

ILD Integration (From ILC to FCC-ee)

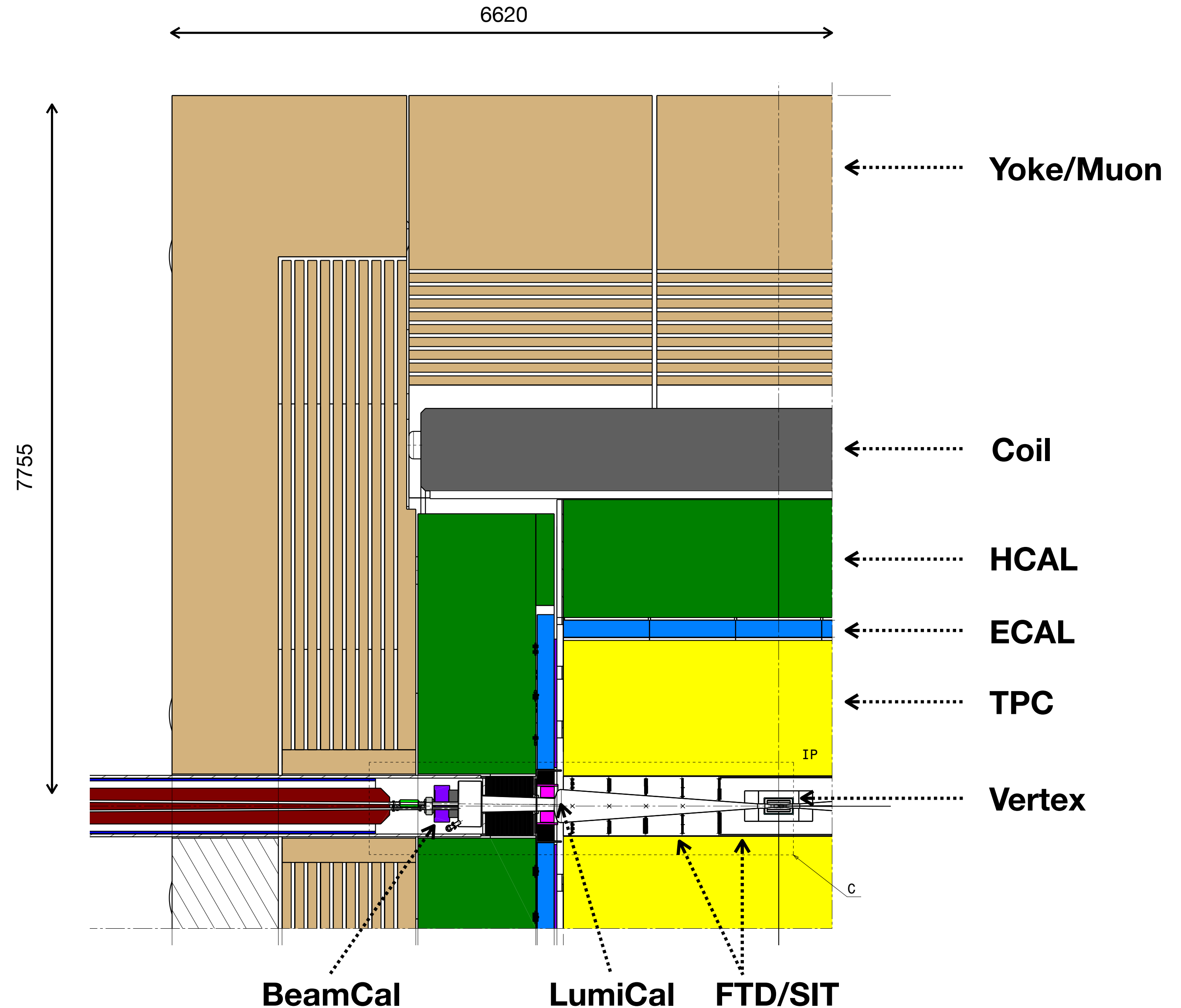
Karsten Buesser

15.09.2026

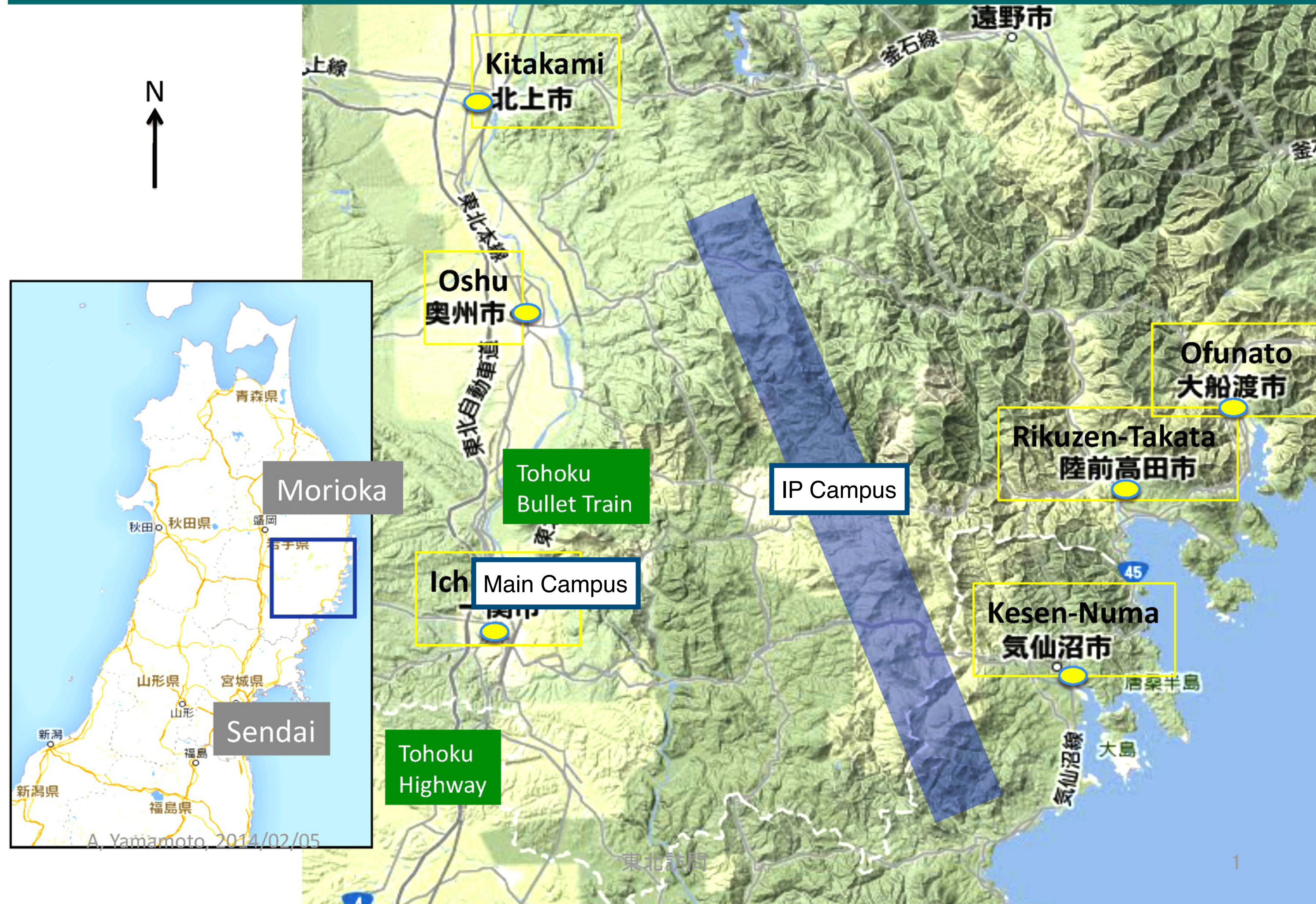
The ILD Detector

International Large Detector

- The ILD concept was developed in the framework of the International Linear Collider
- A multi-purpose detector for e^+e^- collisions from the Z to the TeV range
- Many engineering design decisions were done with the specific boundary conditions of a Linear Collider built on a green-field mountain site in Japan
- Adaptation to FCC-ee is to some extent straight-forward, but details have not been considered in all points yet



