



**16th International Workshop  
Garm**

**“Indoor radon surveying and mitigation in a dwelling of Celleno town (central Italy) located in a medium geogenic radon potential area”**



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Bing images

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*The aim of this research was:*

- to identify and assess the contribution of radon sources;
- to study and evaluate the factors affecting radon entry into the building, either geogenic or anthropogenic;



to keep indoor levels below reference values and  
reduce radon risk in a dwelling of Celleno town  
(central Italy).



**Legislative Decree 101/2020** has established the maximum radon  
limit in workplaces and civil dwellings at  $300 \text{ Bq/m}^3$ .





### Celleno: Geographic setting



Giustini et al., 2022

Geographic Coordinates:  
 42°33' 50.59" N  
 12°07'38.83" E



**Average Indoor Radon  
 > 2000 Bq/m<sup>3</sup>**



### Celleno: Geological setting

Area characterized by Vulsini volcano complex

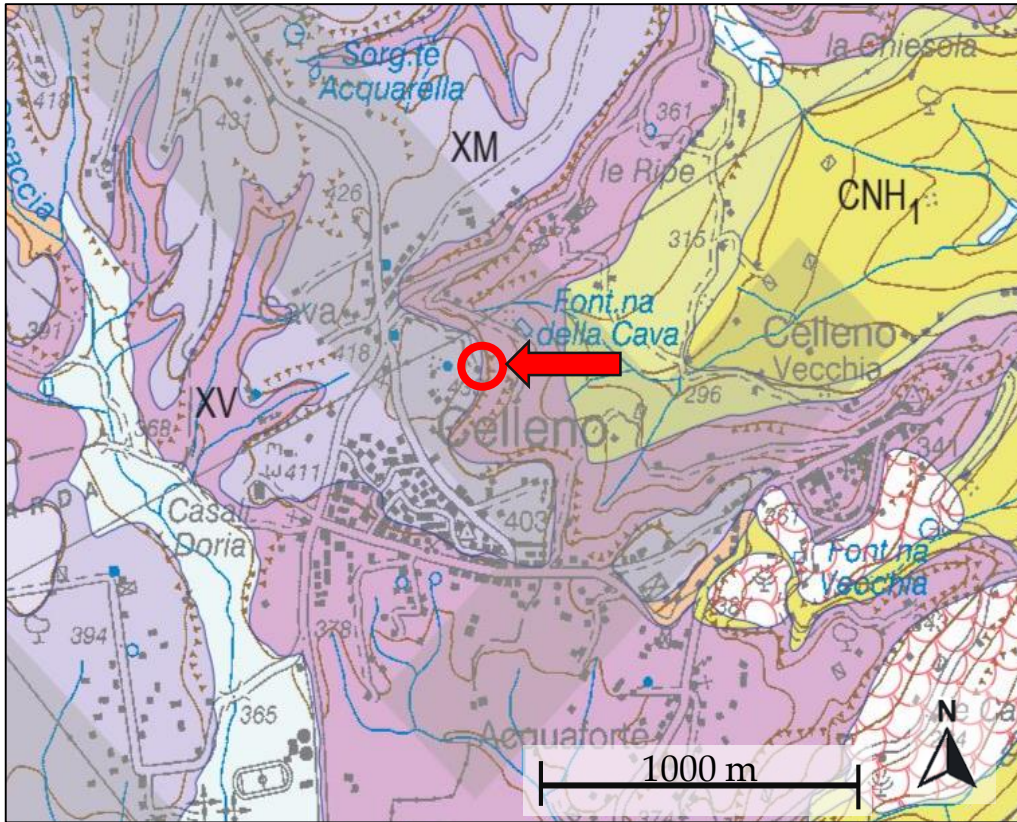
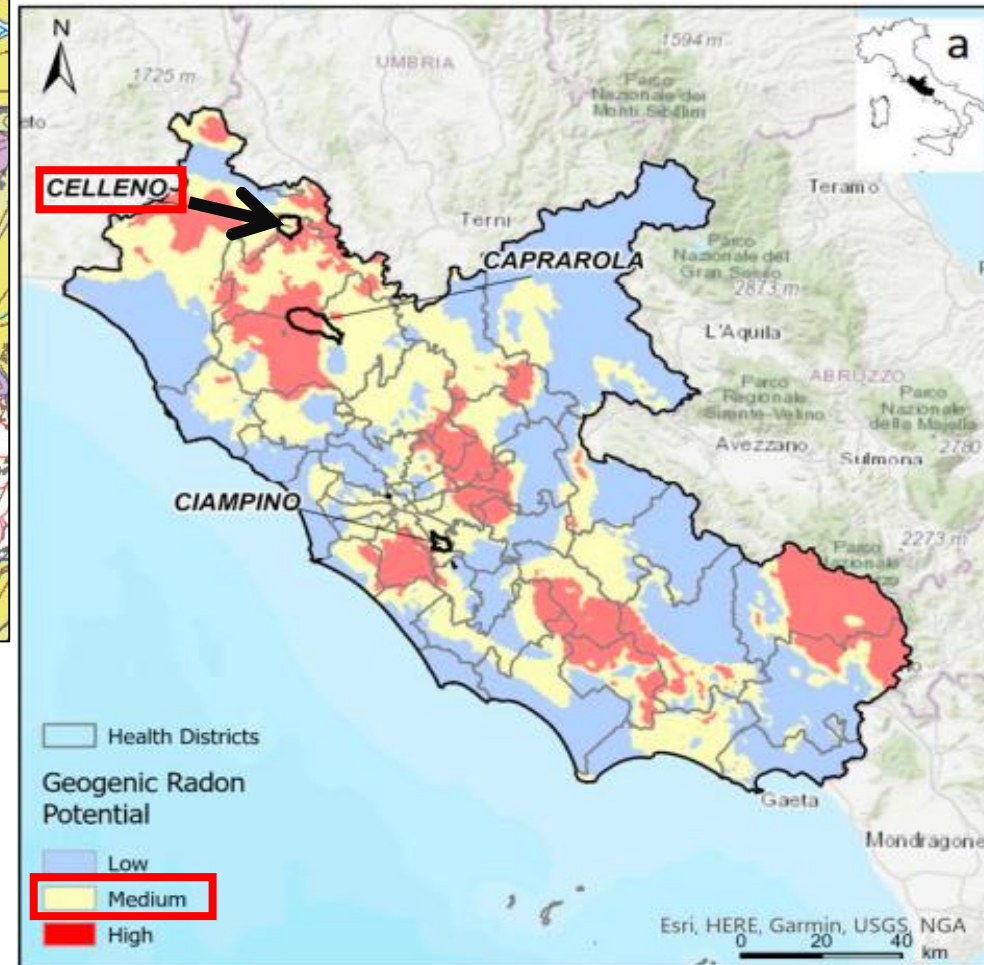


With high radionuclide concentrations ( $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{40}\text{K}$ )

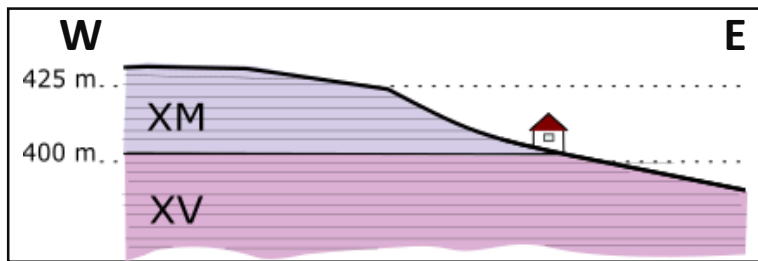


(from EU-funded LIFE-Respire project 2017-2020)

Geogenic Radon Potential (GRP) map of Lazio Region (Giustini et al., 2022)



Extract from the Geological Map, Sheet 345 Viterbo (1:50.000).



