Detector Utility Requirements

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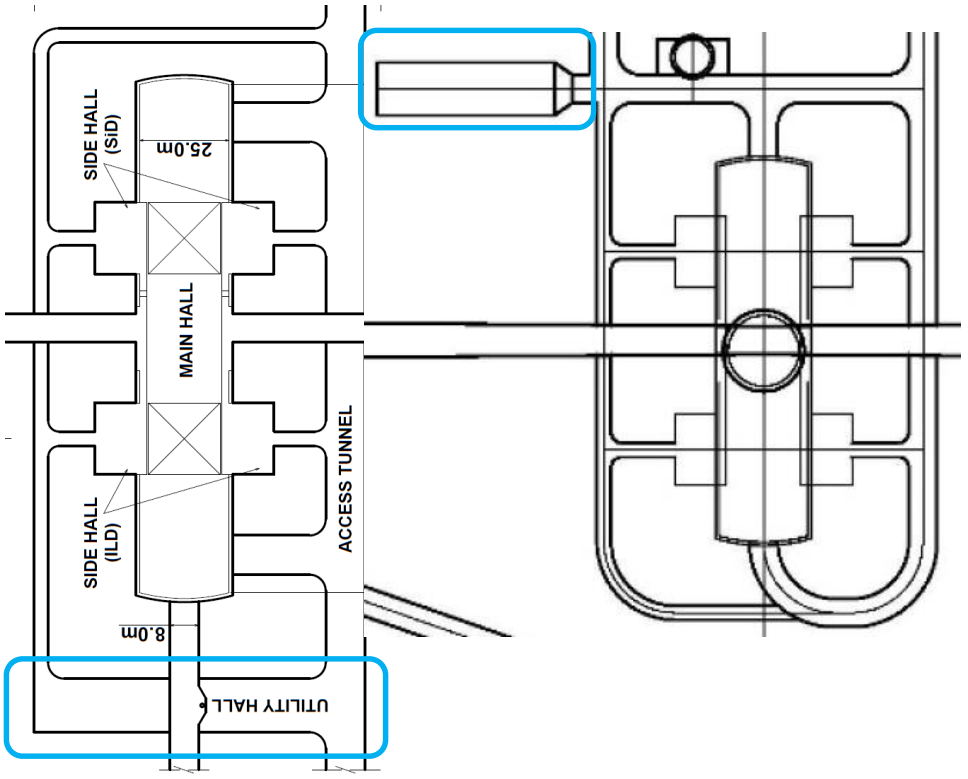
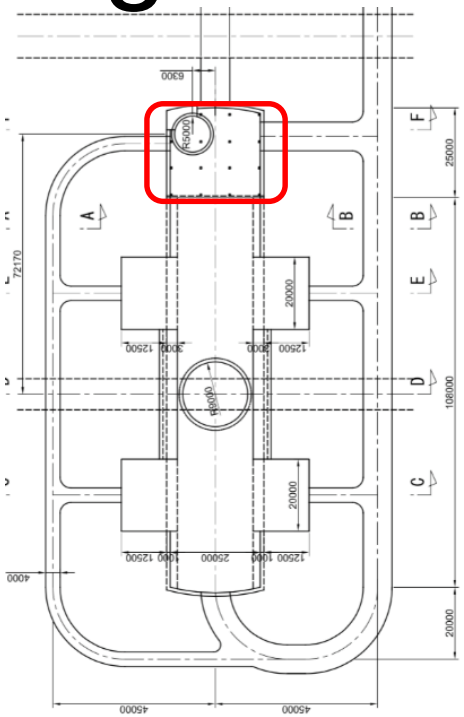
INTRODUCTION

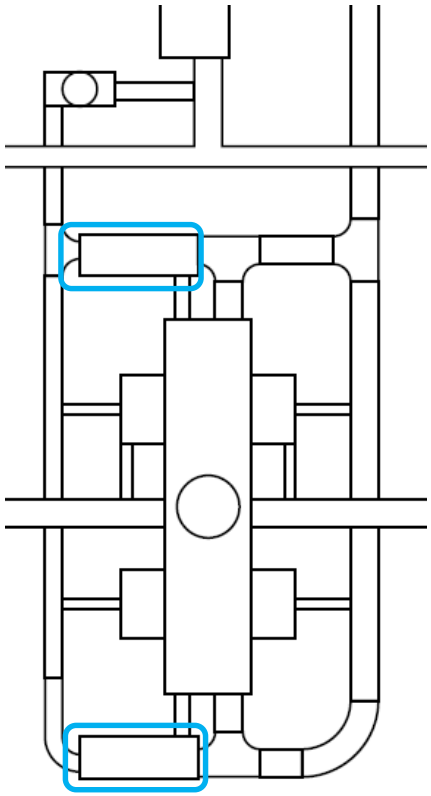
Utility Cavern at IR

- Several designs have been proposed for Utility/Service Cavern (USC) at IR
- However, requirements for the utilities to be put in USC have not been considered well
- We have to clarify the requirements from detector side to make a consistent design of USC
  - SiD made a rough estimate in 2012
  - ILD is surveying requirements from sub-detector groups

USC designs







TDR
- 1200 m^2
- Asymmetric wrt detectors
- Obsolete

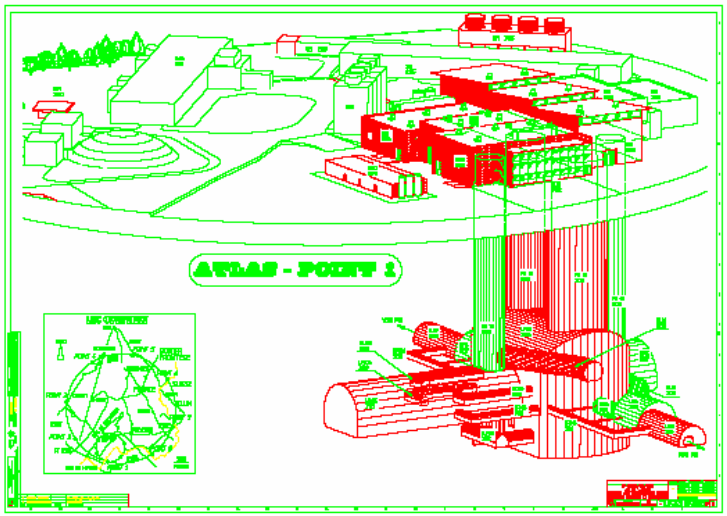
TDR-Mod
- 750 m^2
- Asymmetric wrt detectors
- Dead-end

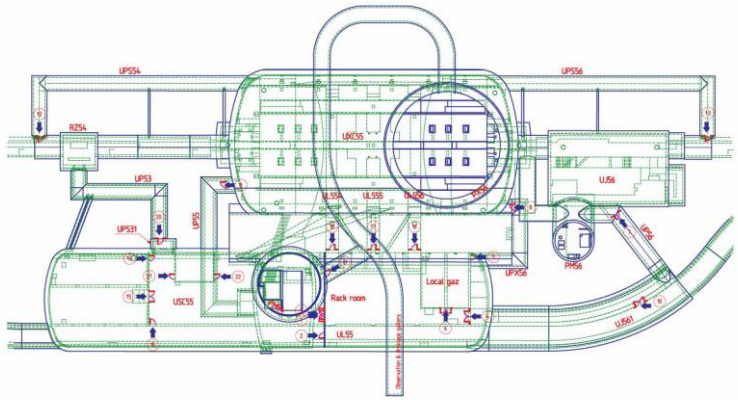
Tohoku design
- Utilities for accelerator only

Proposal by Y.S.
- 408 m^2 x2
- Symmetric wrt detectors

Comparison with LHC exp.

- 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





How much space do we need for ILC experiments?

ELECTRICITY

Basic concept

- On surface: 275(154)kV → (66kV) → 6.6kV
- 6.6kV AC is sent to underground USC through Utility Shaft
- In USC: 6.6kV → 400(3ϕ) / 200(3ϕ,1ϕ) / 100V(1ϕ)
- Power dissipation is eventually extracted by cooling water (→ cooling tower on surface)

Tentative estimation for ILD

Item		Power (kW)			
QD0/QF1/Crab cavity	Power supply	50			
	Cold box	150			
	He Compressor	300	(Surface)		
Detector Solenoid	Power supply	250			
	Cold box	50			
	He Compressor	500	(Surface)		
Sub-detector			FEE	BEE	Cooling
	Muon	10	5	5	
	HCAL	28	22	6	
	ECAL	38	18	12	8
	VFC	7	2	5	
	SET	7	2	5	
	TPC	19	12	5	2
	SIT	6	1	5	
	FTD	6	1	5	
	VTX	13	1	2	10
Computer farm		1000	(Surface)		
Water pump		25	(11kWx2+3.7kW)		
HVAC		600	(Surface, CMS)		
Lighting		25			
Air compressor		50	(Surface)		
Platform mover		100			
Crane for ILD	5t x 3	21			
	40t	50			
Total		3305			
Underground		**1155**			

Sub-detectors:

- Y.S.'s guess (based on TDR description, if exists) except for HCAL, ECAL, and VTX

Not listed:

- Infrastructure in assembly halls
- Computers for rec/ana/sim.
- Office building
- Cooling tower and chiller on surface

Comparison with other study

	CMS	CLIC	SiD	ILD
Detector Solenoid	900	900	294	800
QD0/QF1/CC	NA	NA	NA	500
FEE	600	<10	12	64
BEE	650	<10	70	50
PC farm	800	1000	NA	1000
DH utility	NA	NA	105	246
Cooling	850	750	NA	45
HVAC	600	600	NA	600
Sum	4400	3250	481	3305

