TILT MONITOR AT IP

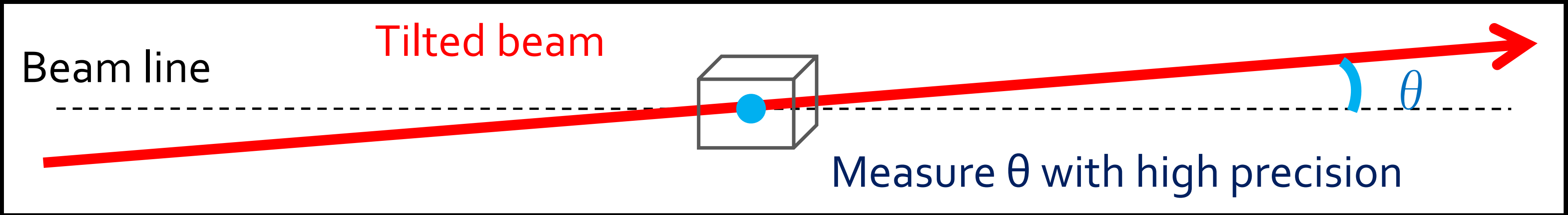
Daisuke Okamoto, Yosuke Honda
Tomoyuki Sanuki, Toshiaki Tauchi

8th ATF2 project meeting

Contents

Motivation

Tilt monitor has the new feature: “single cavity measurement”



We can get the direct data of beam orbit tilt

That is useful

Complemental device of the IP BPM system

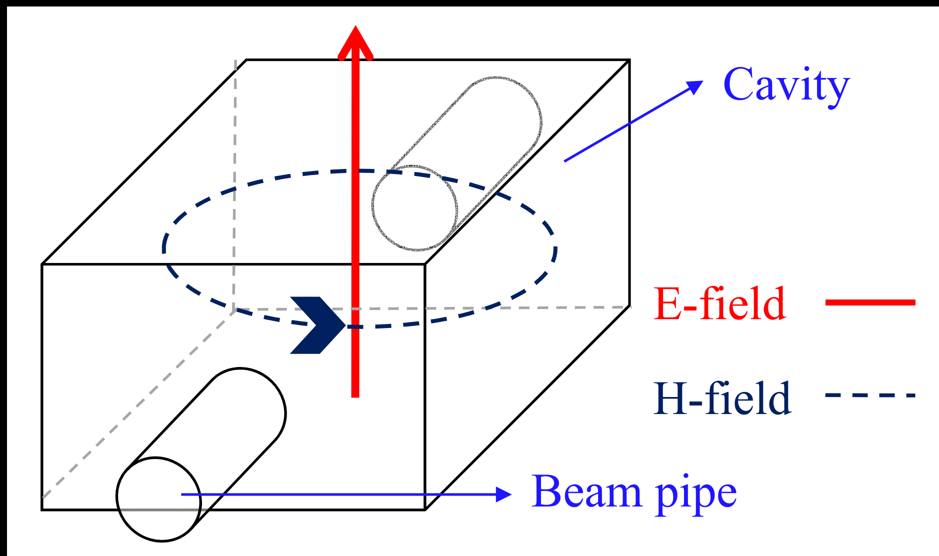
there is the large range angle jitter around IP

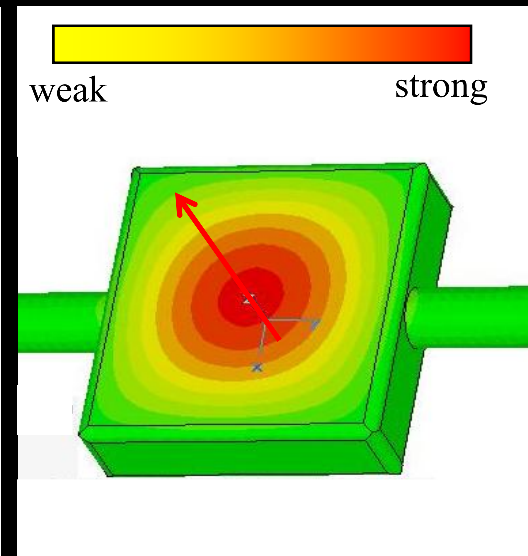
Expected sensitivity is 30nrad

Feedback for the direct tilt data

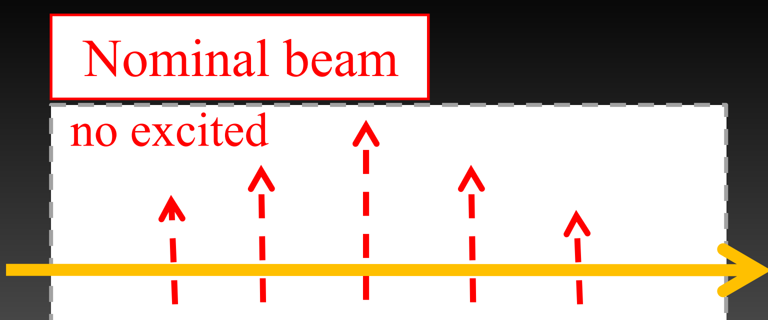
Principle-Resonant mode

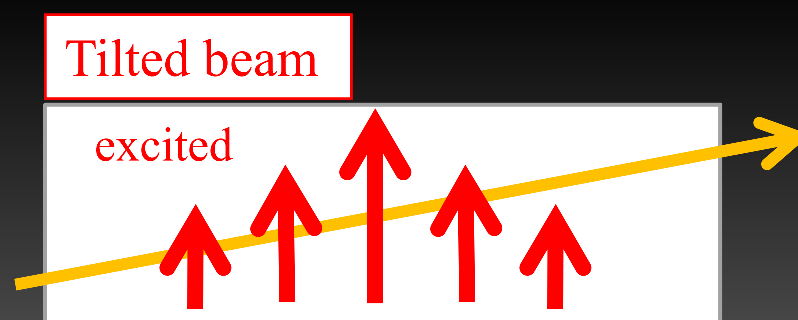
Tilt monitor uses monopole mode.





