New scheme of HOM damping of L-band cavity using a radial transmission line

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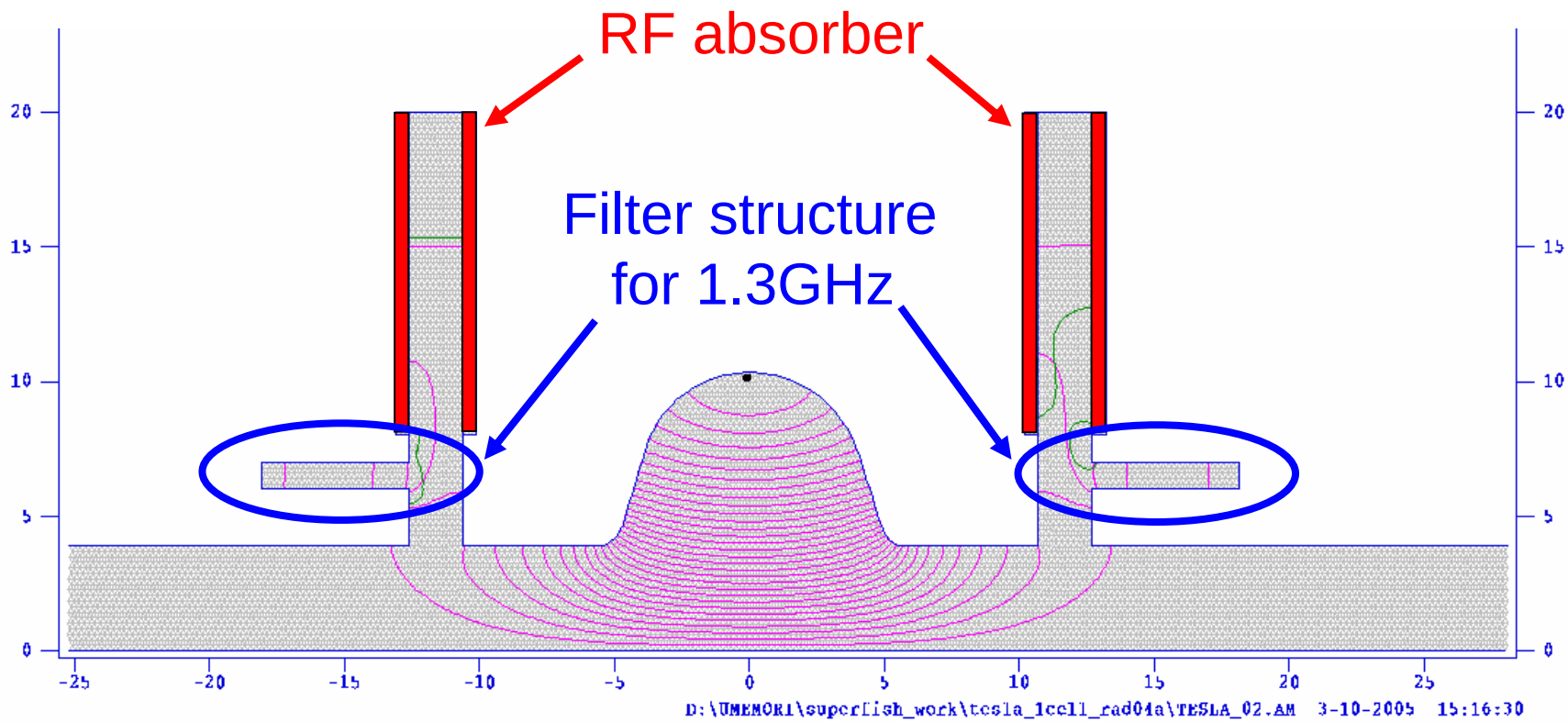
Concept of HOM damper using a radial transmission line with filter structure



Original idea was proposed by T. Shintake for normal conducting cavity.

