METHODS FOR THE RADIOMETRIC CHARACTERIZATION OF A SEISMO-VOLCANIC AREA USING RADON, THORON AND THEIR PARENTS

F.De Cicco [2,3], U.Marseglia[1], C.Mattone[1,2], M.Pugliese [1,2], M.Quarto[1], V.Roca[1,2], C.Sabbarese[2,3], F.Giudicepietro[4], W. De Cesare[4], I. Aquino[4], C. Del Gaudio[4], C. Ricco[4]

[1] Dipartimento di Scienze Fisiche, Università di Napoli Federico II, Italy
[2] Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, Italy
[3] Dipartimento di Scienze Ambientali, Seconda Università di Napoli, Italy
[4] Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli, Italy

Istituto Nazionale di Geofisica e Vulcanologia
INGV Sezione di Napoli
OSSERVATORIO VESUVIANO

INFN Sezione di Napoli

Radon in not homogenous soils

Radon in soils is not constant

because of variations

of emanation and/or trasport of the gas

depending on variations

of environmental parameters and

of porosity and/or permeability

that can be due to the activity of

faults, earthquakes, volcanic areas and gas fluxes

The results of radon measurement in a site of a soil do not always provide the same value.

Why?

Because of the influence of climatic parameters

Because of some problems of the measurement methodology and/or instrument.

Because anomalous values is present due to remote causes.

Carlo Sabbarese -
carlo.sabbarese@unina2.it

As it is possible to distinguish between changes due to local effects from remote ones?

Our solution is:

- assembling many sites of measurements (like an array of seismology instruments) to investigate an area,

  for studying spatial and temporal correlation of the signals.

- using a reliable multiparametric system which offers:
  - adequate integration time
  - sensitivity and accuracy
  - separation of radon from thoron signal.

Our project … to test the idea

The objective is

to carry out the areal acquisition of many signals

(like geochemical and geophysical parameters), useful to define the observed variations of meaningful "radon-signal".

The selected area is a seismo-volcanic area of approximately 5 km^2.

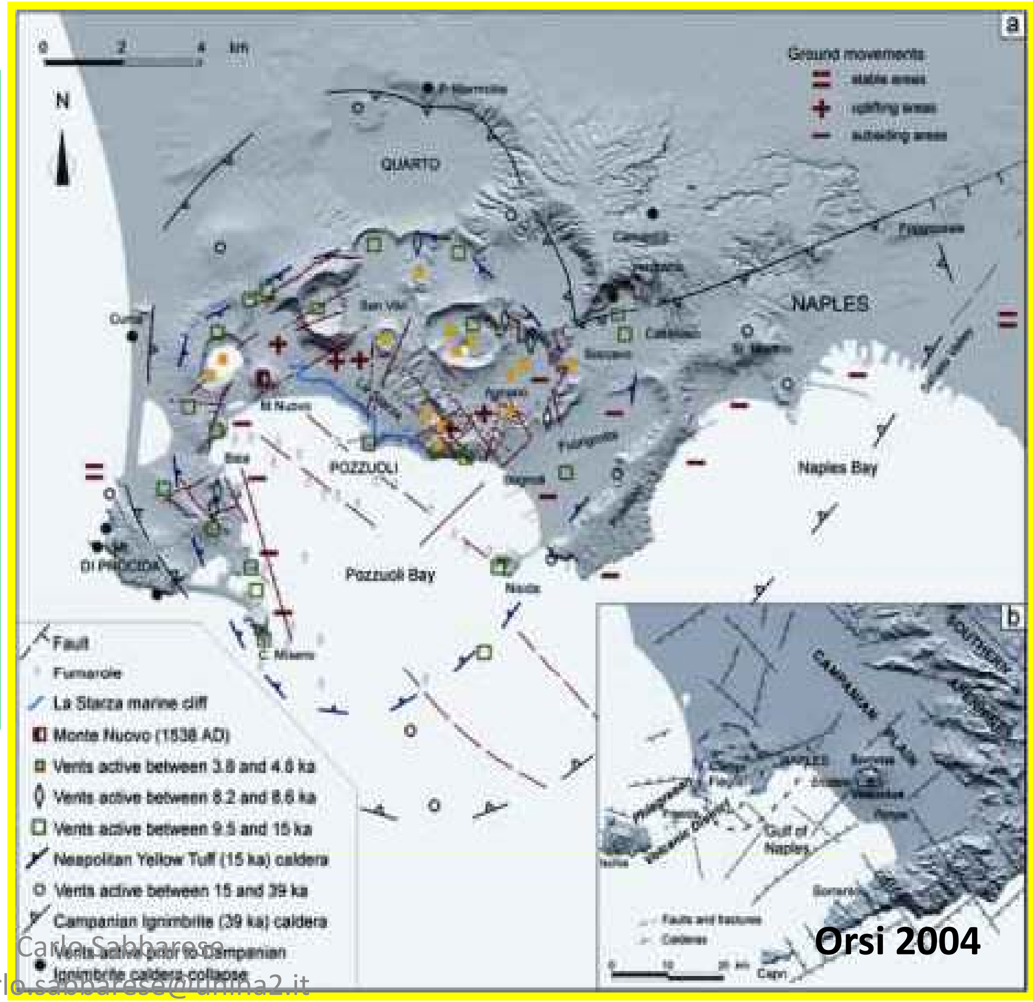
Many stations will be installed to constitute a network around an area.

Each station is equipped with an instrument which measures continuously using adequate frequency and separates ^{222}Rn and ^{220}Rn

Area under study

The area under survey has a particular seismo-volcanic activity : Solfatara-Agnano, inside the Phlegraean Fields caldera (Southern Italy).

