

Nextef2 : Reborn X-band High- Gradient Test Stand at KEK

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for Nextef team

High Energy Accelerator Research Organization (KEK), Japan

The 14th Workshop on Breakdown Science and High-Gradient Technology (HG2022)

May 16, 2022

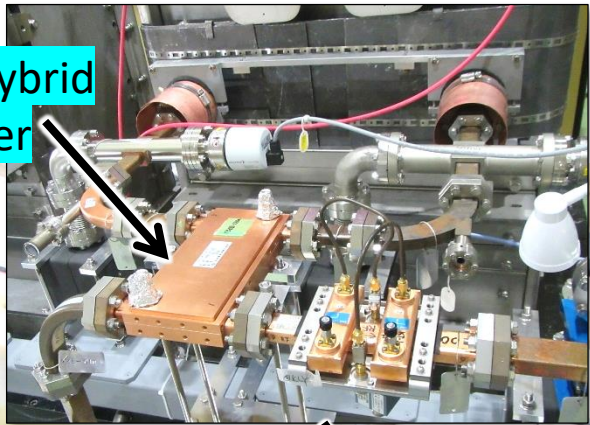
Recent History

- In 2020, the X-band modulator was upgraded to have fire extinguisher built-in.
- In 2021,
 - Jan. – Mar., high-power transmission-line waveguides laid
 - July, official safety inspection by KEK
 - September, official permission by KEK for high-power operation
 - October, started diode-mode operation of the modulator
 - December, reached $E_s=36\text{kV}$ (rated)
- In 2022,
 - Jan. – April., computer control system created
 - Started high-power RF operation

➔ Reborn into “**Nextef2**”

