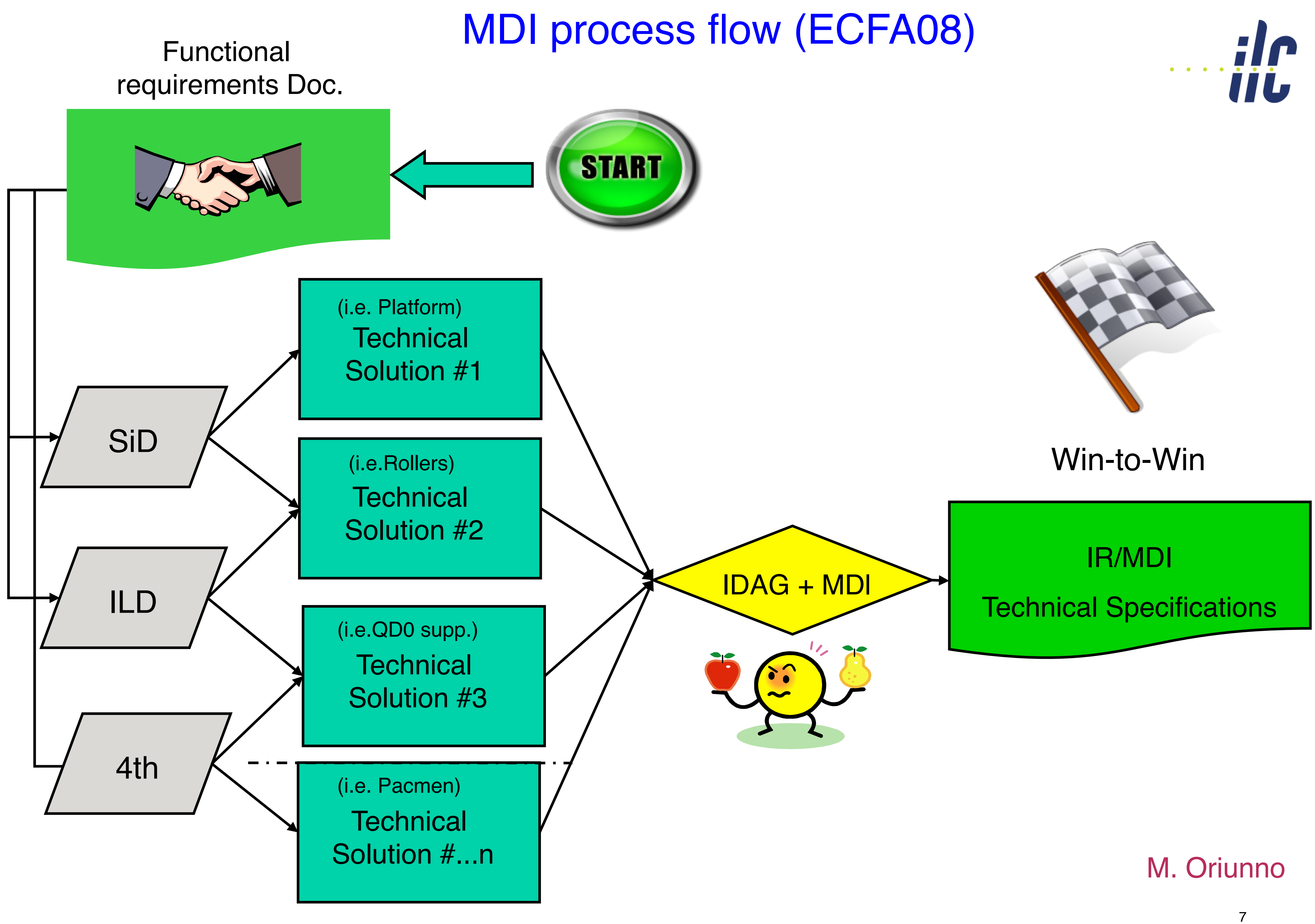
MDI Developments

Report from ALCPG'11 in Oregon

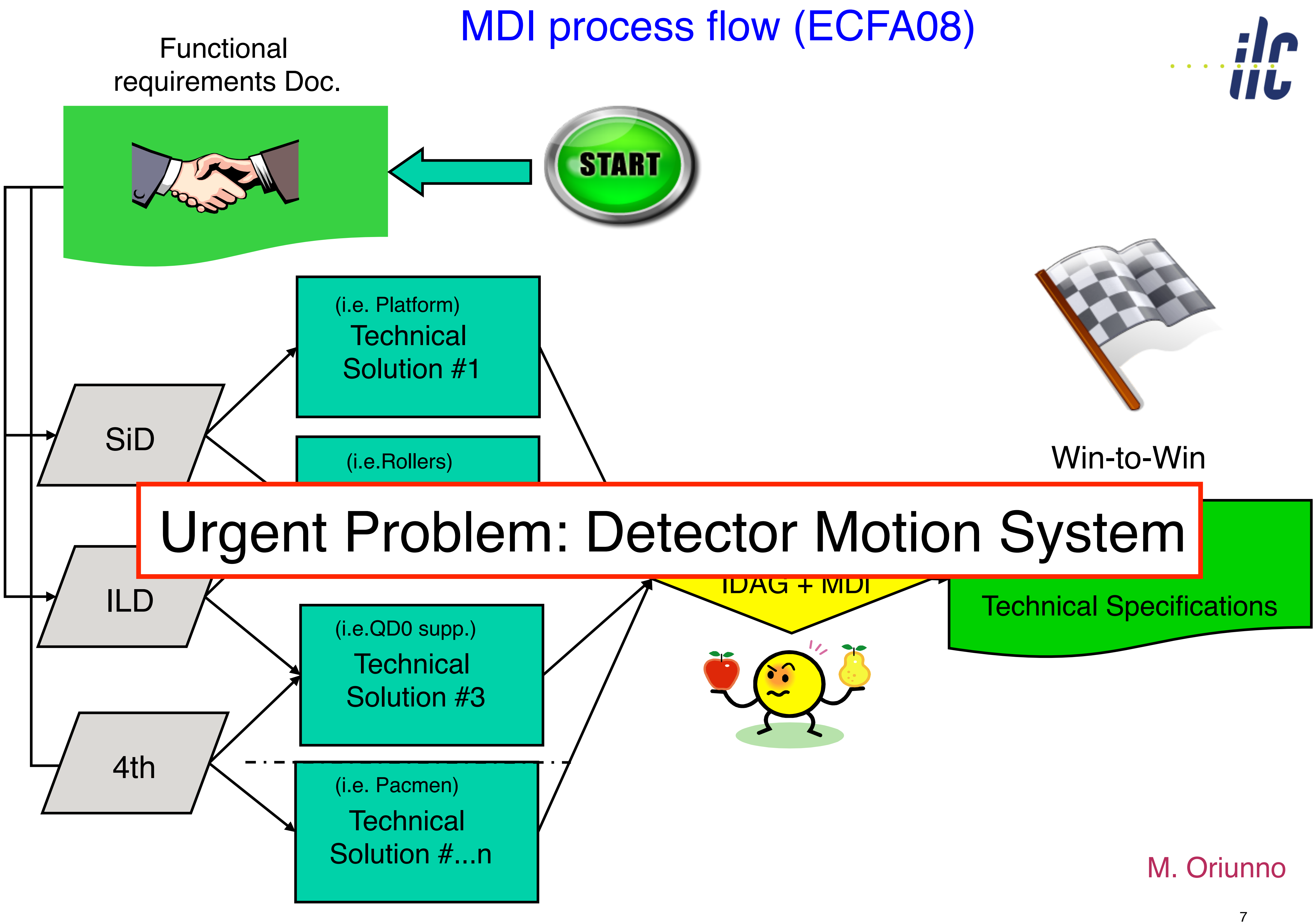
Karsten Buesser
DESY

ILD Regional Integration Workshop
LAL Orsay
19. April 2011

MDI Work Flow



MDI Work Flow



Urgent Problem: Detector Motion System

ILD and SiD Differences

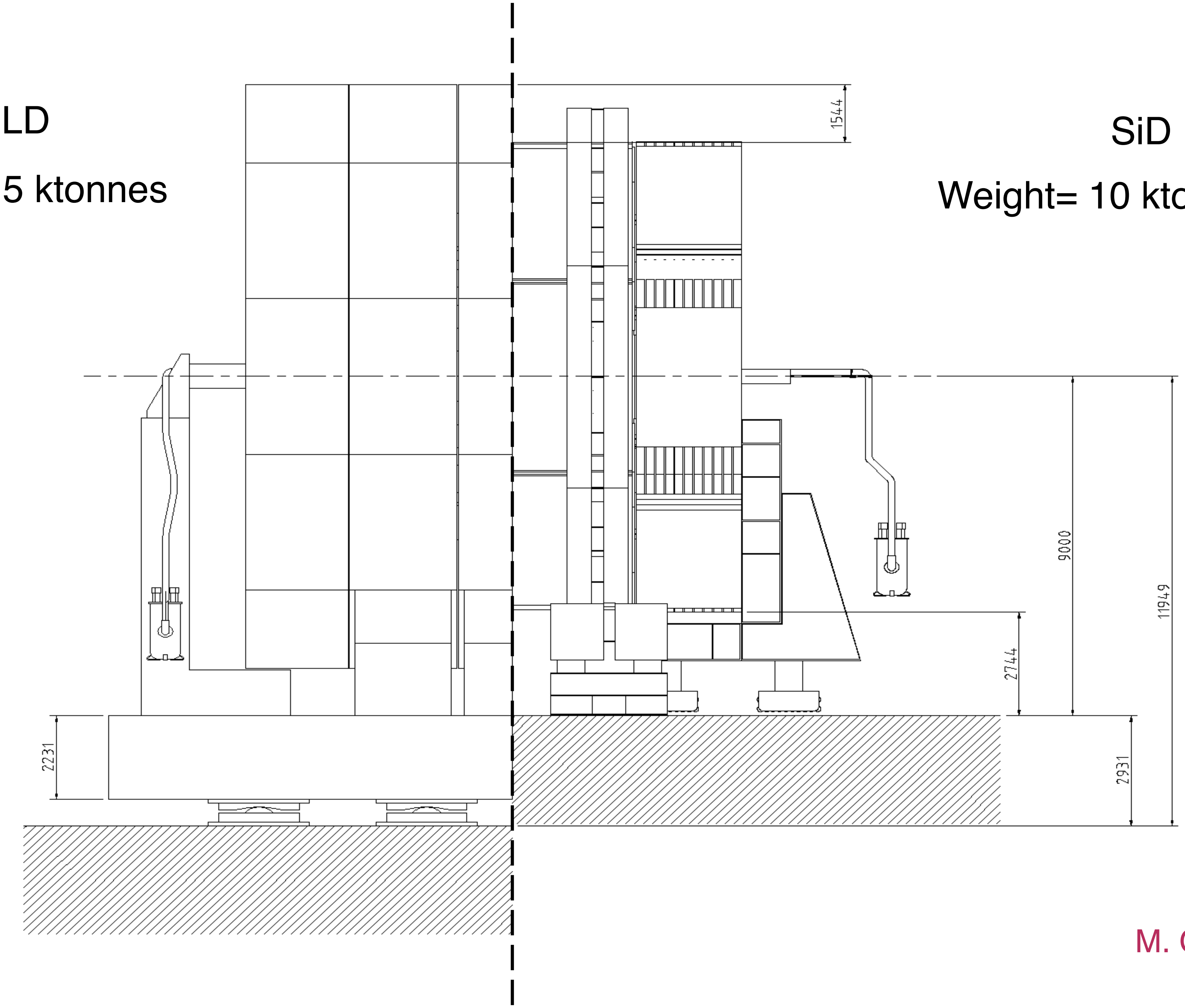
ILD and SiD differences

ILD

Weight= 15 ktonnes

SiD

Weight= 10 ktonnes



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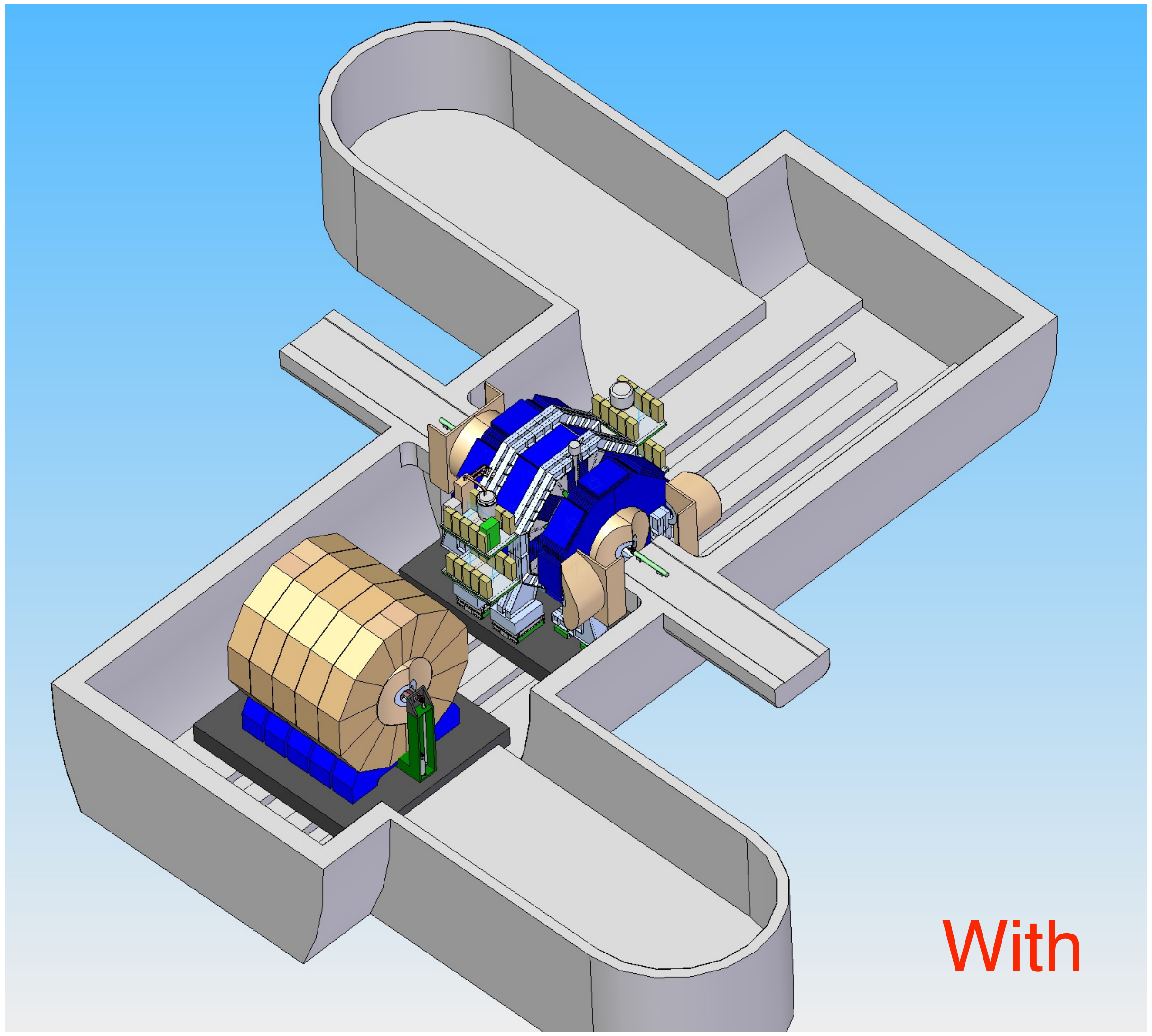
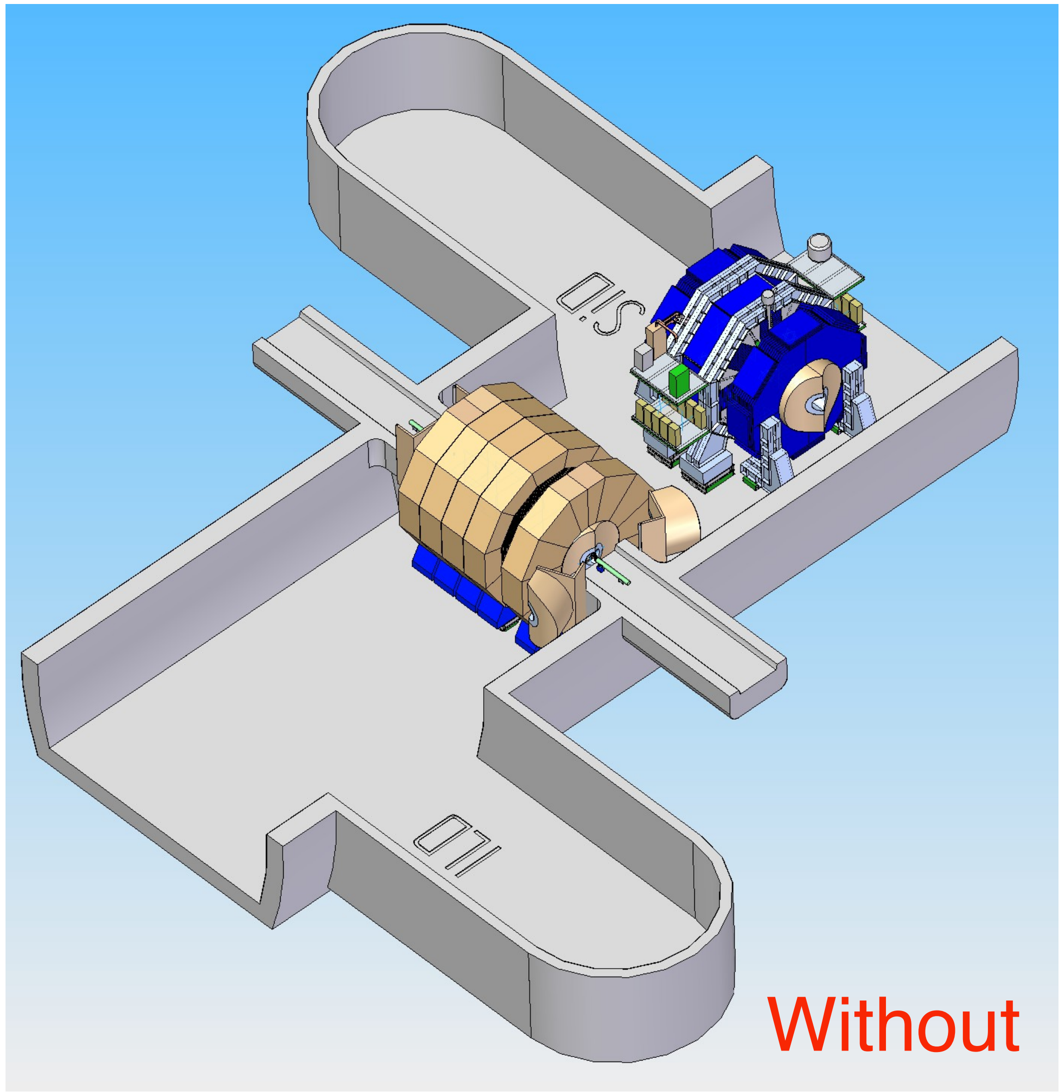
SiD and ILD with or without a platform ?