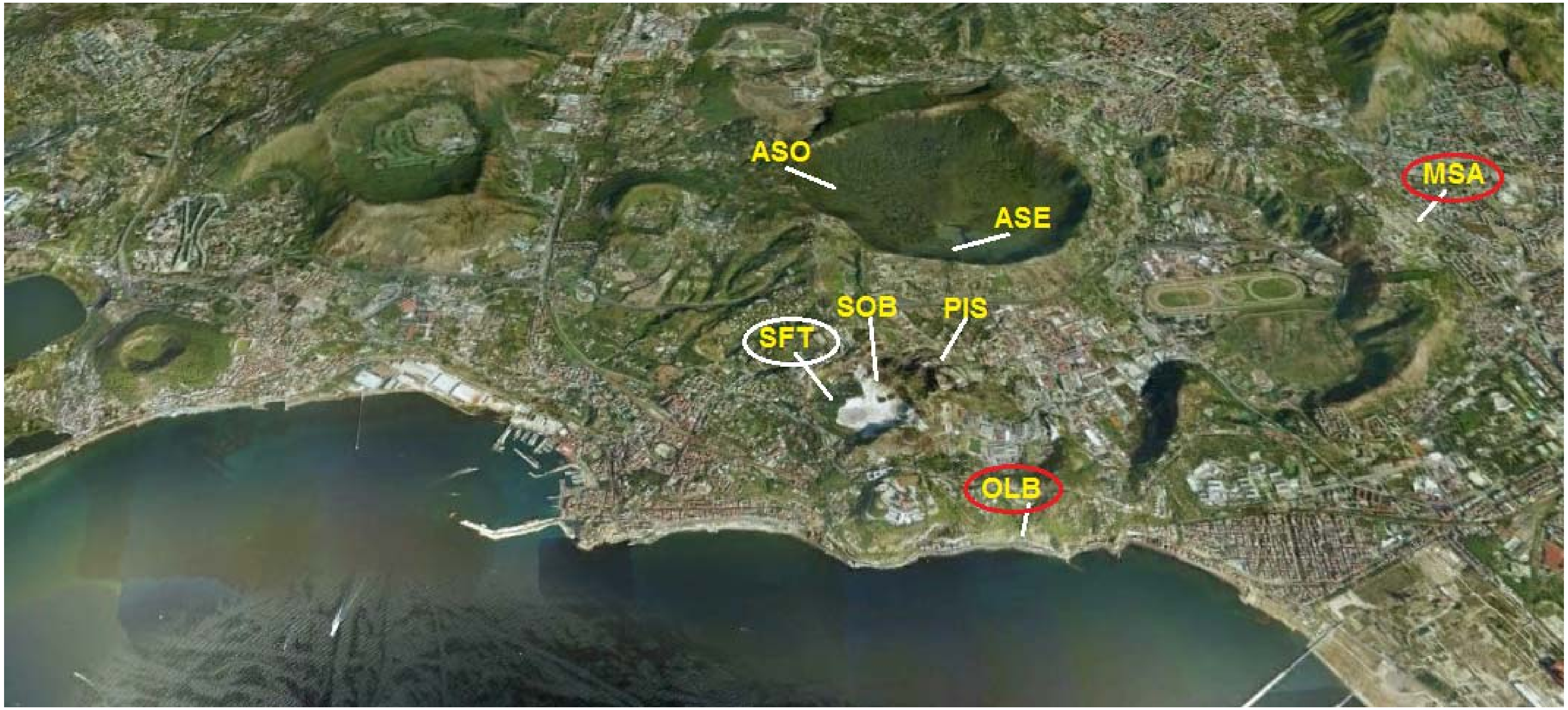
This area is frequentely interested to bradysismic events.



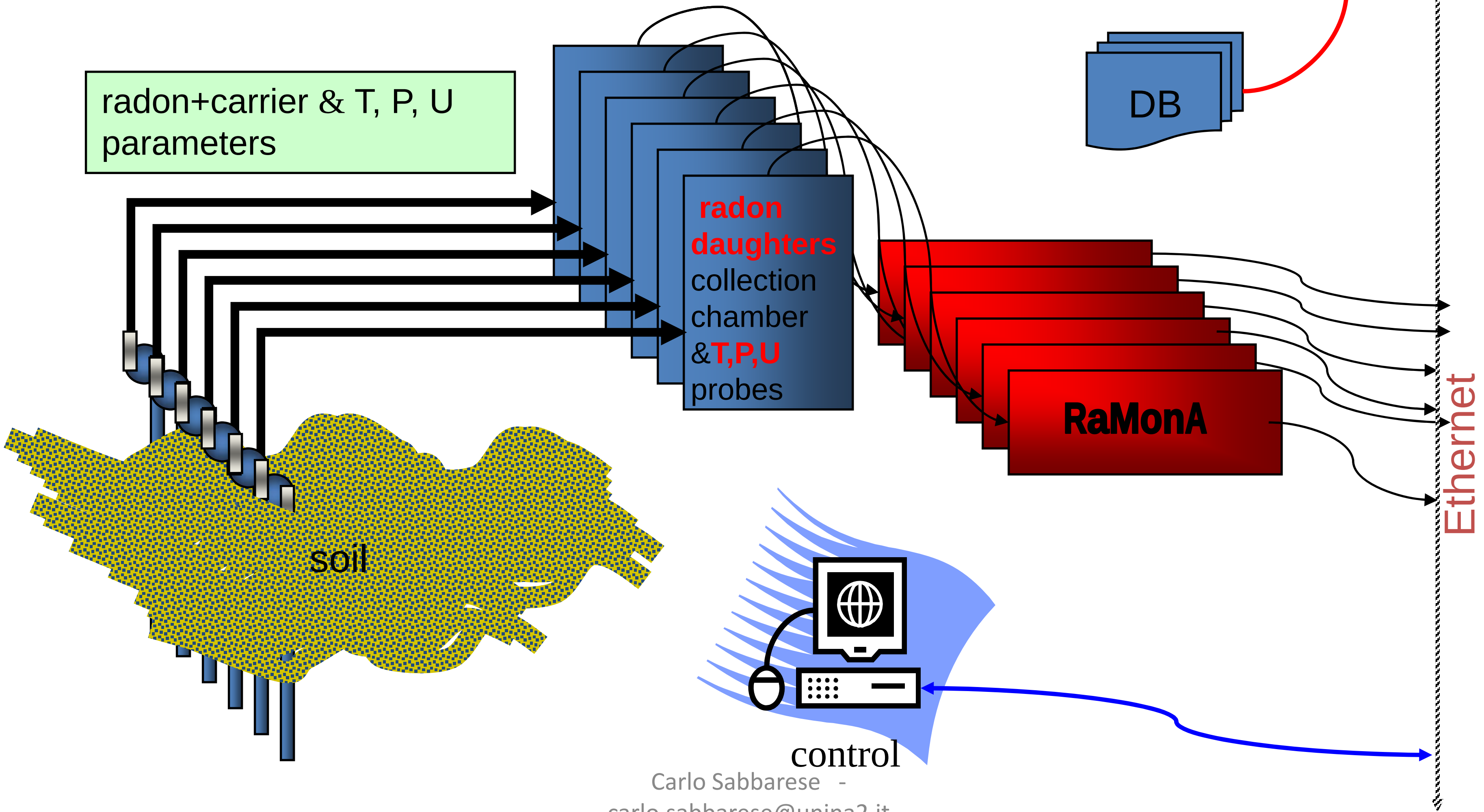
Carlo Sabbarese
carlo.sabbarese@unina2.it

