dRICH gas system, principle and technical needs

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INFN TRIESTE

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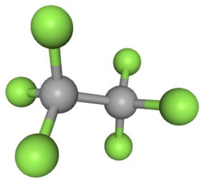
OUTLOOK of this report

- **Basic information**
- **Technical aspects**
- **Realization model**

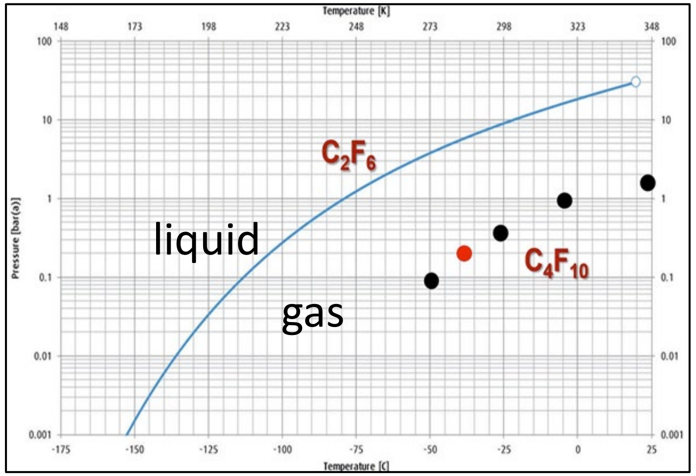
BASIC INFORMATION – the radiator gas

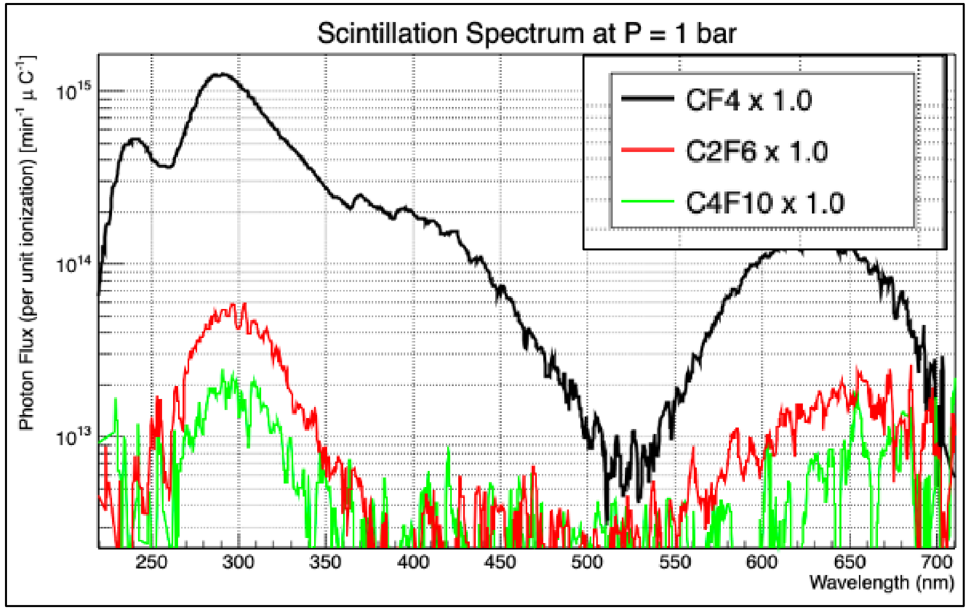
- **Baseline radiator gas: C_2F_6** (Hexafluoroethane)
  - C-F gasses selected because of **high molecular weight** and **low chromaticity**



- **C_2F_6 challenges**
  - Expensive → **Closed loop circulation**
  - **Low T condensation at atmospheric pressure**
  - **C-F gasses are greenhouse gasses**, with high GWP →
    - Closed loop and gas recovery;
    - minimal losses;
    - potential restrictions in usage and procurement difficulties
  - **Scintillation properties** (never used in RICHes so far)
    - f.i., the usage of CF_4 in LHCb RICH2 requires a substantial fraction of quenching
    - Under study by lab exercises and theoretical chemistry calculations

Phase diagram





BASIC INFORMATION – the gas system

dRICH gas circulation system, scope:

- **Control the pressure inside the vessel** preserving a constant and small ΔP [O(1 – 3.5 mbar)] respect to the pressure in the surrounding environment (dynamic process) to avoid mechanical stress on the vessel
- **Filtering the impurities**, particularly oxygen and water vapor
- Ensuring temperature and composition **homogeneity inside the vessel**
- Realize **vessel filling** before a data taking period and **gas recovery** at the end of a a data taking period
  - During long data taking shutdown the vessel is flushed with **stand-by gas**
    - **Most obvious stand-by gas : N_2**, but C_2F_6 / N_2 separation is extremely challenging
    - **Present baseline for the standby gas: CO_2**
      - Option: two stage standby, from CO_2 to N_2 by open flushing to save on cost
- **Standby-gas circulation** during shutdown periods

BASIC INFORMATION – the gas system components

dRICH gas circulation system, components by main blocks:

- **Gas vessel**
- **Gas storage**
- **Compressor set**
- **Control gauges** (pressure, temperature)
- **Operation control** (electrovalves, flow regulator)
- **Electronics control** implemented by an uninterruptible PLC
- **Safety bubblers**
- **Filter set**
- **Separator** (C_2F_6 / stand-by gas)
- **Wasted gas recovery system**
- **Monitoring equipment**

BASIC INFORMATION – the monitoring equipment

dRICH gas system, monitoring equipment:

- **Oximeter**
- **Spectrophotometer:** monitor of gas transparency
- **Interferometer:** real-time measurement of the refractive index (interferometer response combined with T and P monitors allows for quasi real-time data processing)
- **Sonar system:** measuring the fraction of standby-gas in the vessel atmosphere (particularly relevant during filling and gas recovery)

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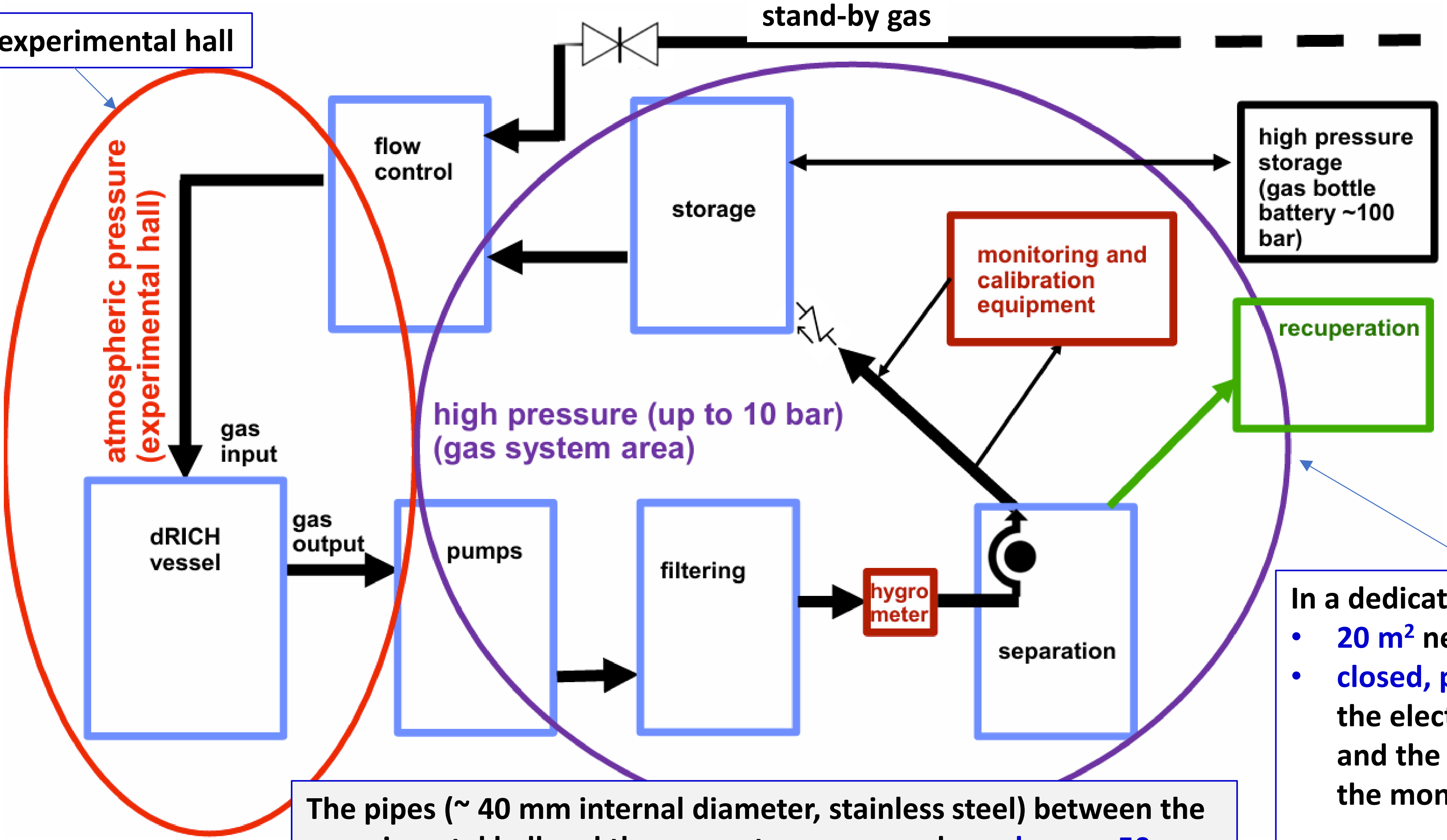
Gas system, schematics

