Ground Motion at Various Sites in Japan

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Motivation of this study

- The beam size at the interaction point is very small in a future very high energy electron-positron linear collider.
  The vertical beam size is about 6nm at the interaction point (IP) in the ILC.

--> Relative stability of the vertical position between final focusing quadrupole magnets installed at both sides of IP is required to be higher than 1nm.
In the frequency region higher than 10Hz, the stability of about 10nm is also required in the BDS area and 30nm in the main linac area.

The stability of the ground is one of important issues for the construction of a future very high energy electron-positron linear collider.

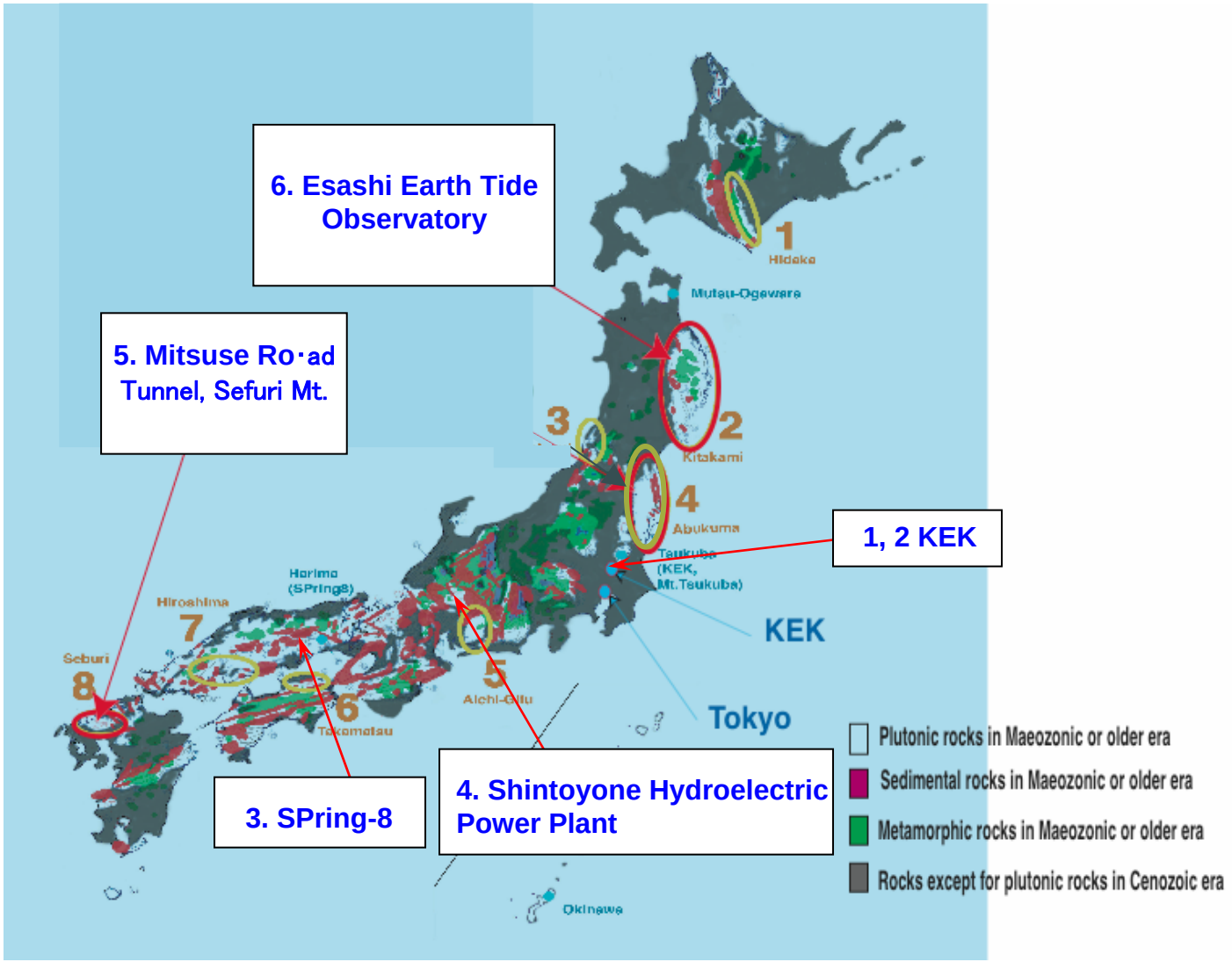
Contents

1. Comparizon of GM (Ground Motion) at various sites in Japan

2. Influence of traffic nearby to the GM

3. GM at the time of an earthquake

Measured Sites



Measured Sites (cont.)

Pont 1: Surface near to the D9 electric power station of KEKB at KEK
Geology -- Kanto diluvium formation

Pont 2: KEKB tunnel near to the D9 electric power station at KEK
10m deep underground
Geology -- Kanto diluvium formation

Pont 3: Bottom of the access tunnel of Shintoyone Hydroelectric Power Plant
Geology -- granite layer

Pont 4: On the crop of bedrock in the west area of SPring-8
Geology -- Kamigori metagabbro layer

Pont 5: Refuge of Mitsuse road tunnel in Sefuri Mountain, Saga
Geology -- granite layer

Pont 6: Esashi Earth Tide Observatory of Mizusawa Astronomical Obsevatory
Geology -- granite layer

Measured Sites and Instruments (cont.)

KEK site is soft ground area (alternative layers of sand, clay and gravel).
The other areas are hard rock areas.

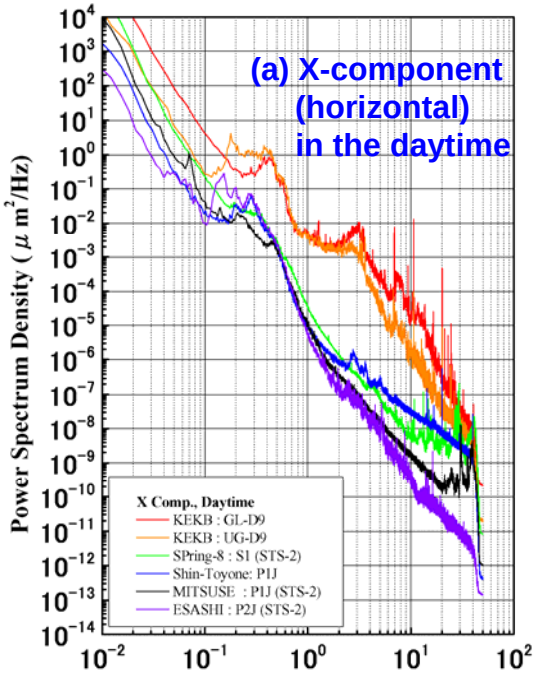
Ground motion was measured with velocity sensors:

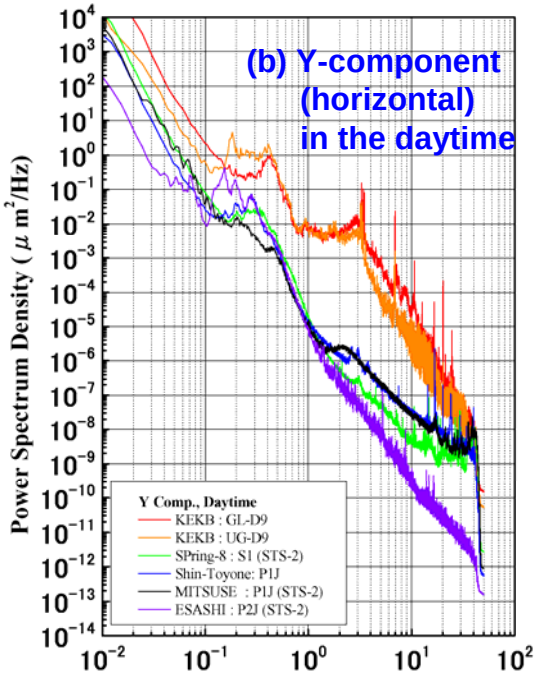
VSE355G2 of Tokyo Sokushinn Co., Ltd.
at the points 1 - 3

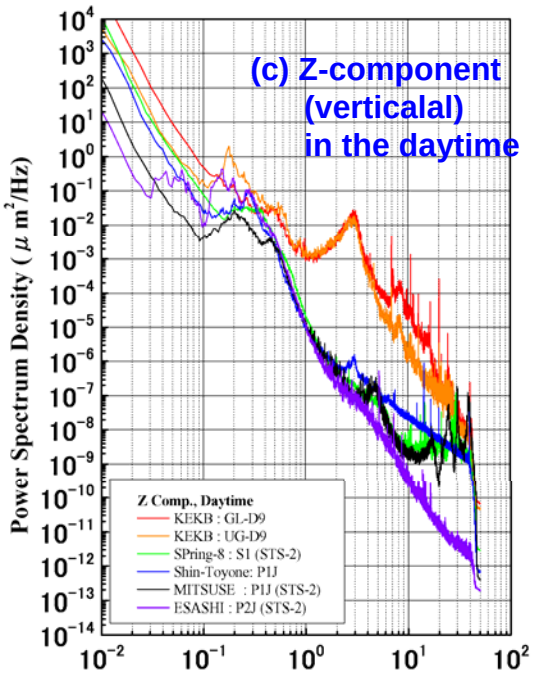
STS-2 of G. Streckeisen AG
at the points 4 - 6.