Phlegrean Fields area

and measurement sites



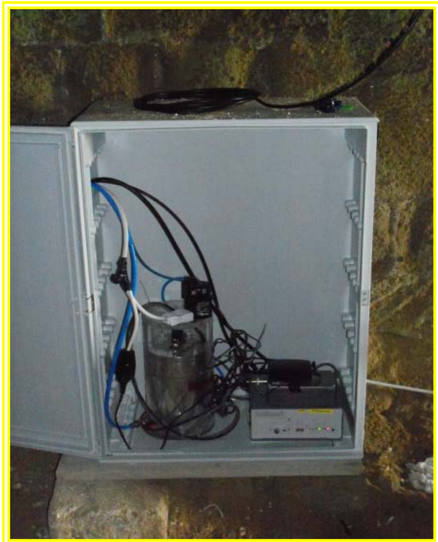
A net of RaMonA systems for the monitoring of radon in the soil gas



Start of the project

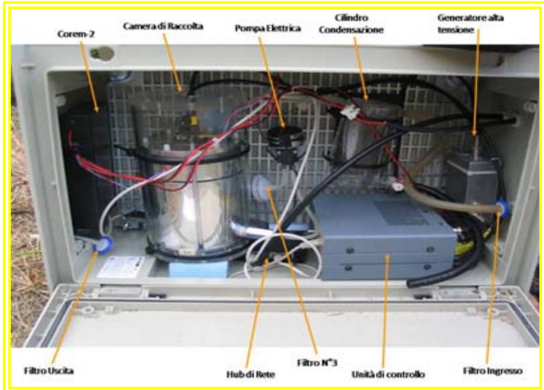
- In the selected area, seven radon monitoring stations will be installed, in association with other pre-existing seismic, infrasonic, tiltmetric and geochemical stations managed by Osservatorio Vesuviano.
- Data transmission will be managed depending on the acquisition site characteristics, and will be based on pre-existing facilities. Connectivity will be realized via radio, telephonic line or wireless.
- Installation of the radon monitoring network will allow a high resolution long-term recording of areal Rn patterns to be compared and processed together with other physical and chemical observables.
- Monitoring start-up was on January 2011 with three stations. At present, two are running

OLIBANO'S SITE



Carlo Sabbarese -
carlo.sabbarese@unina2.it

SOLFATARA'S SITE



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Measurements carried out

Gamma ray spectrometry of soil samples to quantify the direct progenitors of Rn-222 and Rn-220;

In situ air soil radon using passive detectors (LR-115) and subsequent laboratory analysis to determine both values of diffusion coefficient and radon soil concentrations;

Emanation coefficients of soil samples by alpha spectrometry using the RaMonA system (in laboratory);

Grabe-sample radon soil concentration using the RaMonA system (in situ);

Continuous monitoring using the RaMonA system (in situ).

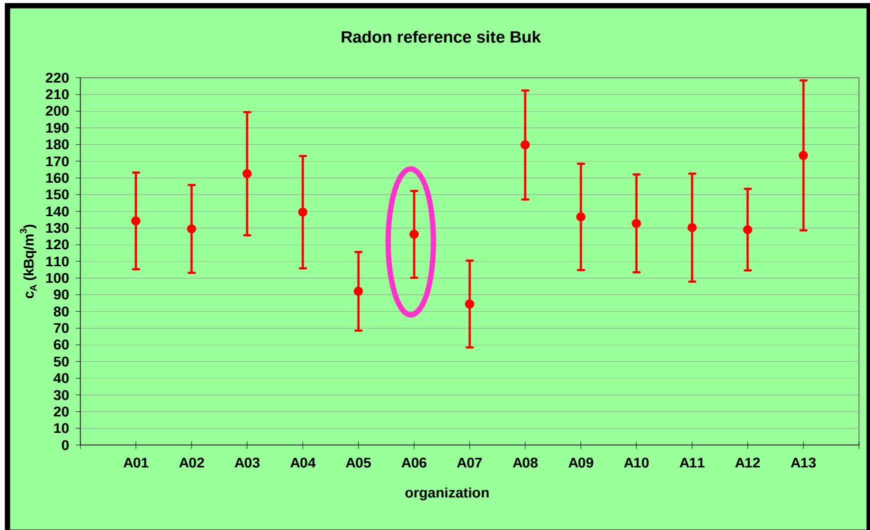
RaMonA system

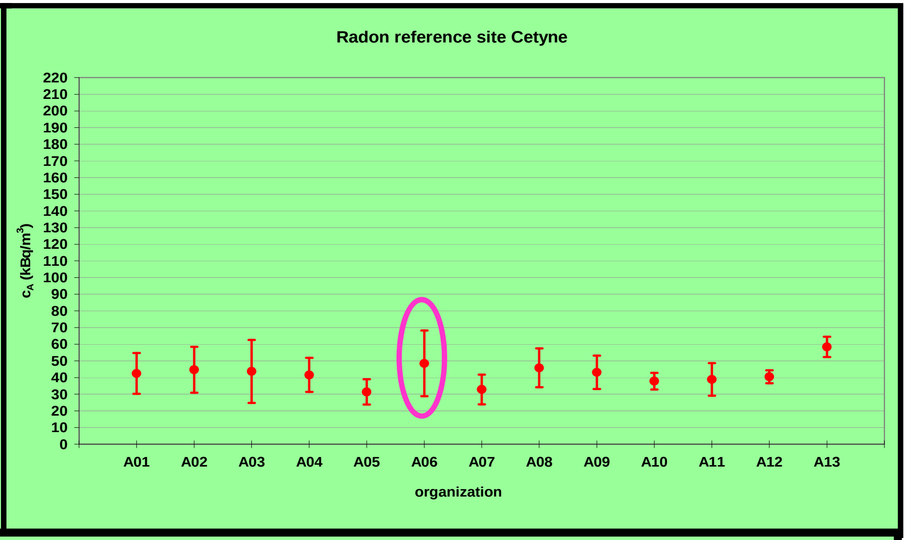
It measures

- ^{222}Rn and ^{220}Rn using an electrostatic collection cell and an alpha detectors allowing to perform spectrometry of the alpha radon and thoron daughters
- climatic parameters to normalize the measured activity to standard environmental conditions.

