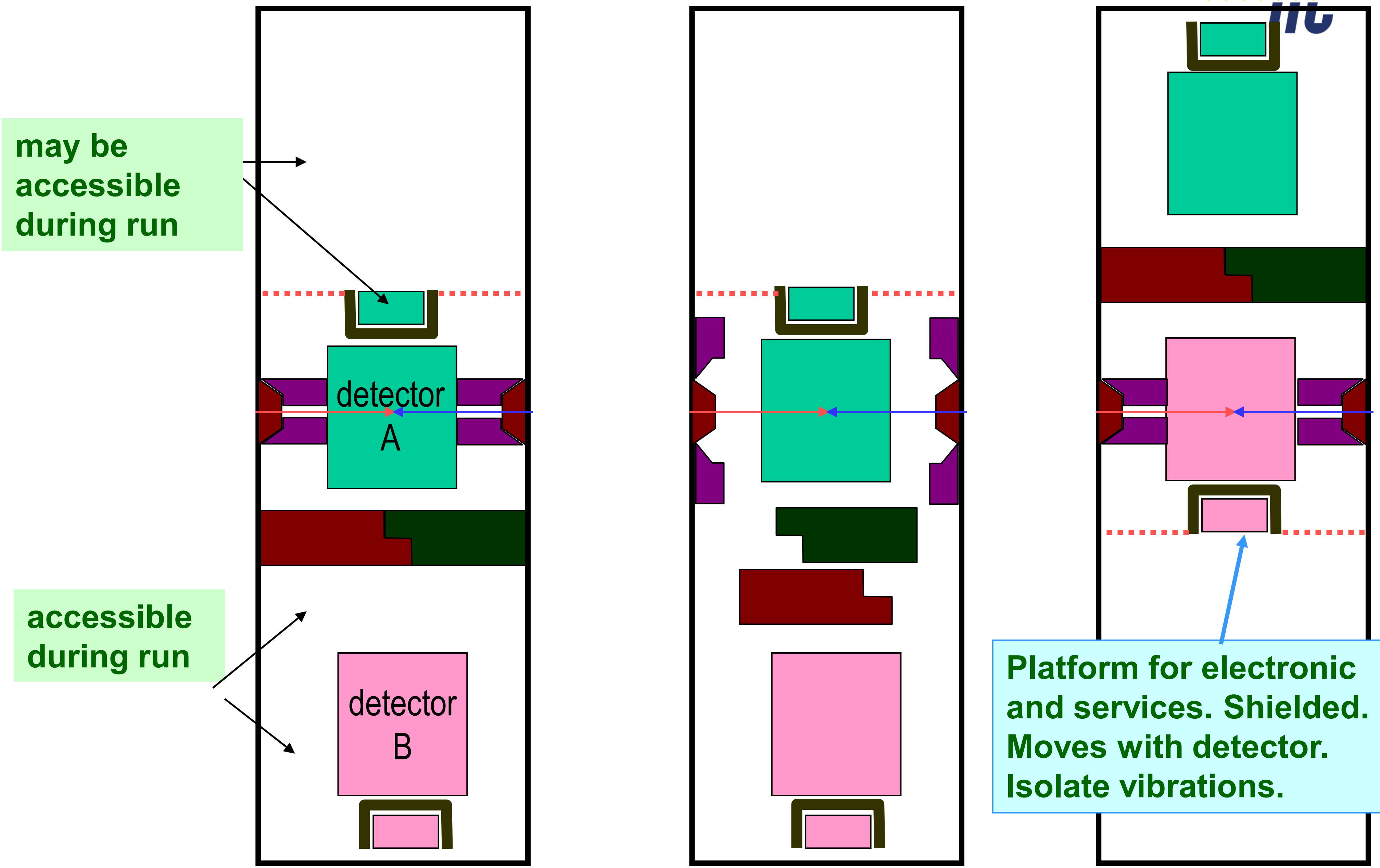
Planning the Push-Pull

Marco Oriunno, SLAC

First idea (~2006)



The Challenge

- Unprecedented for the HEP community
- Underground operations ~100 m
- Large Masses ~15’000 T
- Precision mechanism ±1 mm
- Fast interchange ~ few days
- Very low vibrations

Beam Delivery System Req.

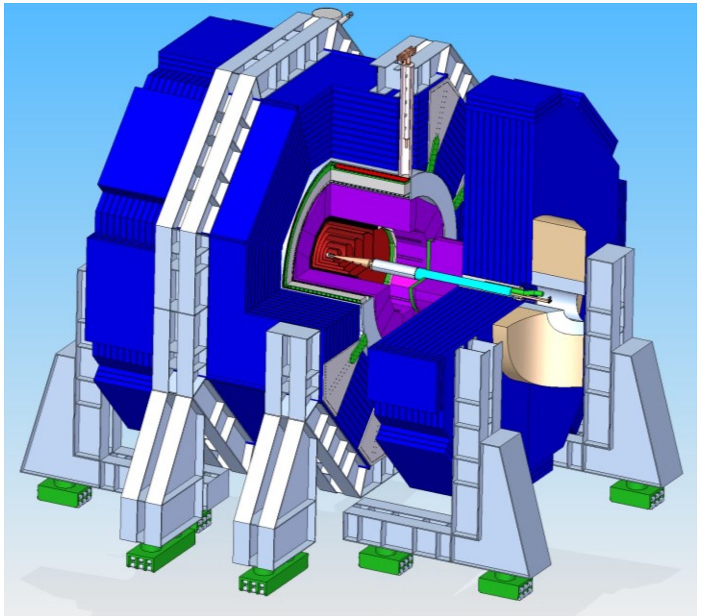
- A small L* (3.5 m – 4.5 m) to maximize luminosity, and thus the last machine elements penetrate inside the detector.

- Small size beams (nm level), requiring extreme stability of the BDS.

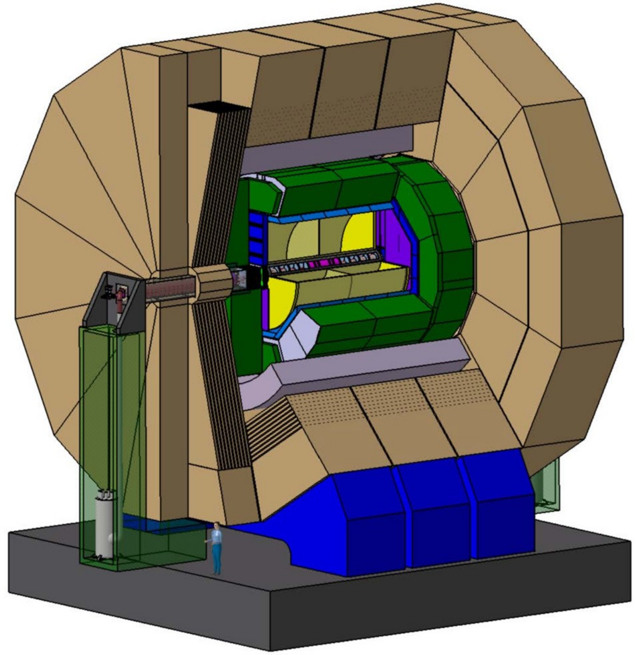
- A beam fast Feed Back system is also mandatory to correct movements at higher frequencies.

- Pre-alignment system is needed to correct for slow drifts

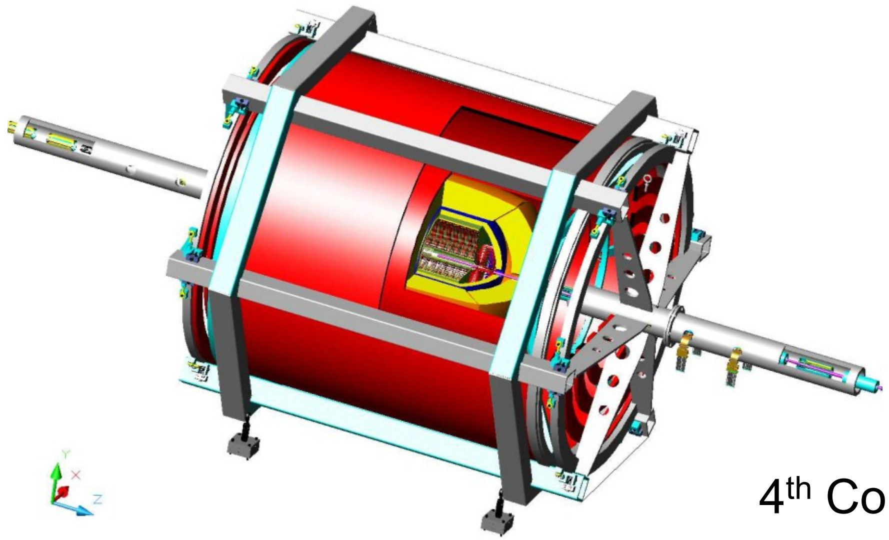
Push-Pull solutions (LoI)



