Vibration monitoring of buildings and structures using a remote sensing radar sensor

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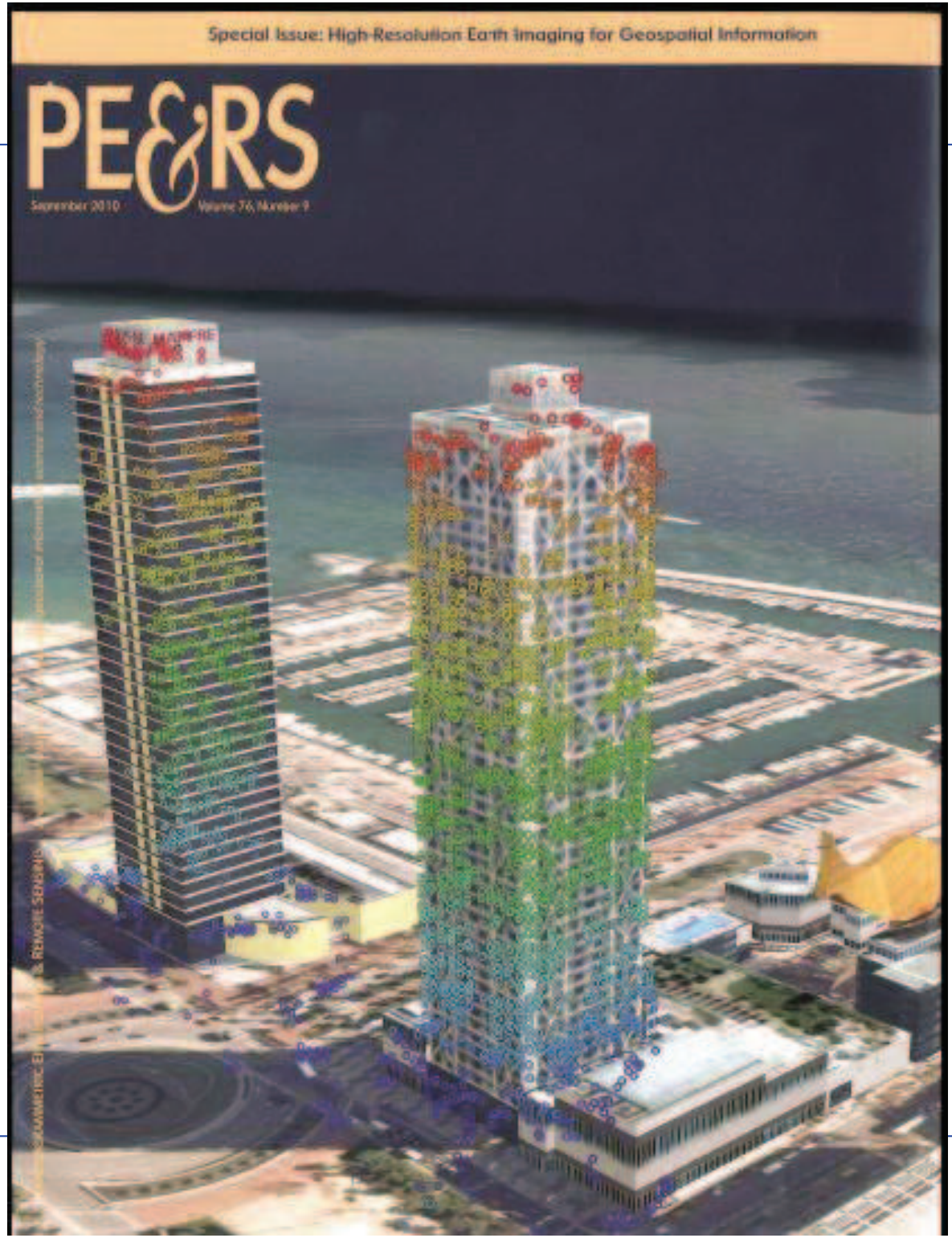
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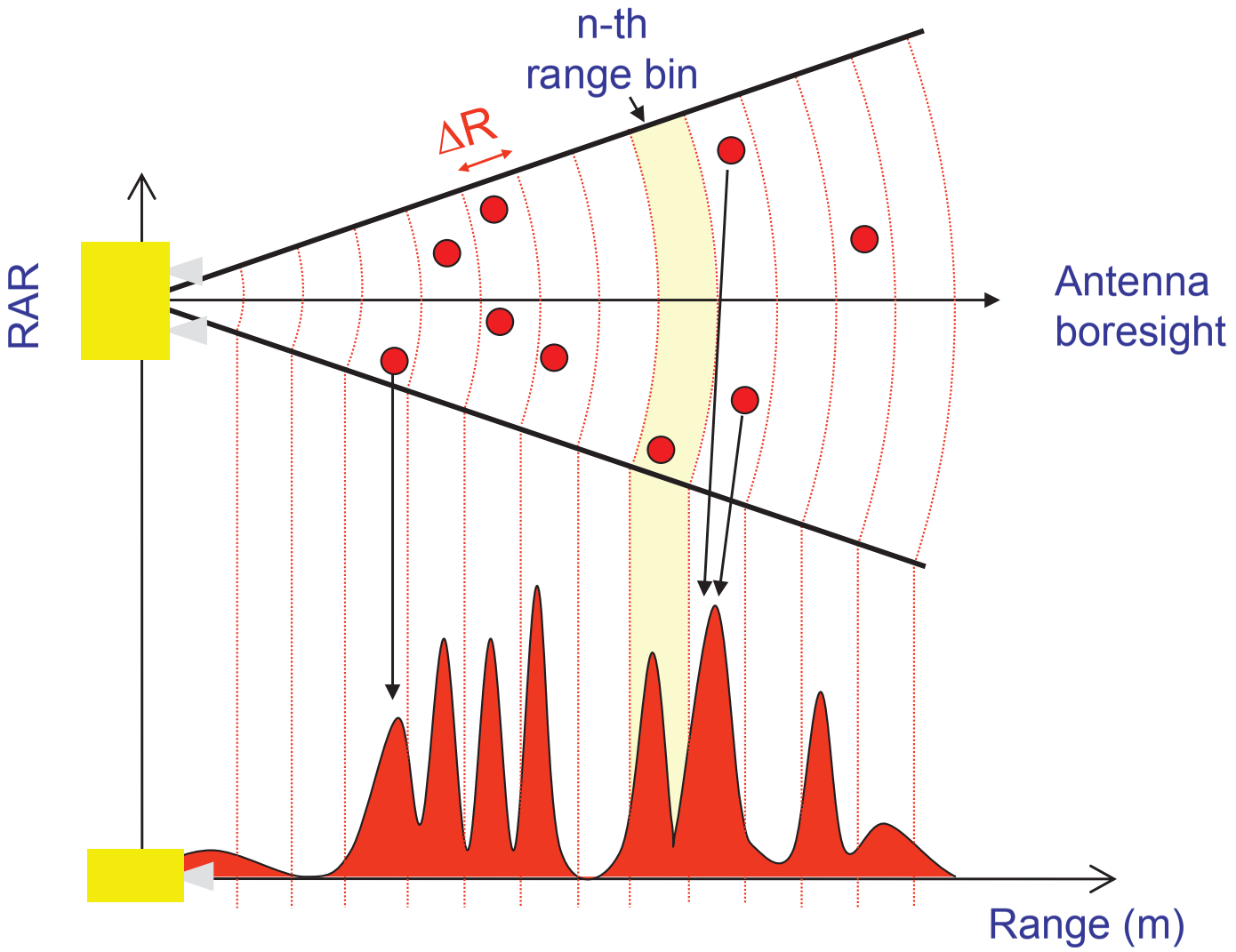
Real Aperture Radar (RAR): Basics

