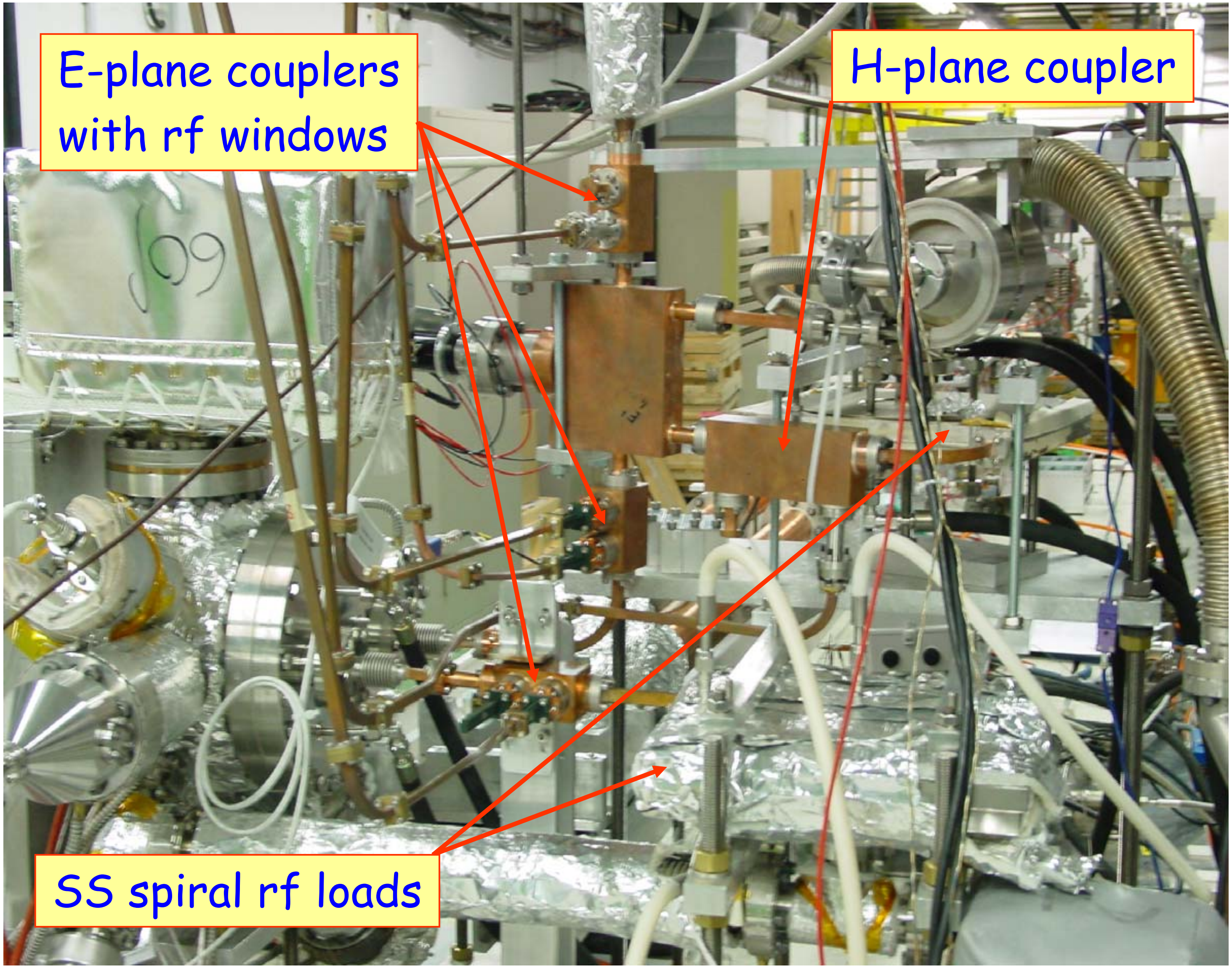
30 GHz rf components for CTF3

Alexej Grudiev
CERN AB/RF

Outline

- CTF2 layout
- High power rf loads
  - Spiral load
  - "Fork" load
- High power directional couplers
  - H-plane coupler
  - E-plane two holes coupler
  - Dual directional coupler with pumping
- Low power rf windows
  - Brazed window
  - Cu-plated window
- RF vacuum valves
  - quasi-optical design
  - compact design

CTF2 test stand



Spiral rf load

Attenuation constant of TE$^{\square}_{10}$:

$$\alpha = \sqrt{\frac{\pi\rho}{\lambda Z_0}}\,\frac{1}{b}\left[\frac{1+\dfrac{2b}{a}\left(\dfrac{\lambda}{2a}\right)^2}{\sqrt{1-\left(\dfrac{\lambda}{2a}\right)^2}}\right]$$

$a = 8.64\,mm$

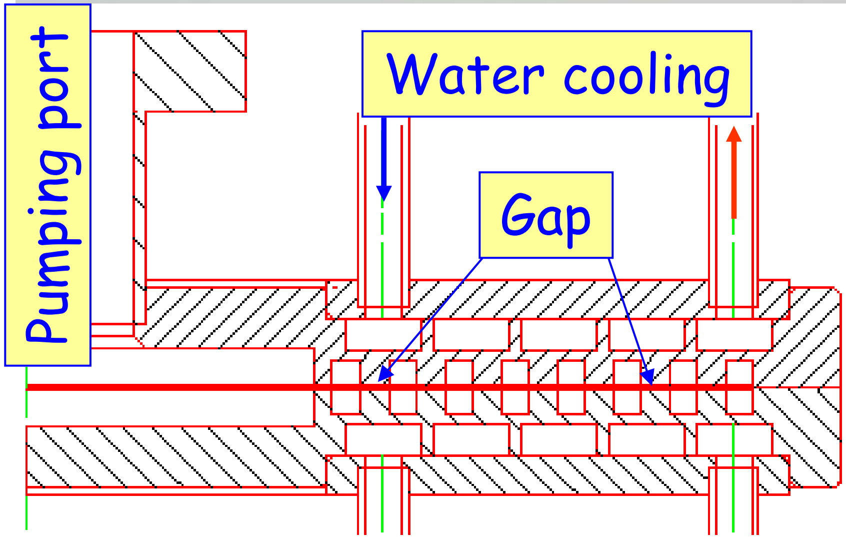
$b = 3\,mm$

$\rho = 0.91\,\mu\Omega\cdot m$

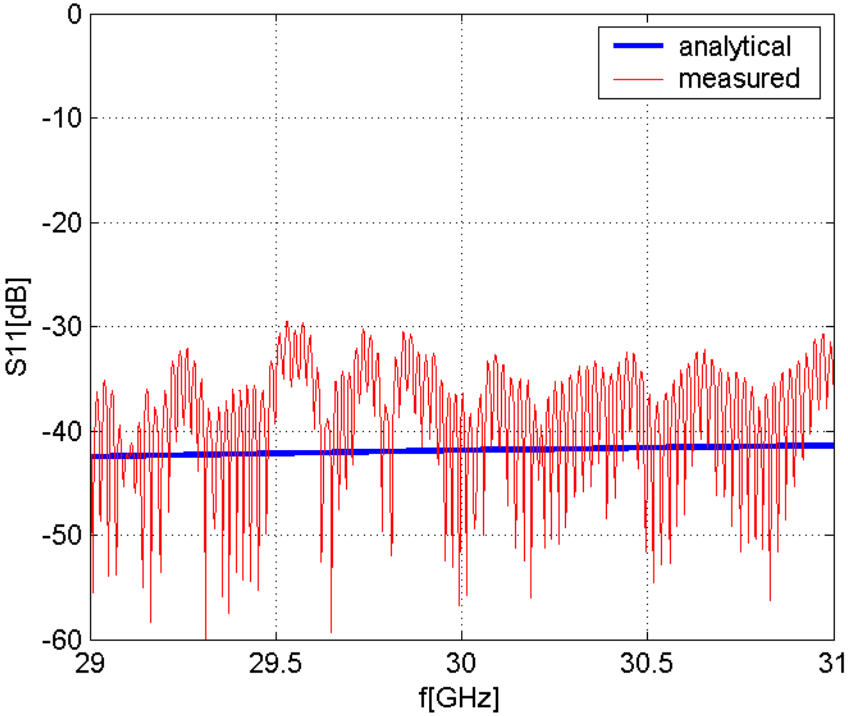
$\alpha = 3.8\,dB/m\,@\,30GHz$

Two halves of the load. 5.5 m waveguide milled in spiral form.

Spiral rf load

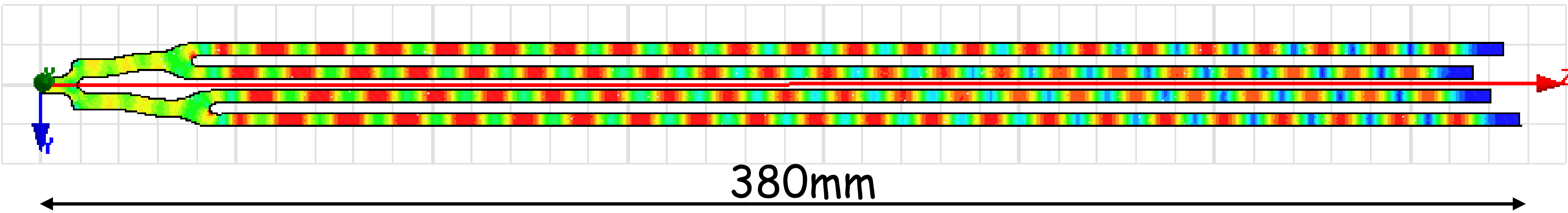


Reflection: -35dB@30GHz



5.5 m long waveguide is pumped through 1 mm gap between two ridges forming waveguide walls. There is no coupling because of the symmetry of TE_{10}-mode.

