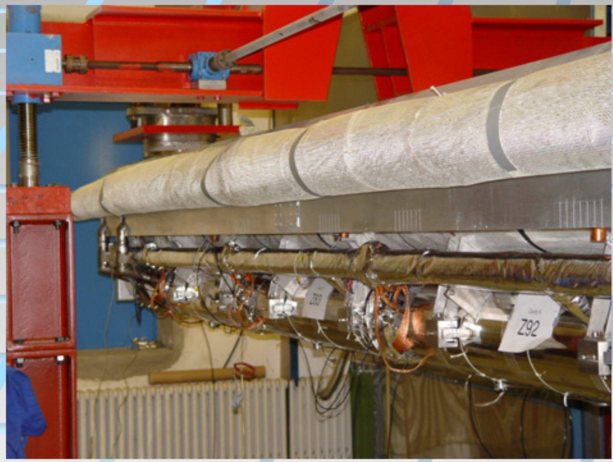
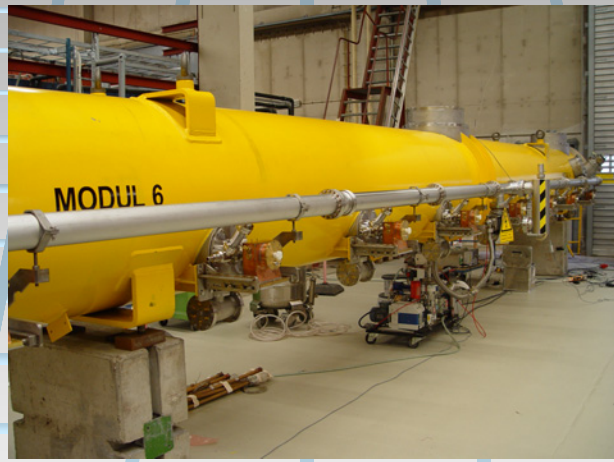
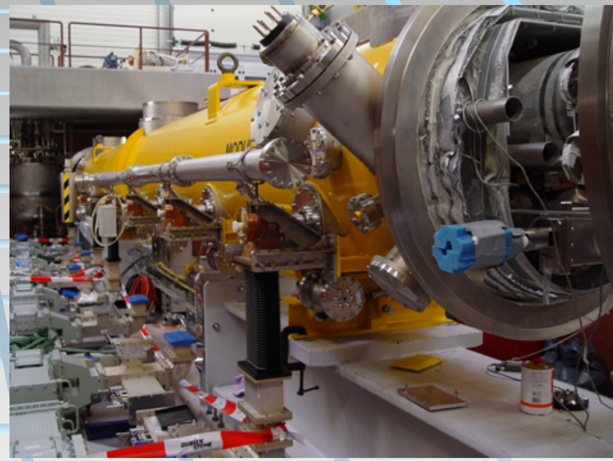
Vibration Studies of a Type III XFEL/ILC Cryomodule (Module 6)

R. Amirikas, A. Bertolini, W. Bialowons







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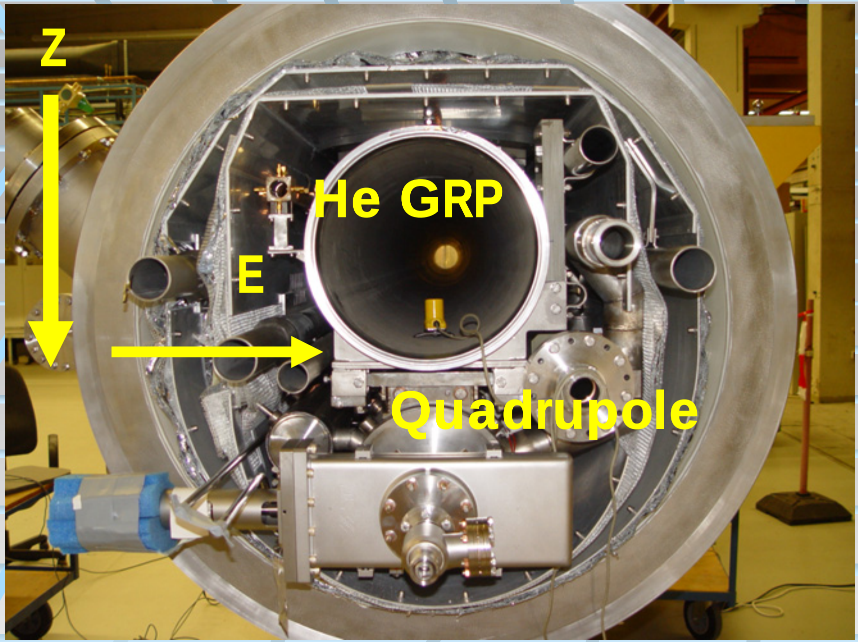
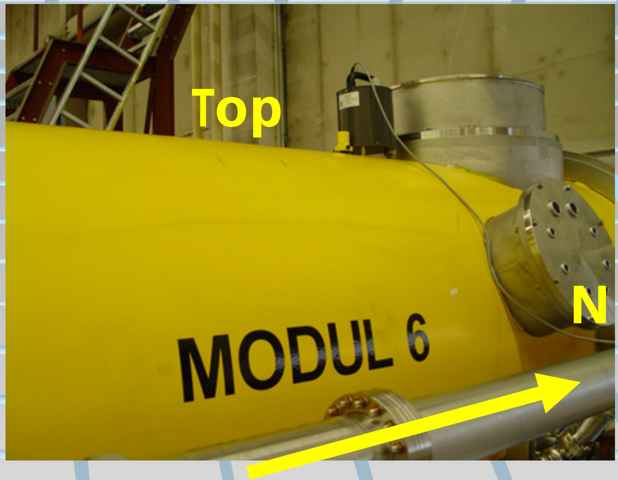
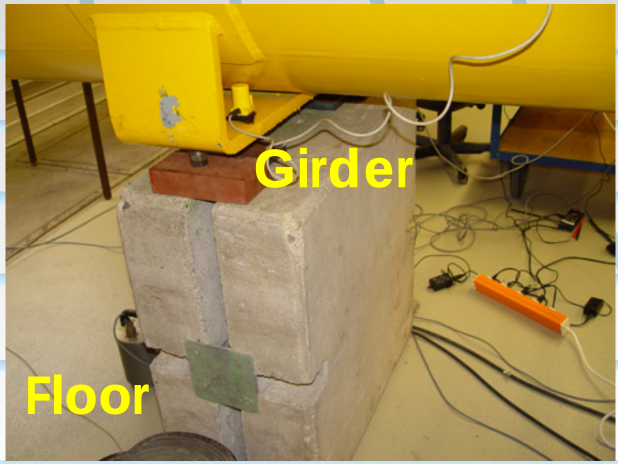
General Methodology

