Report from the MDI Common Task Group

Karsten Buesser
DESY

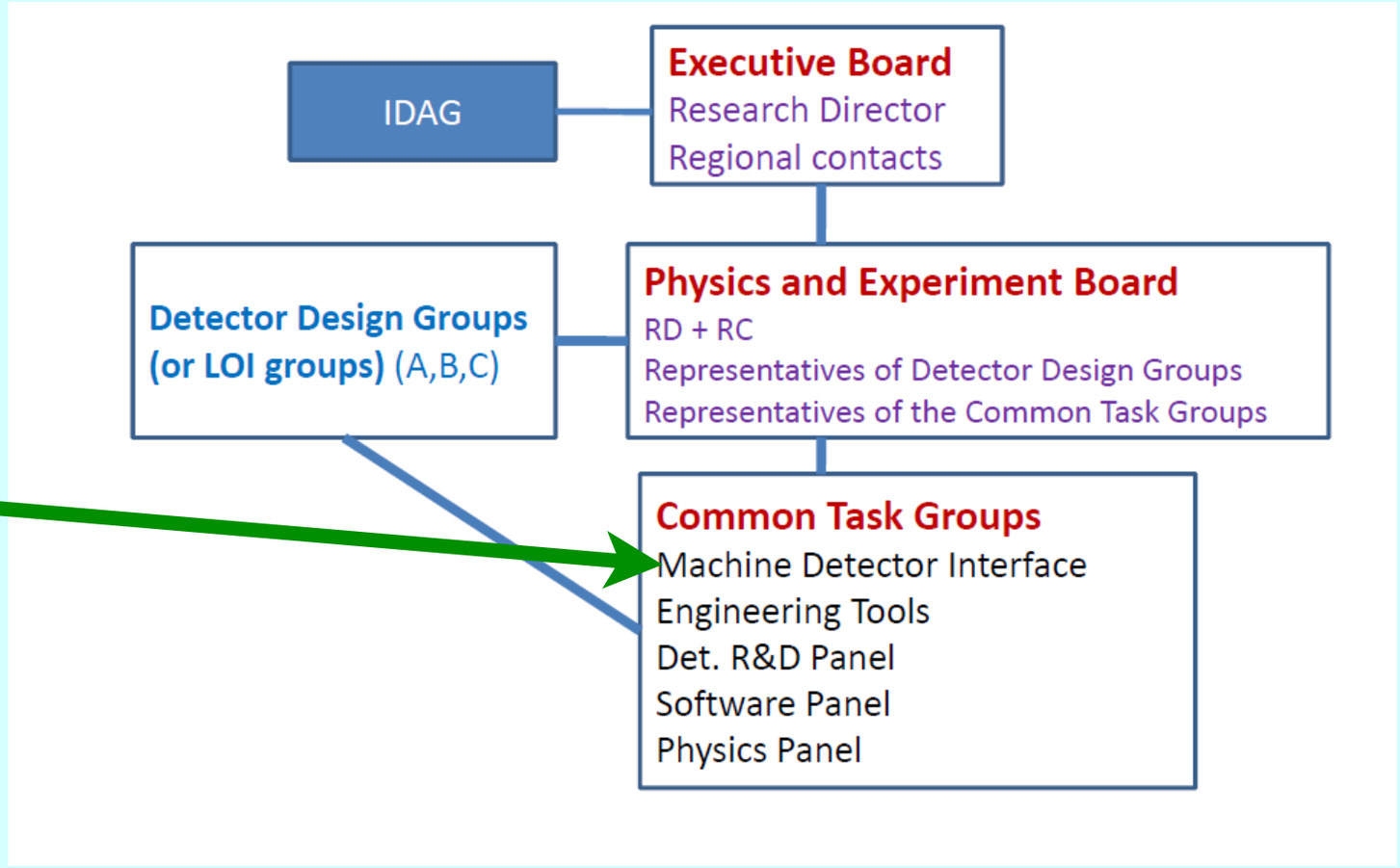
PAC Review

3 November 2009

The MDI Common Task Group

- Common task group of the Research Director‘s organisation:

- Members:
  - J. Hauptman (until 01.09.09)
  - A. Mikhailichenko (until 01.09.09)
  - P. Burrows (deputy convener)
  - M. Oriunno
  - K. Buesser (convener)
  - T. Tauchi



- Usually meets in phone meetings
- Close contact to the GDE BDS group

ILC-Note-2009-050
March 2009
Version 4, 2009-03-19

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), J.Hauptman (Iowa State Univ.), T.Tauchi (KEK), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

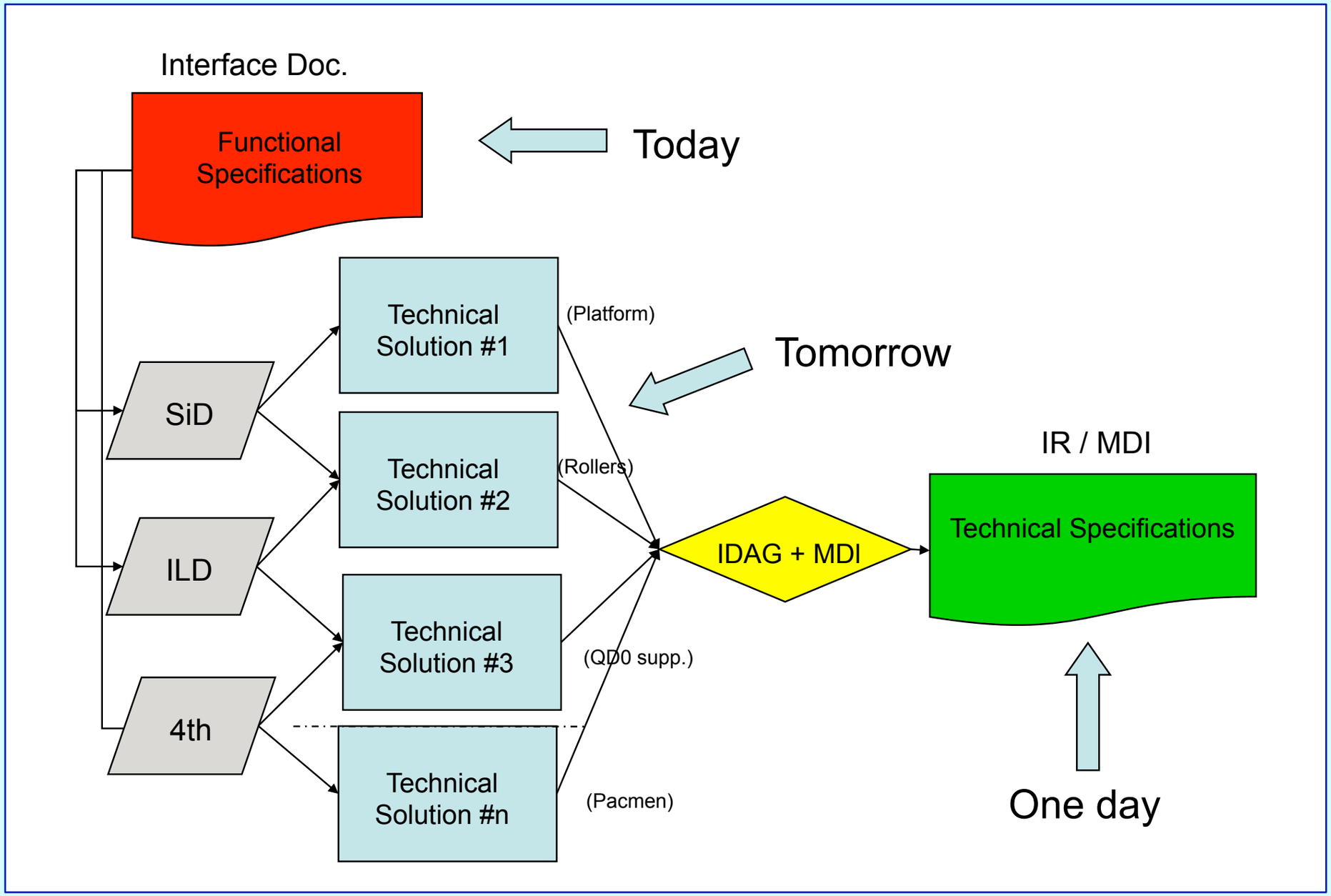
Abstract
The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper attempts to separate the functional requirements of a push pull interaction region and machine detector interface from any particular conceptual or technical solution that might have been proposed to date by either the ILC Beam Delivery Group or any of the three detector concepts [2]. As such, we hope that it provides a set of ground rules for interpreting and evaluating the MDI parts of the proposed detector concept's Letters of Intent, due March 2009. The authors of the present paper are the leaders of the IR Integration Working Group within Global Design Effort Beam Delivery System and the representatives from each detector concept submitting the Letters Of Intent.

IR Interface Document

- Common document of the MDI-D common task group together with the GDE-BDS group
- Definition of the functional requirements to allow a friendly co-existence of two detectors and the ILC machine in a push-pull scenario
- Provide a set of ground rules, not technical solutions to the problems!

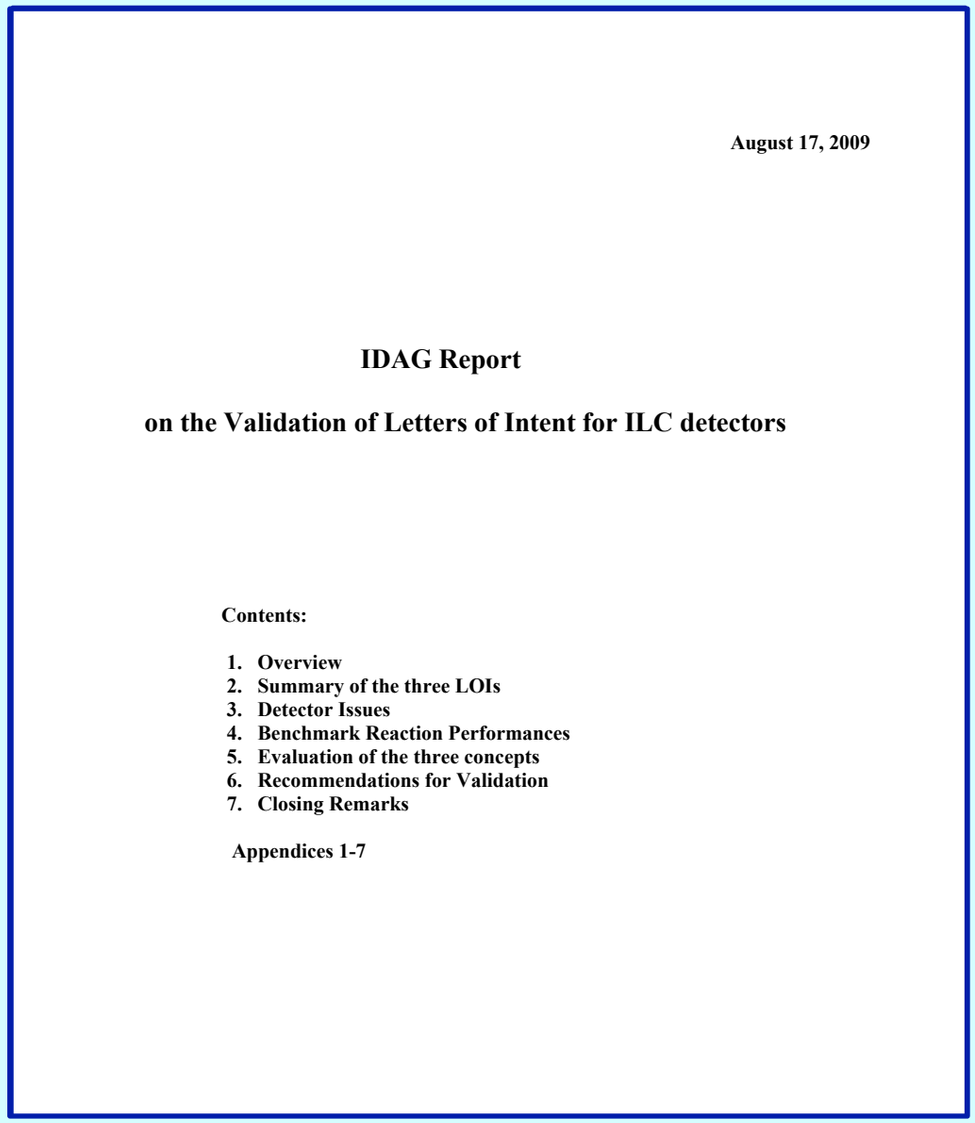
- Document has been discussed in detail between the MDI-D and the GDE-BDS groups
- Approved by concept groups, BDS technical area leaders and PM for accelerator systems
- Published as ILC-Note-2009-050

Bi-lateral Discussions



IDAG Report

- IDAG published its report in August 2009:



August 17, 2009

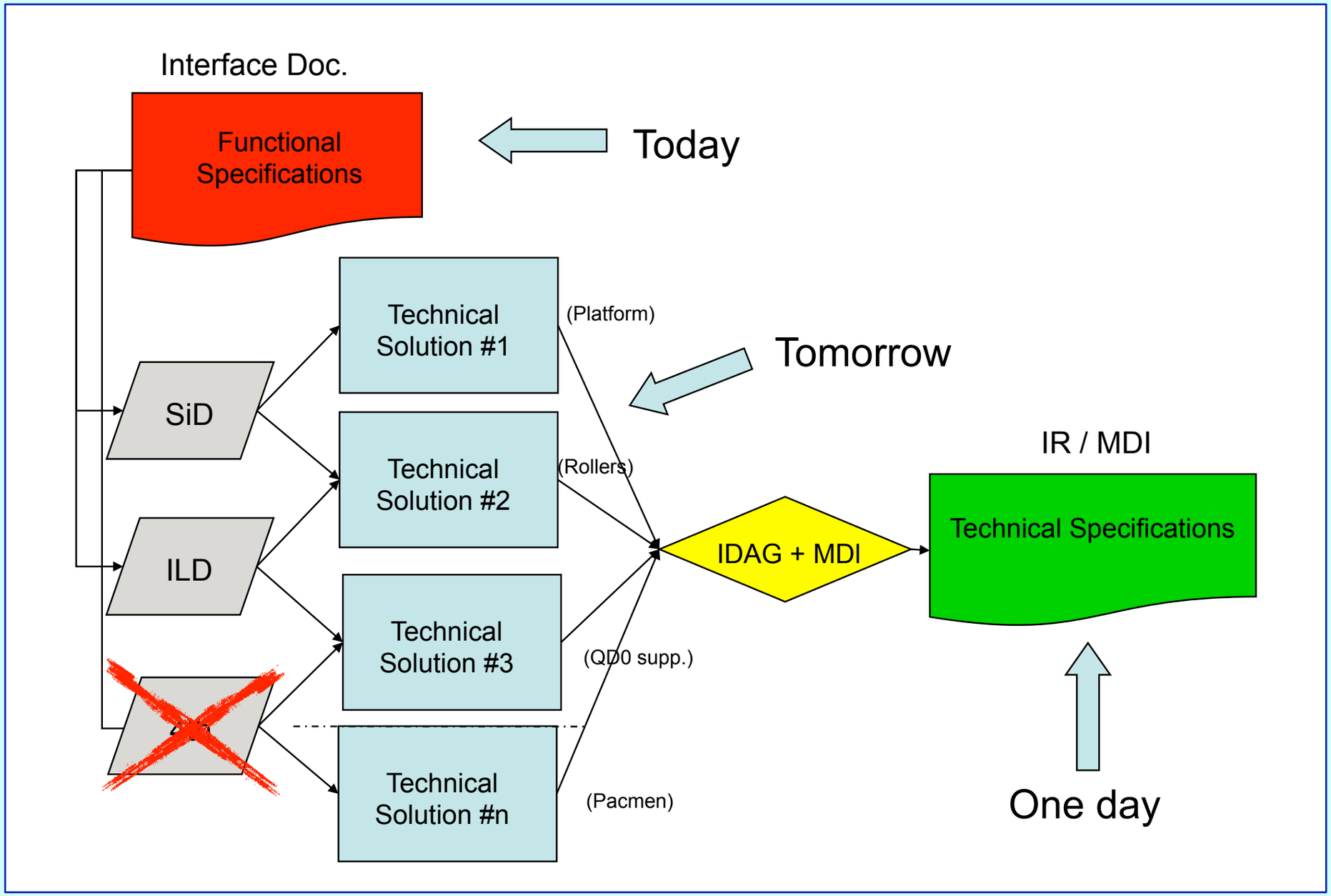
IDAG Report

on the Validation of Letters of Intent for ILC detectors

Contents:

- ILD and SiD got validated, 4th concept not

Bi-lateral Discussions



IDAG Findings

1. All the three LOIs present detector designs which are compatible with the L*, β* and related beam parameter specifications as laid out in [1,2].
2. All the three LOIs offer conceptual solutions which claim to allow rapid “detector push- pull”.
3. However, full details of specific engineering design solutions for the detector push-pull are yet to emerge. Thus, the actual push-pull performance is yet to be proven, and adequate intermediate engineering milestones have yet to be clearly laid out. The work toward them is all left for the TDR period.
4. The document [2] gives a snapshot of present MDI conditions to consider. IDAG understands that the work by the MDI panel must continue into the TDR period, and the MDI definitions will be continually refined and updated accordingly.