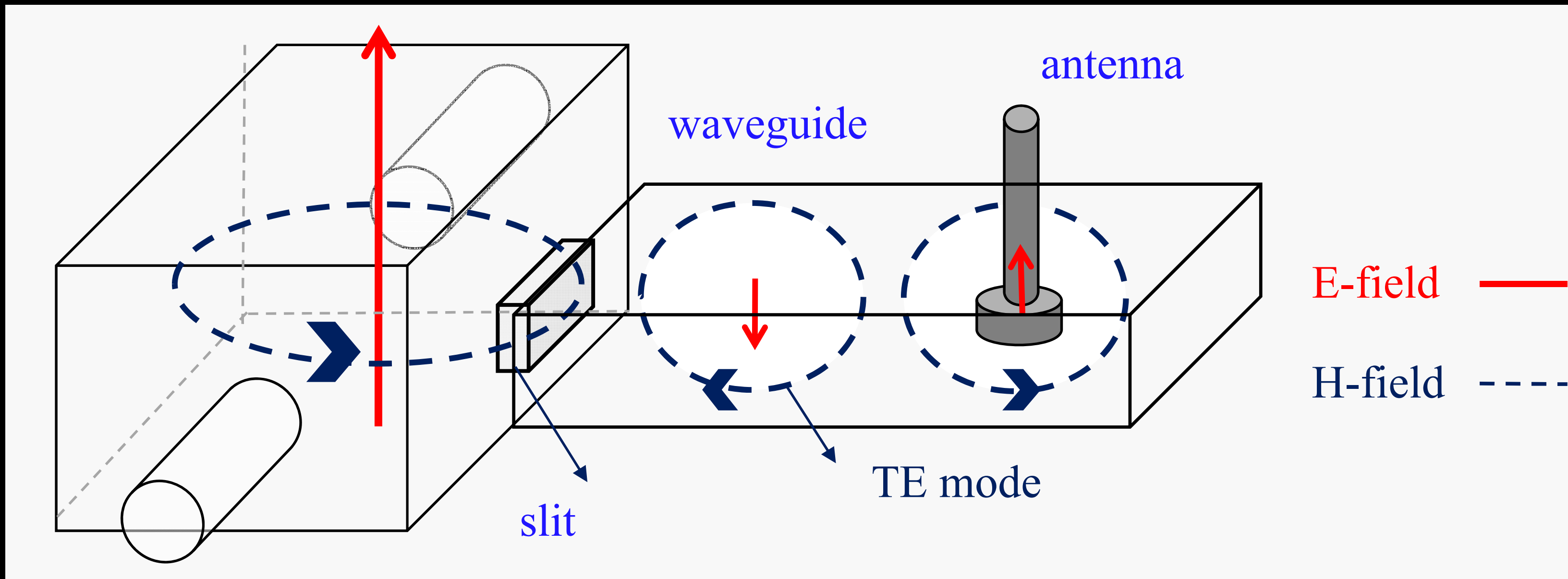
Monopole mode is perpendicular to nominal beam axis





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

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) ∝ θ

Design concept

Sensor cavity

As the excited energy becomes larger
Resonant frequency is set to 2.142GHz (357MHz ×6)

Waveguide + antenna

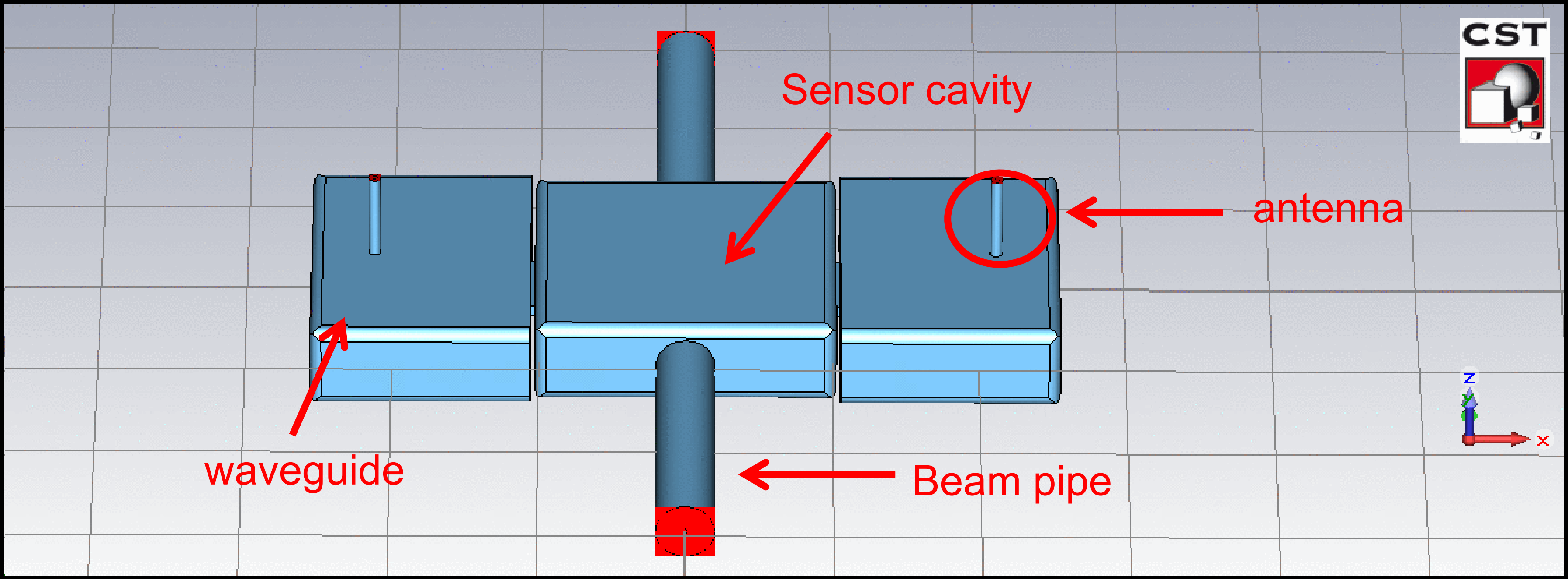
The TE mode signal is coupled with antenna at 2.142GHz

Slit

Slit connects the sensor cavity and waveguide
We set the decay time τ of the extracted power
150nsec --- bunch interval of ILC-like beam

The monopole mode signal is extracted from two port for symmetry.

