# Cryogenic System of Interaction Region (SiD, ILD, QD0, QF1, Crab Cavity) in the Japanese Mountain Site

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Two cryogenic facility configurations for IR are proposed.

∗ IR= (SiD, ILD, Crab cavity, QD0, QF1)

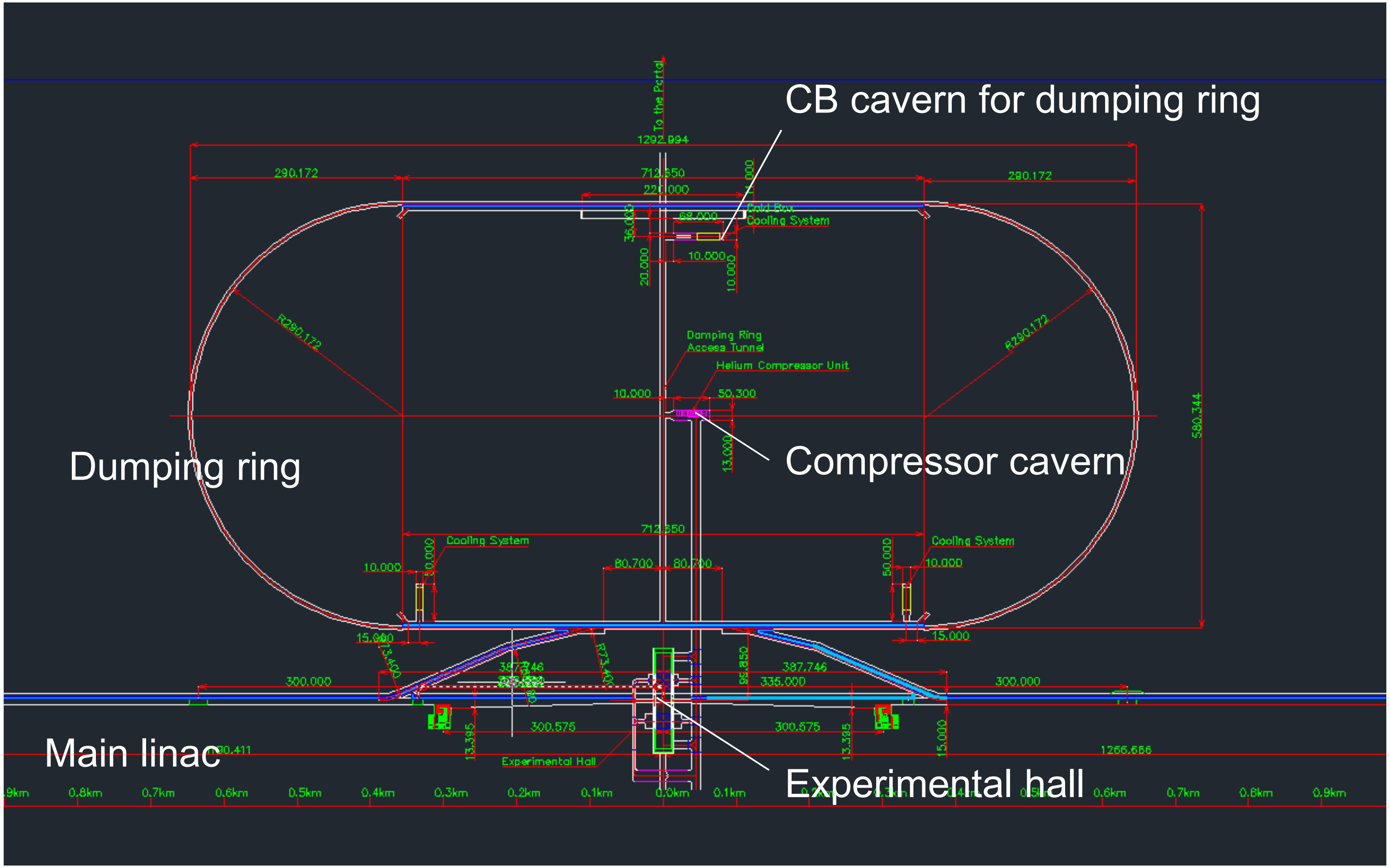

1. Cryogenic facility layout including dumping ring

2. Two Conceptual cooling schemes (Plan-A & Plan-B)
   - ✓ Layout
   - ✓ flow diagram
   - ✓ Advantage and disadvantage

3. Transfer Tube (TRT)
   - ✓ Rigid type TRT, Flexible type TRT

4. Summary

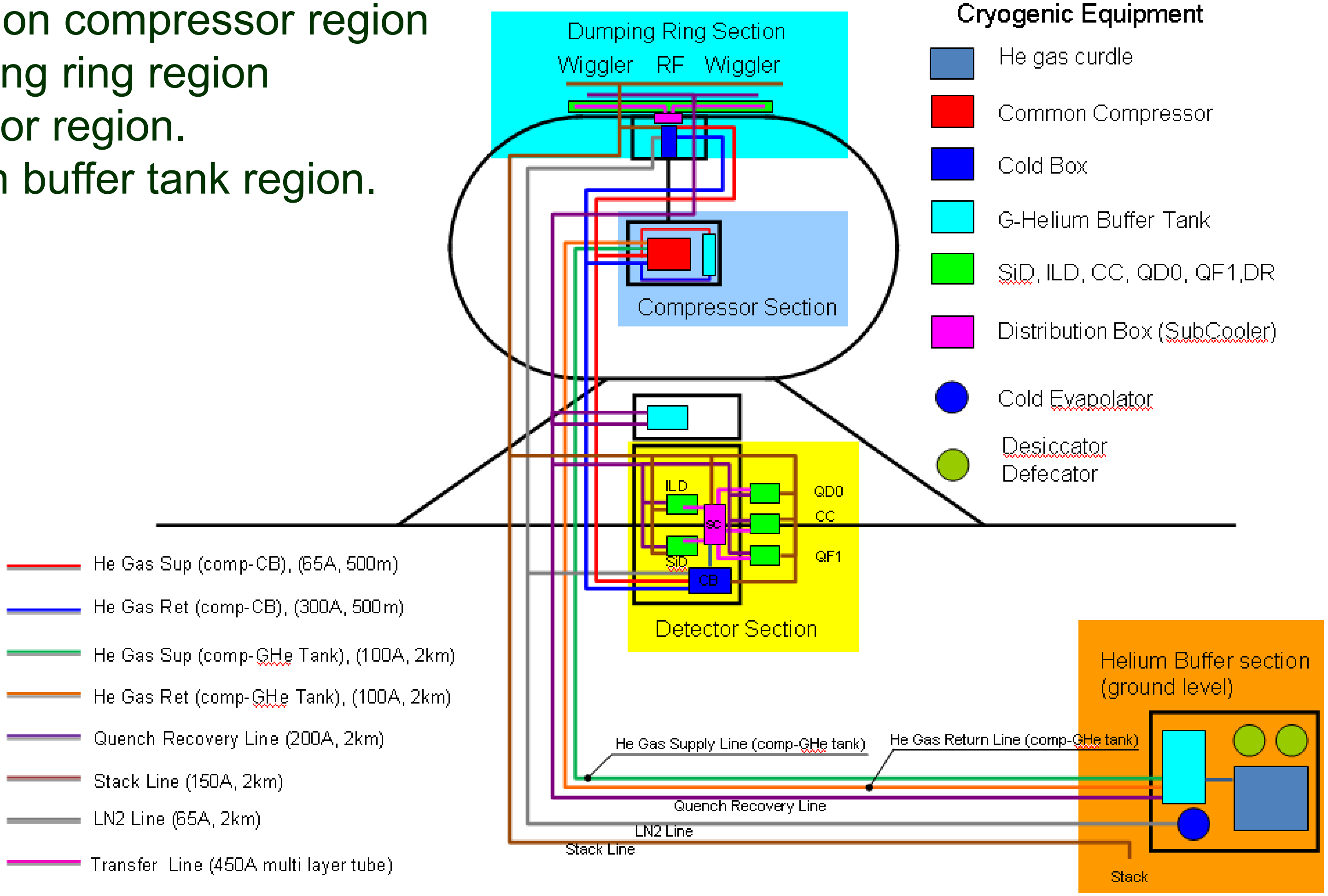
# Overall layout at Interaction Region



# Cryogenic overall block diagram example

Cryogenic system for IR including dumping rings is composed of four regions.

1. Common compressor region
2. Dumping ring region
3. Detector region.
4. Helium buffer tank region.




Cryogenic system for Detector region (SiD/ILD, CC, QD0, QF1) will be discussed.

# Equipment installed in each region

Compressor Region (Compressor cavern)

- Common Compressor
- Helium Buffer tank ( in order to control pressure fluctuation)
  - Volume ~ 100 $m^3$ buffer tank

Discussion Item

Interaction Region（Experimental Hall）

- Cold Box (Single or more cold box? → Discussion Item)
- Subcooler for Liquid Helium and Superfluid Helium (Distribution Box)
- Liquid Nitrogen Equipment for precooling (Gas-Liquid Separator)

Dumping Ring Region

- Cold Box
- Distribution Box (subcooler)
