MAKING TRACKS I: CLOUD CHAMBER
TEACHER NOTES

DESCRIPTION

Students can “make” tracks in the sense of experiencing, analyzing, and understanding the tracks that particles make in cloud chambers and bubble chambers. These are old technologies. Current experimental particle physicists use complex detectors that handle the much higher rates of events and data from modern accelerators. However, cloud chambers and bubble chambers are uniquely visual, giving students a direct view of tracks that particles produce in a medium. This provides direct evidence that particles are passing around and through us all the time.

In Making Tracks I, students look at cloud chambers to see particle tracks appear and disappear before their eyes. Then, in Making Tracks II, they examine bubble chamber events to discover the behaviors and properties of particles. (Bubble chamber portion is based on the teacher materials for the PBS Nova program *The Elegant Universe: Einstein’s Dream*.)

STANDARDS ADDRESSED

Next Generation Science Standards

- Science Practices
  1. Asking questions
  2. Developing and using models
  4. Analyzing and interpreting data
  6. Constructing explanations
  7. Engaging in argument from evidence
- Disciplinary Core Ideas – Physical Science
  - PS1.A: Structure and Properties of Matter
  - PS2.B: Types of Interactions
  - PS3.B: Conservation of Energy and Energy Transfer
- Crosscutting Concepts
  1. Patterns
  2. Cause and effect: Mechanism and explanation
  3. Scale, proportion, and quantity

Common Core Literacy Standards

- Reading
  - 9-12.4 Determine the meaning of symbols, key terms . . .
  - 9-12.7 Translate quantitative or technical information . . .

Common Core Mathematics Standards

- MP7. Look for and make use of structure.

IB Physics Standard 7: The Structure of Matter

- Aim 1: The research that deals with the fundamental structure of matter is international in nature and is a challenging and stimulating adventure for those who take part.

ENDURING UNDERSTANDING

Indirect evidence provides data to study phenomena that cannot be directly observed.

Learning Objectives

Students will know and be able to:

- Identify particle tracks in a cloud chamber.
- Predict the electric charge of a particle in a bubble chamber from its motion in a magnetic field.
- Apply conservation of electric charge to explain the shapes of tracks from particle decays.
- Use conservation of momentum to infer the existence of "hidden" particle tracks.

Prior Knowledge

None needed.

Background Material

About Cloud Chambers:

- Wikipedia at http://cern.ch/go/7h7h
- Nuledo at http://cern.ch/go/7hcV

Resources

1. Prep material (optional):
   1.1. Seeing the Invisible at http://cern.ch/go/Xr9q
2. Build a Cloud Chamber:
   2.1. CERN (with video) at http://cern.ch/go/9dqn
   2.2. Symmetry at http://cern.ch/go/8mCm
   2.3. QuarkNet at http://cern.ch/go/m9vh
   2.4. Inexpensive commercial kit at http://cern.ch/go/7qvw
3. Cloud Chamber videos:
   3.1. Diffusion cloud chamber at http://cern.ch/go/wb7B
   3.2. CERN cloud chamber at http://cern.ch/go/6gbF
   3.3. BNL/SB QuarkNet 2007 at http://cern.ch/go/Zc69

Implementation

In this activity, your students work in small groups to observe and possibly identify particles leaving tracks in a cloud chamber. We recommend that students read the CERN page *Seeing the Invisible* (Resources 1.1) to help them draw more meaning from viewing cloud chamber tracks. The first part of the page covers cloud chambers.

There is no substitute for the experience of building and operating a cloud chamber. Please check Resources 2.1–2.4 on building a cloud chamber and note that it takes some special materials like dry ice and isopropyl alcohol, time, and some trial and error. We encourage you to try this so that students can observe a cloud chamber in action.

However, if you cannot build and operate your own cloud chamber, students should watch the video in Resource 2.1, in which Sarah Charley of US/LHC builds a cloud chamber and explains how it works in just over 4 minutes. Then, divide students in small groups that can use one of the cloud chamber videos (Resources 3.1–3.3) to make their observations.

In either case, ask your students to characterize the main types of tracks they see and take notes according to the format in the Student Report Form. Students should look for four distinct types of tracks. They may not observe all four, and they may not report what you expect. One suggestion for making drawings is for students to pause the video and use screen capture to copy the image and paste it into their team report. When they are done, have the same discussion described below.

Each team reports what they have seen to the whole class. By tabulating and comparing, you can guide them toward these main types:

- Long, thin, straight track (muon)
- Short, fat track (alpha particles coming from radon atoms)
- Curly or zig-zag tracks (electrons and positrons)
- V-shaped tracks (particle decays)

Students may not see all of these, and they will see some tracks that are unclear. Remind them that physicists are most interested in the events that occur often. This reproducibility is an indication that an event is not just a random squiggle and may represent particles.

ASSESSMENT

Assessment may be based upon:

- Observed student work on building a cloud chamber, if possible.
- Team Report Form or equivalent.
- Participation in discussion.