Tapered coaxial coupler

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Design Changes

Previous design

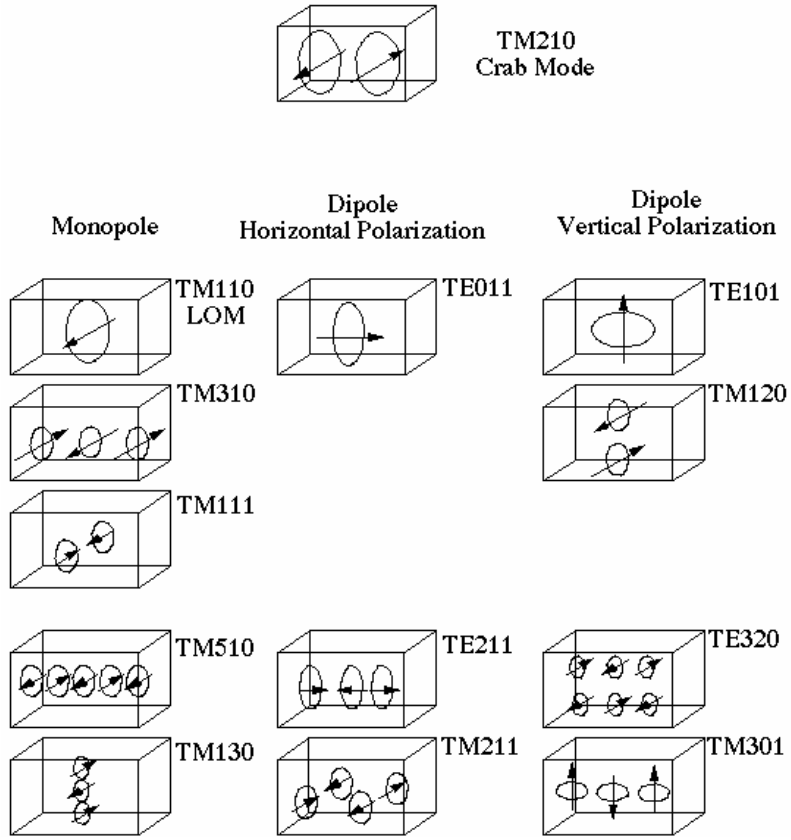
Straight coaxial coupler
HOM/LOM damping of the cavity : OK
Mode damping in the coupler: insufficient
Dangerous parasitic modes in the coupler.
The most dangerous mode is 1/4λ mode which has high Q-factor.

Current design

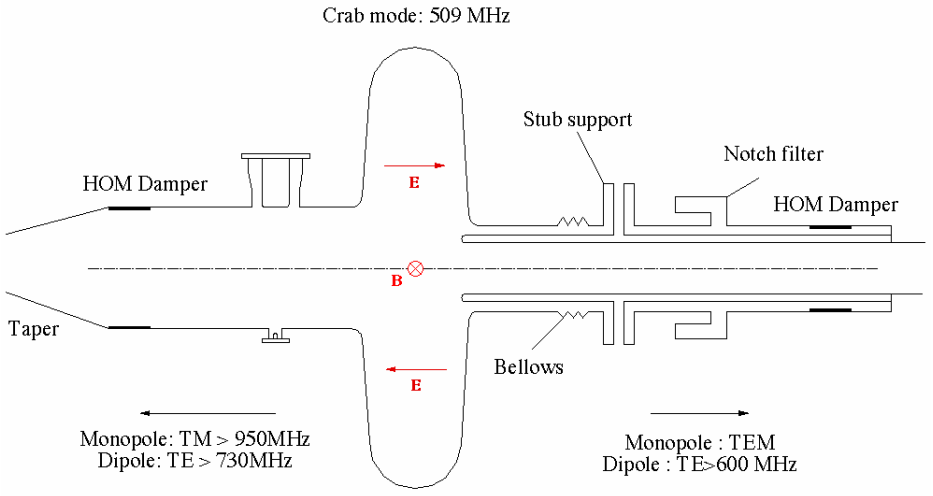
Three modifications applied
- Tapered coaxial coupler
- Tip cutting design
- TE-mode stop band splitting of notch filter

