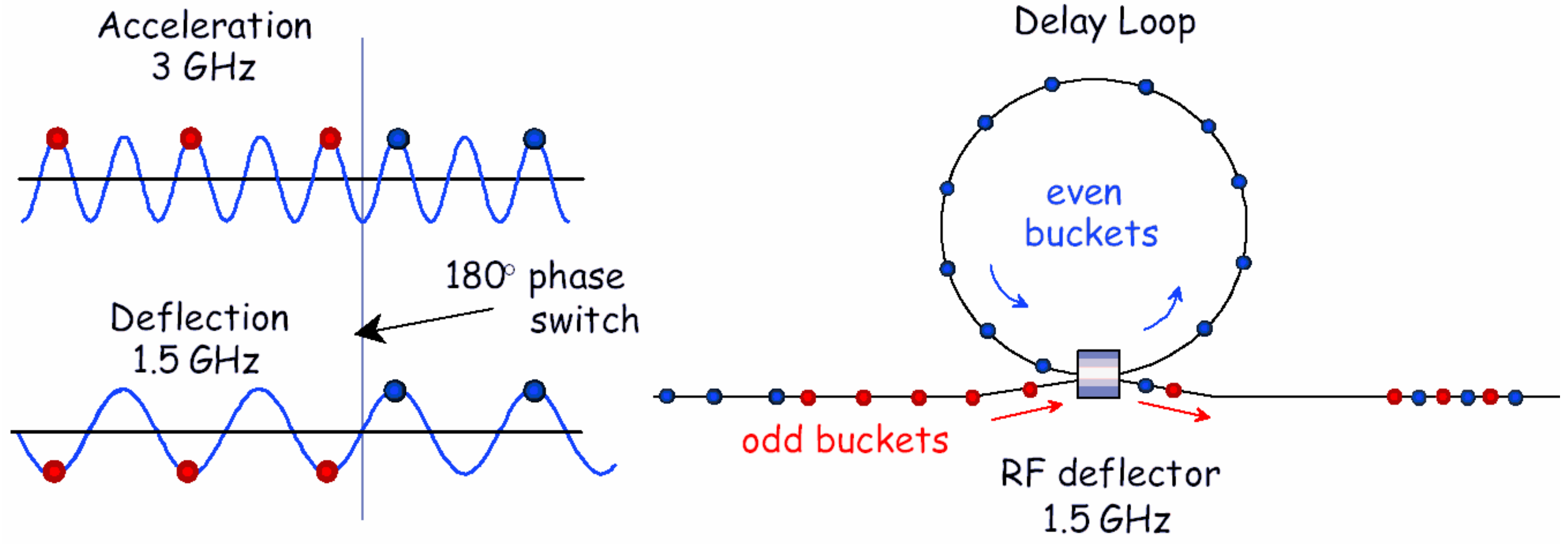
THE 1.5 GHz RF DEFLECTOR FOR THE CTF3 DELAY LOOP

F. MARCELLINI

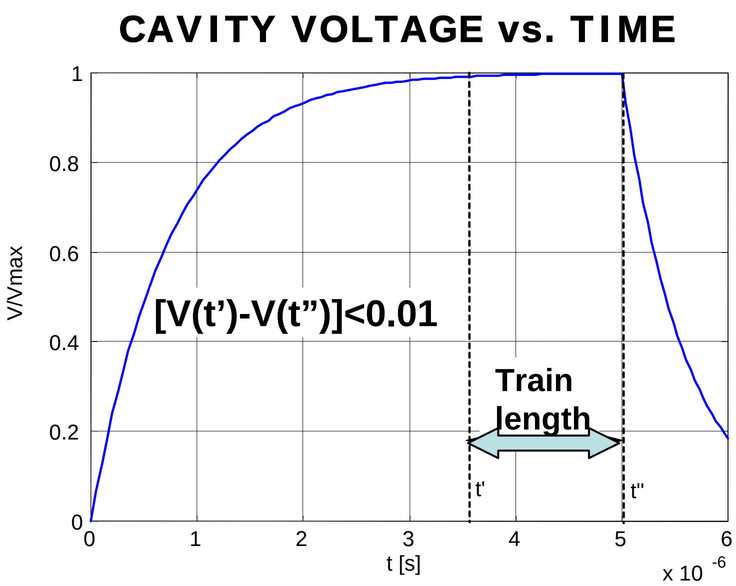


Even and odd trains are deflected by kicks of the same amplitude but opposite sign.
Only even trains are injected into the ring.

DESIGN PARAMETER

Frequency **[GHz]**	**1.4995**
angle of deflection **[mrad]**	**15**
Max. Beam energy **[MeV]**	**300**
Klystron output Power **[MW]**	**20**
Pulse length **[μs]**	**5**

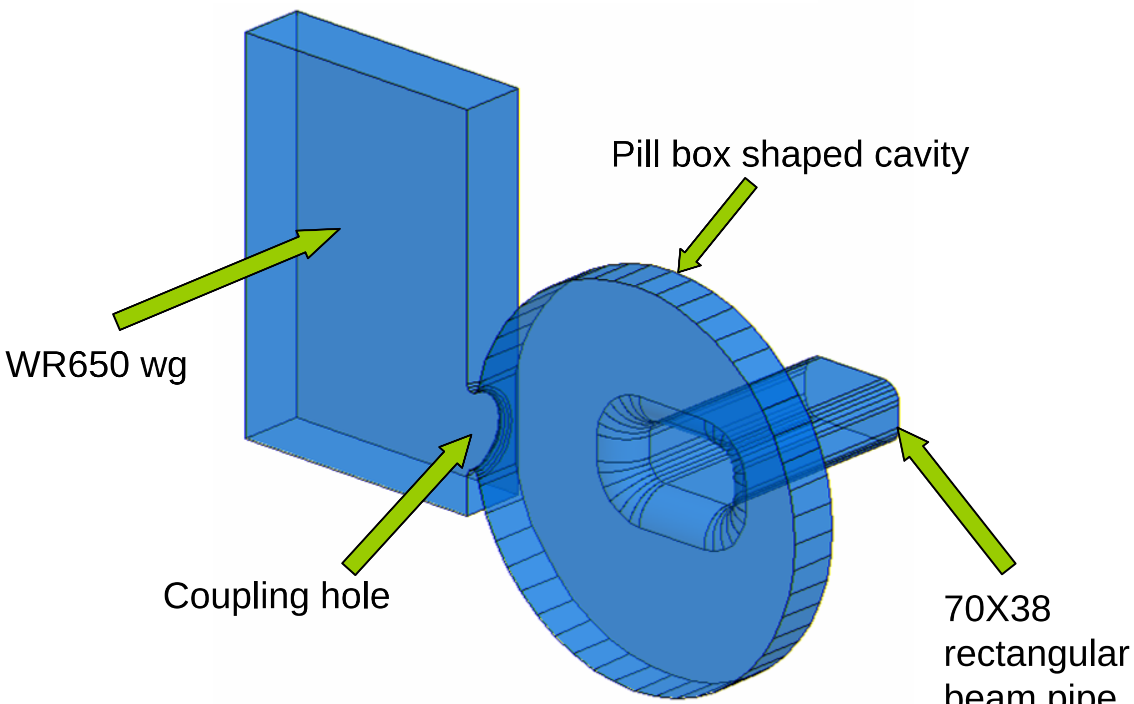
The required deflection is too large to get with a traveling wave structure of reasonable dimensions. It is necessary to resort to a standing wave cavity.



The major drawback of this choice is the slow voltage filling time of a resonant SW cavity.

To keep acceptable the difference (less than 1%) of deflection angle between the head and the tail of the train the cavity Q must be reduced, but not beyond a certain threshold, when the shunt impedance becomes too low.

A good compromise is obtained with a loaded Q value between 3000 and 3500.

