Siting the ILC in Kitakami

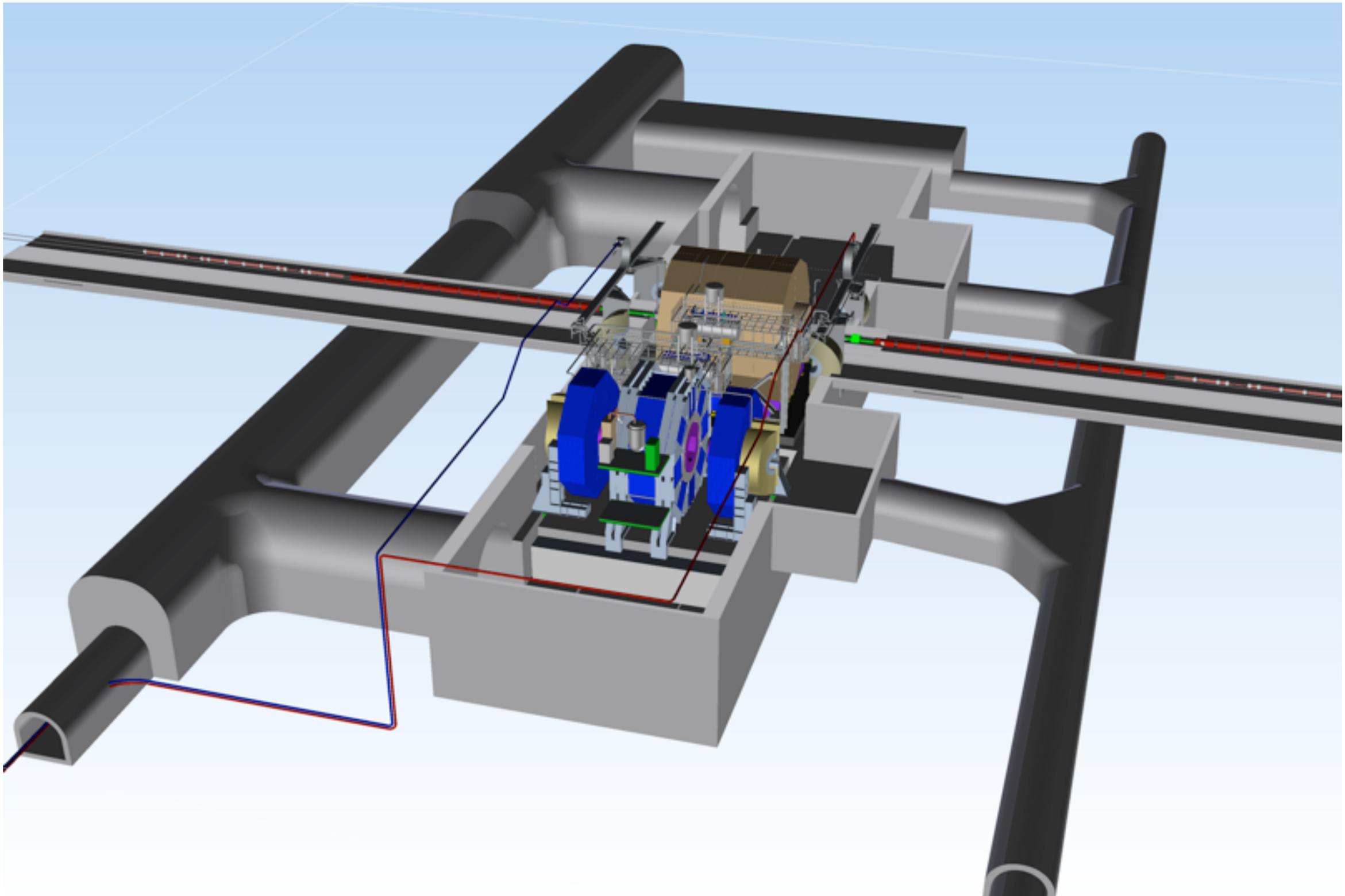
Detector Perspective

Karsten Buesser

23.05.2014

ILC@DESY Project Meeting

Japanese Experimental Hall Design - TDR

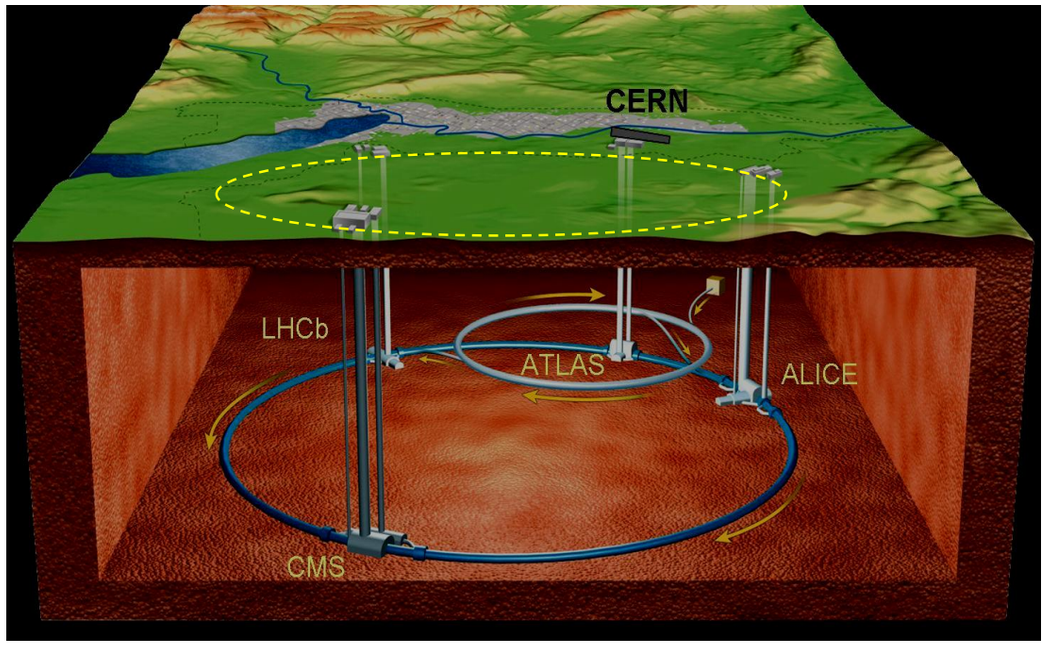


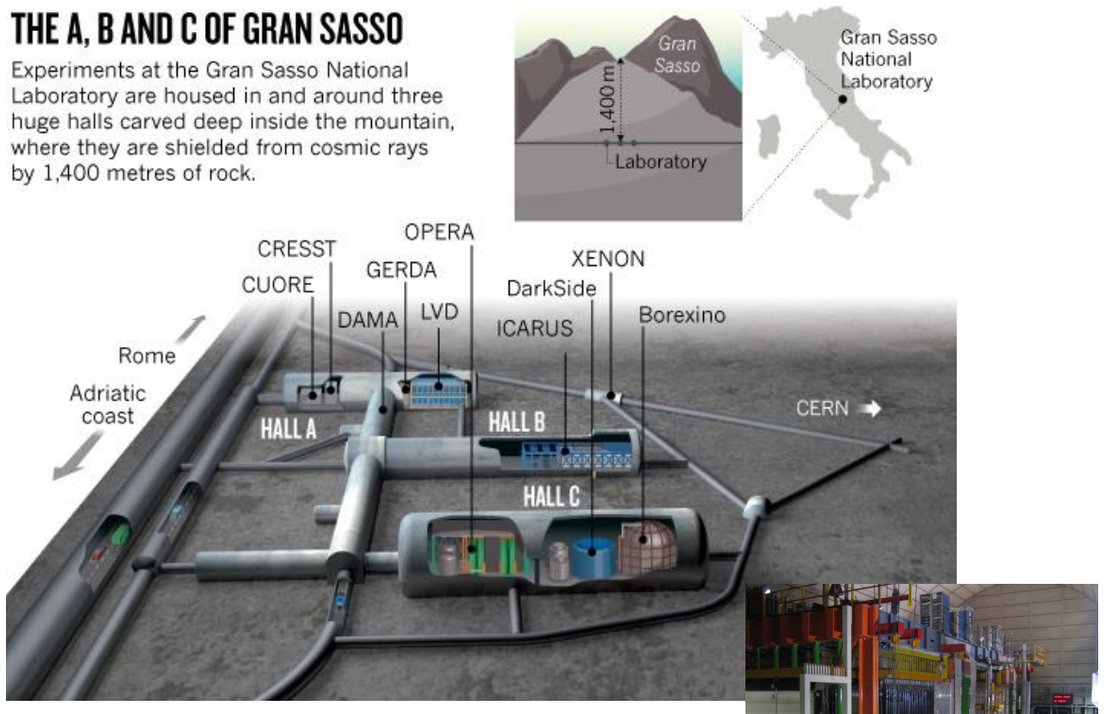
Some History….

- Surface and underground assembly scenarios have been discussed since many years
- Surface assembly „à la CMS“ has actually been enforced to the ILC baseline by an official change control process in 2006:
  - http://www.linearcollider.org/wiki/lib/exe/fetch.php?media=bcd:ccb-com-bds20061102.pdf
- Main arguments in favour of the vertical shaft surface assembly scheme:
  - timing issues: underground facilities can be ready much later
  - cost issues: underground halls are smaller
- Since then we learned about Japanese sites that ruled out vertical shaft access scenarios, so we had to adapt to horizontal tunnel scenarios
- Now we know about Kitakami, where it actually looks possible to at least look into possible VS solutions
- Need to understand how the basic principles (timing, cost) are affected by the real situation in Kitakami in both possible scenarios: HT, VS (or hybrid)

Experience

- LHC: flat-top geography
  - access via vertical shafts
- Gran Sasso: mountains
  - access via highway tunnel
- Both work fine, but Kitakami is different:
  - VS - no real flat-top surface:
    - access to assembly areas could be more difficult
  - HT - tunnel very different from Gran Sasso:
    - ~7% slope
    - curved