Large HOM damper

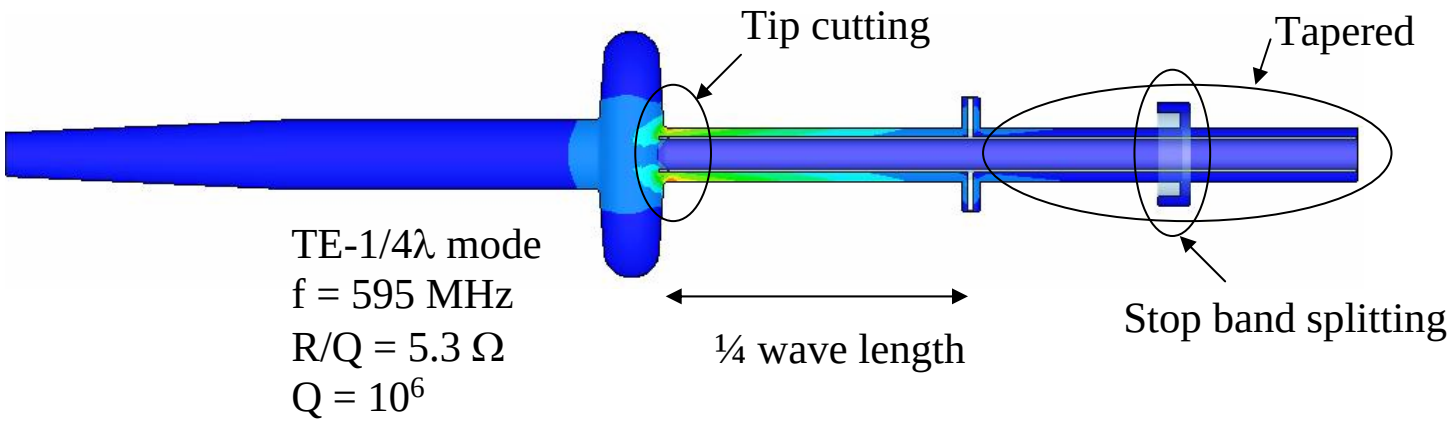
HOM damping scheme



Monopole modes (including LOM) can propagate along the coaxial coupler.
Dipole modes above 600 MHz can propagate.
Crab mode (509 MHz) can not propagate.
Attenuation factor of this mode : 60 dB/m
If the coupler deflects, crab mode can propagate as TEM mode in the coupler.
Notch filter push this mode back to the cavity.



Parasitic mode in the coaxial coupler



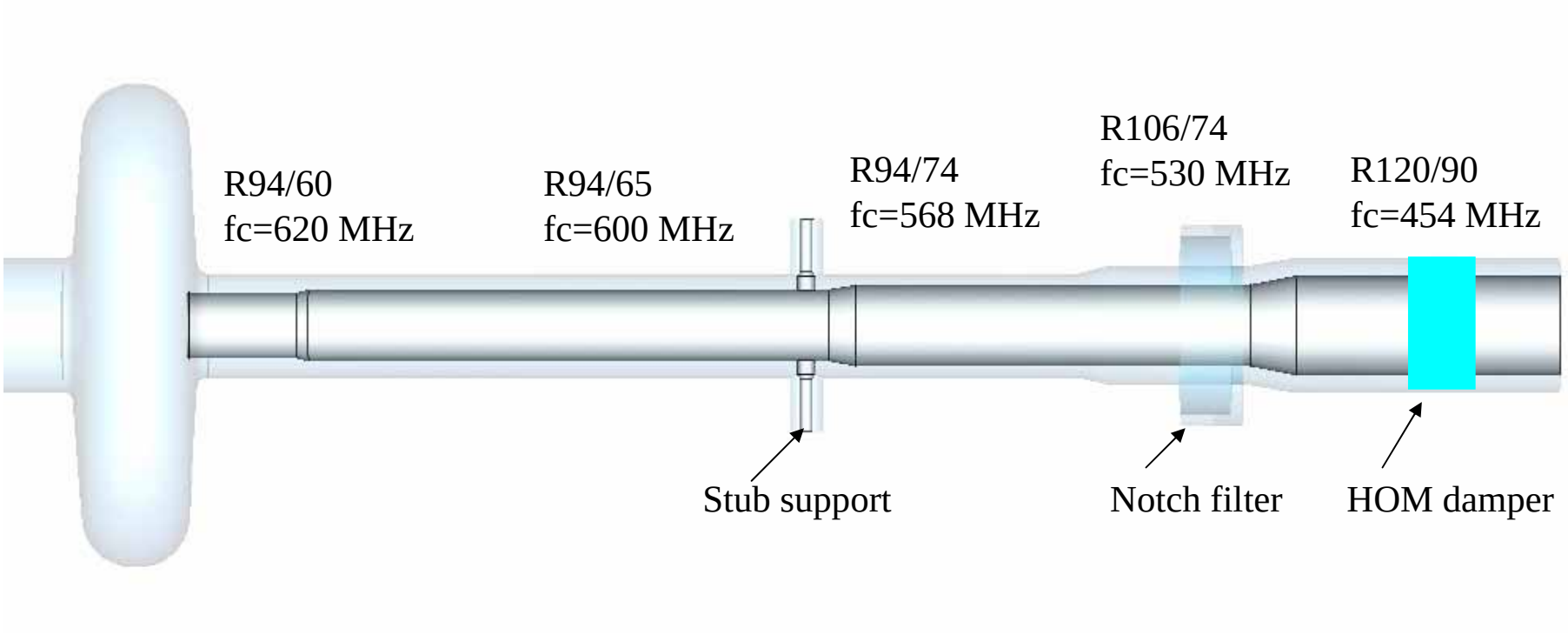
Coaxial coupler has parasitic modes.
The most dangerous mode is the TE-1/4λ mode.
High R/Q (5.3Ω) and lower f than cut-off.
Can not propagate to HOM damper.
This mode remains with high Q factor and gives high impedance.

