Safety issues (seismic, radiation and magnetic field) in Japan

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ECFA LC2013, DESY, 27 -31 May 2013

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   - Seismic Actions on Structures

   to show the standard procedure for seismic analysis
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10. Summary

Radiation Rules at KEK

- Normal operation
  - **0.2 μSv/h for Non-designated area (K1)**
  - **1.5 μSv/h for Supervised area (K2)** **experimental hall**
  - **20 μSv/h for Simple controlled area (K3)**
  - **100mSv/h for access restricted**
- Shielding 100 **μSv/event**
- Mis-steering beam loss
  - **1 hour integration of dose rate should not exceed 1.5 μSv/h using radiation monitor.**

    (Terminate injection and wait 1 hour)

SiD and ILD : Shielding capability of 250 mSv/h / 18 MW = 0.014 mSv/h/kW is required everywhere to meet SLAC requirement

T.Sanami, IRENG 09/14/2007

Limits of static magnetic field

Ministerial ordinance of Economic industrial ministry in Japan :
The technical standard regarding electric installation, 27th provision 2, 2011

less than 200μT (2G) in the place where the person enters easily

Guidelines on LIMITS OF EXPOSURE TO STATIC MAGNETIC FIELDS, ICNIRP, HEALTH PHYSICS 96(4):504-514; 2009

ICNIRP : International Commission on Non-Ionizing Radiation Protection

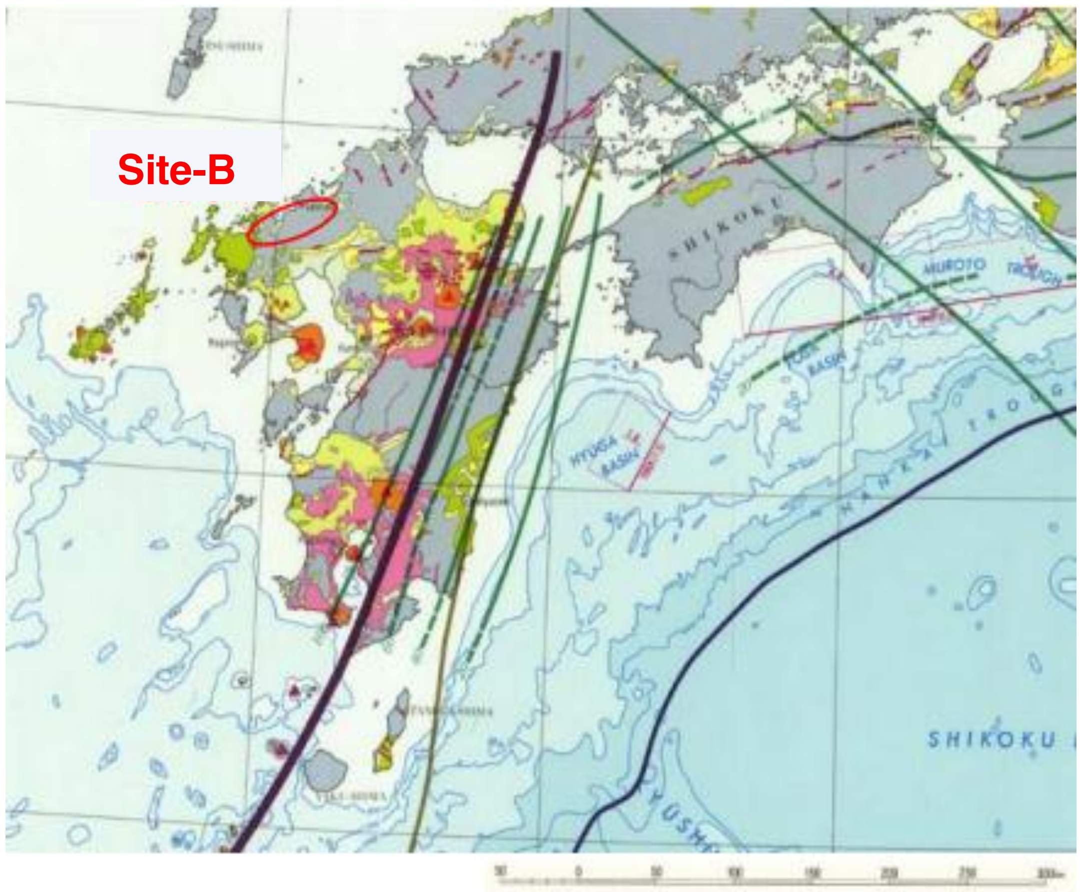
Table 2. Limits of exposure[a] to static magnetic fields.

Exposure characteristics	Magnetic flux density	
Occupational[b]		
Exposure of head and of trunk	2 T	
Exposure of limbs[c]	8 T	
General public[d]		
Exposure of any part of the body	400 mT	(4KG)

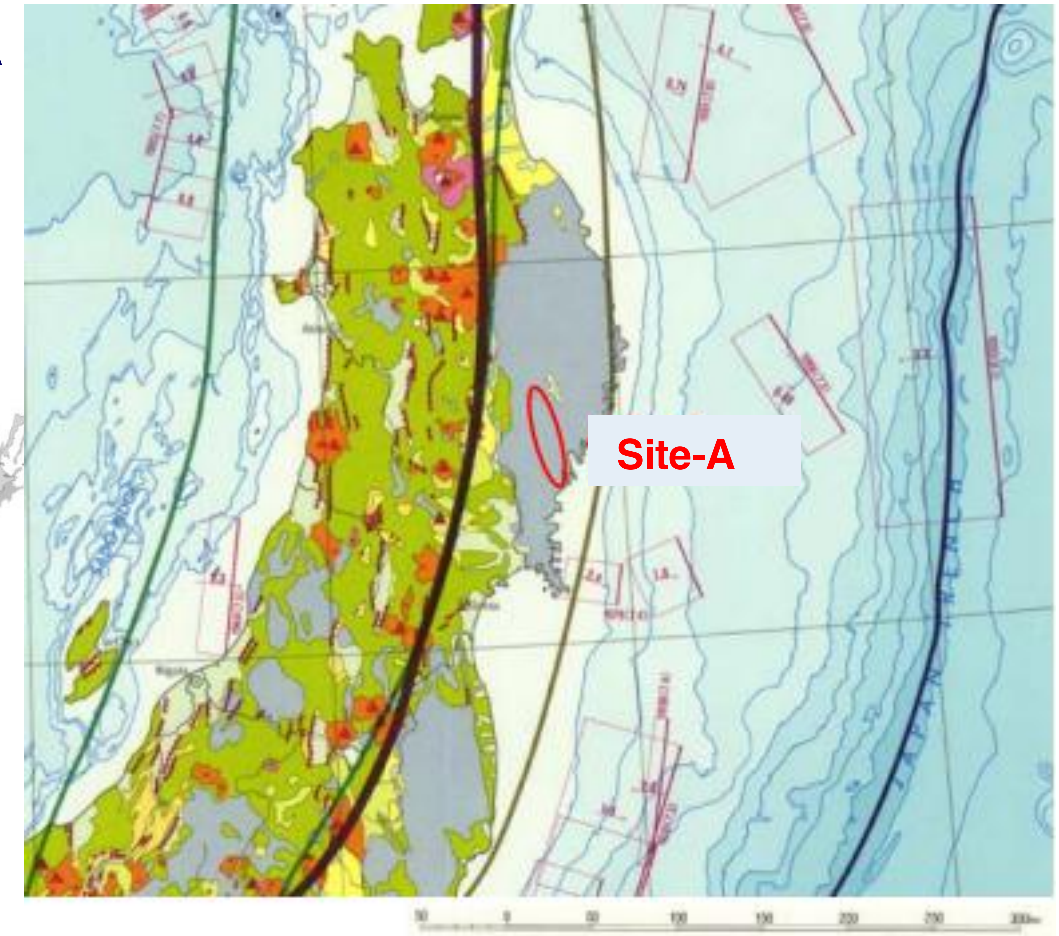
[a] ICNIRP recommends that these limits should be viewed operationally as spatial peak exposure limits.
[b] For specific work applications, exposure up to 8 T can be justified, if the environment is controlled and appropriate work practices are implemented to control movement-induced effects.
[c] Not enough information is available on which to base exposure limits beyond 8 T.
[d] Because of potential indirect adverse effects, ICNIRP recognizes that practical policies need to be implemented to prevent inadvertent harmful exposure of persons with implanted electronic medical devices and implants containing ferromagnetic material, and dangers from flying objects, which can lead to much lower restriction levels such as 0.5 mT. (5G)

Outline about Two Candidate Sites in Japan

SEFURI-Site



KITAKAMI-Site

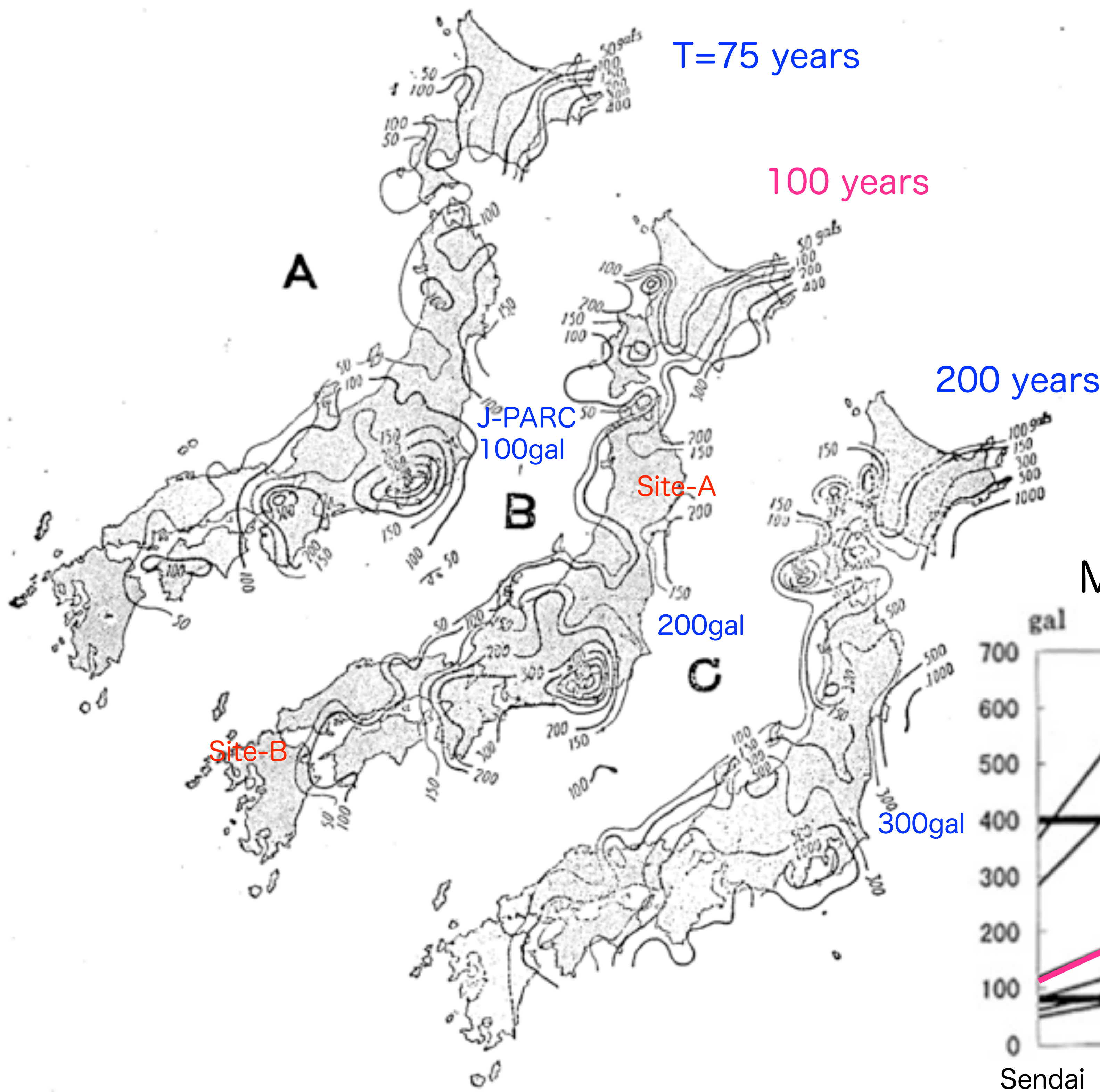


- Belong to FUKUOKA & SAGA Prefecture in KYUSHU District
- Located in stable Granite zone
- Have not Active Fault zone
- Separate from Volcano Front line
- Annual average Temperature:12℃
- Annual total Precipitation : 2,400mm