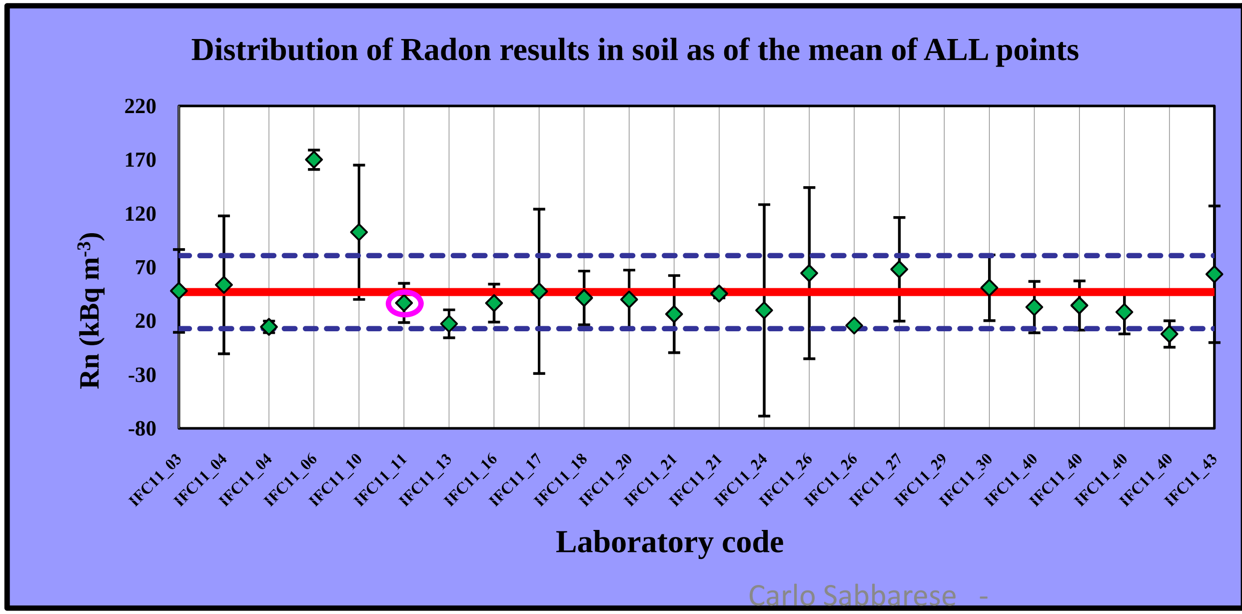
The presence of an Ethernet interface makes possible to drive remotely many stations, each identified by own IP address.

Intercomparison results of RaMonA for radon in soil





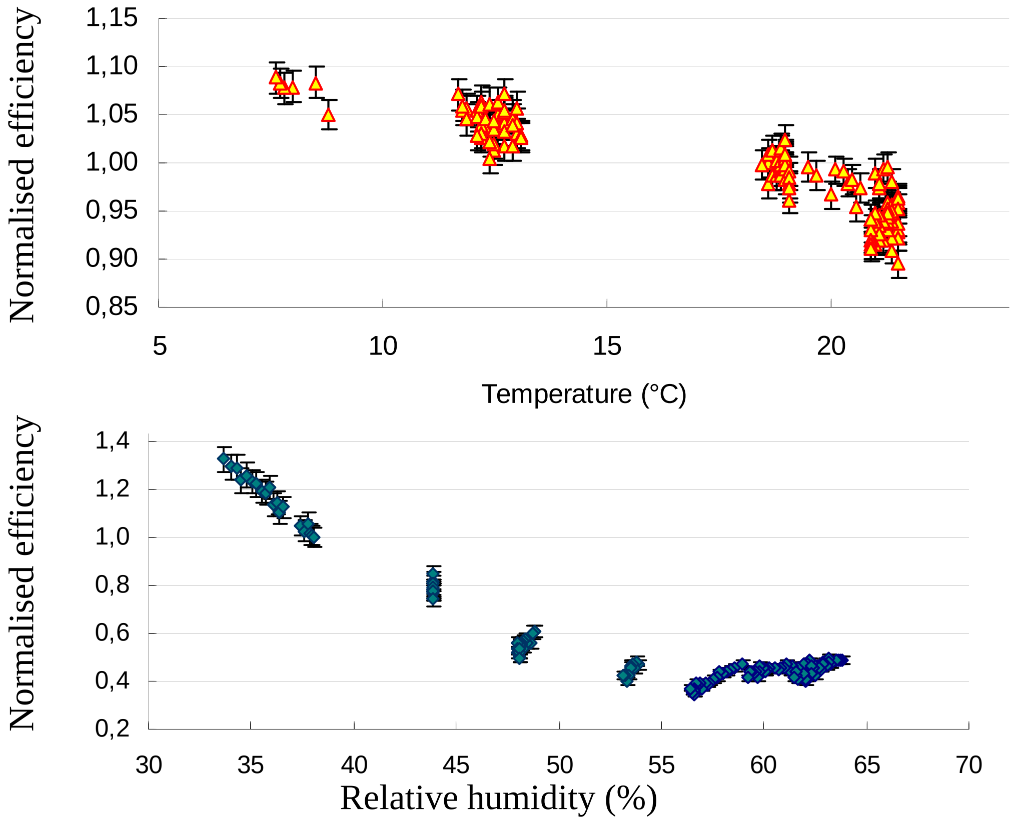
Geological Aspects of Radon Risk Mapping, 20 - 24 September 2010, Prague