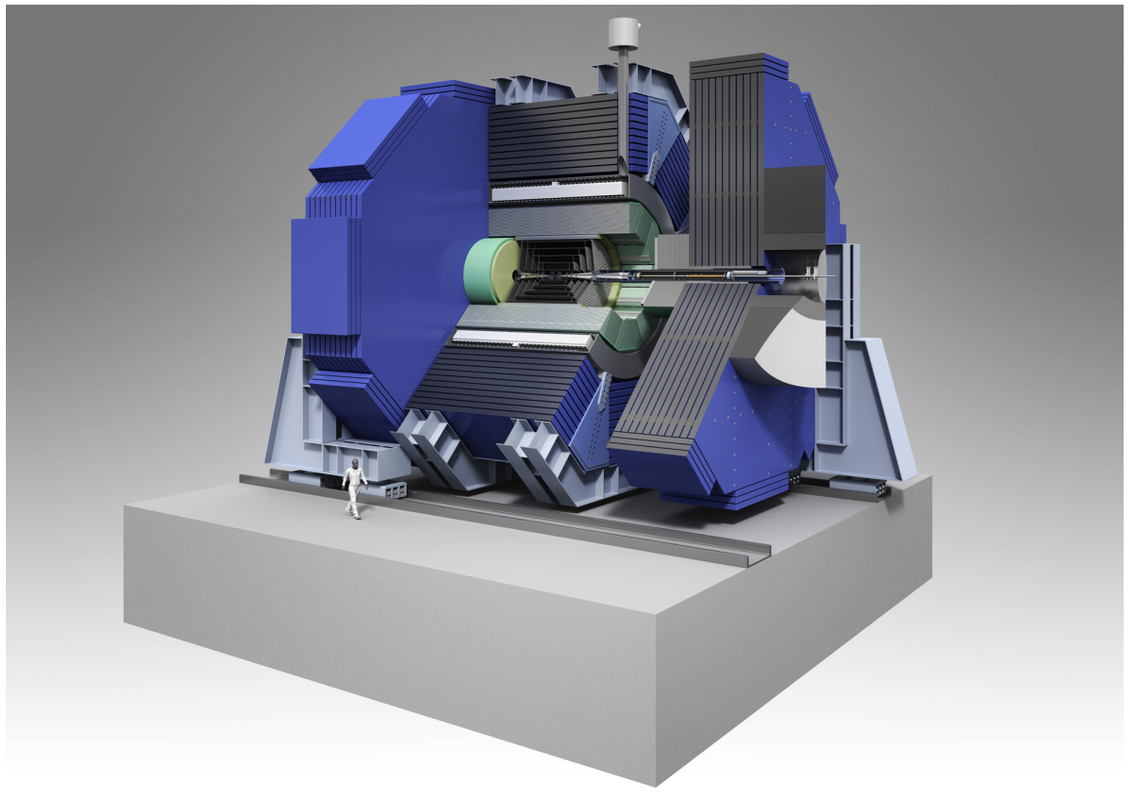


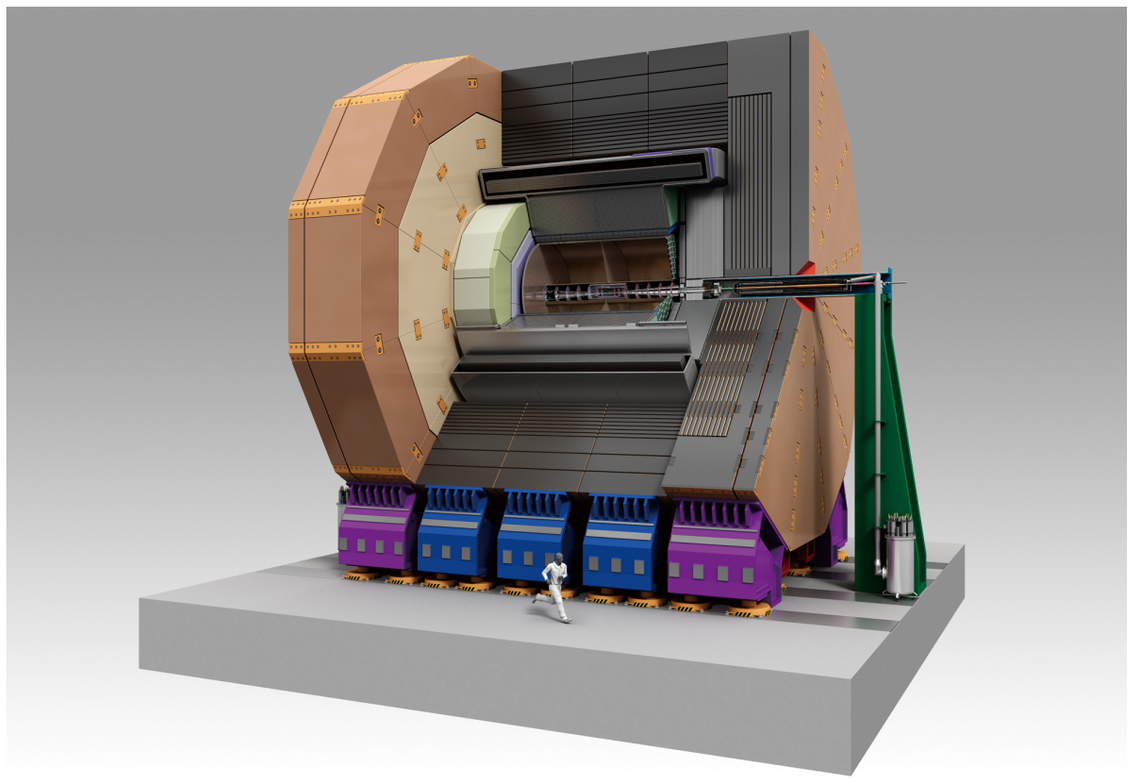


Opera experiment: 5000t

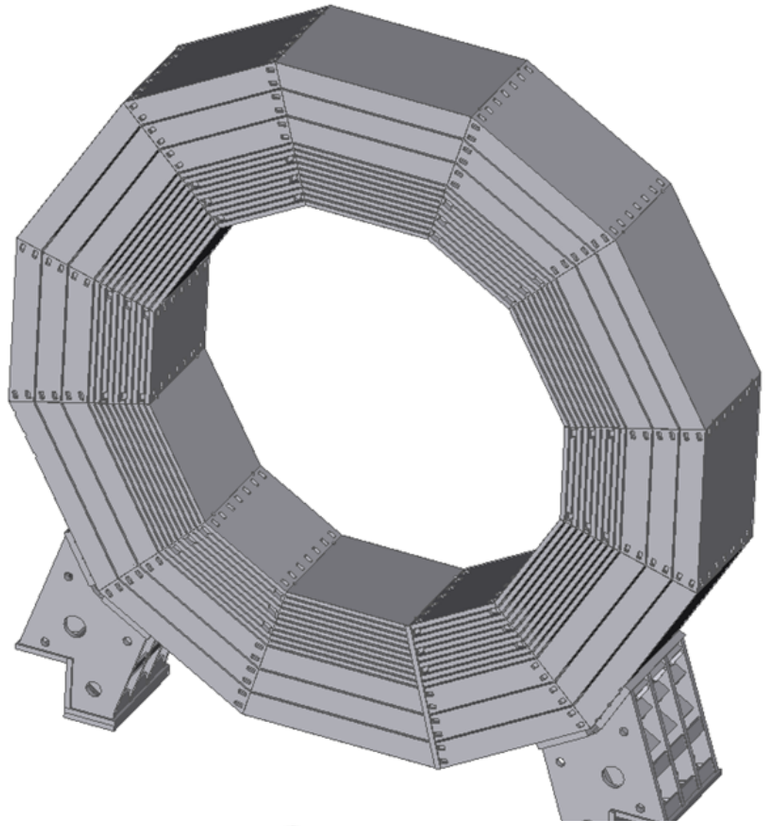
Detector Designs

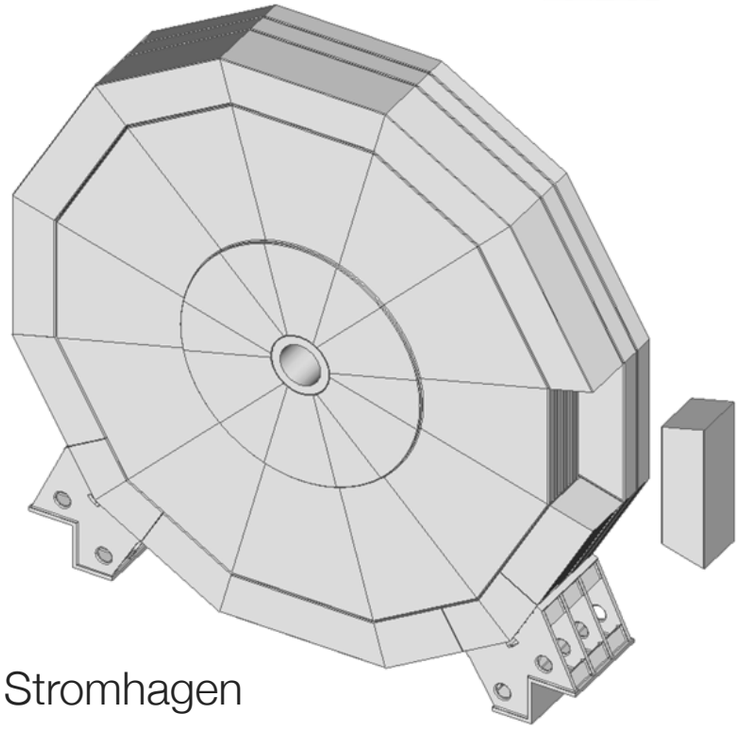
- Both detectors have large iron yokes
  - limits on magnetic fringe fields in the hall
- Both detectors have a large solenoid coil
- Modular assembly out of pre-constructed parts
- Subdetectors and structural elements will probably be built in many different labs and contractors around the world
  - need to discuss exact procedures w.r.t. Kitakami realities…

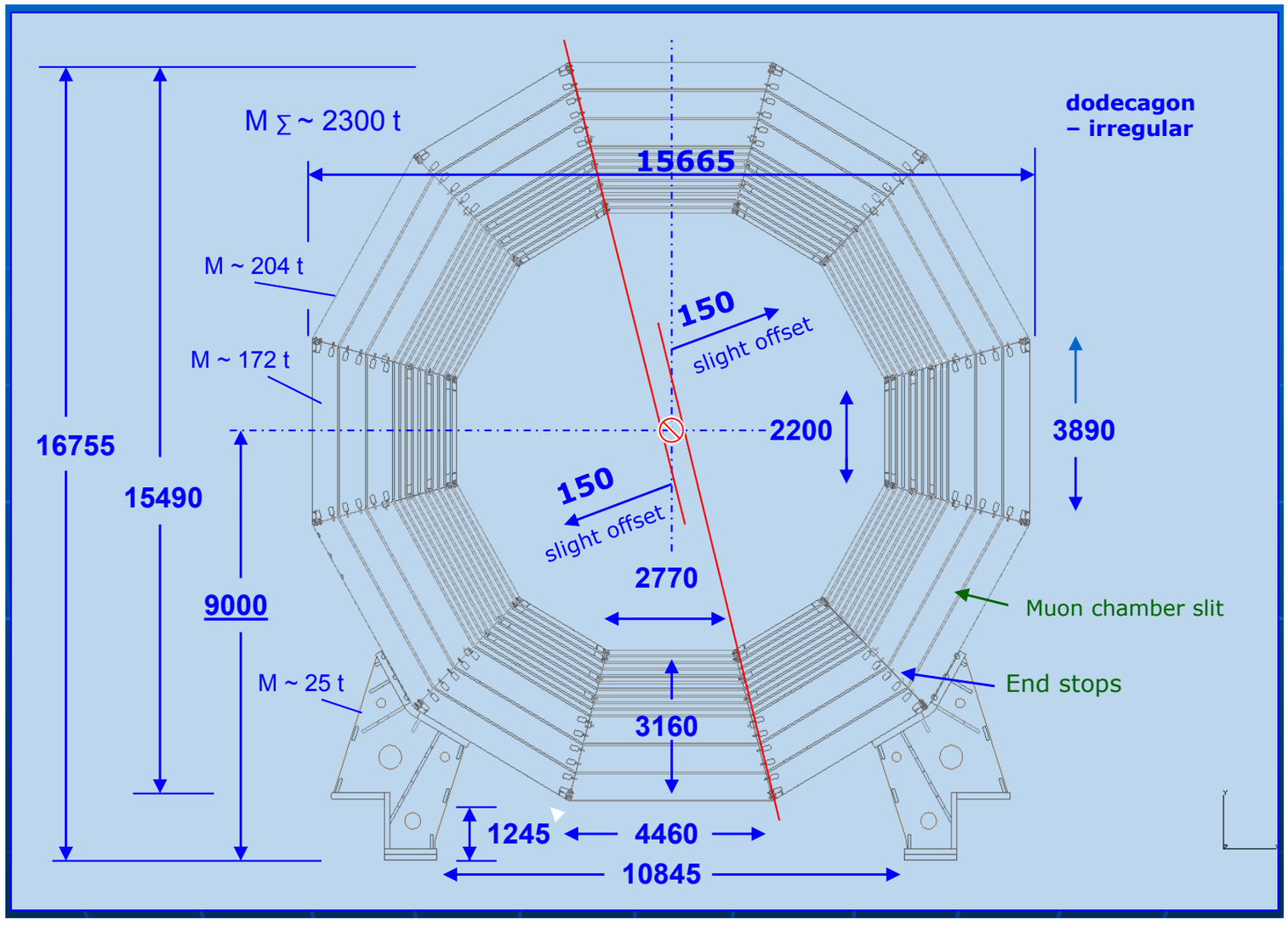




ILD Yoke



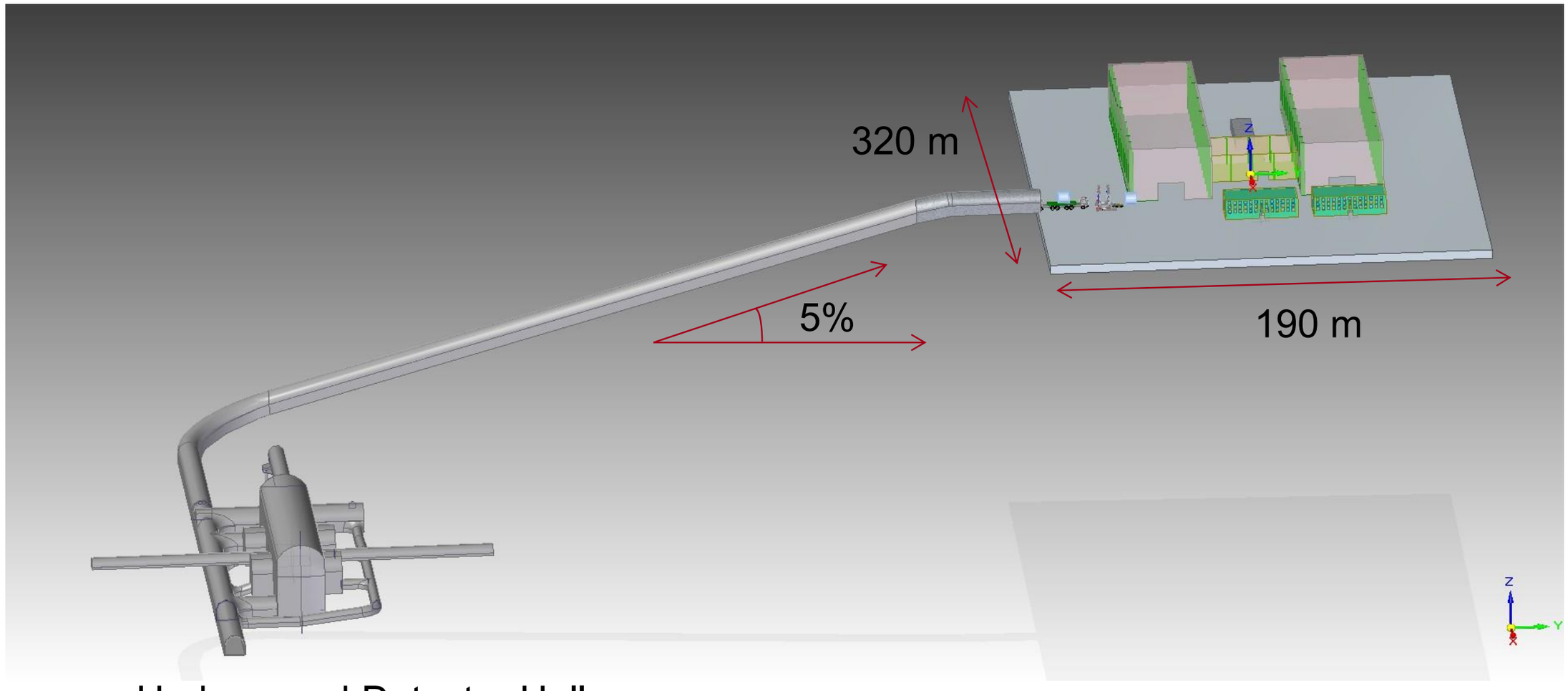




R. Stromhagen

Horizontal Tunnel Access (HT)

