Dry Ice Cooled Cloud Chamber D-113
(IAEA Special Edition)

Operation Manual

RADO Corporation.

20230525 D-113 IAEA

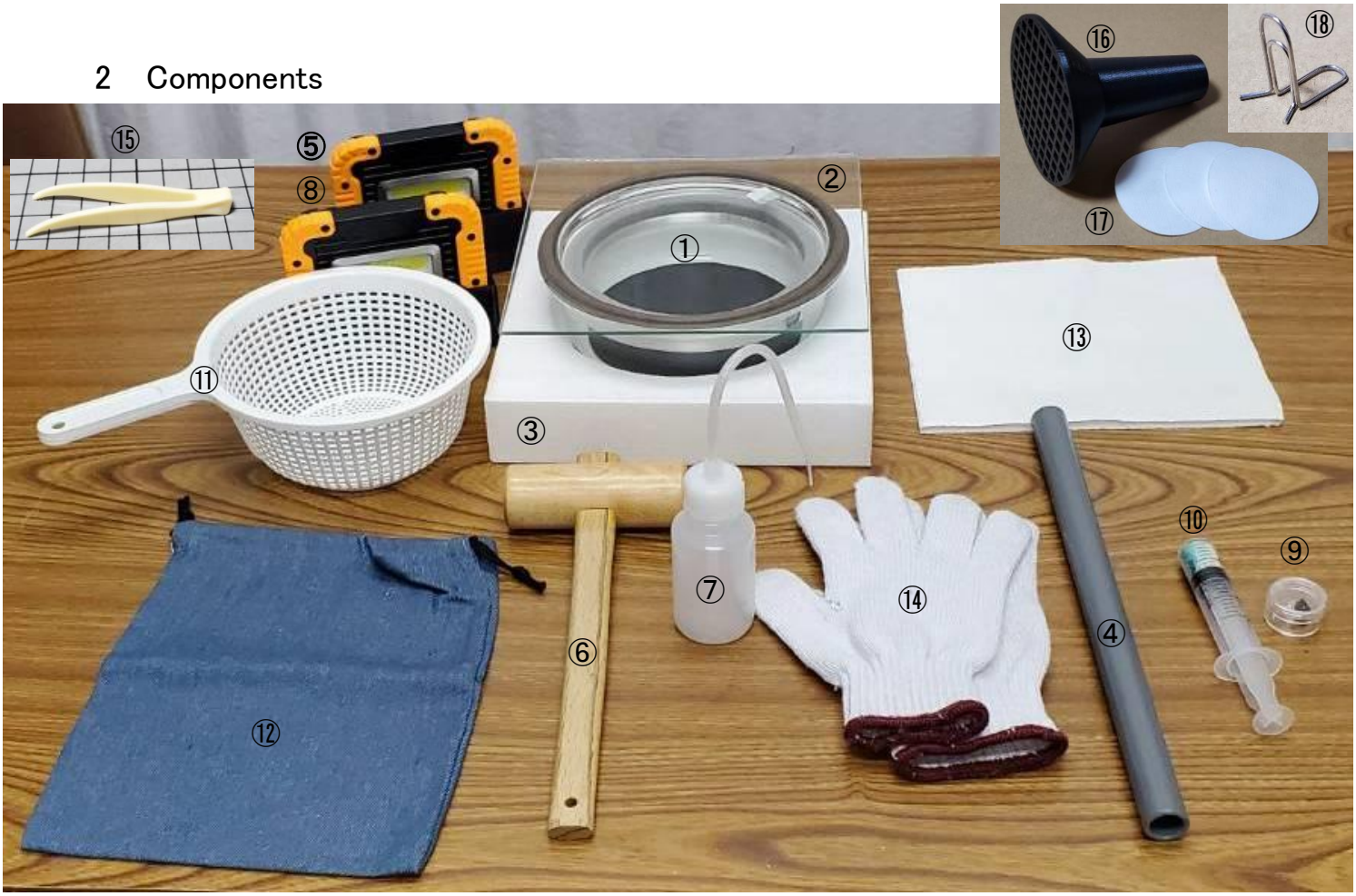
1 Features

This cloud chamber is easy to handle, yet it allows clear observation of natural radiation tracks.

Related experiments can also be performed using radiation sources.

It is suitable for group experiments consisting of 5 to 6 students.