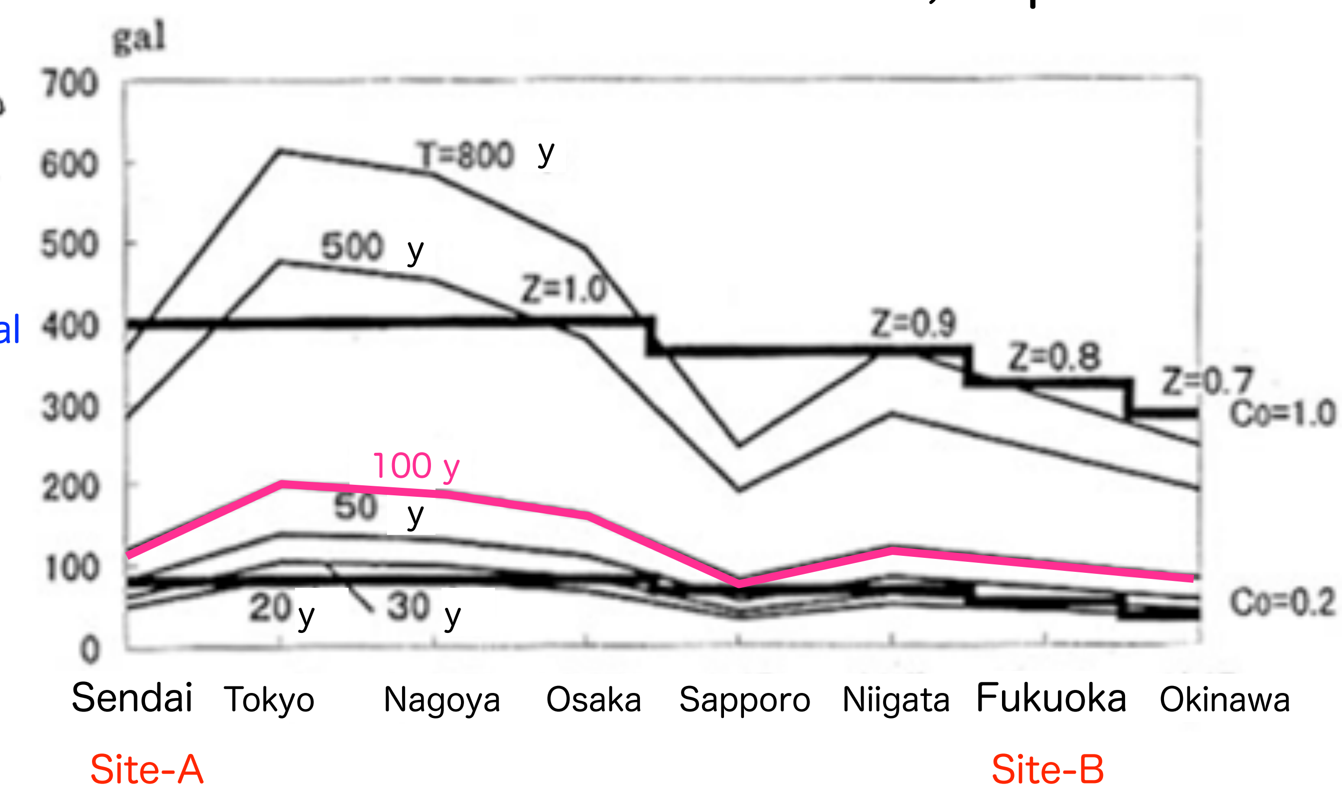
- Belong to IWATE & MIYAGI Prefecture in TOHOKU District
- Located in stable Granite zone
- Have not Active Fault zone
- Separate from Volcano Front line
- Annual average Temperature:10℃
- Annual total Precipitation : 1,300mm

Seismic Hazard Map in Japan : Maximum acceleration (gal) in recurrence intervals of earthquake

Kawasumi map : based on earthquakes from 679 to 1,948 in Japan

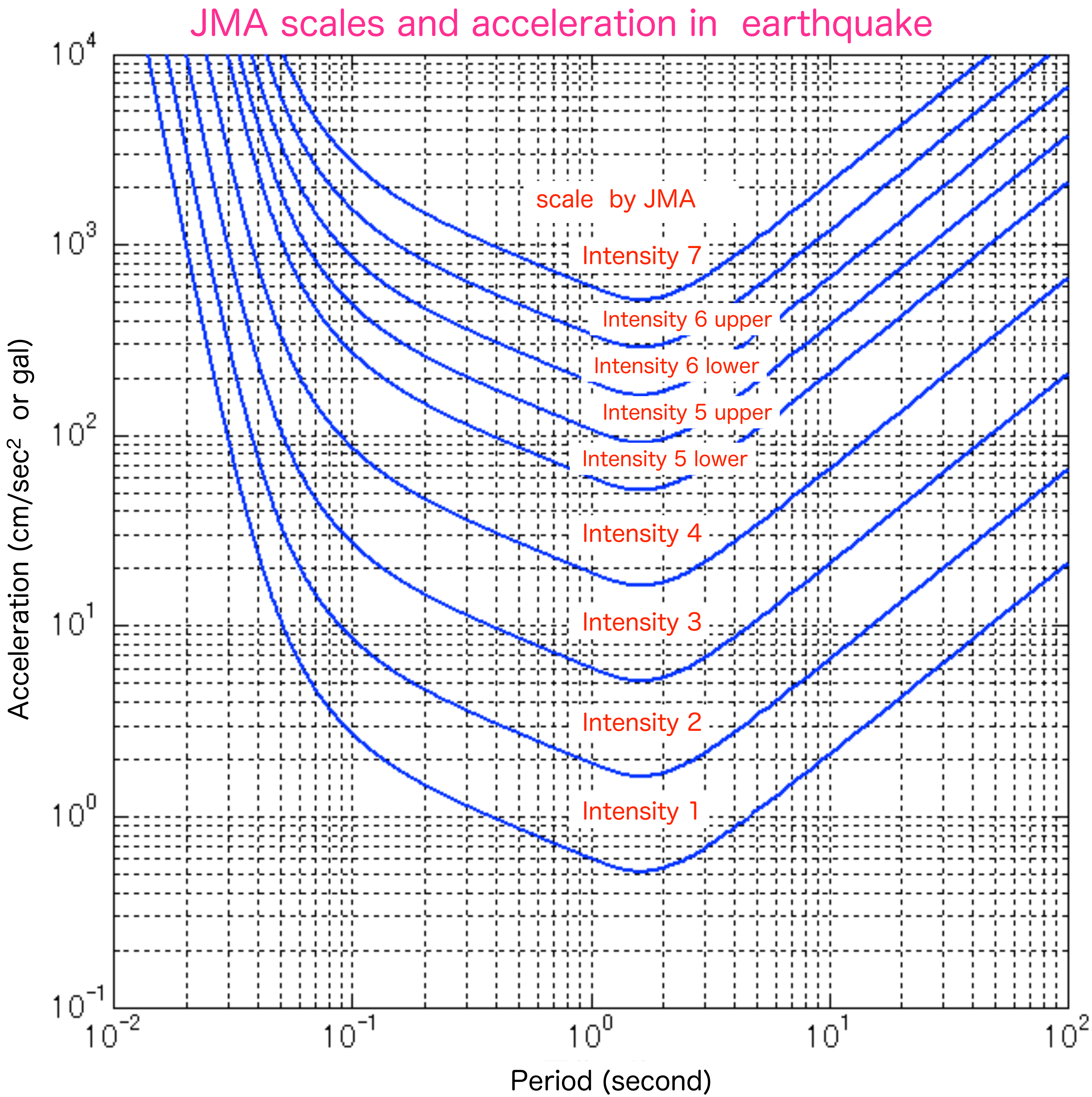


Max. acceleration in cities, Japan



JMA (Japan Meteorological Agency)				http://www.jma.go.jp/jma/kishou/know/shindo/explane.html	
Scale(m)	gal JMA lower end	Acc(cm/s²) $0.45 \times 10^{0.5m}$	**People**	**Indoor Situations**	**Outdoor Situations**
0			Imperceptible to people.		
1	**0.8**	**1.4**	Felt by only some people in the building.		
2	**2.5**	**4.5**	Felt by most people in the building. Some people awake.	Hanging objects such as lamps swing slightly.	
3	8	**14**	Felt by most people in the building. Some people are frightened.	Dishes in a cupboard rattle occasionally.	Electric wires swing slightly.
2012.12.7 (M7.3)@Tsukuba **4**	25	**45**	Many people are frightened. Some people try to escape from danger. Most sleeping people awake.	Hanging objects swing considerably and dishes in a cupboard rattle. Unstable ornaments fall occasionally.	Electric wires swing considerably. People walking on a street and some people driving automobiles notice the tremor.
5-Lower	80	**142**	Most people try to escape from a danger. Some people find it difficult to move.	Hanging objects swing violently. Most Unstable ornaments fall. Occasionally, dishes in a cupboard and books on a bookshelf fall and furniture moves.	People notice electric-light poles swing. occasionally, windowpanes are broken and fall, un-reinforced concrete-block walls collapse, and roads suffer damage.
5-Upper		**253**	Many people are considerably frightened and find it difficult to move.	Most dishes in a cupboard and most books on a bookshelf fall. Occasionally, a TV set on a rack falls, heavy furniture such as a chest of drawers falls, sliding doors slip out of their groove and the deformation of a door frame makes it impossible to open the door.	In many cases , un-reinforced concrete-block walls collapse and tombstones overturn. Many automobiles stop because it becomes difficult to drive. Occasionally, poorly-installed vending machines fall.
2011.3.11 (M9.0)@Tsukuba **6-Lower**	250	**450**	Difficult to keep standing.	A lot of heavy and unfixed furniture moves and falls. It is impossible to open the door in many cases.	In some buildings, wall tiles and windowpanes are damaged and fall.
6-Upper	400	**800**	Impossible to keep standing and to move without crawling.	Most heavy and unfixed furniture moves and falls. Occasionally, sliding doors are thrown from their groove.	In many buildings, wall tiles and windowpanes are damaged and fall. Most un-reinforced concrete-block walls collapse.
7		**1423**	Thrown by the shaking and impossible to move at will.	Most furniture moves to a large extent and some jumps up.	In most buildings, wall tiles and windowpanes are damaged and fall. In some cases, reinforced concrete-block walls collapse.

H. Yamaoka, “Magnet seismic analysis”, 10 July, 2007, KEK



2013年 5月 29日 水曜日

International Standard
Based for Design of Structures - Seismic Actions on Structures

ISO3010 2001

International Organization for Standardization

a) (ultimate limit state: ULS) The structure should not collapse nor experience other similar forms of structural failure due to severe earthquake ground motions that could occur at the site .

b) (serviceability limit state: SLS) The structure should withstand moderate earthquake ground motions which may be expected to occur at the site during the service life of the structure with damage within accepted limits.

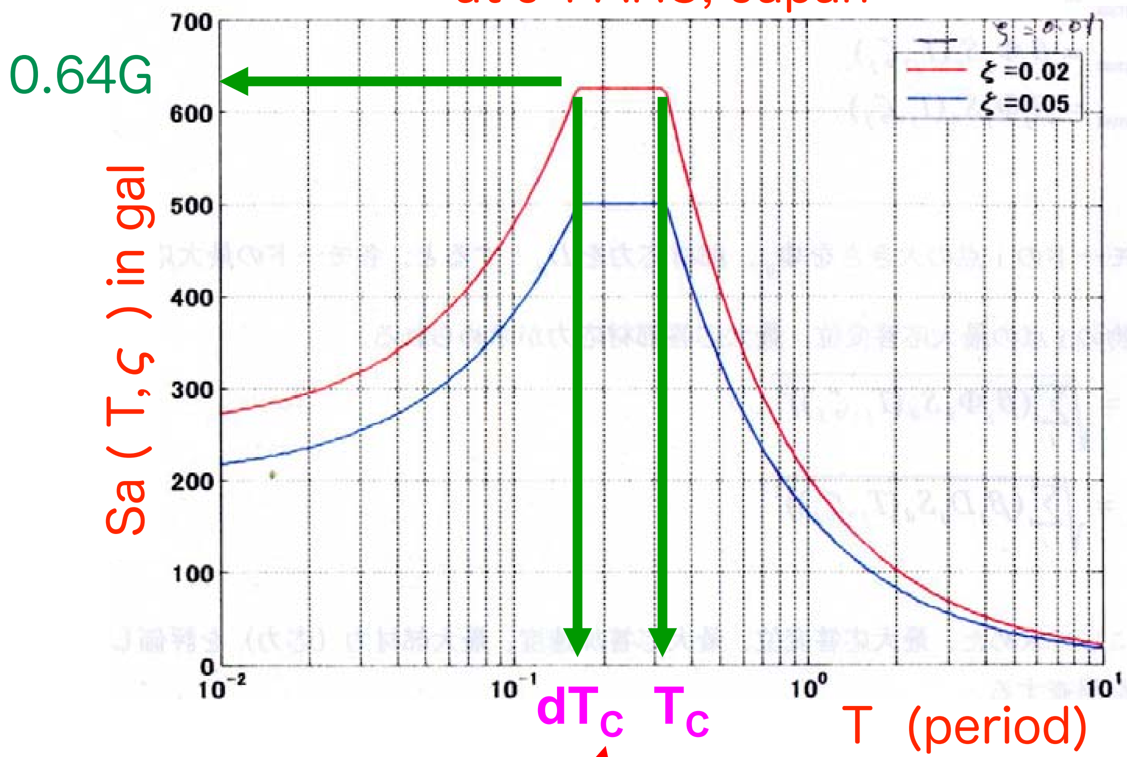
In both cases, the seismic force can be the maximum acceleration of earthquakes in the recurrence intervals of 100 years.

The ISO 3010 is expected to be used as a raw material for new national regulations or as a guideline for revising existing national regulations.

