Liquid Helium Recovery in Spain

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Helium recovery options and carbon footprint implications
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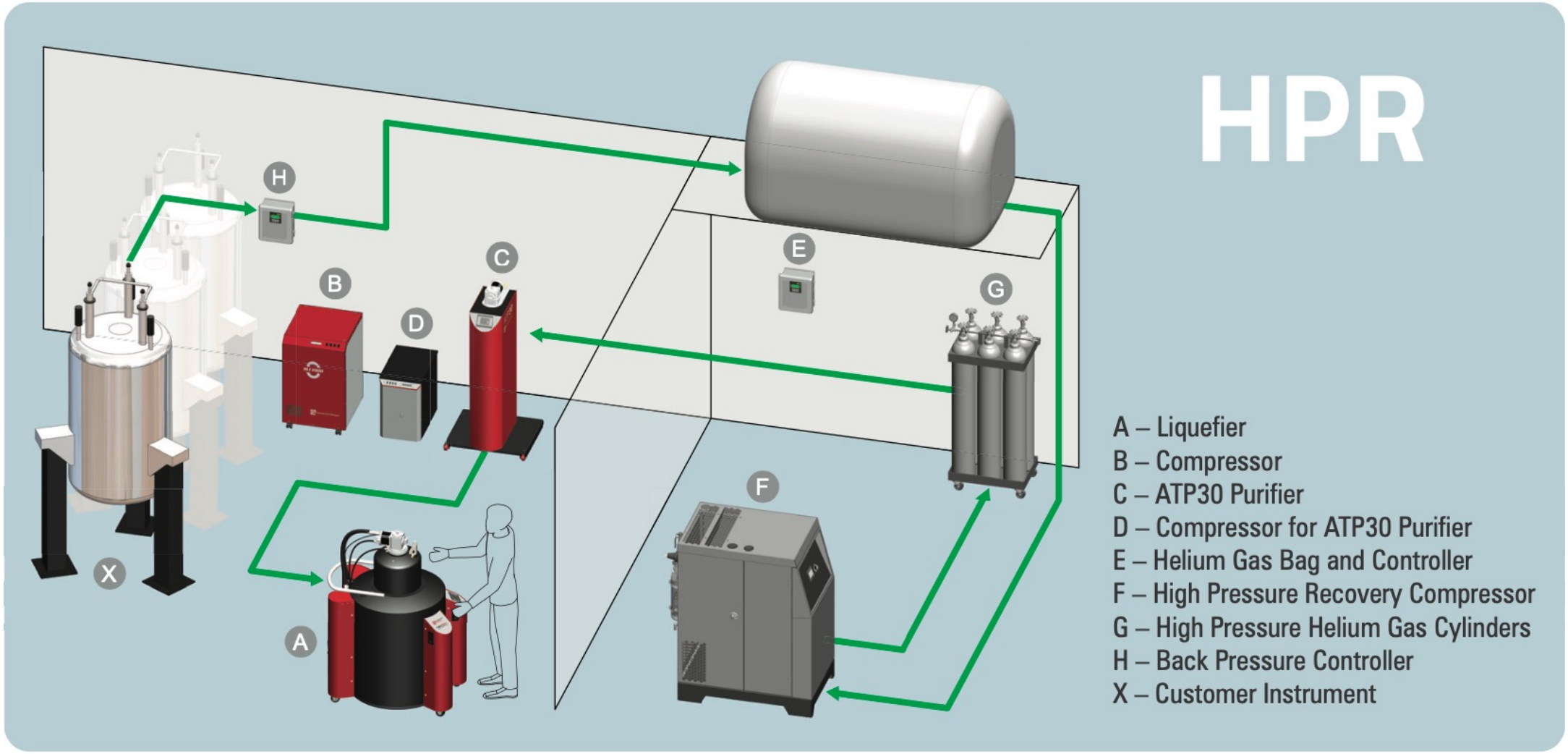
Helium consumption by high field NMR in Barcelona

