Gas system status

System checks

- Key issues:
  - is the impact of vessel's acrylic on moisture (and, in turn, on the detector response) relevant?
  - what is the impact of the filters on the radioactivity of the gas mixture?
  - what is the impact of leaks on the detector response?
  - is the CF_4 release in the atmosphere tolerable?
- To answer this question, a continuous monitoring of the operating conditions of the gas system and several dedicated checks were performed in the last months
  - monitoring of gas tightness
  - monitoring of gas density
  - monitoring of humidity
  - impact of filters (different combinations tested)

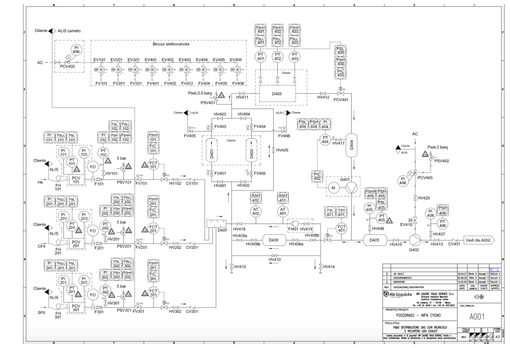
System checks

- Key issues:
  - is the impact of vessel's acrylic on moisture (and, in turn, on the detector response) relevant?
  - what is the impact of the filters on the radioactivity of the gas mixture?
  - what is the impact of leaks on the detector response?
  - is the CF_4 release in the atmosphere tolerable?
- To answer this question, a continuous monitoring of the operating conditions of the gas system and several dedicated checks were performed in the last months
  - monitoring of gas tightness
  - monitoring of gas density
  - monitoring of humidity
  - impact of filters (different combinations tested)

