

Measurement of beam oscillation and magnet vibration for the SPrin Storage Ring

SPring-8

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Background and Objective

- n For low emittance synchrotron radiation source, emittance growth due to vibrations that lead to brightness decrease is a serious problem

Therefore the objective is

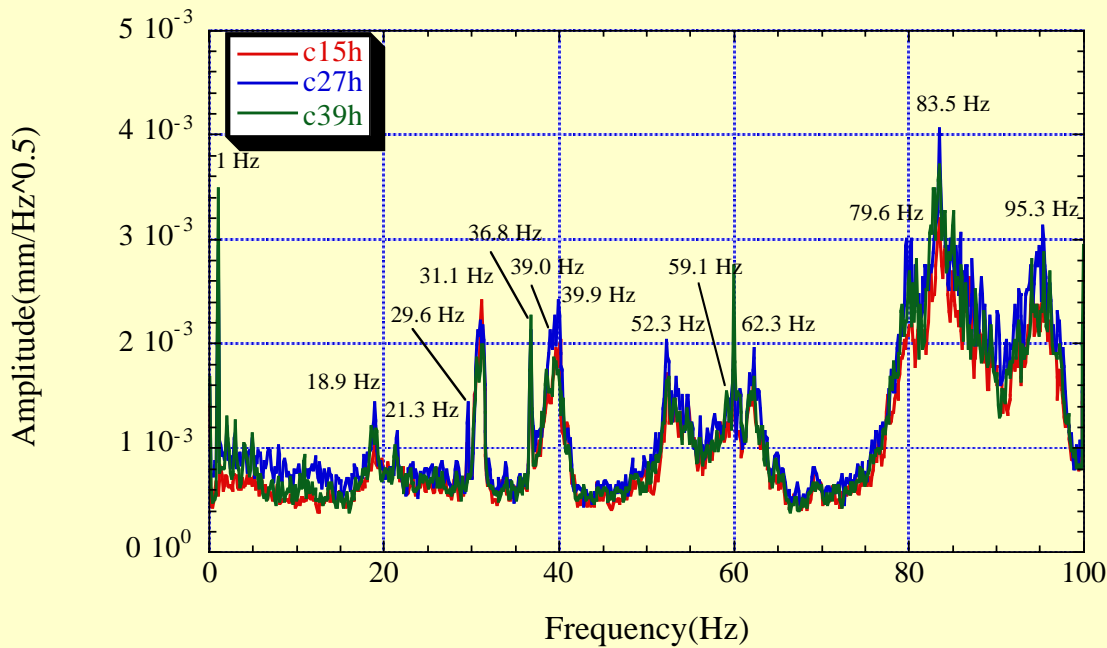
- n To measure the beam oscillation and
- n To clarify the source of beam oscillation.

For 10~100 Hz;

- * Measured magnet, girder and floor vibration and magnet and girder.

- * Effect of cooling water was investigated.
- * Source of beam oscillation was clarified.
- * Suppression method is discussed.

Horizontal Oscillation Spectrum of Electron Beam



Effective emittance growth

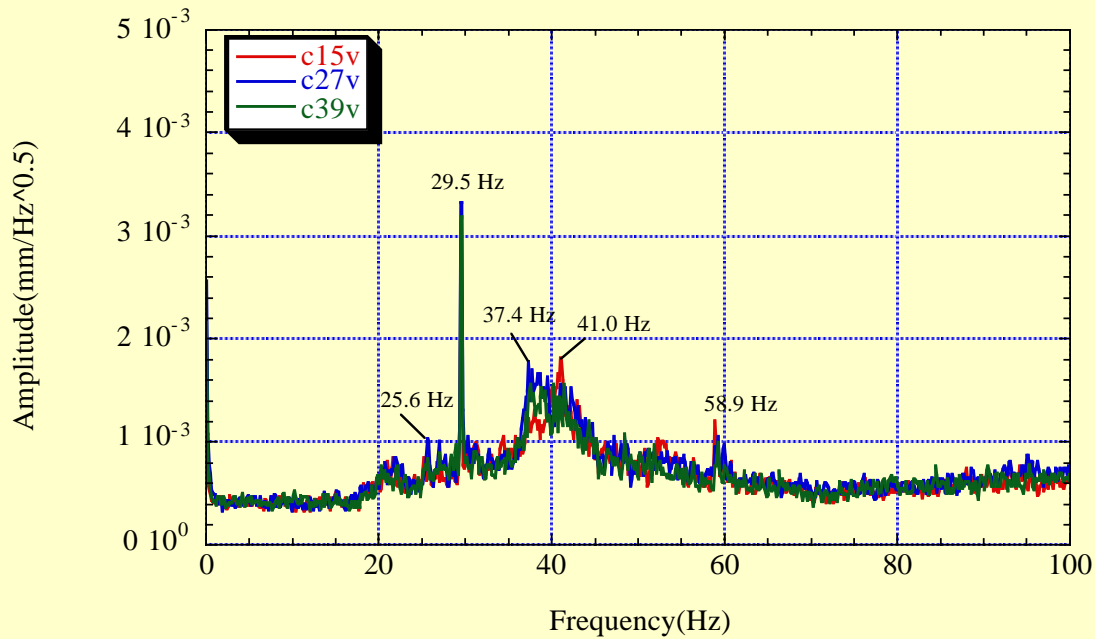
$$\varepsilon = (1 + 1.2 \times 10^{-3}) \varepsilon_0$$

