Vibration Stability-NSLS-II Girder Magnet Assembly

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Outline

Ref: http://www.bnl.gov/ps/nsls2/about-NSLS-II.asp
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1. Introduction
2. NSLS-II Girder-Magnet Assembly Overview
3. Vibration Test Results for Girder-Magnet Assembly
4. Tunnel Floor Vibration Results

Introduction

Introduction

Light Sources	E [GeV]	Storage Ring Cir. [m]	Min e-Beam Size [um]
TPS	3	518.4	5.11
SSRF	3.5	432	9.9
Spring-8	8	1436	6
Diamond Light Source	3	561.6	6
NSLS-II	3	792	2.9
Max IV	3	528	< 6

- Modern synchrotron facilities are designed to generate electron beam with very low emittance and small beam size.
- Critical design goals
  - High beam stability – 1/10th of the beam size
  - Long beam lifetime
- Design considerations for mechanical components:
  - Ease of alignment / High mechanical stability

Alignment versus Stability

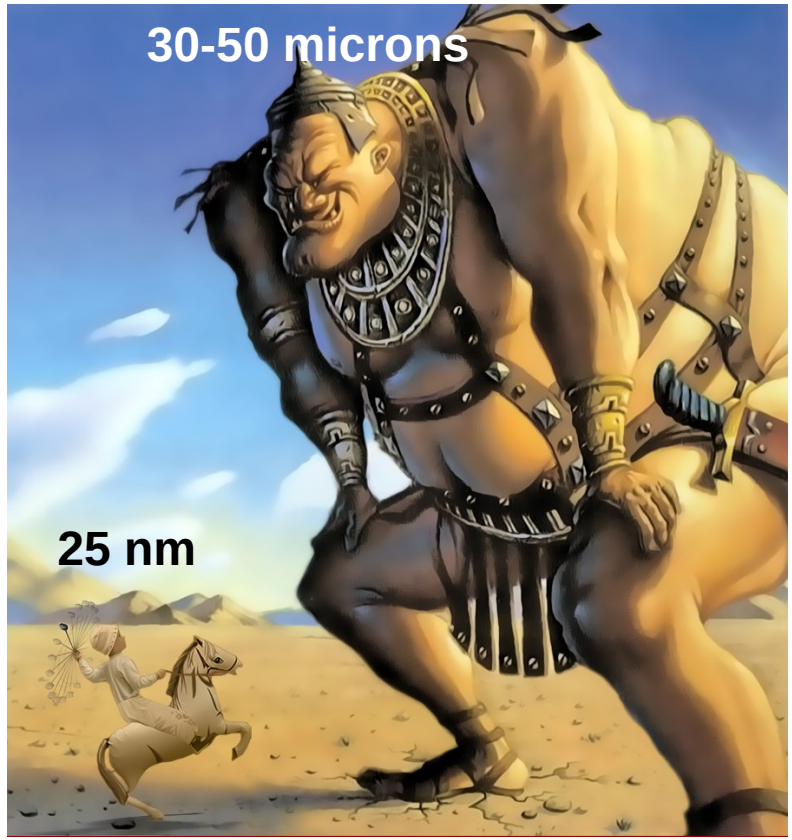
Easy-ALIGNMENT

- **Typical Alignment Tolerance: 30-50 microns**
- Easy alignment requires flexible and movable components
- Low Frequency: Alignment typically done once in 2 years

