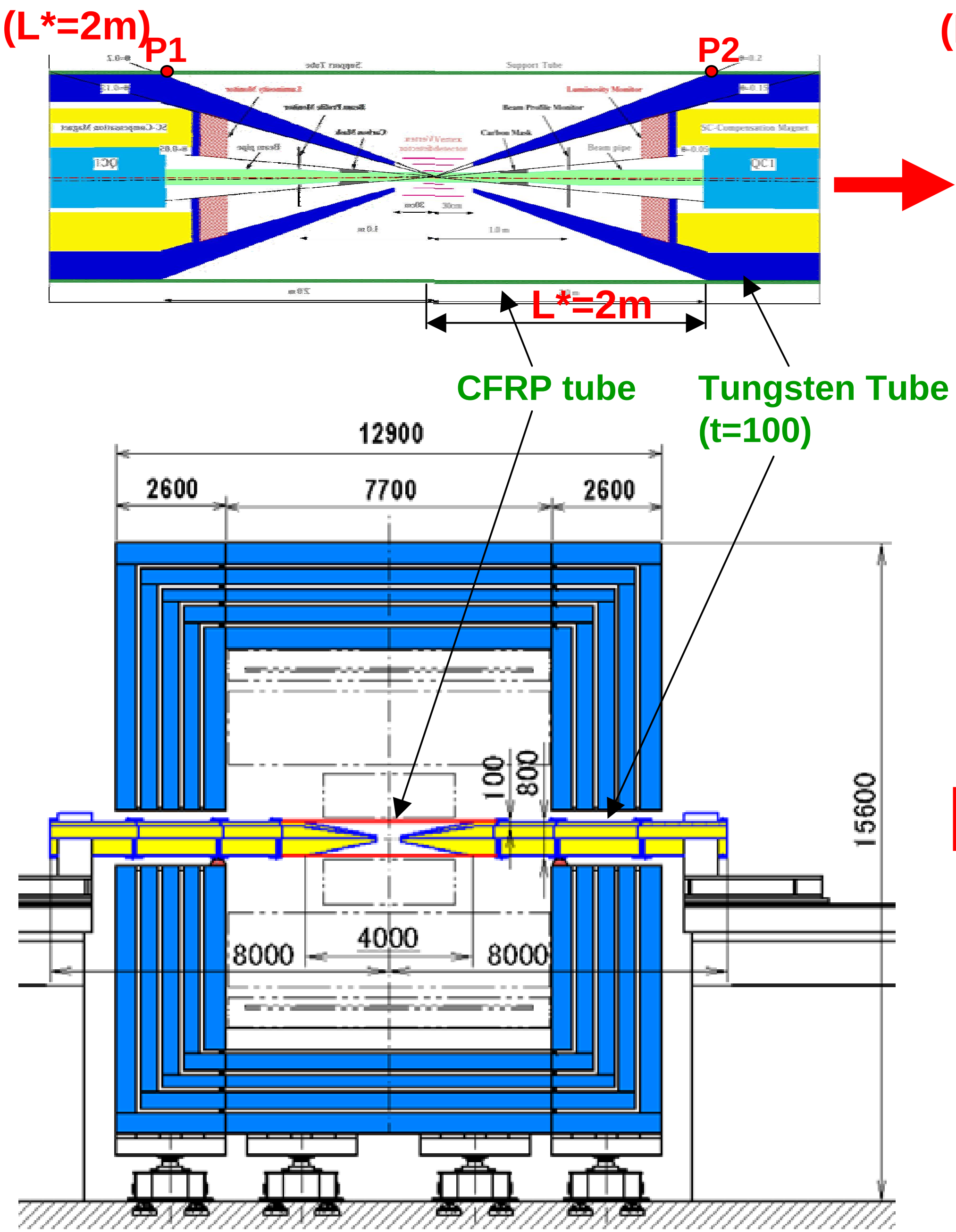
Mar. 04, ’05

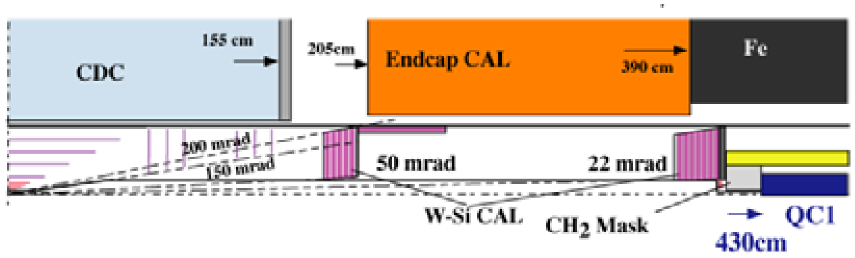
Stabilization of final doublet and Support tube R&D

KEK H. Yamaoka

Introduction



(L*=4m)



- For high luminosity
  Effects of;
  Ground motion, culture Noise
  have to be eliminated.
- Components at IR region
  Supported by
  Tungsten tubes, CFRP tube

→ Analyses, Excitation tests

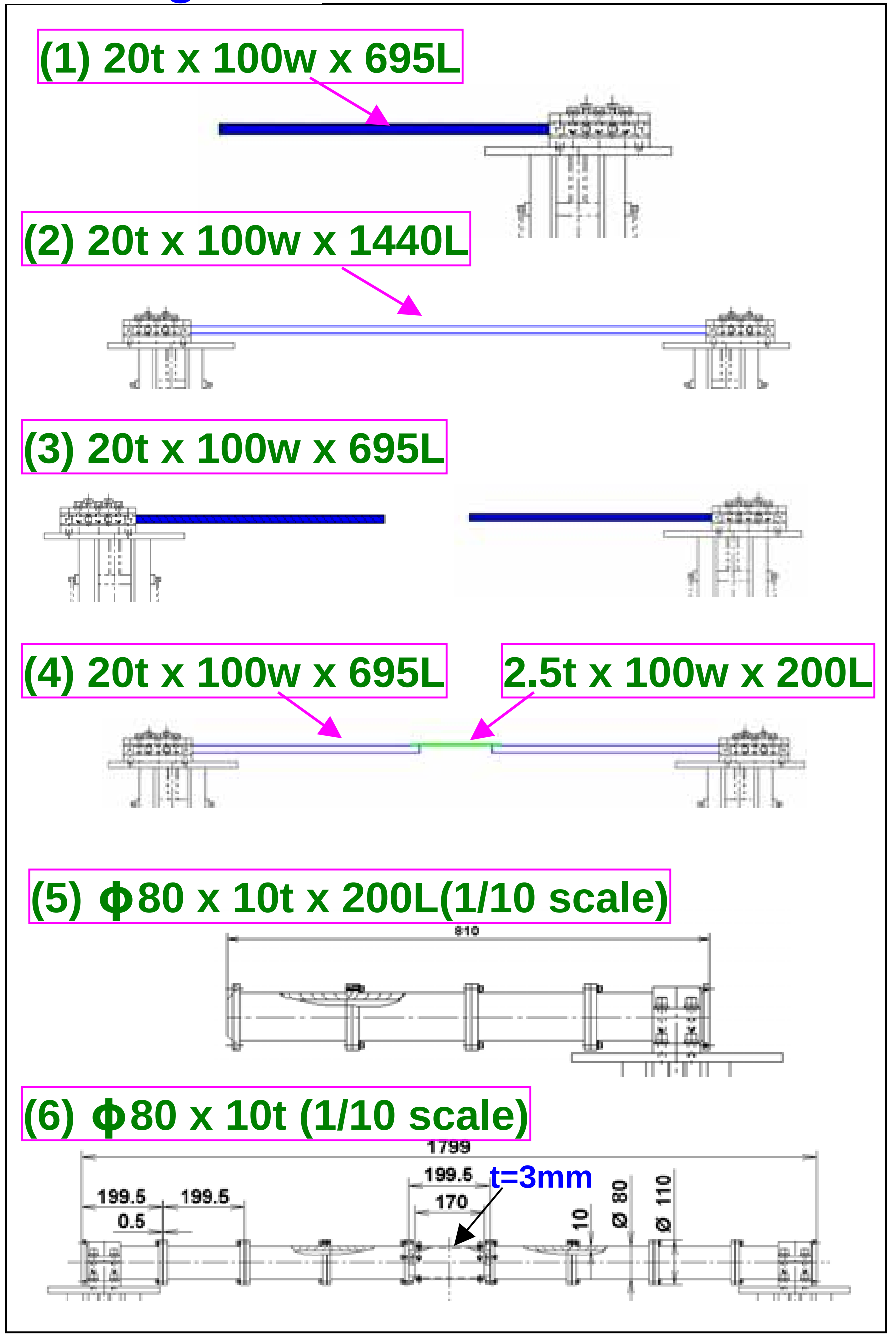
Study Items;

