Gas Purification System

for an Alpha counter

GPS

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Deep Underground Physics

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Motivation

- The LSM need an Alpha counter to monitor the surface of the sample for the rare events detectors :
  - Dark Matter experiments
  - Double Beta decay experiments
- The best solution is to use the counter inside of the underground lab for un in-site measurement AND to reduce the Cosmic rays impact
- The bigger surface of the samples will give better sensitivity
- The more sensitive commercial existing detector is XIA Ultralo-1800 (*funded by UGA and CNRS*)

Alpha Counter

- XIA UltraLo-1800 a commercial Alpha counter with very low background noise:
  - Big surface of the samples : - 1800 cm^2 for square section
  - - 707 cm^2 for disk
  - Sensitivity : 0.001 Alpha/cm^2/h
  - Energy resolution : < 9% FWHM (for a calibration source at 4.6 MeV)
  - Typical counter efficiency : > 90% (2π)
  - Electronic Background Suppression : distinguish between Alpha coming from the wall and the surface of the samples

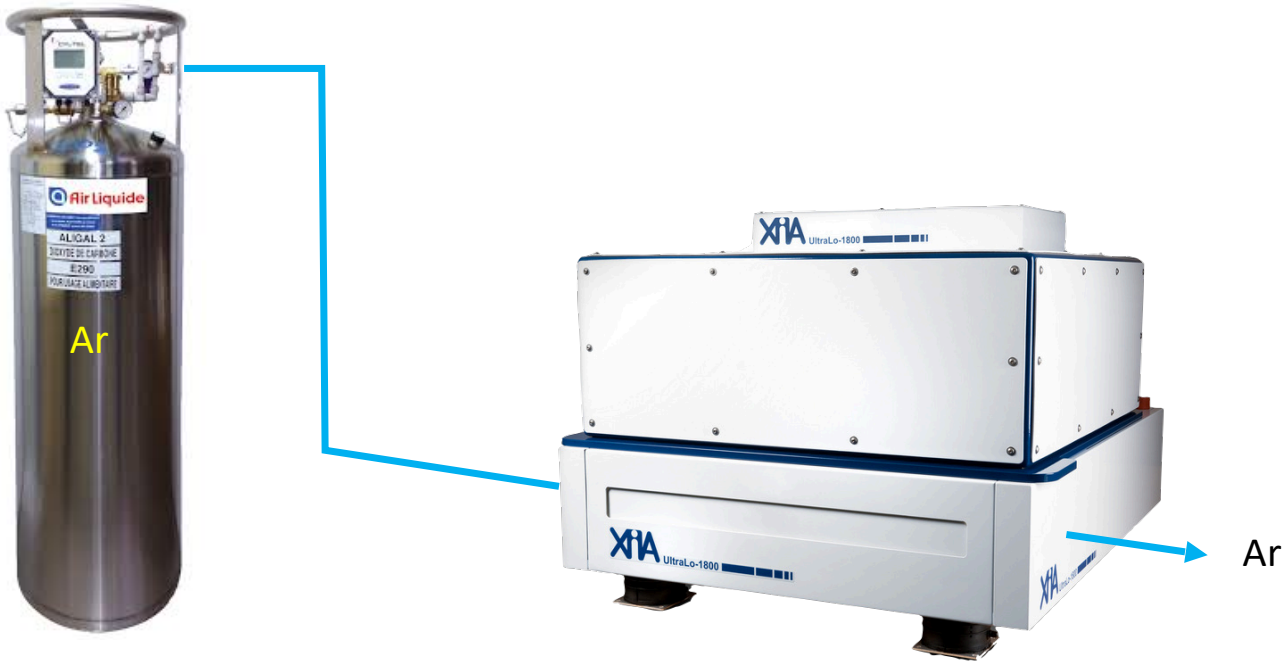
XIA : UltraLo-1800 environment

- Using the Liquid Argon :

  More radiopure than Ar-G
- Before each measurement :

  Ricing ≈ 700 L
- During the measurement (2-3 days up to 2-3 weeks) :

  Flushing ≈ 300 L/h



Idea for a Gas Purification and recirculation System

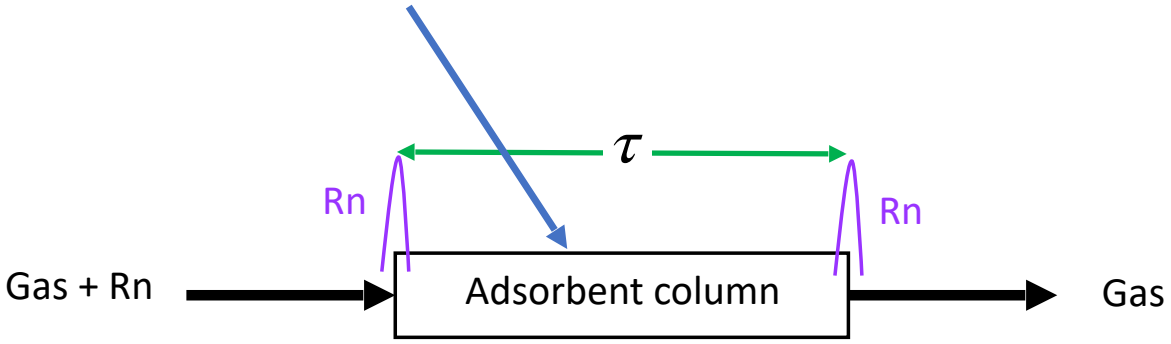
- It's no "more acceptable" in environmental point of view to continue to flushing the detectors
- Cost of the gas / year is also no negligible parameter (≈ 10 k€ /year)

