HIGHLY SENSITIVE PASSIVE DETECTORS FOR SHORT-TERM PRE- AND POST- MITIGATION MEASUREMENTS

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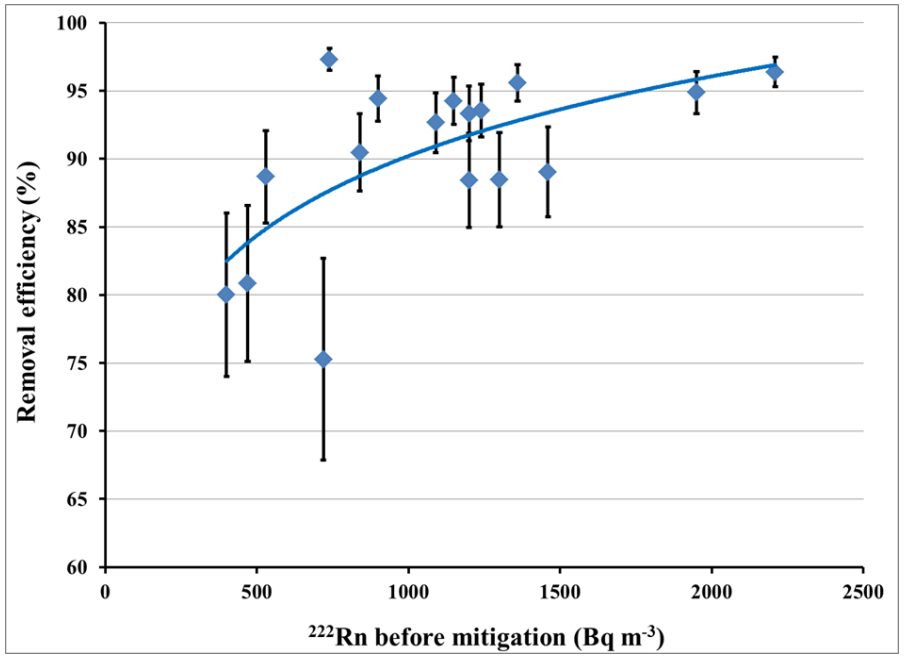
The focused challenge: How to evaluate by short-term (e.g. one week) integrated measurements at normal living conditions the radon reduction achieved after the mitigation work is completed?

Measurements in many points needed in large buildings

Mitigation efficiency is site-specific



A novel method for passive ^{222}Rn measurements with sufficient sensitivity for that purpose is proposed:

The approach is based on a modification of the CD/DVD method for radon measurements:

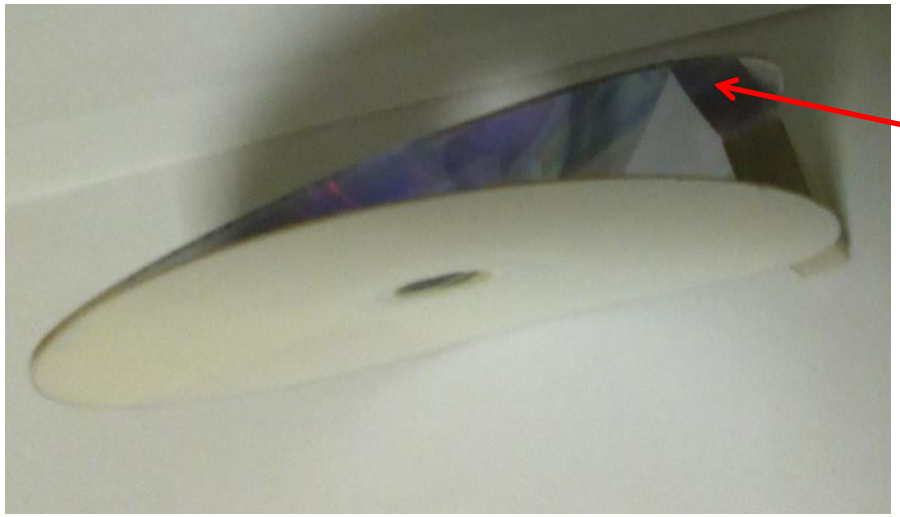
The method employs DVDs-based detectors of:

- low background (n_B),
- large total detection area (S)
- increased calibration factor ***CF***
  (***CF=net track-density/^{222}Rn exposure***)

In result the achievable ***MDAC*** (Minimum Detectable Activity Concentration) can be significantly lower than that of many passive ^{222}Rn detectors.