Design



frequency	2.142GHz
τ(power)	150nsec
τ(amplitude)	300nsec
Loaded Q	2020
B(Qwall/Qext)	4.93

Sensor cavity size

Width	102.8mm
length	94mm
height	30mm
pipe radius	10mm

Expected performance

Evaluating the extracted power

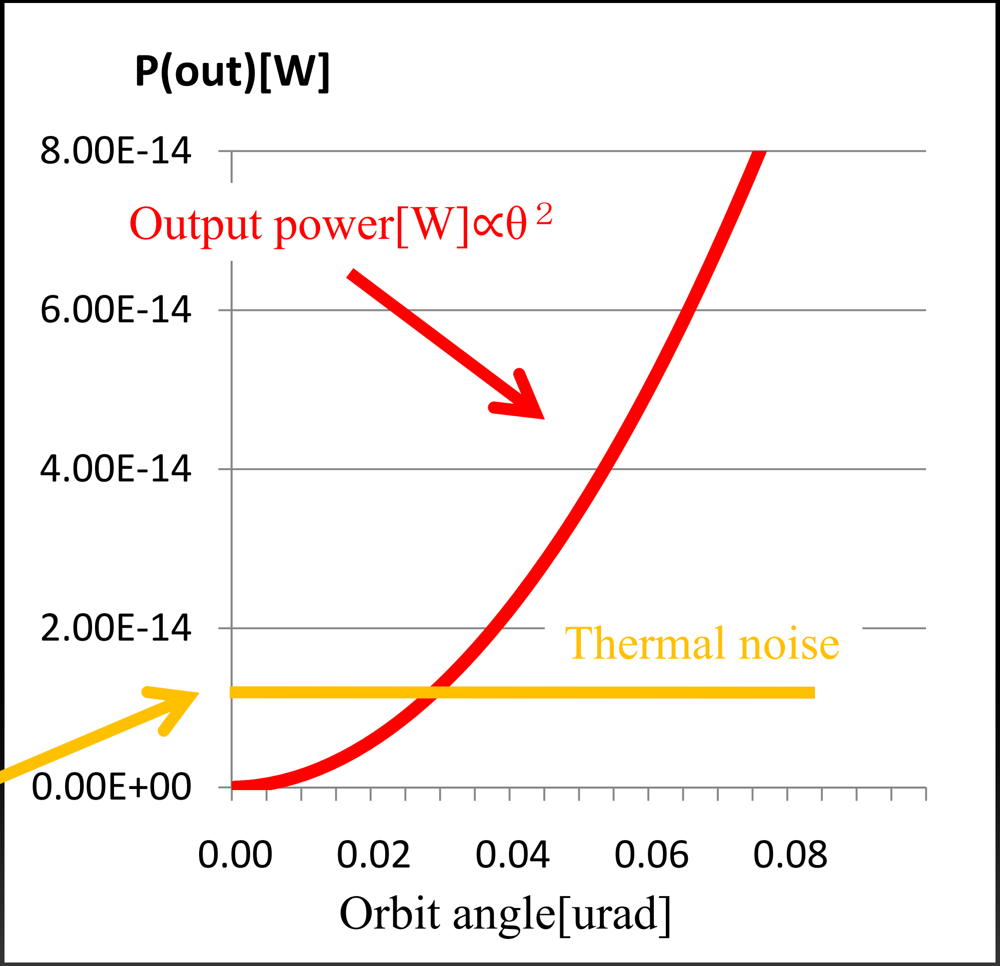
Thermal noise

Determined by temperature(T) and bandwidth(Δf)

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

Room temperature 300[K]
Bandwidth ～3MHz

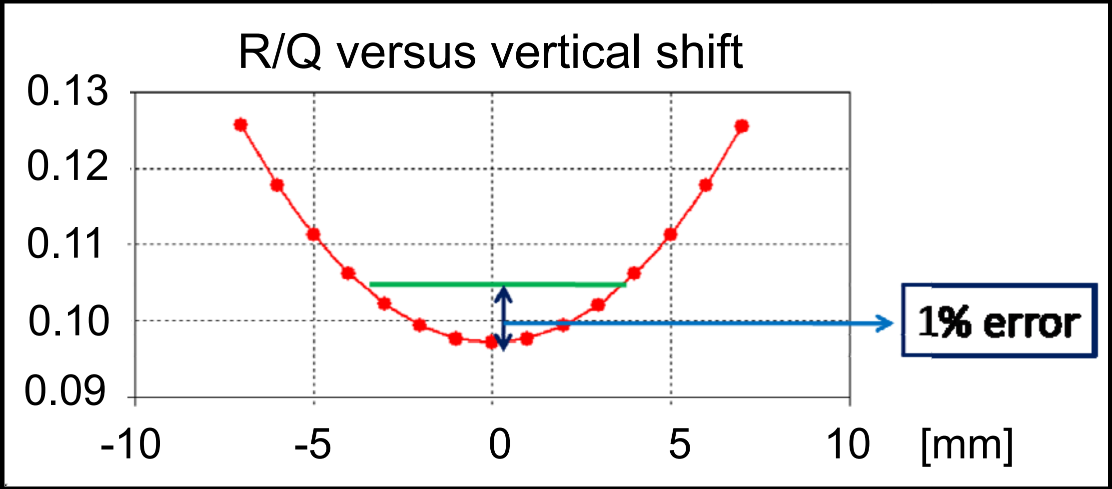
$P_{TN} = 1.24 \times 10^{-14}$ [W]