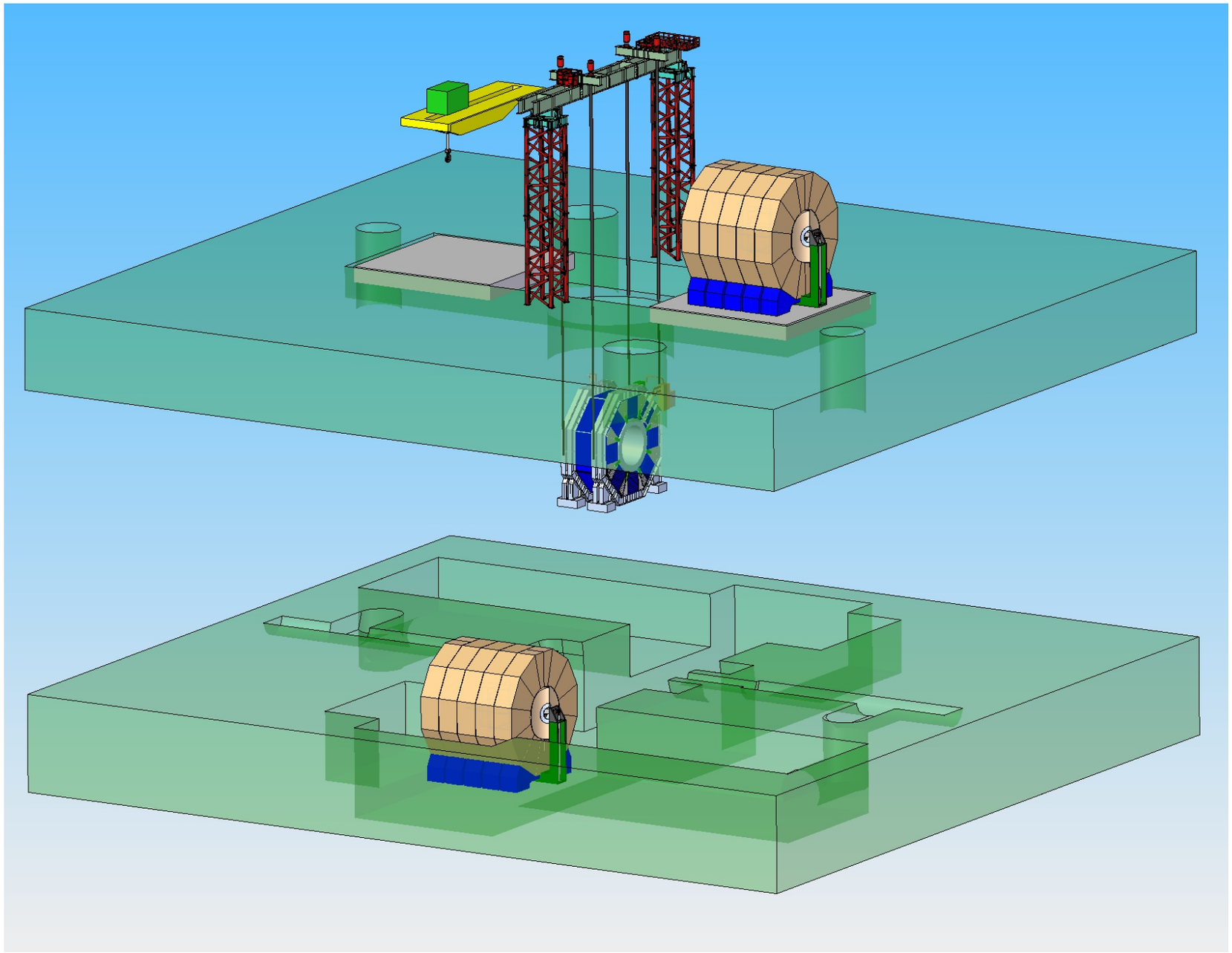
- Tunnel with length of ~1km and slope of up to 7%, 11m diameter
- Need transportation system from assembly yard to underground hall
- Potential long ways for services
- Detector assembly model: assemble from parts that fit - in size and mass -into the tunnel



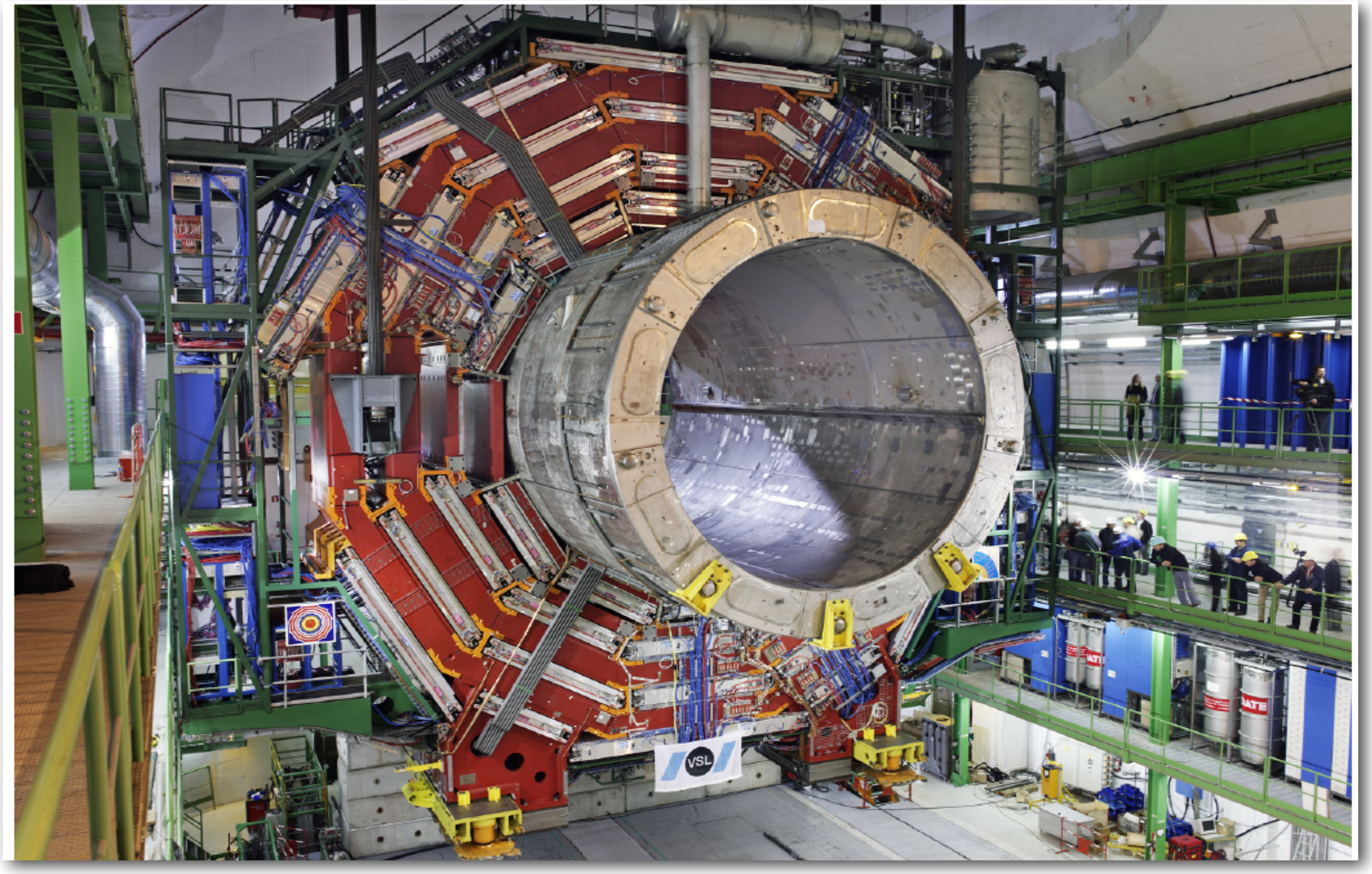
Undergound Detector Hall

Vertical Shaft Access (VS or hybrid VS+HT)

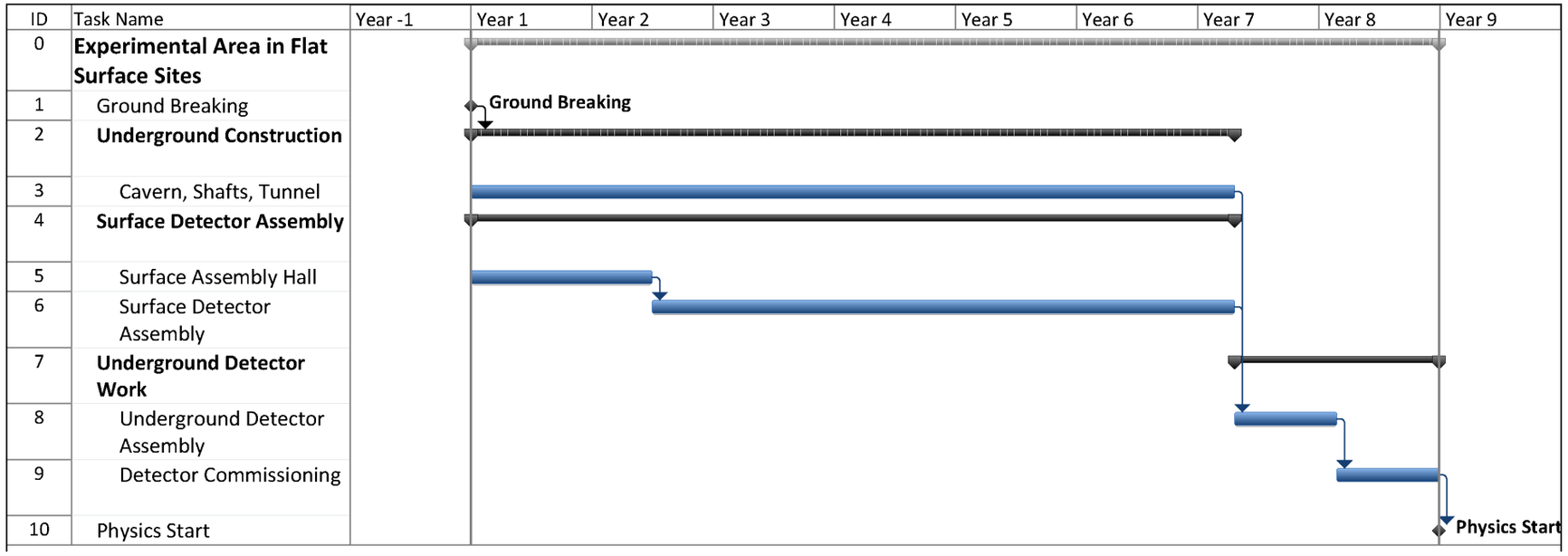
- Detector assembly mostly done on surface
- Big pre-assembled, instrumented and tested parts are being lowered late in the project phase
- Need temporary gantry crane for ~4000t
- 2x250t hall crane in surface hall, extend over shaft
- Surface hall needs one platform
  - SiD will be constructed on it
  - ILD parts can be moved on platform after SiD has been lowered
- Alignment of surface halls and underground hall is coupled by VS

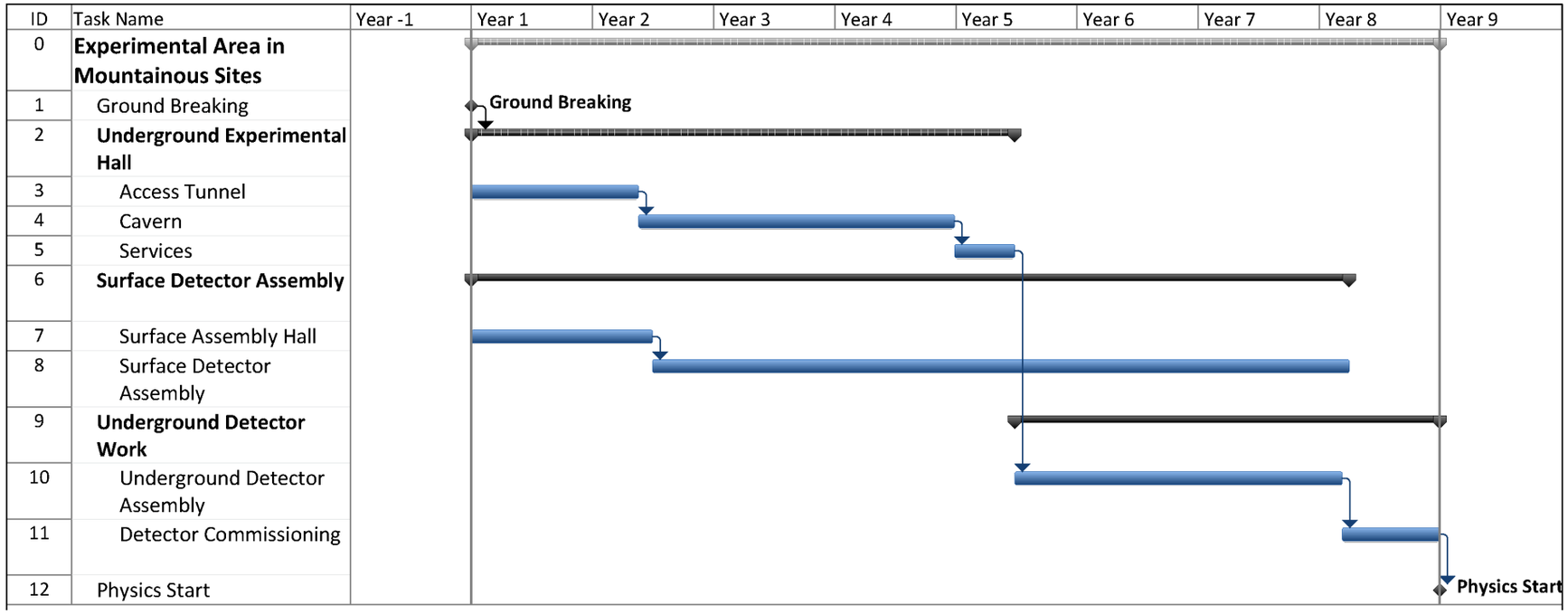


CMS Experience



ILD Installation Timelines





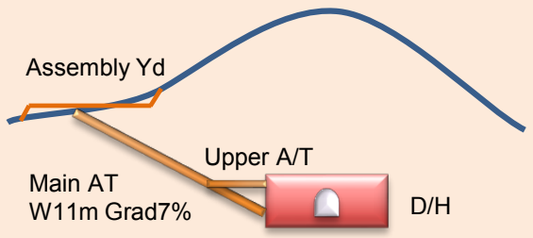
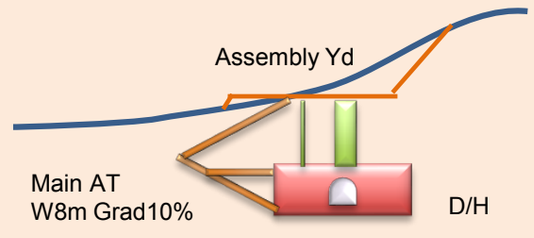
- Underground work VS: 1y assembly, ~1y commissioning
- Underground work HT: 3y+ assembly, ~1y commissioning