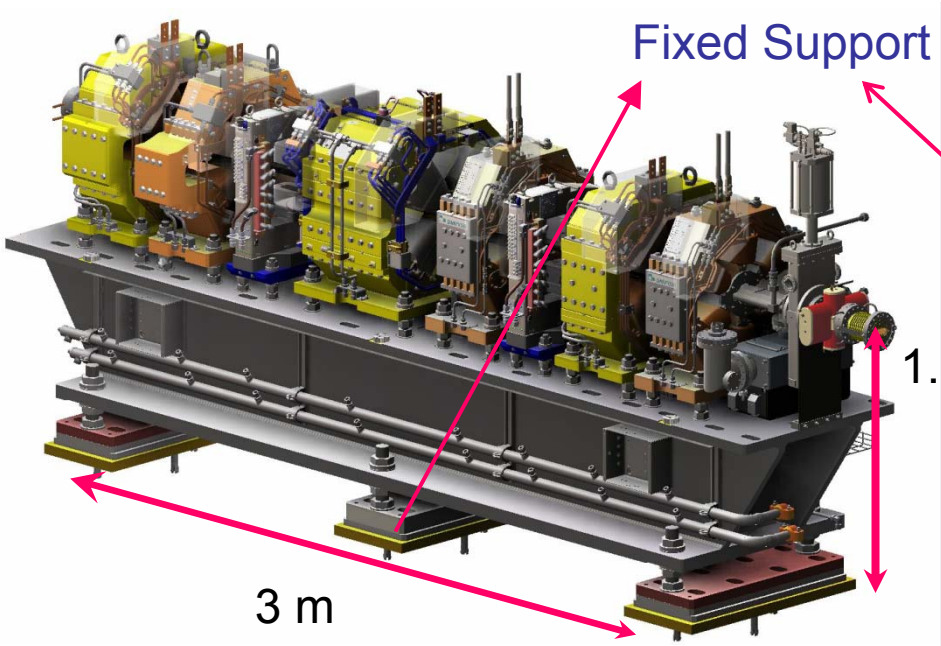
High-STABILITY

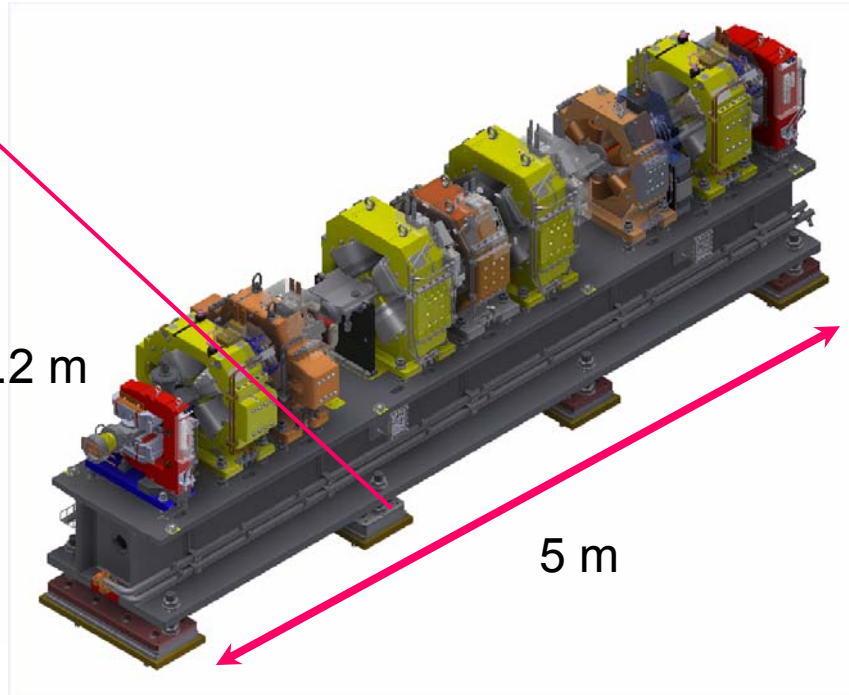
- **Mechanical Stability Specs: 1/1000th of Alignment Tolerance**
- High Stability requires stiff design with multiple support points
- Stability is critical during the continuous operation of the facility

High Stability vs Easy-Alignment Trade offs!



NSLS-II Support System Design

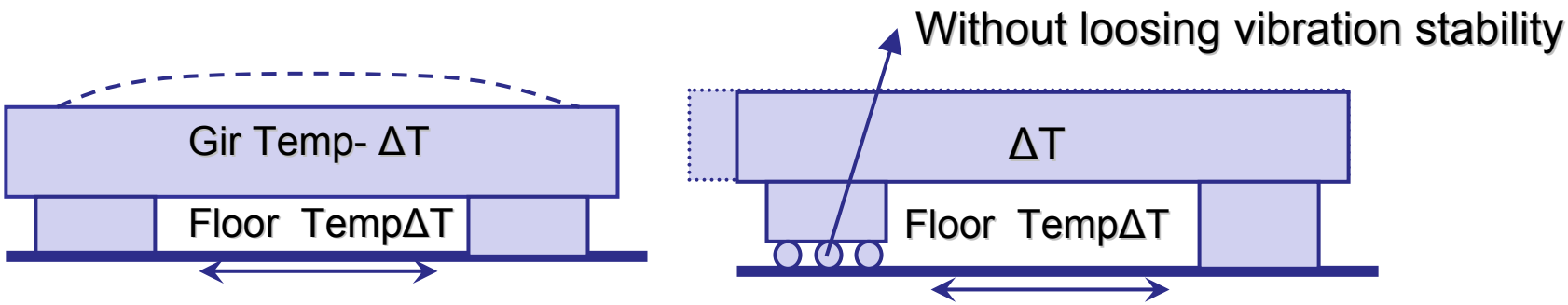


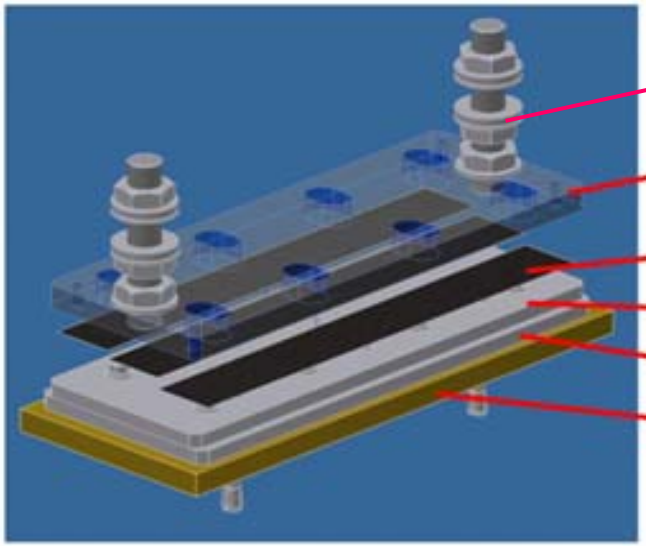


Key Design Features:

- ❑Beam Height = 1.2 m
- ❑Internal ribs for high torsional rigidity
- ❑Several girder support points
- ❑Viscoelastic pads incorporated for thermal stability

Viscoelastic Pads





Alignment Stud

1.5” Top Steel Plate

0.01” Viscoelastic Film (3M™ F9473PC)

1” Bottom Steel Plate

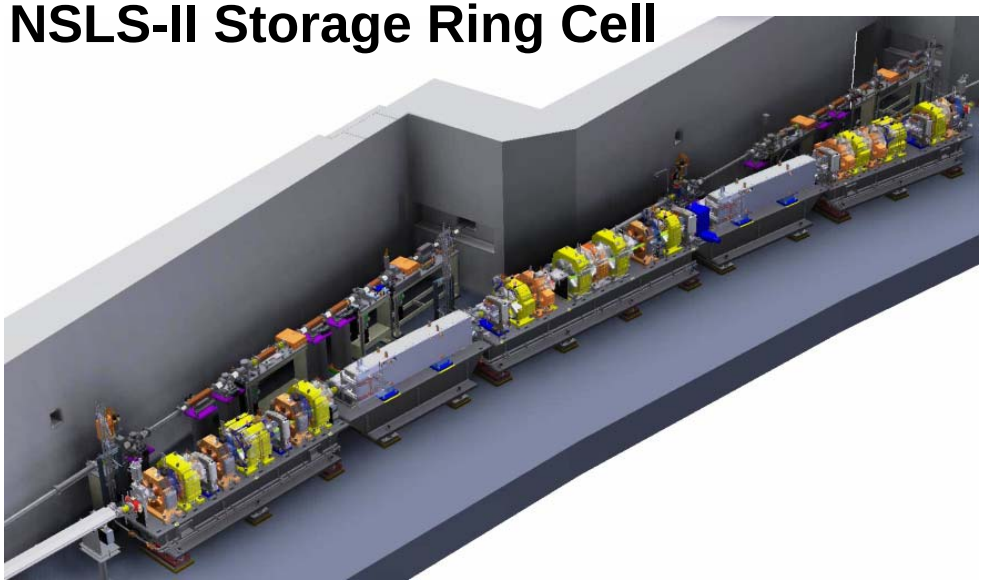
1” Steel Plate for Grout

Grout

The viscoelastic film allows top plate to move relative to the bottom plate freely at slow cycles (< 0.1 Hz). The girder can expand or contract without bending.

