IR stability at SuperKEKB

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R. Sugahara
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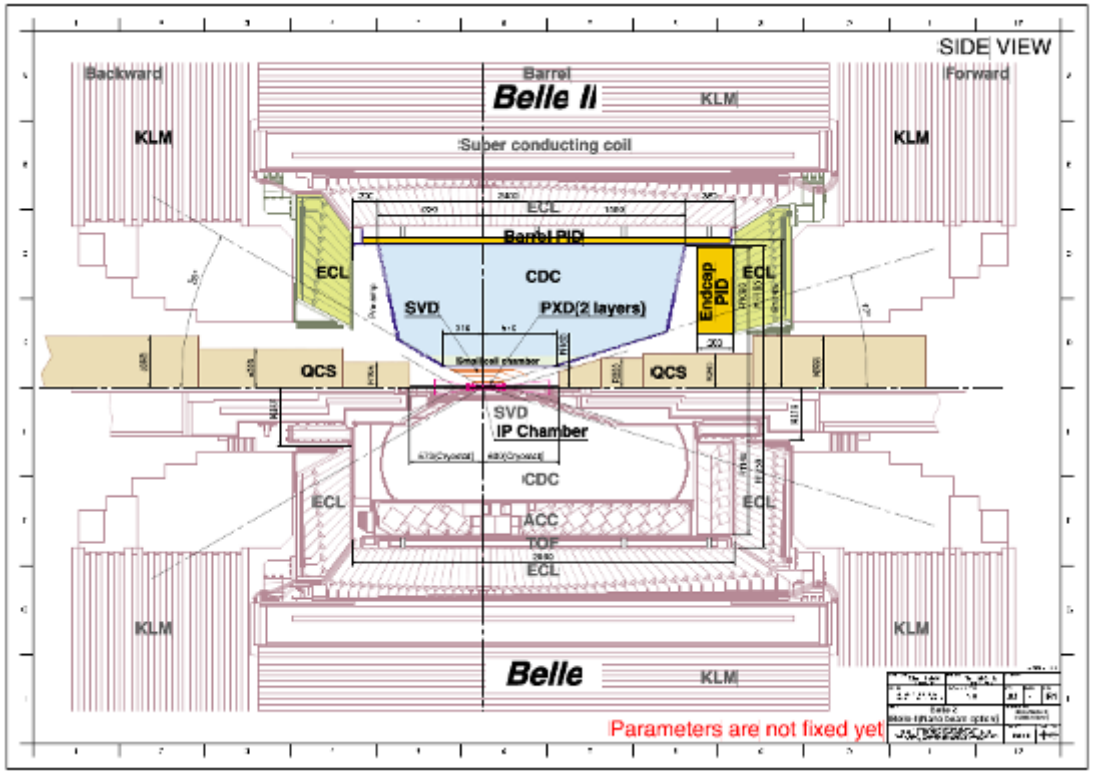
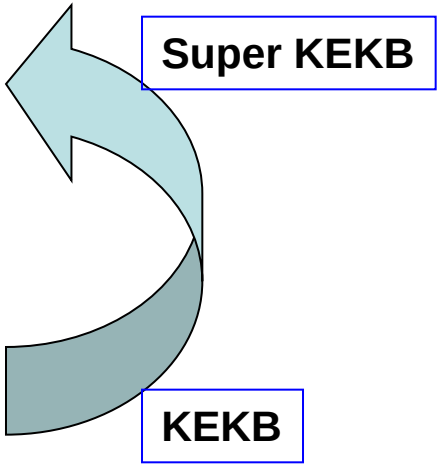
Introduction





The beam size of Super KEKB is expected to be very small

→ Beam oscillation amplitudes must be kept much smaller than are required at present.

Large vibration amplitude results in luminosity degradation.

In order to evaluate the present vibrations around the IP,

→ Vibration measurements were carried out on the *KEKB tunnel floor*,

on some of *the magnets* in the interaction region (IR),

on *magnet supports*, on *movers* and on *the Belle detector.*

➔ *Understanding who is shaking. Also reduction of* the effects.

Vibration measurement at KEKB

Measurement items

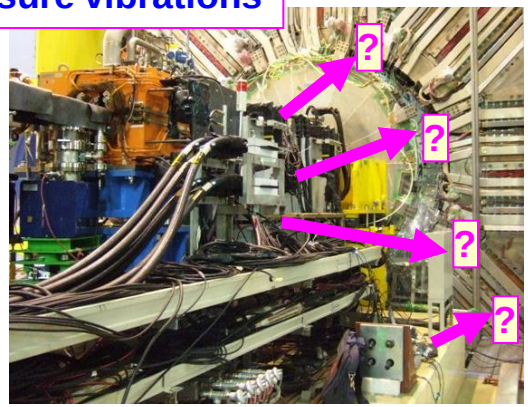
- Vibrations on each positions
- Influence of air conditioner
- Cooling effects of the magnets
- Coherency between both sides

Servo Accelerometer
MG - 102
Tokkyokiki Corp.

Size	40×40×50mm
Max. input	± 2 G
Resolution	1 / 10^6G

Acc. 0.1 ~ 400Hz
Acc. 60dB = 1gal/V

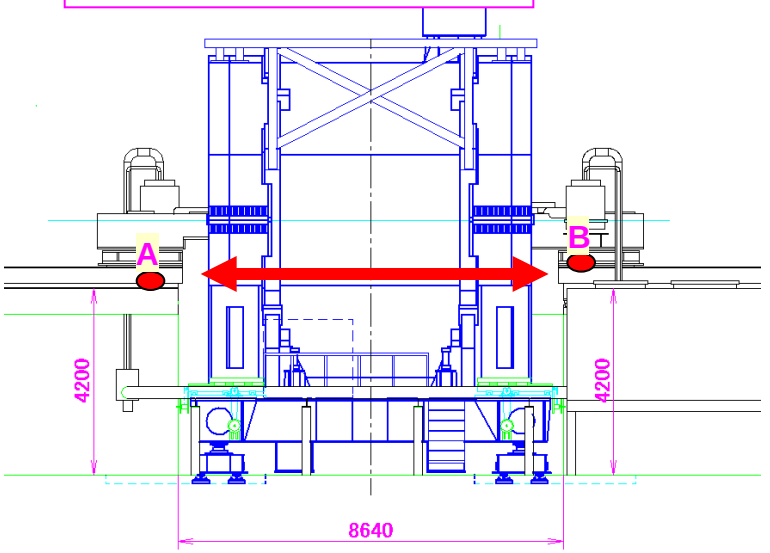
Measure vibrations



Influence of air conditions

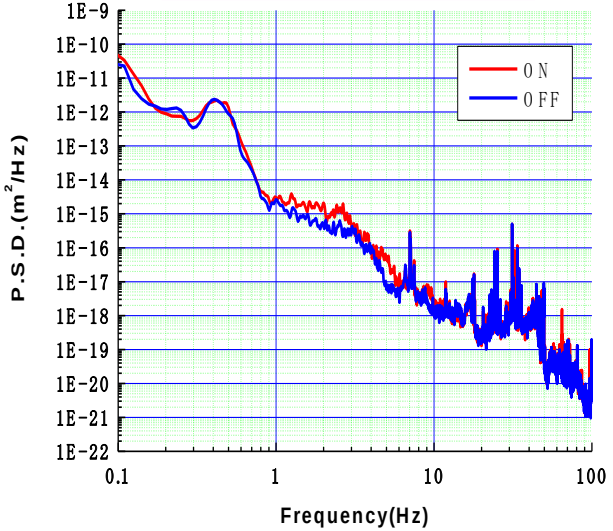
Air conditioner

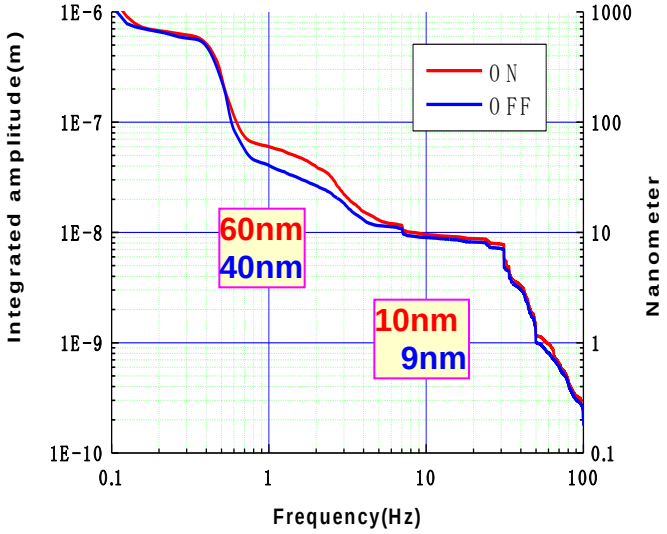
Coherency between A-B



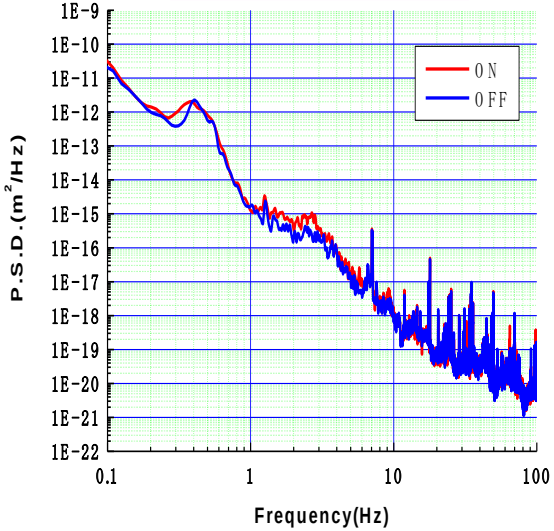
On the KEKB-floor (Air conditioner → ON/OFF, *cryogenic system → off*)

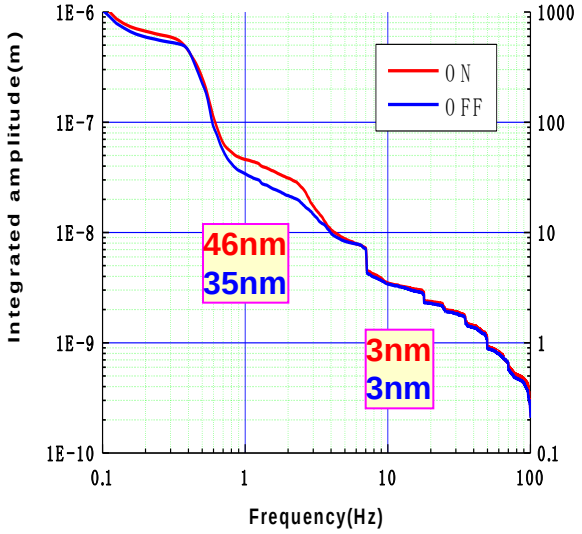
OHO-Perpend.



