Vibration Stability Measurements of the XFEL Cryomodule Support Systems

1) Pull Rod Version (Zugstangenlösung), ´Version A´

2) Bolt Version (Stehbolzenlösung), ´Version B´

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Definitions

Correlation (f) =
$<X(f).Y^*(f)>/\sqrt{[<X(f)X^*(f)><Y(f)Y^*(f)>]}$

PSD= Power Spectrum Density ($\mu m^2/Hz$)

$X(f)X^*(f) = PSD_{signal1}$

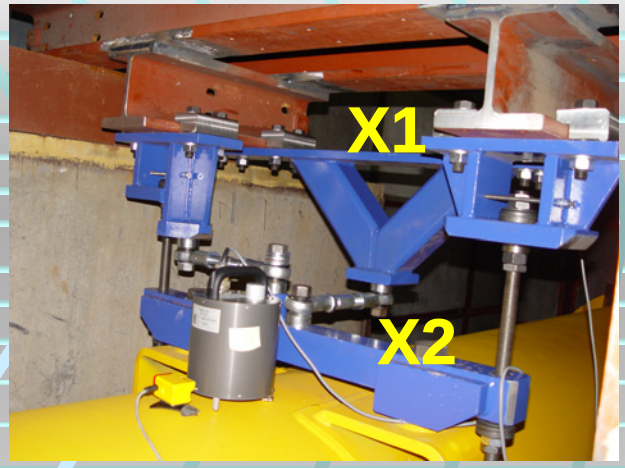
$Y(f)Y^*(f)=PSD_{signal2}$

Coherence (f) = | Correlation (f) |

Amplitude Transfer Function= $|XY^*|/XX^*$

$\approx \sqrt{PSD_{signal2}}/\sqrt{PSD_{signal1}}$

Pull Rod, Version A



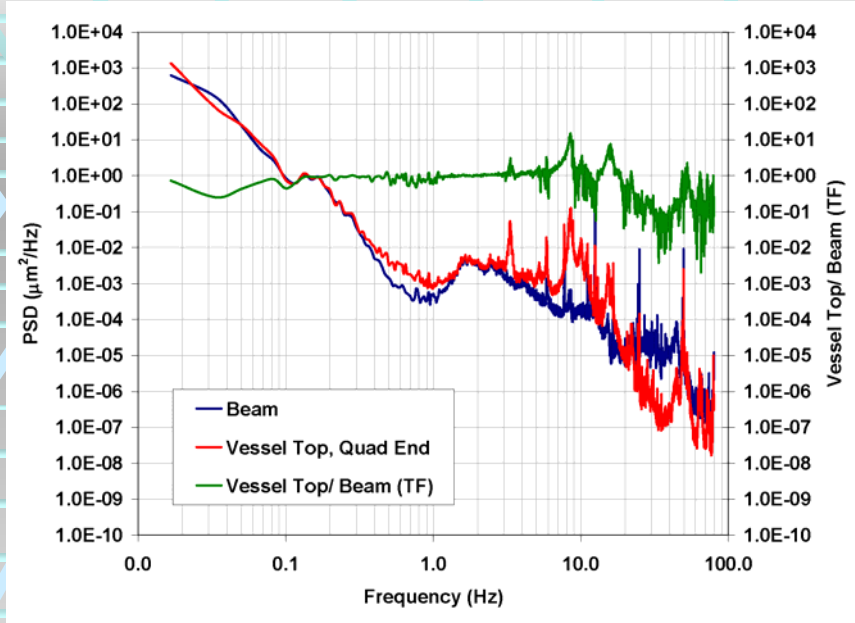
Quadrupole end (fixed point)

Other end

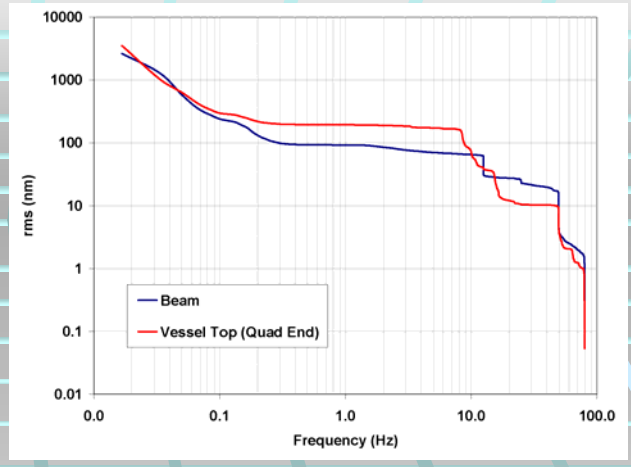
Sensor positions (in V + HT):

- Beam vs. vessel top (both ends)
- Quad end vs. middle (no support)
- Beam vs. support
- Reference measurement on the floor
- Comparison between 2 points on the support (X1, X2)