"Fork" rf load



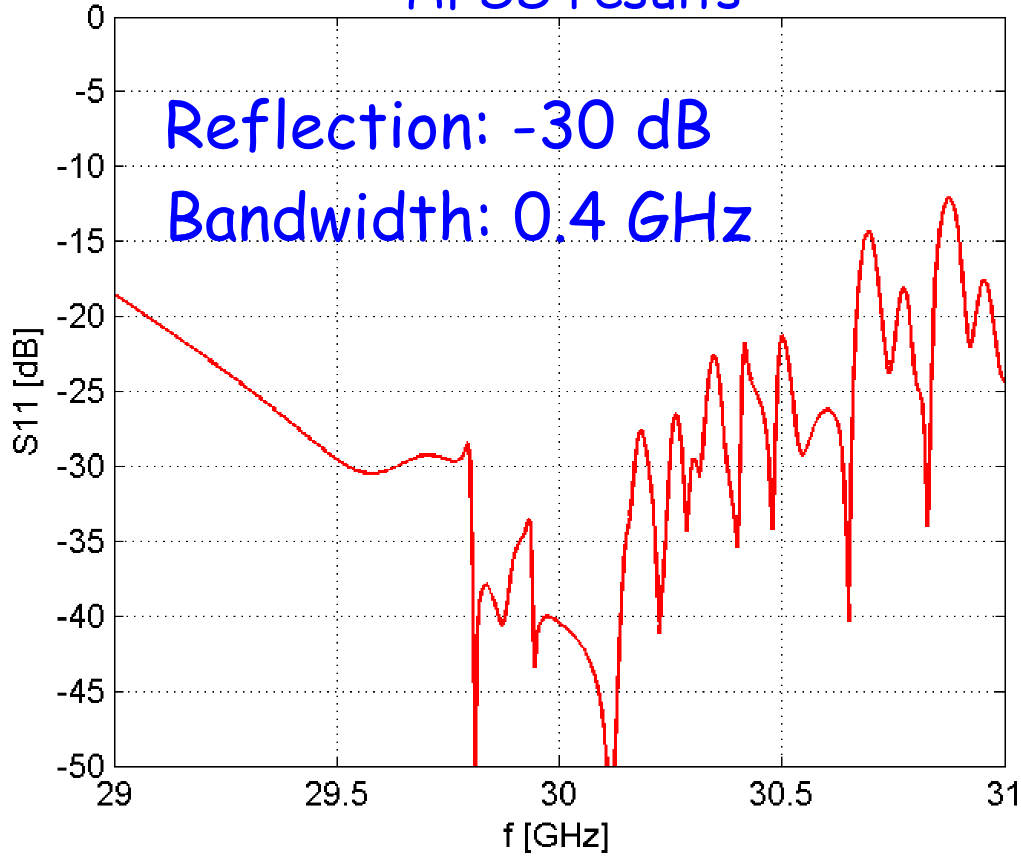
Advantages:

- More compact
- Less weight
- No pumping slots
- Power division by 4

Disadvantages:

- Electric field enhancement ~50%
- Limited bandwidth

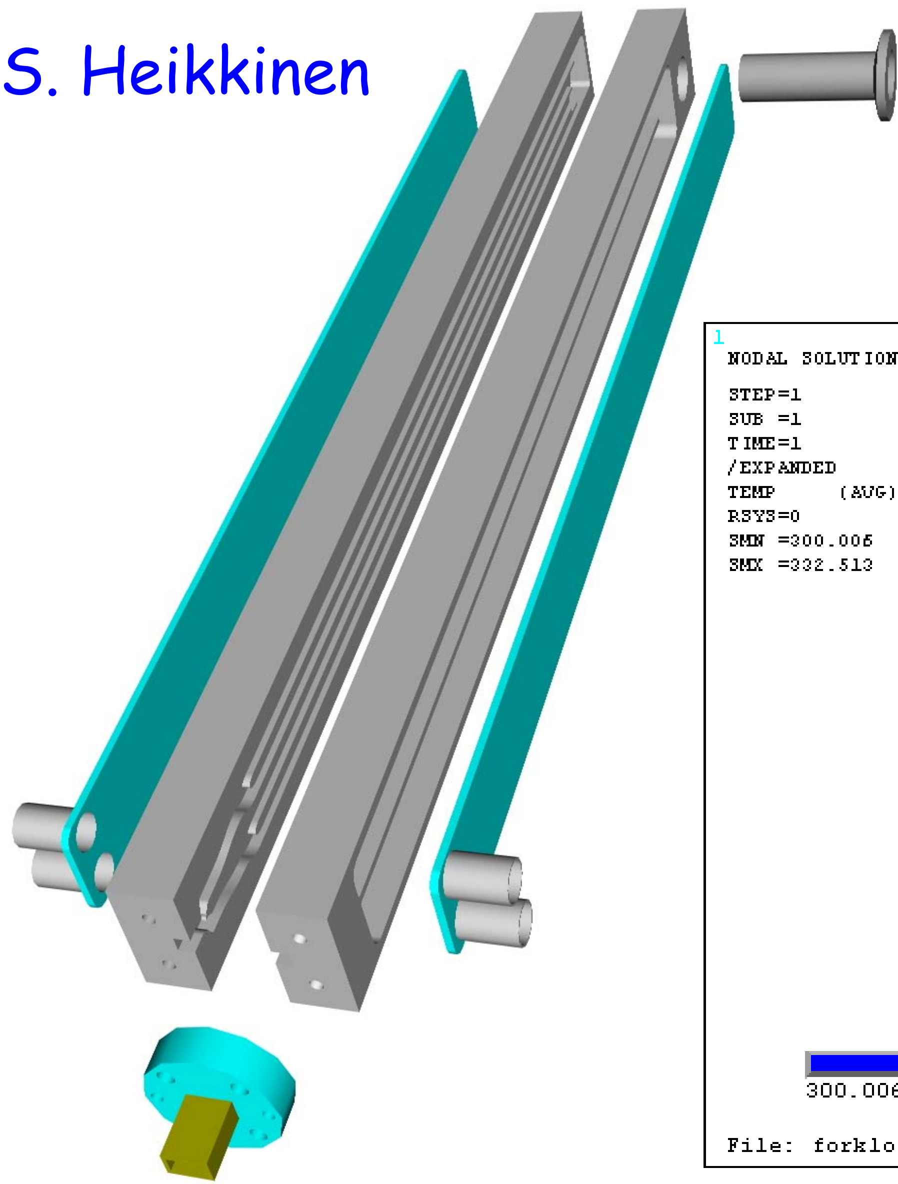
HFSS results

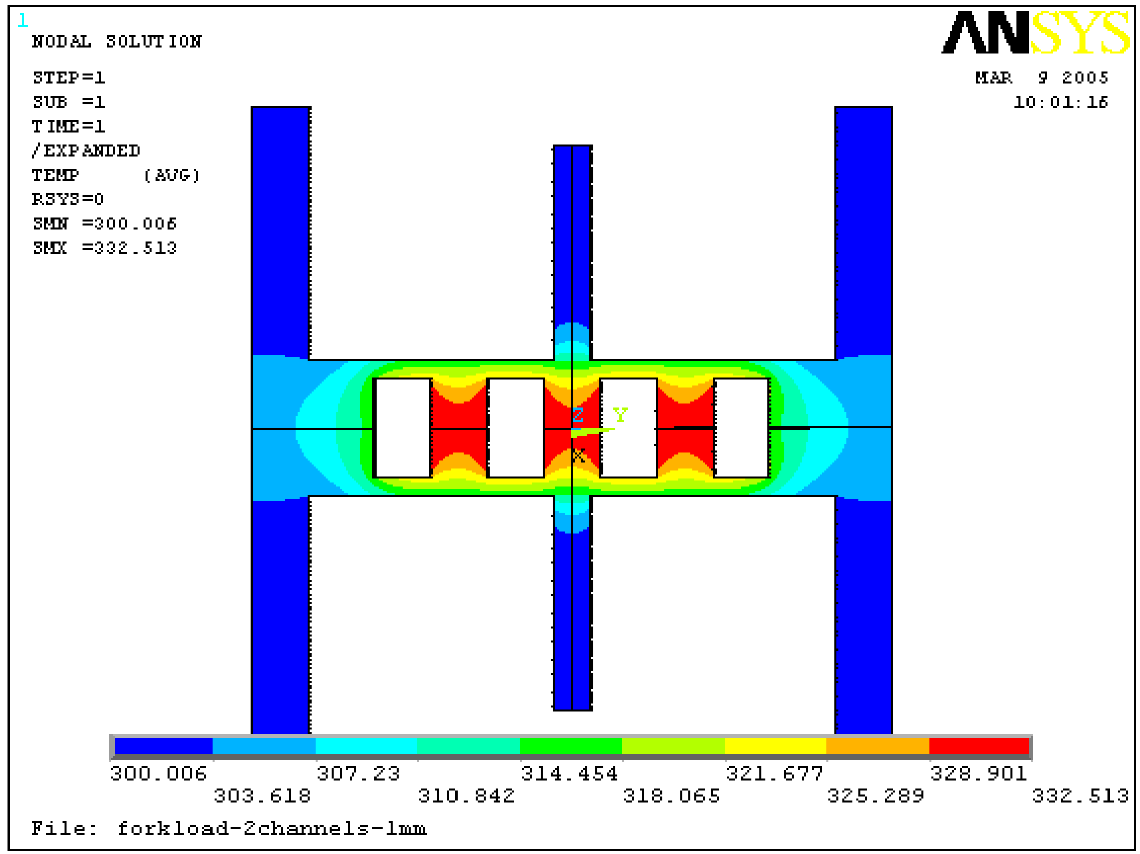


"Fork" rf load

S. Heikkinen

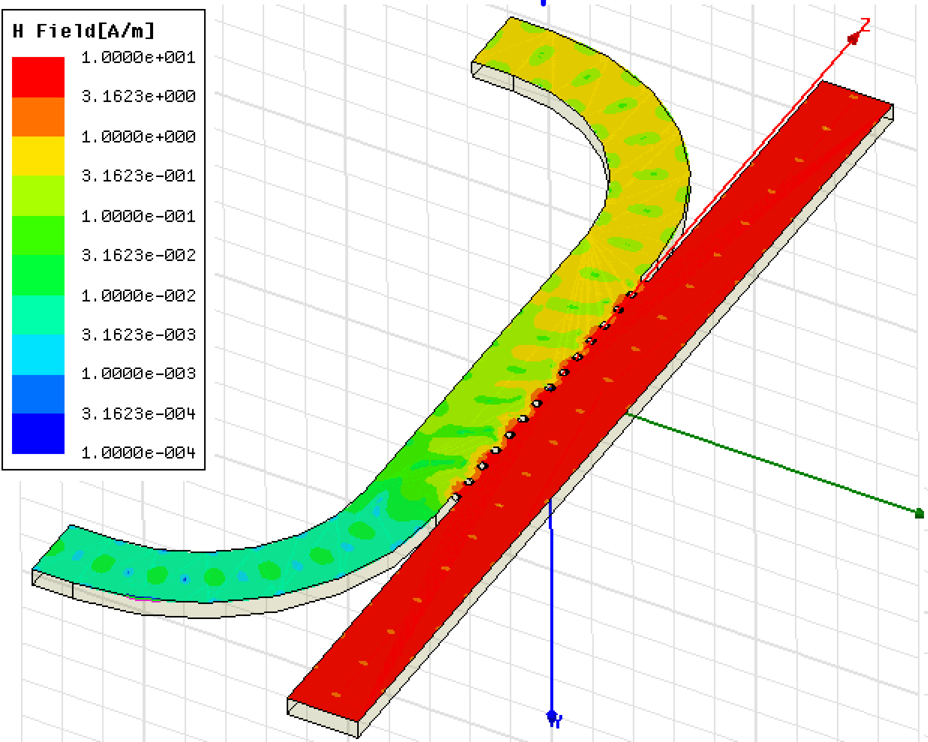
1 kW average input power and 1 mm thick walls between wave-guides and cooling channels result in 30 K temperature increase.