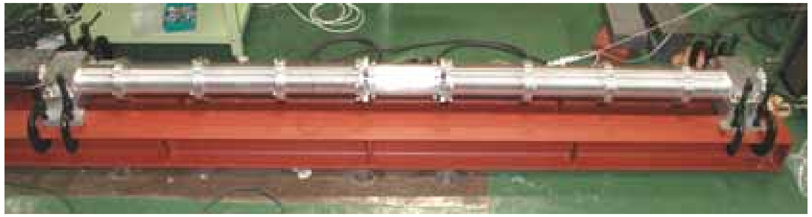
- Check consistency
  Analyses ⇔ Exciatation test
- Is necessary CFRP tube?

→ If yes, how much thickness?

- How much is relative amplitude?
  |P1-P2| < 2nm(Criteria)

Exciting Test





Input exciting force

(Excitation table or Impact hammer)

↓

Measurement: natural frequencies

Mode shape

↓

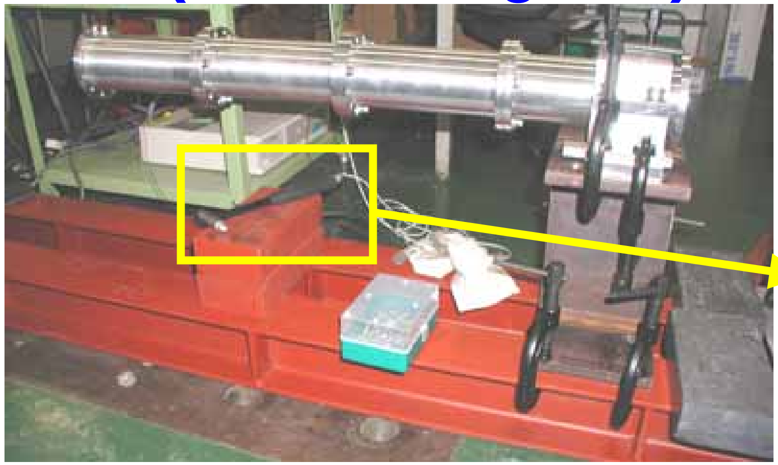
Compare to the FEM results

○ Tests(Hammering test)

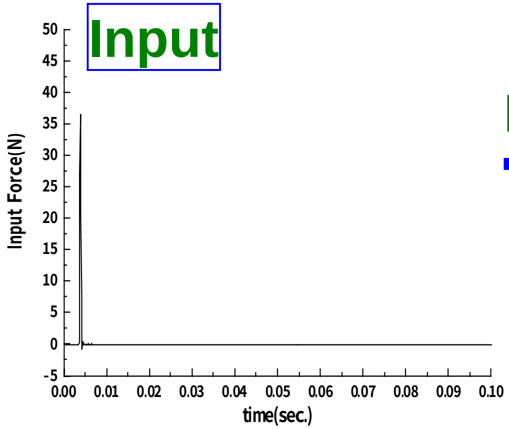
FRF(Frequency Response Function)

