The MicroRadon Project

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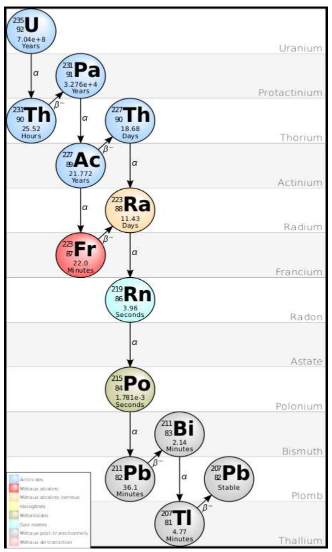
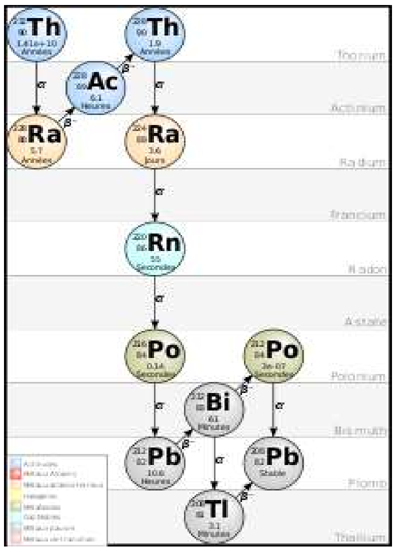
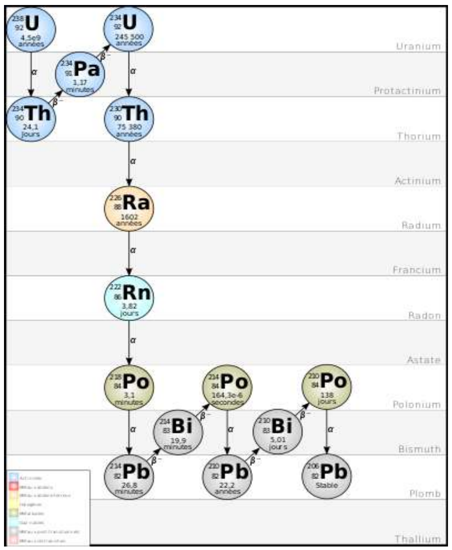
Radon : Radioactive, Natural, Noble gas, produced in U and Th decay chain





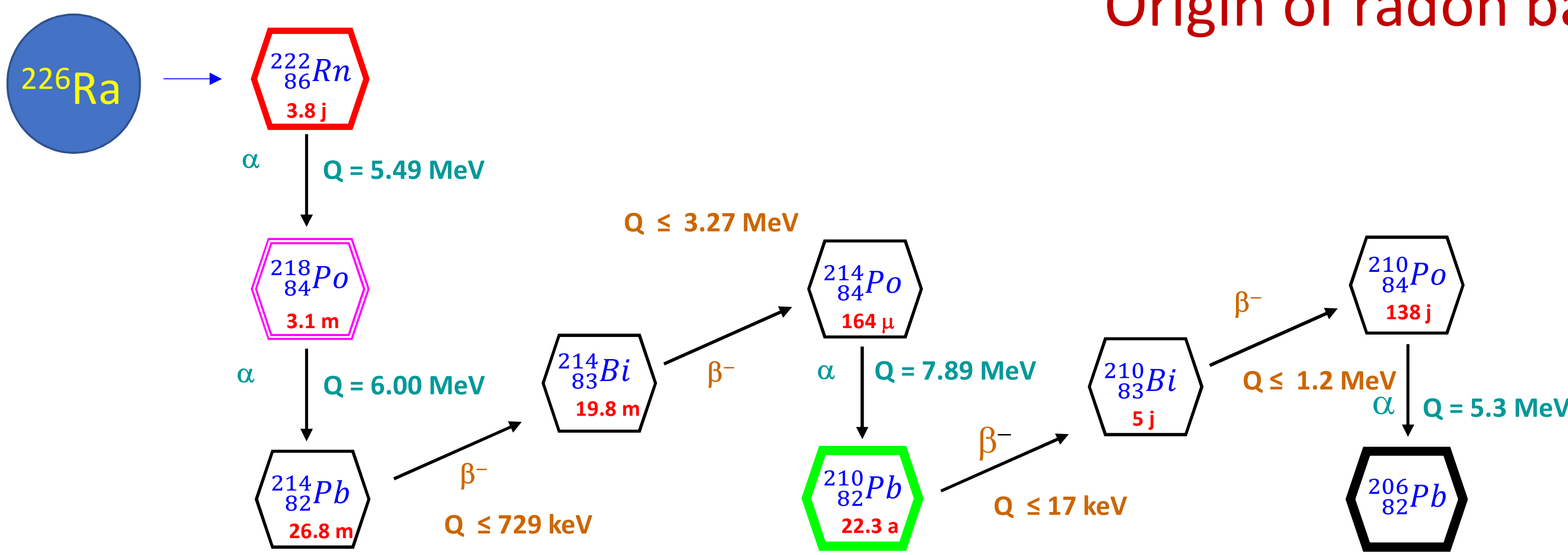


^{219}Rn (3.96 s)

^{220}Rn (55 s)

