Detector Utility

2019/2/28

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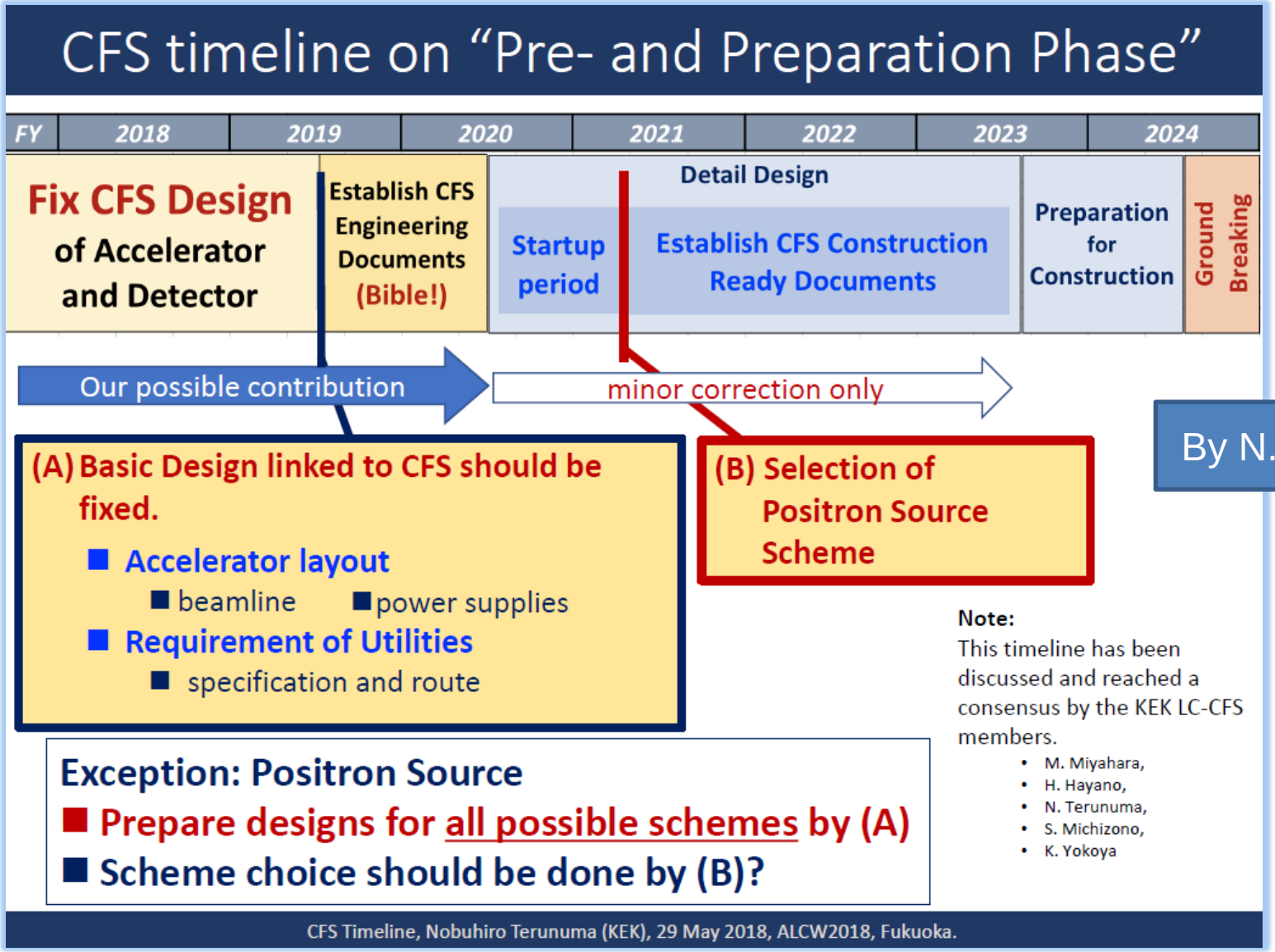
@ILC Infra/CFS mini-workshop

CFS Schedule



By N.Terunuma

CFS Schedule

- If a positive statement by Japanese government is made, ILC basic design linked to CFS has to be fixed by 2019 summer
- CFS Engineering Documents will be made in ~1 year based on this basic design
- Based on the CFS Engineering Documents, CFS detailed design will be made by civil engineering companies in ~3 years

- So, detector groups should clarify the requirements for the experimental hall and the utilities by 2019 summer
- Particularly, design of underground facility is urgent

Necessary utilities for detectors

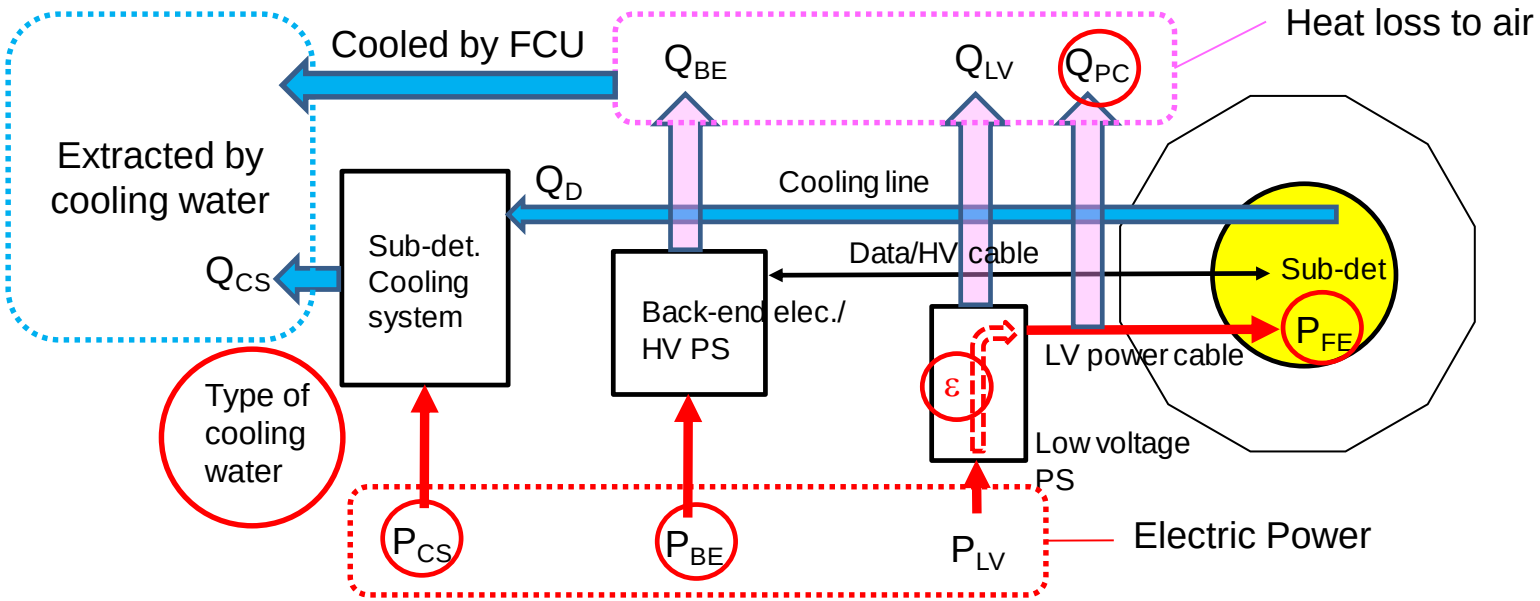
- Electricity
- Heating, ventilation, air conditioning (HVAC)
- Cooling water
- Cryogenics for s.c. magnets
- Chamber gas
- (Network for data transfer)
- Assembly hall (with gantry crane)
- Sub-detector assembly building
- etc.

Utility Survey

- Requirements for utilities for sub-detectors of ILD were surveyed in 2018
  - Electric power
  - Cooling water
  - Space
- Two rounds of the survey were made, but only 5 sub-detector groups responded
  - Vertex detector
  - TPC
  - ECAL
  - SDHCAL
  - AHCAL
- Requirements for other sub-detectors will be supplemented by Y.S. to estimate total necessary electric power and cooling water
  - Power consumption by sub-detectors is relatively small compared to magnet power
  - So, rough estimate on the sub-detector power consumption would be OK

Utility Survey

- 6 items for electricity/cooling water



- P_{FE} : Power consumption of sub-detector Front-end Electronics
- Q_D : Heat loss in sub-det. (= P_{FE})
- Q_{PC} : Heat loss in power cables
- P_{LV} : AC power input to LV PS
- ε : Efficiency of LV PS (P_{LV}*ε= P_{FE} +Q_{PC})
- Q_{LV} : Heat loss in the LV PS (=(1-ε)*P_{LV})
- P_{BE} : AC power input to back-end elec./HV power supply
- Q_{BE} : Heat loss in the BE/HV PS (=P_{BE})
- P_{CS} : Electric power to drive the cooling system
- Q_{CS} : Heat to be extracted from cooling system (= Q_D +P_{CS})

