

Workshop on Accelerator R&D
for Ultimate Storage Rings
Huairou. BEIJING
31-Oct-2012



Ground Vibration for BAPS

Daheng Ji
IHEP



Outline

- Introduction
- Instrumentation
- Geographical environment
- Ground vibration inside circle
- Ground vibration outside circle
- Summary





Outline

- Introduction
- Instrumentation
- Geographical environment
- Ground vibration
- Vibration sources identification
- Summary





Introduction

■ Beijing Advanced Photon Source(BAPS)

- Designed as a USR
- Electron emittance smaller than 100 pm-rad.

■ Beam stability requirement

- $\Delta\text{RMS}_{\text{beam}} < 10\%$ beam size.
- Amplification factor from quadrupole displacement.

Low ($f < 1\text{Hz}$)

Ocean waves,
micro seismic activities

Intermediate ($1 < f < 100\text{Hz}$)

Traffics, machine operations,
water flow, wind,...

High ($f > 100\text{ Hz}$)

Generated by small electro-
mechanical structure Vibro-
acoustic



Outline

- Introduction
- **Instrumentation**
- Geographical environment
- Ground vibration inside circle
- Ground vibration outside circle
- Summary



Instrumentation

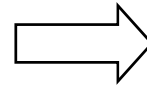


- **Vibrometers: 3 by 941B vibration pickup;**
- **Data Acquisition: INV3060A,**
 - Sampling frequency: 204.8KHz,
 - 24 bit AD,
 - 16 channels,
 - 120dB;
- **Geophones: CMG-6TD,**
 - Sampling frequency: 500Hz.



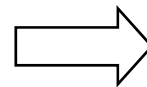
Measurement Indicators

RMS of Displacement



Characterization of the vibration amplitude and changes

Power Spectral Density (PSD)



Describes how the power is distributed with frequency.

$$\bar{x}(f) = \sqrt{\frac{1}{N\Delta t} \sum_{f_k}^{f_{max}} S_x(f_k)}$$

$$S_x(f_k) = \frac{1}{4\pi f^2} S_v(f_k) = \frac{N\Delta t^3}{2\pi^2 k^2} \left| \sum_{n=1}^N v(n) e^{-i2\pi kn/N} \right|^2$$





Outline

- Introduction
- Instrumentation
- **Geographical environment**
- Ground vibration inside circle
- Ground vibration outside circle
- Summary