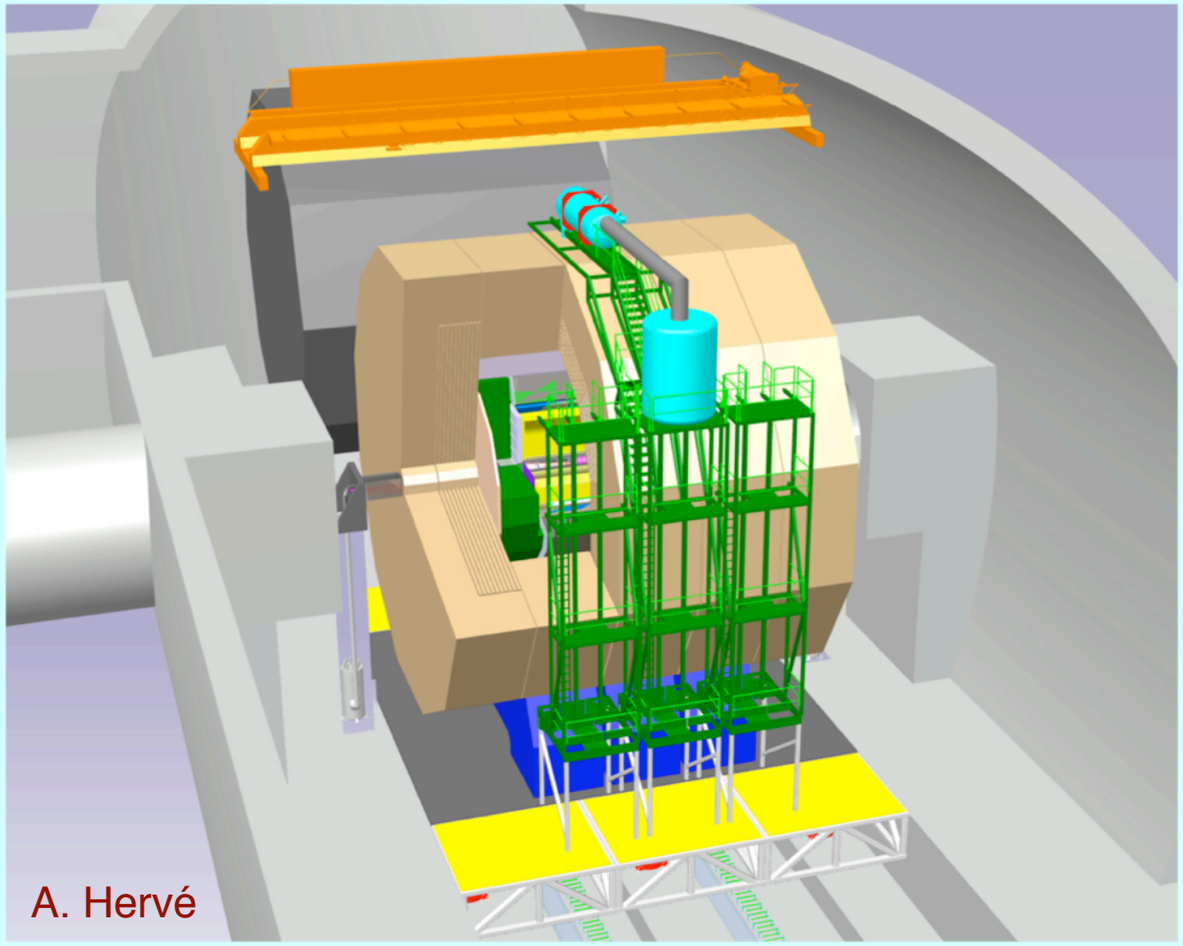
[1]: ILC RDR

[2]: Functional Requirements Document

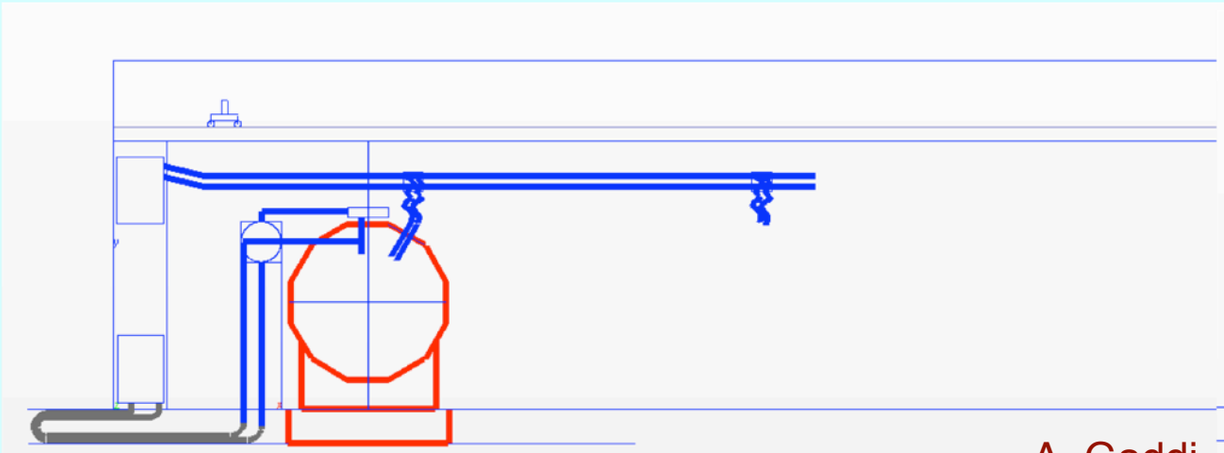
Pushing and Pulling ILD

ILD would move on a platform

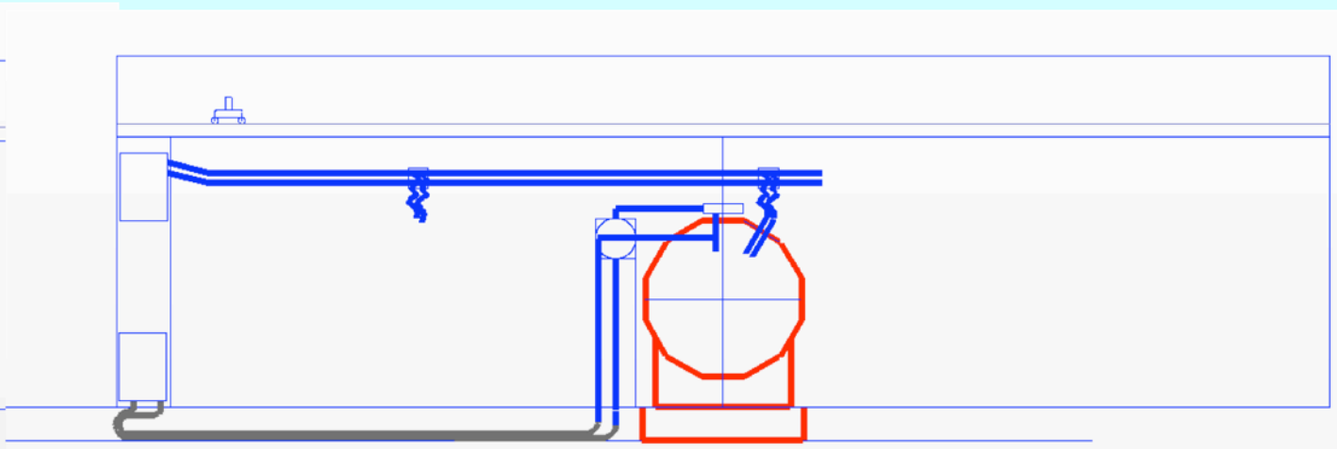
- Minimise vibrations during movement
- All services would be run through cable-chains (including cryogenics)
- Main bus-bar for voltage supply to the detector solenoid
- Aim: two days for the push- or pull-operation
  - one day for the mechanical movement
  - one day for calibration



A. Hervé

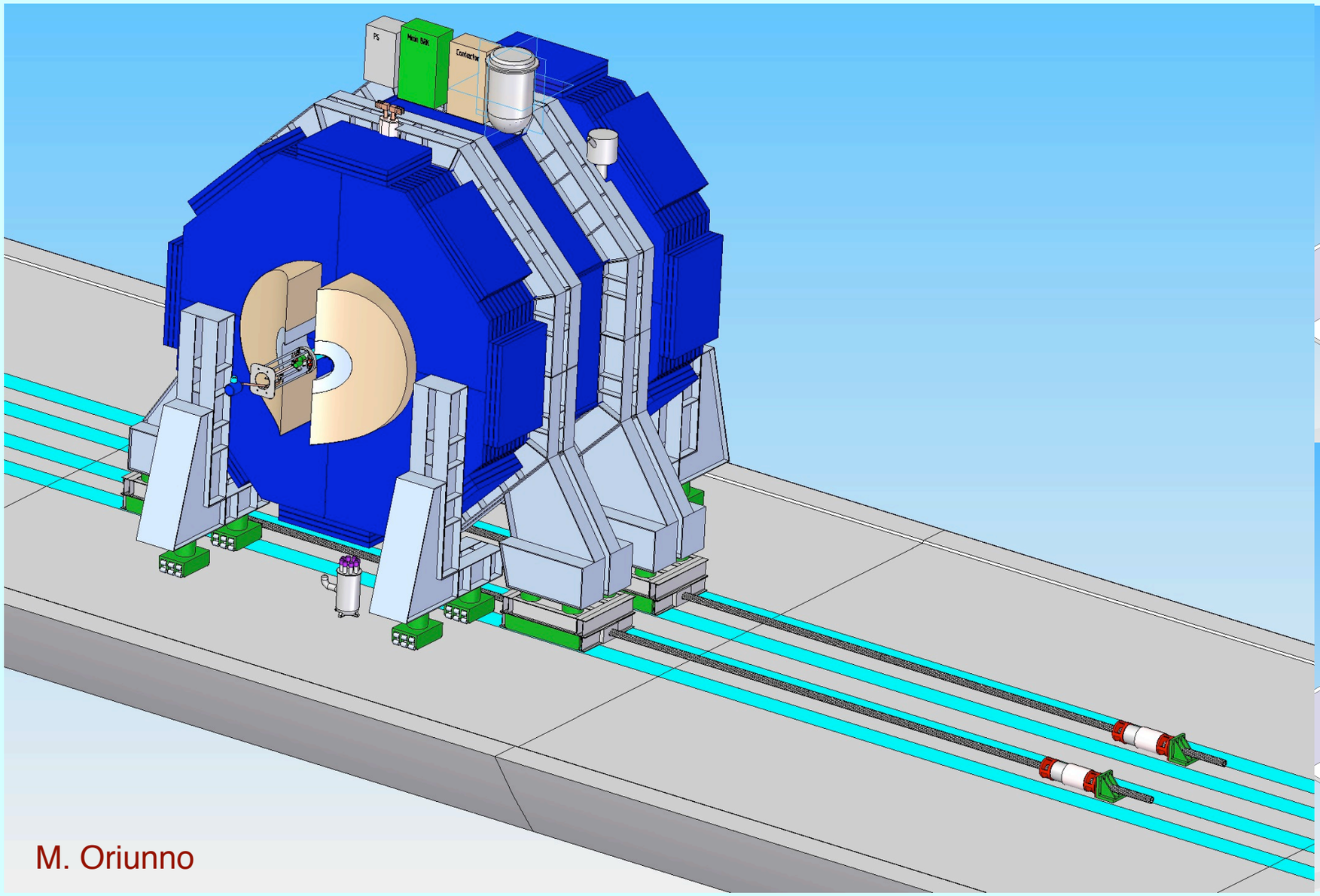


A. Gaddi

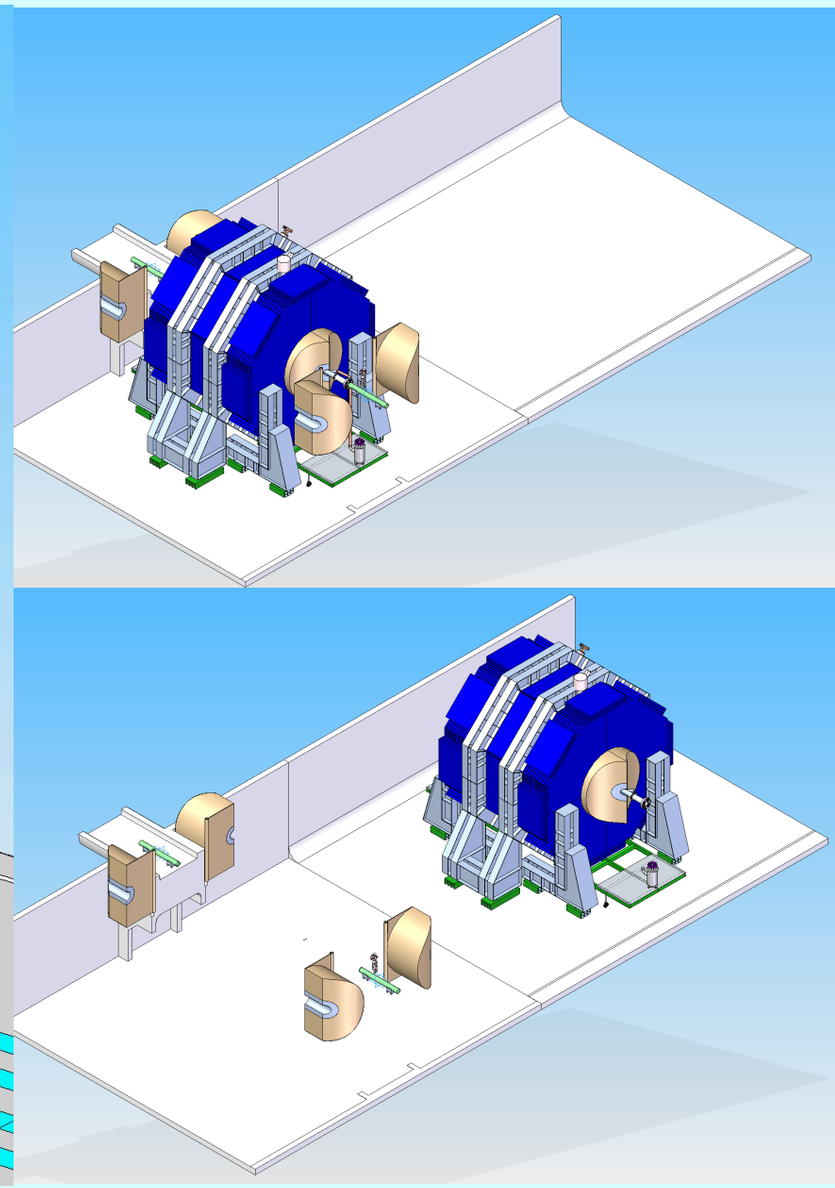


SiD Push-Pull Concept

- SiD would run on hardened steel rails using Hilman rollers
- Time needed ~1 day for luminosity-luminosity transition



M. Oriunno



Platform Issues

IDAG Report:

- ILD plans to have a 2 m-high platform. (...) SiD does not plan to use a platform at this moment. ILD is also larger in radius than SiD (...). If ILD/SiD (...) are to push-pull, either ILD (...) will have to give up their platform, or SiD will have to include one to bring their detector up to the height of the beam-line.

SiD-ILD-BDS Discussions

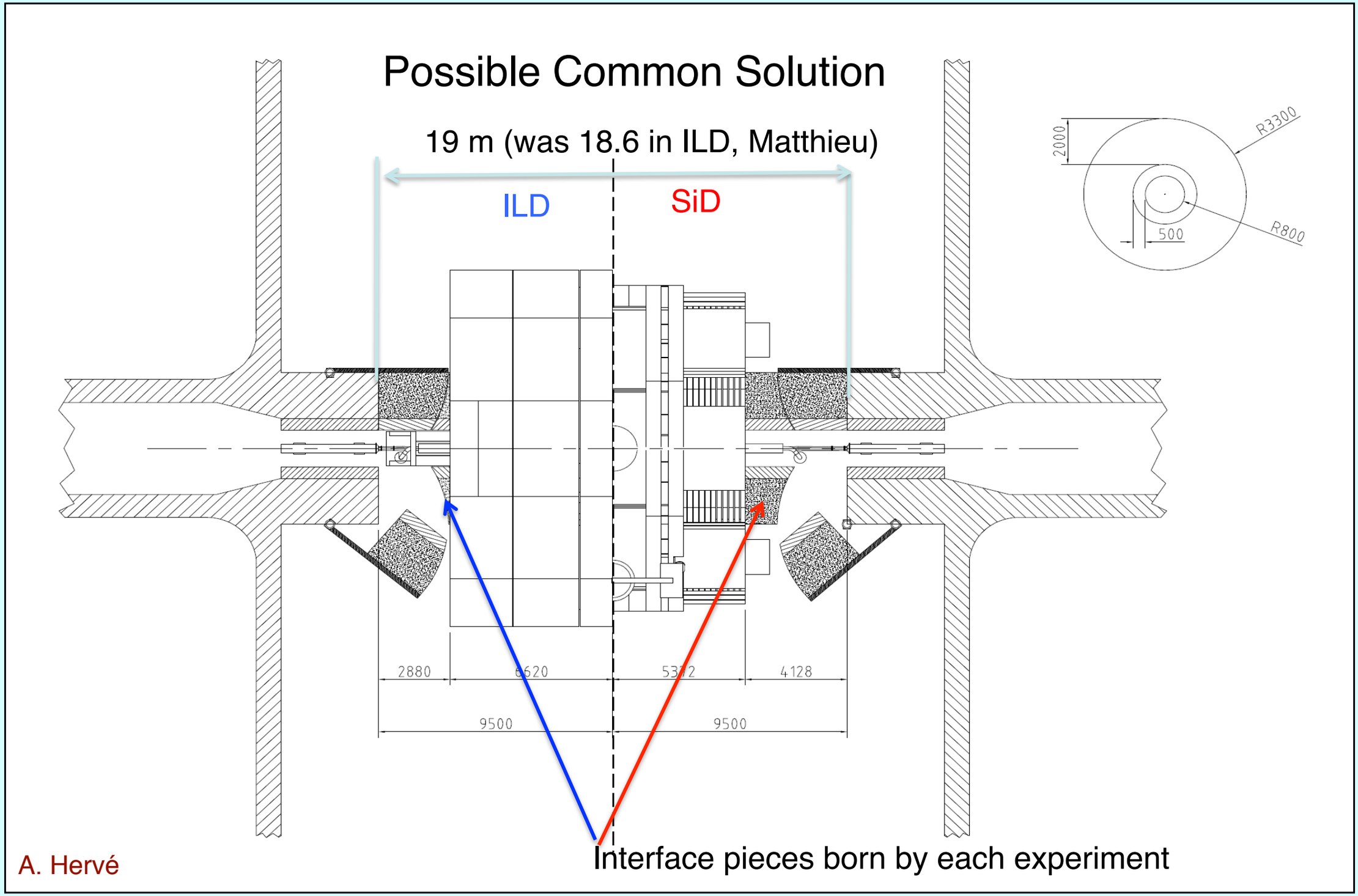
ILD members spent two months this summer at SLAC to discuss with SiD and ILC-BDS people:

- Ways to get to a common IR hall design where
  - ILD moves on a platform
  - SiD does not

- Common push-pull system
- Common shielding („pacman“) design
- Implications on the interface with the beam delivery system
  - Final focus magnets supports and alignement