=> <u>After discussing with José BUSTO @ CPPM (specialist of gas purification and recirculation system)</u>

- Using the gas Argon instead of liquid Argon
- Purification for : Radon, Oxygen, Humidity

Gas Purification System

- Radon trapping
  - Capture by physisorption on micro-porous materials
  - Radon is slowed down but not to stopped

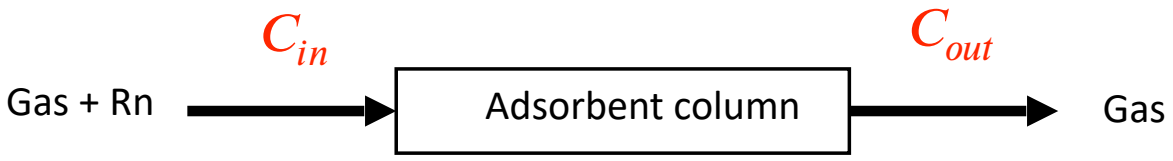


Gas chromatography => retention time $\tau = \frac{m \bullet k}{\varphi}$

m : mass adsorbent
f : gas flow
k : adsorption factor

Gas Purification system

- Radon reduction



$$If\ t < \tau \Rightarrow C_{out}^{Rn} \sim 0$$

$$If\ t > \tau \Rightarrow C_{out}^{Rn} = C_{in}^{Rn}/2^{\frac{\tau}{T_{1/2}}}$$

Rn capture depends =>

: mass
: flow
: K → high dependence on temperature

Example of existing system

- Anti-Rn system (J-trap): Study of emanation of SuperNemo demonstrator

(< 150 mBq/m3) -> 2016

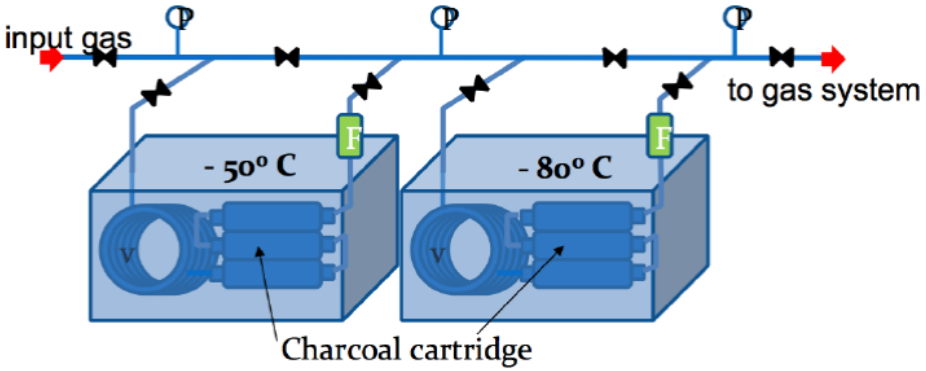


Figure 7.4: Schematic of the GPS developed at CPPM.

Gas	Source	Radon Level (µBq/m^3)
He	Cylinder	70-100
N_2	Cylinder	400-1000
N_2	Boil-off	90-140
N_2	GPS	20