ILC Candidate site in Kitakami, Tohoku





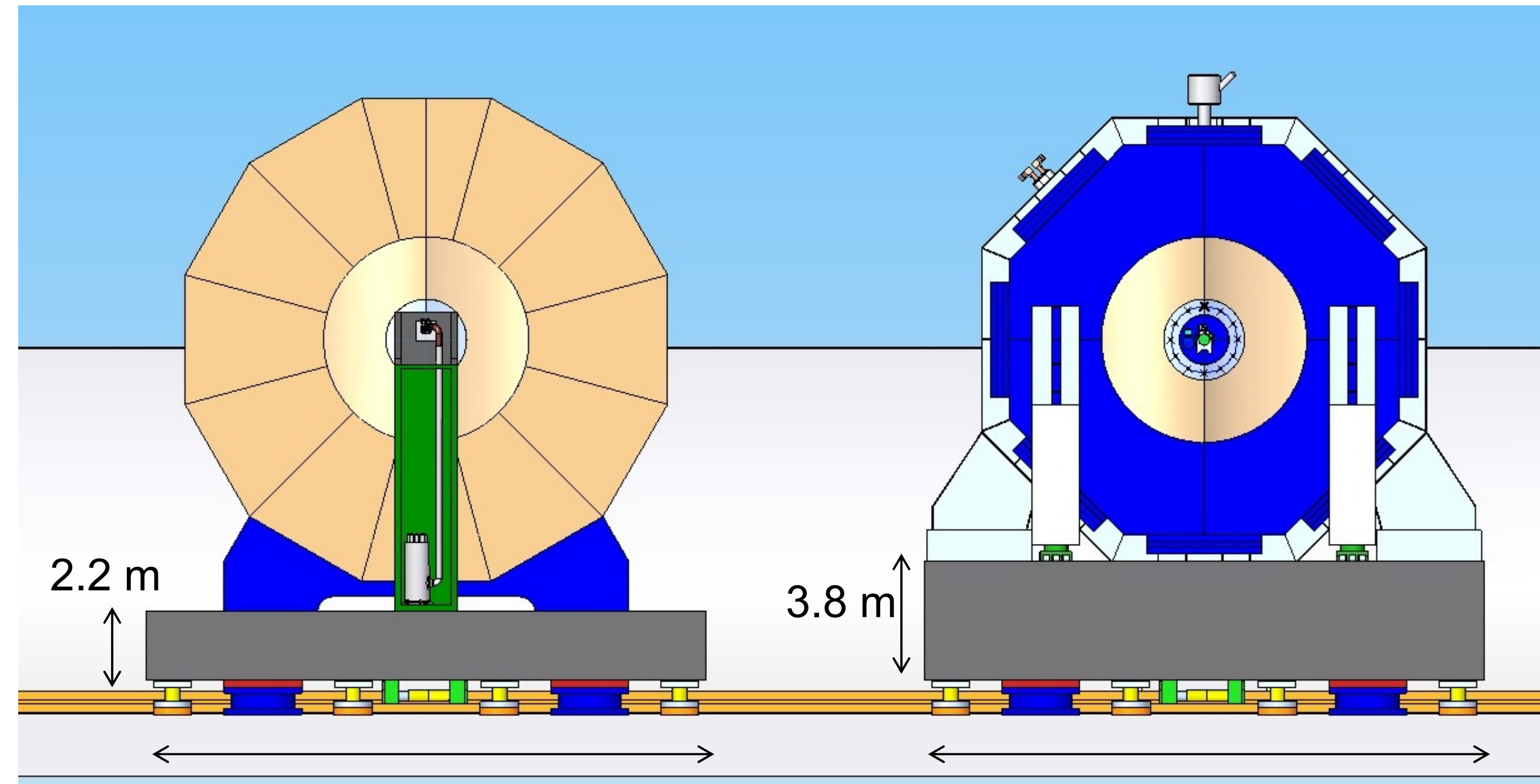
Push-pull System

ILC Baseline

- one interaction region for two detectors
- push-pull system allows for lumi-lumi transition within $O(1d)$

Constraints

- Set of rules for the friendly co-existence of two detectors
 - one taking data, one being maintained
- Functional requirements laid down in 2009
 - SLAC-PUB-13657
 - geometric boundary conditions
 - magnetic and radiation environment
 - vacuum
 - alignment and vibration limits
 - etc.



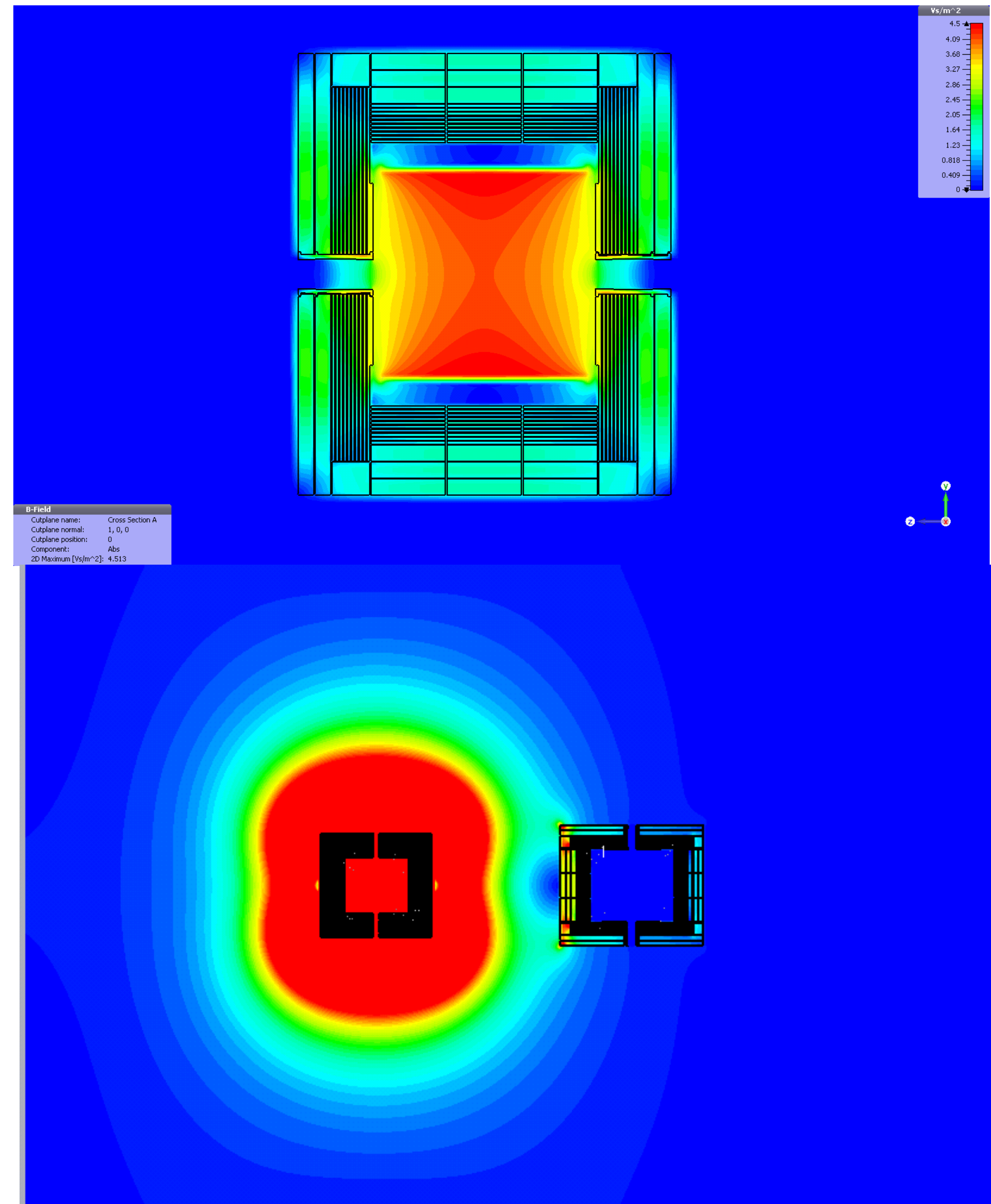
Magnetic Fields

Magnetic stray fields

- are of concern in an environment shared by two detectors
- „on-beam“ detector should be able to operate while maintenance work in „off-beam“ detector, 10m away, is required
- For ILC we agreed on a limit of 50G (5 mT) at a position of 15m off the detector beam axis

Limits drive thickness of iron yokes

- and this defines the radius of the central access shaft
- Studies showed that a weaker stray field limit of 100G could reduce the yoke radius by 60cm, saving ~500t of iron