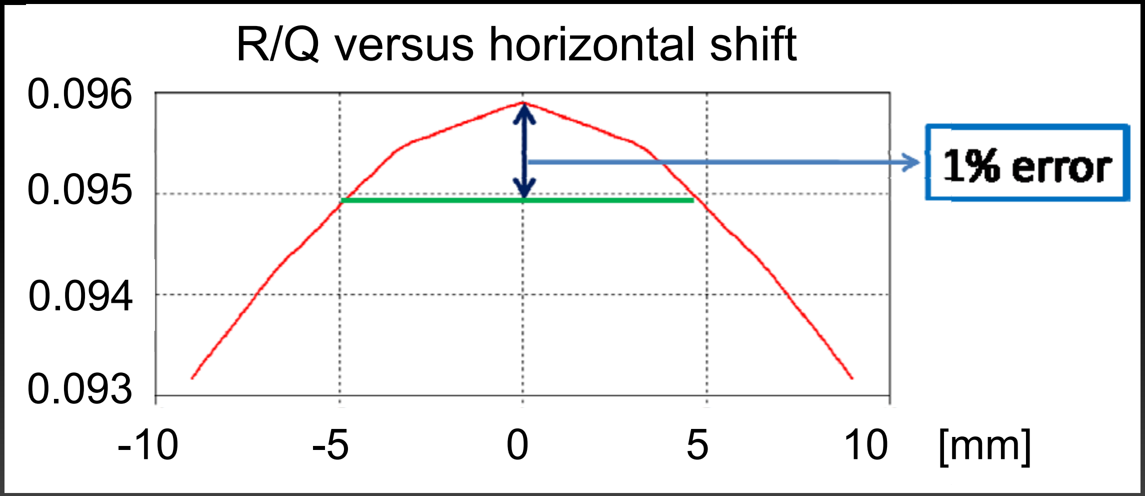
The limitation : about30nrad

Influence of the beam position shift

The influence of the beam position is very small

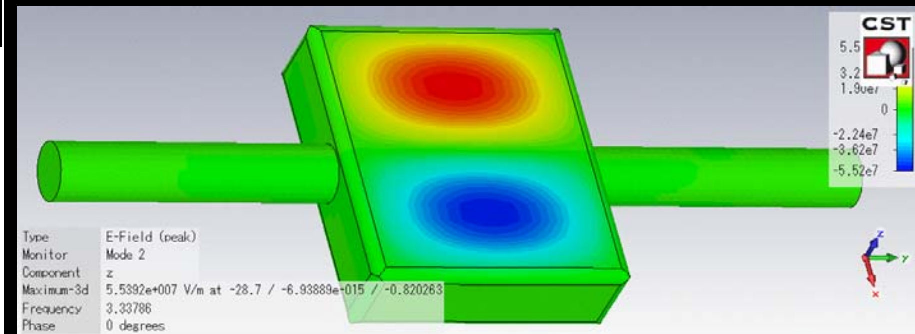


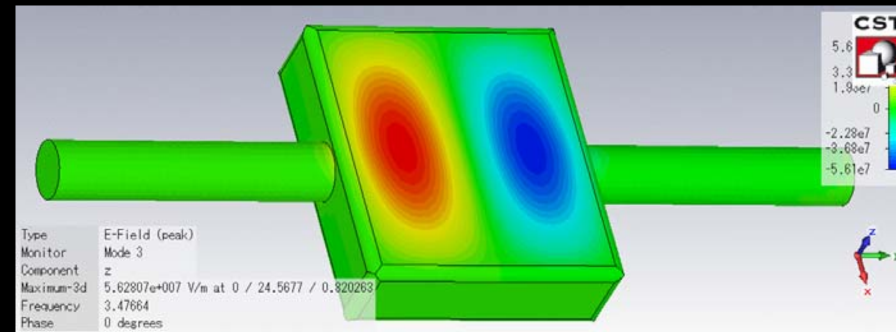
Only R/Q is related with the beam pass



We can ignore the beam position signal, even that is a few millimeters.