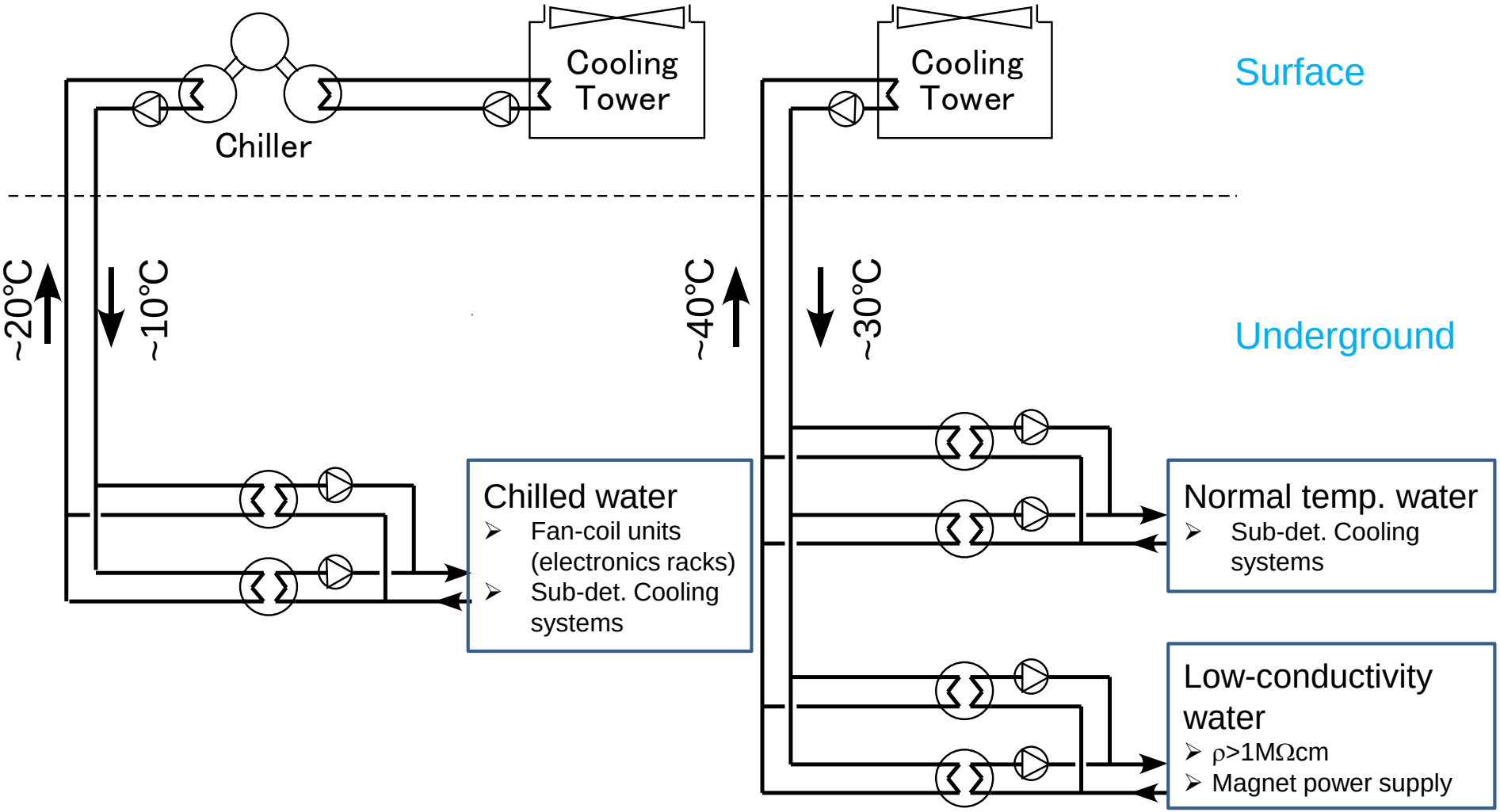
- He compressor is not included in SiD Detector Solenoid
- Cranes and lighting are not included in SiD DH utility
- CMS and CLIC data is taken from LCD-Note-2013-011

COOLING WATER

Cooling water

- Two types of water are supplied from surface
  - Normal temp. water: T~30 ℃
  - Chilled water: T~10 ℃ (TBD)
  - High pressure due to Δh~100m can be isolated by heat exchangers in USC
- Sub-detectors are cooled by sub-detector cooling systems
  - Coolant could be CO2, water, or something else
  - Sub-detector cooling systems are cooled by cooling water
- Electronics racks are cooled by fan-coil units
  - Cool air flow generated by chilled water removes heat, and returns to room temperature

Cooling water



Requirement

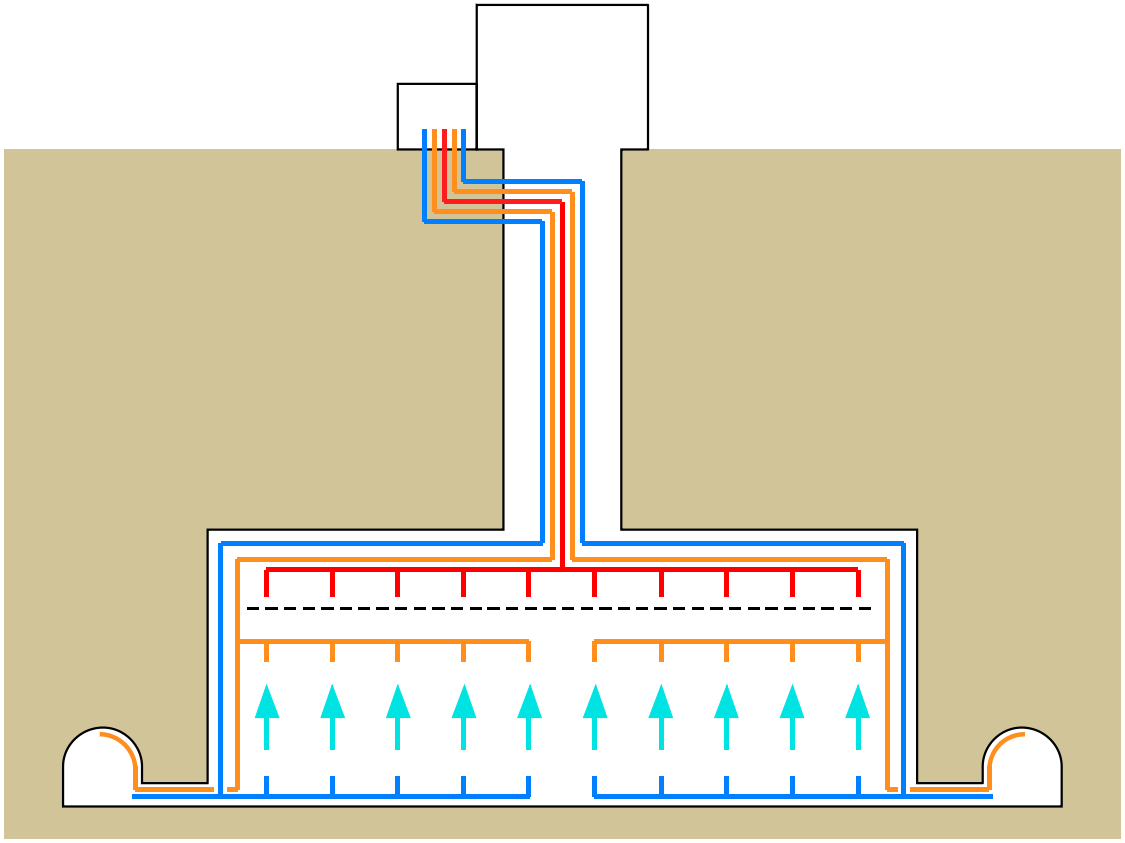
- Cooling water for underground facilities

		Chilled Water			Low-conductive Water			Normal Water			
Item		Heat (kW)	dT	Flow (L/min)	Heat (kW)	dT	Flow (L/m)	Heat (kW)	dT	Flow (L/m)	
QD0/QF1/CC	Power supply				50	10	71				
	Cold box				150	10	214				
Detector Solenoid	Power supply				250	10	357				
	Cold box				50	10	71				
Sub-detector	Muon	10	5	29							
	HCAL	28	5	80							
	ECAL	38	5	109							
	VFC	7	5	20							
	SET	7	5	20							
	TPC	5	5	14				14	5	40	NW for precision chiller
	SIT	6	5	17							
	FTD	6	5	17							
	VTX	2	5	6				11	5	31	NW for precision chiller
Pump		11	5	31	11	10	16	3.7	5	11	
Cubicle (AC transformer)		58	5	165							95% efficiency, FCU
Total		178		508	511		730	29		82	
Primary Loop		**Chilled Water**			**Normal Temperature Water**						
				508						**812**	