ILD Biggest Parts: Yoke and Coil

- In each case: need to test the coil on site
- For high-field tests this requires the existence of a yoke
  - VS: yoke parts will be delivered from vendor to assembly hall
  - Yoke will be pre-assembled in assembly hall
  - Coil will be assembled from modules and then tested in yoke on surface
    - requires cryo installations on surface in-time
  - HT: yoke needs to be pre-assembled somewhere (surface hall or at vendor)
  - Yoke parts need to be transported through HT
  - Yoke rings will be assembled in underground hall
  - Coil will be assembled from modules in underground hall and then tested in yoke
    - requires cryo installations in underground hall in-time
  - If anything does not work as predicted, it needs to be transported back to the surface for modification

Kitakami Options

- Baseline case with horizontal tunnel access has been studied since some time:
  - including geological studies
  - could be realised at the site
- Hybrid solution with horizontal tunnel and vertical shaft are being discussed recently:
  - seems possible at Kitakami
  - detailed geological studies pending
  - has advantages for ILD
- Breaking news from AWLC:
  - new proposal by SiD (later…)

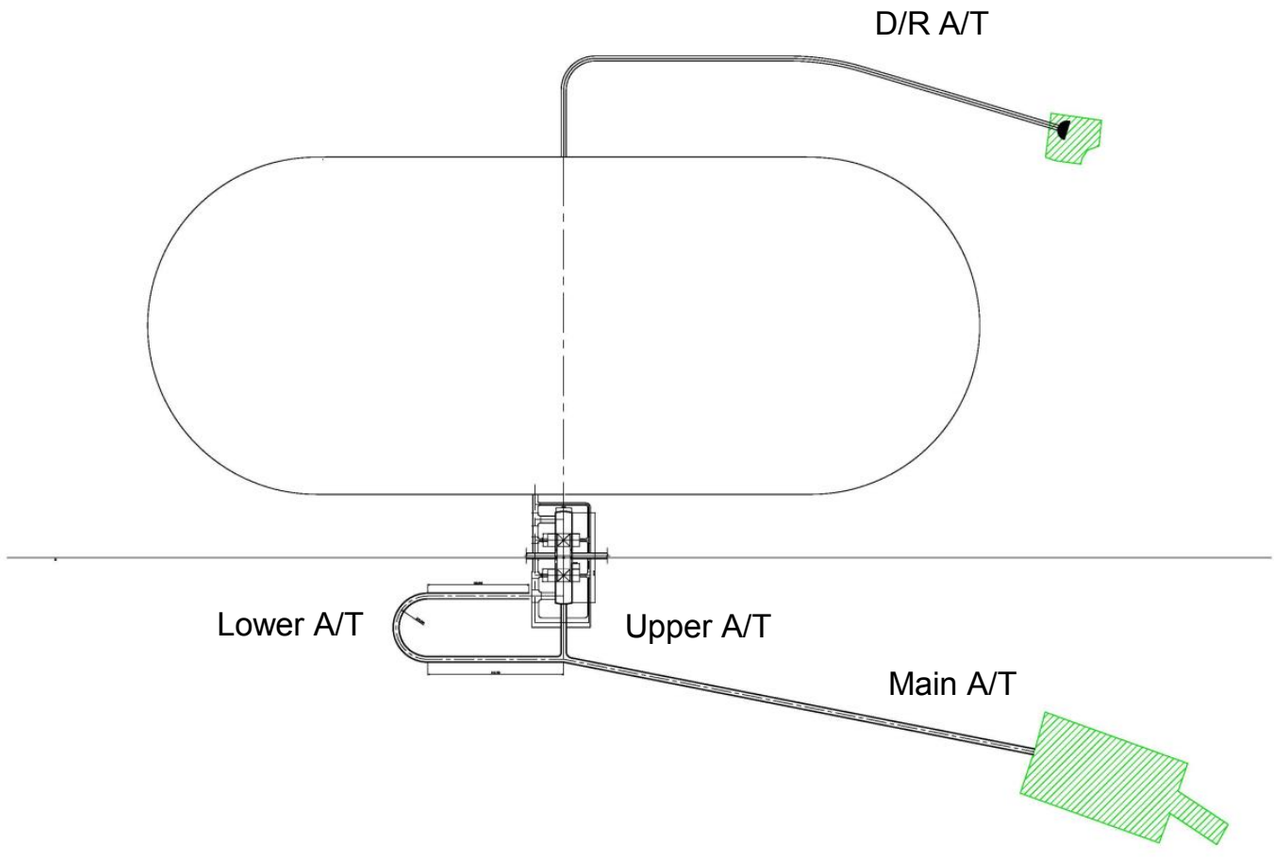
Baseline	Hybrid-A
	
• 1 HT (11x11m 7%grad) • Detector assembling is inside of DH	• 1 HT (8.0x7.5m 10%gradl) • 2 VS (D18m, D10m) • Detectors assembling is on-ground.
• UT lines in DR/AT	• UT lines in UT shaft
• DH 175,000m3 • L144m H42m W25m	• DH 128,000m3 • L108m H42m W25m
• Heavy lowering system non	• Heavy lowering system necessary
• Location of DH and assembly yd. can be selected individually.	• Assembly hall is above D/H
• Human pass way :car • Machine and materials tunnel by vehicles	• Human pass way :elevator • Machine and materials tunnel by vehicles
• Environmental impact will be smaller during construction.	• Noise reduction
• Evacuation ways Main AT and DR HT	• same as on the left

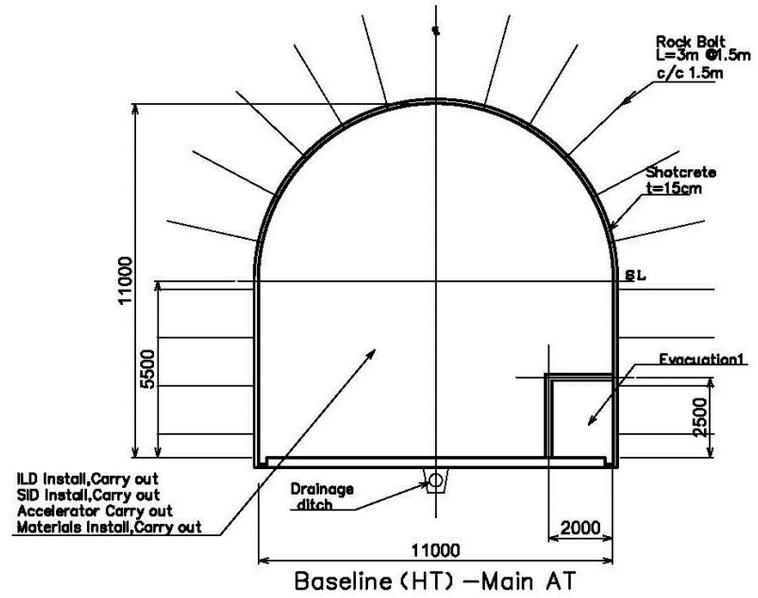
Y. Nishimoto

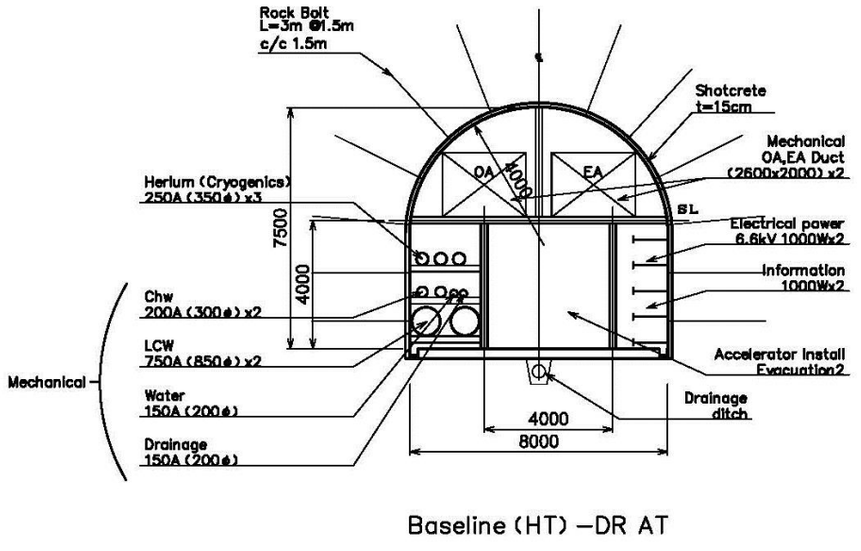
Baseline General layout

Tunnel access for D/H

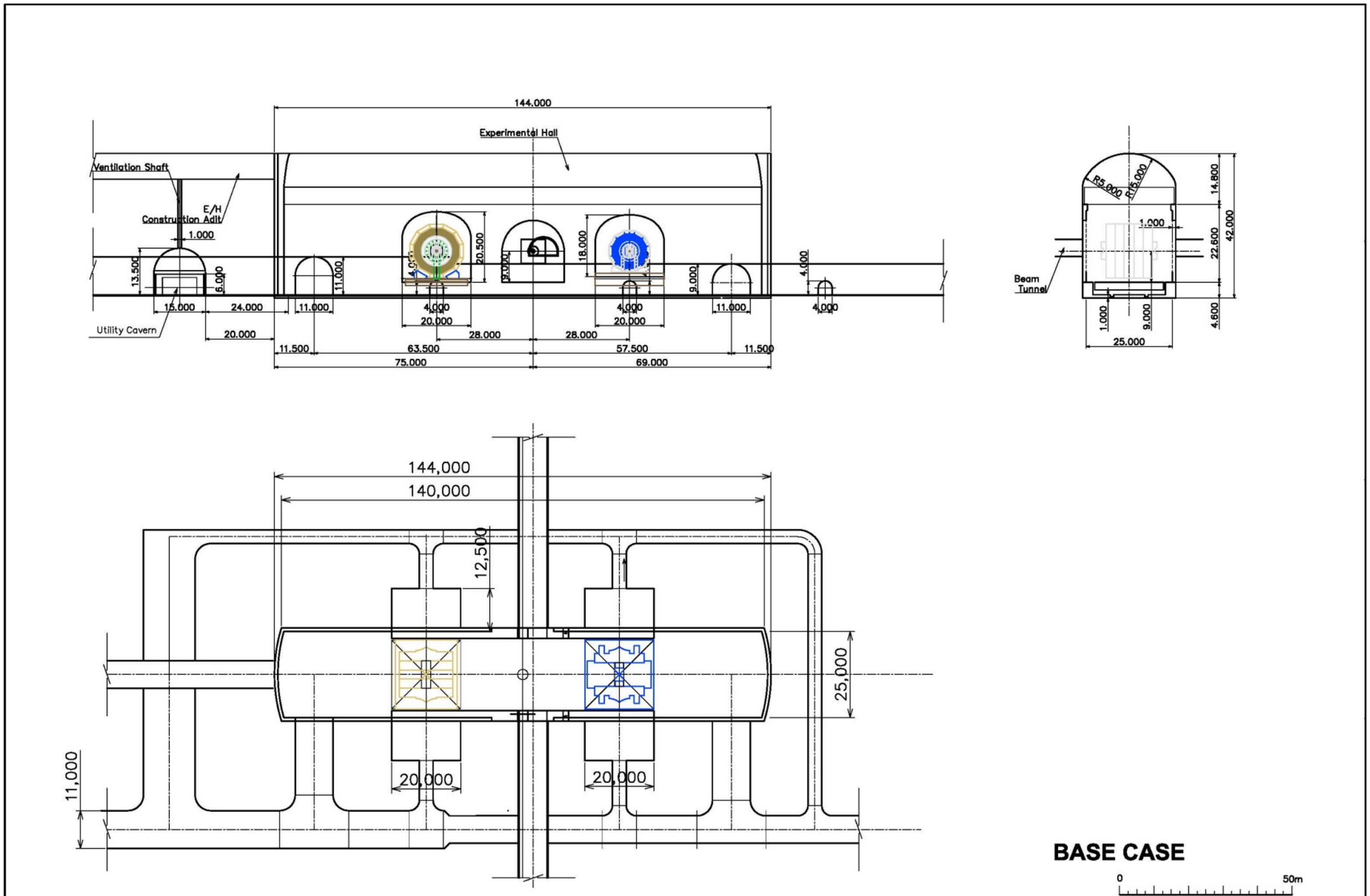
Considering minimize of construction cost, total tunnel length shorter.
Main A/T divides into Upper A/T and Lower A/T.







