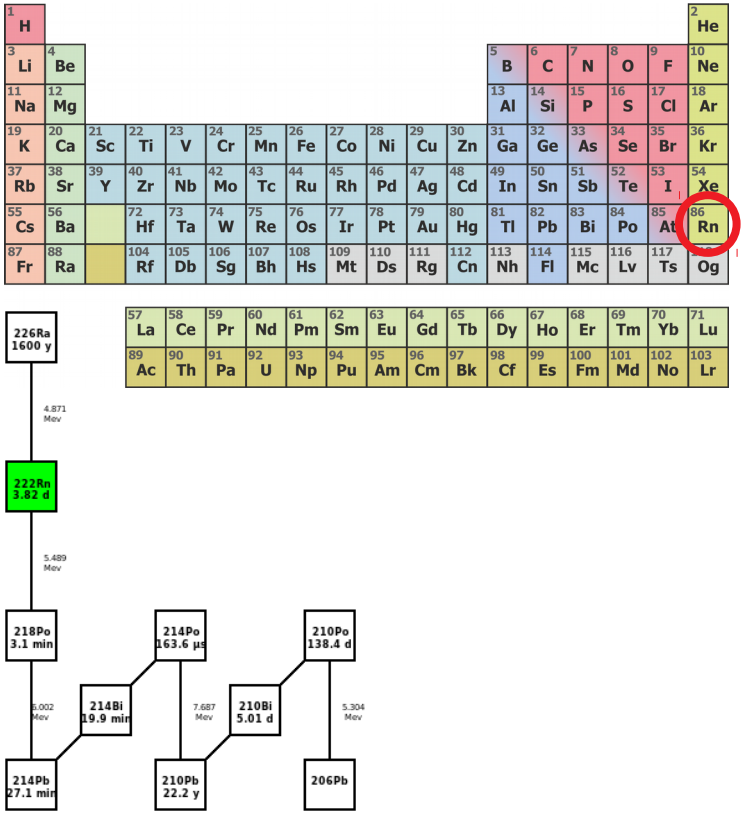
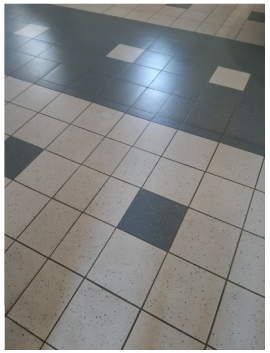
The MicroRadon project

Everything you always wanted to know about radon
but fail to find any data about it

What is radon?



- A noble gas => (almost) no chemistry
- Main isotope ^{222}Rn, $T_{1/2}$ = 3.82 day
- Only trace quantities : 100 Bq/m^3 <=> 1.9*10^{-12} PPM !
- Human exposure: 70 % of the annual radiation dose from natural radiation sources
- Emanate from ground and building materials



CPPM tiels : 950 Bq/m^3/m^2

Radon vs low energy experiments

- 2 big questions for low energy particles experiments:
  - Is dark matter WIMP?
  - What is neutrino nature: Dirac or Majorana?
- Rare events => very low count rate (**~10/year**)
- Low energy events (**kev-Mev**)

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- Particles energies in the radon chain:

α	5-8 MeV
β	≤ 3.27 MeV
γ	≤ 2.20 MeV
Nucleus recoil	~ 100 keV
(α,n) on light nucleus	

- Typical concentration (indoor): **a few 10-100 Bq/m3**

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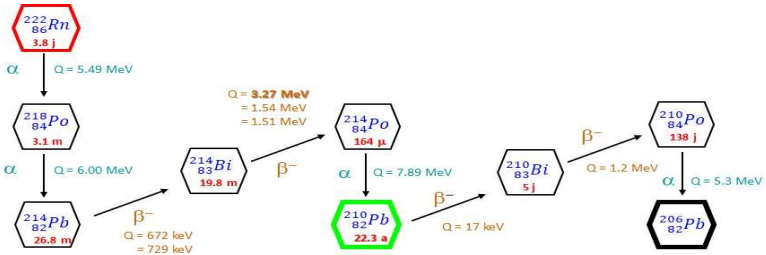
=> should achieve 1-10 µBq/m³ (or µBq/kg)

Where radon background comes from ?



