

Vibration measurement of a big detector system in the moving

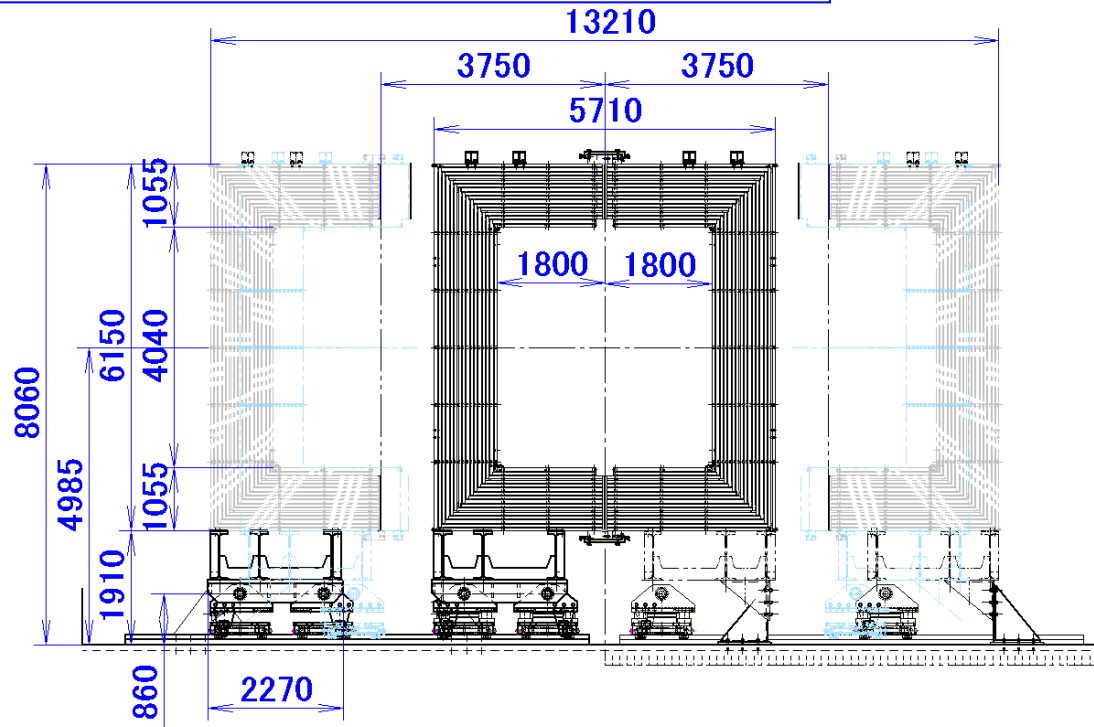
KEK **Hiroshi Yamaoka**
Toshifumi Tsukamoto

Introduction

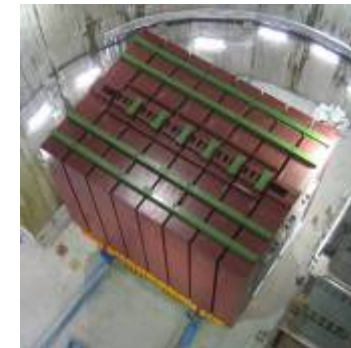
(Neutrino Facility @J-Parc)



ND280 detector (Total: 1000tonnes)



(Closed position)



(Open position)



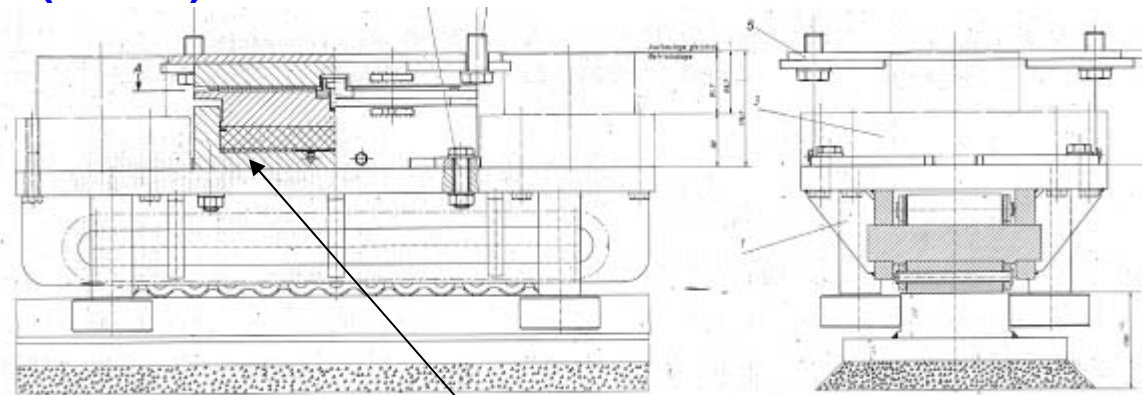
Magnet Moving System



Procedure of the moving.

- Clamp the rail.
- Pulling the yoke.
- Un-clamp the rail.
- Extend the piston.

