Ion Chamber

Radon Measurements

Theremino System
Rev.1

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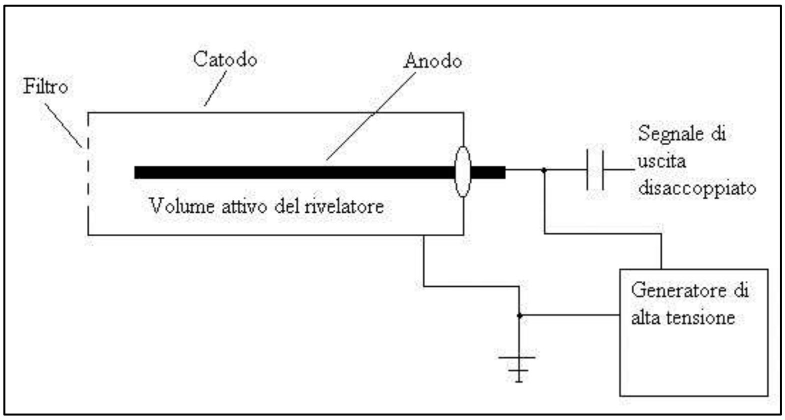
Misure con Camera a Ioni

Theory



The **Ion Chamber** is a gas particle detector.
Its operation is based on the following experimental observations: when a charged particle passes through a gas causes its ionization, that is, transforms its molecules that meets in ion pairs.
If the gas, moreover, is located in an electric field (that is, between two electrodes), then the ions and electrons created migrate towards the electrodes of opposite sign.

Such a device can operate in two ways:

- as an integral detector, that is, as the current meter flowing as a result of the discharge of ions on the electrodes (current mode).