Seismic Analysis with the class-1 geology (hard soil)

following the guideline of construction loads by Architectural Institute of Japan

Example： Acceleration Response Spectrum
at J-PARC, Japan



$0 \le T \le dT_C$

$$S_a = \left(1 + \frac{f_A - 1}{d} \cdot \frac{T}{T_C}\right) \cdot F_h \cdot G_A \cdot R_A \cdot A_0$$

$dT_C \le T \le T_C$

$$S_a = f_A F_h \cdot G_A \cdot R_A \cdot A_0$$

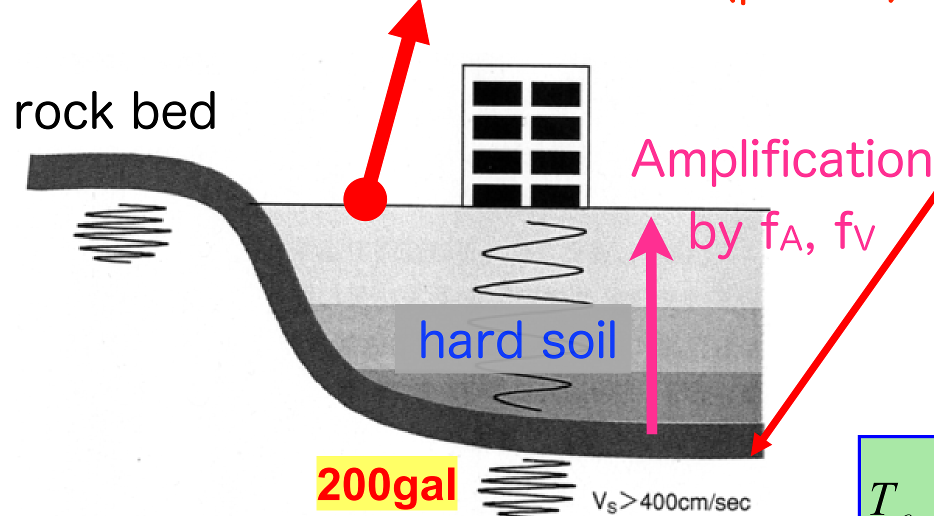
$T_C \le T$: Velo = const.

$$S_a = \frac{2\pi \cdot f_V \cdot F_h \cdot G_V \cdot R_V \cdot V_0}{T}$$

hard soil

$$A_0 = 15 V_0$$

A_0=200gal: *representative value of earthquake*



In case of hard soil,

f_A=2.5, f_V=2.0, d=0.5, R_A=1.0, R_V=1.0,
G_A=1.0, G_V=1.0, T_C=0.33

$$F_h = \frac{1.5}{1 + 10\varsigma}$$

ζ(Damping ratio) =0.02 → F_h=1.25

Steel structure： ς =0.02

$$T_c = \frac{2\pi f_V \cdot G_V \cdot R_V \cdot V_0}{f_A \cdot G_A \cdot R_A \cdot A_0} = \frac{2\pi \cdot 2 \cdot 1 \cdot 1 \cdot A_0/15}{2.5 \cdot 1 \cdot 1 \cdot A_0} = 0.33 \text{ sec}$$

$dT_C \le T \le T_C$

$$S_a = f_A F_h \cdot G_A \cdot R_A \cdot A_0$$
$$= 2.5 \cdot 1.25 \cdot 1.0 \cdot 1.0 \cdot 200 \;. = 625 \;(gal)$$

T_c=0.33sec= *3Hz*
dT_c=0.16sec= *6.3Hz*

H. Yamaoka, “Magnet seismic analysis”, 10 July, 2007, KEK

Site-dependent parameters in seismic analysis

f_A (2.5 hard): ratio of $G_A R_A A_0$ of $S_a(T, \varsigma=0.02$ for steel structure) in $dT_c<T<T_c$, amplification factor

f_v (2.0 hard): ratio of $G_v R_v V_0$ of $S_v(T, \varsigma) = S_a(T, \varsigma)T/2\pi$ in $T_c<T$, amplification factor

d (0.5 hard): dT_c/T_c, ratio of lower bound of period (dT_c) relative to the upper one (T_c=0.33sec hard) in the constant $S_a(T, \varsigma)$

F_h (1.25 hard): Correction factor of damping constant, $1.5/(1+10\varsigma)$, $F_h=1$ for $\varsigma=0.05$ (ferroconcrete)

A_0 (200 at J-PARC hard): Basic maximum acceleration of ground motion

V_0 (A_0/15 hard) : Basic maximum velocity of ground motion

R_A (1.0 hard): conversion coefficient of recurrence intervals (std:100y) of the maximum acceleration

R_v (1.0 hard) : conversion coefficient of recurrence intervals (std:100y) of the maximum velocity

G_A (1.0 hard): site-dependent correction factor of the maximum acceleration

G_v (1.0 hard): site-dependent correction factor of the maximum velocity

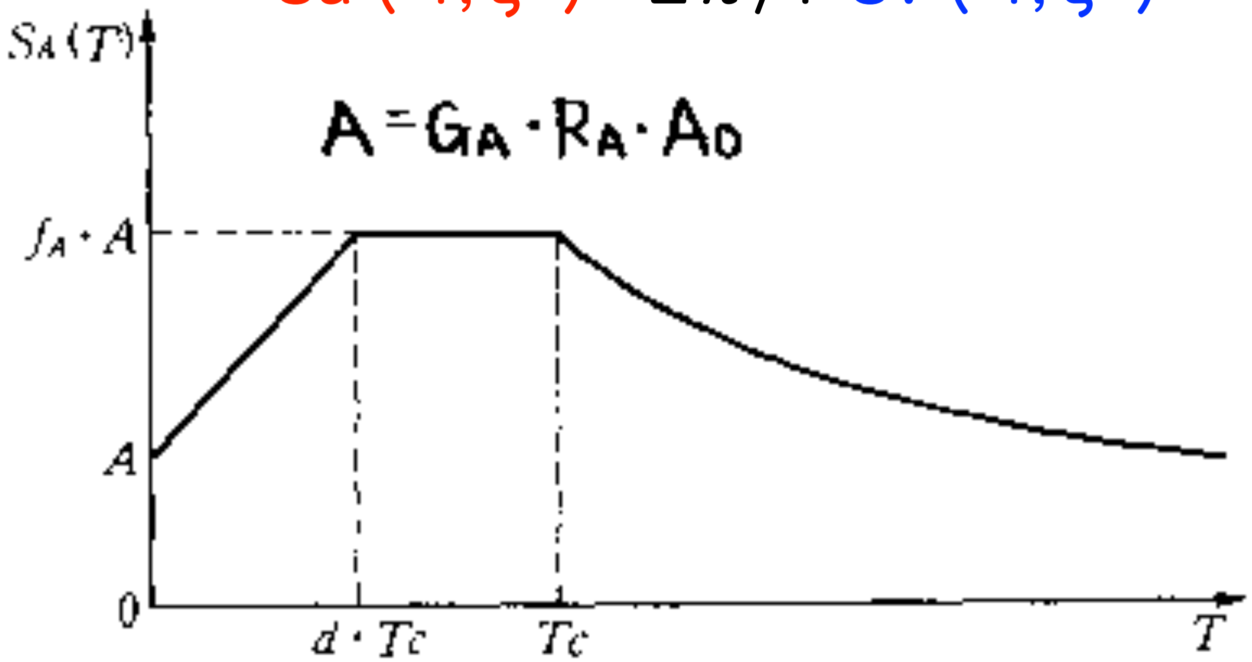
Natural vibration analysis of structures

Calculation of natural frequencies, own natural periods, natural angular frequencies, natural vibration modes, impulse constants, effective masses then,

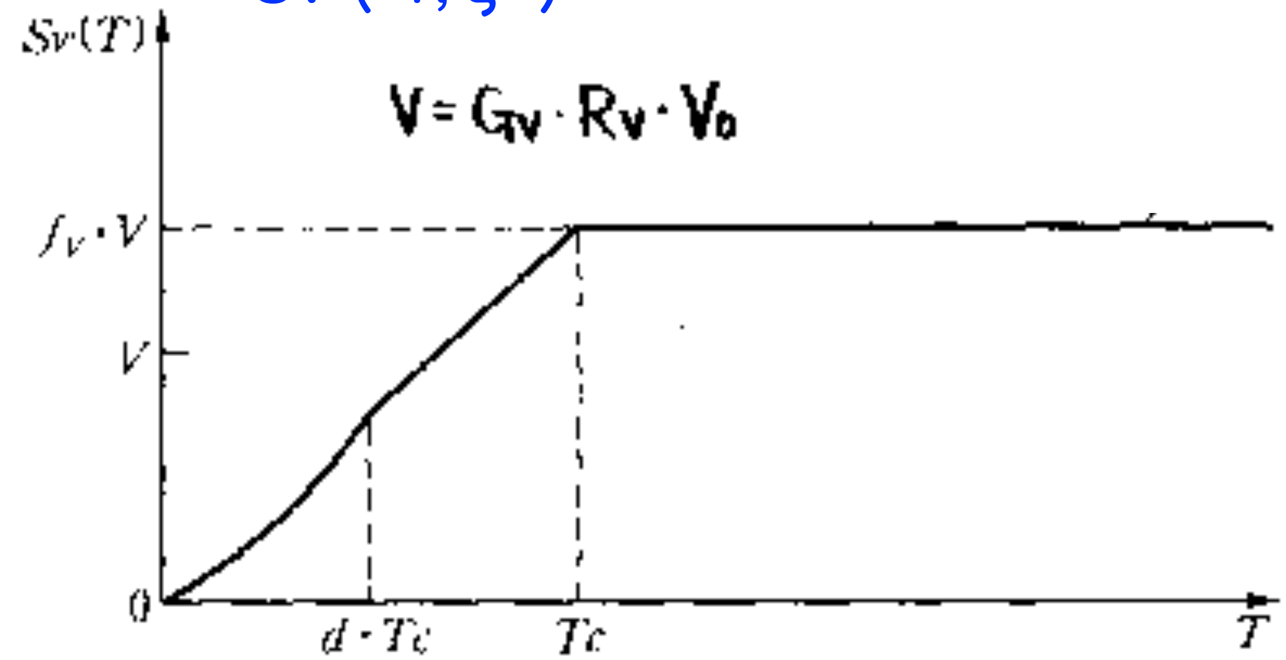
Estimation of maximum displacement, maximum response acceleration, and maximum stress to be reviewed if it is less than the allowable stress.

Acceleration and Velocity Response Spectrum

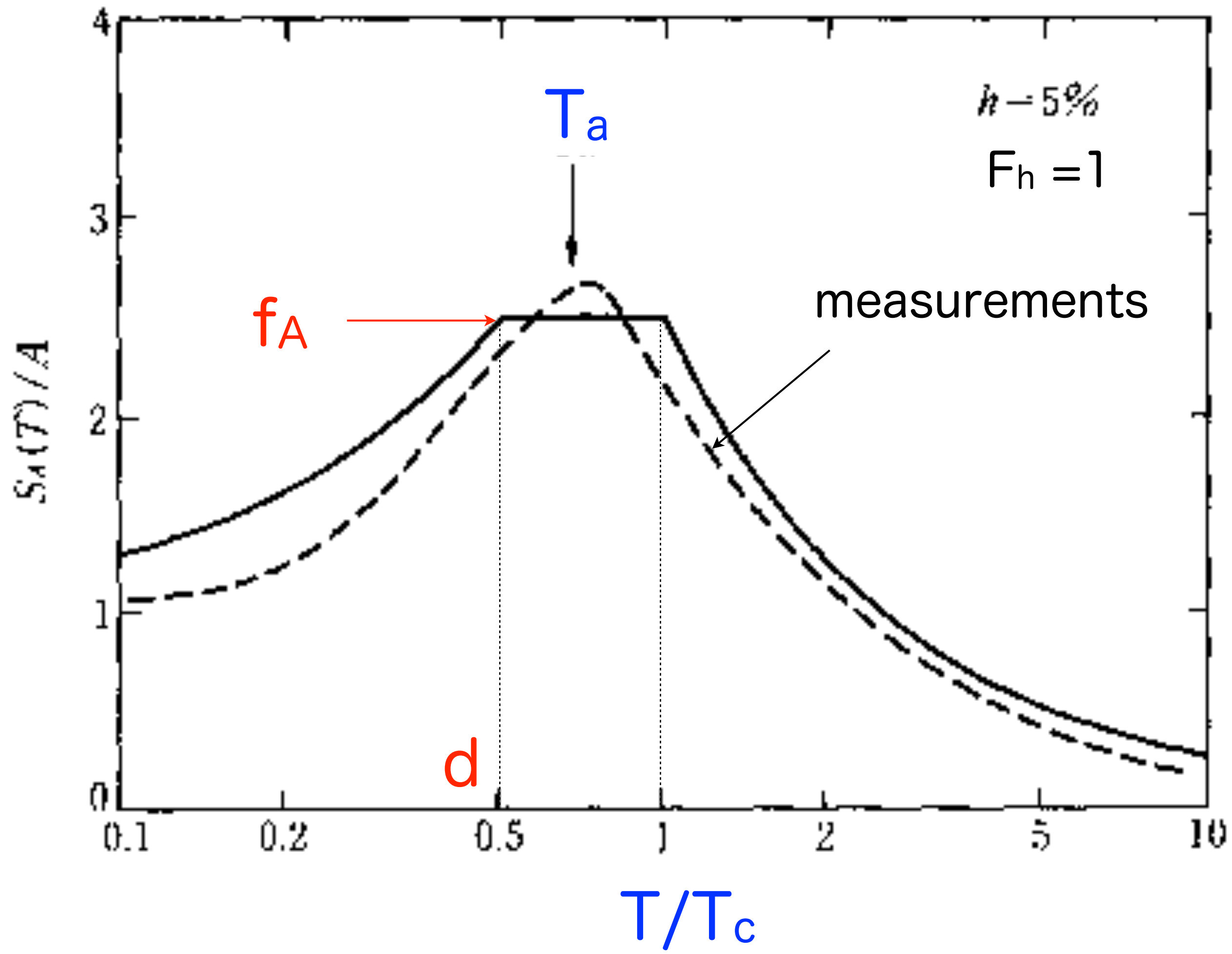
Sa (T, ς) ~2π/T Sv (T, ς)



