CAVITY BEAM ORBIT TILT MONITOR

Tohoku university　Daisuke Okamoto

contents

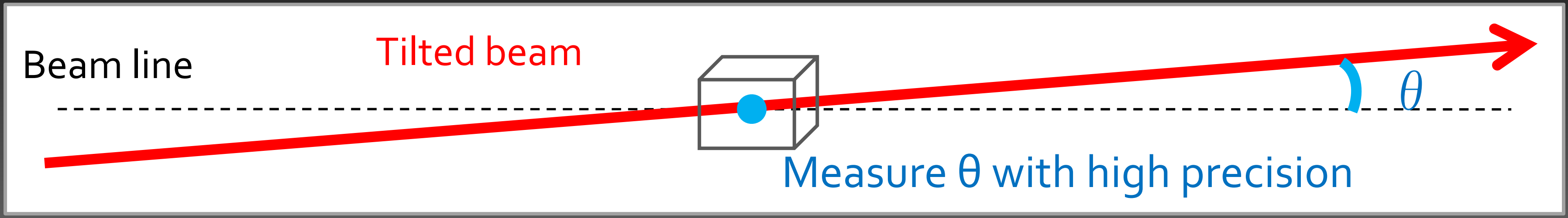
TILC09

Motivation

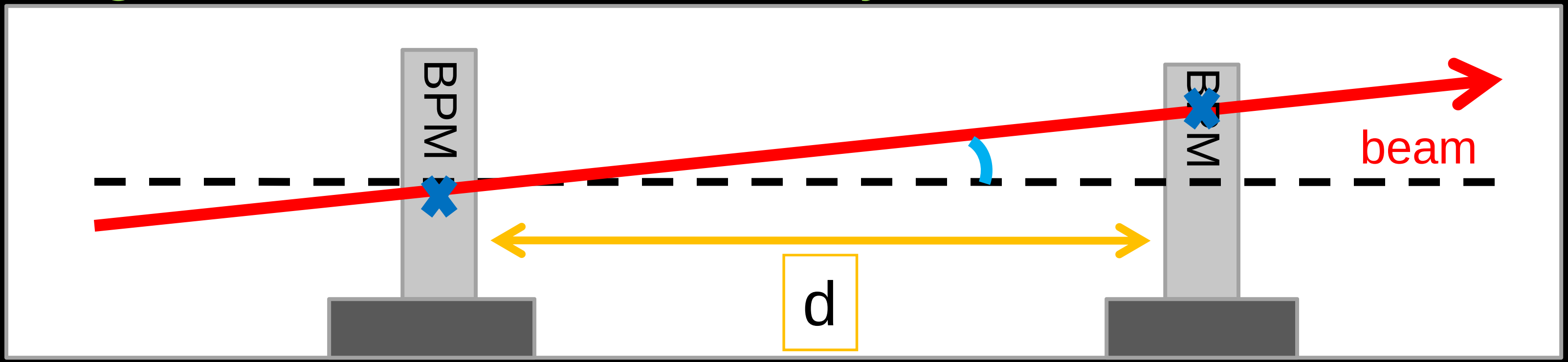
This monitor measures the beam orbit tilt
with high precision.

It can be a useful tool to monitor beam in many case.

Feature: We can get the tilt date from only one cavity, not necessary two point data.



Angle detection from two cavity



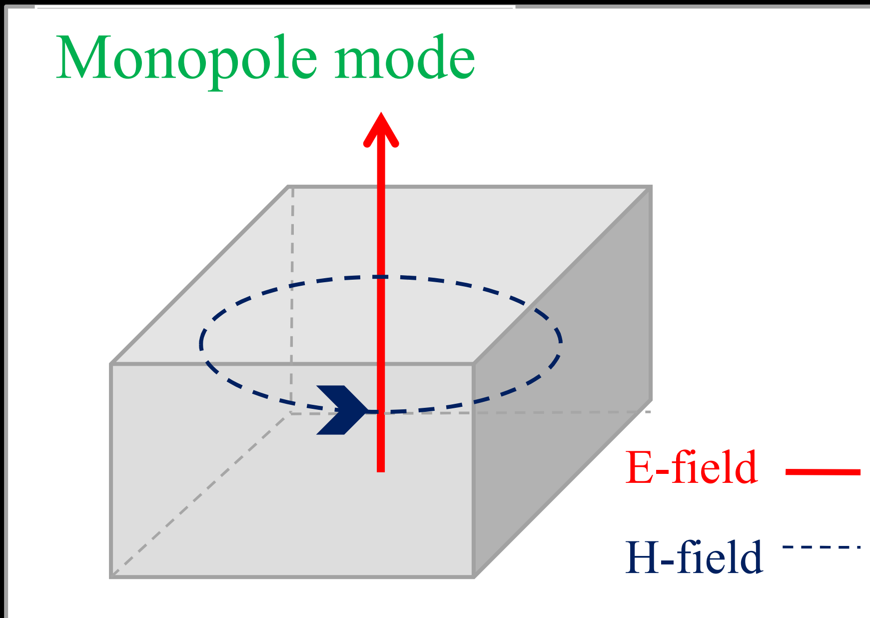
Angle resolution depends on the “d” and BPM resolution.

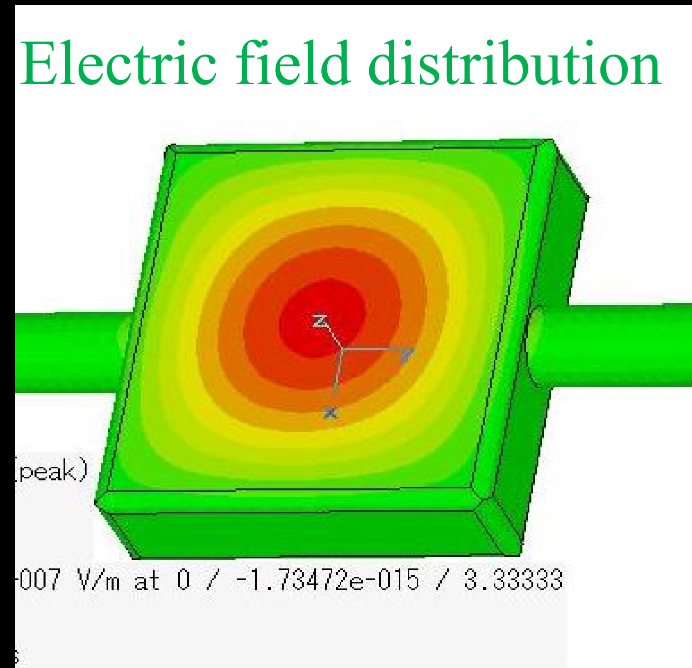
The Longer d leads to the better angle resolution, but relative alignment becomes severer

Our tilt monitor simply detects the beam tilt angle solely.

