FPC and HOM Test Boxes

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28/10/15

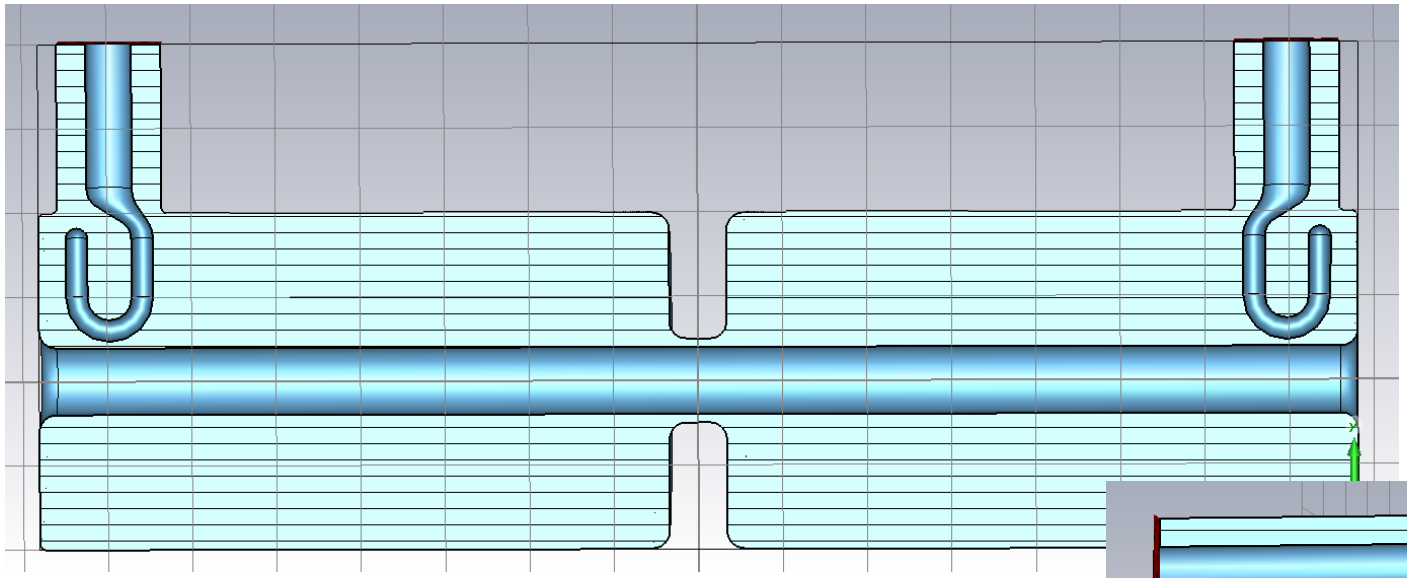
FPC Test Boxes

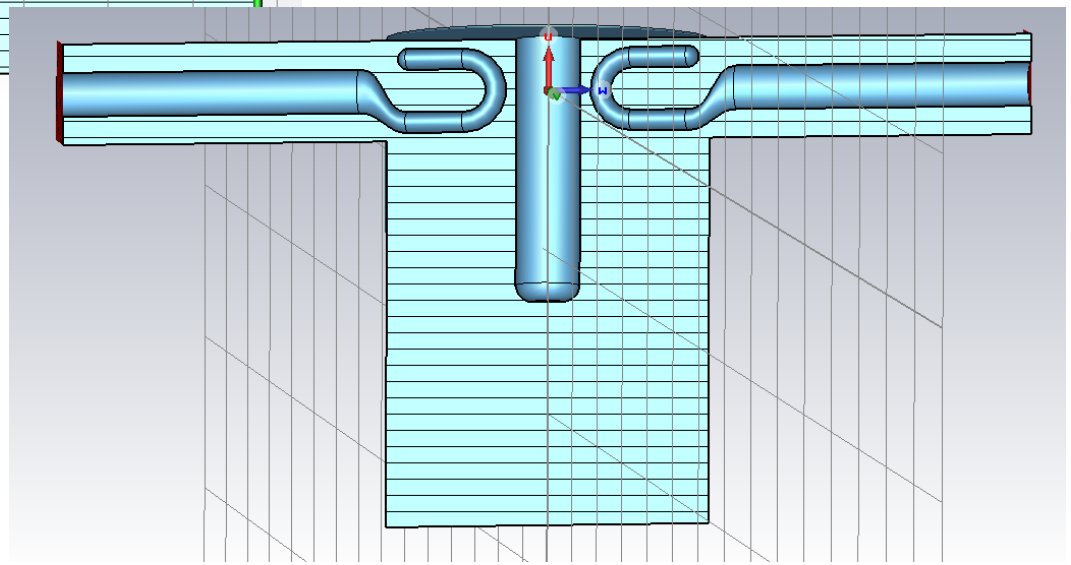
Aim

- Condition the FPCs with up to 0.5MW.
- Maintain peak fields below 3MV/m during conditioning.
- S11<-30dB over 0.5MHz bandwidth.

- There are two FPC designs, one for the RFD cavity, and one for the DQW
- The FPCs for both cavity designs are to be tested in pairs.

Possible designs

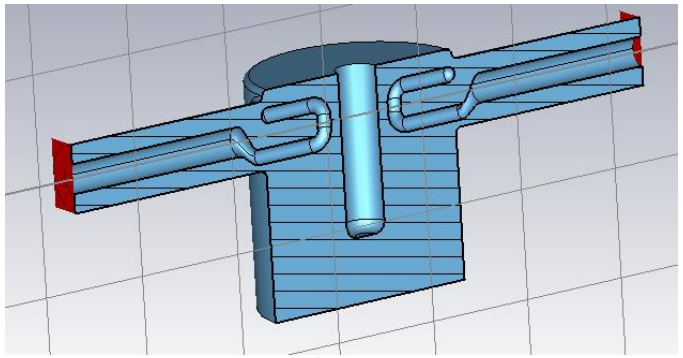




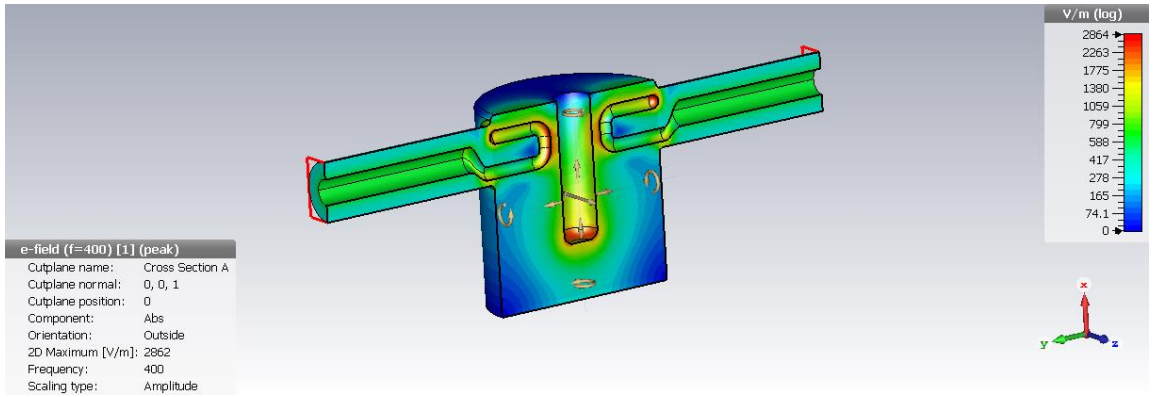
Quarter wave resonator prefer for easier construction and easier tuning.

FPC Test Box Fields

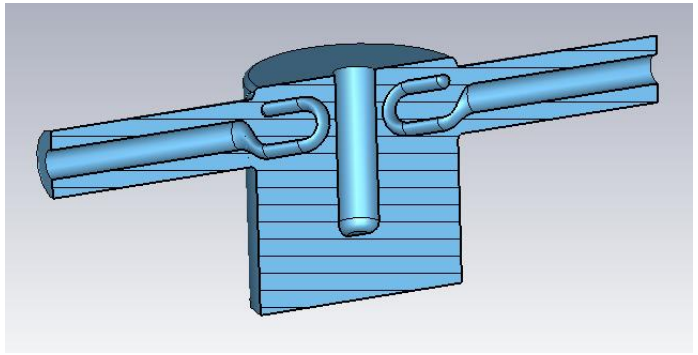
RFD FPC Test Box



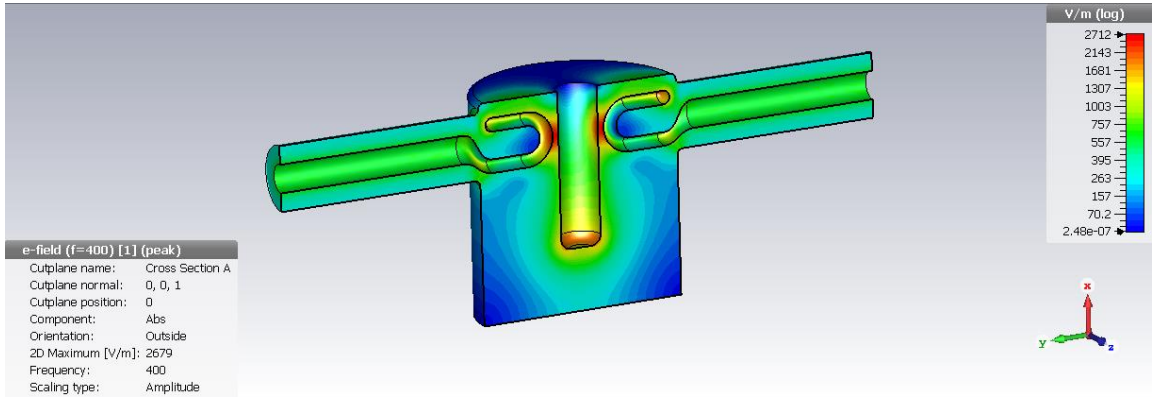
RFD FPC Test Box E field: peak = 2.86MV/m @ 500 kW