- Liquid Nitrogen Equipment for precooling (Gas-Liquid Separator).

Ground Region

- Helium buffer storage tank
- High purity helium gas curdle
- Purifier, Desiccator
- Cold Evaporator

# Cooling requirements for superconducting equipment

| Superconducting equipment | Coolant condition | Heat Load |
|---|---|---|
| SiD | Two phase flow (4.5 K) | 400 W @ 4.5 K |
| ILD | Two phase flow (4.5 K) | 400 W @ 4.5 K |
| Crab cavity | Saturated He II (1.8 K ~ 2.0 K) | 100 W @ 2.0 K |
| QD0 | Pressurized He II (1.8 K ~ 2.0 K) | 100 W @ 2.0 K |
| QF1 | Pressurized He II (1.8 K ~ 2.0 K) | 100 W @ 2.0 K |
| Dumping ring | | |

To obtain actual cooling capacity of CB, safety factor and extra heat load such as TRT has to be considered.

# Cryogenic cooling schemes for interaction region

How to cool down SiD/ILD, QD0, QF1 and crab cavity?

- Plan-A : Single Cold Box
  - Detectors (SiD, ILD), Crab Cavity, QD0, QF1
    （ Cold box for detector and two distribution box is installed on 6F utility space. ）

  → Flexible type transfer tubes is required for push-pull operation
  - Limit minimum bending radius for TRT = several m?

- Plan-B : Three Cold Boxes
  - SiD and QD0 （Cold box is installed near the SiD.）
  - ILD and QD0 （Cold box is installed near the ILD.）
  - Crab Cavity, QF1 （Cold box is located at 6F utility Space.）

  → There is no need to use flexible type TRT.
  - Each cold boxes for SiD/ILD keeps pace with detector.

