CERN OPENDAYS
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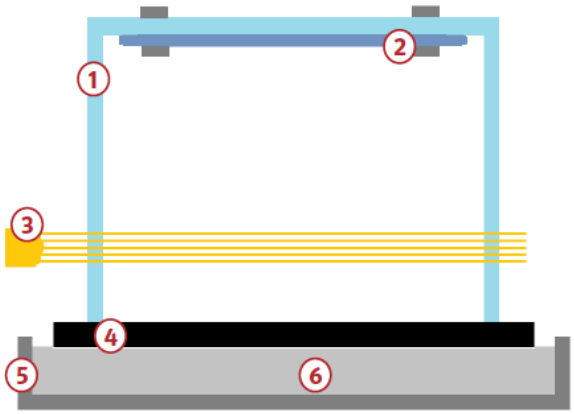
BUILD YOUR OWN CLOUD CHAMBER AT HOME

Particles coming from the universe (*cosmic rays*) are crossing the earth all the time – they are harmless but invisible to us, also called natural radiation. Cloud chambers are detectors to make the tracks of the particles visible. Some decades ago – these detectors were used at CERN in the first experiments to detect particles. Wouldn't it be nice to build such a detector at home in your kitchen? We show you how to build a small one at home in your kitchen for your own research ...

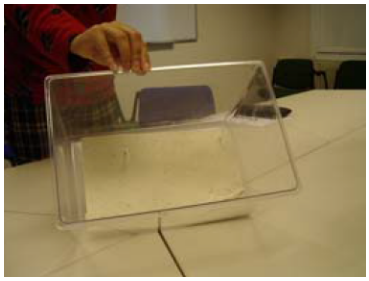
Shopping list

- ☐ A clear, see-through box-like plastic container, with flat sides and an open top, roughly 20 x 30cm (open side) x 15cm (height)
- ☐ A metal plate (at least 5mm thick) to cover the open size of the container completely (plate must be a little bit larger than the box). The plate should be preferably black and should have a little grooves matching the side walls of the plastic box. As this is probably hard to find, you can also use a flat metal plate and use black electrical tape to make the metal plate surface black.
- ☐ A thick felt (few mm), a bit smaller than the bottom of the box.
  4 clips (self-adhesive cable-tie holders + cable ties) to attach the felt to the inside of the bottom of the box
- ☐ A small wooden box that is just a little bit larger in area than the metal plate and approx. 5cm in height. The box later on has to take the ice plates and the metal plate but the sides should not be much higher so that it doesn't cover the plastic box.
- ☐ A very intense, bundled light source, e.g. a slide projector, strong flashlight ...
- ☐ Pure (not 70%) isopropyl alcohol – make sure you get the right one – it will only work well with this one it and keep it out of reach of children).
- ☐ Dry Ice (Careful with your hands – always use thick gloves and never touch the ice directly! The ice is at -78oC; touching it directly will give you a burn.)
- ☐ Security goggles to handle the ice
  Gloves to handle the ice and the alcohol

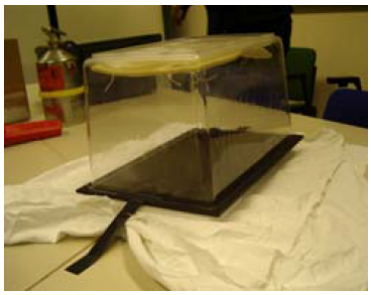


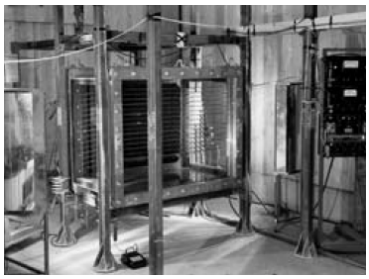
1. Plastic box
2. Felt with alcohol
3. Light source
4. Metal plate
5. Wooden box
6. Dry ice

Step by step instructions:



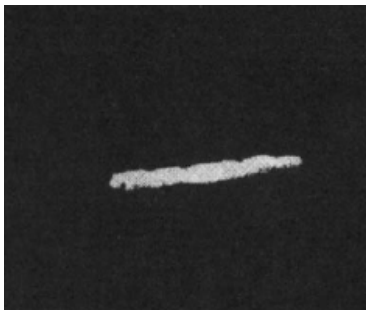
1. PREPARING THE BASE PLATE - If you were not able to get a black metal plate, you have to wrap one side of the metal plate completely with the black electrical tape. This will make it much easier for you to see the “white particle tracks” later on in front of a black background. The bottom will be in contact with alcohol when you run the chamber, so do not use alcohol-soluble tape or glue to attach it. If you have already a black metal plate you can skip to point 2.
2. PREPARE THE ALCOHOL DISPENSER - Attach the cable tie holders to the bottom of the box and clamp the felt with the cable ties to the bottom of the box. Later on these felts will be soaked with alcohol and will produce a rainlike mist of alcohol. Also, you can drill very small holes in the bottom of the box, just above the felt. Like this you will be able to easily add later on alcohol to keep the chamber running for a longer time
3. ADD THE ALCOHOL TO THE CHAMBER - Next you have to add the alcohol to the chamber. Make sure you have plastic gloves on so that the alcohol does not touch your skin excessively. Again – never ever drink the alcohol and keep it away from children! It is very crucial that you use the right alcohol – the chamber will not work with another one! You have to add the alcohol to the felt – add so much alcohol that the felt is thoroughly soaked with alcohol. This alcohol will later form the mist in which you see the tracks appearing. Also put alcohol into the little deepening of your metal plate if you have it. This will help sealing the box.
4. PUT THE CHAMBER TOGETHER - Now you can close the chamber: Put the metal plate with the black surface pointing to the inside of the box and turn it around. Your chamber should how have the plastic box inverted, metal plate on the bottom. Fit the box so that the box walls fit the grooves in the metal plate. Make sure there is some alcohol in the grooves - that will seal the box better. If you metal plate has no deepening you must seal the box in addition by putting black electrical tape around the connection of the box with the plate. Make sure that you seal the box carefully and completely.