(Roller)



Oil Damper

Vibration Measurement

(South-side yoke, Jan. 15, 2009)



NP3560B
Piezo tri-axial acc. sensor
 $1\text{mV}=1\text{m/s}^2$
2~5kHz
This sensor was stuck on the support stand.



LION LS10C
Servo accelerometer
 $0.3\text{V}=1\text{m/s}^2$
DC~40Hz
 $<10^{-5}\text{m/s}^2$
These sensors were stuck on the roller.

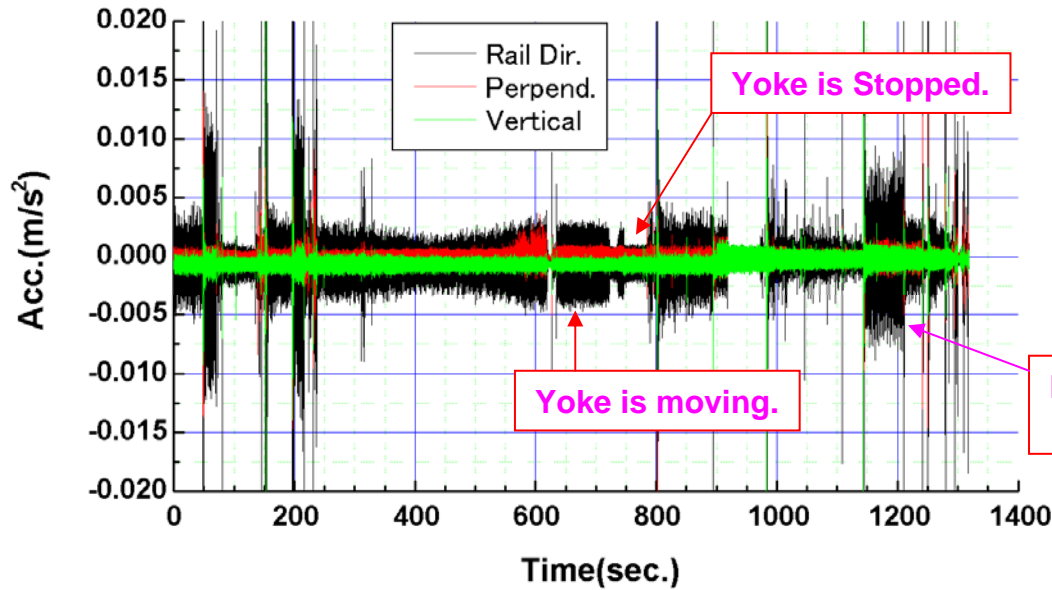
(North-side yoke, Jan. 16, 2009)



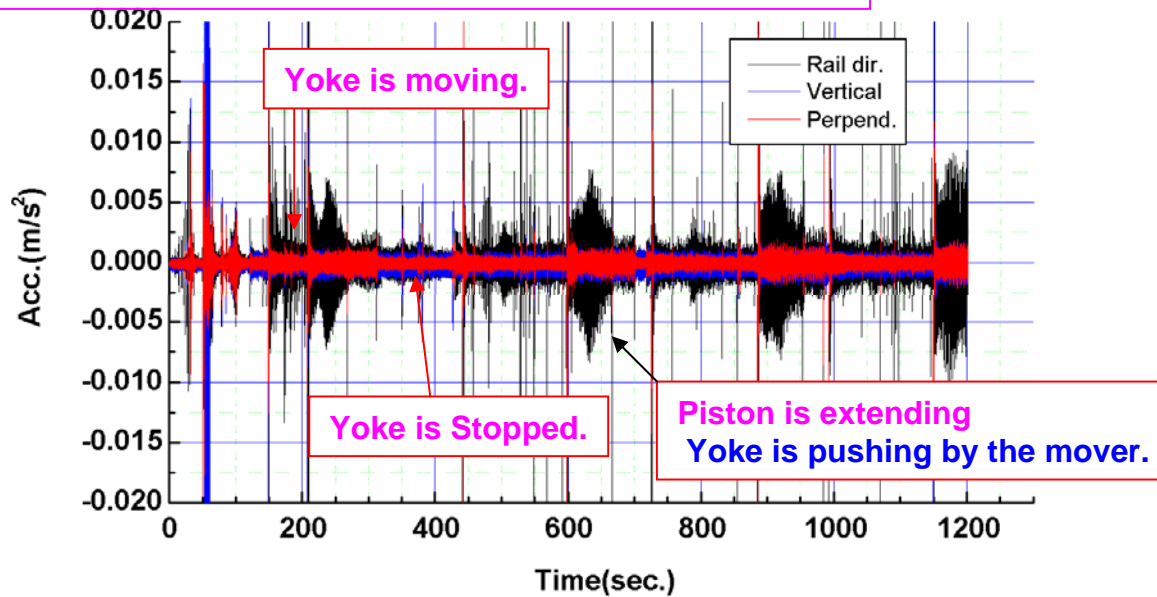
All sensors were stuck on the roller. 4

Measurement results

Time data- On the roller (@South yoke)

