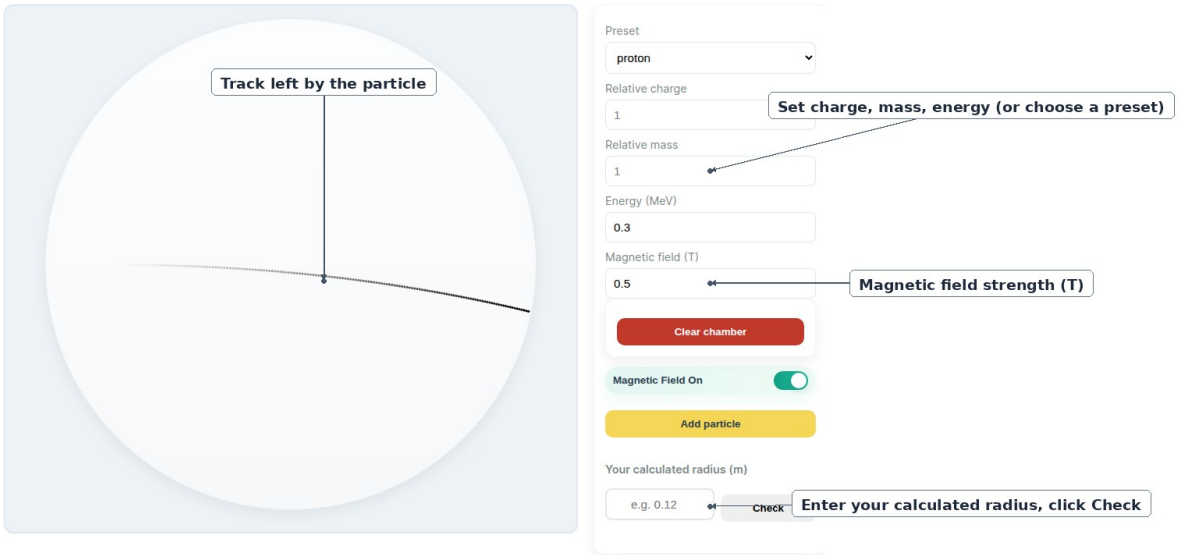
Investigating Particle Tracks in a Bubble Chamber

Charge, Mass and Momentum from Radius of Curvature

Aim:

You are investigating how the tracks left by charged particles in a bubble chamber reveal information about the particles that made them.



Method:

1. Choose the "none" preset so that you can set your own values. Set the Relative charge to 1, then choose fixed values for Energy (MeV) and Magnetic field (T). Keep these three values the same for the whole investigation.
2. Switch the Magnetic Field on.
3. Set the Relative mass to a chosen value, then click Add particle to produce a track.
4. Before you click Check, calculate the radius of curvature you expect, using **momentum p (kg m s^{-1}) = √(2 × mass (kg) × energy (J))** and **radius r (m) = p ÷ (charge Q (C) × magnetic field B (T))**. Convert using 1 relative mass unit = 1.672 × 10^{-27} kg, 1 MeV = 1.6 × 10^{-13} J, and 1 relative charge unit = 1.6 × 10^{-19} C.
5. Enter your answer into "Your calculated radius (m)" and click Check. Record the relative mass, your calculated radius, and the radius the Check tool gives, in your results table.
6. Click Clear chamber, change only the Relative mass, and repeat for at least seven more values, spread across a wide range.
7. Now choose the photon preset. A question appears on screen. With the Magnetic Field still on, increase the Energy (MeV) from a low value and click Add particle each time, until you find the lowest energy at which the photon produces an electron-positron pair instead of simply crossing the chamber untouched.

Lowest photon energy that produced a pair: ..... MeV

Prediction:

An electron and a positron have equal mass and equal energy, but opposite charge. Predict: with the magnetic field on, will their tracks curve in the same direction, or in opposite directions?

Test it in the sim: with the field still on, add an electron, then clear the chamber and add a positron with the same Energy (MeV). Compare the two tracks.

Results:

Relative mass	Relative charge	Energy (MeV)	Calculated radius (m)	Check tool radius (m)

Analysis:

Plot a graph of the radius of curvature (m), using your Check tool column, on the vertical axis against relative mass on the horizontal axis. Describe the shape of the graph. As relative mass increases, with charge and energy fixed, what happens to the radius of curvature?

How closely did your calculated radius match the radius from the Check tool each time? If any did not match closely, check your unit conversions.

Which way did the electron’s track curve, and which way did the positron’s track curve? Was your prediction correct? What does the direction a track curves tell you about the sign of a particle’s charge?

Explaining why:

rest mass energy of an electron = 0.511 MeV

A photon converts entirely into an electron and a positron, each with this rest mass. Calculate the minimum photon energy needed to produce the pair. Show your working.

How does this calculated minimum compare with the threshold energy you found by trial in the sim?

Why does a photon leave no track in a bubble chamber, while the electron and positron it produces do leave tracks?

The pair appears as two tracks starting from a single point. Compare the total charge before the event (the photon) and after (the electron and positron). What does this tell you about charge conservation at that point?

Compare the radius of curvature of the electron track and the positron track produced from the same photon. What does this tell you about their momenta, and what does it show about momentum conservation at the point of pair production?