In the experimental hall

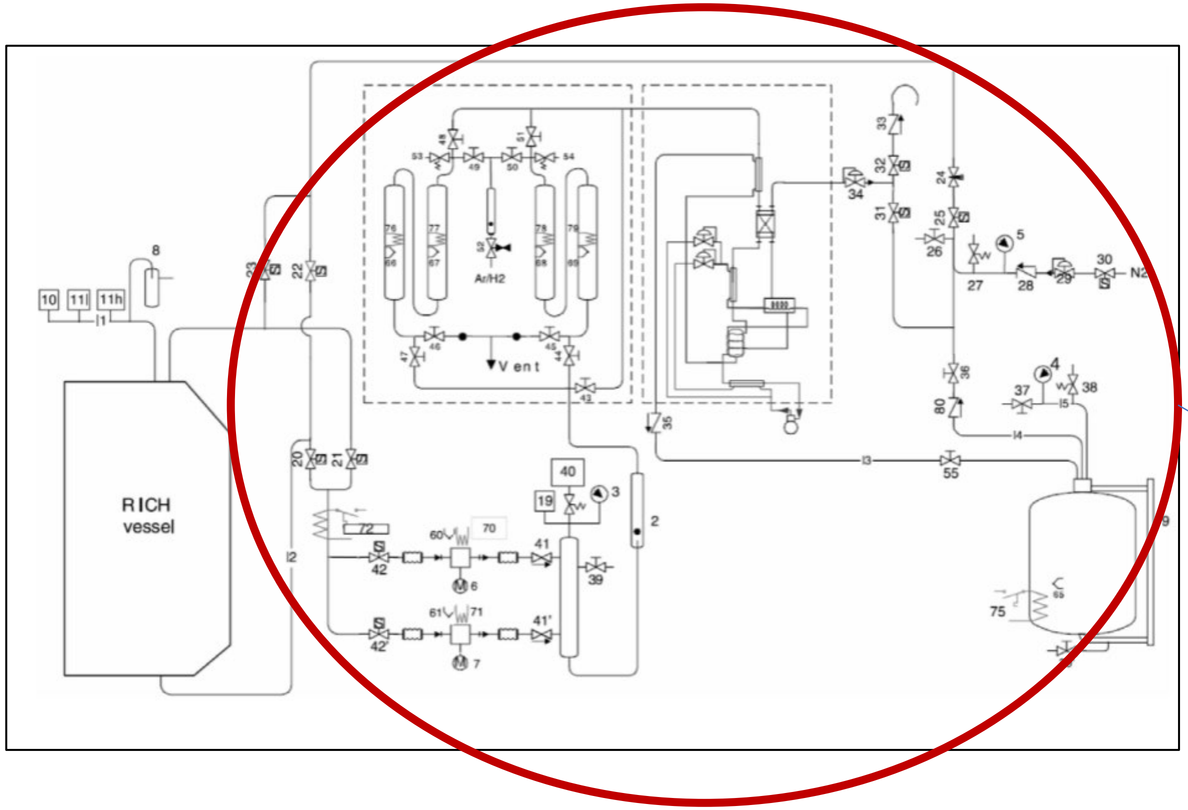


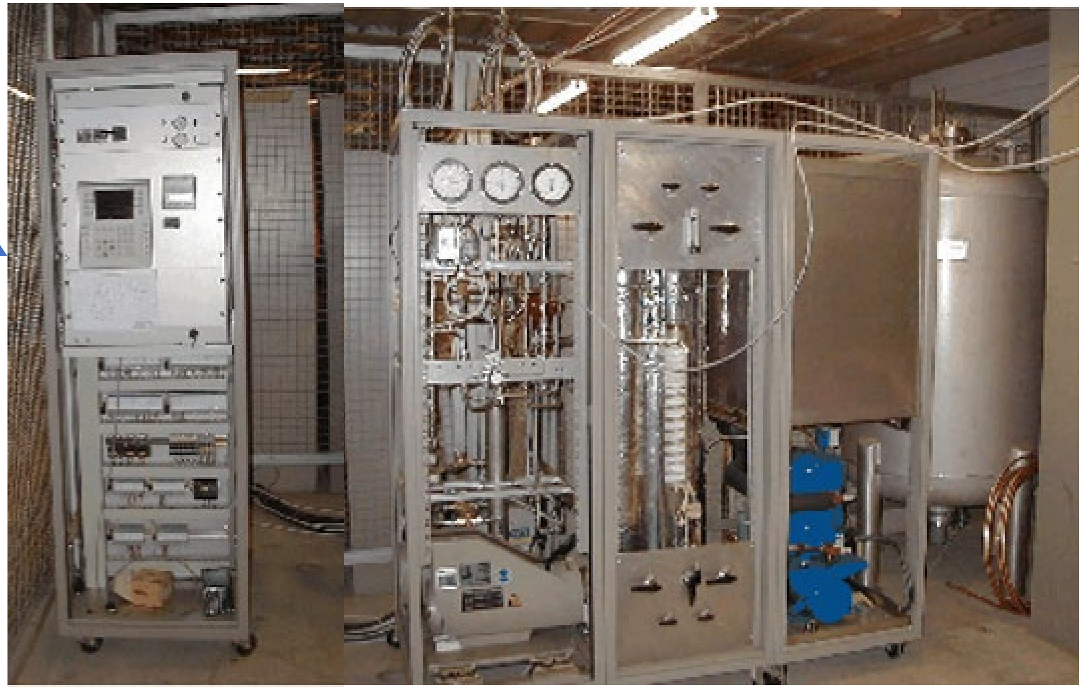
In a dedicated gas system area,

- 20 m^2 needed
- closed, protected because of the electronic control system and the delicate equipment of the monitoring system