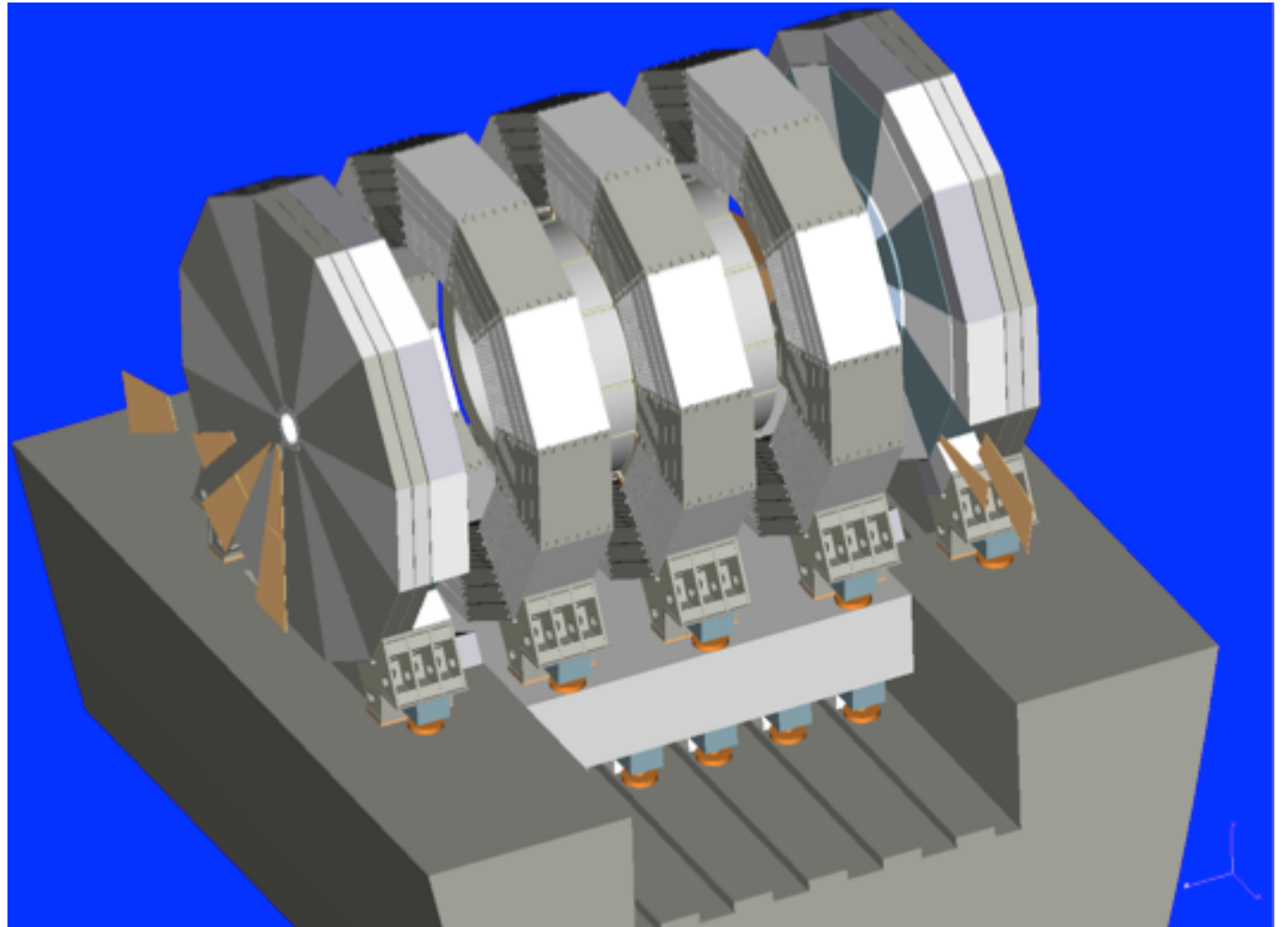
ILD Mechanical Structure

Main structure

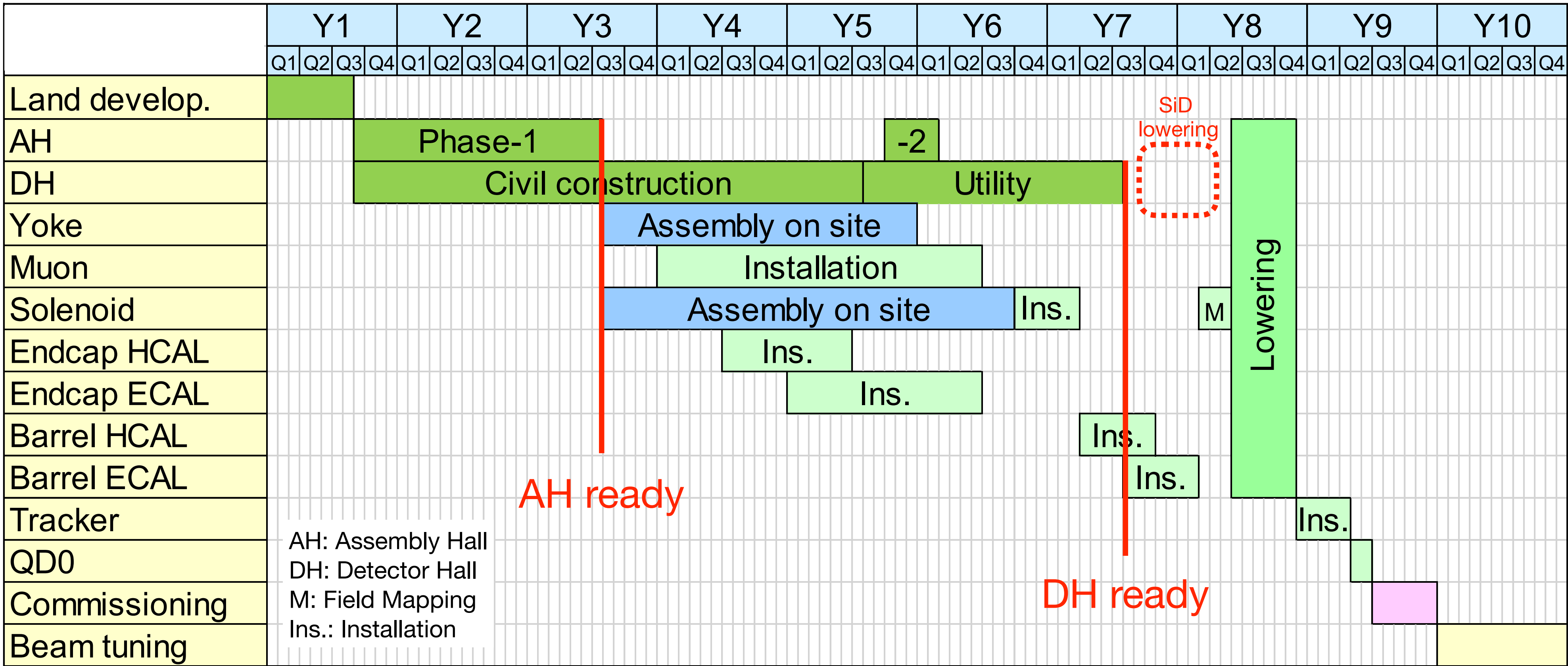
- 5 Yoke rings
- central ring carries solenoid and inner detectors
- 2 endcaps with endcap calorimeters

Designed for push-pull

- on platform for rapid beam-beam transition



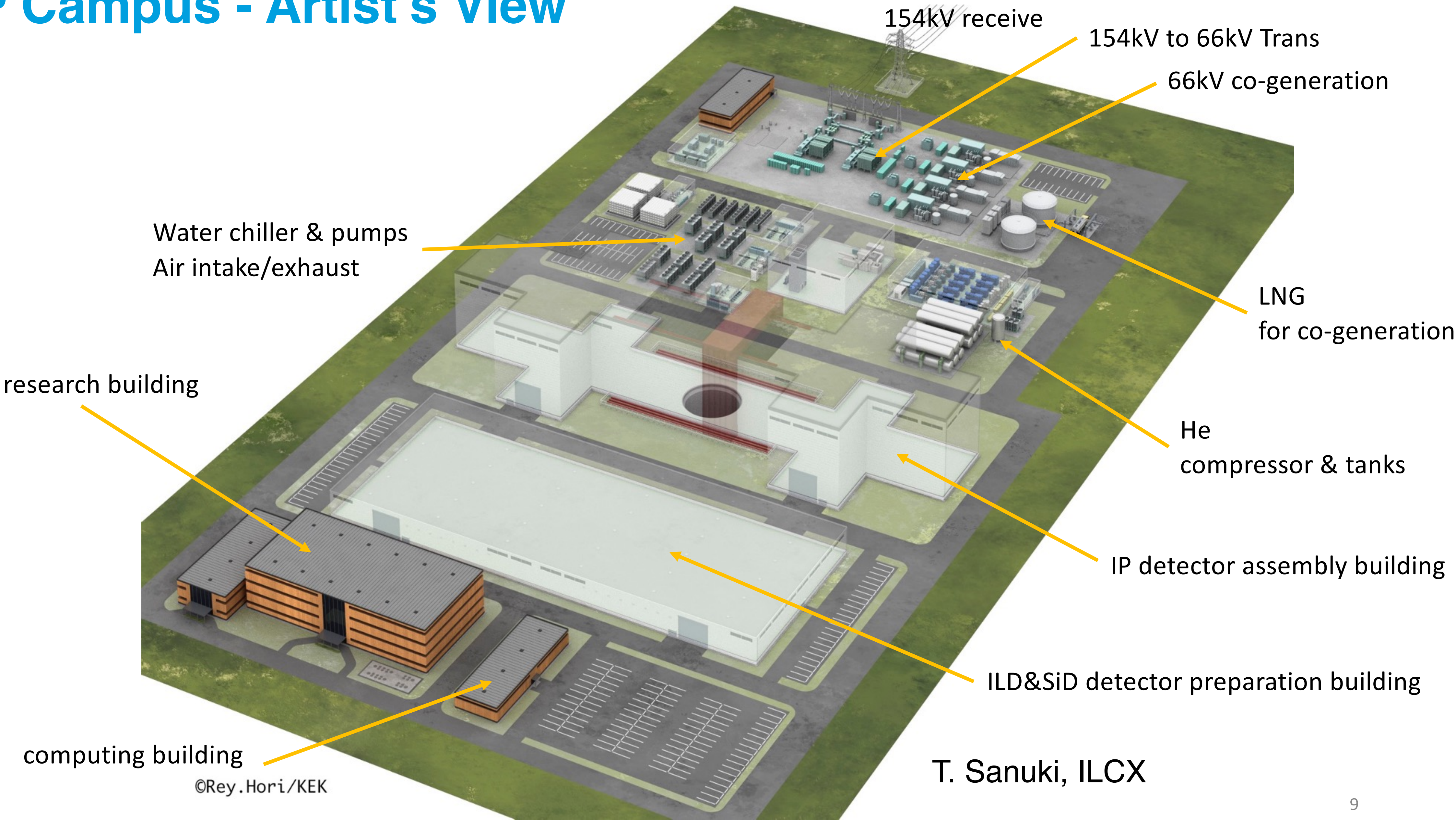
Technical Detector Construction/Assembly Time Line