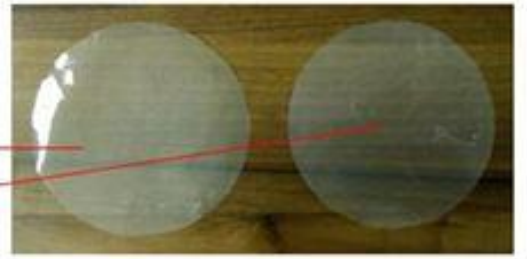
$$MDAC = \frac{2.71+4.65\sqrt{n_B}}{CF.t.\sqrt{S}}$$

DVDs are used as large area track detectors. The sensitivity is amplified by using Makrofol N foils as radon absorbers/radiators:

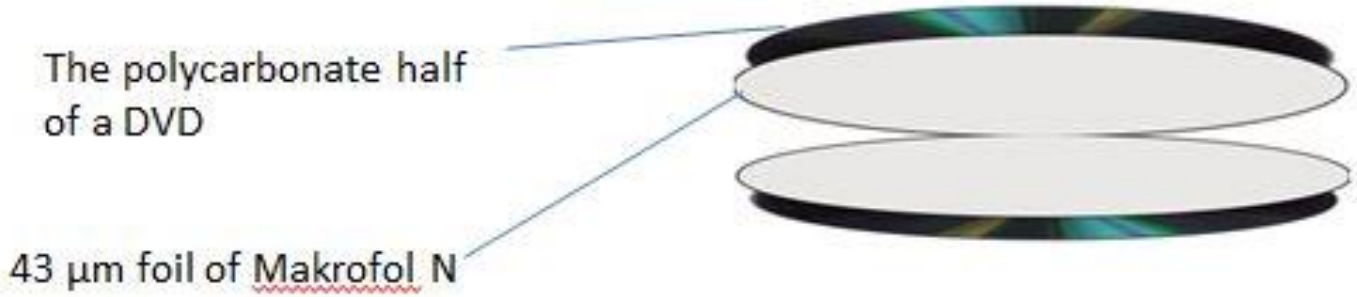


Surface with very low background: 1.1 ± 0.3 cm^{-2}. With thermal annealing can be reduced to 0.5 cm^{-2}.