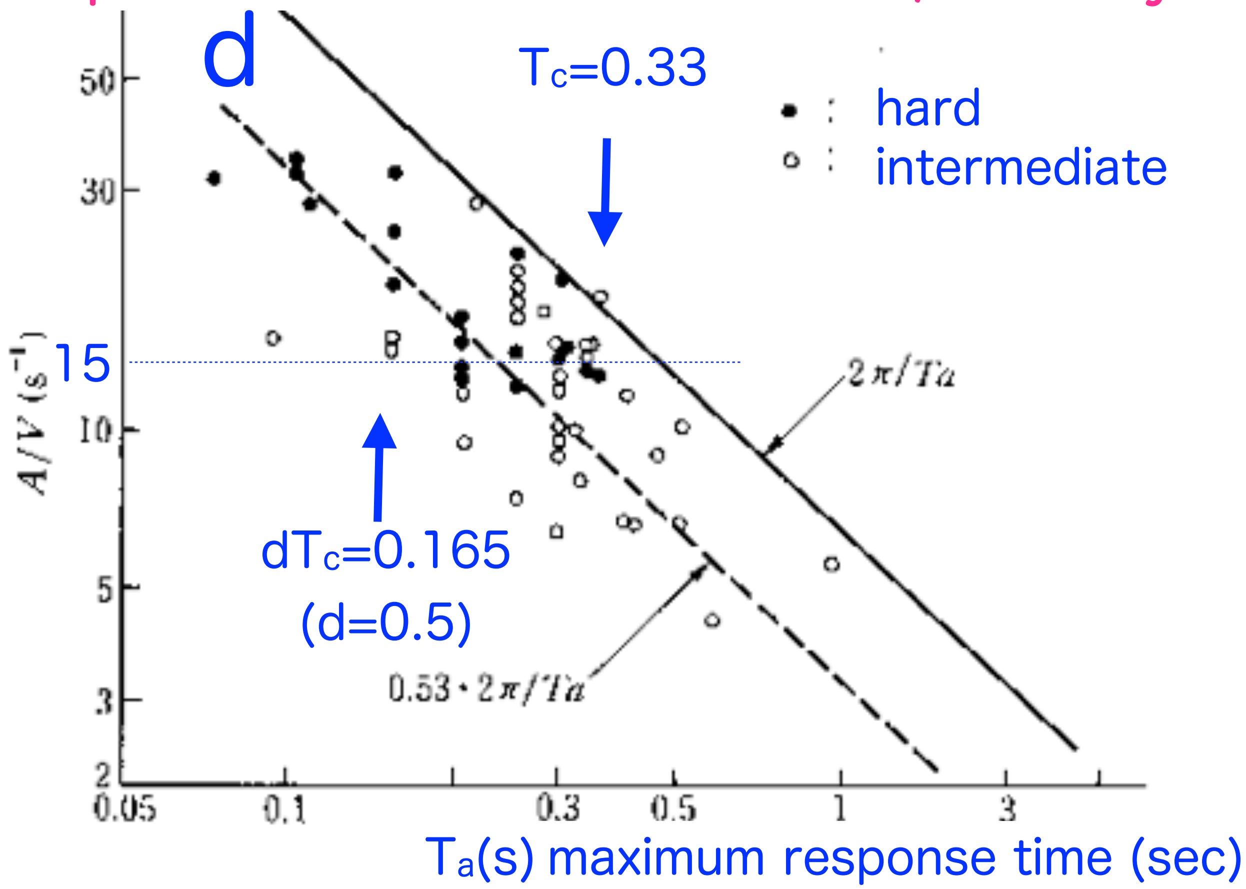
Sv (T, ς)



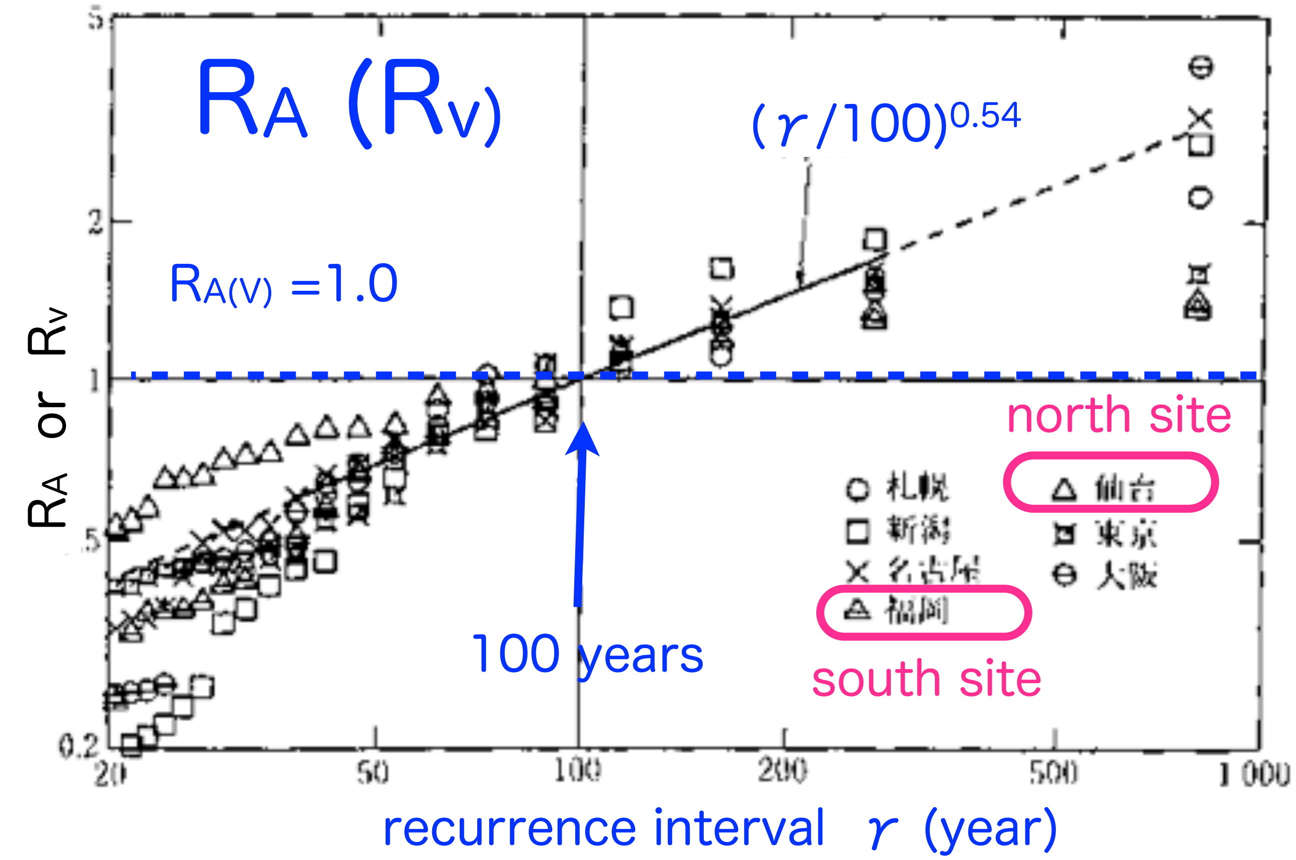
Normalized acceleration response spectrum



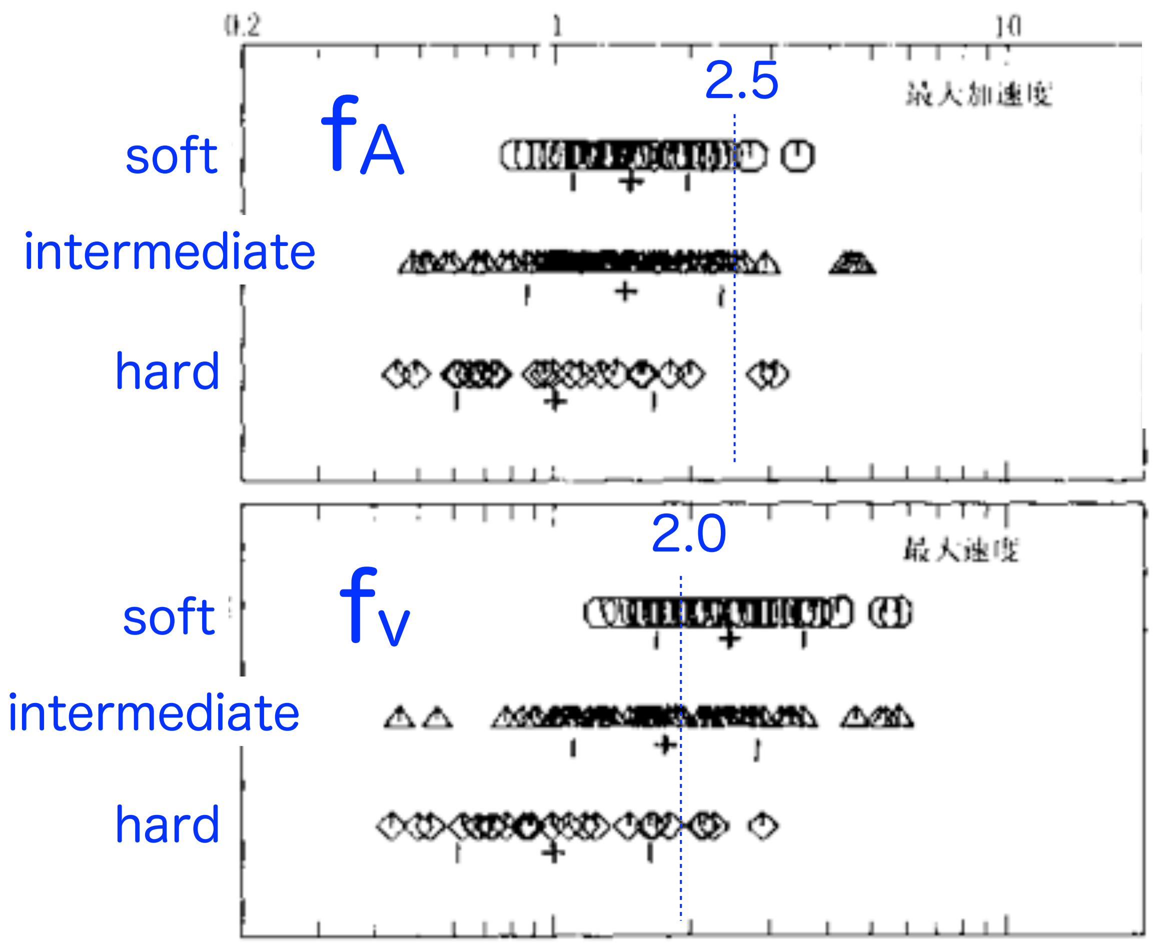
Response time of acceleration/velocity



Conversion coefficients(recurrence intervals)

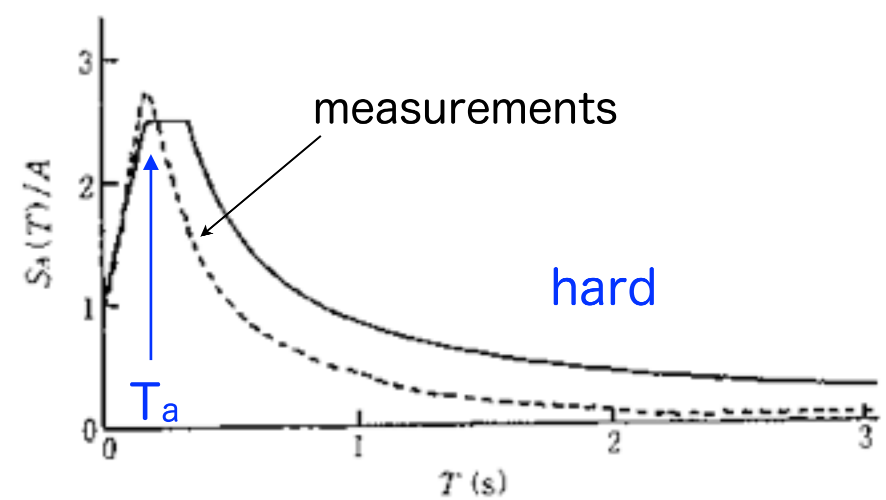


Amplification (千葉県東方沖地震,1987)



G_A, G_V, T_c in various soil(geology)

地盤種別	G_A	G_V	T_c (s)	soil
第Ⅰ種：標準地盤（堅固な地盤）	1.0	1.0	0.33	hard
第Ⅱ種：緩い洪積地盤または締った沖積地盤	1.2	2.0	0.56	inter-mediate
第Ⅲ種：軟弱地盤	1.2	3.0	0.84	soft