Feature of radial line damper with filter structure

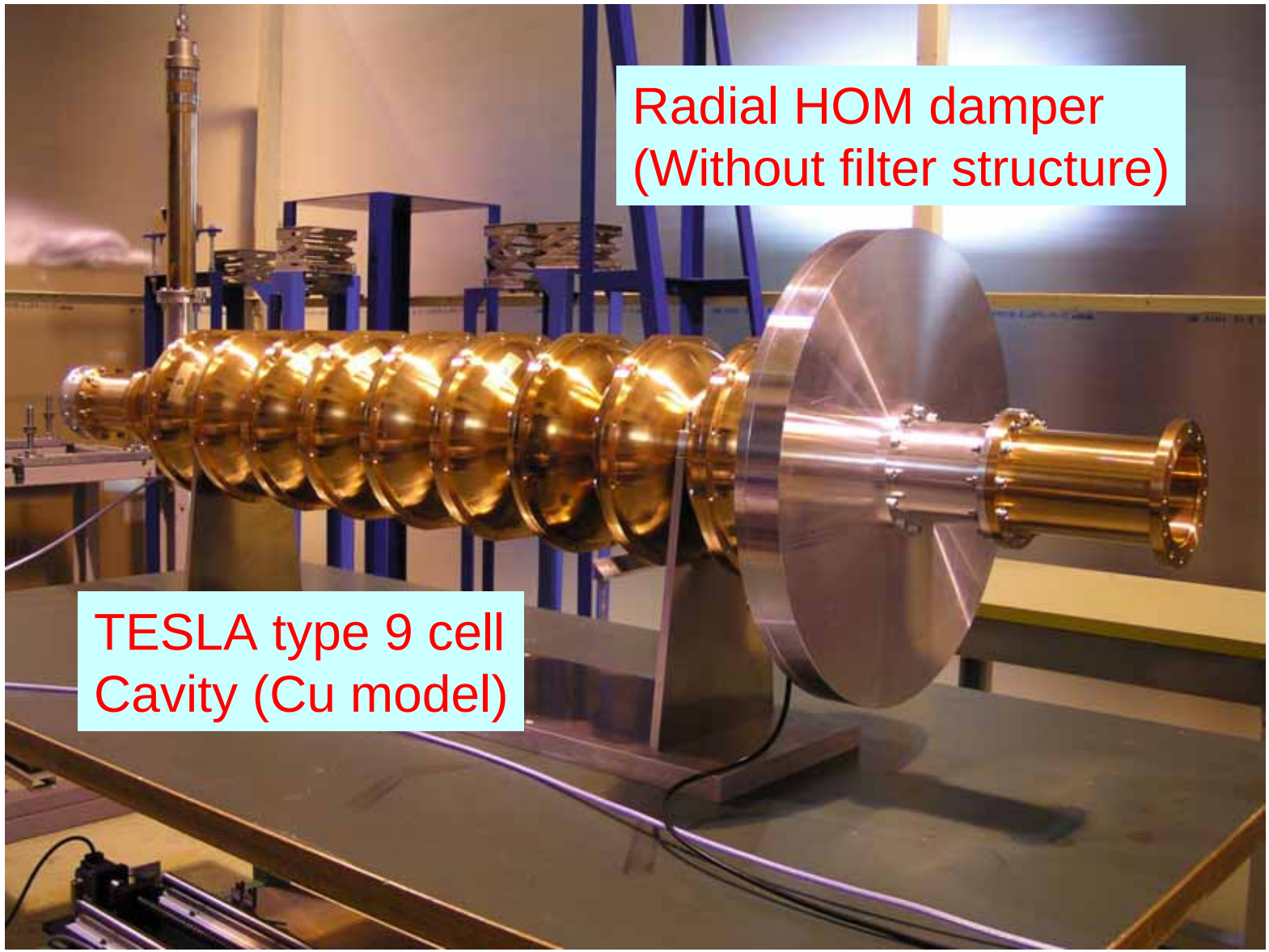
- Strong damping is expected
  - But, need filter for acceleration mode
- Broadband
- Effective for all polarizations
- Quadrupole modes can be damped

Simulation (MAFIA, 1cell)

- Estimation by perturbation method using MAFIA.
- Q value of the fundamental mode can be kept $>10^8$.
- All dipole and monopole modes, except TM010, can be damped to < a few thousands.
- Quadrupole modes can be also damped to $\sim 10^6$.
- The results are very promising.