Main reason to go for CMS-style surface installation process is time

- Underground areas (detector hall DH) only available 7 years after ground breaking, ~11 years after project start
- ATLAS-style underground assembly would delay detector by several years, well after the machine would be ready
 - It worked for ATLAS because the detector cavern was started to be constructed while LEP was still running....

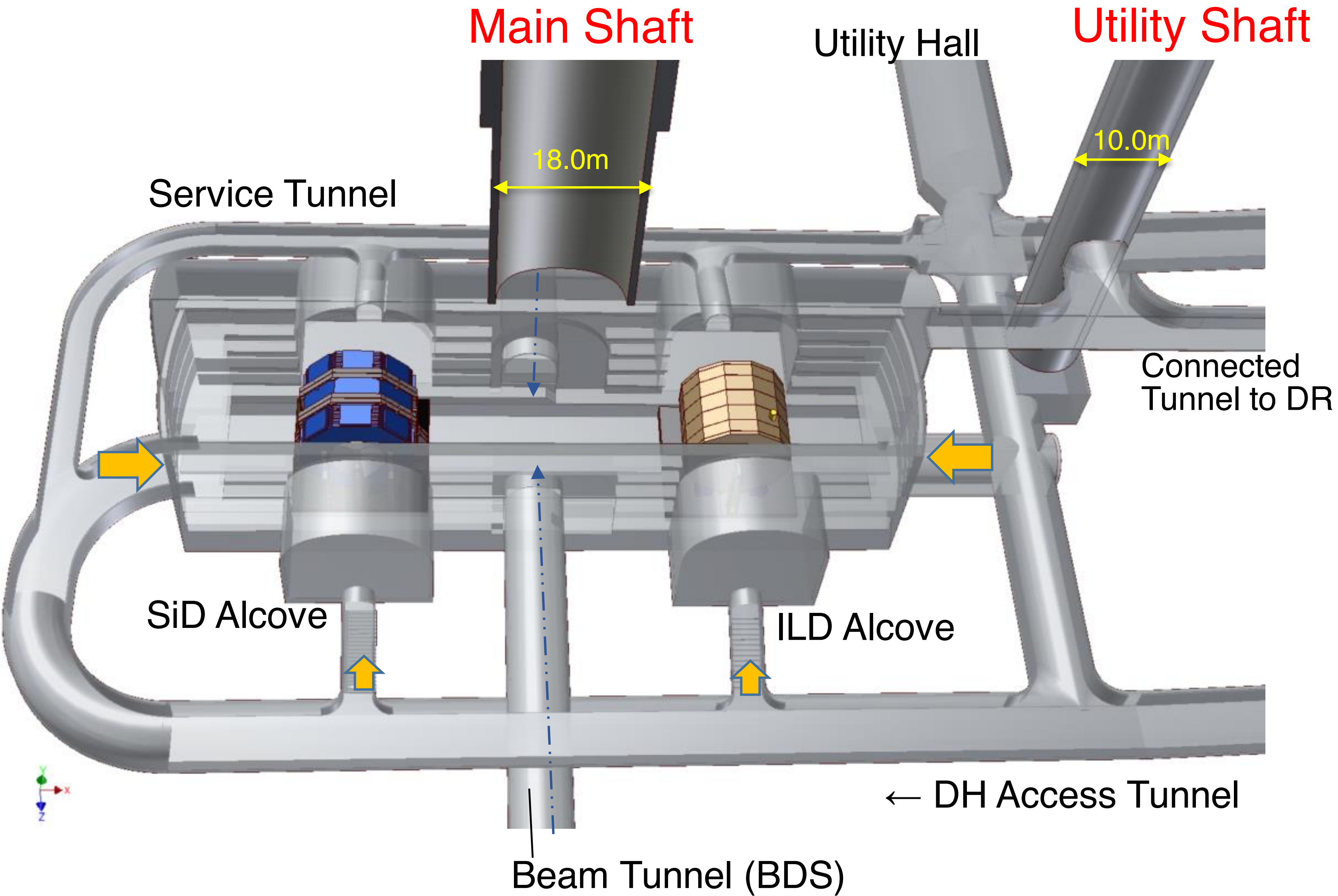
IP Campus - Artist's View



©Rey.Hori/KEK

T. Sanuki, ILCX

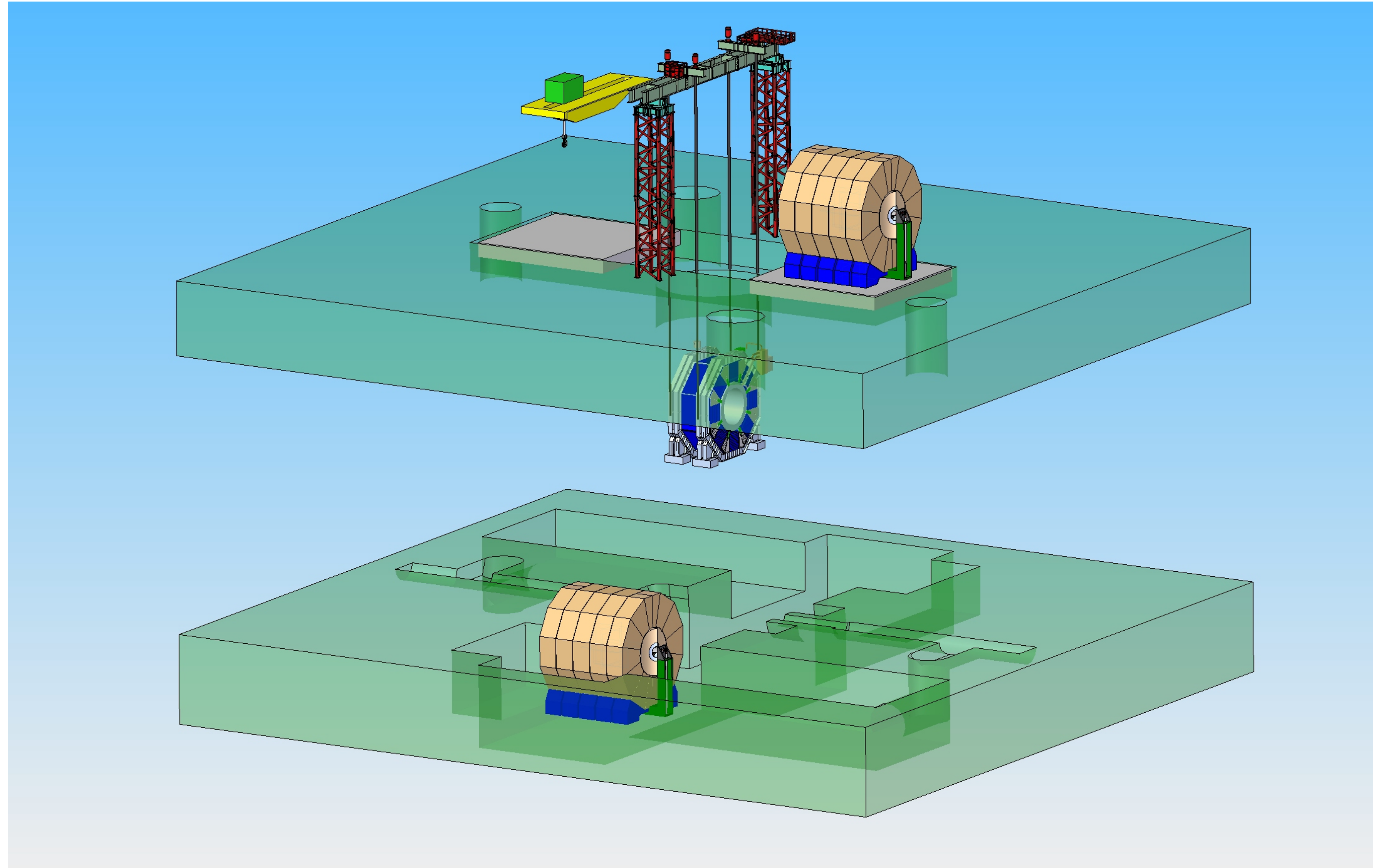
Underground Detector Hall



Surface Assembly - CMS Style

Handling

- Gantry crane (temp)
 - 4000t, driven by SiD, not ILD!
- 250t cranes in assembly hall
- 40t cranes in underground area
- air pads
- platform system



Question by FCC-ee: what is the largest piece of ILD?