Stability Specifications

NSLS-II Storage Ring Cell



One straight section for ID

Two Dipole girder-magnet sections

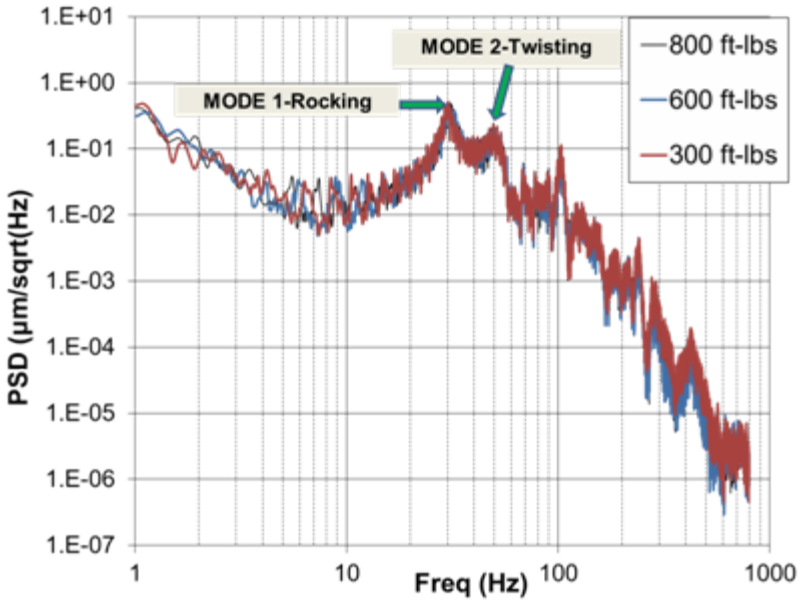
Three Multipole girder-magnet section

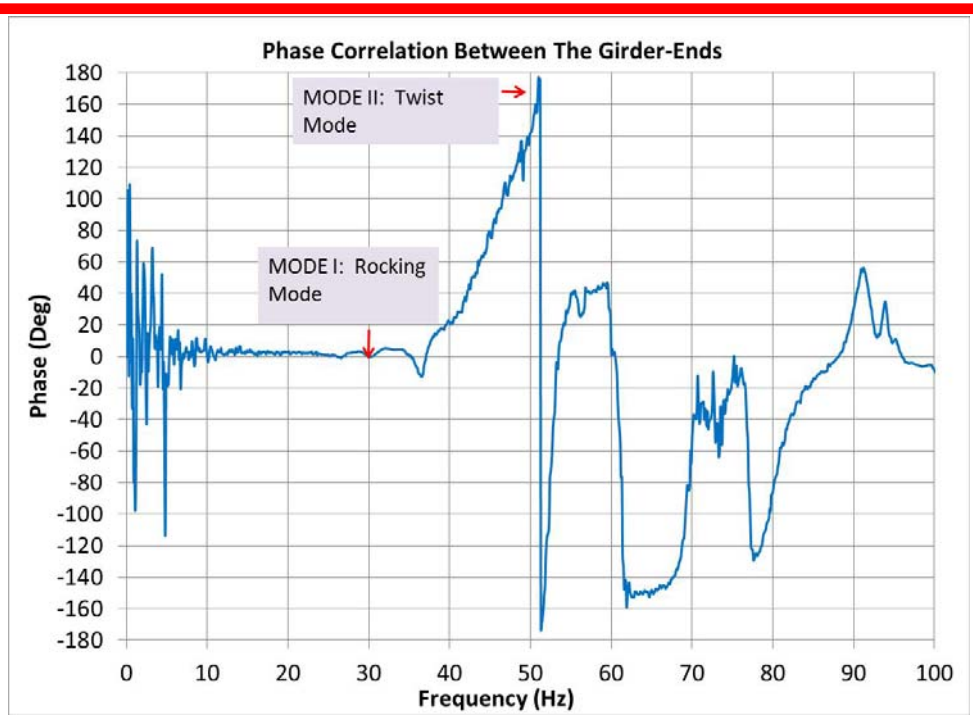
Stability Specifications For NSLS-II Girder-Magnet Assembly

- Relative RMS motion (vertical) between the magnets on a single girder $\leqslant$ 25 nm
- Relative RMS motion (vertical) between the girders $\leqslant$ 70 nm
- Allowable relative RMS motion in the horizontal direction, 5-10 times larger than vertical specification.

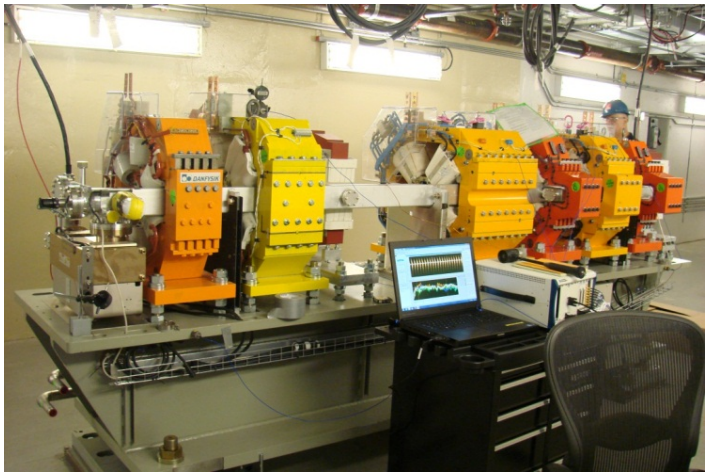
Vibration Measurements- Girder-Magnet Assembly

Girder-Magnet Natural Frequencies





Test Setup for Modal Testing

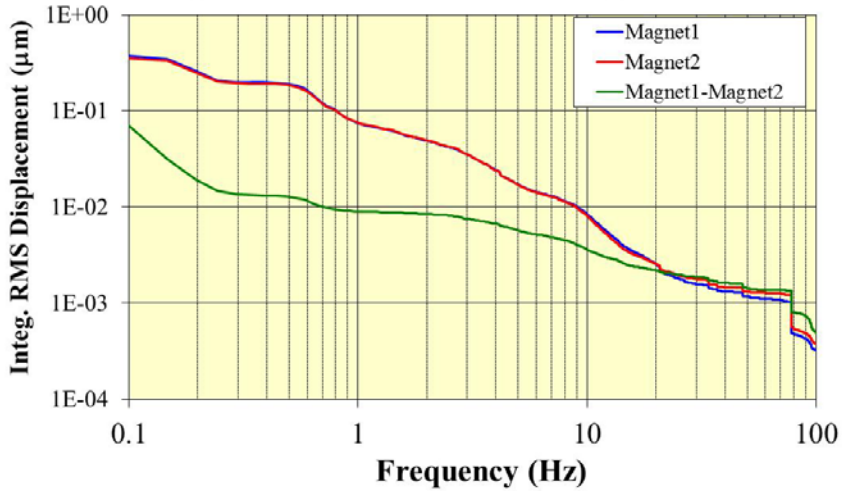


The Natural Freq. for the Assembly :