2 Components



① Cloud chamber :

② Glass lid

③ Styrofoam tray

④ PVC pipe

⑤ 2 LED lights

⑥ Mallet

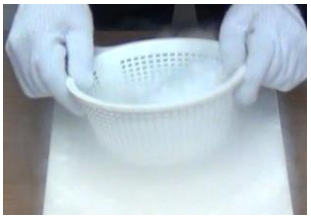
⑦ Plastic bottle

⑧ LED stand

⑨ Monazite ball







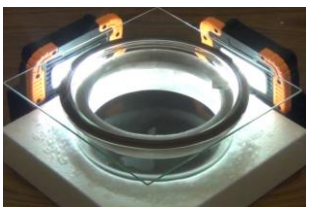
⑩ Radon gas source
⑪ Colander
⑫ Drawstring bag
⑬ Paper towel
⑭ Gloves
⑮ Tweezers
⑯ Filter attachment
⑰ Dust sampling filter
⑱ Filter stand

3 Consumables required for experiments

⑲ Dry ice (about 1 kg)
⑳ Ethyl alcohol (99.5 percent or more pure)

4 Operating procedures

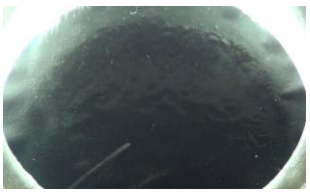




1) Pour about 100 milliliters of alcohol into a plastic bottle.
2) Put about 1 kg of dry ice into a drawstring bag.
3) Hit the drawstring bag many times with a wooden hammer to become powder the dry ice inside.
4) Using a colander, pour the dry ice powder into the styrofoam tray and raise the center slightly.
5) Hold both ends of the cloud chamber and place it so that the bottom is tapped on the dry ice powder a few times. This operation brings the bottom of the cloud chamber and the dry ice powder into close contact.
6) Pour a generous amount of ethyl alcohol on the sponge inside the cloud chamber.
7) Wet the black paper with a small amount of alcohol and firmly adhere the black paper to the bottom of the container. To prevent accumulation of air bubbles between the black paper and the glass bottom, make sure to squeeze the black paper from the center to the periphery by hand to expel air.
8) Cover the container with a glass plate and darken the room.
9) Illuminate the inside of the cloud chamber with two LED lights.

10) Firmly rub the PVC pipe provided in the set with kitchen paper to generate static electricity, and then move it back and forth repeatedly over the glass lid from side to side, just barely touching the glass lid, to remove ions in the glass container.

11) A few minutes after the cooling starts, traces of natural radiation can be observed in the glass container.



5 Observation method

1. Observation of natural radiation tracks

After completing the above operation procedure, wait for a few minutes.

1) Condensation trail a few centimeters long may sometimes become visible. These are tracks of alpha rays emitted from radon (Rn), a radioactive element that comes out of rocks on the ground and is in the air.

Alpha-ray

2) Thinner, shorter, and more undulating than alpha-ray tracks are beta-ray tracks. They are thought to have been knocked out by radioactive materials in the air or high-energy cosmic rays.

Beta-ray

3) Tracks that are thinner, longer, more undulating or straighter than alpha-ray tracks visible across the glass container are considered to be cosmic ray (muon) tracks.

cosmic-ray

These tracks show that we are constantly breathing radioactive air and living in a shower of radiation.

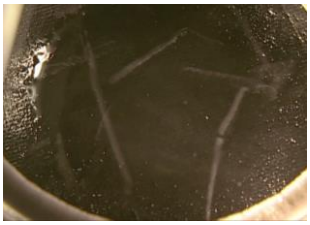
2. Observation of tracks using a radiation source

1) Monazite Ball

Pick up the Monazite Ball provided in the set with tweezers and place it inside the glass container. After placing the glass lid, rub the PVC pipe to generate static electricity and repeatedly move it back and forth, and from side to side over the glass lid to remove ions from the container.

Alpha-ray tracks can be observed radiating out from the Monazite Ball.

2) Radon gas



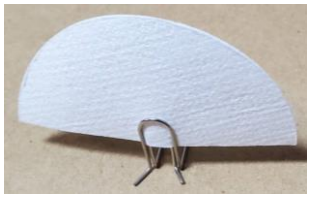
Pull the piston of the syringe containing the radiation source provided in the set 1 to 2 cm, temporarily peel off the vinyl tape on the lid of the glass container, push the piston toward the inside of the container, and inject radon gas accumulated in the syringe into the glass container. Many V-shaped α-ray tracks can be observed after adhering back the vinyl tape, and using the PVC pipe to remove the ions from inside the container.

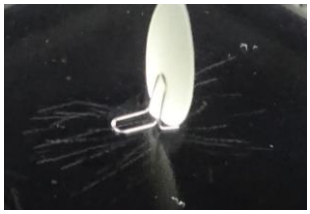
This shows the short half-life (0.145 seconds) of the radioactive decay series when radon (Rn) from the thorium (Th) series alpha-decays to lead (Pb) via polonium (Po). (It appears that two α-decays, Rn to Po and Po to Pb, occur simultaneously.) Below is part of the decay series.