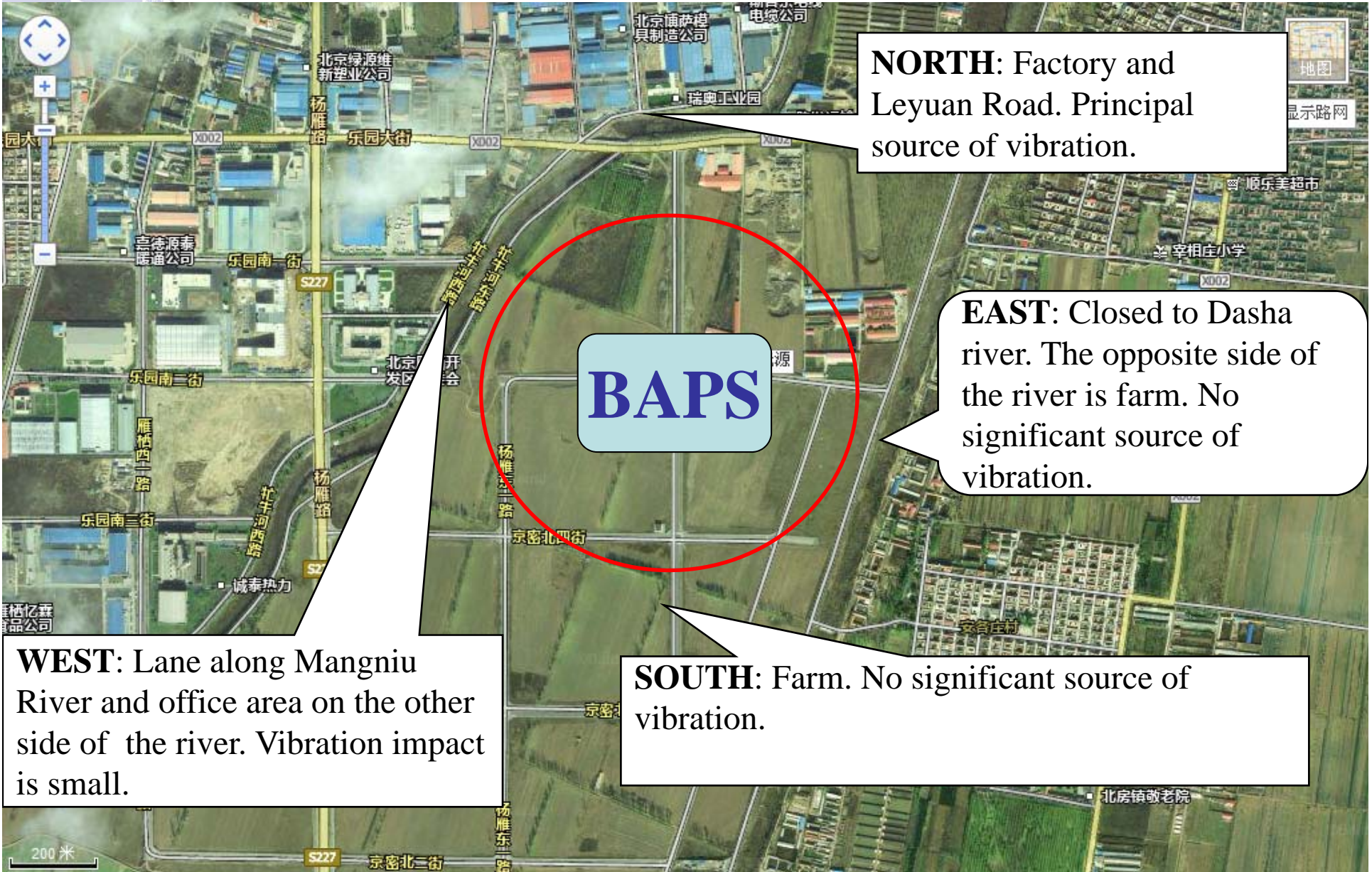


Here we are.

BAPS

IHEP





NORTH: Factory and Leyuan Road. Principal source of vibration.

EAST: Closed to Dasha river. The opposite side of the river is farm. No significant source of vibration.

BAPS

SOUTH: Farm. No significant source of vibration.

WEST: Lane along Mangniu River and office area on the other side of the river. Vibration impact is small.