The pipes (~ 40 mm internal diameter, stainless steel) between the experimental hall and the gas system area can be as long as 50 m

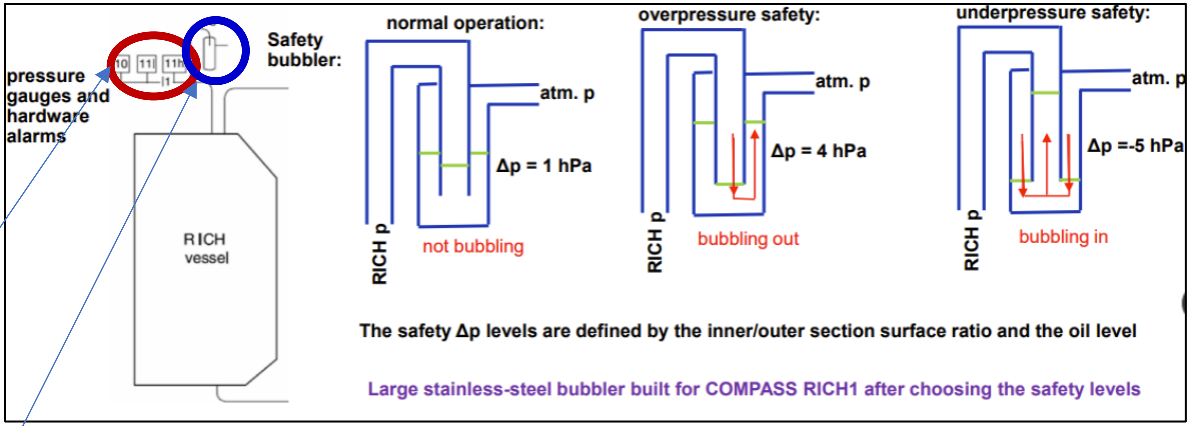
System complexity – an example (COMPASS RICH)





