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

ILD Workshop

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Two cryogenic facility configurations for IR excluding dumping ring are proposed.

1. Cryogenic facility layout including dumping ring

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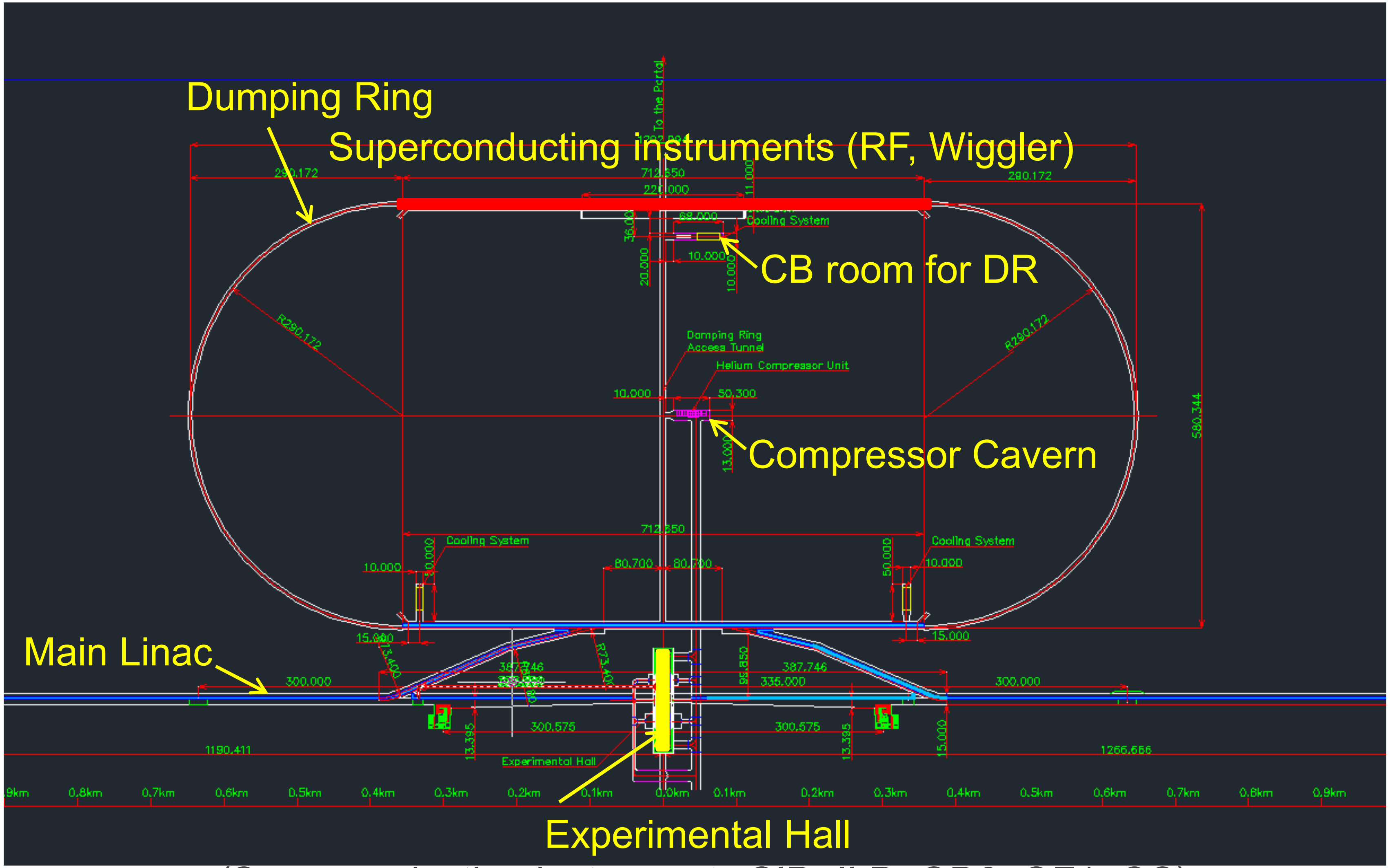
   - ✓ flow diagram
   - ✓ Advantage and disadvantage