SiD

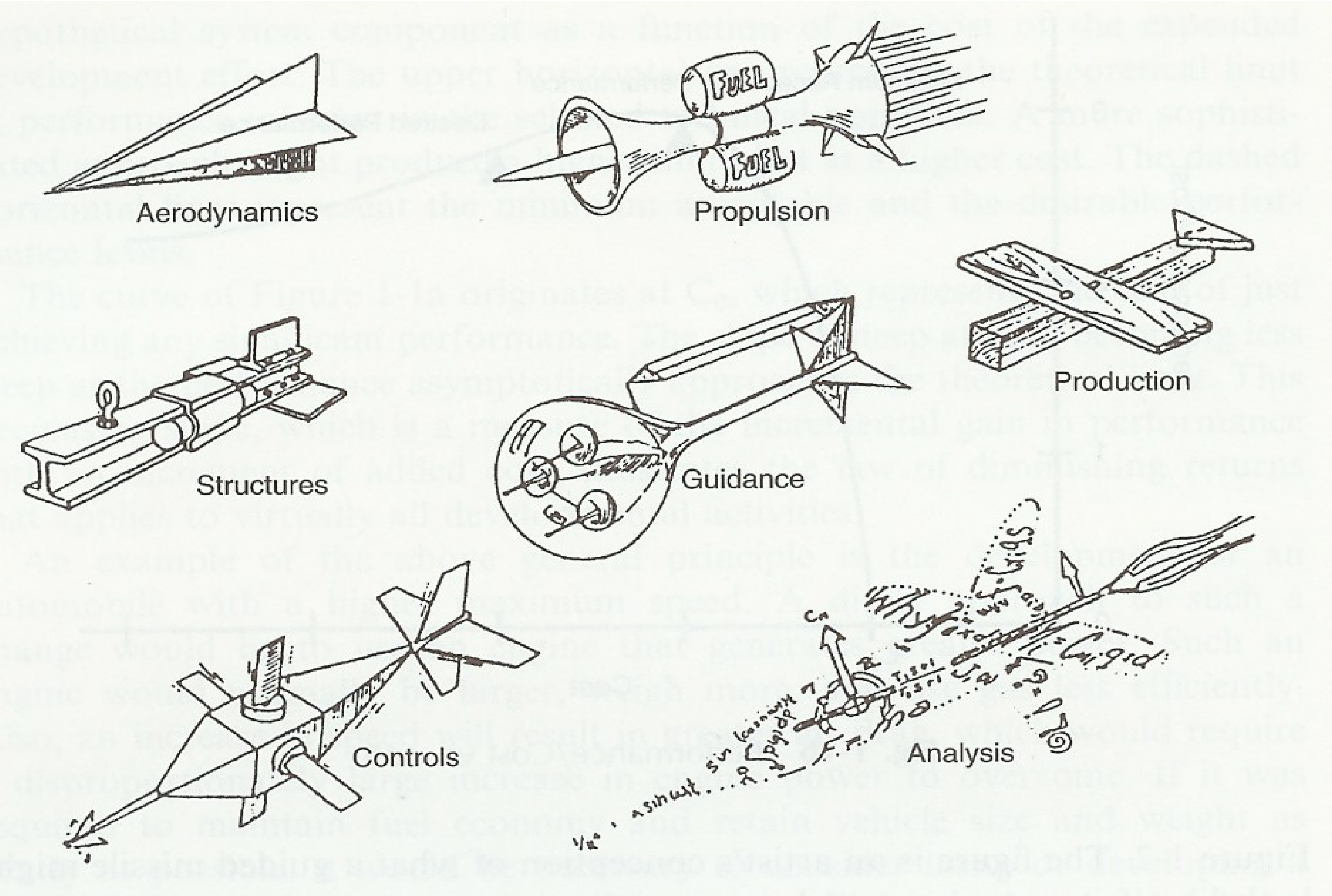


LCD+GLD = ILD

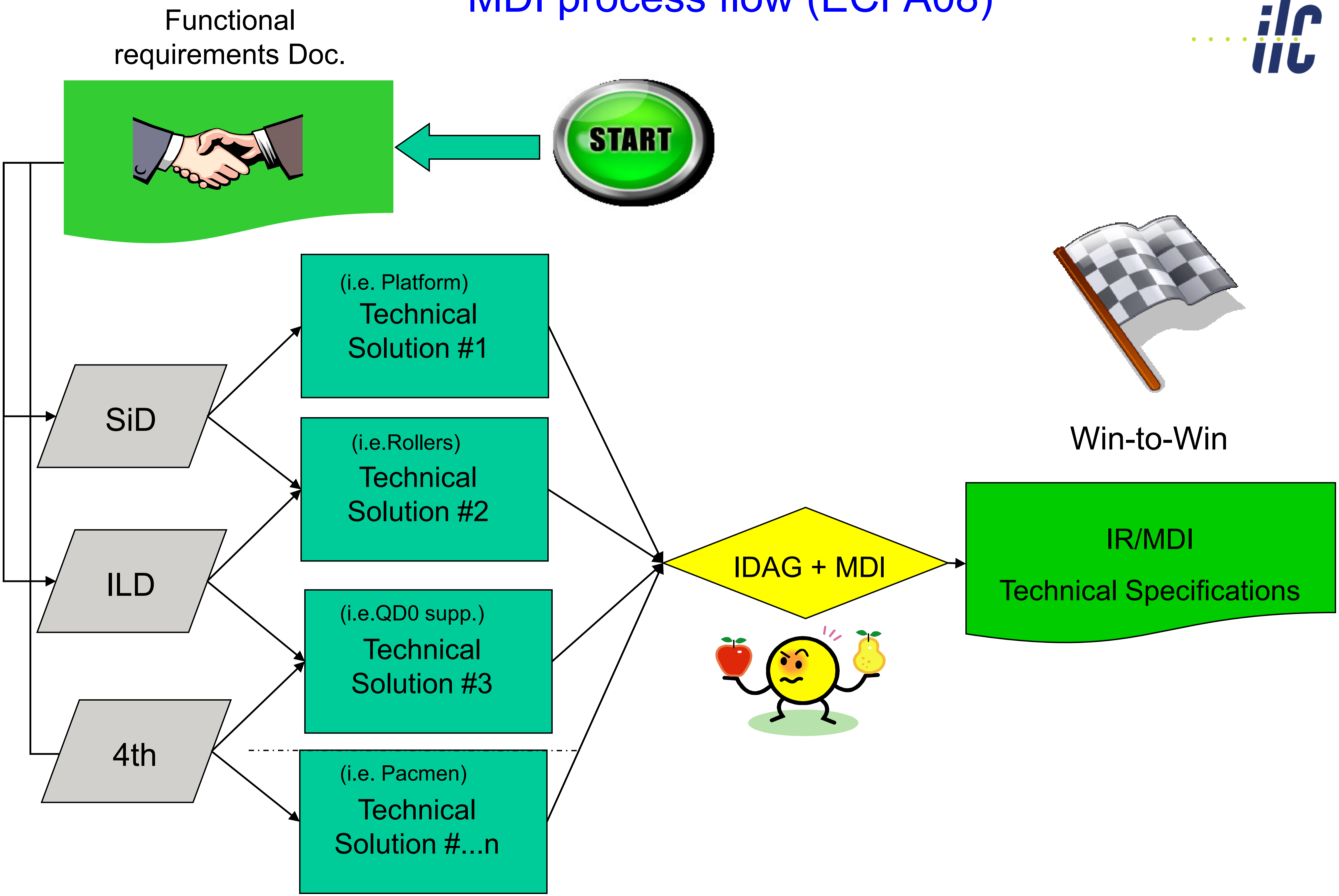


4^{th} Concept

Conceptual Design by features



MDI process flow (ECFA08)



Functional requirements

ILC-Note-2009-050 March 2009

Final Doublet
Elapsed time for an exchange of detectors
Roll out time
Roll in time
Cryogenic safety assumptions
Vacuum
Beam feedback system
Beam-Beam parameter space
QD0 support and alignment
Length of IR Hall
Beam height above the reinforced floor of the IR cavern
Radiation environment
Magnetic environment
The garage area housing the off beam line detector
The beam line
The area around the on beam line detector

