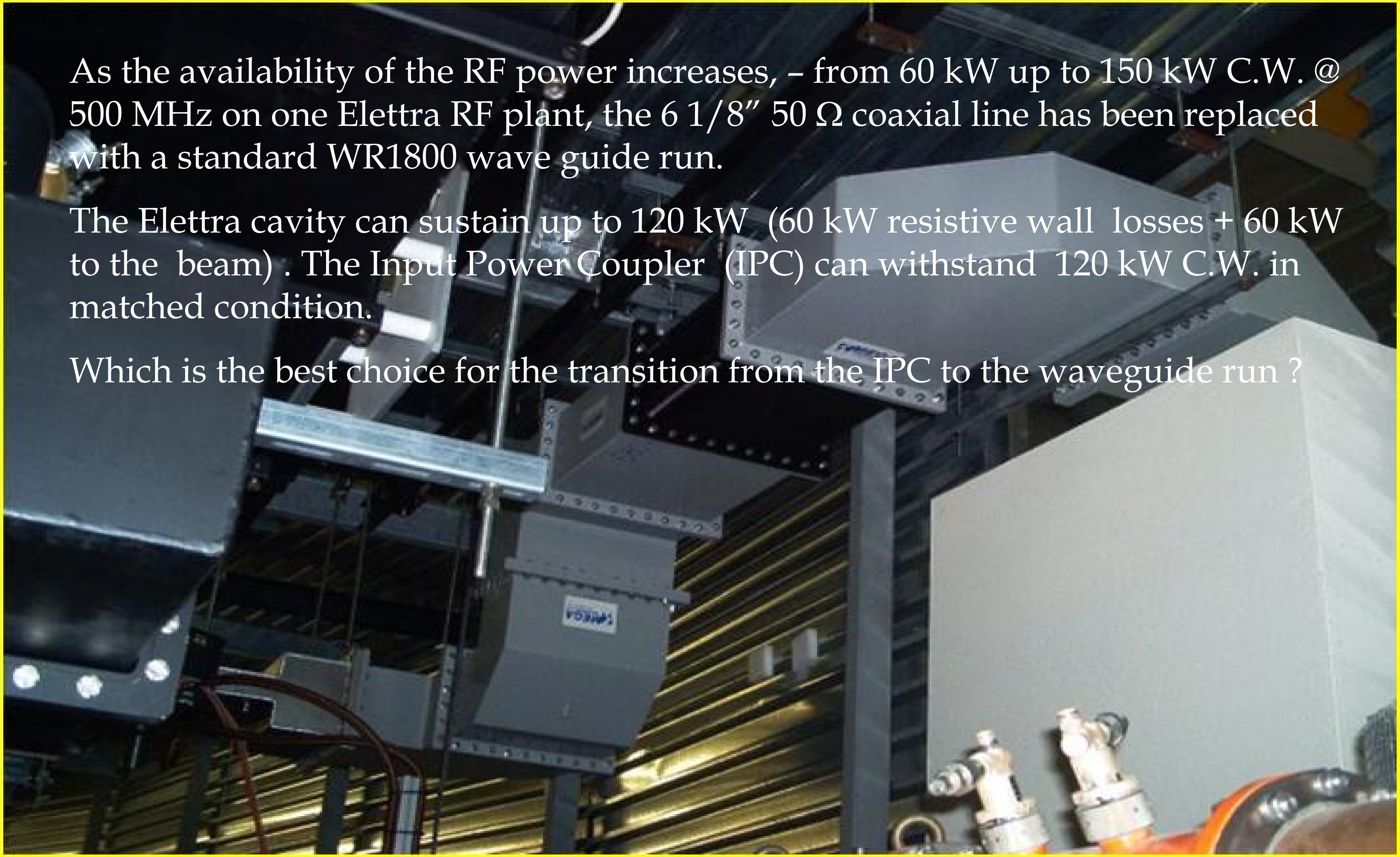
The transition for the Elettra Input Power Coupler to the standard WR1800

Cristina Pasotti, Mauro Bocciai, Luca Bortolossi, Alessandro Fabris, Marco Ottobretti, Mauro Rinaldi Alessio Turchet

Sincrotrone Trieste, Trieste, Italy.

12th ESLS RF Meeting, Diamond Light Source,
1-2 October, 2008



As the availability of the RF power increases, – from 60 kW up to 150 kW C.W. @ 500 MHz on one Elettra RF plant, the 6 1/8″ 50 Ω coaxial line has been replaced with a standard WR1800 wave guide run.

The Elettra cavity can sustain up to 120 kW (60 kW resistive wall losses + 60 kW to the beam) . The Input Power Coupler (IPC) can withstand 120 kW C.W. in matched condition.

Which is the best choice for the transition from the IPC to the waveguide run ?

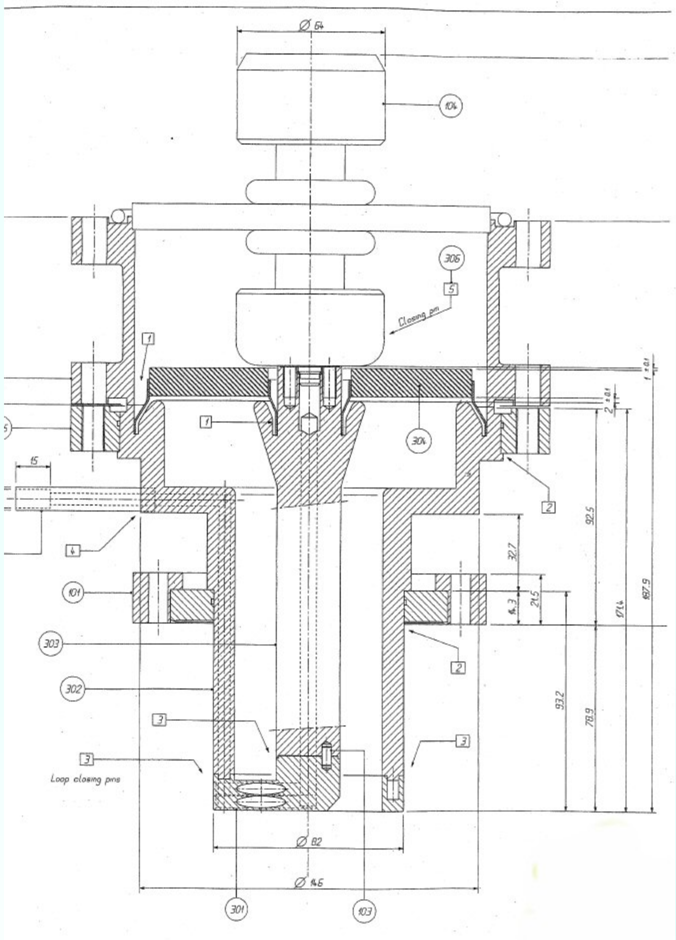
The original ELETTRA Input Power Coupler

From the cavity equatorial port, diameter =84 mm, to the coaxial line in two parts:

A under ultra high vacuum part ending with a brazed alumina disk and having two water cooling channels for the inner conductor and the coupling loop

In air side coaxial part, 80 mm length, which keeps as constant as possible the 50 Ω impedance @ 500 MHz along the path and realizes the mechanical connection with the IPC inner conductor.

