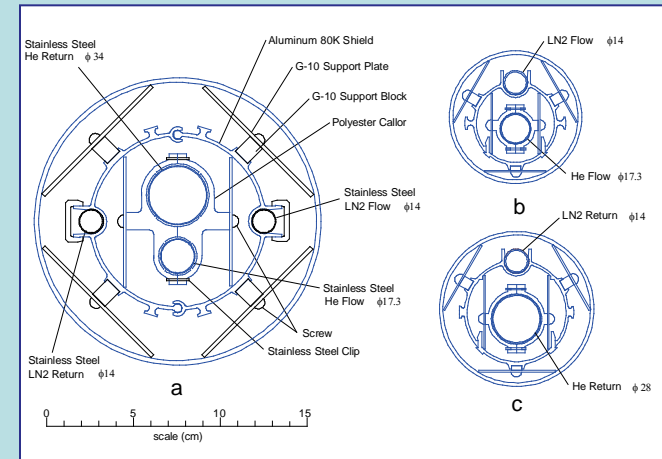
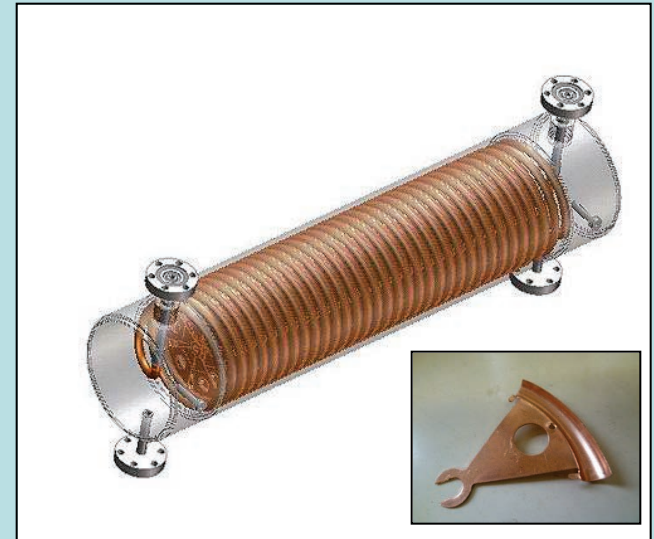


2K Cryogenic System Design for cERL at KEK

Contents:

- Background and Goal
- 2 K Super-fluid Helium
- Liquefier vs. Refrigerator
- JT-Heat Exchanger
- High Performance Transfer Line
- 2K Cryogenic System for cERL
- Summary



KEK
Kenji. Hosoyama

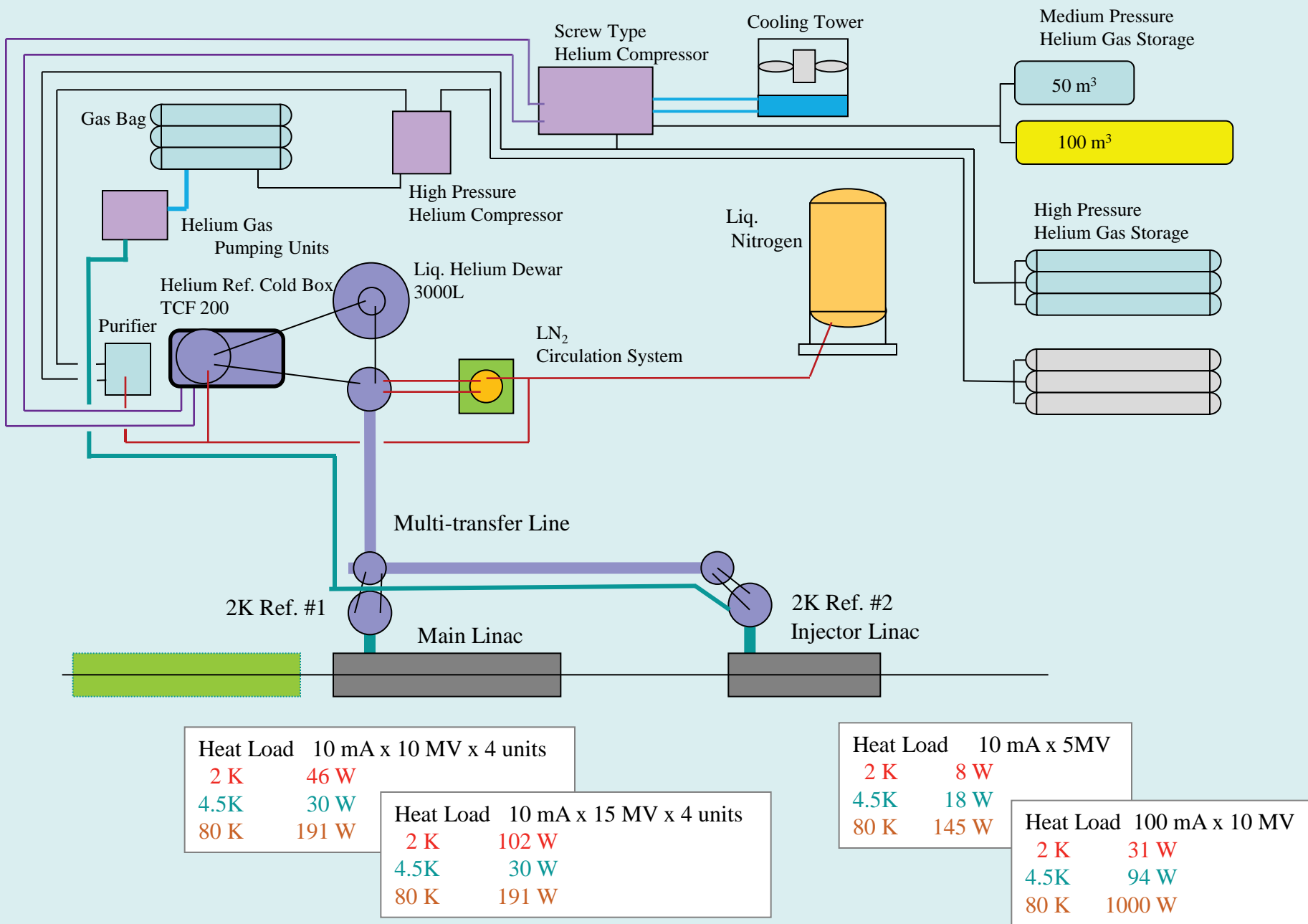
Background and Goal

- We had an old helium refrigerator (TCF200 500W at 4.4K or 250L/h)
got from NIMS (National Institute for Material Science).
- Design, construction and operation of 2K 40W cryogenic system for ILC prototype cryomodule was successfully completed.

For base line design of cERL 2K system, we adopted this.