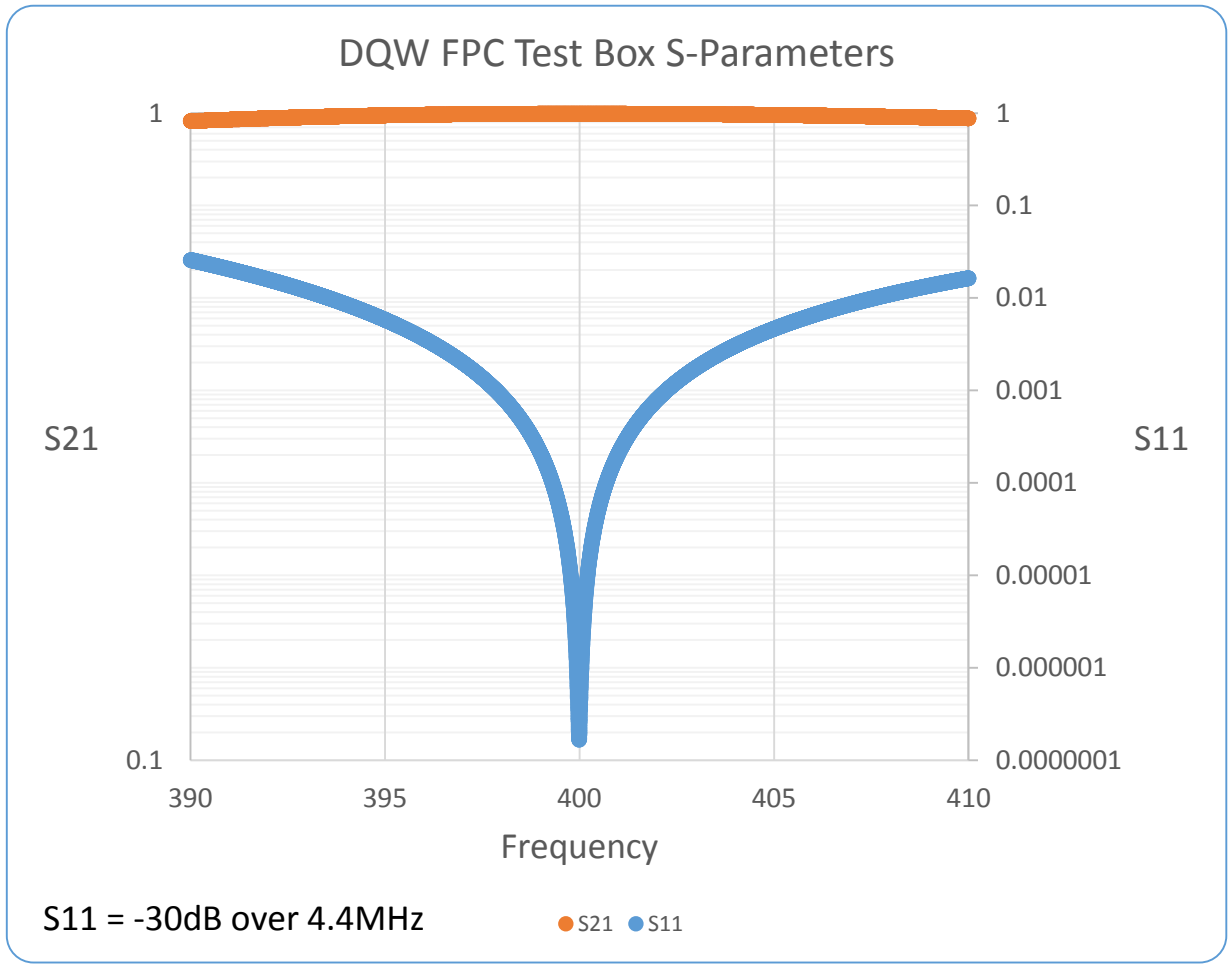
DQW FPC Test Box



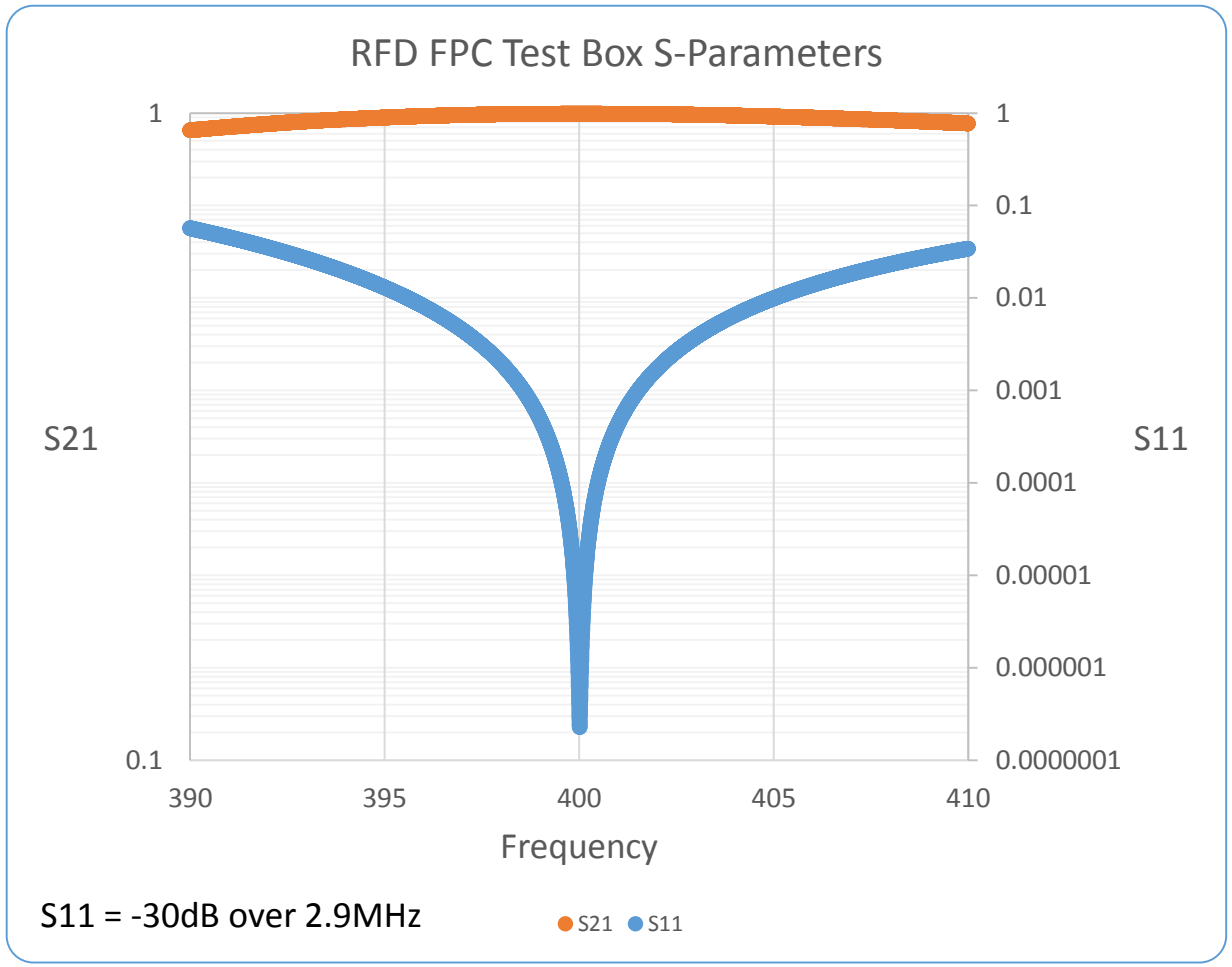
DQW FPC Test Box E field: peak = 2.69MV/m @ 500 kW



S-parameters

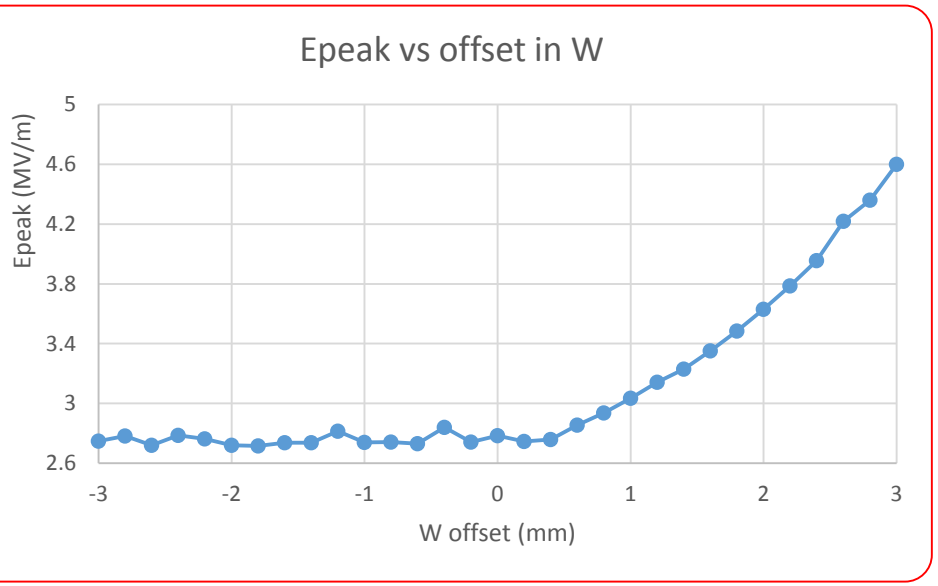


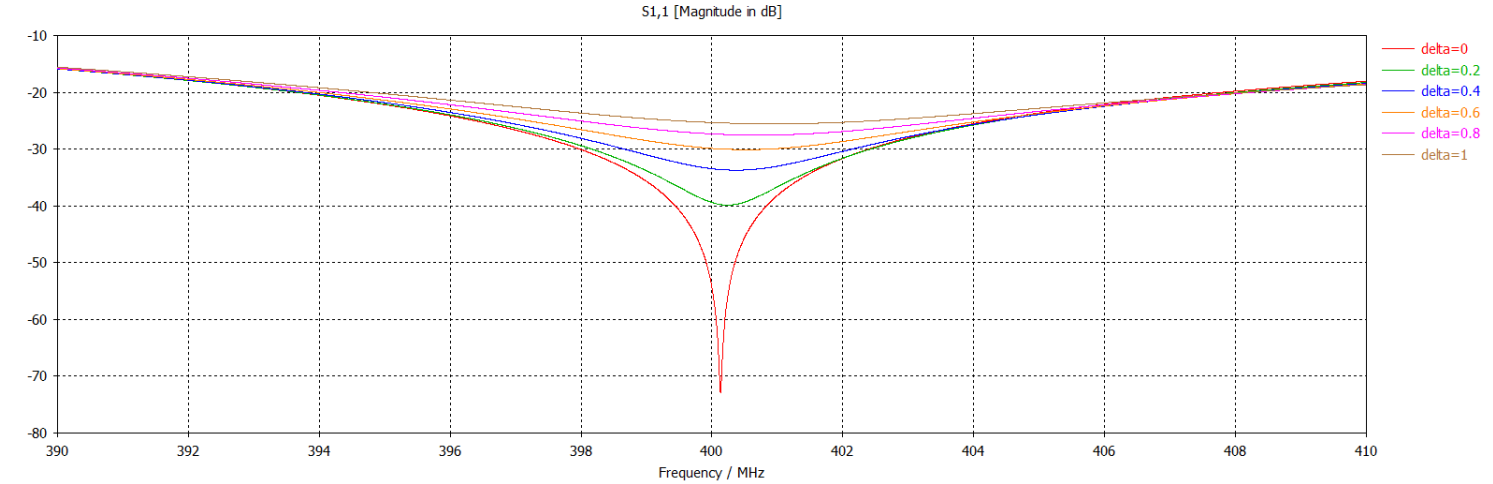
S11 = -30dB over 4.4MHz



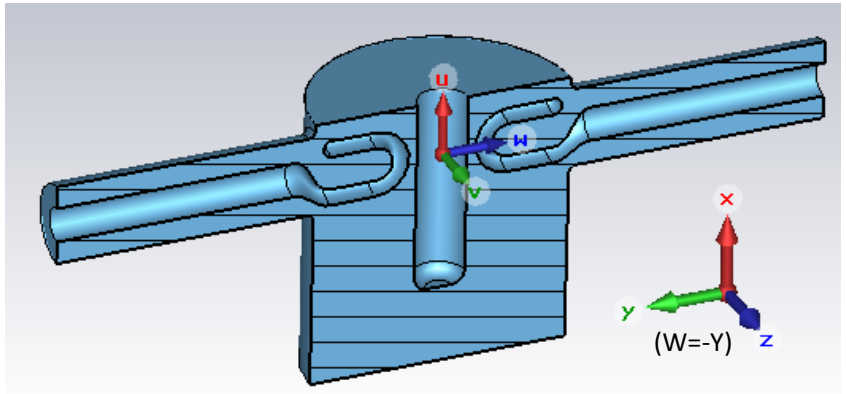
S11 = -30dB over 2.9MHz

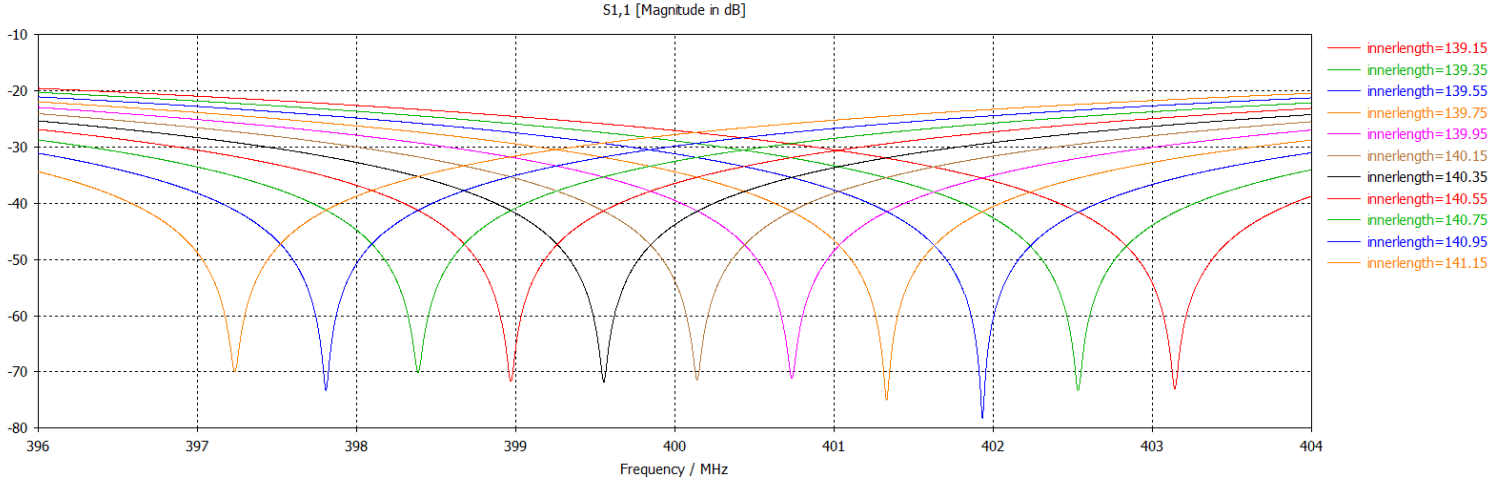
- Both test boxes meet requirements for peak fields and bandwidth.





