Update on dRICH gas activities

dRICH Meeting

July 22nd, 2026

Chandradoy Chatterjee, Silvia Dalla Torre. Fulvio Tessarotto

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C_2F_6 scintillation

dRICH radiator gas system design

Operation during test-beam

Monitoring tools

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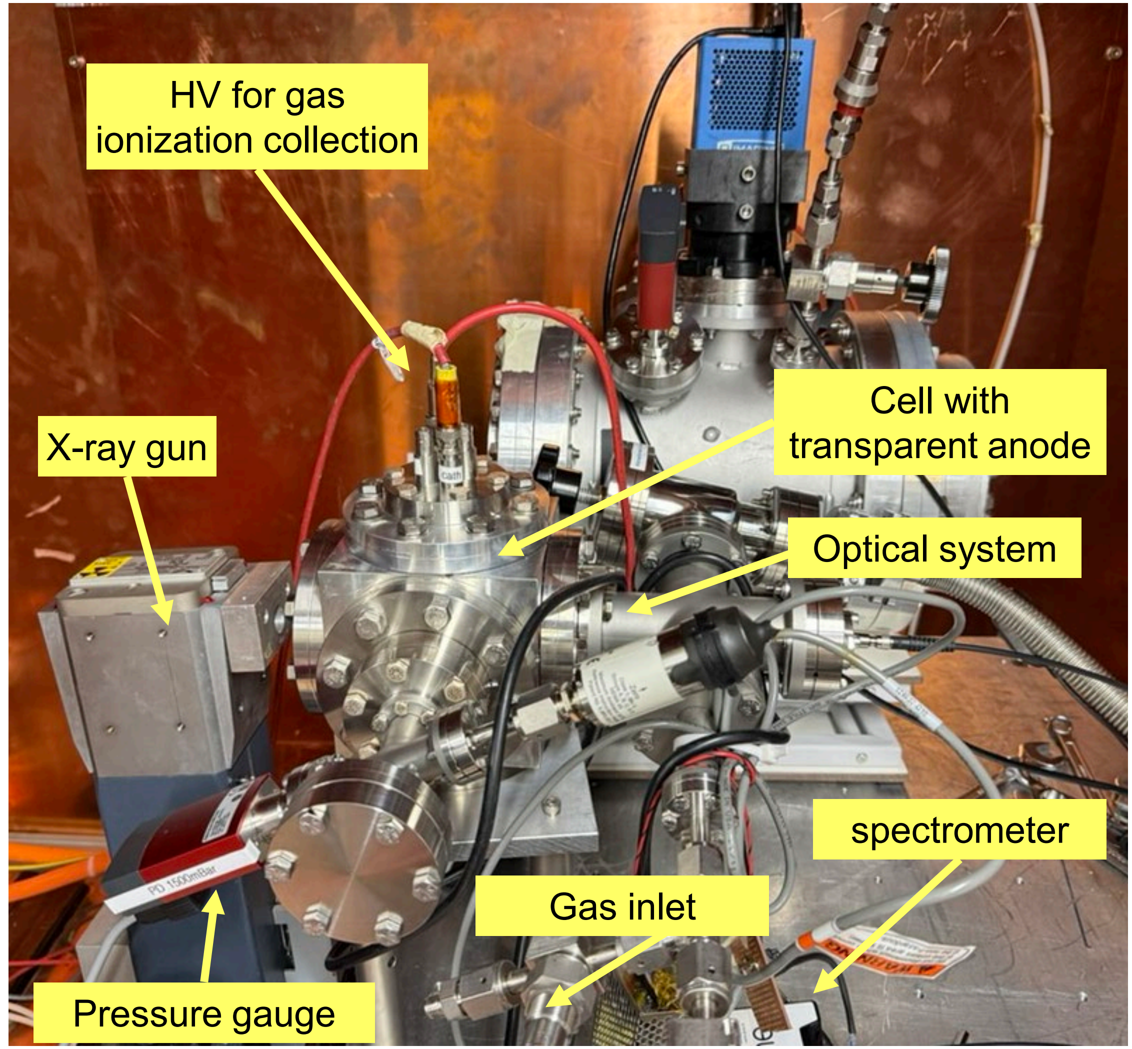
C_2F_6 scintillation measurement

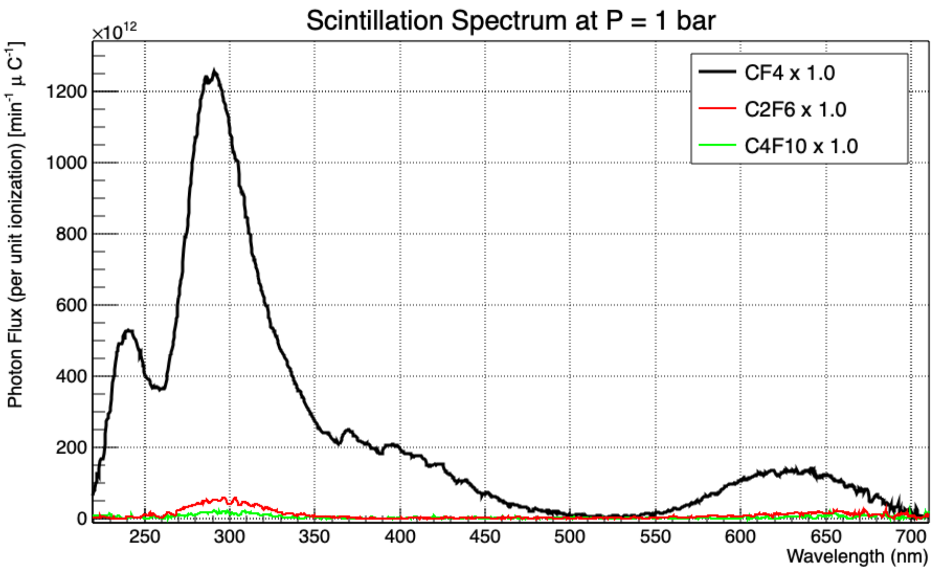
In the Gas Detectors R&D Laboratory at CERN

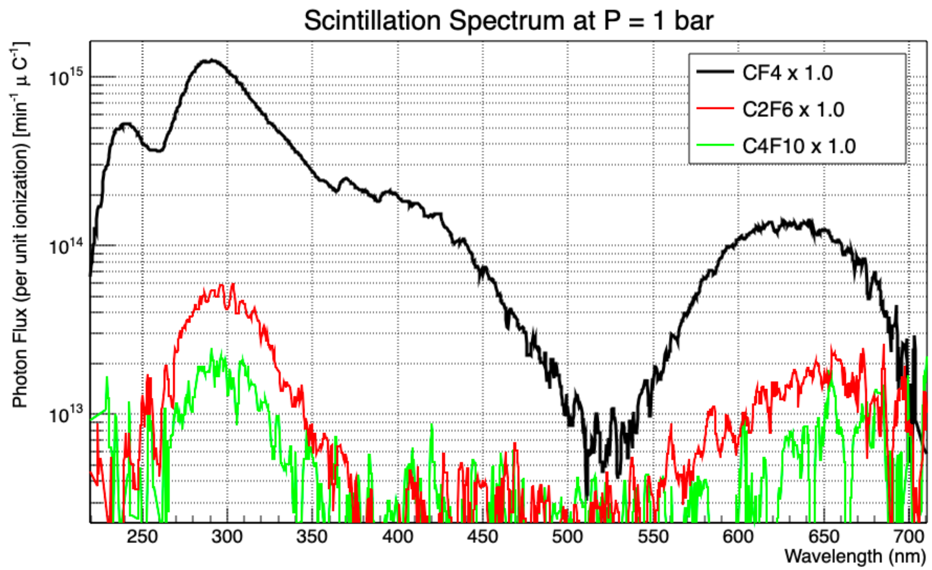
1) November - December 2025

2) More extended: April 2026



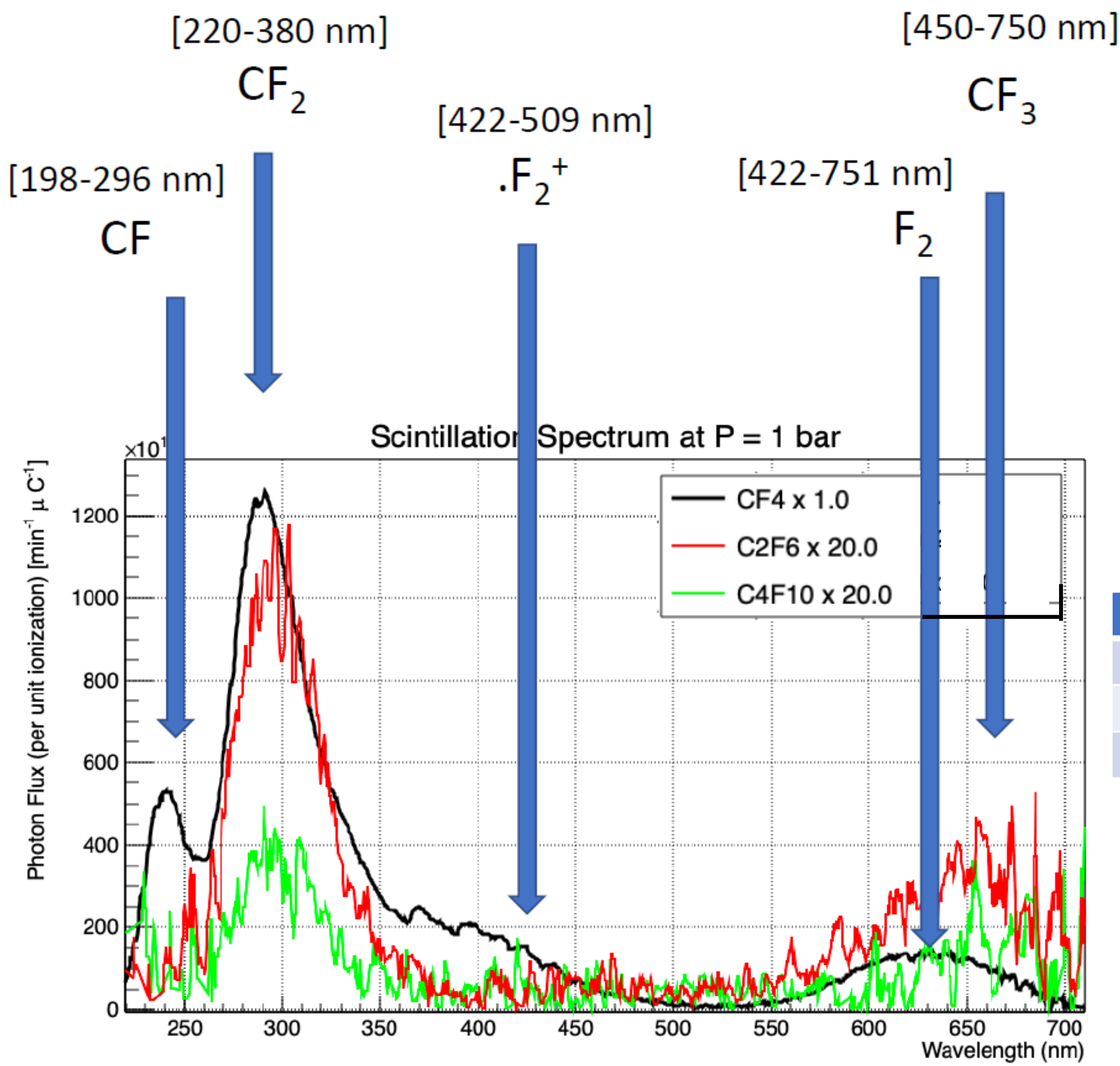
Scintillation comparison CF_4 – C_2F_6 – C_4F_{10}