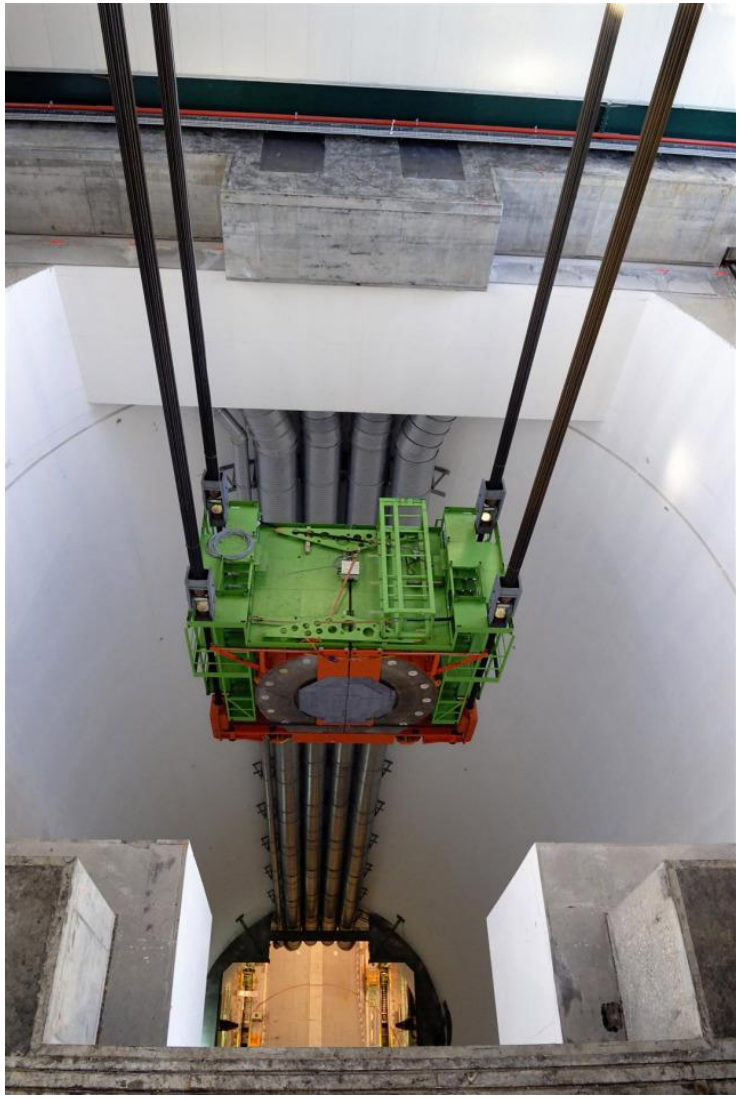
HVAC

HVAC

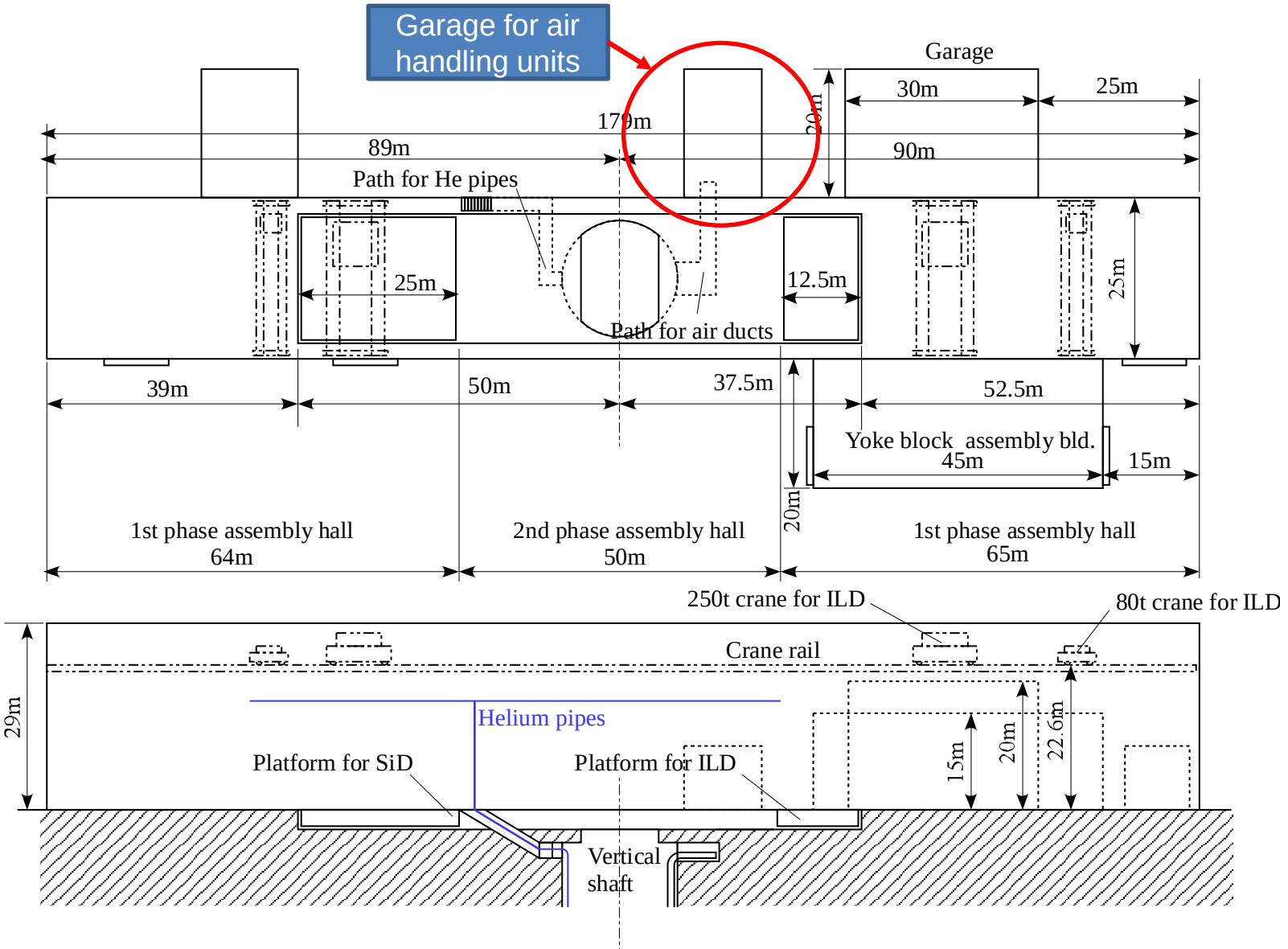
- Air handling units on surface (next to assembly hall)
- Air ducts through main shaft



HVAC - CMS



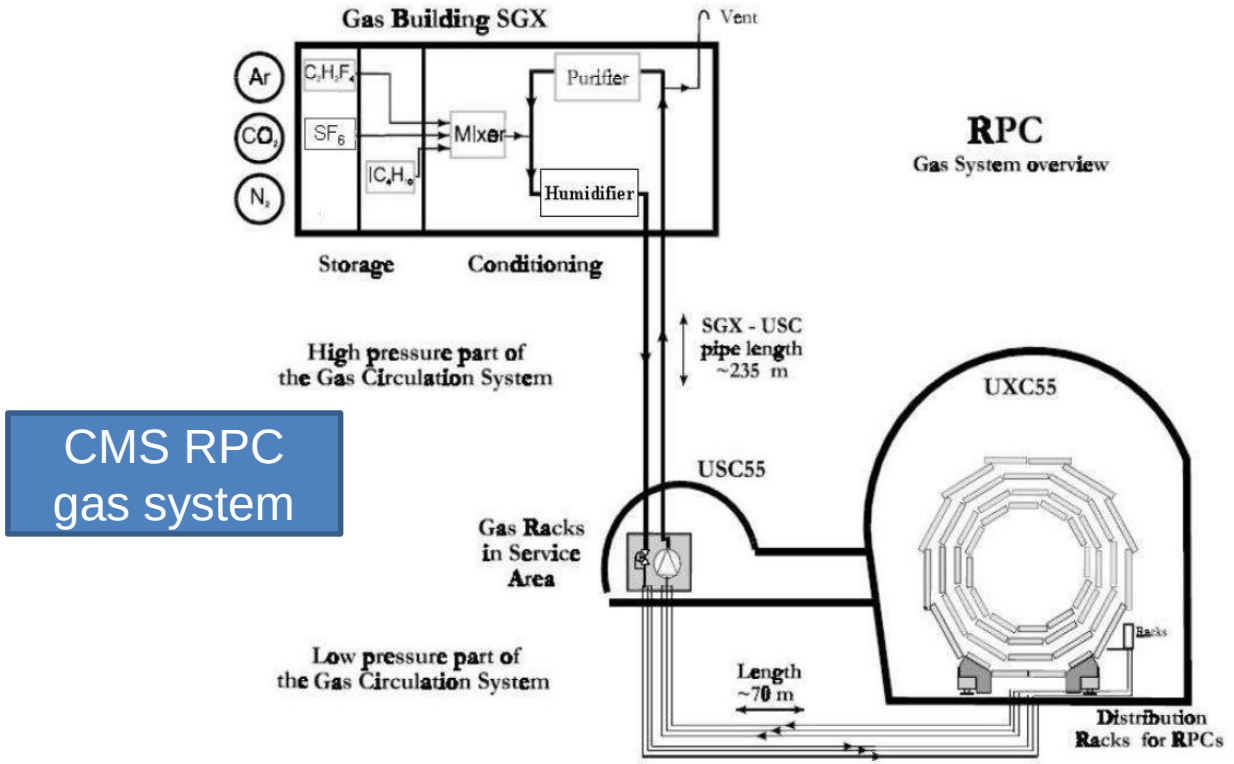
HVAC – Assembly Hall



OTHER SERVICES

Chamber gas

- Chamber gas is necessary for TPC and SDHCAL
- Gas storage on surface like CMS
- Gas system underground
  - TPC: Some space on the platform
  - SDHCAL: 4x4m^2 space in USC