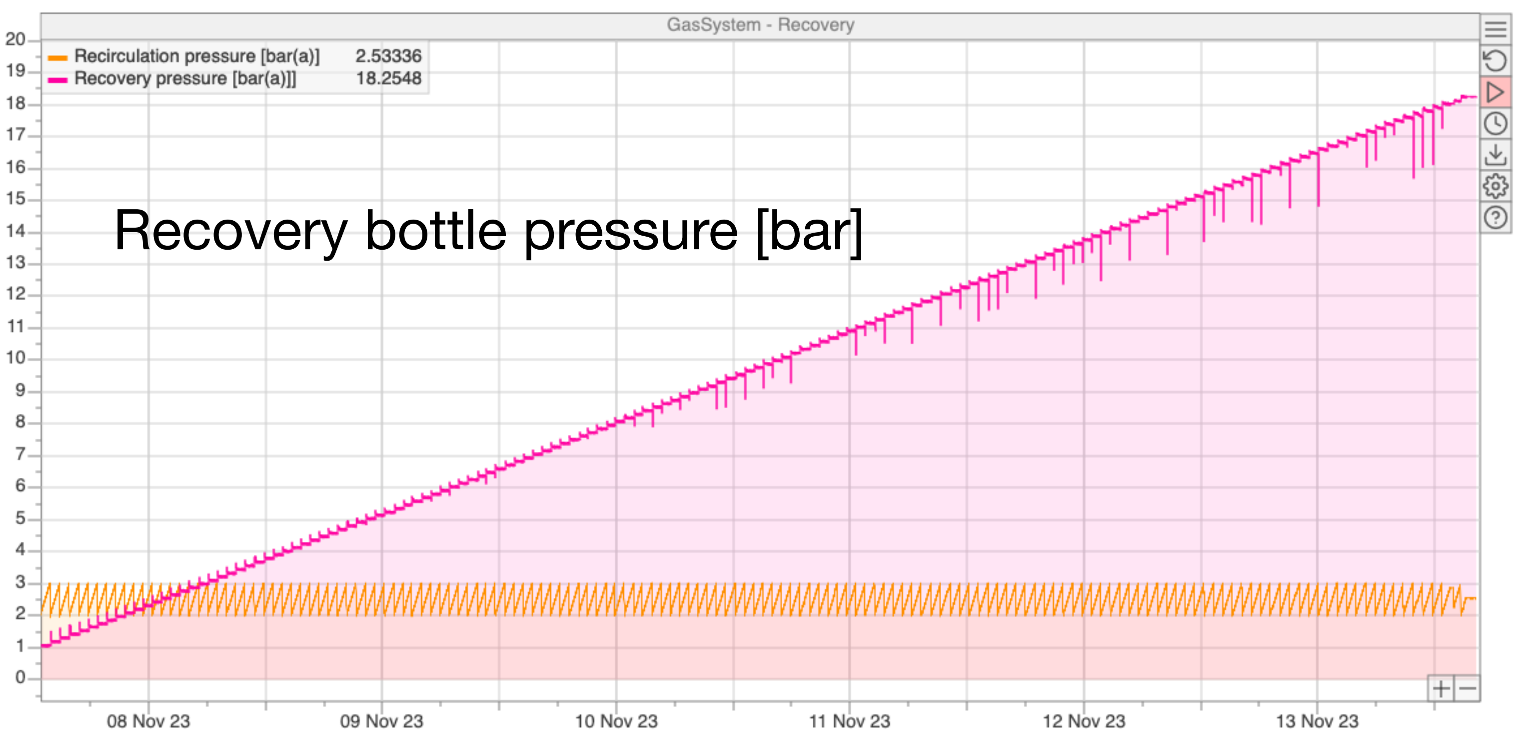
Gas tightness

- 2 distinct aspects, not to be confused:
  - leaks in the detector volume and the circulation system —> impact on CF_4 release and possible impact on the detector response
  - leaks in the recuperation system (downstream of the booster) —> impact on CF_4 release; impact on the detector response is very unlikely (back-diffusion of contaminations is now prevented by valves installed in September)