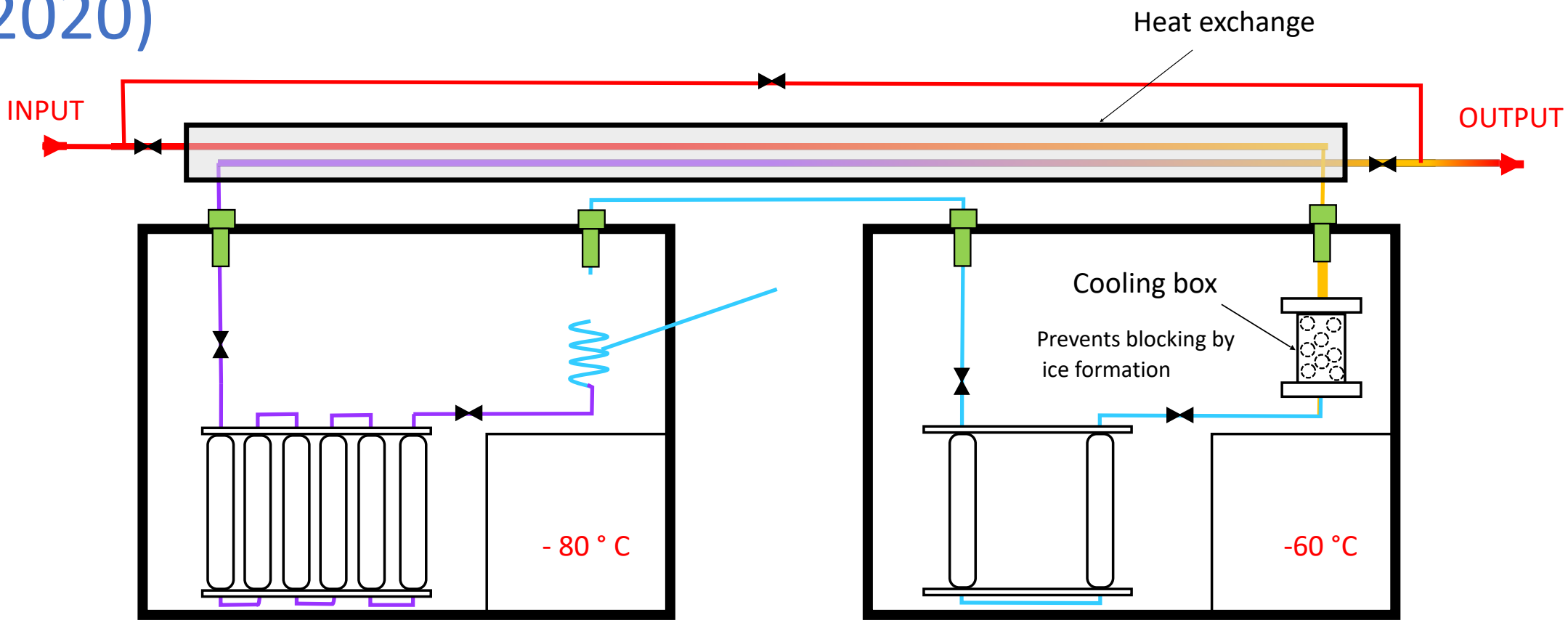
Table 7.1: Radon activity measured from various carrier gas and containers.

(Thesis: Xin Ran Liu (UCL))

Deux freezers @ - 80 ° C «stockage bio »

- 1st on @ -50°C (3 L Charcoal Cartridge)
- 2nd @ -80°C (1 L Charcoal Cartridge)

Anti-Radon system for gas SN purification @ LSM (2020)



6 cartridges of 250 g-> 1500 g

Radon adsorption

2 cartridges of 500 cm³ -> 250 g

Pre-cooling, water absorption, ….

K-factor measurement and reduction coefficient

- K-factor in N_2 ($N_2 \approx$ Ar from adsorption point of view)

Temperature [°C]	-12	-30	-50	-70	-80
k (J-trap) [m3/kg]	25.3 ± 3.3	59.3 ± 6.0	183.0 ± 18.8	442.2 ± 44.1	-
k (Germanium) [m3/kg]	19.8 ± 4.4	57.7 ± 10.7	159.4 ± 27.9	-	765.1 ± 131.2

- Reduction factor $\frac{C_{in}^{Rn}}{C_{out}^{Rn}} = 2^{\frac{\tau}{T_{1/2}}}$

300 L/h	Temperature		
	-30	-50	-70
1 cartouche	1.45E+00	3.17E+00	1.62E+01
2 cartouches	2.11E+00	1.00E+01	2.62E+02
3cartouches	3.07E+00	3.18E+01	4.25E+03
4 cartouches	4.46E+00	1.01E+02	6.88E+04
5 cartouches	6.48E+00	3.19E+02	1.11E+06
6 cartouches	9.41E+00	1.01E+03	1.81E+07

Flushing time/flow

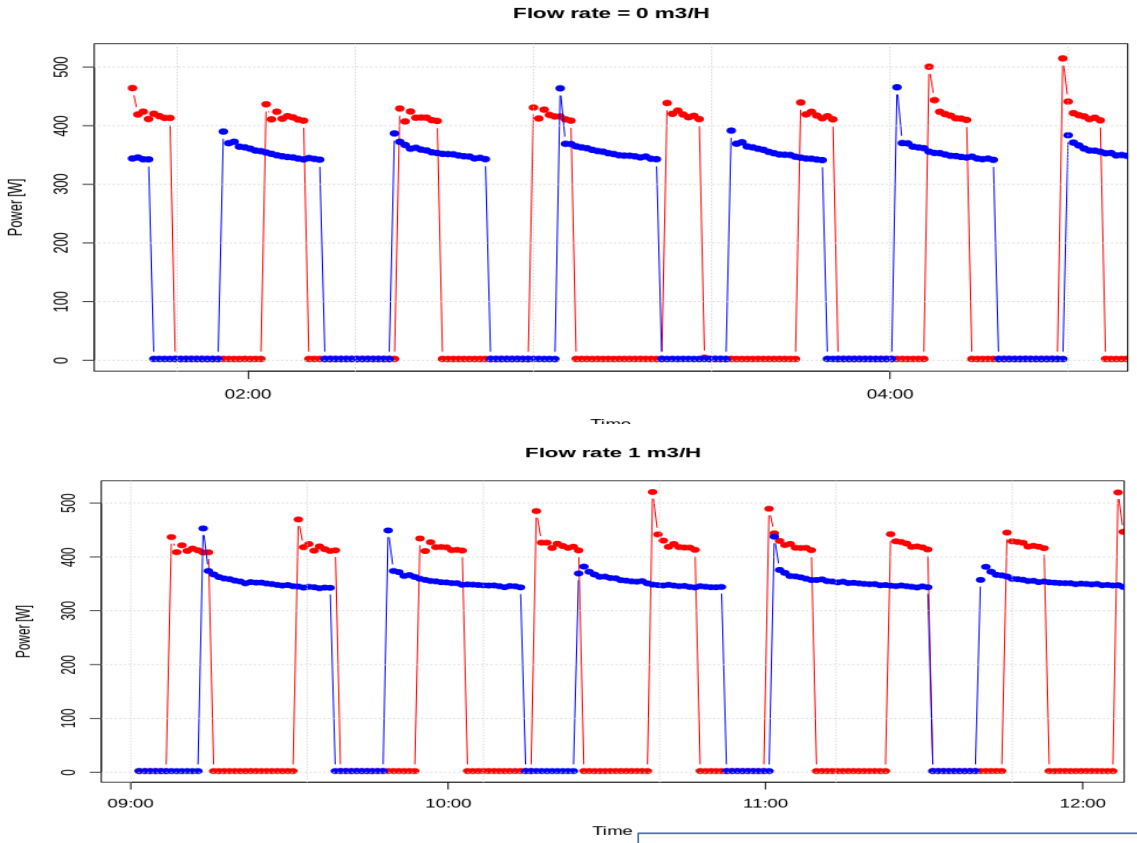
900 L/h	Temperature		
	-30	-50	-70
1 cartouche	1.13E+00	1.47E+00	2.53E+00
2 cartouches	1.28E+00	2.16E+00	6.40E+00
3cartouche	1.45E+00	3.17E+00	1.62E+01
4 cartouches	1.65E+00	4.65E+00	4.10E+01
5 cartouche	1.86E+00	6.83E+00	1.04E+02
6 cartouches	2.11E+00	1.00E+01	2.62E+02