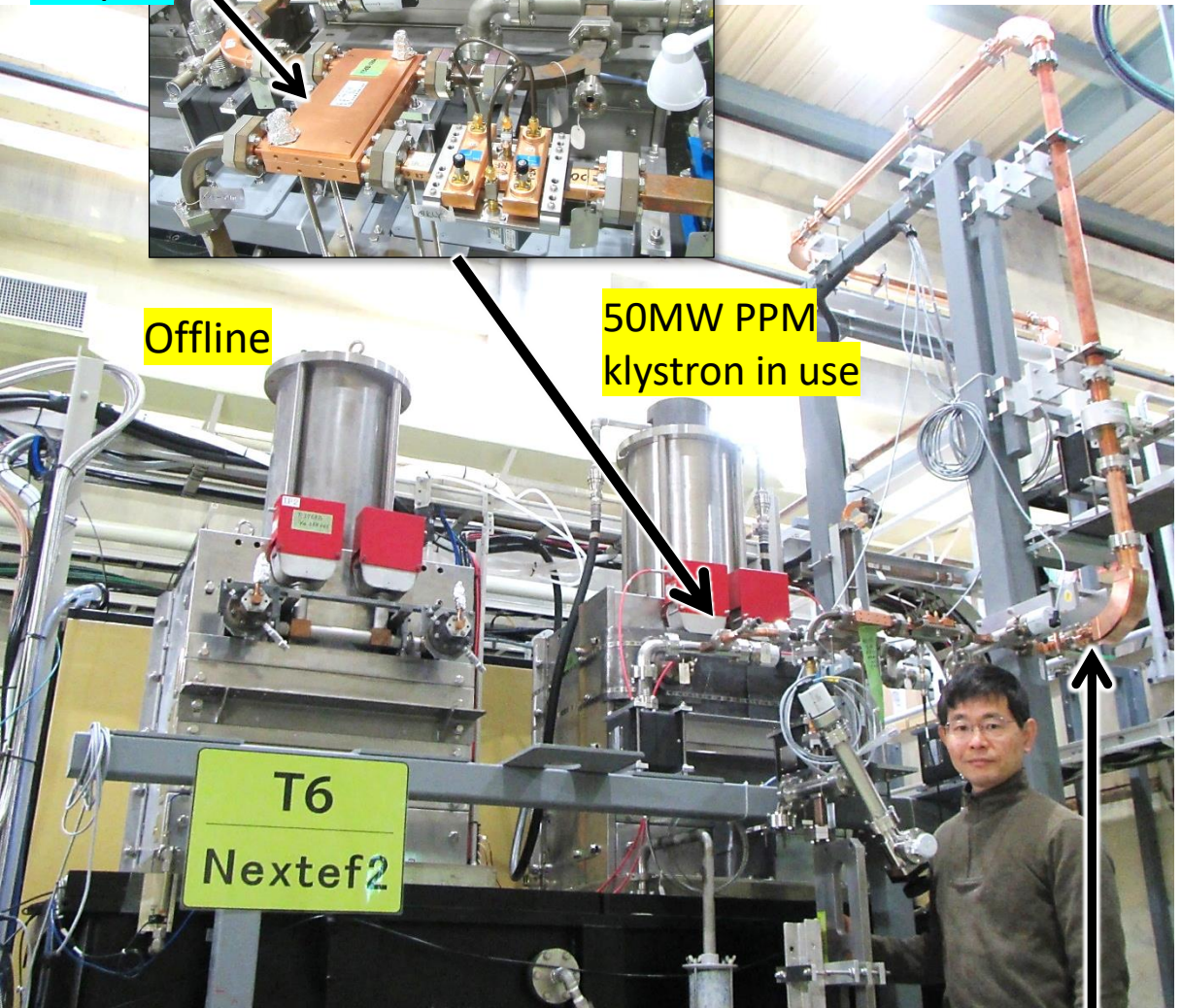
High RF-Power Transmission Line

3dB hybrid coupler

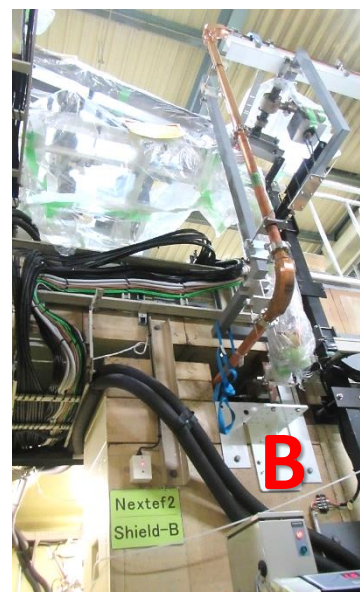
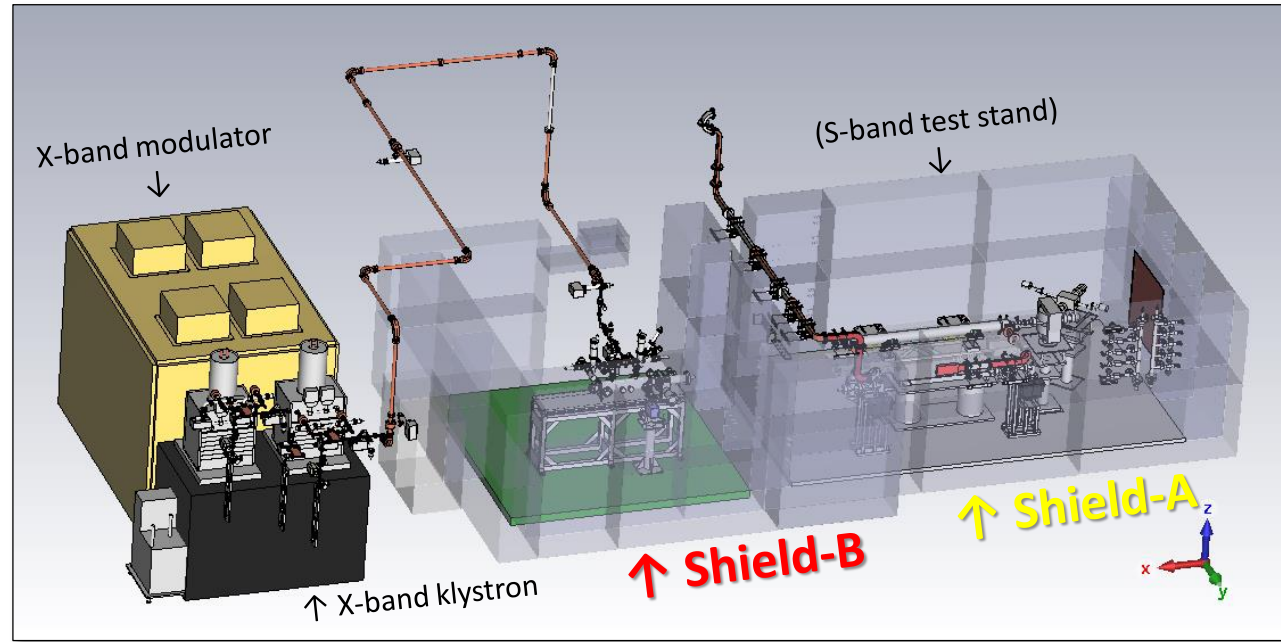


Offline

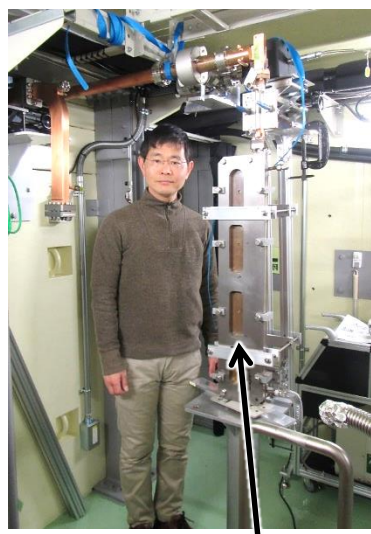
50MW PPM klystron in use



Circular low-loss waveguide (WC40)