# Size and Spec of Cold Box for Each Plan

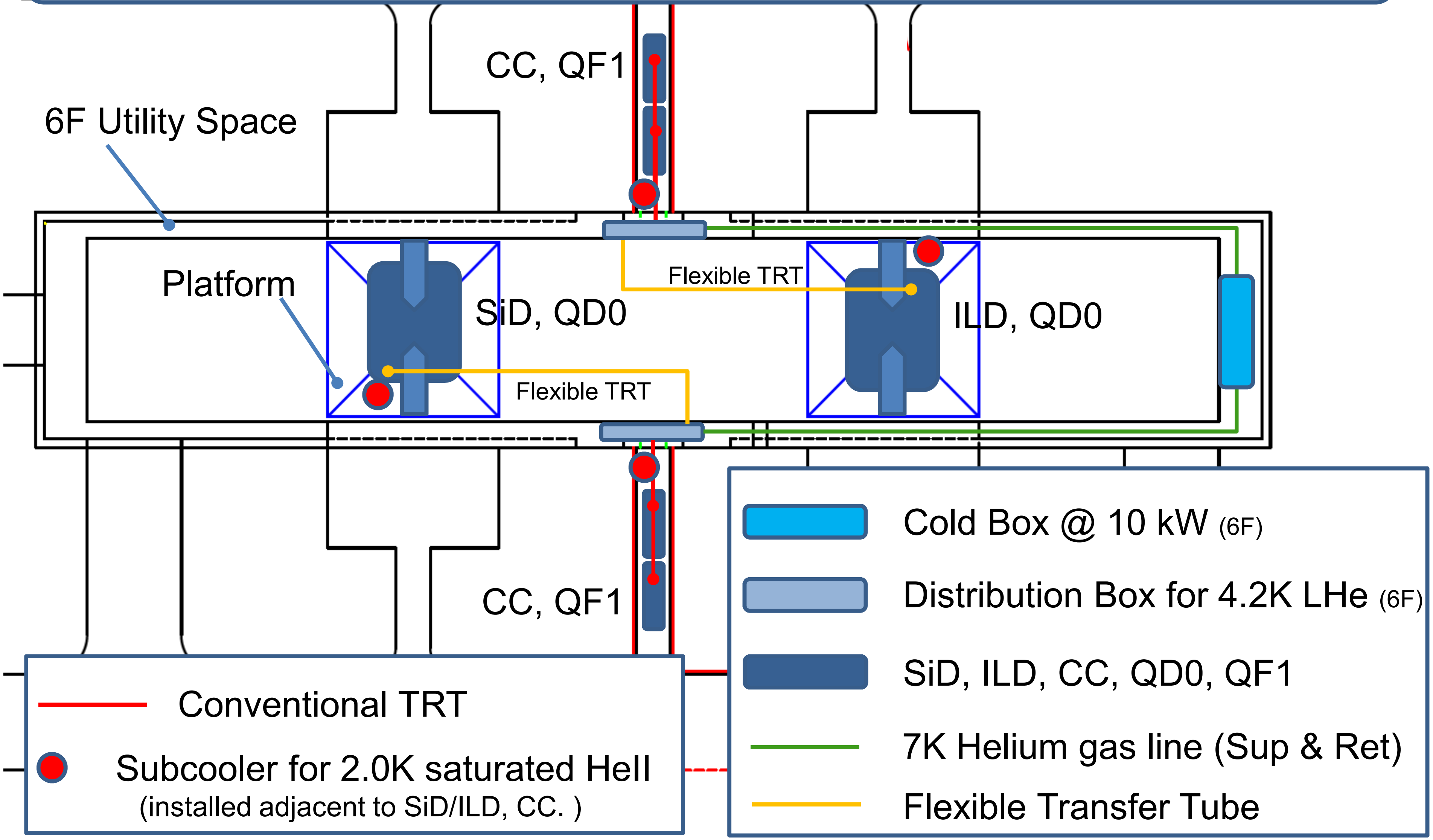
- Plan A : Size of cold box
  - Cooling capacity ~ 10 kW
  - Size ~ Diameter=5m, Length=11.3m, Height=6m

- Plan B : Cooling capacity
  - CB for SiD+QD0, 2.0 kW @4.2 K
  - CB for ILD+QD0, 2.0 kW @4.2 K
  - CB for QF1, Crab cavity, 2.0 kW @4.2 K
  - Size ~ Diameter=2m, Length=6m, Height=3.5m
  - Weight ~ 5 ton

Cooling capacity difference between each plan mainly depends on length of TRT.