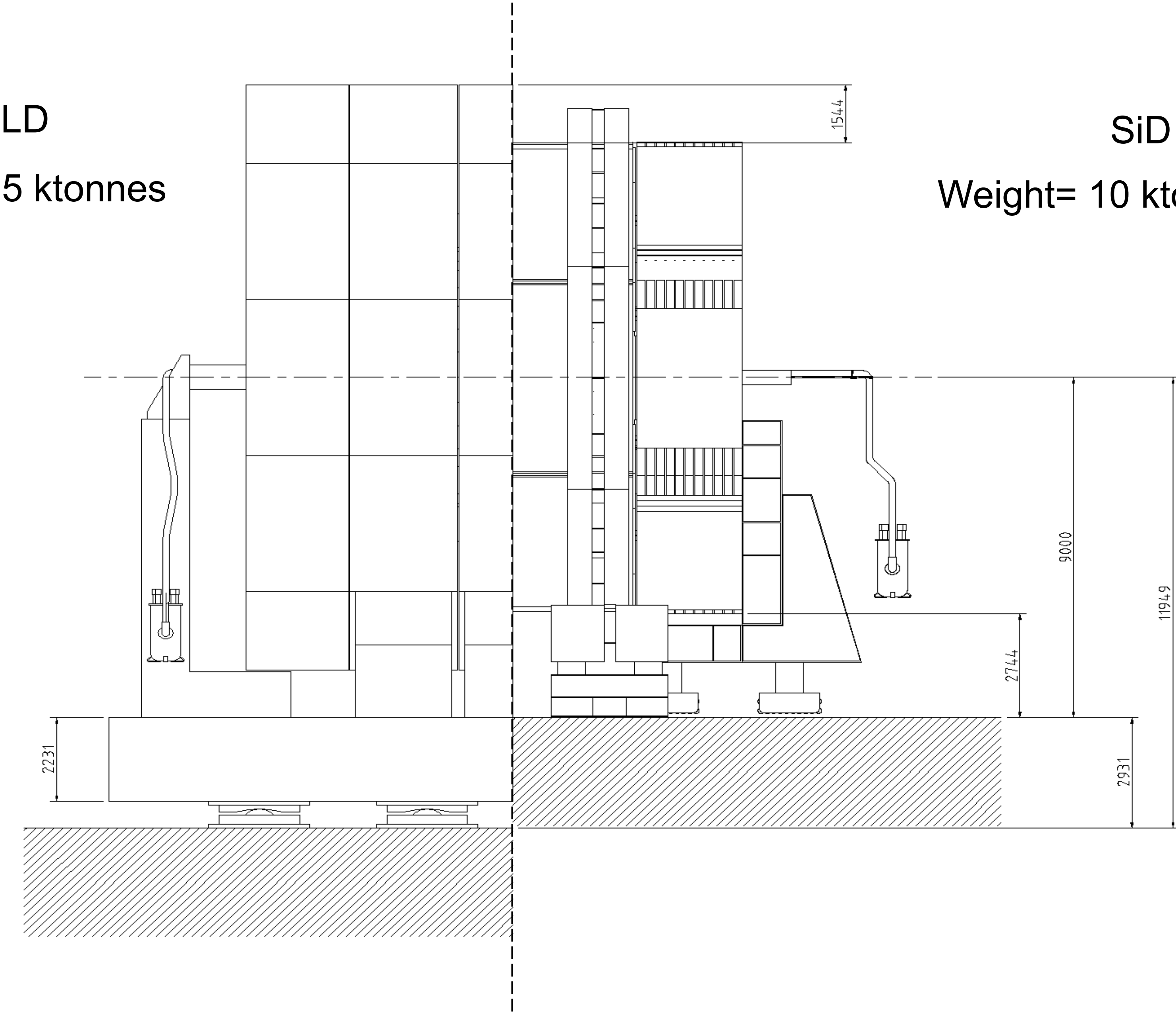
ILD and SiD differences

ILD

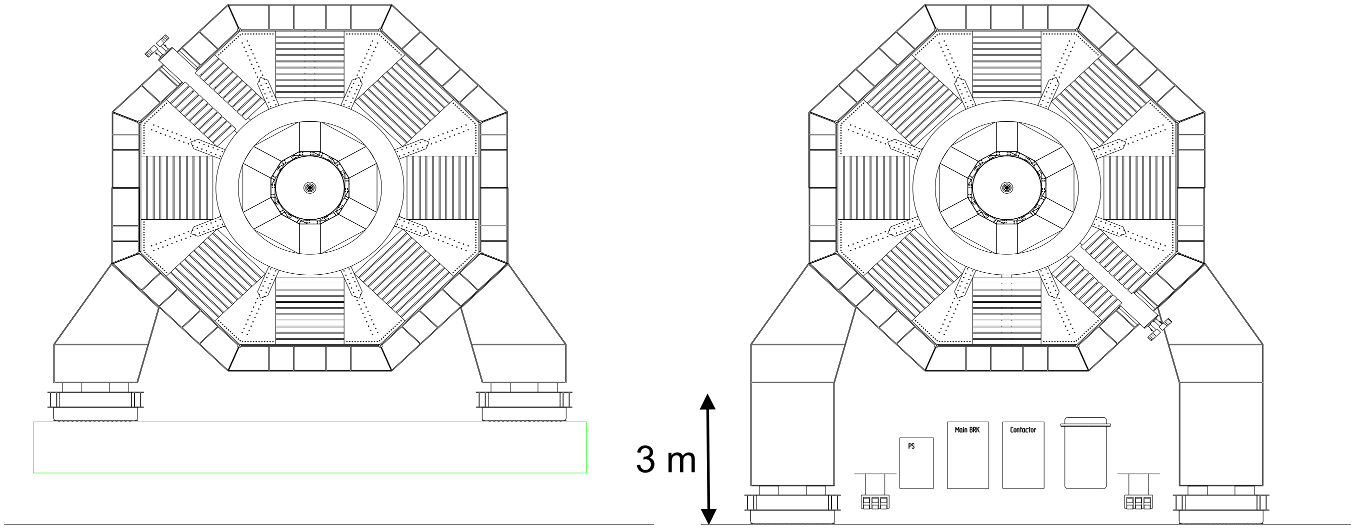
Weight= 15 ktonnes

SiD

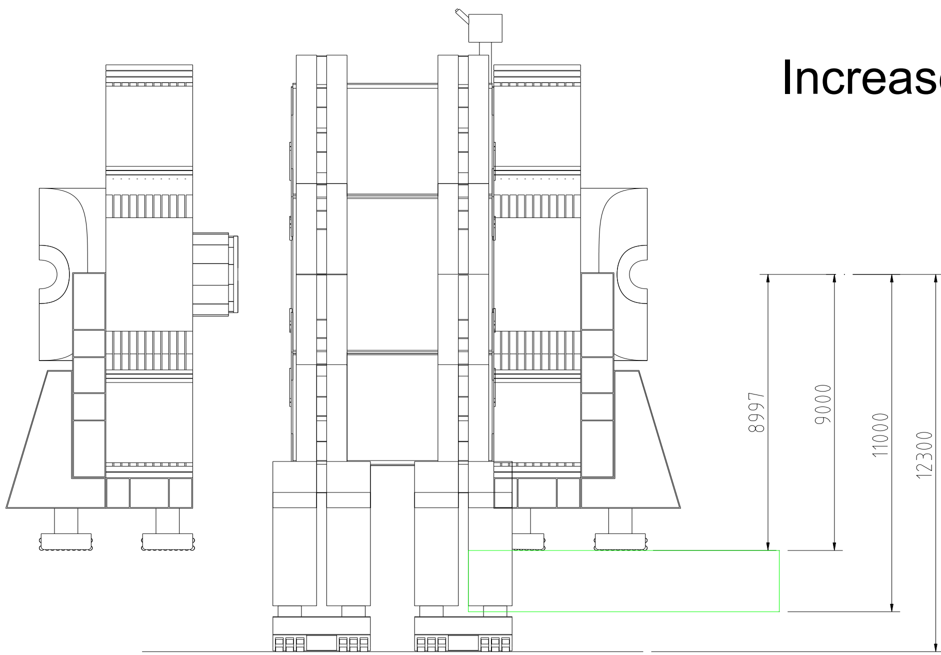
Weight= 10 ktonnes



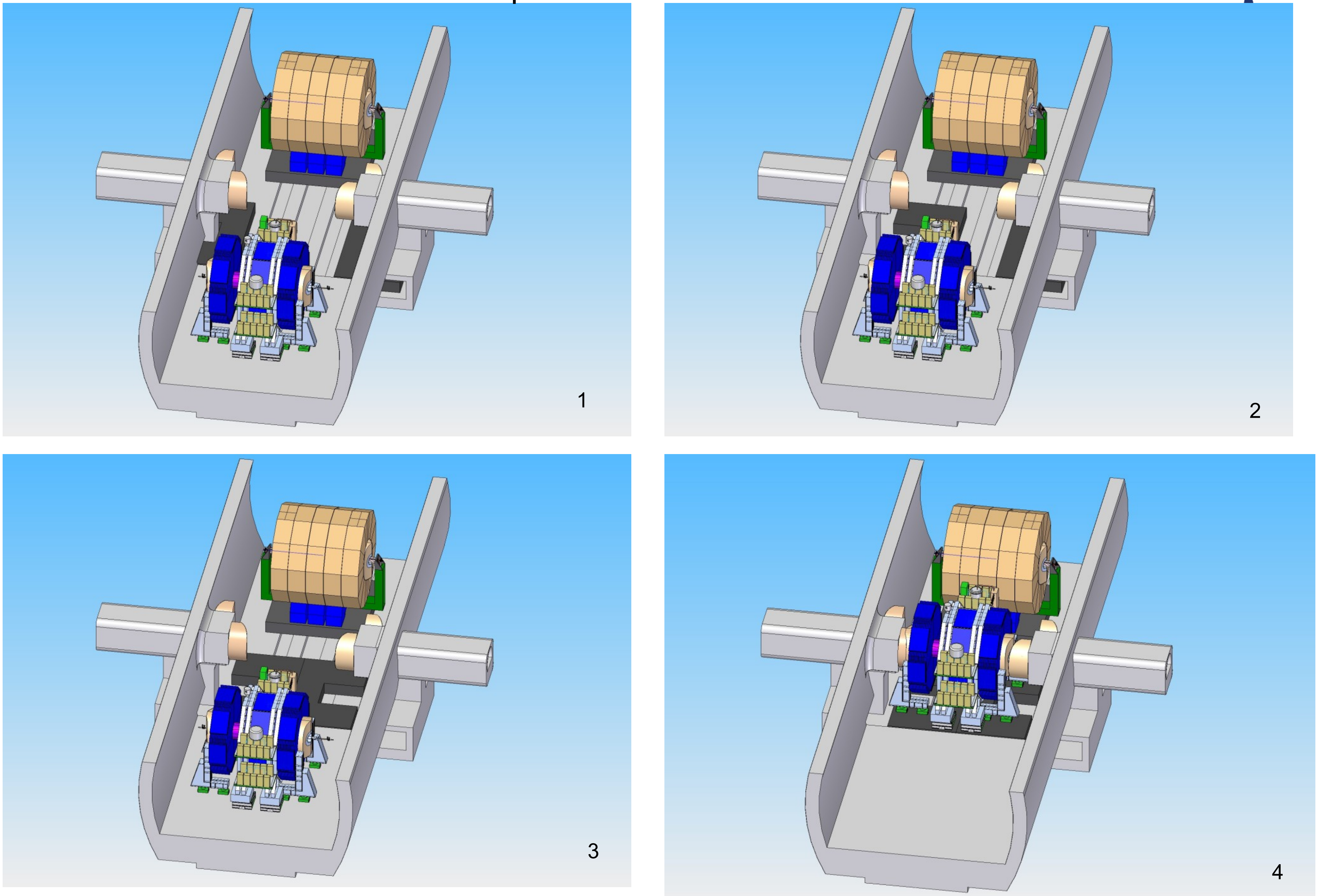
SiD with long legs



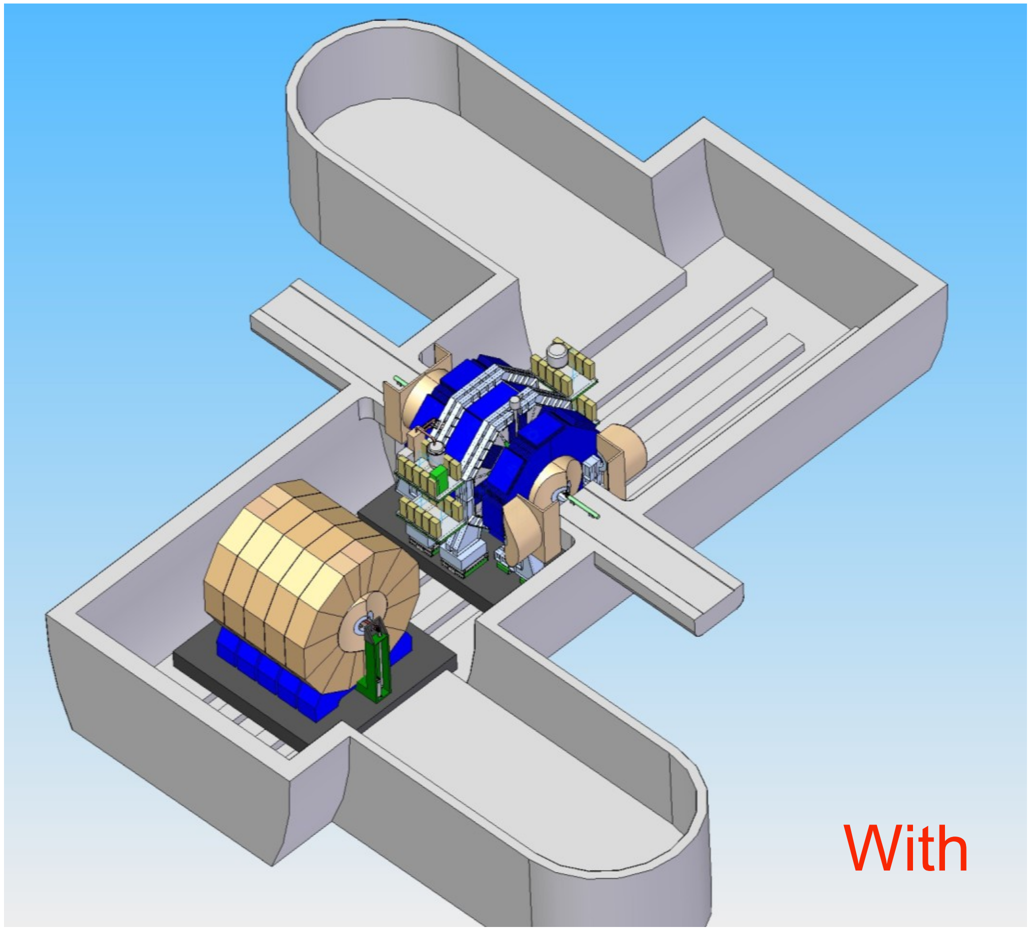
Increased exposition to vibrations

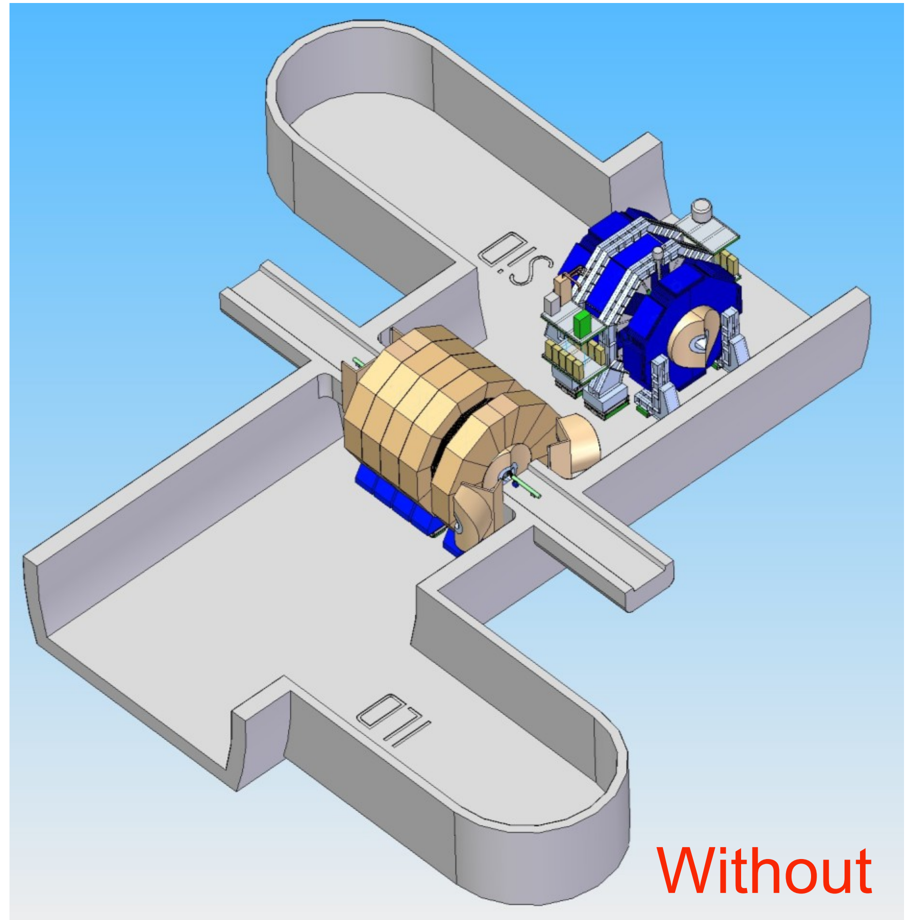


Half platforms in lateral alcoves

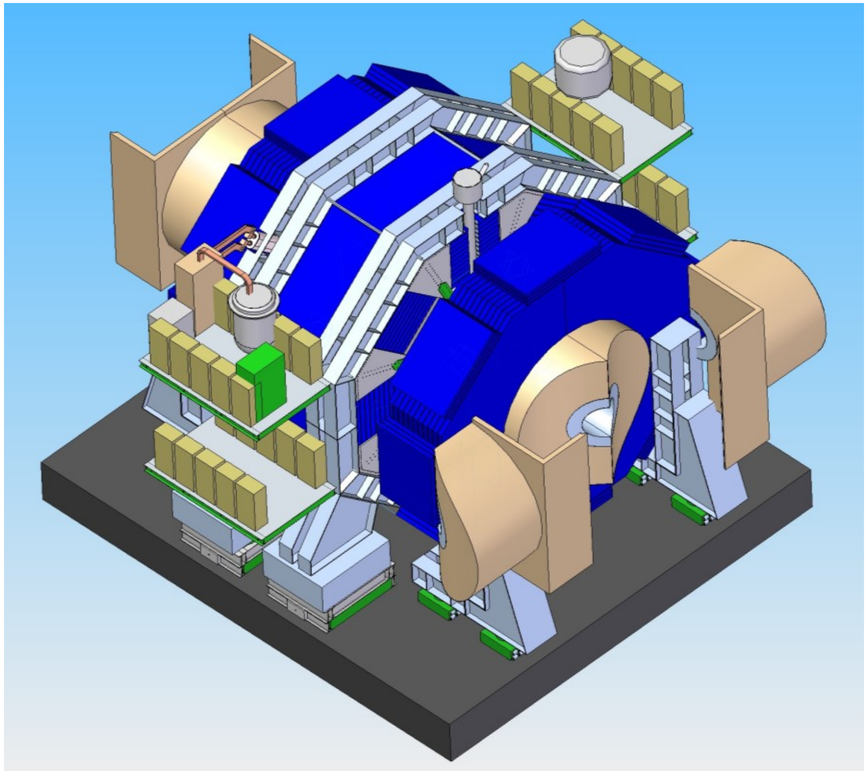


SiD and ILD with or without a platform ?

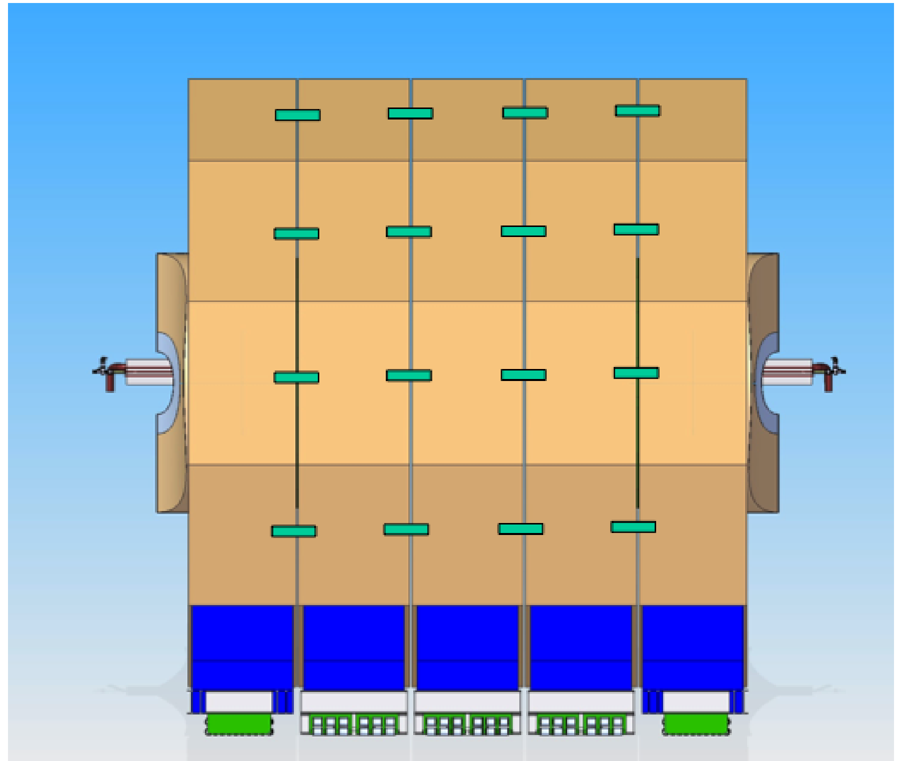




Trade off study



SiD on Platform



ILD without Platform

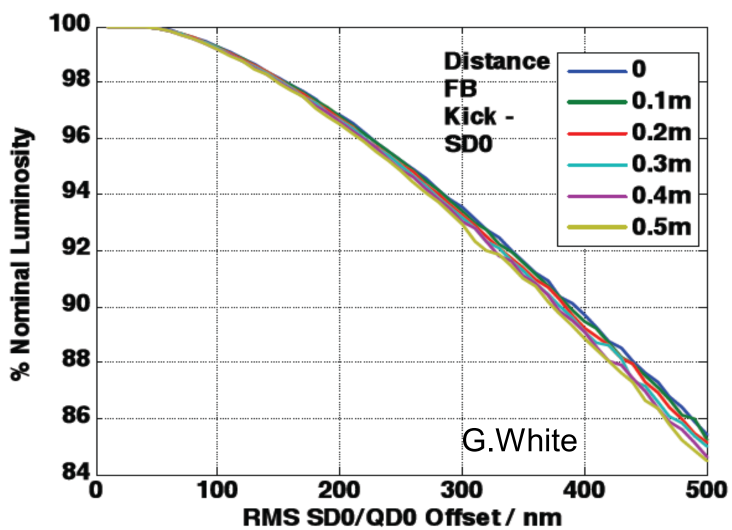
Mandatory requirements	SiD	ILD
Design Change Impact	None	High
Vibrations Amplification	Unkwon	Unkwon

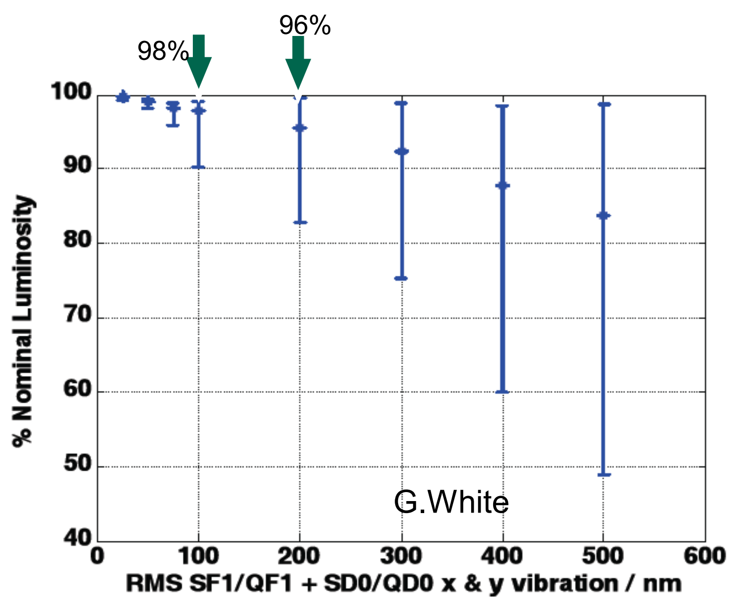
Vibrations

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

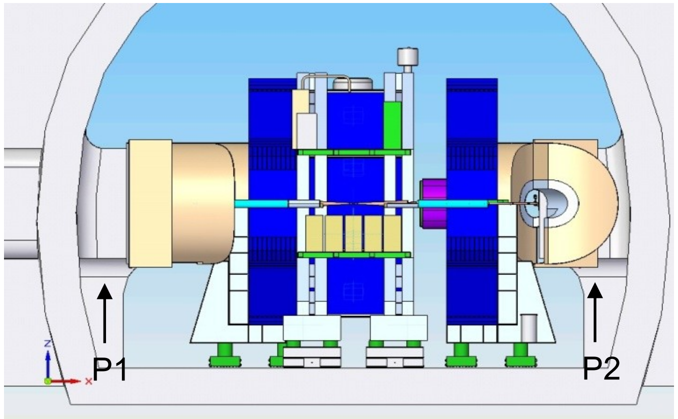
Max. Integrated displacement: 50 nm > 5 Hz