RAR geometry

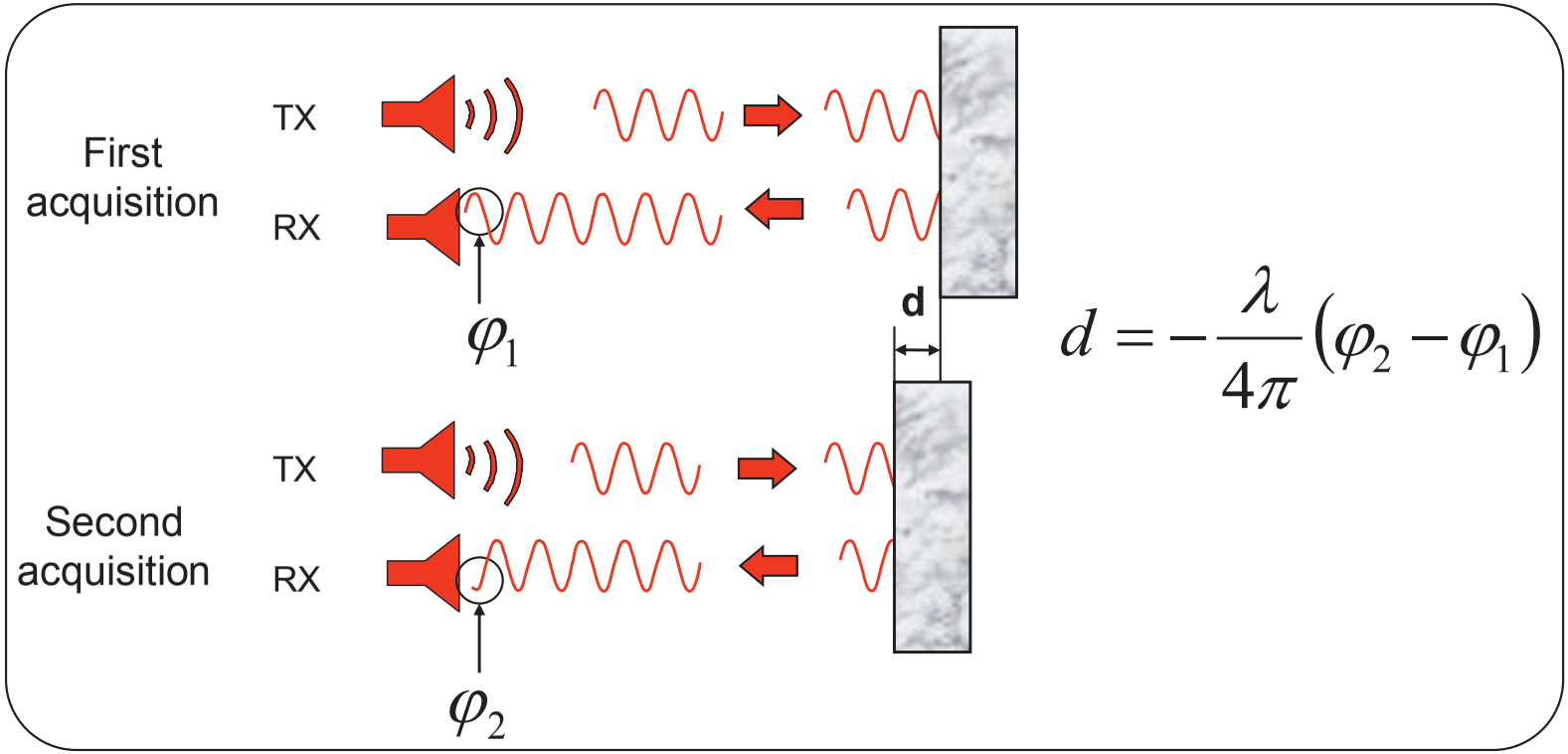


RAR system

Ibis-S – IDS Spa

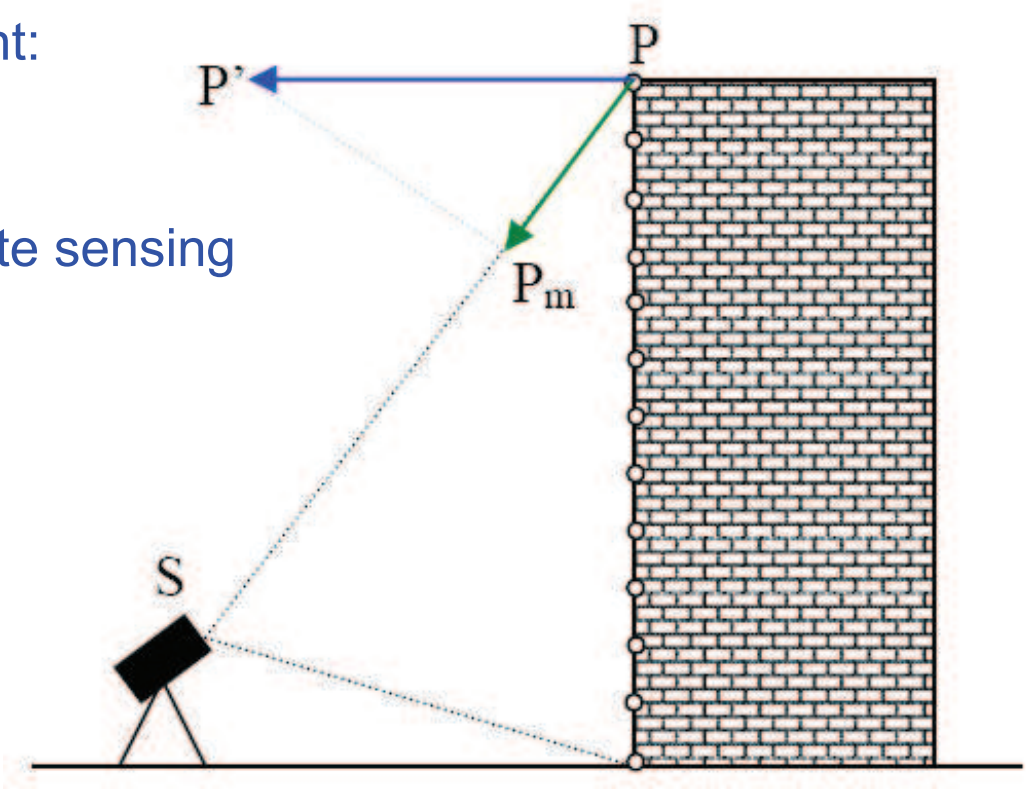
Measurement principle: interferometry

- We exploit the phase of the signal.
- We exploit the difference of phases measured in two or more acquisitions.



Key characteristics

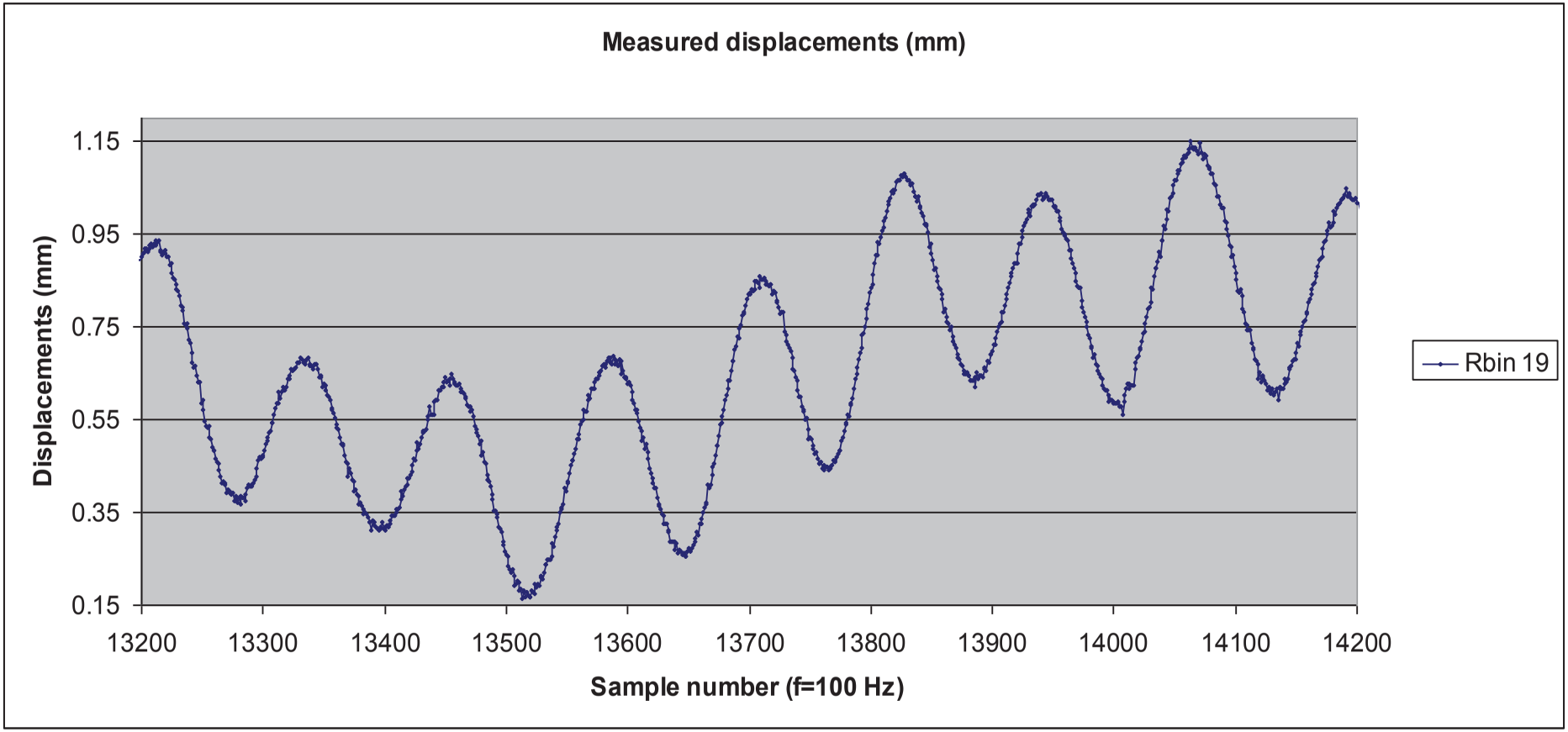
- High sensitivity to displacements.
- The sensitivity depends on the power of the target response, which depends on the target geometry/material, sensor-target distance, etc.
- The maximum acquisition rate (Ibis-S) is 200 Hz.
- We measure in the line-of-sight: $\overline{PP_m}$ instead of $\overline{PP'}$.
- Easy-to-deploy and fully remote sensing measurement



