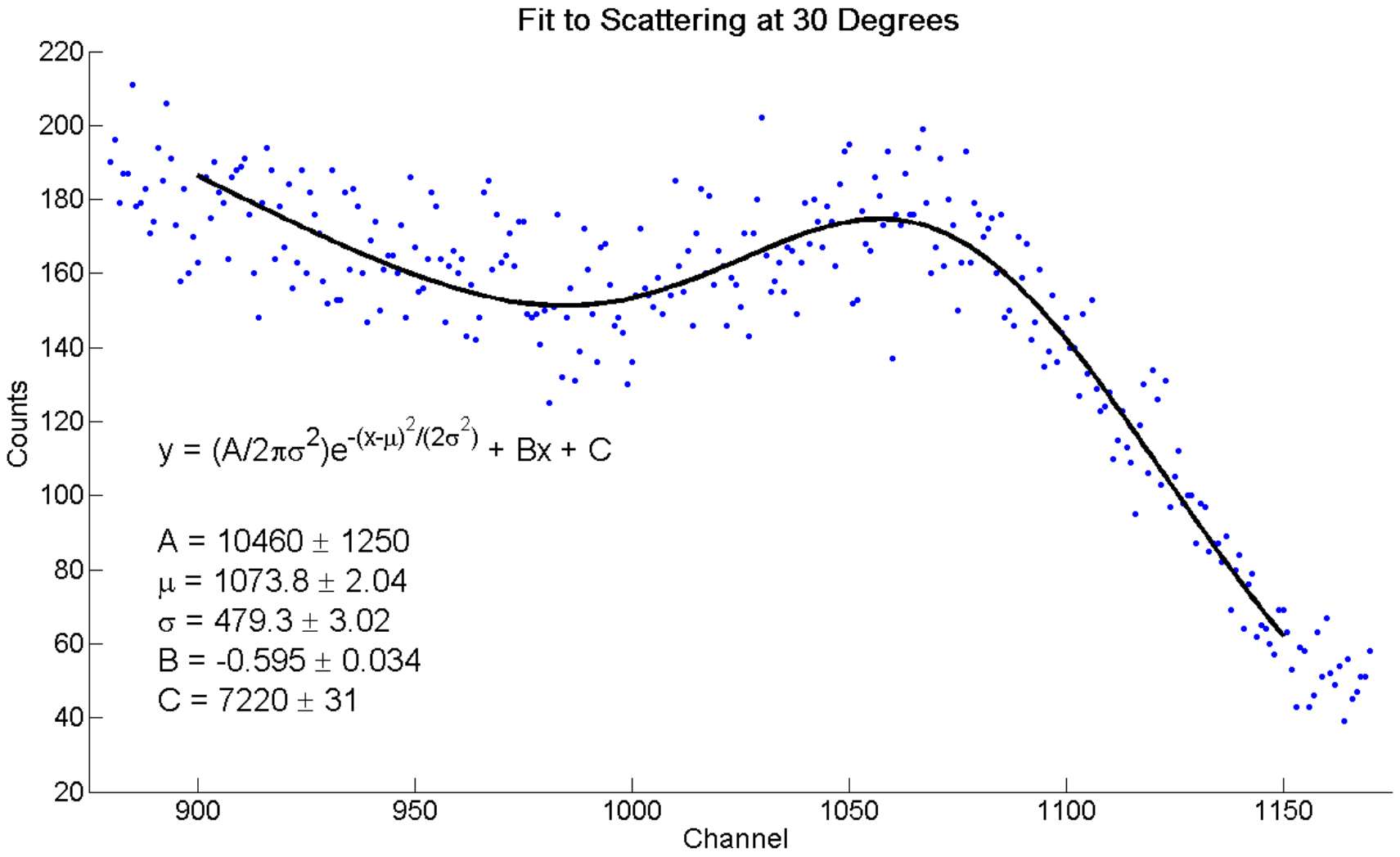
Adapted from MIT Department of Physics, "Compton Scattering: Lab Guide" (2011).