45 minutes

450 L/h	Temperature		
	-30	-50	-70
1 cartouche	1.28E+00	2.16E+00	6.40E+00
2 cartouches	1.65E+00	4.65E+00	4.10E+01
3cartouche	2.11E+00	1.00E+01	2.62E+02
4 cartouches	2.71E+00	2.16E+01	1.68E+03
5 cartouche	3.47E+00	4.67E+01	1.07E+04
6 cartouches	4.46E+00	1.01E+02	6.88E+04

90 minutes

Operation temperature



Tests of compressor power regulation

No gas flow

T = -60 °C => 8 min ON et 18 min OFF

T = -80 °C => 18 min ON et 12 min OFF

1 m^3/h N_2

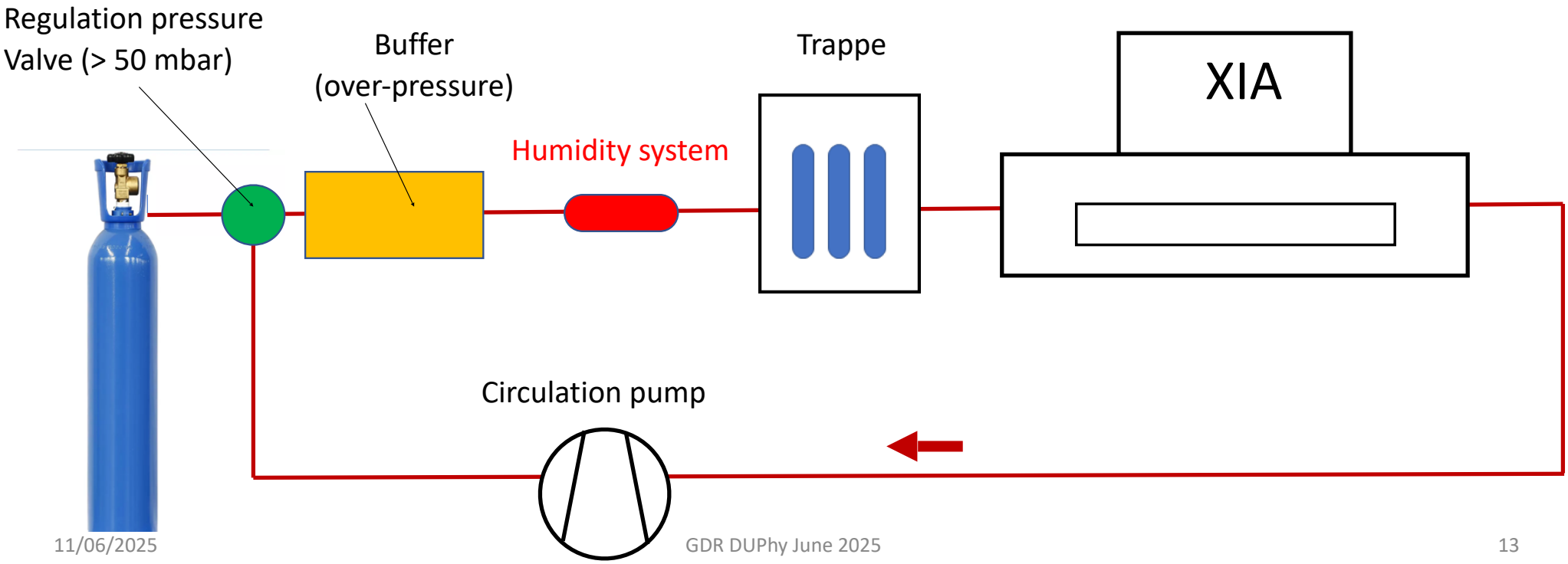
T = -60 °C => 10 min ON et 14 min OFF

T = -80 °C => 24 min ON et 10 min OFF

- 50 °C ou - 60 °C looks OK

GPS for XIA Ultralo 1800 #1

- To avoid any leak in the detector, the system must operate with over-pressure
- Re-injection of the gas for any leak