- Helium boil off: 3653 L/year
  - 1GHz (4K): 80 mL/h *(1 GHz (2K): 250 mL/h)*
  - 800 MHz (2K; 2000): 300 mL/h *(current generation 4K 47 mL/h)*
  - 600 MHz: 20 ml/h
  - 500 MHz (Varian): 5 ml/h
  - 400 MHz (Varian): 12 ml/h
- Helium loss on refils (assuming 15%) : 548 L/year
- Total helium consumption: 4200 L/year


HPR
H
B
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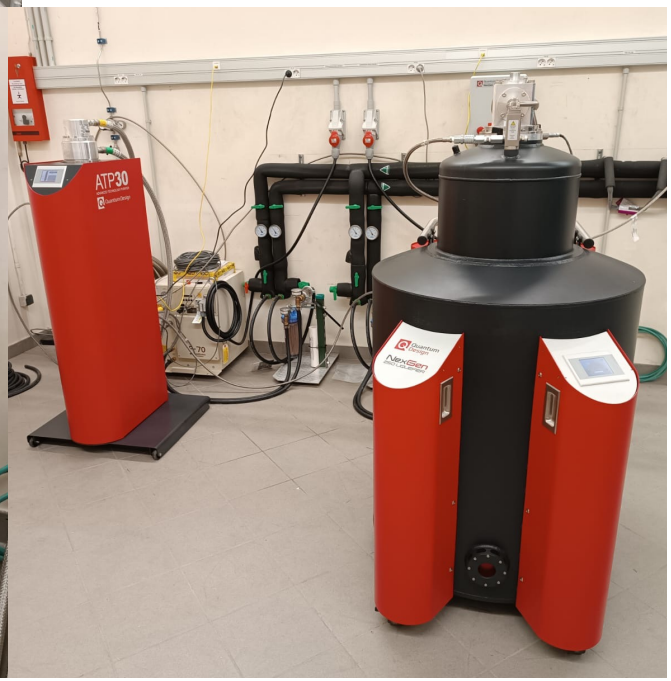
A – Liquefier
B – Compressor
C – ATP30 Purifier
D – Compressor for ATP30 Purifier
E – Helium Gas Bag and Controller
F – High Pressure Recovery Compressor
G – High Pressure Helium Gas Cylinders
H – Back Pressure Controller
X – Customer Instrument

High pressure recovery footprint

Bauer + high pressure storage: aprox. 13 m^2
Purifier +Liquifier + compressor: 5 m^2
Balloon: 18 m^2

Piping system:
Recovery system: copper tubing diameters 28; 35; 54 mm
High pressure (200 bar): steel tubing 8 mm diameter.



Estimation of the volume of the balloon

- Capacity of magnet dewar (1st generation 800 MHz): 255 L
- Helium refil from 48% to 96%
  - Liquid helium colectad in magnet: 122 L
  - Volume of helium gas at 4K displaced: 122 L
  - Liquid helium used from liquifier: 139 L

- Helium gas (1 atm, 298K) released: 22 m^3
  - From efficiency in liquid helium transfer (15%): 17 L of liq He -> 13 m^3
  - From desplaced gas at 298K : 9 m^3

- Effective gas collection capacity of a 40 m^3 ballon: 28 m^3

  (assuming the minimum volume of gas in balloon is approx 12 m^3)

Our 40 m^3 balloon reaches 100% capacity in a 120-125 L transfer

High pressure storage

- We have two sets of 18 cillinders with a maximum pressure of 200 bar and a nominal volume of 50 liters.
- Maximum storage: 1800 L
- Equivalent to 360.000 L (360 m^3) of helium gas at atmospheric pressure
- Equivalent to 477 liters of liquid helium

Helium purification

Helium contamination is mainly by air (nitrogen, oxygen, water) and diffussion through the balloon walls, plus manipulation during transfers. Oil from 2K pumps (or from DNP pumps) is an additional risk

Oil mist filter at the outlet from oil pumps (alternative, use oil free pumps)

Chemical drying

ATP-30 purifier: Helium is cooled at around 11K which condenses all contaminants.