growth 0.12 %

ε_0 : actual emittance

ε : effective emittance

Vertical Oscillation Spectrum of Electron Beam



Effective emittance growth

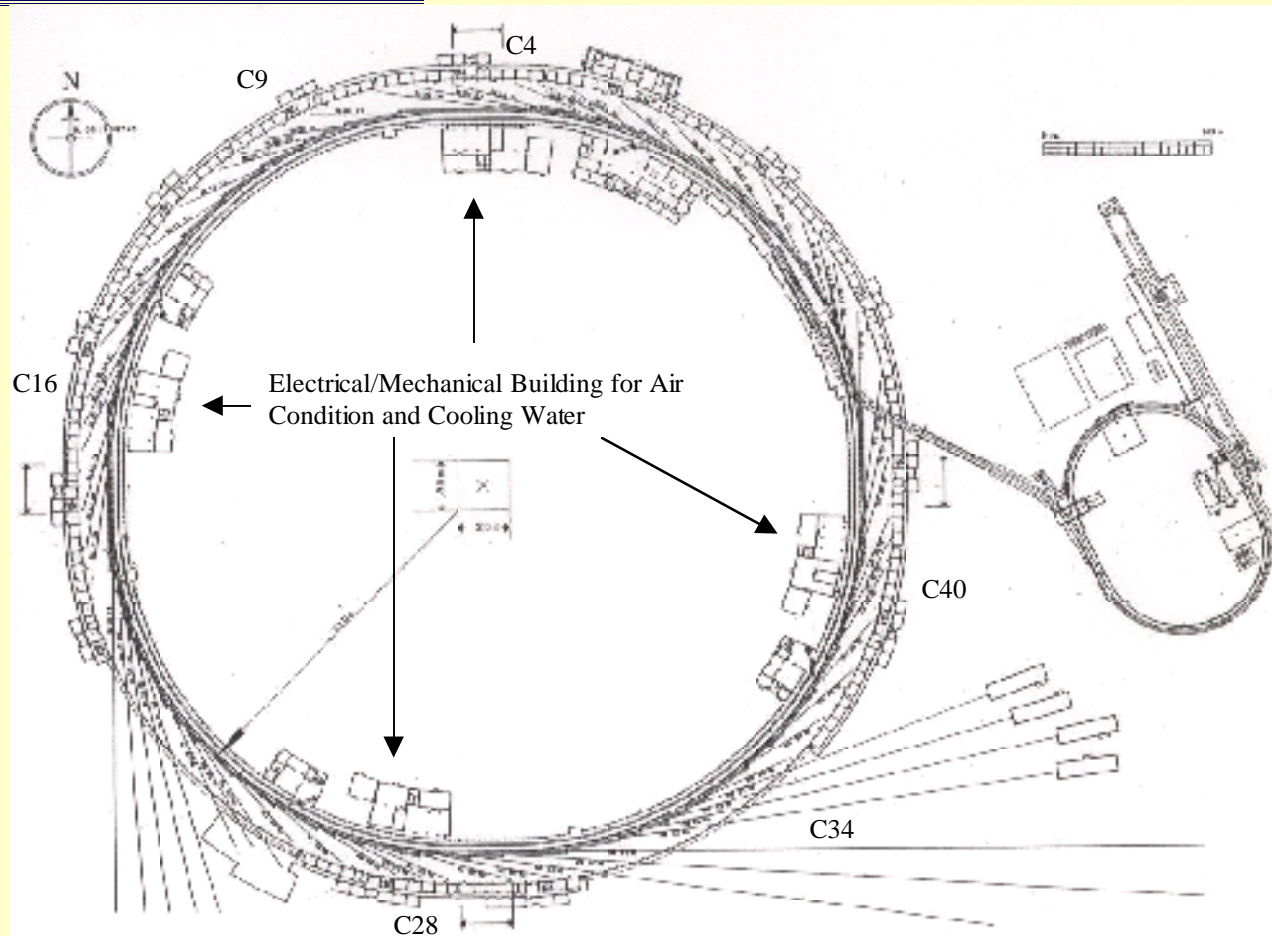
$$\varepsilon = (1 + 1.2) \varepsilon_0$$

growth 120 %

ε_0 : actual emittance

ε : effective emittance

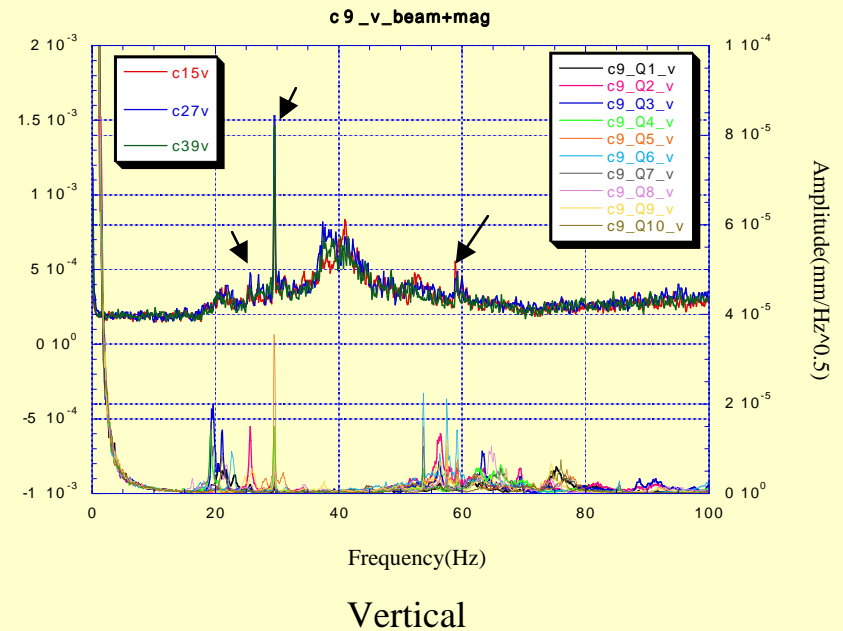
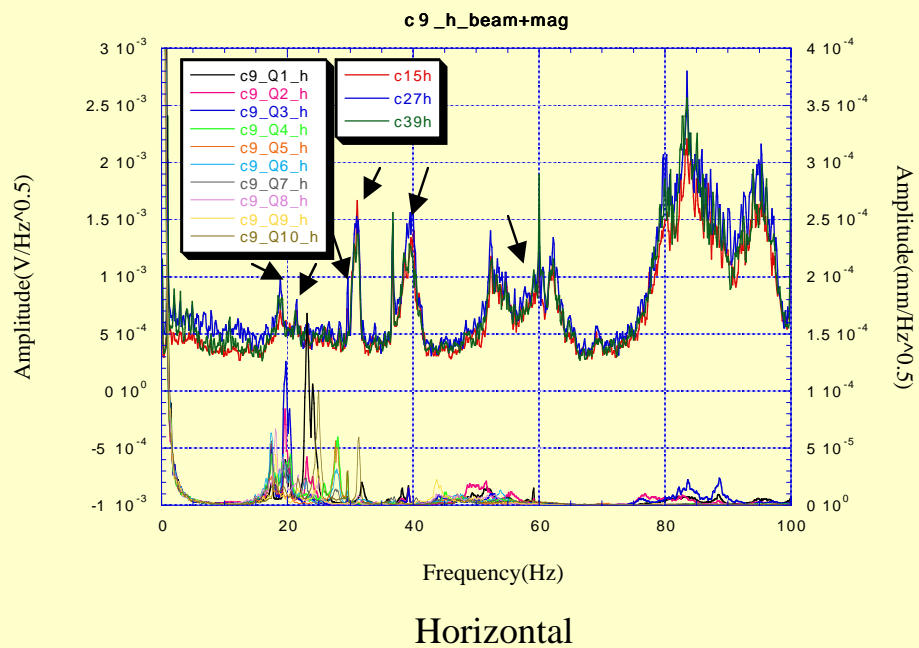
SPring-8 Storage Ring



