ENVIRONMENTAL INVESTMENT CENTRE

Continuous and spot measurements

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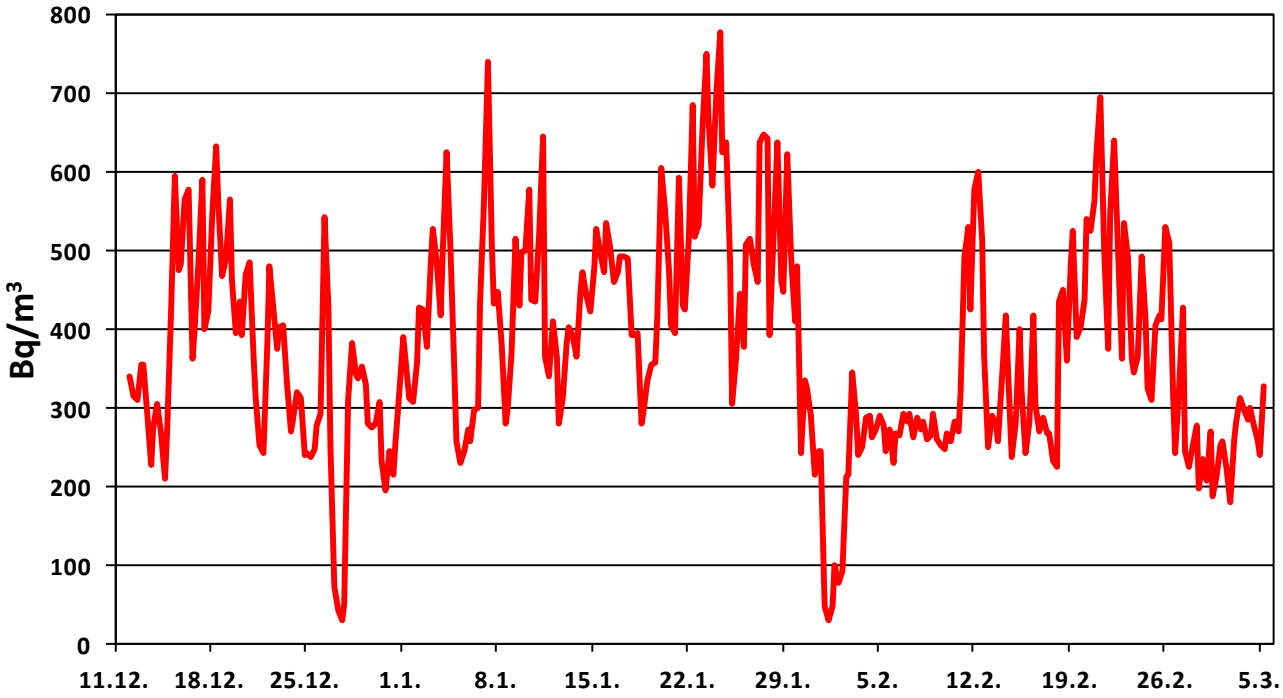
Principle

- Continuous sampling of air (passive/active)
- Continuous detection of radiation emitted by radon and its daughters
- Integration interval typically 10–60 minutes
- Measurement results are quickly available and stored into a data logger
- Temporal changes in radon concentration can be detected



Examples of application

- Ionization chambers
  - E.g. Saphymo Alpha Guard
- Scintillation counters
  - E.g. Pylon AB6A
- Semi conductors
  - E.g. Sarad RTM 1688-2

