Low-activity measurement of radon and radon daughters in air for volcanology

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Objective

Present the radon research at LPC (with V. Breton, P. Chardon), in collab. with LMV

Apollo 16

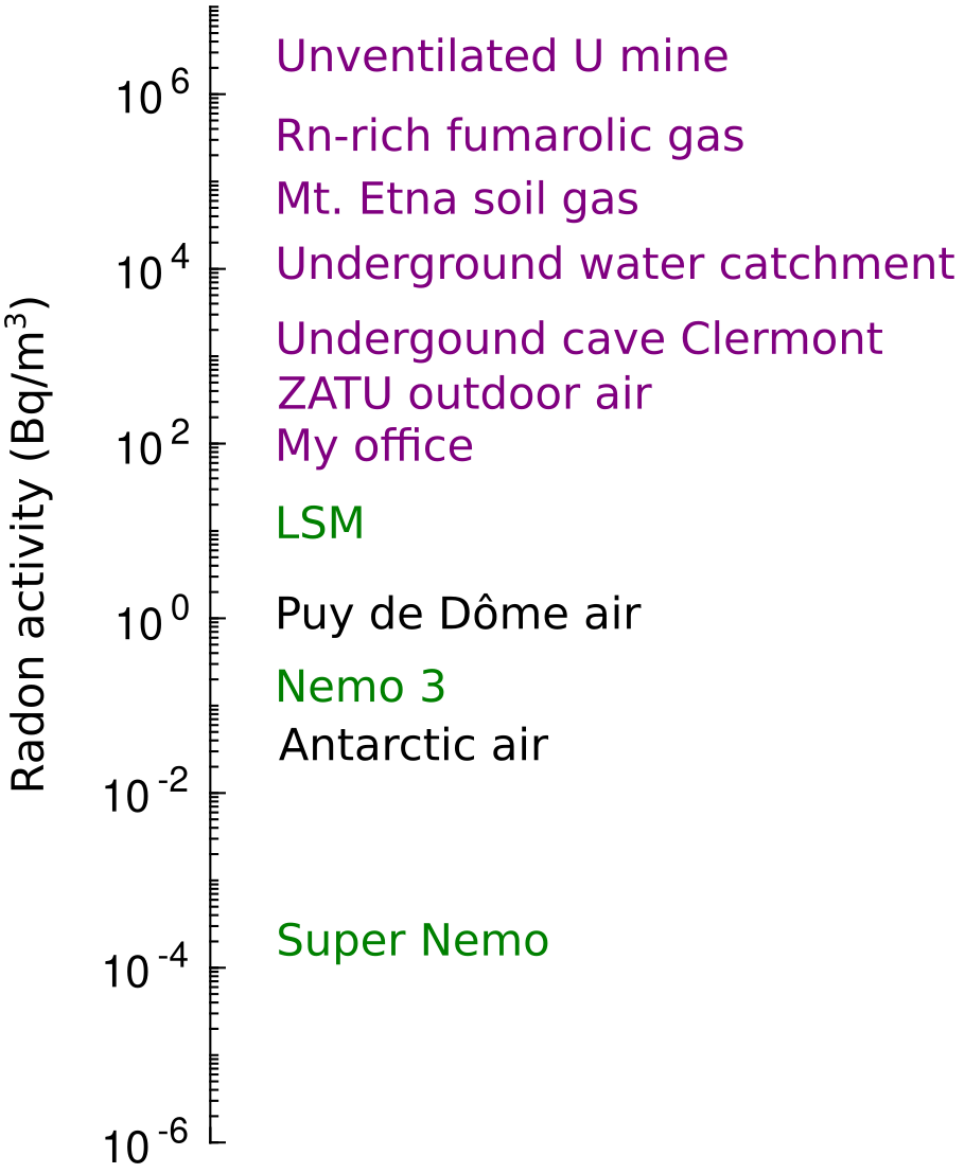
Zones Ateliers
LTSER FRANCE TERRITOIRES URANIFERES