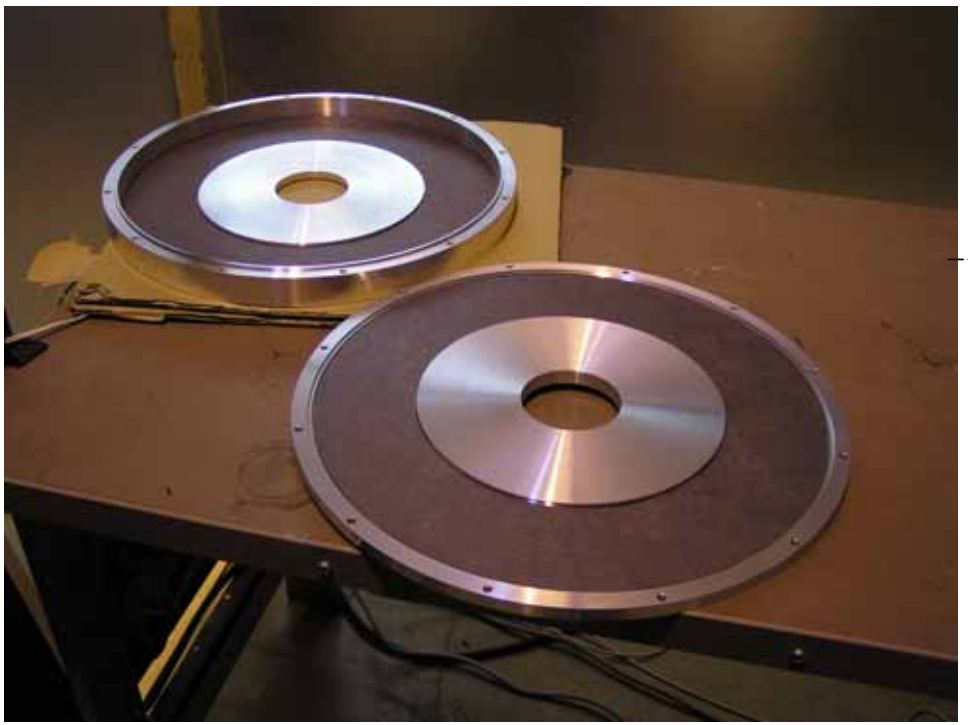
Freq. [MHz]	Mode	Q	Rsh/Q [ohm]	Rt/Q [ohm/cm^2]	Rt/Q [ohm/cm^4]
1301	TM010	4.3×10^8	105.6		
1673	TE111	118		14.9	
1835	TM110	3343		31.7	
2294	TE221	2.4×10^6			2.3×10^{-3}
2426	TM011	2332	29.6	1.5	
2473	TE211	1.5×10^6			1.7×10^{-3}
2696	TM020	875	0.3	1.0	