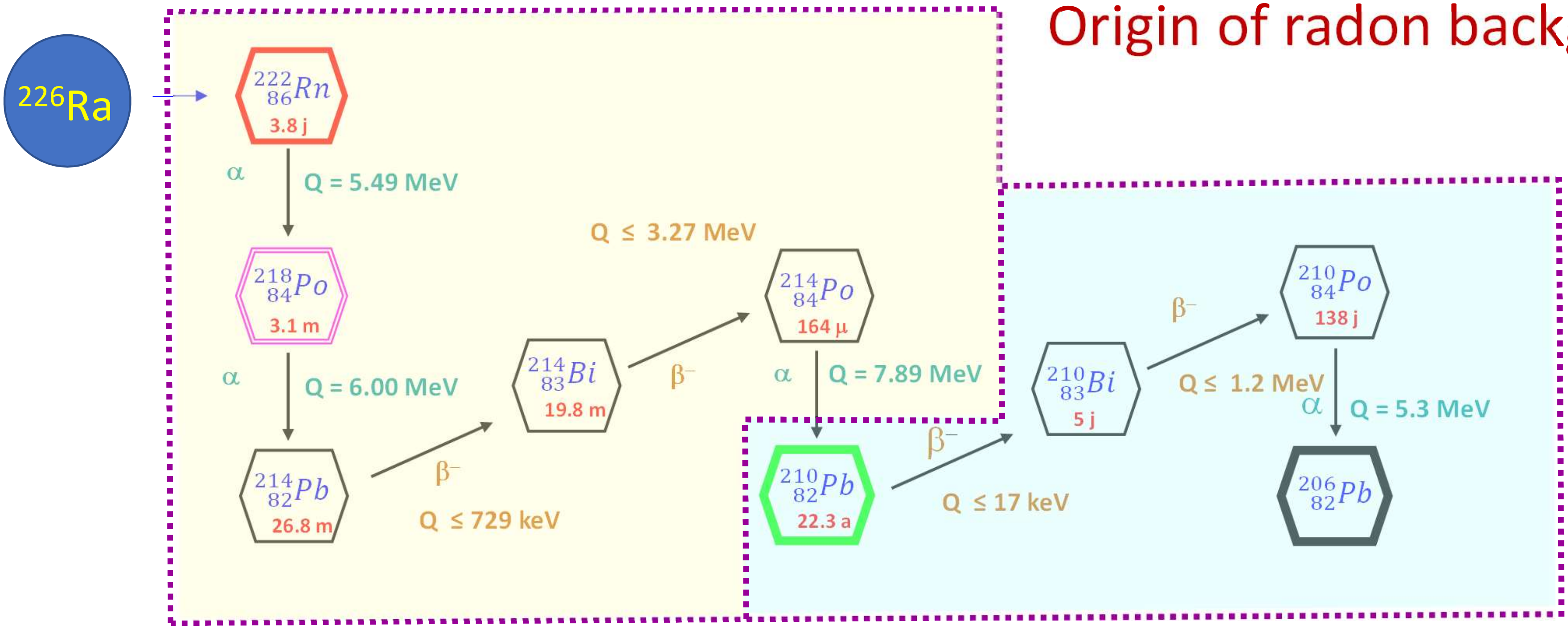
^{222}Rn (3.82 d)

Origin of radon background



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

Origin of radon background



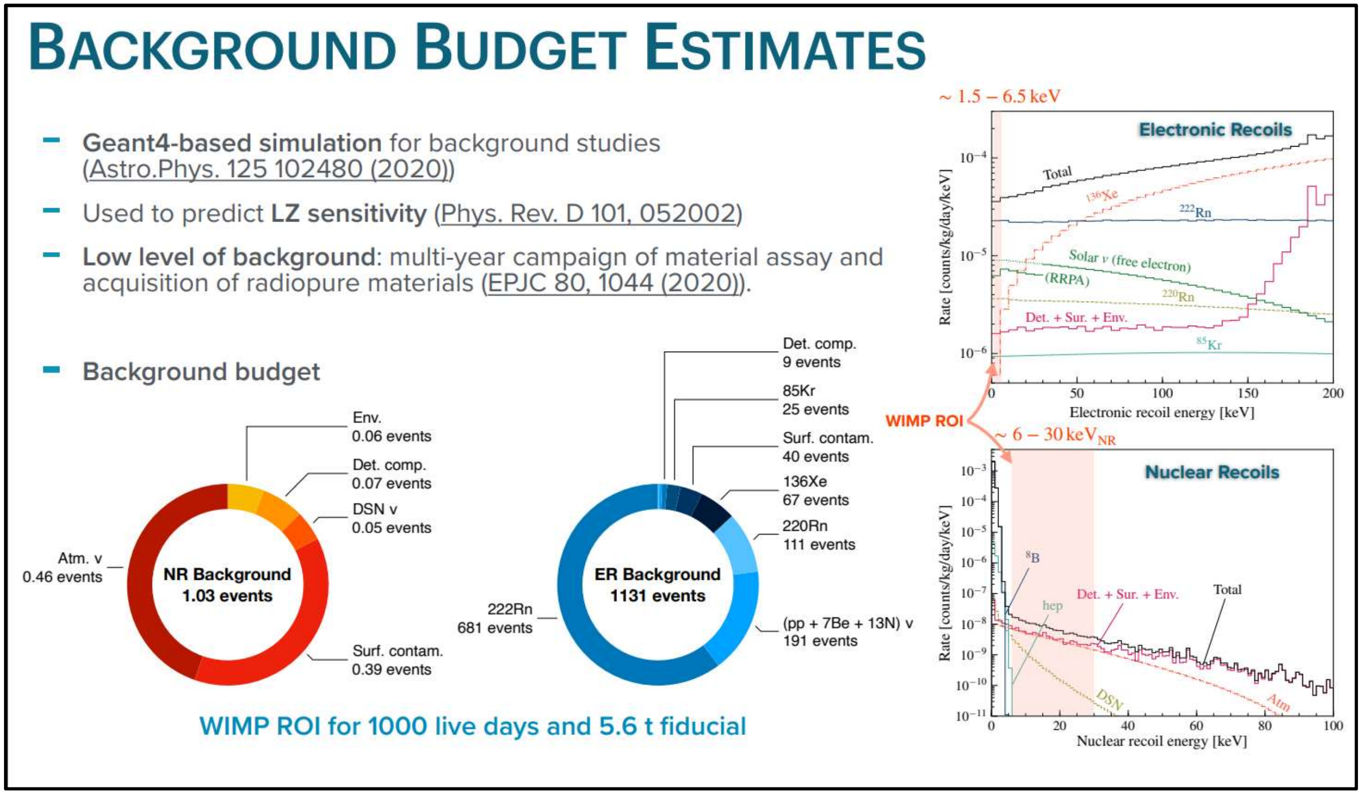
Direct background

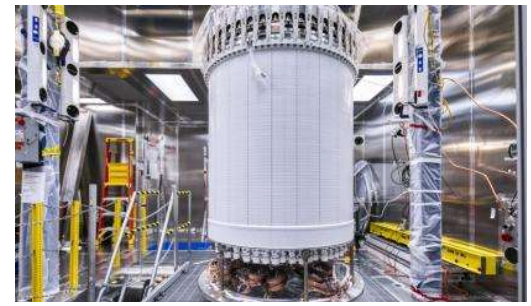
No radon => No background

Not corelated background

- *Surface contamination*
- *History of materials*

Radon contraints





LZ Dark Matter Experiment (Liquid Xe TPC)

μRn

The MicroRadon Projet

Master Projet of IN2P3

Start in Janury 2020 (with COVID)

Goal : study the fundamental mechanisms of radon background (emanation and transport) under severe or special experimental conditions. Develop new materials and capture techniques.