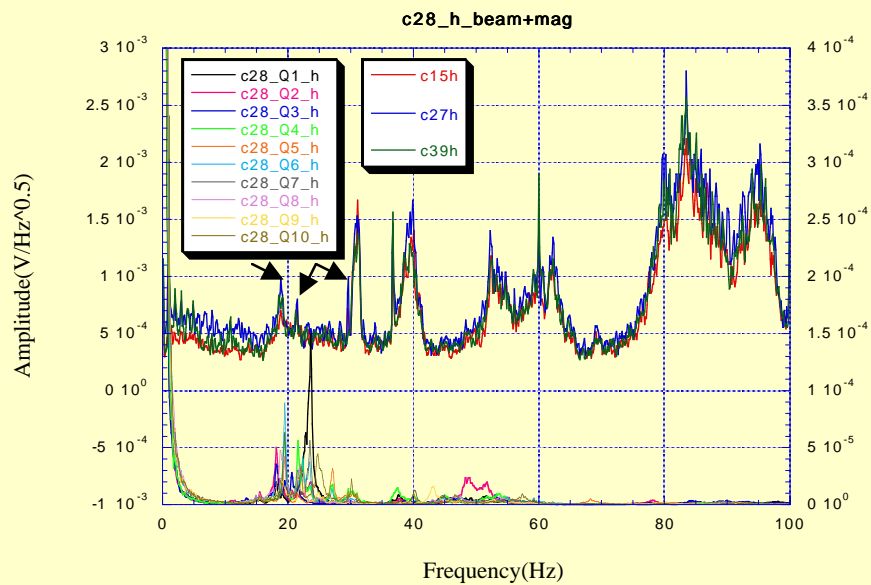
平成13年10月15日

軌道安定化ワークショップ

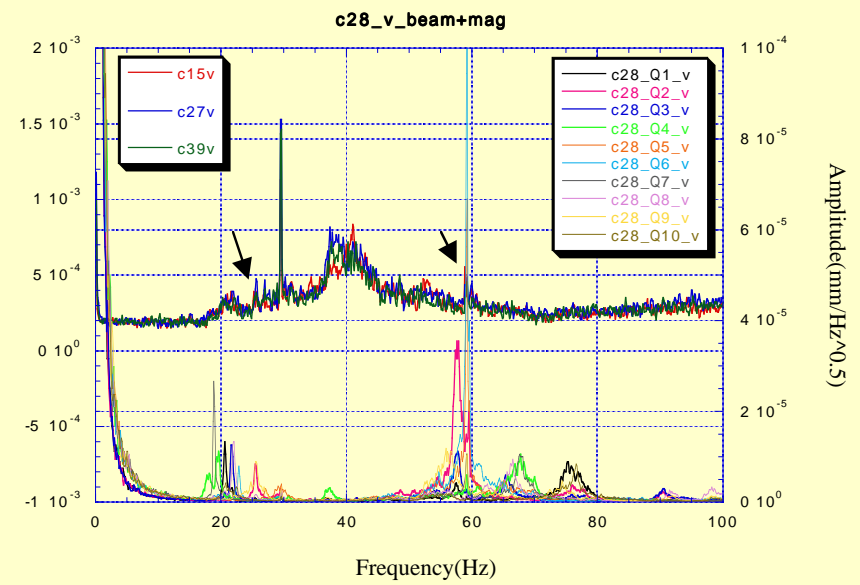
Frequency Spectrum of Magneteflow C



Frequency Spectrum of Magnet 1 floor 28C

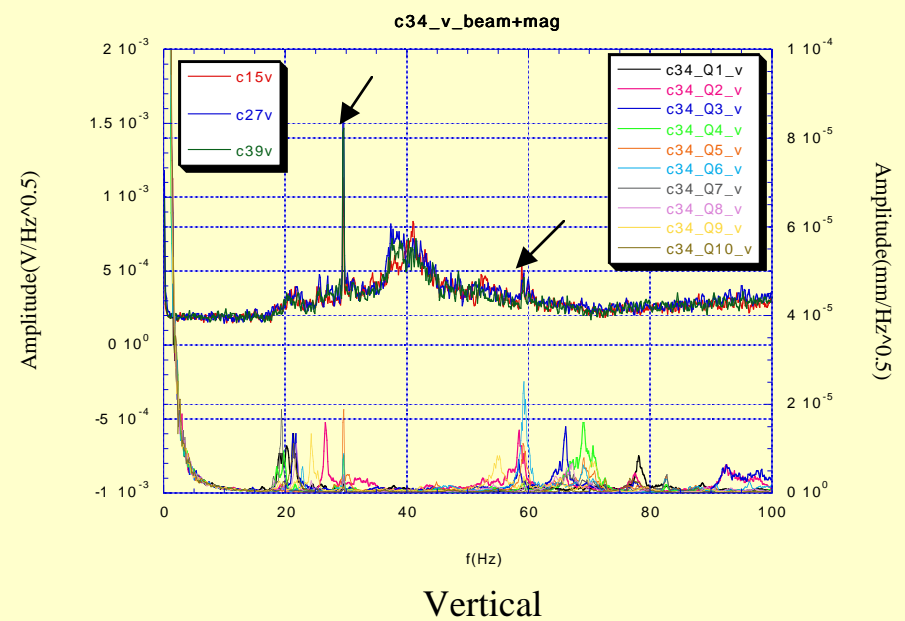
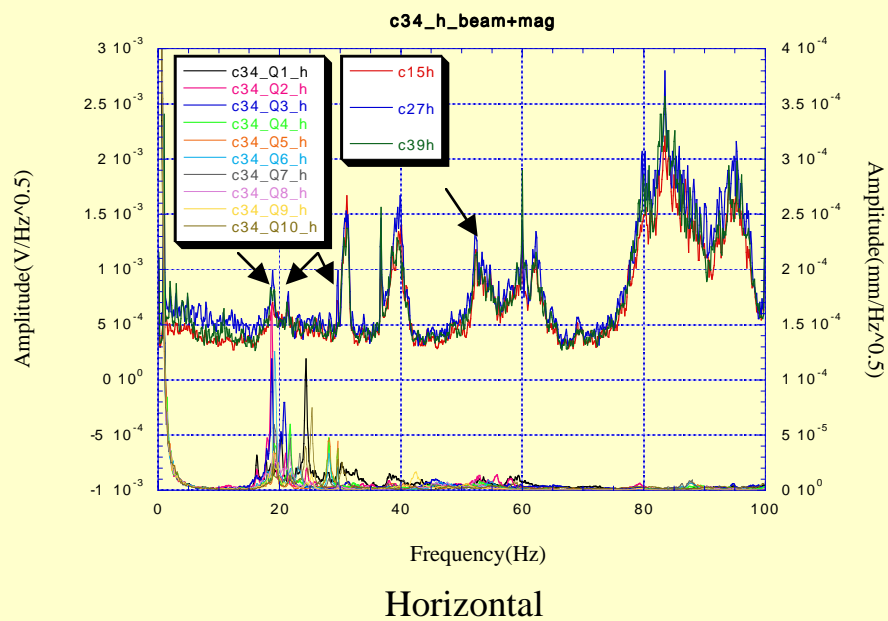