Is this (right) the largest piece to be lowered? Yes, nearly...

- Cryogenic ancillaries might be missing
- Possible design changes from different boundary conditions (stray fields)
- Depends on assembly scenario, calorimeters might be installed underground

Dimensions

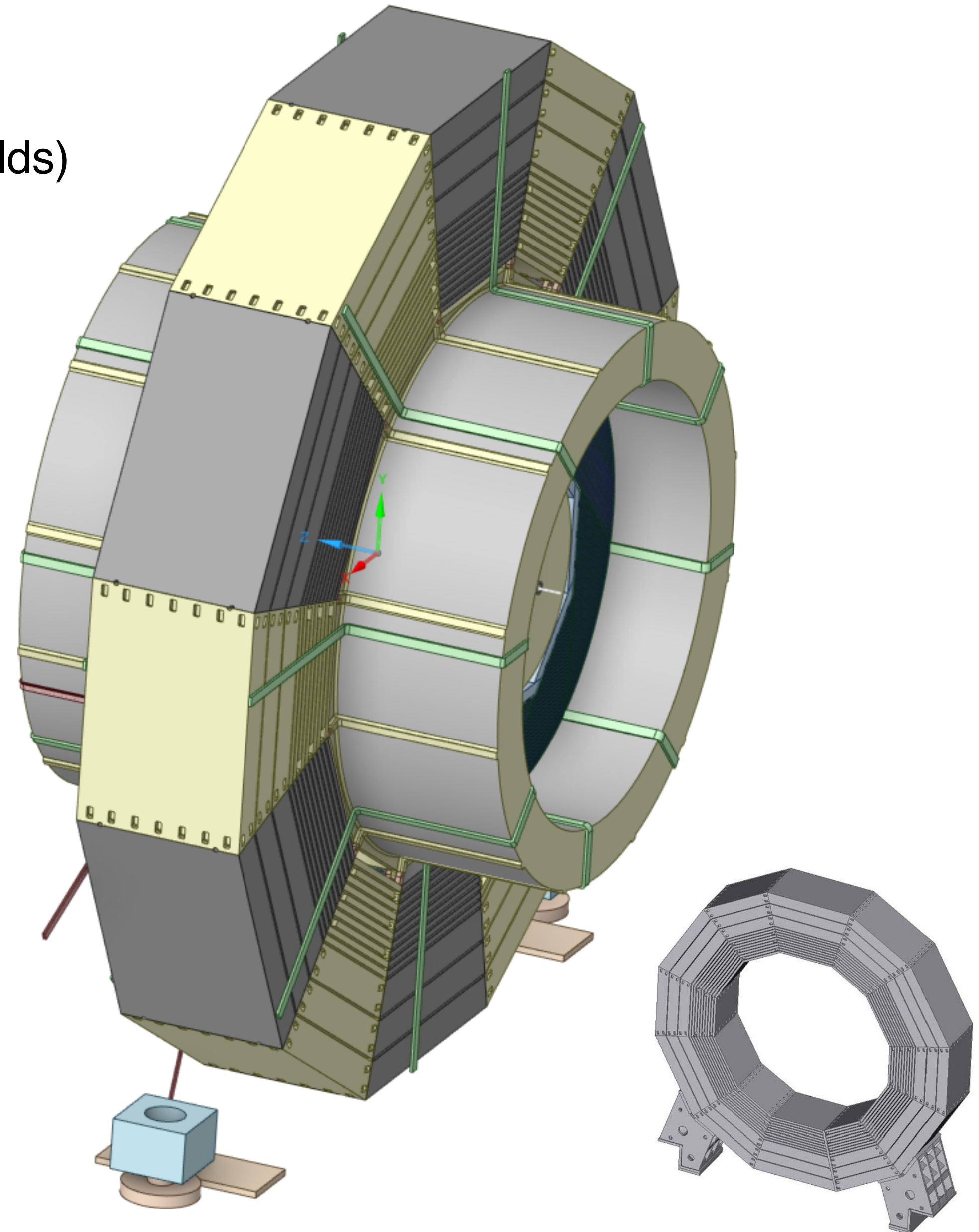
- Yoke outer radius 7755 mm
- Magnet cryostat length 7810 mm

Masses

- Central yoke ring: 2300 t
- Barrel calorimeters: 700 t
- Magnet (cold mass, cryostat): 250 t
- Other (yoke feet, ancillaries): 50 t (estimate)
- Total: 3300 t

Main shaft diameter

- Was chosen at 18m for ILC
- Could maybe be reduced to ~17m, depending on ancillaries