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	150			
	Cold box	150			
	He Compressor	300	(Surface)		
Detector Solenoid	Power supply	250			
	Cold box	50			
	He Compressor	500	(Surface)		
Sub-detector	**Total**	**161**	FEE	BEE	Cooling
	Muon	12	5	5	2
	HCAL	45.5	27.5	8	10
	ECAL	40	20	12	8
	VFC	9	2	5	2
	SET	9	2	5	2
	TPC	16.2	15	NA	1.2
	SIT	8	1	5	2
	FTD	8	1	5	2
	VTX	13.5	2	1.5	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		3432			
Underground		**982**			

Sub-detectors:

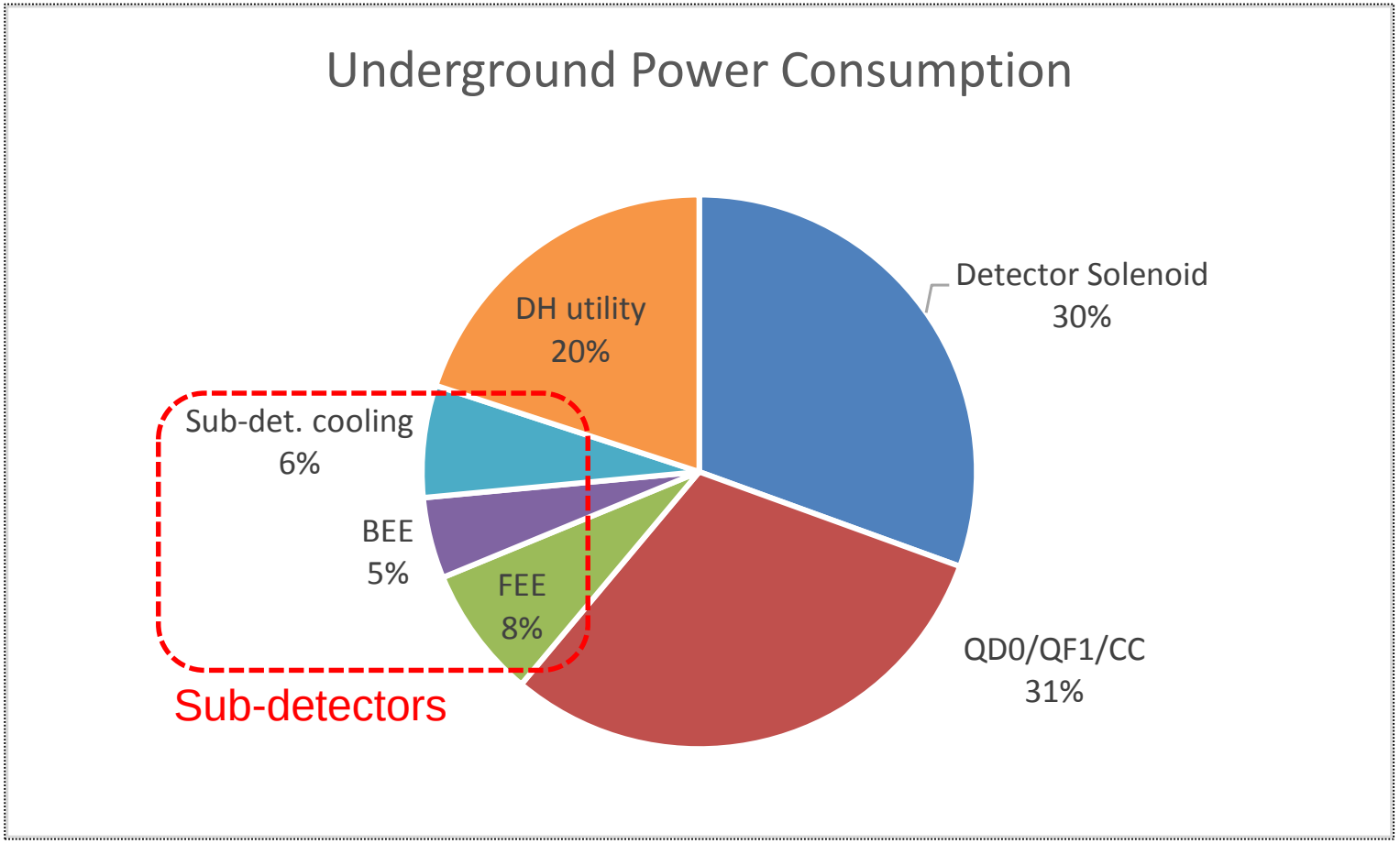
- Y.S.'s guess (based on TDR description, if exists) except for HCAL, ECAL, TPC, and VTX

Not listed:

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

Underground Power Consumption

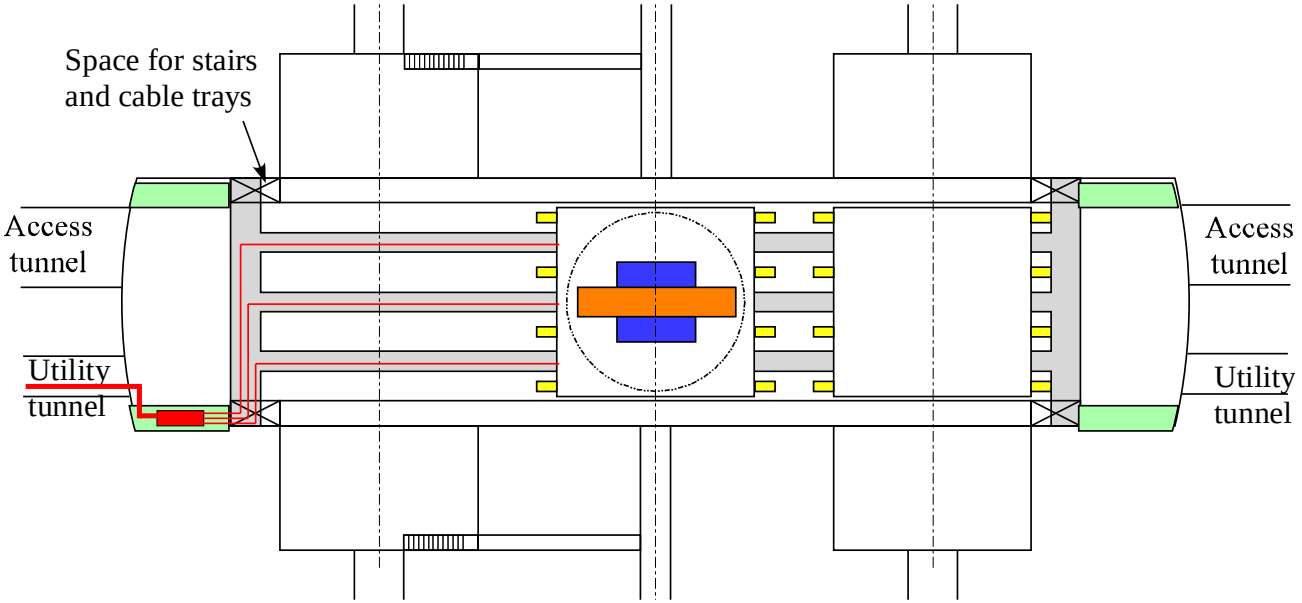
- Total underground power ~ 1MW



DC Power Supply

- ~80kW is necessary for front-end electronics
- Distance between cubicle (AC transformer) to the platform is long (~80m)
- AC line between cubicle and the platform should be flexible enough for push-pull operation
- In order to minimize power loss in the flexible AC cables, 400V-3ϕ AC input is preferable for high-power DC power supplies on the platform

- A possible configuration
  - Cubicle (USC) →[Thick cables]→ Power distribution panel (Service gallery 2F) →[Flexible cables]→ DC PS (Platform)



Comparison with other study

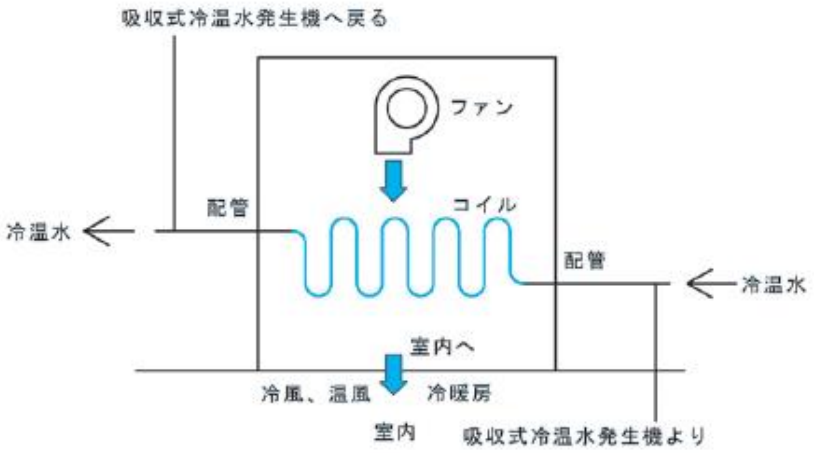
	CMS	CLIC	SiD	ILD
Detector Solenoid	900	900	294*	800
QD0/QF1/CC	NA	NA	NA	600
FEE	600	<10	12	75
BEE	650	<10	70	47
PC farm	800	1000	NA	1000
DH utility	NA	NA	105*	246
Cooling	850	750	NA	65
HVAC	600	600	NA	600
Sum	4400	3250	481	3432