- Systematic approach: from room temperature to 2K measurements in order to facilitate comparison between ´warm´ vs. ´cold´ on the same cryomodule.
- Repeated measurements on more than one cryomodule (eg. Superstruktur, Module 6 etc.) to gain a better understanding of a cryomodule stability as a whole.
- Repeated measurements on each cryomodule to check for reproducibility of data.
- Effect of the cryomodule support system (eg. ceiling vs. floor)
- Data management, storage and our homepage as a tool for communicating our data (beyond the scope of this presentation)

Stability Within the Module



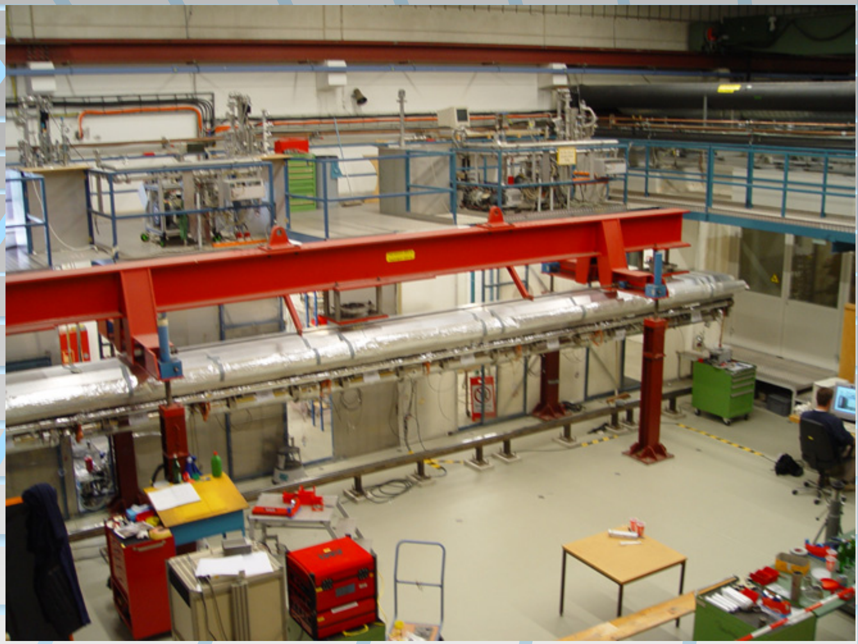




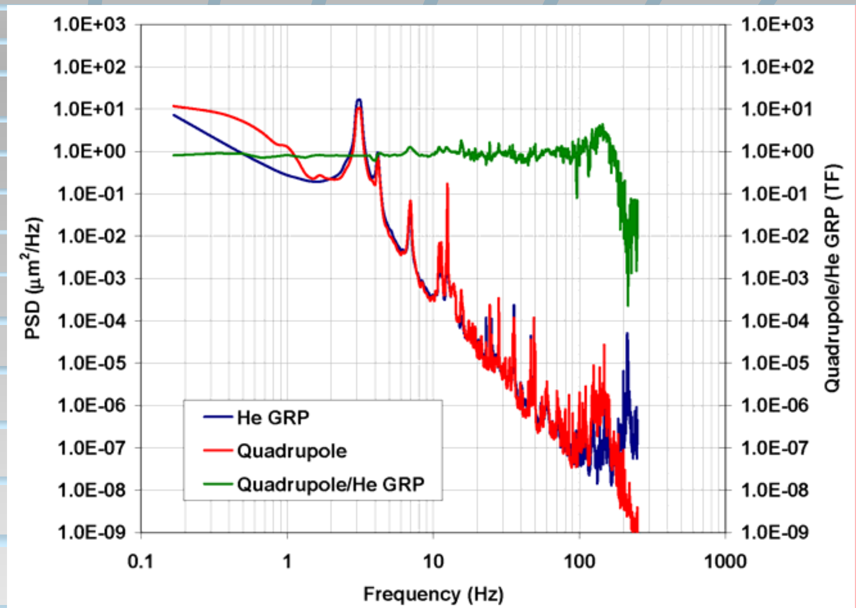
Sensor positions (in V + HT):

- Vessel top vs. He GRP
- He GRP vs. quadrupole
- Vessel top vs. quadrupole
- Reference measurement on the girder/floor

Stability Within the Module

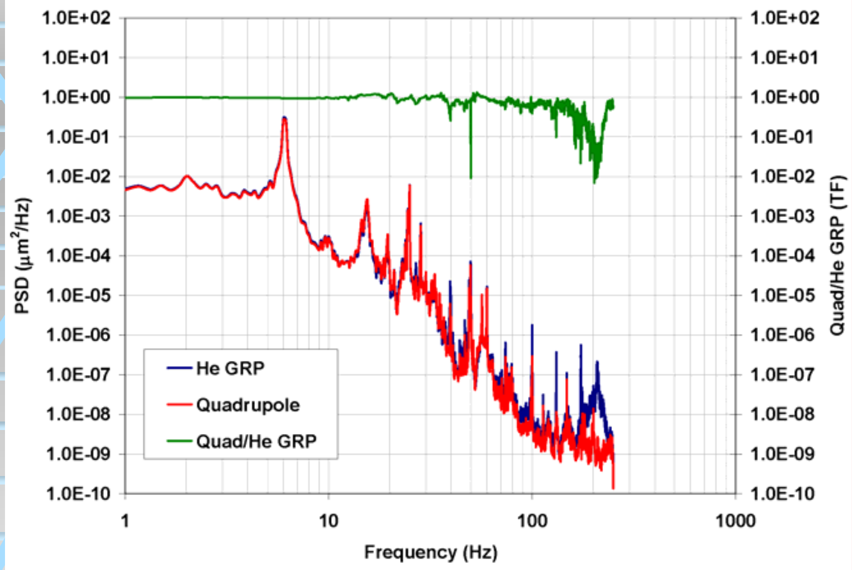


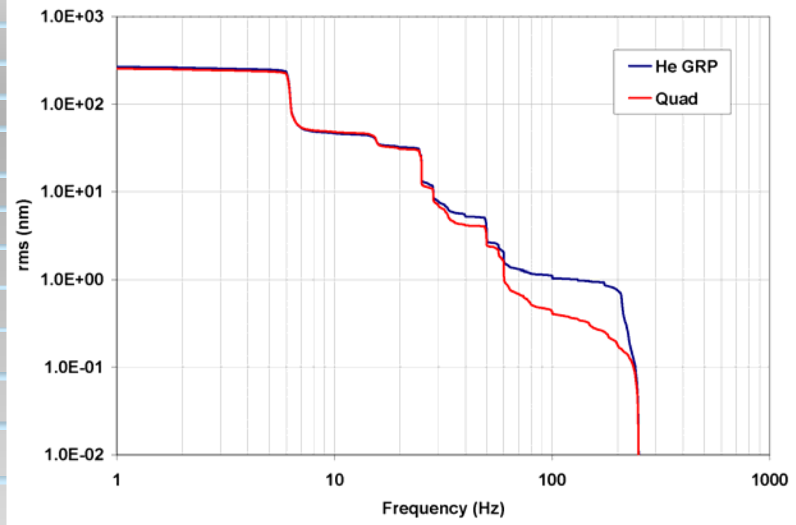
Integrated rms of motion > 1.7 Hz:
Vertical quad/He GRP=774/783 (~1%)
Horizontal transverse quad/He GRP=1488/1840 (~20%)