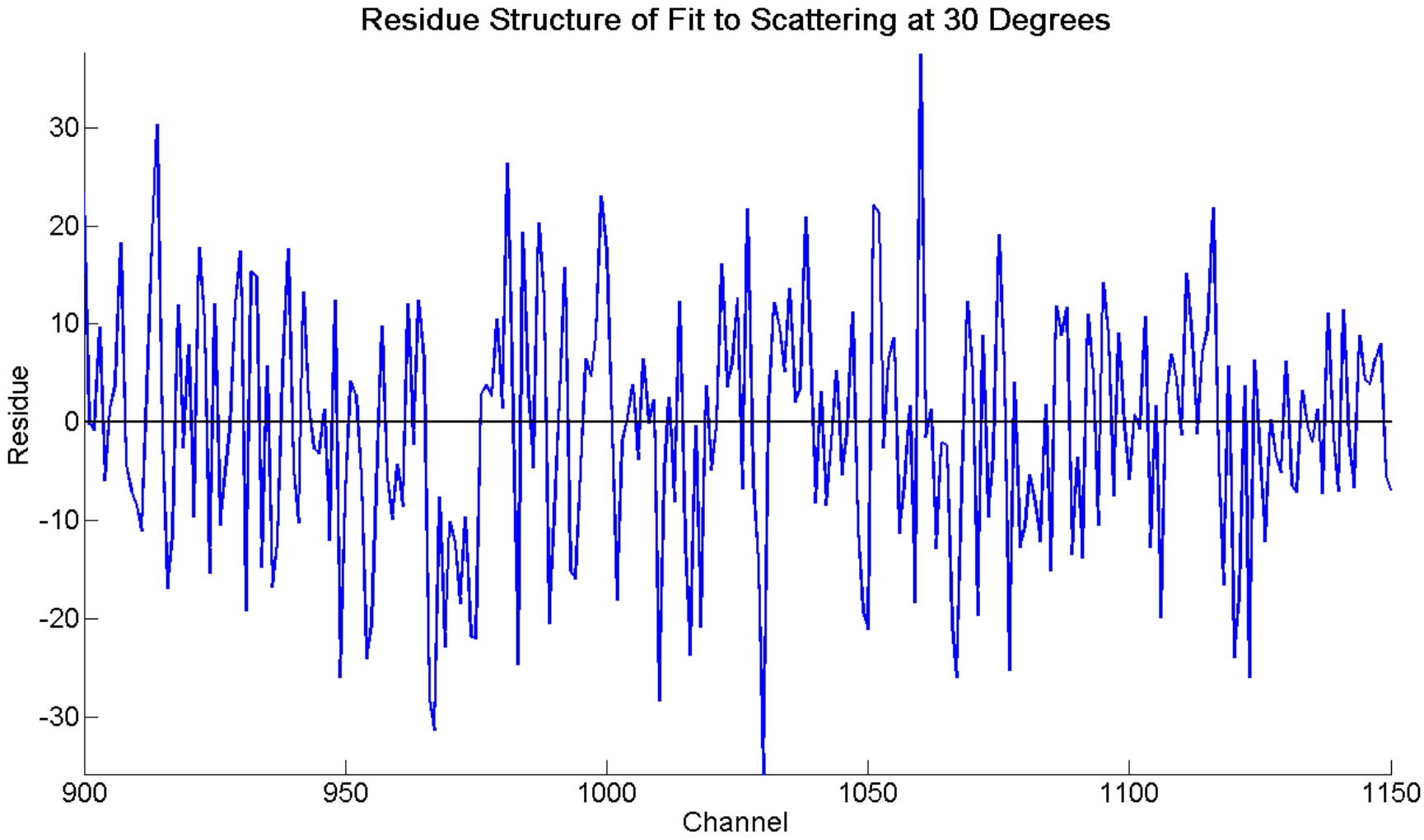
Procedure

- Calibrate amplifier and signal chain gain
- Obtain MCA spectra on coincidence at various angles
- Determine peaks
  - Scattering detector: Photopeak of scattered photons, at E'
  - Recoil detector: Portion of Compton continuum coinciding with scatter, at E_e