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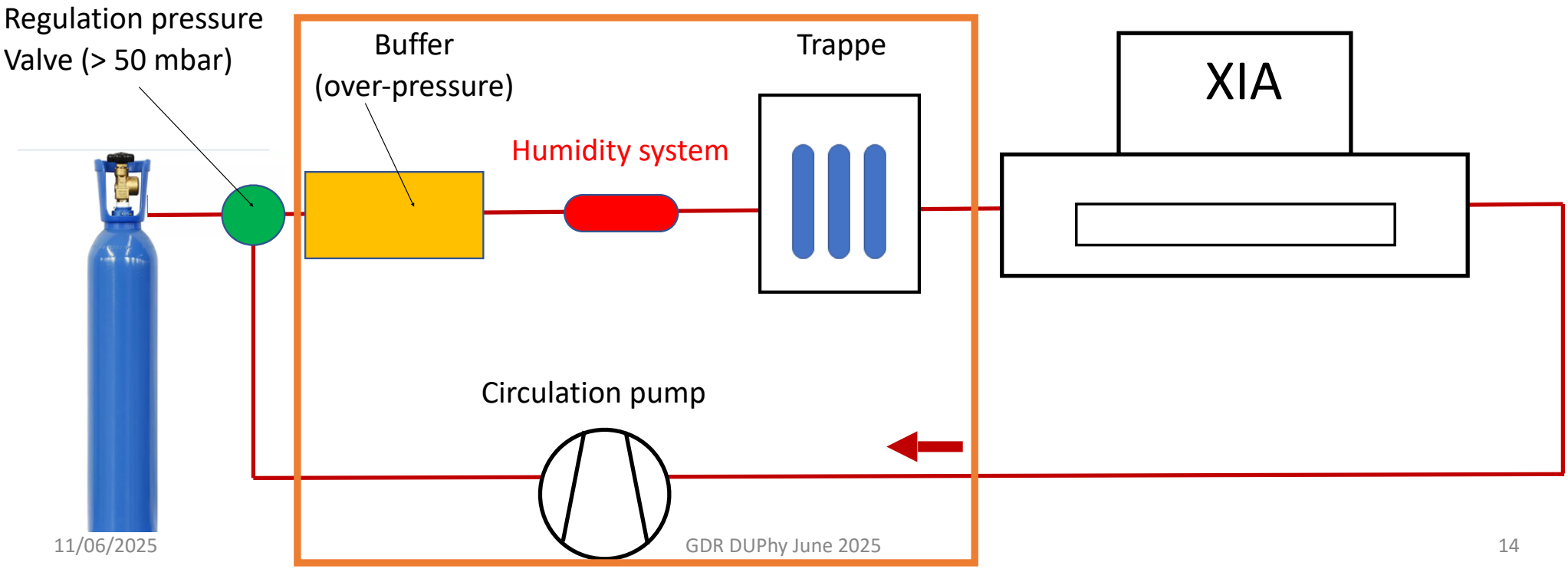