Scheme not to scale.





Building material: Tuff

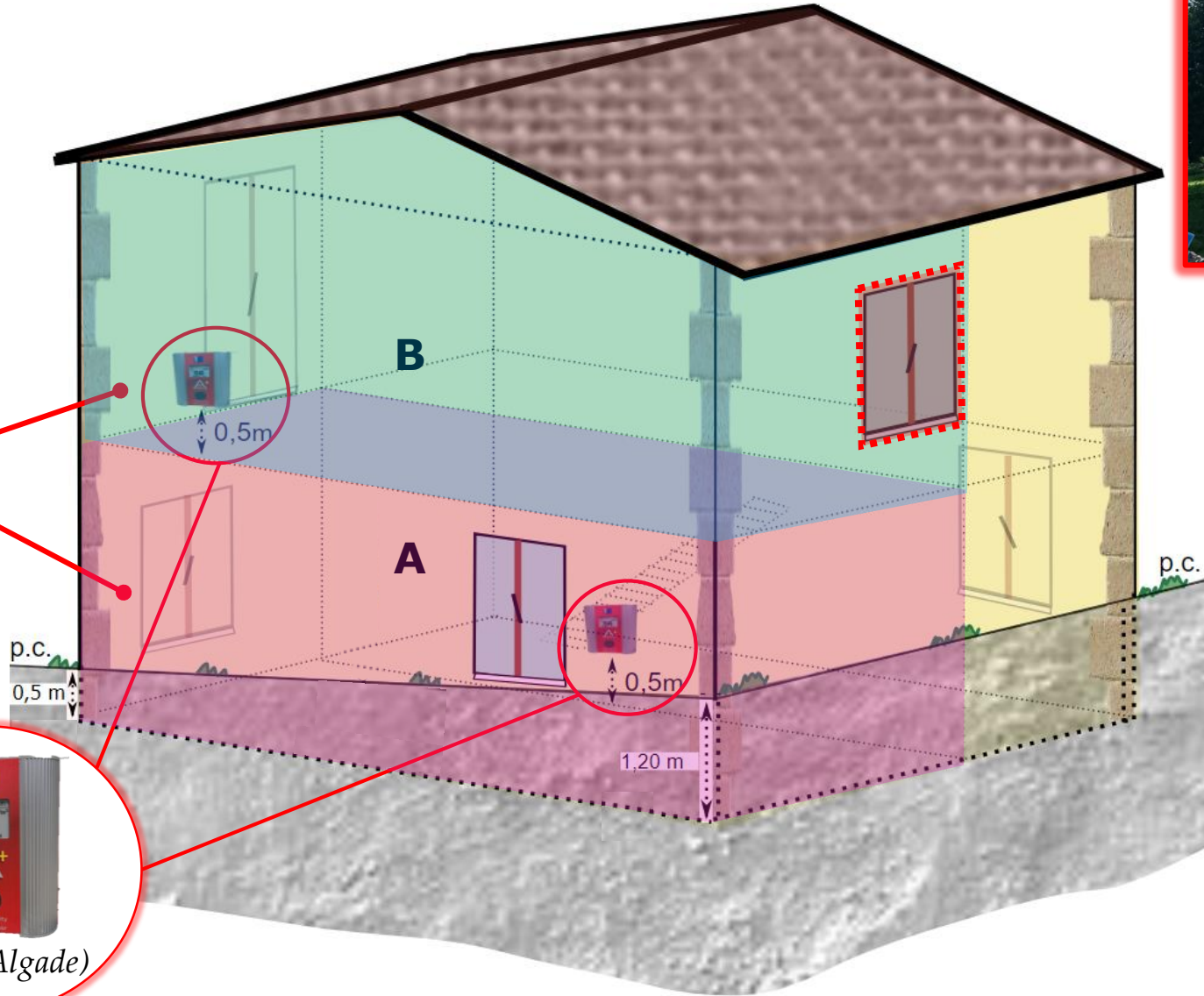
Geological Bedrock: Tuff

Rooms



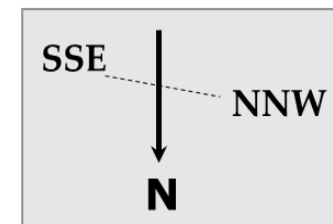
AER+ (Algade)

The study house



1° Floor

Ground floor semi-buried





Building interventions  
(Previous to this study)