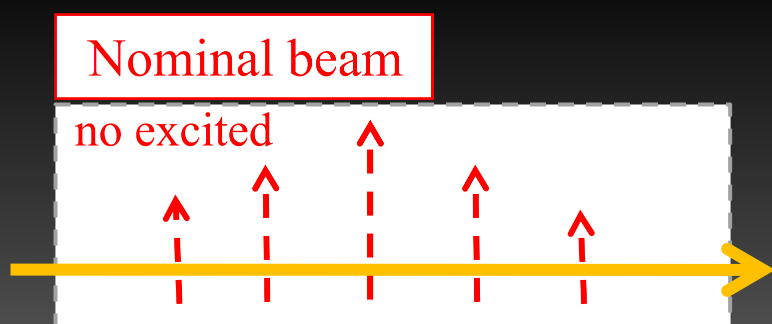
Principle-Resonant mode

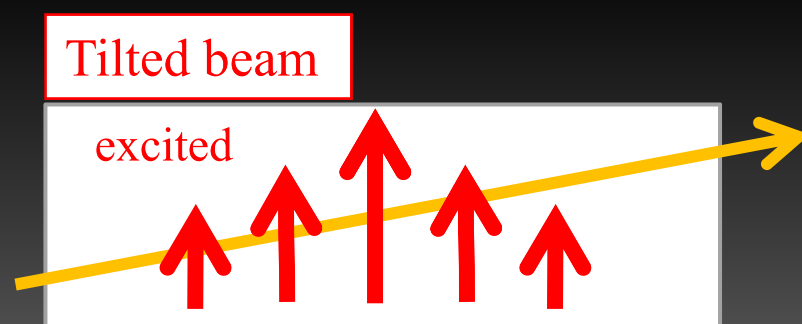
Tilt monitor uses monopole mode.





Monopole mode is perpendicular to nominal beam axis

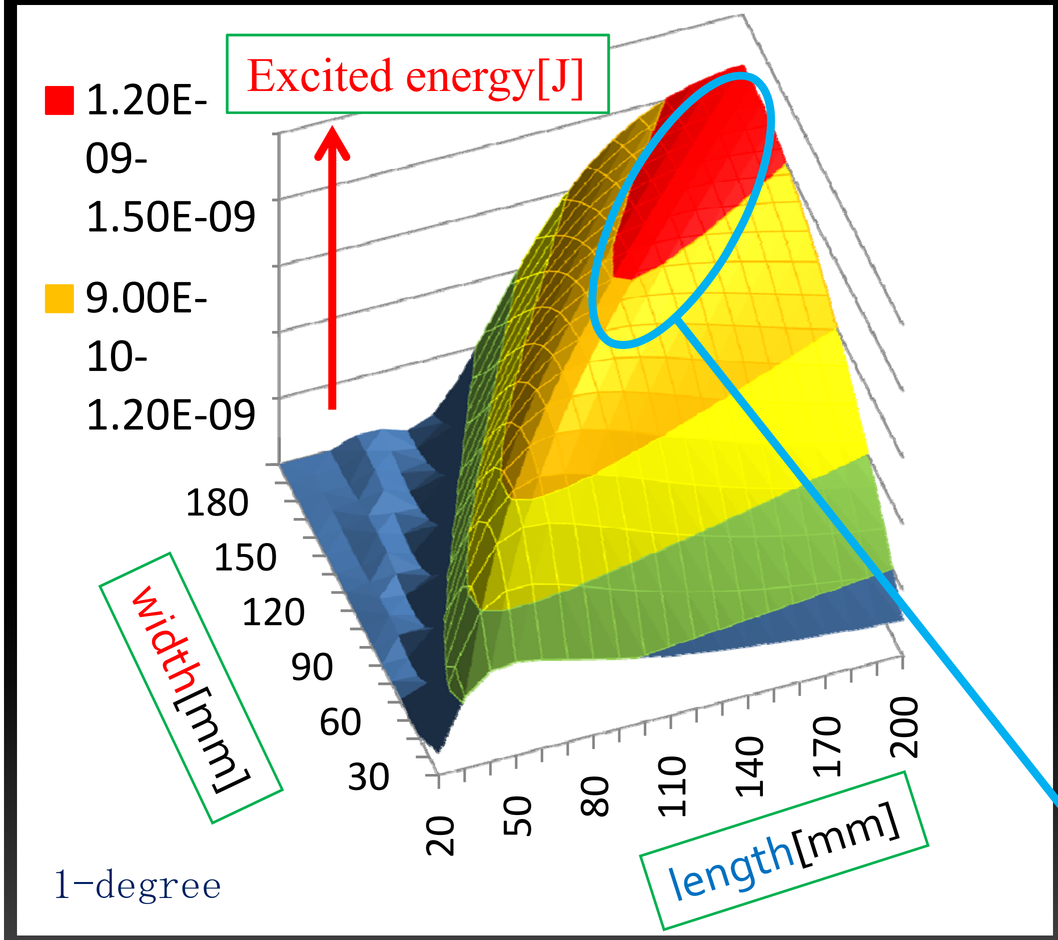


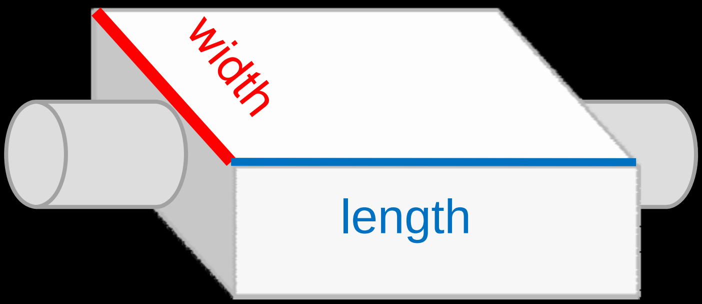


U (excited energy) $\propto \theta^2$ (including time transit factor)

Sensor cavity

Excited energy versus cavity width and length





Width : length=1:1.1
is almost best set

Around 100[mm]is good

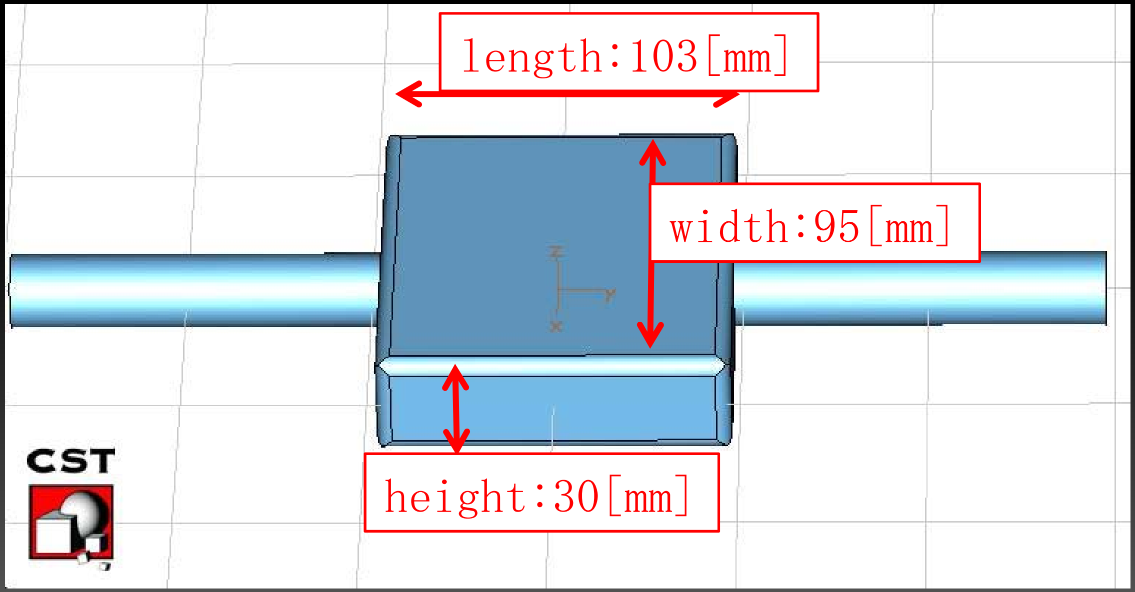
Frequency condition

There is a requirement for the frequency from beam bunch interval.