LP2i Bordeaux

CENTRE DE PHYSIQUE DES PARTICULES DE MARSEILLE CPPM

IPHC Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

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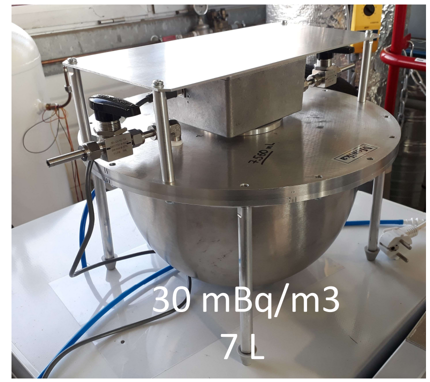
Chemistry and Material Science

Equipment and facilities

- **Radon detection**



AlphaGuard (~ 5 Bq/m^3)

Rad 7 (~ 5 Bq/m^3)

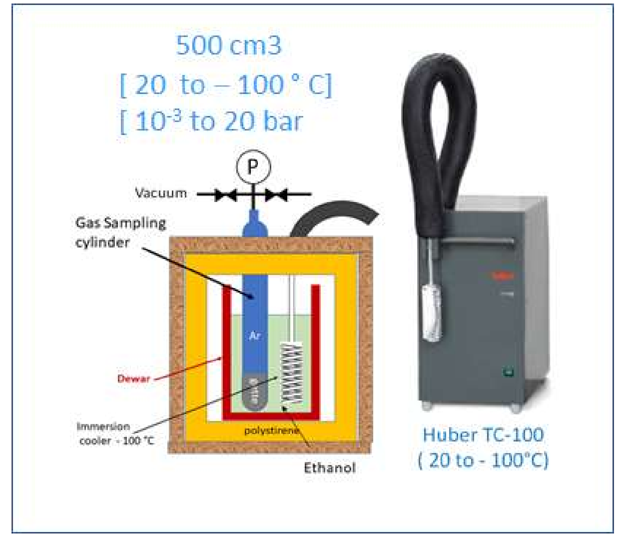
RadonEye (~10 Bq/m^3)

LUCAS cell (~20 Bq/m^3)

➢ Radon emanation chamber

SuperNEMO, JUNO emanation in N_2

Emanation studies in Ar, Xe, He,



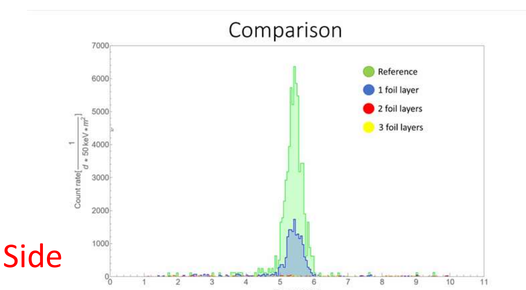
Cu getter émanation for DUNE (20 to – 90° C)

➢ Radon chamber

5 L, 25 kBq/m^3
Temperature and %HR controled

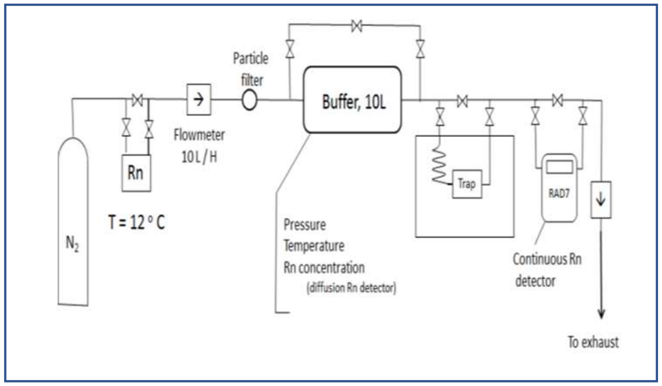
30 L, 100 kBq/m^3 + test chambre

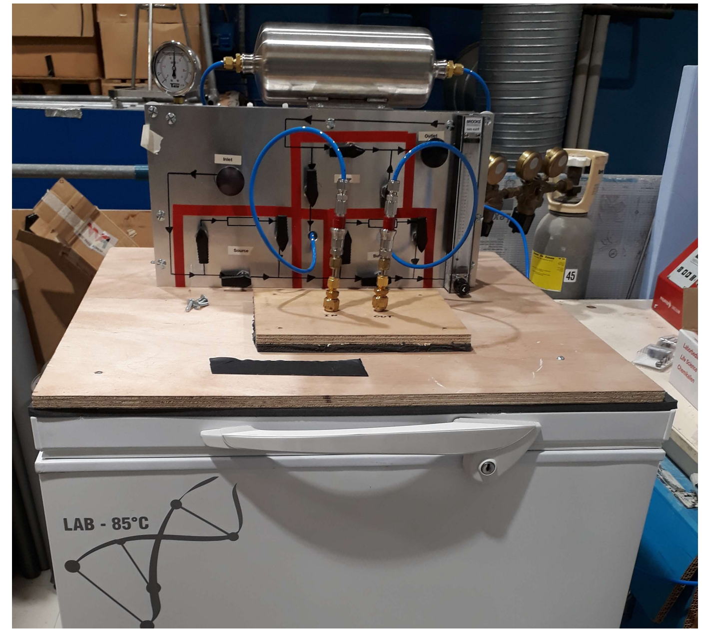
^{210}Po deposition
on Cu plates for Dark Side