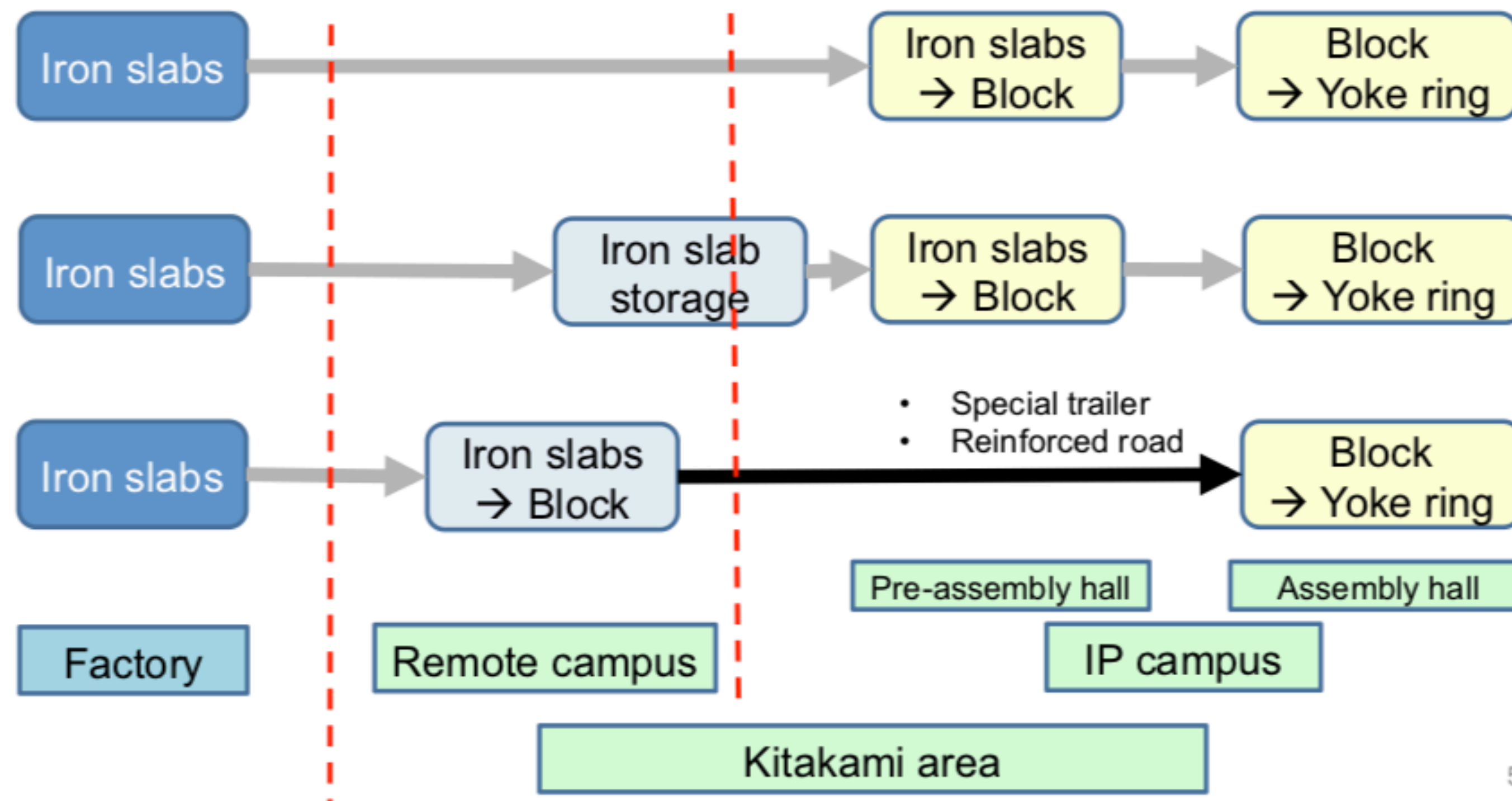


ILD Assembly

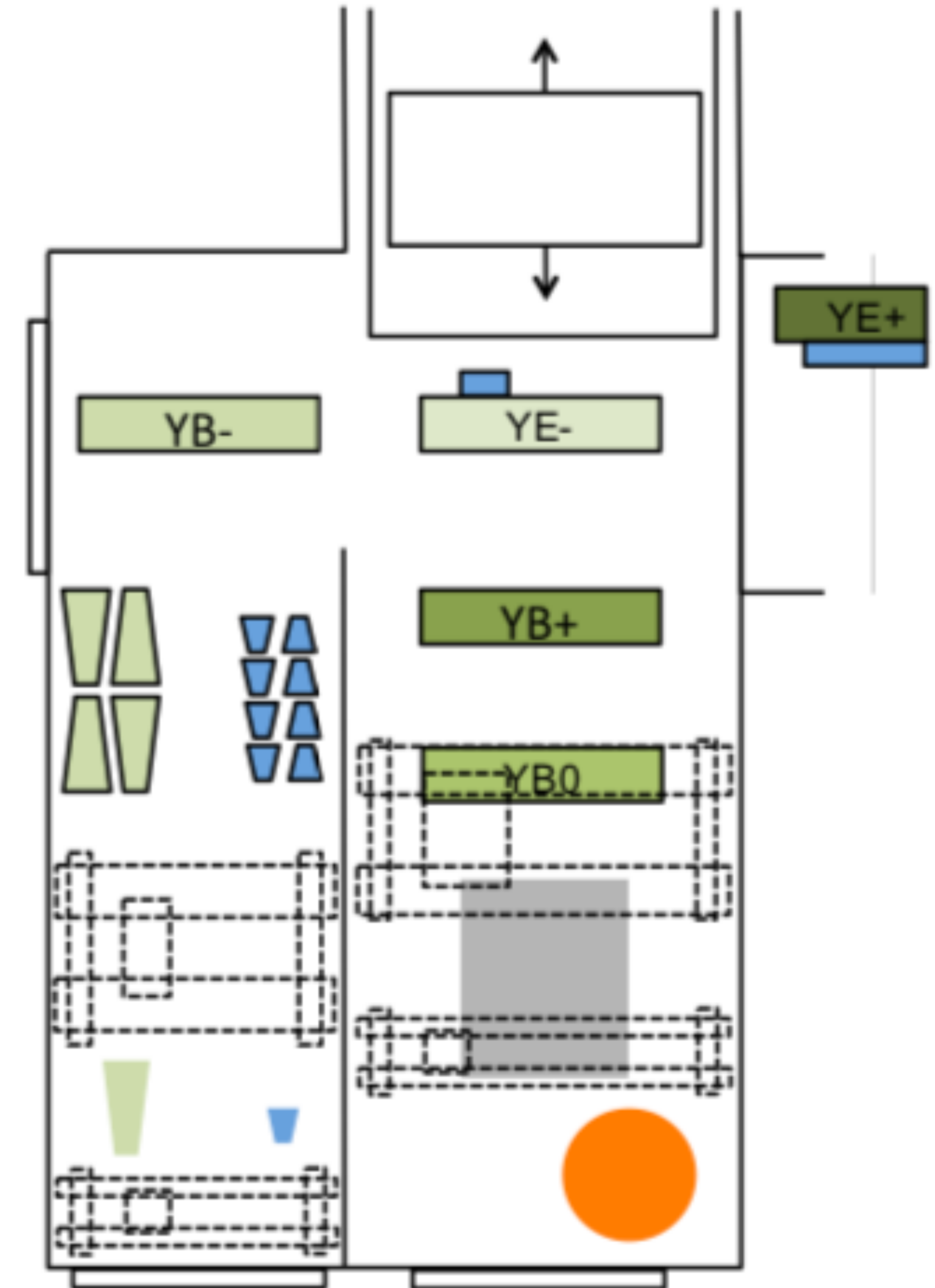
Limitations on transportation in Japan

- Heavy load transports are very difficult
- No realistic way to transport O(200t) yoke segments
- Plan therefore foresees yoke segment construction on site

This could be very different for FCC!



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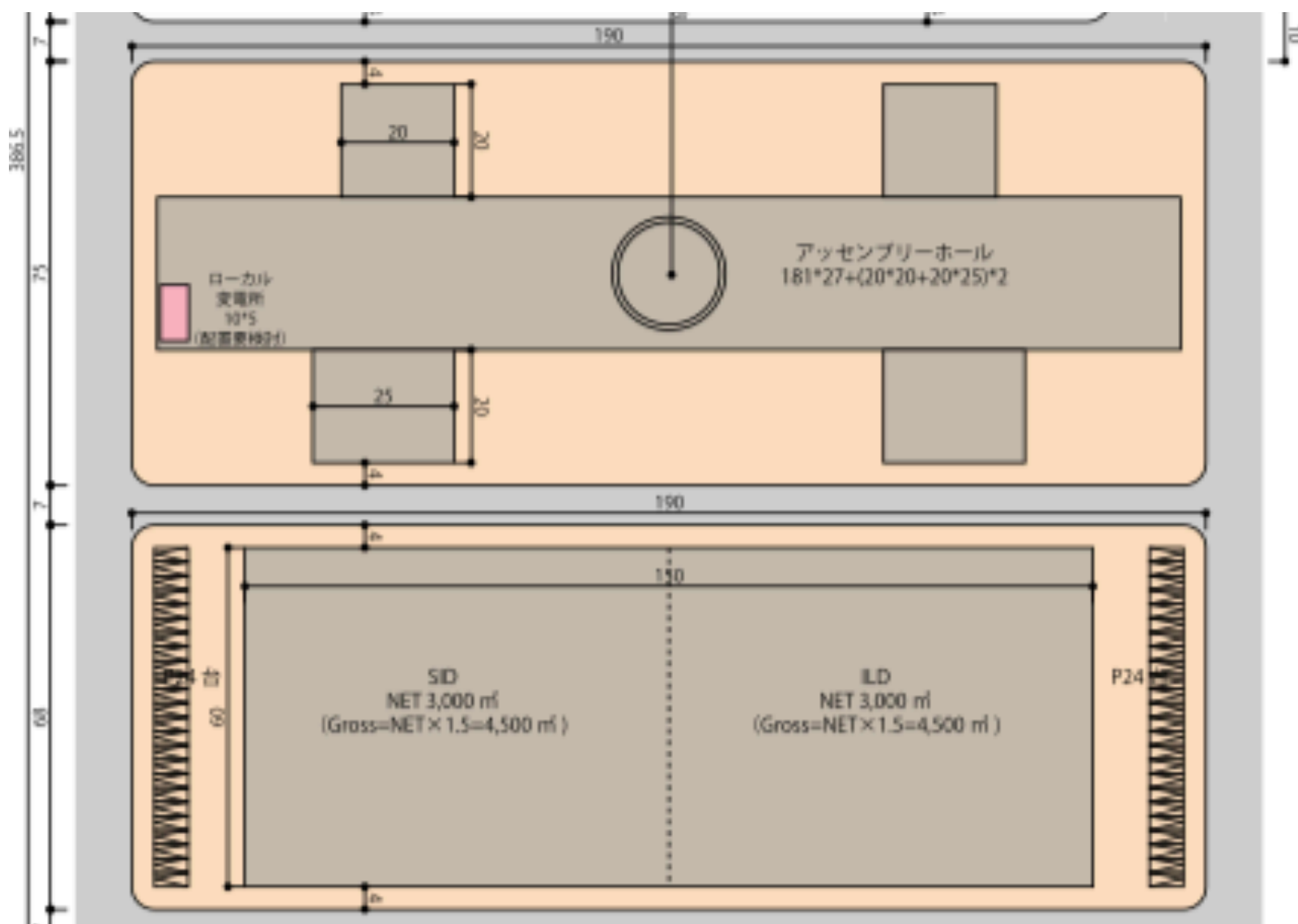