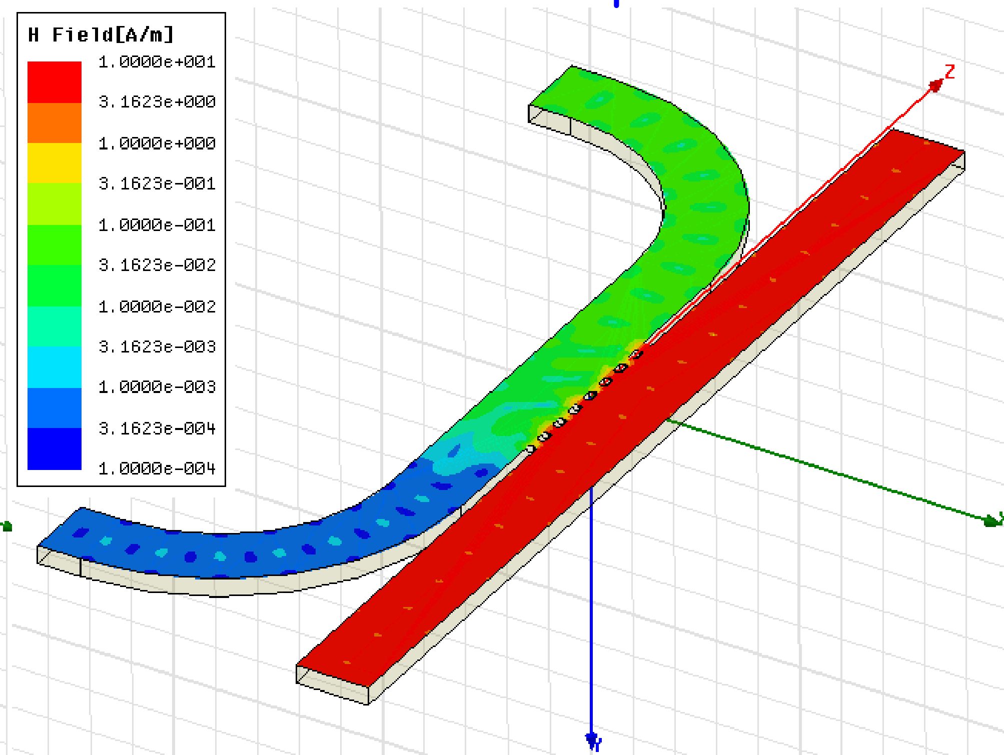
H-plane directional couplers

-30 dB coupler



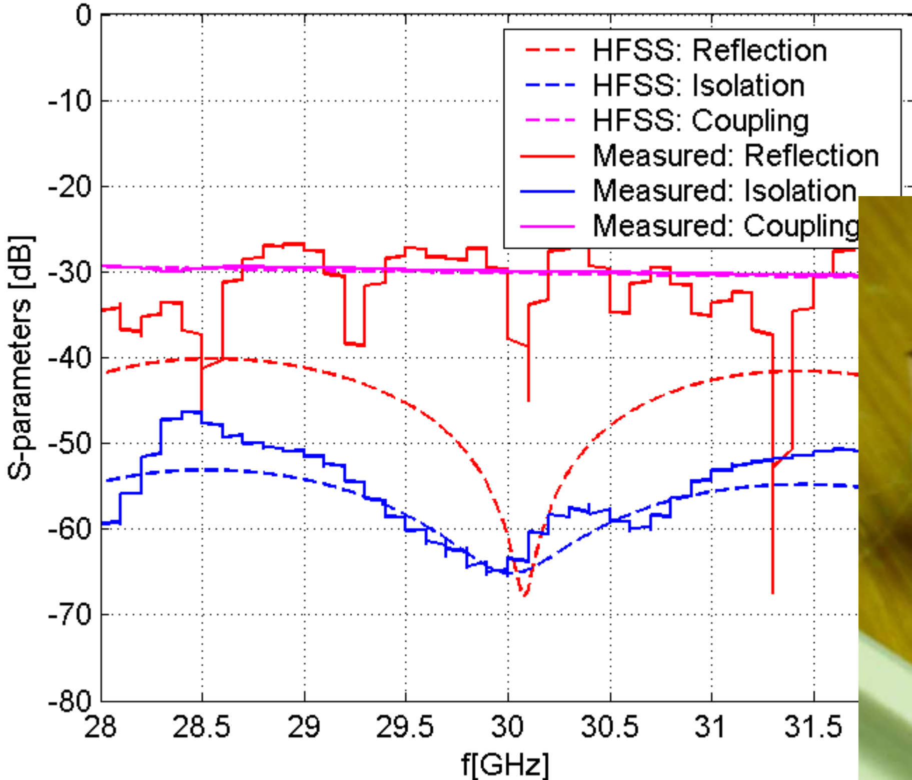
14 holes of 1.98mm diameter

-50 dB coupler



8 holes of 1.38mm diameter

H-plane directional coupler: -30dB



- Requires many holes
- Requires brazing

Measured / HFSS

Coupling: -30 / -30 dB

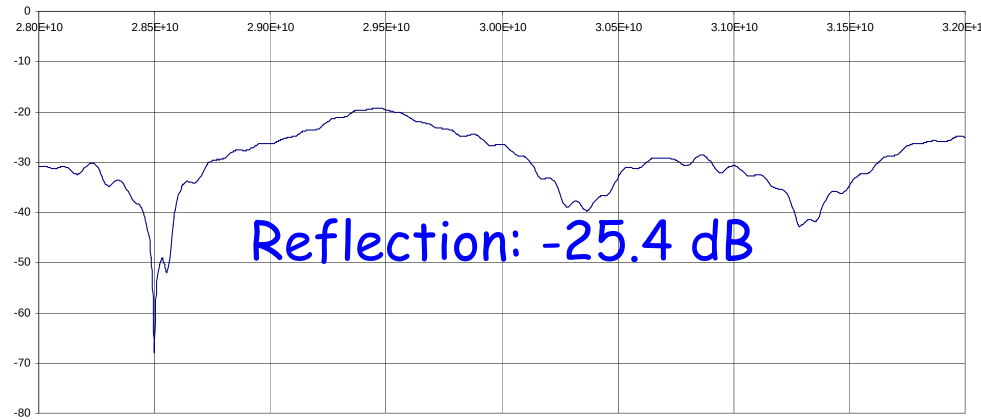
Directivity: -35 / -35 dB

Reflection: -30 / -60 dB

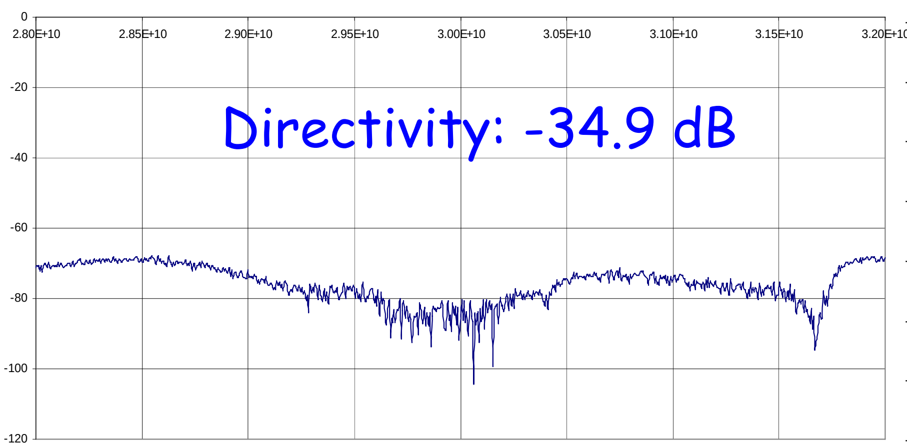