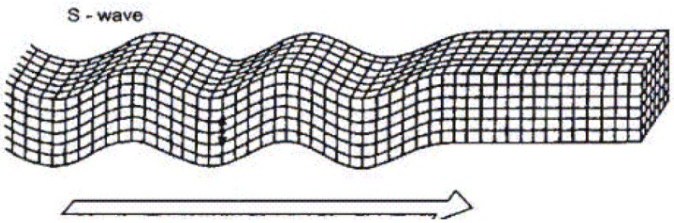




Lumi loss due to beam offset in SD0 (beamsize growth) and IP misalignment of beams

Vibrations : Absolute, Relative and Coherent and motion





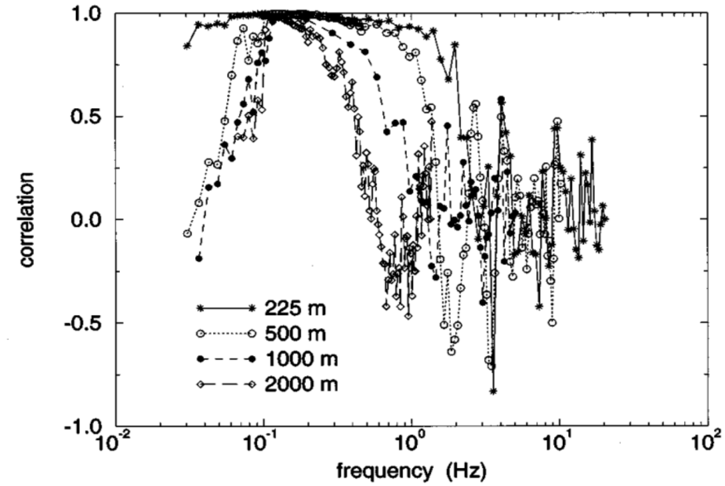


FIG. 3. Correlation spectra of ground motion measured at CERN in the LEP tunnel [7]. The distances between sensors were 225, 500, 1000, and 2000 m.

Coherence : $N_{12}(f) = \dfrac{p_{12}}{\sqrt{p_1 p_2}} = J_0(\omega L / v)$

If P1=P2, then :

Jo = 0th Bessel function
L= distance between points
v = speed of sound in rock, ~3 km/s

$$\rho(\omega, L) = p(\omega) 2\{1 - \mathrm{Re}[N_{12}(\omega, L)]\}.$$

Relative displacement spectrum

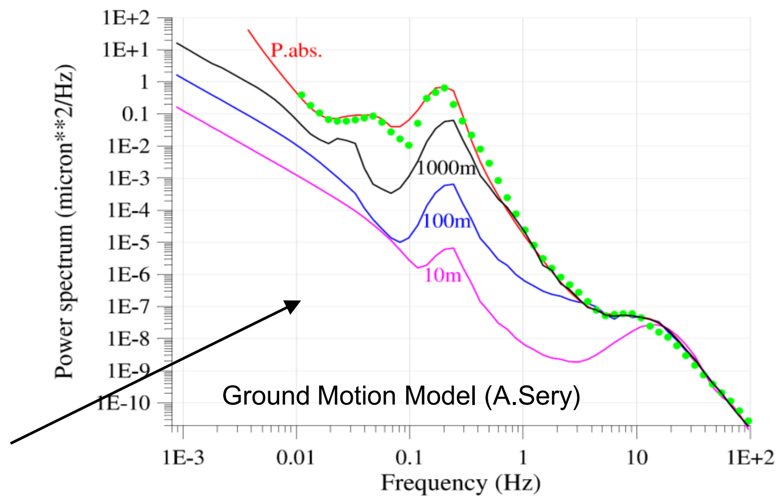
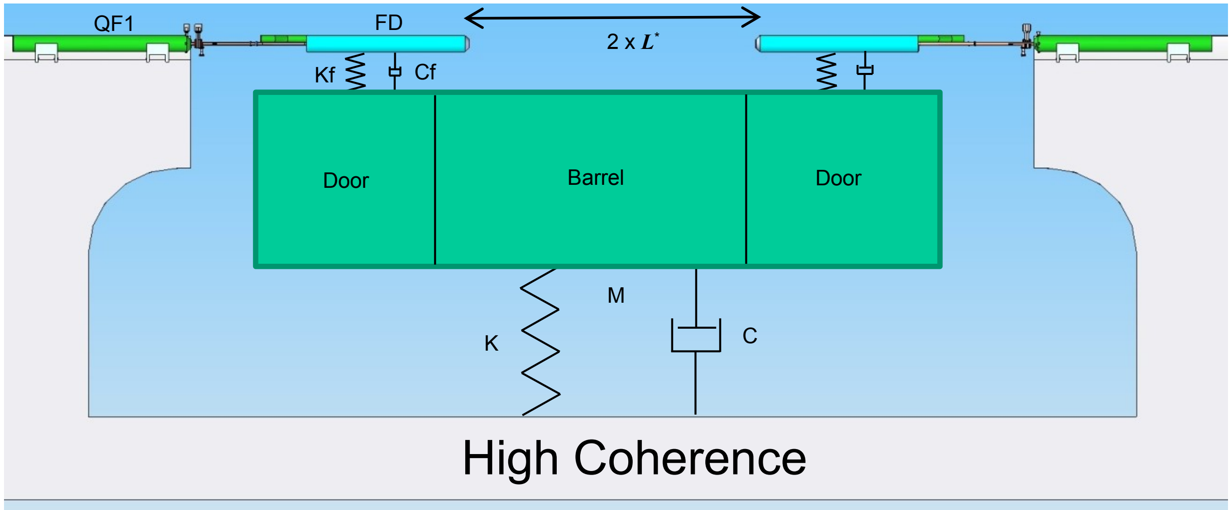
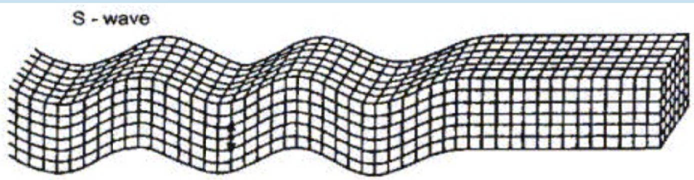
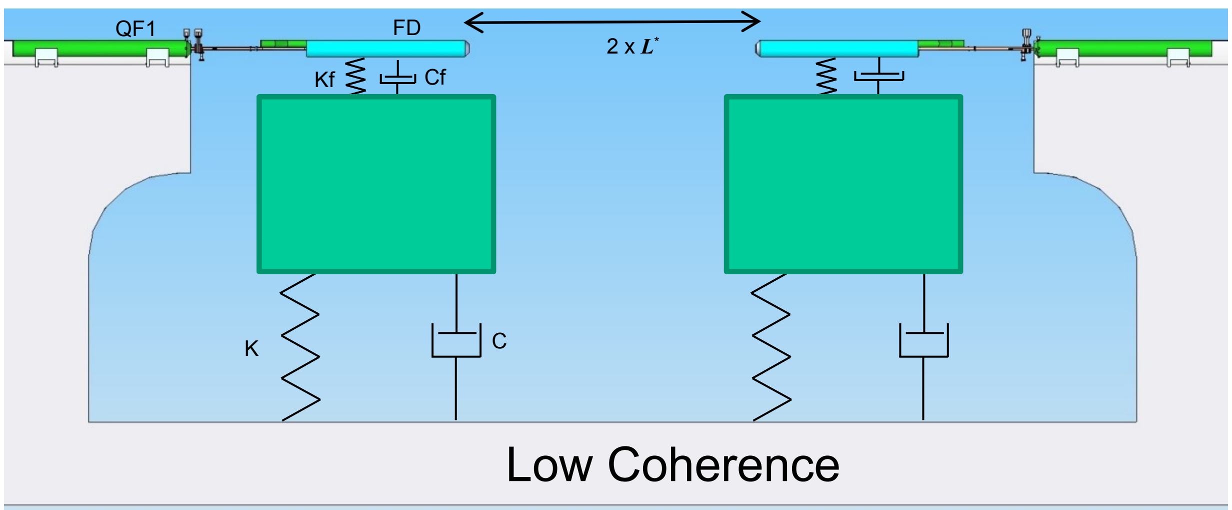


Figure 3: Measured (symbols) and modeling spectra $p(\omega)$ of absolute motion and $p(\omega, L)/2$ of relative motion for the 2 a.m. SLAC site ground motion model.

QD0 Supports

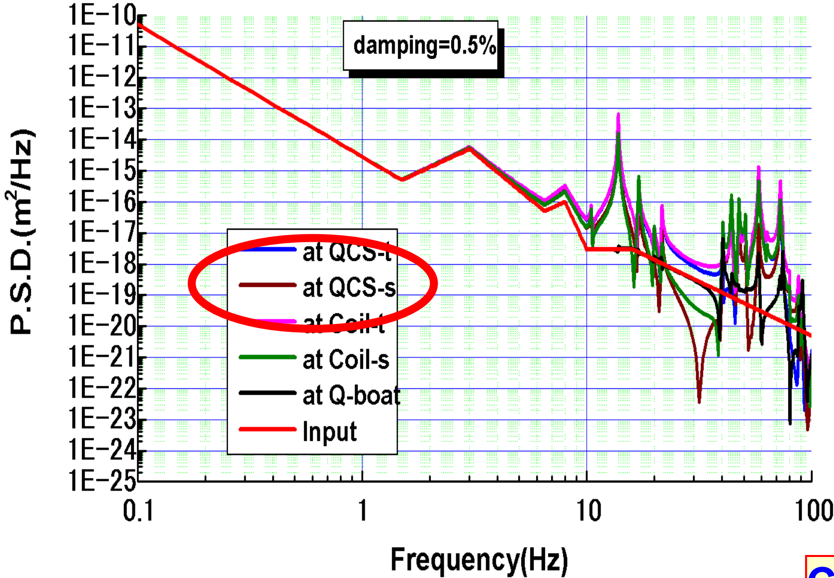


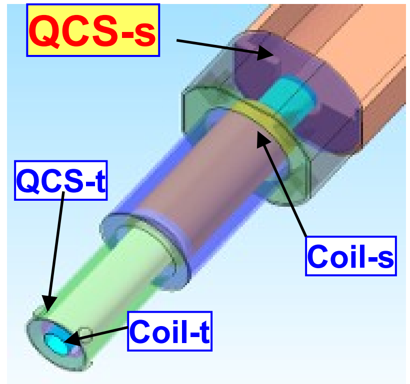




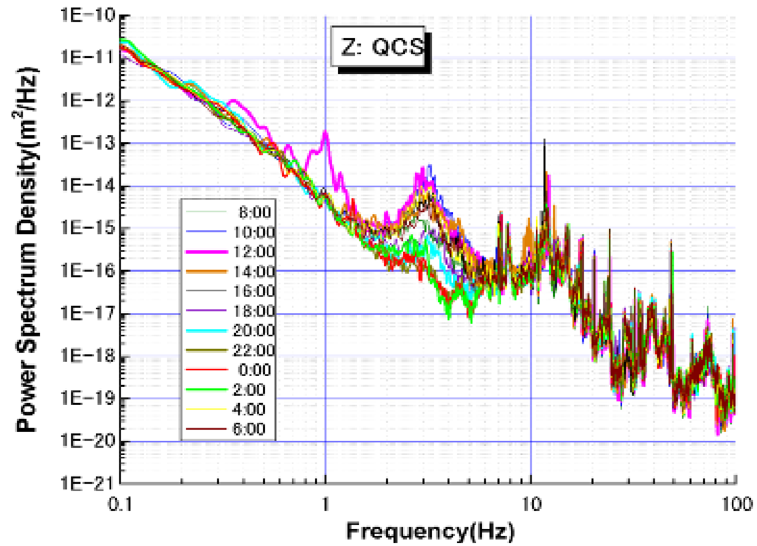
Response amplitude (*Comparison of computations and measurements*)

