Mini-Workshop on ILC CFS and Infrastructure for Detectors

KEK, 27th November 2018

Karsten Buesser
10.01.2019

Workshop

7th workshop of the series on detector related infrastructure for the ILC

- Initiated by the ILC P&D Infrastructure WG (S. Yamada)

Topics:

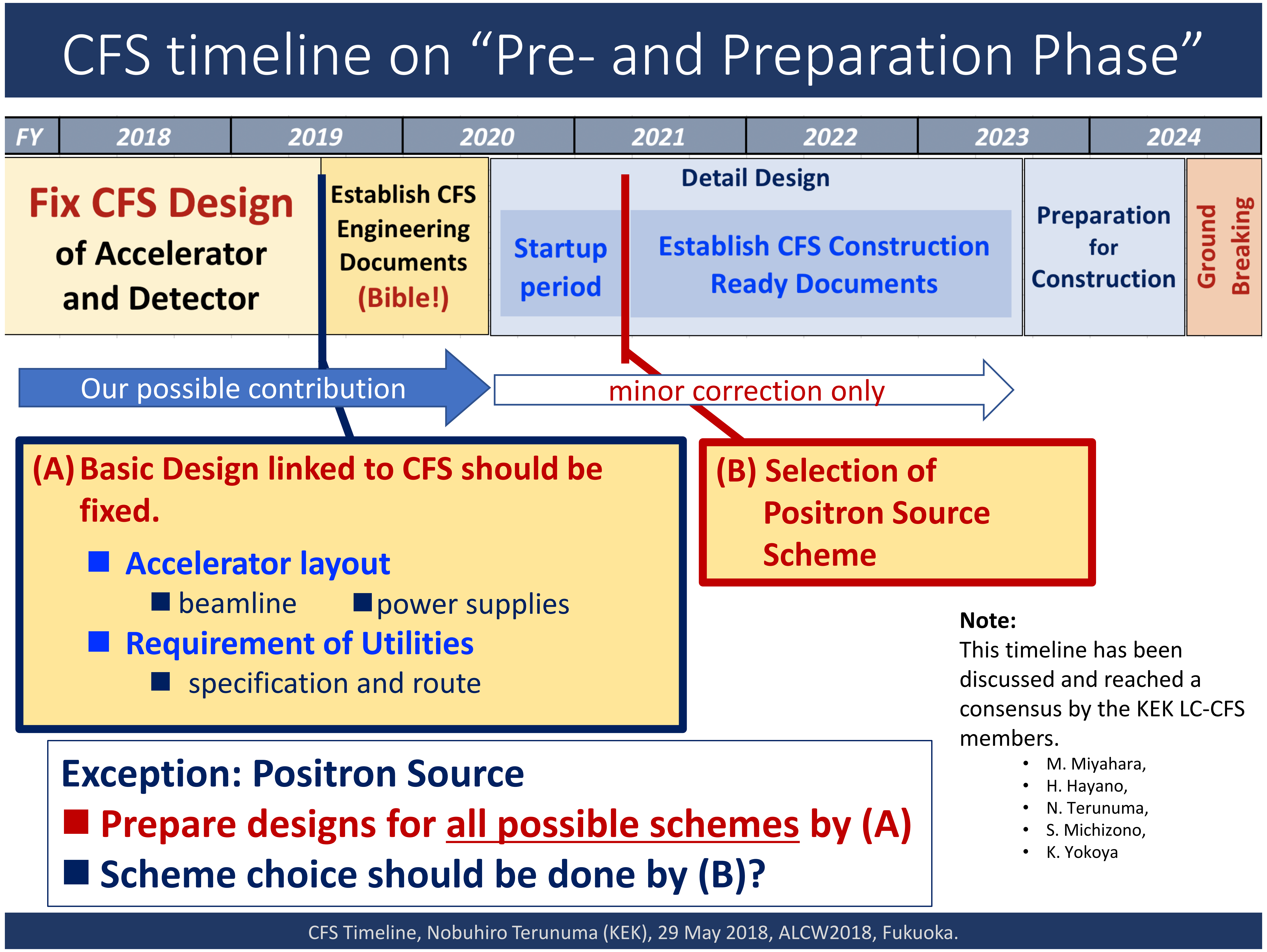
- Situation in Japan
- CFS risks (especially in view of SCJ deliberations)
- Seismic response and isolation
- Magnet developments
- Detector utilities
- Detector assembly

Here only my very personal selection, please check Indico agenda for all talks:

- https://agenda.linearcollider.org/event/7976/

CFS Risks

CFS Schedule and Risks



CFS risks discussed in SCJ meetings

Common issues for the central region are…

- **Countermeasure against accidents**
  - **Earthquake, fires, …**
  - **Radioactives**
    - **Shield walls**
    - **Measure for a leak of beam dump water (accumulated Tritium)**
    - **Air control/management**
  - **Power failures**
- **Tunnel structure and Groundwater**
  - **A proposal to measure the long-term power blackout (arises in the SCJ discussions.)**

N. Terunuma

Beam Dump for ILC-250 and Upgrades

Beam dump parameters

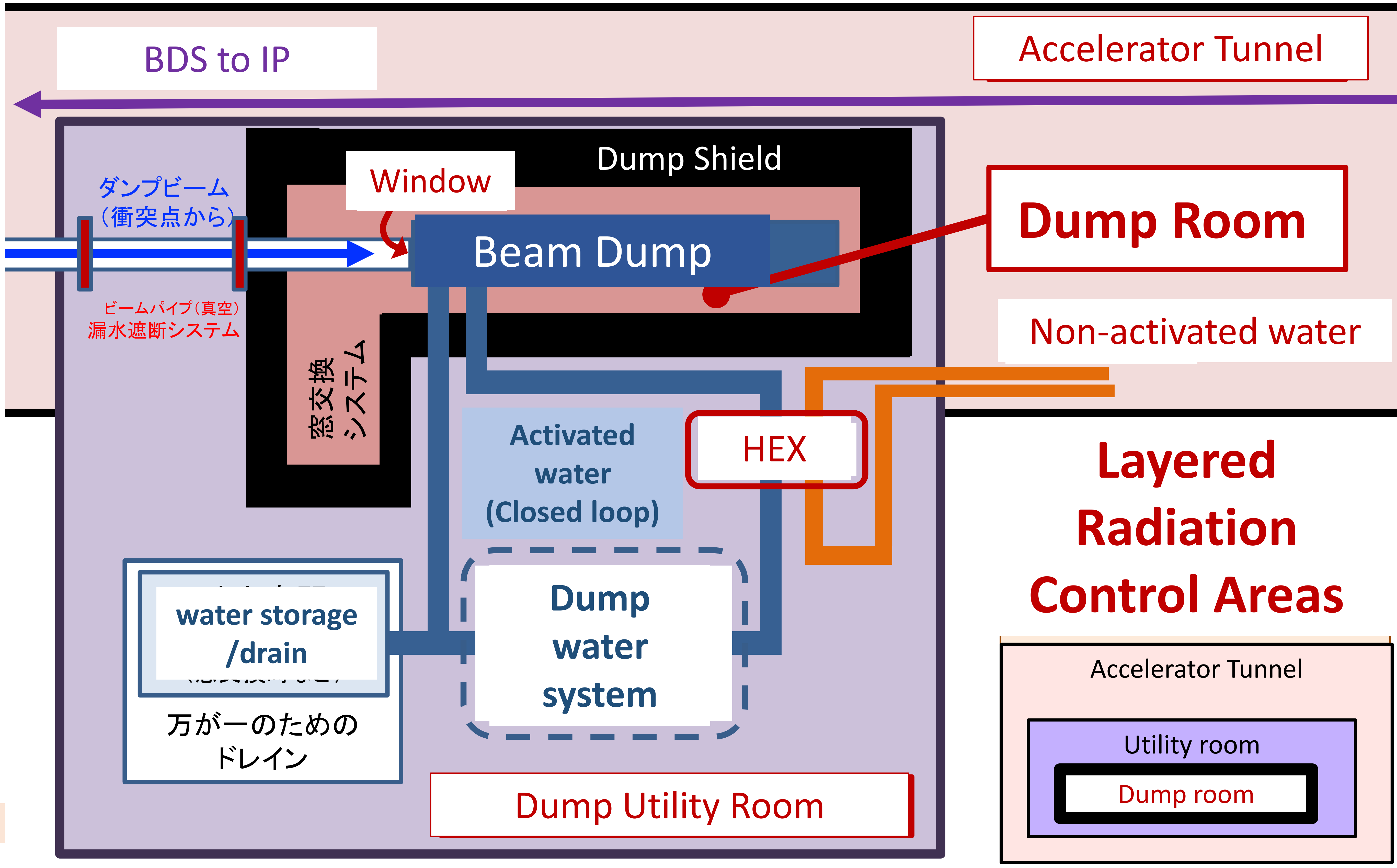
	TDR		250 GeV ILC
Center of mass energy (GeV)	500	1,000 (for future upgrade)	250
Beam energy(GeV)	250	500	125
Repetition (Hz)	5	4	5
Number of bunches	1312	2450	1312
Bunch interval (nsec)	554	366	554
Pulse width (msec)	0.727	0.897	0.727
Number of charges	$2x10^{10}$ (3.2nC)	$1.74x10^{10}$ (2.79nC)	$2x10^{10}$ (3.2nC)
Charges per pulse (μC)	4.20	6.83	4.20
Pulse current (mA)	5.78	7.61	5.78
Pulse energy (MJ)	1.05	3.41	0.53
Average power(MW)	5.25	13.7	2.63

Design：20% margin → **17 MW**

20%

LCWS2018 ILC accelerator by S.Michizono

Radiation Safety Concept of Beam Dump Area ムダンプ1



ビームダンプ施設は加速器ビームラインと同じ地下100mに構築

日本学術会議 2018/9/13

N. Terunuma

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Beam Dump - Activated Water

Beam dump water

	TDR beam dump design	ILC-250
Beam energy	**500 GeV**	**125 GeV**
Max. temperature	Circulating Water ：155℃ Beam window(1mm) ：74℃	Circulating water ：73℃ Beam window(1mm) ：82℃
Recent R&D Window → max.5 mm	Beam window(5mm) ：110℃	Beam window(5mm) ： 115℃
Water pressure	**10 atm** （Boiling point 180℃）	**3 atm** （Boiling point 133℃）

Speed of water from the broken window

- Pin-hole
  - Repeat leak, freeze, thaw, leak (to the beam pipe)
  - Many experiences
- Bigger hole
  - Slower speed than the small-hole

Water speed (small hole)	**Max. 45 m/s**	**Max. 24 m/s**

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Tritium

^{3}H Half life12.3year β decay 18.6 keV(max.) electron release

Tritium is generated by ^{16}O spallation reaction inside beam dump cooling water.

Facility	Tritium	
ILC Main dump	**100 T Bq. (saturation)** e+,e−total 0.3g(^{3}H)/100t=0.003 wppm	• 2.6 MW, 5,000 hour operation • 100m underground • Closed water circulation (e+,e−total 100 m^{3})
J-PARC Hg target	**92 T Bq. (saturation)**	• 1MW, 5,000 hour operation • Hg：Closed circulation1.4 m^{3} JAEA-Technology 2009-010
Fukushima fission reactor (Contaminated water)	**2,500 T Bq.**	• 2016.9.22（Tokyo Electric Power Supply） 2016.11.11TEPCO

LCWS2018 ILC accelerator

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Emergency Response Plans

Countermeasure against the Power failure

	ILC	LEP/ LHC
< 30 sec.	Battery （Control, monitor）	Battery （Control, monitor）
> 30sec.	Emergency generator （light, drainage, **He storage** ） （Note：**He system should** be kept <+1atm. **Quick storage will be necessary.**）	Emergency generator （light, drainage） （Note：**He system can be** ~20atm.）
More…	< **3 days:** power recovery (Generator fuel stockpile）	< **1 days**: power recovery (Generator fuel stockpile）

N. Terunuma

Emergency response at ILC

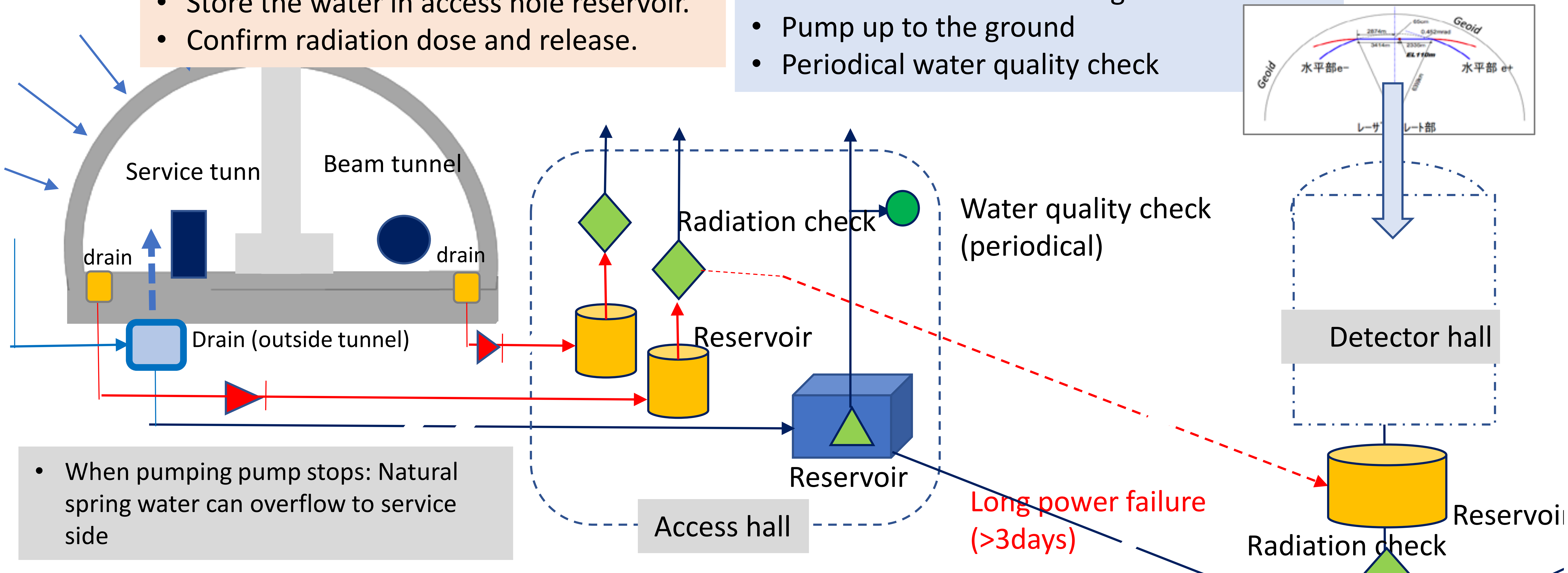
	ILC	LEP/ LHC
Power failure	1) <30 sec.：Battery （Control, monitor） 2) >30sec.：Emergency generator （light, drainage, **He storage** ） （Note：**He system should** be kept <+1atm. **Quick storage will be necessary.**） 3) <3 days：power recovery (Generator fuel stockpile）	1) <30 sec.：Battery （Control, monitor） 2) >30sec.：Emergency generator （light, drainage） （Note：**He system can be** ~20atm.） 3) <1 days：power recovery (Generator fuel stockpile）
Fire	1) Kamaboko-tunnel, Retreat to non-fire side/tunnel -> evacuation 2) The air conditioning circulation speed is controlled below the moving speed of a person. Evacuation faster than smoke (distance: <2.5 km + access tunnel) Note: Fire-resistive cable	1) Retreat to non-fire side -> evacuation 2) The air conditioning circulation speed is controlled below the moving speed of a person. Evacuation faster than smoke (distance: <3.4 km + elevator) Note: Fire-resistive cable
He leakage	1) Carry an oxygen tank, retreat along the tunnel bottom (He diffuses and stays at the top of the tunnel) (No liquid nitrogen underground) 2) Other than He leakage point (Cryo-unit), normal He recovery	1) Carry an oxygen tank, retreat along the tunnel bottom (He diffuses and stays at the top of the tunnel) (No liquid nitrogen underground) 2) Other than He leakage point (Cryo-unit), normal He recovery
Earthquake	1) Stand by next to stable large equipment. 2) Evacuate after the decay of the shake. Note: Earthquake vibration is relaxed to ~ 1/5 level at depth of 100 m	1) No large earthquake experience in this area. 2) No special guidelines.
Spring water	• Detection at advanced pit, drainage enhancement • Evacuate to the beam tunnel side (no drain pump) · evacuate. • In case of overflowing spring water, via service tunnel, detector hall → radiation monitor → natural drainage.	• Prevention of spring water by the freezing method of the surrounding soil (during CMS shaft construction) • There is no large spring water in tunnel after completion of construction. Trace amount of spring water is pumped up, radiation monitor and drainage.
Tunnel access・ License/ Equipment	1) Issue license after lecture and examination 2) Equipment at entry: - ILC-ID (Licensed) - Radiation worker batch (with monitor) - Helmet (LED search light attached - Portable oxygen tank (<30 minutes), - Oxygen concentration meter (with alarm) · Bicycle, electric working vehicle (option)	1) Issue license after lecture and examination 2) Equipment at entry: - CERN-ID (Licensed) - Radiation worker batch (with monitor) - Helmet (LED search light attached - Portable oxygen tank (<30 minutes), - Oxygen concentration meter (with alarm) · Bicycle, electric working vehicle (option)

