Cryogenic System of ILC IR

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KEK/IPNS/Cryo

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Contents

Overview of cryogenic system for IR

Scheme Decided

Following superconducting magnets are controlled by cryogenic system located in IR.

- **ILD + 2QD0s** ⇒ Dedicated CB(#1) and Comp(#1)
- **SiD + 2QD0s** ⇒ Dedicated CB(#2) and Comp(#2)
- **QF1s and CCs** ⇒ Dedicated CB(#3) and Comp(#3)

Brief specification on above system were already decided.

Undetermined Item

Followings are not decided so far[a].

- **DR**,⇒ Dedicated CB(#3) and Comp(#3)
- BDS Cryo (superfluid He II)[b]

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[a] **DR superconducting magnets** should be involved in IR cryogenic system. Practical specification on CB etc. have never been decided.

[b] BDS had better be cooled down by using cryogenic system which is a part of ML cryogenics. Or dedicated 2K and 4K CB for BDS had better be installed near the BDS.

Cryo Configuration (ILD,SID,QD0,QF1,CC,DR)

Hybrid A' (All pipes for Helium and cooling water.)

cooling tower for IR compressors including DR.
volume flow rate = 1500L/min per 1 comp.
total volume flow rate = 6000 L/min (4 comps)

sub buffer tanks for comp

main buffer tank

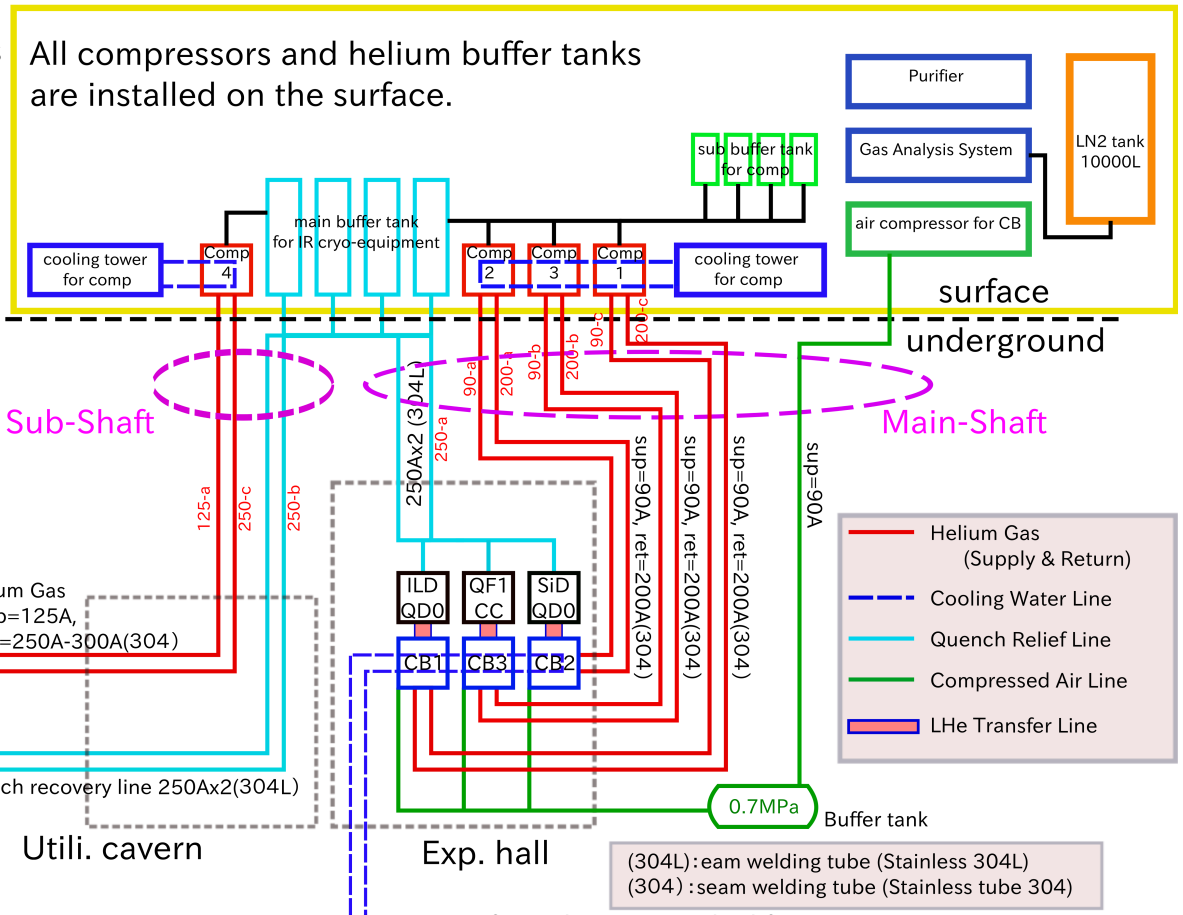
cooling towers

superconducting magnets (ILD, SiD, QD0)

CB

Comp

sub buffer for DR quench



cooling water for turbine is supplied from cooling water system located in the underground
100L/min per one CB.
Inlet temp = 31 deg.