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

4. Summary

Overall layout of Interaction Region

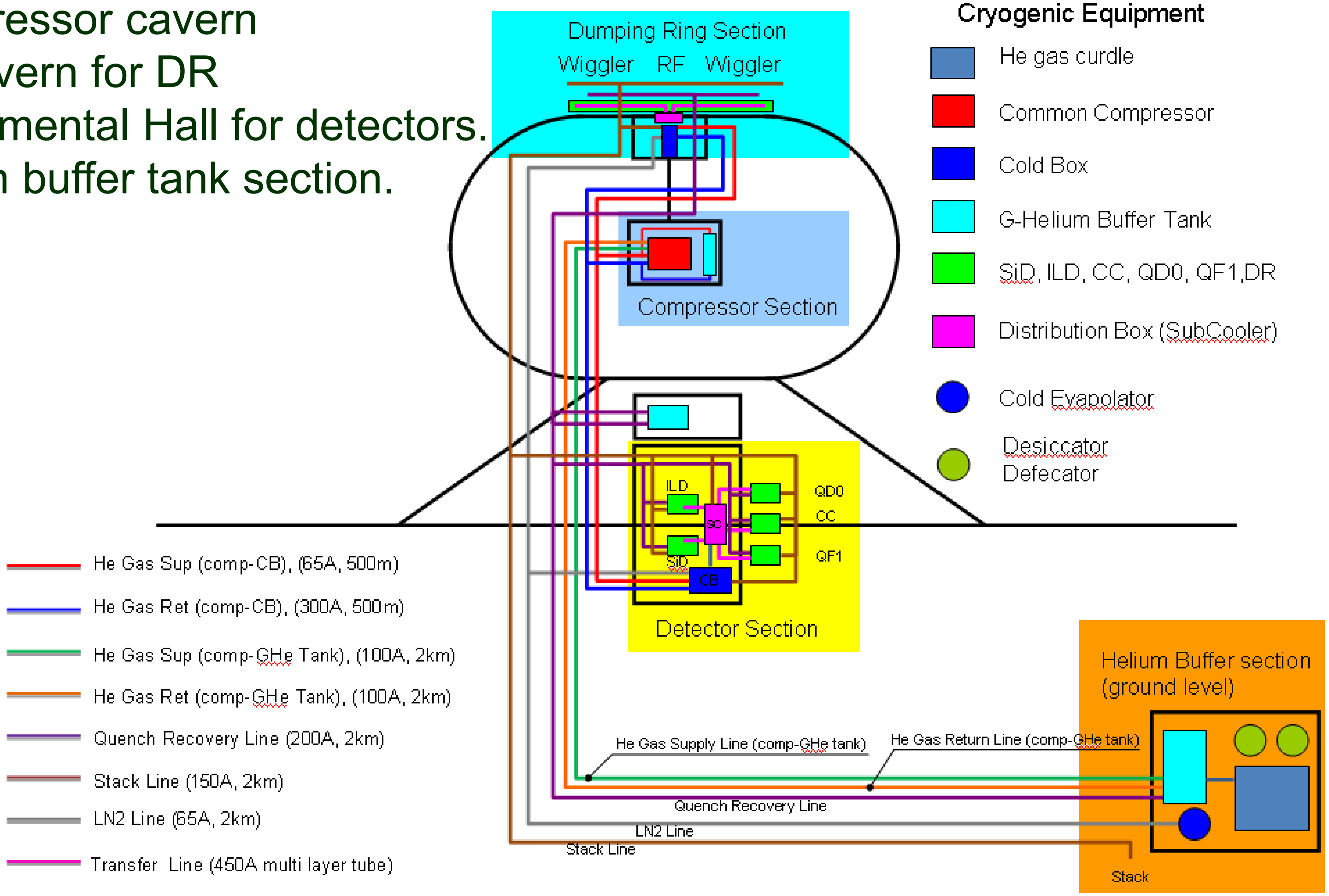


(Superconducting instruments SID, ILD, QD0, QF1, CC)

Cryogenic overall block diagram example

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

1. Compressor cavern
2. CB cavern for DR
3. Experimental Hall for detectors.
4. Helium buffer tank section.



Cryogenic system for experimental hall (SiD, ILD, CC, QD0, QF1)
excluding dumping ring will be introduced.

Equipment installed in each region

Compressor section (Compressor cavern)

- All Compressors for detectors, QD0, QF1, CC and DR
- Helium Buffer tank (in order to control pressure fluctuation) ~ Volume ~ 100 m^3

Discussion Item

Experimental Hall

- **Superconducting instruments (SiD, ILD, QD0, QF1, CC) are installed.**
- **Cold Box (Single or more cold box? → Discussion Item)**
- **Subcooler for Liquid Helium and Superfluid Helium (Distribution Box)**
- **Liquid Nitrogen Equipment for precooling**

Dumping Ring section

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

Helium gas buffer tank section

- Helium buffer storage tank for magnet quench
- 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 determine 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 is installed on 6F utility space. ）

  → Flexible type transfer tubes for push-pull operation
    ･Limit minimum bending radius for TRT

- Plan-B : Three Cold Boxes (CB1, CB2, CB3)
  - CB1= SiD and QD0 （Cold box is installed on the platform for SiD.）
  - CB2= ILD and QD0 （Cold box is installed on the platform for ILD.）
  - CB3= CC and QF1 （Cold box is located at 6F utility Space.）

  → Conventional type transfer tube

Size and Spec of Cold Box for Each Plan

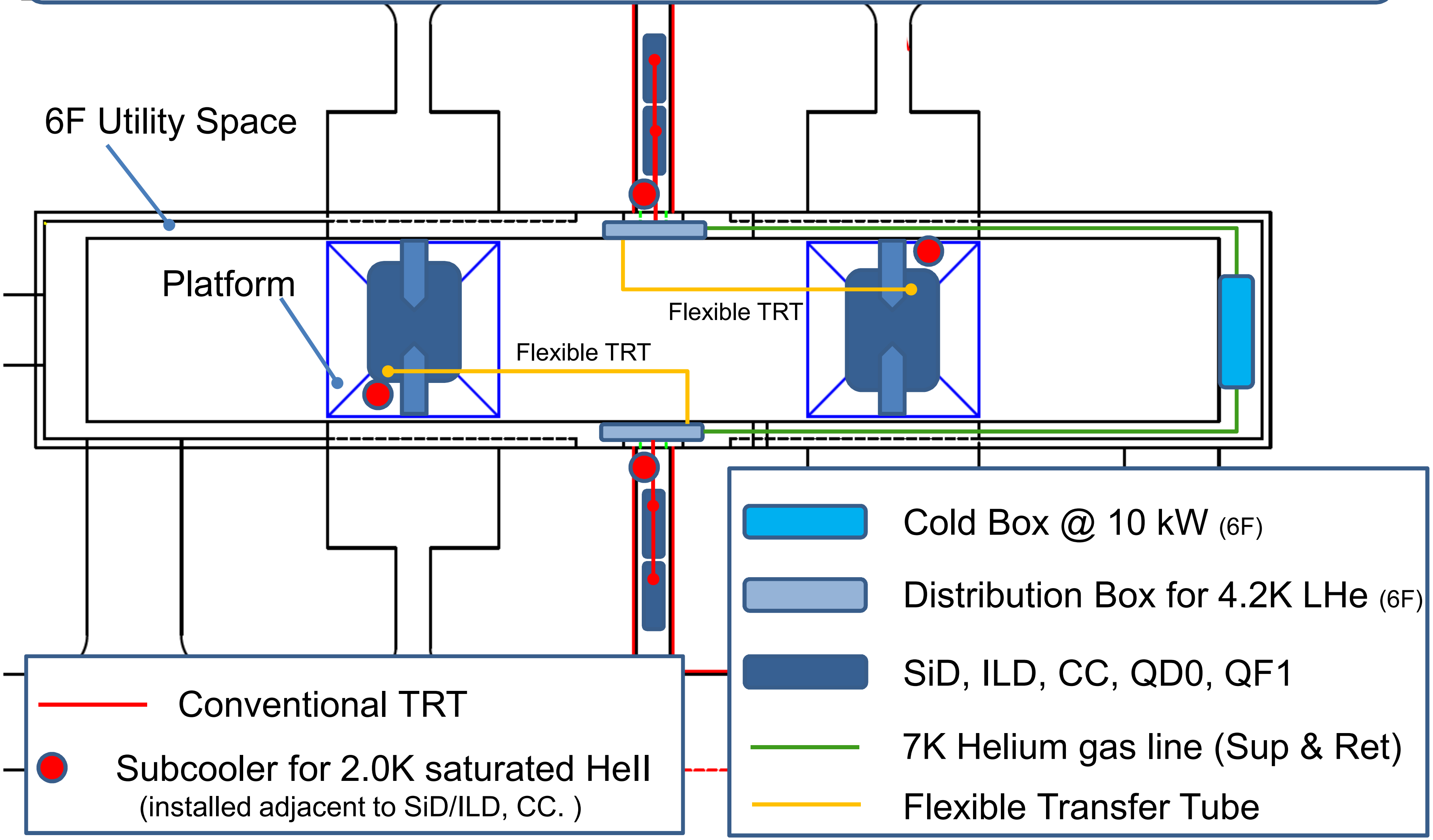
- Plan A :
    - Cooling capacity ~ 10 kW
    - Size ~ Diameter=3m, Length=10m, Height=4m