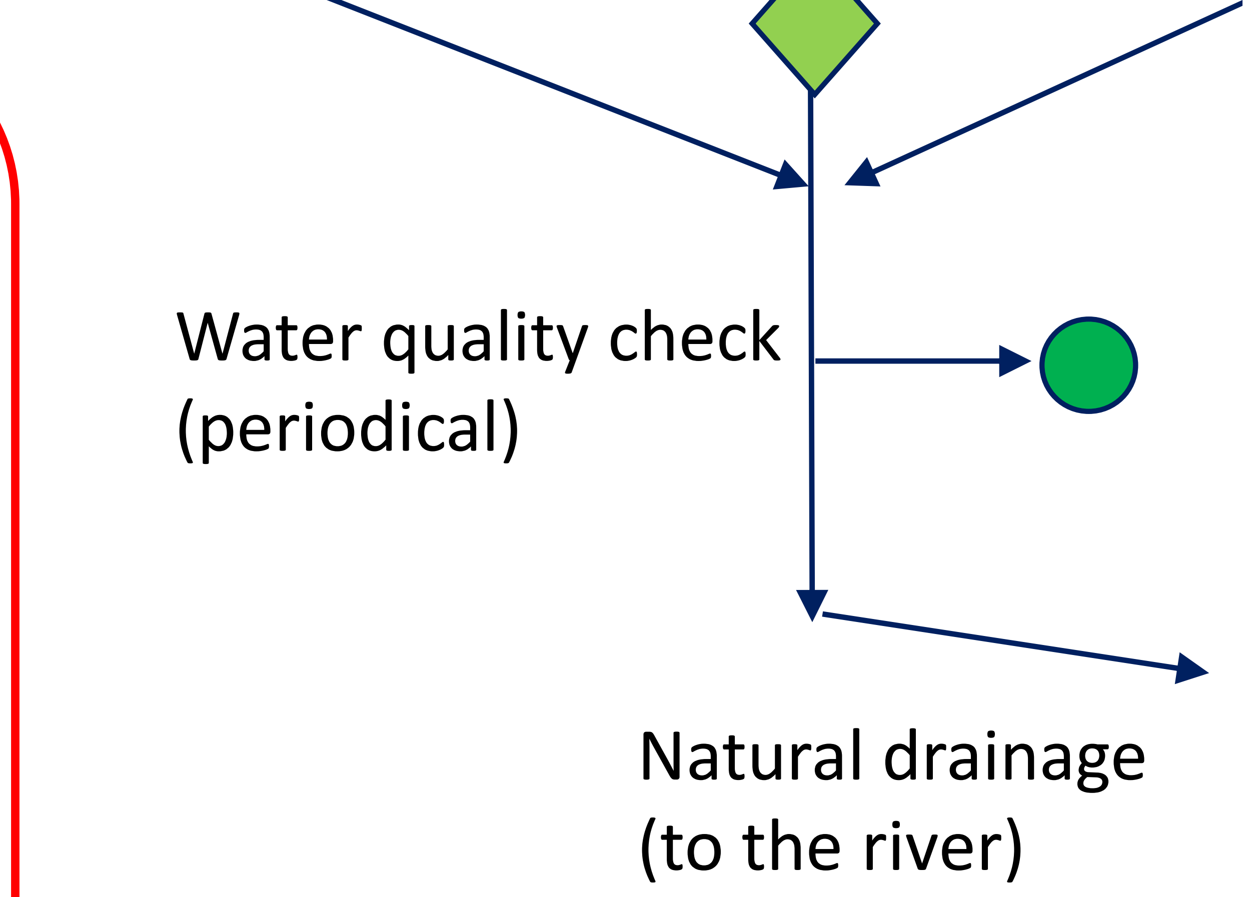
LCWS2018 ILC accelerator by S.Michizono

ILC tunnel drainage concept

Tunnel inside drain (managed drainage)
- Store the water in access hole reservoir.
- Confirm radiation dose and release.

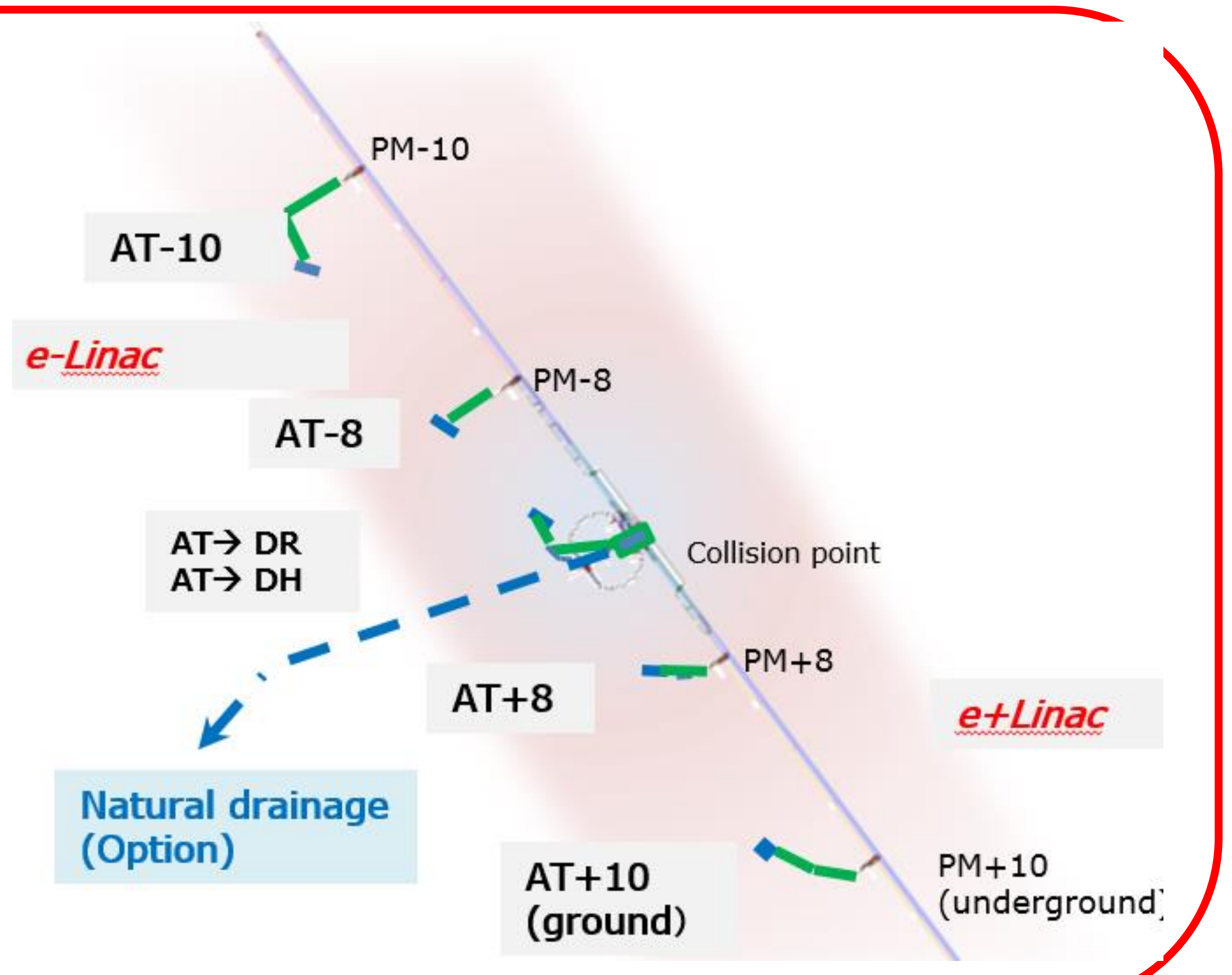
Natural spring water (unmanaged drainage)
- Collect the water in underground reservoir
- Pump up to the ground
- Periodical water quality check





- When pumping pump stops: Natural spring water can overflow to service side

ILC candidate site is under mountain but ~100m higher from sea level.
(Natural drainage to the river is possible.(optional))



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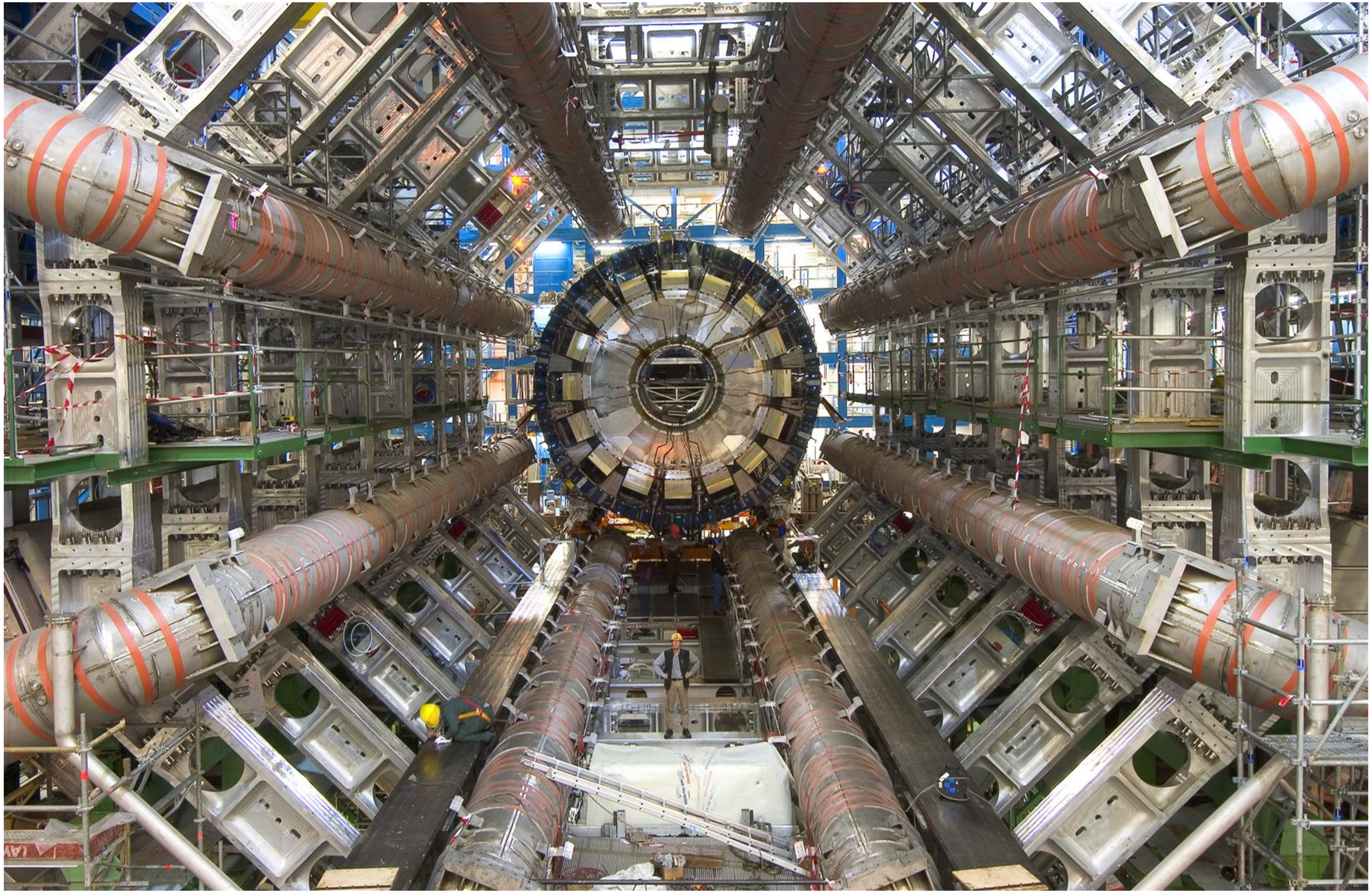
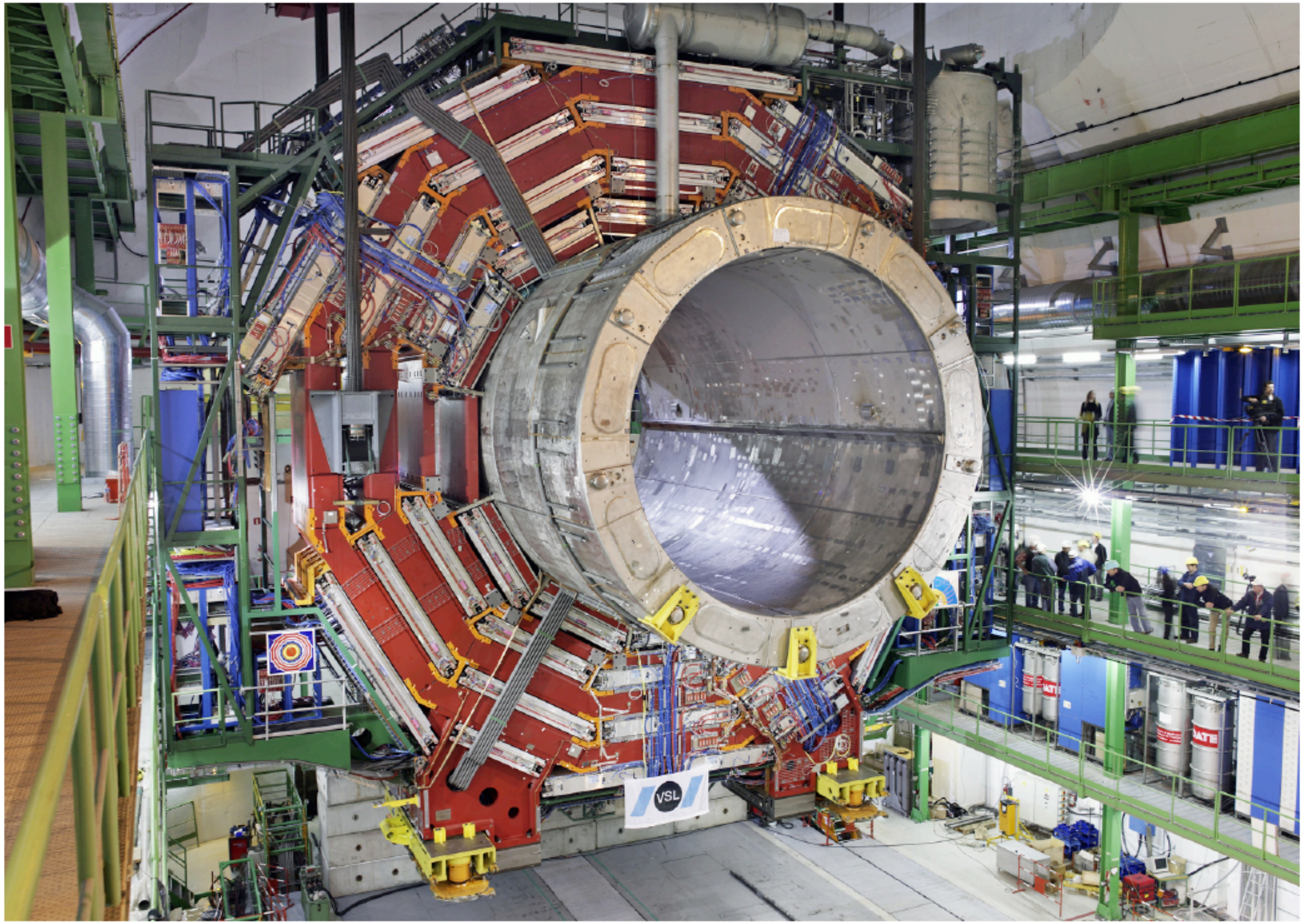
Detector Assembly

