Large-scale 4.5K Helium Refrigeration System

GSI FAIR

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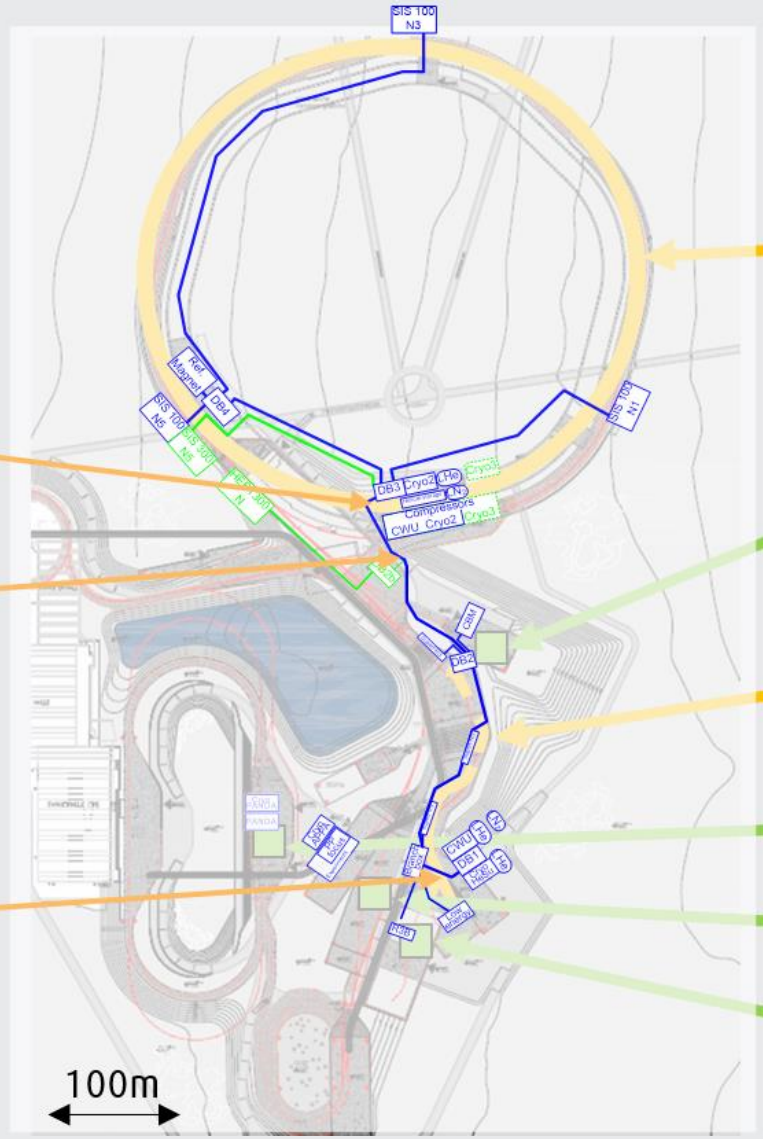
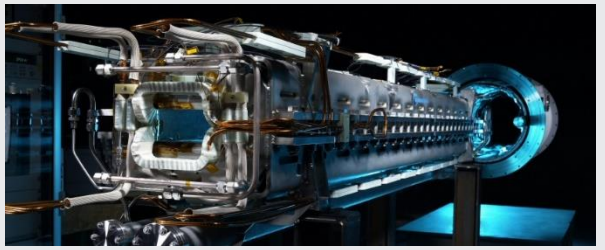
FAIR Cryogenics Overview





