

Latest developments around gas distribution

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Réunion GDR DI2I

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Subatech Nantes

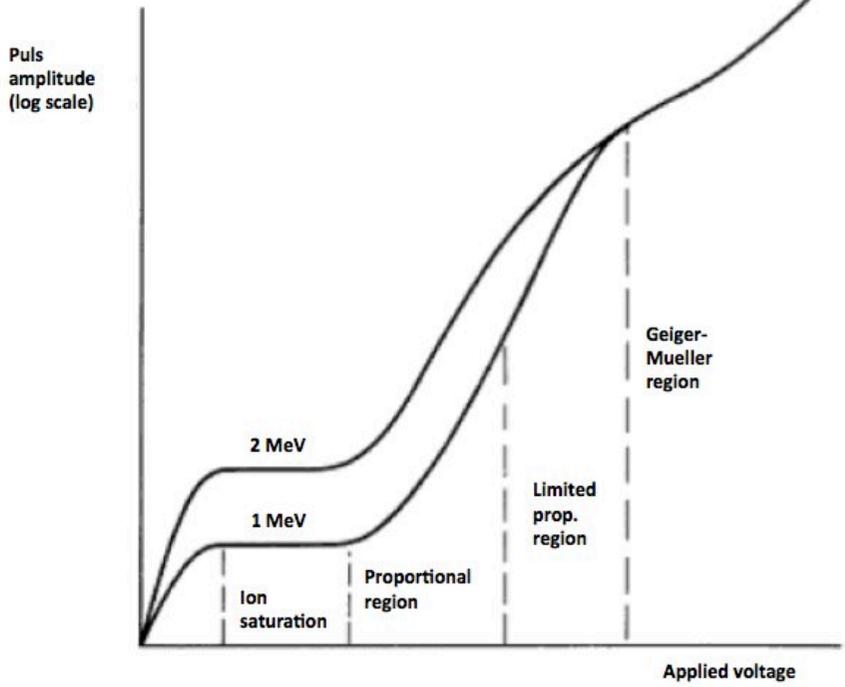
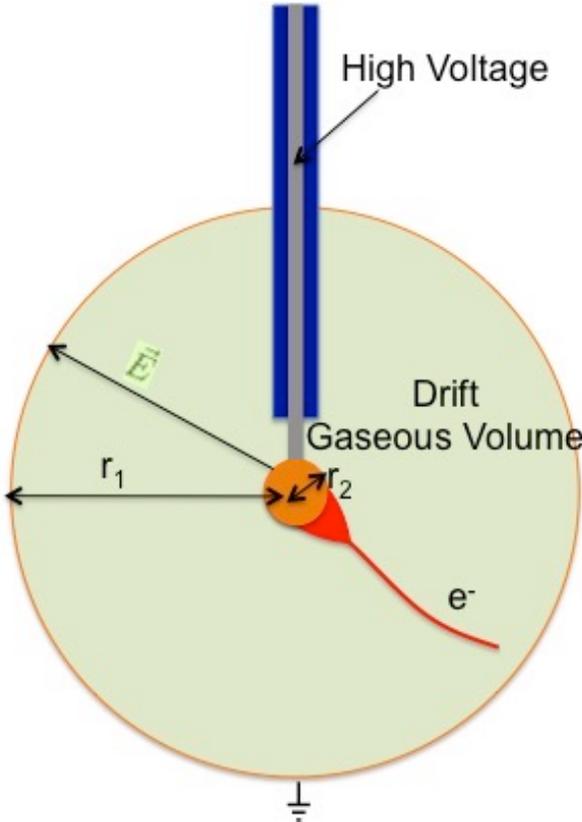
Introduction

- Gaseous detectors
 - many experiments => laboratories
 - Accelerators
 - Particle Physics: DM, $\beta\beta 0\nu$...
- Different kind of the gas
 - Noble gas: He, Ne, Ar, Xe even Rn
 - Greenhouse gas: $C_2H_2F_4$ (GWP 1430) , SF_6 (GWP 22800) , CF_4 (GWP 7390) , C_4F_{10} (GWP 8860)
 - Mixture gas: Noble gas with a quencher Or With Alcohol
- Operation mode:
 - Sealed mode
 - Circulation mode
 - Flush mode
- Volume
 - From a few cm^3 up to several $100 m^3$

Introduction

- Environmental issues
 - Greenhouse gas $C_2H_2F_4$, SF_6 , CF_4 , C_4F_{10}
- Economic issues
 - Cost of the gas 3He , Xe, Ne ...
- Societal issues
 - AND next generation...

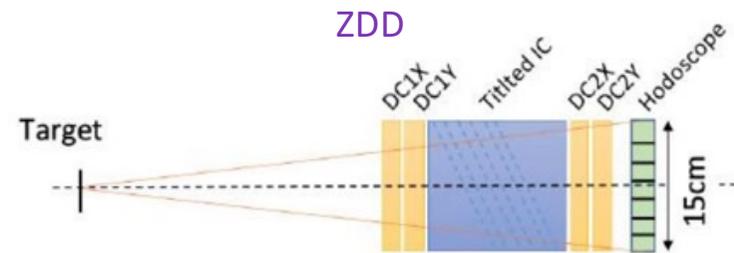
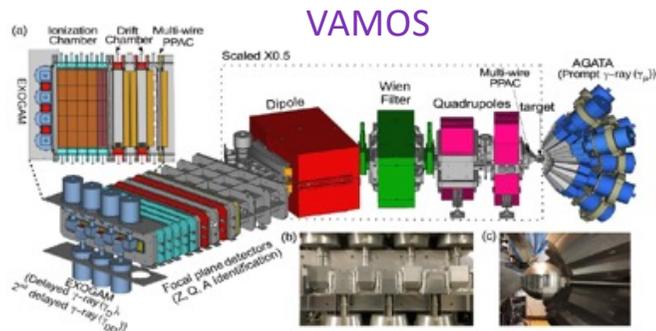
How it works



Example of the different gas system

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• Détecteurs gazeux au GANIL



- Utilisation de gaz fluorés (CF₄, C₃F₈...)
-> rejet interdit.
- Utilisation de gaz rares (Kr, Ne, Xe, He³...)
-> cher €€€.