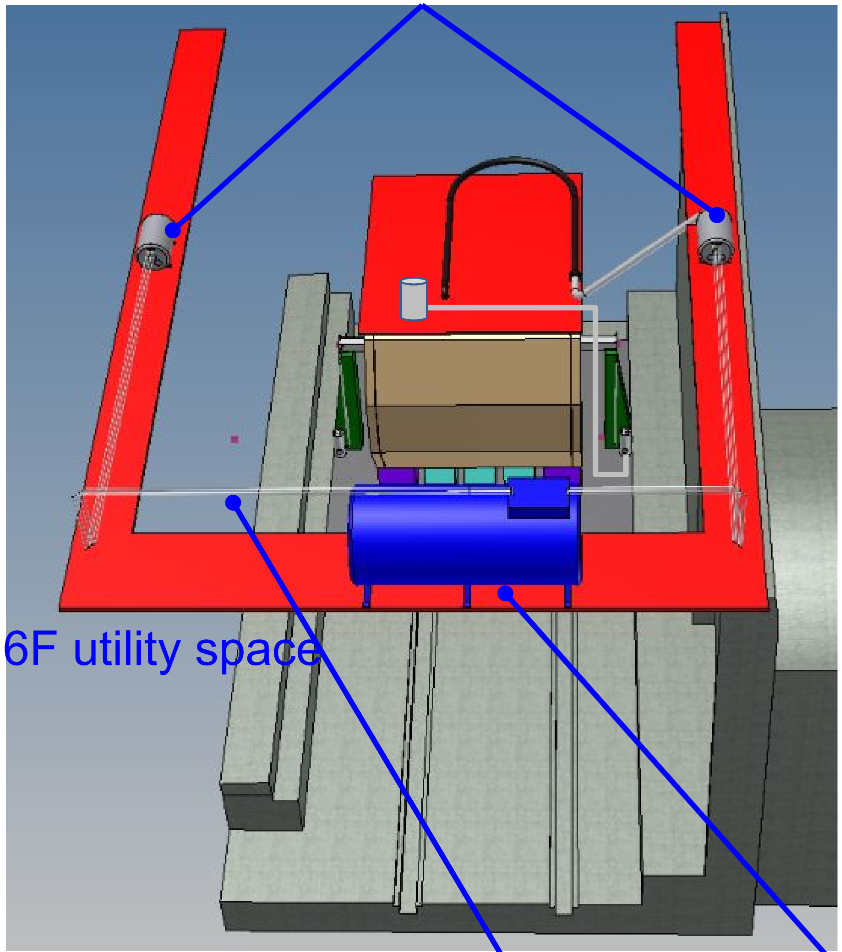
# Plan-A: Layout of cryogenic equipment

- ✓ Cold box and two distribution boxes are installed on 6F.
- ✓ It is essential to use flexible type TRT between distribution boxes and detectors.



# Schematic 3D view of Plan-A

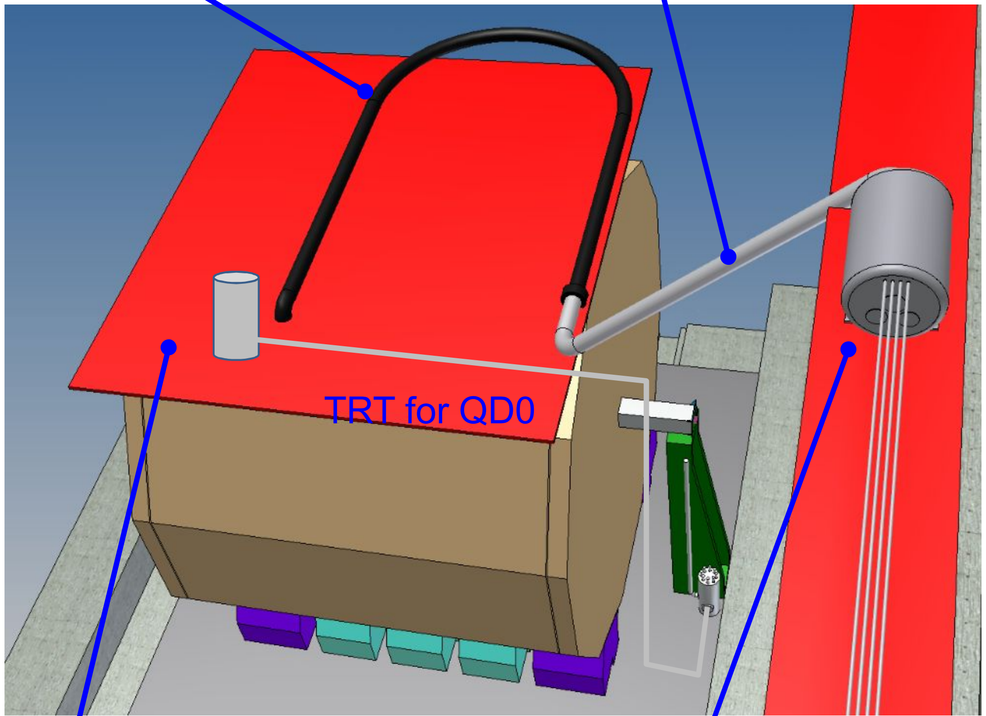
Distribution Box




7 K Helium gas line

Flexible type TRT

Transfer tube for SiD/ILD
OD=457.2mm




Platform in order to sustain flexible type transfer tube

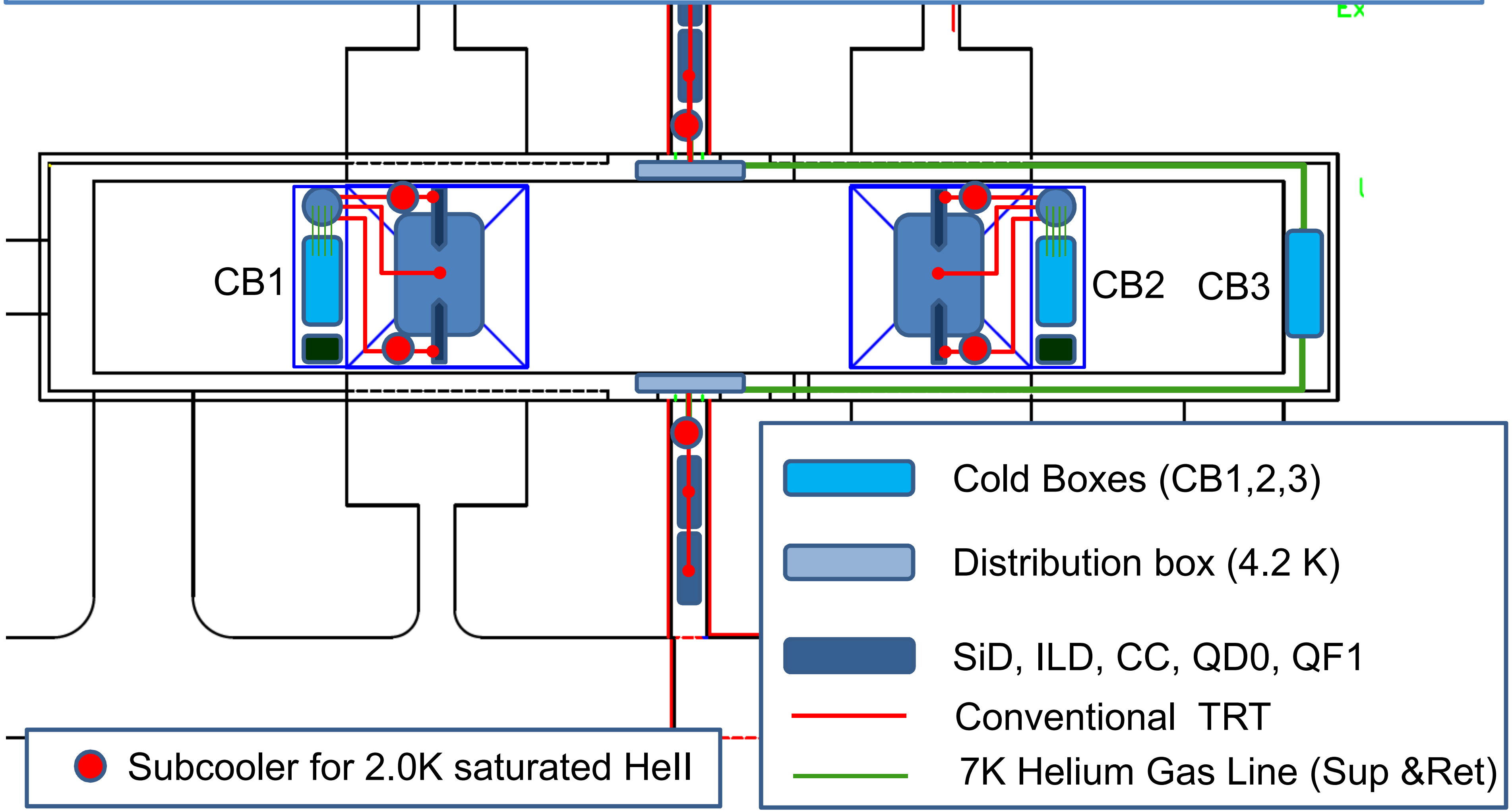
Distribution box
(4.2 K)