	VSE355G2	STS-2
Frequency range (Hz):	0.012 - 70	0.00833 - 50
Sensitivity (V/kine):	2.5	15

(* kine = cm/sec)


(a) X-component
(horizontal)
in the daytime
Power Spectrum Density (μ m²/Hz)
X Comp., Daytime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)


(b) Y-component
(horizontal)
in the daytime
Power Spectrum Density (μ m²/Hz)
Y Comp., Daytime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)


(c) Z-component
(verticalal)
in the daytime
Power Spectrum Density (μ m²/Hz)
Z Comp., Daytime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
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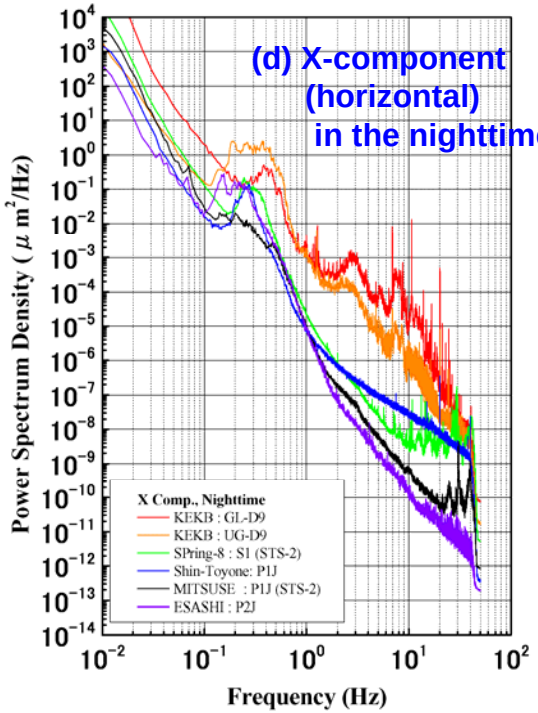
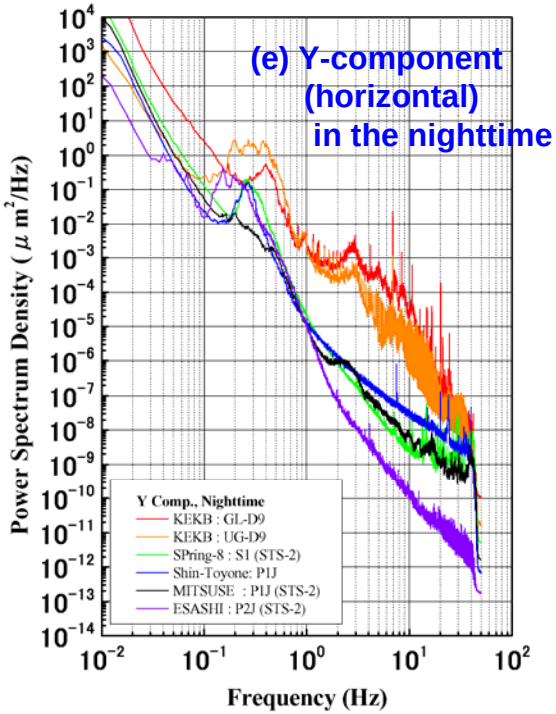
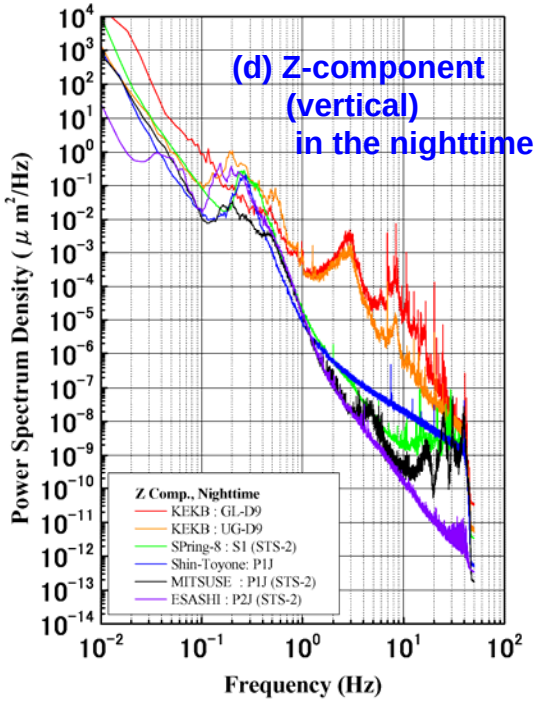
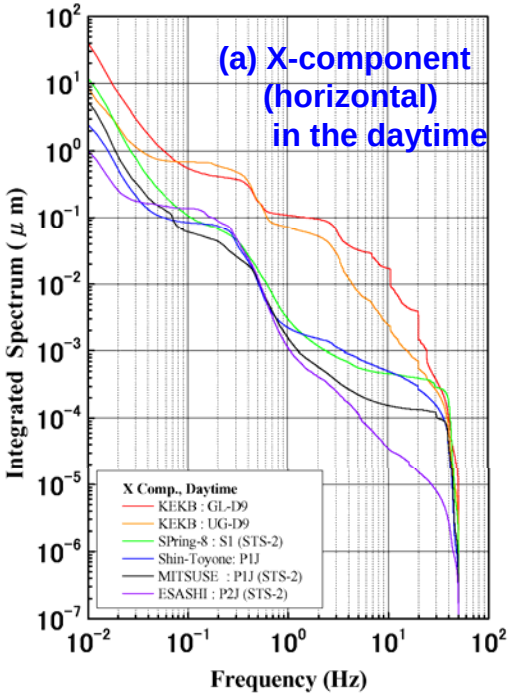
ESASHI : P2J (STS-2)


(d) X-component
(horizontal)
in the nighttime
Power Spectrum Density (μ m²/Hz)
X Comp., Nighttime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J
Frequency (Hz)


(e) Y-component
(horizontal)
in the nighttime
Power Spectrum Density (μ m²/Hz)
Y Comp., Nighttime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)
Frequency (Hz)


(d) Z-component
(vertical)
in the nighttime
Power Spectrum Density (μ m²/Hz)
Z Comp., Nighttime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)
Frequency (Hz)


(a) X-component
(horizontal)
in the daytime
Integrated Spectrum (μ m)
Frequency (Hz)
X Comp., Daytime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
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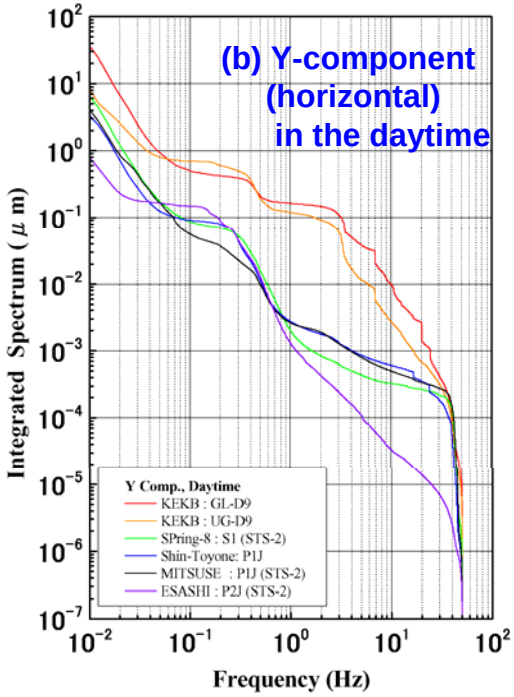
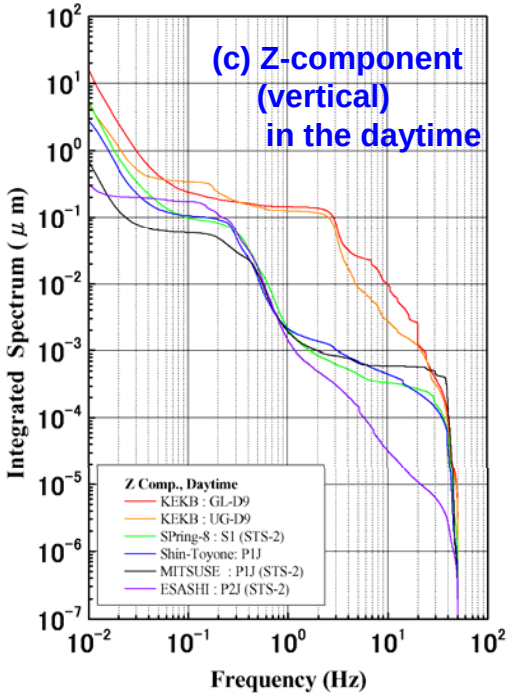