- 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

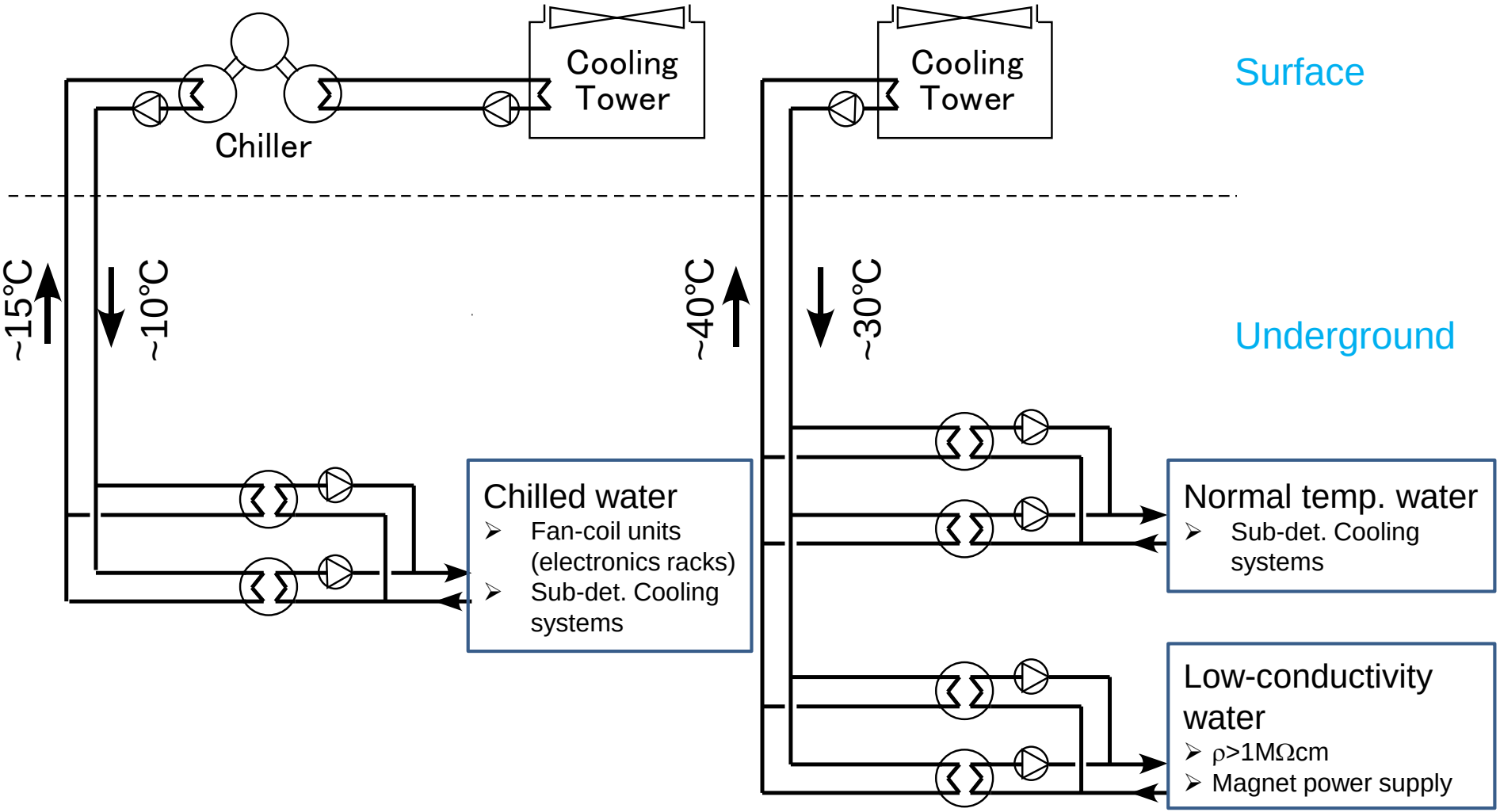
COOLING WATER

Basic concept

- Two types of water are supplied from surface
  - Normal temp. water: T~30 ℃, ∆T~10 ℃
  - Chilled water: T~10 ℃, ∆T~5 ℃ (TBD)
  - High pressure due to ∆h~100m can be isolated by heat exchangers in USC
- Sub-detectors are cooled by sub-detector cooling systems
  - Coolant could be CO2, water, air, 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



Schematic


Cooling Tower
Chiller
Cooling Tower
Surface
Underground
~15°C
~10°C
~40°C
~30°C
Chilled water
Fan-coil units (electronics racks)
Sub-det. Cooling systems
Normal temp. water
Sub-det. Cooling systems
Low-conductivity water
ρ>1MΩcm
Magnet power supply

Requirement

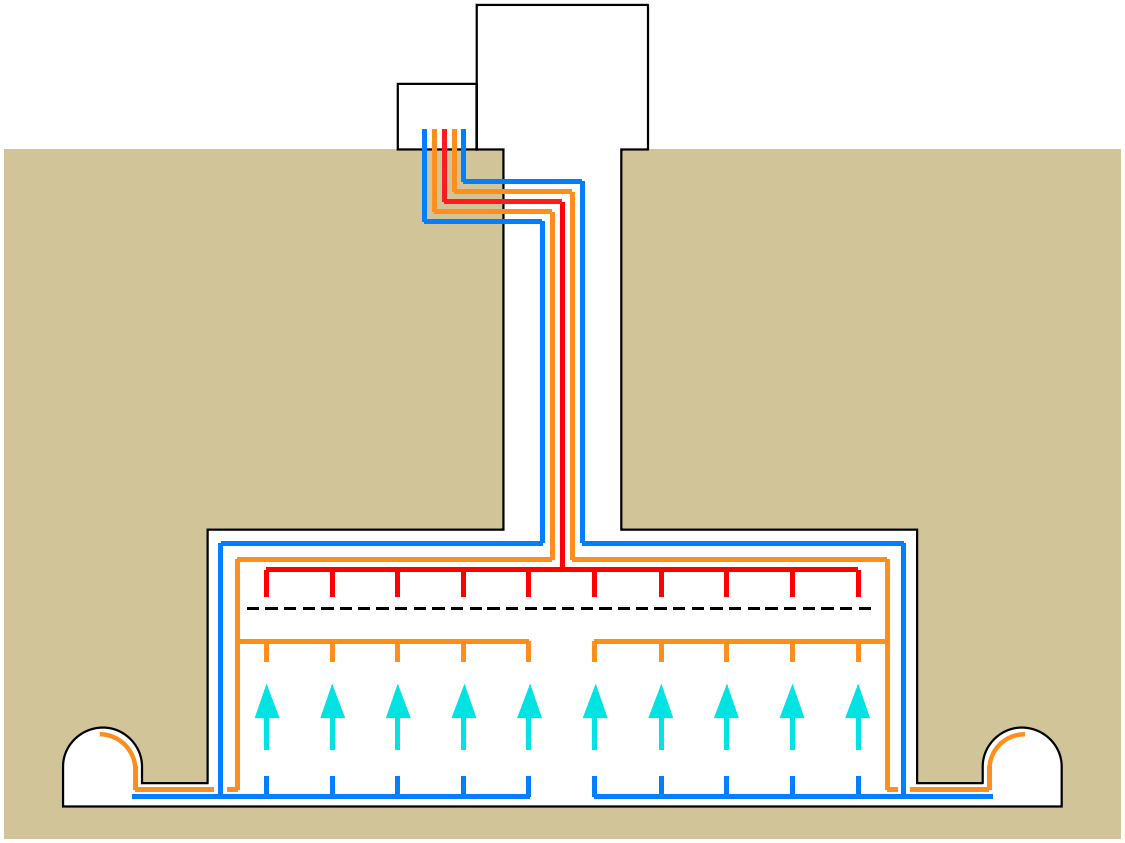
- Cooling water for underground facilities

		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				150	10	214				
	Cold box				150	10	214				
Detector Solenoid	Power supply				250	10	357				
	Cold box				50	10	71				
Sub-detector	Muon	12	5	34							
	HCAL	45.5	5	130							
	ECAL	40	5	114							
	VFC	9	5	26							
	SET	9	5	26							
	TPC	3	5	9				13	5	38	NW for precision chiller
	SIT	8	5	23							
	FTD	8	5	23							
	VTX	13.5	5	39							
Pump		11	5	31	11	10	16	3.7	5	11	
Cubicle (AC transformer)		49	5	140							95% efficiency, FCU
Total		208		595	611		873	17		48	
Primary Loop		**Chilled Water**			**Normal Temperature Water**						
				595						**921**	

