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THE APPLICATION OF THE ALPHA SPECTROMETRY TO THE CONTINUOUS RADON MONITORING IN THE SOIL GAS: LIMITS AND PERSPECTIVES

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Why Radon measurements in soils?

Radon anomalous levels in soils

can be due to variations of

emanation and/or trasport of the gas

depending on variations of

porosity and/or permeability

that can be caused from activity of

faults, earthquakes, volcanic areas and gas fluxes

why radon anomalies are not always observed?

- Because radon signal *depends also on site of measurement*, *being* earth crust not homogeneous
- Because the measurement is *not* performed using *adequate monitoring system and/or observation time*
- Because not always data analysis includes the influence of the environmental parameters (moisture, in soil or external temperature, atmospheric pressure, wind speed, …)

how it’s possible to solve these problems?

- assembling many sites of measurements (like an array of seismology instruments) to investigate one 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.

our project … to start to understand

The objective of a project which is starting within a collaboration among Universities of Naples, INFN and INGV-OV consists in trying to exceed these limits

In particular, our aim is to carry out the areal acquisition of many signals, useful to define the observed variations of meaningful “radon-signal”

For that, many stations defining an *ad-hoc* network around an area of approximately 5 km^2 will be installed and they will constitute a first necessary step towards the comprehension of the phenomenology of diffuse radon degassing

the site

The area under surveying encompasses the thermal area of Solfatara-Agnano inside the Phlegraean Fields caldera (PFc), and falls within the municipalities of Naples and Pozzuoli

why this site and what to do there ?

The “bradyseismic” episodes occurring within PFc, especially in the investigated zone, represent the ’step zero' of the magmatic activity that can potentially evolve from uneruptive unrest towards eruptive conditions

The whole study area is affected by large CO_2 emissions at surface. For example, Solfatara crater alone (0.5 km^2, located in the surveyed area) releases in average 1500 tons of CO_2 per day. An energetic release of approximately 100 Mw corresponds to this diffuse emission from the soil

Monitoring plan

In the selected area within PFc, seven radon monitoring stations will be installed, in association with other pre-existing seismic, infrasonic, tiltmetric and geochemical stations of ther 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.

The installation of the radon monitoring network will allow a high resolution long-term recording of areal Rn patterns, that will be compared and processed together with other physical and chemical observables.

Monitoring start-up is planned for January 2011. At present, detection systems that will be used are under test and calibration.

These systems are Ramona monitors, that have been developed in the Naples Department of Physical Sciences.

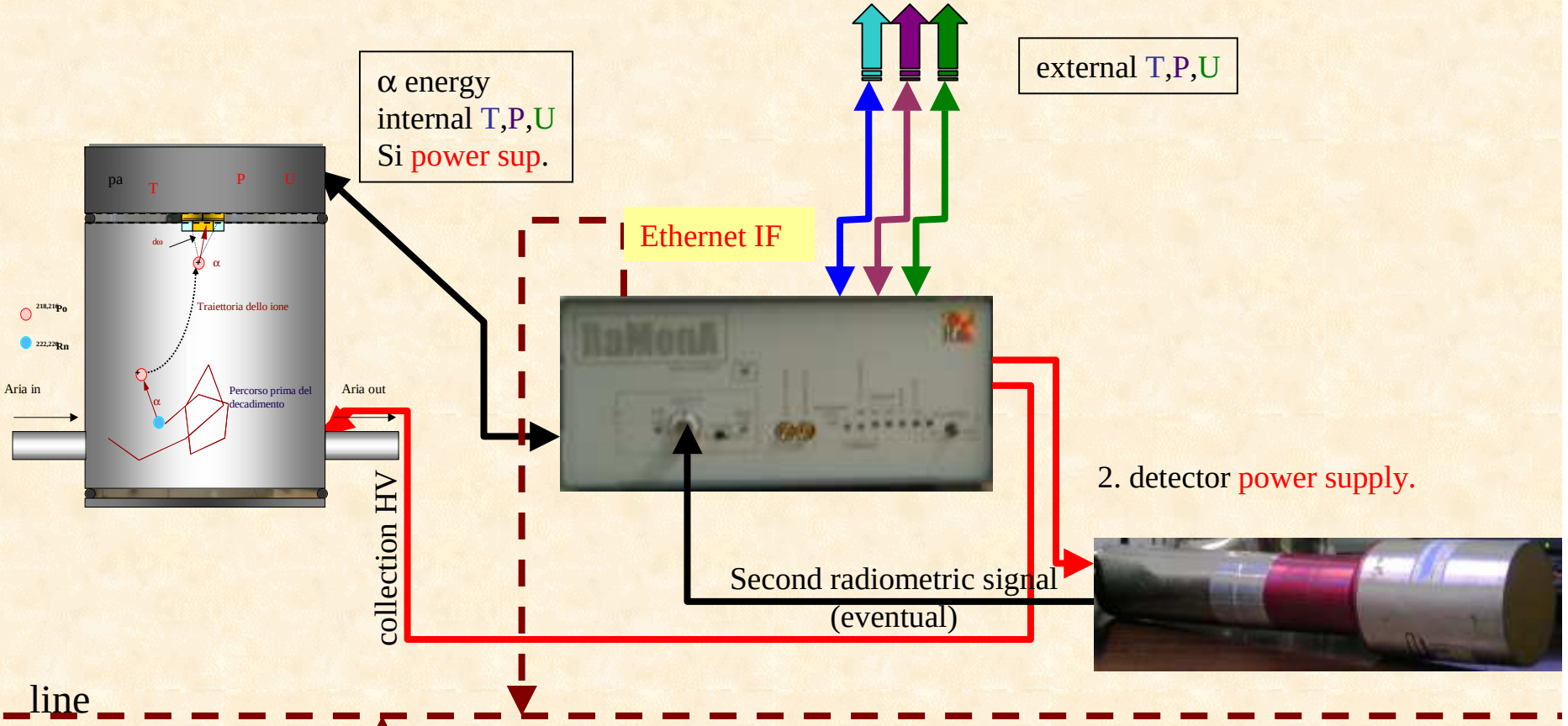
They allow the continuous monitoring of:

- radon concentration in the air flowing through the sensible element of the system and of
- climatic parameters, need to normalize the measured concentration to standard environmental conditions.

The detection unit of the system consists of a collection chamber where the spectroscopy of alpha particles emitted by the ionized radon daughters transported by an electrostatic field on to a silicon detector and by their descendents, is performed.

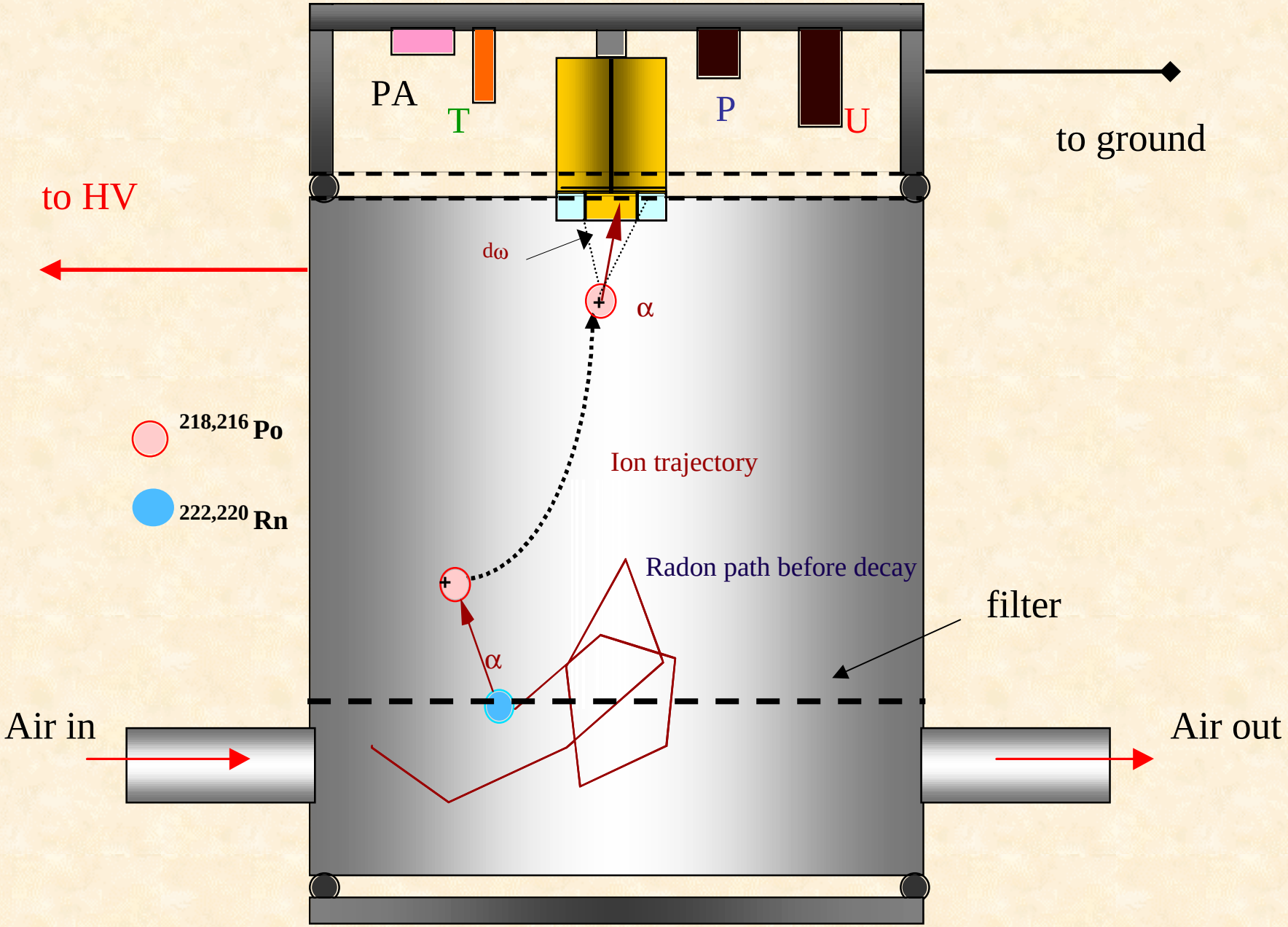
The presence of an Ethernet interface makes possible to drive remotely many stations, each identified by own IP address.