Hook position in W needs to be within 0.4mm to keep -30dB over ±0.5MHz





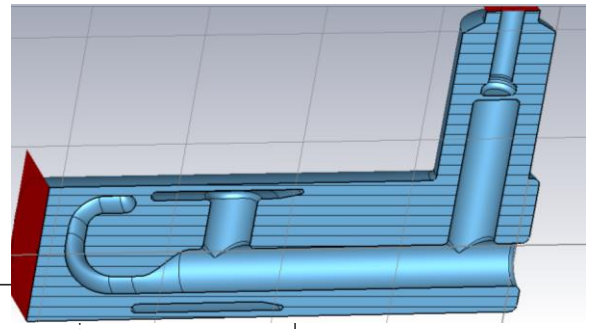
Still have S11<-30dB at 400MHz with inner length 0.6mm from nominal value

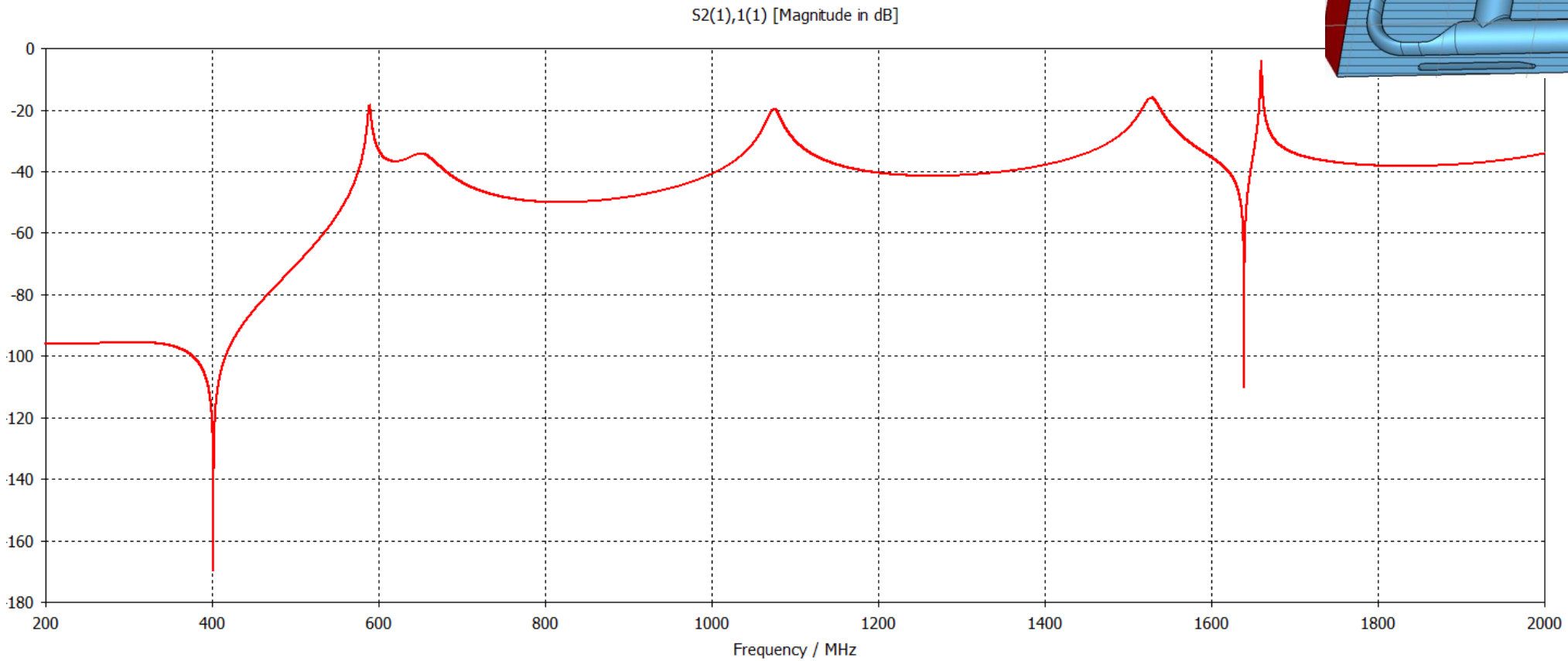
HOM Coupler Test Box – Low Power

- Aim:
  - Analyse the frequency response of the HOM coupler for comparison for simulations
  - Use measurement to guide the tuning of the prototype filters (if required)

- First looking at the DQW HOM couplers, as they are being manufactured first, and are the first which will require testing

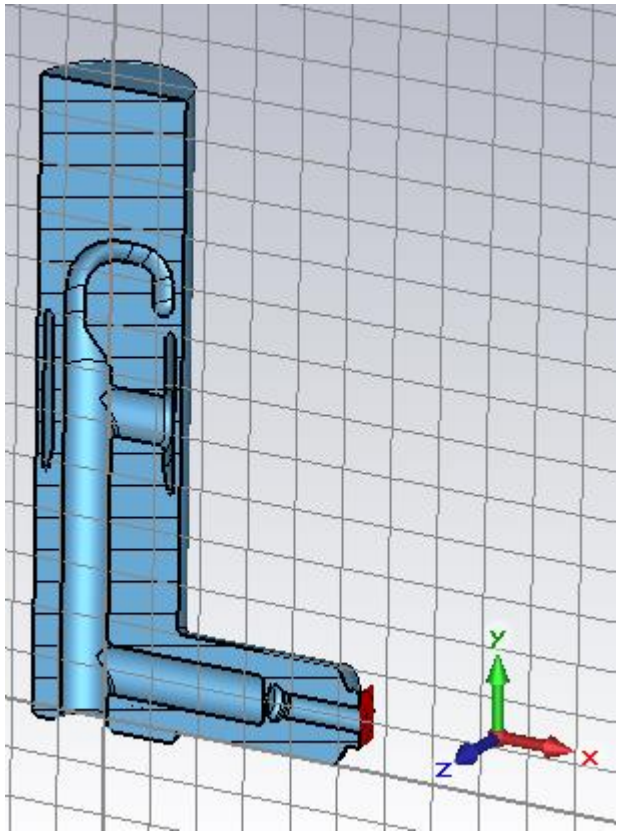
DQW HOM Coupler



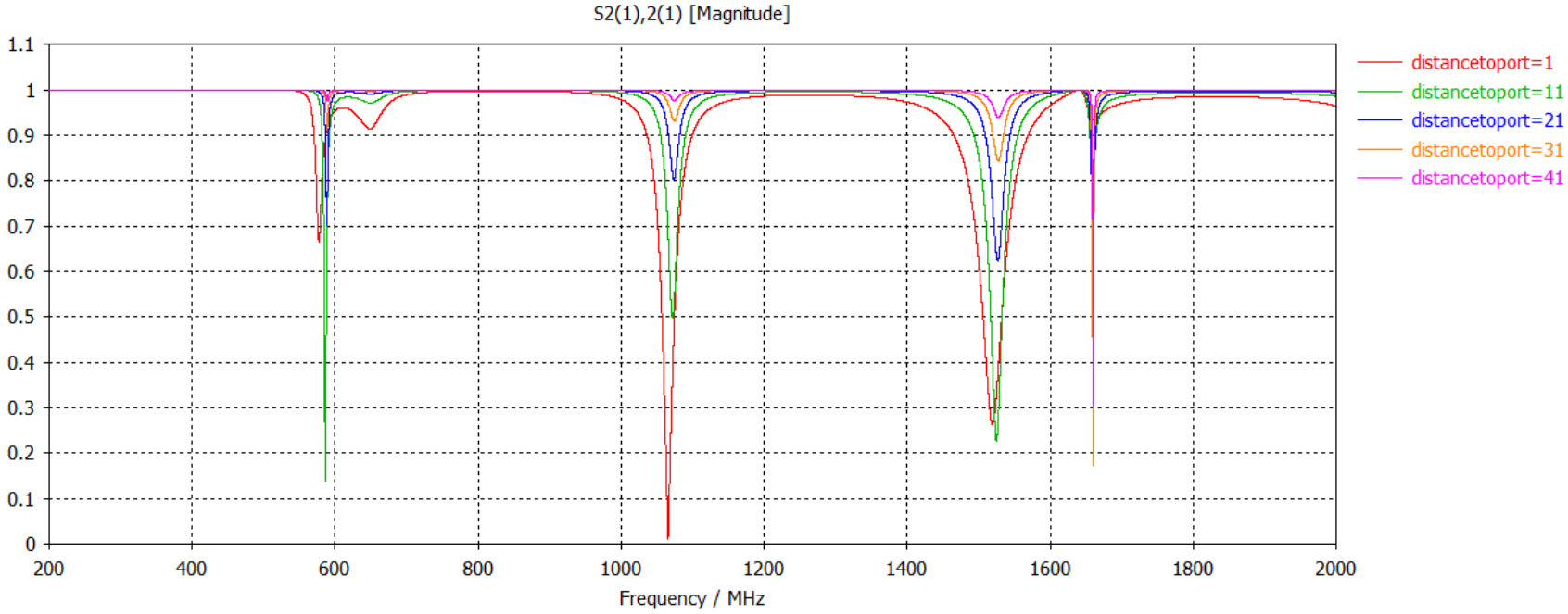


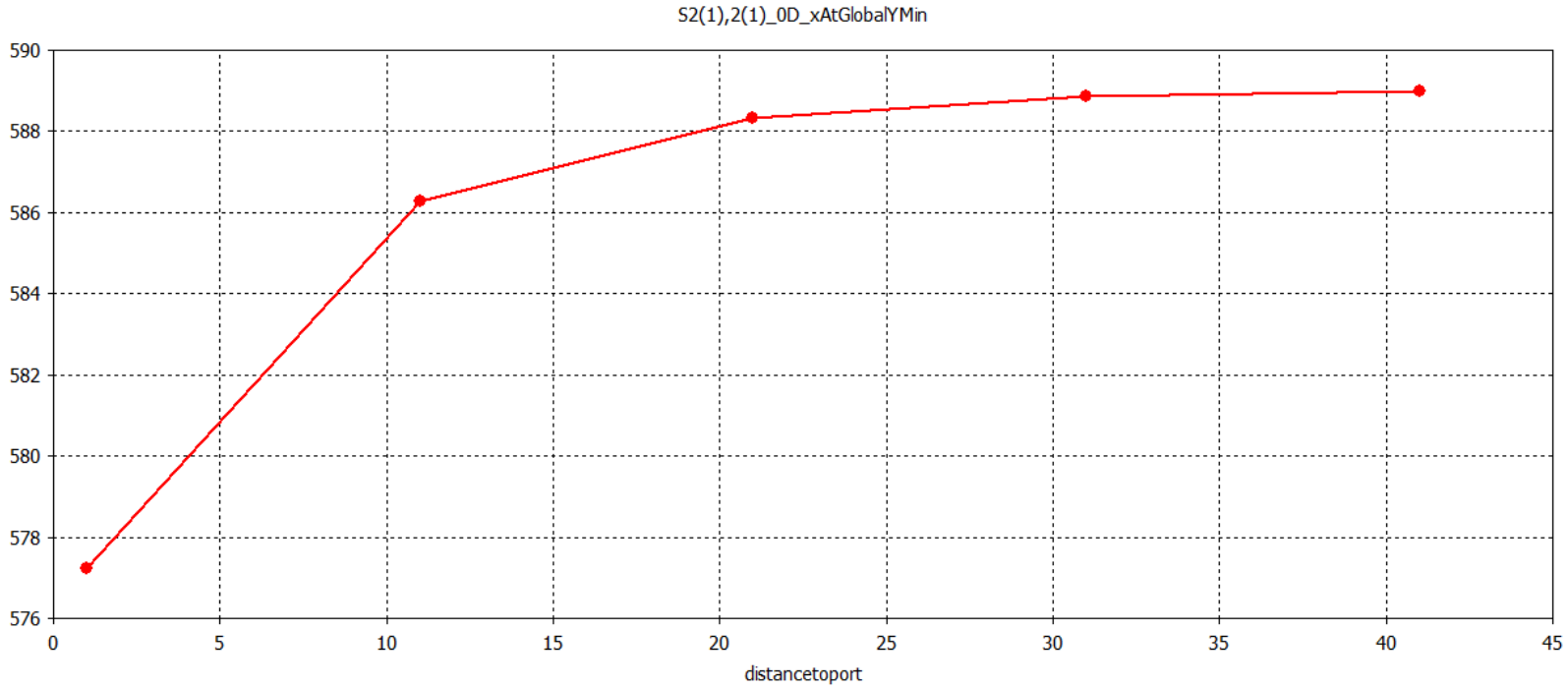
- Most crucial feature is the notch at 400MHz.