First result from 2025 campaign ➔ new measurement performed in April; higher accuracy and mixtures C_2F_6/CO_2 with various percentages of CO_2

C_2F_6 scintillation spectrum description



CF_4 and C_2F_6

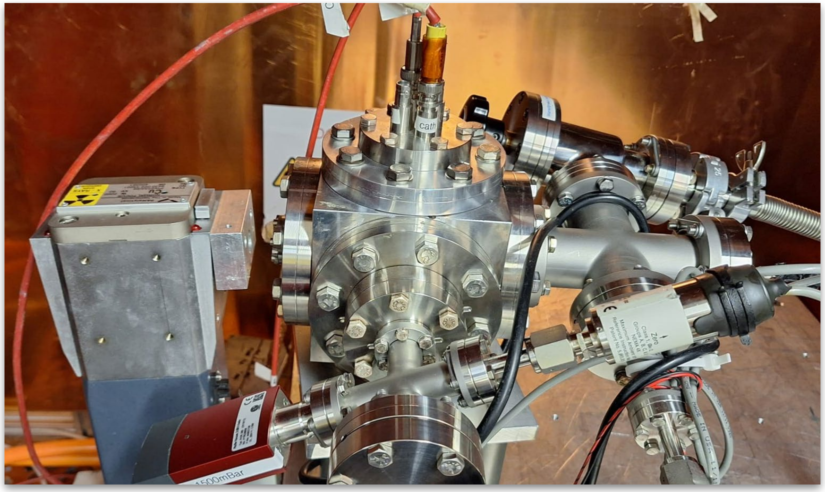
different CF_2/CF_3 intensity ratio → different processes

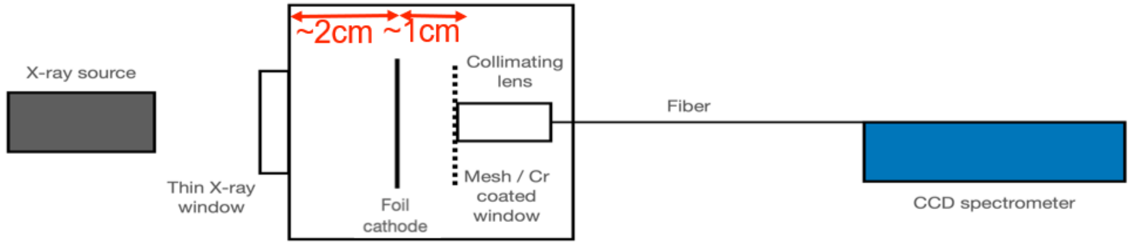
molecule	Intensity [CF_2/CF_3]
CF_4	10 : 1
C_2F_6	3 : 1
C_4F_{10}	2 : 1

C_2F_6 and C_4F_{10}

almost the same ratio→ similar mechanism

Better understanding of the setup

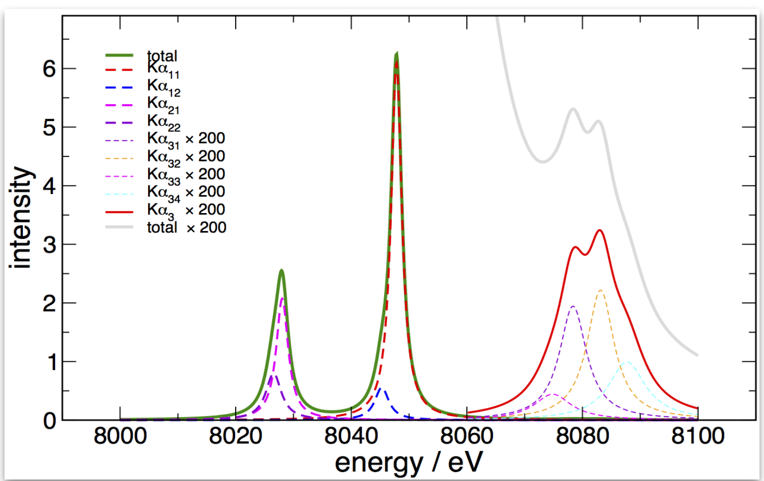


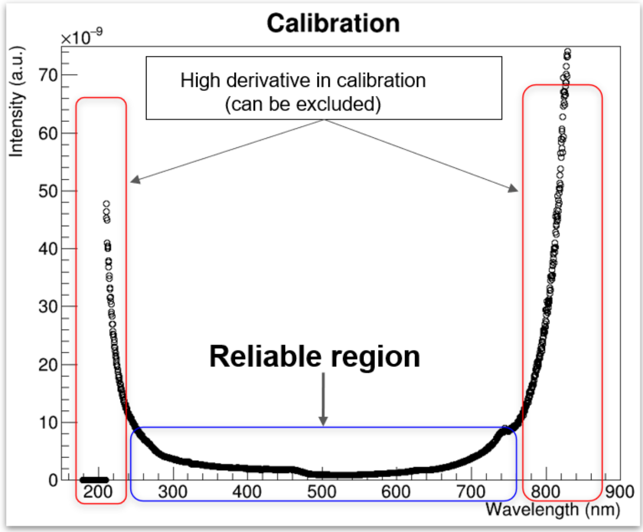


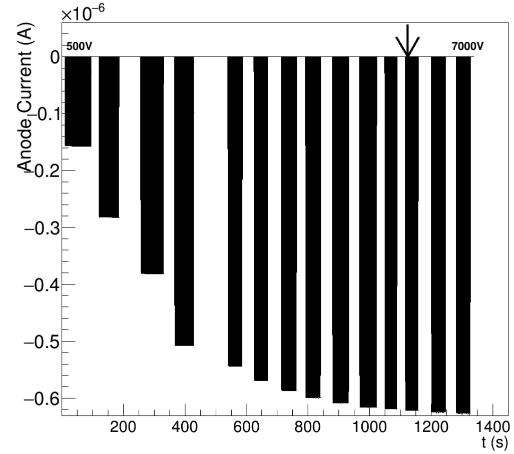
- ❑ **Cu source**
- ❑ **Some filtering by Al window**
- ❑ **Good approximation of a parallel-plate**
- ❑ **No filed shaper**
- ❑ **1 cm field gap**

Accurate HV setting:
plateau at ~ 5 kV for C_2F_6 at 1 bar

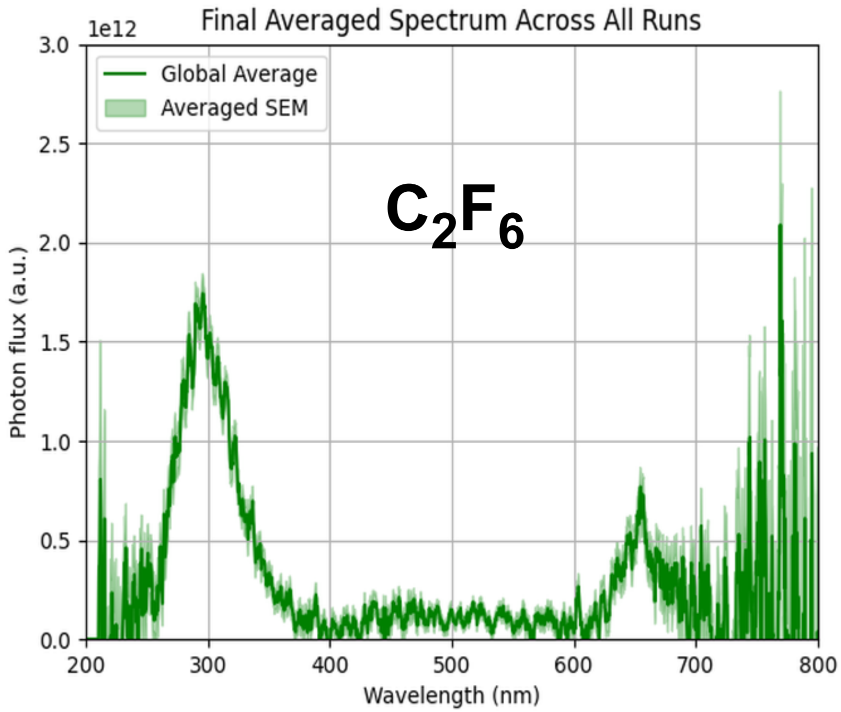
Copper x-ray Kα spectrum (NIST)

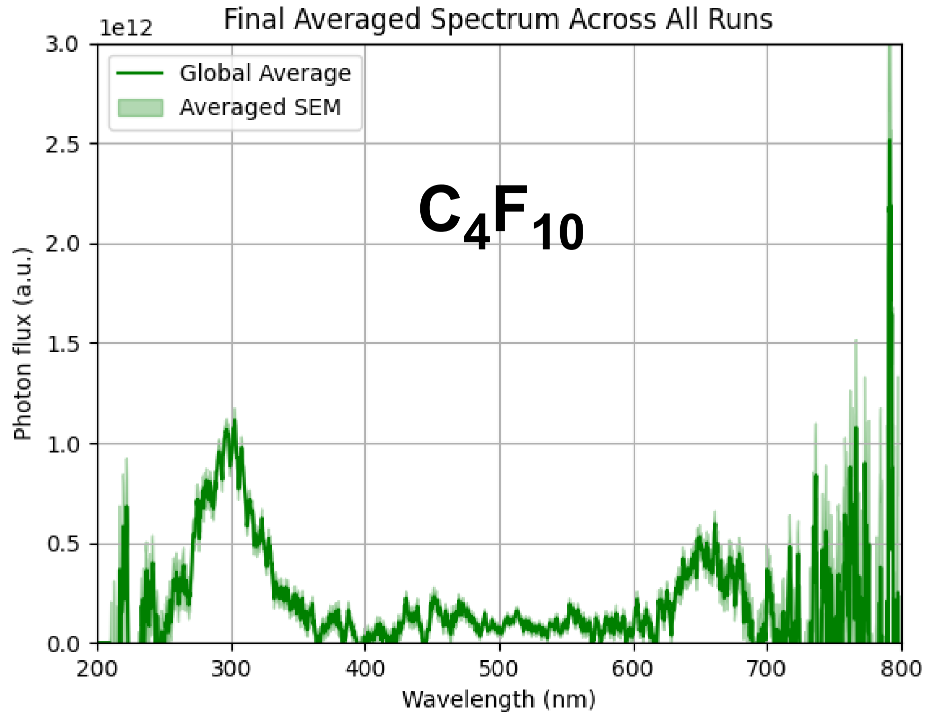






Scintillation campaign of April 2026





- C_2F_6, CF_4, C_4F_{10}
- Mixture of these gases and CO_2
- Other mixtures
- Effect of pressure
- Effect of statistics
- Effect of measurements in different days (micro-alignment and/or T/P)
- Effect of integration time.