$$H_{ij}(f) = \frac{X_i(f)}{F_j(f)}$$

X_i: Output Acc.
F_j: Input force

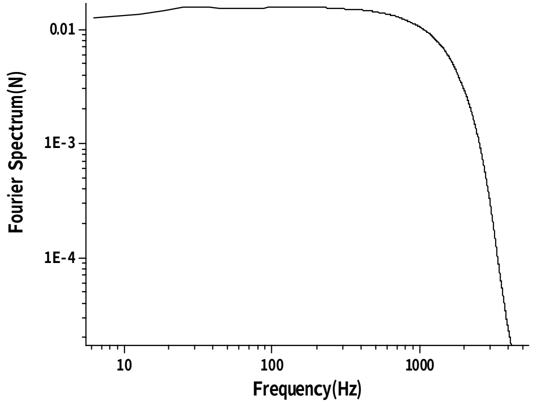


Input

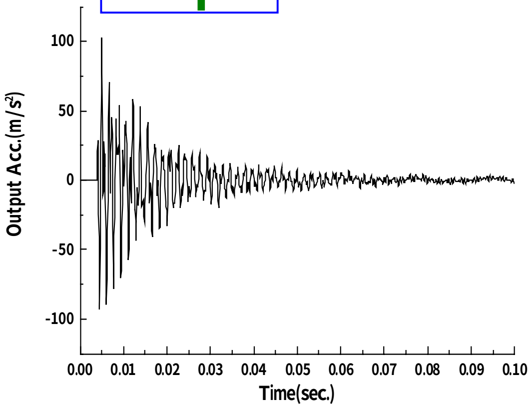


FFT

Input

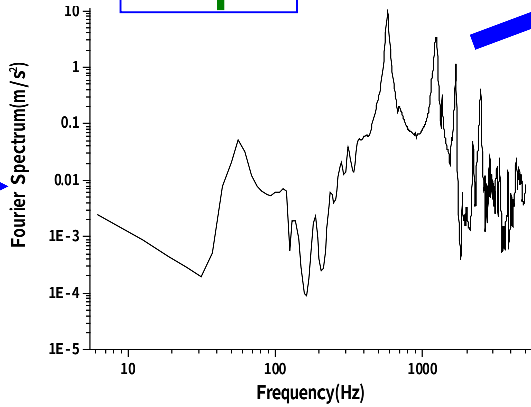


Output



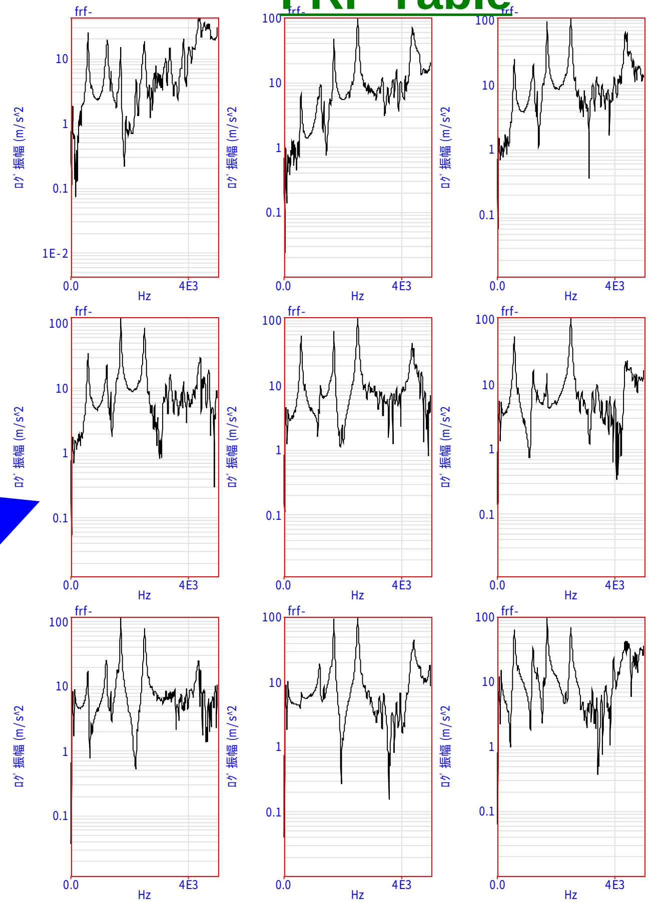
FFT

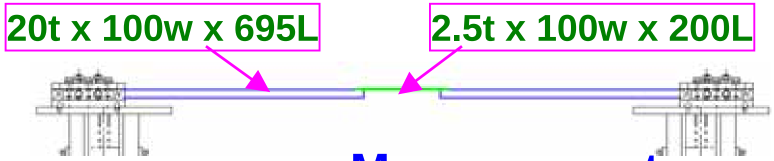
Output

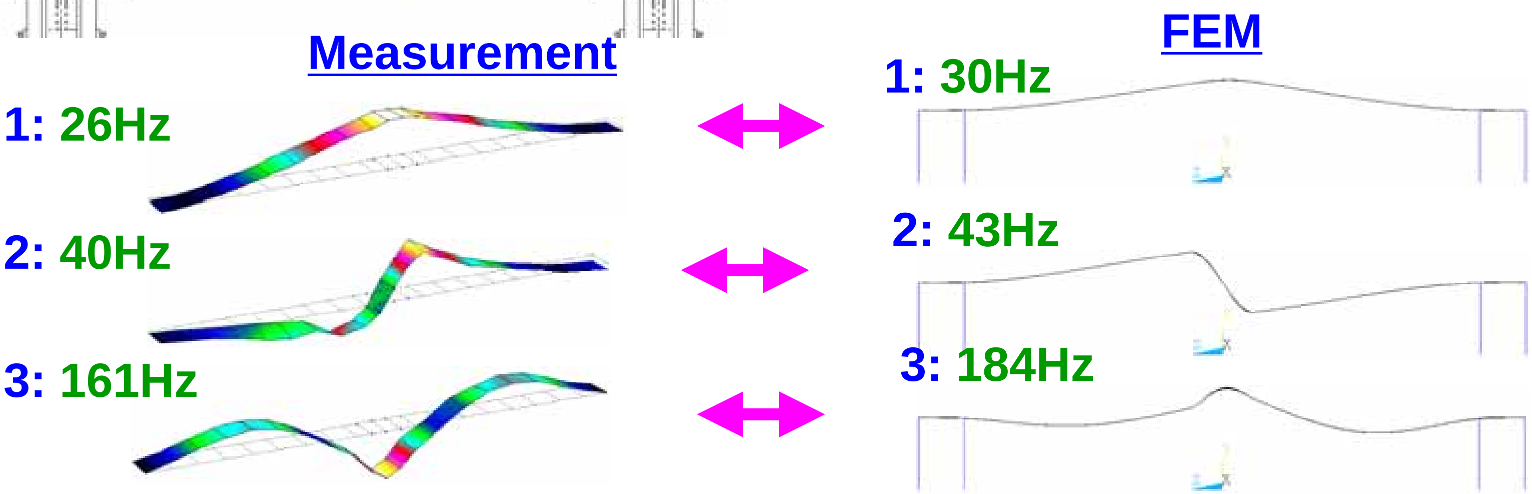


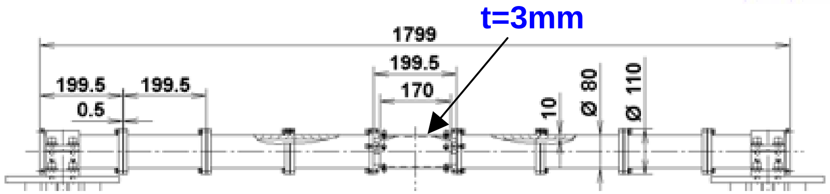
FRF

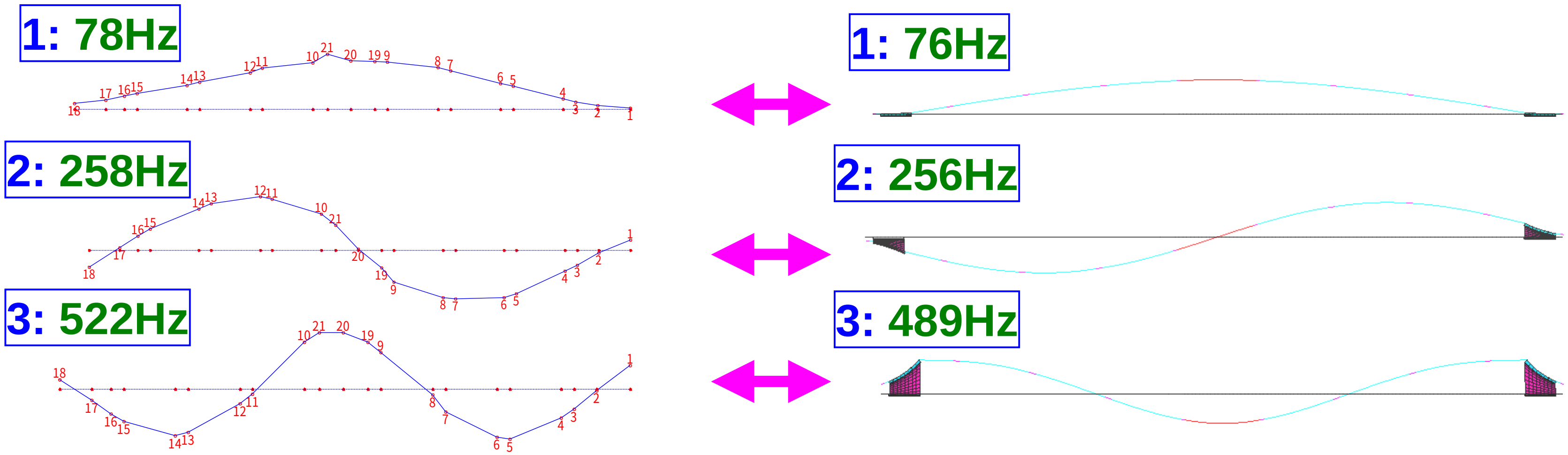
FRF Table







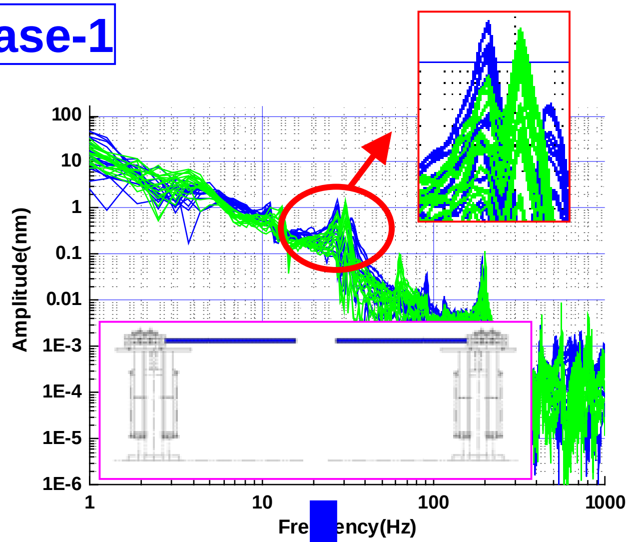




1st 〜3rd mode: Good agreement with FEM

