The contribution of ^{222}Rn and ^{220}Rn bearing building materials to indoor radon.

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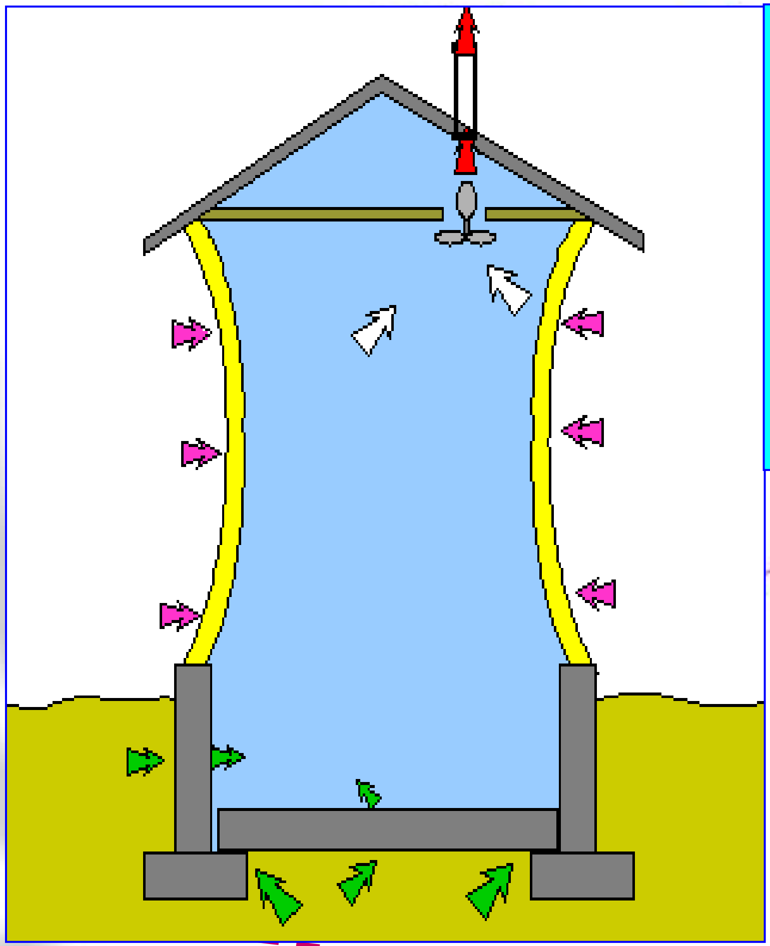
Outline

- Sources of indoor radon
- The contribution of building materials to indoor radon
- The scale model room of Università «Roma Tre»
- Experiments
- 1. The effect of inner and outer covers on indoor radon
- 2. Modelling the influence of air introduction versus air extraction in the model room
- Future developments

Sources of indoor radon: ^{222}Rn

$T_{1/2}$ ^{222}Rn:
~ 3.8 days

^{222}Rn ---> ^{218}Po ---> ^{214}Pb --->



Main Sources

- **Soil**
- **Building materials**

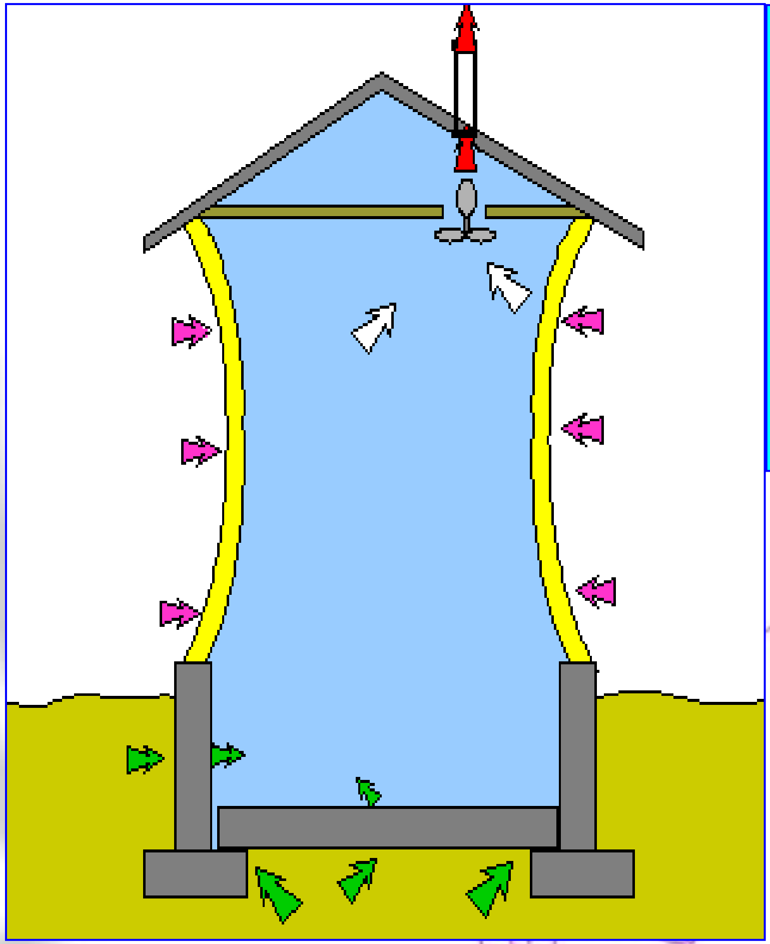
Temperature and pressure gradients between soil and indoor environment drive radon fluxes inward

$^{238}U \xrightarrow{\alpha}$ --- ---> $^{226}Ra \xrightarrow{\alpha}$ ---> ^{222}Rn (gas) $\xrightarrow{\alpha}$ ---

Sources of indoor radon: ^{220}Rn

$T_{1/2}$ ^{220}Rn:
~ 56 s

^{220}Rn --- > ^{216}Po --->



Main Sources

- **Soil**
- **Building materials**

Temperature and pressure gradients between soil and indoor environment drive radon fluxes inward

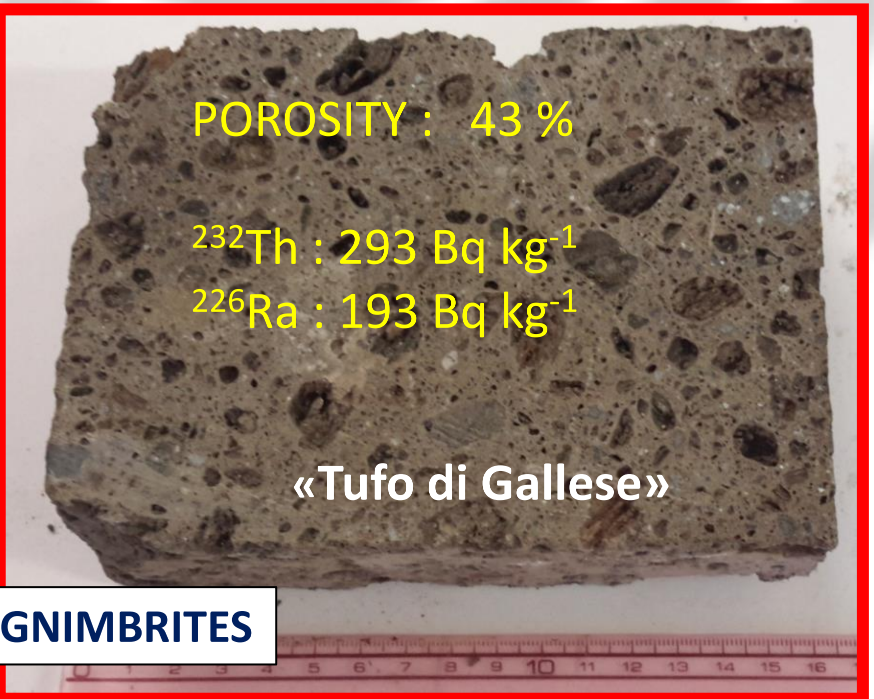
$^{232}Th \xrightarrow{\alpha}$ --- -- $^{224}Ra \xrightarrow{\alpha}$ --- > ^{220}Rn

Use of ignimbrites in central Italy

Lithoid ignimbrites have always been used to build edifices in central Italy (picture of Caprarola town, Viterbo).