- as a differential detector, ie as counter of the charged particles that are formed in the ionization chamber (pulsed mode).

Conceptually simple, the device presents special construction differences depending on the type of radiation that must reveal. For example, because the particle α can be stopped by very thin walls, then it is necessary to place the source directly inside the chamber itself. In the case of the **Radon** the chamber it is provided with opening through which the **radon** can diffuse.

Equipment

Ion Chamber

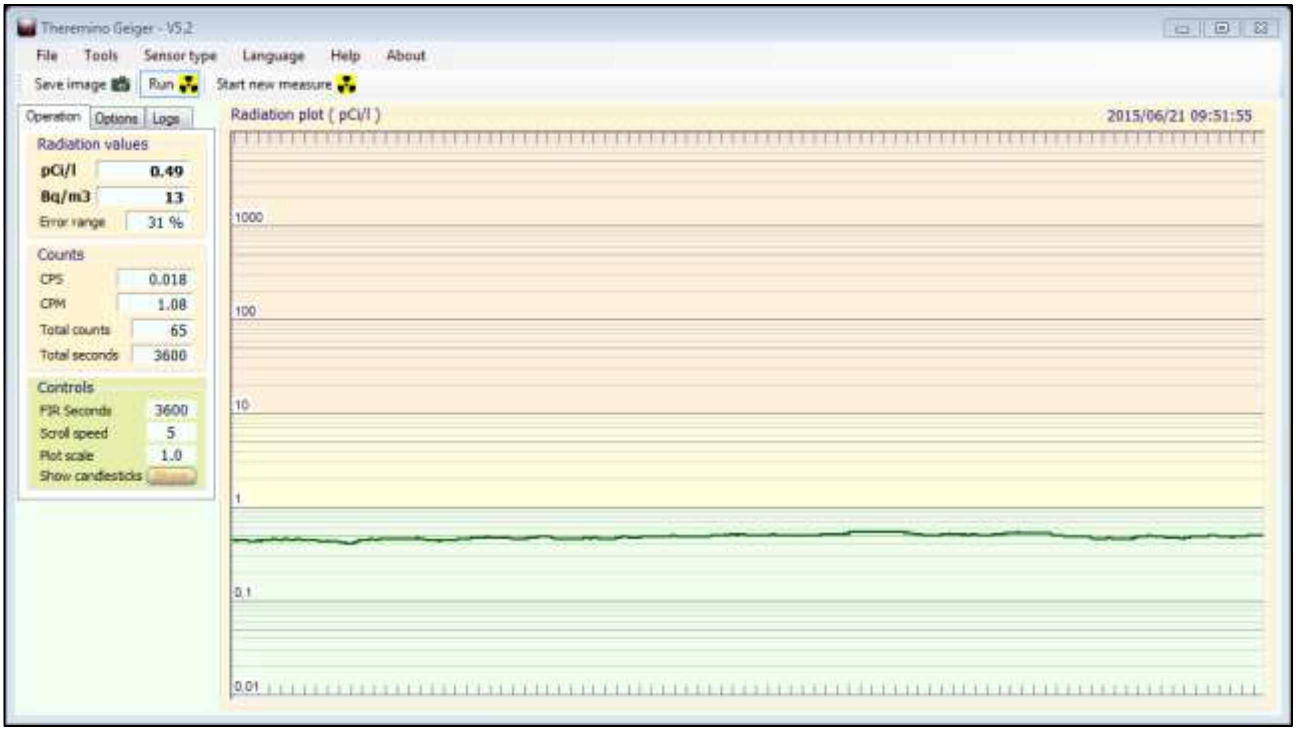
Impulse Ion Chamber
Passive Diffusion Sampling
Range di mis. da 0.5 a 74000 Bq/mc
(0.01 to 2000 pCi/l)
Sensitivity 0.05 cpm/Bq/mc
(2.0 cpm/pCi/l)
Accuracy +/-50%
(calibration not needed)
Volume camera 1000 cc