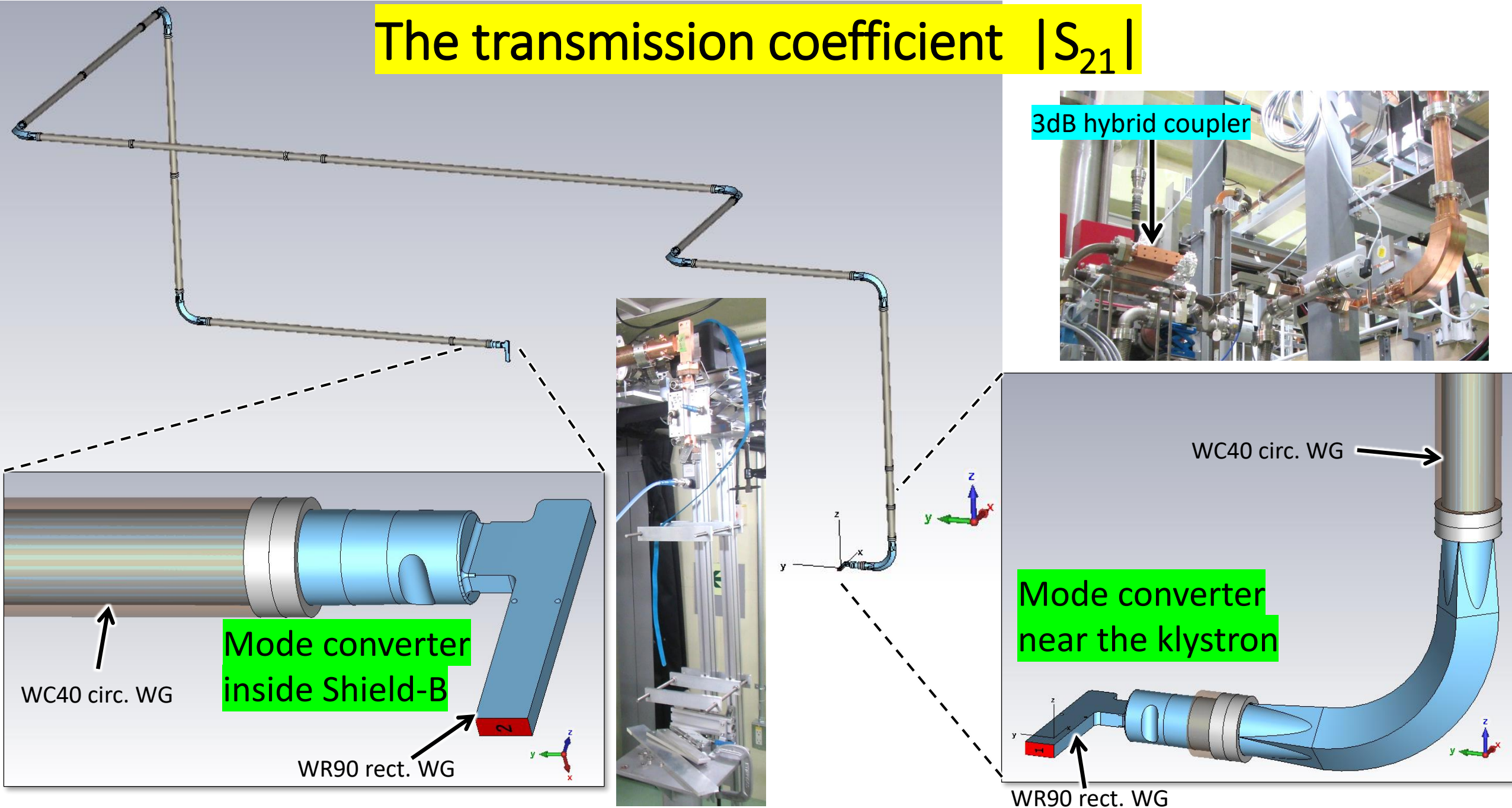


↑ Inside Shield-B →

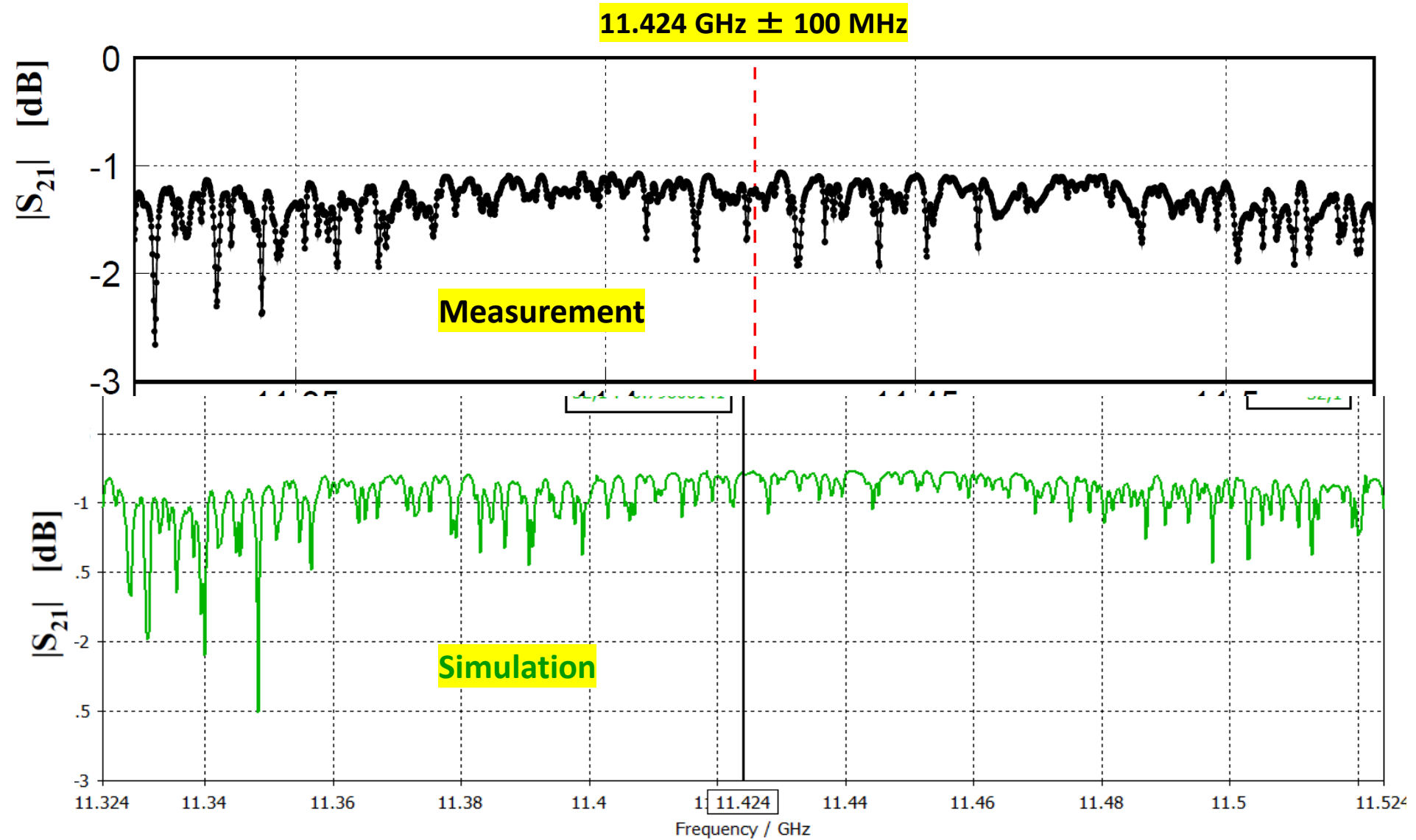


Terminated with a dummy load

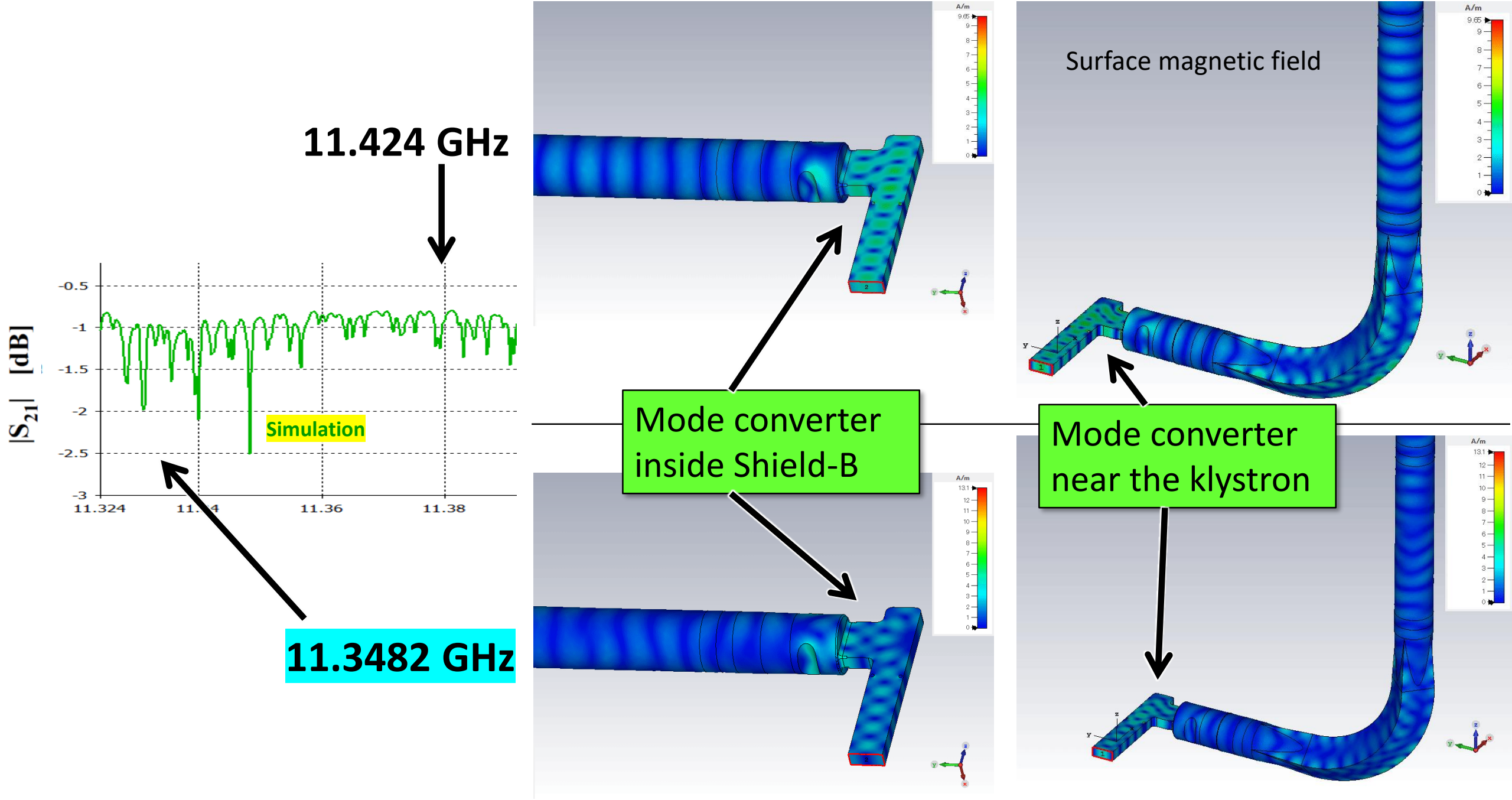
The transmission coefficient $|S_{21}|$



$|S_{21}|$ of the Transmission Line



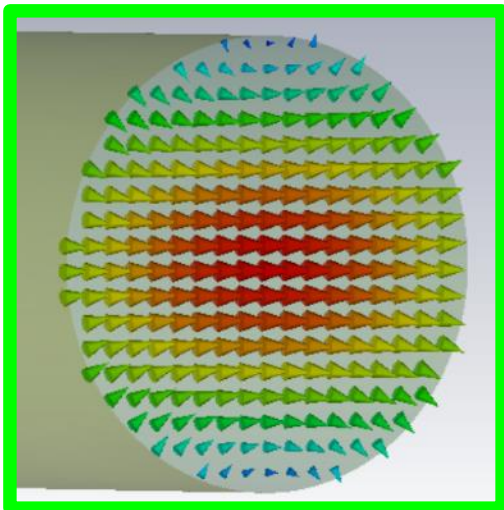