Real Aperture Radar: an example

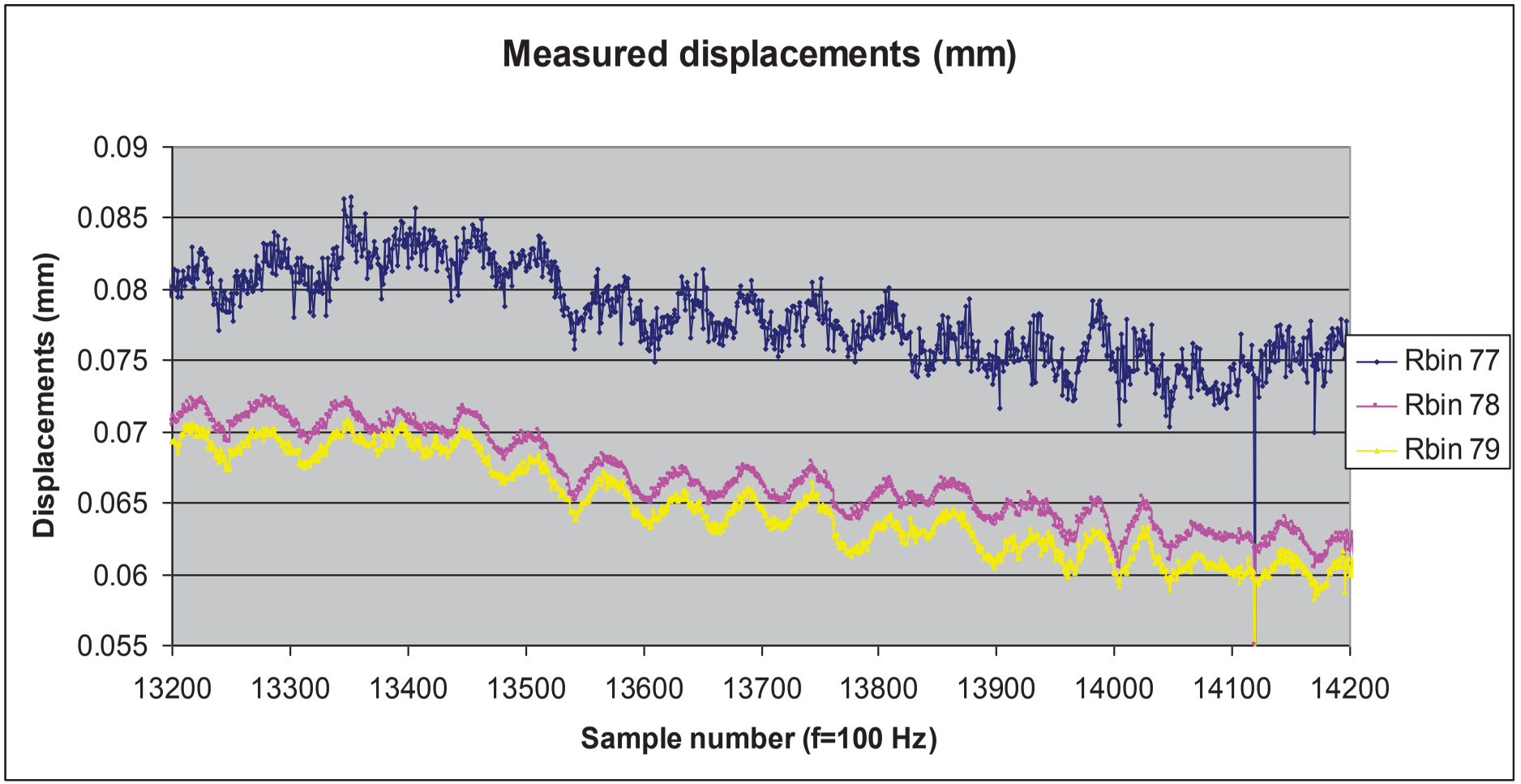
Example: building and light pole

Light pole



Point	Object	Distance LOS [m]	SNR [db]
19	Light pole	9	49.2

Building



Punt	Objecte	Distancia LOS [m]	SNR [db]
77	Façana	37.9	**62**
78	Façana	38.4	**78.4**
79	Façana	38.9	**75.4**

1st application: Collserola tower

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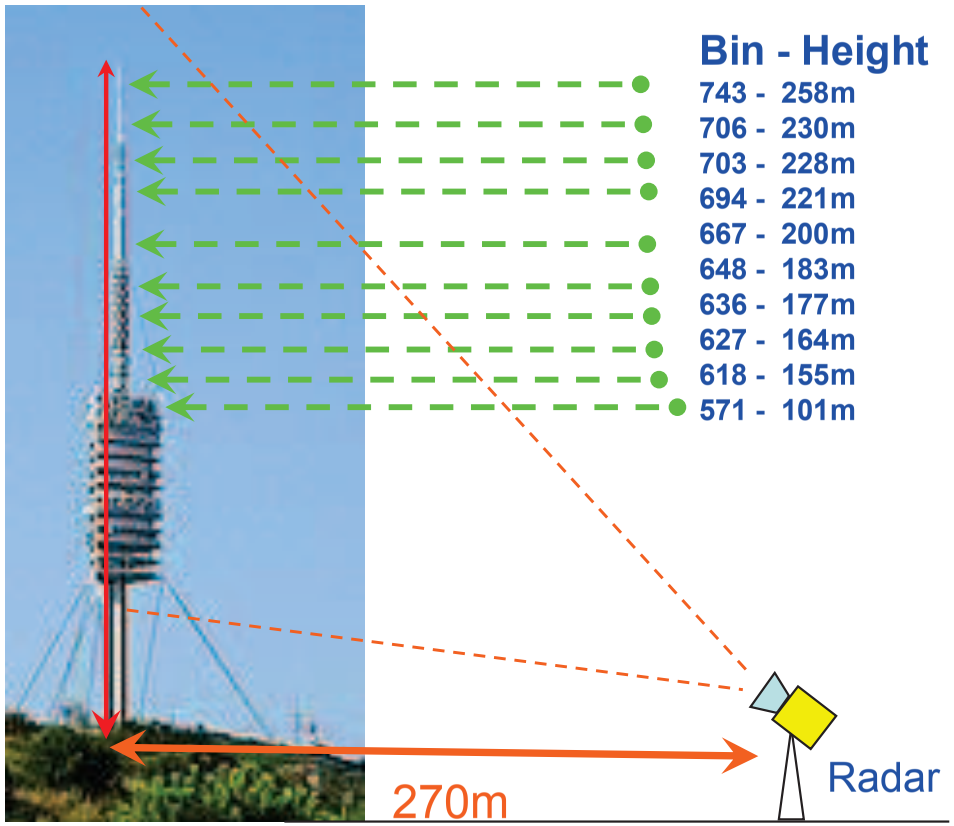
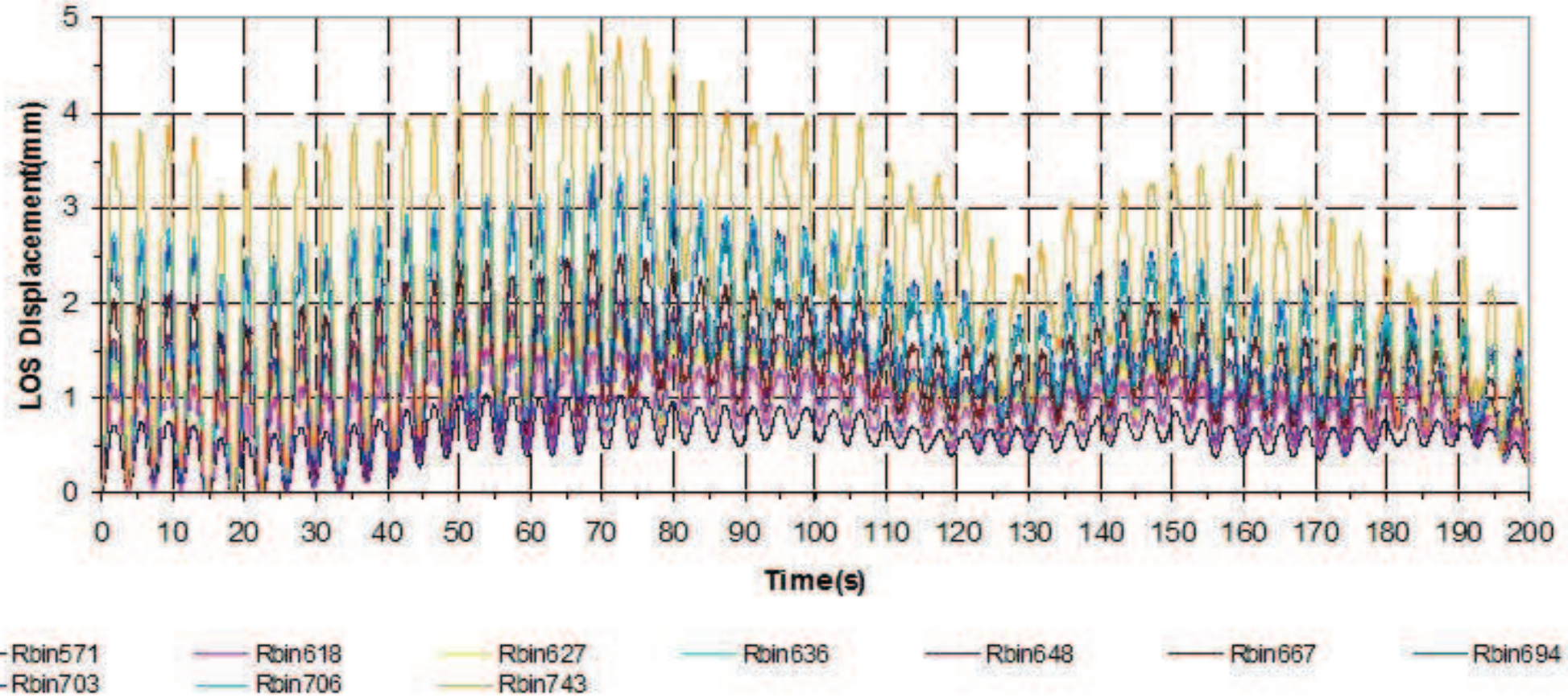
Measurement scheme

- Measurement scheme: the radar was located **270 m** far from the base of the structure observing the structure with an elevation angle of 22.5º.