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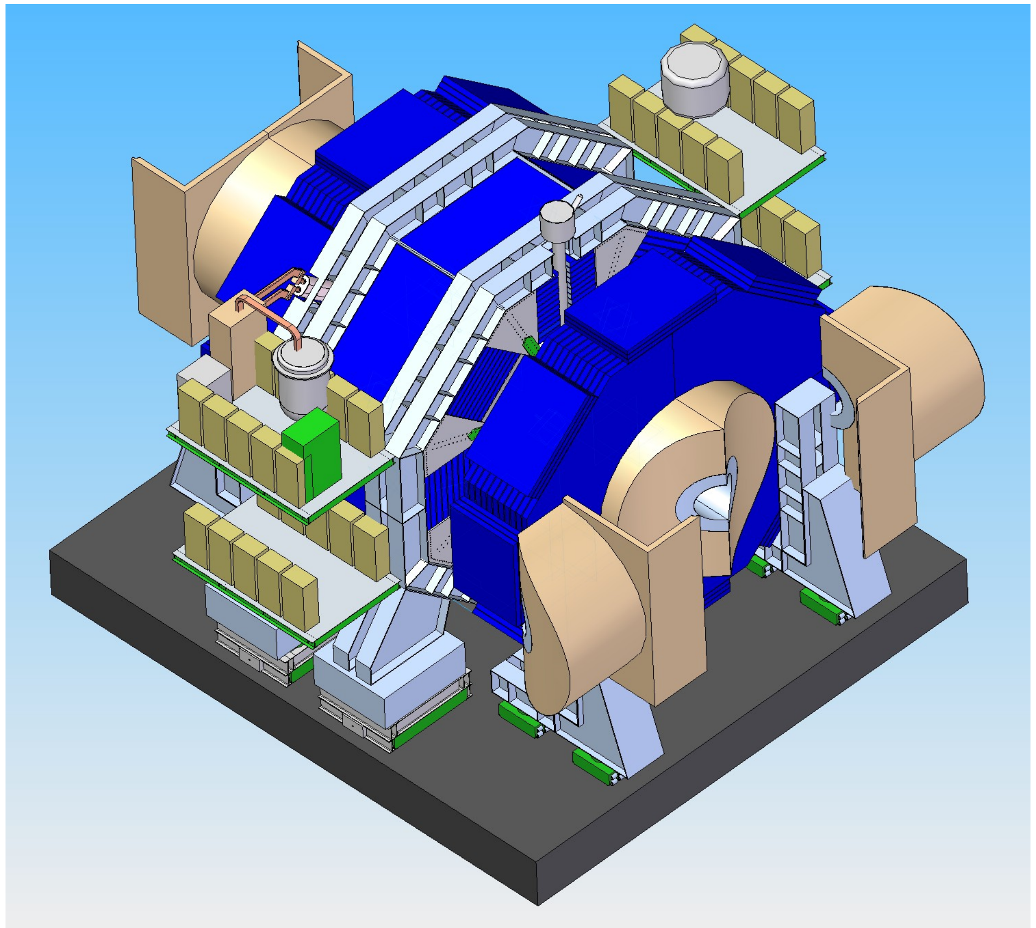
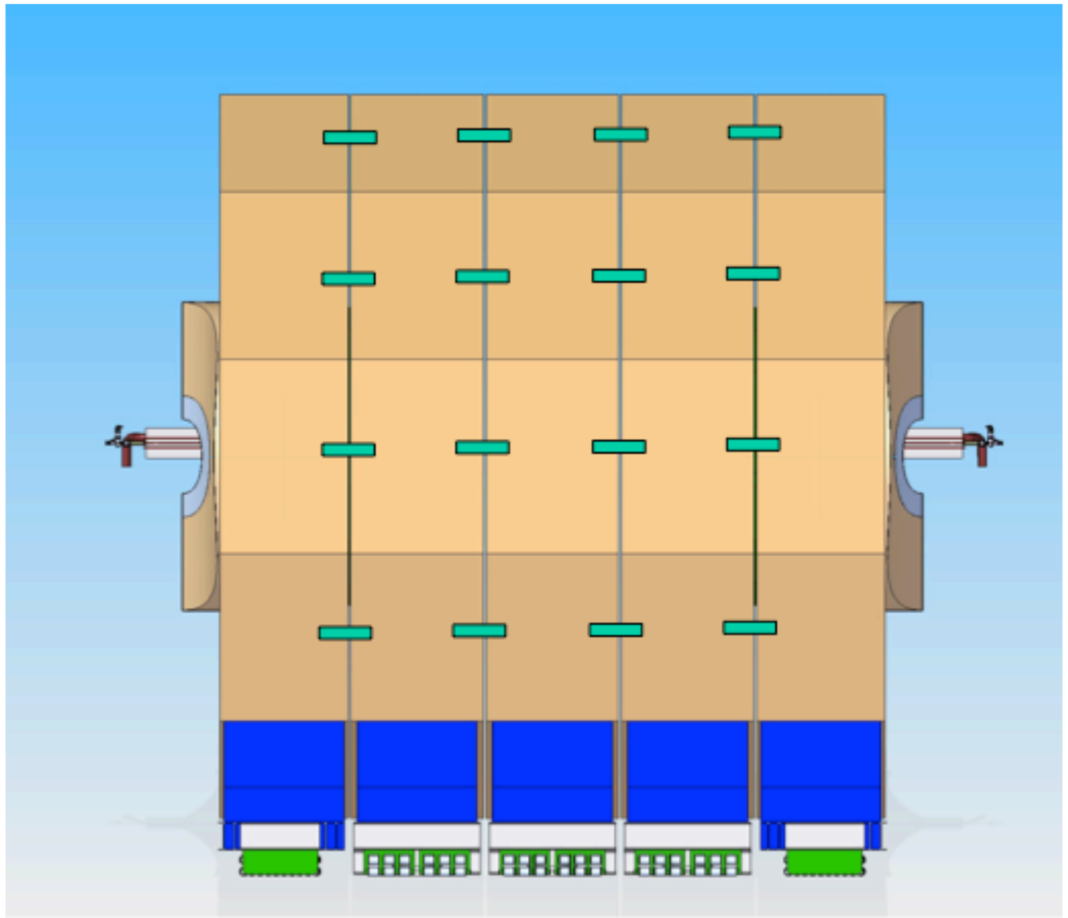
Trade off study



SiD on Platform



ILD without Platform

Mandatory requirements	SiD	ILD
Design Change Impact	None	High
Vibrations Amplification	Unkwon	Unkwon

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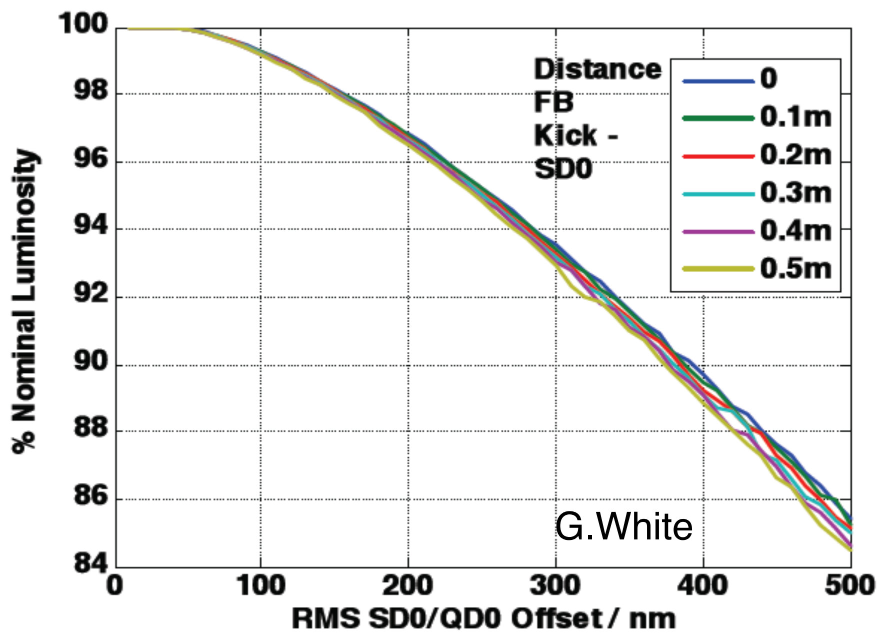
Vibrations

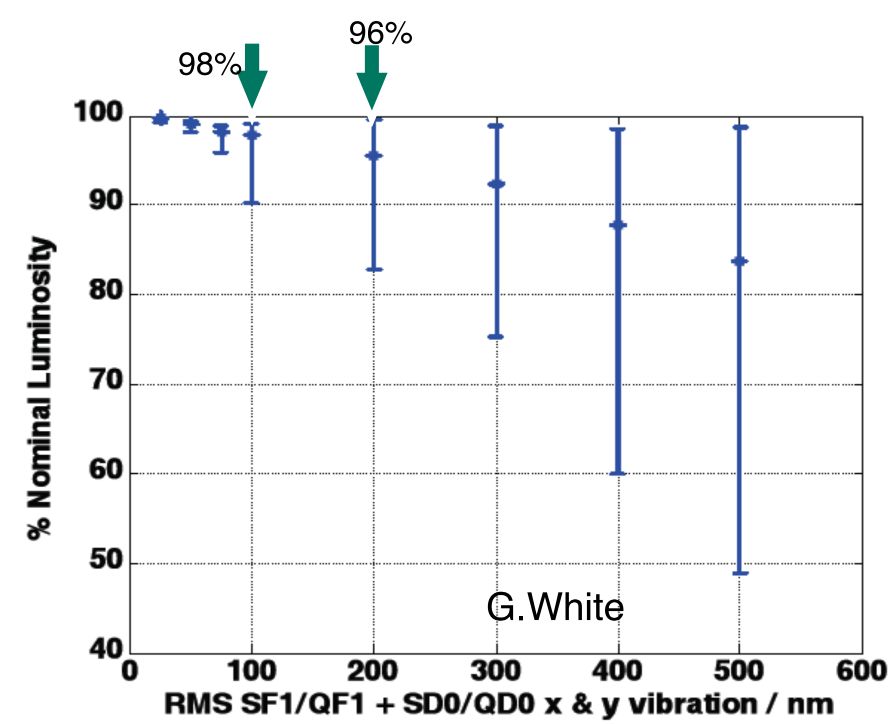
Vibrations

Most acute luminosity loss mechanism due to relative jitter of final focusing magnet elements : Ground Motion and Mechanical vibration sources

ILC has Active Fast Feedback based on beam trajectory after collision

Max. Integrated displacement: 50 nm > 5 Hz





Lumi loss due to beam offset in SD0 (beamsize growth) and IP misalignment of beams

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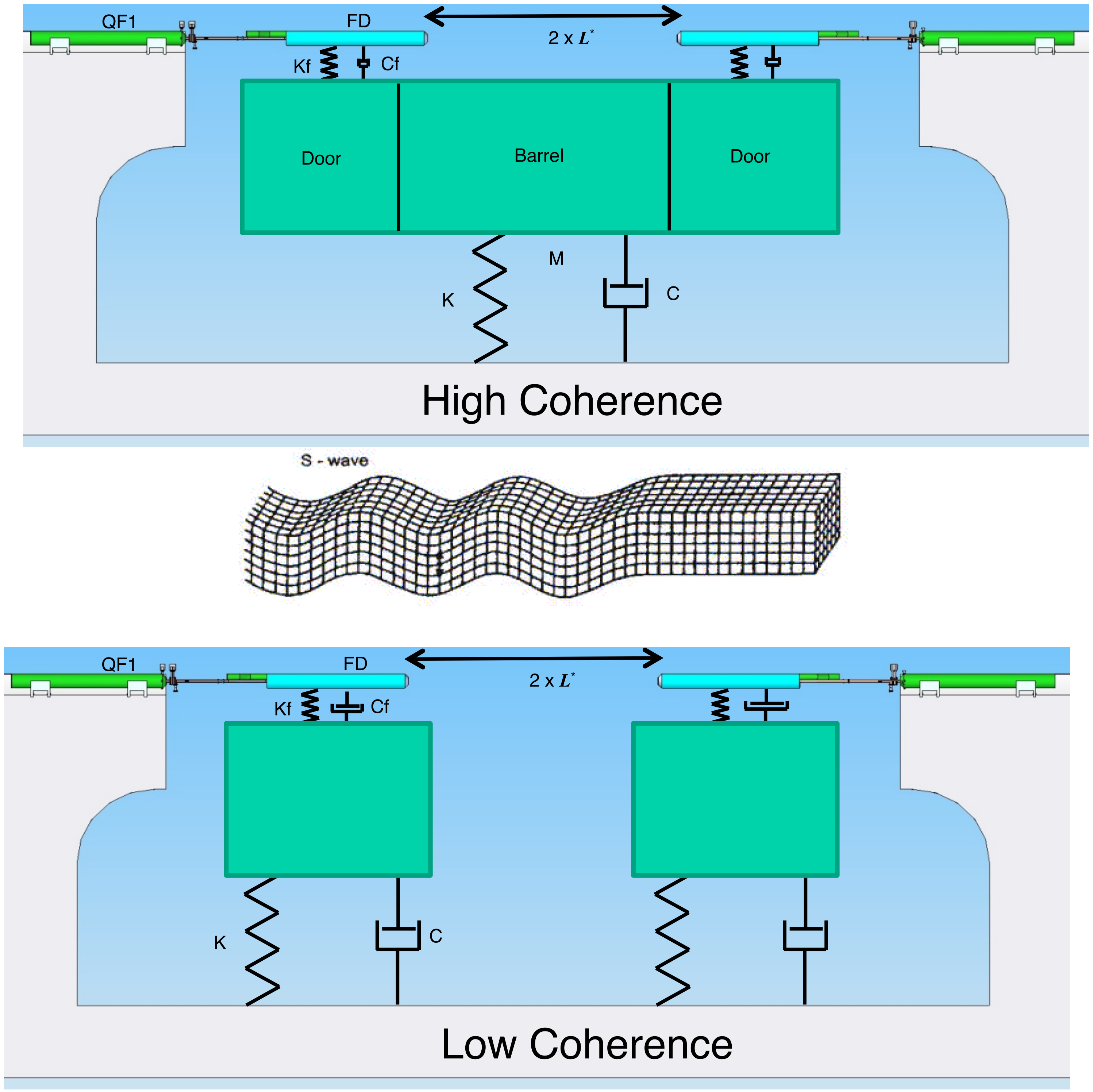
QD0 Support Models

QD0 Supports



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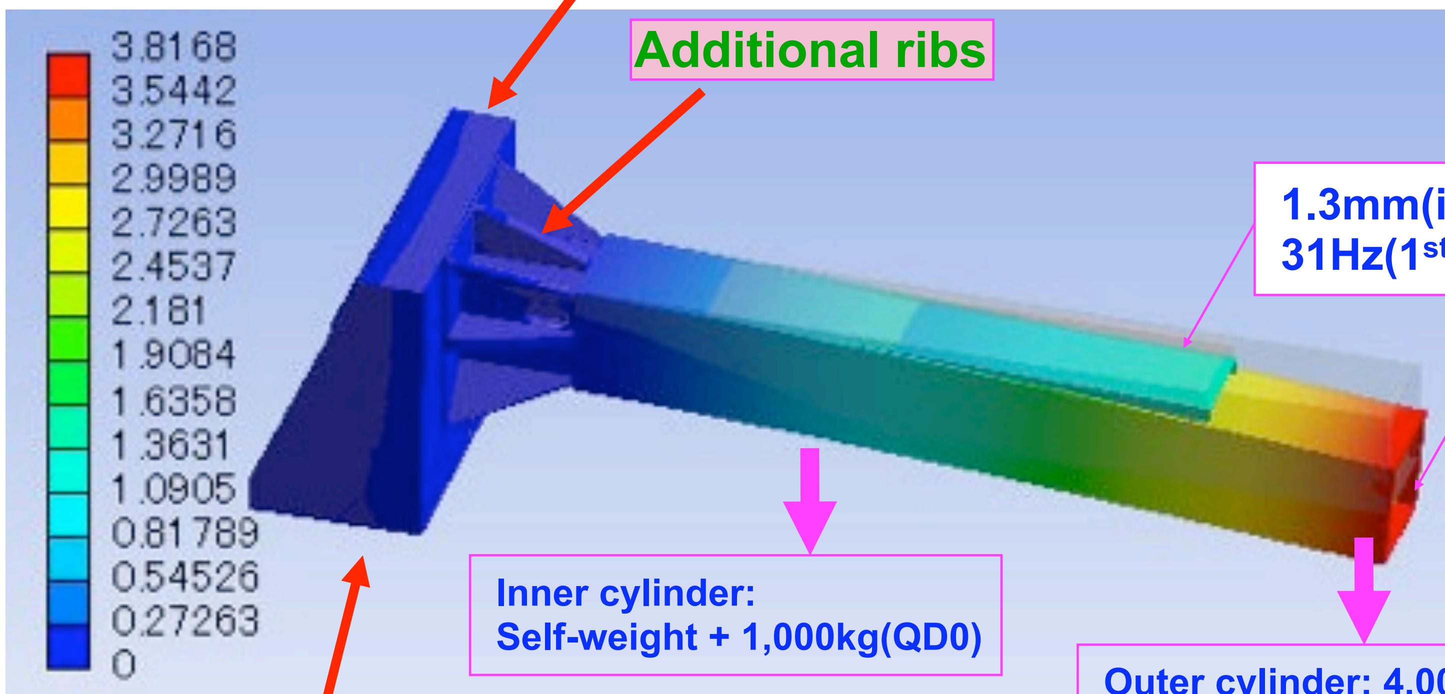
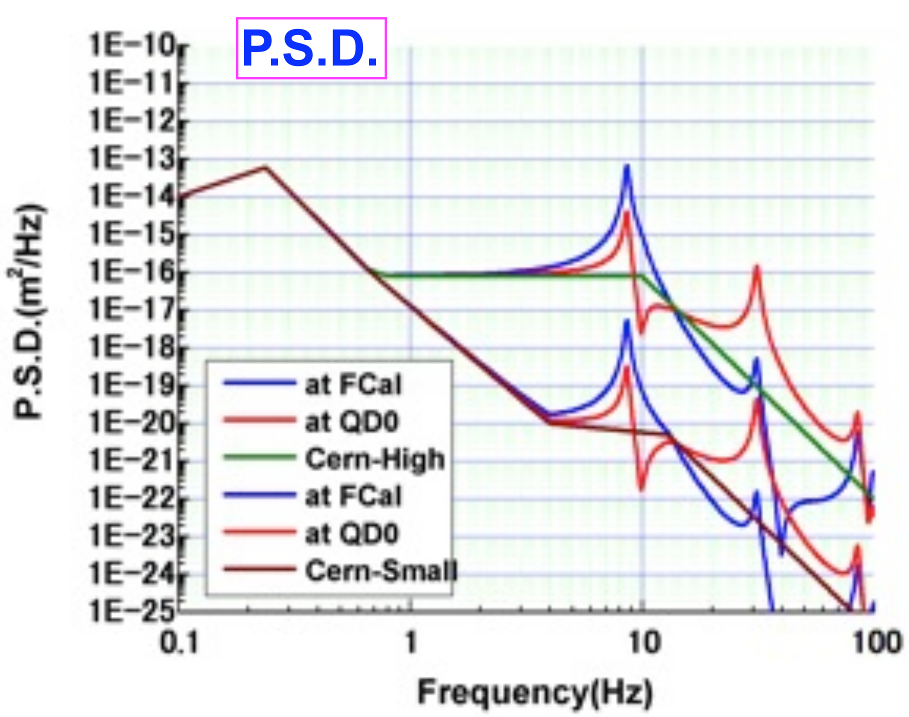
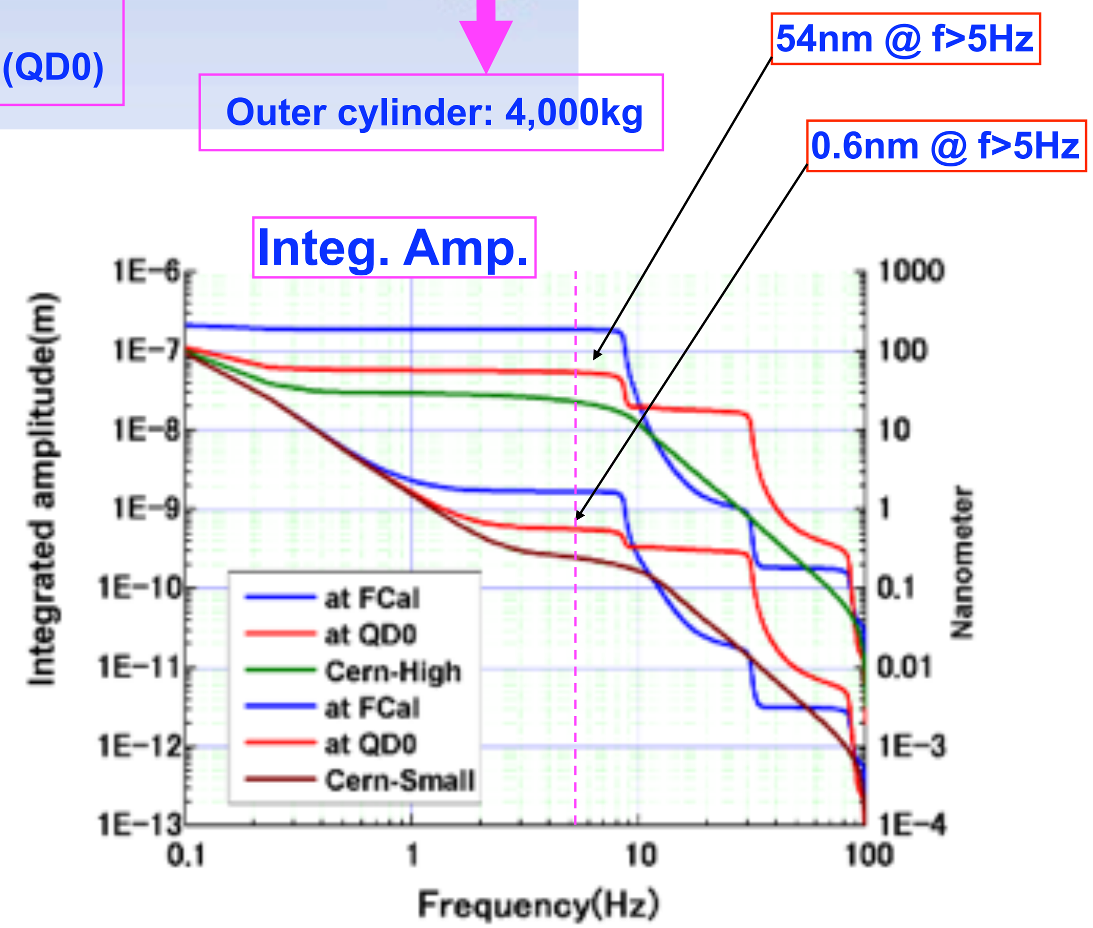
ILD QD0 Support Vibration Analysis