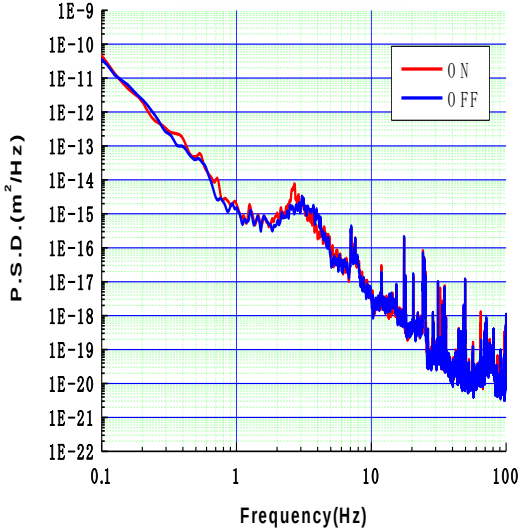


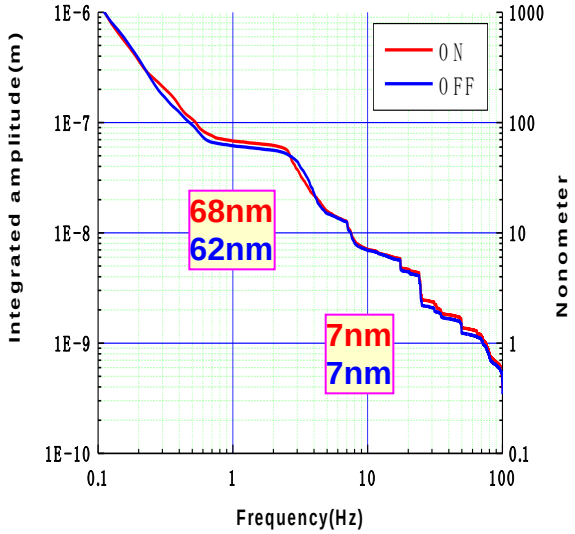
OHO-Beam





OHO-UD

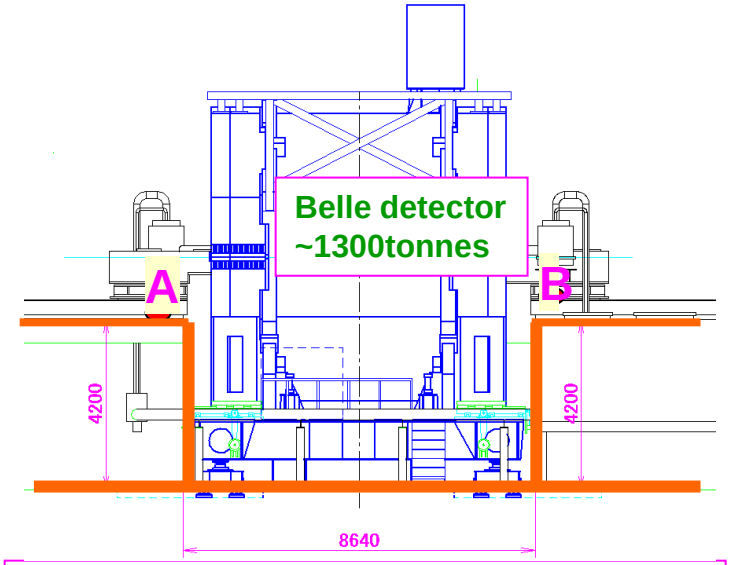




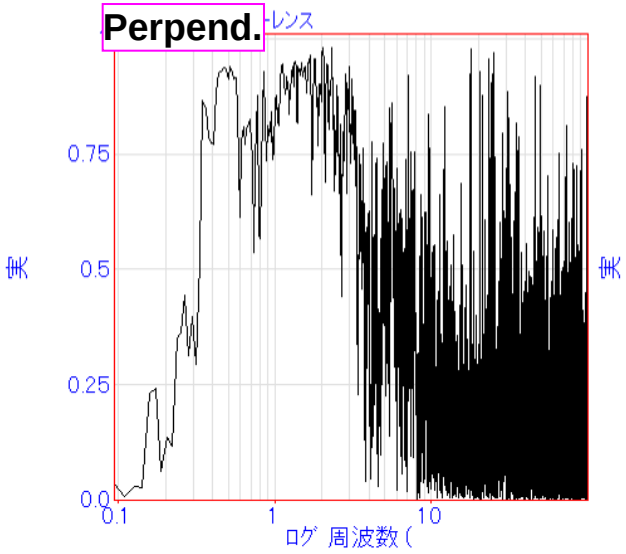
➔ It seems that frequency around 1-3Hz is a little bit smaller at air-con(OFF)??

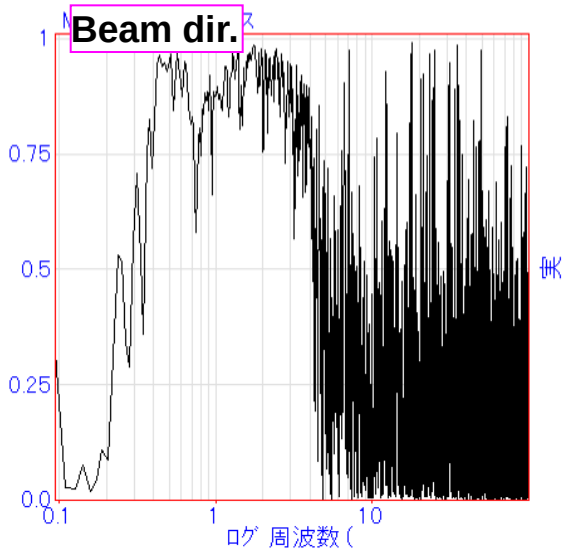
→ No obvious differences.

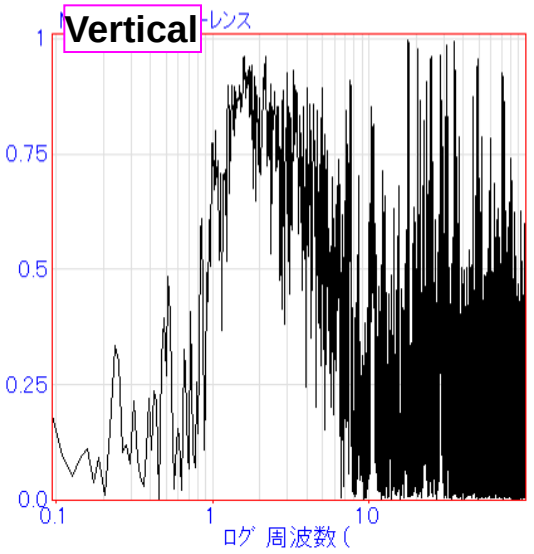
Coherency measurement at KEKB-tunnel



Coherency between position-A/B.





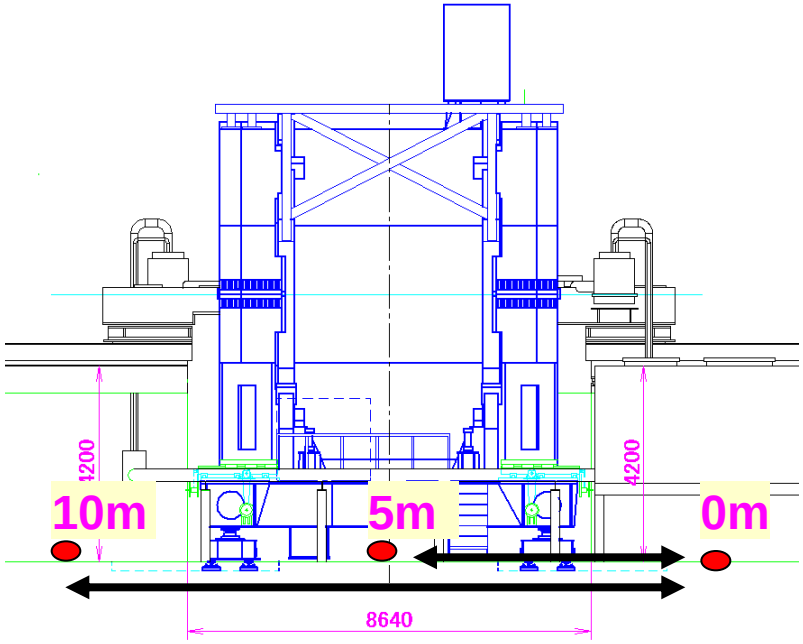


➔ **It seems that there is no coherency between two positions.**
Except for the frequency of microseismic(0.XHz) and resonance of soil(~3Hz).

Measurement: B

How is the coherency between two positions?

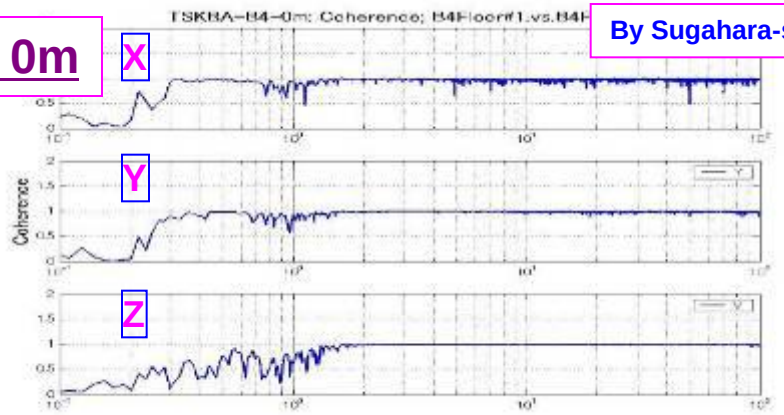
Measure: Distance dependency.



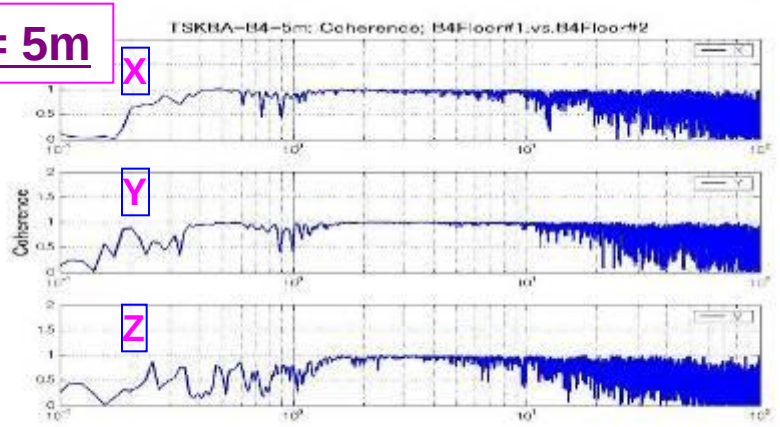
- Coherency: >10Hz is getting worse as distance becomes larger.
- Vertical dir.: <1Hz is bad.