PSD (horizontal transverse) of module 6 core (He GRP, quad and the cavity string) before placement in the vessel (1 June 2006)

Stability Within the Module





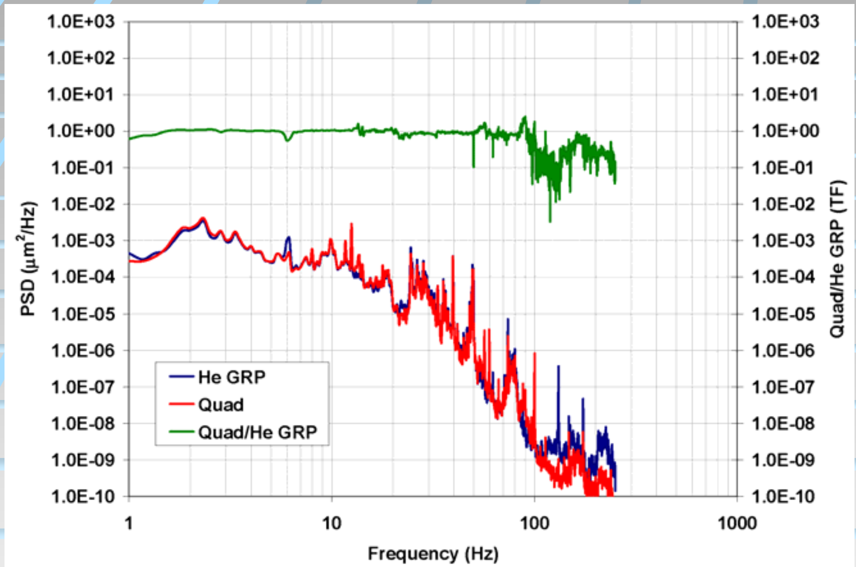
Girder resonance @ 6.0 Hz

PSD (HT) of module 6 (as placed on its test stand) on 25 August 2006, quad vs. He GRP

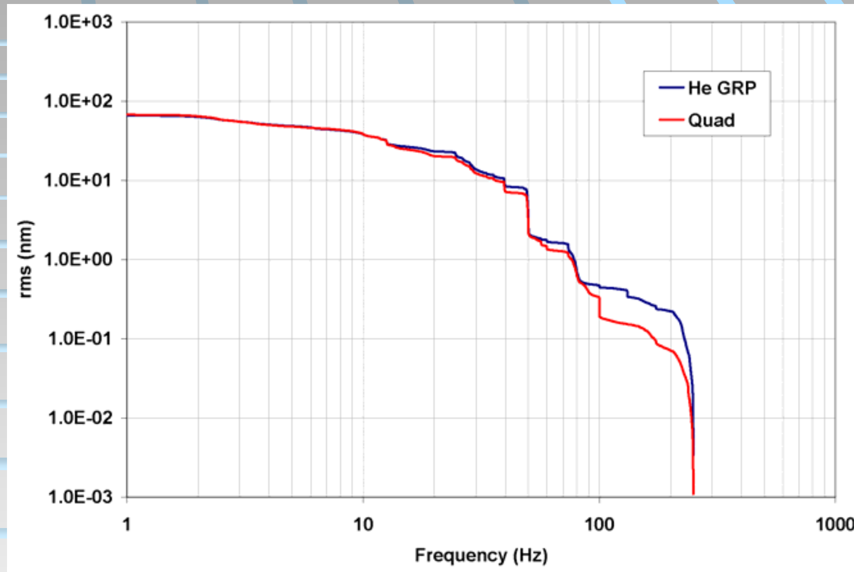
Integrated PSD (rms) @ f > 1.7 Hz: quad/He GRP=255/267~0.95

Module 6 on the test stand in #70

Stability Within the Module



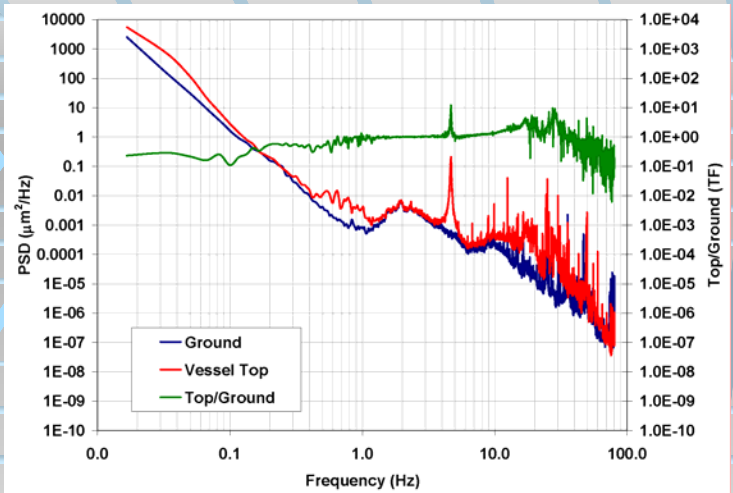
PSD (V) of module 6 (as placed on its test stand) on 25 August 2006, quad vs. He GRP



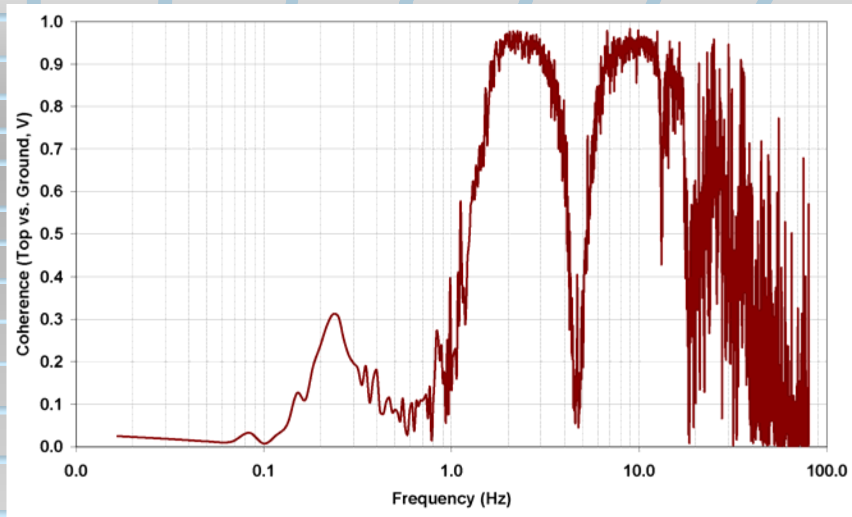
Integrated PSD (rms) @ f > 1.7 Hz: quad/He GRP=67/65 ~1

Conclusion: Throughout our measurement program, stability within the module (quad vs. He GRP, quad vs. vessel top) is consistently observed within a 20% window maximum.