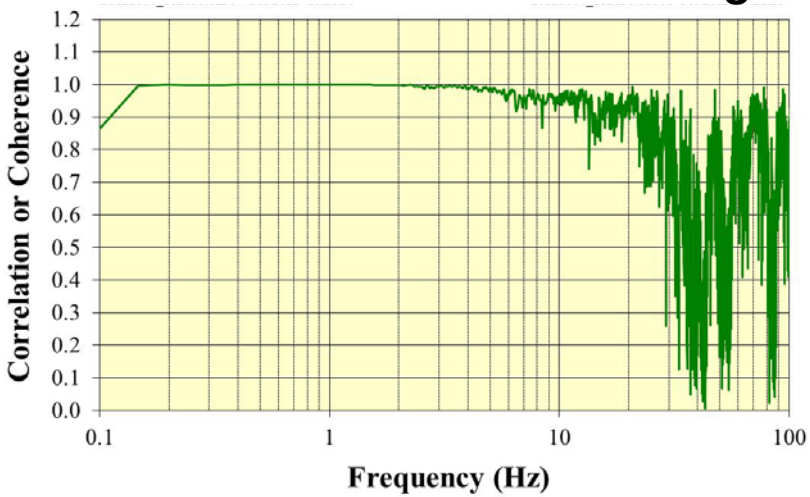
- 1st Mode Rocking: ~30 Hz
- 2nd Mode Twist: 50 Hz

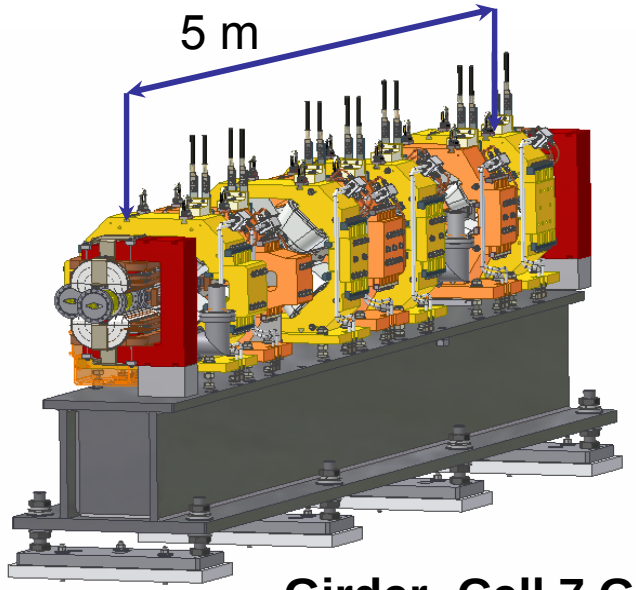
Relative Motion between Magnets on a Single Girder-G4

