GROUND VIBRATION PROBLEMS AT THE LIGHT SOURCES

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OUTLINE

- **Vibrational Stability Requirements**
- **Ground Vibrations at Light Sources**
- **Magnet Vibrations**
- **Girder Design and Viscoelastic Damping**
- **Vibrations and Beam Motion**
- **Summary**

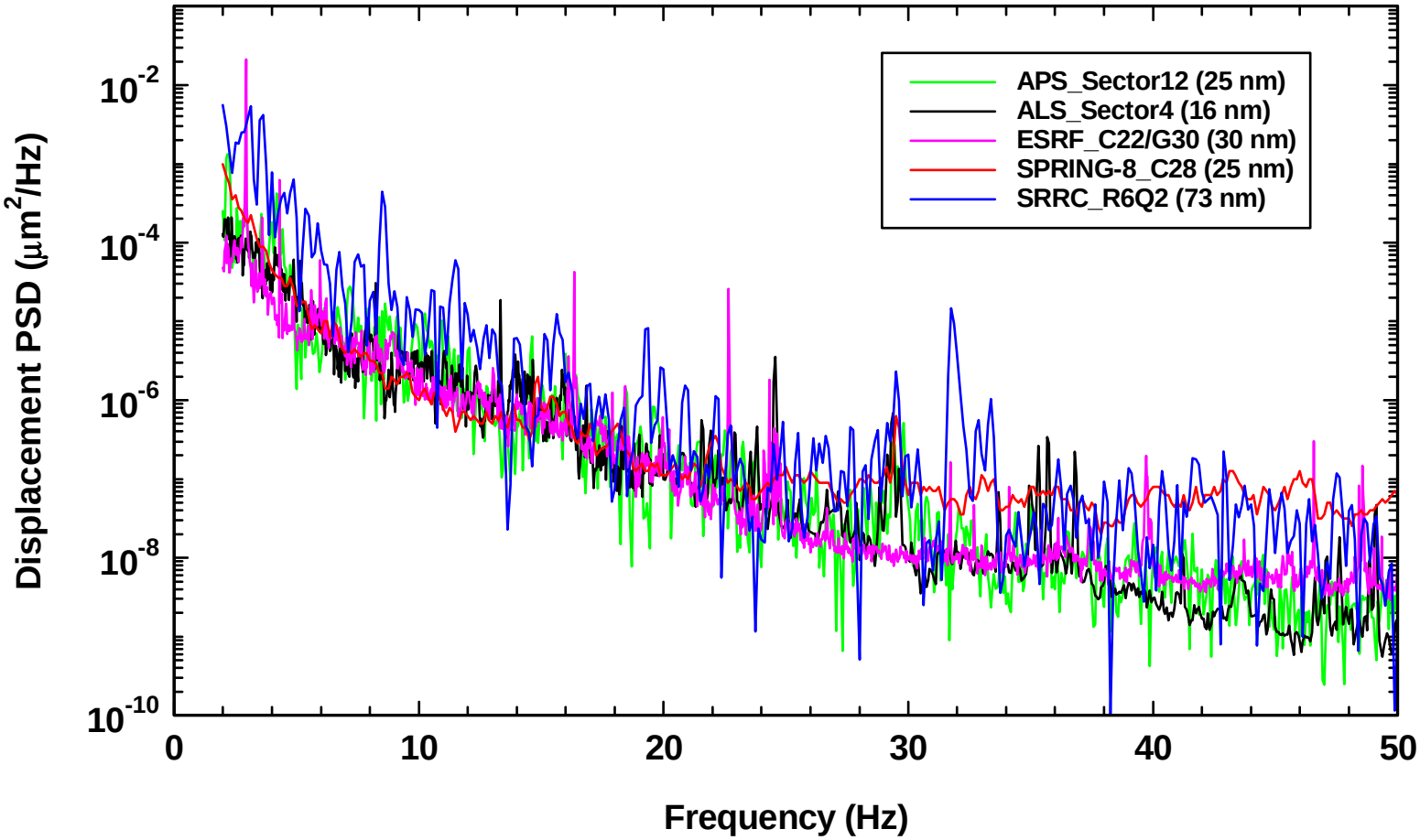
VIBRATIONAL STABILITY REQUIREMENTS

PRESENT GOAL:

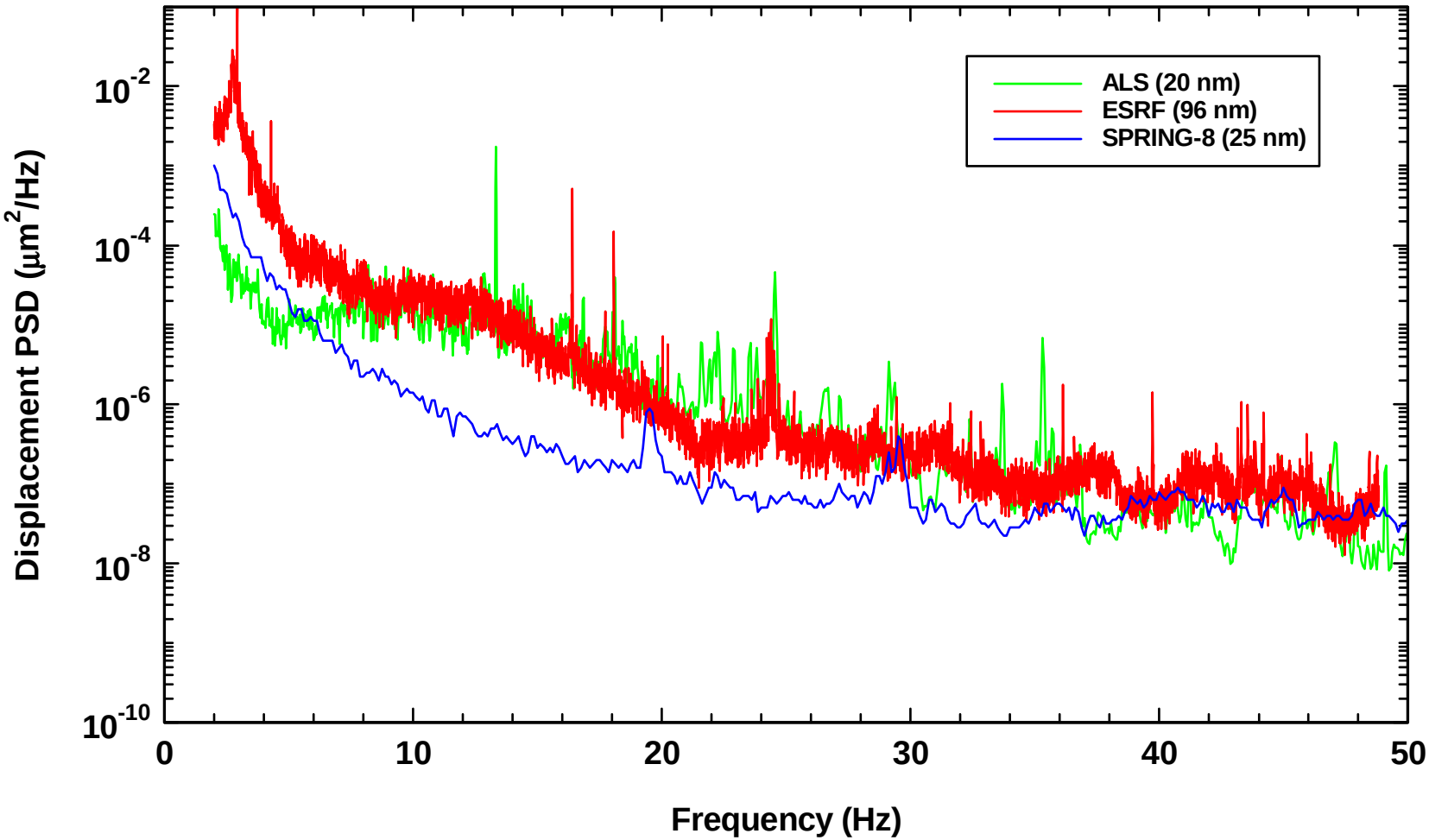
- **Beam motion to be within 10% of the beam size (5% at APS).**
  - **ΔX (beam) $\approx$ 10 – 25 μm (rms)**
  - **ΔY (beam) $\approx$ 1 – 5 μm (rms)**
- **Beam optics magnification**
- **Budget for vibrations**
  - **ALS - ΔX (magnet) < 0.1 μm (0.1 Hz to 1 kHz)**
  - **APS - ΔX (magnet) $\leq$ 0.11 μm (4 – 50 Hz)**
  - **ESRF - Reduce Q (50) by a factor of 5**
  - **SPRING-8 - No specific requirement**
  - **SRRC - No specific requirement**

