

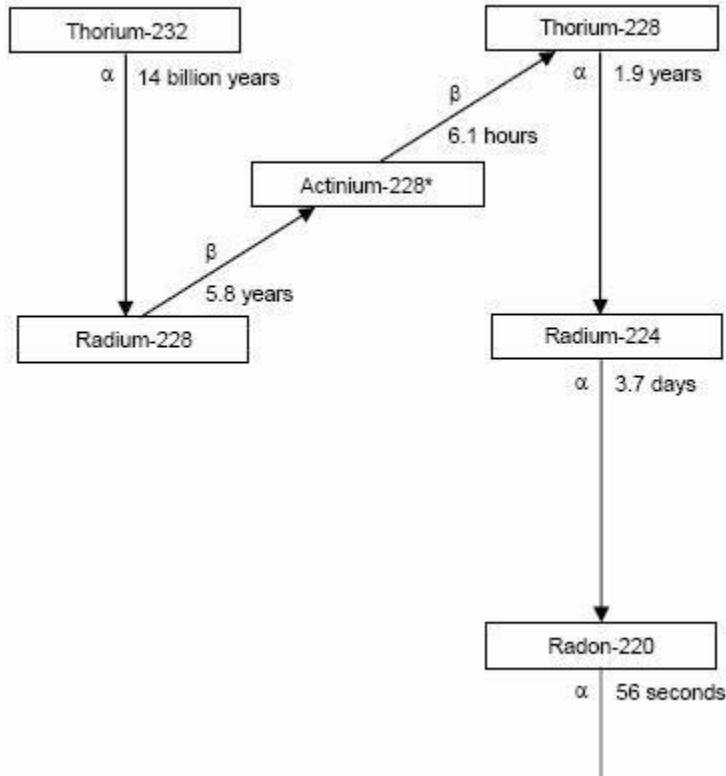
Direct detection of Alpha Decay from Radon Gas

by George Dowell

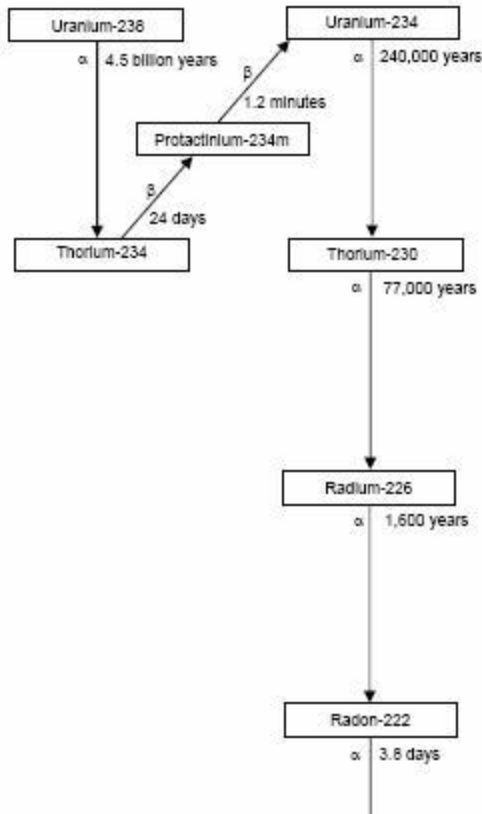
Radon collection is one of the few "separations" that can be done in the home lab, and is relatively easy.

There are a number of Radon isotopes, all coming from decay of different Radium isotopes. The two of major interest to us in the home lab are

- 1) Rn-220, also called Thoron, from Radium 224, which is in the Thorium-232 decay chain, milked from Thorium Lantern Mantles,



- 2) Rn-222 the one commonly called RADON when we are referring to Radon in homes. Rn-222 comes from the Radium 226 in the Uranium-238 decay chain. Radon is a gas, heavier than air and sometimes is called "radium emanation". Milked from Radium Watch Hands or natural Uranium ore.