Considering phase matching, the following condition is required

357 [MHz]× n　(n= 0, 1, 2, ・・・

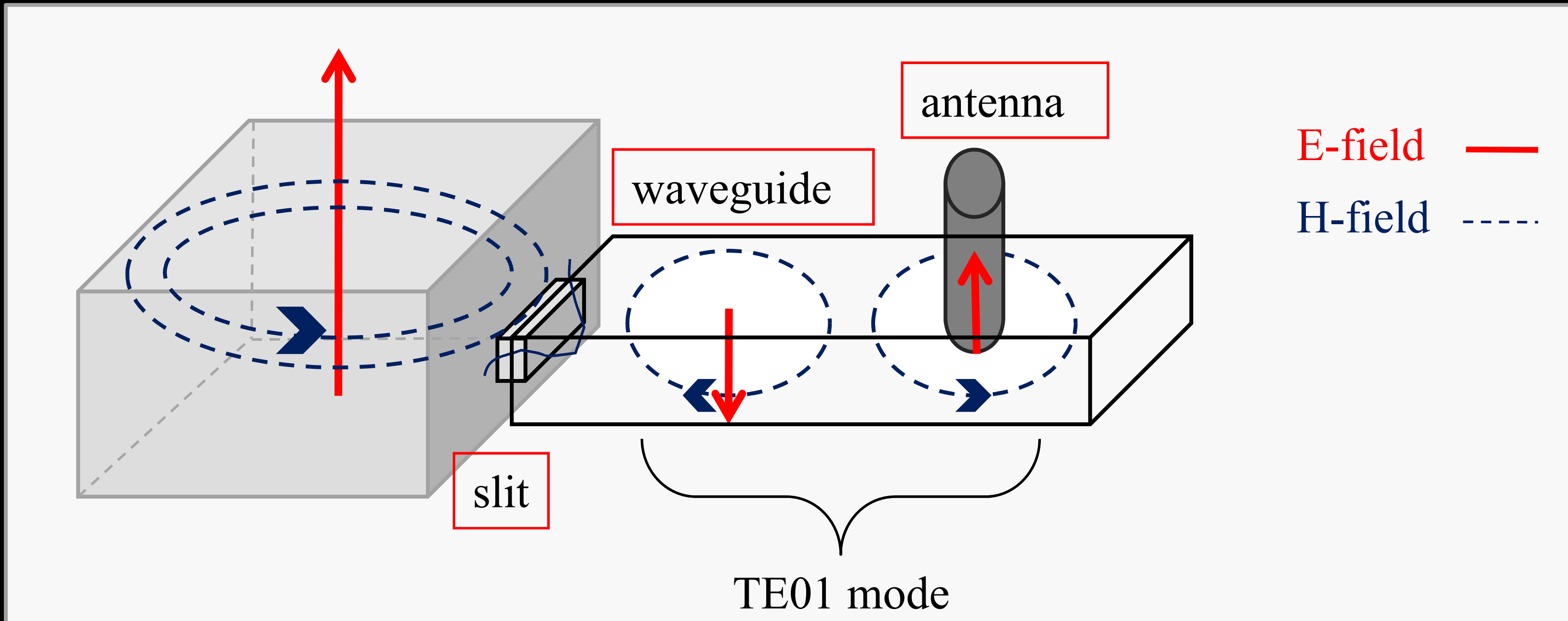
Determined Sensor cavity size



Monopole frequency

2.142GHz

How to extract the signal



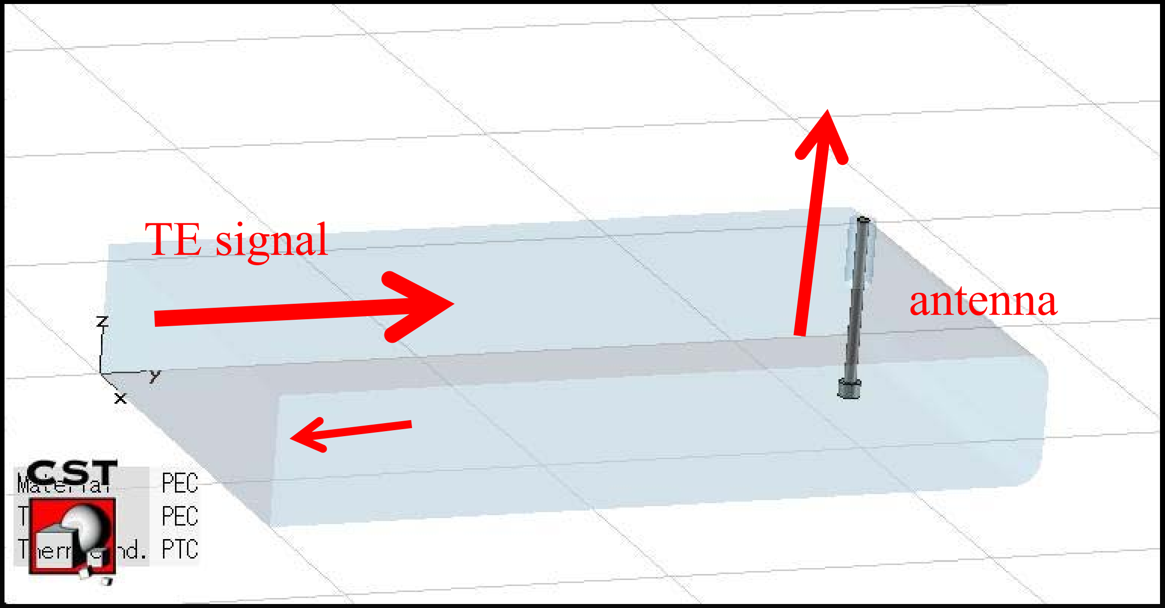
The magnetic field of monopole mode is extracted through slit, and transmitted by TE mode.

TE mode signal is couple to the coaxial antenna.

V(extracted signal) $\propto \theta$

Waveguide

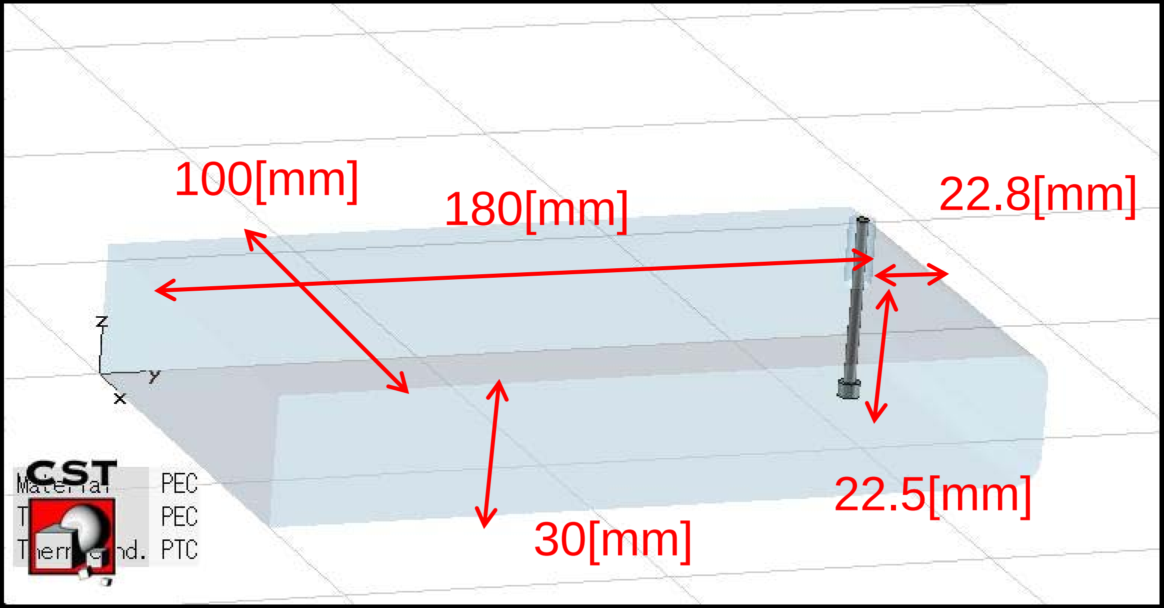
TE mode signal is perfect to match with antenna at 2.142[GHz].