- **FUTURE GOAL :**
  - **Sub-micron beam stability**

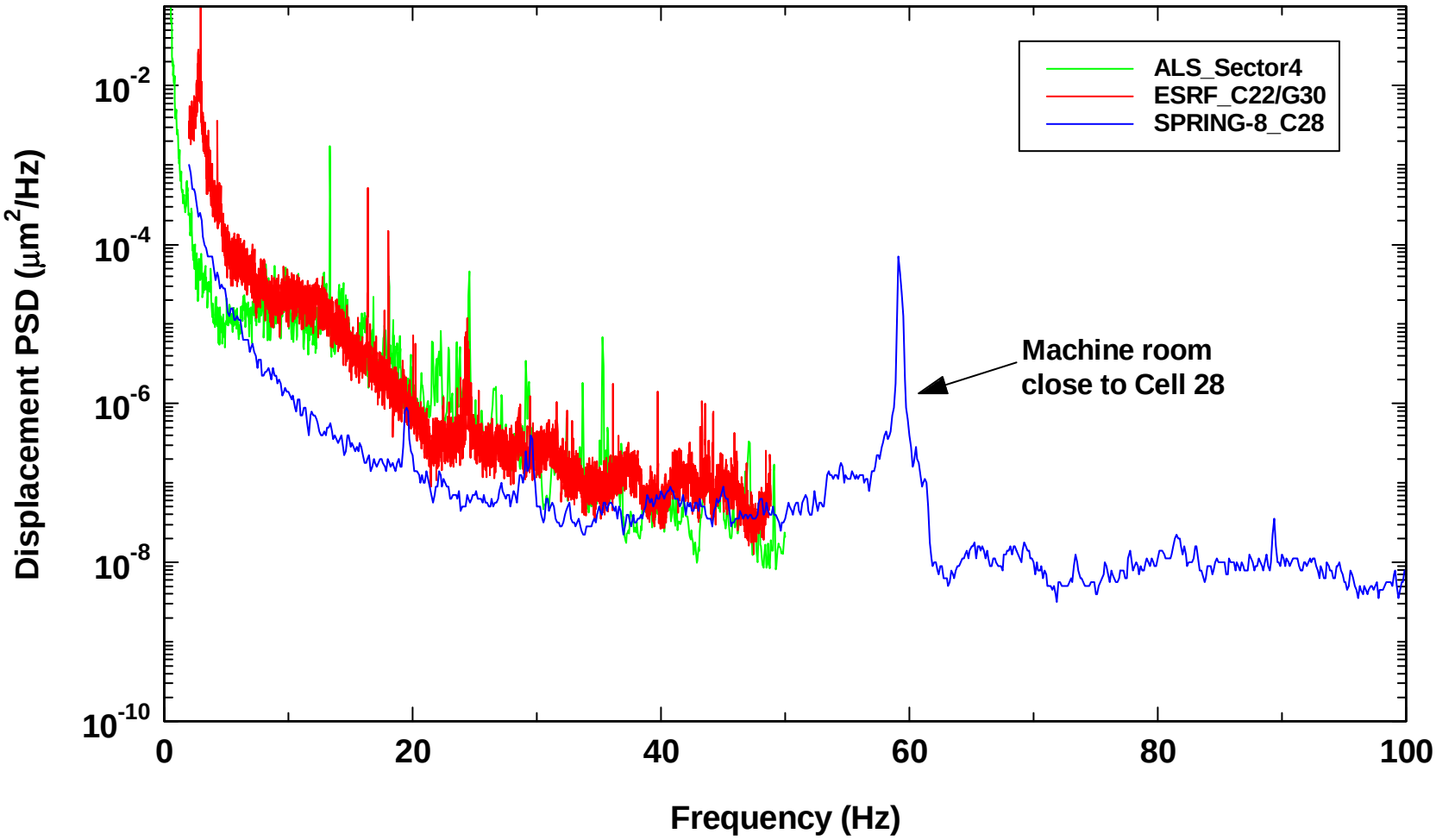
PSD - Horizontal Ground Motion



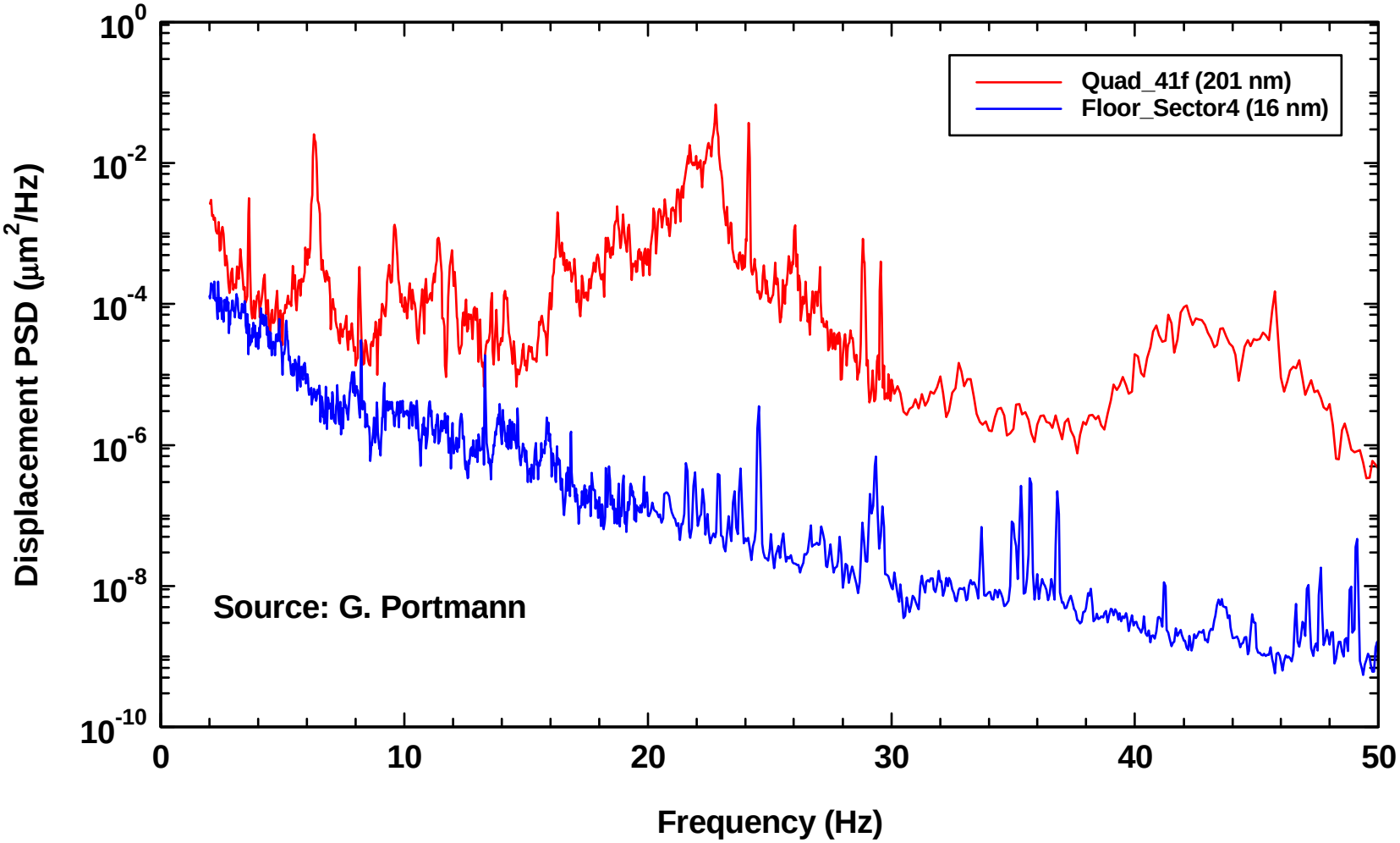
PSD - Vertical Ground Motion



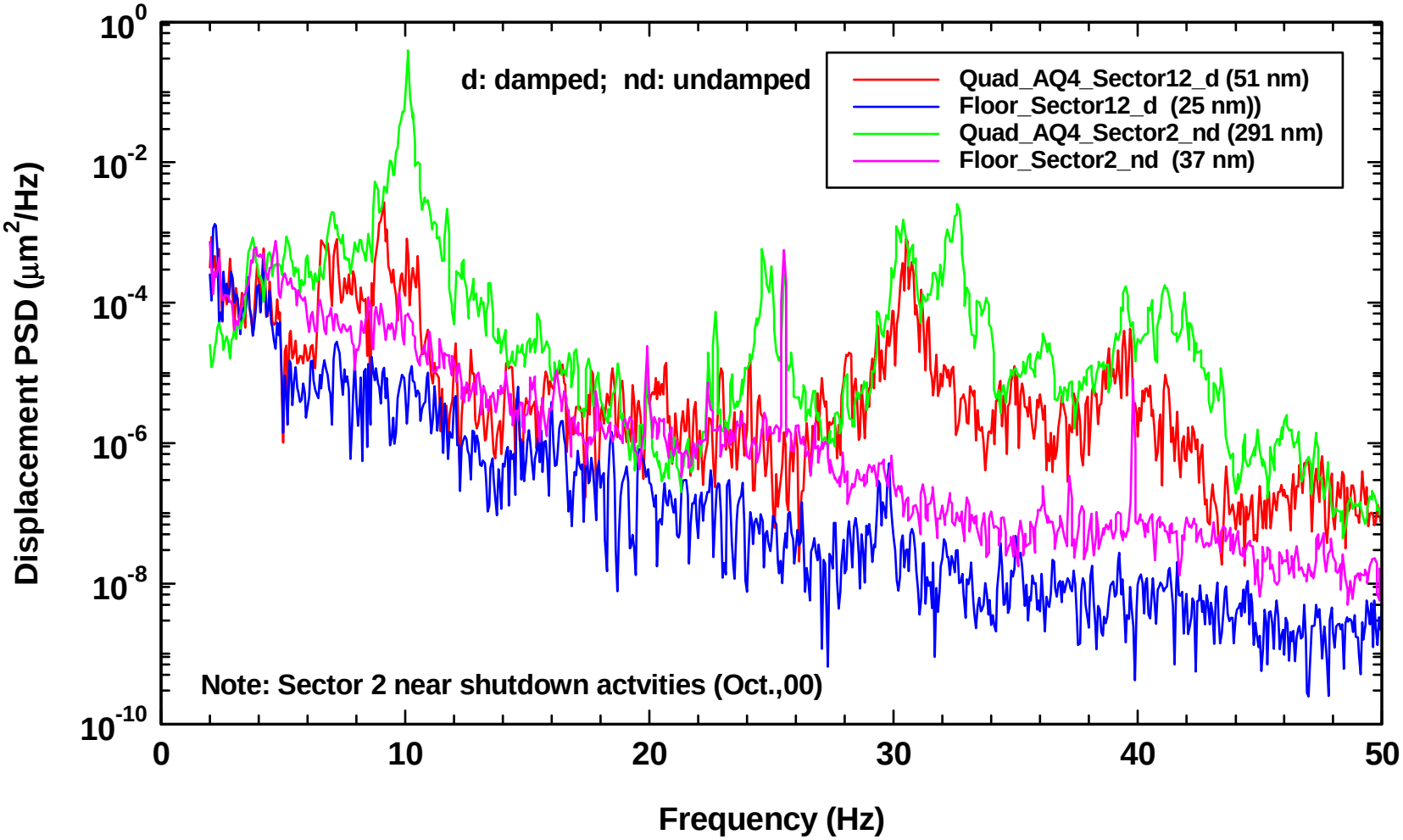
