

## MOTIVATION

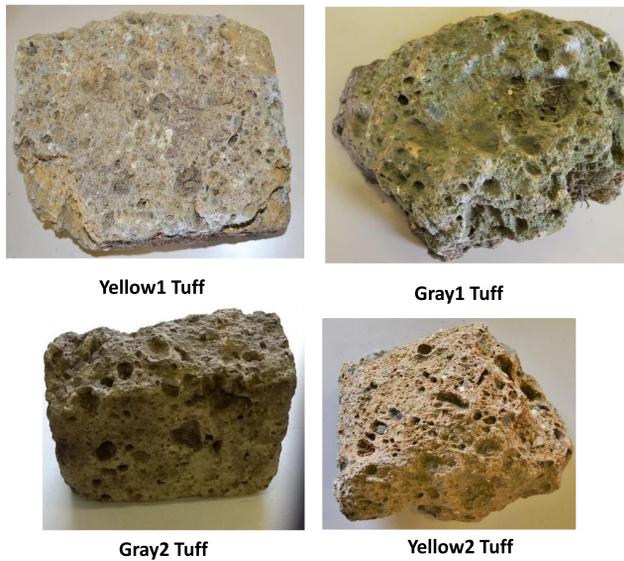
It is important to evaluate the contribution of building materials to the increase of indoor concentration of gas radon, this is particularly true in various areas of Italy such as the Lazio Region where volcanic tuff is widely used as a building material. The calculation of the mass exhalation rate allows to evaluate the contribution of indoor gas radon taking into account not only the radio content but also the properties of the material.



A house of Lazio Region with a external walling of tuff (left) a particular tuff brick (right).

## MATERIALS

Dried samples of Lazio tuff with different physical-chemical properties were studied using the closed chamber built at the Physics Department of UNICAL. The samples have been used to characterize the chamber and test its performance and extract the mass exhalation rate.



## EXPERIMENTAL SET-UP

The radon closed chamber is made in Plexiglas (125 l)

- It has a removable top sheet ;
- a shelf for supporting instrumentation;
- two tight connectors.

Used detectors:

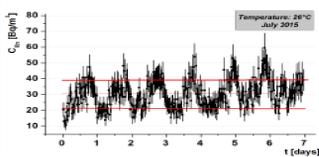
- ✓ CPRD interfaced with an AB5 Pylon monitor;
- ✓ Alphaguard or RAD7 for measurements comparison.



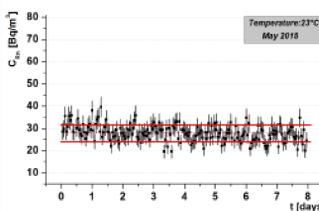
## CHAMBER CHARACTERIZATION

Chamber background and chamber leakage are two quantities that have to be estimated for the mass exhalation rate calculation.

### CHAMBER BACKGROUND



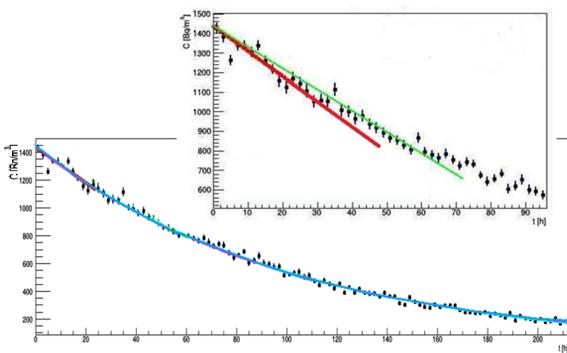
Background outside the chamber (laboratory).



Background inside the chamber.

Measurements inside the chamber are more appropriate and preferable.