(b) Y-component
(horizontal)
in the daytime
Integrated Spectrum (μ m)
Frequency (Hz)
Y Comp., Daytime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)


(c) Z-component
(vertical)
in the daytime
Integrated Spectrum (μ m)
Frequency (Hz)
Z Comp., Daytime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
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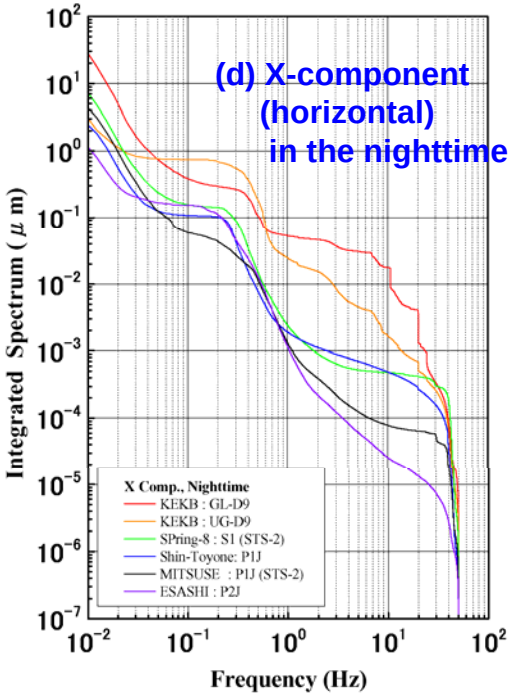
(d) X-component
(horizontal)
in the nighttime
Integrated Spectrum (μ m)
Frequency (Hz)
X Comp., Nighttime
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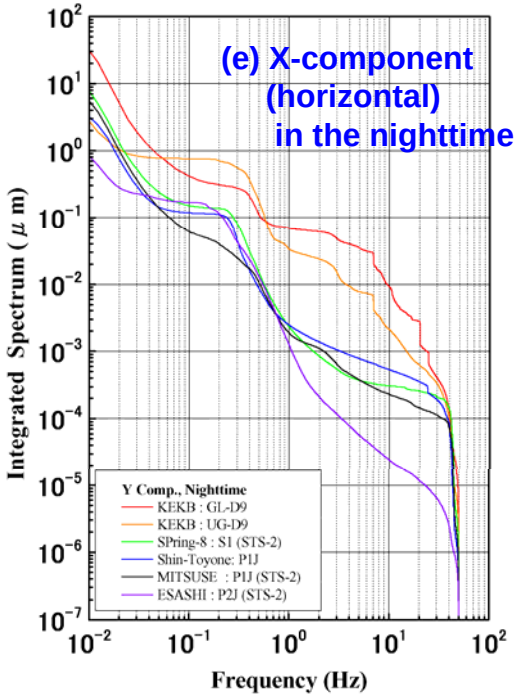
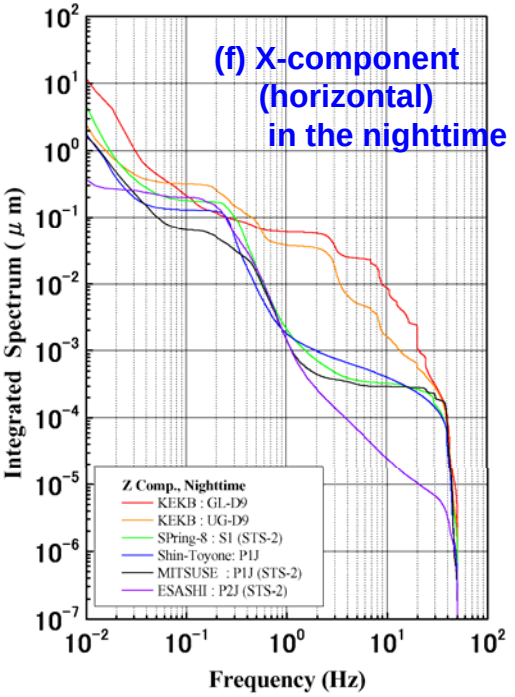
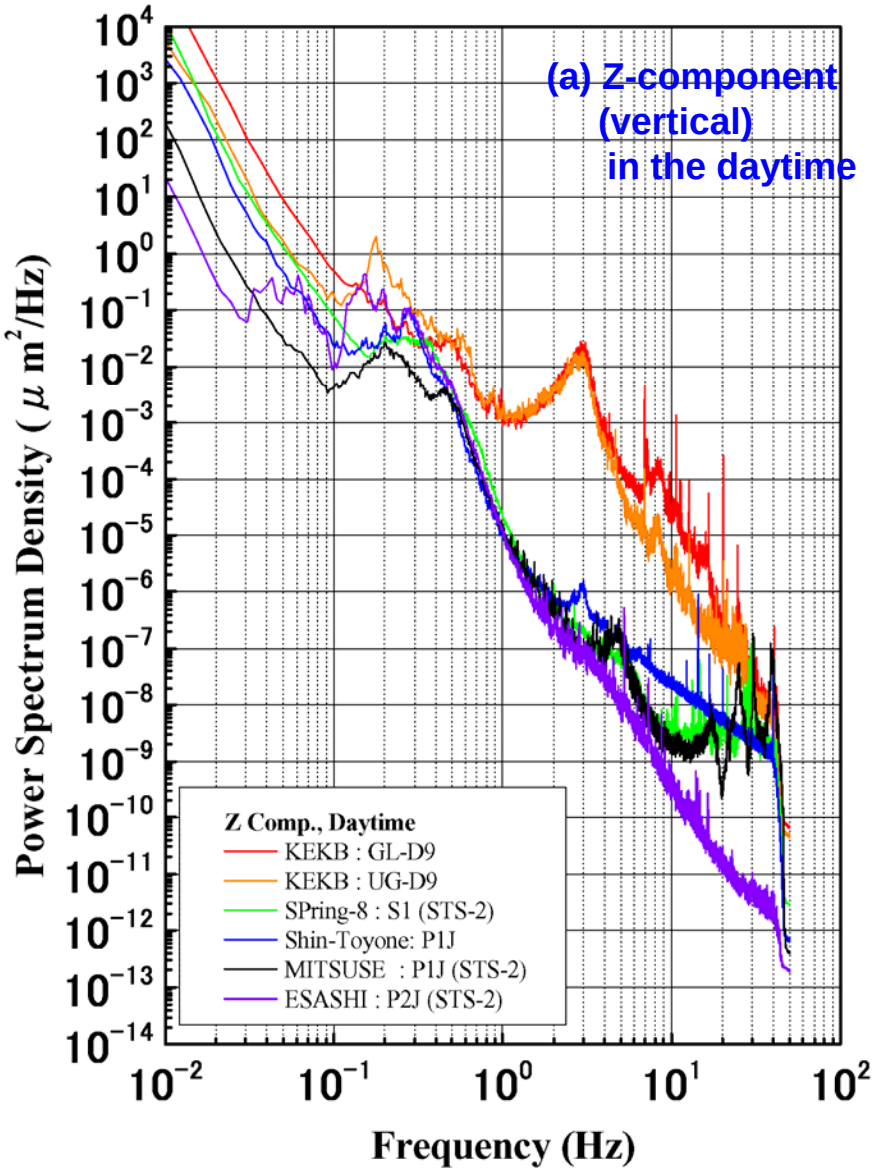
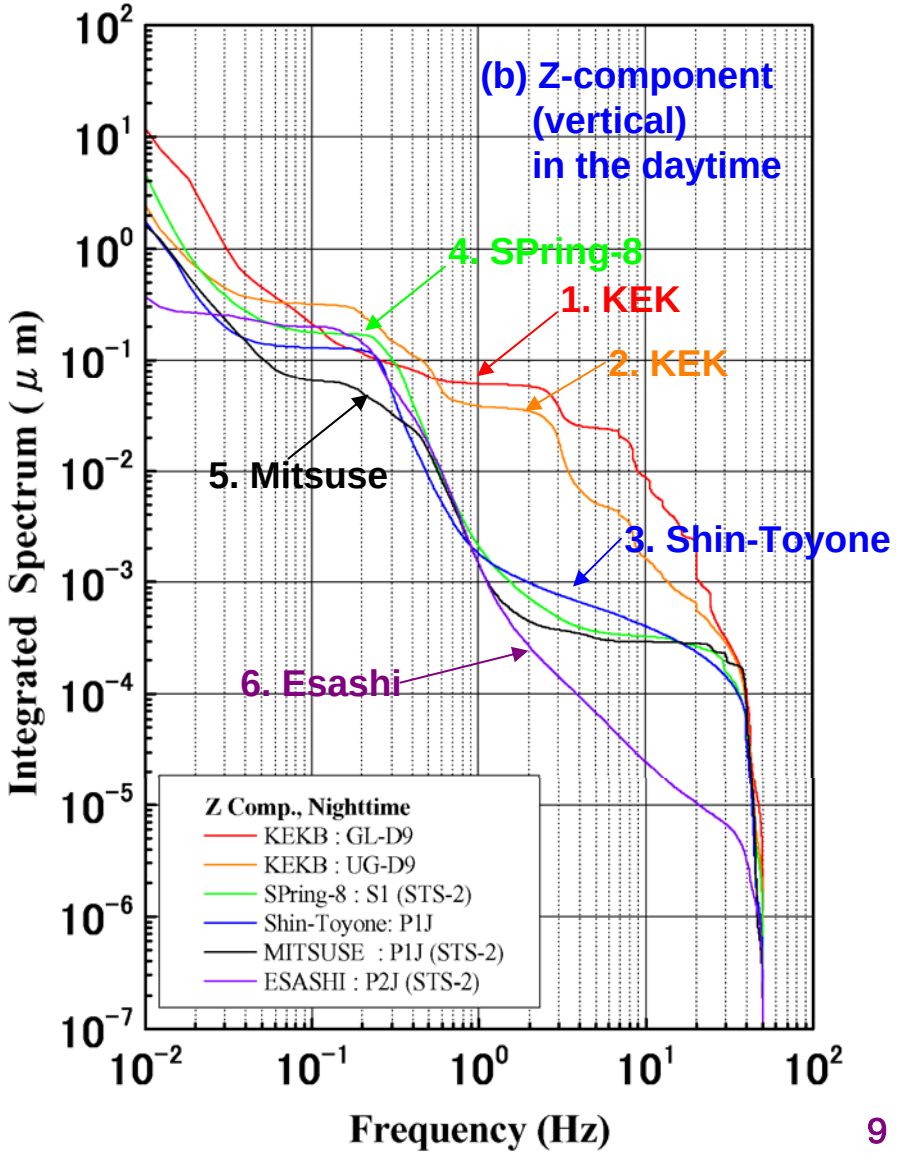