fast-ramped iron dominated magnets

cycle A	cycle B	cycle C
Q_{dyn}= 4600 W	= 4040 W	= 13500 W

upto 9 magnets in one cryostat

Integral cold mass:	1500 t
HE inventory Super-FRS:	6350 kg

Scope of Supply Linde Kryotechnik

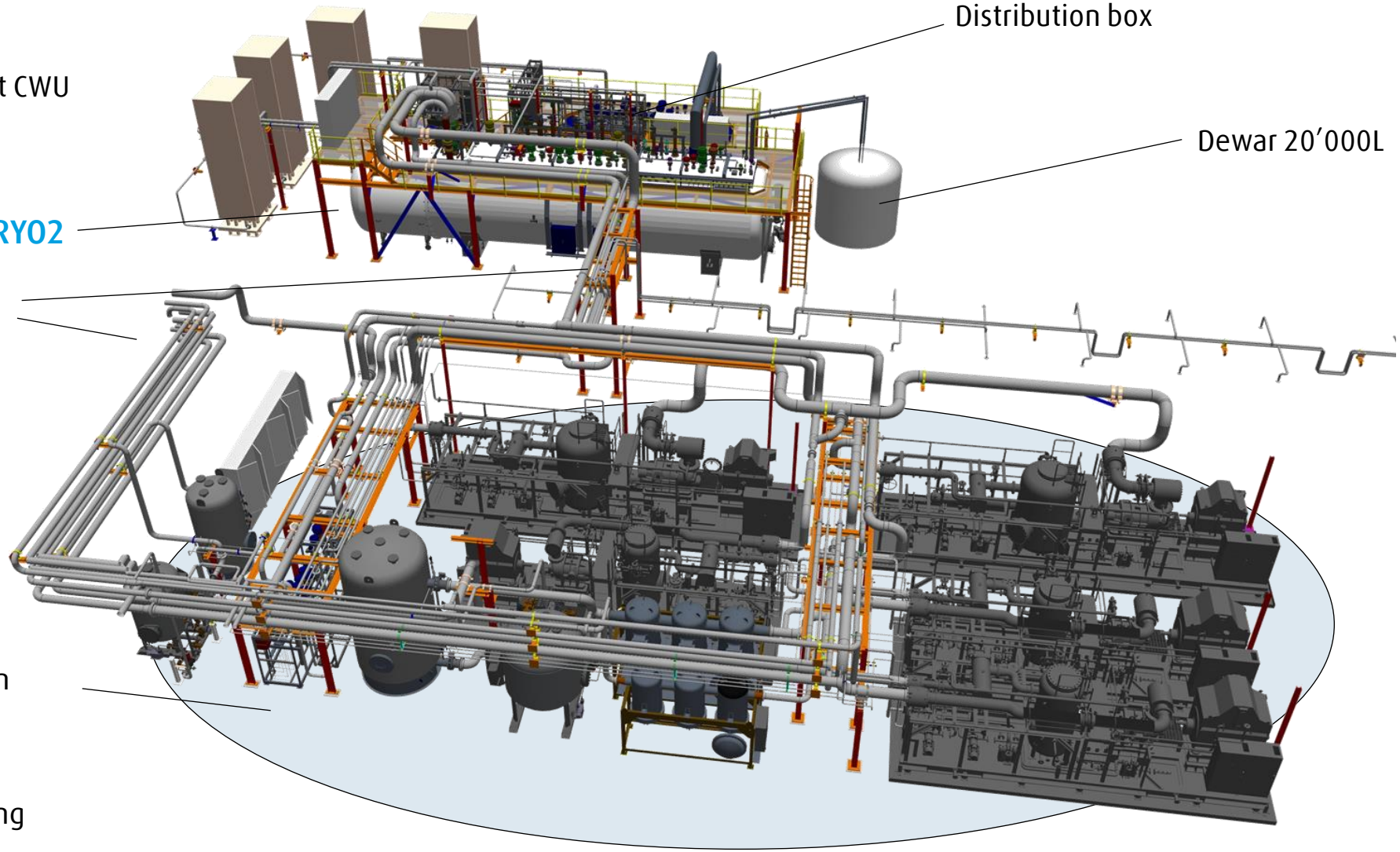
Cool down / Warm-up Unit CWU
(LN_2 cooled cold box)