Importance of Girder/Support Systems



PSD (vertical) of module 6 (as placed on concrete blocks) on 23 June 2006, vessel top vs. floor

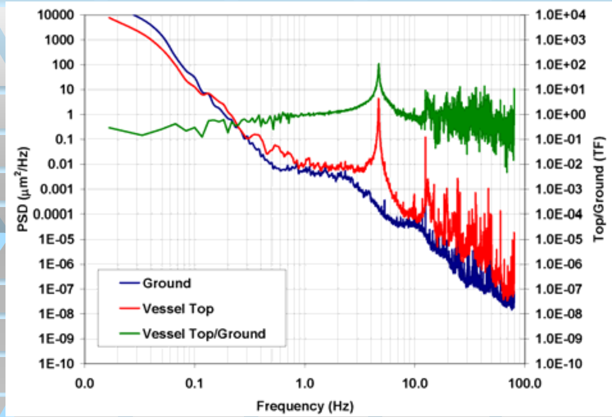


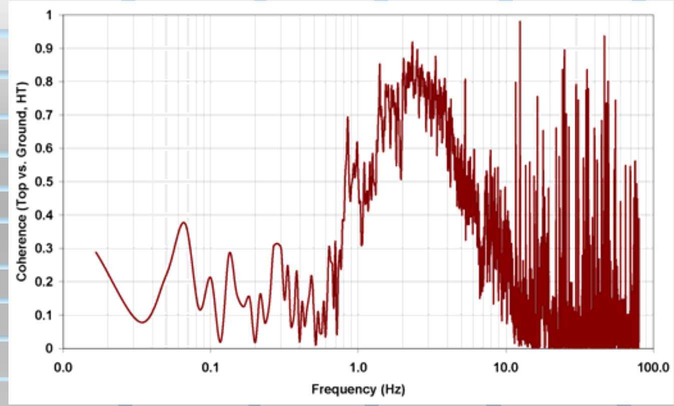
Coherence of the PSD signals shown on the left, loss of coherence at 4.7 Hz is clearly seen.

This girder resonance @ 4.7 Hz, is seen all the way along the length of the module.

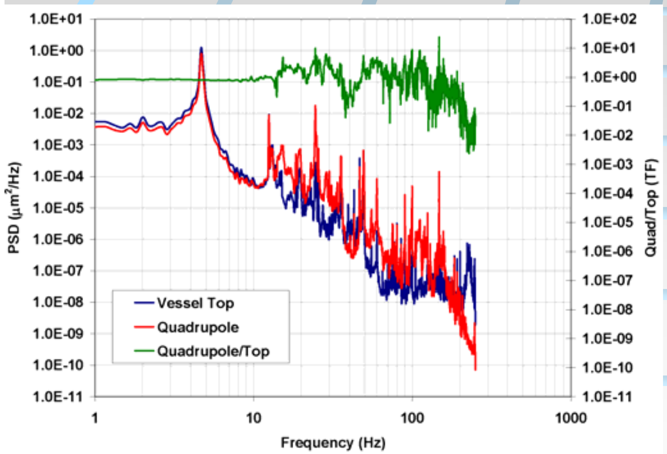
Module 6 on concrete blocks in Hall 3

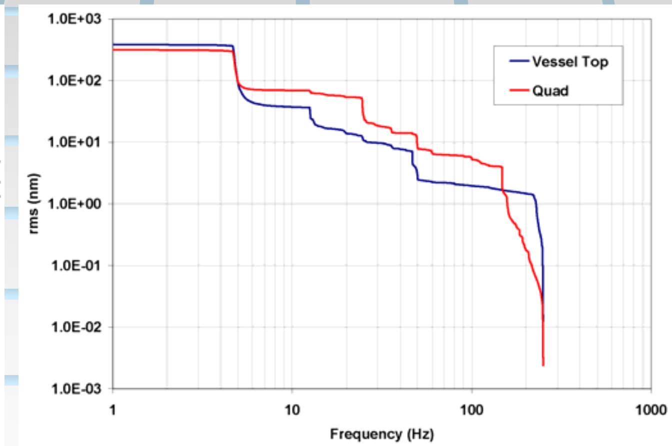
Importance of Girder/Support Systems

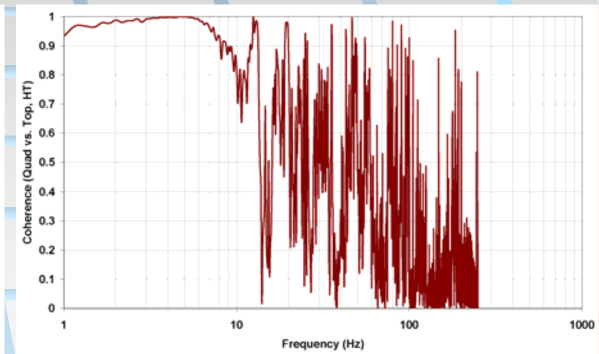




PSD (horizontal transverse) of module 6 (as placed on concrete blocks) on 23 June 2006, vessel top vs. floor and the resultant coherence plot (right)