ACTAR TPC



From C. NICOLLE – GANIL-SPIRAL2 – GDR Réseau détecteurs gazeux

Mayaito Detector : Set-up expérimental de recirculation de gaz

- Banc de pompage pour vide secondaire de l'ensemble
- Détecteur et sa chambre à vide
- Système de régulation en pression/débit du gaz.
- Pompe de recirculation du gaz
- Filtre pour purifier gaz

Monitoring en pression/température
-> 0-10V -> Numexo2.

3 conditions de fonctionnement:

- Statique
- Boucle fermé sans filtre (by-pass)
- Boucle fermé avec filtre

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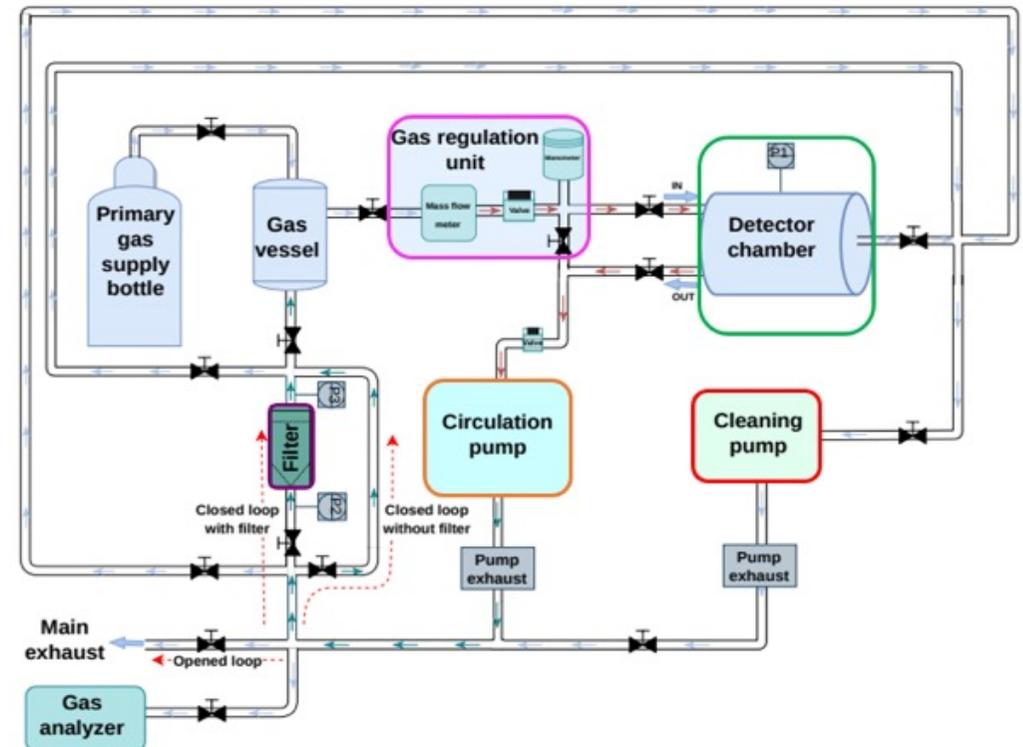
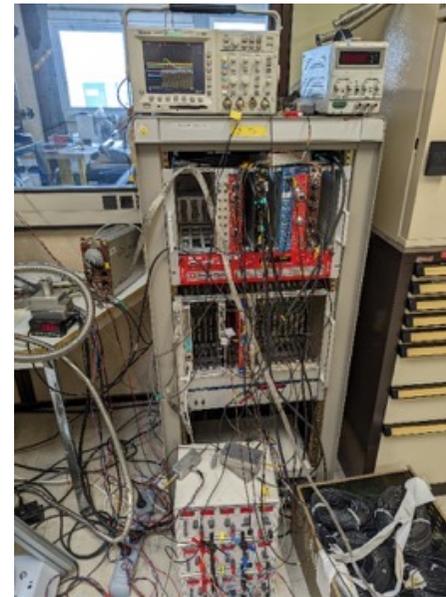
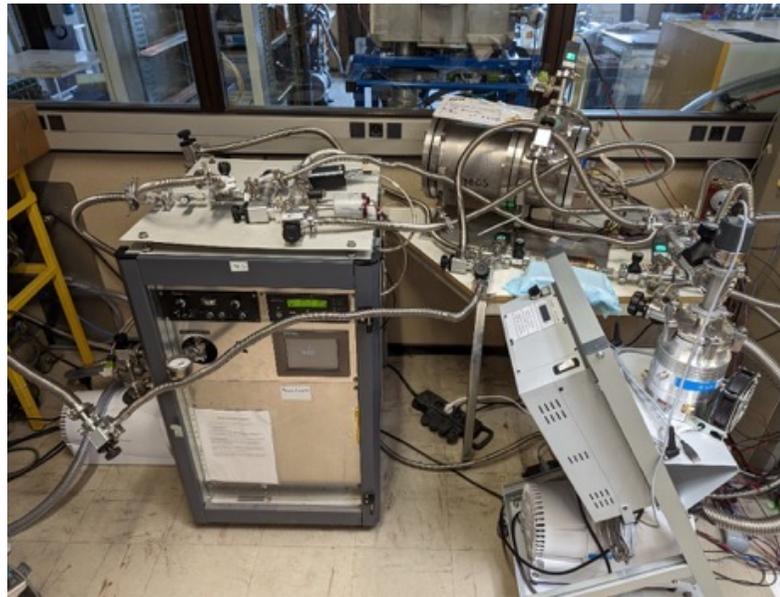