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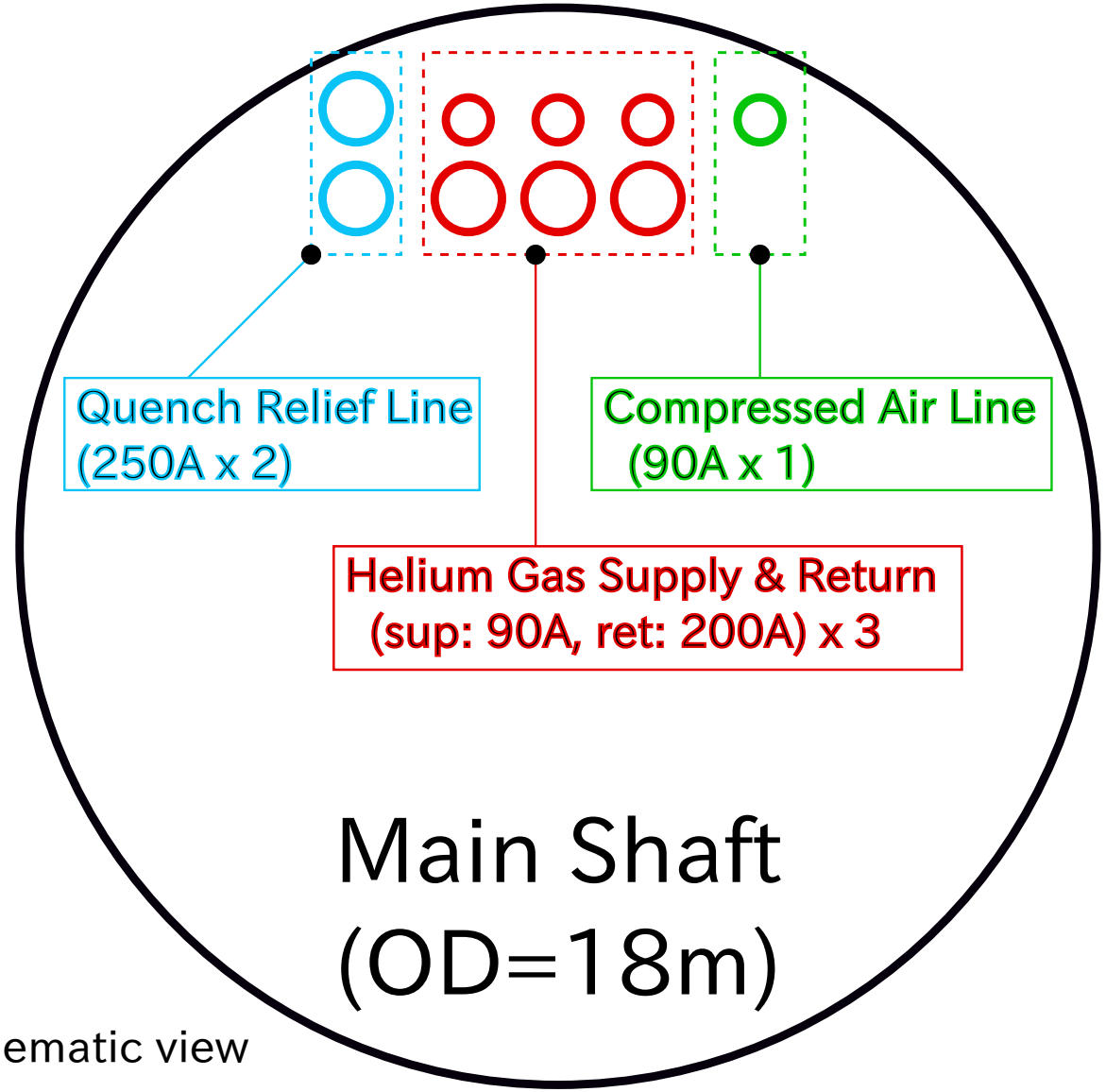
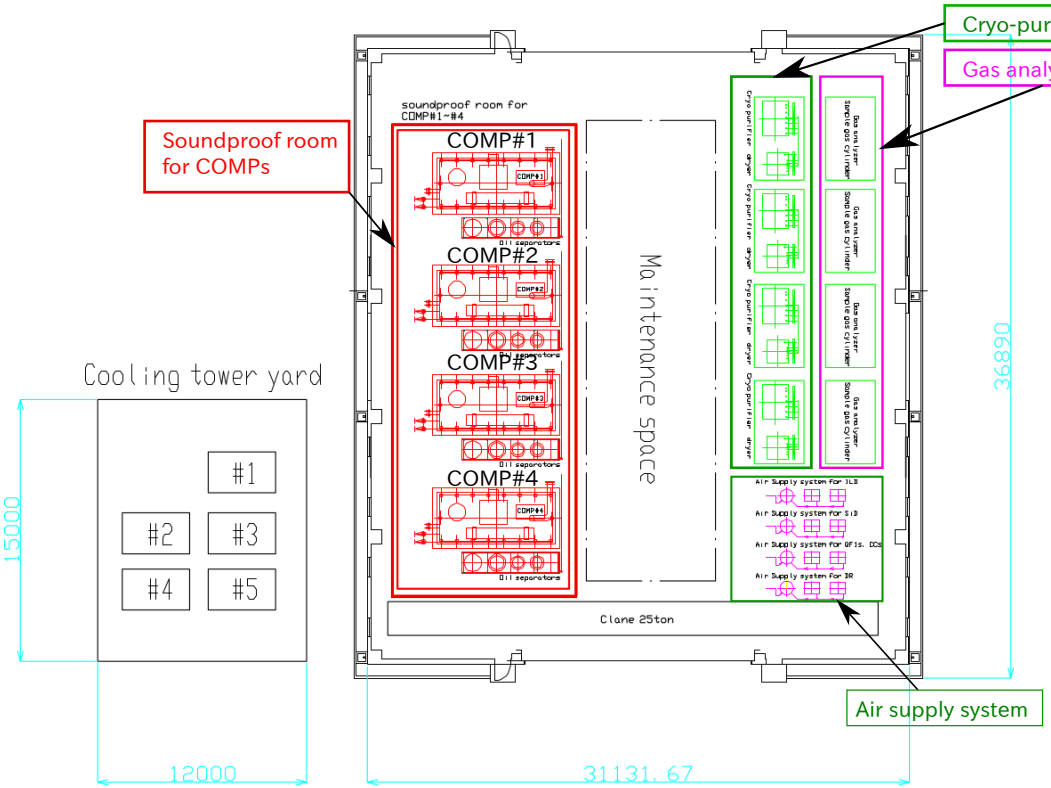
Pipes passed through MS



schematic view

Compressor house (layout example)



Compressor: main specification

COMP #1 : for ILD+QDOs (500 kW)
COMP #2 : for SiD+QDOs (500 kW)
COMP #3 : for QF1s, CCs (300 kW)
COMP #4 : for DR (600 kW?)

Total Cooling water for each compressor

COMP #1 : 1700 L/min (cooling tower #1
COMP #2 : 1700 L/min (cooling tower #2
COMP #3 : 1000 L/min (cooling tower #3
COMP #4 : 2000 L/min (cooling tower #4

Cooling tower #5 is for other equipmen

- 4 helium compressors (in the soundproof room).
- Air supply system, cryo-purifier, dryer and gas analyzer.
- 25 ton crane for installation and maintenance.
- Total ventilation capacity of 40000 m^3/hour.[a]

[a] 40000m^3 is obtained from Japanese High Pressure gas regulation.

Helium Compressor

Helium compressor

- 4 compressors are installed on the surface (in a compressor house).
- Mechanical noise have to be reduced.
  - Bare intensity of mechanical noise is around 100 dB in the case of MYCOM.
  - Noise intensity can be reduced to 70 dB by employing soundproof house (example of J-PARC neutrino cryo-system).
- Required amount of cooling water (after cooler and oil cooler) for 4 compressors are described below.

COMP. No.	Cryo equipment	Shaft Power	Cooling Water
Comp1	ILD+QD0s	~ 500 kW	~ 1700 L/min
Comp2	SiD+QD0s	~ 500 kW	~ 1700 L/min
Comp3	QF1s & CCs	~ 300 kW	~ 1000 L/min
Comp4	DR(RFs & Wigglers)	~ 600 kW	~ 2000 L/min

Necessity of liquid nitrogen tank

♠ **In the underground**

- Liquid nitrogen should not be employed from the view point of safety.