- Plan B :
    - 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=6.7m, Height=3m

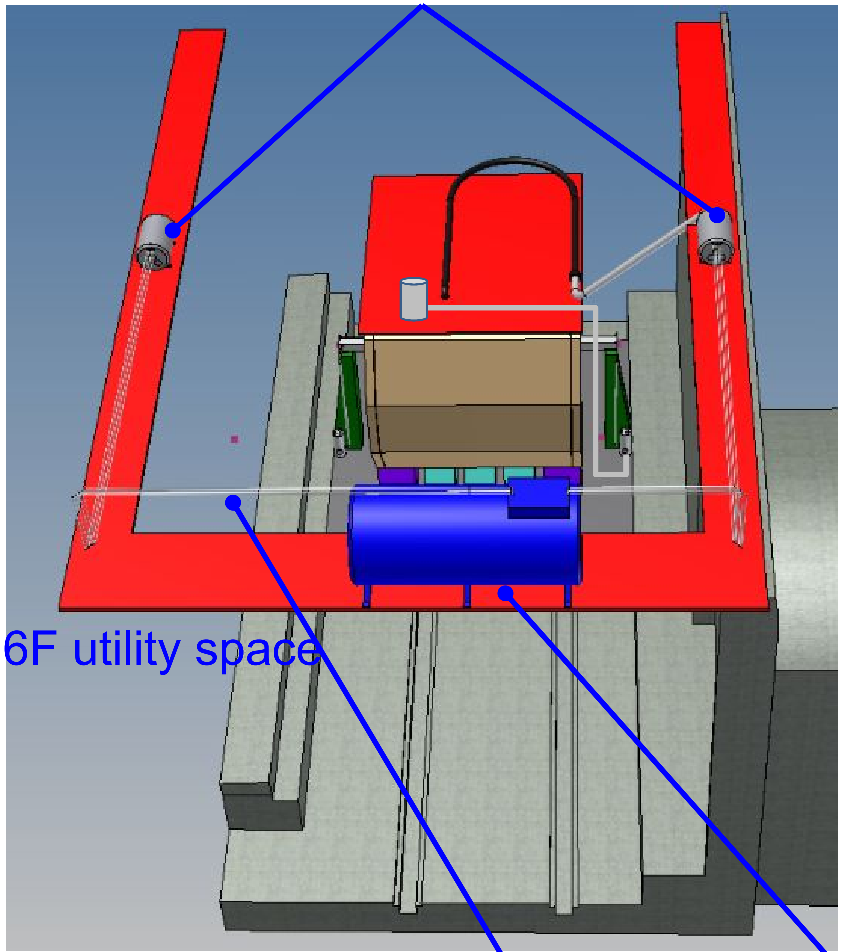
Cooling capacity difference between each plan mainly depends on the influences of cryogenic instruments such as TRT, distribution box etc .

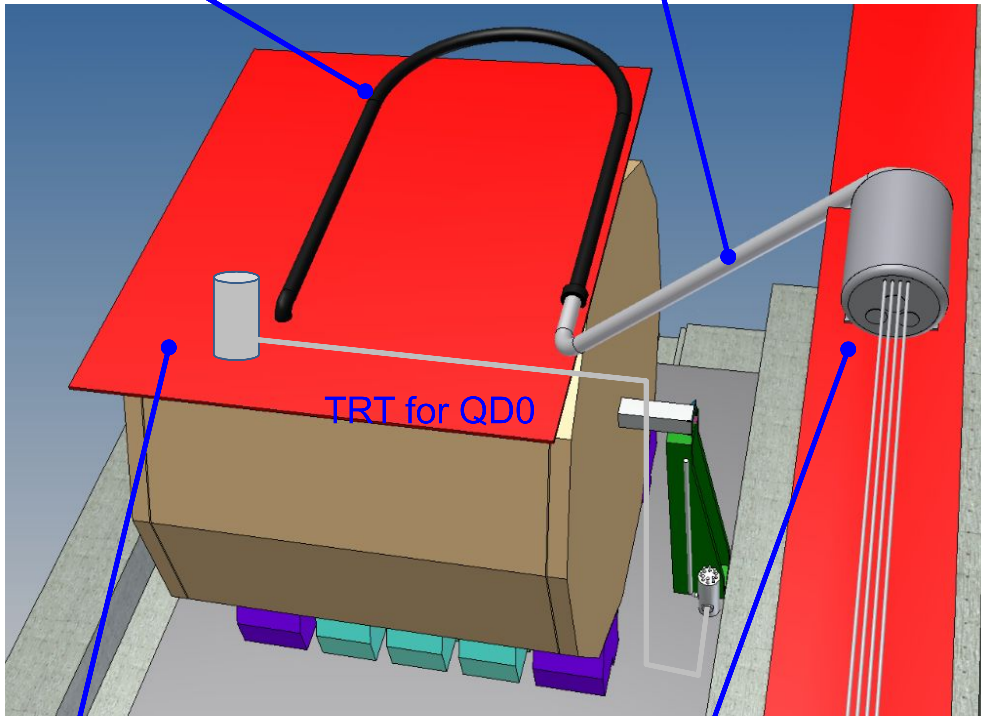
Cryogenic Layout in the experimental Hall (Plan-A)