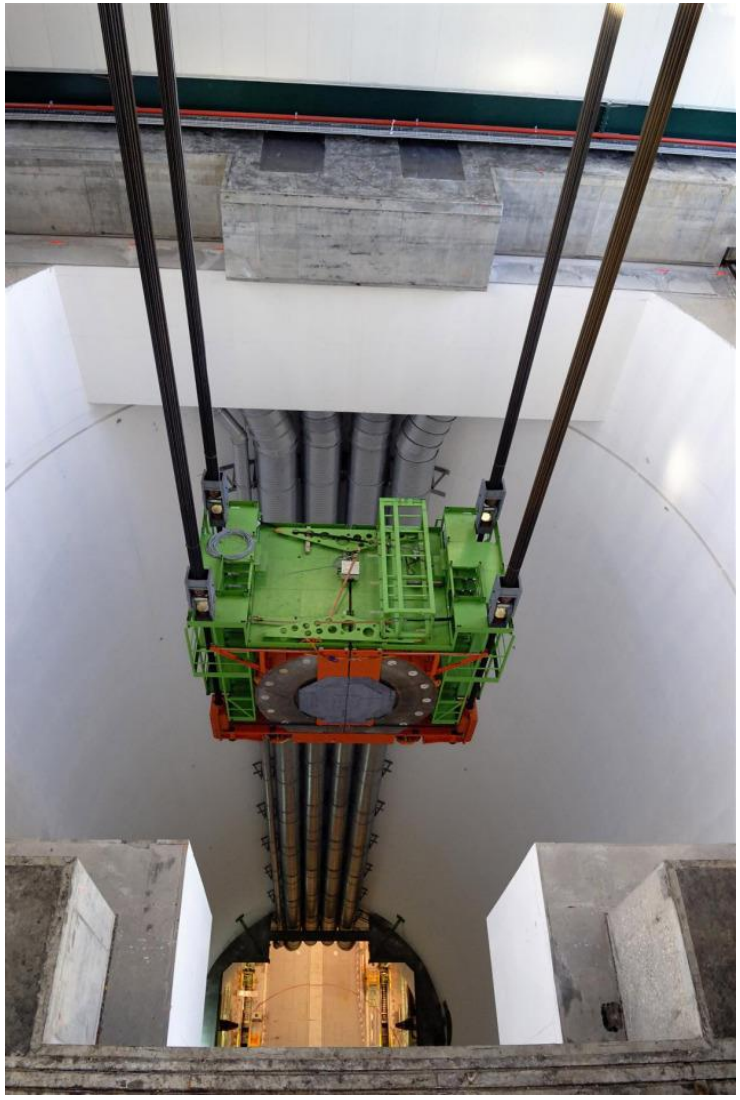
HVAC

HVAC

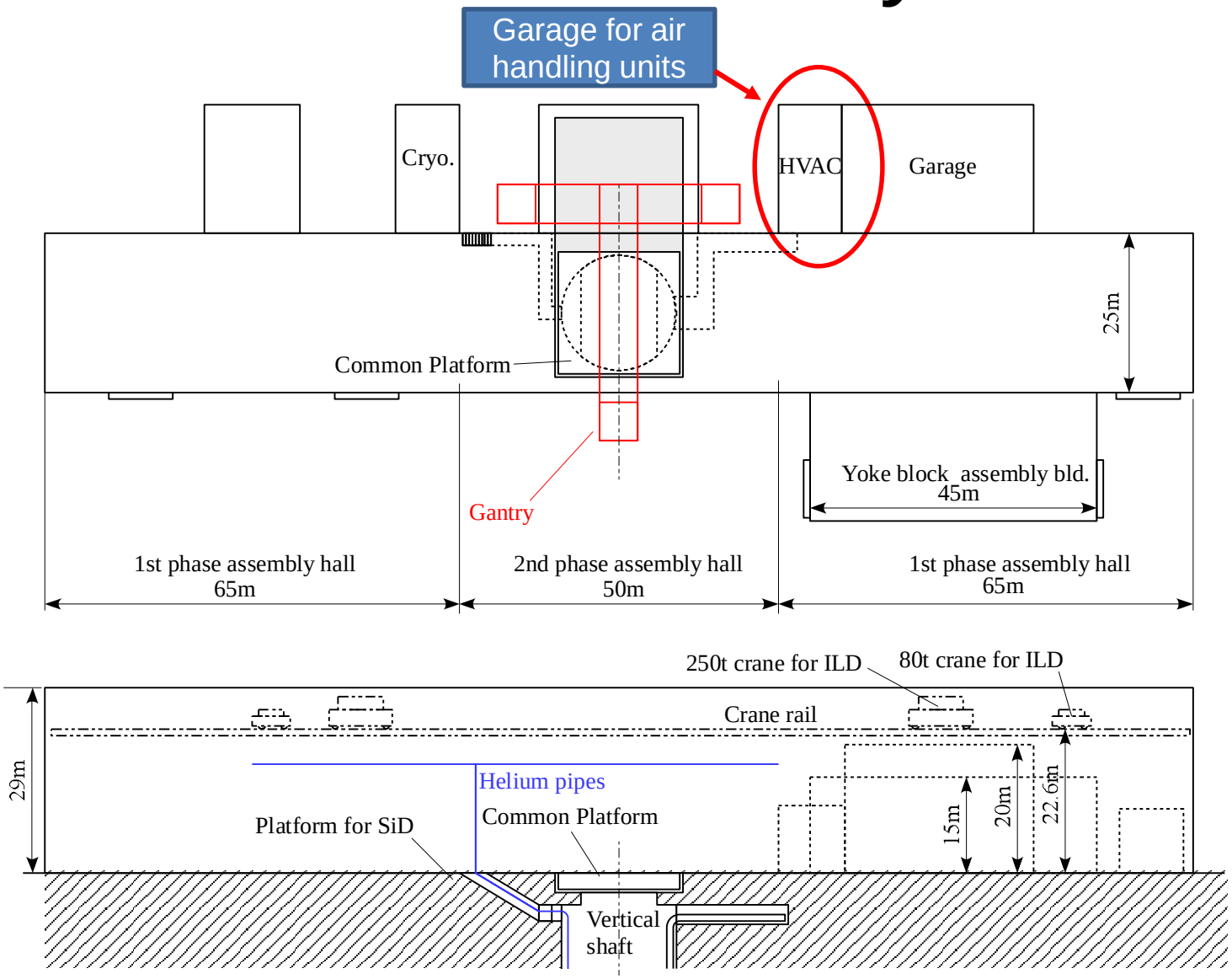
- Air handling units on surface (next to assembly hall)
- Air ducts through main shaft
- Necessary capacity has not been studied yet



HVAC - CMS



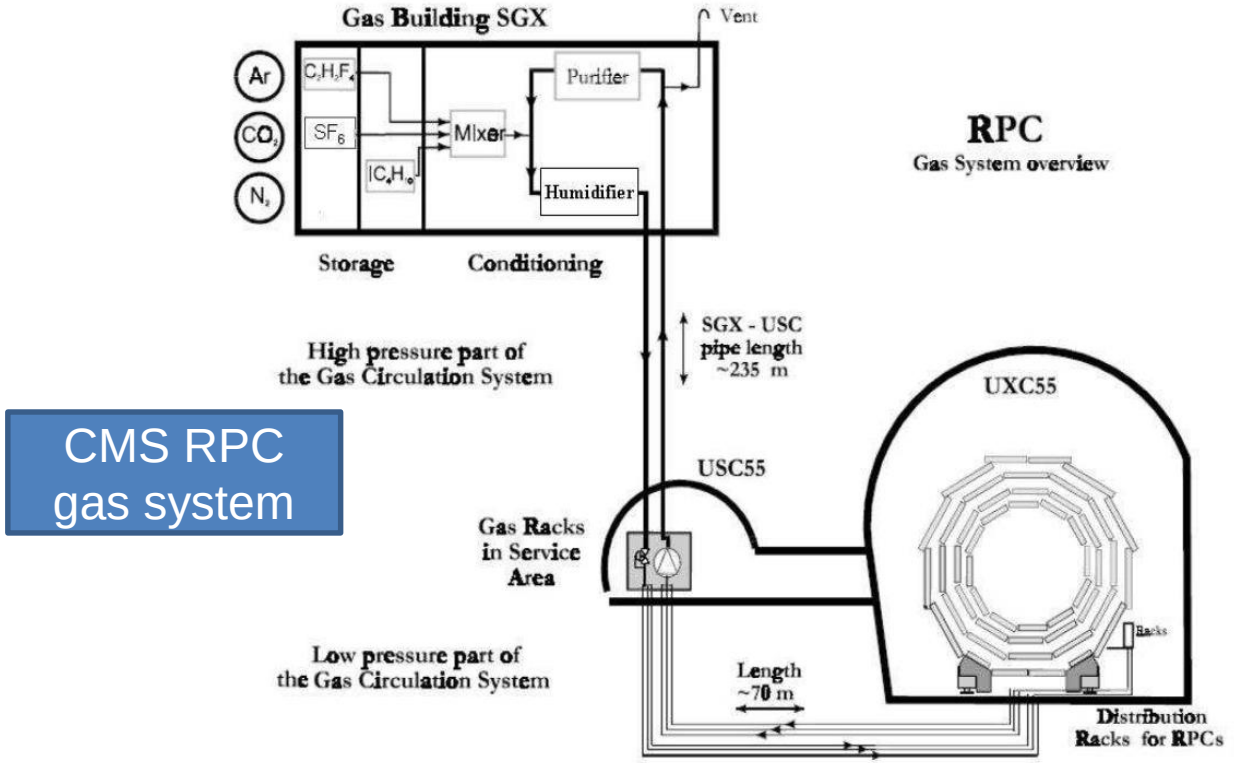
HVAC – Assembly Hall



OTHER SERVICES

Chamber gas

- Chamber gas is necessary for TPC and SDHCAL
- Gas storage on surface: 8x4m^2 for each
- Gas system underground
  - TPC: Some space on the platform
  - SDHCAL: 4x4m^2 space in USC and small space on service gallery and platform