Makrofol N: a foil of unique radon absorption ability

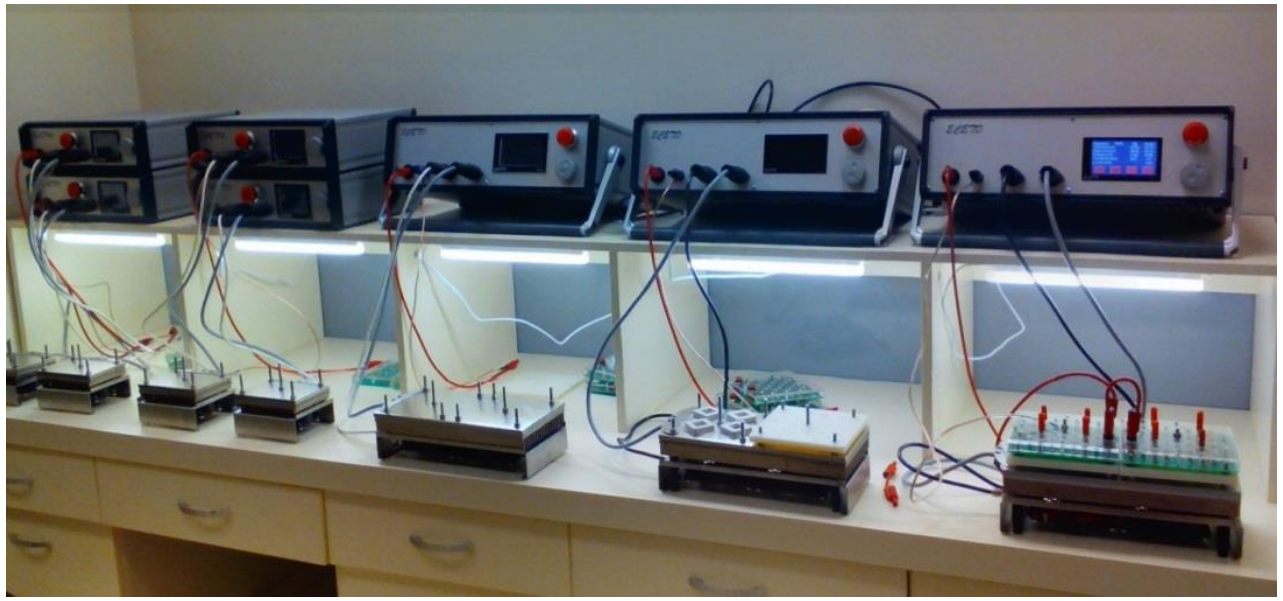


The concept to couple track detector with absorber of Makrofol N was proposed by Tommasino et al. (*Radiat. Meas. 44 (2009) 719-723*). In the present case the detectors are DVDs:

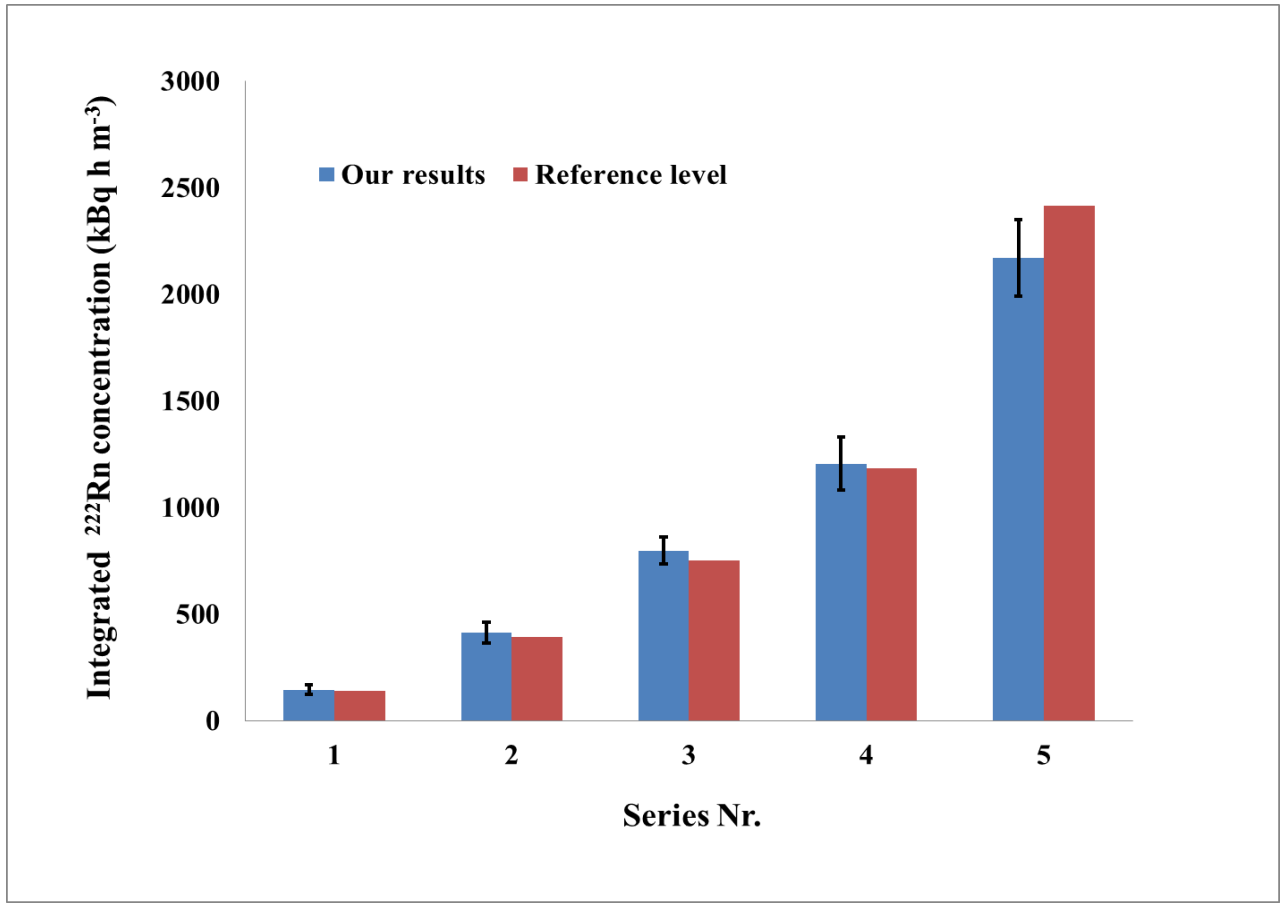


Detector element of total area of 200 cm^2

