



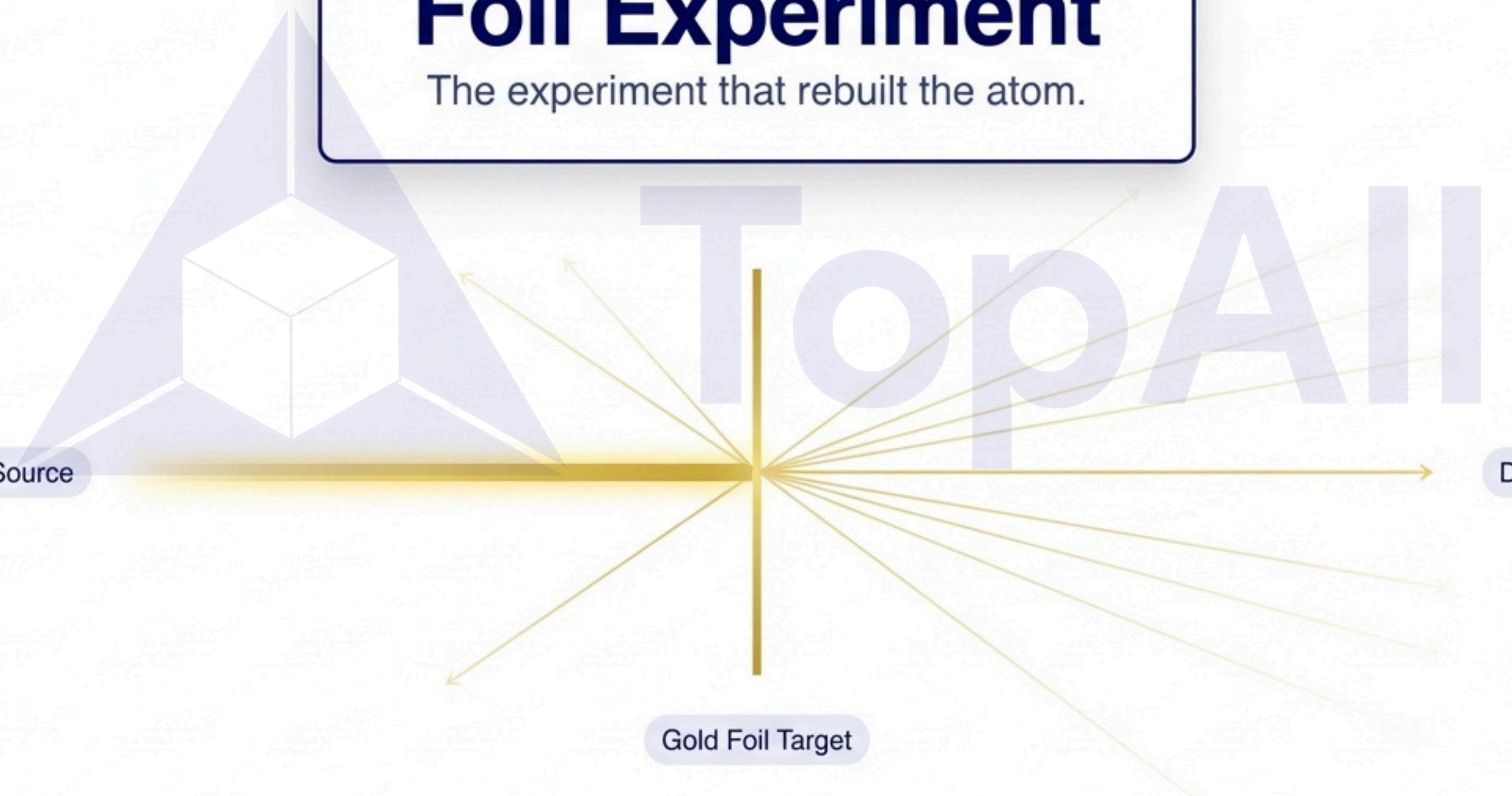
# Rutherford's Gold Foil Experiment

The experiment that rebuilt the atom.

