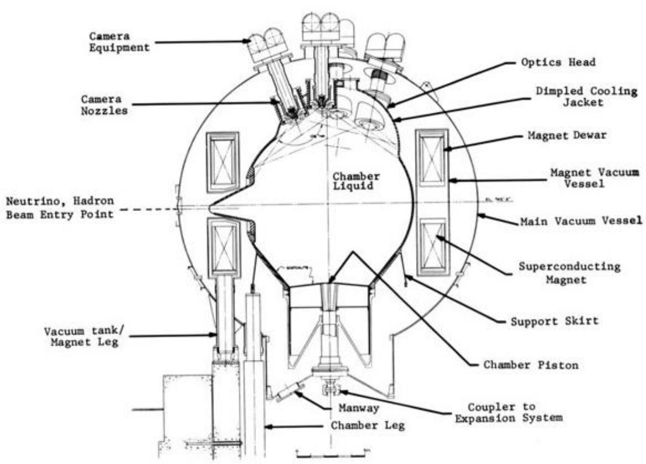
MAKING TRACKS II: BUBBLE CHAMBER
STUDENT GUIDE

Particle physicists build accelerators and detectors to study subatomic particles. Accelerators make high-energy beams of particles to study their interaction with other particles. The accelerator is called a “collider” when the particle beams are traveling in opposite directions in the accelerator tunnel. In a “fixed-target experiment,” the beam hits particles in a target that is fixed in place outside the accelerator. The target can be a solid material or a gas held inside a container. Either way, the experimenters study the particle interactions that occur when energized particles strike particles. But how?

Physicists “see” atomic and subatomic particles with detectors, devices designed to interact with particles and produce some evidence of their existence and behavior. If you have not already looked, visit the CERN Seeing the Invisible site at http://cern.ch/go/Xr9q.

From the 1950s into the 1970s, physicists built sophisticated detectors that enabled them to examine photographs of particle events. These detectors, called “bubble chambers,” are still used in certain experiments today.

Source: The Village Crier Vol. 3 No. 38, Septermber 23, 1971



A line drawing showing the major elements of the NAL 15-foot Bubble Chamber

https://news.fnal.gov/2013/05/bubble-chamber/ https://history.fnal.gov/photos/VCVol3No44_pic2.jpg

The image on the left is a bubble chamber used at Fermilab in the 1970s. (You can see this bubble chamber on display if you visit Fermilab.) The diagram on the right is a diagram of the inside of the bubble chamber. The bubble chamber contains a superheated liquid. When a charged particle passes through the liquid, the particle transfers a small amount of energy to the liquid. That energy boils the liquid along the path of the particle, forming visible bubbles which make the track. Cameras take photographs of the events—lots of them. Technicians, called “scanners,” study the photos to spot interesting interactions. They save these images for further study by physicists. We will study an image from one of these bubble chambers to learn how particles interact.

What is the research question?

- What are the properties of particles and their interactions that we can determine using a bubble chamber image?

What tools do we need for our analysis?

You will need:

- An introduction to bubble chambers: Wikipedia article at http://cern.ch/go/7vRZ.
- The bubble chamber photograph below.

What will we do?

Work in teams as directed by your teacher. After your introduction, read "What do we know?" Keep it handy as a reference. Then examine the bubble chamber image on the next page and answer the questions that follow. Finally, discuss your answers in class.

What are our claims? What is our evidence?