Normalized acceleration response spectrum

2013年 5月 29日 水曜日

2011.3.11
M9.0

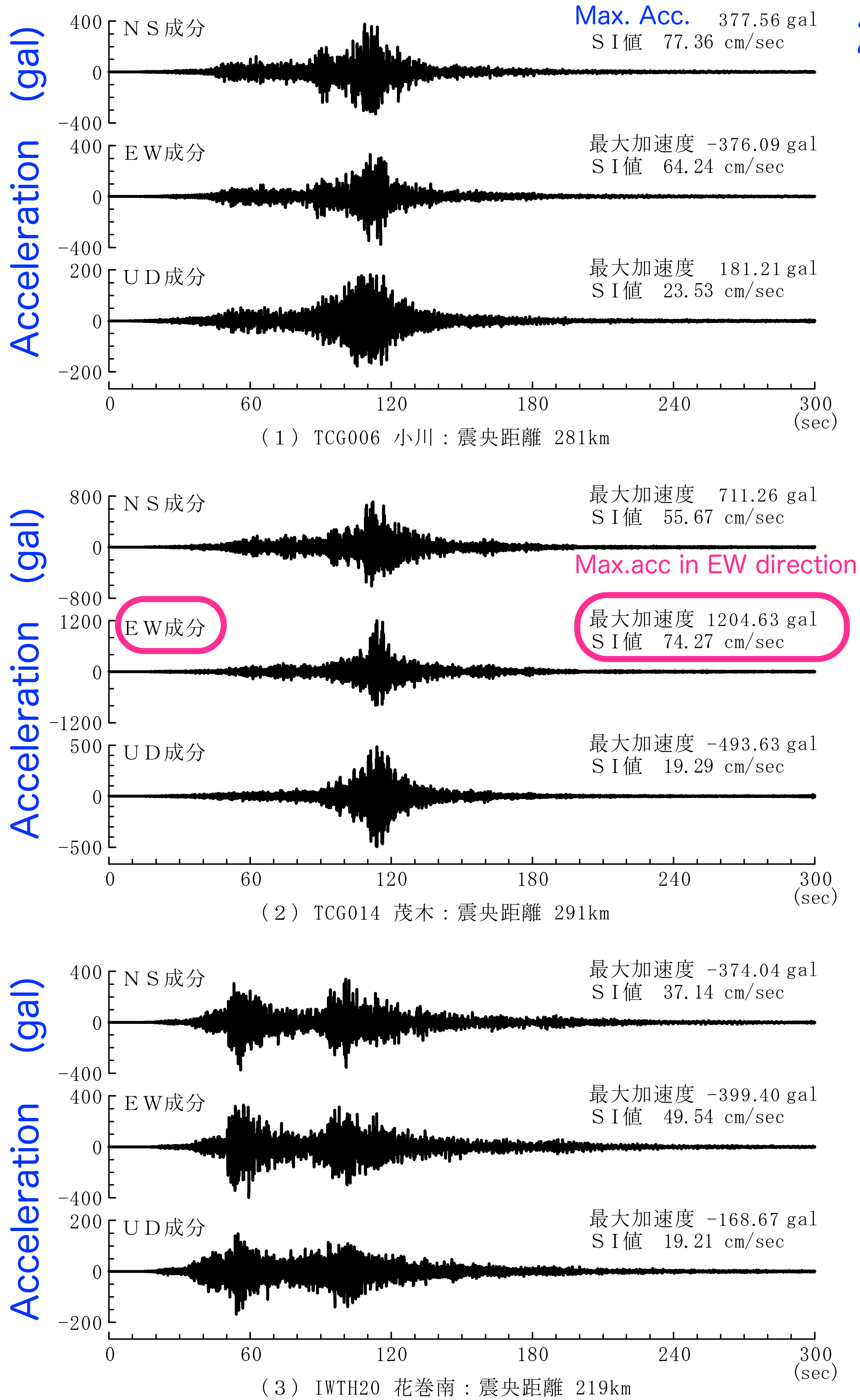


図 ー （２） 2011.03.11 14:47 東北地方太平洋沖地震（M9.0, 深さ24km）の加速度波形（防災科学技術研究所K-NET, KiK-netによる）Ｉ種地盤

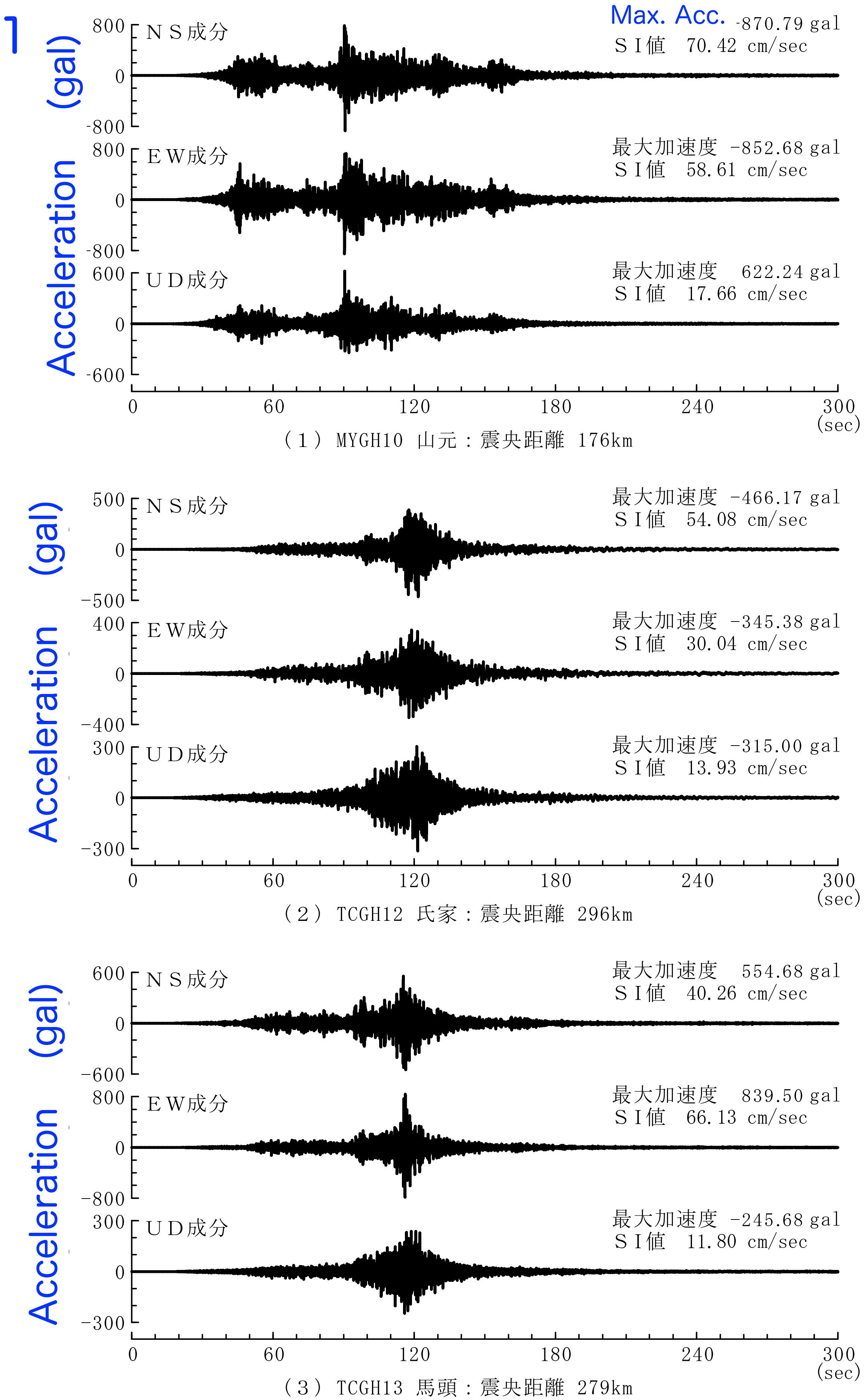
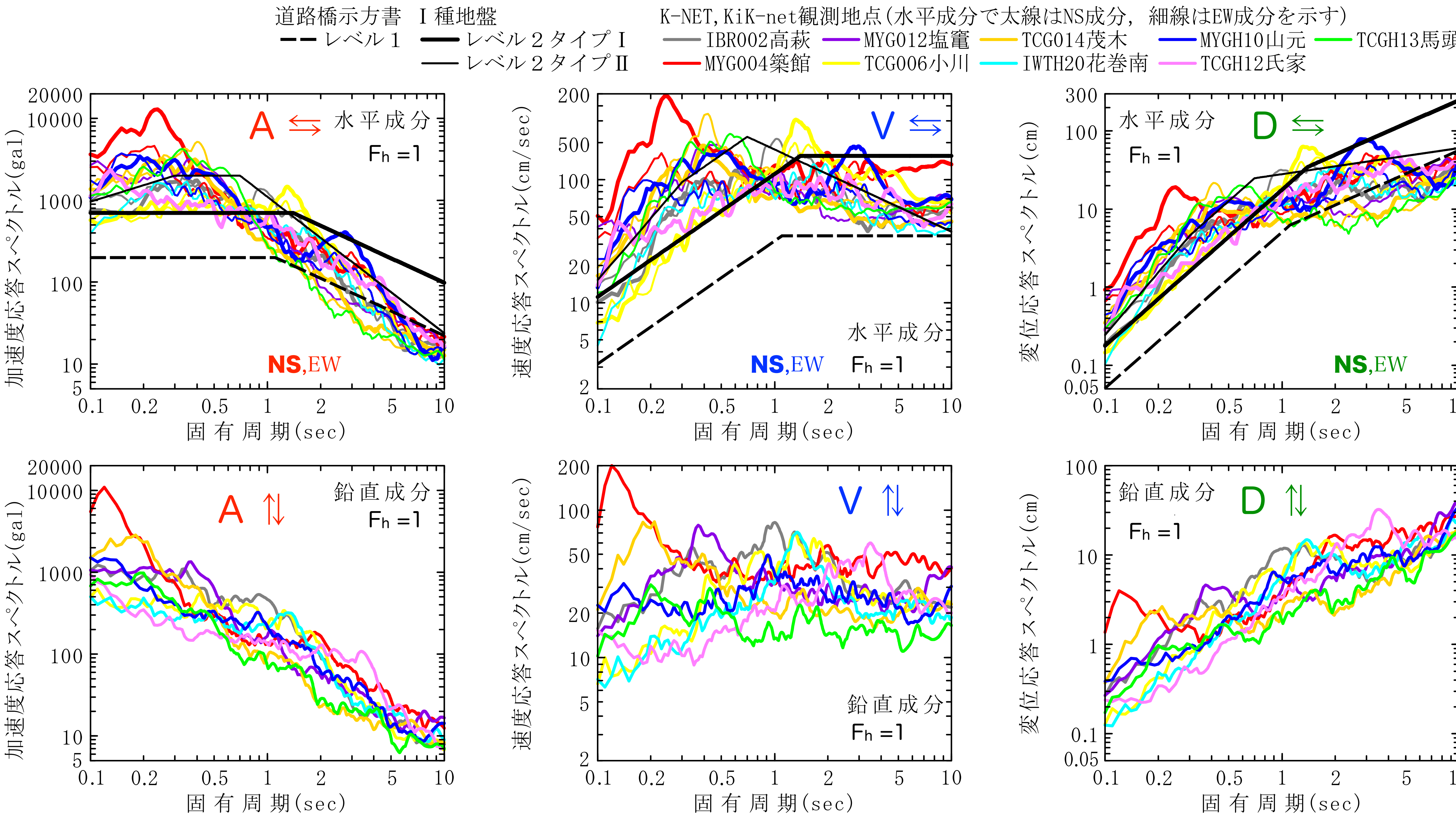


図 ー （３） 2011.03.11 14:47 東北地方太平洋沖地震（M9.0, 深さ24km）の加速度波形（防災科学技術研究所K-NET, KiK-netによる）Ｉ種地盤

Acceleration/Velocity/Displacement Response Spectrum

2011.3.11 M9.0 24m in depth



（１）加速度応答スペクトル　（２）速度応答スペクトル　（３）変位応答スペクトル

Acceleration : shear force　Velocity : kinetic energy　Displacement : strain

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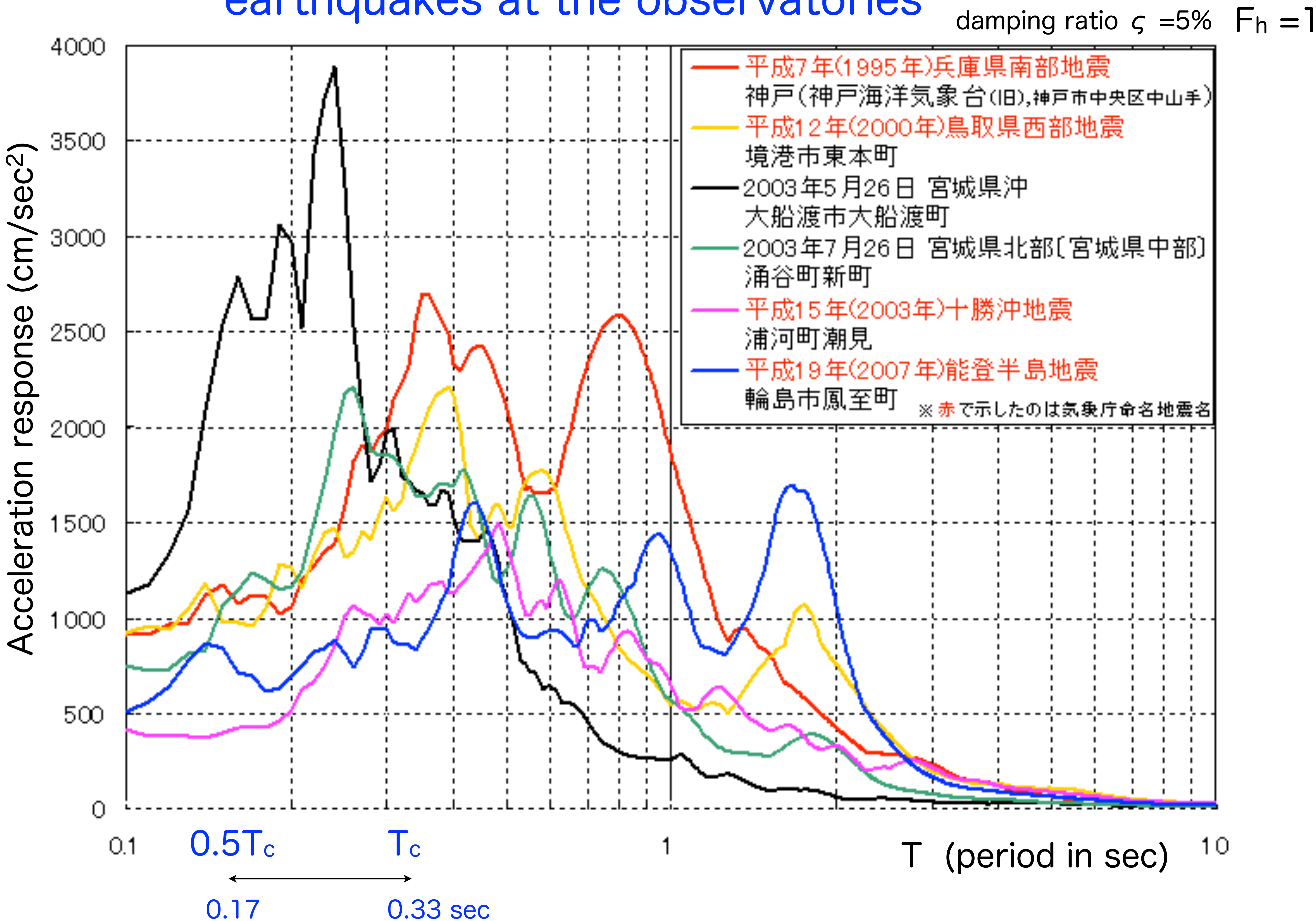
Acceleration Response Spectrum of various earthquakes at the observatories