Fig 1: Experimental set-up with the detector chamber and the gas supply

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Mayaito Detector : Set-up expérimental de recirculation de gaz



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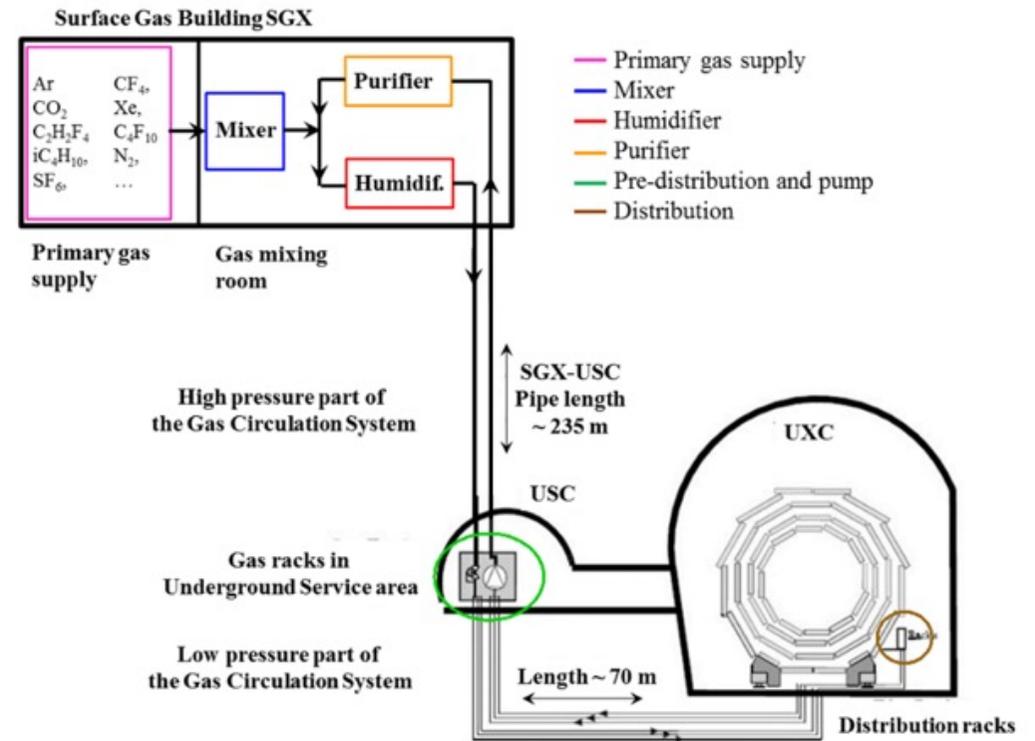
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@ CERN

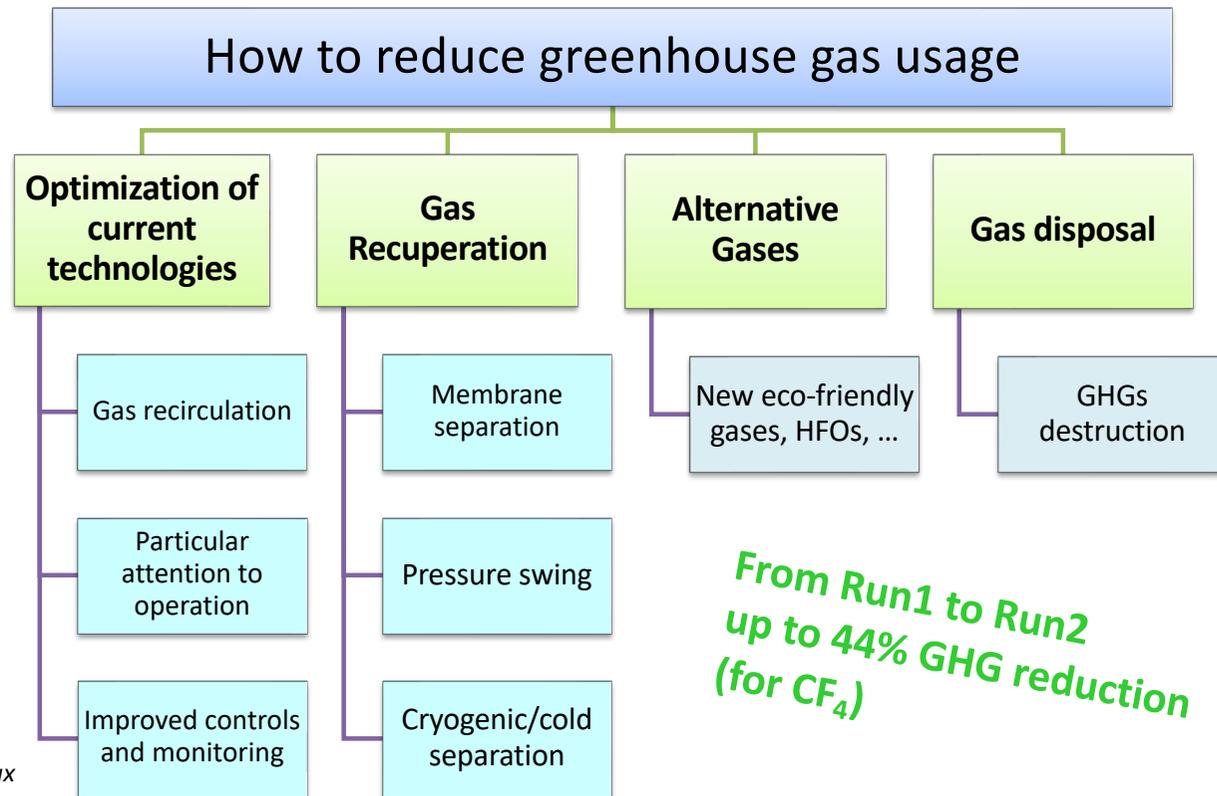
Gas systems extend from the surface building to service balcony on the experiment following a route few hundred meters long.