Horizontal

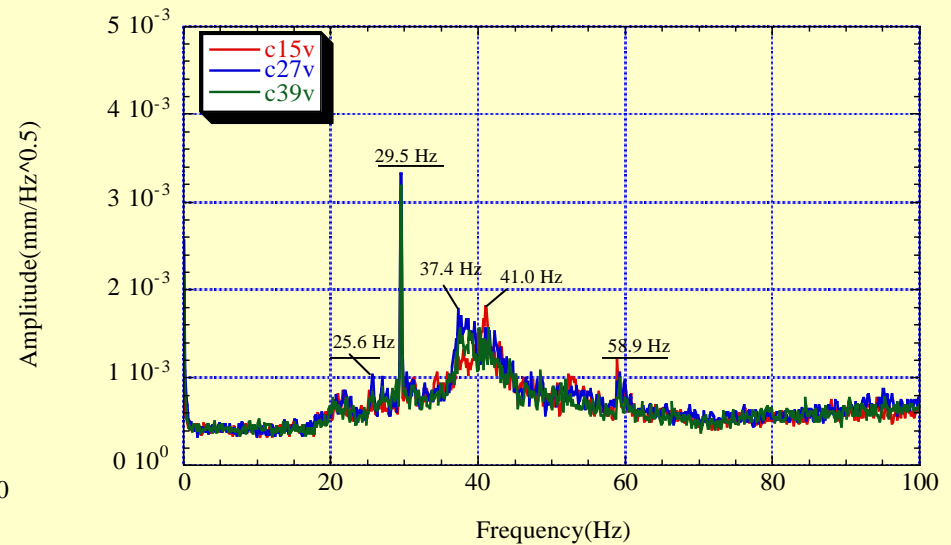
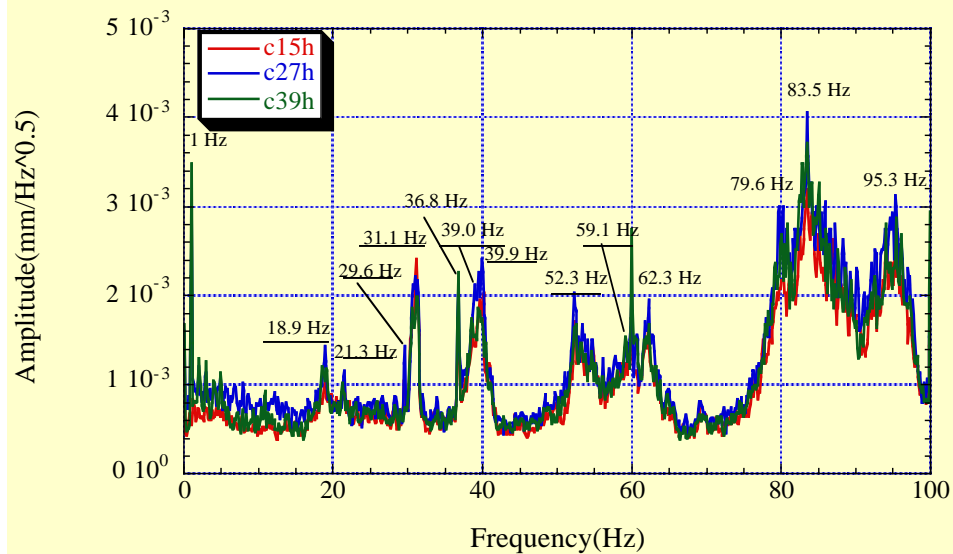