By Sugahara-san

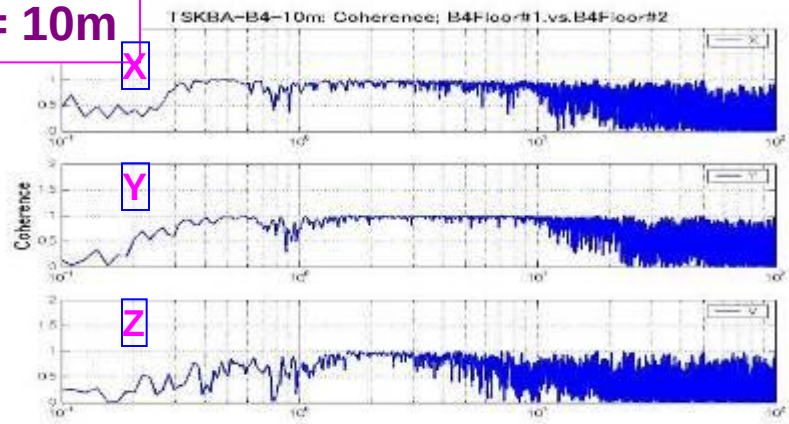
L = 0m



L = 5m

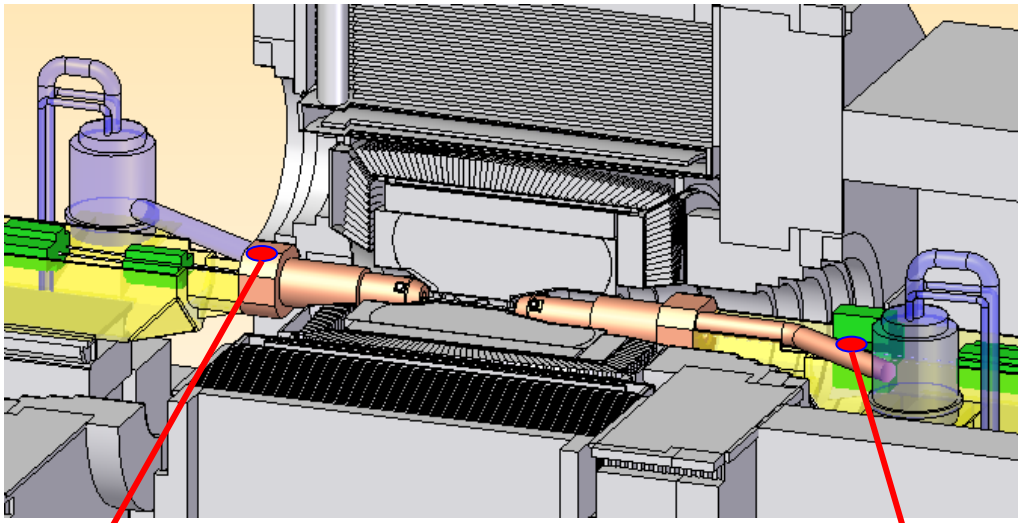


L = 10m

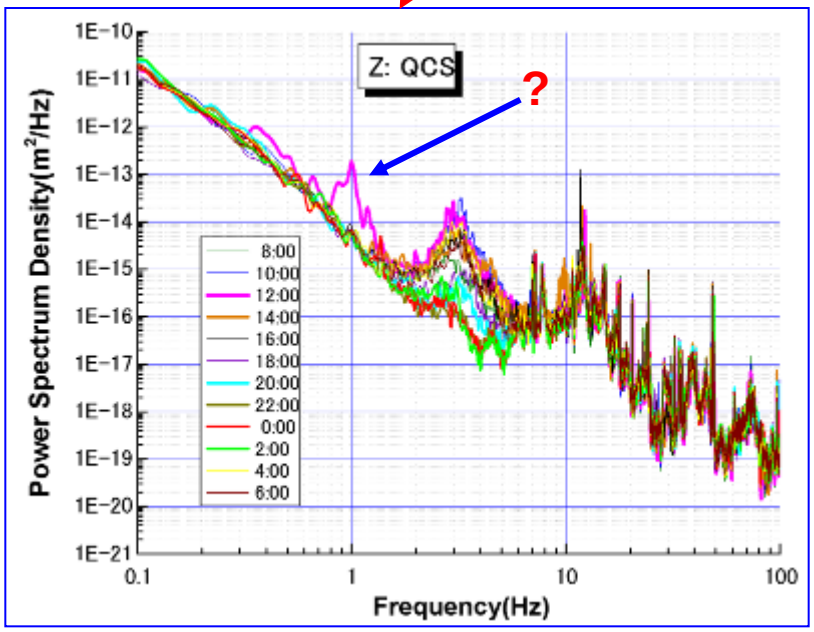


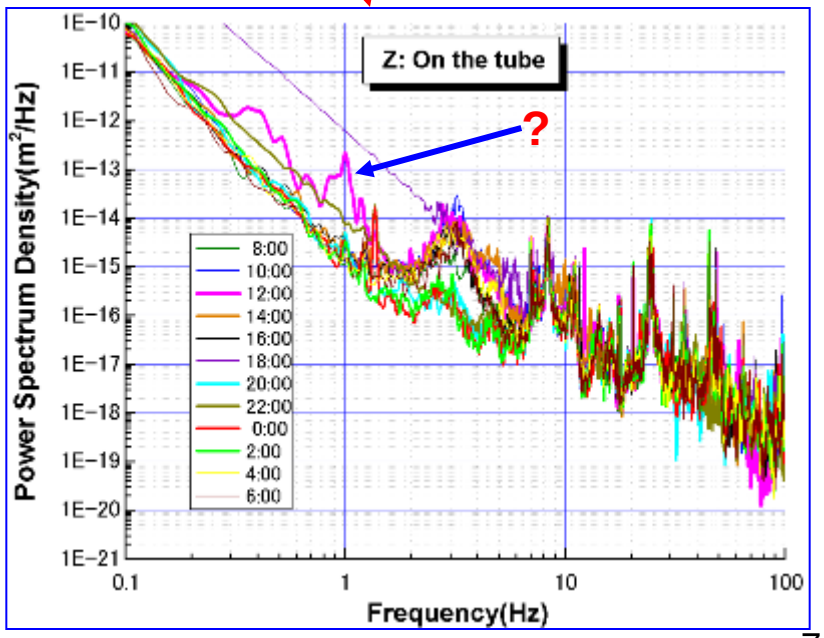
0.1 1 10 100Hz

Measurements during the magnet cooling



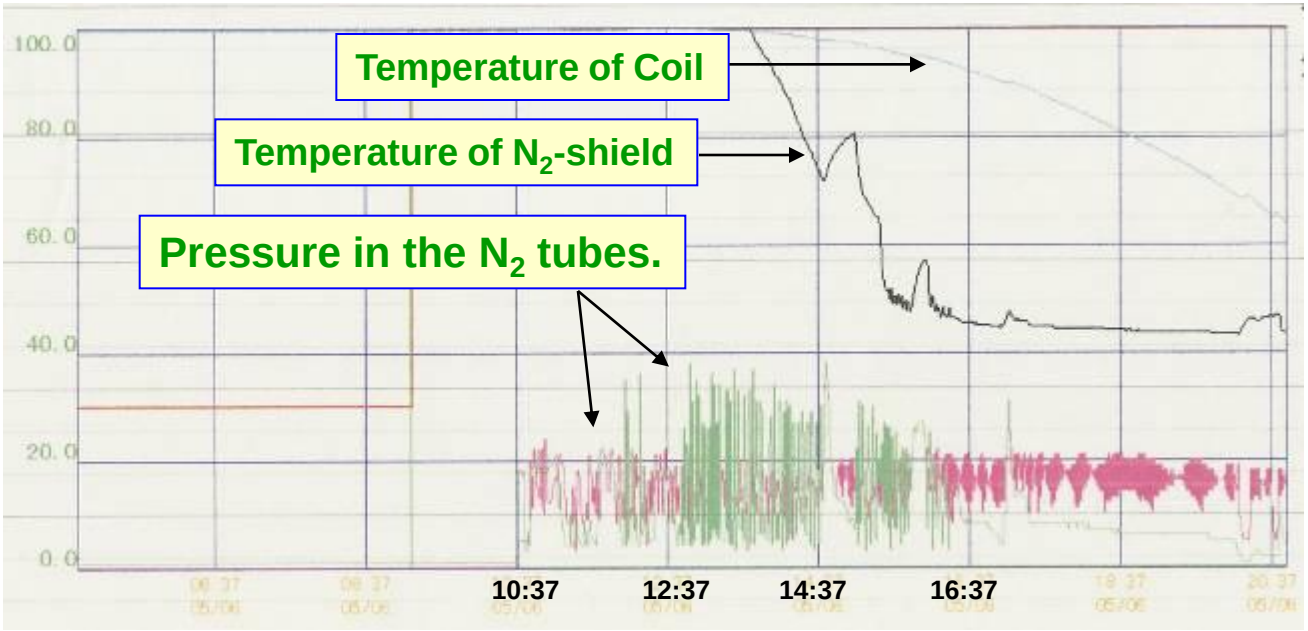
P.S.D. in the vertical direction

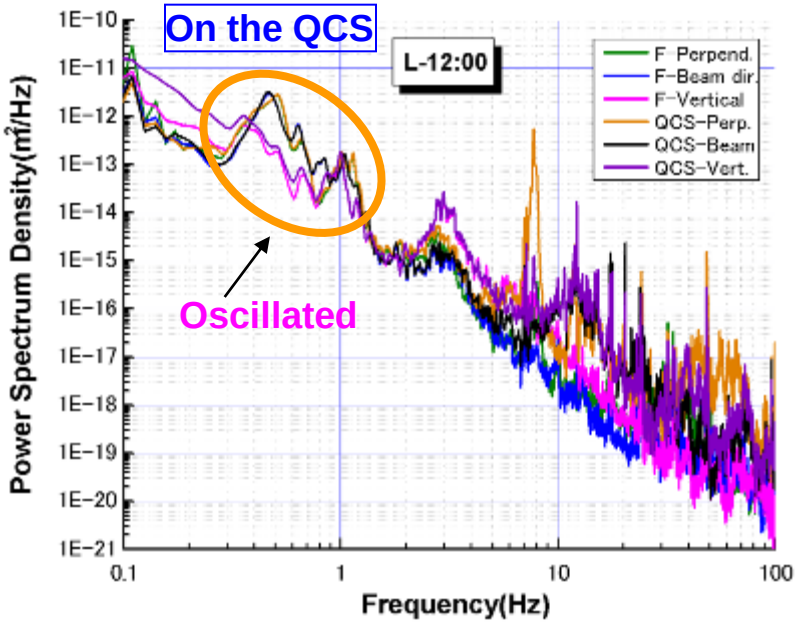


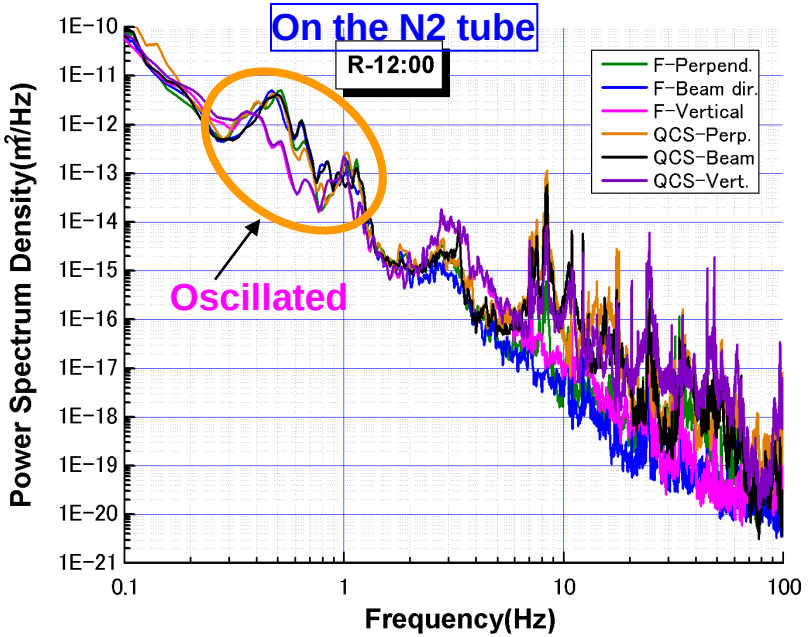


- What happened at 12 o'clock??

- What was happened at 12:00?? ➔ Cooling just had been begun.