Cold box @ 10 kW
D=5m, H=6m, W=11.3 m

* This 3D view omits the TRT for CC and QF1.

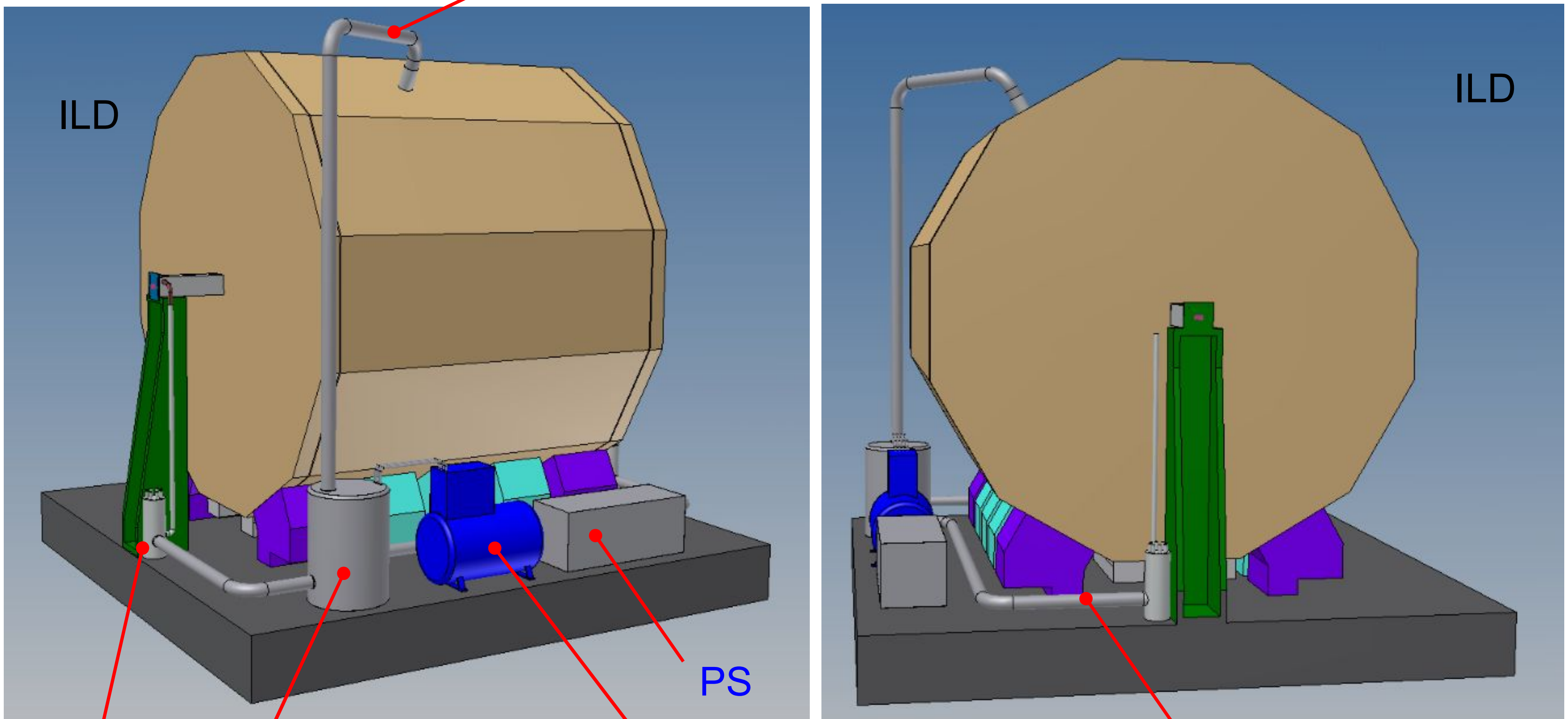
# Plan-B: Layout of cryogenic equipment

- ✓ CB3 and distribution box for CC and QF1 are installed on the 6F.
- ✓ CB1, 2, distribution boxes and PS are installed adjacent to SiD/ILD.
- ✓ It is necessary to use flexible tube for warm helium gas to supply cold box with helium gas from the common compressor.