- Primary gas supply point is located in surface building
- Gas system distributed in three levels:
 - Surface (SG)
 - Gas Service room (USC)
 - experimental cavern (UXC)
- The gas systems were built according to a common standard allowing minimization of manpower and costs for maintenance and operation.
 - Construction started early 2000
 - Operational since 2005-2006
- The CERN gas service team (EP-DT-FS, BE-ICS)



From R. Guida CERN EP-DT – GDR Réseau détecteurs gazeux

Gaseous detector systems at LHC
And
CERN Strategies

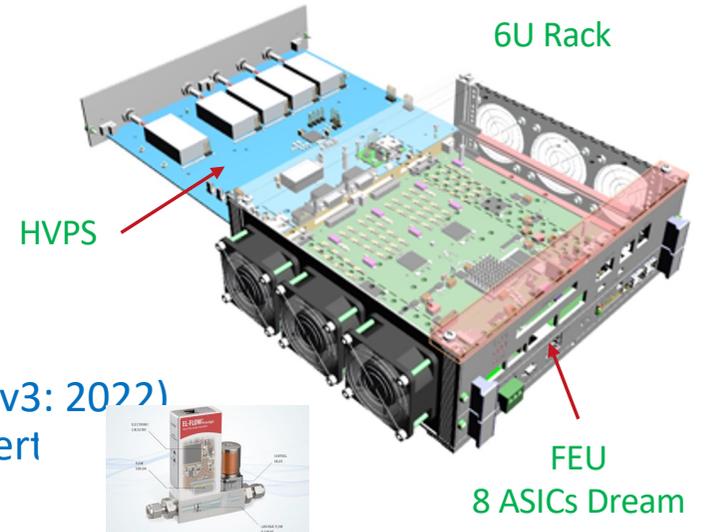
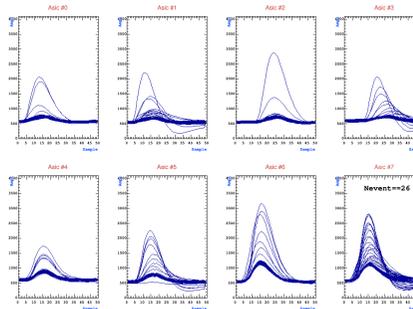


From R. Guida CERN EP-DT – GDR Réseau détecteurs gazeux

@ CEA (Egypt)

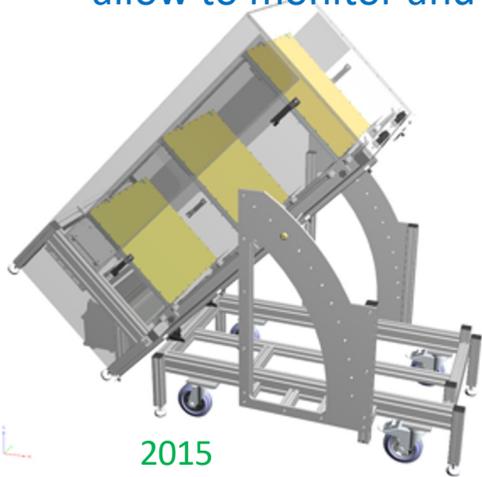
• Evolution of the Irfu's telescopes : ↗ compactness, transportability and **autonomy**

- 2015: WatTo, ~200 kg
- 2016: ScanPyramids (outdoor), ~130 kg
- 2018: ScanPyramids (indoor) cube, ~45 kg
- 2019: G2G3, EDF, ..., cube optimized, ~45 kg

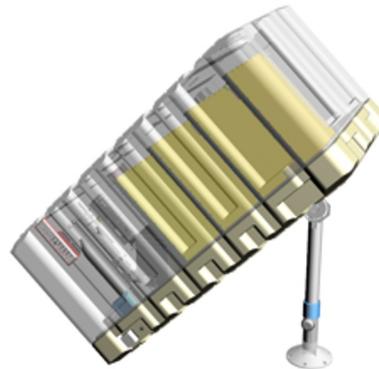


• Electronic and control cards from Irfu :

- Front-End Unit (FEU) developed for Clas12
- Specific High-Voltage Power Supply (HVPS) card (v1: 2015, v2:2016, v3: 2022) allow to monitor and control flowmeter (v2) and sensor of gas proper