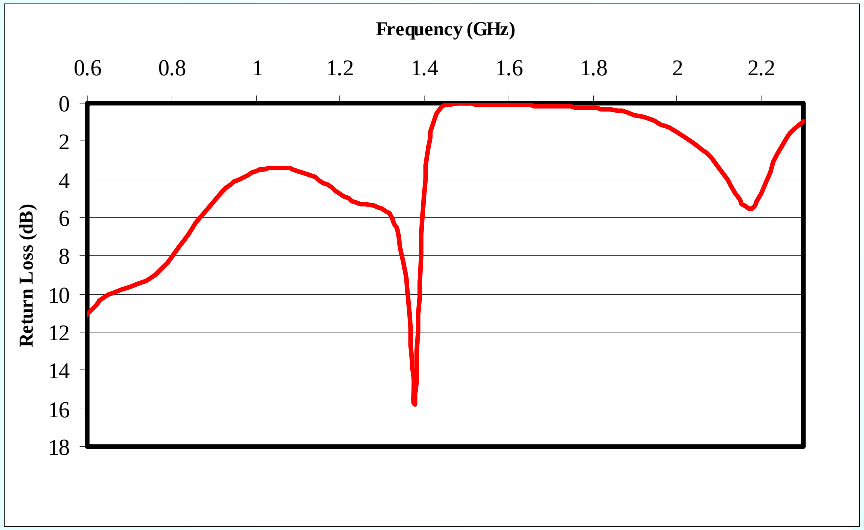
Forced air flow to cool down the steatite centering disk ensures the IPC operation up to 120 KW C.W., matched condition.



Machine operations have shown a kind of weakness of the IPC in the curvature's surface near the alumina disk even at a relatively low input power, but having high mismatch load (during Elettra injection operation at 0.9 GeV andor setting wrong temperature of the cavity and subsequent excitation of any longitudinal HOMs).

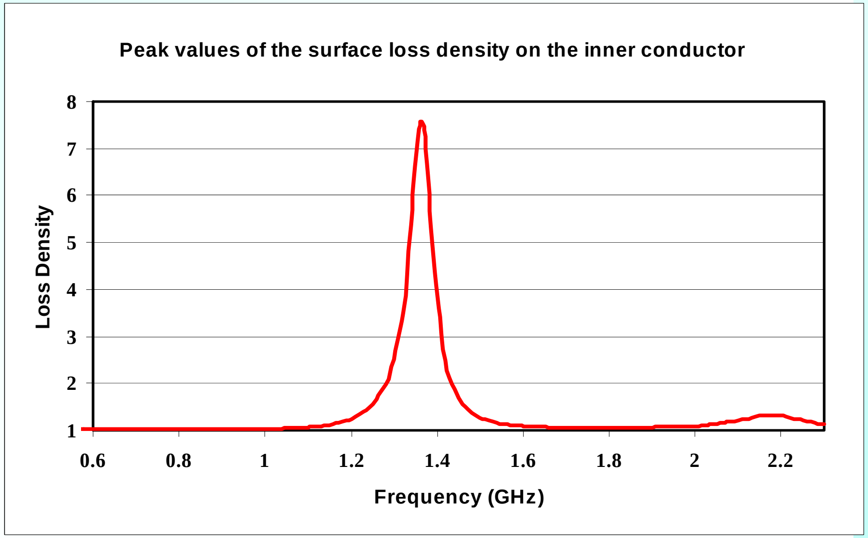
The design of the transition to the WR1800 shall take into account not only the performance at 500 MHz but also these phenomena and try to reduce them.

Numerical simulation have shown the IPC weak around that point: a high return loss around 1.36 GHz and 2.19 GHz. Stationary fields arise in these frequency range in the air part of the IPC causing a huge increase of the loss density