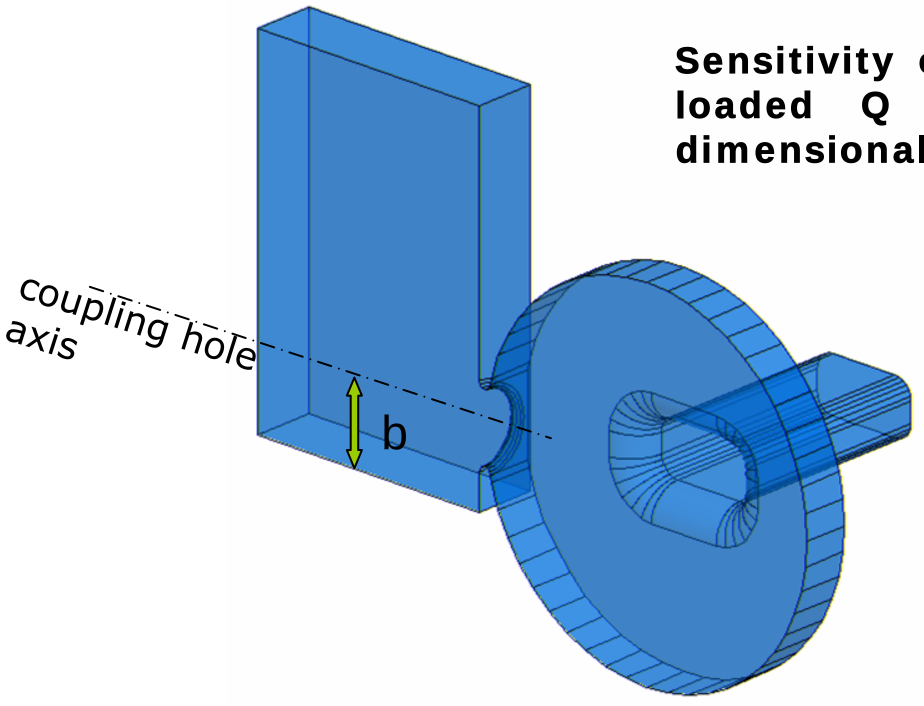


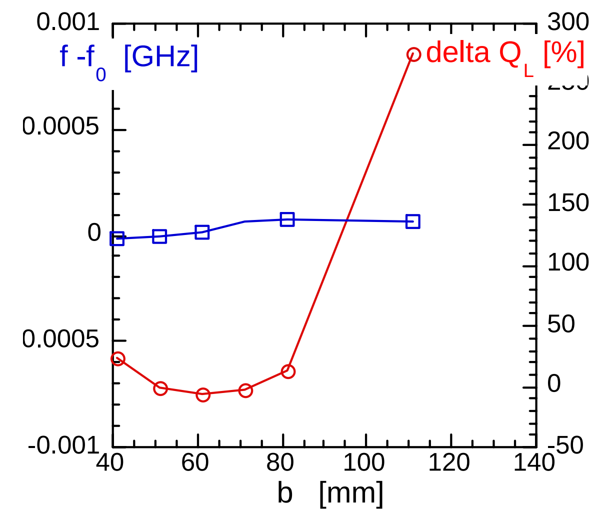
The cavity deflector has been designed starting from a simple pill box shape.

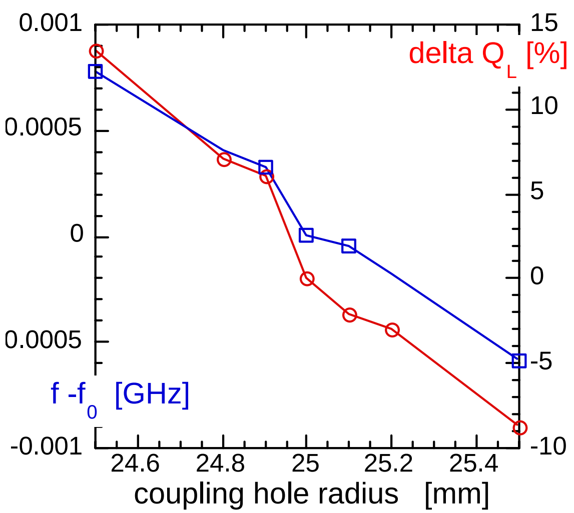
The cavity is externally coupled to a rectangular waveguide (WR650, the same standard of the klystron output) through a hole.

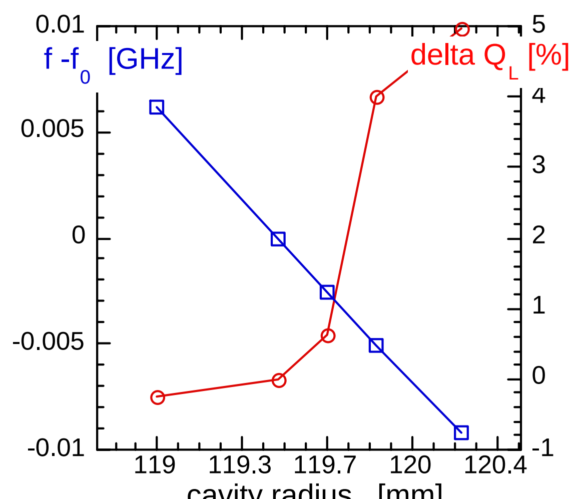
The hole dimensions set the input coupling coefficient β and they have been chosen to obtain the wanted cavity loaded Q.

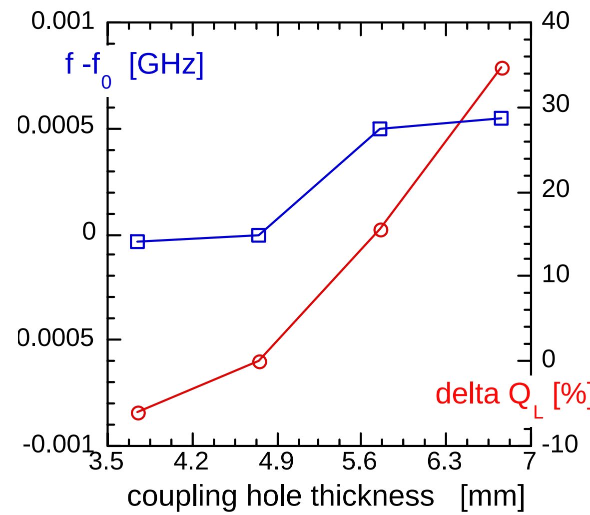
Sensitivity of the resonant frequency and of the loaded Q to small variations of the main dimensional parameters has been evaluated.

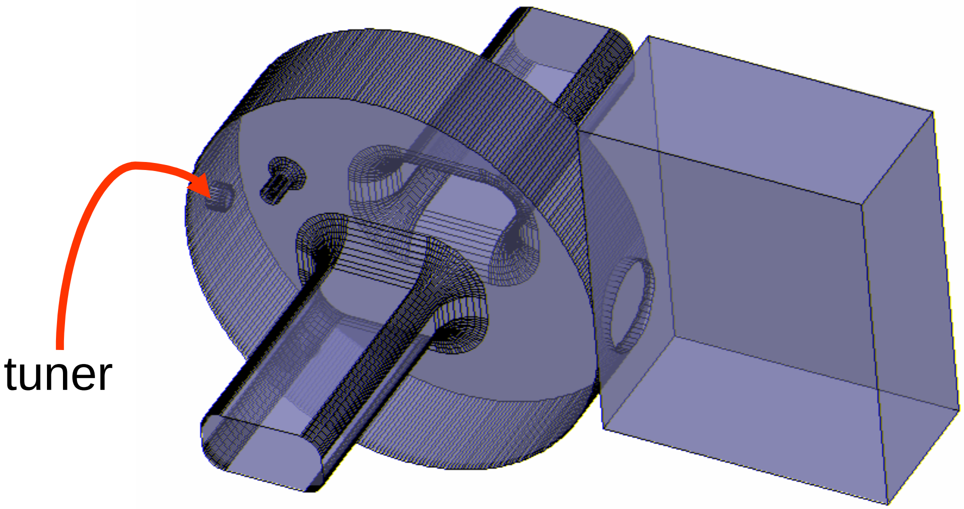


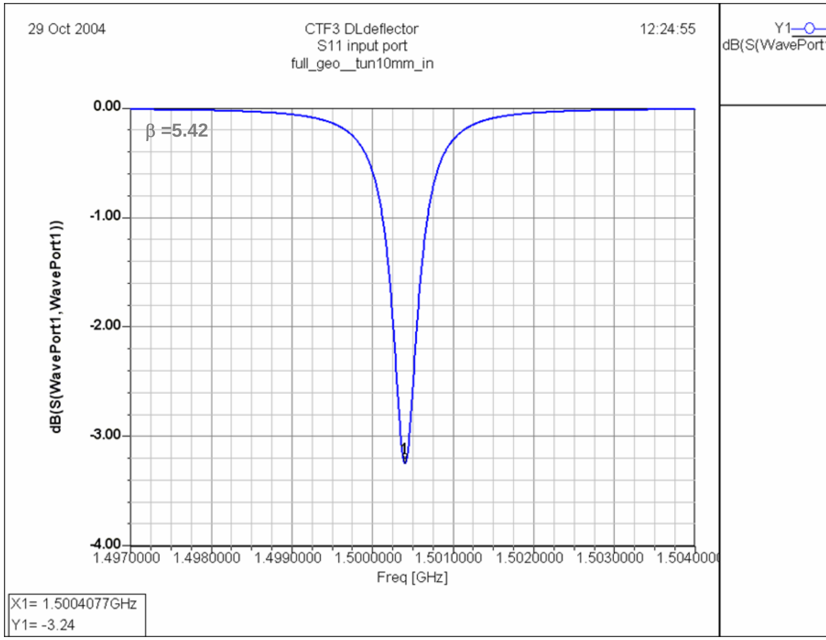


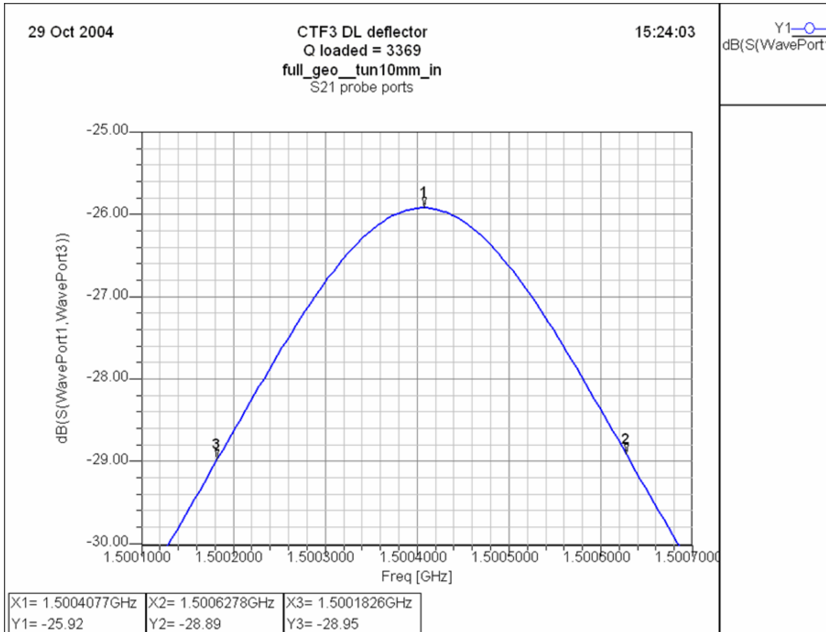












Tuning sensitivity and range of tuning

$$\Phi = 30mm \Rightarrow \quad \frac{\partial f}{\partial ID} = 562.9 \ [kHz/mm]$$

$$\Phi = 20mm \Rightarrow \quad \frac{\partial f}{\partial ID} = 257.6 \ [kHz/mm]$$