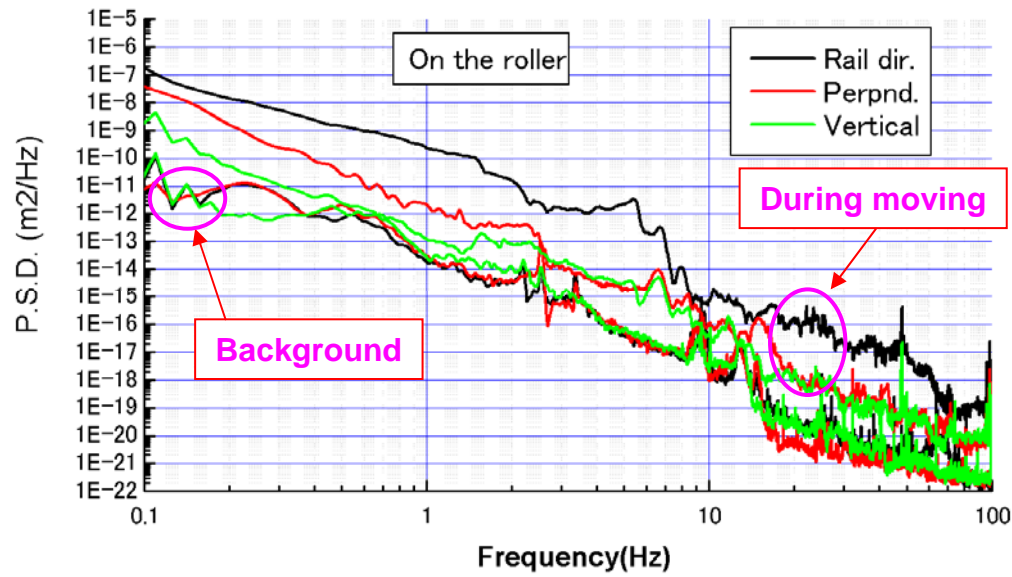


Time data- On the support stand (@North yoke)

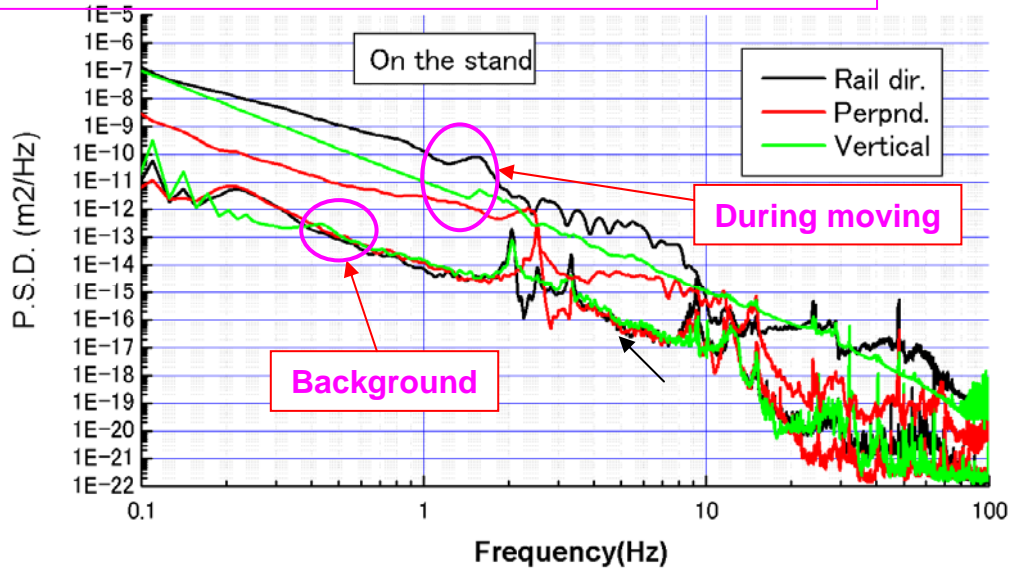


- Piezo-sensor couldn't detect these vibrations.