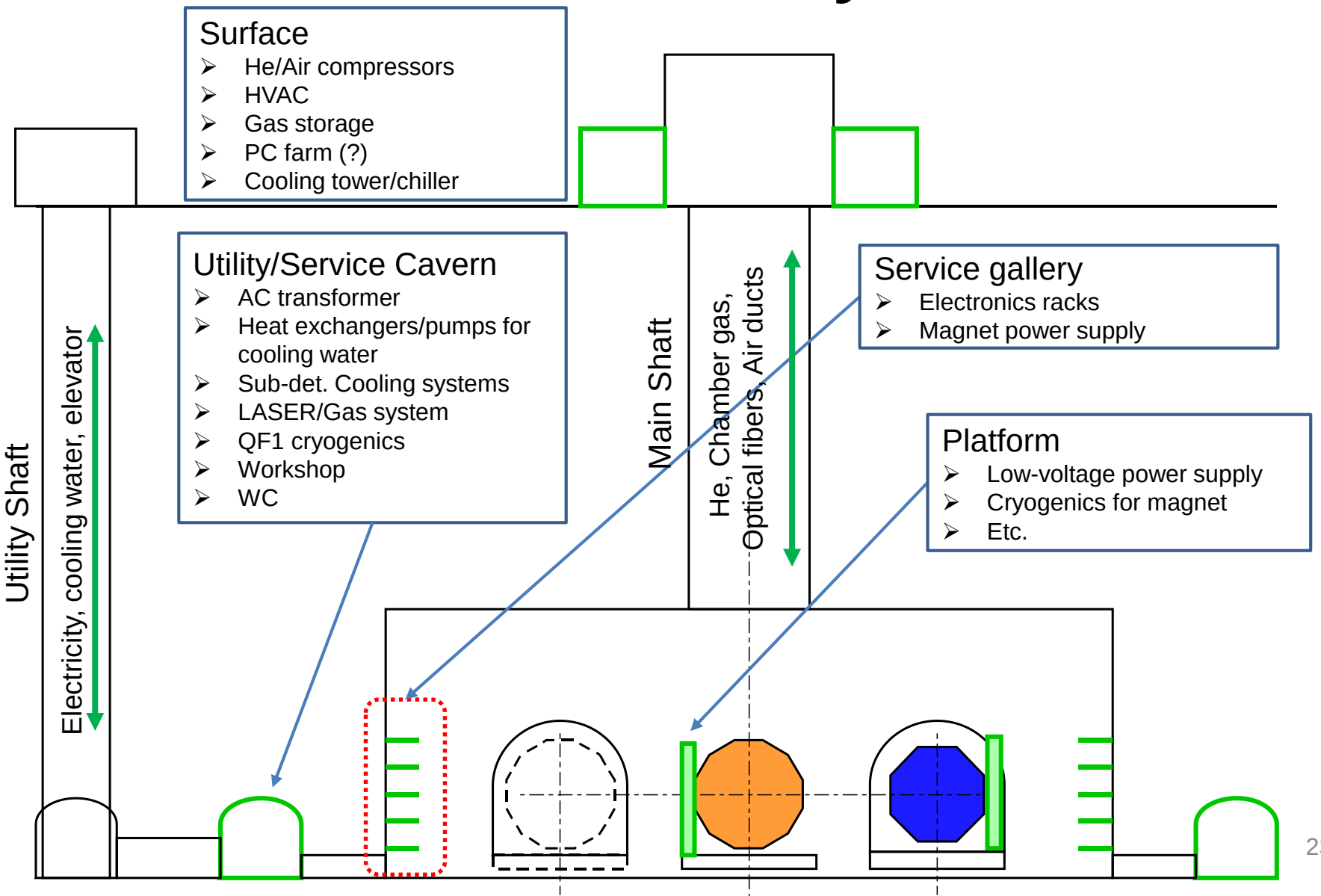
CMS RPC gas system

LASER system

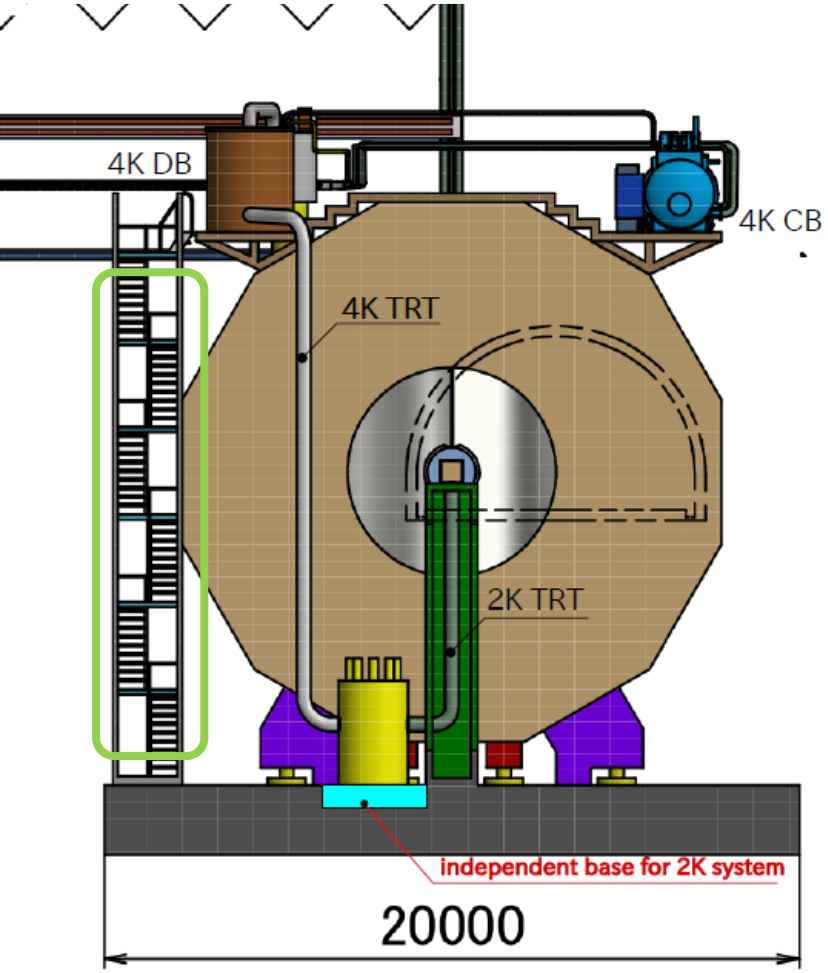
- Laser system will be used for tracker alignment and calorimeter calibration
- Laser light source requires isolated space