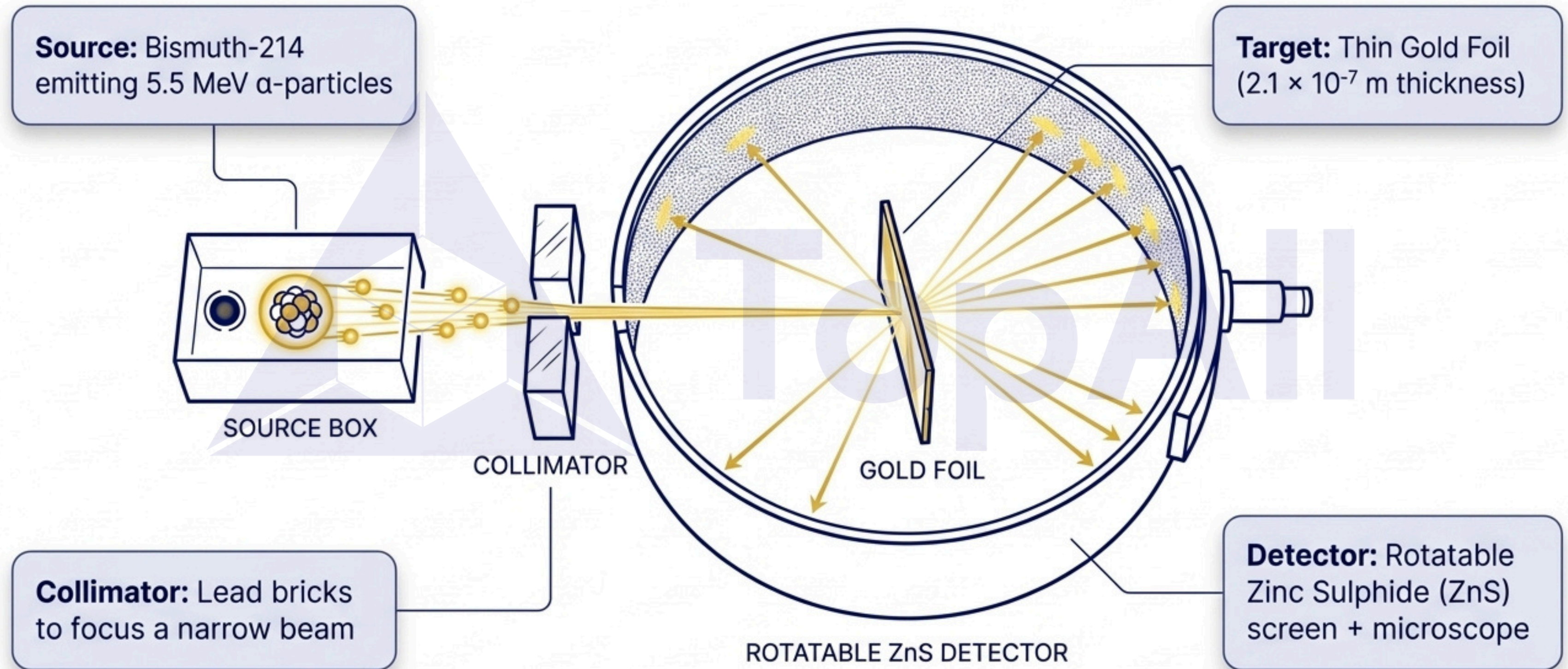
Alpha Particle Source

Detector Screen

Gold Foil Target



# The Experimental Setup (Geiger-Marsden, 1911)



# What Was Observed?



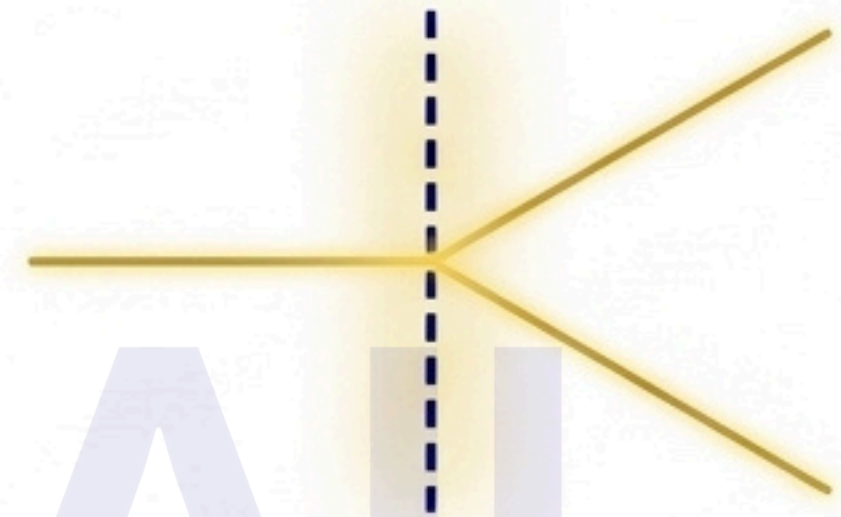
## Passed Straight Through

The vast majority (~99.86%) of  $\alpha$ -particles went through the foil completely undeflected ( $\theta = 0^\circ$ ).