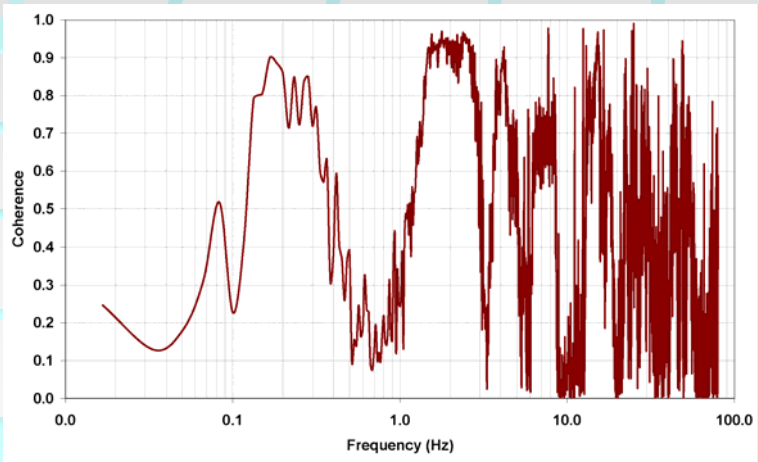
Pull Rod, Version A (Quad End, Vertical)



PSD, Vertical, beam vs. top (quad end)

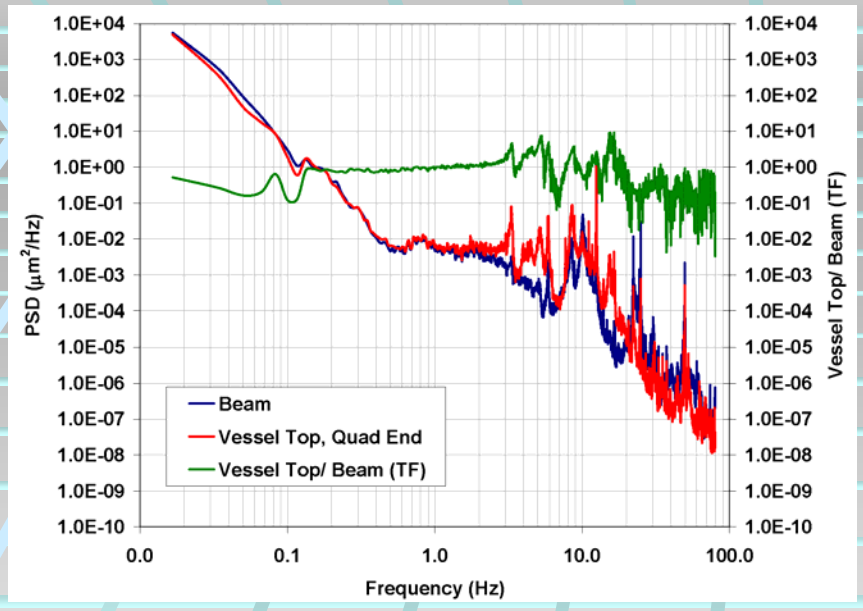


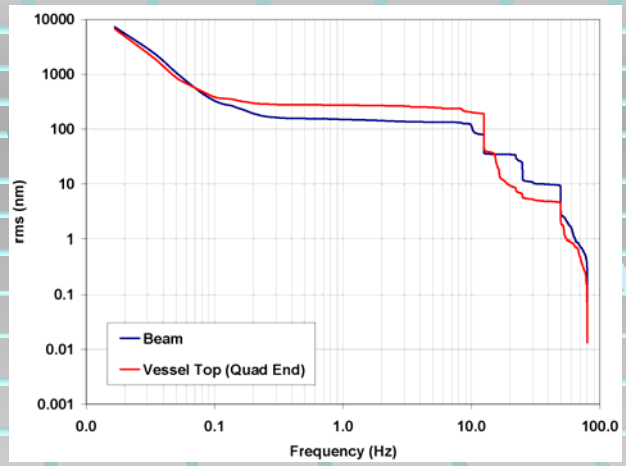
Integrated PSD @ f > 1 Hz, Vertical, beam vs. top (quad end)



- From TF, one sees peaks at 3.4, 8.6, 16.35 Hz
- Amplification Factor (AF) @ 1 Hz: vessel top/ceiling beam=193/92~2
- Good coherence (i.e. > 0.5), only upto 3 Hz
- In the vertical direction, support is not rigid.

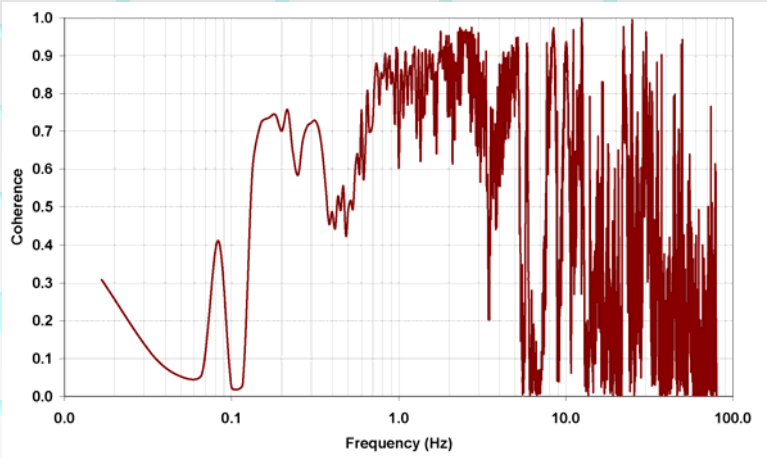
Pull Rod, Version A (Quad End, Horizontal Transverse)