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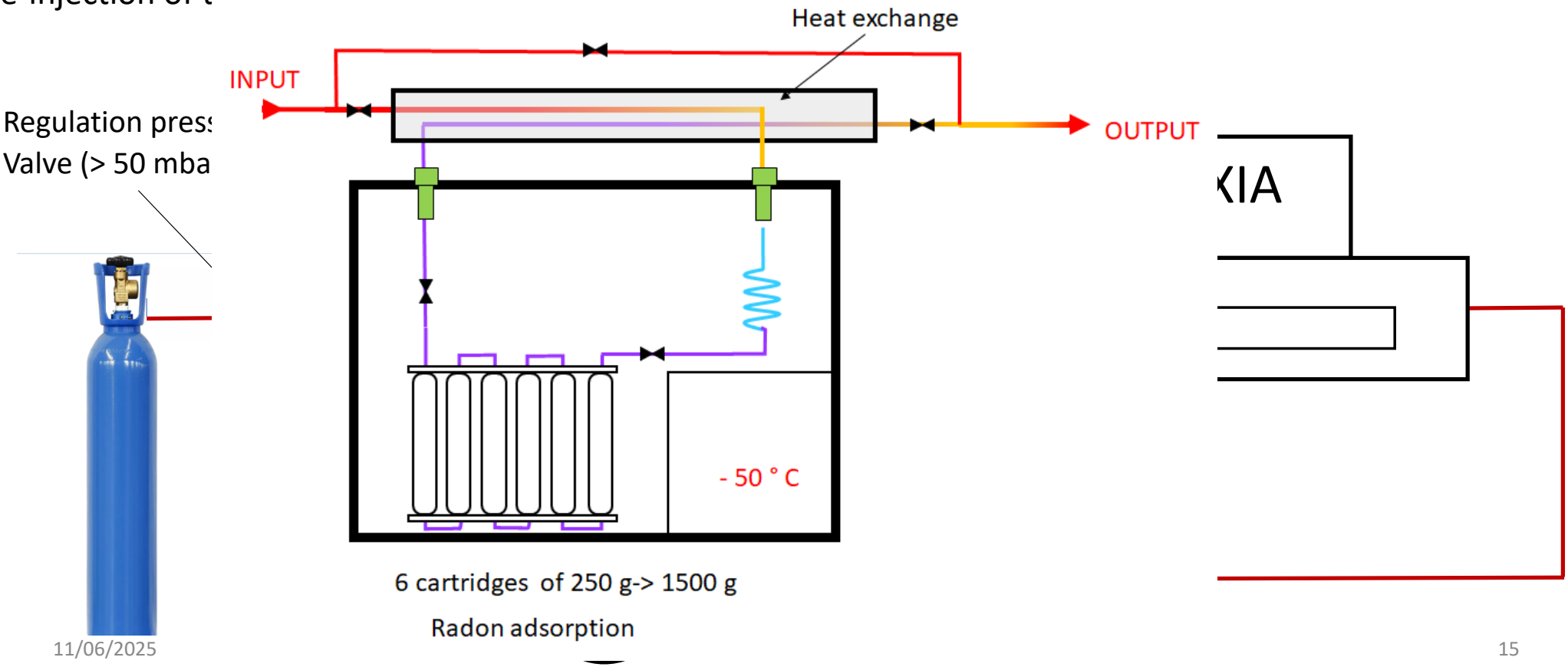
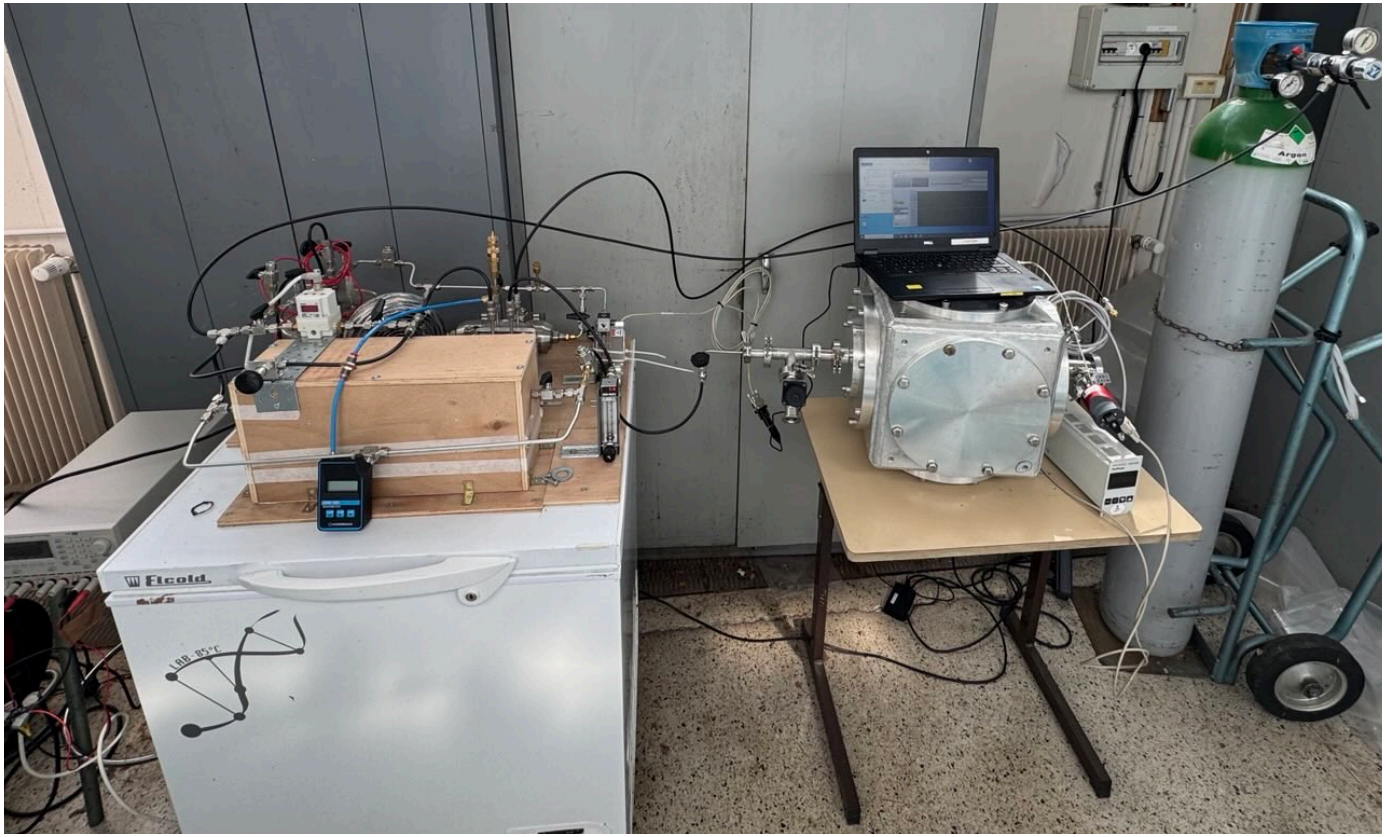