Main cold box CRYO2

Interconnecting piping

Warm compressor station

Installation & Commissioning



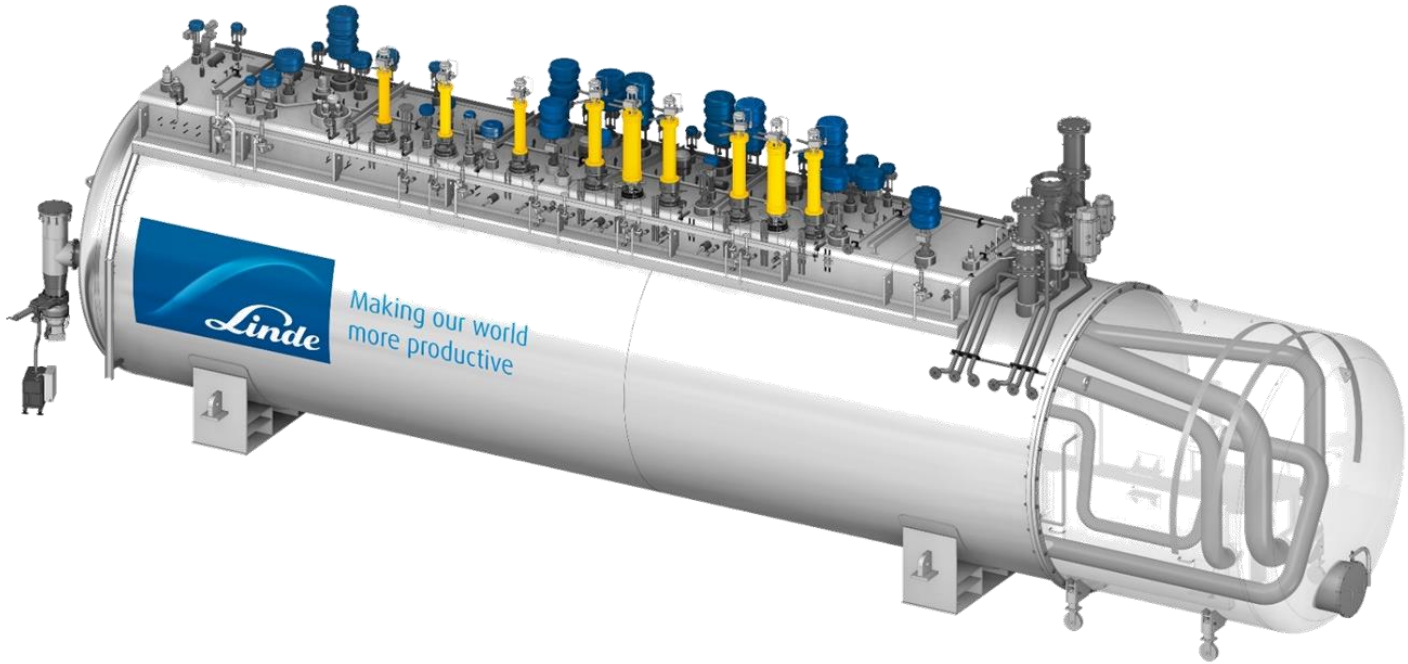
Coldbox hall

Buffer Tanks

Compressor hall

Performance Data CRYO2

Operation mode	Refrigeration @ 4.5K [kW][1]	Refrigeration @ 50K [kW][2]	ṁ @ 4.5K [g/s][3]	ṁ @ 50K [g/s][3]
Normal operation[4]	7.4 – 14	49	17	33
Super FRS filling	7.4	49	41	33
80K Hold		49		10
Minimum Load	3	8	11	