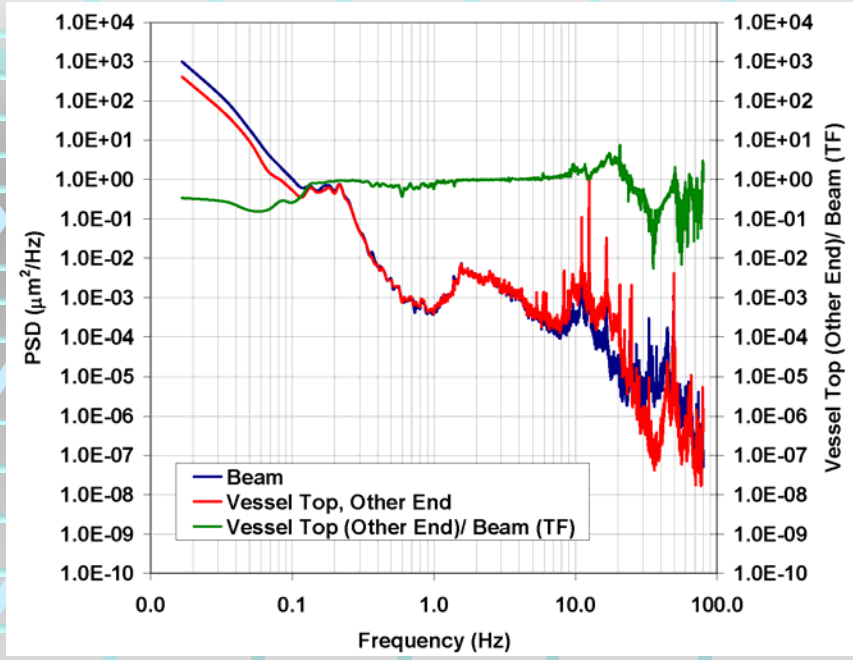
Integrated PSD @ f > 1 Hz, HT, beam vs. top (quad end)

PSD, HT, beam vs. top (quad end)

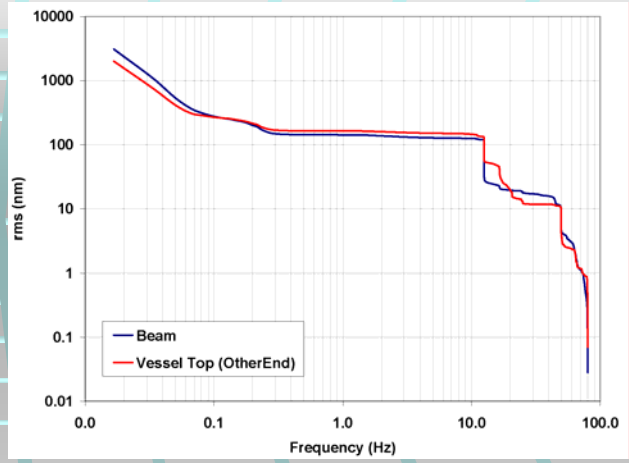


- **Coupling of many of these peaks in both vertical and horizontal directions**
- **Amplification Factor (AF) @ 1 Hz: vessel top/ceiling beam=274/150~1.8**
- **Good coherence (i.e. > 0.5), only upto 3 Hz, same as vertical.**
- **In the horizontal transverse direction, support is not rigid.**

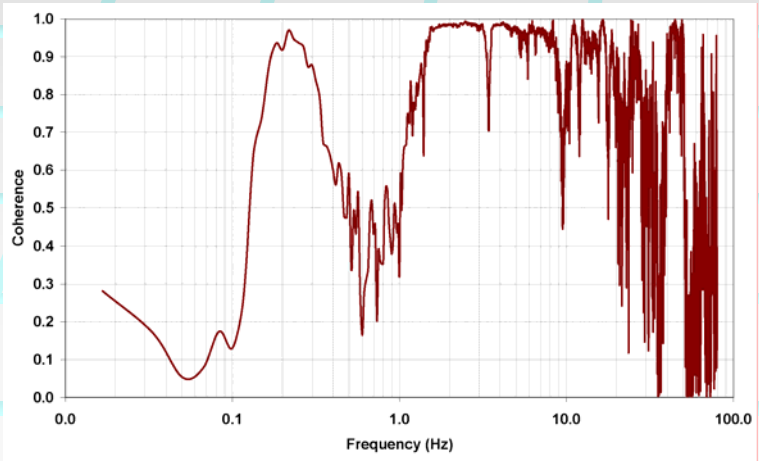
Pull Rod, Version A (Other End, Vertical)



PSD, Vertical, beam vs. top (other end)