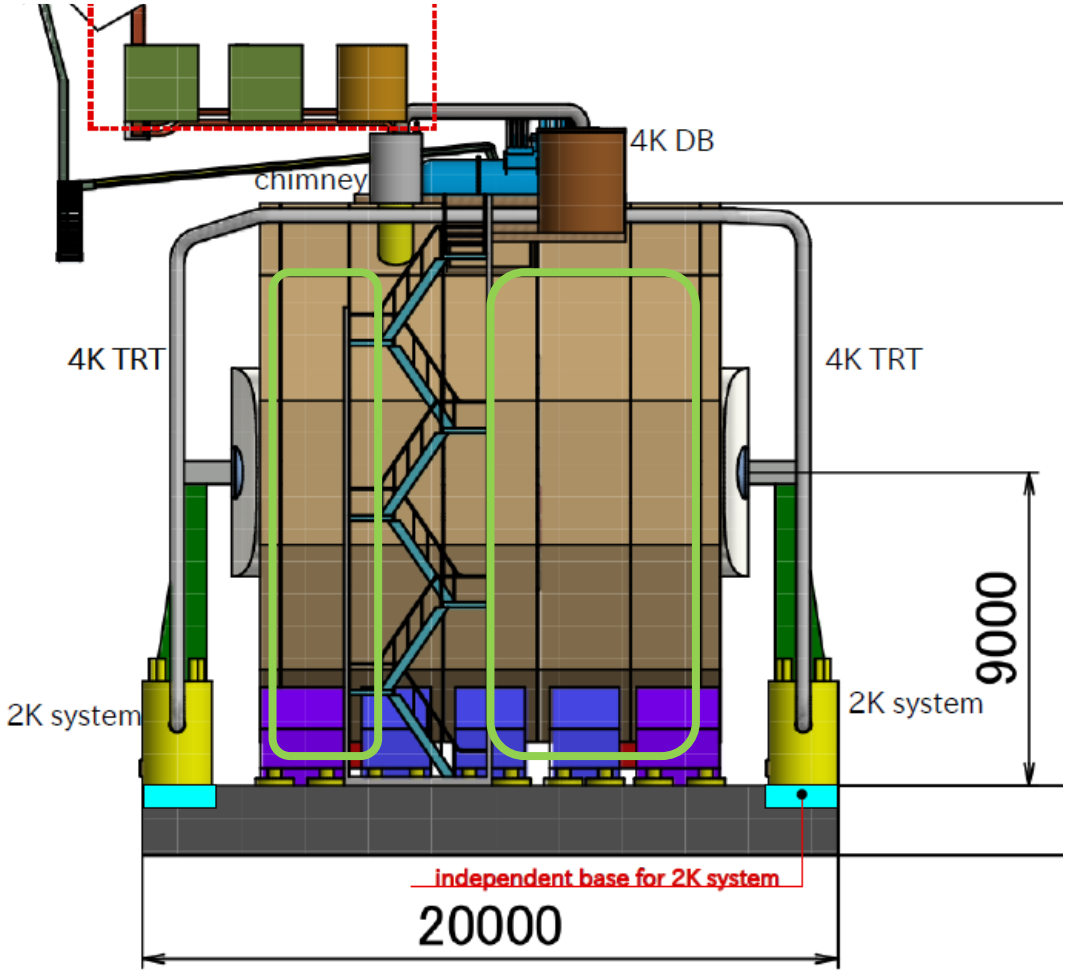
SPACE

Location of Utility/Service



Detector Platform

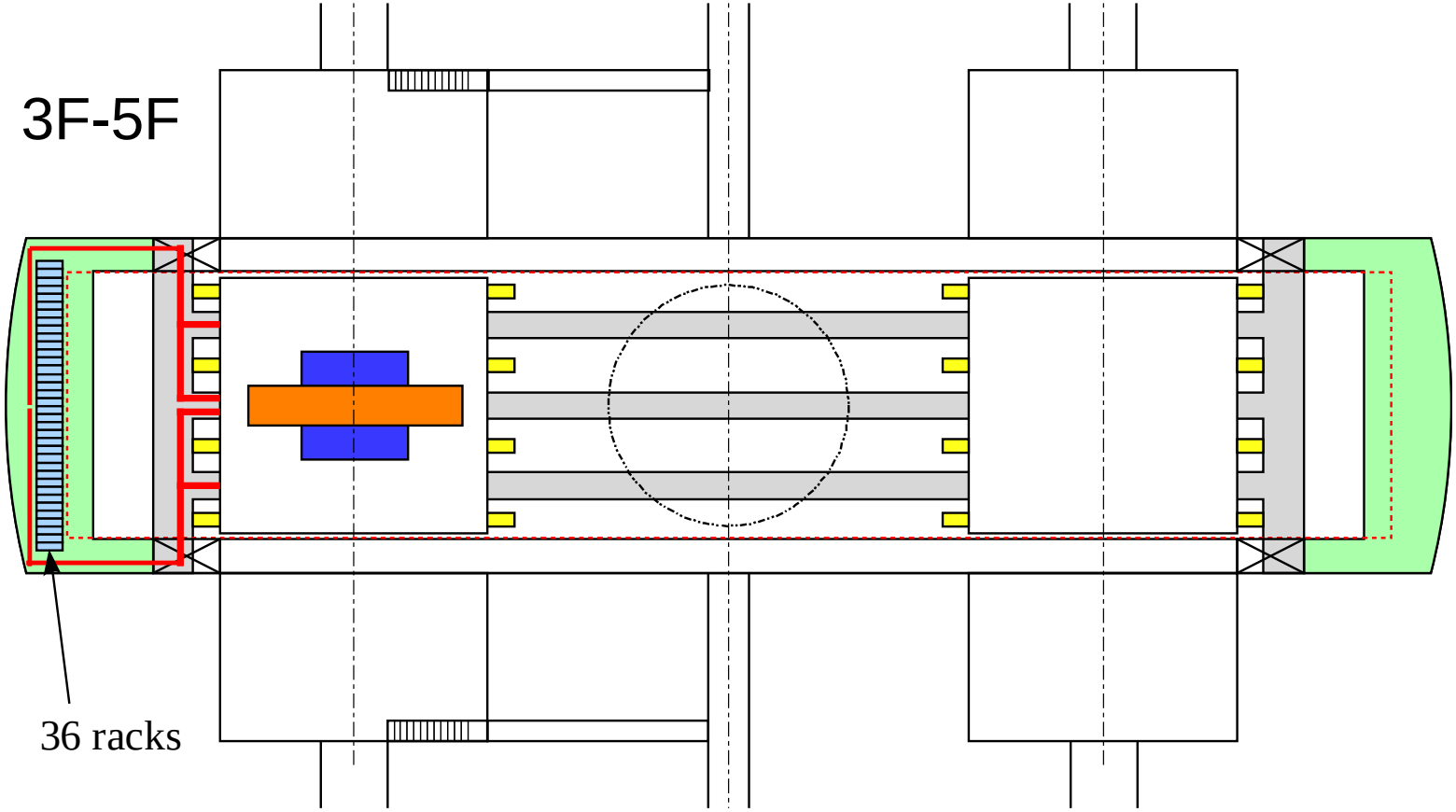




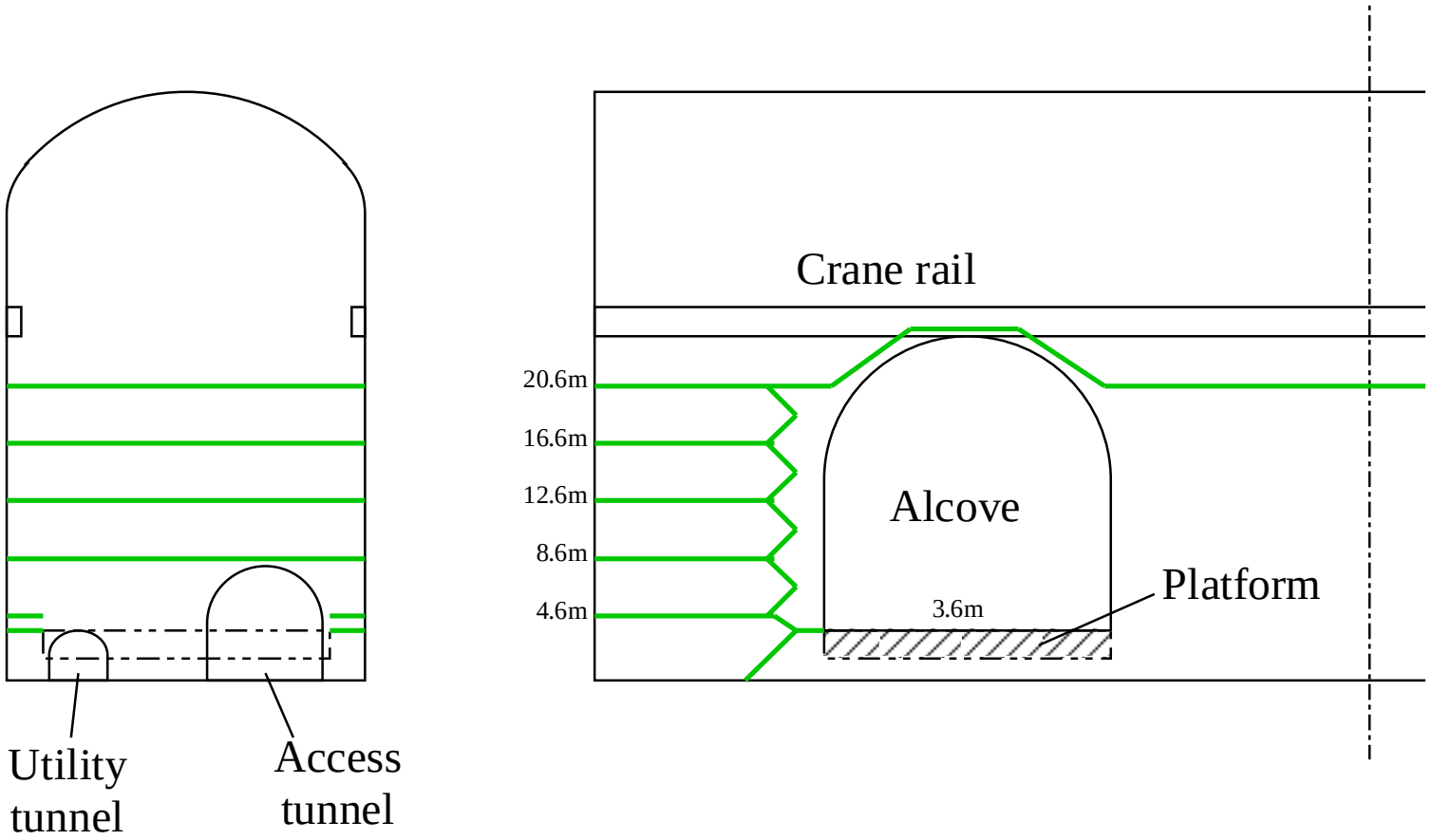
: Space for electronics racks

Service gallery

- 2F is just a path to platform
- 3F-5F are used for electronics racks (~100 racks can be put)
- 6F is for magnet power supply