- High performance transfer line system and JT heat exchanger have been developed by our group at KEK.
- cERL 2K cryogenic system;
 - Two 2K refrigerators for injector and main linac.
 - Cooling power of each 2K ref. can increase up to 80W
by addition of pump units.
 - Total cooling power can upgrade by adding a new liquefier.

Helium Ref. System for cERL



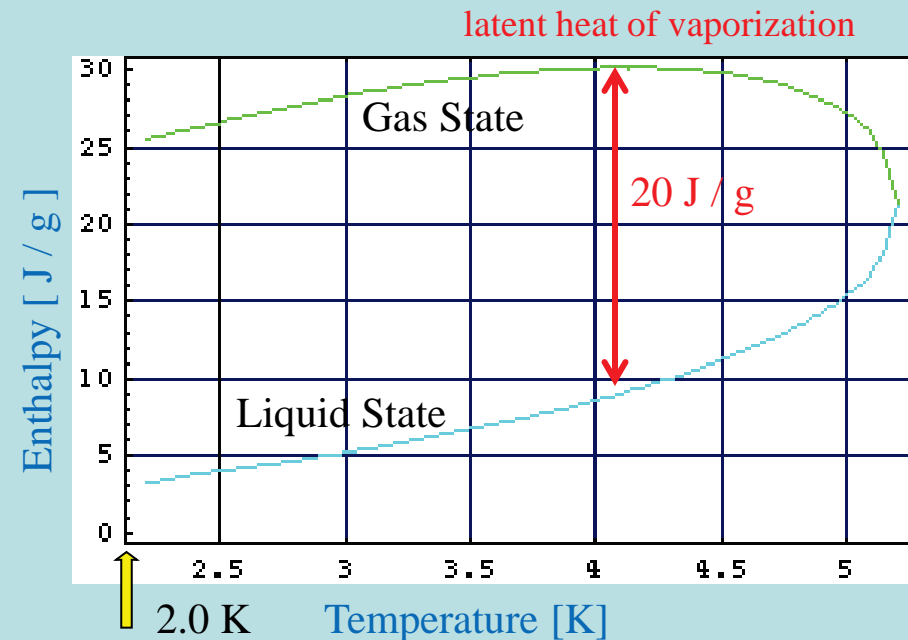
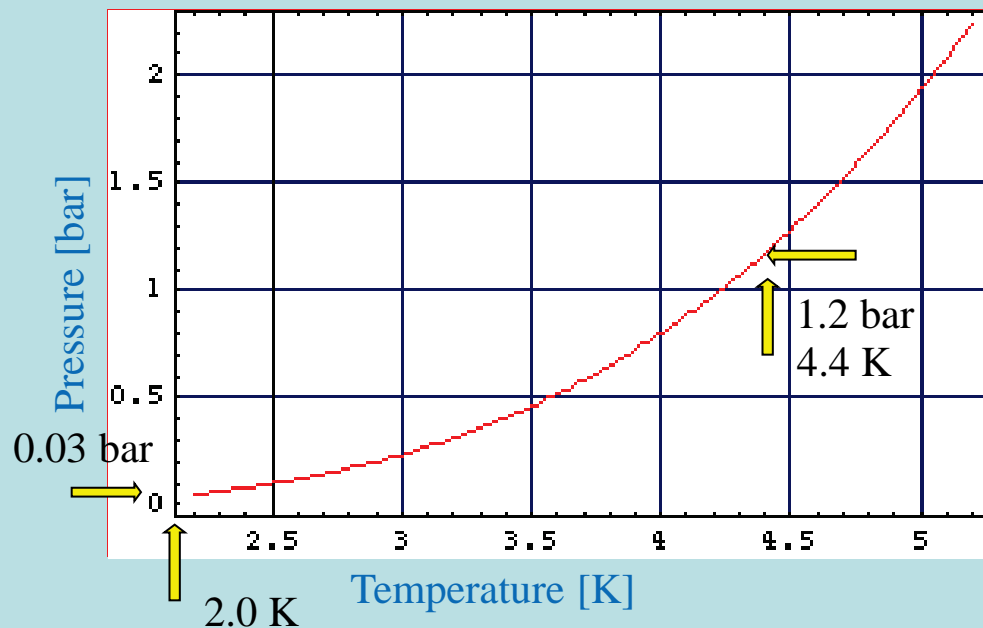
2 K Super-fluid Helium

How to make 2K Super-fluid Helium ?