The Ramona system

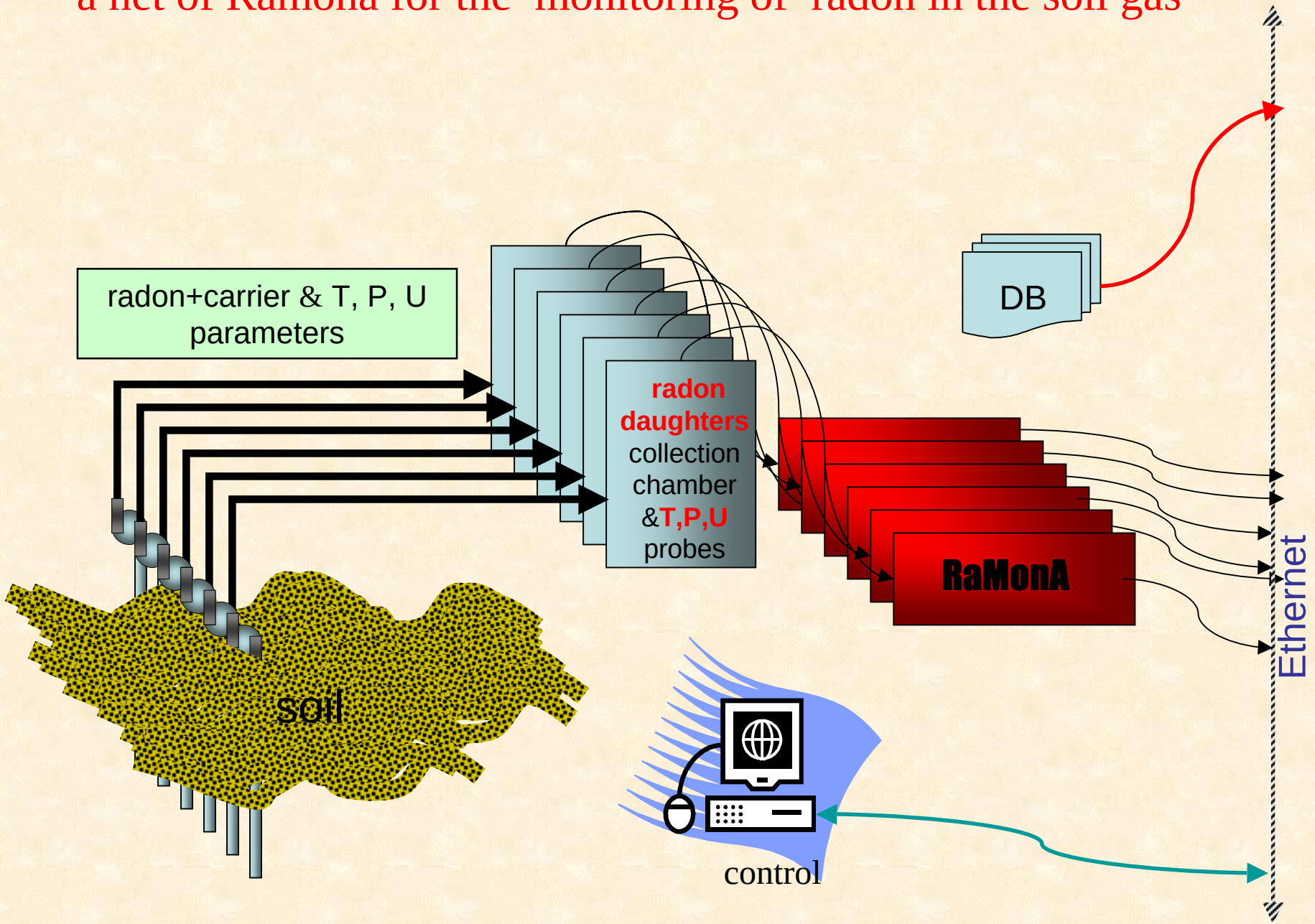


The collection chamber, an eventual second detector and a second set of climatic sensors are connected directly to the control unit, which provides for the necessary power supply and all electronic functions

The collection chamber