Calculation-3

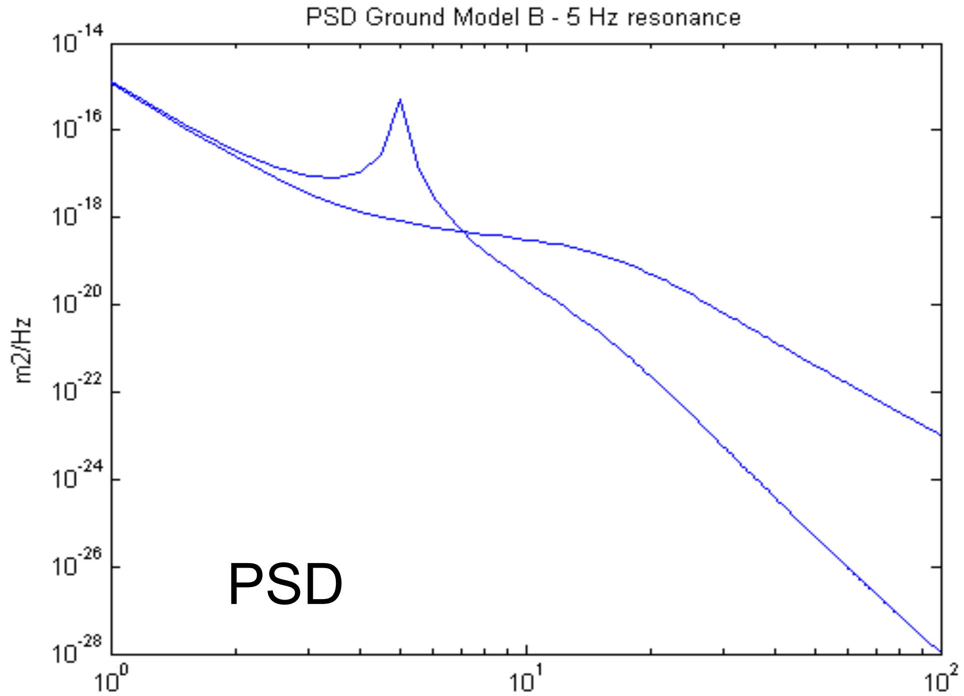




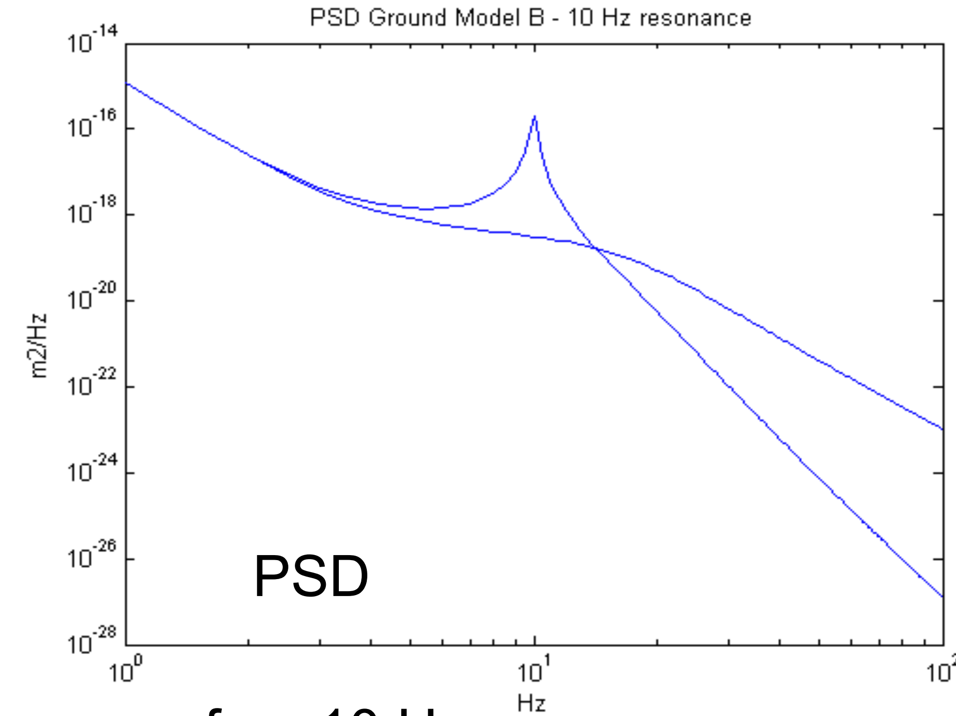


SiD Vibration Analysis - No Platform

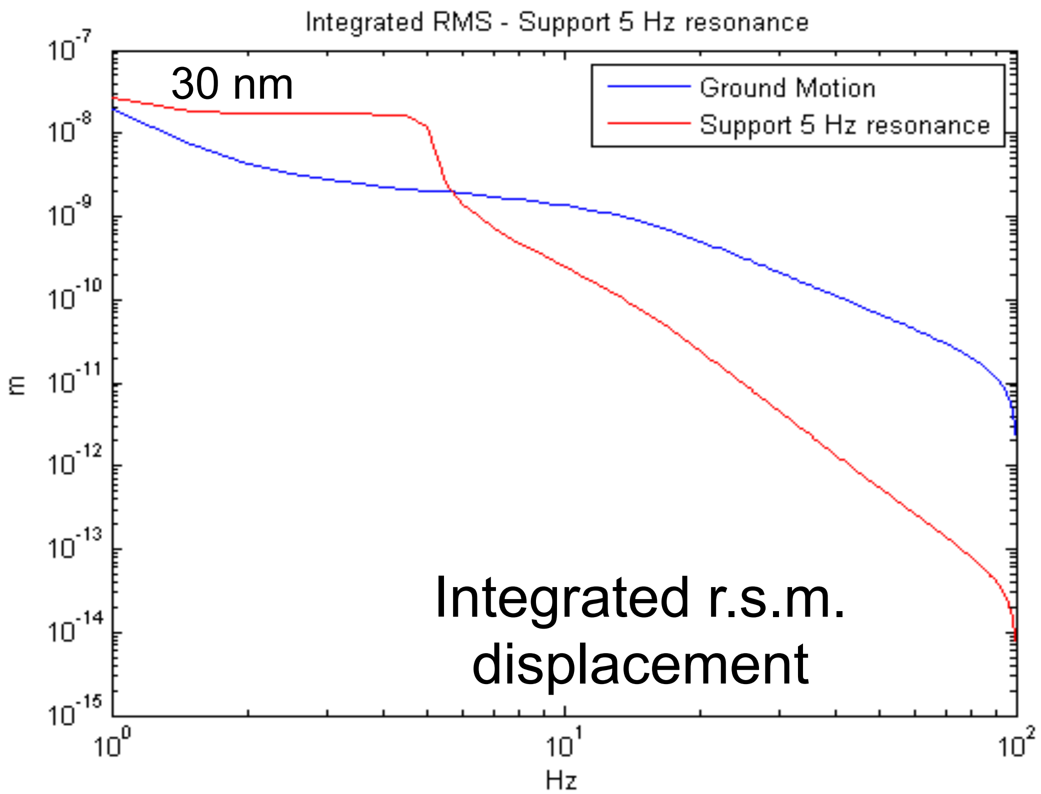
Random vibration Studies : SiD O.K. on the floor, no platform

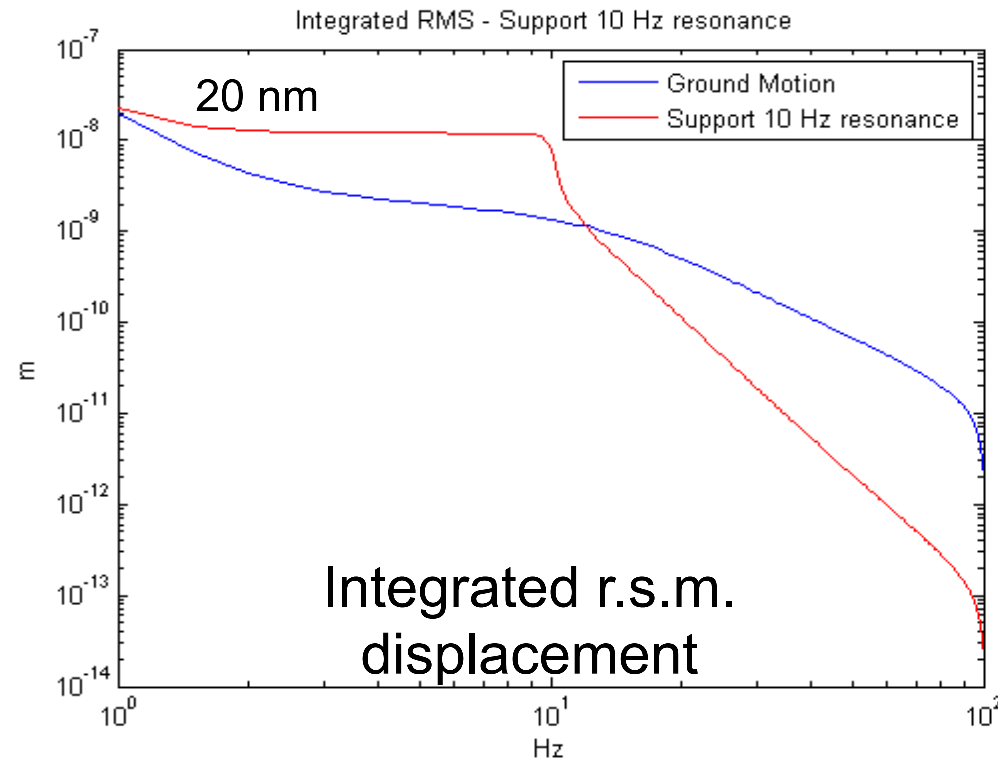


fo = 5 Hz



fo = 10 Hz





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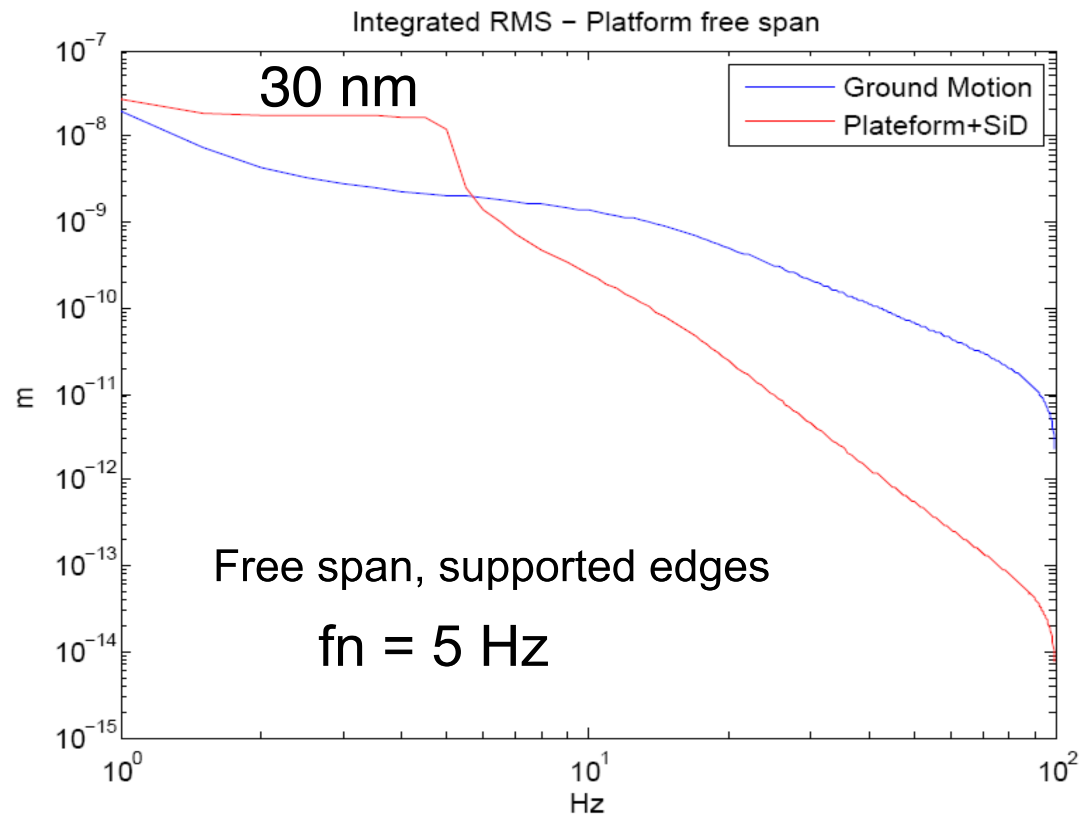
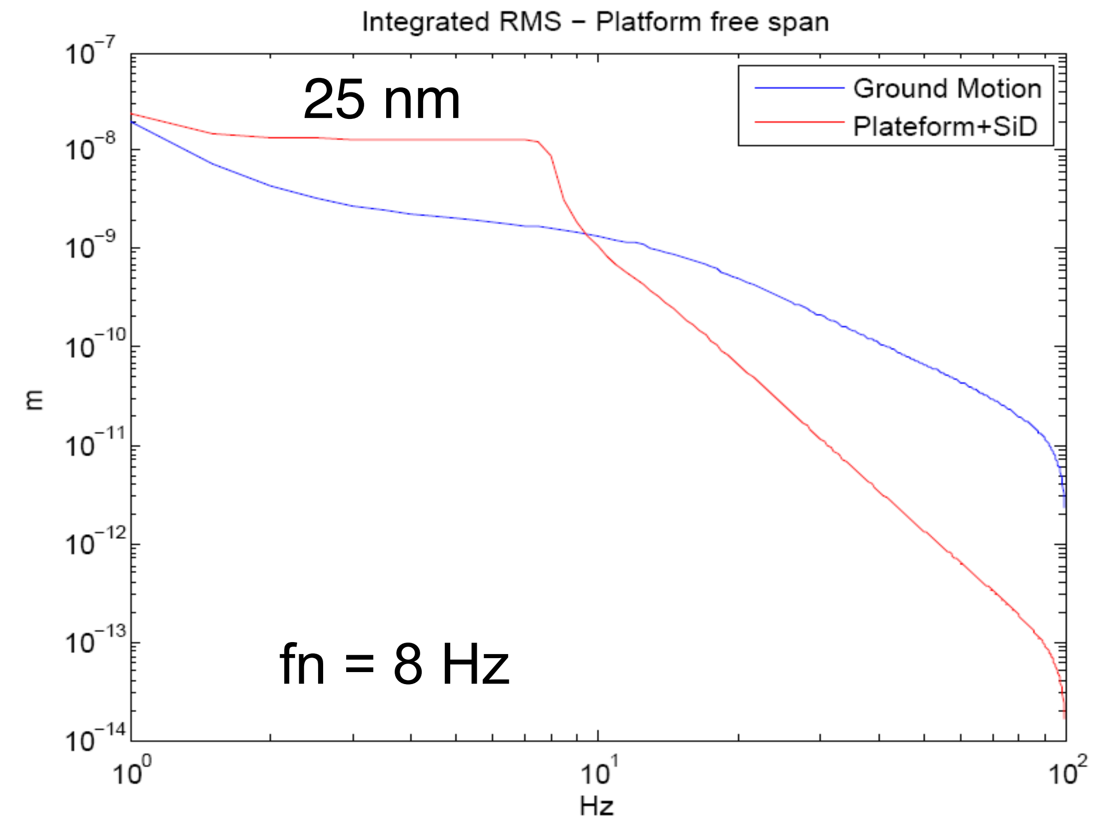
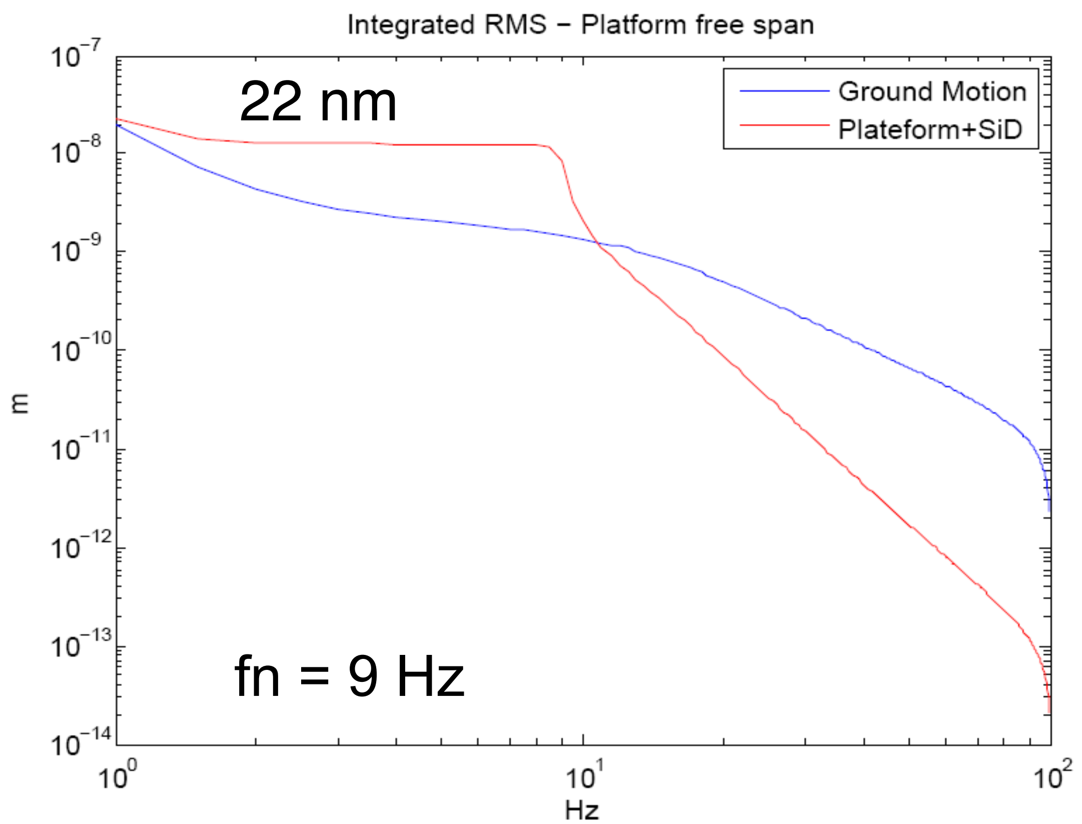
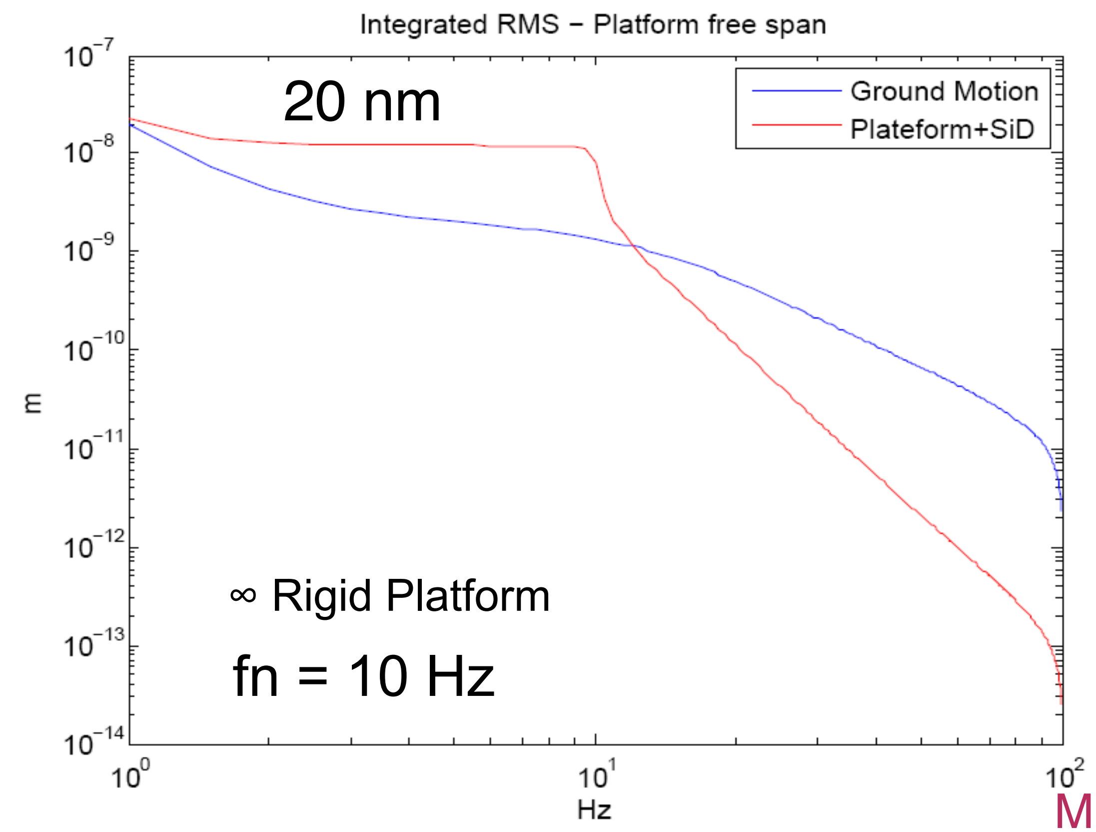
SiD Vibration Analysis - with Platform