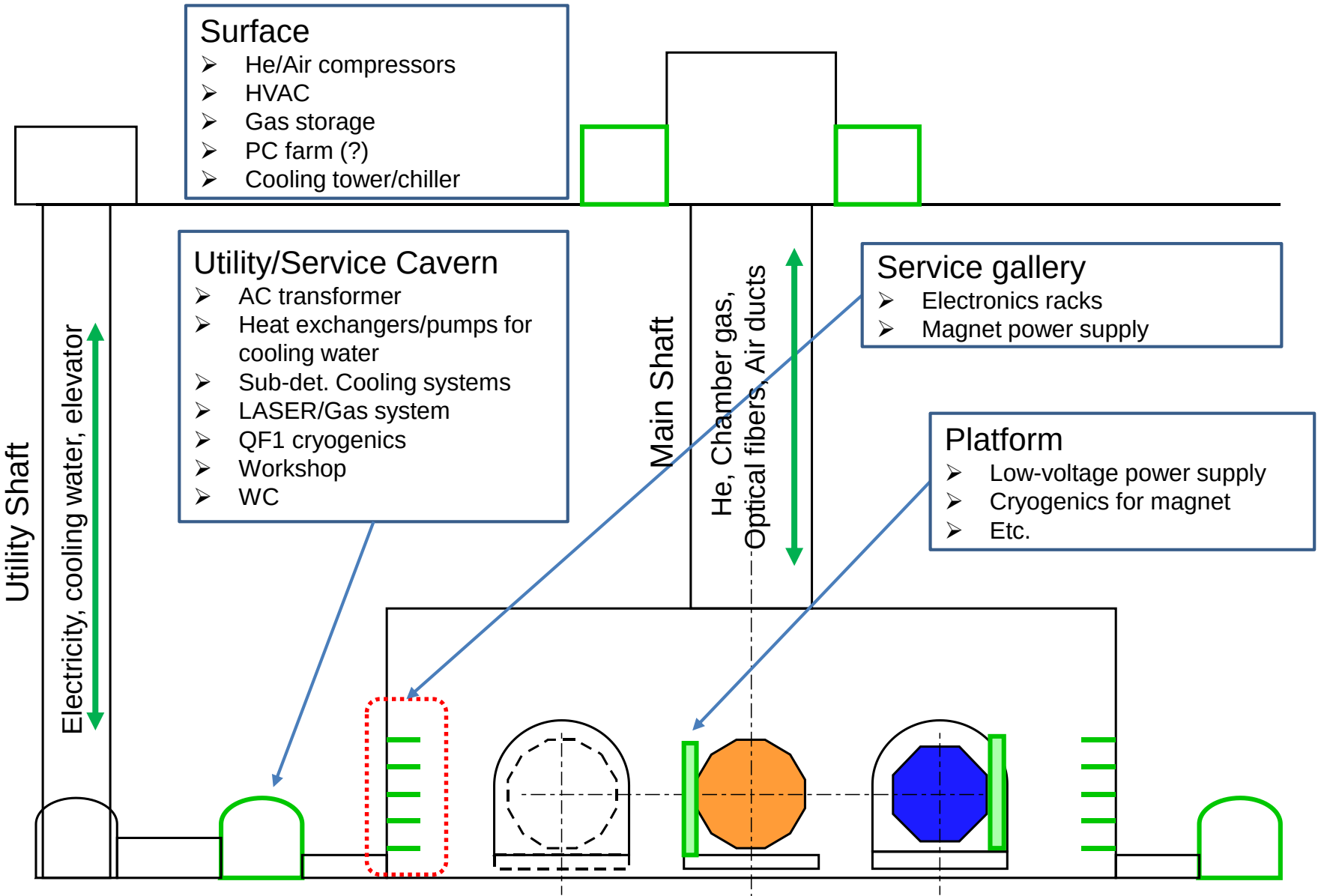
CMS RPC gas system

LASER system

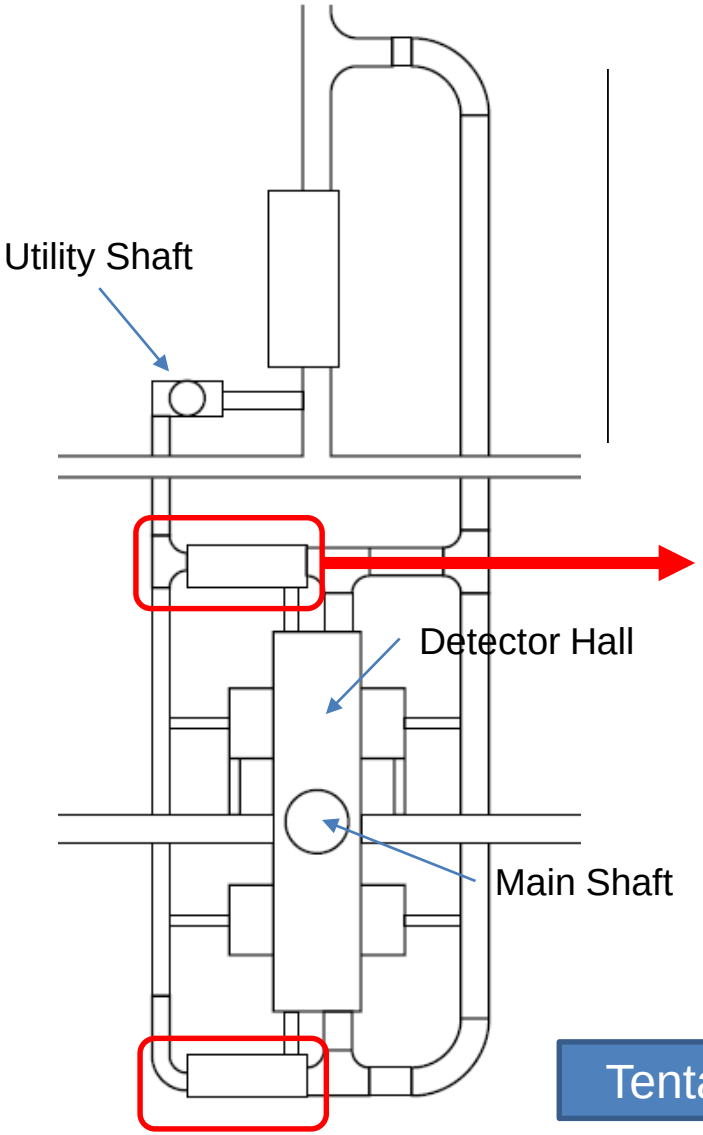
- Laser system will be used for tracker alignment
- Laser light source requires isolated space for safety reason