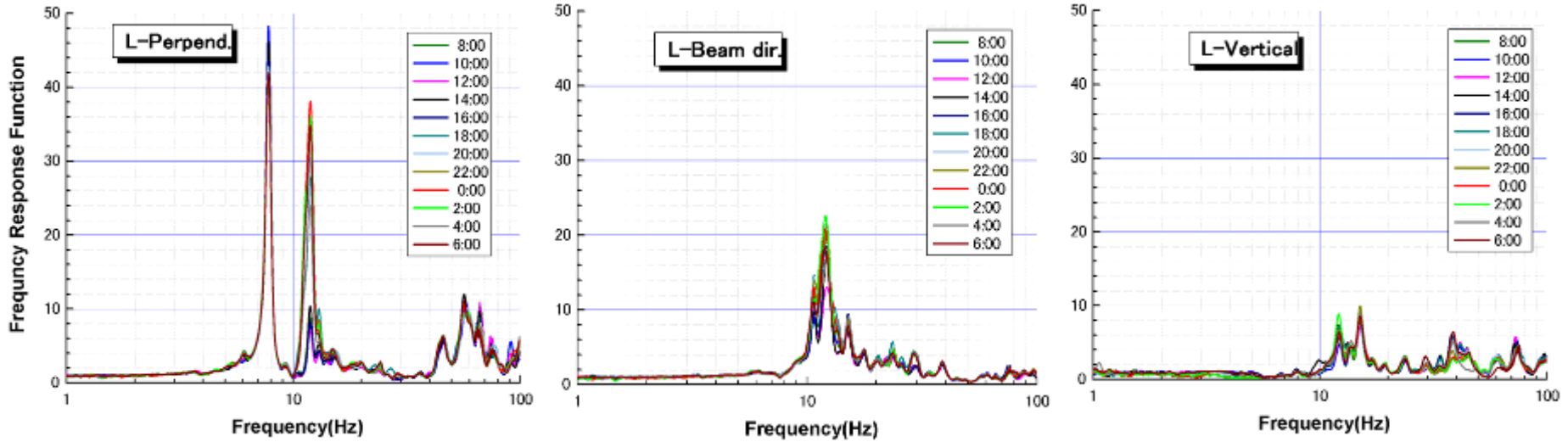




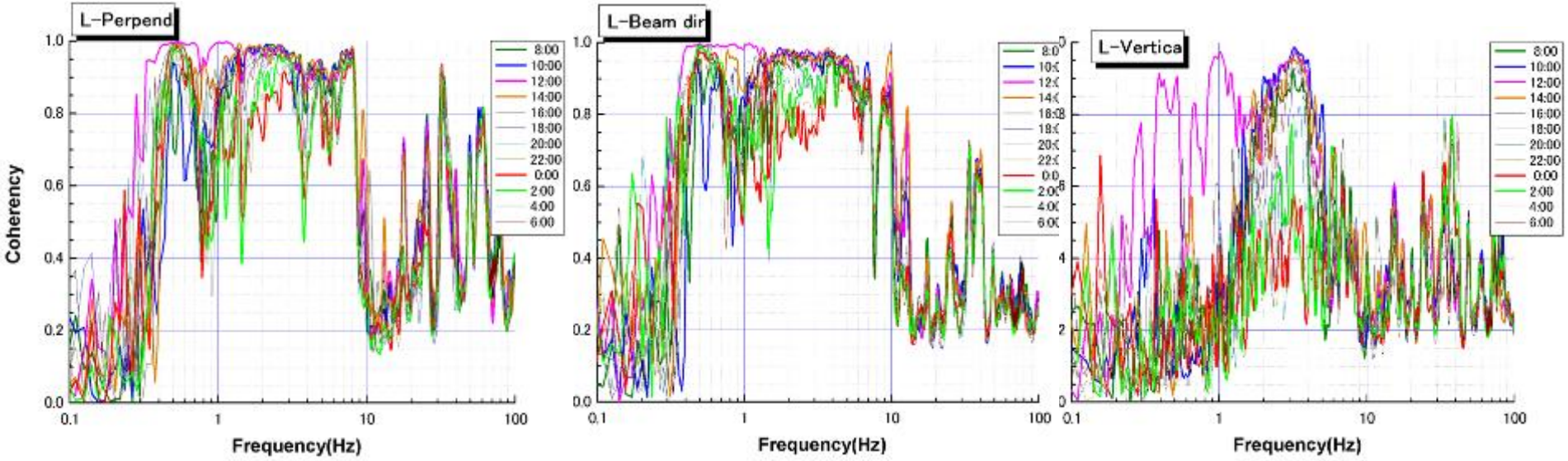


➔ Oscillations around 1Hz at 12:00 were observed in all directions.

Frequency Response Function (QCS – Floor)

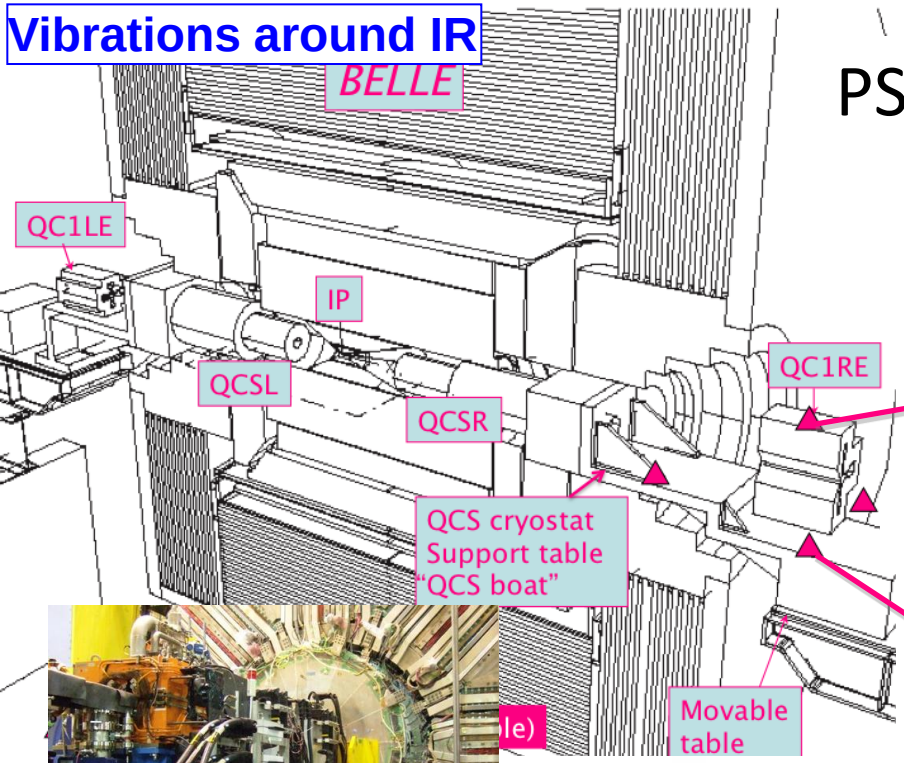


Coherency (QCS – Floor)

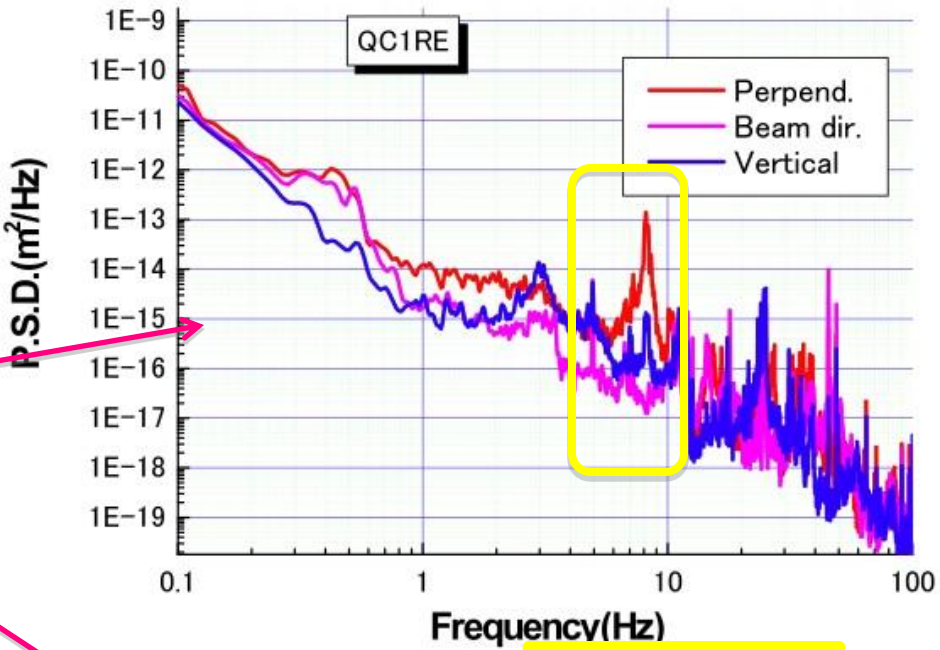


→ Coherency around 1Hz measured at 12:00 became better than other data.