200 米



Position of Monitoring Point

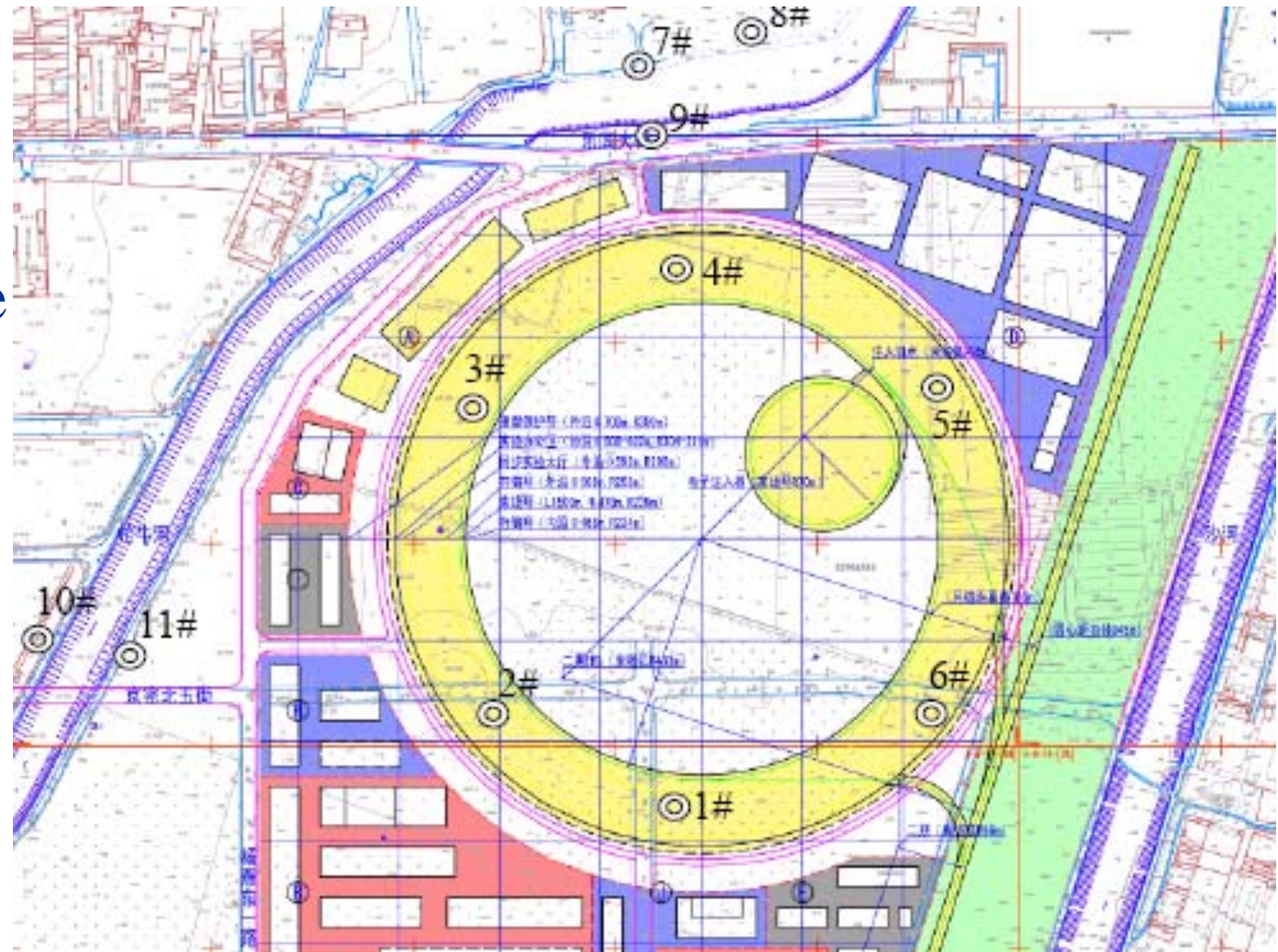
11 points

■ 6 in circle.

● 24 hrs each.

■ 5 outside circle

● 1 hr each.