Source: saphymo.com

Source: pylonelectronics.com

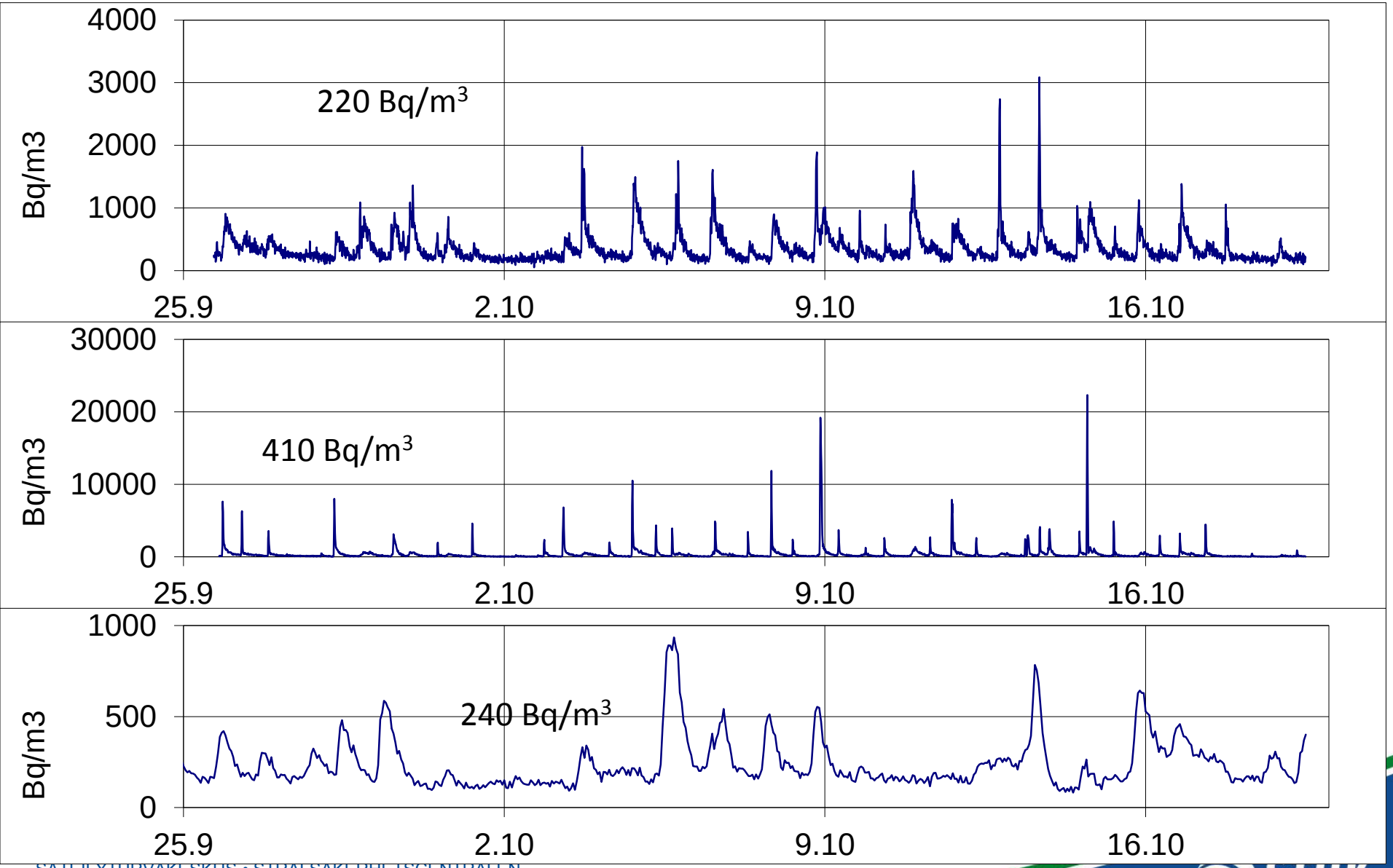
Source: sarad.de

Continuous measurement

Continuous measurement gives information on radon concentration at specific times. This is beneficial for:

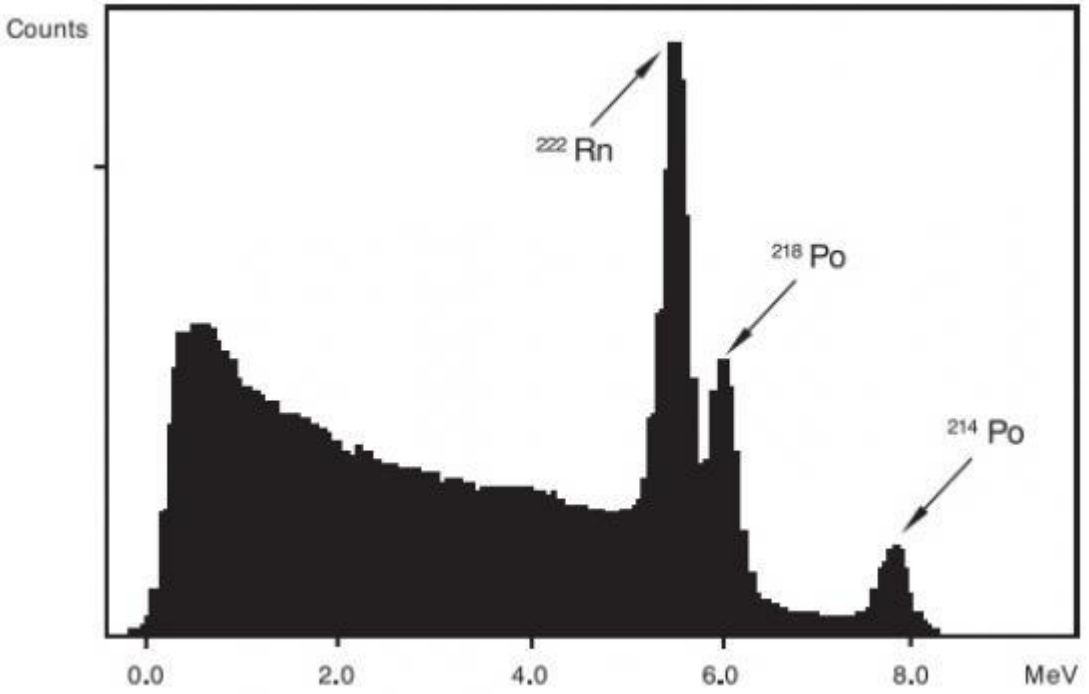
- Work places, where exposure takes place only at certain hours
- Investigation of remediation actions:
  - Effect of ventilation rate/timing
  - Effect of sub-slab depressurization (SSD)
  - Effect of abandonment of drilled well
- Research projects and detailed investigations
- Advanced monitors also measure temperature, atmospheric pressure, relative humidity, dose rate and records movements during the measurement period

Case study


4000
3000
2000
1000
0
Bq/m3
220 Bq/m3
25.9
2.10
9.10
16.10
30000
20000
10000
0
Bq/m3
410 Bq/m3
25.9
2.10
9.10
16.10
1000
500
0
Bq/m3
240 Bq/m3
25.9
2.10
9.10
16.10

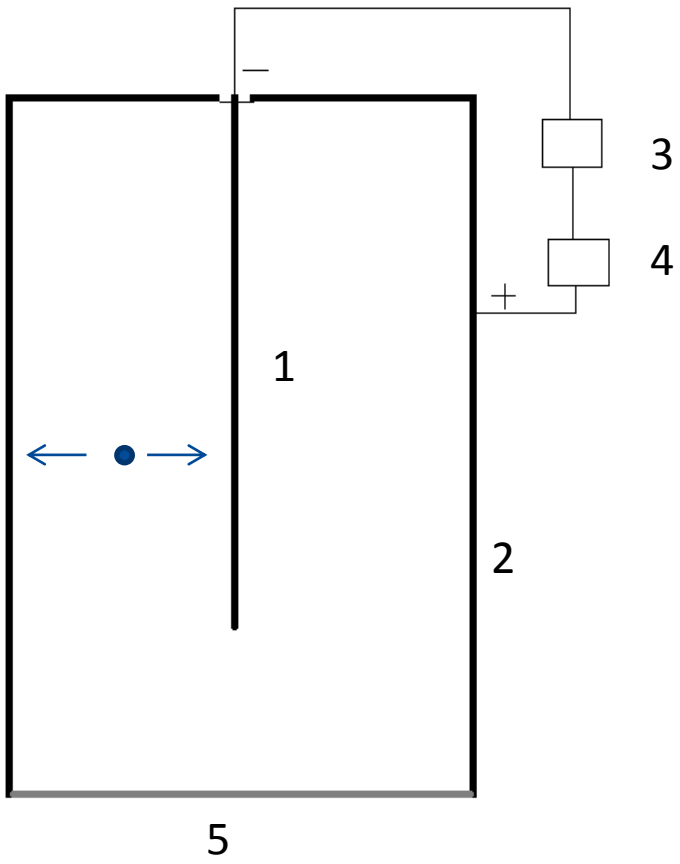
Ionization chambers

- Gas-filled chamber that collects charges caused by radiation induced ionization
- Ionization chamber do not use multiplication and the information can be plotted on a spectrum (pulse-type chambers)



