Detector Utility/Service Cavern

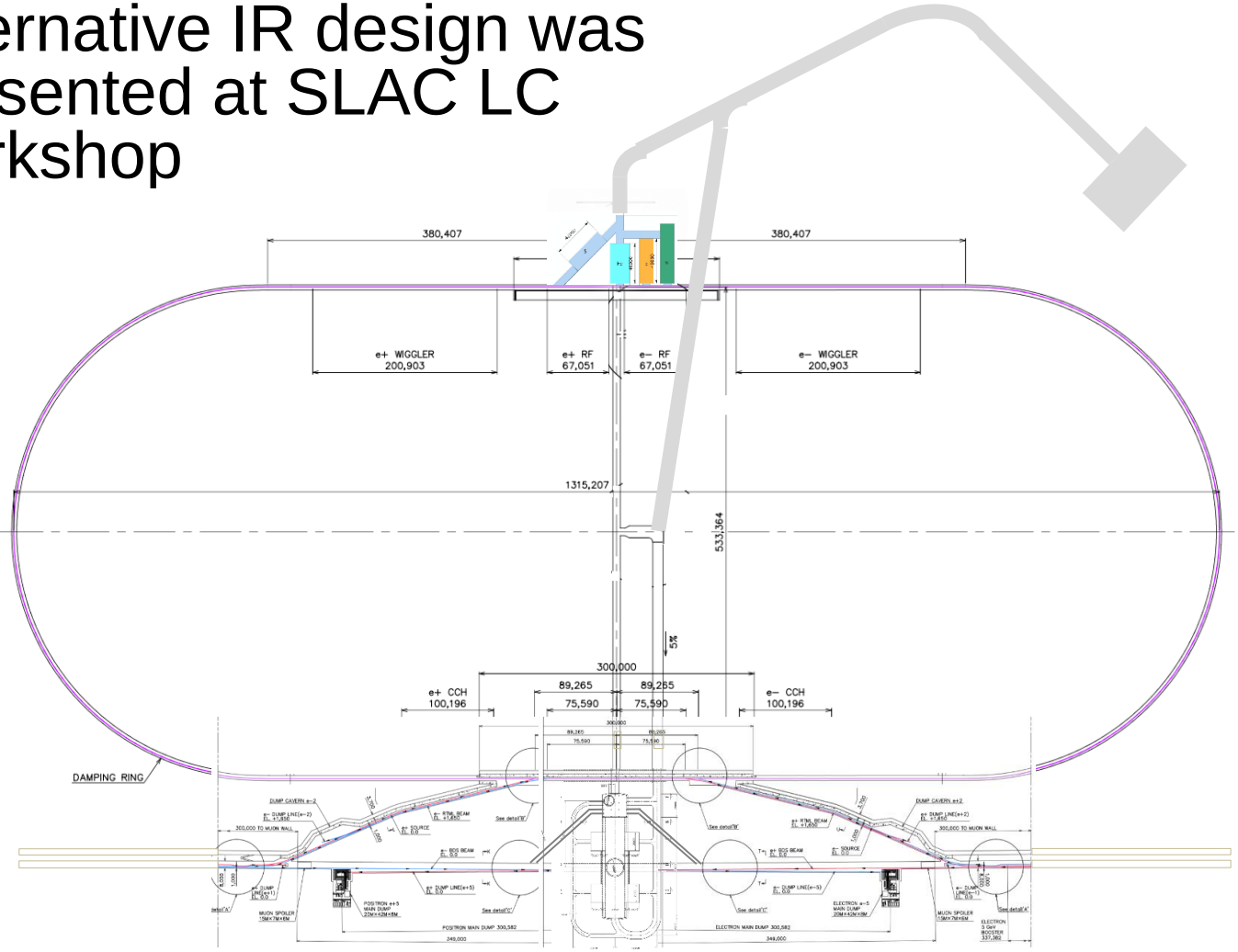
2017/9/28

Yasuhiro Sugimoto

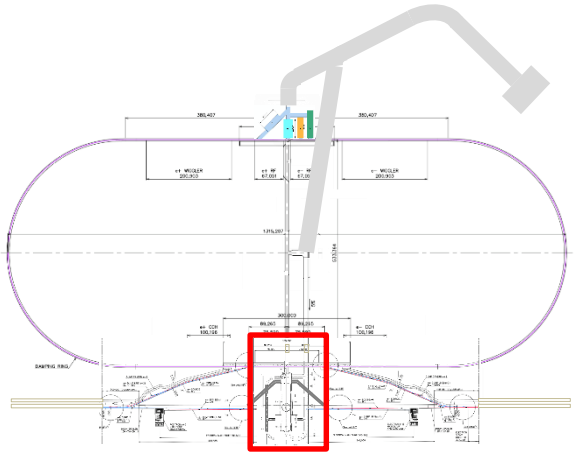
INTRODUCTION

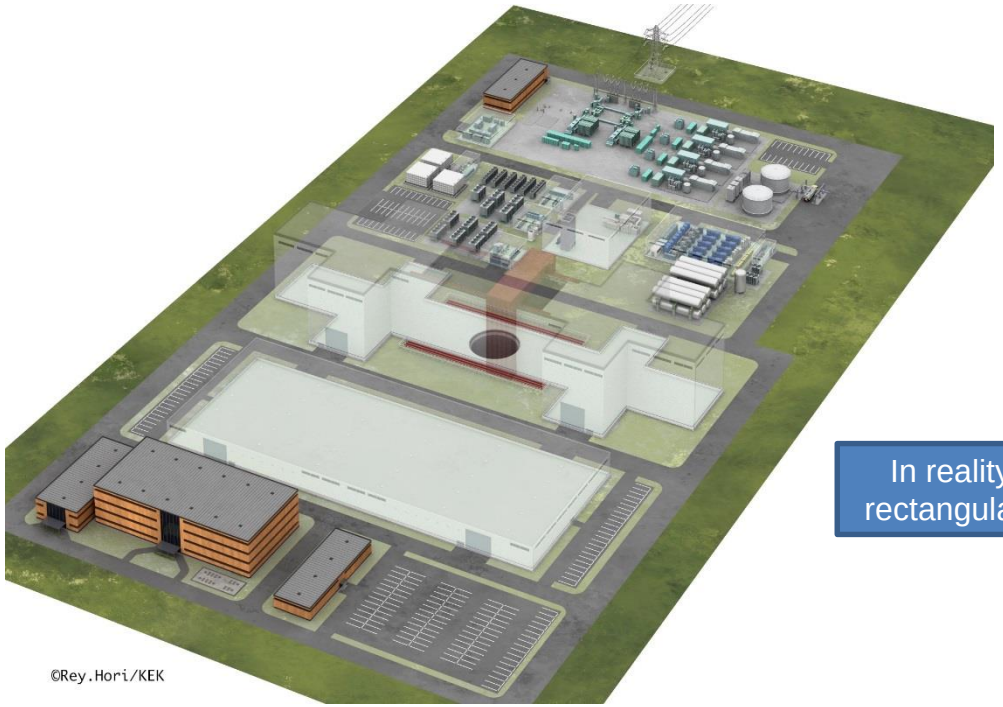
Alternative IR design by Tohoku team

- Alternative IR design was presented at SLAC LC workshop



Alternative IR design by Tohoku team





AS-0 衝突点キャンパス　モデルスタディ　170412

総敷地面積：
=78,453.5≒**7.85ha**
Net 61,491.5 ㎡
道路等 16,962 ㎡
(Gross=NET×1.28)