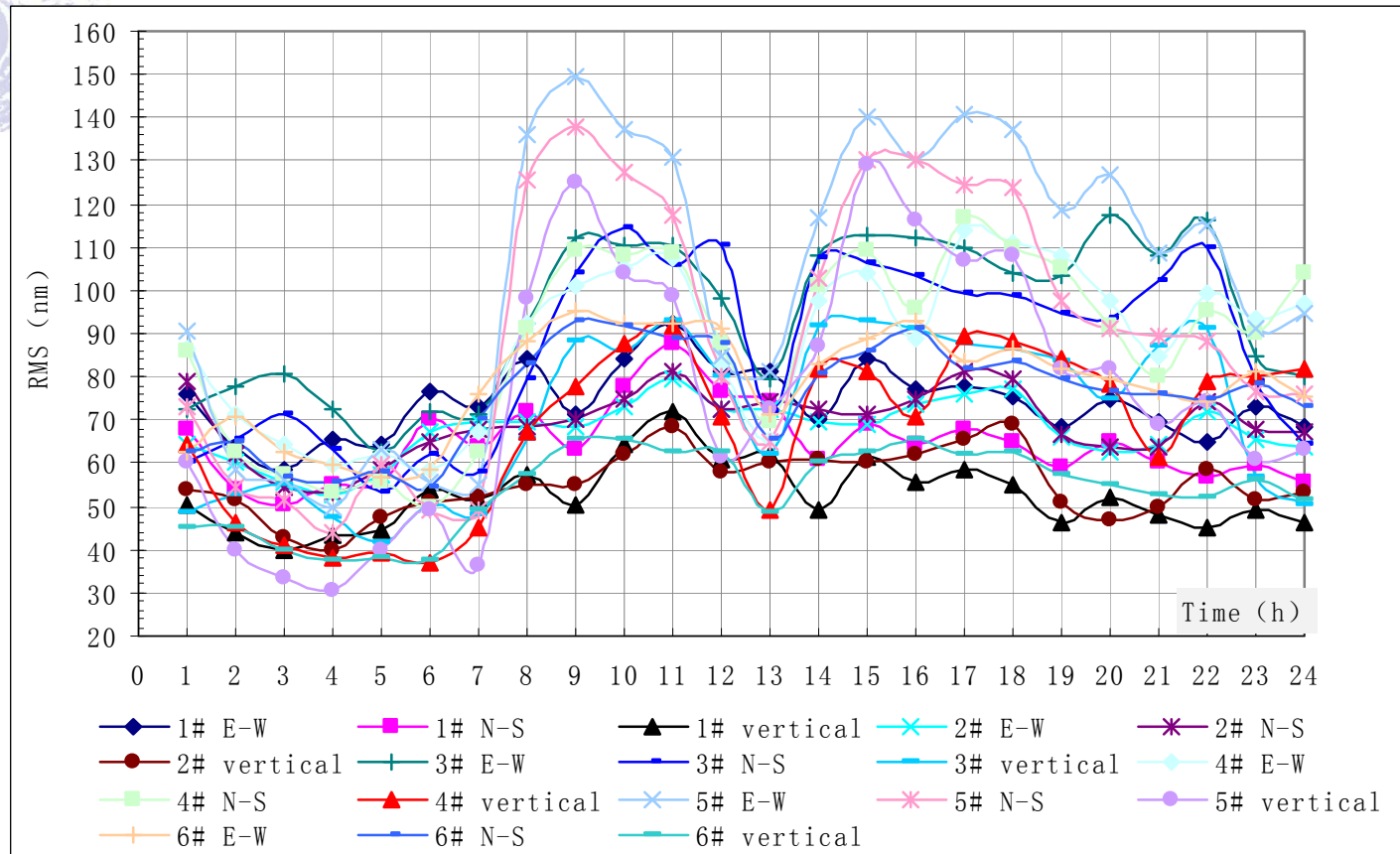
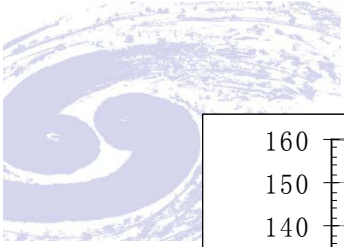




Outline

- Introduction
- Instrumentation
- Geographical environment
- **Ground vibration inside circle**
- Ground vibration outside circle
- Summary





Quiet period : 23:00~7:00 and 12:30~13:30

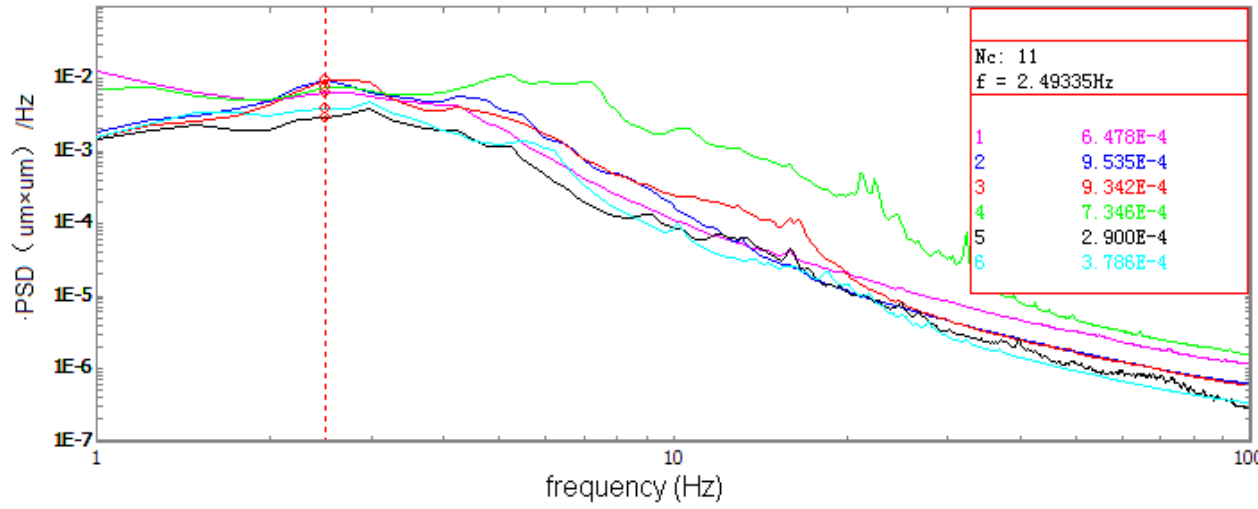
Noise period: 8:00~22:00 (except for noon)