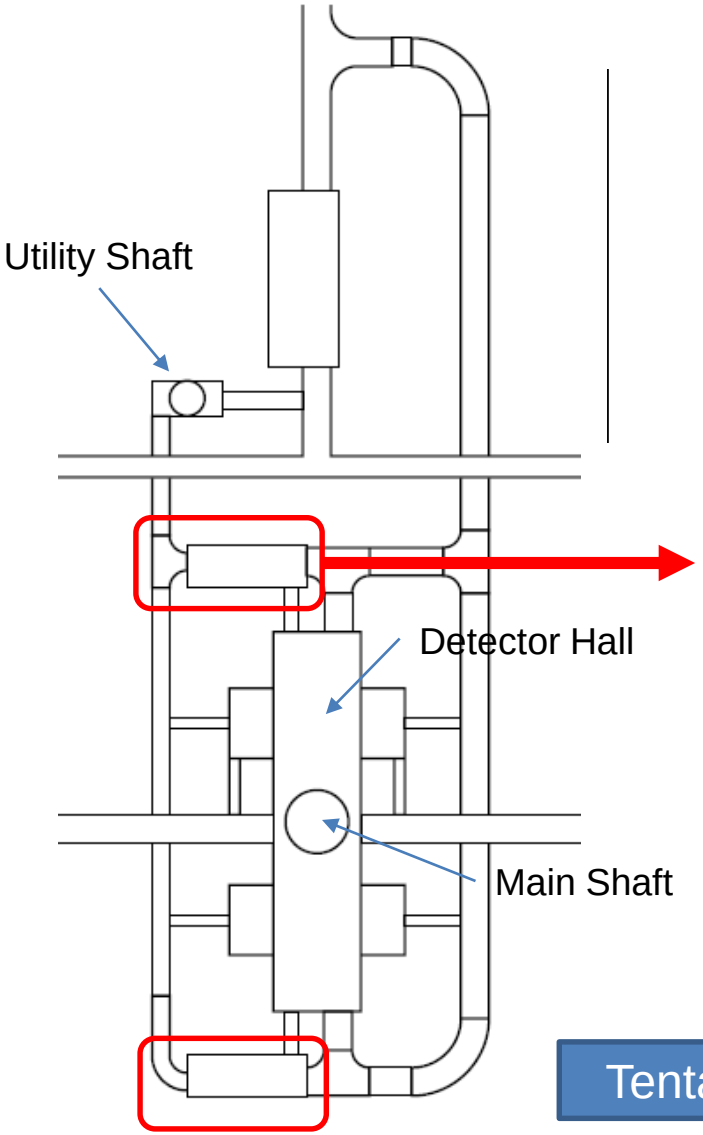


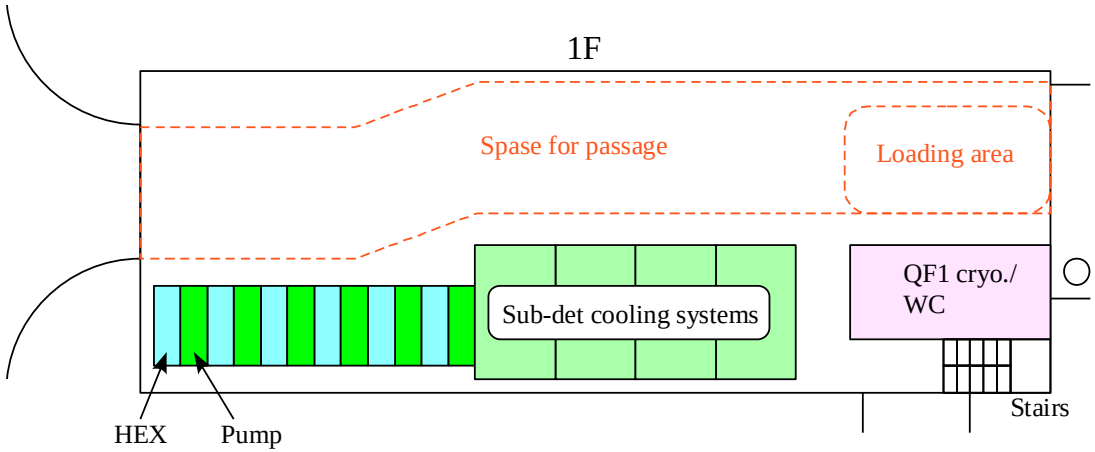
Service gallery

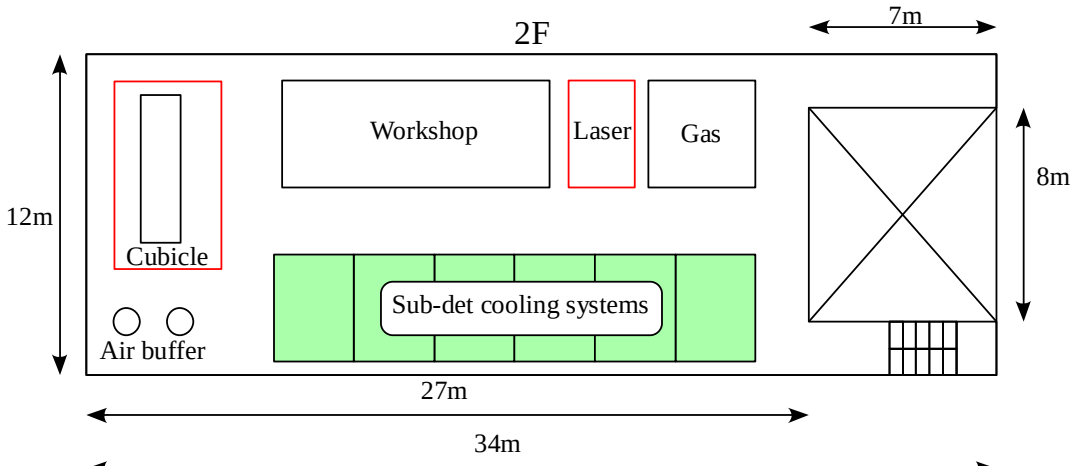


POSSIBLE CAVERN DESIGN

Utility/service cavern



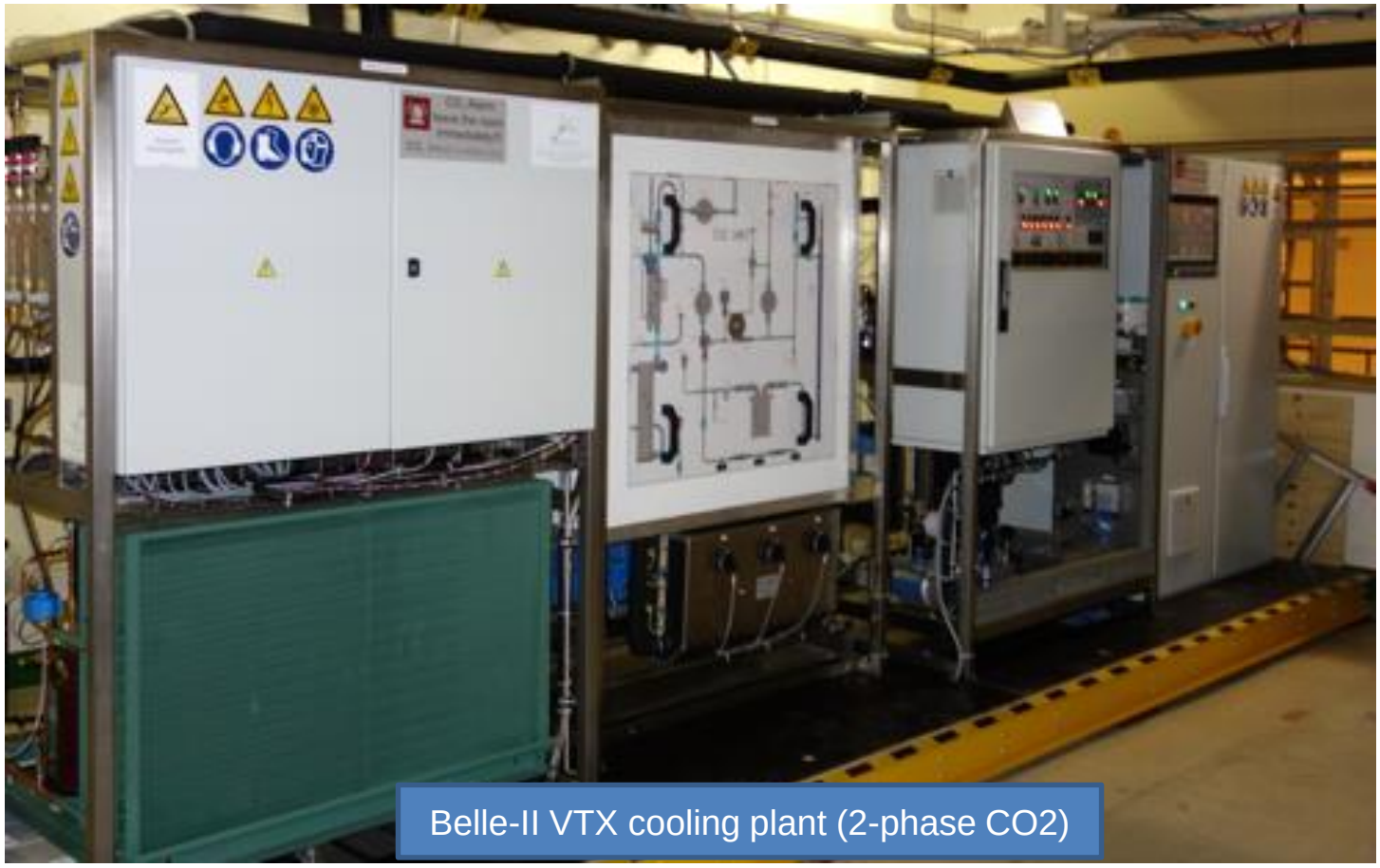




Tentative design

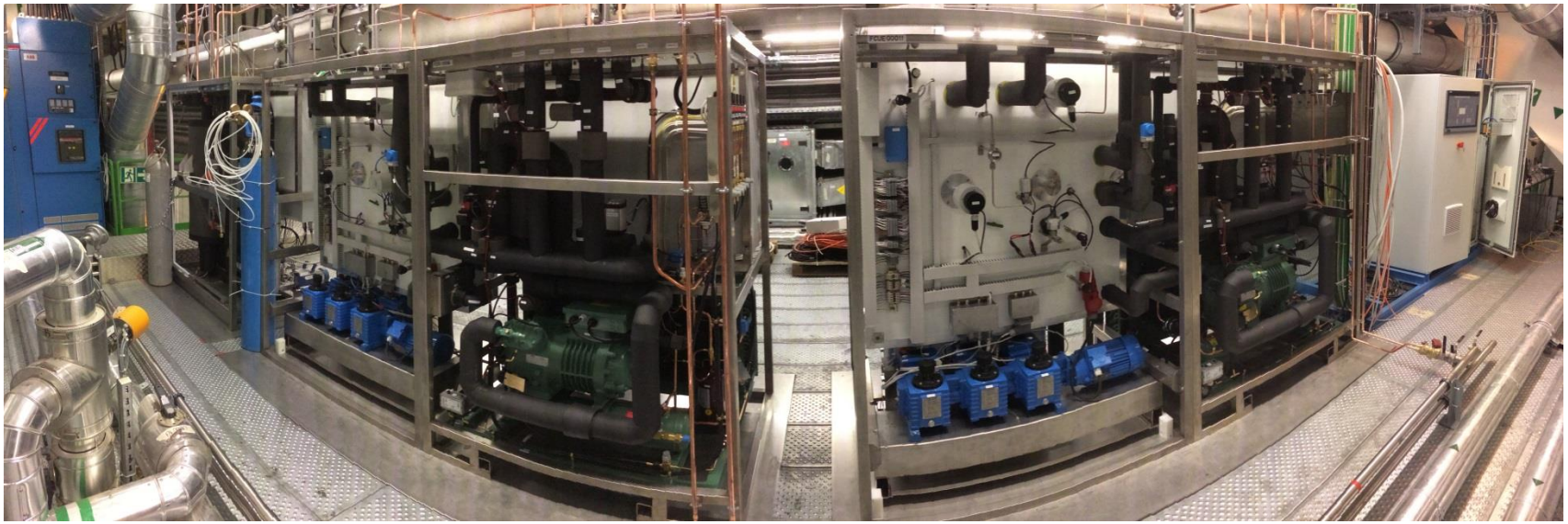
Sub-detector cooling plants

- Sub-detector cooling plants require quite large space
- Some of them (ECAL cooling system) have to be put on the level of 1F of DH or below



