Two Types of Cloud Chambers

This information is adopted from http://makeprojects.com/Project/Cloud+Chamber/2182/1#s10775

Safety Issues:

These experiments use dry ice, which is cold enough to freeze live skin. Do not treat dry ice the way you would water ice. Handle it with gloves and be aware of its significant desublimation rate – large quantities of it will displace oxygen if in an enclosed container, such as the passenger compartment of a car or an ice chest.

Rubbing alcohol can be flammable and is toxic. Be sure to wash hands after using it and do not expose its fumes (which are more flammable than the liquid) to flames.

Materials

A transparent, air-tight container – these are described below.

Some dark felt or similar material.

Cardboard and/or wood.

Thin metal. Sheet metal is ideal but aluminum foil will work.

A bright light – the brighter the better but a high quality flashlight will do.

A room that can be darkened.

Rubbing alcohol

Dry ice

Gloves

Type 1 – Cheap, Quick, and Simple – You Get What You Pay For

Ionizing radiation from cosmic sources, such as muons, and from telestial sources, such as radon gas decay, can be made visible inside a chamber that takes very little time to assemble if you've got some dry ice on hand. (Dry ice is easy to get from many grocery stores, warehouses, or welder's supply stores. Visit http://dryicedirectory.com to search for dry ice dealers by area code.)

1. Warm a large jar with a metal lid under a flow of hot water.
2. Thoroughly rinse the inside with rubbing alcohol and dump out the excess. Replace the lid.
3. Center a cake of dry ice on top of a towel. Use gloves when handling the dry ice to prevent freezing your skin.
4. Place the jar, lid side down, in contact with the dry ice and wrap the remaining dry ice up in the towel to prevent it from "smoking."
5. The alcohol will evaporate from the warm sides of the jar and condense near the frigid lid.
6. Shine a bright flashlight into the jar from the side, and you'll see pinprick-sized droplets of alcohol coalescing near the bottom. These are residual dust particles, not traces of radiation. However, their formation indicates the chamber is working. They, and the tracks we want to see

described in the next step, will be most easily visible if you look toward but not directly into the light.

7. After a minute or two, when the dust inside the jar has settled out, about once a minute, just above where the droplets are forming, a ghostly line will suddenly appear and then disintegrate as a falling rain of alcohol. These traces of condensed alcohol are caused by ionizing particles of radiation passing through the jar.

These thin trails of vapor form most readily where the alcohol is at its dew point or slightly supersaturated. The disturbance caused by ion trails generated from ionizing radiation is large enough to cause the alcohol to condense and form tiny droplets that scatter bright light.

These droplets coalesce along the track and essentially amplify its width over a trillionfold to make the particle's passage plainly visible. For obvious reasons, a radiation detector that uses tiny droplets to reveal its quarry like this is called a "cloud chamber."

While the cloud chamber in a jar couldn't be simpler to construct, it has three drawbacks. First, it's small, so you often have to wait a long time before another cosmic ray will happen to pass through at just the right spot. Second, the curved glass makes the tracks hard to see. And finally, the show only starts after any dust particles inside have settled, and it stops as soon as the alcohol has all condensed. That limits you to just a few minutes of good viewing.

A far better chamber would operate with a large enough volume for tracks to appear every few seconds, have flat sides for clear viewing, and would contain a reservoir of alcohol large enough to keep the show going for hours.

Type 2 – Less Cheap, More Time Consuming, More Complex – Well Worth the Effort

Here's how to make a superior cloud chamber. The trick to creating cloud chambers is to find the right vessel. A basketball display case, glass fish tanks (available at DI for little money) and similar straight-walled, glass, sealed containers are all good candidates.

When the chamber is operating, tracks form within at a height of about 4cm, which makes the active volume a whopping 2,700 cubic centimeters. This results in a particle track every few seconds.