電力関係敷地
=(158+15)×73
=**12,629 ㎡**

He 関係用敷地
+UT Shaft
+ 機械設備用敷地
=173×72.5
=**12,542.5 ㎡**

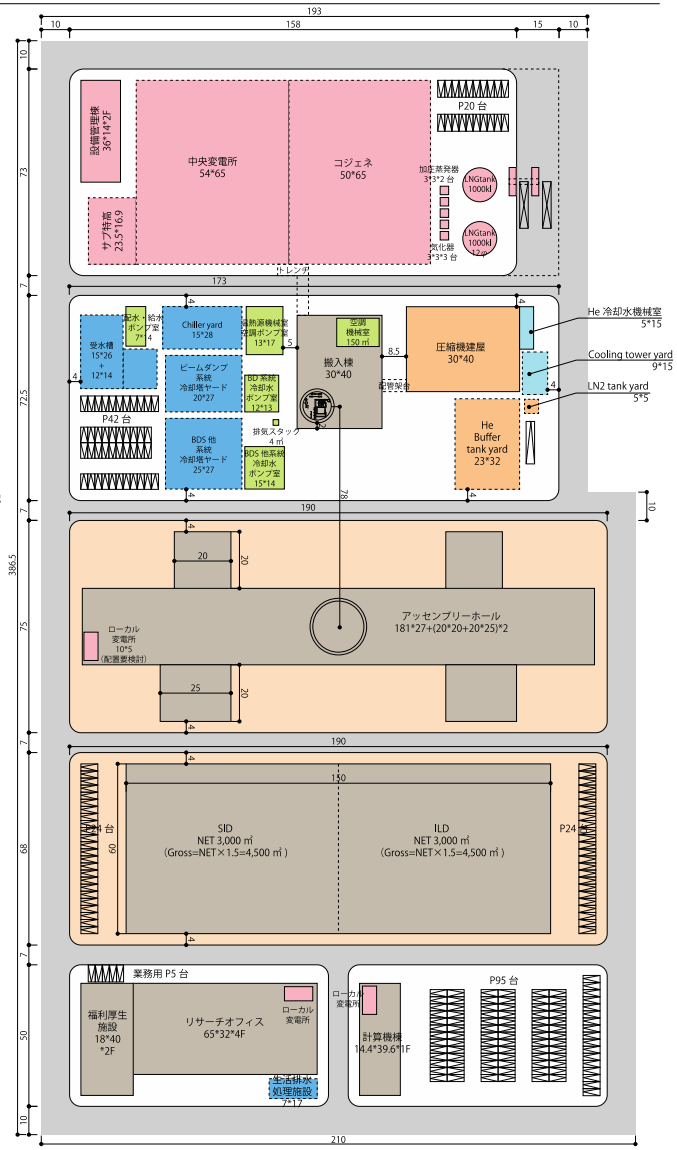
アッセンブリーホール用敷地
=190×75=**14,250 ㎡**

SiD/ILC 用敷地
=190×68=**12,920 ㎡**

オフィス
+ 福利厚生施設用敷地
=91.5×50=**4,575 ㎡**

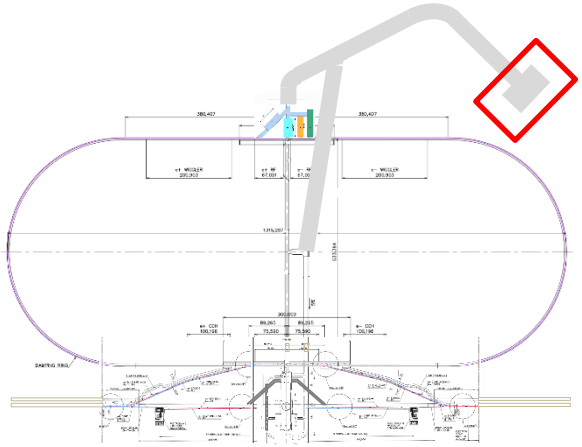
計算機棟・駐車場用敷地
=91.5×50=**4,575 ㎡**

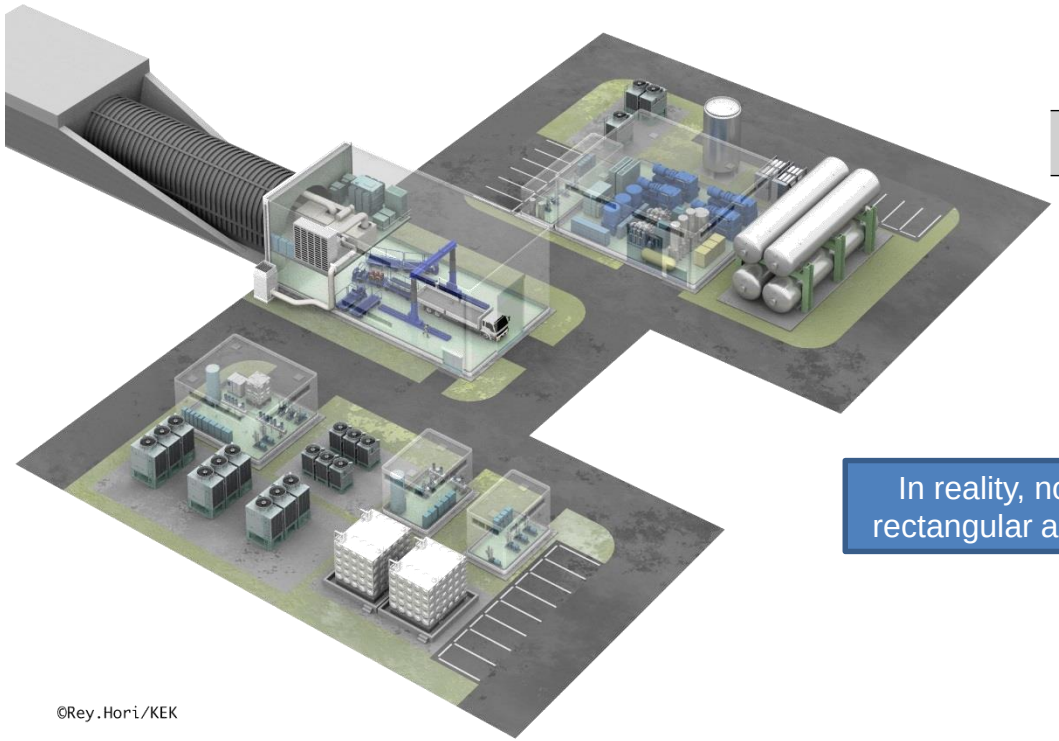
駐車場　合計 205 台

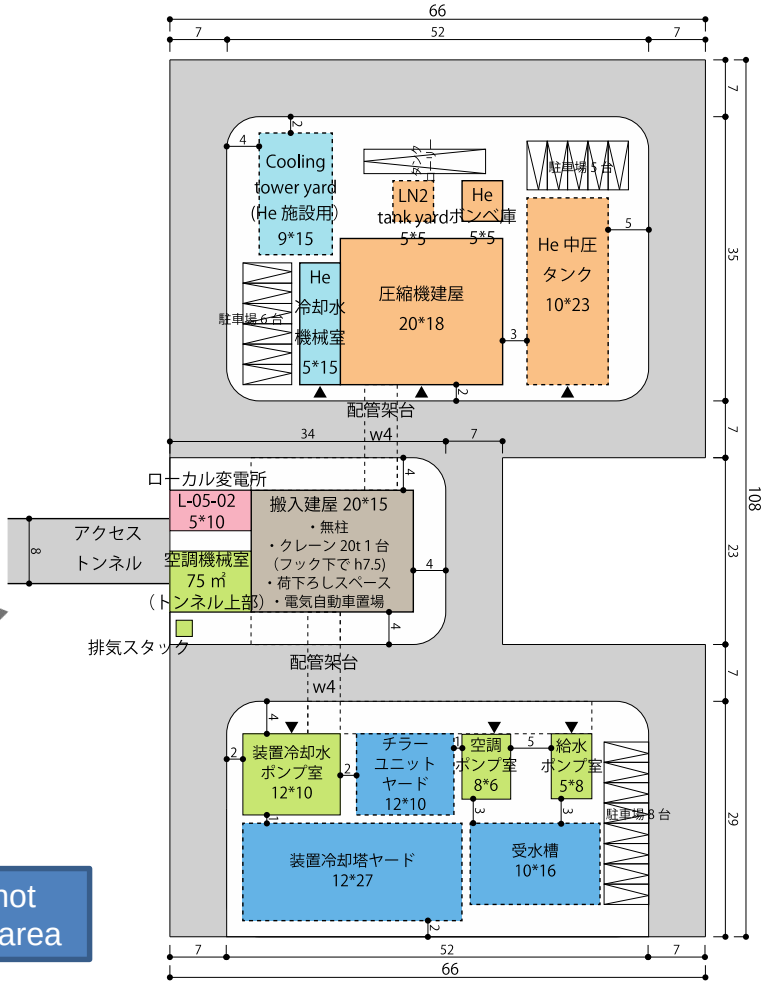


In reality, not rectangular area

Alternative IR design by Tohoku team







In reality, not rectangular area

浄化槽 yard（大きさ未定）

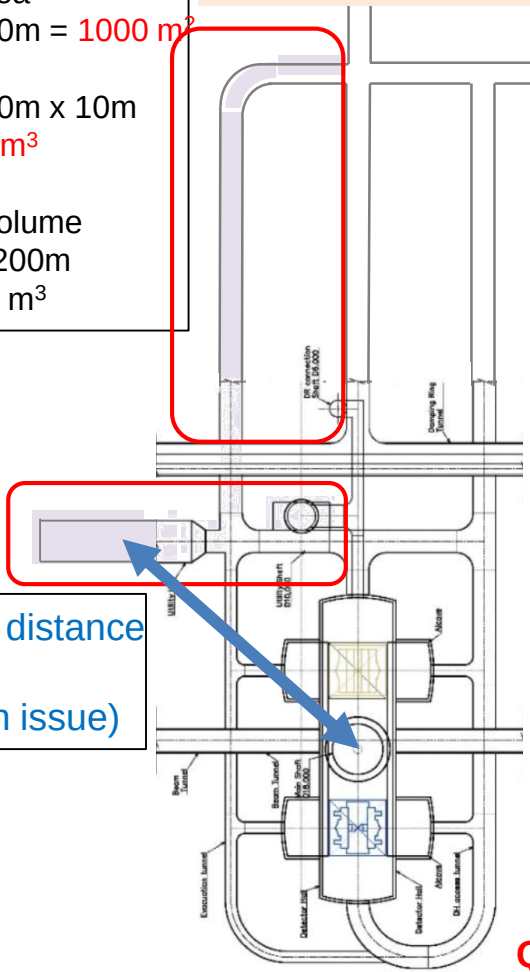
Alternative IR design by Tohoku team

TDR modified (two vertical shafts) **Proposed design of Utility cavern**

TDR modified

Utility hall
Floor Area
50m x 20m = 1000 m^2
volume
50m x 20m x 10m
=10,000m^3

Tunnel volume
53m^2 x 200m
=10,600 m^3



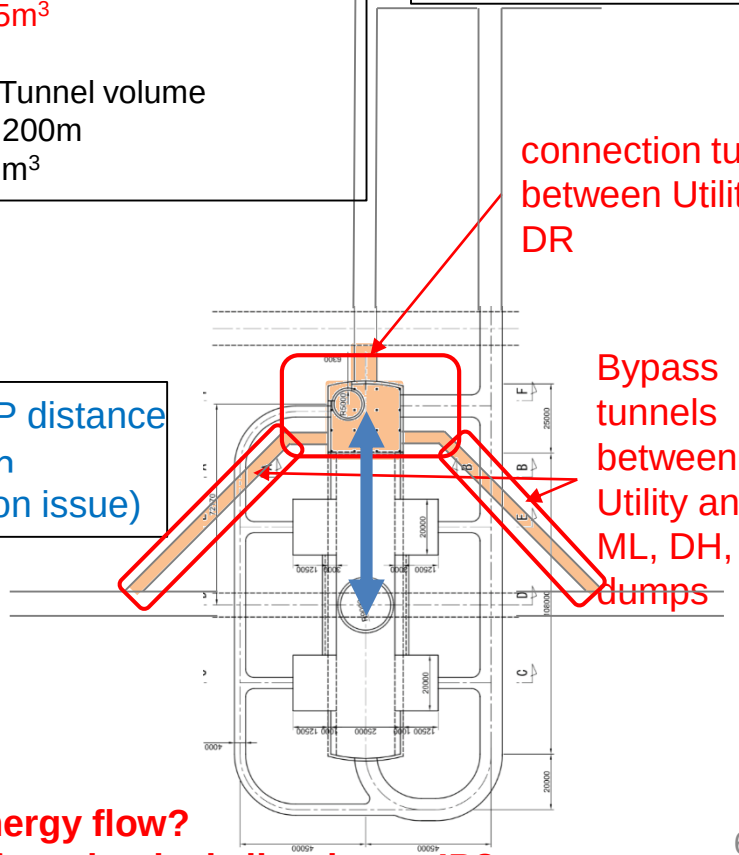
Utility-IP distance
109m
(vibration issue)

Utility hall
Floor Area
25m x 25m x 5floors = 3125 m^2
hall volume
25m x 25m x 43m
=26,875m^3

Bypass Tunnel volume
13m^2 x 200m
=2,600 m^3

Required Utilities footprint
Device Footprint = 1305 m^2
Elevator footprint x 5 floors
= 780 m^2
Carry-in space = 296 m^2

Utility-IP distance
66. 5m
(vibration issue)

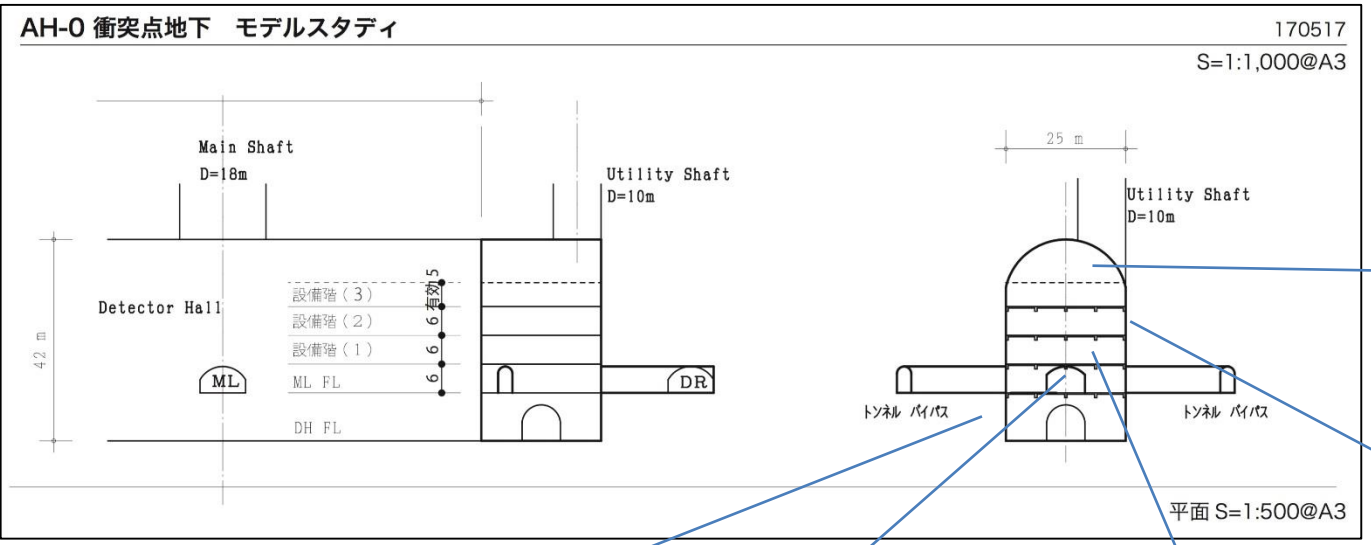


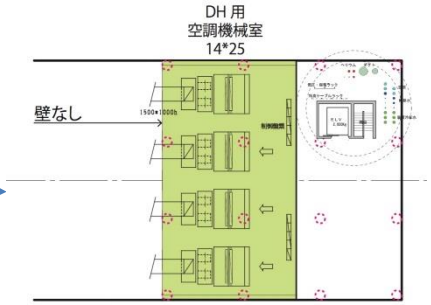
connection tunnel between Utility and DR

Bypass tunnels between Utility and ML, DH, BDS, dumps

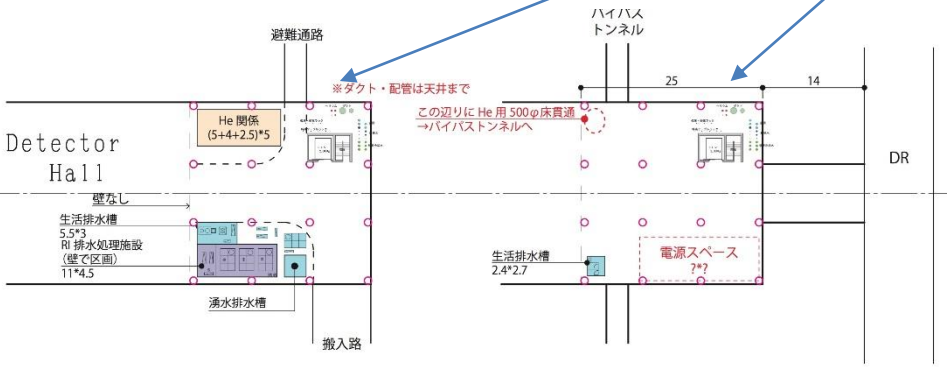
Q: How simple is Energy flow?
what is the effect of mechanical vibration to IP?

Alternative IR design by Tohoku team

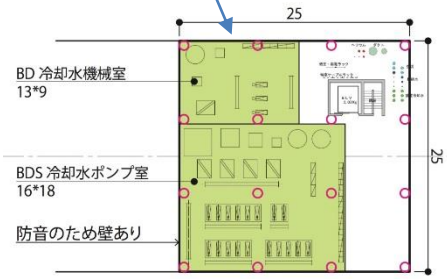




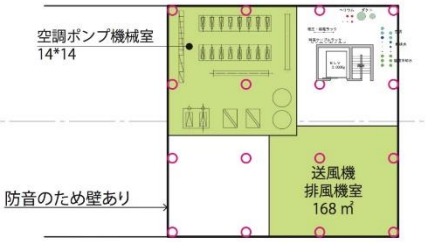
5th Floor



1st Floor　2nd Floor



3rd Floor



4th Floor

Alternative IR design by Tohoku team

- In this design, DH is extended, and the extended part is used for utilities for accelerator
- Original utility cavern is removed
- No consideration for detector services/utilities
- Many other concerns
  - Level of the 5th floor is higher than crane rail
  - Vibration
  - Noise
  - Effect of stray B field when a detector magnet is ON in the garage position
  - Radiation safety
  - Fire safety
  - Legitimacy with “Building Standards Law”
  - Confusion during construction/operation
    - Utilities for Acc., ILD, and SiD at the same place???