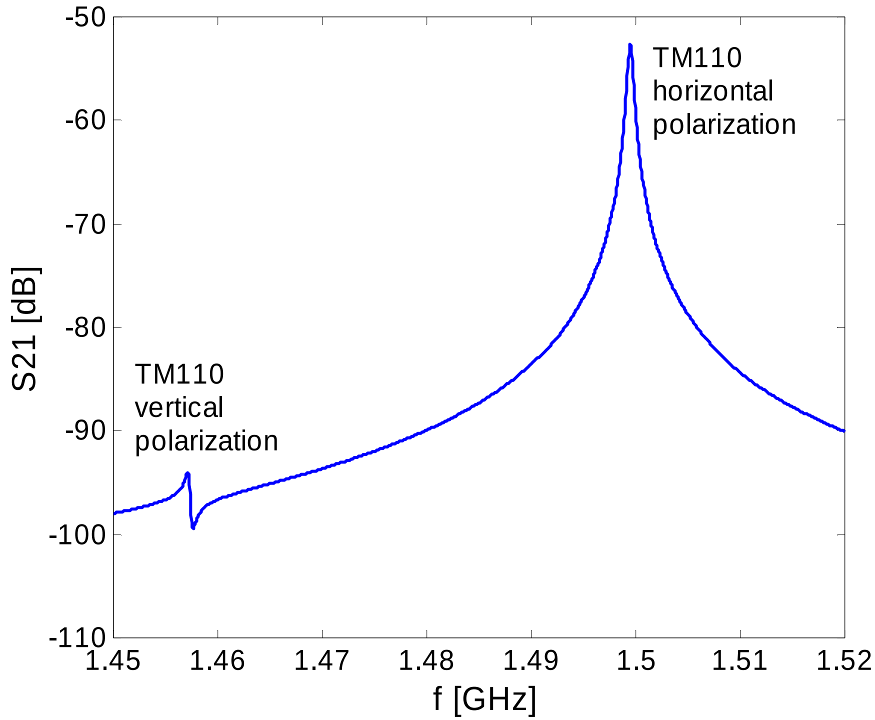
$$\Phi = 15mm \Rightarrow \frac{\partial f}{\partial ID} = 152.4 \ [kHz/mm]$$

$$ID\max = 19mm \ \Rightarrow \ \Delta f \ = 2.9MHz$$

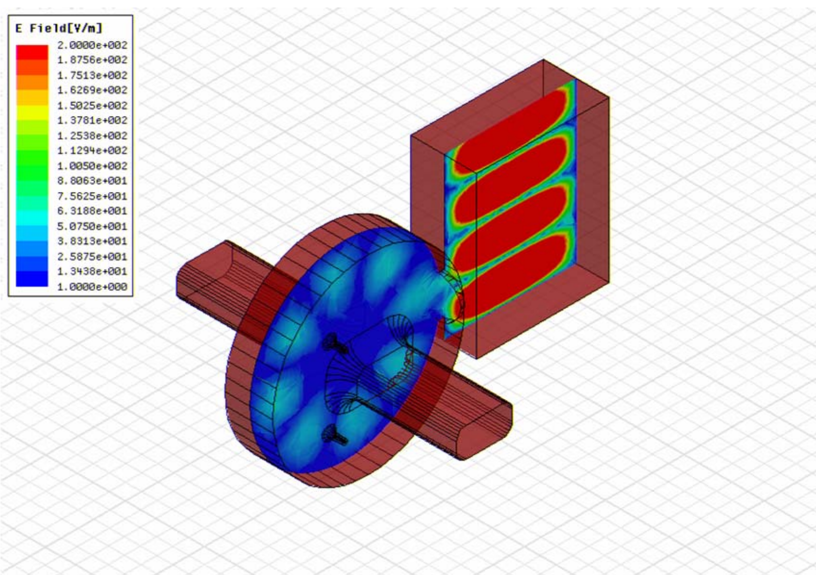
$ID = Insertion\ \ Depth \qquad \Phi = tuner\ \ diameter$

CAVITY PARASITIC MODES

Resonant frequencies of the most dangerous parasitic modes for the beam dynamics (monopoles and dipoles) are far enough from the lines of the beam power spectrum.



The vertical polarization of the TM110 results more than 40 MHz apart from the horizontal one.

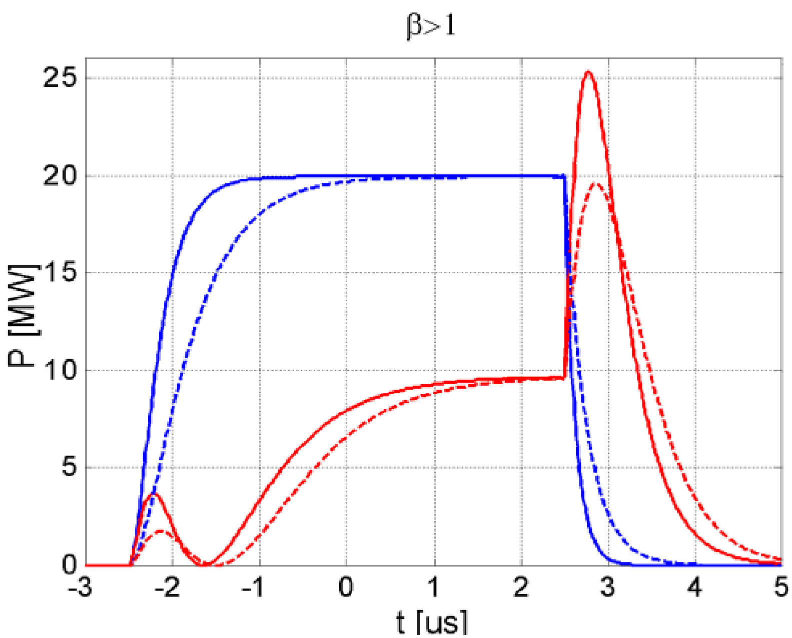


Example of HOM (octupole–2.98GHz).

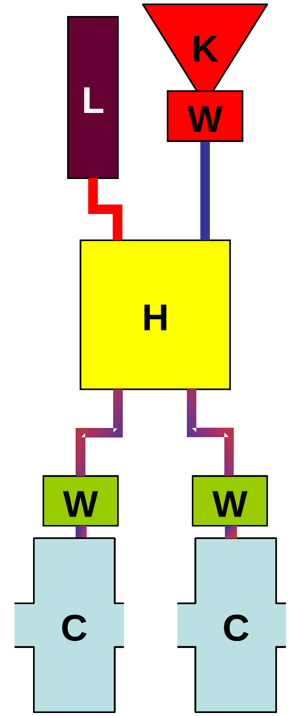
Electric field (magnitude) representation.

TIME DOMAIN CAVITY RESPONSE

The reflected power depends on:
- the cavity input coupling coefficient
- the pulse rise time



Reflected power for 2 arbitrary slopes of the input pulse
Blue – RF input pulse.
Red – cavity reflected power.



Klystron needs to be isolated from the reflected power.
This can be done by a circulator...
...or by a **90 deg hybrid junction** according to the scheme of sled used in the linac technology

Power coming from klystron is split in equal parts by the hybrid and feeds two cavities, excited in the TM110 deflecting mode. Power reflected at the cavity inputs add in phase at the fourth port of the hybrid, where it is connected a load. In principle no power reaches the klystron.
With 2 cavities the total shunt impedance is doubled.
Deflecting voltage results increased by a factor $\sqrt{2}$.

WHOLE DEFLECTOR STRUCTURE DESIGN

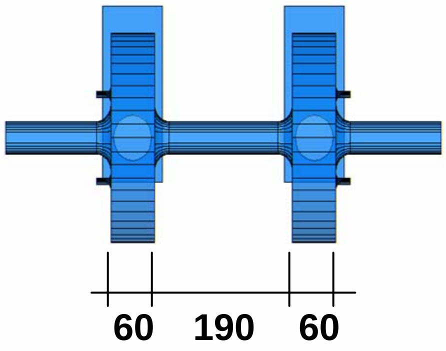
Basic components: 1)Two identical cavities (the same described above). 2) One 3dB hybrid coupler.