RMS of Displacement (nm)

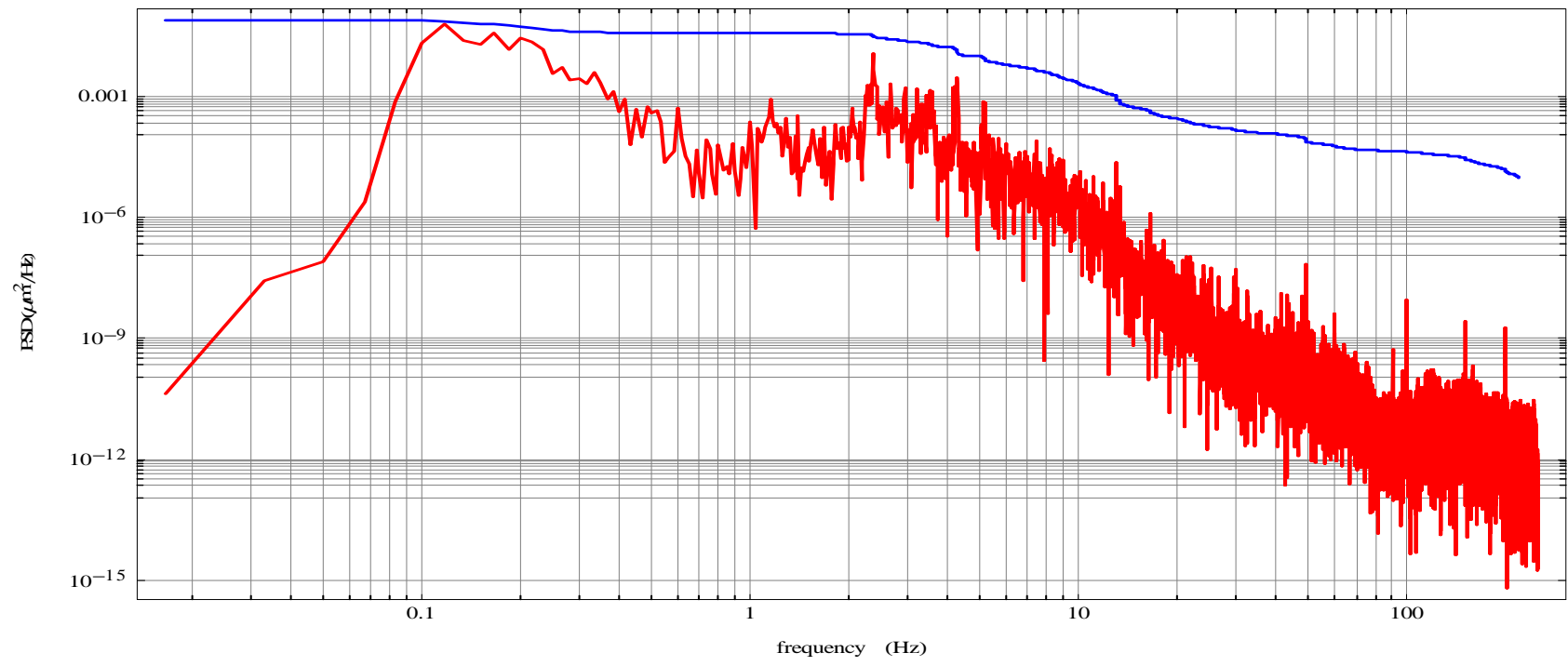
		horizontal	verticality
Noise period	Min	57.00	44.82
	Max	117.13	92.79
Quiet period	Min	50.29	30.70
	Max	84.49	82.00