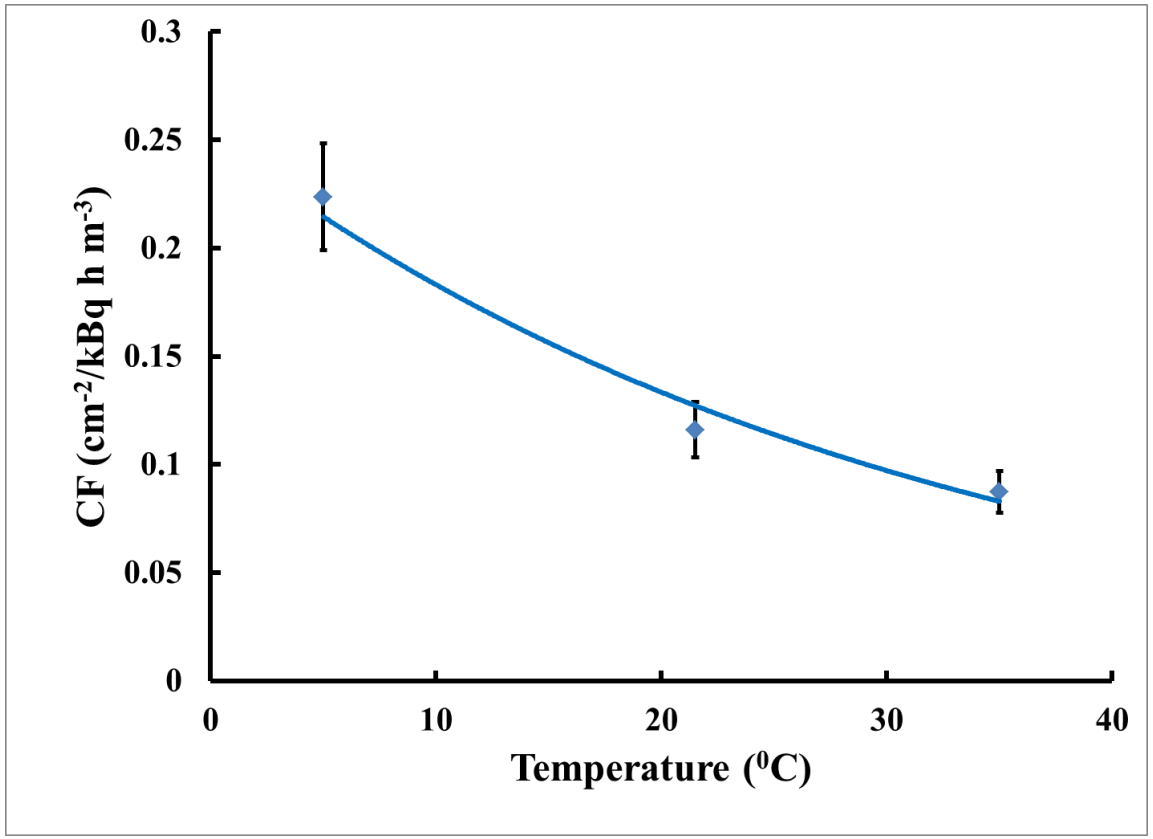
Etching of DVDs (infrastructure created within FP7-EURATOM Project DoReMi)