Integrated RMS displacement



Correlation between the two magnets

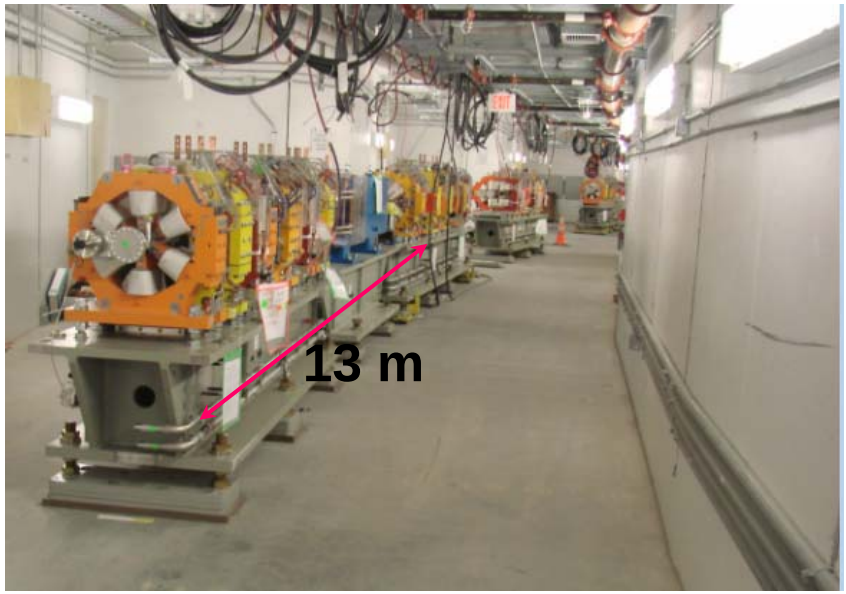


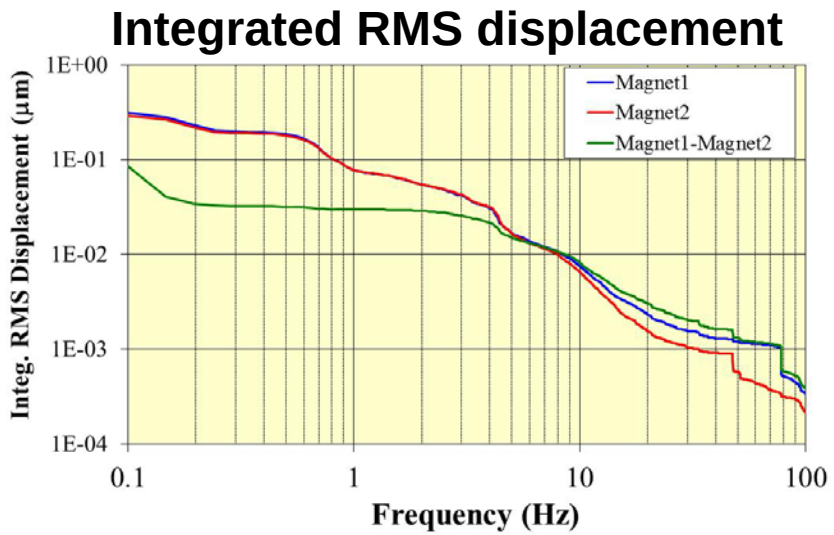


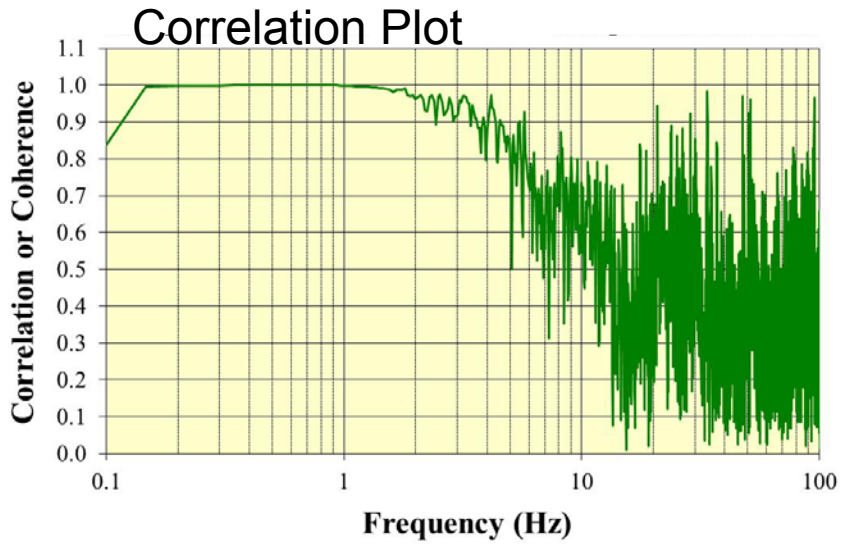
Girder- Cell 7 G-4

- Vibration measurement taken on two farthest magnets on a single girder.
- Good correlation between the two points for frequencies below 25 Hz
- Relative Integrated RMS motion (vertical) between the magnets **2-100 Hz = 8 nm ; Spec.- 25 nm**

Relative Motion between Magnets on Two Separate Girders



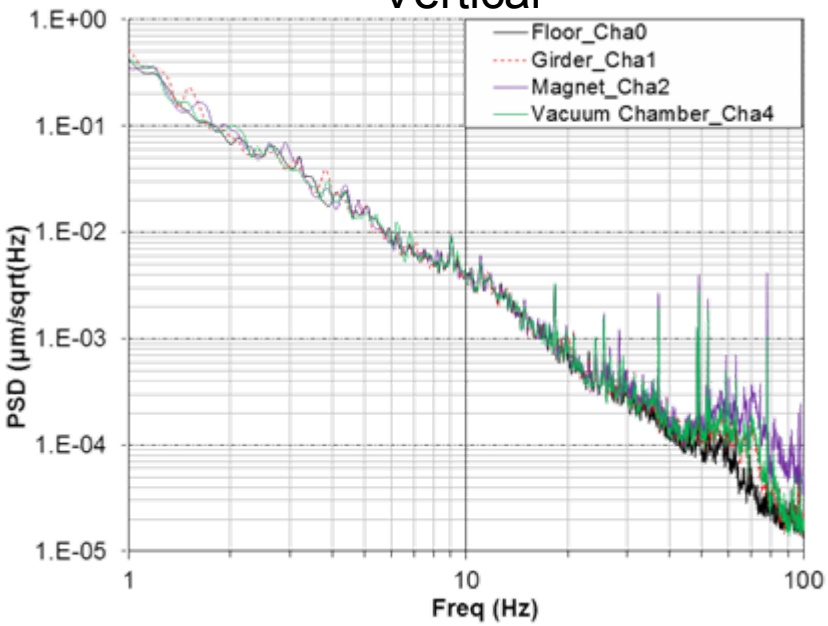




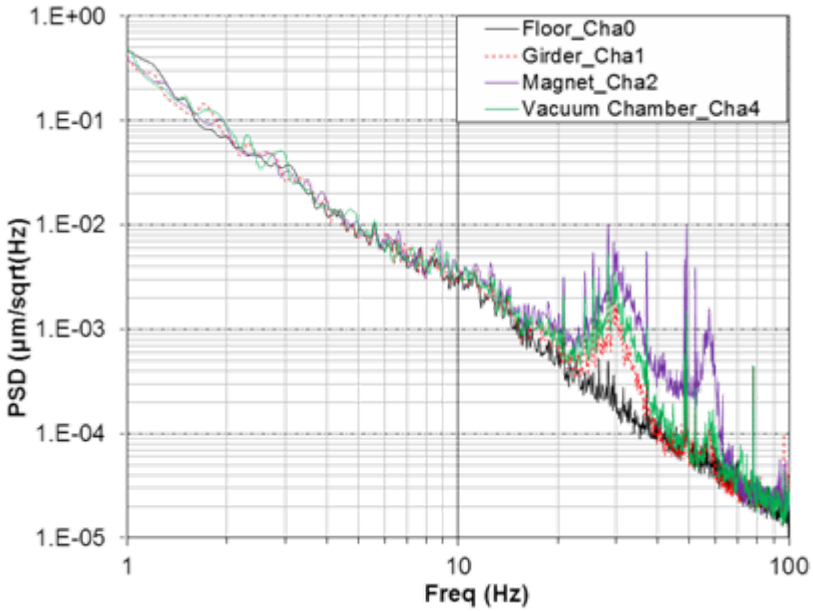
- Vibration measurement taken on two farthest magnets on two separate girders: Cell 7, G2 and G4
- Good correlation between the two points for frequencies below 5 Hz
- Relative Integrated RMS motion between the magnets **2-100 Hz = 28.8 nm, Girder-Girder Spec: 70 nm**