Open Boundary



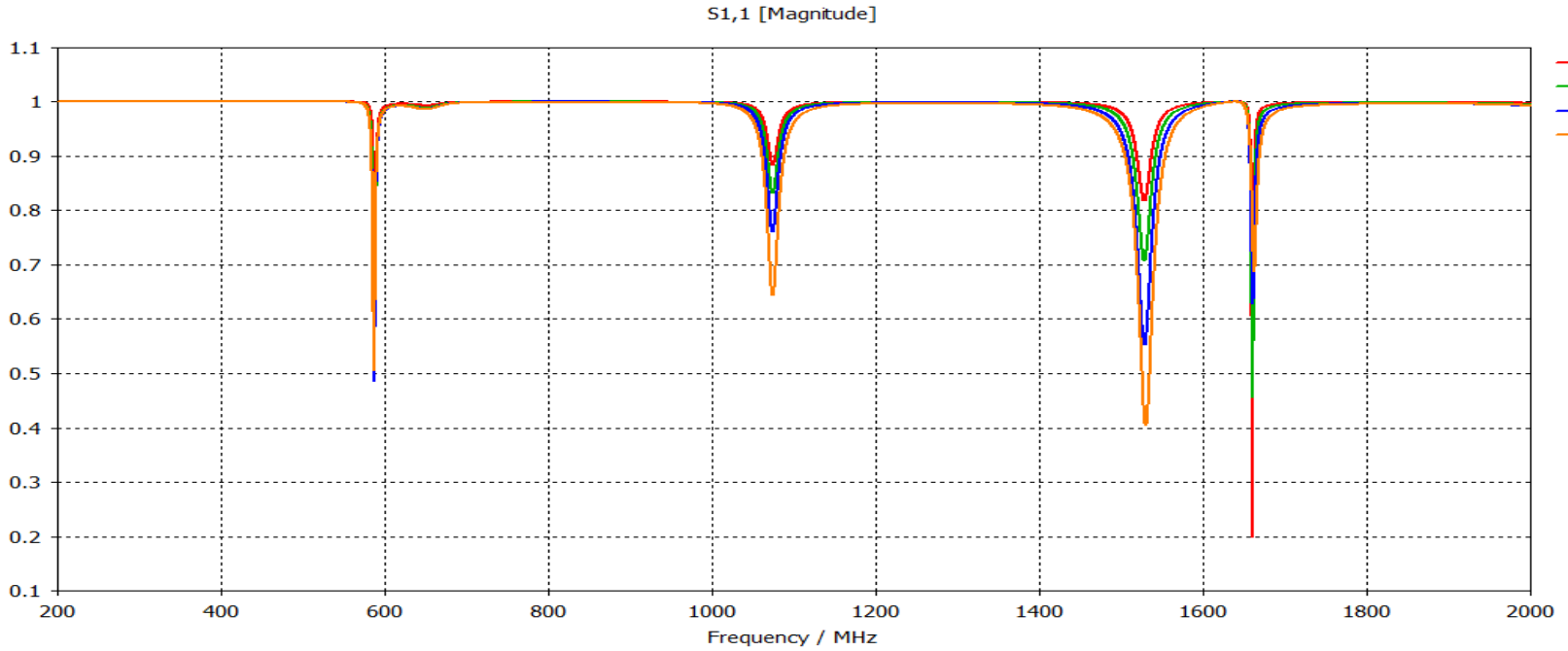
- Open boundary at Y-max.
- Sweeping length of waveguide in Y direction.

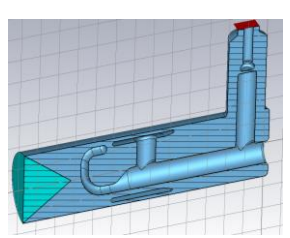


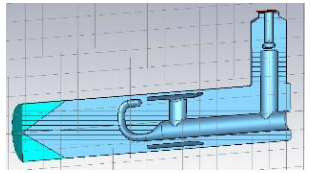


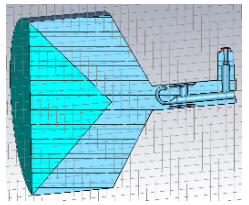
Terminate into Absorber

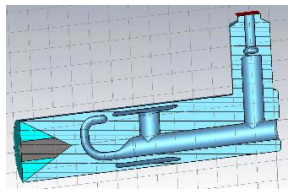
- By choosing the absorber shape, the frequency response is made to match that of an open port.
- Numerous absorber designs considered

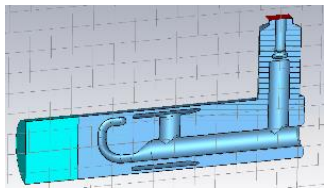


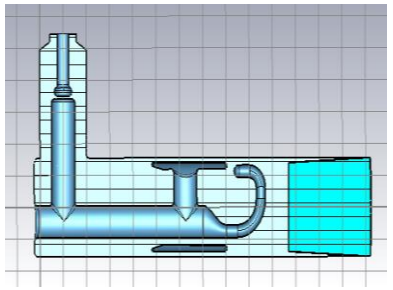








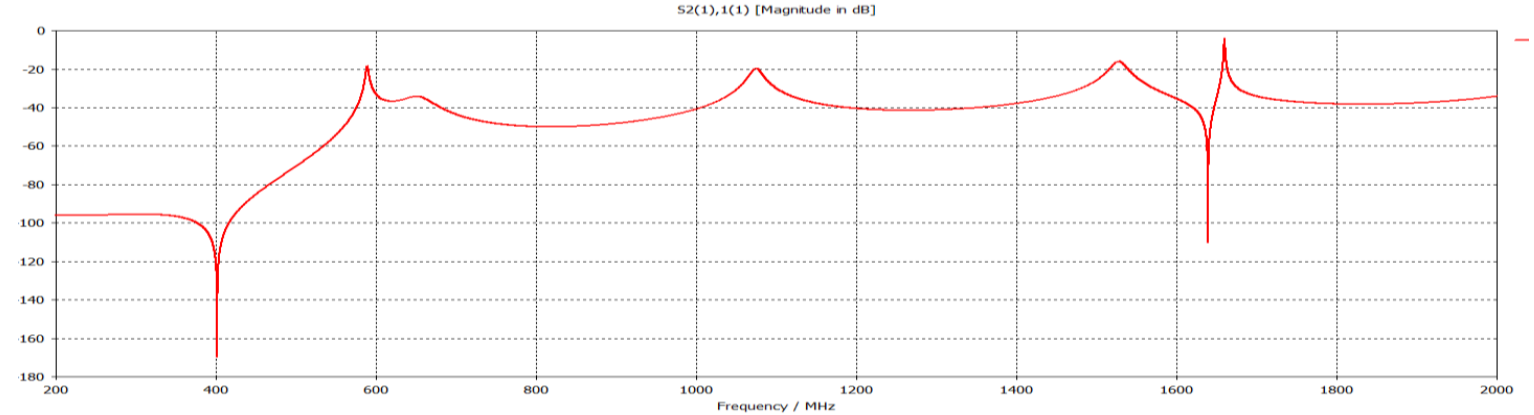


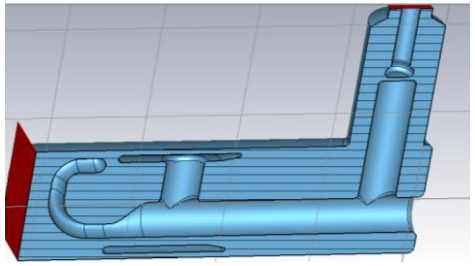


Absorber		Open		
f / MHz	s11 min	f / MHz	s11 min	Df / MHz
585.0	0.505	585.7	0.06	-0.7
1074.4	0.644	1071.4	0.455	3.0
1530.2	0.404	1524.5	0.18	5.7
1662.7	0.688	1658.9	0.842	3.8

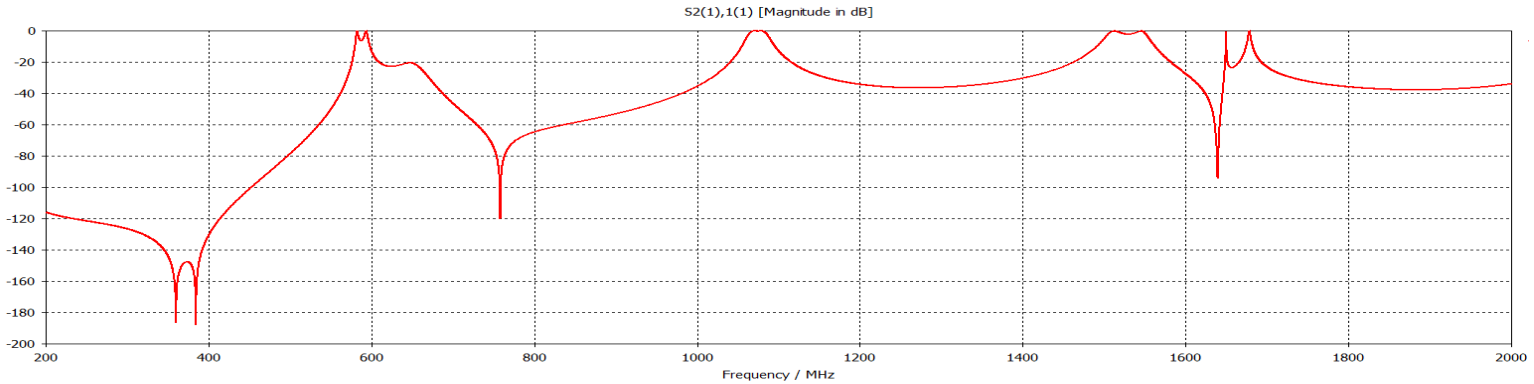
- None show the notch at 400MHz in S11
- Need to consider design which allows S21 measurement

