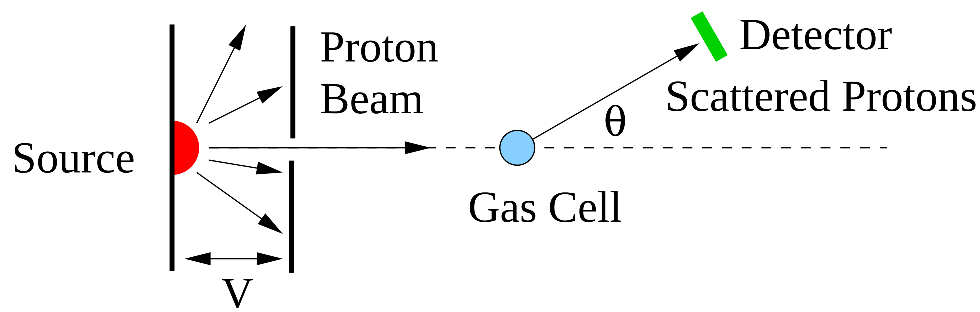
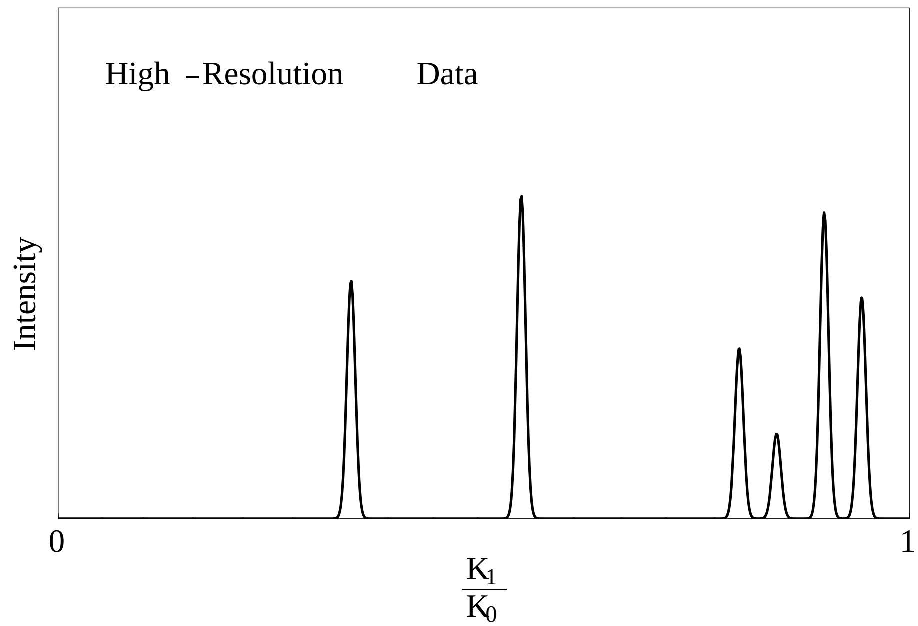
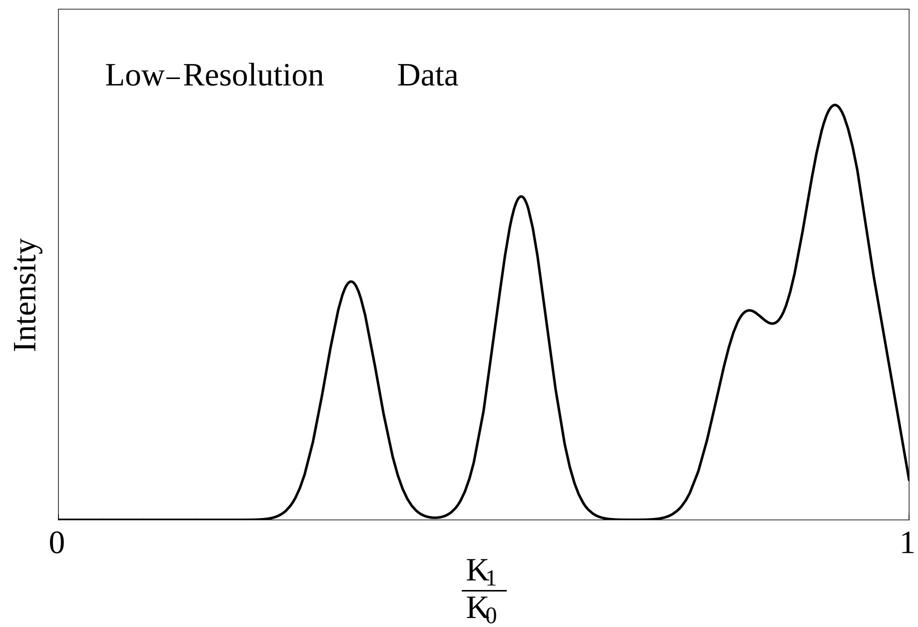
Chemical Analysis