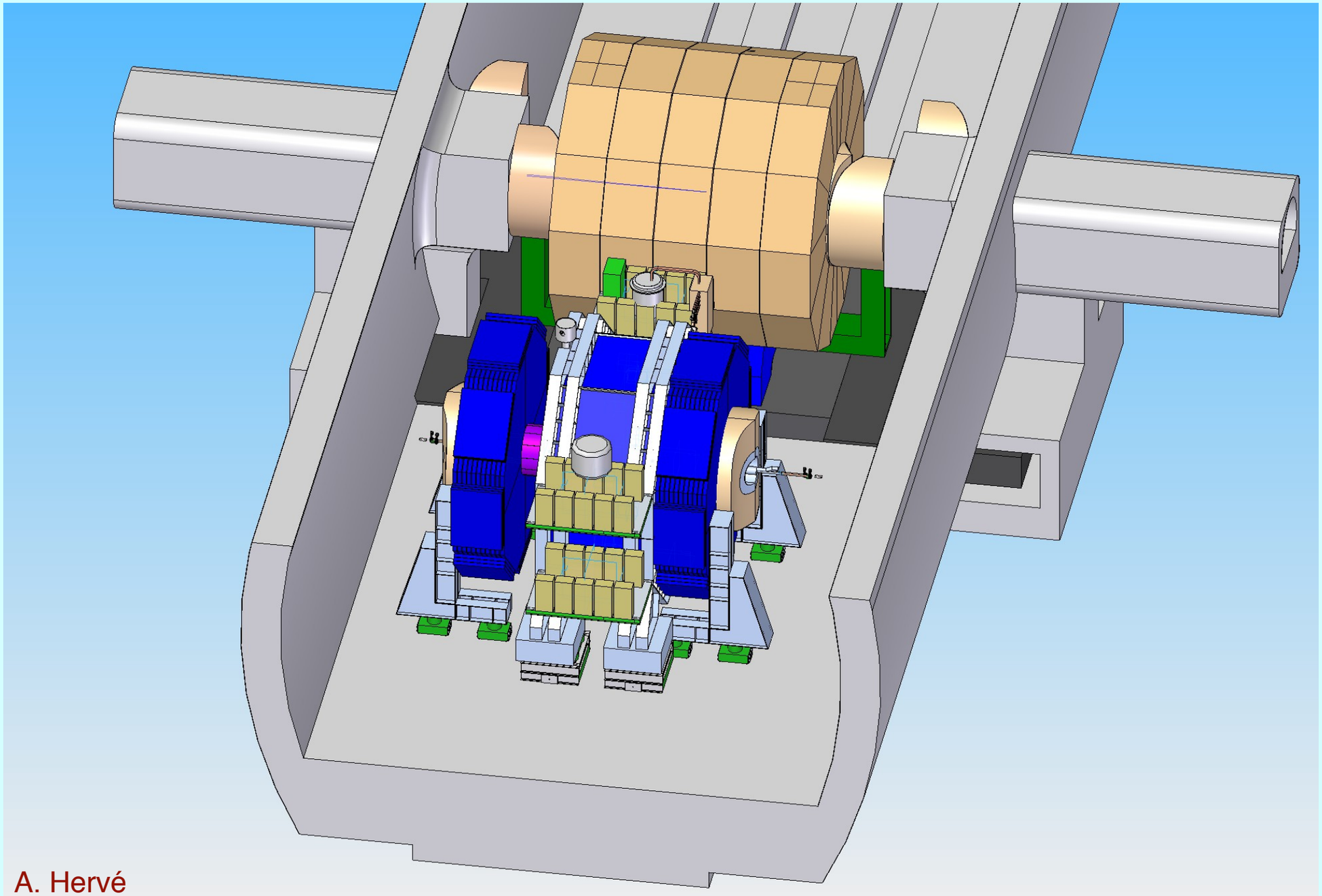
- Impressive progress in a relative short time!

Possible Common Pacman Design



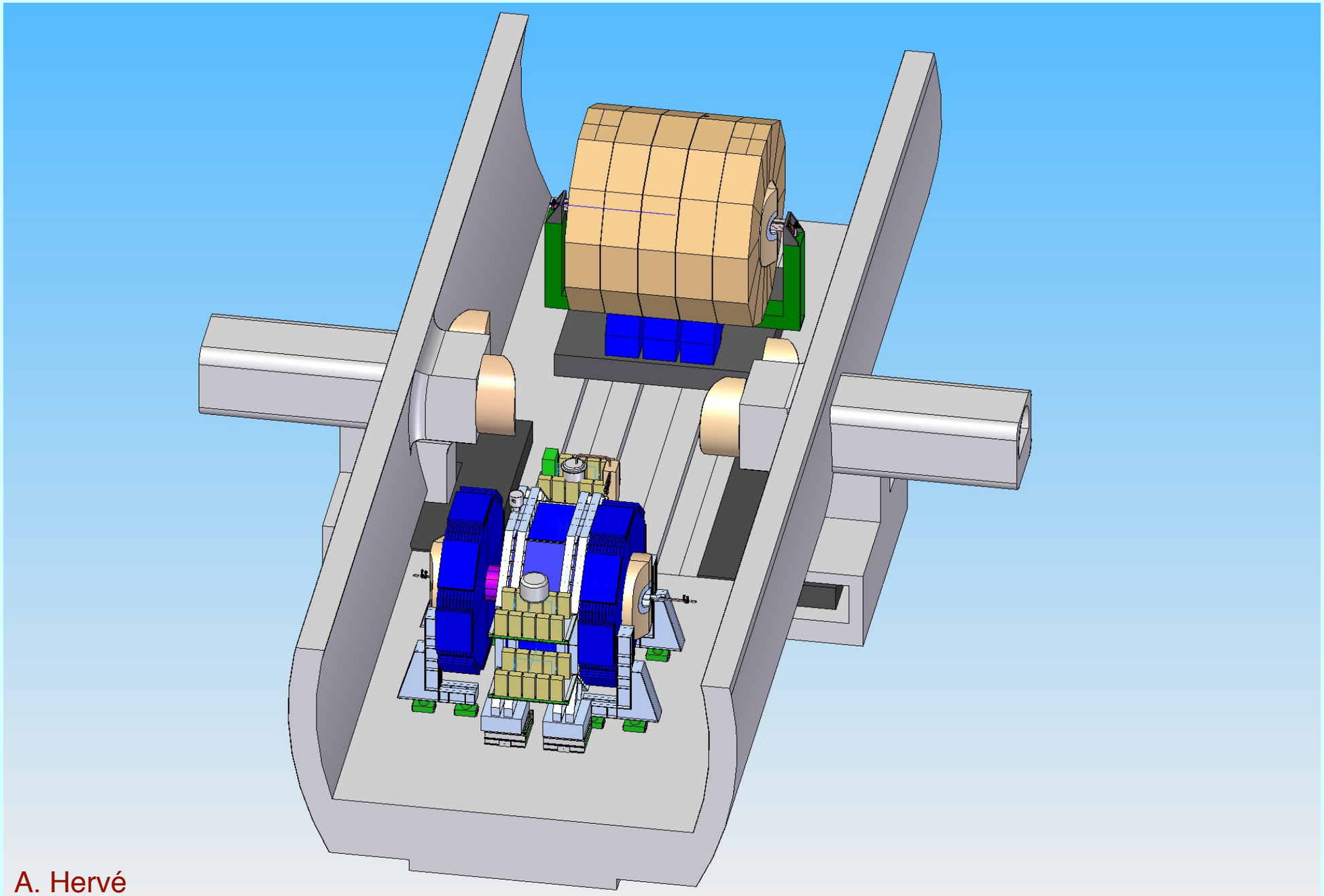
A. Hervé

Common Hall Design Study



A. Hervé

Common Hall Design Study



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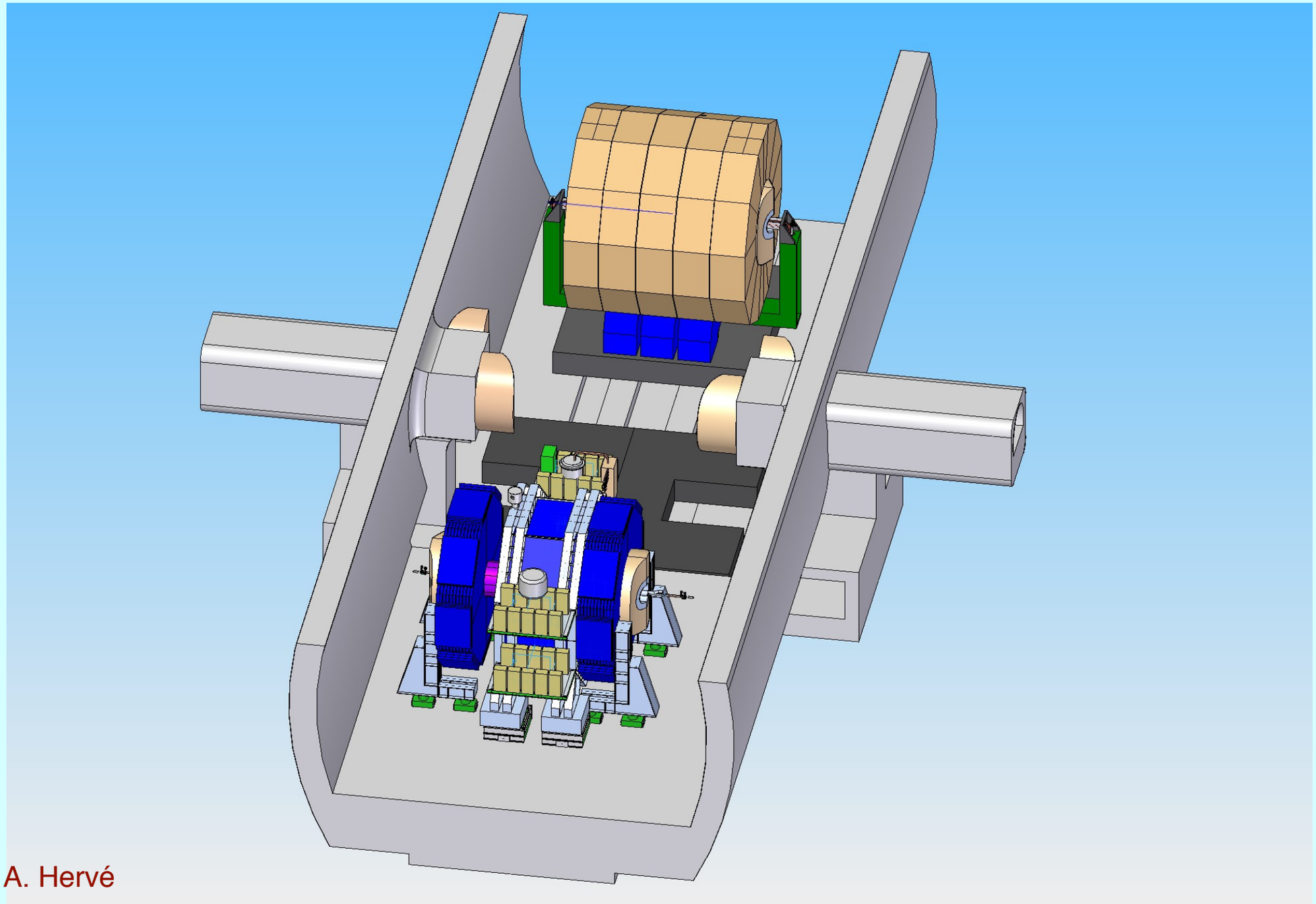
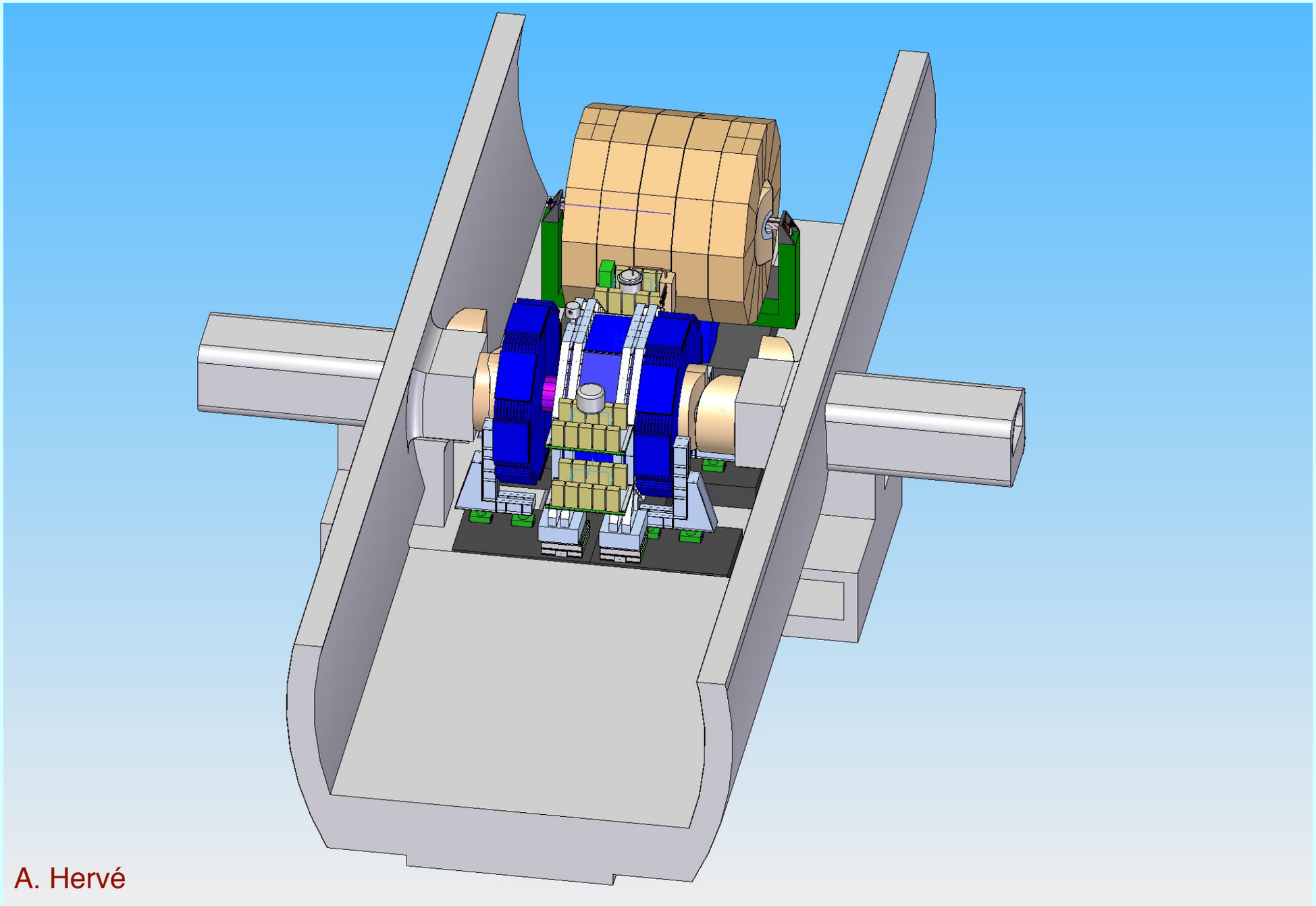
Common Hall Design Study



A. Hervé

Common Hall Design Study



A. Hervé

Platform or Not?

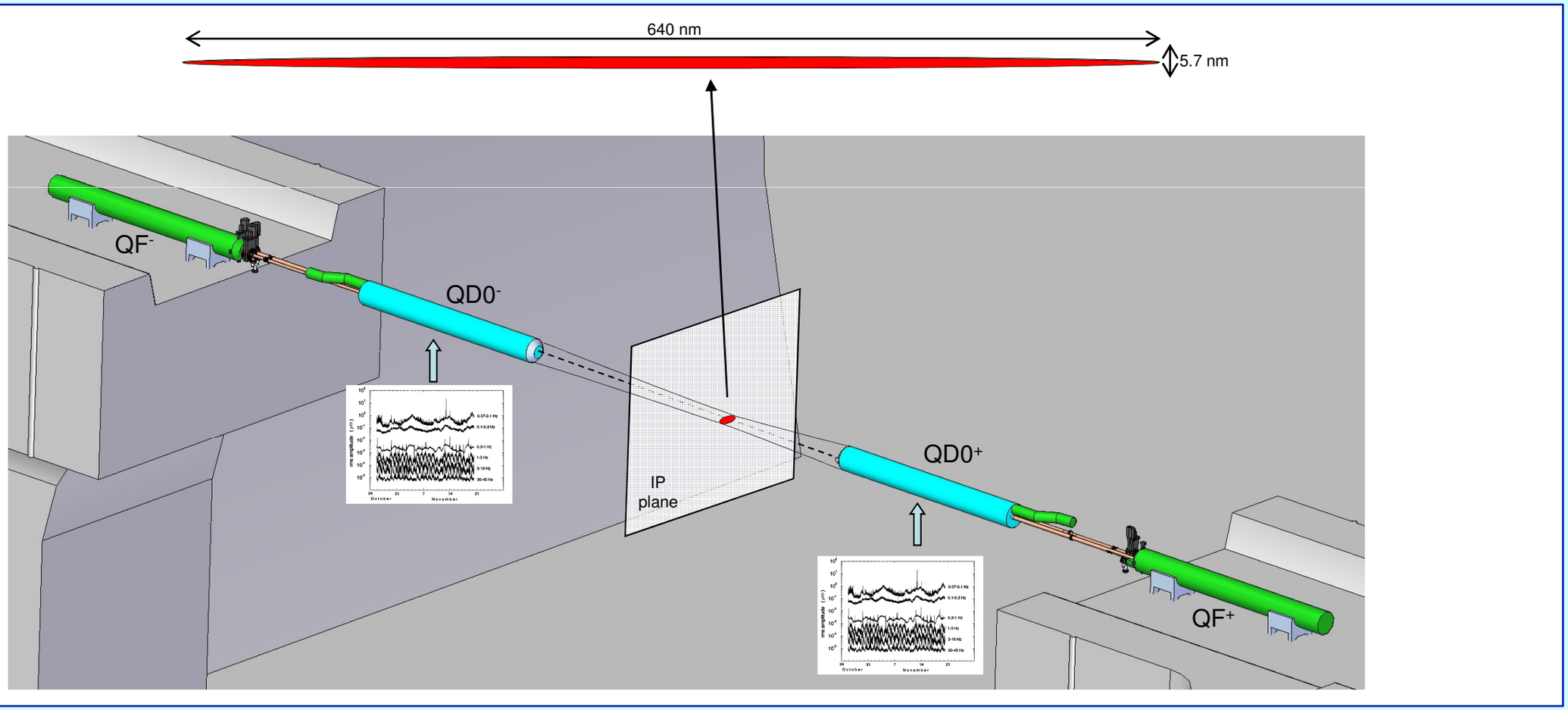
- The conceptual study showed that it could be possible to combine the SiD and the ILD approach.
  - Problems:
    - complicated
    - higher risk for loosing measuring time and integrated luminosity
    - the SiD support on the beam is very similar to a platform
- It would be best if a simple common solution could be agreed upon:
  - Both experiments on platforms
  - No experiment on a platform

- Main arguments:
  - Pro Platform:
    - Detector solenoid is sensitive to vibrations during movements
    - Alignment is easier
  - Contra Platform:
    - Platform could be an additional source of vibrations
    - Platform is heavy and makes alignment more problematic

Vibration Issues

IDAG Report:

- The RDR (and MDI document) assumes a bunch-by- bunch feedback system that compensates for such quad (and other) motions. It is a quantitative question which none of the LoIs have yet addressed in detail whether the quads can be well enough isolated from vibration sources to keep the beams within capture range of this feedback.