Gas tightness



- The total leak can be estimated by comparing the rate of fresh flow and the rate of recovery bottle filling



Leaks:

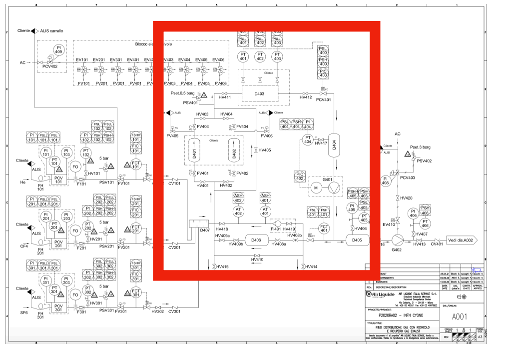
September: 0.8 l/h
October: 0.8 l/h

A leak fixed in the filter section

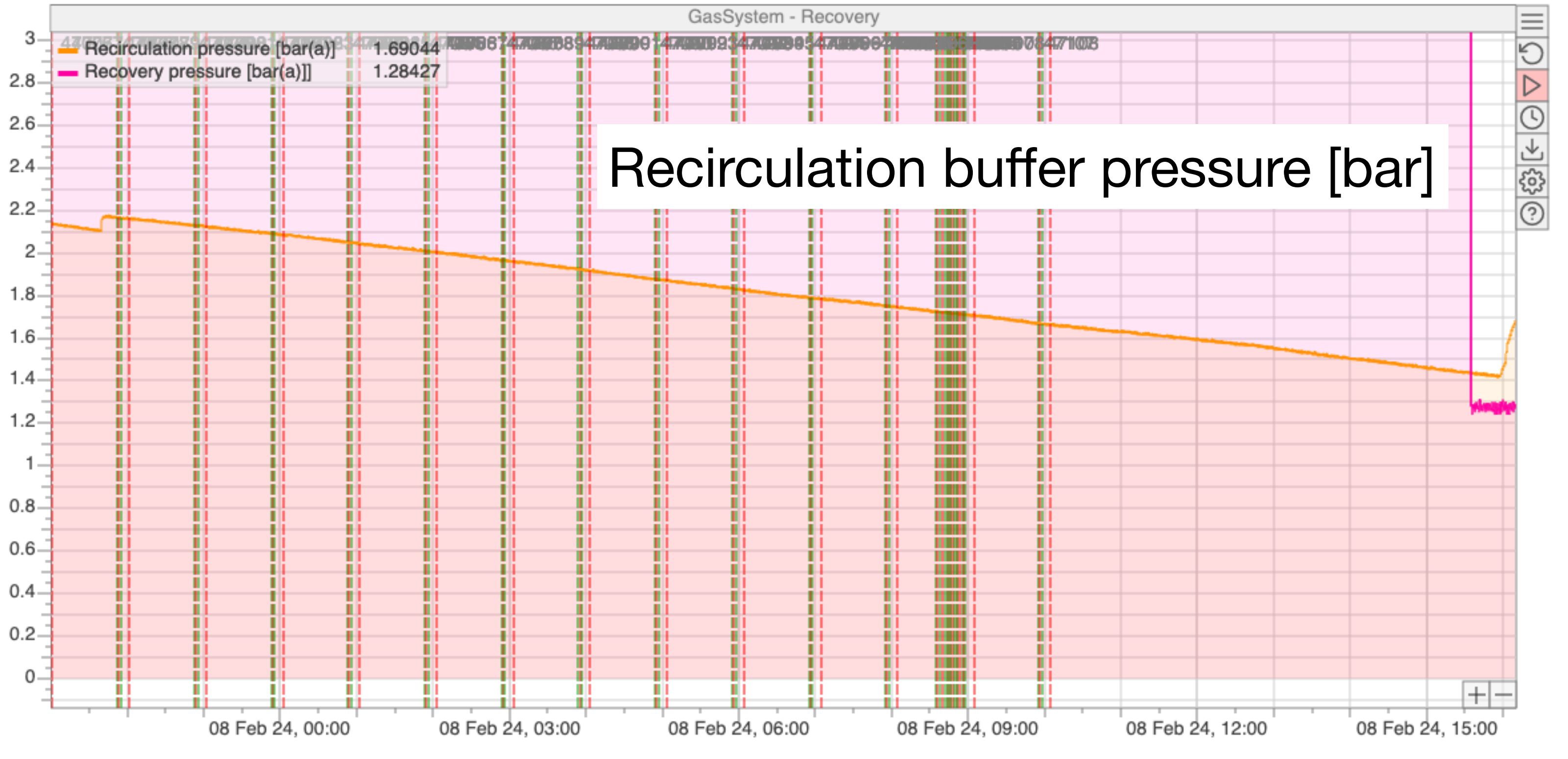
November: 0.3 l/h
December: 0.3 l/h
January: 0.35 l/h