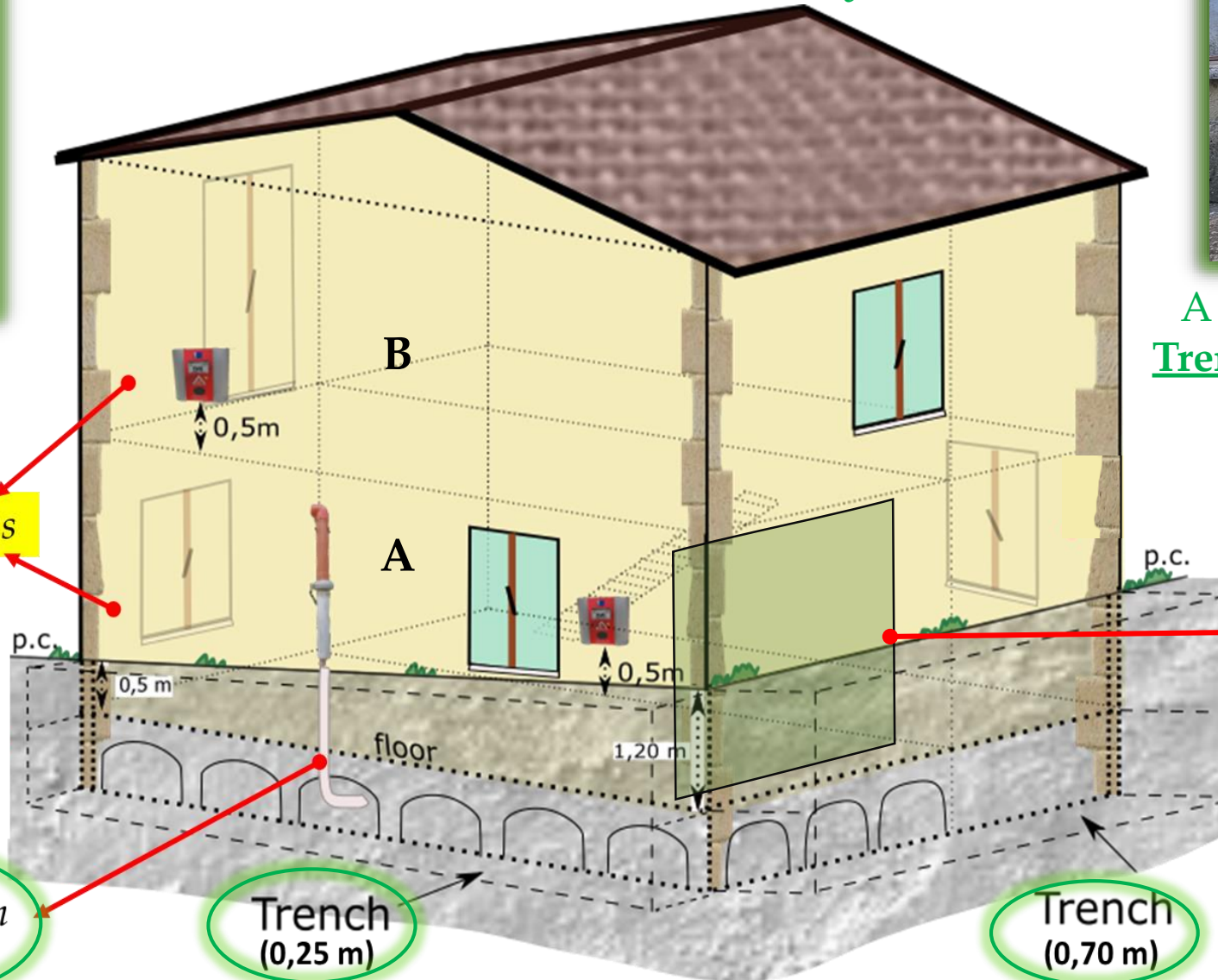


A bitumen membrane and some aluminum plates

+

rooms

A ventilation system:  
A network of pipes  
(connected to an  
external fan) below  
the floor of room A.



Ventilation system

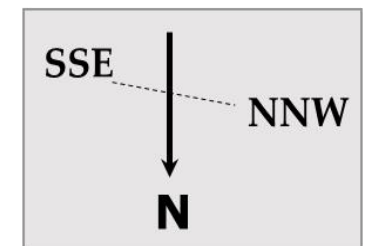
Trench (0,25 m)

Trench (0,70 m)

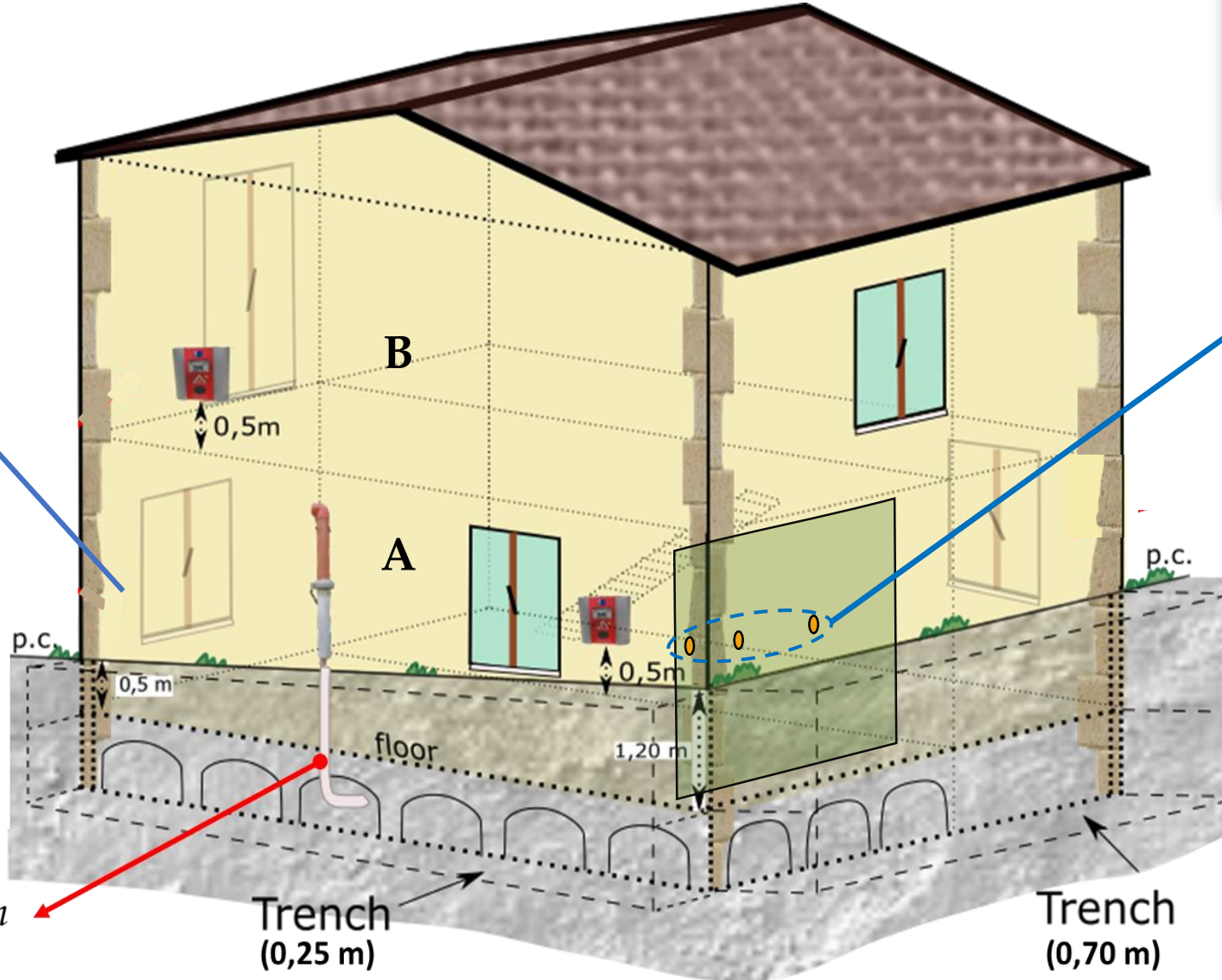


A naturally ventilated Trench around two sides of the house.

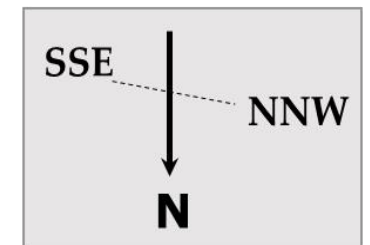
-A Wall made of perforated bricks was then built at a certain distance from the main wall of room A.