GPS @ LPSC-LSM



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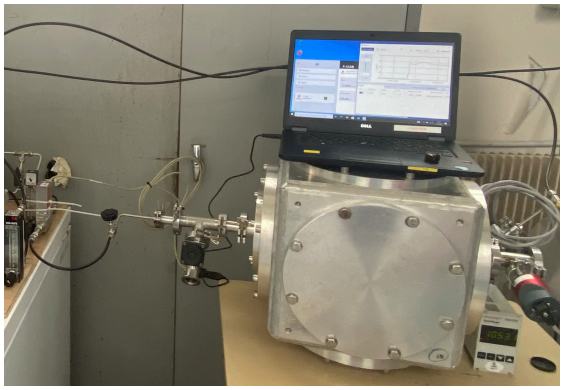
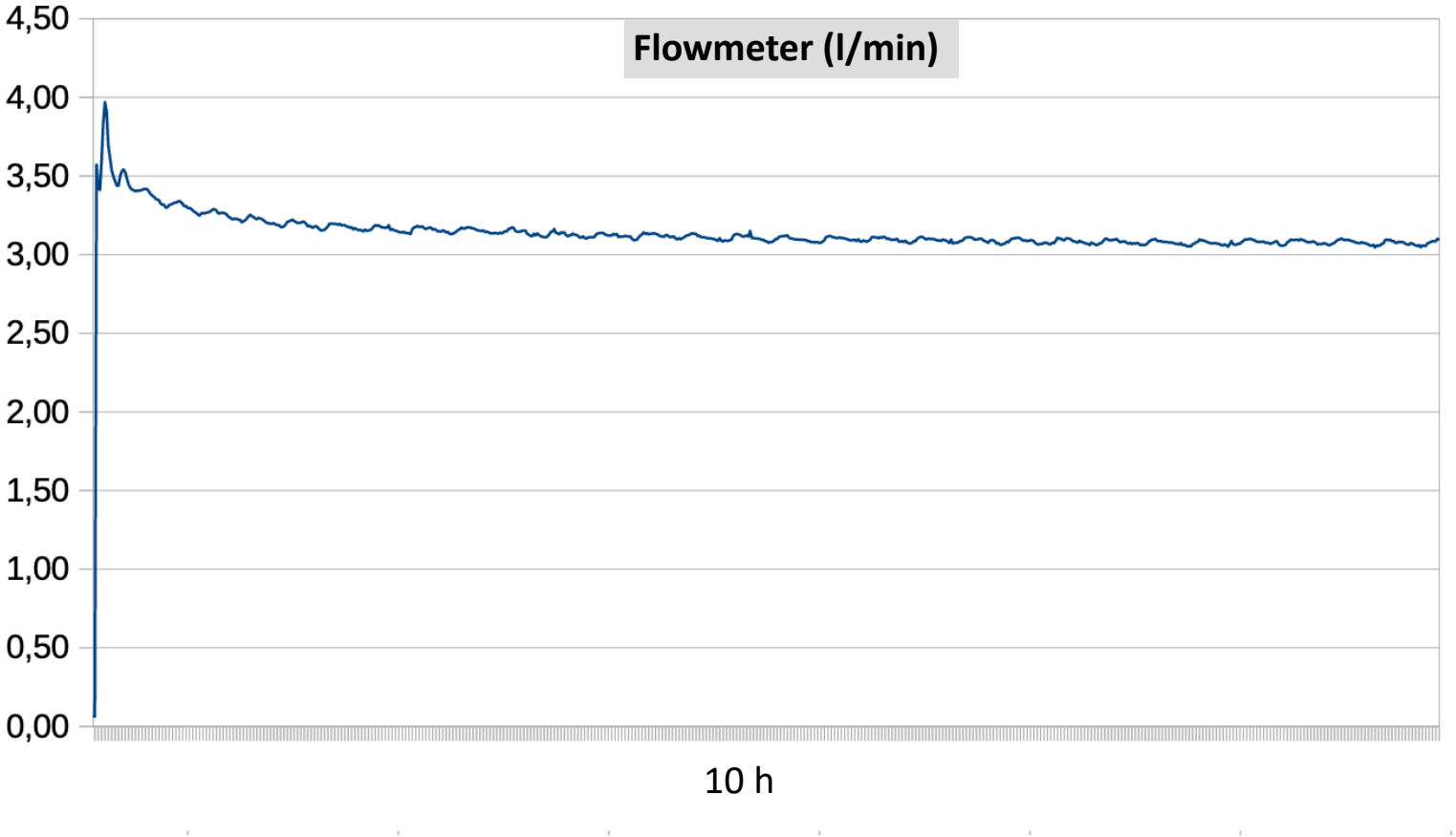
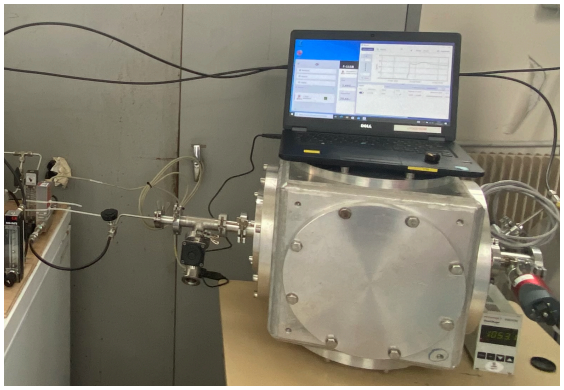
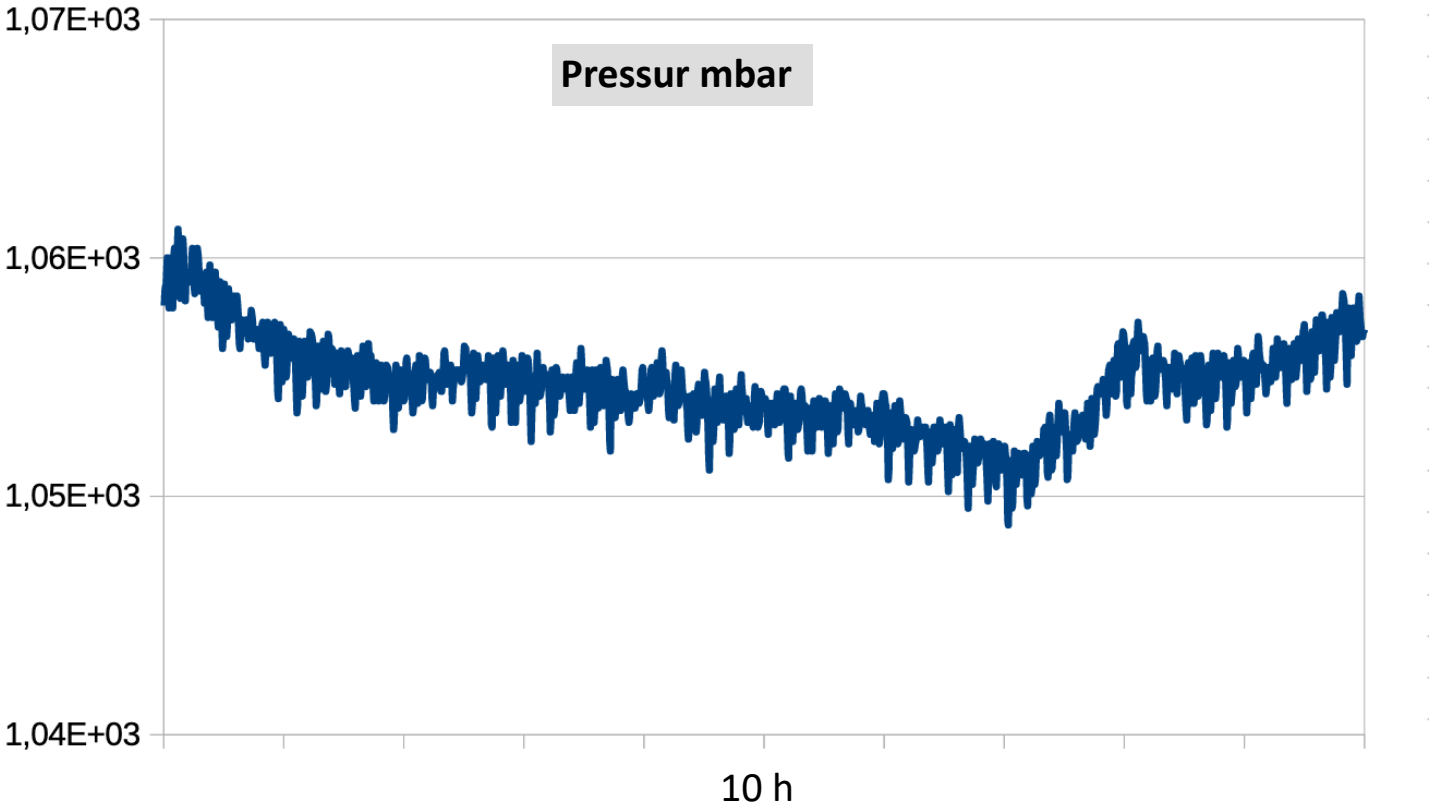




GPS @ LPSC-LSM





Summary

- LPSC-LSM is equipped by an Alpha Counter, XIA Ultralo-1800 detector
- XIA Ultralo-1800 is a gaseous detector, working with dry, ultra pure Argon, in preference : boiloff from ArL
  - 700L for rinsing after each opening
  - 300L/h for measurement time
- Tanks to ENIGMASS, a Gas Purification [and recirculation] System is fabricated, which could be used with XIA Ultralo-1800 (with the support of CPPM)
- Firsts tests show a good stability in term of
  - Pressure inside of the test chamber
  - Gas flow inside of the test chamber

Thanks for your attention

Grazie per l'attenzione

Sépâsse Az Shoma

سپاس از شما

Gracias por su atención

Merci pour votre attention