ATLAS - Underground Assembly



CMS - Surface Assembly



ILC History

CMS-style of assembly was adopted for ILC CDR

- Change Request from 11/2006:
  - „To specify in the BCD that assembly of the detectors will be done on-surface, in a manner similar to that for the CMS detector at CERN.“
  - Approved for main reasons:
    - Cost savings due to smaller underground hall
    - Reduction of overall construction time by 2-2.5 years as detector construction can start earlier over ground
    - General: dis-entanglement of construction schedules for machine and detectors

TDR discussed two cases:

- Flat-top sites: vertical access possible, CMS-style
- Mountain sites: only horizontal tunnel access, modified assembly style (ATLAS-like)

After Kitakami site has been proposed:

- Adopt CMS-style also for hilly site, where vertical shafts are possible
- Change request in 09/2014: „Detector Hall with Vertical Shafts“

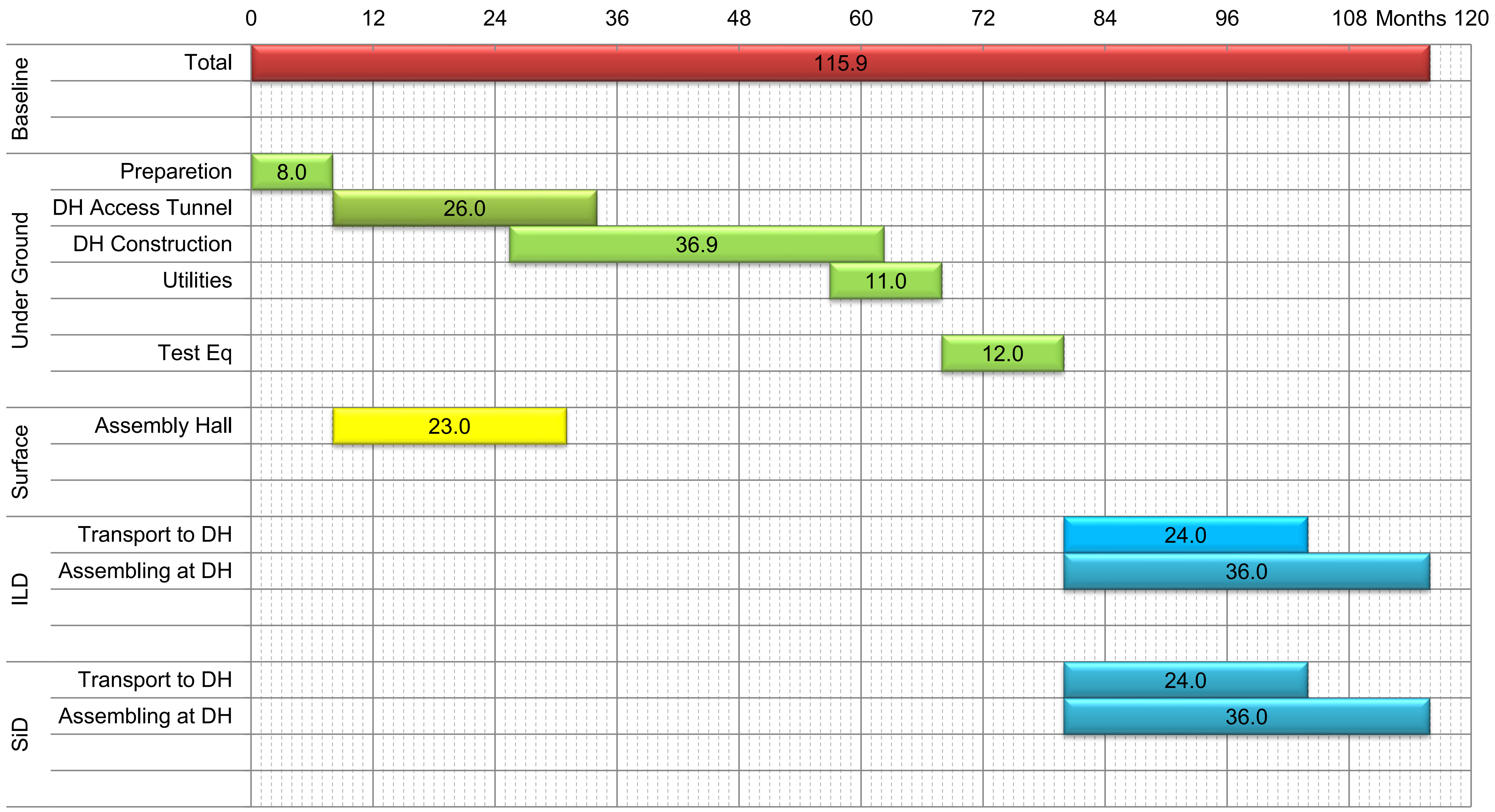
Now SCJ questions the realism of the gantry crane concept „not possible in Japan“

Time Schedules

From J-POWER:

- For horizontal access: 116 months
- For vertical access with gantry crane: 103 months
- important: common underground time for installation of detectors and machine

Const. Schedule for the Baseline Design

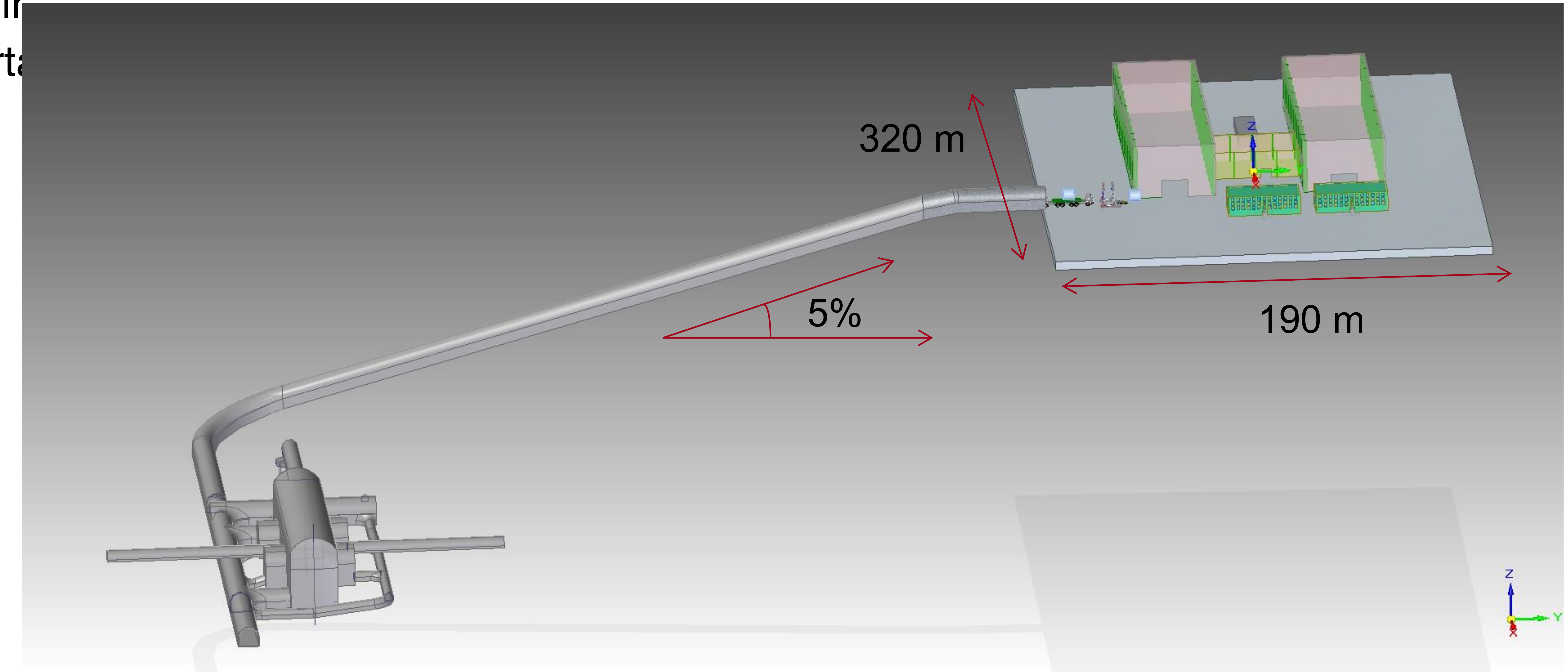


Const. Schedule for the Hybrid A' Design

Alternative: Underground Asssembly

Studies assumed only horizontal access via tunnel of up to 10% slope

- Large tunnel diameter requir
- Specialised tunnel transport



Undergound Detector Hall

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Surface Assembly - Pros and Cons

Pro	Contra
Timelines of underground construction work and detector assembly period on surface are almost decoupled	Large surface detector assembly facility with high crane capacity (2 x 250t)
Timelines of detector assembly for two foreseen detectors are almost decoupled	High capacity gantry crane (3000-4000t)
Smaller underground hall in length and height, smaller crane capacities (80t)	Two moving concrete platforms CMS style on surface (studies for one platform under way)
Main detector components - including coil - tested on surface	Higher earthquake risk during detector assembly on surface
Short underground detector installation period (~1y)	
Relaxed safety requirements during underground installations (substantially less personnel in underground areas for shorter time	
Machine supply lines through vertical shaft	

Underground Assembly via Tunnel - Pros and Cons

Pro	Contra
Reduced earthquake risk during installation work in underground hall	Timelines of underground construction work and detector assembly are highly coupled
Somewhat smaller surface facility for detector pre-assembly; crane capacity comparable	Timeline for detector assembly for two detectors underground are highly coupled
	Long detector installation period in underground hall (~3 y)
	Outside tunnel infrastructure required: storage, buffer space, connection to tunnel transport
	Larger underground hall in length and height with higher underground crane capacity (2 x 250t)
	Stronger safety requirements: much more people for longer time underground
	All detector system tests can only be done underground; requires early cryogenic system underground

Gantry Crane Risks

Most of those risks should be

- CMS experience!

Possible risks

- Strand jacks
- Connection between strands and detectors
- Beam
- Column
- Foundation
- Operation
- Platform in Assembly Hall
- Cost

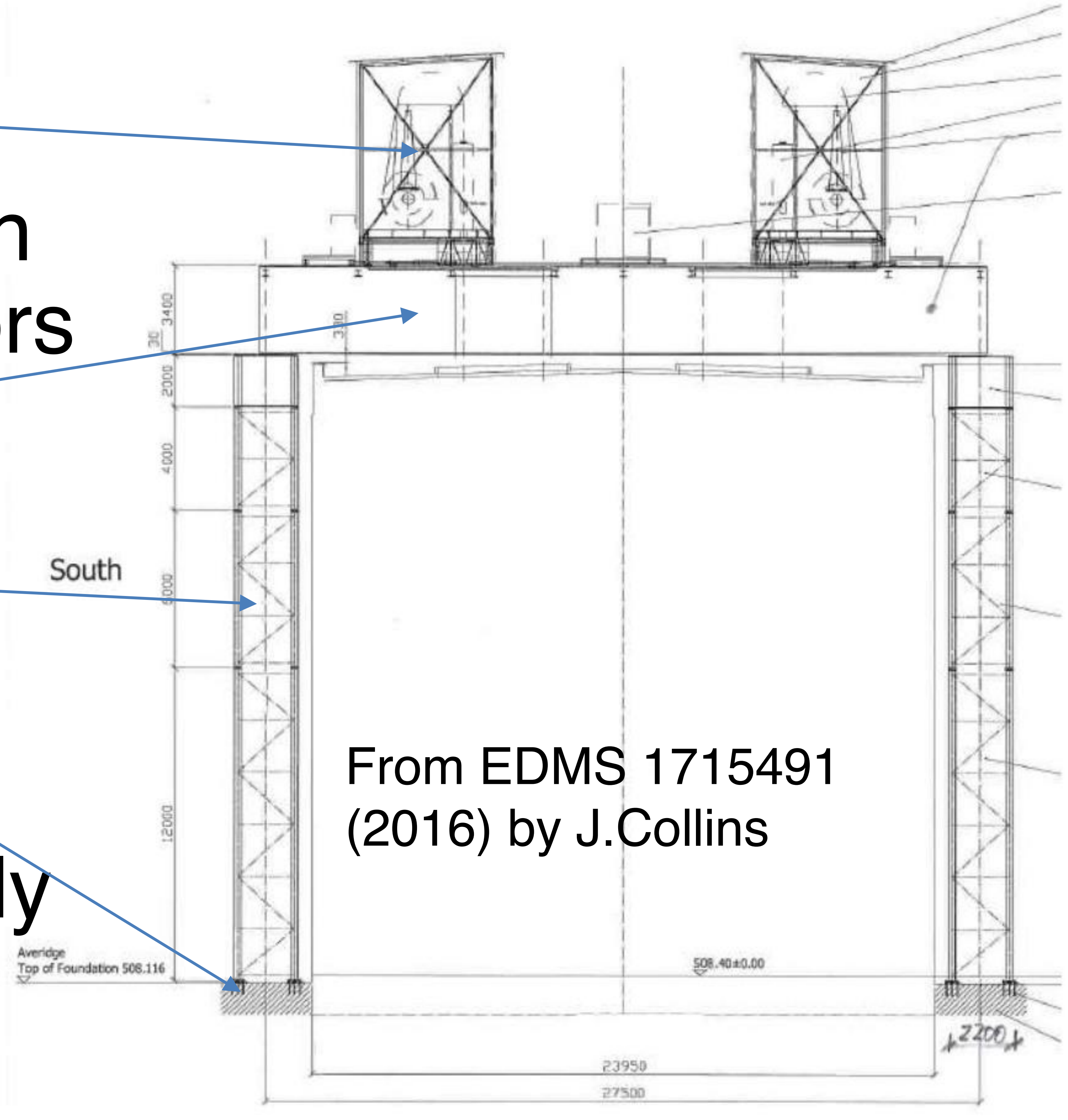

Figure 5: Front view (VSL, 2006)