Many resonances!



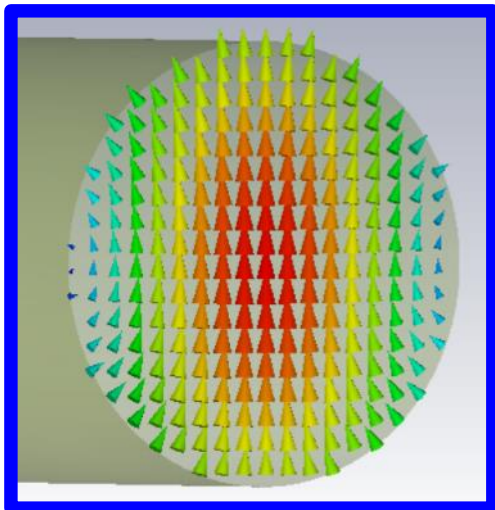
10 traveling modes in WC40

E-field vectors

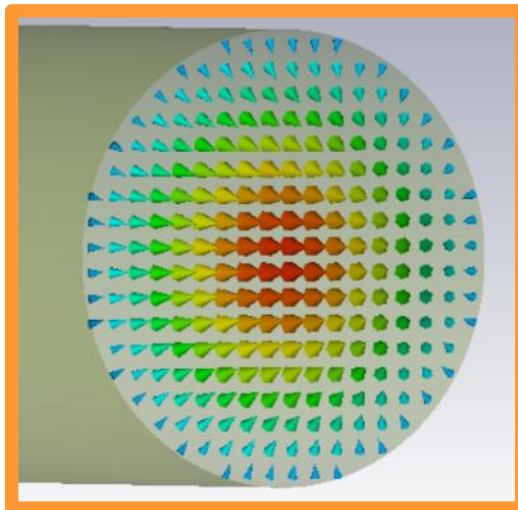
Mode 1



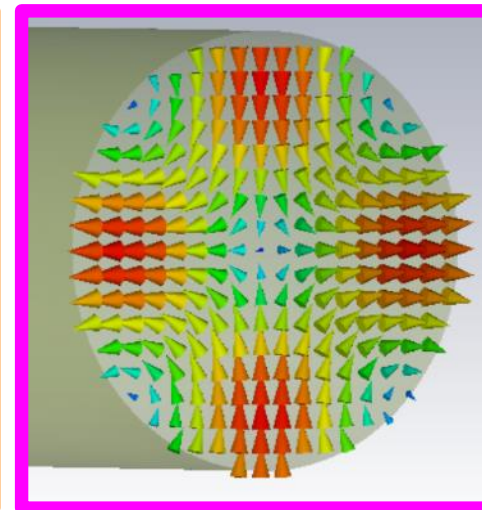
Mode 2



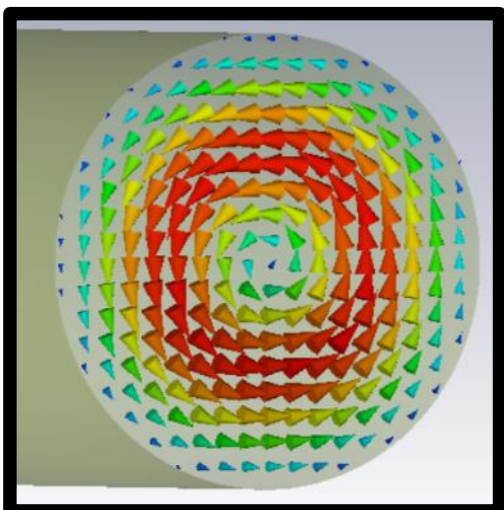
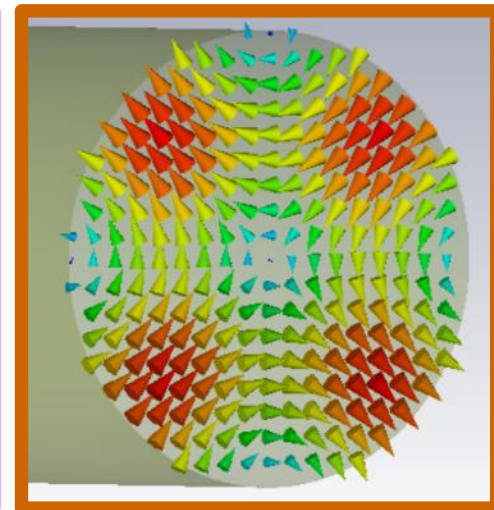
Mode 3