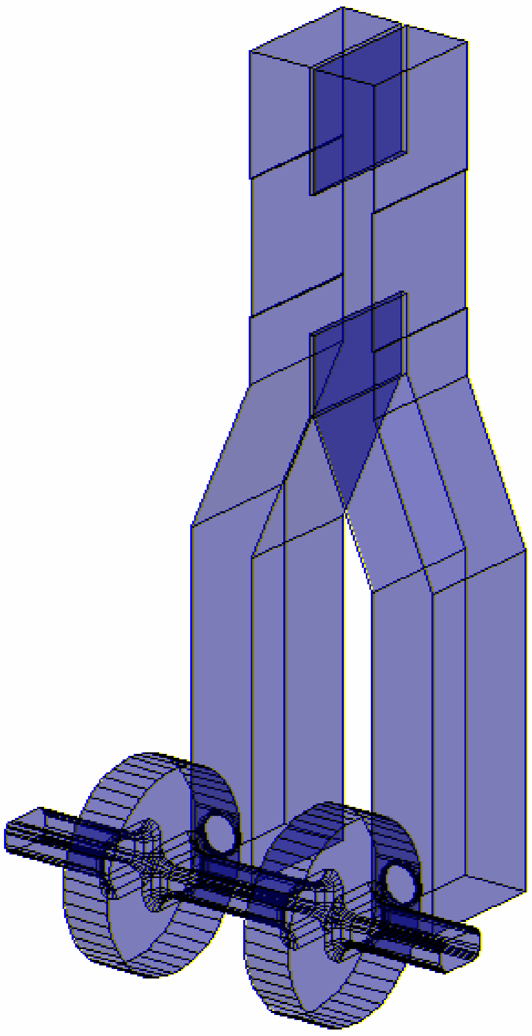
The hybrid is longitudinally aligned at the center of the two cavities.

The fields in the two cavities resonates in quadrature.

Then the cavities have to be placed an odd multiple integer of $\lambda/4$ of the RF wavelength apart along the beam line to kick the beam with the same amplitude and phase.

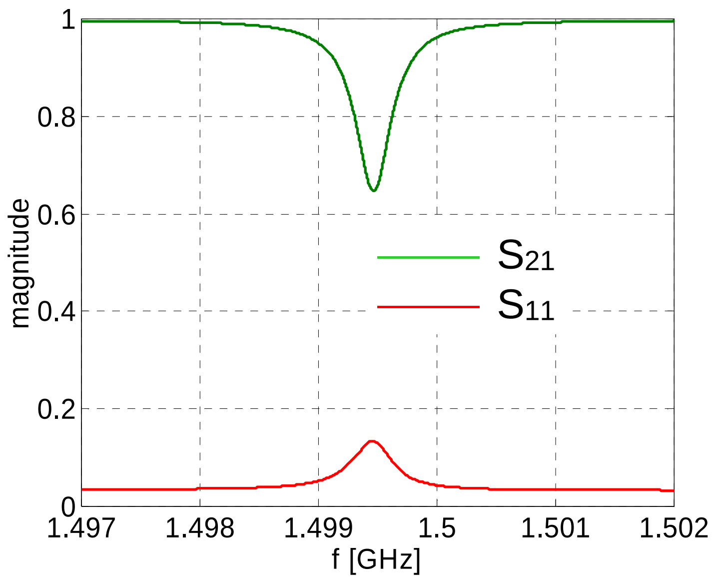
For reasons of space the distance between the gaps has been chosen 250mm, i.e. 5/4 λ_{RF}





THE WHOLE SYSTEM FREQUENCY RESPONSE

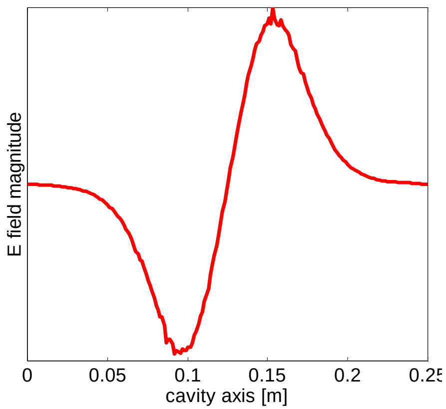
The peak in transmission between klystron and load ports is due to the power dissipated into the structure, while the not completely flatness of the reflection response is caused by some small residual mismatch. However the effect of these mismatches is below the threshold reported in the klystron data sheet.

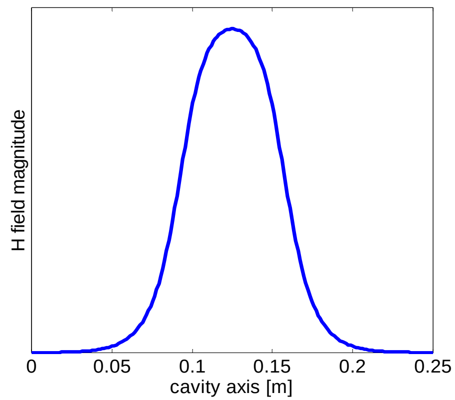


Reflection at the klystron port (red). Transmission between klystron and load ports (green).

DEFLECTING FIELDS AND MAX ANGLE OF DEFLECTION

Deflecting component of electric (red trace) and magnetic (blue) field along the axis of the single cavity.



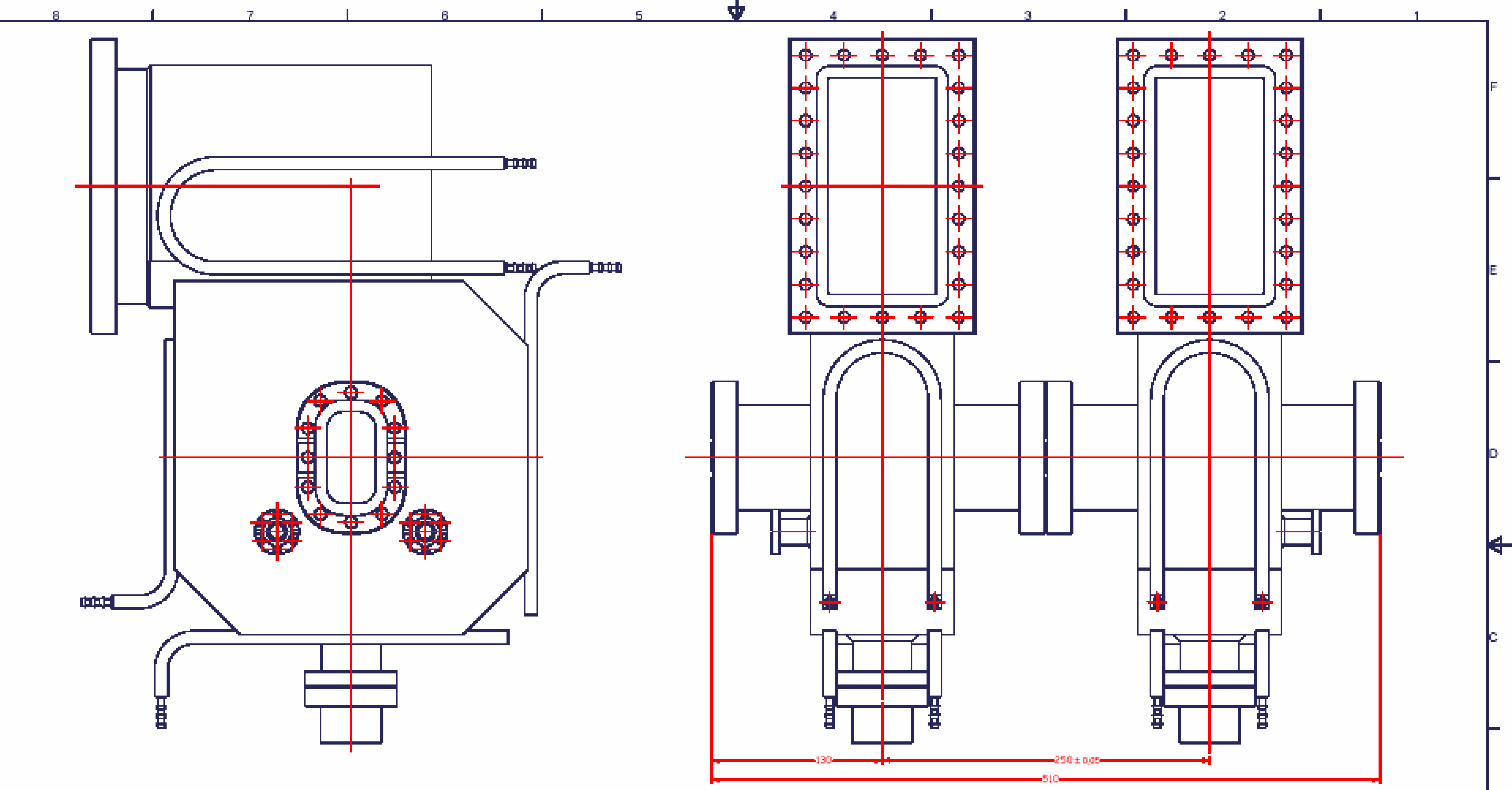


Deflecting voltage has been calculated integrating the transverse components of both the electric (Ehorizontal) and the magnetic (Bvertical) field on the axis of the two cavity structure.