Vertical

Frequency Spectrum of Magnet 1flor34C

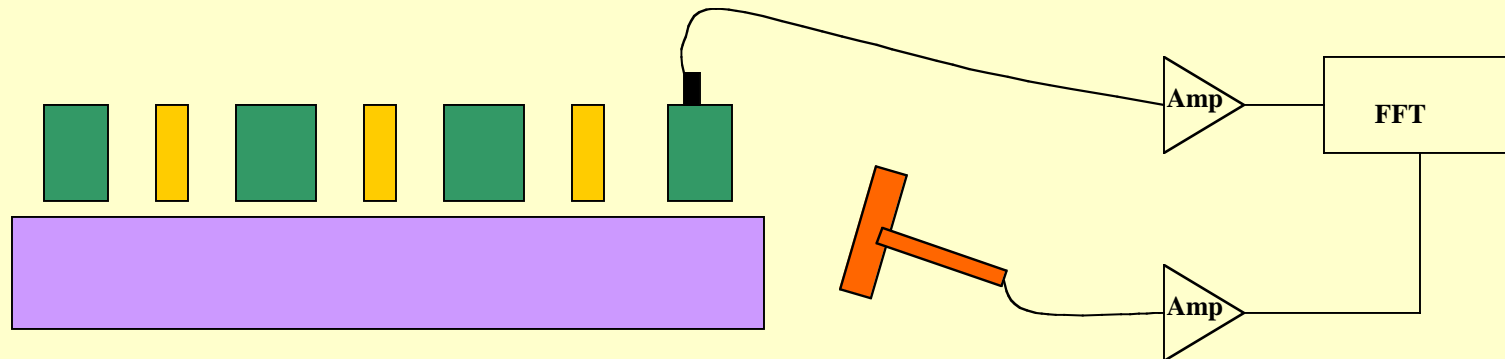


Horizontal Oscillation Spectrum of Electron Beam



- Frequencies with underline are found in magnet vibration spectrum.
- Unidentified frequencies are 1, 36.8, 62.3 and around 80~100 Hz for horizontal and around 40 Hz for vertical.

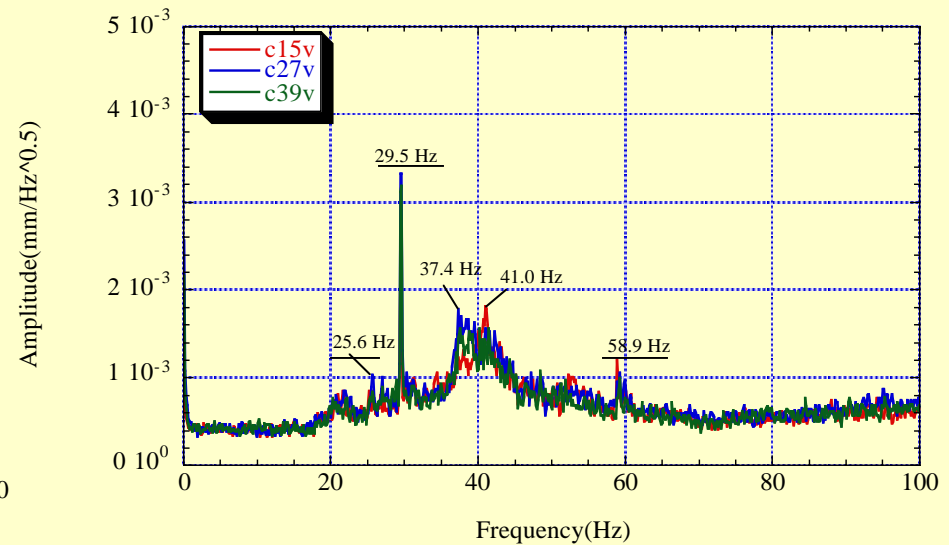
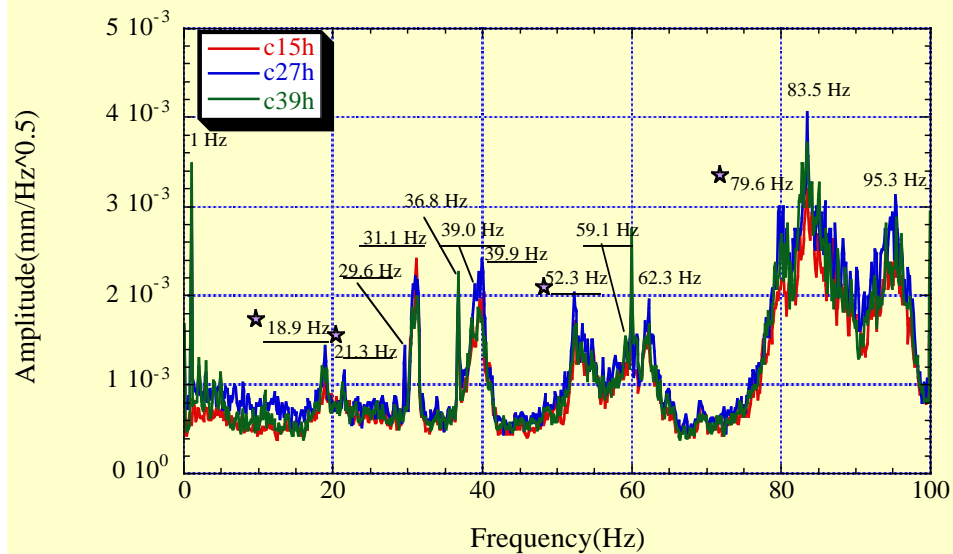
Measurement of Resonance Frequency of Magnet and Girder by Hammering Method