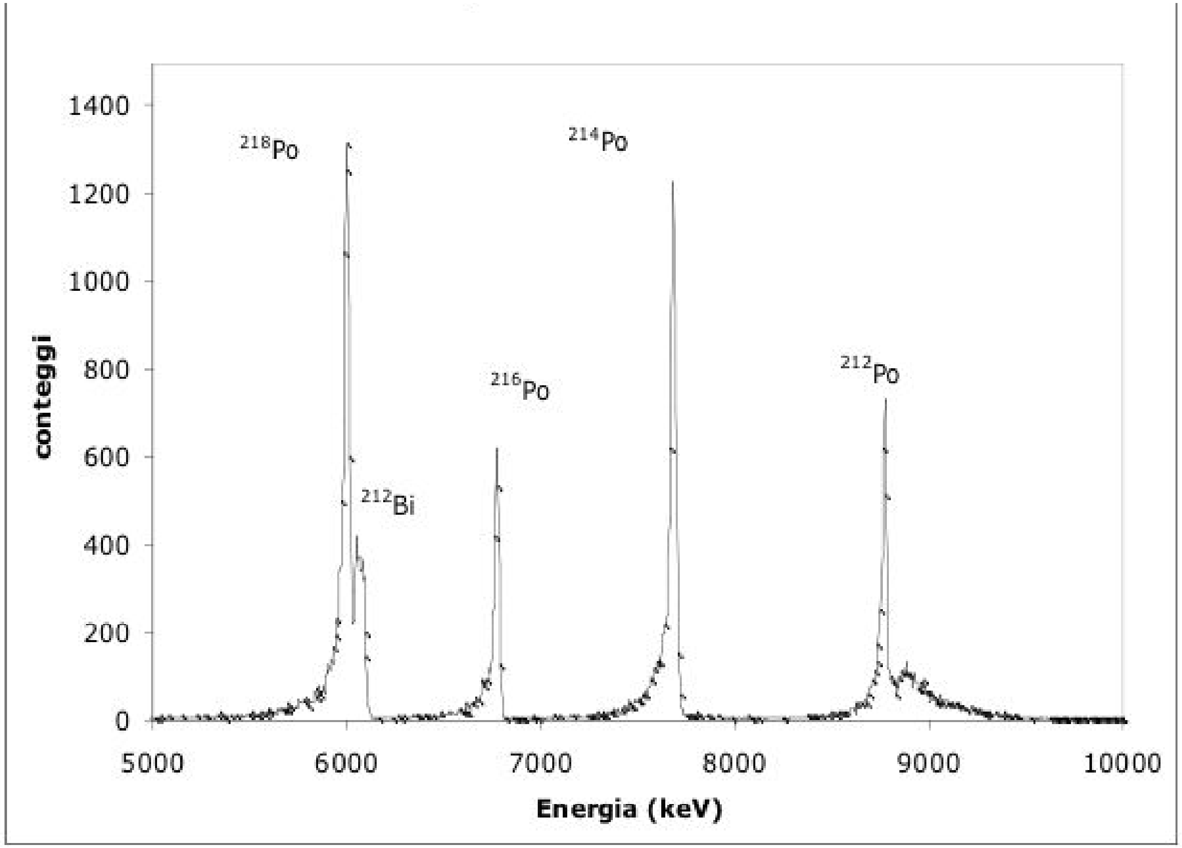
International intercomparison exercise on natural radiation measurements under field condition 23-27 May in Saelices el Chico-Salamanca, Spain

Carlo Sabbarese -
carlo.sabbarese@unina2.it

RaMonA efficiency vs T and UR



^{220}Rn and ^{222}Rn daughters α spectrum from soil gas



The interference between ^{218}Po line and ^{212}Bi line suggests to obtain radon concentration from the ^{214}Po line, but …

Analysis of the radon signal

^{220}Rn can be eliminated by using filters and/or low flux values of the air flowing through the measurement chamber.

On the other side, the measurement of ^{220}Rn, offers a tool to distinguish from local and remote measured ^{222}Rn in a site.

… because ^{220}Rn can only come from small distance from the measurement point.

If the ratio between radon and thoron parents in a site is known, from the measurement of the thoron it can evaluate the radon.

This procedure needs

^{226}Ra and ^{232}Th specific activity measurements

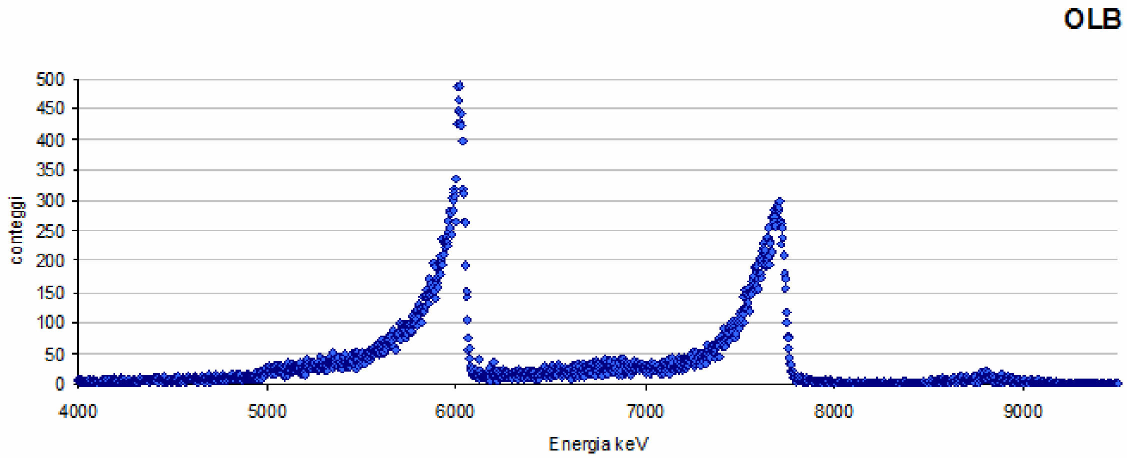
^{222}Rn and ^{220}Rn emanation coefficient measurements

