Gas handling for LIME and CYGNO-04

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The CYGNO/INITIUM gas system

- Designed for CYGNO-1m³
 - mixing of up to 3 gases (calibrated for He, CF₄ and SF₆)
 - typ. flow of fresh gas ~ 10 sl/h (max. 20 l/h) $-> 1 \text{ m}^3 / 100 \text{ h}$
 - max. recirculated flow (with purification) ~ 100 l/h —> 1 m³ recirculation in
 ~ 10 h
 - regulation of absolute detector pressure in firmware
 - leakage-free gas recovery for clean disposal of CF₄
 - up to 1.6 m³ of mixture per recovery bottle $-> \sim 1$ bottle / week
- Used so far for LIME
 - desirable operating with << 5 l/h of fresh gas
 - regulation of differential pressure in software (in steps of 1 mbar)

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 - some manometers with oil -> possible gas poisoning
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 - it is strongly recommended to keep humidity low, not only for data taking, but always when the gas system is in operation
- A pressure control valve and the recirculation pump also failed in the meantime:
 - look like accidental mechanics/electronics failures, with no indication of system design problems

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Current status and upgrades

- The system has been functioning smoothly for the past few months without any real technical issues:
 - one or two stops due to human errors —> we are perfecting the alarms to prevent it
- An upgrade of the firmware by AirLiquide is also planned
 - direct regulation of differential pressure in steps of 1 mbar
- Tests and possible installation of reversible safety valves replacing the bubbler to be planned
- In a few weeks, we expect to receive some parts to complete our collection of spares for all critical components
- Finally, we can concentrate on the impact of the gas system operations on the detector performances (in particular, gas purity)

Purification — status

- The system is designed to host 2 lines with **custom-developed filters**:
 - one line in operation, one line in regeneration by vacuum at ambient temperature
- With the only goal of developing experience with gas filtering, we are currently operating the system with commercial gas filters:
 - oxygen trap (4A molecular sieves + catalyst), ok also for moisture
 - 5A molecular sieves (moisture trap, should also trap radon)
- Observations:
 - 5A sieves absorbs CF₄
 - seems to be only a transient of new/regenerated filters, more studies planned
 - In the meantime, we operated with oxygen traps only:
 - we can keep low humidity with 1 l/h fresh + 30 l/h recirculated gas (but we have some indication of low light yield)
 - we are currently running at 5 l/h fresh + 20 l/h recirculated
 - need for systematic measurements at different rates to quantify the effectiveness of filtering
 - regeneration effectiveness is erratic (works for some filter units, not for others)
 - try alternative strategies (high temperature, etc.)

Purification — status

- Observations:
 - some hints of contamination in some runs (unexpected, evenly space distributed lines in energy spectra)
 - trends in light yield vs. z suggest occasional contaminations
 - to date, humidity still shows a decreasing trend after months of operations



Purification – plans

- CF₄ absorption tests by 5A molecular sieves
 - it is critical to understand if we have the possibility of using radiopure 5A molecular sieves to absorb radon
- Test of filter regeneration at high or low temperature
- Test of custom (radiopure) 5A molecular sieves
 - we have a small quantity, provided by the UK group
- Oxygen sensor (currently not working) to be fixed