Small leaks and no evidence of deterioration

Gas tightness



- The leak in the detector and gas circulation system can be estimated from the pressure drop in the recirculation buffer when the fresh flow is off

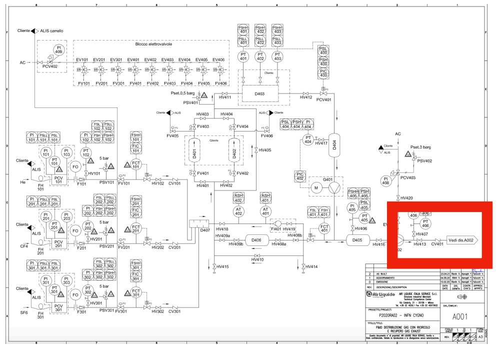


Without fresh flow
no booster operations
no external pressure
Measured leak: 0.2 l/h

The difference of this and the total leak rate is the leak rate in the recovery system: 0.3 l/h - 0.2 l/h = 0.1 l/h

—> Interventions by AirLiquide (new booster gaskets + installation of two valves to isolate leaks in the booster) were a complete success

Gas tightness



- The leak in the recovery lines (no booster) can be estimated looking at the drop of pressure in the recovery bottle in between two booster's actions

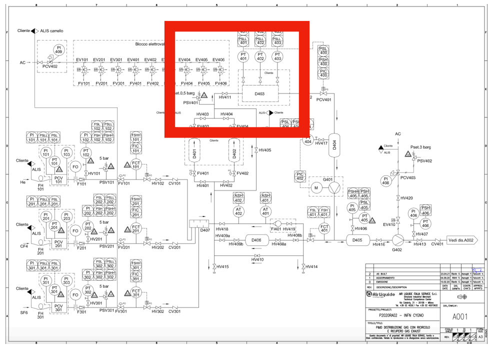
Recovery pressure

Drops ≲ 0.02 bar/h over ≲ 1 l
→ ≲ 0.02 l/h

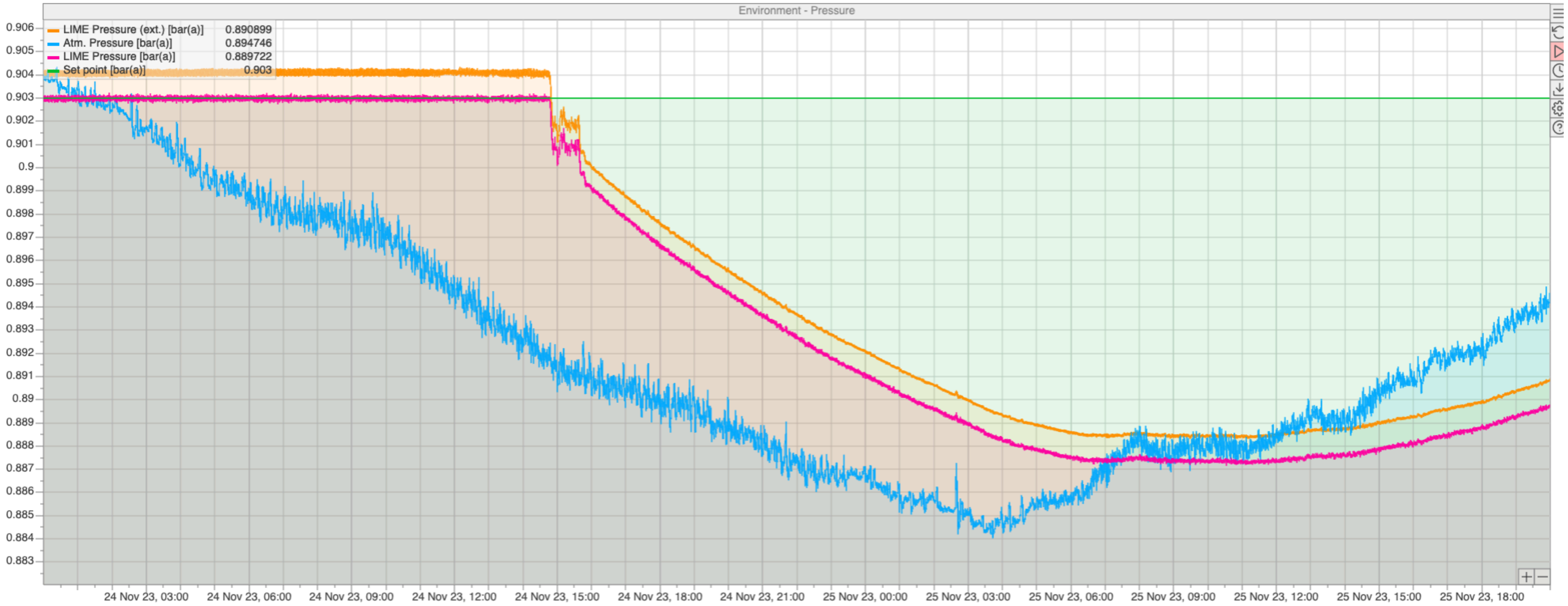
No evident dependence on absolute pressure

Although the interpretation is not immediate (due to the action of the check valves), leaks in the recovery lines look irrelevant

Gas tightness



- The leak in LIME (including part of gas lines and circulation system) can be estimated from the pressure drop in LIME when the system is off