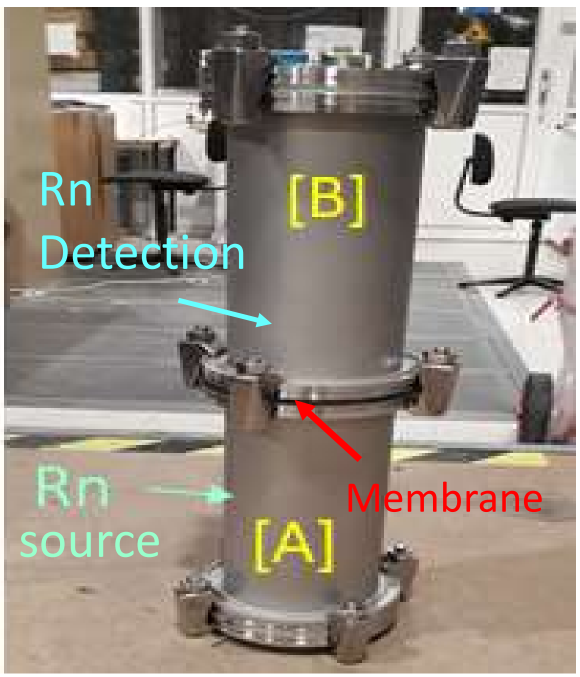
➢ Study of dynamical radon capture [+ 20 to – 80 °C]