1972 1991 2015 2017

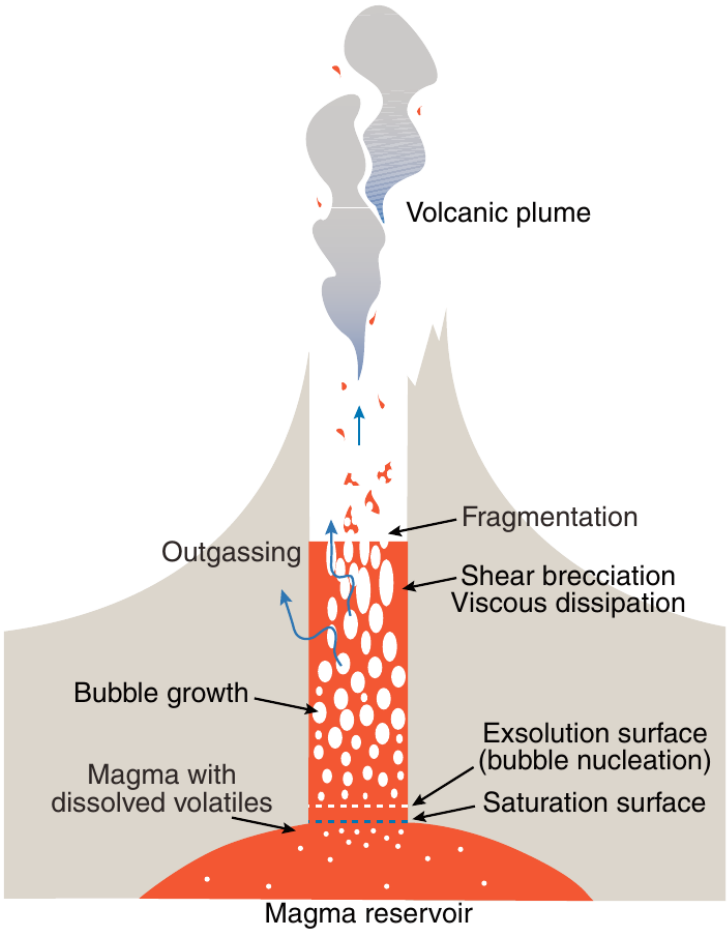
Sonde Clipperton I

Rn dans les panaches volcaniques

What is low activity for us ?



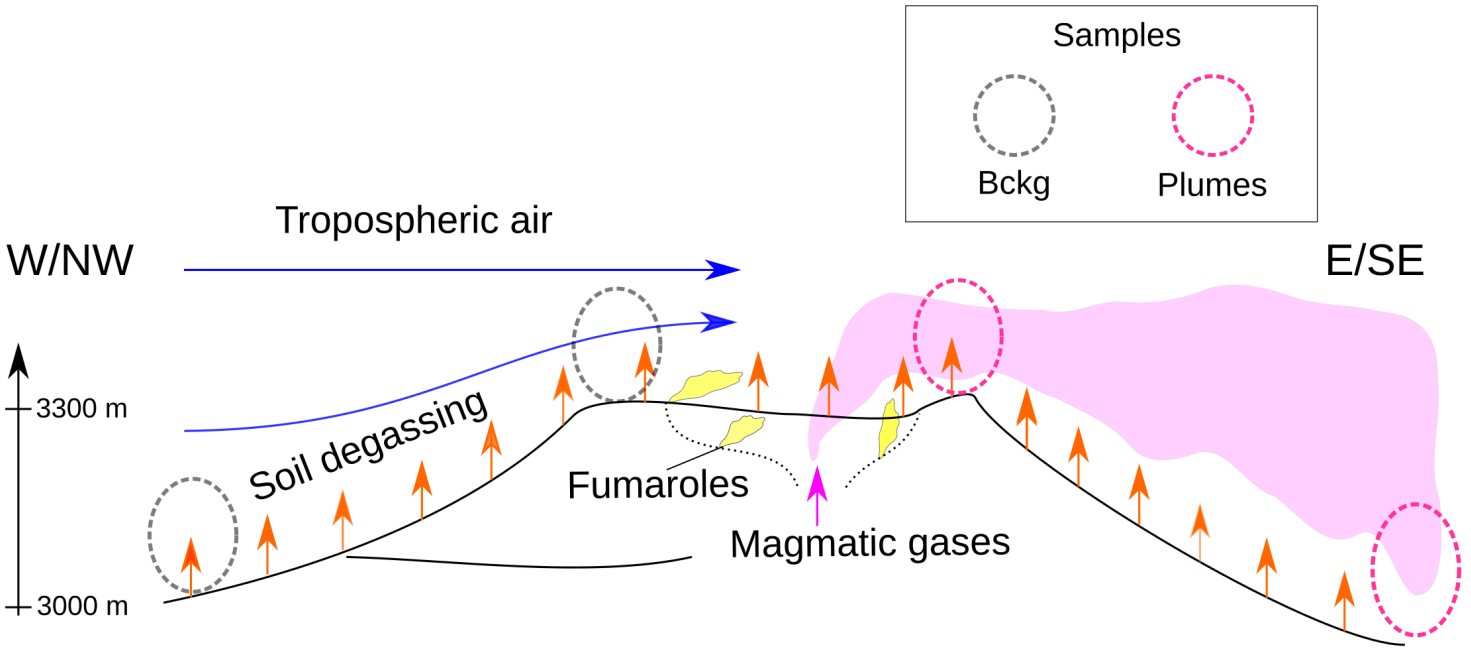
Dynamics of magmatic degassing



From *Gonnerman and Manga, 2007*

- Gas/melt partition coefficient of Rn is very high
- ^{222}Rn source at depth is known (^{226}Ra)
- radon concentration at vent is linked to the gas rise time

Radon activity in volcanic plumes



Tropospheric air is about $1\,\mathrm{Bq\,m^{-3}}$

Magmatic gases: unknown

Which instrument to use ?

