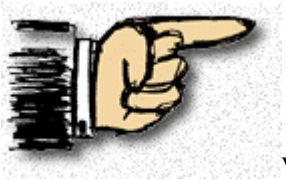
How to Build a Cloud Chamber



Warning : Dry ice and isopropanol can be dangerous!

What you will need to build the chamber:

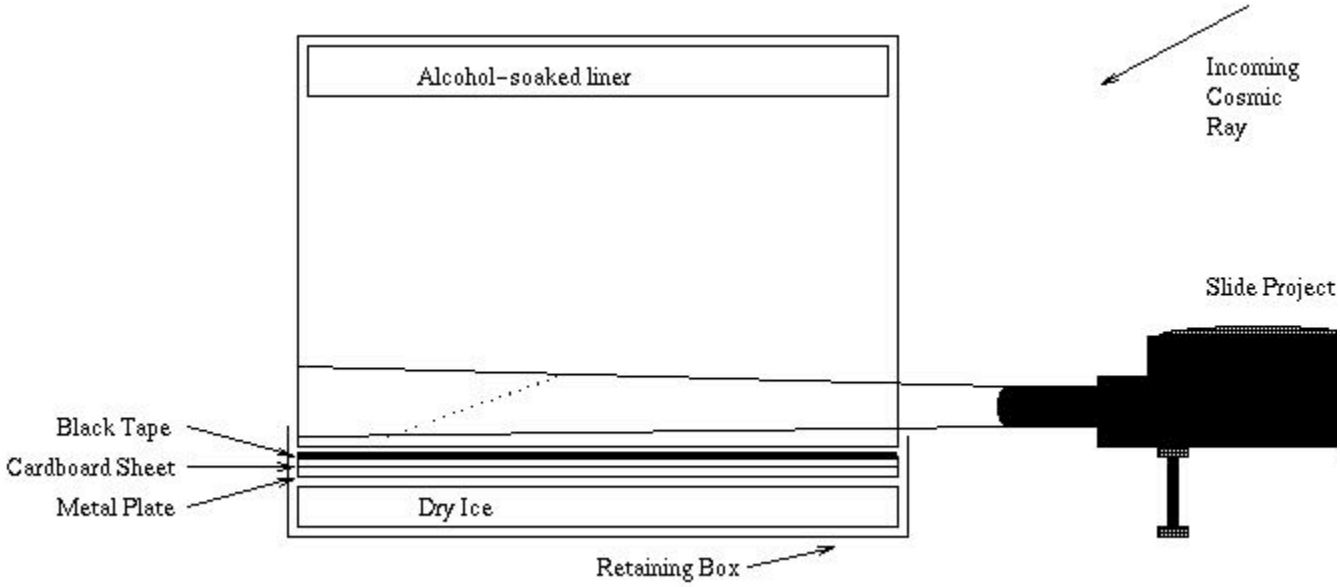
- **A clear, see-through container with an open top, about 6" by 12", and about 6" high. Make sure it is boxlike with flat sides, rather than being round.**
- **A slide projector or other very strong light**
- **A sheet of metal to cover the top of the container**
- **A piece of thin cardboard (from a notebook or cereal box) the same size as the metal sheet**
- **Black electrical tape**
- **Felt for lining the container**
- **A box a little bit bigger than the metal sheet**
- **4 binder clips**

Line the sides of the container near the bottom with cloth or tissue. This lining will be soaked with alcohol when you run the chamber, so do not use alcohol-soluble tape or glue to attach it.

Cover one side of the cardboard with the black electrical tape; this will make the particle tracks easier to see. Place the cardboard, tape-side up, on the sheet of metal, then cover the container with the metal and cardboard, so that the tape is facing the inside.

Use the binder clips to securely fasten the container to the metal/cardboard top. This is to prevent air leaks, so be sure it is tight. Turn the container over so that the metal is on bottom and the felt is at the top. Place the container into the box. Place the slide projector against one side of the chamber so that it shines in.

This is the "dry" configuration of the chamber. You won't see anything yet, but now you are ready to go.



