Direct measurement of radon and thoron exhalation rate with high resolution alpha spectrometry

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Outline

- Remembering RaMonA…
- A chamber for particular set up
- Direct exhalation rate measurement
- Calibration using a radon chamber
- Conclusions and perspectives

RaMonA

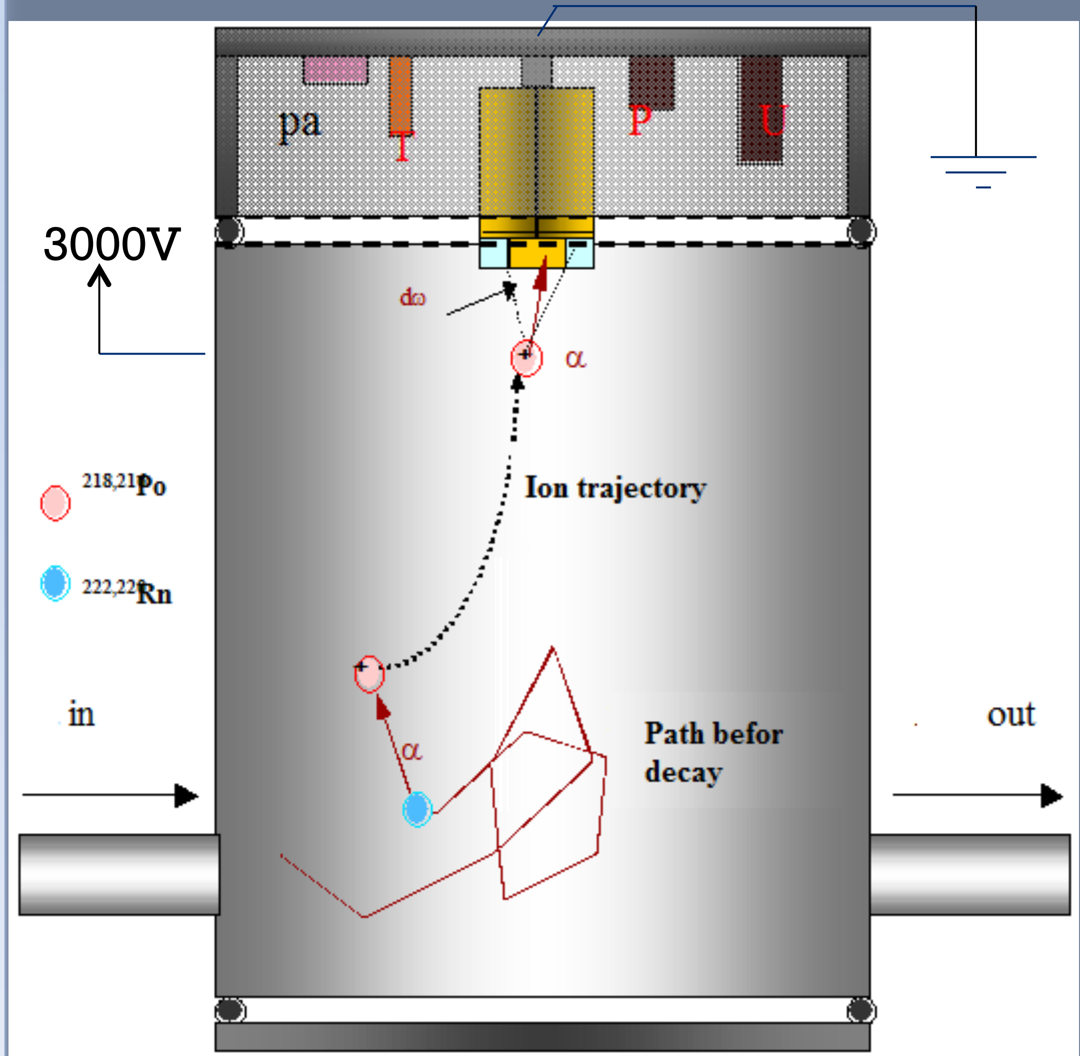
developed at the Department of Physics of the Naples University Federico II.

It allows to carry out the continuous monitoring of:
- radon and thoron specific activity;
- weather parameters ;

It has been used for different scopes:

- indoor, outdoor and in soil monitoring;
- measurement of emanation coefficient on various materials samples;
- reference monitoring of radon chambers

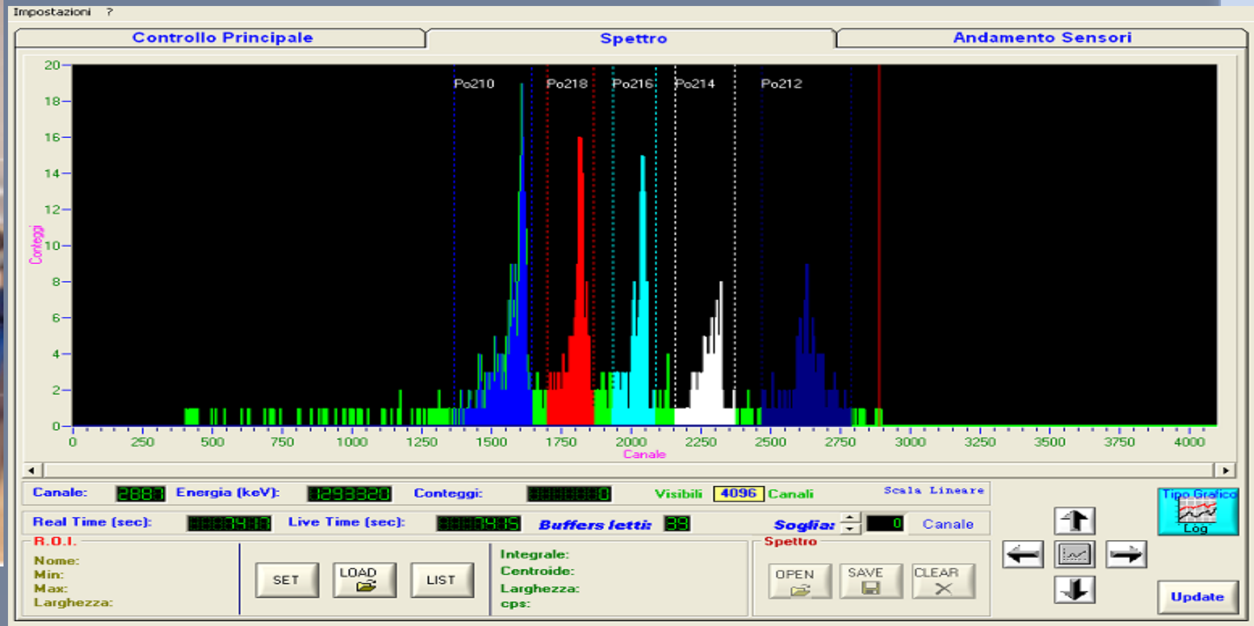
Collection chamber



The detection unit consists of an metallic cell where the radon and thoron daughters are collected by an electrostatic field on a silicon detector which produces high resolution alpha spectra