ILD Assembly Space Requirements

ILD requirements based on Japanese site

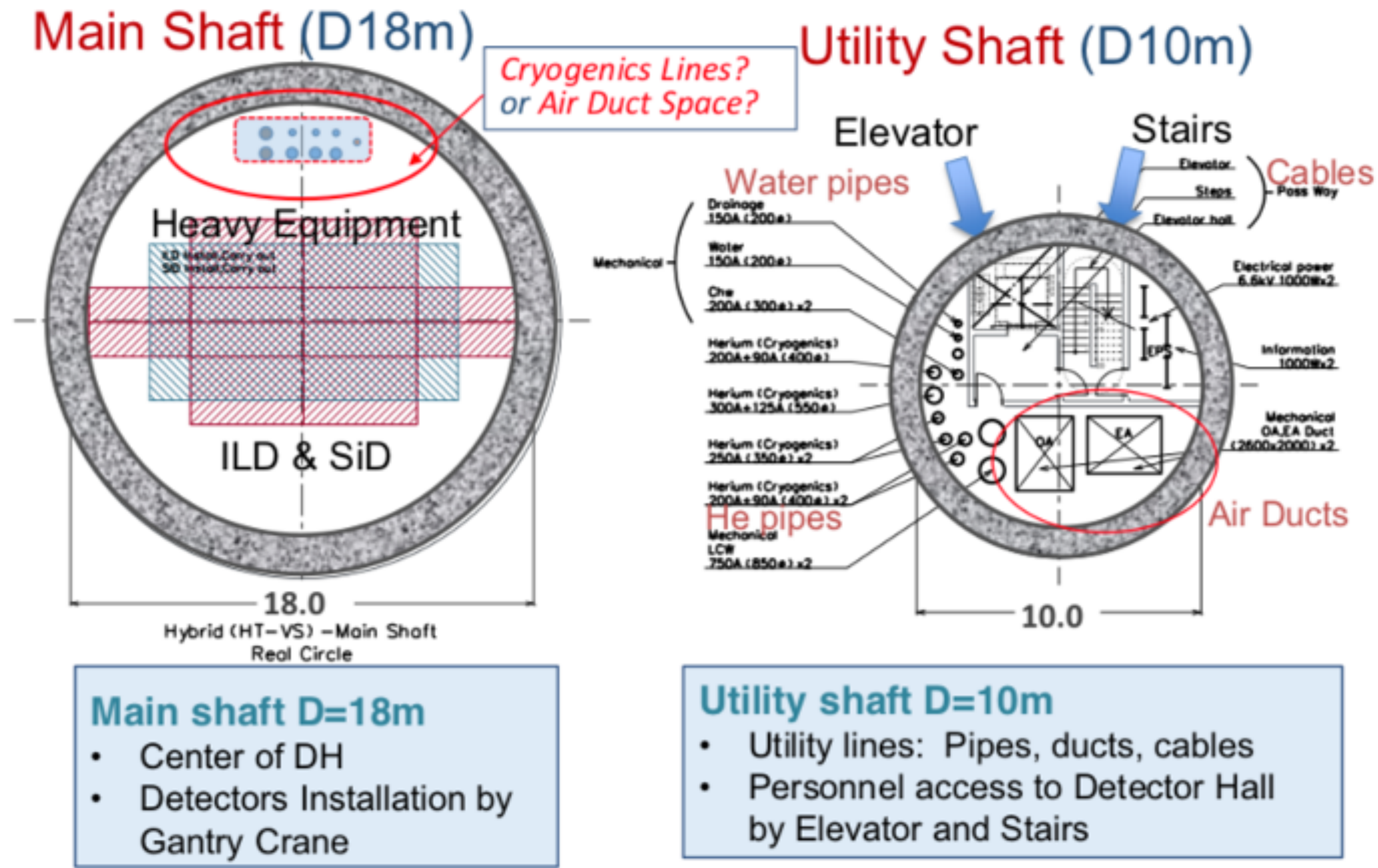
- ~3500m2 in Detector Hall (similar as for CMS)
- ~3000m2 in Assembly Building nearby
 - To avoid heavy load transports
 - Assembly of yoke elements
 - Subdetector assembly (HCAL!)

If heavy load transportation is easier at FCC, pre-assembly could be done offsite

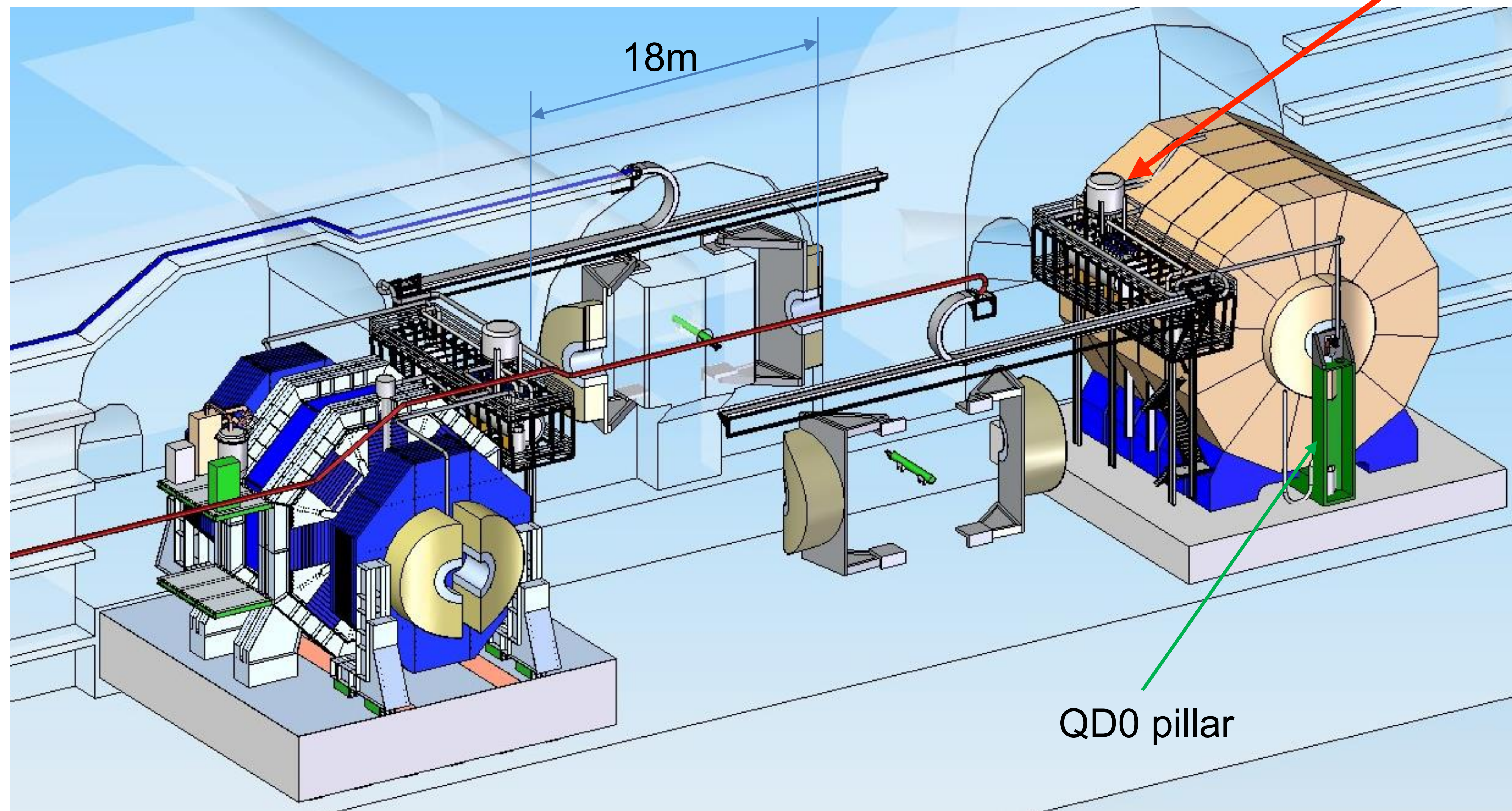


DHCAL total 1400 m ²	assembly, GRPC 1,200 Strage 200 +250t crane	
ECAL : barrel total 520 m ²	strage 160 +15t crane test 40 assembly 200 strage /test 120	TPC total 100 m ² clean room 100
ECAL : endcap total 310 m ²	strage 80 test 50 assembly 180	VTX/FTD total ? m ² ?

Access Shafts



Push-pull



FCC-ee Detectors Envelope Definition Document

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1211 Geneva 23 - Switzerland



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FCC-ee detectors external envelope definition

ABSTRACT:

This document shows the estimation of FCC-ee detectors external envelopes.

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2. Proposed FCC-ee detector concepts designs

Each detector concept has a single coil magnet in the design. Five detector concepts are under consideration as seen in Figure 1: CLD (nominal radius 6 m), ILD (nominal radius 7.83 m), ALLEGRO (nominal radius 5 m), ALFA (nominal radius 6 m), and IDEA (5.6m).