M. Oriunno

ILD/SiD/BDS Joint Work Plan

From the ILD/SiD/BDS joint summary of summer work at SLAC:

„Subsequent discussions resulted in the conclusion that further progress on design choices for the detector supports and motion systems could only be made after a quantitative vibration and stability analysis of the combined detector/support/motion system was developed, focused in particular on the effect of ground and local vibration sources on the stability of the final doublet. In connection with this analysis a cross-regional experimental program was proposed and various analytic tools discussed.“

ILC Feedback Systems

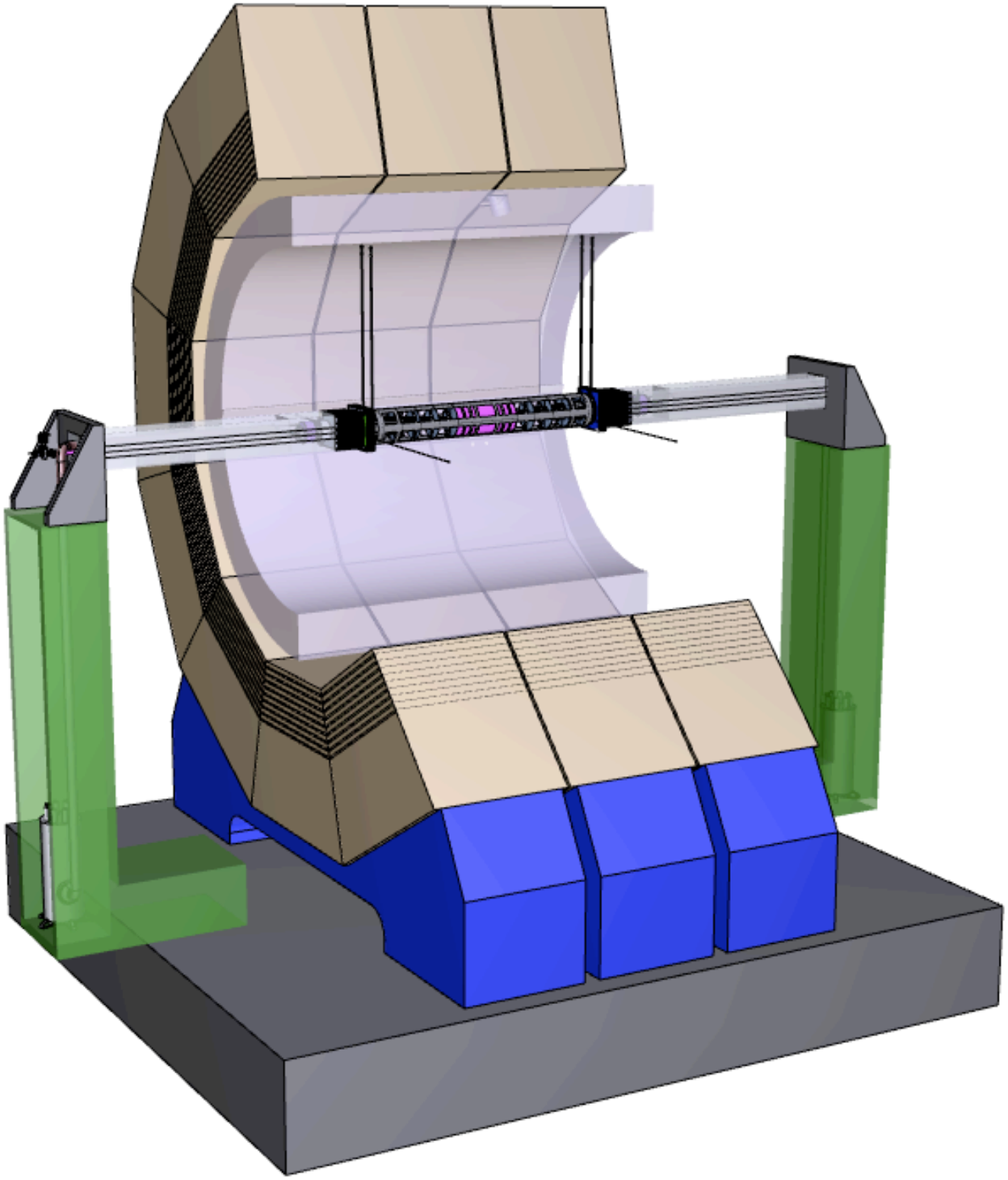
- Two Luminosity Feedback systems are implemented in ILC :
  - At 5 Hz to control the orbit in the BDS (low frequency)
  - An intra-train system to address ground motion and mechanical disturbances (high frequency~1000 Hz)

- The mechanical stability requirements of the QD0 are set by the capture range of the IP fast feedback, as written in the “Functional Requirements” document:

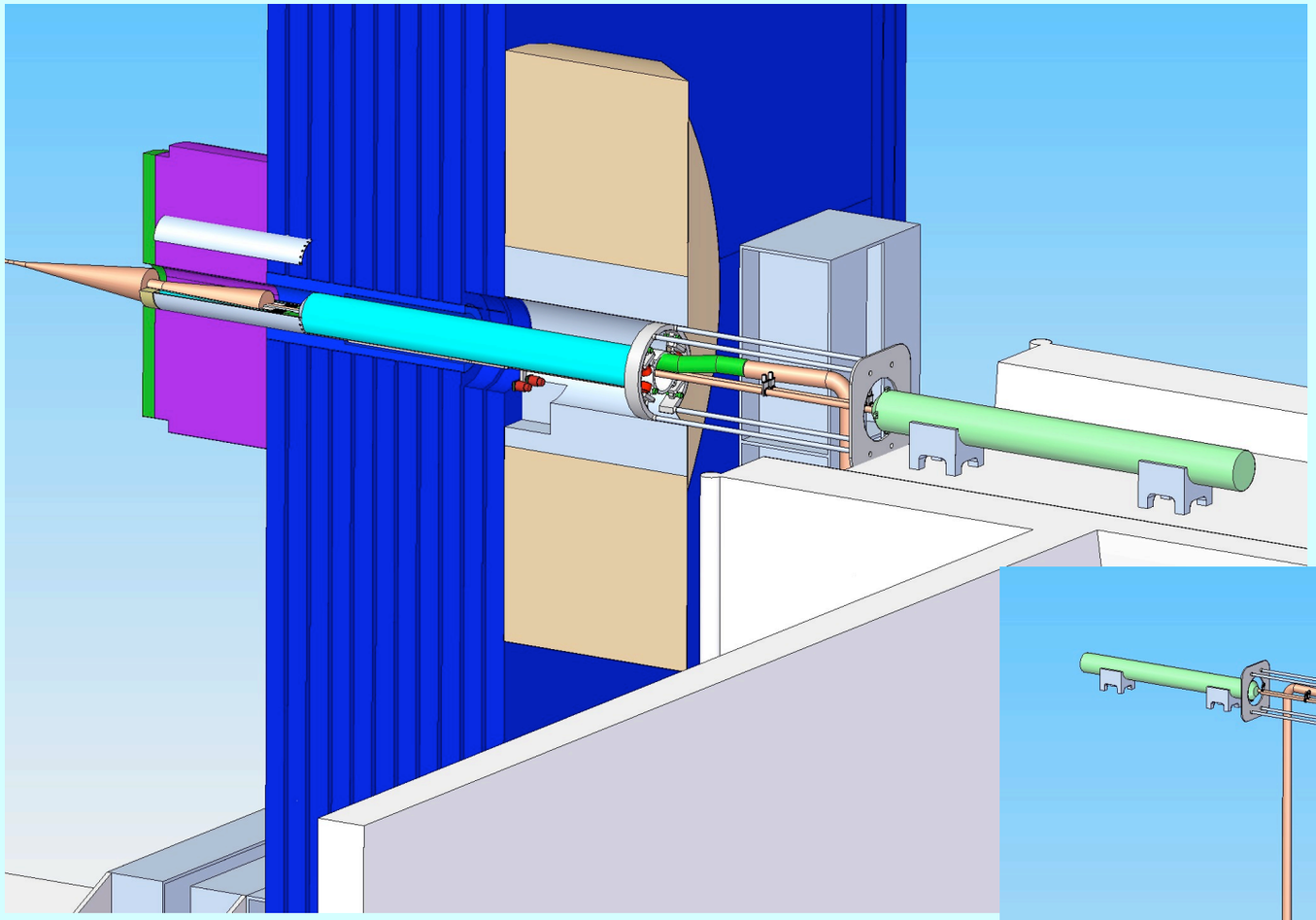
- QD0 vibration stability: $\Delta(QD0(e+)-QD0(e-)) < 50$ nm within 1ms long bunch train

QD0 Support in ILD

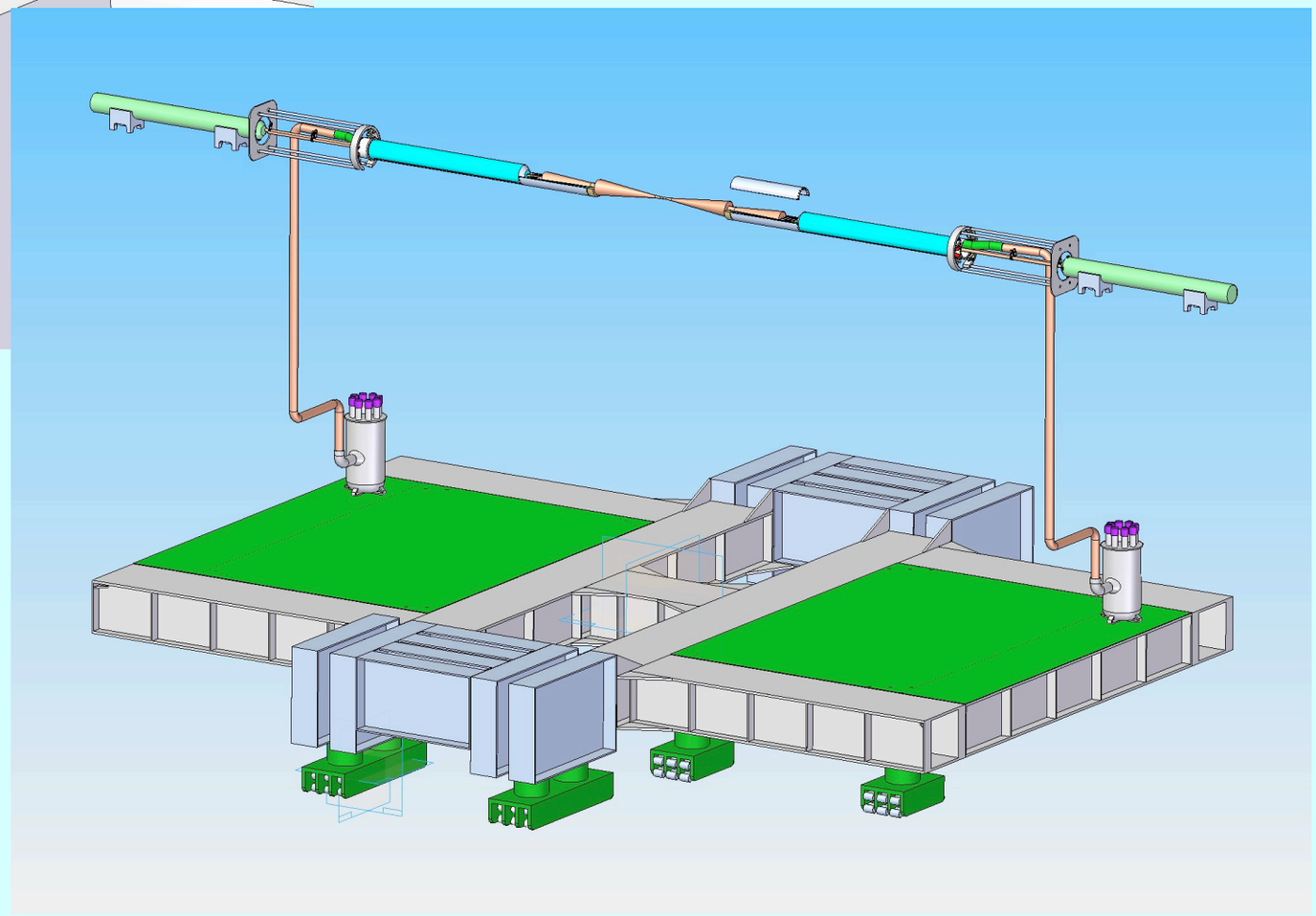
- QD0 supported from pillar and suspended from solenoid cryostat