a net of Ramona for the monitoring of radon in the soil gas

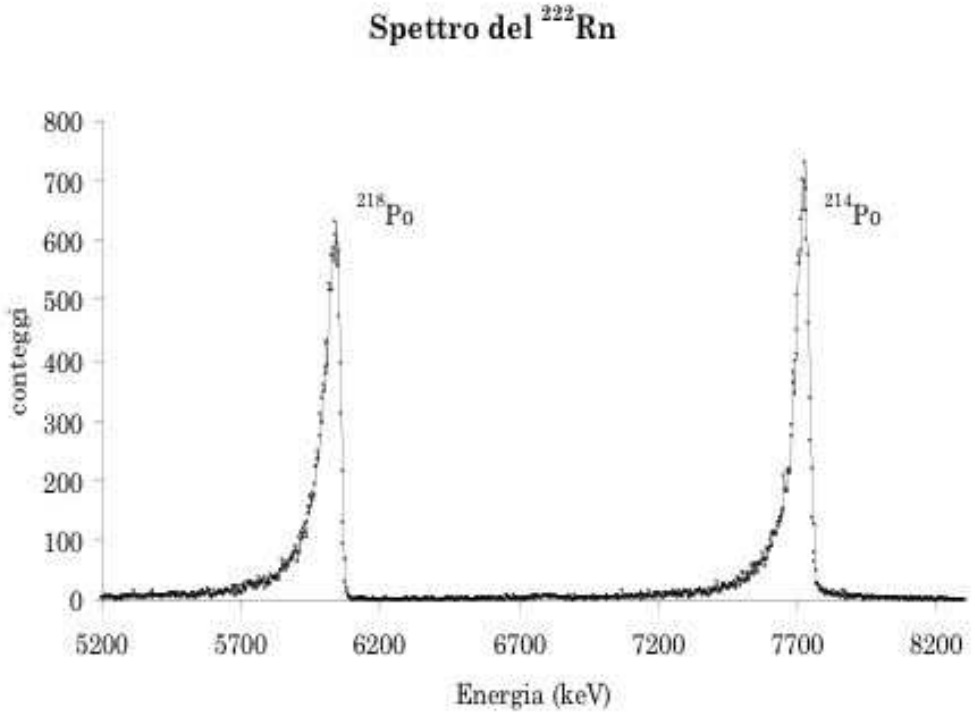


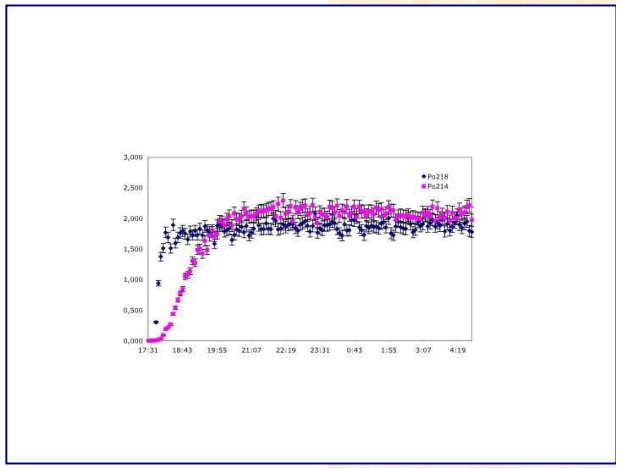
The **alpha particle spectrometry** on the gas coming directly from soil is the main peculiarity of this system. With this technique, in fact, which allows to detect independently radon and thoron daughters:

- the variation of radon levels can be monitored, when it is necessary, with a delay of 30 minutes
- the external background is completely eliminated;
- the influence of the thoron detection, as well
- **otherwise** this isotope can help for quantifying the influence of the radon originated near the measurement site, *if the site radiological characteristics have been studied*

The more simple case:only ^{222}Rn

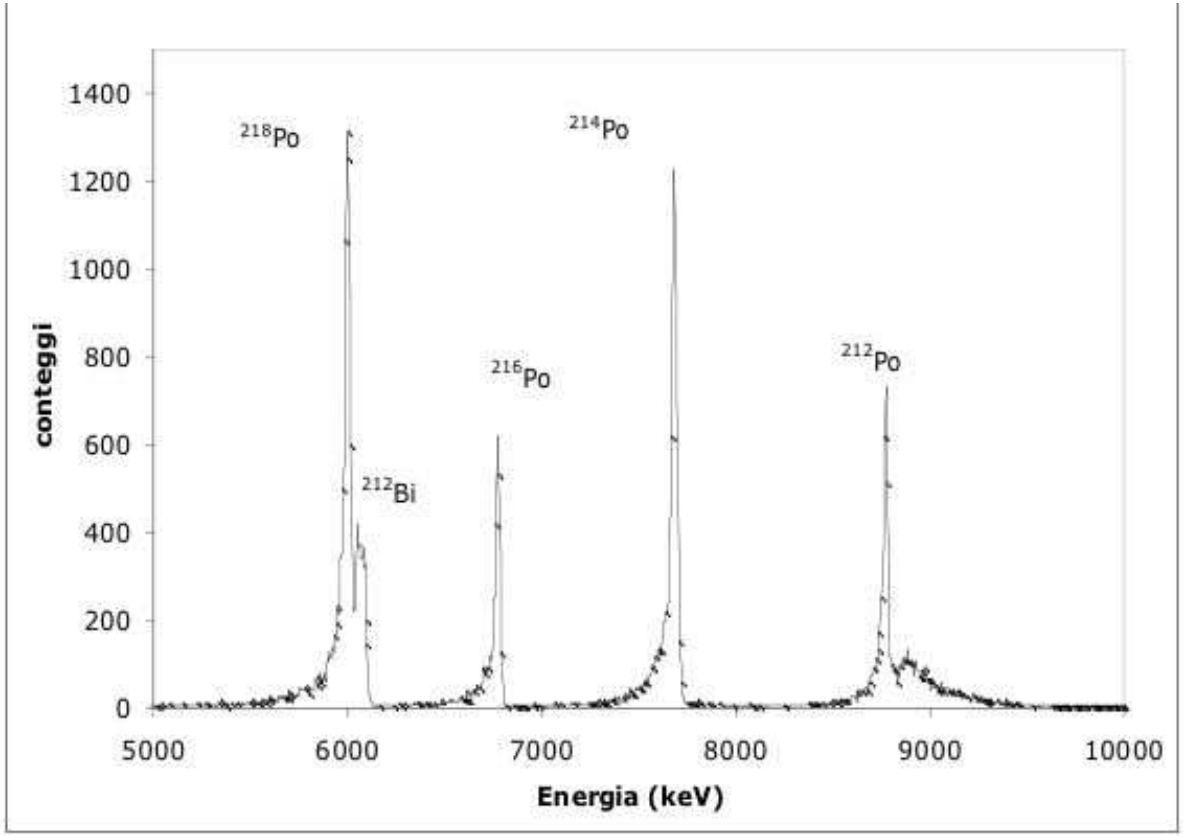
The ^{222}Rn daughters alpha lines are perfectly separated, therefore the response time of the detector is 30 min if one uses the ^{218}Po 6 MeV line.