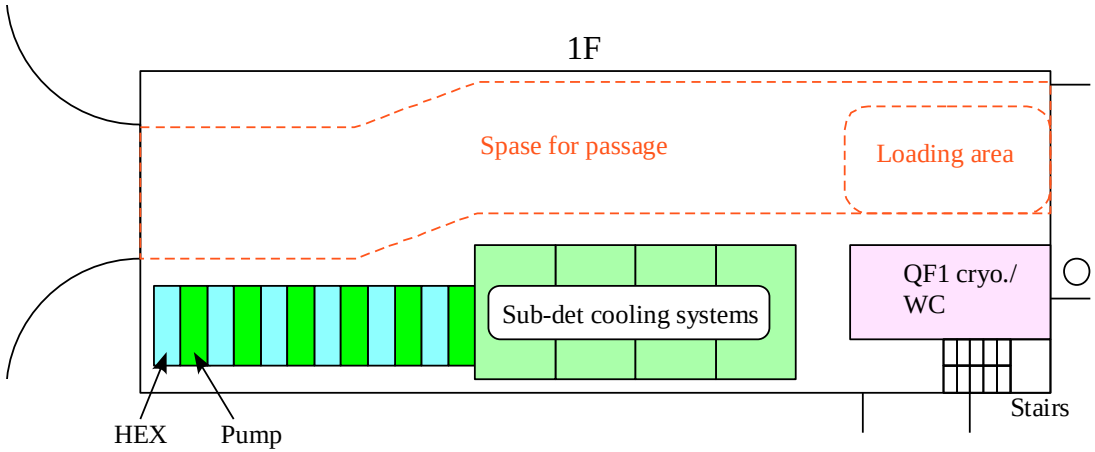
SPACE

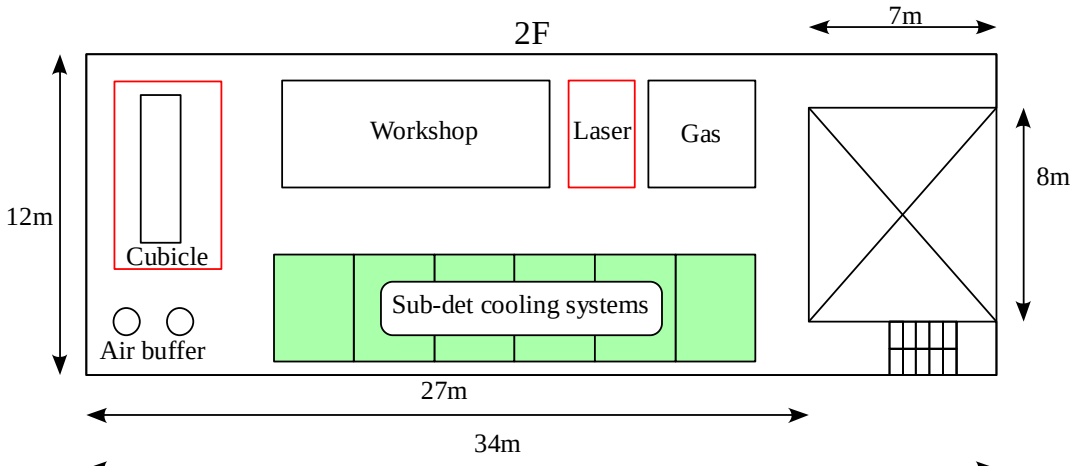
Location of Utility/Service



Utility/service cavern

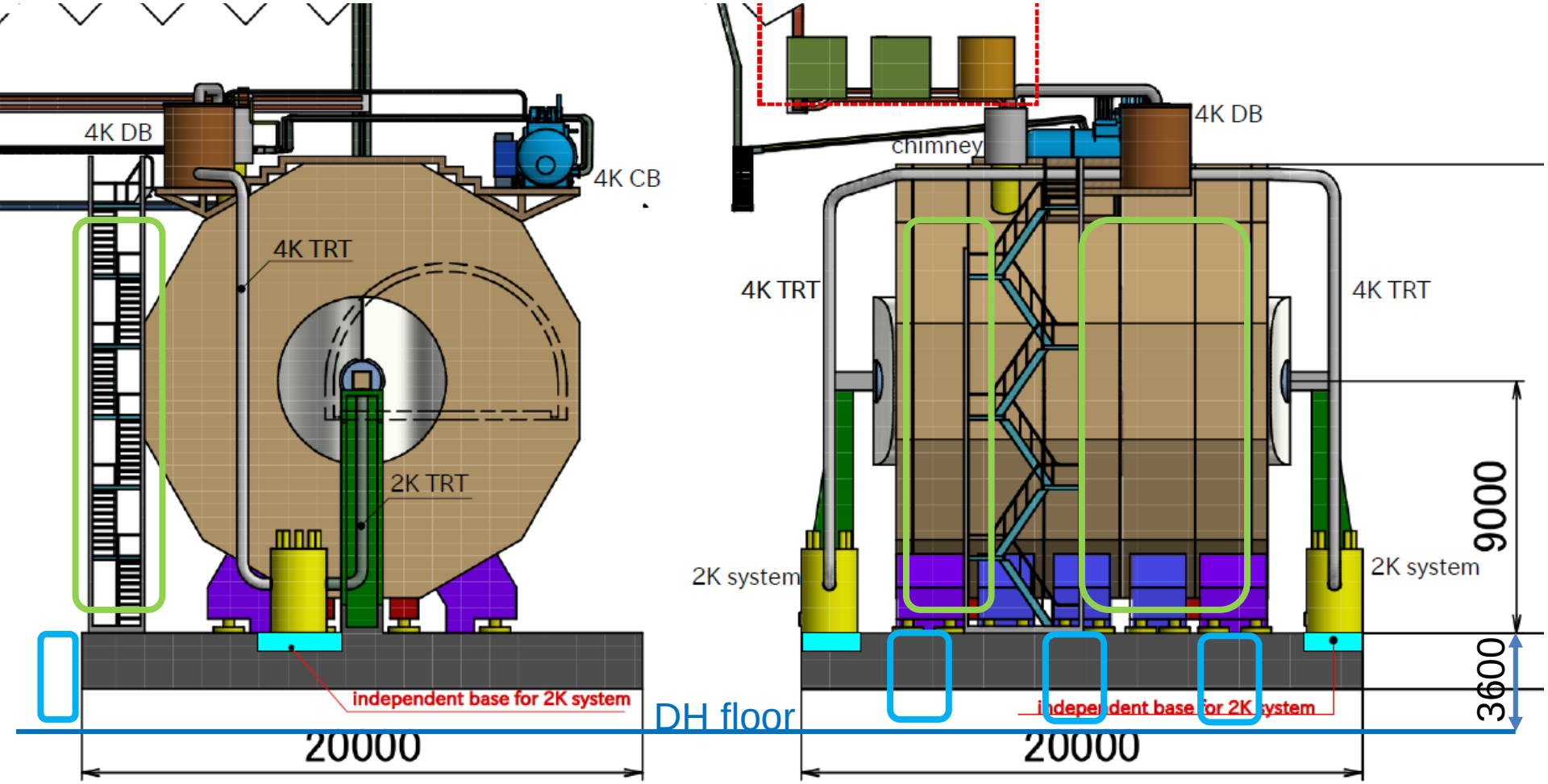






Tentative design

Detector Platform

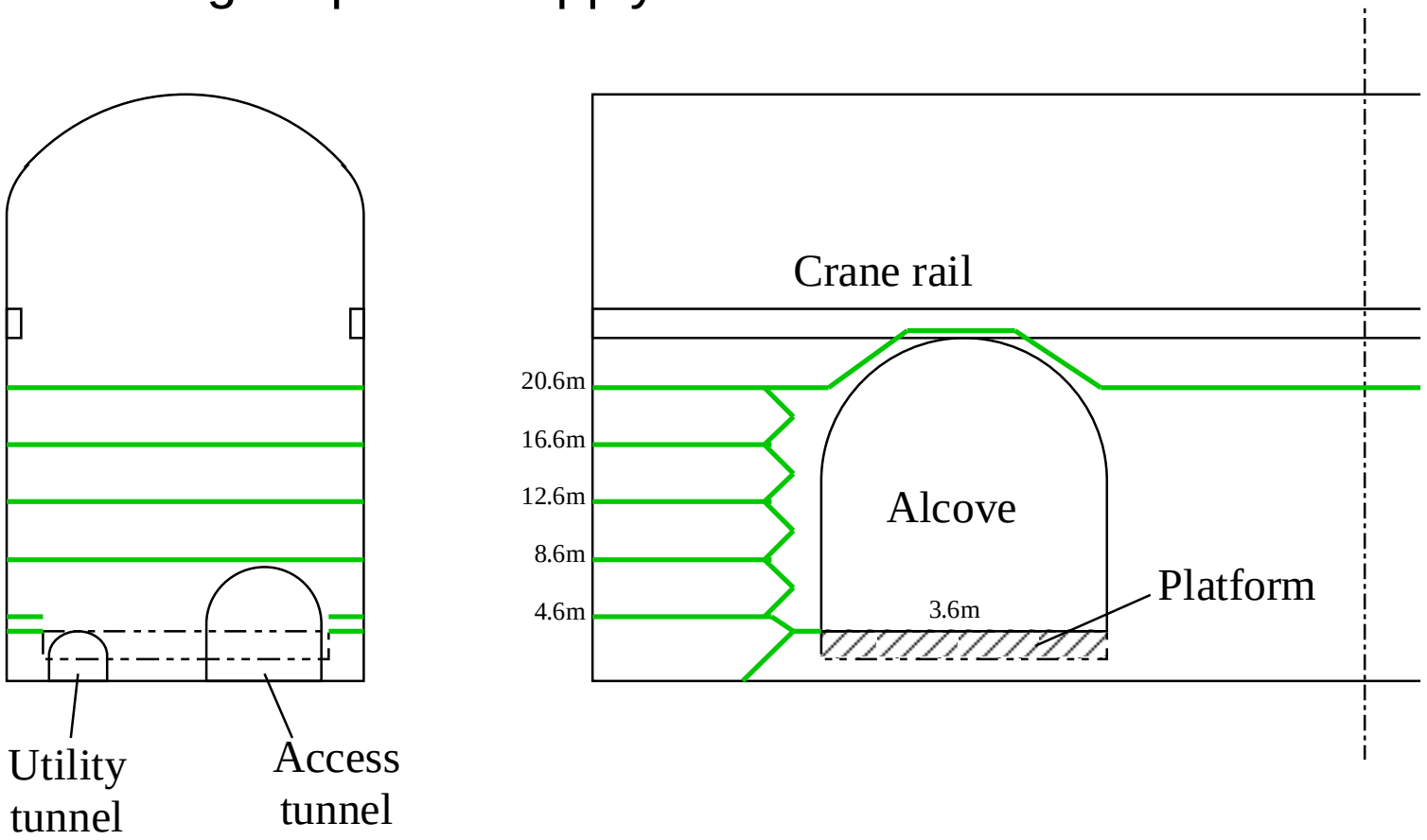


: Space for electronics racks

: Space for L.L. cooling system if Δh>9m is needed (?)