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



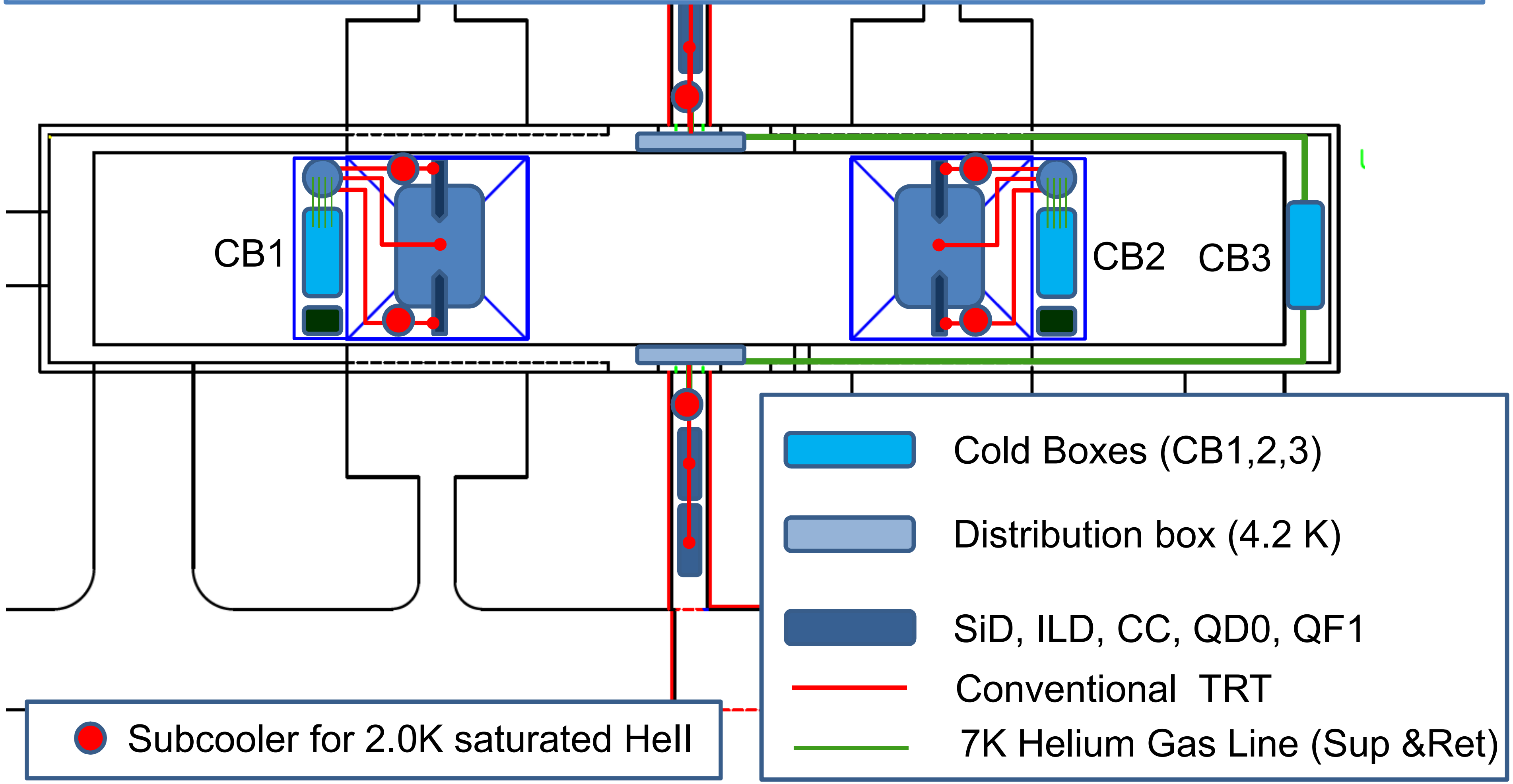
Schematic 3D view of Plan-A



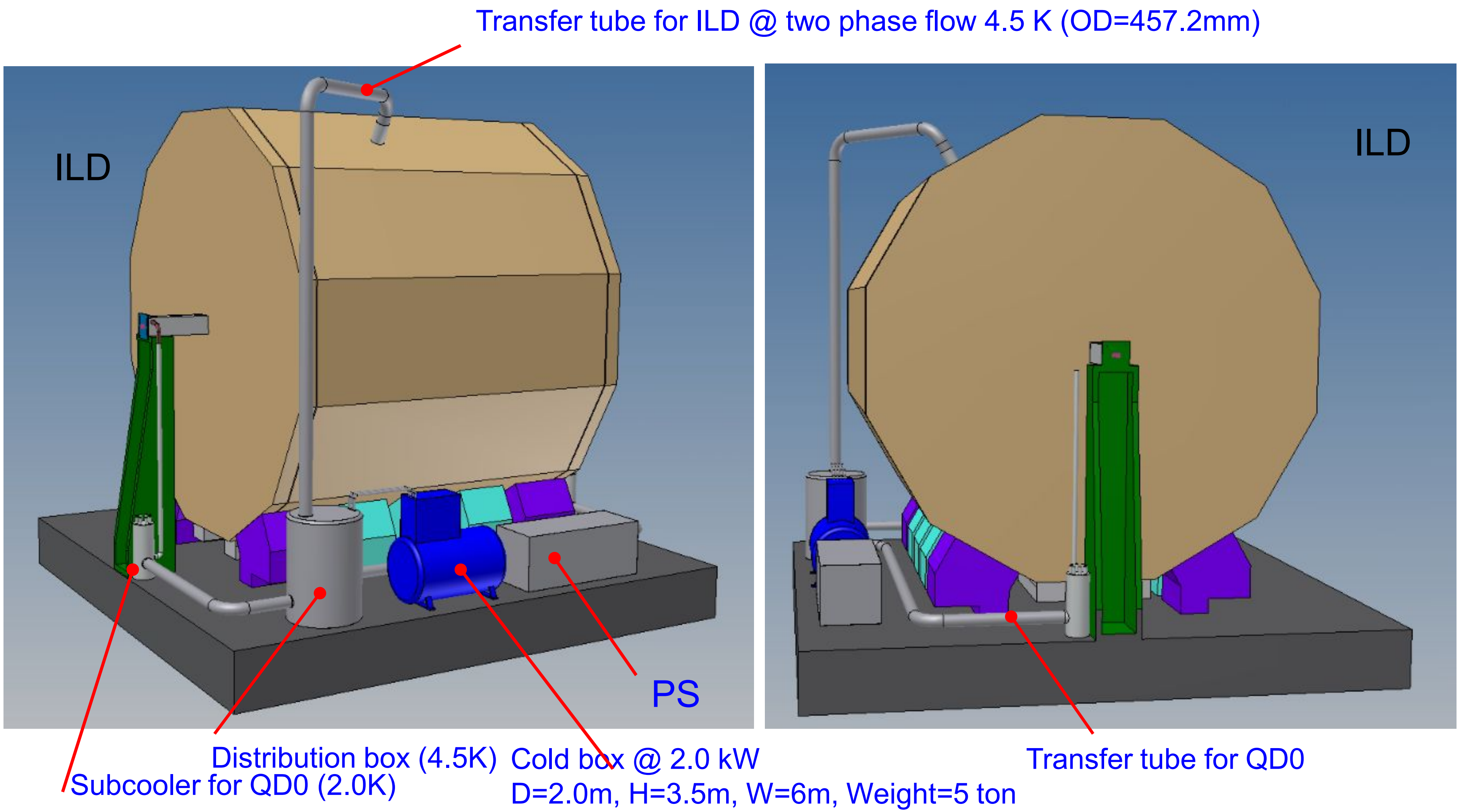


Cryogenic Layout in the experimental hall (Plan-B)

- ✓ CB3 and distribution boxes for CC and QF1 are installed on the 6F.
- ✓ CB1, 2, distribution boxes and PSs are installed on the each platform for detector
- ✓ Flexible tubes for helium gas at 300K are used between each cold box for detectors and common compressor.
- ✓ Minimum bending radius of the flexible tube for 300K He gas is at most 0.7 m.