## Slight Deflection

A very small fraction (~0.14%) were scattered by more than  $1^\circ$ .



## Bounced Back

Approximately 1 in 8,000  $\alpha$ -particles deflected by more than  $90^\circ$ , effectively rebounding straight back.



# You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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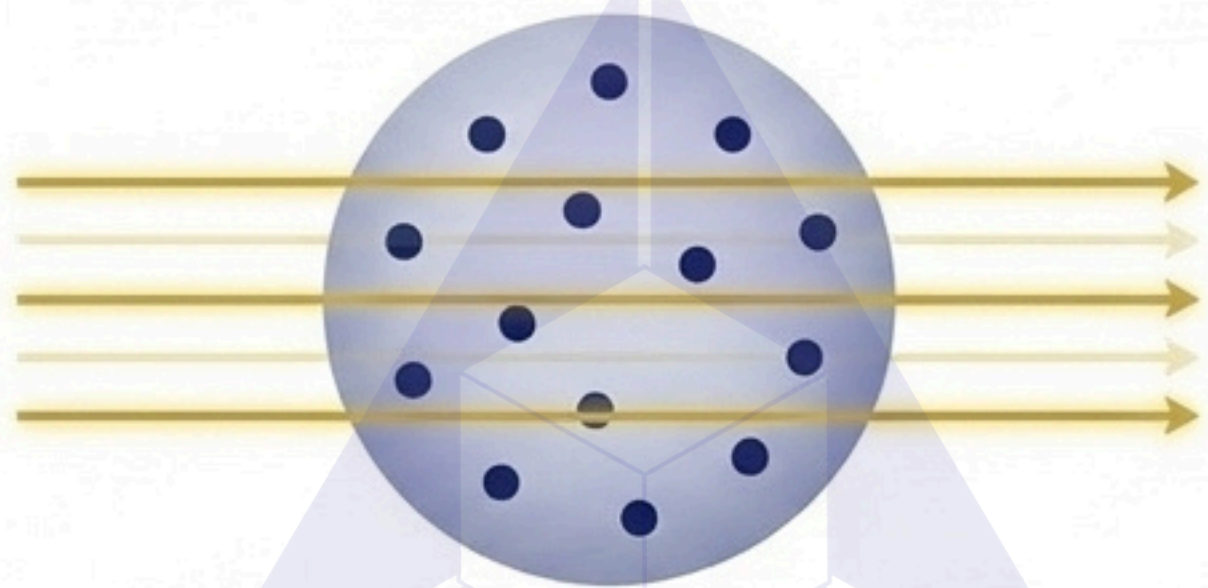
## Key Highlights

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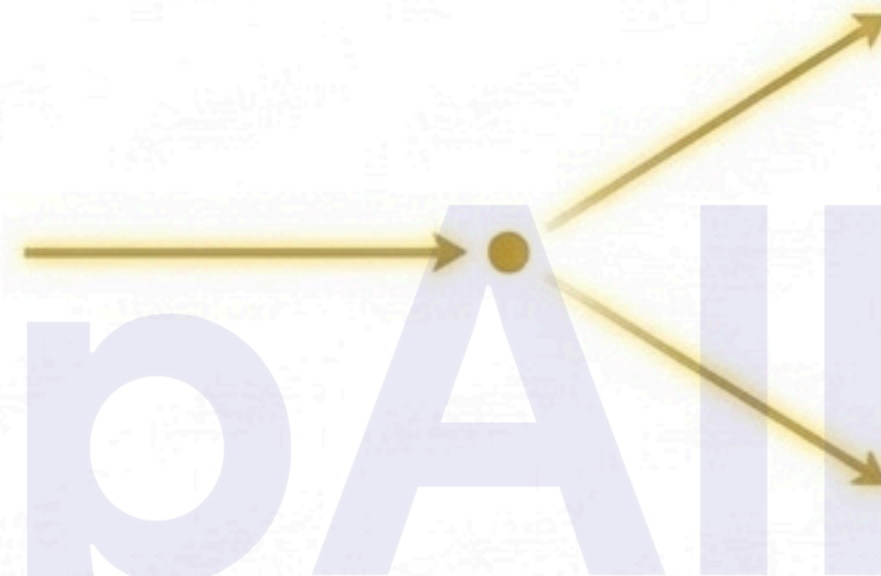
# Why This Was Shocking

## Expectation (Thomson Model)



If positive charge is uniformly distributed, the massive, high-energy (5.5 MeV)  $\alpha$ -particles should easily blast through with almost zero deflection.

