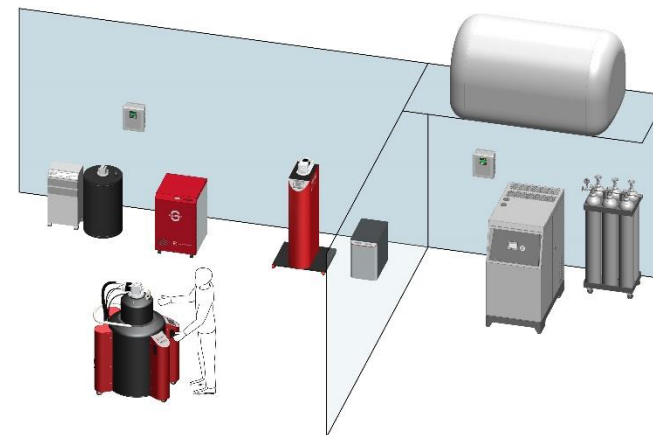

Helium liquefaction and recovery for NMRs



Outline

- Physical working principle
- NexGen Liquefiers
- Gas purifiers
- Helium recovery



Motivation: Lab Scale Helium Liquefier

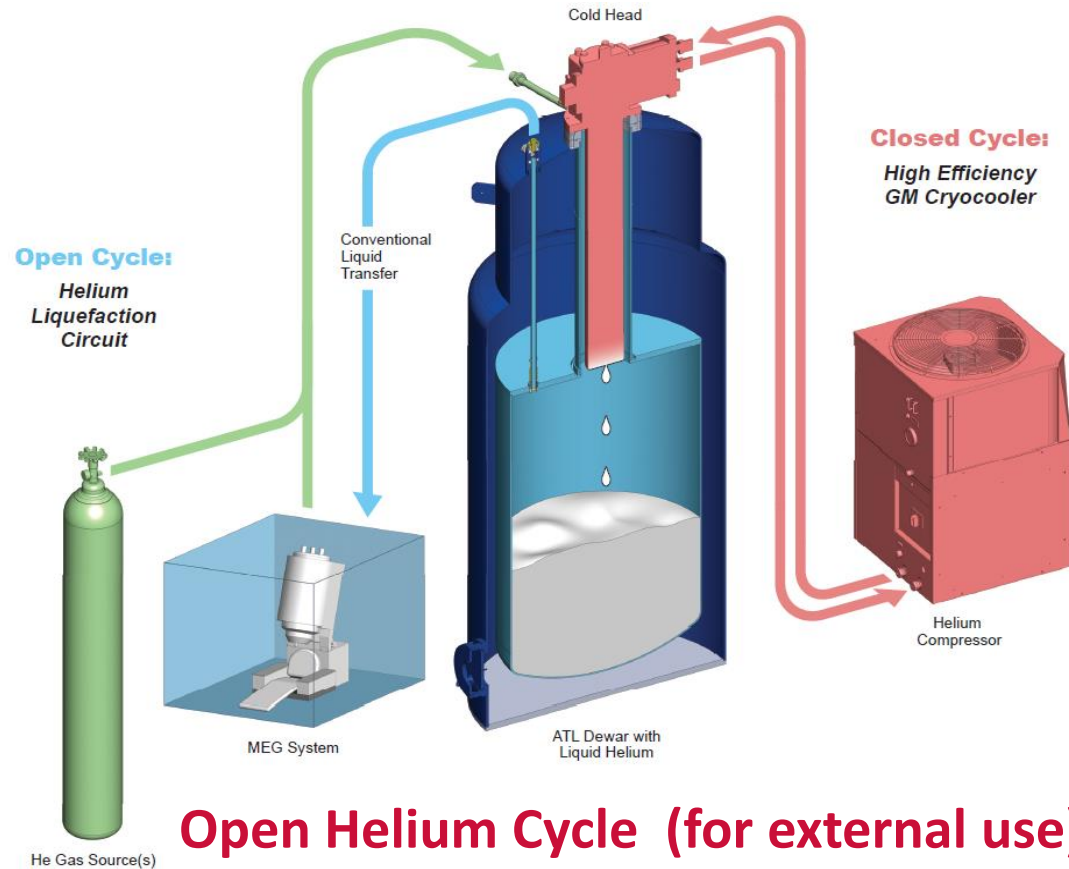
Solution: Lab Scale Helium Liquefier

- **Liquefaction rate matches consumption**
- Provides **mobility** and modularity
- Easy to transfer to experiment
- **Small space** requirements
- Energy Efficiency
- Easy-to-Use
- Fully **Automated** Operation
- Self-Cleaning
- Uninterrupted Service



Uni Leiden: Big Dewar of industrial liquefier (left) and ATL160 (right)

NexGen Helium Liquefier: Working Principle



Closed Helium Cooling Cycle

- External compressor provides high pressure gas
- Gas is expanded in the cold head and produces cold
- Low pressure gas goes back into the compressor

Open Helium Cycle (for external use)

- Gas from user experiment or helium gas bottles is introduced into the dewar of the NexGen and liquefied

NexGen liquefiers

NextGen 160

NexGen 250

ATL 160 XL

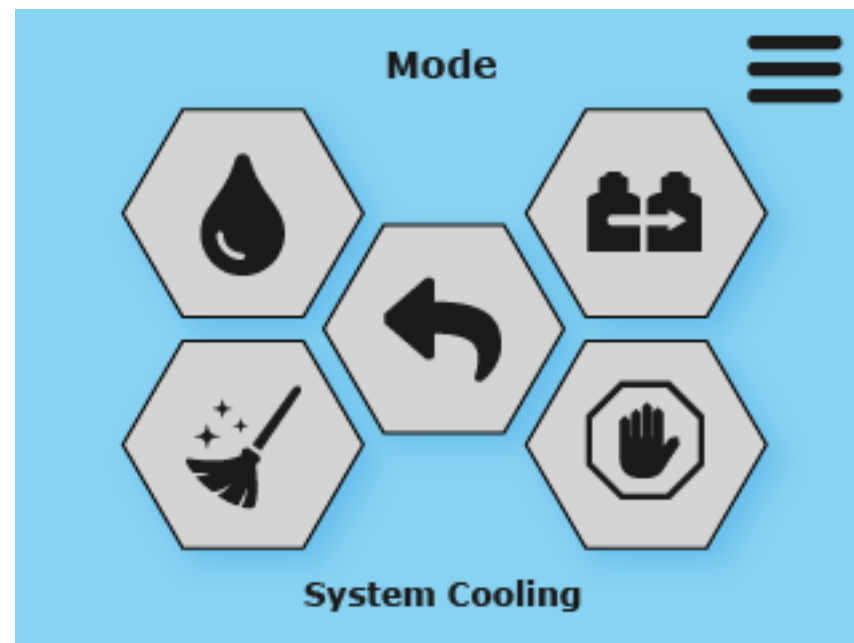
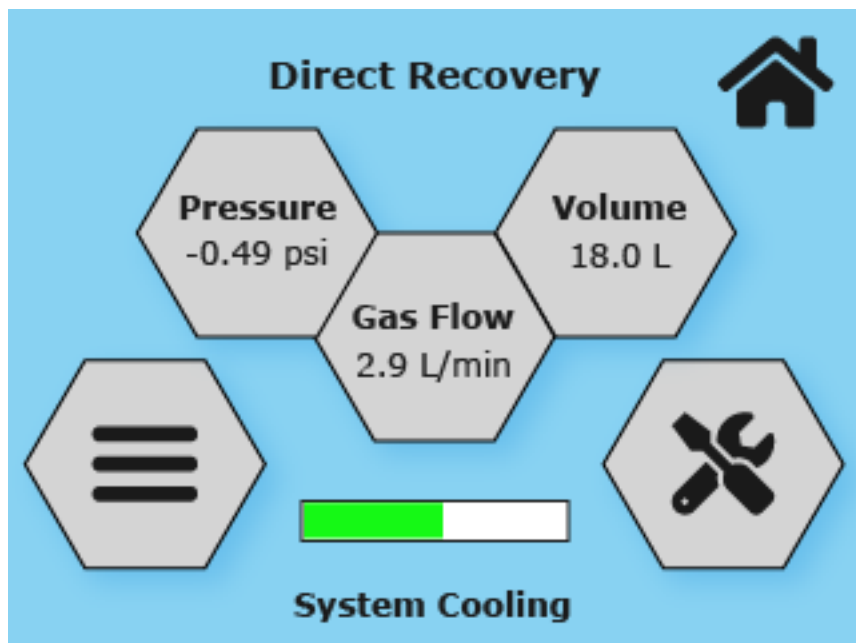