Source: http://www.gammadata.se

Principle



1. Cathode
2. Anode
3. DC voltage source
4. Current meter
5. Membrane (filter)

Ion pairs are formed during ionization (5.5 MeV → 160 000 pairs). The greater the energy, the more ion pairs are formed and the higher current is generated

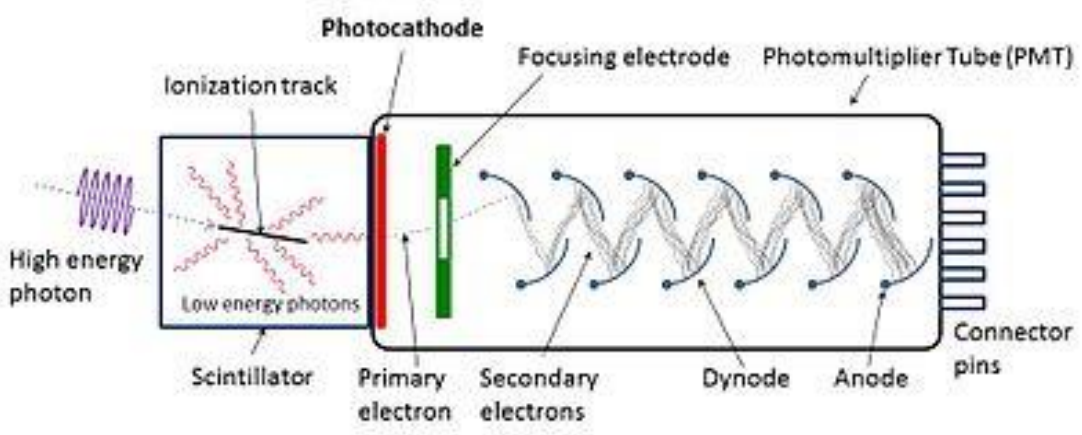
Gamma subtracted by compensation chamber

Characteristics of pulse-ionization chamber

- Good counting efficiency (4π)
- Spectral information (reactive to changes, Po-214 separately)
- Linear response
- Can be used in passive sampling mode (diffusion through membrane) or active mode (pumping air into the chamber)
- If thoron is present, the spectral data can be used to separate radon/thoron concentration
- High humidity may interfere (air-dry membrane or compensation)

Scintillation detectors

- Radiation particle hits scintillation medium and excites it
- Excitation state is released with visible light
- Light is transformed into an electric current by photo multiplier tube