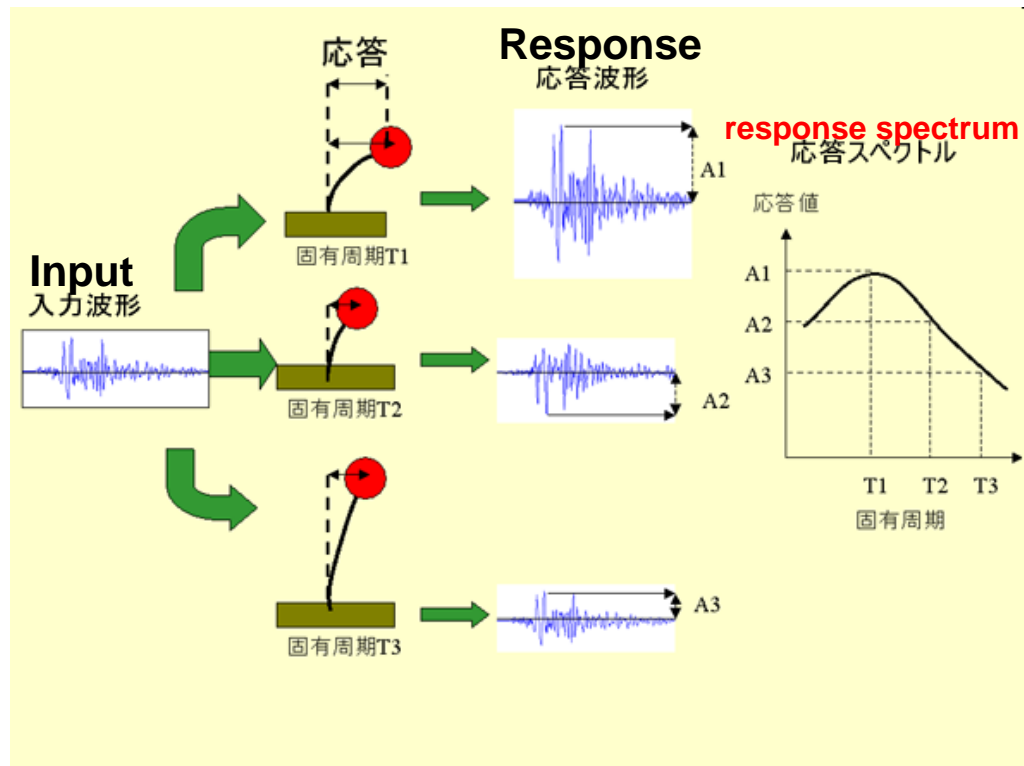
Time data- On the roller (@South yoke)



Time data- On the support stand (@North yoke)



Calculations of response spectrum from data



$$m\ddot{x}_i + c\dot{x}_i + kx_i = -m\ddot{z}_i$$

$$m\ddot{x}_{i+1} + c\dot{x}_{i+1} + kx_{i+1} = -m\ddot{z}_{i+1}$$

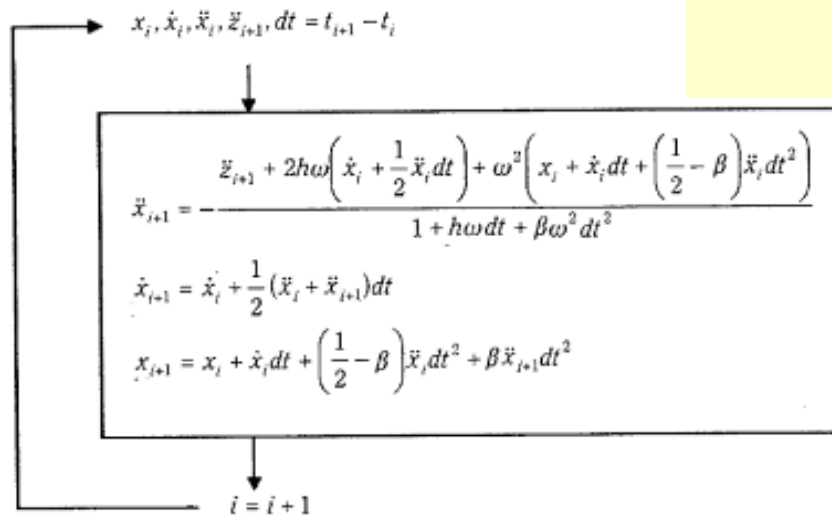


図4.22 Newmarkのβ法

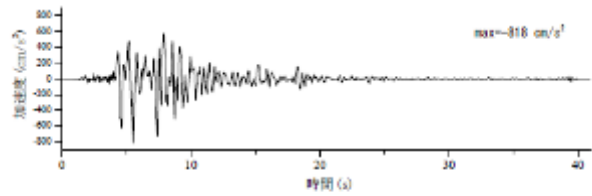
From Wikipedia, the free encyclopedia

A **response spectrum** is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of [oscillators](#) of varying [natural frequency](#), that are forced into motion by the same base [vibration](#) or [shock](#). The resulting plot can then be used to pick off the response of any [linear](#) system, given its natural frequency of oscillation. The science of [strong ground motion](#) may use some values from the ground response spectrum.

Damping must be present, or else the response will be infinite. For transient input (such as seismic ground motion), the peak response is reported. Some level of damping is 7 generally assumed.

For example..

(Kobe earthquake)



Response: Acc.

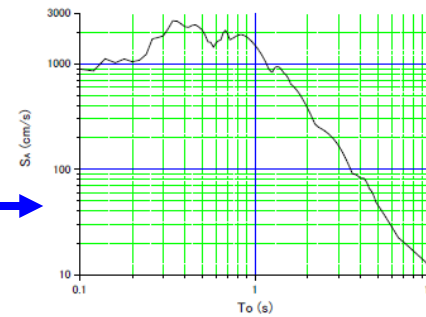


図4 加速度応答スペクトル ($h=0.05$)

Response: Velo.

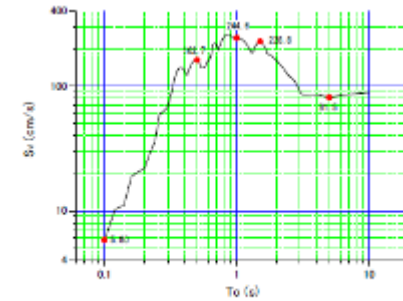


図3 速度応答スペクトル ($h=0.05$)

図1 1995年兵庫県南部地震のときに神戸海洋気象台で観測された南北方向の地動加速度

Response: Amp.