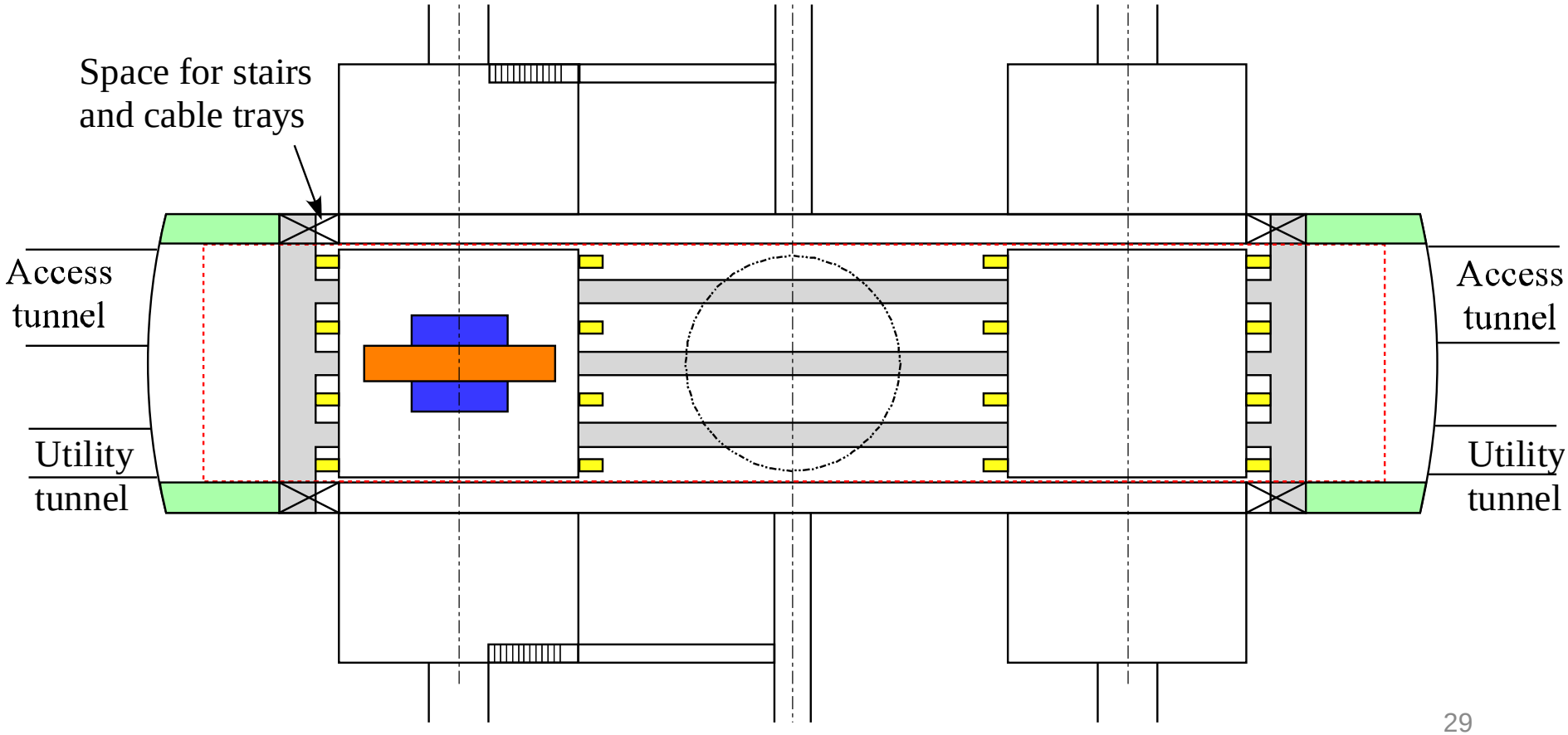
Service Gallery

- 2F : Power distribution panel
- 3F-5F : Electronics racks
- 6F : Magnet power supply