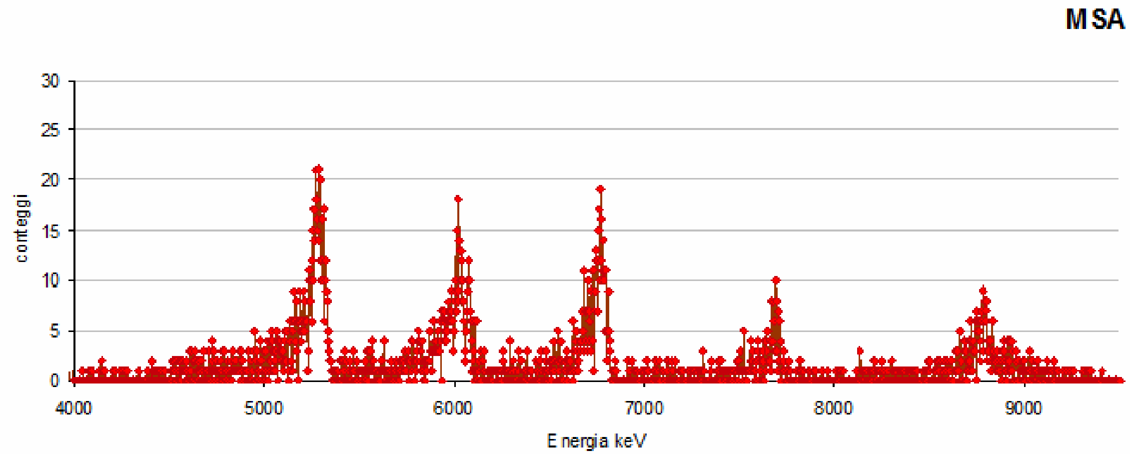
and

the knowledge of the dependence of emanation coefficient on temperature and relative humidity

Some results

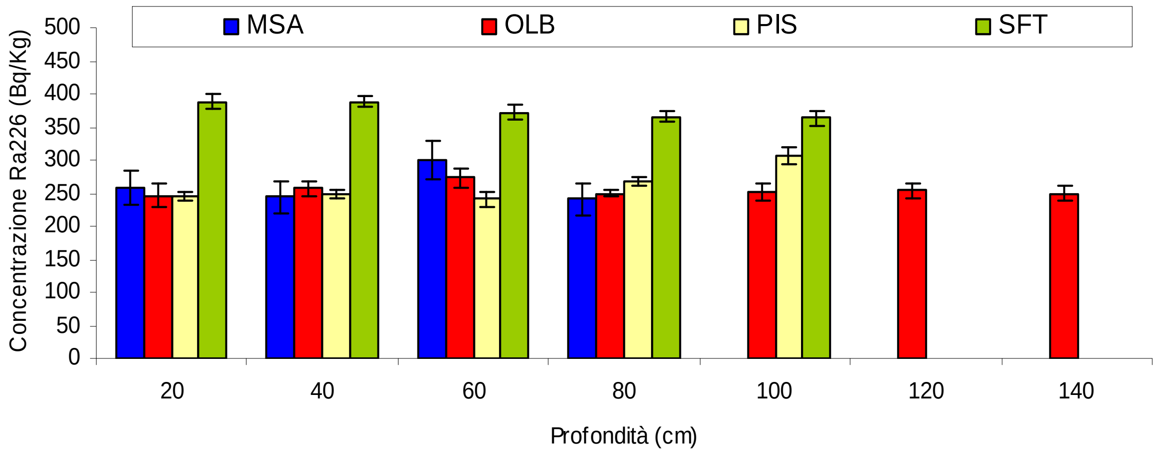
Alpha spectra from OLB and MSA sites



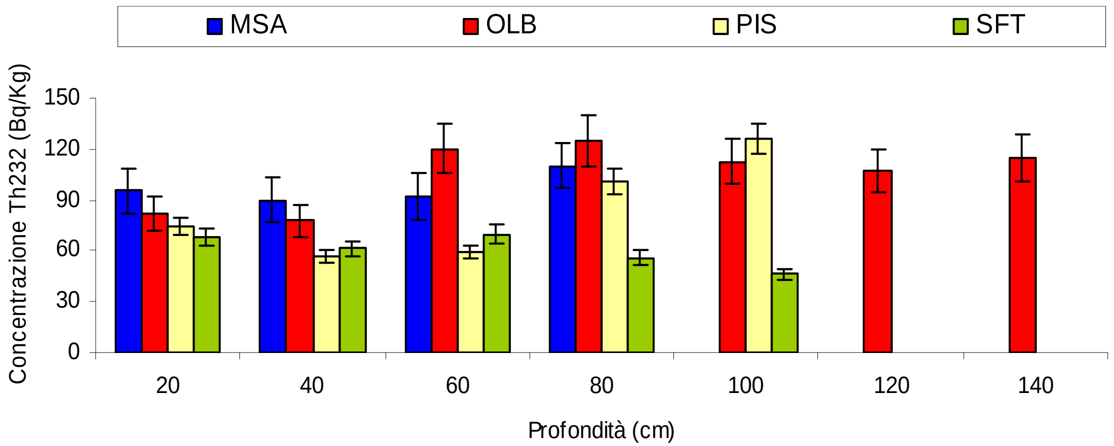


^{226}Ra and ^{232}Th specific activities vs depth in soils of 4 investigated sites