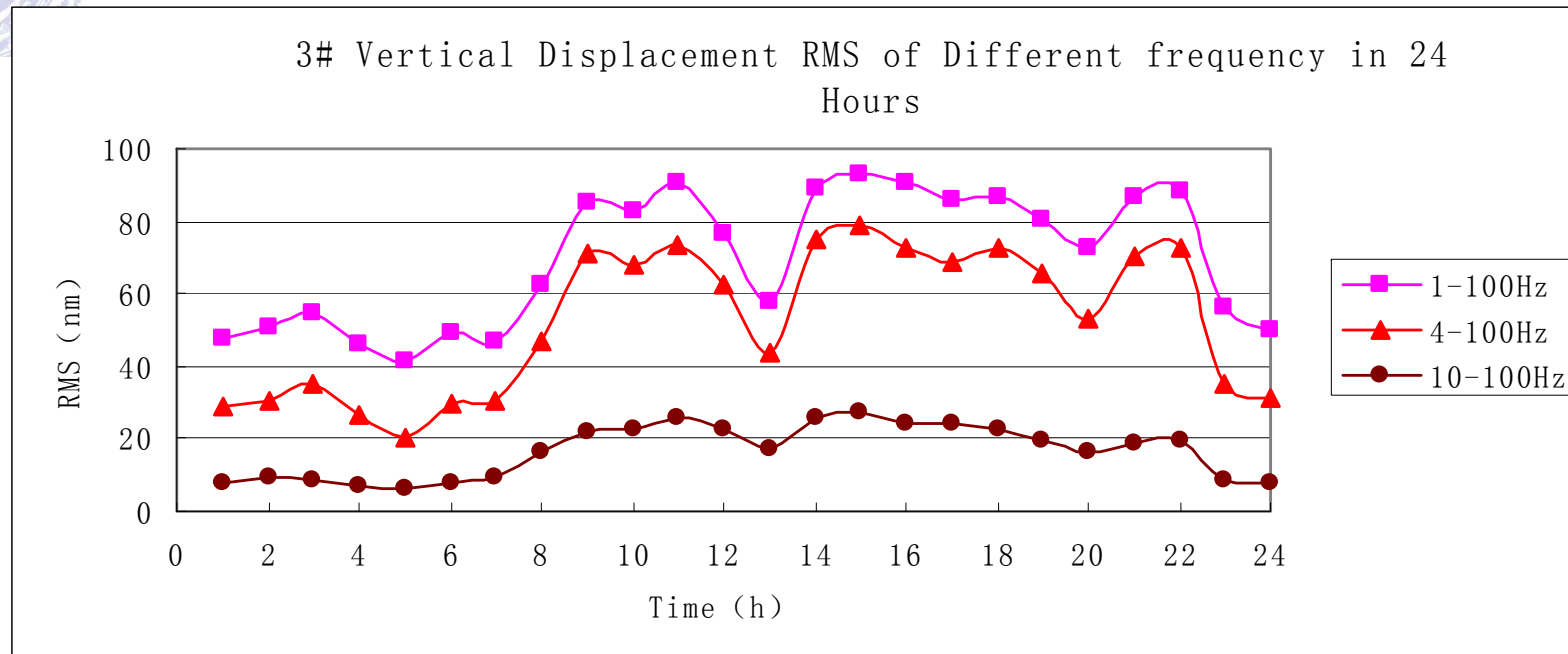
Average RMS of Vertical Vibration Amplitude at Different Position and Time(nm)

Pos.	Noise period	Quiet period	24 hr
1#	55.37	48.46	52.49
2#	58.63	50.39	55.2
3#	85.67	51.25	71.33
4#	79.24	52.21	67.98
5#	95.83	47.44	75.67
6#	60.31	44.77	53.84
Average	67.84	49.09	62.75
Standard deviation	13.65	2.75	10.10
Coefficient of Variance	0.20	0.06	0.16



Frequency Peak:
 2.4Hz, 4.3Hz, 5Hz,
 13Hz, 50Hz, 100Hz;
 Natural frequency:
 2.4Hz





The RMS difference between quiet period and noise period in 1~100Hz and 4~100Hz are both more obvious than that in 10~100Hz. That means the vibration at 1~10Hz is most contributed by human activities, and vibration at 1~10Hz is the major component of low frequency vibration.