# Schematic 3D view of Plan-B

Transfer tube for ILD @ two phase flow 4.5 K (OD=457.2mm)



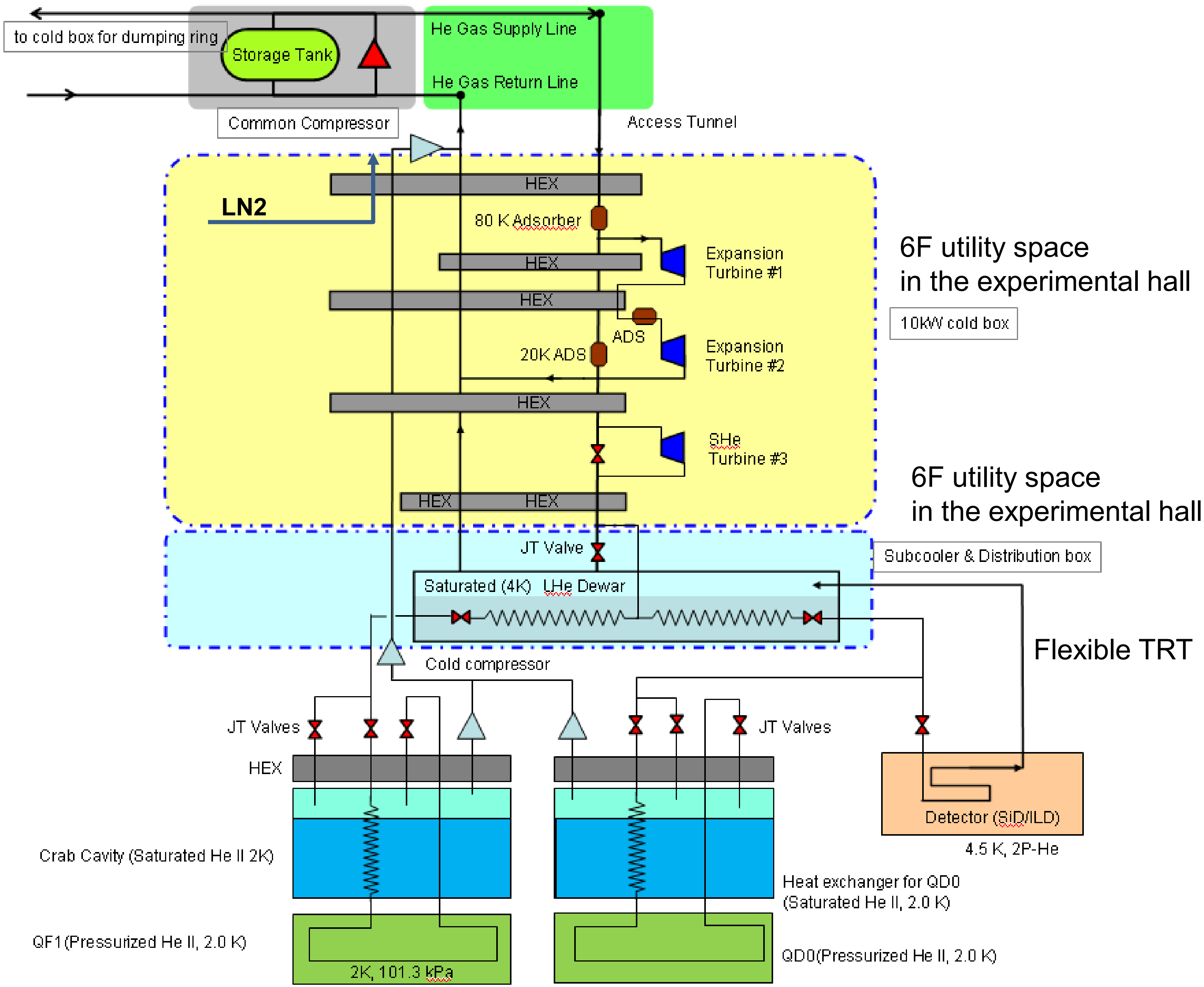

Transfer tube for QD0

Distribution box (4.5K)