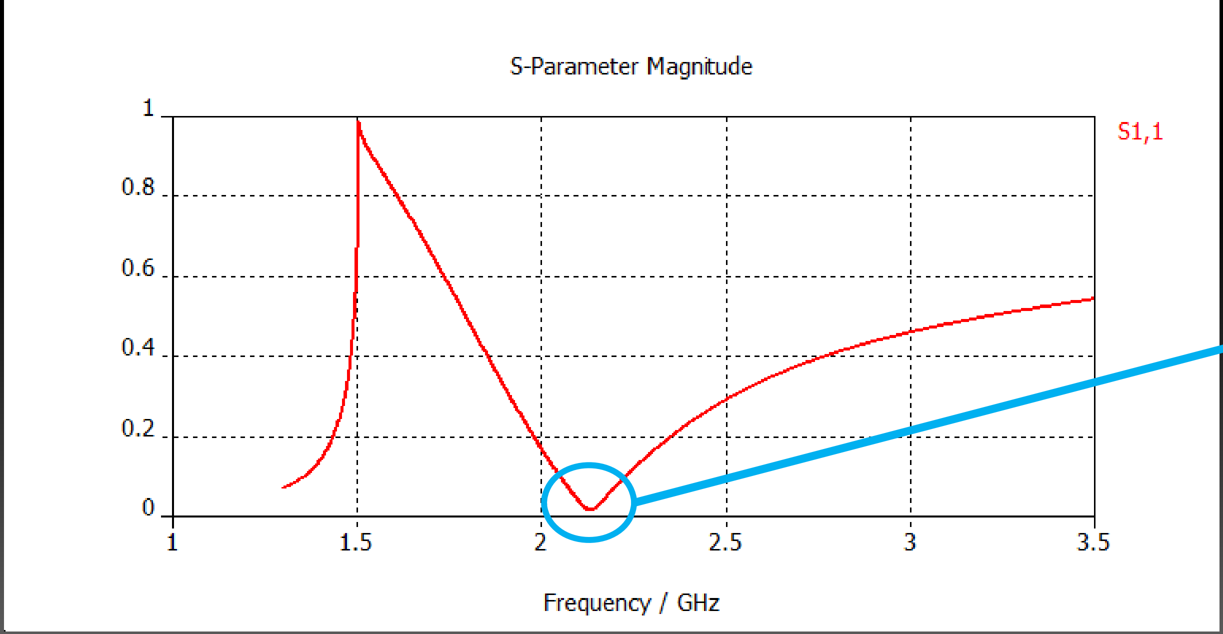
We must set the cut off frequency. f ＜ 2.0GHz

Monopole mode frequency must be separate waveguide's resonant frequency.

Determined waveguide-antenna design

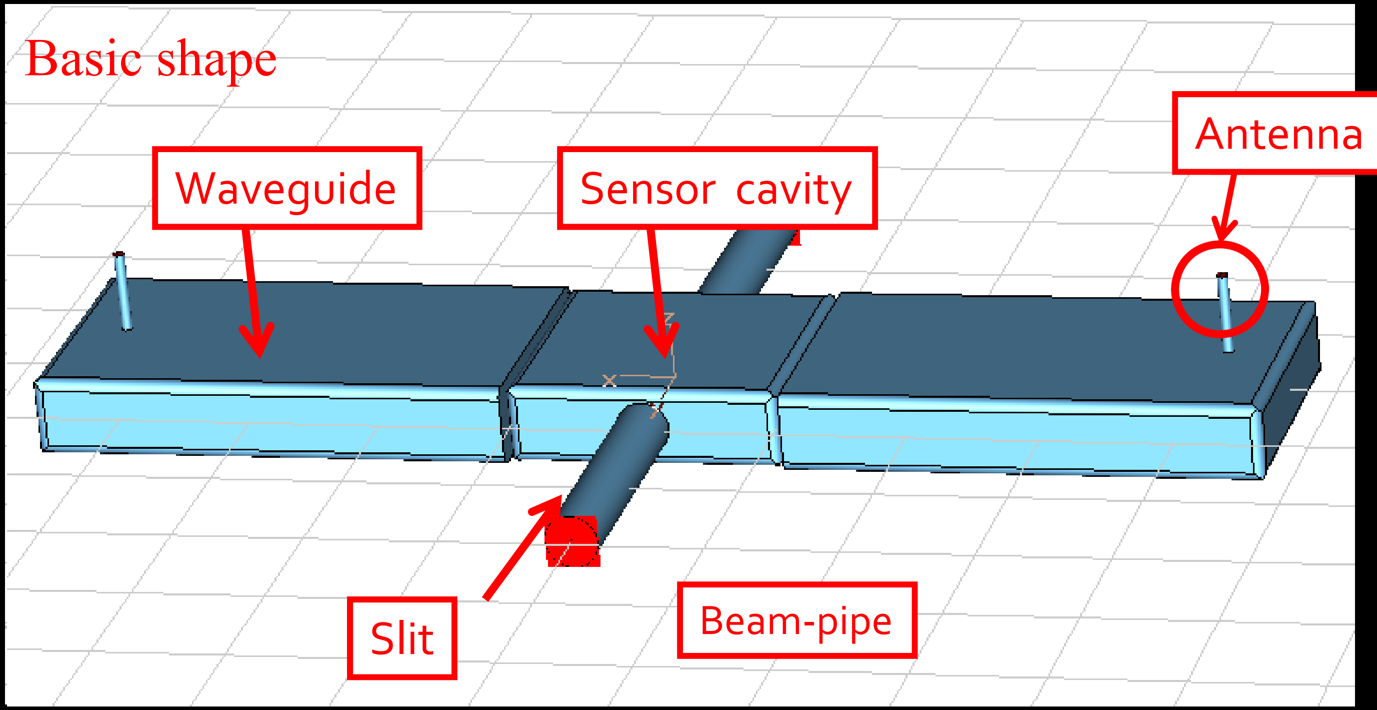


Cut off ~ 1.5GHz

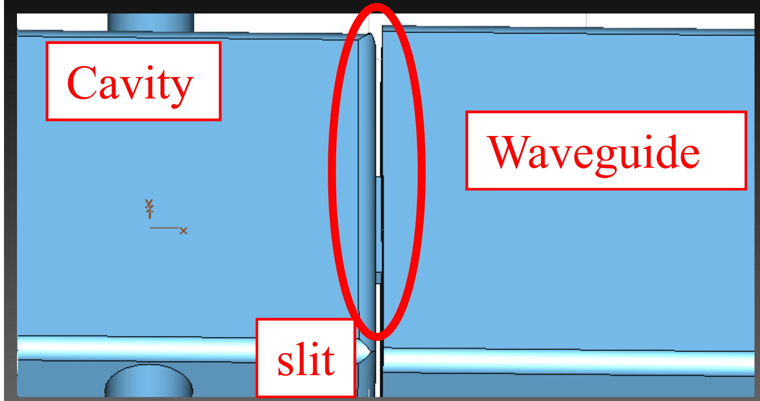


At 2.142Ghz Reflection amplitude is zero

Total Structure



Two port for symmetry, and to reduce the coupling.