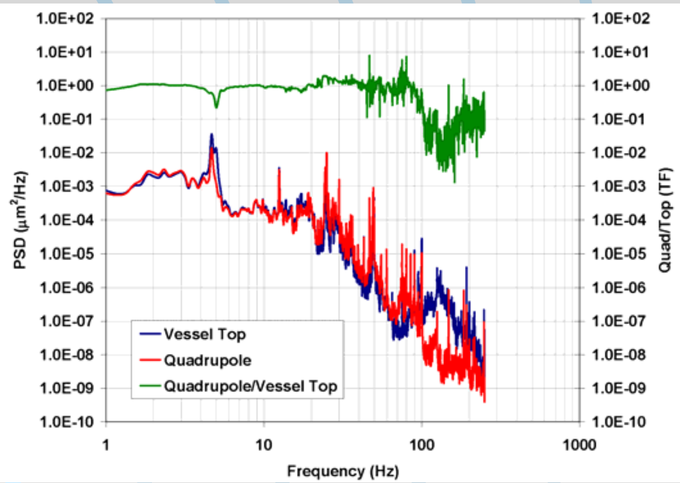


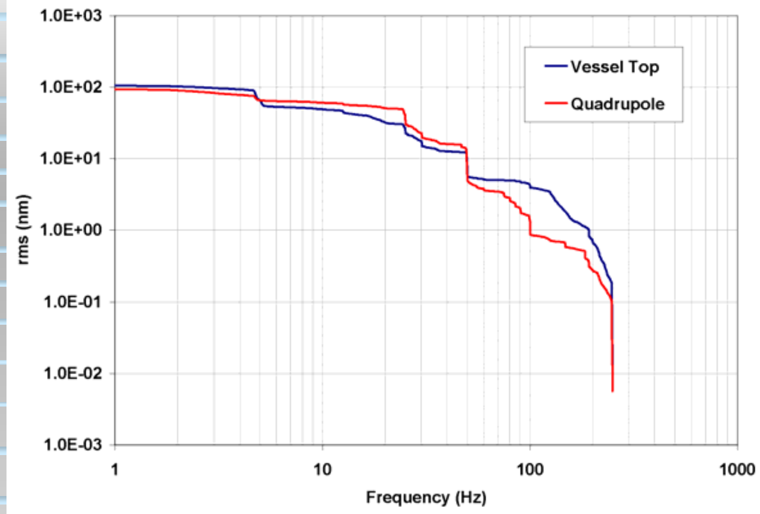


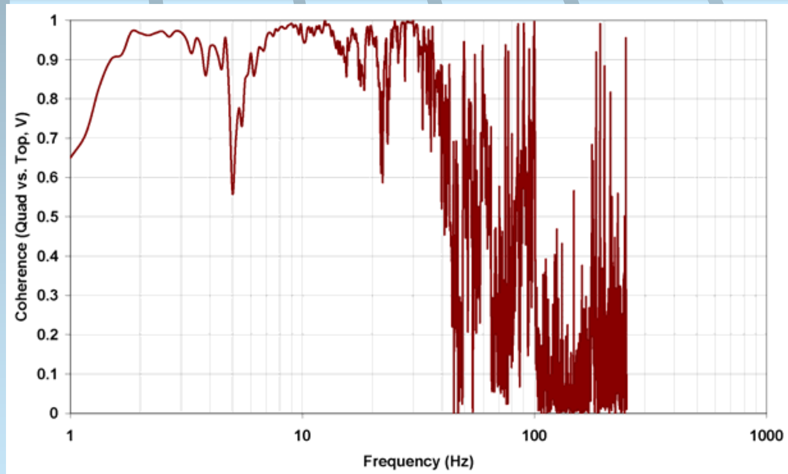
Girder resonance @ 4.7 Hz, can be seen on the quad measured on 23 June 2006.

PSD (HT) and integrated rms of motion > 1 Hz; TF @ 1 Hz, quad/top=320/390 ~0.82

Importance of Girder/Support Systems



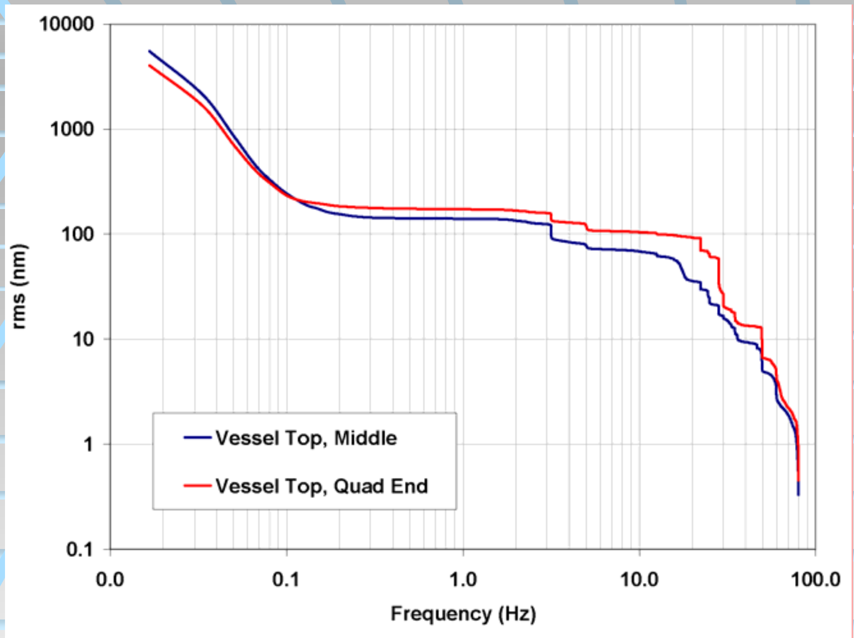




Conclusion: The support system used for a machine such as XFEL/ILC may play a crucial role in the stability and hence, the quality of its beam/s. A careful design of such girders/support systems should be implemented such that the overall system does not contain resonances below 10 Hz, at least.

PSD (V) and integrated rms of motion > 1 Hz;
TF @ 1 Hz, quad/top=93/105 ~0.88

Stability Along the Module (Vessel Top, Vertical)

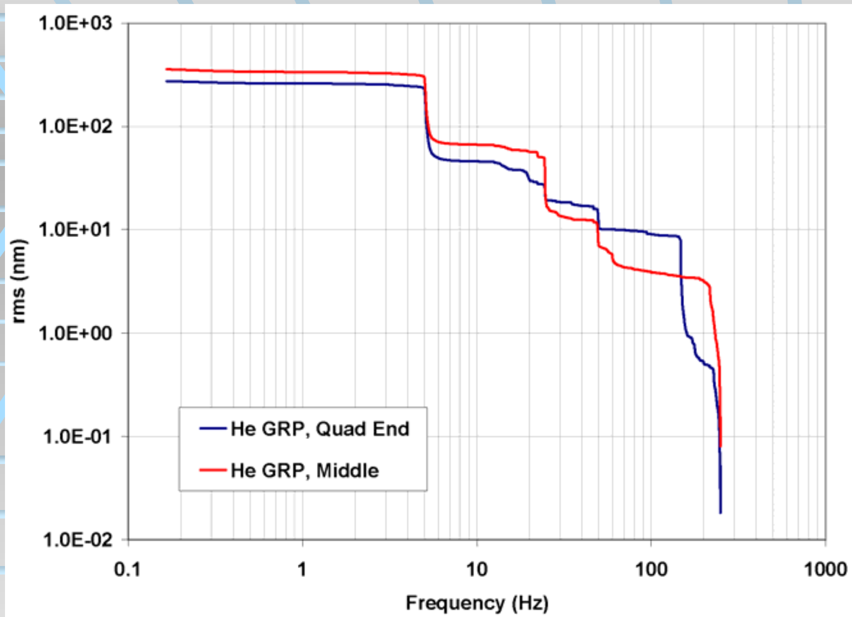


Average integrated rms of motion > 1 Hz (vertical); TF @ 1 Hz: vessel top, middle(X2)/vessel top, quad end (X1)=139/167 ~0.8

Sensor positions (in V + HT) on 24 July 2006:

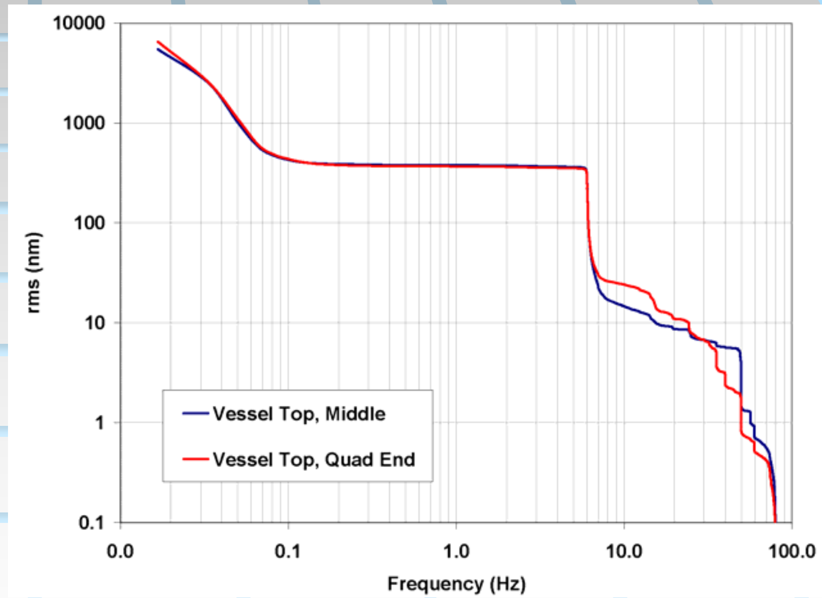
- **Synchronized measurements on the vessel top, quad end (X1) and middle (X2)**
- **Simultaneous geophone measurements in the He GRP at the same positions, quad end (Y1) and middle (Y2)**

Stability Along the Module (He GRP, HTransverse)



Conclusion: Our measurements show that in going from the quad end of the module to the other end, a variation of up to 20% (in vertical direction) and 30% (in horizontal transverse) is seen in the rms motion. This is a worse case scenario and it improves by a better girder and other connections. Please see below:

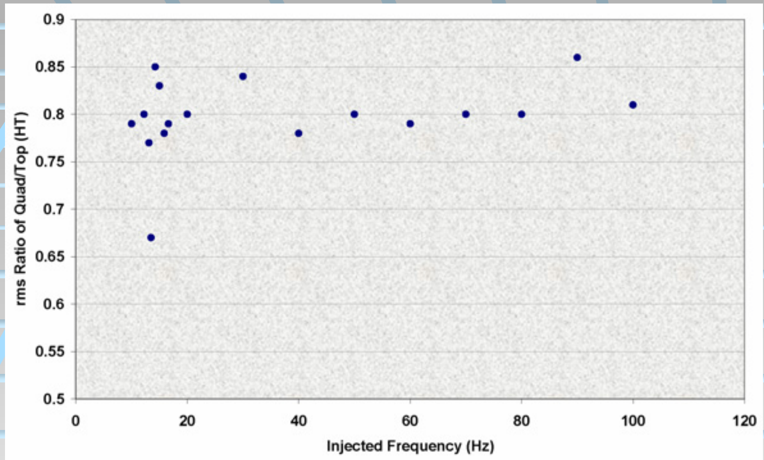
Average integrated rms of motion > 1 Hz (HT); TF @ 1 Hz, He GRP, middle (Y2)/He GRP, quad end (Y1)=340/264 ~1.29 (measurement on 24 July 2006)



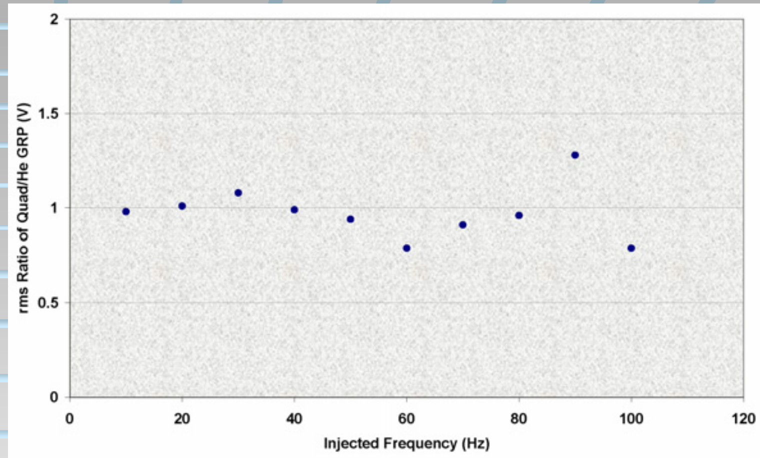
Average integrated rms of motion > 1 Hz (HT); @ 1 Hz, Vessel Top, middle /Vessel Top, quad end =378/368 ~1.0 (measurement on 29 August 2006 in #70)

Reproducibility of Our Data

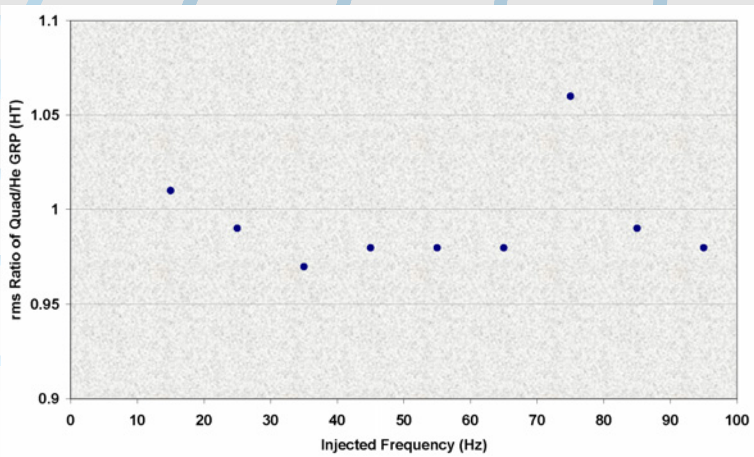
In order to check reproducibility in our measurements, a single frequency was injected in the system (i.e. floor and hence the module), via a shaker, in both vertical and horizontal transverse directions and the rms of the signal was measured via gepohones (@ f > 2 Hz)



Quad/Top @ 2 Hz in HT



Quad/He GRP @ 2 Hz in V



Quad/He GRP @ 2 Hz in HT

Conclusion: Our measurements within the vessel (quad vs. He GRP and quad vs. Vessel top) are reproducible.

Example of a Machine on the Tunnel Floor (LHC)

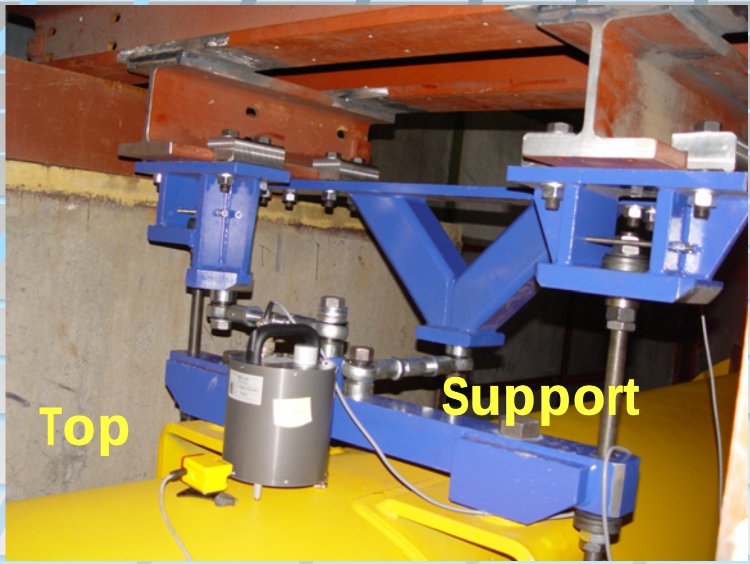
Photos: courtesy of CERN

Cryomagnets of the LHC are 15 meters long and weigh 32 tons. Each cryomagnet is placed on three jacks. This kind of support system could be implemented for the ILC.