Building interventions  
During this study (room A)



-3 holes have been drilled in the external wall, where behind a cavity is created by the wall made of perforated bricks.



- Application of an anti-radon membrane (Aquaflex S1K), which has also been used to seal the soil gas entry points in room A.

Ventilation system

Trench (0,25 m)

Trench (0,70 m)



Why was chosen AQUAFLEX S1K?

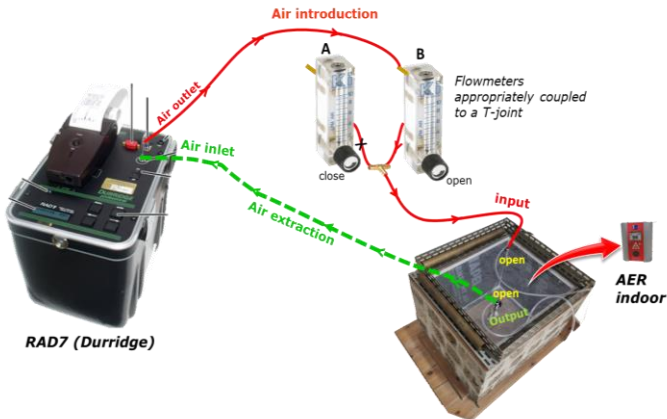
From Laboratory Experiments

(Portaro et al., 2023)

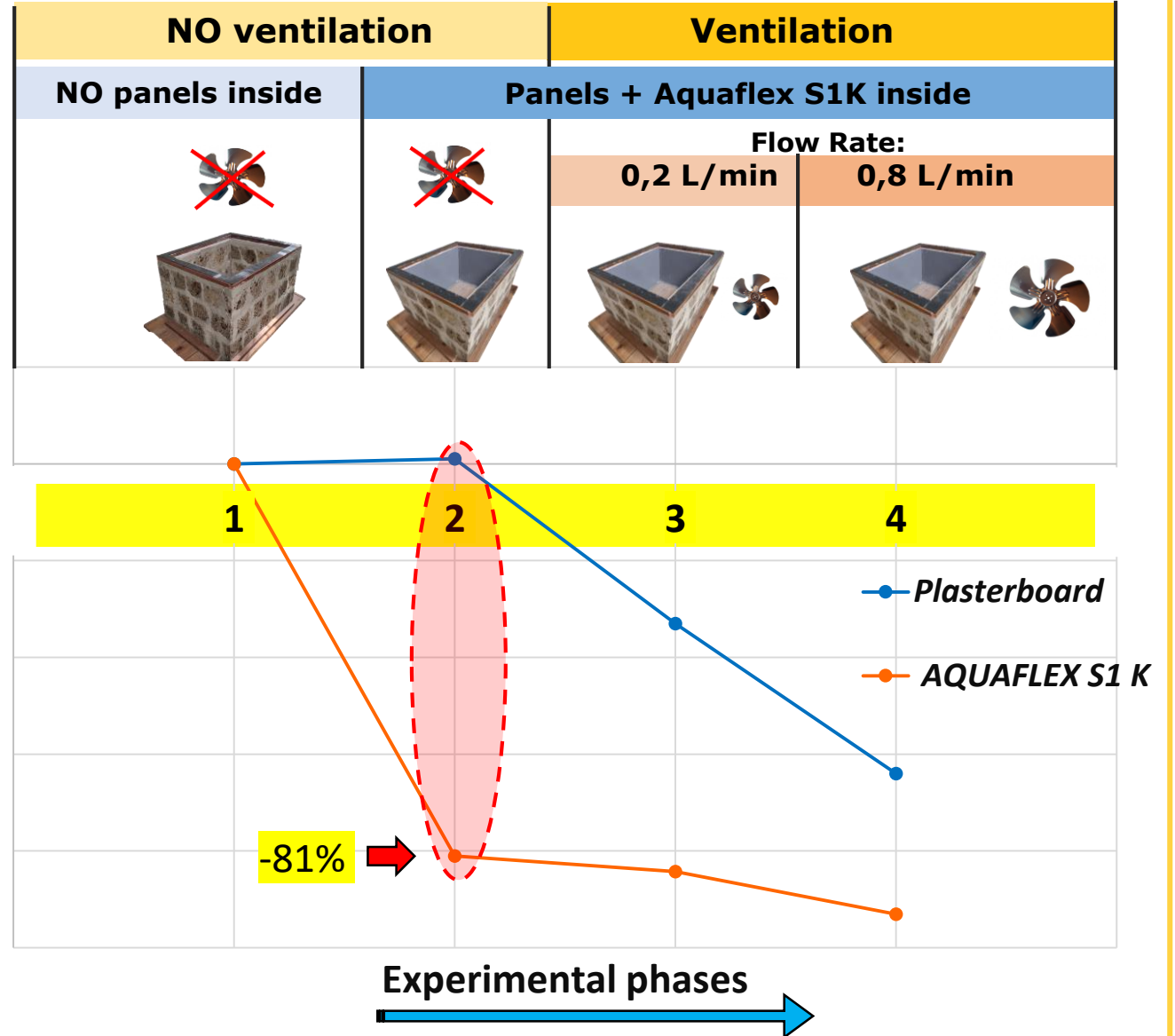


Silane terminated polymers

The anti-radon membrane gave an indoor radon reduction of 81% in the worst conditions (such as no ventilation).