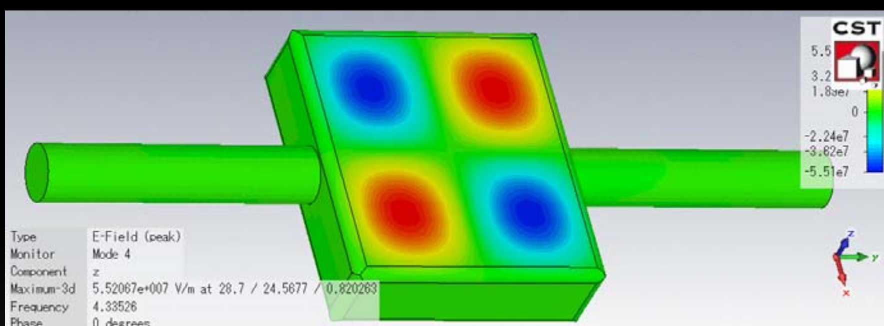
Other resonant modes





Resonant frequency 3.337GHz

3.476GHz

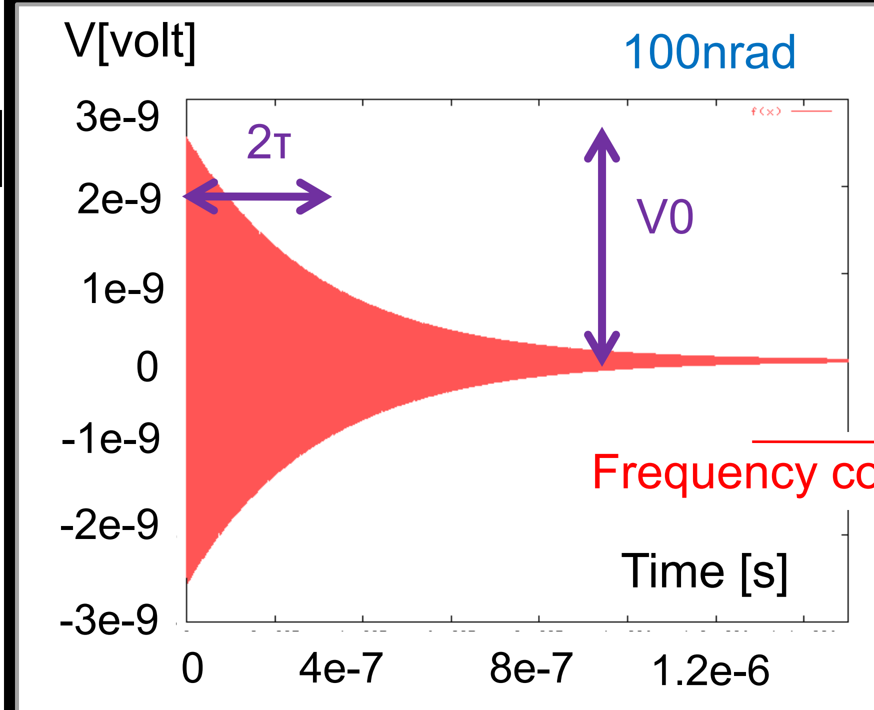


4.335GHz

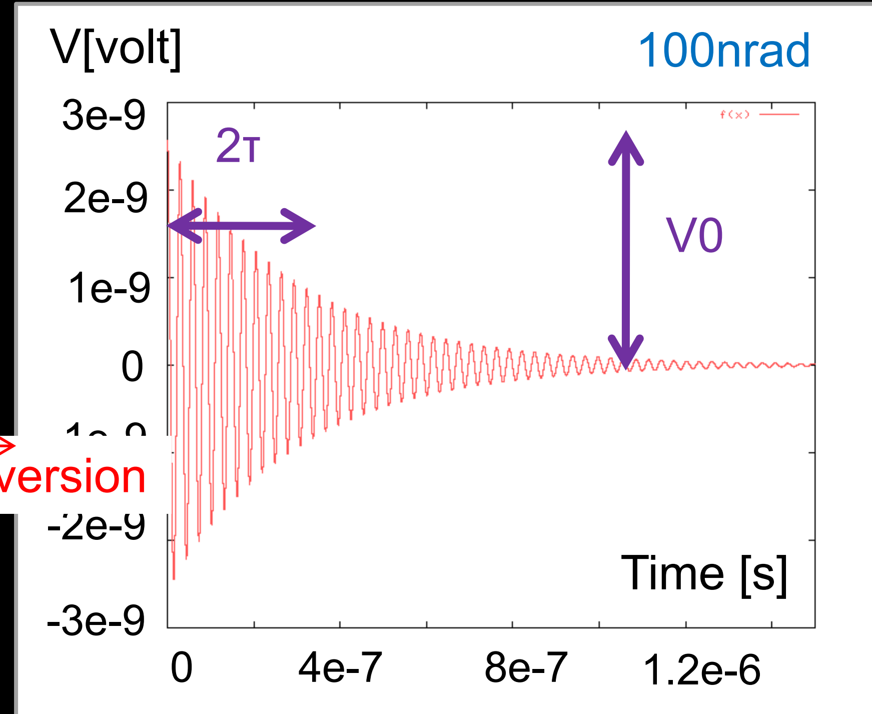
Other mode's are over 5GHz

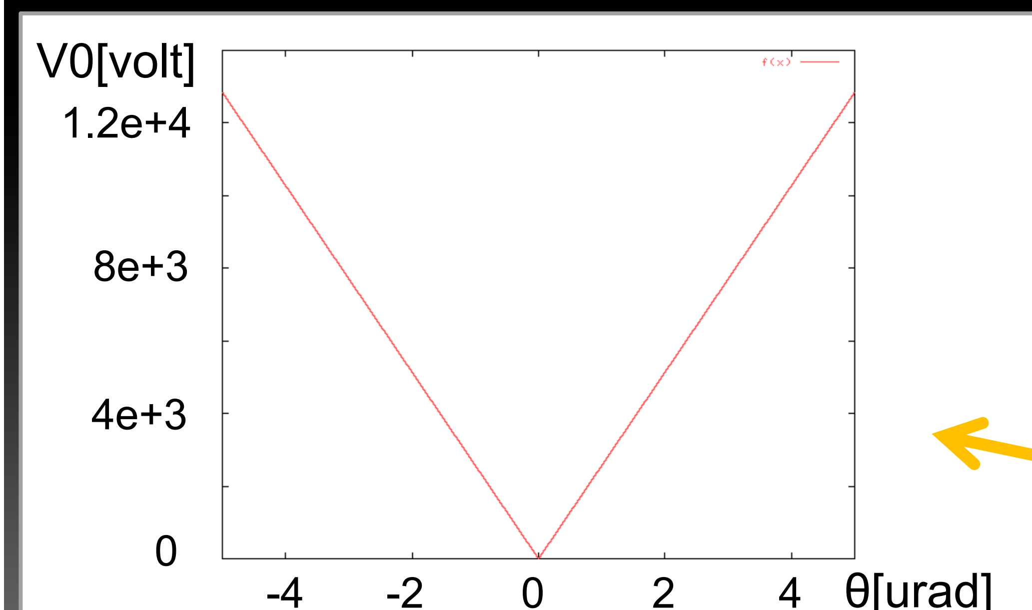
Monopole mode frequency : 2.142GHz

The monopole mode frequency is enough to separated from other mode's frequencies



Frequency conversion





signal

Decay time τ=150nsec

We will measure the amplitude V0 of the signal

$V0 \propto \theta$

About IP BPMs

In the IP BPMs, distance between the BPMs are set to 7.6[cm]

Due to large angle jitter by strong focus

For this narrow space monitoring,
tilt monitor would have a good performance

In the 7.6cm distance, 30nrad sensitivity is equal to the 2.3 nm position resolution.

We can use tilt monitor as the complemental device of the IP-BPM system to improve the position resolution

Also, the direct beam tilt data would be useful for the feedback

Prototype

We would like to test the prototype,
we will formal l y report the plan in the TB&SGC meeting

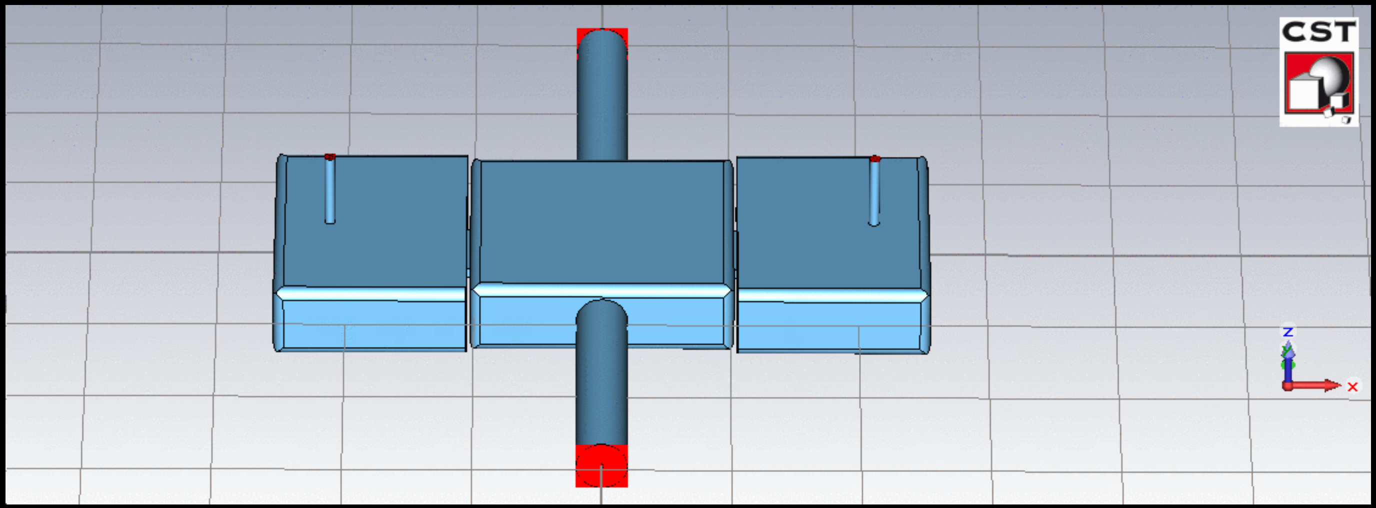
The prototype design

Some parameters were changed due to new resonant frequency.

2.142GHz → 2.856GHz

We can use the same electronics as that of BPM, after some modifications.