Support structure should be modeled in FEM.

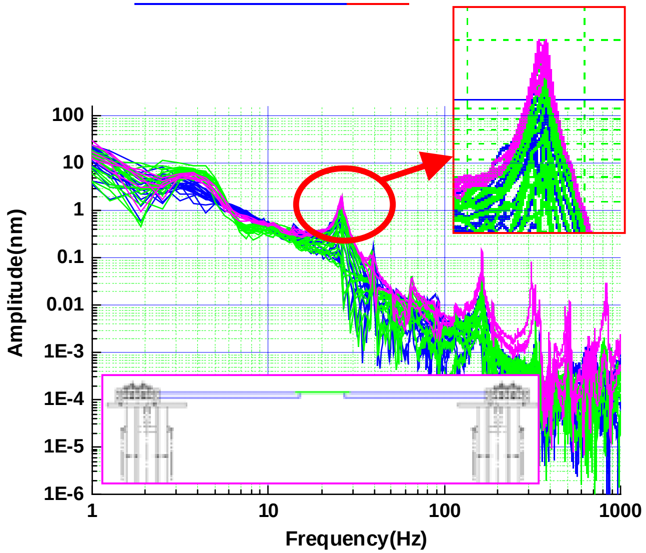
Case-1



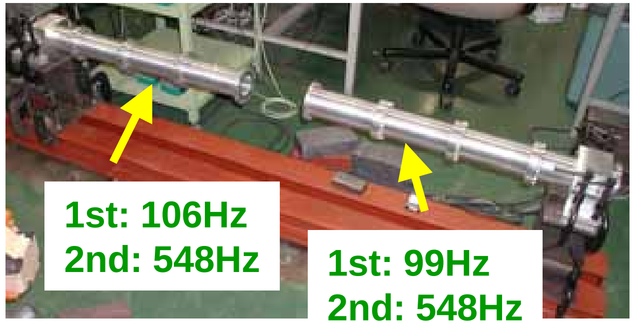
20mm thick plate

2.5mm thick plate

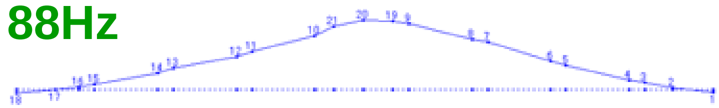
Stiffness: 1:512



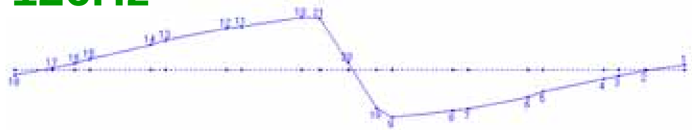
Case-2



1st: 88Hz



2nd: 126Hz

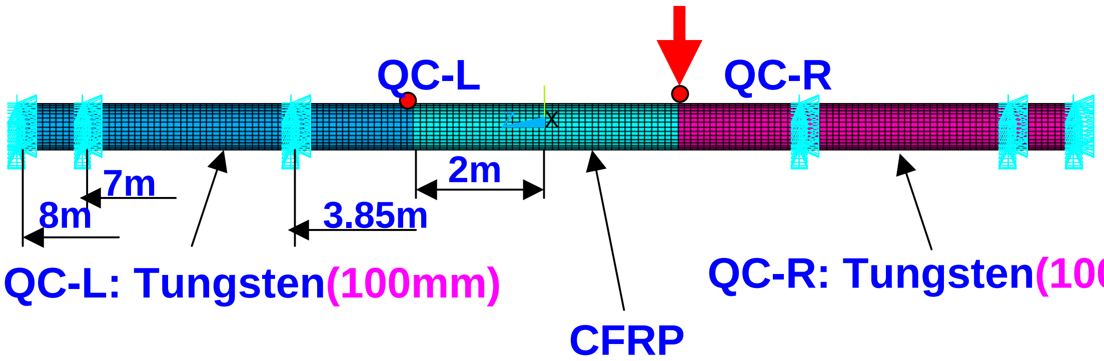


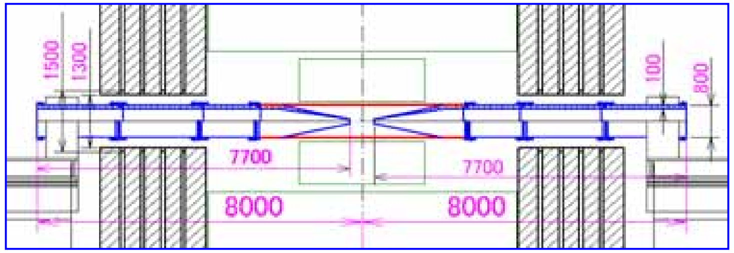
By connecting very weak structure,
Deviation can be absorbed.
Correlation can be given.
→ Relative amplitude can be estimated.