Preliminary work: building materials available in building materials store in Caprarola

PHREATOMAGMATIC PRODUCTS



LITHOID IGNIMBRITES

The contribution of building material

Lithoid ignimbrite from Vico apparatus

Exhalation rates

^{222}Rn

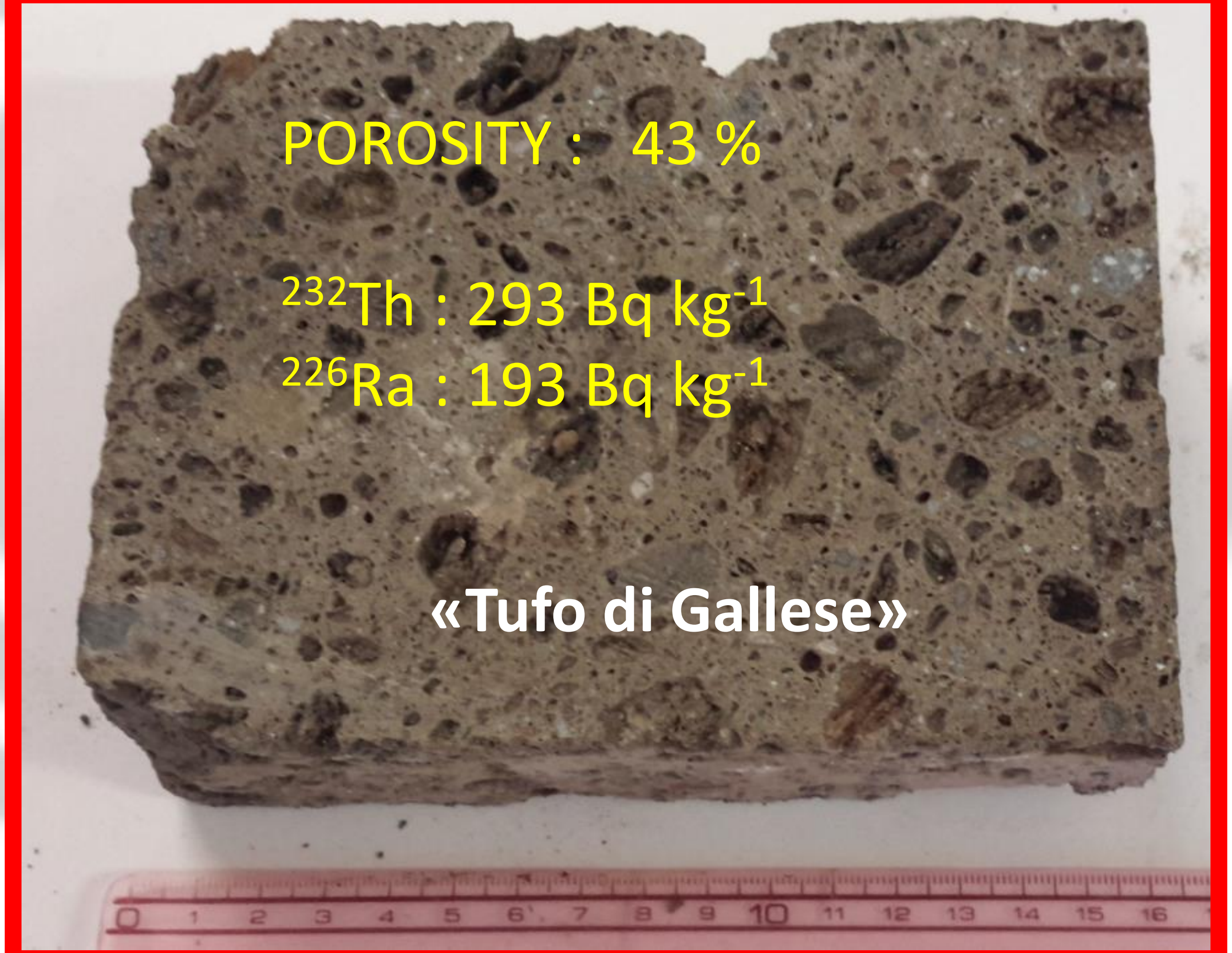
Bq m^{-2} h^{-1}

5.91 ± 0.14

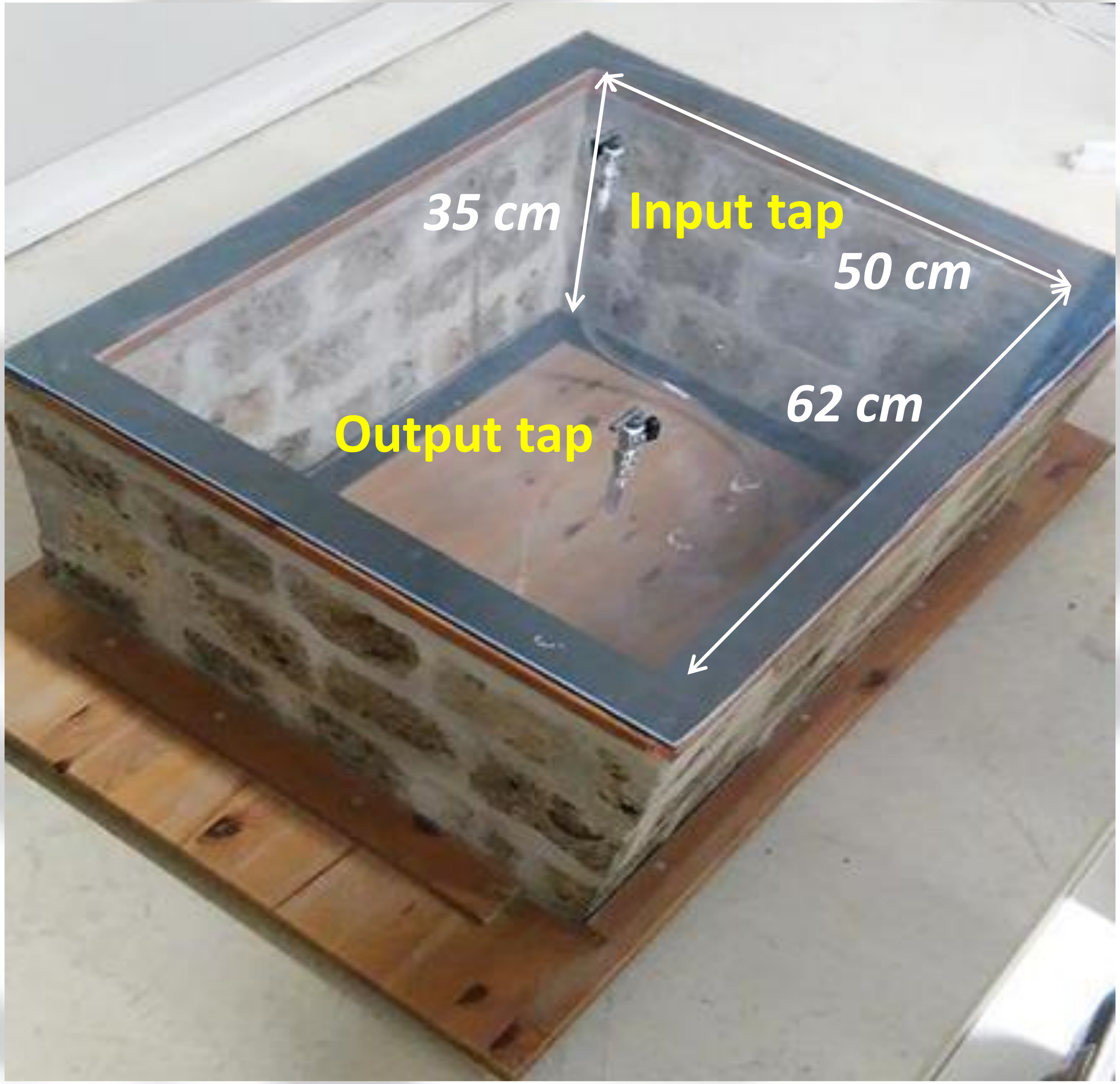
^{220}Rn

Bq m^{-2} h^{-1}

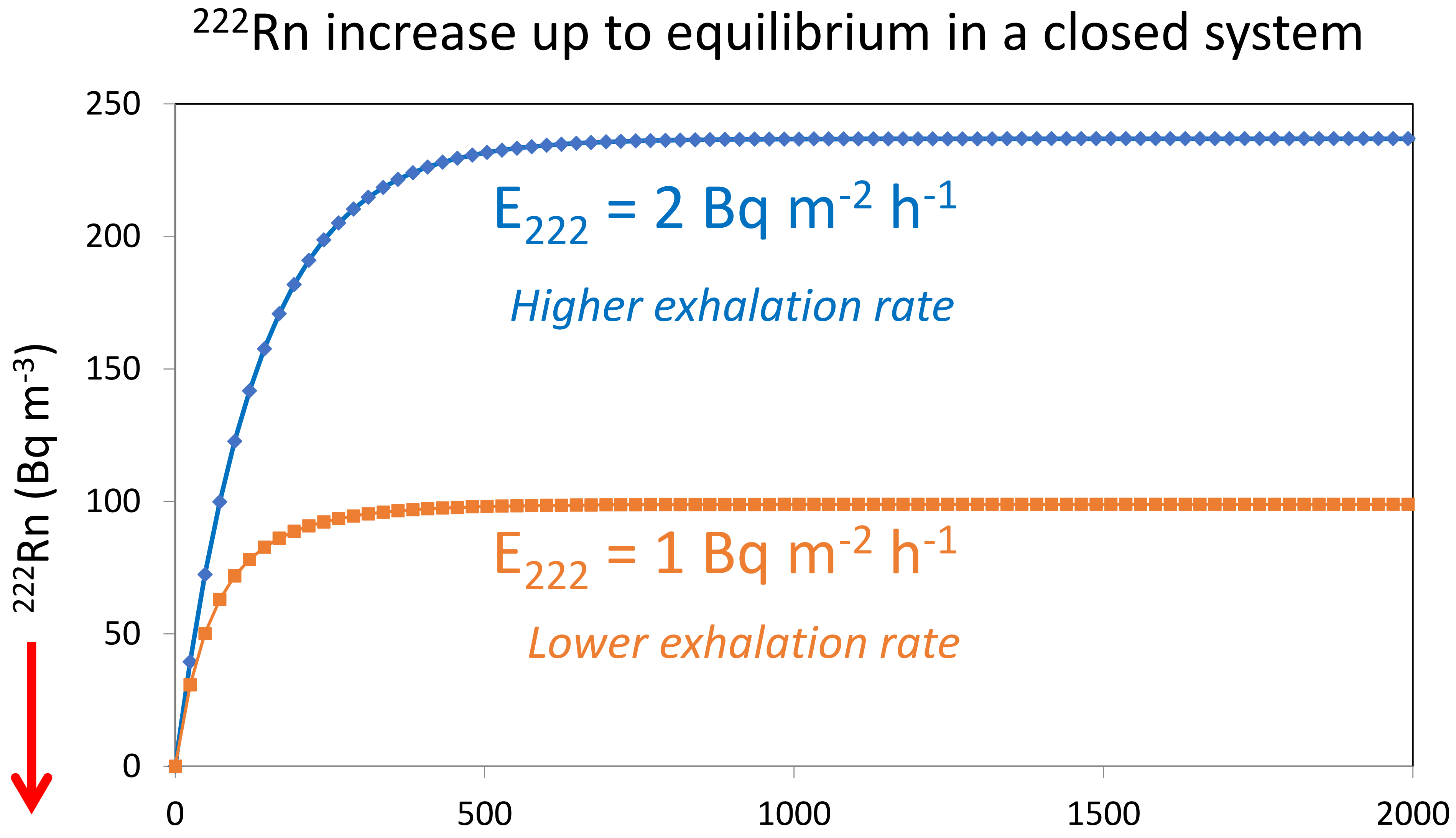
6434 ± 494



THE SCALE MODEL ROOM: ~ 0.1 m^3



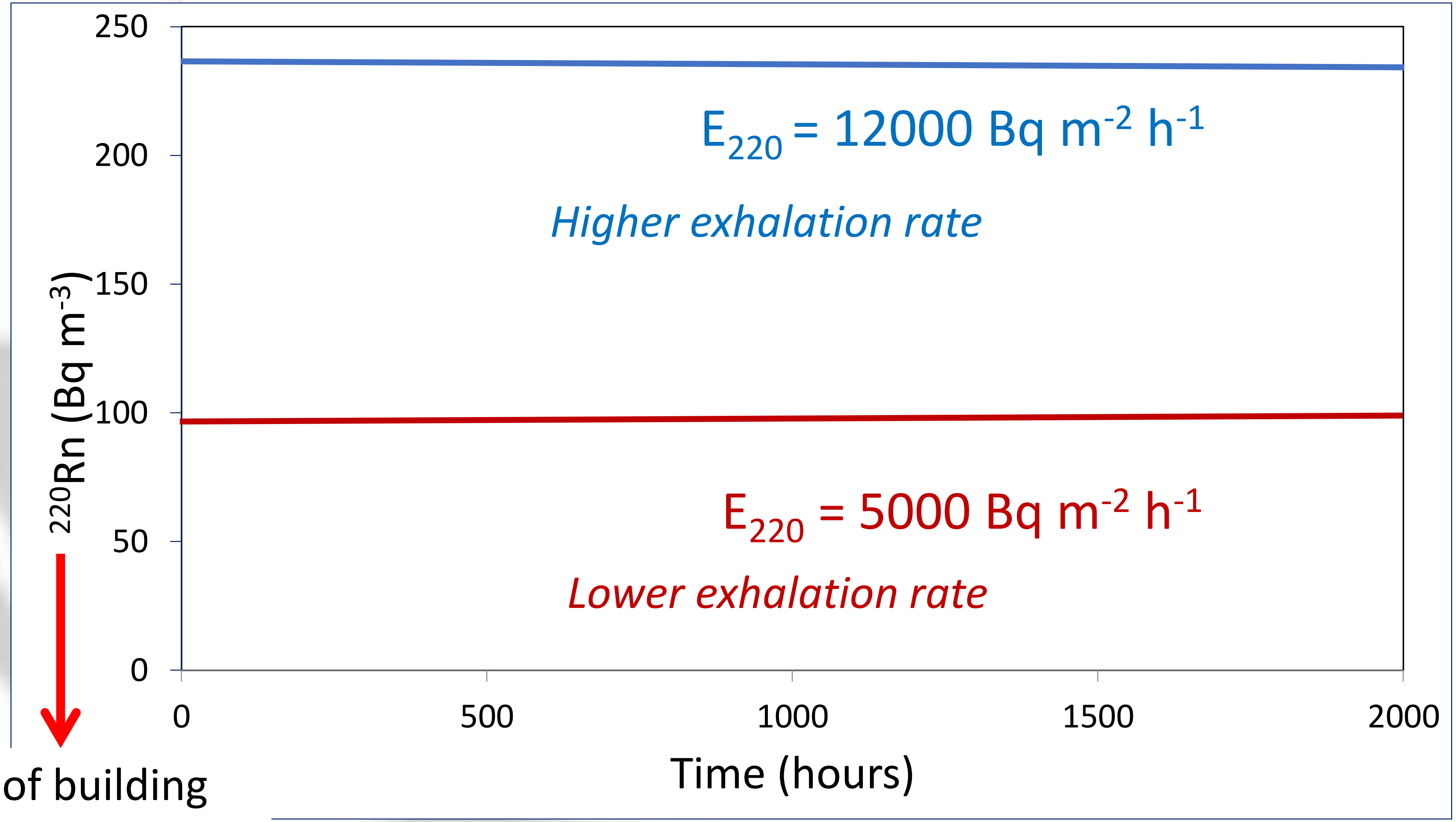
$T_{1/2}$ ^{222}Rn:
~ 3.8 days



Contribution of building materials to indoor radon

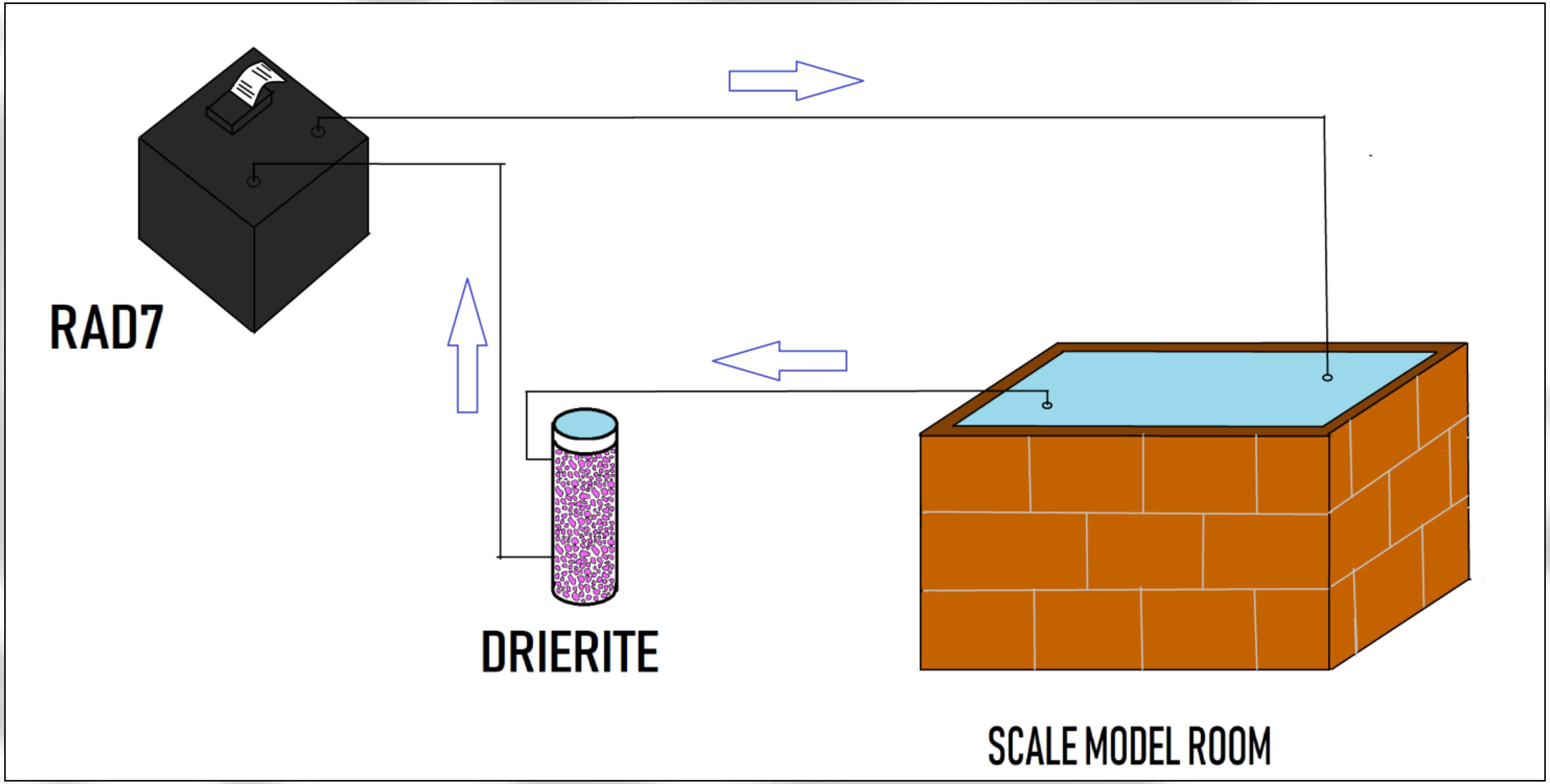
^{220}Rn increase up to equilibrium in a closed system

$T_{1/2}$ ^{220}Rn: ~ 56 s