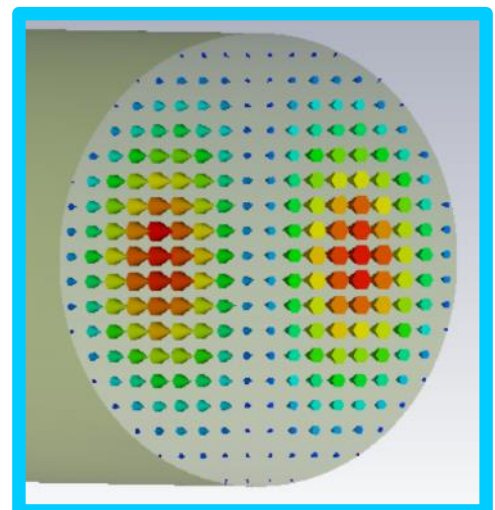
Mode 4



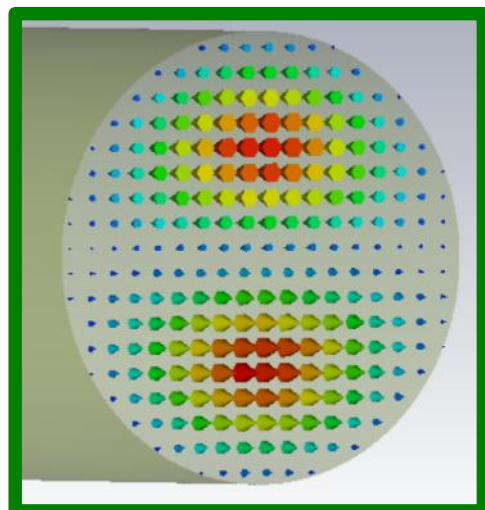
Mode 5



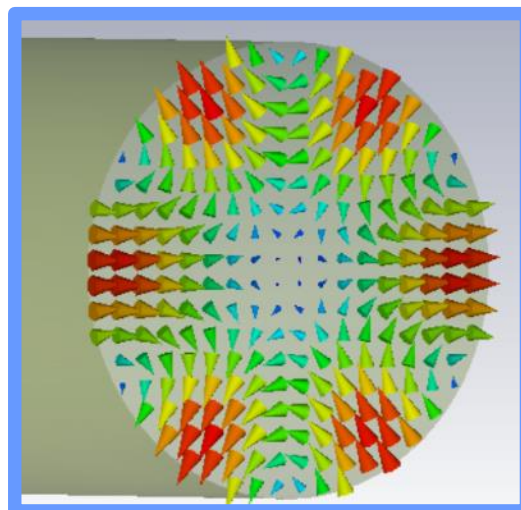
Mode 6 (TE₀₁)