NexGen liquefiers

	NextGen 160	NexGen 250	ATL 160 XL
Liquefaction rate [liters/day]	25+	25+	35+
Dewar capacity [liters]	160	250	160



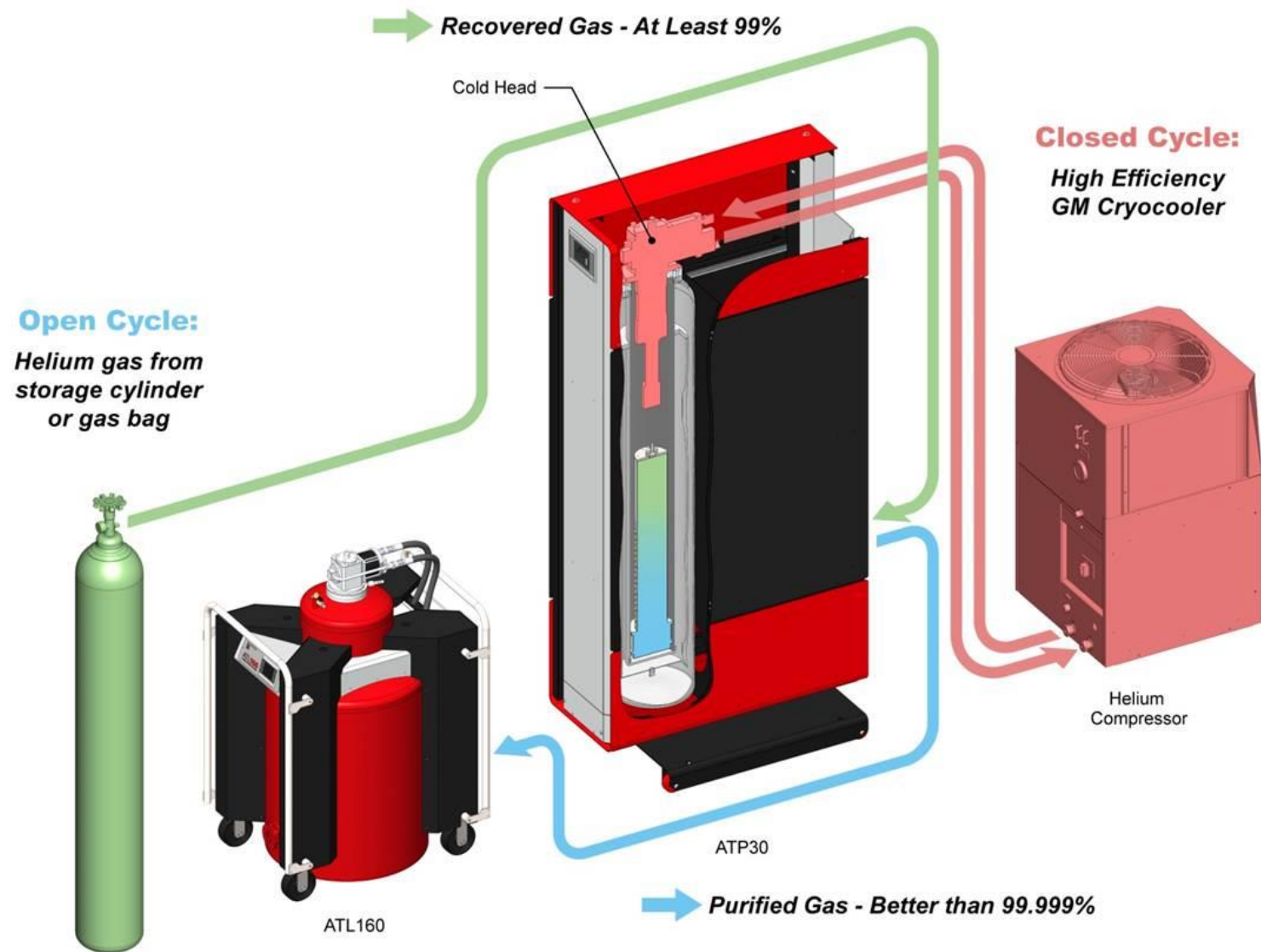
User Interface



ATP-30 Gas Purifier



ATP Working Principle



ATP30

Purifies 30 liters of helium gas per minute

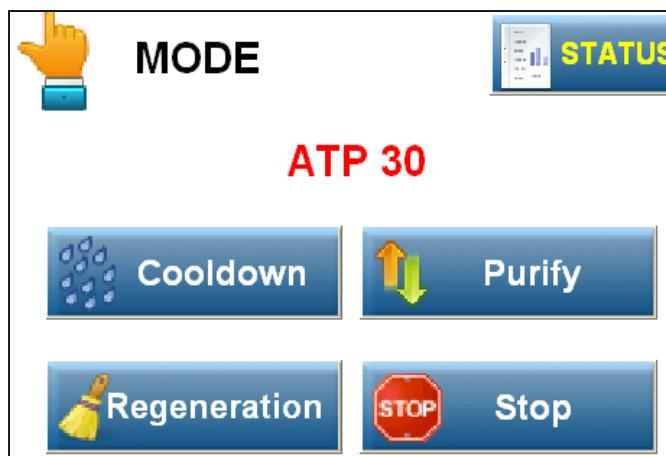
Purifies helium gas to 99.9995% (better than UHP)