Three modifications were applied to extract this mode.

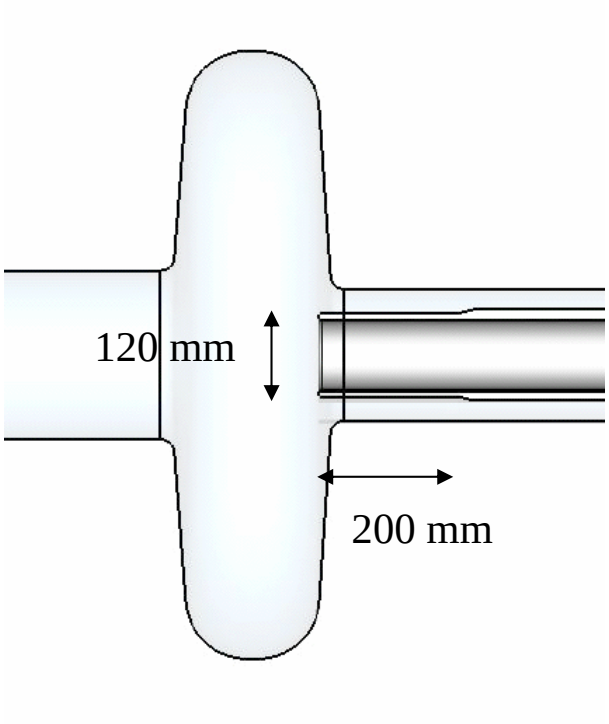
1. Tapered coupler design for lower cut-off.
2. Tip cutting design for raising f of TE-1/4λ mode.
3. TE stop band splitting of notch filter.

Tapered coaxial coupler design

Coaxial coupler has several tapered sections.
Decrease cut-off frequency (fc) for TE-mode propagation.



Tip cutting design



To raise the frequency of TE-1/4λ mode, outer diameter of the coupler is adjusted to 120 mm, which gives the cut-off of 620 MHz.

Tip cutting design makes TE-1/4λ mode above 600 MHz and lower R/Q.

Effect of tip cutting design
Δf, Δf/ΔL, Qext and R/Q

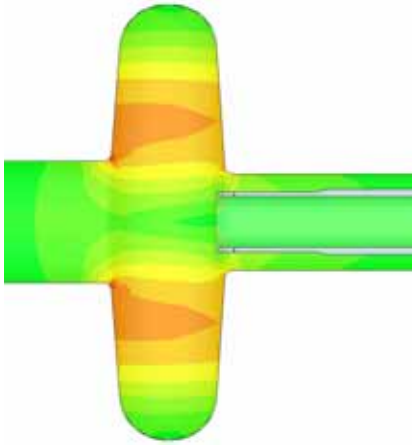
Frequency shift of the crab mode
Tuning parameter Δf/ΔL
External Q factor of the TM110 mode (LOM)
R/Q of TE-1/4λ mode

The coupler has to be inserted 5 mm
to compensate frequency shift of crab mode.