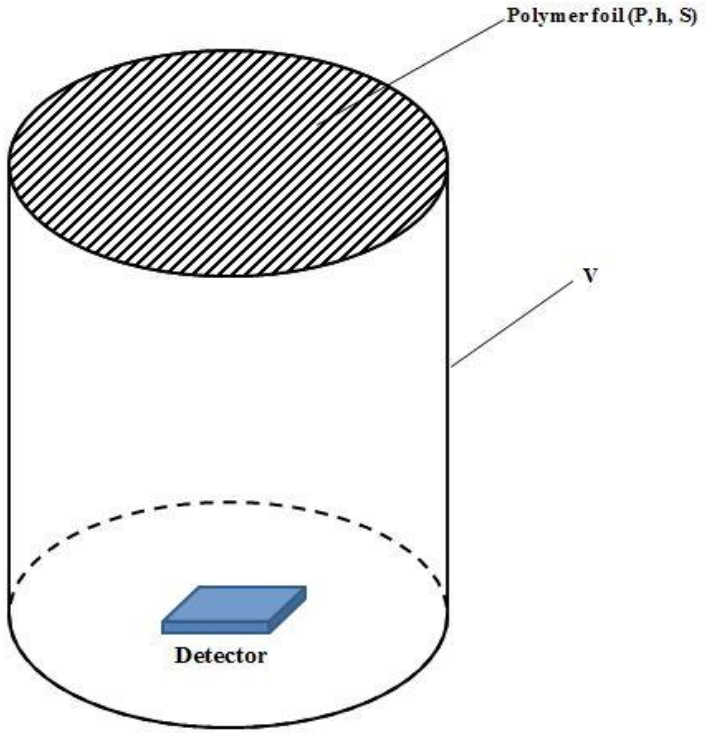
QA of the method: performance at the Public Health England (PHE-UK) 2017/2018 radon inter-comparison (*Pressyanov D., Dimitrova I., Dimitrov D. IEEE-NSSS/MIC 2018*)



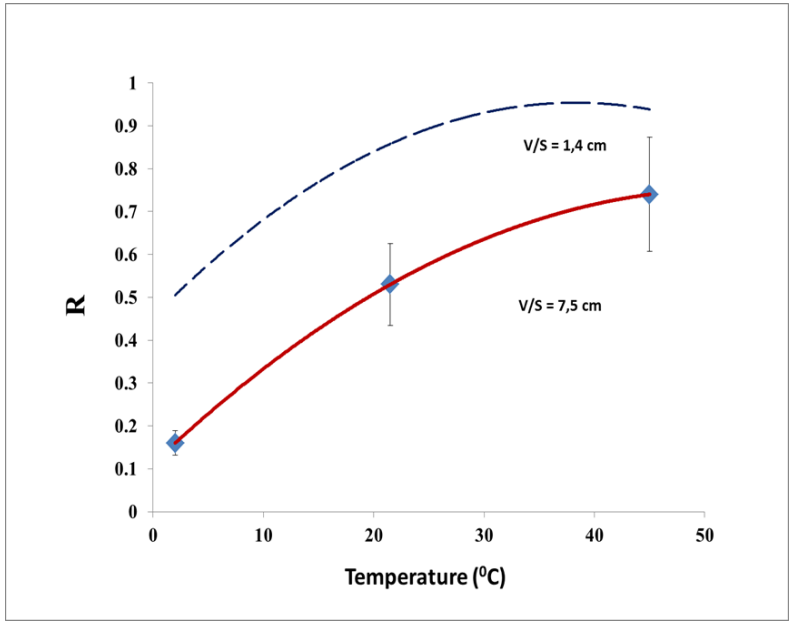
Problem: Strong temperature dependence of the response (*CF* drops by factor of 2.6 from 5 ^{0}C to 35 ^{0}C)



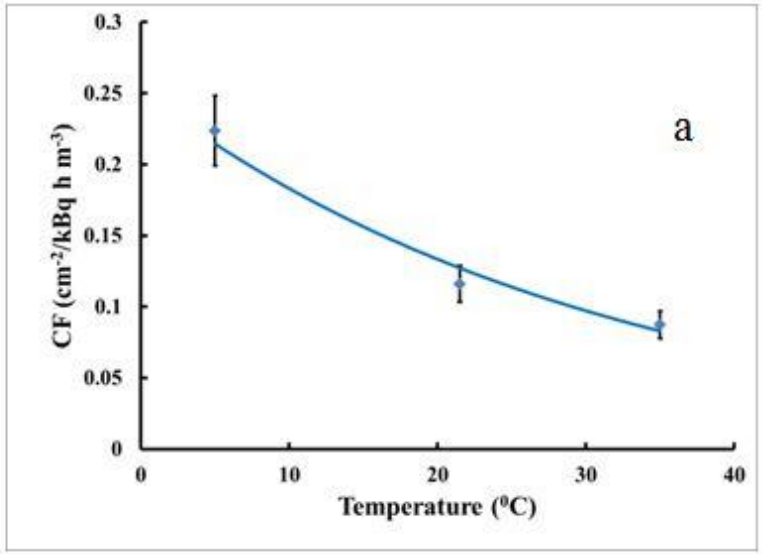
However…polymer barriers against thoron and humidity (Ward W.J . et al., *Rev. Sci. Instrum. 48 (1977) 1440-1441*) incur reciprocal temperature dependence (Fleischer R. L. et al., *Radiat. Meas. 32 (2000) 325-328*)…



