

The Cavity for RF Input Coupler Conditioning at SPring-8

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at CWRF2012

SPring-8



SPring-8 standing wave cavities

508.58 MHz

Storage Ring



× 32

max 150 kW

Booster Synchrotron

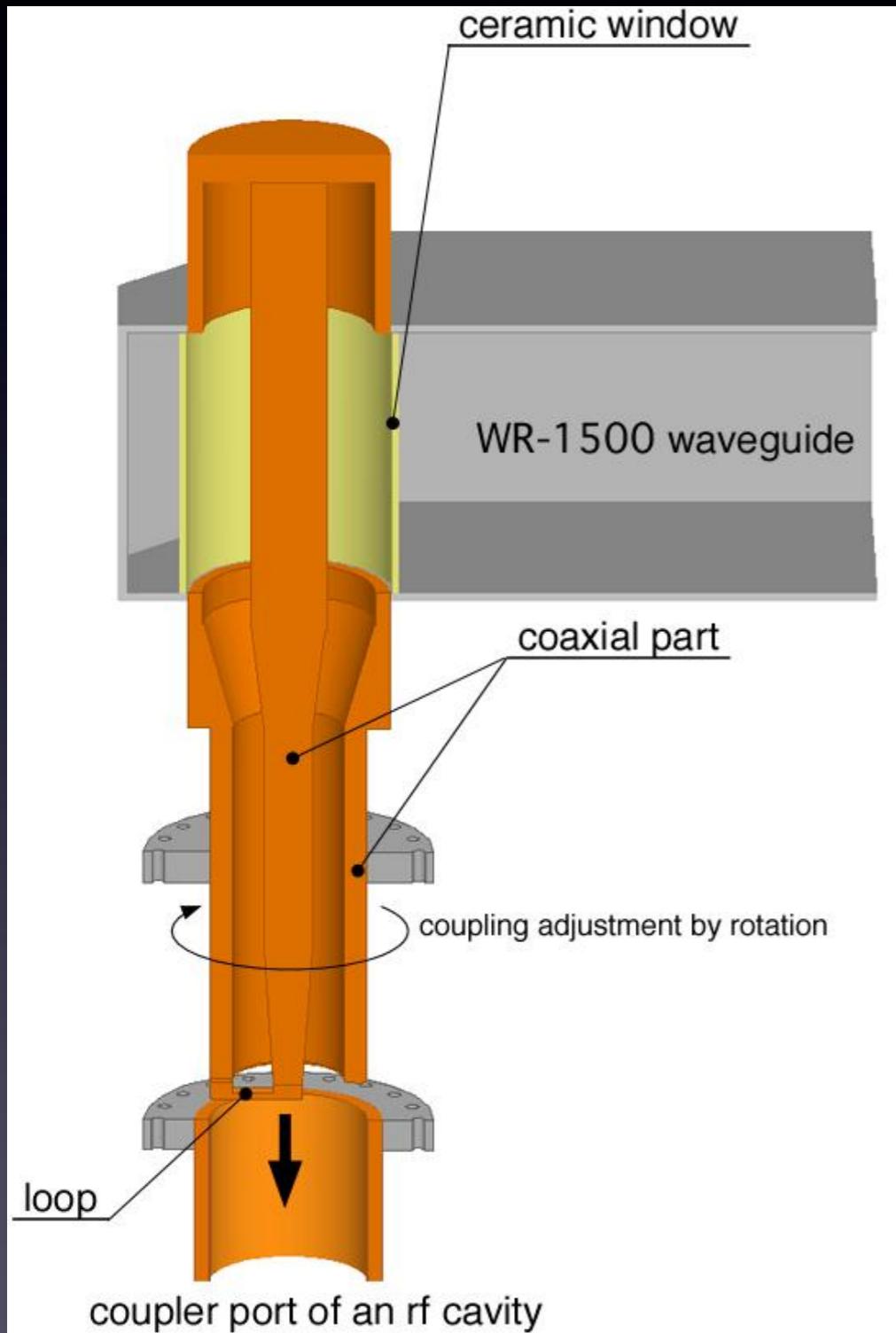


× 8

max 300 kW

RF input coupler

RF input couplers for the standing wave cavities at SPring-8 (Toshiba E4263)
both for the storage ring and the booster synchrotron



- WR-1500 wave guide,
WX-77D wave guied to coaxial
converter
- Loop coupling at the tip
- rated pore: 300 kW
- Vacuum sealing with cylindrical
ceramics

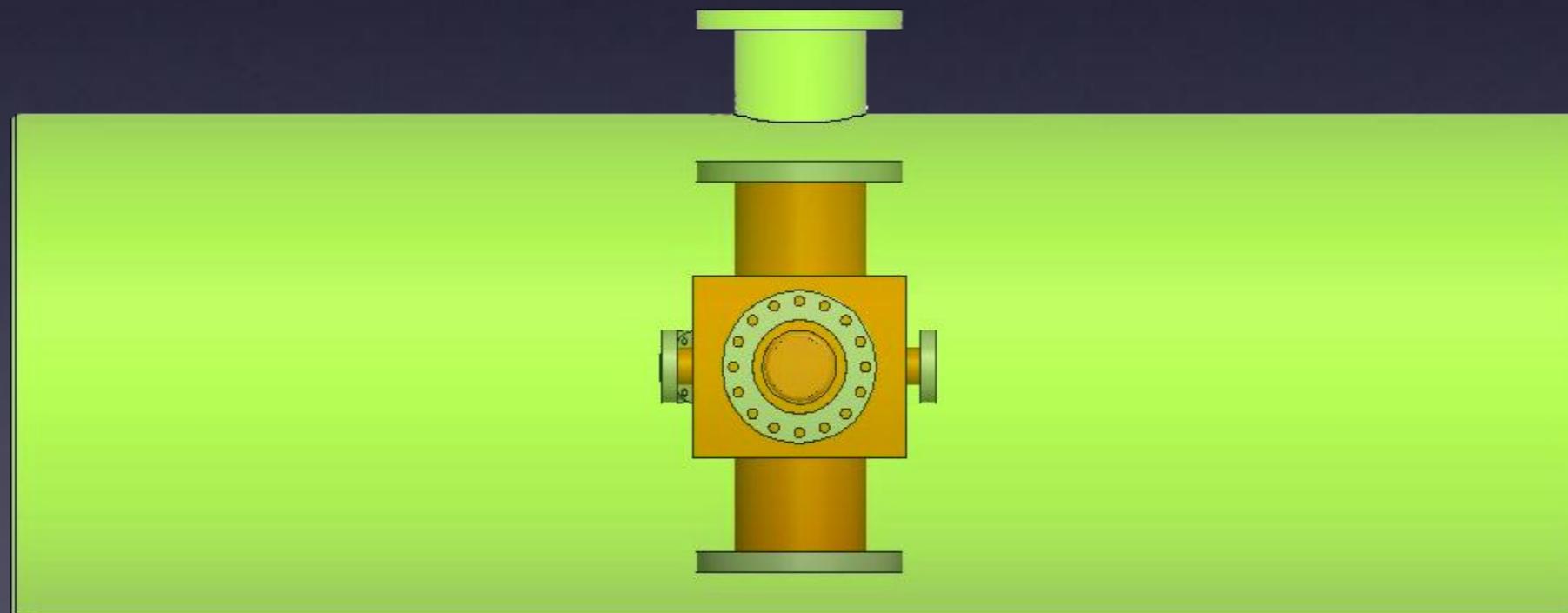
Motivation

- Coupler must be conditioned with 300 kW
- Vacuum leak of the prototype 5-cell cavity