What you will need to run the chamber

- Pure (not 70%) isopropyl alcohol
- 1 lb. Dry ice, cut into thin slices

In order to run the chamber you will need two additional items: pure isopropanol and dry ice. (You can usually get dry ice at ice cream stores.)

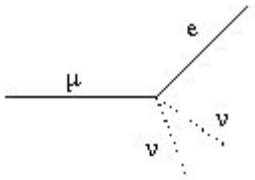
Place the dry ice in the box underneath the chamber, between the box and the metal plate. Make sure that the slice of dry ice is shorter than the sides of the box.

Remove the container from the box, open it, and soak the felt with the alcohol. Also place enough alcohol on the tape so that it is covered with a thin layer of liquid. Clip the metal and cardboard back into place, then replace the chamber on top of the dry ice. Be sure that the metal plate is resting directly on the dry ice. Turn on the slide projector lamp.

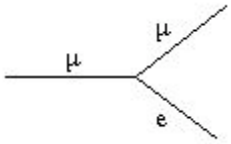
What you will see

- At first, you will only see a rain-like mist of alcohol
- After about 15 minutes, you should start to see the tracks of particles passing through. The tracks look a little like spider's threads going along the chamber floor. It may help to turn off any room lights.
- For a 6"x12" chamber, you should see about one track per second.
- Look for these different things:

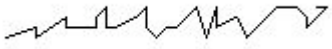
- A track which goes straight, then "kinks" off to the left or right sharply. This is a "muon decay". The two neutrinos (the dashed lines) are not detected in the chamber.



- Three tracks which meet at a single point. In these events, one track is an incoming cosmic ray. This particle hits an atomic electron. The electron and the outgoing cosmic track are the two other tracks.



- A very windy, jagged track. This is "multiple scattering", as a low-energy cosmic ray bounces off of one atom in the air to the next.
- You might notice that some tracks are very "bright" and thick, and others are very faint.



What else could you do?

- Use a Polaroid camera to record the events
- Place a very strong magnet underneath the chamber. You will see the particles bend when they are near the magnet.
- Place several plates of metal upright, one behind the other, in the chamber. See how many plates tracks can go through.

Troubleshooting

Like any experiment, you may find yourself with difficulties. Here are a few common ones and their solutions.

- "I don't see anything!". Solution: Be sure the light is well placed. Make sure the dry ice is neatly packed and in good contact with the metal plate. Try adding some alcohol.

- "I only see mist, and no tracks". Solution: Wait. It takes about 15 minutes for the chamber to get to the right temperature.
- "I waited 15 minutes, and still nothing!". Solution: Be sure the light is well placed and shining into the chamber. Check that the chamber is airtight.
- "It's airtight, and there's good light". Solution: if you see only a very thick mist, try opening the chamber, letting some escape, then starting over. If nothing works, try a new container which is a little shorter or taller.
- "I see big clouds at the edges of the chamber." Solution: This probably means you have an air leak. Be sure that the chamber is tightly sealed.

How does this work?

Because there is so much alcohol, the chamber is saturated with alcohol vapor (the gaseous form of alcohol). The dry ice keeps the bottom very cold, while the top is at room temperature. The high temperature at the top means that the alcohol in the felt produces much vapor, which falls downwards.

The low temperature at the bottom means that once the vapor has fallen, it is *supercooled*. That is, it is vapor form, but at a temperature at which vapor normally can't exist. It as if you had made steam at 95 C.

Since the vapor is at a temperature where it normally can't exist, it will very easily condense into liquid form. When an electrically charged cosmic ray comes along, it *ionizes* the vapor--that is, tears away the electrons in some of the gas atoms along its path. This leaves these atoms positively charged (since it removed electrons, which have negative charge). Other, nearby atoms are attracted to this ionized atom. This is enough to start the condensation process. So you see little droplets forming along the path the particle took through the chamber.

There is also an exhibit on cosmic rays at the Exploratorium in San Fransisco.

You can also find a page full of links for more information on cloud chambers.

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http://w4.lns.cornell.edu/~adf4/cloud.html