Scale model room experimental setup

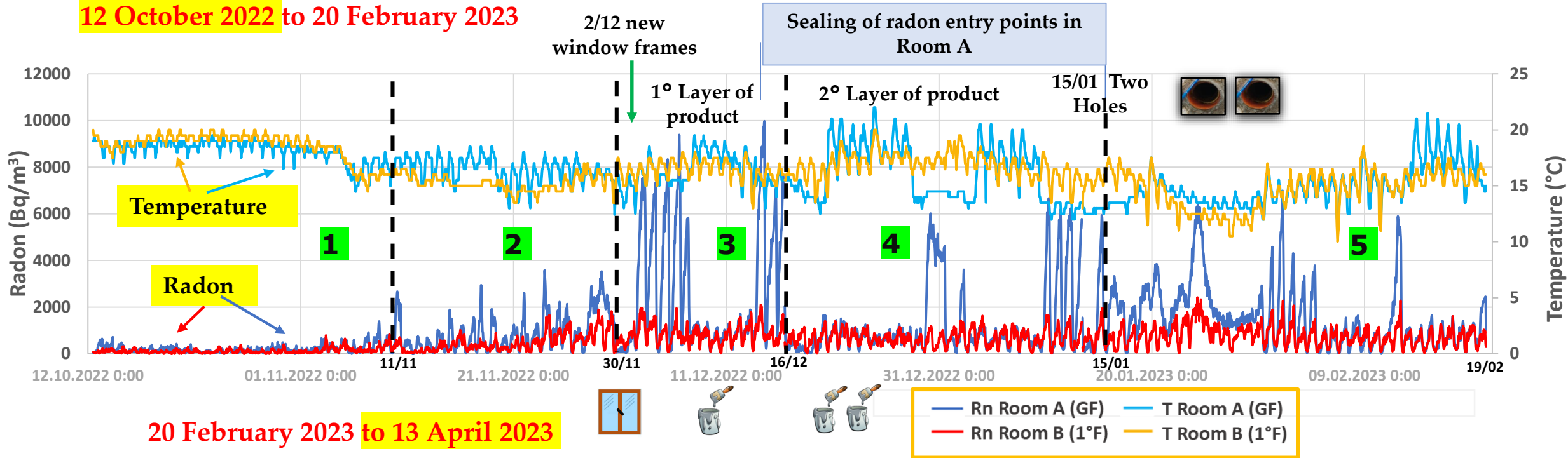


$$RIR = (Rn_{part\ 2\ or\ 3\ or\ 4} - Rn_{part\ 1}) / Rn_{part\ 1} \times 100$$

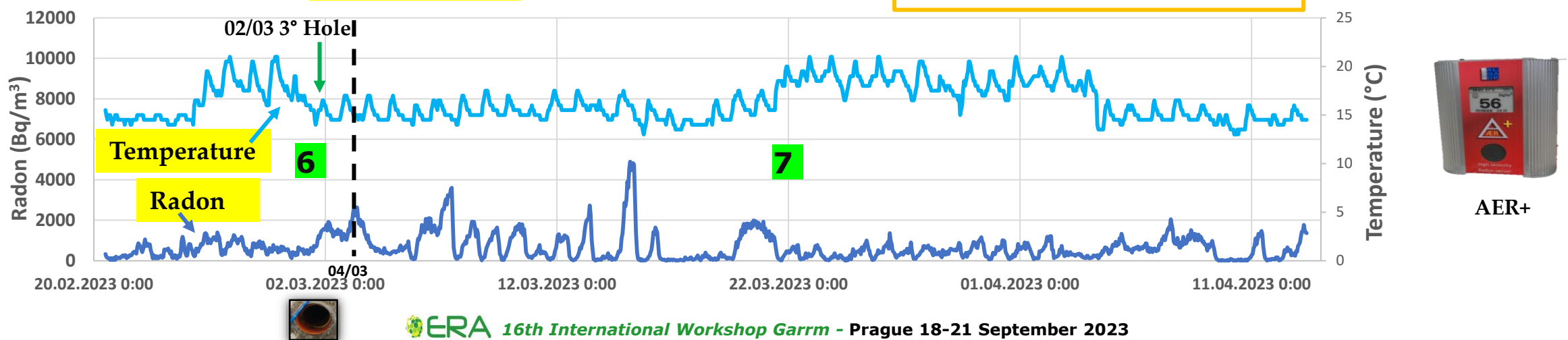


# Indoor Radon and Temperature monitoring

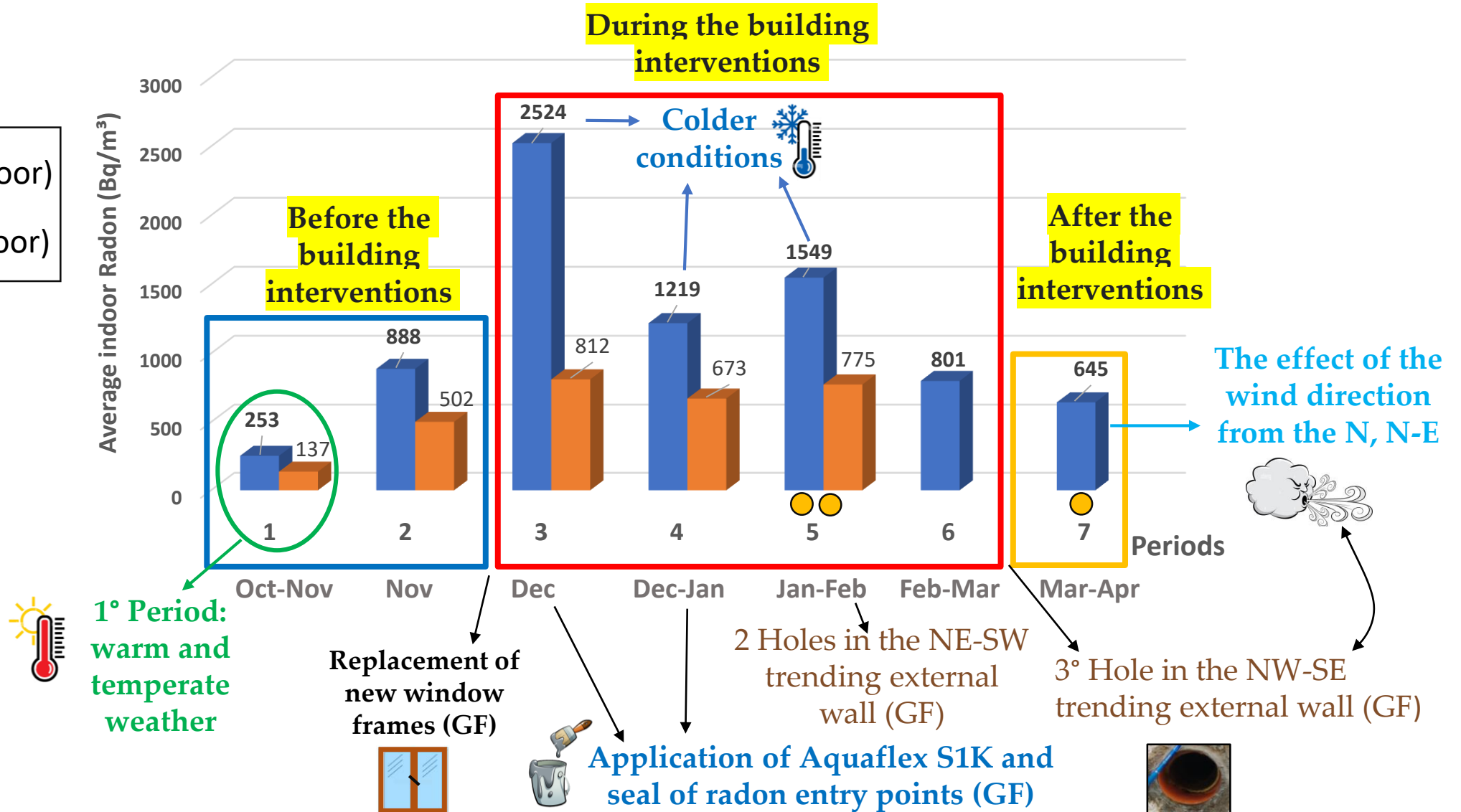
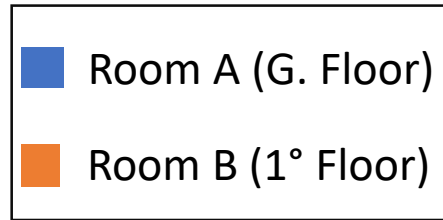
12 October 2022 to 20 February 2023