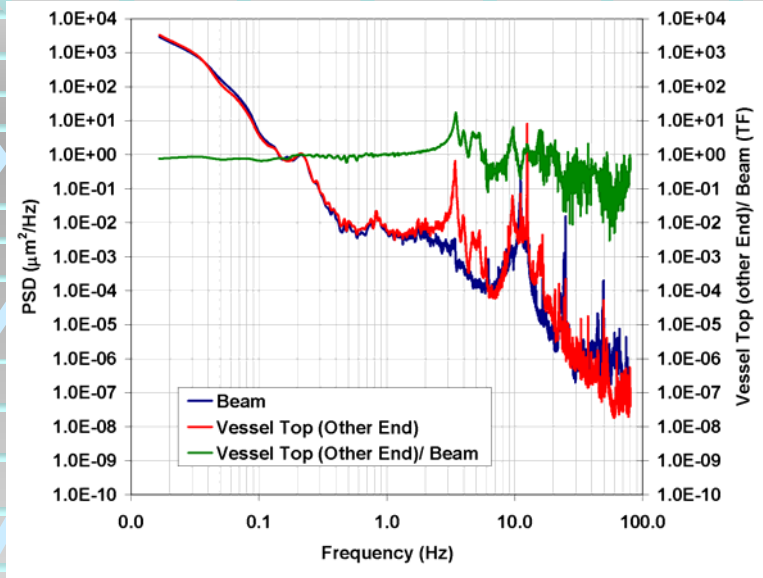


Integrated PSD @ f > 1 Hz, Vertical, beam vs. top (other end)

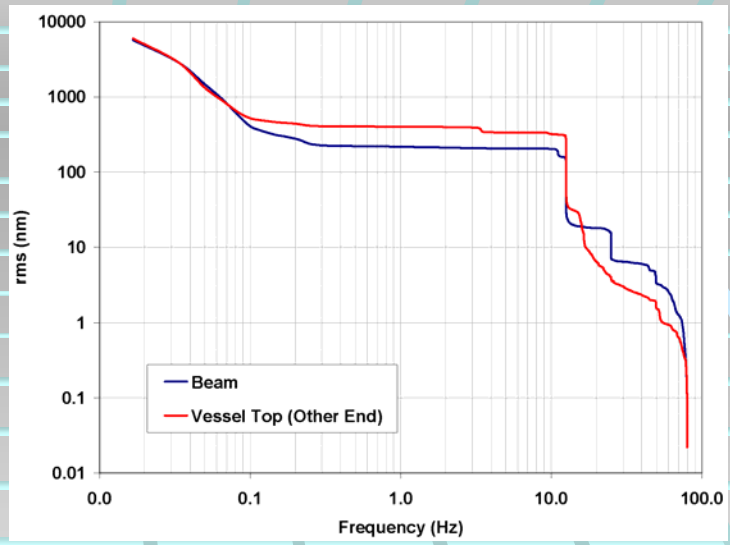


- Verical direction in the other end, rigid
- AF @ 1Hz of vessel top/ ceiling beam=163/141~1.2
- Damping of the vessel top signal after 25 Hz?

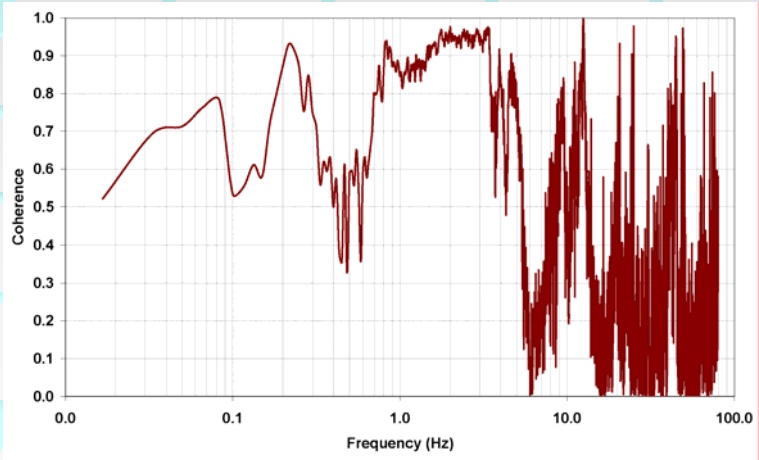
Pull Rod, Version A (Other End, Horizontal Transverse)



PSD, HT, beam vs. top (other end)