Porous optimization for
Rn adsorption in carbon
adsorbents → SuperNEMO





$$K = \frac{Rn\ in\ the\ Adsorbent}{Rn\ in\ the\ Gas}\ [m^3/kg]$$

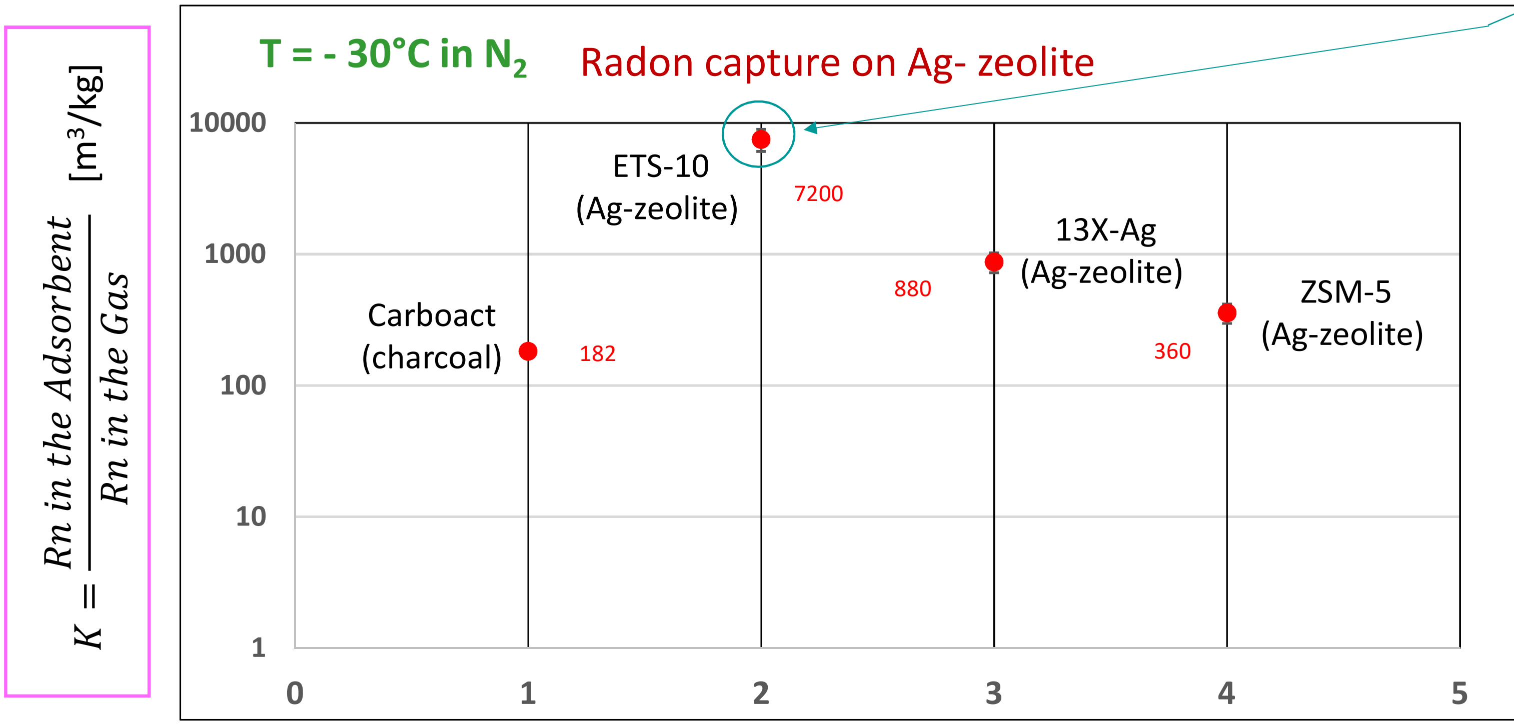


➢ Radon diffusion (bi-)chamber

Radon diffusion of JUNO liner in air/water μRn

Some preliminary results

❑ Adsorption **on silver** zeolite



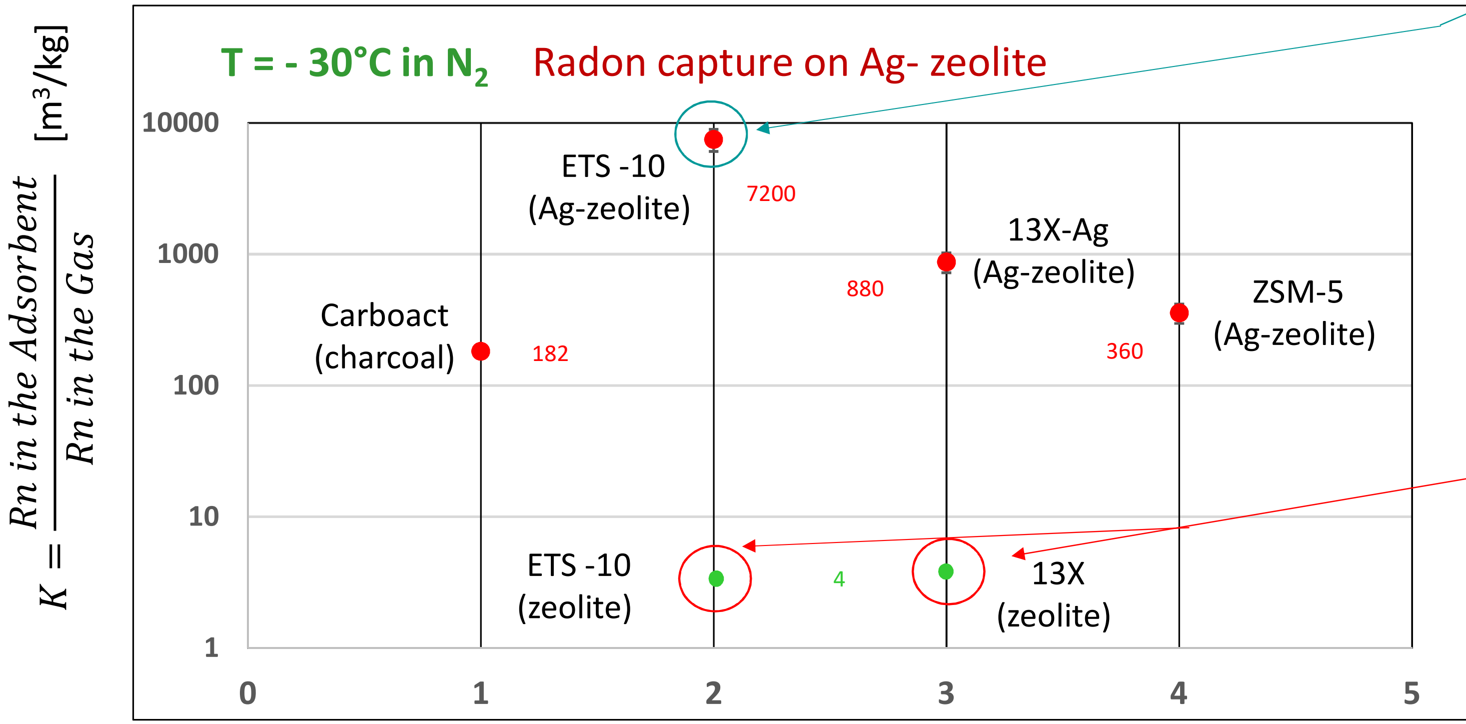
Very high adsorption (K factor)

⇓

Huge Rn reduction in a column :

$$\rho \propto (2)^{\frac{m \cdot K}{\varphi \cdot T_{1/2}}}$$

❑ Adsorption **on pure** zeolite



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No Rn adsorption on pure zeolite

Very important effect of silver on radon adsorption

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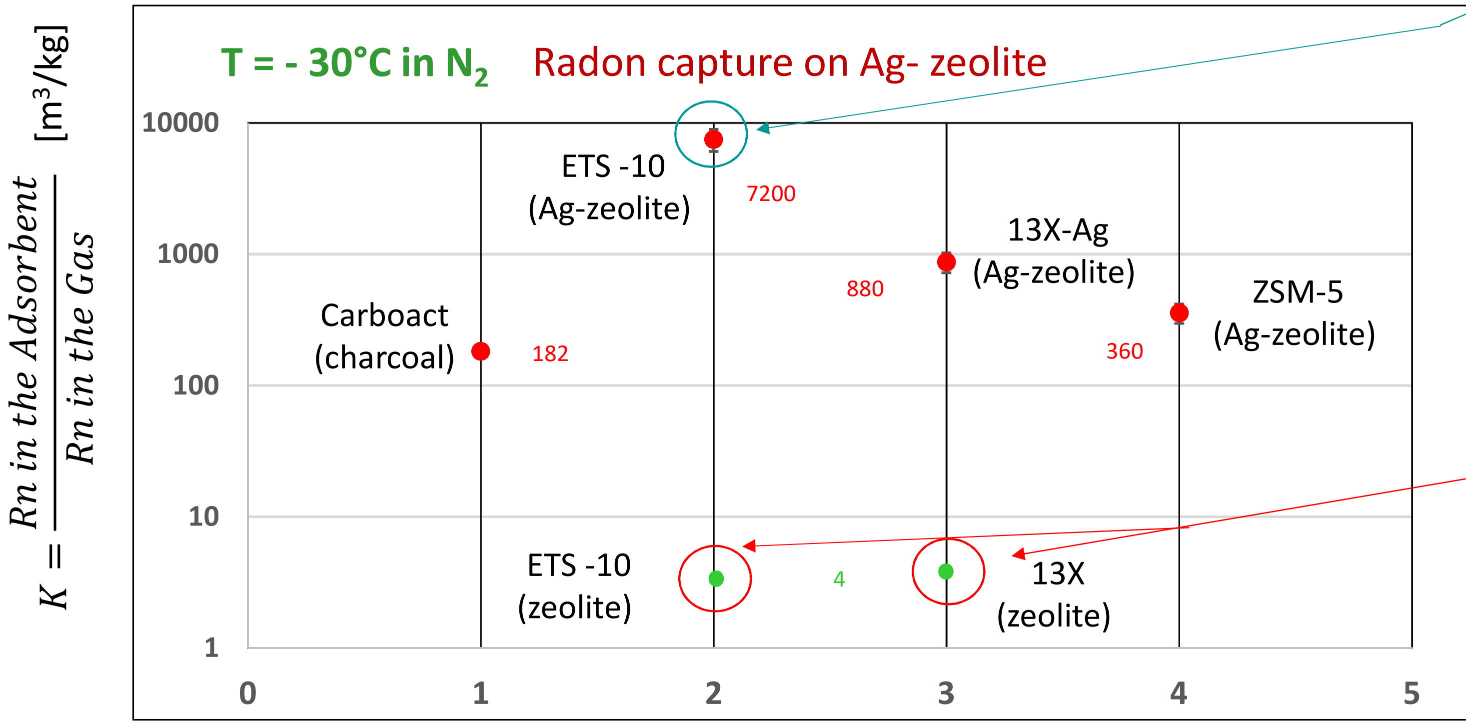