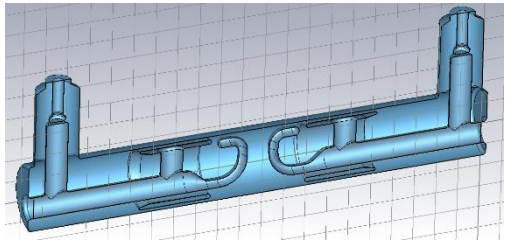
S21





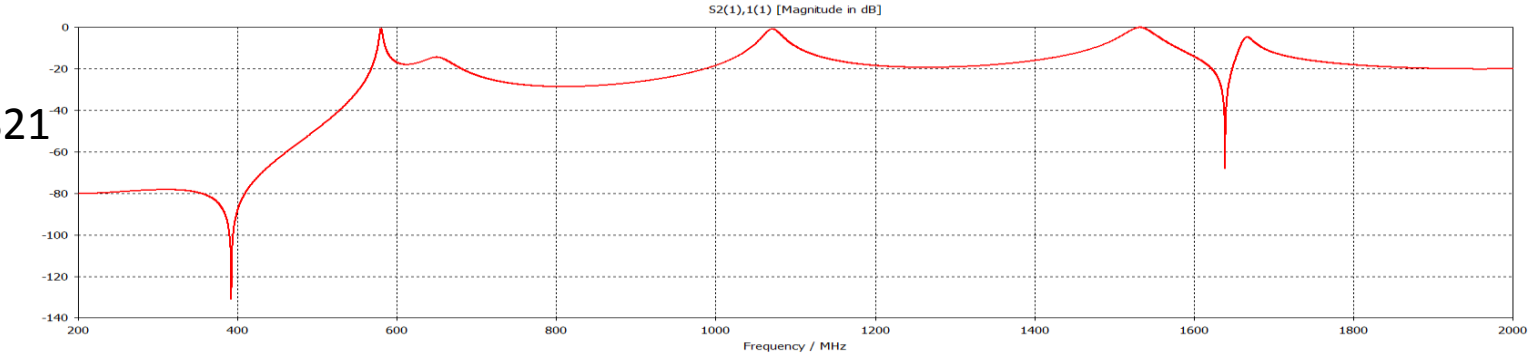
S21

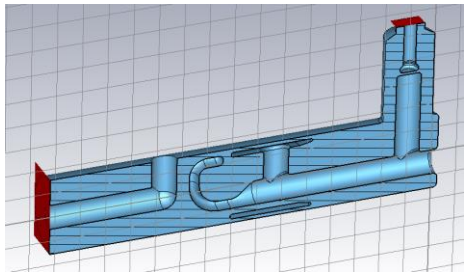




Peaks split due to interaction between the two filters

S21

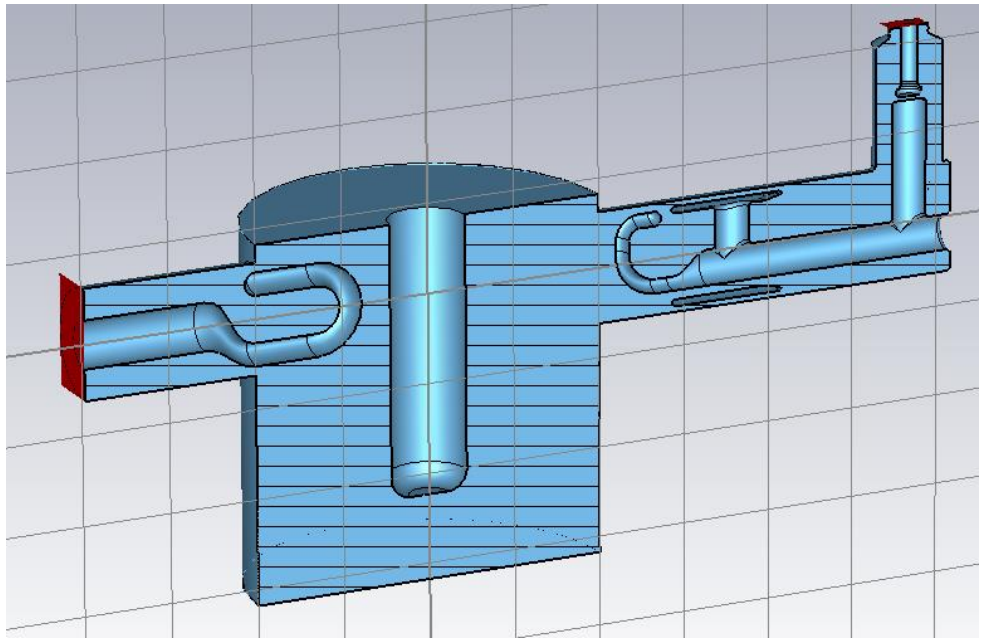




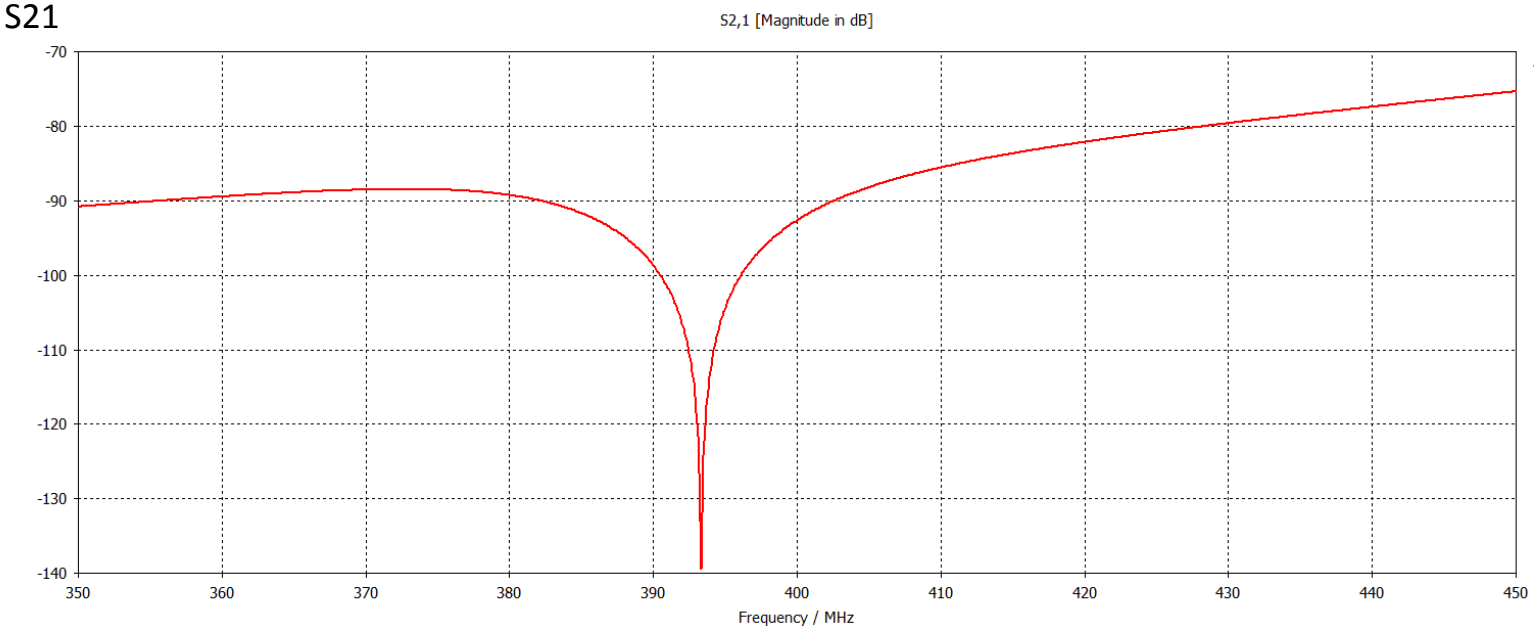
Notch frequency is 10MHz from frequency on lone HOM coupler

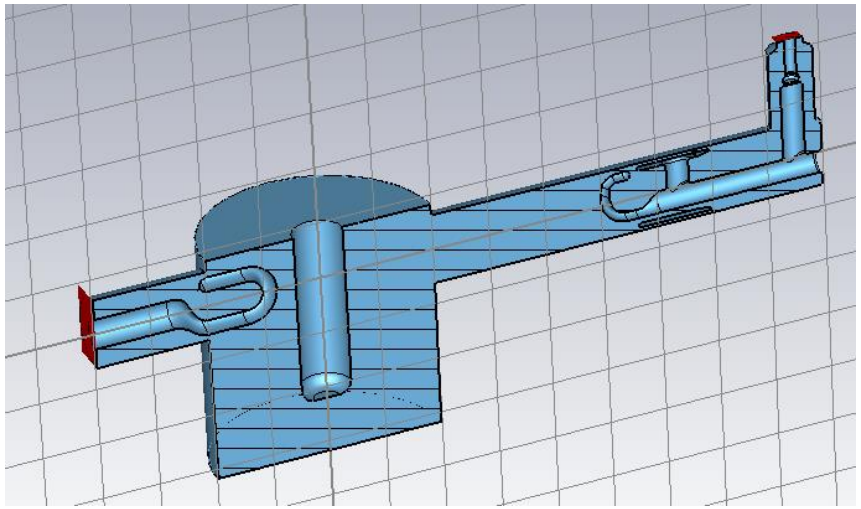
QWR

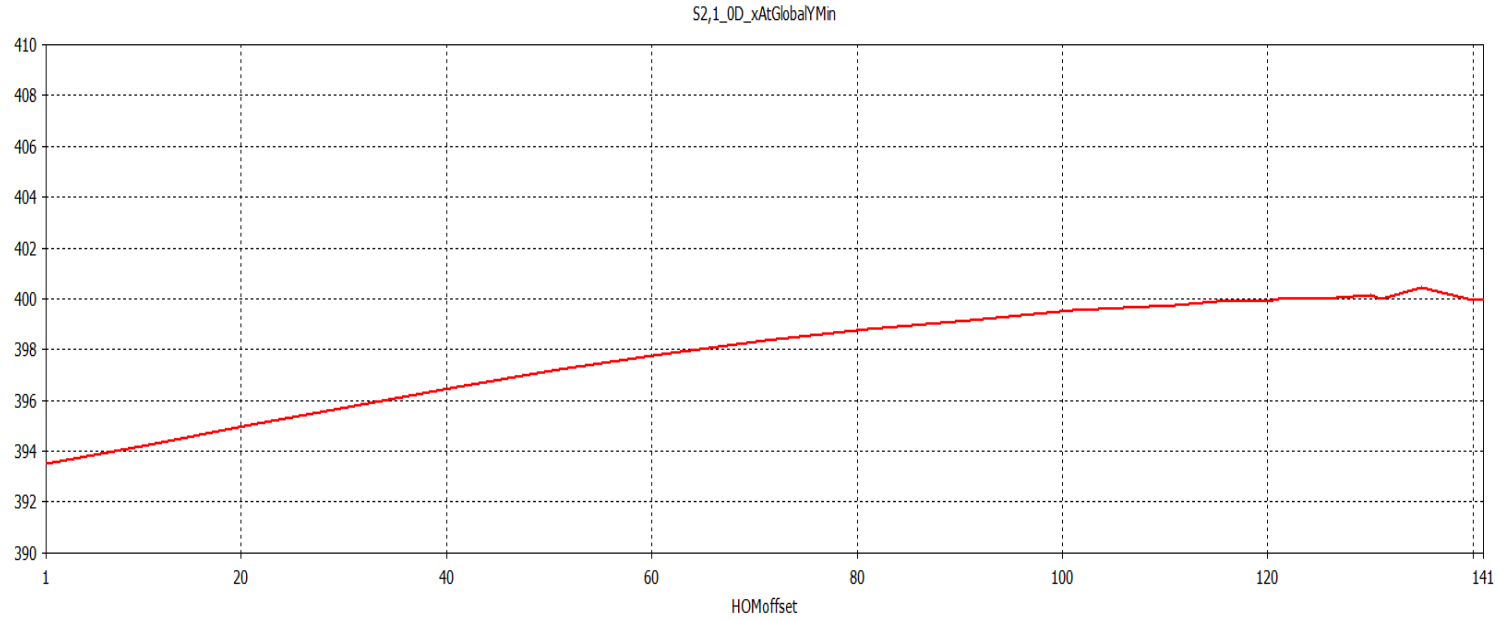
- Using a QWR to match the coupler at the frequency of the notch improves transmission around notch, making it visible in S21.
- For this, the FPC test box QWRs would be used
- See notch, but not at the frequency seen on the lone HOM coupler