Fail-safe Operation – Stops operation before "dirty" gas passes through to contaminate liquefier

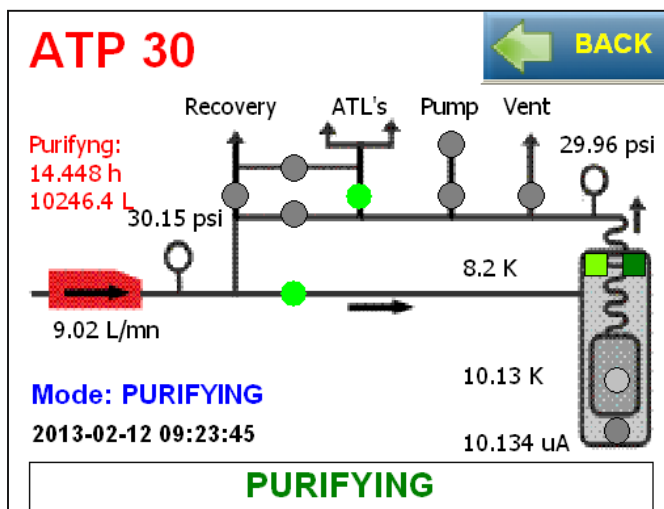
Full regeneration of system in 5 hours



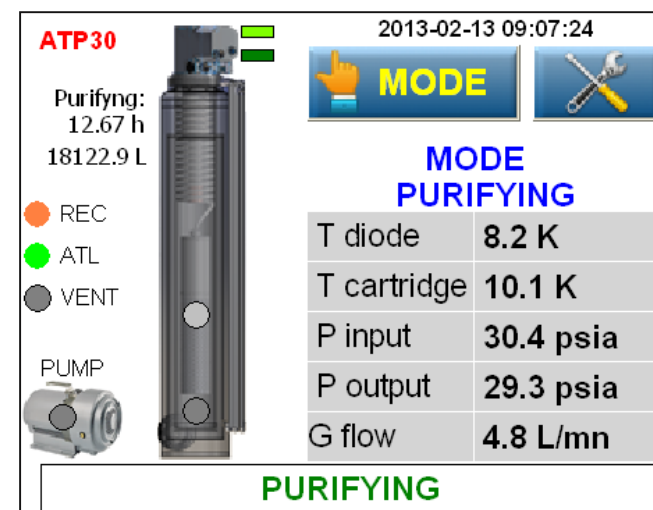
ATP30 User Interface



Flow Chart Screen



Mode Selection



Main Screen

H₂ Detector

Detects H₂ contamination in liquid Helium

Impedance based design with pump

Hydrogen contamination as low as 0.35 ppb can still plug impedances

ATP with hydrogen removal option can remove hydrogen below 0.1 ppb

With touch screen interface and automated hydrogen detection



Summary

- Easy to handle solution for small and medium cryogenic labs
- Helium production can easily be scaled
- No single point of failure

Recovery Solutions

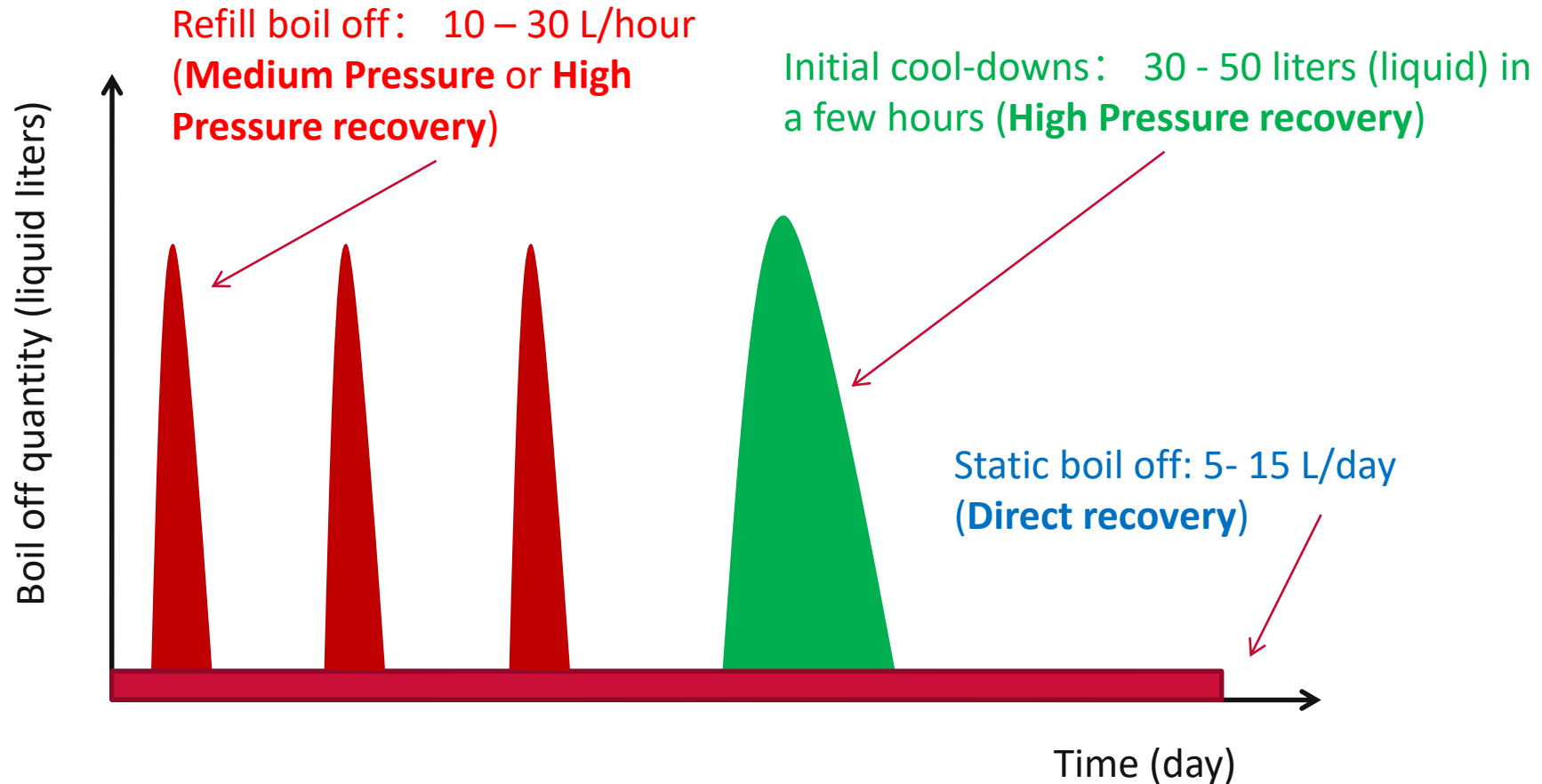


Outline

- Direct Recovery
- Medium Pressure Recovery
- High Pressure Recovery
- Customer Installation Examples