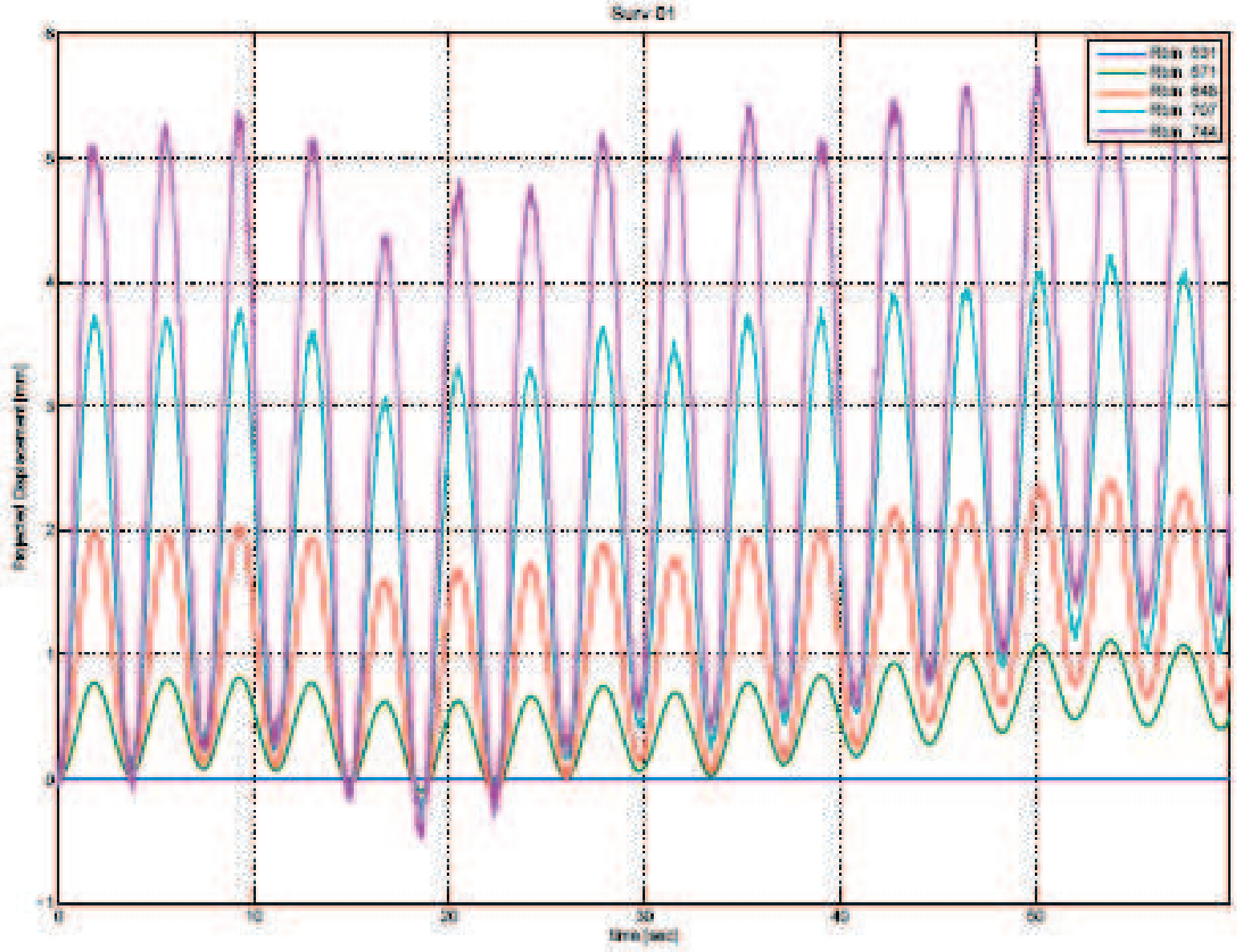


Displacement time series

- Displacement time series (along the line of sight - LOS) for different bins.
- Amplitude ranges from 100 μm to 4 mm.
- We observe a periodicity (T=approx. 3.77s) for all selected points.

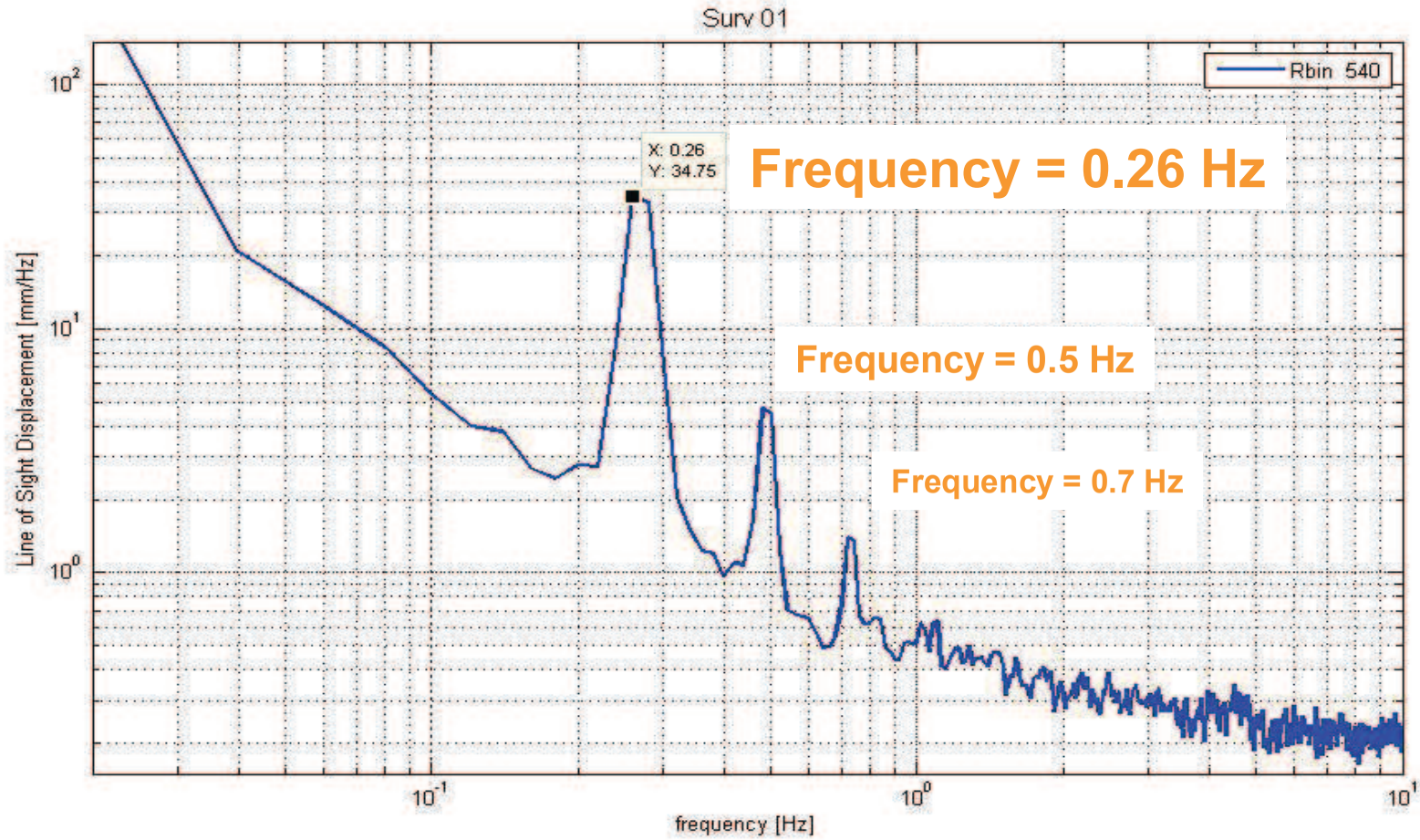


Displacement time series



Natural frequencies

❑ We observe the expected peak at 0.26Hz and some more peaks with a lower amplitude which could be ascribed to higher modes.