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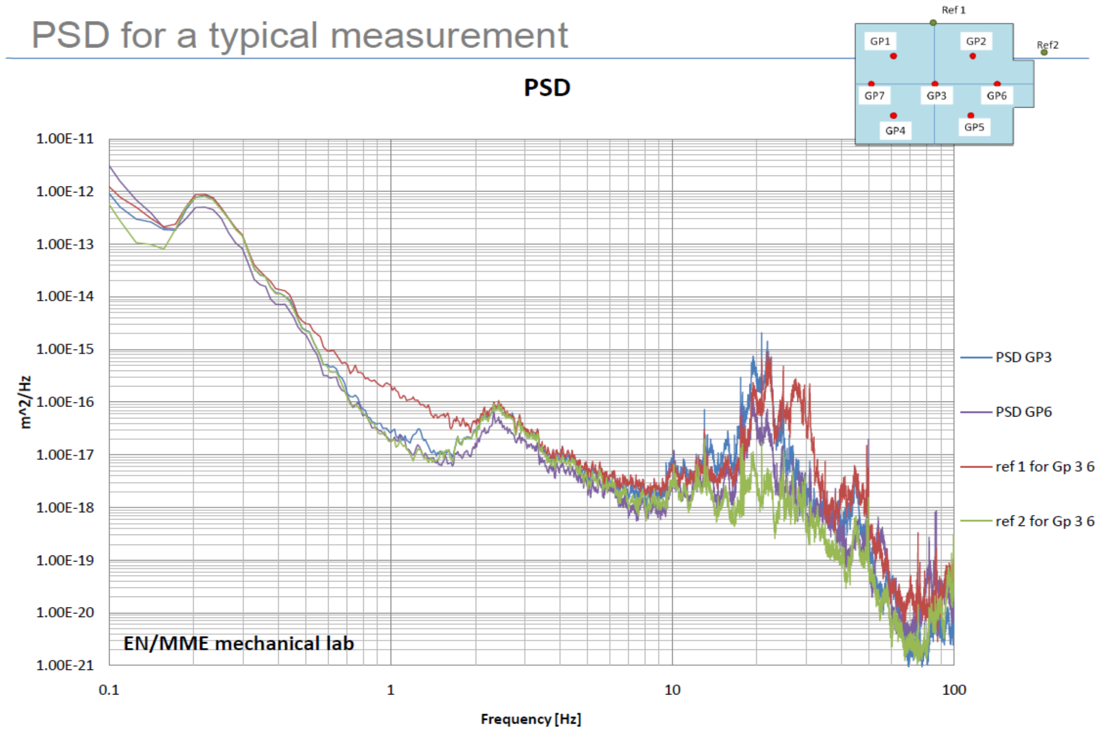
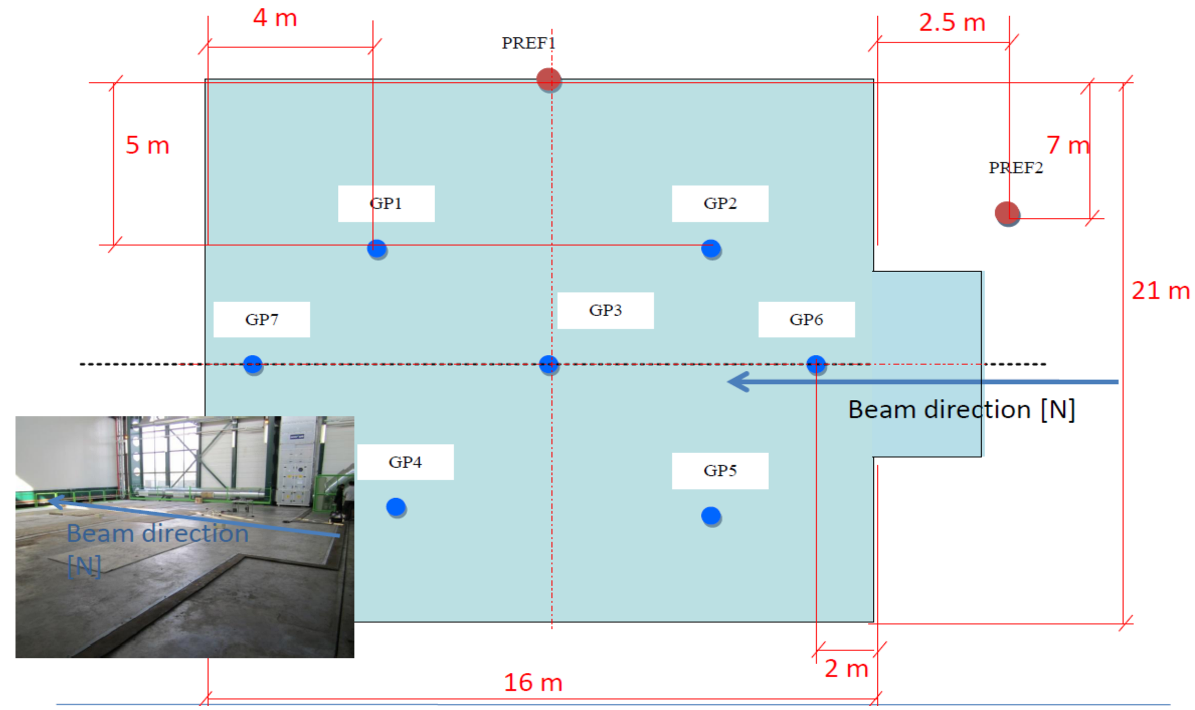
Vibration Measurements at CMS Plug

Experimental Vibration measurements – CMS Plug

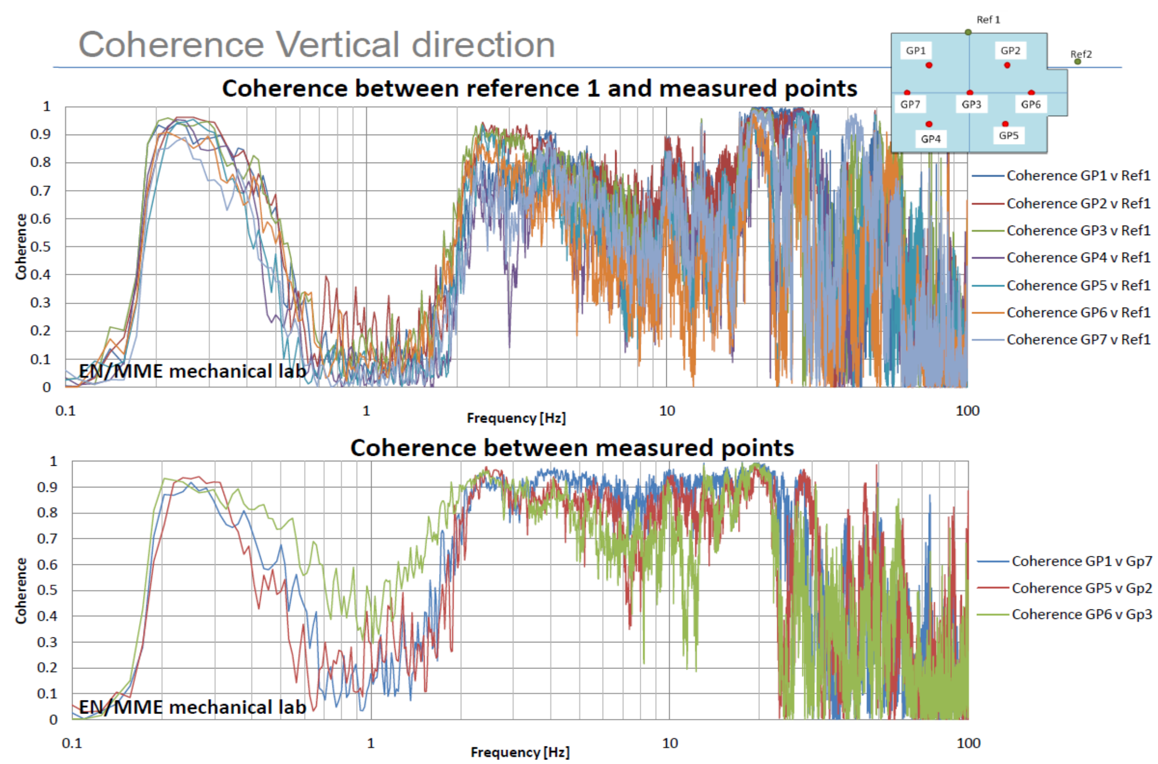
PSD for a typical measurement



Sensor position



Coherence Vertical direction



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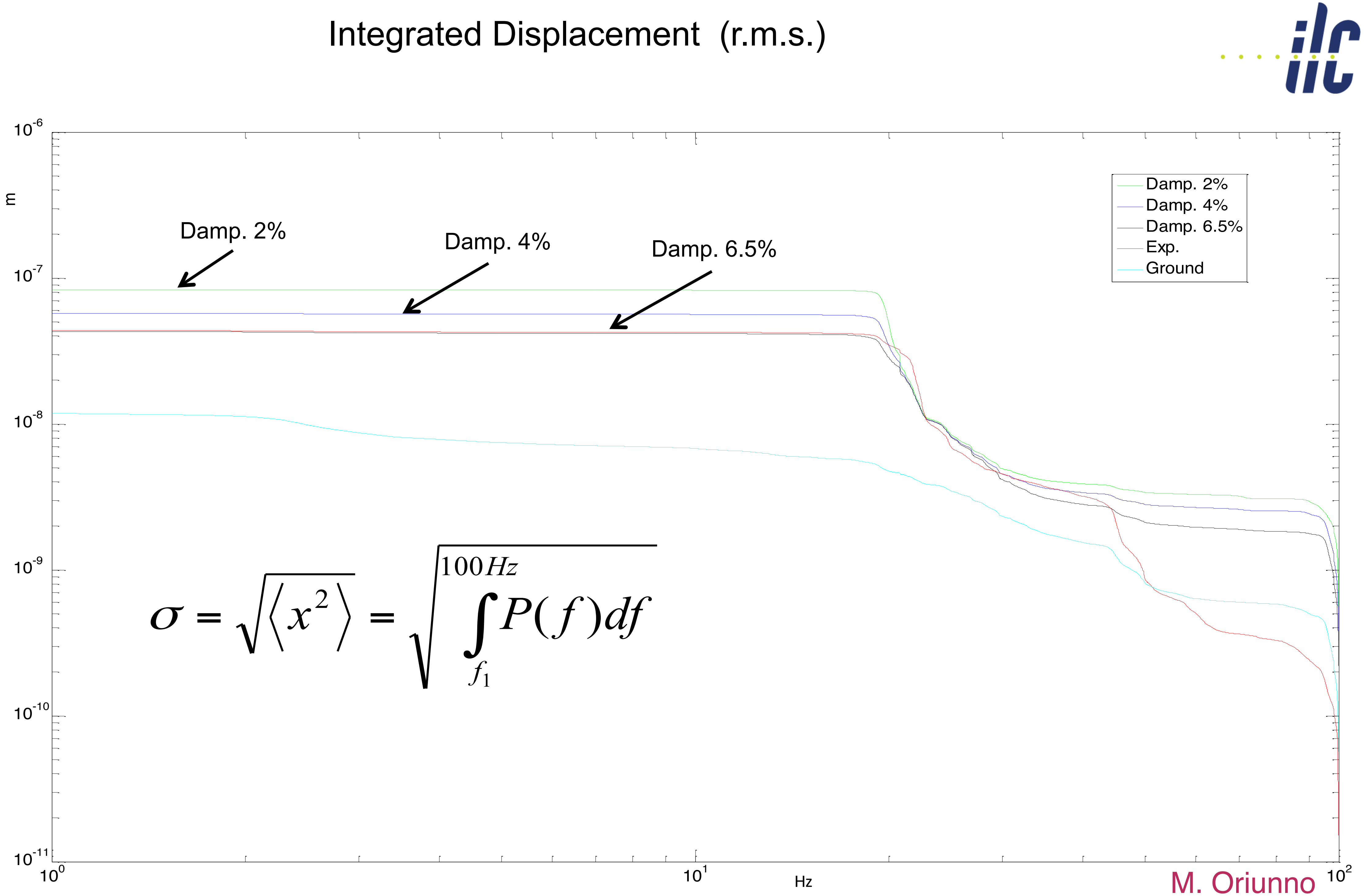
Platform Vibration Amplification



$$\sigma = \sqrt{\langle x^2 \rangle} = \sqrt{\int_{f_1}^{100Hz} P(f)\,df}$$

Marco‘s Conclusions

Conclusions

- Platforms are a technically acceptable solutions for the push pull, which preserves the respective design of the detectors and does not amplify the ground vibrations.
- The platforms must be designed according to a set of Functional Requirements, specifying the static and dynamic performances. These requirements will be defined by the detectors.
- The design and construction of the platforms becomes a task of the CFS group, which will develop the project along the requirements list and together with the detectors.

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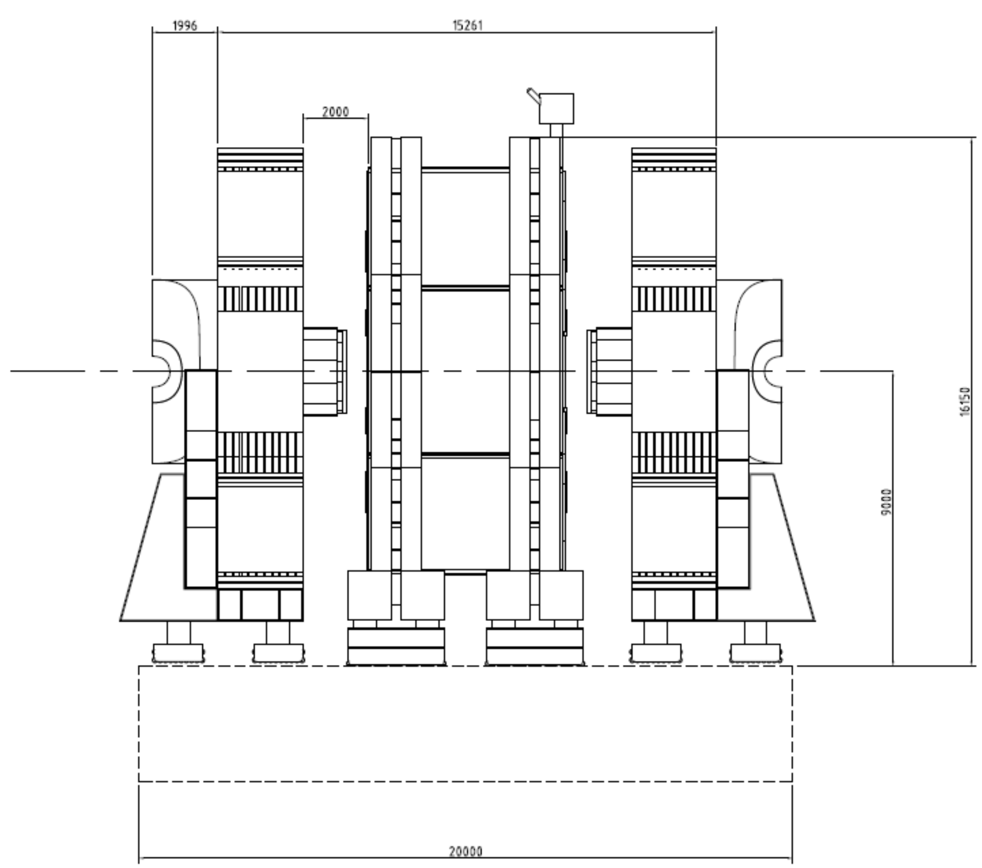
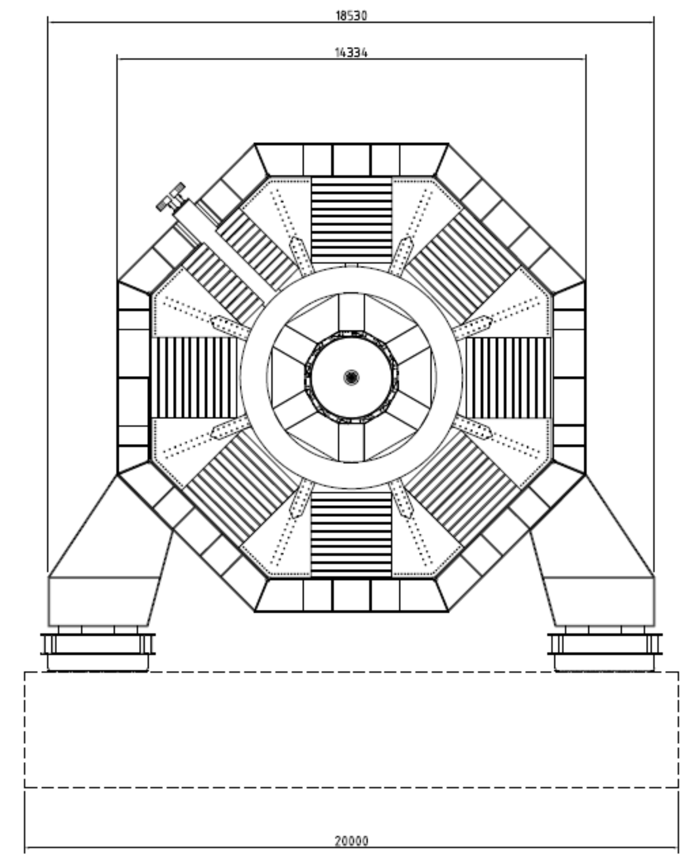
SiD Platform Requirements

SiD Platform Functional Requirements





SiD nominal mass: Barrel 5000 T; (each) Door 2500 T

Dimensions:
Z = 20.0 m
X = 20.0 m
Delta Y = 9 m (Top of Platform to beamline)

Positioning Tolerance on beamline
Consider points Z=+-max, X=0. Position to + 1mm wrt references in X,Y,Z
Consider points Z=+-max, X=+-max: Position to +- 1 wrt references in Y.

Static Deformations: <+-2 mm

Vibration budget < 50nm between 1 and 100 Hz, at the QD0's (relative)

Seismic stability: Appropriate for selected site. (Beamline must be designed with sufficient compliance that VXD will survive)

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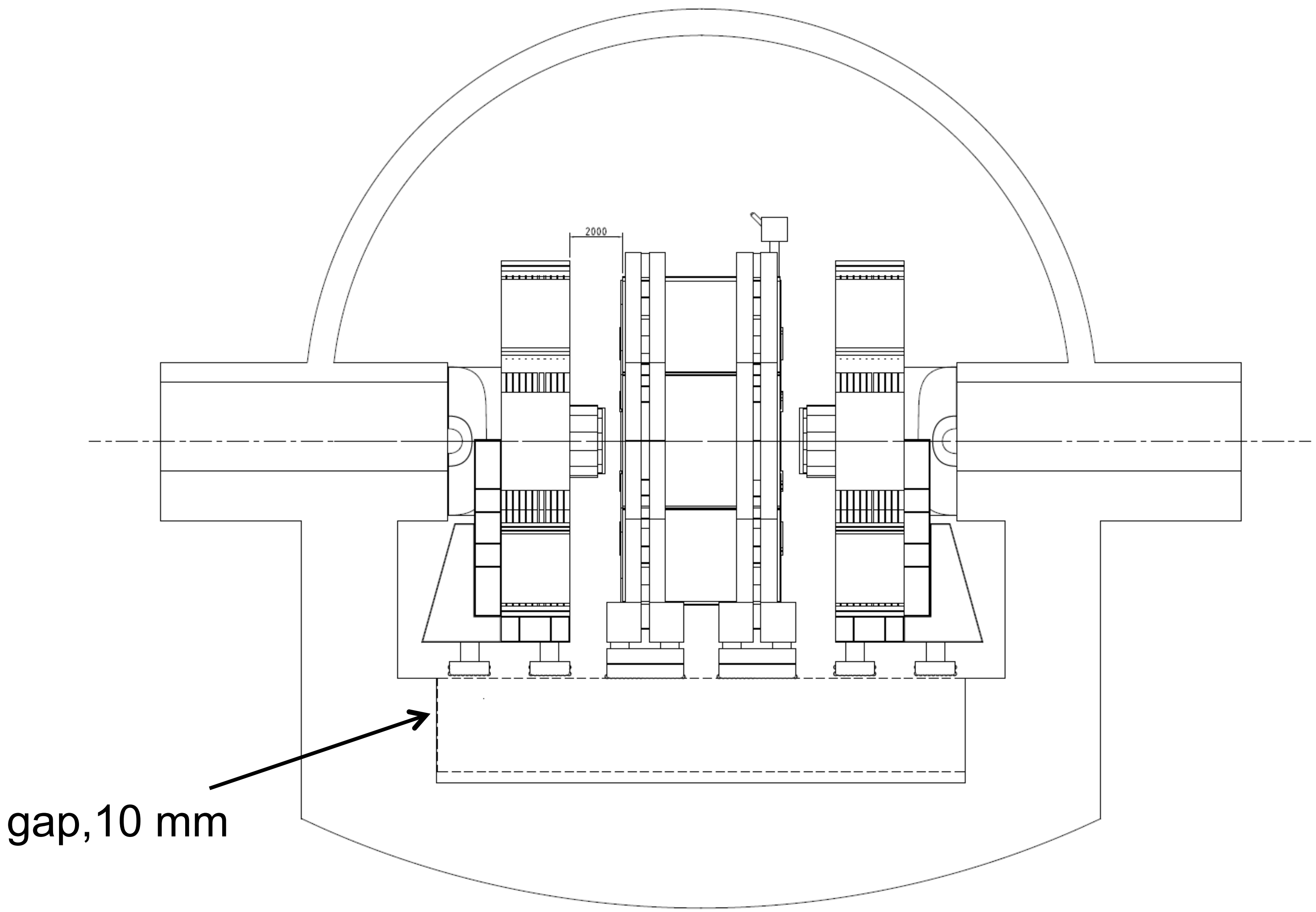
SiD Platform Requirements

SiD Platform Functional Requirements



Wall clearance ~10 mm. Platform comes to side wall, there is no apron or apron matches platform elevation.