Resonance Frequency of Magnet and Girder

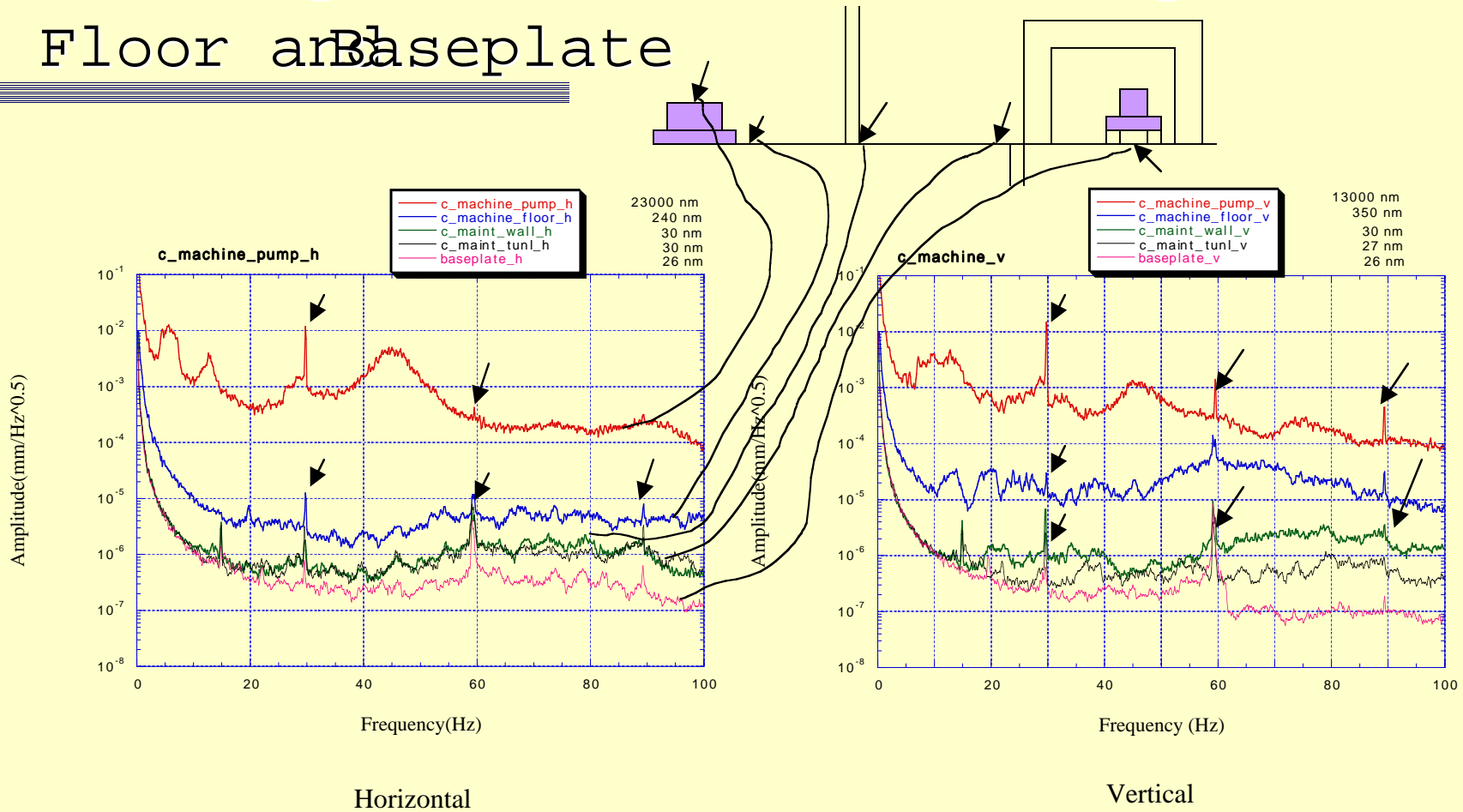
	Horizontal Frequency (Hz)							Vertical Frequency (Hz)			
A girder	38.0	45.3	<u>52.3</u>	57.8	78.8	94.5	-----	44.8	58.0	78.0	-----
Bgirder	<u>19.0</u>	<u>21.0</u>	27.8	50.3	89.3	-----	-----	27.8	45.3	58.3	65.8
a type (Q1,Q10)	24.3	<u>52.5</u>	58.5	-----	-----	-----	-----	21.3	78.3	-----	-----
b type (Q4,Q7)	<u>21.0</u>	22.3	27.8	44.8	-----	-----	-----	19.8	27.5	67.3	-----
c type (Q3,Q6,Q8)	<u>18.8</u>	22.0	27.8	47.0	54.3	-----	-----	22.8	59.5	-----	-----
d type(Q2,)	18.3	20.8	24.5	<u>52.0</u>	55.5	78.8	-----	26.8	58.3	77.3	93.0
e type(Q5)	<u>19.0</u>	<u>21.0</u>	27.8	37.8	41.8	45.3	68.3	30.3	59.5	65.5	70.3
f type(Q9)	<u>19.0</u>	<u>21.5</u>	25.3	42.0	<u>79.5</u>	-----	-----	24.0	54.0	70.0	89.0

Horizontal Oscillation Spectrum of Electron Beam

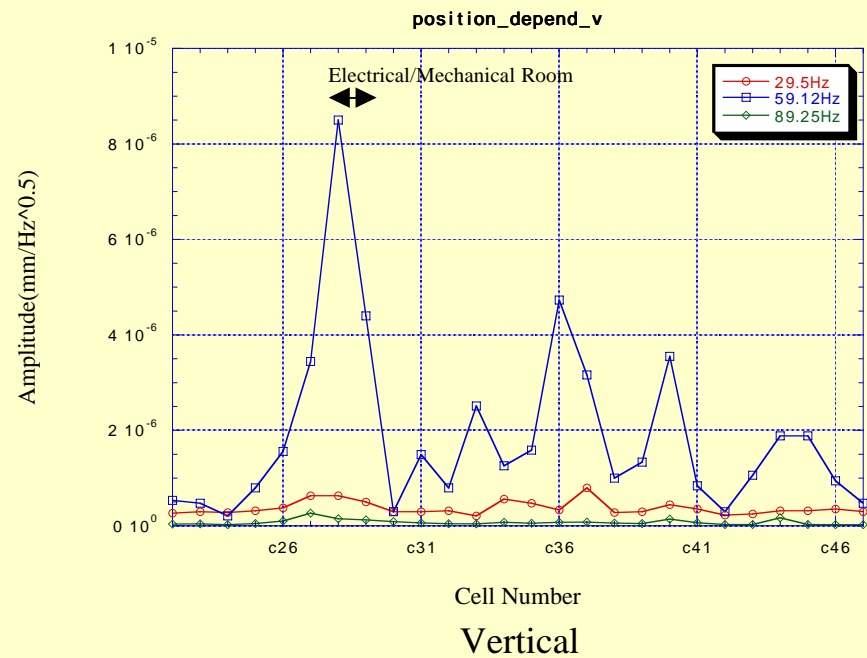
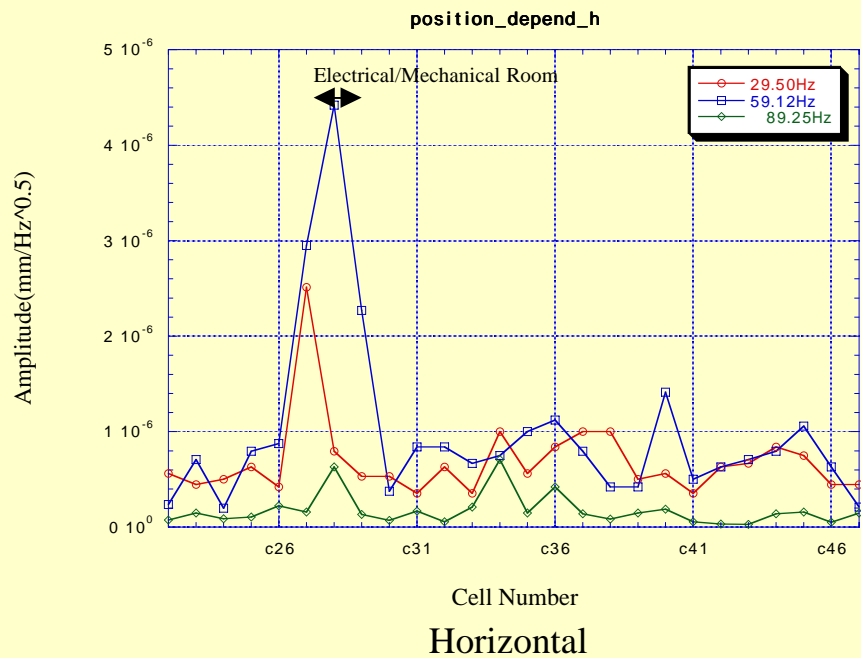