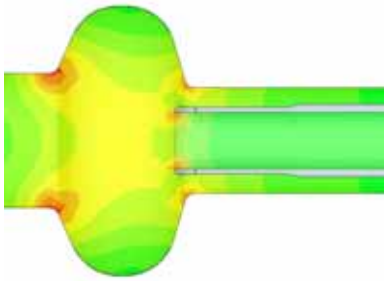
	Δf(crab)	Δf/ΔL	Qext(LOM)	R/Q(TE-1/4l)
No cutting		30 kHz/mm	69	5.2 Ω
Tip cutting	-145kHz	30 kHz/mm	58	2.1 Ω

Effect of tip cutting design

Electro-magnetic property



Electric field



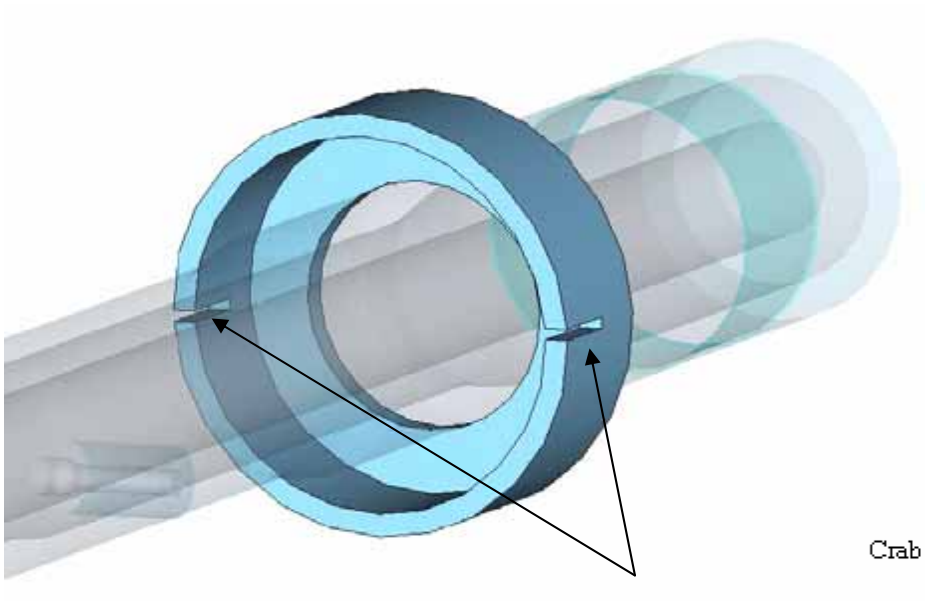
Magnetic field

Peak fields at the tip of coupler were calculated using MAFIA.
Tip cutting design has lower peak electric field, although the tip was inserted 5mm.

Peak electric and magnetic fields.
Operating kick voltage: 1.44 MV

Tip cutting	5.5 MV/m	420 G
Tip cutting +10mm insertion	6.5 MV/m	447 G
No cutting	6.7 MV/m	420 G

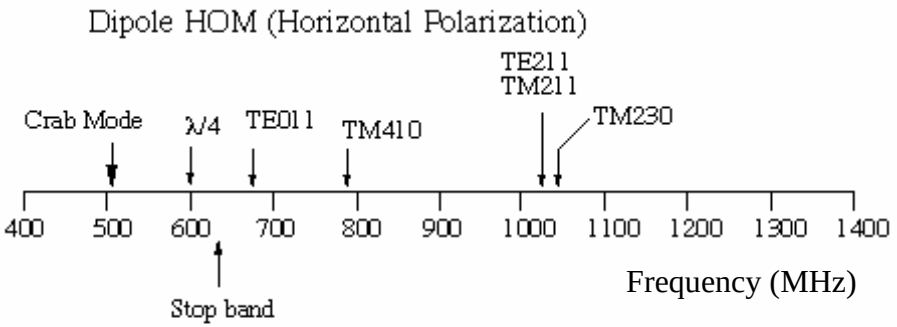
Stop band splitting design of the notch filter