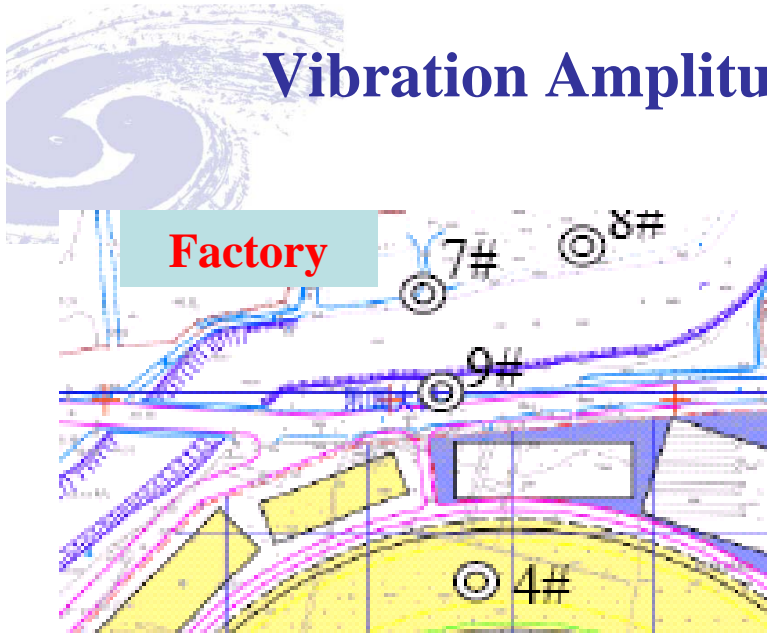


Outline

- Introduction
- Instrumentation
- Geographical environment
- Ground vibration inside circle
- **Ground vibration outside circle**
- Summary



Vibration Amplitude Outside Circle Analysis Result (1)



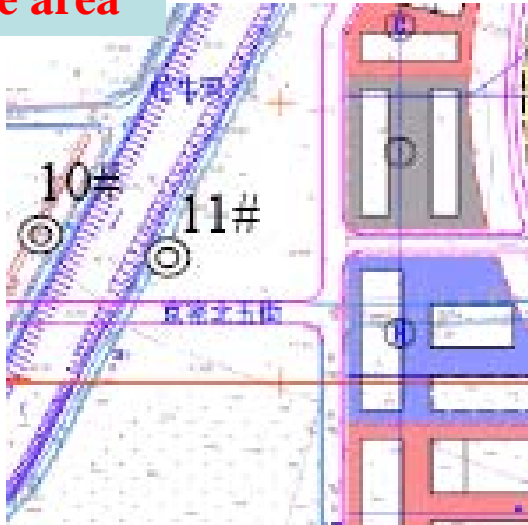
No.	Vibration Amplitude RMS (nm)		
	East-West	North-South	Vertical
7#	231.64	133.45	156.66
8#	121.93	115.14	104.88
9#	109.26	92.86	99.71

Vibration amplitude at 7# is bigger than others because it is closer to the factory. Amplitude at 9# is smaller than that at 8#, although 9# is closer to factory than 8#. That's because the river decay the vibration from factory.

9# is at the north of Leyuan Road. So the vibration is also affected by traffics.

Vibration Amplitude Outside Circle Analysis Result (2)

Office area



No.	Vibration Amplitude RMS (nm)		
	East-West	North-South	Vertical
10#	94.18	81.55	86.69
11#	98.75	72.02	69.93

10# and 11# are in the opposite side of the river in east to west direction. Vibration amplitude at 10# and 11# are similar at this direction. But the vibration at North-South and Vertical direction of 11# is smaller than 10#.

It also confirms that the river could decay the vibration obviously.



Outline

- Introduction
- Instrumentation
- Geographical environment
- Ground vibration inside circle
- Ground vibration outside circle
- **Summary**





Summary

- Quiet period : 23:00~7:00 and 12:30~13:30;
Noise period : 8:00~22:00(except for noon).
- The horizontal vibration is bigger than vertical vibration in circle.

RMS of Displacement (nm)			
		horizontal	verticality
Noise period	Min	57.00	44.82
	Max	117.13	92.79
Quiet period	Min	50.29	30.70
	Max	84.49	82.00

- Leyuan Road is the major vibration source inside circle. The vibrations during quiet period inside circle are similar. But at noise period, vibration at 3#、4#、5# point are bigger than that at 1#、2#、6#.
- The peak of PSD is at 2.4Hz. And the vibration between 1Hz and 10Hz offer most contribution.
- Mangniu River and Shahe river could decay the vibration obviously.



Thanks for your attention!

