The problem with the thoron interference and the solutions we can propose

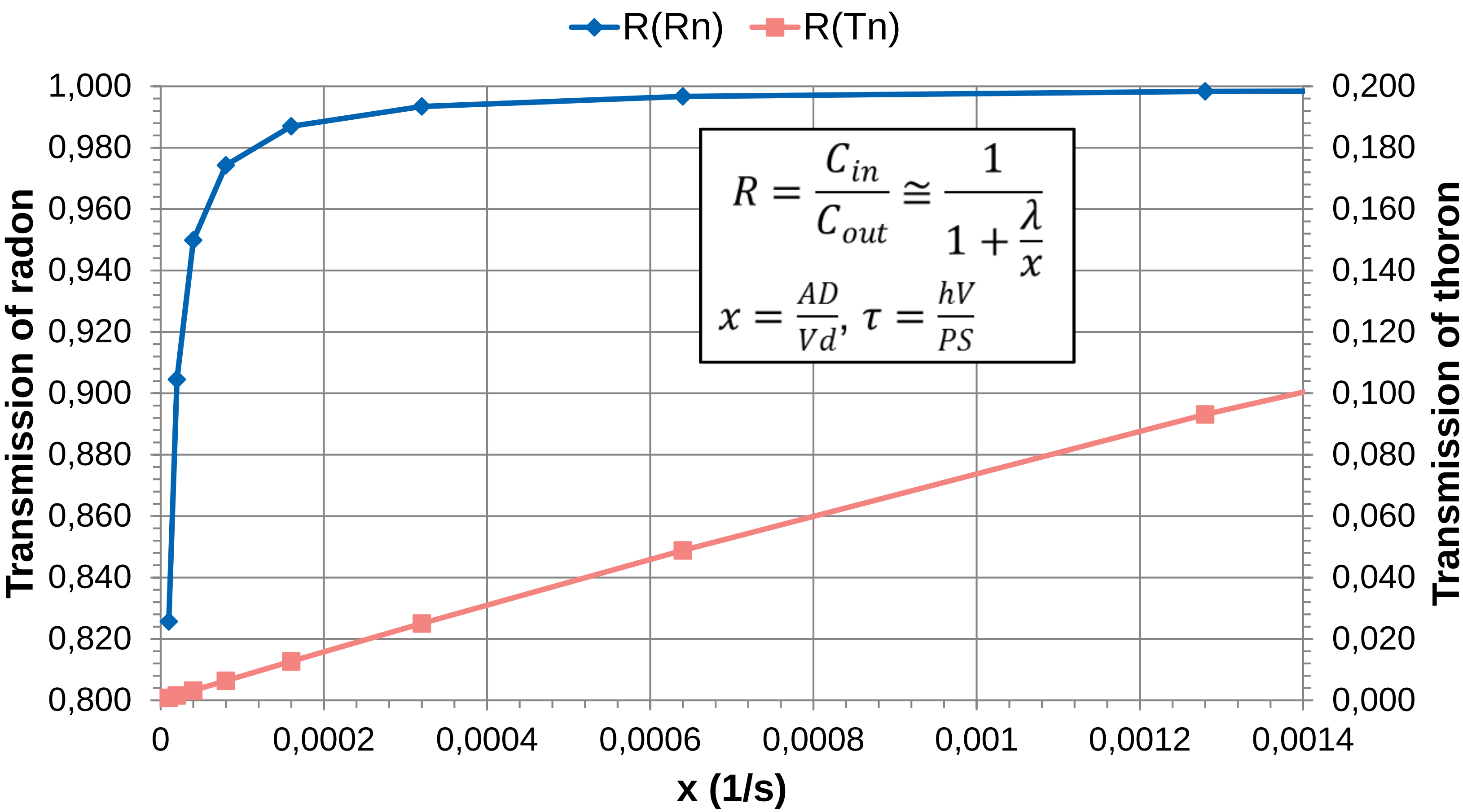
SUBG, IRSN, CEA, STUK, BEV-PTP

The approaches to reduce thoron interference

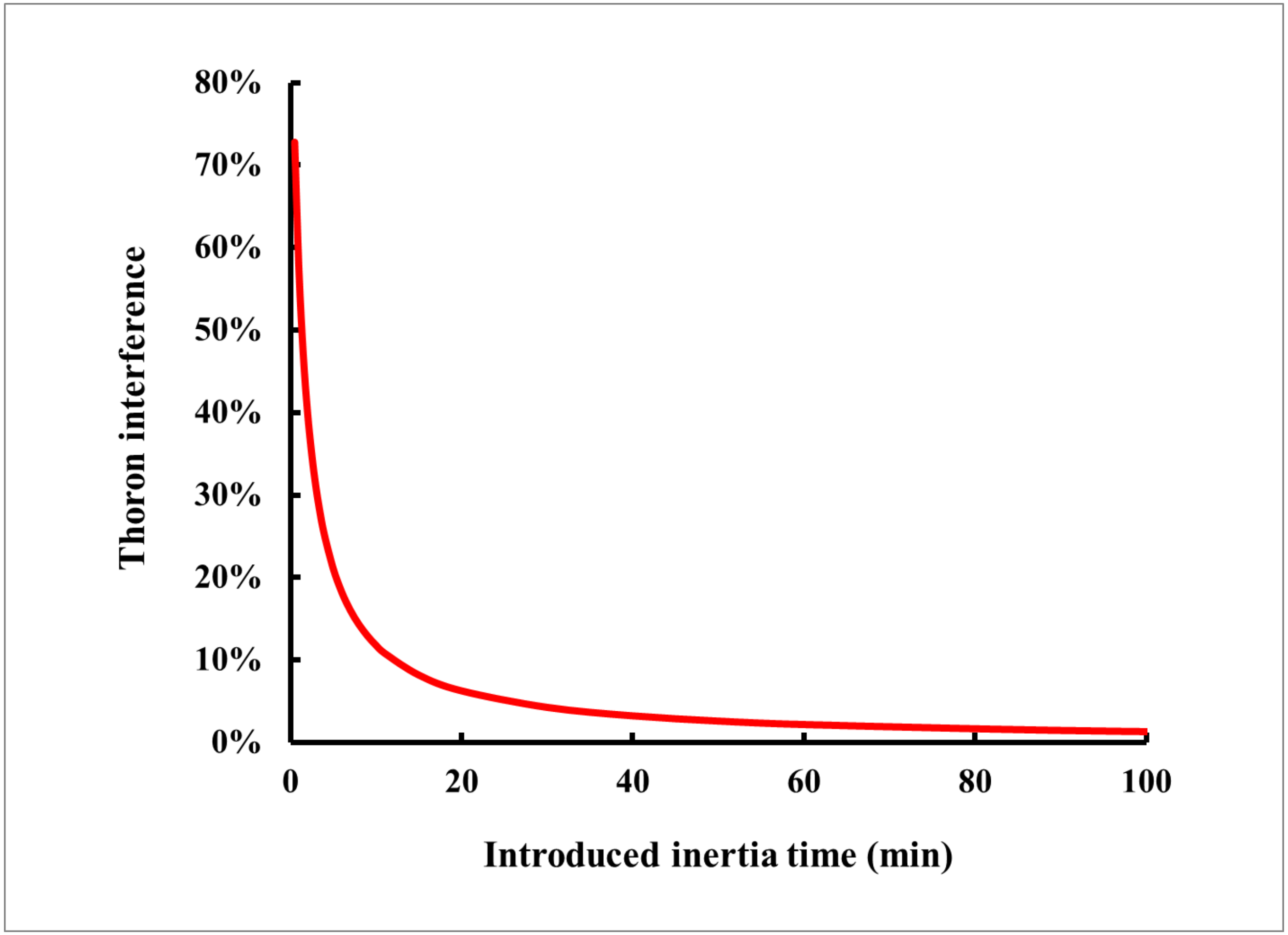
- **By alpha-spectroscopy detection (e.g. new models of AlphaGUARD, RAD7);**
- **By barrier in which most of thoron to decay before reaching the detector. The barriers used are:**
  - **Diffusion barriers (diffusion through pin holes or diffusion through polymer foils)**
  - **Pipe delay line (delay caused by flow in a pipe).**

None of the options is "for free". The monitors that use the first mode are not sufficiently cost-efficient for mass radon surveys needed to address the EU-BSS requirements. The "barrier options" face other problems.