PSD - Vertical Ground Motion



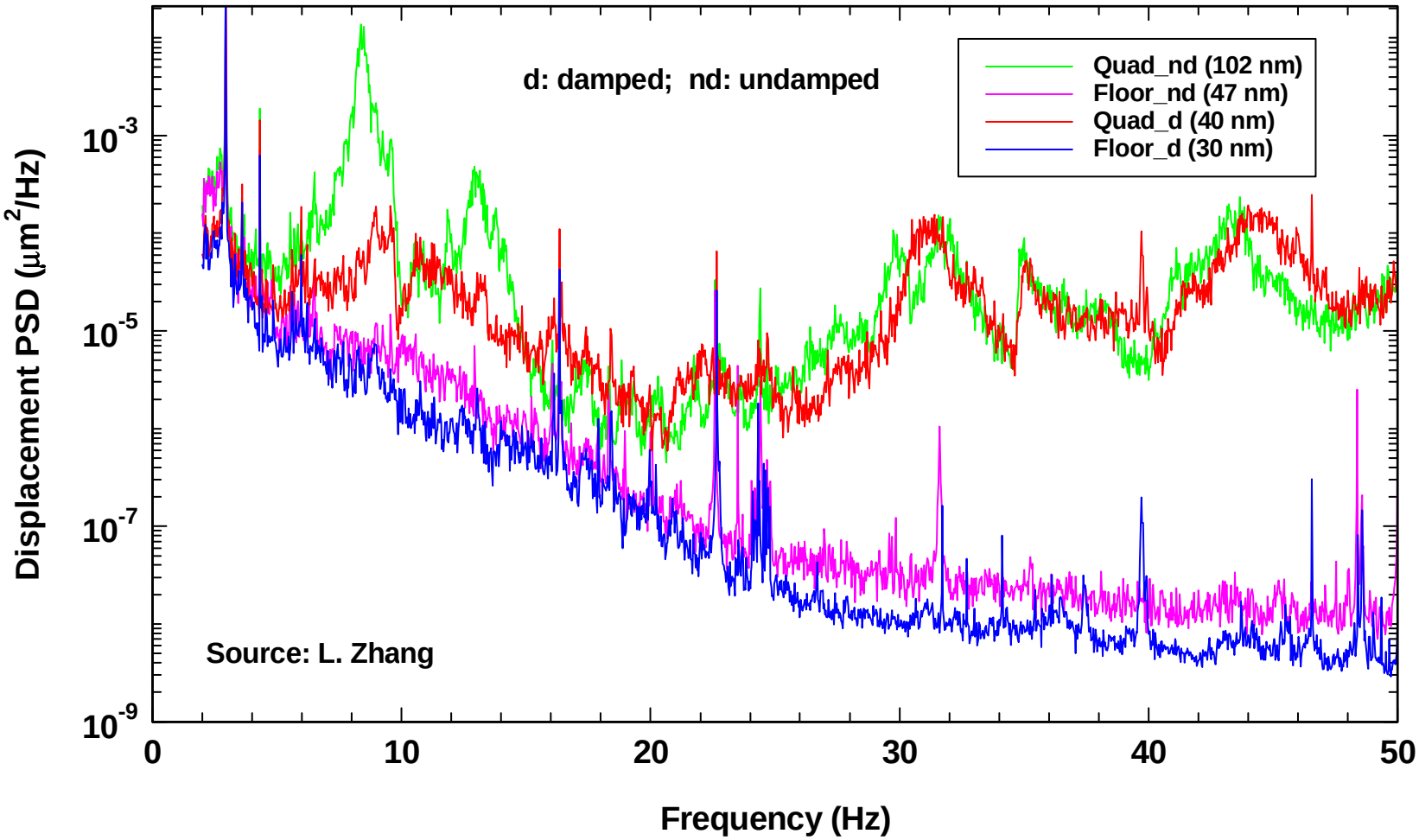
ALS
Horizontal Motion Spectra



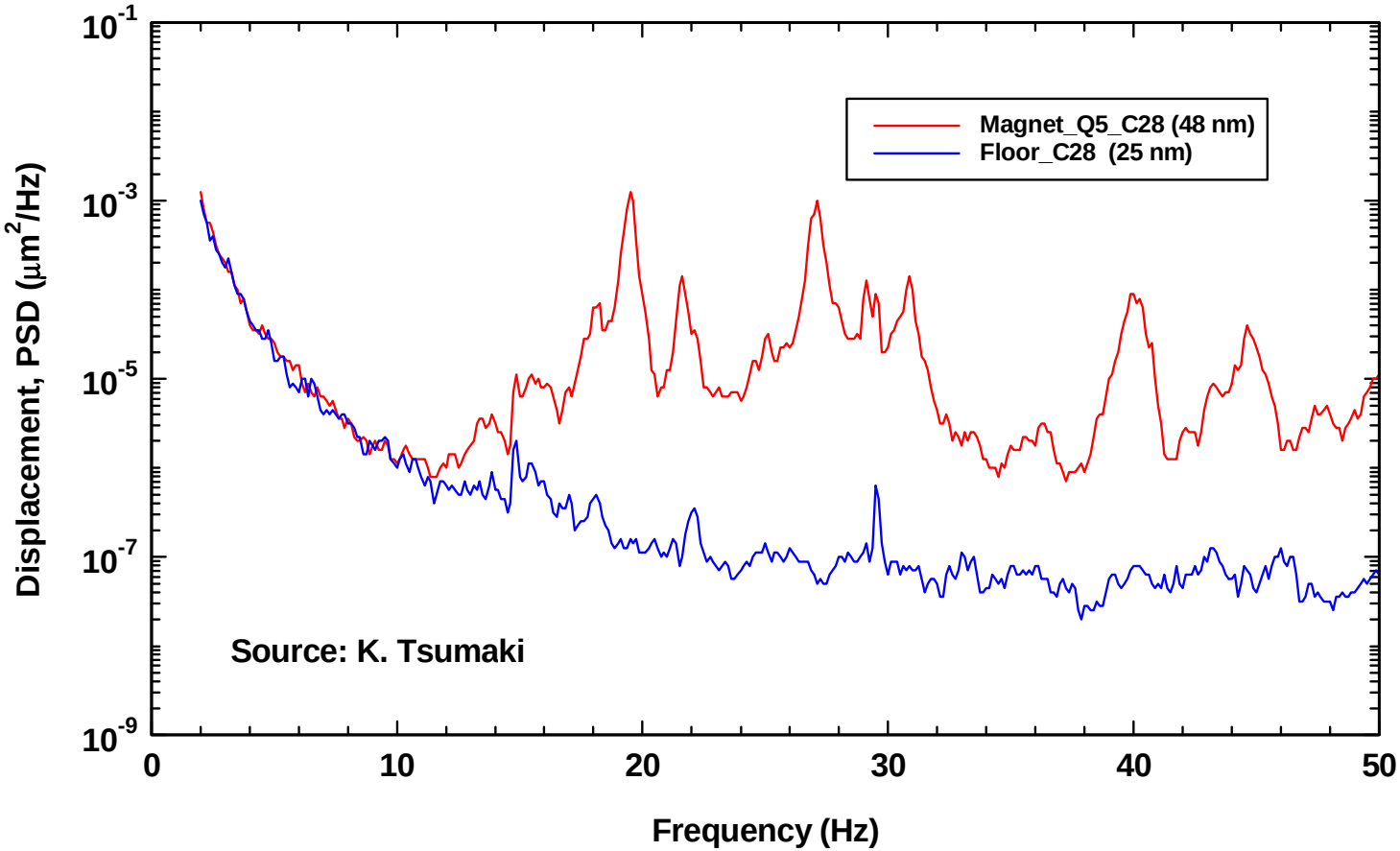
APS
Horizontal Motion Spectra - Sectors 2,12



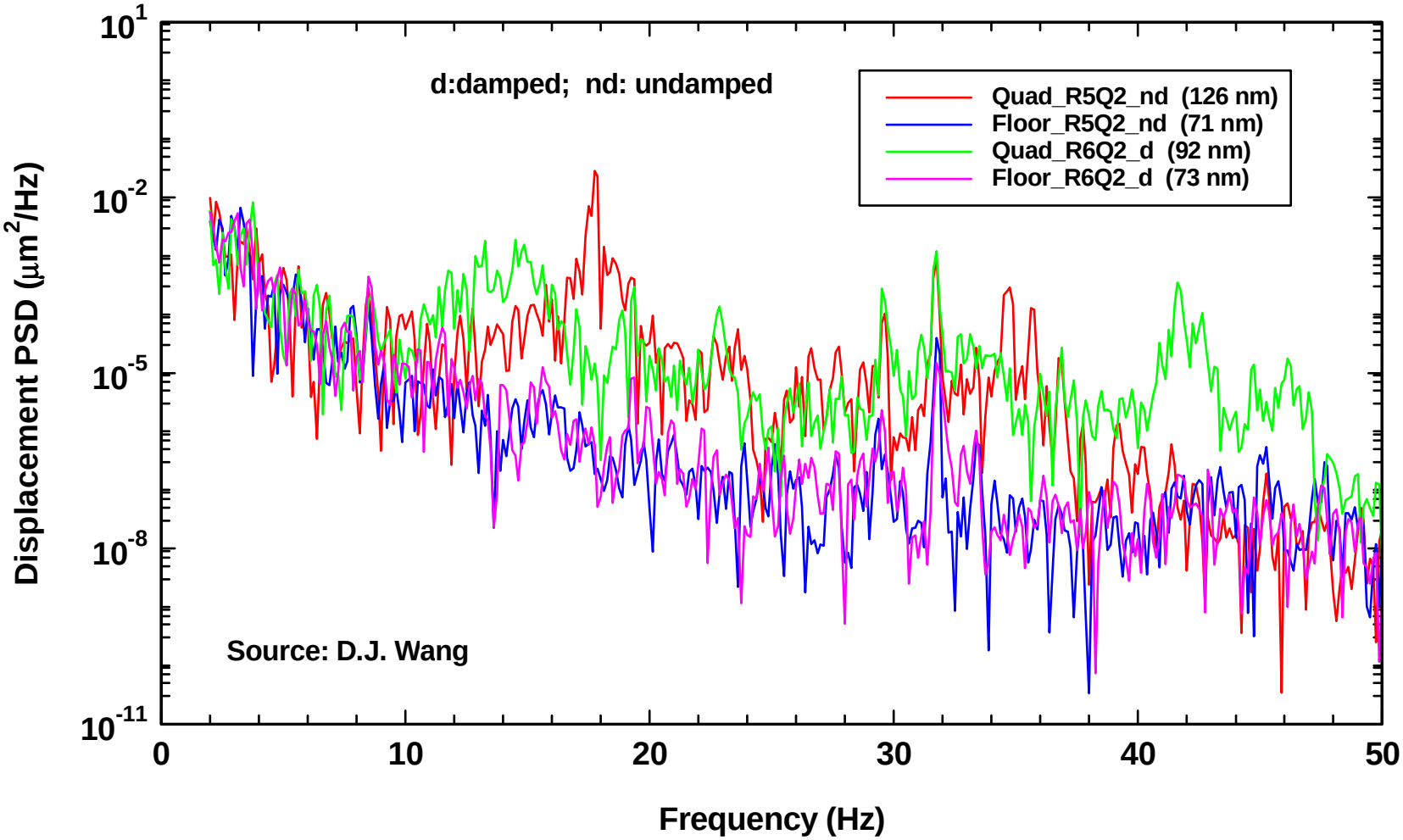
ESRF
Horizontal Motion Spectra - Cell22/G30



SPRING-8
Horizontal Motion Spectra - Cell 28



SRRC
Horizontal Motion Spectra - R5Q2/R6Q2



Horizontal Motion Band Power (2-50 Hz) and Band Power Amplification

Facility	Floor (nm)		Quad (nm)		Amp. Undamped	Amp. Damped
	Undamp.	Damp.	Undamp.	Damp.		
ALS	16		201		12.6	
APS	37 (1)	25	291 (1)	51	7.9	2.0
ESRF	47 (2)	30	102	40	2.2	1.3
SPRING-8	25 (3)		48 (3)		1.9	
SRRC	71 (3)	73	126	92	1.8	1.3