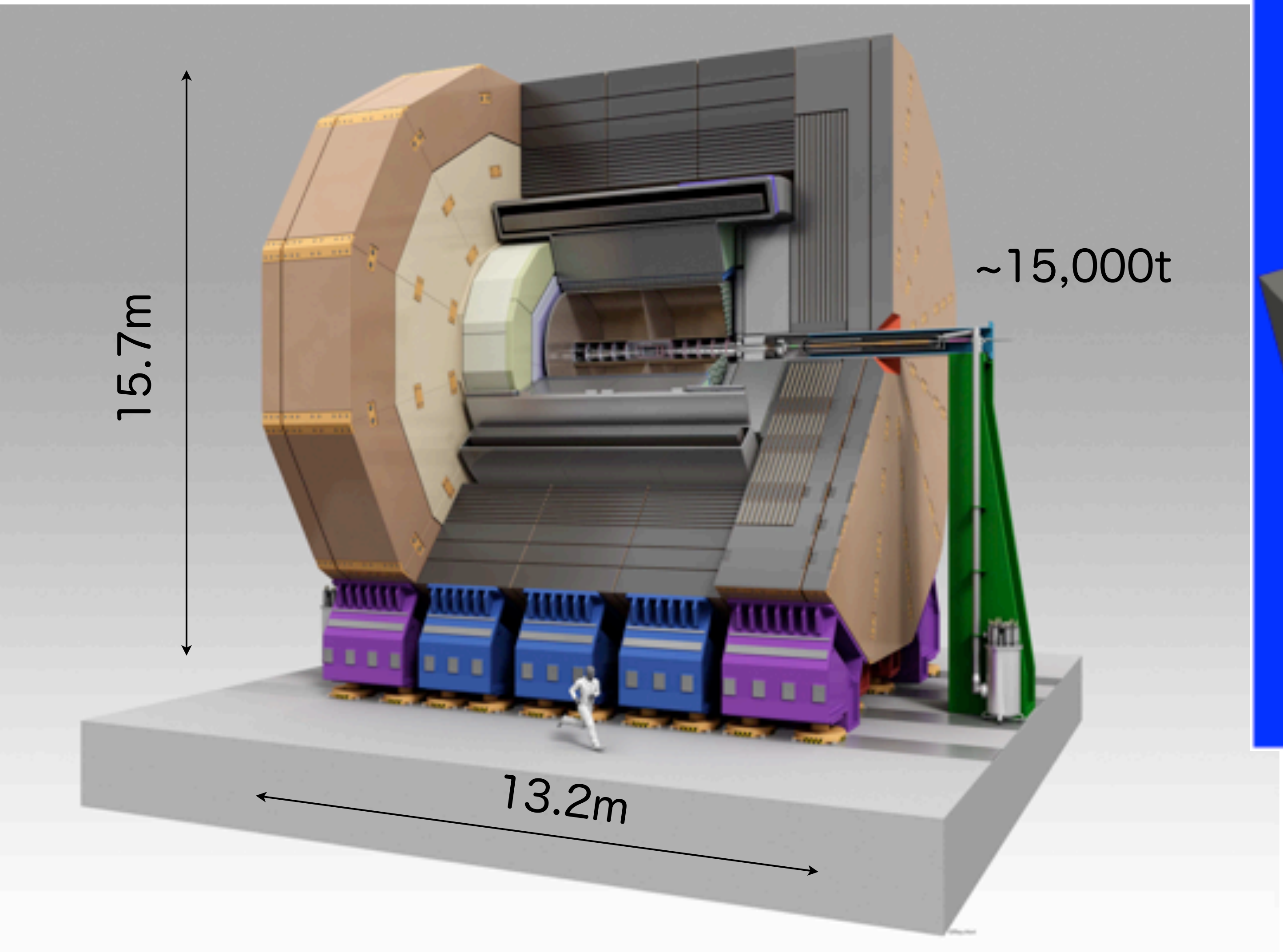


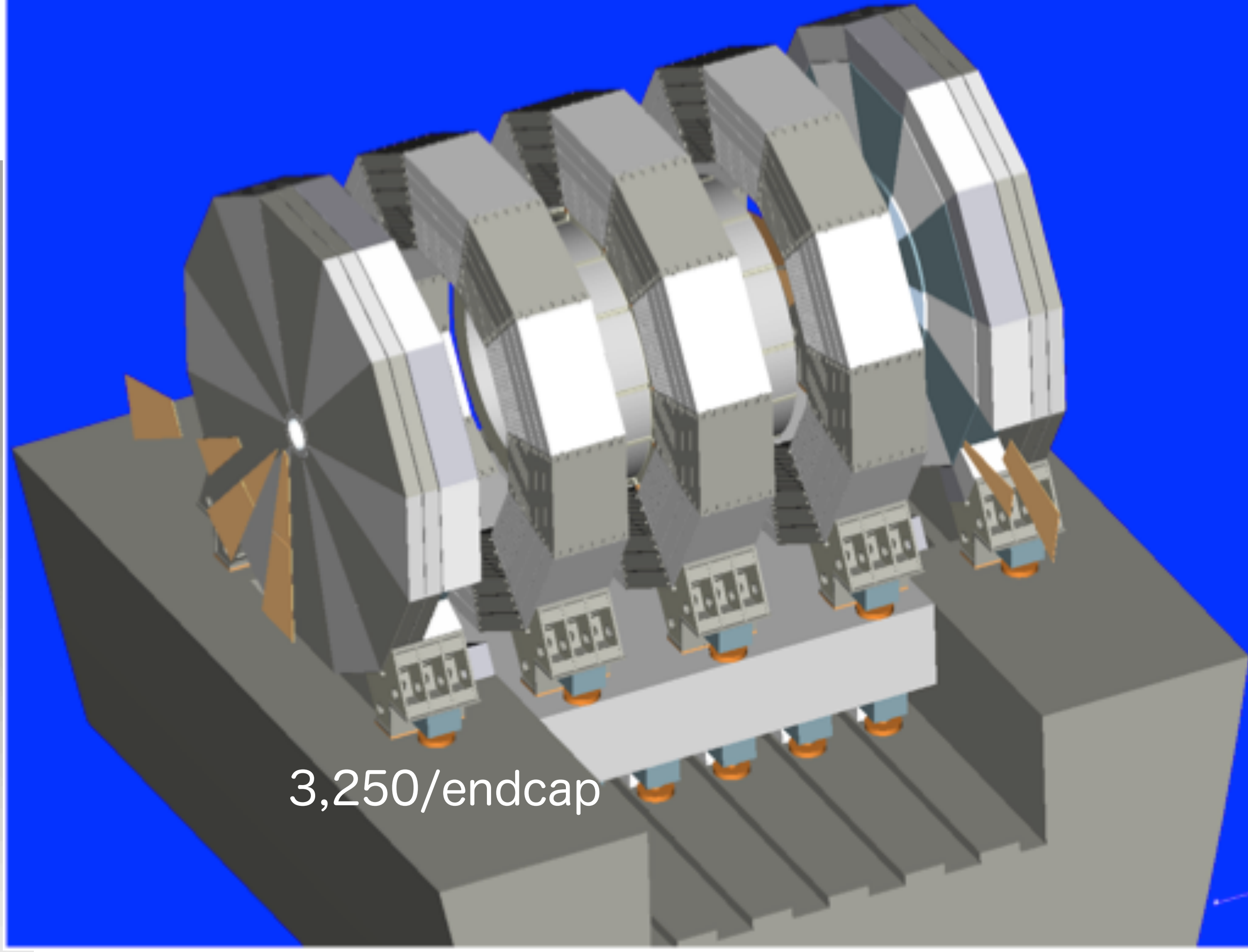
Material Strength and Allowable stress

	Material		Steel	Aluminum	Stainless
			SS400	AC4C－T5	SUS304
Material strength	Tensile (σu)	N/mm2 (=MPa)	400	137	520
	Yeild (σy)	N/mm2	205	108	205
	F -1	F-1＝σy	205	108	205
	F-2	F-2=0.7*σu	280	96	364
	F	Smaller value	205	108	205
Material Allowable Stress	Allowable stress(MPa)				
	Tension	ft＝F/1.5	137	72	137
	Shearing	fs＝F/(1.5√3)	79	42	79
	Bending	fb＝F/1.3	158	83	158
	Hertz stress	fp＝F/1.1	186	98	186
	Bolt(Tension)	ft＝F/2	103	54	103
	Bolt(Shear)	fs＝F/(1.5√3)	79	42	79
	Bolt(Hertz)	fp＝1.25F	256	135	256
	Roller	fp＝1.9F	390	205	390
	Welding(PT)	fs＝F/(1.5√3)	79	42	79
	Welding(No PT)	fs＝0.45F/(1.5√3)	36	19	36
			237@Bend		
	Earthquake	(Above)x1.5	(=158x1.5)		

H. Yamaoka, “Magnet seismic analysis”, 10 July, 2007, KEK

ILD Detector in TDR





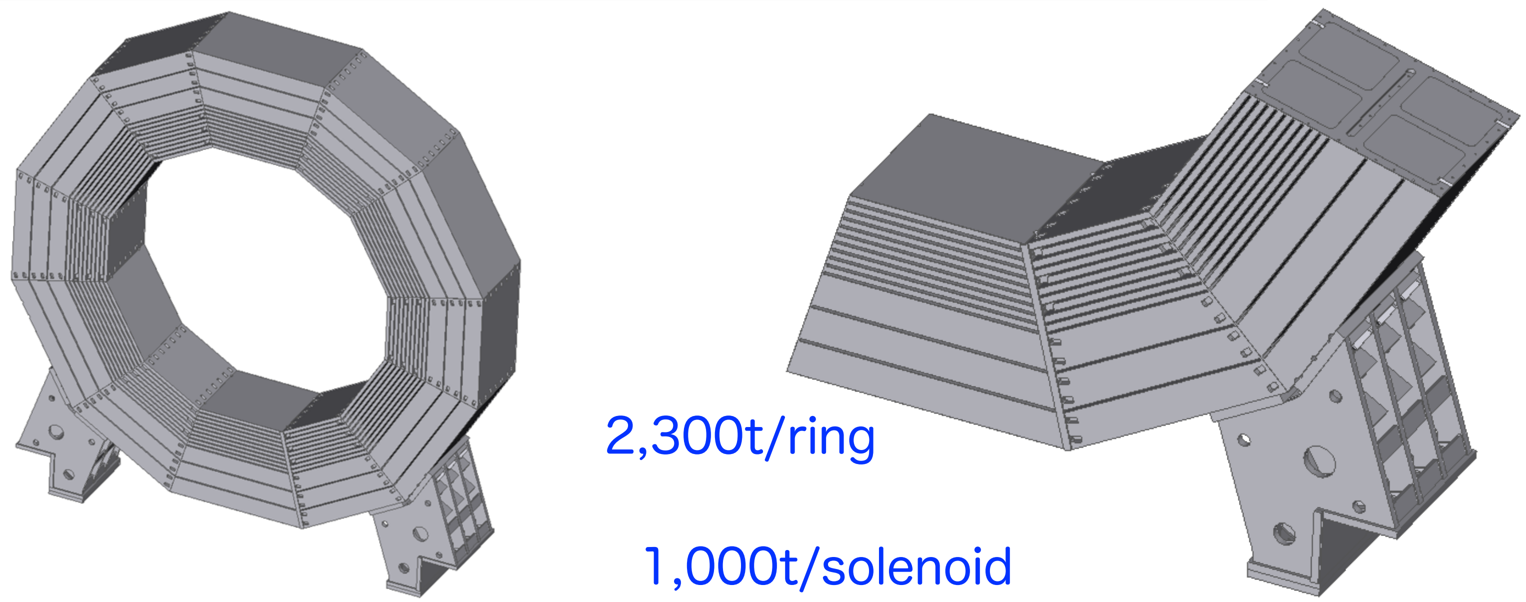
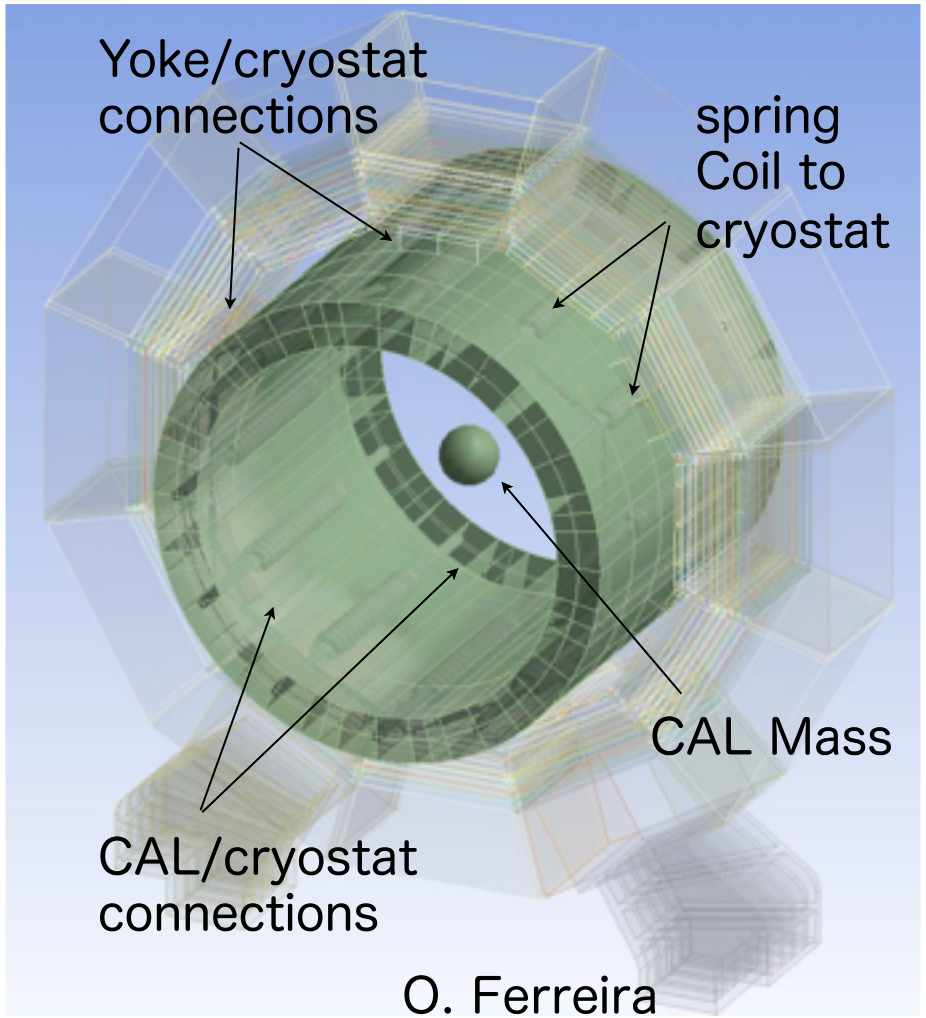


