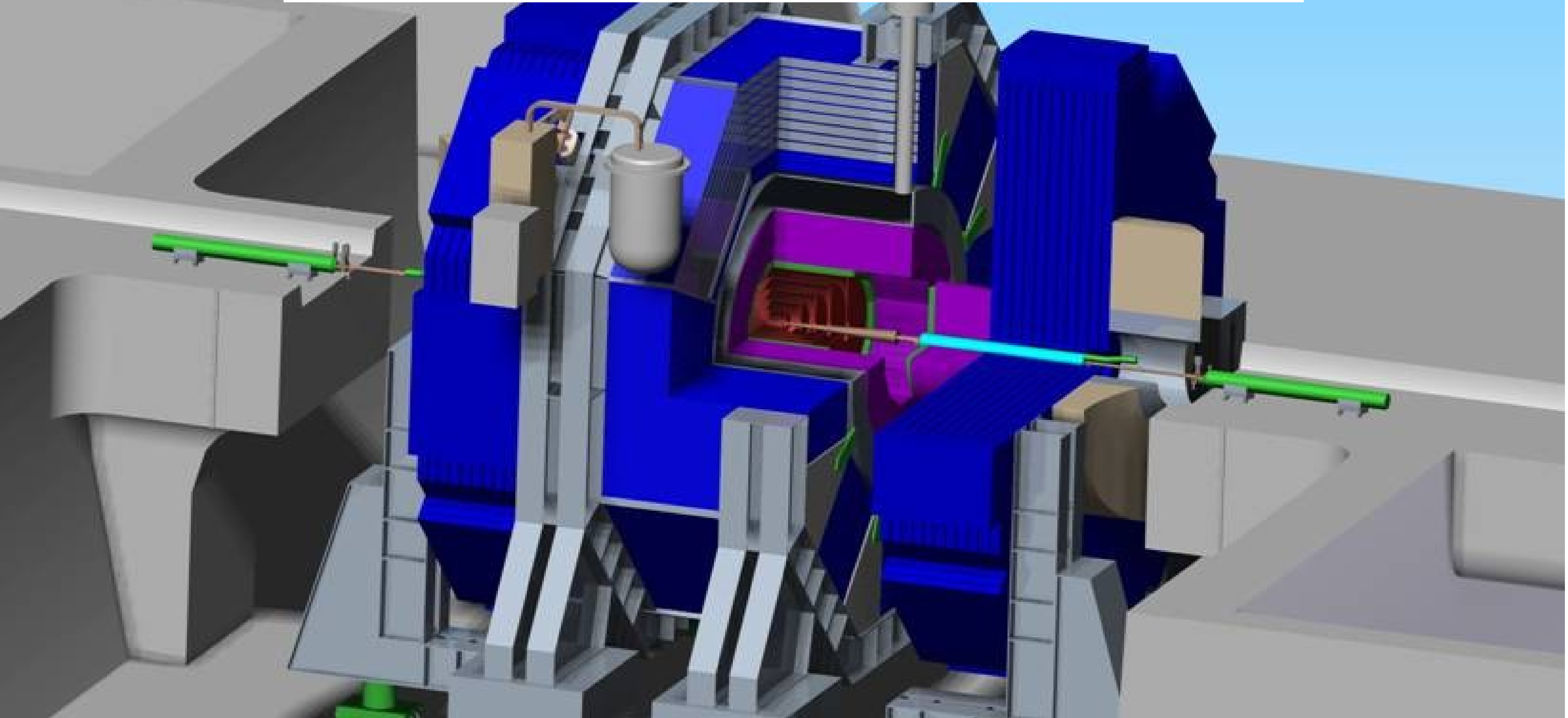
ILD Workshop, Paris May 24, 2011



# ILC Push-Pull : Platform

Marco Oriunno, SLAC

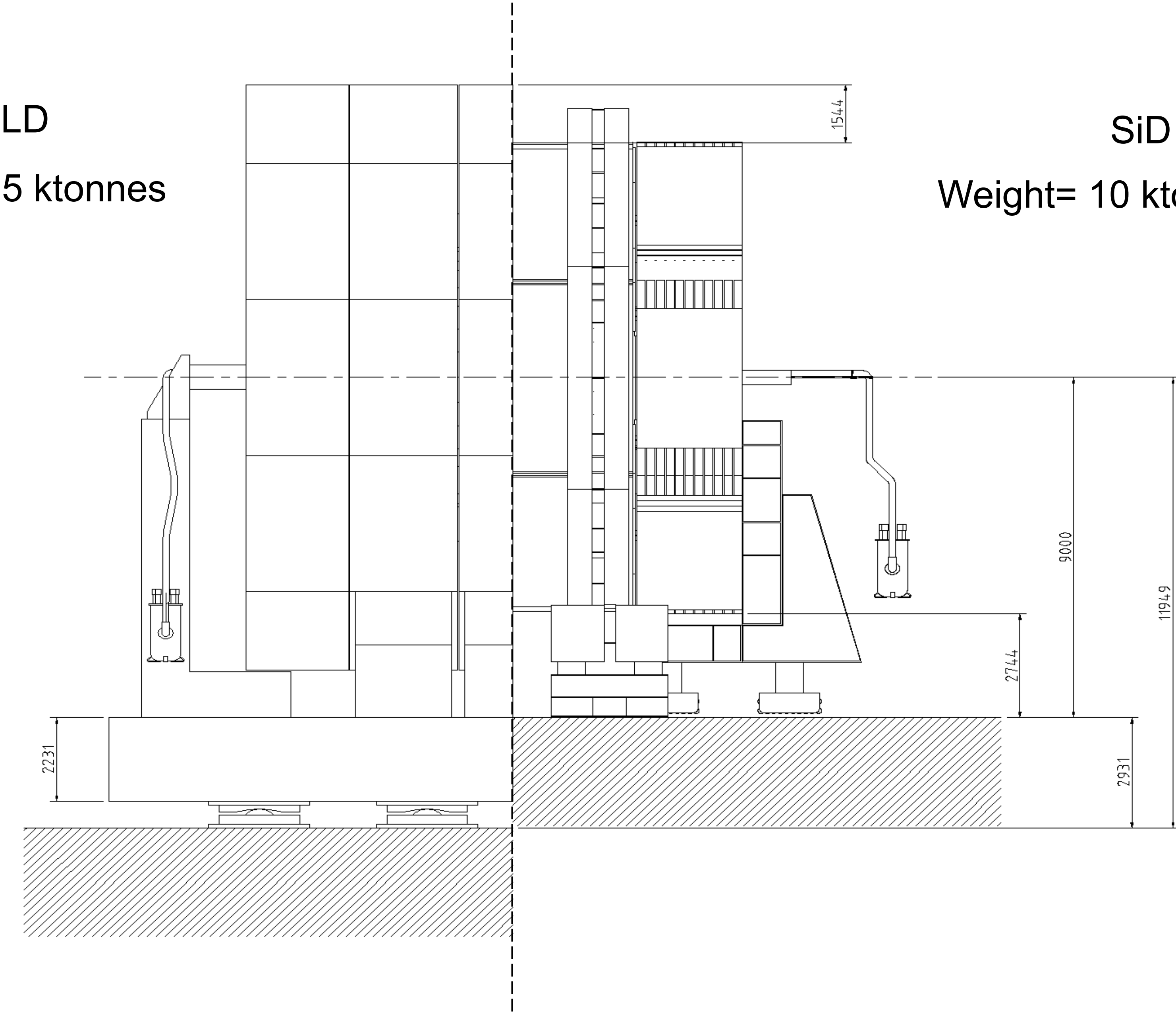
# ILD and SiD differences

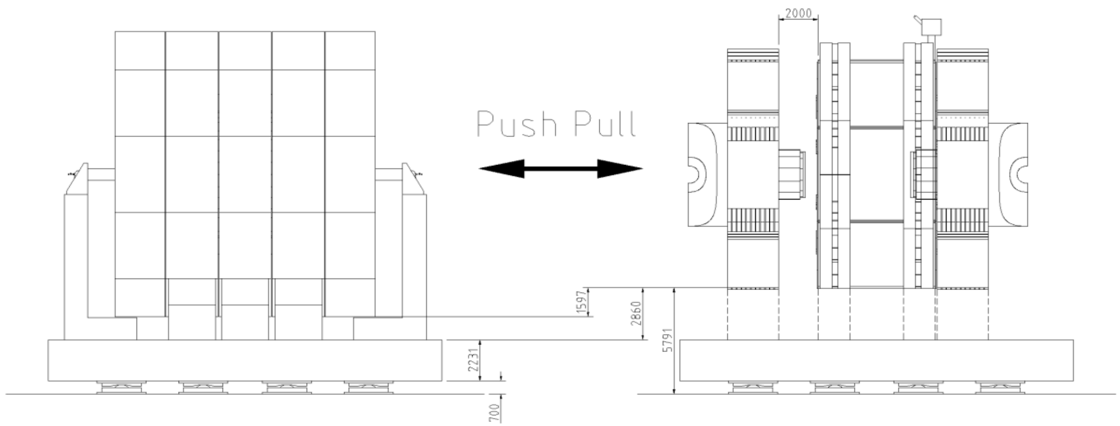
ILD

Weight= 15 ktonnes

SiD

Weight= 10 ktonnes

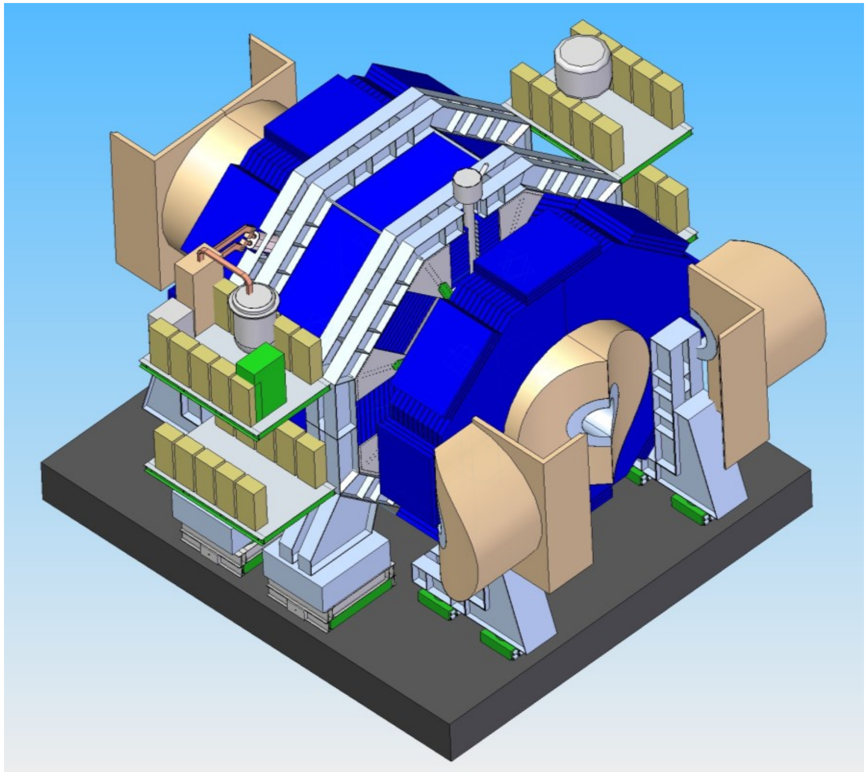




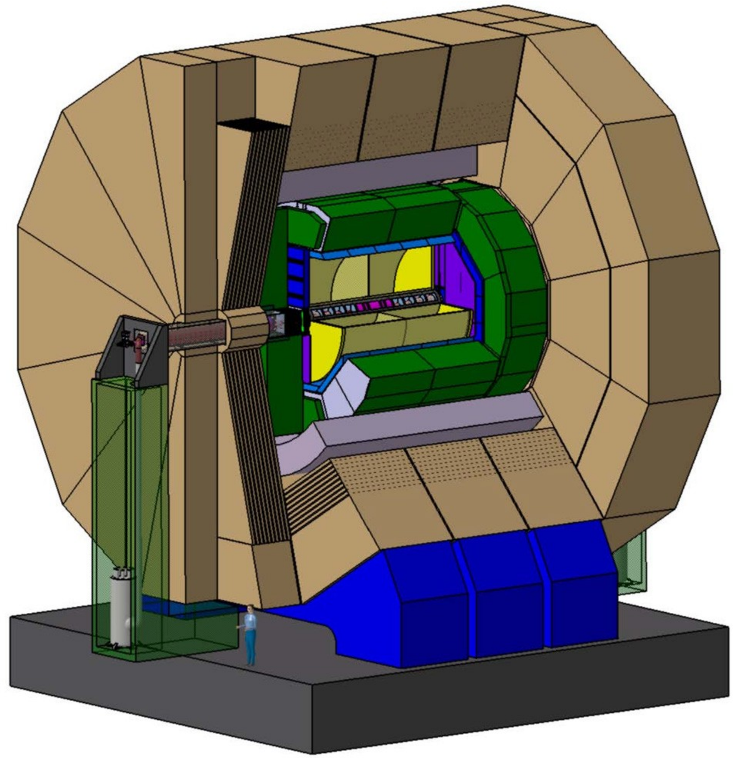

# Option 3, ILD and SiD on platforms

Under Study

# Trade off study - Conclusion



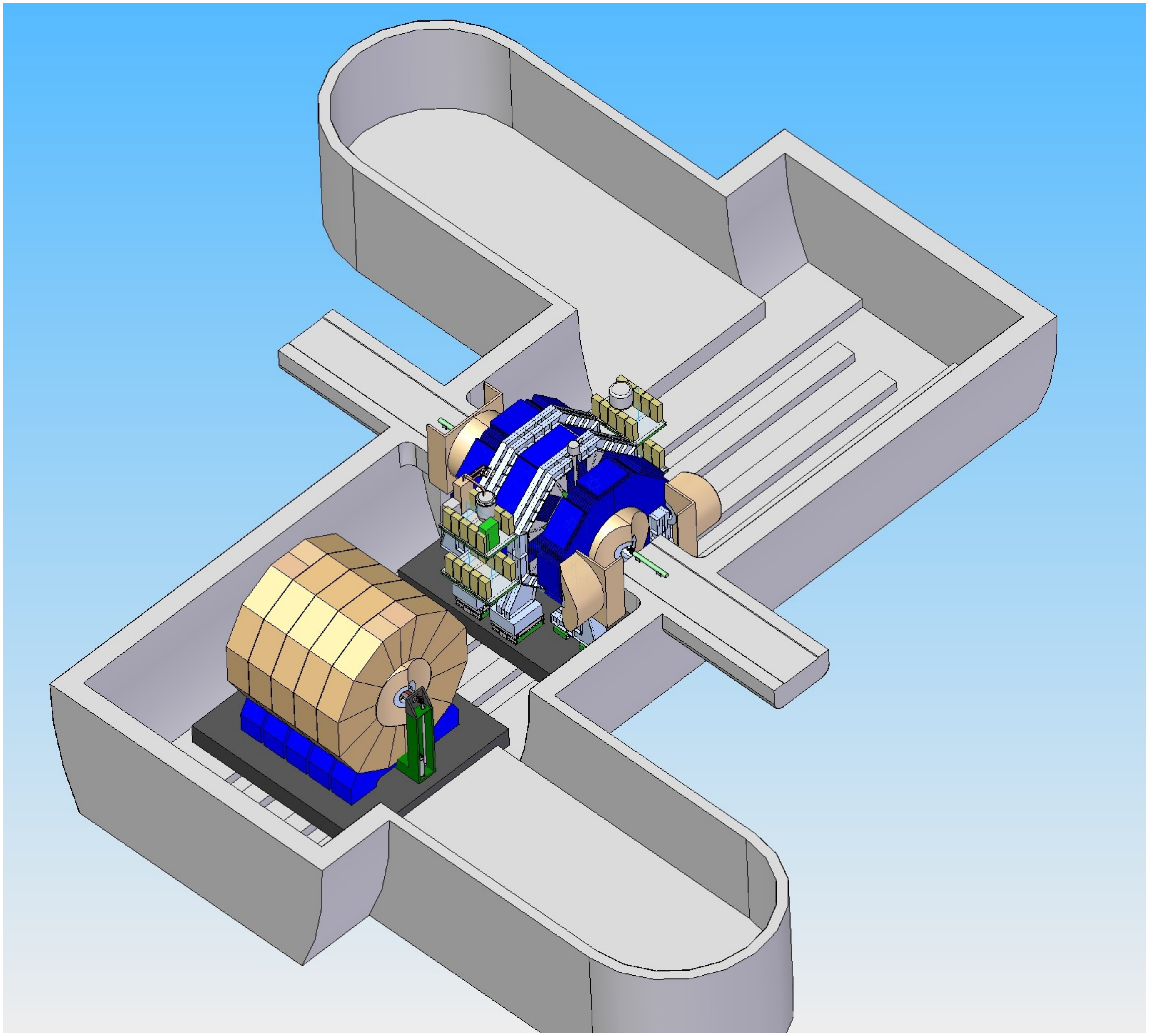
SiD with Platform



ILD withPlatform

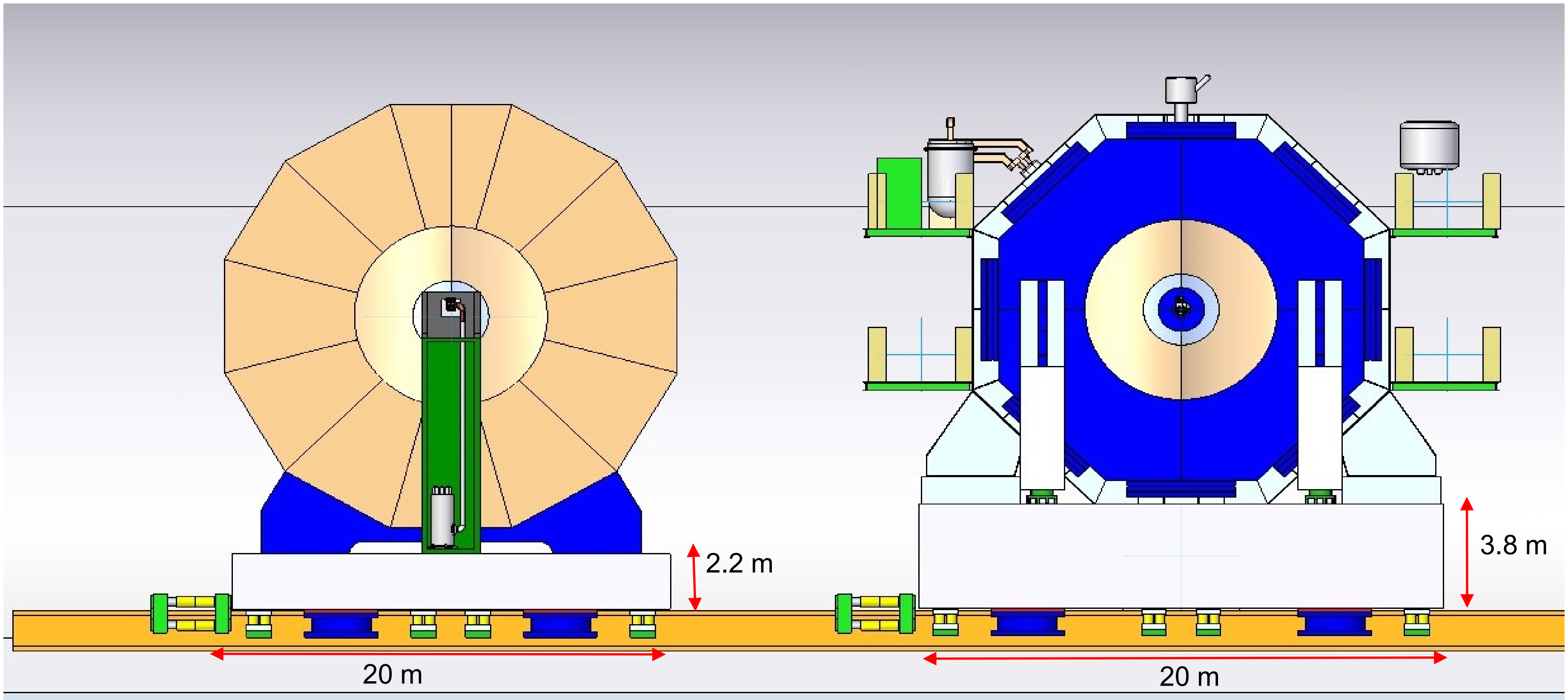
| Mandatory requirements | SiD | ILD |
|---|---|---|
| Design Change Impact | None | High |
| Vibrations Amplification | Low | Low |