Contribution of building materials to indoor radon

Experimental set-up



EXPERIMENTS. 1. The effect of inner and outer covers on indoor radon

Experimental condition	Test #	^{222}Rn	^{220}Rn	T (°C)
Not covered	1	770 ± 50	523 ± 203	18-24
Covered with external coatings	**2**	**10623 ± 137**	**530 ± 124**	**20 - 26**

External covers enhance ^{222}Rn levels, but not ^{220}Rn

RADON LEVELS ARE EXPRESSED IN Bq / m3

Experimental condition	Test #	^{222}Rn	^{220}Rn	T (°C)
Covered with external coatings	2	10623 ± 137	530 ± 124	20 - 26
Covered with external coatings and internal shield of plasterboard	**3**	**13154 ± 211**	**230 ± 103**	**25 - 31**

The addition of an internal shield of plasterboard does not influence ^{222}Rn levels, but cut ^{220}Rn

Experimental condition	Test #	^{222}Rn	^{220}Rn	T (°C)
Covered with external coatings and internal shield of plasterboard	3	13154 ± 211	230 ± 103	25 -31
As previous test, but with a doblue coat of paint	**4**	**11400 ± 155**	**bdl**	**23-27**

The addition of a double coat of paint slightly reduces ^{222}Rn levels, but strongly ^{220}Rn

bdl stands for below detection limit

Experimental condition	Test #	^{222}Rn	^{220}Rn	T (°C)
As previous test, but with a doblue coat of paint	4	11400 ± 155	bdl	23-27
As previous test, but without external coating	**5**	**1040 ± 71**	**bdl**	**23-27**

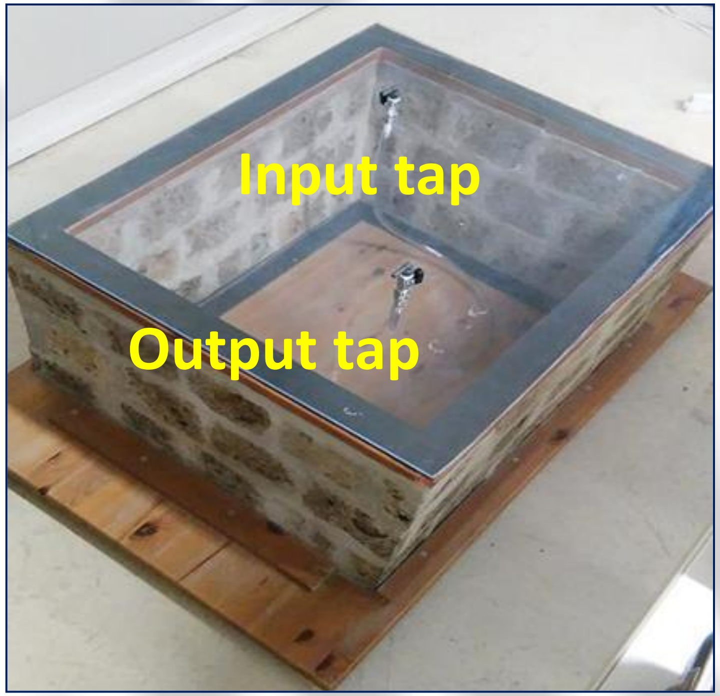
Removing the external coating strongly reduces ^{222}Rn levels, without effects on ^{220}Rn