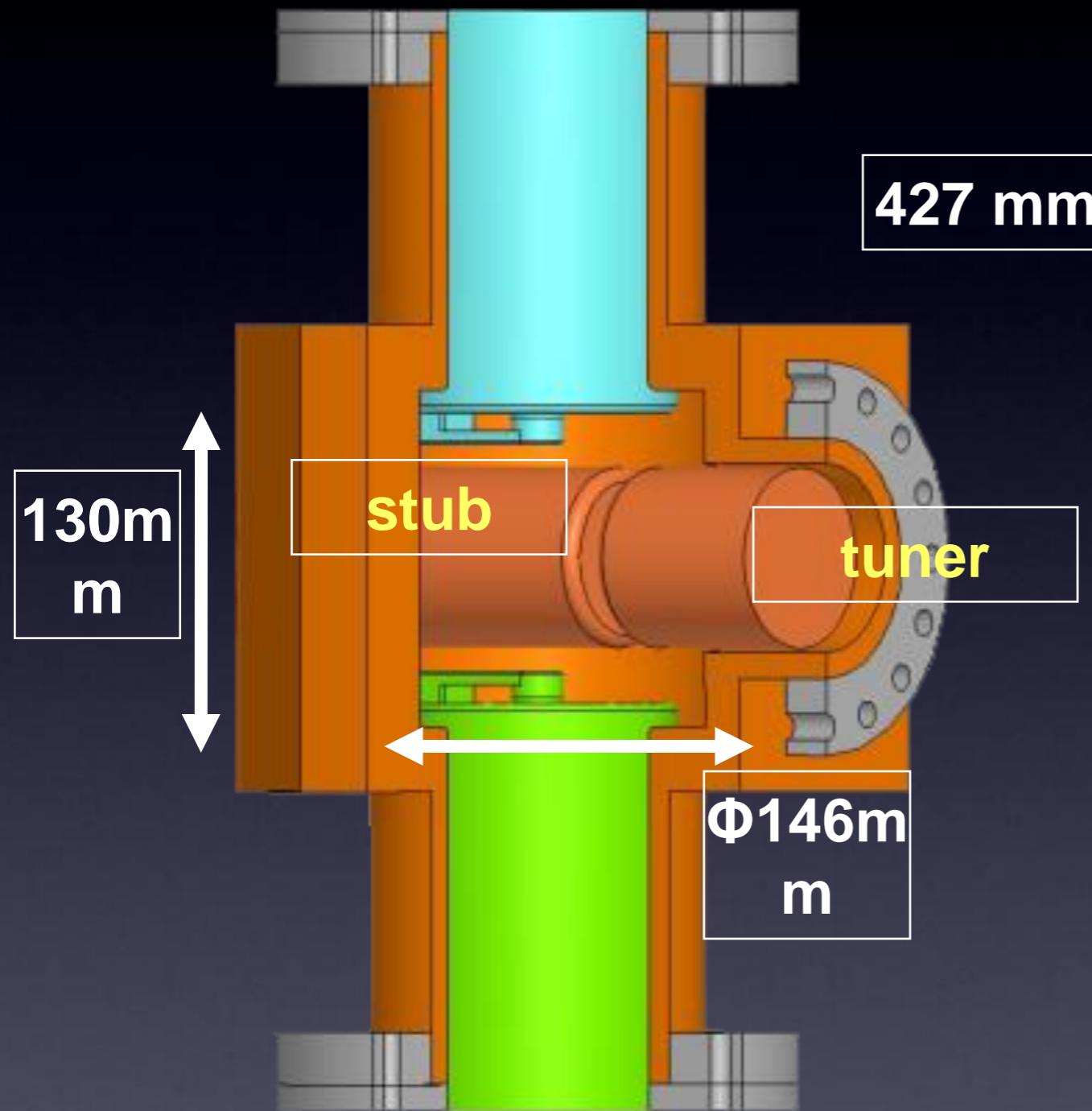
Cavity for Coupler Conditioning

- 2 couplers are connected face to face on each side of the cavity
 - (inspired by a cavity developed at KEK by F. Naito)
- small in size
- easy to handle (small amount of radiation, etc.)
- low cost (lower than 1/10 of the 5-cell cavity)