The obtained shunt impedance is

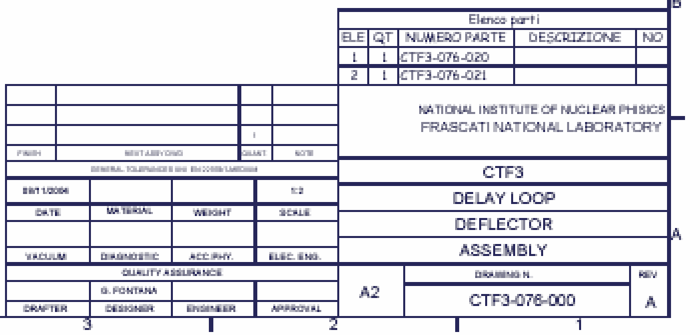
$$R = \frac{V^2}{2P} = 0.625\ [M\Omega]$$

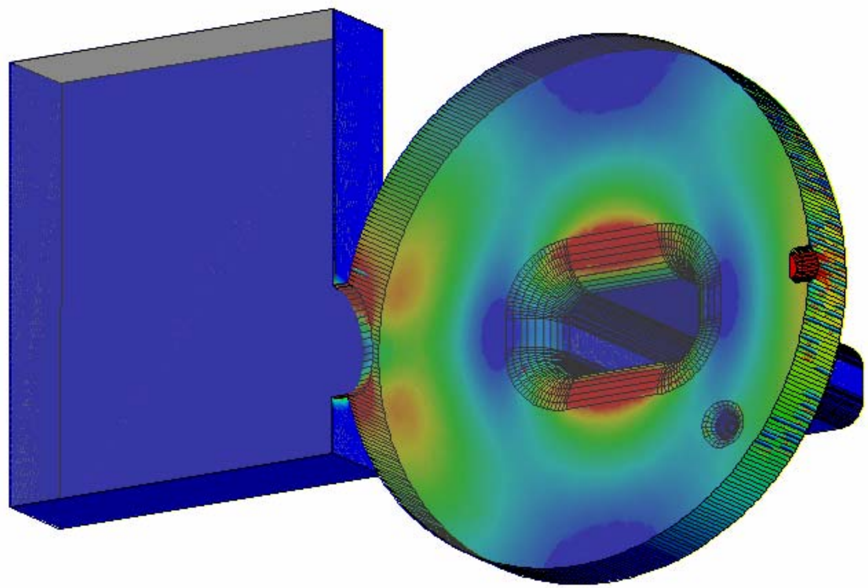
Operating at full power (20MW), the maximum angle obtainable is 17 mrad on a 300 MeV beam.



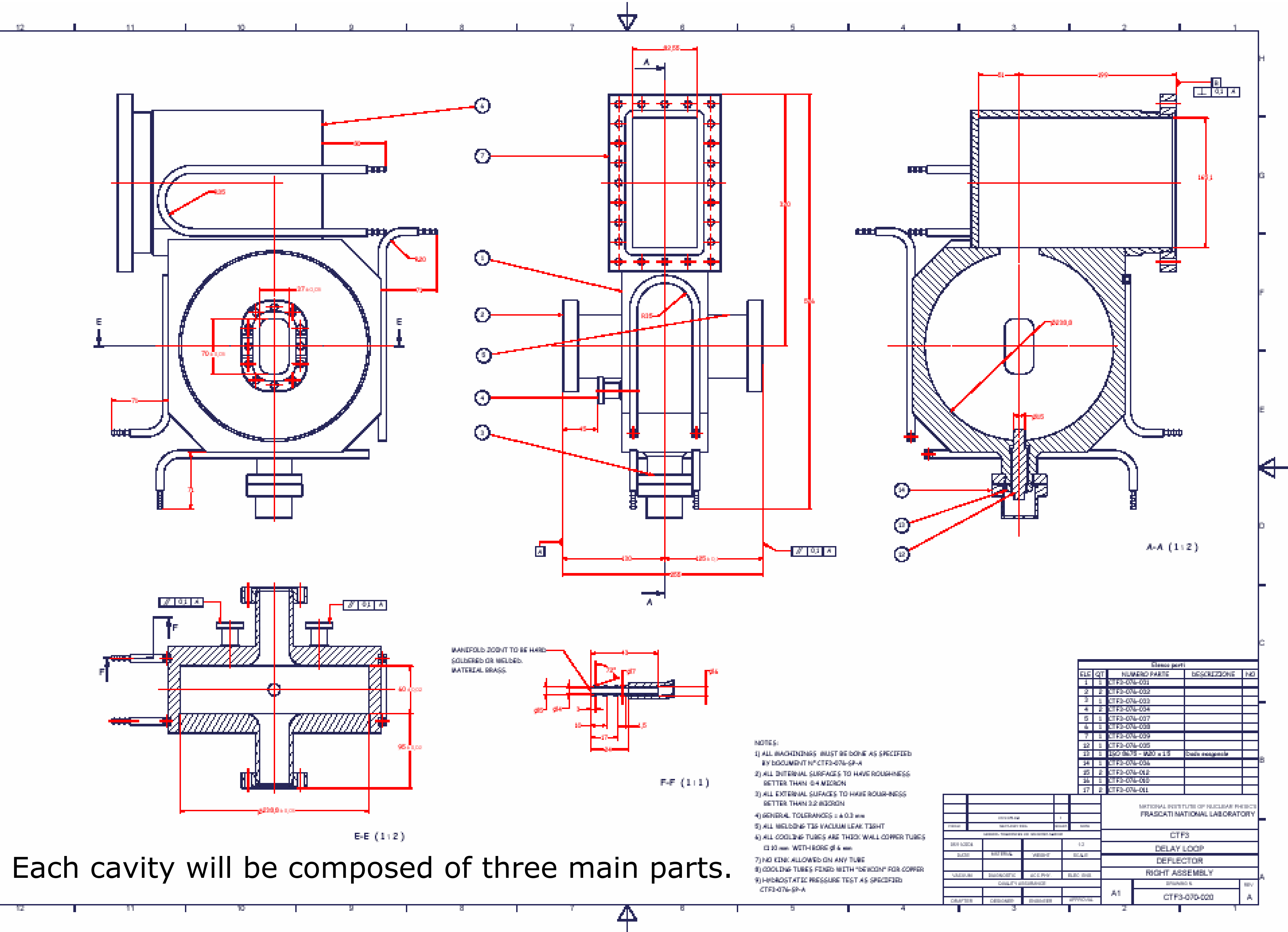
Mechanical drawings of the two cavities have been done.
Cavities will be in copper OFHC, flanges in stainless steel.
The manufacture has been proposed to the Andrzej Soltan Institute (Poland). We are waiting for their quotation.

Thanks a lot to Serge Mathot for his very helpful suggestions about brazing.