2nd application: Cables of the Collserola tower

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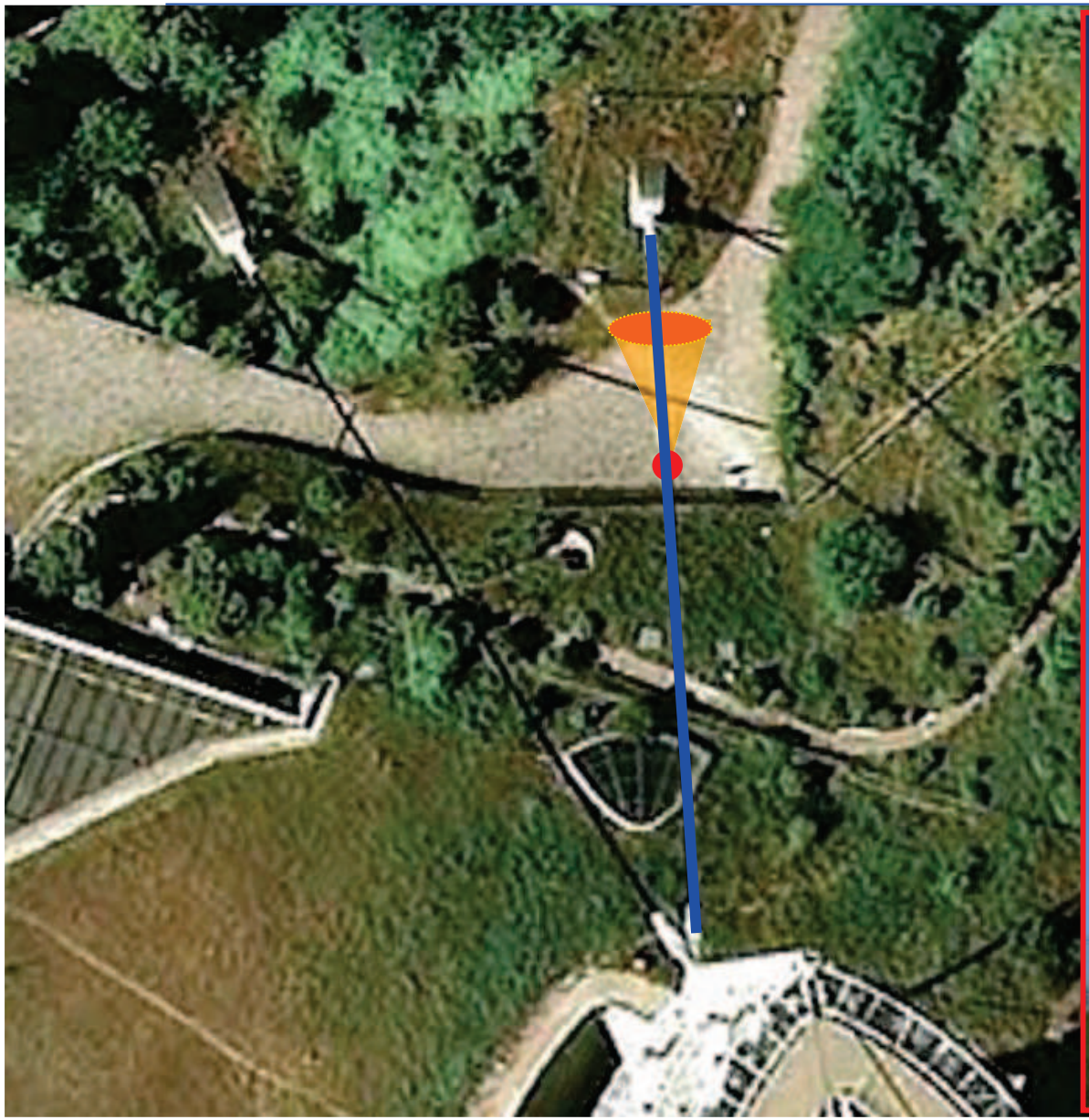
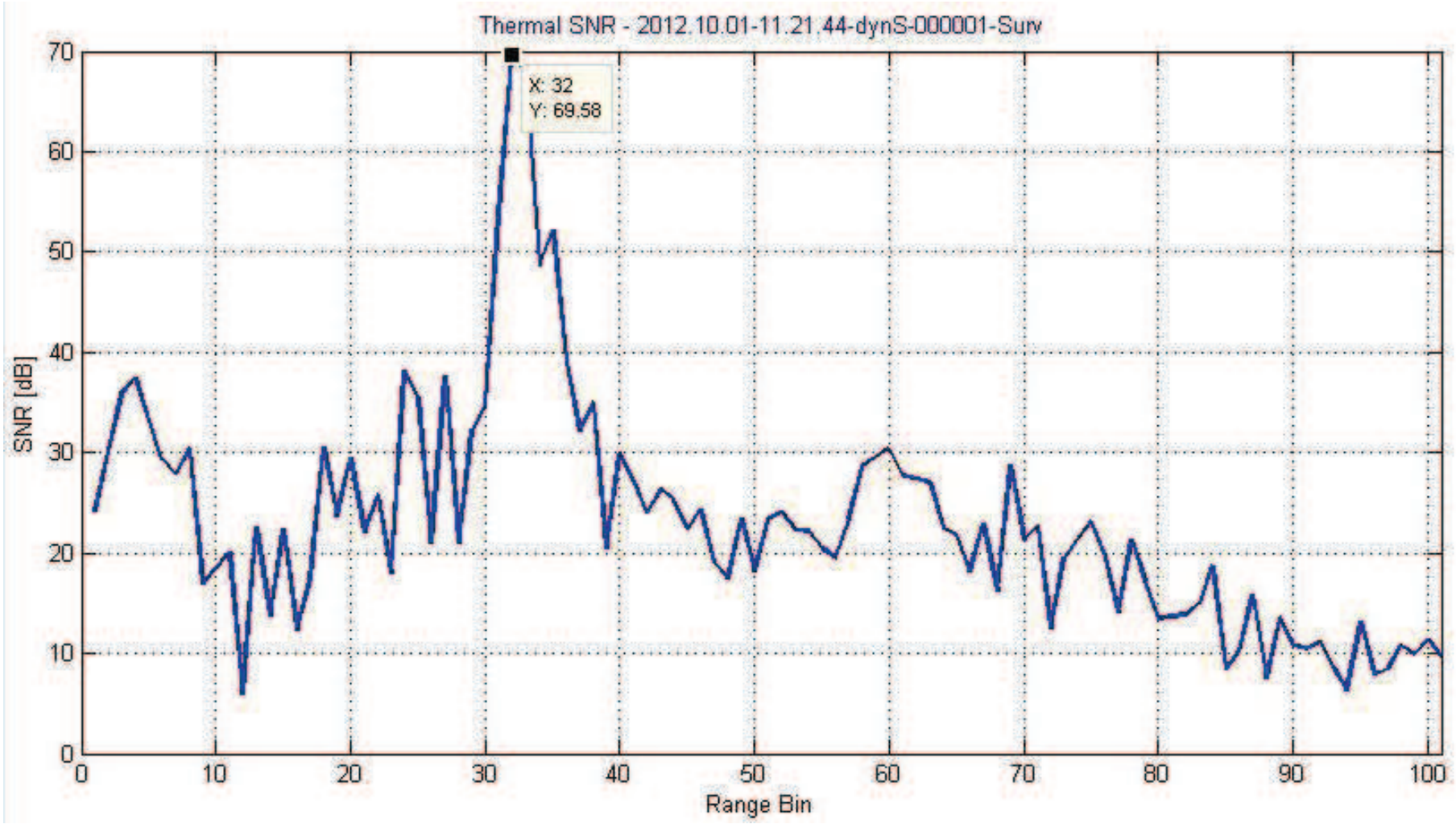
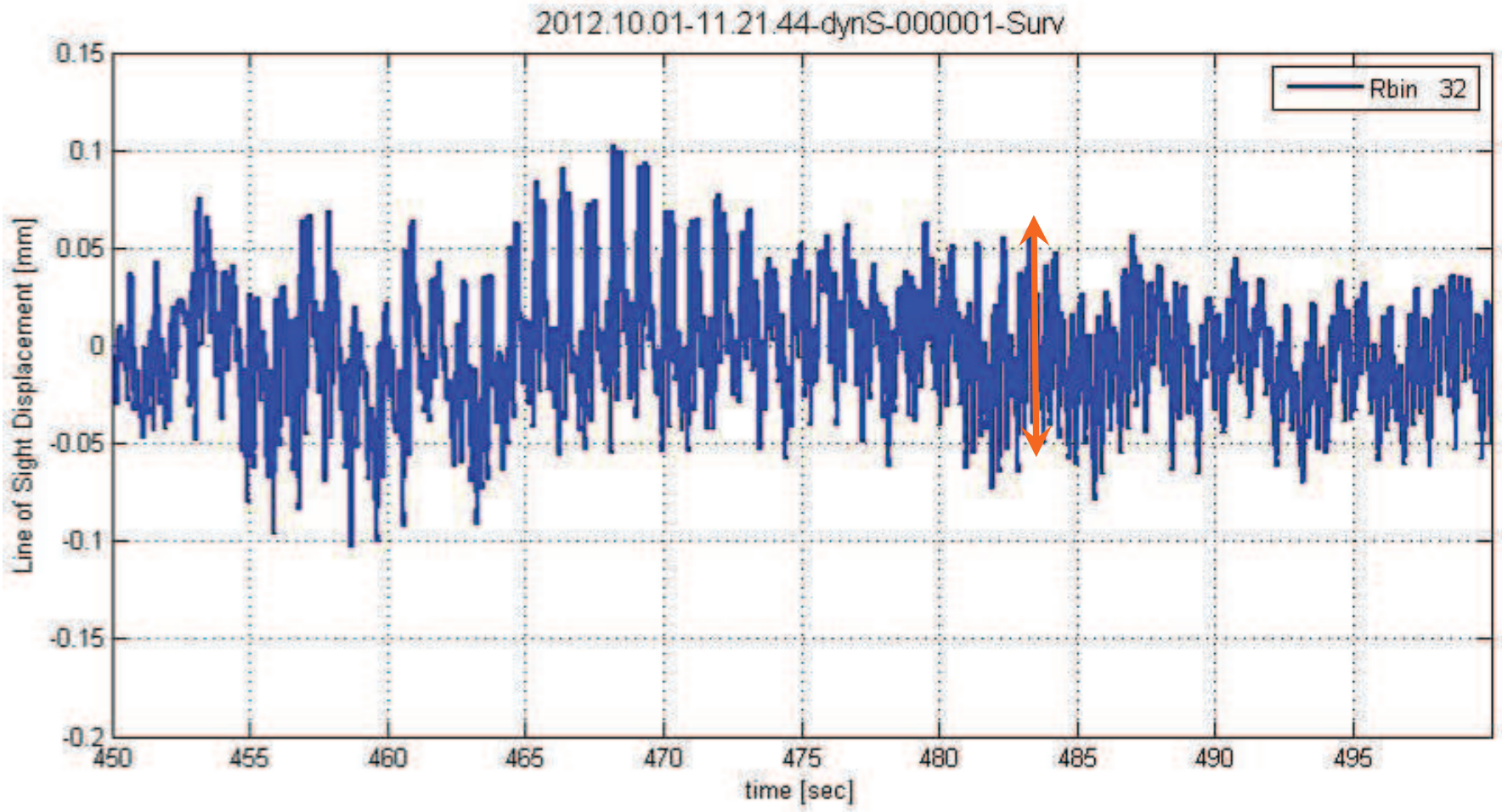
Measurement scheme