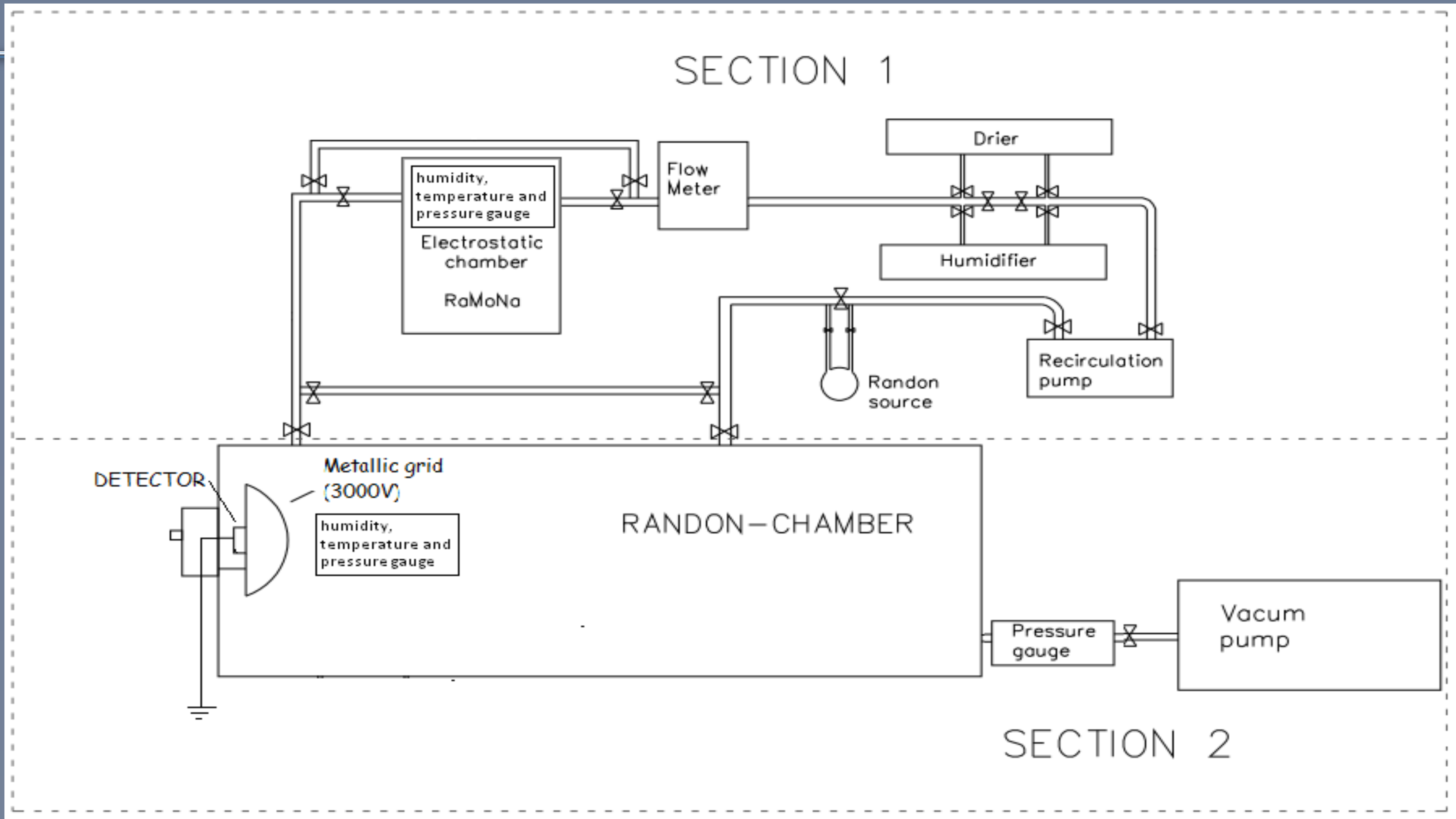
The control and acquisition functions are integrated in one module.

A dedicated software allows to drive remotely the system and collect and stored data.



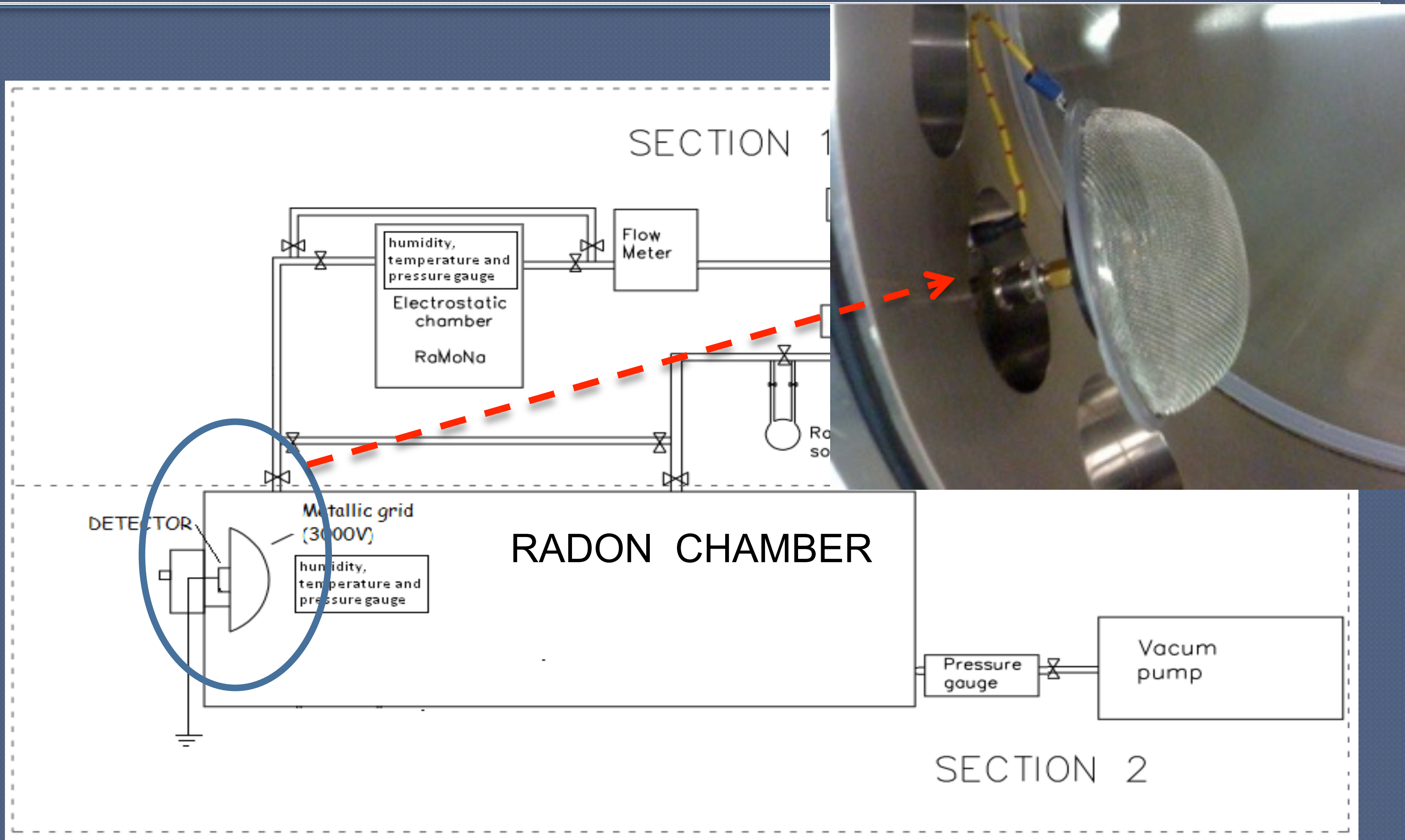
A typical α-spectrum of ^{222}Rn and ^{220}Rn daugthers