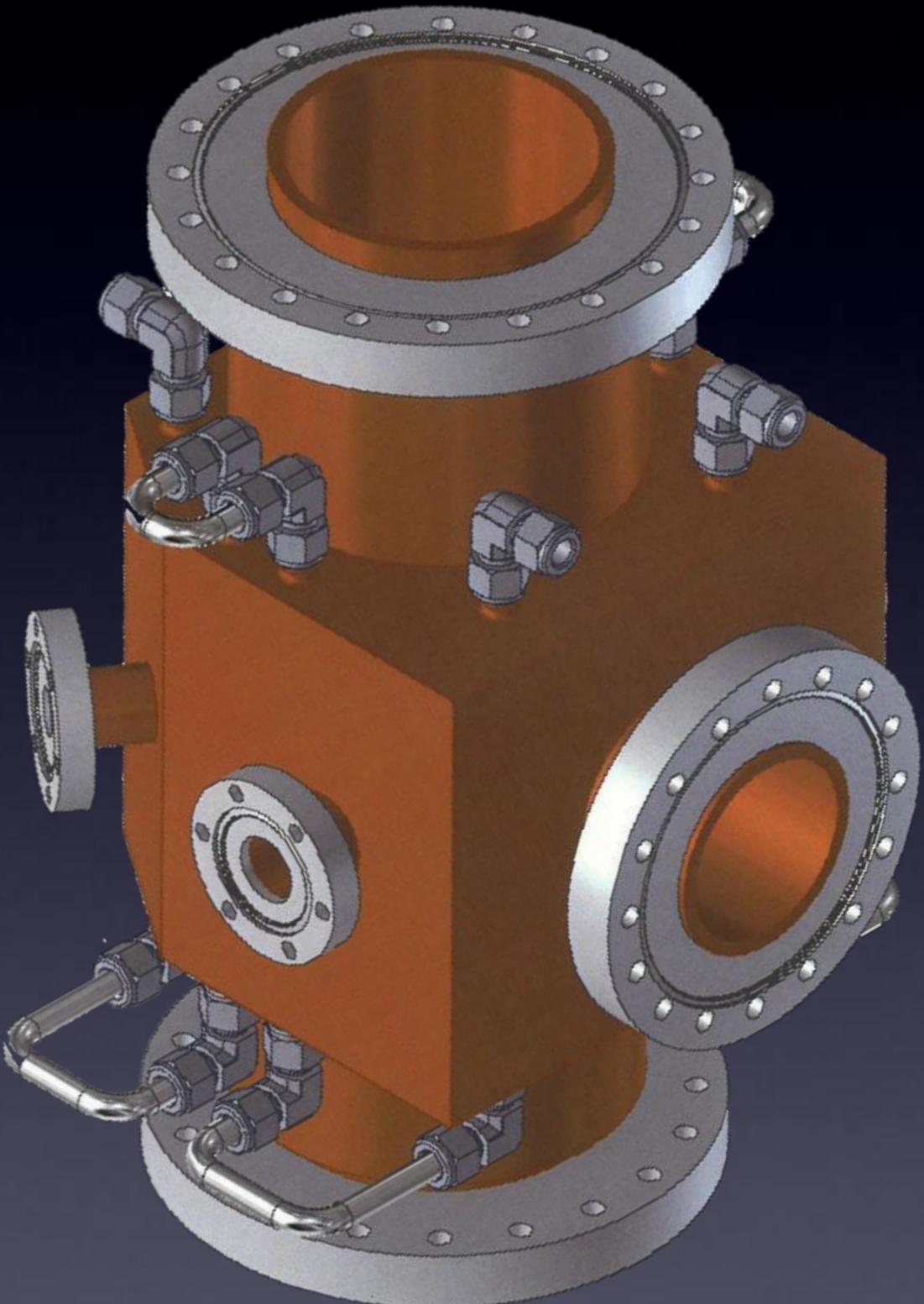


structure

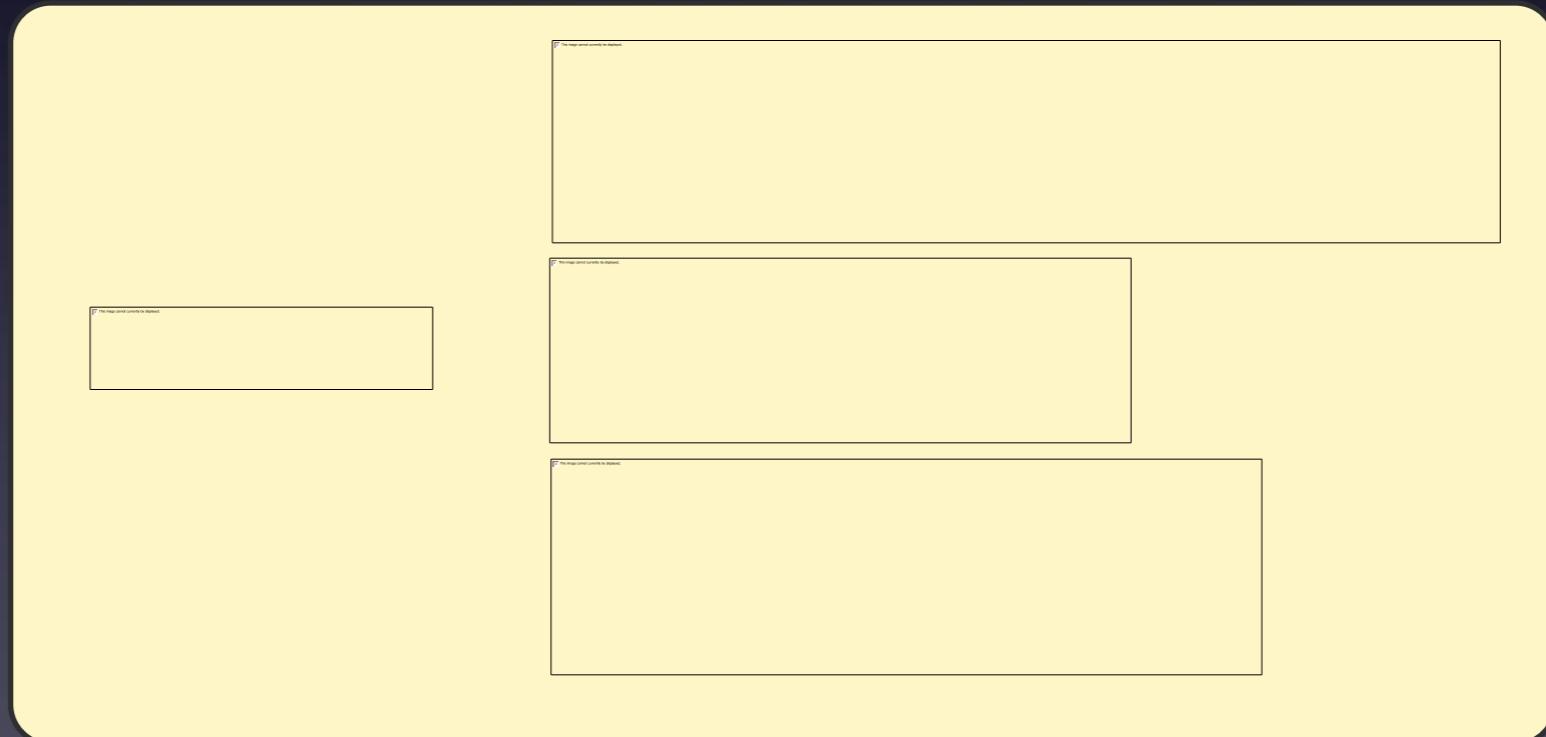
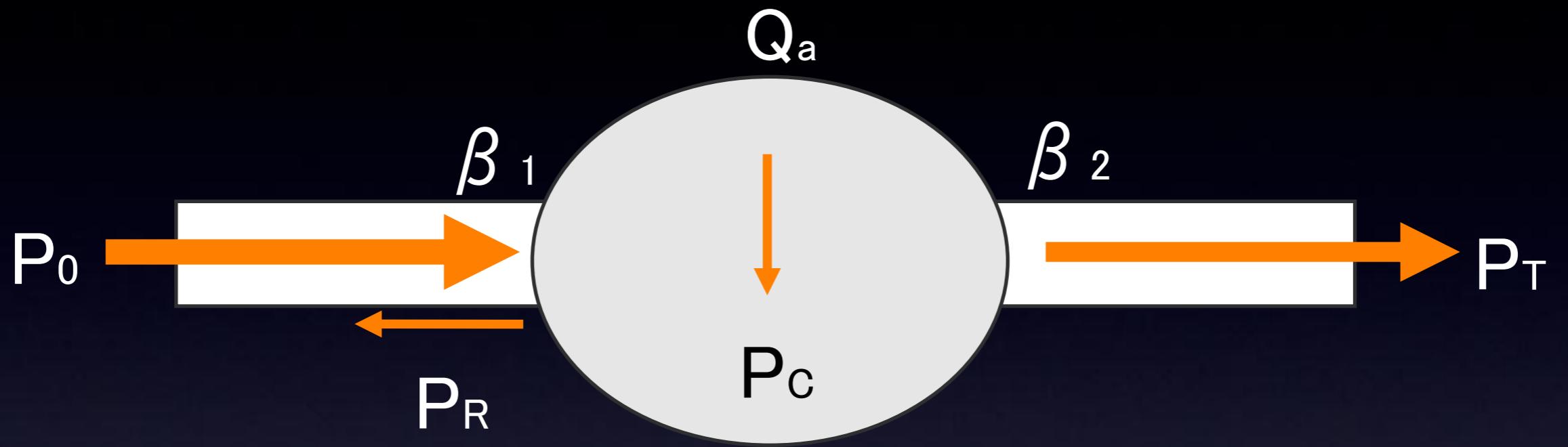
coupler, upstream



coupler, downstream



Two-aperture cavity



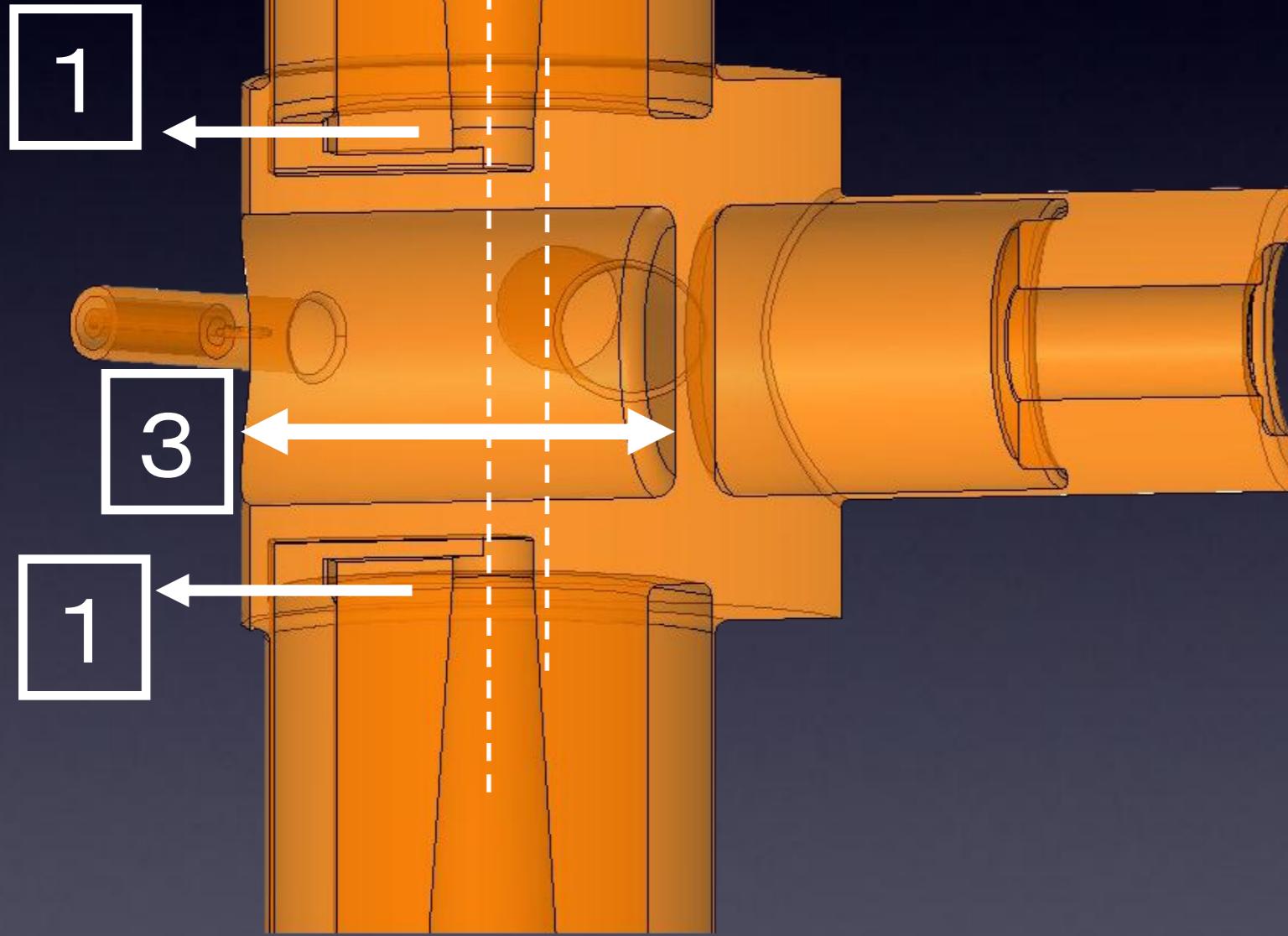
→ larger β is better

Characteristics of the cavity (estimated with HFSS)

resonant frequency	508.58 MHz
coupling coefficient β	58
unloaded Q	4380
external Q	73.3
power transmission rate P_T/P_0	98.3%
power dissipation rate P_c/P_0	1.7%
VSWR	1.02