## Reality (Rutherford's Data)



The 1-in-8,000 massive deflection was scientifically impossible under Thomson's model.

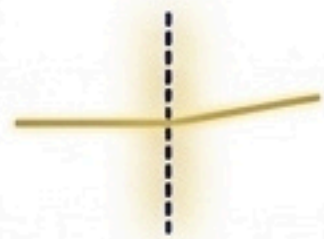
"It was as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you."

# Rutherford's Deductions



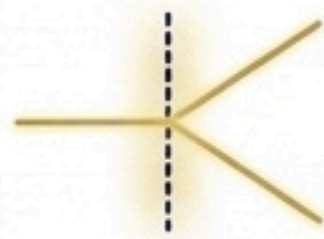
Observation: Most pass straight through.

**Conclusion: Atom is mostly empty space.**



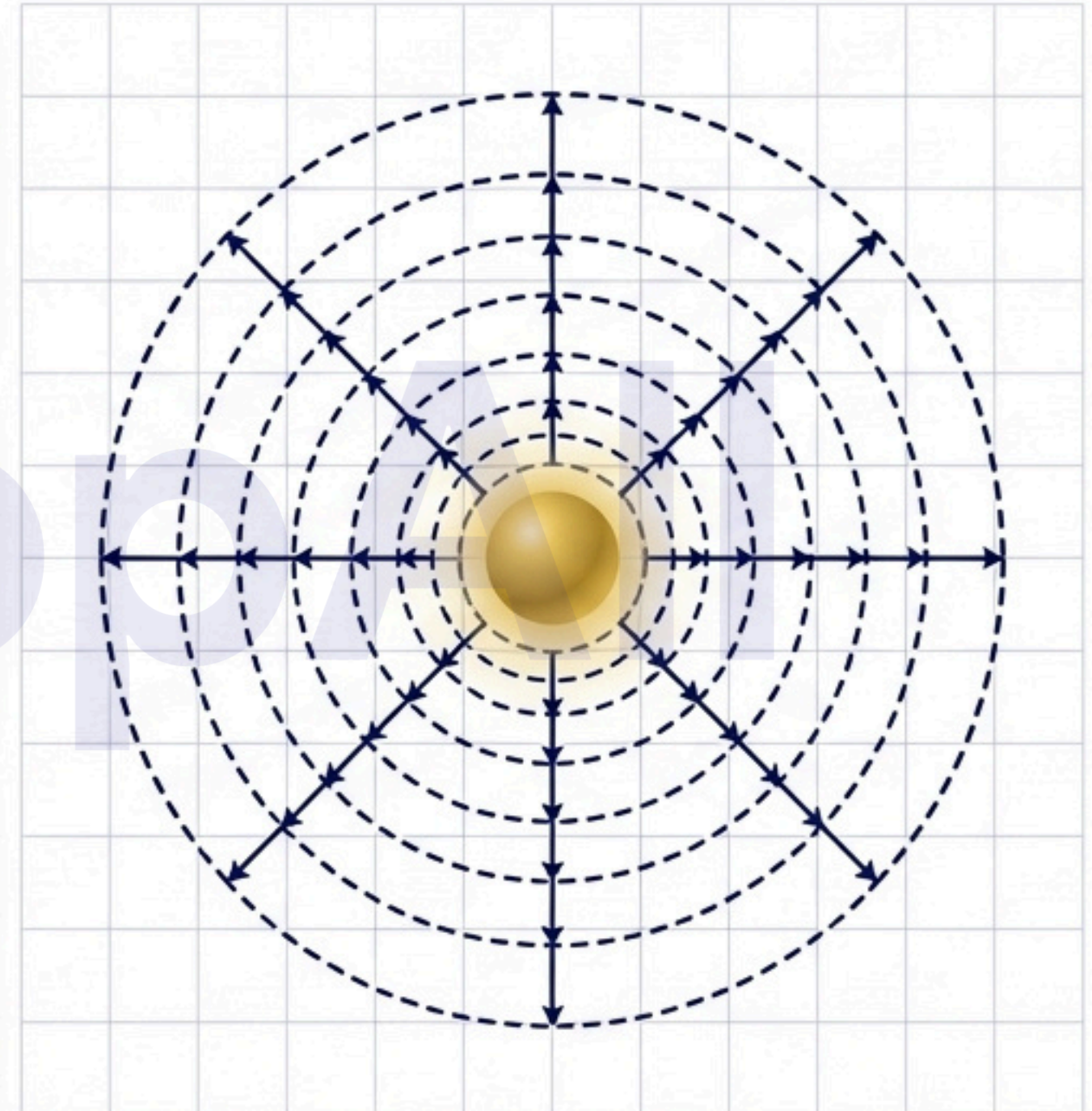
Observation:  $\sim 0.14\%$  slightly deflected.