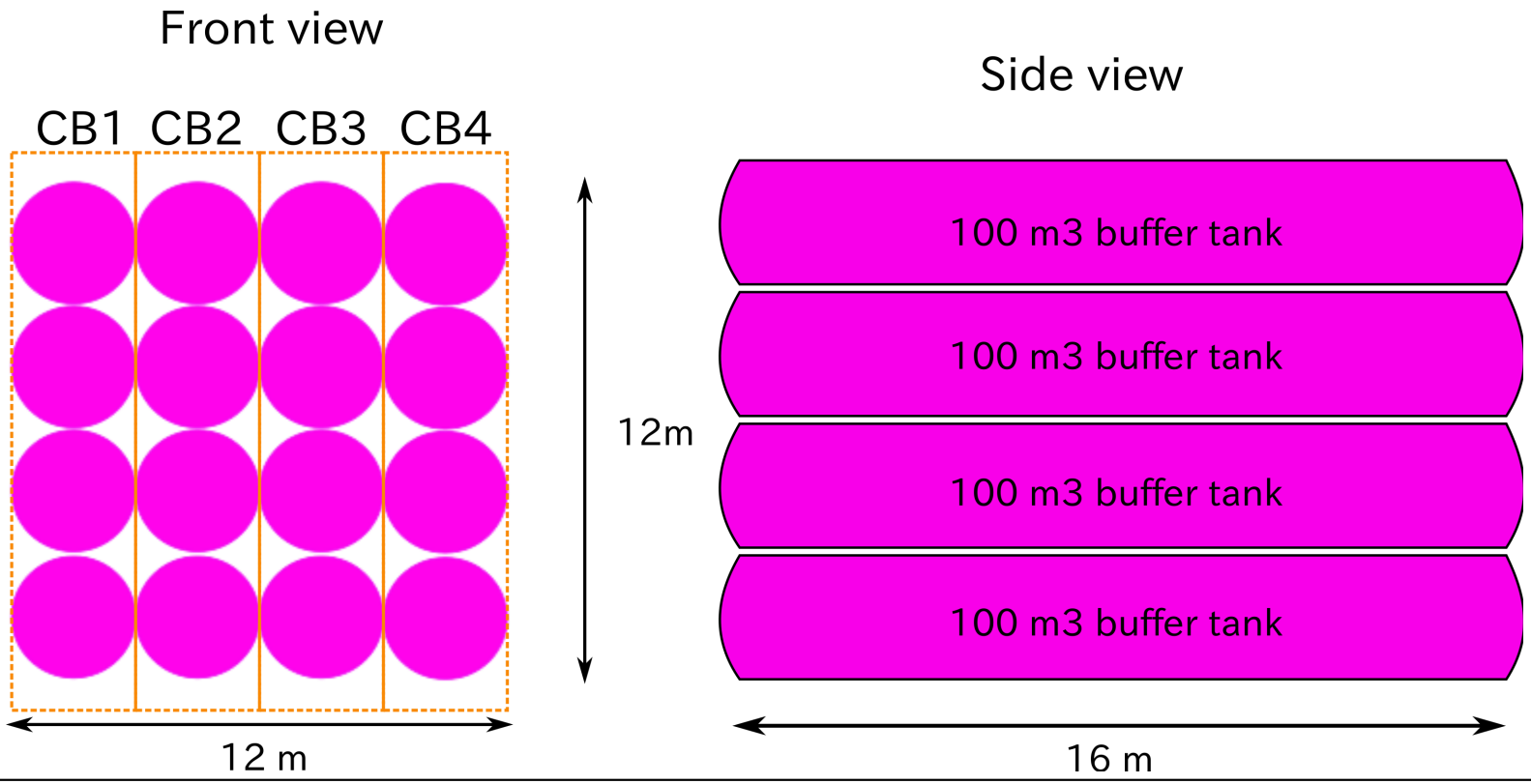
♠ **On the surface**

- Liquid nitrogen should be employed following two operation.
  1. cryo-purifier
     ⇒ Gas analyzer and cryo-purifier are also installed in the compressor house.
  2. charcoal and MS baking process [a] during maintenance season.
     ⇒ LN2 Evaporator also should be prepared in this case.

[a] Charcoal and MS (each vessel volume is $\sim$ OD=1.5m, height=3.5m) should be employed for oil separator.

Liquid nitrogen tank with the size of $\sim$ 10000 L had better be employed proximity to comp. house.