(e) X-component
(horizontal)
in the nighttime
Integrated Spectrum (μ m)
Frequency (Hz)
Y Comp., Nighttime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)


(f) X-component
(horizontal)
in the nighttime
Integrated Spectrum (μ m)
Frequency (Hz)
Z Comp., Nighttime
KEKB : GL-D9
KEKB : UG-D9
SPring-8 : S1 (STS-2)
Shin-Toyone: P1J
MITSUSE : P1J (STS-2)
ESASHI : P2J (STS-2)

Power Spectrum Density



Integrated Spectrum (Square root of integrated PSD)

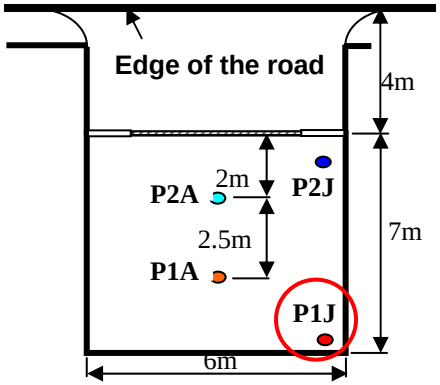


Characteristics of Spectra

- Amplitude of spectrum density and the integrated spectrum for KEK are larger by 2-4 orders of magnitude and 1-2 orders of magnitude respectively than those for the hard rock area. This is because the KEK site is located in the soft ground area and close to a main road.

- Peak is observed clearly in the KEK site around 3Hz which is said to be caused by artificial vibrational noises such as traffic, motors, etc. This peak around 3Hz is not observed or quite small in the hard rock sites.

- It is interesting that the amplitude of the spectra for Mitsuse road tunnel is as small as those for SPring-8 in spite of frequent traffic near by in the frequency region higher than 1Hz.

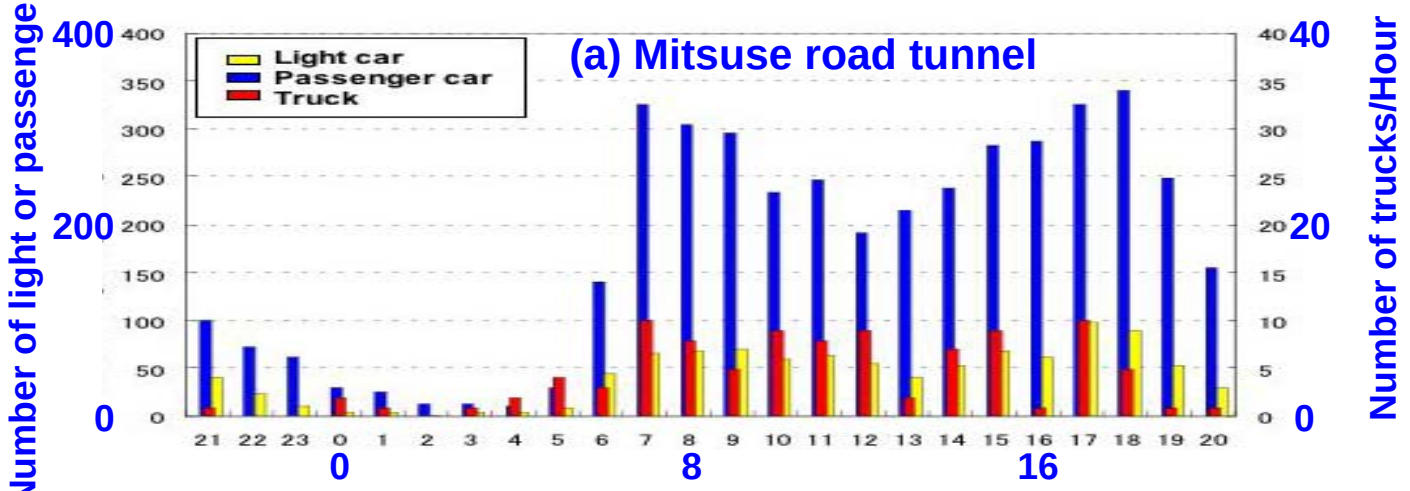


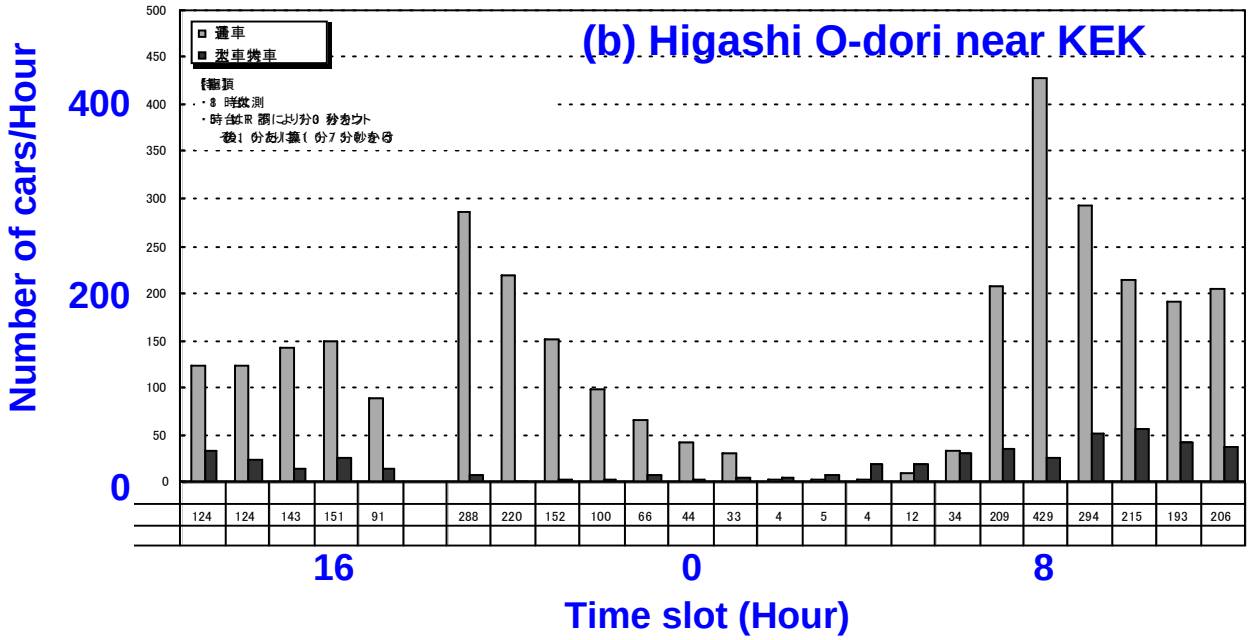
Characteristics of Spectra (cont.)