The presence of radon depends on:

- ^{226}Ra concentration in materials

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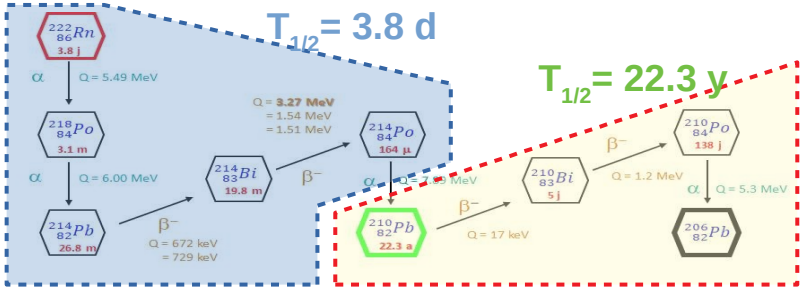

Direct background

No radon => No background

Non correlated background

- Surface contamination
- History of materials

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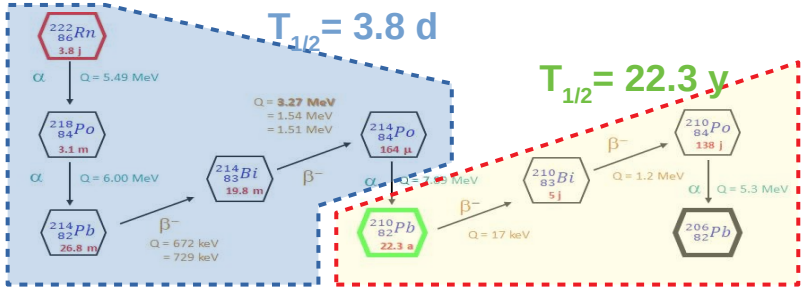

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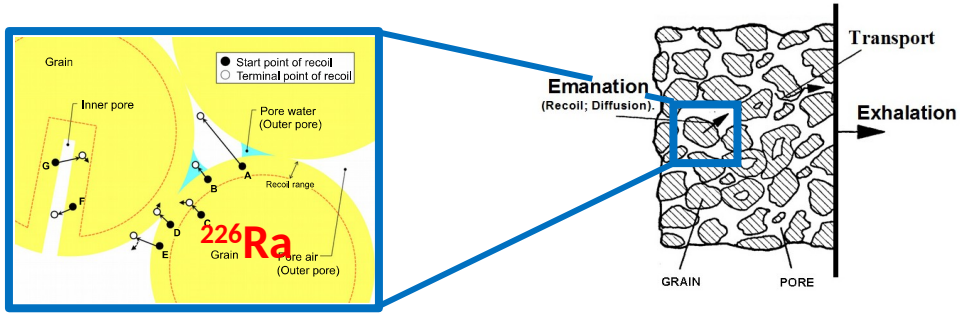

A, F => radon in inter-grain : transport
B => radon stop in liquid => transport
E, G, D, C => radon is inserted in neighbouring grain: radon lost

The presence of radon in the detector depends on:

- ^{226}Ra concentration in materials
- History of materials
- Temperature
- Composition of inter-grain: humidity, gas (He, Xe, air...))
- Porosity (self-adsorption)
- ...