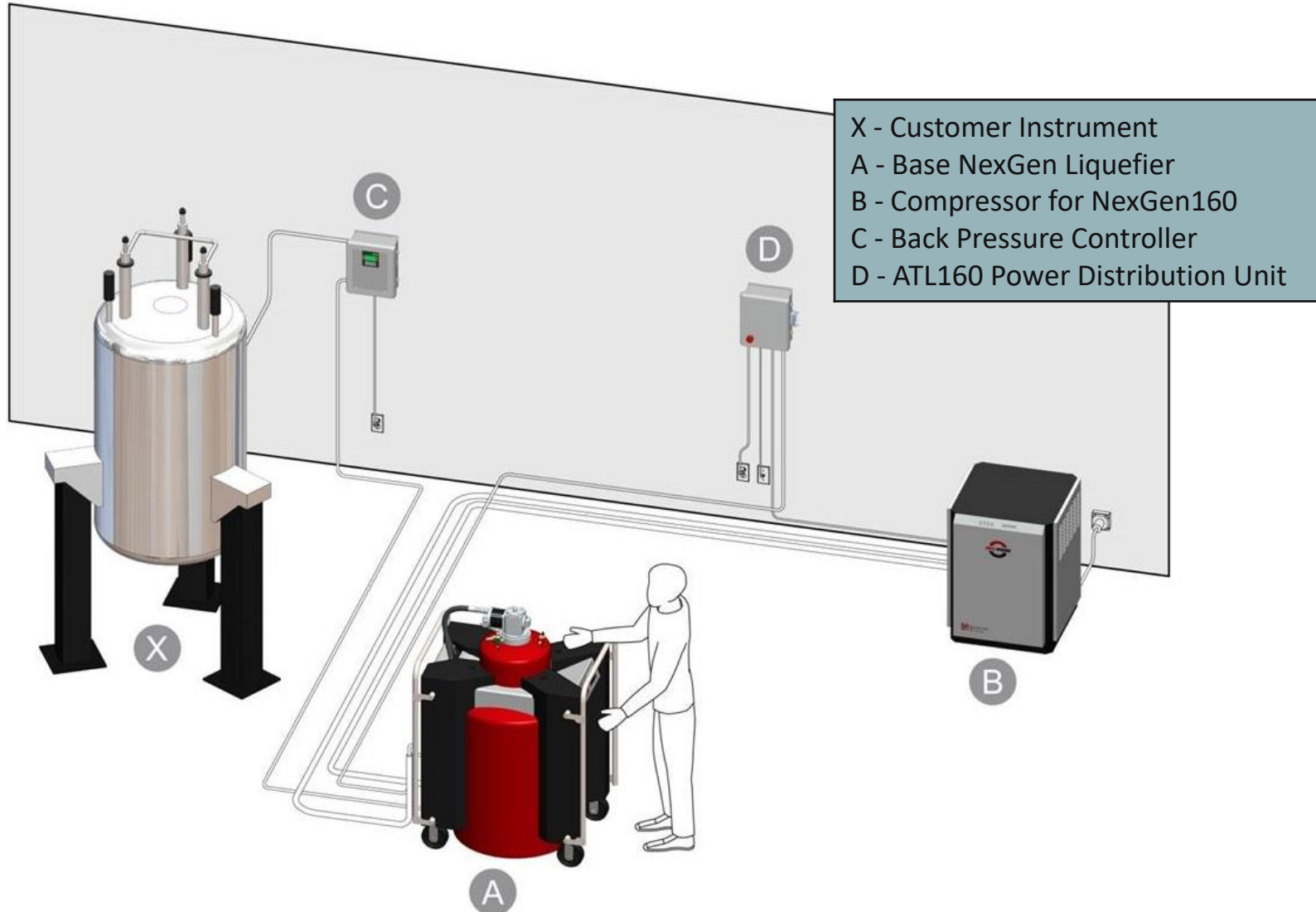


Types of Helium Boil off

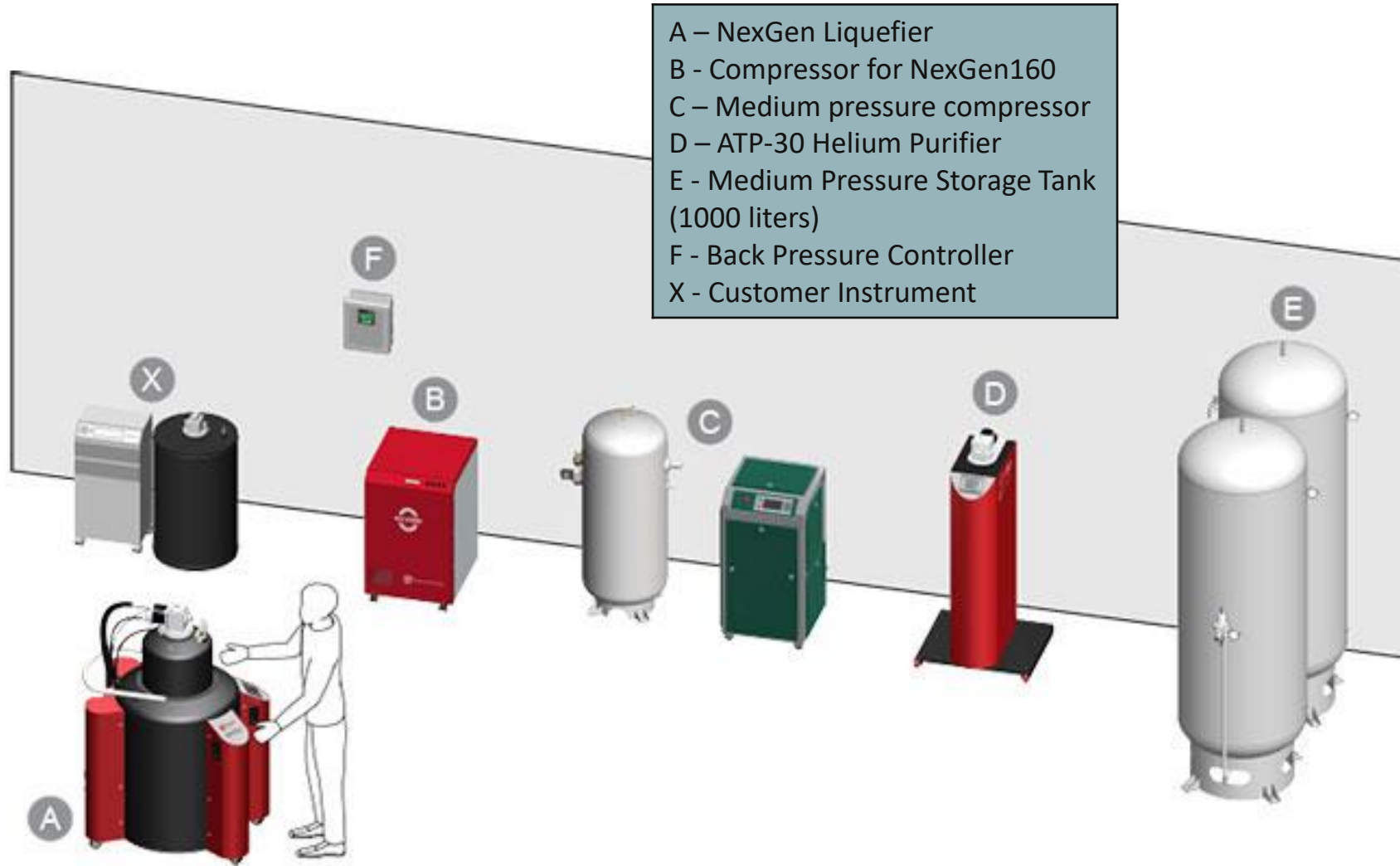


1 liter of liquid → 750 liters of gas