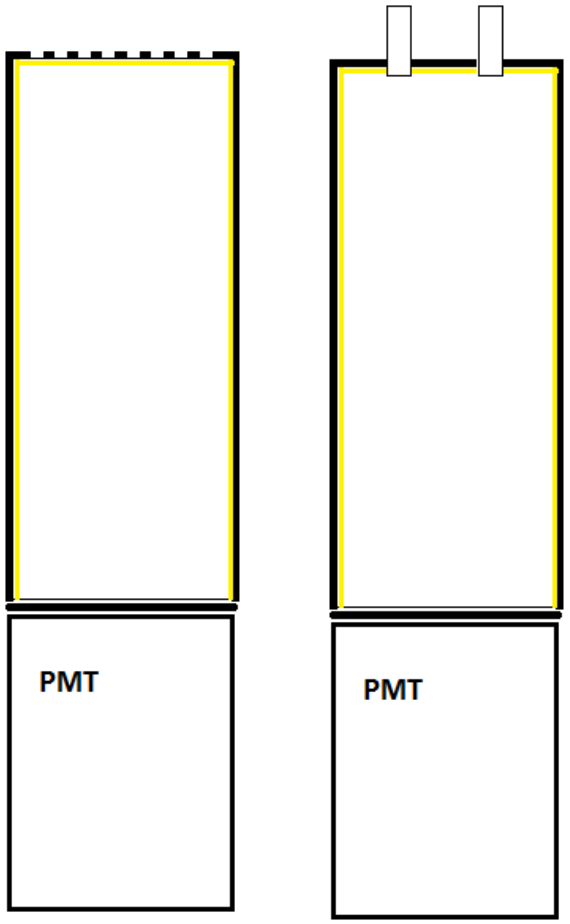


Source: wikipedia

PMT

Lucas cells

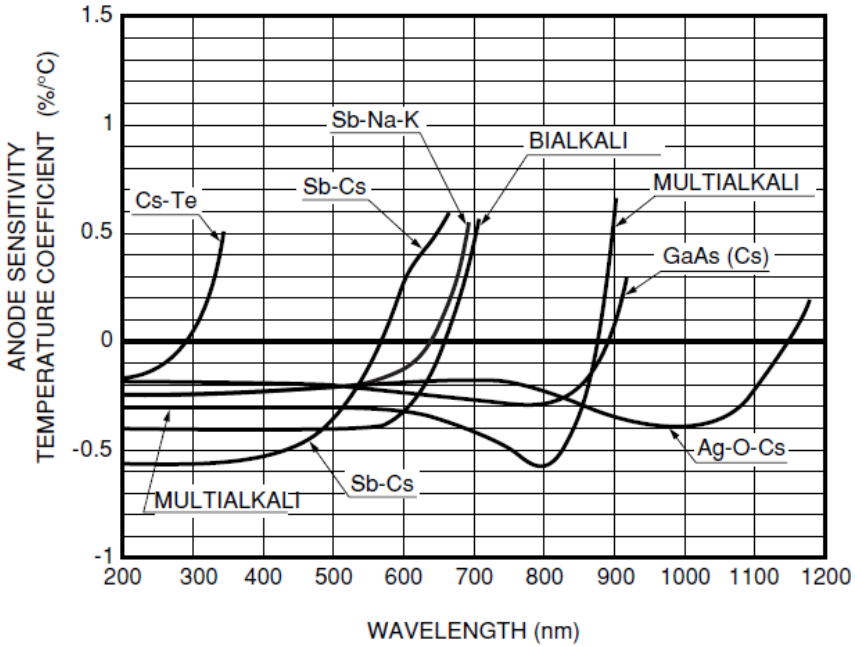
- Lucas cells are coated inside with ZnS(Ag) which is excited by alpha rays
- There is a glass window facing the photocatode and PMT
- Radon gas is introduced into a lucas cell either by diffusion (passive sampling) or by pumping (active sampling)
- Lucas cells are attached to scintillation counters, which record number of pulses per selected intagral
- Typically 0.15 – 2.5 litres volume