Summary of the first set of experiments

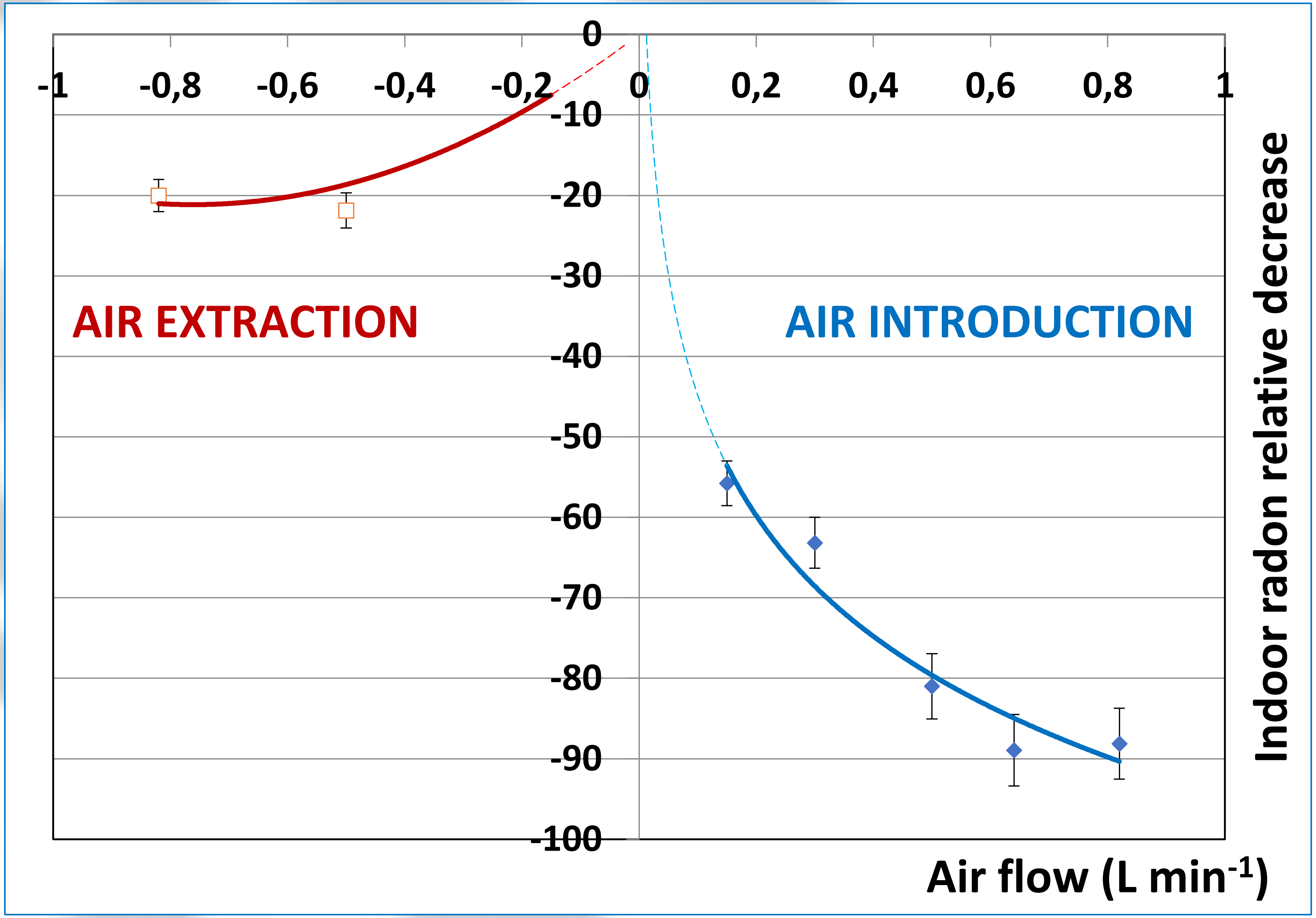
- **External covers should be removed from buildings in order to promote ^{222}Rn exchange and dilution; No effect on ^{220}Rn**

- **Internal covers strongly cut ^{220}Rn, with a limited effect on ^{222}Rn**

EXPERIMENTS. 2. The influence of air introduction versus air extraction in the model room



THE MODEL ROOM WAS INTERNALLY COVERED WITH THE PLASTERBOARD

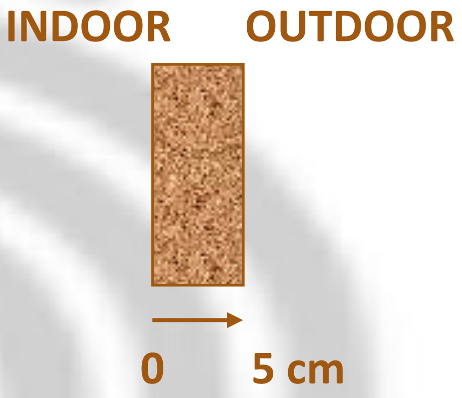


Summary of the second set of experiments

- **Air introduction is more effective than air extraction to reduce indoor radon in small rooms with high radon levels**

- **The higher the air flow, the stronger the ^{222}Rn decrease**

A modified version of Fick's second law was used to describe the radon diffusion through the wall.



$$\frac{dC(x,t)}{dt} = D\frac{d^2C(x,t)}{dx^2} - v\frac{dC(x,t)}{dx} + g - \lambda C(x,t)$$

where:

C(x, t) is the radon concentration (B… ores of the building material

D is the radon diffusio…

x is the distanc… of the wall to the outdoor direction…

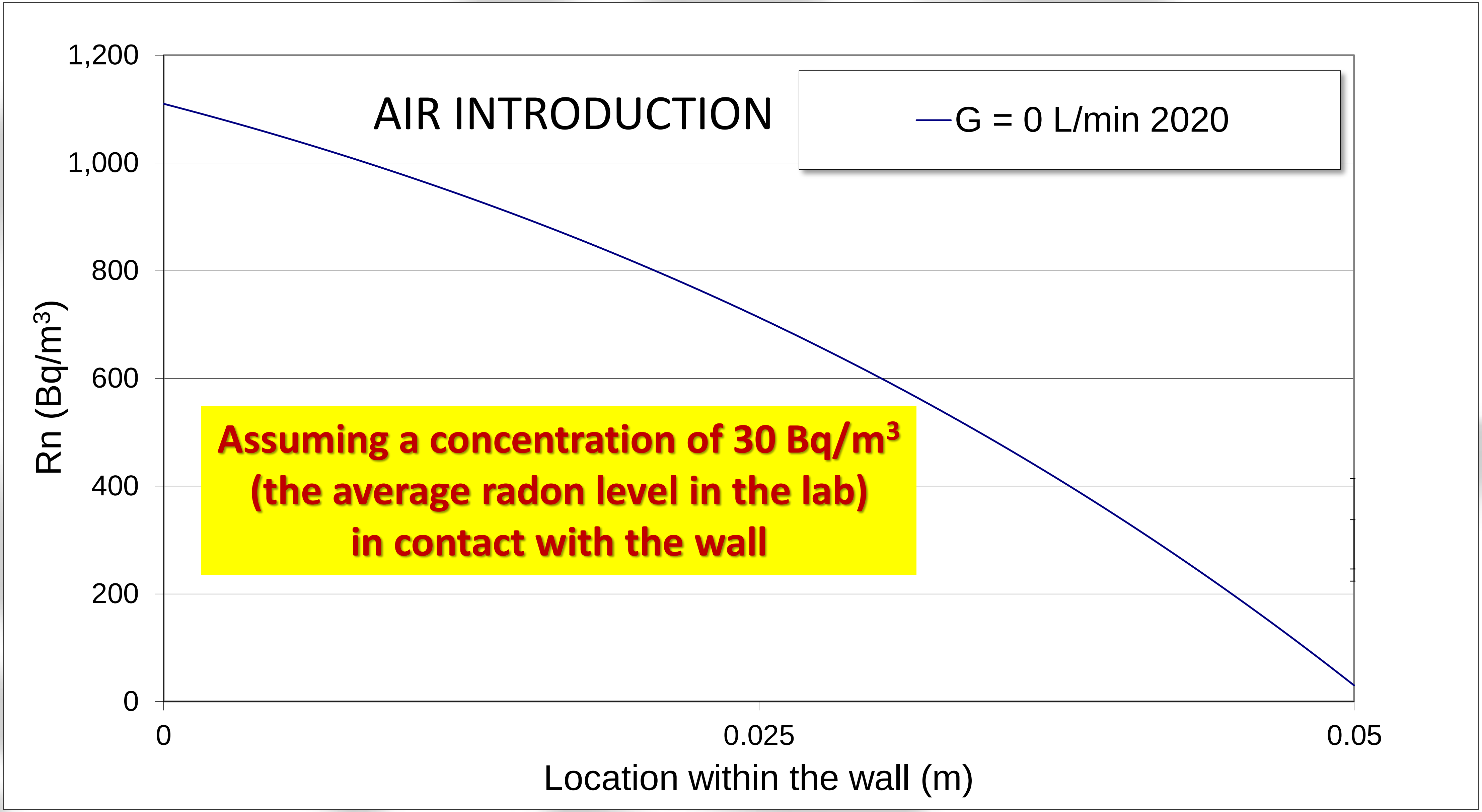
v i… ough the wall (m/s)