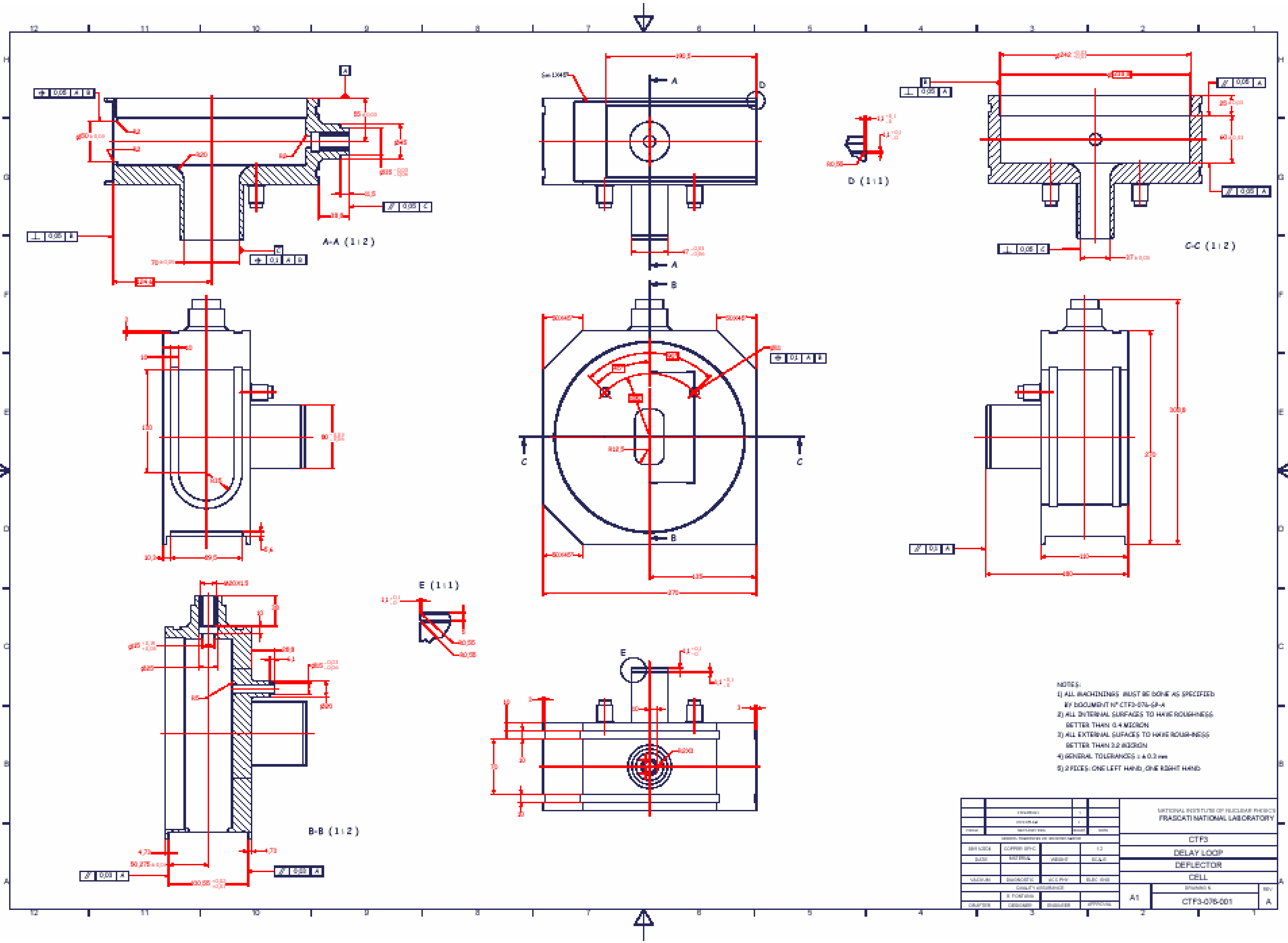


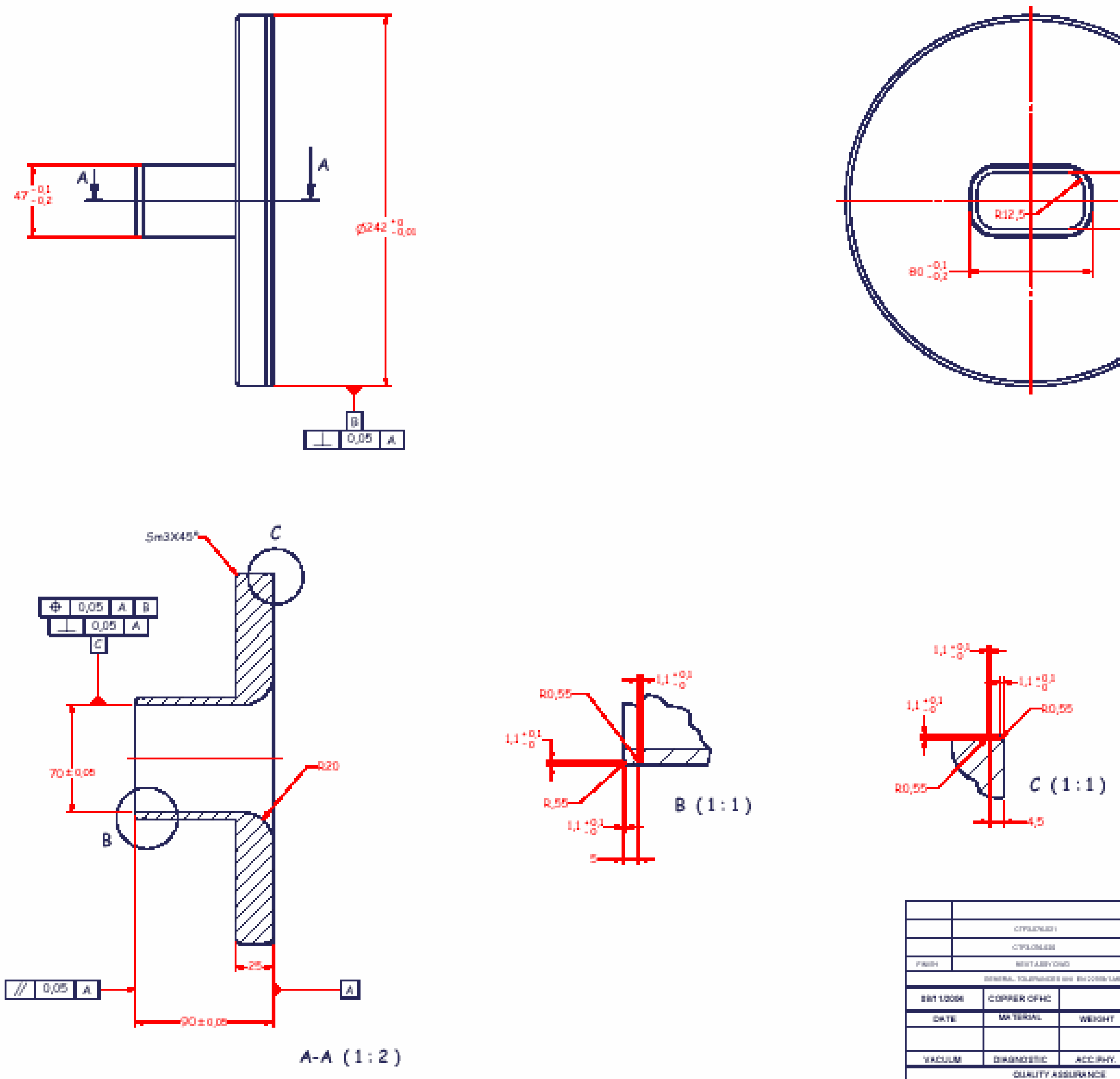


Distribution of losses on the cavity walls.
Average power dissipated in each cavityis 2.5 kW at full power operation (i.e. 20 MW klystron output peak power).
In the drawings each cavity drawn results provided with 5 coils for cooling, even if **thermal analysis has to be done yet.**



Each cavity will be composed of three main parts.


A-A (1:2)
C-C (1:2)
D (1:1)
E (1:1)
B-B (1:2)
NOTES:
1) ALL MACHININGS MUST BE DONE AS SPECIFIED BY DOCUMENT N° CTF3-076-SP-A
2) ALL INTERNAL SURFACES TO HAVE ROUGHNESS BETTER THAN 0.4 MICRON
3) ALL EXTERNAL SUFACES TO HAVE ROUGHNESS BETTER THAN 3.2 MICRON
4) GENERAL TOLERANCES : ± 0.3 mm
5) 2 PICES: ONE LEFT HAND, ONE RIGHT HAND
NATIONAL INSTITUTE OF NUCLEAR PHYSICS
FRASCATI NATIONAL LABORATORY
CTF3
DELAY LOOP
DEFLECTOR
CELL
COPPER OFHC
1:2
SIZE
MATERIAL
WEIGHT
SCALE
VACUUM
DIAGNOSTIC
ACC PHY.
ELEC. ENG.
QUALITY ASSURANCE
DRAFTER
DESIGNER
ENGINEER
APPROVAL
A1
DRAWING N.
CTF3-076-001
REV
A



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	[illegible]	1	
	[illegible]	1	
FINISH	[illegible]	QUANT.	NOTE
GENERAL TOLERANCES [illegible]			
[illegible]	COPPER OFHC		1:1
DATE	MATERIAL	WEIGHT	SCALE
VACUUM	DIAGNOSTIC	ACC.PHY.	ELEC. ENG.
QUALITY ASSURANCE			
	G. FONTANA		
DRAFTER	DESIGNER	ENGINEER	APPROVAL

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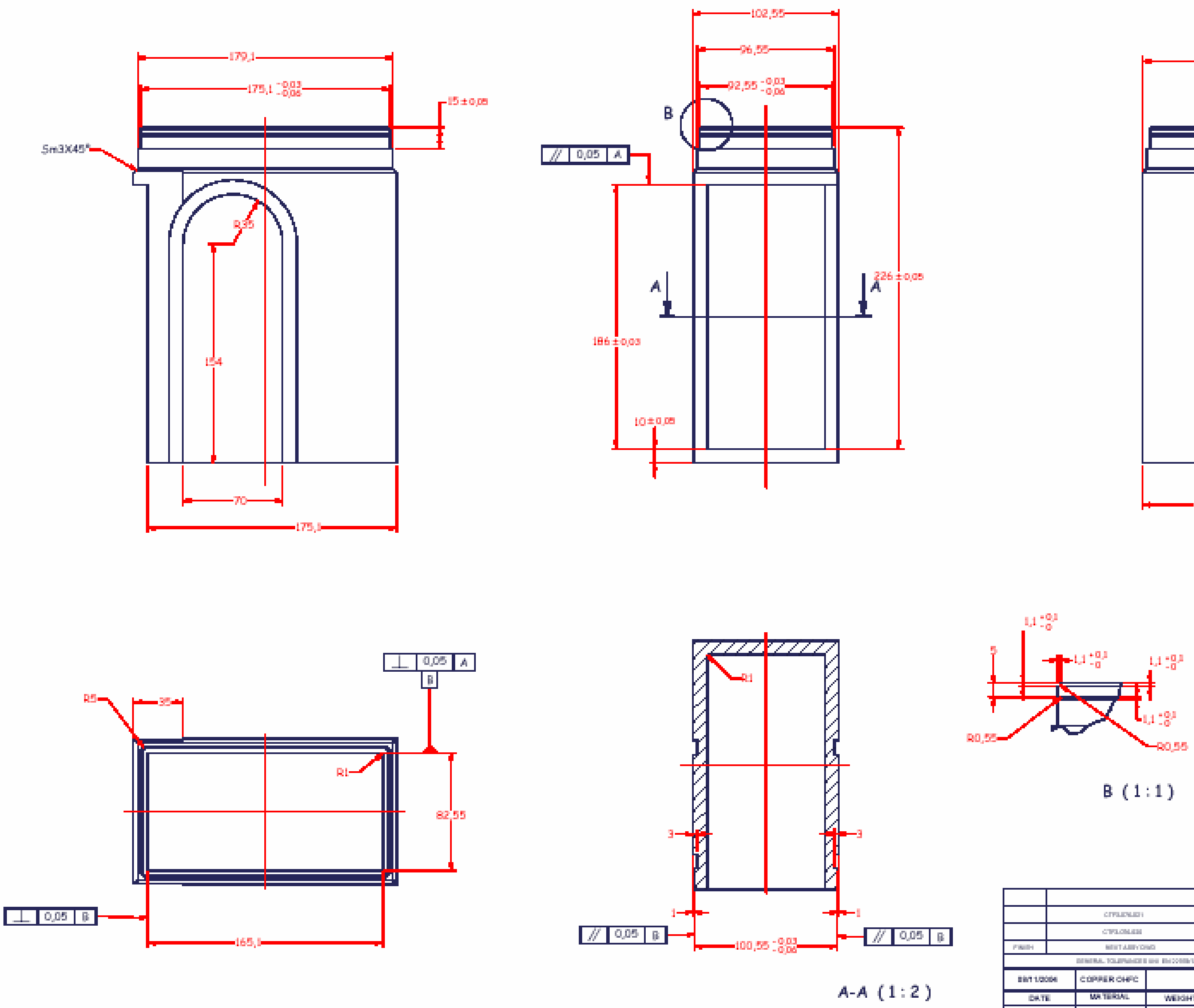
CTF3
DELAY LOOP
DEFLECTOR
PLATE