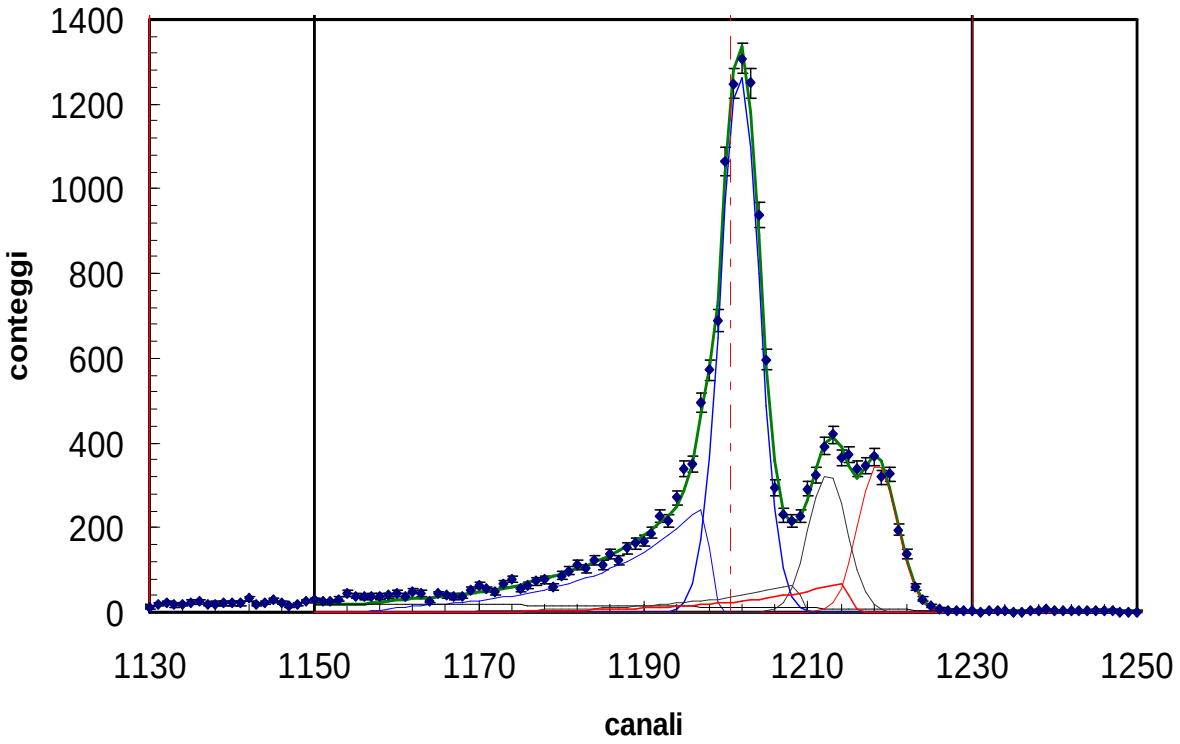
If this line could not be used, the use of ^{214}Po 7,7 MeV line makes this time of about 3 h, usually acceptable for geological applications

α spectrum from soil gas.
In this case both major decay series are present



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

… the alytical solution of the ^{218}Po - ^{212}Bi triplet is possible.



The off-line analysis of stored spectra, allows simple solution of interference problems.

A less precise but practical solution is the evaluation of ^{212}Bi interference by then calculation of thoron concentration via other line of thoron descendents: ^{216}Po (6,7 Mev) and ^{212}Po (8,7 MeV)