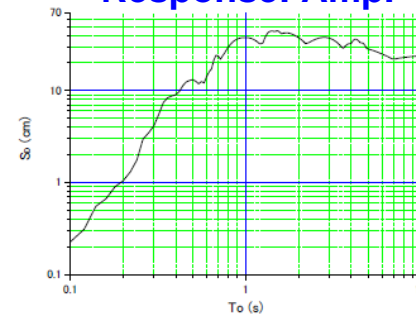
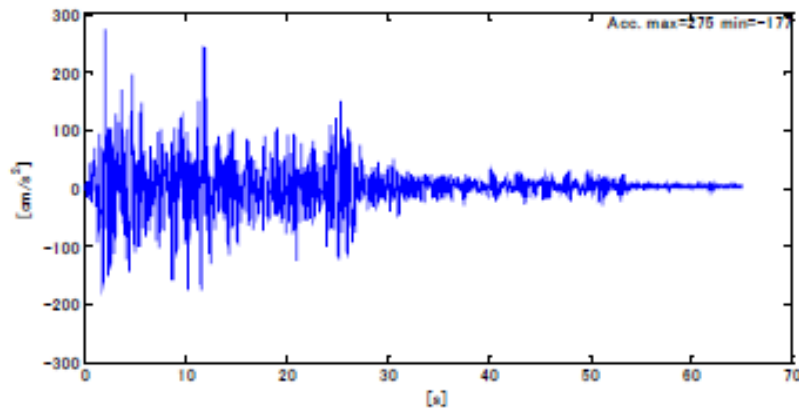
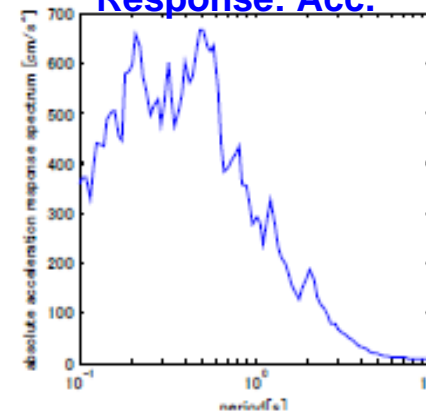


図5 変位応答スペクトル ($h=0.05$)

(Elcentro earthquake)



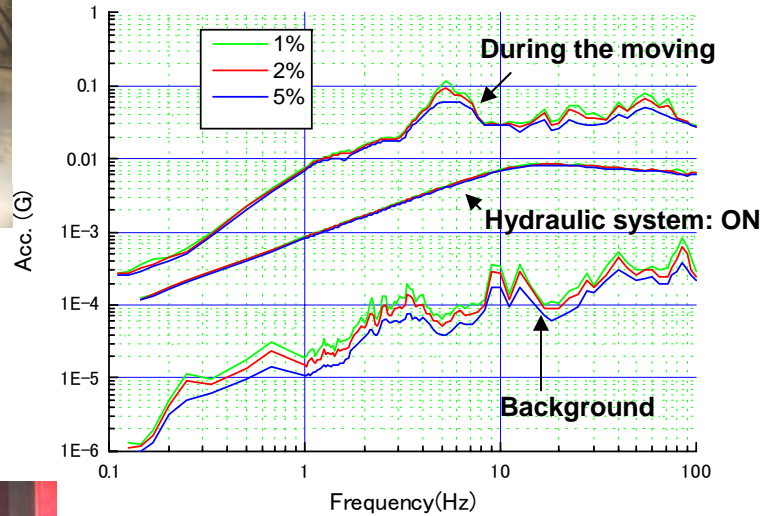
Response: Acc.