10 times 2025 statistics, first results confirmed for C_2F_6 and C_4F_{10}

Analysis ongoing + new QC calculations

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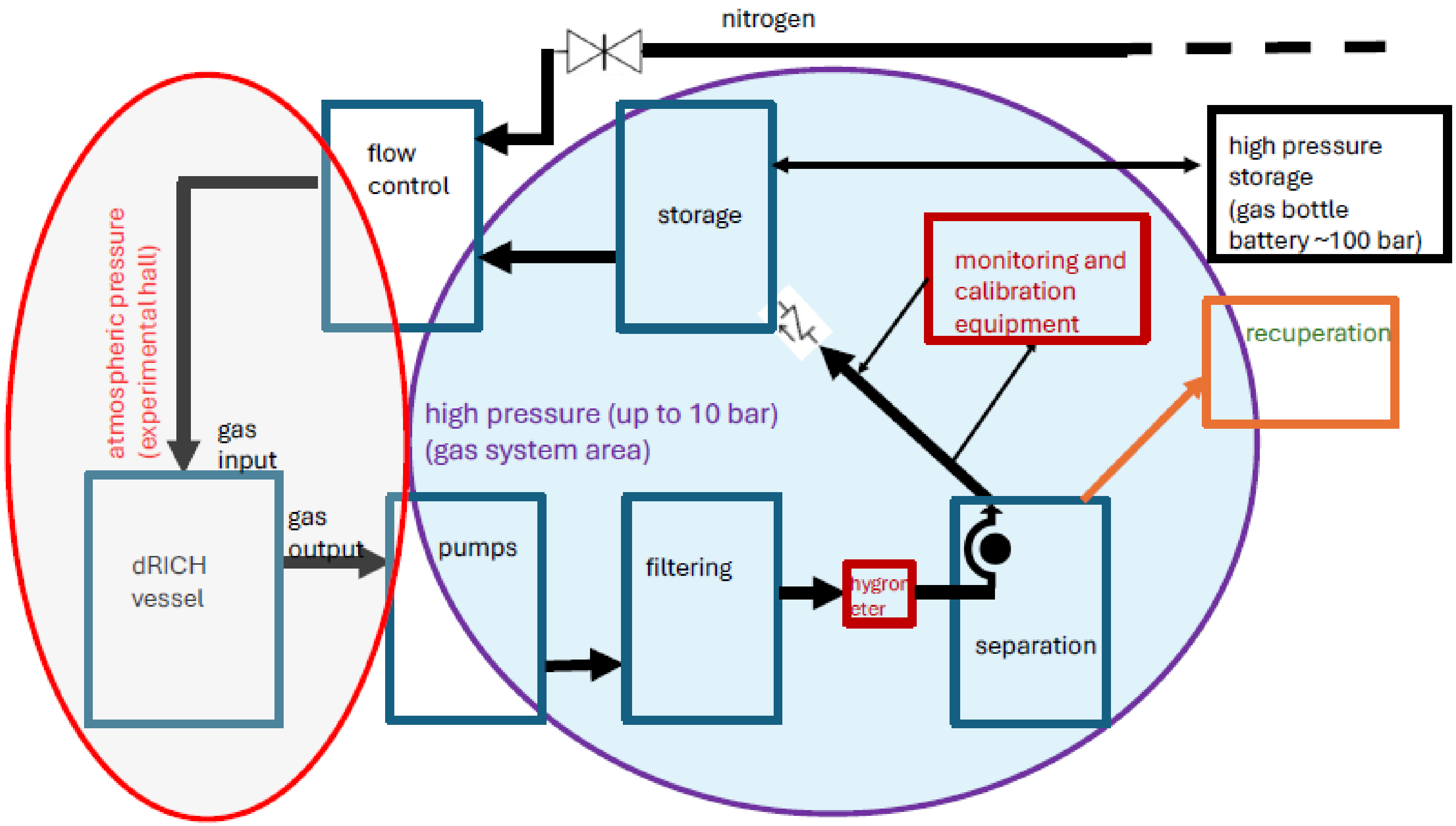
Block diagram of the dRICH gas system



The design and prototyping of the gas system is ongoing in collaboration with the CERN Gas group

Progress in the design of the gas system

Definition of the overall circuit scheme: well advanced

Some elements have already been identified:

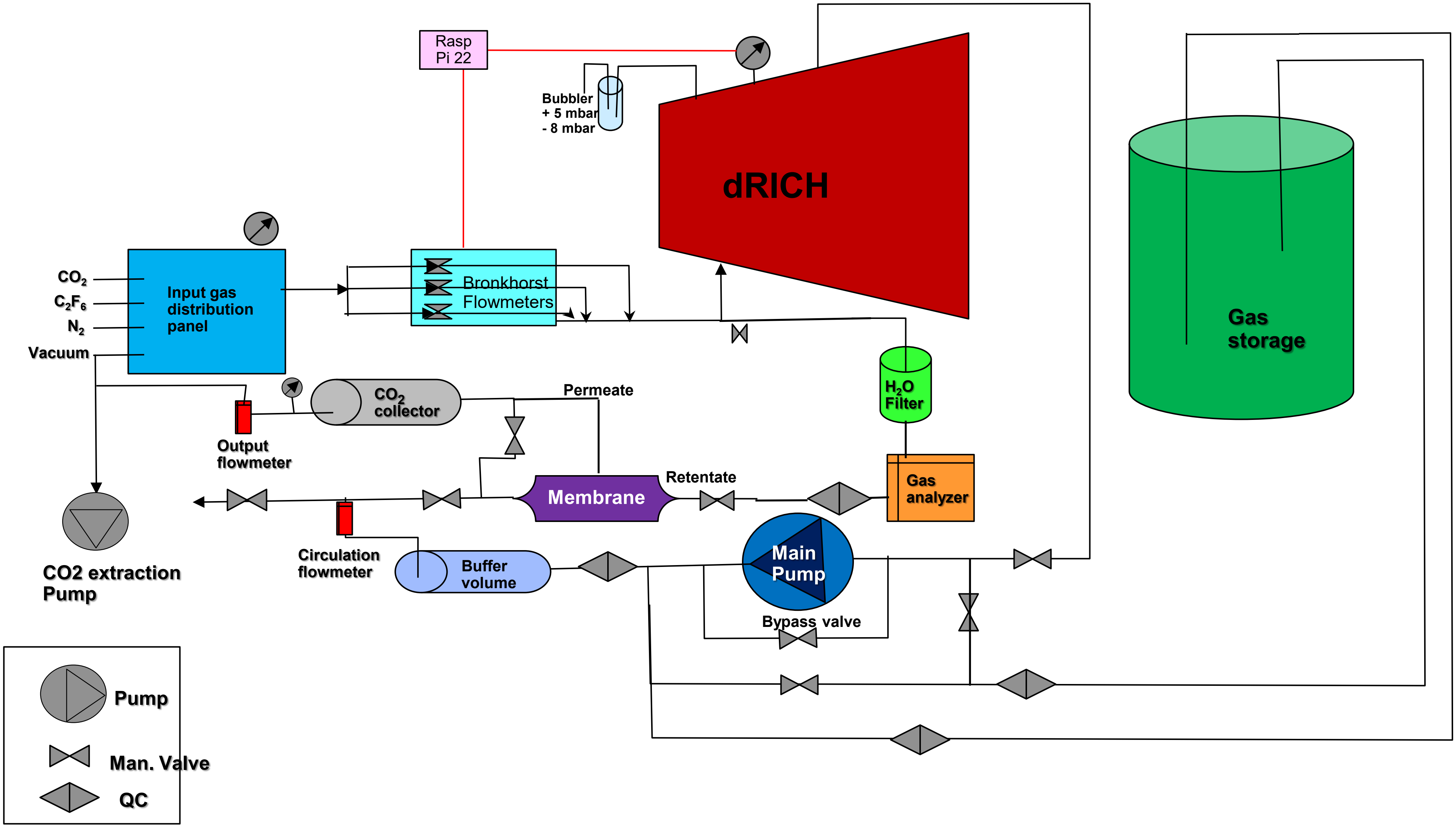
- Compressor: Haug Kompressoren, Pluto 11E 50 (SOGX50-D4)
- Membranes: UBE membranes CO_2 Separator Grade CO-C07FS
- ....

Components of the gas system which must be prepared on site and installed:

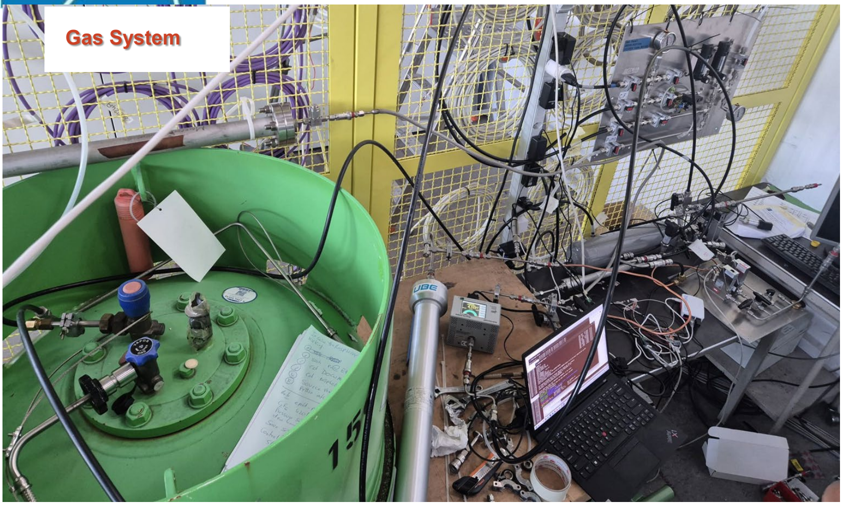
- **Main gas pipes**
- **Compressors**
- **Gas storage volumes**
- **Main electrical power distribution**