Asymmetric structure

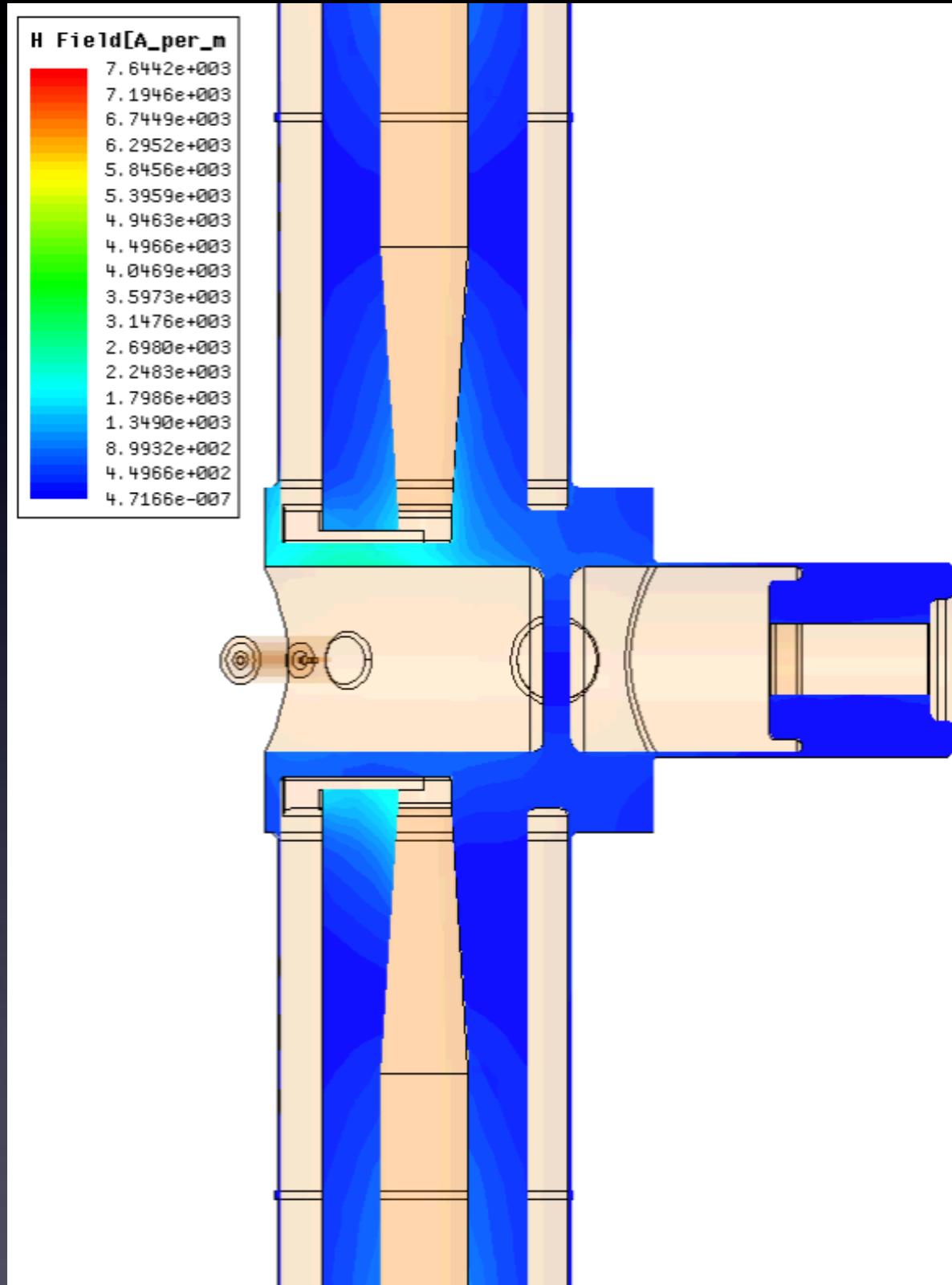
Protection of the coupler and tuner



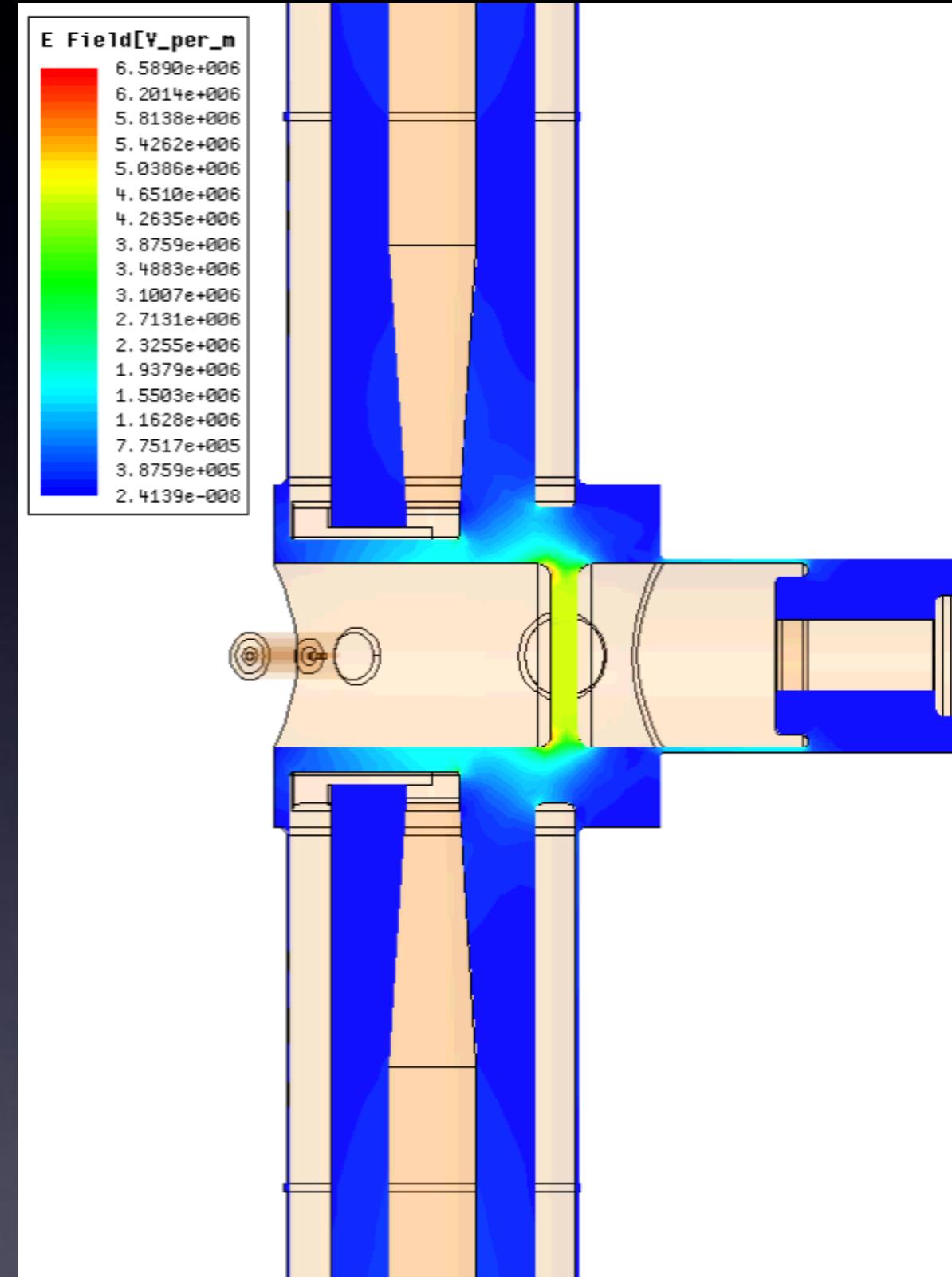
from

- discharge
- leakage of magnetic field

magnetic field



electric field

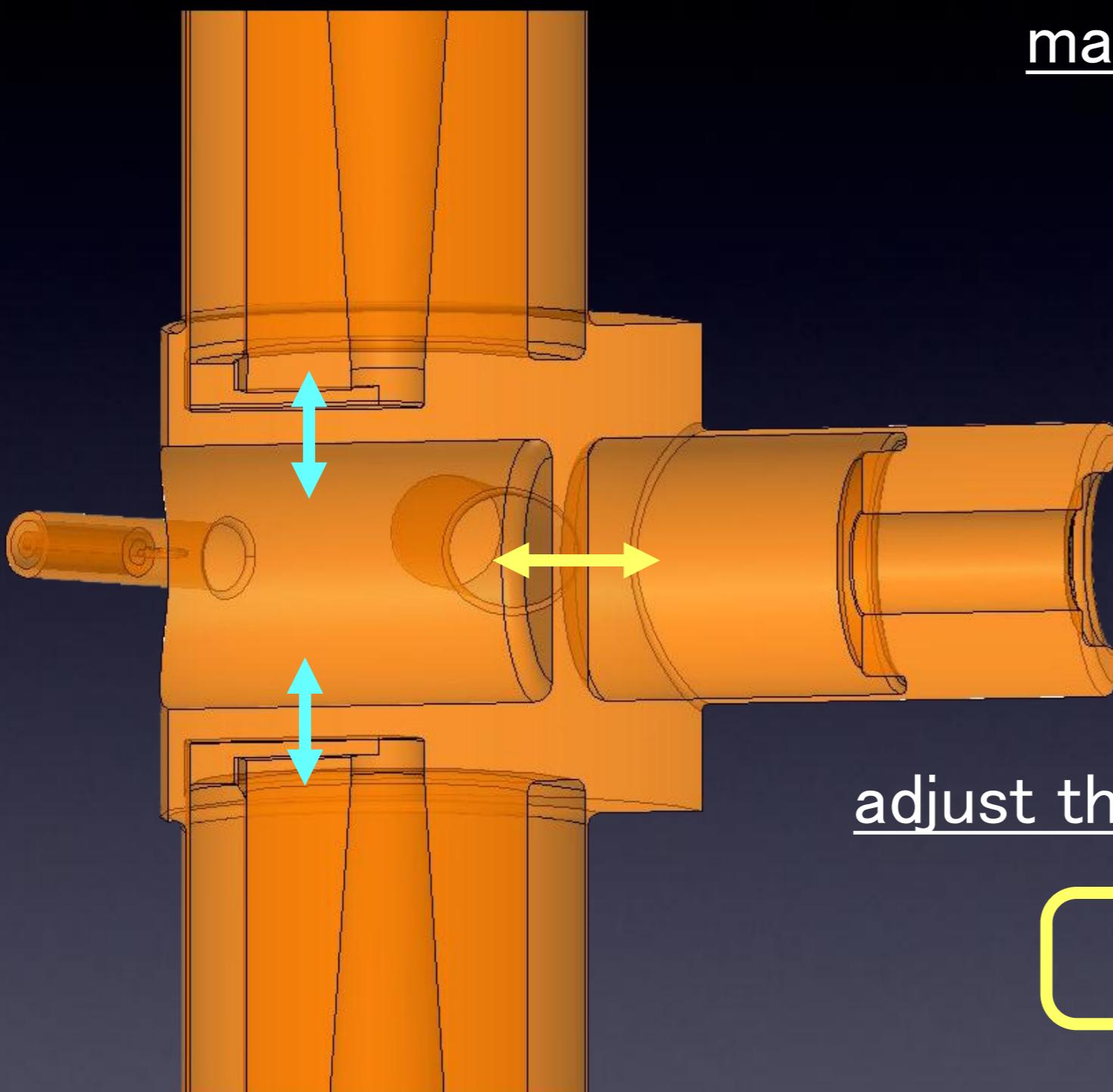


resonant frequency change
accorging to the errors at
manufacruring, and assembling