Diffusion through a membrane or pin hole. Transmission *R* of radon and thoron (by O. Holmgren et al., 2018)

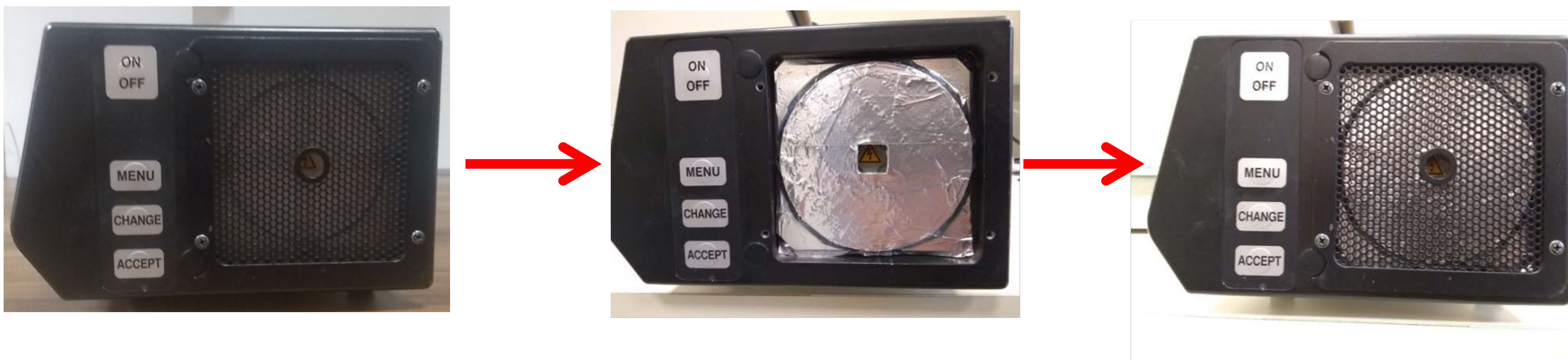


Diffusion barriers introduce inertia in the response: (The interference = R_{Tn}/R_{Rn}, where $R = \frac{C_{in}}{C_{out}}$ =1/(1+$\lambda\tau$) and τ is a "inertia time constant" due to the process of diffusion). The capacity of the monitors for fast response is limited by τ. The better is thoron reduction the greater is inertia introduced.



Reducing the thoron interference of active monitors operating in diffusion mode: placing an additional diffusion barrier at the air entry

AlphaGUARD PQ2000 Pro (old version, measures only radon):



- **Diffusion mode (10 min), standard filter: 8.81 ± 1.28 %**
- **Diffusion mode (10 min), added Al foil: 4.23 ± 0.84 %**

Reducing the thoron interference by delay in a pipe line (by O. Holmgren et al., 2018): an option suitable for active radon monitors operating in flow mode. The delay time is $t=V/Q=LS/Q$ (L is the length of the pipe, S is the area of its hole and Q is the flow-rate)

Thoron interference of AlphaGUARD in flow mode (1 l/min): 28.0 ± 8.8 %

Relative radon and thoron concentration at the end of the pipe as a function of the delay time *t*.

t (min)	$C(t)/C_0$ Radon	$C(t)/C_0$ Thoron
1	1,000	0,473
2	1,000	0,224
4	**0,999**	**0,050**
8	**0,999**	**0,003**
16	0,998	6,34E-06

Length of the pipe necessary to achieve delay time of 8 and 4 min at air-flow rate 0.5 l/min for different pipe diameters. The “pipe-volume” is 4 and 2 L, respectively.