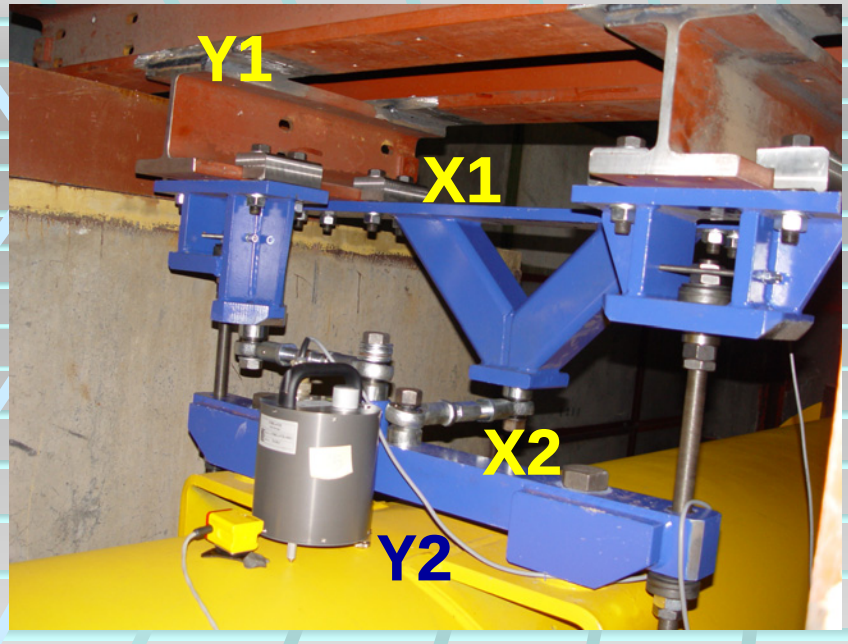


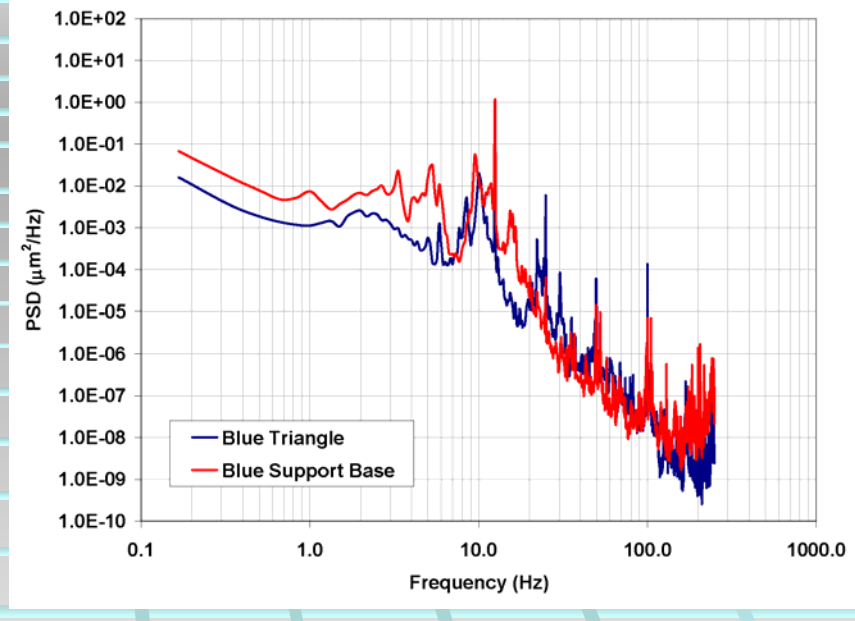
Integrated PSD @ f > 1 Hz, HT, beam vs. top (other end)



- Horizontal transverse direction in the other end, not rigid
- AF @ 1Hz of vessel top/ ceiling beam=400/216~1.9

Geophone Measurements in in Horizontal Transverse





Geophone measurements were done comparing two points within the support structure: (X1, Y1) vs. (X2, Y2).

It turns out that X1/Y1~1, and so is X2/Y2 . The difference is in when one looks at (X1, X2)

- **AF @ 2 Hz of X2/X1= 337/134~2.5**

Conclusion: pull rod version of XFEL support system does not look very promising.

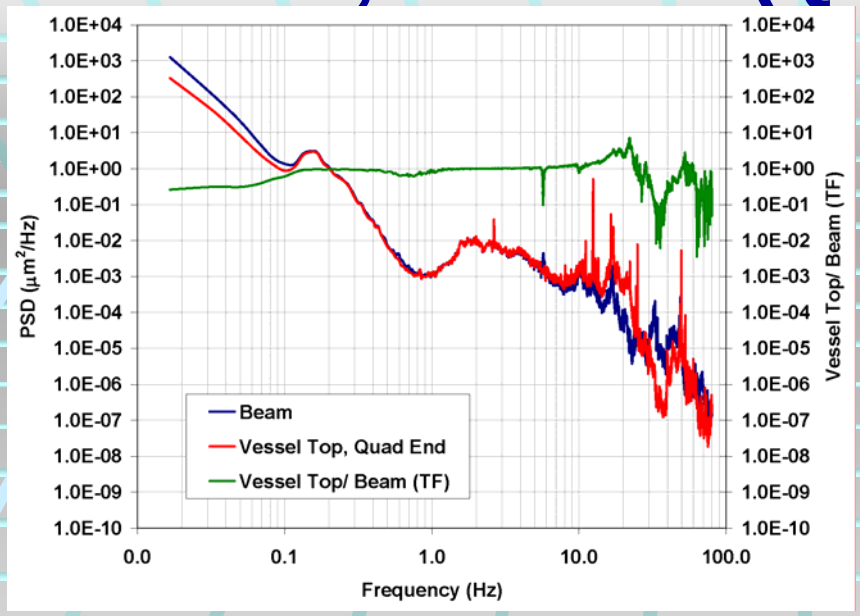
Bolt, Version B

Quadrupole end (fixed point)