Use the latent heat of vaporization of helium

	Cold Pump	Large System	CEBAF, LHC,
⇒	Warm Pump	Small System	KEK

Saturated Vapor Pressure of Helium



Liq. He 1 l 1 / 8 kg 1 / 8 x 20 = 2.5 kJ

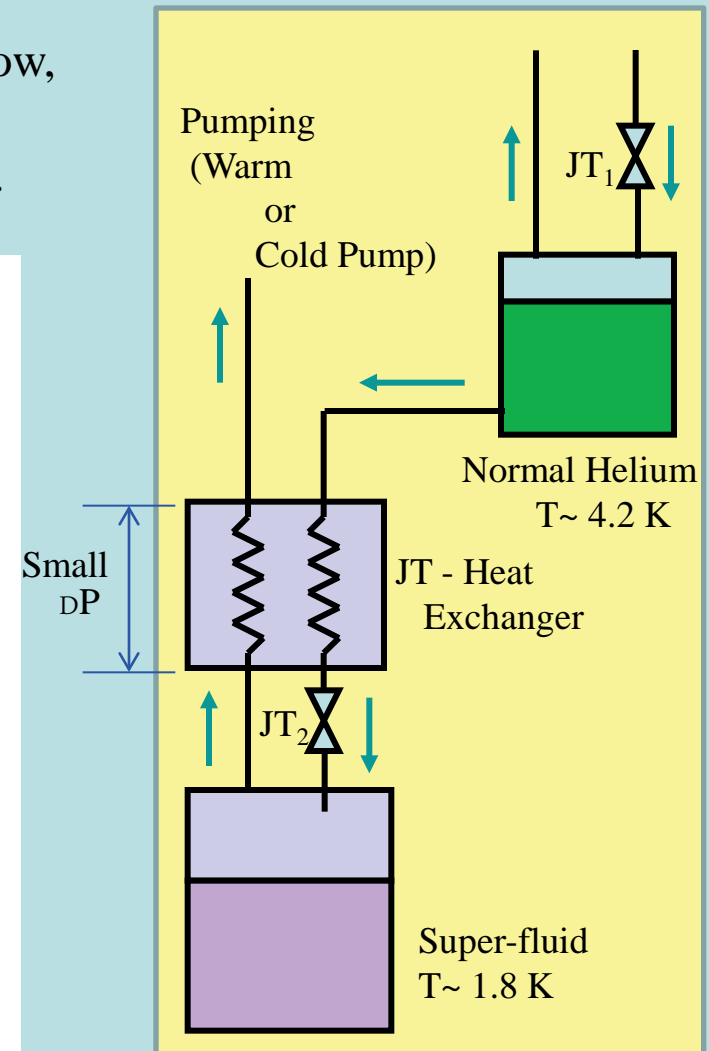
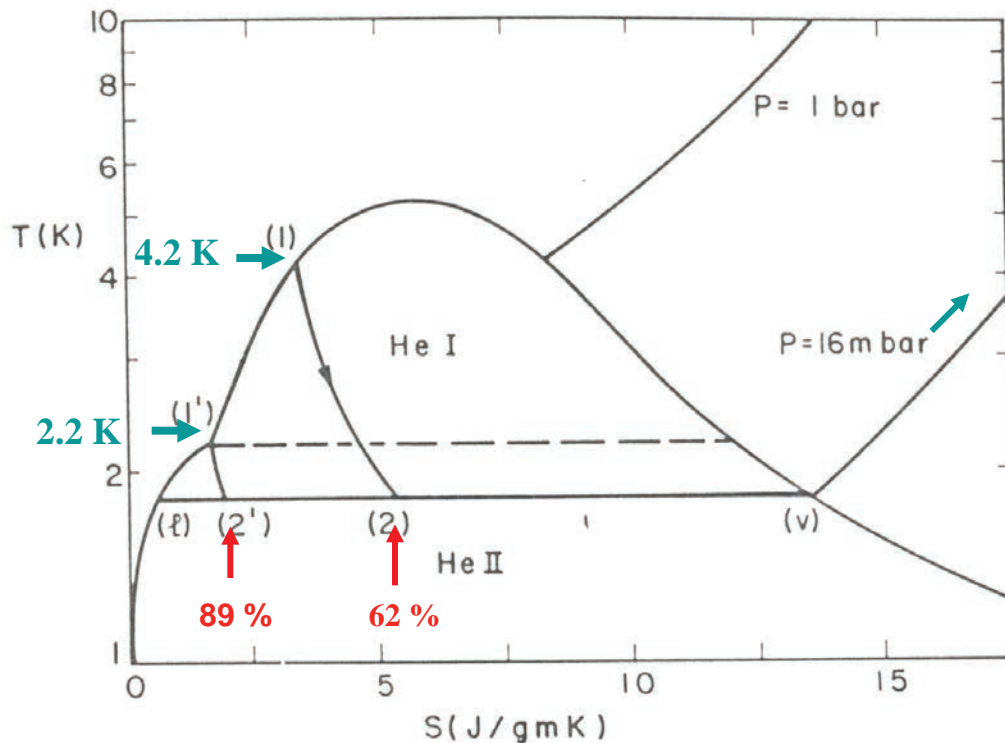
Liq. He 1 l / hr -- 2.5 / 3.6 = 0.7 W

Cooling Power 1W -- Liq. He Consumption 1.4 l / hr

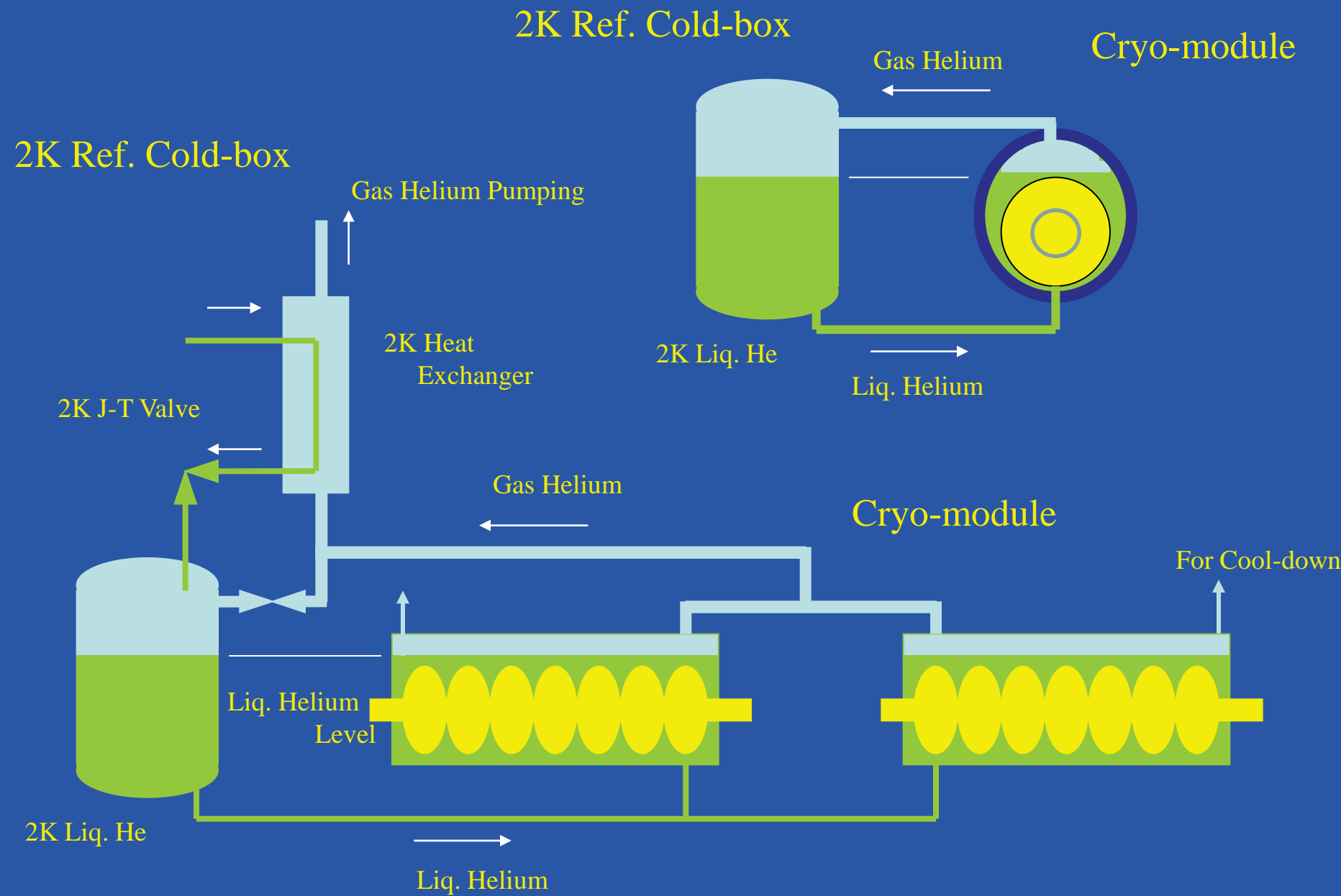
JT-Heat Exchanger

Production ratio of 1.8K liquid helium can increase from 62% to 89% by lowering the temperature of expand liquid helium from 4.2K to 2.2K using the cold vaporized gas through JT-heat exchanger.