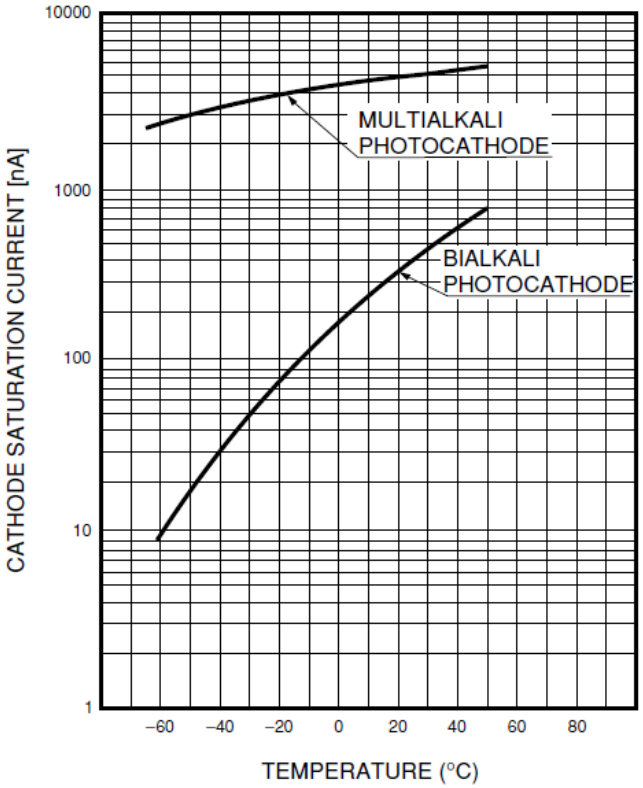


Pylon AB-5

Characteristics of Lucas cells/PMT

- Good geometric efficiency
- Very straight forward to calibrate
- Can be used in active/passive mode
- Suitable for grab sampling (spot measuremen
- Method is sensitive to temperature.

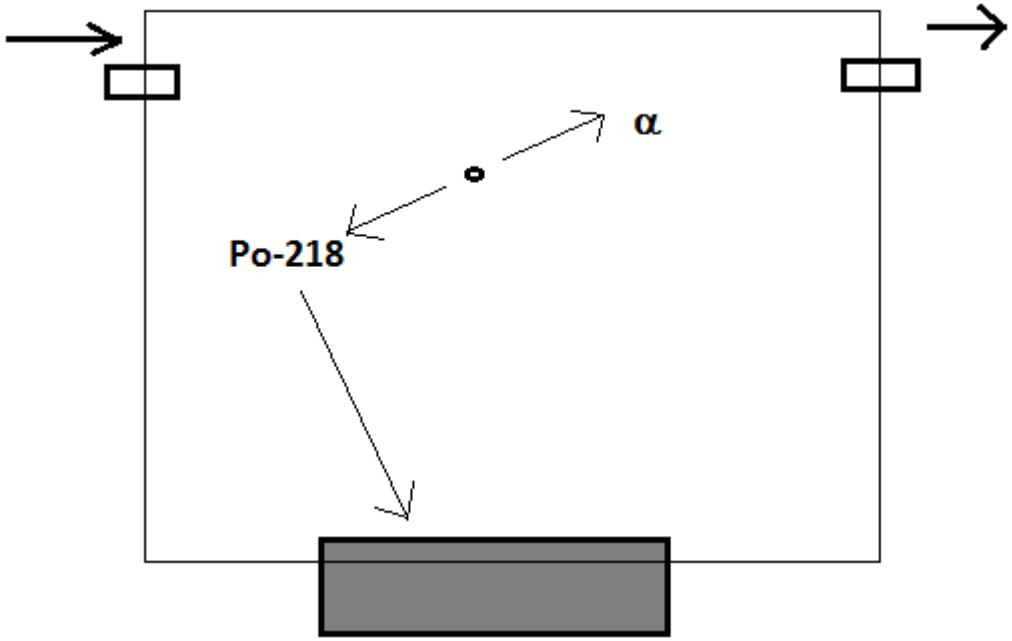




Source: Hamamatsu. PMTs Basics and application. 3rd ed.