HT Hall Design (TDR)

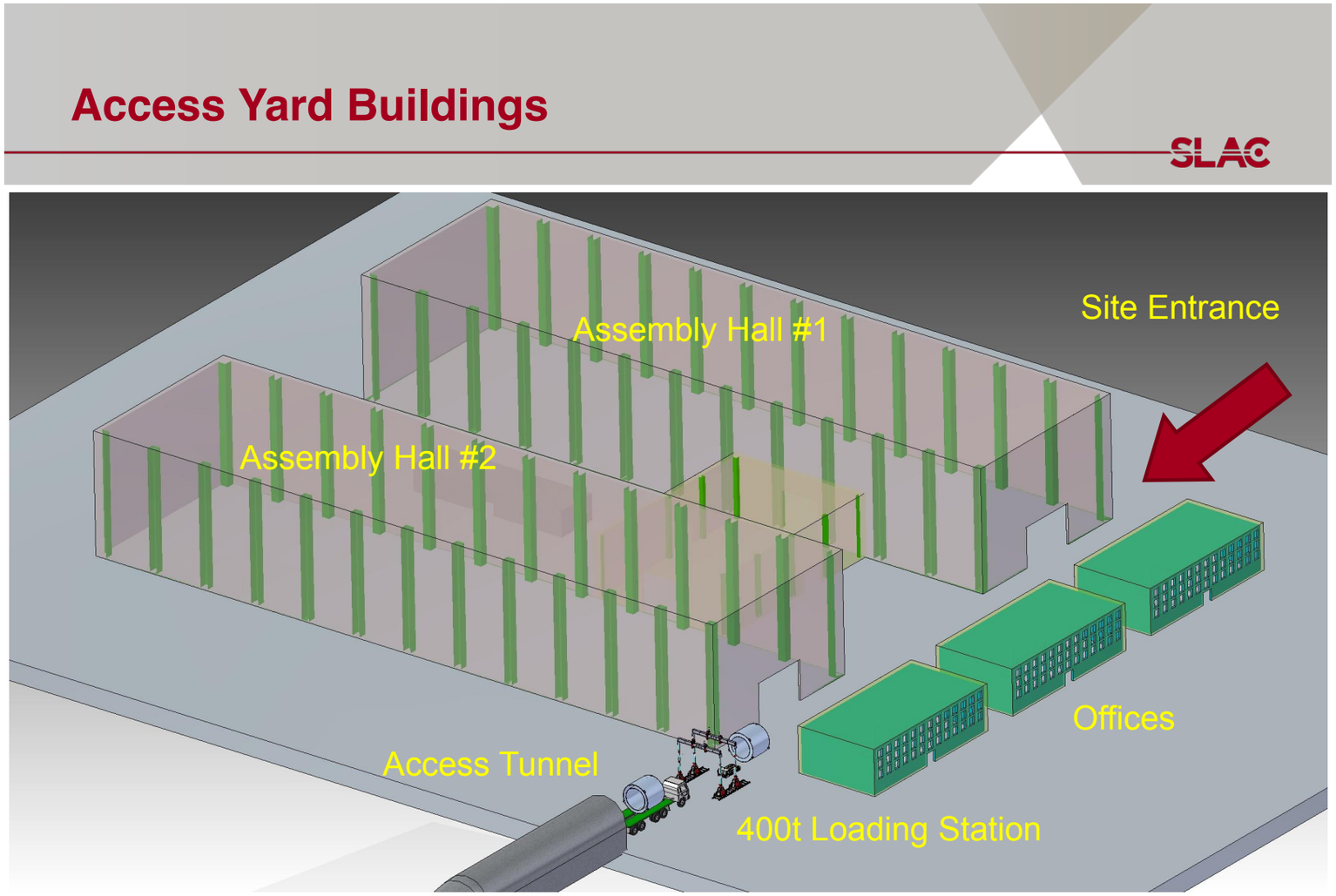


HT Design Requirements

- Floor space is probably ok
  - detailed assembly studies still pending
- 2x~250t crane coverage needed along main hall
  - 1x~250t for SiD, 1x~250t for ILD, need to be able to use both in rare cases
- some crane coverage in alcoves
- crane hook height needed (ILD requirement) is defined by:
  - detector height: 17m above platform
  - yoke segment height: 3.5m
  - tools, traverse, etc: 2m
  - in current design: 22.6m, so just ok
- Cryogenics infrastructure needed right after underground hall has been handed over to detector collaborations

Surface Installations HT

- Size of surface halls probably similar to VS case
  - height could be reduced if yoke has been pre-assembled at vendor
  - storage (buffer) space
- 250t crane needed in surface hall (plus one for SiD)
  - handling of yoke elements
  - handling of coil elements
  - loading of detector parts on tunnel transportation system
- 2x20t crane for subdetector assemblies
- If tunnel transportation system can be extended to outside, detector hall can be further away from tunnel portal (if needed)

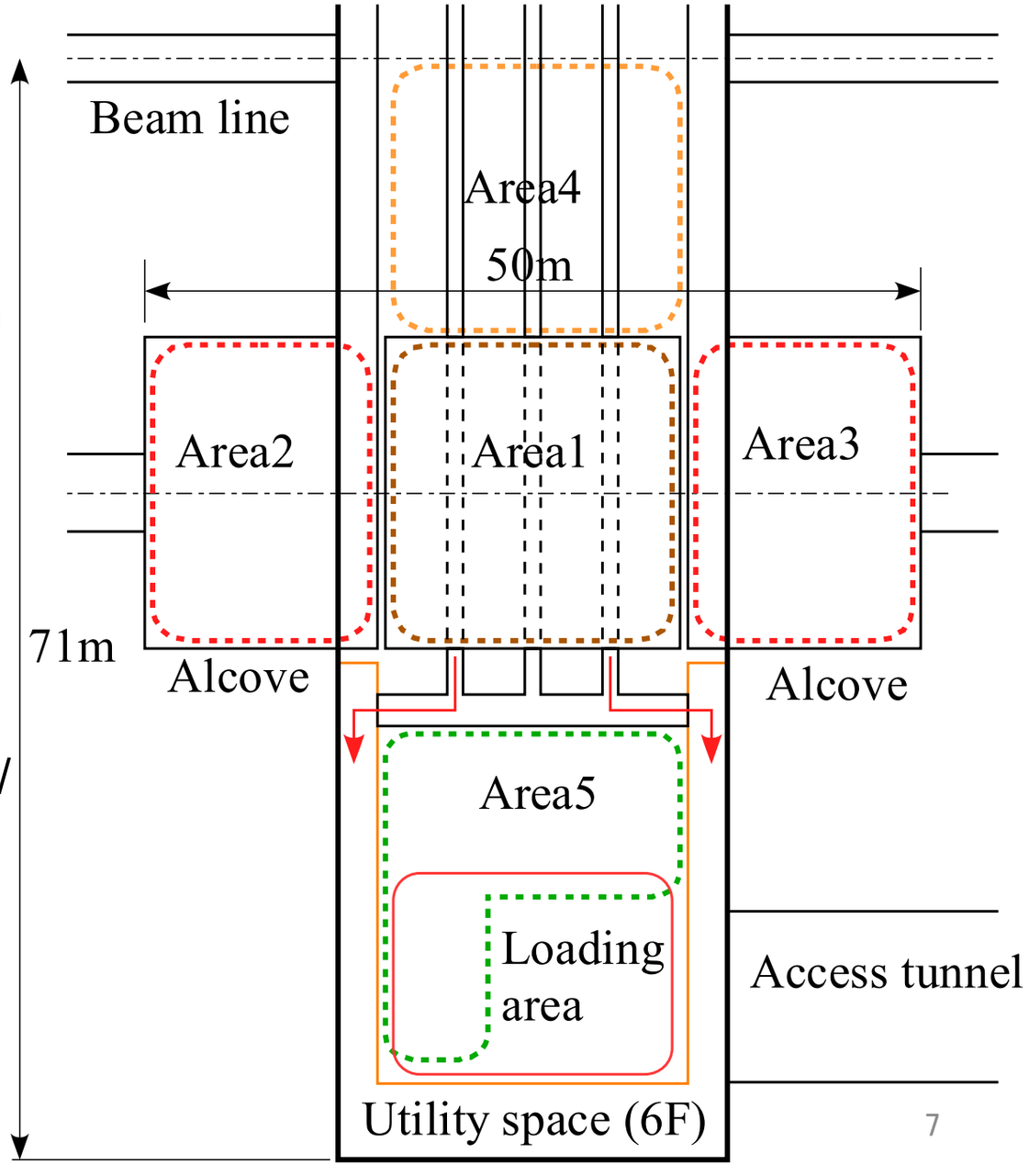


ILD Installation Study (Preliminary)

Detector assembly area

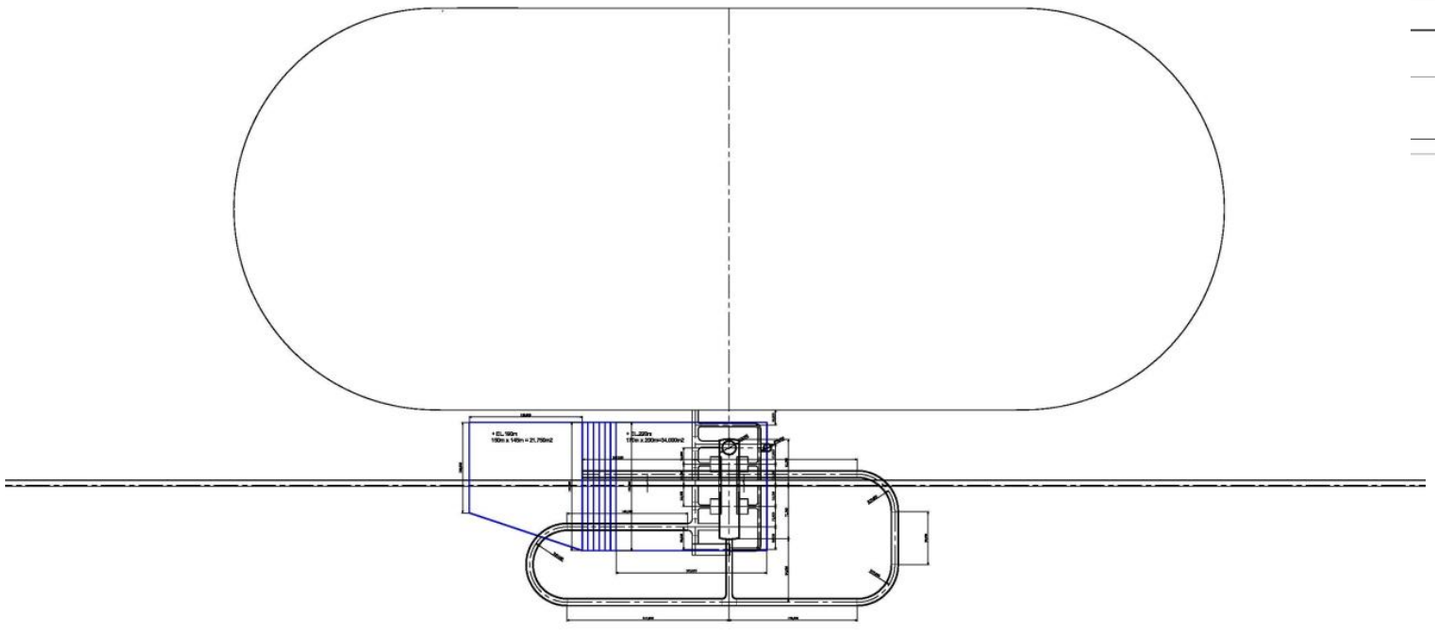
Y. Sugimoto

- Area 1: Platform
  - YB0 assembly
  - Barrel detectors installation/ cabling
  - Endcap calorimeters installation
- Area 2/3: Alcoves
  - Endcap calorimeters cabling
  - QD0 support tube assembly
  - FCAL install/cabling
- Area 4: Tentative platform on beam line side
  - YE, YB+, YB- (iron yoke and muon detector) assembly/install/ cabling
- Area 5: Loading area side
  - HCAL rings assembly
  - Tooling assembly
  - Storage area

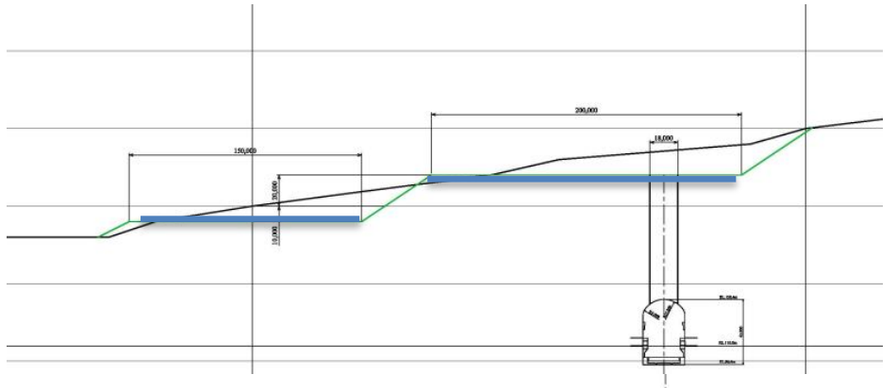


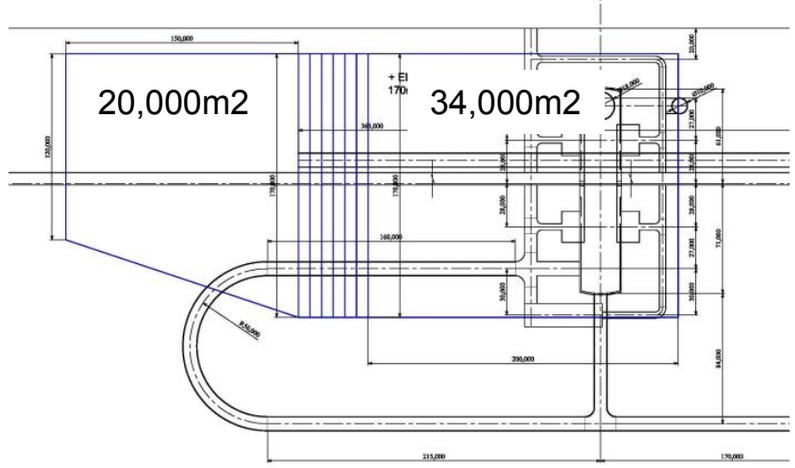
Hybrid Case Common layout

Access tunnel arrangement
- 2 hear-pin curves , because 3 points (portal, upper connection, lower connection) are near.
- Keep sufficient separation distance from B/T, D/H, D/R.
- Min. radius is 50m transporter vehicle.
- Gradient
  - Hybrid A,C 7% and adding 10% level part
  - Hybrid B 10% and adding 10% level part