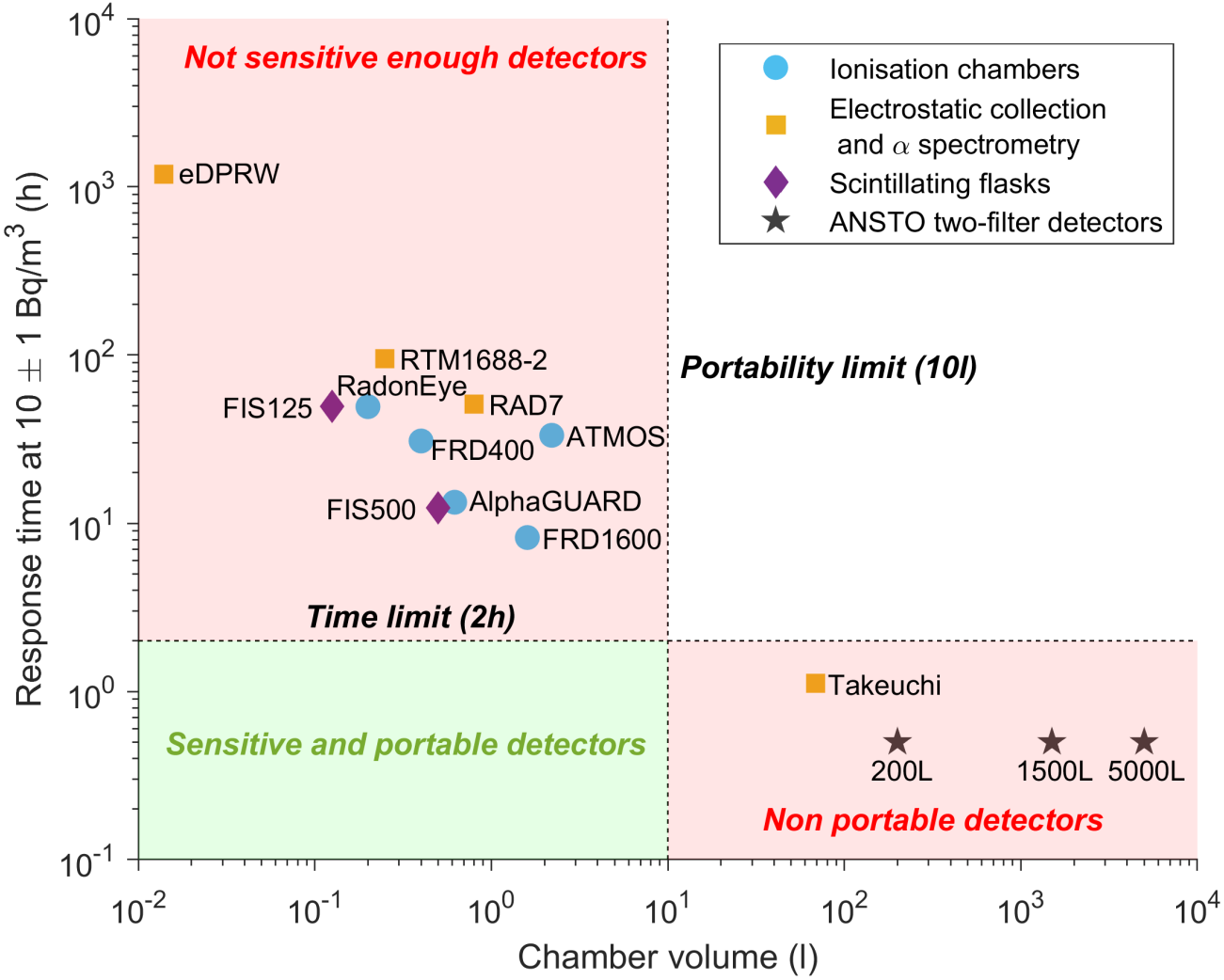
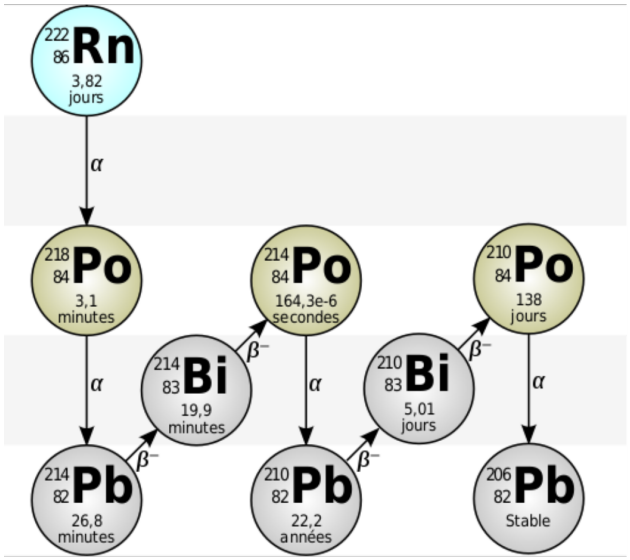
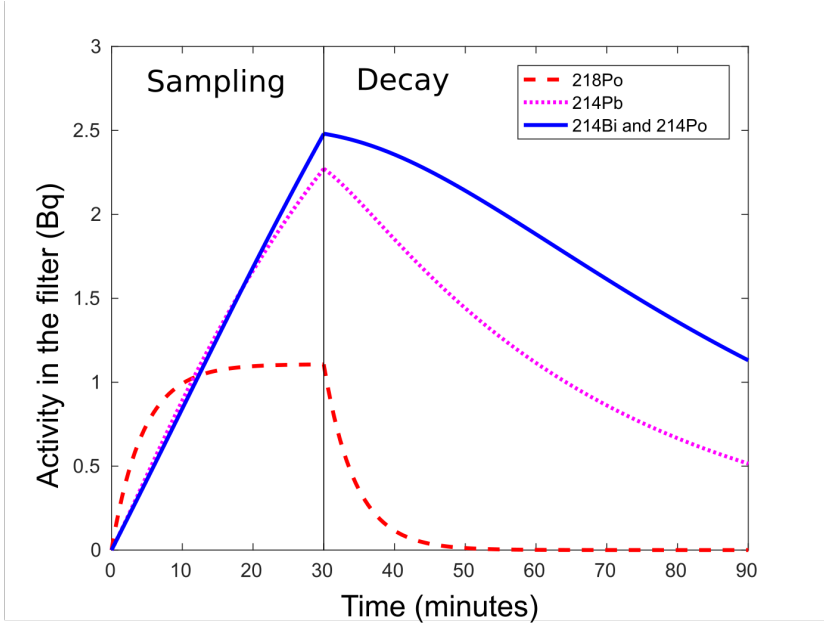