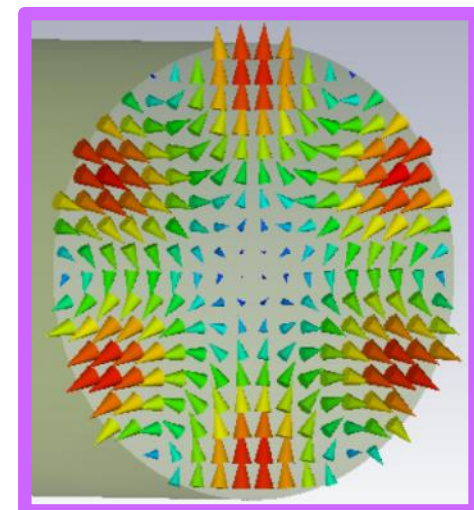
Mode 7



Mode 8



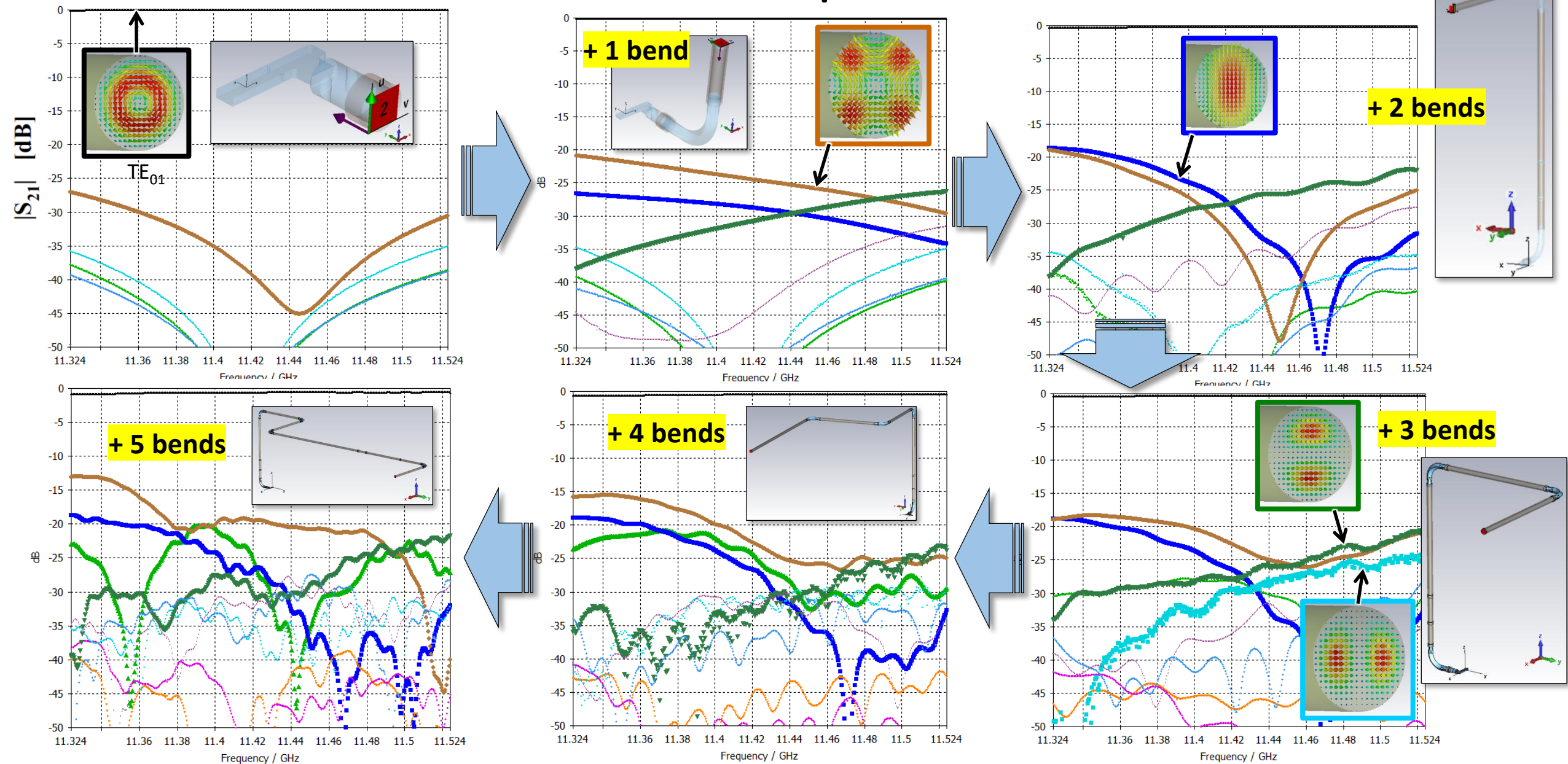
Mode 9



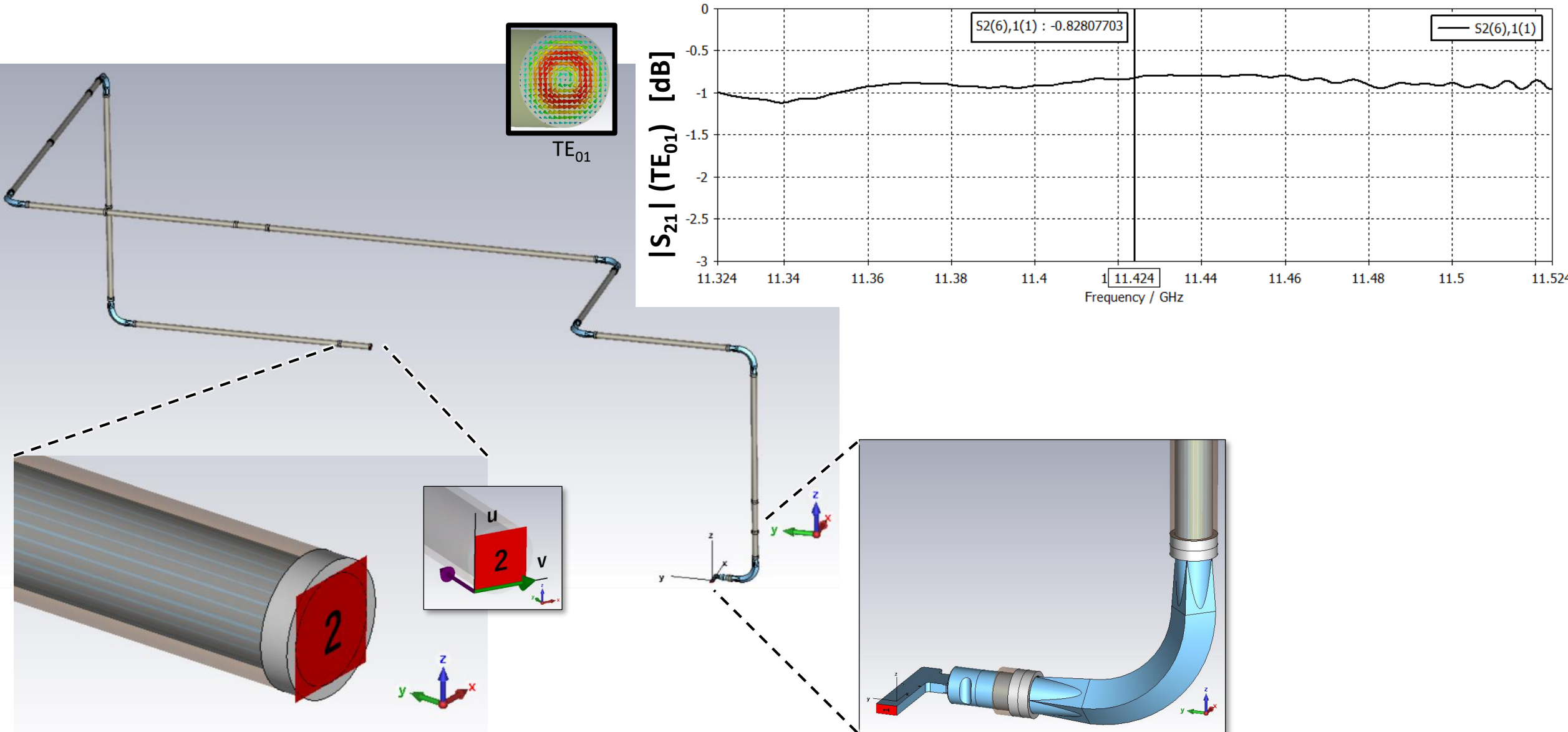
Mode 10

Mode 11 and higher
have a cutoff freq. > 12 GHz.