Detector Services/Utilities

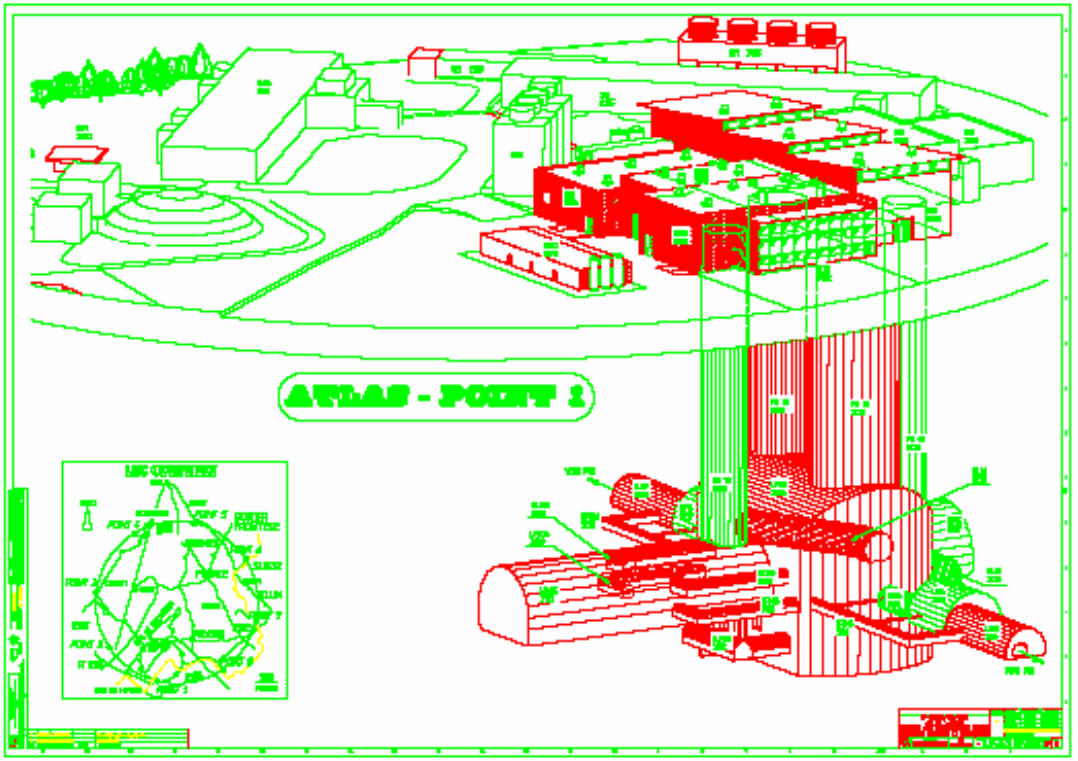
- I cannot accept the alternative design because there is no consideration on detector services/utilities, and not enough space for them
- Then, how much space do you need?
- ……. I don’t know exact number

- We have to clarify requirements for underground services/utilities for detectors

SERVICE CAVERNS FOR LHC DETECTORS

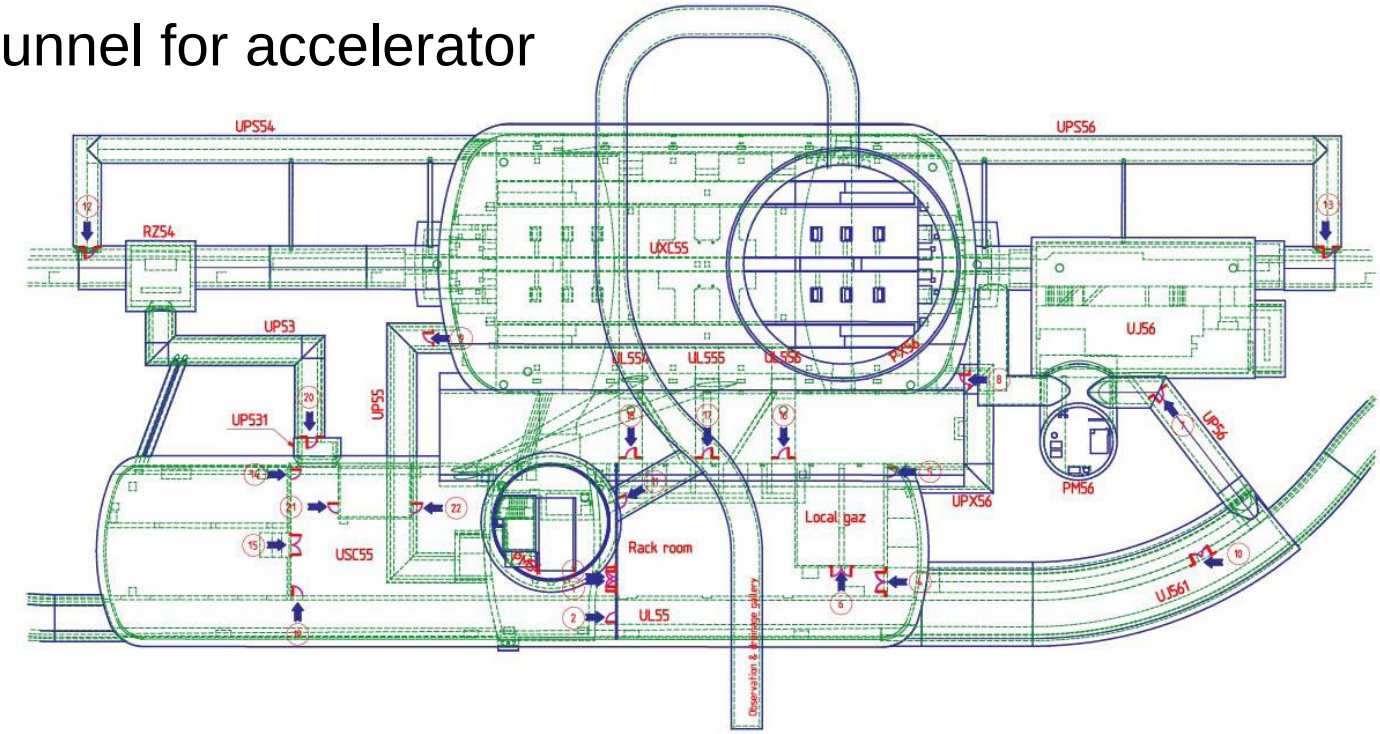
ATLAS

- USA15
  - Size: 20mx62m = 1240 m^2 (height=13.5m)
  - 2~3 floors
  - Separated from UX15 by 2m thick wall
- Another small service cavern US15
- ~100 electronics racks are placed in the detector hall

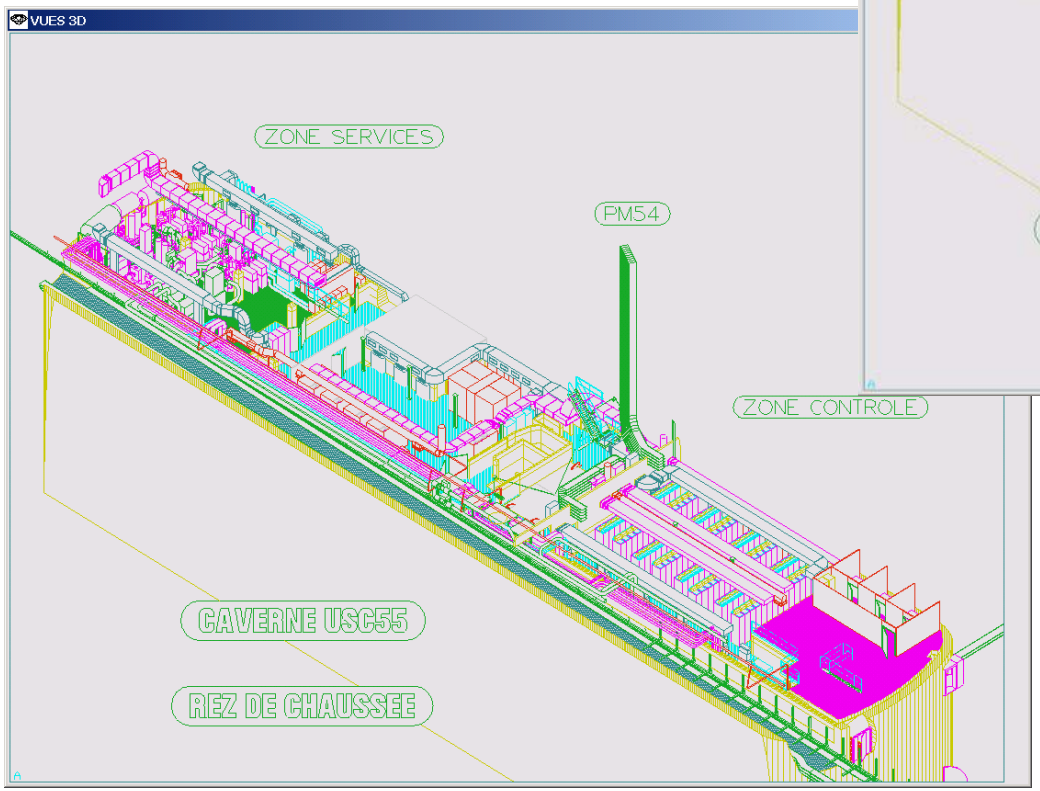


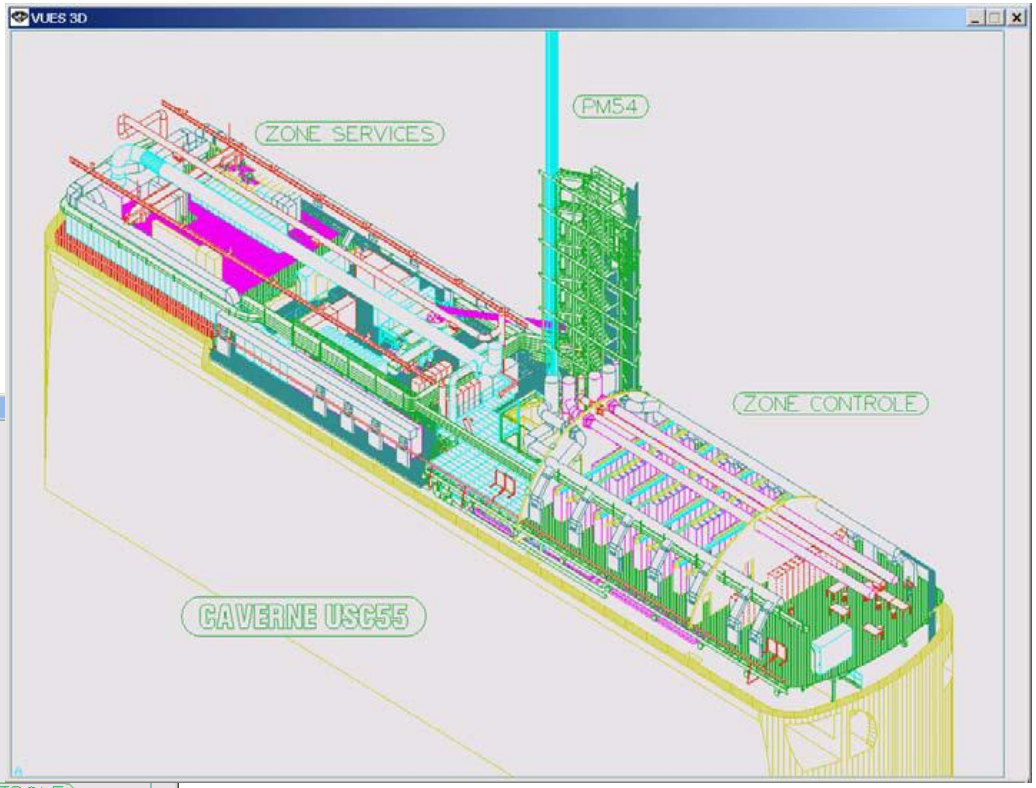
CMS

- USC55
  - Size: 18mx85m = 1530 m^2
  - Two floors
  - ~1/3 is used for electronics racks
  - Bypass tunnel for accelerator

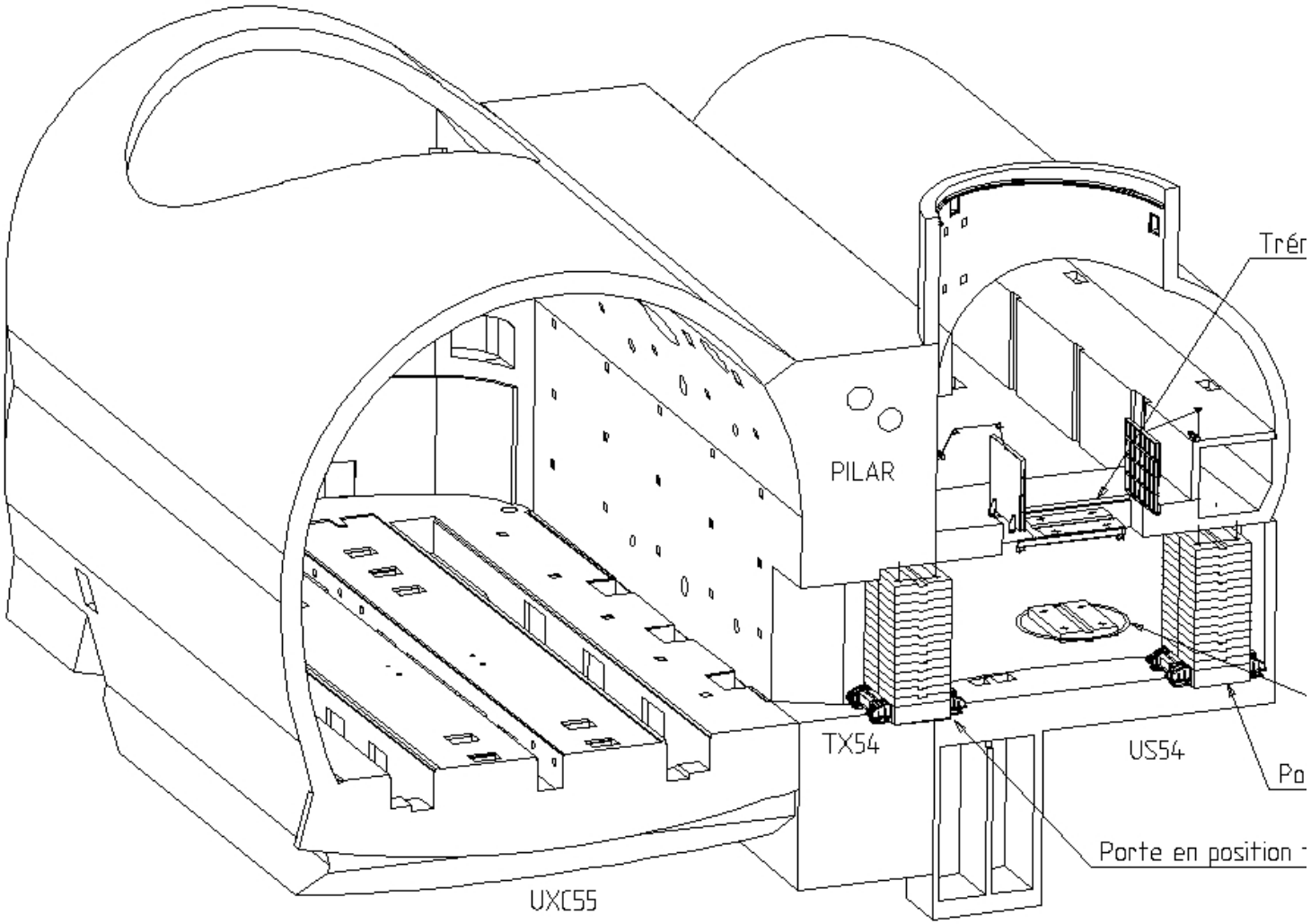


CMS


VUES 3D
ZONE SERVICES
PM54
ZONE CONTROLE
CAVERNE USC55
REZ DE CHAUSSEE


VUES 3D
ZONE SERVICES
PM54
ZONE CONTROLE
CAVERNE USC55

CMS



SERVICE/UTILITY REQUIREMENTS FOR ILC DETECTORS

Requirement survey

- Requirements for the ILC Detector Hall have been summarized as an excel file by MDI community
- However, space requirement is not listed there