# Push-Pull with platforms

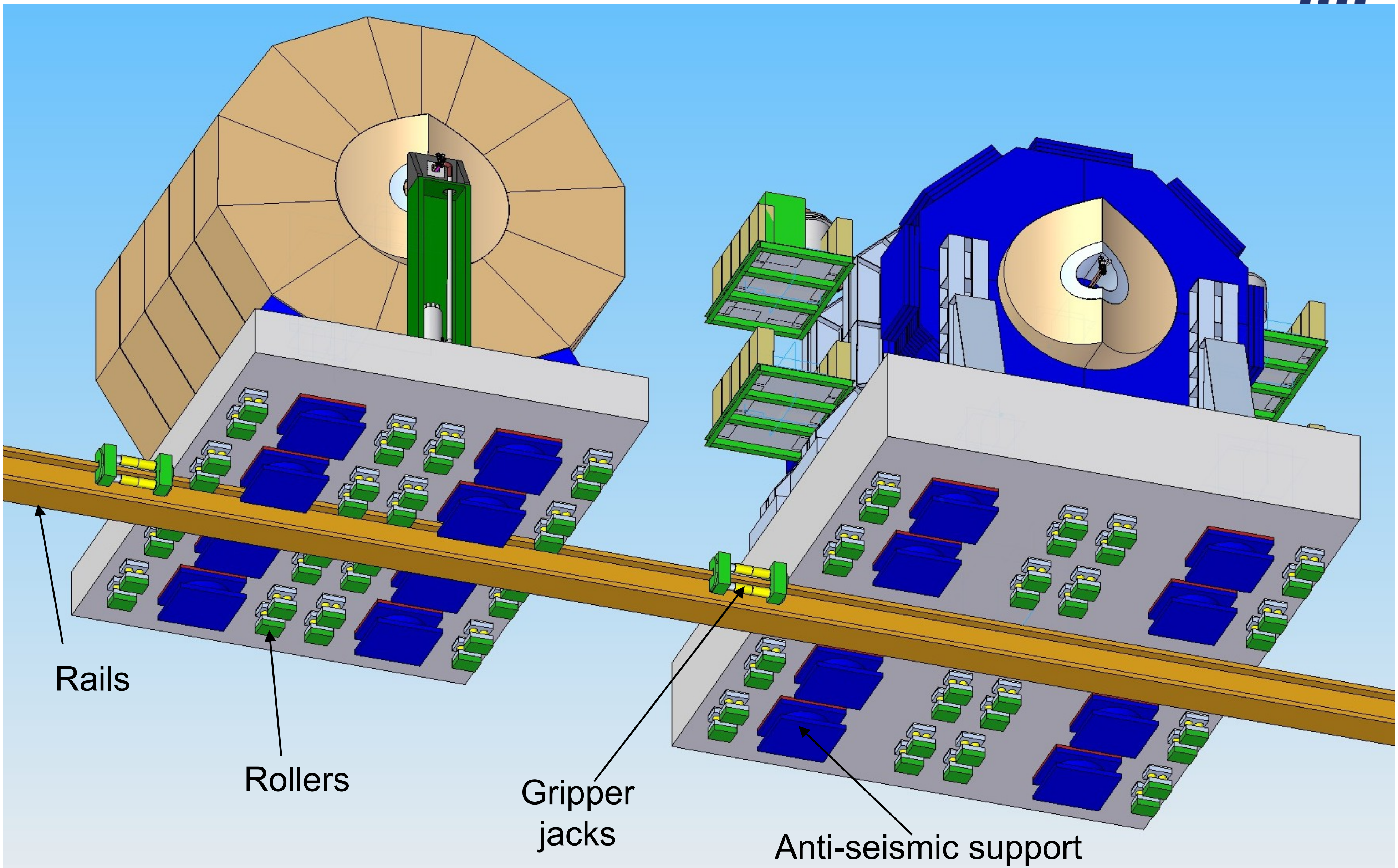


# Thicker platform ?

## Extra Height to accommodate the difference of the two detectors

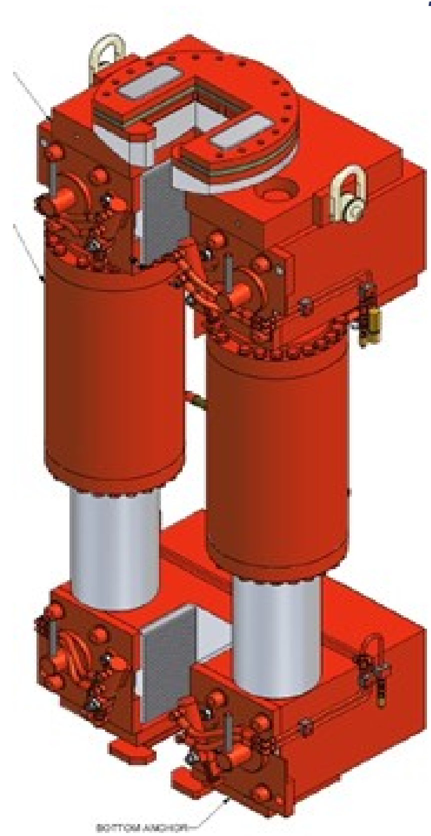


# Gripper Jacks on rail

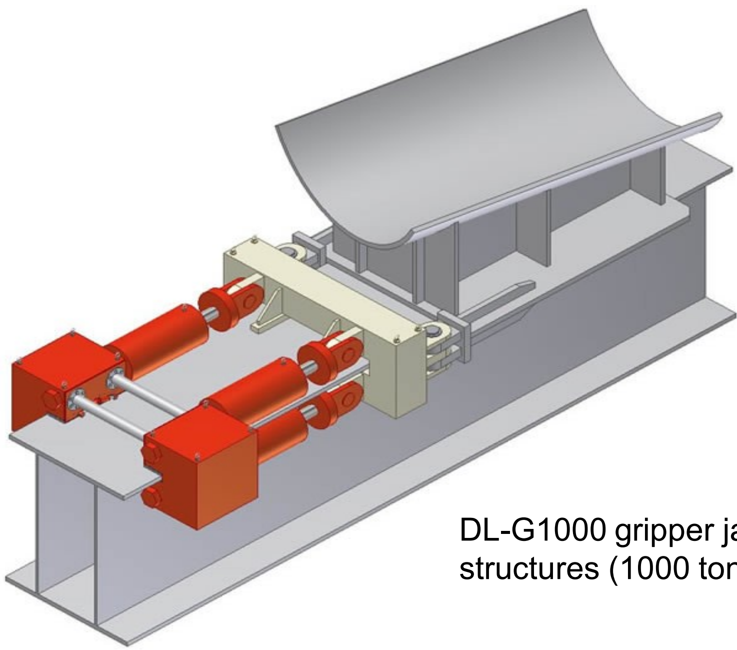


SLAC

# Motion system

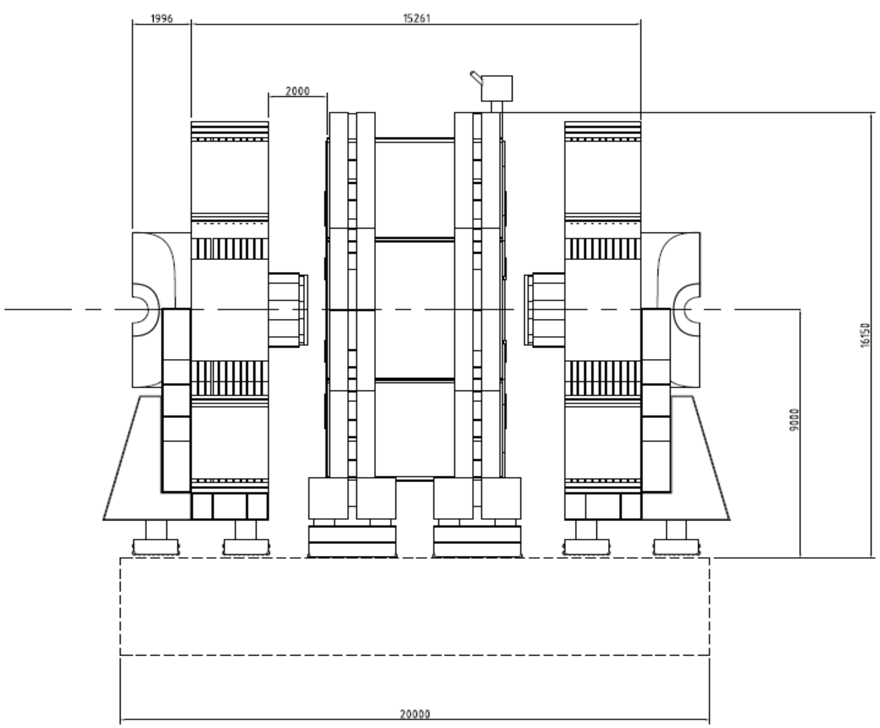


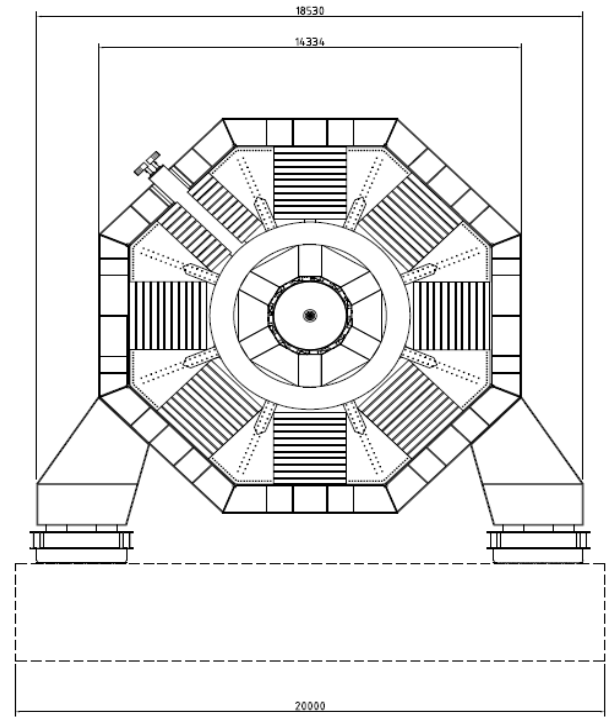
Gripper Jacks, 1’000 T



DL-G1000 gripper jack for load out of offshore structures (1000 tonnes push / pull capacity)

# 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)

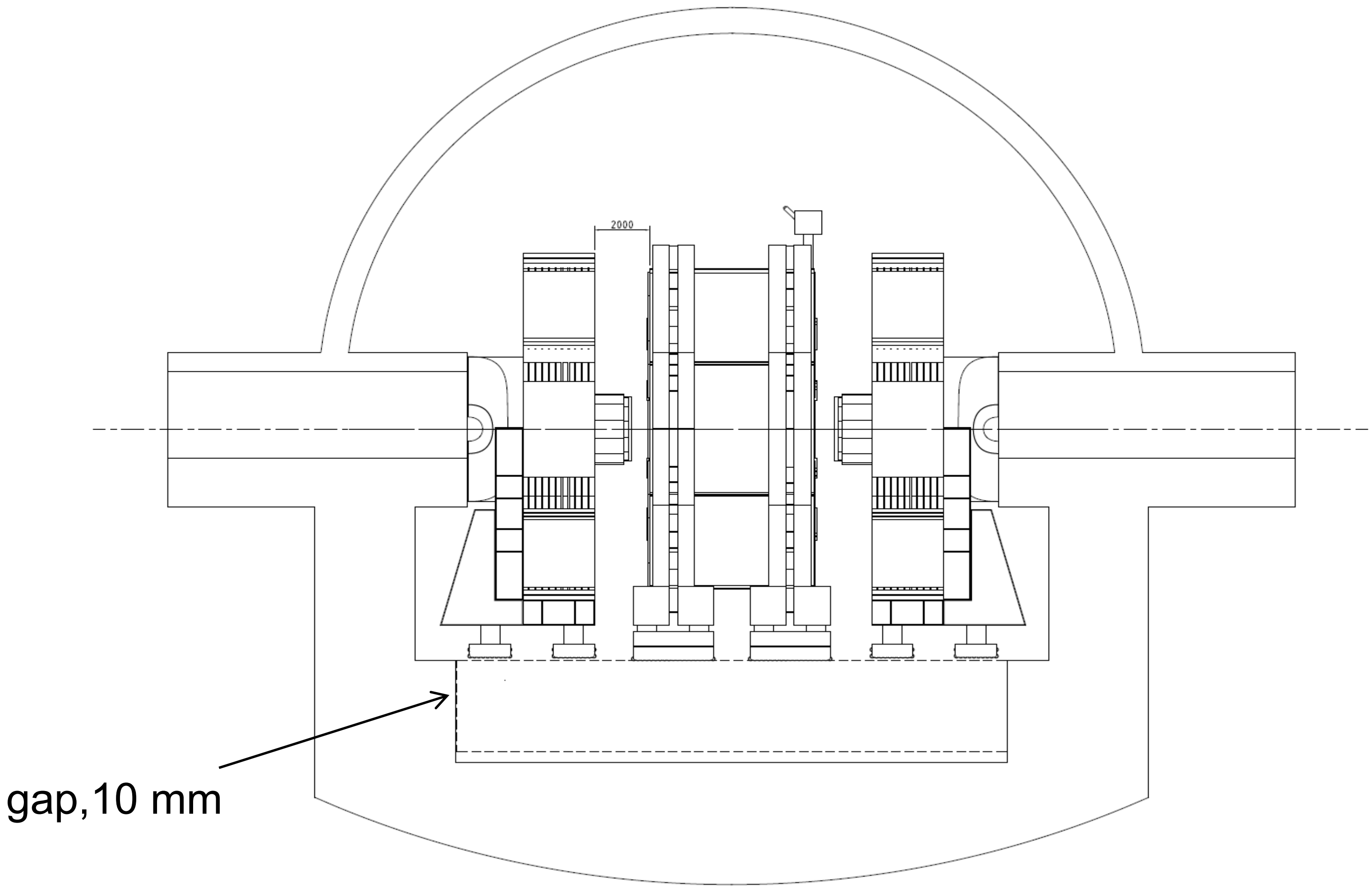
Positioning Tolerance on beamline
- Consider points Z=+-max, X=0. Position to + 1mm wrt references in X,Y,Z
- Consider points Z=+-max, X=+-max: Position to +- 1 wrt references in Y.

Static Deformations: <+-2 mm

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

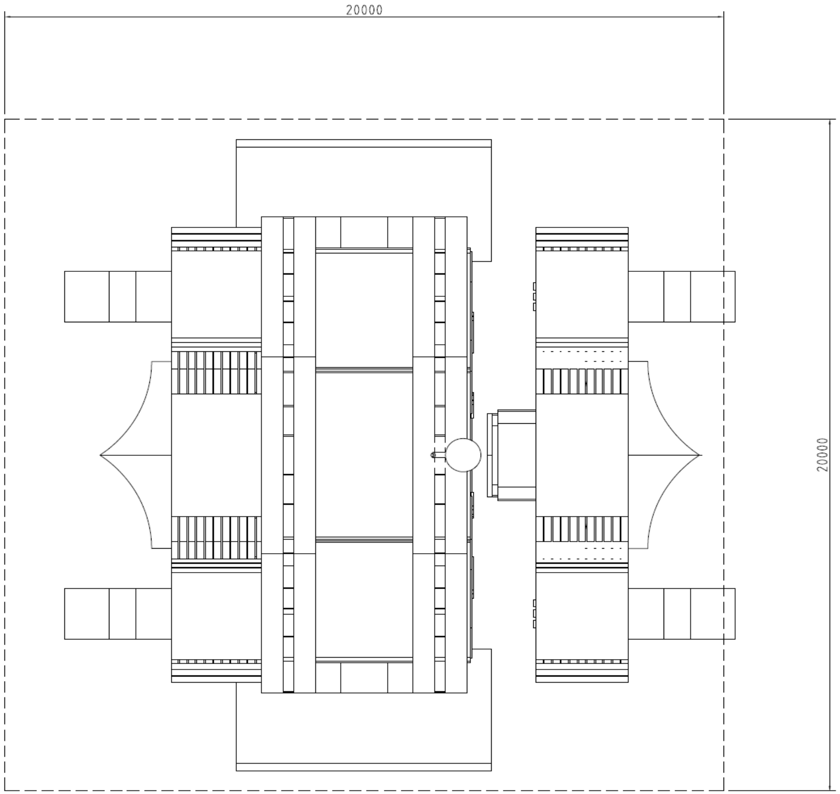
Seismic stability: Appropriate for selected site. (Beamline must be designed with sufficient compliance that VXD will survive)

# SiD Platform Functional Requirements

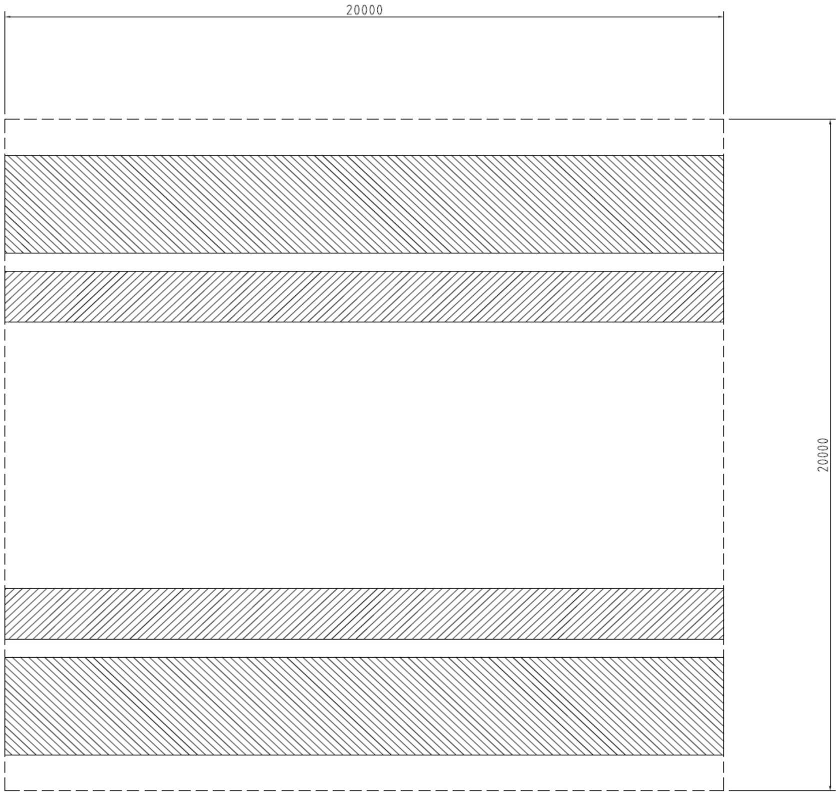



Wall clearance ~10 mm. Platform comes to side wall, there is no apron or apron matches platform elevation.