H-plane directional coupler: -50dB

Tested up to 30 MW

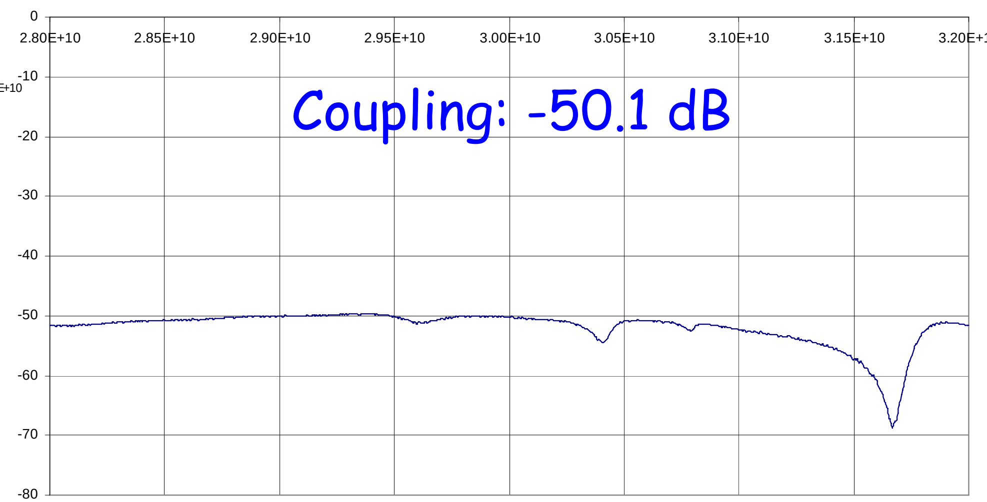
Reflection in P4



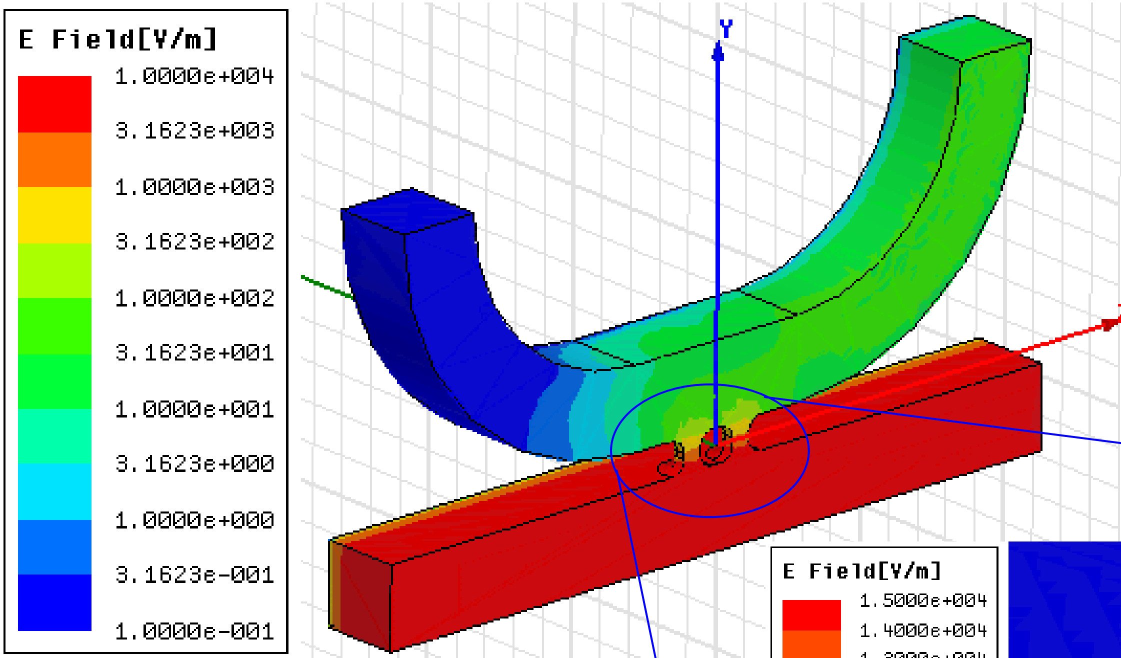
Isolation 4-->3



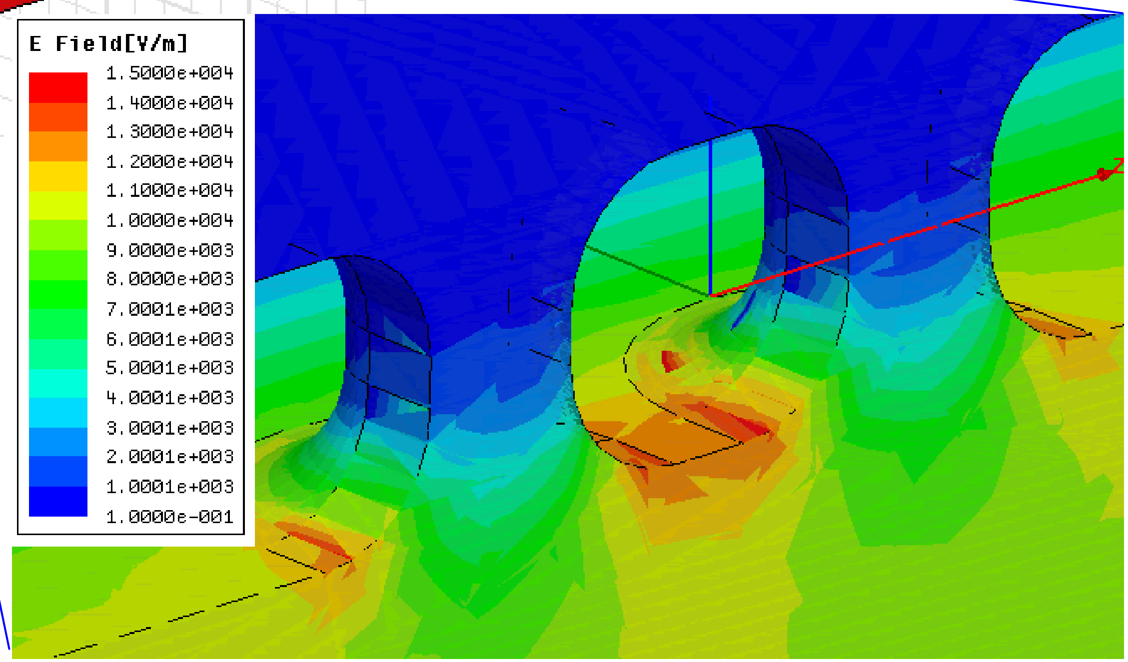
Coupling 1-->3



E-plane directional coupler

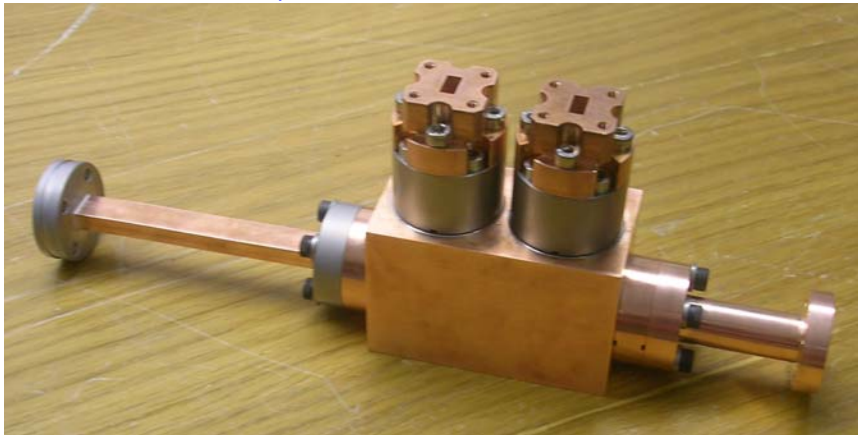


- Only two holes
- No brazing required
  but
- E-field enhancement:
  ~20%

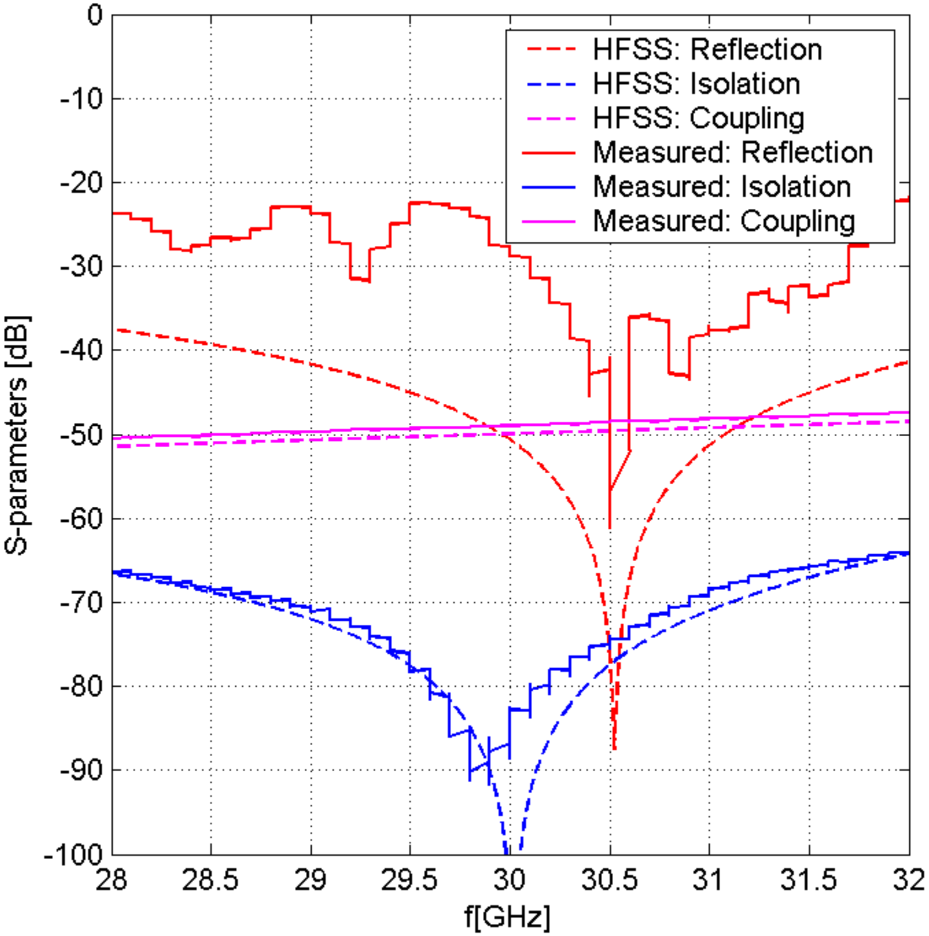


E-plane directional coupler

Dir. coupler and rf windows