Helium buffer tank yard

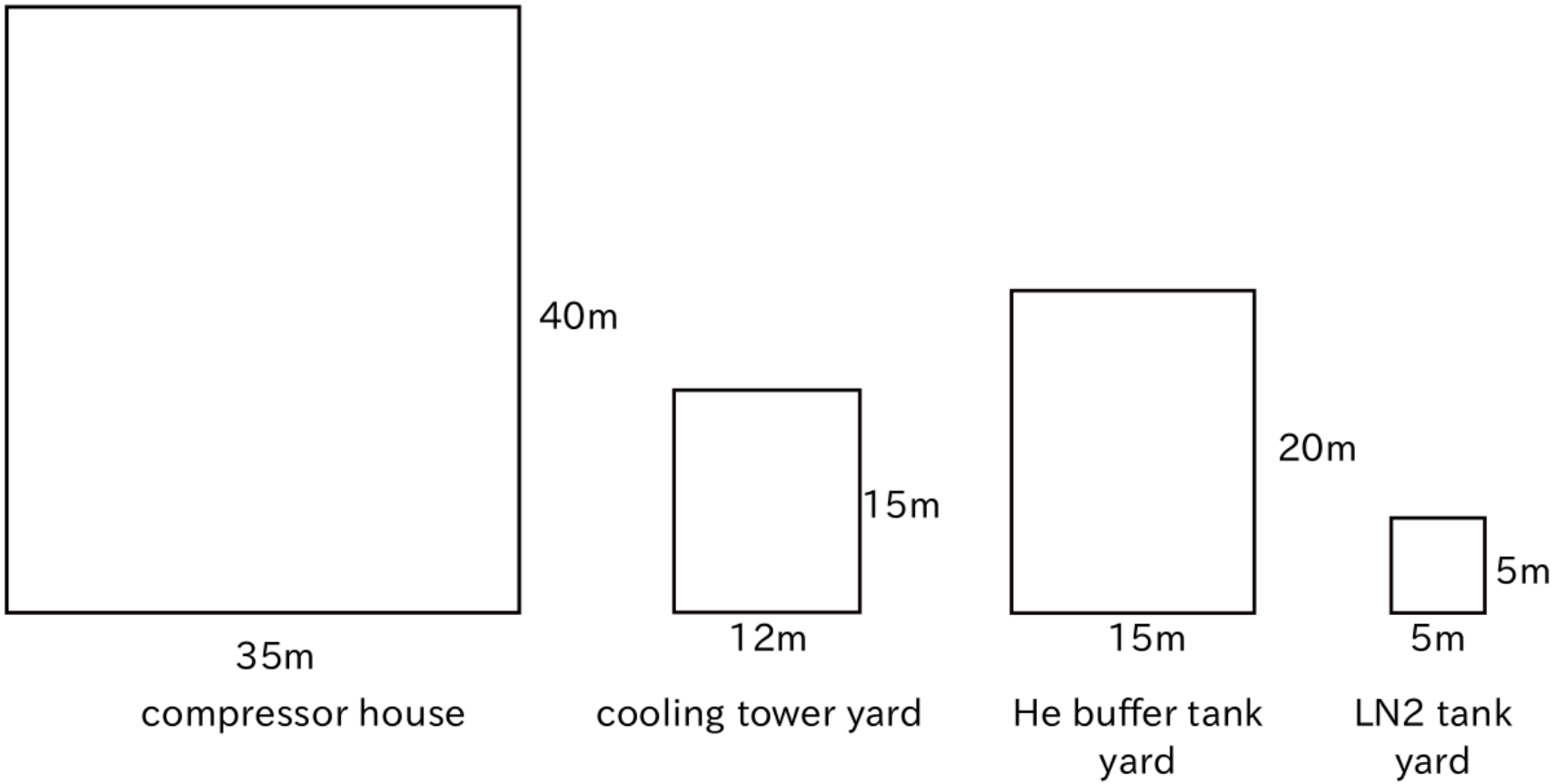


Total volume $\sim$ 1600 m^3, Allowable pressure$\sim$ 2.0 MPa

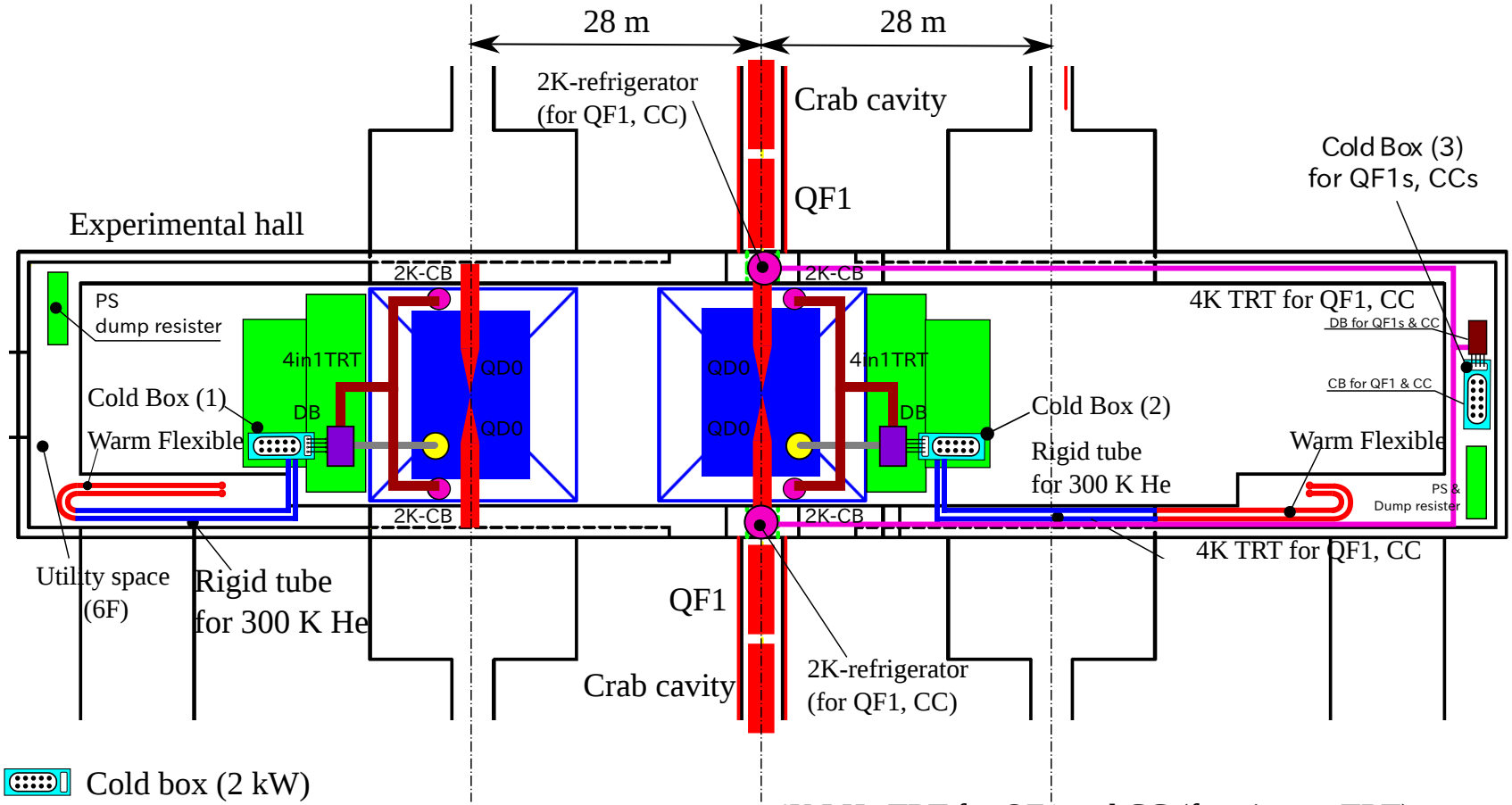
- ILD : 400 m^3
- SiD : 400 m^3
- QF1,CC,DR : 800 m^3

Summary on surface area

Summary on surface are for IR cryogenics



Layout example in DH (ILD,SiD,QD0,QF1,CC)

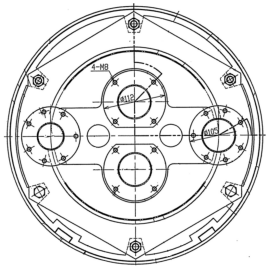


- Cold box (2 kW)
- 2K refrigerator for QF1 and CC
- 4K distribution box
- 2K refrigerator for QD0
- Chimney and current lead box for detector
- Power supply for detector and QD0

- 4K LHe TRT for QF1 and CC (four in one TRT)
- Fixed 300K Helium gas line (supply and return)
- Fixed TRT for 4.2 K liquid helium (Four in one)
- Fixed TRT for superfluid helium (2K, 4K 70K shield).
- Flexible 300 K helium gas line (supply and return)----
- Bus bar for detector between PS and chimney.