INFORMATION/COMMENTS ABOUT THE COMPONENTS

- **Gas vessel – the RICH vessel**
  - Need to have precisely the same pressure at the two fused silica faces, one facing the radiator gas and the other a nitrogen flux for SiPMs→ **interlock**
  - need of an **array of T sensors** inside the RICH vessel



- **Control gauges** (pressure, temperature)
  - Particularly, the pressure gauges at the vessel are key to ensure safety operation: to be duplicated

- **Safety bubblers – passive pressure safety system**

INFORMATION/COMMENTS ABOUT THE COMPONENTS

- **Operation control** (electrovalves, flow regulator)
  - The **flow regulator** is the element controlling the pressure assuming compressors at fixed rate; to be duplicated for safety

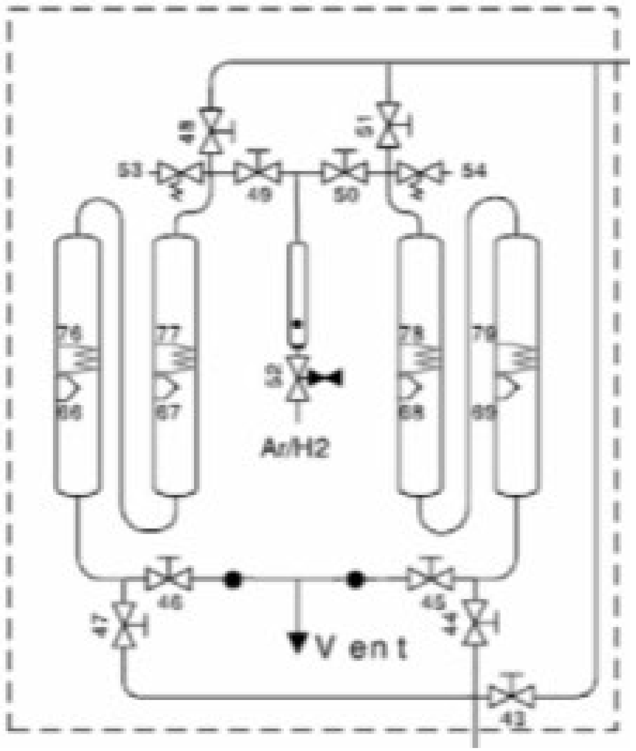
- **Electronics control** implemented by an uninterruptible PLC

- **Compressor set**
  - 2 in parallel for safety considerations

- **Gas storage** for shutdown period and to have an adequate spare amount
  - Due to the non favorable phase diagram, only storage at high pressure possible (~ 40 bar)
  - A set of 24 bottles (50 l each) or a dedicated storage vessel ?
  - This implies a dedicated compressor, not the same used for circulation

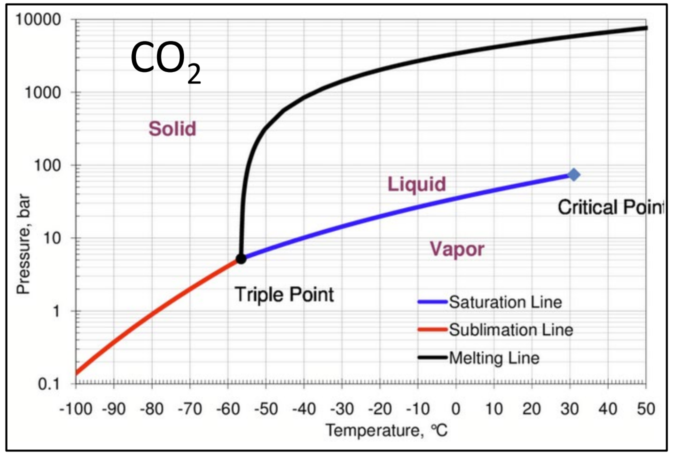
INFORMATION/COMMENTS ABOUT THE COMPONENTS