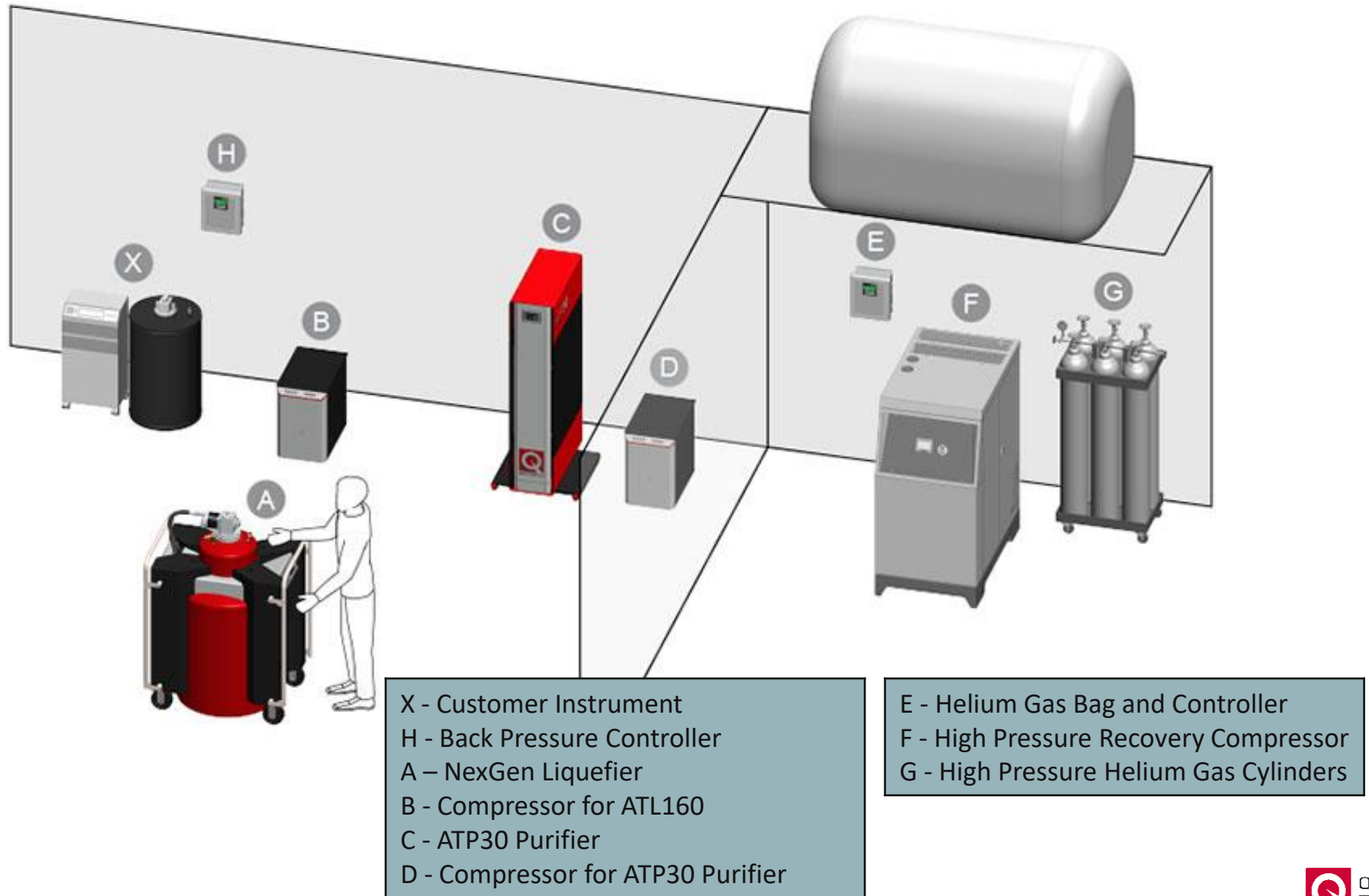
Direct Recovery



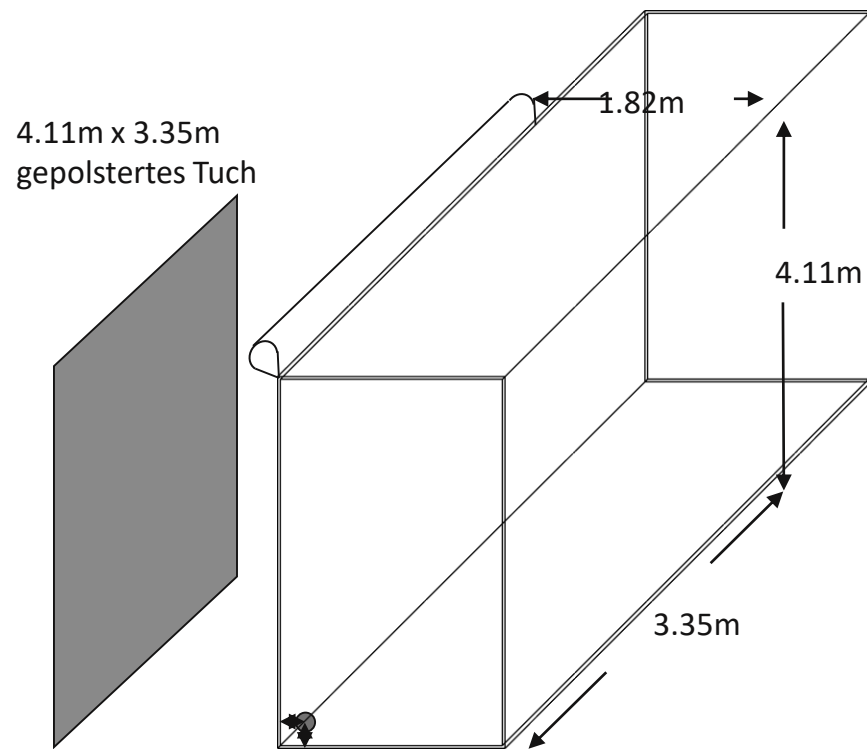
Medium Pressure Recovery: Short Term Storage