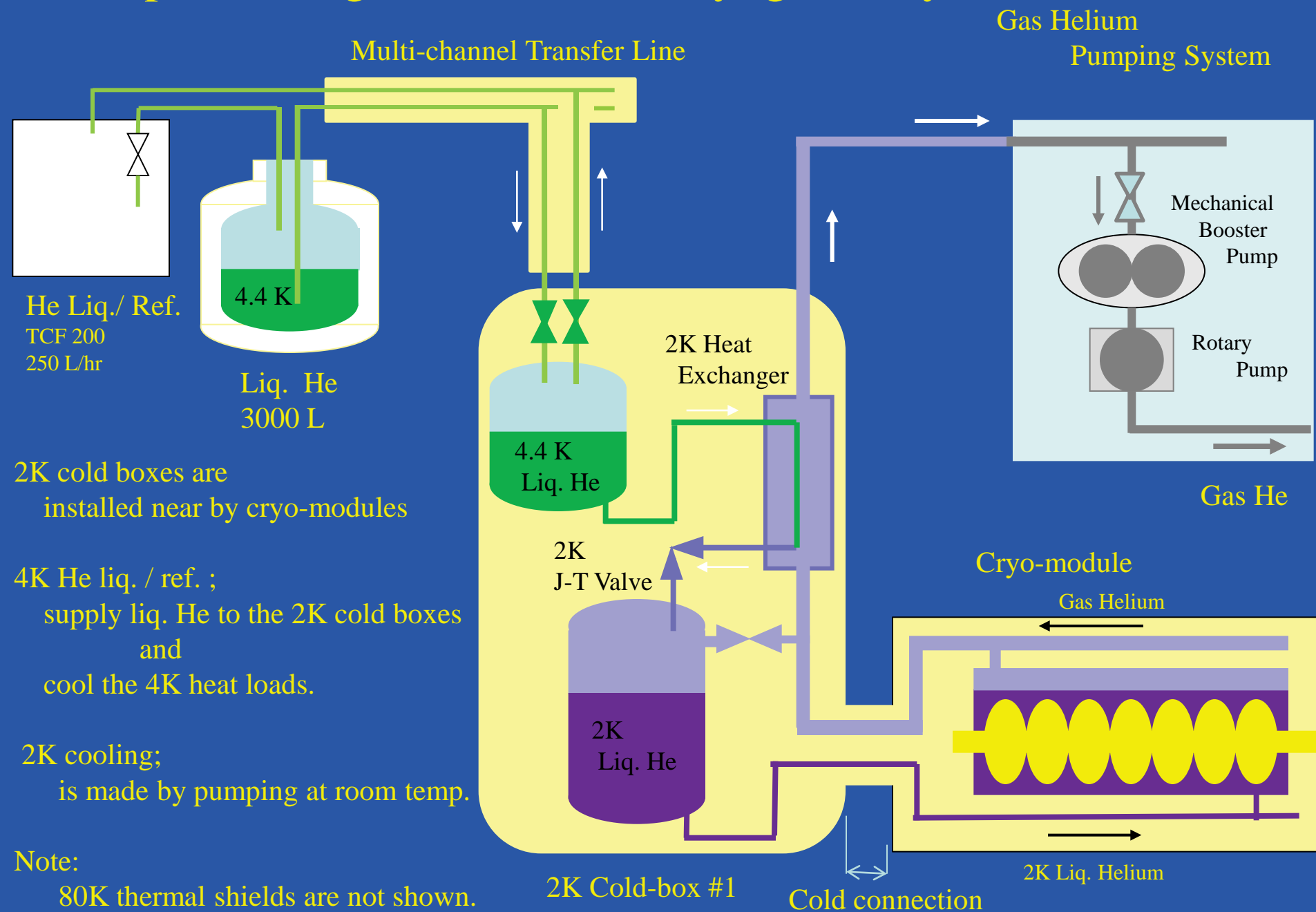
Because saturated pressure of the 2K helium is very low, i.e. $\sim 0.03\text{bar}$, specially designed heat exchanger is required.