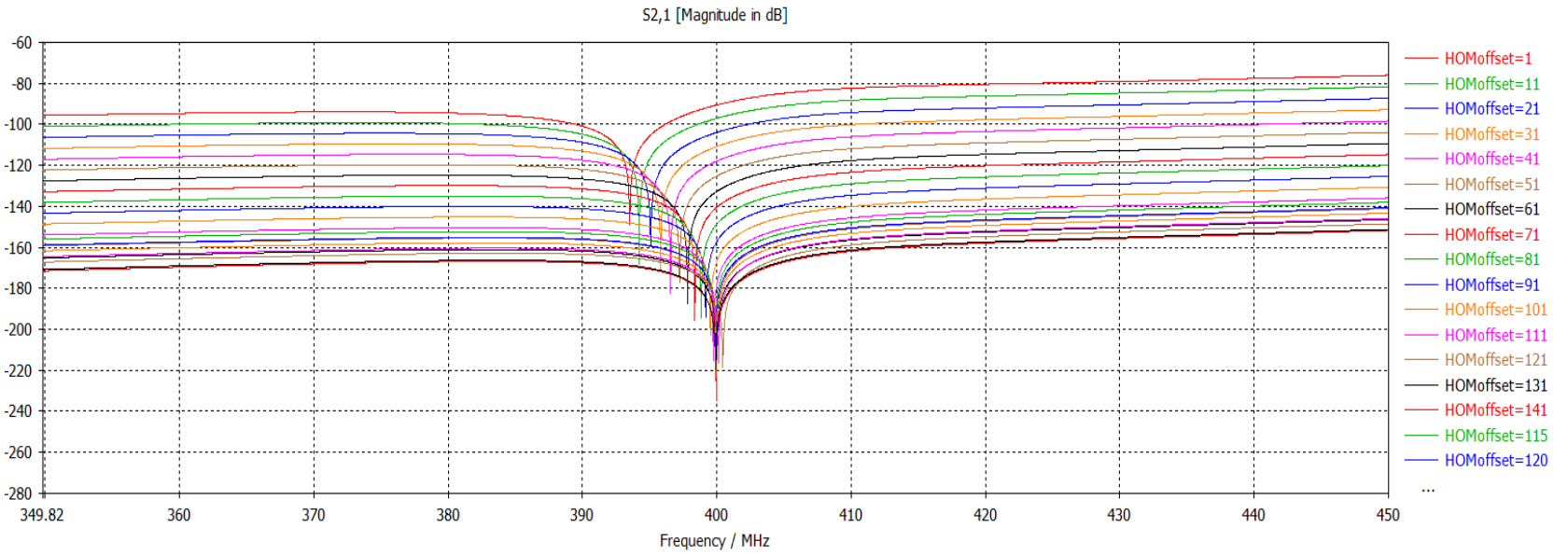


S21





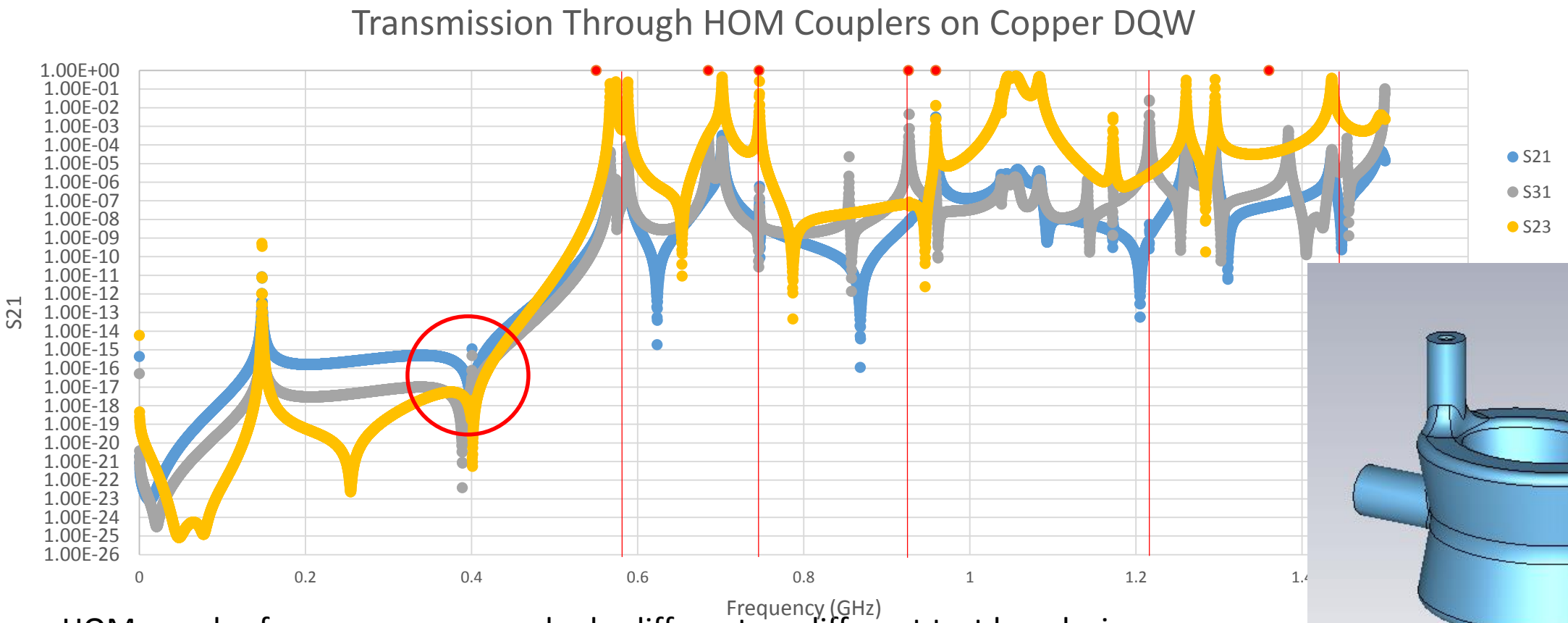


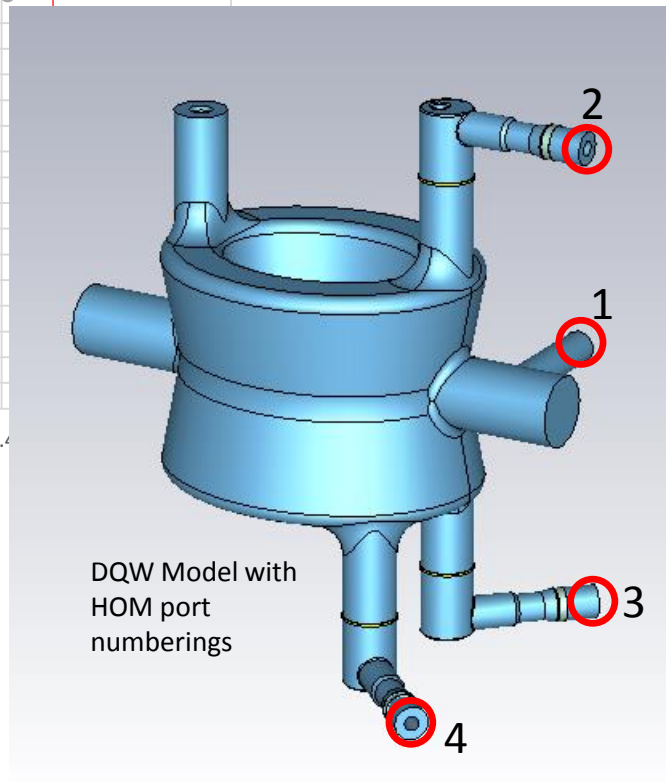


As the distance between the HOM coupler and the QWR is varied, the notch frequency shifts.

Copper DQW show all critical modes asre resolved

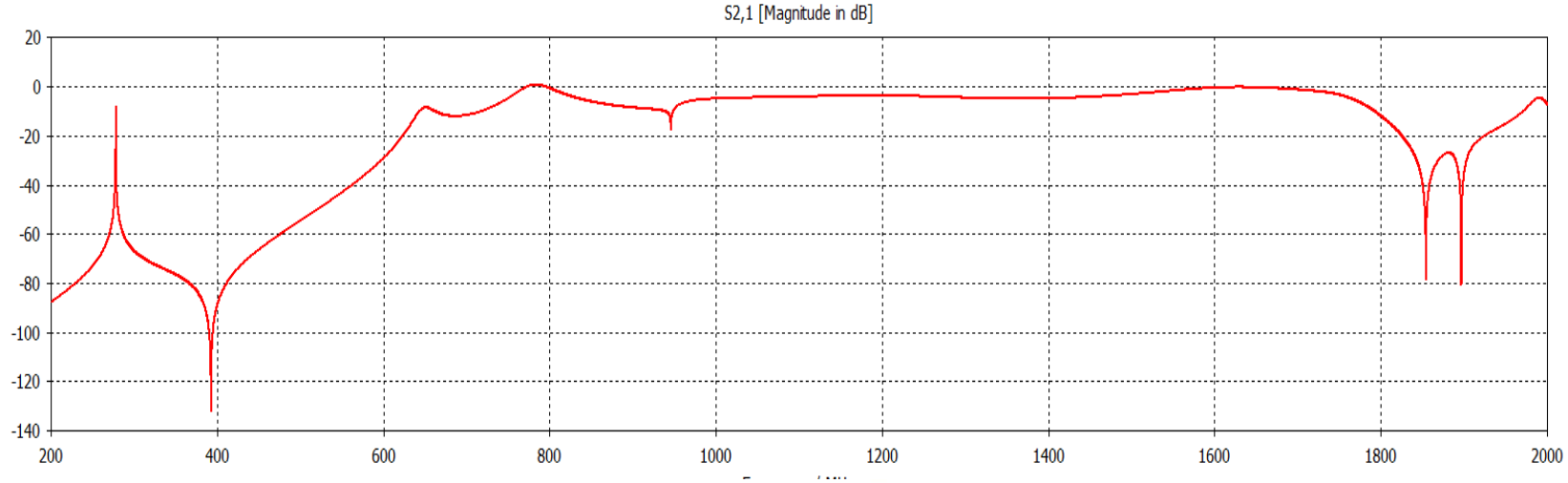
High Impedance HOM Frequency (MHz)
400
588
747
927
1220
1440

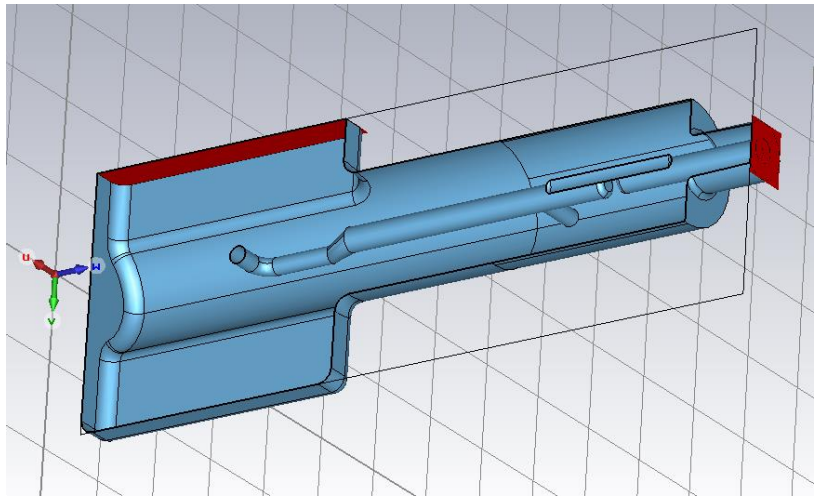


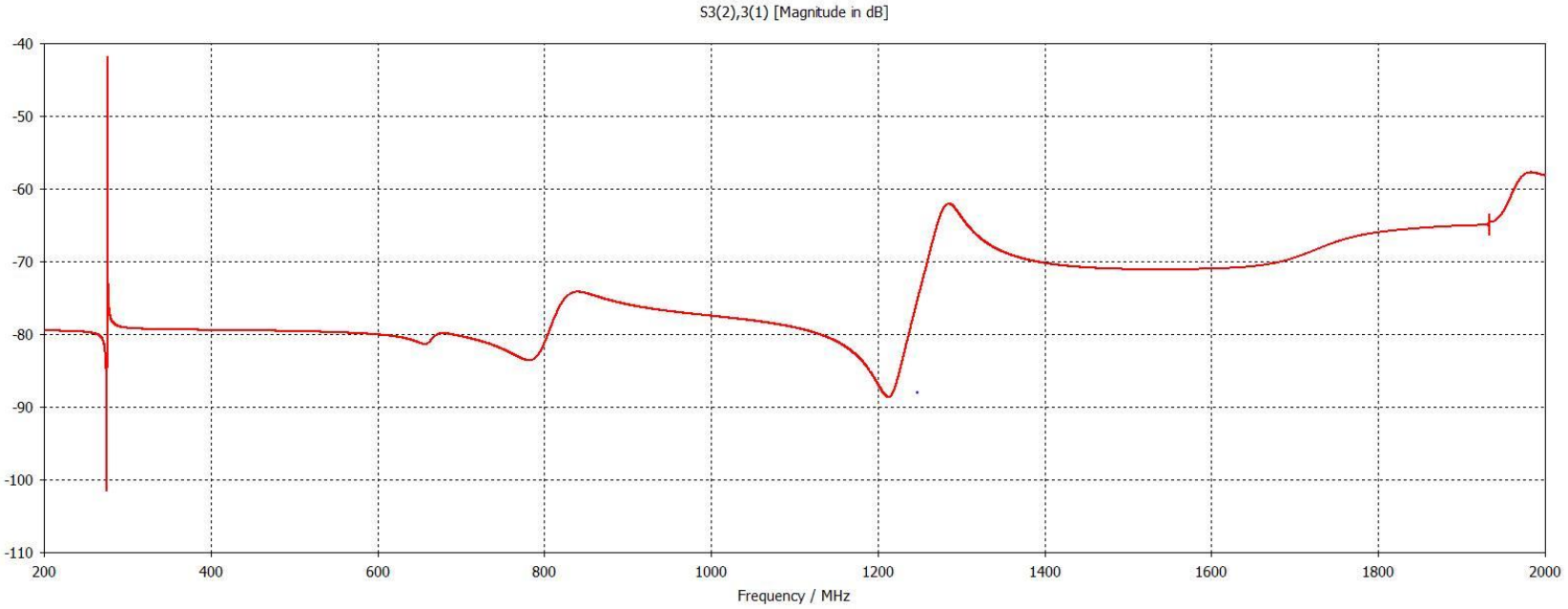


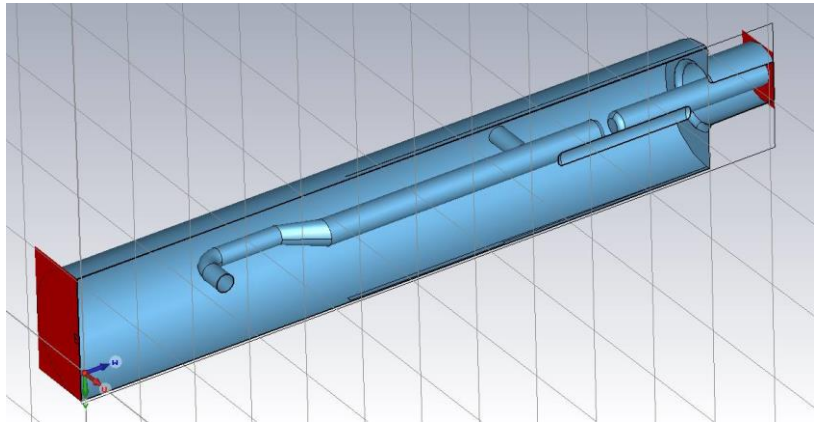
- HOM coupler frequency response looks different on different test box designs.
- Using a copper DQW cavity the observed frequency is what would be seen during operation, allowing for best tuning of the HOM coupler.