High Pressure Recovery: Mid to Long Term Storage



Components - Gasbag



Alternative: Cyling mounting



Components – High Pressure Compressor

- Levelmeter and automated pumping
- Includes water- and oil adsorber
- Dimensions: 235cm x 104cm x 167cm



Components – Gas bundle

- Capacity per bottle @ 200 Bar: 13 l LHe
- Typical bundle size: 12 or 18 bottles



Components - Back Pressure Controller

- Pressure changes in an NMR directly affects the noise spectrum
- An active BPC should be part of the recovery system



Comparison of recovery solutions

- **Direct recovery**

- + Minimum space and price
- Limited recovery rate (70-80%) due to transfer loss

- **Medium pressure recovery**

- + High recovery rate (>95%) for 1-3 instruments
- Limited storage capacity for 1-3 instruments

- **High pressure recovery**

- + Versatile, customized and scalable
- + highest recovery rate (>98%)
- Space requirement and costs



ATL160



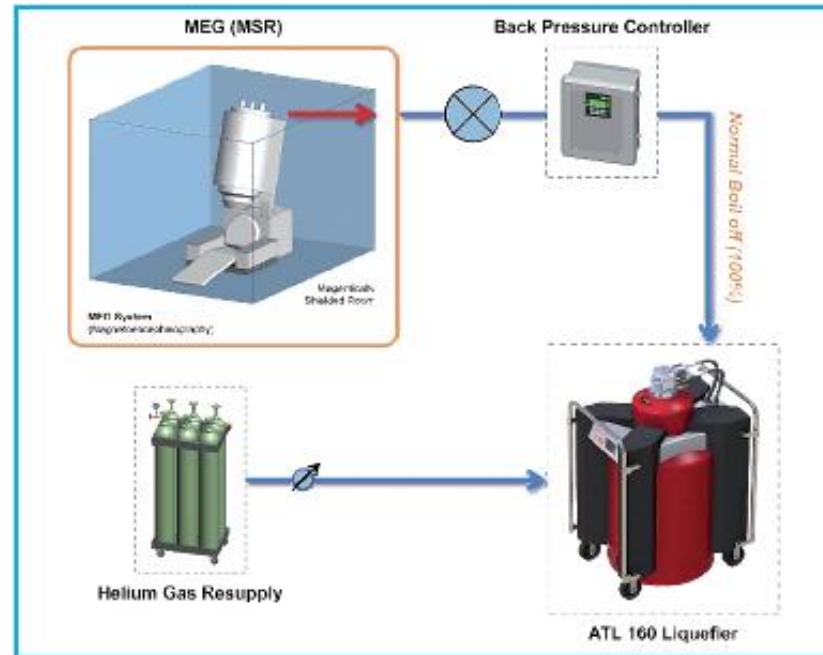
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Direct recovery system schematic