Figure: Sensitivity vs. size of several radon volumetric detectors.

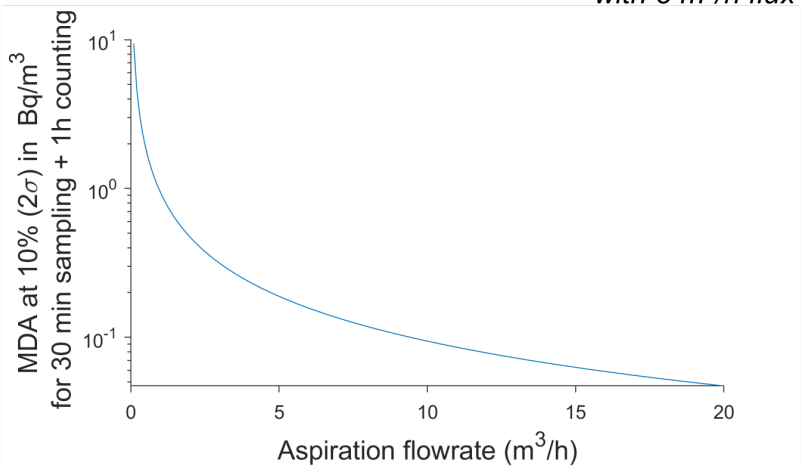
The active filter method



^{238}U decay chain



Active filter method
with 5 m^3/h flux and 1 Bq/m^3



In the field

Figure: Sampling at Bocca Nuova crater (Mt. Etna, Sicily).

The **RAVIOLI** detector

Radon **A**nalysis on **V**olcanoes with **I**n-situ **O**bservations of short-**L**ived **I**sotopes

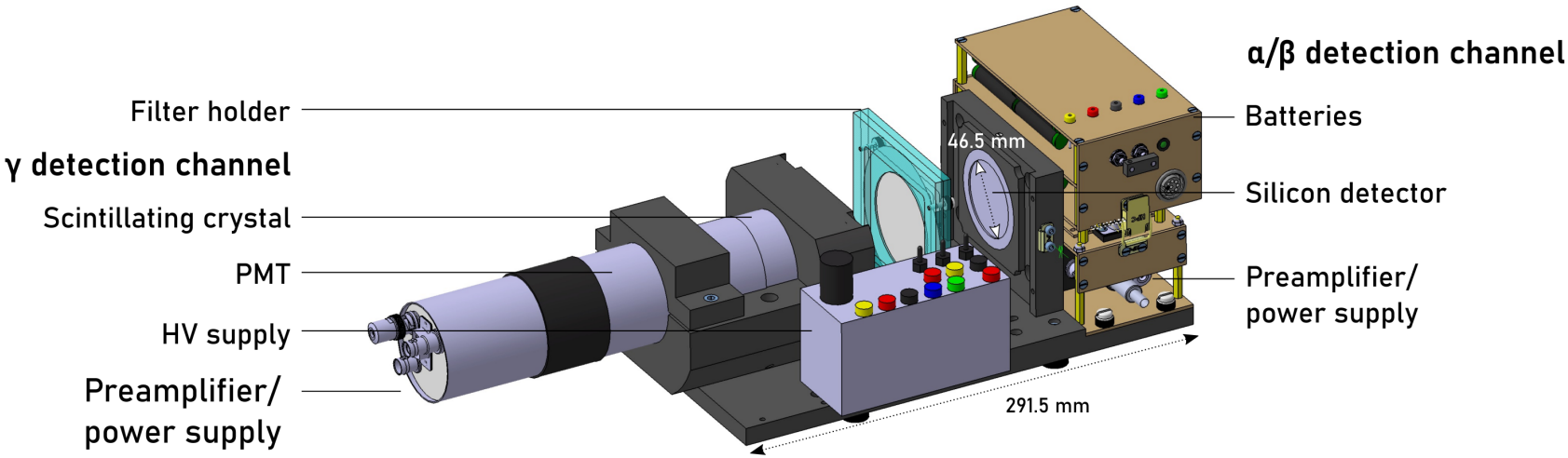


Figure: A field $\alpha - \beta - \gamma$ spectrometer for volcanoes.