Consider the design of a spectrometer to determine the components of a gas. A proton beam is accelerated across the voltage $V = 1000\ eV$ and strikes the gas. The energy and angle of the elastically scattered protons are measured with the detector as shown. The goal is to separate carbon from oxygen in the gas mixture using the energy of the scattered protons. What is the ratio of the incoming to outgoing proton energy as a function of scattering angle? The energy resolution of the detector is about $10\ eV$ and the data can be collected quickly if the detector is at a forward angle. What is the optimum angle to place the detector to enhance the energy separation of protons elasticallly scattered off oxygen and carbon and to perform the measurement quickly?

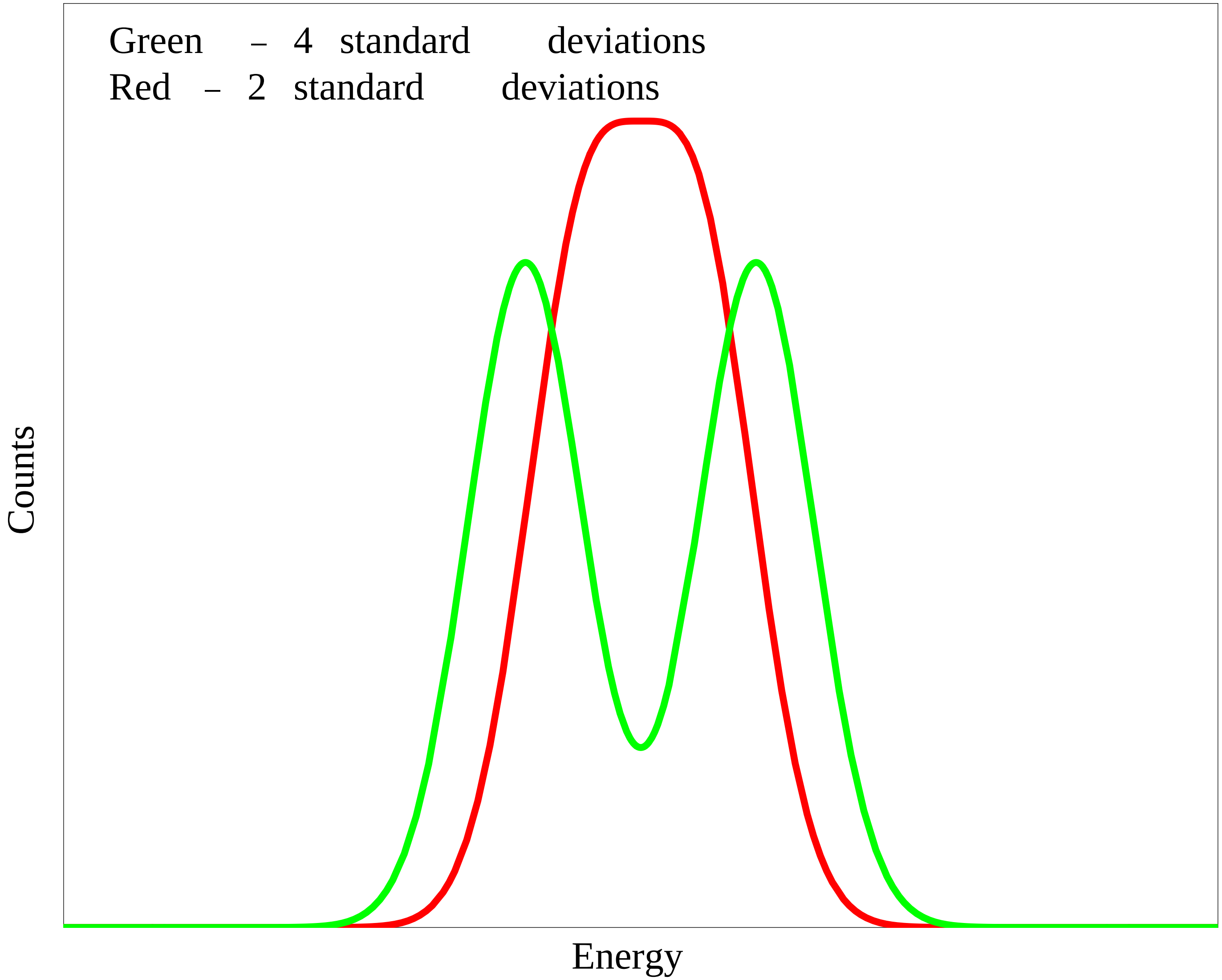


Low- versus High-Resolution Data





Choosing the Separation



Newton's Laws

1. Consider a body with no net force acting on it. If it is at rest, it will remain at rest. If it is moving with a constant velocity, it will continue to move at that velocity.