- Amplitude of spectra for Esashi site is the smallest in the frequency region higher than 1Hz. This is because the Esashi site is located in the hard bedrock area and the environment is very quite.

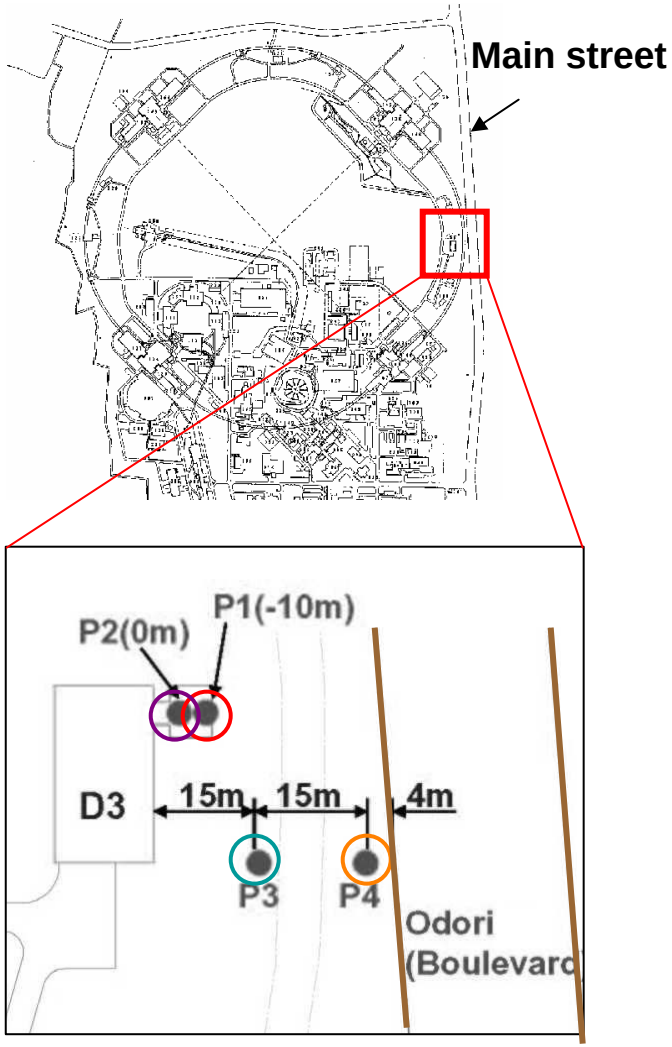
- Amplitude of spectra for sites of hard rock area (points 3 - 6) is almost the same in the frequency region lower than 1Hz. This is because the vibrational source around 0.3Hz is the natural phenomena such as ocean swells, winds, etc.

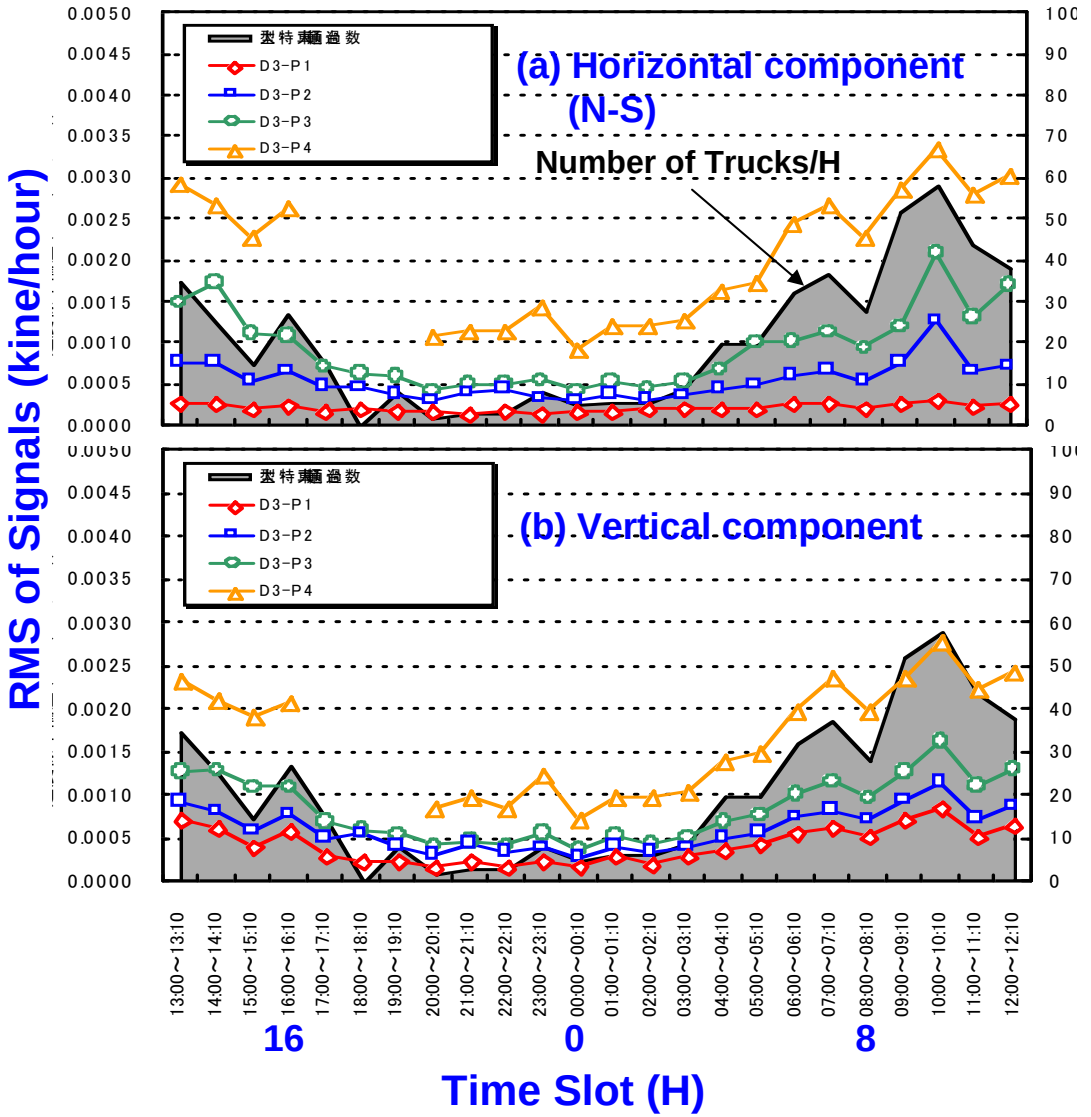
Traffic


(a) Mitsuse road tunnel
Light car
Passenger car
Truck
Number of light or passenger cars/H
Number of trucks/Hour
0
200
400
0
20
40
21 22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0
8
16


(b) Higashi O-dori near KEK
Number of cars/Hour
0
200
400
124 124 143 151 91 288 220 152 100 66 44 33 4 5 4 12 34 209 429 294 215 193 206
16
0
8
Time slot (Hour)