2015



2016

gazeux

DI2I



2018

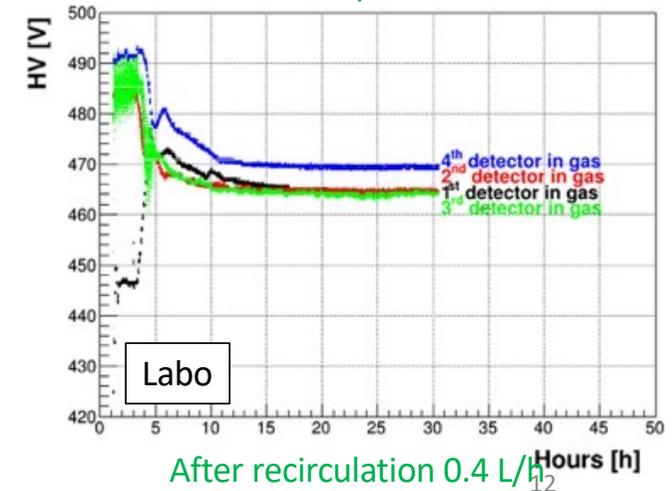
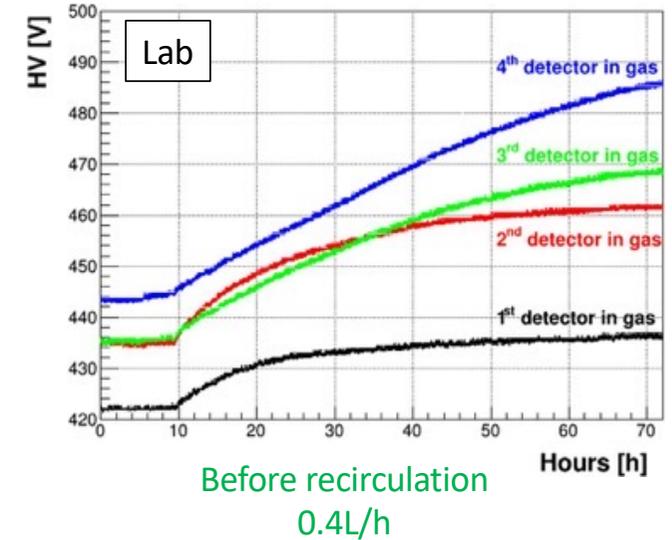
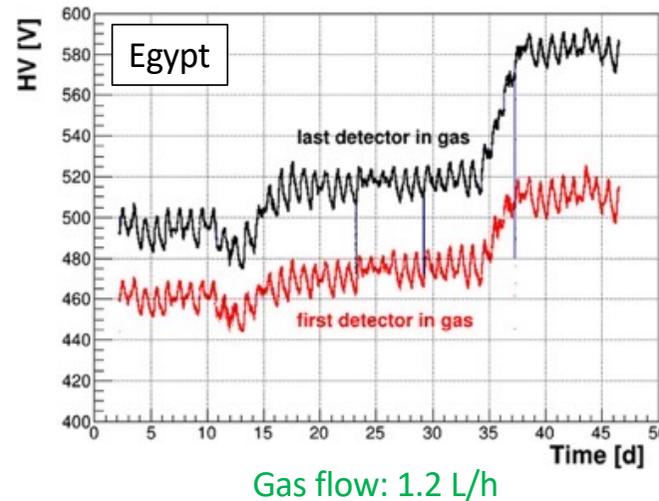
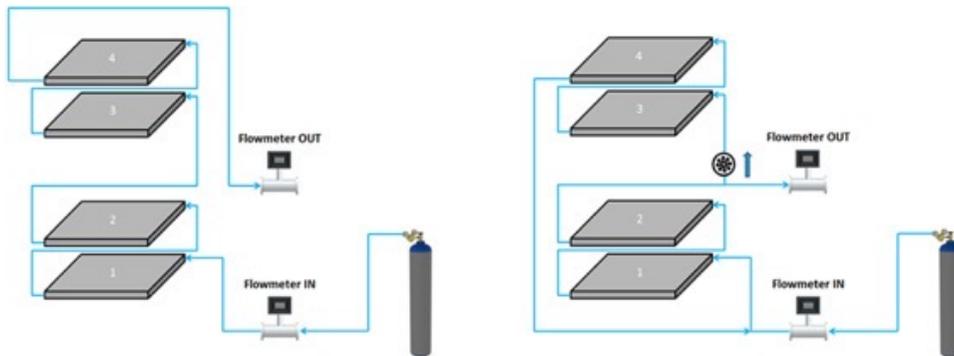


2019-today

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Muon Tomography Telescopes

- Detectors flushed in serial
 - Gain: $\Delta \sim 10\% = f(\text{flux})$
 - 1.2 L/h
 - B5 \rightarrow 3 weeks of autonomy
- Recirculation system:
 - Input gas flow: 0.4 L/h
 - Turbine or micro-pump ($\sim 5\text{L/h}$)
 - \rightarrow Homogenize the gas
 - \rightarrow Balance the efficiencies



From D.Attié Recirculation/purification for muon tomography – GDR Réseau détecteurs gazeux