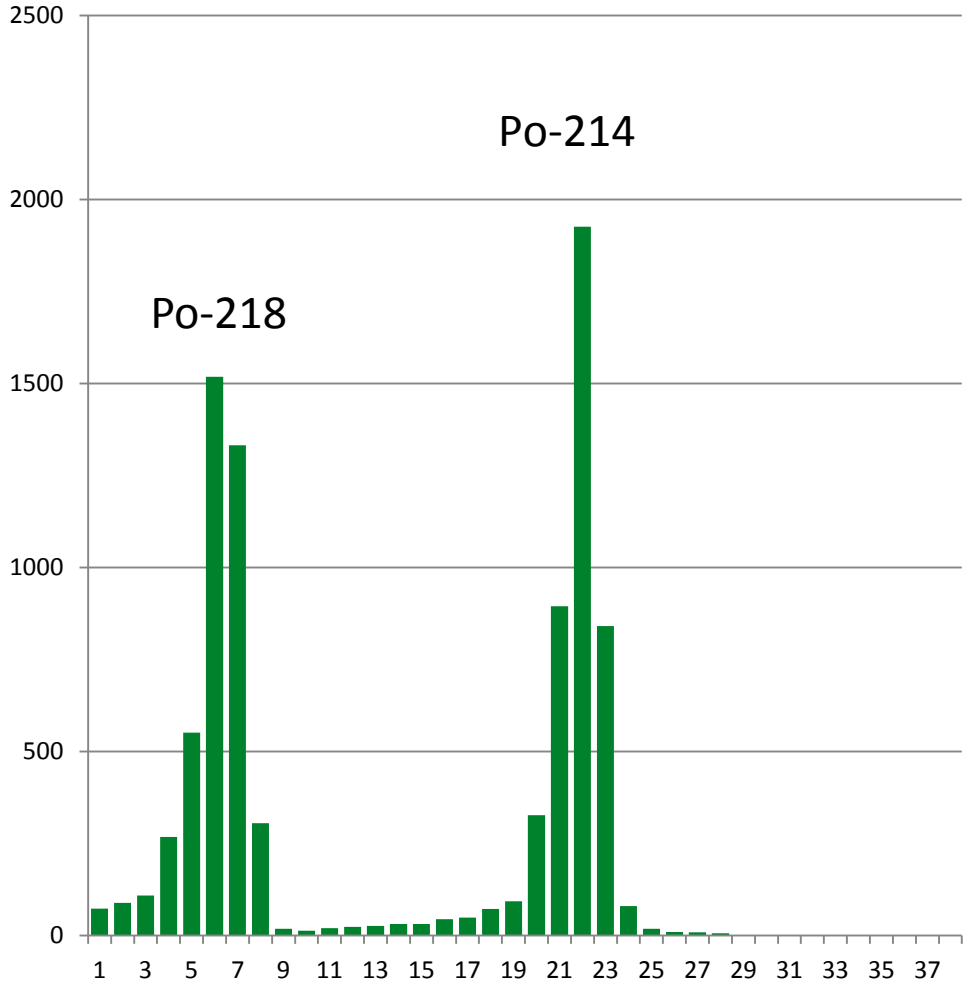
Semiconductors

- When operating in continuous method mode, they usually apply active sampling, either continuous or interval pumping
  1. A known volume of air is sampled into a chamber
  2. As radon decays, Po-218 is charged positively and is collected on the semiconductor by electrical field
  3. Measurement is carried out and recorded on a logger



Semi conductors

- Multi channel analyzer can produce spectrum
- Alpha spectrum has a good resolution and possible thoron interferences can be detected/measured
- Nowadays semiconductors are cheap and can be used in inexpensive instruments



Characteristics of semiconductors

- Sensitivity is smaller compared to ionization chamber and Lucas cells (smaller chamber, 2π geometry)
- If only Po-218 is used, can react quickly to changing radon concentration

Common features

- When active sampling is used, it is important to filter the incoming air with enough low pressure drop
- Pumping rate may affect the result and hence the pump must also be calibrated/checked regularly
- If spectrum is not recorded, thoron may interfere with the results when active pumping is used
- Expensive instruments: where can you leave them?

Calibration of continuous measurement

- If the monitor has several modes of operation (10 minute/ 60 minute interval, interval pumping modes, varying pumping rates, etc.) the calibration must usually be made for these all
- Generally calibration is carried out at STAR against secondary standard
- Zero concentration
- Concentration near reference level (300 Bq/m3)
- Concentration at high level (3000 Bq/m3)

Not all instruments have a precise calibration when they come from the factory. In Dec 2015, I received a brand new (and expensive) semiconductor for calibration check. The calibration factor was +30% off (and higher than the theoretical maximum for the system was).

Spot measurements

- Grab sampling with a pump
- Measurement either in situ or later in the lab
- Many continuous measurement monitors can take grab samples

- Are carried out when other methods cannot be used (underground construction)
- Measurement either in situ or later in the lab
- Many continuous measurement monitors can take grab samples
- Searching for radon inflows at construction site
- Remember: enough samples must be taken