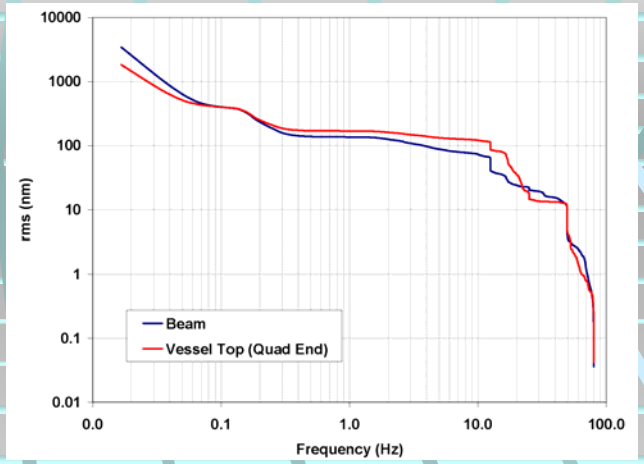
Sensor positions (in V + HT), same as version A

Other end

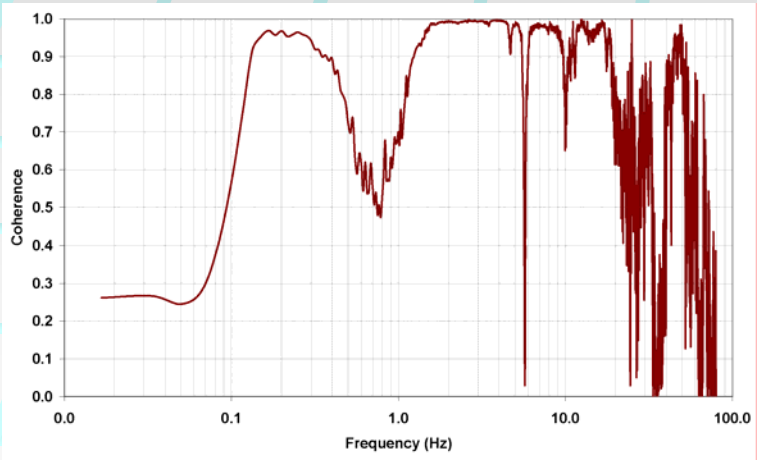
Bolt, Version B (Quad End, Vertical)



PSD, Vertical, beam vs. top (quad end)

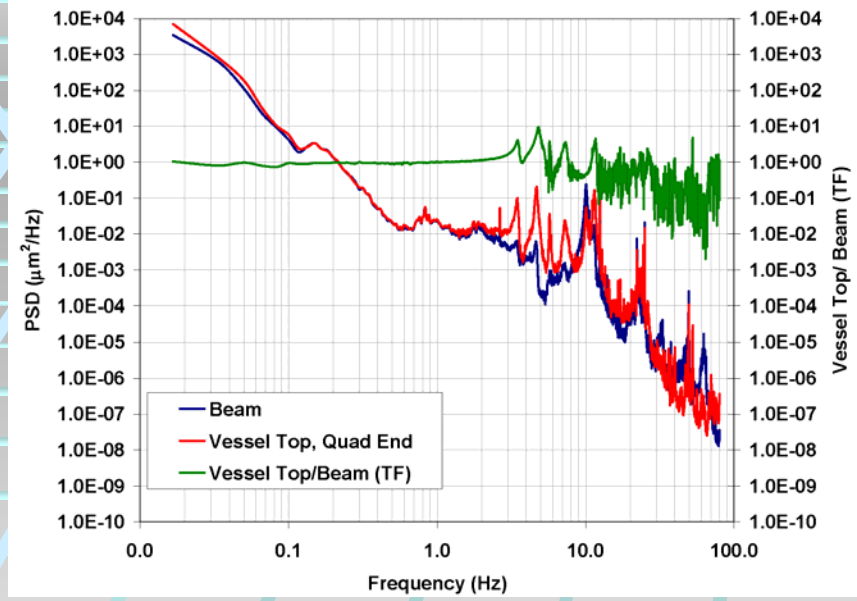


Integrated PSD @ f > 1 Hz, Vertical, beam vs. top (quad end)