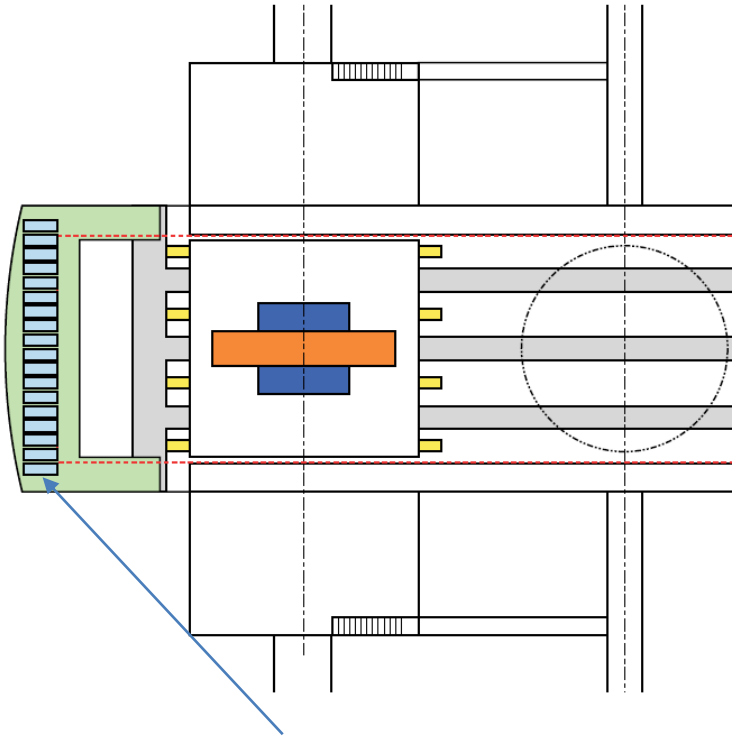
Requirements for the ILC Detector Hall								
Title	**Description**	**Rationale**	**Numerical Value**	**Justification**	**Building**	**Area**	**Trade**	**Su**
Magnetic Stray Field	The magnetic stray field at the IP caused by a detector in parking position must be less than	use of iron-based tools	50G	CMS experience, measurements at DESY	DH	Operation	Detectors	
Magnetic Stray Field	The magnetic stray field around the detector must be less than	functioning of detector near electronics and equipment	2000G	unclear	DH	Safety	Detectors	
Beam Height	The beam height above the IR floor must be	detector diameter	9m	ILD and SiD design in DBD	DH	Operation	Civil	
DH crane operation	It must be possible to operate a crane in the DH for ILD and SiD independently	decouple installation schedule			DH	Operation		
DH crane combination	For heavy loads, it should be possible to couple both DH cranes	assuming individual crane capacity is less than maximum required load			DH	Operation		
DH crane coverage	The DH crane must cover a region of size ... In the DH in single / coupled operation	Underground installation work	S25m xH35m	footprint of detector, platforms and pacman assembly space	DH	Operation		
DH Crane hook height	The main hall crane must have a hook height of at least	Underground installation work	20.5m	needs to be checked	DH	Operation		
DH Crane hook height	The main hall crane must have a hook height of at least	Underground installation work	20.5m	needs to be checked	DH	Operation		
DH Crane hook height	The main hall crane must have a hook height of at least	Underground installation work	5m above detector	needs to be checked	DH	Operation		
DH Crane hook height	The main hall crane must have a hook height of at least	Underground installation work	5m above detector	needs to be checked	DH	Operation		
DH Crane capacity	The DH crane must be able to move a mass of (single / coupled operation)	Underground installation work	(250t + 80t)x2		DH	Operation		
DH Crane capacity	The DH crane must be able to move a mass of	Underground installation work	40t x 2	does this cover the pacman load?	DH	Operation		
AH Crane capacity	The Assembly hall crane must be able to move a mass of	Surface assembly work	250t	Yoke iron segments	AH	Operation		
AH Crane capacity	The Assembly hall crane must be able to move a mass of	Surface assembly work	(250t + 80t)x2	coil modules	AH			
Pre-assembly hall Crane capacity								

Services/utilities to be considered

- Detector services
  - Electronics racks (Back-end electronics, low voltage PS, etc.)
  - Sub-detector cooling plants
  - Laser system for calibration
  - Chamber gas (including control system)
  - Cryogenics for solenoid/QD0
- Utilities
  - Electricity
  - Cooling water (normal/chilled water)
  - HVAC (Heating, ventilation, and air conditioning)
  - He gas
  - Compressed air for air pad/other controls
- Others
  - Workshop
  - Sanitary

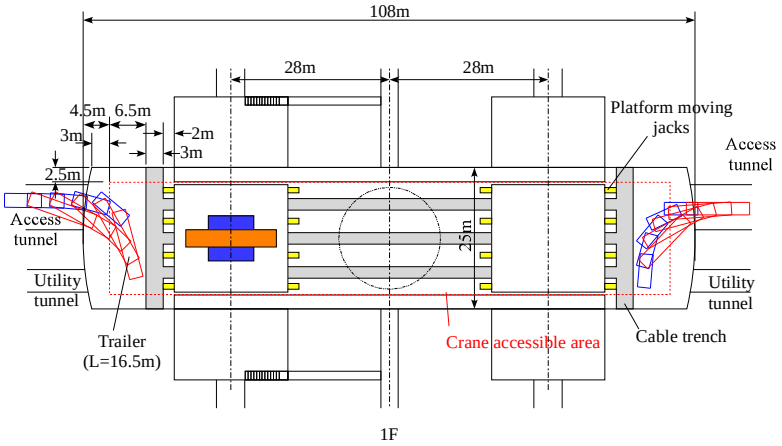
Electronics racks

- So-called 19-inch racks
- Used for back-end electronics, low voltage power supply, controllers for services, computer farm, etc.
- CMS uses ~250 racks with 1.6MW power consumption
- ILD
  - One rack would occupy 1.2x3 m^2 footprint including space for cables, cooling, and operation
  - ~60 racks can be put on the 2~5F of utility gallery
  - If we assume 120 racks (1/2 of CMS) is necessary, 60 racks have to be placed in service cavern
  - Each rack would be cooled by a fan-coil unit using chilled water as coolant
  - How many racks do we need in total?

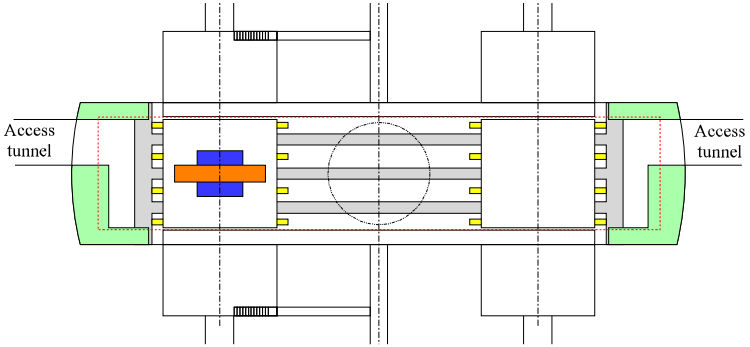


Utility gallery

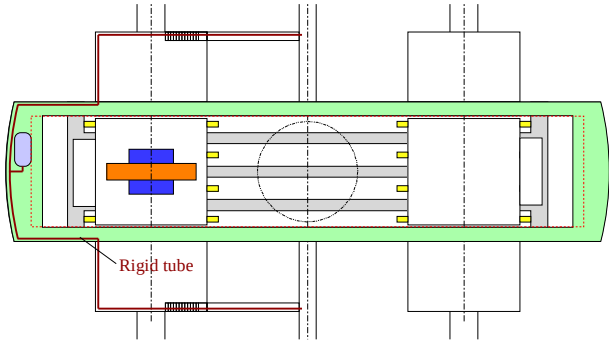
- Utility gallery for each detector in DH
  - 1F: to be used as loading area
  - 2F: 142 m^2
  - 3F-5F: 570 m^2
  - 6F: 386 m^2 (for cryogenics)
  - Space for passage for people/apparatus should be secured



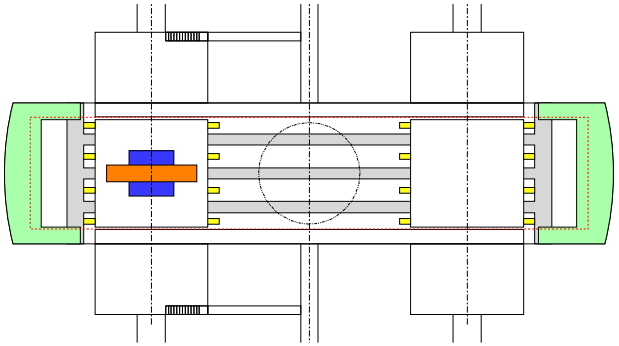
1F



2F

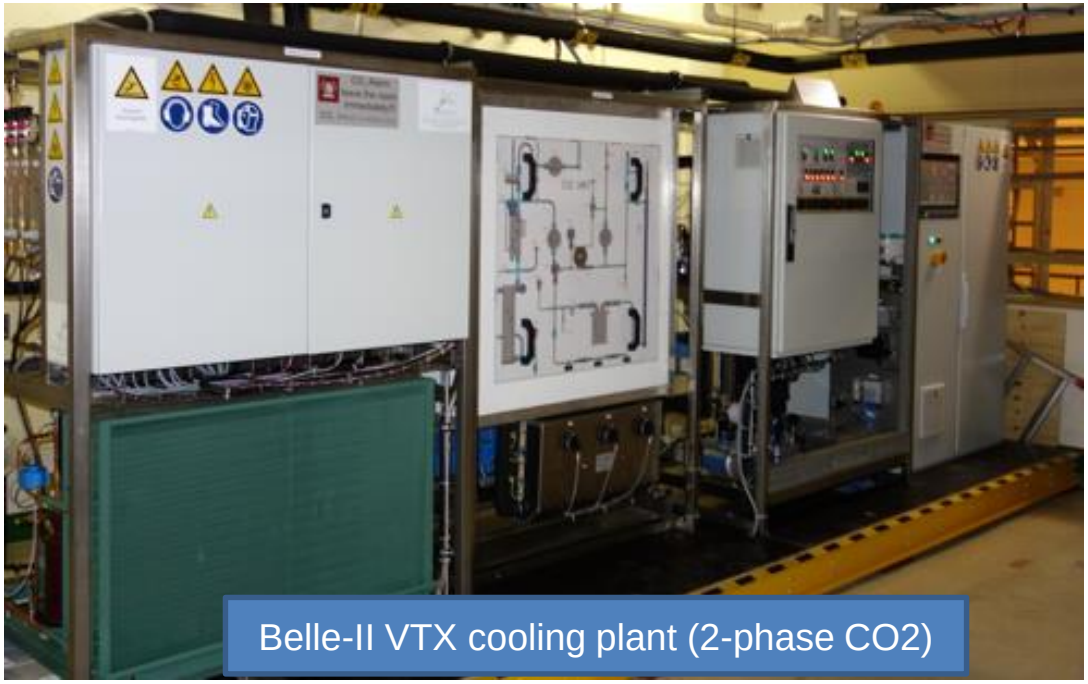


6F


3-5F

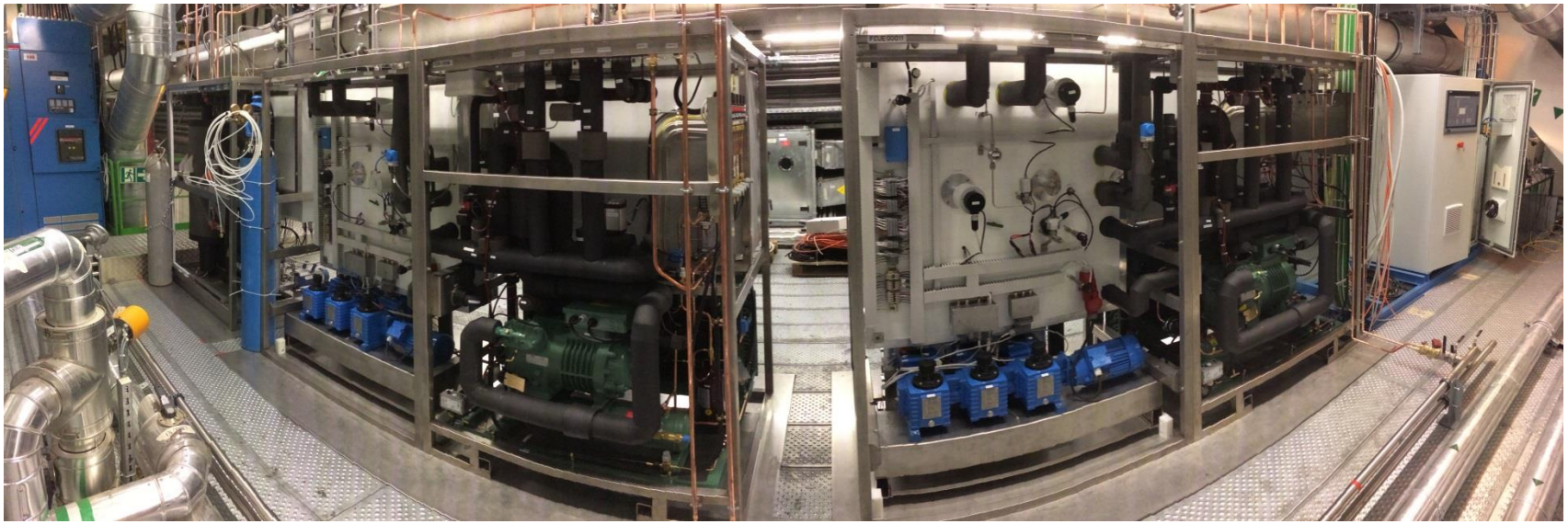
Sub-detector cooling plants

- Sub-detector cooling plants require quite large space
- Some of them (ECAL cooling system) have to be put on 1F or below
- Cooling water (normal or chilled) is necessary for the cooling plant (secondary loop)