# SiD Platform Functional Requirements




Detector Top View

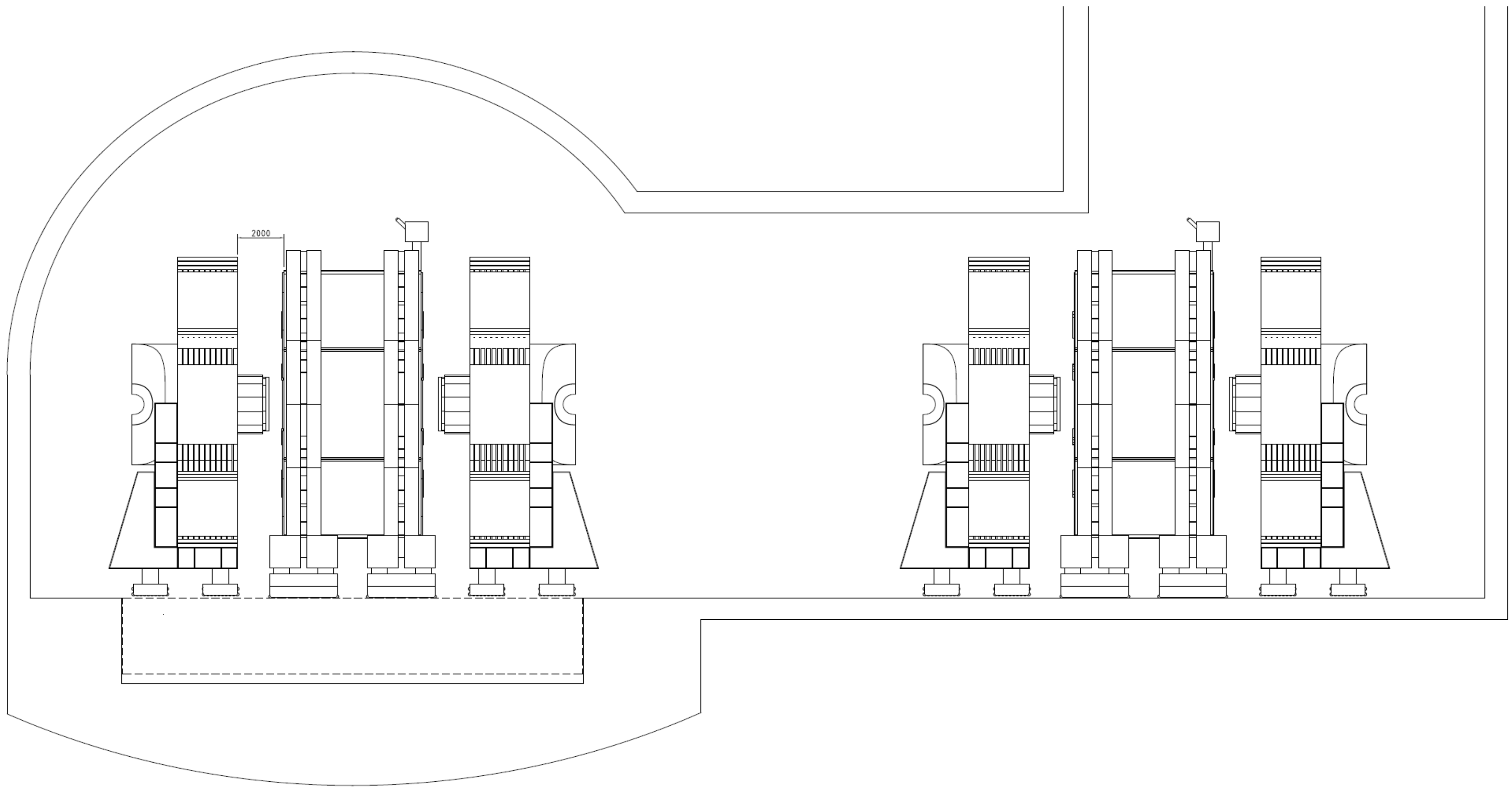



Platform Top View

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: | < 0.01 g |
| Transport velocity: | V>1 mm/s after acceleration |

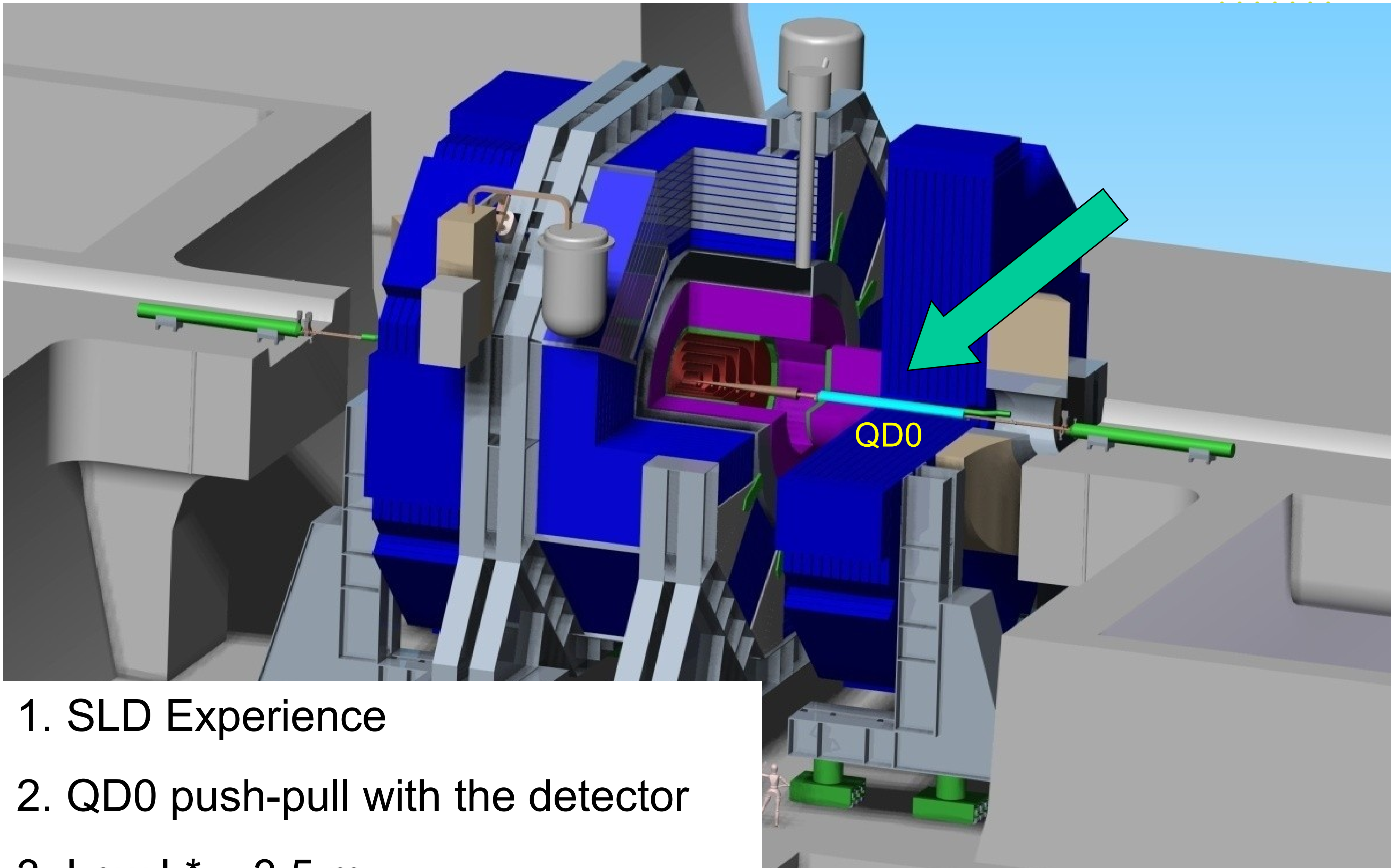
Life: 100 motion cycles.

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)

# QD0 supported from the doors



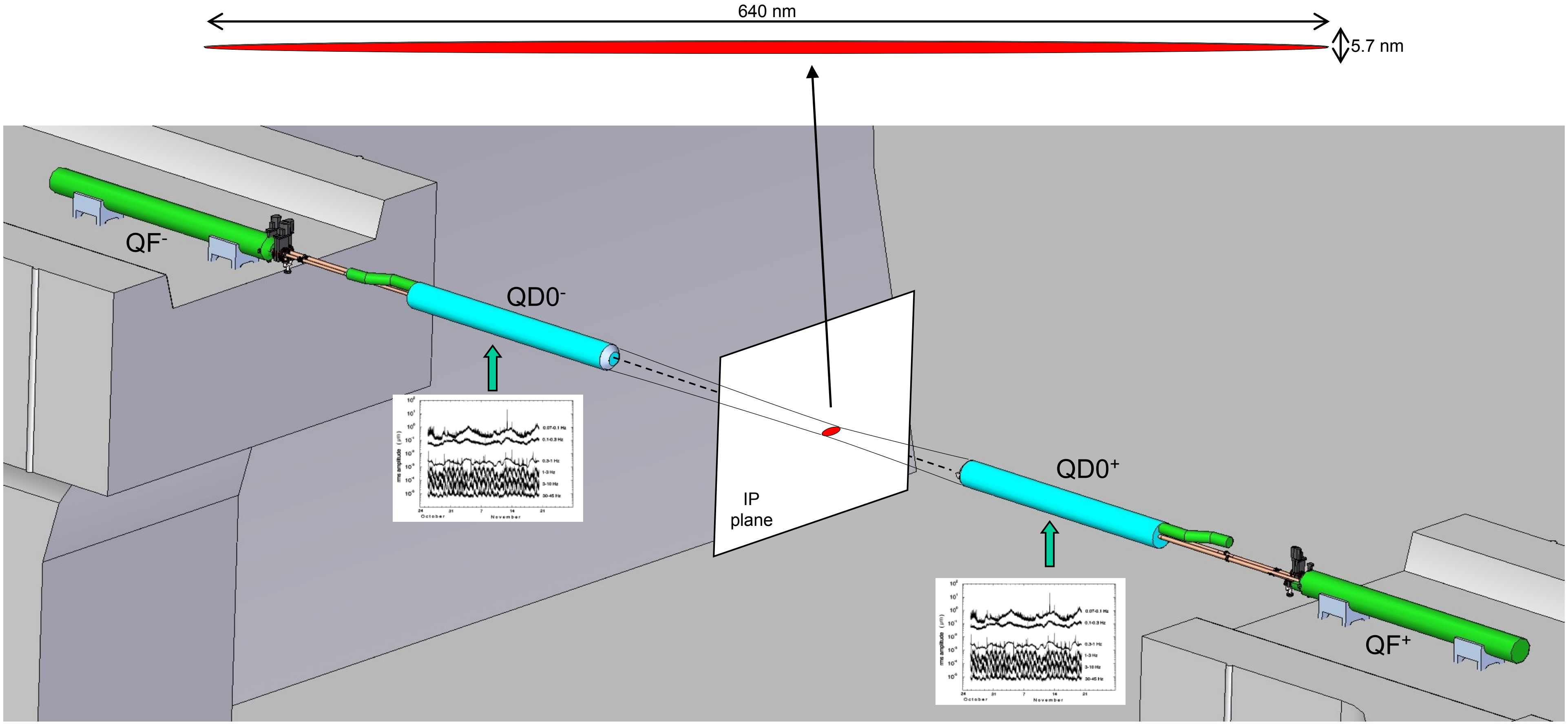

1. SLD Experience
2. QD0 push-pull with the detector
3. Low L* ~ 3.5 m

# Luminosity Loss & Vibrations

Sub-nanometric stability of the focusing system is required to maintain the luminosity to within a few percent of the design value.

Ground motion is a source of vibrations which would continuously misaligning the focusing elements.

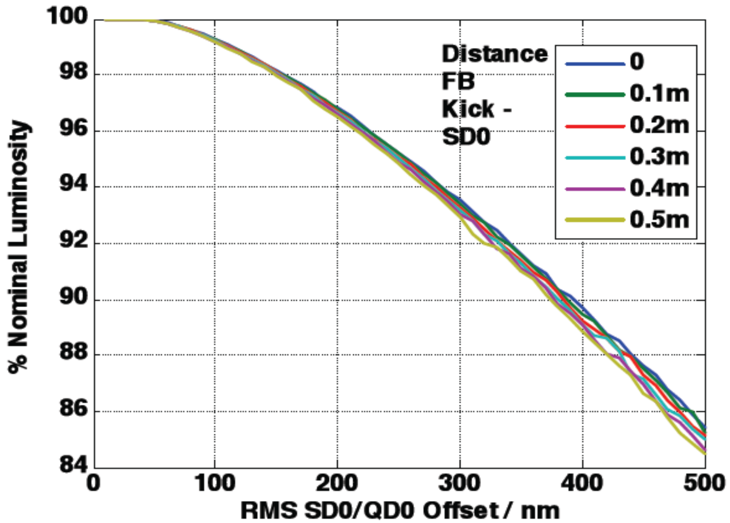
The design of the support of the QD0 is a fundamental issue

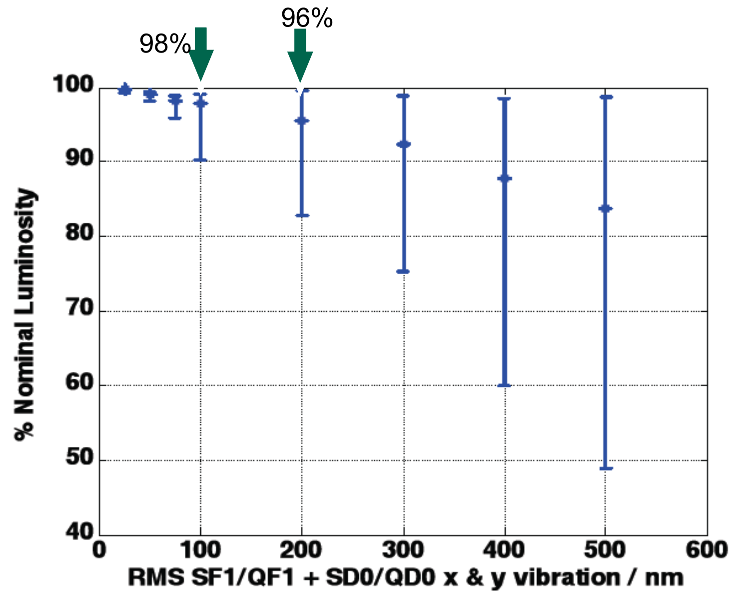


# Luminosity Loss & Vibrations

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

Max. Integrated relative displacement: 200 nm > 5 Hz




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

Definition: *Luminosty* ~ Collision Rate at the Interaction point

# Luminosity feedback systems and stability

Two Luminosity Feedback systems are implemented in ILC :

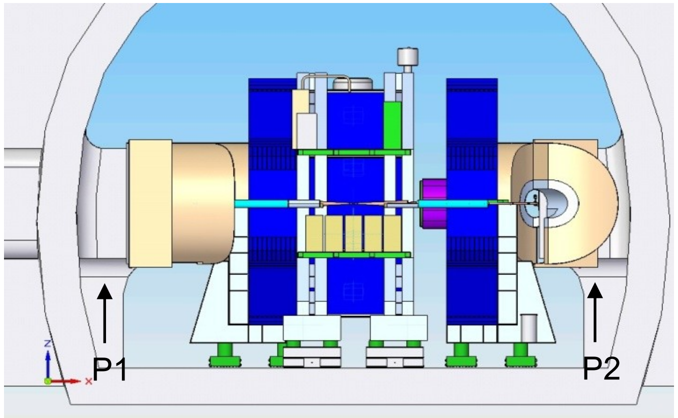
• A 5 Hz to control the orbit in the BDS (low frequency)

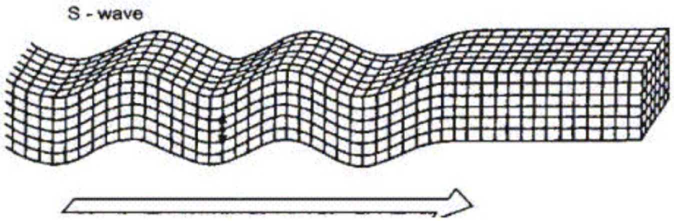
QD0 alignment accuracy: ± 200 nm and 0.1 μrad from a line determined by QF1s, stable over the 200ms time interval between bunch trains

• A Intra-train system to address ground motion and mechanical disturbances (high frequency~1000 Hz)

QD0 vibration stability: Δ(QD0(e+)-QD0(e-)) < 50 nm within 1ms long bunch train “

# Vibrations : Absolute, Relative and Coherent and motion



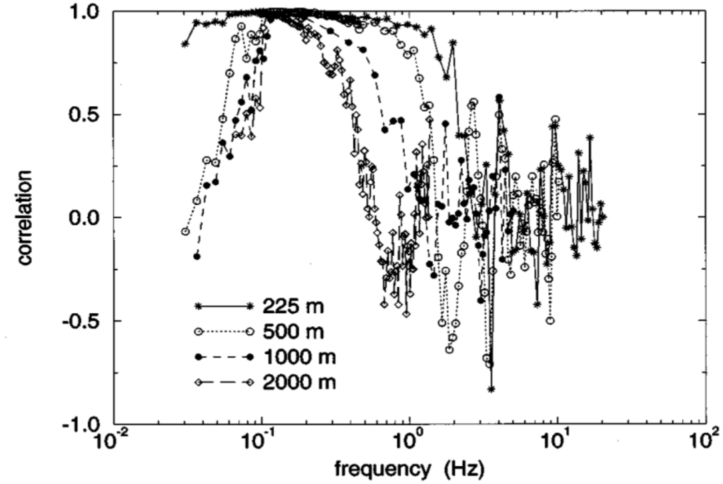




FIG. 3. Correlation spectra of ground motion measured at CERN in the LEP tunnel [7]. The distances between sensors were 225, 500, 1000, and 2000 m.