Ground forming “Just trial study”
- Two elevation along the slope
  EL. 190m and 220m
- Each land area : more than 20,000m2
- Near the existing road

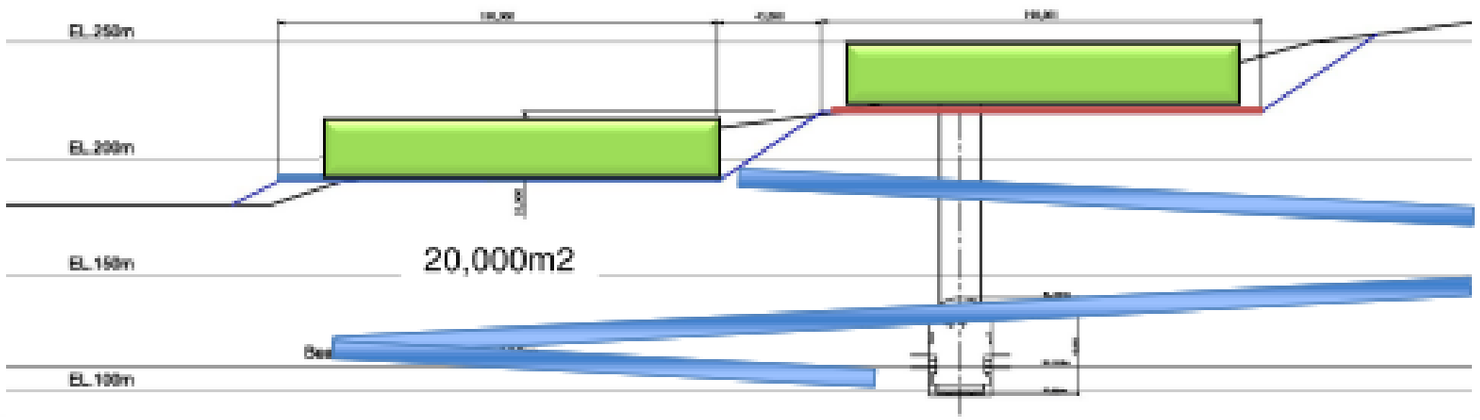




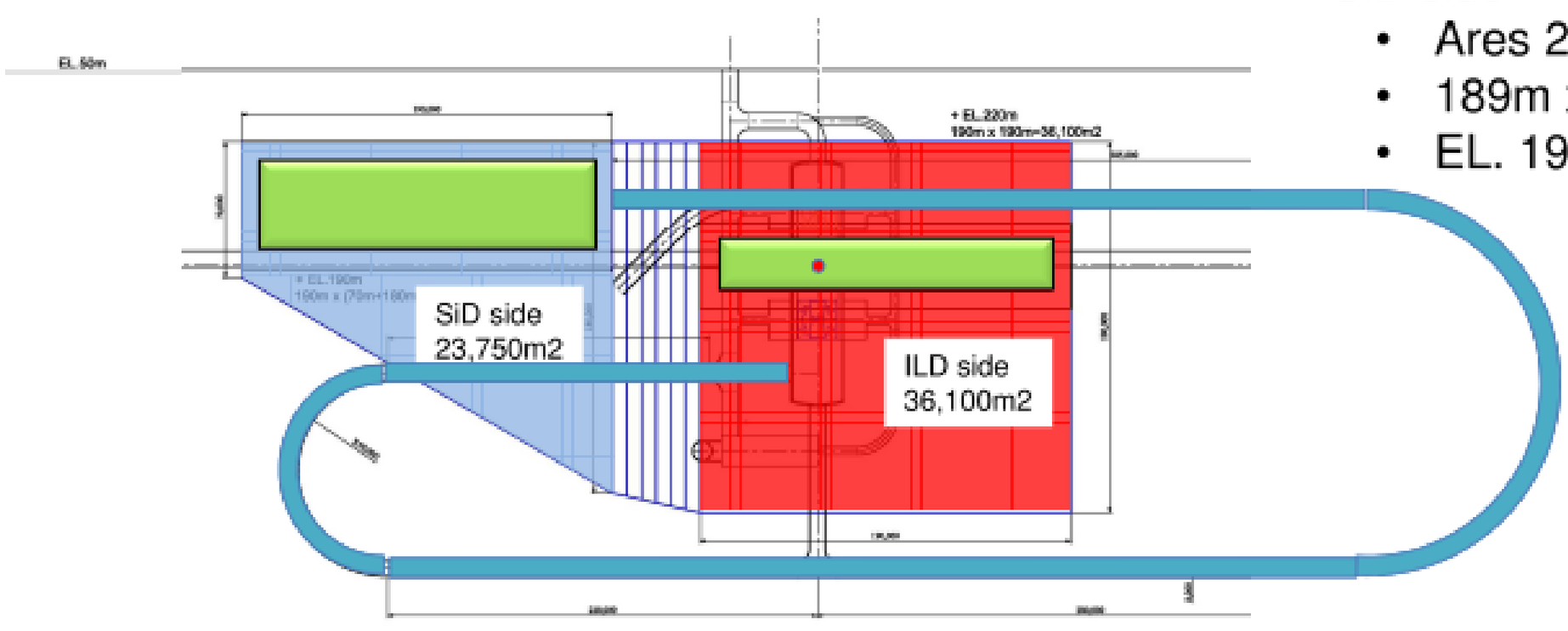
Elevation & Plan Views of Hybrid Tunnel/Shaft Access

SLAC

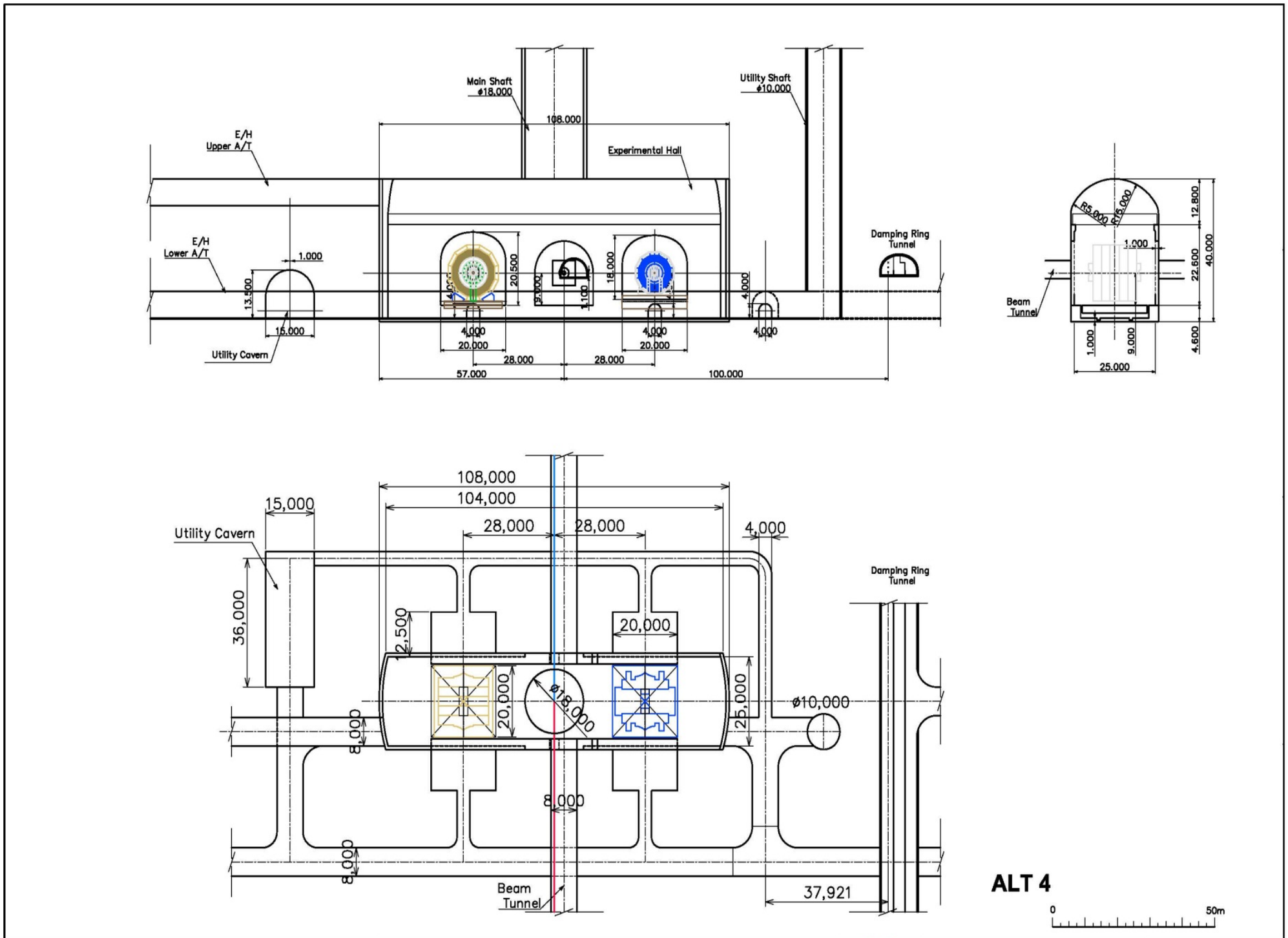
Hybrid Assembly yard



- Two step land formation
- ILD side
  - Area 36,100m2
  - 190m x 190m
  - EL. 220 m
- SiD side
  - Ares 23,750m2
  - 189m x (180m+70m)/2
  - EL. 190 m



Hybrid HT+VS Hall Design

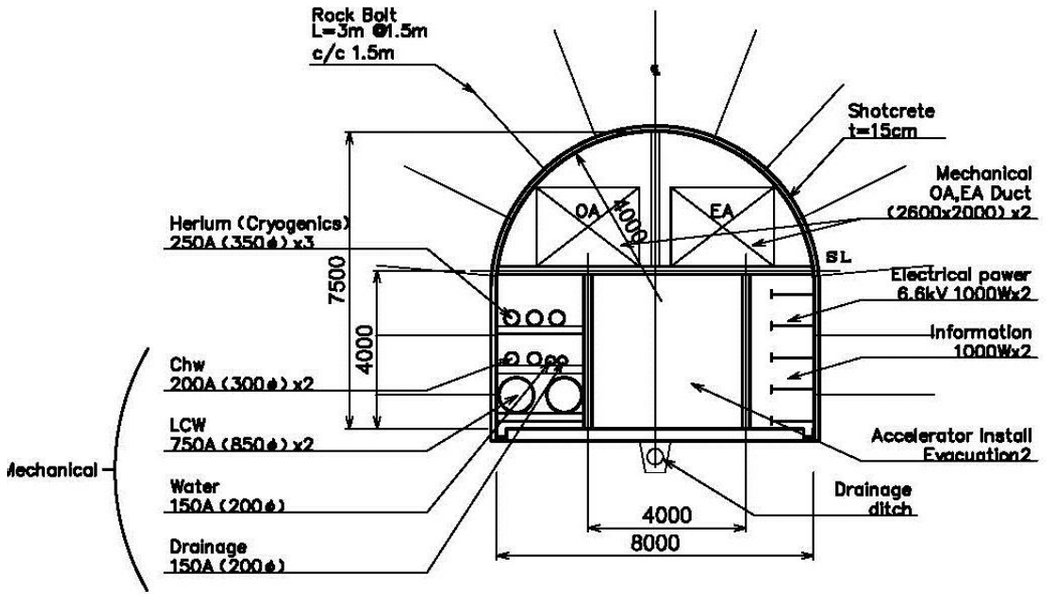


HT+VS Design

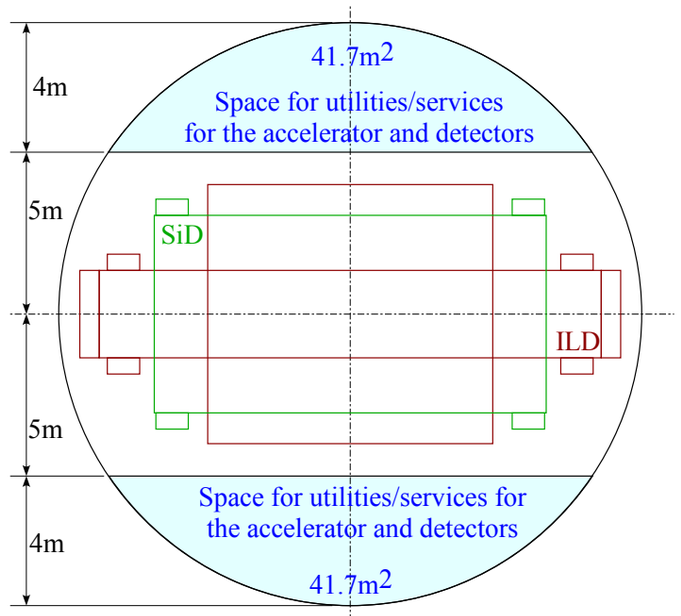
- Floor space is probably ok for ILD
  - detailed assembly study still pending, but much easier than at HT
- SiD requires larger assembly/loading area in the hall, similar as in HT reference case
- SiD HT access into the hall needs to be optimised (similar as in HT reference case)
- 2x40t crane coverage along main hall for ILD
- ~215t crane~for SiD
  - some crane coverage in alcoves
  - crane hook height needed (ILD requirement) is defined by:
    - detector height: 17m above platform
    - some height above detector: 2m
    - in current design: 22.6m, so could be reduced
- Cryogenics infrastructure needed later