Belle-II VTX cooling plant (2-phase CO2)

Sub-detector cooling plants



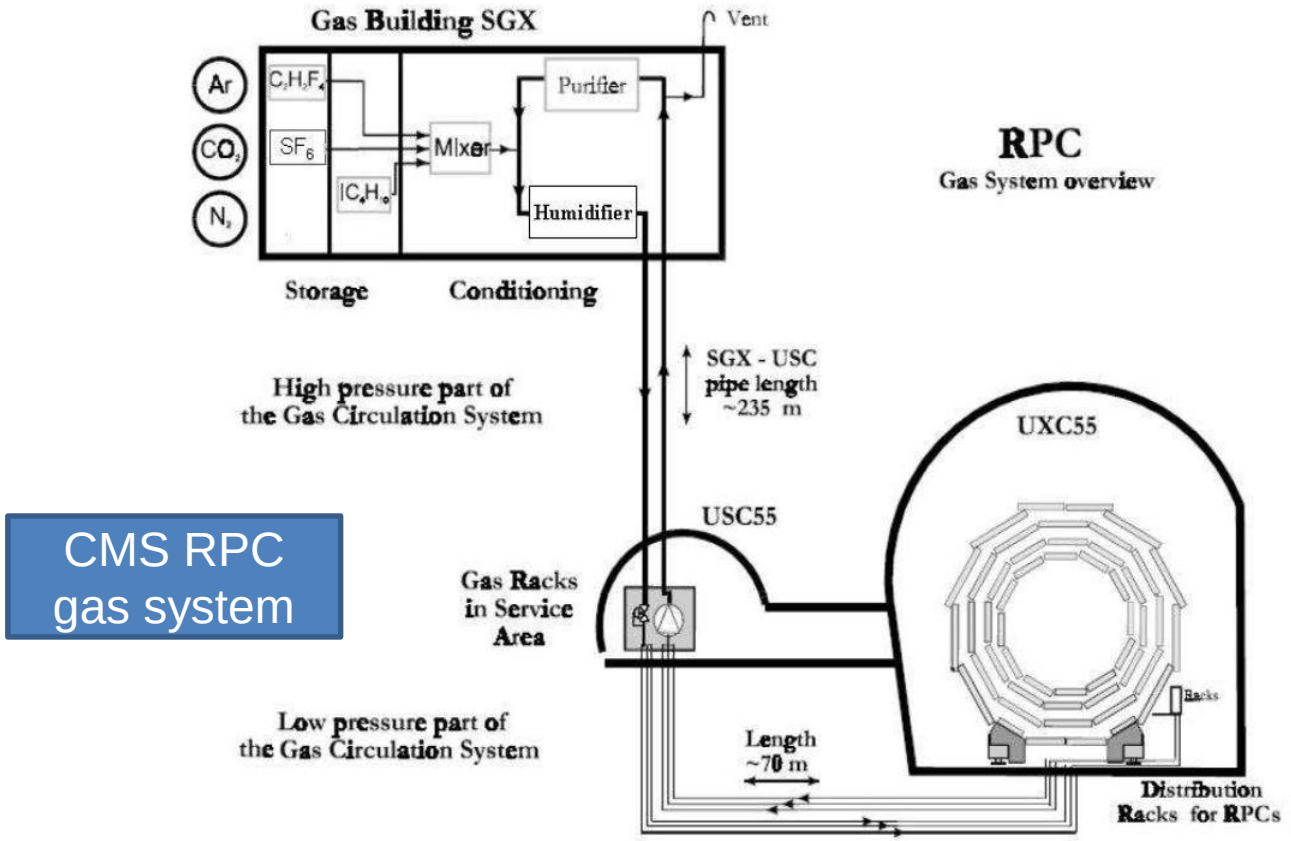
ATLAS IBL (Si detector) cooling system (2-phase CO2) in the service cavern

Laser system

- Laser system will be used for tracker alignment and calorimeter calibration
- Laser light source requires isolated space

Chamber gas

- Chamber gas is necessary for TPC and SDHCAL
- Gas storage on surface like CMS?



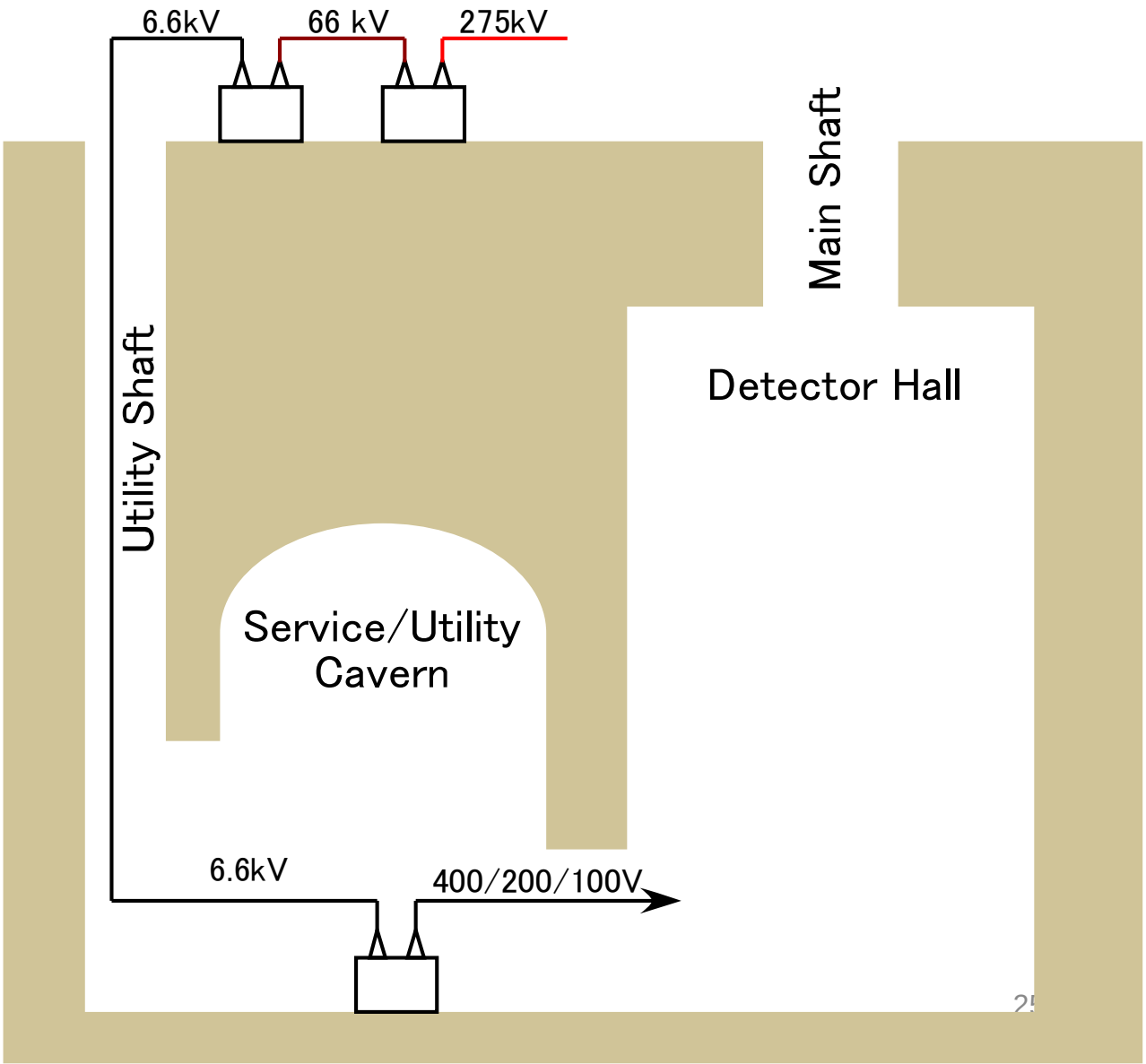
CMS RPC gas system

Cryogenics

- He compressor on surface
- Pressurized He through main shaft or utility shaft?
- Cold box is attached to detector (platform)
- DC power supply on 6th floor of Utility Gallery
- Dump resister on 6th floor of Utility Gallery?
- Cold box for QF1 on 6th floor of Utility Gallery(?)

Electricity

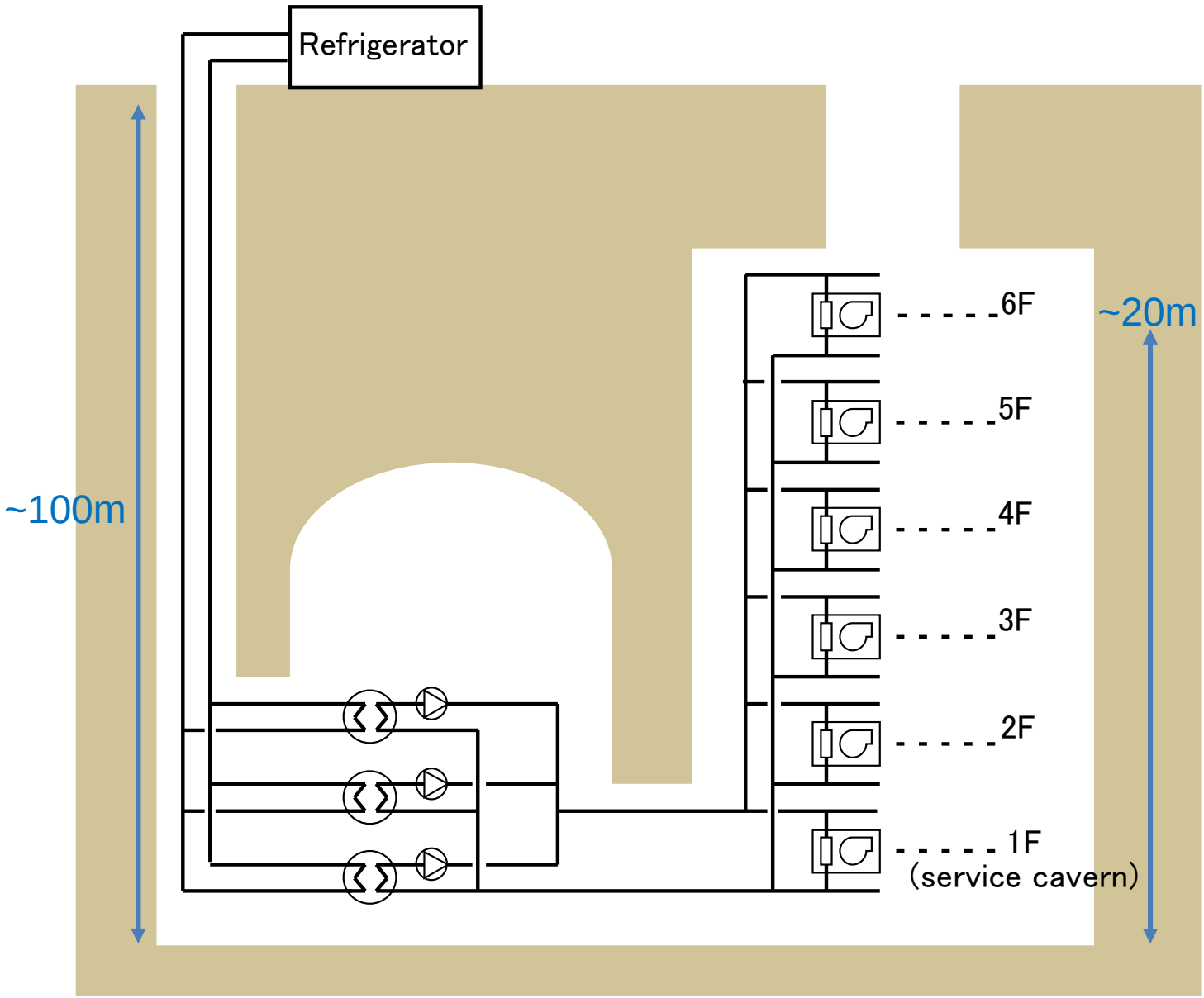
- 275kV→66kV trans and 66kV→6kV trans. on surface
- 6kV→400/200/100V trans. in Utility/Service cavern (restricted area)