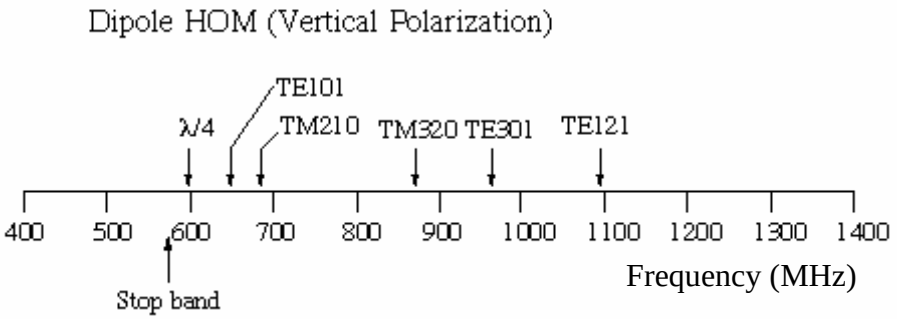


Previous design has a stop band at 630 MHz for TE mode. This band is close to the TE-1/4λ mode.

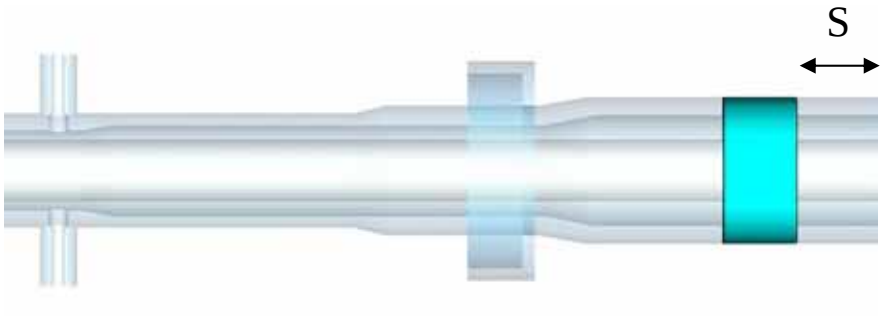
Stop band splitting notch filter has partitions in mid-plane to separate stop bands for horizontally polarized TE mode (650 MHz) and vertically polarized one (570 MHz).

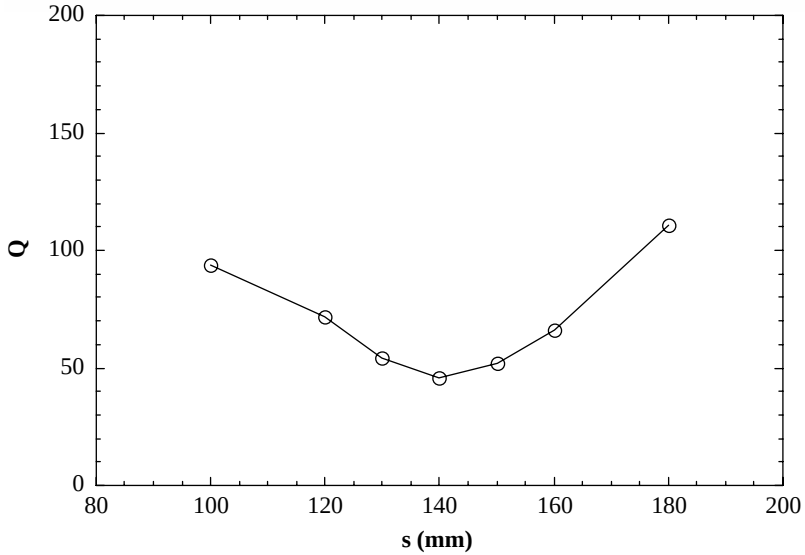
Stop band (H-V splitting)	
TEM	509 MHz
TE(H)	650 MHz
TE(V)	570 MHz





HOM damper



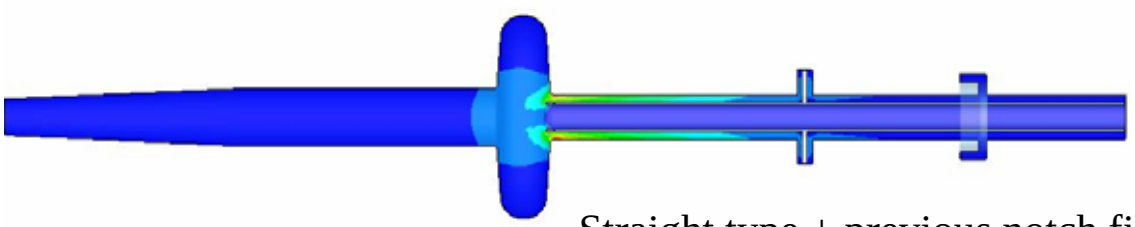


Q factor of the TM110 mode (LOM) as a function of damper position.