Calculation of relative amplitude (L*=2m)

(Model-A)

$F_0\cos(\omega t)=(m \cdot a)\sin(\omega t)$ ← ω= 0 – 1000Hz





	3mm	5mm	10mm
0Hz			
1Hz			
3Hz			
5Hz			

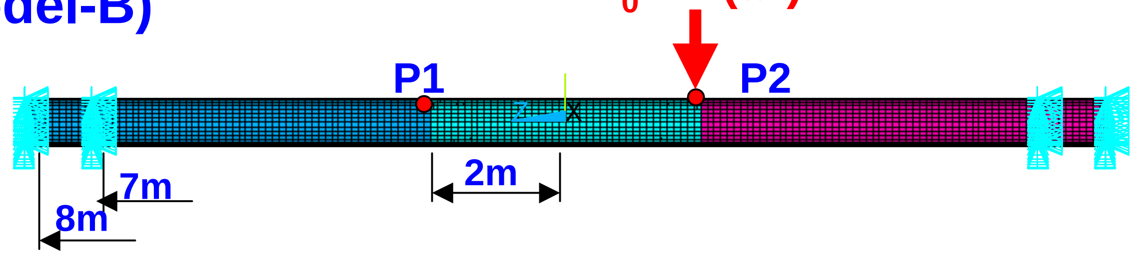
→ CFRP thick.

← Calculate relative amplitude
(QC-R)-(QC-L)

Difference of 1st mode of resonant frequency between QC-R and QC-L.

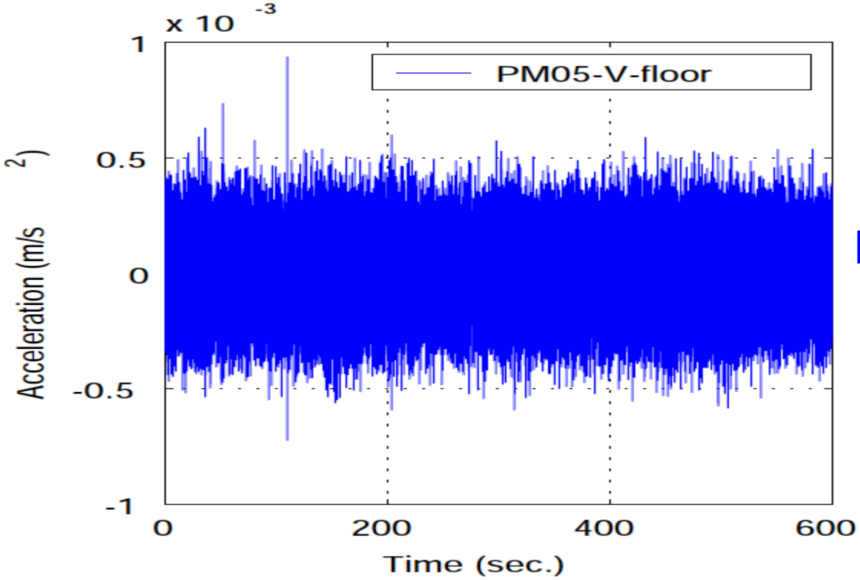
(Model-B)

$F_0\cos(\omega t)$

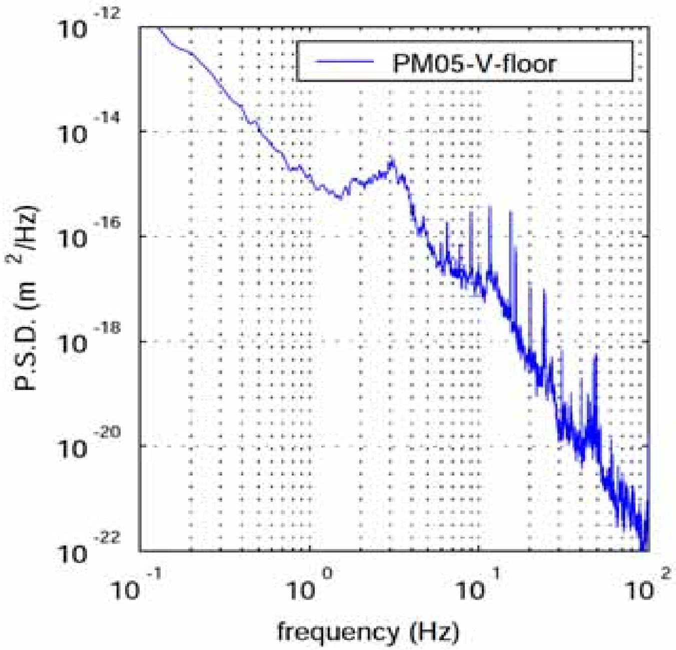


Estimation of Input Acc.

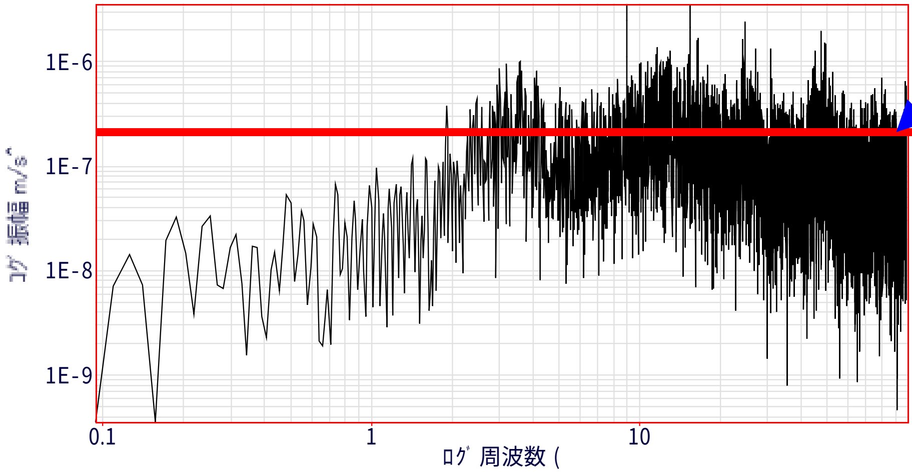
Data: Vertical @ATF(17:00 Feb. 10, 2004)



P.S.D.