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

If P1=P2, then :

Jo = $0^{th}$ 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

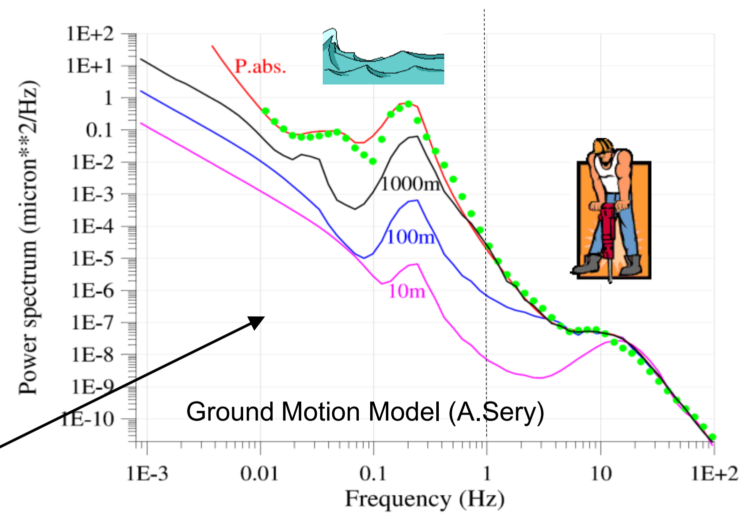
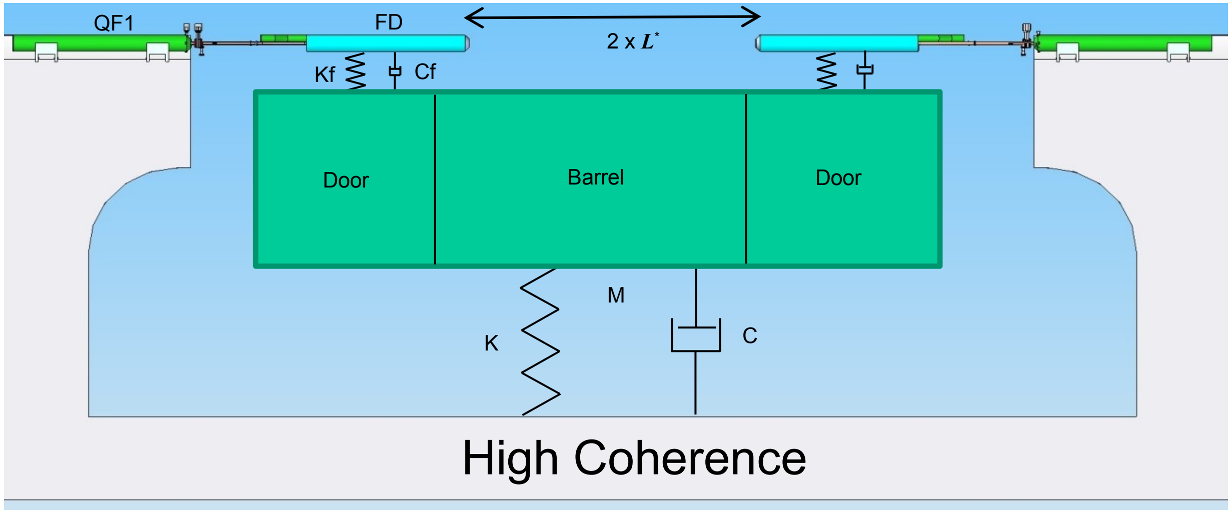
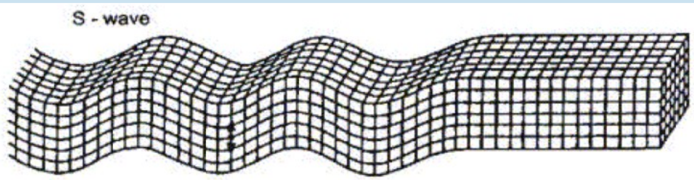
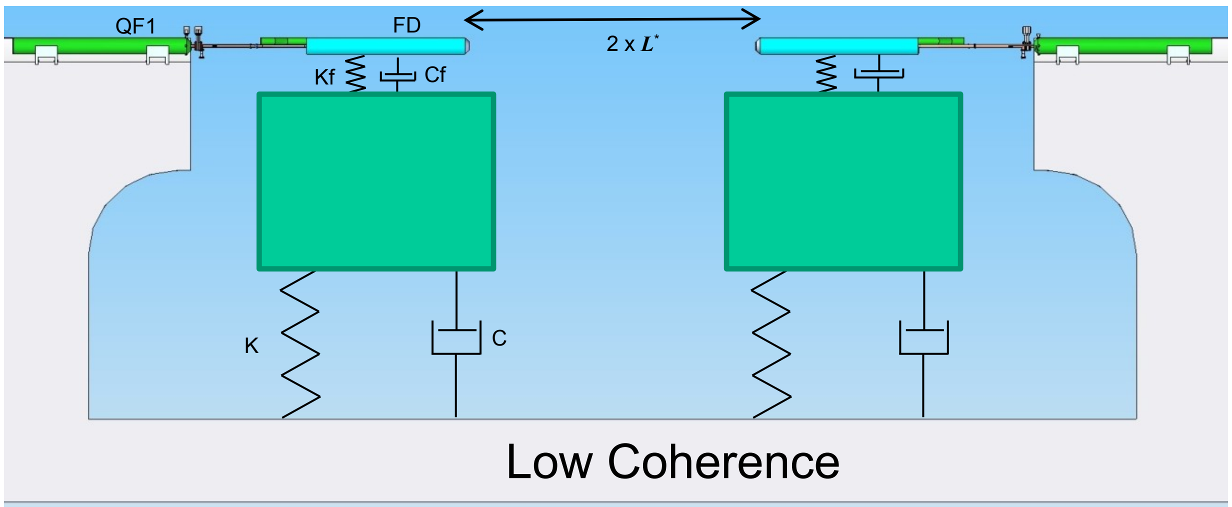



Figure 3: Measured (symbols) and modeling spectra $p(\omega)$ of absolute motion and $p(\omega, L)/2$ of relative motion for the 2 a.m. SLAC site ground motion model.