Prototype design and performance



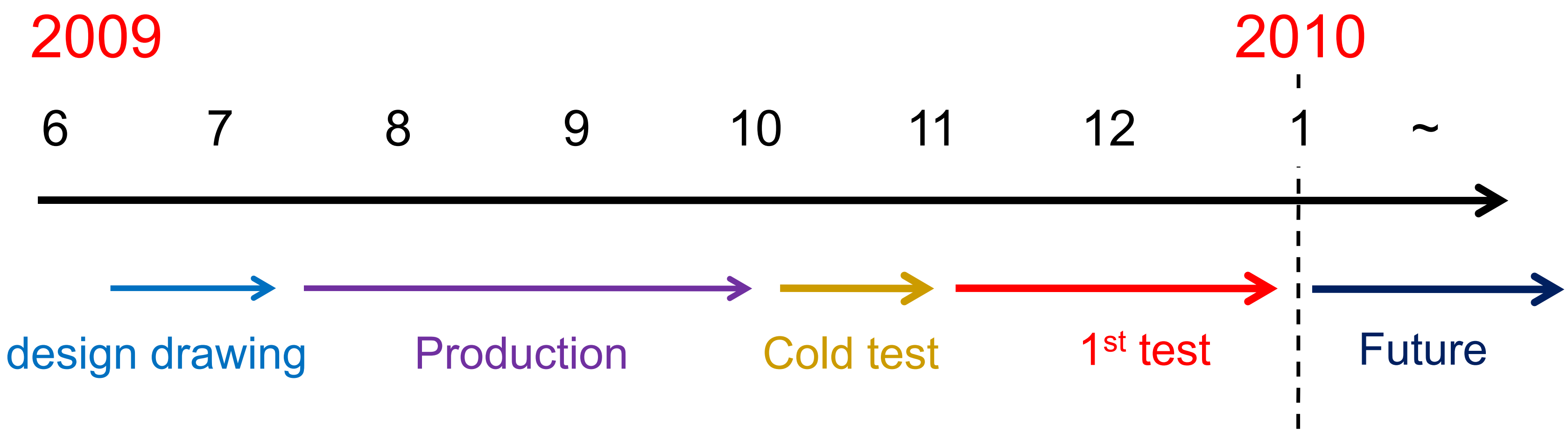
frequency	2.856GHz
τ(power)	150nsec
τ(amplitude)	300nsec
Qloaded	3470
B(Qwall/Qext)	3.45

Sensor cavity size

Width	77.4mm
length	70.4mm
height	30mm
pipe radius	10mm

Sensitivity 30nrad → 35nrad

Time schedule



Cold test

Basic test --- resonant frequency, Q-value and so on

1st test

We will test the basic relation of amplitude of the signal and beam orbit for some urad beam tilt.

Future

We will aim the 30nrad sensitivity and 2-3nm position resolution with BPMs

Summary

We have studied about beam orbit tilt monitor

The expected sensitivity of the tilt monitor is 30nrad
35nrad for prototype

The critical preventing mode didn't exist, it's is safe to extract the monopole mode

We will use the tilt monitor as complemental device of the IP-BPM

We are preparing the actual monitor "prototype"
We would like to finish the basic test within this year.

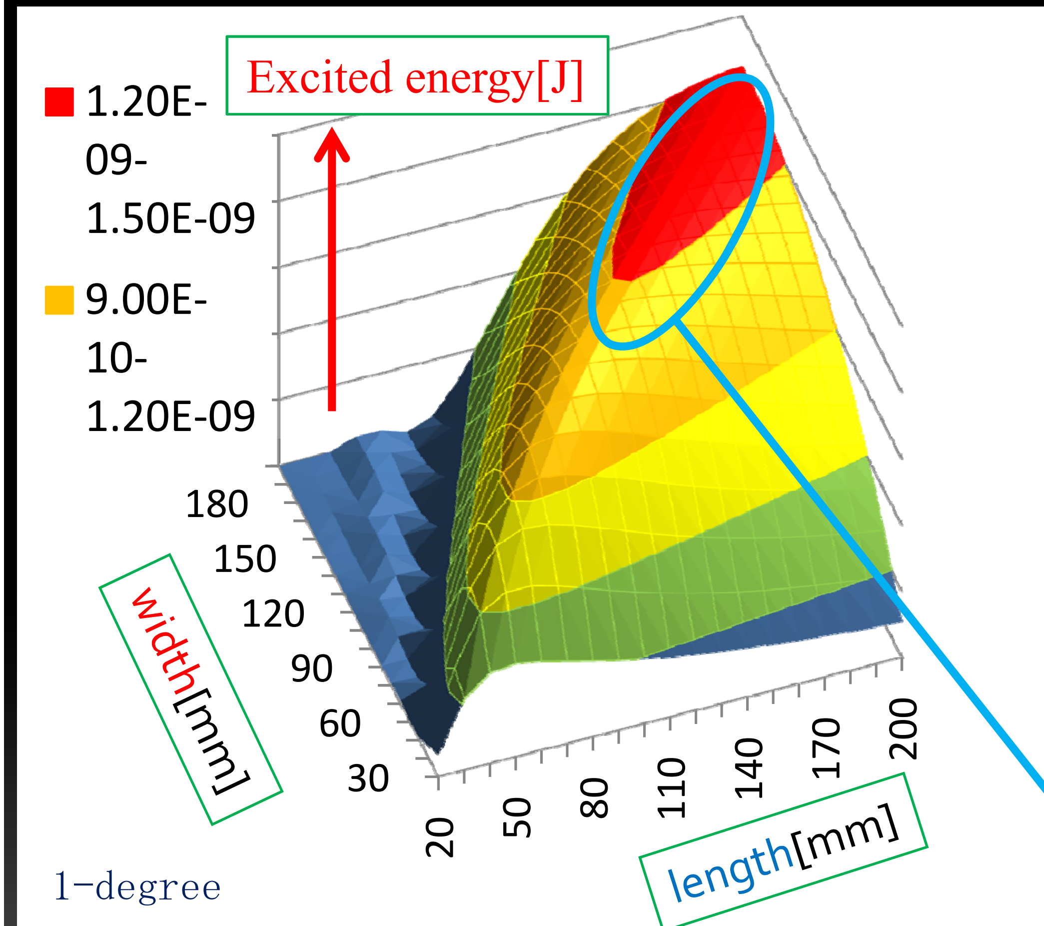
We will continue the study of tilt monitor
as the new type of the cavity beam monitor.