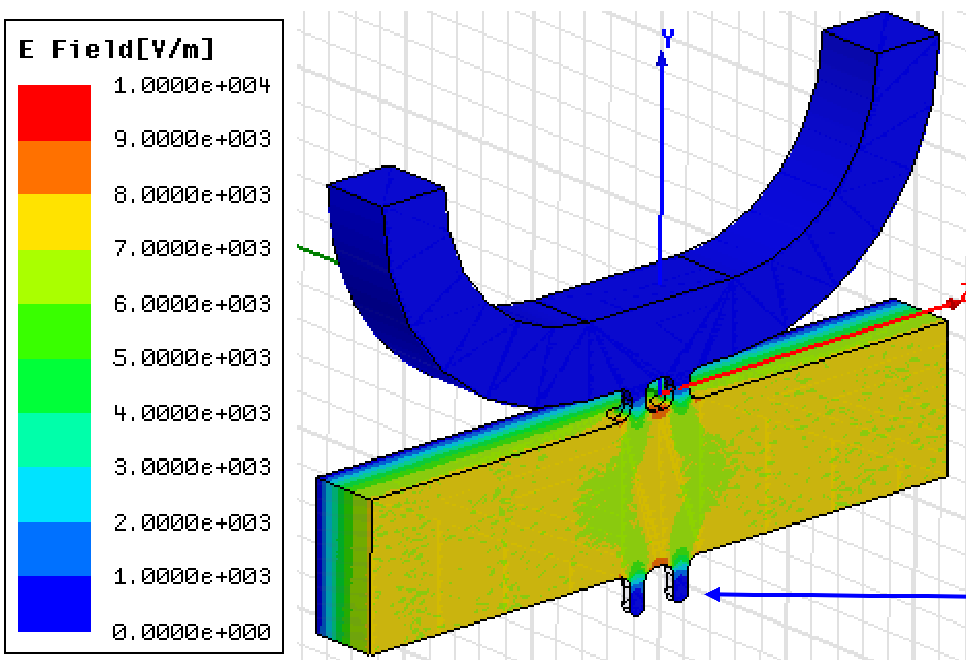
Tested up to 60 MW, 50 ns



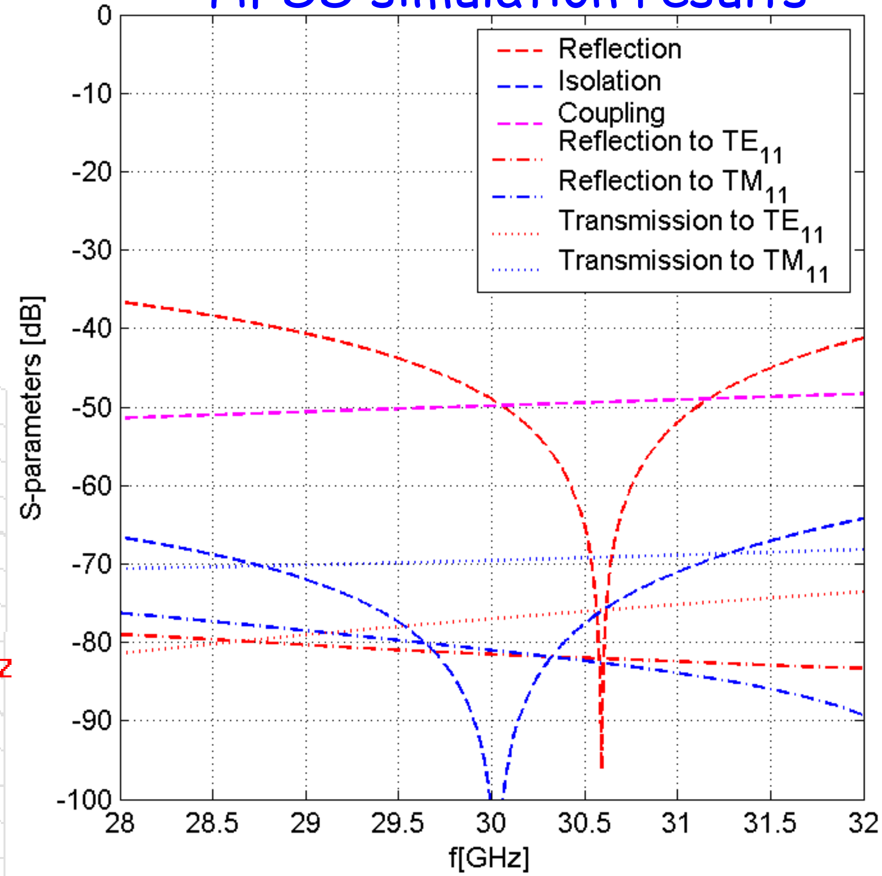
	Measured / HFSS
Coupling:	-49 / -50 dB
Directivity:	-35 / -45 dB
Reflection:	-30 / -50 dB

E-plane directional coupler □-wg

Square cross-section high power waveguide is overmoded.



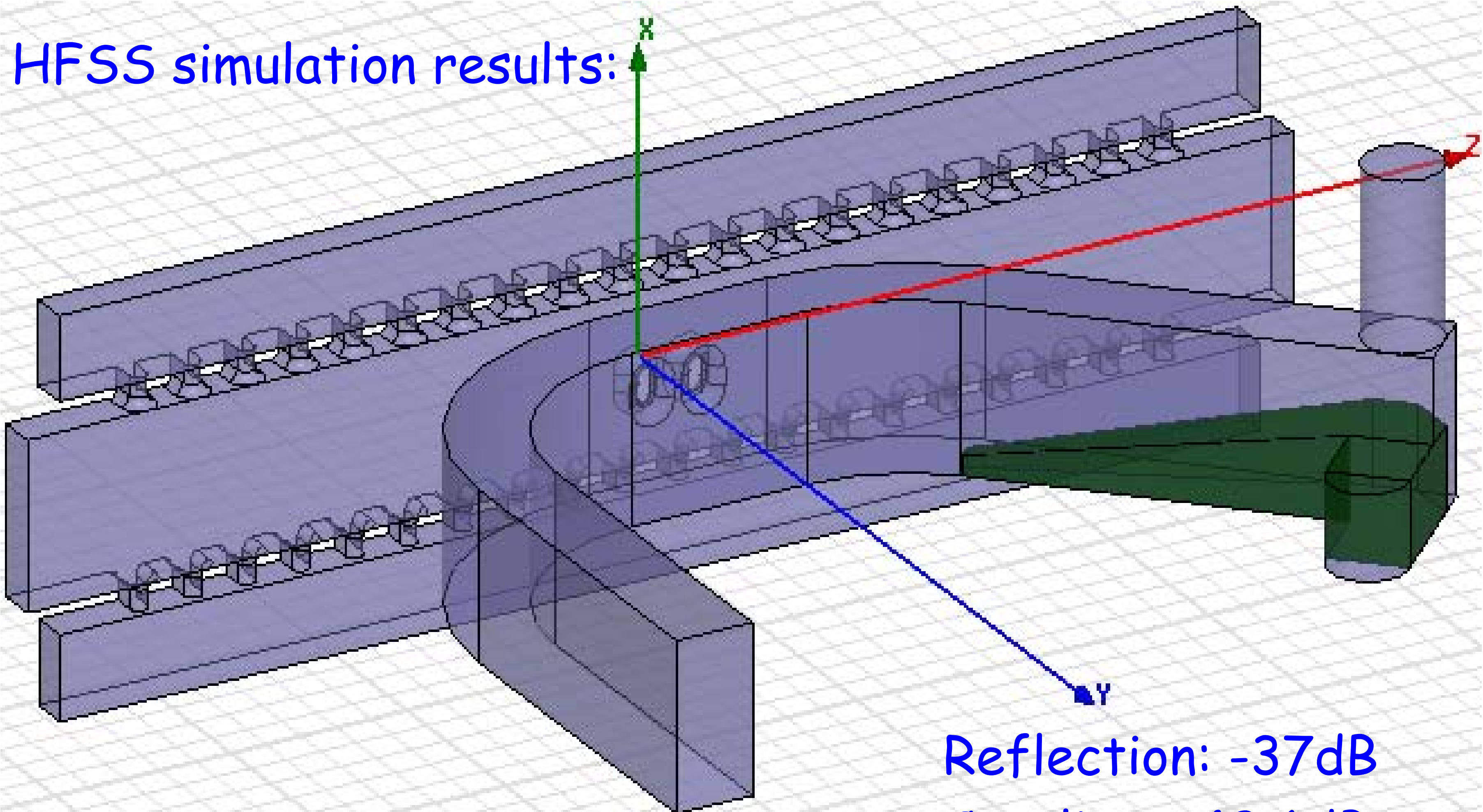
HFSS simulation results



Additional holes reduce mode conversion to below -70 dB

Dual directional coupler with loads

HFSS simulation results:



Reflection: -37dB

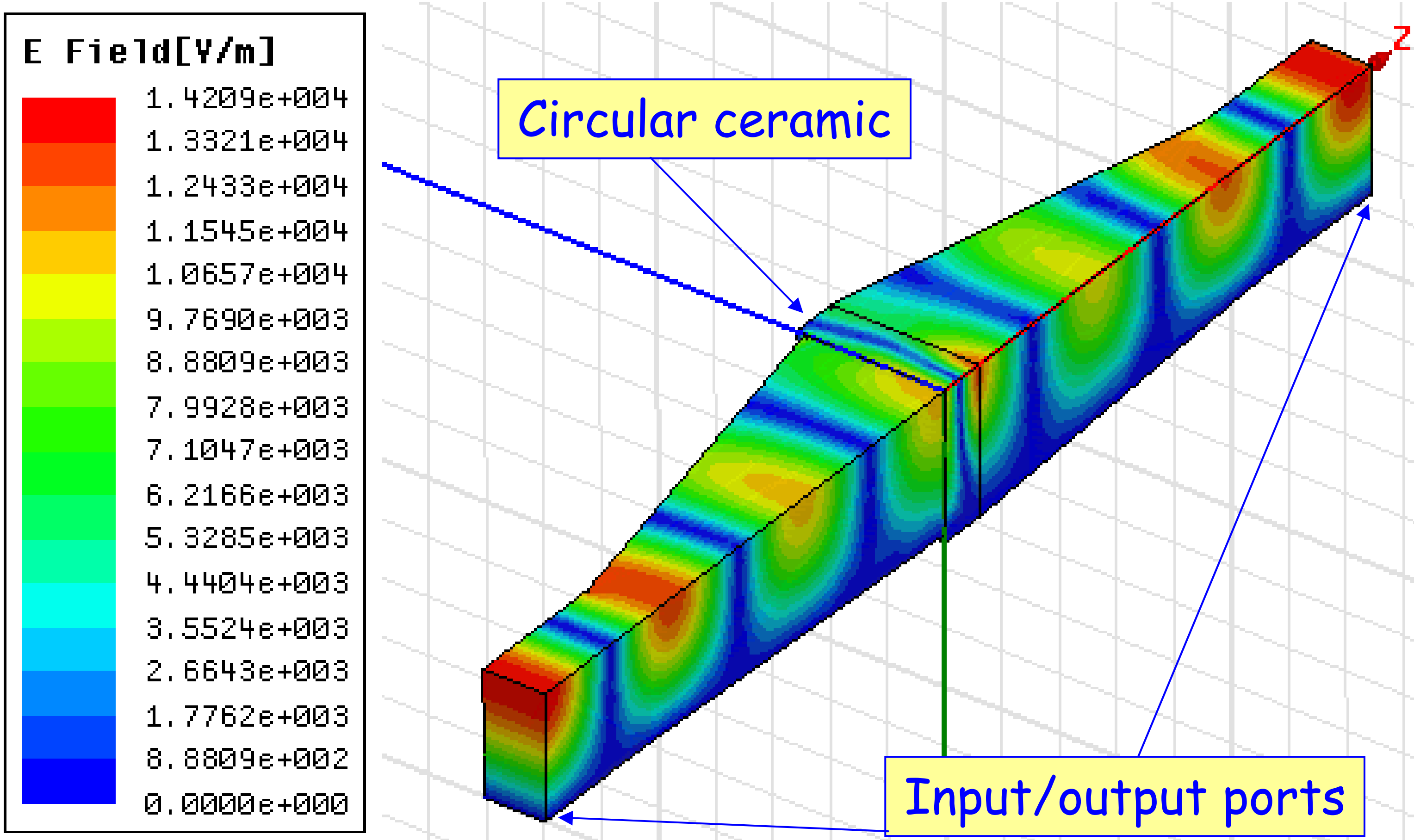
Coupling: -49.6dB

Directivity: - 37dB

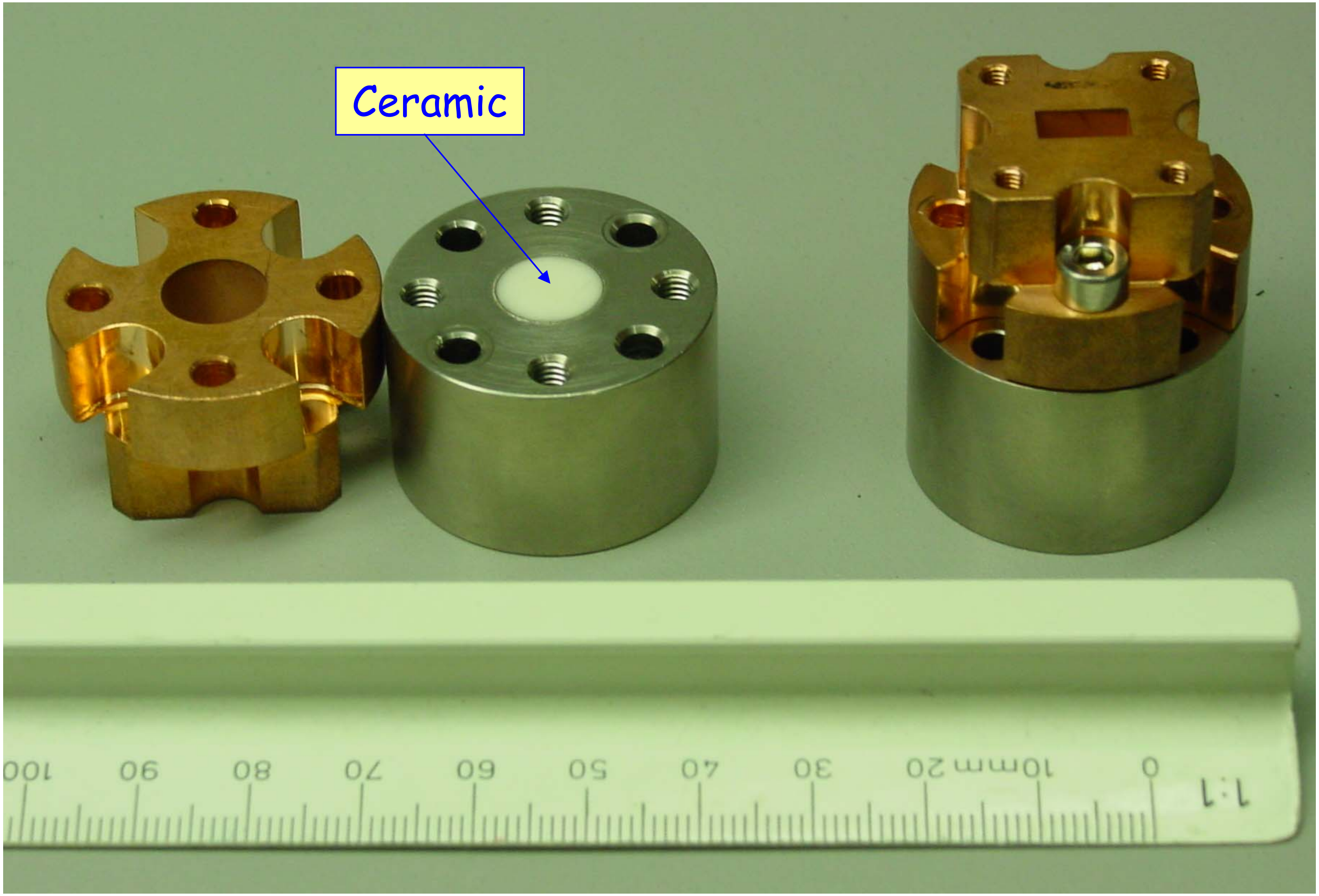
Coupling to pumping holes below: -50dB

Brazed rf window

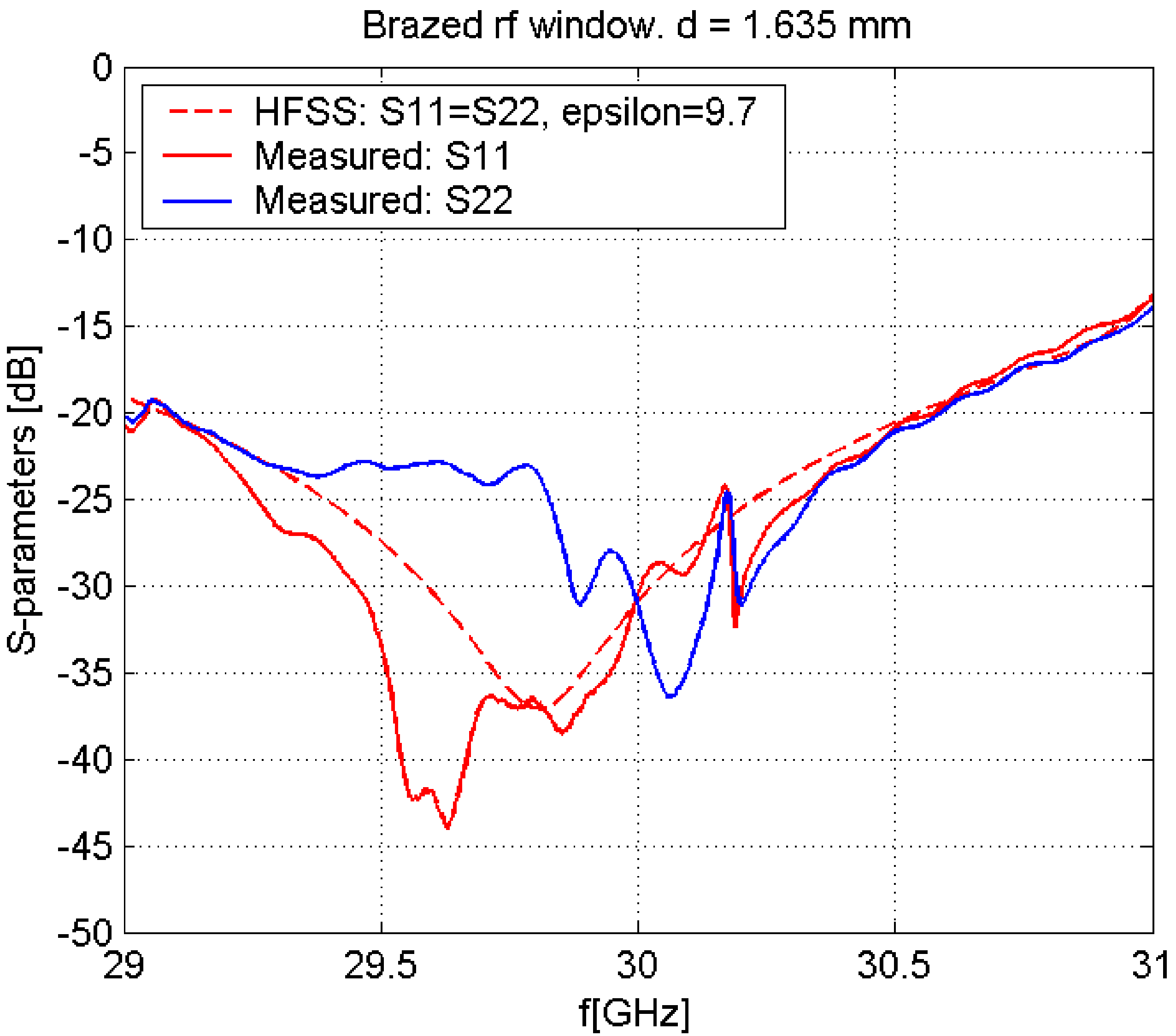
HFSS model : (1/4 of the rf window)