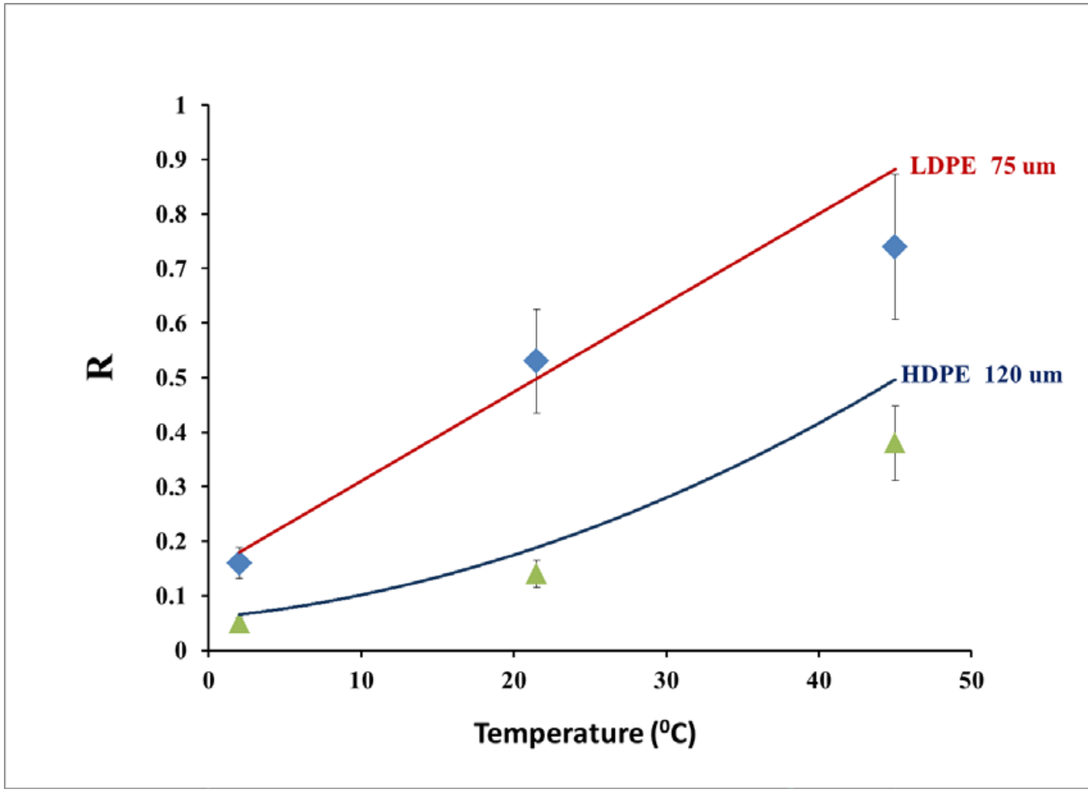
Diameter (mm)	Delay 8 min Length (m)	Delay 4 min Length (m)
10	50,9	25.45
20	12,7	6.35
30	5,7	2.85

Is it necessary the buffer (delay) volume to be a pipe?…

Thoron interference reduced by diffusion barriers:

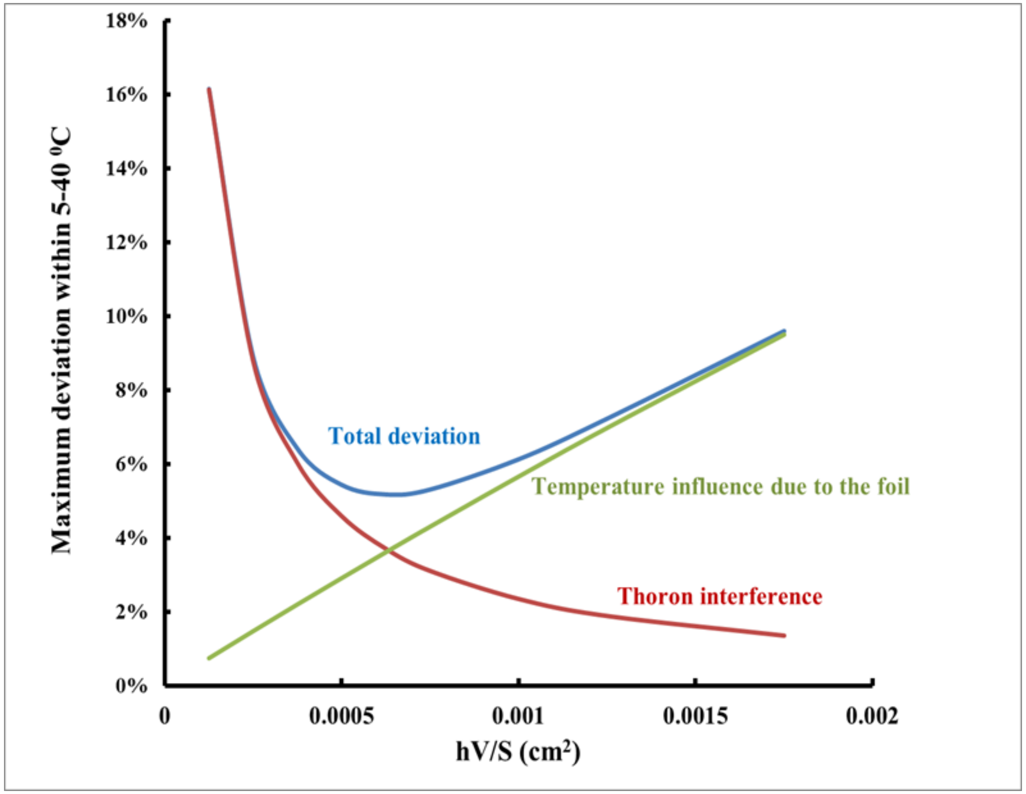
- **In most of the monitors used nowadays radon (and thoron) diffuses through small holes/gaps or fiber filters;**
- **Although in most cases thoron interference is restricted to within 10%, such barriers do not isolate the detection volume from the environment, making the response affected by high humidity levels and the thoron interference is affected by the turbulence of the surrounding air;**
- **The use of polymer foils went down in the last 20 years. It seems that one reason is the fact identified by Fleischer et al. (2000) that polymer foils introduce temperature bias in radon response. However, polymer foils can protect the detector volume from humidity and to reduce the thoron interference to less than 1%.**
- **Therefore, within WP2 the research of the properties of polymer foils was resumed to search for design that balances between the thoron interference and temperature bias.**