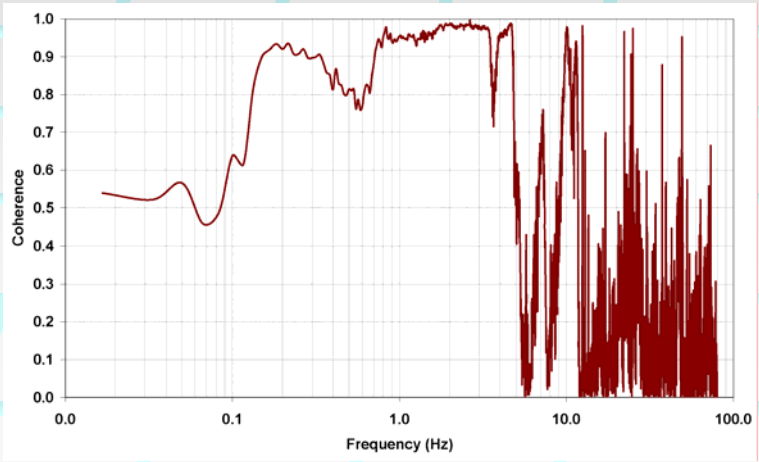


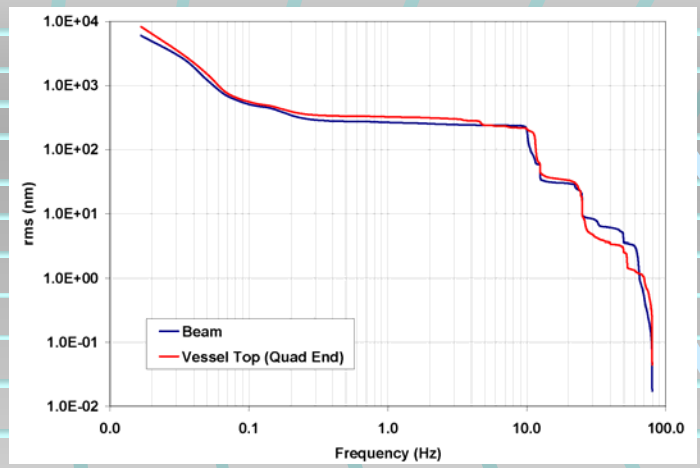
- An almost 1:1 transfer function in the vertical direction
- AF vessel top/ceiling beam @ 1 Hz= 168/135~1.24
- Coherence upto 21 Hz, except the drop of 5.6 Hz

Bolt, Version B (Quad End, Horizontal Transverse)



PSD, HT, beam vs. top (quad end)

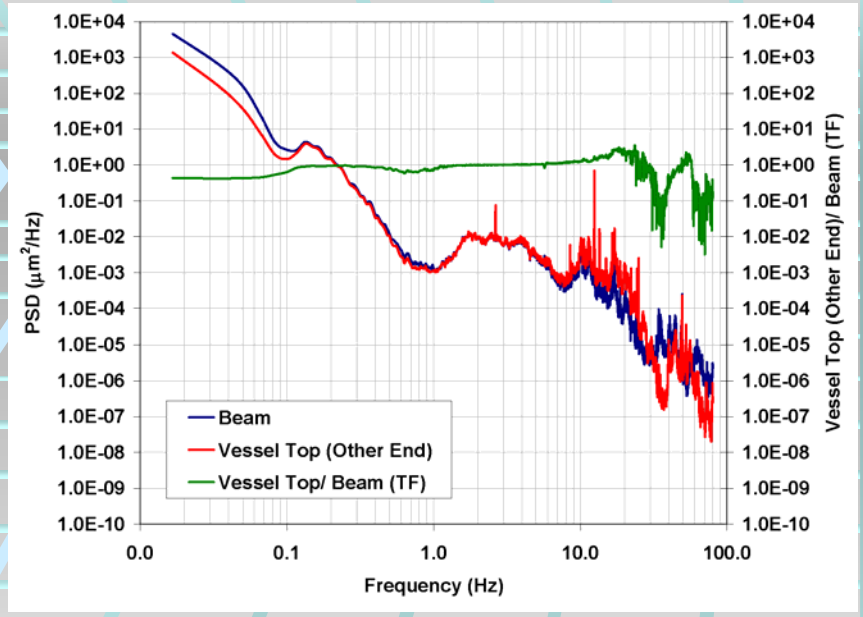


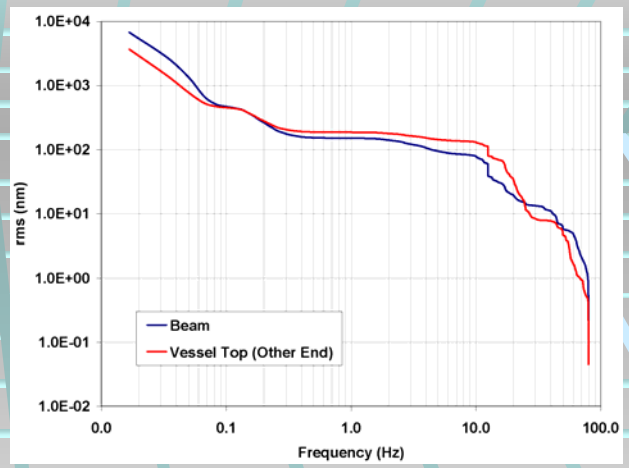


Integrated PSD @ f > 1 Hz, HT, beam vs. top (quad end)

- AF vessel top/ceiling beam @ 1 Hz= 323/265~1.22
- Coherence upto 5 Hz only
- The low frequency peaks (< 7 Hz) are from the ceiling beams as our geophone measurements indicate.
- We recommend shortening of this support system so that these peaks are pushed forward.