Prototyping started: first test in realistic conditions performed in June

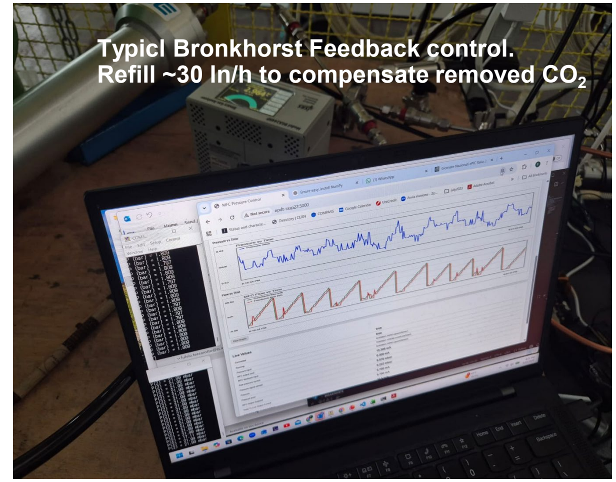
Scheme of the test beam gas system

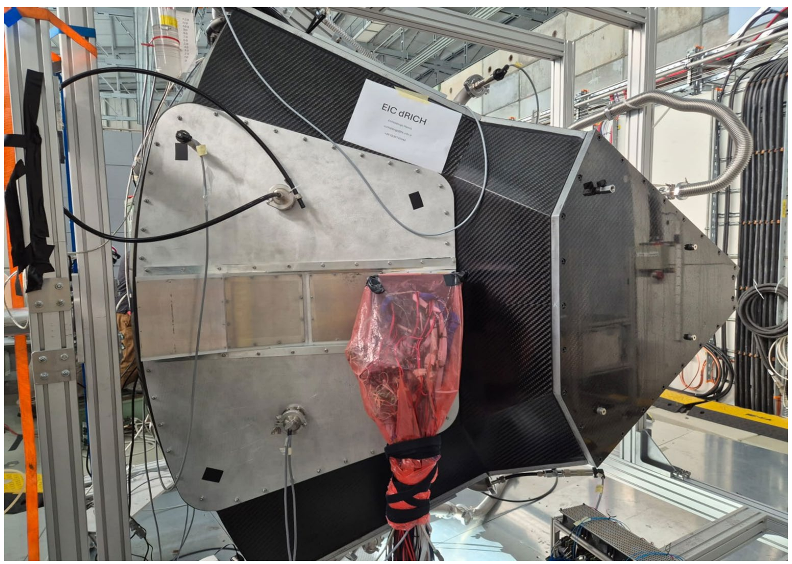


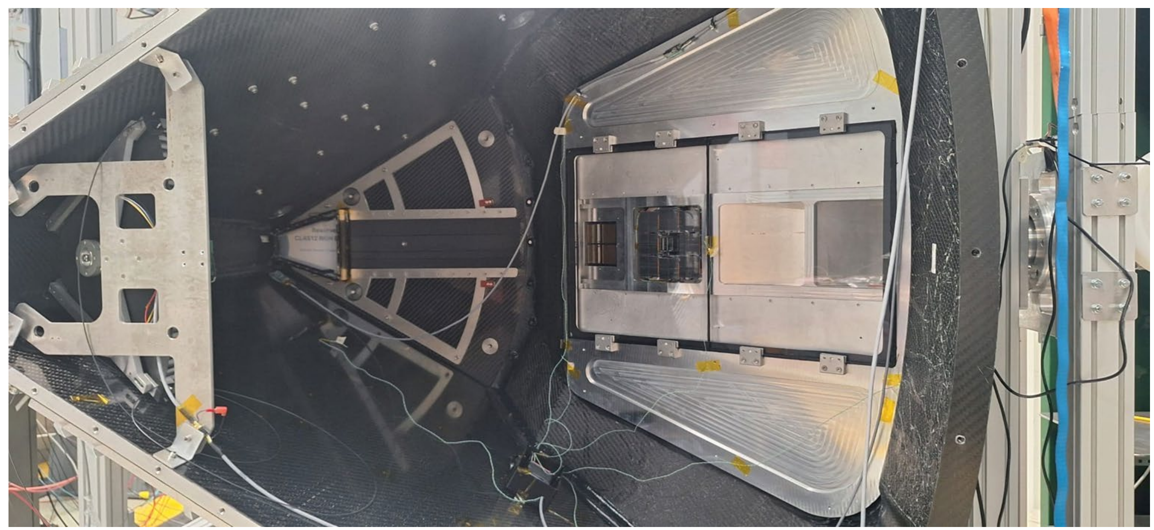
Vessel and gas system overview



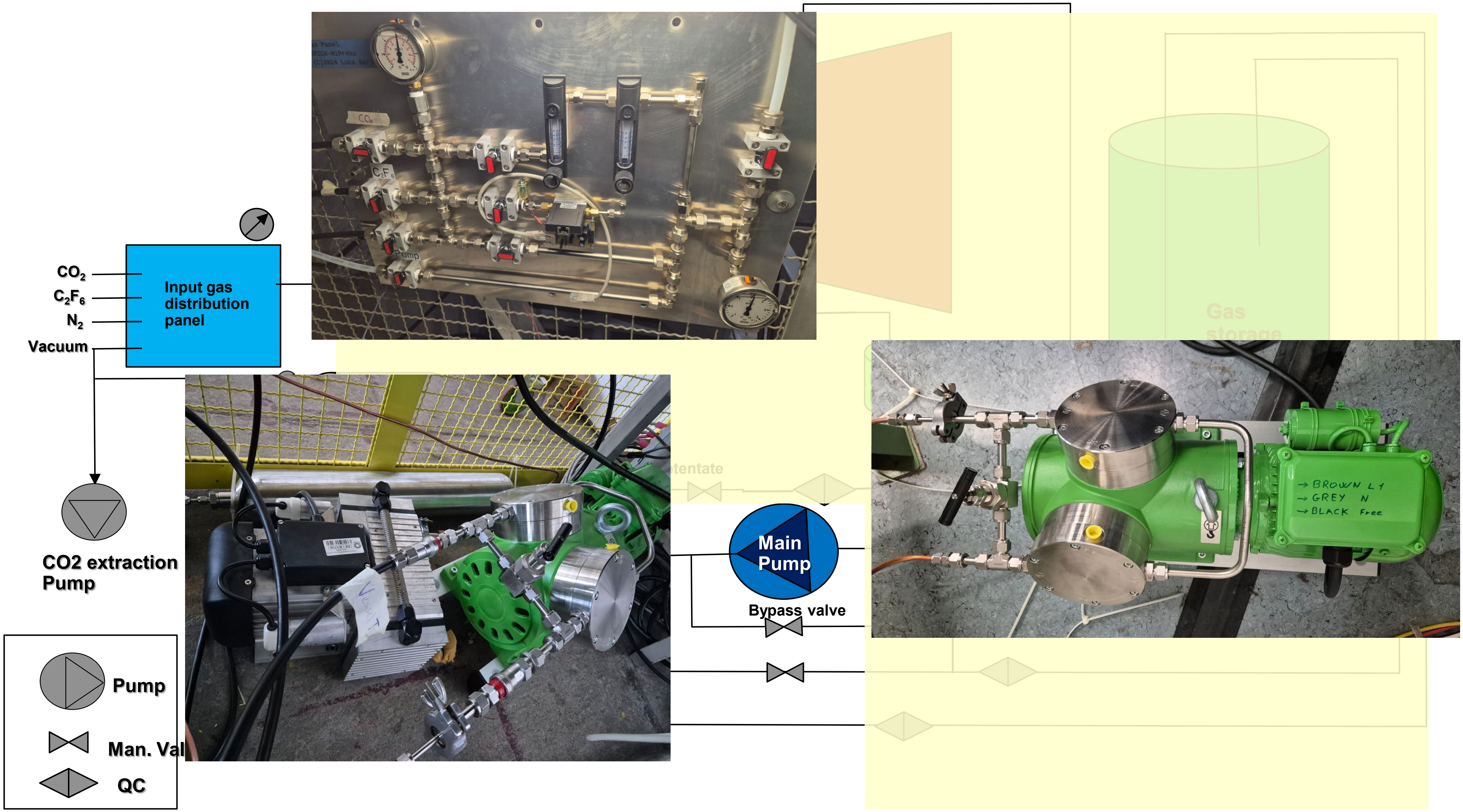
Final CO_2 Contamination in C_2F_6 for a delta-P ~ 4 bar







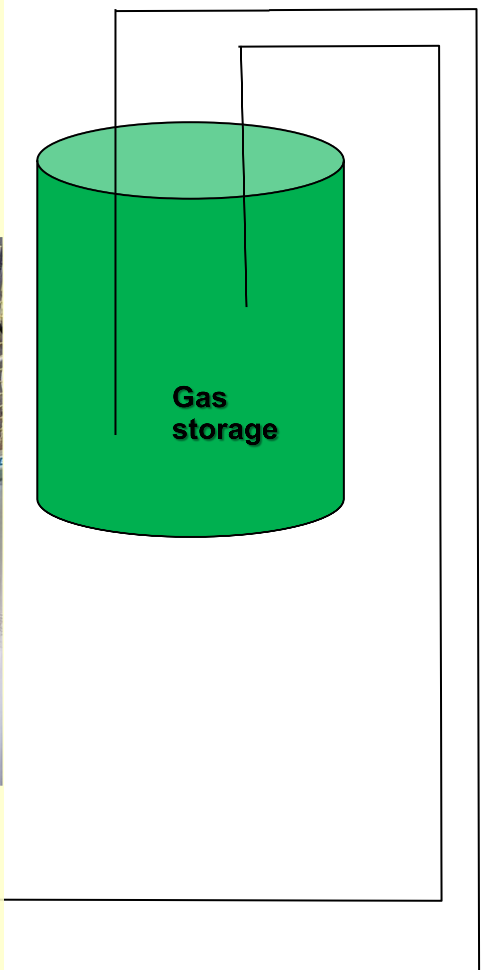
Input panel and pumps



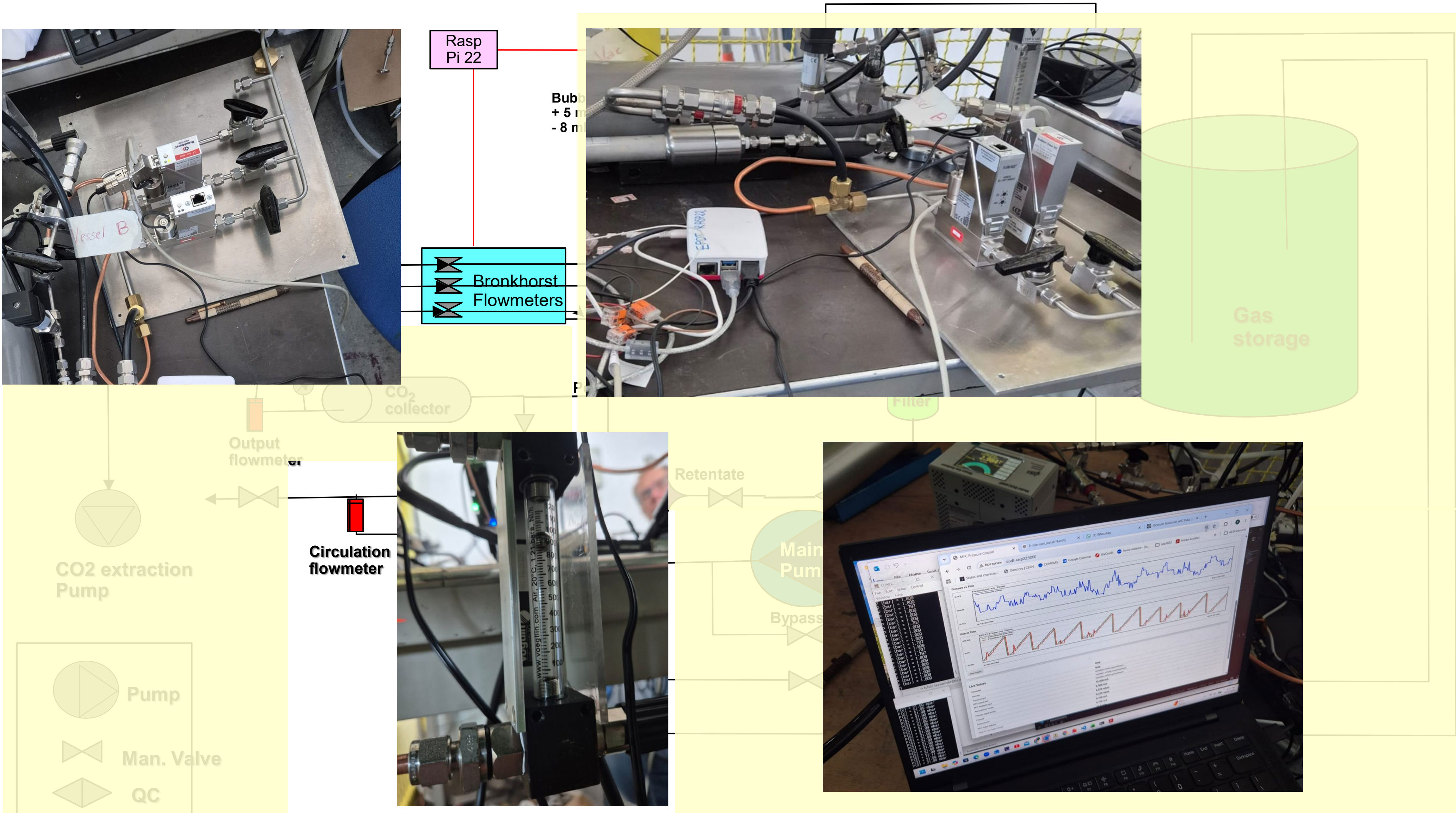
Temporary storage volume

380 l recovery drum (50 bar max)