At D3 Electric Power Station in KEK





- GM has a good correlation with the passage of heavy cars

GROUND MOTION AT THE TIME OF AN EARTHQUAK

JP1: on an outcrop of the bedrock

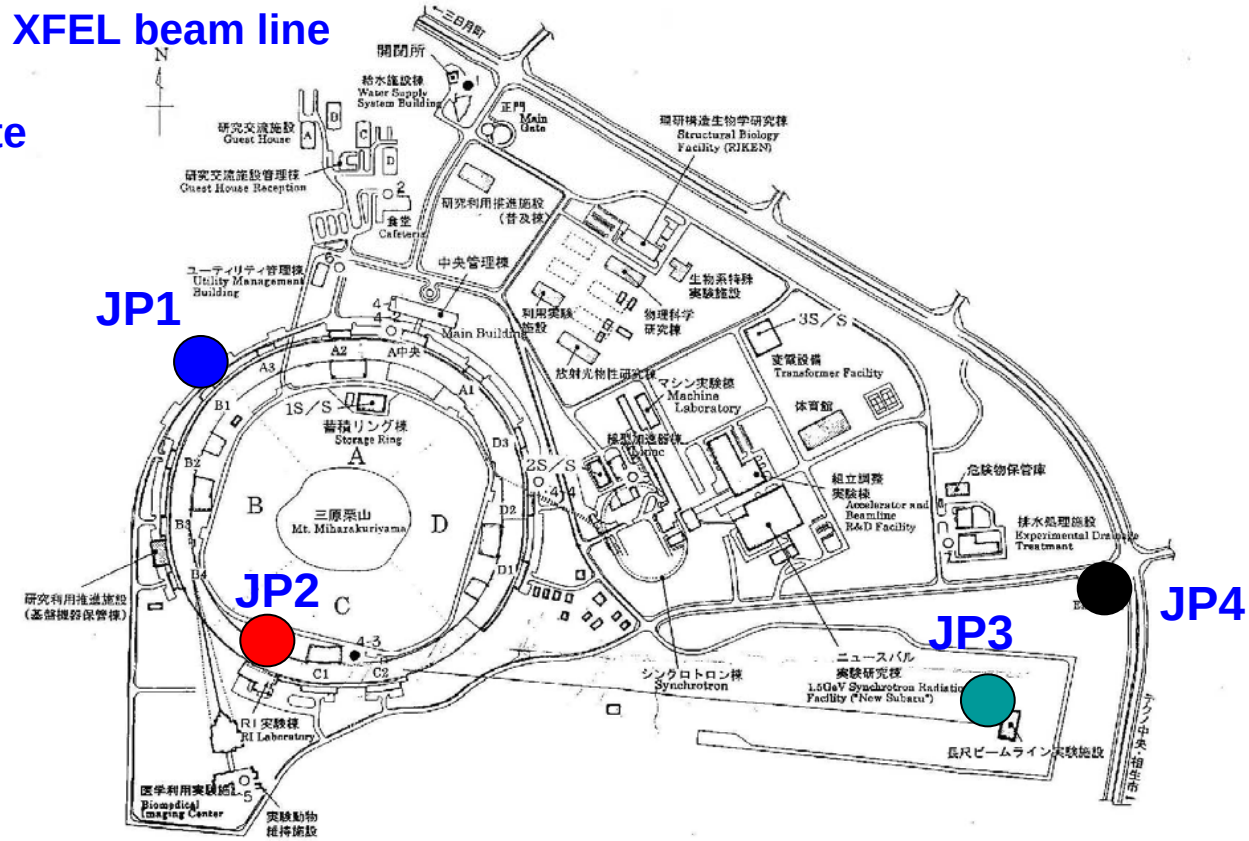
JP2: on a granite base block in a room

JP3: a mound covering the XFEL beam line

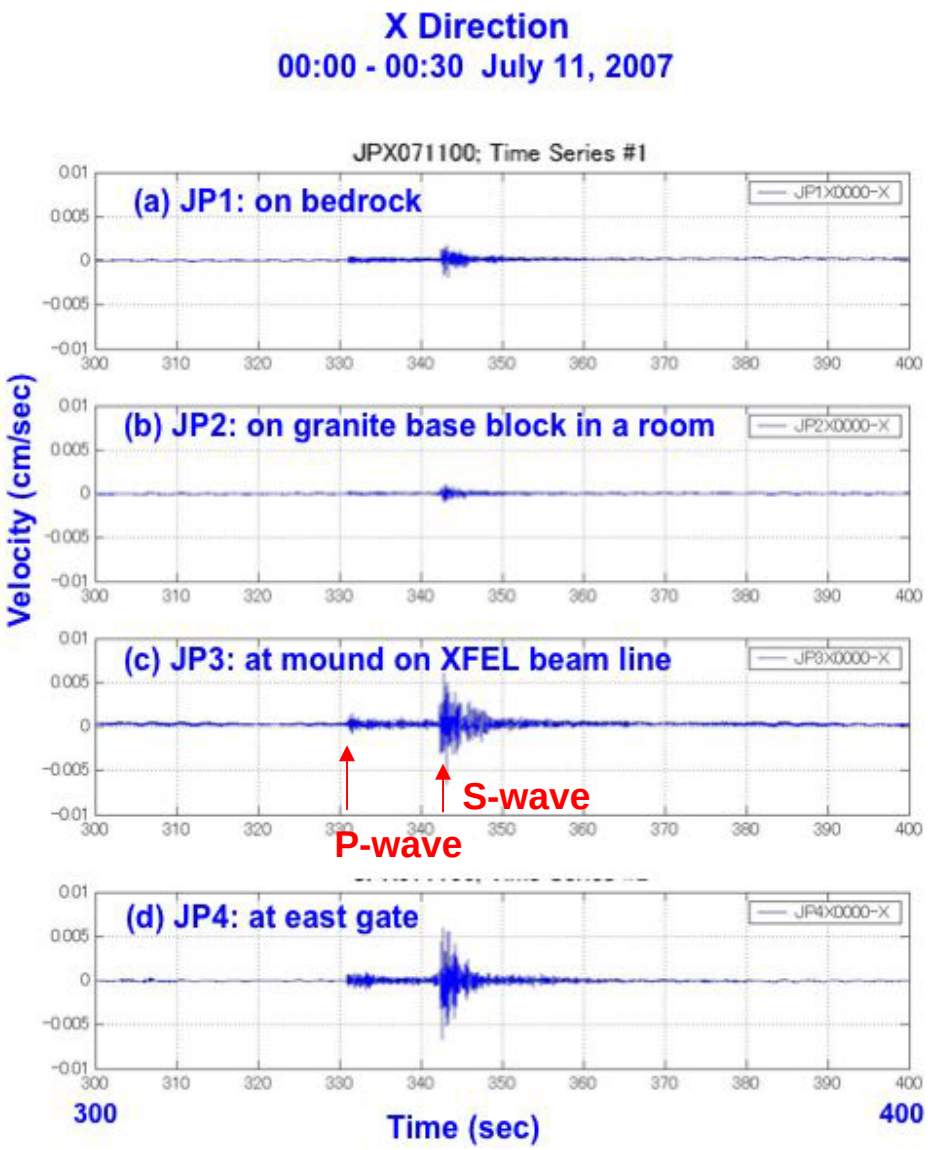
JP4: ground at the east gate

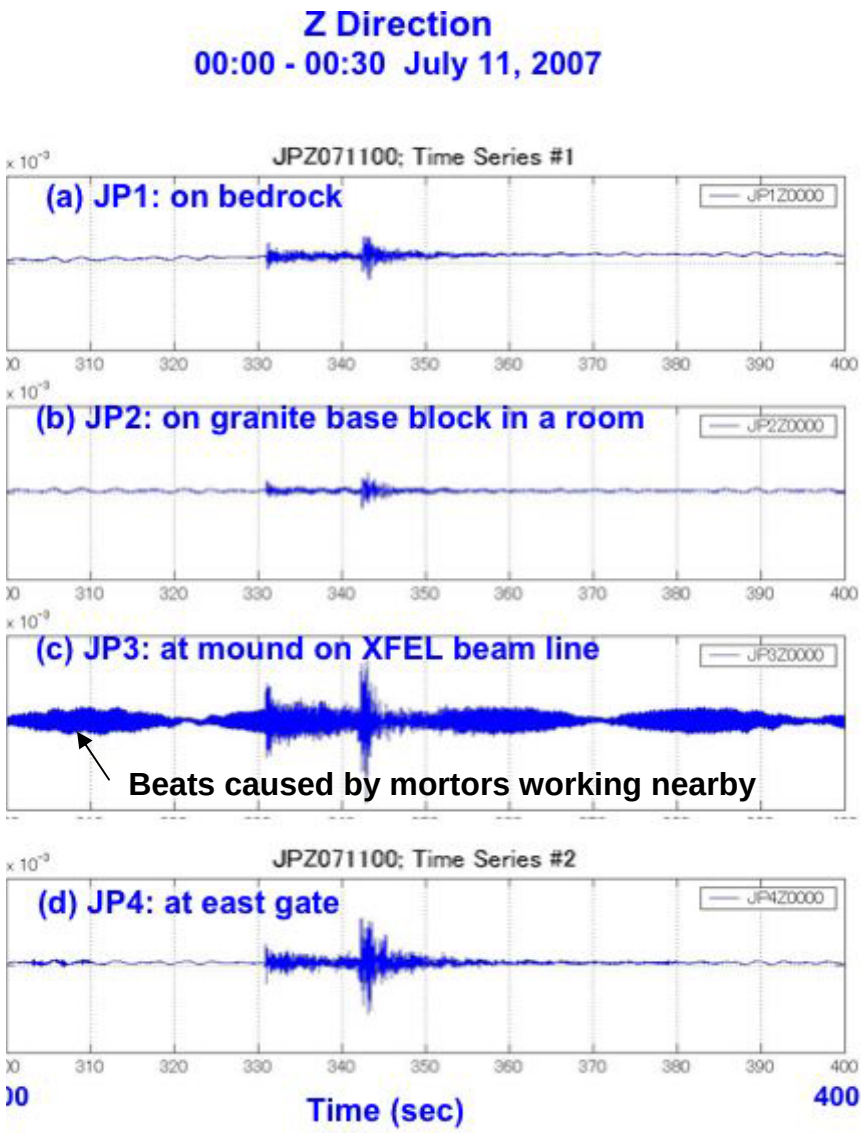
Earthquake was observed at 00:05:30 on 11 July 2004 at the time of remeasurement at Spring-8