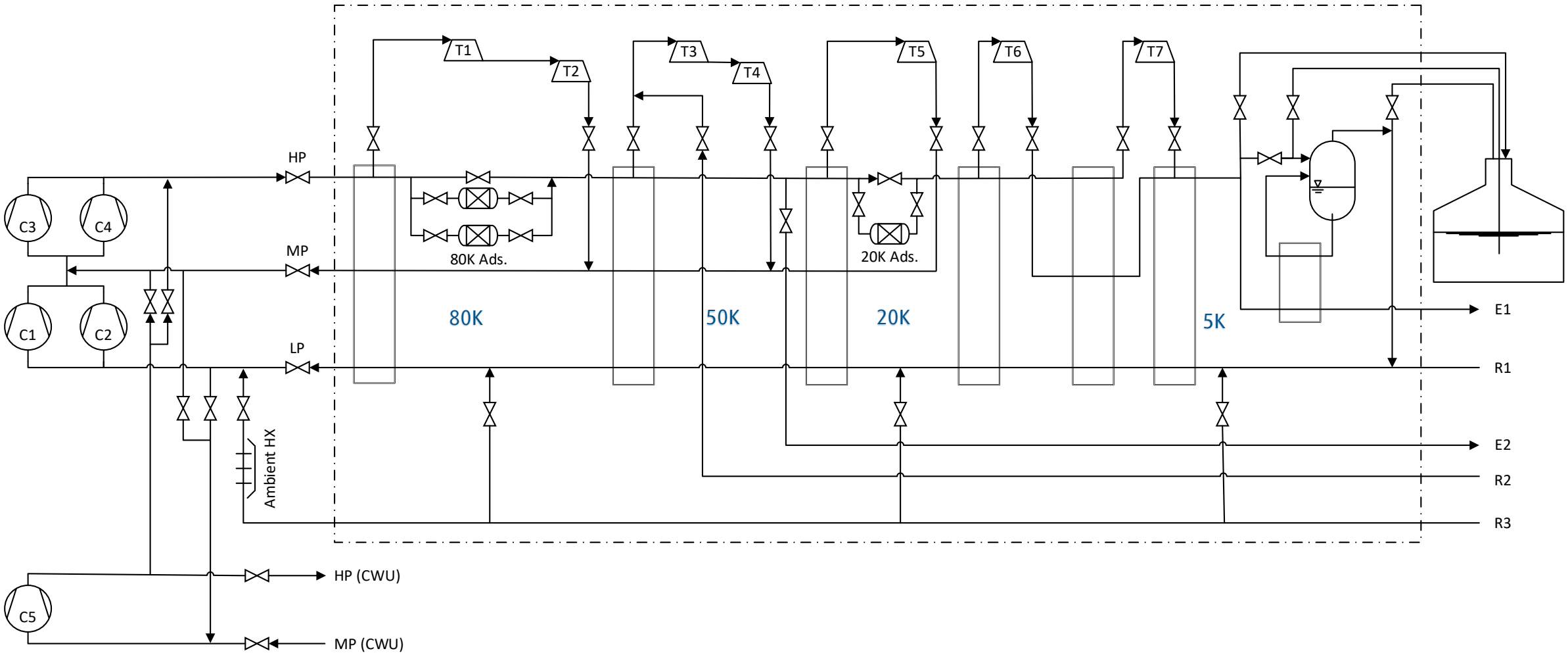
1 Supply at 4 bar.a, return at 1.2 bar.a and ~4.7K

2 Return at 80K

3 Return at 300K

4 4.5K equivalent performance of 20kW

Process Design
Overview Cryoplant



Process Design
Gas Management

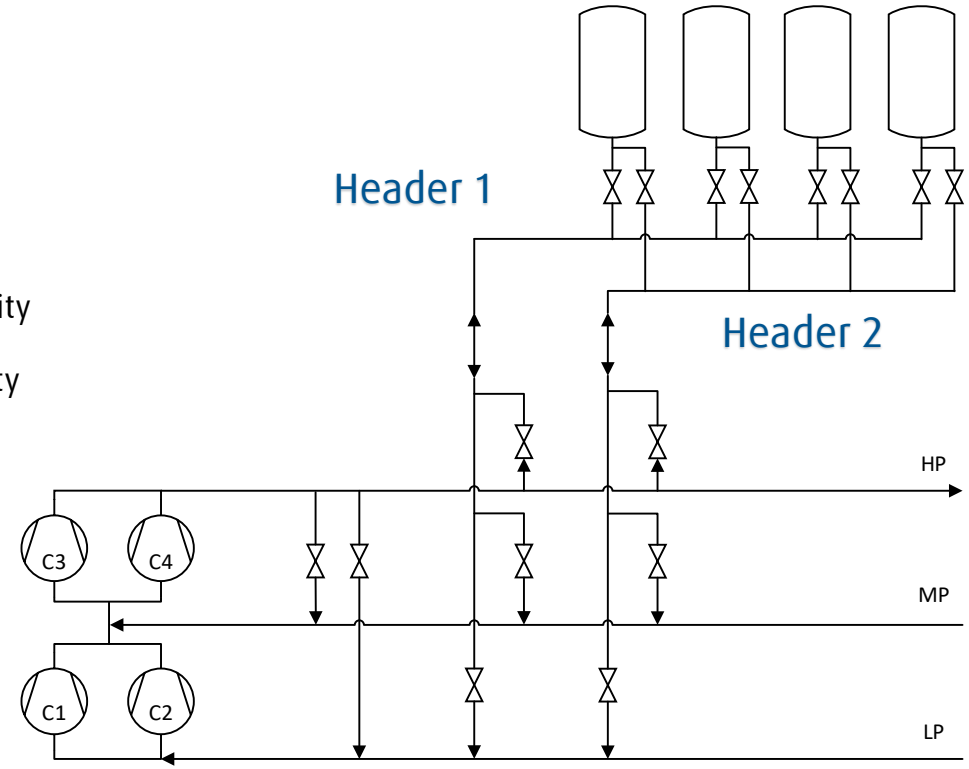
Feature: Two Buffer headers instead of one
with loading and unloading valves for each, loading to MP and LP