Random Vibration Measurement – Girder, Magnet and Vacuum Chamber

Vertical

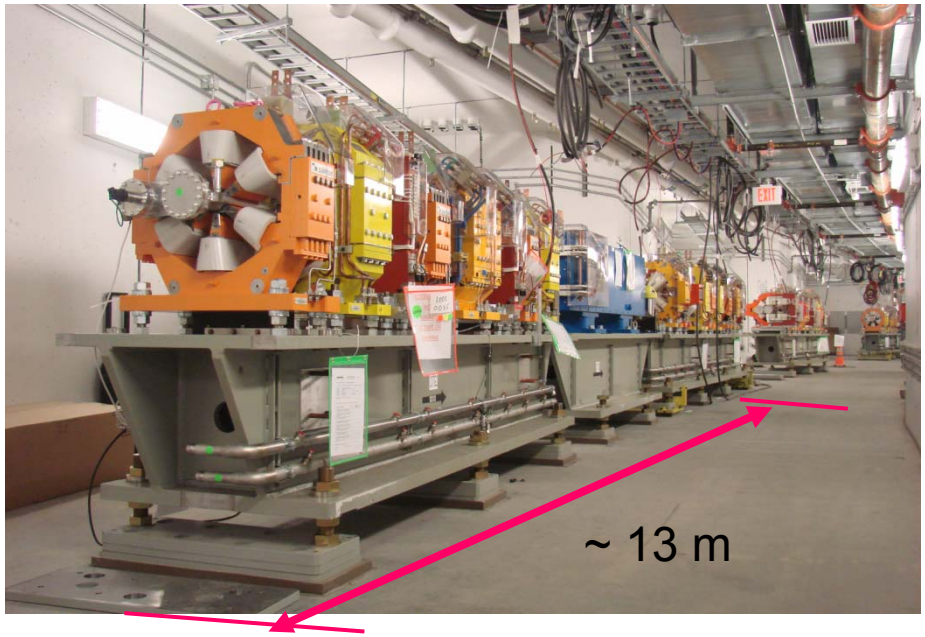


Horizontal



	Vertical				Horizontal			
	2-100 Hz		30-100 Hz		2-100 Hz		30-100 Hz	
	RMS [nm]	Ratio	RMS [nm]	Ratio	RMS [nm]	Ratio	RMS [nm]	Ratio
Floor	75.03	1.00	1.46	1.00	57.56	1.00	0.96	1.00
Girder	73.37	0.98	1.97	1.34	60.53	1.05	2.88	3.00
Magnet	81.20	1.08	3.34	2.28	61.77	1.07	8.39	8.76
Chamber	79.93	1.07	2.16	1.48	66.56	1.16	5.00	5.20

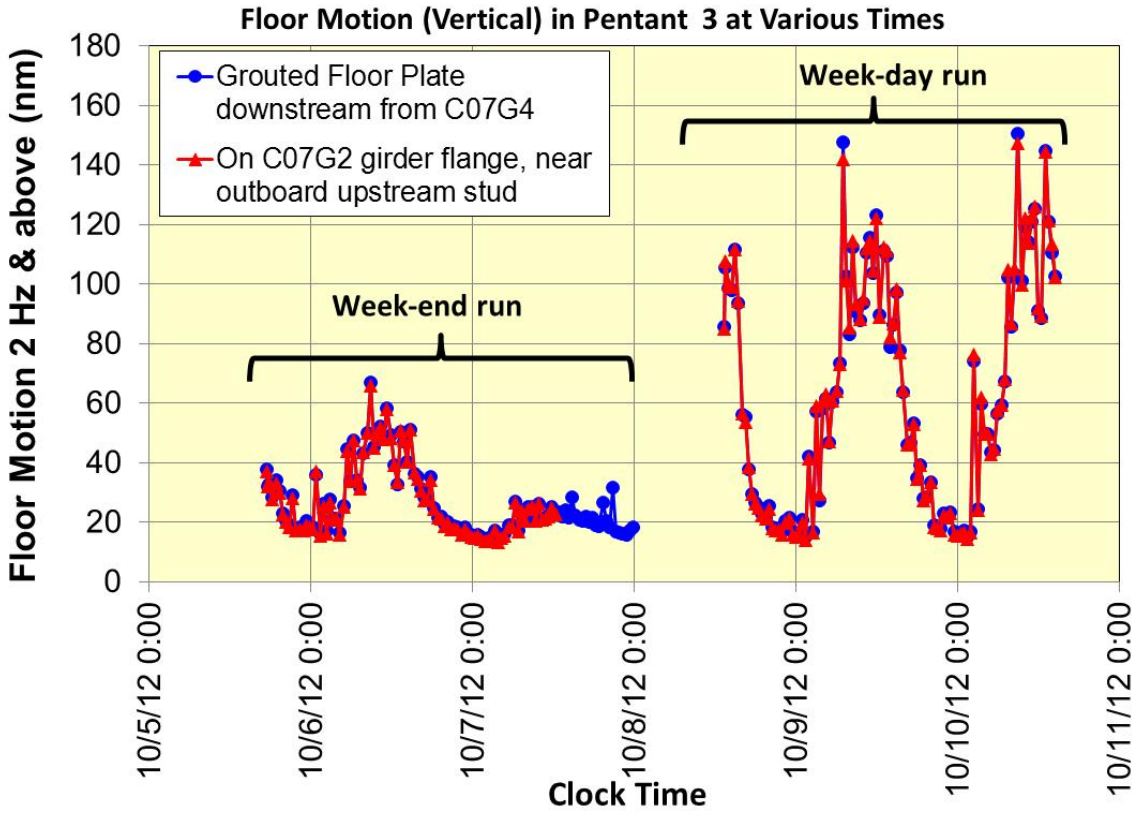
Floor Vibration Measurements



Sensor used for floor vibration:

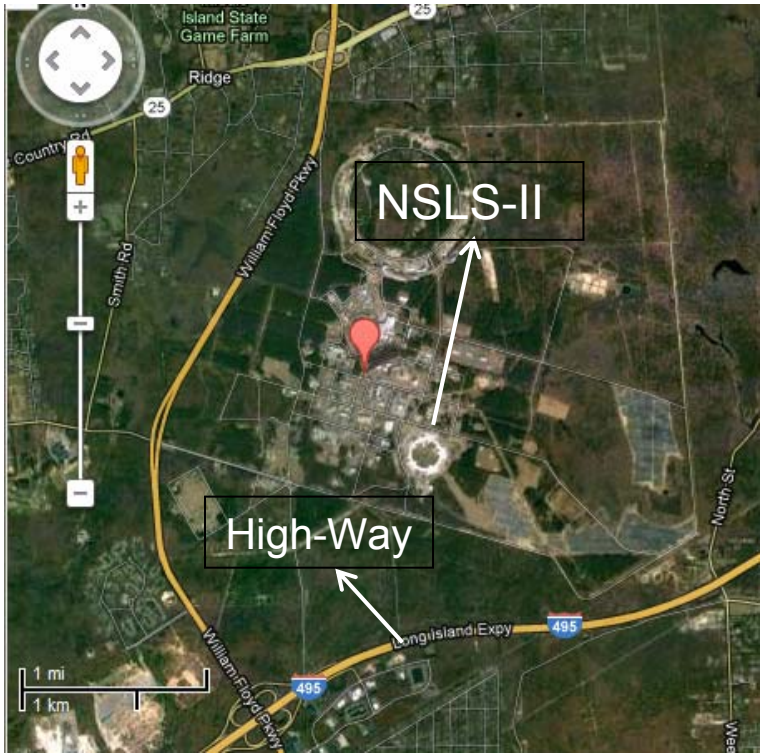
High sensitivity geophones
Model#L4
Manufacturer: Sercel