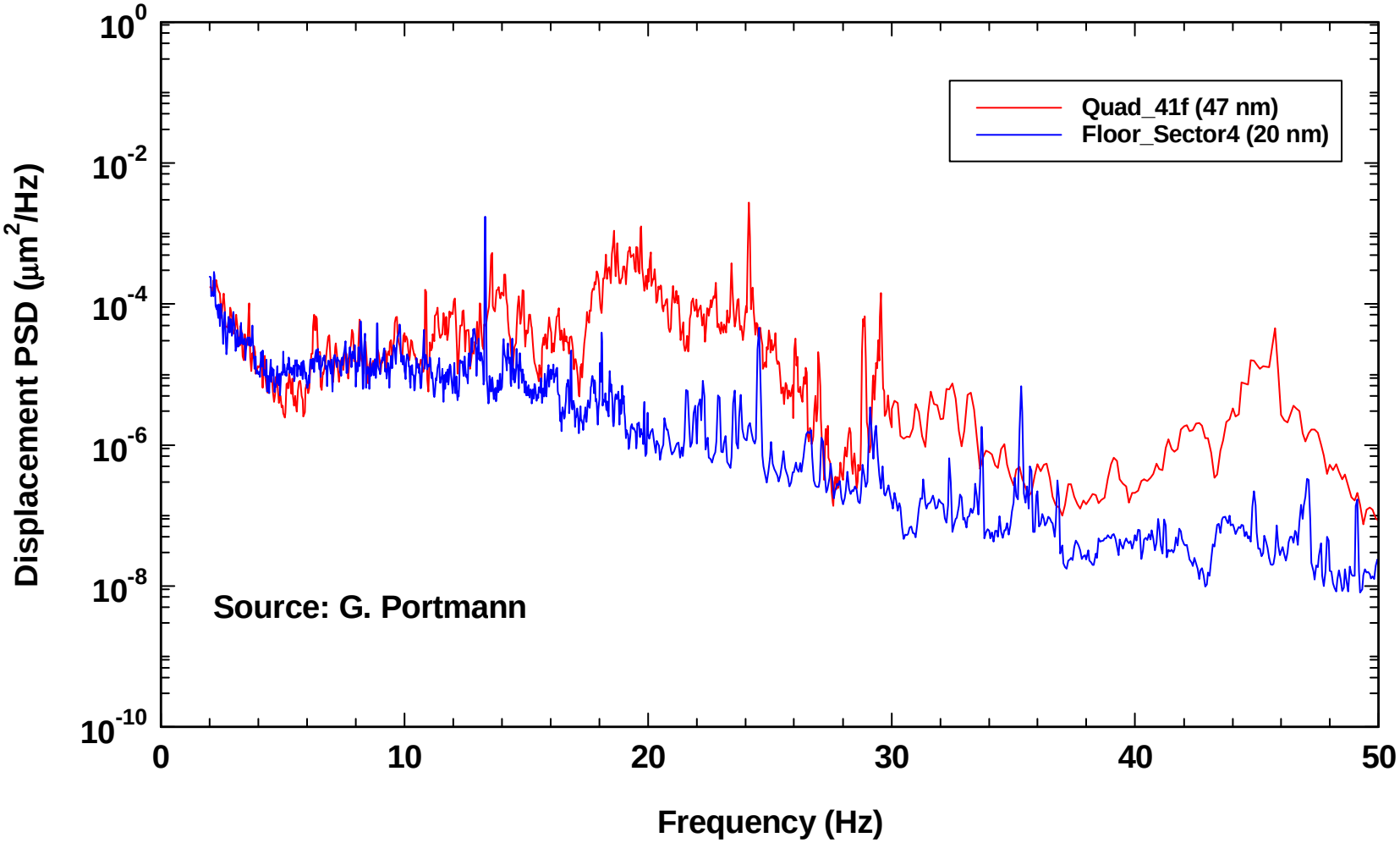
Notes:

(1) Location close to shutdown activities.

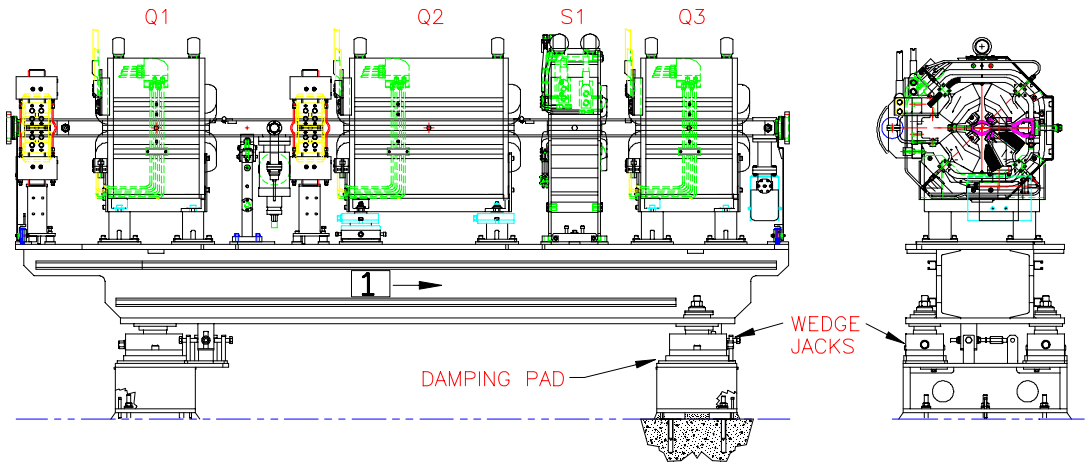
(2) Vacuum pumping operation during vibration tests.

(3) Location close to mechanical equipment room.