Service Paths

- How much space is needed for service paths into the central region?
  - Study from Nikken-sekkei: 10m (78,5m^2) shaft would accommodate elevator plus all services for accelerator (cooling, air ducts, cables, etc.)
  - Study from Nishimoto-san (JPower) shows solution for service paths in HT baseline design.
    - Problem: Services run through DR access tunnel, O(km) lengths
- Preliminary study (Y. Sugimoto) shows that there is much space available for services in large vertical shaft

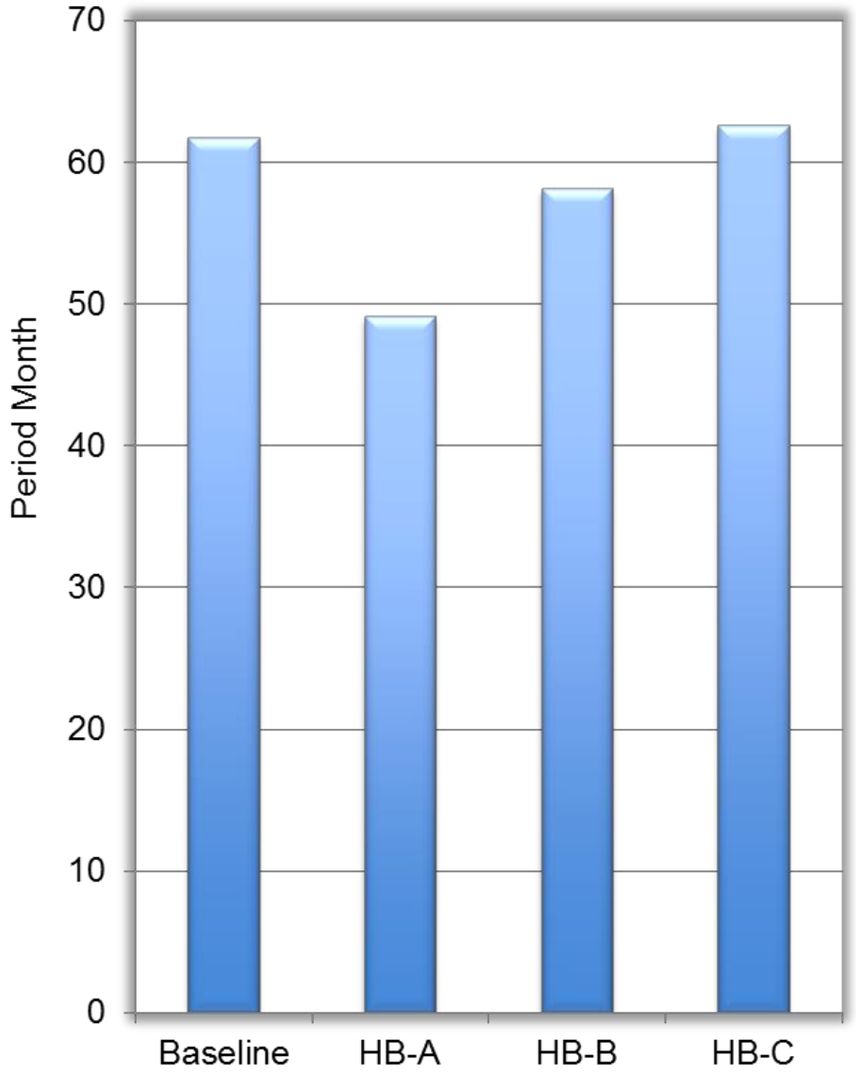


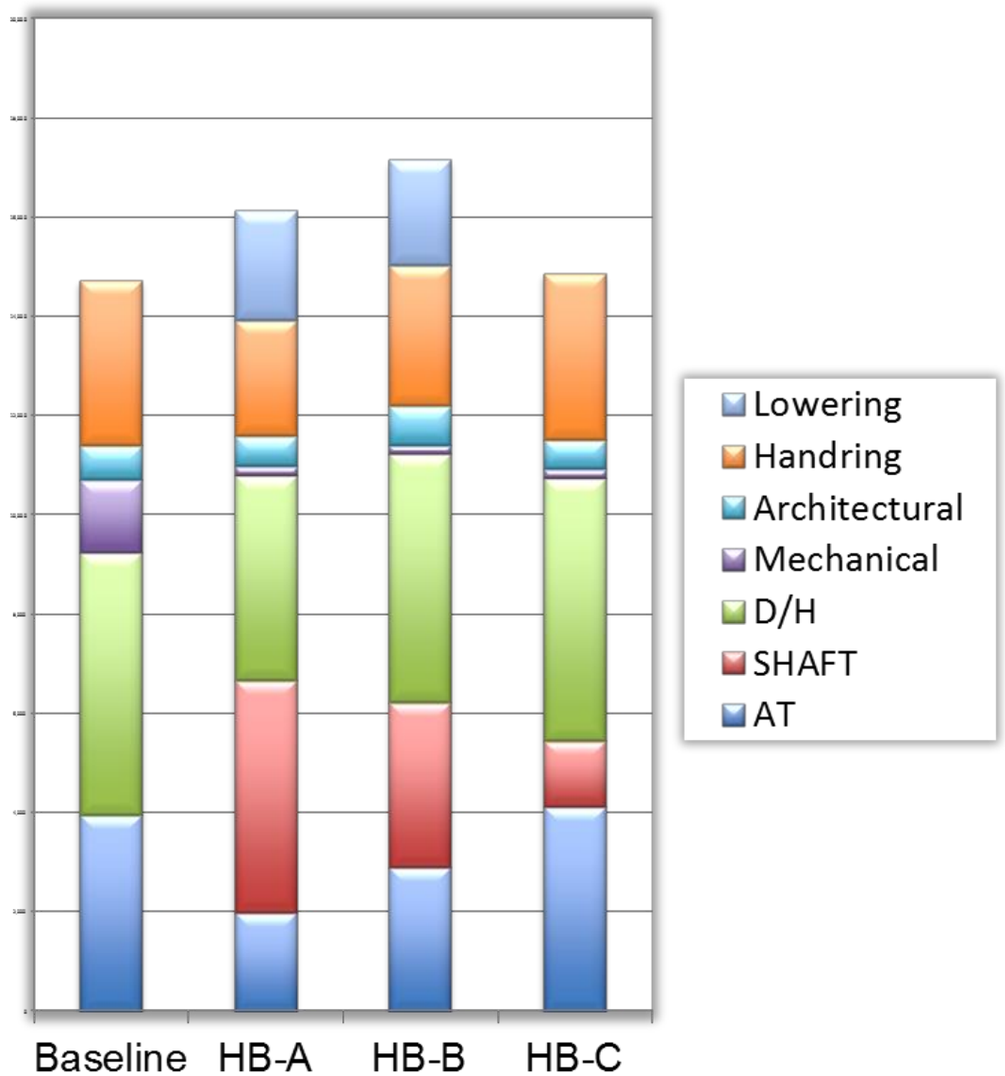
Baseline (HT) –DR AT



Summary of Cost and Schedule

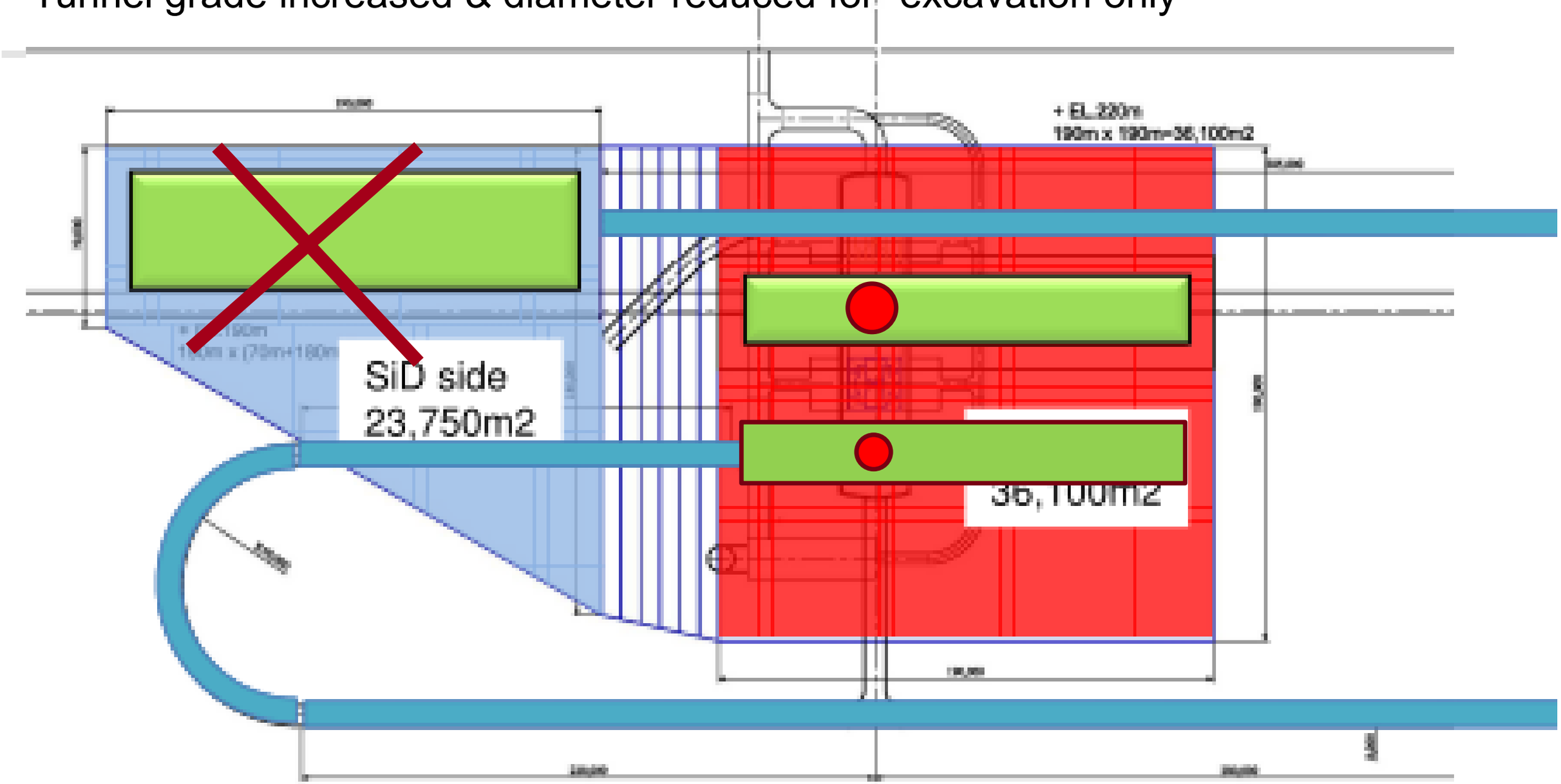
Preliminary!





SiD request to study alternate variant

Parallel hall at same grade with second 6-8m access shaft over SiD “garage”
Tunnel grade increased & diameter reduced for “excavation only”



A new proposal: outcome from AWLC

- So far SiD insisted of using the horizontal tunnel in any case for their assembly
  - changed their mind during AWLC with new information about transportation issues (see next slide)
- Optimise horizontal tunnel for CFS needs: excavation of cavern
  - make it smaller and steeper
- Add medium size shaft for SiD assembly
- Put both assembly areas close to each other at the same altitude
- Has a potential for cost savings
- Needs detailed study on time lines and cost

- Is ok for ILD

Transportation Issues

- Need to understand better the requirements for the transportation of the detector elements to the site and into the caverns
- Heavy equipment transportation:

SPMTs with load distribution frames for the transport of ships

Scheuerle/Kamag

- News at AWLC about boundary conditions in Japan:

Transportation Issues

- Open Questions:
  - what is the maximum load for a heavy weight transport to the IR area?
    - physical limits (roads), legal/administrative limits?
    - transports of O(80t) have been done in the area
  - is there a difference in limitations for HT or HT+VS scenario?
  - are the numbers for the capacity of the port facilities (below) final?
- current assumptions: detector parts have up to 210t mass!