RaMonA characterization

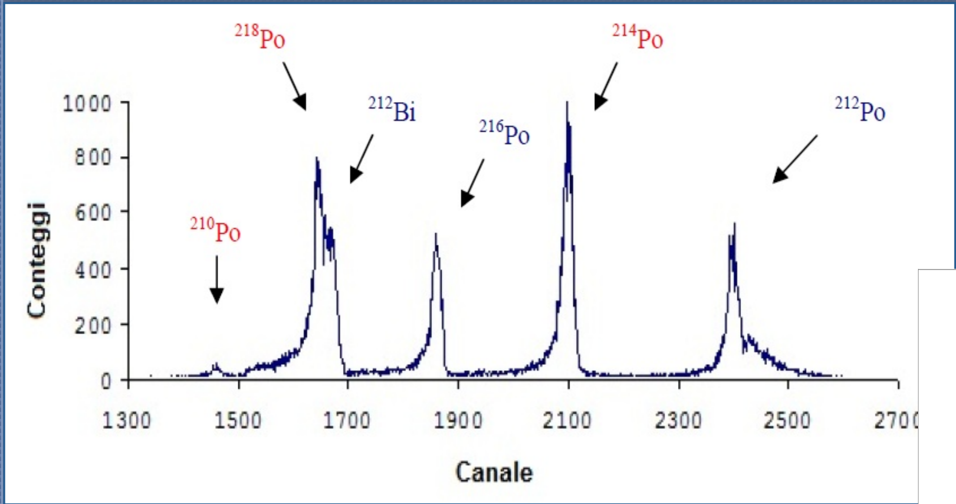


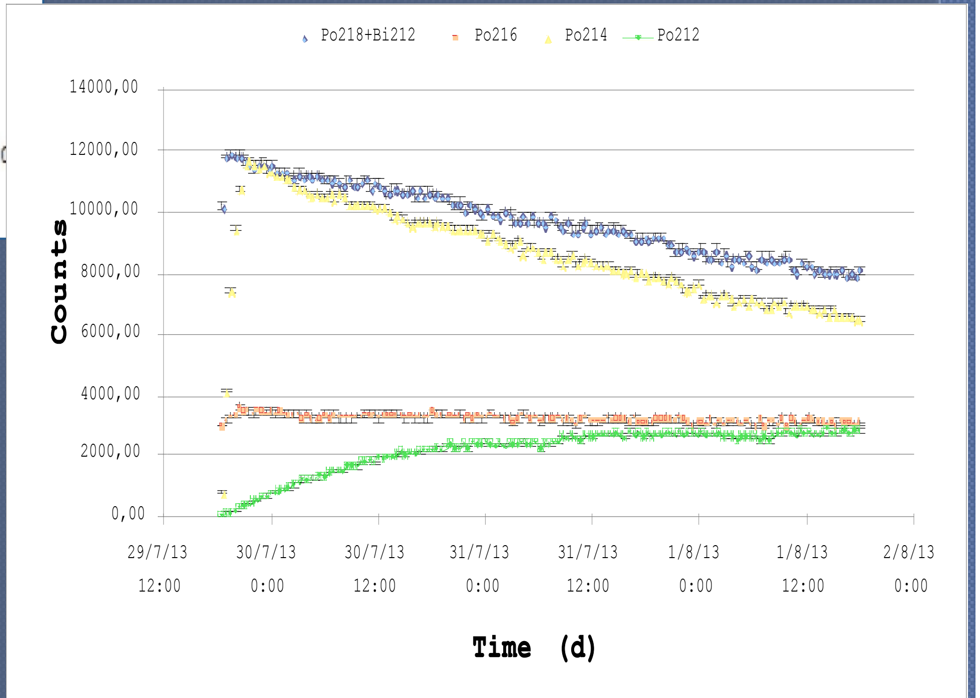
Its use in conjuction with a Radon Chamber where well characterized atmospheres can be realized

A little, semispherical electrostatic cell is the internal monitor of the radon chamber



The presence of the specrometer inside thr R.C. allows the accurate monitoring of mixed ^{222}Rn ^{220}Rn exposures

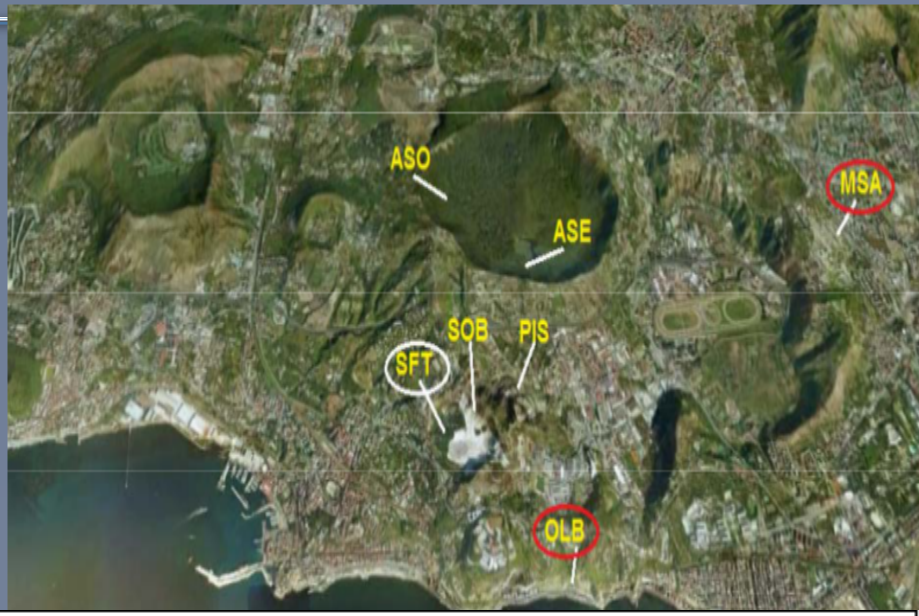


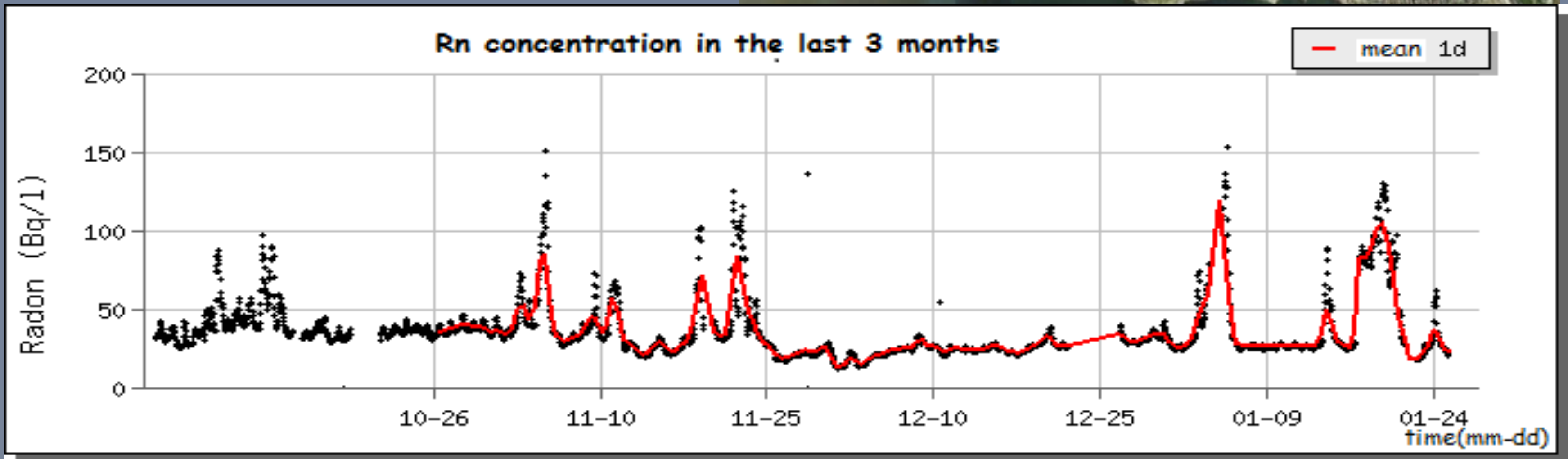


Calibration factors:

c(Po218)=(0,0100±0,0002) [cps/Bq/l]
c(Po214)=(0,0102±0,0004) [cps/Bq/l]
c(Po216)=(0,011±0,001) [cps/Bq/l]

In some "quiet" places of the Phlaegrean Fields the continuous monitoring has been possible

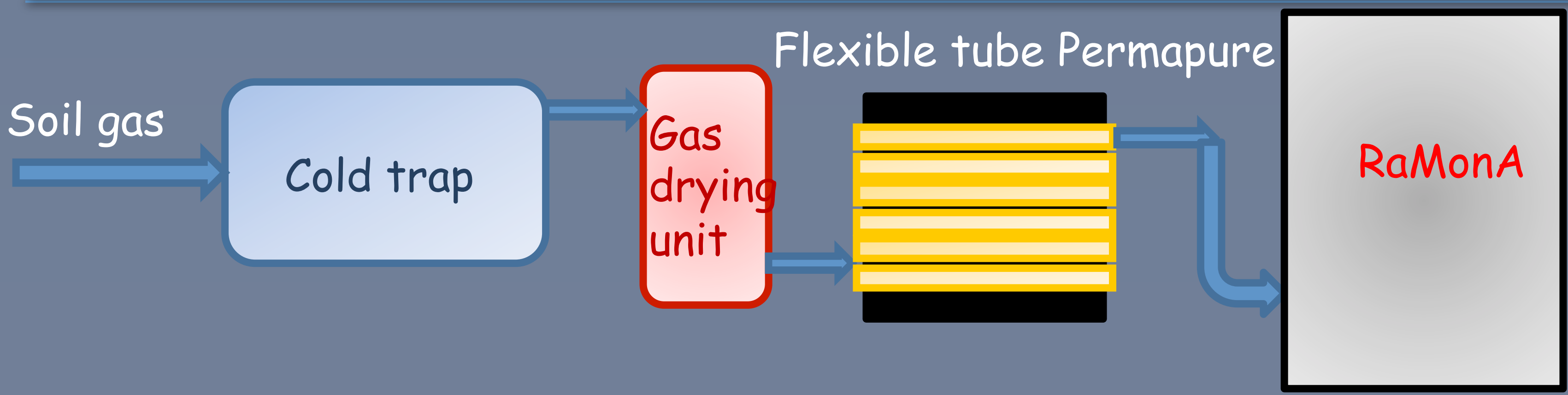




Some problems occur in the monitoring of the radon in soil gas in the sites characterized by intense volcanic activihty