Sensitive to the gaps

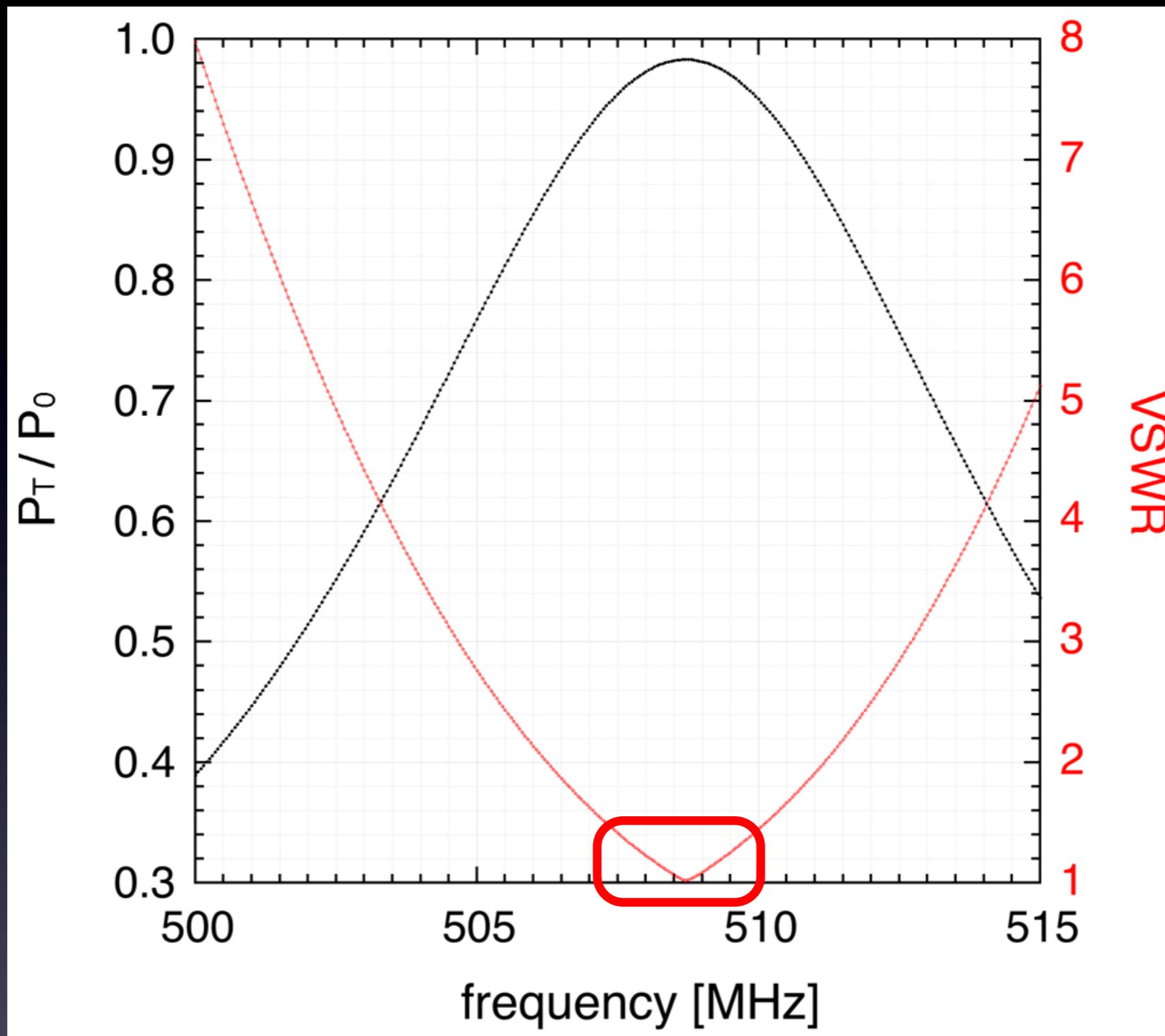
-1.6 MHz/mm



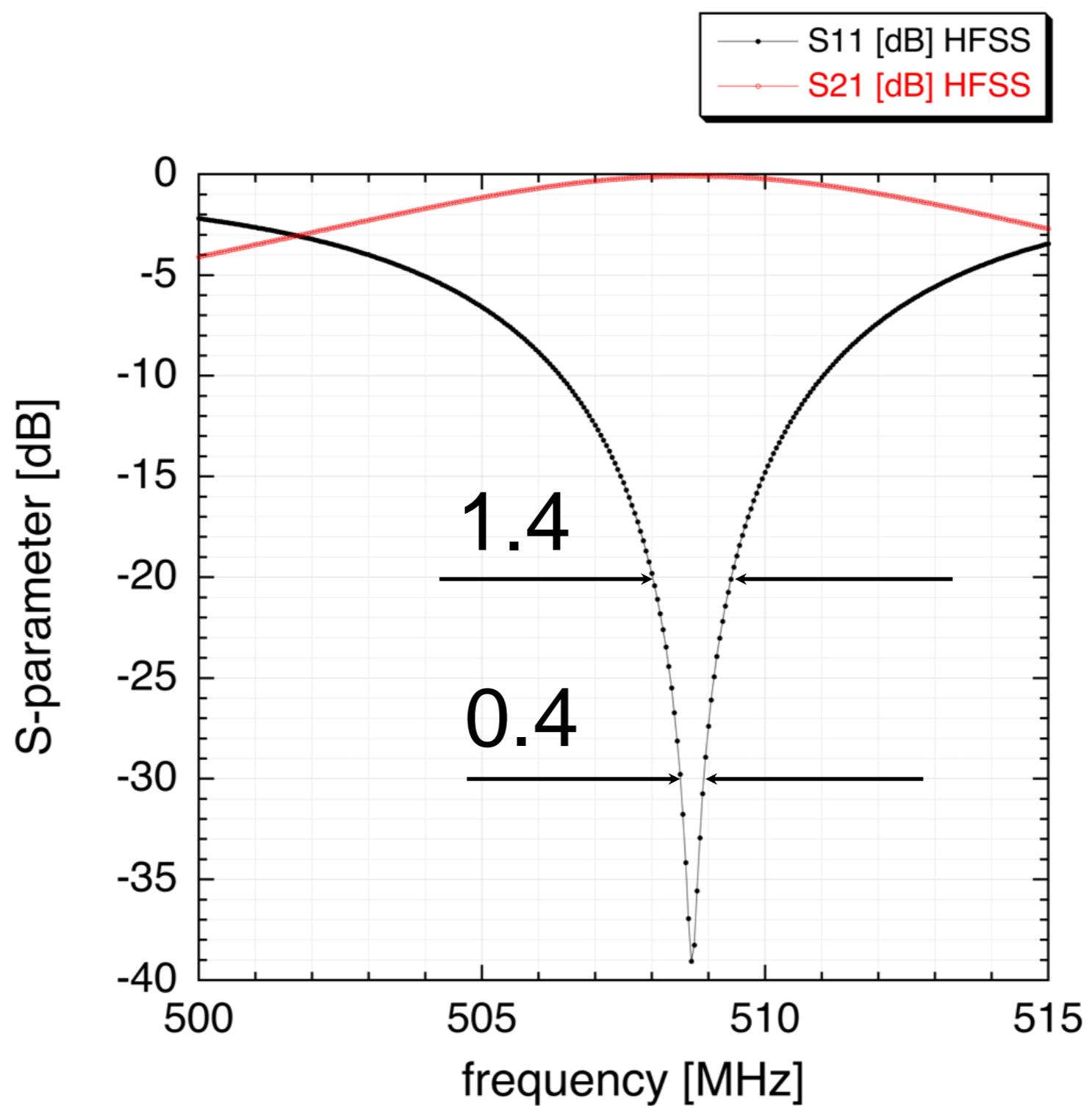
adjust the frequency by the tuner

-12.5 MHz/mm

tunable range > ± 50 MHz

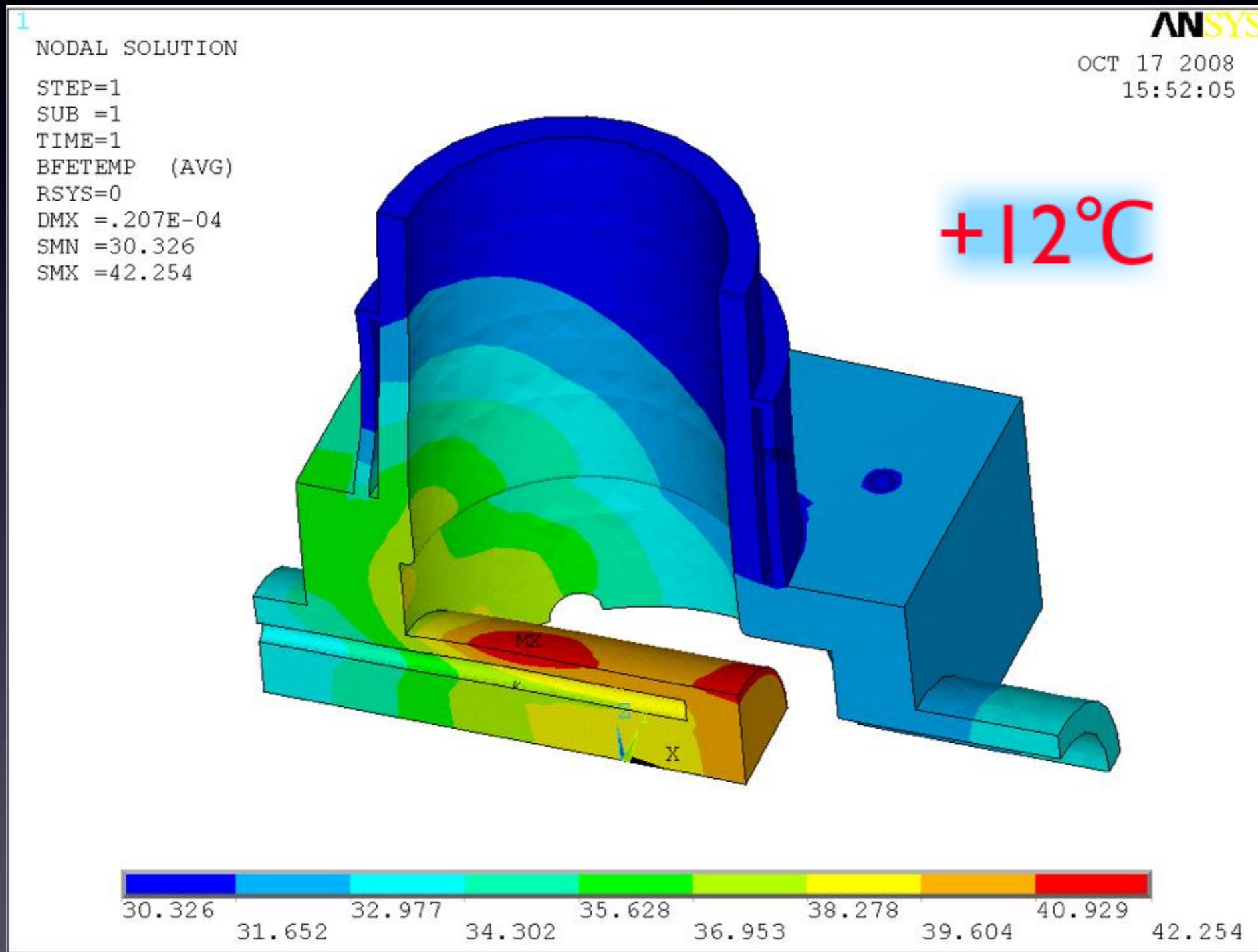


VSWR = 1.02 ; 0.65 MHz (< 1.1)