- Frequencies with underline are found in magnet vibration spectrum.
- In the above frequencies, 18.9, 21.3 52.3 and 79.6 Hz are the resonance frequencies of magnet and girder for horizontal direction.
- Unidentified frequencies are 1, 36.8, 62.3 and around 80~100 Hz for horizontal and around 40 Hz for vertical.

Power Spectrum of Vibration Pump for a Floor and Baseplate

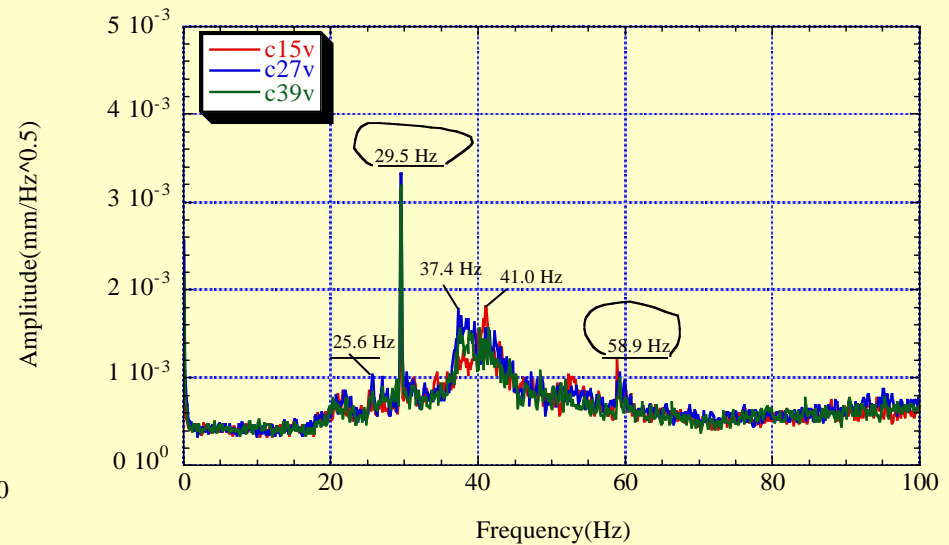
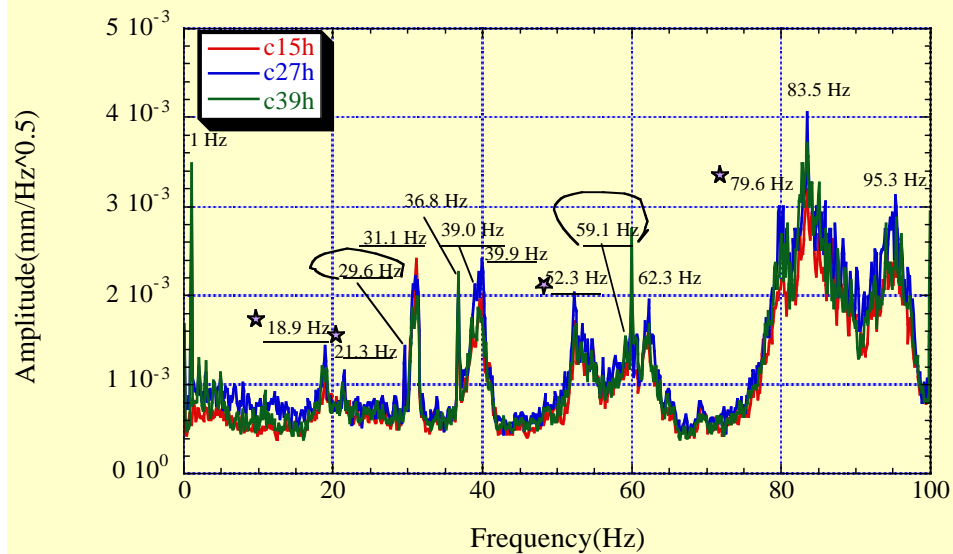


Vibration Distribution around Electrical/Mechanical



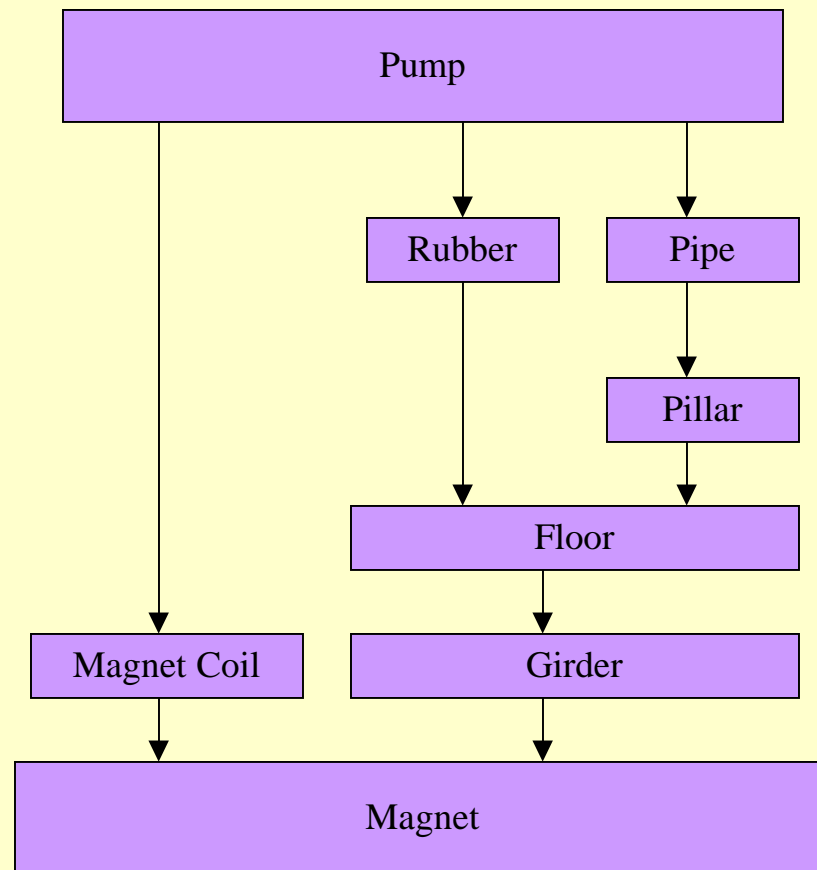
Main component of pump vibration(59.12 Hz) decreases rapidly with the distance from Electrical/Mechanical