20 February 2023 to 13 April 2023

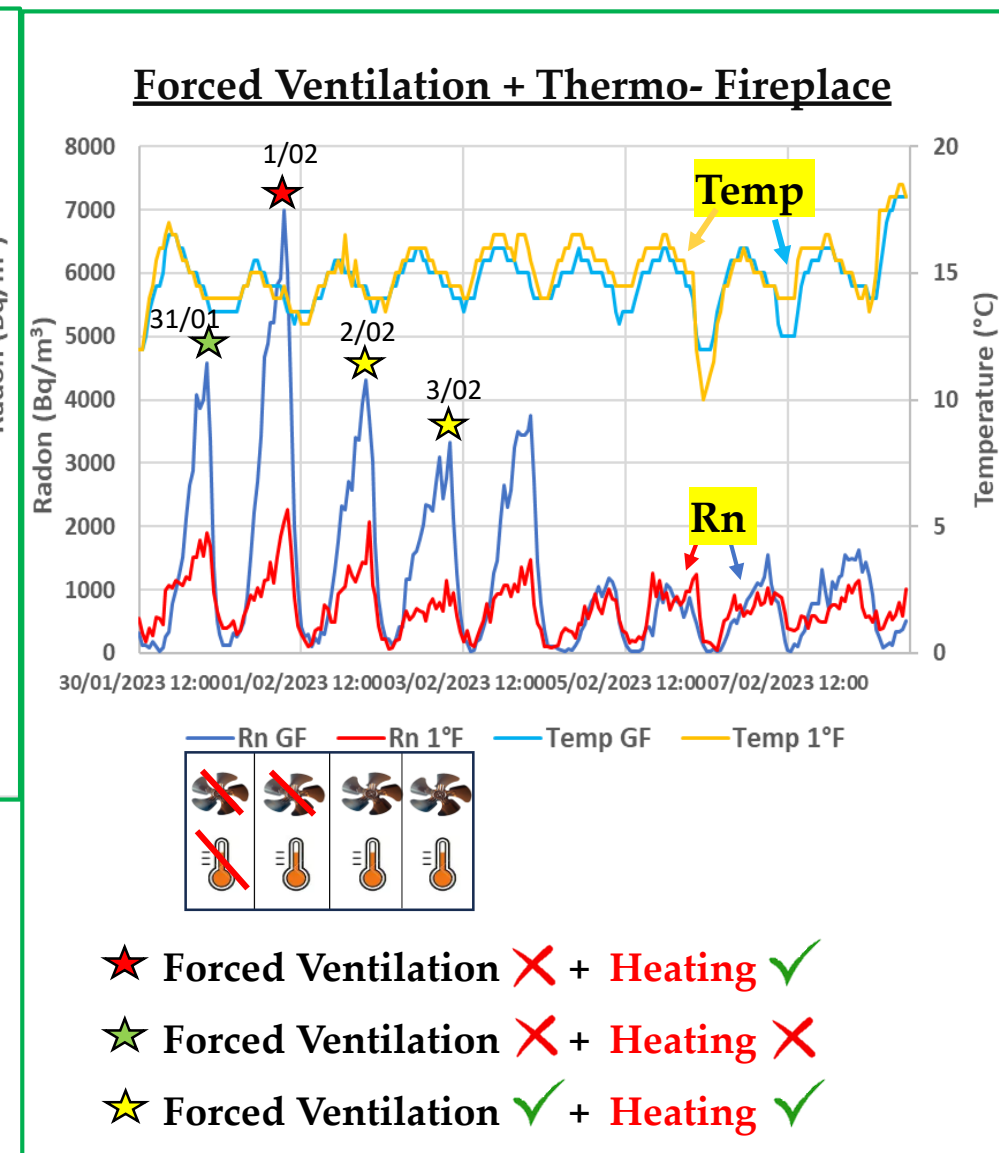
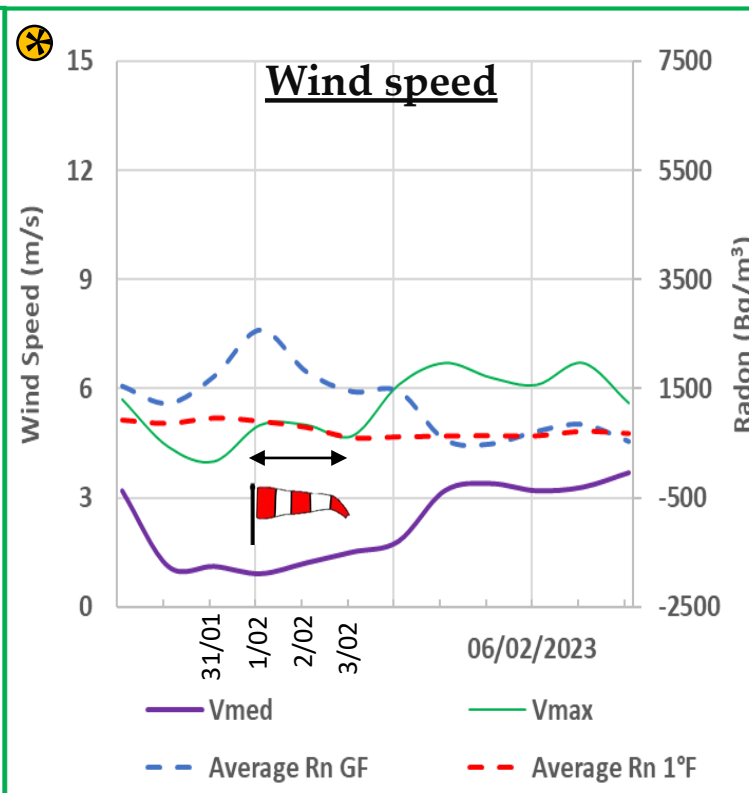
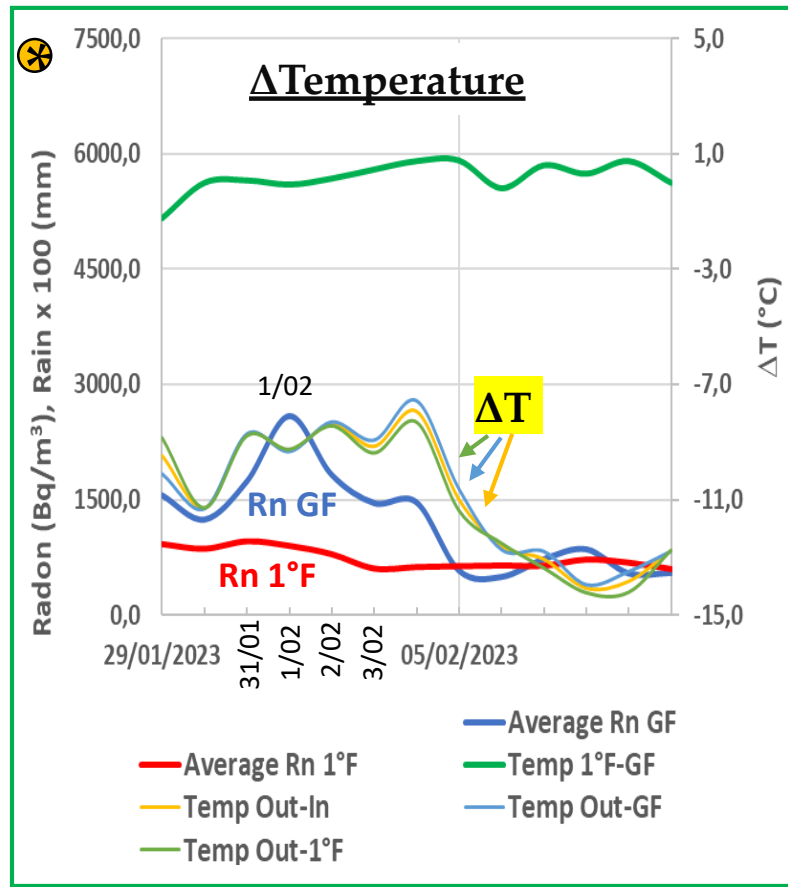