RFD HOM Coupler





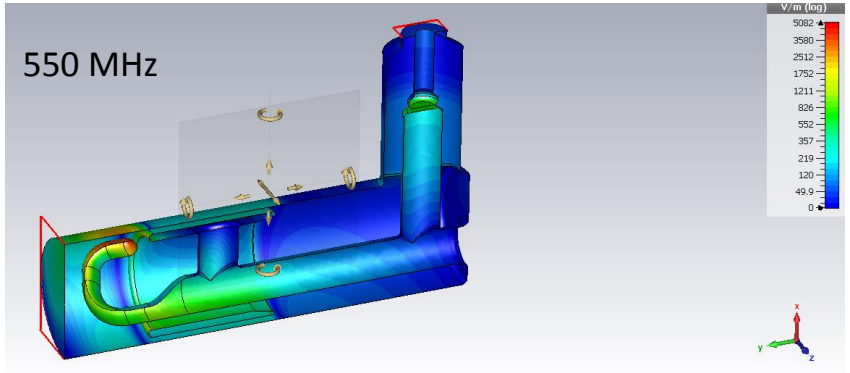


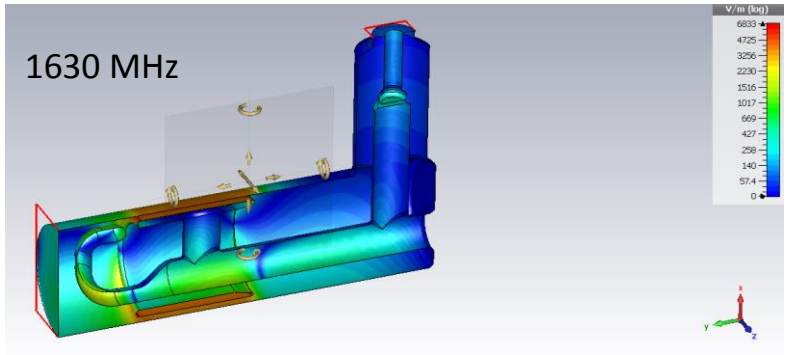


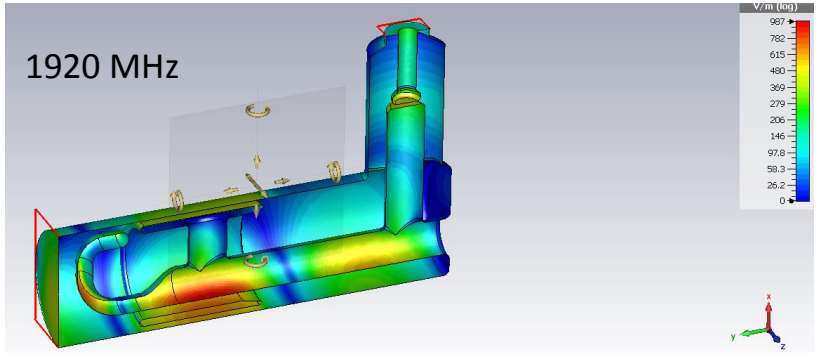
DQW HOM Coupler Test Box - High Power

- HOM couplers expected to see high power during operation (~1kW), desirable to condition couplers prior to use.
- Transmission through HOM coupler is incredibly poor at some frequency, ideally a MW power source would not be required.
- To avoid use of MW power source, the couplers must be matched over a broad range (200MHz-2GHz).

Fields without matching:

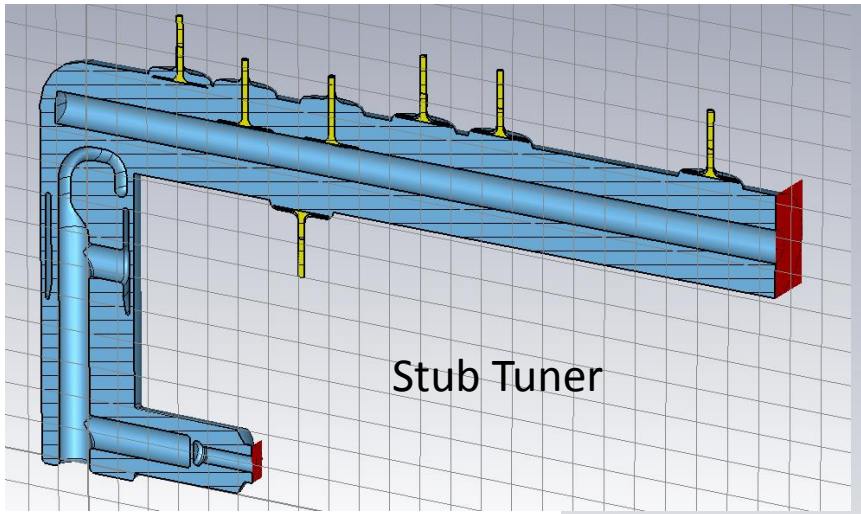


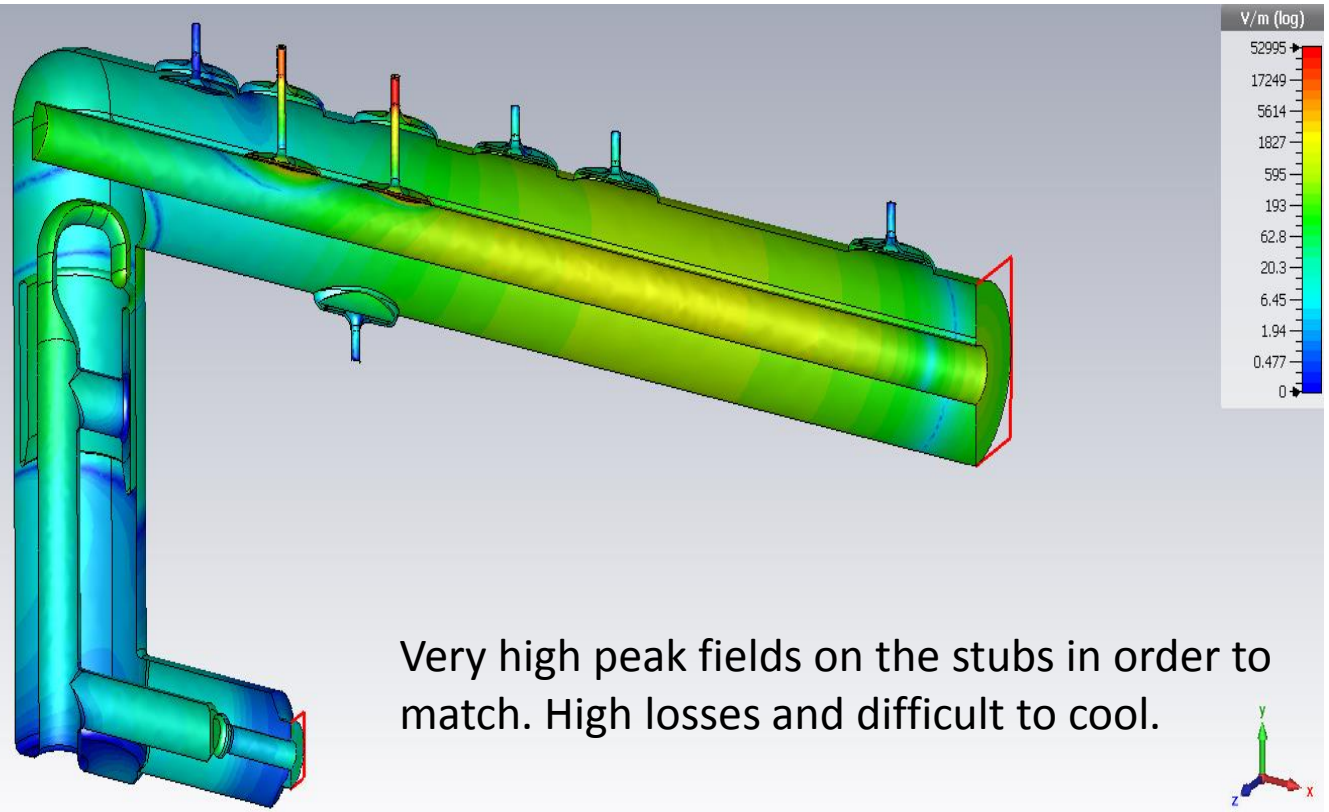




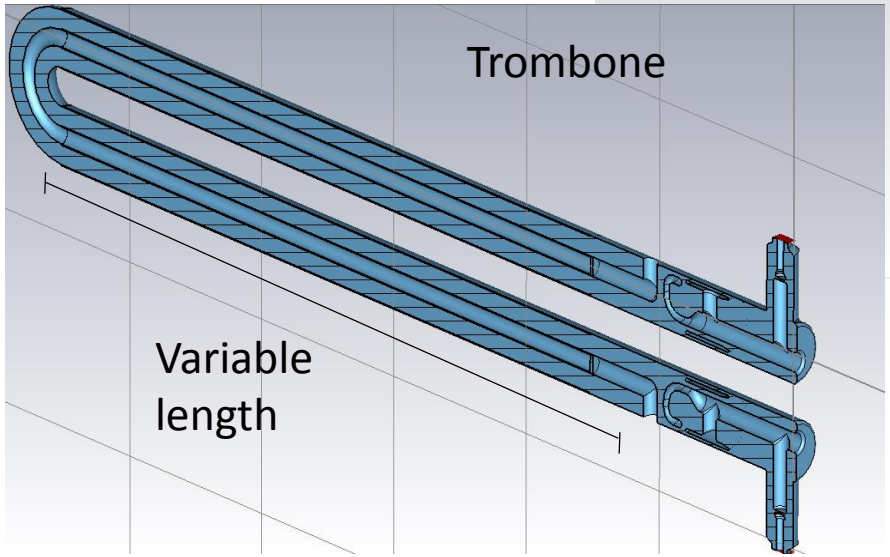
- Fields are standing wave inside the coupler. We can get fairly high fields in the coupler with 1 kW but it will be less than in the real cavity.

Designs Considered



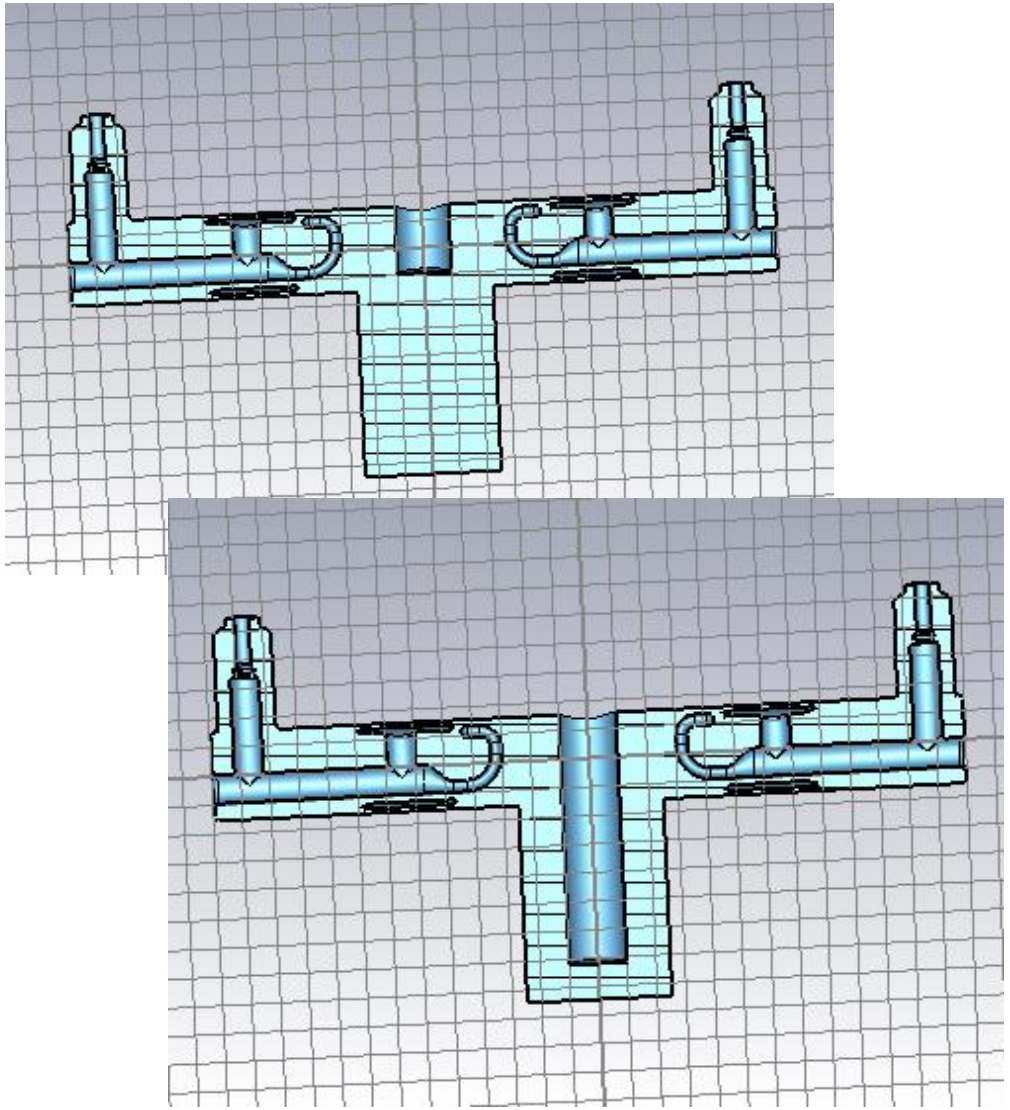


Very high peak fields on the stubs in order to match. High losses and difficult to cool.