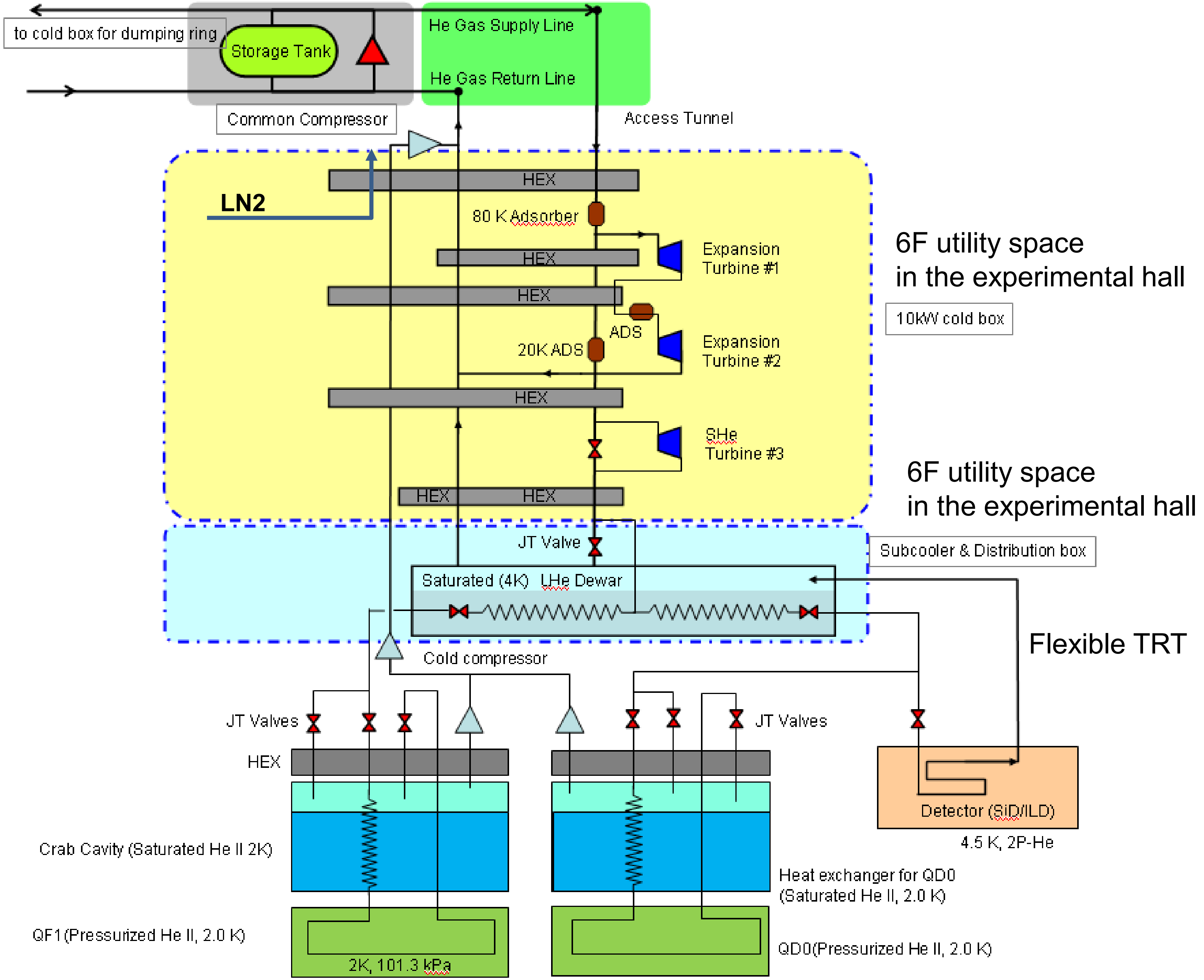
Schematic 3D view of Plan-B



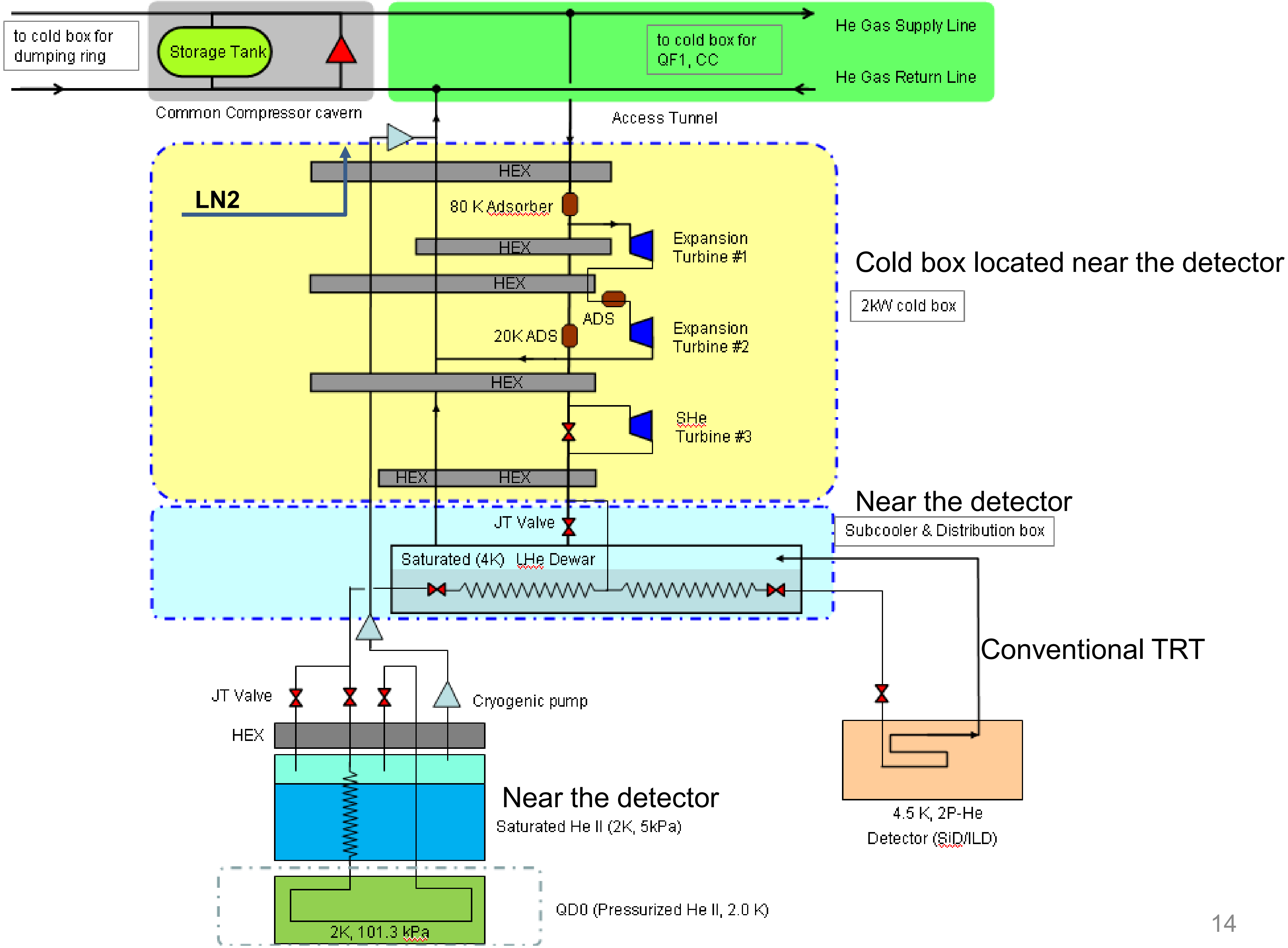
Vibration Reduction Method

- Optimization of support post for QD0 by means of modal analysis
- Application of high vibration reduction material such as D2052 etc.