Polymer foils introduce temperature bias. Experimental results for V/S = 7,5 cm, cans with LDPE and HDPE

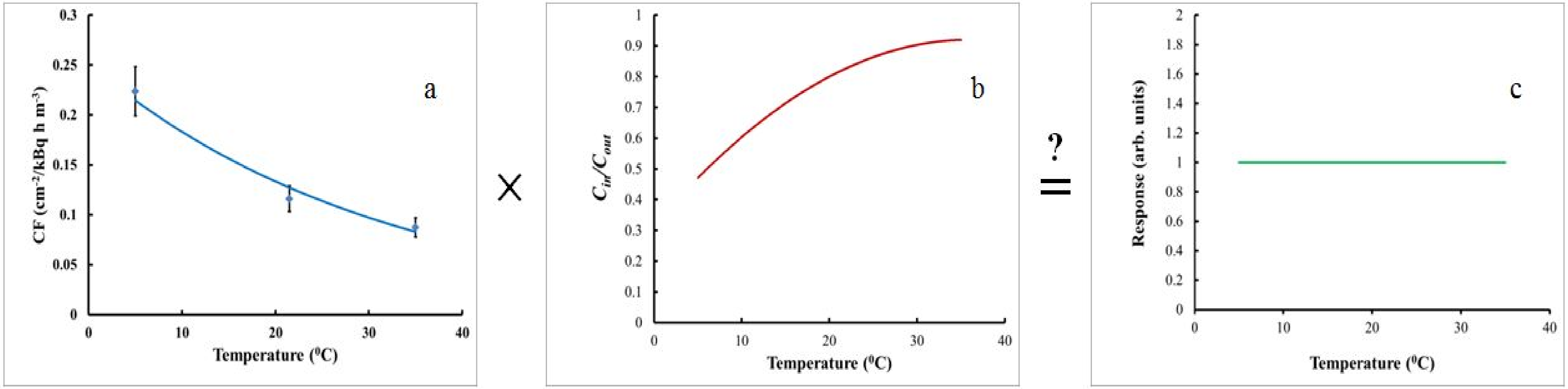


Solid lines: theoretical model, using *K* and L_D data of S. Georgiev, K. Mitev et al. (*Int. J. Env. Res. Public Health 16 (2019) 4523*)

One may compromise between thoron interference and the temperature influence introduced by the polymer foil. In any case the maximum deviation within 5-40 ^{0}C cannot be reduced to less than 5%...unless one surprising opportunity is being employed



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



The temperature dependence of the detector response may be employed to design the "compensating module" by which one may eliminate:
<u>thoron interference + temperature dependence + humidity/moisture influence</u>

What can be the benefit from packaging pin-hole diffusion chamber with thin polymer foil…

Thoron interference < 5%
Temperature bias: 10%

Thoron interference << 1%
Temperature bias: ~ 2-3%
and… no influence of humidity

Thank you!