$$R = \frac{C_{in}}{C_{out}} = \frac{1}{1+\lambda\frac{hV}{PS}},$$



Beyond state-of-the art: A module can be designed with *R(T)* that compensates that of *CF(T)* so that *CF*×*R* ≈ const.:



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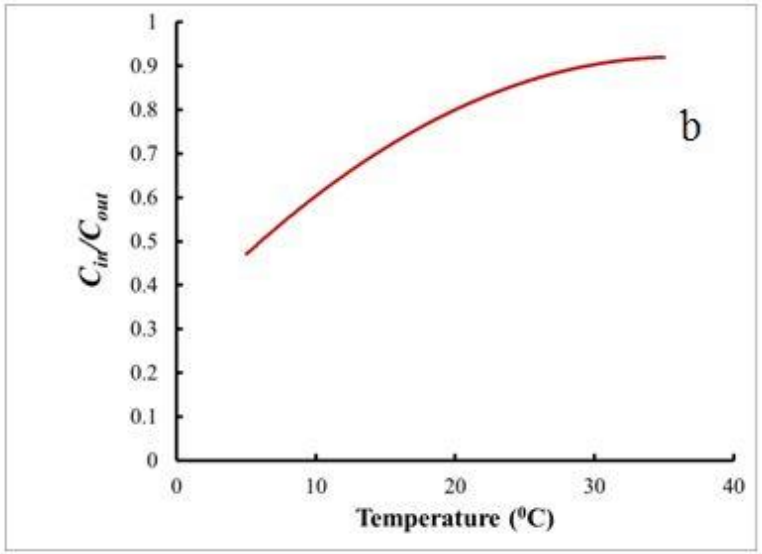

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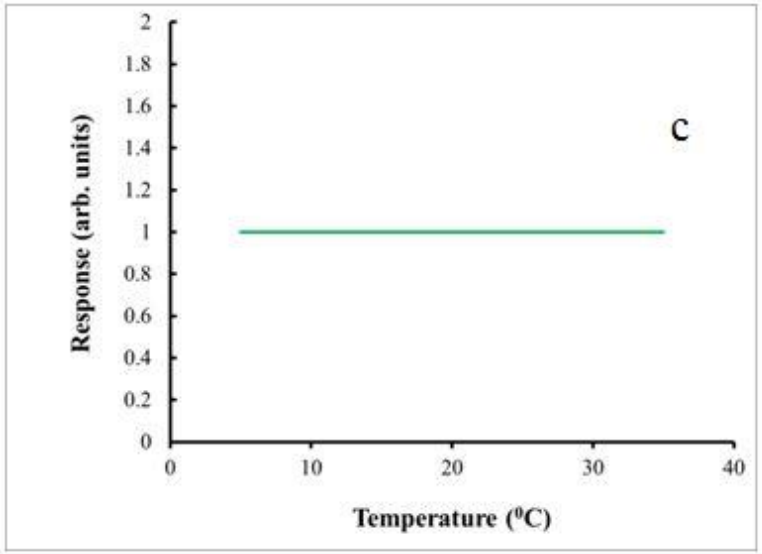
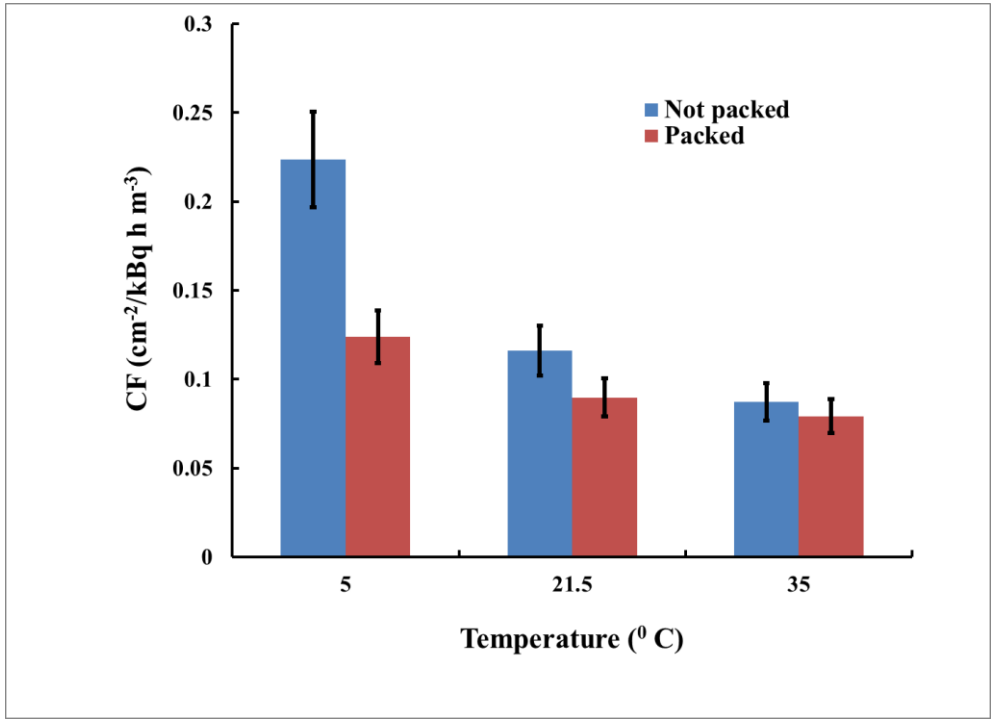