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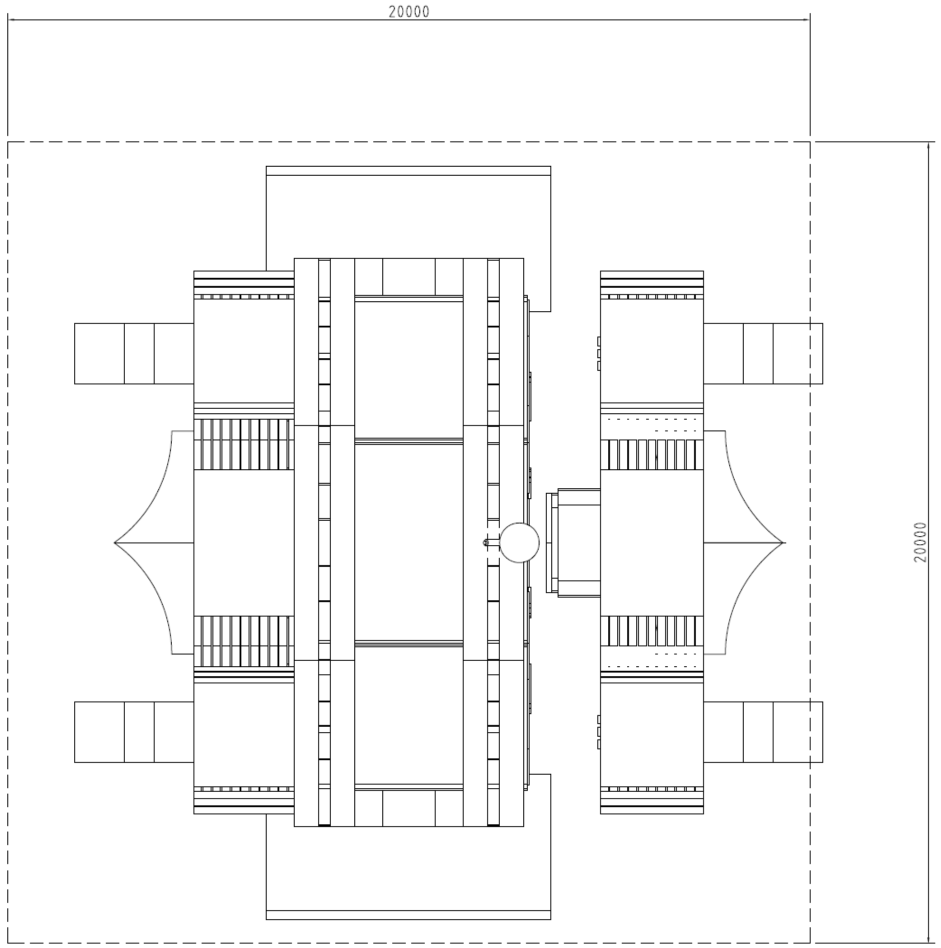
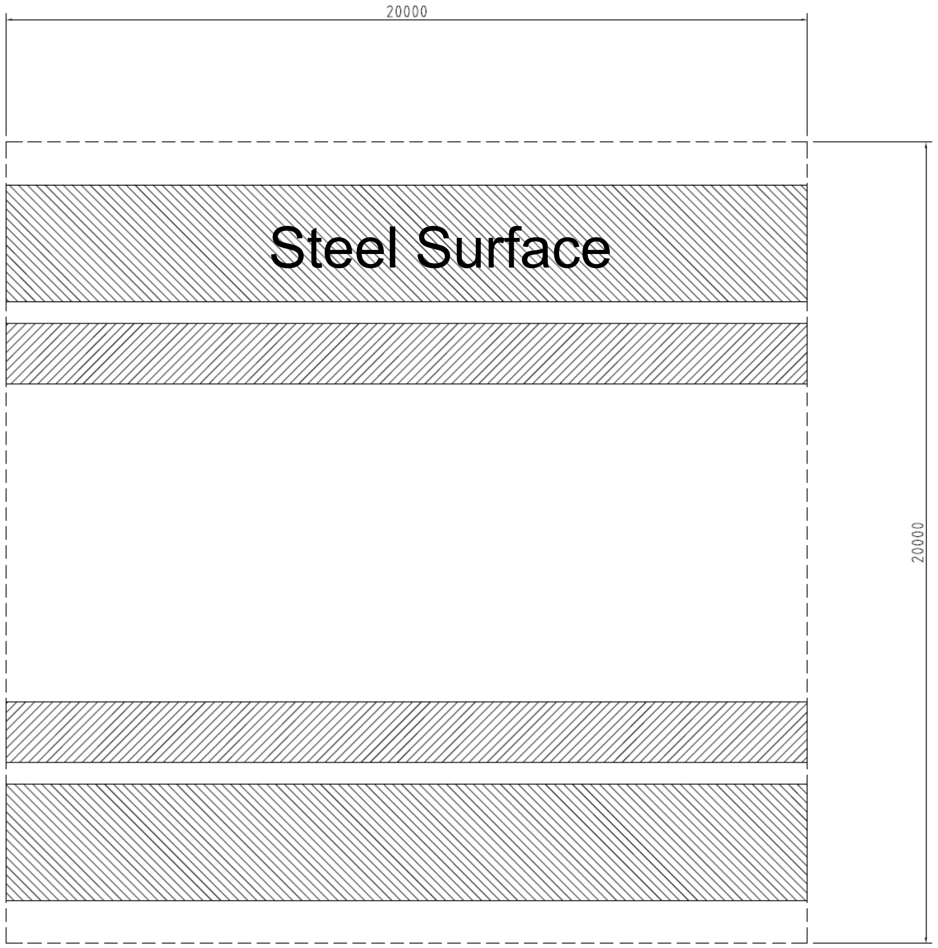
SiD Platform Requirements

SiD Platform Functional Requirements



Detector on platform Top View



Platform Top View

Surface Features:

- Steel Surface near legs
- Steel rails for doors
- “Receptacles” for tie seismic tiedowns of SiD Barrel and Doors
- Removable Safety railings

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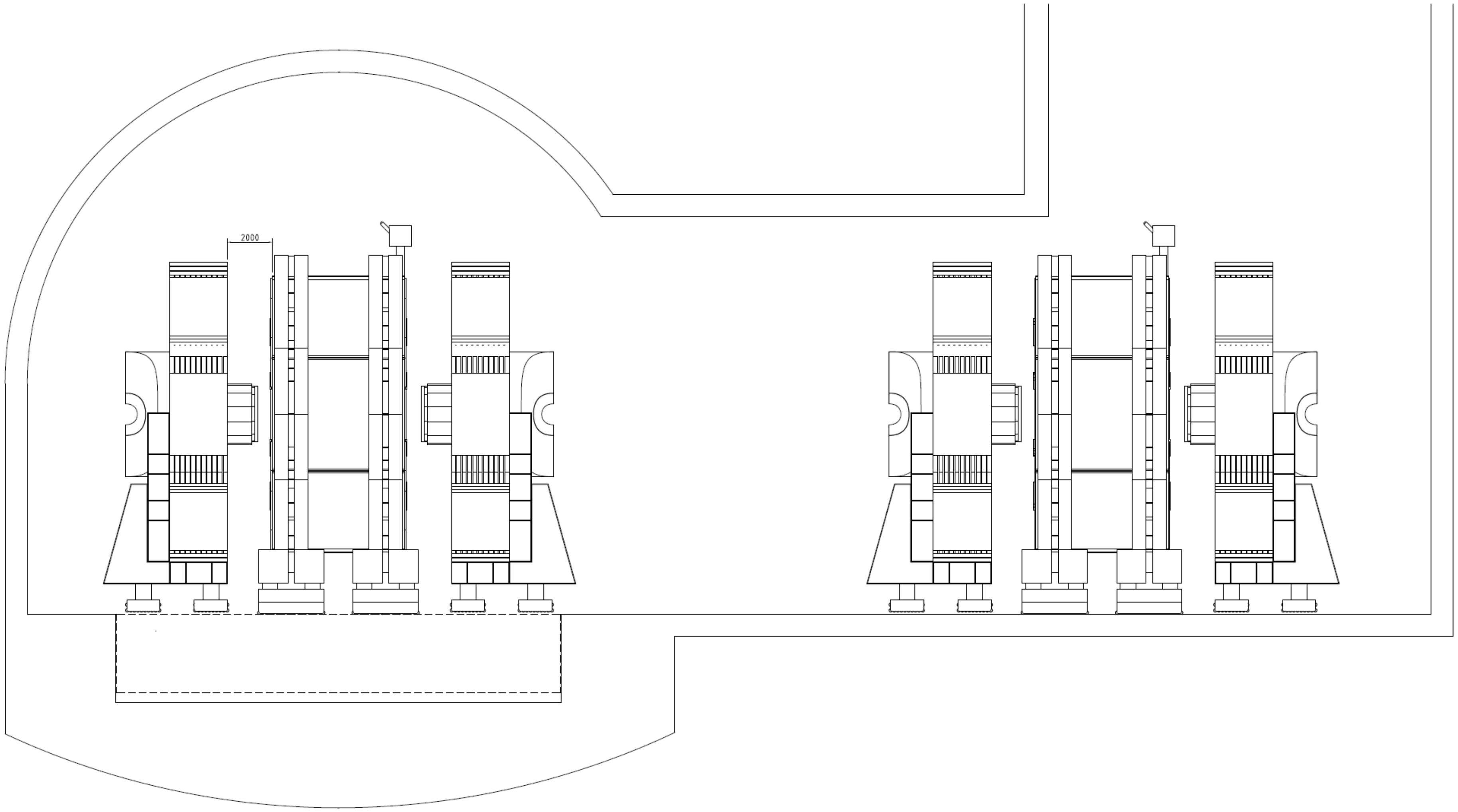
SiD Platform Requirements

SiD Platform Functional Requirements



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Accelerations: <1 mm/s^2

Transport velocity: V>1 mm/s after acceleration

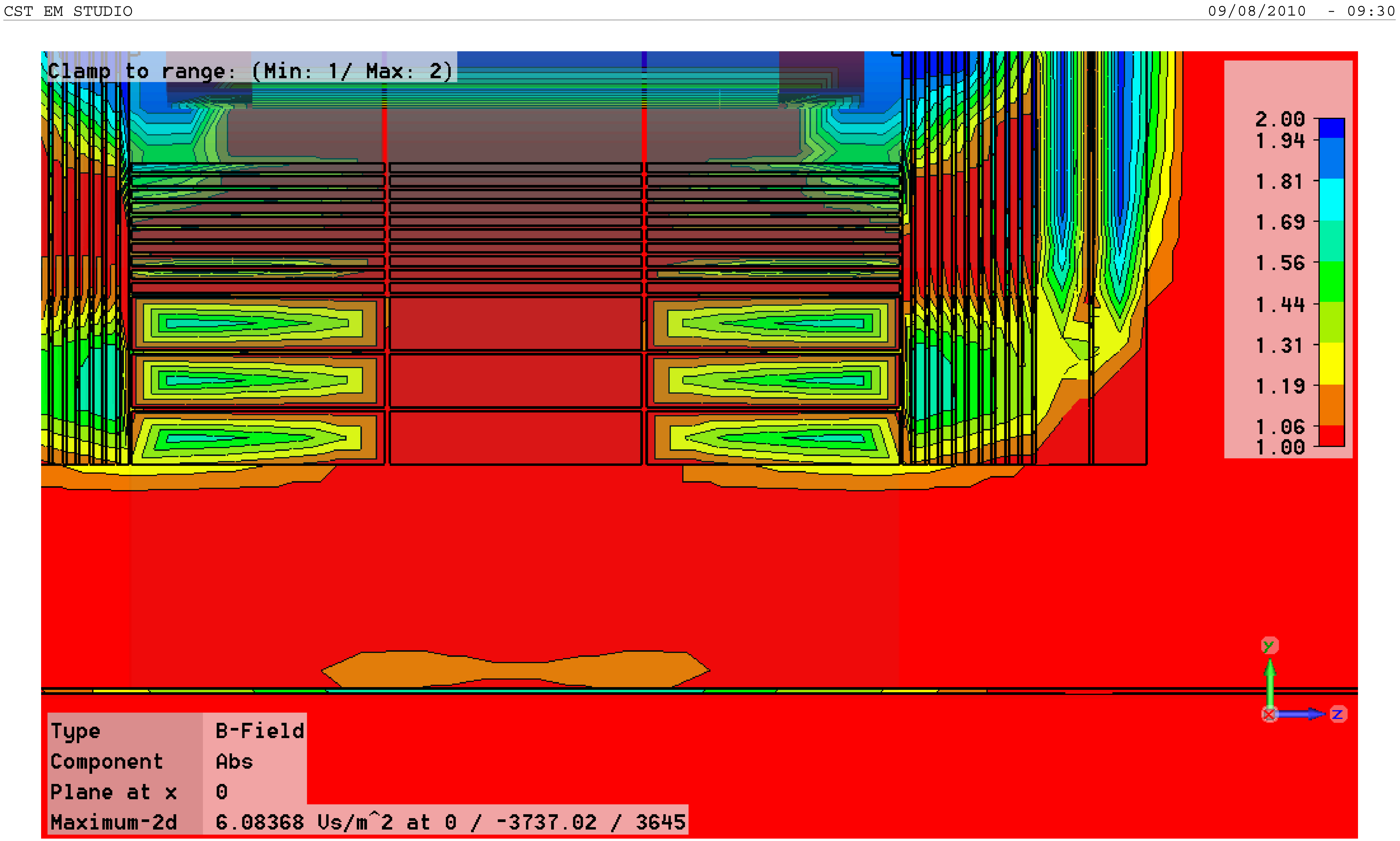
Life: 100 motion cycles.

Reliability: Transport modularity must be such that repairs/ replacement/maintenance can be accomplished in garage position and within 20 elapsed days.

Any equipment required for transport shall reside below the platform surface.

Transport equipment shall not eject particulates that reach platform surface (need spec on how much)

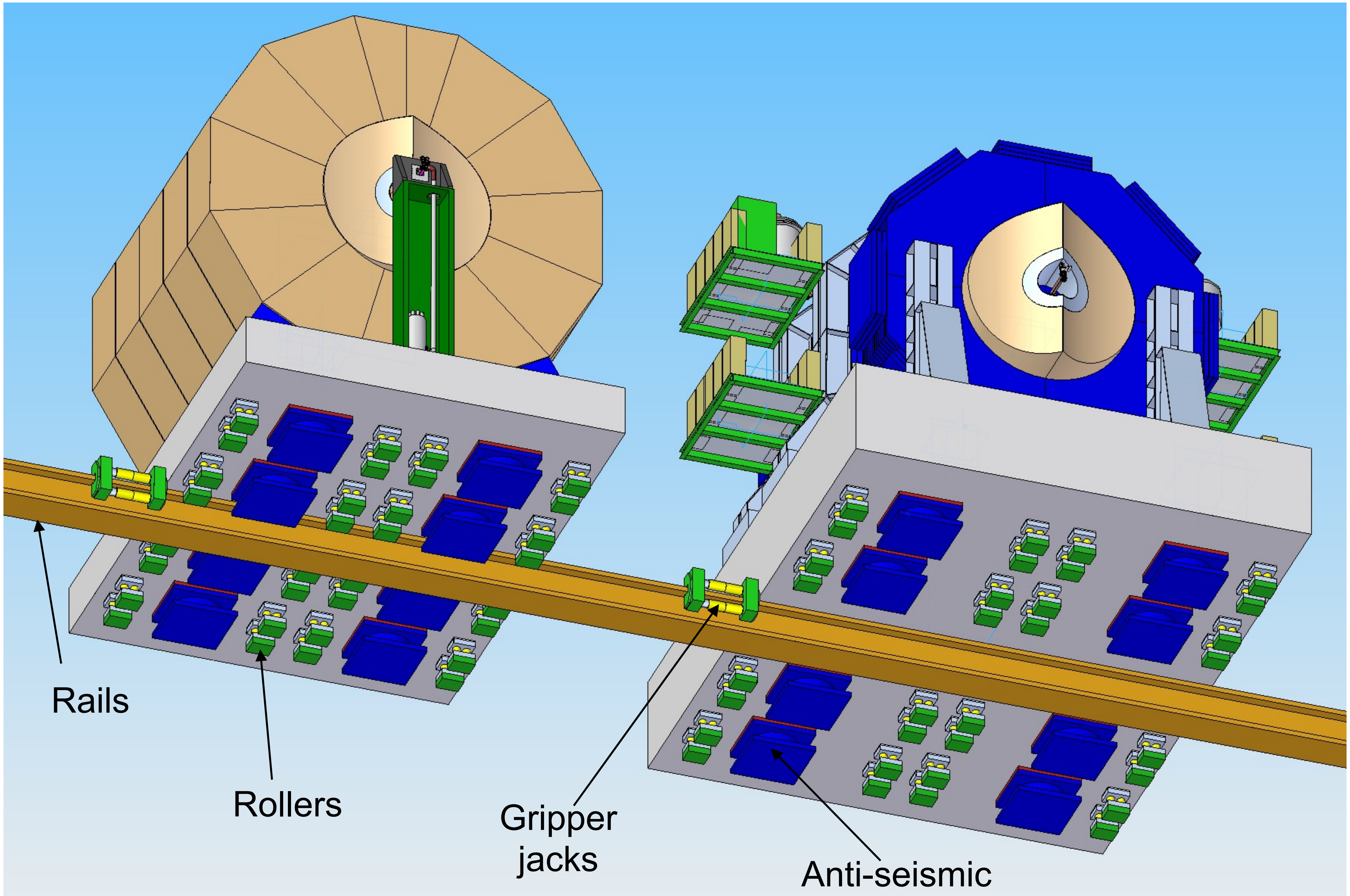
Magnetic Field on Steel Floor



- Simulation with steel layer on platform
- Large induced magnetic fields! Might have consequence on reinforcements in concrete?