Radon in Buildings - Rn^{222}

Radon is a chemical element with symbol **Rn** and atomic number 86. It is a radioactive, colorless, odorless, tasteless noble gas, occurring naturally as a decay product of radium. Its most stable isotope, 222Rn, has a half-life of 3.8 days. Radon is one of the densest substances that remains a gas under normal conditions. It is also the only gas under normal conditions that only has radioactive isotopes, and is considered a health hazard due to its radioactivity. Intense radioactivity has also hindered chemical studies of radon and only a few compounds are known.
Radon is formed as one intermediate step in the normal radioactive decay chains through which **thorium** and **uranium** slowly decay into lead.

Measure Setup

placing the sensor on the floor and wait for a time comprised between one and two hours



Location : ground floor - Trento
Sensor : Ion Chamber
Result : 13 Bq/m^3

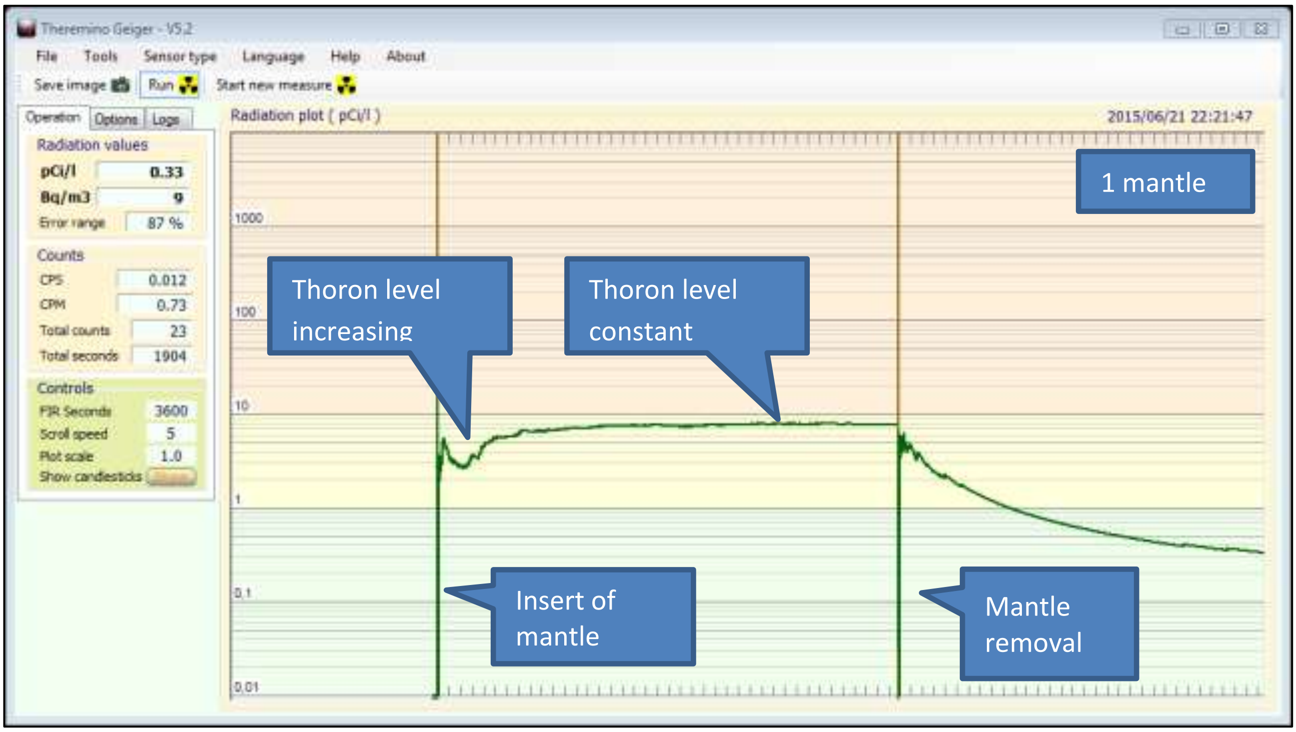
Location : first floor - Trento
Sensor : Ion Chamber
Result : 6 Bq/m^3

Thoron from thorium mantle - Rn^{220}

"**Thoron**" is the name that identifies the radon isotope with atomic weight 220. It can also be harmful to human health because, as the 222Rn is an alpha emitter and presents itself in the form of gases. The time decay of thoron is about **55 seconds**, for this reason it is assumed that his presence in the home is less than the average 222Rn.

Measure Setup

Place the sensor on the container in which has been inserted the thorium mantle. Thoron gas that is emitted by thorium slowly accumulates in the bowl and then fill in about ten minutes the ionization chamber.