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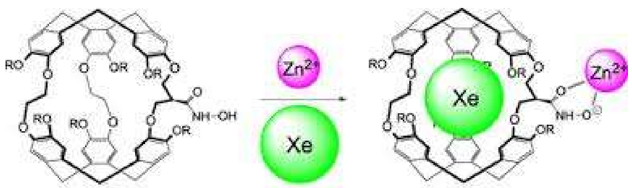
ETS-10 extraordinary adsorbent but, with very high dependence to water traces and little internal radioactivity

Optimisation of radon adsorption in porous materials v.s. the chemical composition should be further investigated

❑ Xenon / Radon adsorption selectivity with macromolecular cages : **Cryptophane**



2: R = $CH_2COO^{\ominus}$

- Used for xenon storage
- Tunable size of the cage

=> Xenon and Radon very close atomic radius *(ρ_{Xe} = 4.10 Å, ρ_{Rn} = 4.17 Å)*

→ purification of Xenon by gas chromatography is very challenging

iSm2 Institut des Sciences Moléculaires de Marseille UMR 7313

Study radon and xenon adsorption on crytophanes

Adsorbent	Rn capture in N2 @ - 30°C	Xenon adsorption @ -30°C
Cryptophane A in MCM-41	107 m3/kg	0.11 mmol/g
Active charcoal K 48	180 m3/kg	2.31mmol/g

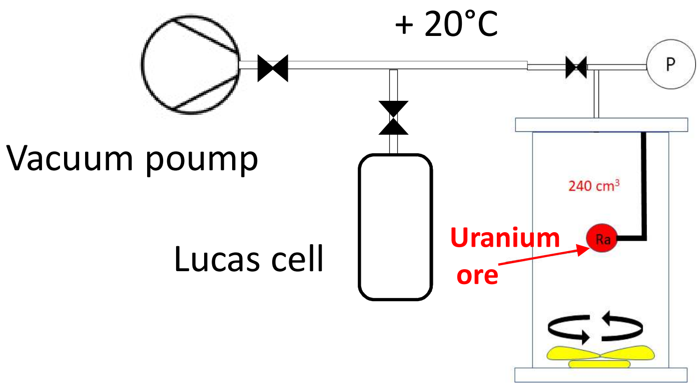
High selectivity for radon compare to classical active charcoals

=> highly promising Rn/ Xe selective materials

❑ Emanation in Xe

Big amount of data emanation in N_2, air, Ar, ..., but almost nothing in the Xe

Gas phase



Very preliminary results

- Ar : 11261.9 ± 141.2 Bq/m^3
- Xe : 11169.6 ± 275.6 Bq/m^3

Lucas cell efficiency : $\frac{\varepsilon(Ar)}{\varepsilon(Rn)} = 1.7$

➡ Emanation in Xe ~ 1. 7 x Emanation in Ar

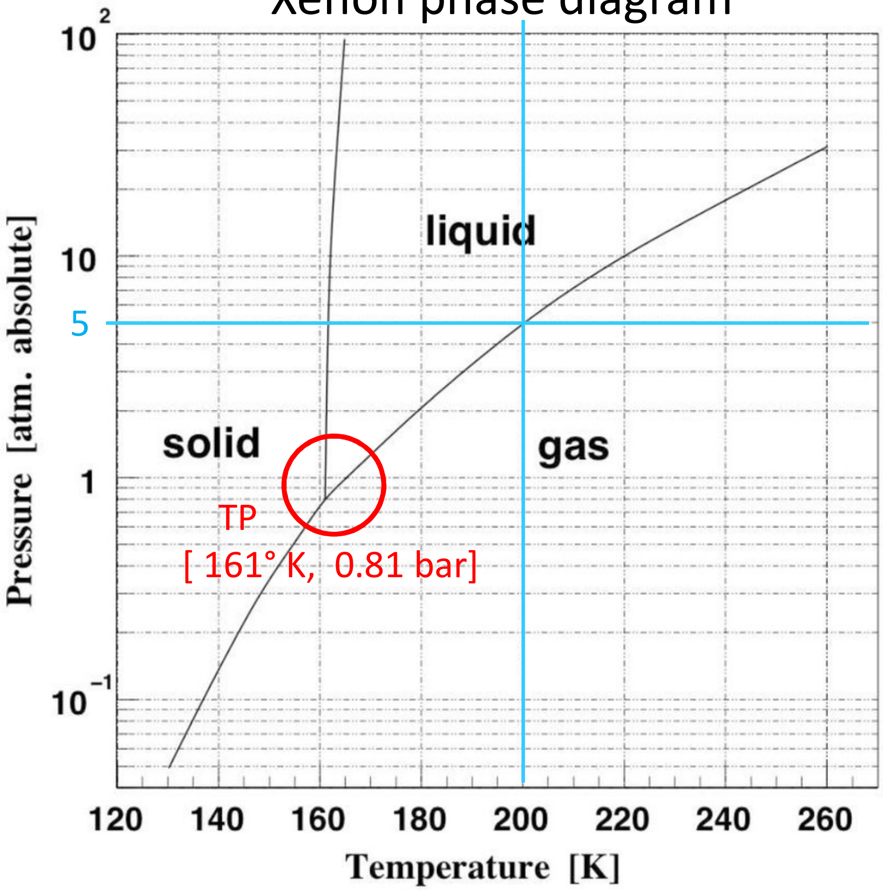
To be confirmed with other gases and other Rn sources

↳ depend on the texture, porosity, roughness, of the sources

Liquid phase

What is the effect of liquid phase on radon emanation ?

Xenon phase diagram



- Available cryogenic system => - 90°C

=> Study of liquid phase effect at -73° C at different pressures.