SiD Proposal on Platform Movement

Gripper Jacks on rail



- Will be discussed with CFS group

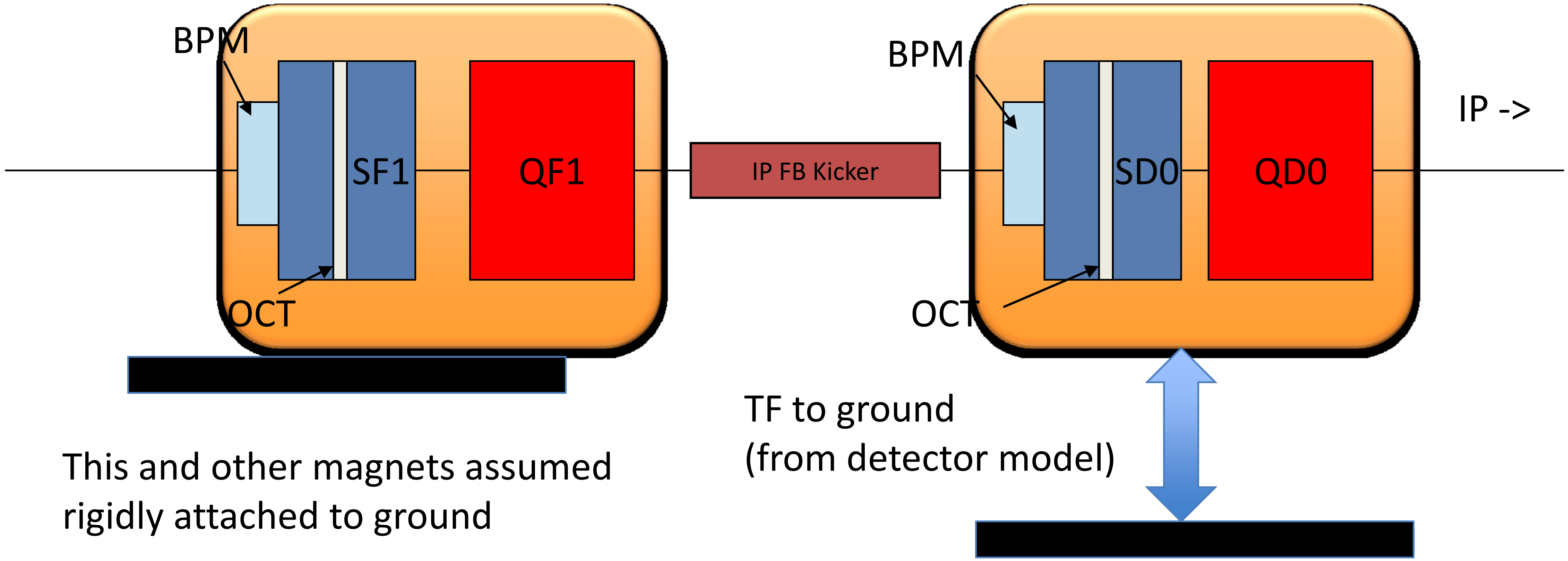
Simulation Overview

- Lucretia simulation of ILC BDS
  - ILC2006e (RDR) lattice and beam parameters
  - Reduce Nb 2625 -> 1320 for luminosity calculation with fast feedback to more closely mimic SB2009 parameter set
  - Electron and positron beamlines
- Ground motion applied to all ILC elements plus transfer function (TF) between ground and QD0/SD0/OC0 system.
- 50 consecutive pulses (10s) modelled with ground motion + pulse-pulse feedback.
  - Results shown for GM models 'A', 'B' and 'C'
  - QD0 system TF calculation for SiD "rigid support from platform" (Marco).
- Fast IP position feedback for tolerance estimates.
- Simplifications
  - RTML and Linac excluded from tracking simulation
  - Incoming beam perfectly aligned with first element (upstream FFB)
  - No intra-pulse misalignments
  - No other mechanical noise model of magnets applied

Simulation Parameters

- Initially perfect lattice.
- BPMs
  - Cavity systems throughout BDS
    - Resolution = 100nm
    - Scale factor error = 1%
  - Stripline BPMs for fast feedback
    - Resolution = 2um
    - Scale factor error = 1%
  - Corrector magnet field errors 0.1%
- 5 Hz feedback
  - Simple gain feedback, convergence 50 pulses
- Intra-pulse feedback
  - Based on detection of beam-beam kick at IP for small offsets using downstream stripline BPM and correction using stripline kicker system between QF1 & QD0 cryomodule systems
  - Feedback is PID controller using linearised look-up of beam-beam kick to IP beam offset model (up to turn-over point). Feedback convergence ~20 bunches for offsets left of turn-over point.

IP Region Final Doublet



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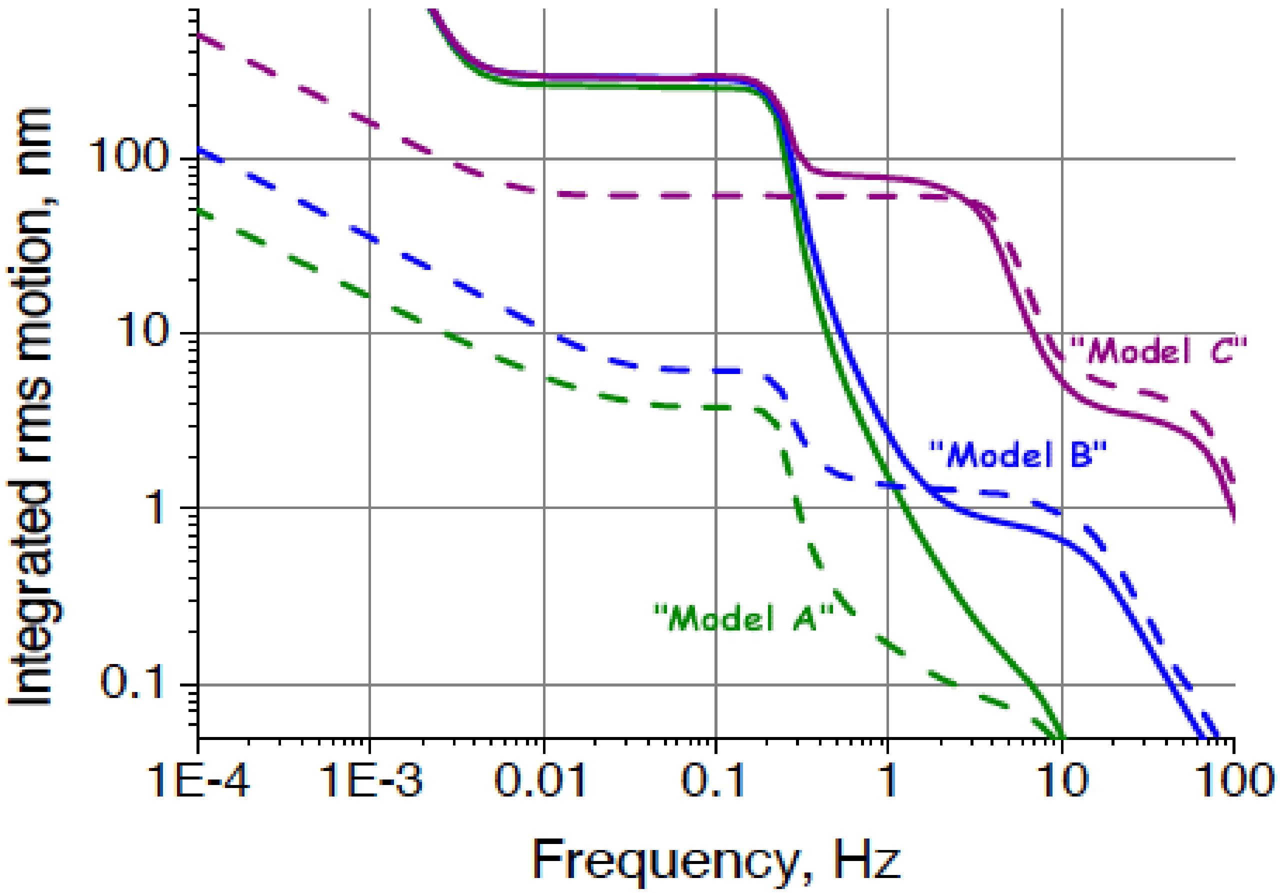
Ground Motion Spectra



- The simulation applies offsets due to ground motion according to Model 'A', 'B' or 'C'
- The spectra for these models indicative of 'quiet', 'average' and 'noisy' sites, mainly in terms of the magnitude of high frequency noise, are shown above

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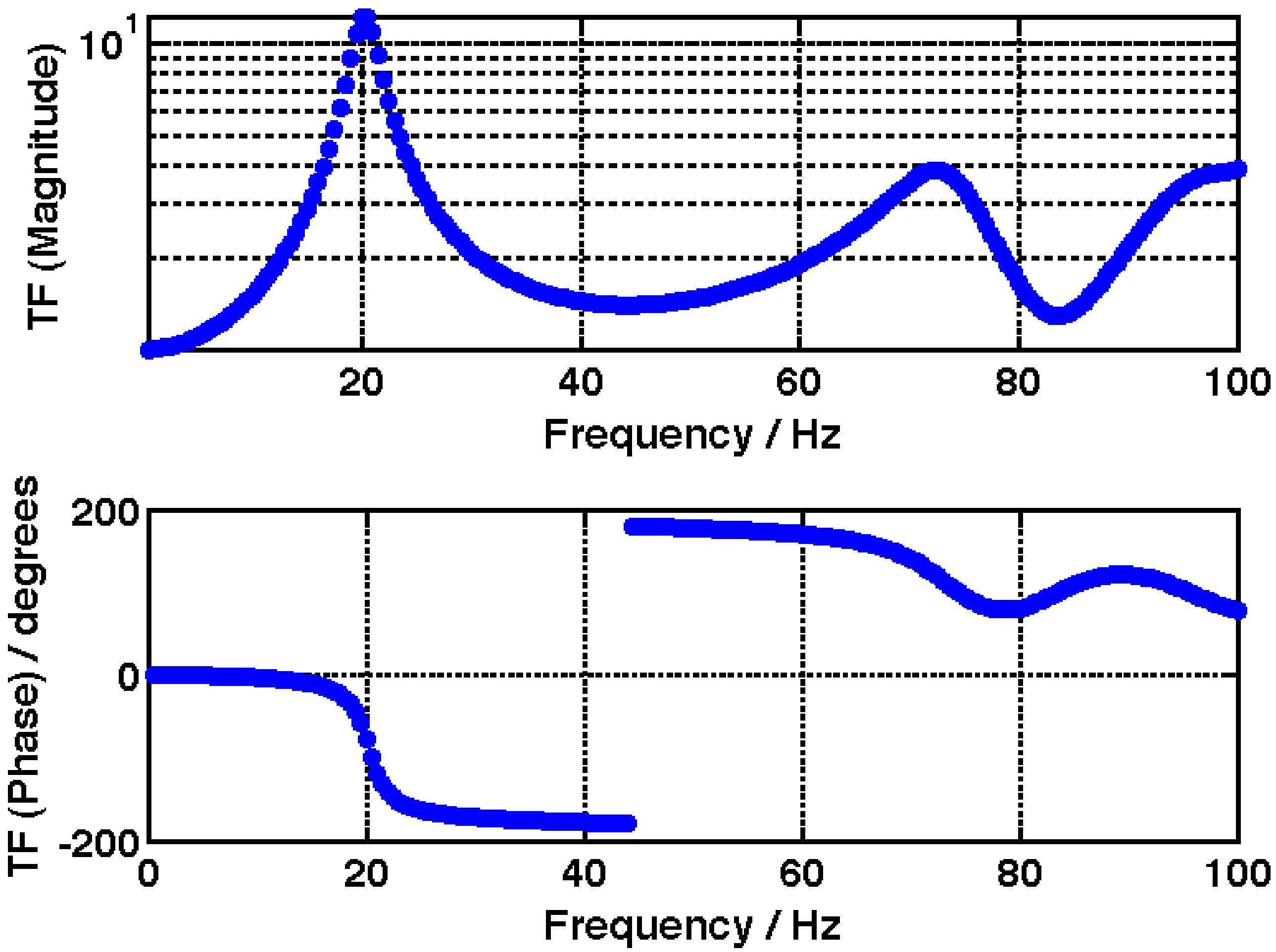
„Realistic“ Transfer Function for QD0

QD0 TF



- “Rigid support structure” model from SiD group (Marco). QD0 rigidly attached to detector platform.
- Apply to simulation girder element attached to SD0/OC0/QD0 cryomodule.

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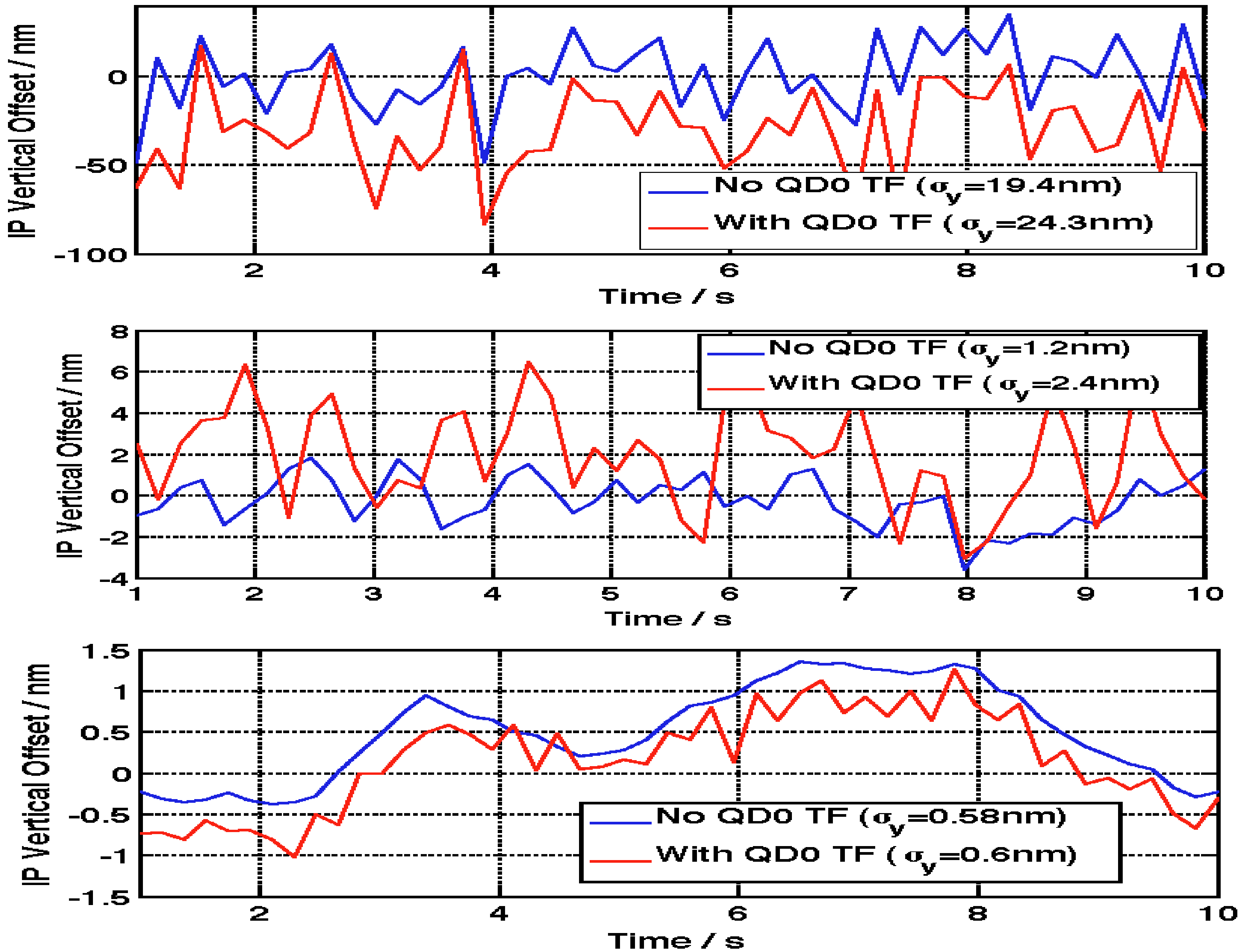
GM Induced Jitter @ IP (Vertical Offset between e- and e+ beams at IP) with and without QD0 TF



GM 'C'

GM 'B'

GM 'A'

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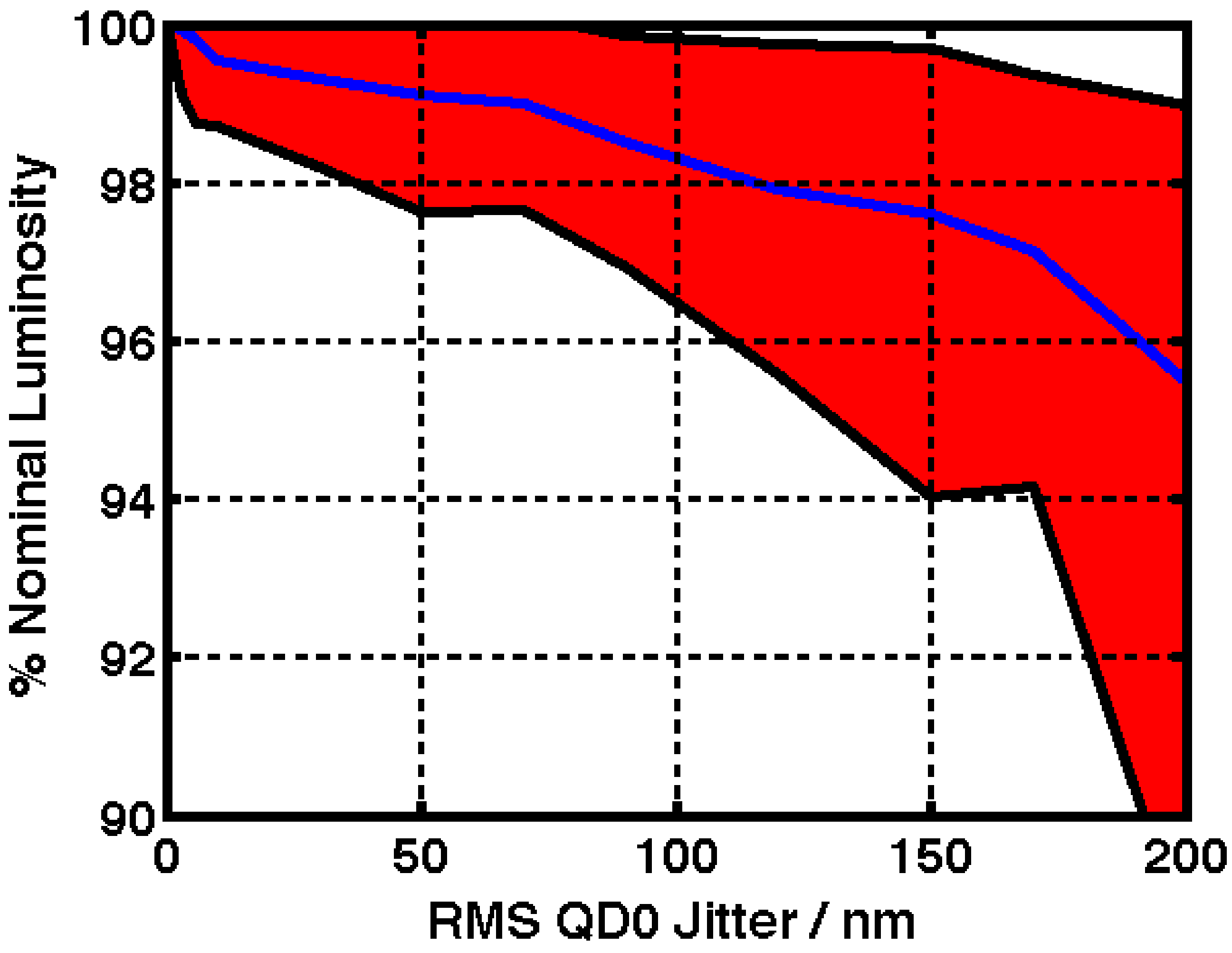
Luminosity Loss vs. QD0 Jitter



- Data shown gives % nominal luminosity for different levels of uncorrelated QD0 jitter.
  - 100 pulses simulated per jitter cases with FFB
  - Mean, 10% & 90% CL results shown for each jitter point from 100 pulse simulations
- **Tolerance to keep luminosity loss <1% is <50nm RMS QD0 jitter.**

G. White

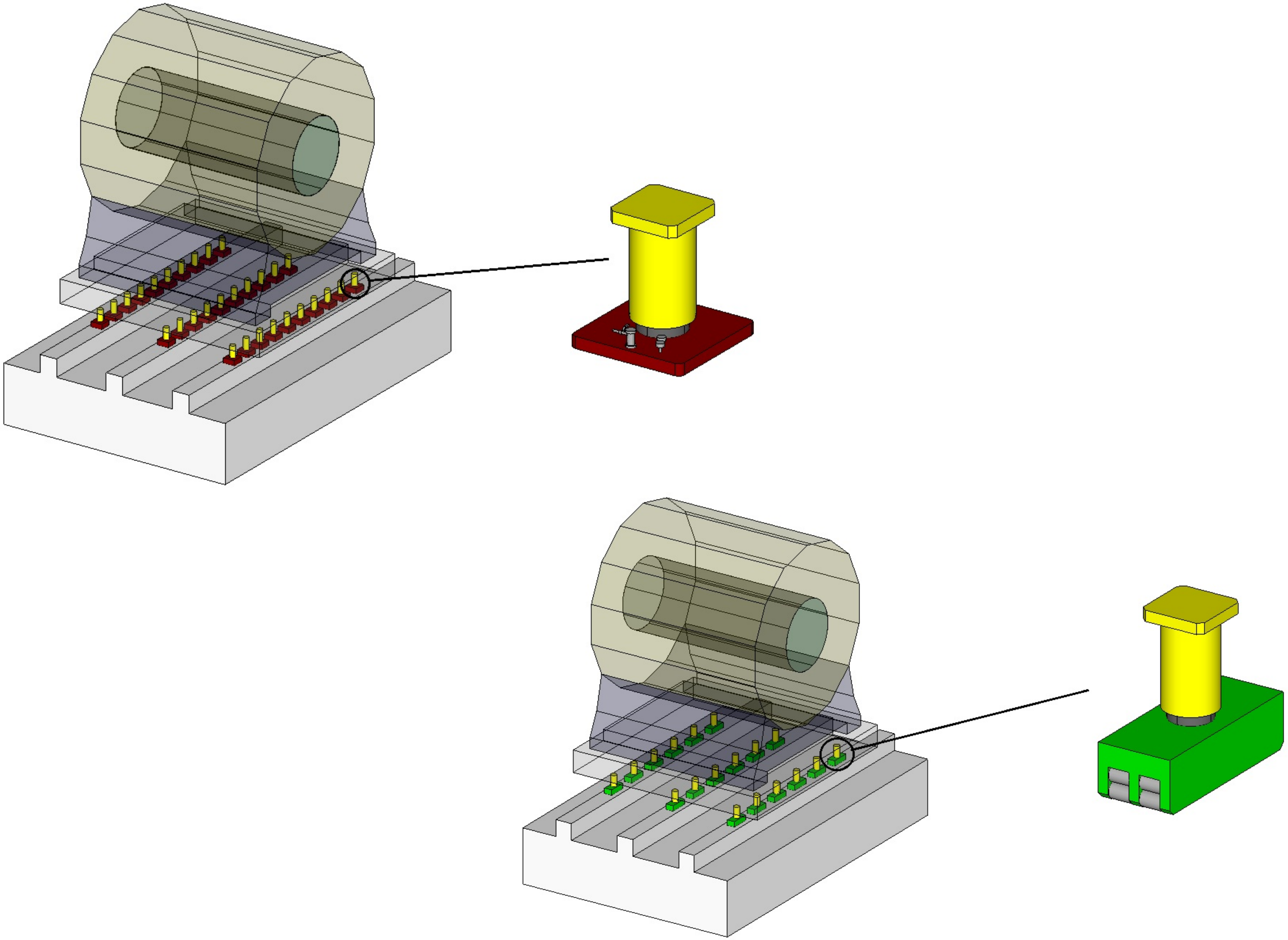
J. Osborne at ALCPG'11: Discussions with ARUP

Task 1 - The design of the underground concrete platforms required to transport each of the two Linear Collider Detectors on and off the beam-line position.