### CHAMBER LEAKAGE



Detector and Sample	Linear fit			Global fit		
	$\lambda$ [h <sup>-1</sup> ]	Uncertainty %	$\chi^2/ndof$	$\lambda$ [h <sup>-1</sup> ]	Uncertainty %	$\chi^2/ndof$
CPR Detector - Gray2 Tuff	0.0021	15	3.8	0.0024	2	1.9
CPR Detector - Yellow1 Tuff	0.0035	10	2.2	0.0037	4	1.6
CPR Detector - Spring water				0.0023	4	1.4

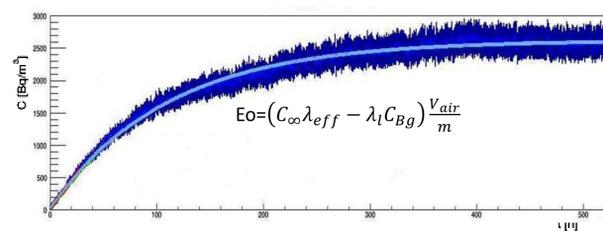
Chamber leakage has been evaluated:

- by an exponential fit assuming as effective slope the sum of leakage and decay constants;
- comparing the slope obtained from a linear fit in the first 24 h measurements to the theoretical slope (assuming only the radon decay contribute).

Exponential fit method preferable.

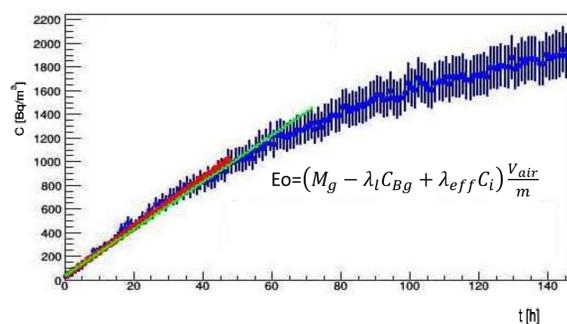
## MASS EXHALATION RATE EXTRACTION (TWO METHODS)

### GLOBAL FIT



Radon concentration activity growth curve. The blue line represents the result of the global fit. ( $C_\infty$  and  $\lambda_{eff}$  extracted from the fit)

### LINEAR FIT



The initial data of the growth curves can be used to extract the mass exhalation rate. The green line is the result of a linear fit. The red line is the theoretical slope. ( $M_g$  extracted from the fit)

Detector and Sample	Linear fit			Global fit			Time	
	Eo	Uncertainty	$\chi^2/ndof$	Eo	Uncertainty	$\chi^2/ndof$	Counting interval	Total time
	Bq/Kgh	%		Bq/Kgh	%		Hours	Days
Alphaguard	0.4	5	0.5	0.39	3	0.7	1	20
CPR Detector	0.35	6	1.3	0.35	5	0.8	1	20
CPR Detector	0.36	3	0.9	0.35	3	0.4	1	20
CPR Detector	0.31	14	1.1	0.37	9	0.4	2	20

Various tests with the same sample have been performed (different measurement conditions and detectors) to validate the chamber performance and the best mass exhalation rate extraction procedure.

## RESULTS

Sample	Linear fit		Global fit	
	Eo	Uncertainty	Eo	Uncertainty
	Bq/Kgh	%	Bq/Kgh	%
Yellow2 Tuff	0.36	2	0.37	1.9
Gray2 Tuff	0.46	1	0.51	0.9
Yellow1 Tuff	0.23	2.1	0.24	1.1
Gray1 Tuff	0.56	2	0.63	1.9

Mass exhalation rate for Lazio's tuff. Spread in the results depends on the Ra-226 content and on the physical properties of the samples (porosity etc.).

## SUMMARY

The method for the measurement of the exhalation rate allows a valid procedure to evaluate the indoor contribution of building materials to the radon concentration taking into account the realistic conditions of the indoor materials.

The method presented in this work is accurate and improves to respect to the standard procedure with closed chamber and is part of an extended experimental project in collaboration with ARPACAL.

From the comparison with measurements obtained by gamma spectrometry, it will be possible to further improved the methods for the evaluation of the indoor gas radon concentration.