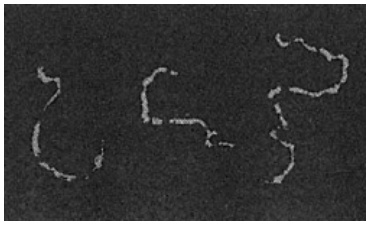


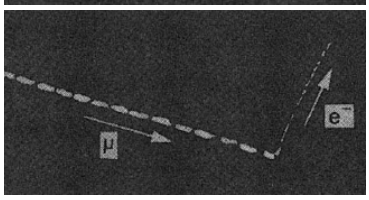


5. PREPARE THE ICE - Now take the dry ice and put it into the wooden box. Make sure to use thick gloves (the ones for handling heavy things or heavy winter gloves) and safety goggles when handling the ice. The temperature of the ice is -78°C! Finally put the box with the metal plate on the bottom on the ice. Now your chamber is ready to detect particles tracks !!!

6. RUNNING THE CHAMBER - The chamber will take a few minutes to get to an equilibrium state before you can see the first track appearing. Turn off the room lights and turn on your light source (flash light or slide projector) and point it through the chamber along the bottom of your chamber. At first, you will only see a rain-like mist of alcohol. The sensitive place of the chamber where you will see tracks is near the bottom of your chamber. Make sure that the chamber stays sealed and that you have no air leaks. After about 10 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. You should be able to see a couple of tracks per minute. If needed, you can add extra alcohol through the holes in the top of the box without reopening the box.







WHAT CAN YOU SEE ?

You will see different kinds of tracks coming from different cosmic particles. You might notice that some tracks are very "bright" and thick, and others are very faint. Besides straight lines of tracks from one particle you might see:

- A thick, few centimeters long track. This is most likely caused by an alpha particle, which is the nucleus of the Helium atom (first picture to the left).
- A very windy, chaotic track. This is "multiple scattering", as a low-energy cosmic ray bounces off of one atom in the air to the next (second picture to the left).
- A straight track that sharply "kinks" off to the left or right. This is a decay of a muon particle. The two dashed lines are particle called neutrinos (the dashed lines) that your chamber is not able to detect (third picture to the left).
- Three tracks that meet at a single point. In these events, one track is an incoming cosmic ray, a particle called muon. This particle hits an atomic electron. The electron and the outgoing cosmic track are the two other tracks (without picture).

HOW DOES THIS WORK?

As the top of the box is at room temperature, the alcohol evaporates from the felt (i.e. exists in gaseous form) and slowly sinks down in the direction of the bottom of the chamber. Because there is so much alcohol, the chamber will be saturated with alcohol vapour. The dry ice keeps the bottom very cold – so that the vapor, once it has fallen, is in a so called supercooled

state. This means, the alcohol is in vapor form, but at a temperature at which vapor normally can't exist. It is, as if you had made steam at 95oC. Since the vapor is at a temperature where it normally can't exist, it will very easily condense into liquid form if anything disturbs its equilibrium.

Now what happens if a charged cosmic particle crosses the chamber? The particle will ionize the vapor: it tears away the electrons in some of the gas atoms along its path. This leaves these atoms positively charged (since the electrons that have negative charge have been removed). This is enough to start the condensation process: Small droplets of alcohol form along the path of the initial particle through the chamber. These droplets are the tracks you see appearing.

TROUBLESHOOTING

Like in any real experiment, things might not work from the beginning and you may find yourself with difficulties. Here are a few common problems and their solutions:

- "I don't see any tracks!" - Solution: Be sure the light is well placed. The sensitive part of the chamber is near the bottom where the alcohol is in its supercooled state. Make sure the dry ice is neatly packed and in good contact with the metal plate. Try adding some alcohol so that the chamber is well saturated. Check that the chamber is airtight.
- "I only see mist, and no tracks." - Solution: Wait. It takes about 10-15 minutes for the chamber to get to the right temperature. Make sure that you use the right alcohol – other alcohol have different “activation energies” that so that cosmic rays will not be able to start the condensation process.
- "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.

TO LEARN MORE ABOUT IT …

If you want to learn more about cosmic particles and cloud chamber have a look at the following sites:

Wikipedia helps:
http://en.wikipedia.org/wiki/Cloud_chamber

Nice movie of an impressing cloud chamber at work:
http://www.richannel.org/the-modern-alchemist-cloud-chamber

Foland cloud chamber page (this is who we learned it from!)
http://w4.lns.cornell.edu/~adf4/cloud.html

Further Readings:

C. T. R. Wilson: *On an Expansion Apparatus for Making Visible the Tracks of Ionising Particles in Gases and Some Results Obtained by Its Use.* Proc. R. Soc. Lond. A. 1912 87 277-292 doi:10.1098/rspa.1912.0081 (published 19 September 1912)

CERN Cloud chamber workshop developed by:

D. Bertola, M. Cirilli, J. Flammer, G. Schlager, S. Schuh, P. Schune, M. Storr