Overview of WP2 activities

SUBG, IRSN, CEA, STUK, BEV-PTP

Dobromir Pressyanov,

WP2 leader

Task 2.1, "Ensuring traceability of the secondary thoron reference instruments used in the experimental research to the primary thoron measurement system at IRSN"

A2.1.1	IRSN and SUBG will establish and evaluate the reference thoron atmospheres in their reference test chambers. The range of thoron activity concentrations that can be created in both chambers will be assessed. IRSN will assess the homogeneity of the thoron atmosphere in their BACCARA 1 m^3 test chamber using numerical simulation and experimentation. SUBG will study experimentally the inhomogeneity in their 50 L test chamber.	**IRSN**, SUBG

- **Range of thoron concentrations was evaluated and the activity concentrations in which calibration exercise to be made was targeted;**
- **Thoron homogeneity studied by numerical simulation and experimentally. Two experimental methods were tested:**
  - **LSC of exposed aerogels;**
  - **Exposure of SSNTDs of Kodak-Pathe LR-115/II.**

K. Mitev et al. Methods for the experimental study of ^{220}Rn homogeneity in calibration chambers, ***Applied Radiation and Isotopes*** (submitted).

Task 2.1, “Ensuring traceability of the secondary thoron reference instruments used in the experimental research to the primary thoron measurement system at IRSN”

A2.1.2	IRSN, SUBG and STUK will jointly organise an exercise to calibrate **their** secondary thoron reference instruments for activity concentrations of 10^2-10^6 Bq/m^3 at the IRSN radon/thoron calibration laboratory at Saclay, France. Information from A2.1.1 on the homogeneity of the thoron atmosphere will be taken into account. SUBG will participate in the calibration with its reference thoron monitors – AlphaGuard 2000 RnTn Pro and RAD 7, whilst STUK will participate with its thoron monitors: AlphaGuards and Lucas cells (Pylon Inc). In addition BEV-PTP will send their AlphaGuard to IRSN for calibration.	**IRSN**, BEV-PTP, STUK, SUBG

Calibration exercise was carried-out in May 2018 and the results were reported (Annex to D2)

Task 2.2, “Investigation of the influence of thoron on radon measurements and calibrations”

A2.2.1	IRSN, SUBG and STUK will study the influence of thoron on active radon monitors. Measurements will be performed in both thoron and radon plus thoron atmospheres using the secondary reference instruments calibrated in A2.1.2. At least 10 instruments available at IRSN, CEA, SUBG, STUK will be studied for example AlphaGUARD (different types), DoseMan, radhomeHR3, BARASOL, monitors with Lucas cells, RAD7 etc. Theoretical models and analysis will be employed by IRSN, SUBG and STUK to determine, understand and potentially correct for the influence of thoron on the performance of the radon monitors.	**IRSN**, CEA, STUK, SUBG

- **Experimental study of the thoron influence was carried out and theoretical analysis was made to understand the reason for thoron influence of different monitors;**
- **Theoretical analysis and experiments were made to reduce the thoron influence by additional diffusion barriers.**
- **Possibility to correct the thoron influence by delay lines was considered;**
- **Technical report is being prepared (Annex to D2).**

Task 2.2, “Investigation of the influence of thoron on radon measurements and calibrations”

A2.2.2	CEA, IRSN, STUK, and SUBG will study the influence of thoron on passive integrating radon detectors. Measurements will be performed in both thoron and radon plus thoron atmospheres using the secondary reference instruments calibrated in A2.1.2. At least 10 detectors available at IRSN, CEA, SUBG and STUK will be studied, for example diffusion chambers with different alpha-track detectors, E-Perm electret chambers, compact disks/DVDs, etc. Theoretical models and analysis will be employed by CEA, IRSN, STUK, and SUBG to determine, understand and potentially correct for the influence of thoron on the performance of the radon monitors.	**SUBG,** CEA, IRSN, STUK

- **Experimental study of the thoron influence was carried out and theoretical analysis was made to understand the reason for thoron influence of different passive monitors;**

- **Theoretical analysis was made and experimental research was carried-out to correct the thoron influence by using a polymer foil as diffusion barrier.**