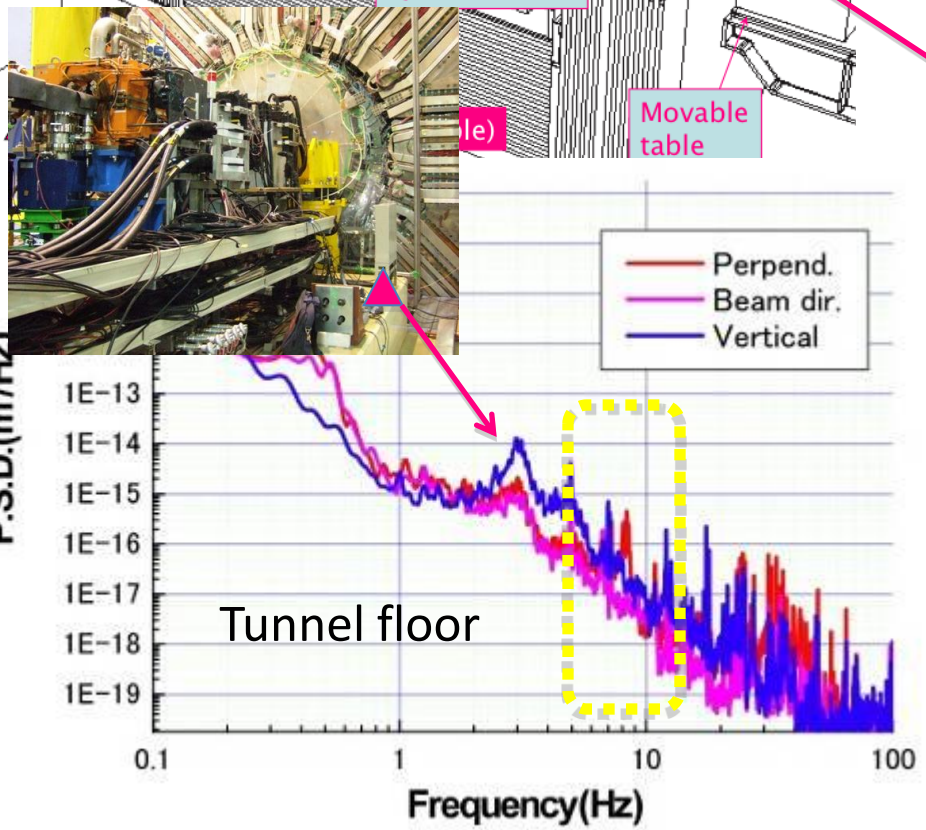
Vibrations around IR

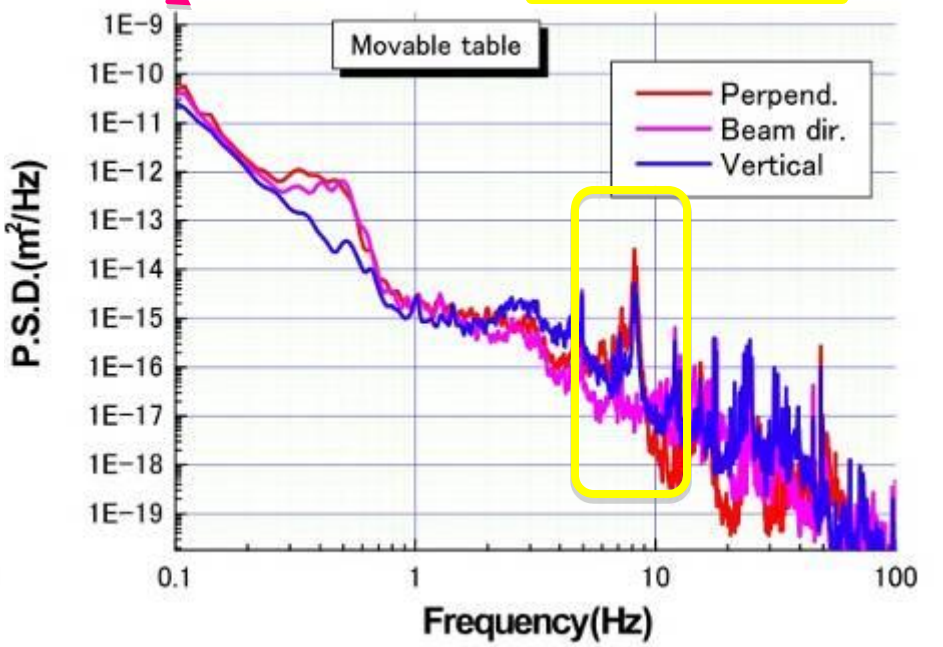


PSD

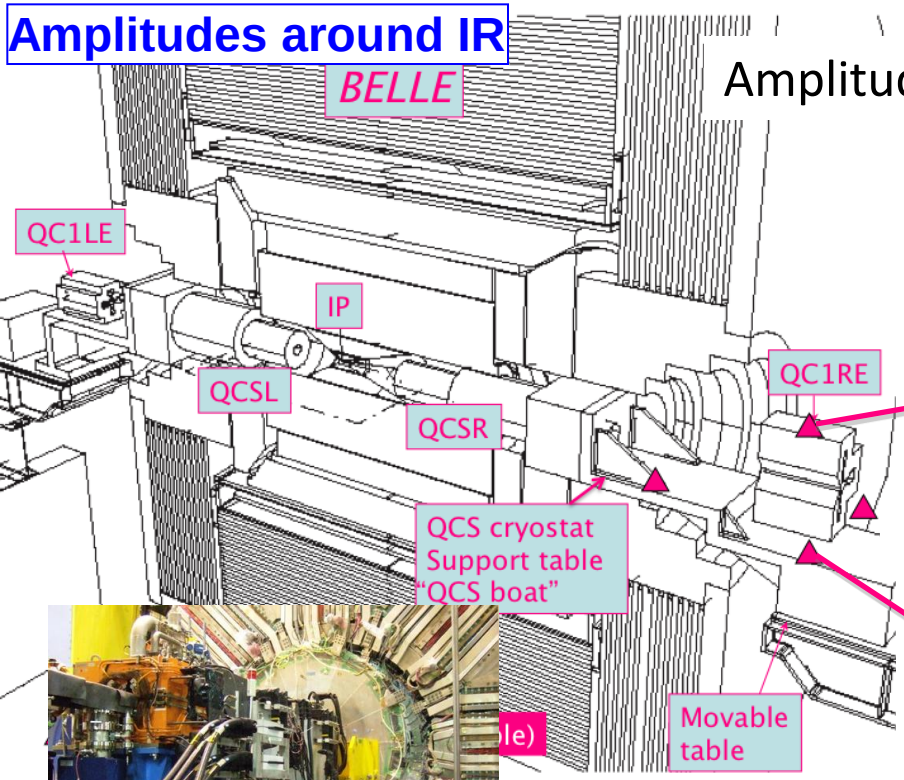


~8Hz peak

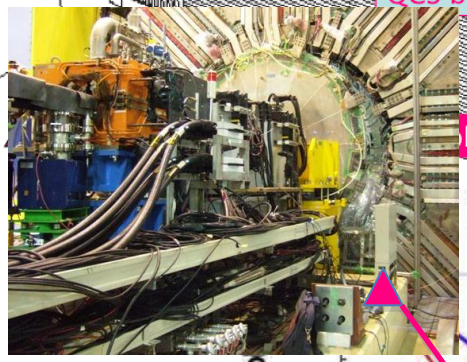


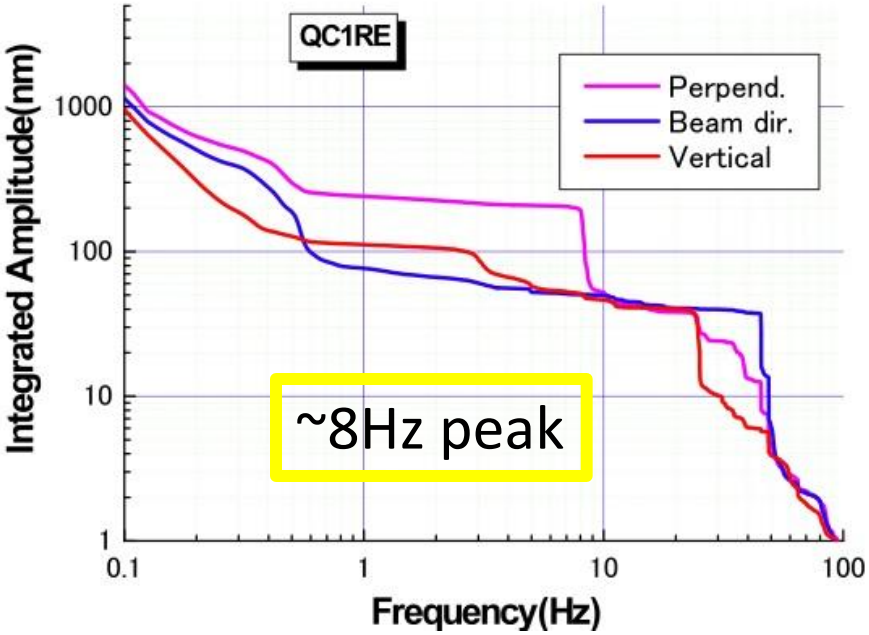


Amplitudes around IR

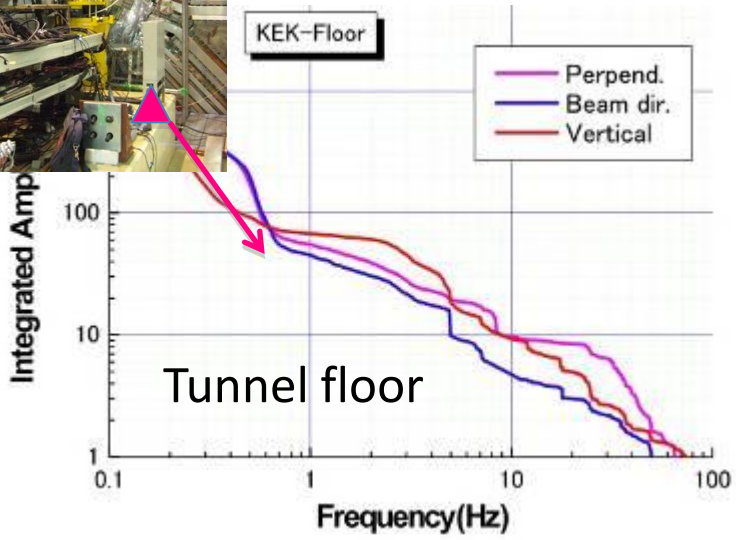


Amplitude

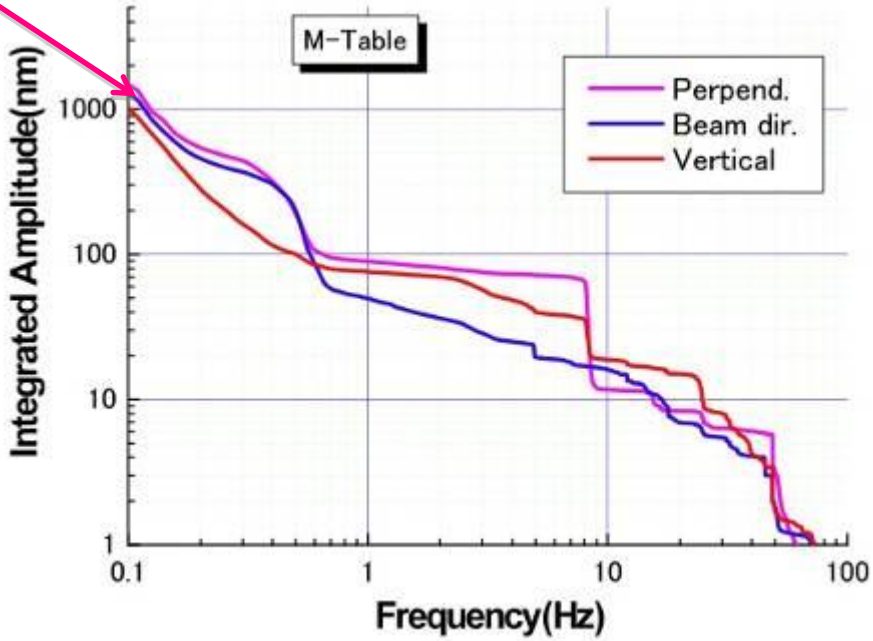




~8Hz peak

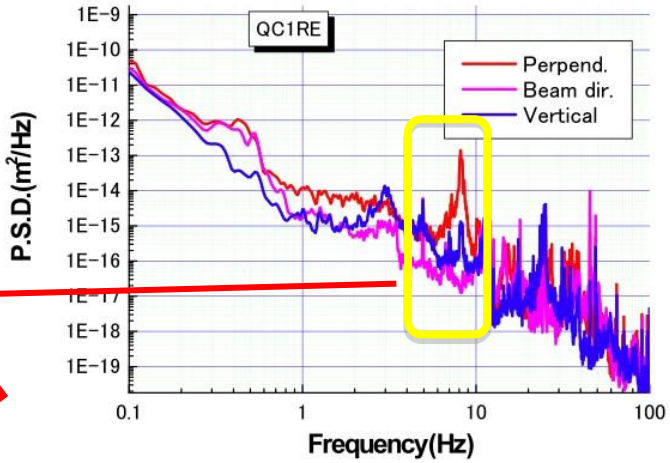


Tunnel floor



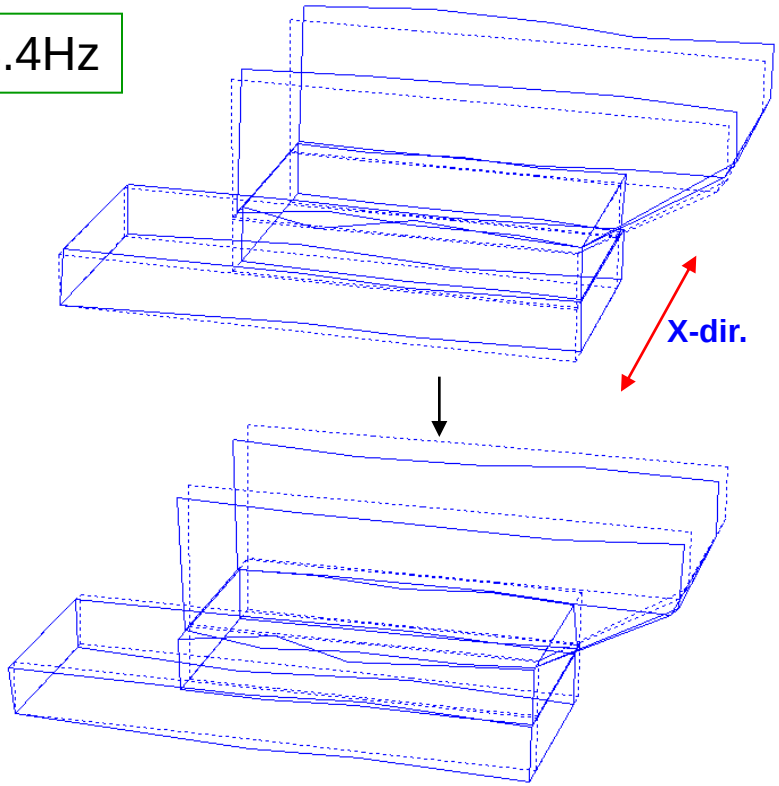
➔ **Amplitude in the perpendicular dir. is bigger than others due to peak at 8Hz.**