Collection can be accomplished by adsorption onto activated charcoal, or air pumping. see:

<http://www.p2pays.org/ref/17/radon/pubs/devprot3.html>

Once the sample is captured, you have pure Radon gas for a time, depending on half-life of the isotope.

Our goal is to count Alpha particles coming from the Radon, and time the half-life. Using a Lucas Cell makes it easy. A Lucas Cell consists of a container, whose inside walls are coated with Zinc Sulfide, at one end is a clear window so the scintillations can be observed and counted by a photomultiplier tube, and the other end contains one or two valves for the introduction of air. Cells with one valve must be first pumped to a vacuum with a pump, then an air sample is "grabbed" by releasing the valve until the air is sucked inside, then closed again.

Grabbing air samples to test for Radon in air can be accomplished by pumping out the air from a Lucas Cell, transporting the cell to the test site (cave, mine etc.), then quickly crack open the valve. Air rushing in will fill the cell with a representative sample and the Lucas Cell can be immediately tested on a portable PMT tube as shown in this apparatus that I made up from commercial parts, a hand vacuum pump, and cardboard tubes:



Naturally this is called a **GRAB SAMPLER**

Here is a picture of an original handmade Lucas Cell given me by Henry Lucas himself along with one of his original papers from the meeting where he presented these devices to the world back in the 1950's. :



Cells with two valves use a simple air pump to circulate the air, until a sample is collected, when both valves are closed.

Other Alpha detectors can be used like the mica end-window GM tube or the Pancake GM tube. Be sure to cover the mica window with a layer or Rad Mylar so when the Radon gas decays back into a solid, those radioactive daughters don't

contaminate the window. Rad Film or Rad Mylar is thin enough to pass Alpha particles. Small samples can be obtained from the author for a nominal fee. All-metal GM tubes don't detect Alpha particles, the walls are too thick.

Once the air and Radon are inside the Cell, you must count the CPM being created by the Alphas right away. For Radon-222, the counts will remain steady over a period of time, hours at least. The reason for this is the long half-life (3.8 days) of the Radon itself, and also the high energy of the Alphas from the decay daughters, Po-218 and Po-214. Over time, the energy of the Alphas will shift from 5.49 MeV of Rn-222 to 6.02 MeV of Po-218 to 7.69 of Po-214. See the decay scheme at:

<http://www.ead.anl.gov/pub/doc/natural-decay-series.pdf>

For Thoron, it is more dramatic, and far better for lab demonstration purposes. I use a "cow" for collection, which is simply a large kitchen funnel with a coffee filter in the bottom. In the bowl of the funnel is placed the uranium ore or thorium mantles. On the spigot is a tube going to an air pump, which sucks the air over the samples, and delivers it via another inline filter to the Lucas Cell (or whatever detector you choose).

Picture shows 15 gm Th-232 in Pepsi Bottle cow. Airpump is surplus "breathing machine" or nebulizer purchased at a garage sale for 5 bucks. Container of activated carbon in background is for canister collection experiments.