- Two platforms would be required, one for each detector.
- Load of each detector, excluding platforms, of approximately 14,000tons
- Intermediate supports determined by the preferred movement system.
- Platform movement on/off the beamline to be moved over a period of the order of five hours,
- Up to 20 movements per year during machine operation.
- Accelerations of the detector during movement to be limited to 0.5g
- Location of the platforms to within +/-1mm and +/-0.1 milli-rads of their target location relative to final focus quadrupole base slab.

ARUP's were asked to tender for 4 distinct tasks

J. Osborne at ALCPG'11: Discussions with ARUP

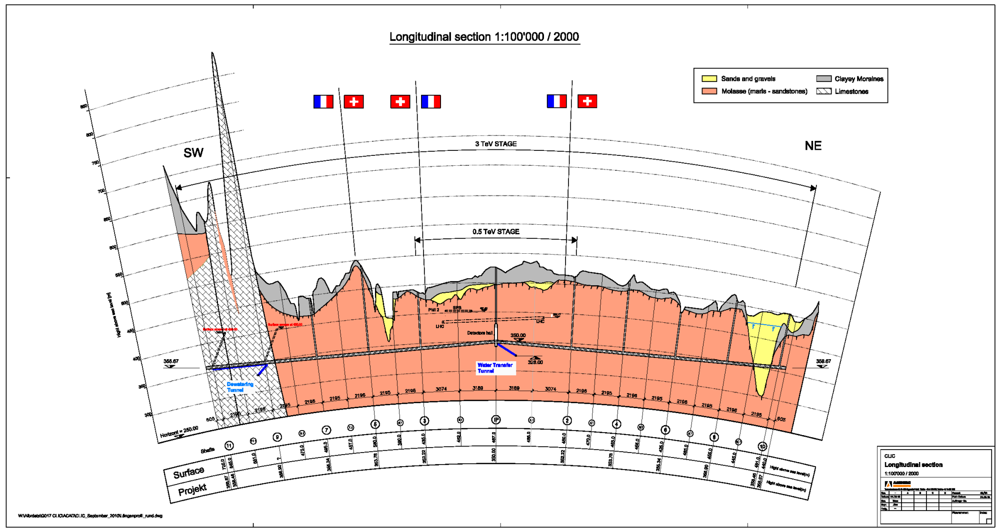


Air pads v Rollers for concrete platform movement will be further analysed

J. Osborne at ALCPG'11: Discussions with ARUP

Task 2 - A detailed study of the potential behaviour of the rock mass surrounding the experimental area during the estimated 20-year life span of the machine.

- Experience from other cavern rock related mass conditions should be taken into account e.g LHC.
- 2D and 3D effects to be assessed.
- The study should assume that the experimental area is to be built in CERN geology, in the Molasse Rock
- The long-term behaviour of the excavation



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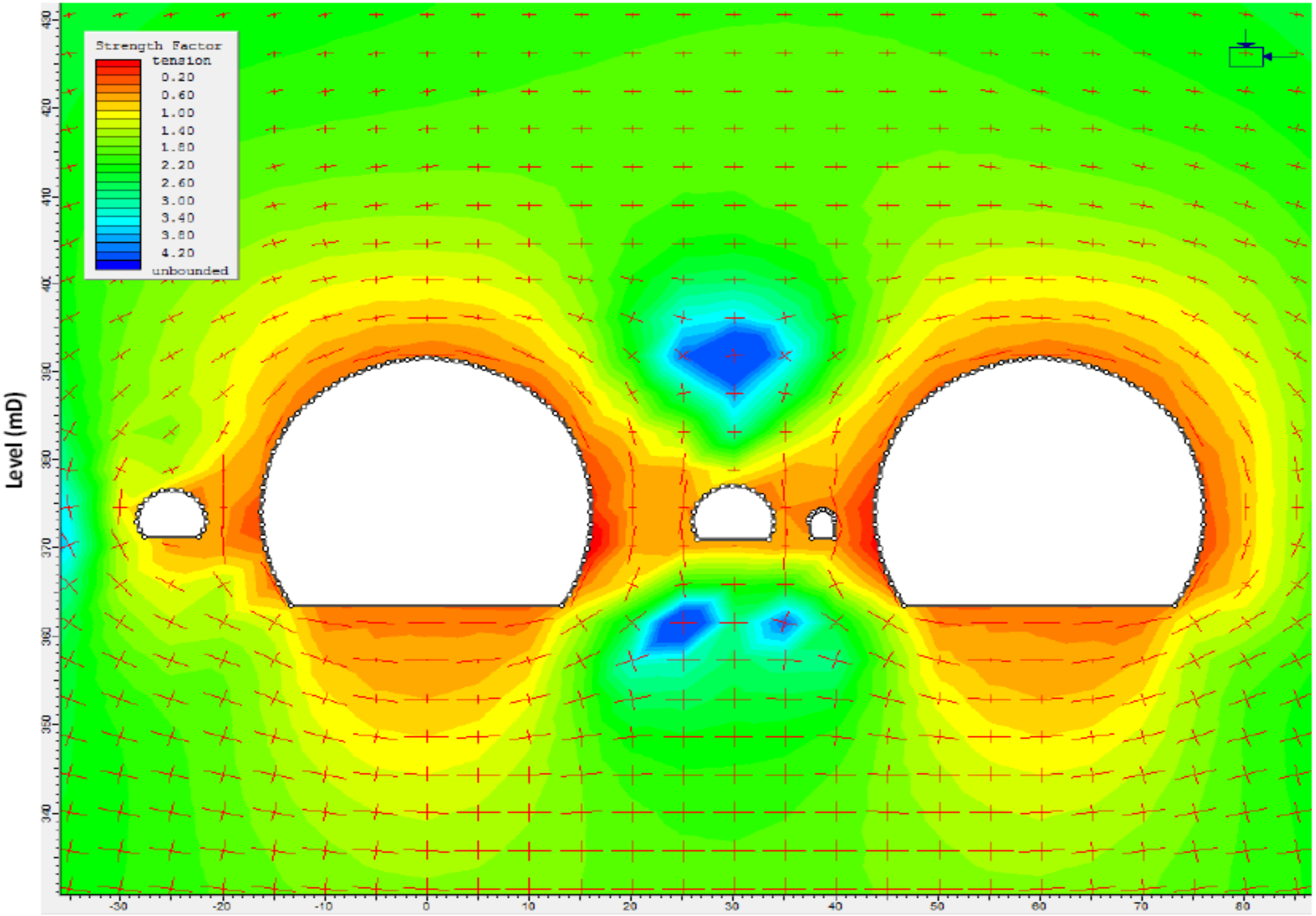
J. Osborne at ALCPG'11: Discussions with ARUP



2d and 3d models will be developed for CLIC to do a "Time-dependant" state analysis.
Possible 2nd phase use of these models for ILC layouts/geology.

J. Osborne at ALCPG'11: Discussions with ARUP

Task 3 - Passive isolation slab design

- Required maximum relative rms displacement of the beams is 0.1nm.
- Below 4Hz, vibration can be mitigated by active systems through steering the beam.
- Provide passive isolation at the end of each accelerator tunnel, where the beams emerge from the tunnel before entering the detector.
- Slab could be approximately 50 – 100 tons of concrete, resting on several springs and dampers – this will be assessed through our evaluation, as outlined below.

Task 4 - Review of the Experimental Area design

- Layout of the shafts/cavern based on available geotechnical information and current space proofing.
- Review of suitability of various strata depths for cavern location

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Budget for this Linear Collider IR study needs to be sourced :

- Possible cost sharing CERN & Fermilab

Some key decisions for ILC to resolve first, in order to allow a more 'useful' study :

- Are both detectors using the "concrete" platform strategy
- Are the level of the platforms the same
- For the overall layout :
  - Gantry crane capacity in the experimental hall
  - Should shafts be directly over the cavern or offset
  - Self shielding detectors

13

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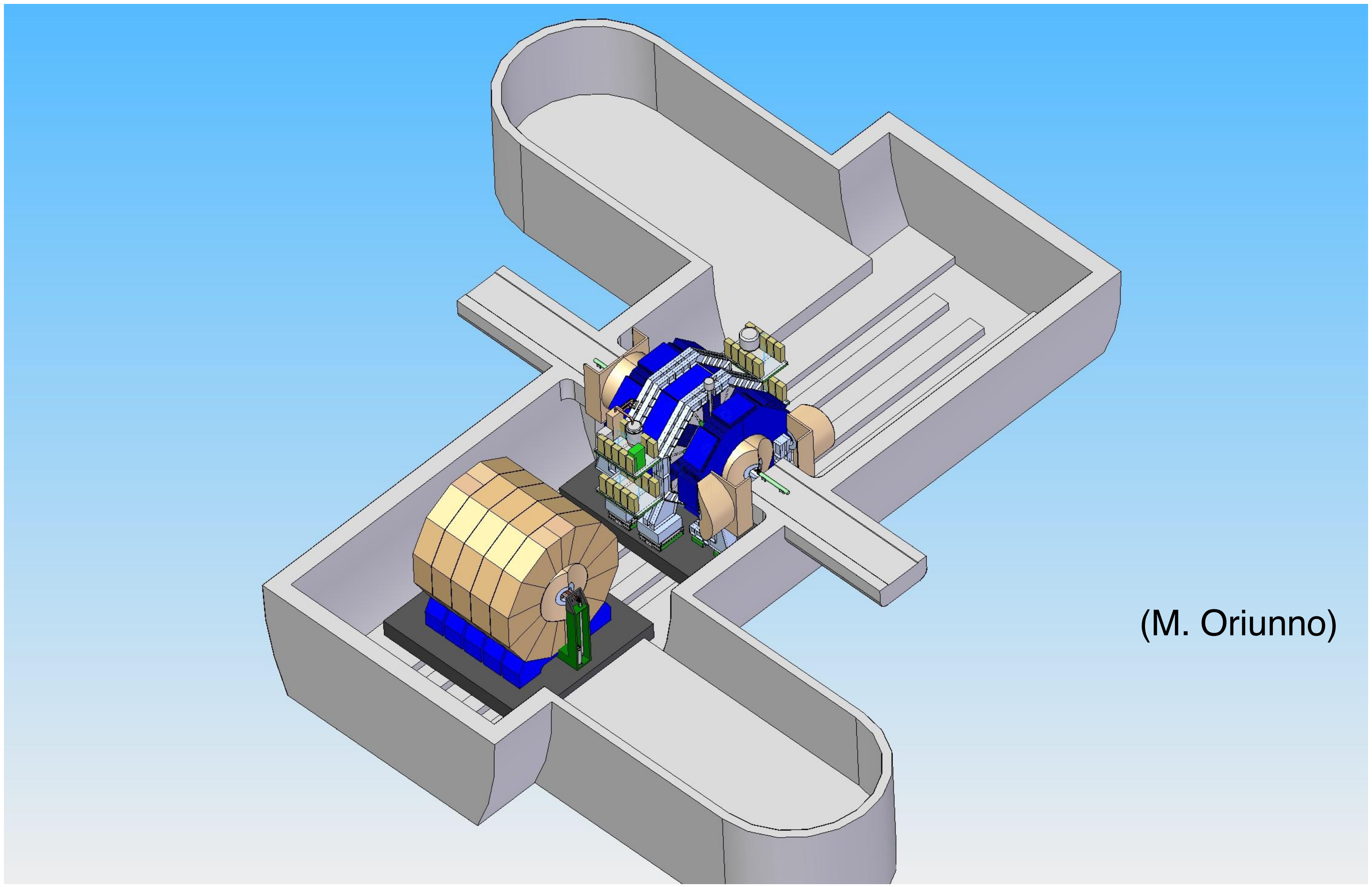
More about experimental hall: this afternoon.....