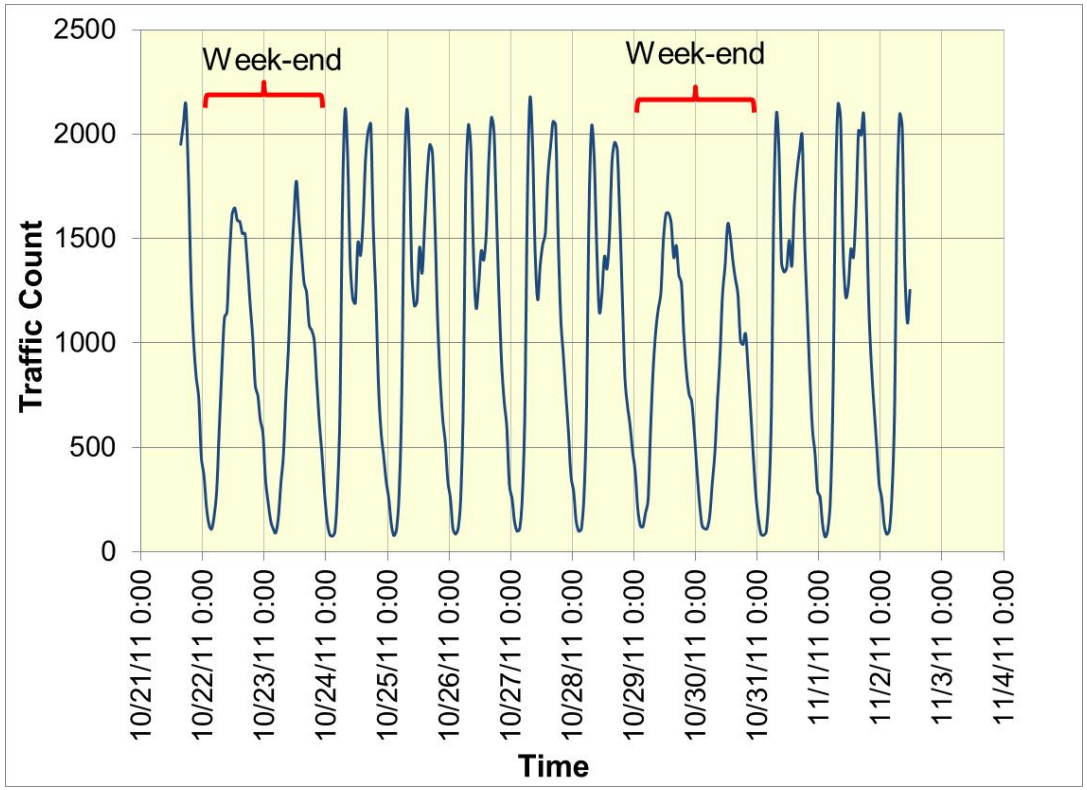
Day-Night Variation in Floor Vibration Level



- Week-end run- Integrated RMS displacement (Vertical) for 2-100 Hz, varies from 67 nm (noisy) to 13 nm (quiet)
- Week-day run-Integrated RMS displacement (vertical) for 2-100 Hz varies from 150 nm (noisy) to 15 nm (quiet)