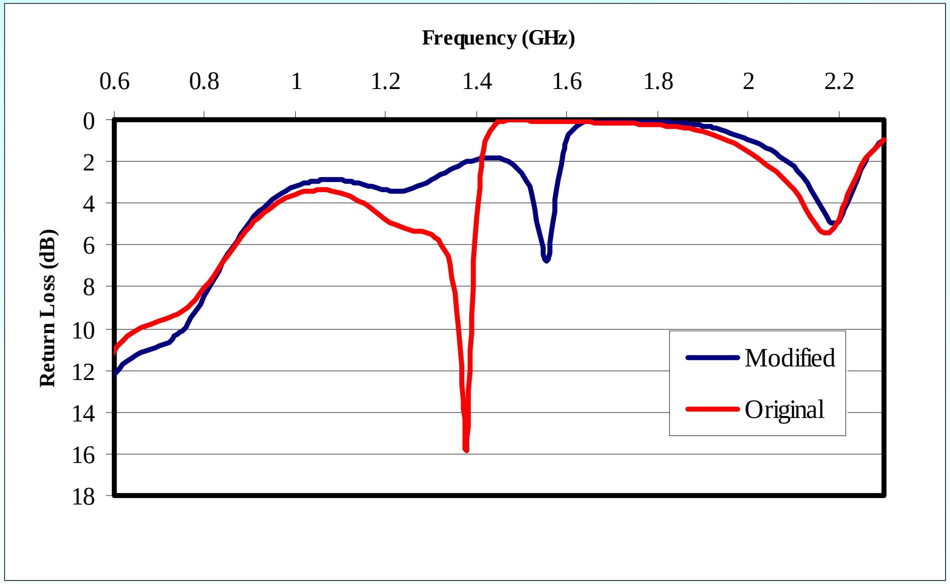


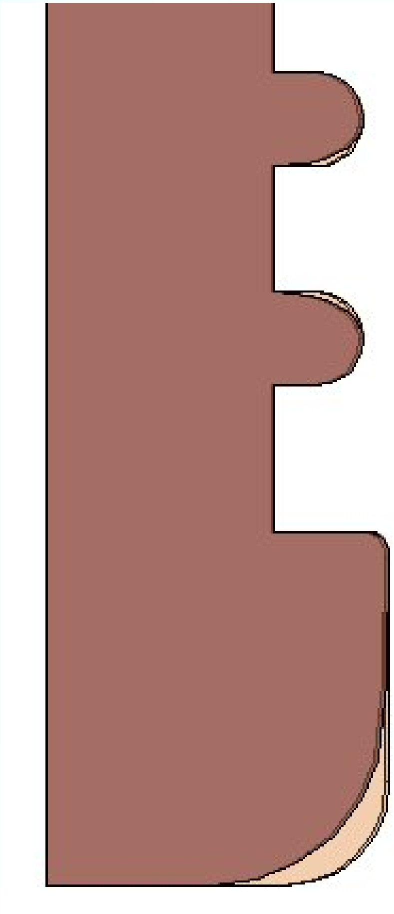
Longitudinal H.O.M.s

L3	1420 MHz	R/Q =	4.48 Ω
L4	1510 MHz	R/Q =	4.14 Ω
L5	1606 MHz	R/Q =	9.85 Ω
L9	2126 MHz	R/Q =	7.13 Ω



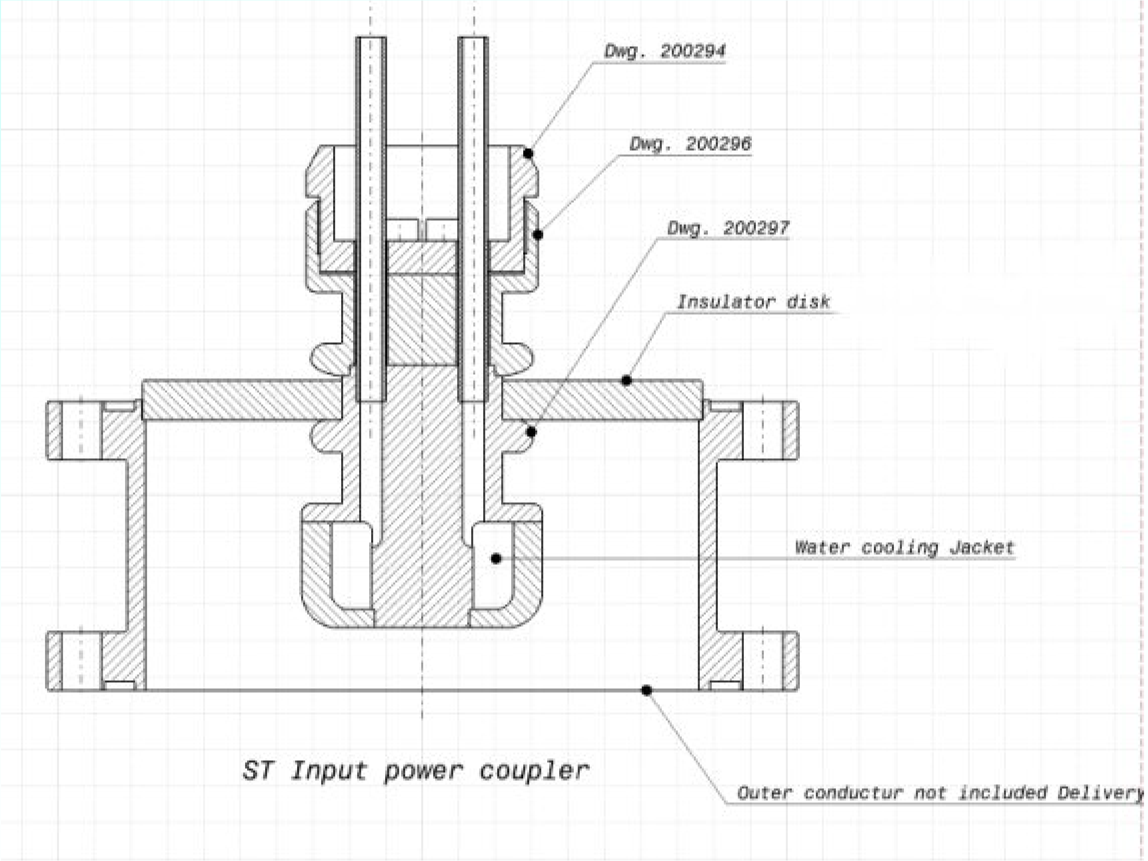
Reduction of the reflection coefficient at the HOMs frequency is obtained smoothing the curvature radius. Further "curve cutted" shape are not allowed also for mechanical reason, even though they could reduce the reflection along the frequency range.