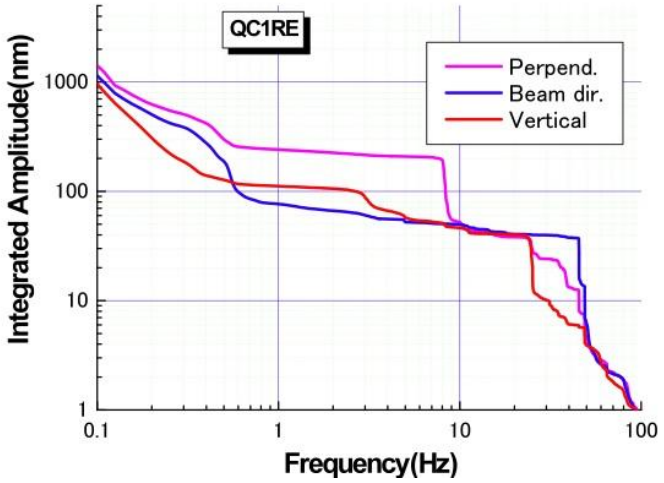
Hammering test



Result: Measured mode shape in X-direction

8.4Hz





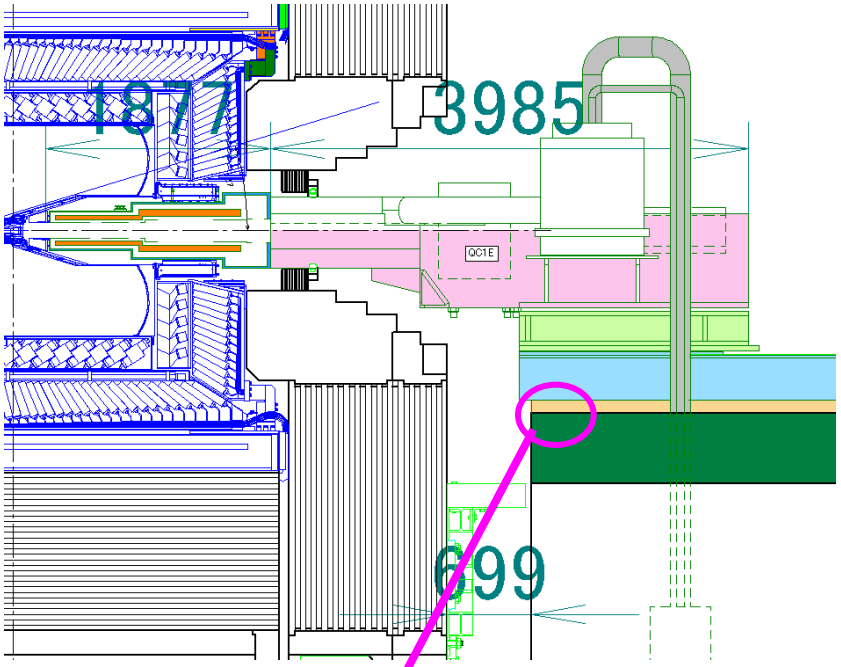
What is the motion at 8Hz??
This un-known peak makes large amplitude.

Measurement Result:
Support system for the magnet (Magnet table + QCS boat) is vibrated with same phase around 8Hz.

Measurement results

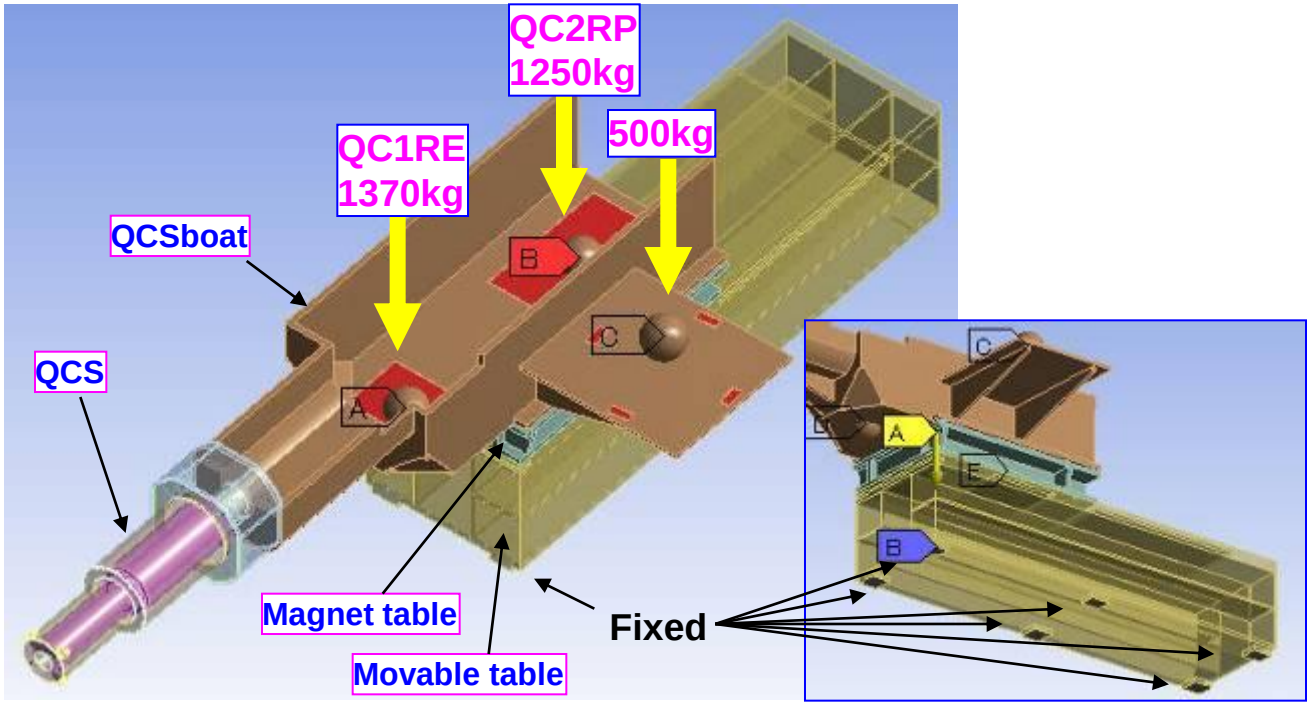
- First resonance is around ~8Hz.
- Amplitude grows bigger.

- This peak comes from the stiffness of the magnet support.
→ The magnet support structure is mounted on the rails.
→ This is not fixed rigidly.
→ It should be fixed rigidly to eliminate unnecessary gap.



Linear guides

Calculations on the QCS-support system



1. Loads

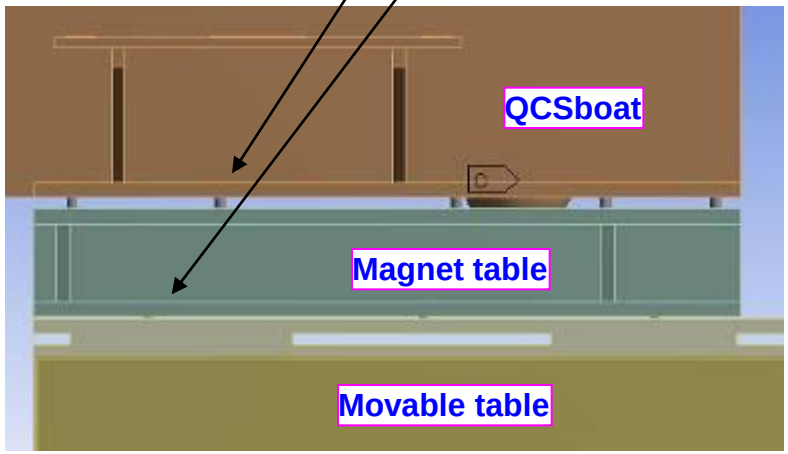
- Self-weight
- QC1RE: 1370kg
- QC2RP: 1250kg
- Box: 500kg

2. Materials

Cryostat: SUS
Coil: Cu
Supp.-rod: Ti-alloy
QCS table: SS400

3. Thread bolts

→ 10-M30
6-M24
Pre-tension: Not defined

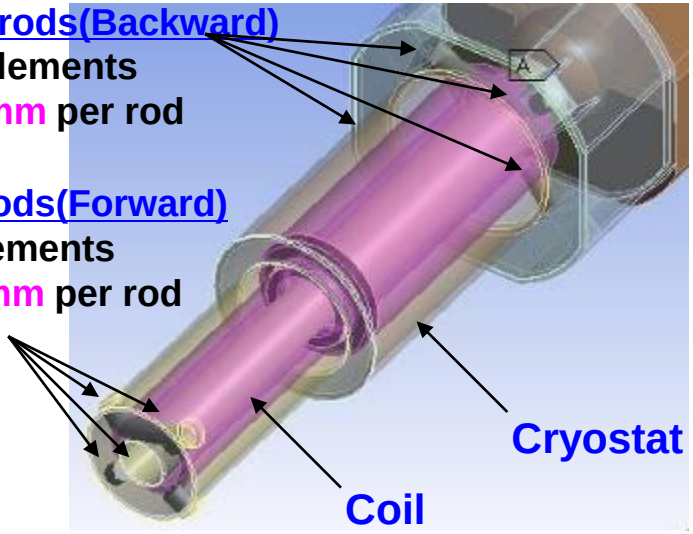


4. Support-rods(Backward)

→ Spring elements
k=6171kg/mm per rod

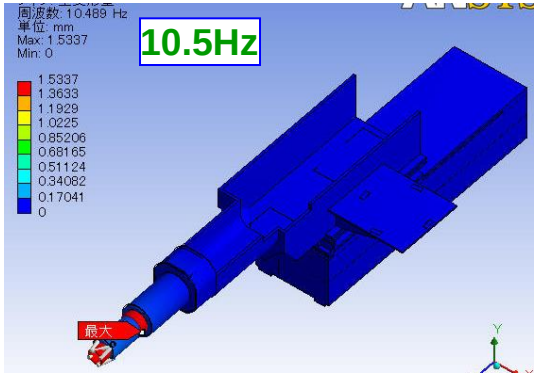
5. Support-rods(Forward)

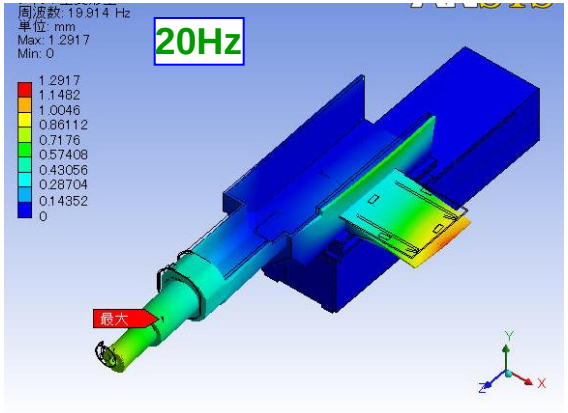
→ Spring elements
k=12521kg/mm per rod

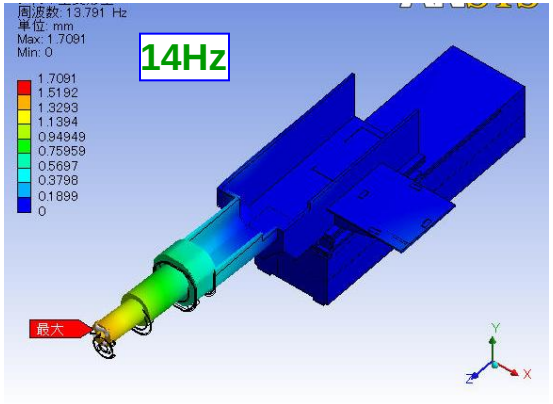


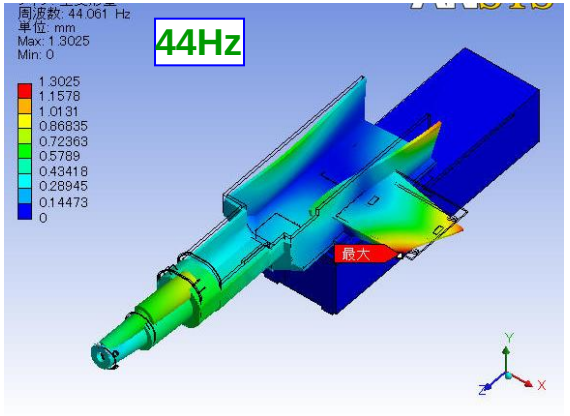
→ **Respond amplitude due to ground motion is calculated.**