## Phases of the building interventions during this study and radon averages





**Example 1: Effect of temperature, wind speed, forced ventilation, and thermo- fireplace on radon concentration**



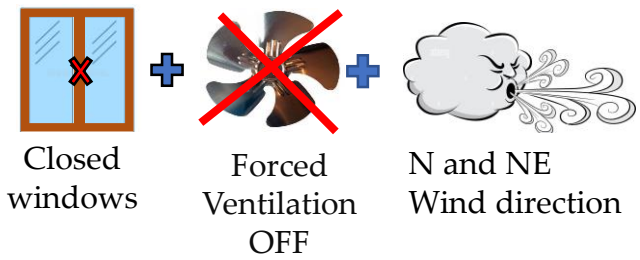
Between January 31<sup>st</sup> and February 3<sup>rd</sup> 2023 **no temperature differences** between outside and inside.



**The wind speed** is relatively constant until February 3<sup>rd</sup>.



**Example 2: Effect of wind direction on radon concentration and building interventions**

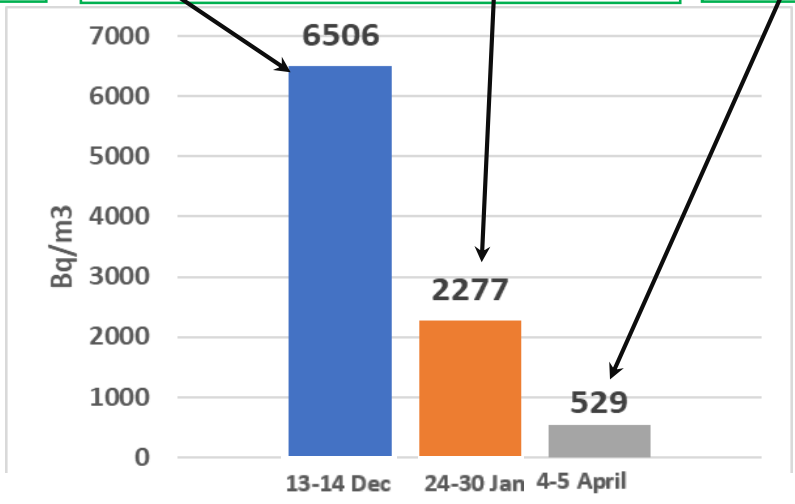
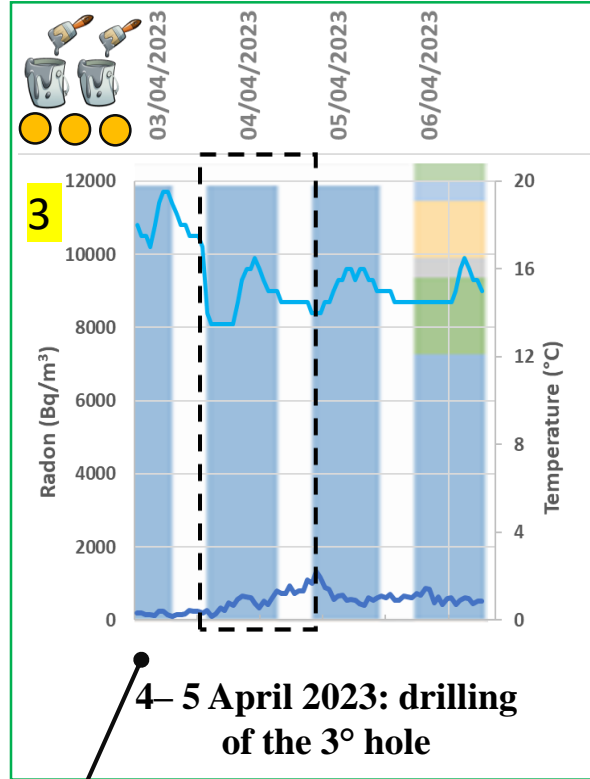
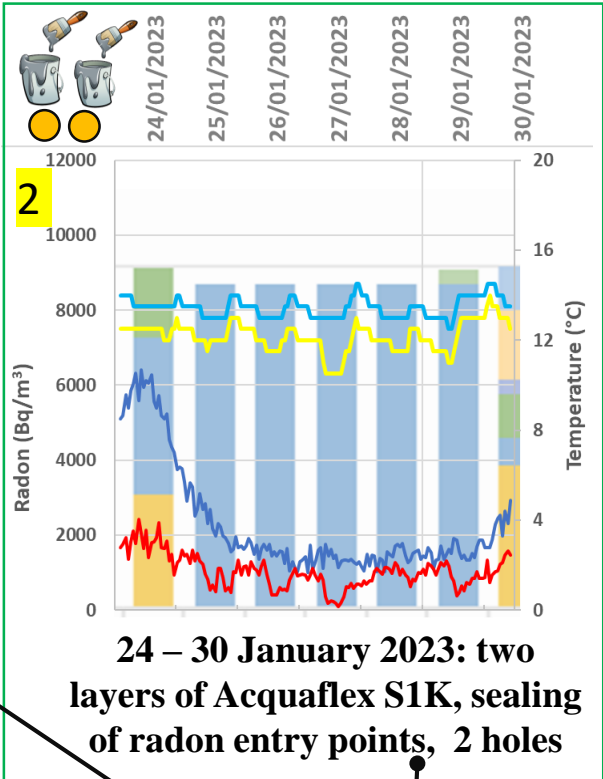
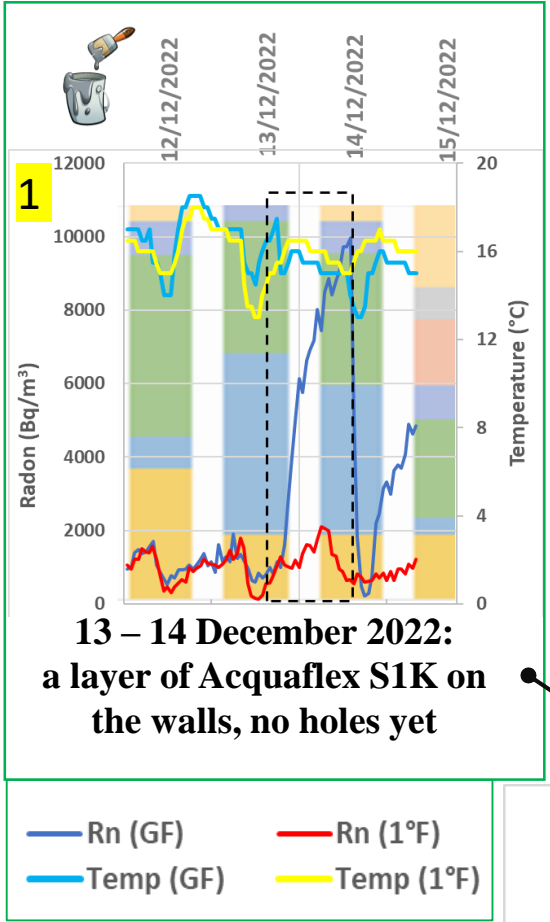