^{226}Ra



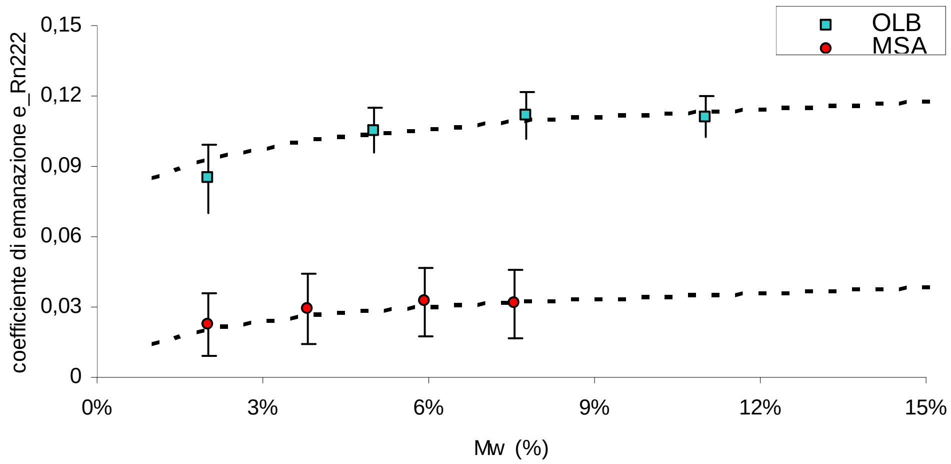
^{232}Th



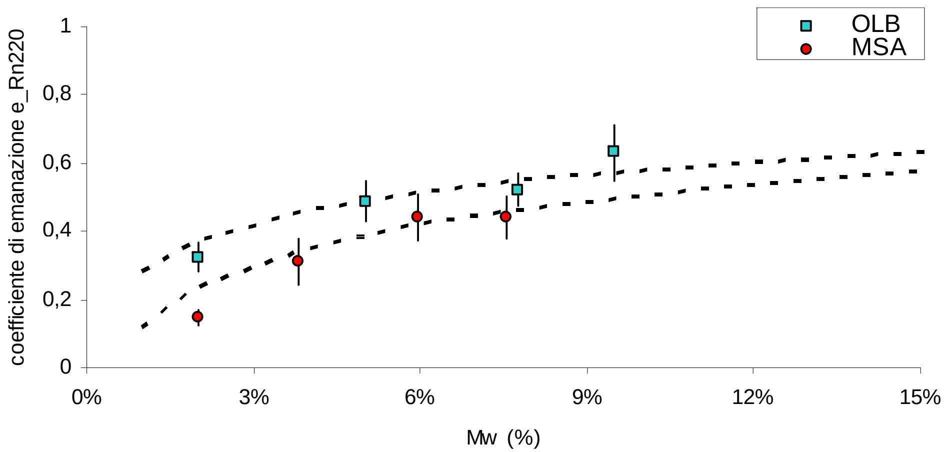
Carlo Sabbarese -
carlo.sabbarese@unina2.it

Emanation coefficient vs. relative humidity in the samples of OLB and MSA sites

^{222}Rn

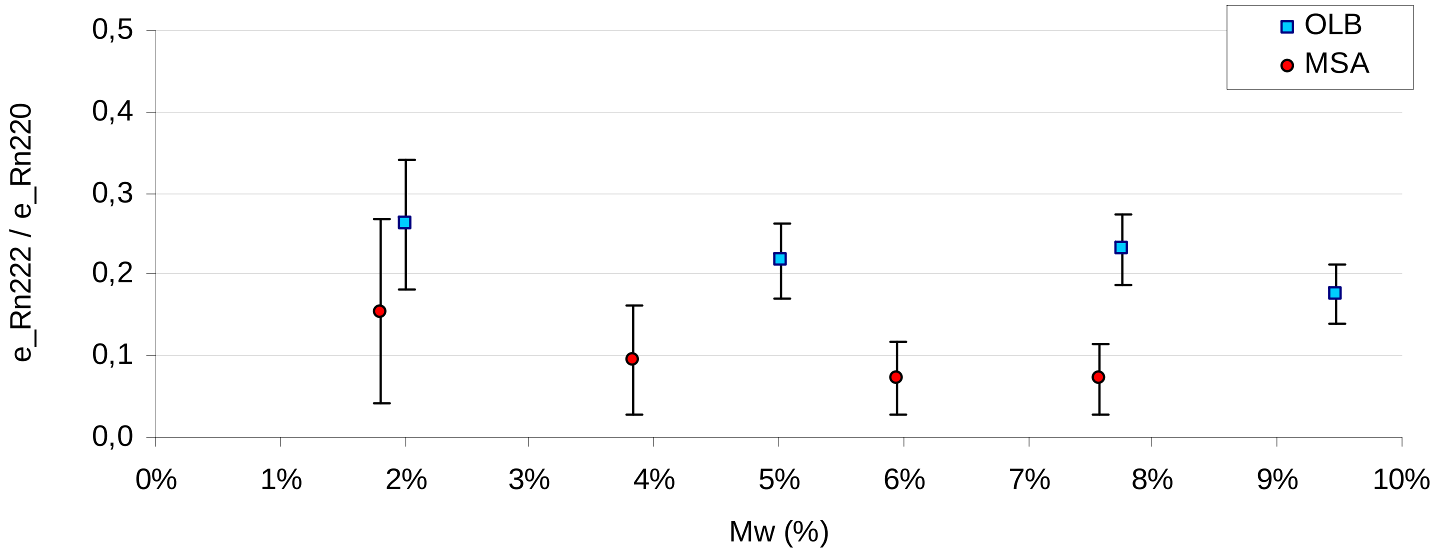


^{220}Rn



Carlo Sabbarese -
carlo.sabbarese@unina2.it

Emanation coefficients ratio vs. relative humidity in the samples of OLB and MSA sites



Remote ^{222}Rn

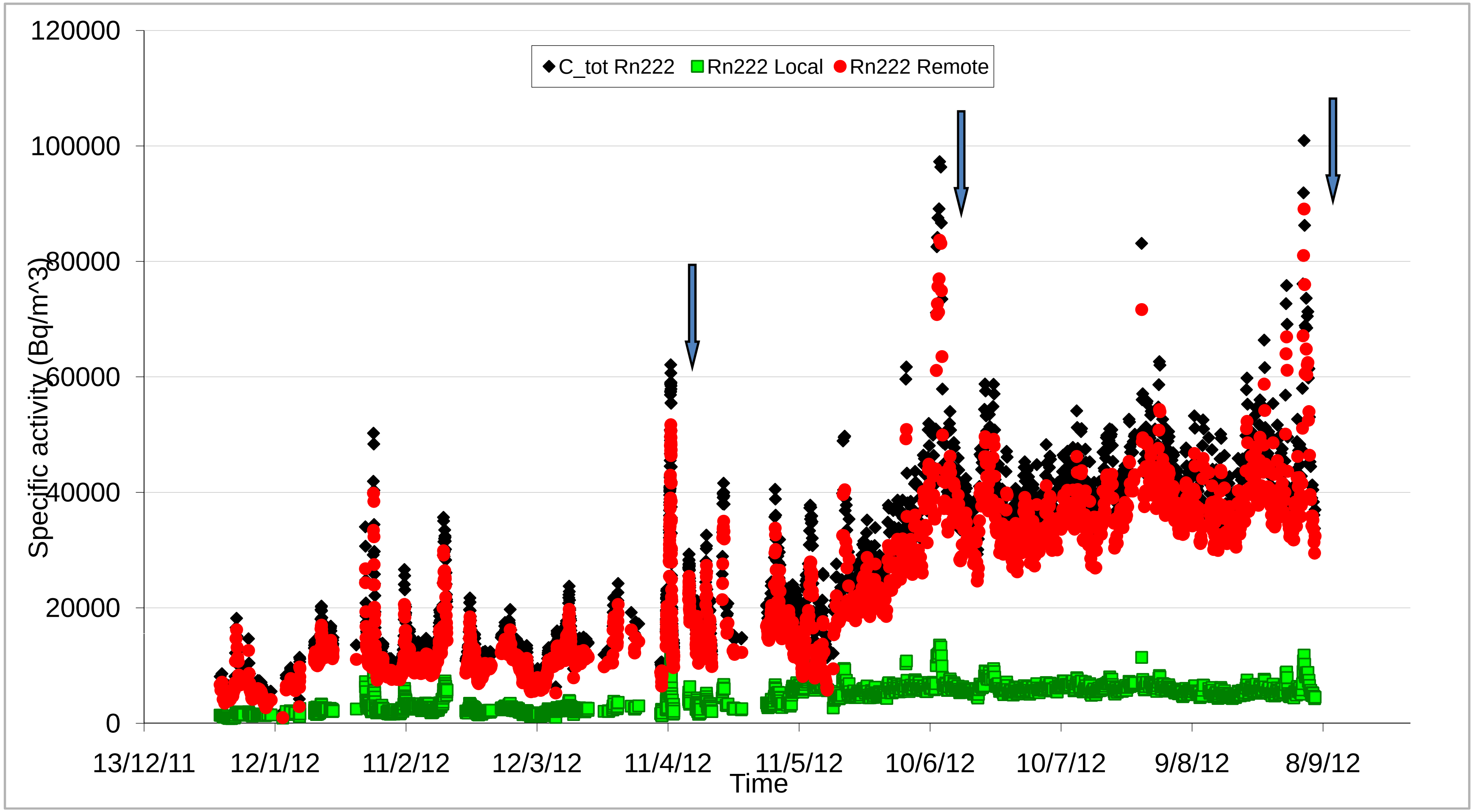
Remote ^{222}Rn = (Total ^{222}Rn) - (Local ^{222}Rn)