The Phlaegraean Fields is a particular seismo-volcanic area which is frequentely interested by seismic events. Here, corrosive and hot gases in presence of the intense moisture make very difficult the monitoring of the radon in soil gas without the use of appropriate tools

the dehumidifying system



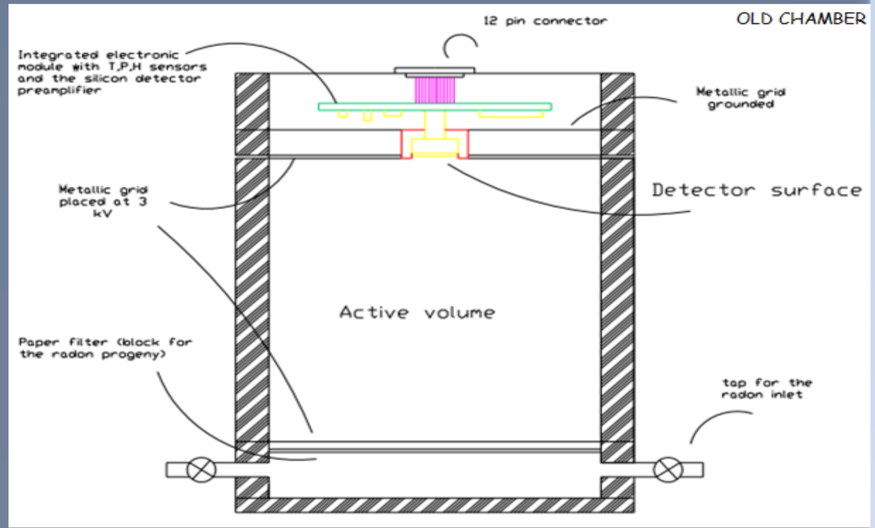
In order to achieve a “nice climate” into the chamber some tools have been tested.

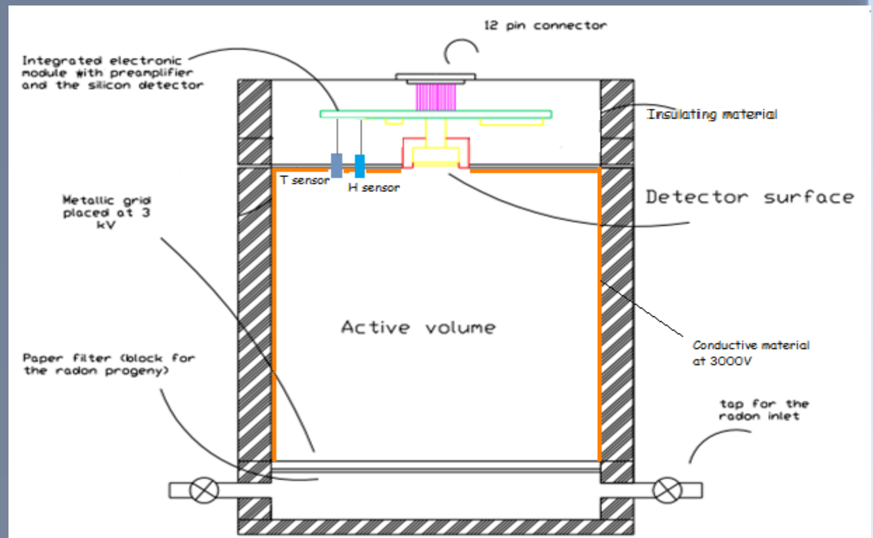
Cold Trap: device that condenses all vapors.
Gas drying unit: a drierite
Permapure pipes (if temperature is not too high)

the design of a new collection chamber

Structural changes:

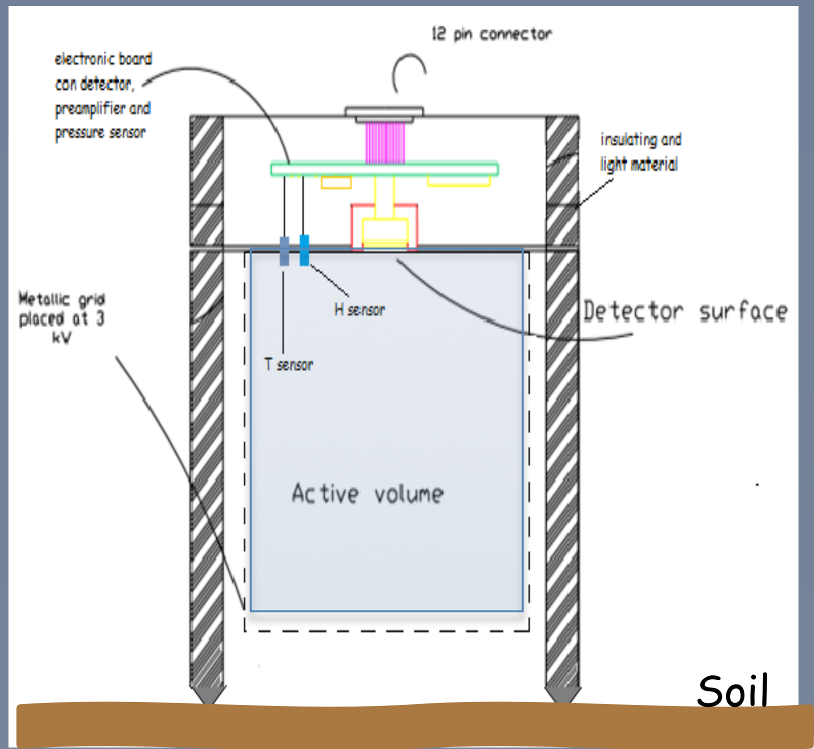
- Insulating and lighter material;
- hermetic separation between collection volume and he electronic circuits



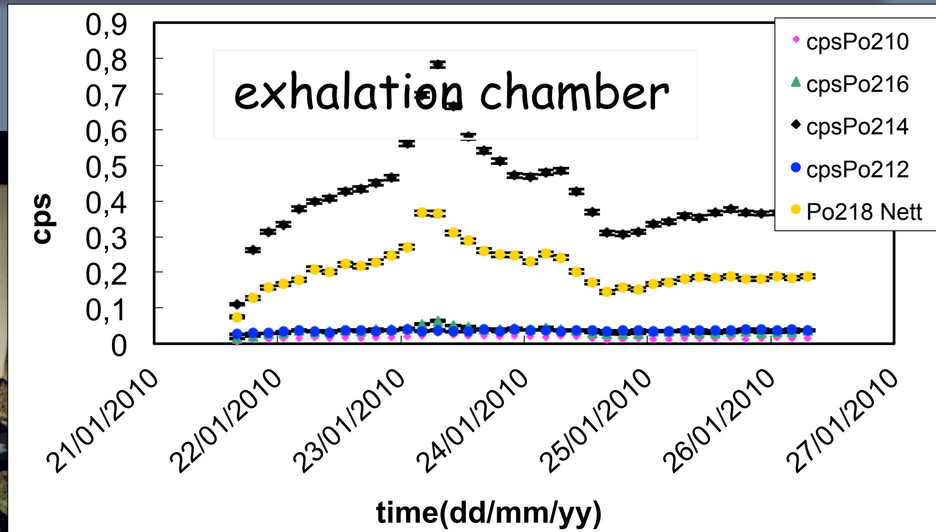


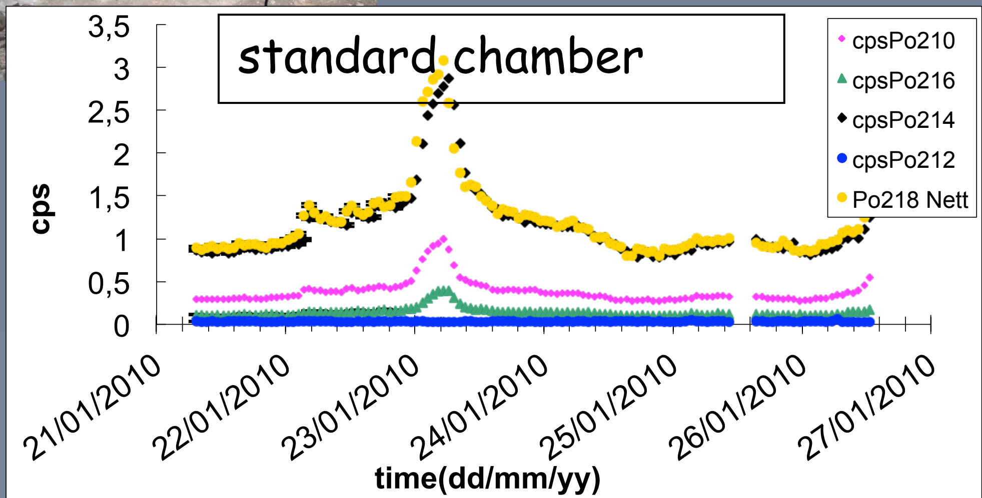
The new "open" chamber

This chamber is open at the bottom and has different structure and active volume.
The inlet gas is not forced and radon goes into only by diffusionn from soil surface.