	(α-decay)		(α-decay)		(α-decay)	
^{224}Ra	$\rightarrow$	^{220}Rn	$\rightarrow$	^{216}Po	$\rightarrow$	^{212}Pb
(Half-life)		(Half-life)		(Half-life)		(Half-life)
3.66 days		55.6seconds		0.145 seconds		10.64 hours

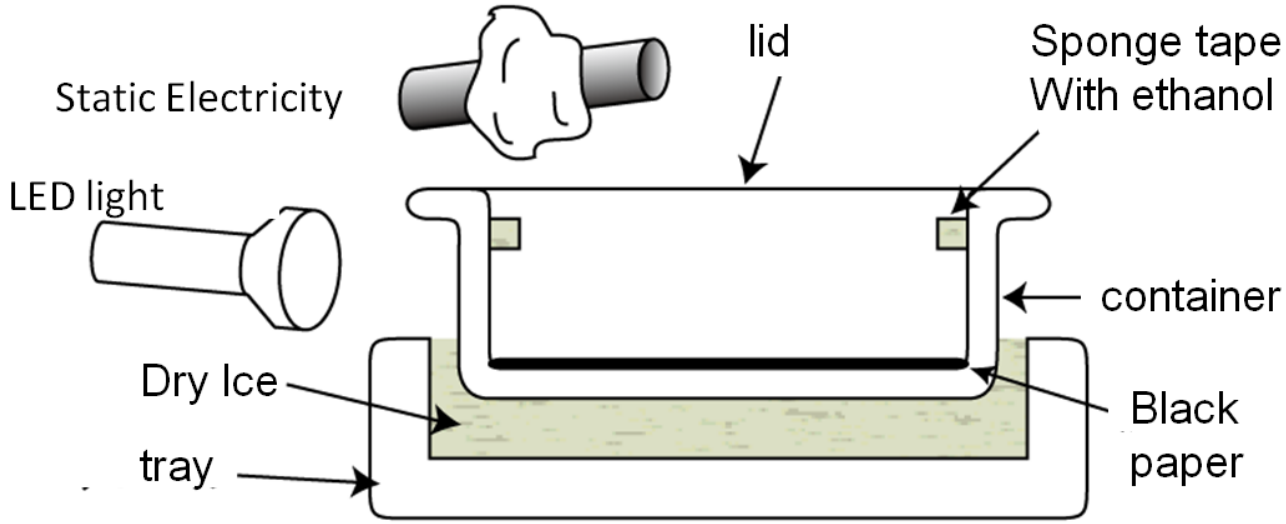
Also, the V-shaped tracks visible at this time disappear after a few minutes because the half-life from ^{220}Rn to ^{216}Po is about 1 minute (55.6 seconds).

3) Dust sampling filter





In a room with bare concrete closed all night, use a filter attachment and a vacuum cleaner to absorb dust in the air to the filter. Set the filter on the filter stand and place it in the cloud chamber. The alpha-ray tracks emitted from radon adsorbed on the filter paper can be observed.



6 When the tracks cannot be observed

The following 5 causes may be considered. Check and address the treatment for each cause as mentioned below.

Cause 1 Insufficient alcohol vapor in the cloud chamber.

Treatment: Pour plenty of alcohol on the sponge.

Alcohol may not have vaporized sufficiently inside the container because the entire glass cloud chamber had been over-cooled by dry ice due to prolonged observation, or a sufficient temperature gradient may not have been created inside the cloud chamber. Remove the cloud chamber temporarily from the dry ice and warm it to about the room temperature using a hair dryer, etc. before resuming the test.

Cause 2 Insufficient cooling of the vessel bottom

Treatment A.

If too much alcohol accumulates at the bottom of the cloud chamber, the cooling effect will be reduced, so tilt the cloud chamber and allow the alcohol to flow back to the sponge.

Treatment B.

If the outer surface of the bottom of the cloud chamber is not firmly in contact with the dry ice, stir the dry ice again and break it up into small pieces. Hold the cloud chamber with both hands and lightly tap it on the pile of the dry ice several times so that the surface of the dry ice becomes even.

Treatment C.

If ice or frost on the outer surface of the bottom of the cloud chamber prevents it from tight contact with the dry ice, scrape them off well and reposition it.

Treatment D

When air accumulates between the cloud chamber and the black paper laid inside the cloud chamber, and the paper is not adhered to the bottom (turn the cloud chamber over and look at it from the back to see the air accumulation), press the paper with your fingers to expel the air.