2K Ref. & Cryo-module

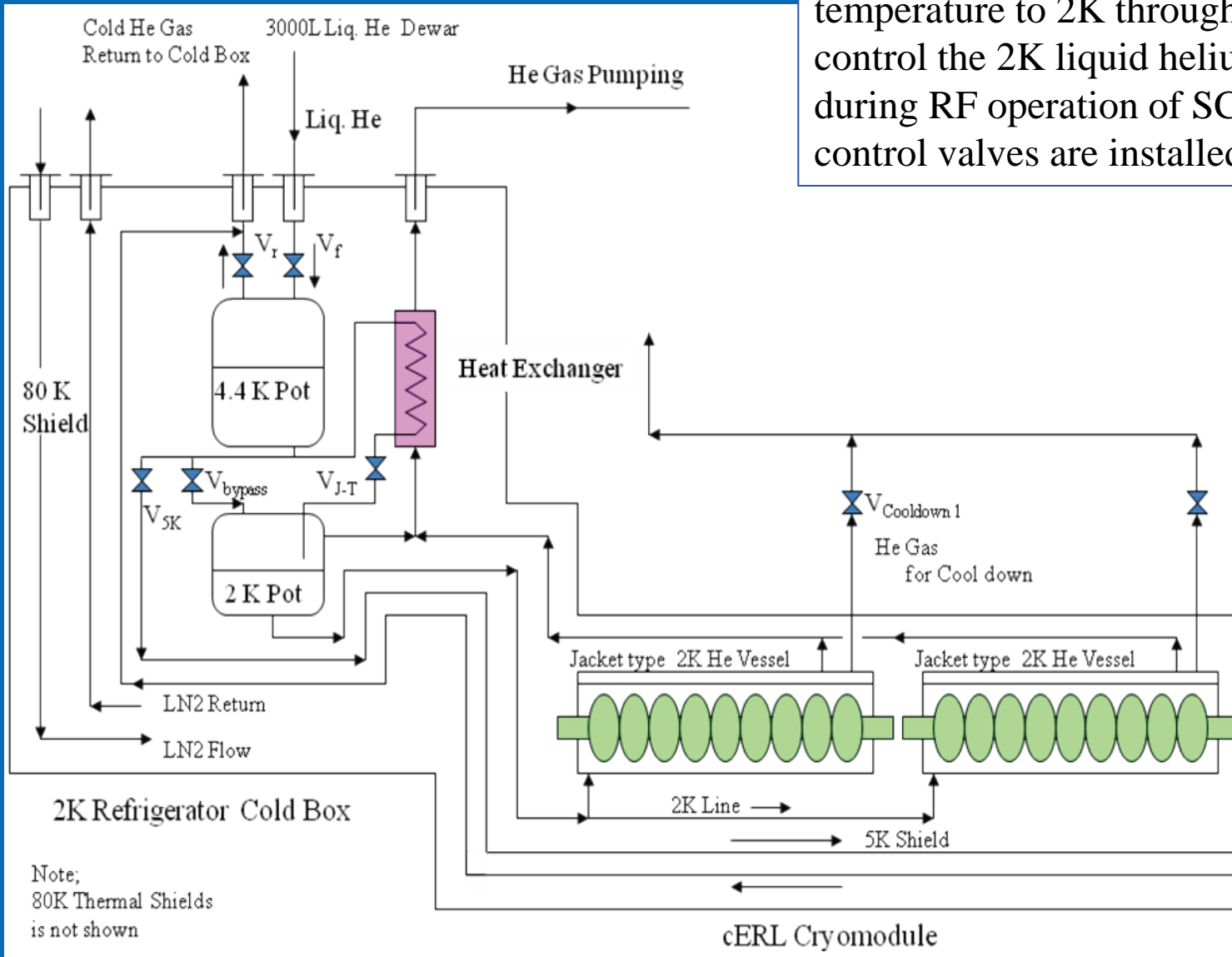


Conceptual design of cERL 2K cryogenic system



Detailed Design of 2K Cold Box

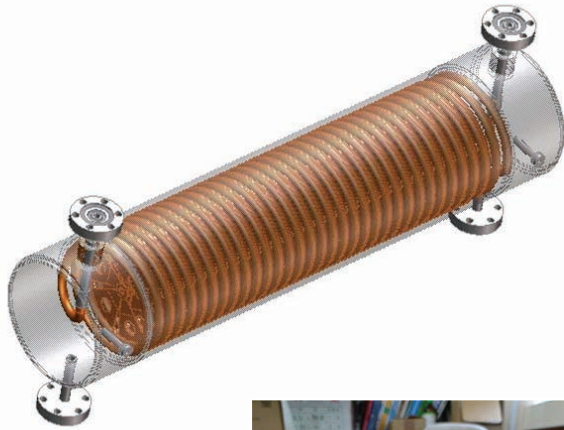
To cool down the cryomodule from room temperature to 2K through 4.2K and to control the 2K liquid helium level constant during RF operation of SC cavity, many control valves are installed.



Heat Exchanger

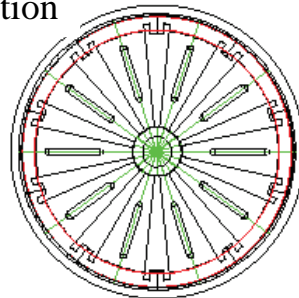
Lower pressure drop structure in return line
Leak tight: the body made of steel parts
and assembled by argon welding

Conceptual Design of JT Heat Exchanger for Version 2 (2K 30W)

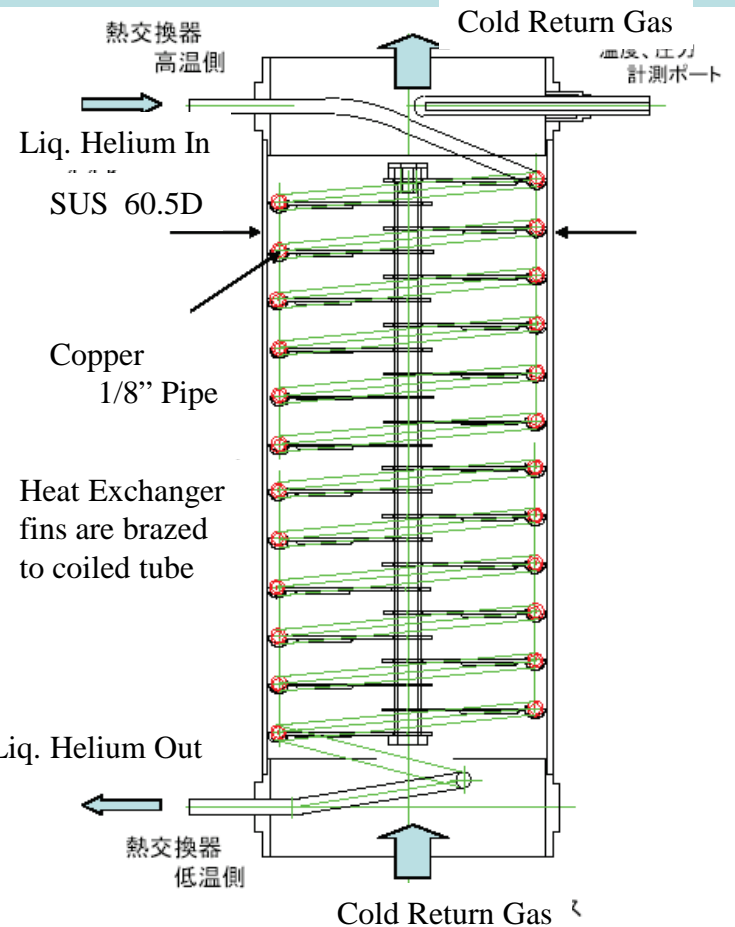
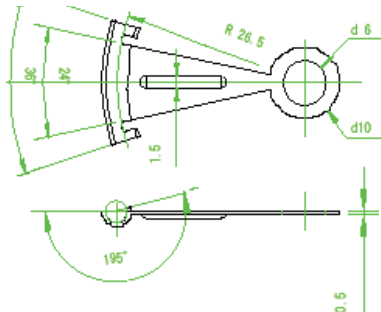


Heat Exchanger

Cross-section



Heat Exchanger Fin
made by punching press



Comment :