Patent application submitted (Bulg. Pat. Appl. Reg. Nr. 112897, priority: 19.03.2019; inventor: D. Pressyanov).

Proof-of-the-concept: the “module” is a hermetic package of foil of 75 µm low density polyethylene with controlled *V/S* ratio (≈ 4 cm)

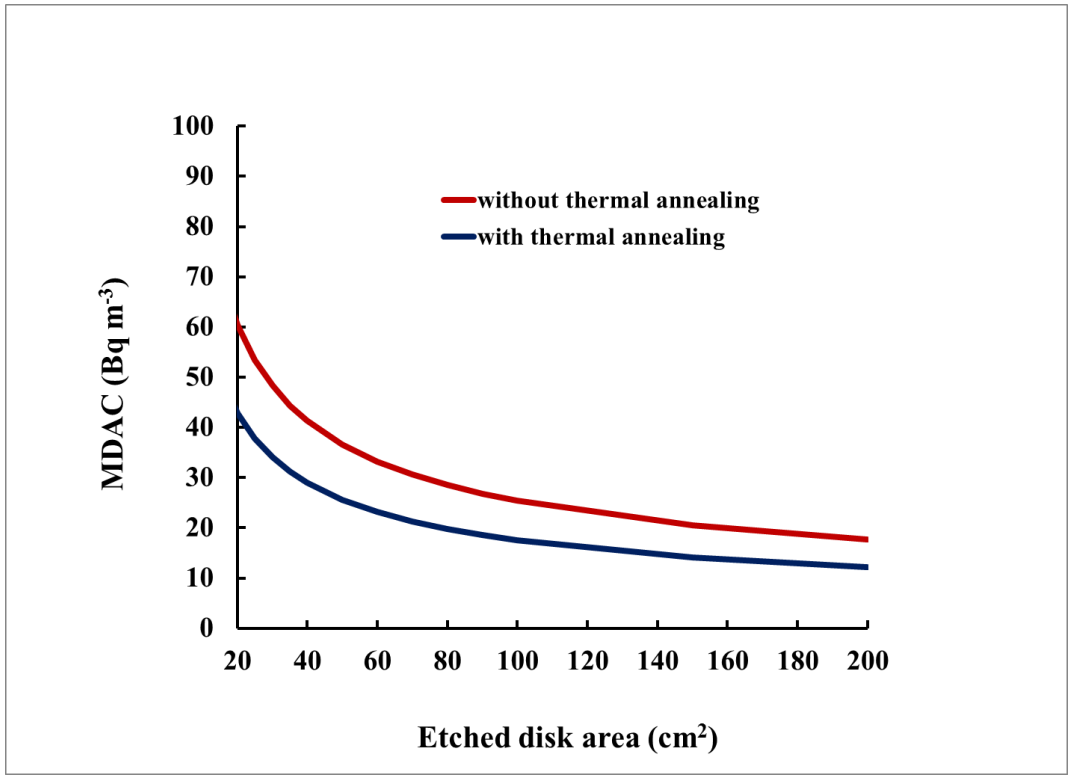
Results…



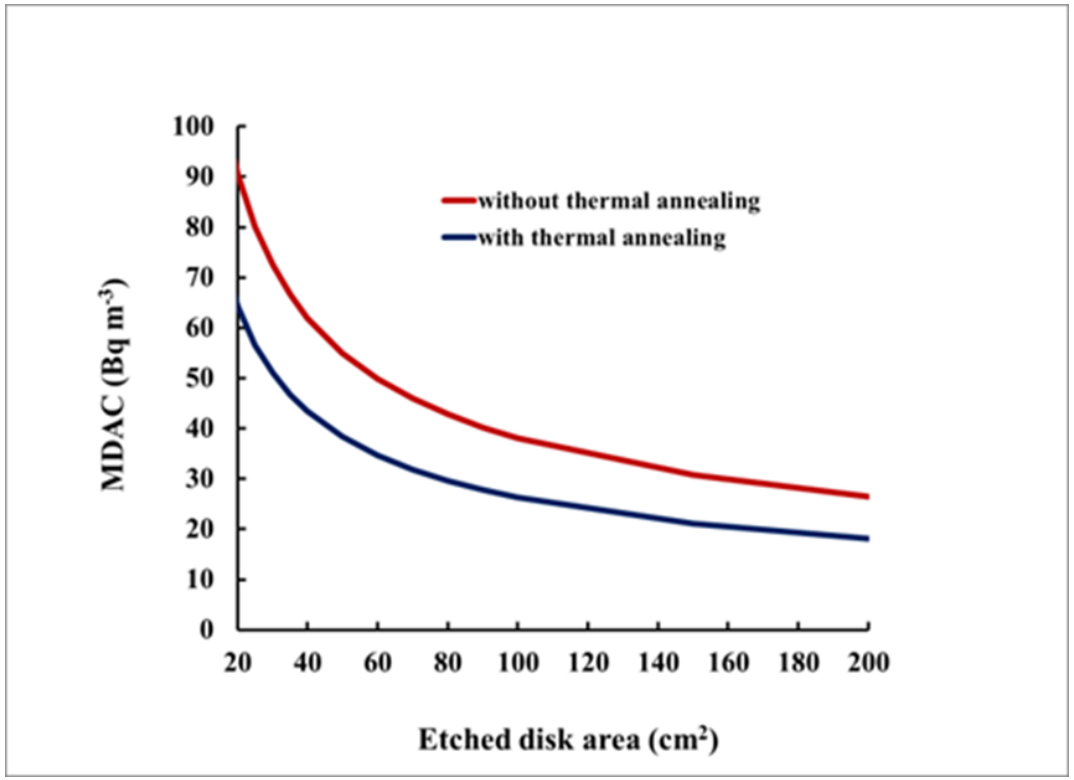
NB: The module (package) is also an effective barrier against humidity and thoron interference!

Minimum detectable activity concentration after one week exposure (disk element surface area = 200 cm^2)

Not packed detectors



Detectors packed in the compensating module



The proposed concept for "compensating module" gives an opportunity to compensate the temperature dependence of many wide spread radon detectors which response decreases with increasing the temperature:

Such detectors are e.g.:

- **Detectors we present in this report**;
- **The most widely used track detectors: CR-39**. These detectors show fading, and the (fading) decrease of the signal is larger at higher temperature (see e. g. Enomoto H. and Ishigure N., 2011; Caresana M. et al., *Radiat. Meas. 45 (2010) 183–189*);
- **Detectors based on activated charcoal**.

Conclusions:

- **New design of passive detectors is proposed. Within one week exposure time quantitative measurements at ^{222}Rn levels below 100 Bq m^{-3} can be made and MDAC below 20 Bq m^{-3} is achievable;**

- **A technical challenge was identified and a step beyond state-of-the art was proposed: a compensating module (patent pending) that provides technical solution capable to reduce or eliminate the temperature dependence (+ thoron interference + humidity influence) on the detectors described in this report, as well as on many other kinds of radon detectors.**

Acknowledgement:

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Thank you!

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