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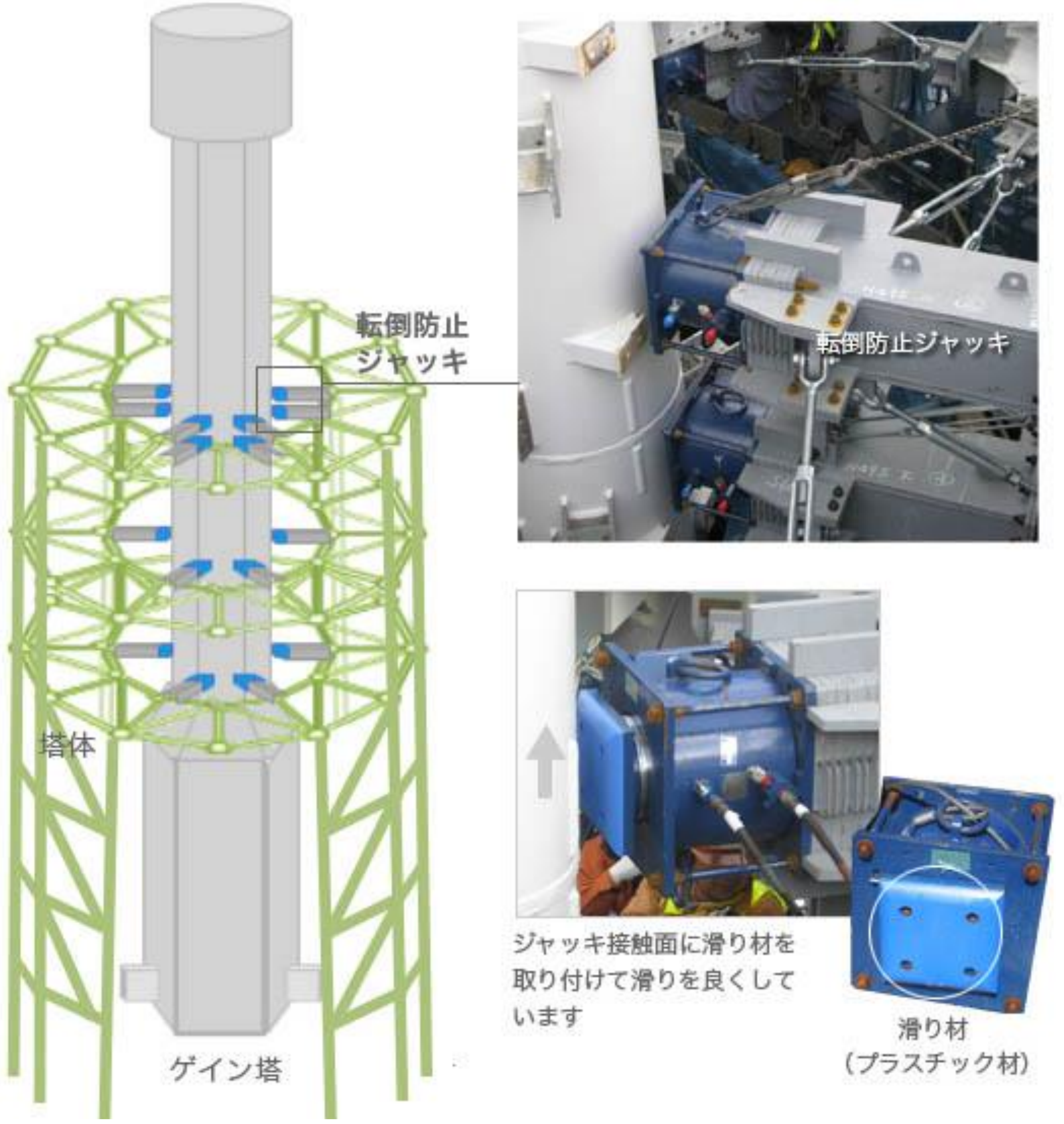
Y. Sugimoto

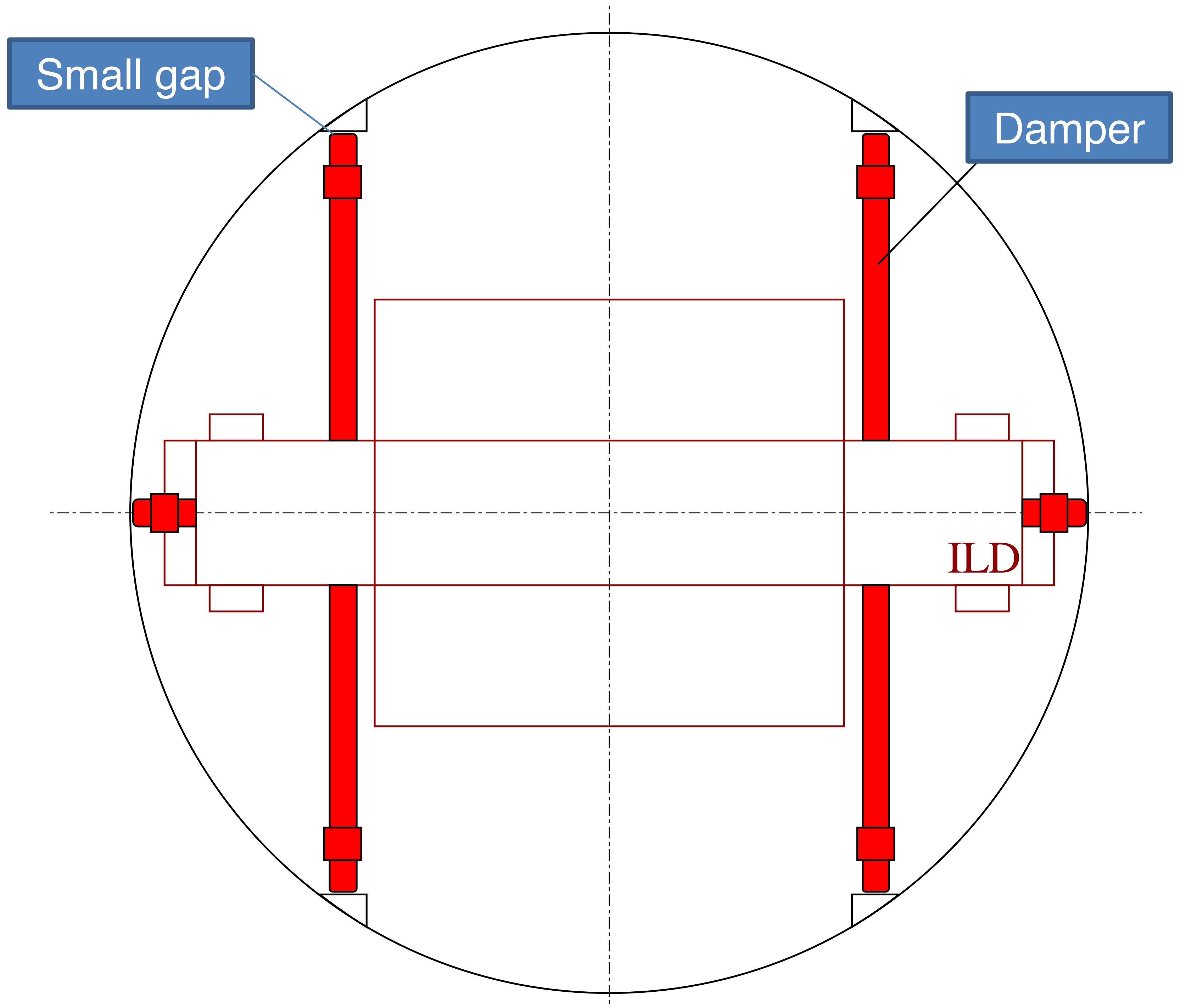
Gantry Crane and Earthquakes

Operation – Lowering

- Protection against big earthquake during lowering
  - 3.11. earthquake happened during lifting up 3000t Gain Tower of Tokyo Sky Tree
  - There was no damage because it was supported from the side
  - We should adopt similar way during detector lowering



Operation – Lowering



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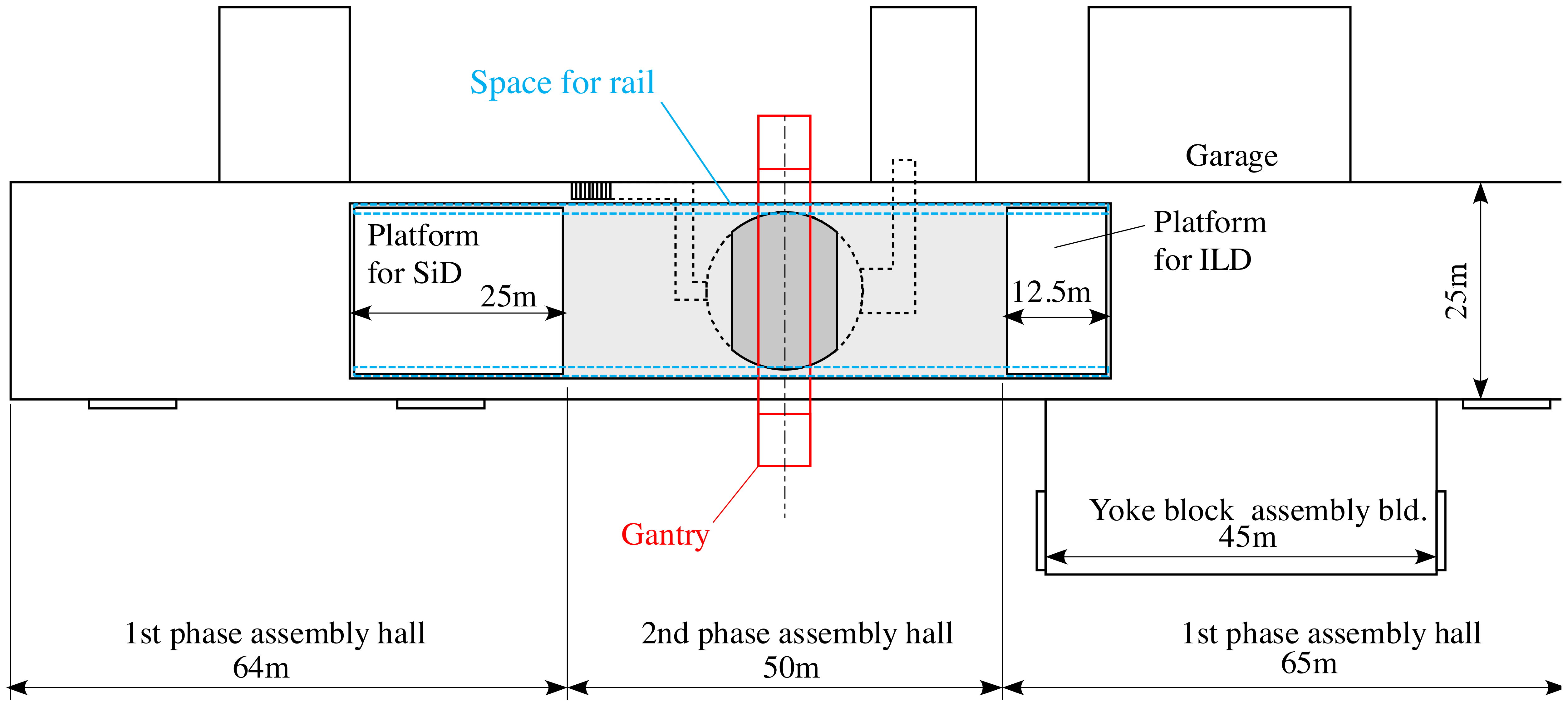
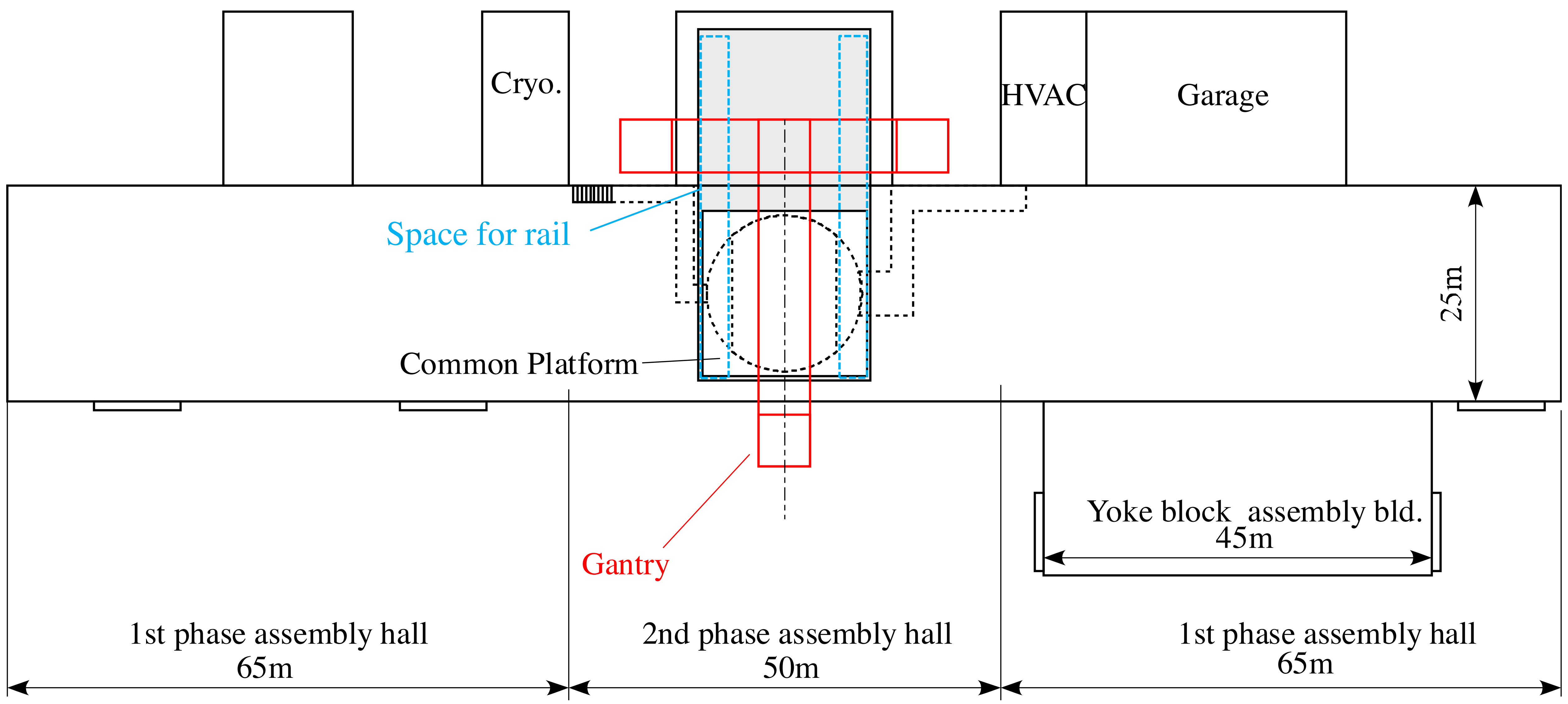
Surface Platform Proposal

New proposal for surface hall platform arrangement (cost!)