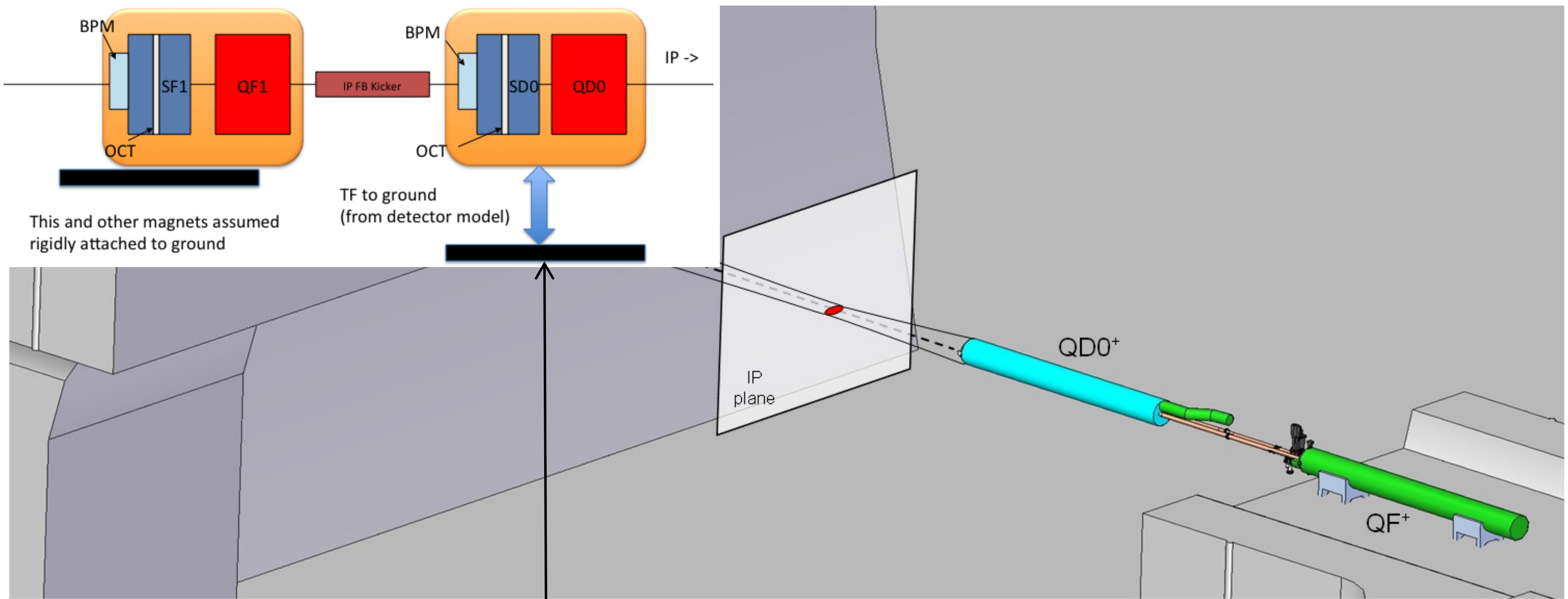
# QD0 Supports

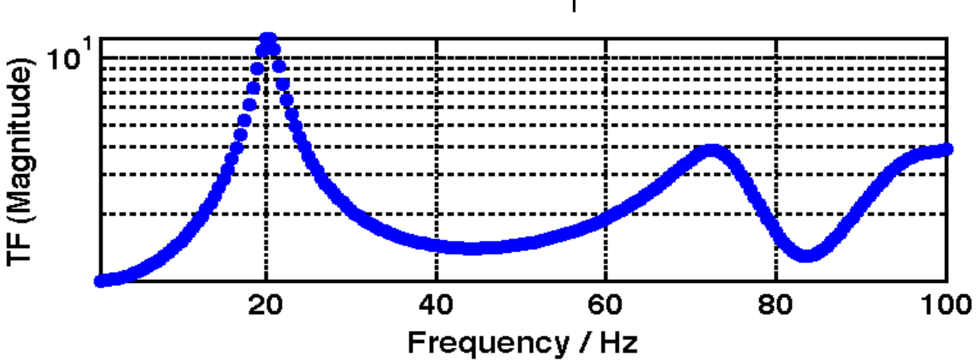


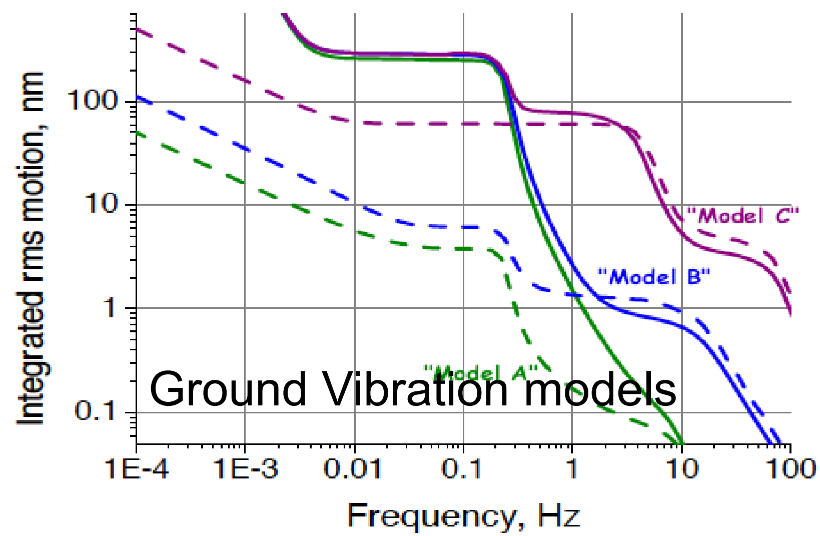



# IP Region Final Doublet : QD0+QF1

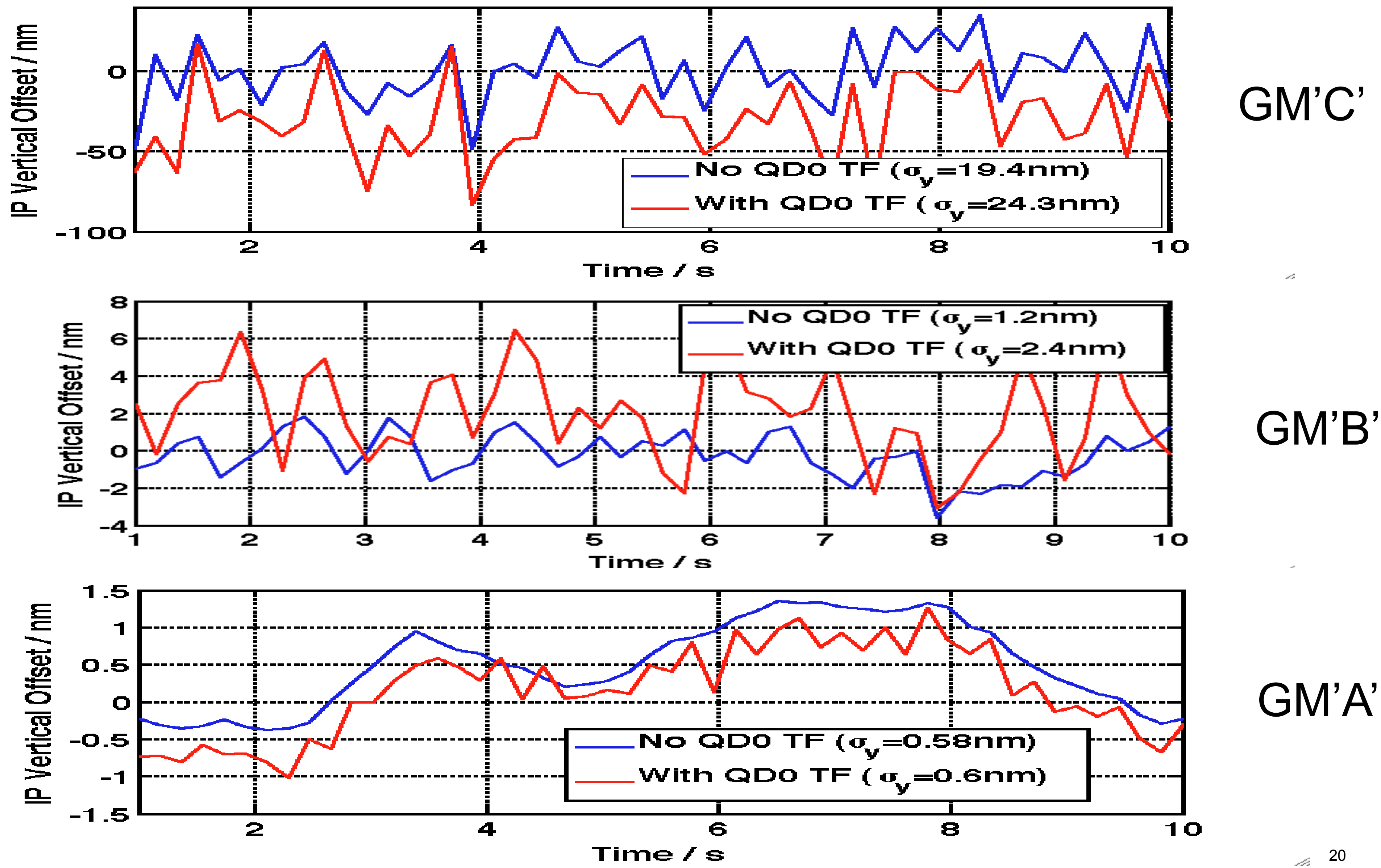



Platform Transfer Function



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

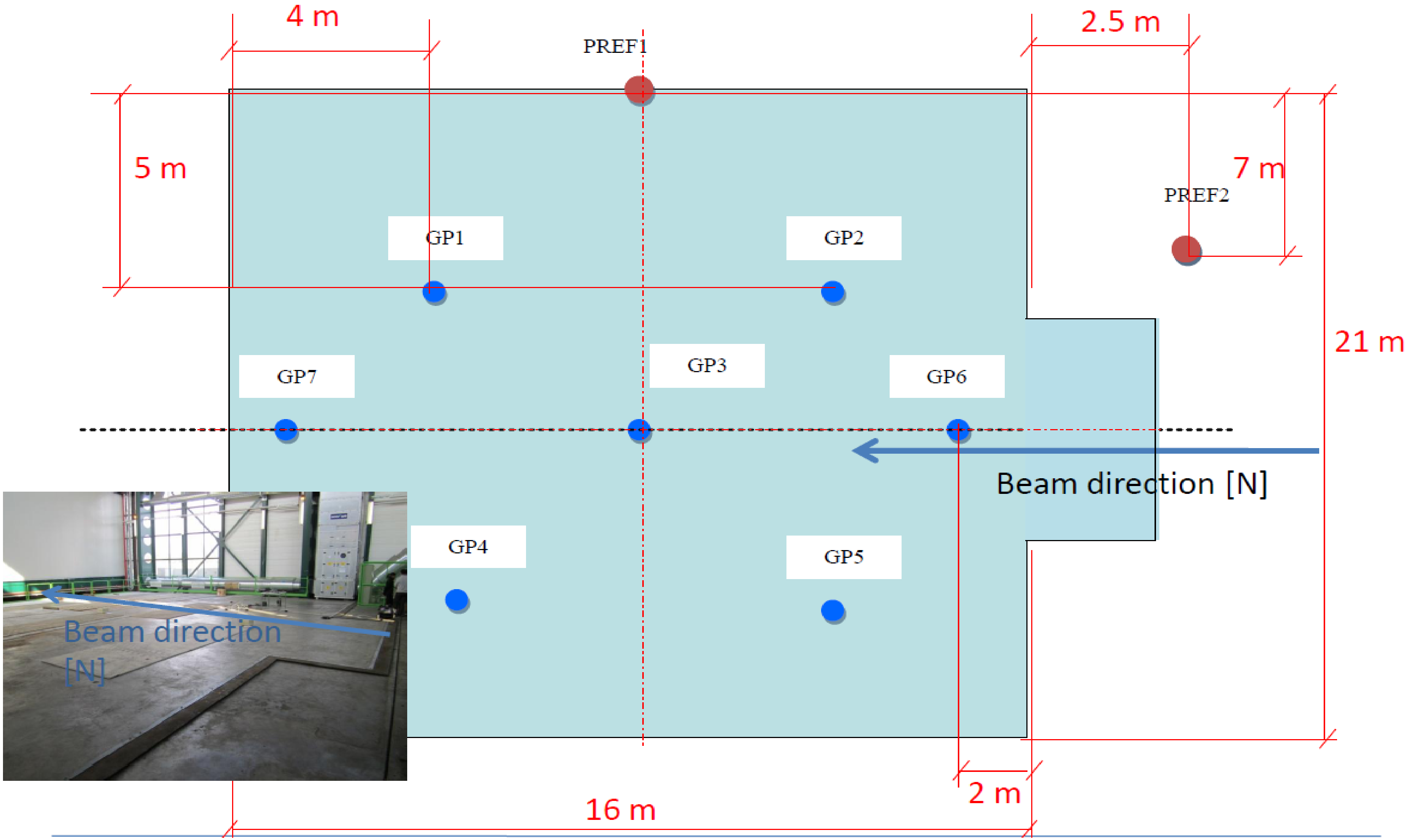


## Platform Simulation

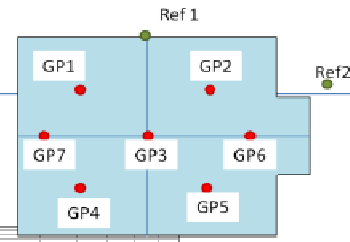
## Benchmark with exp.data


142 tons of high
tensile steel in plug
2004

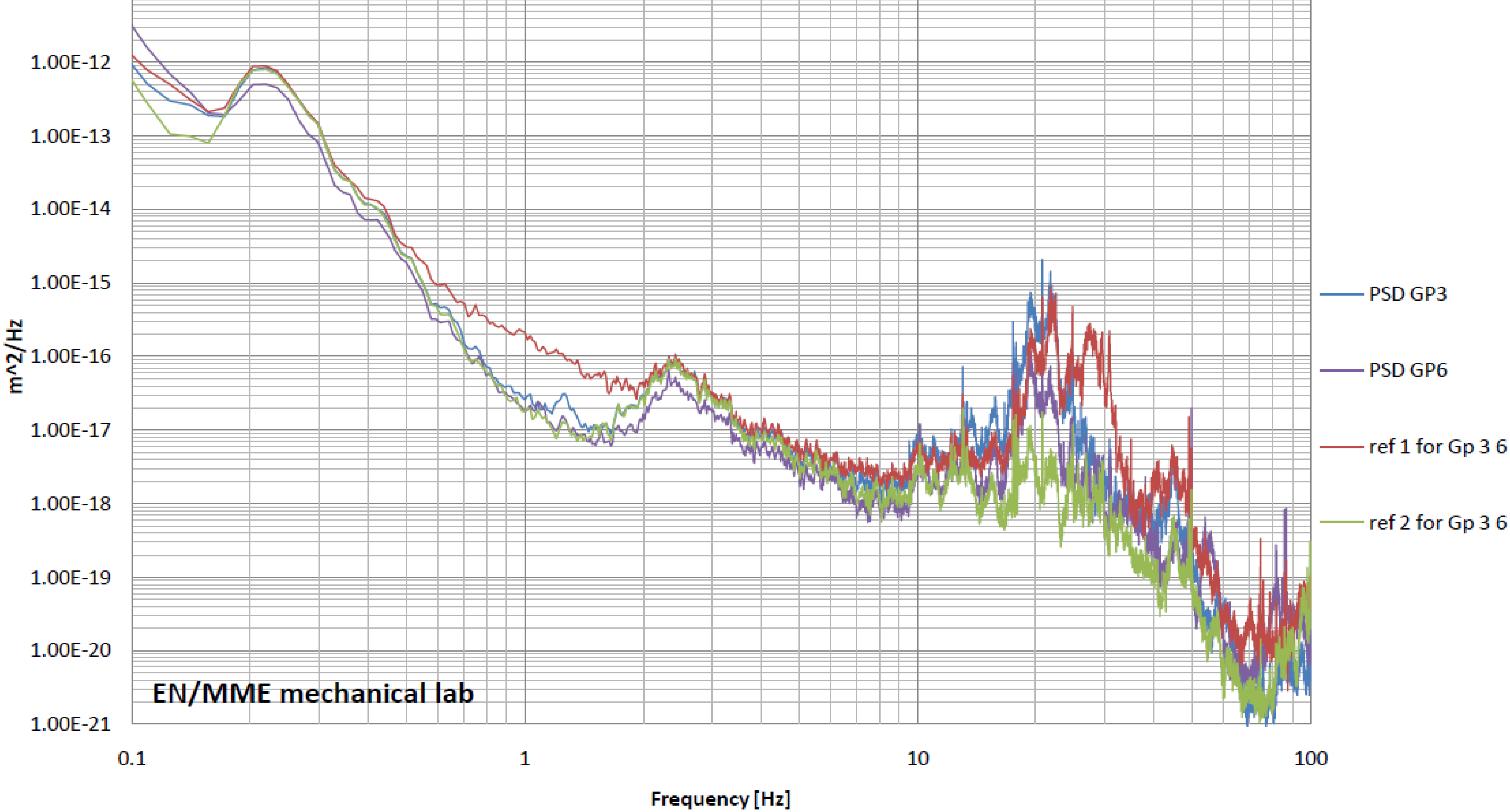
# Sensor position

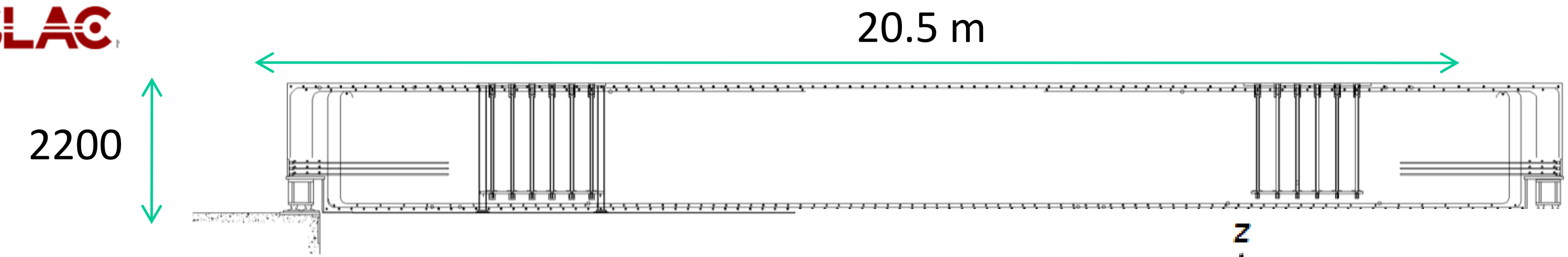


# PSD for a typical measurement




**PSD**






CMS Platform (as built)

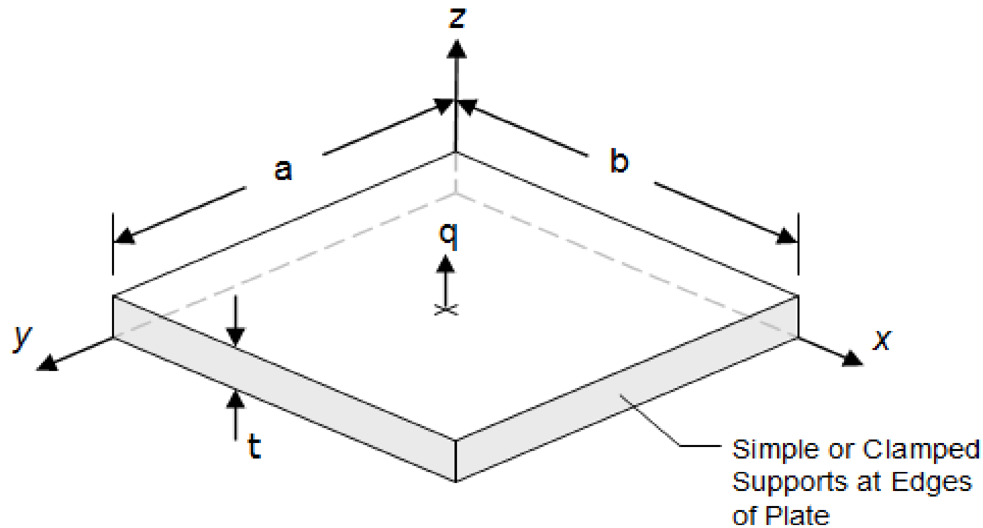
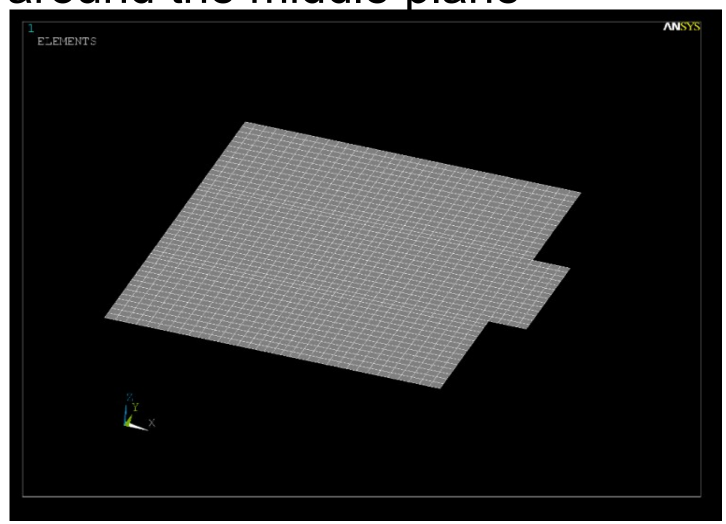
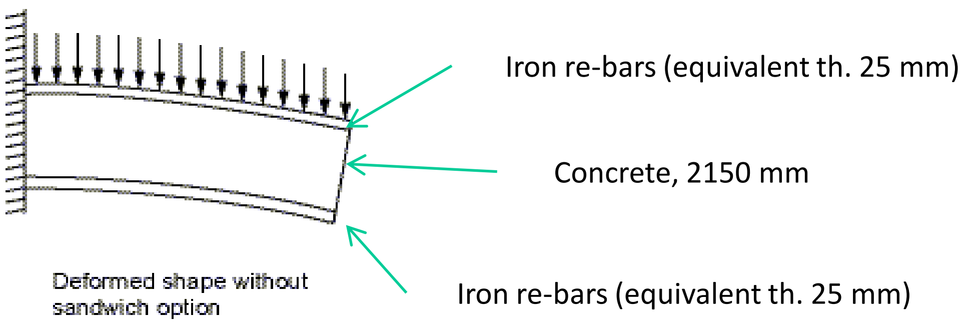




Plate Model: zero thickness with bending stiffness around the middle plane



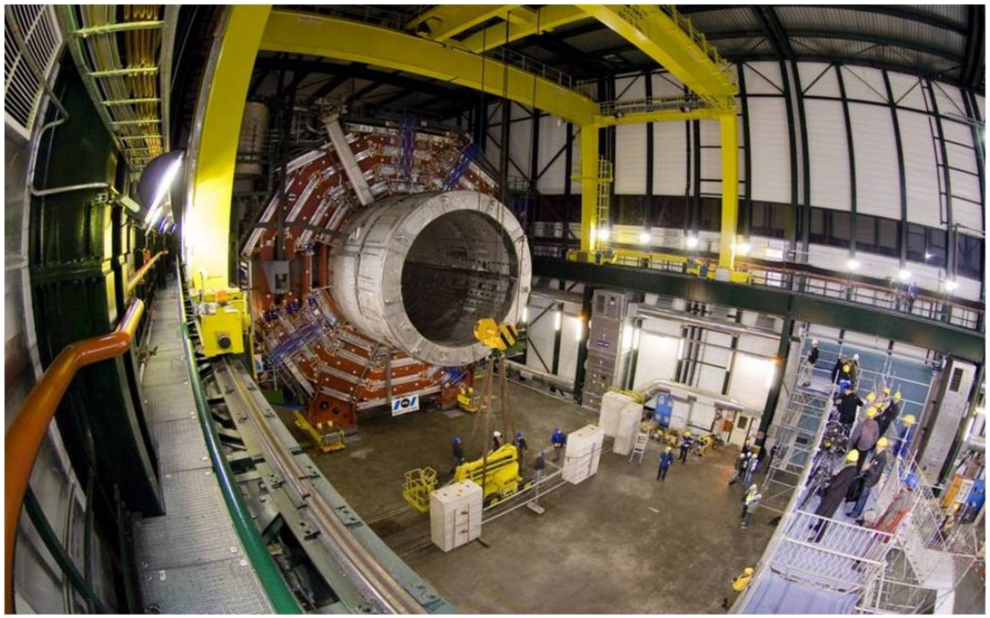



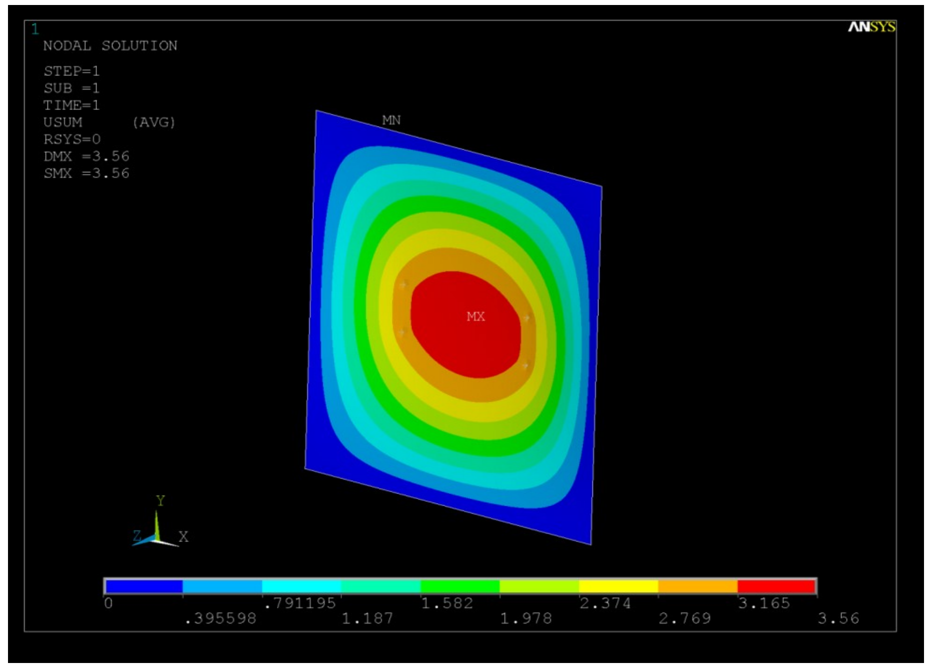

Total thick. 2.2 m

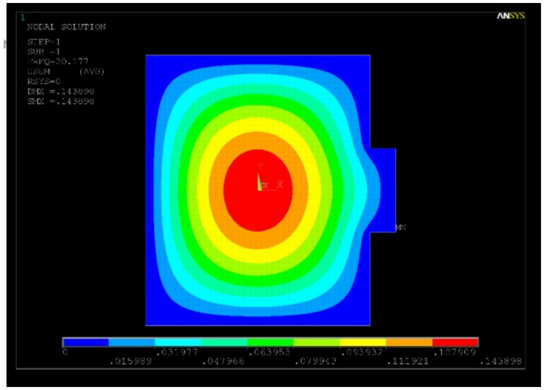
# Bencmark with static test done on the platform

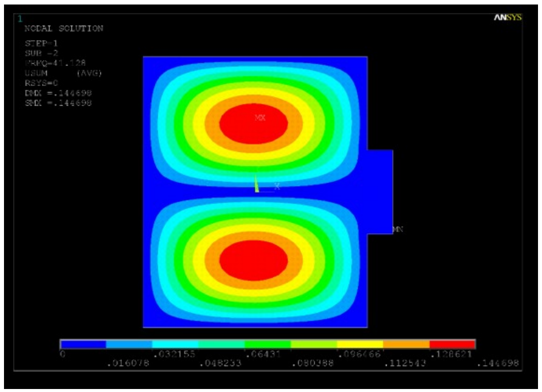
Dummy load = 2500 tons,
Weight of the platform =  1780 tons
Max sag at the center = 3.5 mm

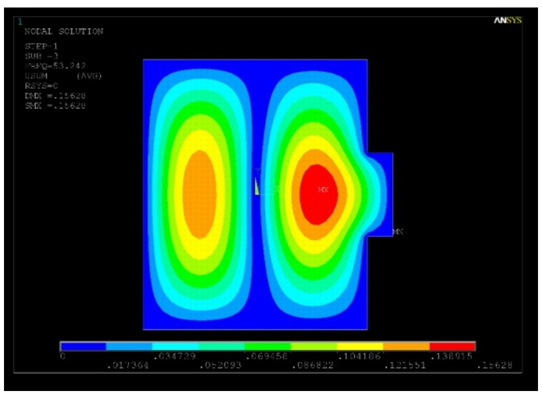
N.B. = Platform Simply supported on the edges



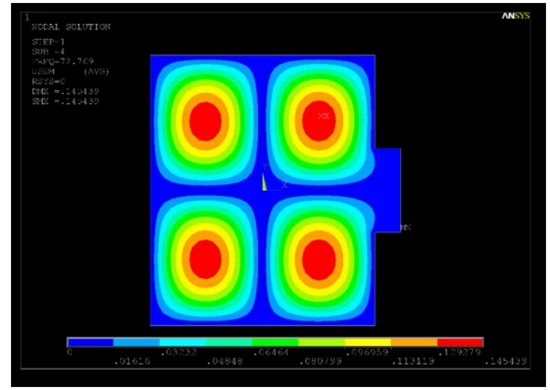


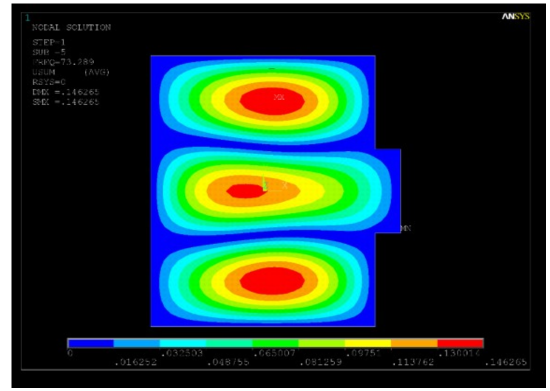


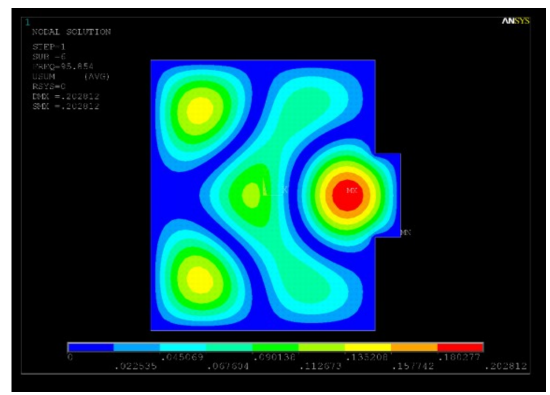




| Mode | FREQ |
|---|---|
| 1 | 20.17 |
| 2 | 41.12 |
| 3 | 53.24 |
| 4 | 72.76 |
| 5 | 73.28 |
| 6 | 95.85 |