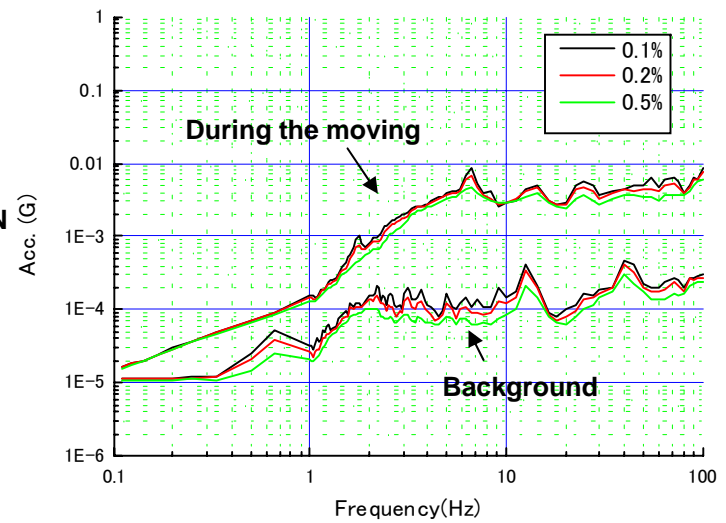
Measurement results



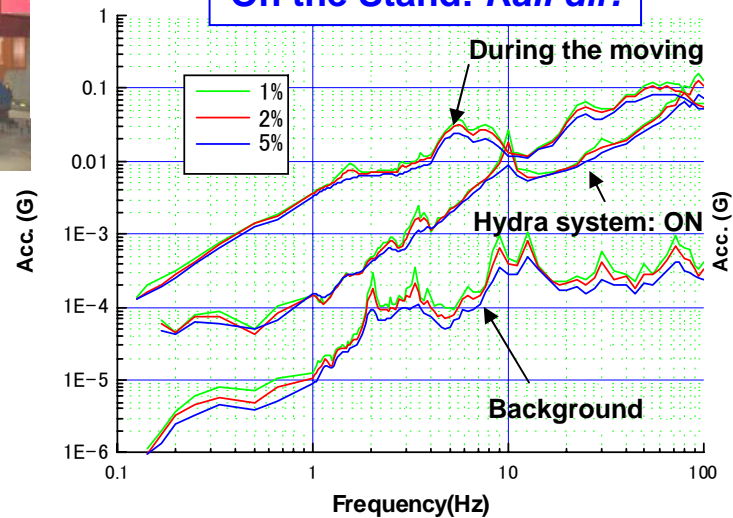
On the roller: Rail dir.



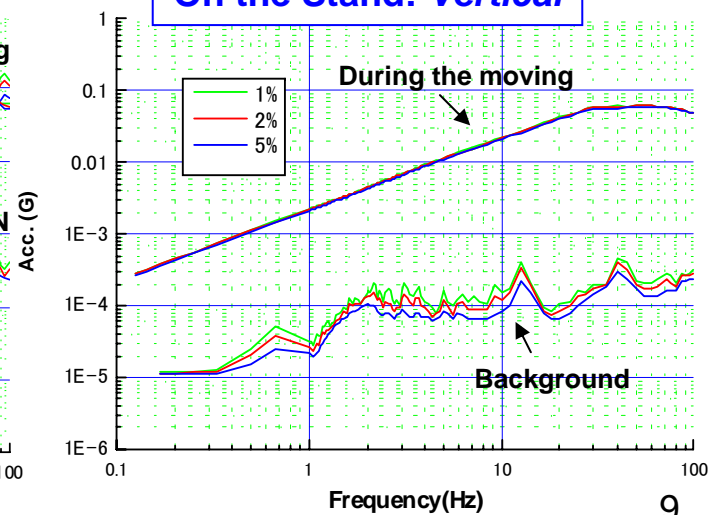
On the roller: Vertical



On the Stand: Rail dir.



On the Stand: Vertical



Conclusion

Results

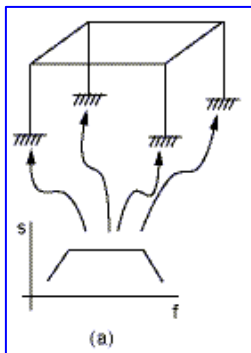
Vibration measurement during the moving on the rail was carried out.

- Neutrino detector at J-Parc
- Weight is 1000t total consists of two iron yokes.
- 4-rollers in one yoke used for moving.
- Peak frequency was measured to 10Hz - 50Hz.
- Response acceleration was measured to 0.1G in rail direction, 0.01G in vertical.

Next step

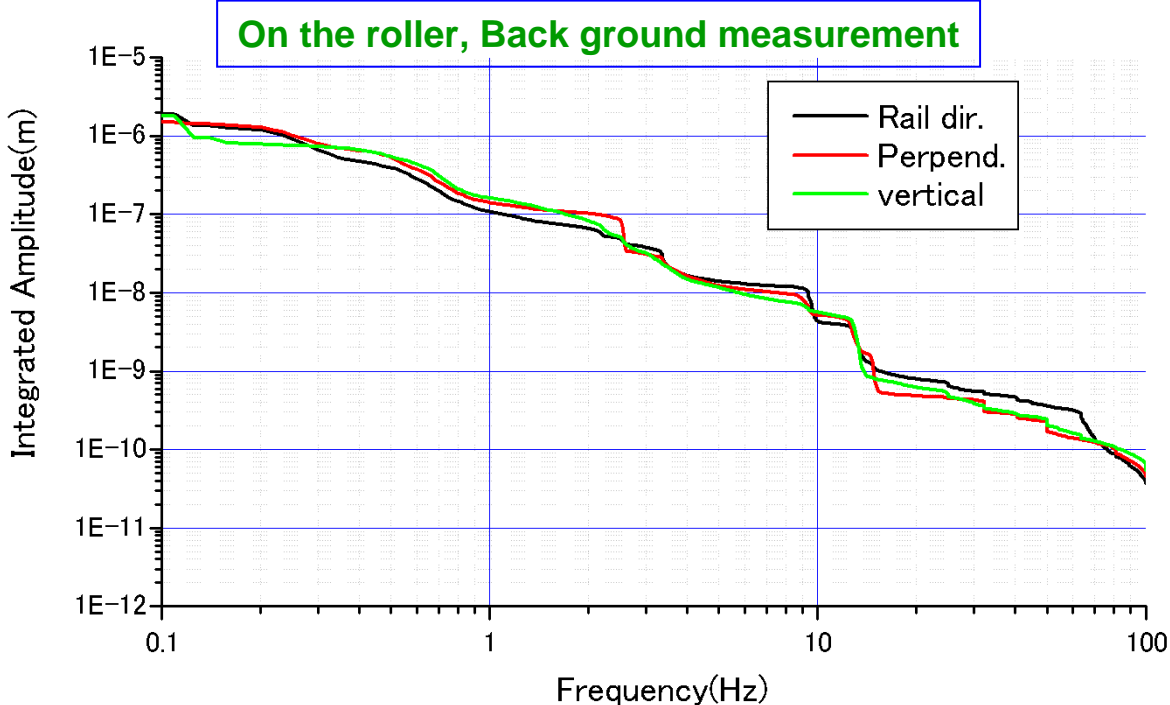
Perform Single-Point Response Spectrum (SPRS) with ANSYS.

