A new thoron atmosphere reference measurement system

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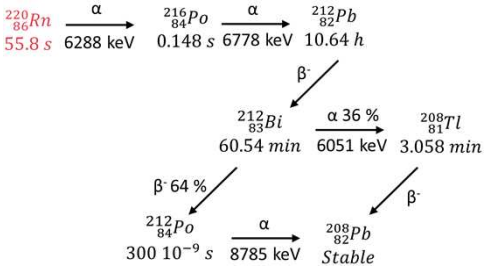
Currently there are many commercial devices to measure radon (^{222}Rn) and thoron (^{220}Rn) activity concentrations in air. These devices require frequent calibration. The LNE-LNHB has already built a radon ($T_{1/2}$ = 3.8 days) primary standard using the defined solid angle method with a frozen radon source. The radon standards are transferred to vials and sent to other laboratories to calibrate the devices (e.g. BACCARA, the radon calibration chamber at the IRSN). Unfortunately, due to the short half-life of thoron ($T_{1/2}$ = 55.8 s), it is not possible to use the same calibration method. This work presents a new portable device used to calibrate thoron atmospheres.

Measurement method

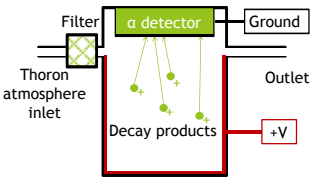
➔ **Method based on alpha spectrometry of thoron and its decay products at atmospheric pressure**



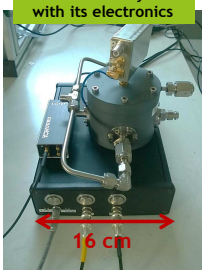
Measurement system specifications:

- Small cylindrical volume with alpha detector: same detection efficiency for thoron and radon gas.
- Electric field (max 200 kV.m^{-1}) used to catch all the charged thoron or radon decay products produced in the chamber.
- Filter at the entrance to trap incoming solid decay products and allowing only the gas through.

Scheme of thoron measurement system

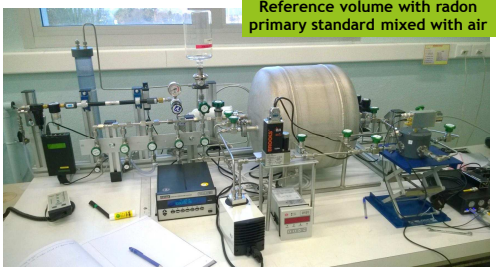


Measurement system with its electronics



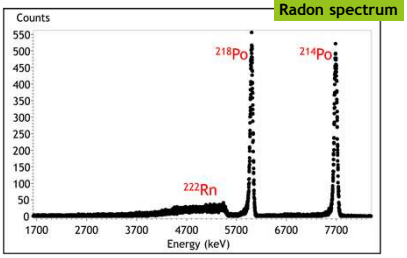
Validation of the measurement system using a radon reference atmosphere

➔ **Experimental setup of the radon atmosphere production**



- The radon activity concentration is known with a relative uncertainty of 0.3% (air-radon mixing ensured by inside fan).
- Regulation of pressure, humidity and measurement of temperature. The gas circulates in a closed loop with a regulated flow rate.

➔ **Radon alpha spectra analysis**



- Broad radon peak due to the alpha particle energy loss in the gas mixture, whereas narrow peaks for the solid decay products deposited on the detector surface.
- The gas detection efficiency:
  - 0.320 (2) experimental
  - 0.3212 (3) calculated (MCNPX)

➔ Results are in good agreement.

➔ **Influence of the experimental parameters**

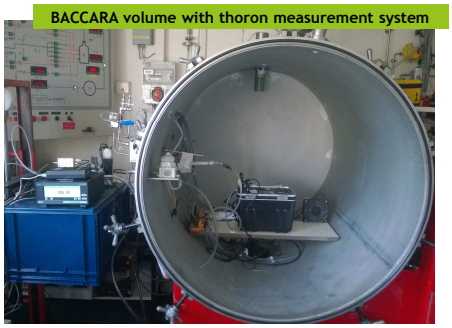
Experimental parameter studied	Range of variation	Influence on the ^{222}Rn and ^{218}Po measurement
Flow Rate	0-2 L.min^{-1}	None*
Pressure	900-1050 hPa	None*
Humidity	14-87% RH	None*
Activity concentration	1-4 MBq.m^{-3} STP	None*
Temperature	21-38 °C	0.18% per °C

* The standard deviation of the results is lower than the measurement uncertainty.

- The temperature variation is the only parameter of influence as it induces electronic drift.
- The 116 measurements performed over 4 days for the same activity concentration show the stability of the system with time.

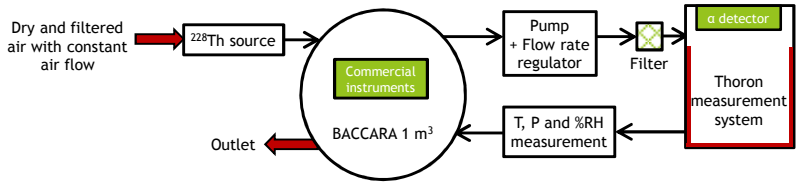
Measurement of thoron atmosphere produced by a ^{228}Th source

BACCARA volume with thoron measurement system

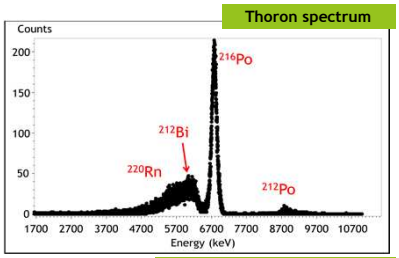


- The reduction of statistical fluctuation requires a measurement of 10 min for a high activity concentration (1 MBq.m^{-3}) and up to one week for thoron atmosphere produced in BACCARA (< 4 kBq.m^{-3}).
- The only parameter of influence is the temperature.
- The short thoron half-life does not influence the measurement for flow rates > 0.8 L.min^{-1}.
- The peak area determination for thoron must be corrected for the presence of ^{212}Bi using ^{212}Po (in equilibrium with ^{212}Bi).

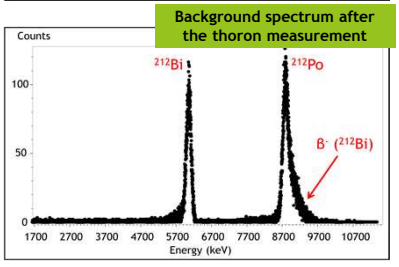
Diagram of the experimental setup



Thoron spectrum



Background spectrum after the thoron measurement



Conclusion

- A portable thoron atmosphere measurement system has been developed by the LNE-LNHB and IRSN and has been validated against a radon primary standard.
- The gas detection efficiency is known with a relative uncertainty of 0.6%.
- The system can be used for direct thoron or radon activity concentration measurements (< 10 MBq.m^{-3}).
- Other application include the determination of ^{228}Th and ^{226}Ra source emanation rate.

Acknowledgment

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