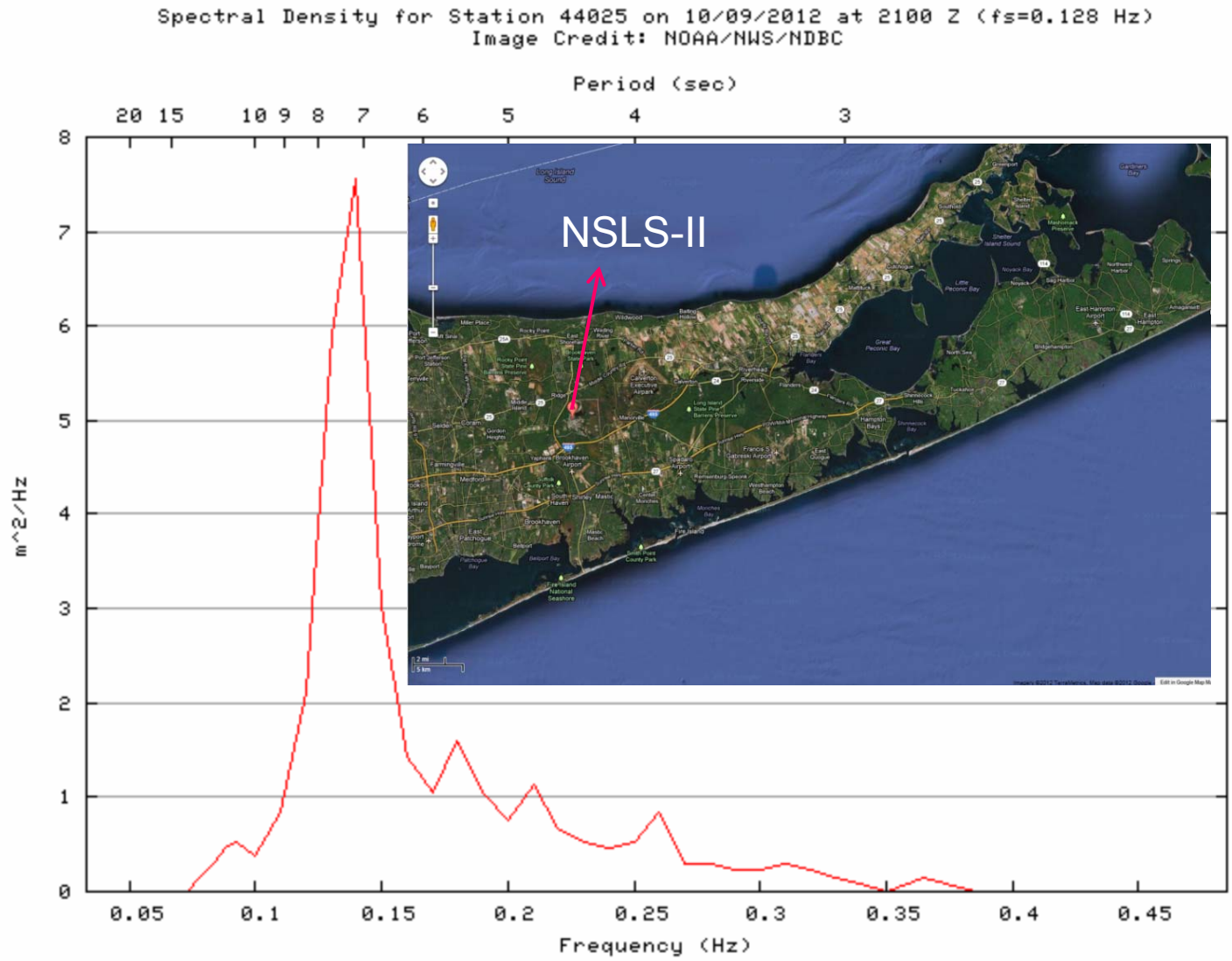
Low Frequency (above 2 Hz) Noise Source





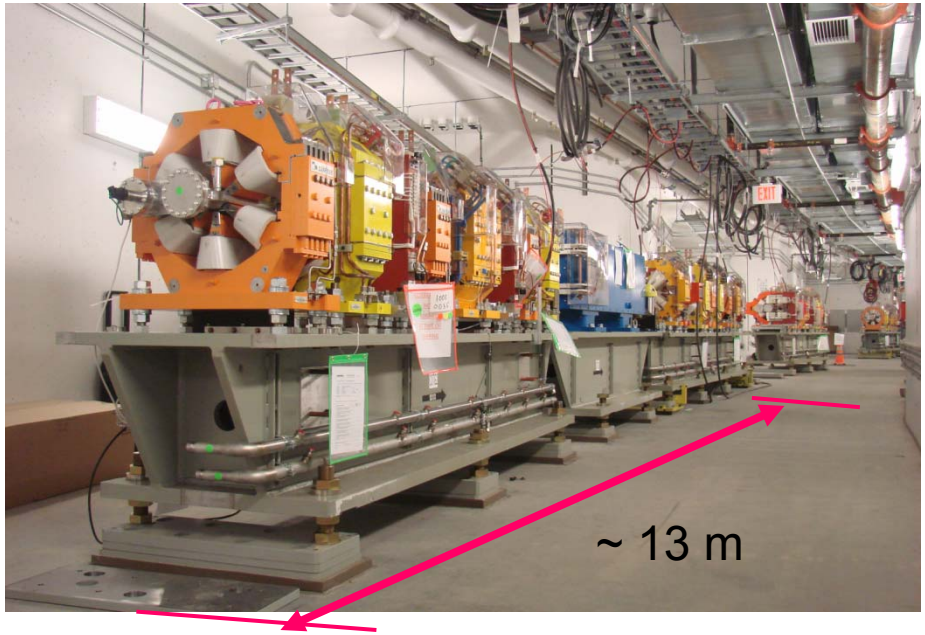
- Major Expressway I-495 at a distance of ~ 1.5 Km from NSLS-II site.
- The floor vibration above 2 Hz due to traffic

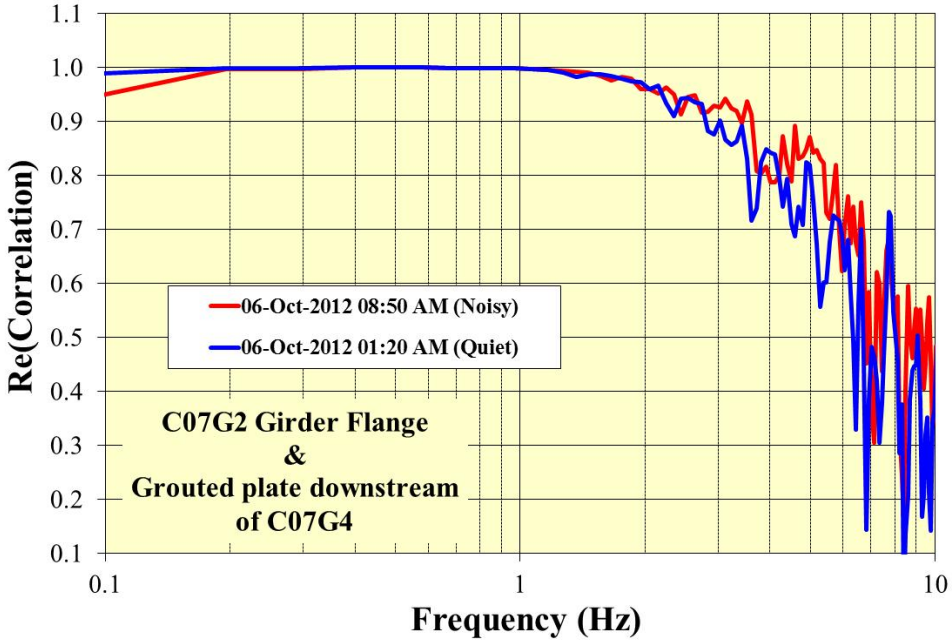
Low Frequency (below 1 Hz) Noise Source



- Distance between NSLS-II site and Ocean - 15 km away
- Ambient Vibration below 1 Hz probably due to ocean waves

Floor Motion Correlation





- Floor motion correlated up 4-5 Hz over a distance of ~ 13 m
- Preliminary data indicated good floor motion correlation below 2 Hz over a distance of 30 m (covering one cell length)
- Above 2 Hz, relative motion between magnet-magnet and girder-girder are within acceptable limits.

Conclusions

- The first natural frequency for the girder-magnet assembly: 30 Hz-Rocking Mode: magnets move in phase.
- The second natural frequency for the girder-magnet: 50 Hz-Twist mode: magnets move out of phase.
- Vibration amplification factor, from floor to girder/magnet in 2-100 Hz is approximately one.
- The contribution from 30-100 Hz (Natural frequencies) where the floor motion is 1 nm has negligible contribution.
- The relative vertical motion between the farthest magnet on a single girder is 8 nm for 2 Hz and above (Specification: 25 nm)
- The relative vertical motion between the farthest magnet on two separate girders is 28.8 nm for 2 Hz and above (Specification: 70 nm)