Target response - SNR

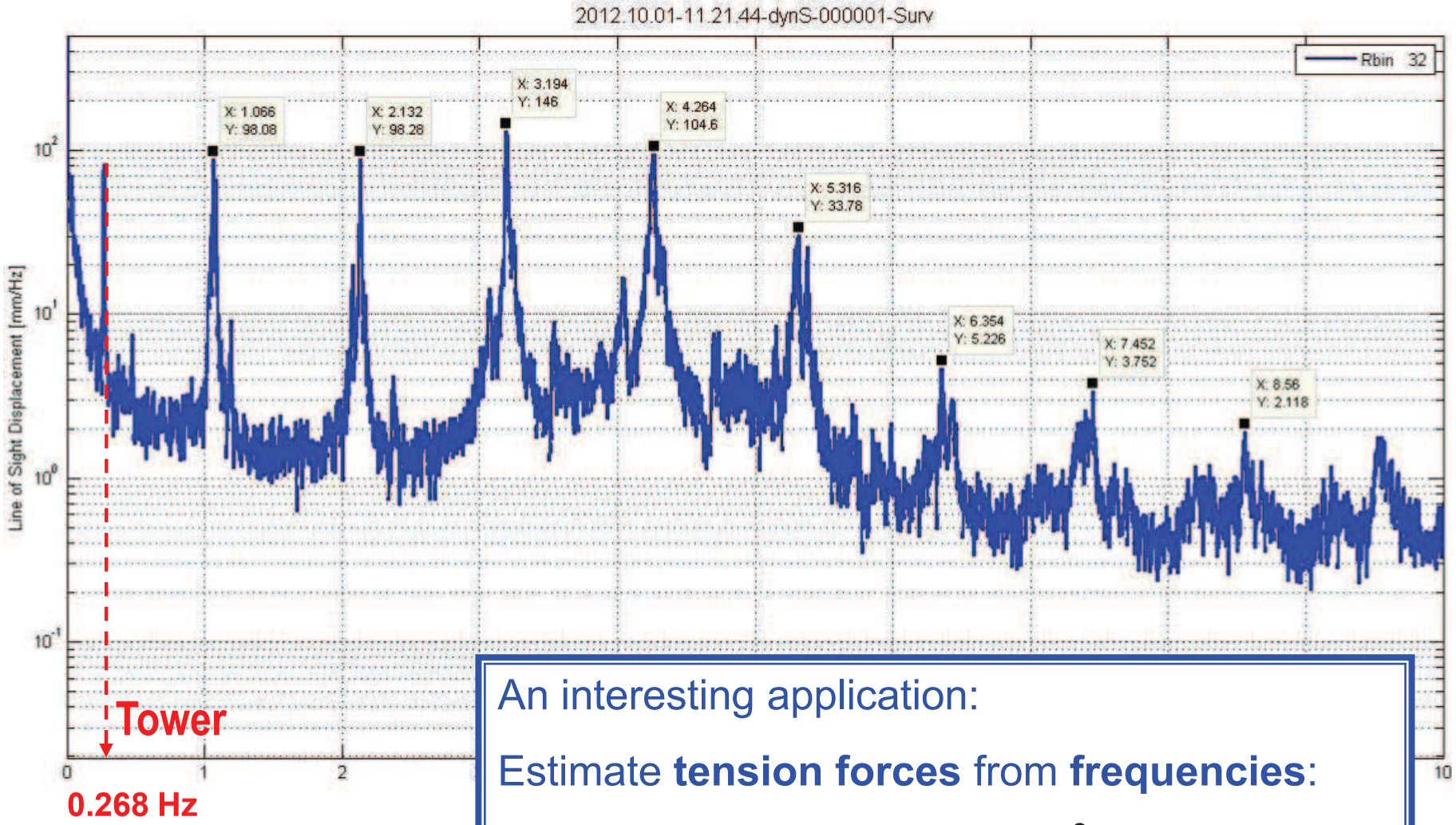


Displacement time series



Peak-to-peak amplitude, 100-130 μm.

Natural frequencies



Peaks in 0.268Hz, 1.0

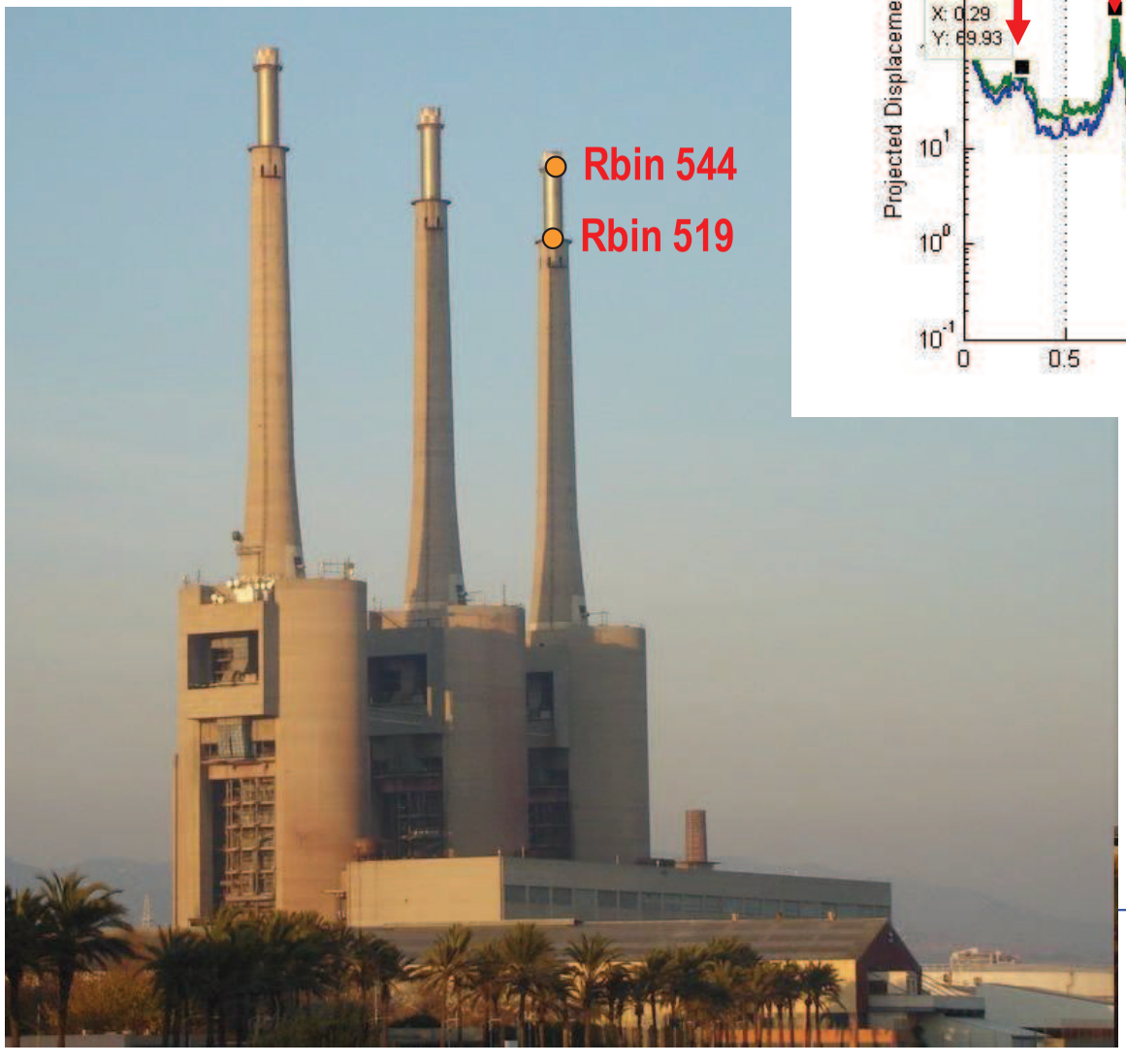
An interesting application:

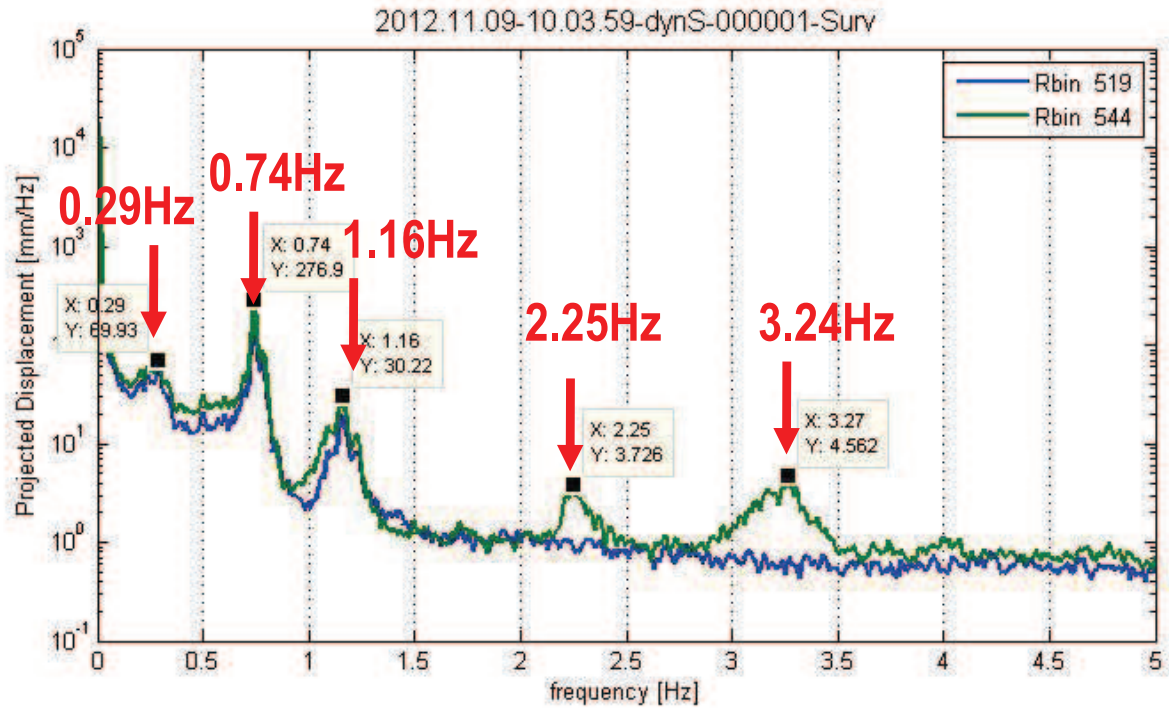
Estimate **tension forces** from **frequencies**:

$$T = 4\rho L^2 \left(\frac{f_n}{n} \right)^2$$

3rd application:
Sant Adrià chimneys

Sant Adrià


Rbin 544
Rbin 519


2012.11.09-10.03.59-dynS-000001-Surv
Rbin 519
Rbin 544
0.29Hz
0.74Hz
1.16Hz
2.25Hz
3.24Hz
X: 0.29
Y: 69.93
X: 0.74
Y: 276.9
X: 1.16
Y: 30.22
X: 2.25
Y: 3.726
X: 3.27
Y: 4.562
Projected Displacement [mm/Hz]
frequency [Hz]

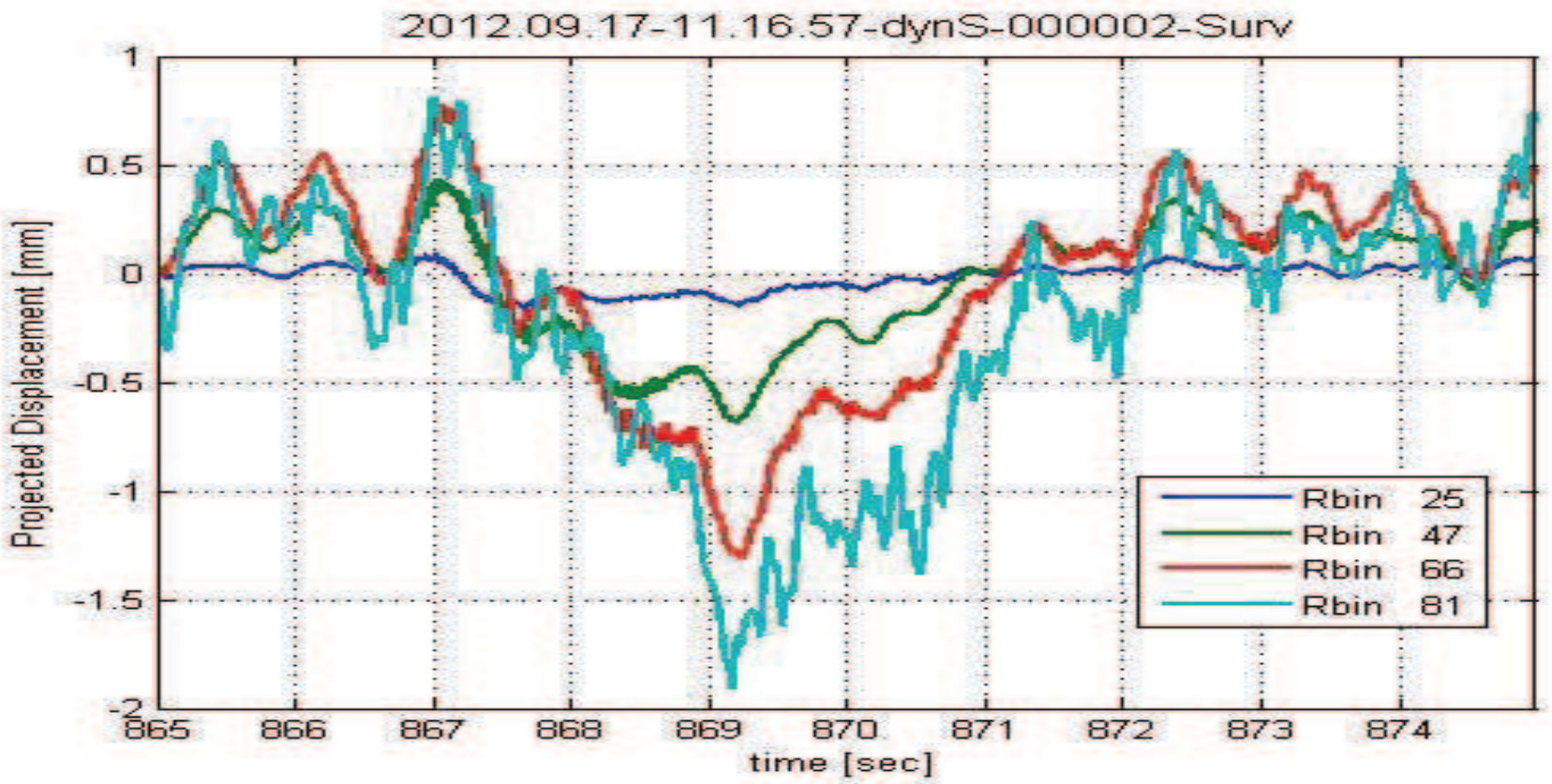
4th application: Amposta bridge

RAR installation

The RAR was installed 7 m below the bridge with an inclination angle of 12.5º.