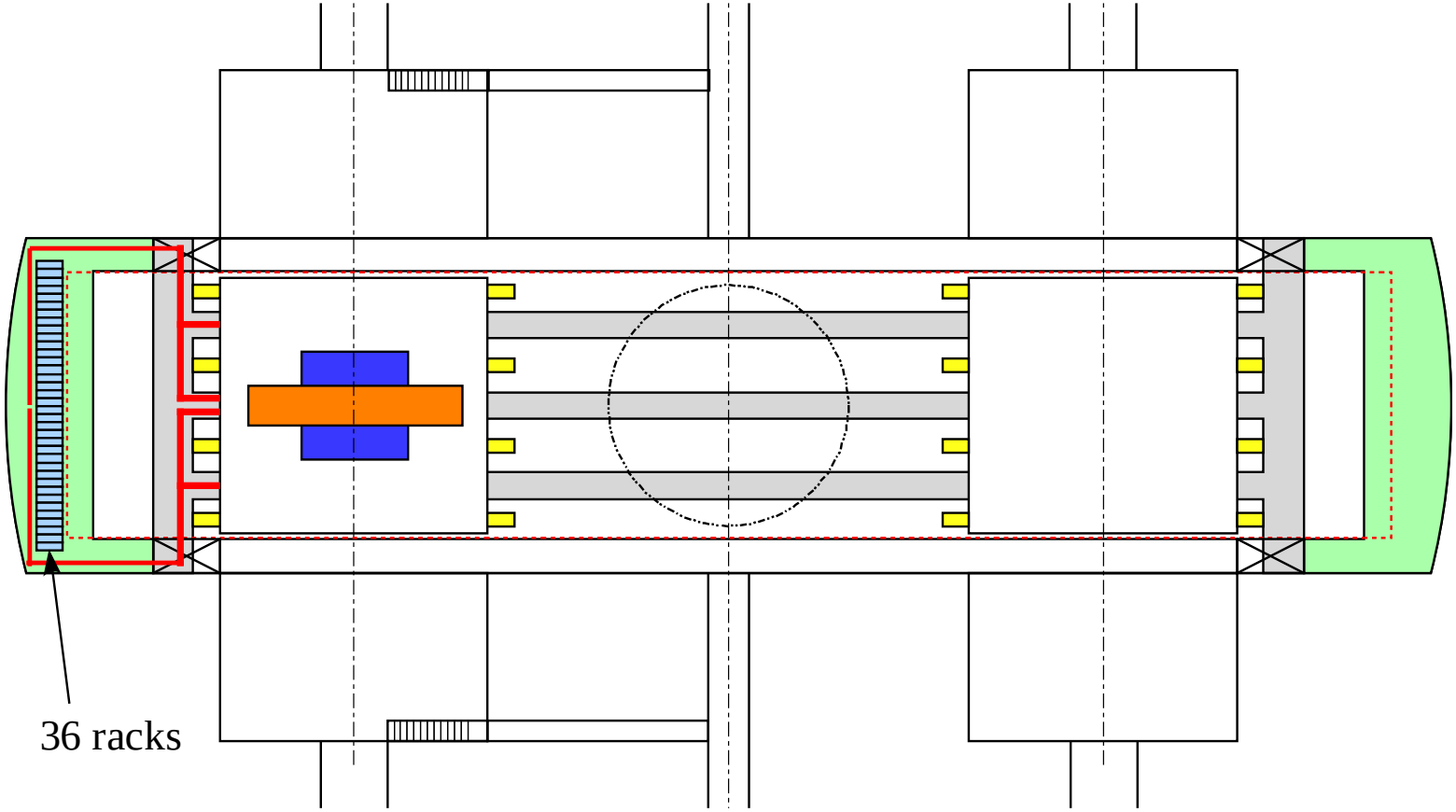
Service Gallery

- 2F



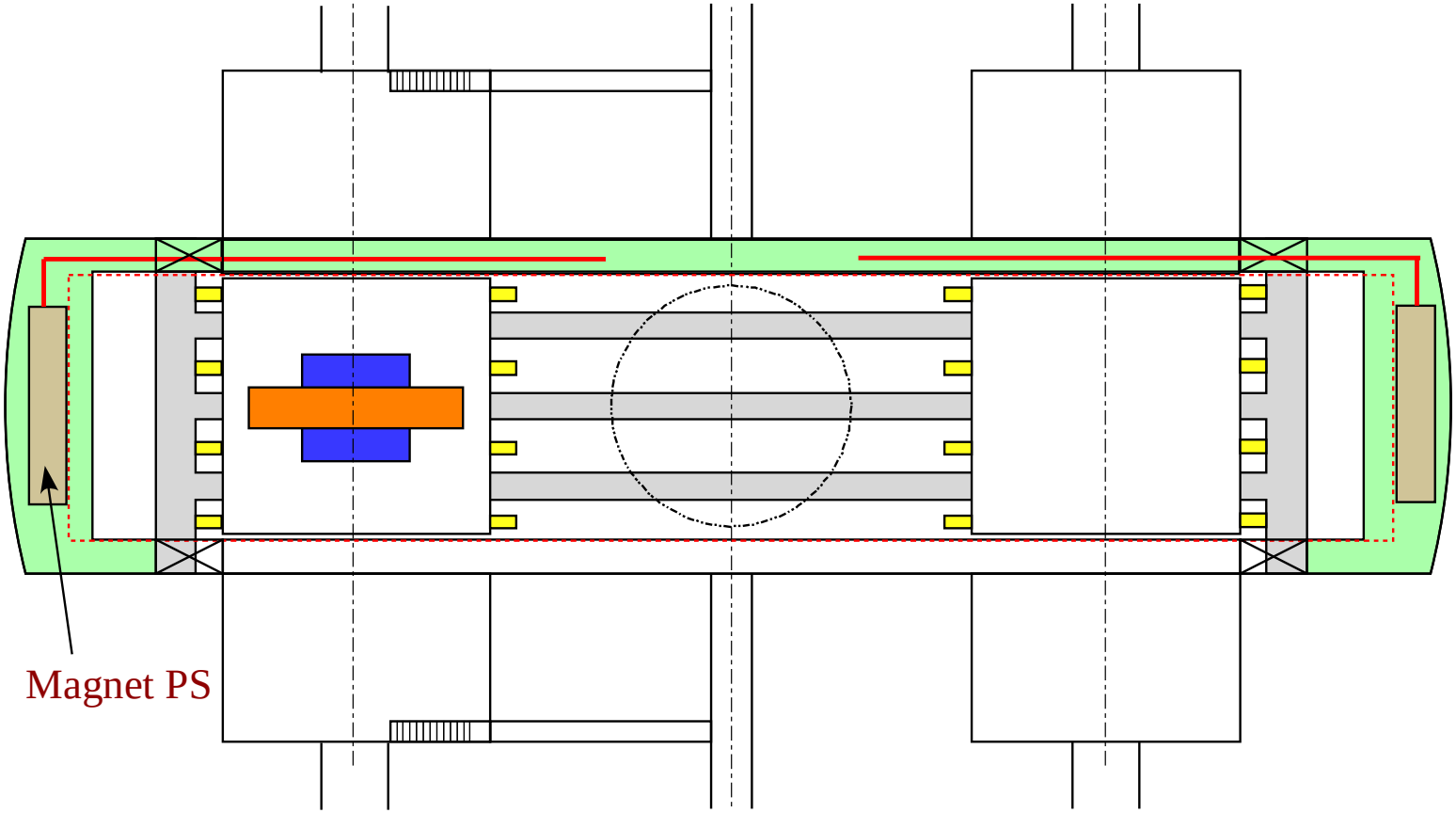
Service Gallery

- 3-5F



Service Gallery

- 6F



Space requirements

- People tends to like space on the platform, where
  - few 100 G leakage field could exists
  - vibration is restricted (pump, fan, etc.)
  - access is limited during experiment
    - Safety: radiation, leakage B field
    - Vibration: human access could cause vibration
- Because space on the platform is limited, there could be severe competition between sub-detectors

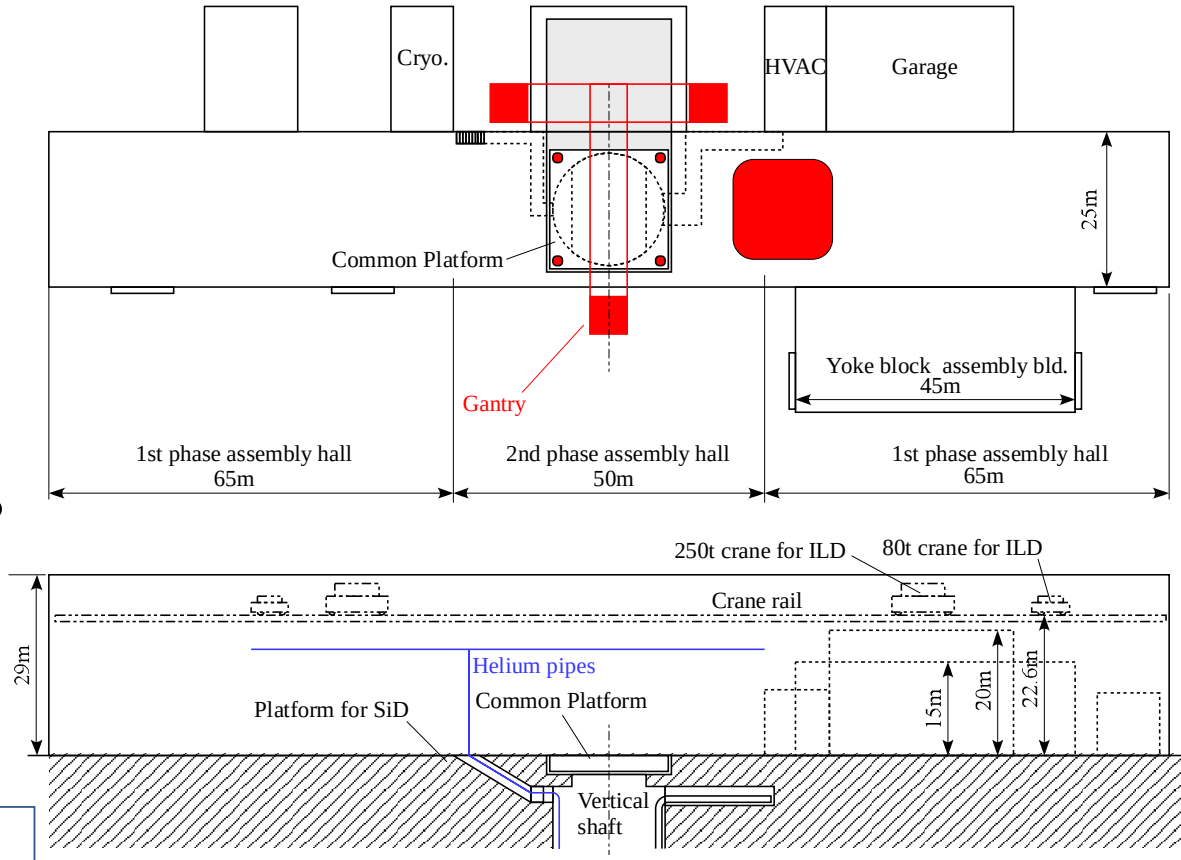
Sub-detector name			VTX	SIT	FTD	TPC	SET	ECAL	SD HCAL	A HCAL	MUON	Lumi CAL	BeamCAL	LH CAL
Number of 19-inch electronics racks	Platform		2 (?)	0	0	0	0	3	6	12	0	0	0	0
	Service gallery		3	0	0	0	0	0	2	1	0	0	0	0
	Utility/Service Cavern (USC)		0	0	0	4	0	0	0	0	0	0	0	0
Sub-detector cooling system	Floor in USC		Don't mind	Don't mind	Don't mind	Don't mind	Don't mind	1st floor	1st floor	0	Don't mind	Don't mind	Don't mind	Don't mind
	WxDxH	m^3	6x1x2	0	0	12x(0.8x0.7	0	4x3x2	4x4x2	0	0	0	0	0
Gas system	Space on surface (WxD)	m^2	0	0	0	8x4	0	0	8x4	0	0	0	0	0
	Space in USC (WxD)	m^2	0	0	0	0	0	0	4x4	0	0	0	0	0
	Space on service gallery (WxD)	m^2	0	0	0	0	0	0	1x1	0	0	0	0	0
	Space on platform (WxD)	m^2	0	0	0	2x2	0	0	2x1	0	0	0	0	0
Laser system	Space in USC (WxD)	m^2	0	0	0	1x0.6	0	0	0	0	0	0	0	0

Requirements from sub-detectors still have inconsistency / incompleteness

ASSEMBLY/PRE-ASSEMBLY HALL

Floor and foundation

- Floor and foundation of AH should be load resistant
  - Columns of GC:
    - ~2000 t / column
  - Platform support:
    - ~6000 t total
    - ~1500 t / support
    - VS works as a pile?
  - Assembly hall floor:
    - ~500 t/m^2 (air-pad)
    - ~15000 t / 16x16m2



It is supposed that granite bed rock can support 100 t/m^2

Pre-assembly hall

- In addition to the main assembly hall on surface, we need pre-assembly hall for sub-detector assembly
- Requirements from sub-detector groups were collected/estimated since 2015

Sub-detector	Area (m^2)	Building
Iron yoke blocks	900 (=20x45)	Yoke assembly building attached to Main AH
SDHCAL/AHCAL	1400/330	• Independent Pre-Assembly Hall at IR • Total 3100/2030 m^2 • FCAL should use HCAL/ECAL space after HCAL/ECAL installation
ECAL	830	
Muon detector	400	
TPC	100	
SET	100	
Si detectors	100	
Utility	170	

SUMMARY

Summary

- ILD requirements for utilities have been surveyed to some extent
- For the moment, it seems power consumption of sub-detectors are relatively small compared to magnet power
- Service gallery and Utility/Service cavern which we propose seem to have enough space for ILD
- Assembly hall has to be carefully designed to make its floor and foundation load resistant
- There are still many items of requirements for detector utilities to be clarified to fix the CFS design in interaction region