QD0 Support in SiD

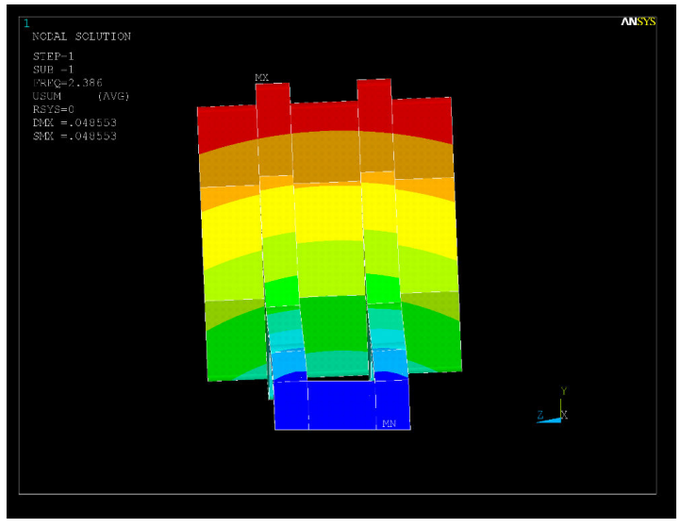


- QD0 supported from wall and endcap door

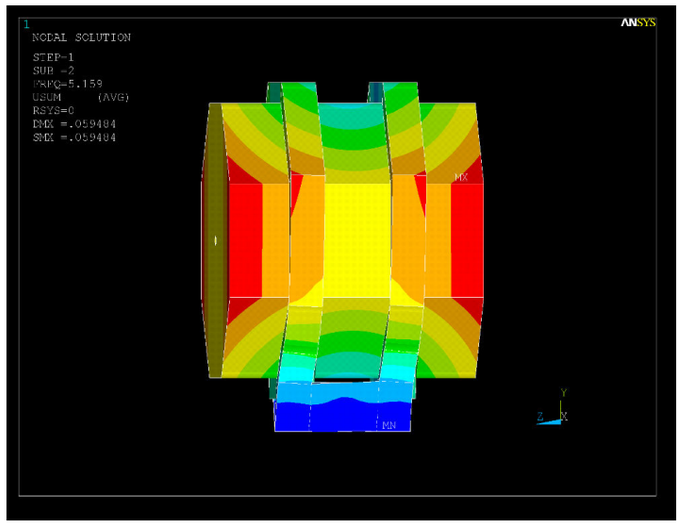


SiD Vibrations

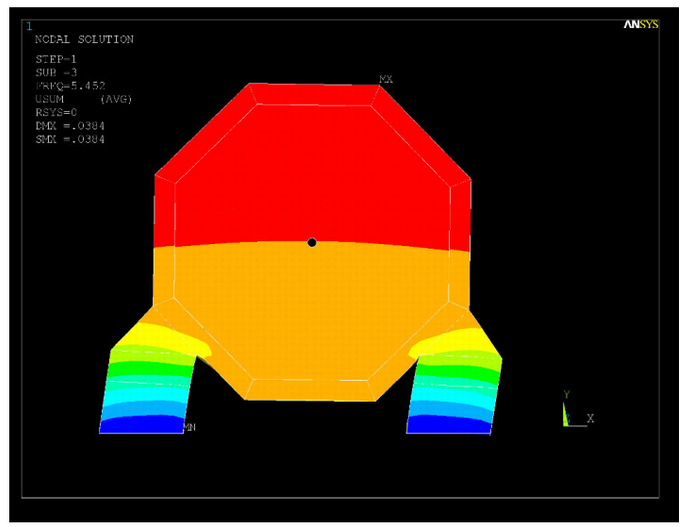
Free Vibration Mode



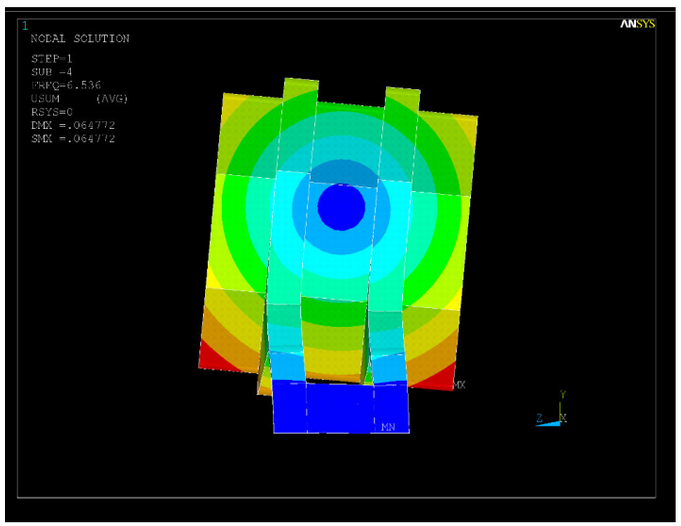
1st Mode, 2.38 Hz



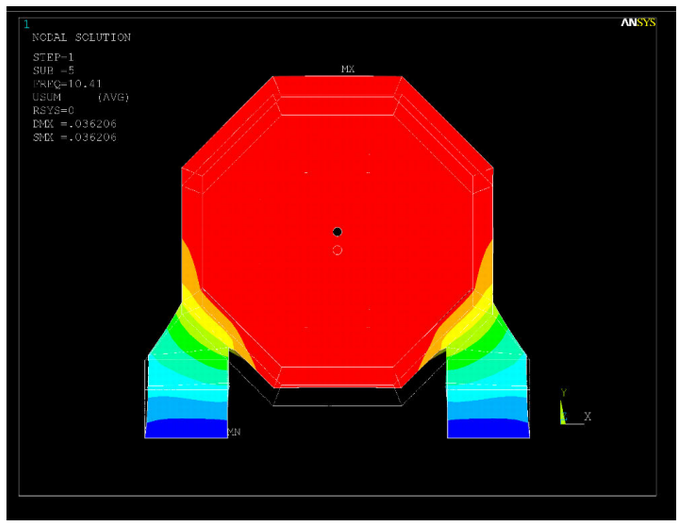
2nd Mode, 5.15 Hz



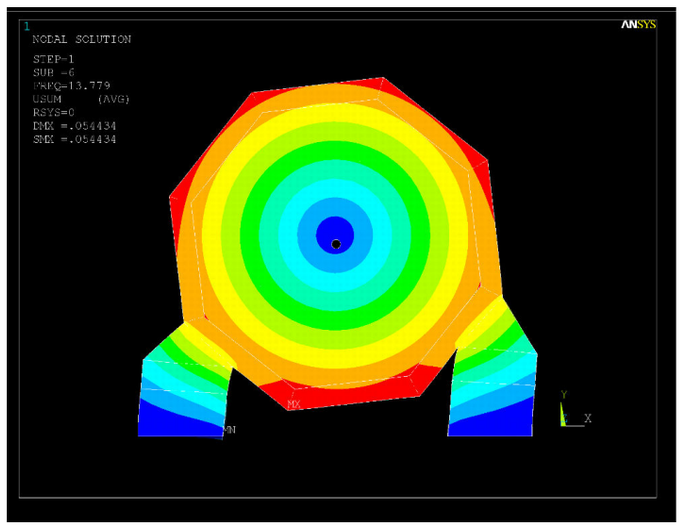
3rd Mode, 5.45 Hz



4th Mode, 6.53 Hz



5th Mode, 10.42 Hz



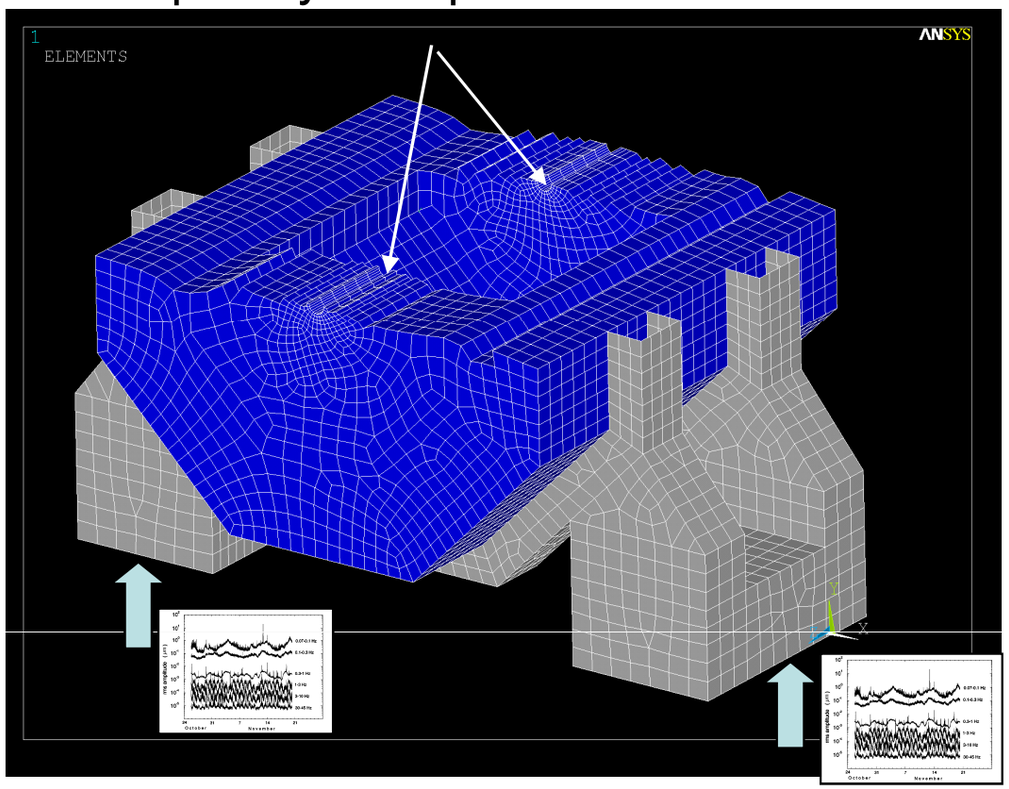
6th Mode, 13.7 Hz

Vertical motion

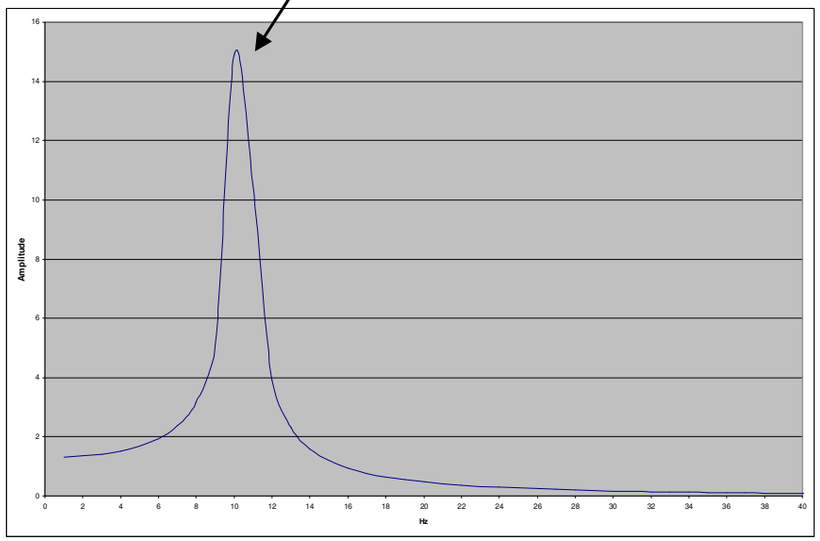
M. Oriunno

Sid Vibration Analysis

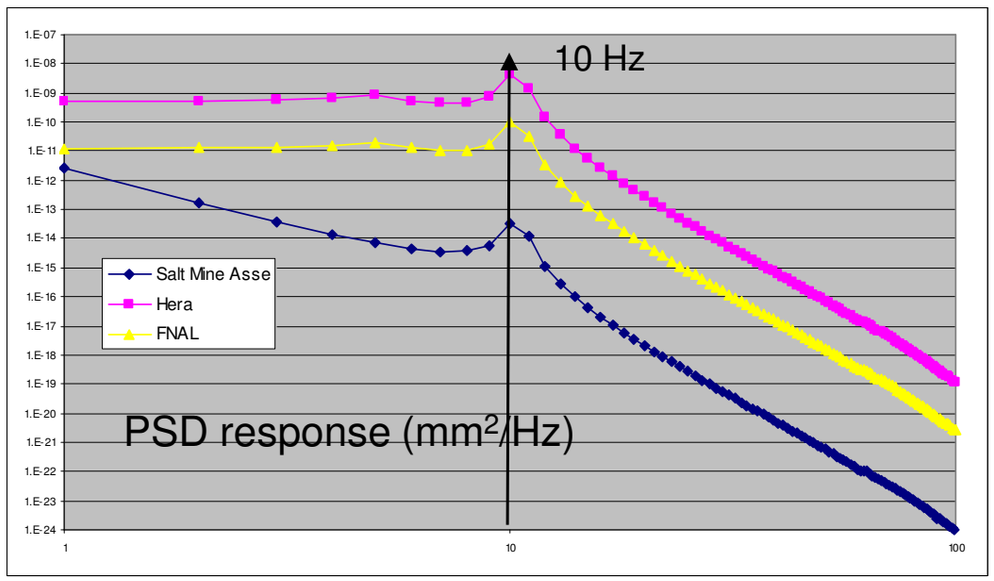
Frequency Response Function

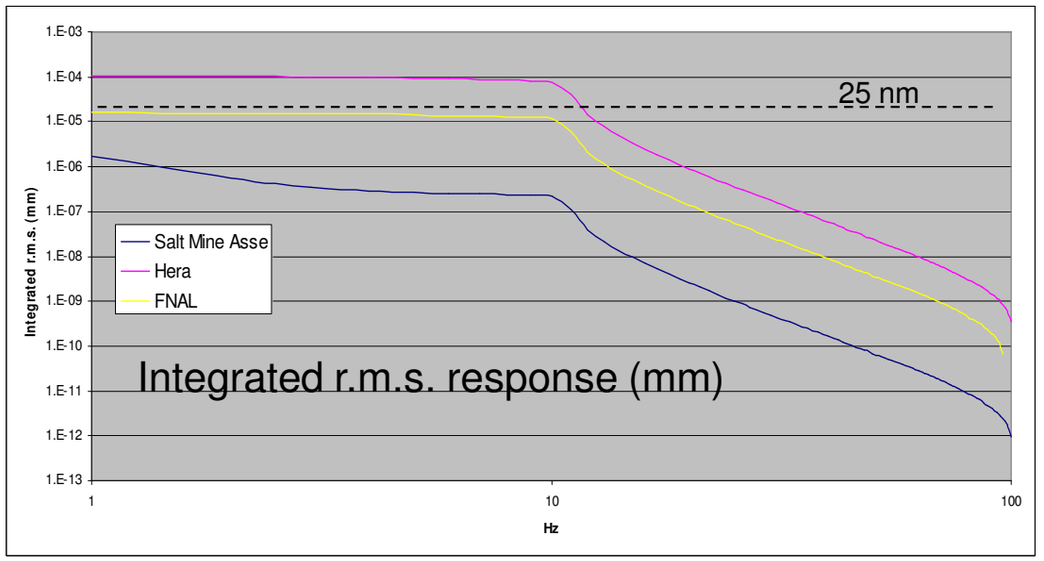


Resonance at 10 Hz (5th mode)



To mitigate the r.m.s. response, the resonance mode must be as high as possible





M. Oriunno

SiD Resonance Mitigation Studies

The vertical mode of resonance depends on the elasticity of the feet

To increase the resonance frequency one can :

Reduce the detector mass ->less iron->more stray field

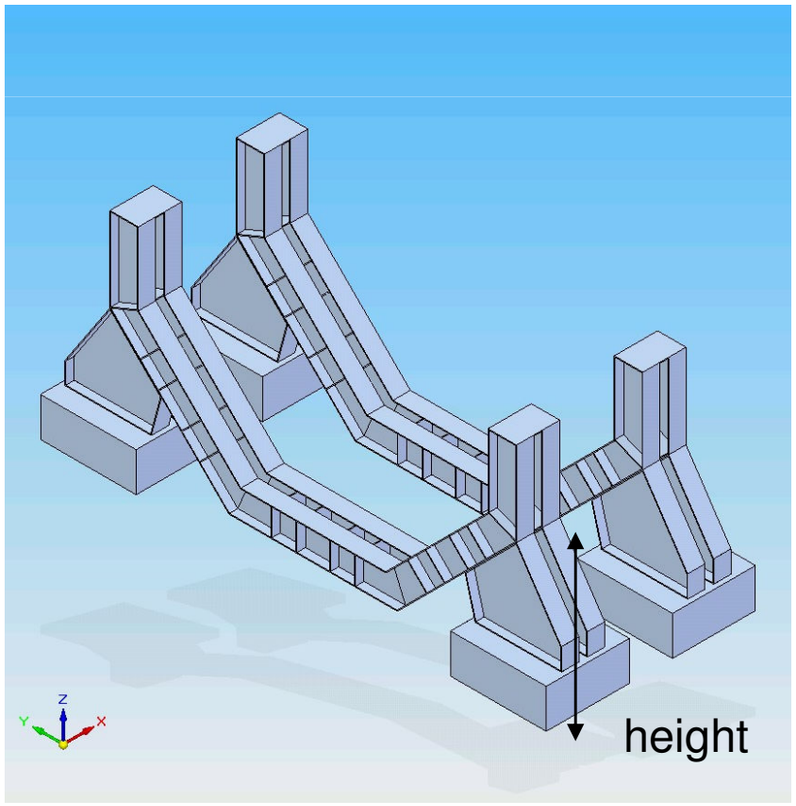
Select a more rigid material -> SSteel ~210GPa

⇒ Lower the height the foot -> lower the center of gravity ~ factor 2

⇒ Increase the cross section area f the foot -> thicker plate ~ factor 2

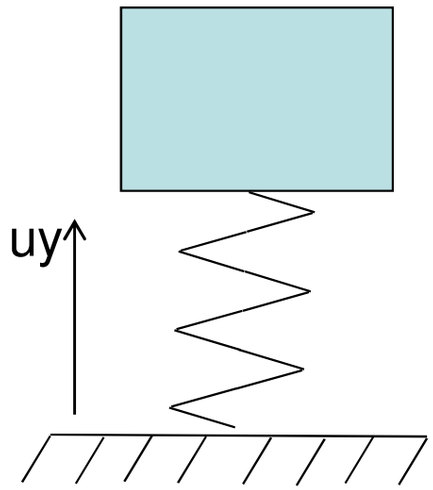
⇒ Additional supports to reduce the specific mass per foot ~ factor 2

~ factor 6- 8, i.e. fo*sqrt(8) ~ 28 Hz



M = ¼ of SiD mass

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$



$$k = \frac{YoungMod \cdot Area}{height}$$

M=2500 tons

E=210 GPa

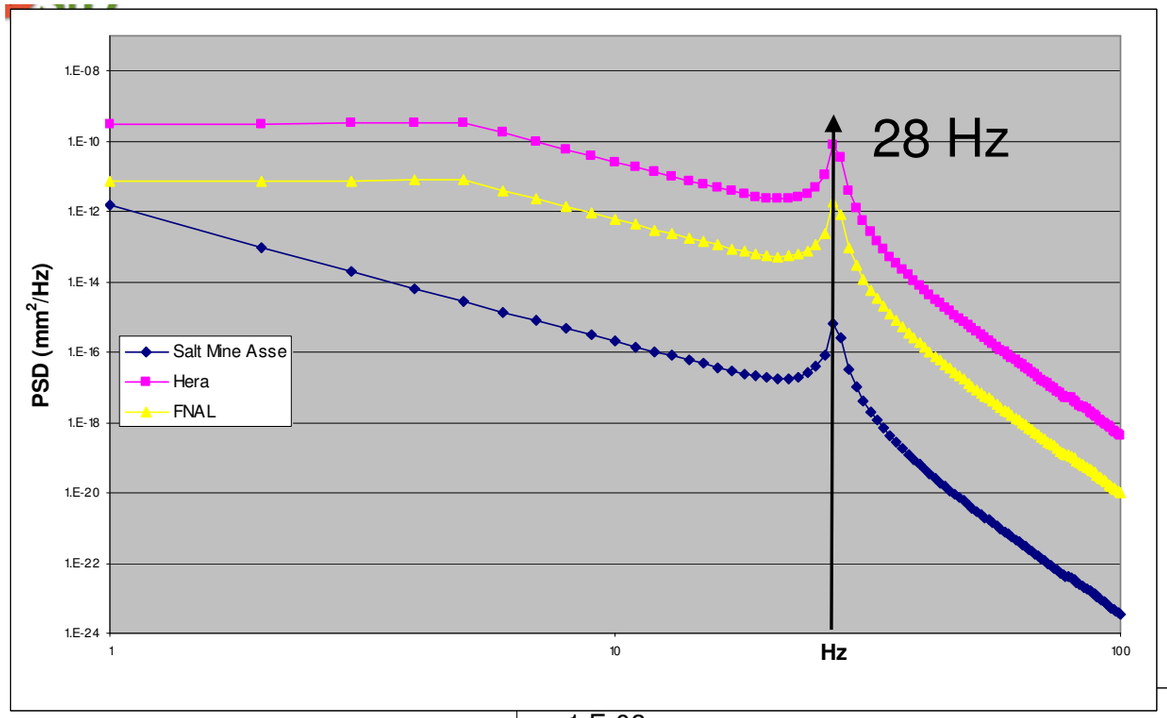
Height =3 m

Plate thickness =30 mm

f = 10 Hz

M. Oriunno

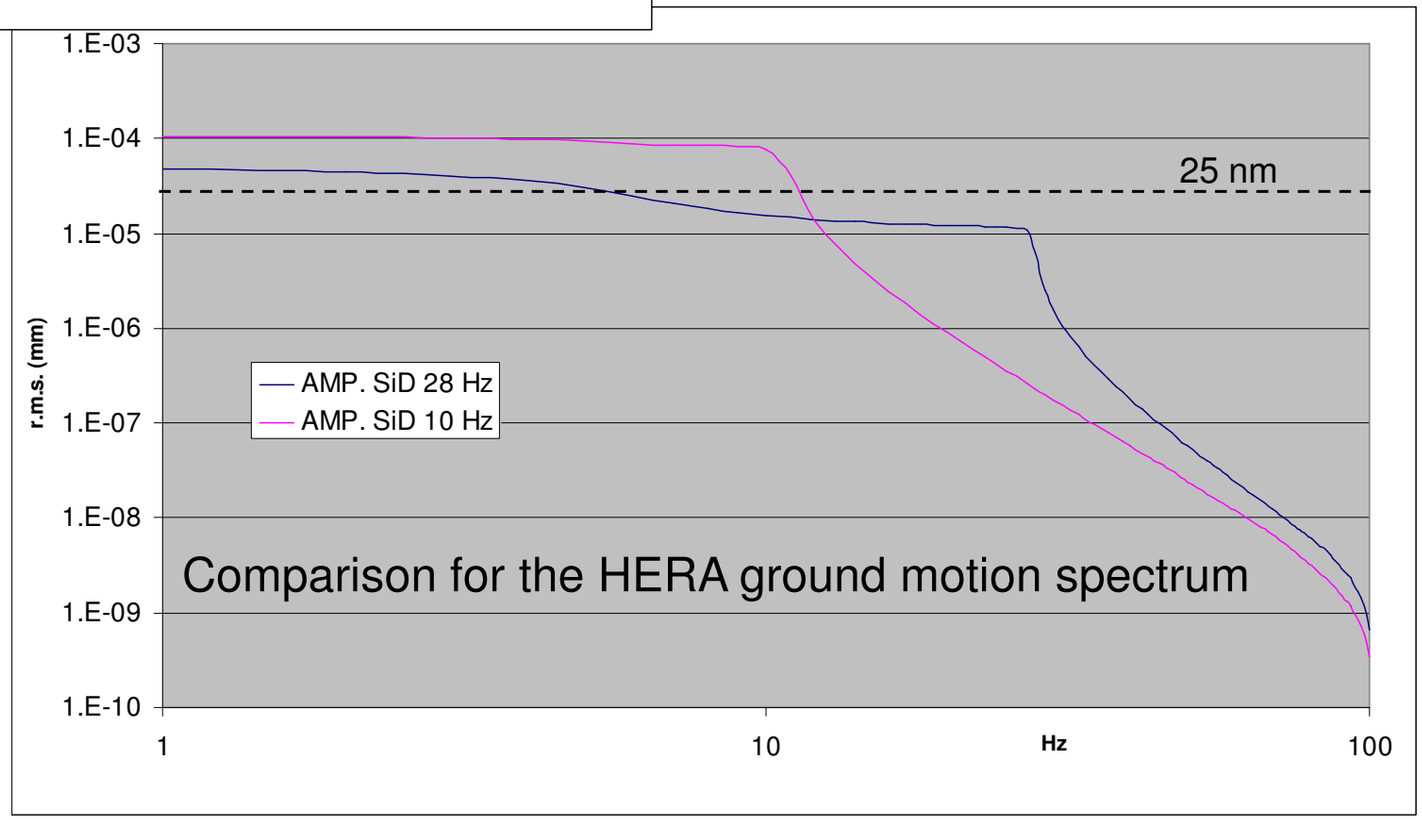
SiD Resonance Mitigation



Shift of the resonance mode from 10 to 28 Hz

~ factor 2 on the r.m.s. amplitude at low freq.