- Present design



- Common Platform option



Y. Sugimoto

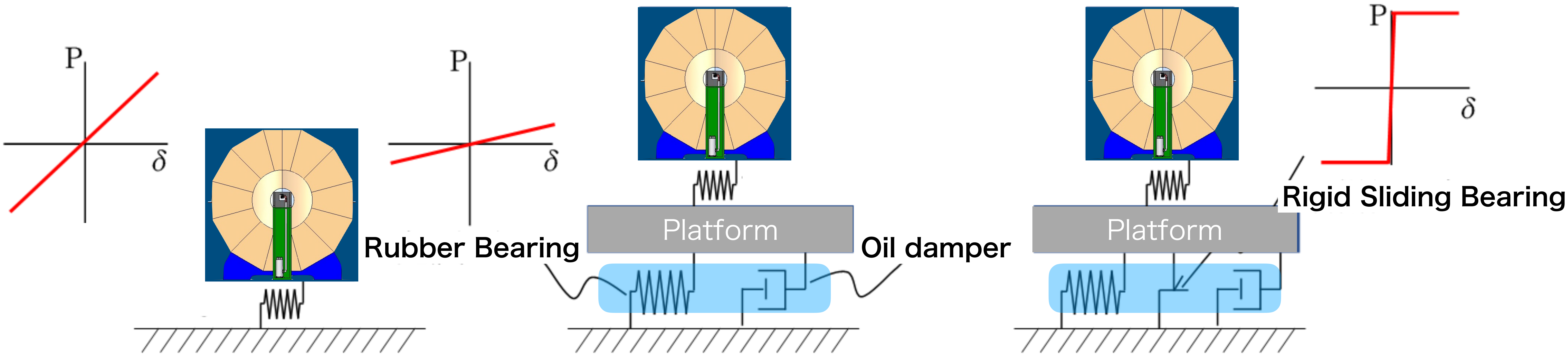
Seismic Isolation

T. Sanuki

Simplified model

Base Isolation

Seismic Resistance | Base Isolation - 1 | Base Isolation - 2



Rubber Bearing
+
Oil damper

Rubber Bearing
+
Rigid Sliding Bearing
+
Oil damper

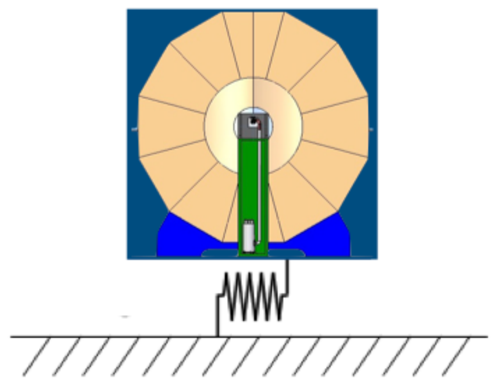
Natural period
~ 0.4 sec
(assumption)

Natural period
~ 4 sec

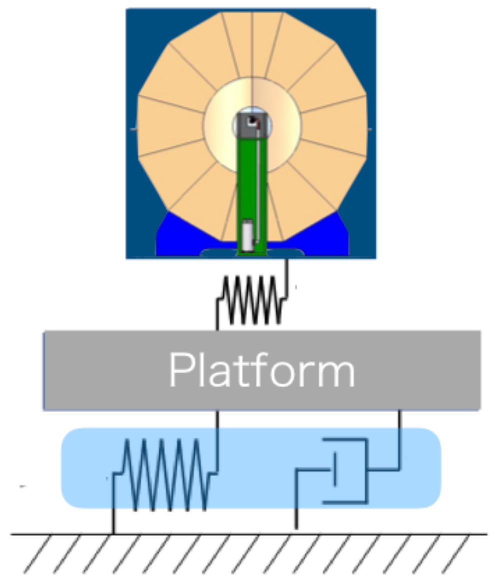
T. Sanuki

Result (Microtremor)

Seismic Resistance

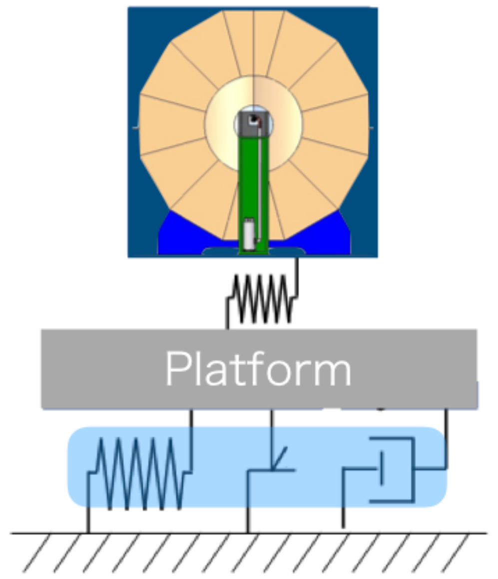


Base Isolation - 1

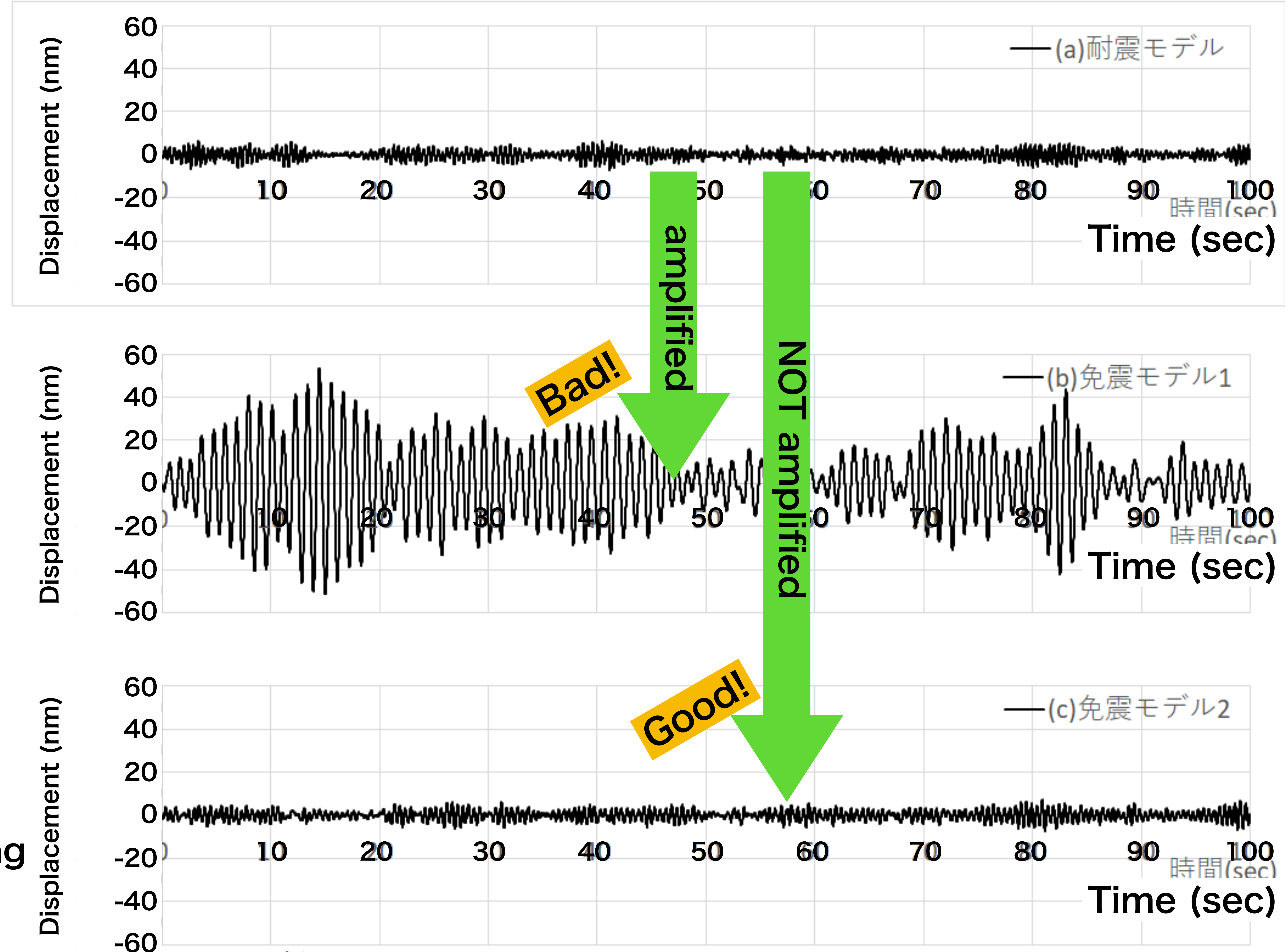


Rubber Bearing
+
Oil damper

Base Isolation - 2



Rubber Bearing
+
Rigid Sliding Bearing
+
Oil damper

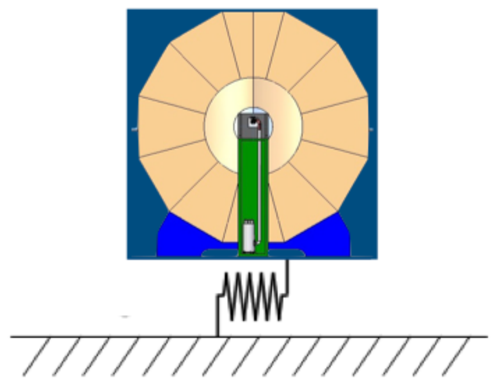


T. Sanuki

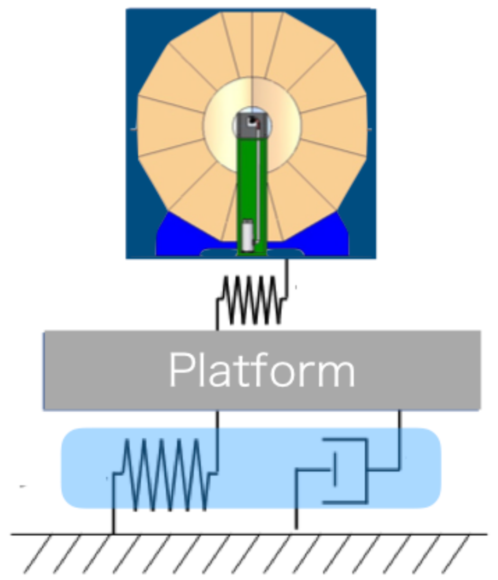
Result (2011 Tohoku Earthquake)