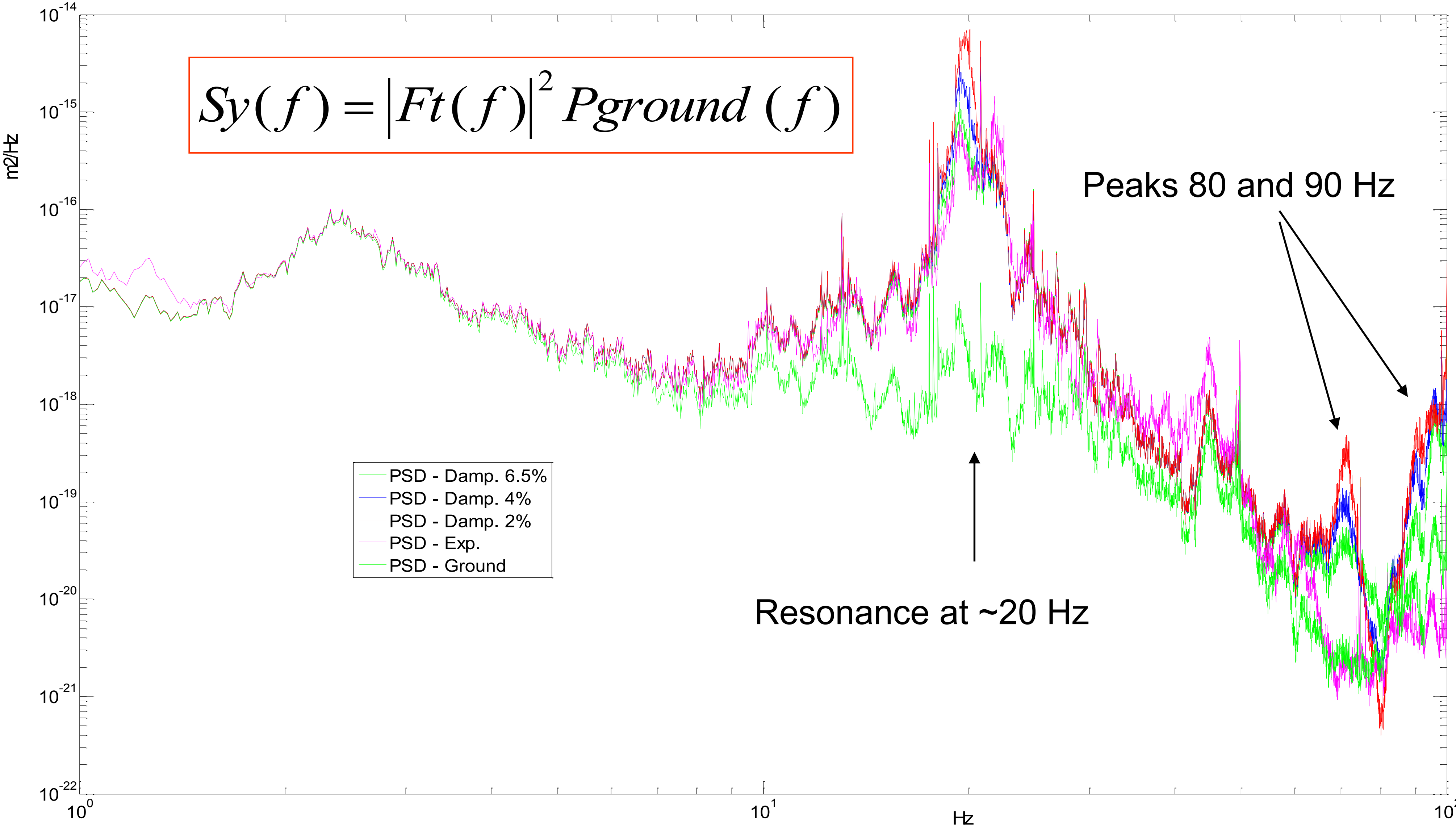


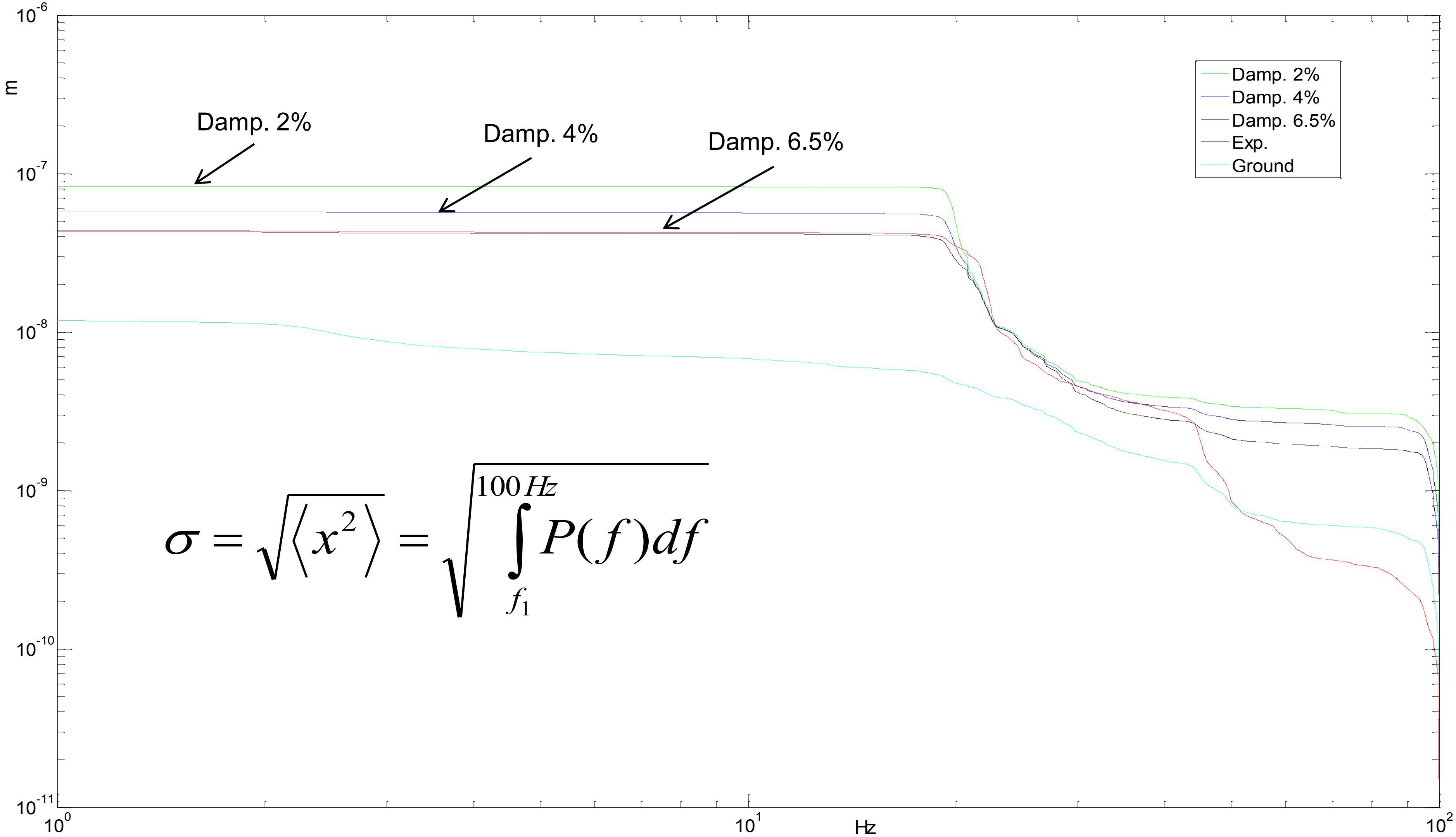



# Simulations vs. Measured PSD (Platform Center)

$$Sy(f) = |Ft(f)|^2 \, Pground\,(f)$$



# 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

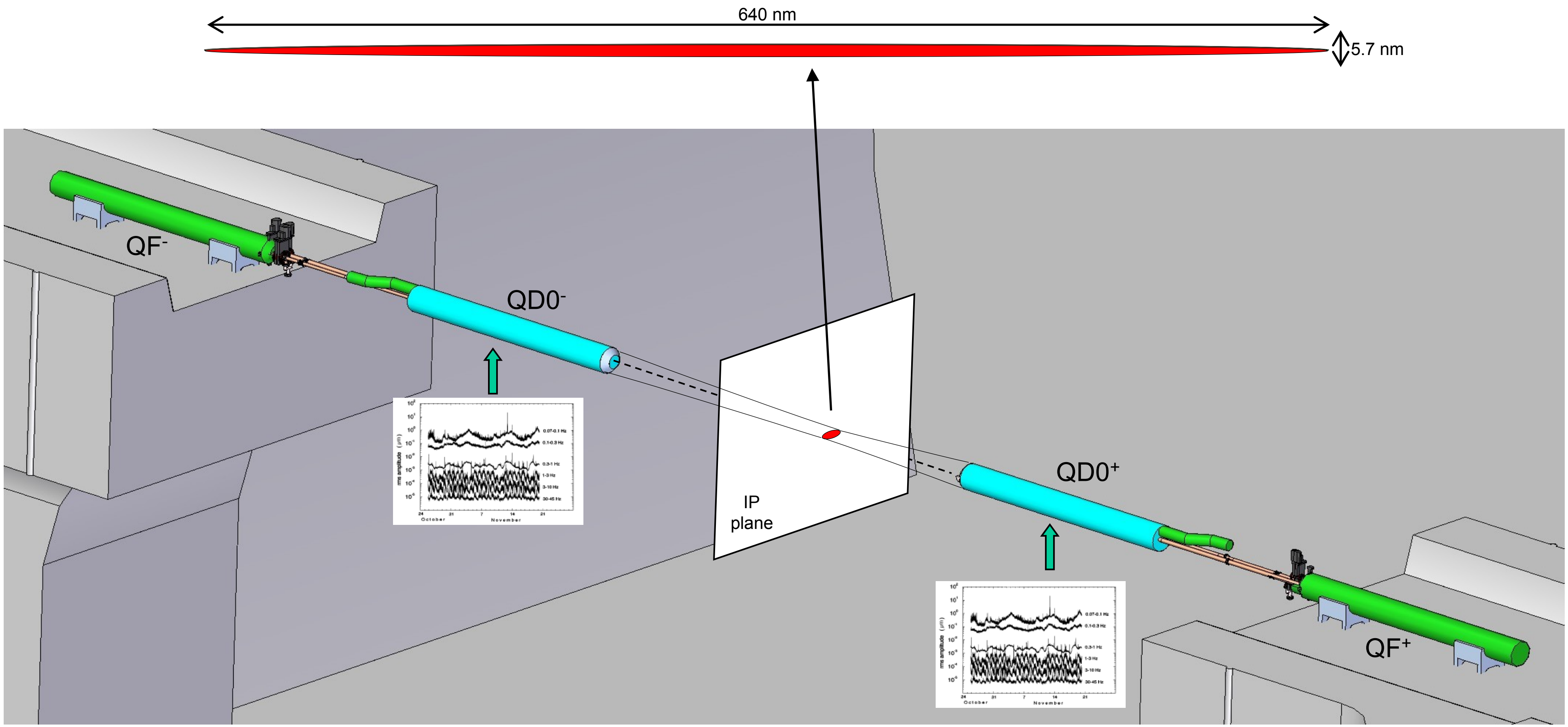
# Bonus Material

# Luminosity Loss & Vibrations

Sub-nanometric stability of the focusing system is required to maintain the luminosity to within a few percent of the design value.

Ground motion is a source of vibrations which would continuously misaligning the focusing elements.

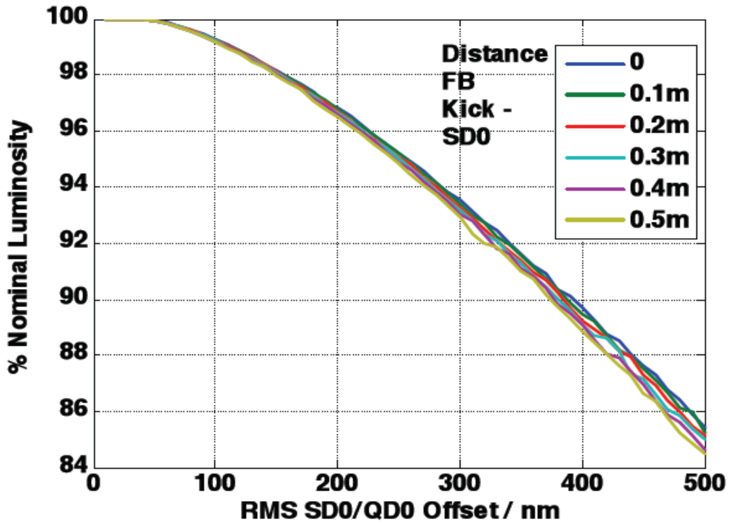
The design of the support of the QD0 is a fundamental issue

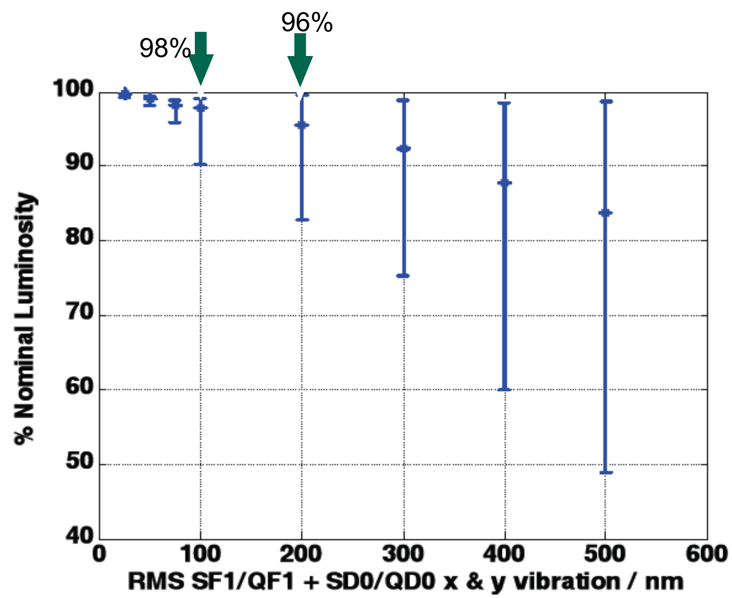


# Luminosity Loss & Vibrations

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

Max. Integrated relative displacement: 200 nm > 5 Hz




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

Definition: *Luminosty* ~ Collision Rate at the Interaction point

# Luminosity feedback systems and stability

Two Luminosity Feedback systems are implemented in ILC :

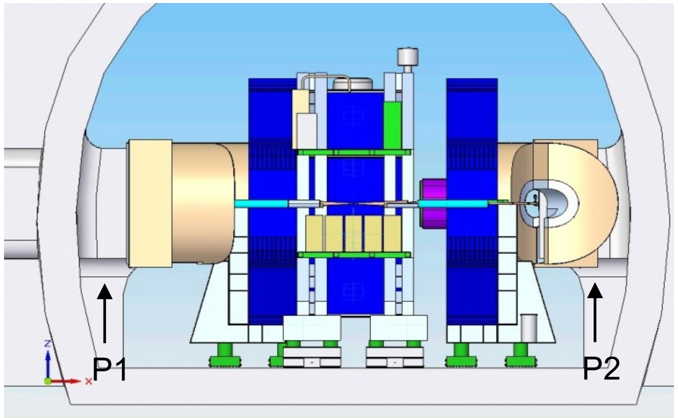
• A 5 Hz to control the orbit in the BDS (low frequency)

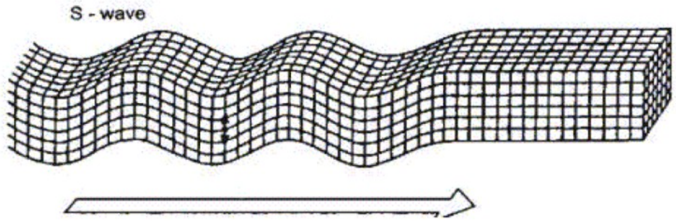
QD0 alignment accuracy: ± 200 nm and 0.1 μrad from a line determined by QF1s, stable over the 200ms time interval between bunch trains

• A Intra-train system to address ground motion and mechanical disturbances (high frequency~1000 Hz)

QD0 vibration stability: Δ(QD0(e+)-QD0(e-)) < 50 nm within 1ms long bunch train “

# Vibrations : Absolute, Relative and Coherent and motion



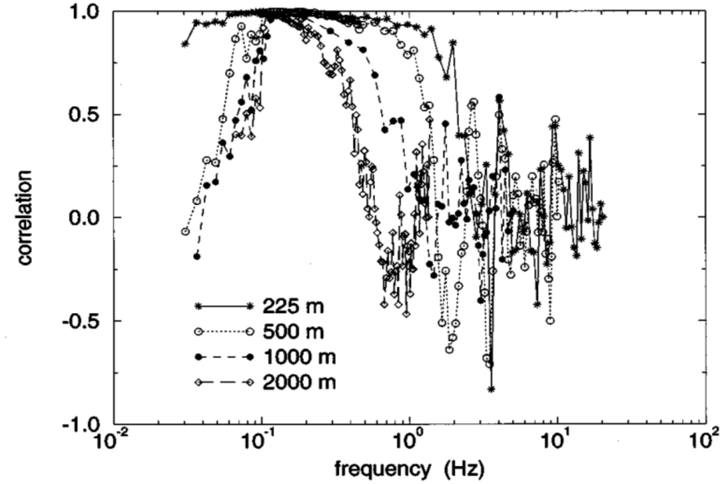




FIG. 3. Correlation spectra of ground motion measured at CERN in the LEP tunnel [7]. The distances between sensors were 225, 500, 1000, and 2000 m.

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

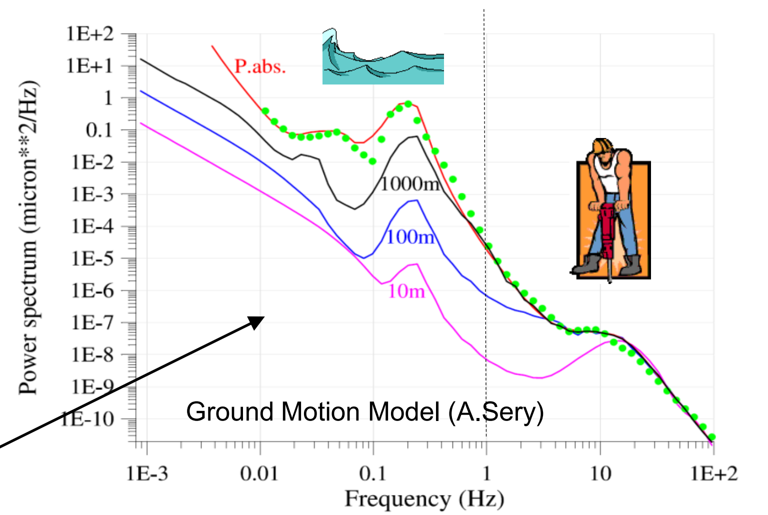
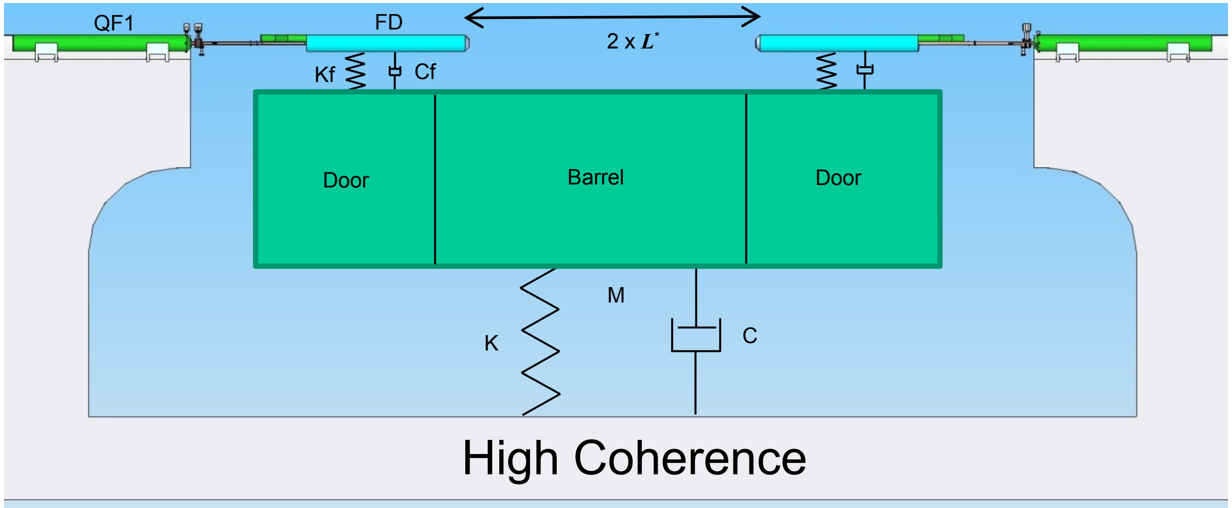
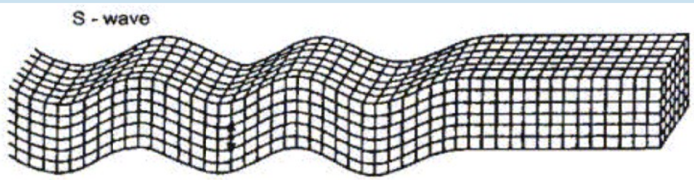
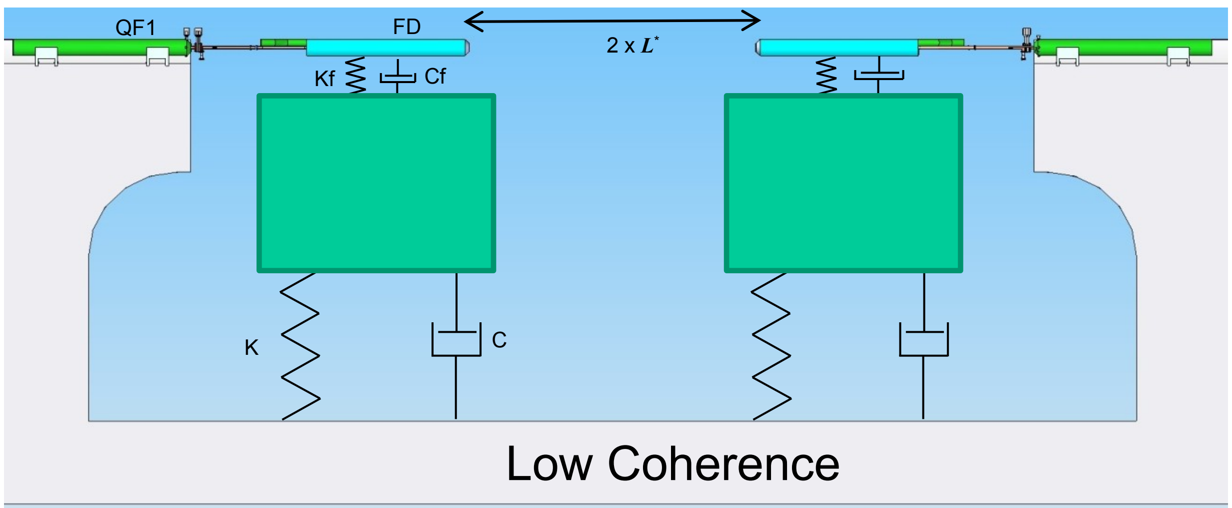



Figure 3: Measured (symbols) and modeling spectra $p(\omega)$ of absolute motion and $p(\omega, L)/2$ of relative motion for the 2 a.m. SLAC site ground motion model.