Calculation: *damp=0.5%*

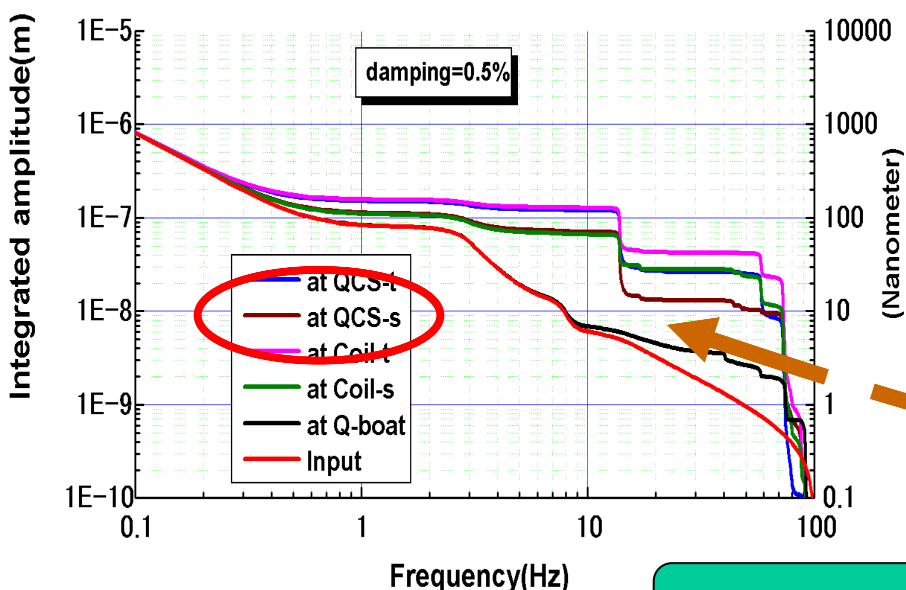


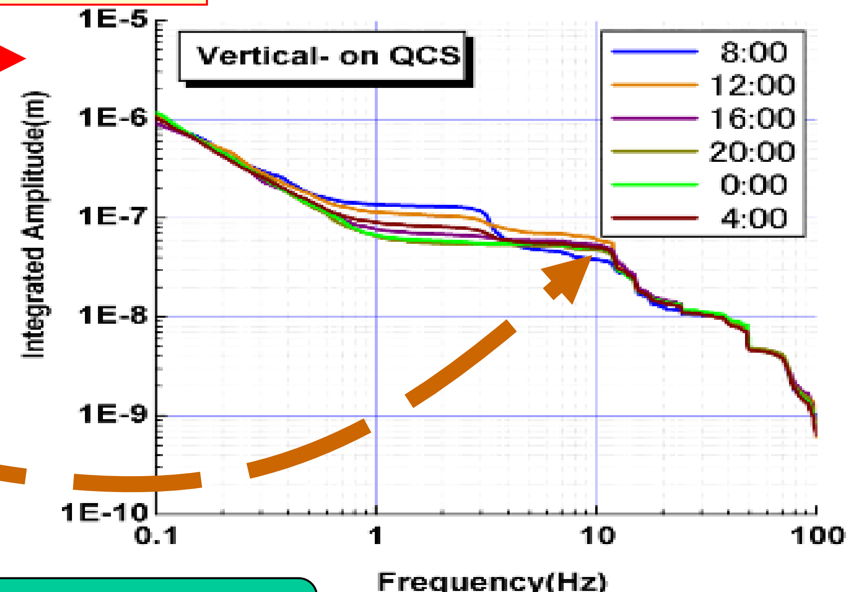


Measurements@QCS-s



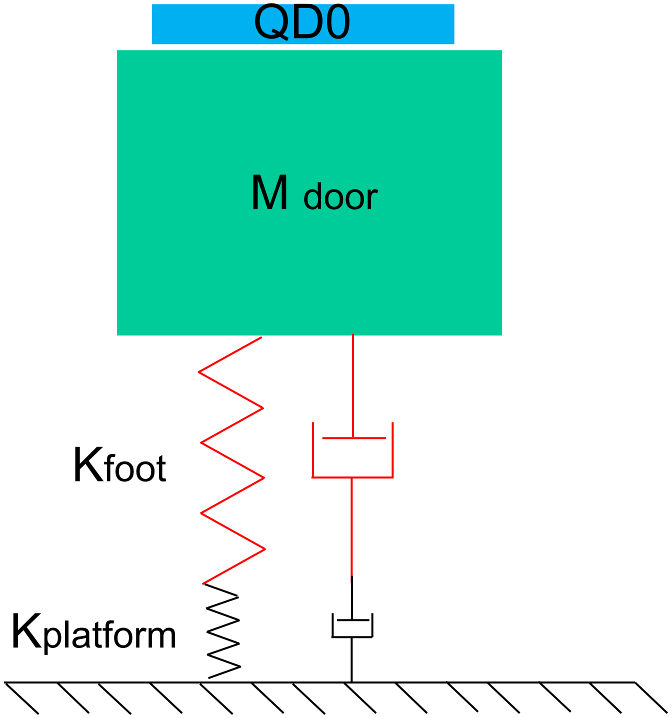
Calculation: **Measurement**





H. Yamaoka / KEK

SiD Vibration Model : 1 degree of freedom M,K,C oscillator



$$f_n = \sqrt{\frac{f_f^{\,2} f_p^{\,2}}{f_f^{\,2} + f_p^{\,2}}}$$

1st mode system

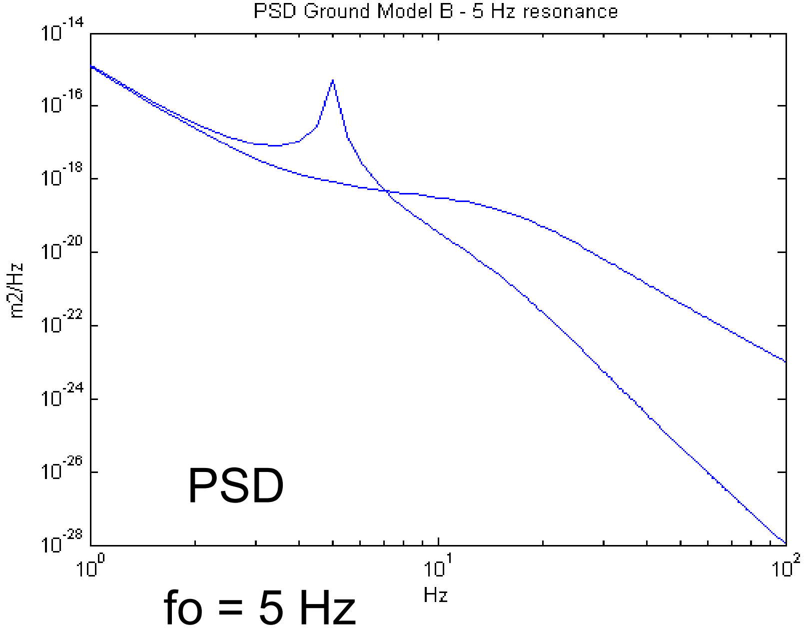
f_f = 1st mode SiD foot

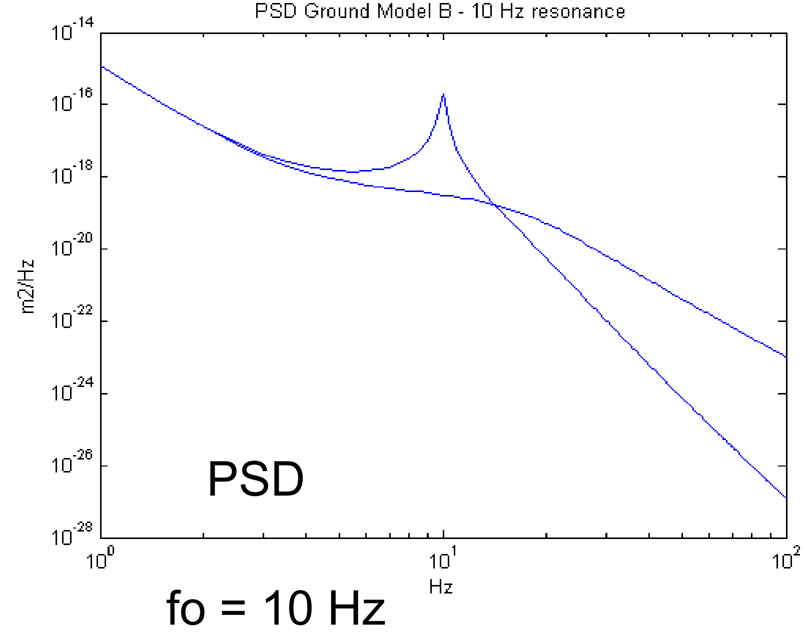
f_p = 1t mode platform

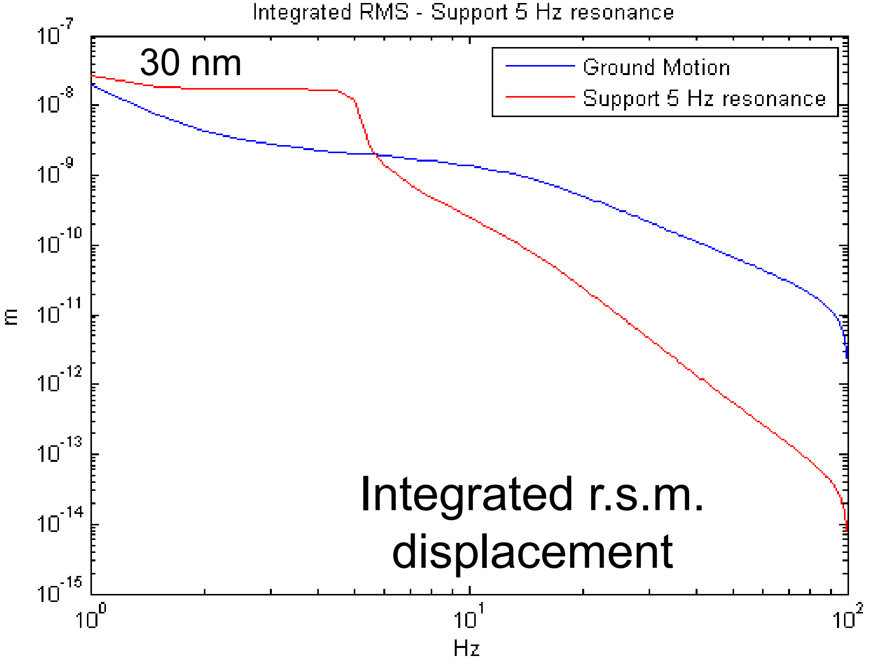
c = 2%

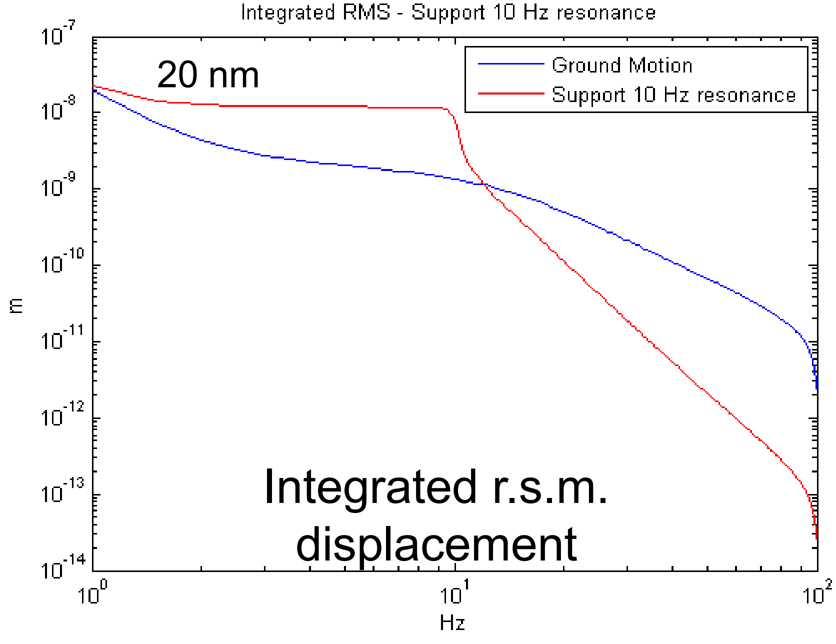
f_{foot} = 10 Hz from FEA,	$f_{platform}$ =		
		6 Hz, supported edges	5 Hz
		15 Hz, int. support, door-on-platform	f_n = 8 Hz
		30 Hz, int.support, door-on-barrel	9 Hz

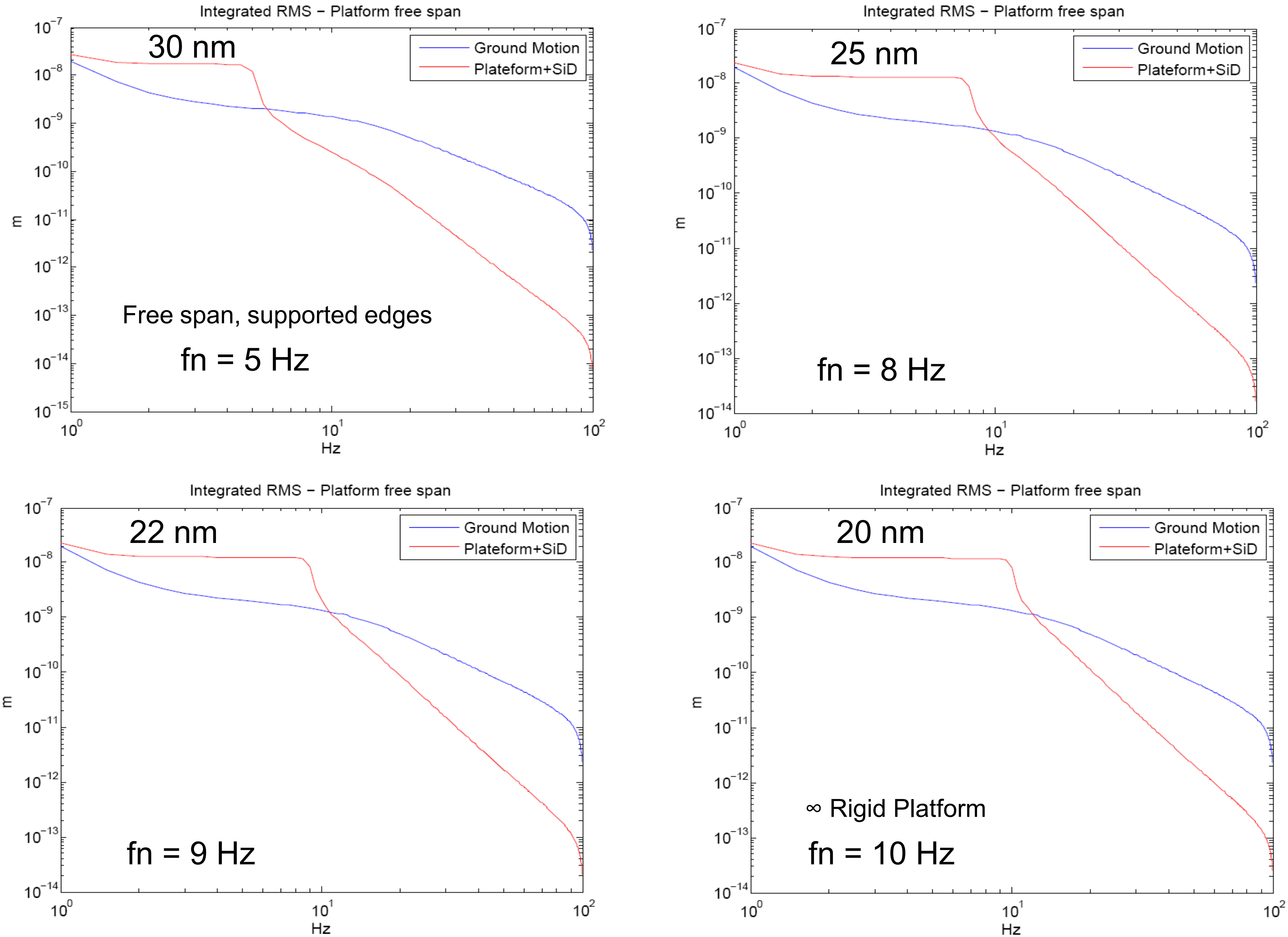
Random vibration Studies : SiD O.K. on the floor, no platform