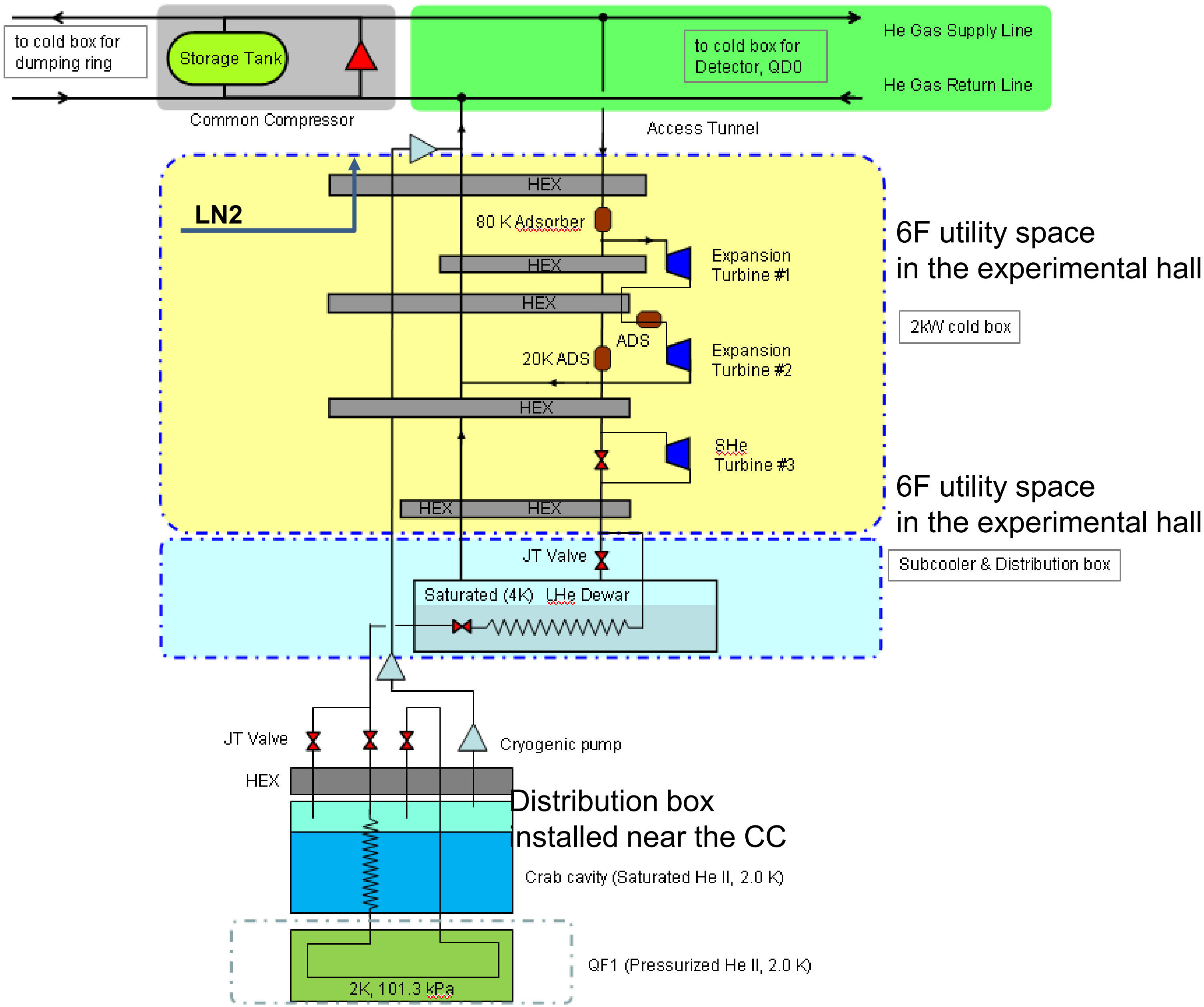
Plan-A: Schematic Flow Diagram



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 tend to be large. Large space for flexible TRT has to be required.
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.