- **Technical report is being prepared (Annex to D2).**

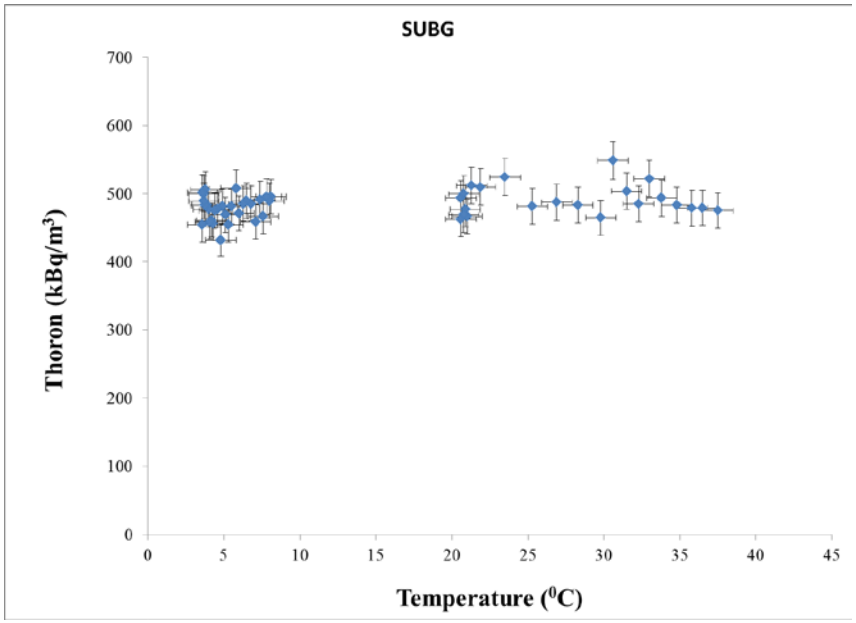
Task 2.2, “Investigation of the influence of thoron on radon measurements and calibrations”

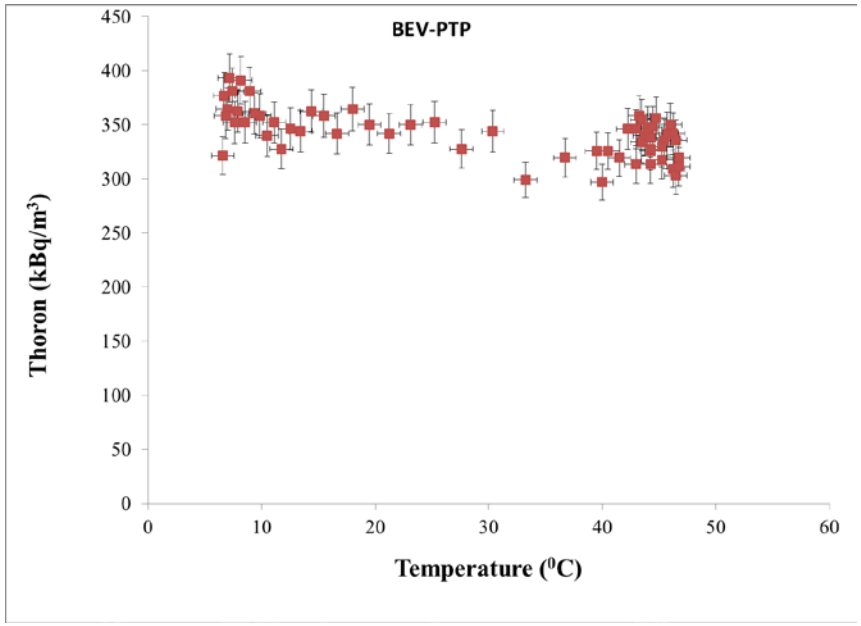
A2.2.3	Using SUBG’s laboratory facilities and the secondary reference instruments calibrated in A2.1.2, SUBG and BEV-PTP will study experimentally the response of radon/thoron measurement instruments/detectors available at SUBG and BEV-PTP at different environmental temperatures (between +5 °C and +45 °C) in both thoron and radon plus thoron atmospheres, under both static and dynamic regimes. SUBG and BEV-PTP will also study the response of radon/thoron measurement instruments under different radon/thoron concentrations ratios. Theoretical models and analysis will be employed by SUBG and BEV PTP to determine, understand and potentially correct for the influence of thoron on the performance of the radon monitors.	**SUBG,** BEV-PTP

The response of the SUBG and BEV-PTP secondary instruments was studied experimentally within the specified temperature interval in thoron, radon and radon+thoron atmospheres. Report was prepared (Annex to D2).

The problem with the temperature dependence of some passive detectors was investigated (D. Pressyanov, D. Dimitrov. The Problem with Temperature Dependence of Radon Diffusion Chambers with Anti-Thoron Barrier. ***Rom. J. Phys. 65 (2020) 801*; D. Pressyanov, T. Ronnqvist, J.-L. Gutiérrez-Villanueva, *Report on MetroRADON Meeting Paris, Sep. 2019*).