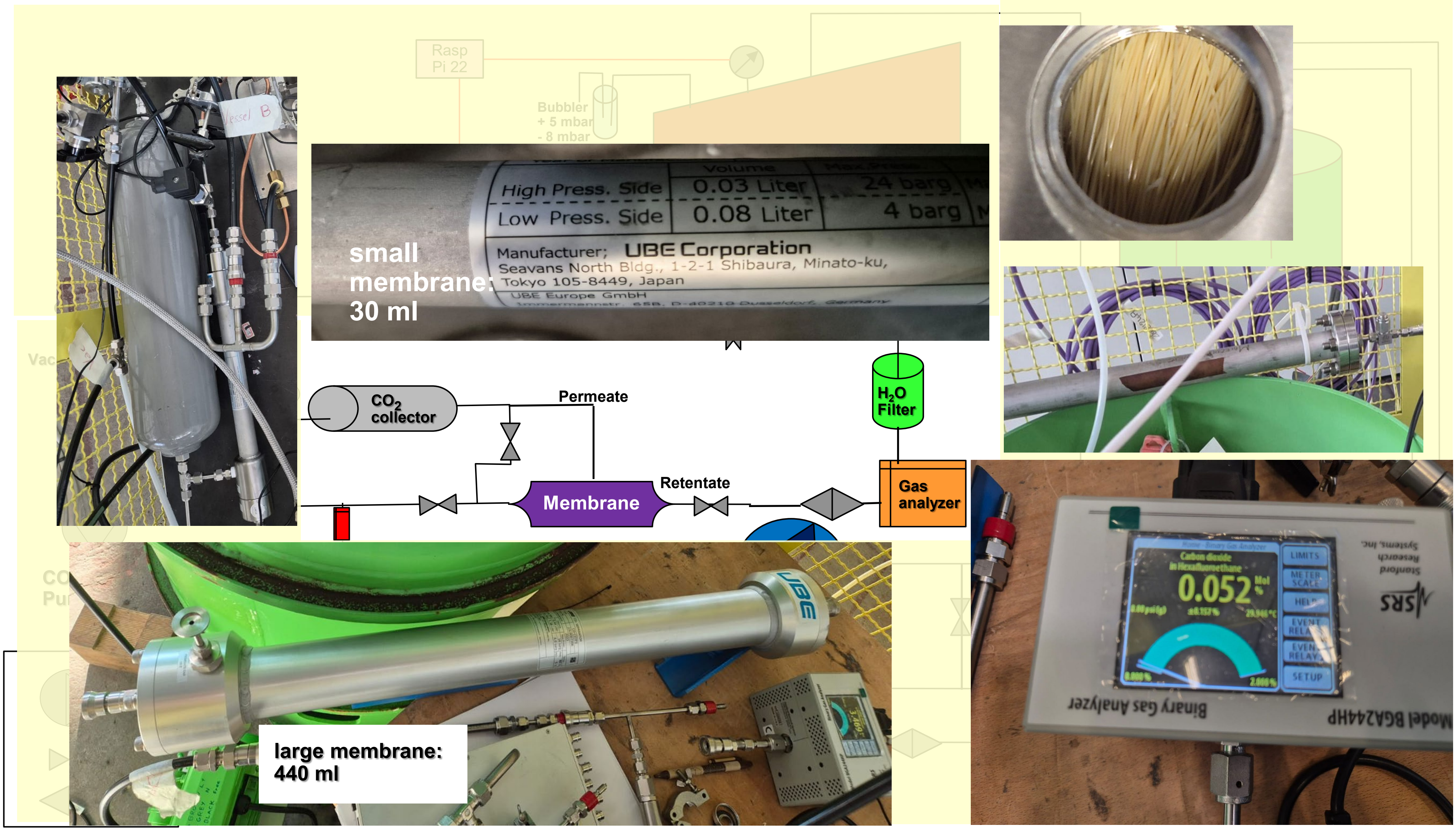
Drum top and bottom connections



Flowmeters and flow control



Membranes, permeate volume, analyzer



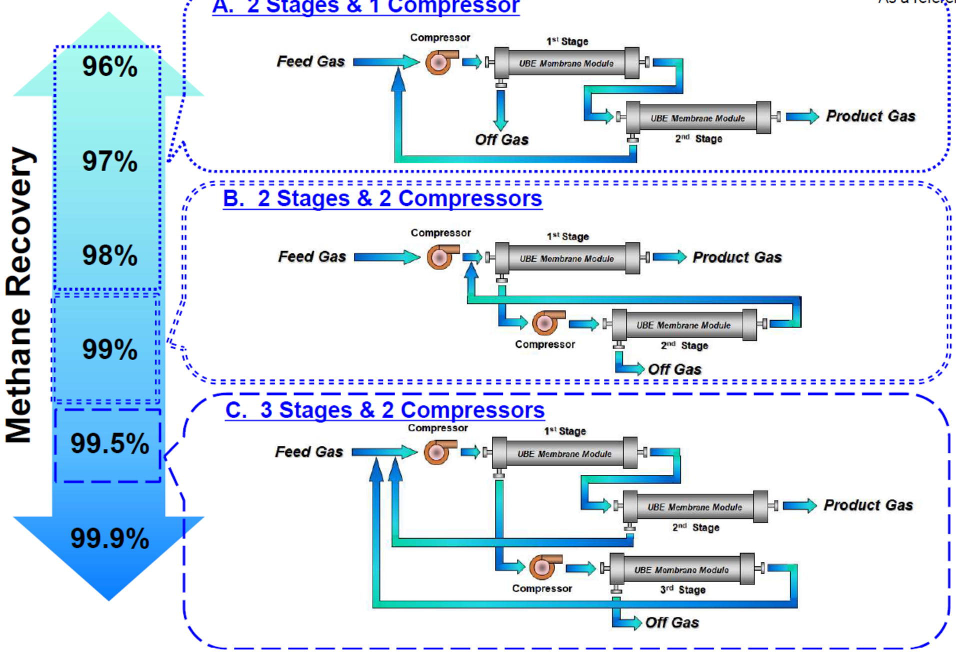
Cascading Membranes

System Configuration of Membranes **

**UBE supplies membrane module/cartridge only.

UBE Corporation

CS-001E_REV.K_250717
As a reference

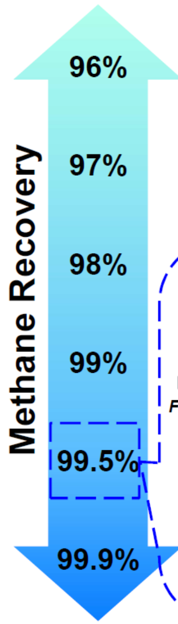


New System Configuration of Membranes **

**UBE supplies membrane module/cartridge only.

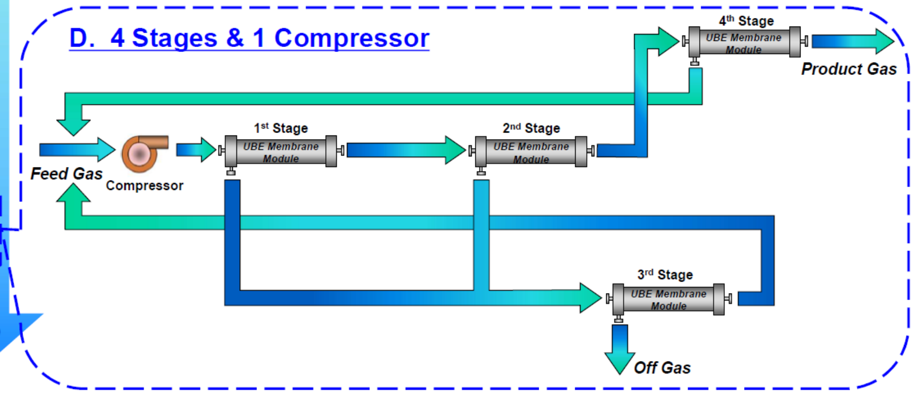
UBE Corporation

CS-001E_REV.K_250717
As a reference



Competitive Advantages

- 99.5 % recovery & 99.0 % purity CH_4, all in one go.
- Save energy with just one compressor.
- Big savings especially for small scale plants.

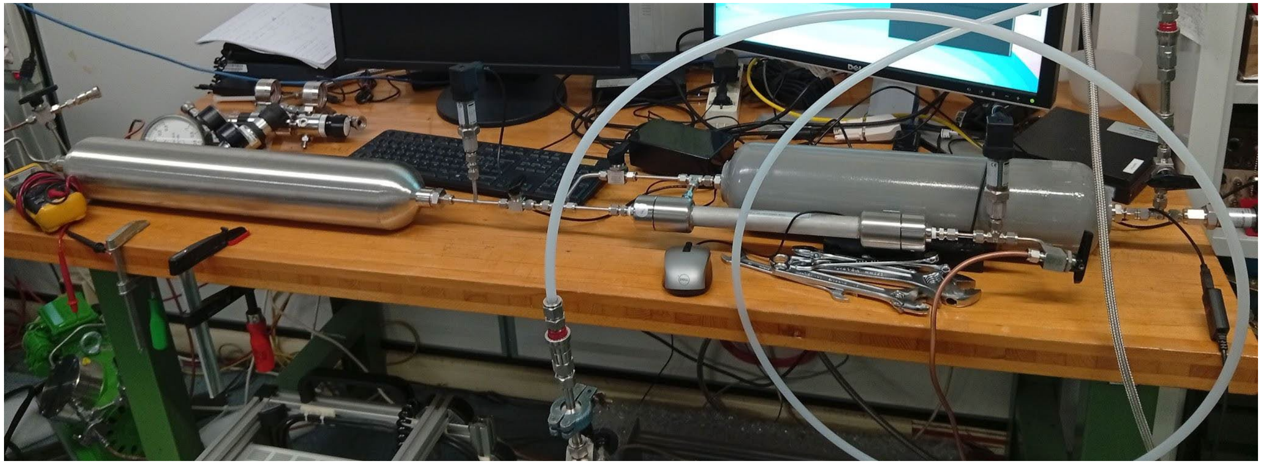


Feed Gas Flow Rate	:	600 Nm^3/h (at 0 °C, 1013 mbara)
Feed Gas Composition	:	CO_2 40 %, CH_4 60 %
Product Gas Purity	:	CO_2 < 1 %

Operating Temperature : 25 °C (77 °F)*

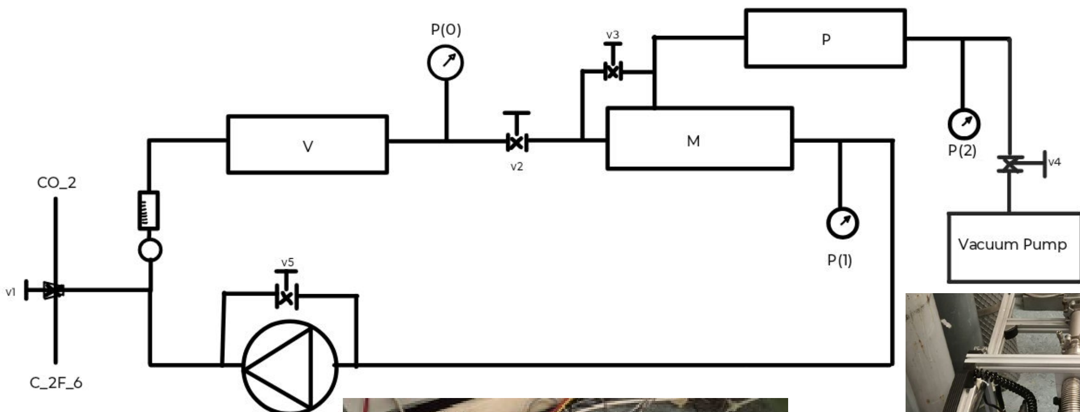
*Maximum allowable temperature is 60 °C (140 °F).