Benefit: High flexibility on gas buffer management
(higher / lower pressure and different purity levels)

Feature: Floating pressure cycle, HP/MP pressure ratio ~constant

HP/MP pressure high	high mass flow over HP compressors and turbines	high capacity
HP/MP pressure low	low mass flow over HP compressors and turbines	low capacity

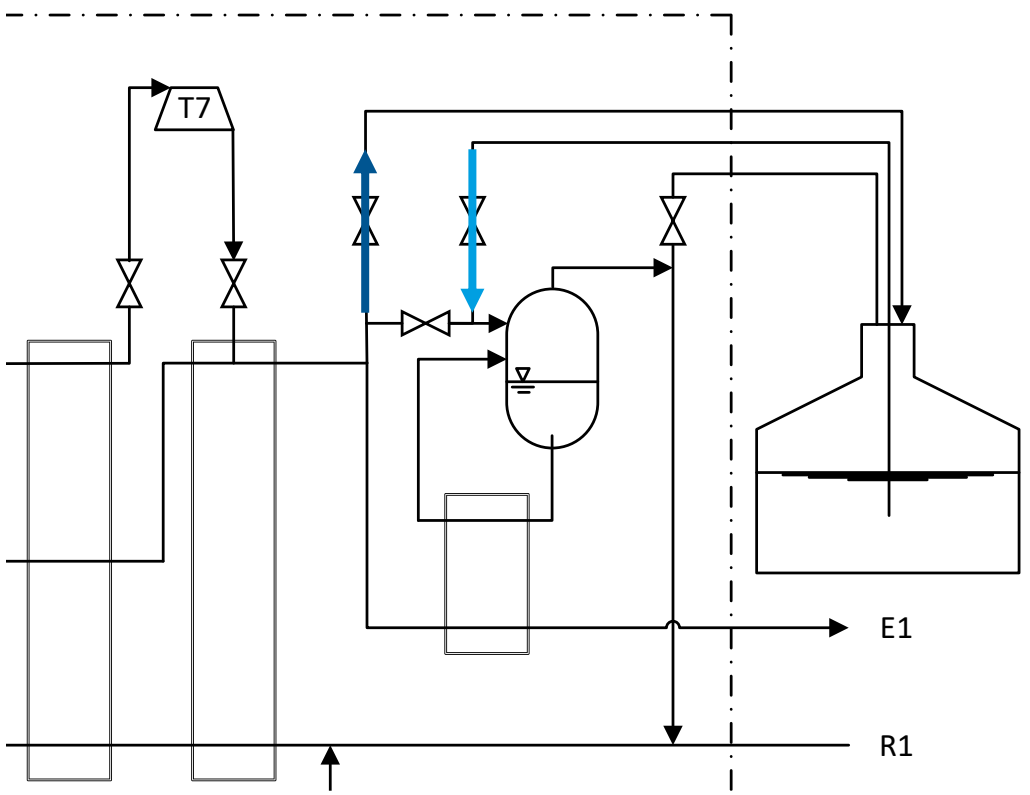
Benefit: No throttling of Turbine inlet valves required,
therefore, high efficiency as well for turndown operations



Process Design
Integrated Dewar

Feature: Integrated dewar acts as cold buffer

1. **Refrigerator capacity > required performance:**
   -> Liquefy to dewar
   -> reduction of HP / MP pressure
   -> reduction of refrigerator capacity
2. **Refrigerator capacity < required performance:**
   -> Load LHe from dewar to phase separator
   -> increase of HP / MP pressure
   -> increase of refrigerator capacity



Main benefits:

- Automated and stable capacity adaption to required performance
- Overperformance for peak load or filling of cryostats possible

Summary

Linde Kryotechnik (LKT) was contracted by GSI FAIR to provide cryogenic cooling for all cryogenic systems of the FAIR project. The plant is delivered and under installation.

Highlights

- CWU compressor can be used as redundancy for HP or LP CRYO2 compressors
- Floating pressure cycle allows high efficiency as well for turndown operations
- Process integrated dewar allows automated and stable capacity adaption to required performance

Future milestones:

- Mechanical completion
- Commissioning including acceptance testing

Thank you for your attention

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