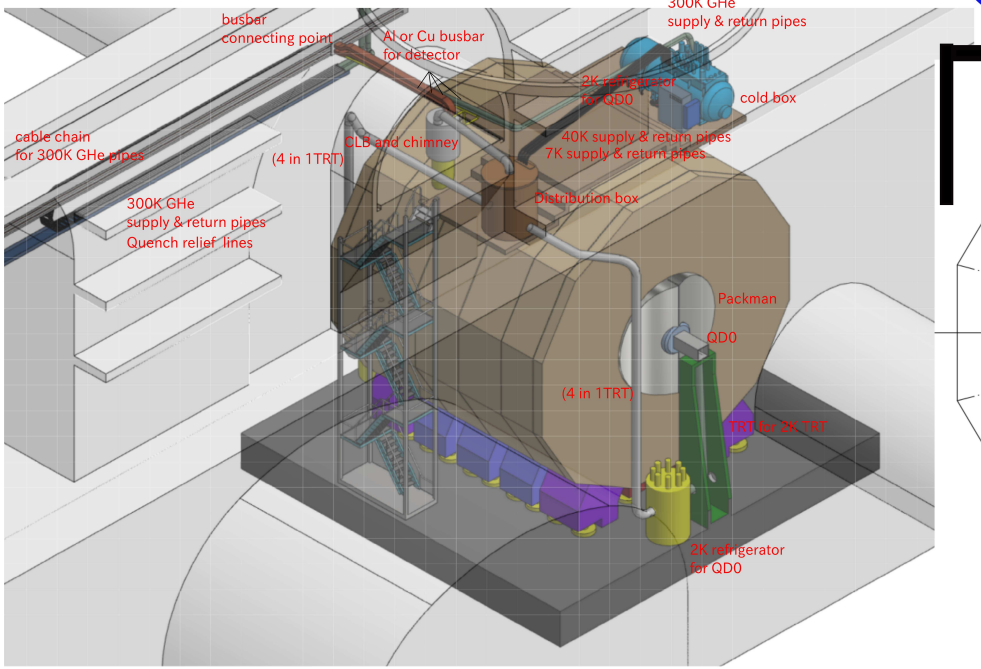
Layout example for ILD

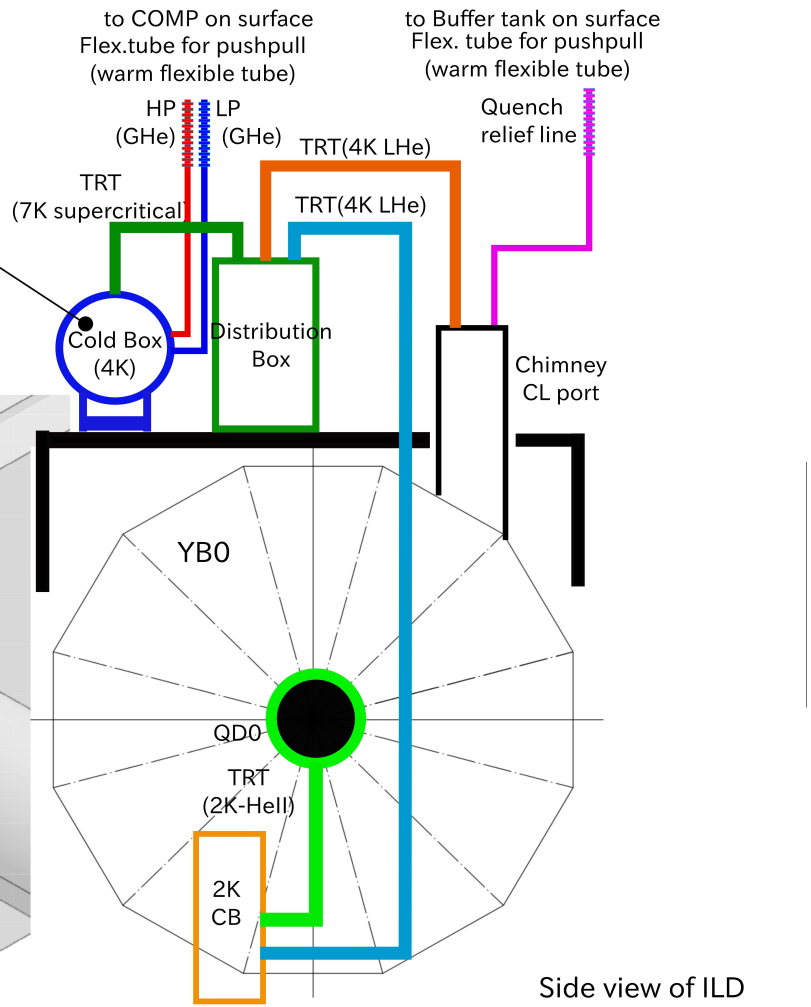
Cross section of TRT
4in1 TRT



2K refrigerator
(BNL)