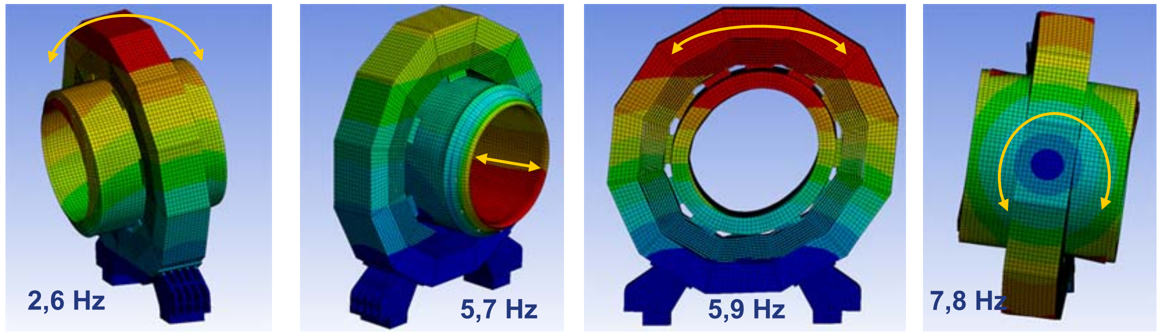
Figure 2.6.2: The yoke barrel design: general view of one barrel ring (left) and detailed view of a sector with one supporting foot (right)



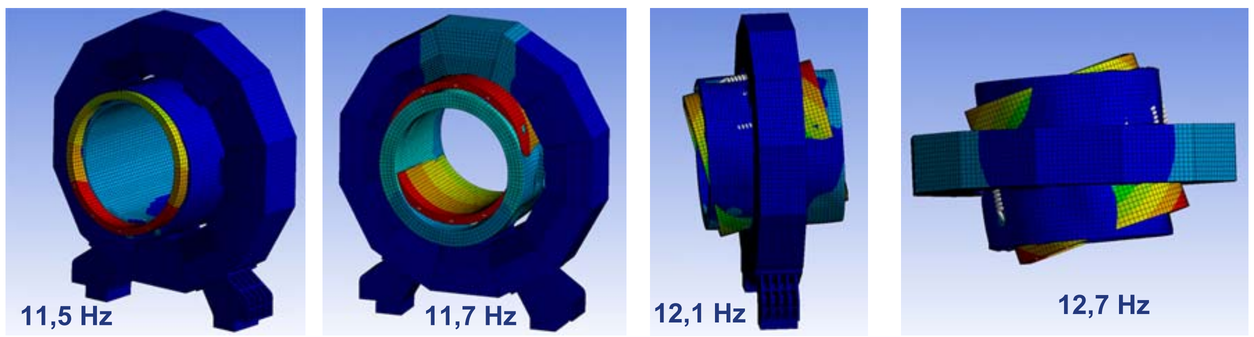
Recent study by O.Ferreira, March 2012

Preliminary results / Eigen Modes

Global modes



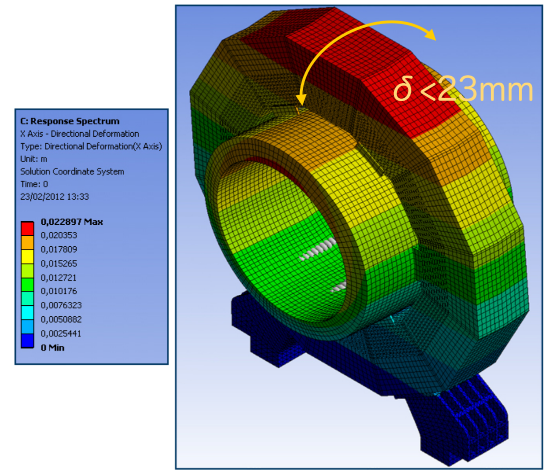
Modes associated with the coil

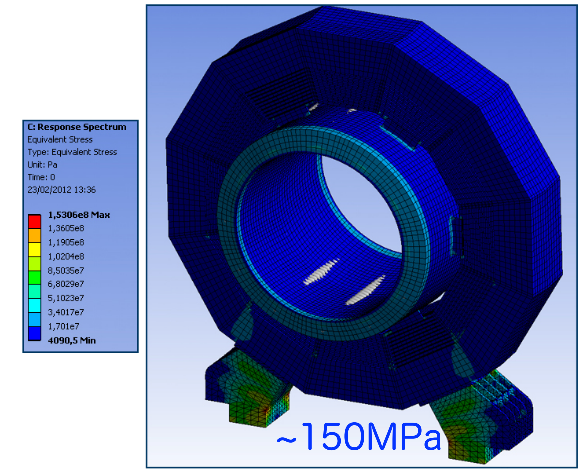


based on ISO3010

hard soil RS Analysis Results $A_0=1.5m/s^2$

- With the acceleration response spectrum applied along the detector axis, the fundamental mode of the structure dominates: back and forth motion of the yoke ring
- The max displacement is around 23mm, which is quite high
- The peak stress is located in the feet. The level seems acceptable but the results need to be checked with a proper design and model
- Attaching the 3 rings together is probably the way to go to increase the overall stiffness and reduce the peak displacement

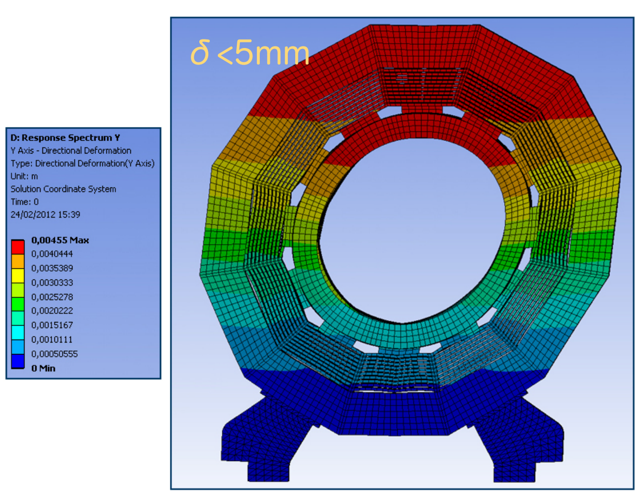


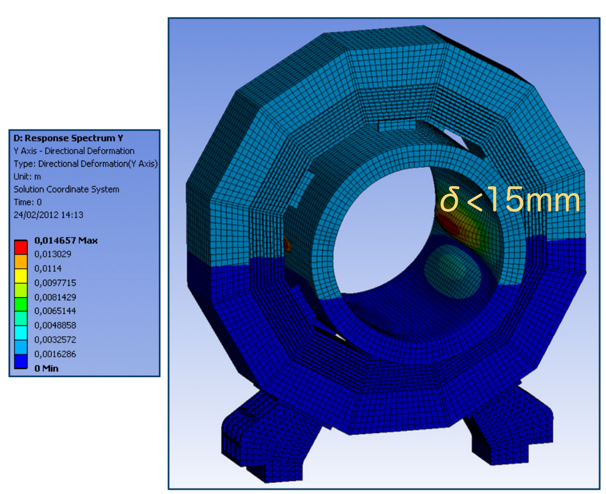


based on ISO3010

hard soil RS Analysis Results $A_0=1.5m/s^2$

- With the acceleration spectrum applied perpendicular to the detector axis, the displacement are significantly lower (less than 5 mm).
  - Due to its geometry, the yoke ring offers a good resistance to side loading
  - The effect is still not negligible
- With a rail type support, the effect is local: it affects only the calorimeters. The peak displacement increased to around 15 mm

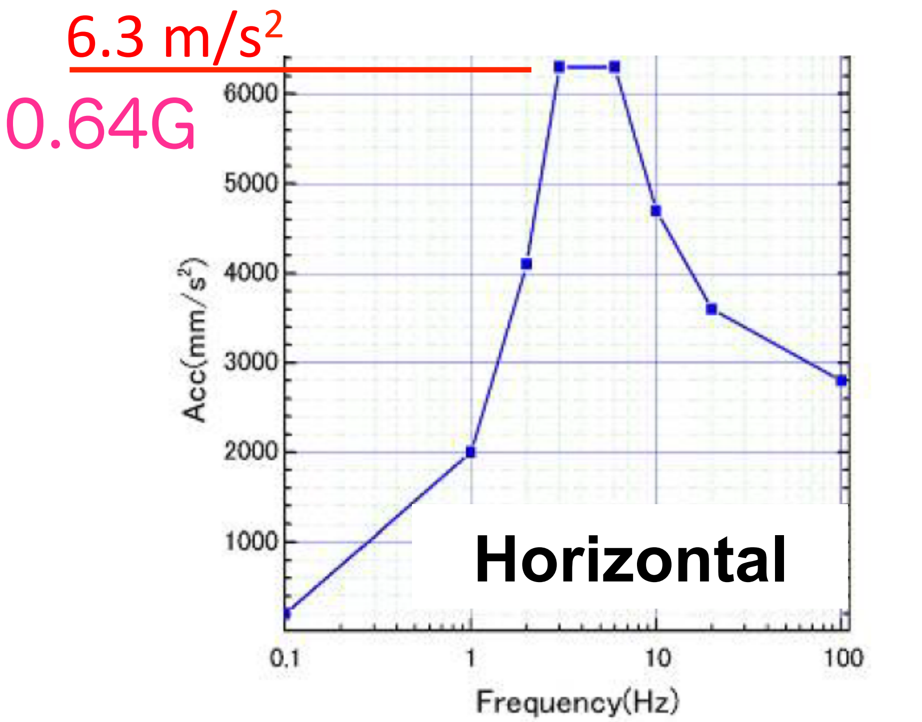




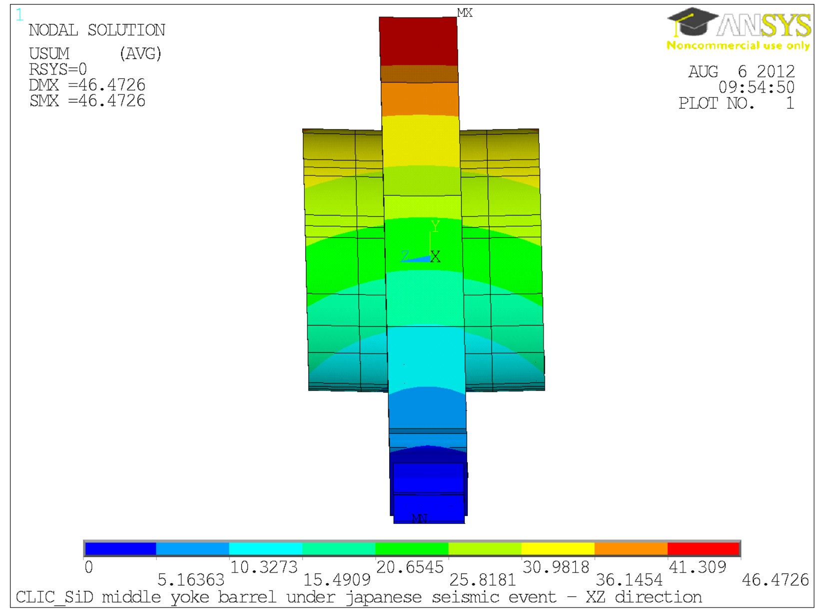
Conclusion

- Seismic load is a major load case that needs to be taken into account when designing instruments to be installed in Japan
- Detectors and ancillary systems should be designed to be seismic resistant
- It is desirable to take into account those aspects as soon as possible in the design phase of the instruments
- Additional and stronger mechanical connections are needed to resist loading from various direction, which significantly impacts the assembly procedure of the detector