Regeneration is performed when the difference between initial and final pressure increases. Regeneration is very simple. (alternative, liquid nitrogen zeolite purifiers require manual regeneration).

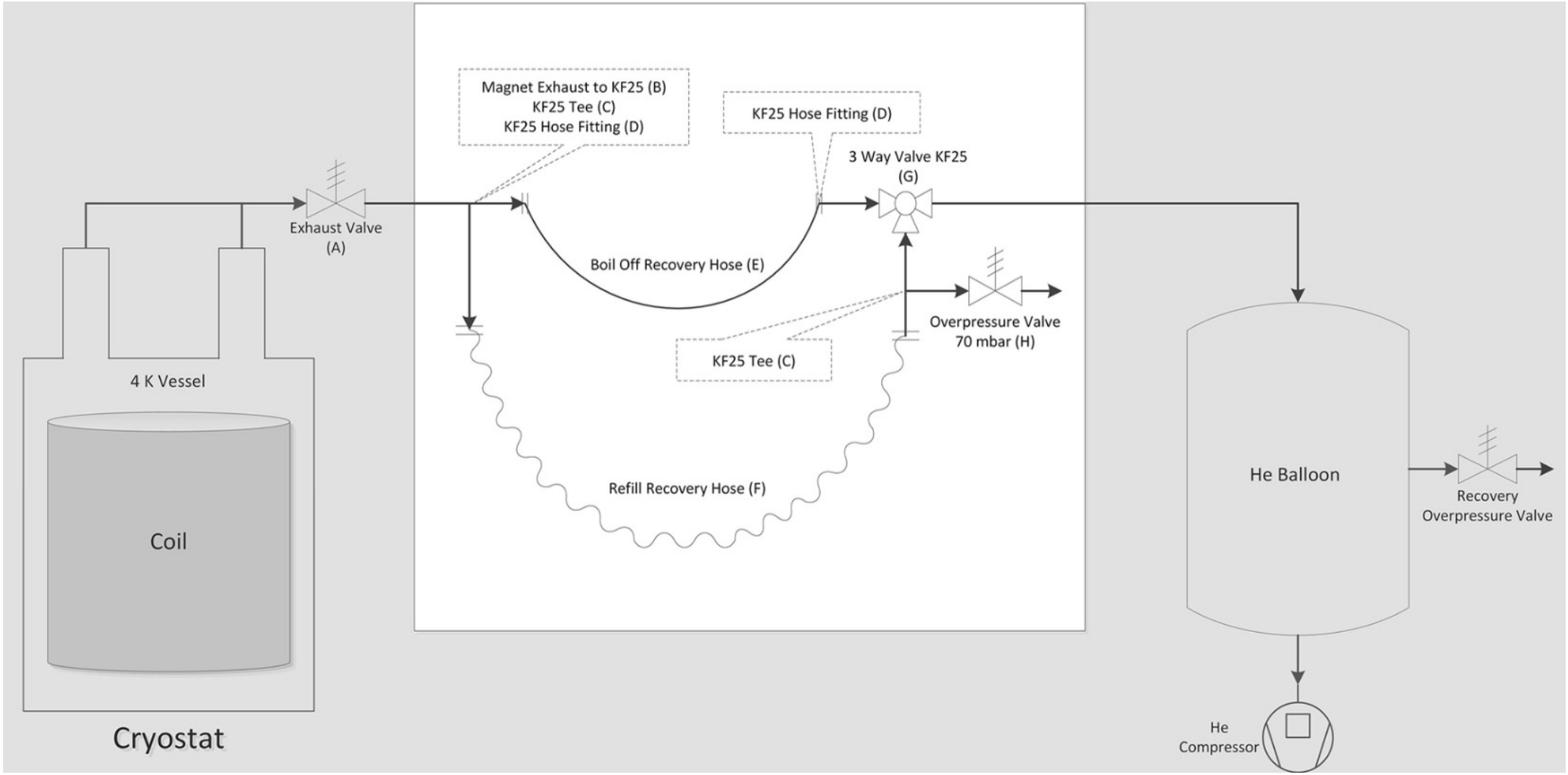
Drawback: it introduces an extra energetic cost in the liquefaction process.