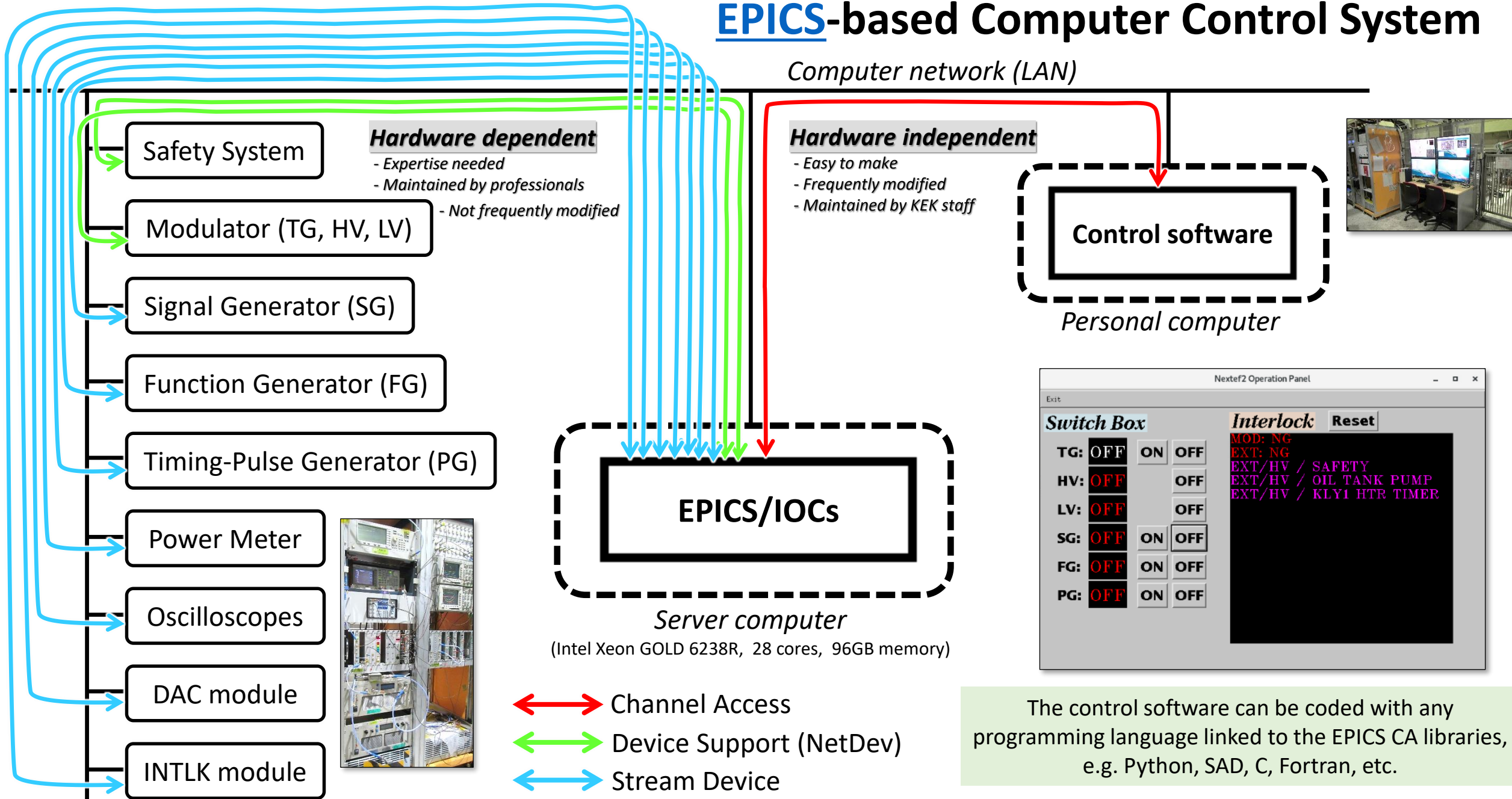
Mode diffusion to parasitic modes

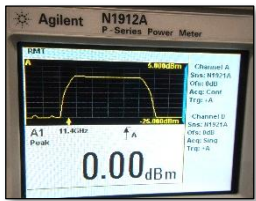


No resonance seen without the downstream mode converter



EPICS-based Computer Control System





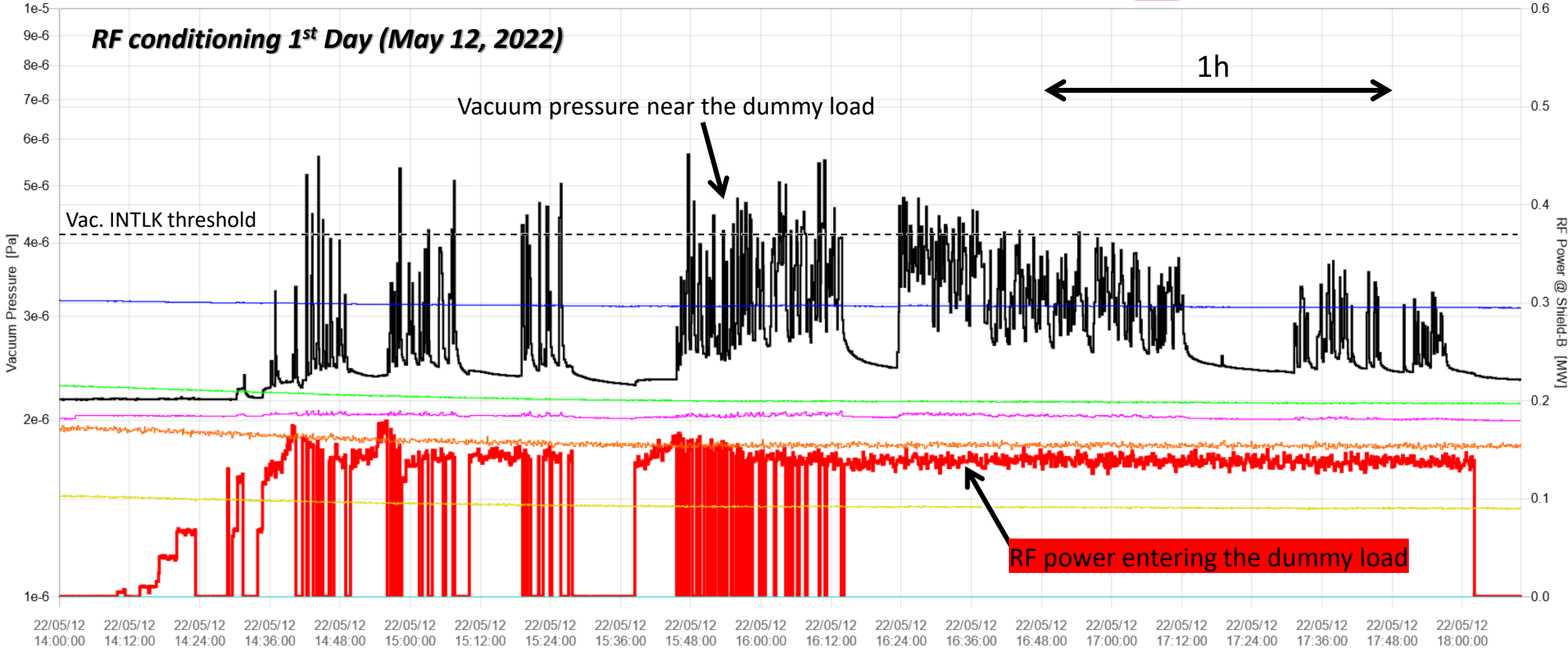
← RF pulse entering the dummy load in Shield-B

High-Power RF Operation Just Started

(Pulse width : 100 ns, Rep. rate: 1 Hz)

LinDL:TR-W1000:Ch49:CCG:KLY1:WinS:Pa LinDL:TR-W1000:Ch50:CCG:KLY1:WinN:Pa LinDL:TR-W1000:Ch51:CCG:KLY1:Comb:Pa LinDL:TR-W1000:Ch52:CCG:KLY1:Load:Pa
LinDL:TR-W1000:Ch60:CCG:WC40:UP:Pa LinDL:TR-W1000:Ch61:CCG:WC40:MID:Pa LinDL:TR-W1000:Ch62:CCG:WC40:DN:Pa LinRF:ShieldB:Pfwd:Meas_MW

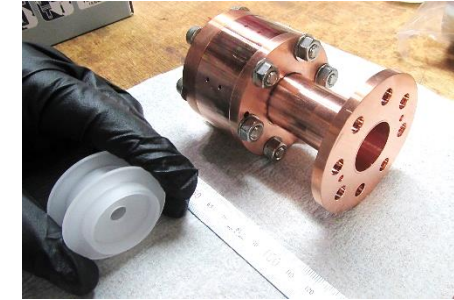
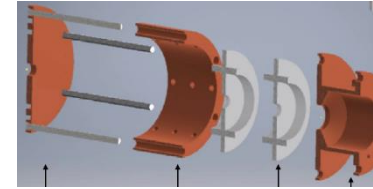
RF conditioning 1st Day (May 12, 2022)



Examples of near-future test structures

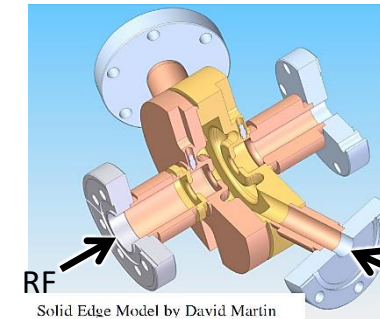
1. Dielectric-assist accelerating test structure

- $\sim 10 \times Q_0^{(conventional)}$
- Developed with C-band structures so far at KEK
- X-band test cavity with dielectric material with DLC to be delivered soon
- Needed RF power : ~ 100 kW (max)



2. SLAC full-choke cavity

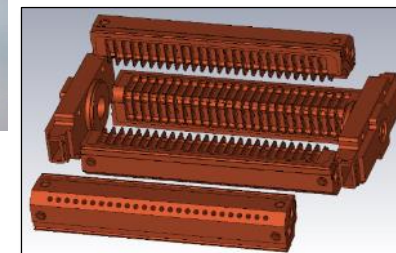
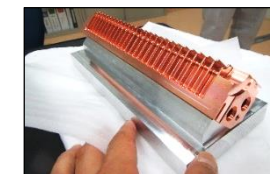
- Basic study of the breakdown mechanism using a high-power pulsed laser or high-spec. cameras.