The most severe case

Seismic Resistance

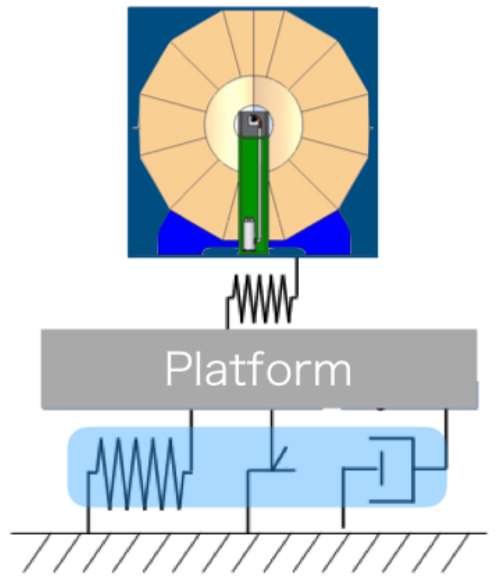


Base Isolation - 1

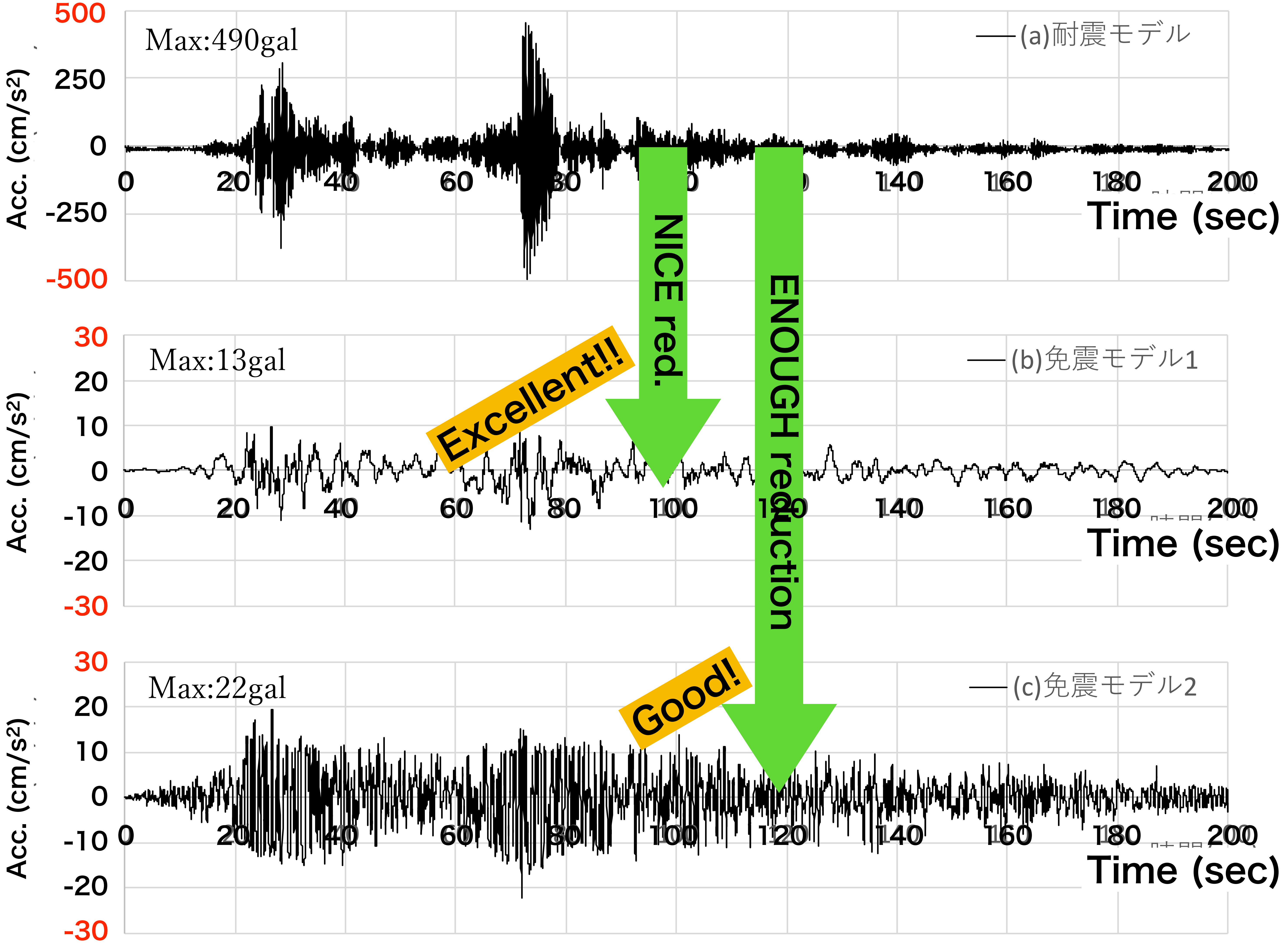


Rubber Bearing
+
Oil damper

Base Isolation - 2



Rubber Bearing
+
Rigid Sliding Bearing
+
Oil damper

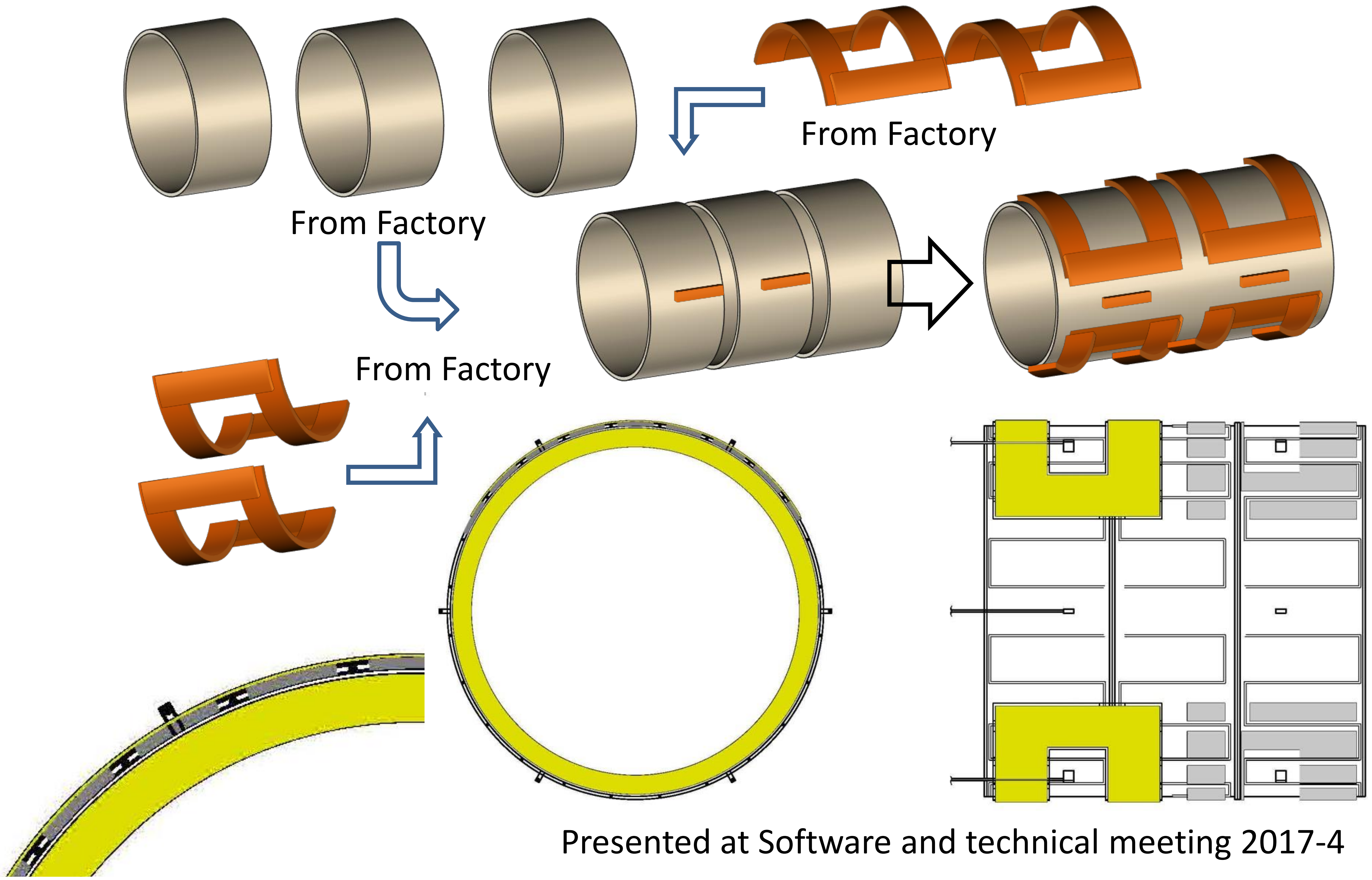


Magnet Developments

Design Study by Toshiba and Hitachi

- Conceptual manufacturing process
- Toshiba suggests to change coil radius to make transportation easier (fits not for ILD-L, but maybe ILD-S)

Outline of ILD magnet manufacturing process



Presented at Software and technical meeting 2017-4

Coil Dimensions and Solenoid Field

	TDR & HITACHI	TOSHIBA
Coil Inner Radius (mm)	3615	3215
Coil Outer Radius (mm)	3970	3570
Length (mm) Each Block Length (mm)	7350 2450	7350 2450
Turn × Layer	309 ×4 300 ×4 (for gap b/w module)	330 ×5
Nominal Current (A)	22400 23072 (in case 300 turn)	15339
Current Density (A/mm^2)	10.6	9.7
Central Field (T)	4.0	4.0
Maximum Field (T)	4.6	4.5
Support Shell Thickness (mm)	50 (Checked by ANSYS)	10 – 100 (now analyzing)

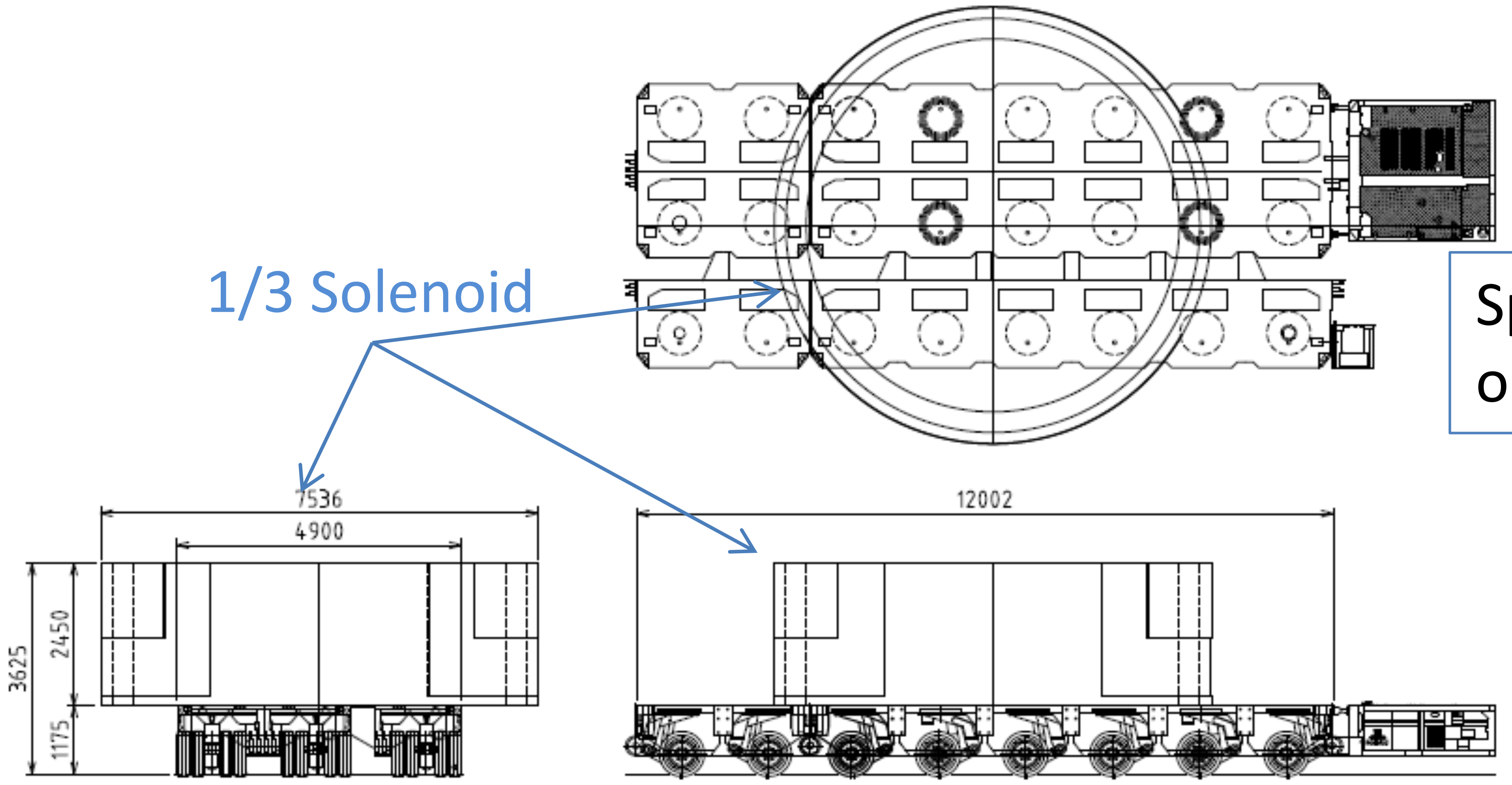
Y. Makida

Transportation

On Jumbo-Carrier

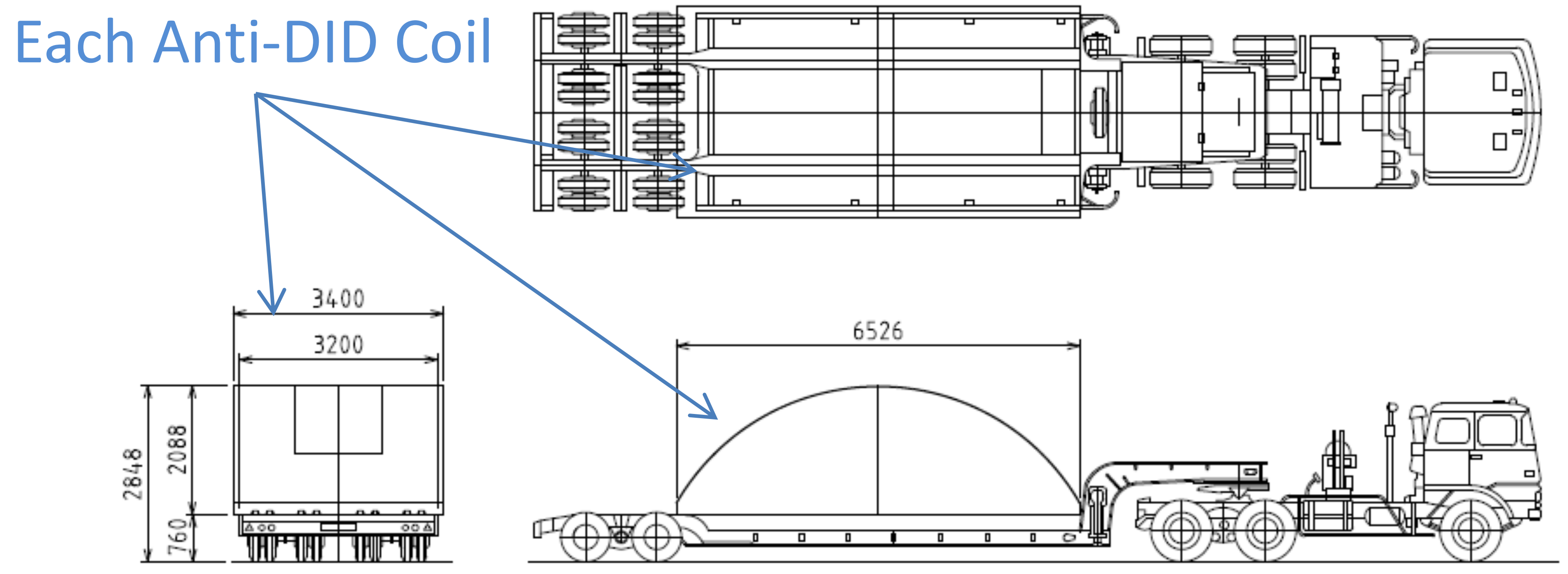
- Anti-DID in segments
- Coil in modules

Transportation Proposal by Toshiba



Special permission on public roads

Solenoid Transportation by “**JUMBO CARRIER**”



Anti-DID Transportation by low-floor trailer

- From view point of transportation from factory to ILC site, solenoid and anti-DID size are considered.
- Anti-DID is smaller and simpler, which meet the field requirement.
- Anti-DID coils are wound in a factory and are set on solenoid in an assembly build on-site.