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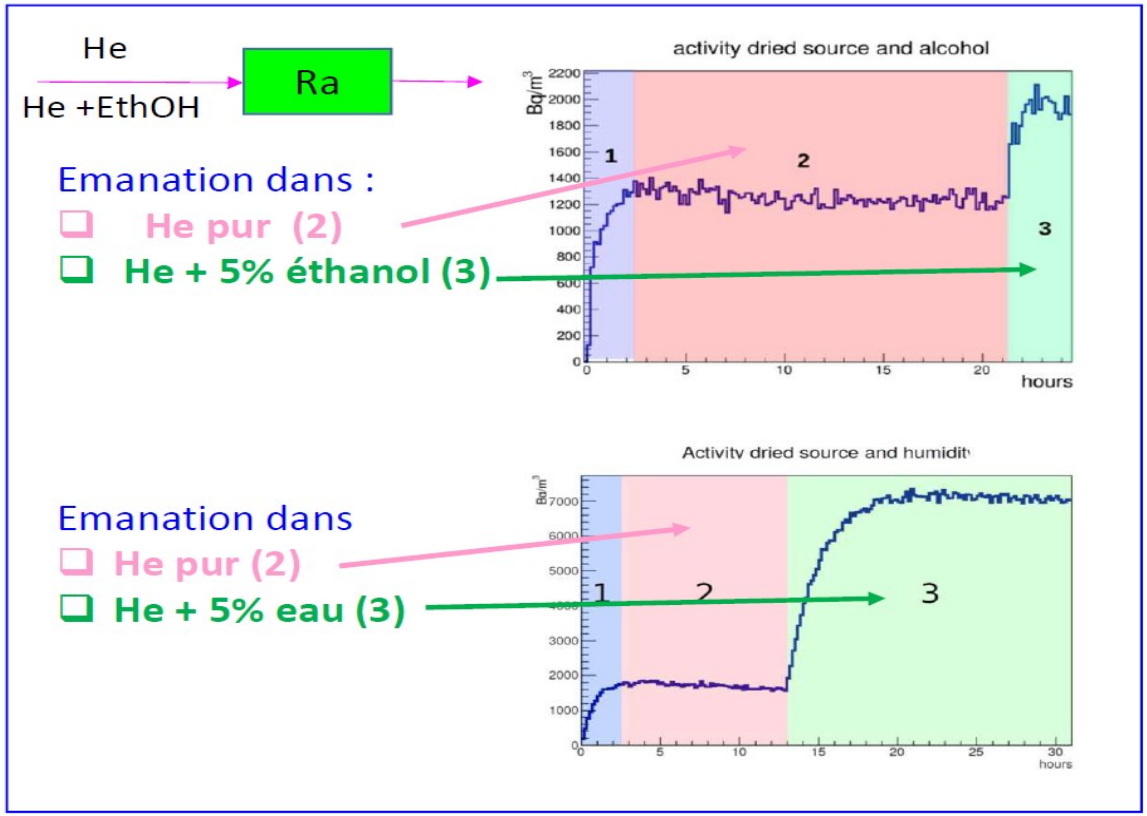
High dependence on the gas environment

Not much data on exotic environments



The MicroRadon project

- Goals of the MicroRadon project :
  - Study the fundamental mechanisms of radon background (**emanation** and **transport**) as close as possible to the required experimental conditions;
  - Develop new materials and **capture** techniques;
- 1.5 years old
- 3 CNRS-IN2P3 laboratories are involved:

MicroRadon - Emanation

State of the art

- Emanation studies are almost exclusively performed in N_2, He or vacuum.
- Very few data are available as function of temperature, gas composition in particular heavy gases (Xe).

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CENBG emanation setup

A **710 l** large chamber in stainless steel

+

70 l detector sensitivity ~**1-3 mBq/m^3**

- For large samples to be qualified at **room temperature**
- Emanations performed in **N_2, He, air or vacuum**

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- A 10 l chamber in a freezer (**0 °C to -80 °C**) for smaller samples and various gas composition (Xe especially)

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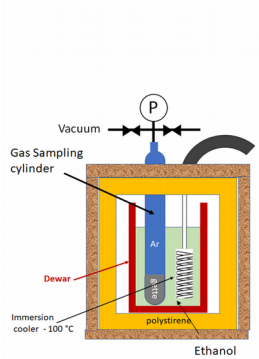
CPPM emanation setup



Huber TC-100 (20 to - 100°C)

Cryocooler **20 to -100 °C**
0.5 l cylinder
From **vacuum to 50 bar**

- Study the fundamental mechanisms of emanation on a reference source as a function of:
  - Temperature
  - Humidity
  - Pressure
  - gases and in liquid gases.