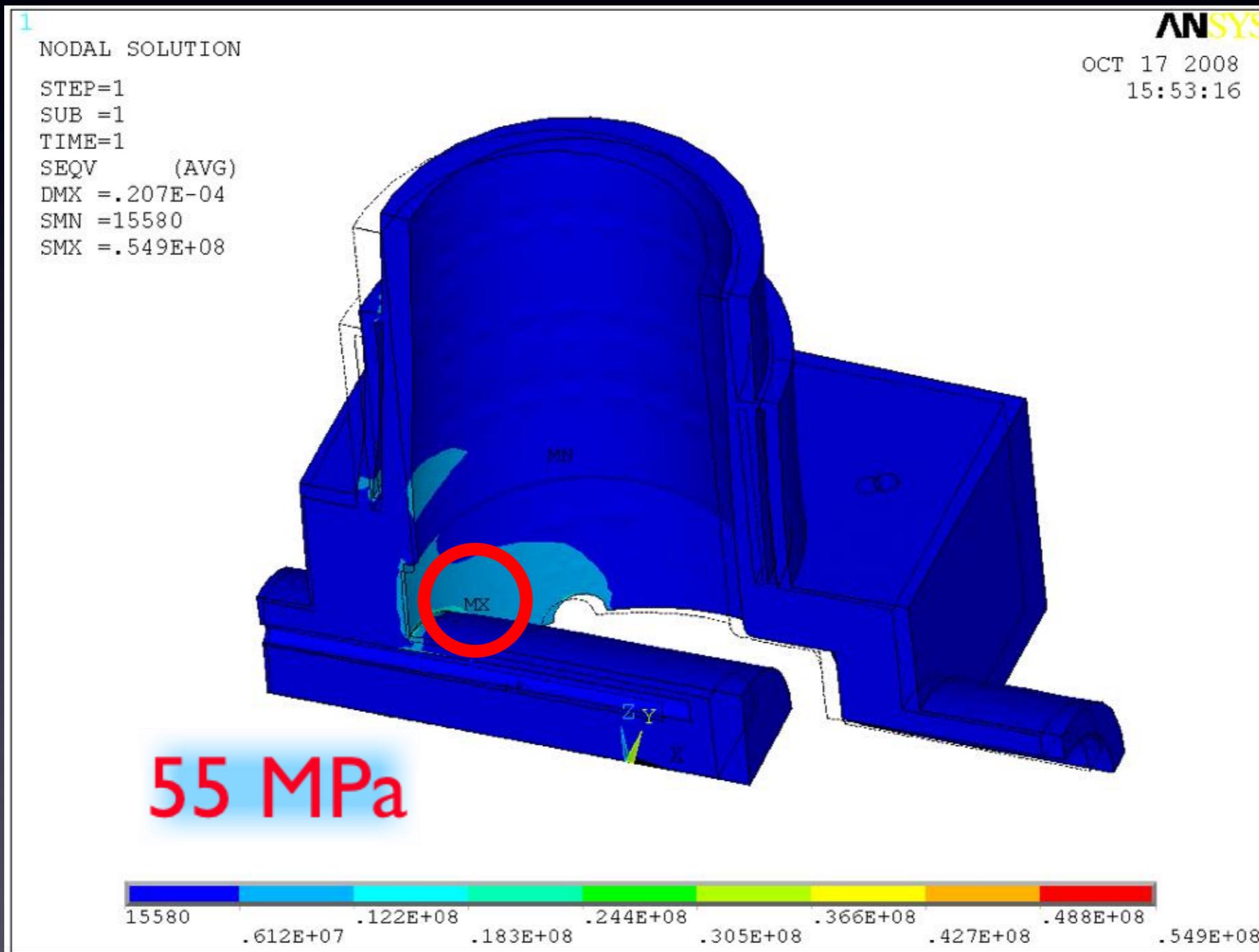
Thermal analysis for 300-kW operation

Water channel 6 L/min 30°C :
 $\Phi 8 \text{ mm} \times 11 + (3\text{mm} \times 71\text{mm}) \times 2$

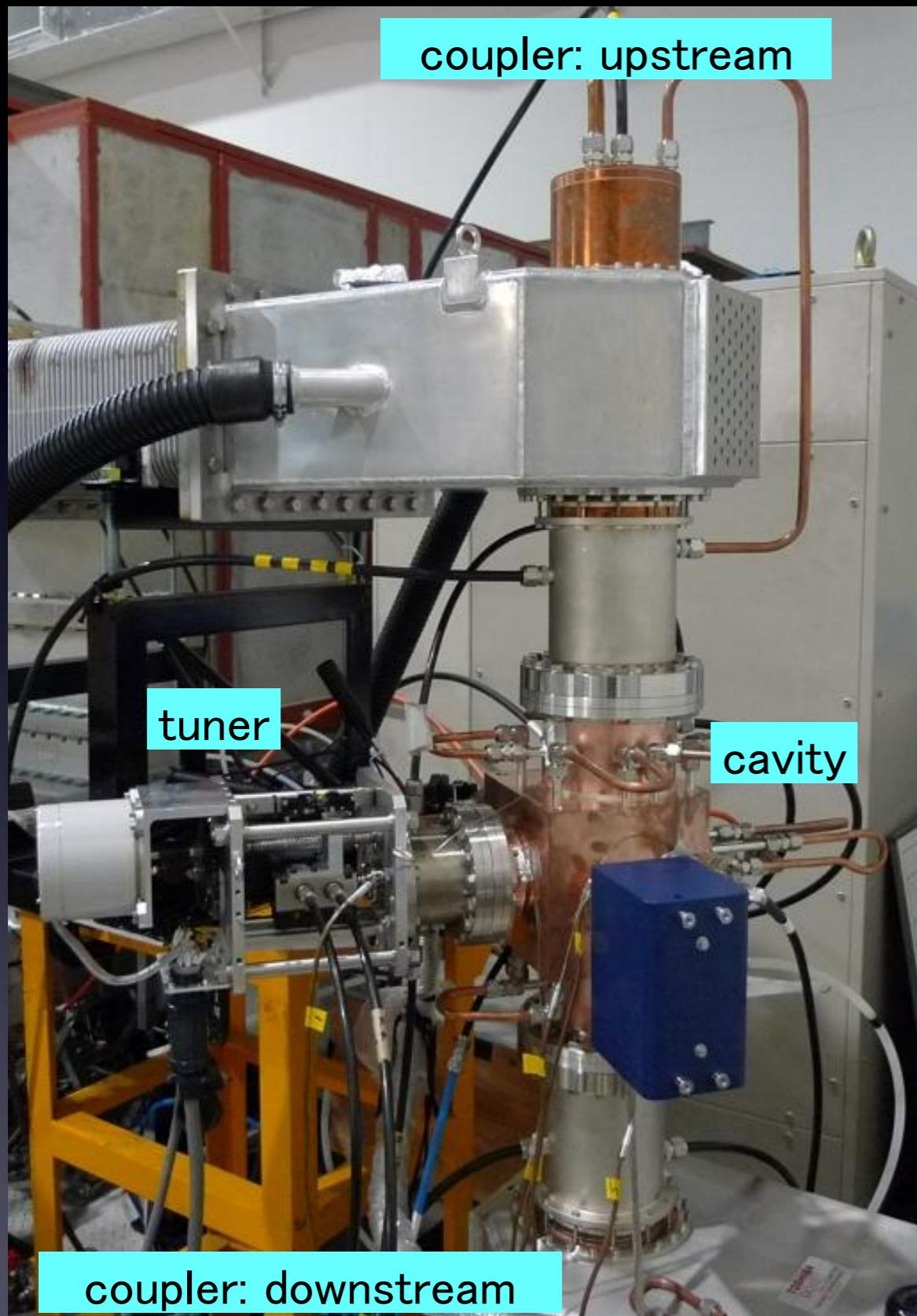


Structure analysis for 300-kW operation

Design goal: one third of tensile strength
of copper at maximum [200 MPa / 3]