1. First, to let the chill of the dry ice in, fashion a cover for the open side of the container, which will be on the bottom during the experiment, by placing a thin piece of conducting sheet metal or aluminum foil over it. This must have an air-tight seal to the rest of the chamber, but you will also have to access the chamber from this side.
2. Cut a square of black felt to exactly fit inside the bottom of the case. This will soak up the excess alcohol used in the chamber and provide a good black contrasting background to view the tracks.
3. Place a second square of black felt on the inside of the top of the chamber. Depending on what chamber you have, this can be a little tricky. It must adhere to the top even when soaked with alcohol yet you should not use anything to attach it that creates a vapor or smell, such as contact cement. Make the square just large enough to completely cover the exposed glass on

the inside of the top. One solution is to pin the felt against the top using a wire screen. Cut the screen so that it is 2-3 cm (about 1") wider than the felt, and use a pair of pliers to bend down the four sides. Press the felt down, and then press the screen in place. If the screen will not stay in place on its own, place something in the corners of the box to hold it in place.

4. Seal any other portion of the box from air currents. This can be done with silicon seal on the outside of the box (not the inside).

Preparing the Chamber

Place the bottom of the chamber directly on top of a block of freshly cut dry ice. You want the entire bottom surface to come to the same temperature. (Any variation will cause air currents to flow inside the chamber and obliterate your tracks.) So if the chamber is larger than the block of dry ice, you'll need to create a tile of four blocks, and then center the chamber on that. As before, wrap exposed dry ice with a towel to prevent smoking.

NOTE: If your supplier gives you irregular hunks of dry ice, you'll need to create a dry ice and alcohol bath. First, wrap the dry ice chunks in a towel and pulverize with a hammer. Next, dump the pulverized pieces into a plastic kitchen trash bag. Lay the bag on top of a doubled towel to provide insulation, and pour in several cups of isopropyl (rubbing) alcohol. (You'll waste less dry ice if you chill the alcohol in your freezer first.)

Then wet the top of the bag with alcohol to provide a conductive seal, and press the bottom of the chamber onto the bag. This will chill the chamber nicely and avoids the mess and alcohol fumes of a traditional alcohol and dry ice bath.

Next, fully charge the top pad of felt with alcohol and evenly moisten — do not saturate — the bottom pad. The alcohol on the bottom helps conduct heat out of the chamber and hastens the formation of the cloud. For this, you'll want the highest concentration of alcohol you can find. Go to your local auto supply store and purchase a bottle of Iso-Heet. This product is used to remove water from fuel lines and, as it turns out, is pure anhydrous isopropyl alcohol.

Now close up the chamber and wait. It will take a while for all the dust in the air inside to settle out and for the temperatures of the different parts of the chamber to equalize. The show will start in about 20 minutes and it will go on for hours.

To see it, turn out the room lights. Then shine a very bright column of light in from one side. A bright flashlight will work, but the batteries soon give out. I use the light from an LCD projector. The placement of the light is absolutely critical. The light must shine across the bottom of the chamber where the droplets are forming, and you must position your head low and at a steep angle relative to the light. Experiment a bit to find the positions that best illuminate the chamber and provide the most spectacular viewing.

Observations

After the chamber has reached equilibrium, droplets will form very fast near the bottom and less so as you move up. The top of the cloud will be about 4cm above the bottom. That's where you want to focus your attention, where the wispy telltale tracks you are looking for will suddenly spring into being. Their appearance, like tiny ghosts dashing through a fog, is something out of Harry Potter.

If you measure their rate and directions, you can learn a great deal. Consider adding a digital camera, shooting either through one side of the case, or through a hole cut in the felt and wire screen on the top. Take a steady march of images and keep only those that happen to capture a track. Long, straight, and slender tracks are most likely made by muons. Thick, stubby tracks that start and stop inside the chamber are created by alpha particles. Their rate will let you set an upper limit on large radioactive nuclei in your environment, like radon

Once you've astonished yourself, make plans to show your chamber to every person you possibly can. No demonstration I know is better able to get people excited about science than this one.