A2.2.3: Two reference monitors (AlphaGUARD PQ2000 RnTn Pro) of SUBG and BEV-BTP were experimentally tested in SUBG for temperature influence on the response to thoron





Slight positive correlation. Bias in 5-45 ^{0}C within 5%

Slight negative correlation. Bias in 5-45 ^{0}C within 10%

Task 2.3, “Development of techniques to reduce the influence of thoron on radon measurements and calibrations”

A2.3.1	STUK and SUBG will undertake a literature review of potential techniques and materials to reduce the influence of thoron on radon measurements and calibrations. Based on these findings, STUK and SUBG will perform an analytical analysis of the different techniques/materials and will identify the most promising ones, based on the effectiveness of the relative differentiation between thoron and radon.	**STUK**, SUBG

The review entitled: *Review of potential techniques and materials to reduce the influence of thoron on radon measurements and calibrations* was prepared (by O. Holmgren, T. Turtiainen, K. Mitev and D. Pressyanov) and published on the project web-site.

Task 2.3, "Development of techniques to reduce the influence of thoron on radon measurements and calibrations"

A2.3.2	SUBG will evaluate the properties of different filters/foils/ membranes identified in A2.3.1 that could potentially serve as selective thoron barriers and will evaluate their radon permeability. SUBG will initially undertake a literature survey of radon (^{222}Rn) permeability data. SUBG will then perform an experimental study of the permeability of radon (^{222}Rn), using it as a thoron (^{220}Rn) surrogate, because both isotopes have the same solubility and diffusion coefficient. Using the radon permeability data, the thoron permeability of the various materials will be evaluated and the most promising materials identified.	**SUBG**

The diffusion barrier properties of different polymers were studied experimentally and their permeability was evaluated. The results were reported in the following journal articles:

- **S. Georgiev, K. Mitev, C. Dutsov, T. Boshkova, I. Dimitrova**. Partition Coefficients and Diffusion Lengths of ^{222}Rn in Some Polymers at Different Temperatures**.** ***Int. J. Env. Res. Publ. Health 16 (2019) 4523.***
- **D. Pressyanov, D. Dimitrov**. The Problem with Temperature Dependence of Radon Diffusion Chambers with Anti-Thoron Barrier. ***Rom. J. Phys. 65 (2020) 801.***

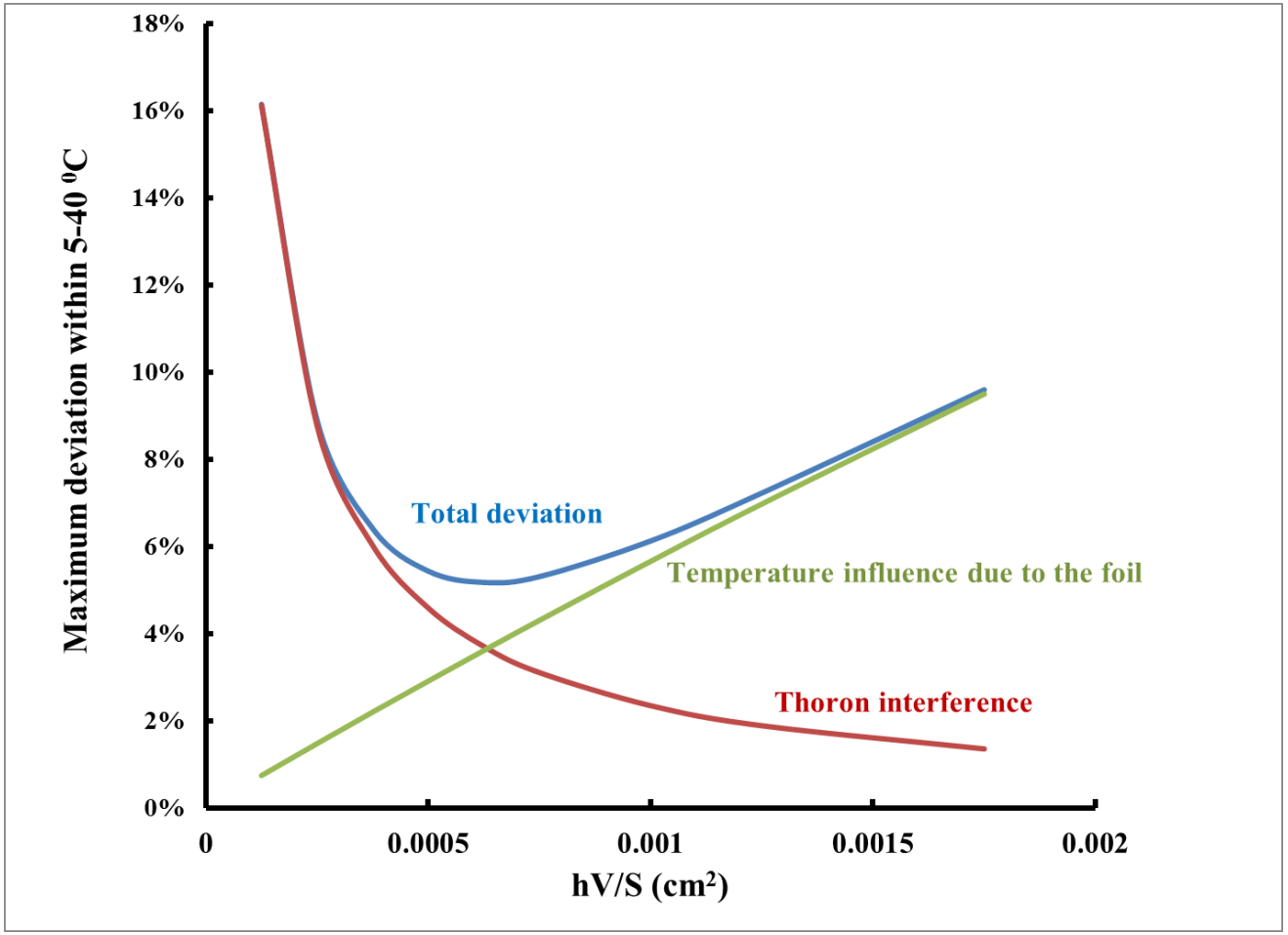
<u>Surprising outcome (not planned):</u> The temperature dependences introduced by polymer anti-thoron barriers and that of many radon detectors are reciprocal. This can be used to reduce/eliminate the temperature dependence, the thoron influence and also the humidity influence (Patent Appl. Bulg. Nr. 112897, WIPO Appl. Reg. Nr. PCT/BG2020/000003).