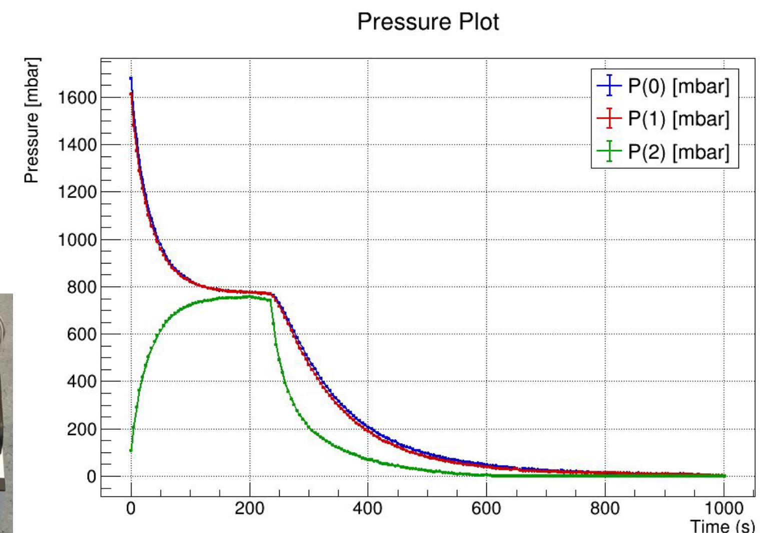
Small selective permeability membrane measurements



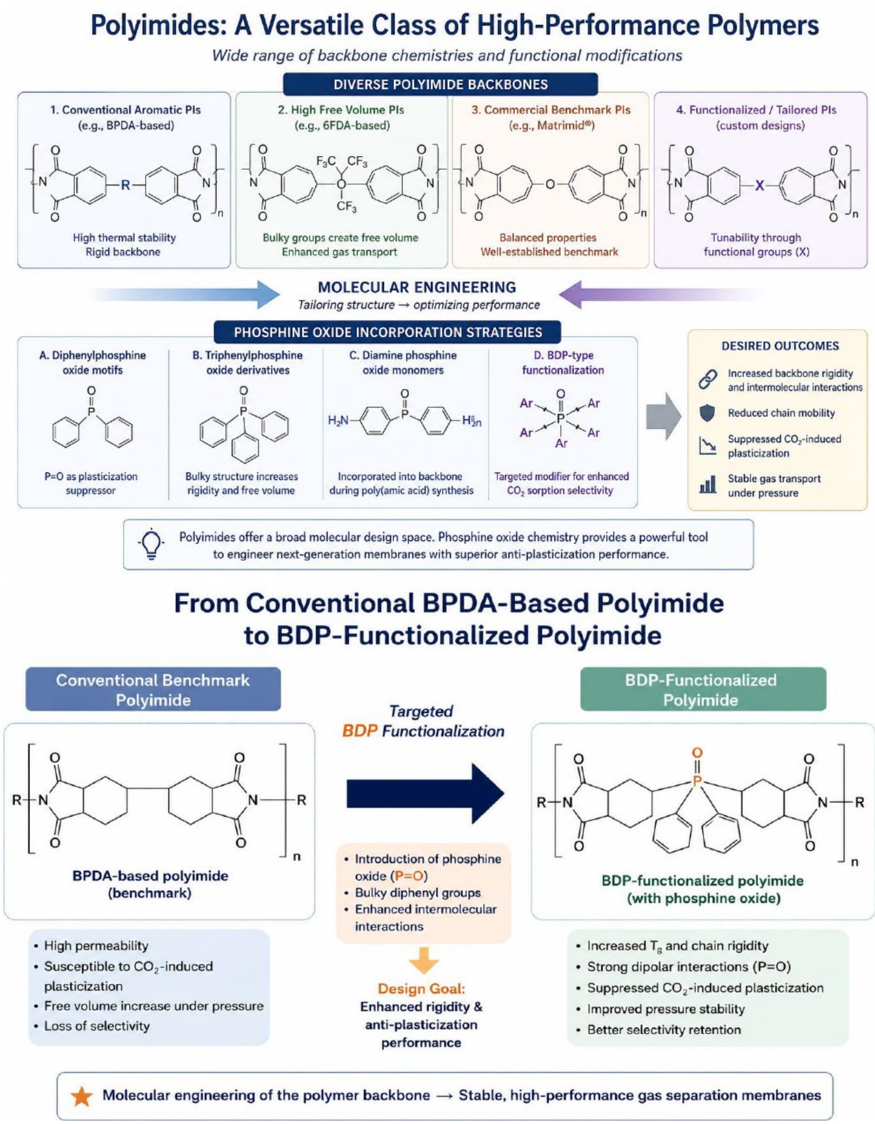
Permeability proportional to Δp.
For Δp = 1 bar we measured:

CO_2	200	l/h
C_2F_6	0.004	l/h
N_2	6	l/h
Ar	10	l/h

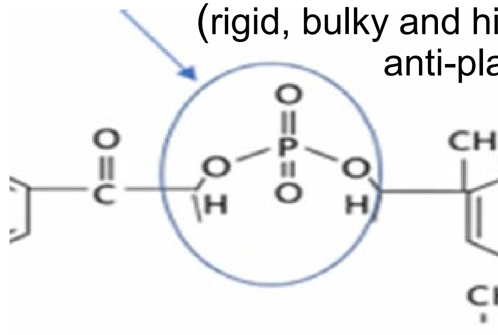


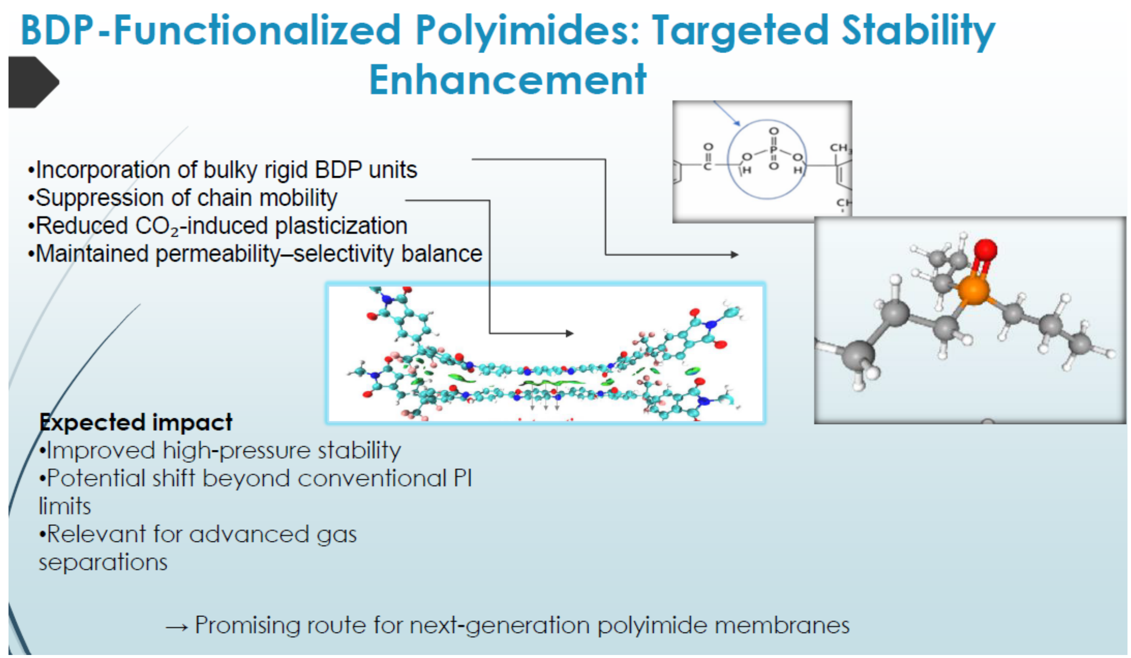


Molecular engineering of specific polyimides for membranes



biphenyl diphenylphosphine oxide
(rigid, bulky and highly polar: anti-plasticization)





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Sequence of operations with C_2F_6

Cleaning and filling:

- Air to N_2: open circuit
- N_2 to CO_2: open circuit
- CO_2 to C_2F_6: recirculation, membrane separation

Normal operation with C_2F_6 :

recirculation on, filtering on, membrane separation on
C_2F_6 input compensates p,T variations, residual CO_2 purge, and leaks (~1 l/h)