Fit Procedure



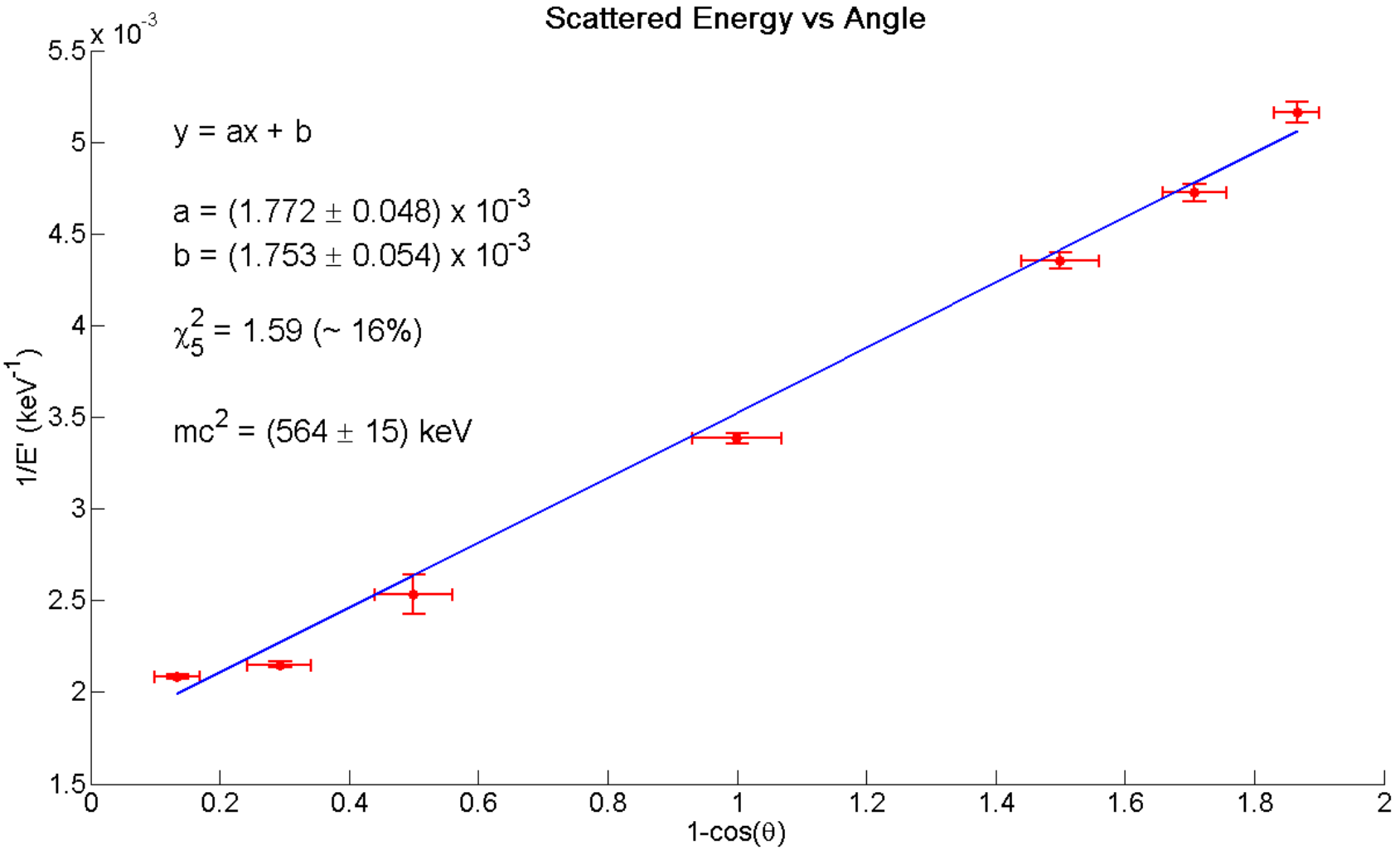
Fit Procedure



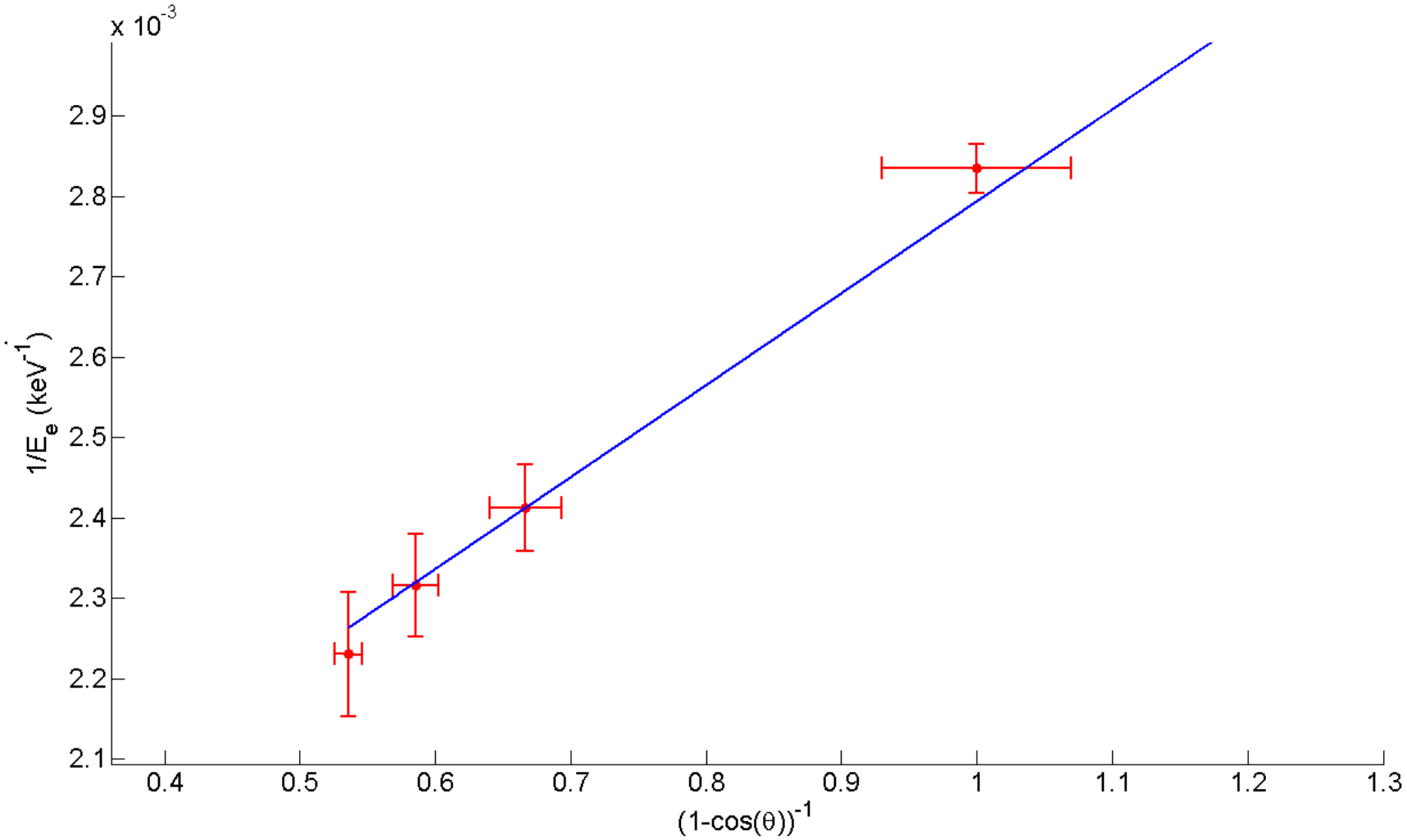
Data

Angle	Detector	Energy (keV)	Theory (keV)
30	S	479.7 ± 3.2	563.8
30	R	167.7 ± 2.0	97.80
45	S	465.3 ± 3.2	479.7
45	R	179.9 ± 2.1	181.9
60	S	394.7 ± 16	401.6
60	R	243.1 ± 3.0	260.0
90	S	295.5 ± 2.6	288.3
90	R	352.8 ± 2.6	373.3
120	S	229.7 ± 2.2	224.9
120	R	414.5 ± 2.8	436.7
135	S	211.6 ± 2.1	206.1
135	R	431.8 ± 2.9	455.5
150	S	193.7 ± 2.1	193.7
150	R	448.4 ± 2.9	467.9

Analysis


Scattered Energy vs Angle
x 10^-3
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1/E' (keV^-1)
y = ax + b
a = (1.772 ± 0.048) x 10^-3
b = (1.753 ± 0.054) x 10^-3
χ²5 = 1.59 (~ 16%)
mc² = (564 ± 15) keV
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
1-cos(θ)

Analysis


x 10^-3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
1/E_e (keV^-1)
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
(1-cos(θ))^-1

Conclusions

- Verified Compton scattering formula

- Obtained a best estimate of mc^2:
  - (552 ± 15 ± 73) keV

Question and Answer