4K cold box

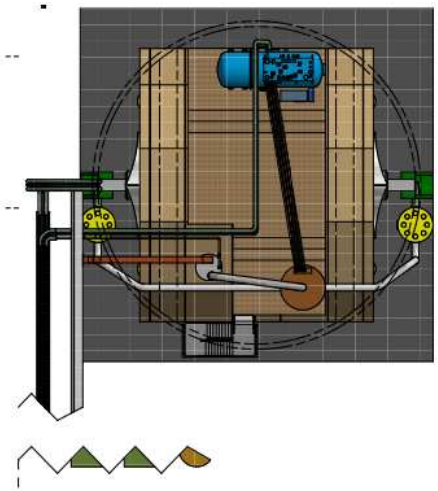


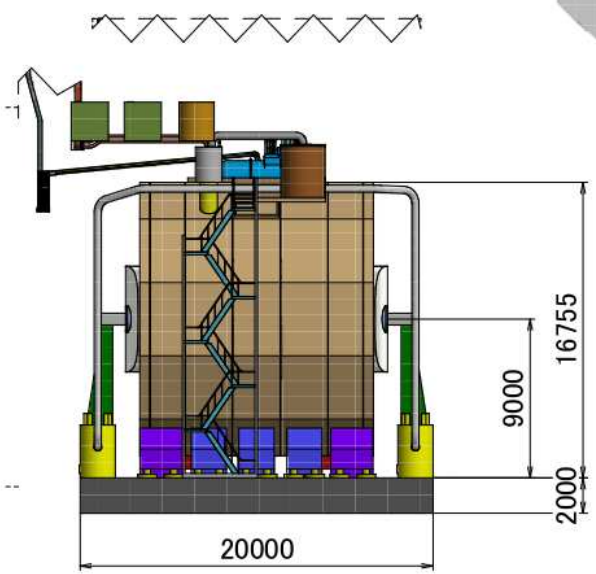


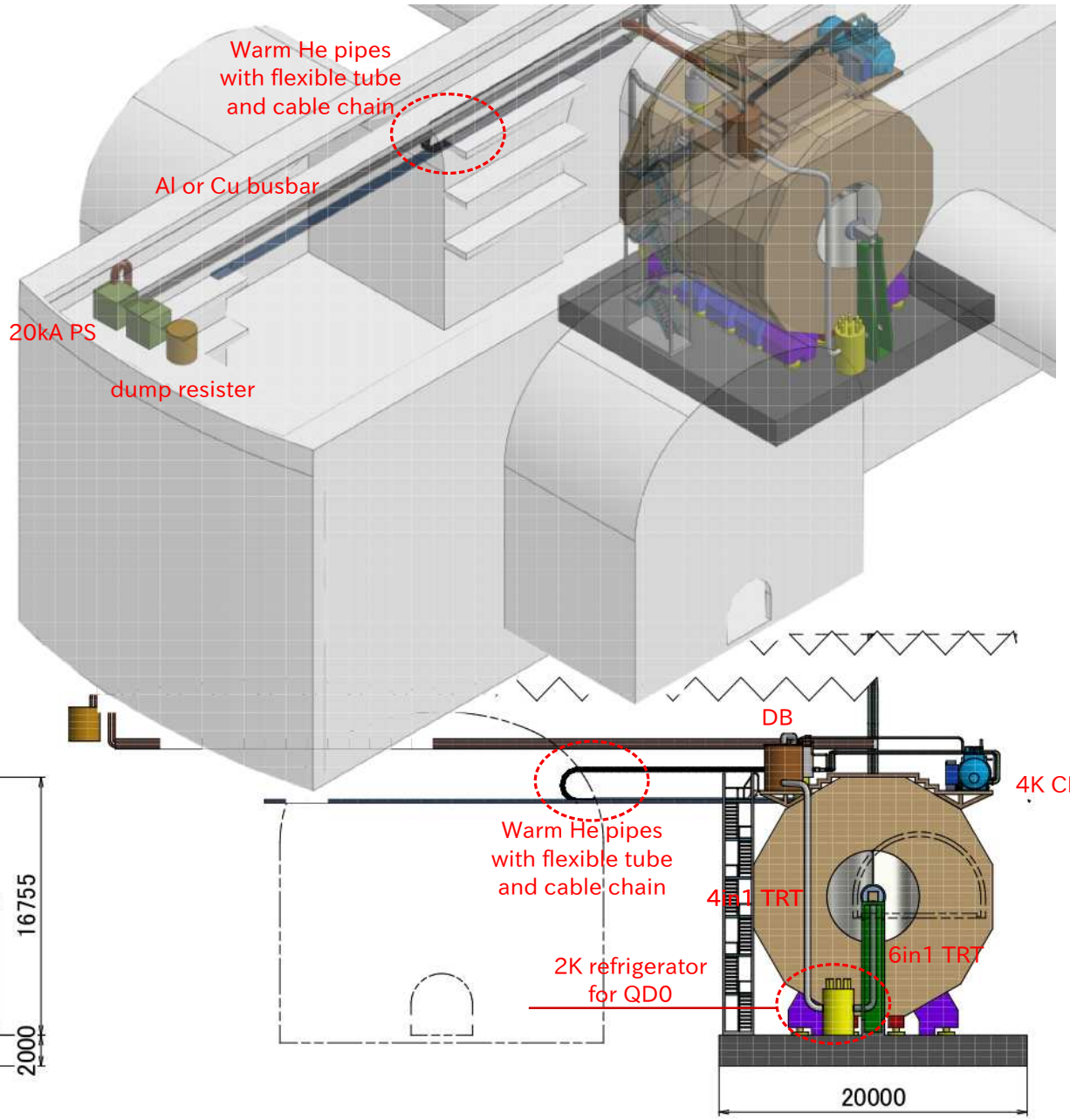
Side view of ILD

Most of the cryo-equipment should be located on the YB0 platform in order that ILD detector should be divided into 5 sectors as easy as possible.

layout example for ILD(2)





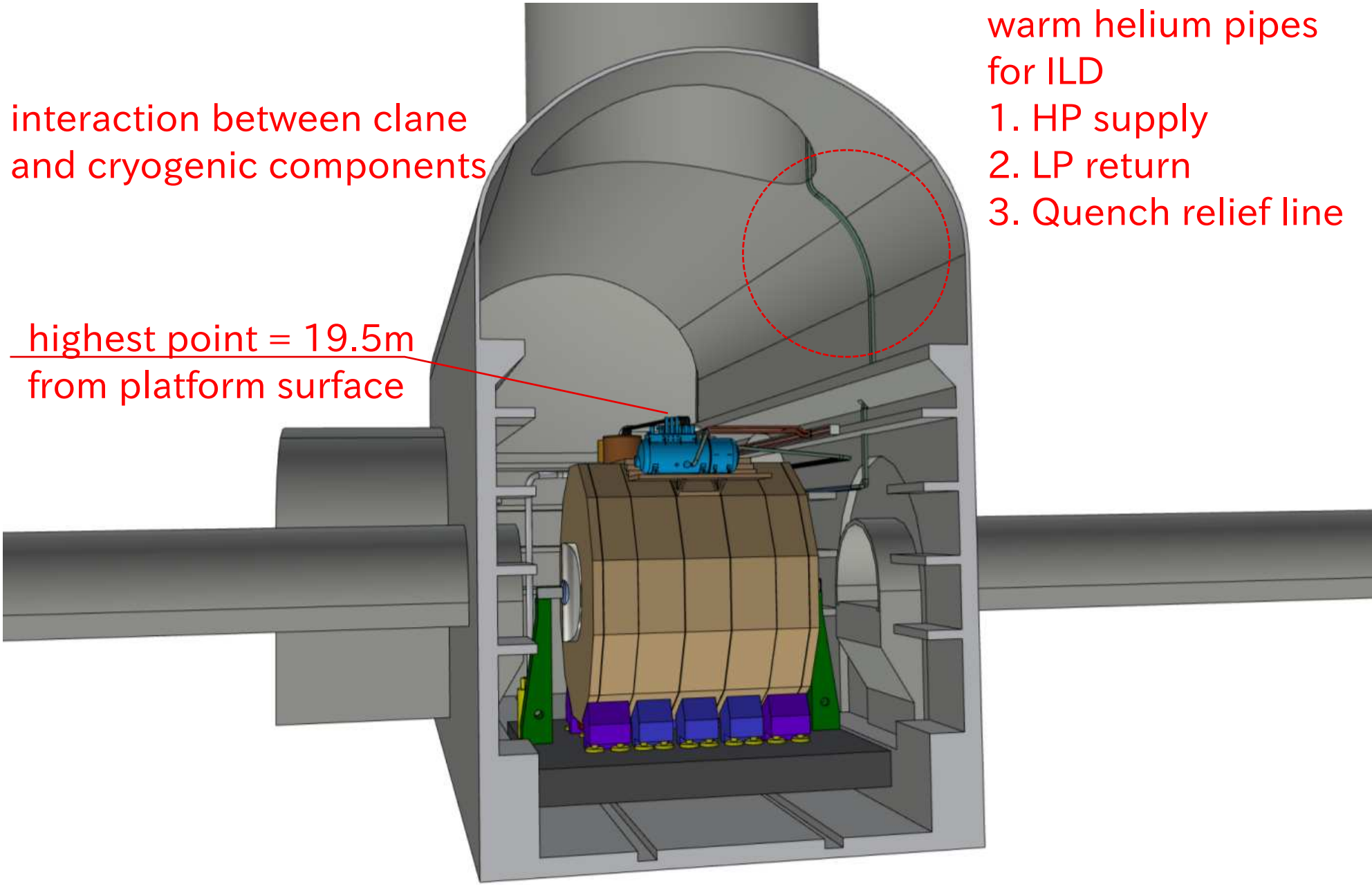


layout example for ILD(2)