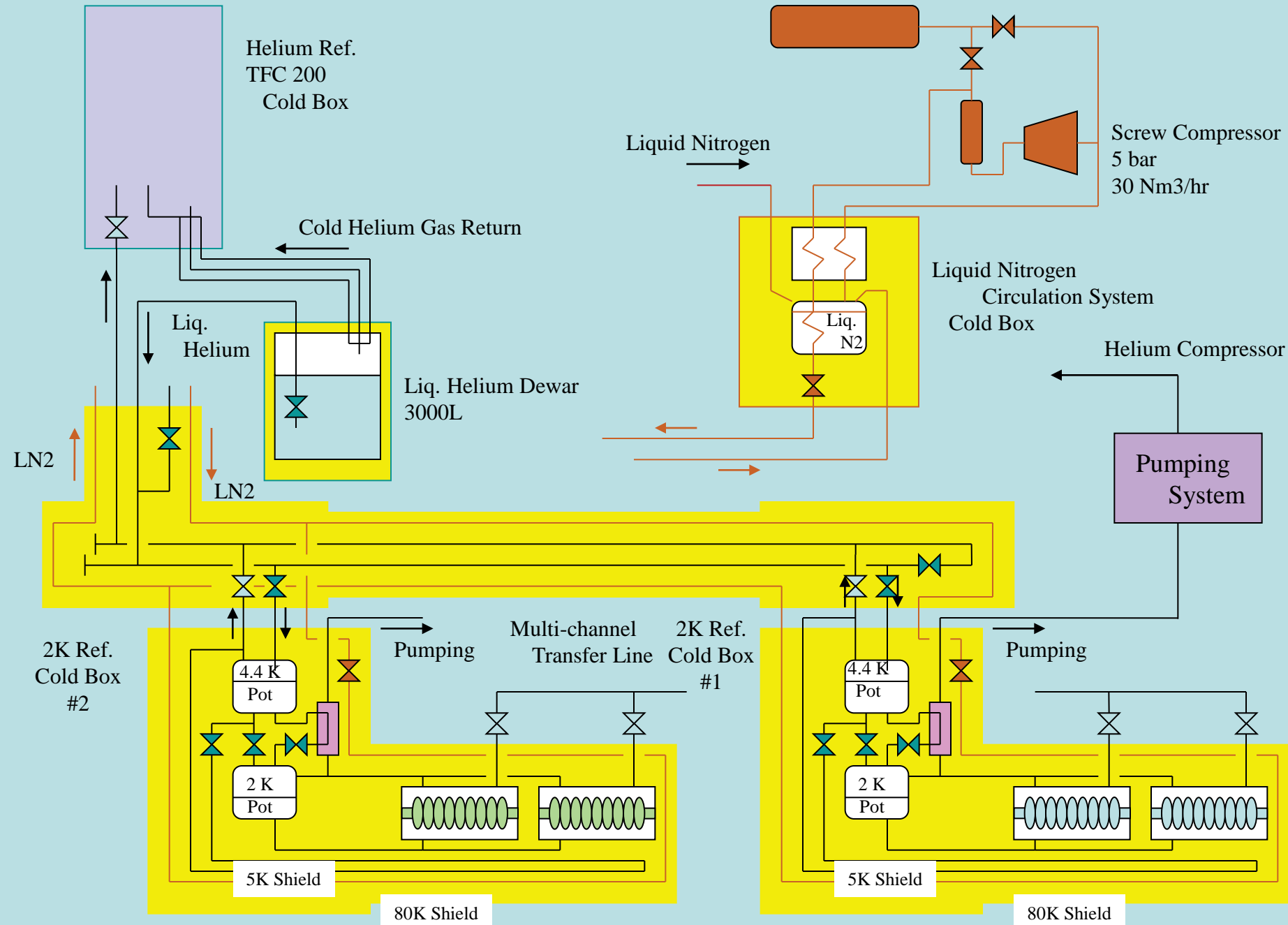
Version 1 : Lamination Type
(1.8 K Magnet Cooling System)

Version 2 : Fined Tube Type 1/8"
(2 K ILC Cavity Cooling System)

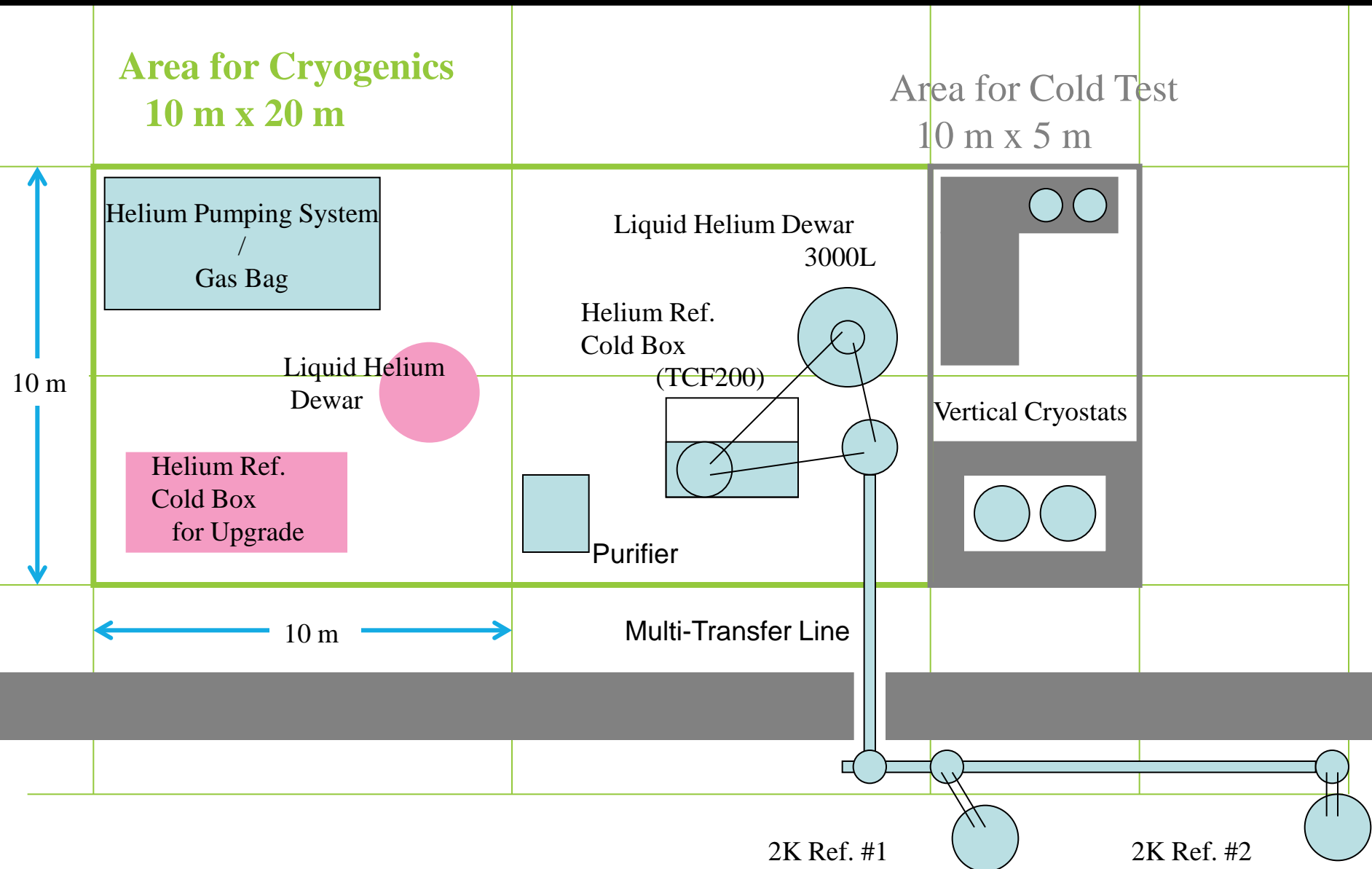
Version 3 : Fined Tube Type 1/4"
(2 K cERL Cooling System)



System flow of cERL Cryogenic System



Layout of Cryogenic System



High Performance Transfer Line 1

Small heat leak to cold helium piping ~ 0.05 W/m

80 K aluminum thermal shield, cooled by liq. nitrogen, intercept the heat leak from the room temperature parts.

Small cold mass --- thin stainless tube (0.5 t)

Stable operation during transient condition, i.e., recovery from the cold helium flow stop.