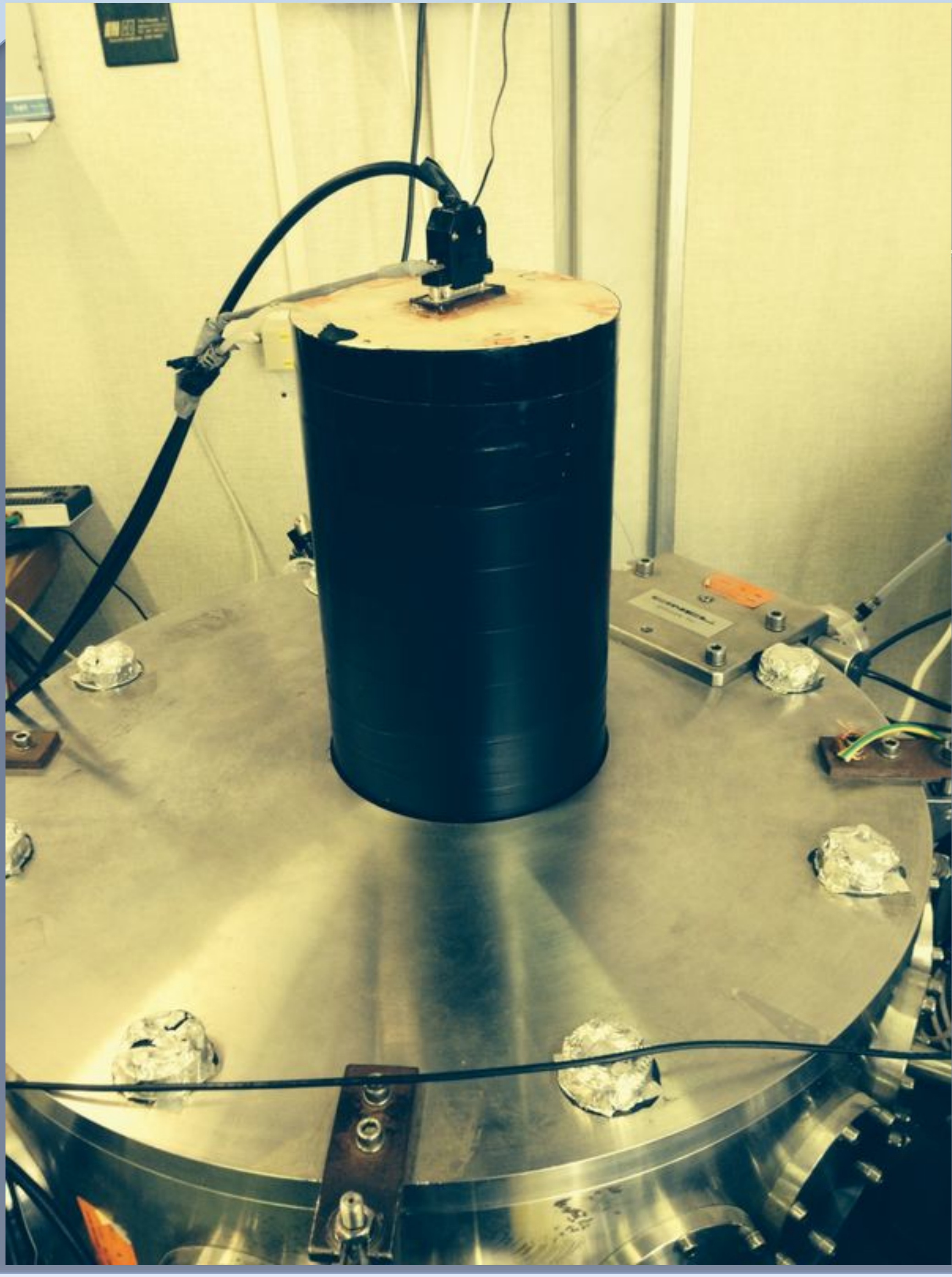


the test of the new chamber



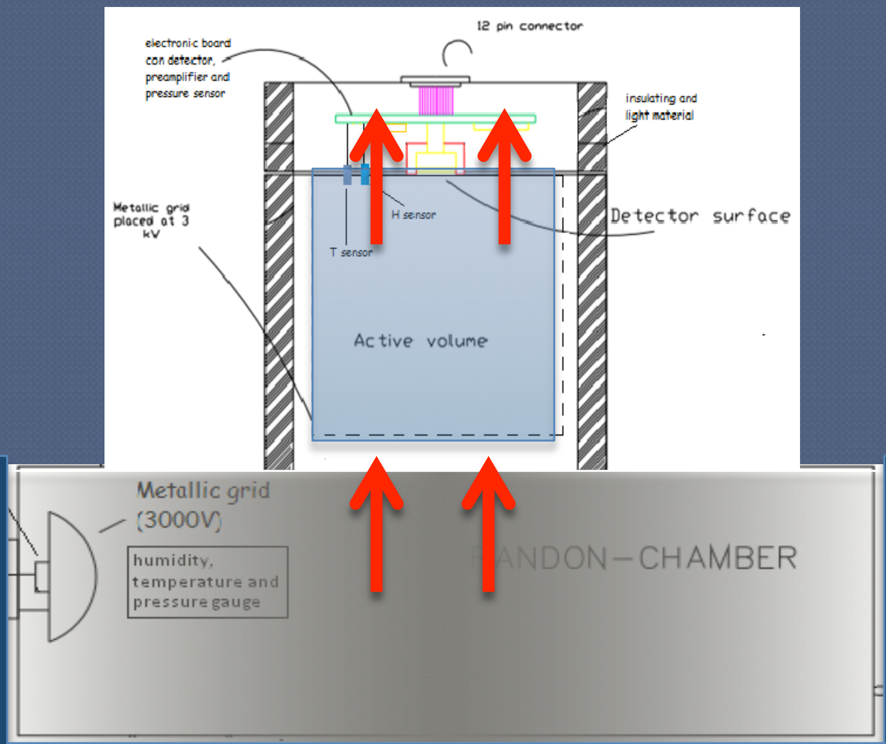


Also the exhalation chamber allow to follow the trend of radon in soil gas



The calibration of the exhalator has been performed by fixing it on the top of the radon chamber.

Schematic configuration of the calibration set up



Model of the mechanism of the calibration apparatus

Inside both chambers the temporal variation of the activity A is

$$dA(t)/dt = E/V - (\lambda+\lambda^{*})\, A(t)$$

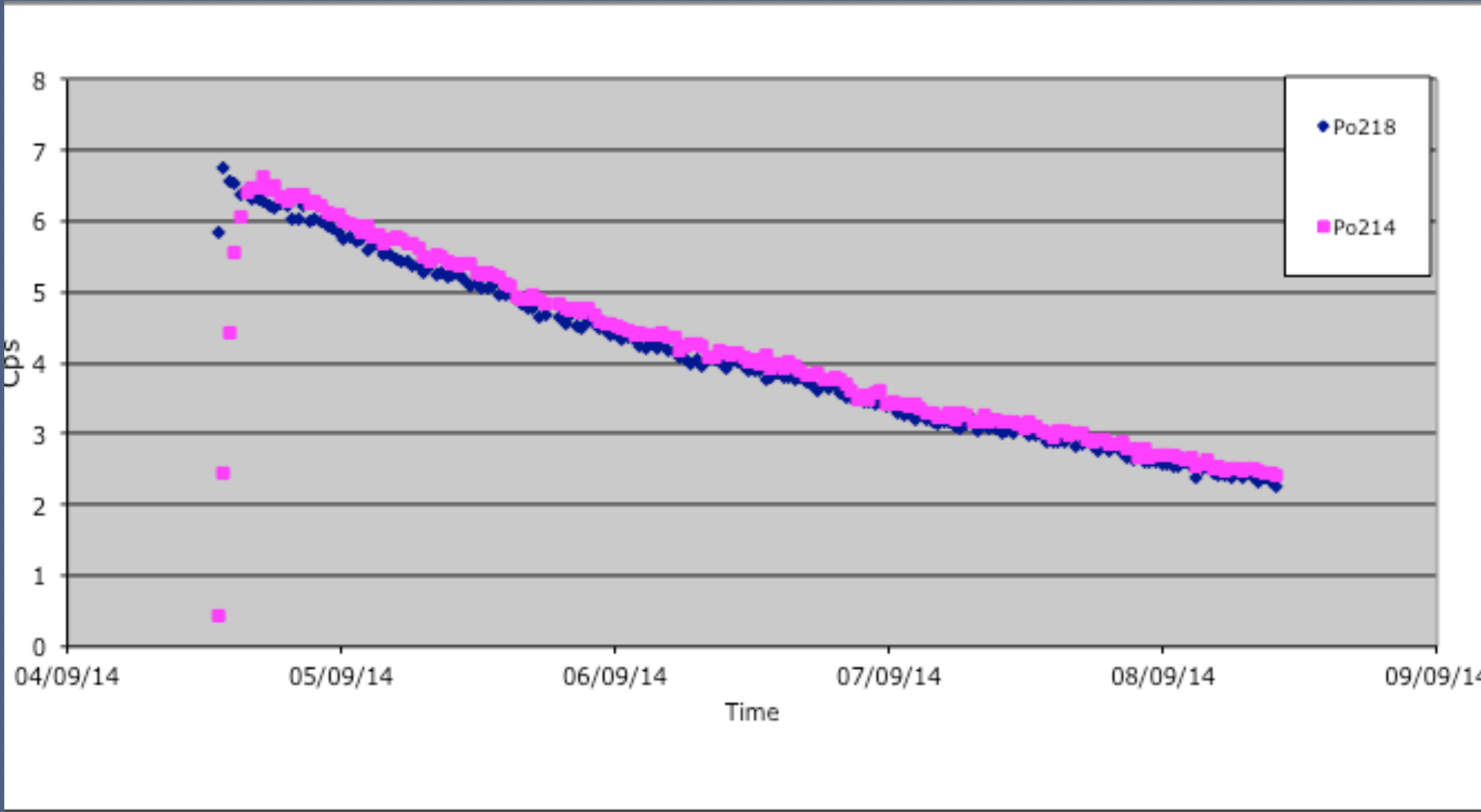
where λ is the radon decay constant, λ^* the loss constant and E the free exhalation rate.