Linear Spectrum



$2x10^{-7}m/s^2$

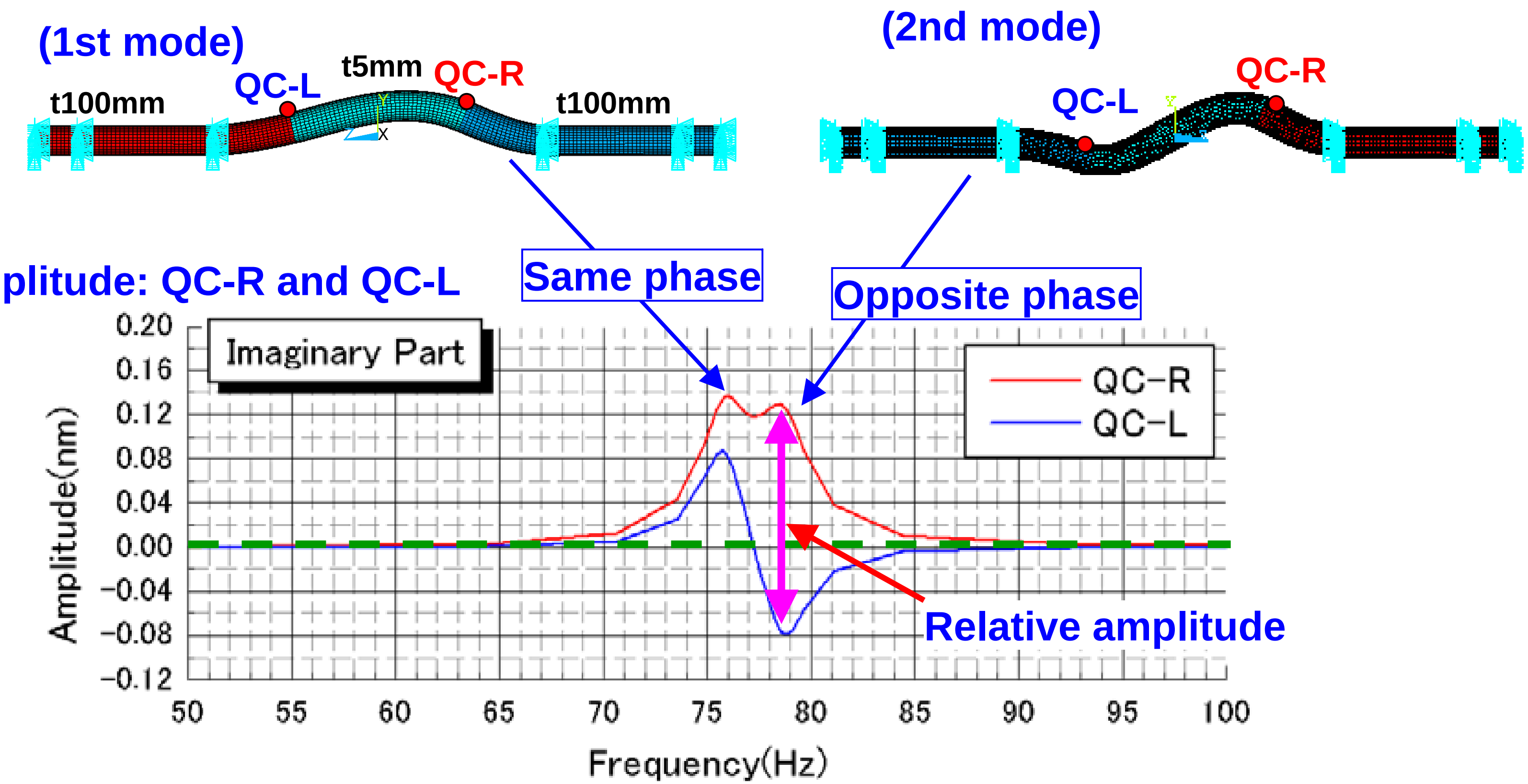
Input data

Input Acc. = $2x10^{-7}m/s^2$

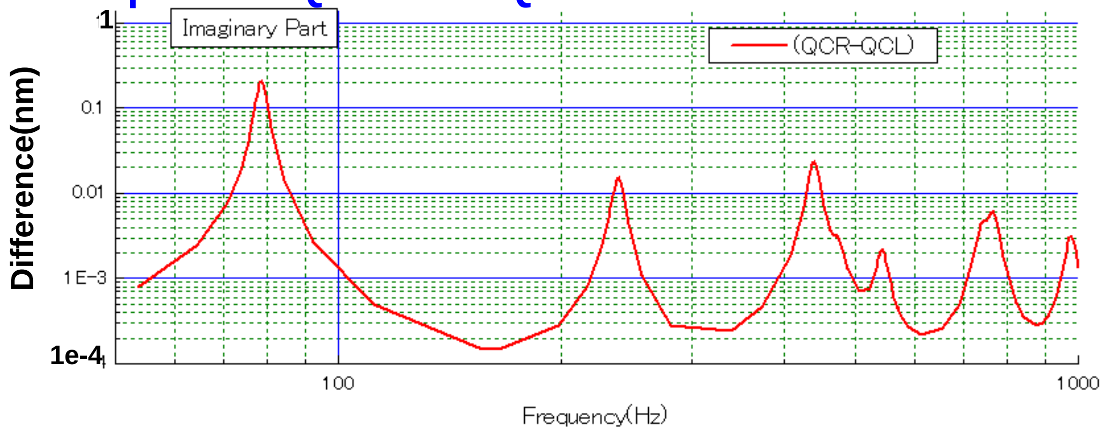
Mass=90tons/9.8[m/s^2]

Self weight

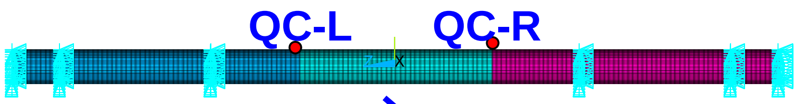
In case of 100mm-5mm(CFRP)-100mm, Δf=0Hz

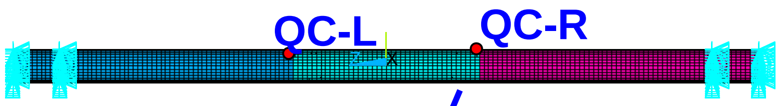


Relative amplitude: QC-R and QC-L



Other calculations(L*=2m)