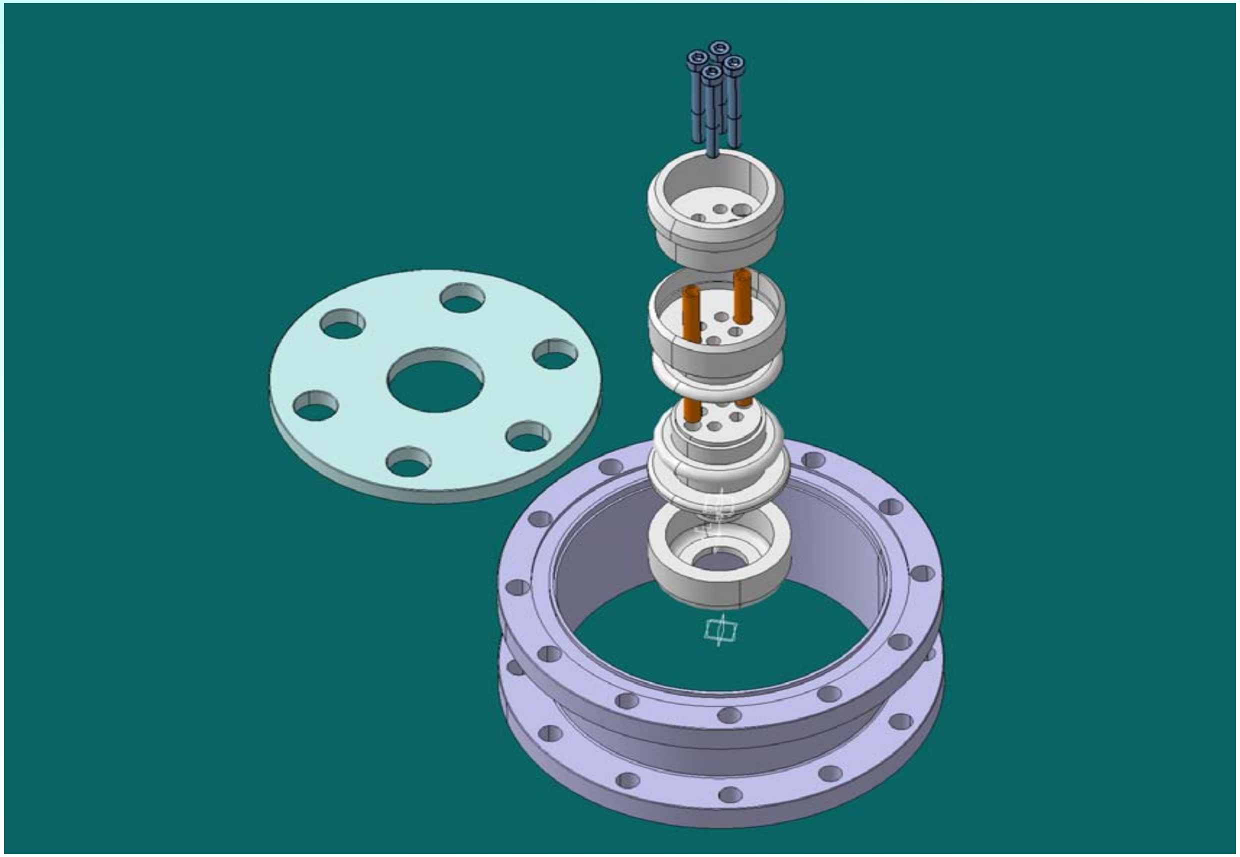


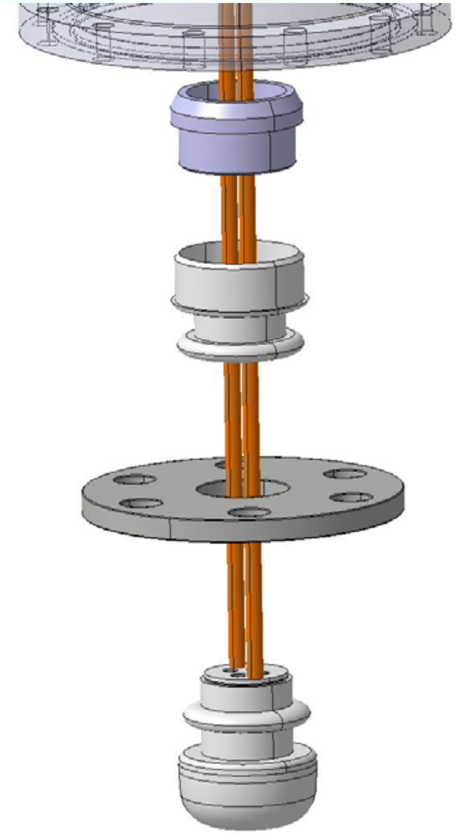
The modified shape still has a return loss ≈ 7dB around 1.55 GHz.

To further reduce the risk of discharge phenomena due to any power coming from HOMs and to relax the 120 kW RF power operation at 500 MHz, it has been decided to water cool also the air part of the IPC modified shape inner conductor .

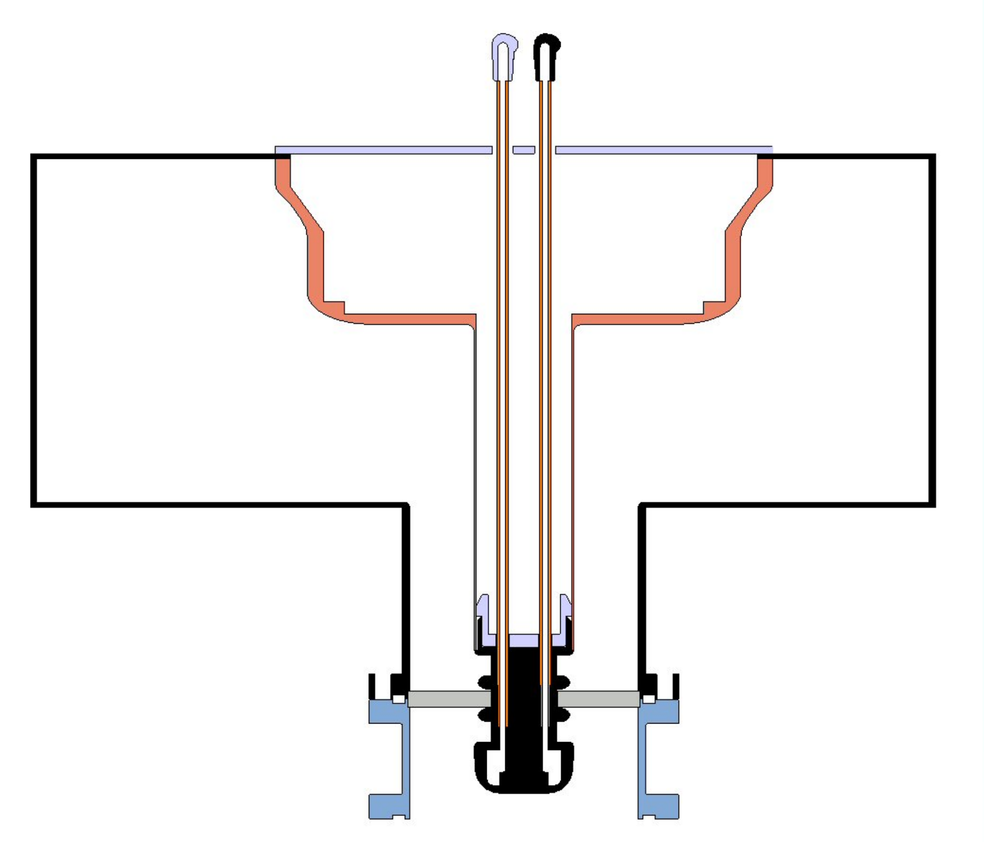


This choice increases the complexity of the inner conductor realization and its installation