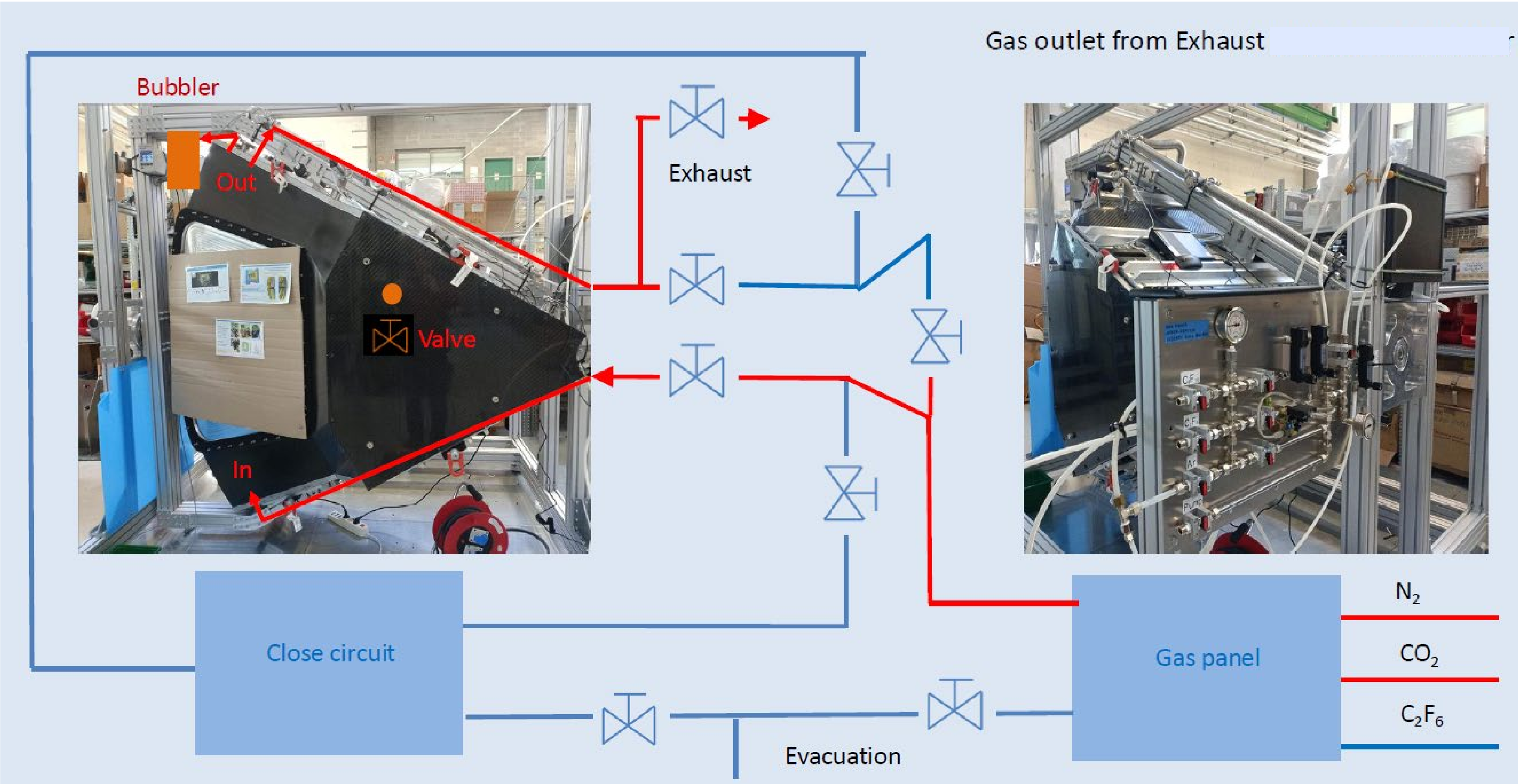
Stand-by operation with C_2F_6 :

no C_2F_6 recirculation, pressure stability by allowing small input flow
problems: contamination level increases, overpressure not compensated

C_2F_6 Recovery:

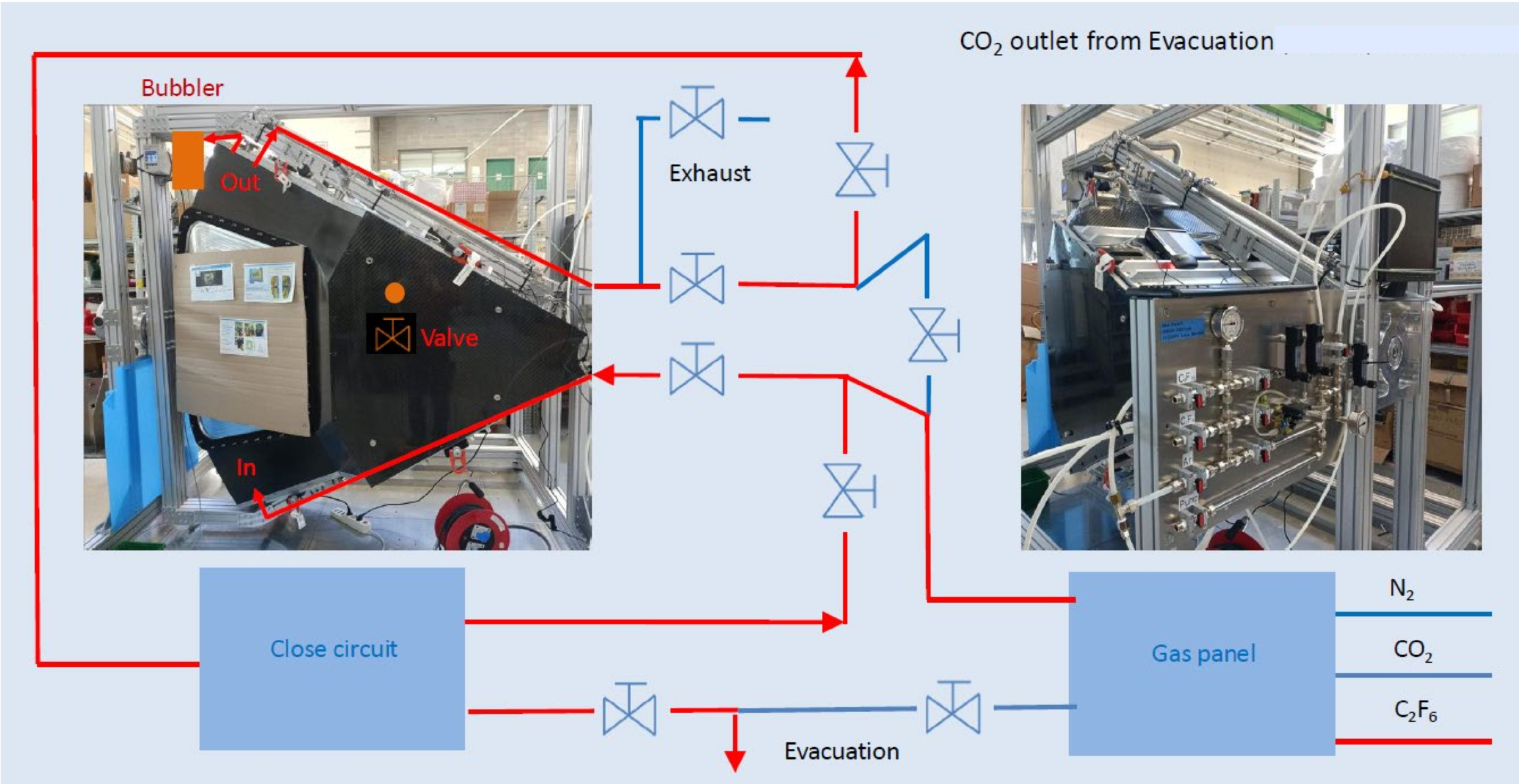
- C_2F_6 to CO_2: circulation, membrane separation at high flow and high pressure
- CO_2 to N_2 or directly to air

flushing N_2 or CO_2 (no circulation)



Air to N_2 and N_2 to CO_2: open circuit

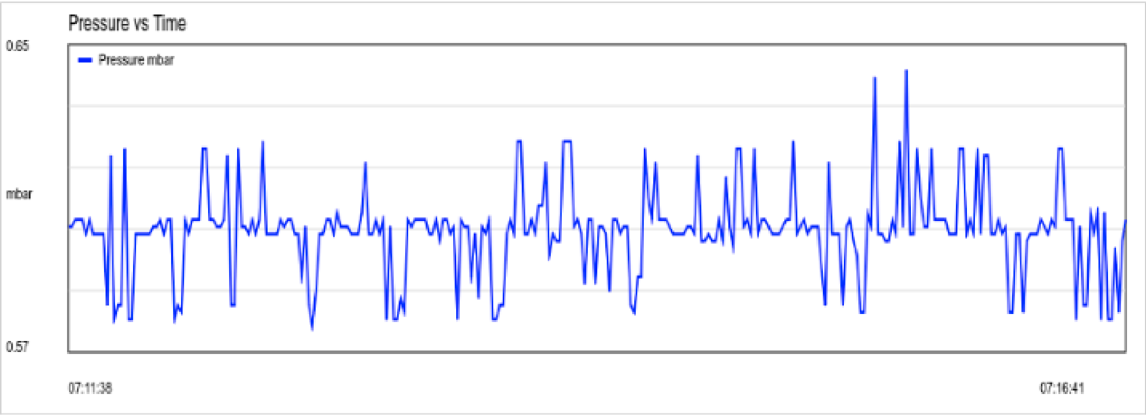
C_2F_6 filling



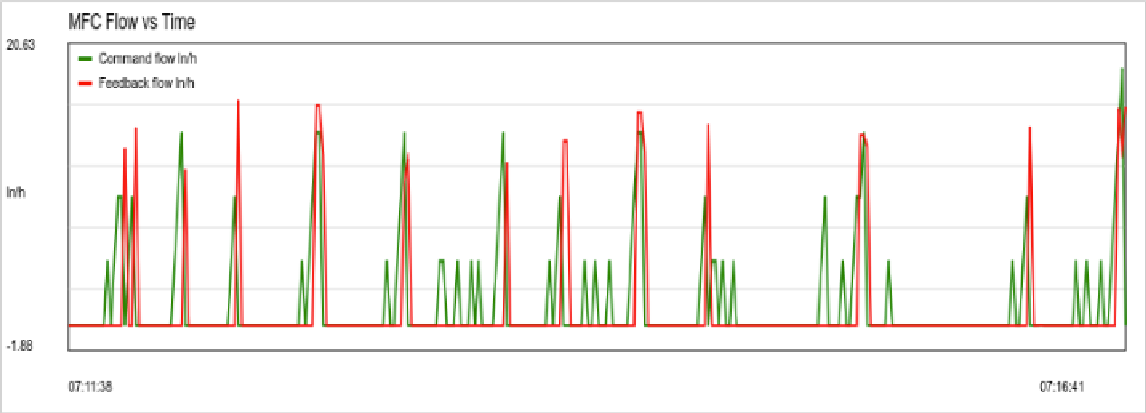
CO_2 to C_2F_6: recirculation and membrane separation