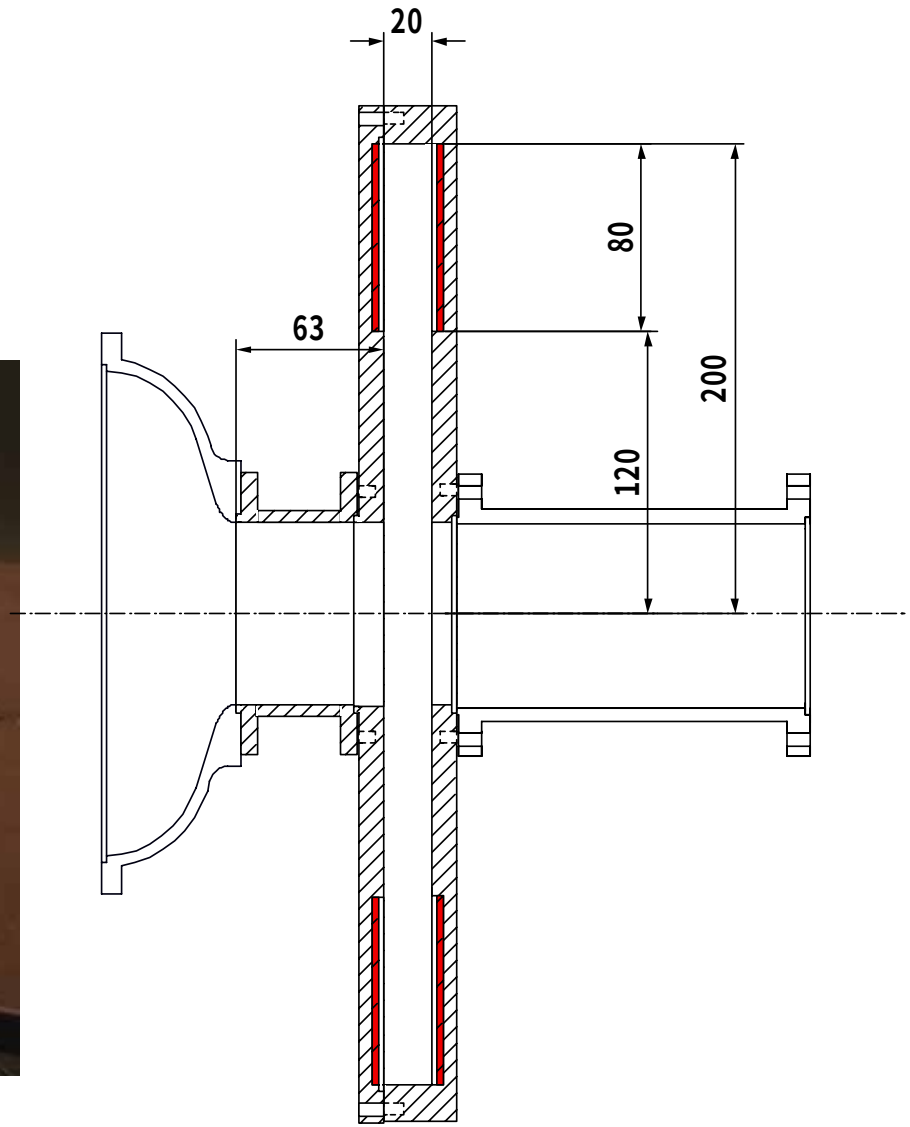
Model of HOM damper and cavity



RF absorber

(TDK IRL02, 2mm thick)