g is … eation rate per unit size of the pores (Bq/m³/s) and

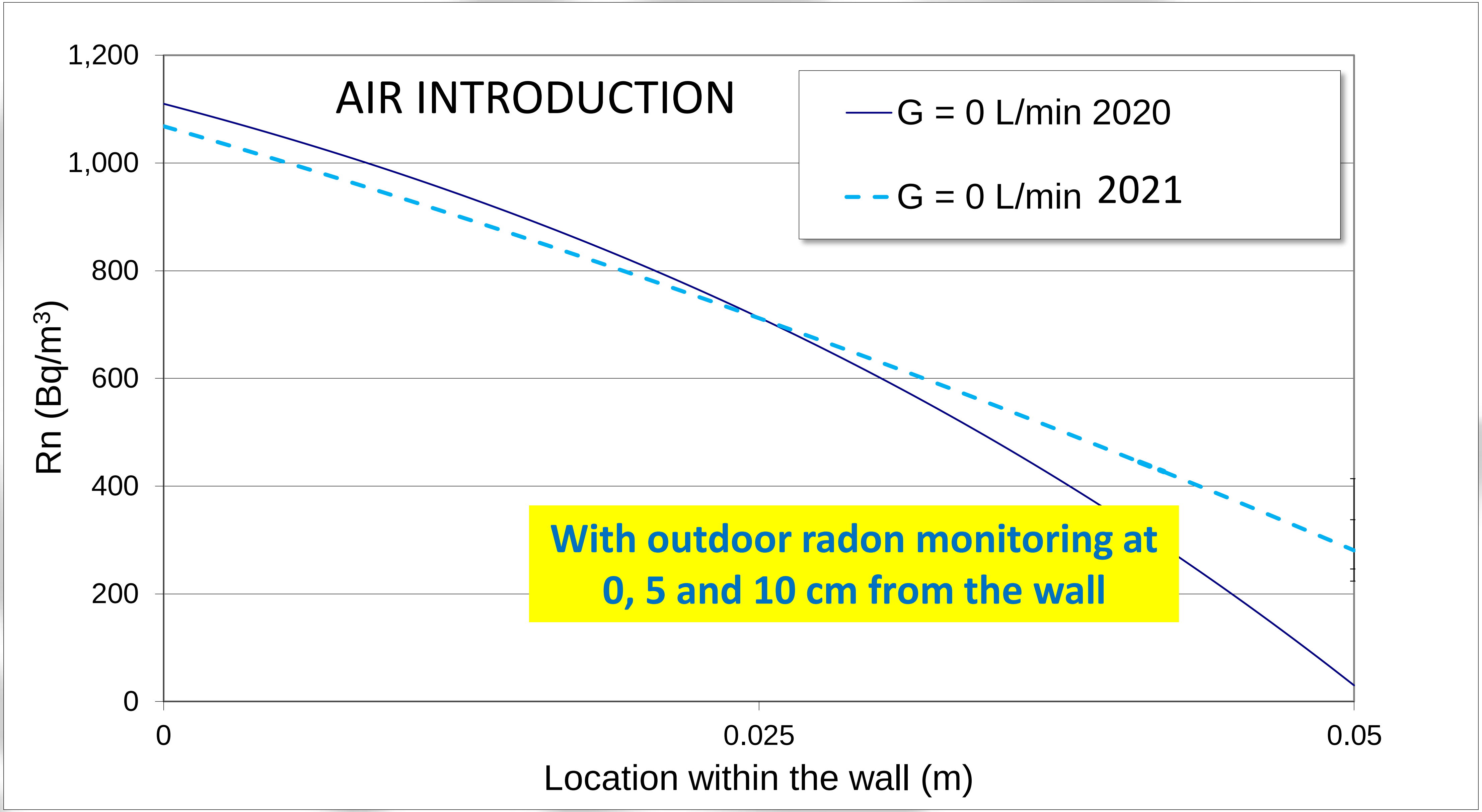
λ is t… adon decay constant (s^{-1})