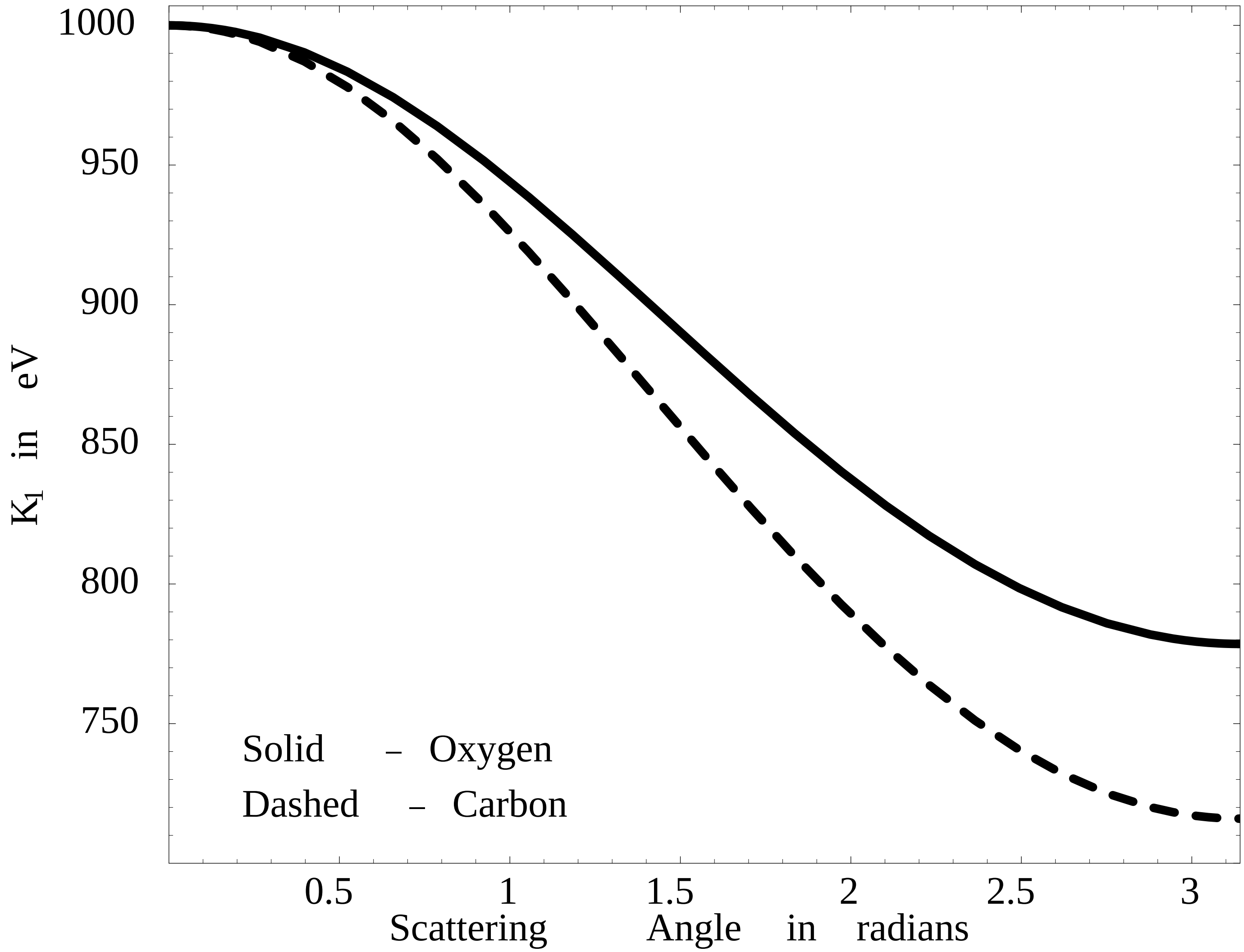
2. For all the different forces acting on a body