Horizontal Oscillation Spectrum of Electron Beam

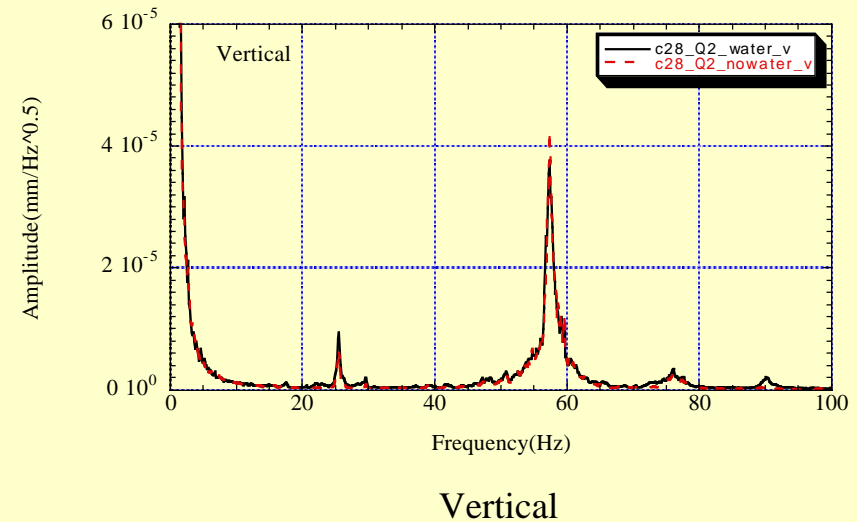
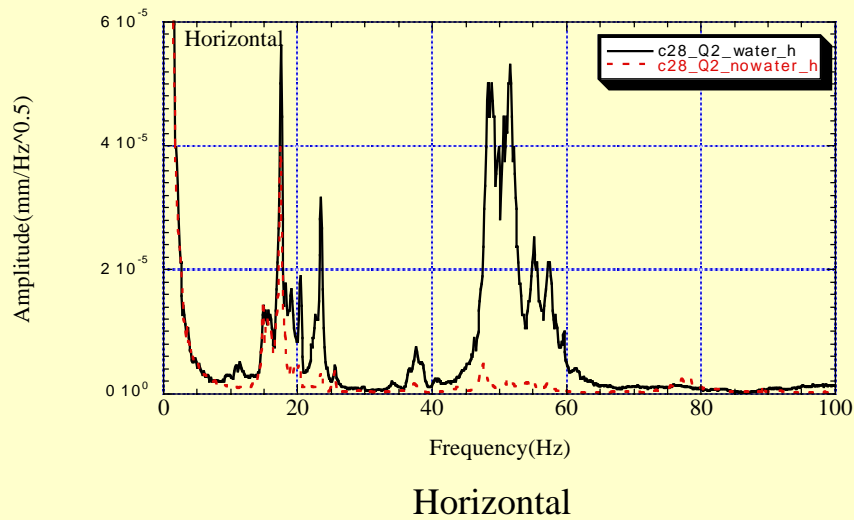


- Frequencies with underline are found in magnet vibration spectrum.
- In the above frequencies, 18.9, 21.3 52.3 and 79.6 Hz are the resonance frequencies of magnet and girder for horizontal direction.
- 29.6, 59.1 Hz for horizontal and 29.5, 58.9 Hz for vertical are the pump frequencies.
- Unidentified frequencies are 1, 36.8, 62.3 and around 80~100 Hz for horizontal and around 40 Hz for vertical.

Propagation Route (How are the pump vibration propagated to the magnet).



Magnet Vibration Spectrum with and without Water Flow in Magnet Coils



Horizontal vibration is via magnet coils, while vertical is via floor and a girder.

Unidentified oscillation

n Horizontal

1 Hz, 3.8 Hz, 62 Hz, 80~9 Hz

n Vertical

around 40 Hz

n Why are 80~95 Hz and around 40 Hz broad peaks?

Betatron wavelength

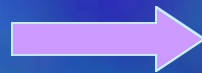
$$\lambda_{x\beta} = 25.1 \text{ m}$$

$$\lambda_{y\beta} = 55.65 \text{ m}$$

Wavelength of vibration

$$\lambda_{xv} = 2200 \text{ m/s} / 88 \text{ Hz} = 25 \text{ m}$$

$$\lambda_{yv} = 2200 \text{ m/s} / 40 \text{ Hz} = 55 \text{ m}$$



$$\lambda_{x\beta} = \lambda_{xv}$$

$$\lambda_{y\beta} = \lambda_{yv}$$

where propagation velocity of floor sinusoids is assumed to be 2200 m/s.

All small magnetic errors around betatron wavelength are sensitive for beam oscillation (An electron does not resonate with quadrupole error distribution.)

Suppression method of beam oscillation

Vertical

- n Cutting the propagation path
 - ex Improvement of the vibration proof bed
- n Reduction of the pump vibration

Horizontal

- n Reduction of the pump vibration
- n Reduction of the water flow

Conclusion

- n We measured the beam oscillation and magnet vibration in the frequency range below 100 Hz
- n Most oscillations seen in the spectrum are resultant from magnet and girder vibration
- n Horizontal vibration of magnets is induced by the water flow in magnet coil.
- n Vertical vibrations are the results of propagation of vibration from cooling water pumps to magnets through floor and girder.