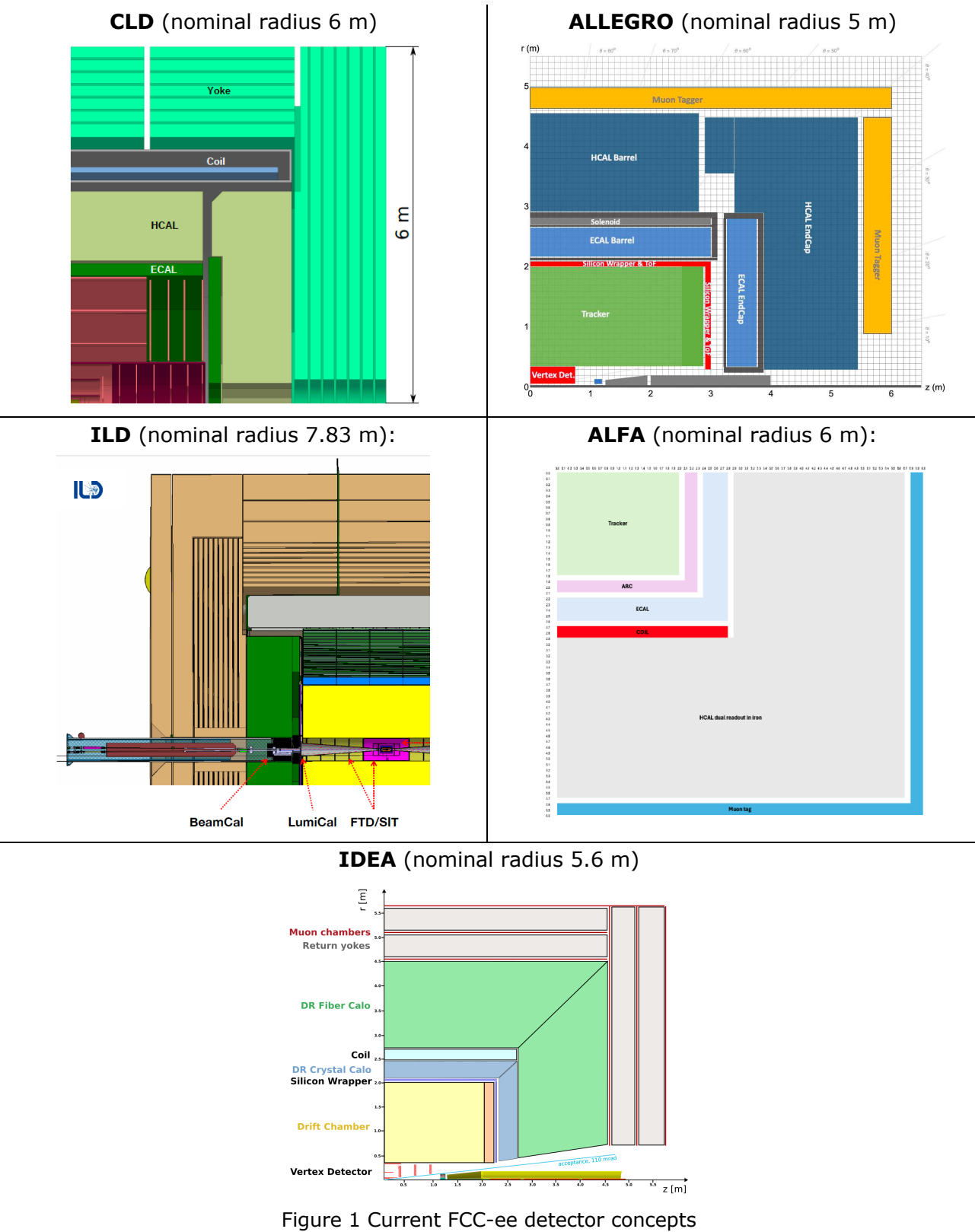


Figure 1 Current FCC-ee detector concepts



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Because the exact technical solutions are not yet defined by the detector team, an uncertainty factor of 10 % is added to the radial dimensions. This uncertainty factor is supposed to cover for any possible differences in technology used Sin this detector design compared to CMS.

3.1.2 ILD

According to documentation describing the ILD, the presented model is already taking into account services, interfaces and support structures space. These spaces are mostly referred to by "dead spaces" and are described in more detail in chapter 5.1.3[2]. It should be verified with the author if given values are still up to date.

Figure III-5.10
Illustration of the main service paths in the ILD detector.

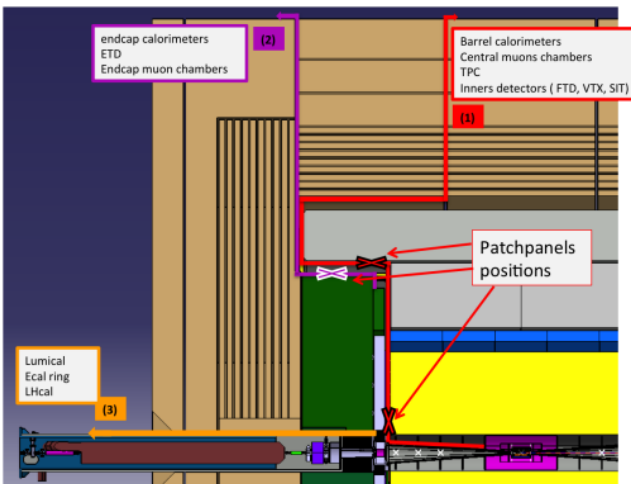


Figure 7 Visualization of cabling in ILD[2]

Thus, the individual external envelope radius for ILD can be estimated to be at **7.833m**. This is more than the CLD estimation which can be correct as the main difference between the two is the difference in magnet dimensions.

Figure III-1.2
Quadrant view of the ILD detector concept. The interaction point is in the lower right corner of the picture. Dimensions are in mm.

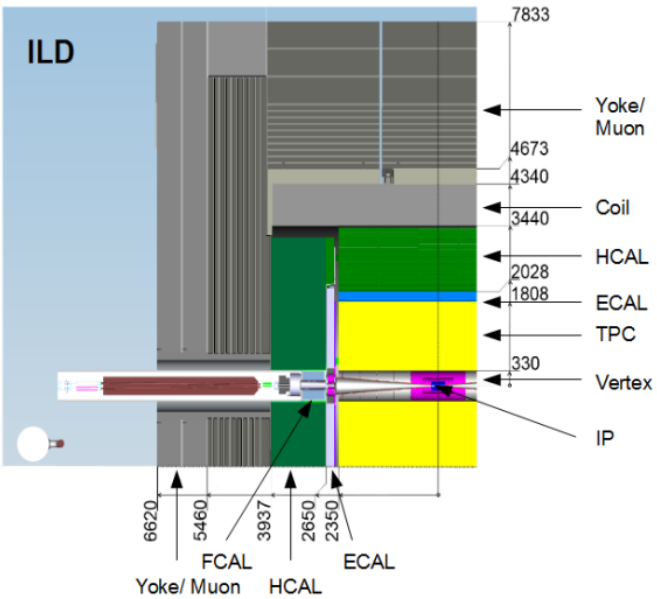


Figure 8 Available dimensions used for estimation of ILD layers dimensions[2]

FCC-ee Detector Envelopes and Masses

Table 4 FCC-ee detectors radial external envelope estimation w/ services and support structures

Detector	Nominal radial envelope [mm]	Individual external radial envelope [mm]	Global external radial envelope w/ integration allowance(250mm) [mm]
CLD	6000	6646	6896
ILD	7833	7833	8083
IDEA	5600	6190	6440
ALLEGRO	5000	6750	7000
ALFA	6000	7250	7500

It is safe to assume **8.1m** global radial envelope for future dimensional considerations. All external envelopes exceed the radius initially considered during the feasibility phase (6m radius).

Table 5 FCC-ee detectors longitudinal external envelope estimation w/ services and support structures

Detector	Nominal longitudinal envelope (half-length) [mm]	Individual external longitudinal envelope (half-length) [mm]	Global external longitudinal envelope (half-length) w/ integration allowance (250mm) [mm]
CLD	5300	5950	6200
ILD	6620	6620	6870
IDEA	5700	6290	6540
ALLEGRO	6000	6750	7000
ALFA	6000	6750	7000

In case of longitudinal envelope, to the largest value with movement tolerance included is 7.0m.
It is therefore safe to assume **7.0m** of half-length global longitudinal envelope for future dimensional considerations.

Table 6 FCC-ee detectors largest component for CMS style assembly, estimated dimensions

	Detector	Largest component dimensions		
		Diameter [m]	Length [m]	Weight [t]
FCC-ee	CLD	13.3	7.4	3500
	ILD	15.6	7.8	3300
	IDEA	12.4	5.0	<3500
	ALLEGRO	13.5	7.8	<3500
	ALFA	≈14.5*	-	<3500

With preassembly on the surface similar to CMS, it can be assumed that all the largest components exceed the weight of 2000t, thus may require a special high load gantry. With assembly piece by piece (ATLAS style), the largest FCC-ee detector (ILD) would require lowering the cold mass of 168 down the shaft.

Selected Open Questions

No personpower!

Physics requirements

- ILD magnet and yoke were designed for 4 T maximum field
- FCC-ee has lower energy range than Linear Colliders, so is 4 T still required?
- Smaller magnetic field would probably change magnet and yoke geometries

Detector Assembly Strategy

- On-surface assembly (CMS-style) was chosen at ILC because of integrated timeline studies together with the machine experts
- ATLAS-type assembly is also possible for ILD, would come with relaxed constraints for the shaft size
 - Biggest element probably the magnet, not the yoke
- Surface and underground facility layouts depend on assembly strategy and detector infrastructure requirements

Cryogenics

- The detector magnet will be assembled on-site and it has to be tested
- Lowering can be done before or after testing
- Testing before requires cryogenic on surface to be ready in time
- Testing after requires cryogenic infrastructure in the hall to be ready in time

Stray field requirements

- Yoke size and mass depends on this, any guidelines available?
- Relaxing requirement from 5 mT to 10 mT reduces yoke radius by 60 cm and mass by ~500 t

Radiation shielding

- ILD@ILC is designed to be fully self-shielding, access to the hall is possible during machine operations
- How is this at FCC-ee? Might also have an impact on yoke thickness...