SPring-8 site

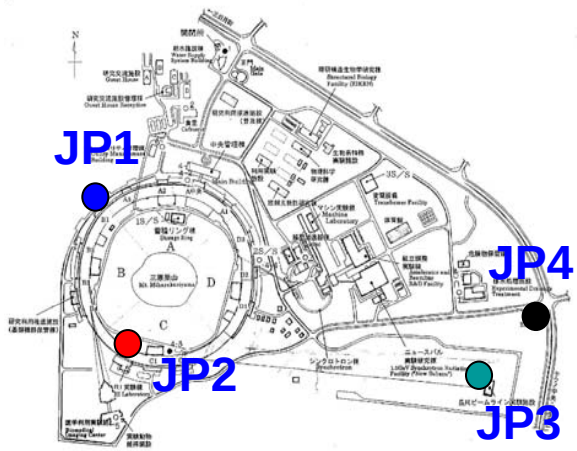


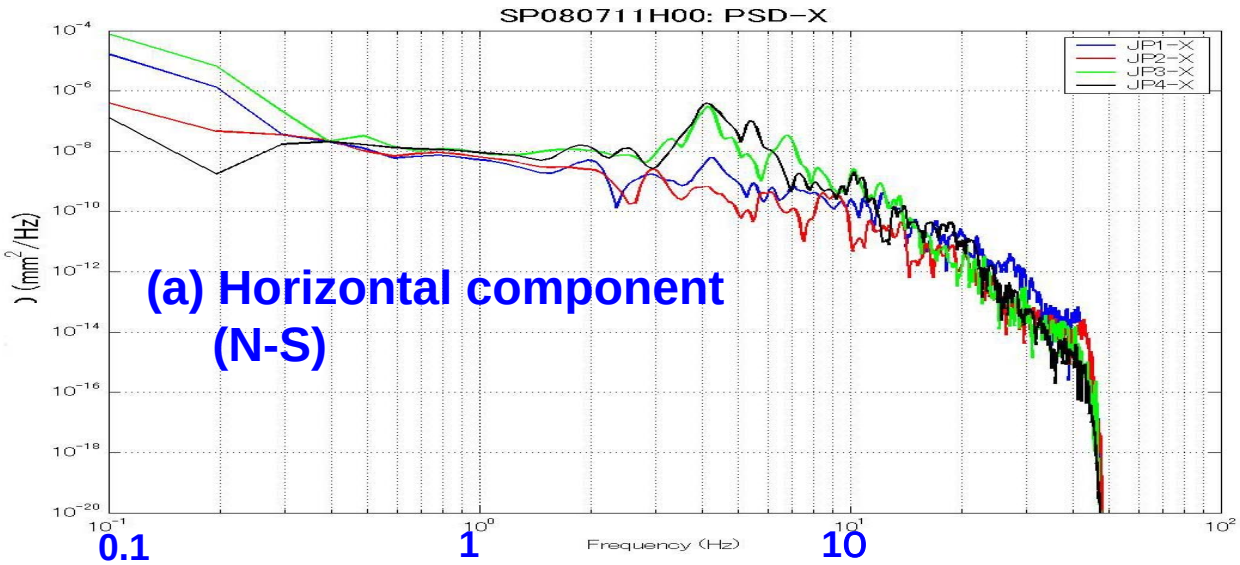
Output From Sensors

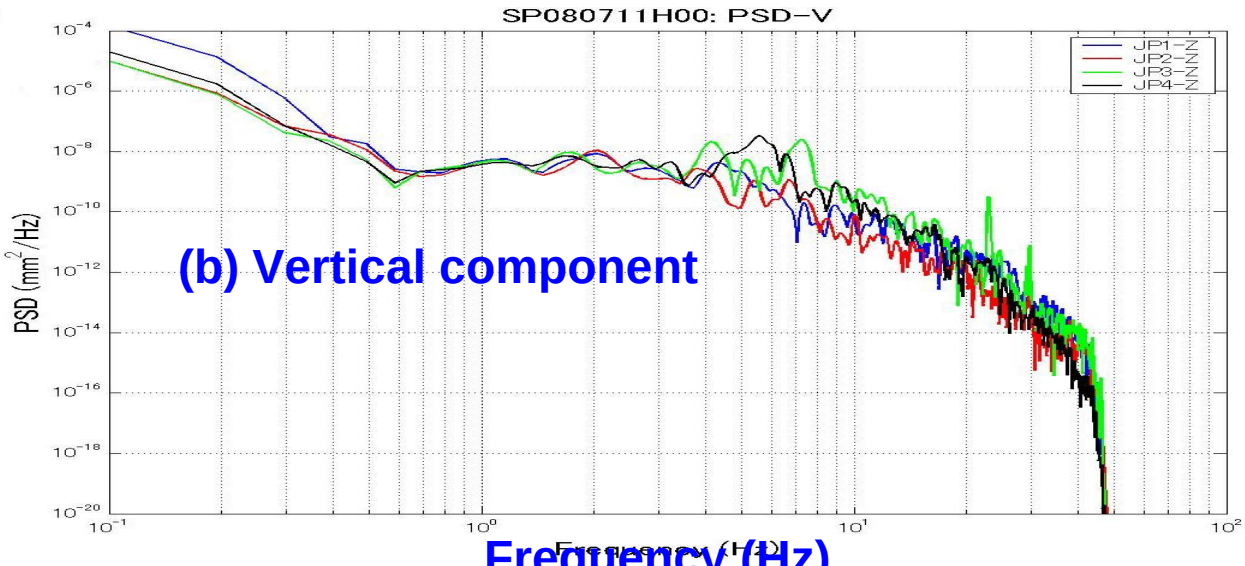




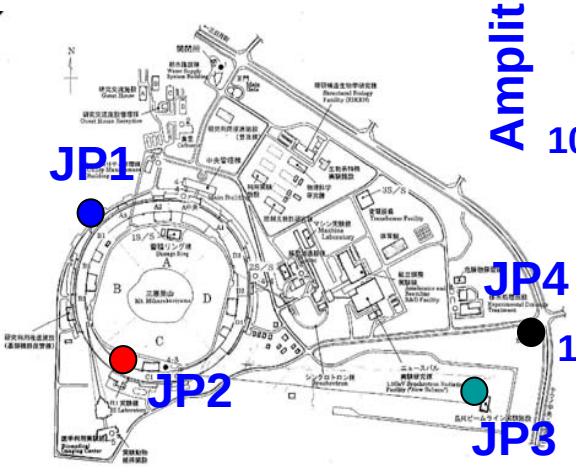
Power Spectrum Density at The Time of an Earthquake