Local ^{222}Rn has been determined using

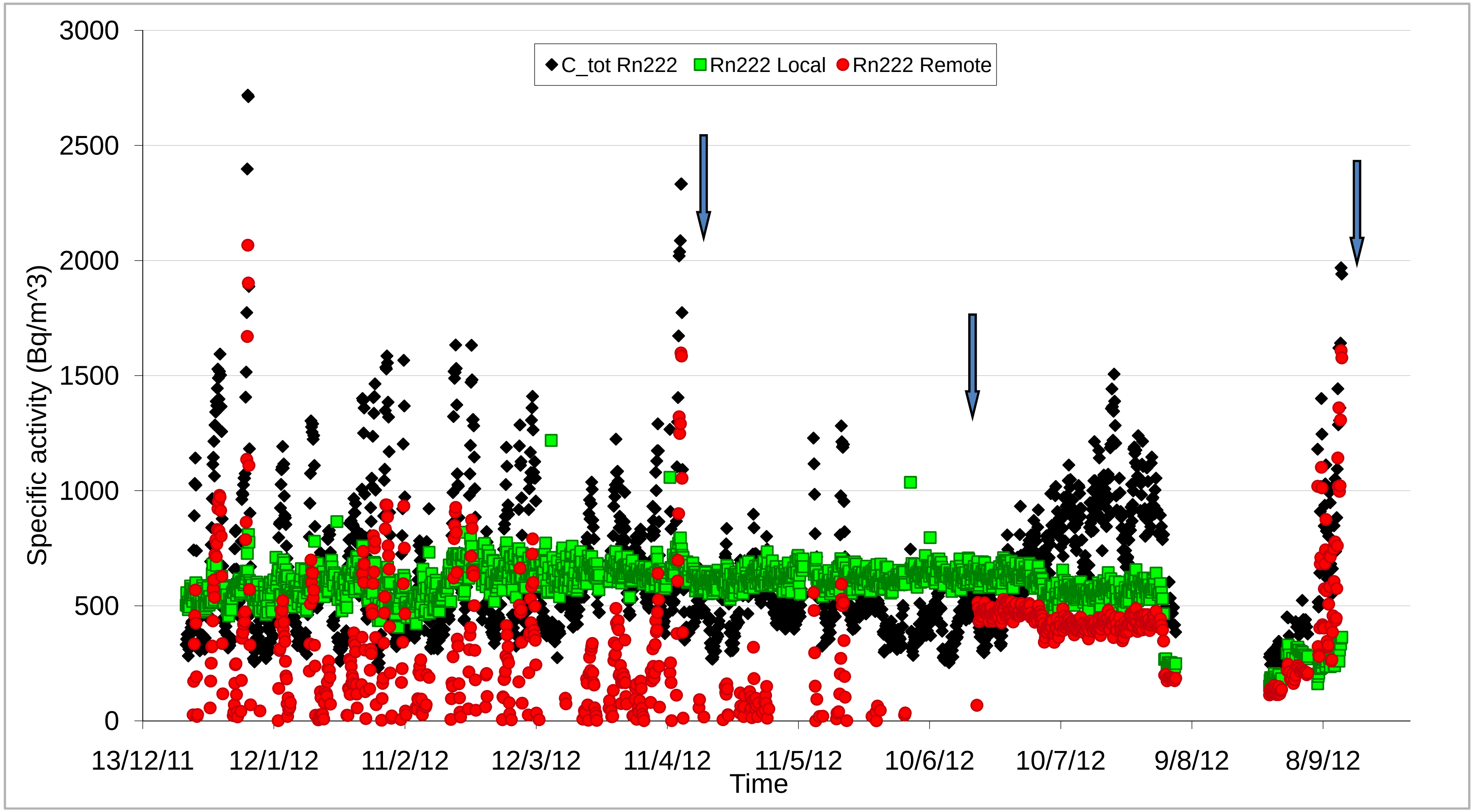
$$(A_{Rn222})_{locale} = A_{Rn220} \cdot \sqrt{\frac{\lambda_{Rn220}}{\lambda_{Rn222}}} \cdot \left(e^{(-\lambda_{Rn222} + \lambda_{Rn220}) \cdot t_{tubo}} \right) \cdot \frac{e_{Rn220}}{e_{Rn222}}$$

Two examples of results of continuous monitoring and of analysis procedure

OLB site: Rn continuous monitoring



MSA site: Rn continuous monitoring



Conclusions

- **A net of measurement points is necessary to study a particular (not homogenous) area**
- **To characterize a site different measurements have been carried out**
- **Continuous monitoring is the principal measurement, but the use Radon signal for geophysical aims, other measurement results have been used**
- **Anomalous signals have been evindenced in different sites.**
- **The work is progress in order to extend the net to characterzie the entire area.**

Thank you for attention

Carlo Sabbarese

carlo.sabbarese@unina2.it