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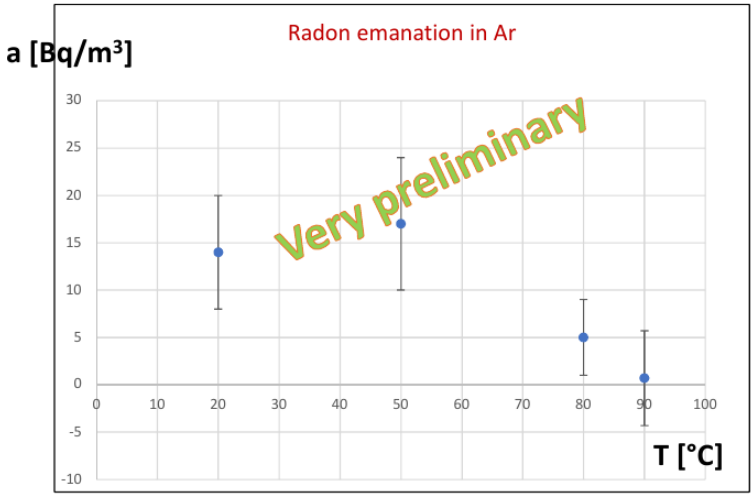
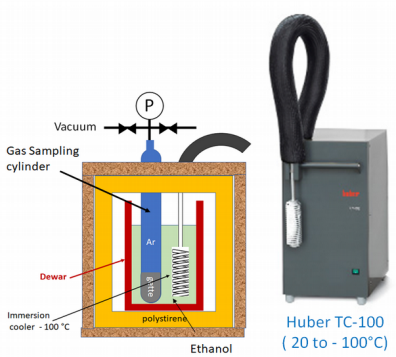
Radon emanation from Cu-getter in Ar → DUNE



Pore closure with decreasing temperature ?

CPPM emanation setup



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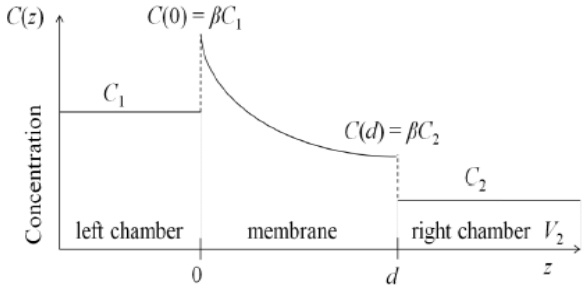
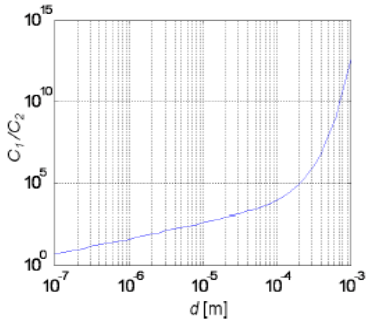
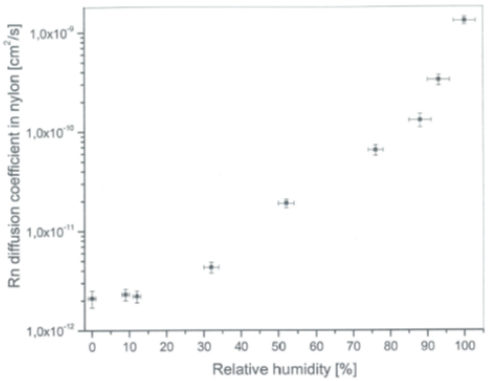
MicroRadon - Diffusion

State of the art

- Less abundant literature than for emanation
- Few data exist on the diffusion as function of temperature or gas.