Vessel pressure stability in normal operation

Pressure vs Time

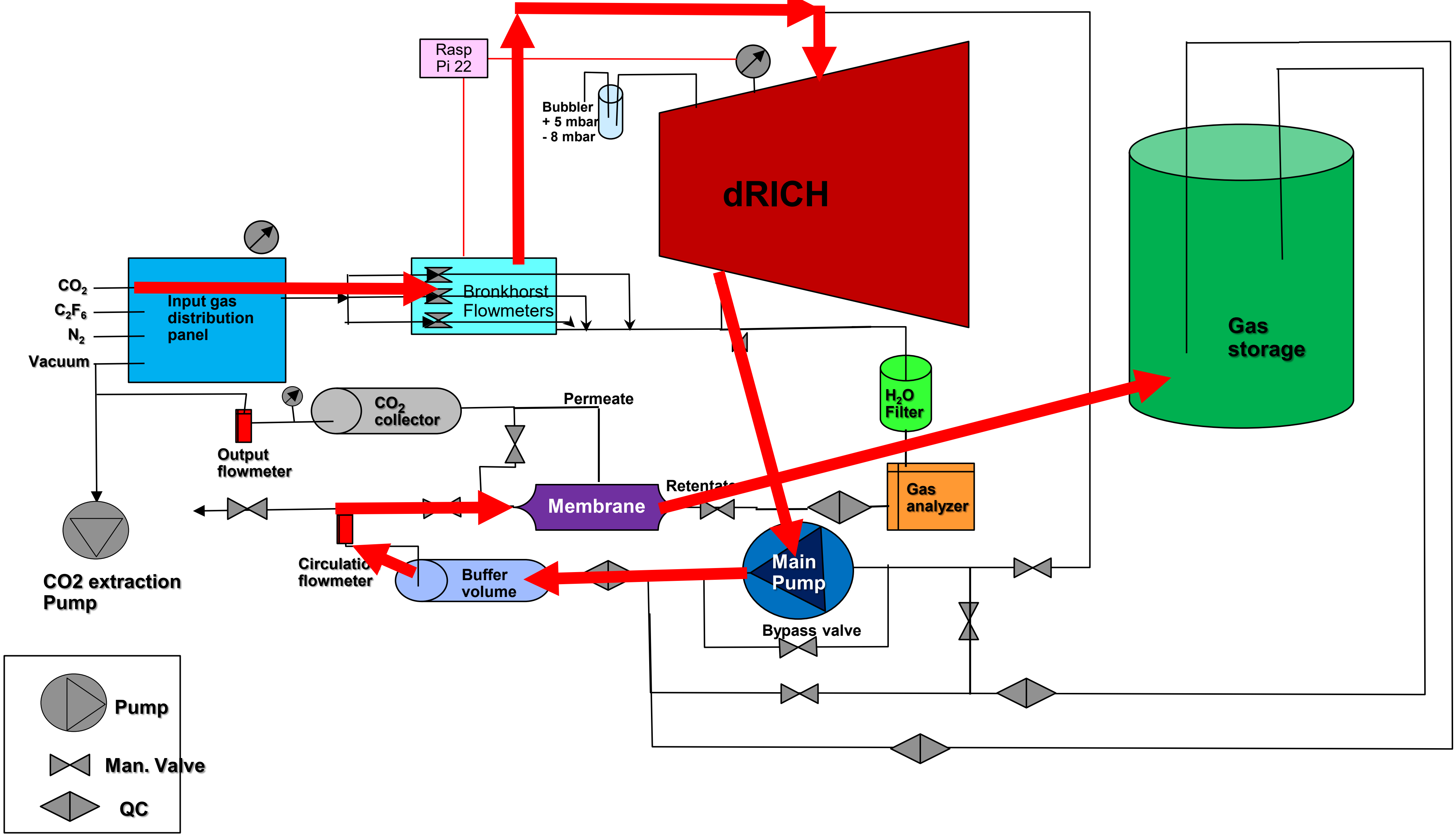


Flow vs Time



During data taking operation: C_2F_6 input compensates leaks and p,T evolution

delicate C_2F_6 recovery operation



C_2F_6 filling and recovery experience

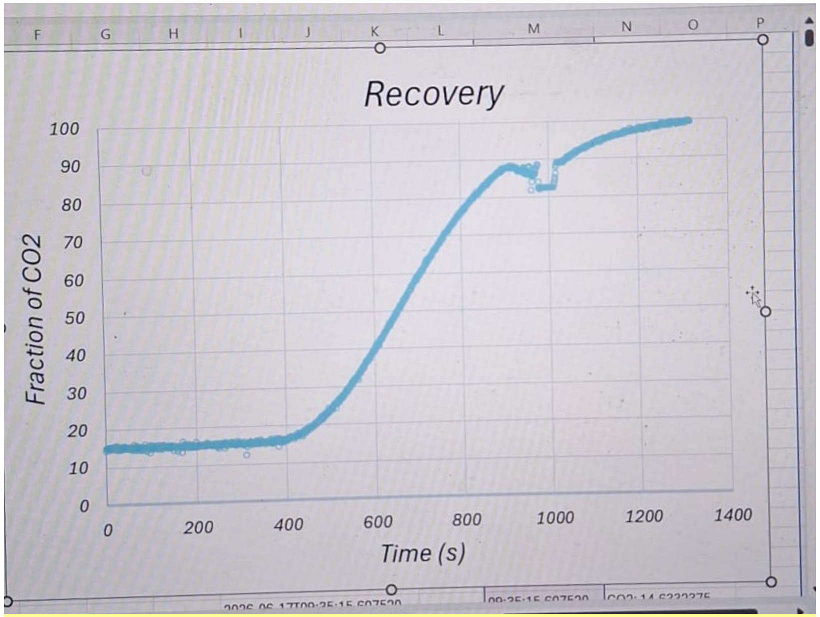
First filling: severe leaks with C_2F_6 after CO_2 operation with small leak

Fast intervention: external "sealing"
Data taking at SPS could be performed

Recovery in the Storage Drum
➔ C_2F_6 successfully reused at PS

Opening and fixing leaks.
C_2F_6 normal operation (~1 l/h)

Filling/Recovery performed three times



C_2F_6 to CO_2 transition in ~1.5 h

Filling: CO_2 extracted from the top, C_2F_6 injected from the bottom, CO_2 filtered by membrane, C_2F_6 from tank to prototype

Recovery: C_2F_6 extracted from the bottom, CO_2 injected from the top C_2F_6 passing the membrane (retentate), <u>only CO_2 permeate purged</u>

C_2F_6 scintillation properties:
- measurements
- calculations

dRICH radiator gas system design

Membranes for gas separation

Test of basic gas circulation system

Monitoring tools

Test-beam with pressurized setup

Monitoring p,T, flow, transp., …

Essential role of p sensors
(4 on vessel, 4 on gas system)

Many temperature sensors helped understanding the status and the transitions

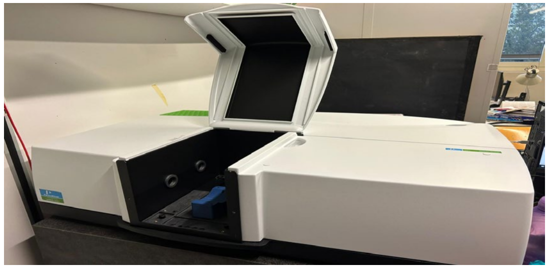
Important moisture measurement and CO_2 measuring device

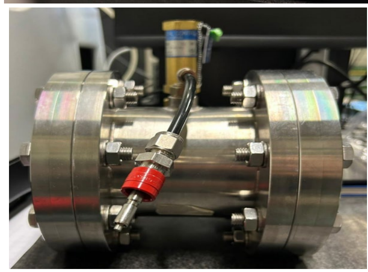
Six flow meters and rotameters

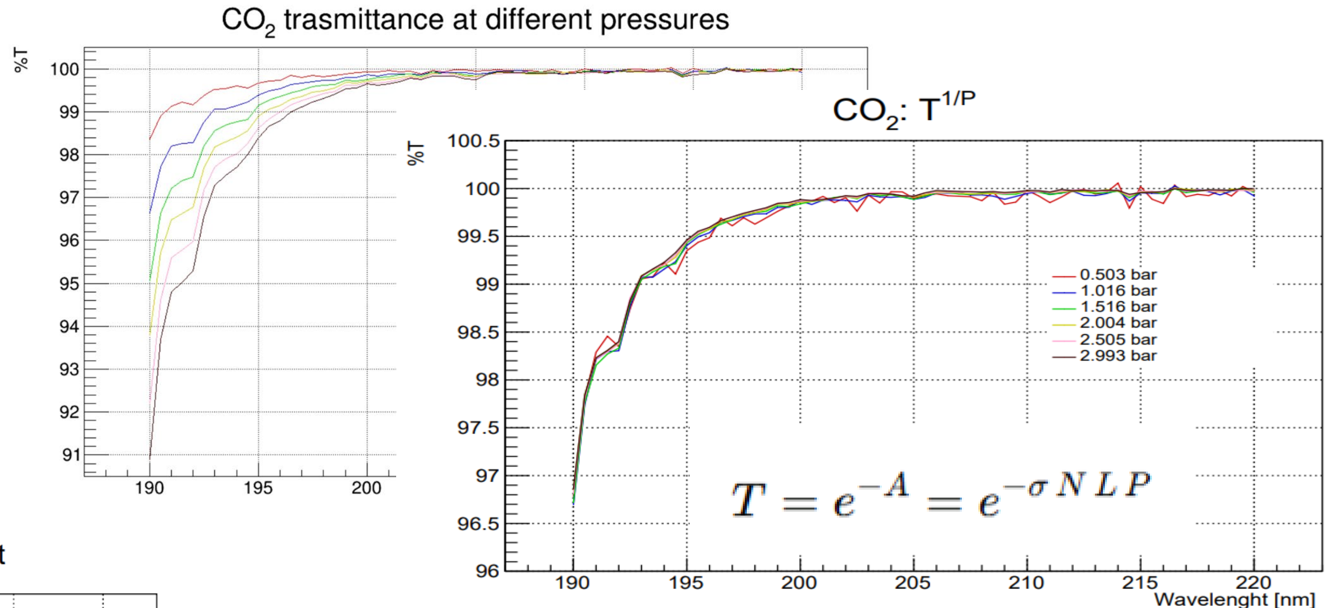
Speed of sound (binary gas analyzer)

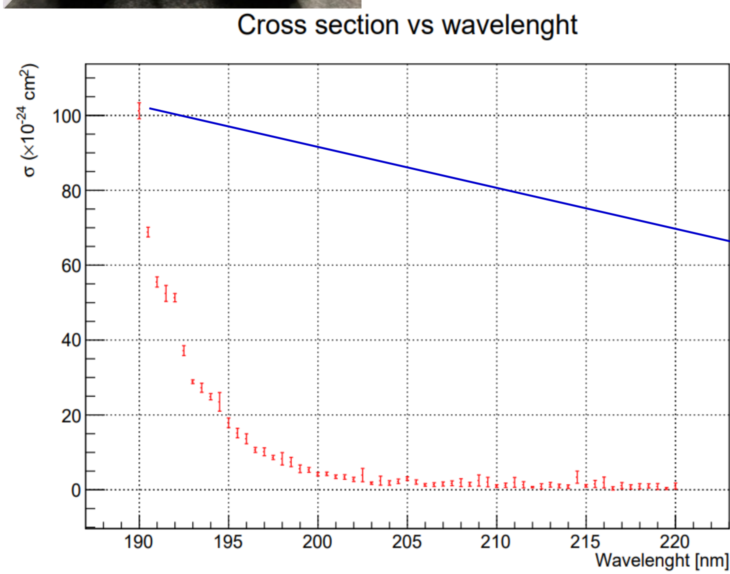
Control and recording

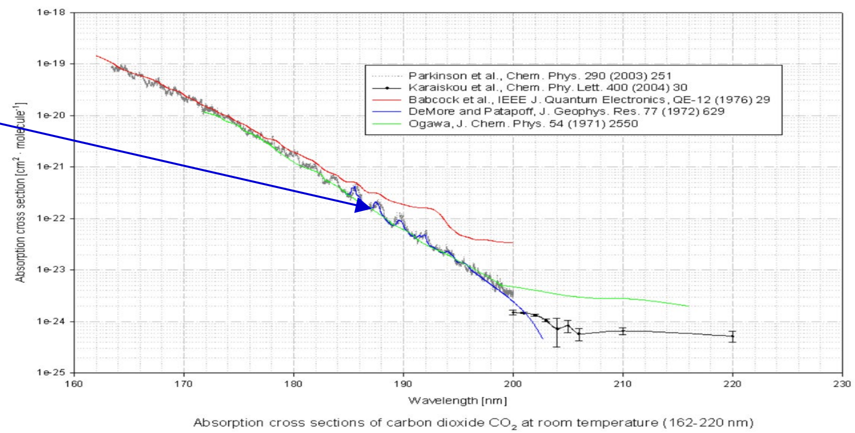
New C_2F_6 transparency measurement 1











A measurement of CO_2 transparency → σ ~100 mbarn

(compatible with literature values)

New C_2F_6 transparency measurement 2