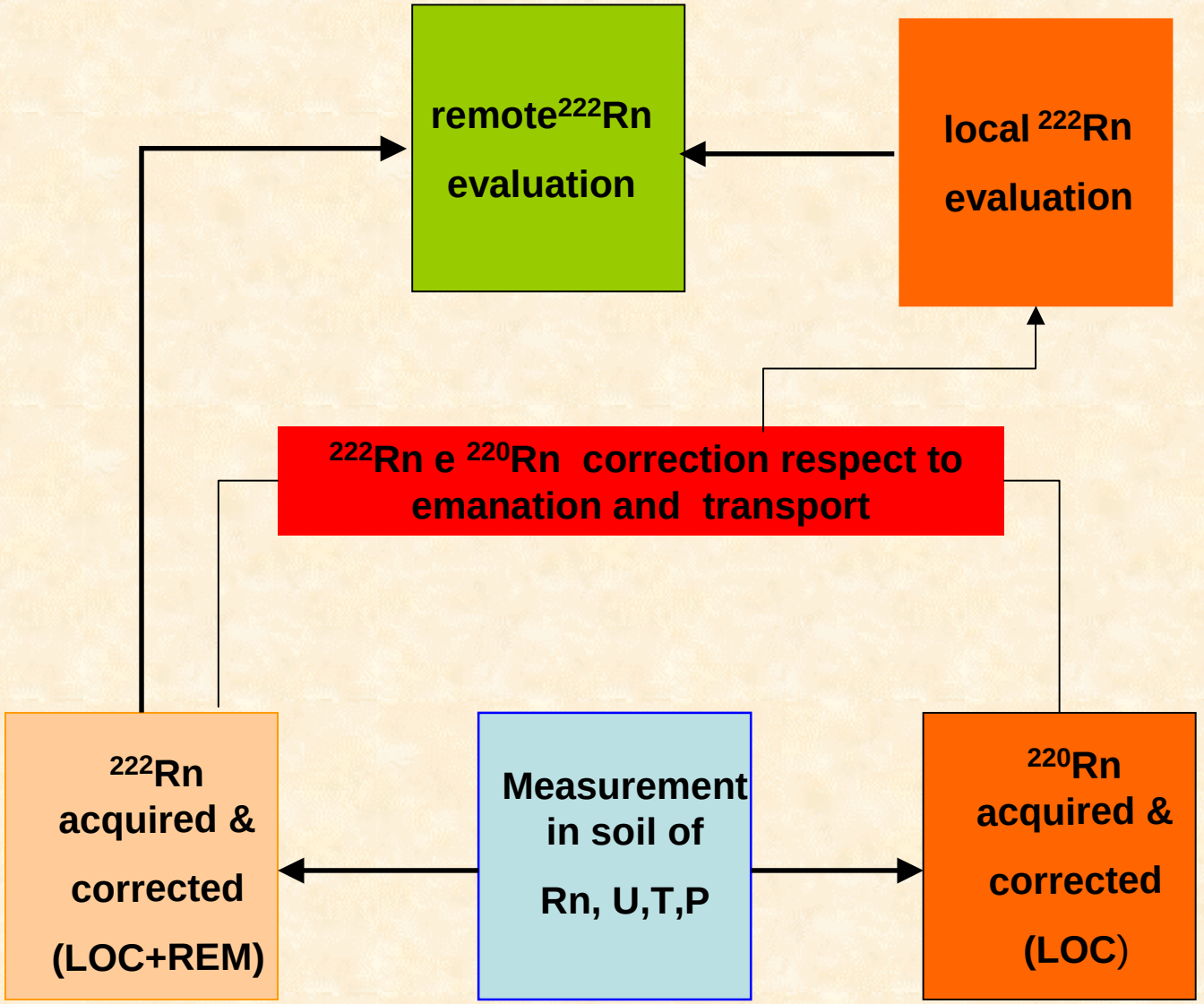
cleaning of the radon signal

Thoron can be obviously eliminated by filtering the air flow through the chamber. The effect depends on total thoron quantity, but filters and slow fluxes obtain the result of eliminate the observable signals of its descendents

On the other side, the measurement of ^{220}Rn concentration offers a tool to eliminate from ^{222}Rn measured concentration its fraction generated in the materials present around the aspiration point

The observed thoron, in fact, can only come from small distance respect to measurement point. If for each site, the ratio between radon and thoron parents is known, from the measurement of the second a evaluation of the first can be obtained

remote radon cleaning procedure outline



This procedure can be developed if, for the measurement point, these steps are carried out:

^{226}Ra and ^{232}Th activity concentration measurement

^{222}Rn and ^{220}Rn emanation coefficients measurement

and

if the dependence of emanation coefficient on temperature and humidity has been studied

Obviously, beyond the radon concentration, also the continuous monitoring of the environmental parameters in the point of aspiration of the soil gas has to be performed, since both influence the emanation conditions.

concluding …

The “radon parameter” is absolutely a meaningful indicator of the dynamics of the earth crust

To be correctly read, it has to be observed in a framework where also other physical and chemical parameters must be collected and correlated

This objective can be reached with long term and high density measurements

The continuous alpha spectrometry od radon daughters allows to obtain high temporal resolution and clean signals

Ramona offers a reliable tool for applying this method