**Conclusion: Intense central electric field.** The positive charge is not spread out; it is highly concentrated.

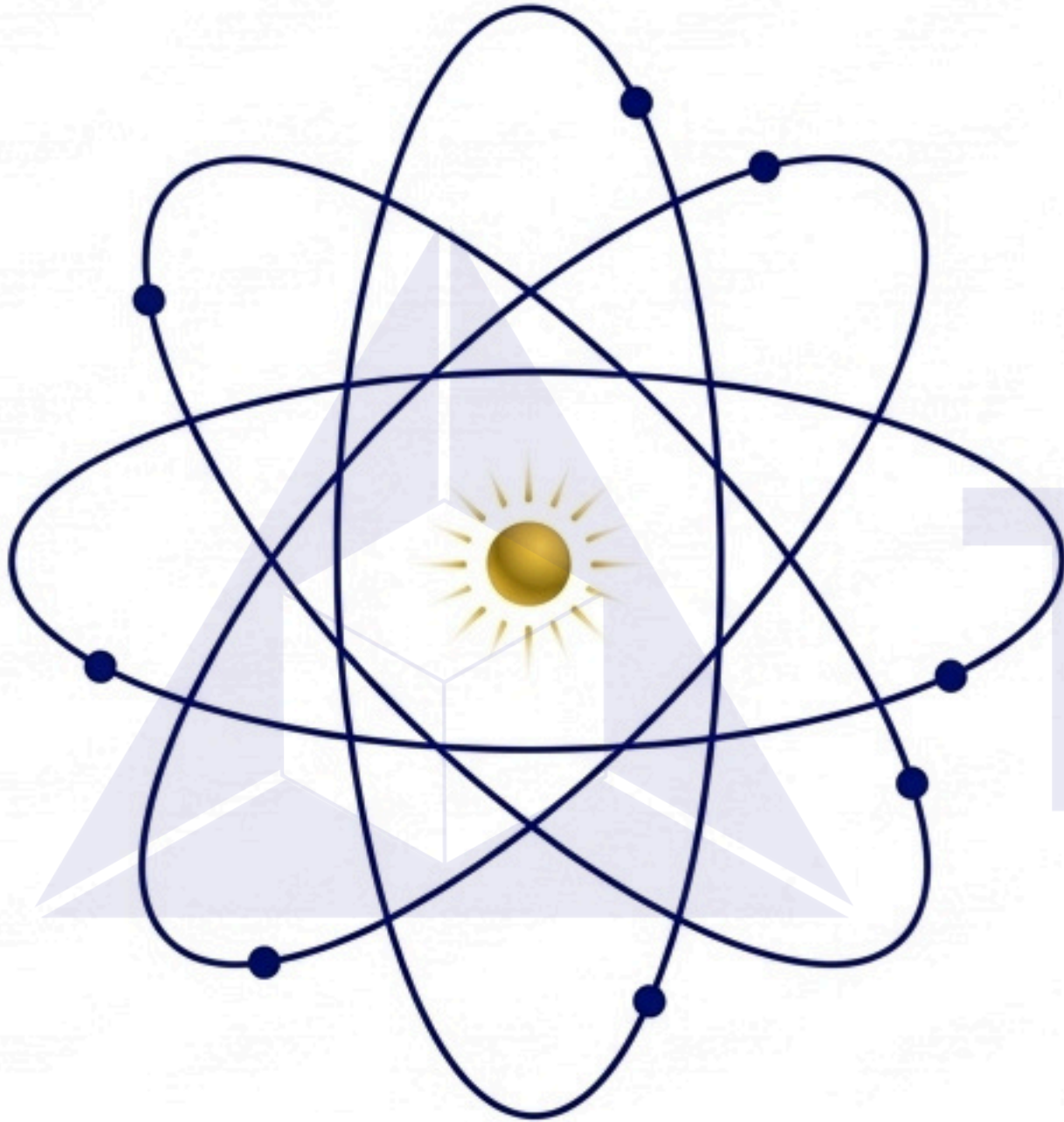


Observation: 1 in 8,000 bounced back.

**Conclusion: A tiny, incredibly dense center.** The greater part of the mass and the entire positive charge must be tightly packed at the center.

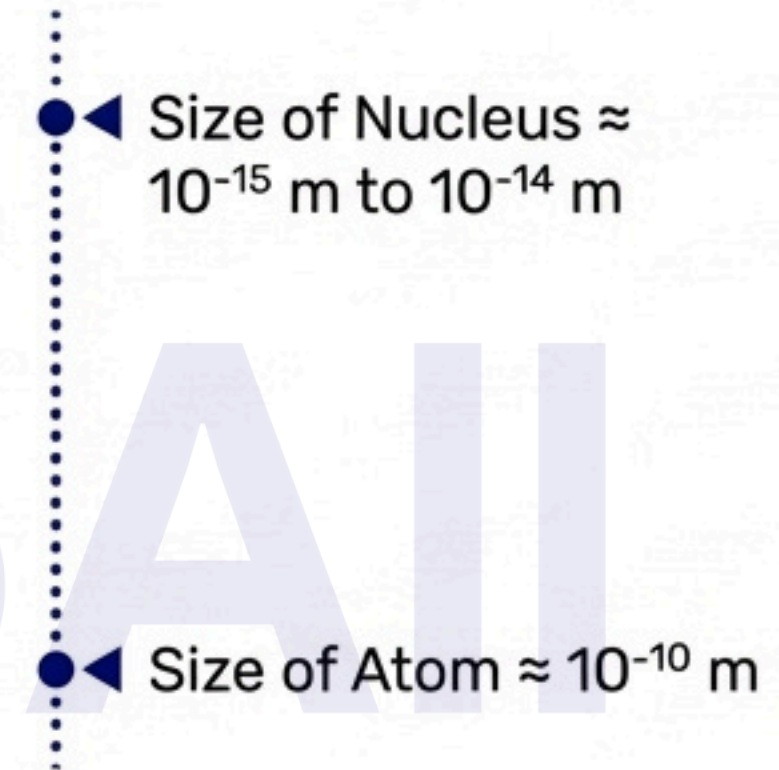


# H2: Rutherford's Nuclear Model



The atom consists of a tiny, massive, positively charged nucleus surrounded by electrons orbiting at a distance, dynamically stable like planets around the sun.

## H3: The Scale of Emptiness



The atom is 10,000 to 100,000 times larger than its nucleus.

If the nucleus were the size of the Sun, the Earth's orbit would be 100x further away than it currently is.

# Key Takeaways

- ✓ **Mostly Empty Space.** The vast majority of the atom's volume contains no matter, allowing most  $\alpha$ -particles to pass through unhindered.
- ✓ **The Nucleus contains the Mass.** Practically all of the atom's mass and its entire positive charge reside in an ultra-dense central core ( $10^{-15}$  m).
- ✓ **Planetary Electrons.** Negatively charged electrons orbit the central nucleus at massive distances, held by electrostatic attraction.

## H2: Check Your Understanding

- **Setup:** 5.5 MeV  $\alpha$ -particles hitting thin gold.
- **Data:** Only 1 in 8000 deflected  $>90^\circ$ .
- **Result:** Discovery of the atomic nucleus.



1. **Q1:** Why did Rutherford specifically choose gold for the foil? (Hint: Malleability and atomic mass  $Z=79$ )
2. **Q2:** What provides the centripetal force keeping electrons in orbit in this model?

### **H4: CAUTION**

Atomic electrons are too incredibly light to affect the trajectory of massive, high-energy  $\alpha$ -particles. Deflection is caused only by repulsion from the nucleus.

Next: 12.2.1 Alpha-particle Trajectory →



# You've Learned the Theory.

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