Cause 3 The cloud chamber is not kept horizontally level.

Treatment A.

If the tracks flows to one side and is unstable, it is because the cloud chamber is not kept horizontally level. Place a piece of paper between the dry ice cloud chamber (Styrofoam cloud chamber) and the table to keep the cloud chamber levelled.

Cause4: Lack of lights or lights inappropriately applied.

Treatment A.

Replace the batteries for the LED light with new ones. The light should be directed slightly downward at an angle from the side of the cloud chamber through the glass to illuminate the surface of the black paper at an angle.

Cause5 Insufficient removal of residual ions inside the cloud chamber

Treatment A

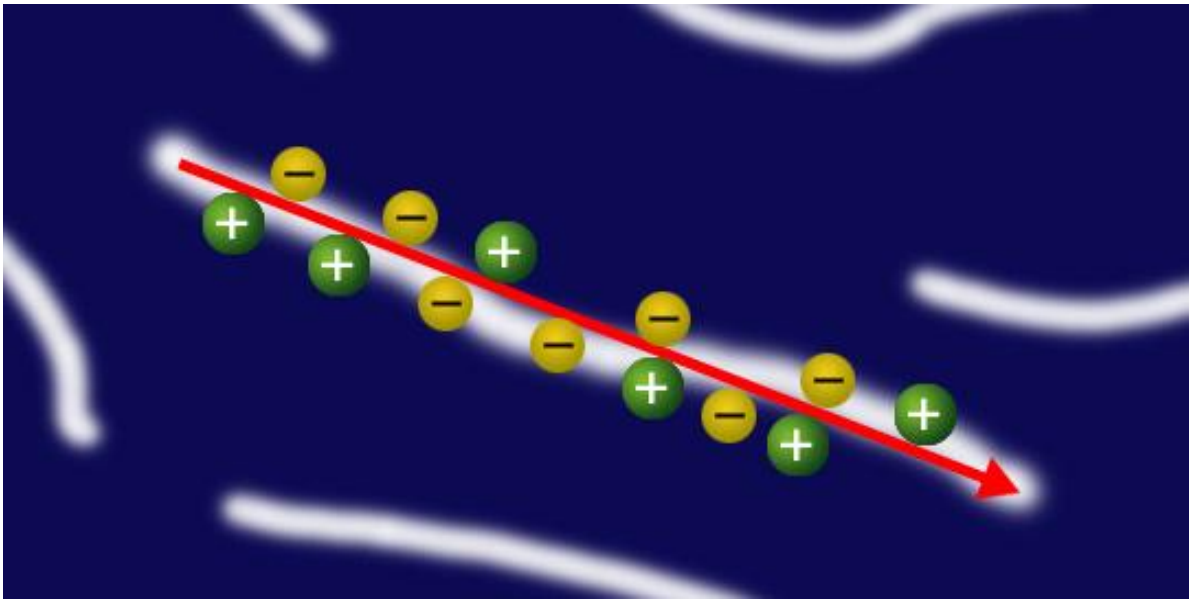
Rub the PVC pipe (or plastic jug) firmly with dry tissue paper to generate a strong static charge and move it back and forth over the cloud chamber repeatedly to remove ions inside.

7 Precautions

1. Do not use fire during the experiment.
2. Ventilate the room occasionally during the experiment.
3. Do not touch dry ice with bare hands.

8 After the experiment

1. Properly dispose of dry ice and alcohol.
2. Dry condensation on the cloud chamber and lid before storing it in the box.



9　Reference (Reason why the tracks are visible)

The cloud chamber is saturated with evaporated alcohol.

The upper part of the cloud chamber is saturated at a temperature close to room temperature (20° C). However, because the lower part is cooled to about −60° C the alcohol vapor is unstable and over−saturated. Under such condition the alcohol molecules try to bond together.

A sharp temperature gradient of approximately 60° C to 80° C between the top and bottom of the cloud chamber causes supersaturation of alcohol.

When radiation passes through this over−saturated container, electrons of nitrogen, oxygen, and other gas molecules along its path are bounced off and ions are formed along the path.

With these ions as nuclei, alcohol molecules condense to form droplets, forming an alcohol cloud.

What is observed as radiation tracks when light is shone on the cloud is this path.

The reason for darkening the surroundings and illuminating the bottom of the glass container with a strong light source from the sides of the container is because tracks appear near the bottom where the over−saturated layer is formed.

Further, in order to condense alcohol molecules only on the ions in the path of the radiation, the glass container must be cleared of any ions that are in the way. This is why the tracks cannot be observed without the PVC pipe with static electricity.

Please refer to the latest manuals and videos here.

https://kiribako-rado.co.jp/manual/

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