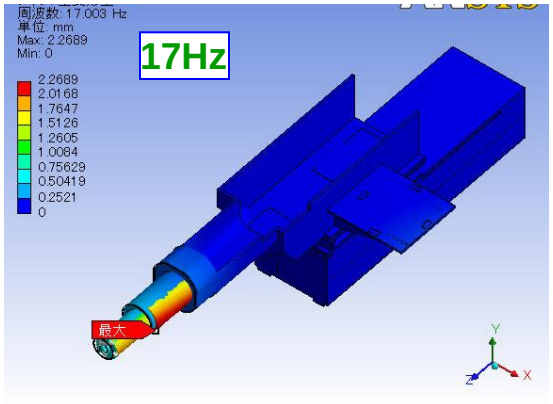
Modal calculation

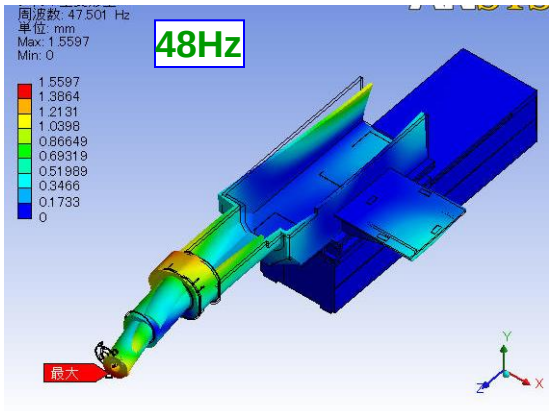




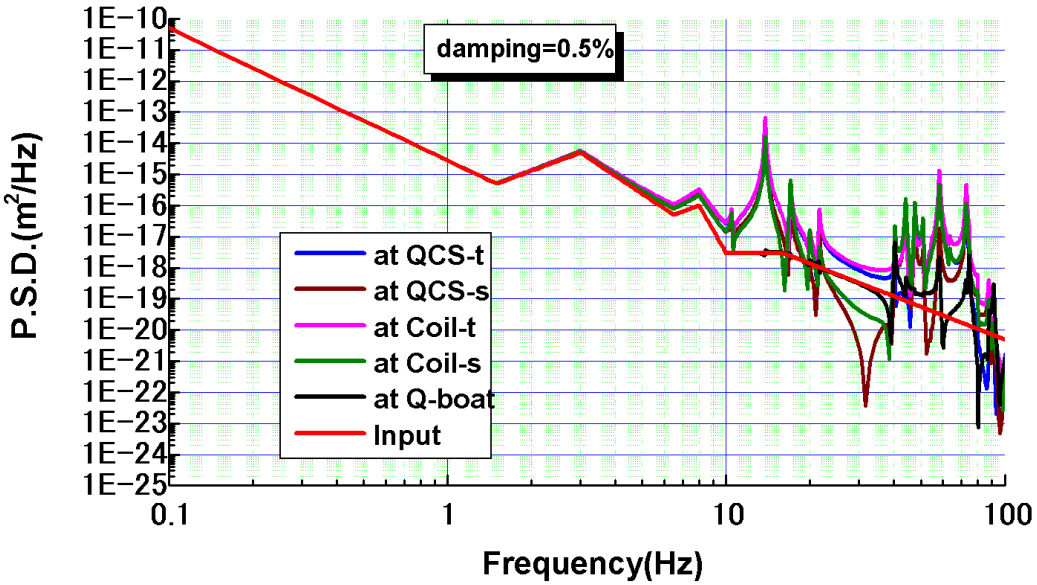


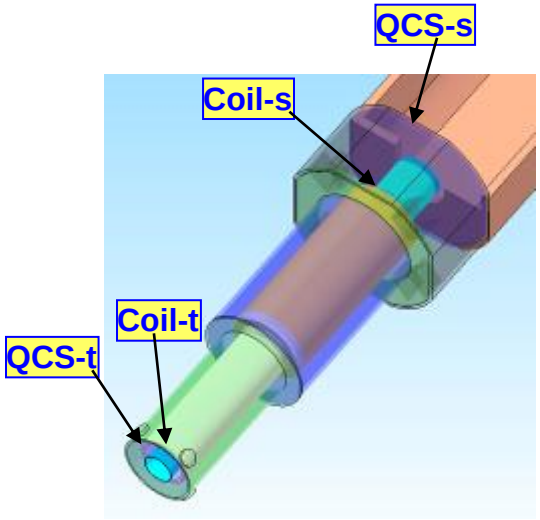


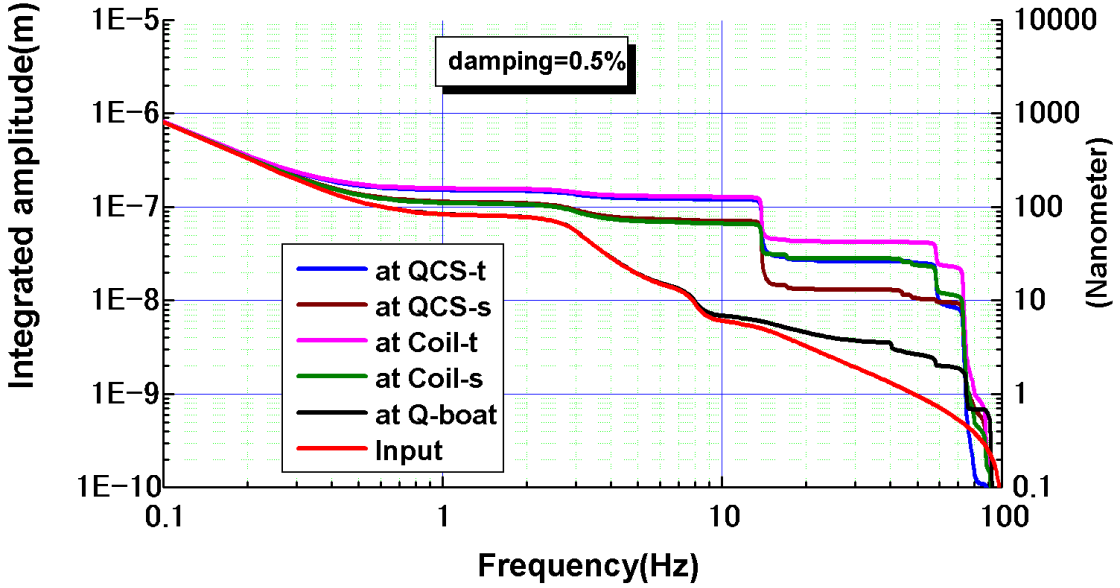




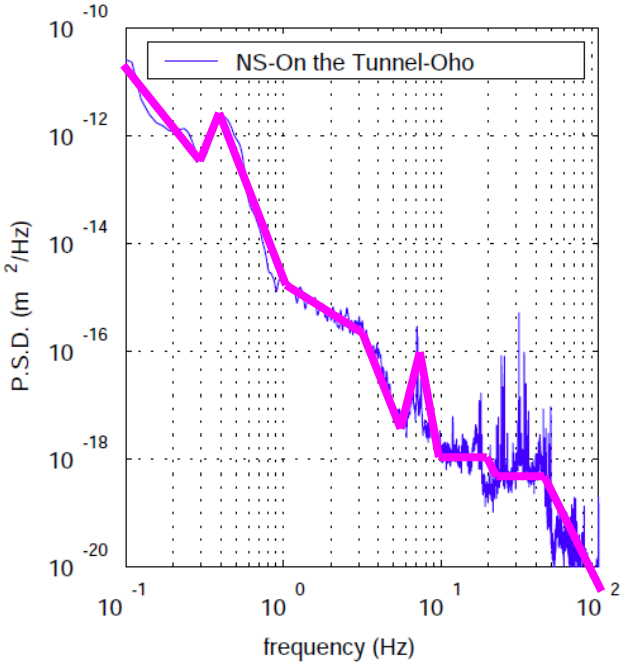
Response amplitude (*Vertical direction*)





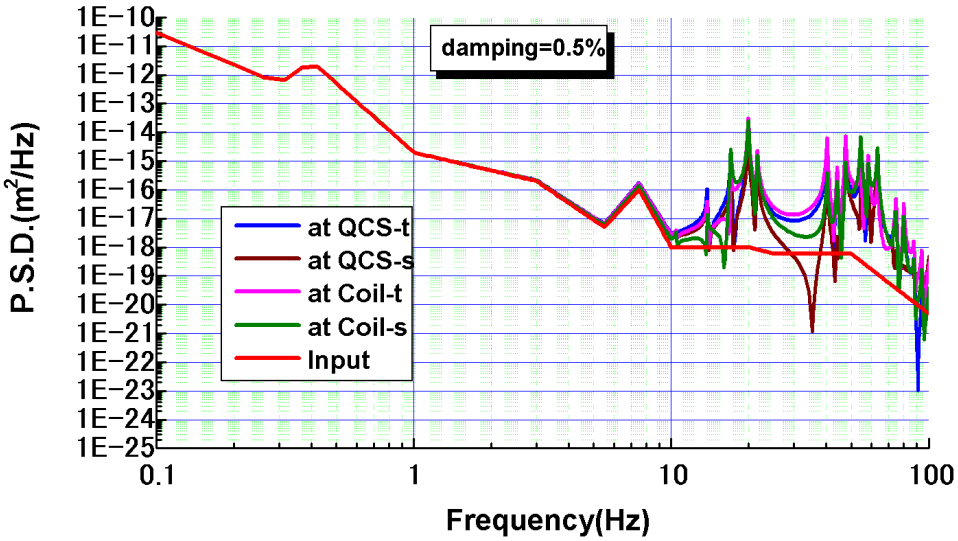


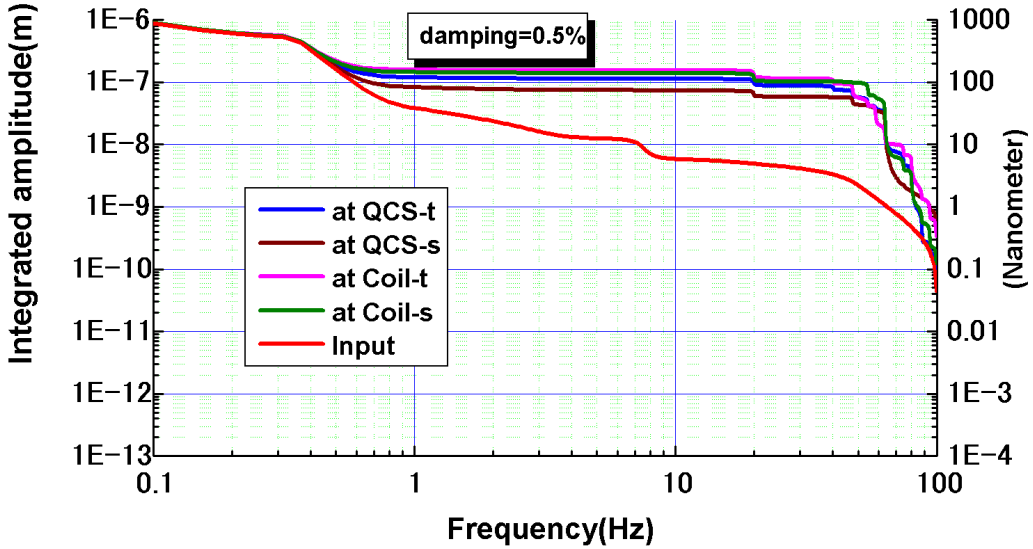
Response amplitude (*Horizontal direction*)



damping= 0.5%

Freq.(Hz)	P.S.D.(m²/Hz)
0.1	3e-11
0.3	5e-13
0.4	3e-12
1.0	2e-15
3.0	2e-16
5.5	5e-18
7.5	1e-16
10.	1e-18
20.	1e-18
25.	6e-19
50.	6e-19
100.	5e-21





Conclusion

1. Power Spectrum Density

Tunnel: H-dir.→ ~0.3Hz (Micro-seismic) , ~3Hz(Resonancy of soil)

V-dir.→ ~3Hz(Resonancy of soil)

Q-table, magnet→ Peak around 8Hz was measured additionally.