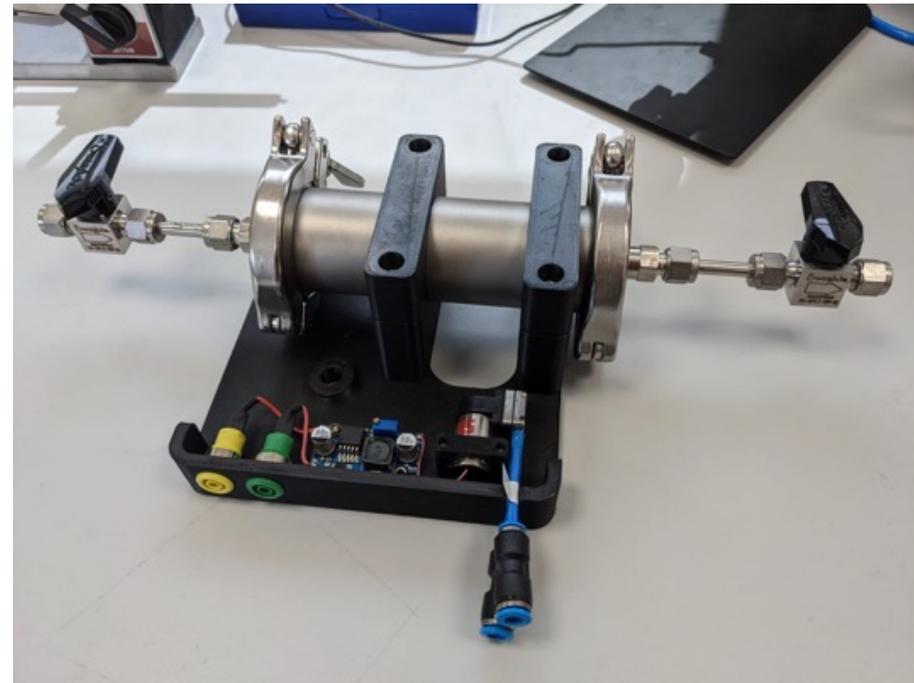
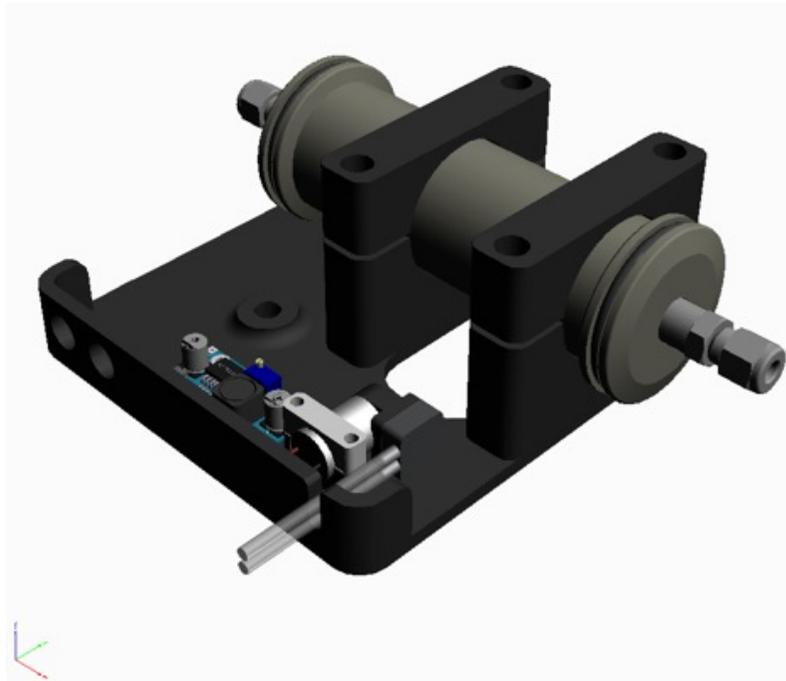
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- **New recirculation system:**

- Micro-pump from RS (2 have been tested during 14 months in continuous operation)
- Components from Pfeiffer's catalogue



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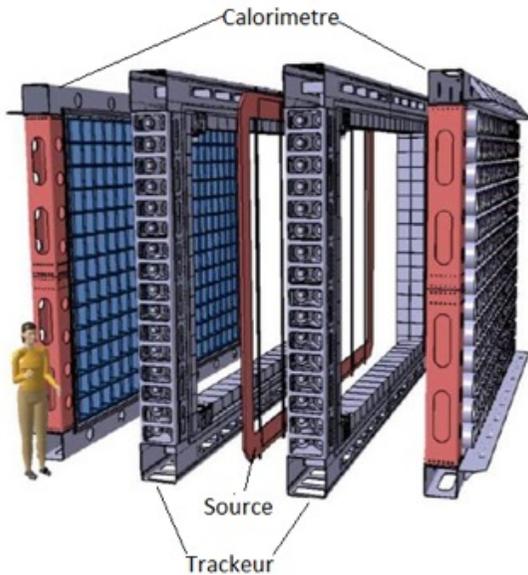
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SuperNEMO $\beta\beta 0\nu$ Expérience

SuperNEMO est un détecteur traco-calorimétrique pour l'étude de la double désintégration beta au LSM

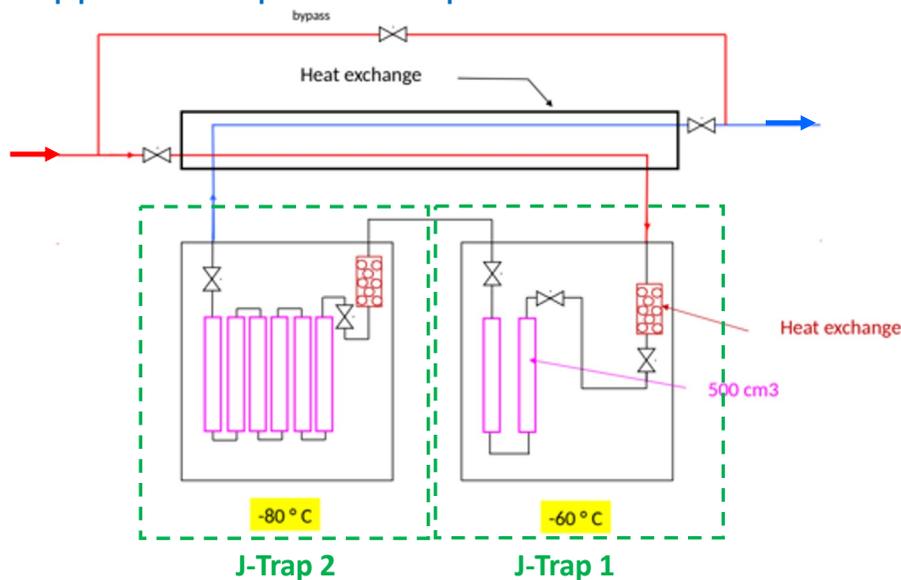


- Le trackeur est constitué par de cellules fonctionnant en régime Geiger dans un mélange de 95% d'He + 4 % éthanol + 1% d'Ar
- Le calorimètre est formé par de blocs de scintillateur plastique couplés à de PM
- ❑ Les conditions de bas bruit exigent une concentration en $^{222}\text{Rn} < 0.15 \text{ mBq/m}^3$ dans le gaz