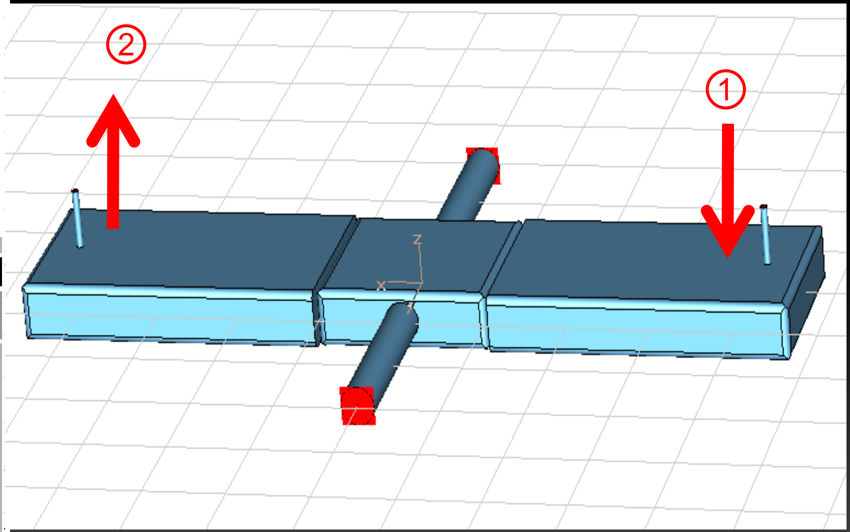
Slit design was determined from total simulation.

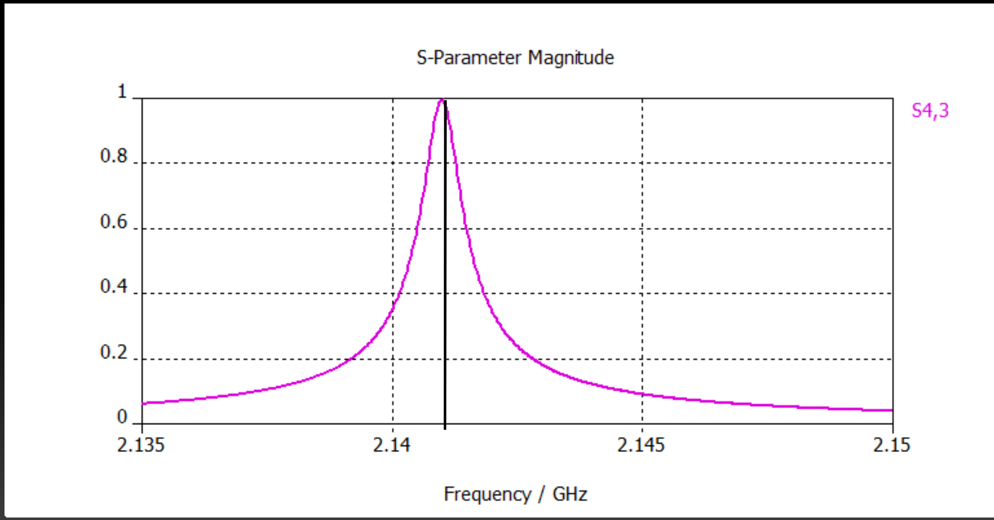
Result of total structure simulation

Loaded Q was determined such that the signal amplitude becomes 1/e when the next bunch comes

Designed loaded Q 2800

Resonant frequency and Q value from S21(transmission amplitude). S21 stands for resonant curve.





Frequency is 2.142GHz Q-loaded 2784

Expected performance

Evaluating the extracted power

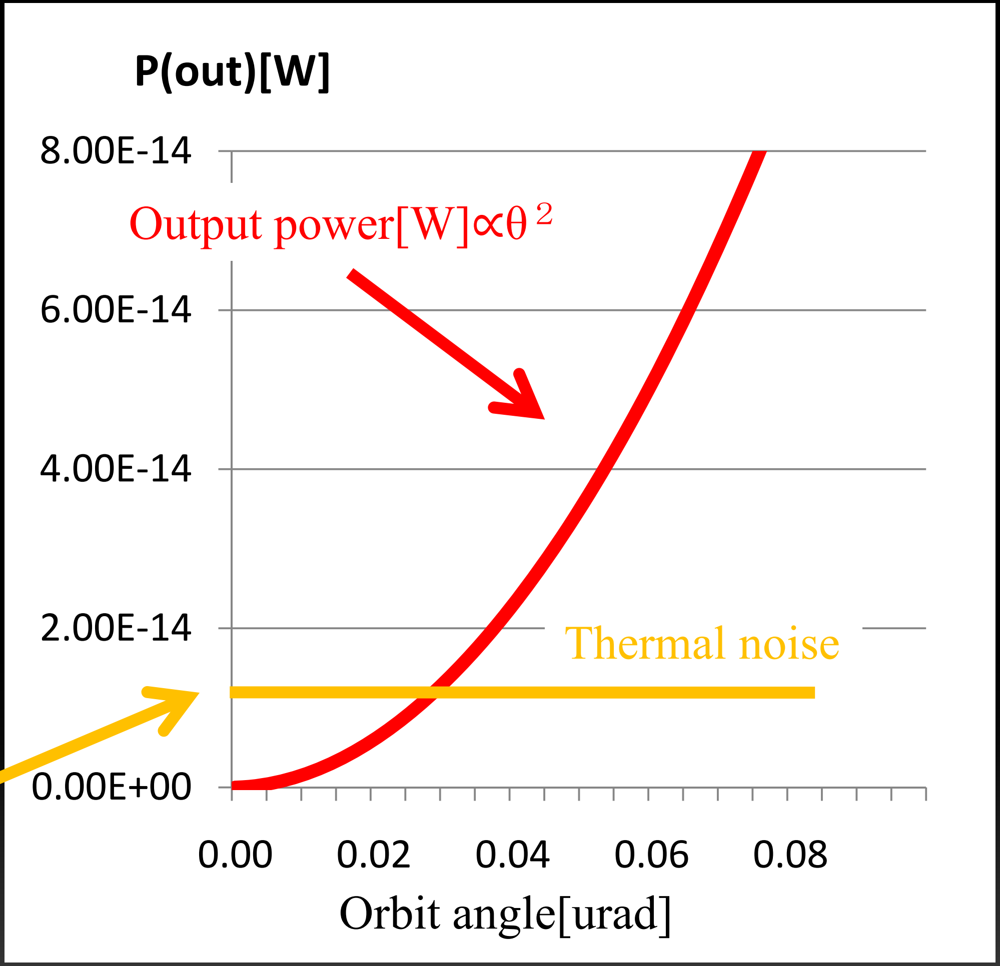
Thermal noise

Determined by temperature(T) and bandwidth(Δf)