interaction between clane
and cryogenic components

highest point = 19.5m
from platform surface

warm helium pipes
for ILD
1. HP supply
2. LP return
3. Quench relief line



Vibration Issue

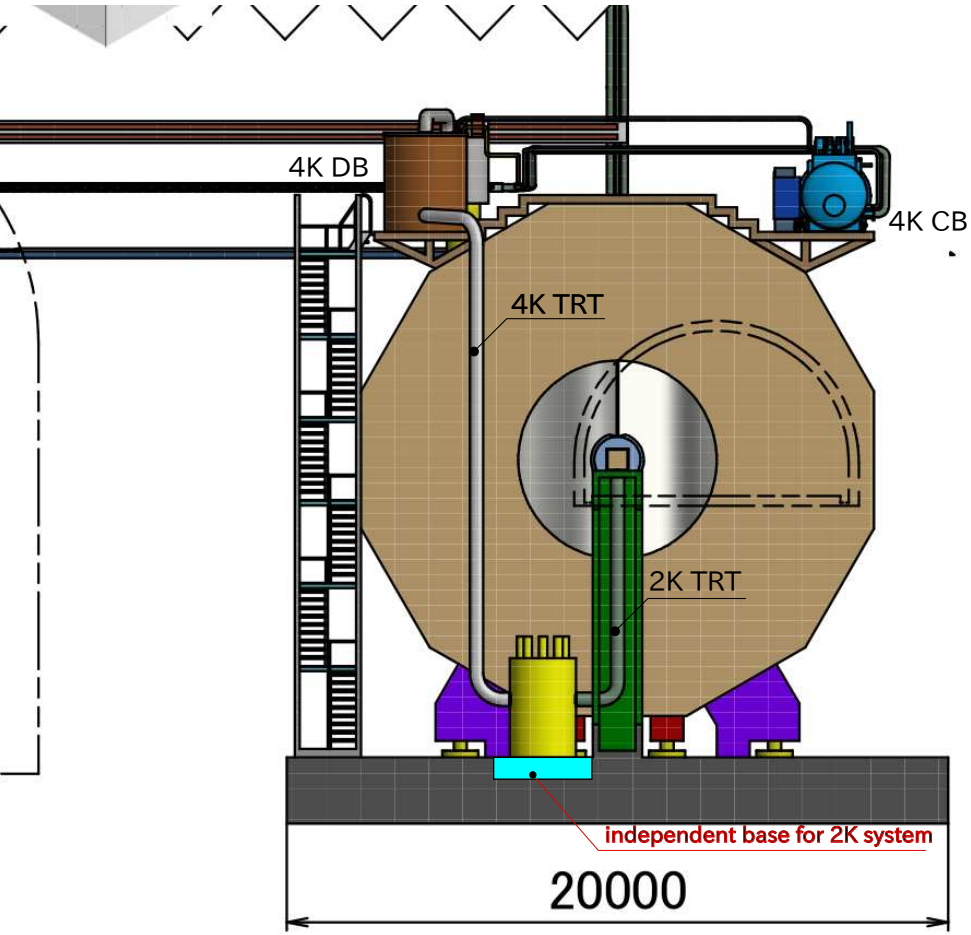
vibration source

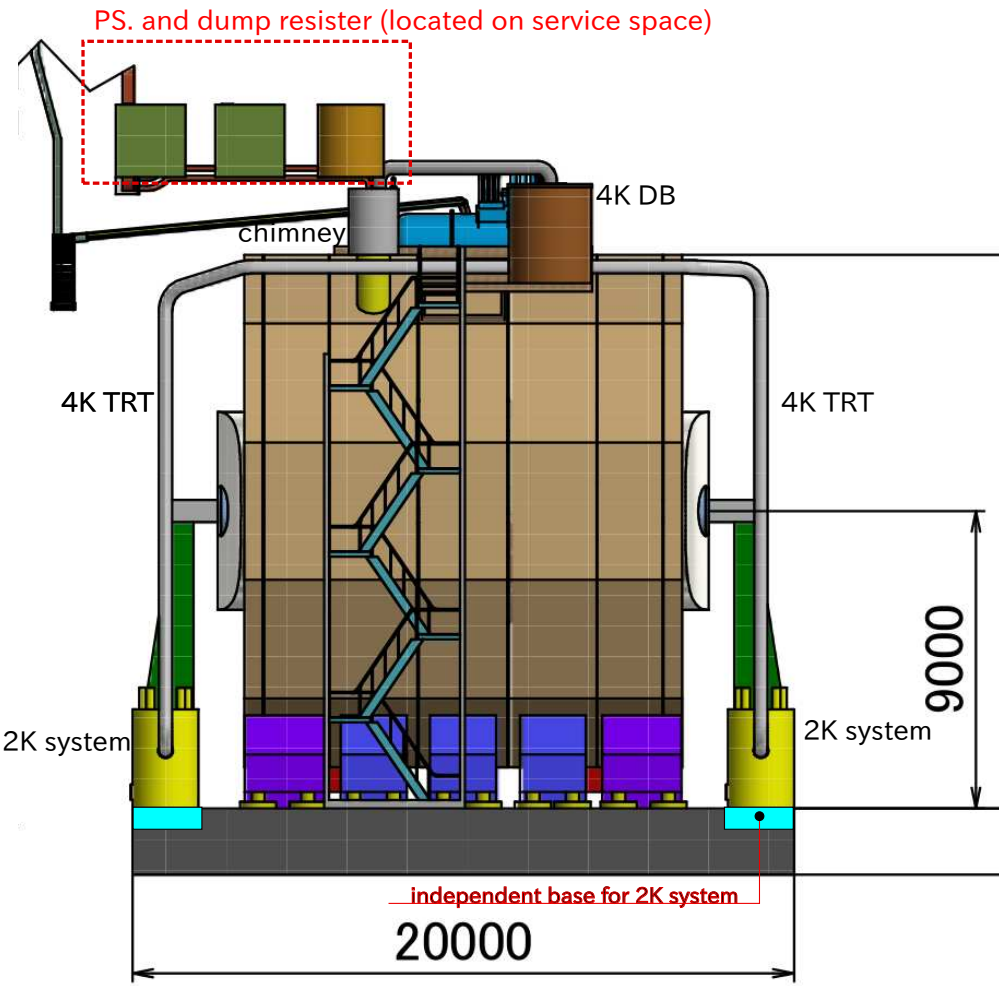
- **Cold Box** does not have vibration source.
  - Vacuum pump is stopped during 4K steady state operation.
  - Expansion turbines do not have vibration.
  - Cooling water for Expansion turbine is not so large amount. So it does not have vibration source.
- **2K Refrigeration System** has vibration source.
  - In order to generate 2K superfluid, vacuum pump have to be operated continuously. This is a source of vibration.
- **Other Utilities**
  - Cooling water for P.S has a large vibration source.
  - Vibraion of cooling water is propagated through Al or Cu bus-bar.