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

SUMMARY

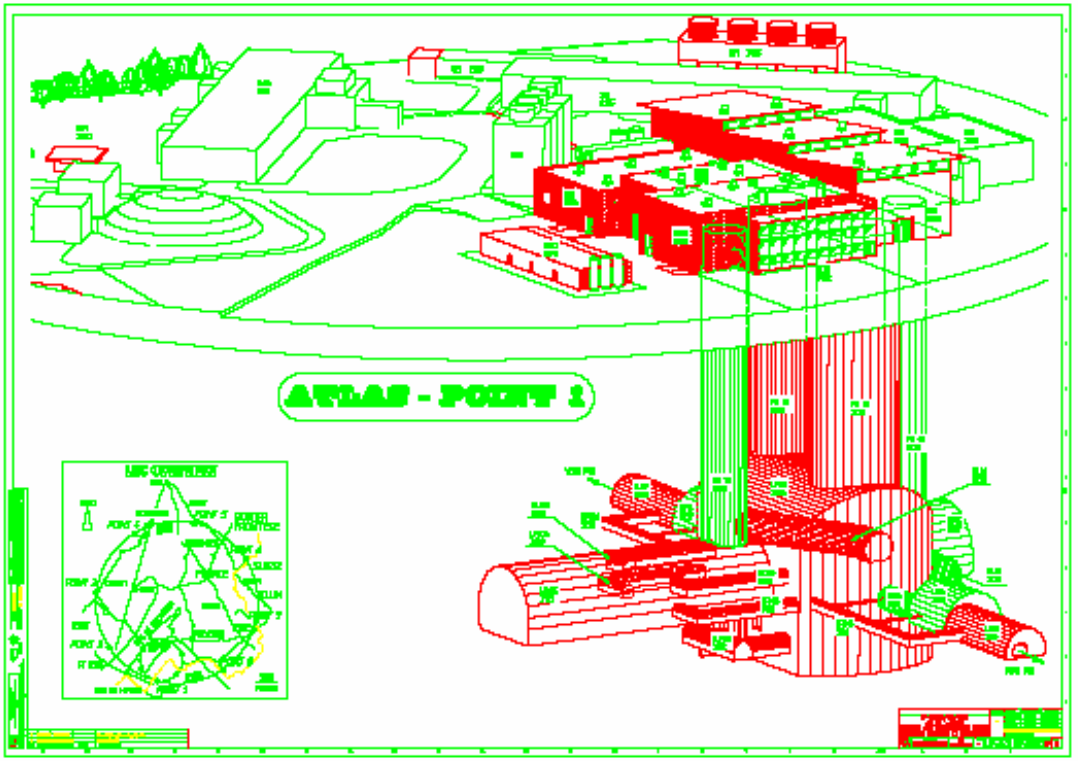
Summary

- We have started survey of utility requirement of ILD, and tentative estimation for power/water/space requirement has been made
- Although power consumption by subdetectors is O(100kW) or less, total underground power consumption is estimated as ~1.2 MW
- ~500 L/min chilled water and ~800 L/min normal temperature water should be sent to underground USC
- Much more power and cooling water would be necessary for surface facilities
- Y.S.'s proposal of 2x408m^2 USCs seems to have enough space for detector utilities, but we have to continue survey of power/water/space requirements to get more reliable numbers