$$\sum \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt} \qquad .$$

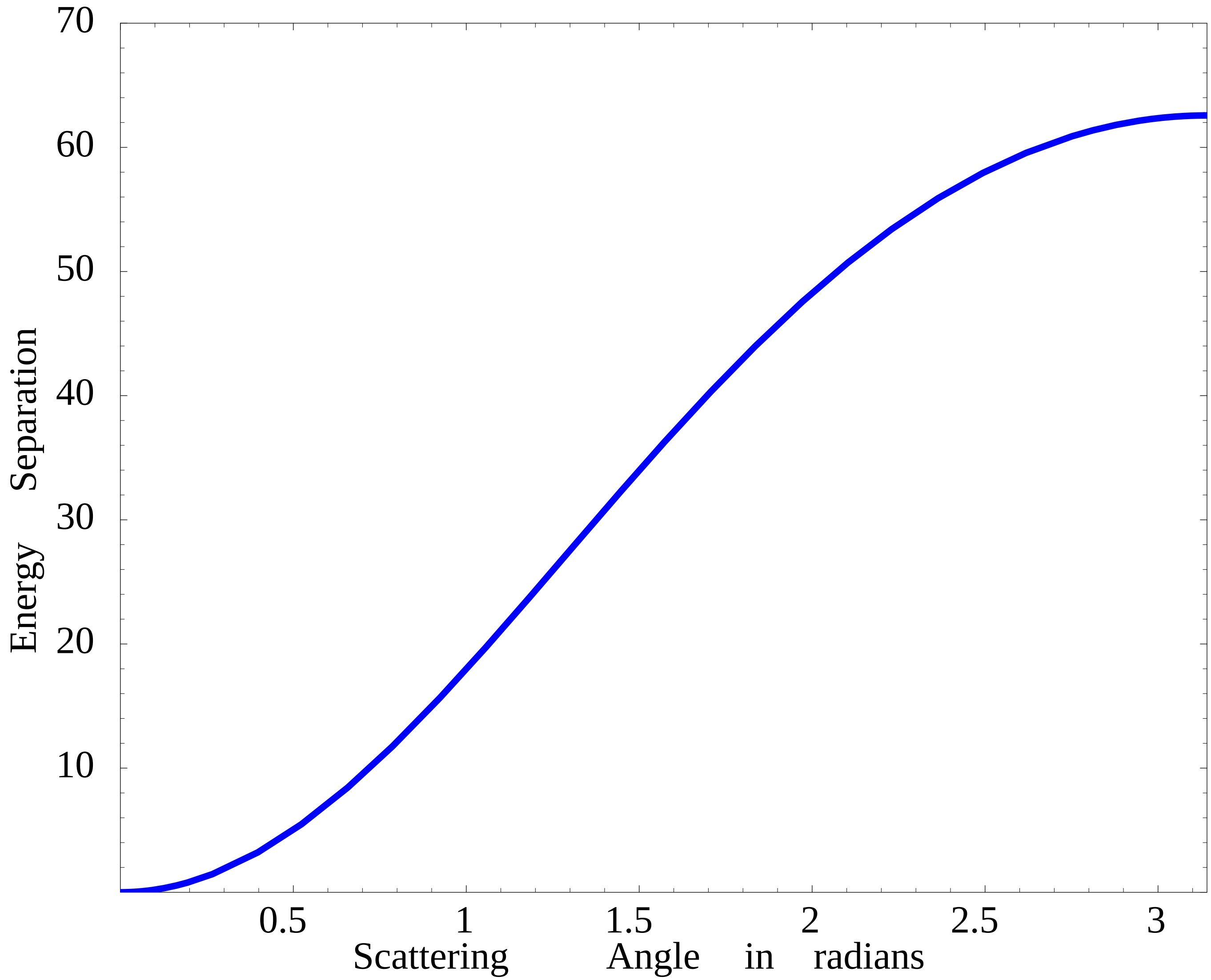
3. For every action there is an equal and opposite reaction.

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Scattered Proton Energy



Carbon-Oxygen Energy Separation



What happened to them?

Extinction of the Dinosaurs

It is now believed the dinosaurs and many other species were driven to extinction 65 million years ago by an ecological disaster brought on by the collision of an asteroid with the Earth. Consider an asteroid that collides at an angle $\theta = 150^\circ$ to the velocity of the Earth and sticks to the surface (a perfectly inelastic collision). Assume the velocity of the asteroid is towards the center of the Earth. How much does the velocity of the Earth change? How much energy is released in the collision? How does this compare with the energy released by the Hiroshima atomic bomb ($6.8 \times 10^{13}\ J$)?

Asteroid:	$m_A = 3.4 \times 10^{14}\ kg$	$v_A = 2.5 \times 10^4\ m/s$
Earth:	$m_E = 6.0 \times 10^{24}\ kg$	$v_E = 3.0 \times 10^4\ m/s$
Collision:	$\theta = 30^\circ$	

Big Explosions

Event	Energy Released (J)	Fatalities
Hiroshima (1945)	6.3×10^{13}	75,000 prompt, 250,000 delayed
Soviet Test (1961)	2.7×10^{17}	None we know of.
Krakatoa (1883)	6.9×10^{18}	36,000
Tambora (1815)	Unknown	92,000

What would happen now?