2. Influence of Air conditioner

A small difference was measured around 1~3Hz

→ No obvious differences.

3. Coherency

(1) Both sides of KEKB-tunnel (Nikko-side ←→ Oho-side)

No coherency except for ~0.3Hz and ~3Hz.

(2) Distance dependency

Frequency above 10Hz is getting worse.

4. Cooling effects

There is no big effects to vibration behavior. It occurs at just beginning of the cooling.

Integrated amplitude(nm)						
	>1Hz			>10Hz		
	Perpend	Beam	Vertical	Perpend	Beam	Vertical
B4 floor	50	46	67	4	3	9
KEKB floor	55	45	68	10	5	9
Mag.-table	90	50	76	12	16	19
QCS-boat	250	60	118	15	21	30
QC1RE	241	77	112	52	50	46
Belle stand	105	69	71	13	11	13

Further measurements/plan;

- BELLE solenoidal field with immune to magnetic fields(SP500).
- Vibration when beam is circulating with SP500.

・ Improving the magnet/BELLE/etc support structure.

Vertical direction tolerance
0.1μm at QC1
⇒ COD of ~ σy at the IP (By Y. Funakoshi)

- An orbital FB is needed.

No active cancellation system is considered at this point.

- We are thinking about something similar to the KEKB iBump system. → To next page...

Orbital FB

SuperKEKB iBump system

Made by Masuzawa-san.

Y.Funakoshi, M.Masuzawa+Magnet group+Monitor group

☆What to monitor to maintain luminosity

Beam-beam kick using BPM data.

☆Magnets to move the orbit

Vertical & horizontal steering magnets.

Probably two systems

(1)System for scanning (finding a good collision point)

(2)System for maintaining a good collision condition.

*The present iBump system does both (1)&(2).

☆Frequency that we deal with

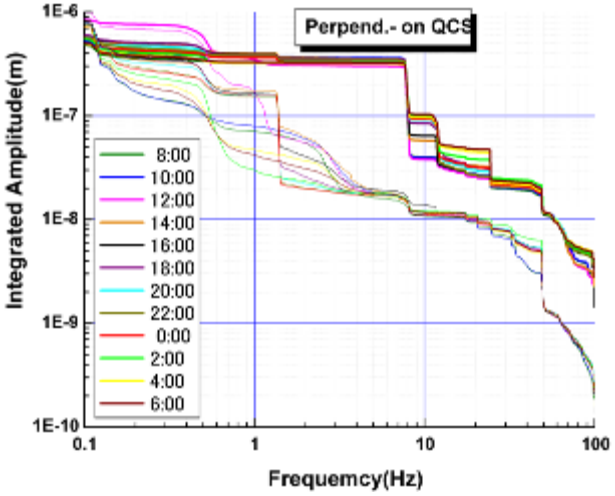
< 50 Hz (or 25Hz)

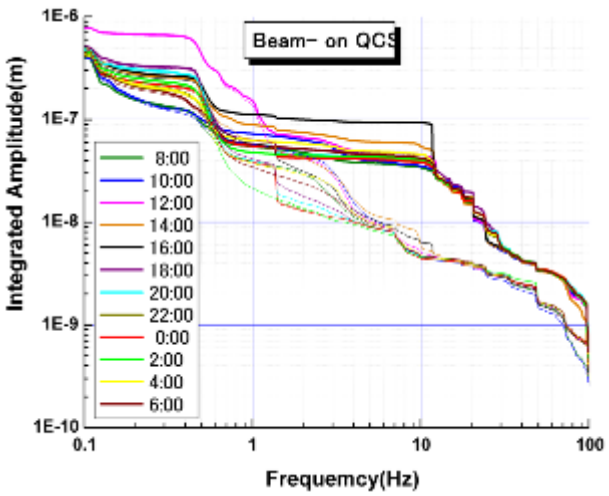
★A practice with one of the iBump magnets will be done in June.

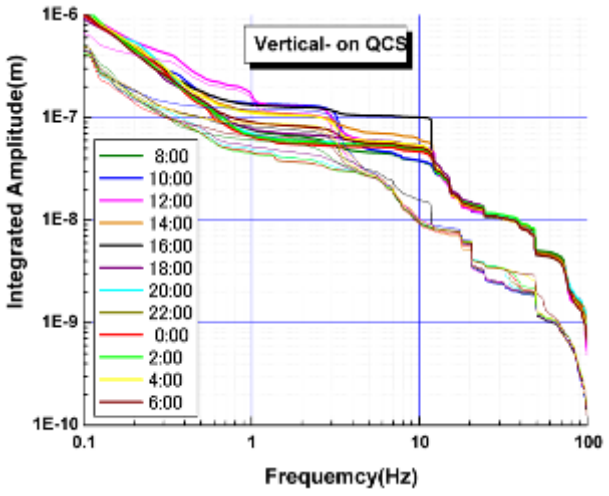
“Practice” does not mean actual FB, but to try to see the beam response to the magnet/power supply we have with the monitor group & magnetic field response to power supply.

Integrated amplitudes

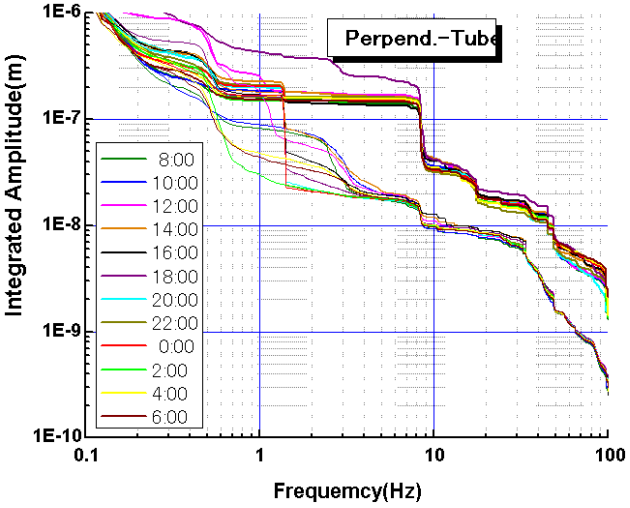
L: On the QCS

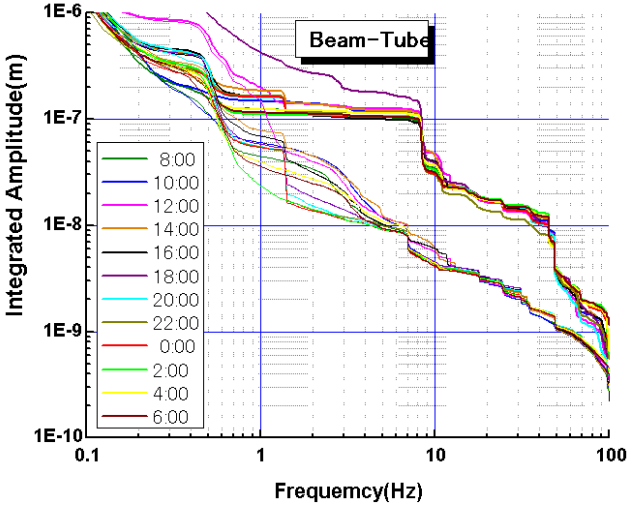


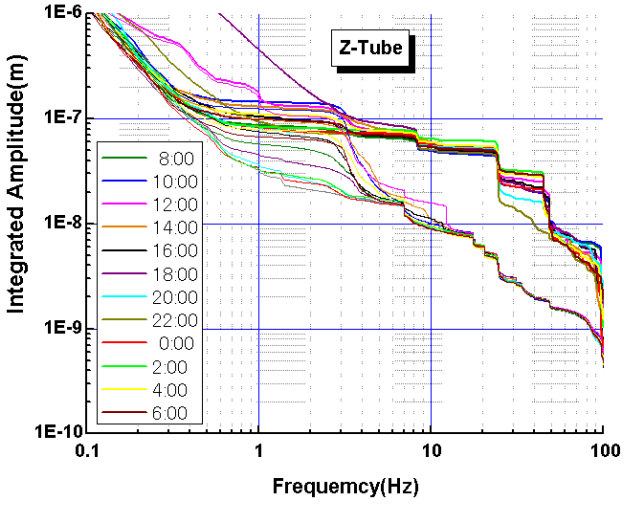




L: On the cooling tube







➔ **Amplitude in the perpendicular is bigger than others due to peak at 8Hz.**

Approaches to know vibration behavior

Ref.: ANSYS help file

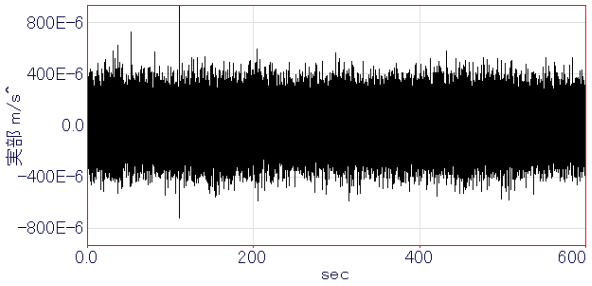
1. P.S.D. (Power Spectrum Density) analysis

A *PSD* is a statistical measure of the response of a structure to random dynamic loading conditions. It is a graph of *the PSD value versus frequency*, where the PSD may be a displacement PSD, velocity PSD, acceleration PSD, or force PSD. Mathematically, the area under a PSD-versus-frequency curve is equal to the variance (square of the standard deviation of the response).

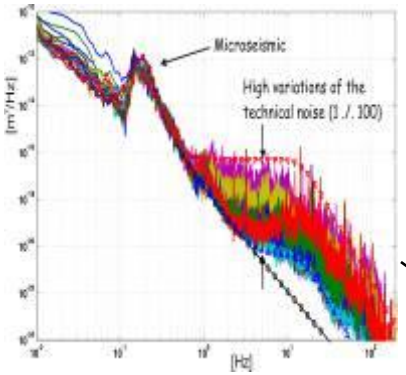
2. Spectrum (SPRS) analysis

A *response spectrum* represents the *response* of single-DOF systems to a time-history loading function. It is a graph of response versus frequency, where the response might be displacement, velocity, acceleration, or force. Two types of response spectrum analysis are possible: single-point response spectrum and multi-point response spectrum.

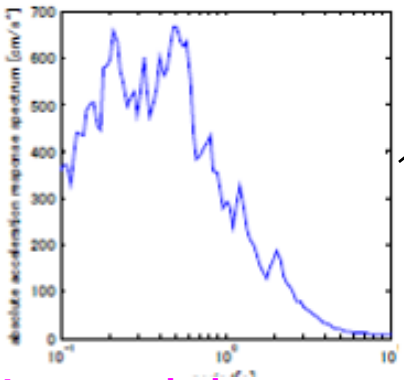
Measure ground motion



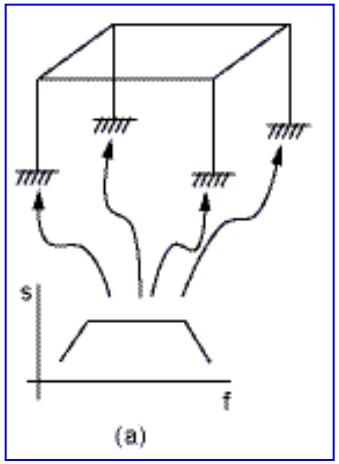
1. P.S.D.



2. Make R. spectrum



Input each data to constraints positions.



Get respond amplitude/stress at each position.