Problem 1: filtration efficiency

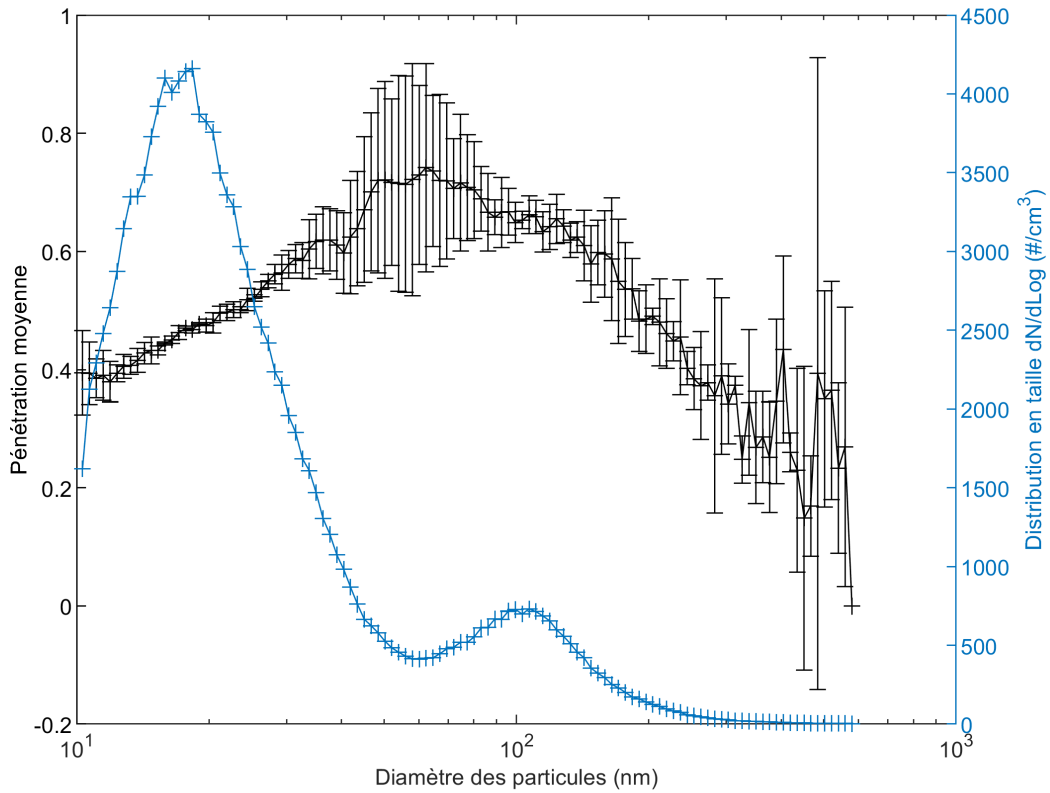


Figure: Aerosol penetration (out/in) through cellulose acetate filters.

Solution: use teflon membranes (and increase pumping power).