Using A(0)=0, the solution is a growth curve:

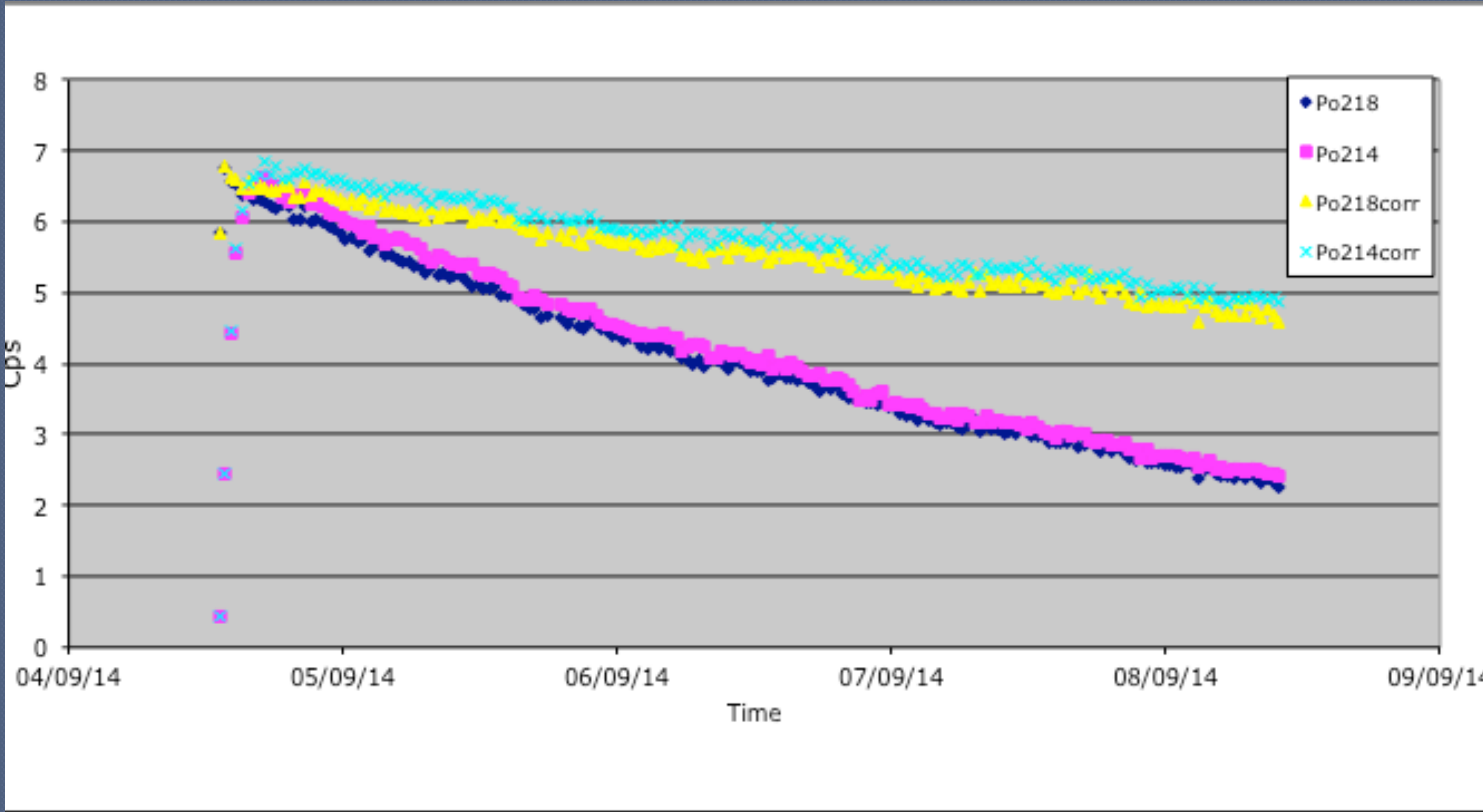
$$A(t)= E/ ((\lambda+\lambda^{*})V)\, (1- \exp(-(\lambda+\lambda^{*})\, t).$$

From the best-fit of the experimental data with this function, λ^* and E being evaluted.

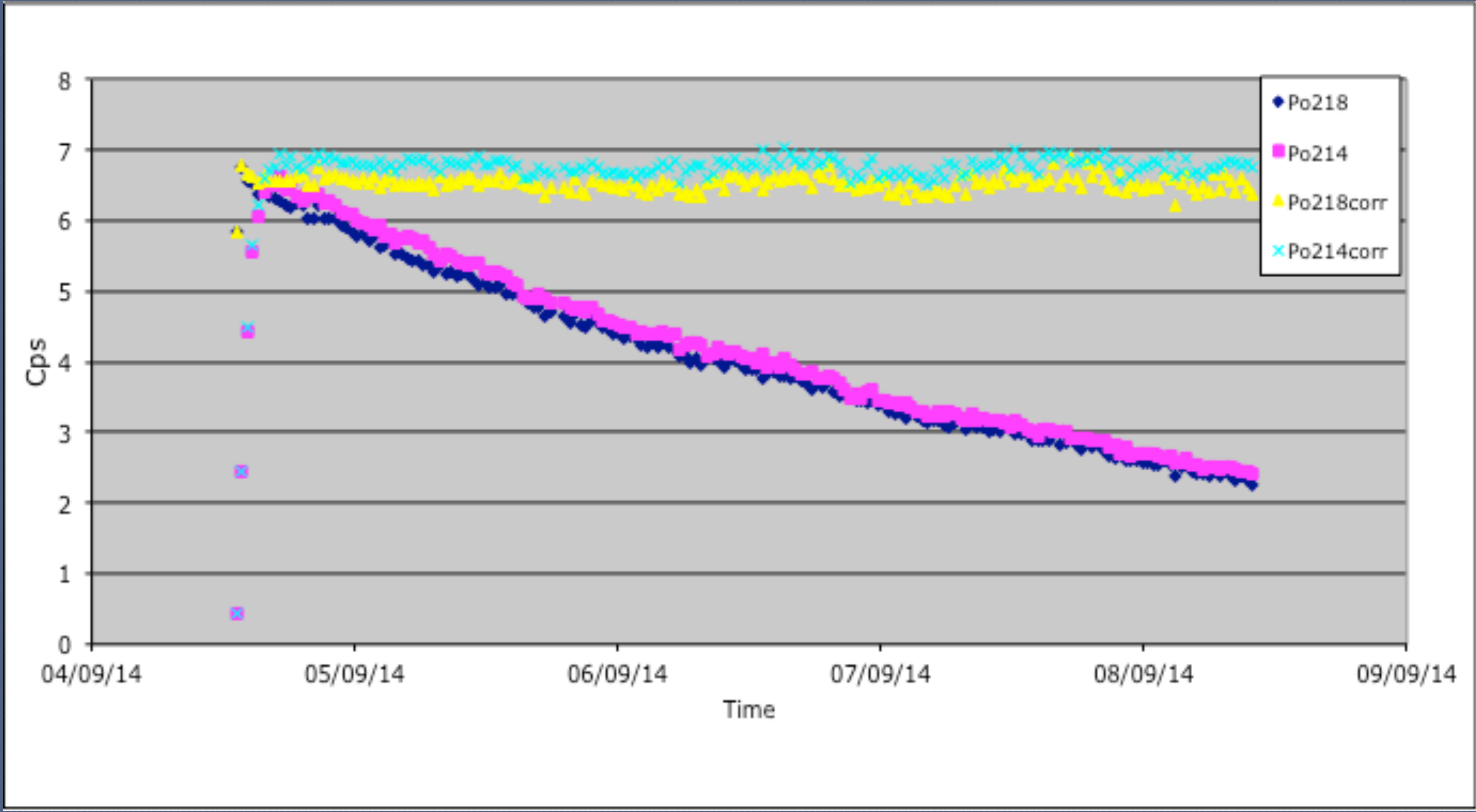
^{218}Po and ^{214}Po concentrations vs time from the internal monitor