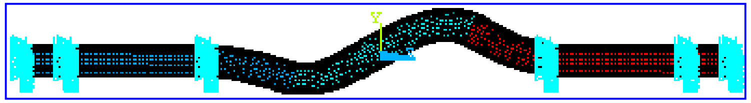


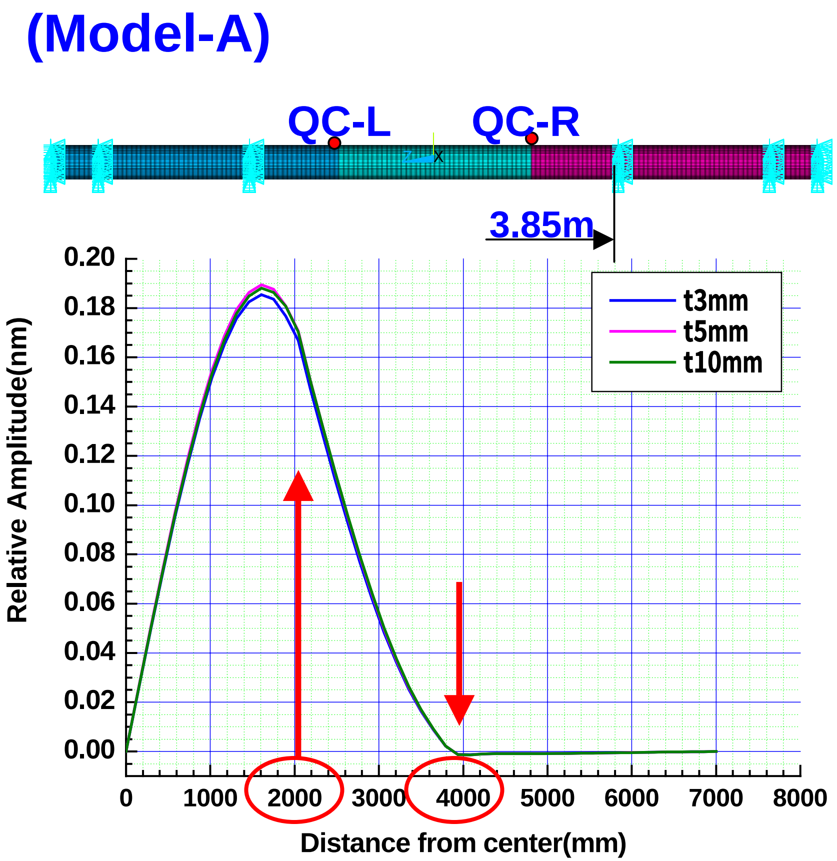


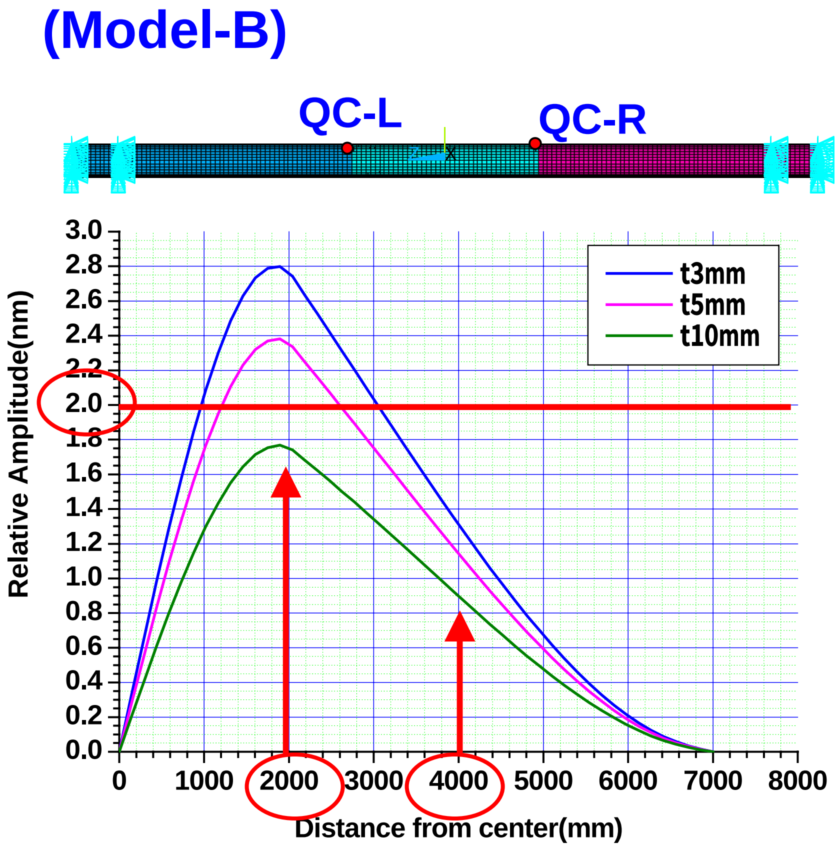
			3-Point fixed(Both end+3.85m)				2-Point fixed(Both end)			
			CFRP			Tungsten	CFRP			Tungsten
Δf	Mode		3mm	5mm	10mm	100mm	3mm	5mm	10mm	100mm
0Hz	1st	Freq.(Hz)	75.8	76.0	76.0	49.2	17.6	17.7	17.9	16.3
		Diff.(nm)	0.098	0.055	0.016	9.09E-05	0.065	0.026	0.008	2.60E-04
	2nd	Freq.(Hz)	77.5	78.6	81.4	113.0	20.2	21.8	25.0	44.4
		Diff.(nm)	0.213	0.206	0.192	0.080	2.816	2.398	1.763	0.325
1Hz	1st	Freq.(Hz)	75.2	75.3	75.5	49.0	17.0	17.1	17.3	16.0
		Diff.(nm)	0.129	0.080	0.035	1.10E-03	0.823	0.480	0.234	3.60E-02
	2nd	Freq.(Hz)	77.0	78.2	80.9	112.6	19.8	21.4	24.7	43.3
		Diff.(nm)	0.174	0.177	0.177	0.081	2.357	2.186	1.696	0.334
3Hz	1st	Freq.(Hz)	73.4	73.7	74.2	48.5	15.6	15.9	16.3	15.3
		Diff.(nm)	0.173	0.133	0.076	3.26E-03	2.339	1.496	0.752	1.30E-01
	2nd	Freq.(Hz)	76.9	77.8	80.4	111.9	19.5	20.9	24.1	41.0
		Diff.(nm)	0.094	0.116	0.143	0.082	1.547	1.726	1.532	0.349
5Hz	1st	Freq.(Hz)	71.5	72.0	72.7	48.1	13.9	14.4	15.1	14.4
		Diff.(nm)	0.204	0.172	0.113	5.62E-03	3.813	2.631	1.396	2.84E-01
	2nd	Freq.(Hz)	76.8	77.6	80.0	111.0	19.3	20.6	23.6	38.4
		Diff.(nm)	0.056	0.078	0.114	0.084	1.077	1.343	1.343	0.359
Canti	1st	Freq.(Hz)	75.6				17.4			
		Amp(p-p)	0.224				3.869			

Diff: Relative amplitude between QC-R and QC-L(ΔZ=4m).

Relative amplitude at 2nd mode







Model-A

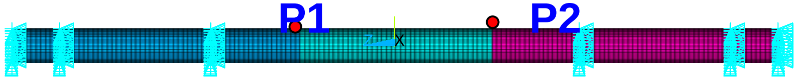
Small enough. Less than 2nm in all cases.

Model-B

Lager than 2nm at L*= 2m except for 10mm thick of CFRP.
Less than 2nm at L*= 4m.

Results

(Model-A)



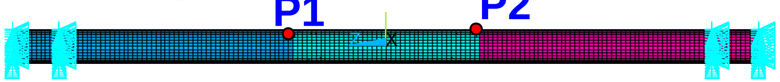
- Natural frequency: 76Hz
- Relative amp. : 0.2nm max. < 2nm(L*= 2m), small enough(L*= 4m)
- This is ideal configuration.
- In case of no CFRP tube(Cantilever): Amplitude=0.2nm <2nm

  CFRP tube is not necessary because of less than 2nm.