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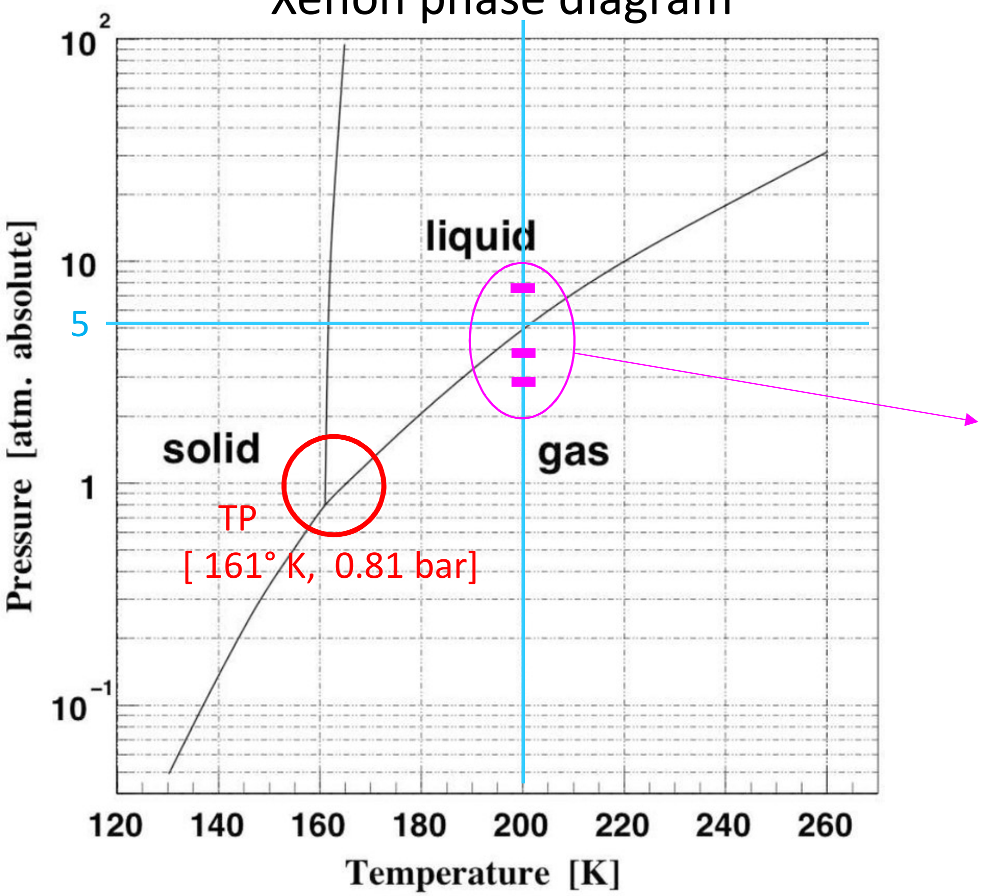

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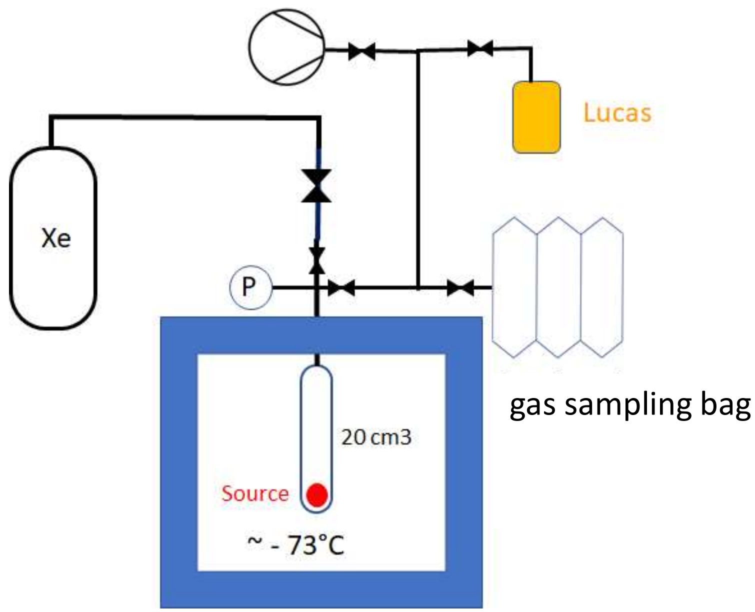
=> Study of liquid phase effect at -73° C at different pressures.

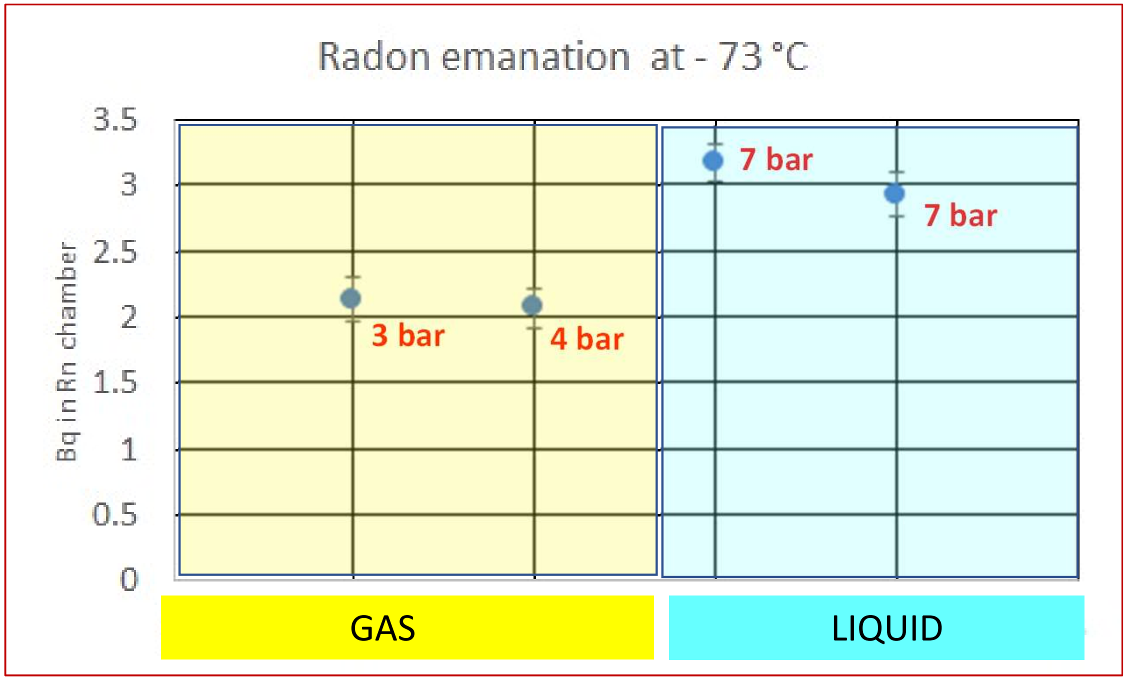
Several measures :