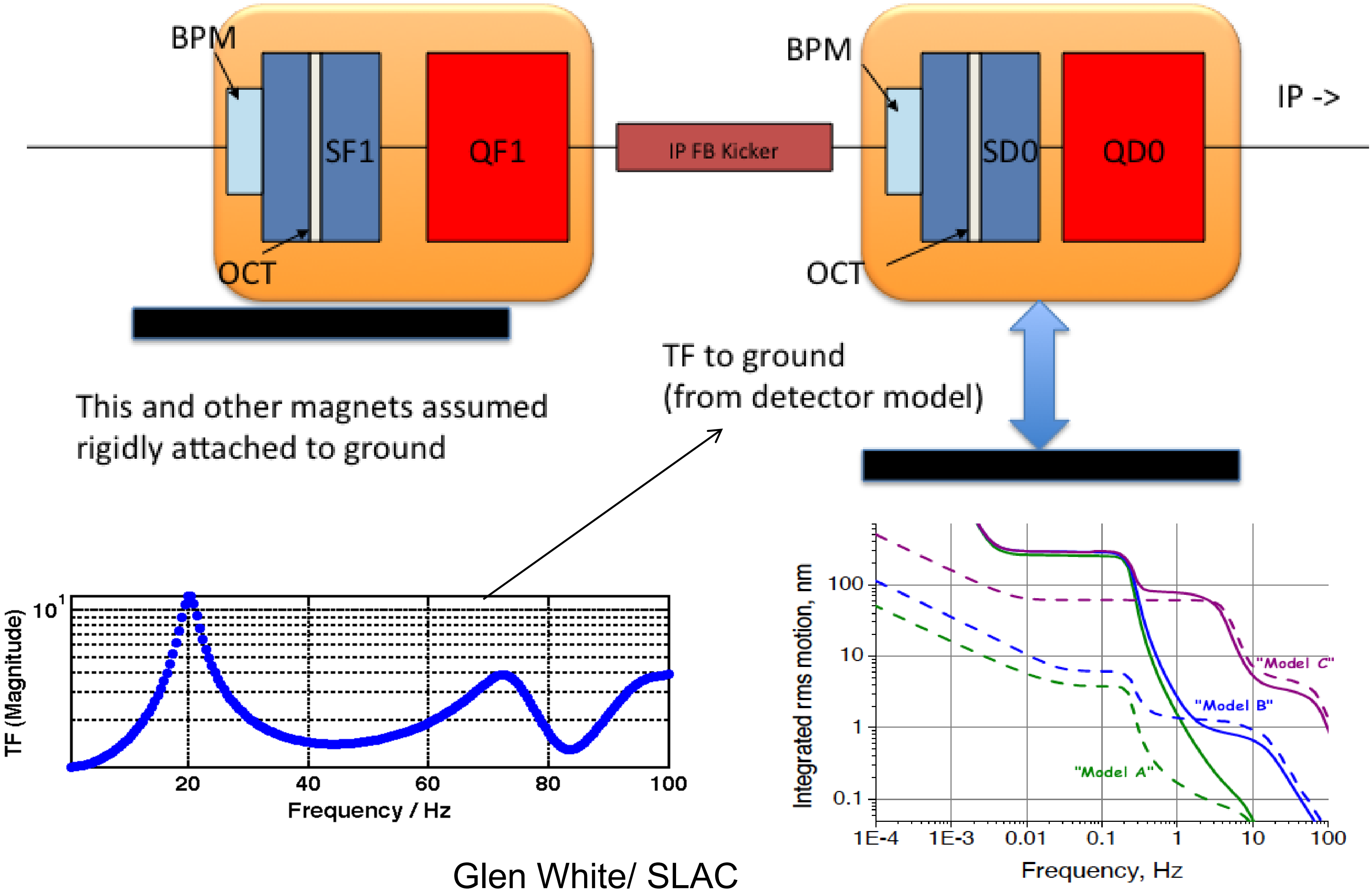






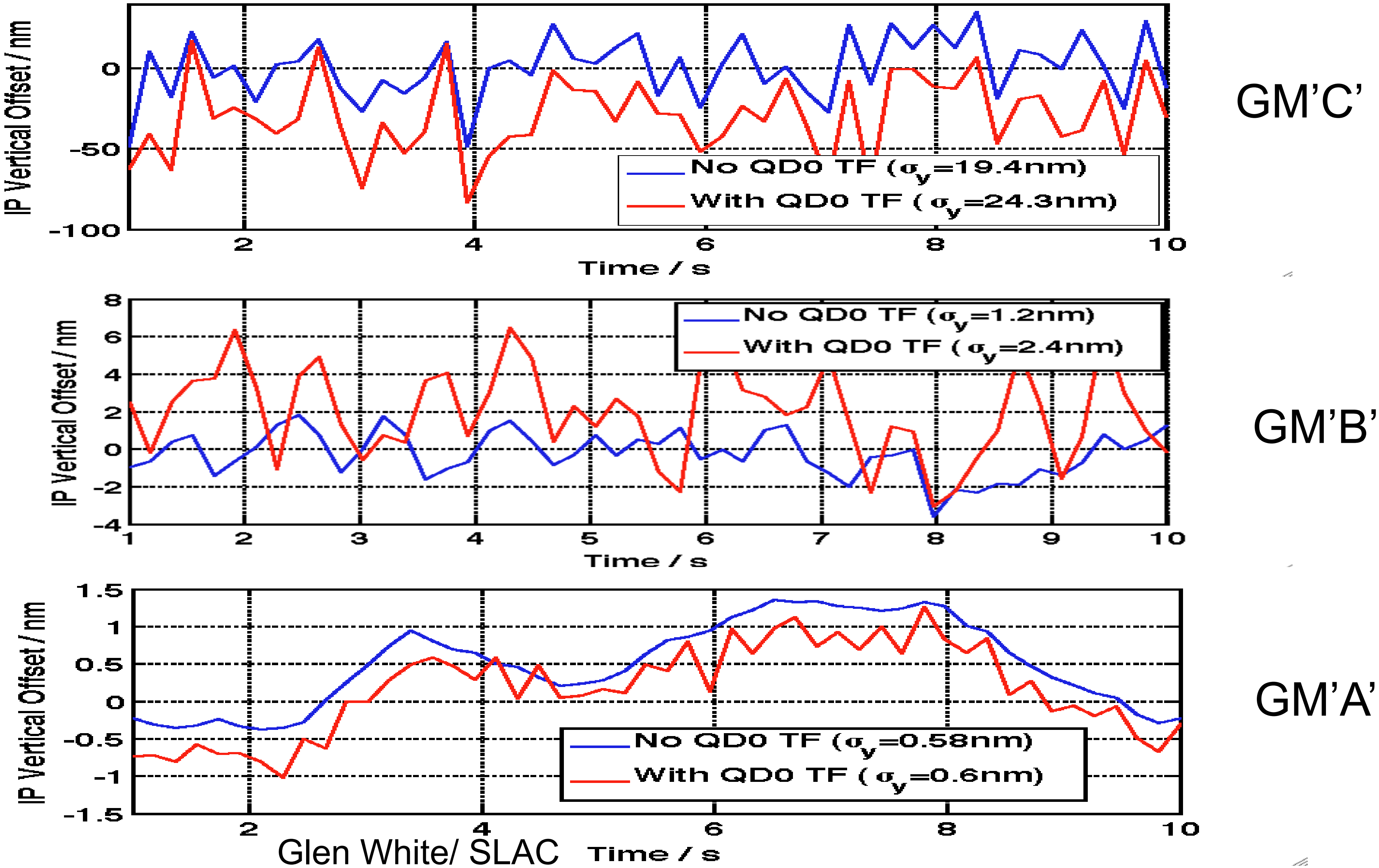

Integrated RMS − Platform free span
30 nm
Ground Motion
Plateform+SiD
Free span, supported edges
fn = 5 Hz
m
Hz
Integrated RMS − Platform free span
25 nm
Ground Motion
Plateform+SiD
fn = 8 Hz
m
Hz
Integrated RMS − Platform free span
22 nm
Ground Motion
Plateform+SiD
fn = 9 Hz
m
Hz
Integrated RMS − Platform free span
20 nm
Ground Motion
Plateform+SiD
∞ Rigid Platform
fn = 10 Hz
m
Hz