This was applied only to experiments without covers

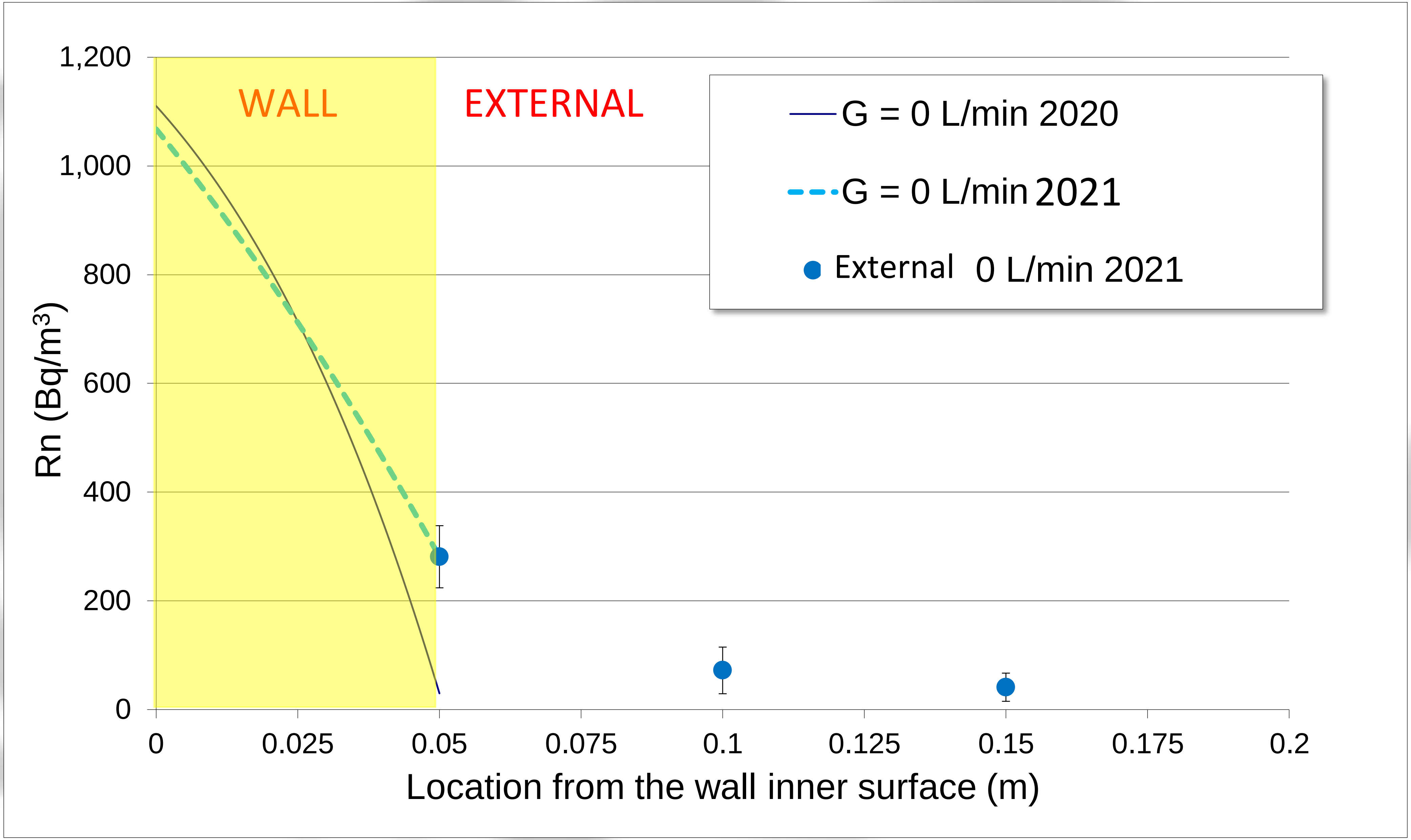
GRAPHICAL SOLUTION OF THE MODELLING



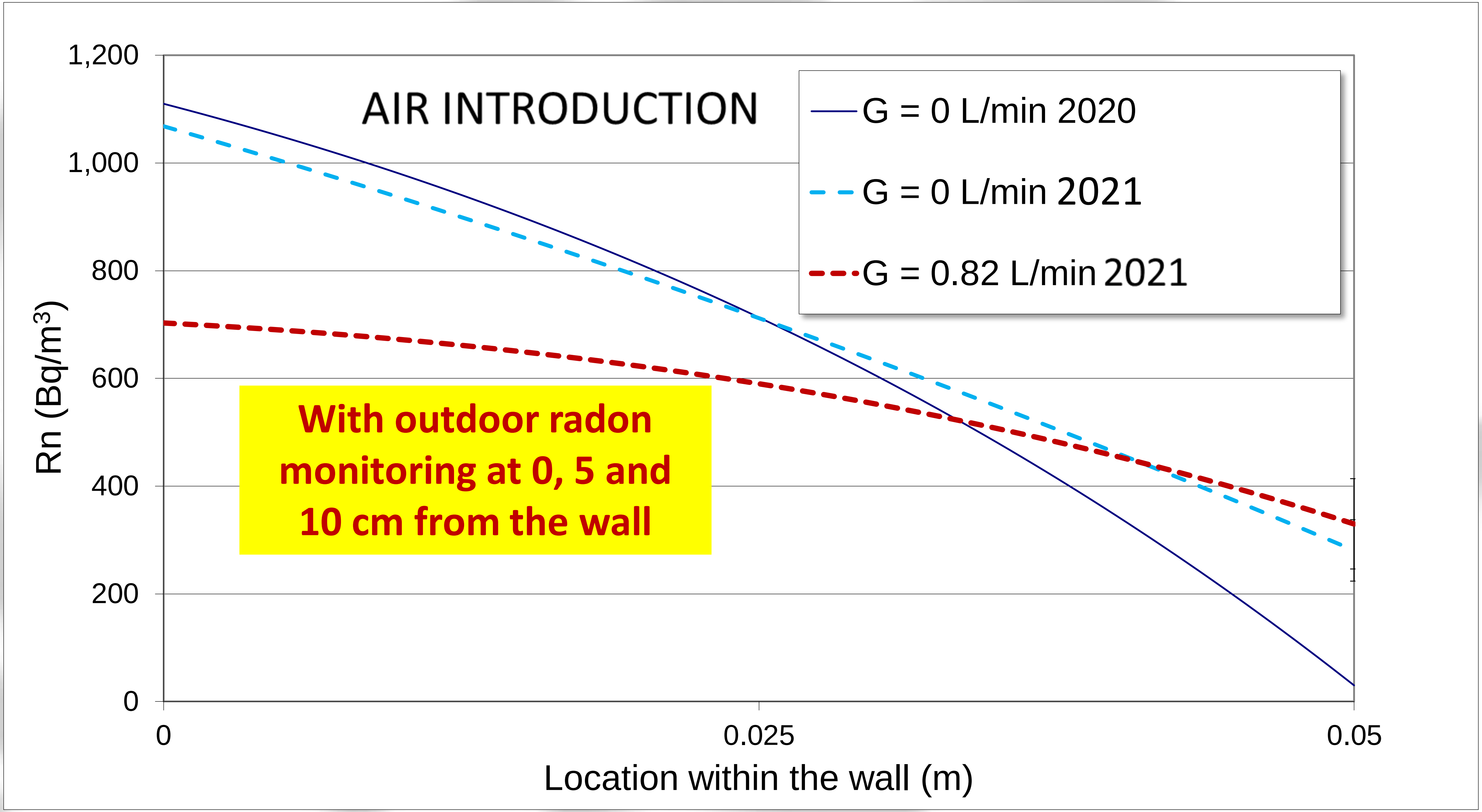
GRAPHICAL SOLUTION OF THE MODELLING

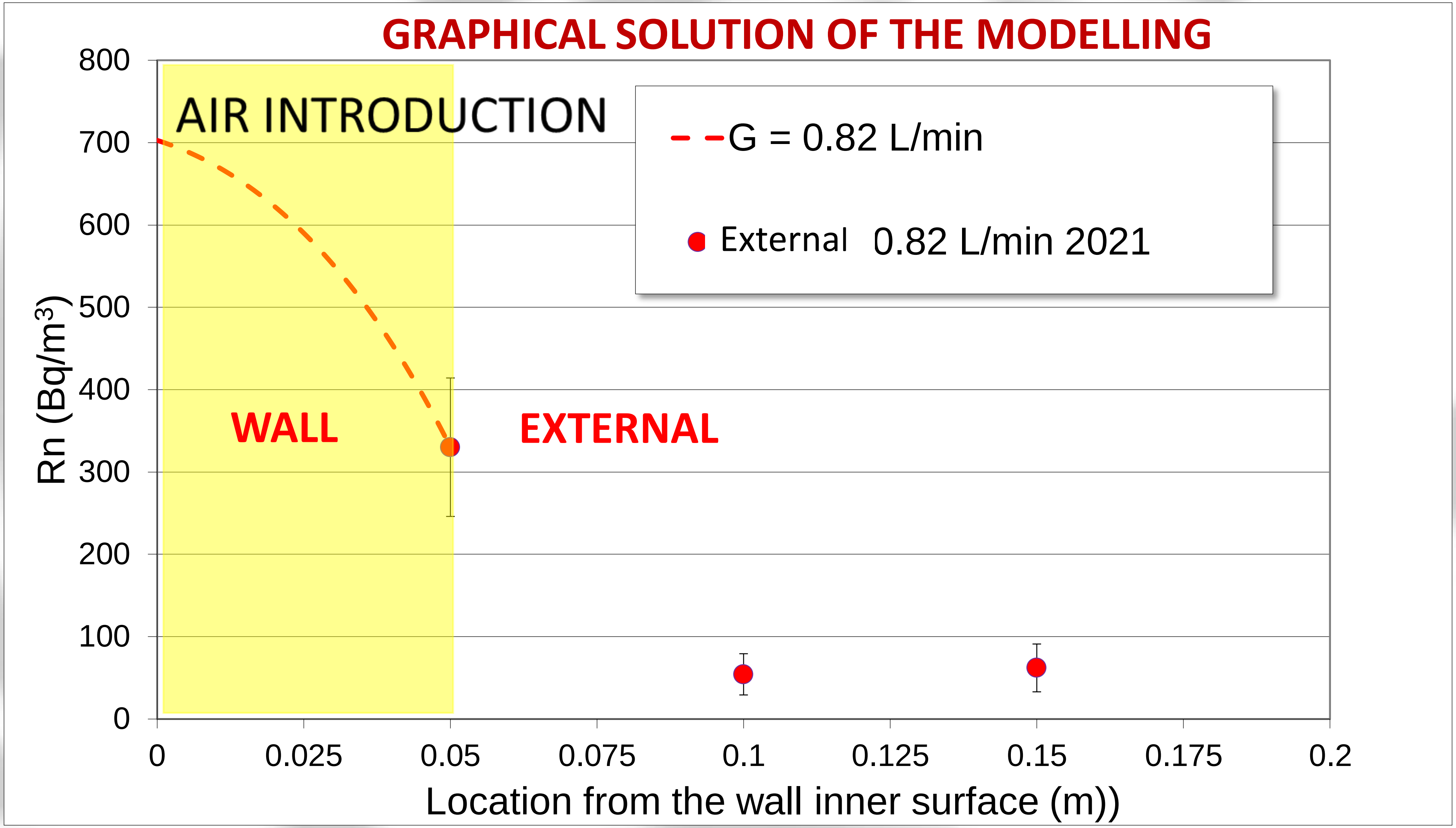


AIR INTRODUCTION

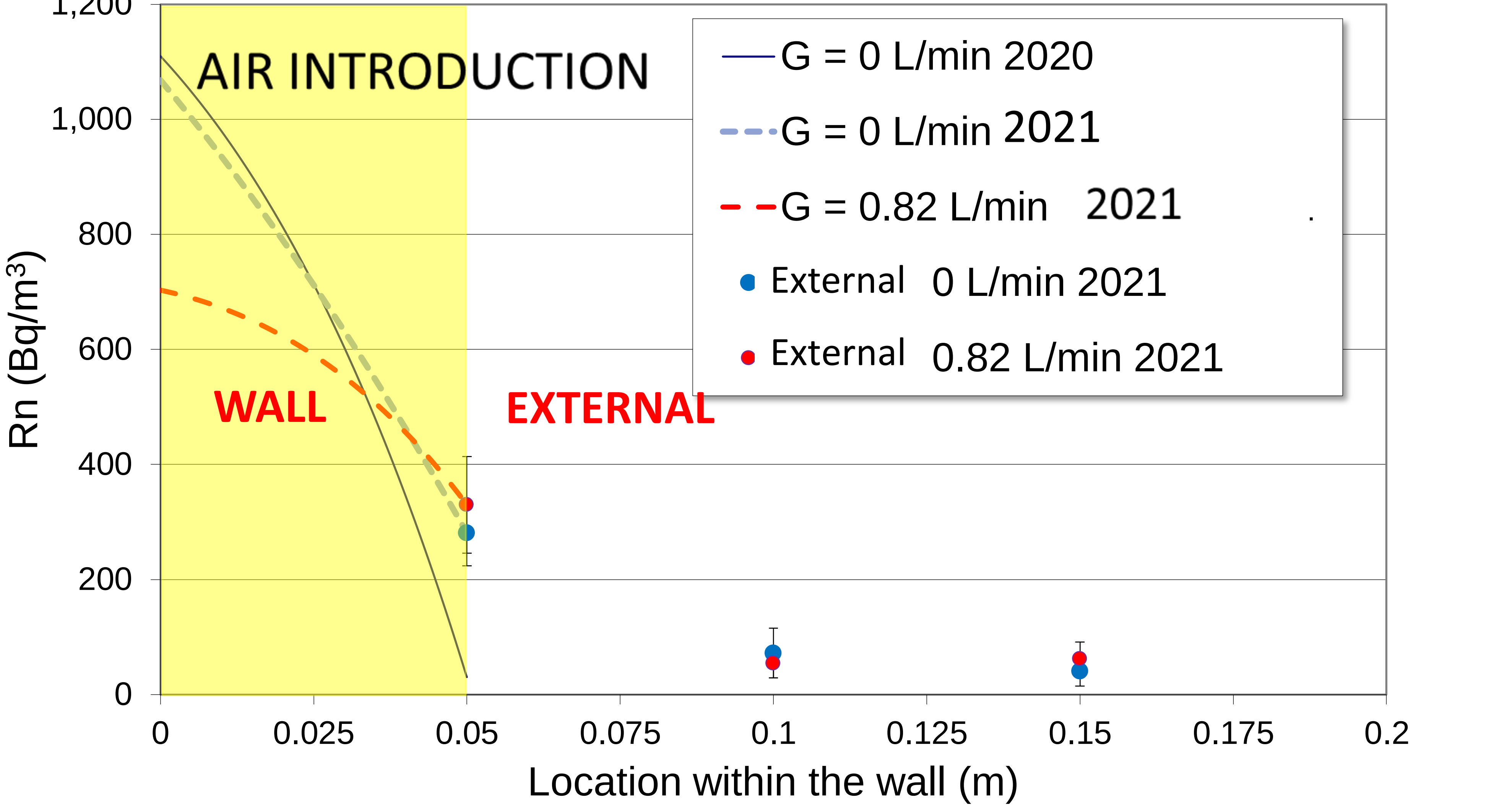


GRAPHICAL SOLUTION OF THE MODELLING




GRAPHICAL SOLUTION OF THE MODELLING
AIR INTRODUCTION
G = 0.82 L/min
External 0.82 L/min 2021
WALL
EXTERNAL
Rn (Bq/m3)
800
700
600
500
400
300
200
100
0
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