- **Filter set**
  - Filter for water vapor (molecular sieve A5)
  - Filter for oxygen (Cu- catalyst)
  - 2 sets to be used alternatively, will regenerating the other set
  - Regeneration system is a separate circuit to be physically integrated with the gas system; it requires: Ar flow, Ar + H_2 (2%) flow and bottle heating

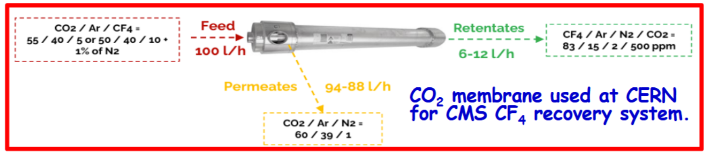


INFORMATION/COMMENTS ABOUT THE COMPONENTS

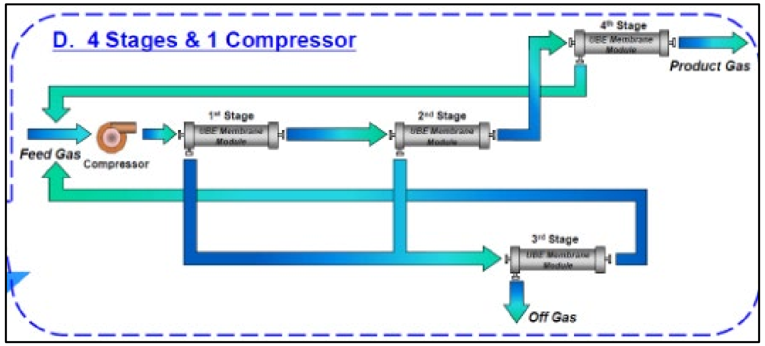
- **Separator** (C_2F_6 / standby gas)
  - Distillation: challenging because of phase diagram of C_2F_6 and of CO_2, that results in an azeotropic mixture extremely difficult to separate
  - Baseline approach, being validated, is with selective permeability membranes



Measured at CERN in collaboration with the CERN gas group



schematics of the separation circuit by membranes: designed to deliver 99.5% purity

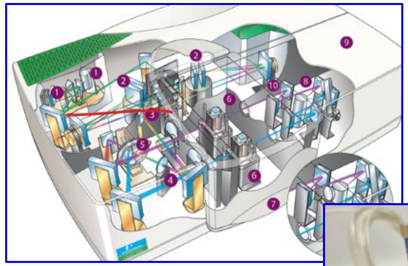


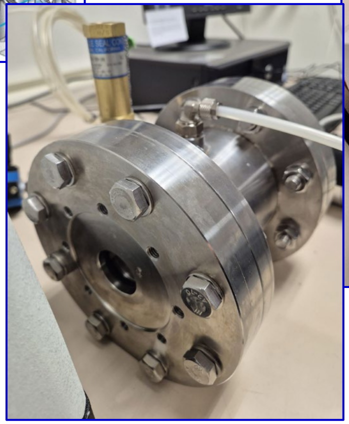
- **Wasted gas recovery system**
  - The outcome of the separator (mainly standby gas with some fraction of C_2F_6) stored in a few dedicated bottles at high pressure (~ 40-50 bar) <u>to be disposed</u>
  - A dedicated compressor needed to fill the wasted gas bottles

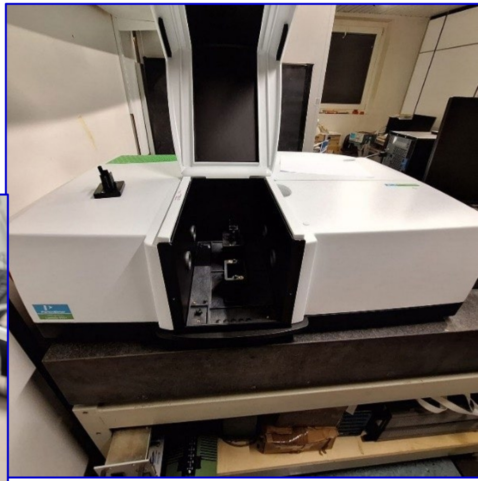
INFORMATION/COMMENTS ABOUT THE COMPONENTS

- **Oximeter**
  - Standard device

- **Spectrophotometer:** monitor of gas transparency
  - A cell of 10 cm length can be used → need to enhance the absorption by pressure: **measure at 10 bar**
  - **A stable optical table** needed to ensure correct spectrophotometer performance