IP Region Final Doublet



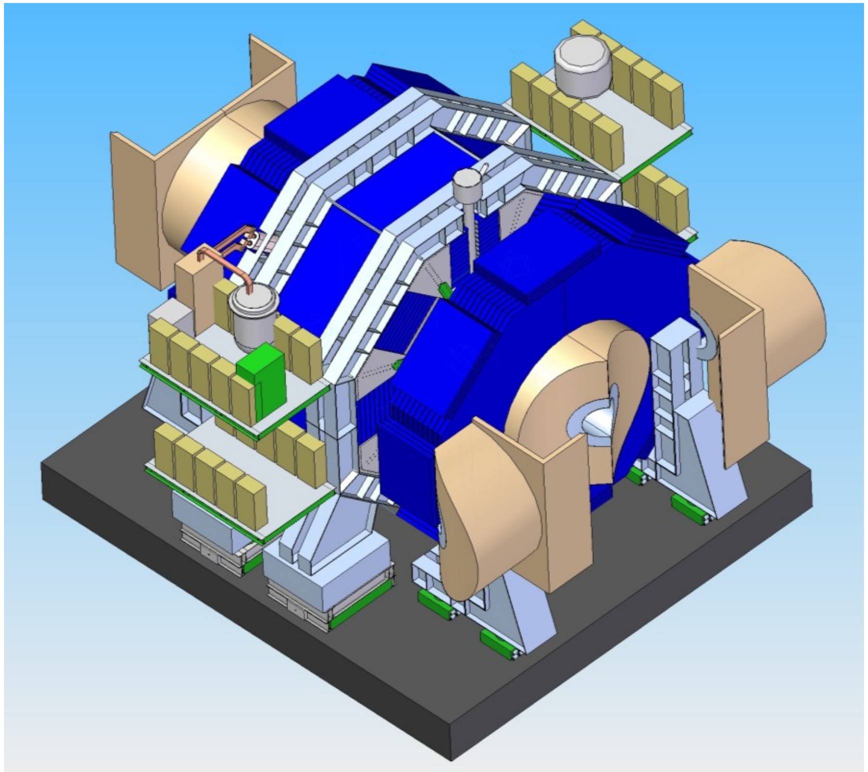
Glen White/ SLAC

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

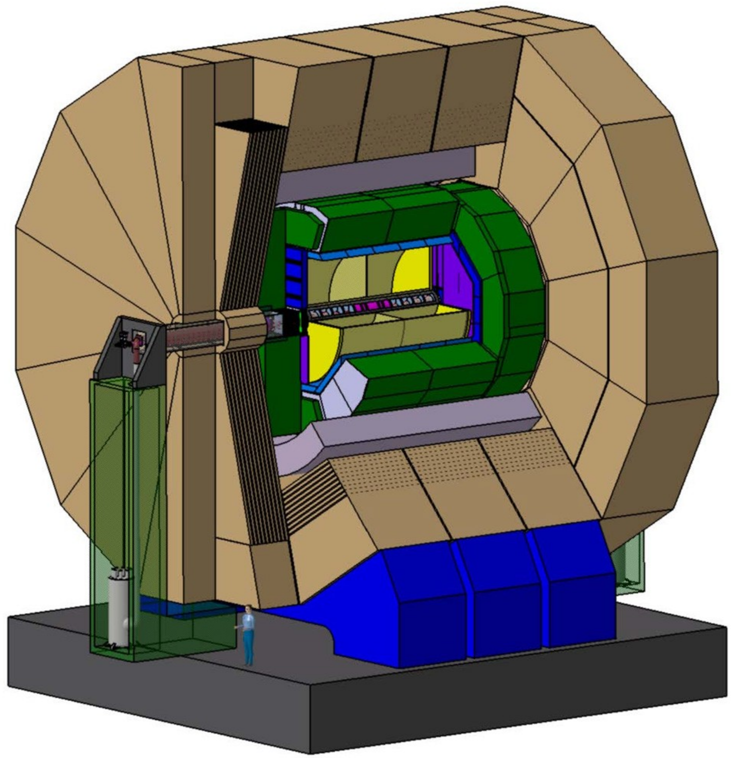


Glen White/ SLAC

Trade off study - Conclusion



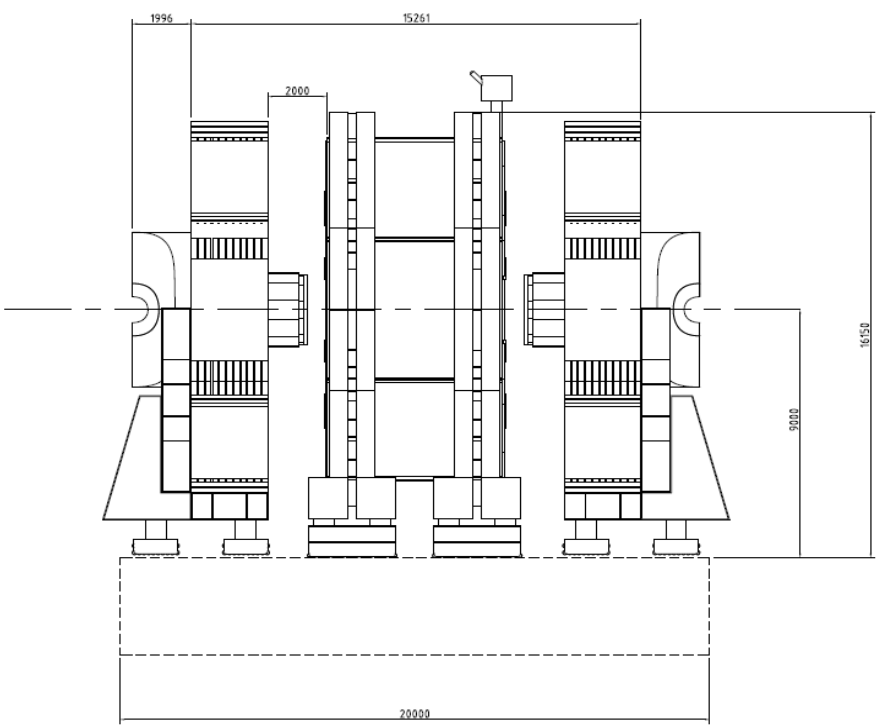
SiD with Platform

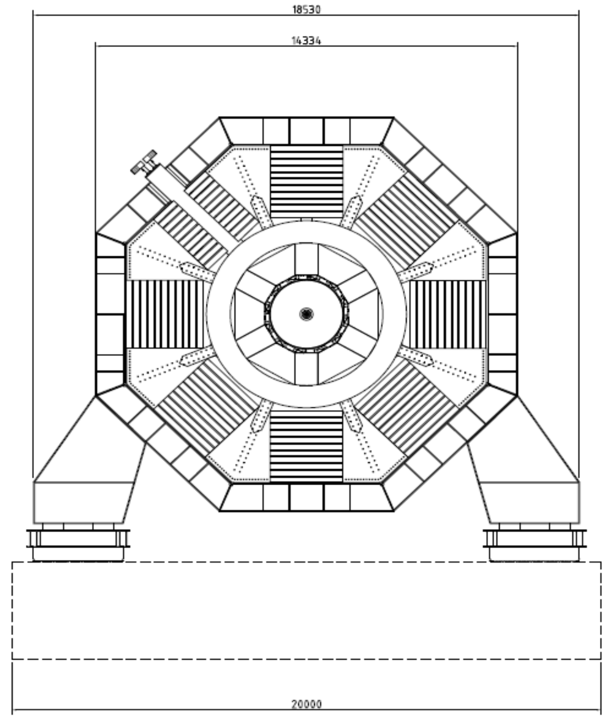


ILD withPlatform

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

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)

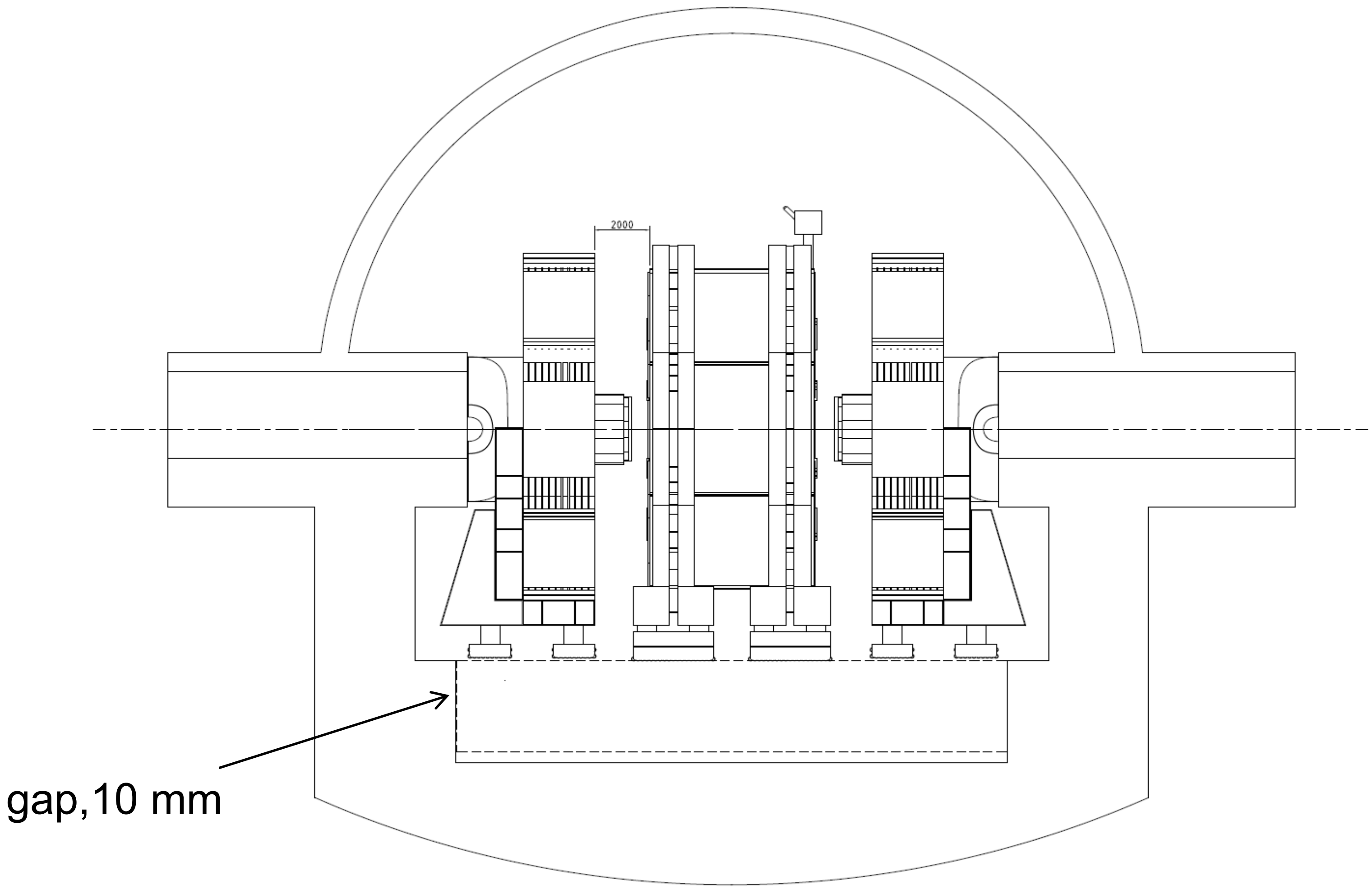
Positioning Tolerance on beamline
- Consider points Z=+-max, X=0. Position to + 1mm wrt references in X,Y,Z
- Consider points Z=+-max, X=+-max: Position to +- 1 wrt references in Y.

Static Deformations: <+-2 mm

Vibration Transfer Function from ground : Amplification < 1.5 between 1 and 100 Hz.

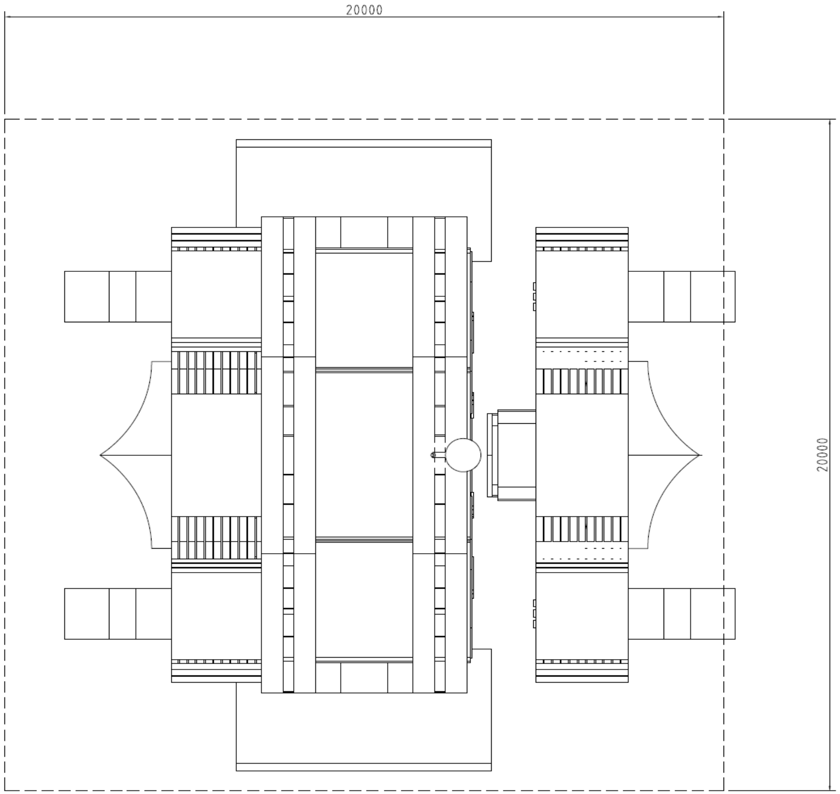
Seismic stability: Appropriate for selected site. (Beamline must be designed with sufficient compliance that VXD will survive)

SiD Platform Functional Requirements

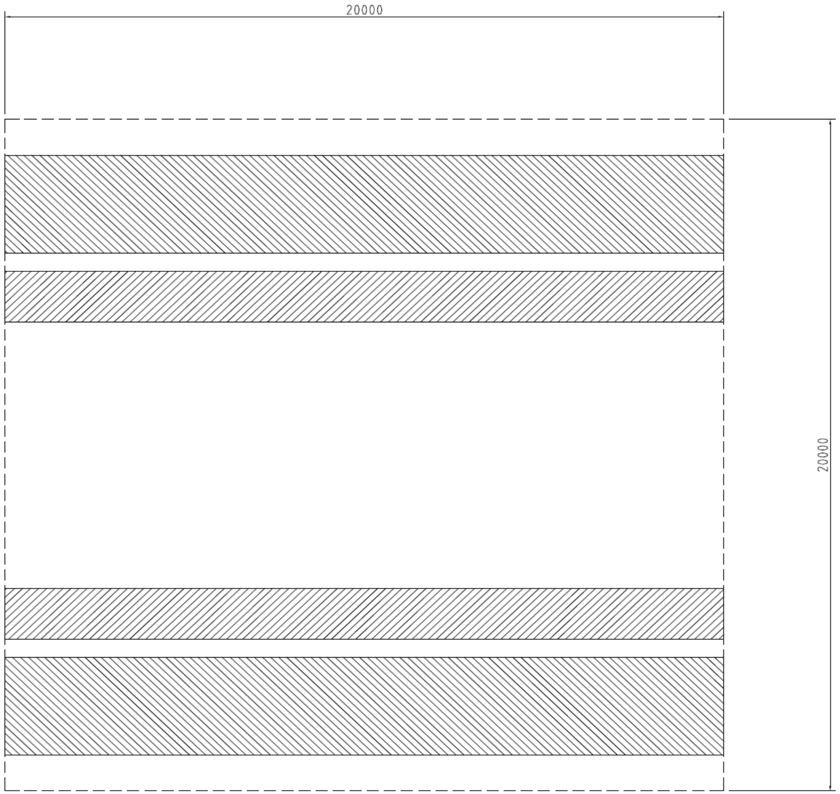


Wall clearance ~10 mm. Platform comes to side wall, there is no apron or apron matches platform elevation.

SiD Platform Functional Requirements



Detector Top View

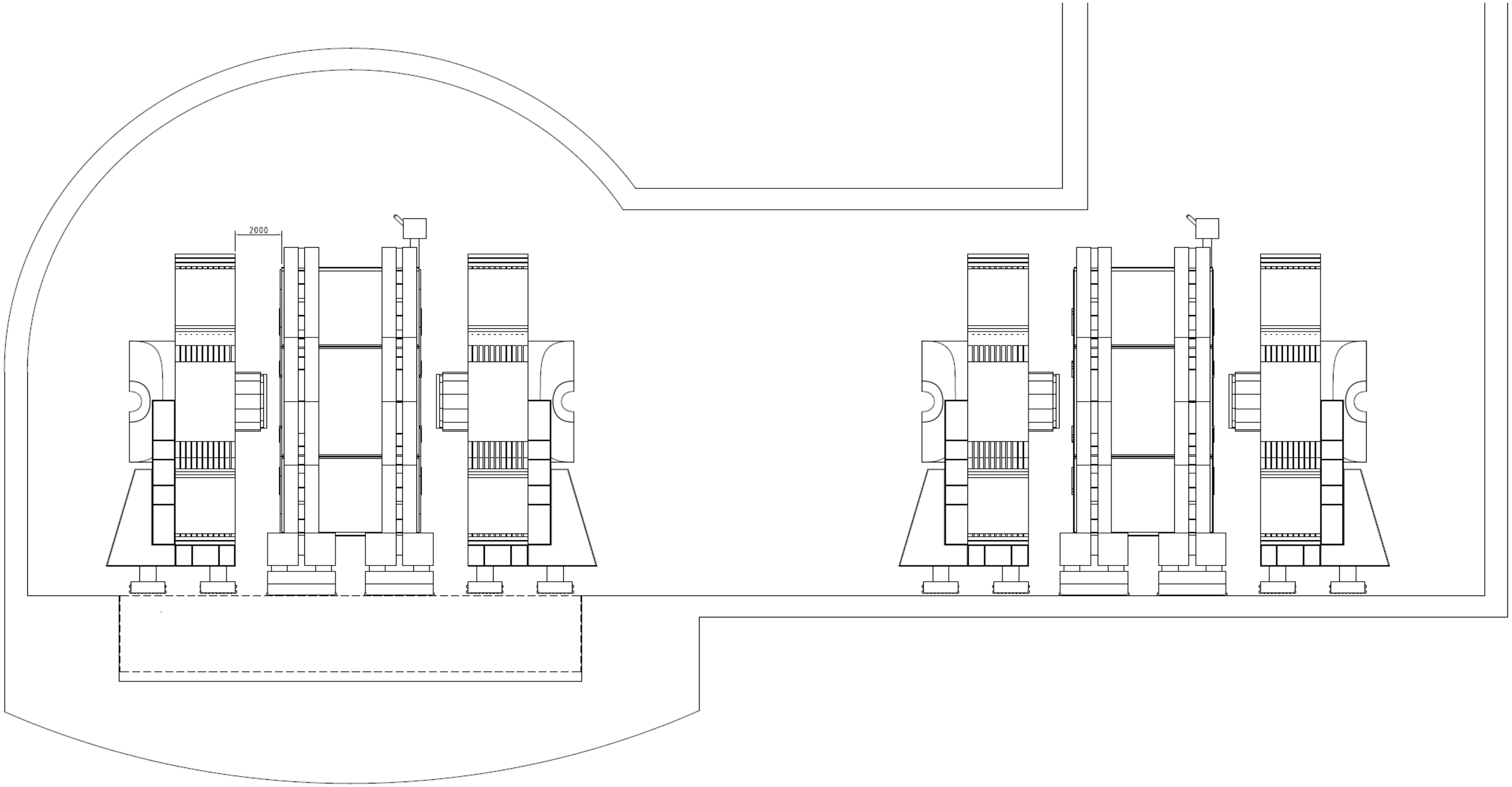


Platform Top View

Surface Features:

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

SiD Platform Functional Requirements



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.