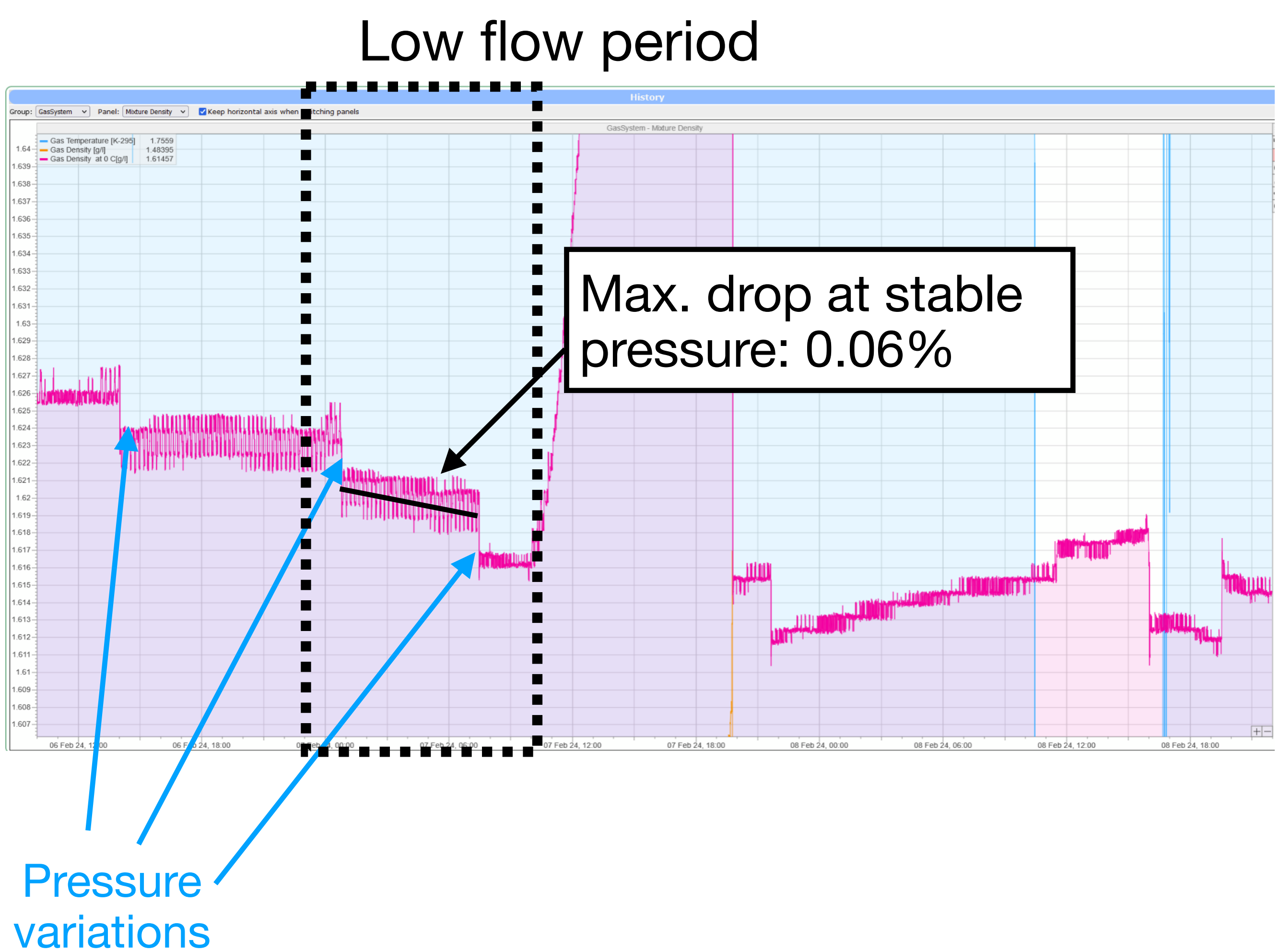
4 mbar in 12 hours over ~100 liters —> 0.03 l/h