$$P_{TN} = K_B T \Delta f$$

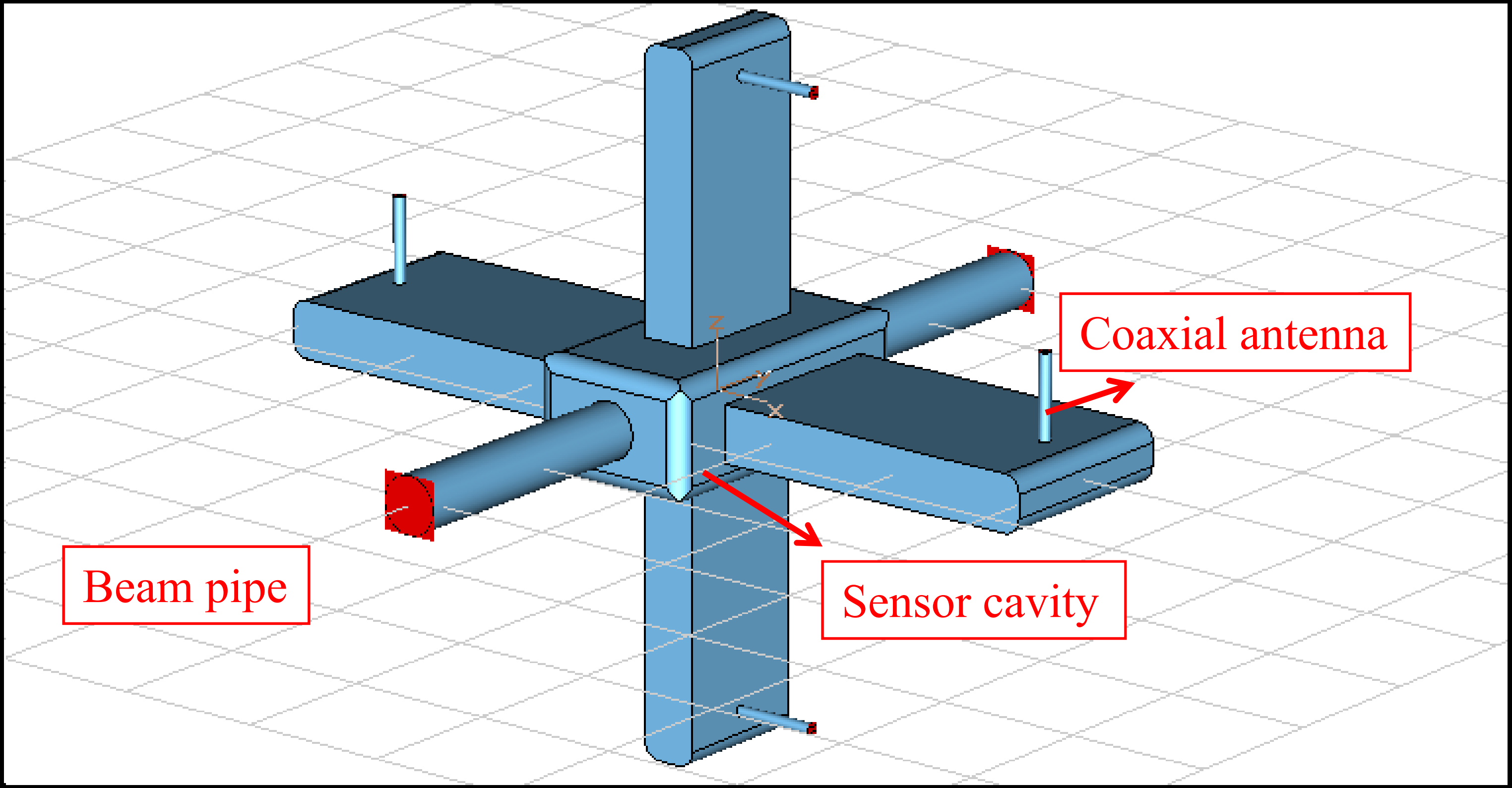
Room temperature 300[K]
Bandwidth ～3MHz

$P_{TN} = 1.24 \times 10^{-14}$ [W]



The limitation :30nrad

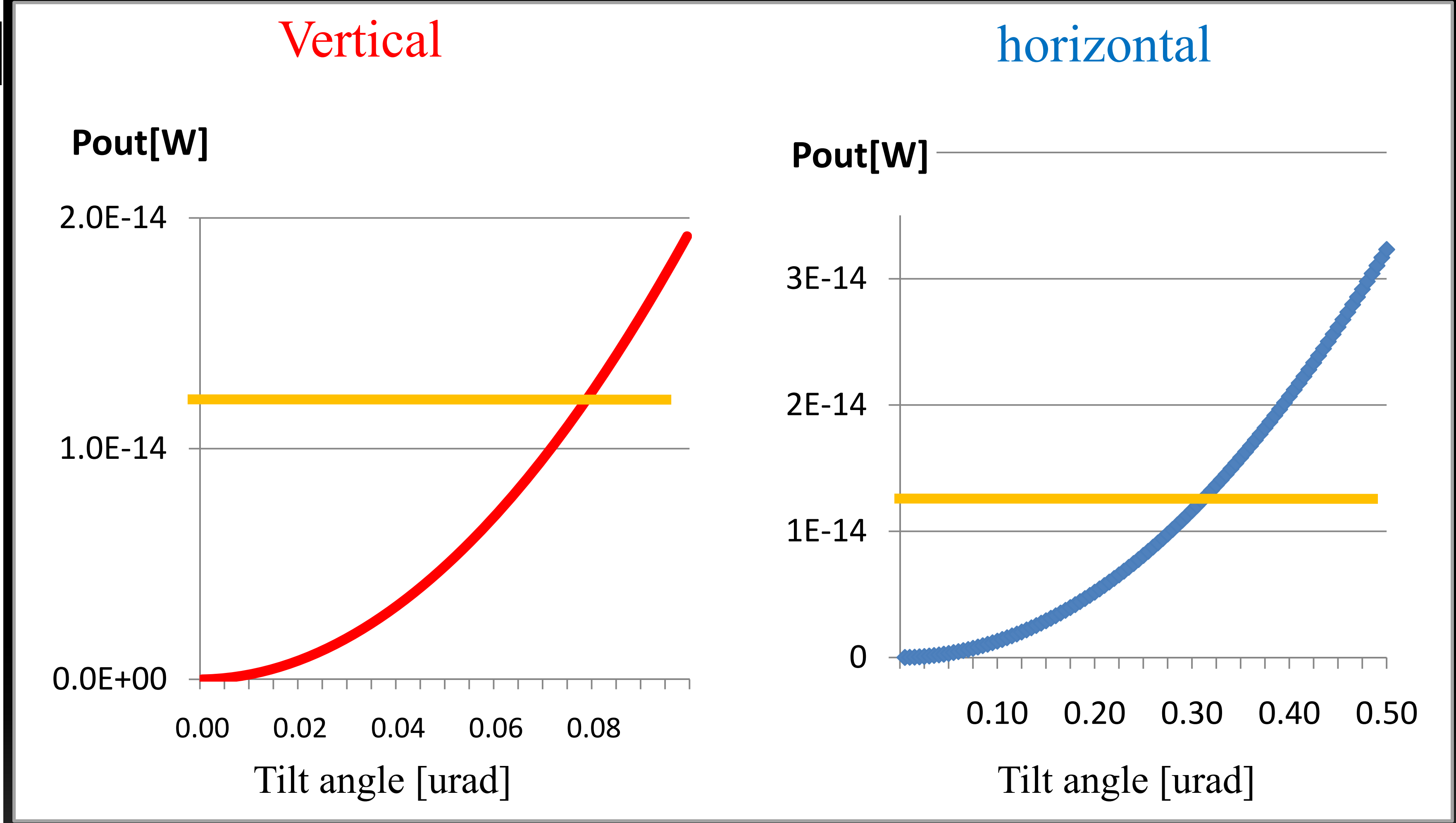
3D monitoring type(type2)



mode	**frequency**	**Loaded Q**
Vertical monopole	2.856GHz	2700
Horizontal monopole	3.947GHz	3700

Of course, the TE mode signal in each waveguide couple to antenna at mode frequency

Expected performance(type2)



The expected sensitivity is about 80[nrad] in vertical direction and 300[nrad] in horizontal direction.