The stability of the support system used for the LHC cryomagnets will be tested this December in CERN, in collaboration with CERN installations group (C. Hauviller)

Measurement of the two Proposed XFEL Module Support Systems (Version A)

Two versions have been designed:
- pull rod version (zugstangenlösung)
- bolt version (stehbolzenlösung)



Quadrupole end (fixed point)

Sensor positions (in V + HT):

- Beam vs. Vessel top (both ends)
- Quad end vs. middle (no support)
- Beam vs. support
- Reference measurement on the floor

Other end

Module 7 is hanging!!

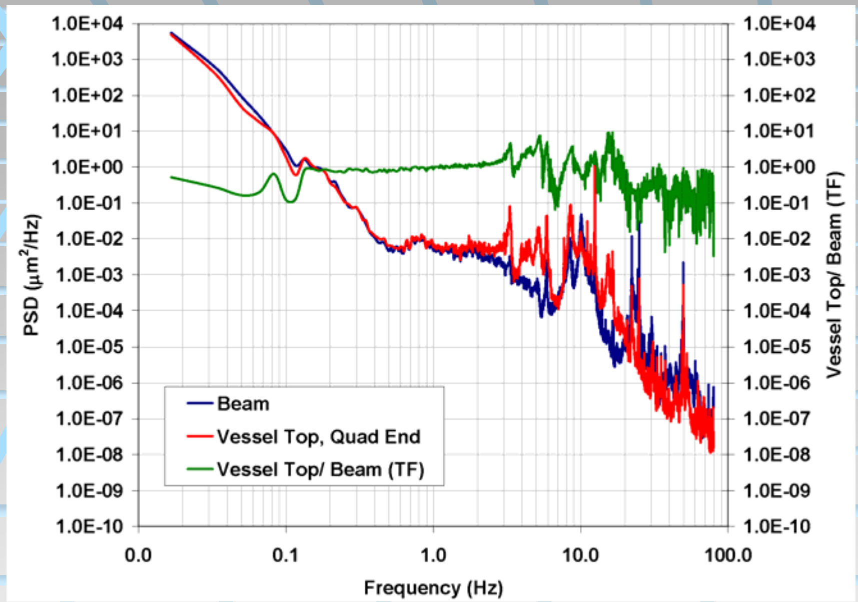
Measurement of the two Proposed XFEL Module Support Systems (Version B)

Quadrupole end (fixed point)
Sensor positions (in V + HT) same as version A

Other end

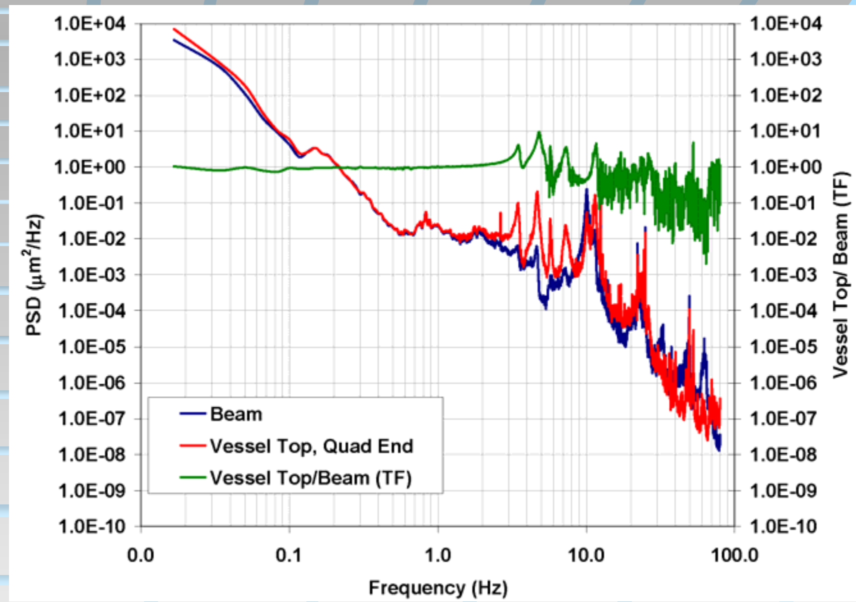
Position of the beams

Measurement of the two Proposed XFEL Module Support Systems (HT)



Version A, HT, beam vs. top (quad end)

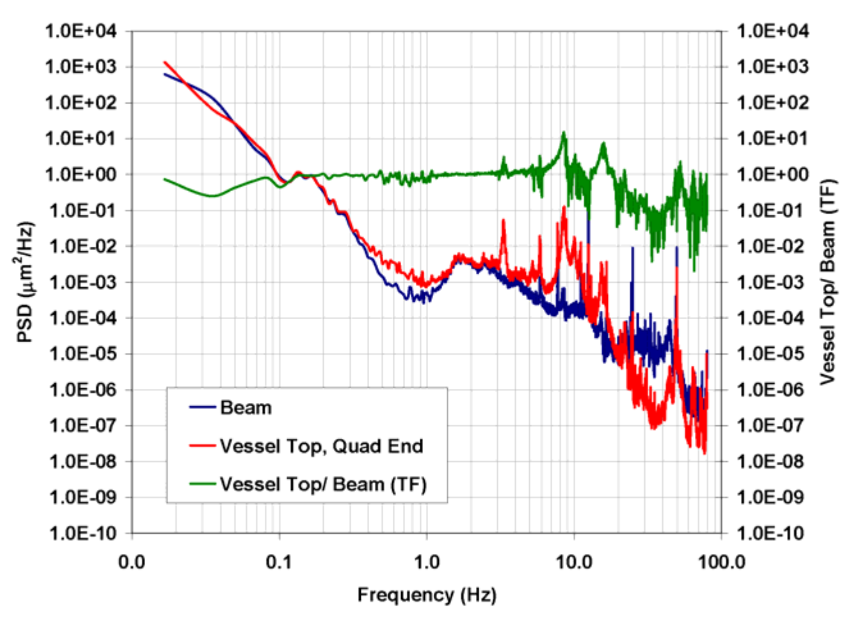
Amplification factor (AF) of version A, in horizontal transverse, @ 1 Hz: 1.83



Version B, HT, beam vs. top (quad end)