@ LSM

SuperNEMO $\beta\beta 0\nu$ Expérience

Le dispositif anti-radon du gaz est assuré à l'aide d'une double trappe appelé J-Trap . La trappe est divisée de deux sous-trappes : J-Trap1 et J-Trap 2



From J. BUSTO

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J-Trap 1 : Assure le pre-cooling du gaz

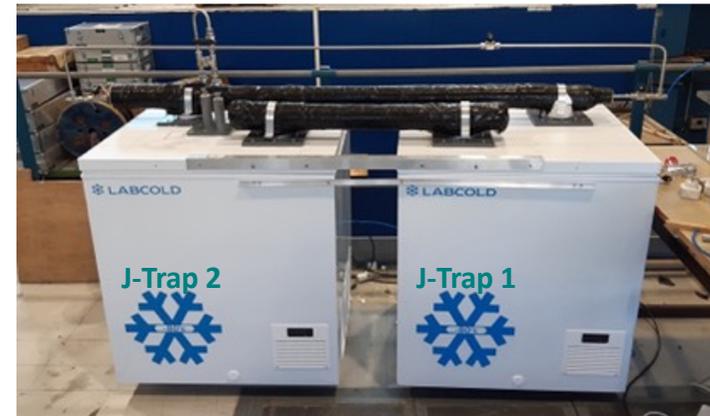
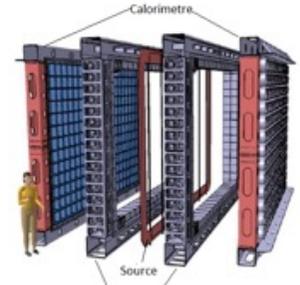
: Elimine les traces de vapeurs (eau, éthanol, ...)

: Elimine une petite partie du Rn du gaz

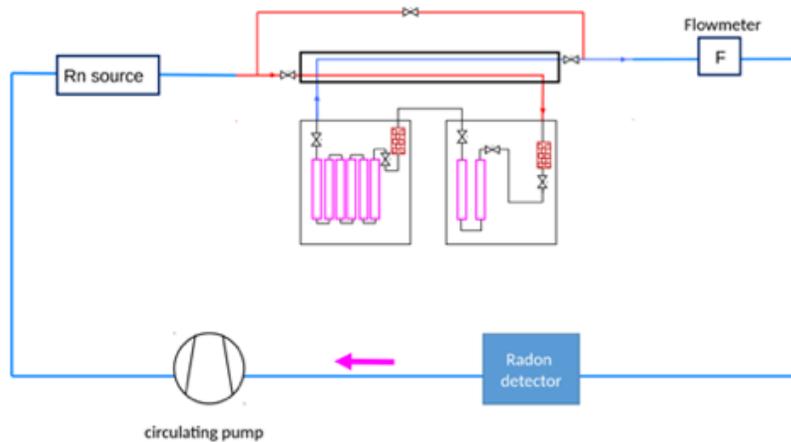
= > 2 cartouches de 500 cm³ remplies avec charbon actif (Shirasagi G2x4) @ - 50°C

J-Trap 2 : Elimine le radon présent dans le gaz

= > 6 cartouches de 500 cm³ remplies avec charbon actif (Shirasagi G2x4) @ - 80°C



Performances de la J-Trap



Taux de réduction du radon à partir du temps de rétention (T_r) du radon dans la J-Trap :

$$\gamma = \frac{C_{out}}{C_{in}} = e^{-\frac{\ln(2)}{T_1} \cdot T_r}$$

C_{out} : concentration Rn à la sortie de la trappe

C_{in} : concentration Rn à l'entrée de la trappe

L'efficacité de la J-Trap a été mesurée dans du N_2 avec une source de radon en circuit fermé

La masse totale de charbon actif est 2 kg
Le flux de gaz est $1 \text{ m}^3/\text{h}$