~ wider range at higher freq.



M. Oriunno

ILD: QD0 Support Vibration Analysis

Calculation results: *Vertical direction*

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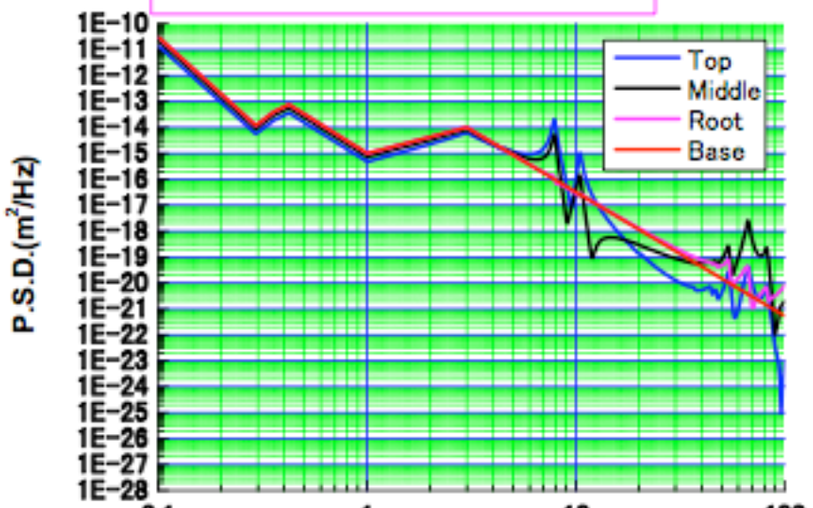
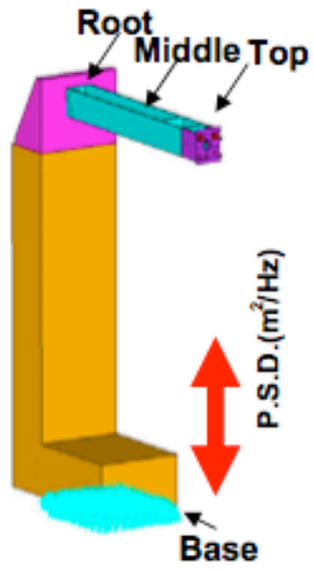
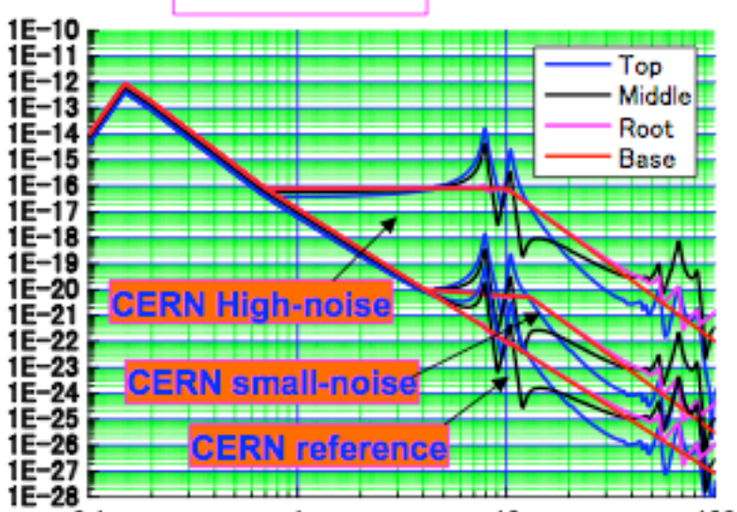
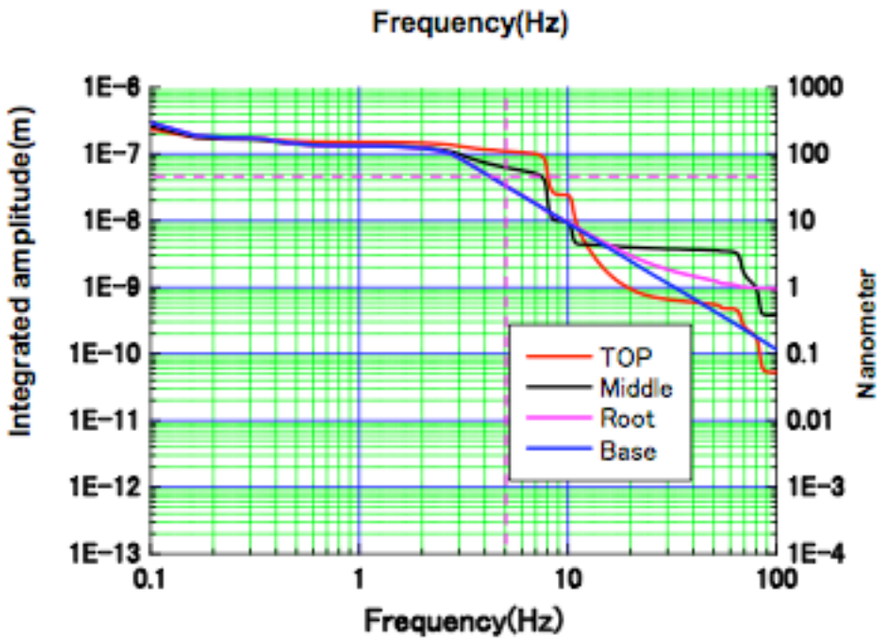
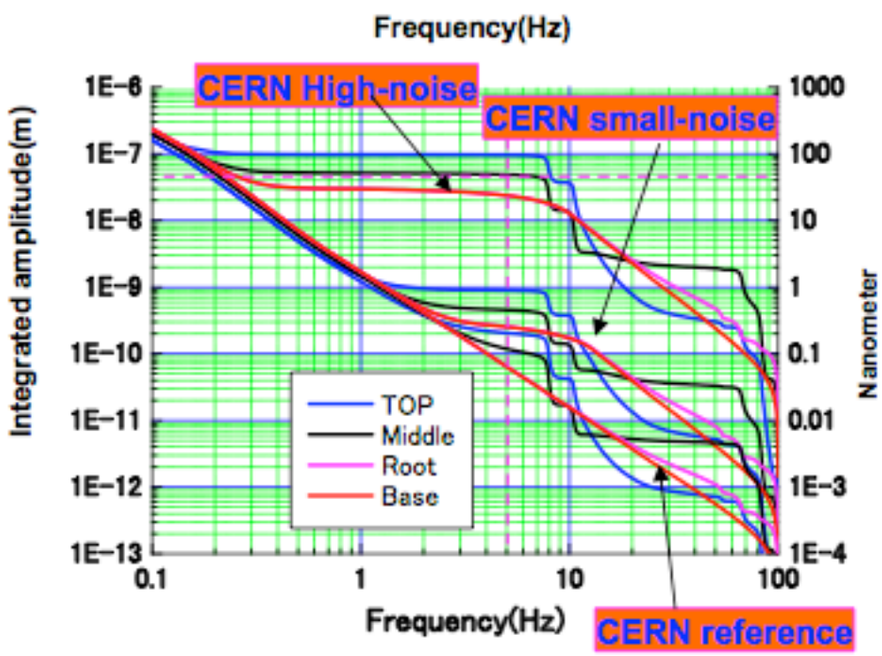




CERN-Data







➔ **Integrated amplitude at 5Hz: Larger than 50nm.(ATF, CERN High)**
Much smaller than 50nm(CERN small, Reference)

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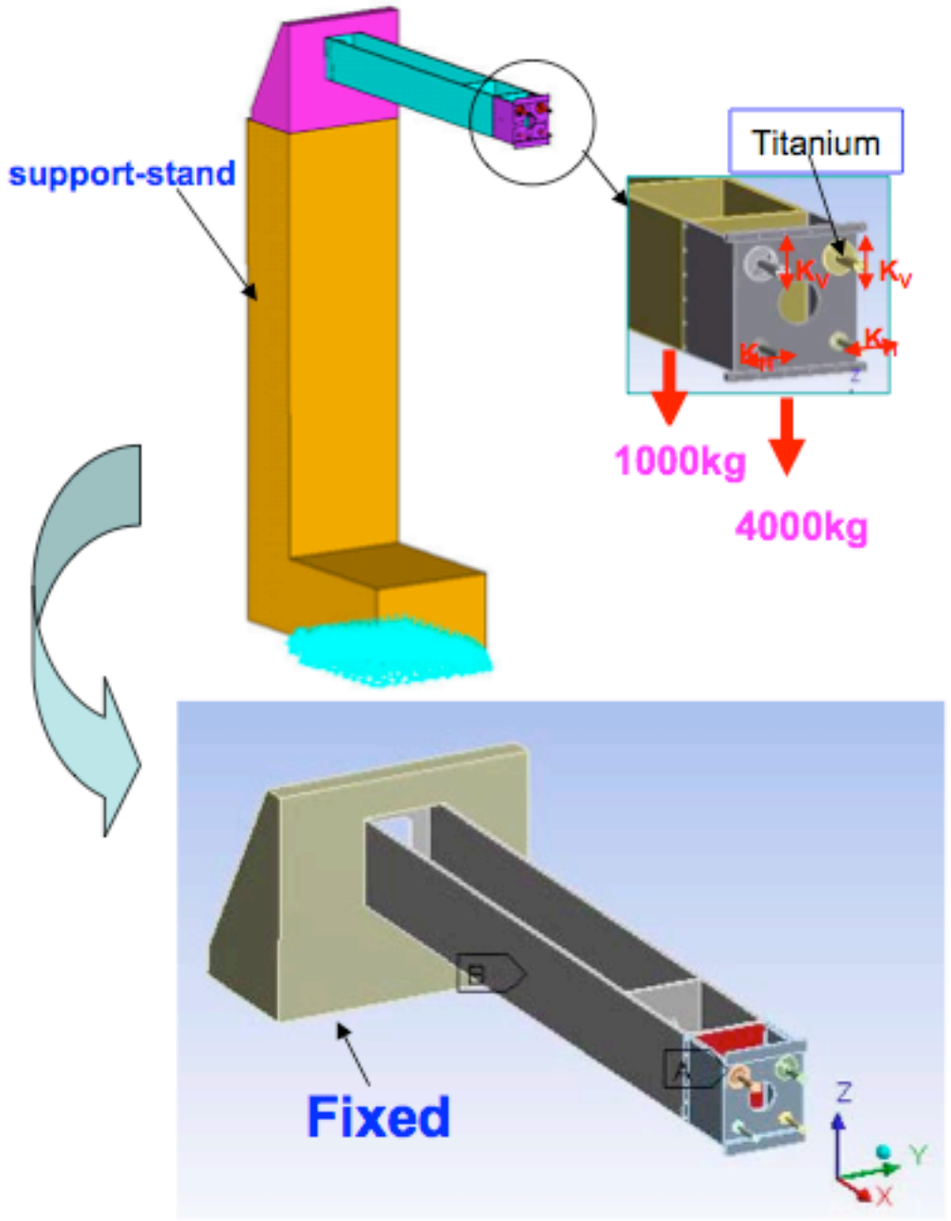
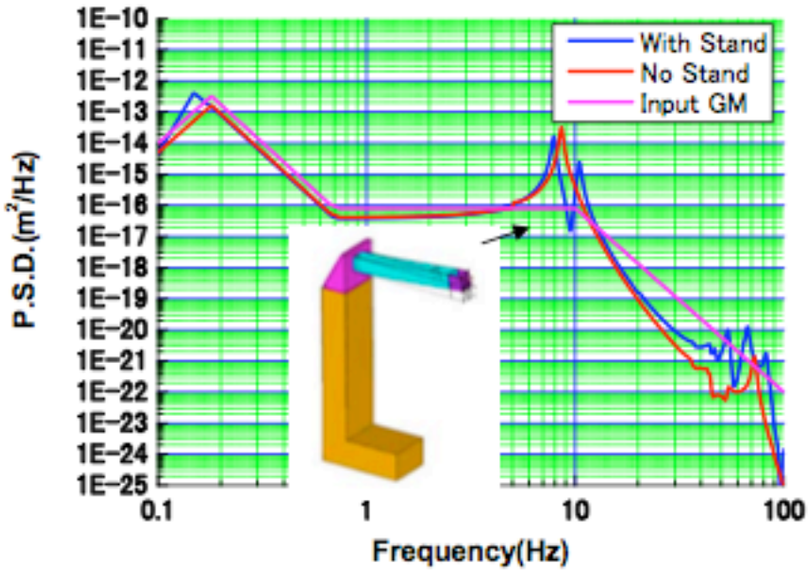
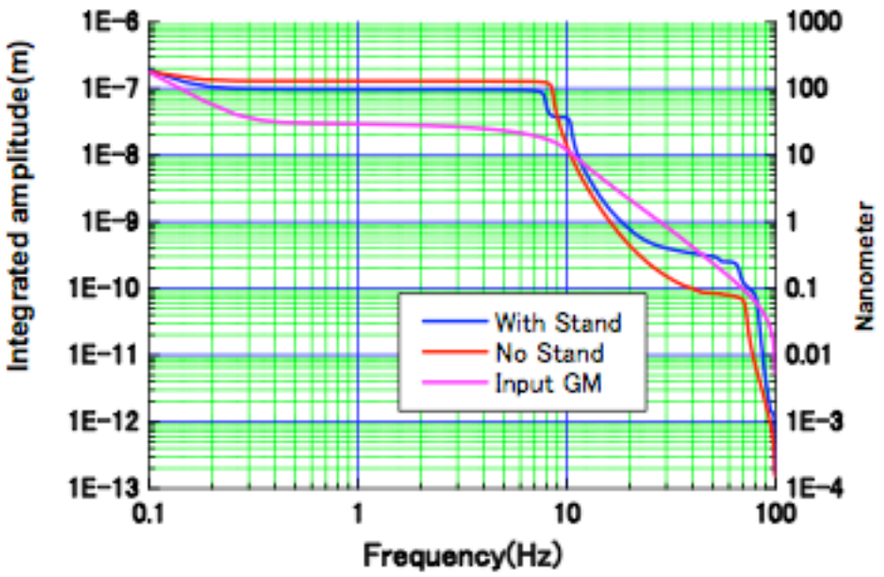
H. Yamaoka

ILD: QD0 Support Study

If the support-stand was removed,







➔ **Integrated amplitude at 5Hz: It is not so different.**
Integrated amplitude at above 10Hz: 'No-support-stand model' is smaller.