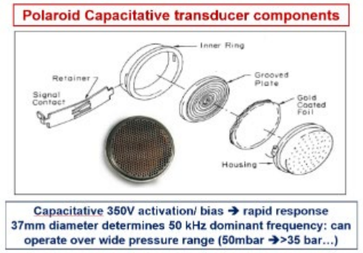






- **Sonar system:** measuring the fraction of standby-gas in the vessel atmosphere (particularly relevant during filling and gas recovery)

Measured speed of sound in C_2F_6: 139.68 m/s



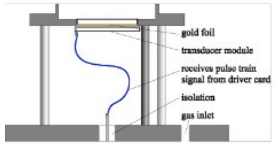


Figure. 1.7 The Sonar System Setup

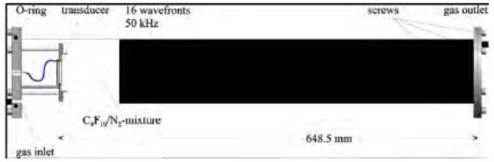
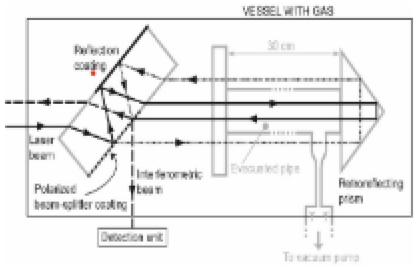


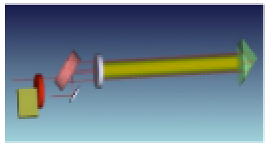
Figure. 1.6 The Sonar System Setup

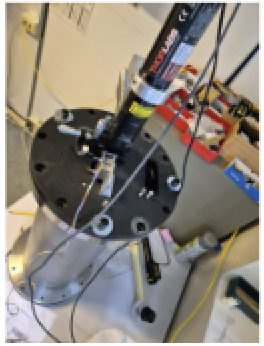
INFORMATION/COMMENTS ABOUT THE COMPONENTS

- **Interferometer:** real-time measurement of the refractive index (interferometer response combined with T and P monitors allows for quasi real-time data processing)
  - As for the spectrophotometer, **a stable optical table** needed to ensure the stability and preserve the alignment of the optical components

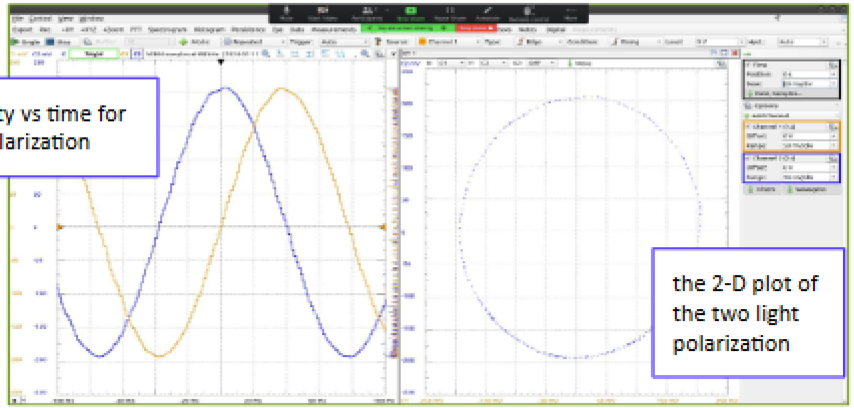
Jamin interferometer, principle schematics and setup picture







Jamin interferometer, results



the light intensity vs time for the two light polarization

the 2-D plot of the two light polarization

one period (360°) corrisponds to a variation of 1 ppm in the refractive index.
a resolution better than 10 ppb can be achieved in refractive index monitoring.

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Realization, the proposed sharing model

1. **Gas circulation system**
   - **Remaining principle studies (separator, recovery system)**
   - **Principle design of the system**
   - **Engineering test article**

   } **INFN Trieste**

   - **Executive drawings/realization compliant with BNL safety regulation - Project Engineer Team**

2. **System Control (electronics and programming) – most likely, BNL-INFN shared effort**

3. **Monitoring equipment – INFN Trieste**

Thank you