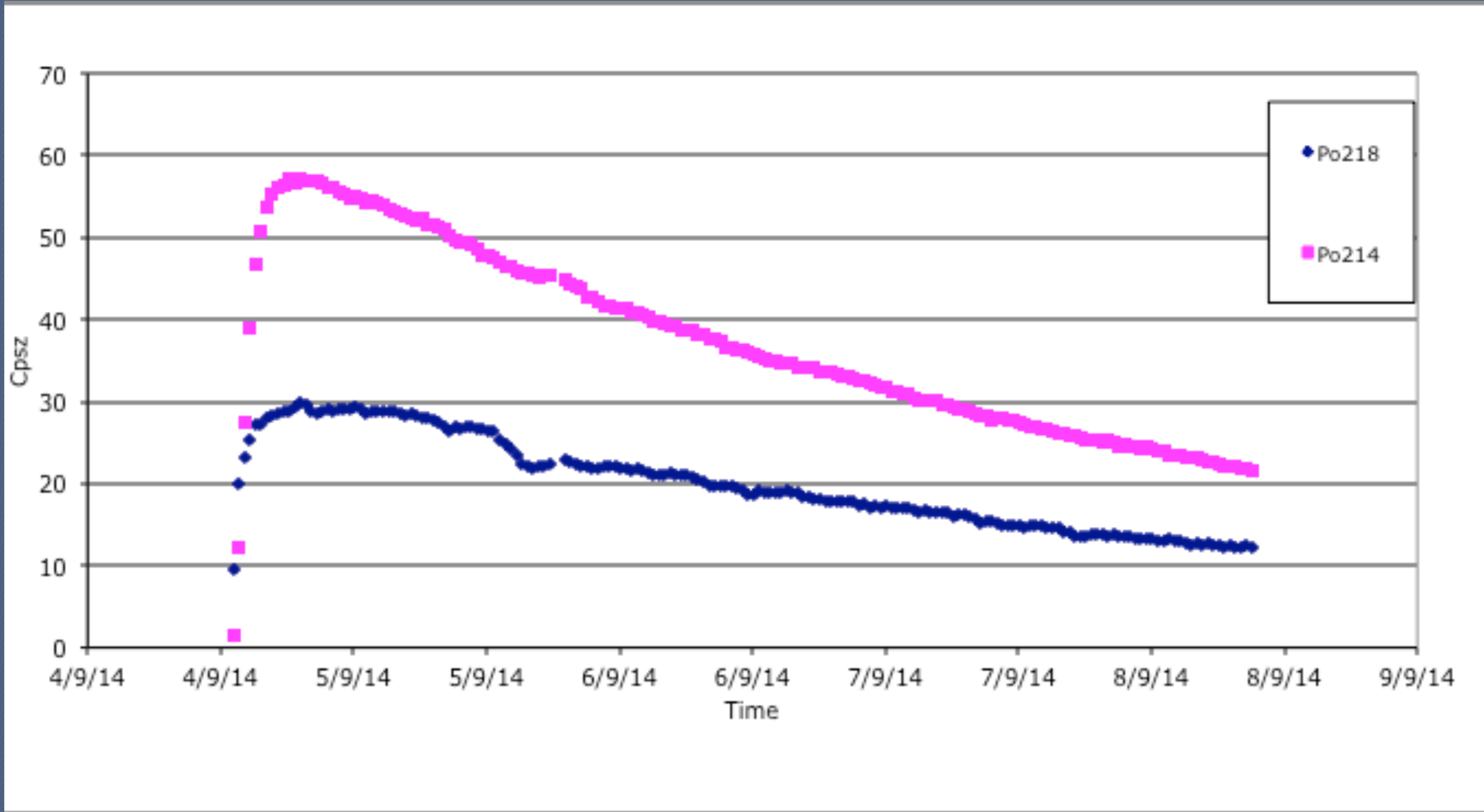
^{218}Po and ^{214}Po concentrations from the internal monitor corrected for radon decay



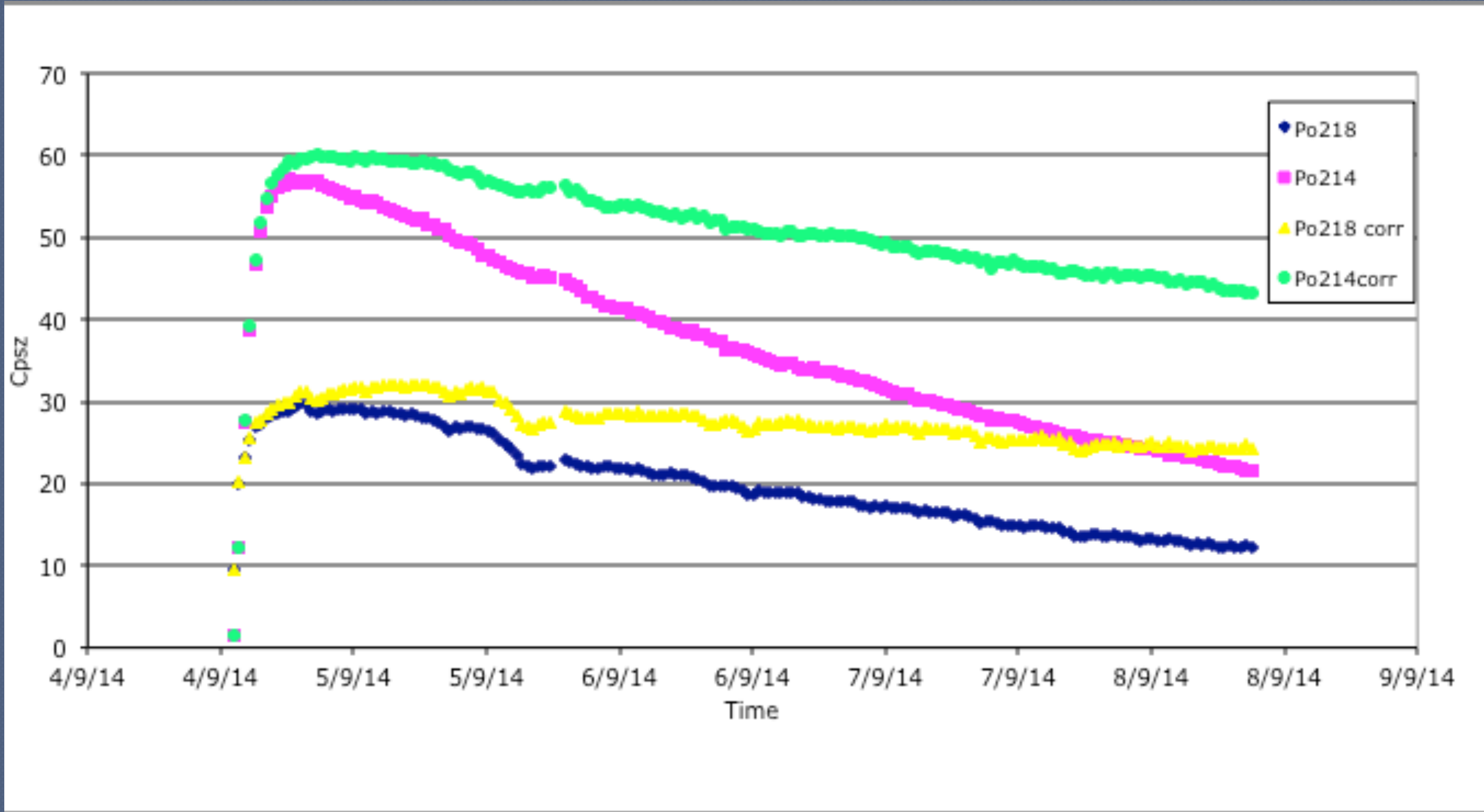
^{218}Po and ^{214}Po concentrations from the internal monitor corrected for radon decay and loss