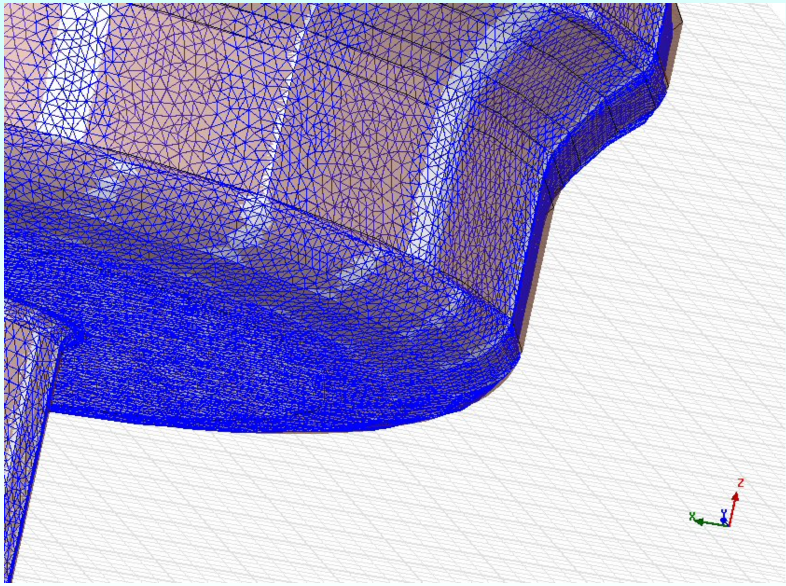


Next step is the transition to the wave guide: a “door-knob” like transition allows the passage of the cooling pipes



The transition external walls has the standard sizes of the WR1800

The inner door knob was designed to minimize the reflection coefficient at 500 MHz



HFSS software simulator:

Half structure simulated

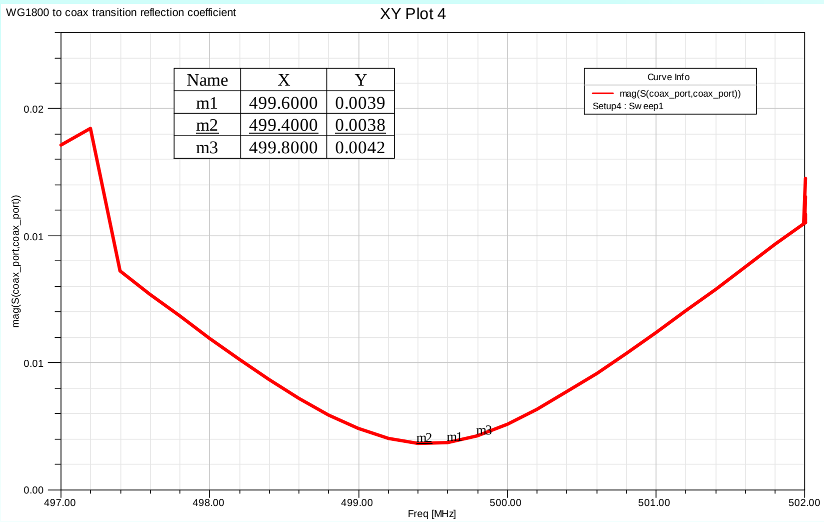
Increased mesh density around the door knob profile

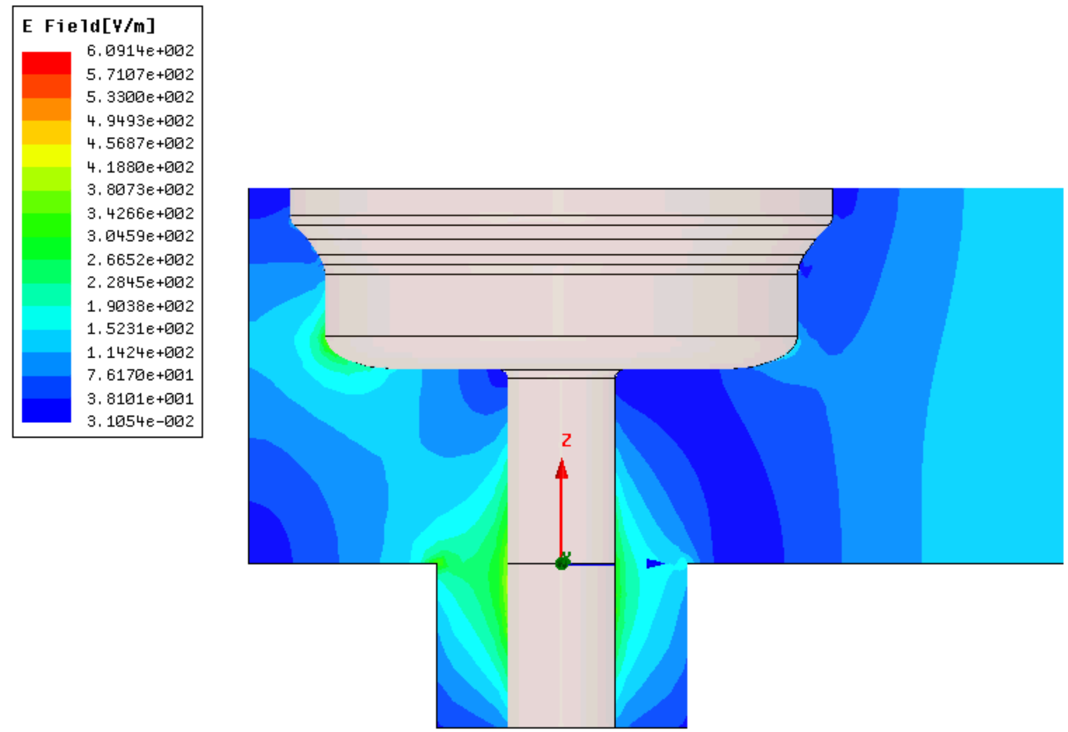
Number of tetrahedras 171350

CPU time 10 hours, Memory 3.6 Gbytes

Simulation running on Intel Xeon CPU 3 GHz Personal Computer

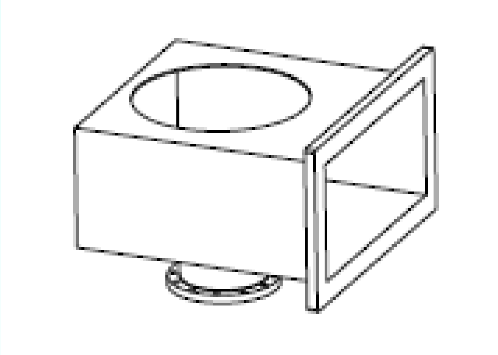
Results: |s11| = 0.0039 @ 499.6 MHz and |s11| < 0.01 497.4 MHz< Freq. <502 MHz





The whole system has been built by Mega Industries –U.S.A.