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H. Yamaoka

Coherency measurement at KEKB-tunnel

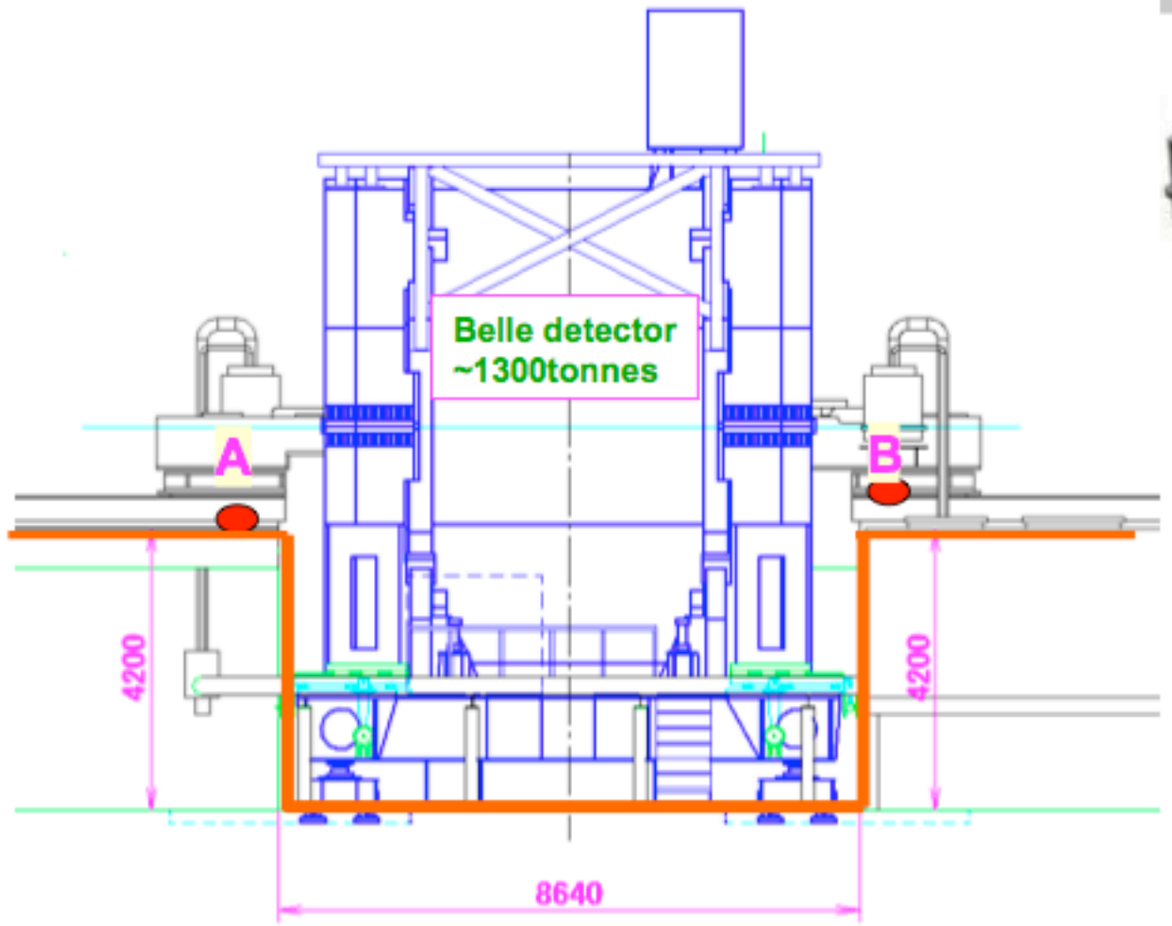
Measurement: A

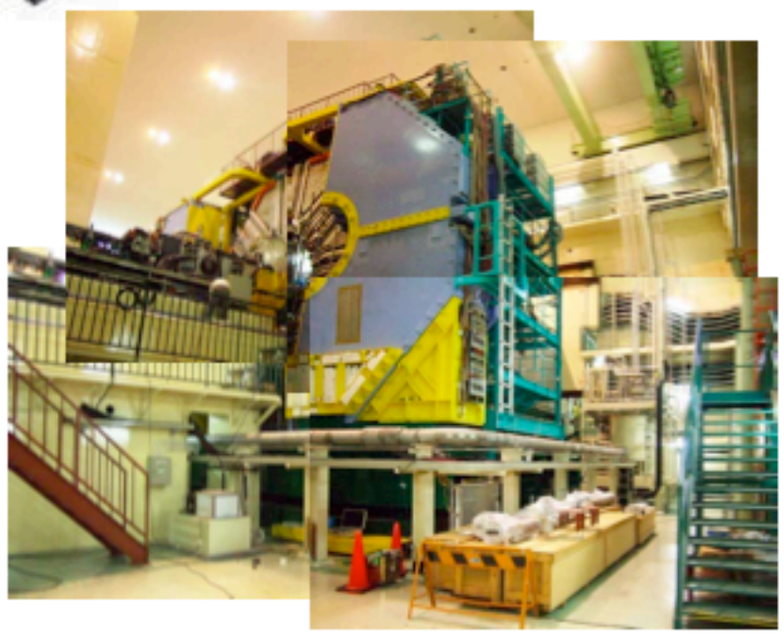
How is the coherency between the position-A and B?

These two points keep coherency??

Servo Accelerometer MG−102	Tokkyokiki Corp.
Size	40×40×50mm
Max. input	±2G
Resolution	1／10^6G

Acc. 0.1～400Hz
Acc. 60dB = 1gal/V





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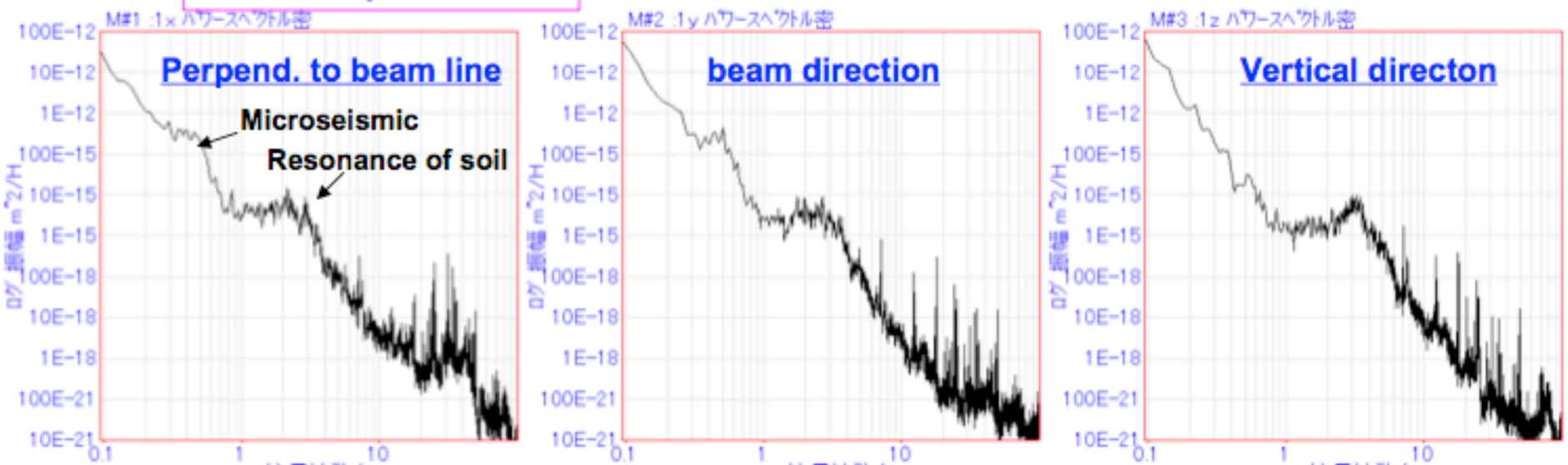
H. Yamaoka

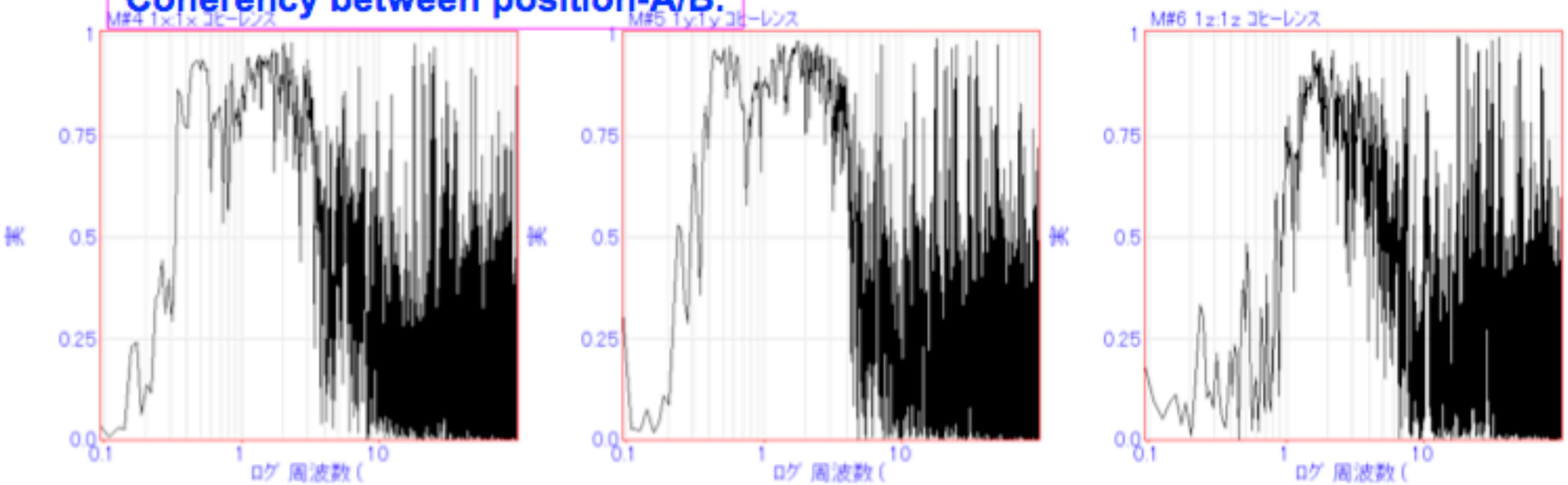
KEK Coherence Study

Results

P.S.D. at position-B.



Coherency between position-A/B.



➔ **It seems that there is no coherency between two positions.**

Except for the frequency of microseismic(0.XHz) and resonance of soil(~3Hz).

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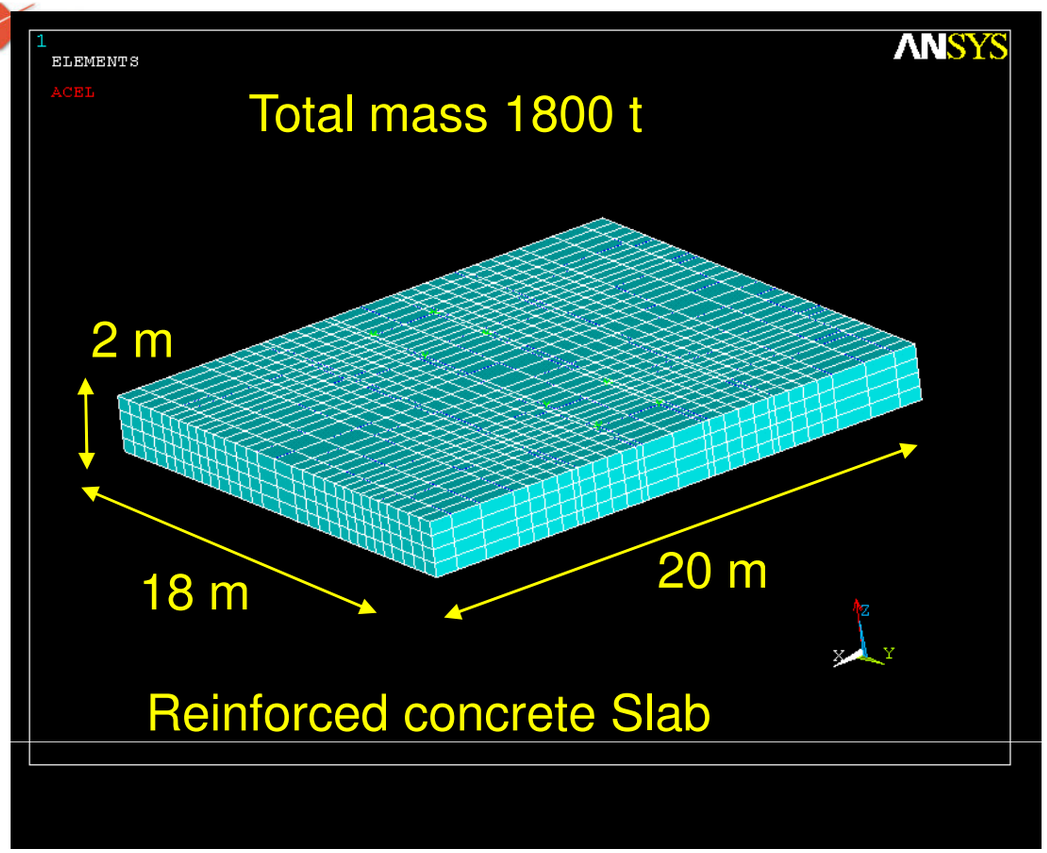
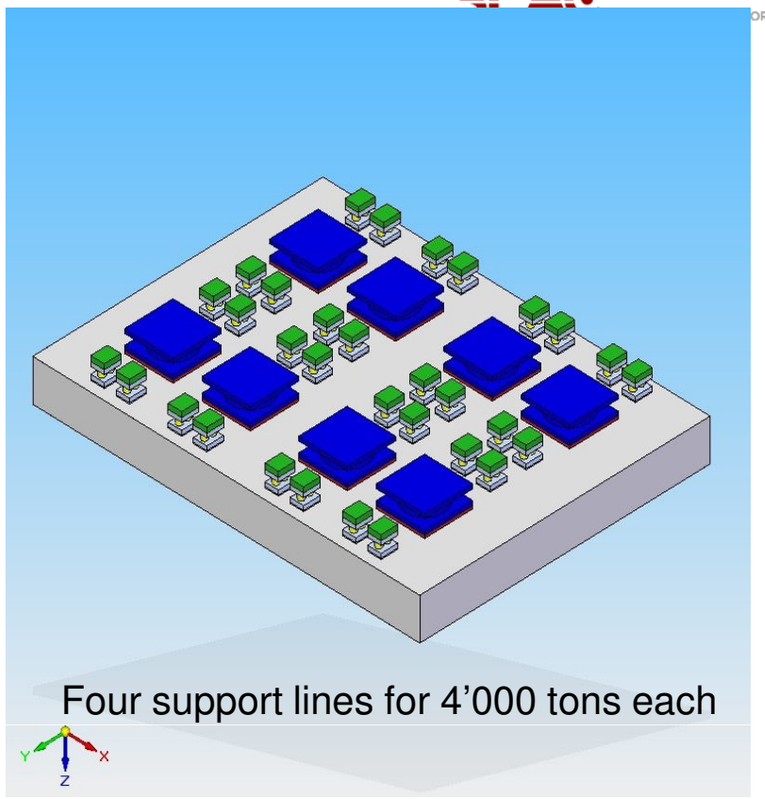
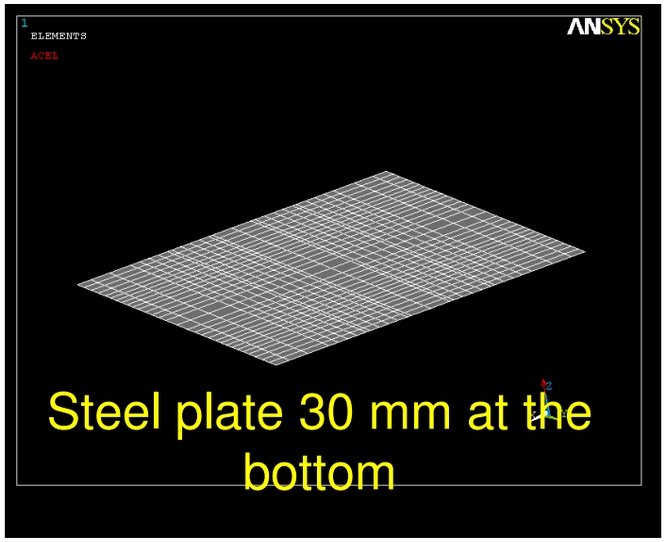
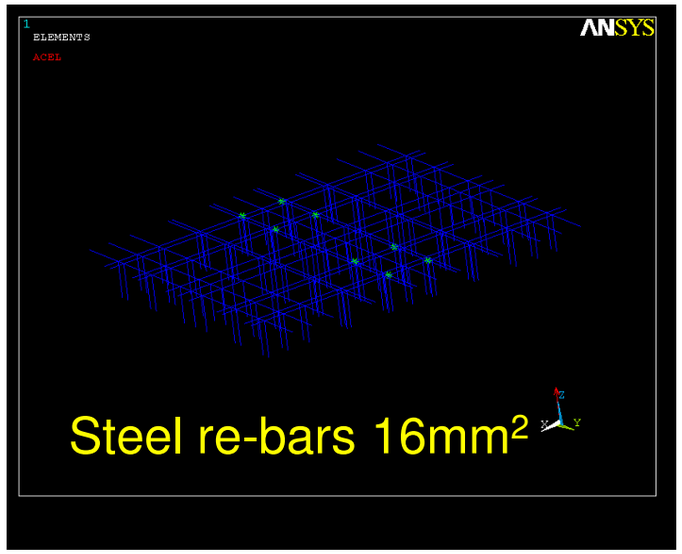
H. Yamaoka