	DRAWING N.	REV
A2	CTF3-076-007	A



NOTES:

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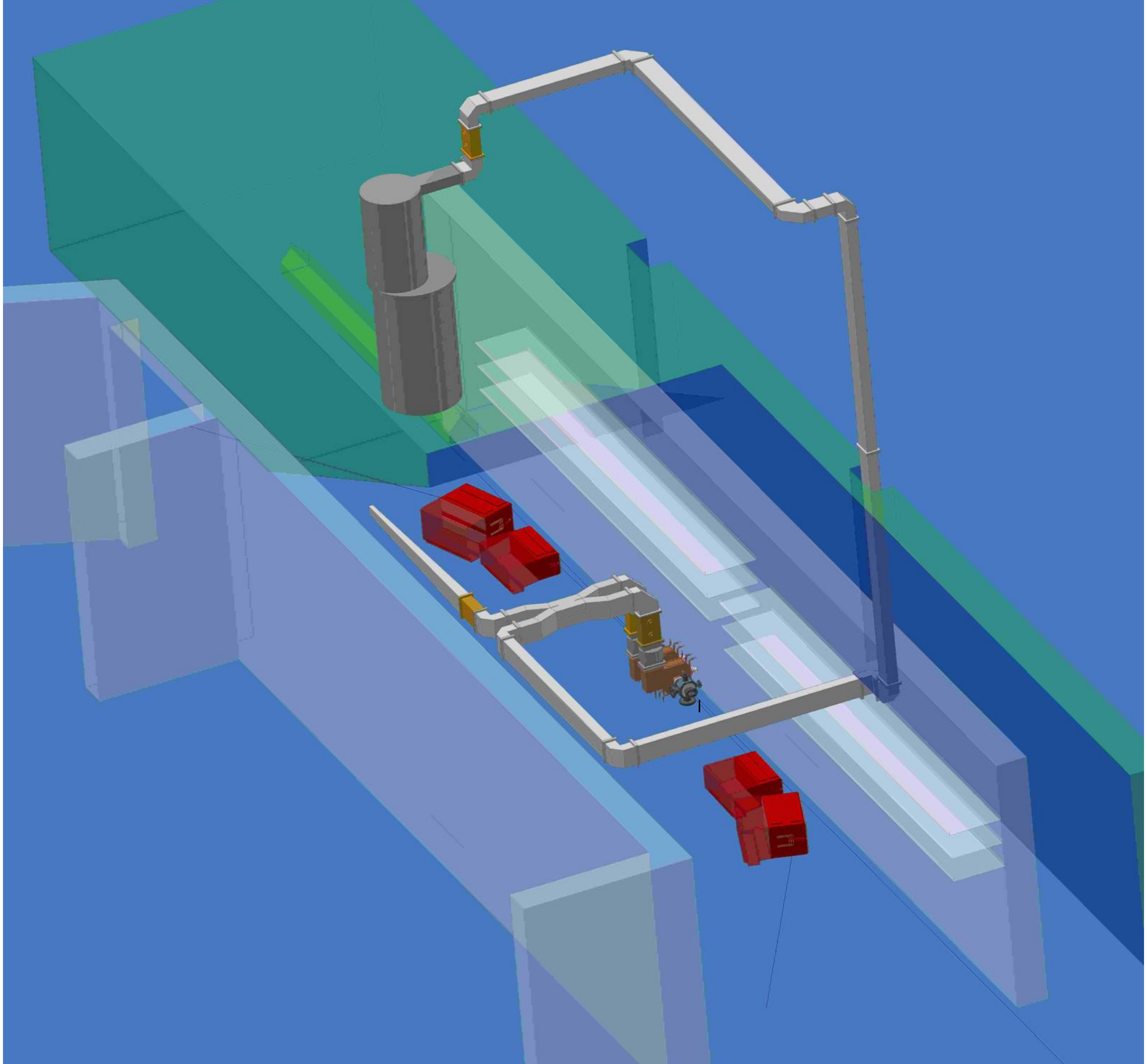
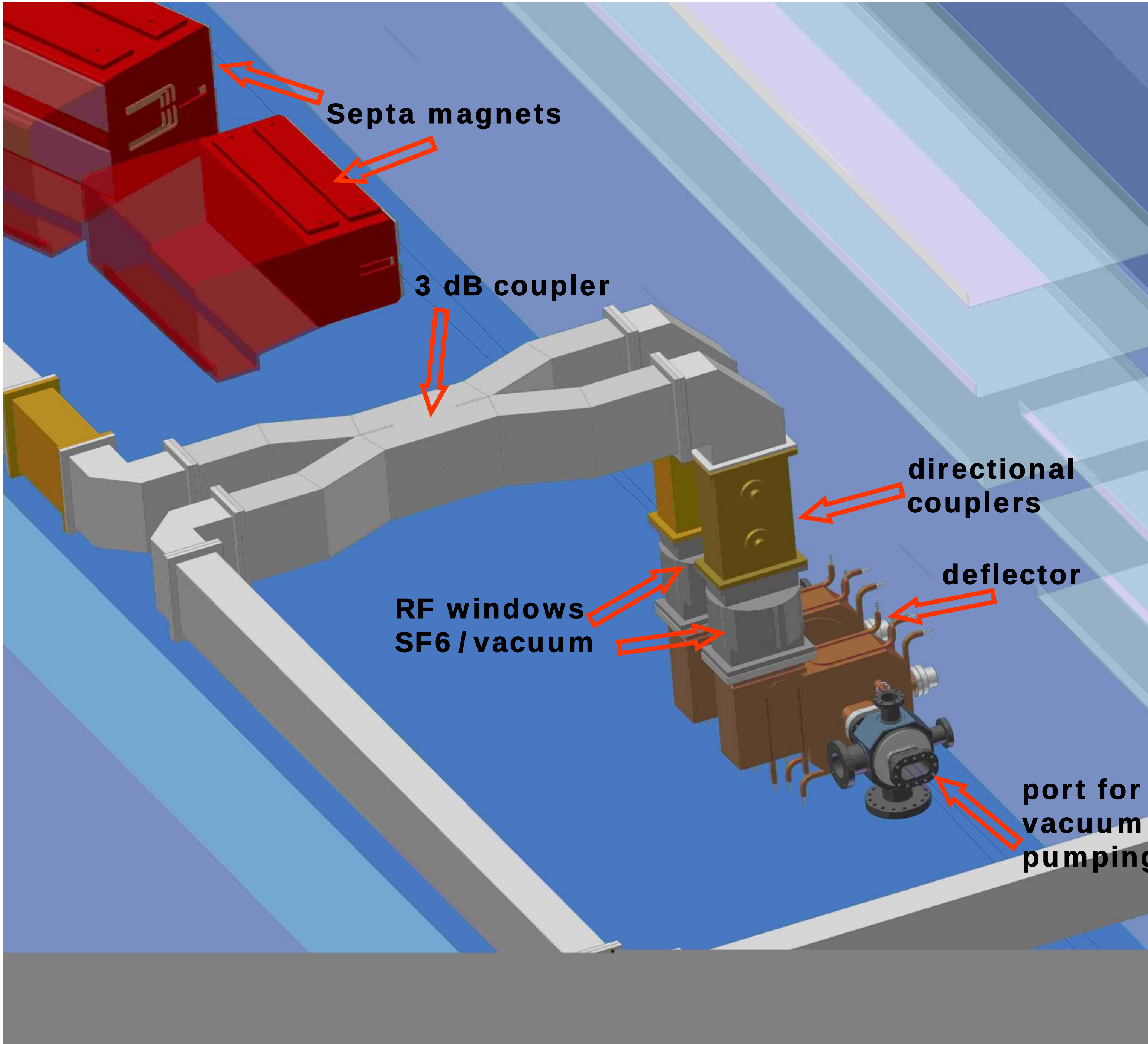
COPPER OHFC			
DATE	MATERIAL	WEIGHT	SCALE
VACUUM	DIAGNOSTIC	ACC.PHY.	ELEC. ENG.
QUALITY ASSURANCE			
	G. FONTANA		
DRAFTER	DESIGNER	ENGINEER	APPROVAL