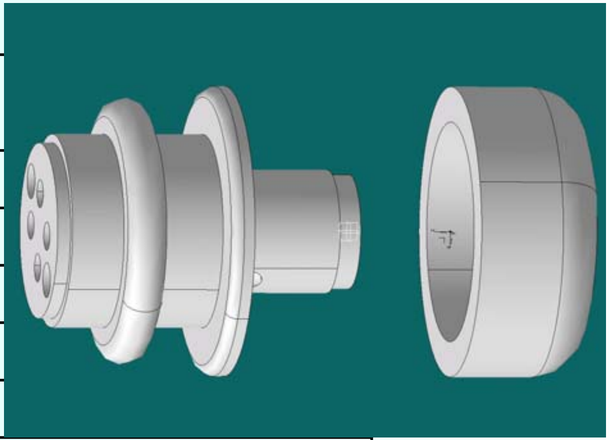
(no prototype has been requested)

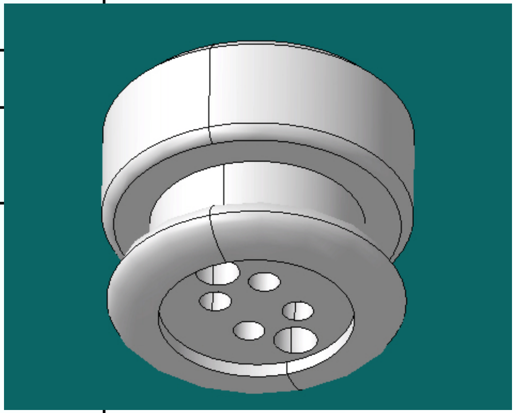


Main Size	CL to WG Flange 305 mm / 12 in CL to COAX flange 245 mm / 9.65 in
Thickness	5 mm / 0.20 in
Tolerance	0.1 mm / 0.004 in
Inner surface roughness	3.2 µm / 126 µin
Material	Aluminum alloy 6061
Finishing	Iridite®
Frequency	499.654 MHz
RF max power	150 kW forward + 150 kW reflected C.W.
Port 1	flange DESY Norm H3-3/1-1a
Port 2	6 1/8" EIA 50 Ω outer conductor rotating flange

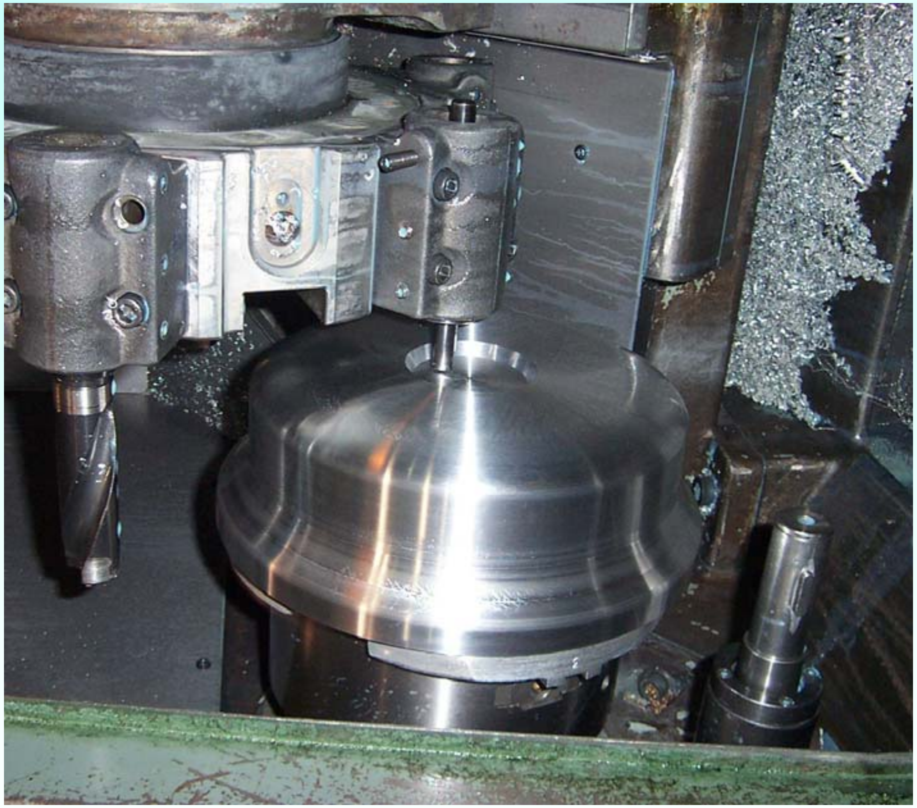
The inner conductor was built by MEGA Industries according to the follow specs (no prototype has been requested):