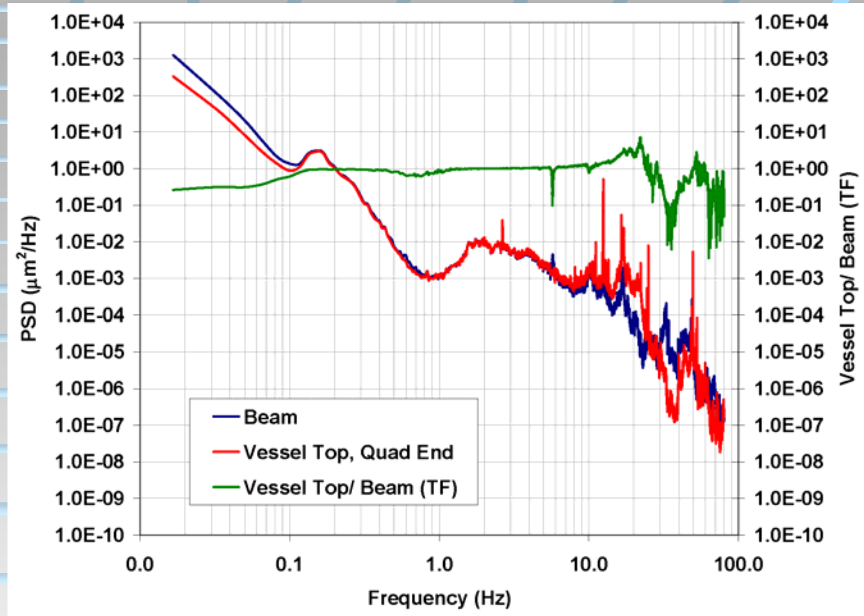
Amplification factor (AF) of version B, in horizontal transverse, @ 1 Hz: 1.22

Measurement of the two Proposed XFEL Module Support Systems (V)



Version A, V, beam vs. top (quad end)

Amplification factor (AF) of version A, vertical, @ 1 Hz: 2.1



Version B, V, beam vs. top (quad end)

Amplification factor (AF) of version B, vertical, @ 1 Hz: 1.24

Comparison of Ceiling vs. Floor of a Shallow Tunnel (HERA)

PETRA-HERA injection point (WR217)

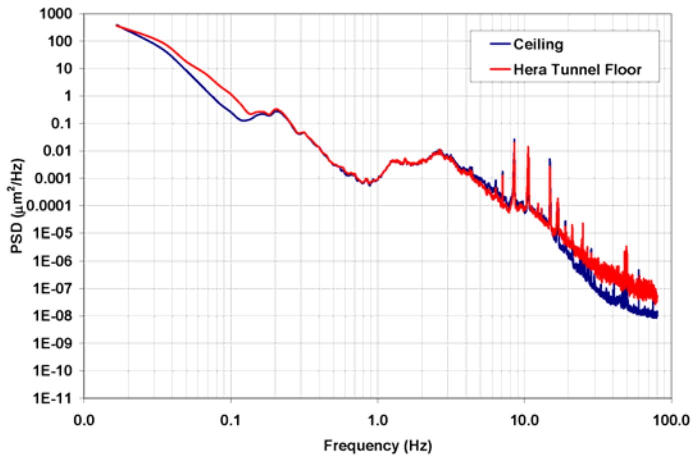
Site map: courtesy of DESY

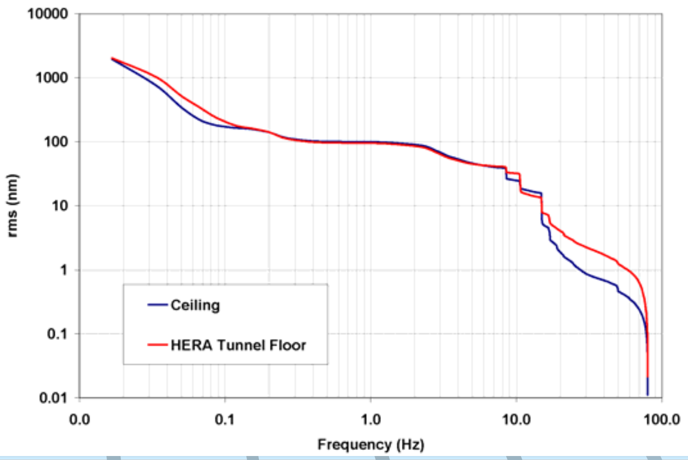
HERA tunnel is not a recent construction, therefore, a comparison study of ceiling vs. floor vibrations, may tell us about the behavior of future shallow tunnels constructed in DESY and vicinity.

Sensor positions:

- Sensor 1 on the ceiling (PETRA-HERA injection point)
- Sensor 2 on the floor of the HERA tunnel
- Data taking period:3 hours and 15 minutes on 25 October 2006

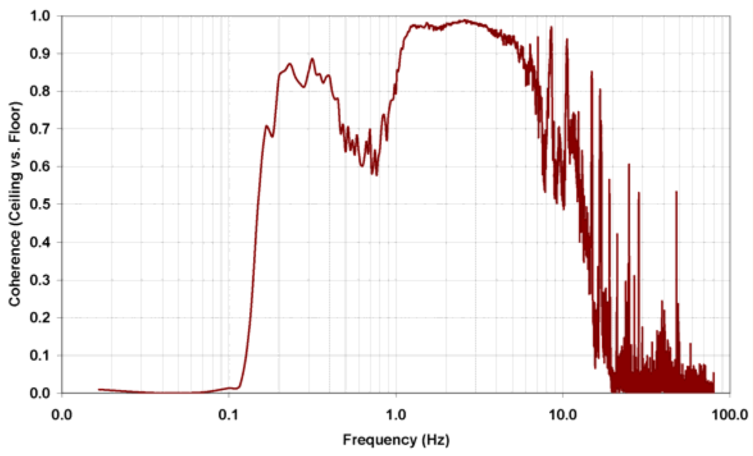
Comparison of Ceiling vs. Floor of a Shallow Tunnel (HERA)





Average psd (V) and integrated rms of motion (nm) > 1 Hz; @ 1 Hz, ceiling/floor=99/95 ~0.96, i.e., a difference at a 4% level is seen. Same result is obtained for the horizontal directions.

Conclusion:High f noise (> 10 Hz) is detected in both ceiling and floor, or as it were two parallel tunnels at a distance of ~ 10 m. However, low f noise (< 1 Hz) was detected on the floor only, or as it were a ´service tunnel´. However, in all these cases (machine in a single tunnel whether on the ceiling or on the floor, or two tunnel solution), facility noise should be damped/minimized.



Coherence signal between the two sensors placed at a distance of ~7 m. Good coherence (> 0.5) upto 13 Hz is seen.

What‘s Next for Module 6?

- A study of facility noise in building 70
- Planned cold measurement on module 6 with geophones

Now let‘s come back to the point we made earlier…

- Data management, storage and our homepage as a tool for communicating our data (beyond the scope of this presentation)