Y. Makida

Hitachi Field Analysis

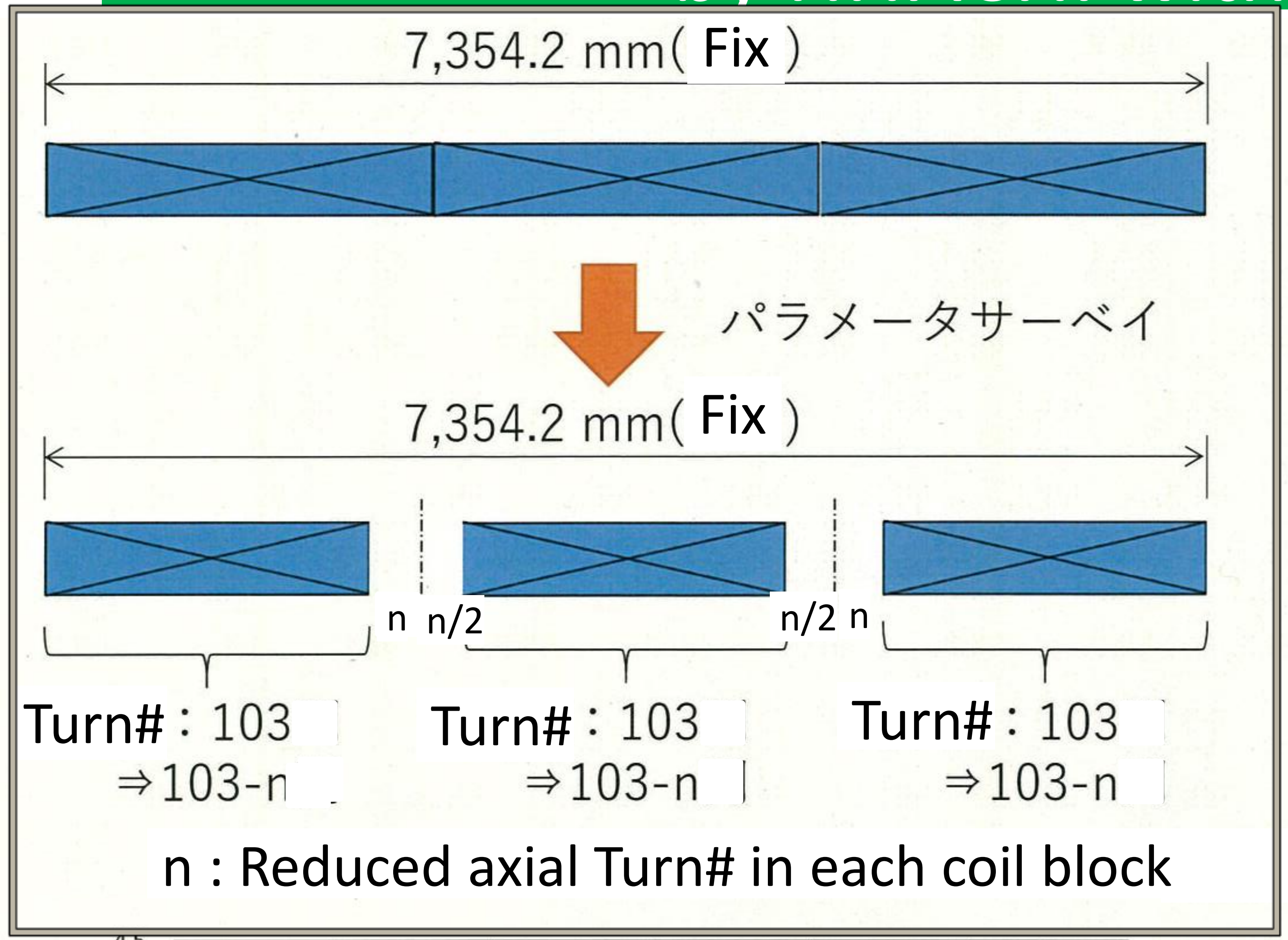
Coil Modules

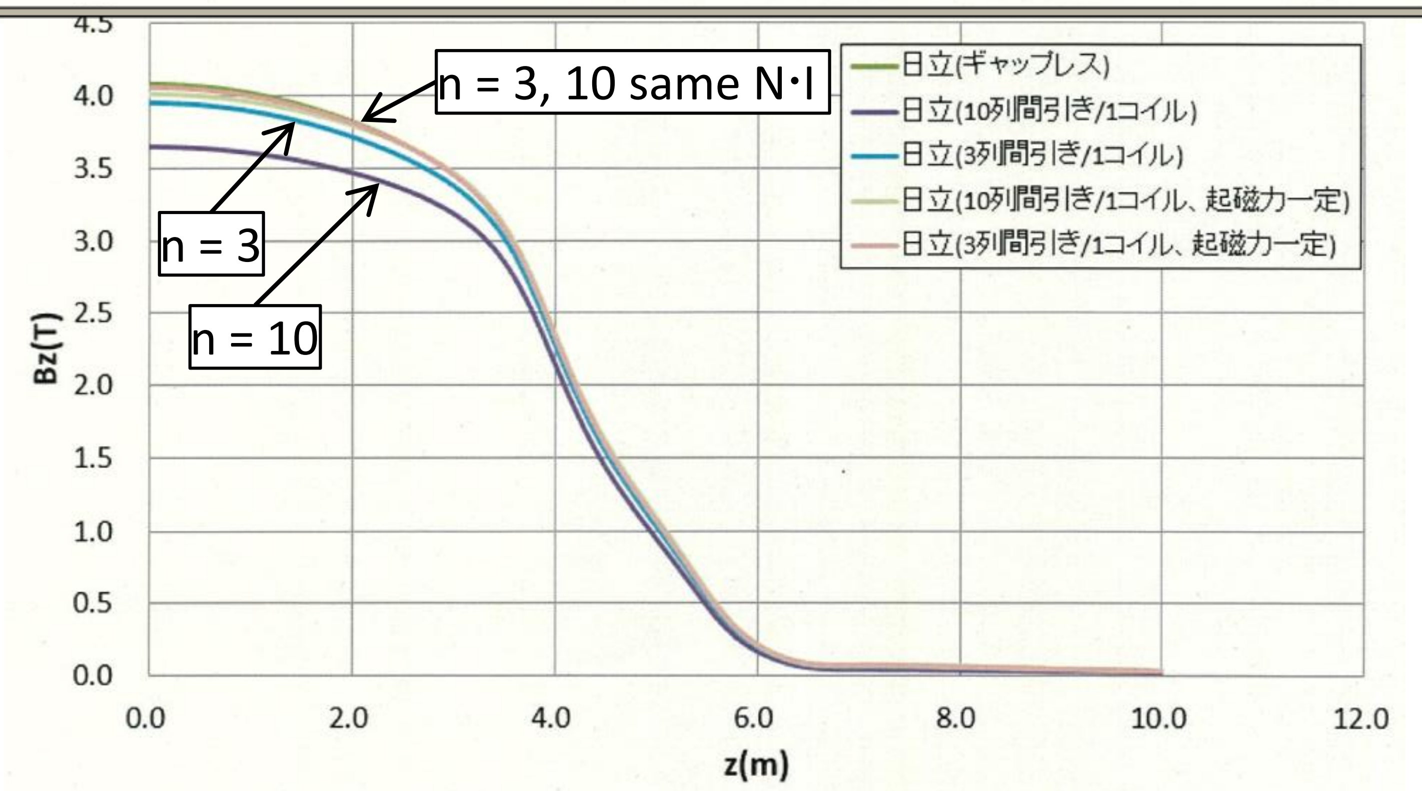
- check reduced module length
- less axial turns in each module
    - cost!
- recover field by increasing the currents

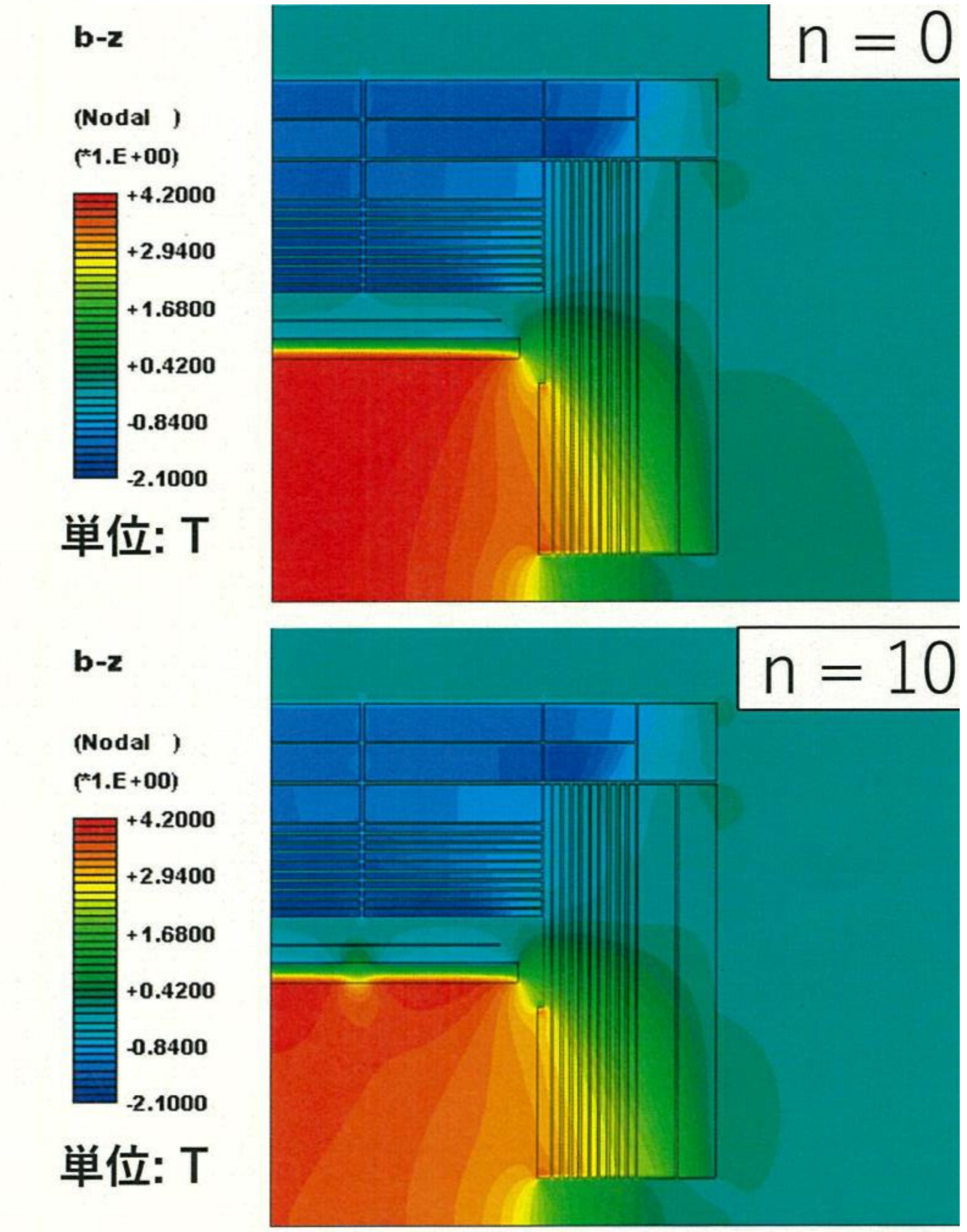
Stress analysis under way

Field Check with Gap b/w Coil Block

by HITACHI with EMSolution





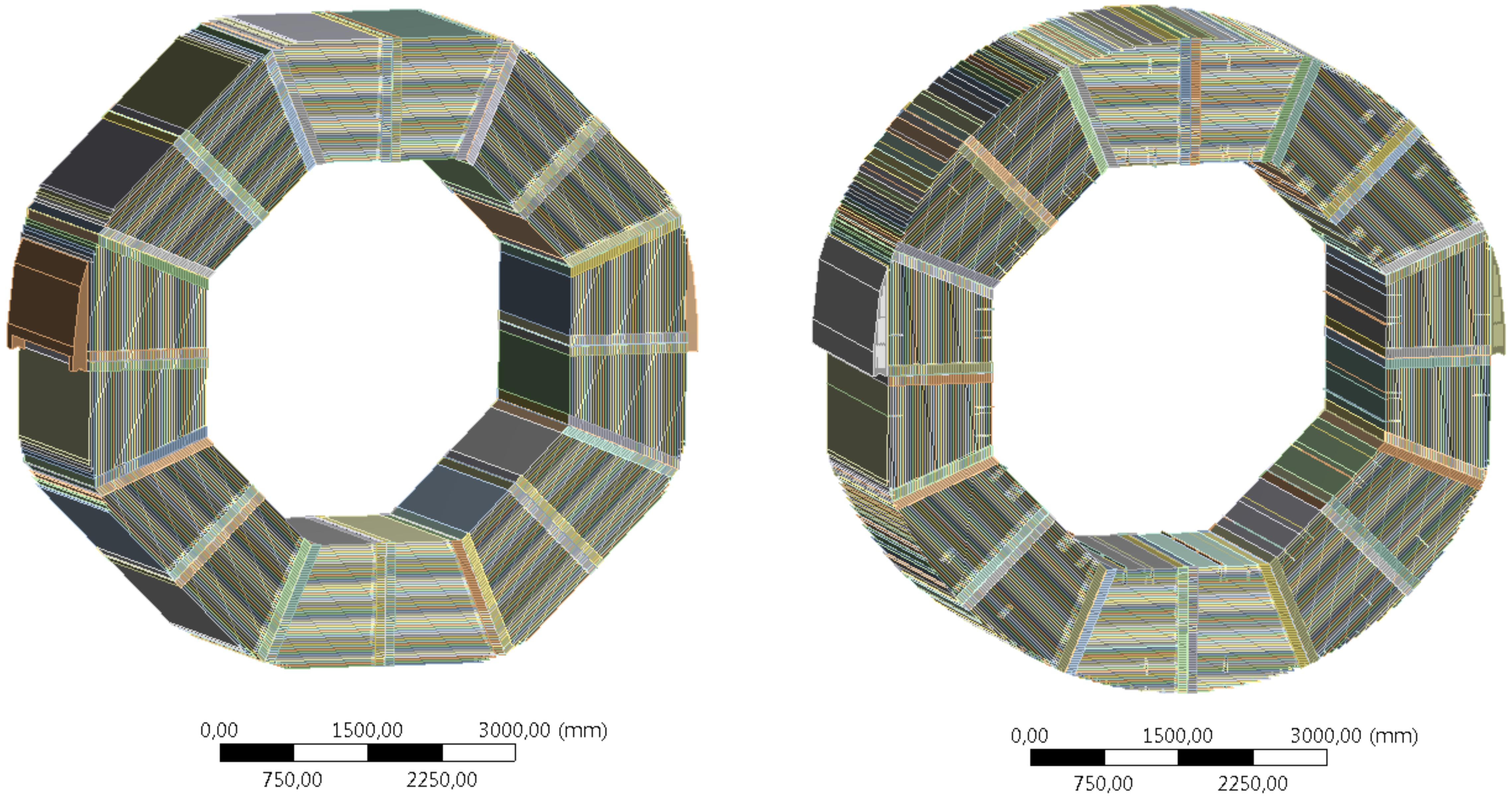


Y. Makida

AHCAL Mechanics

AHCAL Adaptation from LDC to ILD Geometries

> Left, old geometry - right, new geometry



Geometry – Overview general specifications/data

> Reminder: New dimensions and plate thickness

	Old	New
Plate Thickness	16mm	19mm
Number of Plates	49 Layers with: => 46 "full" layers => 3 reduced layers	49 Layers with: => 39 "full" layers => 10 reduced layers
Periodicty	Every 26,5mm	Every 26,5mm
AHCAL Mass (total)	262.108kg	317.271kg
AHCAL Outer Radius	3.392,5mm	3.349mm
AHCAL Inner Radius	1.947,5mm 1445	2.058mm 1291
Coverplates	200mm (width) 15mm (thickness)	200mm (width) 15mm (thickness)

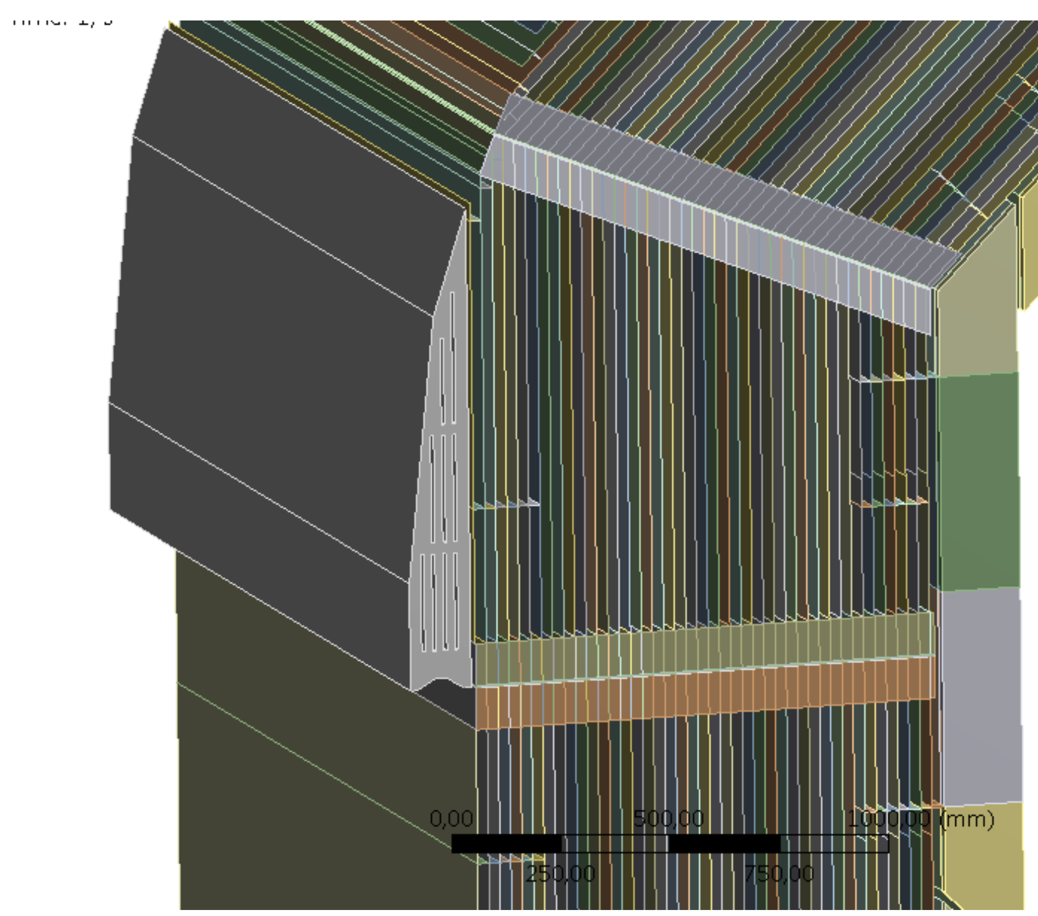
> Including:

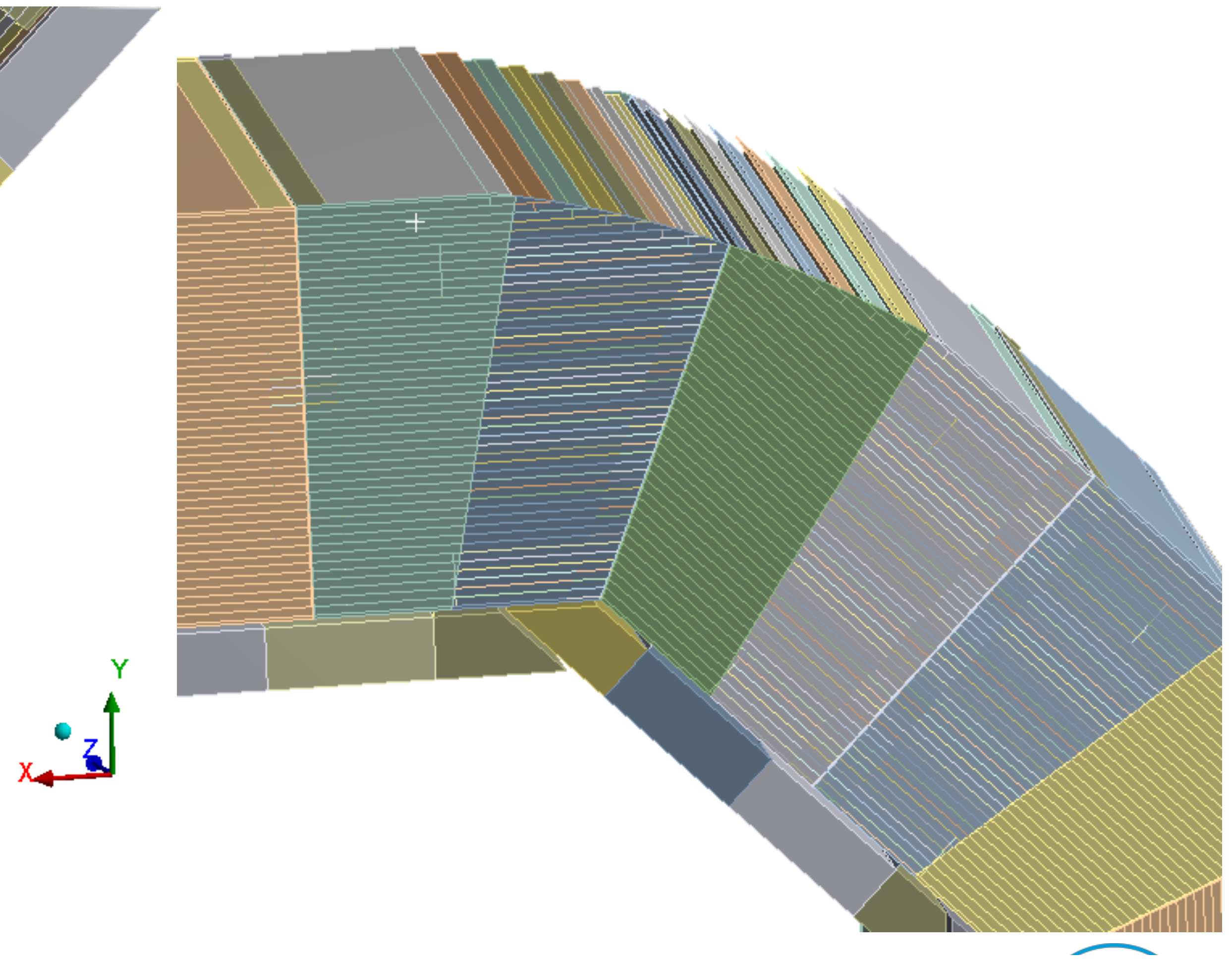
- Detector mass of about 16,82kg/m² (corresponds to thin cassettes)
- ECAL mass as distributed mass in ANSYS or with ECAL geometry

K. Gadow, F. Sefkow, M. Lemke I Optimisation of the AHCAL Structure I 2018-10-23 I Page 3

F. Sefkow, K. Gadow, M. Lemke

Geometry Update



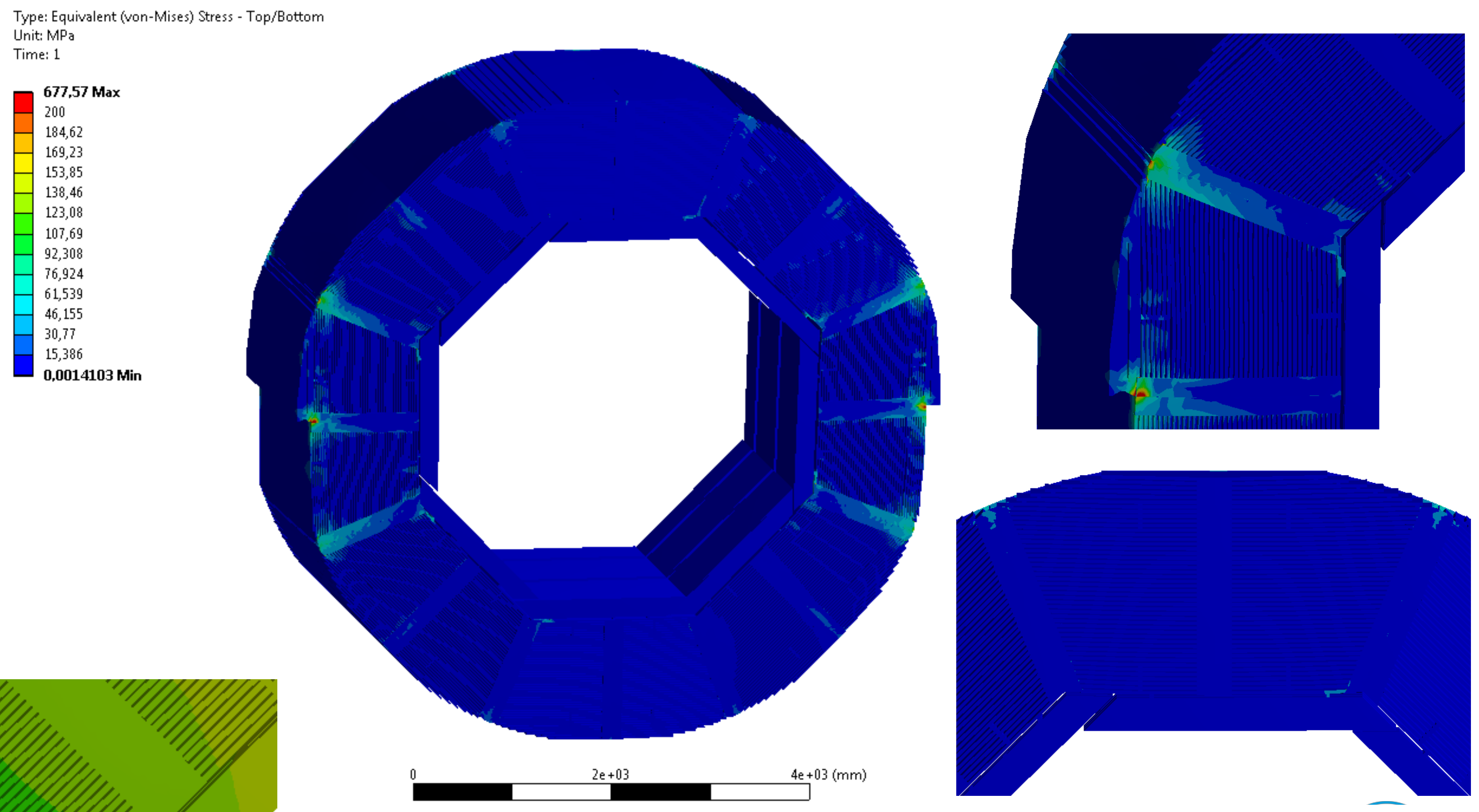


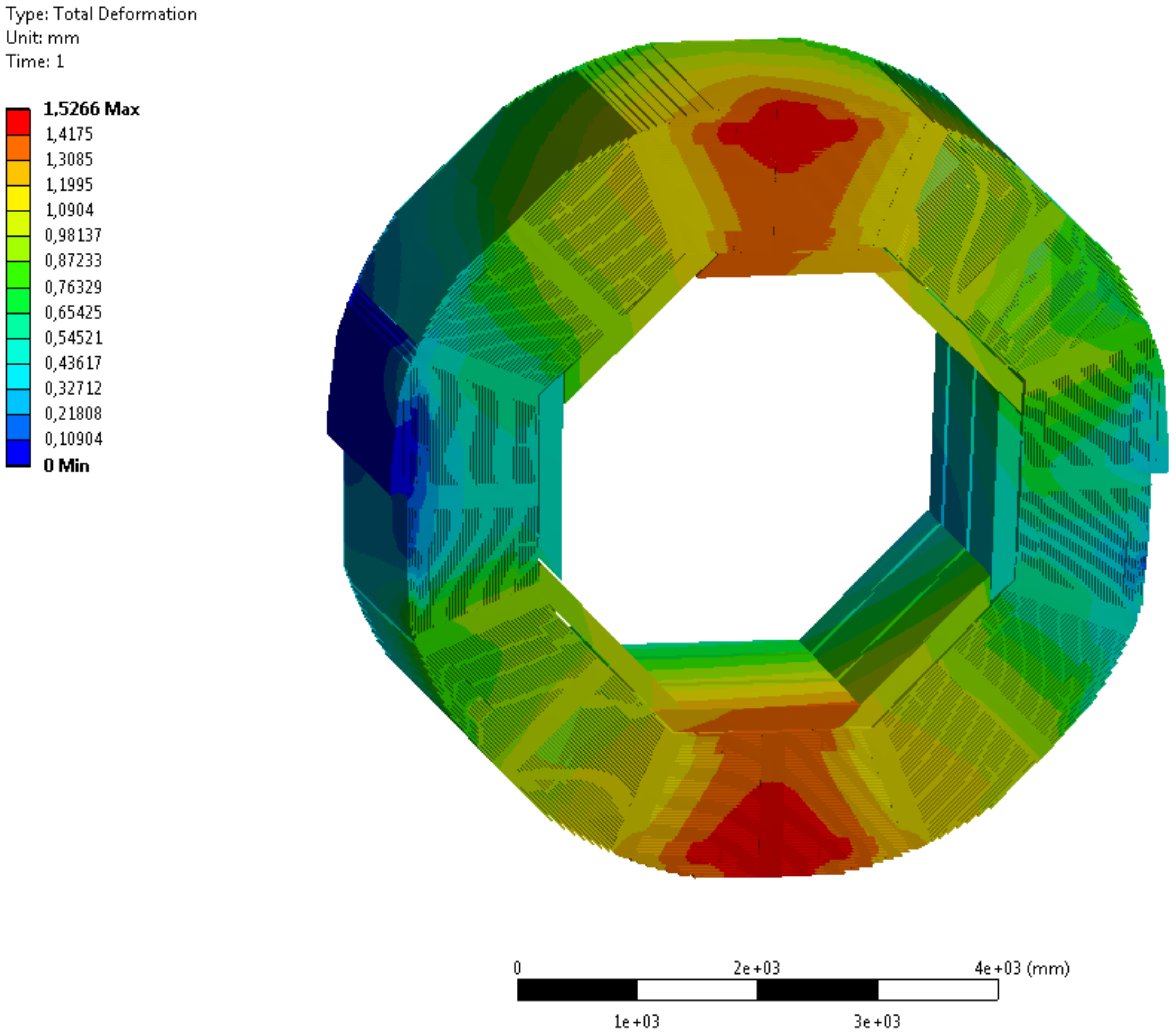
- Small changes in the inner and outer diameter (see slide #3)
- Increase the plate thickness from 16mm to 19mm
- Therefore an reduction of the total number of plates per segment (see slide #3)
- Increase of the total depth from 2.160mm to 2.350mm
- Introduction of additional spacer in the inner and outer areas of the AHCAL Ring => more overall stiffnes and better flow of forces in the structure (ECAL-Loads and Support-Forces, general deformations)
- „Special Design“ of the backplates:
  - Two AHCAL-Rings should be mounted next to each other as near as possible
  - The screws of the backplates have an offset in their arrangement
  - Therefore the screw heads of both AHCAL-Rings have gaps/recesses in the opposite backplate

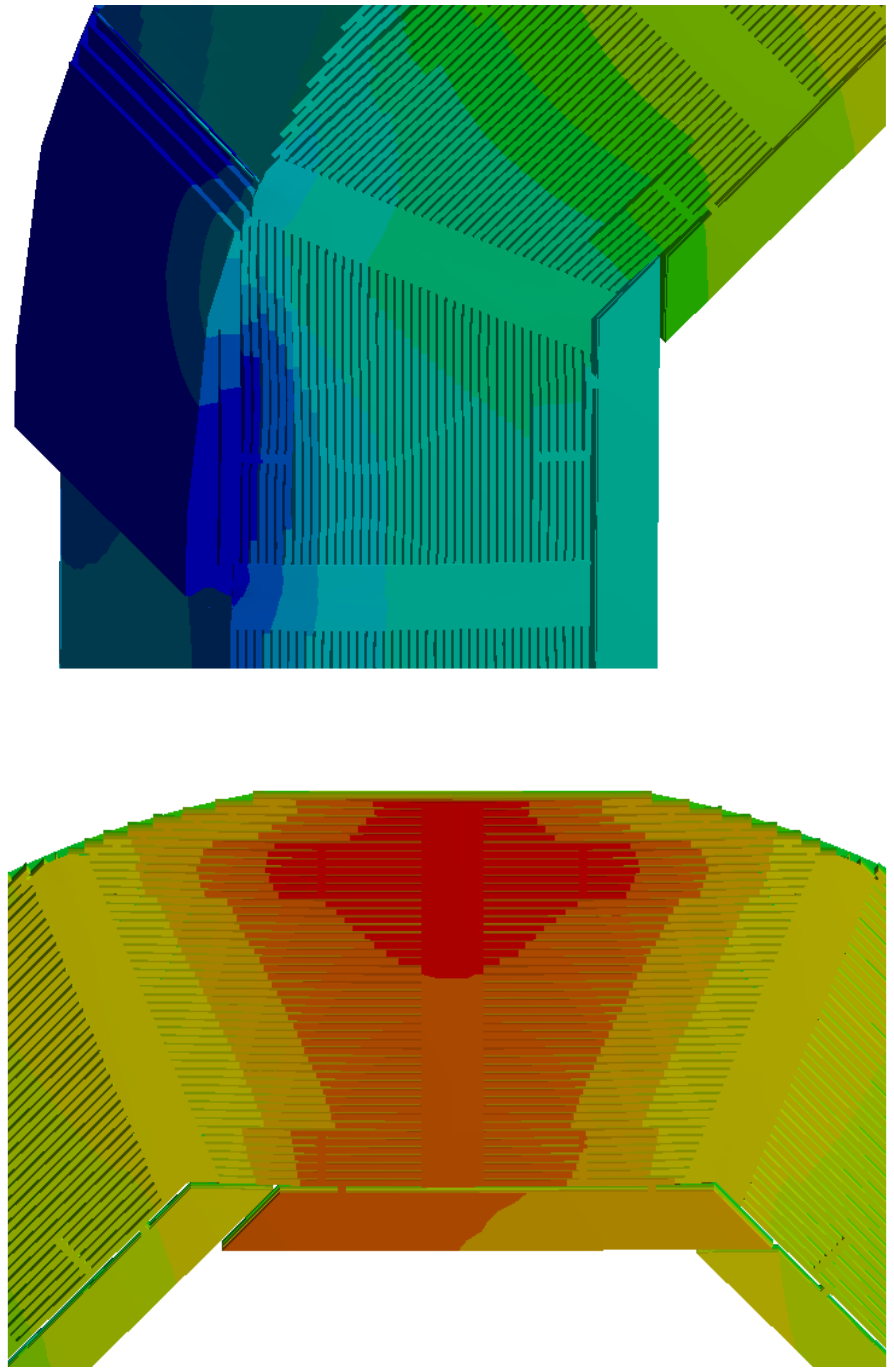
F. Sefkow, K. Gadow, M. Lemke

Static Analysis

- Displacements down to 1.5mm
- Stresses under control







F. Sefkow, K. Gadow, M. Lemke

Upcoming Meetings

Upcoming Meetings with Integration Content

ILD Integration Workshop

- February 11 (10:30) to February 12 (15:00) at DESY
- Review the inputs beyond subdetector technologies that are necessary for the IDR. Among the list of topics are internal cabling, mechanical simulation, Anti-DID effects, cavern utilities, and others.
- https://agenda.linearcollider.org/event/8126/

8th Mini-Workshop on ILC Infrastructure and CFS for Physics and Detectors

- February 28th at KEK, directly after the ILD Meeting (Feb 26/27), exploit synergies!
- Dedicated to discussions on the detector-driven infrastructure needs for the ILC campus at the IP and at the central lab.
- https://agenda.linearcollider.org/event/8123/
    - For crane enthusiasts: KEK colleagues try to organise a visit to a gantry crane company on March 1st.

Summary

Contact

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