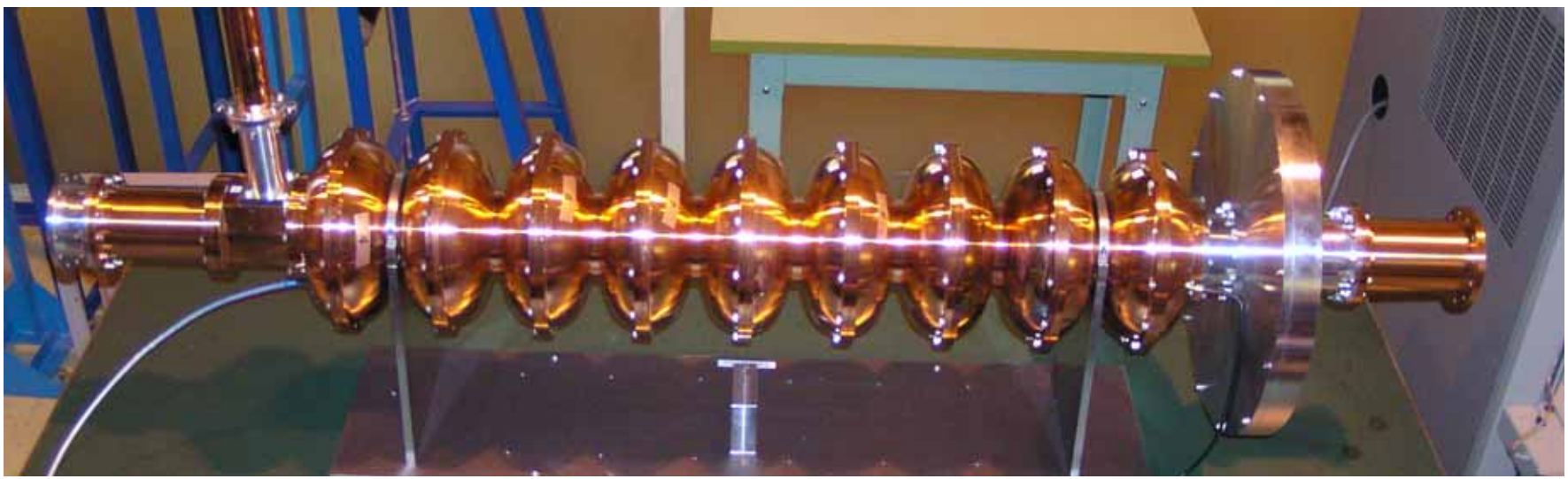


$\varepsilon' = 207.0 \quad \varepsilon'' = 8.5 \quad \mu' = 5.1 \quad \mu'' = 6.3 \quad @\,2GHz$

Low power measurements

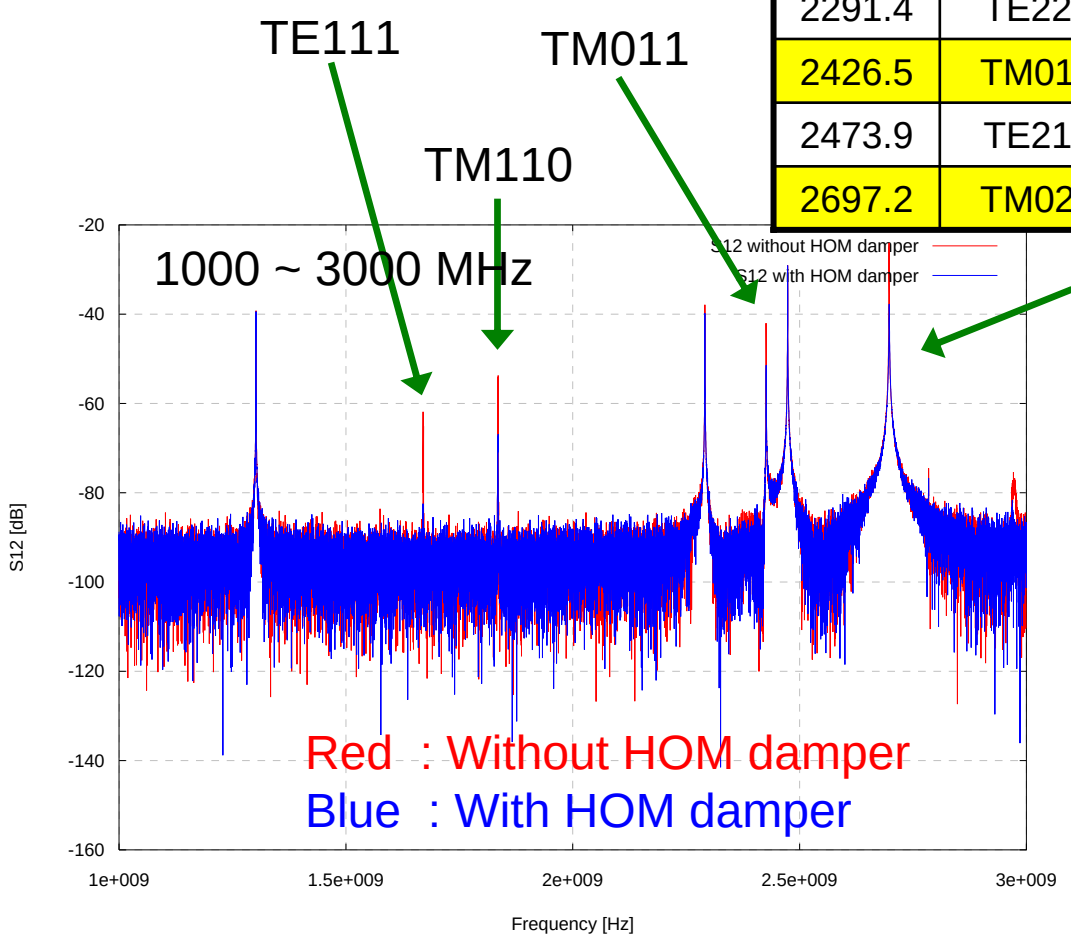
Aimed to investigate the feature of radial HOM damper.

