Tracking Unseen Particles

Problem: To illustrate the basics of a particle tracking detector through a simulation.

Materials: box lids (from shoe or shirt boxes), small objects (stoppers, etc.) to prop up lids, magnetic marbles, ordinary marbles, fine iron filings,

Introduction:
This activity focuses attention on the *particle detector* --- the "heart" of a particle experiment and a vital piece of equipment in particle physics research. Using iron filings and magnetic marbles, assemble a "detectors" and use them to observe "tracks" similar to those left by particles in a tracking detector.

Procedure:

1. Use a shoebox lid to simulate a detector layer that registers particle tracks. The marbles must be able to roll under the lid with about ½ cm of clearance.
2. Iron filings should be thinly sprinkled to cover the box lid.
3. Roll the magnetic marbles under their simulated detectors.
4. Make a sketch of the pattern that was made with the detector.
5. After each trial "reset" the detector by gently shaking the box lid to redistribute the iron filings.
6. Roll plain marbles so that they collide with one or more of the magnetic marbles, which will recoil and create a track that begins in the middle of the detector.
7. Roll a few marbles into the detector. Have another student (who didn't see which marbles were used by the first) analyze the patterns of tracks to determine how many magnetic and non-magnetic marbles went through the detector.

Summing Up:

1. How was the particles path viewable?

2. What was detected by the particle detector?

3. What pattern does the non-magnetic marble make? What particles would the non-magnetic marble represent?

4. What type of collision does the non-magnetic marble and the magnetic marbles in the middle suggest? Which particles does this collision represent?

Teacher Suggestions and Strategies:

This "hands-on" activity focuses students' attention on the *particle detector* --- the "heart" of a particle experiment and a vital piece of equipment in particle physics research. Using iron filings and magnetic marbles, students will assemble their own "detectors" and use them to observe "tracks" similar to those left by particles in a tracking detector.

Materials required (for five teams of students):
ten box lids (from shoe or shirt boxes), small objects (erasers, stoppers, etc.) to prop up lids, magnetic marbles, ordinary marbles, fine iron filings, (Please note that a ready-made version of this activity is available from Science Kit.)

Working in teams, students follow the directions provided in the activity sheet to construct their own detectors. Each team will use an inverted shoe box lid to simulate a detector layer that registers particle tracks in two different ways. This simulation will work well as long as the tops of the marbles are within half a centimeter of the top surface of the cardboard as they roll beneath it. Iron filings should be thinly sprinkled to cover the inside of the box lid.

Have the student teams begin their experiments as instructed on the activity sheets. When they roll the magnetic marbles under their simulated detectors, iron filings will line up above the marble's path through the detector. This is roughly analogous to the various types of real detectors that register the paths of electrically charged particles. After each trial "reset" the detector by gently shaking the box lid to redistribute the iron filings.

In the second part of the activity, the plain marbles will collide with one or more of the magnetic marbles, which will recoil and create a track that begins in the middle of the detector. (See answers to questions below.)

Here's an additional way of using this two-stage detector: Have one student roll a few marbles into the detector. Later, have another student (who didn't see which marbles were used by the first) analyze the patterns of tracks to determine how many magnetic and non-magnetic marbles went through the detector.

Suggested Observations & Answers

1. Iron filings line up above the marble's path through the detector.
2. A magnetic charge.
3. The marble's path does not register. Neutral particles such as photons and neutrons.
4. It suggests the existence of a non-magnetic marble that collided with one of the magnetic marbles in the middle of the detector.
   This is analogous to a real detector in which a neutral particle collides with a charged particle, or produces a pair of oppositely charged particles whose tracks can be observed.