Conclusion

We have studied about tilt monitor.

The basic design phase was finished.

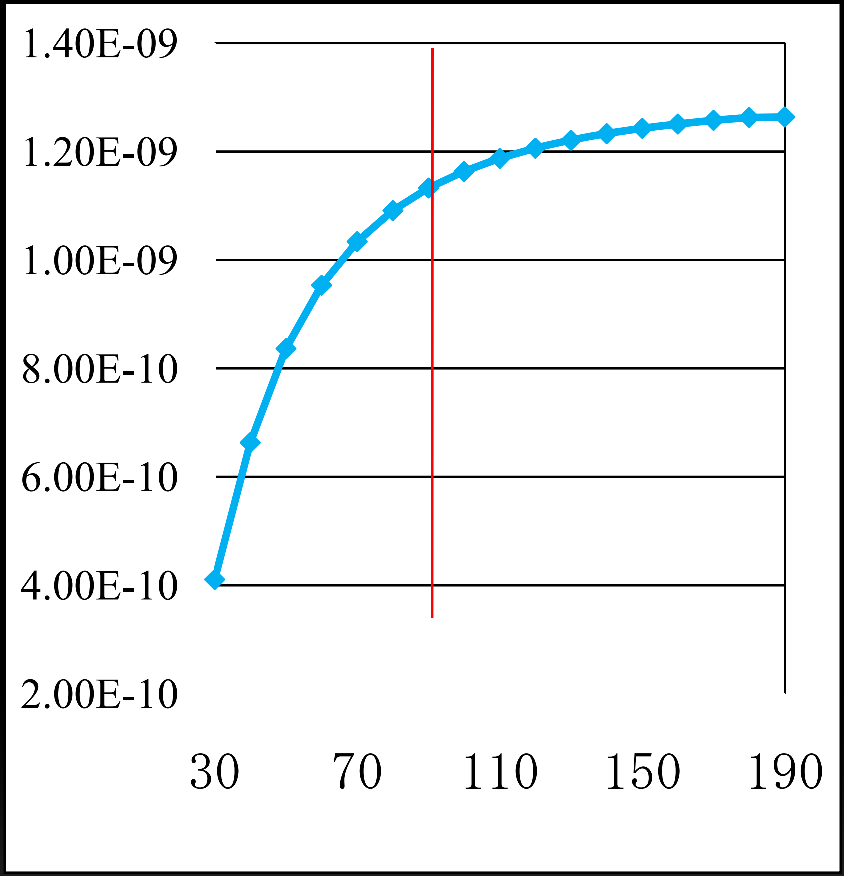
The expected best performance is 30[nrad](vertical)

This is equivalent to 3nm position resolution at 10[cm] distance.

3D monitoring type might be useful as commodity type

PLAN

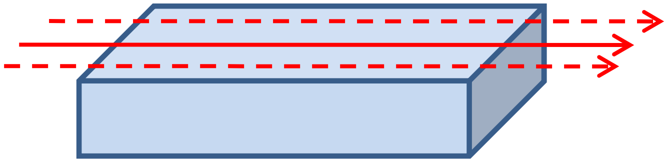
Study of effective usage.
Decision of detecting scheme.
Test the prototype.