HOM damper was located 6cm away from right side end cell.
---- Optimized for 1cell, but not for 9cell



Results (1cell)

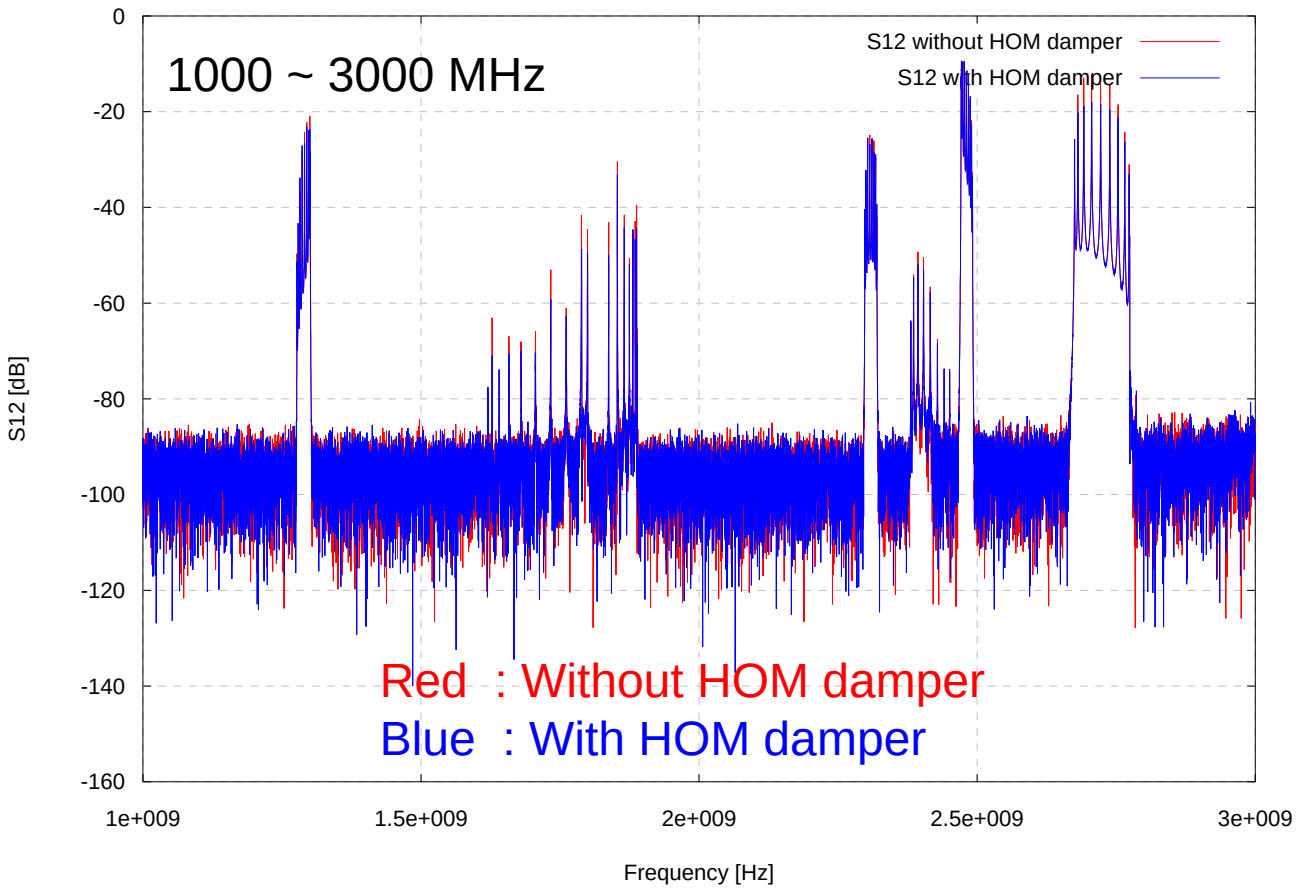
Freq.	Mode	Q value w/o damper	Q value w/ damper	External Q of damper
1301.6	TM010	27073	25803	550234
1670.0	TE111-1	25447	2758	3093
1671.0	TE111-2	25675	2609	2904
1834.4	TM110-1	27249	5637	7170
1835.5	TM110-2	24927	5464	6998
2291.4	TE221	31936	30726	811134
2426.5	TM011	26964	7649	10670
2473.9	TE211	31414	30688	1326699
2697.2	TM020	26198	3660	4255