- in gas phase @ 3 bar and 4 bar
- in liquid phase @ 7 bar

Liquid phase



Radon emanation setup



Emanation in liquid phase Xe ~ 1. 4 x Emanation in gas phase

Very preliminary results (last week)

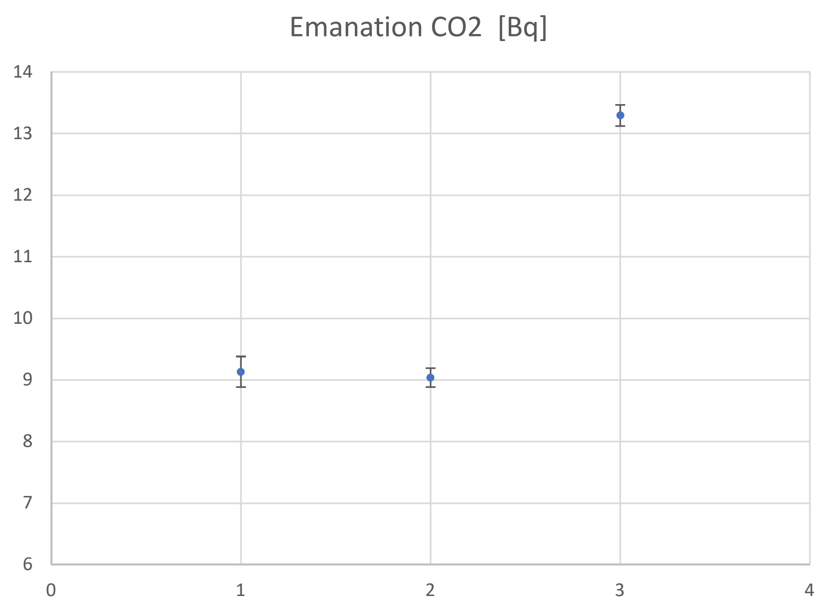
Conclusion

- MicroRadon is a general project for the study of radon in extreme or particular configurations.

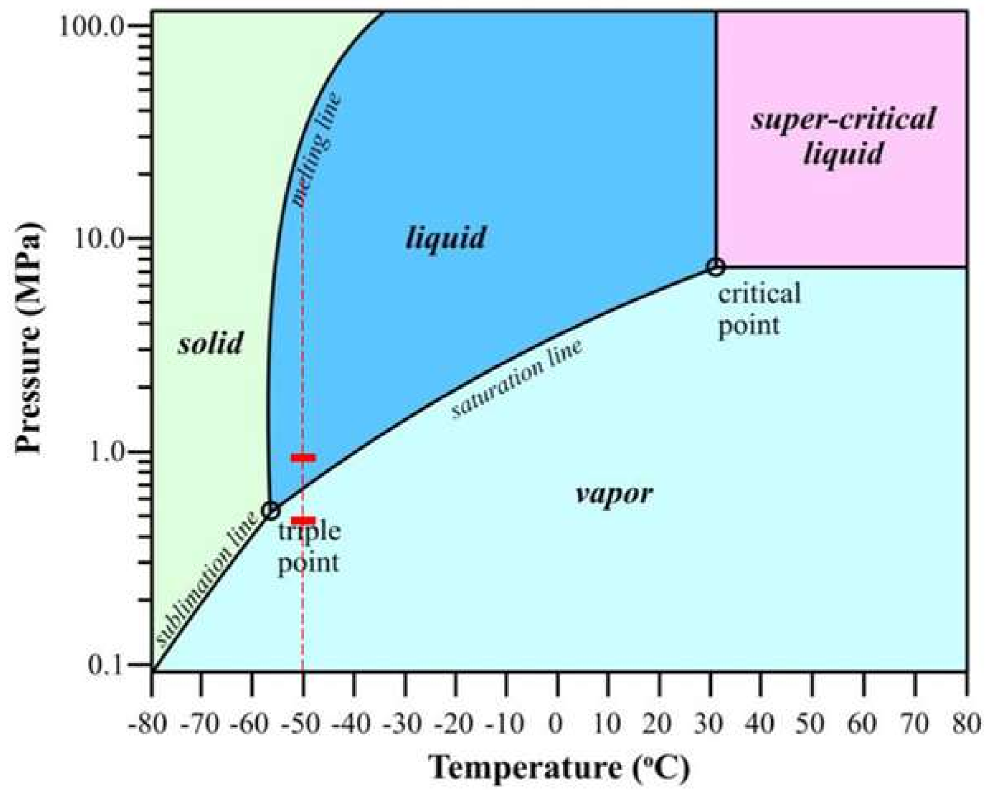
- The very preliminary results obtained show the possibility of using much more efficient and highly selective adsorbents in the future.

- The first studies on emanation in gas and liquid xenon have just started.

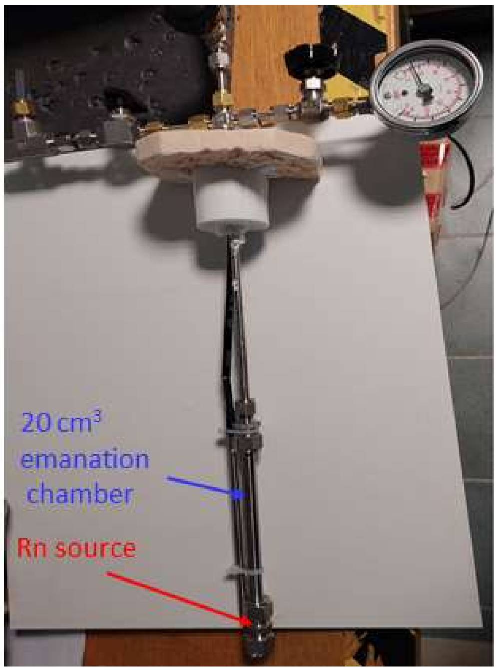
Thank you for your attention



Emanation CO2 [Bq]
14
13
12
11
10
9
8
7
6
0
1
2
3
4



100.0
10.0
1.0
0.1
Pressure (MPa)
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80
Temperature (°C)
solid
liquid
vapor
super-critical liquid
melting line
saturation line
sublimation line
critical point
triple point


20 cm3
emanation
chamber
Rn source