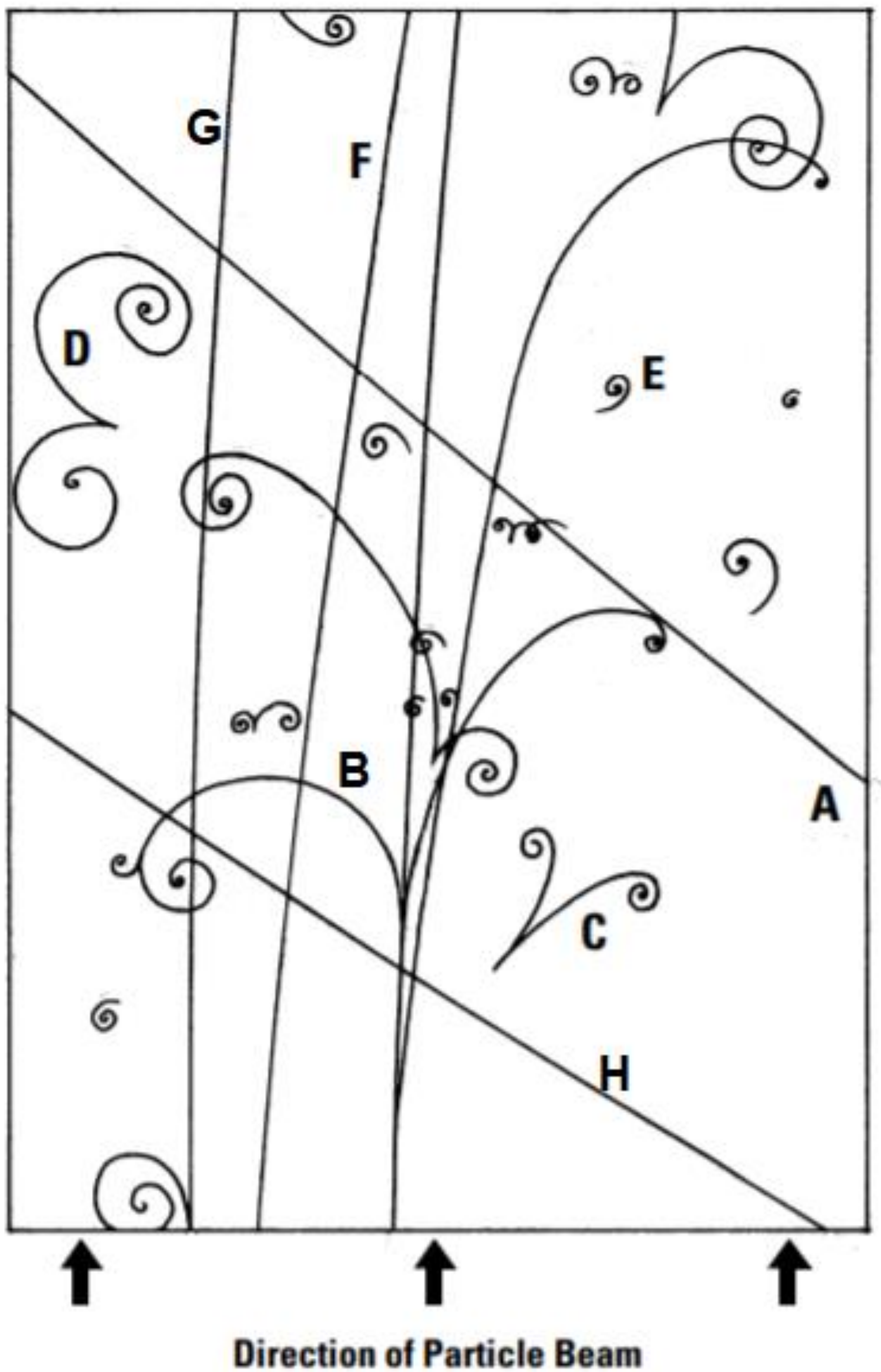
How can we identify particle interactions based on the rules and behaviors of particles shown by their tracks?

What do we know?

1. The image is a replica of a photograph taken of a volume inside a bubble chamber. It appears planar because the photograph is two-dimensional.
2. As shown, the region was exposed to a beam of particles. Assume the beam particles have positive electric charge.
3. Looking at the plane of the bubble chamber image, there is a uniform magnetic field perpendicular to the plane and pointed away from the observer into the page. The paths of electrically charged particles are curved in the magnetic field. The curvature depends on the magnetic field as well as the momentum and electric charge of the particle.
4. Electrically neutral particles leave no tracks.
5. Electrically charged particles can radiate photons that have neither mass nor electric charge.
6. Particles lose energy as they interact with the medium in the bubble chamber.
7. In particle interactions, electric charge and momentum are conserved. Always!

Questions

1. Tracks A, F, G, and H go across the whole image. Are they straight? Why or why not? Which of these would most likely be particles from the beam? Why?
2. Look at tracks B. Why do they curve? Can you figure out the electric charge? (Hint: The beam particles are positive.) We will come back to tracks B later.
3. There are two tracks at C. Why do they curve in opposite directions? Why do their curves get smaller and smaller?
4. Do tracks D follow the pattern of any tracks you have analyzed?
5. Make a claim about why tracks C and tracks D appear to come out of nowhere.
6. Use what you have learned so far to speculate on the nature of track E.
7. This is a challenge question: Let's go back to tracks B. How do you explain that "blossom" at the end?



Discussion

Your teacher will lead your class in a discussion of the claims you can make from the data. Be prepared to provide evidence and reasoning for your claims.