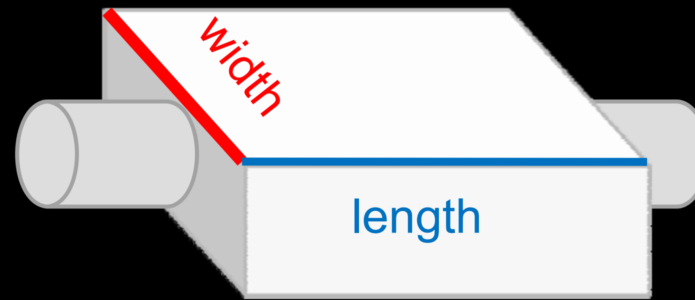
BACK UP

BACK UP

Sensor cavity

Excited energy versus cavity width and length





Width : length=1:1.1
is almost best set

Around 100[mm]is good

BACK UP

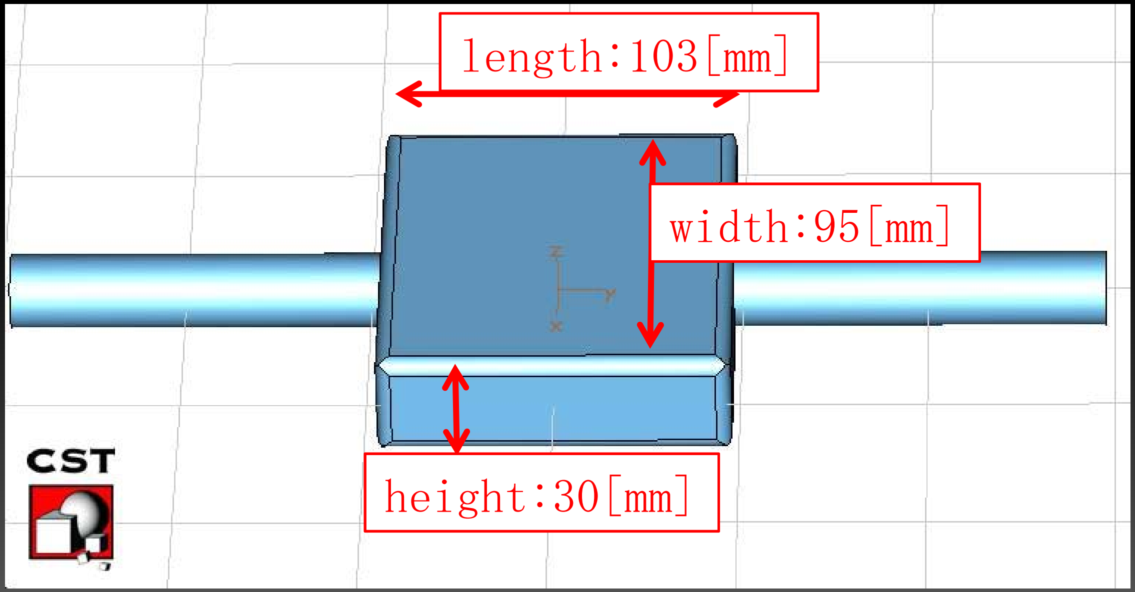
Frequency condition

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

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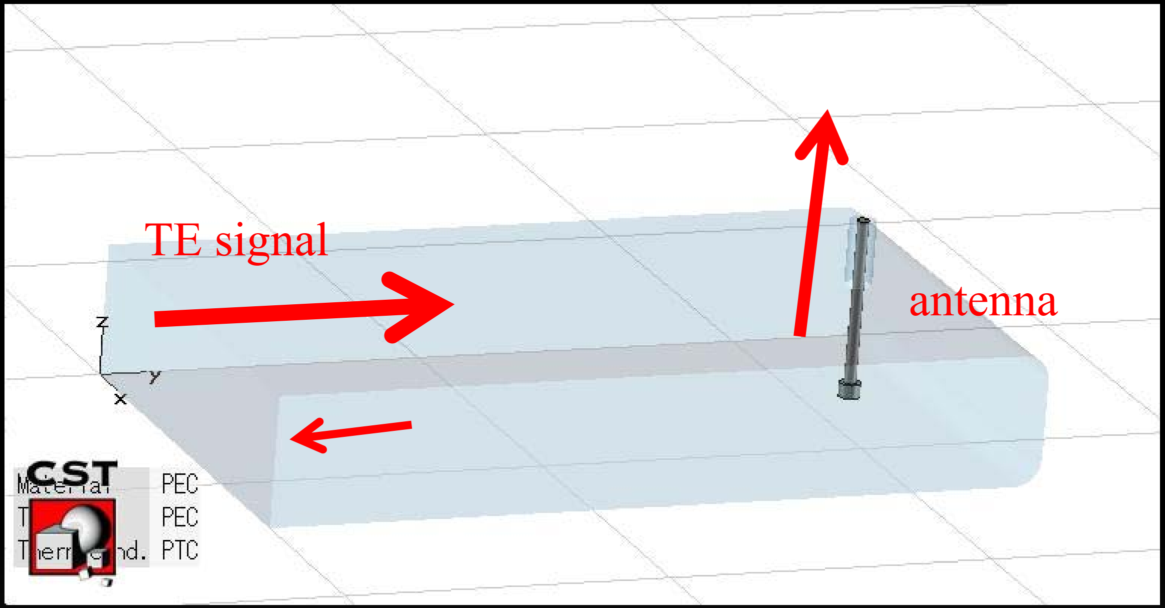
Waveguide

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.