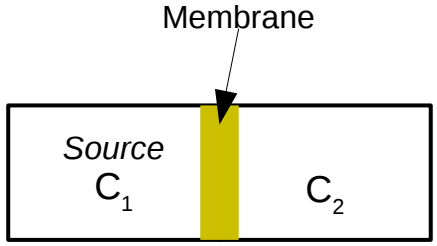




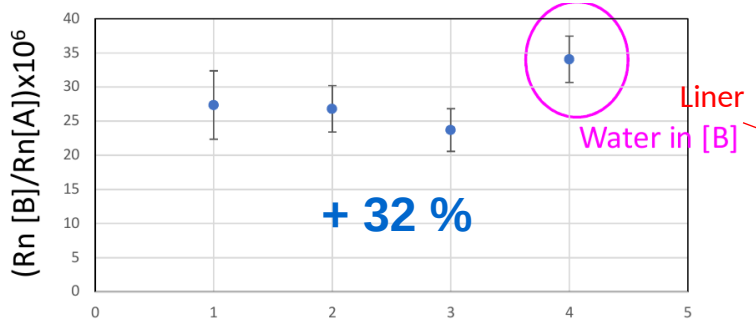


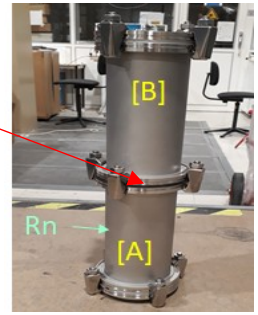
Factor 10^3 on diffusion coefficient

High dependance on humidity



Radon transparency in JUNO liner



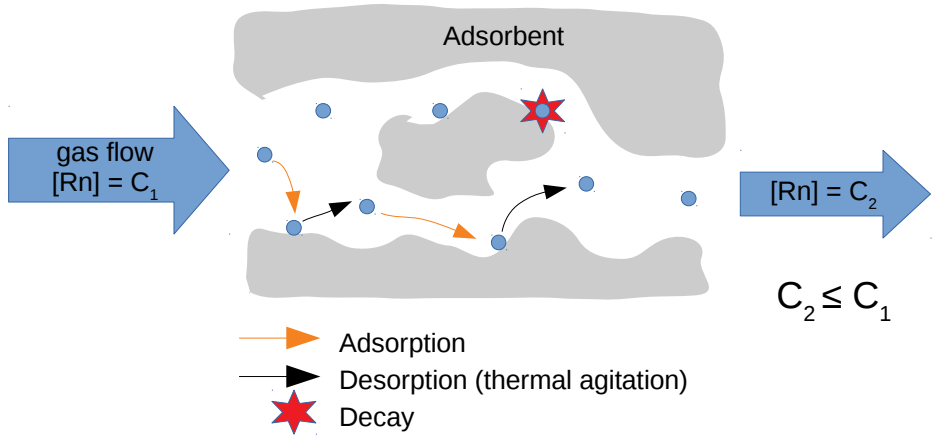


MicroRadon - Capture

State of the art

- Noble gas => no chimical bond
- Physical capture on surface : Van der Waal forces + polarizability

Radon capture mechanism



- No permanent capture (adsorption – desorption equilibrium)
- Slowdown of radon in the column
- If radon decays in the adsorbent => definitly captured

=> **The aim is to slow down the radon enough to achieve a suitable concentration at the outlet.**

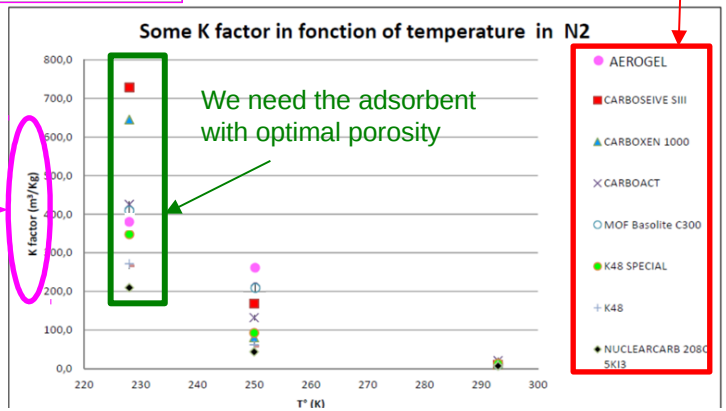
MicroRadon - Capture

State of the art

- Noble gas => no chimical bond
- Physical capture on surface : Van der Waal forces + polarizability
- For the moment almost only activated charcoal has been studied with N_2 gas flow

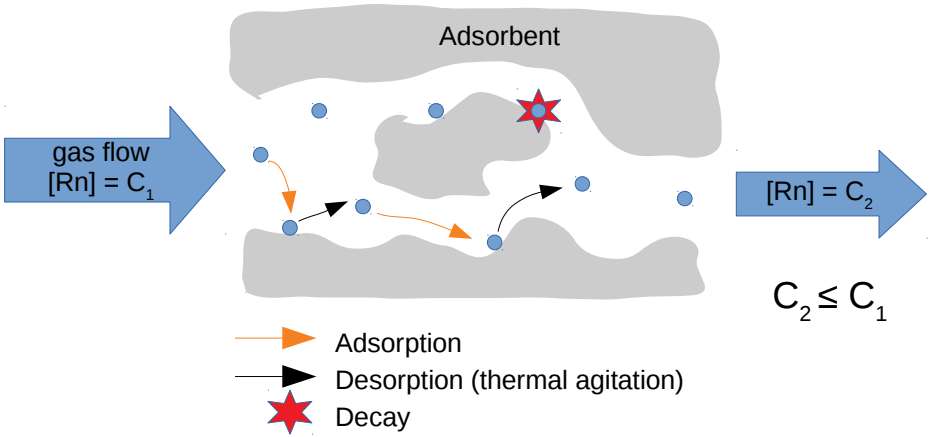
$$K = \frac{Rn\ in\ the\ Adsorbent}{Rn\ in\ the\ Gas}$$