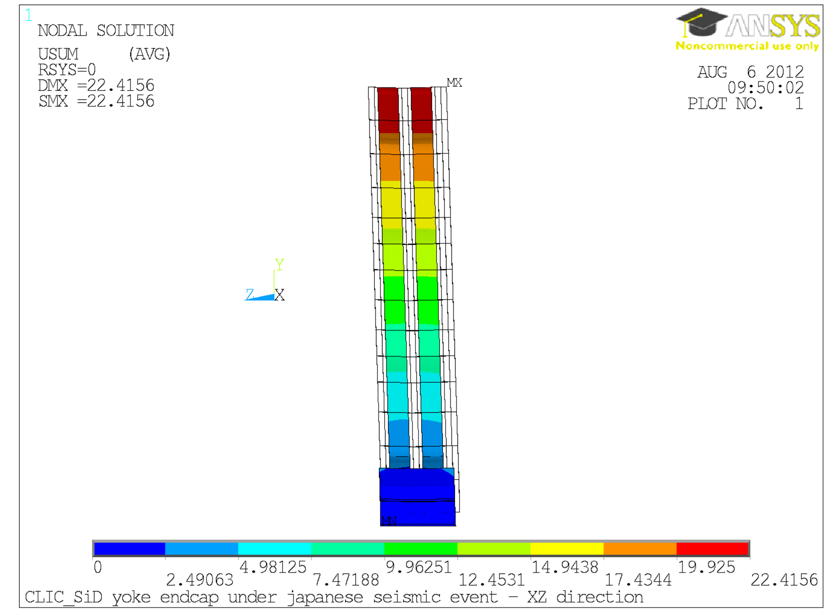
CLIC_SiD yoke – J-PARC spectrum



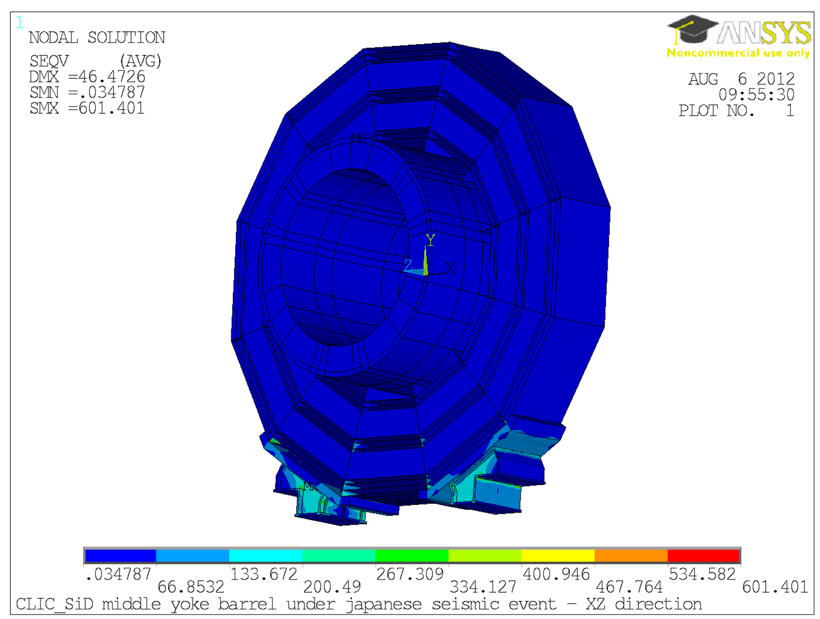
J-PARC - ND280 magnet system spectrum
Courtesy: T. Tauchi (KEK)



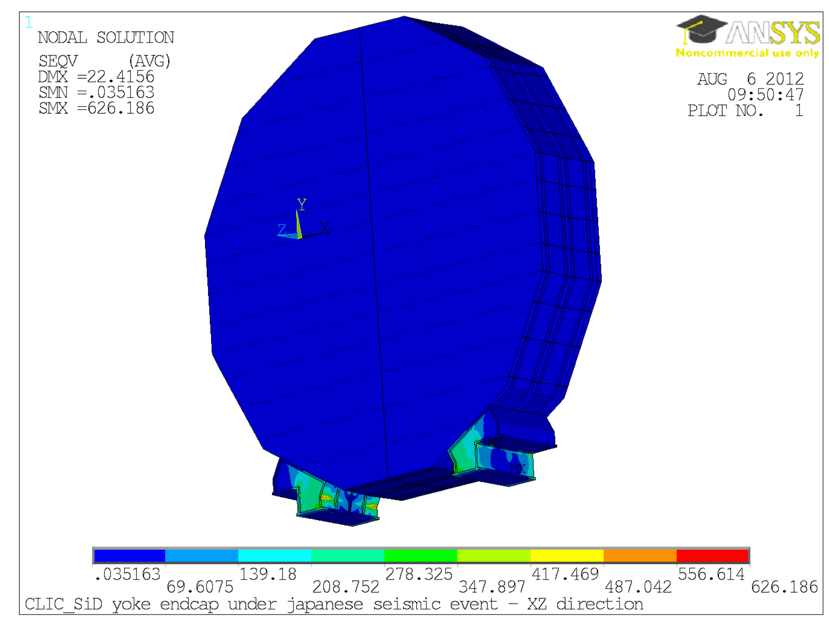
Maximum deformation: **46.4 mm**



Maximum deformation: **22.4 mm**



Maximum v. Mises stress: **601 MPa**

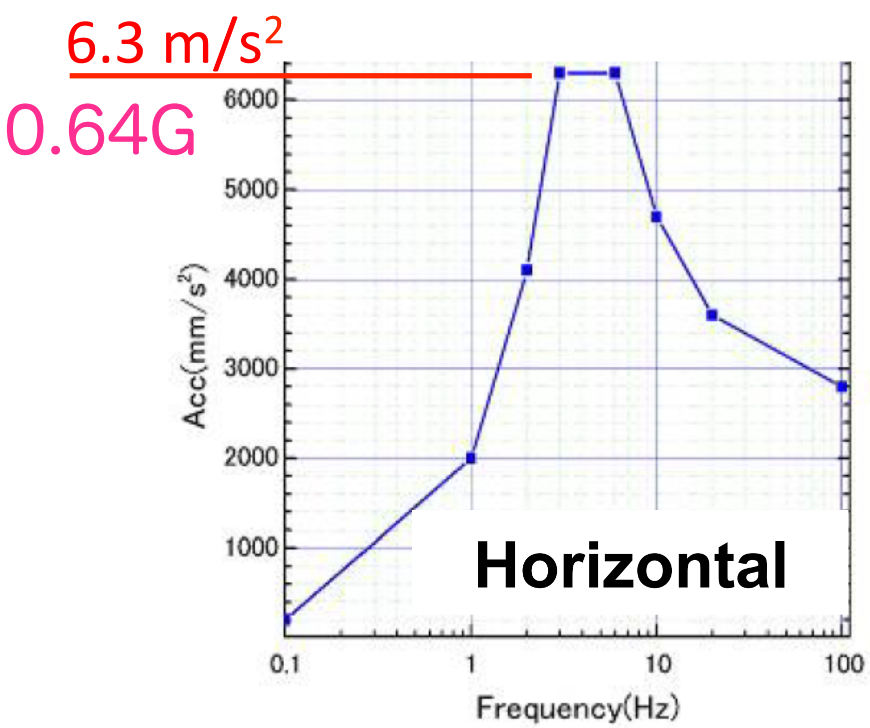


Maximum v. Mises stress: **626 MPa**

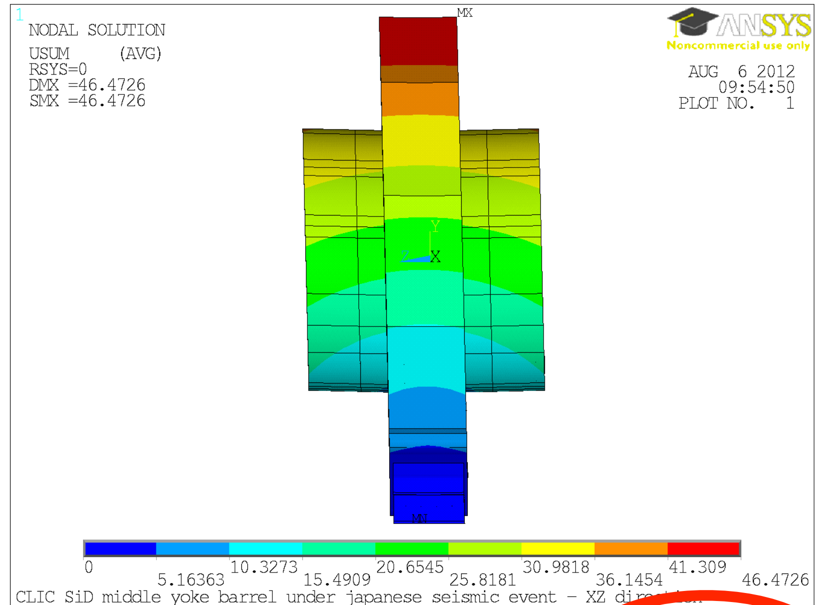
Rigid strategy **not feasible** in high seismicity locations

Fernando Duarte Ramos (CERN)

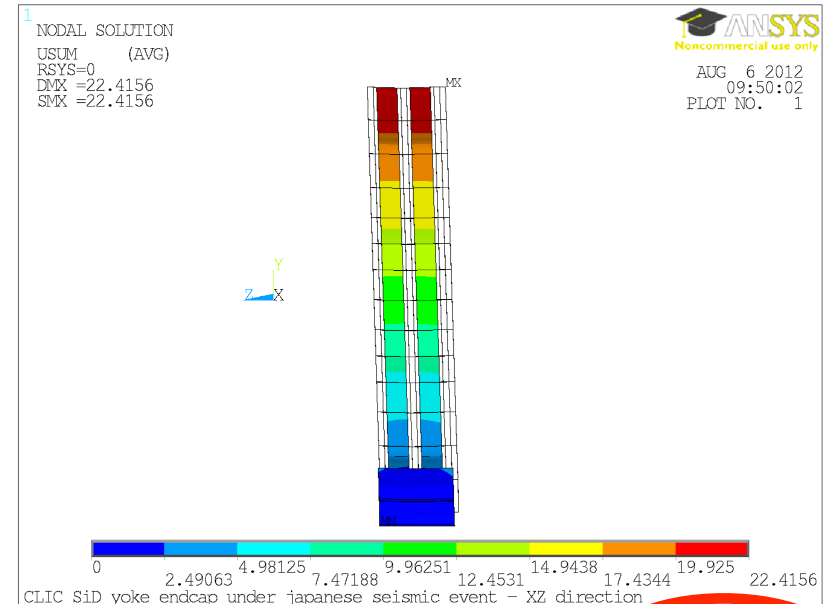
CLIC_SiD yoke – J-PARC spectrum



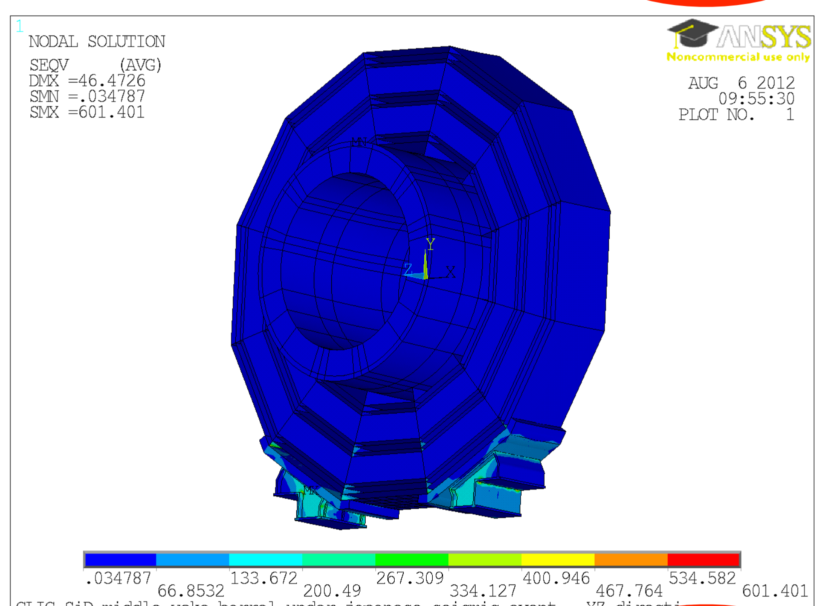
J-PARC - ND280 magnet system spectrum
Courtesy: T. Tauchi (KEK)



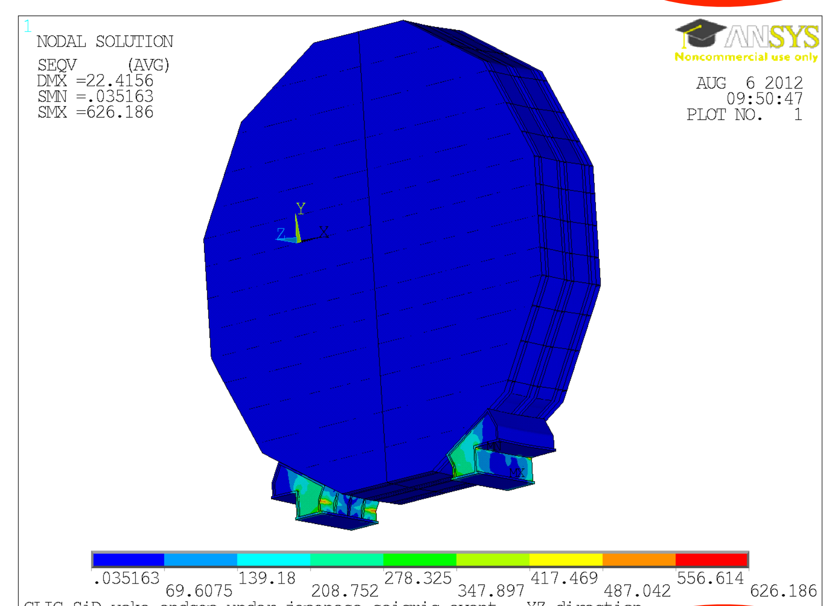
Maximum deformation: **46.4 mm**



Maximum deformation: **22.4 mm**



Maximum v. Mises stress: **601 MPa**



Maximum v. Mises stress: **626 MPa**

Rigid strategy **not feasible** in high seismicity locations

Fernando Duarte Ramos (CERN)

Summary on safety issues

1. Radiation shielding : has been studied by experts
2. Magnetic field leakage : followed ICNIRP guideline
3. Earthquake protection will follow the ISO3010.
4. The protection of CLIC ILD has been investigated.
   - OK at the CERN site, but NO at J_PARC
   - Rigid detector support
   - Above platform isolation
5. We would like to analyze it at the Japanese sites.
   - Rigidness of ILD detector
   - Isolation method with respect to the platform and detailed layout needed