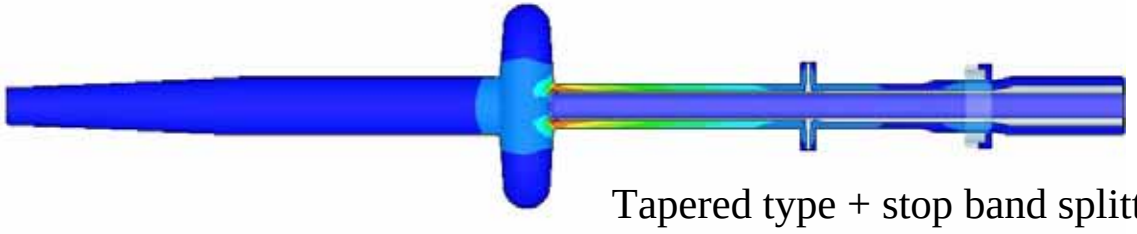
HOM damper
Ferrite RF absorber
Size: 240ϕ x 120 mm
Exactly the same size of LBP damper

Position of the damper was optimized to give minimum Q factor of LOM.

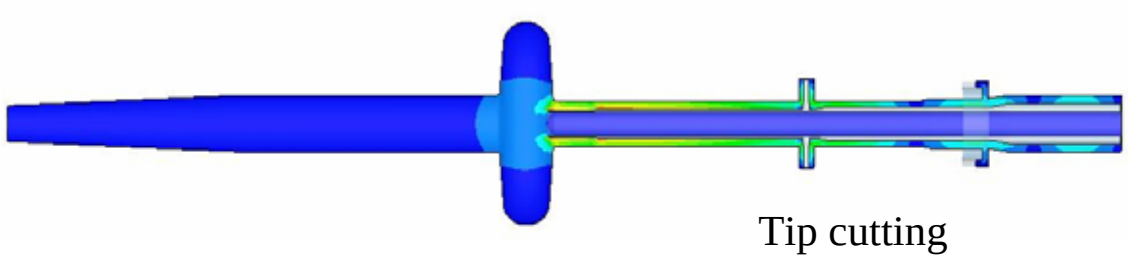
Comparison of TE-1/4λ mode damping



Straight type + previous notch filter



Tapered type + stop band splitting notch



Tip cutting

Type	f	R/Q(MWS)	Q(HFSS)
Straight	595 MHz	5.7 Ω	10^6
Tapered	602 MHz	5.2 Ω	5800
Tapered + tip cutting	607 MHz	2.1 Ω	2700

Q and R/Q of LOM/HOM

Mode	f (MHz)	R/Q (Ω)	Q
Monopole			
TM110	406 /406*	80 /80*	48 /25*
TM310	684	20	47
TM111	894	11	60
TM510	980	0.16	3200
Dipole (H)			
l/4λ	602 /607*	5.2 /2.1*	5800 /2700*
TE011	707	3.1	143
TM410	834	6.8	107
TE211	927	2.1	83
Dipole (V)			
l/4λ	597 /602*	5.0 /2.8*	1700 /1000*
TE101	641	10	181
TM210	661	4.9	47
TM320	909	3.0	185

Calculation results

f, Q : calculated by HFSS
R/Q : calculated by MWS
* tip cutting

summary

Coaxial coupler has dangerous parasitic modes with high Q factor.
Three modifications were applied.

- Tapered coaxial coupler design
- Tip cutting
- TE stop band splitting of notch filter

without disturbing mode-damping of the cavity.
Mode damping of the coaxial coupler was drastically improved.

Tapered coaxial coupler with stop band splitting notch filter is being assembled for low current operation.

Tip cutting design can be used for high current operation
Should be tested before installation.