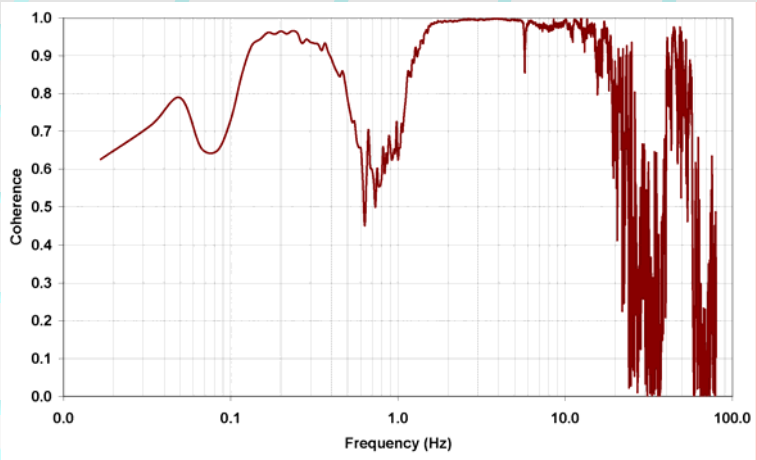
Bolt, Version B (Other End, Vertical)





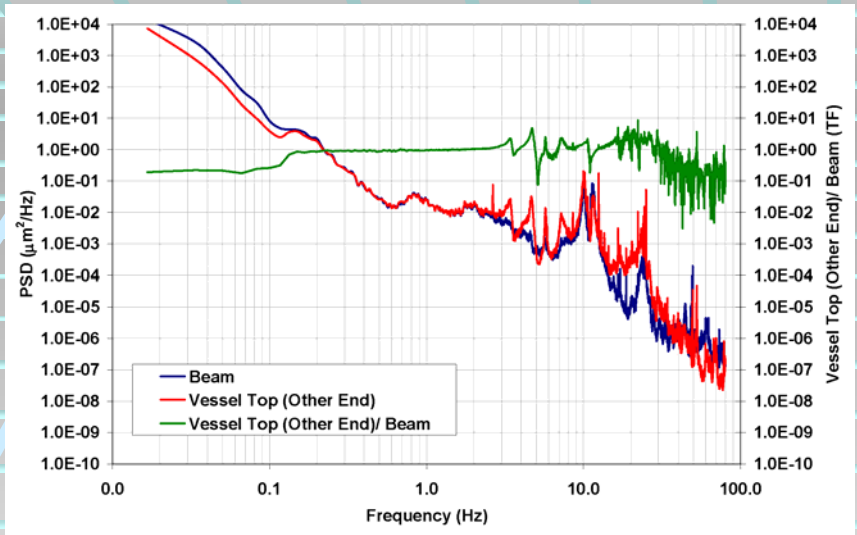
Integrated PSD @ f > 1 Hz, Vertical, beam vs. top (other end)

PSD, Vertical, beam vs. top (other end)

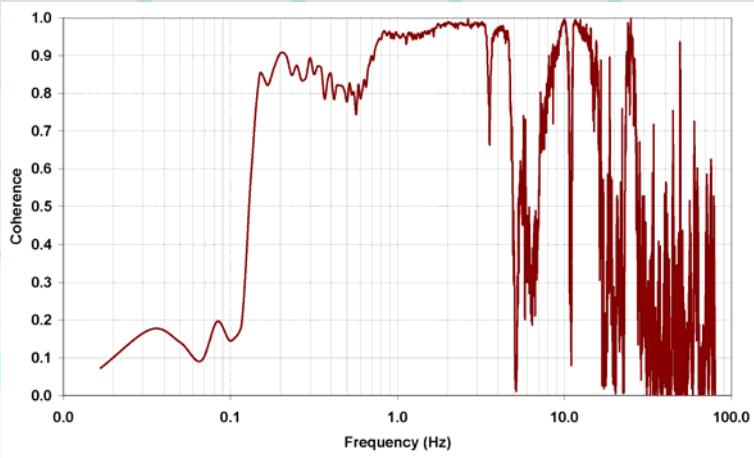


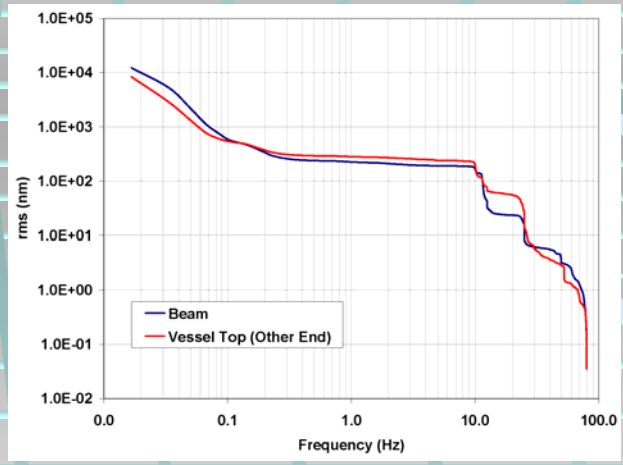
- **An almost 1:1 transfer function in the vertical direction, just as the quad end**
- **AF vessel top/ceiling beam @ 1 Hz= 186/150~1.24**
- **Coherence upto 23 Hz**

Bolt, Version B (Other End, Horizontal Transverse)



PSD, HT, beam vs. top (other end)





Integrated PSD @ f > 1 Hz, HT, beam vs. top (other end)

- AF vessel top/ceiling beam @ 1 Hz= 281/225~1.25
- Coherence upto 5 Hz only
- Same recommendation as the quad end