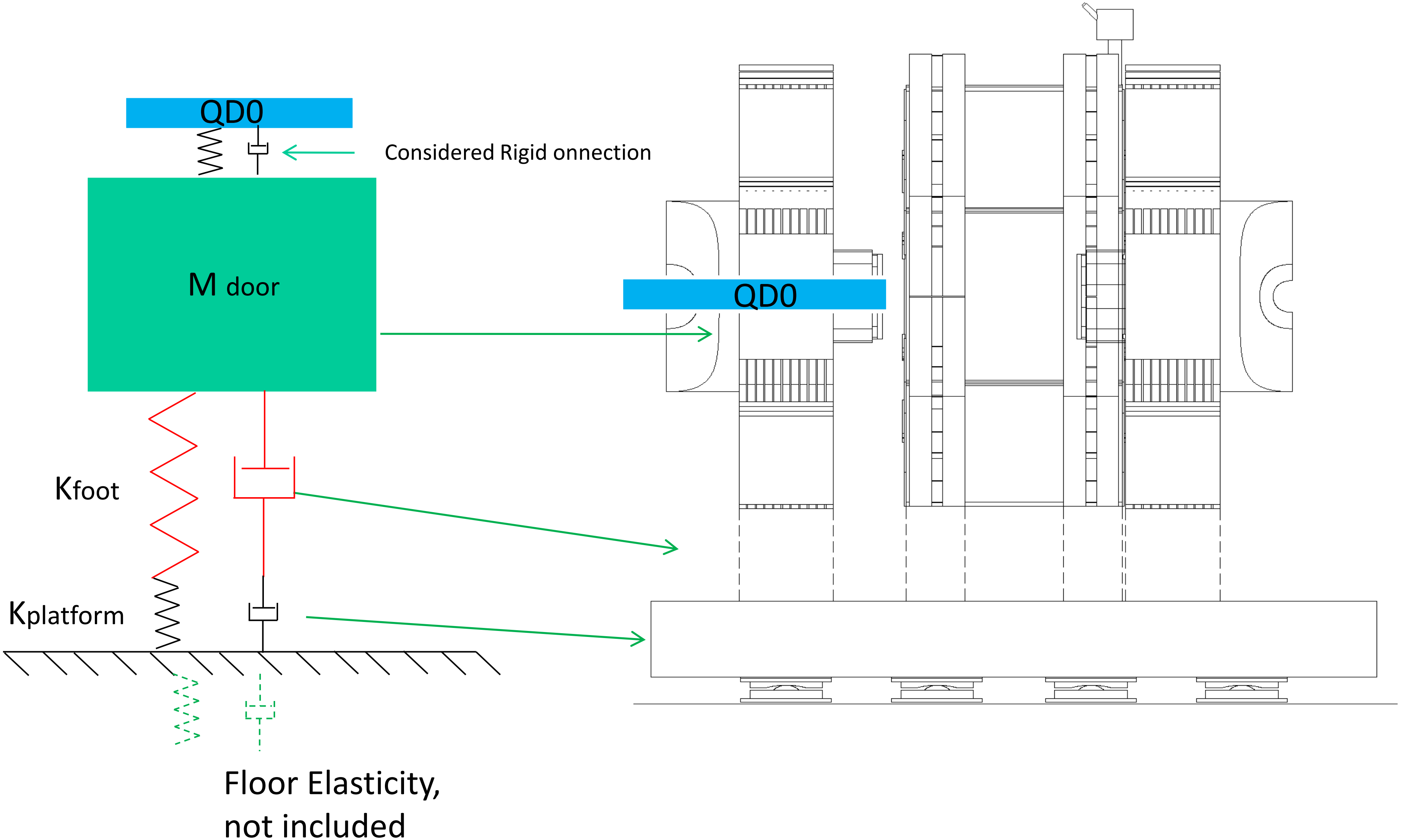
# QD0 Supports



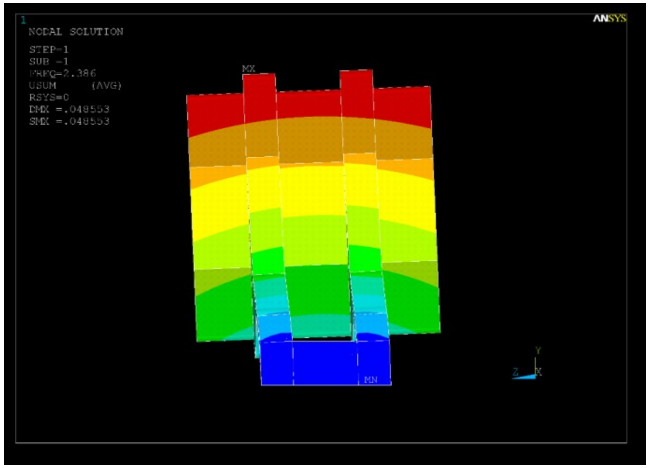



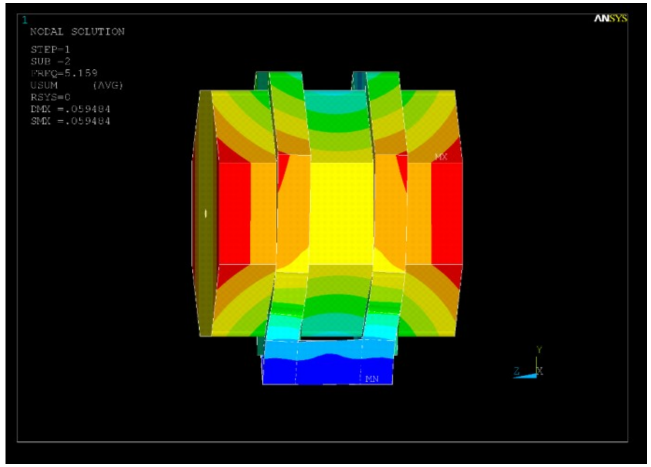
# SiD Vibration Model : 1 degree of freedom M,K,C oscillator



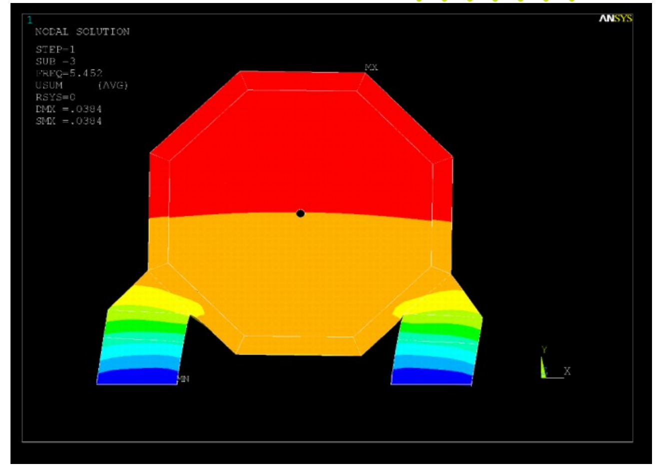
# SiD Free Vibration Mode



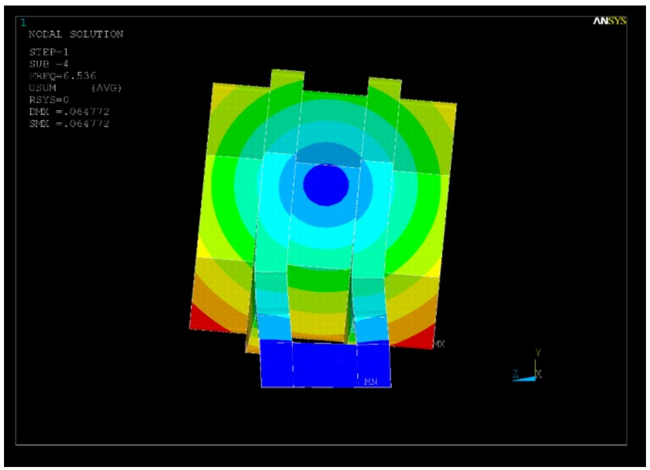

1st Mode, 2.38 Hz



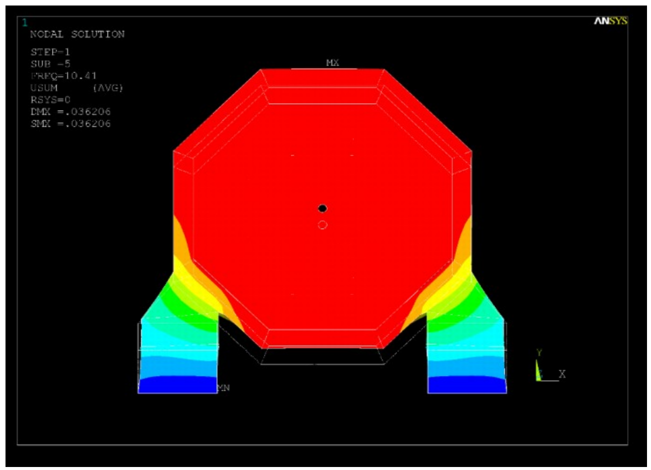

2nd Mode, 5.15 Hz



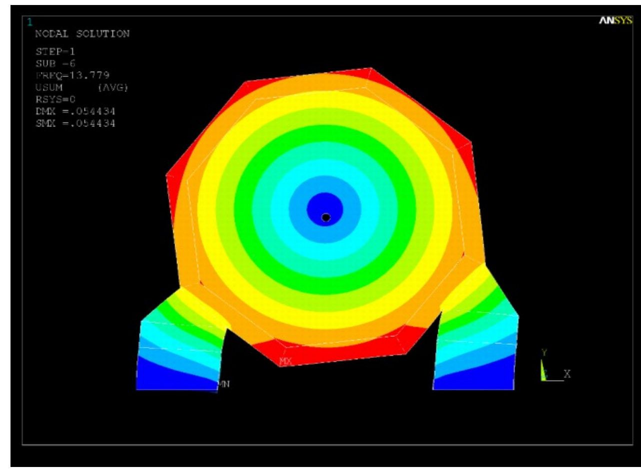

3rd Mode, 5.45 Hz




4th Mode, 6.53 Hz




5th Mode, 10.42 Hz

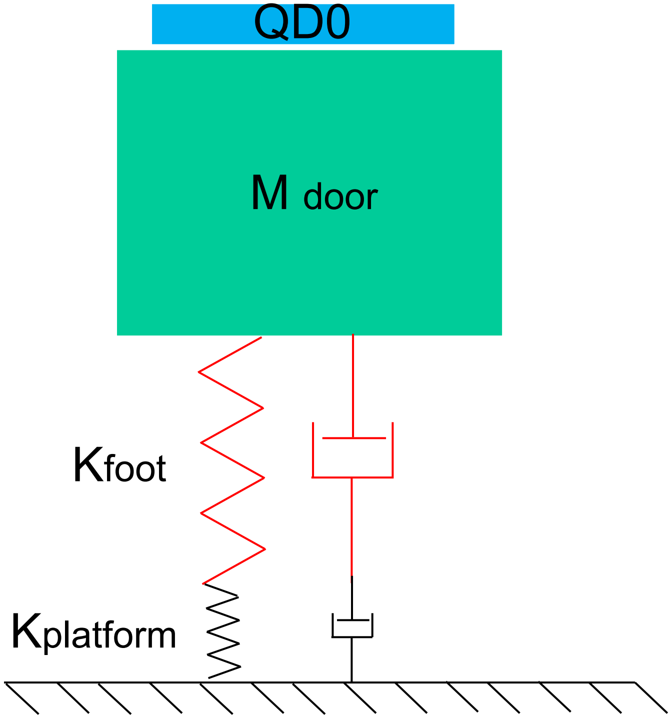



6th Mode, 13.7 Hz

Vertical motion


40

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




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

1[st] mode system

$f_f$ = 1[st] mode SiD foot

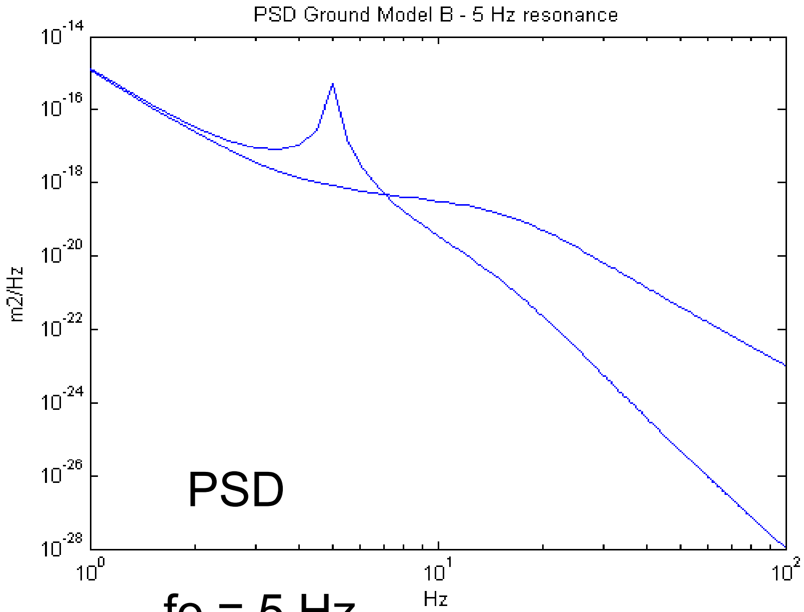
$f_p$ = 1t mode platform

c = 2%

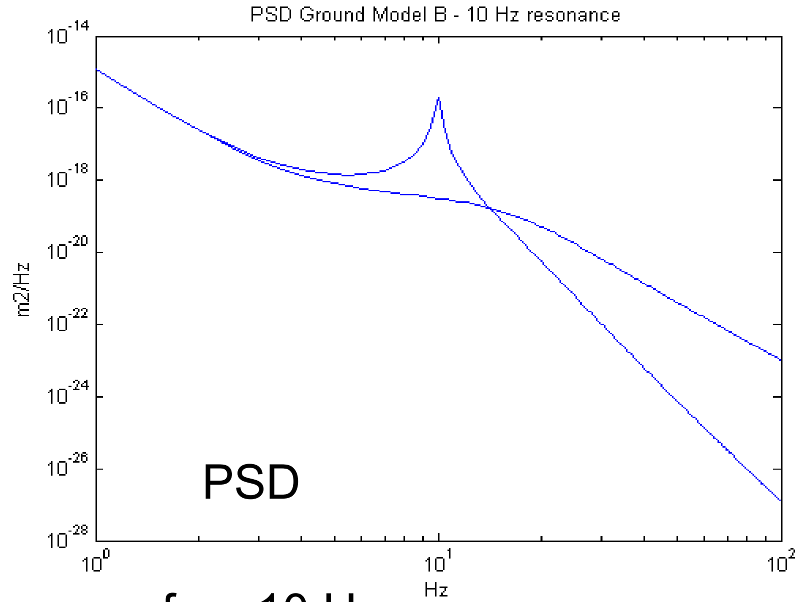
$f_{foot}$ = 10 Hz from FEA, $f_{platform}$ =

| $f_{platform}$ | $f_n$ |
|---|---|
| 6 Hz, supported edges | 5 Hz |
| 15 Hz, int. support, door-on-platform | 8 Hz |
| 30 Hz, int.support, door-on-barrel | 9 Hz |

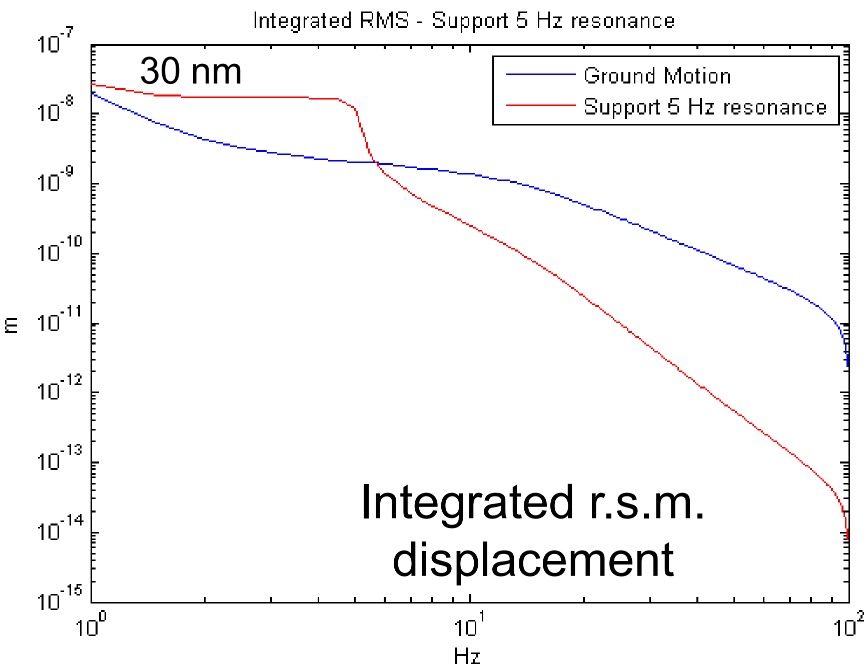
# Random vibration Studies : SiD on the floor without platform