BACKUP SLIDES

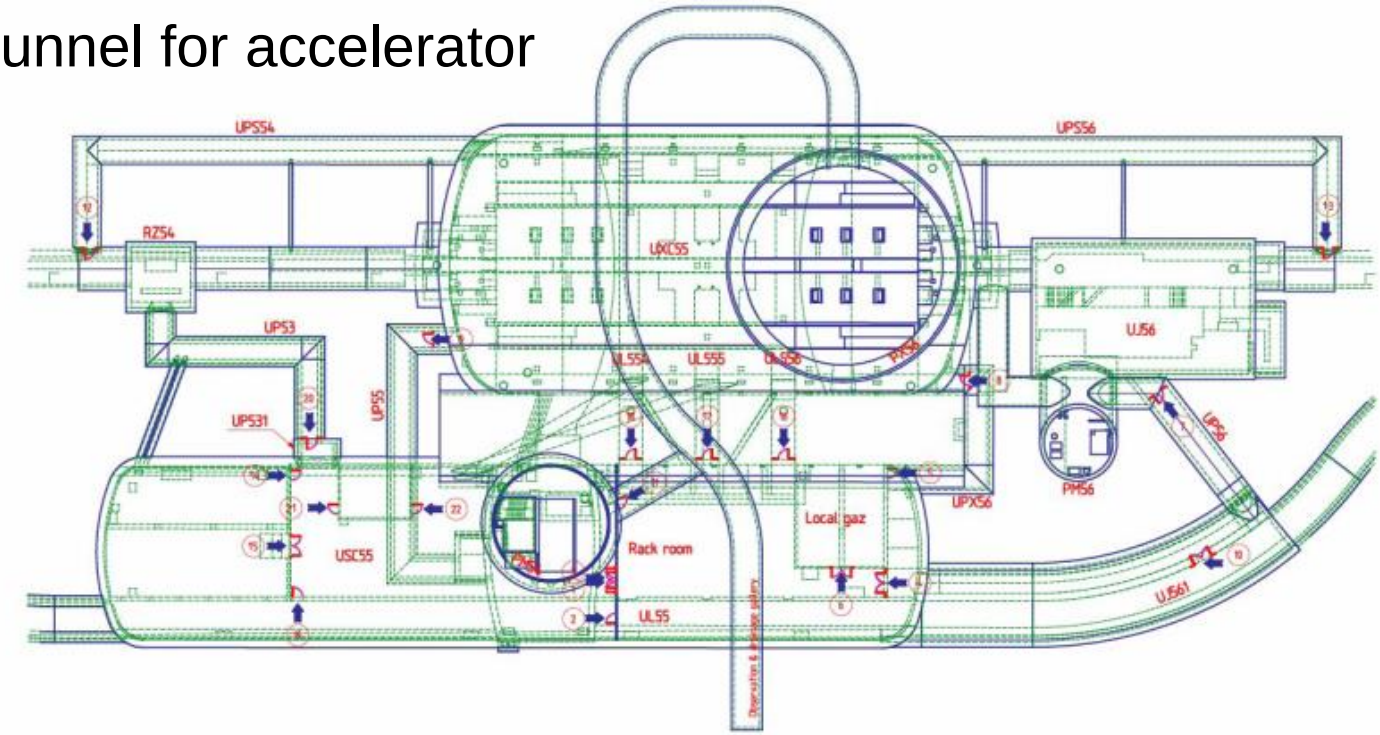
ATLAS

- 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

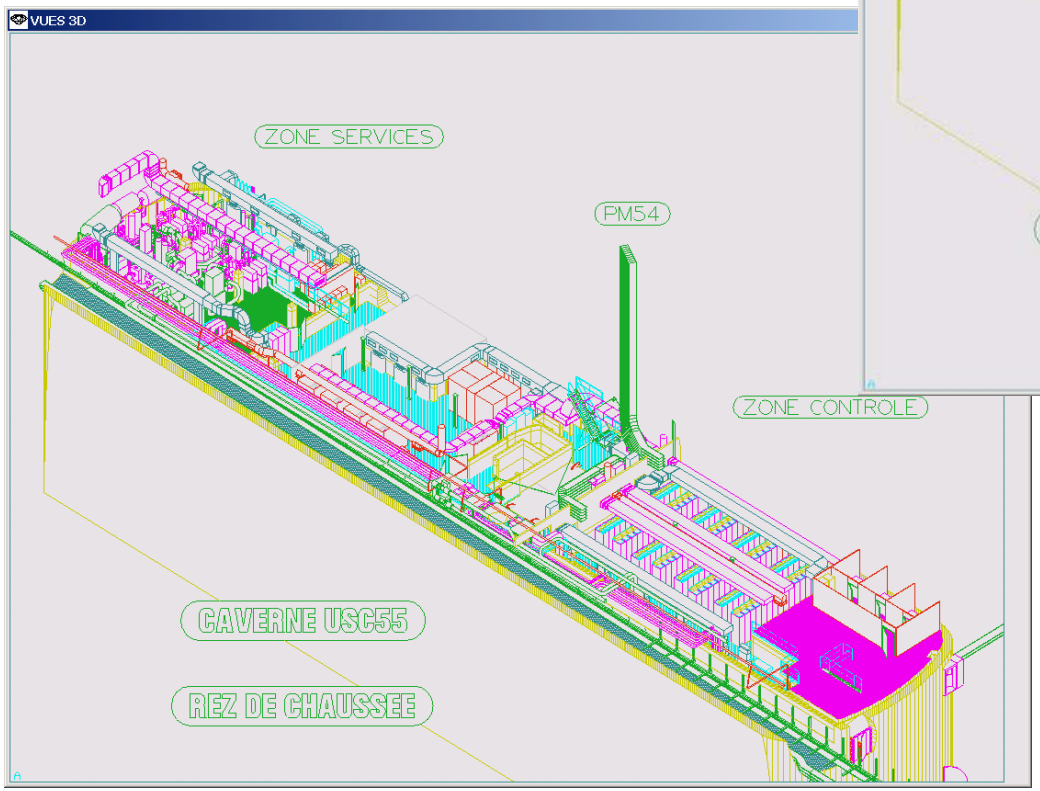


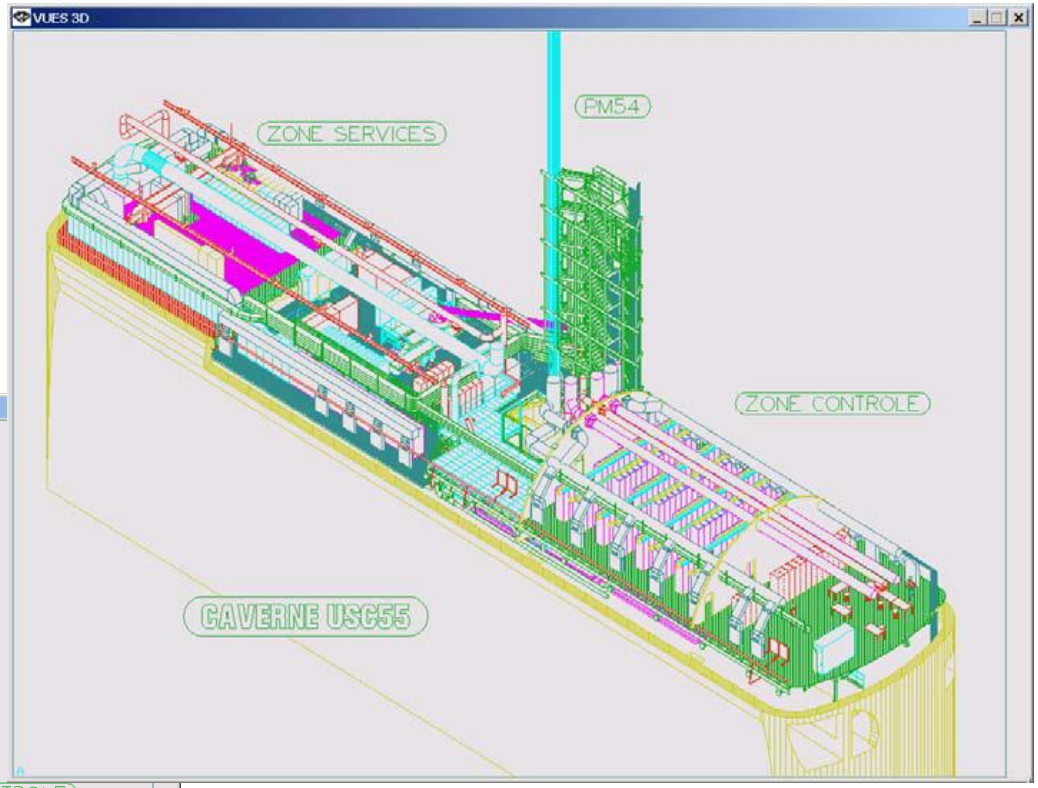
CMS

- 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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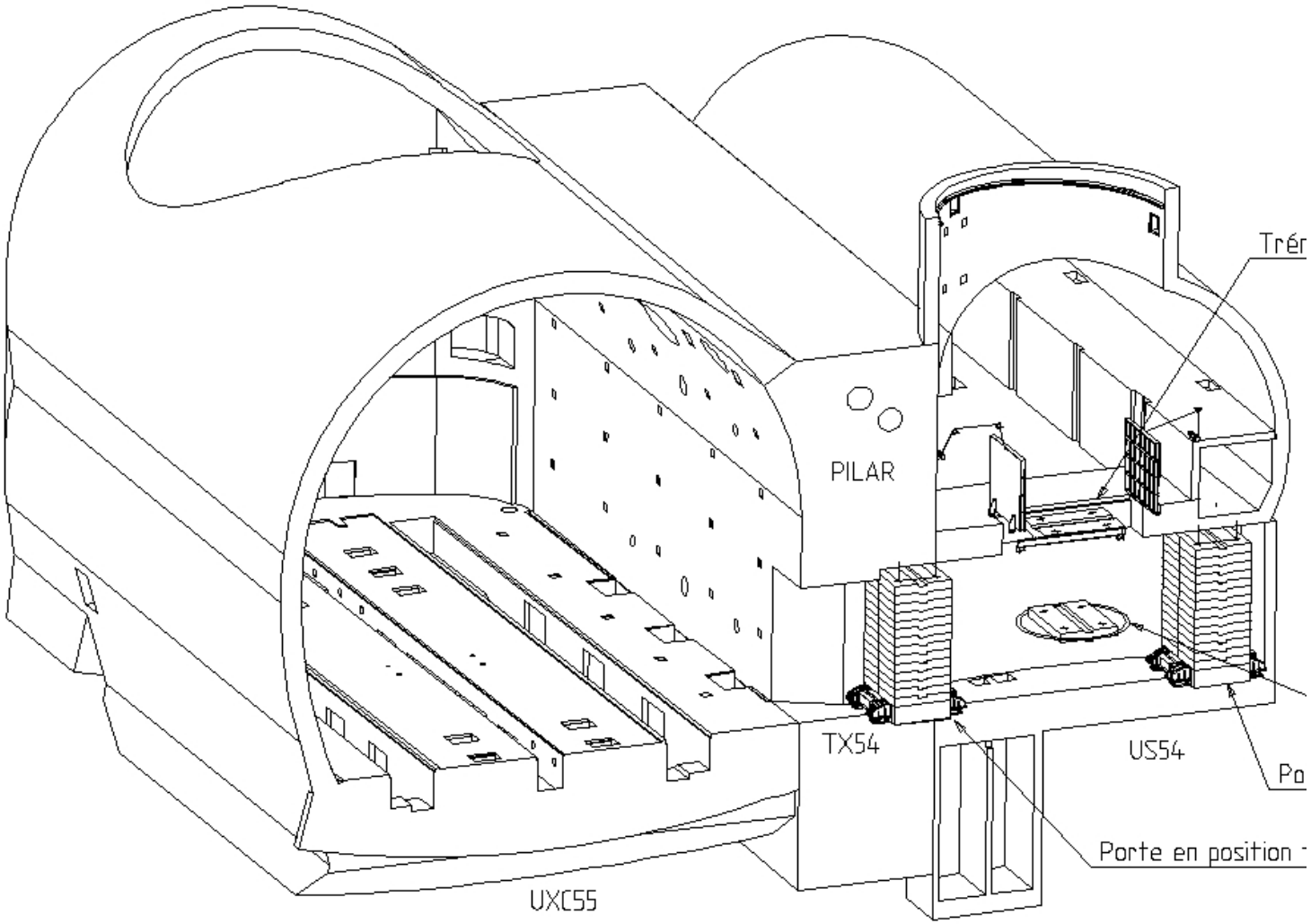
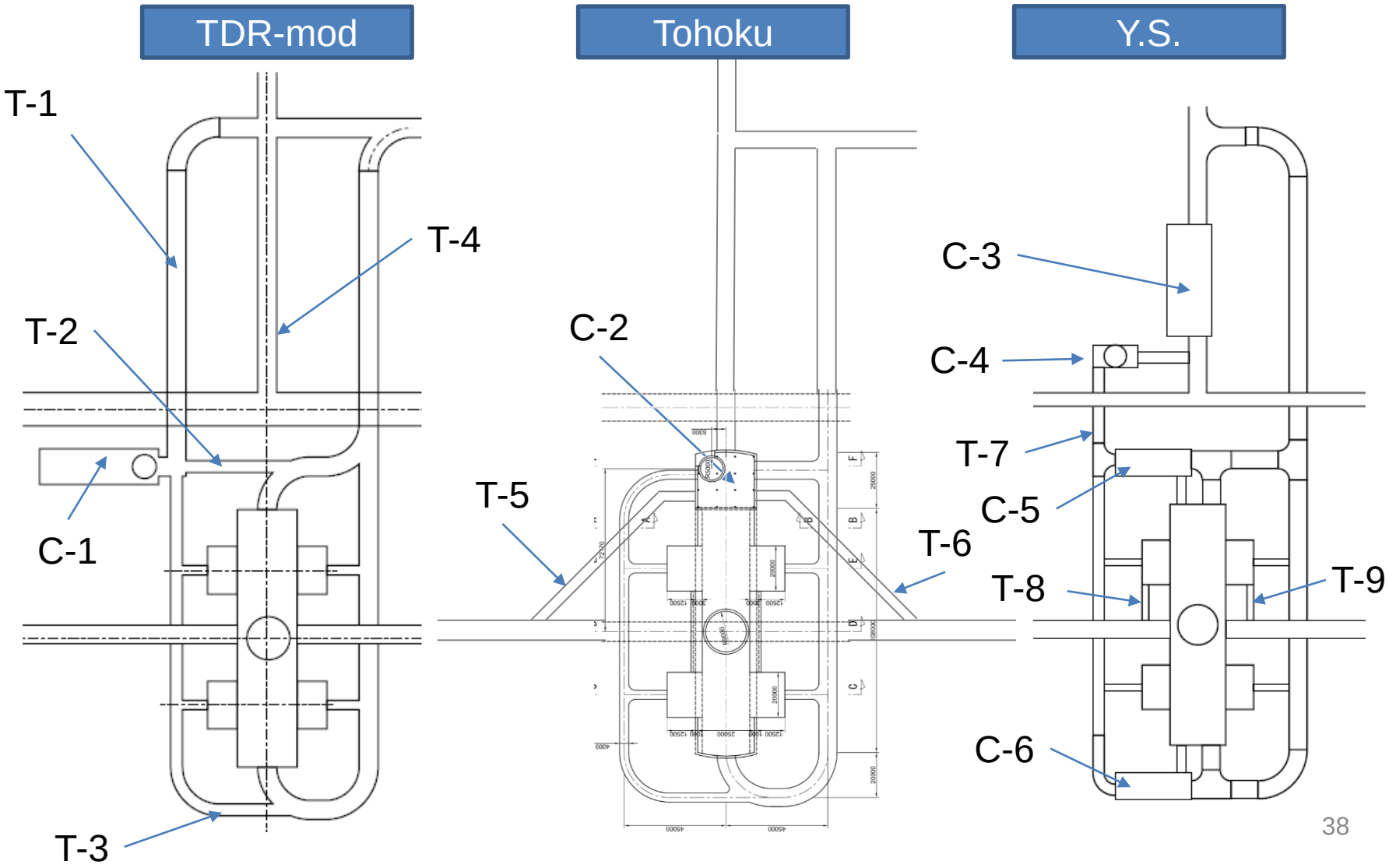
CMS



Comparison of excavation volume



Comparison of excavation volume

	W (m)	H (m)	L (m)	V (m^3)	TDR-mod	Tohoku	Y.S.
T-1	8	7.5	170	10200	10200		
T-2	6	6	40	1440	1440	1440	
T-3	6	6	40	1440	1440	1440	
T-4	8	7.5	45	2700	2700	2700	
T-5	6	6	60	2160		2160	
T-6	6	6	60	2160		2160	
T-7	6	6	40	1440			1440
T-8	3	3	16	144			144
T-9	3	3	16	144			144
C-1	15	12	50	9000	9000		
C-2	25	43	25	26875		26875	
C-3	20	12	50	12000			12000
C-4	10	8	20	1600			1600
C-5	12	12	34	4896			4896
C-6	12	12	34	4896			4896
VS			-πx5x5x43	-3377		-3377	
Total					**24780**	**33398**	**25120**

(V=W*H*L)

USC