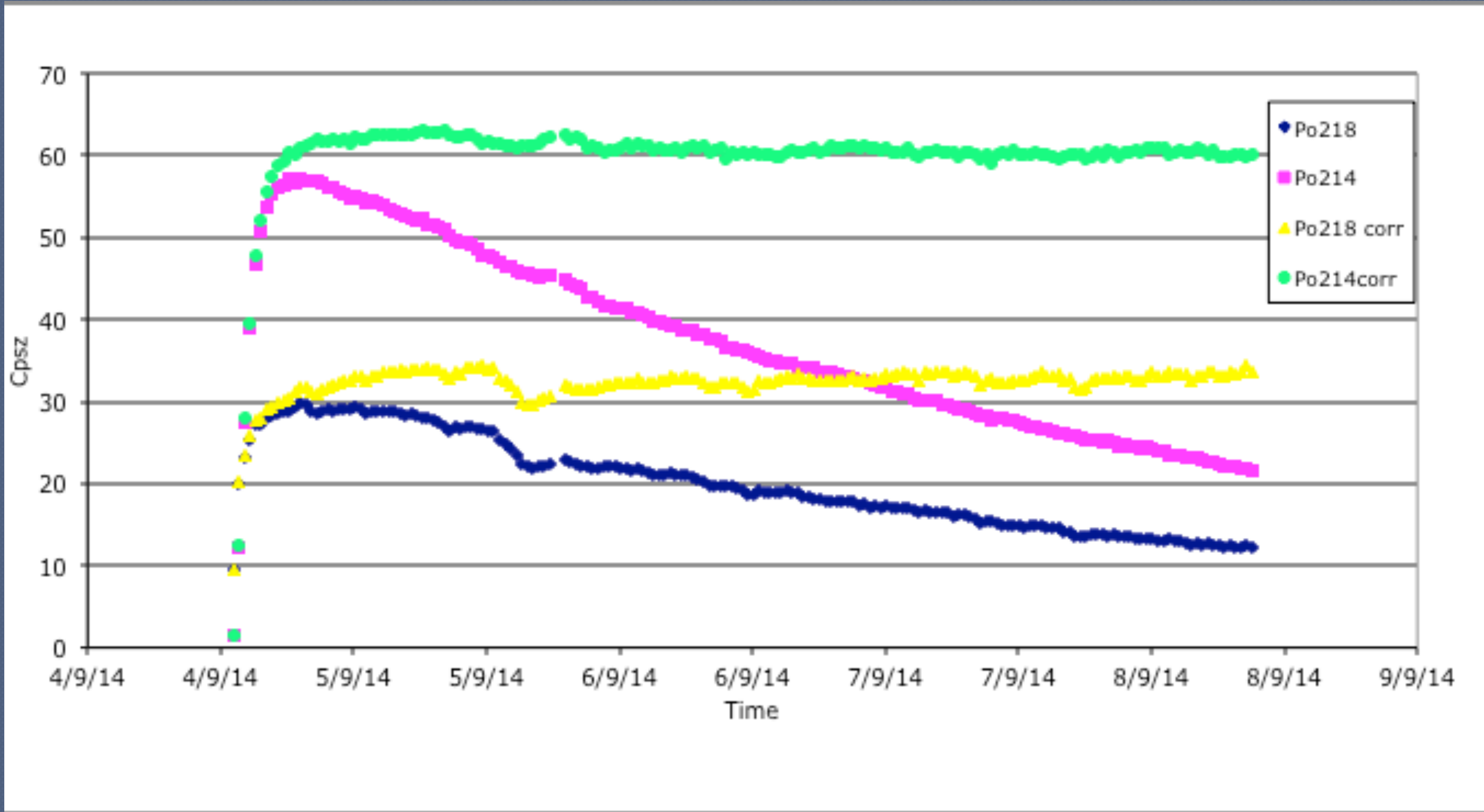
^{218}Po and ^{214}Po concentrations from the exhalator



^{218}Po and ^{214}Po concentrations from the exhalator corrected for decay



^{218}Po and ^{214}Po concentrations from the exhalator corrected for decay and loss



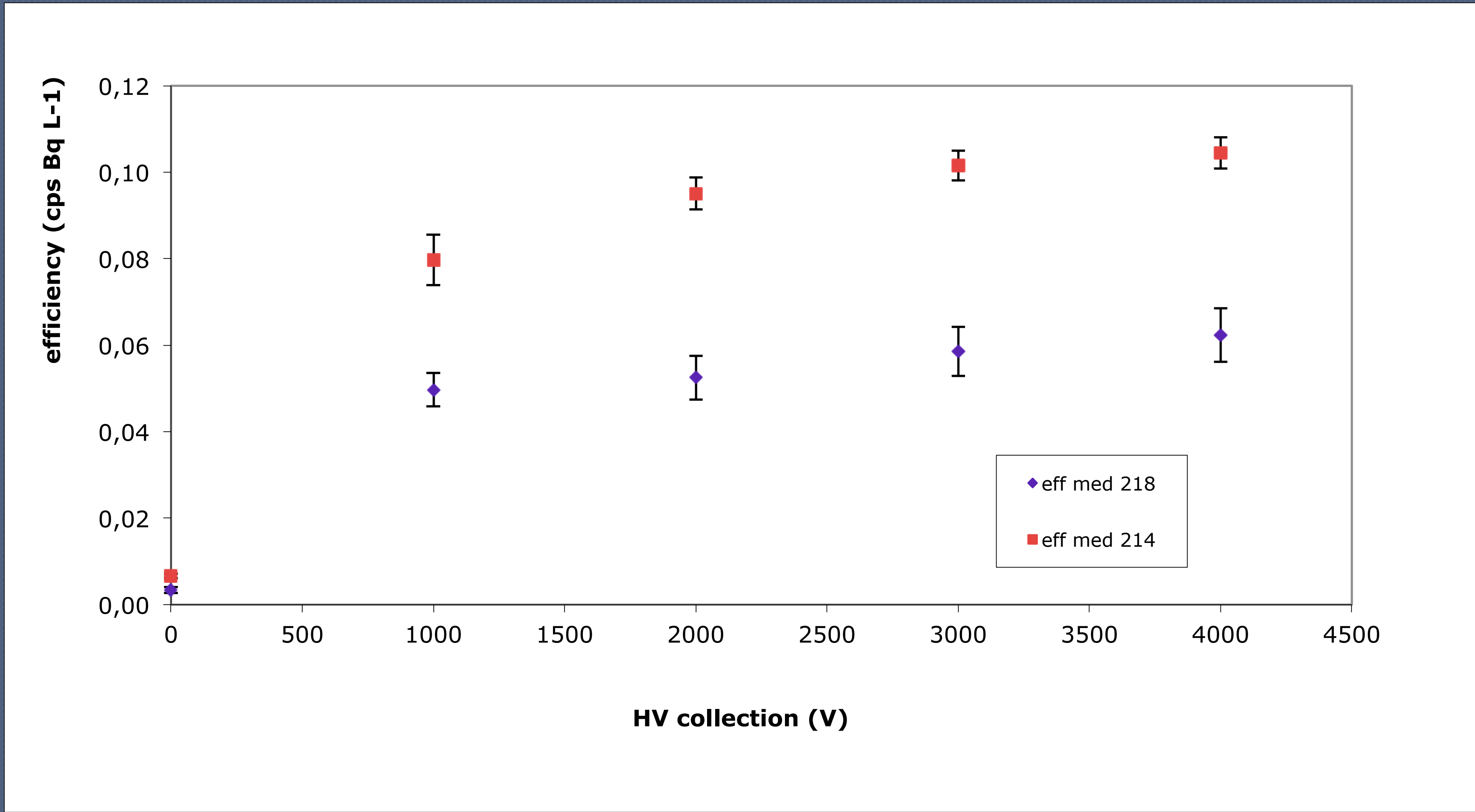
Results

By the analysis of the patterns in the two chambers results that the λ^* value is the same, thank to the dynamic equilibrium achieved in the apparatus. Therefore…

the efficiency of the new open chamber can be assessed

The value for ^{218}Po is close to that of the standard chamber, but those of the ^{214}Po is higher

Efficiency vs collection high voltage



Conclusions

- A new chamber for RaMonA system has been realised
- Tests with new chamber have been carried out
- The chamber can be used in "critical" environments and allows to perform direct exhalation rate measurements.
- The exhalator has been calibrated making use of our Radon Chamber
- The ratio between ^{214}Po and ^{218}Po efficiency resulted higher than 1

and now ?

The calibration of the exhalator for thoron will be performed

The use of the exhalator in field will start

An interpretation of the increased efficiency of ^{214}Po should be done