Build a particle detector

INTRODUCTION

Introduce your students to modern physics and generate excitement about subatomic particles by building a particle detector in class. The cloud chamber is one of the oldest particle detectors. It has led to a number of particle discoveries and was involved in two Nobel Prizes.

LOGISTICS

Activity	Group size	Time	Materials
Build a particle detector	Whole group demonstration	20 minutes for set up, hours of fun!	• Aquarium or other clear container • Black felt • Small magnets • Base to hold dry ice • Sheet of metal, painted or taped over in black • Light source • Dry ice** • Isopropyl alcohol, 90% or greater** • ** PPE: Safety glasses • **PPE: Heavy gloves

CONNECTIONS TO SNOLAB SCIENCE

The cloud chamber is one of the earliest particle detectors ever created. It was invented by Scottish Physicist, Charles Wilson, who was attempting to study cloud formation when he discovered that he'd accidentally invented a particle detector! He went on to win a Nobel Prize for this discovery. Cloud chambers detect charged subatomic particles, like muons, electrons, and alphas. SNOLAB experiments are seeking interactions of other types of particles, namely neutrinos and dark matter.

Cosmic rays are subatomic particles coming from space that strike the Earth's atmosphere and create a shower of secondary particles. These invisible particles constantly bombard the Earth's surface and would interact with our detector at such a volume that it would mask the signal the detectors are looking for. In order to detect neutrinos or dark matter, it's important to shield the experiments from cosmic radiation and other sorts of particles. This is why SNOLAB is located two kilometers underground.

PROCEDURES

Step 1: Use magnets to secure the felt to inside bottom of the aquarium.

Step 2: Wearing gloves and safety glasses, saturate the felt with isopropyl alcohol and pour off the excess. Be sure to have the help or supervision of an adult for this step and work in a well-ventilated area.

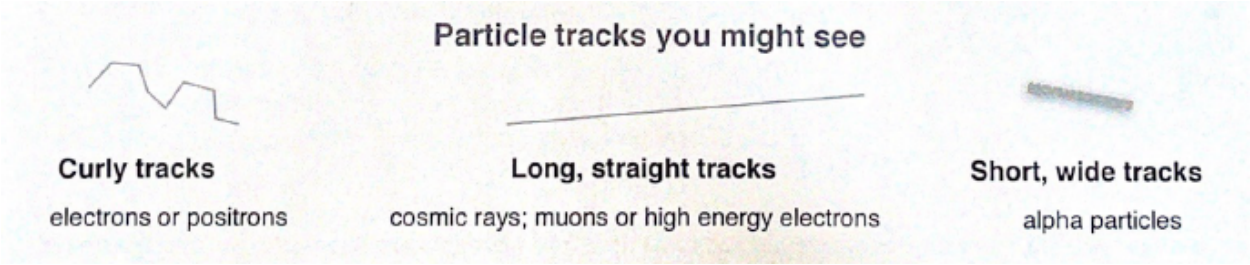
Step 3: Fill the base evenly with dry ice. Place the black metal plate on top (this will make an interesting sound!)

Step 4: Place the inverted aquarium with saturated felt attached on top of the black metal plate.

Step 5: Wait! It will take about 10-15 minutes for the detector to cool down and a stable cloud of alcohol to form.

Step 6: Turn off the lights and shine your light source into the chamber, just above the metal plate.

Step 7: Observe tracks. You will see about a particle per second, which will vary with the size of the chamber.



HOW DOES IT WORK?

As the isopropyl alcohol evaporates from the felt, it sinks, rapidly cooling as it reaches the bottom of the chamber. This creates a supersaturated cloud of alcohol vapour. When a charged particle passes through the cloud, it tears away electrons on some of the gas molecules in its path. This is enough to start a condensation process and small droplets of alcohol form along the length of the charged particle. Tracks will differ in length, thickness, and shape based on the type of particle that is passing through. Once the chamber reaches temperature, it will operate for several hours.

The loud squeaking noise you hear when the metal plate touches the dry ice is the result of instant sublimation that happens when the –78.5°C dry ice contacts the room temperature metal plate. It is the noise of gas escaping under the pressure of the metal plate.

TROUBLESHOOTING

If you can't see tracks:

- Wait. It may take some time for your system to cool down
- Make sure your chamber is as airtight as possible
- Vary your light source and make sure the area just above the metal plate is well-illuminated. Use a bundled LED light
- Make sure the dry ice is in good contact with the metal plate (an even layer underneath to maximize the surface area in contact)

- Make sure the felt is saturated with alcohol and use the right type of alcohol. 99% is ideal, but anything over 90% should work!

If you see big clouds at the edges:

- Check for air leaks and make the system as air tight as possible

If the metal plate is covered in snow:

- If the metal plate is on the dry ice without the chamber in place, vapour from the air may freeze onto the metal plate. Start over, making sure to soak the felt before you fill the reservoir with dry ice so the chamber is closed as soon as possible.

REFERENCES & RESOURCES

Video available on our YouTube channel

Modified from Jefferson Lab How to Build a Cloud Chamber!

How to build a cloud Chamber - filmed in CERN's S'Cool Lab

Making Atoms Visible – Teacher resource from the American Nuclear Society