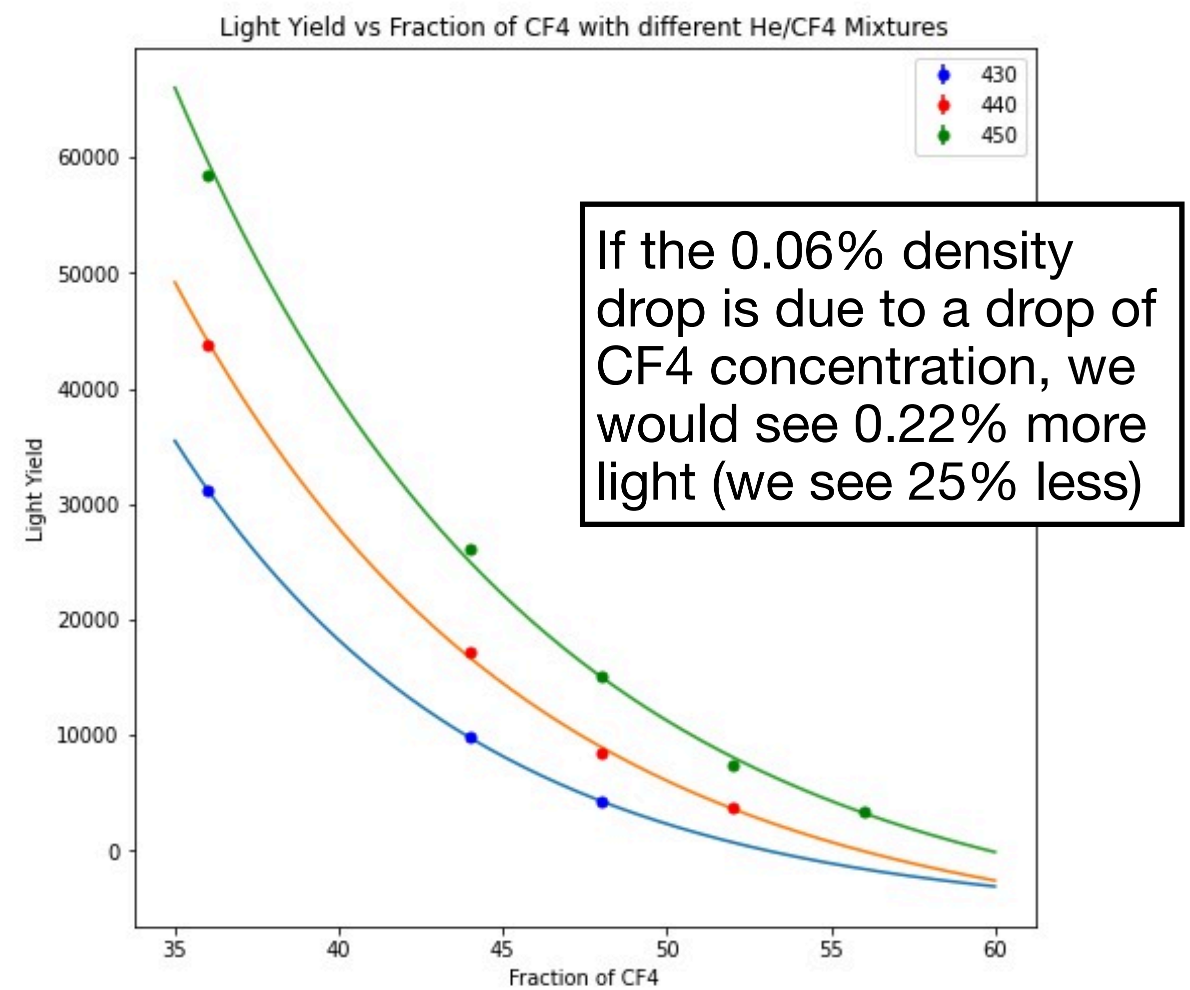
Gas tightness

- 2 distinct aspects, not to be confused:
  - leaks in the detector volume and the circulation system —> impact on CF_4 release and possible impact on the detector response
  - leaks in the recuperation system (downstream of the booster) —> impact on CF_4 release, but impact on the detector response is very unlikely (back-diffusion of contaminations is now prevented by valves)
- Leaks in the recovery system have been reduced to homeopathic levels, as well as leaks in the detector
- Still some measurable leak (< 3 cm^3/min) in the rest of the system (mixing + filters + recirculation)
  - we can say that such leaks are not problematic in terms of CF_4 release
  - still, we need a relatively high fresh flow to preserve a good detector response (i.e. good light yield) **—> contaminants/mixture instabilities**

Mixture stability

- Gas density just follows atmospheric pressure.
- Residual variations (if attributed to a change of CF_4) are too low to explain observed changes in the detector light yield