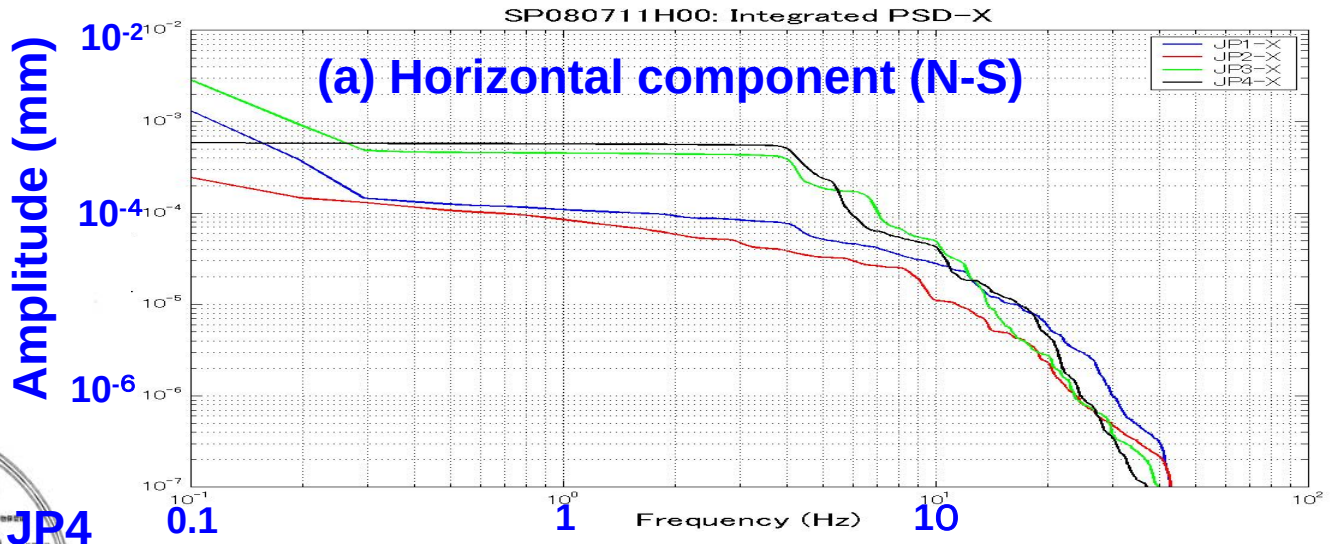


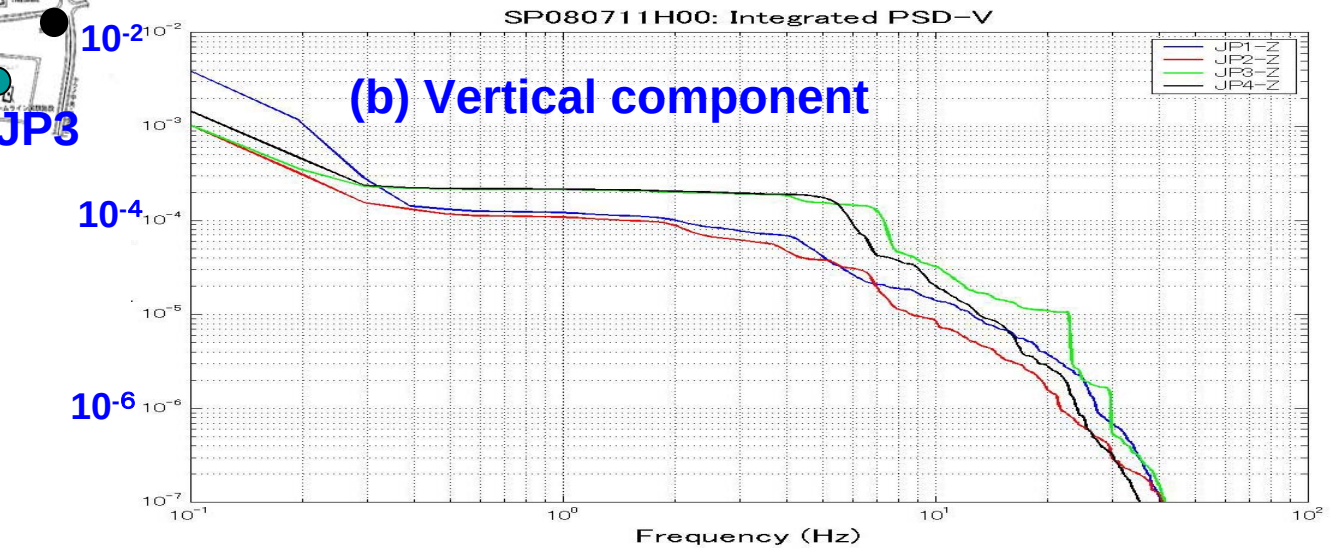




Integrated Spectra at The Time of an Earthquake







Frequency (Hz)

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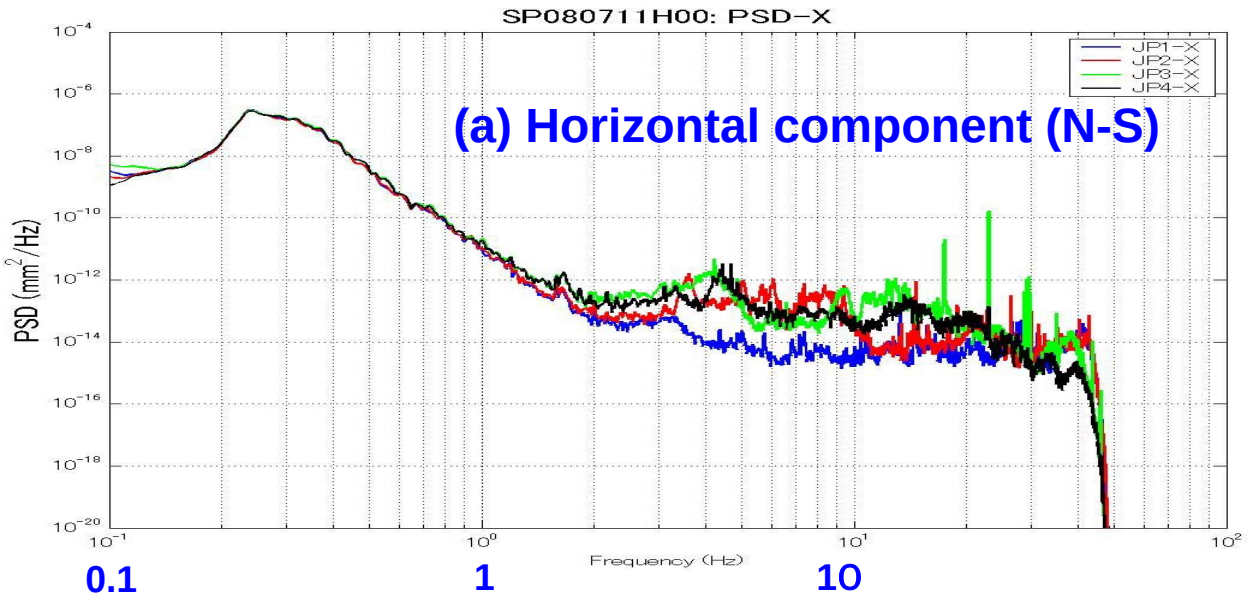
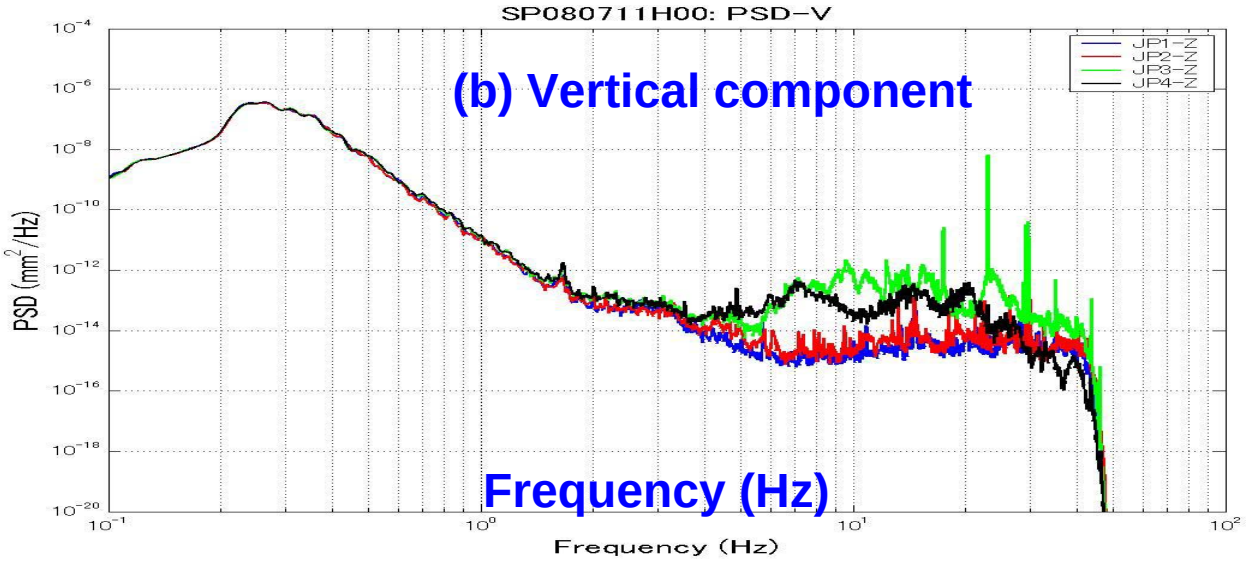
GM in the Midnight at SPring-8

PSD (mm²/Hz)





GM in the Midnight at SPring-8 (cont.)