Cooling water

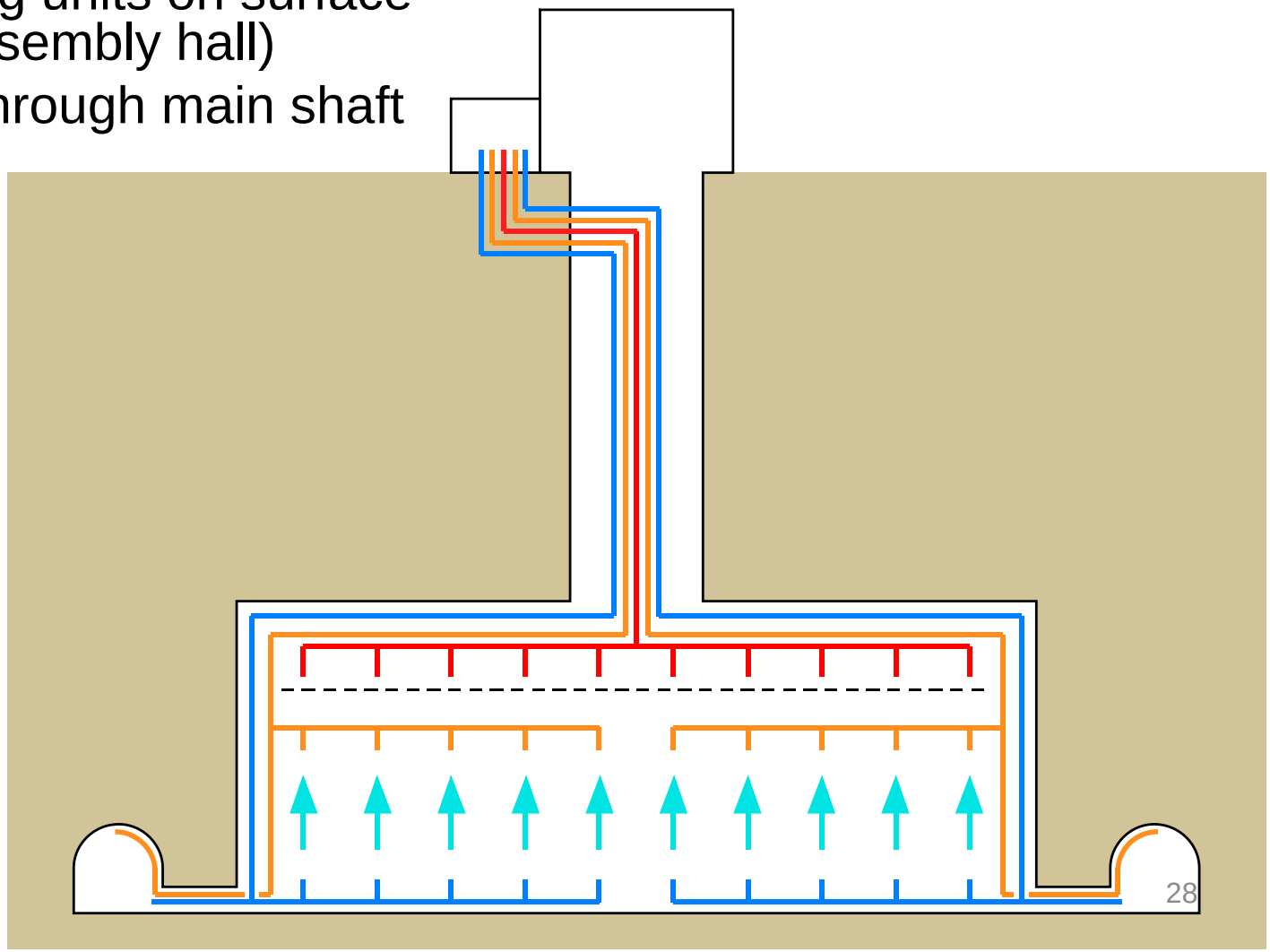
- Normal water
  - Magnet (Solenoid, QD0, QF1) power supply
  - Dump resister (after quench)
  - Precision chillers for sub-detector cooling systems
  - ~800kW→~1m^3/min if ΔT=10℃
- Chilled water
  - Electronics racks through fan-coil units
  - Sub-detector cooling system
  - ~700kW→~2m^3/min if ΔT=5℃
- High pressure due to Δh~100 m should be isolated from underground apparatus using heat exchanger (2-loop system)

Chilled water

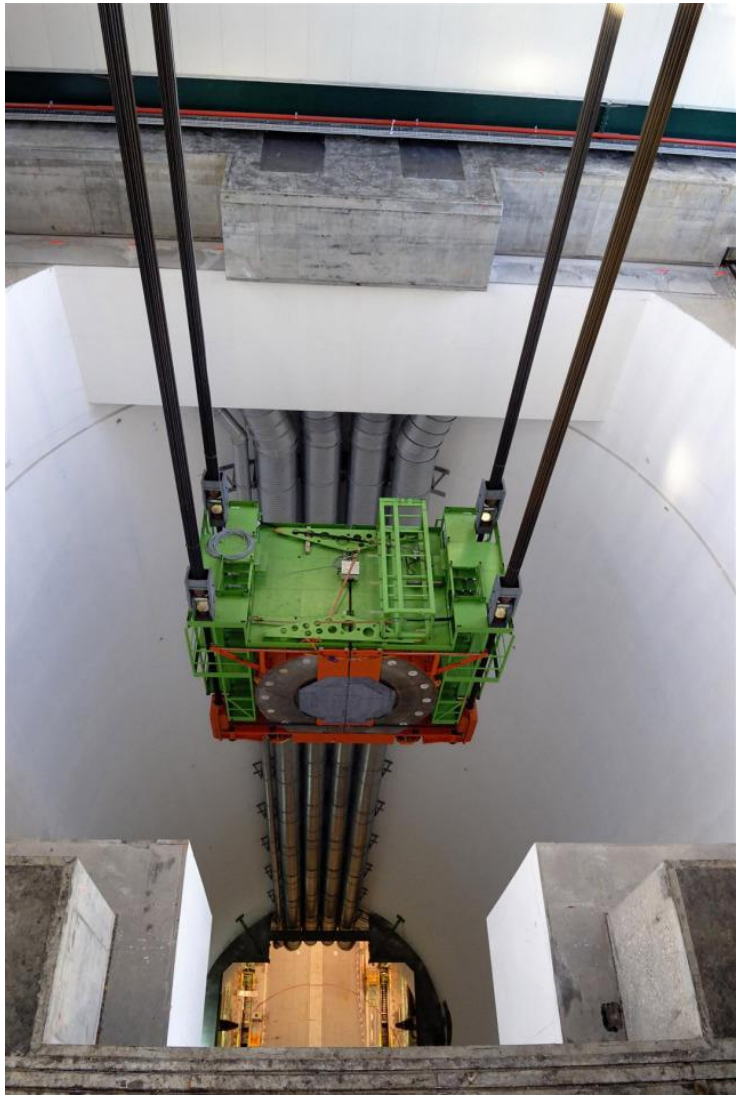


HVAC

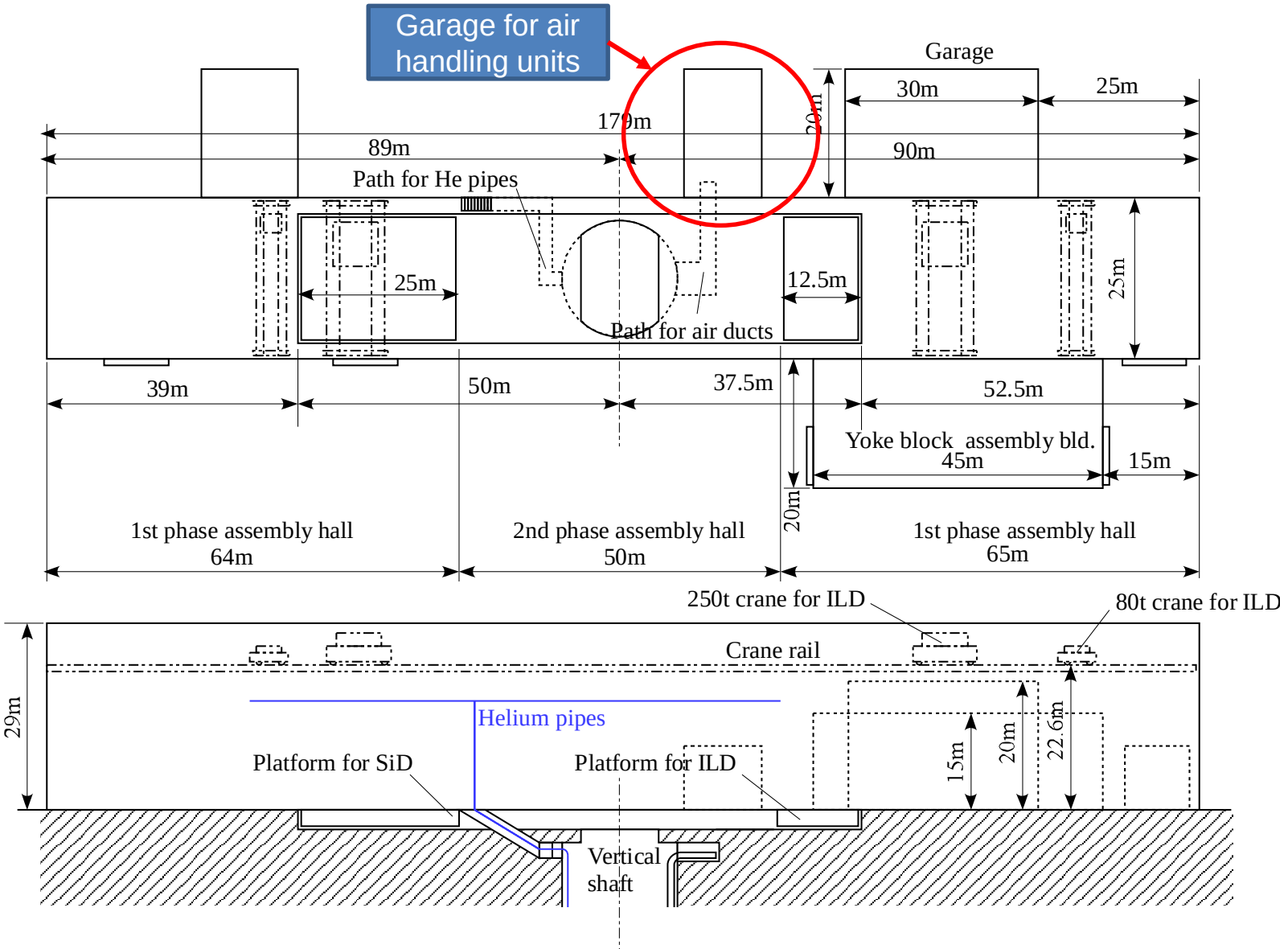
- Air handling units on surface (next to assembly hall)
- Air ducts through main shaft



HVAC - CMS



HVAC – Assembly Hall



Compressed air

- ~5MPa compressed air is necessary for air-pads
- ~1MPa compressed air might be necessary for control and tools
- Compressor on surface
- Buffer tank in service cavern?

Space requirement for service/utility cavern

- Preliminary guess (ILD only)

	Width (m)	Depth (m)	Number	Area (m^2)
Heat exchanger	1	3	6	18
Water pump	1	3	6	18
Transformer	6	4	1	24
Air buffer tank	3	3	2	18
Sub-det cooling system	5	3	10	150
Laser system	3	3	1	9
Electronics racks	1.2	3	60	216
Duct/cable tray	25	1	1	25
WC	10	3	1	30
Workshop	10	3	1	30
Total				**538**

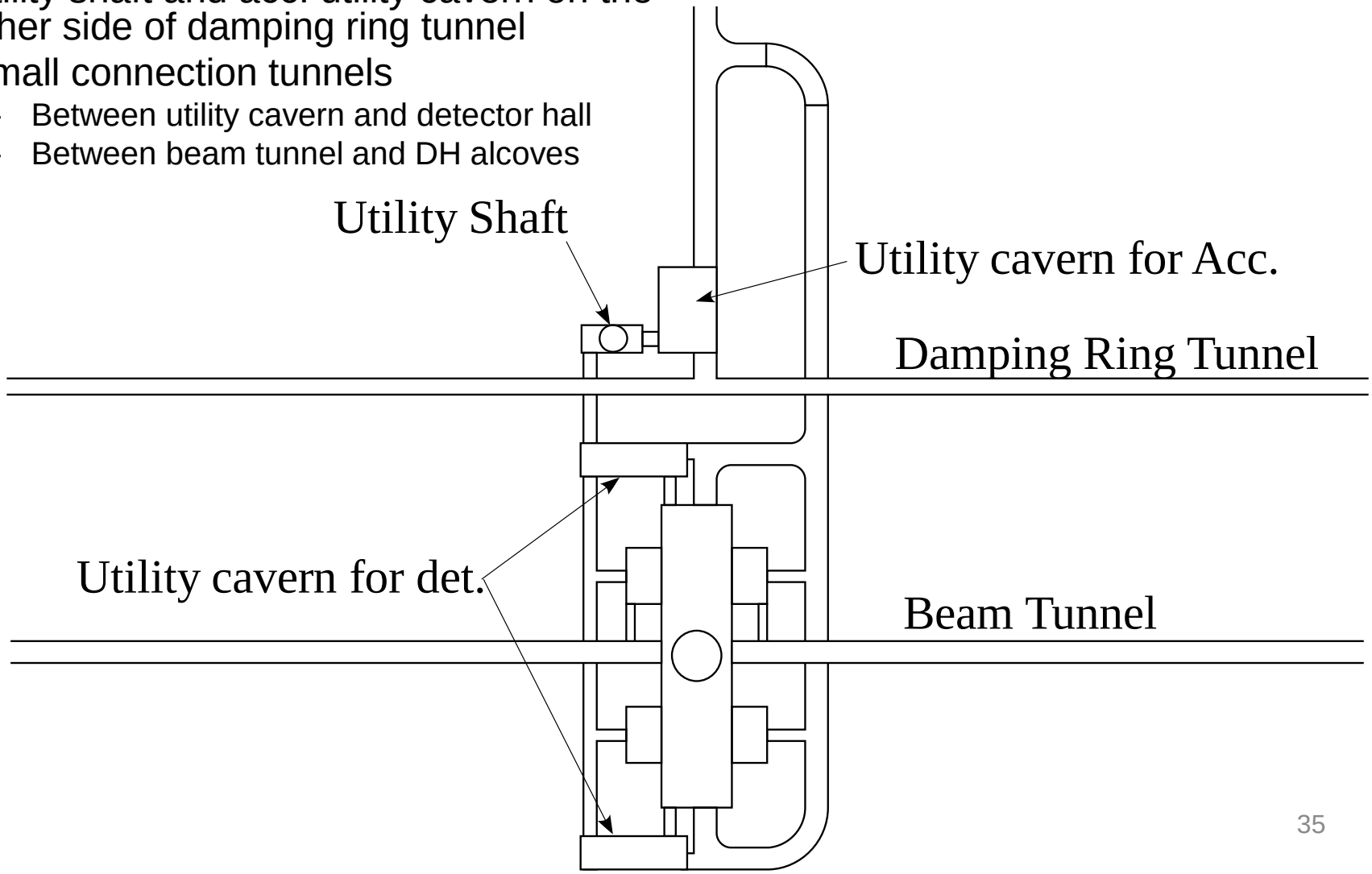
Space requirement for service/utility cavern