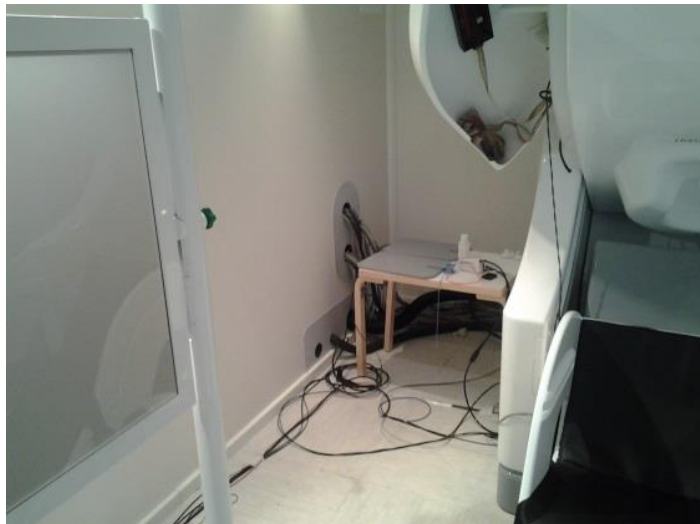
Full Rotation and line movement

MSR penetration does not transmit EMI

Highly pressure sensitive tools

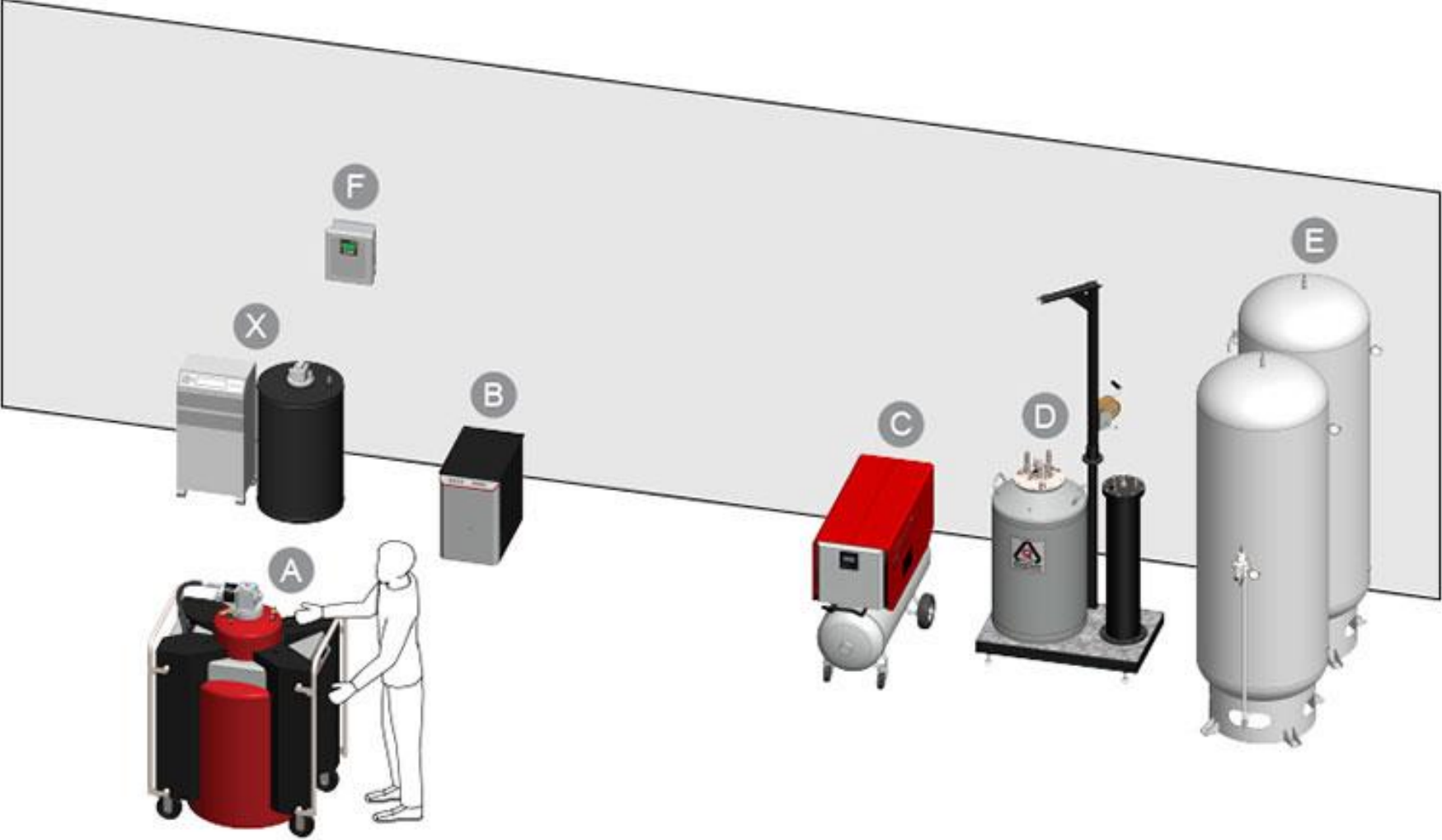


Centro de Tecnología Biomédica, Madrid



Elekta MEG

Medium Pressure Recovery: Short Term Storage



UC Davis Physics Group, small lab, MPR



Recovery from 1 MPMS, 1 PPMS and 1 NMR

~12 liters/day static boil off

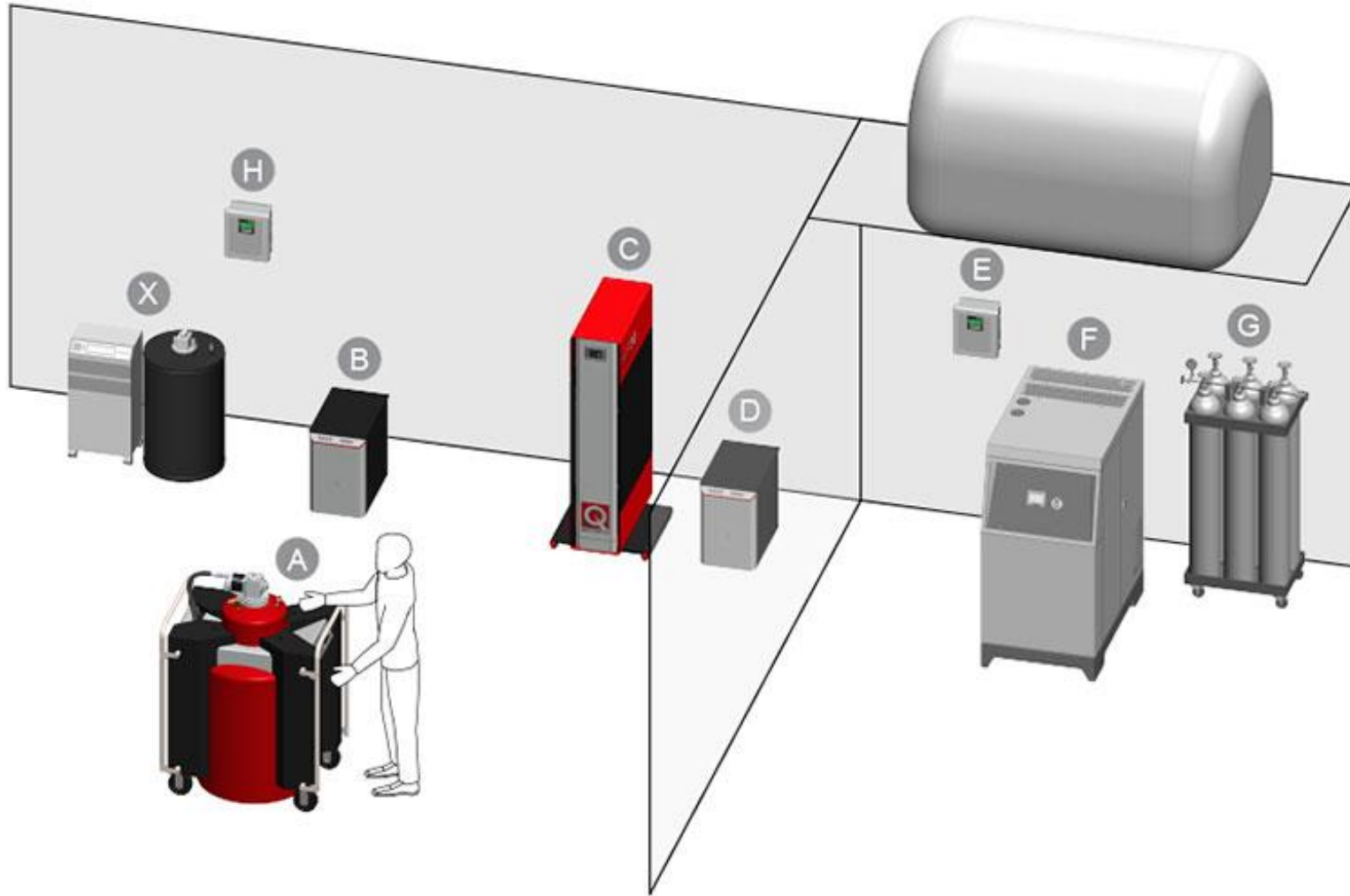
Customer installed recovery pipes

Transfer boil off captured close to 95%