Brazed rf window

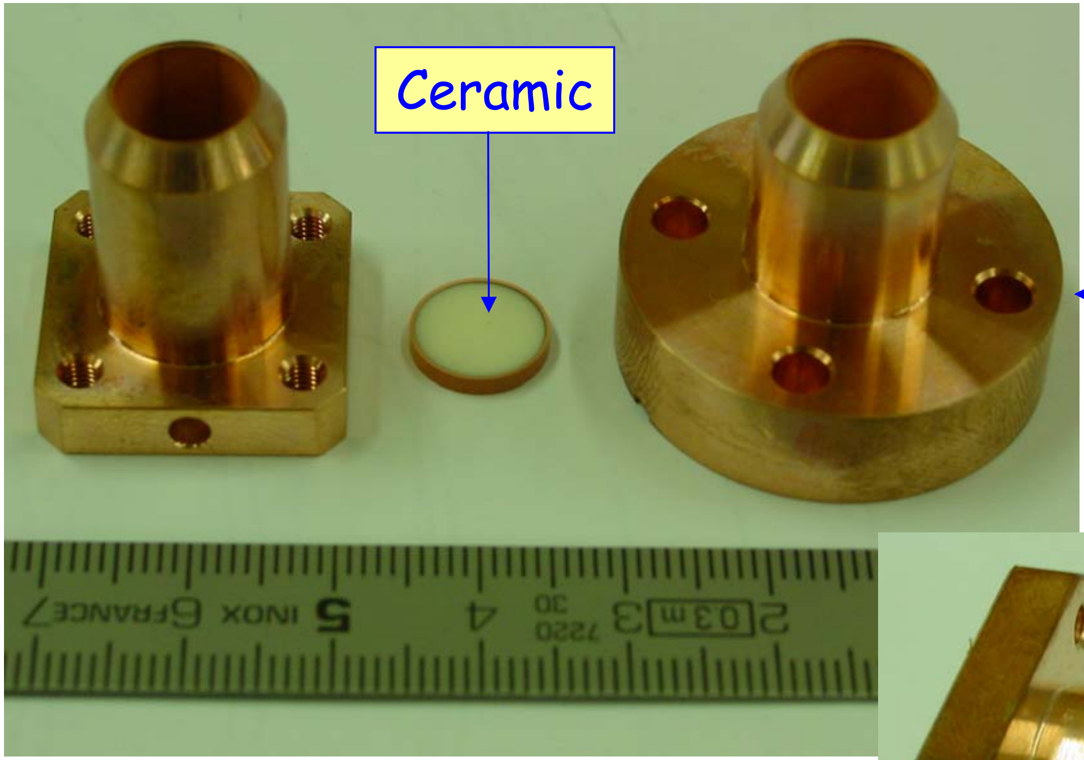


Brazed window



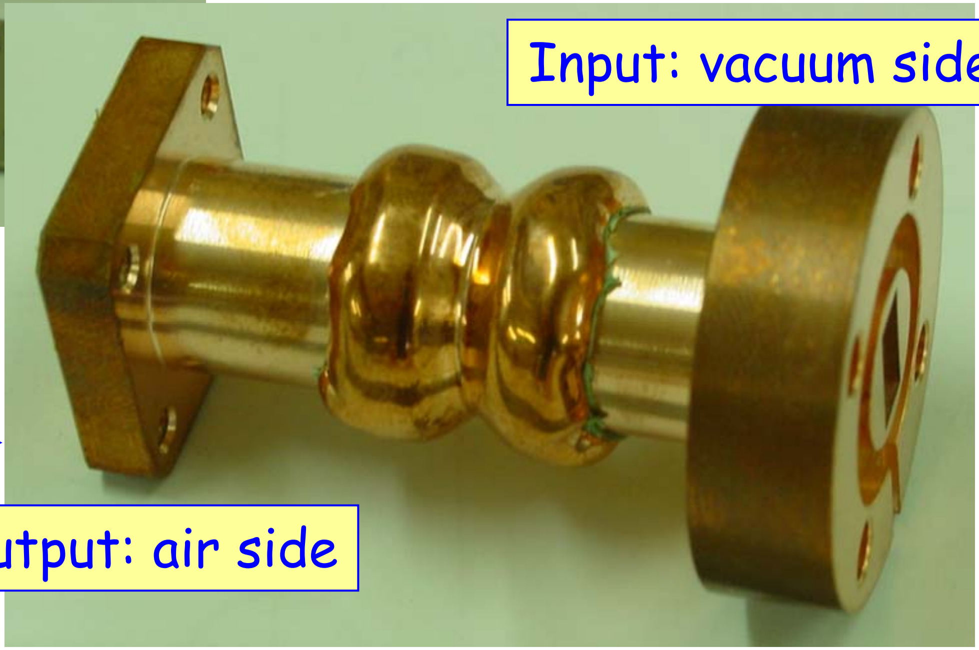
Reflection:
-30dB@30GHz

Cu-coated rf window

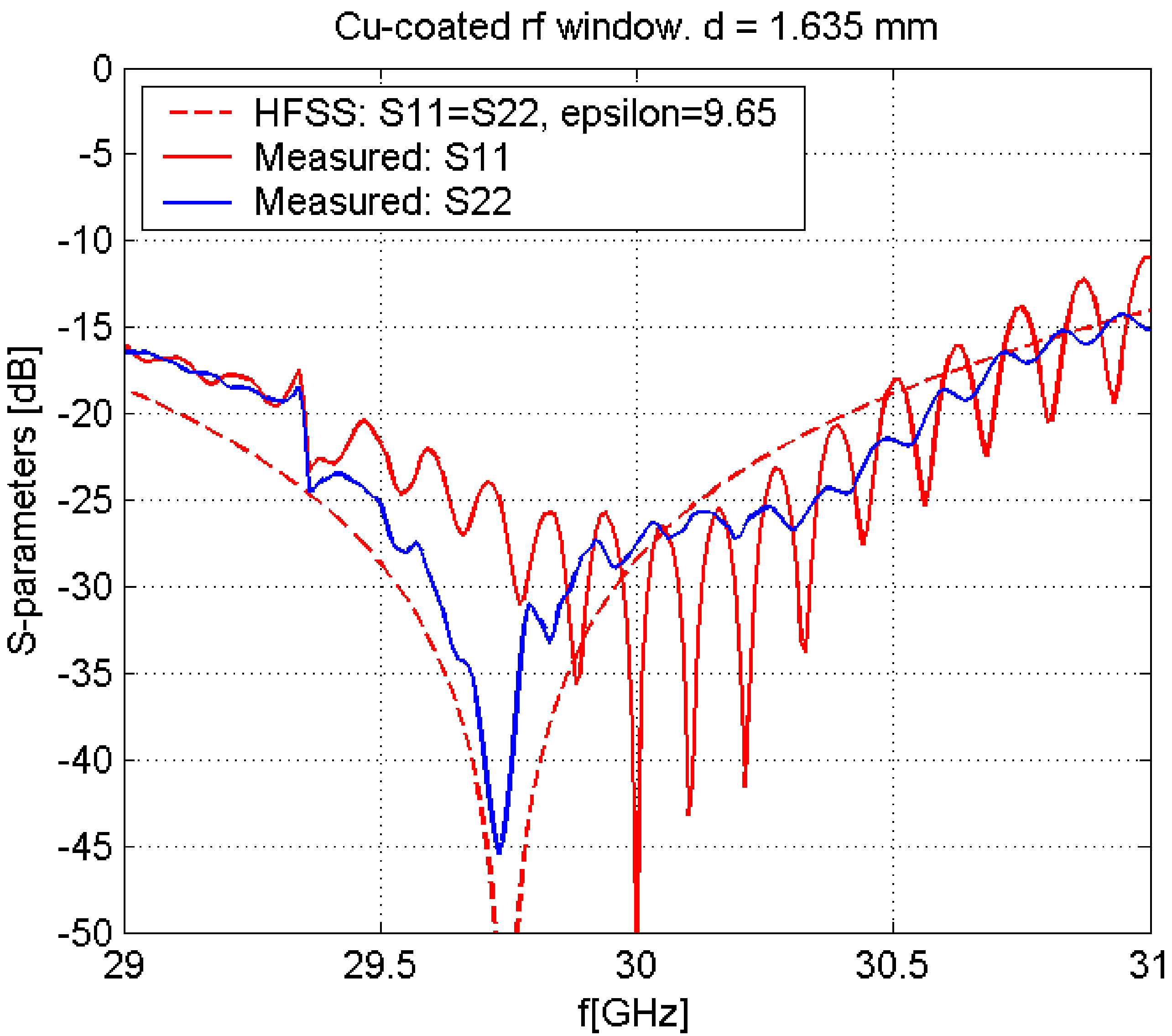


Before Cu-deposition

After Cu-deposition

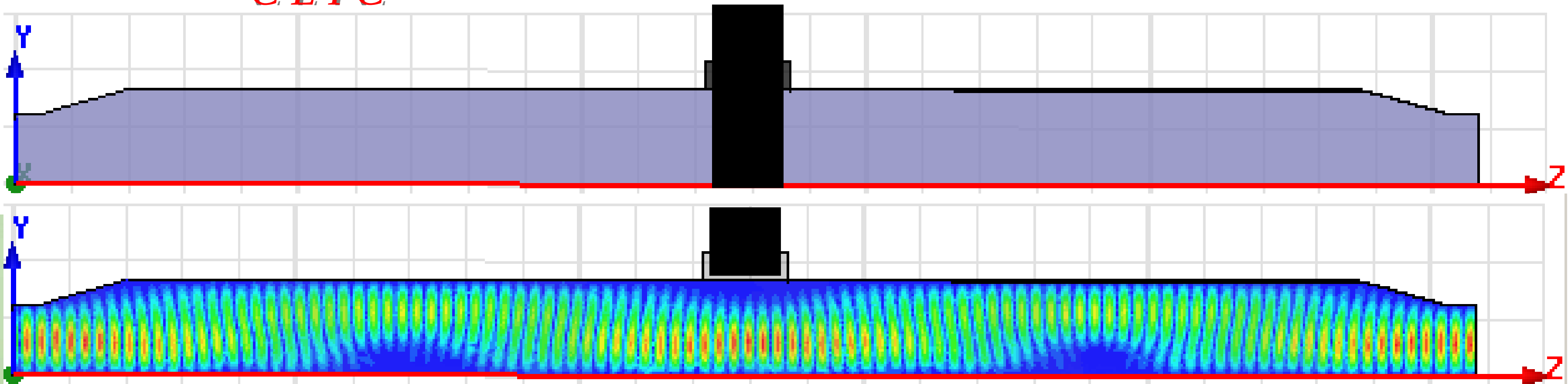


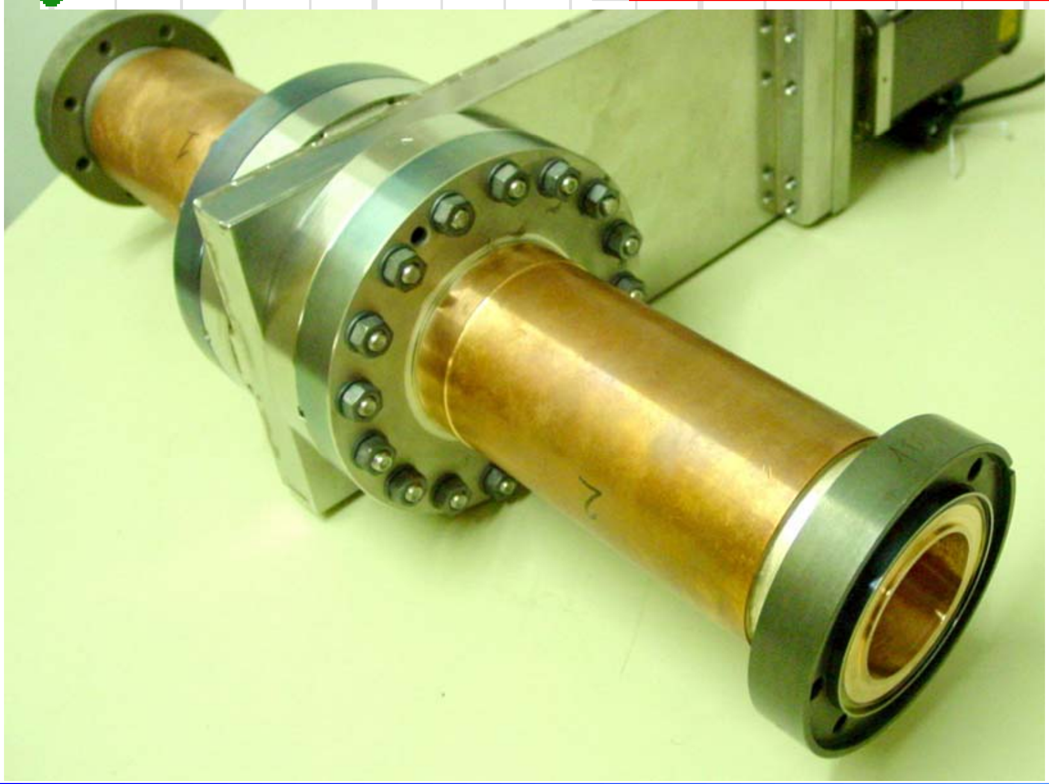
Cu-coated rf window



Reflection:
-28dB@30GHz

Quasi-optical rf vacuum valve





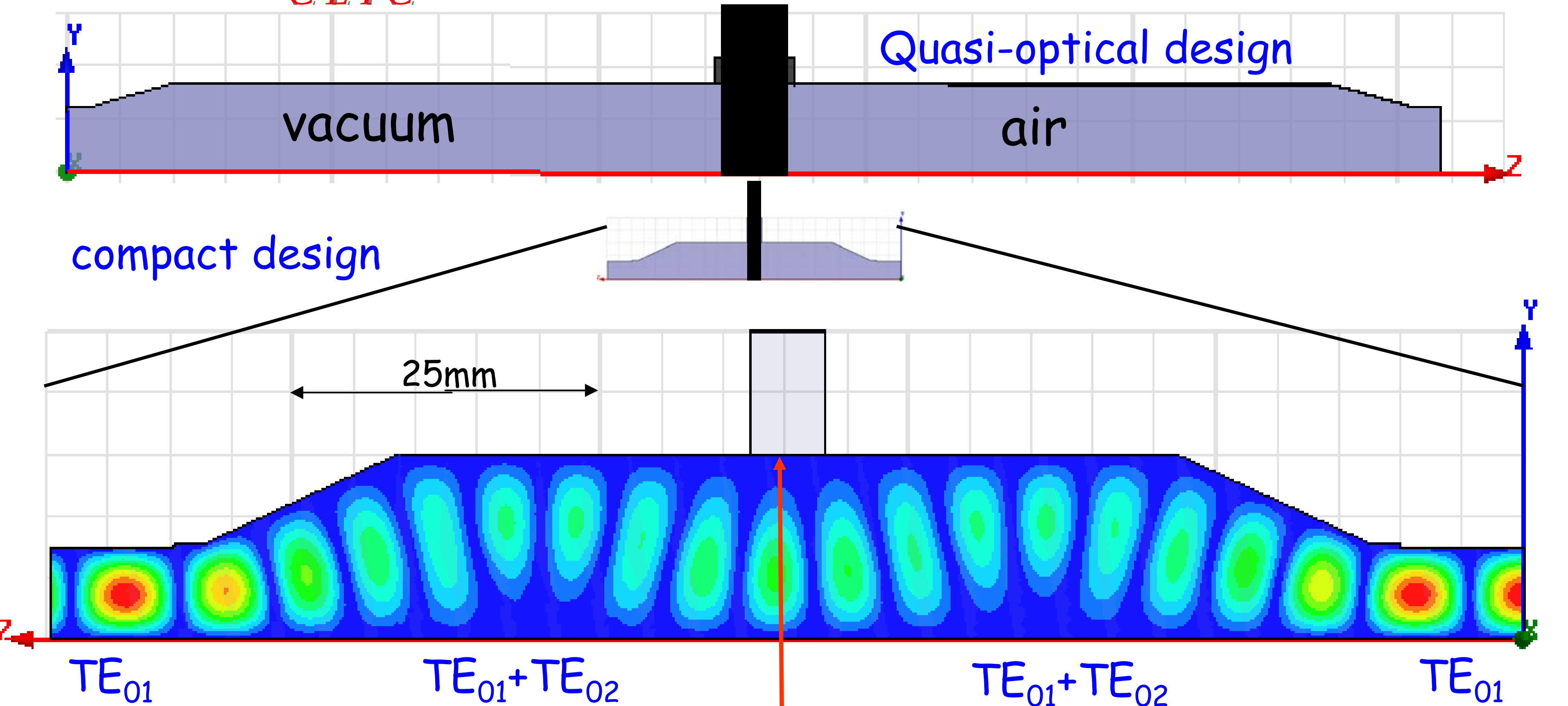
Cold measurements and Vacuum testing is done

measured

$P_{loss} < 1\%$

Almost ready to be installed

Compact dual-mode rf vacuum valve



Zero surface magnetic field

simulated P_{loss} < 1%