Counter-plan

- independent platform (with isolation or reduction of vibration)
- wire type bus-bar to dissipate vibration as easy as possible.

Location of 2K Refrigeration System





- Vibration of vacuum pump can be propagated through 6in1 TRT.
- In order to reduce this effect, location of vacuum pump and interfacial structure between 2K-system and 6in1 TRT should be deeply considered.

During push-pull and maintenance

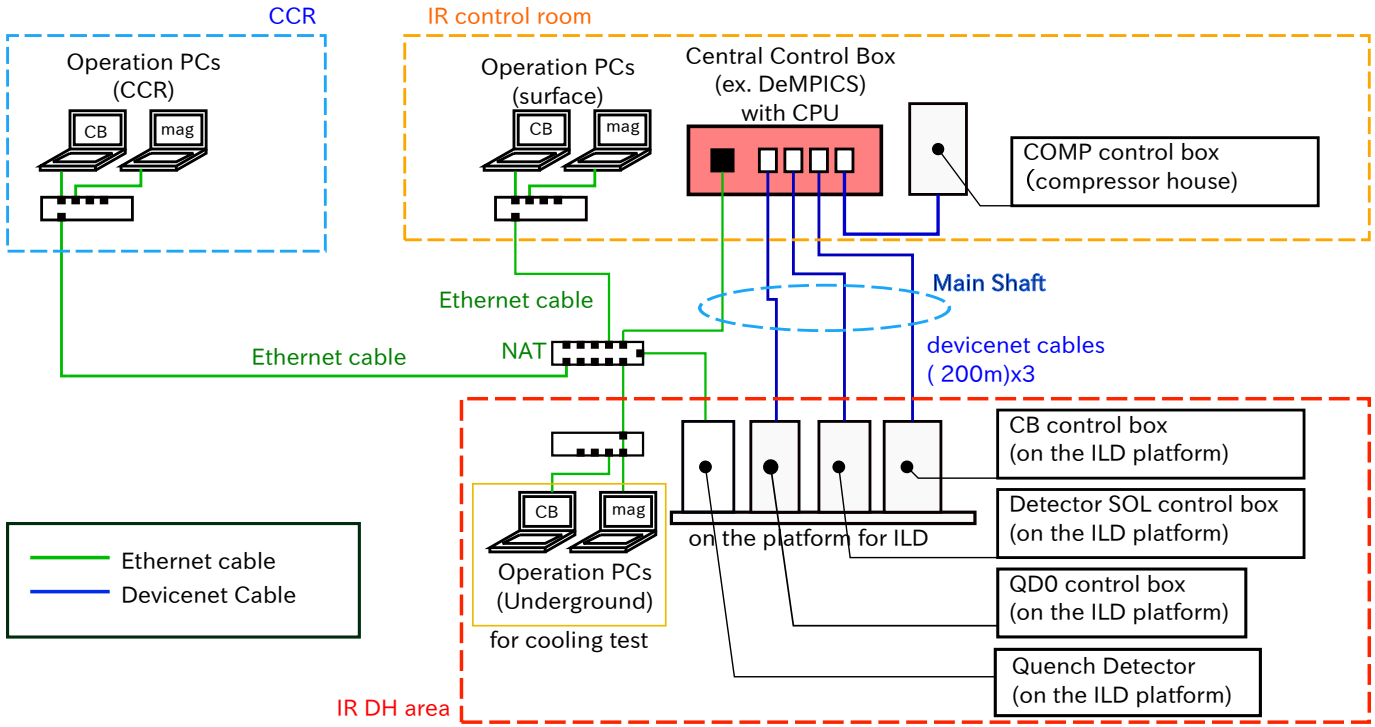
During pushpull

- without breaking up all kinds of tubes.
- Bus-bar (wired type) had better be disconnected.
  $\Rightarrow$ No excitation during push-pull

During ILD maintenance

- End cap (YE+,YE-) are only moved existing gap between end cap and support post.
  - CB, 2K-refrigerator and all kinds of tubes don't have to be divided and removed.
- All iron yokes are divided into 5 sectors.
  - TRT,CB, 2K refrigerator have to be decomposed.

Control System (1) overview



- Each control boxes should be located proximity to each equipment to reduce a lot of signal cables.
- All signals obtained from each control box are concentrated in a CCB.
- Connection method between each control box and CCB are performed by a few device-net cables.
- Connection method between operation computers and CCB is performed by Ethernet cables.

Control System (2) for quench protection

- Sampling time for control system is 1 sec.
- Characteristic time for magnet quench is msec order which is completely different from cryo control characteristic time (sampling time $\simeq$ 1 sec.). So we have to prepare dedicated quench detector system near the magnet control box.
- Magnet control boxes for detector and QD0s are located near the each components. All signals of superconducting magnet (such as voltage between selected two taps) are concentrated in the box.
- The quench detector has a rule in magnet fast down if it detects magnet quench.
- We can know the quench signal and origin of the quench by operation computer.
- The connection method between quench detector and operation computer is performed by Ethernet.

Japanese High Pressure Gas Regulation

- **There are two regulations in Japan. Which is better?**
  - 一般則 [1]
  - 冷凍則 which is better than 一般則. [2]
- **We have to prepare ventilation system in following 3 buildings.**[3]
  - Detector hall. (capacity = 28000m3/h) [4]
  - Assembly hall. (capacity = 28000m3/h)
  - Compressor house. (capacity = 40000m3/h) [5]

[1] 一般則 is applied to general equipment with high pressure gas. 冷凍則 is dedicated regulation which is applied to refrigeration system with any kinds of coolant.

[2] In case of 冷凍則, without overhaul inspection every year.

[3] according to 冷凍則.

[4] Capacity is the summation of ILD, SiD, QD0, CC, QF1.

[5] Capacity is the summation of ILD, SiD, QD0, CC, QF1 and DR.

Summary

- Cryogenic components which should be located on surface are summarized.
- To confirm the size of compressor house or surface layout of cryo-component, we have to clarify cyogenic system for DR and BDS.
- DR had better be cooled down by using cryogenic system located in IR.
- DBS had better be cooled down by using ML cryogenics. BDS is located far from IR ($\sim$ more than 1km).
- Service space in detector hall has important functions for cryo-components of final focus QF1, CC and cable chain for pushpull and reduction of vibration from PS.
- From vibration viewpoint, 2K system has to be located isolated platform for detector. PS can be regarded as vibration source. Therefore, PS should be located on service space. To reduce vibration propagated thorough bus-bar, wired-type bus-bar had better be employed between PS and chimney port (CL port).
- Control system configuration are considered. A lot of signal wires don't have to be employed throught vertical shaft. Transmitted or received of various kinds of signal between surface and cavern can be performed by a few device-net cable and Ethernet cable. To perform this, control boxes for each component are laid near the each cryo-component, this means that it is necessary to prepare a lot of signal cable between each cryo-components and each control box.