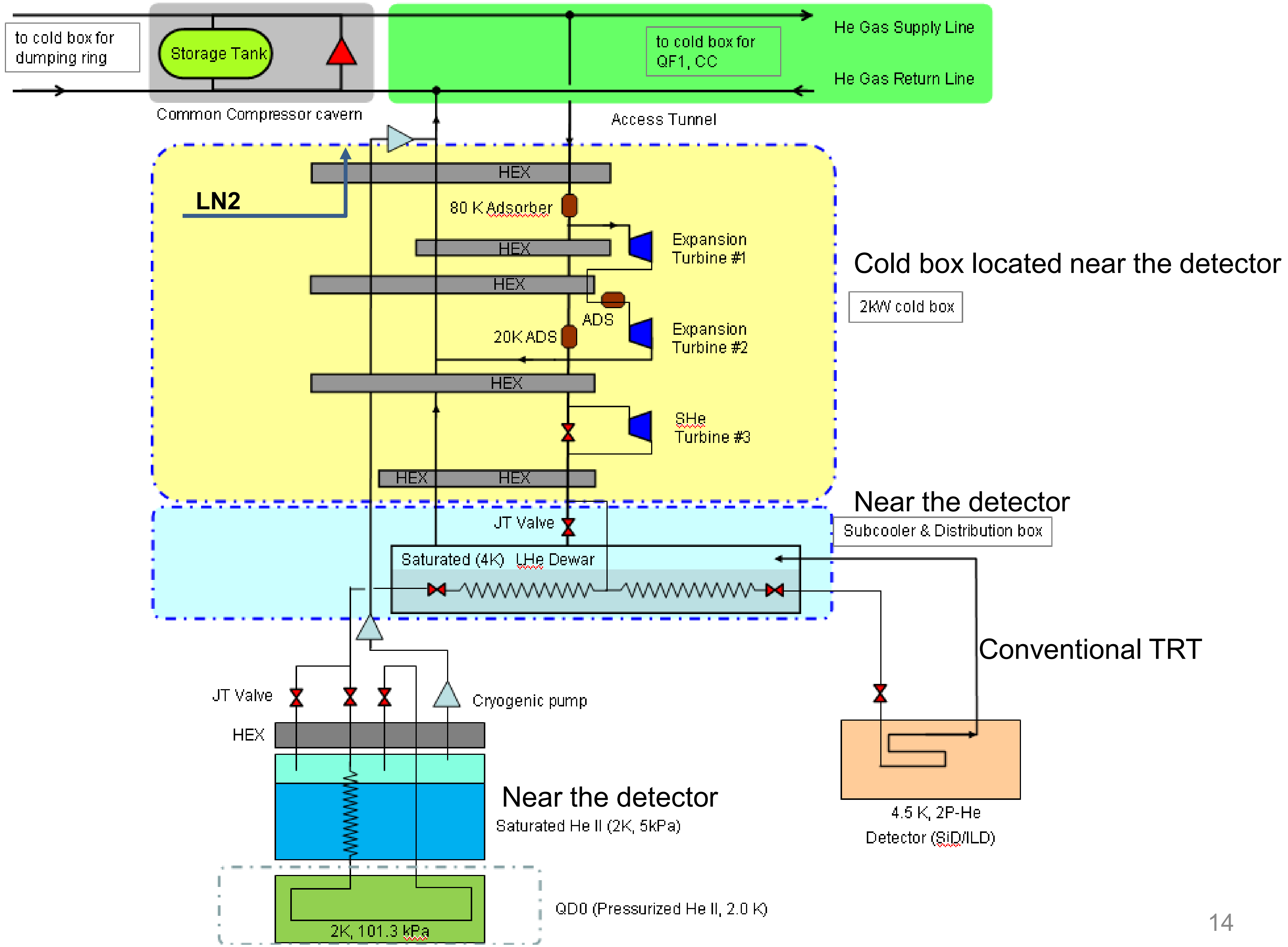
Subcooler for QD0 (2.0K)

Cold box @ 2.0 kW
D=2.0m, H=3.5m, W=6m
Weight=5 ton

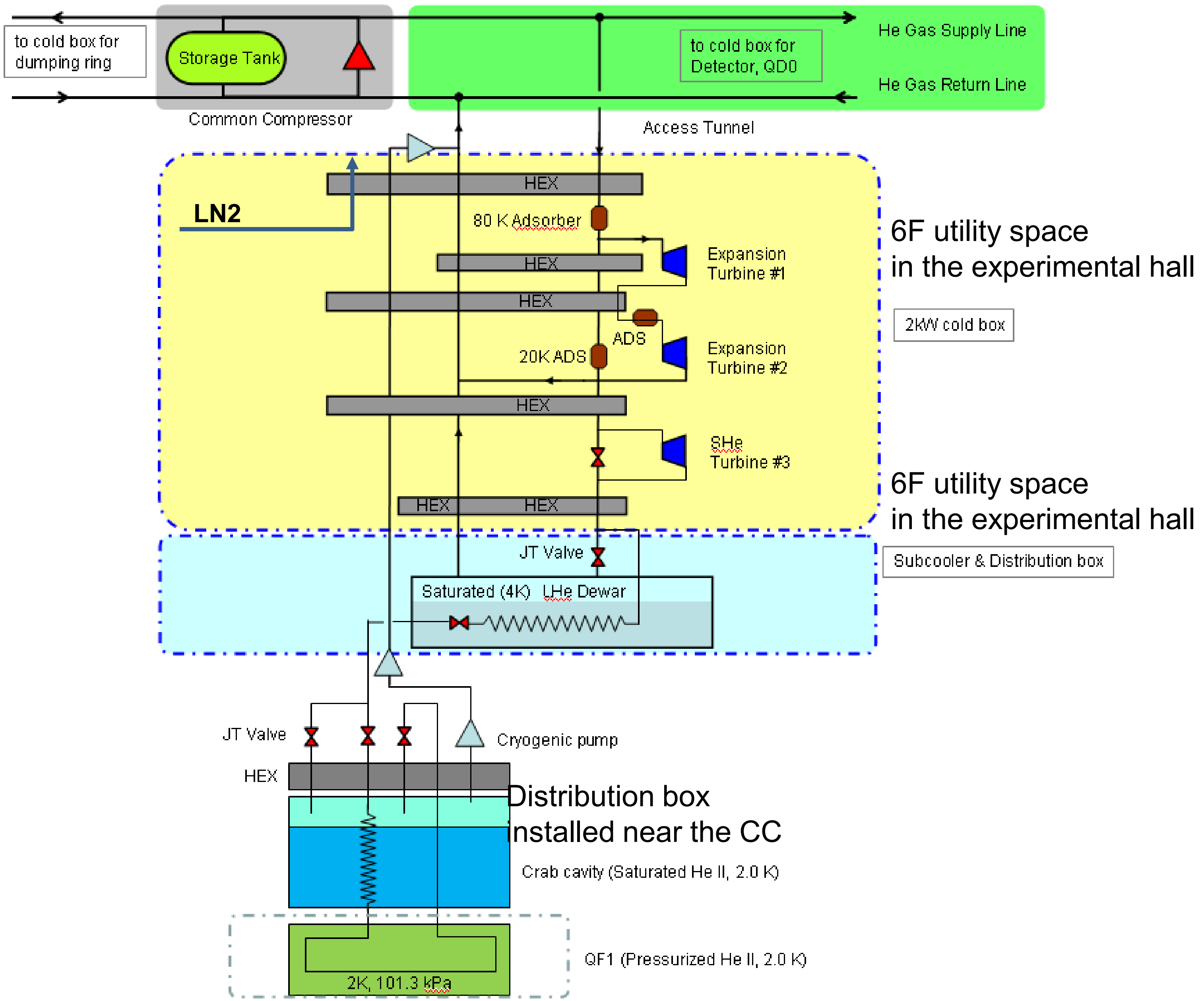
# Plan-A: Schematic Flow Diagram



# Plan-B: Schematic Flow Diagram for SiD/ILD,+QD0



# Plan-B: Schematic Flow Diagram for CC and QF1



# Advantage and Limitations for each plan

Plan-A

(advantage)

1. Maintenance and assembly of detector and cold box can be performed independently.
2. Maintenance of cold box is simple because control point and equipment such as valves are not so much.