Location from the wall inner surface (m))

GRAPHICAL SOLUTION OF THE MODELLING



NO VENTILATION

INNER COATINGS

Reduce ^{220}Rn

OUTER COATINGS

Favour ^{222}Rn accumulation

AIR INTRODUCTION

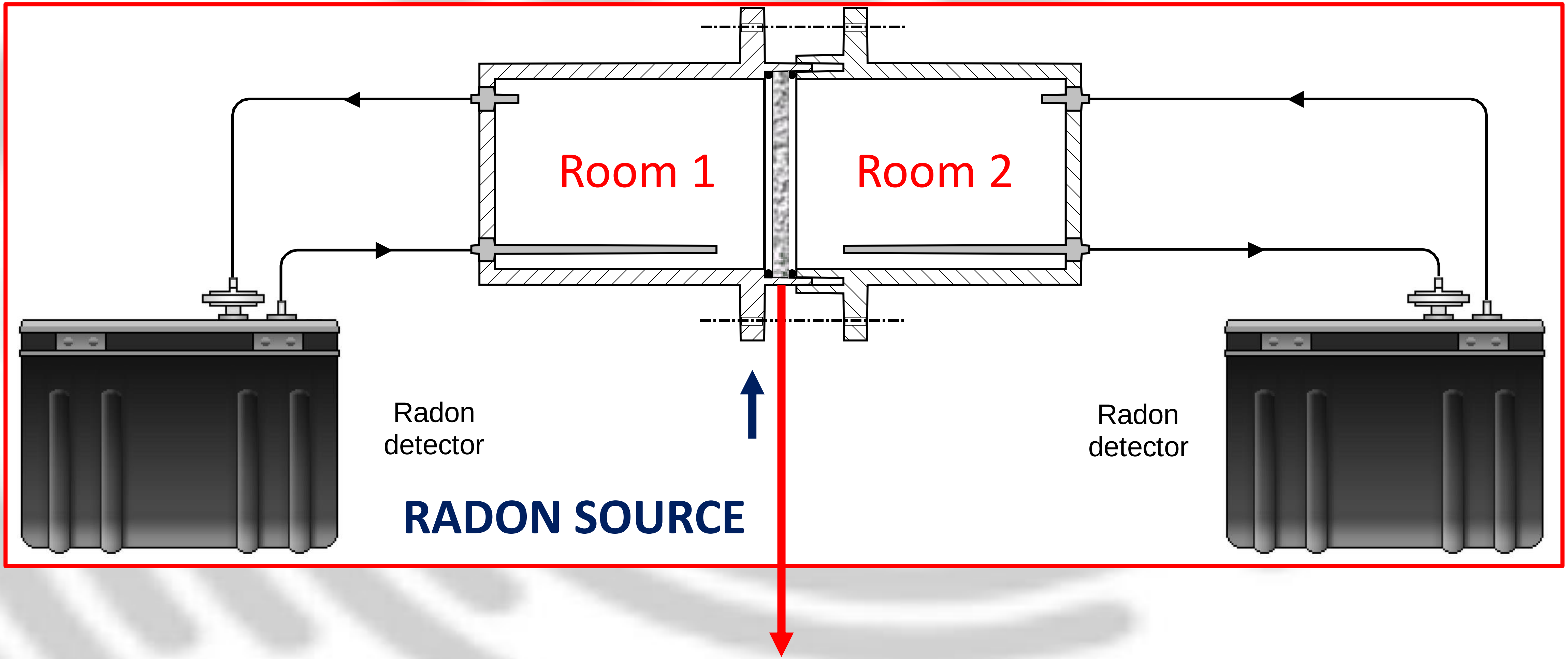
Experiments at highest flow rate (0.82 L min^{-1}), without outer coatings

INNER COATINGS

Reduce ^{222}Rn

With the plasterboard	88 %
Without the plasterboard	33 %

FUTURE DEVELOPMENTS – EXPERIMENTS TO CHARACTERISE SINGLE MATERIALS



Material to be tested

Thank you for your attention !!!