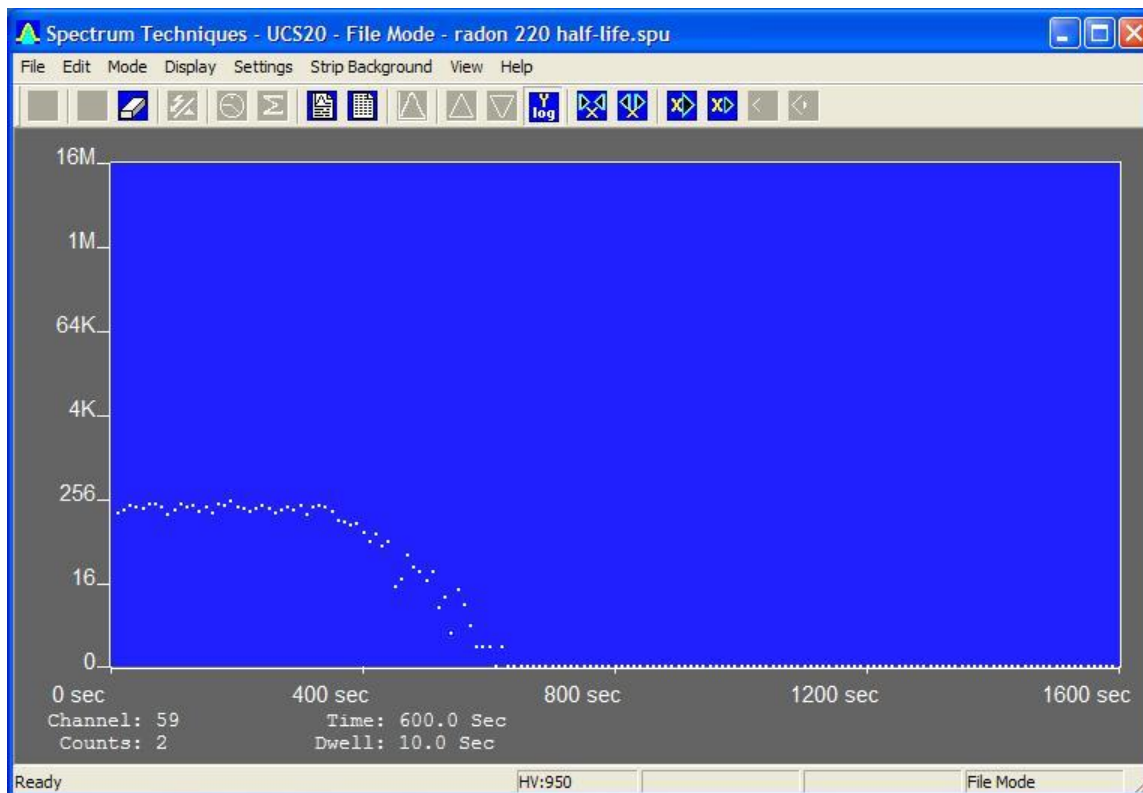
Air is drawn through 40 Th-232 lantern mantles, pulling gaseous Radon 220 (Thoron) off through filter which removes solid decay daughters. Air flows through light trap and valve into a 1 liter ZnS(Ag) chamber. Air exits the other valve and light trap.

After a minute or two , the count rate stabilizes due to direct reading of Alpha particles from the Rn-220. At a point after seeing the steady state, the valves are closed, trapping a given sample which is then observed for decay due to the short 56 second half-life of Rn-220.

Running the air with the cow empty yields around 15 CPM with no radiation present other than random junk in the air. Adding the mantles quickly increases the count to almost 2000 CPM, and this is with the mantles STILL INSIDE the plastic baggies. Each baggies has a tiny vent hole, through which some of the Thoron escapes. Later naked mantles will be tested.

The above are large readings, with HV set to around 900. In practice, HV will be set lower on the plateau with a background reading way down at only 50 CPH (counts per hour), and then the radon will register 200 to 230 CPH per pCi/L.

Thoron collected in this way gives a great reading on the meter, and begins to die away in mere seconds as the half-life of Rn-220 is only 56 seconds. The Polonium-216 daughter decays in less than a second, so within a few minutes the experiment is over. If not flushed, the daughters will again start producing Alphas in about 12 hours, from the further decay into Po-212.



I hope this gives you some ideas for experiments, and reminds you that simple equipment can do real science.

Have Fun

George Dowell

For those of you who have purchased one of my Radon cows, here are some tips on milking it with simple apparatus:.

First of all, it takes about 100-200 radium watch hands to provide enough "parent" to get 1 uCi of activity, depending upon the size of the watch hand. One uCi of parent will produce 1 uCi of the

daughter Ra-222 when equilibrium is reached. Half-life of Ra-222 is 3.8 days.

Once milked, the radon will re establish equilibrium in 20 days.

See:

<http://physics.nist.gov/GenInt/Curie/1927.html>

or use the Universal Decay calculator at:

<http://www.wise-uranium.org/rcc.html>

One whole microCurie of Radium will produce one whole microCurie of Radon every 20 days, but the actual gas volume is quite small, only .000002 mL. Not all of the gas will be free to leave the matrix either, so don't try to calculate the exact dose from simple math.