Trombone mechanical design is impractical

Quarter Wave Resonator

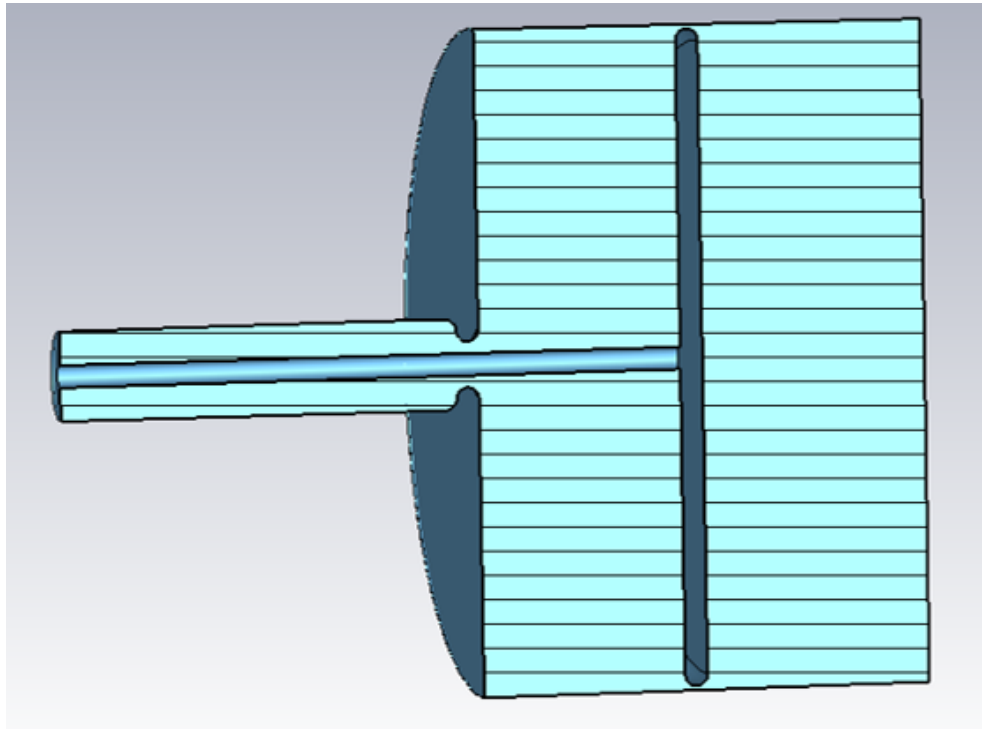


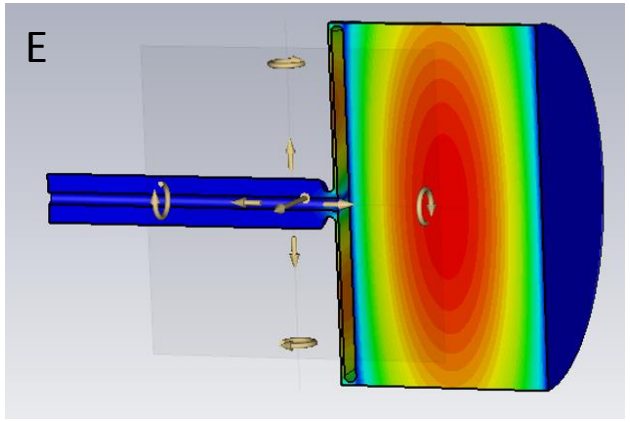
- Requires bellows to adjust inner length.
- Fields will be enhanced on the bellows, leading to significant losses and cooling issues

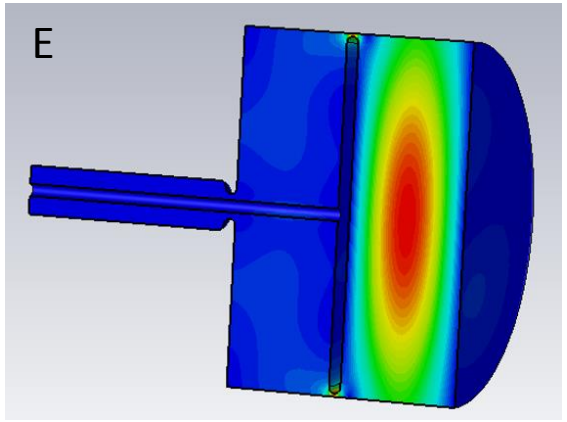
How can we avoid field enhancement on the bellows?

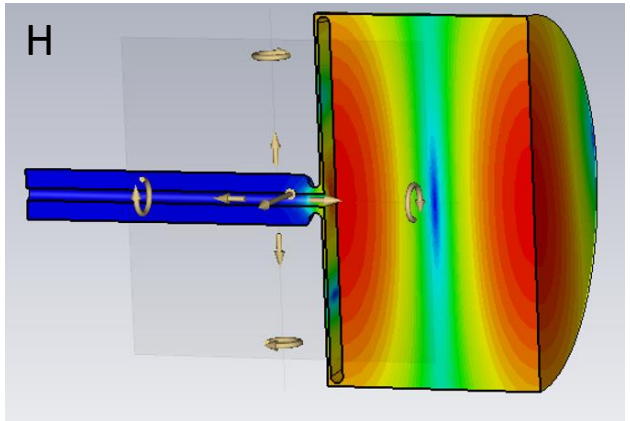
Variable Pillbox

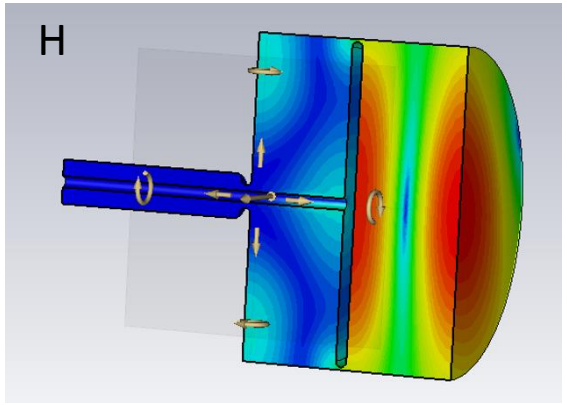
- Operated in TE/TM modes.
- Pillbox length is varied through use of bellows to vary the resonant frequency.
- Entire frequency range of interest can be covered using a few modes.



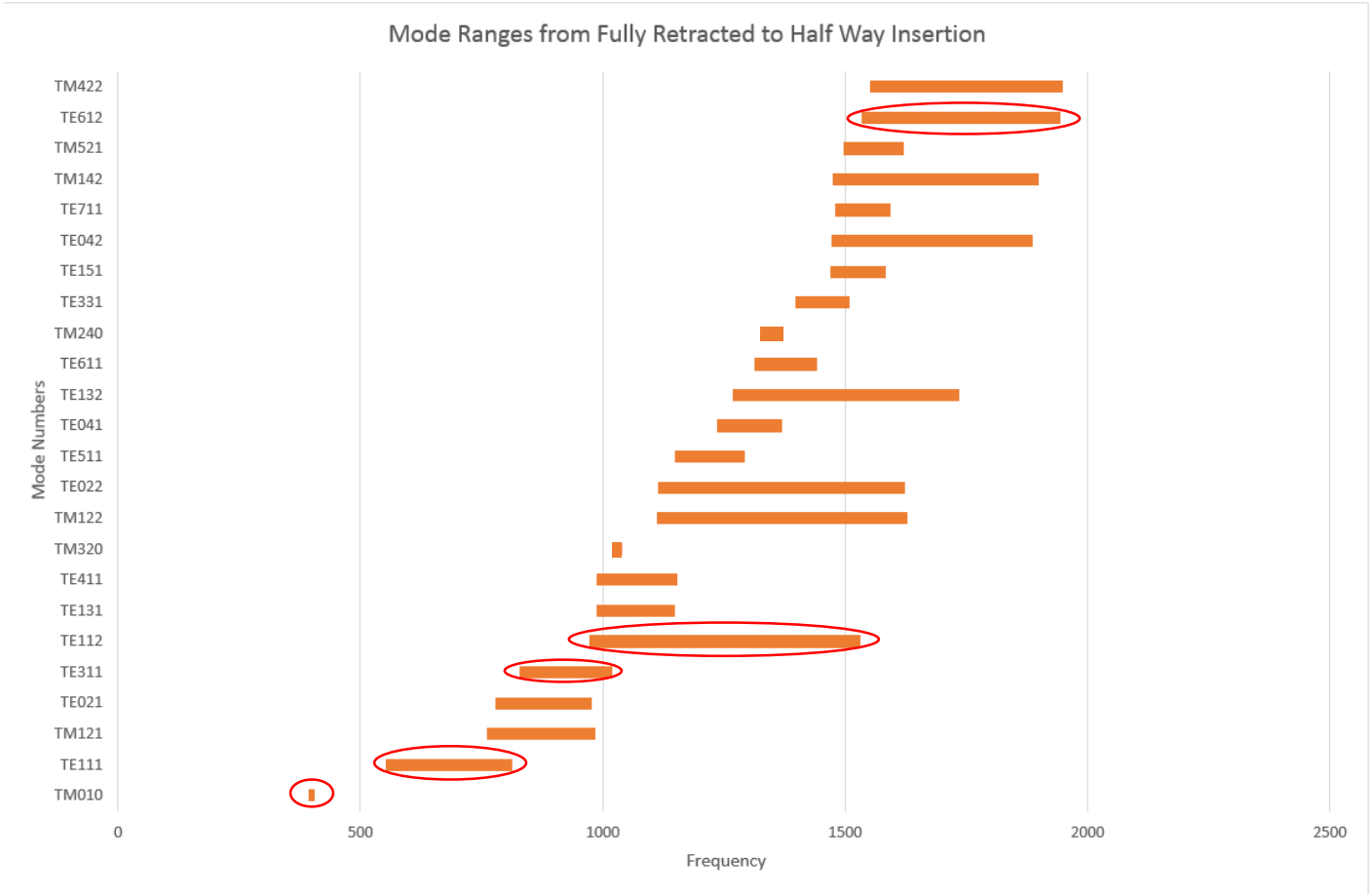








Variable Pillbox Modes



Mode Ranges			
TM010	392	405	13
TE111	551	812	261
TM121	761	985	224
TE021	778	977	199
TE311	829	1020	191
TE112	971	1531	560
TE131	986	1149	163
TE411	986	1153	167
TM320	1020	1040	20
TM122	1112	1628	516
TE022	1115	1624	509
TE511	1148	1294	146
TE041	1236	1370	134
TE132	1268	1734	466
TE611	1312	1442	130
TM240	1328	1373	45
TE331	1396	1509	113
TE151	1469	1583	114
TE042	1471	1887	416
TE711	1478	1594	116
TM142	1474	1898	424
TM521	1496	1622	126
TE612	1533	1943	410
TM422	1552	1948	396

4 modes needed to cover full range from 550MHz to 2GHz, plus one mode at 400MHz

Conclusion

- A test box has been designed for the two FPCs, the mechanical design is underway.
- A low power HOM coupler test box has been investigated, at present a copper DQW cavity appears most suitable.
- A high power HOM test box has also been investigated. A variable pillbox cavity appears to be the best option so far, but requires more work. Failing this, there is the option of using a QWR to condition at a single frequency (as with the FPCs)