$$\gamma(N_2) = 2 \cdot 10^{-4}$$

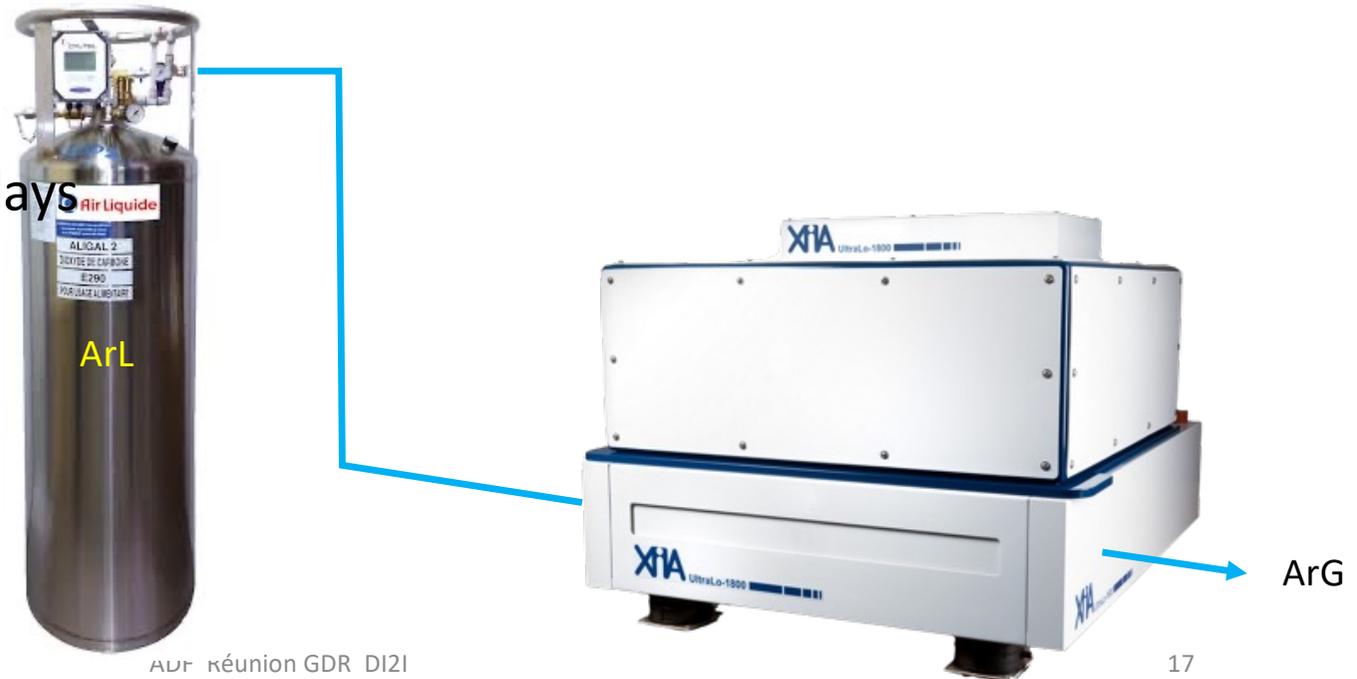
→ $\gamma(He) = 10^{-22} \quad !!$

Extrapolé des mesures sur 1 g dans l'He
(Impossible à obtenir directement dans la J-Trap)

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XIA : UltraLo-1800 (Alpha counter)

- 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 (21kl-151kl)
- df



From J.BUSTO

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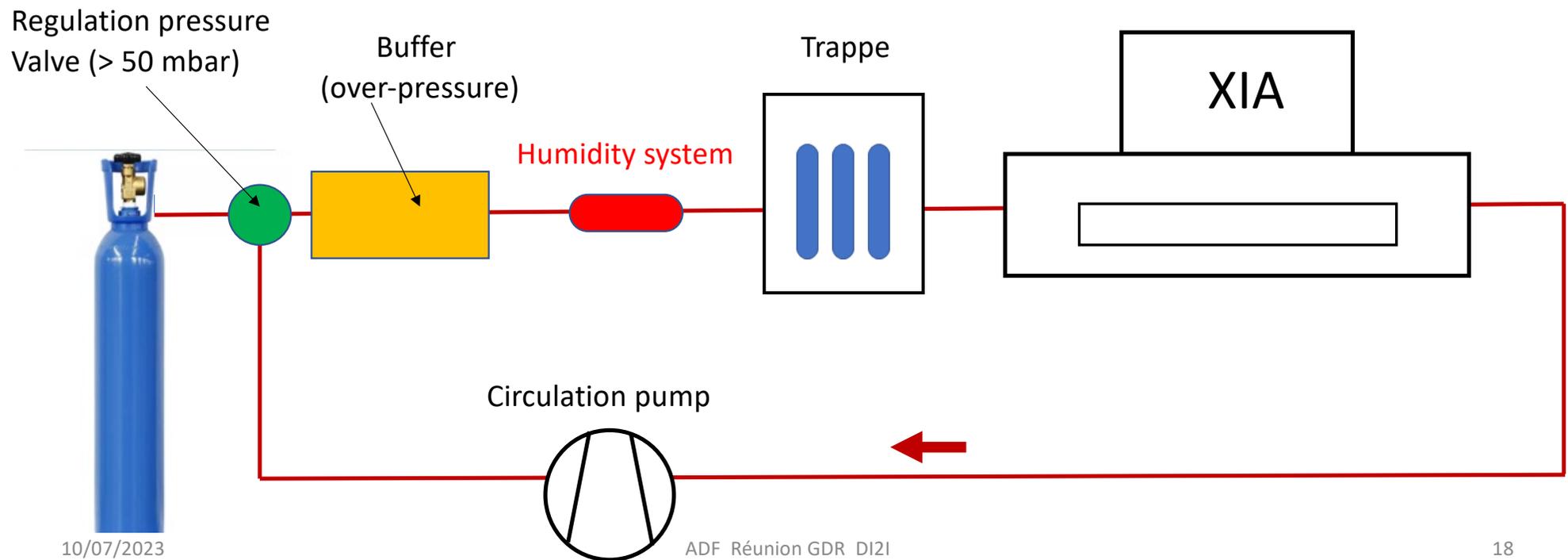
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@ LSM

GPS for XIA Ultralo 1800

- 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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Conclusion

- Gaseous detectors (many experiments)
- Different kind of the gas (Noble gas; Greenhouse gas; Mixture gas)
- Operation mode (Sealed mode; Circulation mode; Flush mode)
- Volume (From a few cm³ up to several 100 m³)
- Detector performance (The detector stability)

Perspectives

- Reducing the leak
- Improvement of the existing system
- To find the alternative gas
 - long-term operation
 - no toxic and flammability gas

Thanks for your attention

Grazie per l'attenzione

Sépâsse Az Shoma

سپاس از شما

Merci pour votre attention

Gracias por su atención