- More than 1000m^2 space might be necessary for utility/service caverns for ILD and SiD
- Alternative design by Tohoku team does not have enough space for detector utilities and services
- It is much more preferable to build utility/service caverns for accelerator, ILD, and SiD separately

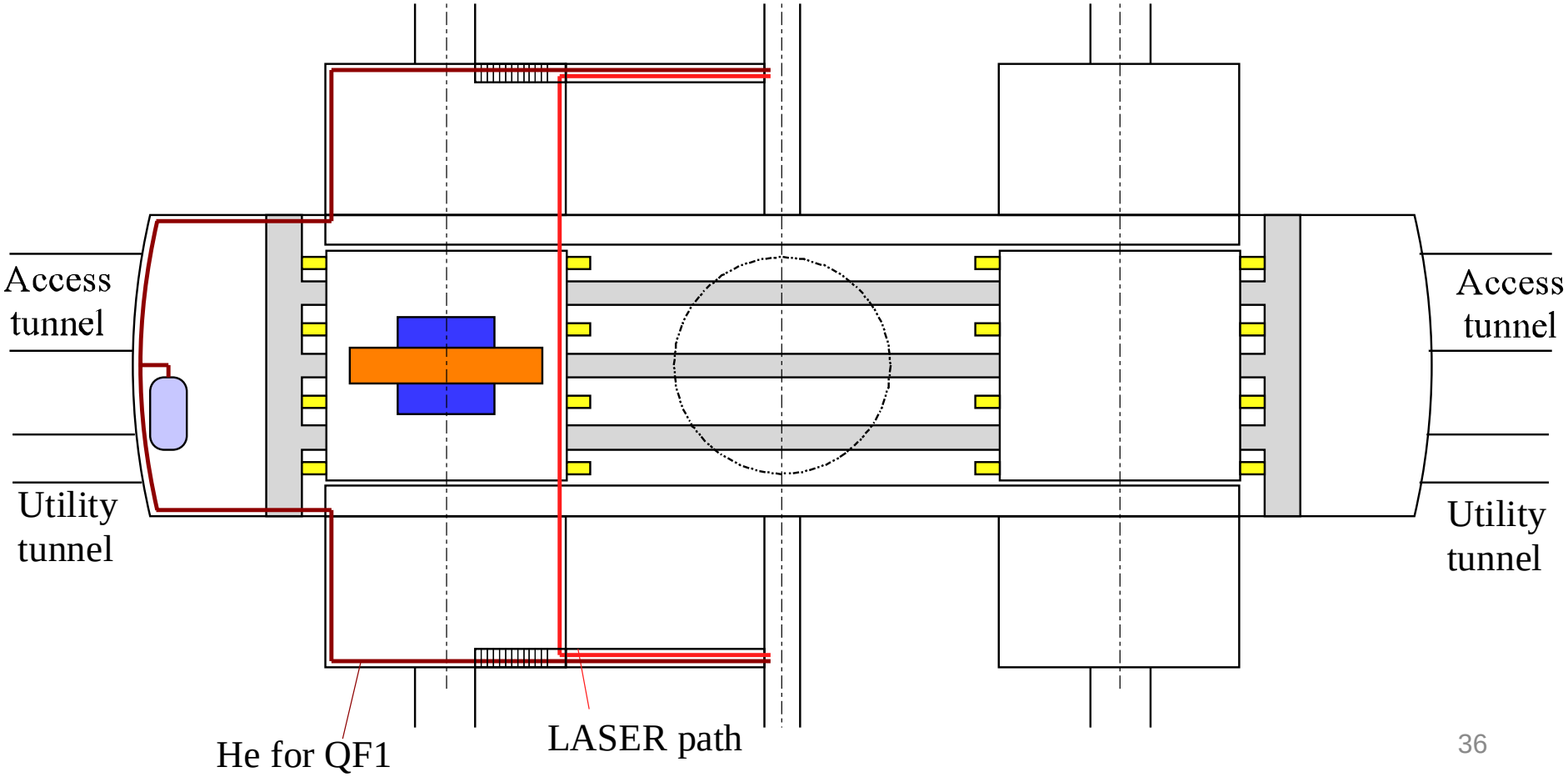
COUNTER PROPOSAL

Counter proposal

- Separated utility caverns
- Utility shaft and acc. utility cavern on the other side of damping ring tunnel
- Small connection tunnels
  - Between utility cavern and detector hall
  - Between beam tunnel and DH alcoves



Small connection tunnels

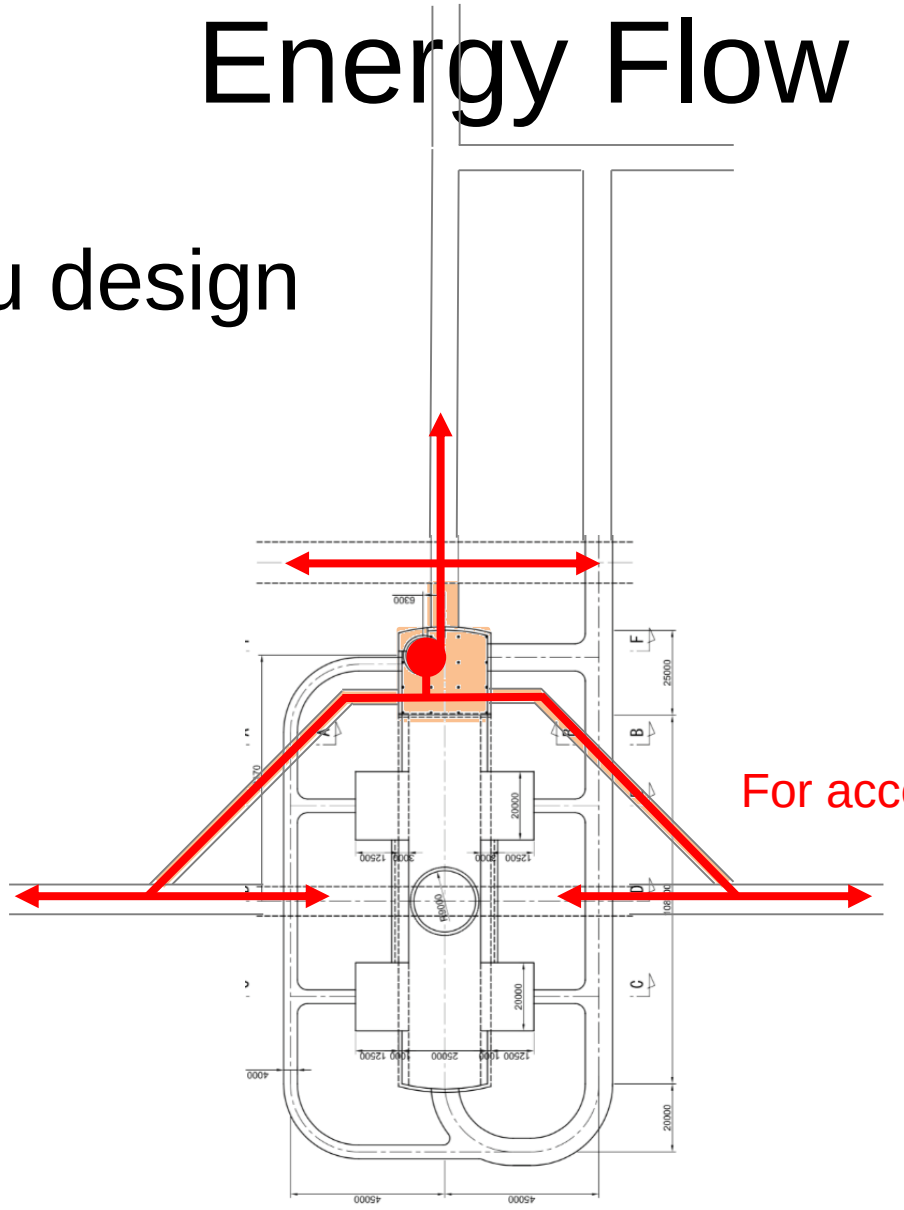


Pros and cons

- Merits
  - Larger space for detector services/utilities
  - Vibration source is far from IP
  - Each utility/service caverns and elevator hall can be separated by firewalls
  - Less confusion in designing, construction, and operation
- Demerits
  - Elevator is far from DH (You have to walk longer)