Helium liquefaction: NextGen 250* Quantum Design

- **Liquefaction rate: 20 L/day at steady state**

- Initial cooling time to 4K from a warm state: approx. 24h
- Fully automated operation
- Dewar storage efficiency is low. Active energy consumption is needed to maintain liquid helium until is used.
- Connected to a water cooled compressor
- Cold head replacement every 12.000 working hours (10.000 liters of liquid helium), costs around 13.000 €.

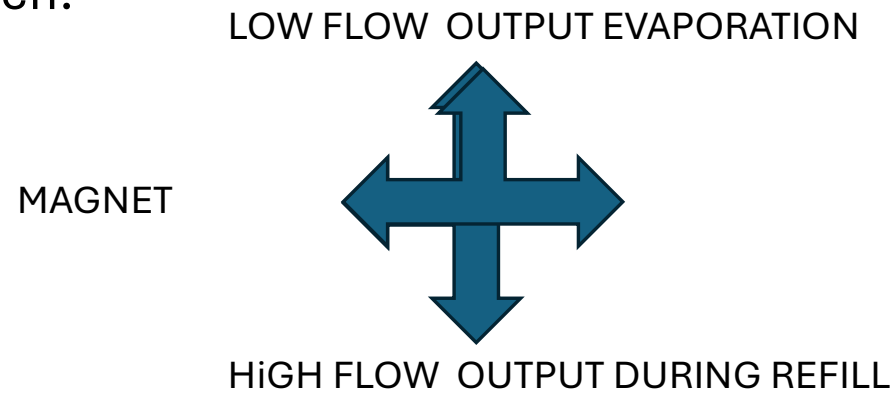
Connection of the spectrometers



Connection of the spectrometers

- All magnets are protected by no return and overpressure valves
- 1 GHZ, 800 MHz and 600 MHz have Back Pressure Controllers.
- No loss of performance or artifacts detected.

- We had an initial issue with increased pressure in the magnets of the larger instruments during refils with helium recovery. It was caused by 90º bends near the exit of the magnet and were minimized by avoiding bends in the high flow branch.



Cost of local helium liquefaction

- Energy cost liquifier: 7.8 kWh/liter
- Energy cost purifier: 7.8 kWh/liter (or 2.72 kWh/liter)
- Cost of energy. (0.2€/kWh) : 3.1-2.1 €/liter
- Cost of liquifier coldhead replacement: 1.3 €/liter
- Cost of purifier coldhead replacement: 1.1 € /liter
- Cost of Bauer maintenance: 0.13 €/liter
- TOTAL COST PER LITER OF LOCALLY LIQUIFIED HELIUM: 5.63€
- PURCHASED LIQUID HELIUM: aprox 18€ /liter (2024)*
- Cost reduction: 12.37 €/liter

- **Estimated future economic savings at University of Barcelona: 52 000 €/year (2024 prices)**
- Additional savings by avoiding loss of unused liquid helium from commercial 250 L dewar.

* plus VAT

Reduction of CO_2 footprint

REMOTE:

- Helium separation from natural gas: 7.43 kWh/L (T. Vosegaard)
- Helium liquefaction at origin: 5.86 kWh/L
- Transport: 0.38 kW/L
- eCO2 (Qatar/Argelia 600 gCO_2/kWh): 8.2 kg CO_2/L

LOCAL:

- Helium separation: 0
- Helium liquefation cold-head: 10.52 kW/L
- eCO2 (Spain 108 gCO_2/kWh): 1.14 kg/L

- **Reduction of CO_2 footprint in Barcelona: 29.6 Ton CO_2 per year**

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Oscar Benítez (Bruker)
Anna Mezquita (PCB)
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Thank you

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Open call for
INTEGRATIVE STRUCTURAL BIOLOGY PILOT PROJECTS

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