→ To estimate deformation, stress of each point of structure.

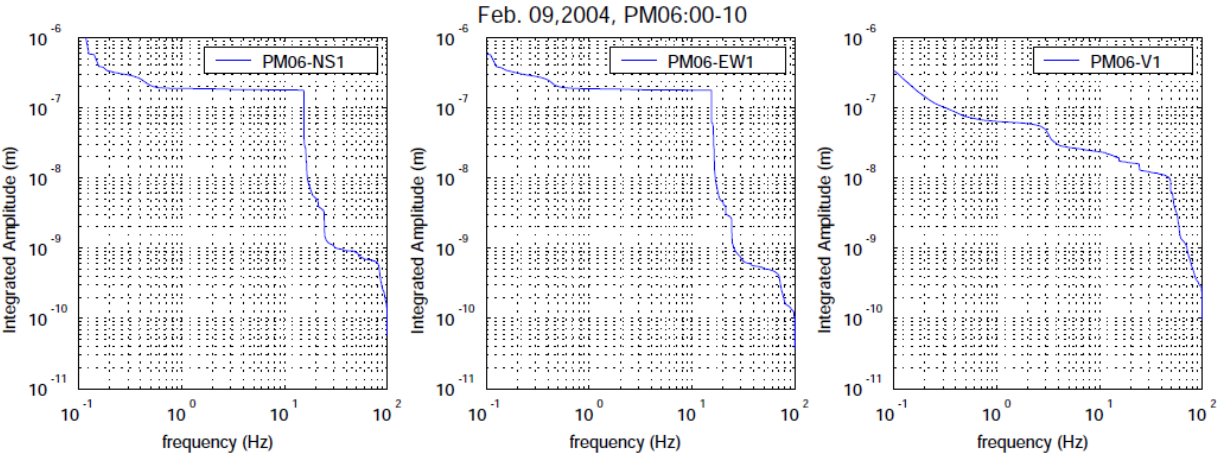


Ref.