Laser or camera

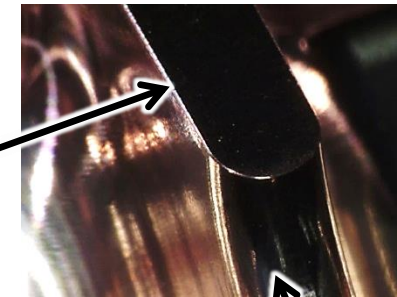
3. Quadrant-type WG-Damped CLIC prototype structure TD24_QUAD

- Using one klystron,
 - $E_{acc} = 100$ MV/m ($P_{in} = 45$ MW : $P_{kly-out} = 60$ MW) *impossible*
 - $E_{acc} = 90$ MV/m ($P_{in} = 36$ MW : $P_{kly-out} = 48$ MW) *difficult*
 - $E_{acc} = 80$ MV/m ($P_{in} = 30$ MW : $P_{kly-out} = 38$ MW) *maybe possible*
 - $E_{acc} = 70$ MV/m ($P_{in} = 22$ MW : $P_{kly-out} = 30$ MW) *possible*
- Need the modulator upgrade to drive two klystrons for $E_{acc} > \sim 100$ MV/m
- The previous version: TD18_QUAD reached $E_{acc} < 60$ MV/m.



HG test of TD18_QUAD at Nextef1 in 2009

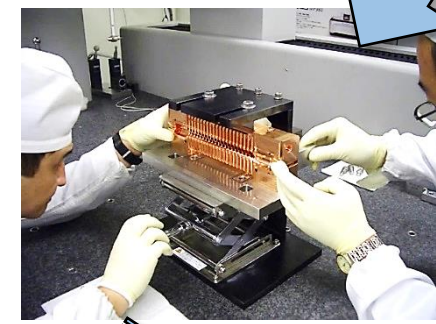
Ultraprecision machining (profile tolerance: 5 μ m)



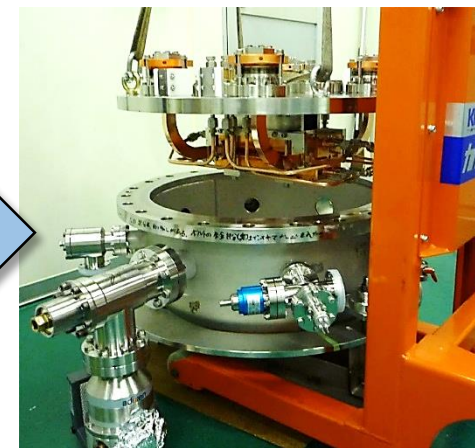
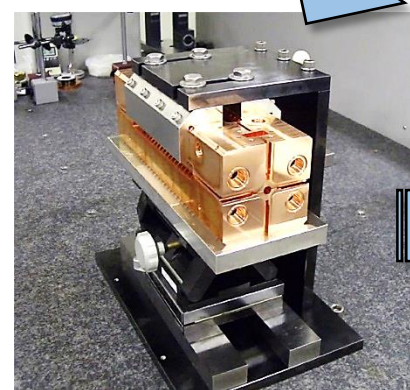
R50 μ m
round chamfer

Iris

Precision alignment (5 μ m)



Into a vacuum chamber

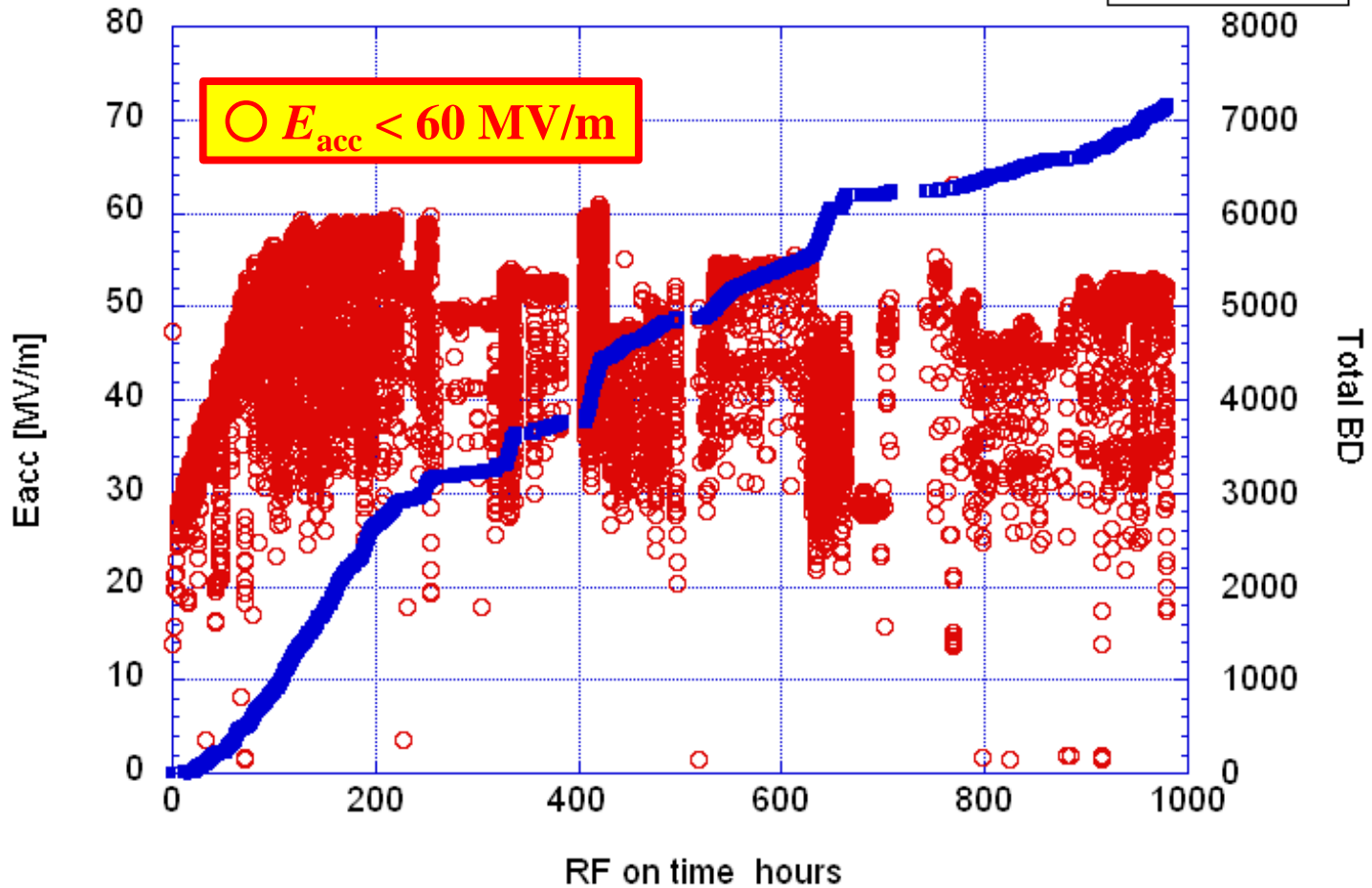


No bonding among the quadrants

Quad #5
Processing whole trend

○ Eacc [MV/m]

□ Total BD



○ $E_{acc} < 60$ MV/m

Summary

- Nextef has been reborn into “Nextef2”.
 - More safety with fire extinguisher built-in
 - More compact and simplicity
 - EPICS-based control system with high easiness in modifying the user interface

- The current RF-power transmission line of WC40 has a problem due to the mode diffusion.
 - Many (not so big) resonances
 - To be modified before going to higher RF power

- High RF-power conditioning just started

- Near-future test structures under discussion