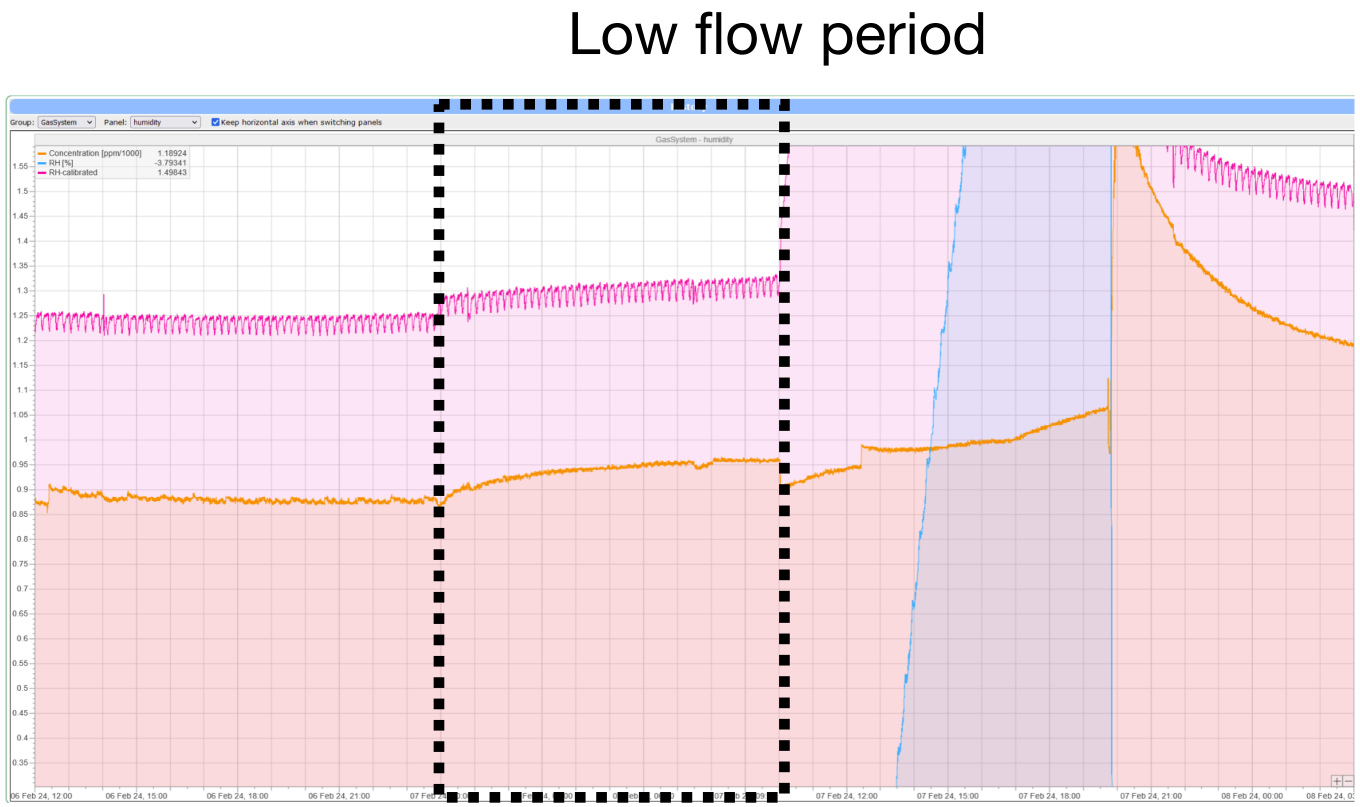


GIN results

Contaminants

- We know that humidity and light yield go togheter
  - is there a causality relation?

- When we lower the fresh flow, a drop of light yield is observed, but much lower than what previous studies indicate to be the impact of humidity



- The humidity increase is a symptom of contaminants entering the detector, but not the contaminant generating the light yield drop
  - next suspect: oxygen —> sensor cell replacement was ordered

Conclusions

- For what concerns the release of CF_4 in the atmosphere, we are at tolerable levels (few ccm of mixture, most likely Helium at large majority)

- Still, we need a relatively high flow to keep the detector response good (i.e. high and stable light yield)

  - CF_4 concentration instabilities are minimal (if any), and hence not the cause of the drop in light yield

  - humidity indicates that contaminants enter the detector, but humidity is not the cause of the drop in light yield —> acrylic vessel is not a problem

  - oxygen contamination to be measured soon (waiting for sensor cell delivery)

Add-on: radiopure filters

- Measurements have shown that filters are critical to maintain a good detector response
- We used commercial filters so far:
  - they are known to contain components that decay into Rn, released in the detector
- Rn-emission-free molecular sieves (MS) have been developed and extensively tested within the CYGNUS community (in Japan and UK):
  - we have ~100 g of these radiopure MS (more would be better for our flow rate)
  - we filled a cartridge with them, to be installed in LIME downstream of the commercial filters
  - the cartridge is equipped with the same particulate filters used by the UK group, to prevent the release of MS powder into the detector
  - more MS from Japan can be delivered upon request

Add-on: Critical components and spares

- Flowmeters —> no spare, we should consider buying at least one (e.g. N_2-calibrated, ~2.5 k€)
- LIME & vacuum pressure sensors —> no spares, we should consider buying one
- Recirculation pressure sensor —> no spares, we should consider buying one
- Pressure control valve —> one spare
- Recirculation pump —> one spare (in reparation)
- Booster —> one spare

N.B. Critical components are defined here as the ones preventing the gas system operations or producing an unacceptable release of CF_4 if not working