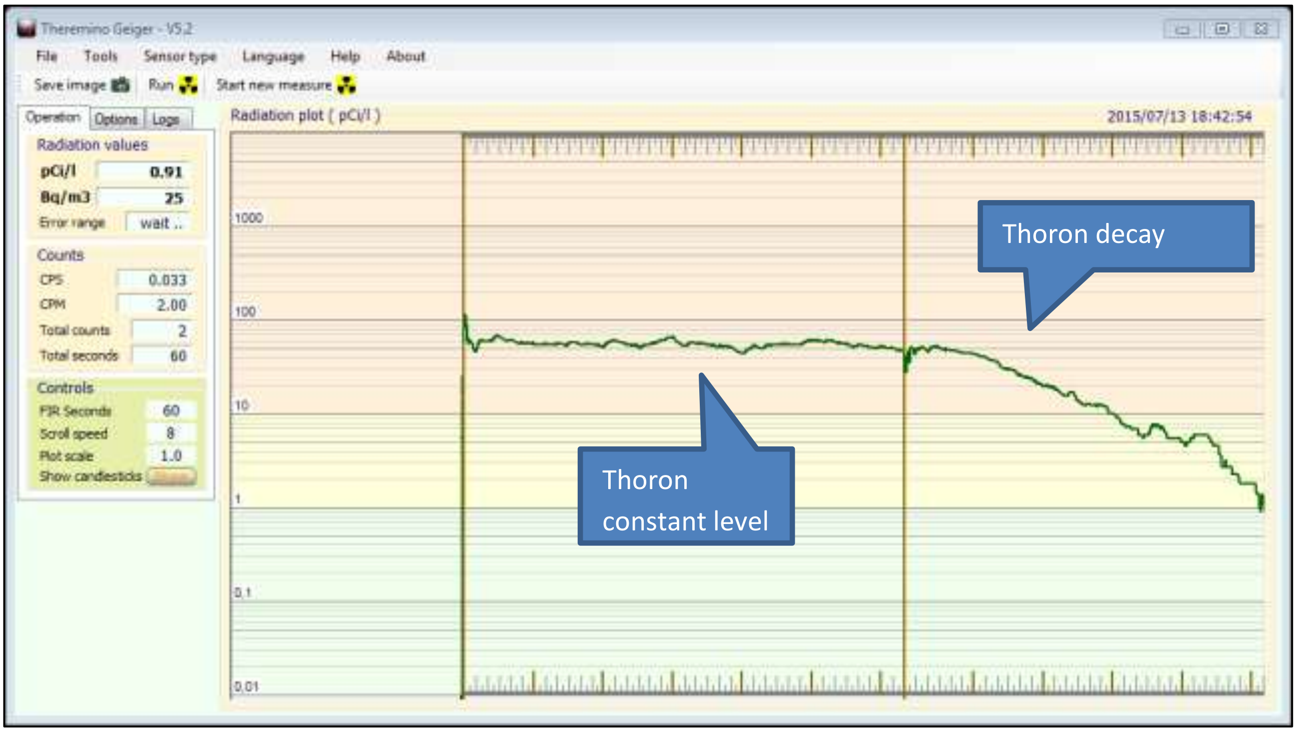


Sensor : Ion Chamber
Result : 200 Bq/m³

Sensor : Ion Chamber
Result: 900 Bq/m^3

Thoron decay measurement

Using the setup described in the preceding pages the decay of thoron has been measured. We have put the mantles inside a bowl , on which the ion chamber has been settled in vertical position so that the thoron that is released from the thorium enter the ion chamber.
After about ten minutes the chamber is full of thoron and the counting rate should stabilize.
At this point the ion chamber is moved and a new measurement is started. The thoron inside the chamber, being very heavy, does not escape and then decays with its specific half-life.
In the chart below you can see qualitatively that decay is linear on logarithmic scales and therefore exponential on a linear scale . Can be estimated a half-life of about 1 minute.



Sensor : Ion Chamber
Result: thoron decay

Half-life calculation

The exact moment when an unstable atom will decay into a more stable is considered random and unpredictable. What you can do, given a sample of a particular isotope, is to note that the number of decays follows a precise statistical law . The number of decays that are expected to happen in an interval dt is proportional to the number N of atoms present . This law can be described by the differential equation of the first order (in which λ is the decay constant) :

$$\dot{N} = -\lambda N$$

With this solution (e is the Euler number):

$$N(t) = N_0 e^{-\lambda t}$$

Which is typical of an exponential decay. It should be noted that this is only an approximate solution, first because it represents a continuous function, while the physical real event assumes discrete values, since it describes a random process only statistically true. However, since in the majority of cases N is extremely large, the function provides a very good approximation.

In addition to the decay constant $''\lambda''$ radioactive decay is characterized by another constant called average life. Each atom lasts for a precise time interval before decaying and the average is just the arithmetic average of the lifetimes of all atoms of the same species . The average life is represented by the symbol τ , linked to λ by :