**Wind directions:**



N and NE






Greater decrease in Radon concentrations!

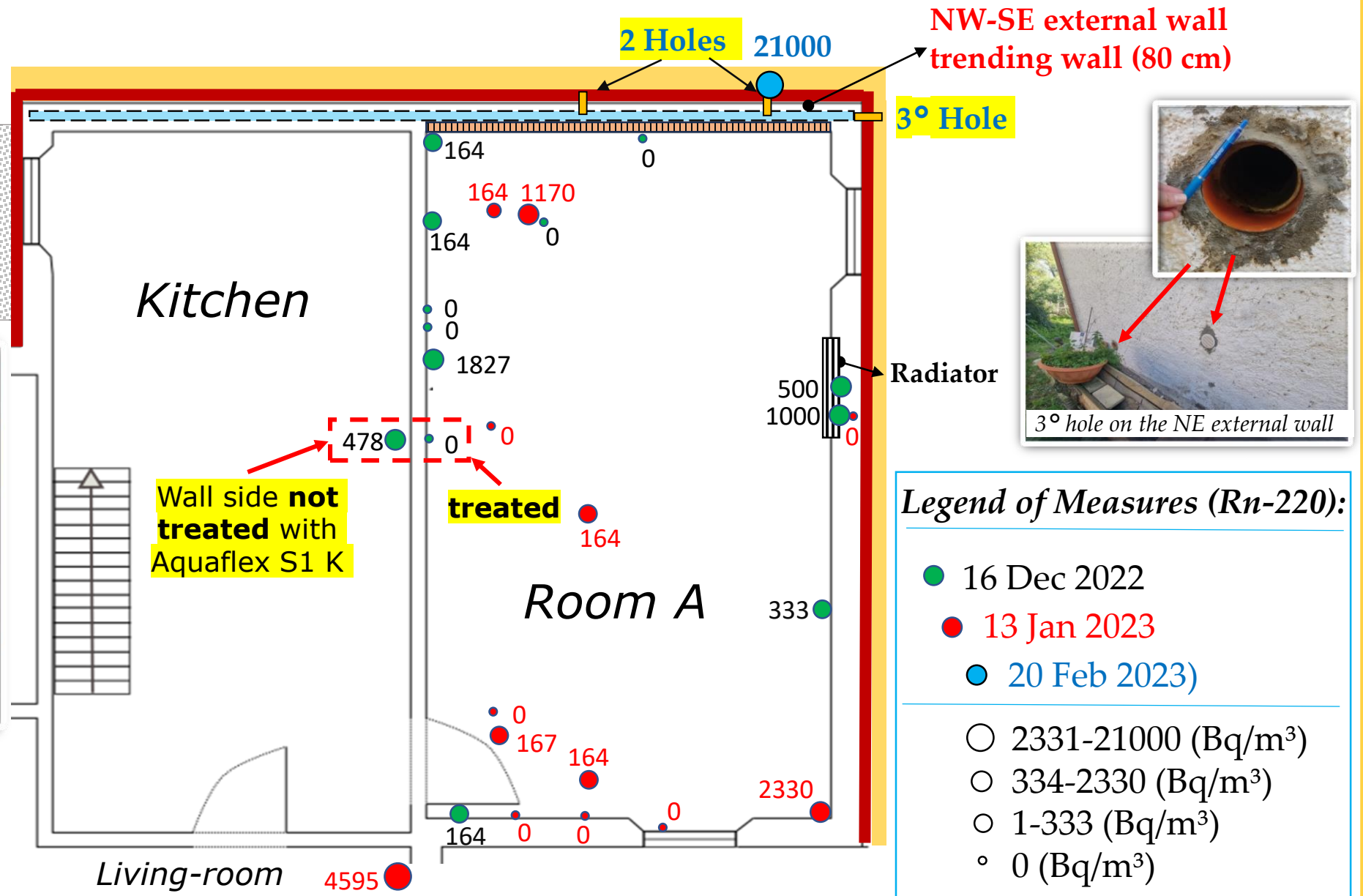




Locations of radon entry points detected by thoron sniffing (Room A on ground floor)

**Symbols:**

-  Trench
-  Side semi-buried
-  Cavity (10 cm)
-  Wall made of perforated bricks
-  Trapdoor



**Legend of Measures (Rn-220):**

- 16 Dec 2022
- 13 Jan 2023
- 20 Feb 2023

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- 2331-21000 (Bq/m<sup>3</sup>)
- 334-2330 (Bq/m<sup>3</sup>)
- 1-333 (Bq/m<sup>3</sup>)
- 0 (Bq/m<sup>3</sup>)



Measurements of radon entry points with RAD7 (Durrige Company Inc)

## Conclusions

The complexity of the system makes it difficult to assess the extent of the contribution of the different factors (geogenic or anthropogenic) in reducing or increasing indoor radon concentrations.

Indeed, the lifestyle of the tenants strongly affects radon concentrations, such as the:

- closing/opening windows;
- switching on/off of the thermo-fireplace and the fan.

However, the actions taken during this study such as the:

- application and seal, of the soil gas entry points, of the Aquaflex S1K product on the walls of chamber A;
- Creation of the 3 holes in the external wall that increased the recirculation of the air in the cavity;

**have reduced indoor radon concentrations**, but not below reference values of Legislative Decree 101/2020.



*Any suggestions to further reduce indoor radon concentrations*

- Apply also an anti-radon membrane below the floor of the house



to screen the rising radon from the ground

- Place an additional fan in the holes made in the external wall of the house



to guarantee a constant exchange and recirculation of air in the cavity



in the absence of the north wind

# Thanks for your attention!

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