Energy Flow

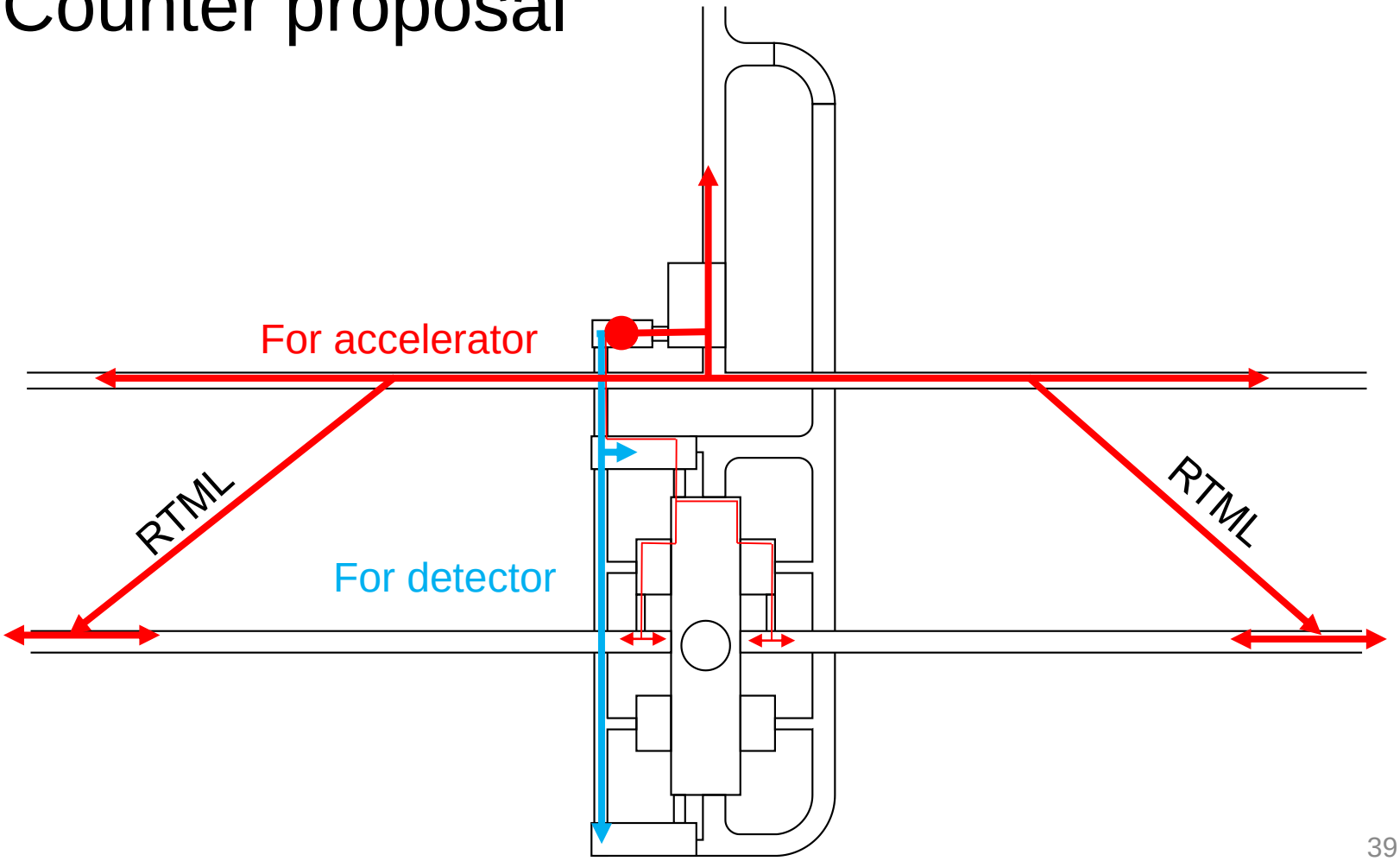
- Tohoku design



For accelerator only

Energy Flow

- Counter proposal

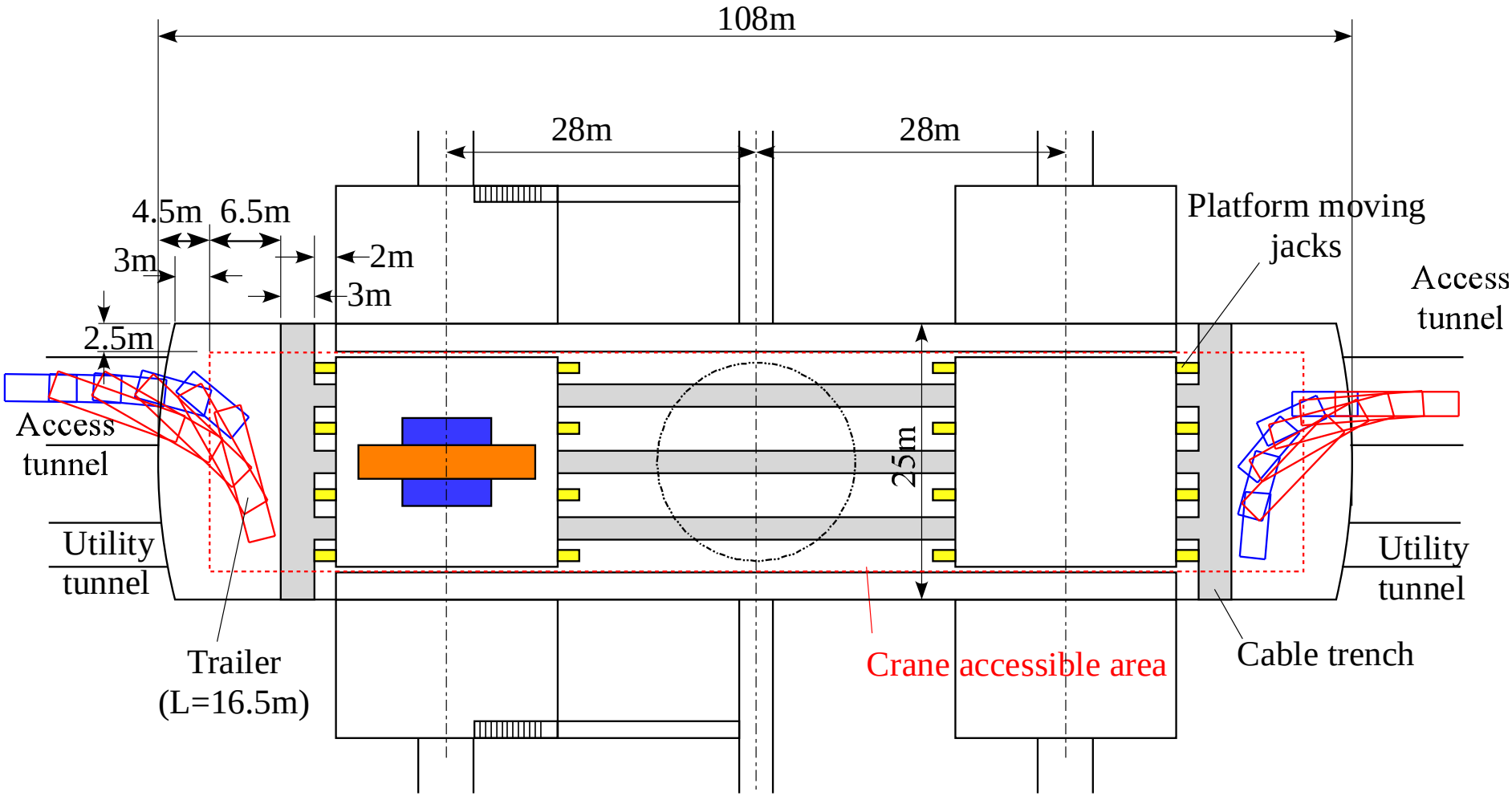


Summary

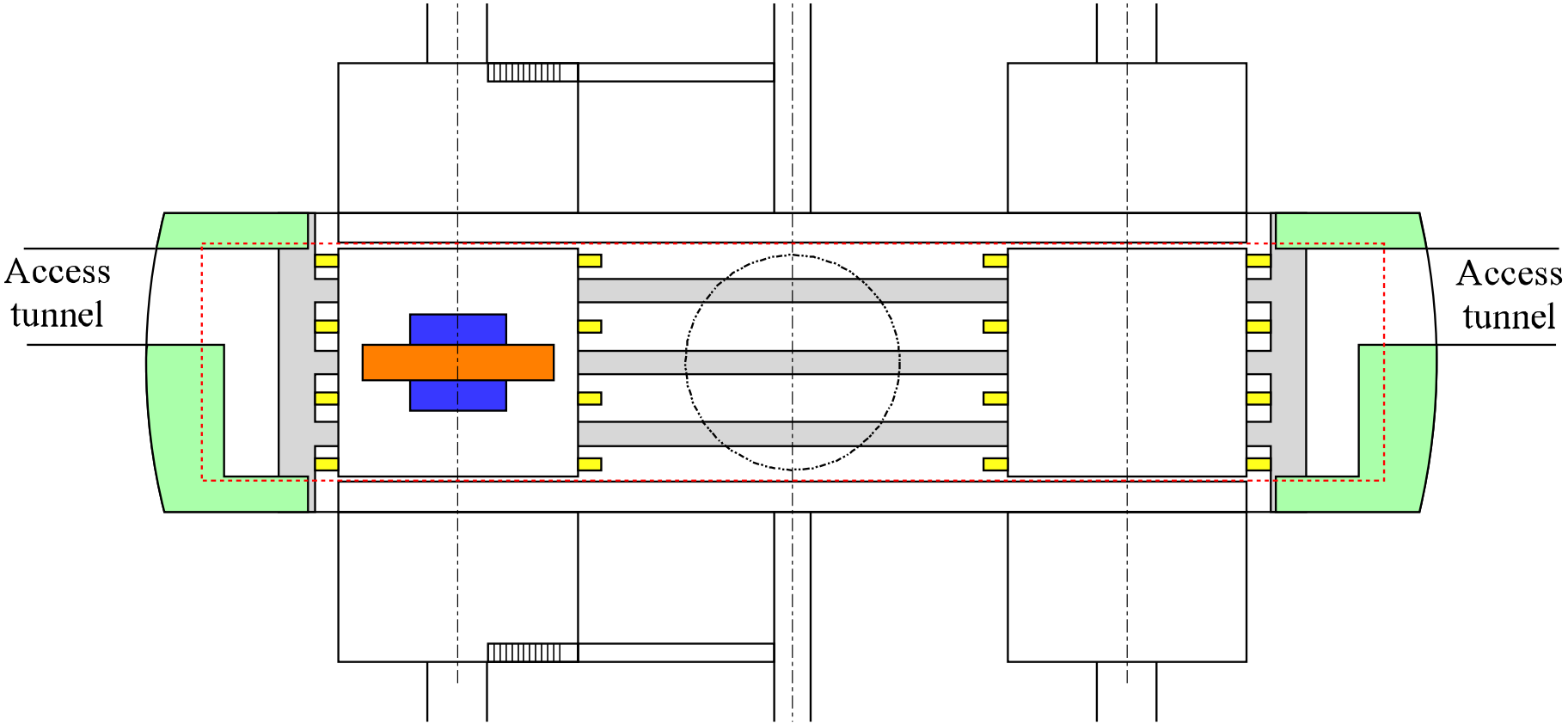
- Alternative design of Utility Hall was proposed by Tohoku team, but detector service/utility was not considered in that design
- Motivated by that design, study on the requirement for utilities for detectors has been started
- A possible counter proposal of the utility caverns has been presented
- **Anyway, each sub-detector group should think about necessary services and utilities**
  - **Number of electronics racks**
  - **Space and cooling water for sub-detector cooling system**
  - **Total AC power (voltage and current)**
  - **Chamber gas system**
  - **LASER alignment/calibration system**
  - **etc.**

BACKUP SLIDES

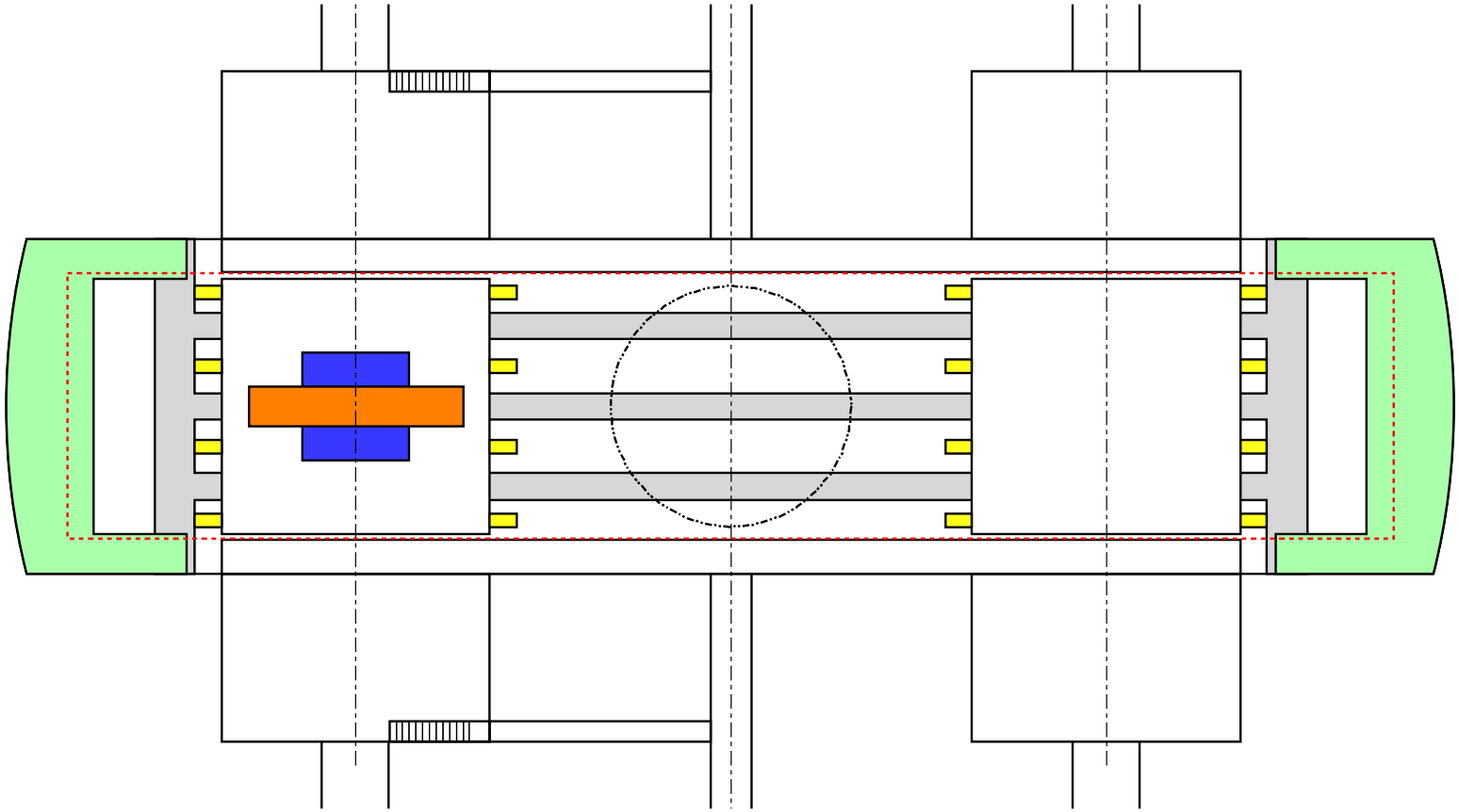
Utility gallery



Utility gallery

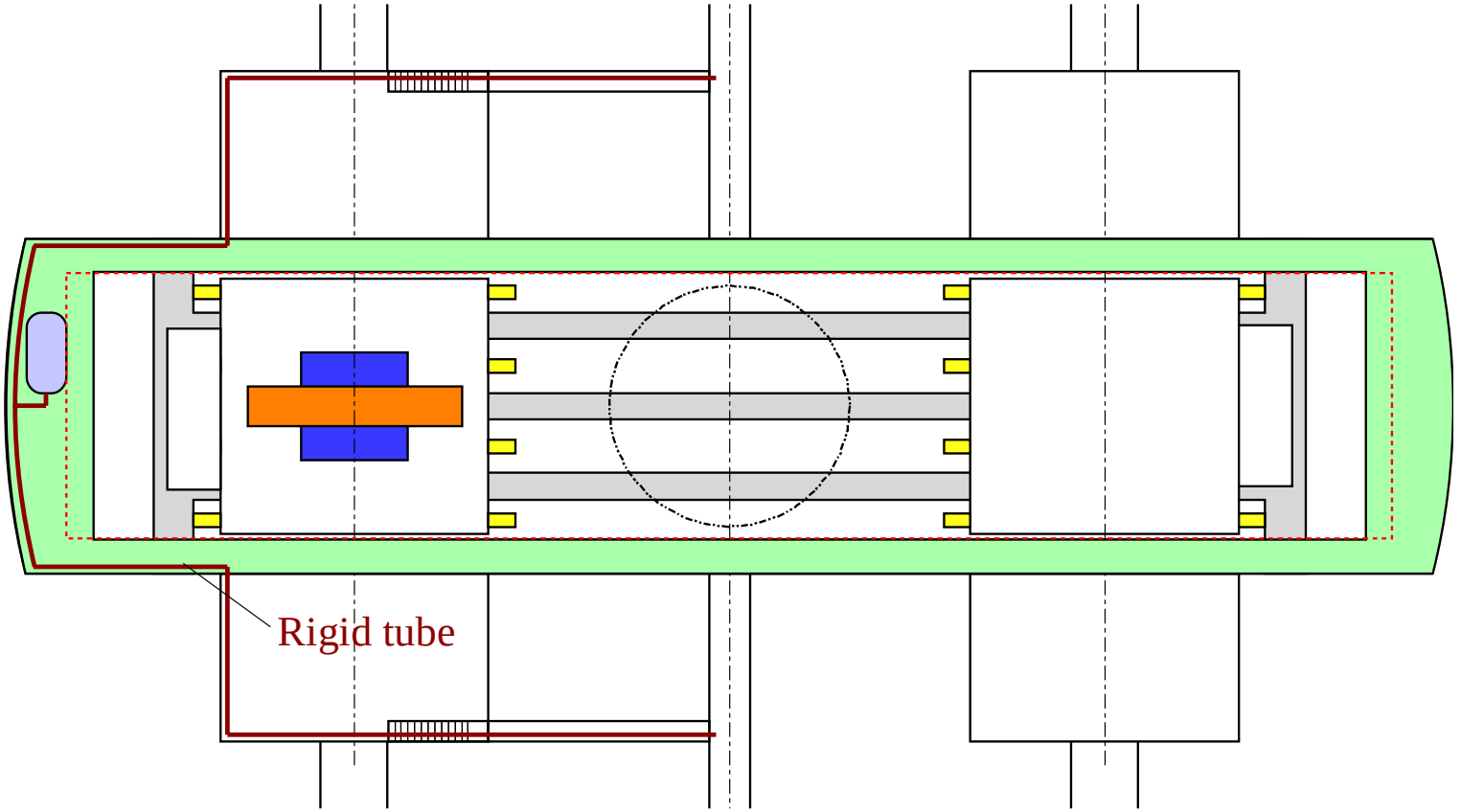


Utility gallery



3-5F

Utility gallery



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