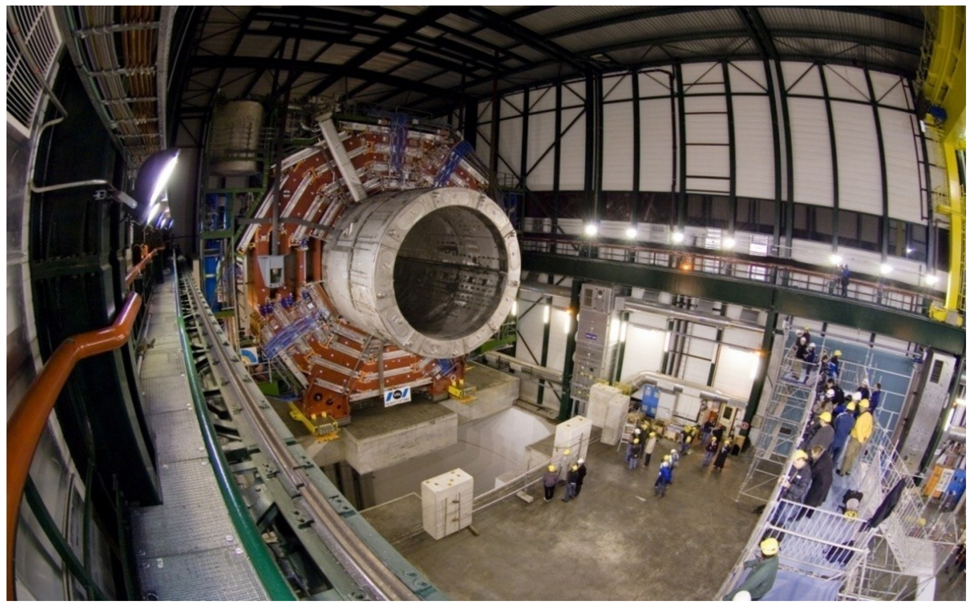
Any equipment required for transport shall reside below the platform surface.

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

Platform Simulation

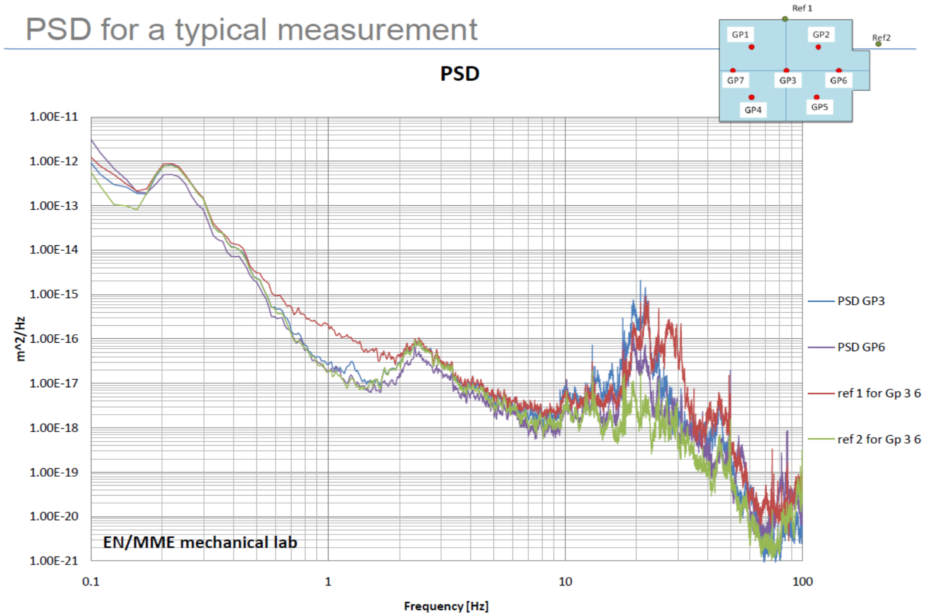
Benchmark with exp.data

The CMS Plug

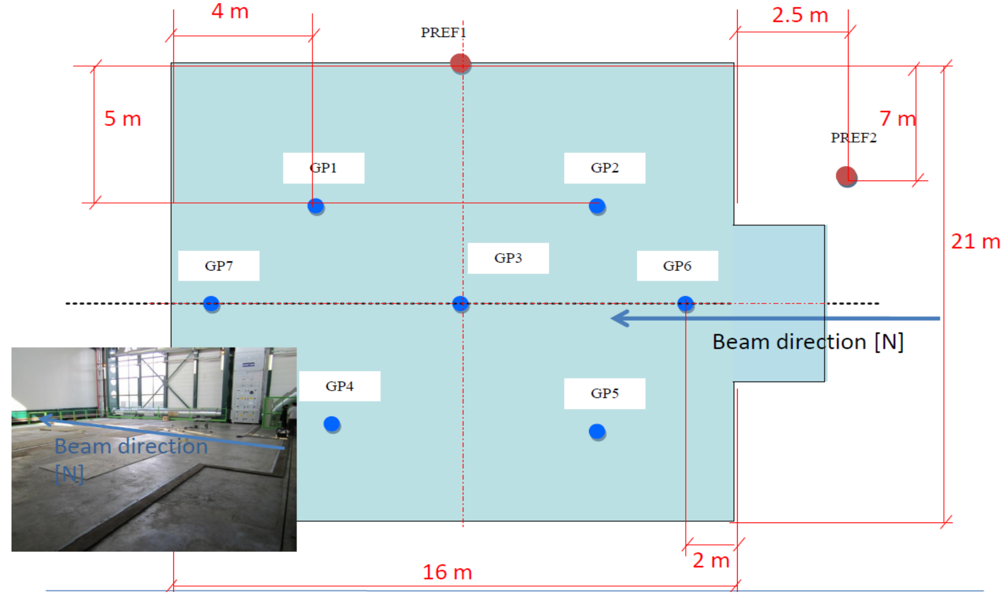


Experimental Vibration measurements – CMS Plug

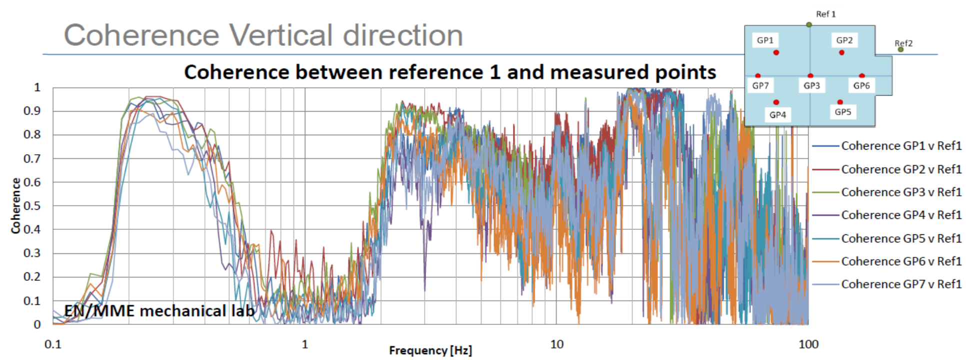
PSD for a typical measurement

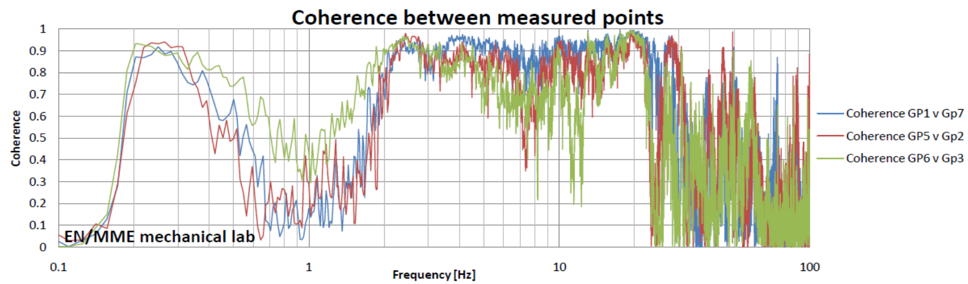


Sensor position

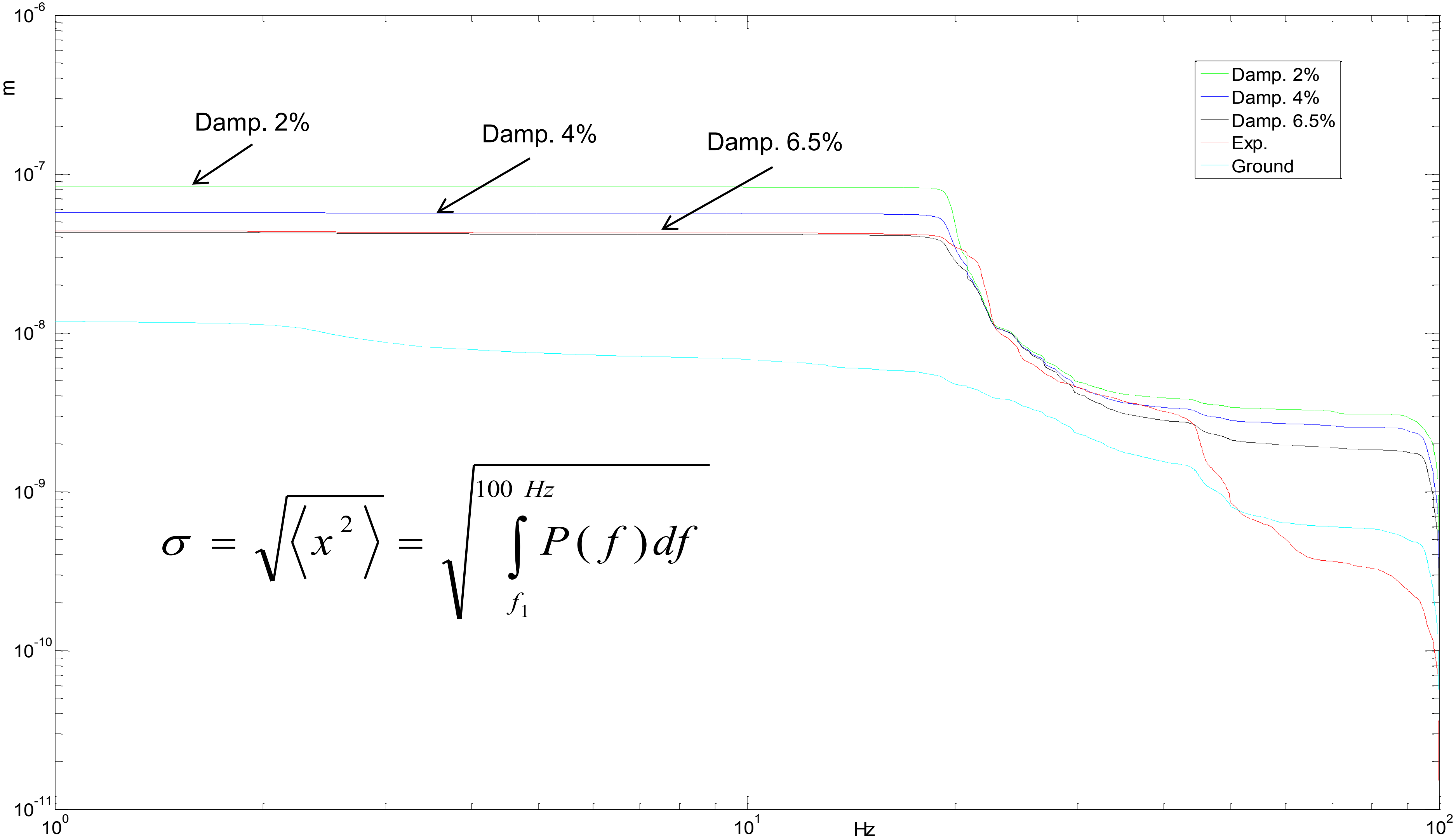


Coherence Vertical direction





Integrated Displacement (r.m.s.)



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

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.

The work ahead

- The effects of vibrations on beam stability remain a subject which need further studies.
- Benchmarking of the FEM and experimental data is in progress : good results so far
- Start the optimization of the Experimental Area, integration of the platforms
- Decide on a Push-pull mechanism : Rollers, Air-pads, hydraulic jacks, etc.
- All above only achievable as common task MDI / CFS