Problem 2: α attenuation

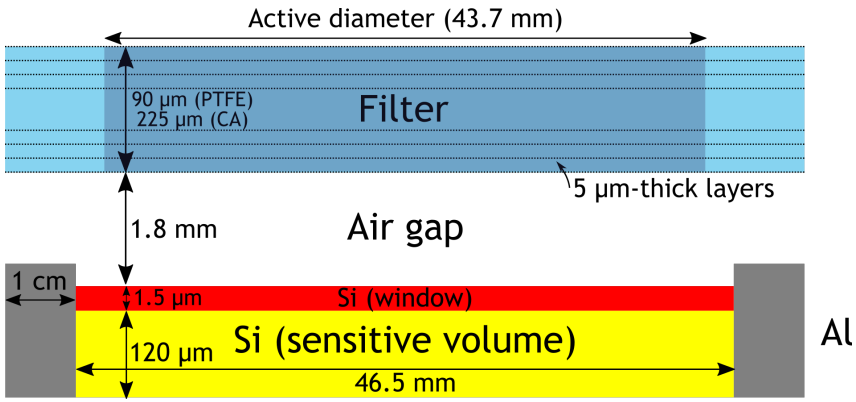


Figure: Detection geometry

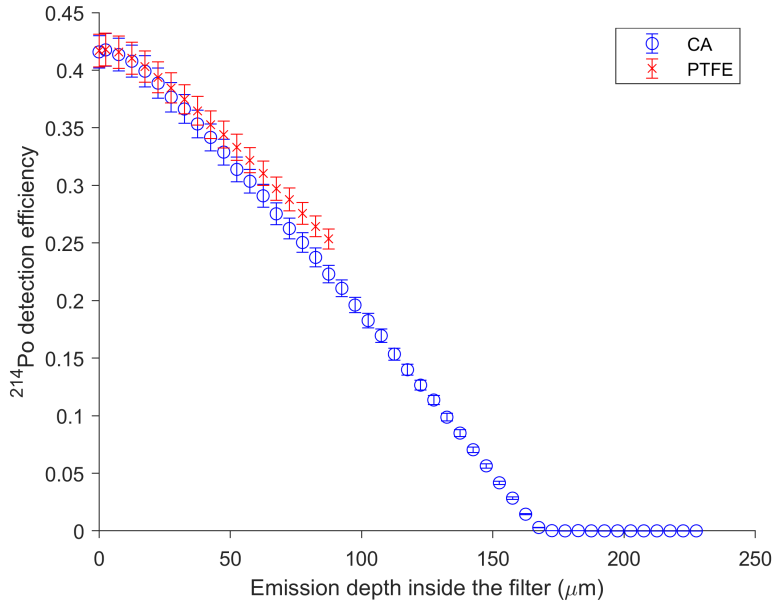
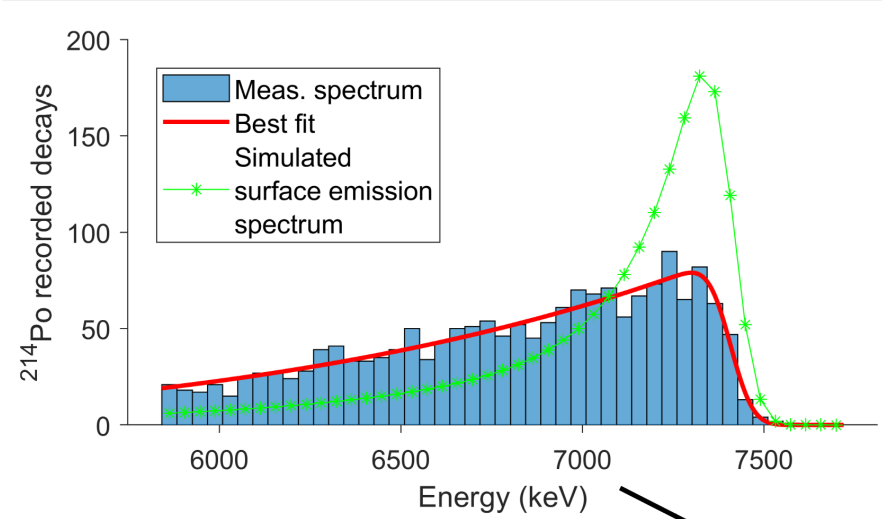
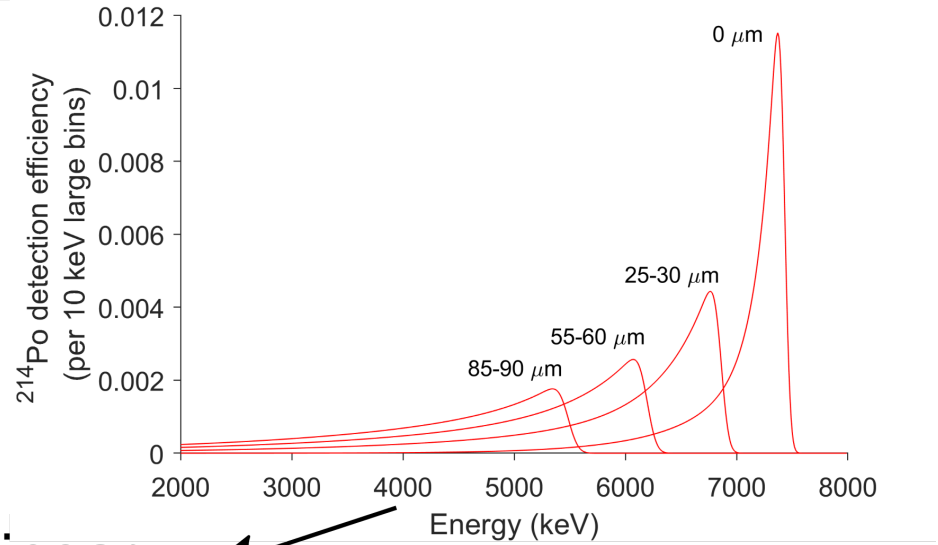