Plan-B

(advantage)

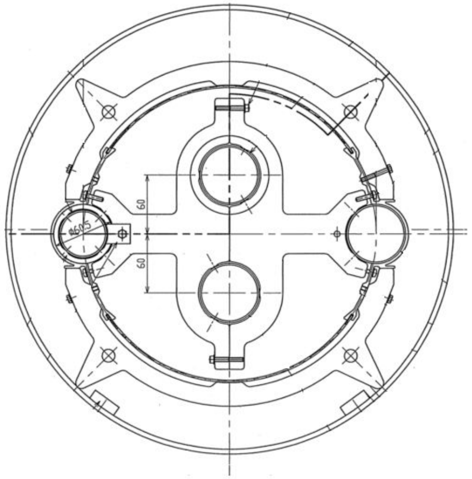
1. There is no need to use the flexible type TRT.
2. Cryogenic Control to keep steady state is quite simple because it is less control point of each refrigerator and cold box is independent of one another.
3. It is easy to perform cooling optimization and power saving operation depending on the situation.

(disadvantage)

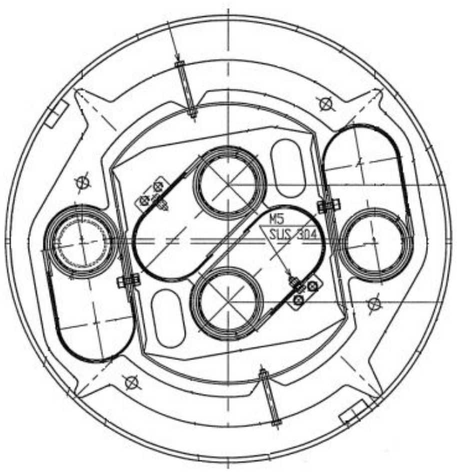
1. Cost of control system becomes larger than that in the case of Plan-A. Failure frequency will be tendency to rise.
2. Confliction between cryogenic facility and detector will frequently occur during assembly and maintenance.

Transfer Tube Example
(Designed by KEK Cryogenic Science Center)

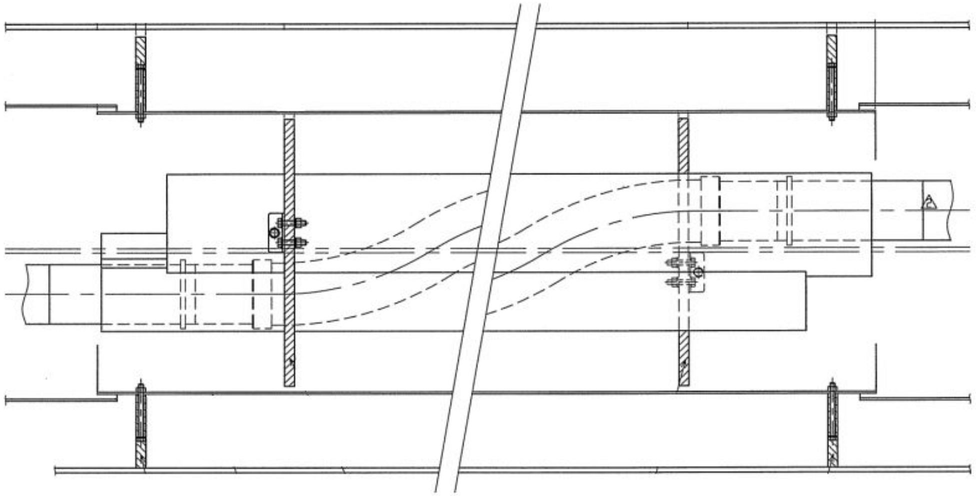
Conventional TRT



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

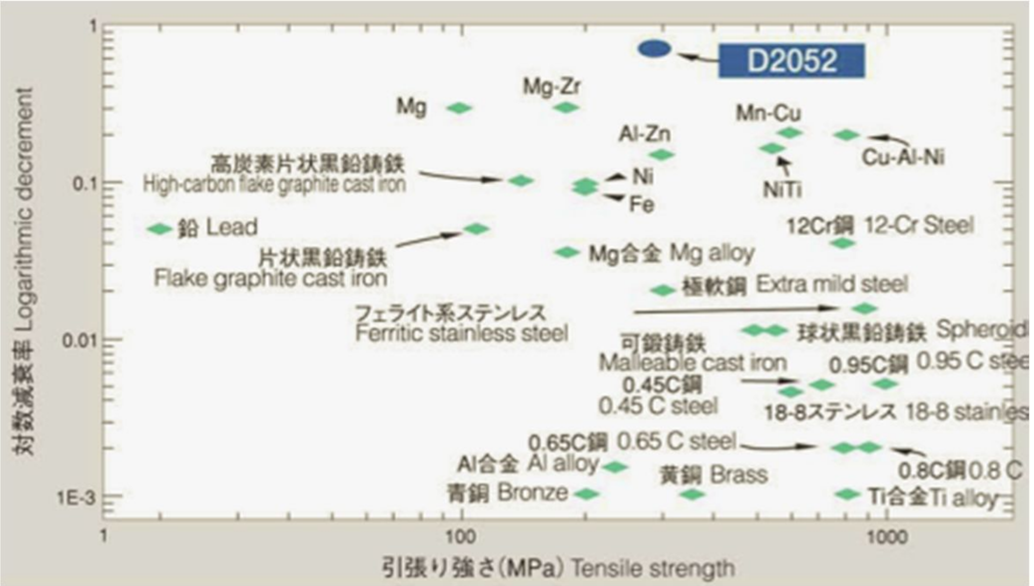
Summary

- We propose two different cooling schemes (Plan-A and Plan-B).
- Flexible type TRT 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.