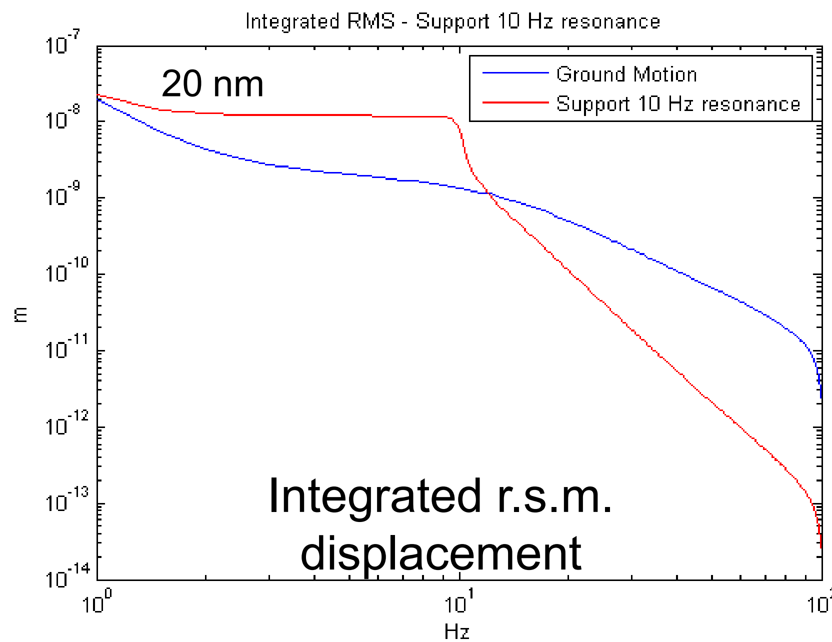



fo = 5 Hz

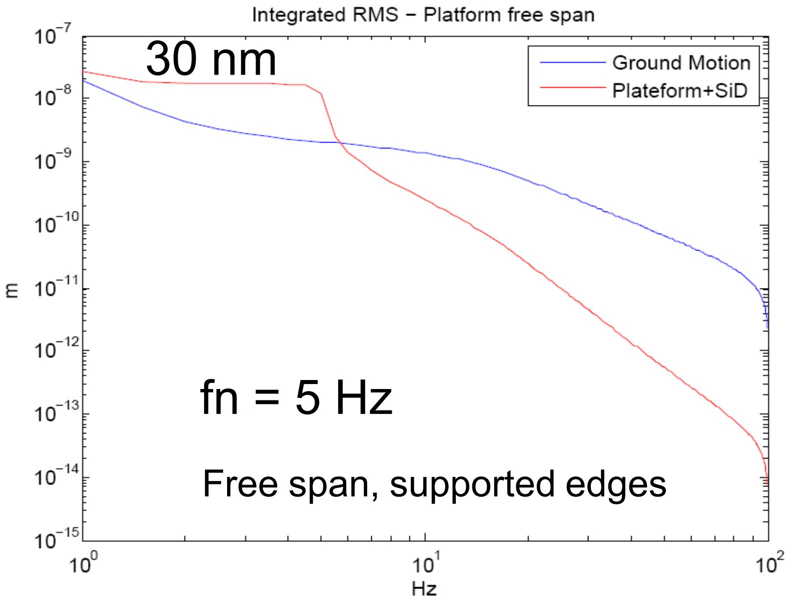


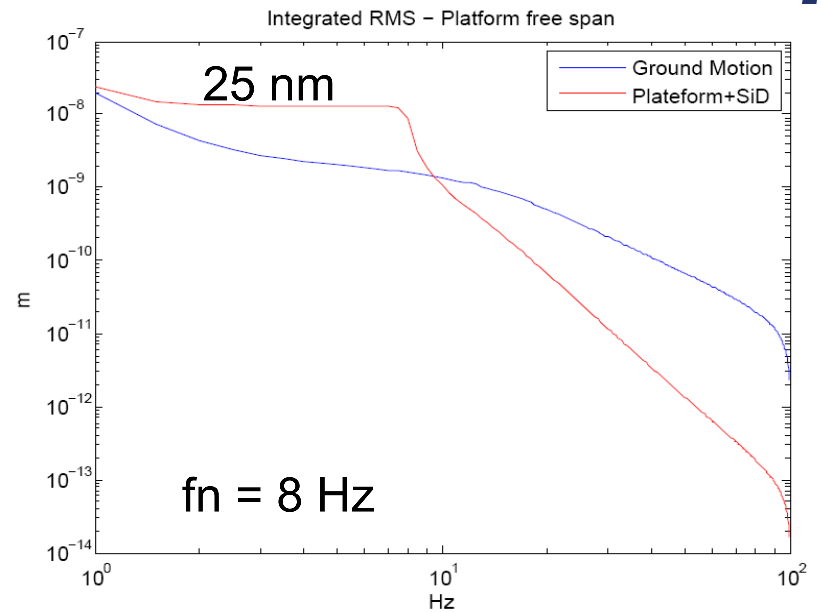

fo = 10 Hz

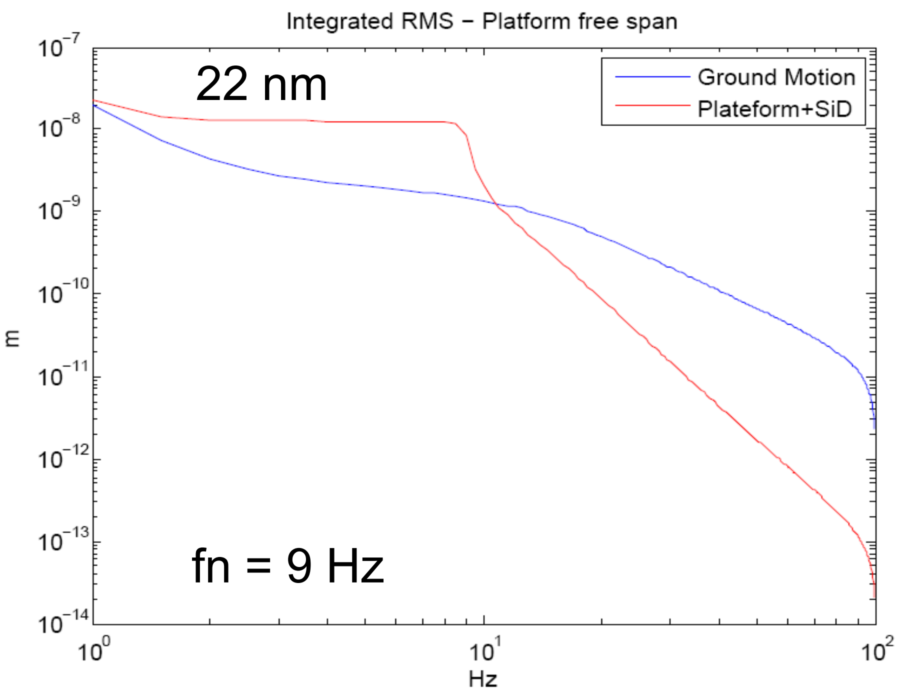


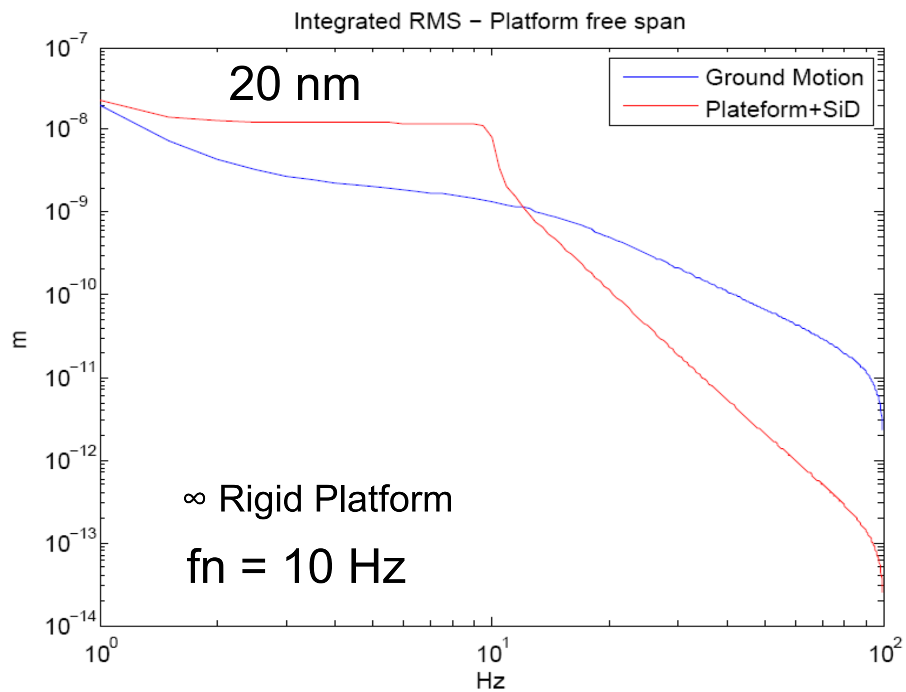



# Random vibration Studies : SiD  on platform

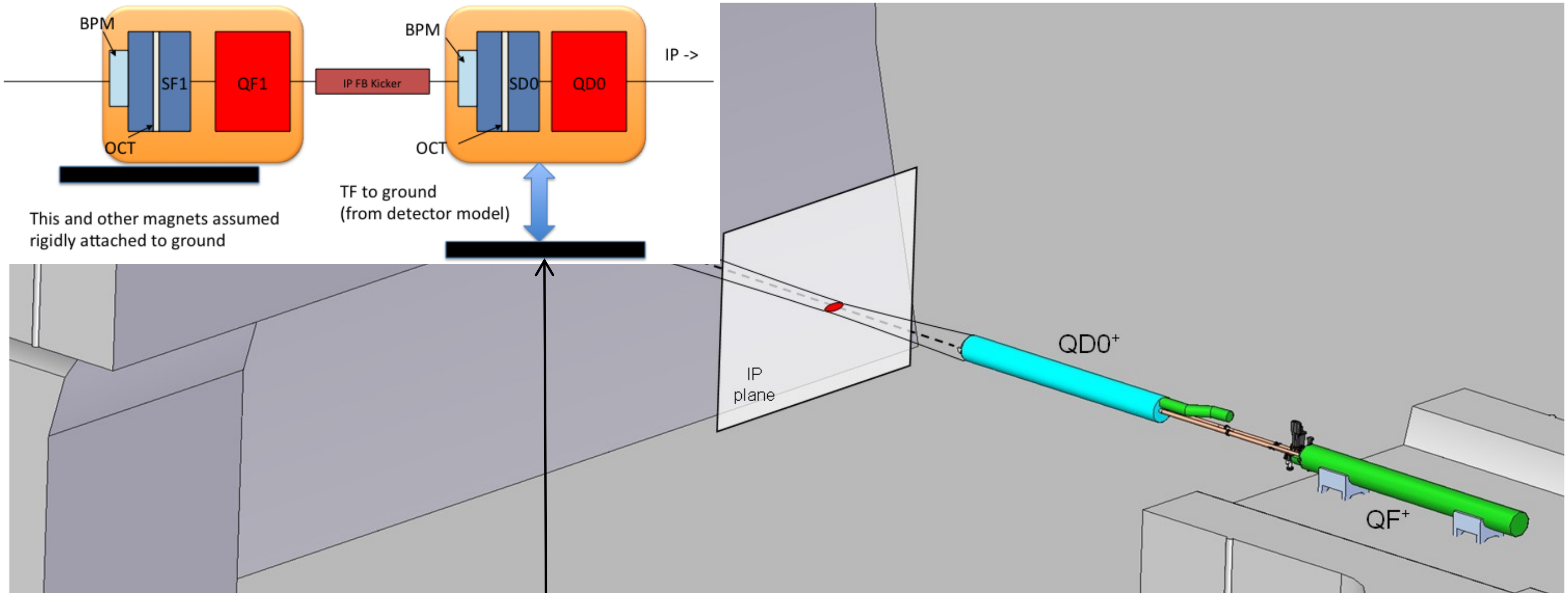


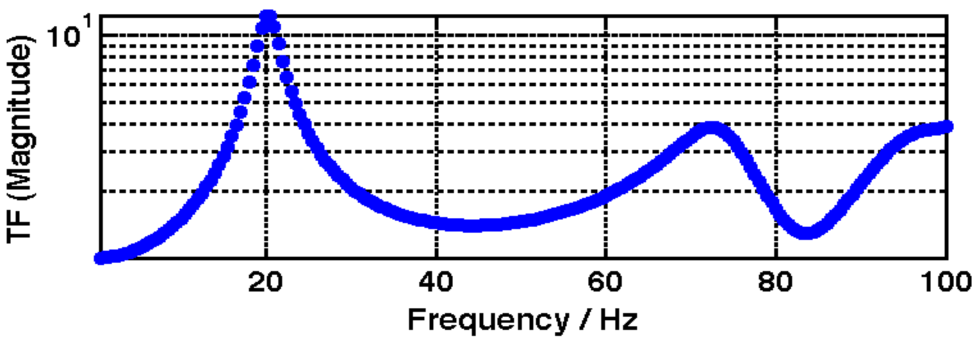



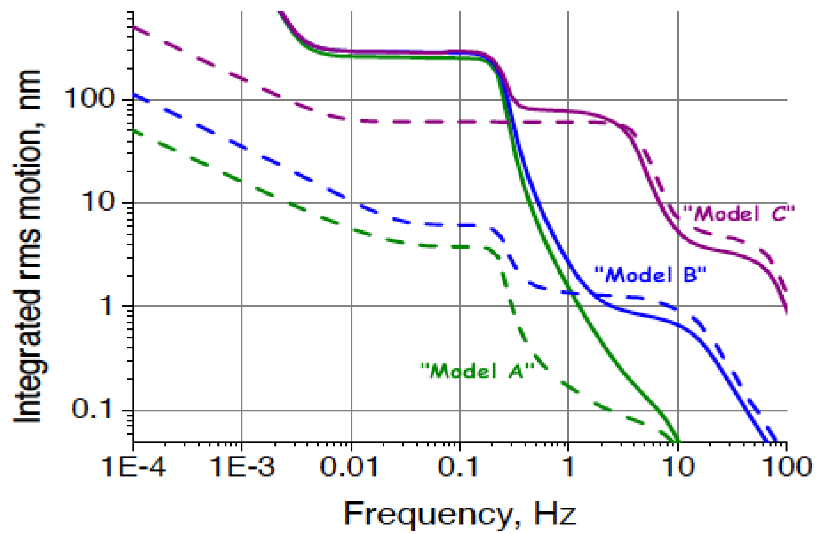



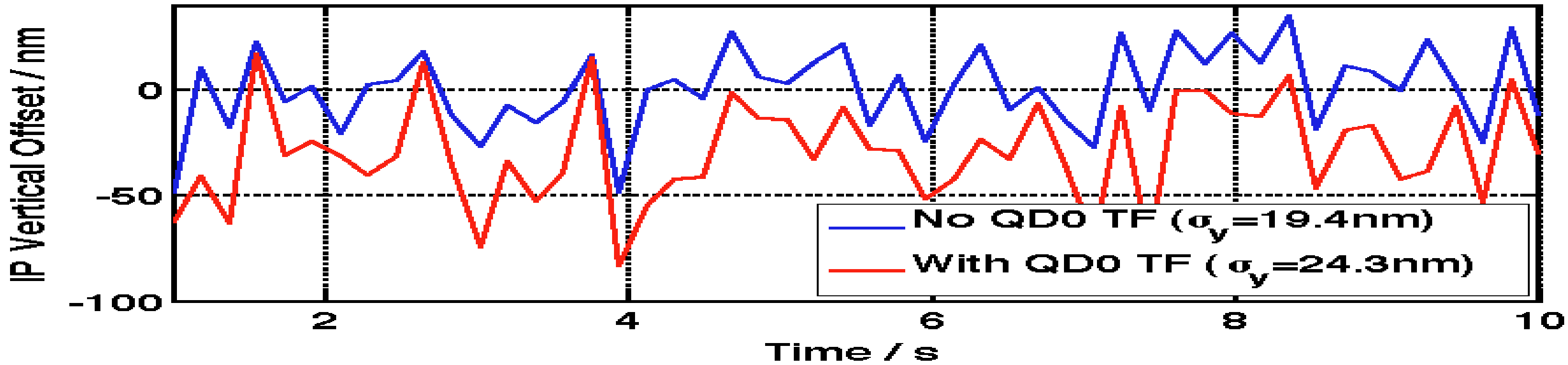
# IP Region Final Doublet : QD0+QF1



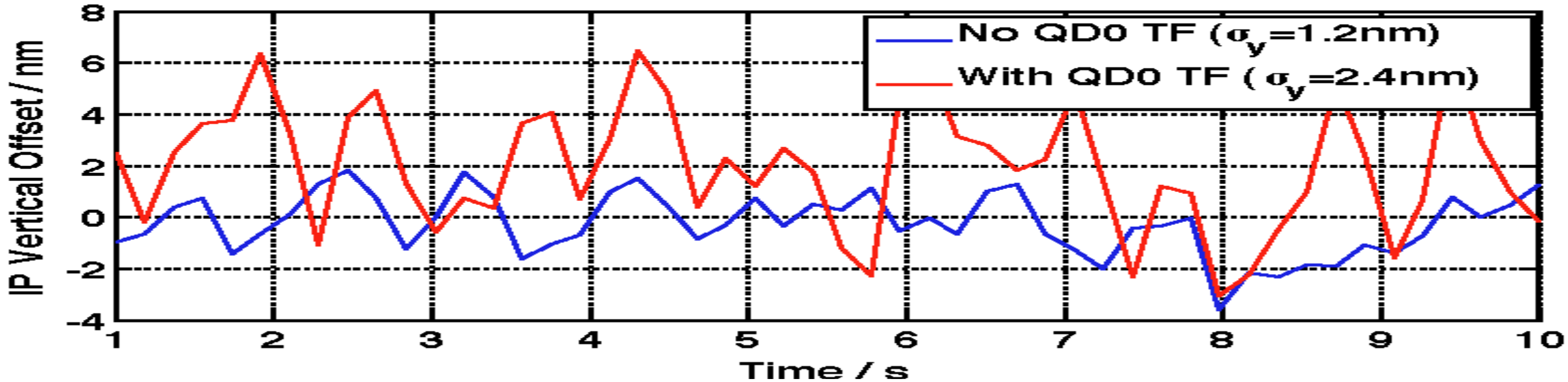



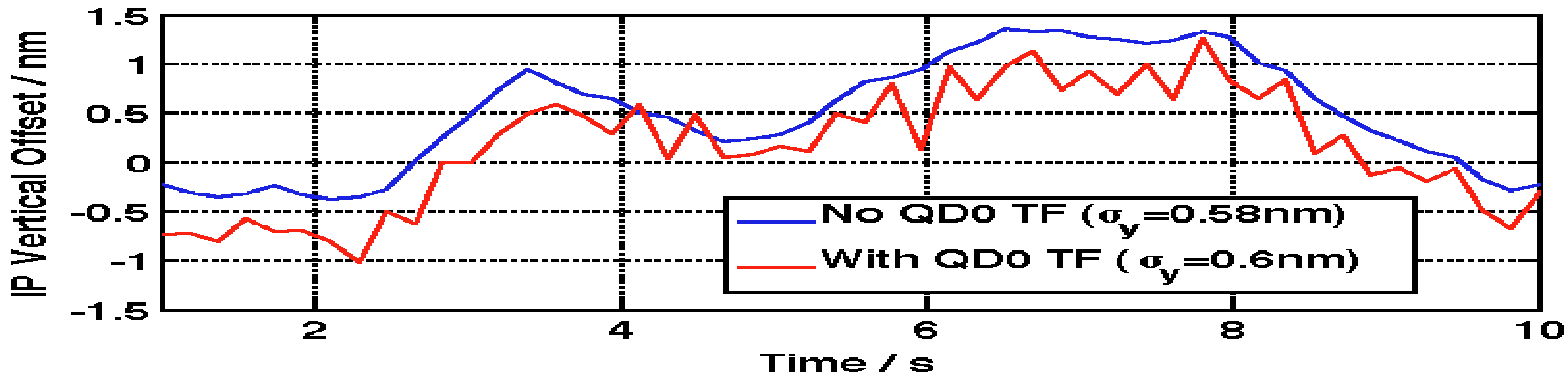
# GM Induced Jitter @ IP (Vertical Offset between e- and e+ beams at IP) with and without QD0 TF




GM'C'




GM'B'




GM'A'