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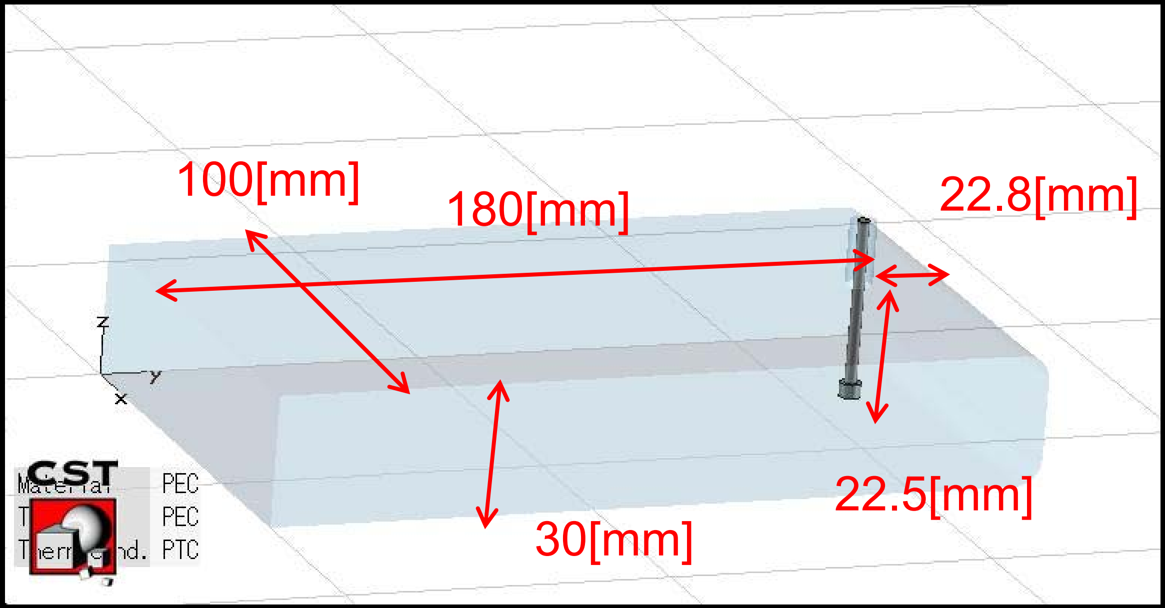
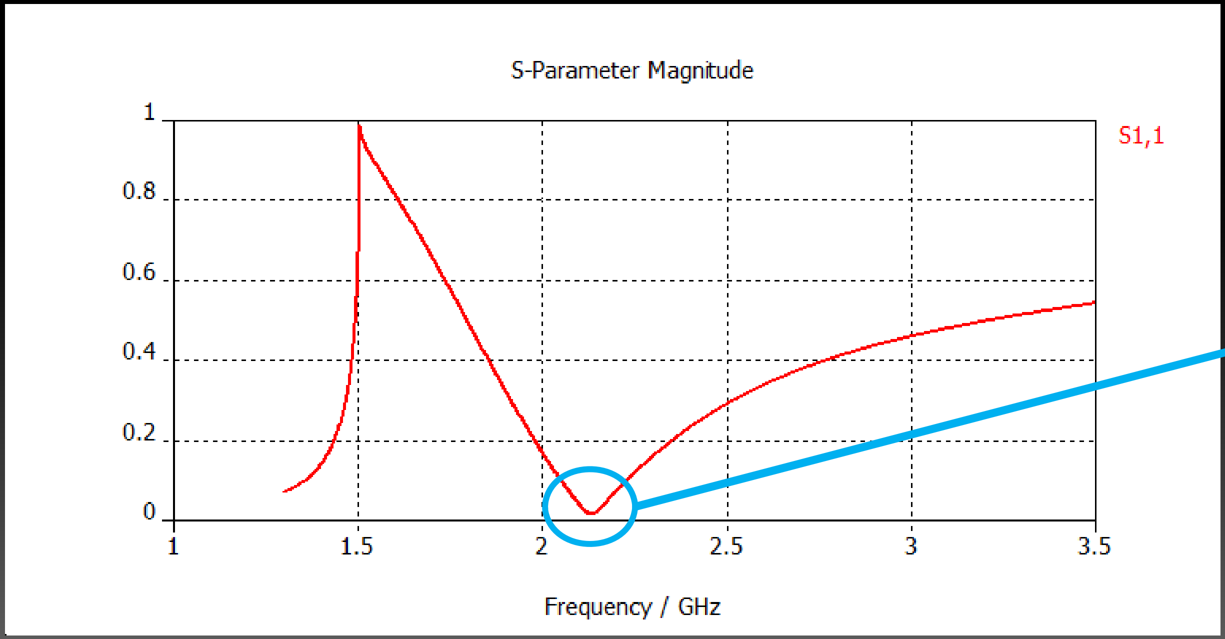
Determined waveguide-antenna design



Cut off ~ 1.5GHz



At 2.142Ghz Reflection amplitude is zero

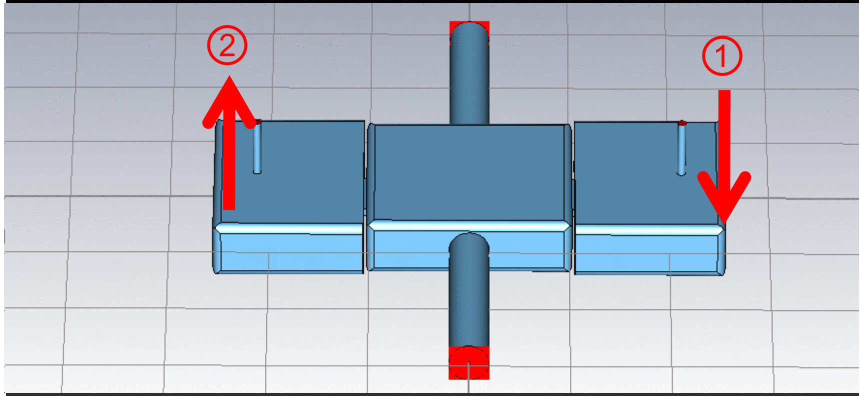
BACK UP

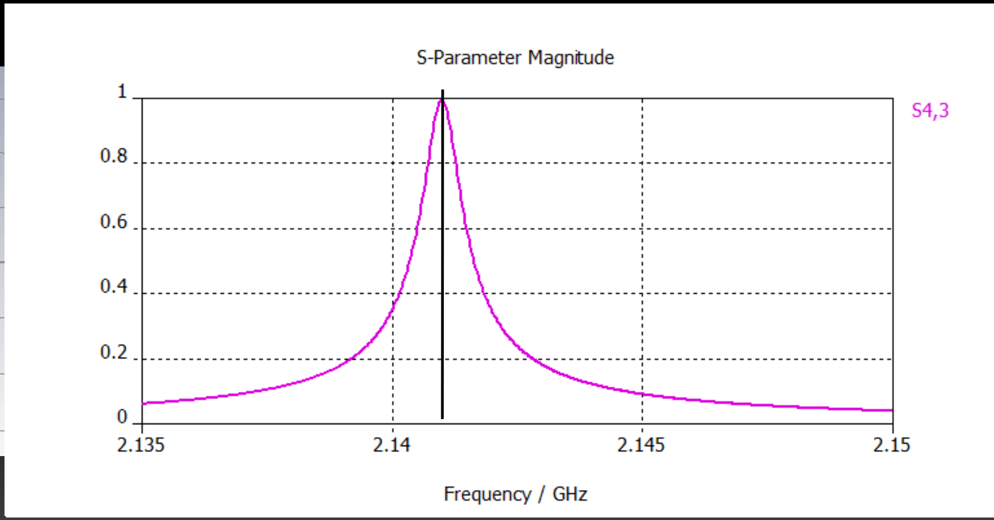
Result of total structure simulation

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

Designed loaded Q 2000

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





Frequency is 2.142GHz Q-loaded 2020