(disadvantage)

3. ・Flexible Type TRT has to be applied between cold box and detectors (SiD/ILD, QD0).
   ・Minimum bending radius of flexible TRT will be quite large such as several meter. Large space for flexible TRT has to be required.
   ・Confliction with another equipment such as crane access will occur frequently.
4. Cooling capacity tends to become large compared with actual heat load depending on the situation. In such case, thermal balance has to be maintained by means of heater installed in the subcooler. It is hard to optimize cooling operation according to the cold mass condition.

Plan-B

(advantage)

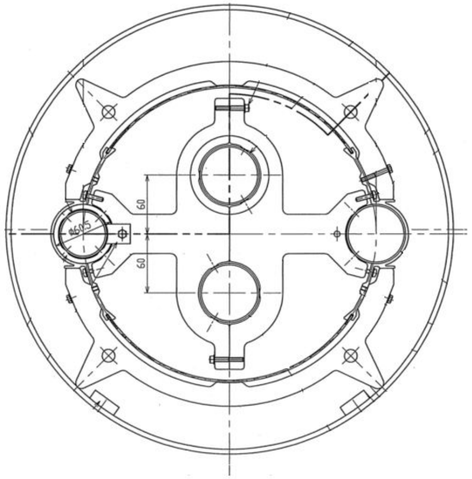
1. There is no need to use the flexible type TRT.
2. Cryogenic Control to keep steady state is quite simple because it is less control point of each refrigerator and cold box is independent of one another.
3. It is easy to perform cooling optimization and power saving operation depending on the situation.

(disadvantage)

1. Cost of control system becomes larger than that in the case of Plan-A. Failure frequency will be tendency to rise.
2. Confliction between cryogenic facility and detector will frequently occur during assembly and maintenance.

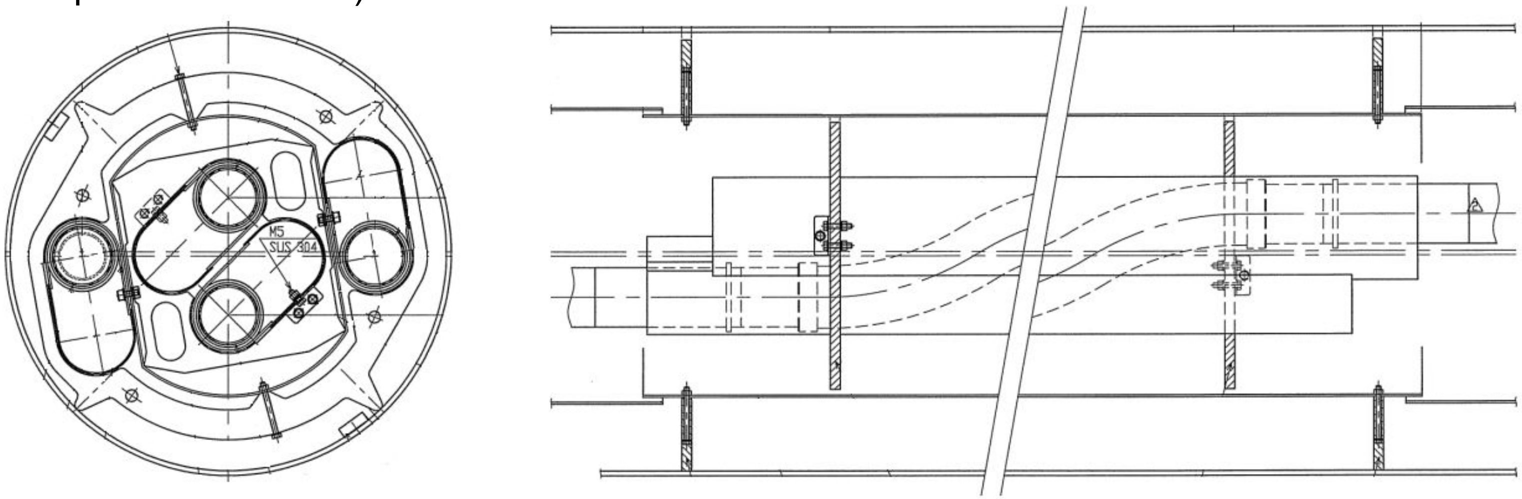
# Transfer tube example

## Conventional TRT



Cross section of TRT @ JPARC
(for supercritical helium)

## Flexible type TRT

Front and side view of compensation structure of thermal shrinkage.

Designed by N. Kimura, T. Okamura, T. Ogitsu

# Summary

- We propose two different cooling schemes (Plan-A and Plan-B).
- Flexible type which must be dynamically driven is disadvantage of Plan-A.
- Of cause, it is necessary to use flexible type tube for warm helium gas in the case of Plan-B. But it is not difficult because of ordinary simple tube and smaller bending limit.
- It is difficult to optimize performance of facility for example power saving mode in the case of Plan-A.
- From the view point of cryogenics and operation, Plan-B is more conventional and simple cooling scheme.