Carbon adsorbants



=> Optimization of: porosity, temperature, chimical composotion

Radon capture mechanism



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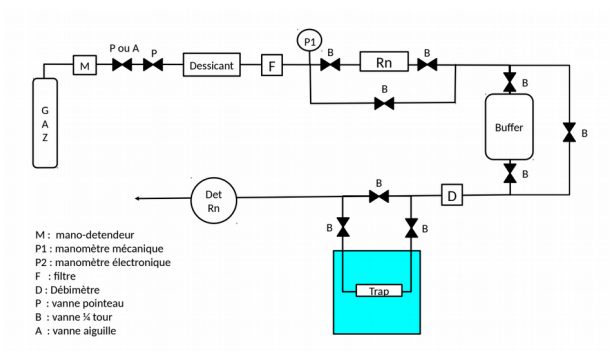
Test bench



- 2 tests bench at CPPM and IPHC
- Small samples: 0.25 – 1 g
- From +20 to -80 °C
- Dynamical adsorption study ~ 1000 Bq/m^3 of ^{222}Rn at 60 l/h
- Open or close circuit (to save gas, Xe…)
- Measurment of radonized samples with a Ge detector

Materials to be tested

- Silver zeolites => huge improvement of capture capacity (*collaboration with IEAP Pragues and Alberta University)*
- Cryptophanes (molecular cages) => high selectivity of captured atom (Rn/Xe) *(collaboration with ISM2)*
- New carbon based materials, carbon foam… *(collaboration with Jean Lamour Institut)*

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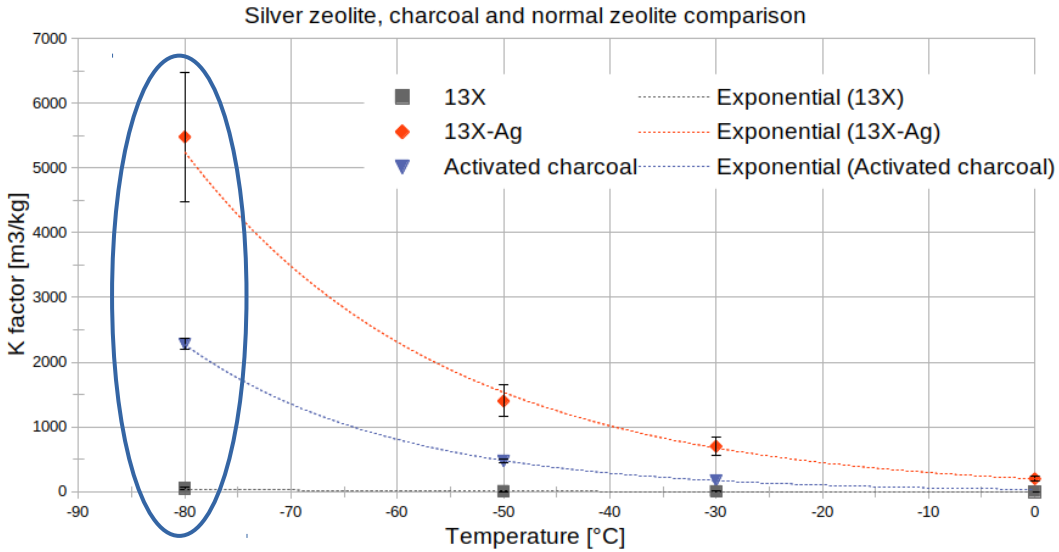

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- **Better results with silver zeolites than with charcoal**
- **Huge effect of silver in radon adsorption !**
- **Why silver ? Nobody knows !**

Conclusions and prospects

- Radon is one of the most complex backgrounds.
- A huge contributor to background in low energy experiments.
- Significants progress have been made over the past decades, but there is still a significant lack of data.
- The MicroRadon project can contribute to a **better understanding of the mechanisms** of radon background and how to reduce it.
- New tests bench to build:
  - a radon chamber to study the surface contamination by the ^{210}Pb ;
  - radon emanations in liquid-gas.
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- Still a lot of work and a lot of (new) questions. Come and work with us :-)