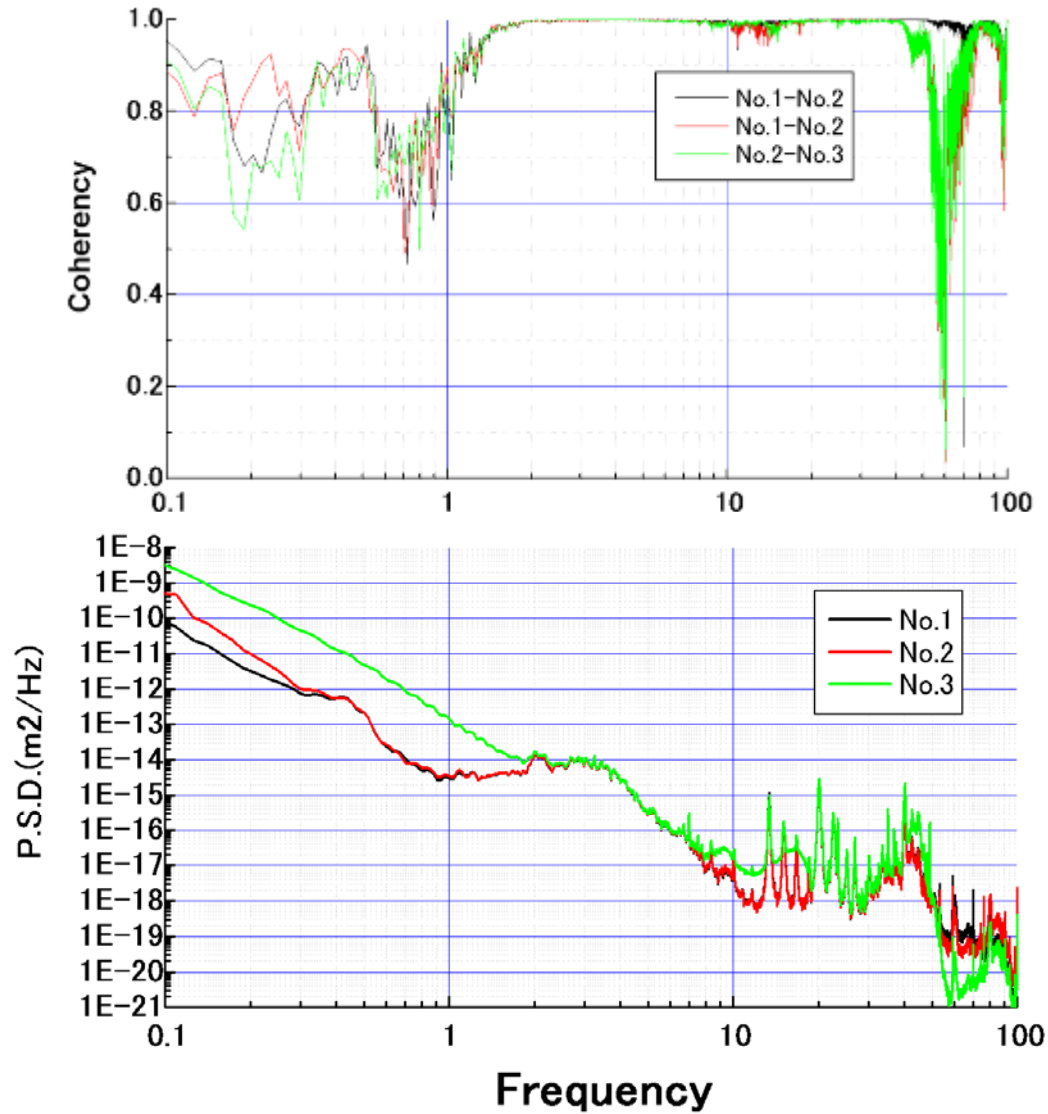
Integrated Amplitude



On the floor at ATF beam line



Sensor check



The **spectral coherence** is a **statistic** that can be used to examine the relation between two **signals** or **data** sets. It is commonly used to estimate the **power** transfer between input and output of a **linear system**.

$$\gamma_{xy} = \frac{|G_{xy}|^2}{G_{xx}G_{yy}}$$

where G_{xy} is the cross-**spectral density** between x and y , and G_{xx} and G_{yy} the autospectral density of x and y respectively.

3. サーボ加速度センサの構成

サーボセンサは図1に示すように振り子、振り子位置検出器、振り子に電気力を作用させるアクチュエータ、装置全体を制御する電器回路の四つの部分で構成されています。外部からの加速度が作用するのは振り子です。重りとバネによる振り子はバネの片端がケースに固定されていて、加速度が加わるとケースに対して変位します。振り子の重りの質量は概ね1g程度ですがバネが非常に柔らかいため共振周波数は非常に低くなっており、僅かな加速度でも振り子は大きく変位します。

振り子のケースに対する変位は、振り子の共振周波数よりも低い周波数域では加わる加速度に比例しています。

振り子位置検出器は振り子のケースに対する位置変位を検出するセンサです。振り子位置検出器はコンデンサ式、光学式等の方式がありますが、LS-10シリーズでは独自の光学式を採用しています。これについては次項で説明します。

アクチュエータは振り子に取り付けられるコイルとケースに取り付けられる磁気回路で構成されています。この構成はマグネットとコイルを使用した動電型スピーカーのようなもので、コイルに電流を流して振り子に電磁力を作用させるために使用されます。

電気回路は振り子位置検出器で得られた電気信号を増幅してアクチュエータのコイルに電流を流すために使用されます。

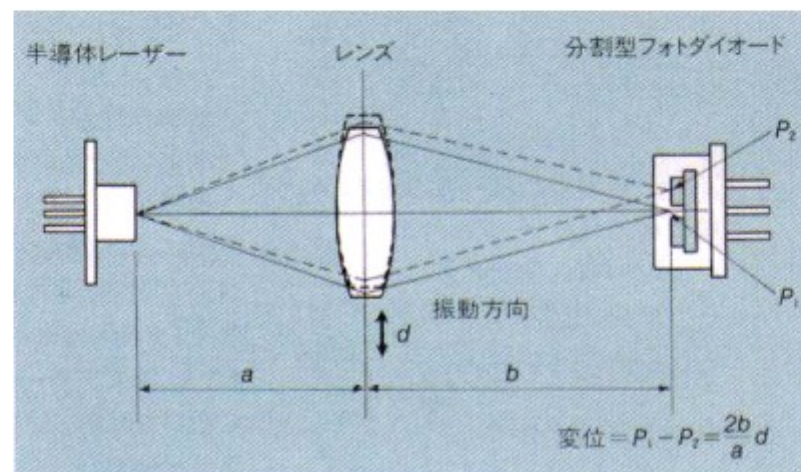


図1 LS-10検出部の構造

$$X(f) = \int_{-\infty}^{\infty} x(t) \exp(-j2\pi ft) dt \quad \text{-----} \quad (4)$$

$$x(t) = \int_{-\infty}^{\infty} X(f) \exp(j2\pi ft) df \quad \text{-----} \quad (5)$$

式 (4) は、 $x(t)$ のフーリエ変換、式 (5) は $X(f)$ の逆フーリエ変換と呼ばれ、この一対の式はフーリエ変換対またはフーリエ積分対と呼ばれます。