Easy to assembling

Leak tight

stainless welding

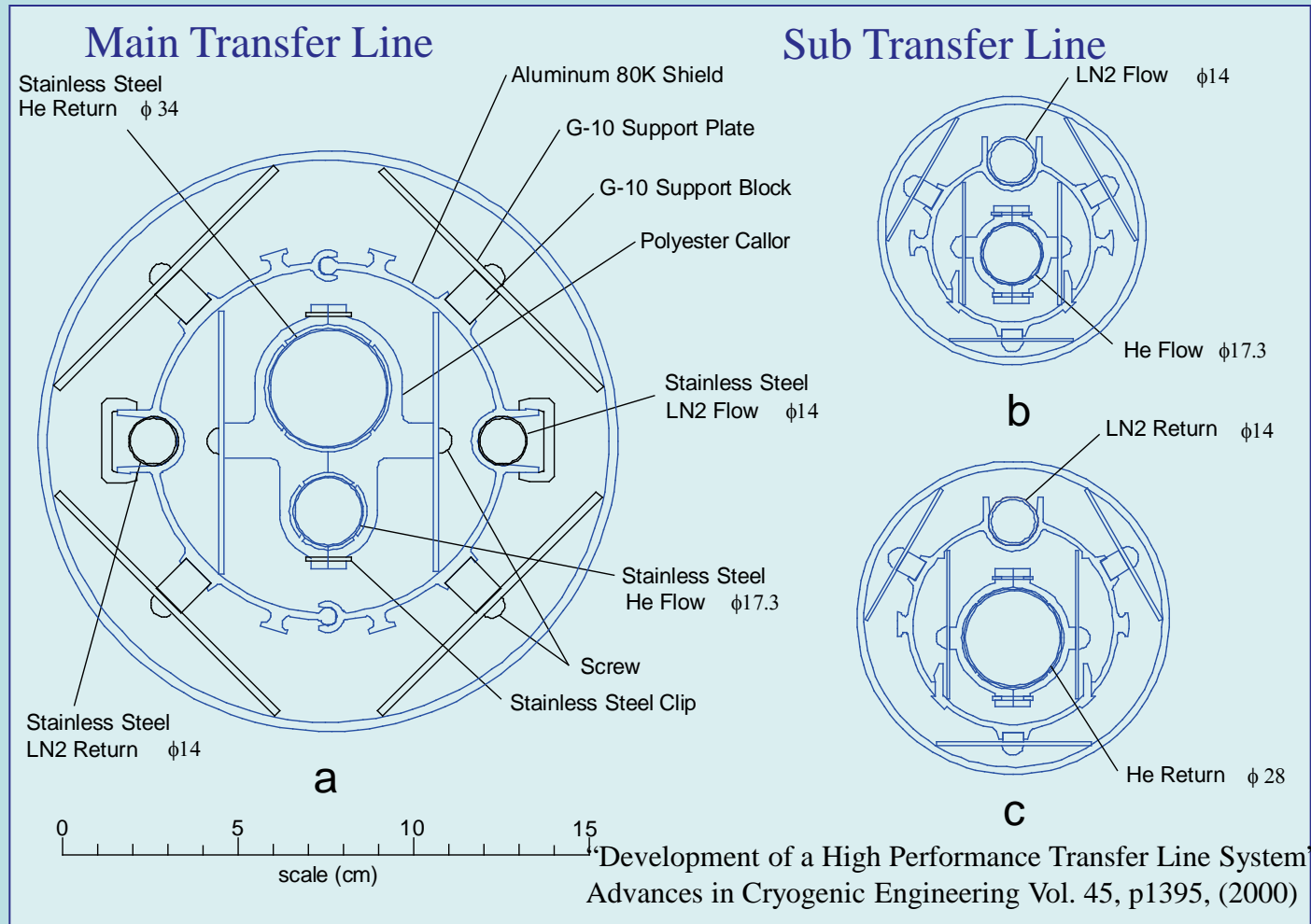
Good thermal contact

Thermal shield is
made by extrusion

Sub-transfer

80 K aluminum
thermal shield

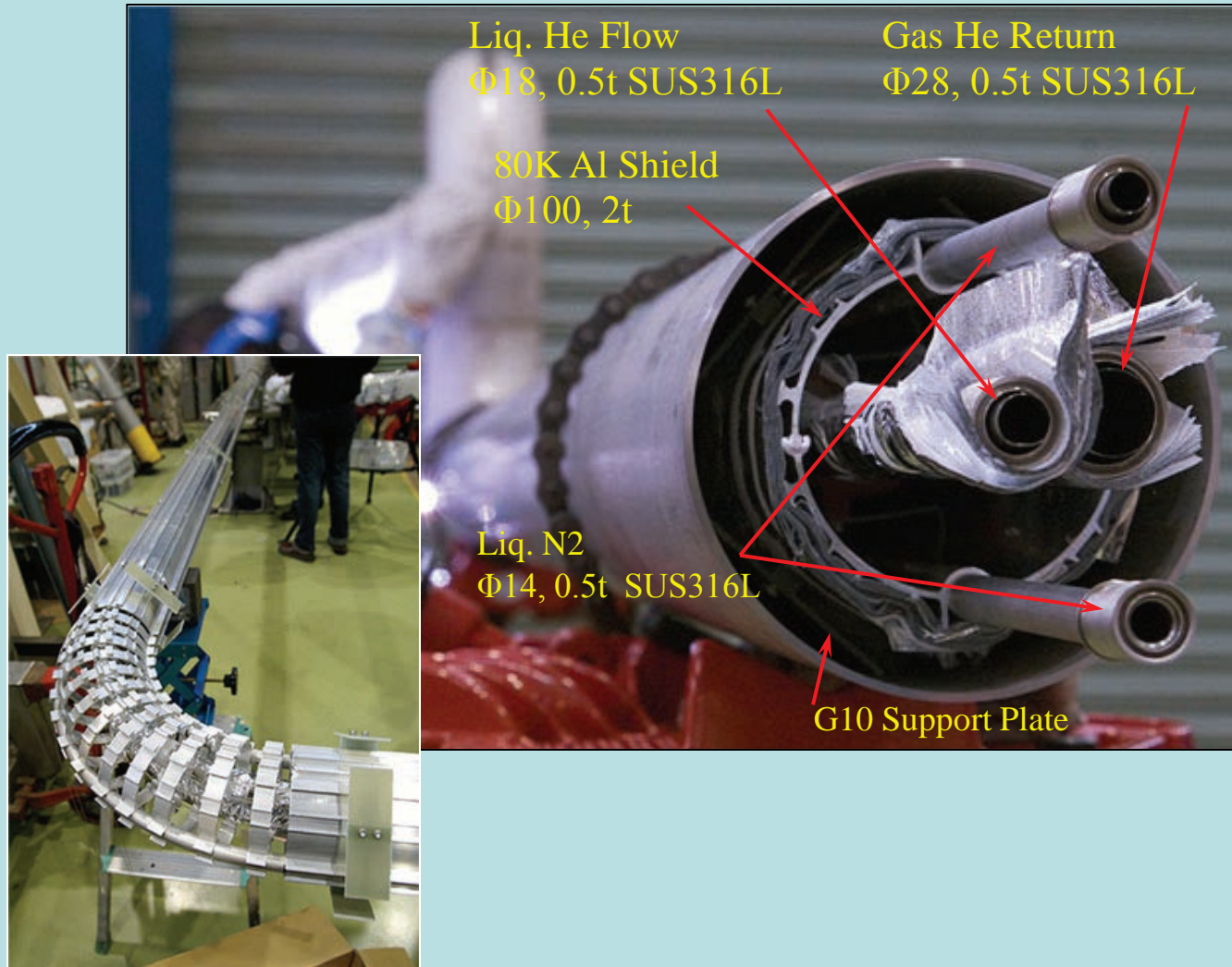
Need liq. nitrogen
circulation system



High Performance Transfer Line 2

By the 80K aluminum thermal shield cooled by liquid nitrogen, the heat leak to helium line can reduce to ~ 0.05 W/m

Main Multi-Transfer Line

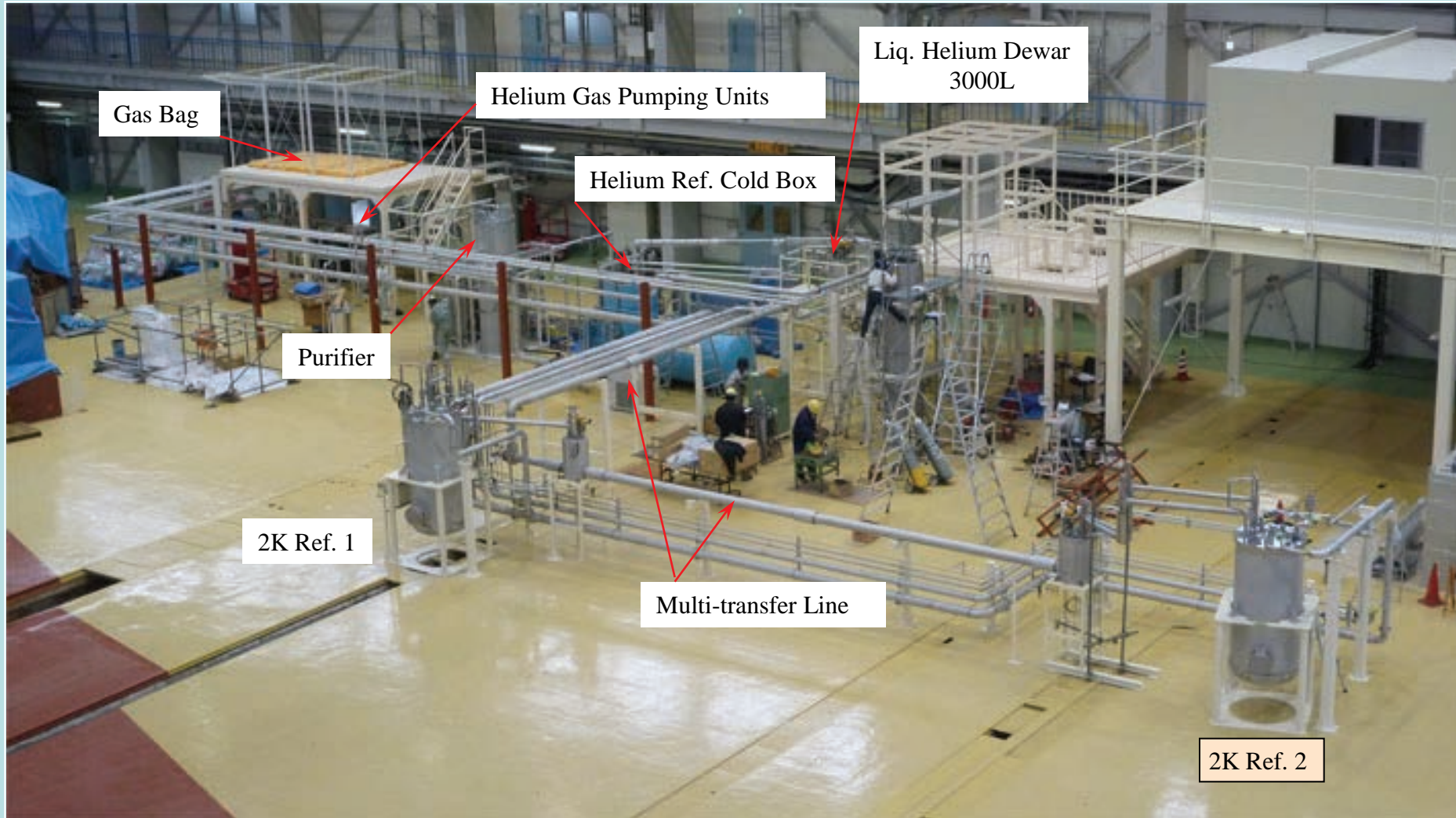


Valve Box
80K Al Thermal Shield



80K Al Thermal Shield
Main Multi-Transfer Line

2K Cryogenic System for cERL 1



2K Cryogenic System for cERL 2



Summary

- The cERL 2K cooling system consisted of helium refrigerator TCF200, two 2K refrigerators with helium gas pumping system and multi-transfer line was proposed and designed in 2008.
- The main components of the system were constructed and installed in the experimental hall of the cERL by the end of FY 2009.
- Before start the new operation of helium refrigerator for cERL, we cleaned up oil in the flow line of the 1st heat exchanger using the solvent and replace the charcoal by new one.
- The commissioning of the helium refrigerator was started in September of 2010.
- The commissioning of the 2K refrigerator and helium transfer line without the cryomodule will be carried out and 2K cooling capacity will be checked very soon.