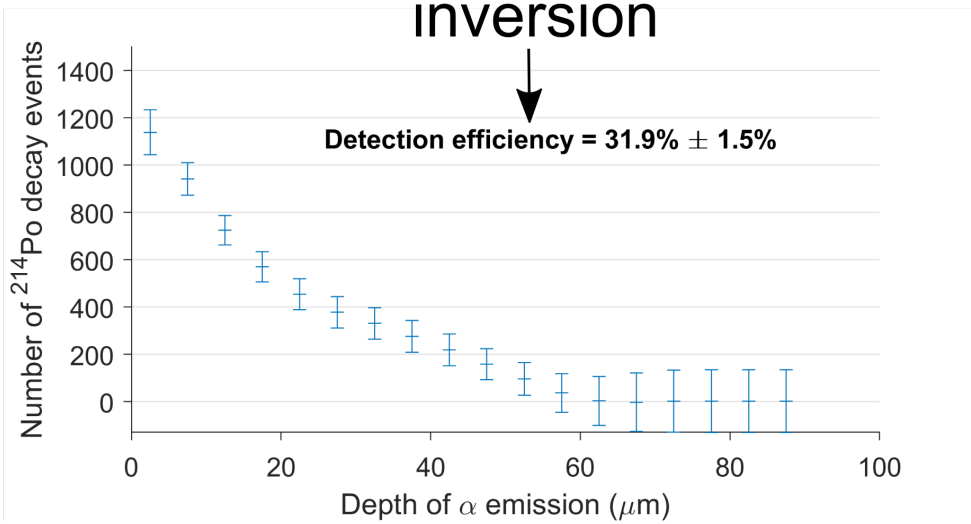
Figure: Efficiency versus depth of emission

Problem 2: α attenuation

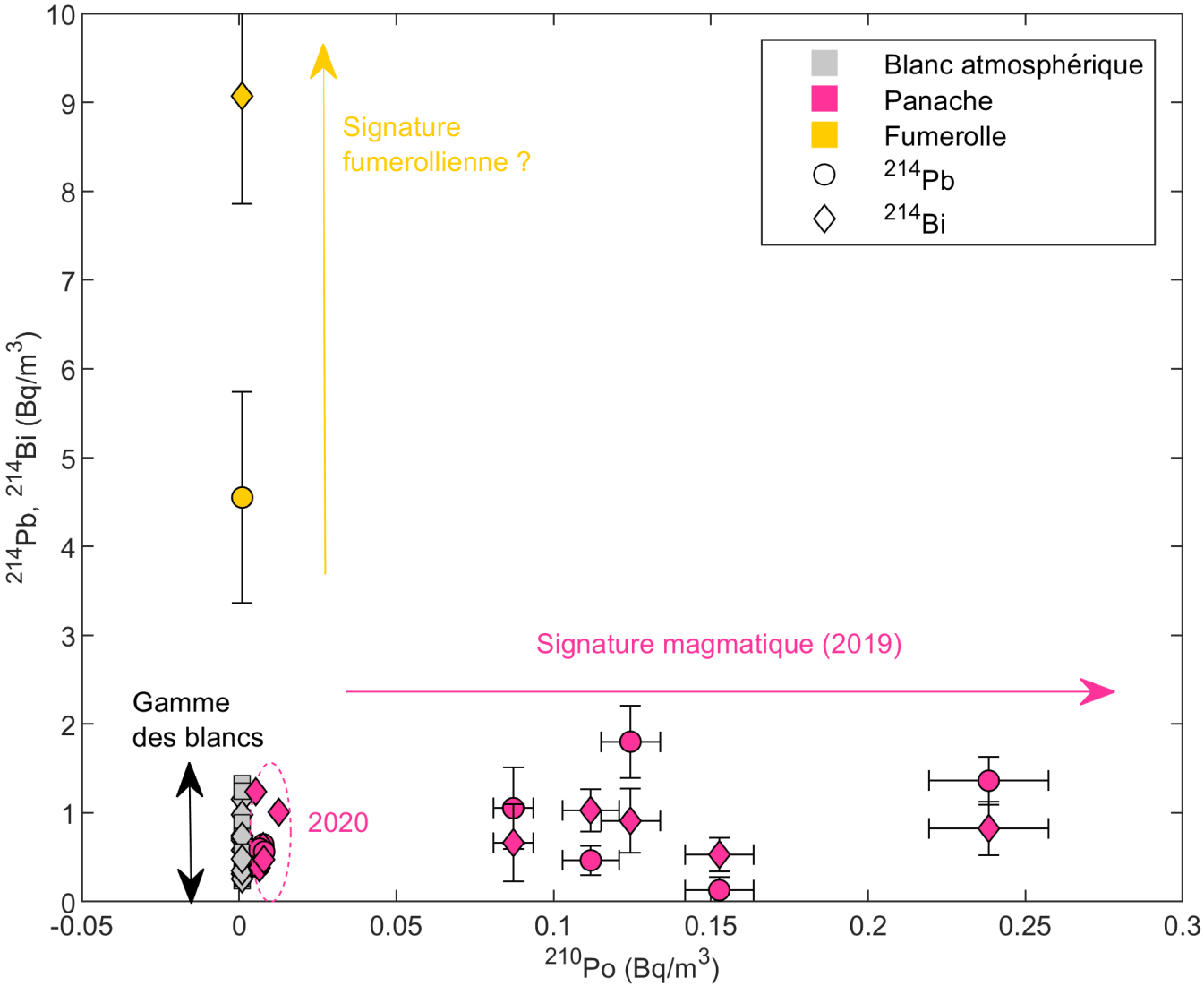




Linear inversion



First results on Mt. Etna



Potential application to very low level measurement of ^{214}Bi for DUPhy ?