Task 2.3, “Development of techniques to reduce the influence of thoron on radon measurements and calibrations”

A2.3.3	SUBG and CEA will develop and then characterise one or more selective barriers for ^{220}Rn identified in A2.3.2. It is well known that radon is soluble in some polymers and this solubility can be used to design/select a polymer membrane that allows diffusion of radon and not thoron. Using data from A2.3.2, the nature and thickness of the membranes will be carefully chosen so that the diffusion time is much greater than the thoron half-life, but much less than the half-life of radon. The performance of such barriers will be experimentally tested on the CEA and SUBG facilities and expressed, for example, as attenuation factors for both gases.	**SUBG,** CEA

- **Study of selective barriers was carried out;**
- **A differential method to correct the temperature dependence introduced when polymer foils are used as diffusion barriers against thoron was proposed and tested experimentally.**
- **A compensated module was proposed to compensate both thoron interference and temperature dependence of detectors which response decreases along with the temperature increase.**
- **A criterion for “best design” of polymer foil package that minimizes the combined bias due to temperature influence and thoron interference was proposed.**

A criterion for “best design” that minimizes the total bias introduced by the polymer foil within given temperature interval… However by a compensated module the design can be even better…



Task 2.3, “Development of techniques to reduce the influence of thoron on radon measurements and calibrations”

A2.3.4	Based on the results from A2.3.1-A2.3.3, SUBG, IRSN, STUK, CEA and BEV-PTP will develop recommendations on the construction of radon monitors that are not sensitive to thoron including the technical concepts / solutions aimed at reducing thoron-related bias in the radon signal in existing monitors. SUBG, IRSN, STUK, CEA and BEV-PTP will also develop recommendations for tests to check the sensitivity of radon monitors and detectors to thoron.	**SUBG,** BEV-PTP, CEA, IRSN, STUK

Such recommendations will be included in D2

Task 2.3, “Development of techniques to reduce the influence of thoron on radon measurements and calibrations”

A2.3.5	Based on the results from A2.1.1-A2.1.2, A2.2.1-A2.2.3 and A2.3.1-A2.3.4, SUBG, IRSN, STUK, CEA, and BEV-PTP will write a report on the influence of thoron on radon monitors used in Europe including proposals for checking their sensitivity to thoron, and recommendations on the construction of radon monitors that are not sensitive to thoron together with technical approaches aimed at reducing thoron-related bias in the radon signal in existing monitors. Once the report have been agreed by the consortium, SUBG will send the report to the coordinator, who on behalf of IRSN, STUK, CEA, and BEV-PTP will then submit it to EURAMET as **D2** *‘Report on the influence of thoron on radon monitors used in Europe including (i) procedures for checking their sensitivity to thoron, (ii) recommendations on the construction of radon monitors that are not sensitive to thoron and (iii) technical approaches aimed at reducing thoron-related bias in the radon signal in existing monitors’.*	**SUBG,** BEV-PTP, CEA, IRSN, STUK

D2 Report is scheduled for submission in March 2020

Thank you!