$$\tau = \frac{1}{\lambda}$$

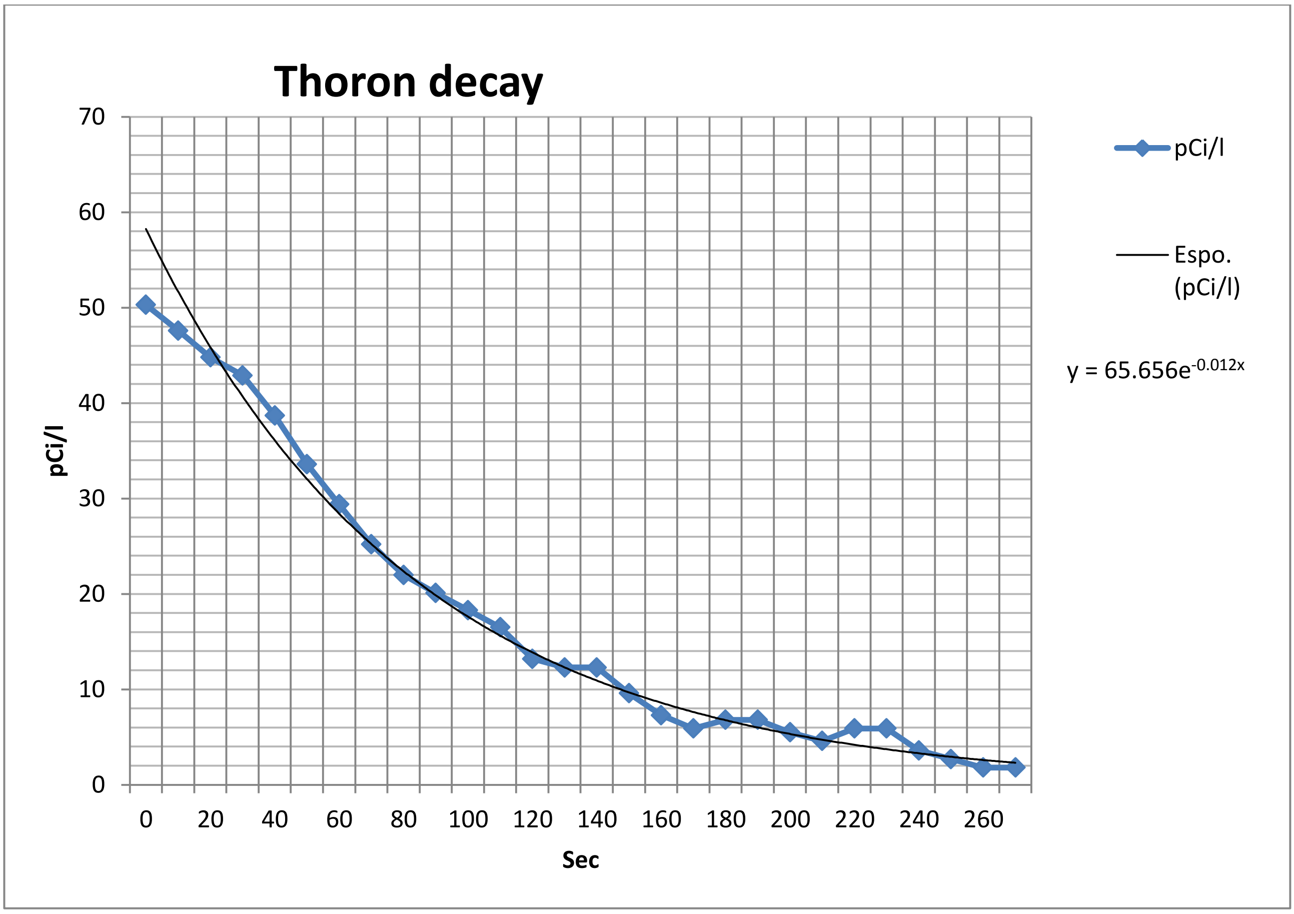
Another parameter often used to describe a radioactive decay is given by the half-life or $t_{1/2}$. Given a sample of a particular radionuclide, the half-life tells us the time interval after a number of atoms equal to half of the total will be decayed, and is linked to the average life from the relation:

$$t_{1/2} = \frac{\ln 2}{\lambda}.$$

These relationships allow us to see that many of the radioactive substances in nature are now expired, and therefore are no longer found in nature, but can only be produced artificially. To get an idea of the orders of magnitude, we can say that the average life of the various radionuclides may vary from 10^9 years till to 10^{-6} seconds.

Decay measurement data

Measurement data were included in the chart below in which it was made an interpolation with an exponential function .



From the interpolation exponential equation is obtained the following value for the decay time constant :

$$\lambda = 0.012$$

The following value for the half-life

$$t_{1/2} = \frac{\ln 2}{\lambda} = 57.8\ sec$$