Homework for Cryogenics in the Japanese Mountain Site

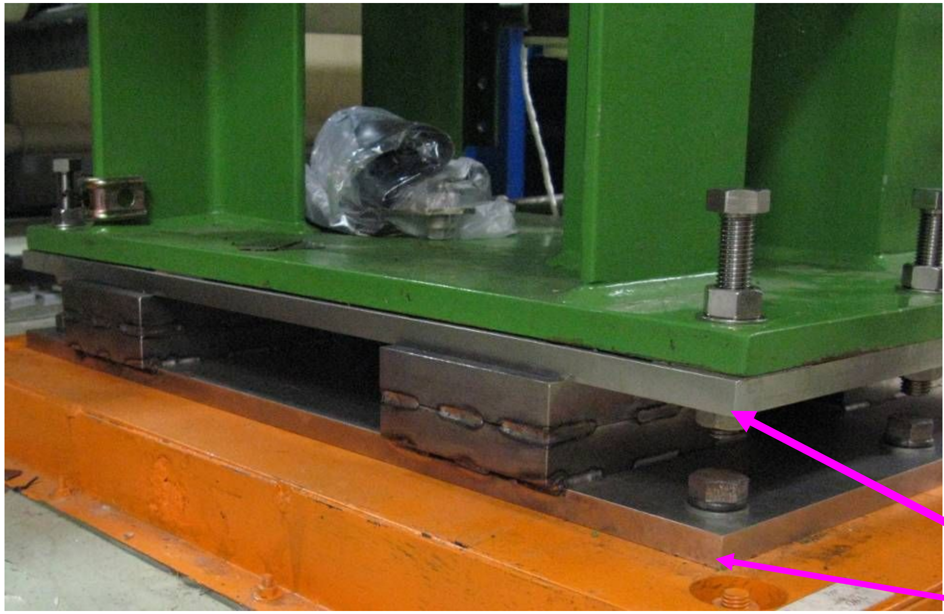
- Helium gas storage method in the Japanese mountain site
- The location of the common compressor cavern for detectors and dumping ring from the view point of utilities especially cooling water in the Japanese mountain site. This is strongly dependent on the site.
- Utilities such as cogenerator etc. for emergency.
- Modal analysis including QD0, detector, cryogenic instruments and vibration of platform in order to find a best way to support the QD0 by combination of high vibration reduction material.

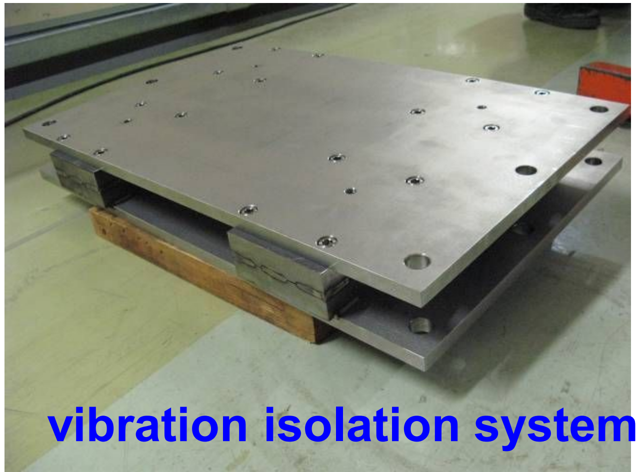
Vibration Adsorption Example



Vibration adsorber

Several vibration absorption boards are installed between top and bottom of the stainless steel boards.

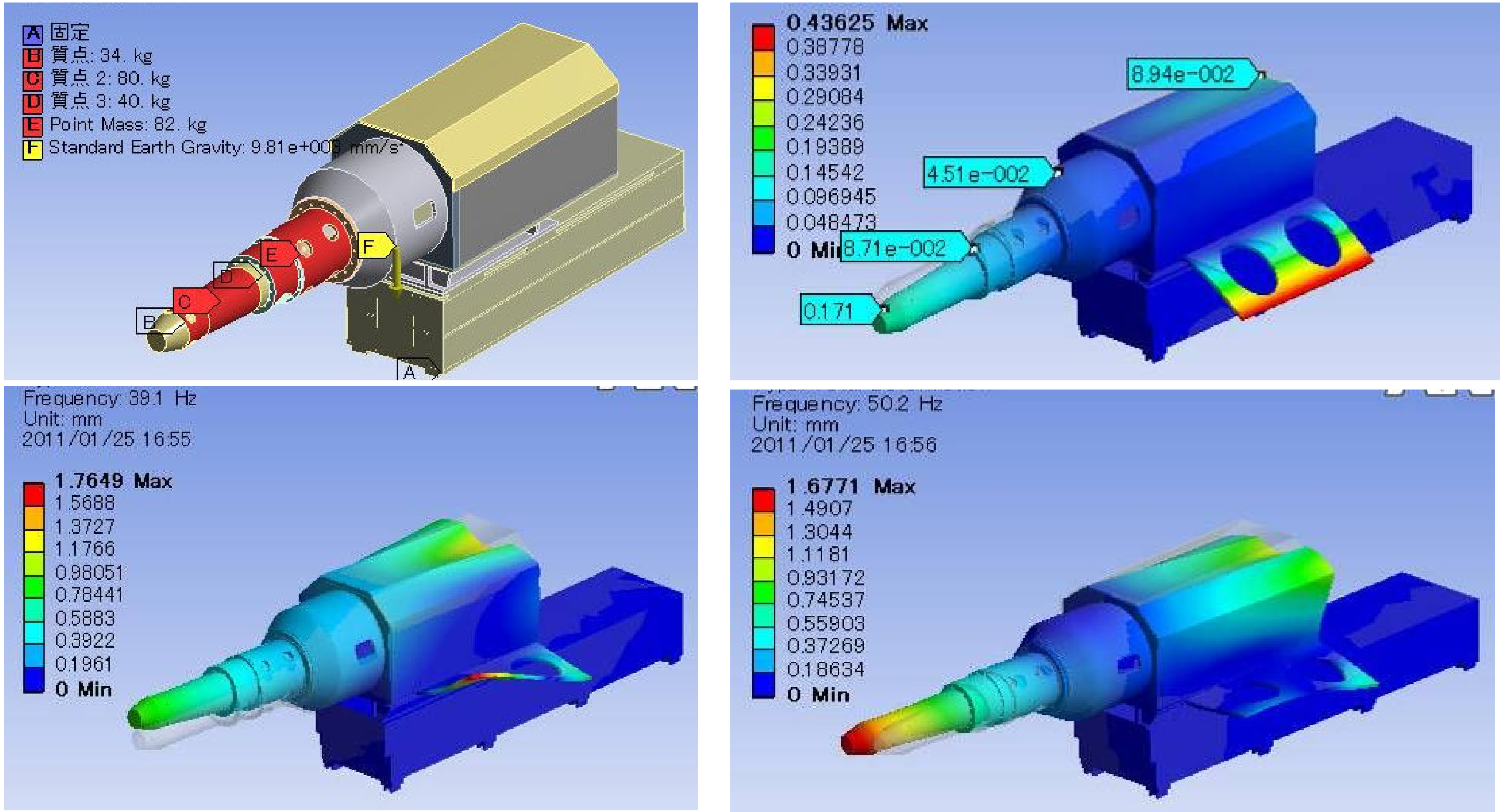




vibration isolation system

Stainless Steel Base

Modal Analysis Example



Instrument Example to measure the vibration

Performed by H. Yamaoka

In order to measure vibration for three orthogonal directions.
Three **laser displacement meters**, LV-9300A
(range,100 micrometers; resolution, 3 nm; frequency range, DC-100 kHz),