MP tanks on balcony

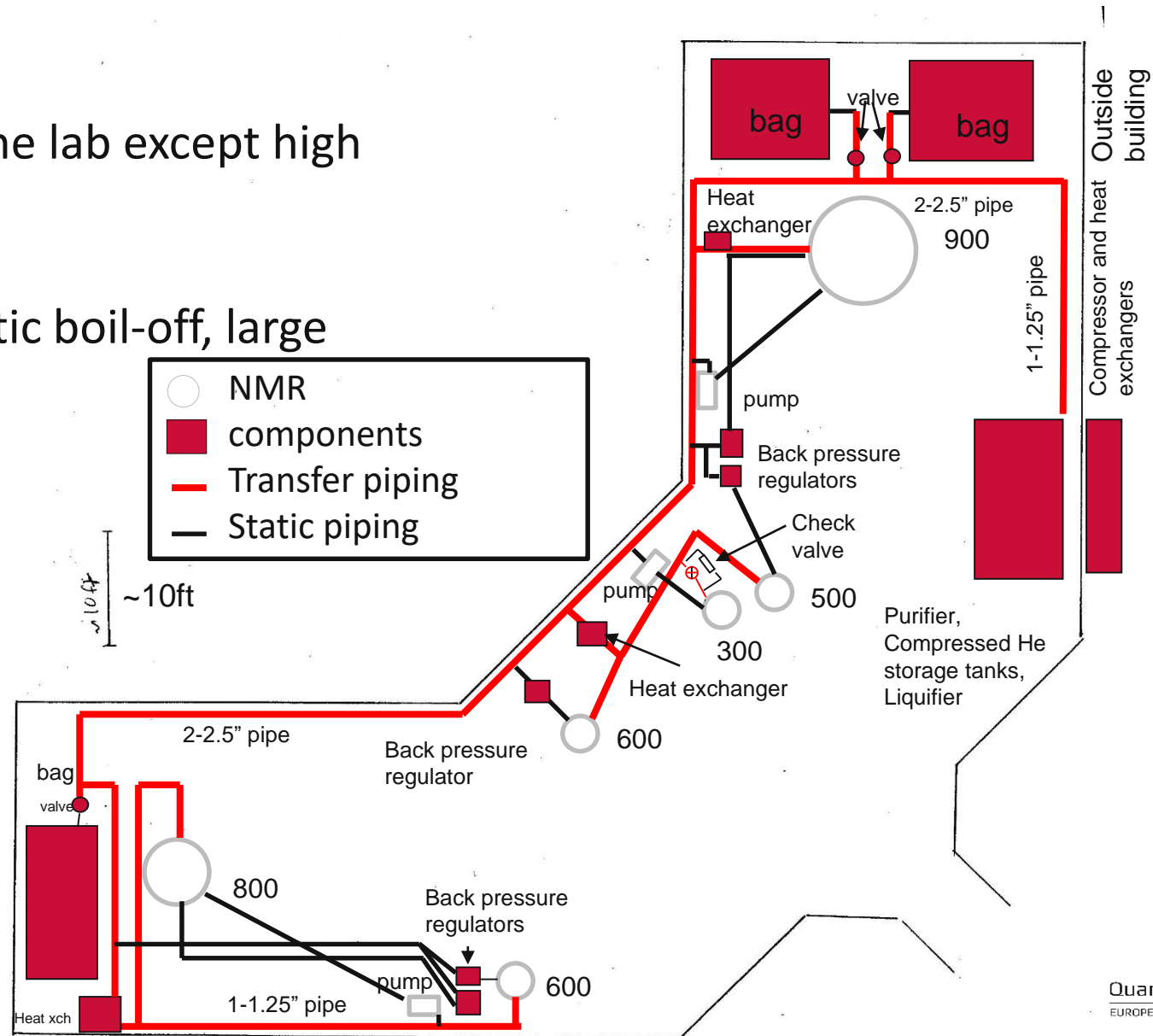
High Pressure Recovery: Mid to Long Term Storage



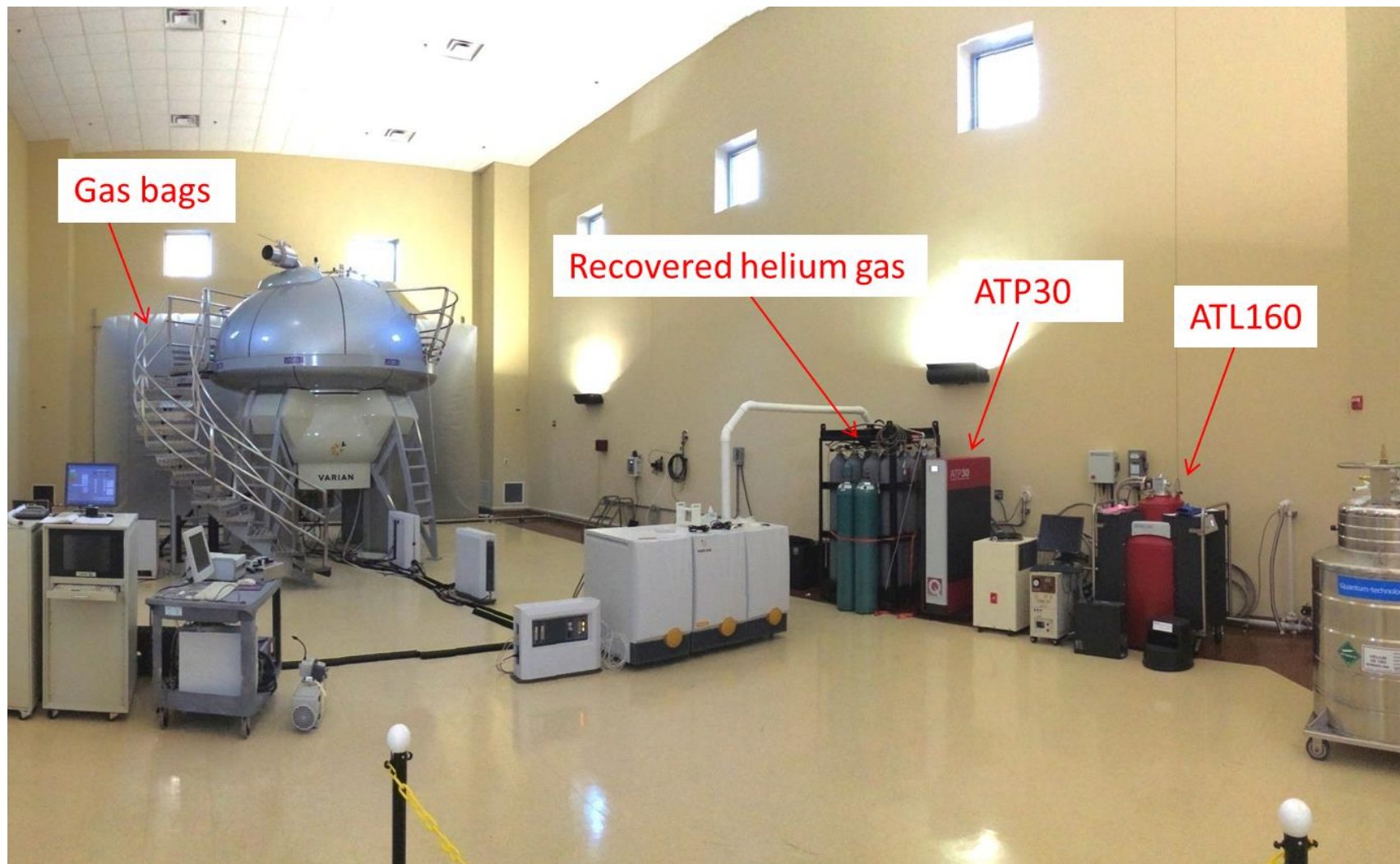
Complex Carbonhydrate Research Center, Uni of Georgia, Athens

- All components installed in the lab except high pressure compressor
- Piping at the ground
- Small diameter piping for static boil-off, large diameter for transfers,

900MHz
800MHz
2x600MHz
500MHz
300MHz



Complex Carbonhydrate Research Center, Uni of Georgia, Athens



Thanks for your attention!