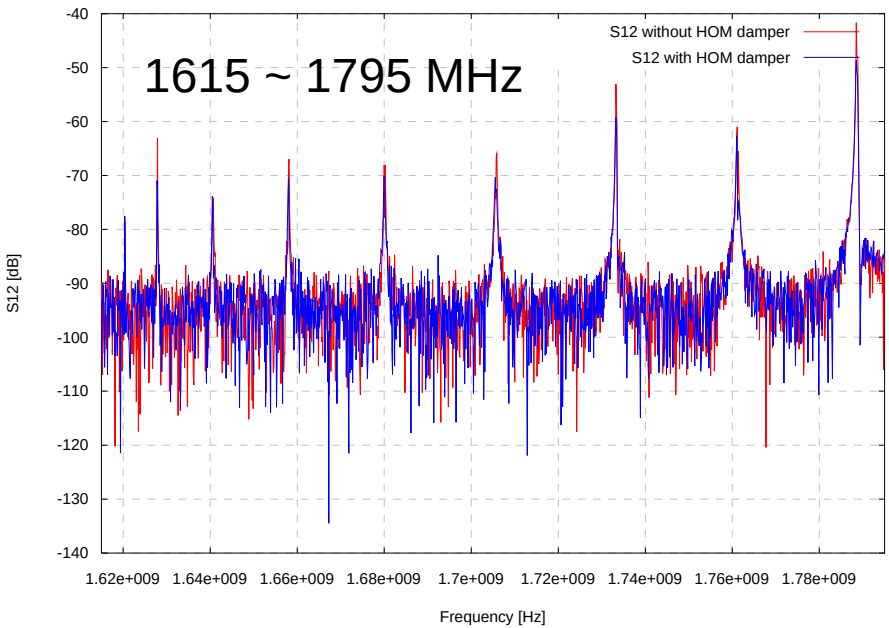
Dipole and monopole modes are damped to several thousands.

Results (9cell)

Frequency	Mode	External Q of damper
1620~1789	TE111	$1x10^4$ ~ $1x10^5$
1799~1889	TM110	$2x10^4$ ~ $1x10^6$?
2381~2457	TM011	$5x10^4$ ~ $1x10^6$?
2675~2773	TM020	$2x10^4$ ~ $3x10^5$?



Results (1cell)
TE111 mode



Red : Without HOM damper

Blue : With HOM damper

Freq.	Mode	Q value w/o damper	Q value w/ damper	External Q of Damper
1620.4	TE111-1	20936	16682	82096
1620.4	2	21278	18278	129631
1627.8	3	20011	13695	43391
1627.8	4	19556	13076	39456
1640.5	5	20726	11094	23871
1640.6	6	20479	10883	23227
1658.1	7	21197	9782	18164
1658.2	8	21651	9733	17682
1680.1	9	22044	9141	15616
1680.3	10	22007	8898	14937
1705.6	11	22841	9101	15130
1705.8	12	22648	8788	14359
1733.2	13	24281	9240	14916
1733.4	14	23754	9404	15567
1761.2	15	24935	10036	16795
1761.5	16	24498	10314	17815
1788.5	17	25554	9166	14293
1788.9	18	24817	9356	15017

Discussions

- Further optimization for 9cell cavity.
  - Placing the damper closer to the cavity
  - Preparing the dampers on the both side
  - Larger beampipe radius
  - etc...

    ⟹ possible to damp to $10^3 \sim 10^4$?
- Design and test of filter structure is scheduled.
- R&D for RF absorber
- Is this radial type HOM damper fit in cryo-module?

Summary

- We proposed a new HOM damping scheme, which uses a radial transmission line with filter structure.
- Simulation shows promising results.
- We have carried out low power measurements.
- HOMs are well damped for 1cell case.
- At moment, the results are not enough for 9cell. But good results are anticipated by placing damper closer to the cavity end.
- We anticipate better HOM damping with some improvements.