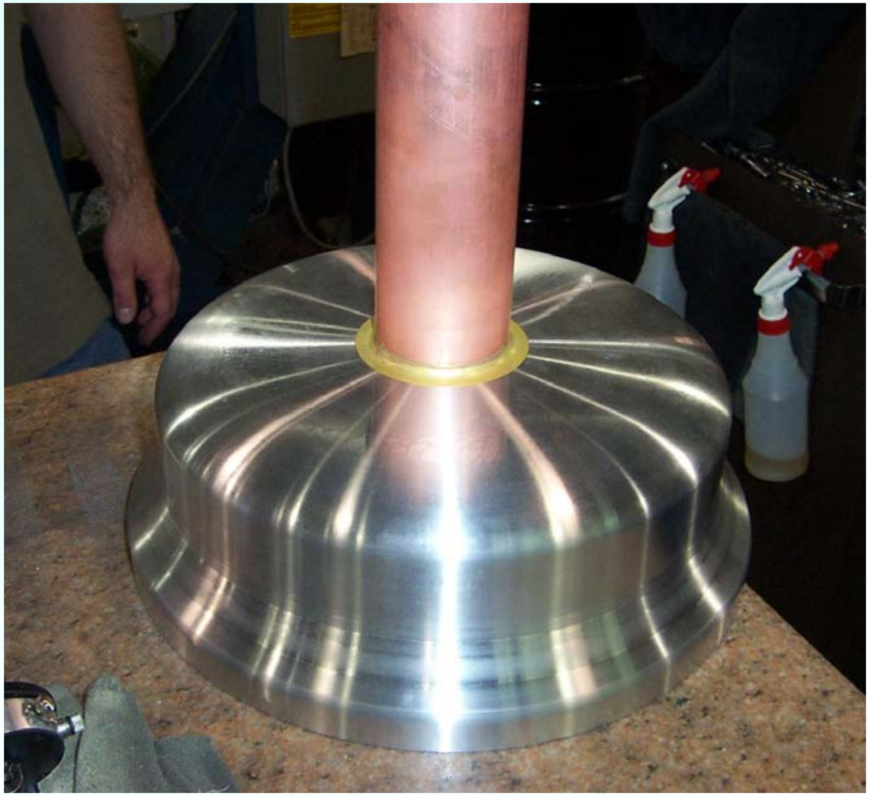
Main Size	72 mm /2.83 in, Ø 66 mm /2.6 in 48 mm / 1.89 in, Ø 63.5 mm / 2.5 in
Tolerances	0.1 mm / 0.004 in
Roughness	0.8 µm RMS / 31.5 µin
Material	Copper
Finishing	Silver coated
Frequency	499.654 MHz
RF max power	150 kW forward + 150 kW reflected C.W.
Losses 150kW	20 Watt
loss density-150 kW	0.6 Watt/cm^2
HOM loss density @ 1.42GHz	6 Watt/cm^2 @1.42GHz, 5kW on the IPC cavity port
Requirements	Low conductivity water cooling jacket. Input and output stiff cooling pipes not shown Allow the passage of the input/output water tubes 4 (four) drill holes M6 to be connected to the IPC RF fingers contacts for 6 1/8" EIA 50 Ω standard male inner conductor

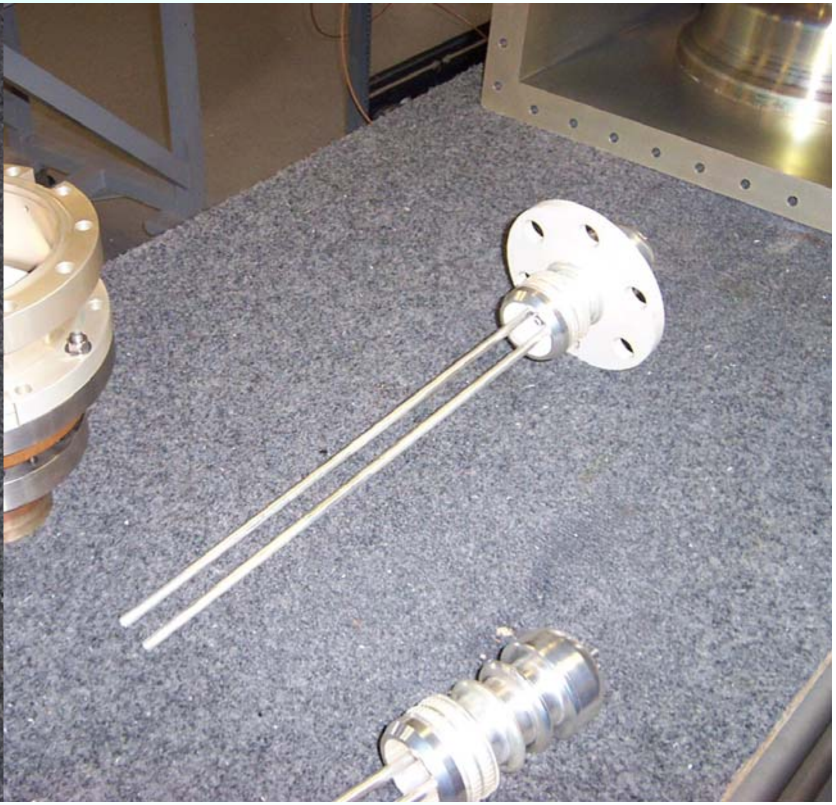




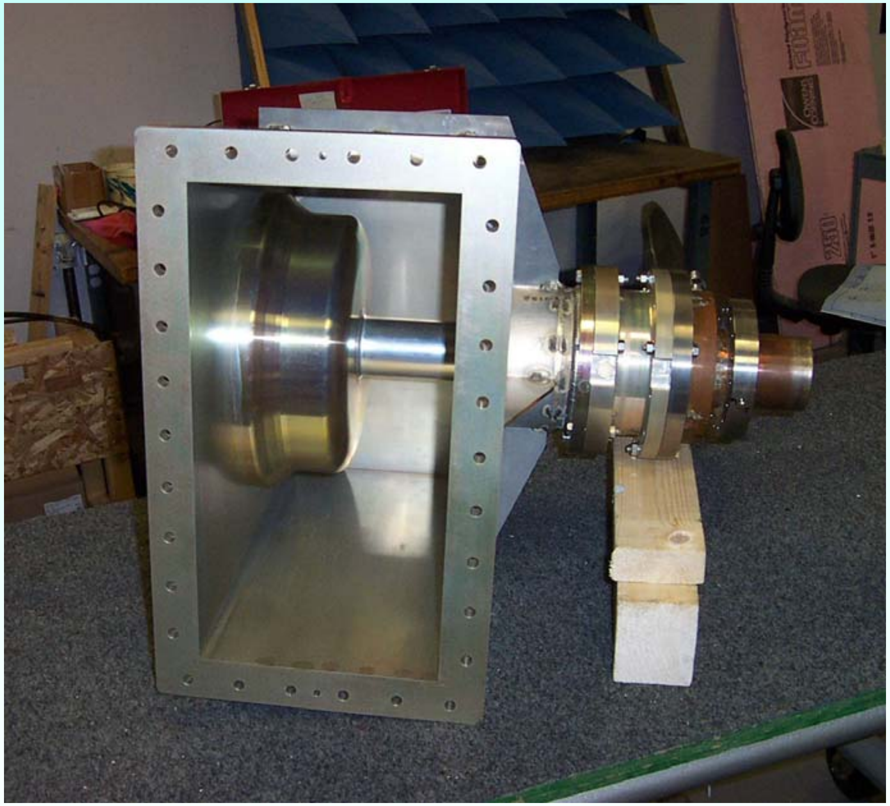
Fabrication steps:

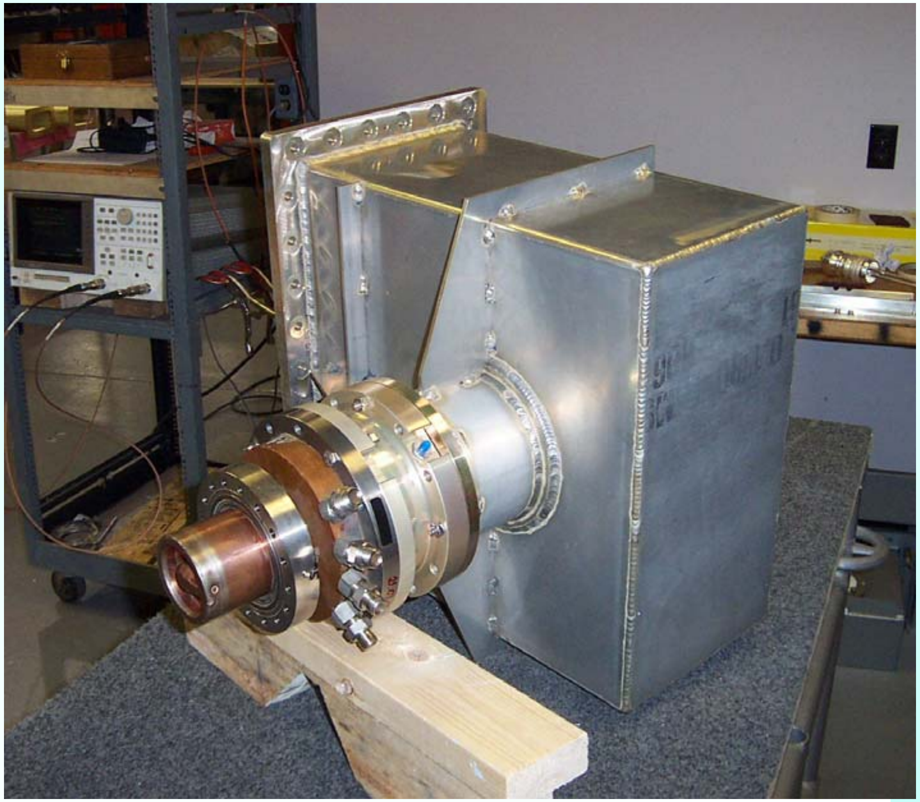




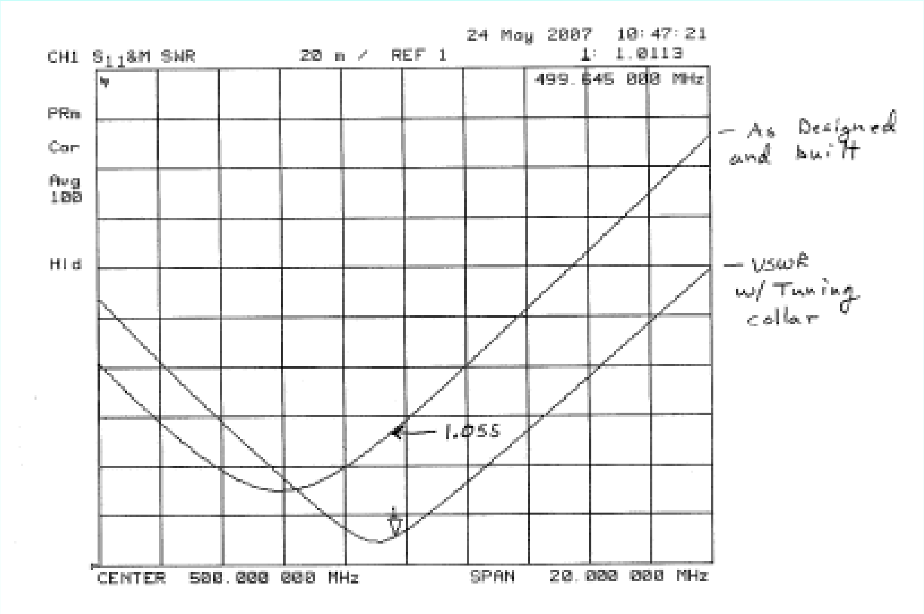


Fit up check:





RF final measurement:



Simulation:

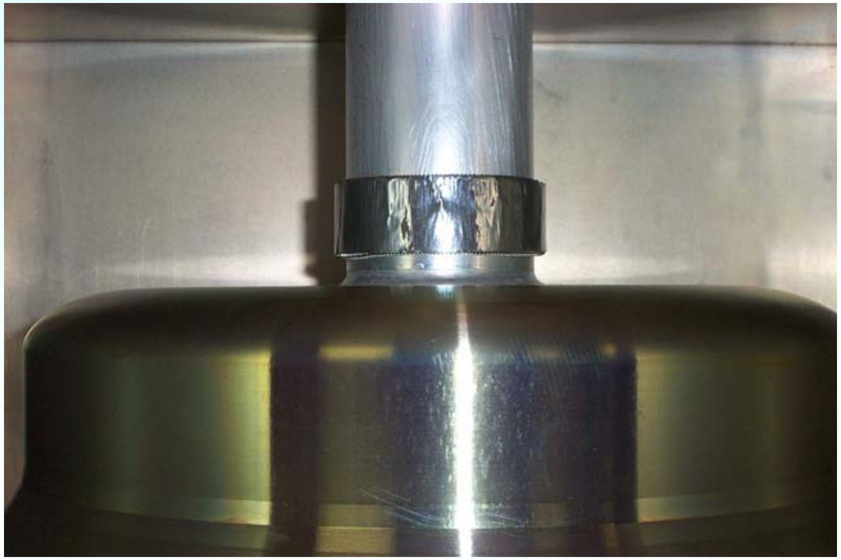
VSWR = 1.008 @ 499.6 MHz

Measure before tuning:

VSWR = 1.055 @ 499.6 MHz

After tuning collar:

VSWR = 1.0113 @ 499.6 MHz



Two complete systems have been built:

One has been tested at DESY test stand at almost full reflection (|S11| =0.35 dB) up to 30 kW, but the estimated dissipation was too high to increase the power level (thanks to Michael Ebert and his staff)

The second has been installed on the Elettra cavity, RF plant #9, on December 2007

The cavity and the transition were tested at the maximum power allowed without beam: 62 kW input power + 5kW reflected power - IPC coupling factor =1.8

Cavity vacuum level ≈ 9.9 10^{-10} mbar @ 62 kW after 8 hours

As soon as possible we will increase the total power delivered to the system with accumulated electron beam.