The THORON Cow of course uses Thorium in the form of mantles to produce the THORON gas, which is an even better type of Radon (Radon 220) from a home lab experiment standpoint. Having a much shorter half-life of only 56 seconds, some pretty dramatic demonstrations can be accomplished, well within the attention span of even grade school aged students.

It takes about 50 mantles to provide an approximate 1 uCi of parent. IF the material is 40 years old, there will be an approximate equilibrium between the parent Th-232 and the daughter Ra-224 which is responsible for the Rn-220. Our mantles are probably no where near that old, but even 9 year old material will have about 50% equilibrium already. One day, we will have to do the age test on this stock on mantles to determine the material's equilibrium fraction. I recommend 100 mantles for a serious Thoron Cow.

Nonetheless, whatever the equilibrium fraction, it is assured that there is at least 50% of the maximum Radon-220 available, and the Thoron Cow can be milked once per hour.

A gas extractor is simplicity itself. Use a squeeze bottle as designed for Ketchup or Mustard that has a pointy top.

Clear plastic versions are more dramatic, and can be obtained from any kitchen supply aisle.

Fill the bottom 1/3 of the container with cotton wadding, then layer on your parent material, either radium or thorium. Finally add another 1/3 filling of loose cotton, leaving 1/3 at the top empty for expansion/contraction. Place a piece of cloth over the container mouth before adding the top to it, to act as a pre-filter against

solids. Cap when not in use to accumulate the gas, and when ready for use, uncap and slip your lab tubing over the pointy dispensing end. A few puffs and you will have enough gas to fill your Lucas Cell, or to use in any other desired detector. Always use an inline filter to eliminate any solid particles that may get into the air stream, any of which would contaminate your detector. Contact me if you need any glass-fiber-on-paper filter media, as I have several boxes of the roll material. It can be cut or punched into standard discs and is very cheap.



Don't forget that any Radon gas is heavier than air.

Radon in water ideas:

George, you can do the by using a de-emanation tube. Its a U shaped glass tube with a frit on the bottom. A frit is just a porous glass disk that when air is gently pumped through it produces a fine cloud of gas bubbles (think of your fish tank bubbler) the bubbles pull the dissolved Rn out of solution and the gas is dried using a drierite column and then captured into a Lucas cell. you count the radon in the water sample this way. Dudley Emer

Other materials gathered so far are activated carbon for the adsorption chamber, and some aeration stones (both from aquarium supply aisle at Wal-Mart).

The idea here is to immerse 100 thorium lantern mantles (300 mg Th-232 each= 30 gm), age them in and bubble off the Rn-220 gas through a filter to a AC (activated carbon) canister, which in turn will be examined in a an Alpha sample counter and a Beta sample counter, as well as a sensitive Gamma scintillator. (Caution Thorium salts are water soluble)

As you may have noticed, Radon decays by Alpha decay, and it has a rather short half life. When you collect Radon in the home to send in to a lab for testing, you are actually collecting the gas on an activated charcoal medium, but the lab is testing for the solid decay daughter that grow in over time. These are tested using a Gamma Spectrometer.

Have fun

George Dowell
New London Nucleonics Lab
GEOelectronics@netscape.com

Similar articles by author:

Pa-234m cow

Ba-137m cow

Materials available from the author:

ZnS(Ag) screens

Thorium Mantles

Radium Watch Hands

Pancake Detectors

LENi Geiger Counter instruments

Rad Film

PMT Dynode Bases- custom made

Custom Made Apparatus- on occasion

Have Fun

Geo

George Dowell

NLNL/ New London Nucleonics Laboratory

Copyright © Viscom Inc. 2007

The treatise may under no circumstances be resold or redistributed in either printed, electronic,

or any other forms, without prior written permission from the author.

Comments, criticism and questions will be appreciated and may be directed to the author by email to GEOelectronics@netscape.com

All PHOTOS bythe author

unless noted otherwise