Performance test1



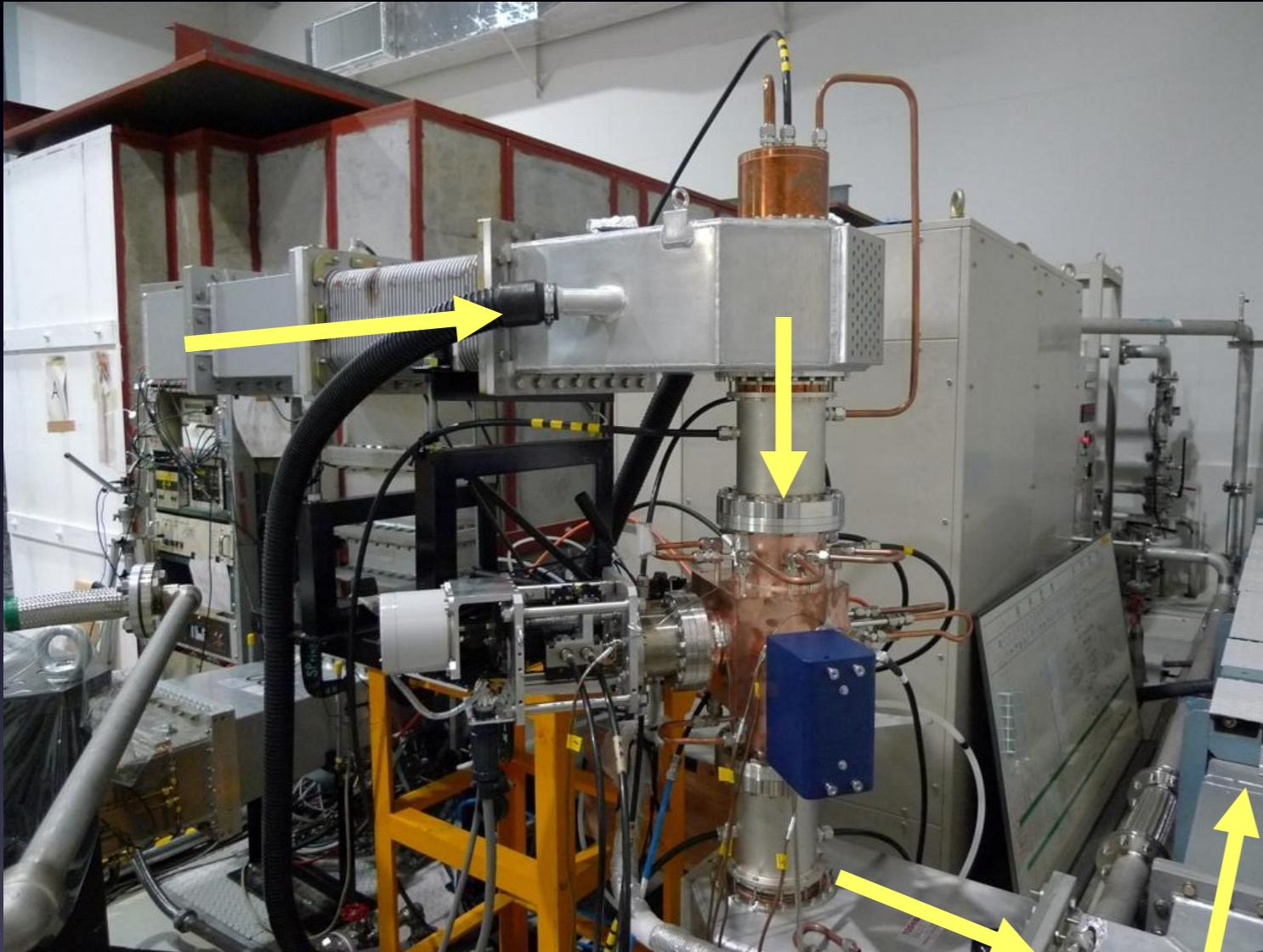
low power test

- frequency:tuned to 508.58MHz
-11 MHz/mm
- transmission loss :≈2.6% (including loss of transition elements)
(calculated cavity loss 1.7%)
- VSWR: 1.02

manufactured as designed

Performance test2

high power test

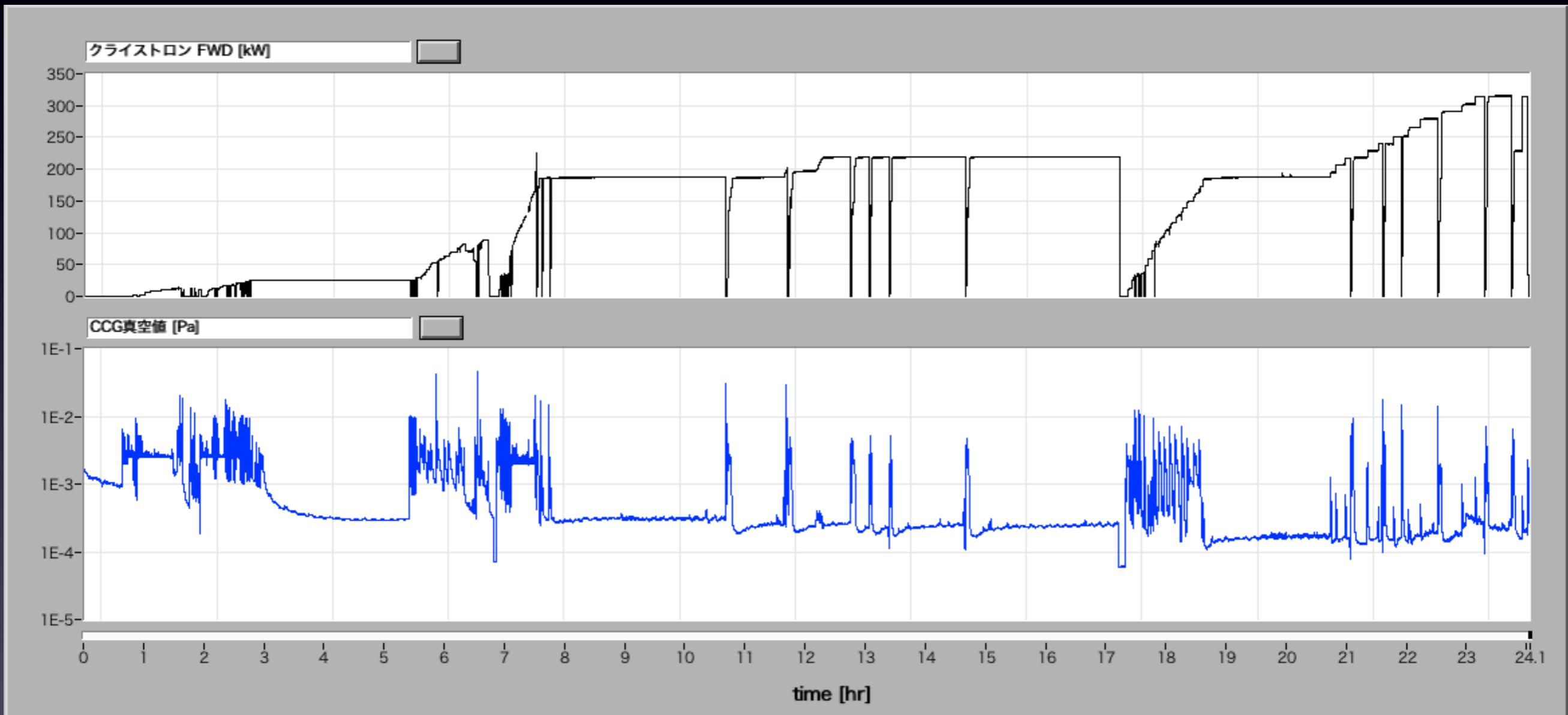


- pressure at the start of the test: 2×10^{-4} Pa
- water supply: 37 L/min.
32.5 °C

Targeted goal: 300 kW

achieved 300 kW
in 20 hours

- without constant reflection
- no abnormal temperature rise of the body
- no vacuum leak (2×10^{-4} Pa @ 300 kW)
- radiation < regulation → no shield



Onsets of Interlock events

- vacuum ($> 8 \times 10^{-3}$ Pa) : 108 times
- power reflection (> 20 kW) : 20 times

Summary

- Developed a compact cavity for coupler conditioning
- Small, easy to handle
- Adjustable frequency by the tuner
- VSWR 1.02 : power loss $\approx 2\%$
- Rated power of the coupler: 300 kW transmission test was successfully achieved