  However, it is difficult to amount them on a very stiff base stand.

So realistic natural frequencies must be lower than this value.

(Model-B)

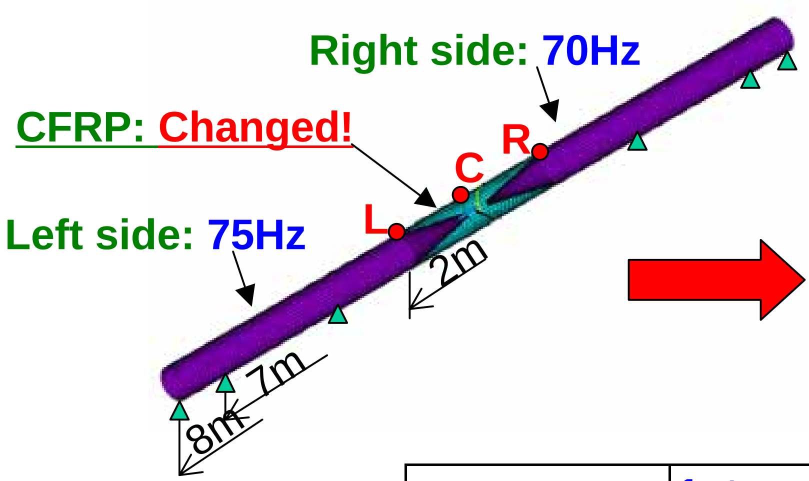


- Natural frequency: 17Hz,
- Relative amp. : 2〜3nm(L*= 2m), 1.2nm(L*= 4m)
- In case of no CFRP tube(Cantilever): Amplitude= 4nm

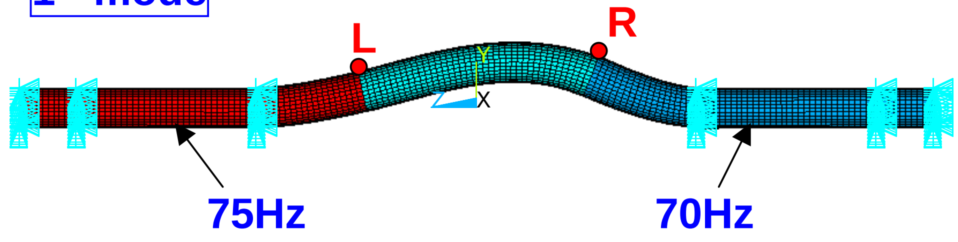
⇒ CFRP tube:

- No efficient to reduce amplitude.
- Deviation of natural frequency between two tubes can be absorbed.

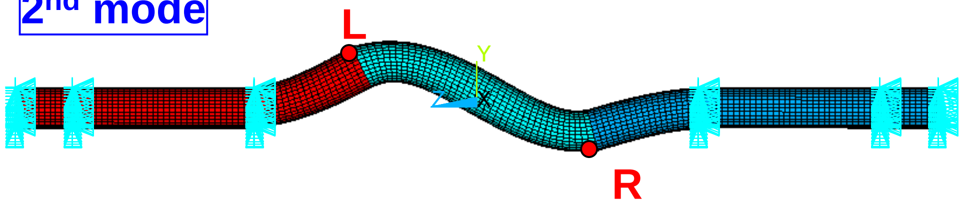
Optimization of CFRP tube thickness



1st mode



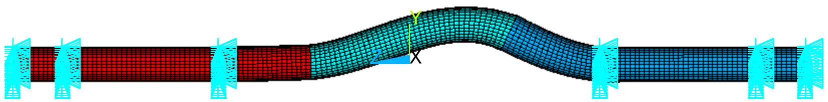
2nd mode



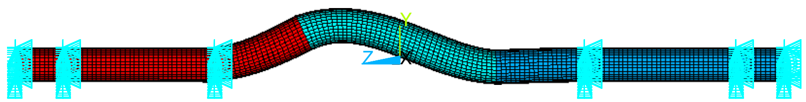
CFRP(mm)	1st mode Freq(Hz)	2nd mode Freq(Hz)
20	73.6	85.2
10	72.9	80.1
5	75.5	78.4
3	72.0	76.5
1	71.5	75.7

Less than this thickness, correlation and opposite phase don't appear at 2nd mode.

1st mode(CFRP: 1mm)

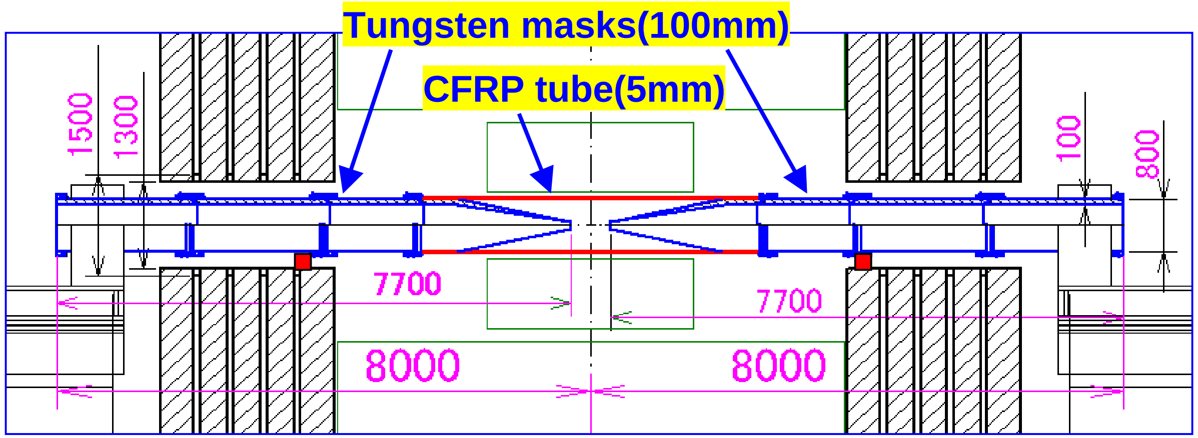


2nd mode



→ **At least, thickness of CFRP: >3mm**

Conclusion



- Tungsten tube: 100mm thick, CFRP: 5mm thick

  → Correlation is given to both-sides tubes in oscillating behavior.

- In case of L*= 2m;

  Support position: Both ends + 3.85m from I.P.
- In case of L*= 4m;

  Support position: Both ends

- Active vibration isolation system is necessary.

  → • CFRP tube is not efficient to reduce amplitude less than 2nm.

  • Amplitude is magnified if support tube is mount on a support stand.

  → To be calculated with measurement data

- It is necessary to design the stiff support base as possible

  → Natural frequency becomes high.

  → Amplitude decreases in proportion to frequency.