ALS
Vertical Motion Spectra



APS Girder Assembly

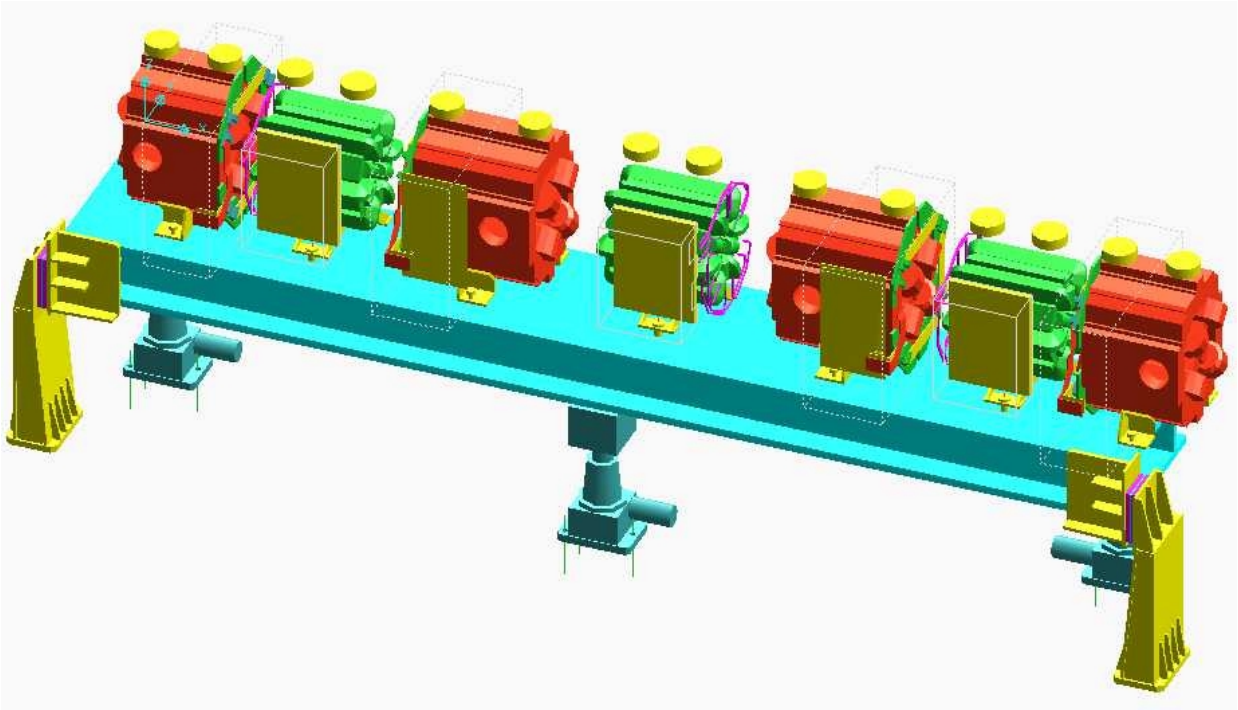


High Q:

- Narrow width
- No mid-point support
- Long lever arm for torsional mode

ESRF Girder Assembly

(Source: L. Zhang)



- Mid-point support
- Damping pads in lateral shear

Viscoelastic Damping

- **Viscoelastic materials (VEMs) absorb vibrational energy by high (up to 100%) cyclic shear strain. The damping pads are most effective when installed in high shear strain regions.**

- **Damping pads can reduce 'Q' by one order of magnitude.**

- **Several VEMs tested at the APS showed high creep and radiation resistance.**

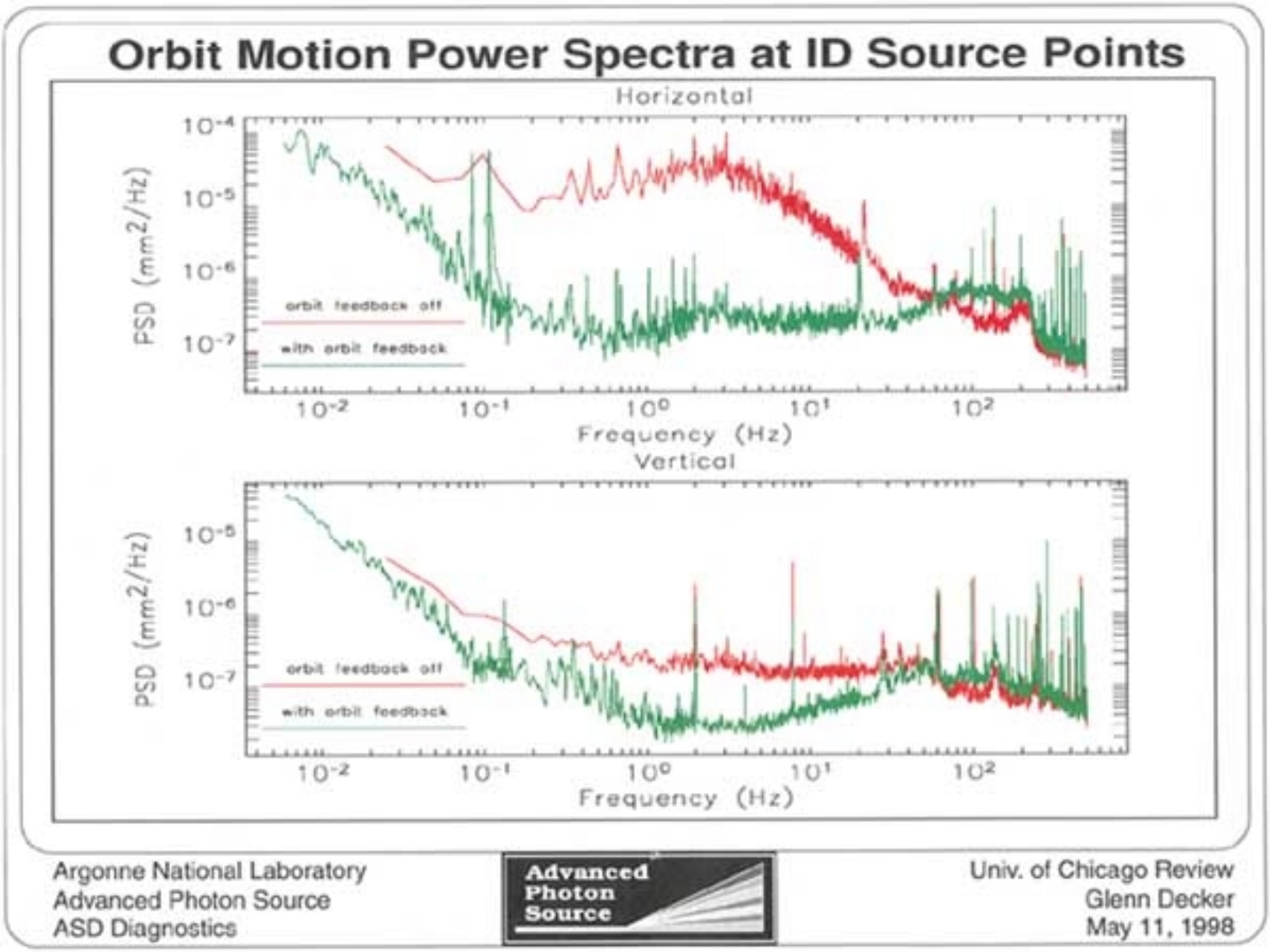
- **The damping pads are inexpensive, and can be installed as retrofit without breaking vacuum connections.**