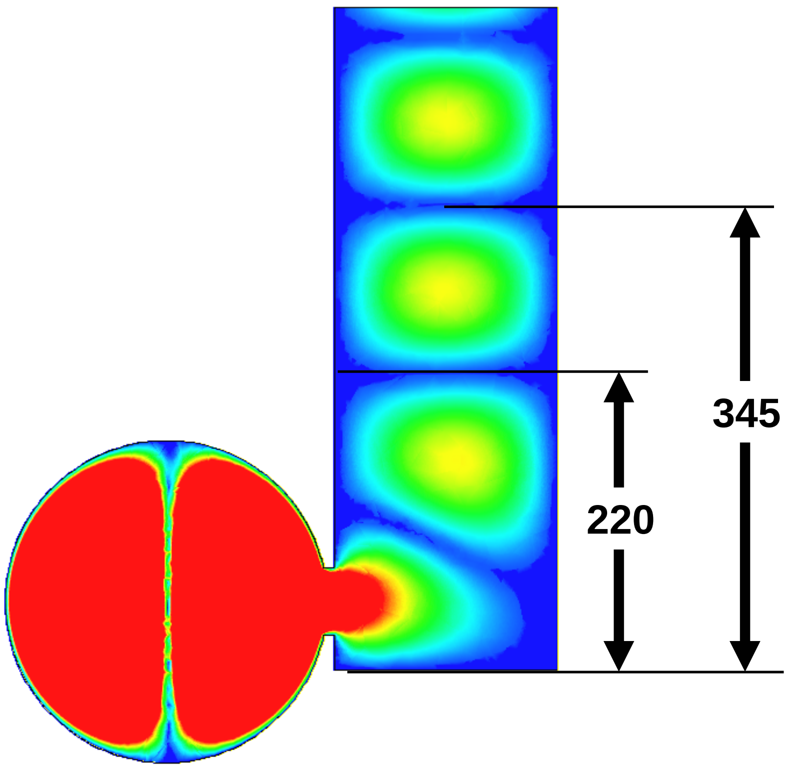
CTF3
DELAY LOOP
DEFLECTOR
WAVEGUIDE

	DRAWING N.	REV
A2	CTF3-076-008	A

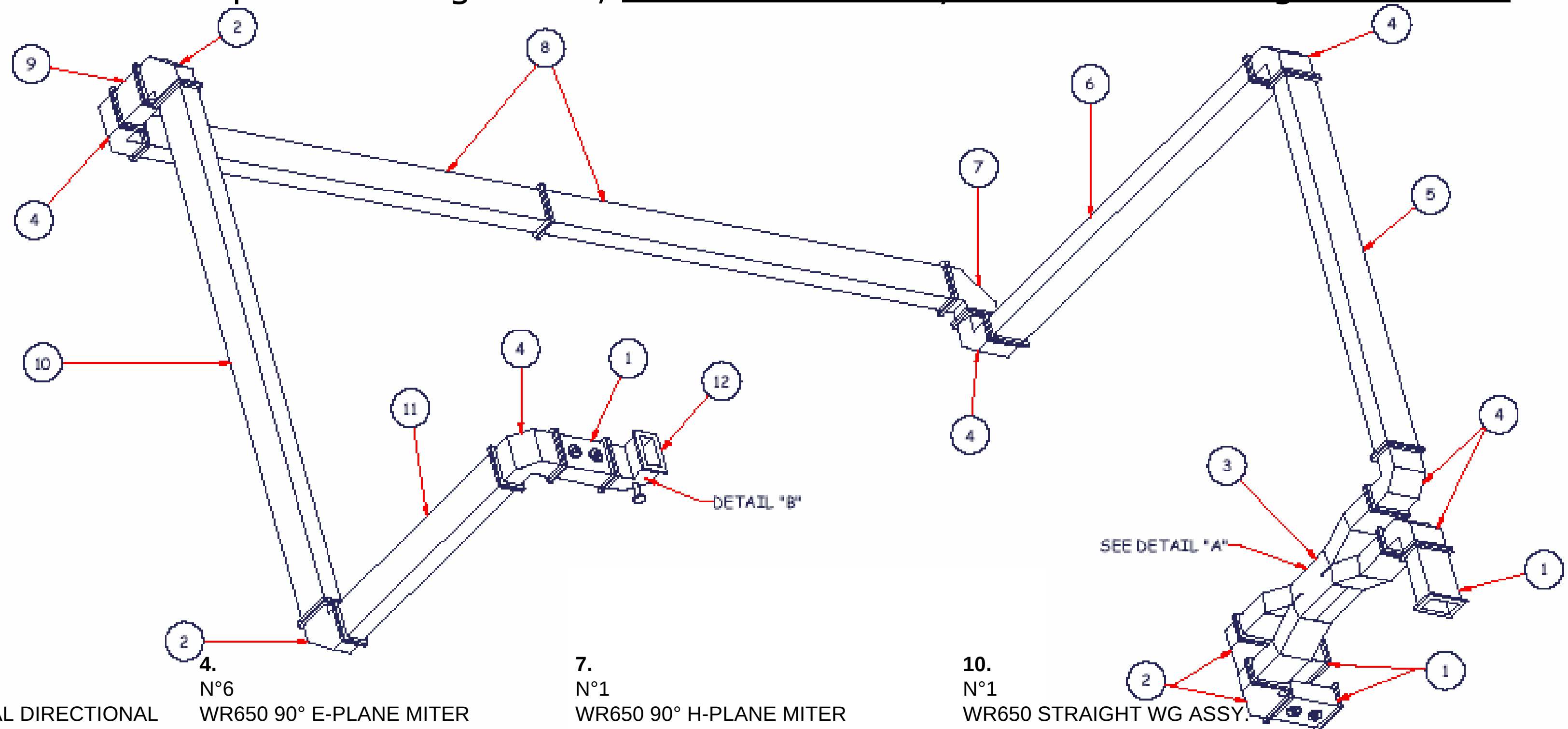



Septa magnets
3 dB coupler
directional couplers
deflector
RF windows SF6 / vacuum
port for vacuum pumping

The RF windows (and the load) have been already ordered from Thales Electron Devices.
They are basically the same window that is mounted on the klystron output.
The wave reflected at the cavity input gives rise to a partly standing wave configuration in the deflector wg coupler.
It is safer for the ceramic if the window is placed in a position where the E field has a minimum.
The length of the wg coupler has been designed to satisfy this condition.



The 3 dB hybrid, all the wgs and the bends needed from the klystron output to the deflector and 4 directional couplers for diagnostics, have been already ordered from Mega Industries.



1.
N°4
WR650 CPLR DUAL DIRECTIONAL REFLECTOMETER
MEGA CAT. NO.: 3719200
COUPLING: 60dB
LENGTH: 12 INCHES
FLANGES: 650CPRG

2.
N°4
WR650 90° H-PLANE MITER ELBOW
MEGA CAT. NO.: 3707001
LEG LENGTH: 6 X 6 INCHES
FLANGES: 650CPRF

3.
N°1
WR650 E-PLANE 3dB HYBRID
AMPLITUDE BALANCE: ± 0.25 dB
PHASE BALANCE: 90° ± 2°
ISOLATIOIN: 28 dB MINIMUM
VSWR: 1.10:1 MAXIMUM
FLANGES: 650CPRG

4.
N°6
WR650 90° E-PLANE MITER ELBOW
MEGA CAT. NO.: 3706001
LEG LENGTH: 6 X 6 INCHES
FLANGES: 650CPRF

5.
N°1
WR650 STRAIGHT WG ASSY. RIBBED
MEGA CAT. NO.: 370300X
LENGTH: 2150mm
FLANGES: 650CPRG

6.
N°1
WR650 STRAIGHT WG ASSY. RIBBED
MEGA CAT. NO.: 370300X
LENGTH: 2212mm
FLANGES: 650CPRG

7.
N°1
WR650 90° H-PLANE MITER ELBOW
MEGA CAT. NO.: 3707001
LEG LENGTH: 6 X 6 INCHES
FLANGES: 650CPRG

8.
N°2
WR650 STRAIGHT WG ASSY. RIBBED
MEGA CAT. NO.: 370300X
LENGTH: 2400mm
FLANGES: 650CPRF (ONE SIDE) / 650CPRG (OTHER SIDE)

9.
N°1
WR650 STRAIGHT WG ASSY. RIBBED
MEGA CAT. NO.: 370300X
LENGTH: 200mm
FLANGES: 650CPRG

10.
N°1
WR650 STRAIGHT WG ASSY. RIBBED
MEGA CAT. NO.:370300X
LENGTH: 2995mm
FLANGES: 650CPRG

11.
N°1
WR650 STRAIGHT WG ASSY. RIBBED
MEGA CAT. NO.: 370300X
LENGTH: 1323mm
FLANGES: 650CPRG

12.
N°1
WR650 90° E-PLANE MITER ELBOW
MEGA CAT. NO.: 3706001
FLANGES: 650CPRG/CPRF, MODIFIED WITH 1 PIPE CONNECTION FOR SF6 INPUT SUPPLIED BY CUSTOMER
LEG LENGTH: 6 X 6 INCHES