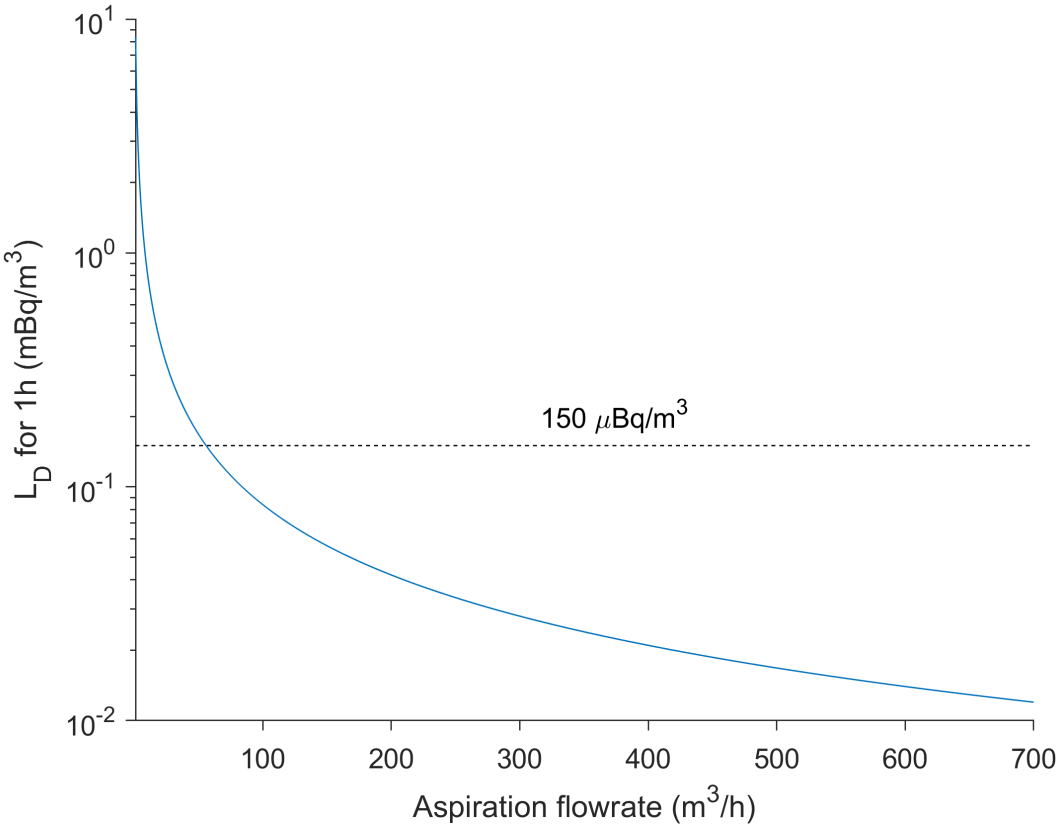
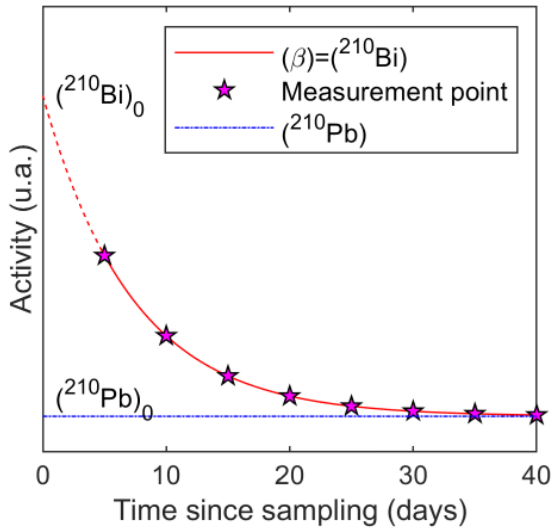


Figure: Detection limit of short-lived radon daughters activity (1h filtration + 1h counting) as a function of aspiration flowrate.

Long-lived radon daughters

Measurement of ^{210}Pb, ^{210}Bi and ^{210}Po on filters by gross α-β counting.



For very low activities ($< 10\,\mathrm{mBq}$ per filter) :

- ^{210}Pb : γ spectrometry at LSM
- ^{210}Po : ID-α spectrometry
- ^{210}Bi : problem (pure beta emitter) $\Rightarrow$ project/idea: beta spectrometry at LSM...

Other radon projects in the lab

- radon emanation from volcanic products (ash, lava, soil)
- numerical modelling of radon degassing in magmas
- radon dosimetry at high time resolution and low activity

Questions ?

Avant

Hopeful volcanologist looking for the last piece of the radon puzzle

Après

Desperate volcanologist looking for the last piece of the radon station