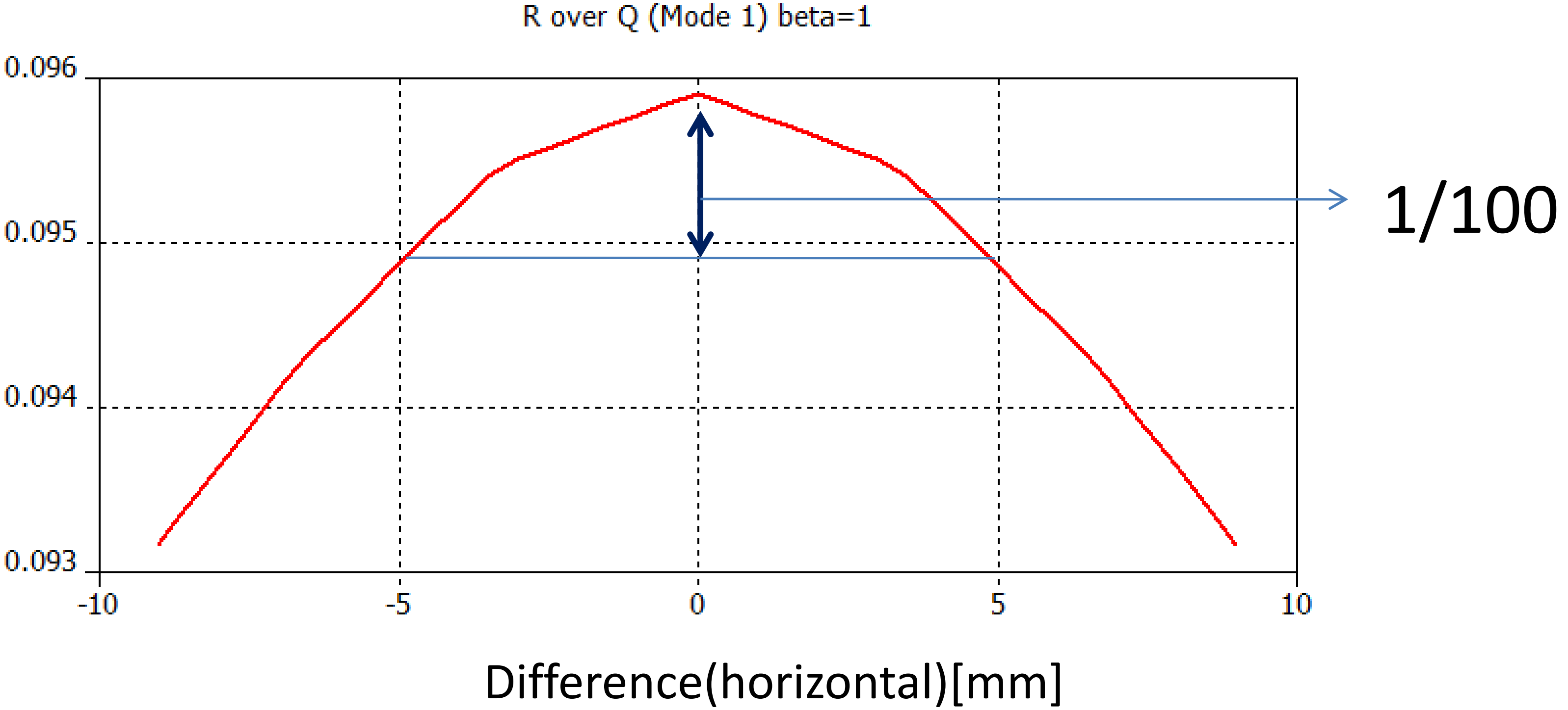

1.40E-09
1.20E-09
1.00E-09
8.00E-10
6.00E-10
4.00E-10
2.00E-10
30
70
110
150
190

Back up

Considering beam route, All we have to do is evaluating R/Q

In case of horizontal difference



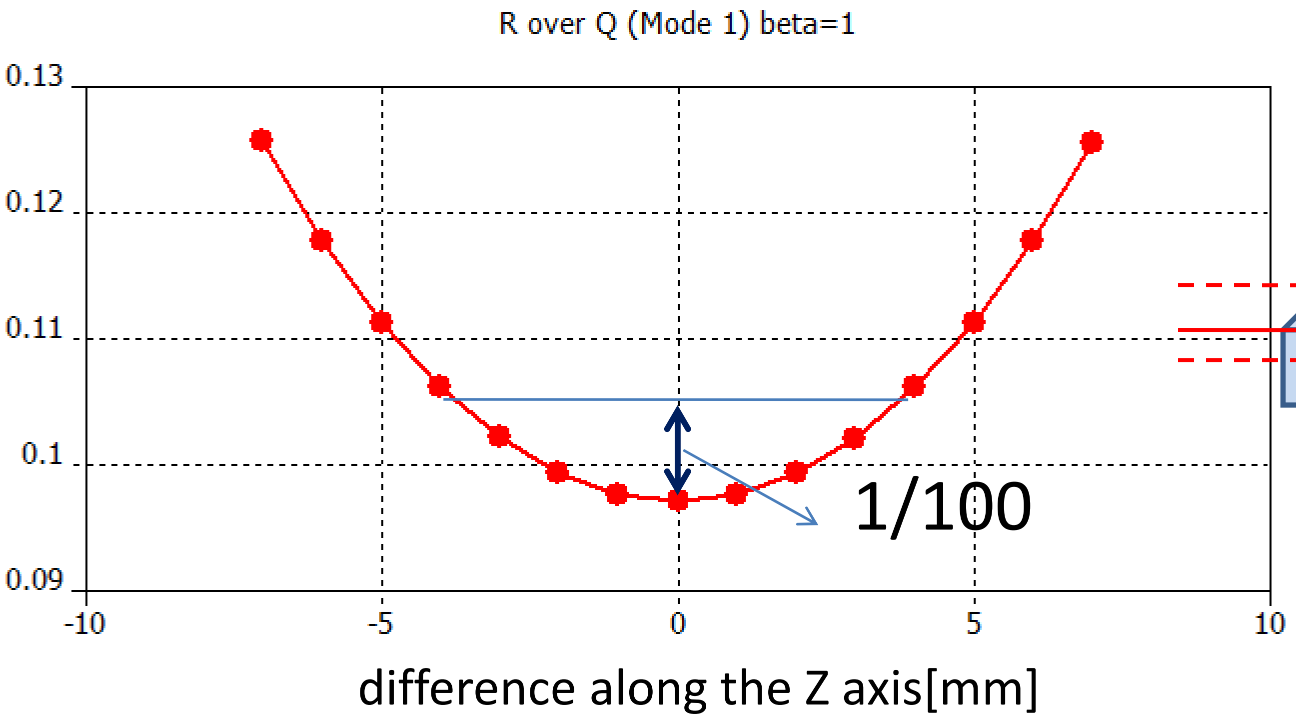


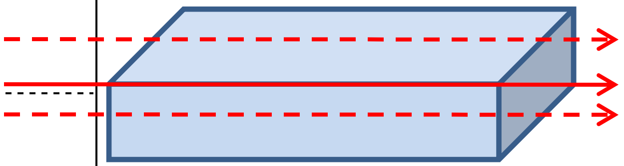
Horizontal difference has almost no influence

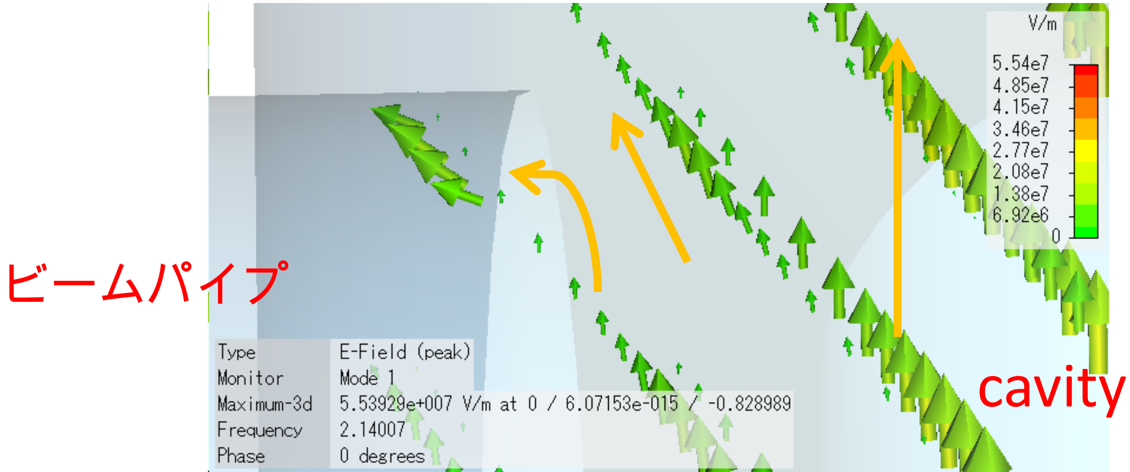
Back up

In case of vertical difference

In principle, there is no influence







We have to be careful around the beam pipe

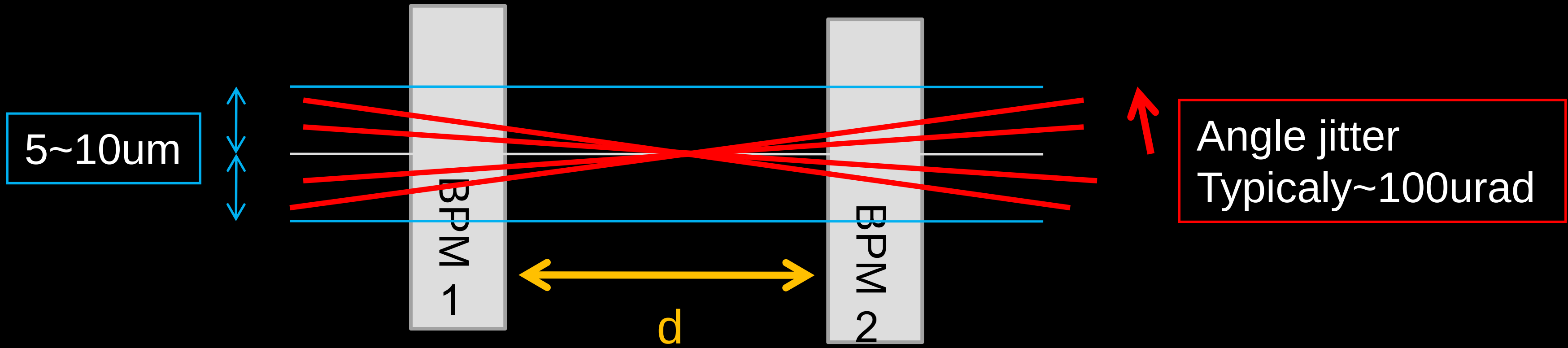
Back up

Usage example

In IP-BPM system, the two cavity are used to determine the beam orbit.

The distance of two cavity is strongly restricted due to

dynamic range and large angle jitter at IP



d has to be d< 0.1[m].

Angle resolution is not good in such small d. If one BPM resolution is 10[nm],

Angle resolution~150 [nrad]

Tilt monitor can be useful in such narrow space monitoring, and addition the beam orbit information to IP BPM.