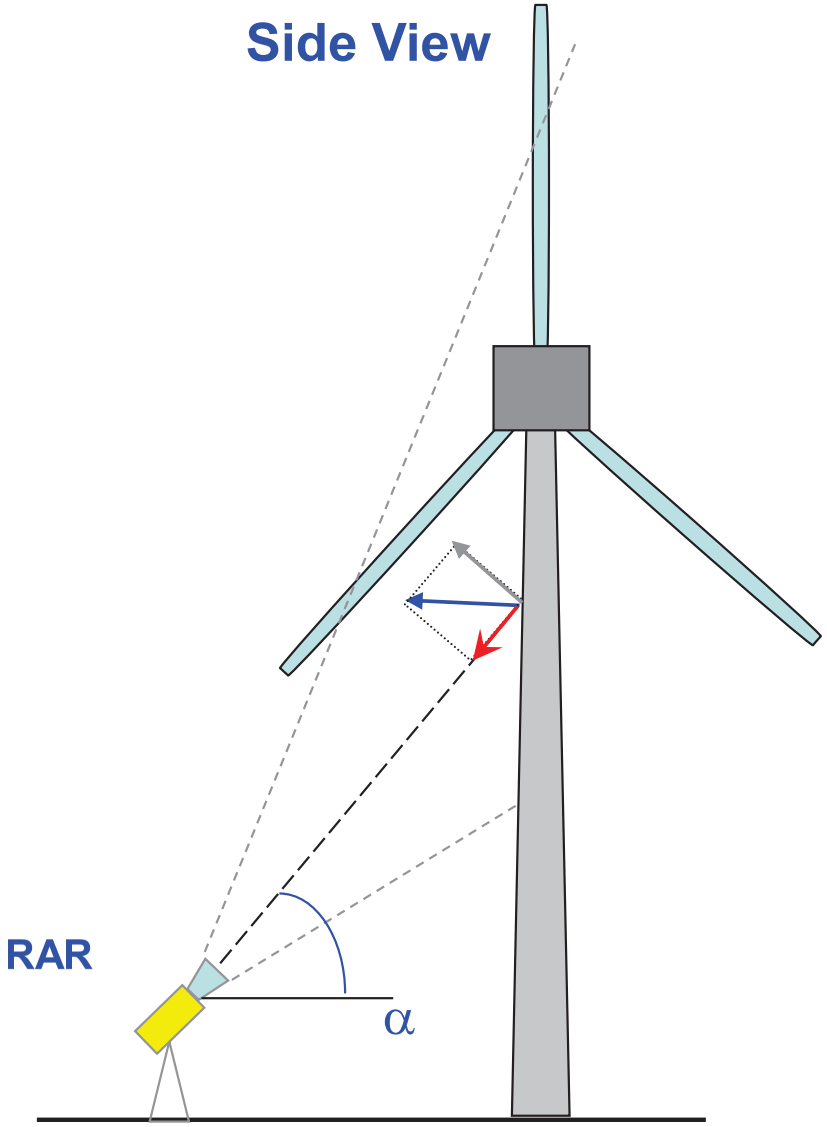
Displacement time series

- Projected displacements produced by a car crossing the bridge between t=867s and t=871s.

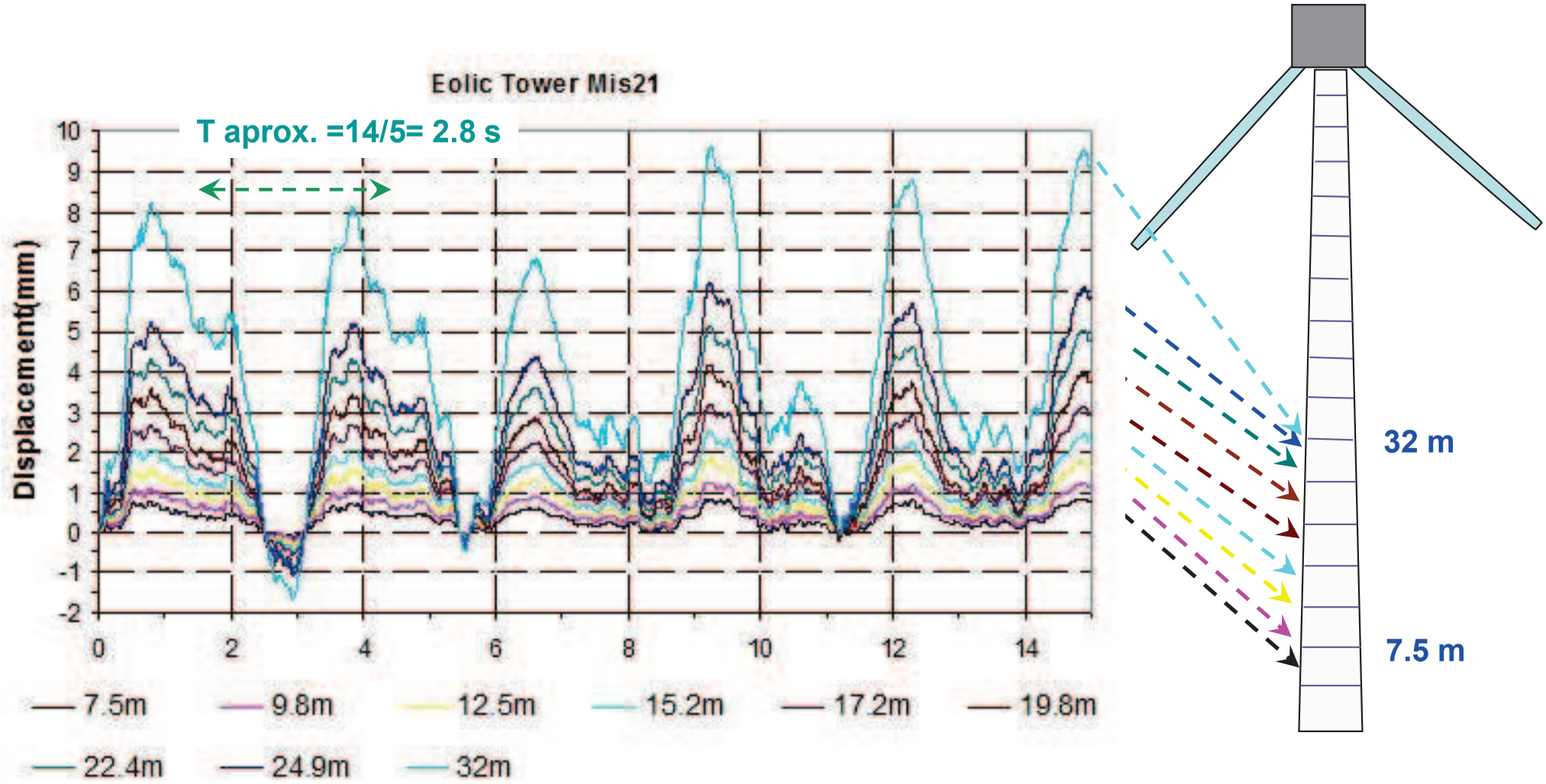


5th application: Wind turbine

RAR installation

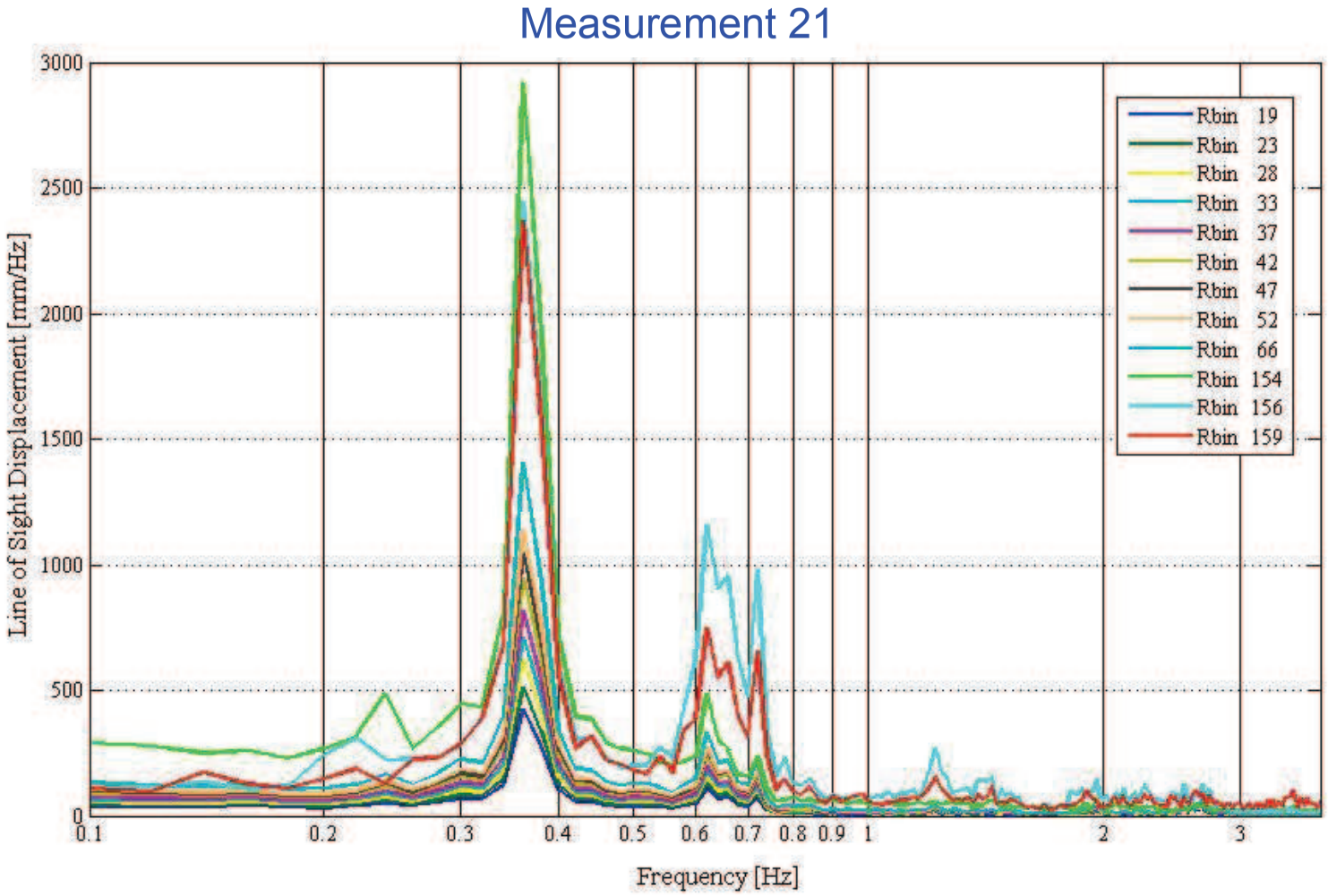


Displacement time series



Natural frequencies

- Main frequency components are at 0.36 Hz and within 0.6-0.72 Hz.



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