Vibrations and Beam Motion

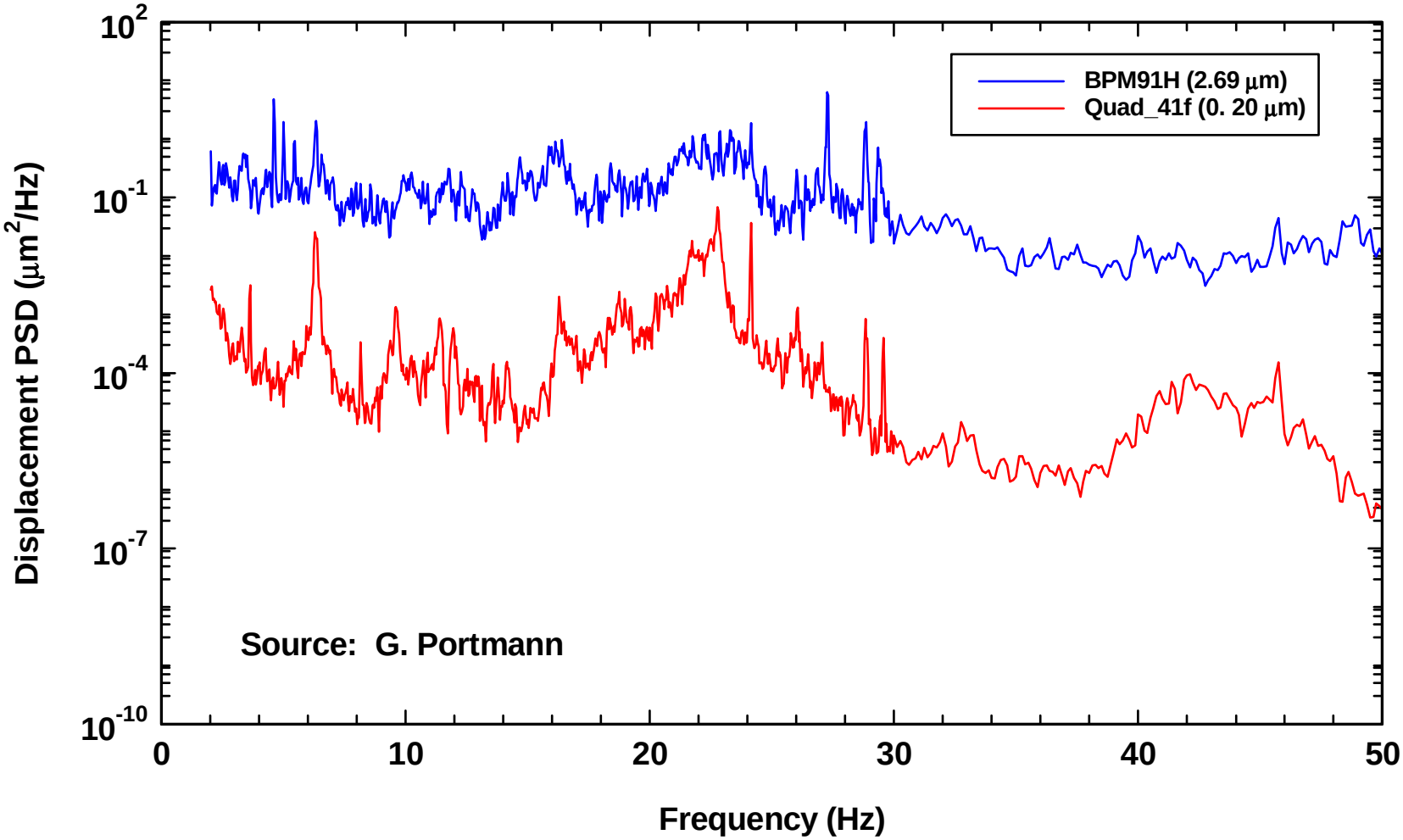
APS Beam Stability Performance to Date (5/98)
(Source: Glenn Decker)

Frequency Band	Horizontal Motion ΔX (microns rms)	Vertical Motion ΔY (microns rms)	**Limitations**
Low Frequency Drift (1.E-06 – 0.017 Hz)	$< \sigma(x)$	2.5 to 20	Electronics Intensity Dependence, Mechanical and Electrical Thermal Effects, RFBPM Bunch Pattern Dependence, IDXBPM stray radiation
Jitter (.017 – 30 Hz)	<4.5, or 1.3% $\sigma(x)$	<1.8, or 10% $\sigma(y)$	High Bandwidth Corrector Availability, IDXBPM stray radiation, [Vibrations]
High Frequency (30 – 500 Hz)	< 12.4	< 7.5	Power Supply, RF Voltage Stability [Vibrations]
Very High Frequency (0.5 – 135 kHz)	5	6	RF Voltage Stability, Multibunch Instabilities
Broadband Total	**14.1 + drift**	**10.1 to 22.3**	**Long Term Drift**

Beam sizes $\sigma(x) = 335\ \mu m$, $\sigma(y) = 18\ \mu m$ @ 1% coupling


Orbit Motion Power Spectra at ID Source Points
Horizontal
PSD (mm2/Hz)
orbit feedback off
with orbit feedback
Frequency (Hz)
Vertical
PSD (mm2/Hz)
orbit feedback off
with orbit feedback
Frequency (Hz)
Argonne National Laboratory
Advanced Photon Source
ASD Diagnostics
Advanced Photon Source
Univ. of Chicago Review
Glenn Decker
May 11, 1998

ALS
Horizontal Beam/Quad Motions



Vibrations and Beam Motion (contd.)

- **ALS:** **1 to 3 μm due to ground vibration (0.1 to 300 Hz)**
- **ESRF:**
- **SPRING-8:**
  - **No effect on horizontal beam size.**
  - **Effect on vertical beam size is being determined.**
- **SRRC:** **No obvious relation.**

SUMMARY

BEAM STABILITY (> 2 Hz)

For Present Stability Goal (5-10% beam size):

- **Vibration problems have been (or can be) addressed by optimizing girder designs, using damping pads and isolating vibrations from mechanical equipment.**