13

Platform Based Detector Motion System

ETH Institute for Particle Physics

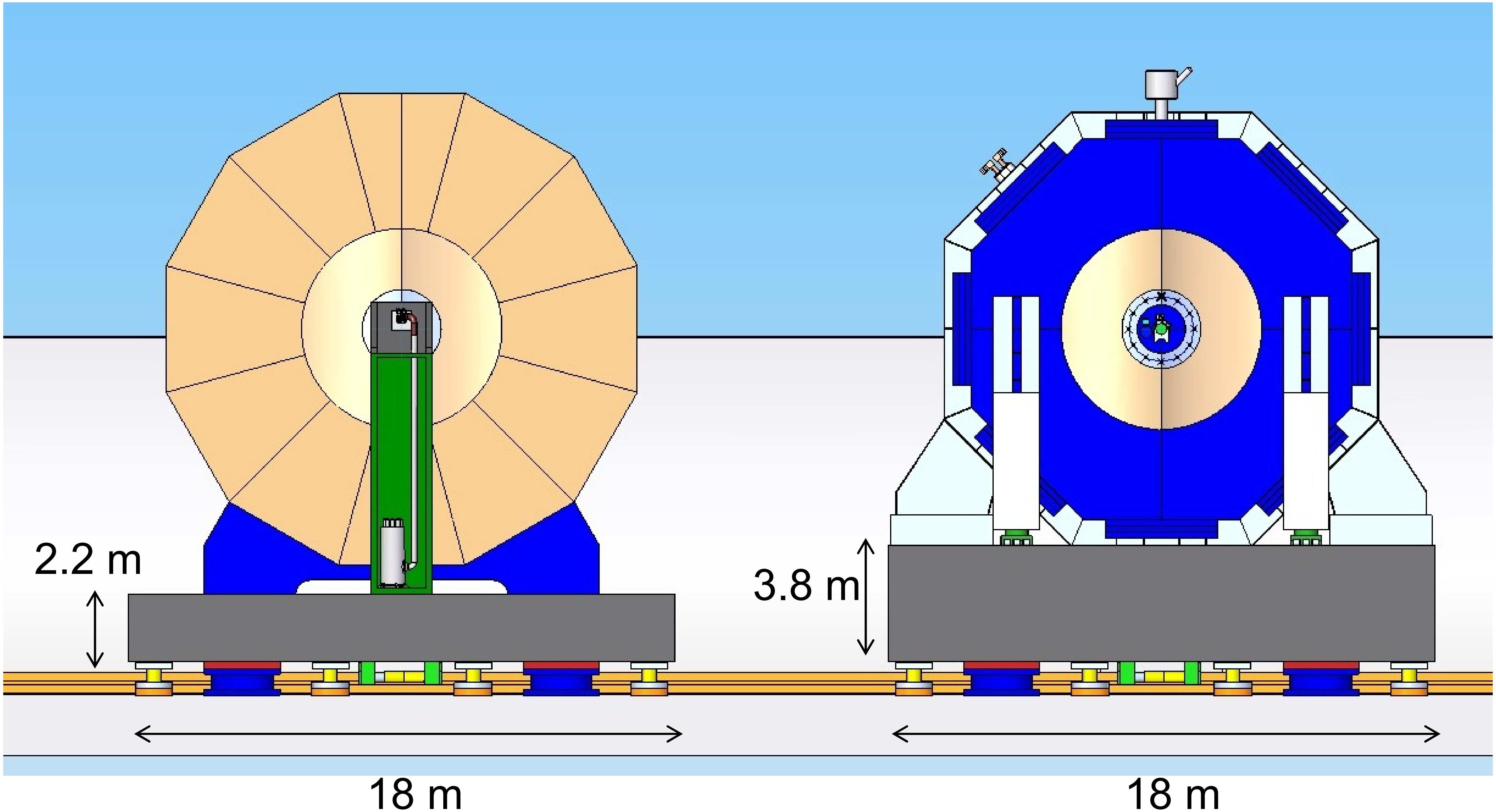
Both detectors on a platform



Alain Hervé, CLIC08 Workshop, 16 October 2008 5

- Now common working assumption

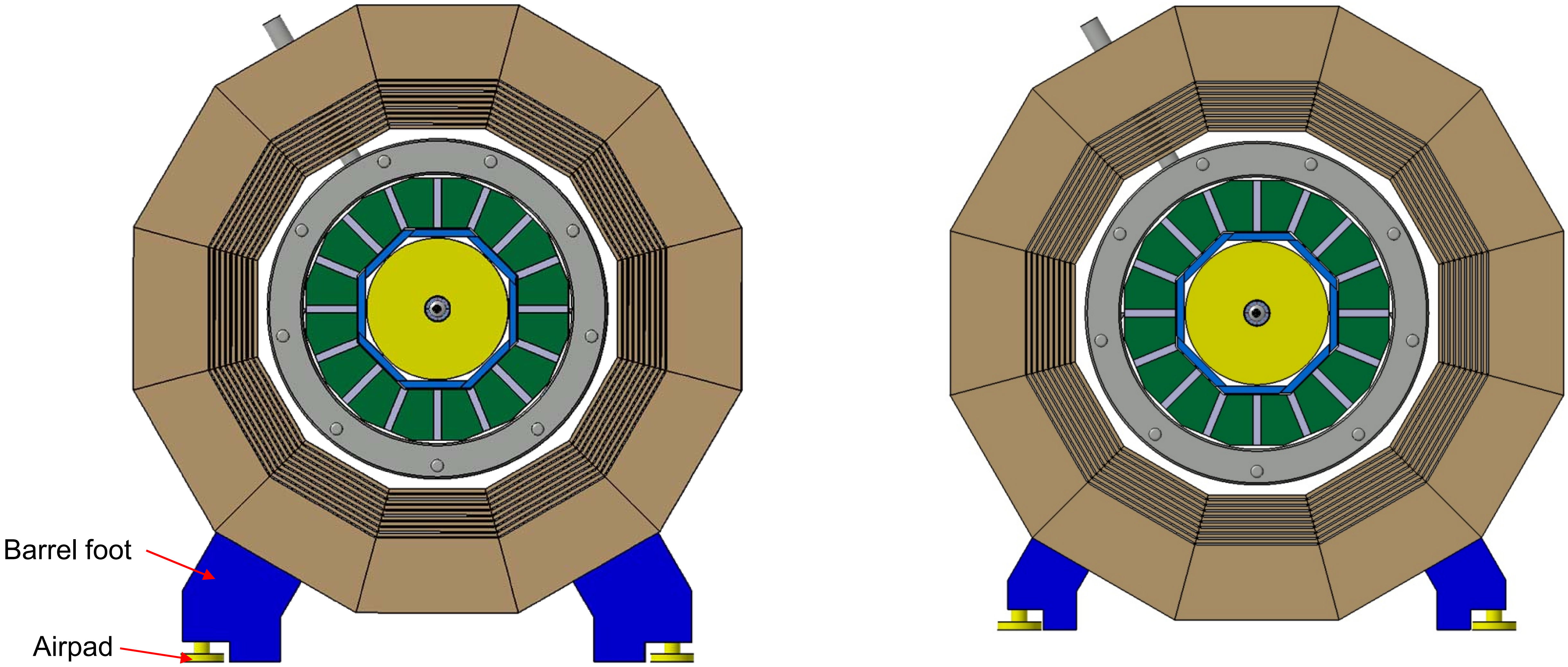
Reducing ILD Beam Height



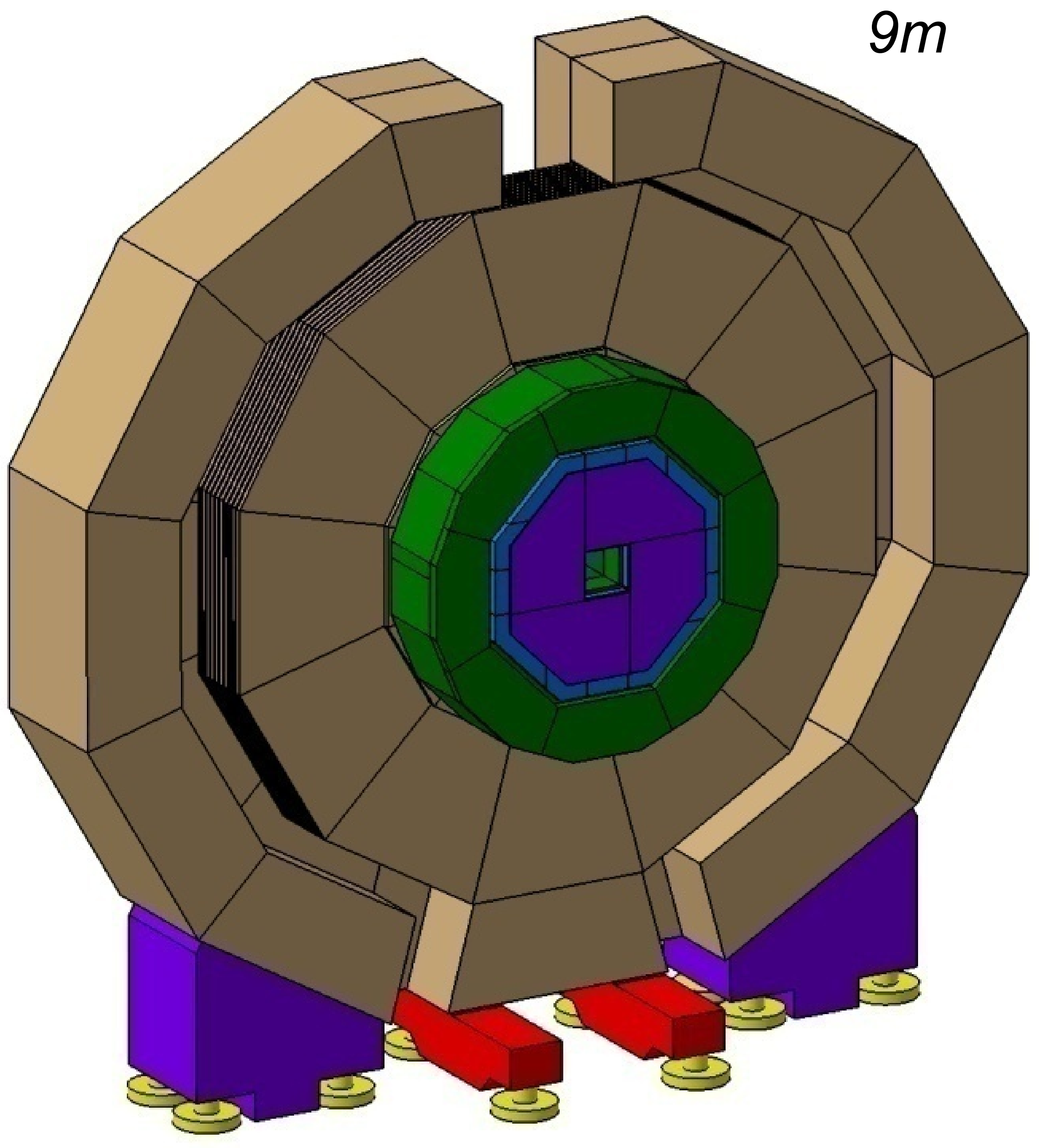
From M. Oriunno @ SiD workshop 2010 after CERN workshop

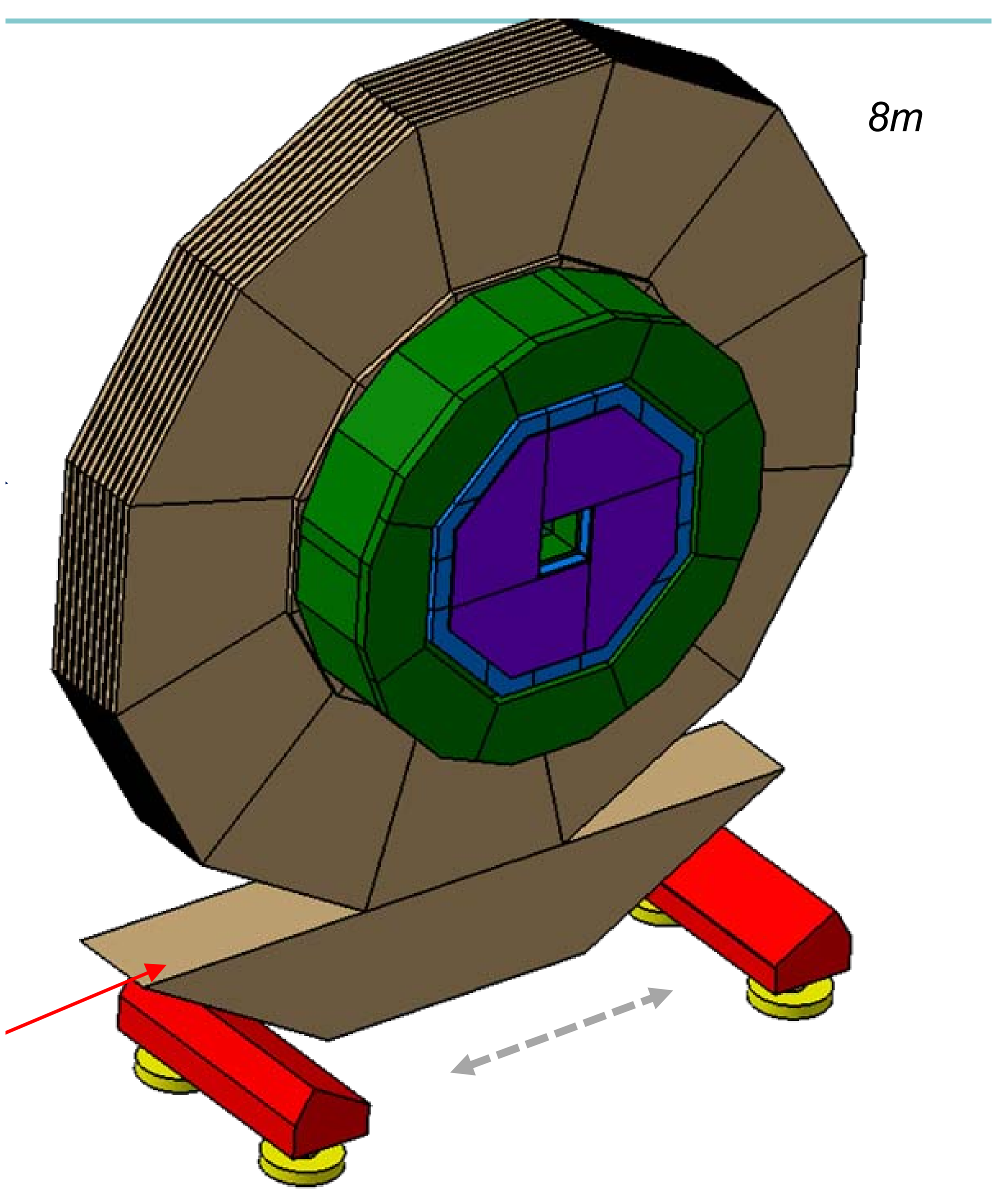
- Beam height difference between SiD and ILD: 1.6m
  - This results in different floor levels in the underground hall

Reducing ILD Beam Height



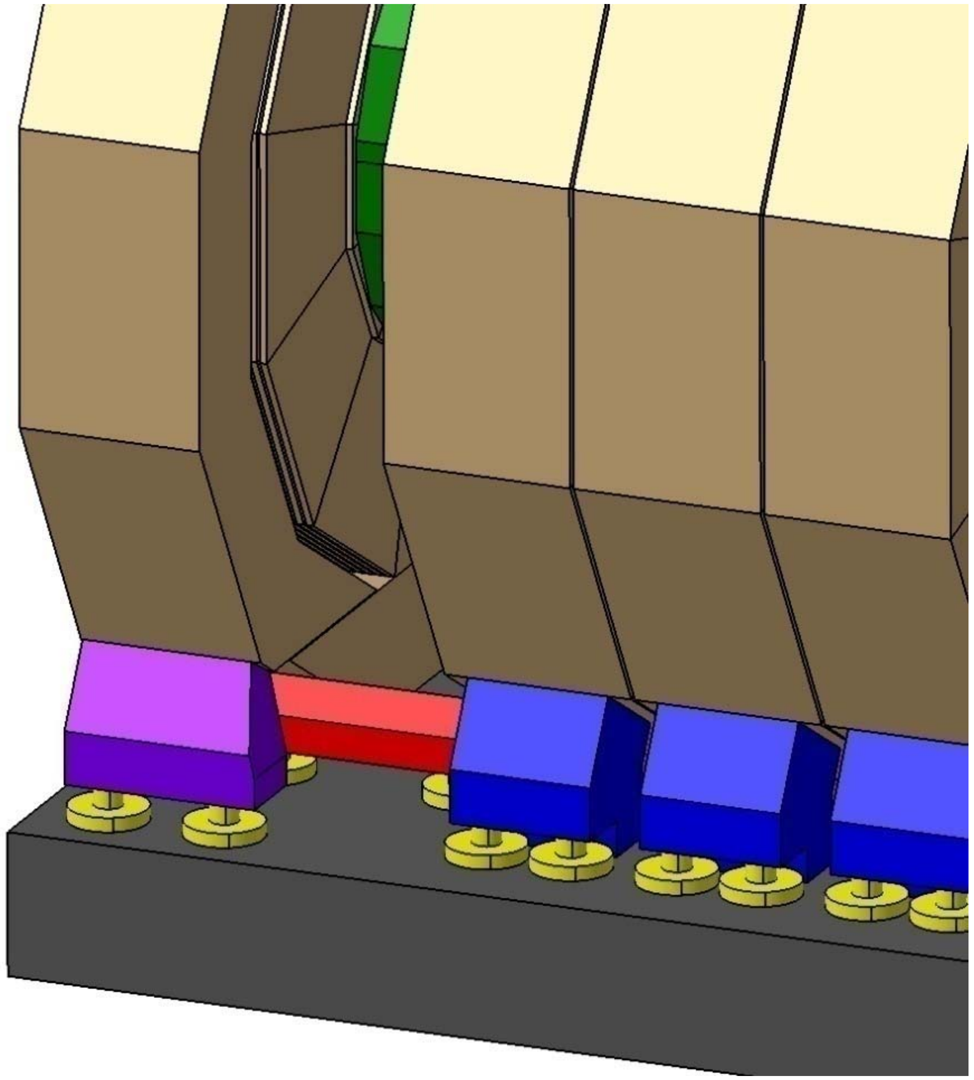
- Barrel yoke modification

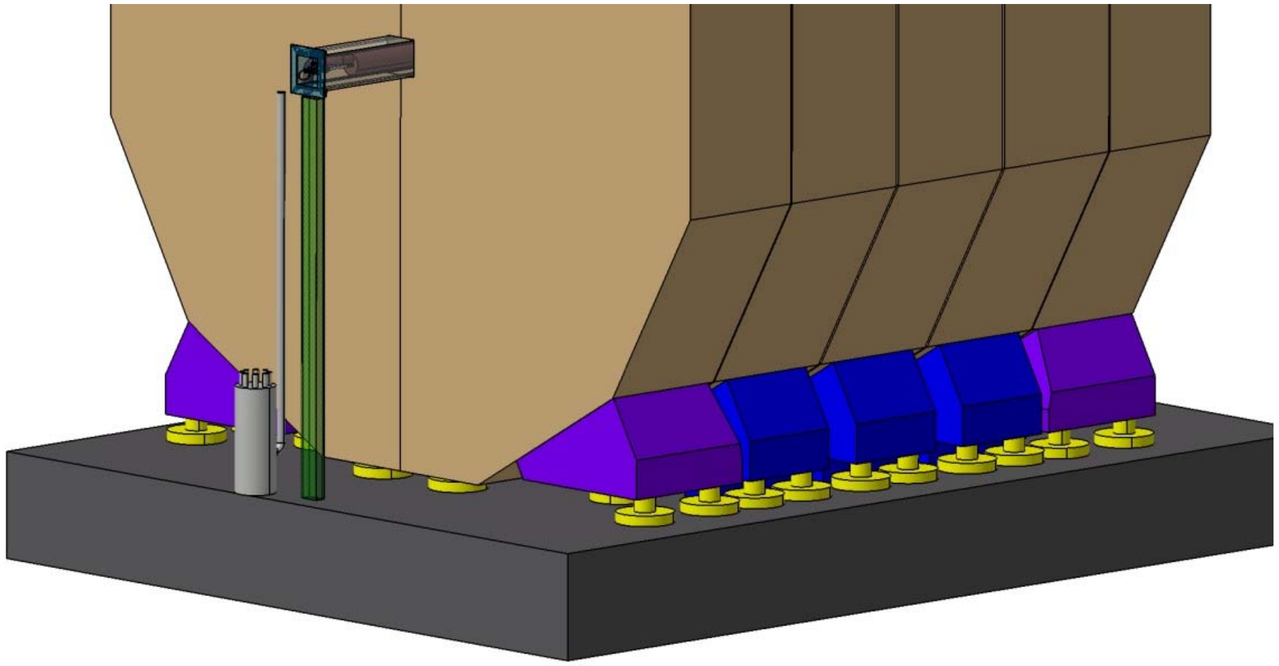


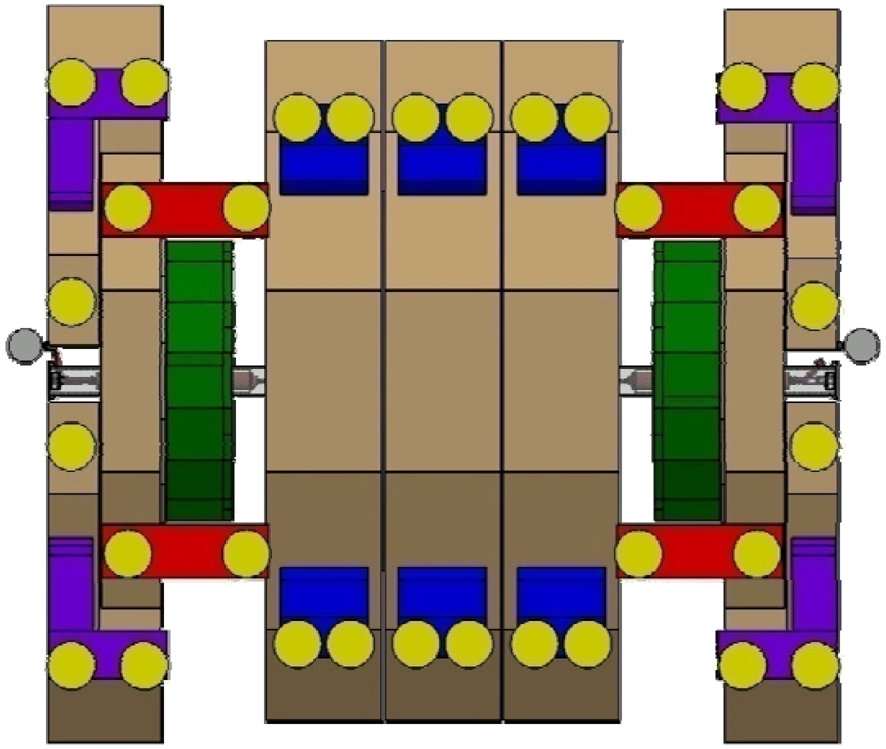


- Endcap yoke is more problematic
  - Split endcap design gets complicated

Reducing ILD Beam Height

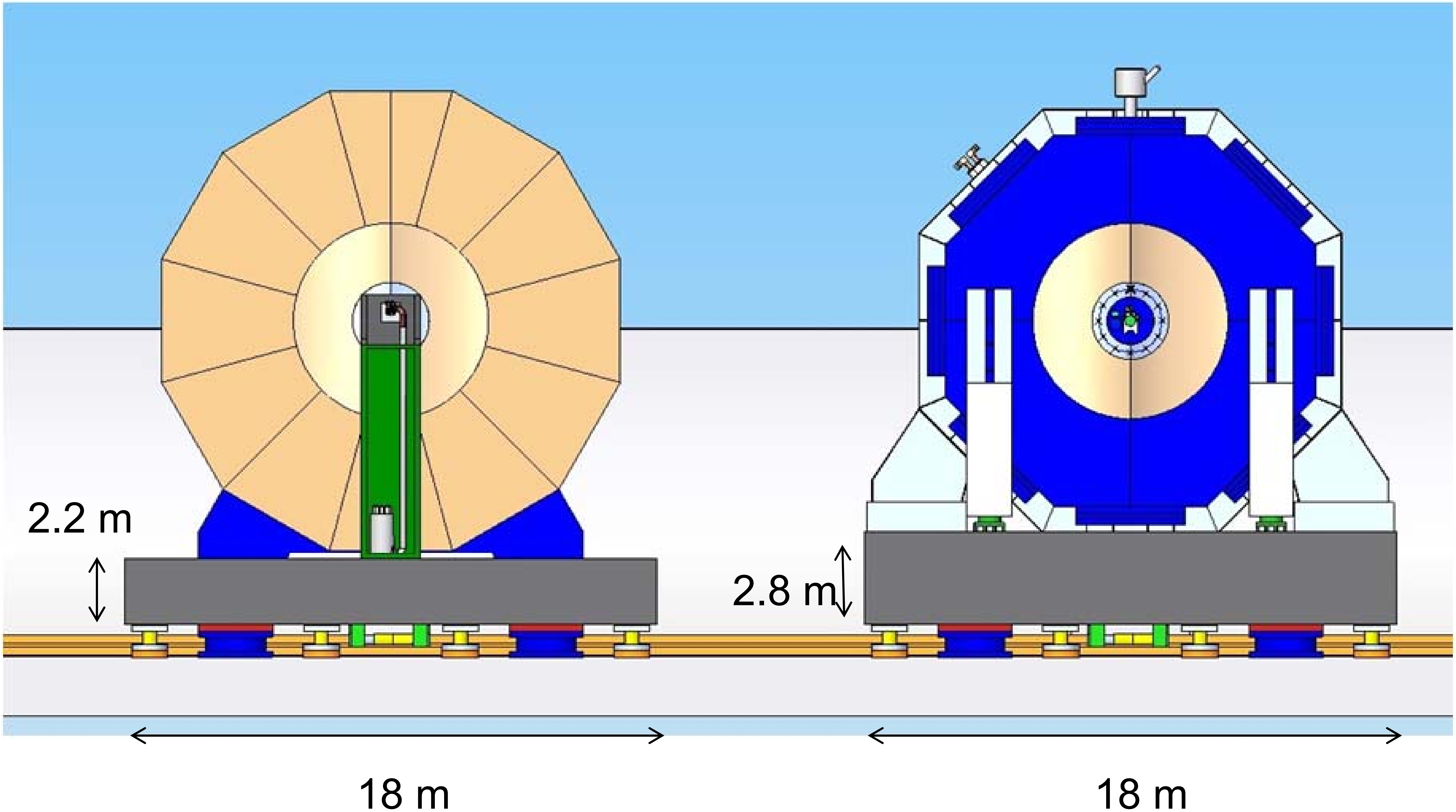






- Possible configuration of feet and airpads

Reducing ILD Beam Height



- Reducing difference to 0.6m
  - Maybe even less if yoke instrumentation design will be changed

Summary

- Important milestone has been reached in time:
  - Common working assumption is a platform based detector motion system
- A lot of work has been done to reach that conclusion, most of it in friendly collaboration with SiD and the GDE
- Need to look at platform requirements (c.f. SiD)
- Need to synchronise with the CFS work on the underground hall and the push-pull system
  - more on the hall later today
- We have many ongoing tasks for ILD, the progress is however resource-driven, not task-driven...