Platform Vibration Analysis





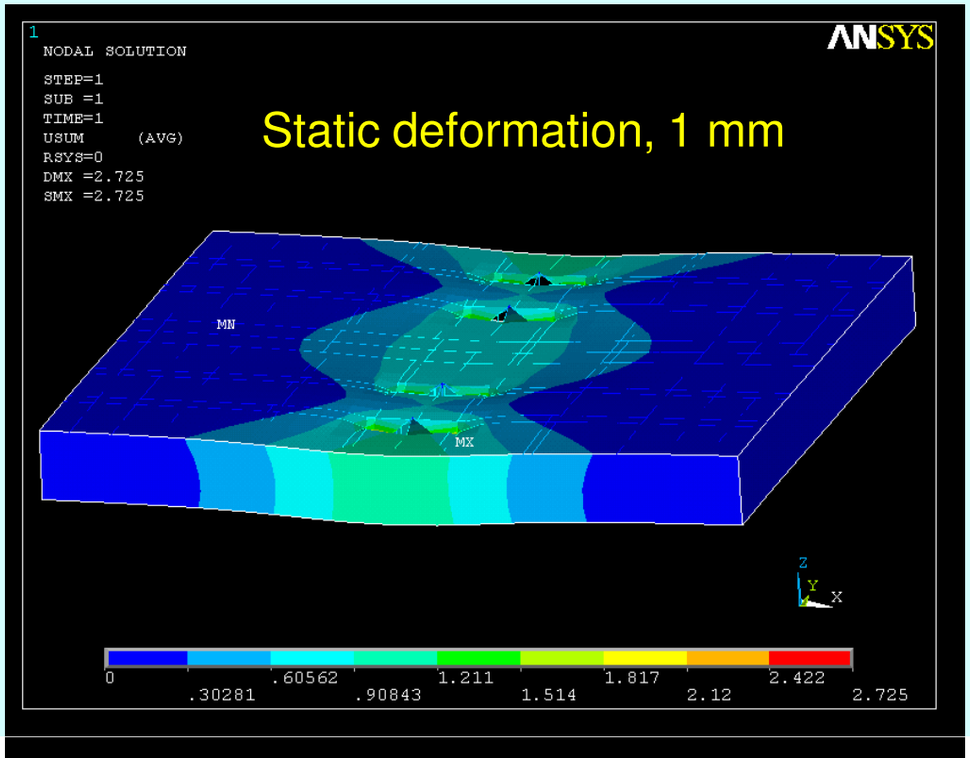


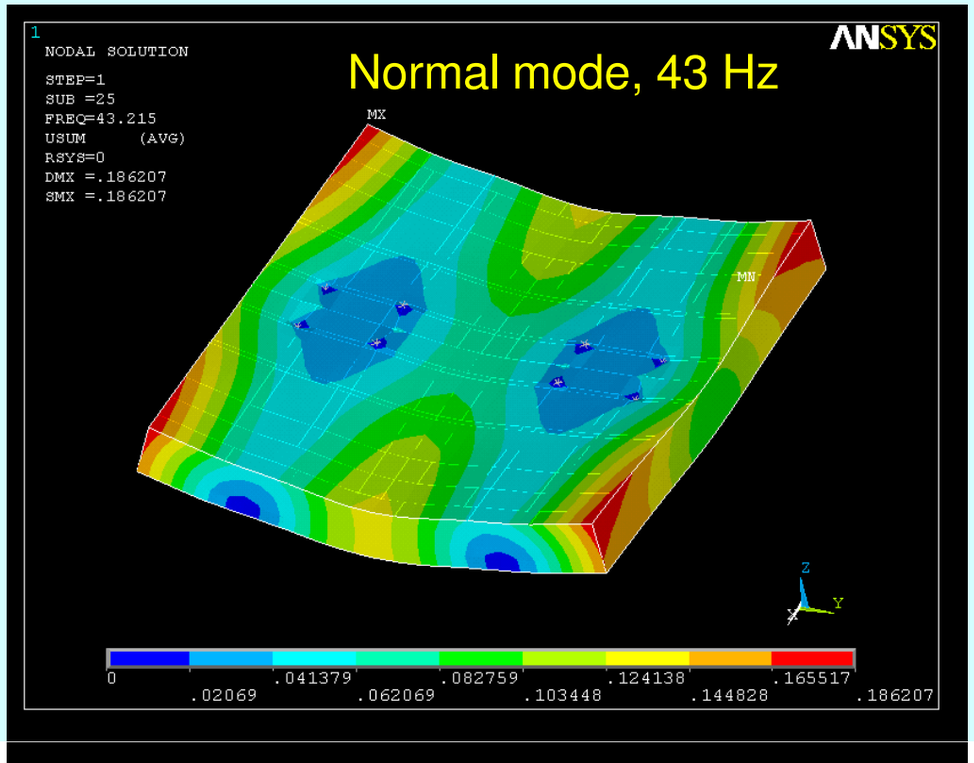


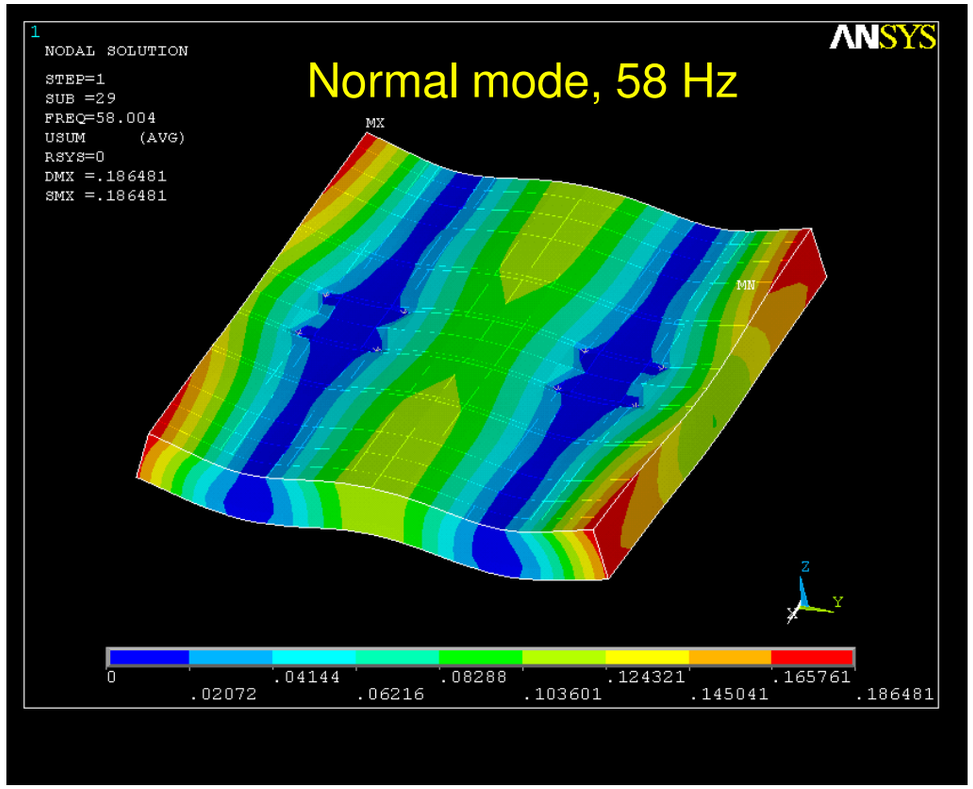
10kt Anti-seismic supports

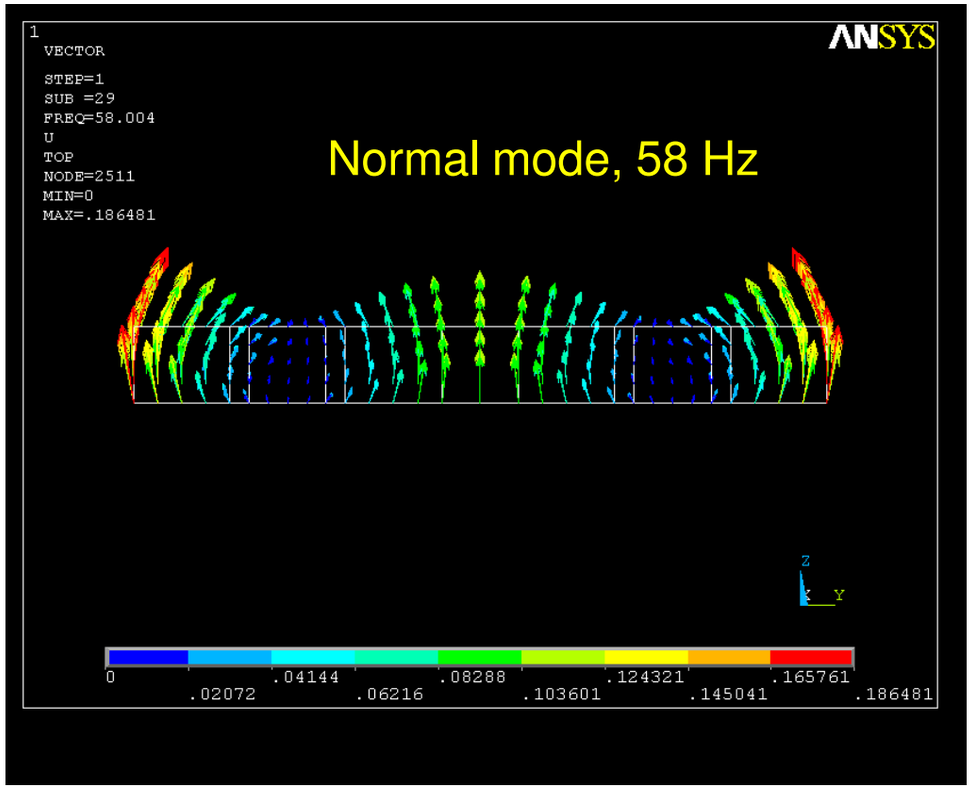
M. Oriunno

Platform Vibration Analysis





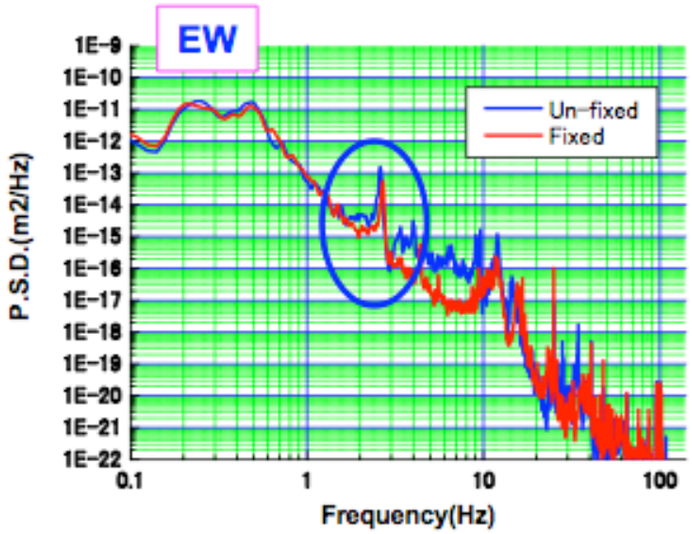


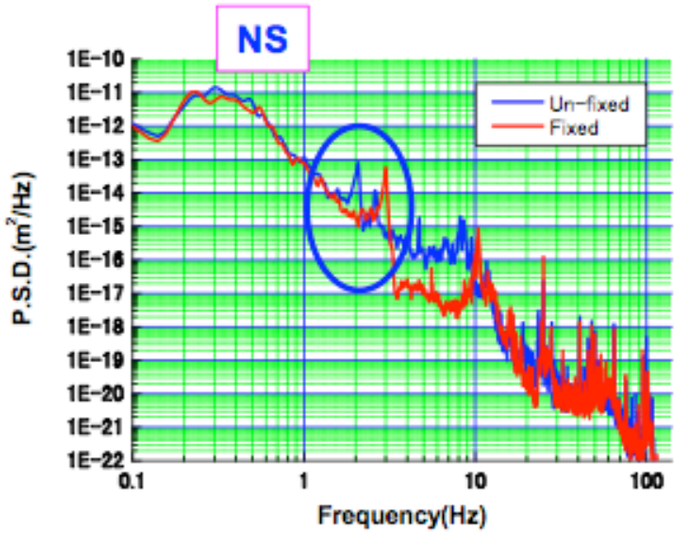


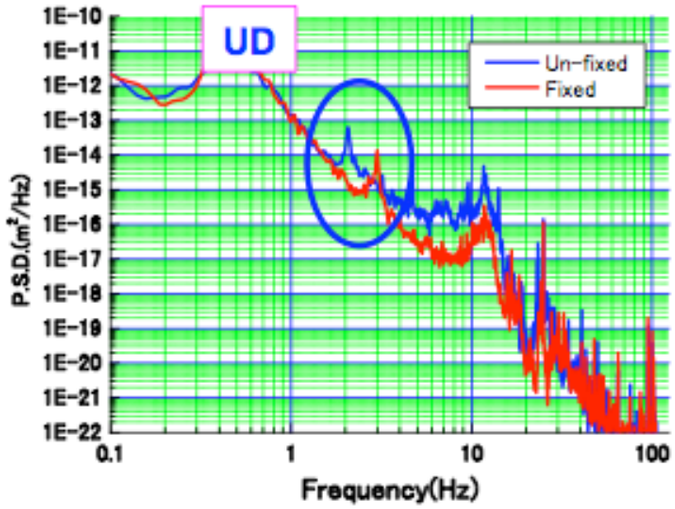
M. Oriunno

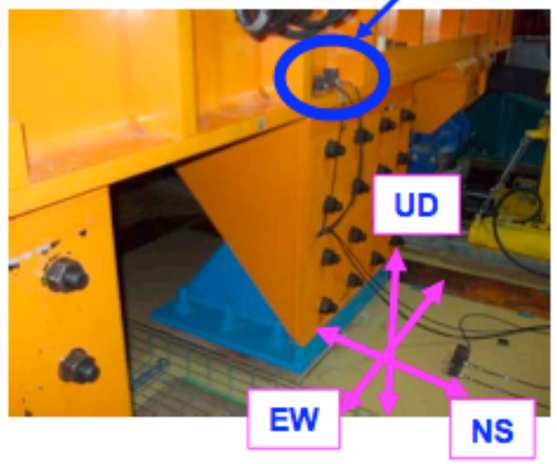
ND280 Measurements

Results









→ - Natural frequency after fixed to the bracket is increased to ~1Hz(NS, UD).
- P.S.D. is reduced because natural frequency is increased.

→ Support stiffness is increased.

→ It is not so big different but it's efficient to use the support-brackets.

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H. Yamaoka

It helps to fix the detector to the floor

CERN Measurements

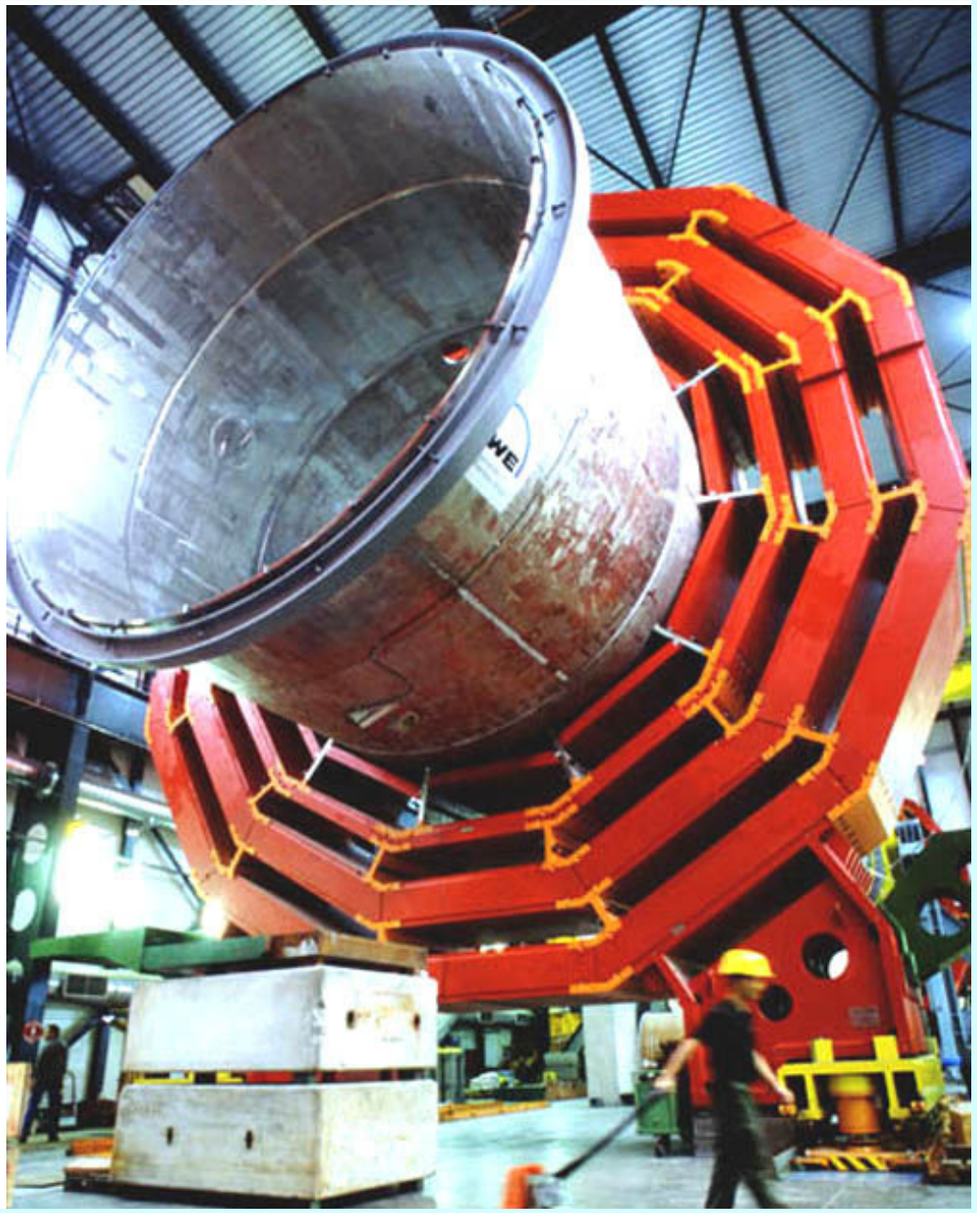
CMS Measurements:

- On top of barrel yoke ring
- On top of endcap ring
- On top of HF tower
- At the extremity of the Rotating Shielding (pacman)
- On and around the plug

- All w.r.t the local ground vibration

- Measurements on the cryostat are also important

- Measurements have been done
- Analysis ongoing, expect results soon



SB2009

- The Strawman Baseline 2009 is a working assumption which will evolve into the new ILC baseline for TDP2
- Many issues of the SB2009 baseline have relevance for MDI, e.g.:

- Beam parameters
- Polarisation issues
- Luminosity issues

- SB2009 detector working group (chair J. Brau) is collecting questions to GDE
- MDI is represented in WG

		RDR	SB2009	
Beam and RF Parameters				
No. of bunches		2625	1312	
Bunch spacing	ns	370	740	
beam current	mA	9.0	4.5	
Avg. beam power (250 GeV)	MW	10.8	5.4	
Accelerating gradient	MV/m	31.5	31.5	
P_{fwd} / cavity (matched)	kW	294	147	
Q_{ext} (matched)		3×10^6	6×10^6	
t_{fill}	ms	0.62	1.13	
RF pulse length	ms	1.6	2.0	
RF to beam efficiency	%	61	44	
IP Parameters				
Norm. horizontal emittance	mm.mr	10	10	
Norm. vertical emittance	mm.mr	0.040	0.035	
bunch length	mm	0.3	0.3	
horizontal b*	mm	20	11	
horizontal beam size	nm	640	470	
			no trav. focus	with trav. focus
vertical β^*	mm	0.40	0.48	0.2
vertical beam size	nm	5.7	5.8	3.8
D_y		19	25	
dE_{BS}/E	%	2	4	3.6
Avg. P_{BS}	kW	260	200	194
Luminosity	$cm^{-2}s^{-1}$	2×10^{34}	1.5×10^{34}	2×10^{34}

Concerns on SB2009

Major concerns in the physics/detector community:

- Higher backgrounds
- Diluted Luminosity spectrum
- Beam energy spreads
- Higher risks for integrated luminosity
- Initial cost savings vs longer running times

- Need to study this in detail using full detector simulations. Need beam parameter sets:
  - also at lower energies (e.g. Higgs measurements at 250 GeV)
  - ideally at all energies 91 GeV → 500 GeV
  - estimates on polarisation at different energies

- List of questions to the GDE has been collected

Conclusions

IDAG has simplified the landscape

- Only SiD and ILD are represented now in MDI-D group

Bi-lateral discussions between SiD and ILD about common issues for the detector hall and push-pull issues have started → start of the TDP for the detectors

Vibration studies are in the focus to help in breaking the symmetry between platform and no-platform decision

SB 2009 is under investigation