□ Transport object

Object	W(m)	L(m)	H(m)	W(t)
Return York	2.0	2.0	2.0	50
Solenoid coil	6.2	6.2	2.8	65
TPC	4.0	5.0	4.0	2
Cryomodule	1.0	15.0	1.0	10

□ Overview of the neighboring port facilities

Port name	Facility	Depth(m)	Ship scale	Unloading machine
Kamaishi	Quay	-11.0	18,000 D/W	30.5t(Rating load)
Ofunato	Quay	-13.0	40,000 D/W	51.6t/45.0t
Kesennuma	Quay	-7.5	5,000 D/W	None
Sendai	Quay	-14.0	50,000 D/W	56.2t/40.6t/36.0t

M. Miyahara, LCWS13

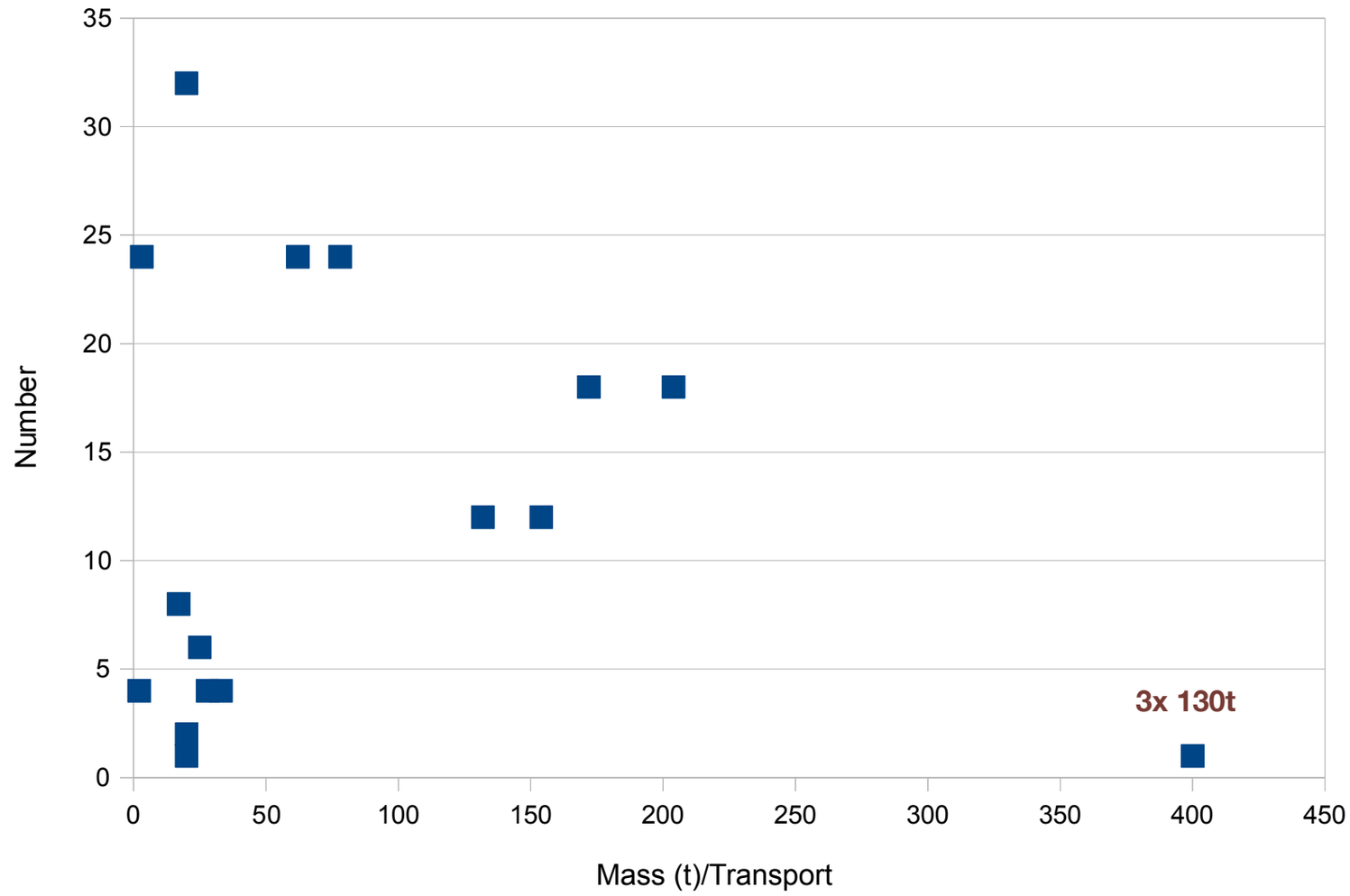
HET current status based on interview of transporter company

- **Less than 60 ton trailer : Many trailers**
- Licensing procedure is comparatively simple without reinforcing
- **60 to 80 ton trailer : Not many trailers but existing**
- Licensing procedure is comparatively simple
- Bridge reinforcing will be required sometime depending on the root
- **More than 80 ton trailer : Very few**
- Licensing procedure should be very complicated and required long term.
- Sometime difficult to get approval.

- In general, if all of packages could be use less than 80t trailer, transportation will be done without difficult procedure.
- However, if in case that there is a merit to use more than 80t trailer, it is need to study how to transport them individually.
  - Information of weights and dimensions of the package?

Transportation Issues (ILD Example)

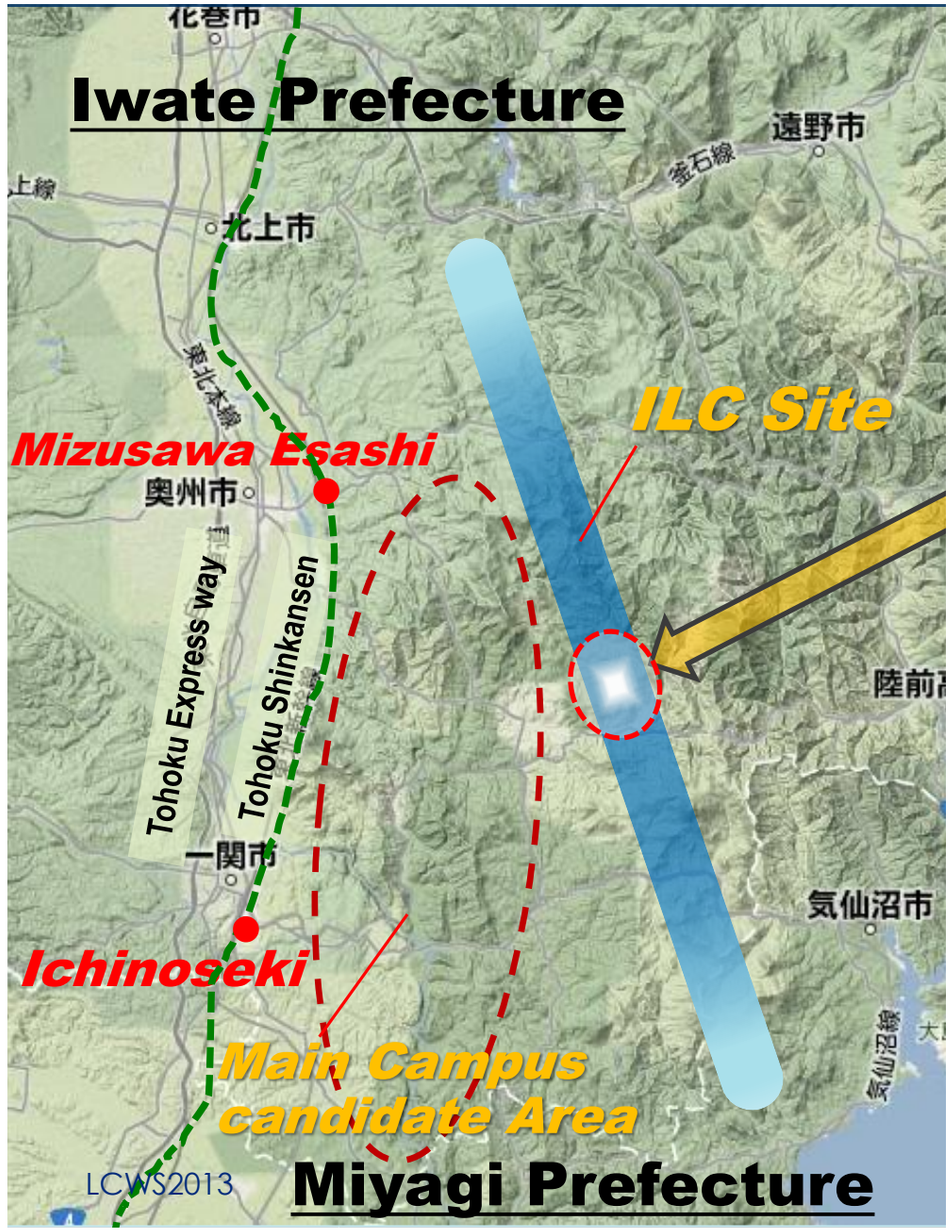
- Only for detector elements:
  - ~200 heavy weight transports
  - 61 transports with more than 100t
- Plus:
  - toolings, etc.
  - services
  - ...



- If the Japanese limitations (as shown before) hold true:
  - we have to re-design the structural elements of the detector (yoke) and maybe the coil
  - if 80t is the maximum, then we need to do more surface assembly work

Rôle of the ILC Laboratory

- What are realistic models for the construction of the detectors?
  - all elements are shipped just-in-time and ready for installation directly to the IP?
  - some pre-assembly work needed at ILC lab?
    - sub-assemblies, testing, repairs
- What services are expected at the ILC lab?
  - office space?
  - detector R&D infrastructure (clean rooms, test beds)?
  - manpower support?
    - only service personnel?
    - scientists?
    - resident in lab, employed by collaborations or by lab?
  - Experience from existing labs:
    - usually large support groups (assembly help, CFS, crane drivers, surveyors, safety, radiation, etc.)
    - usually have own research groups
- PDAD (H. Yamamoto) has just initiated this discussion with the detector groups -> AWLC in May

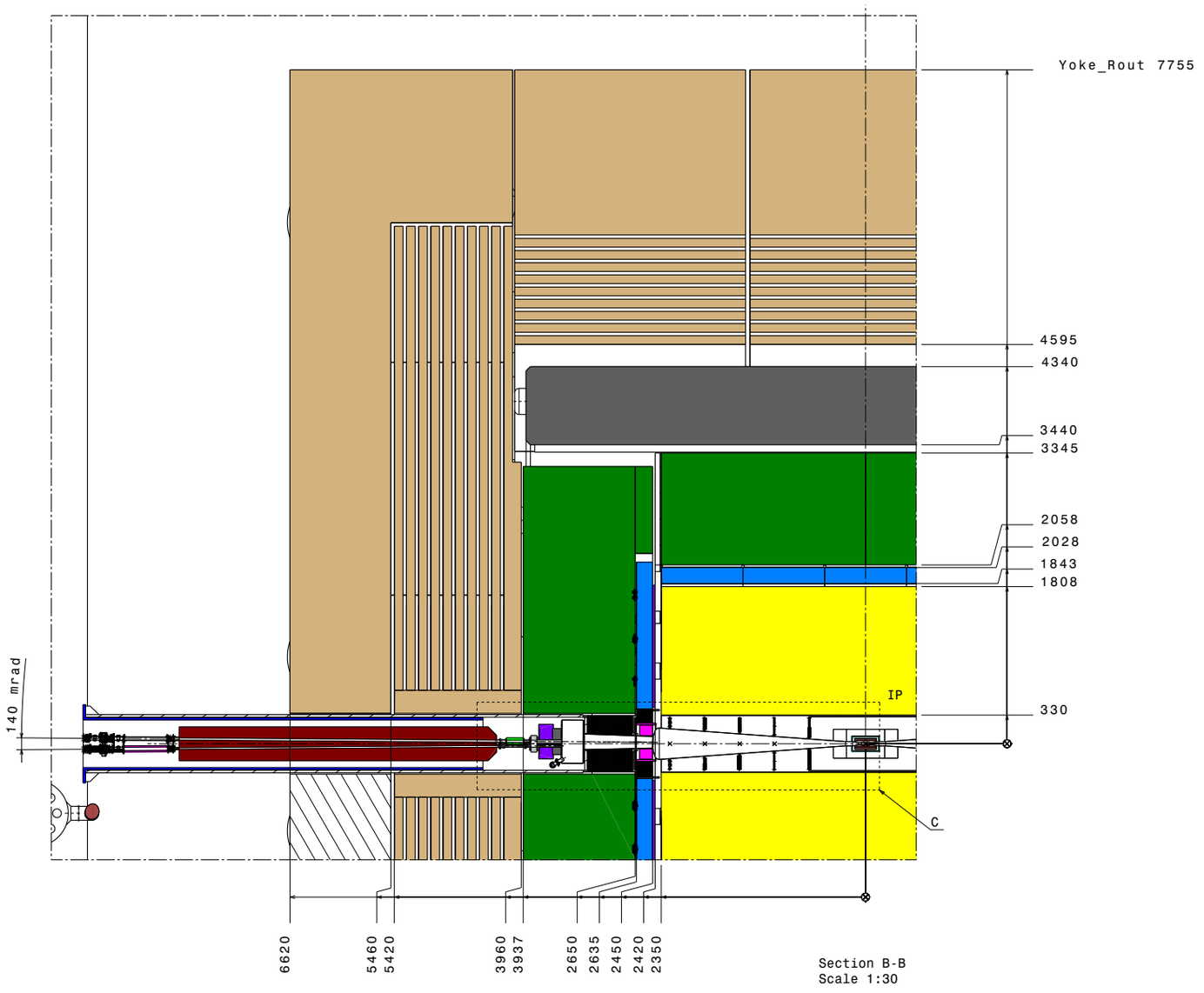


Open Questions (non comprehensive)

- for each, HT and HT+VS
  - road transportation (and port) boundary conditions (loads, legal issues)
  - geological issues (tunnel, shaft)
  - environmental impact (land use, noise, etc.)
  - transportation system in tunnel (truck or other) and shaft (gantry crane)
  - optimisation of access paths (tunnel slope and curves)
  - material flow through access paths
  - realistic models and timelines for detector and machine assemblies using shared infrastructures
  - services on and below surface: electrical, cooling, cryo, counting rooms, office space, etc.
  - service paths to underground area
  - beam commissioning models with or w/o detectors
  - role of ILC laboratory
  - possible changes in detector models

And now to something completely different….

- ILC machine group will push for a common L* for both detectors - as small as possible
  - ILC IR requirements document ILC-Note-2009-050 defined range 3.5m < L* < 4.5m
  - will be challenged now - formal change request will come
- SiD has L*=3.5m, ILD has L*=4.4m
- SiD will not go beyond 3,5m
- Need to move QD0 at least 90cm closer to the IP
- This could be a major task!
  - re-design forward region
  - background and acceptance studies
- Need to inject into ongoing optimisation studies now!



Conclusion

- The MDI discussions showed that all discussed solutions (VS, HT, hybrid) are not fully understood in their consequences for the detectors
  - experience from other installations (LHC, Gran Sasso, etc.) is only partially applicable to Kitakami
- The proceedings of the discussions depend on a better understanding of the general detector (and machine) construction and assembly philosophies
  - what will be produced where and when?
  - what are the local requirements, what can be offered by the ILC lab?
- There are now two favoured solutions for the IR access:
  - baseline with only tunnel access (is now under configuration control)
  - new SiD proposal with two shafts and one CFS-only tunnel
- Most important: the local boundary conditions are crucial. If any of the solutions cannot be adopted for Kitakami (e.g. if geology forbids), we have to live with the remaining ones.