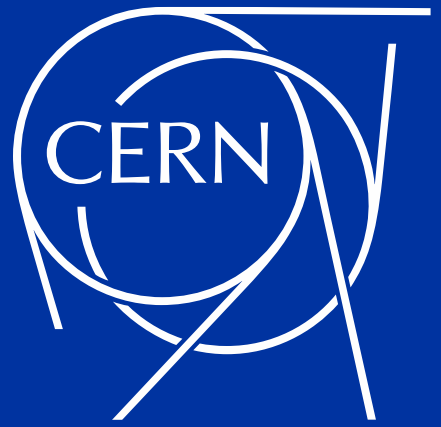


SPS Wire Scanner Task Force Impedance studies

Michael Sullivan

Slide from Benoit

- At first instance the most significant mode is at ~ 781 MHz.
- For preliminary simulations, this mode is studied to see what mitigation techniques can be used.

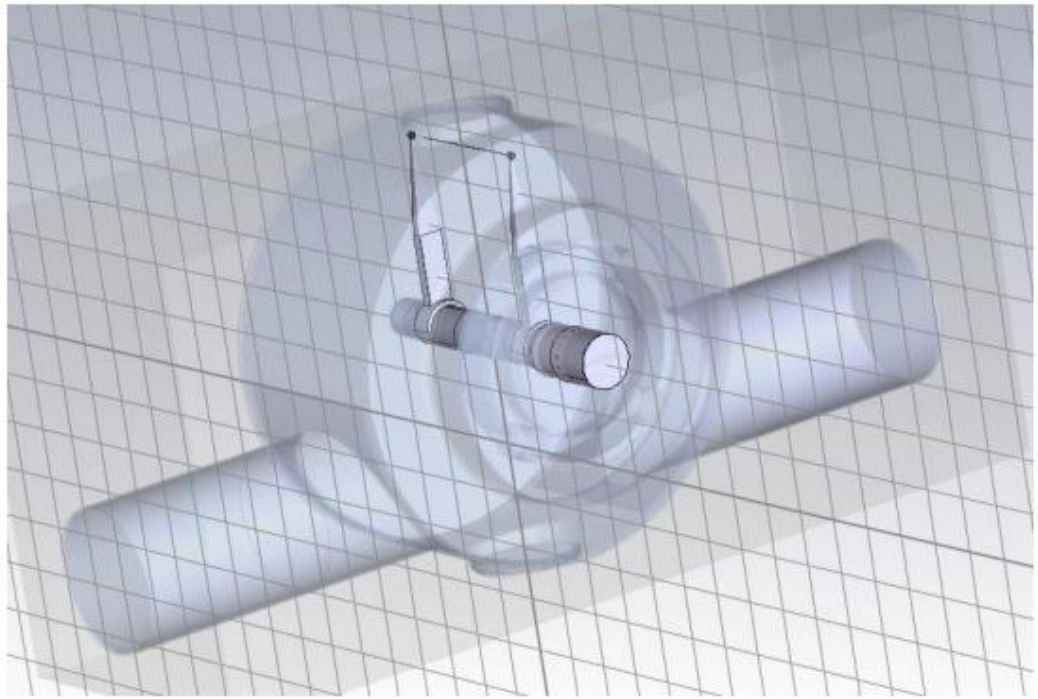
Model of Thomas from 2017

PS/SPS WS:

Eigenmode simulation
(most significant modes)

f [GHz]	Z_s [Ω]	Q_0	R/Q [Ω]
0.149	360.5	1119	0.3
0.781	29711.9	2198	13.5
0.808	3082.6	1827	1.7
1.016	1090.9	1731	0.6
1.116	8880.7	5712	1.6
1.202	14040.5	6425	2.2
1.263	1805.6	4859	0.4

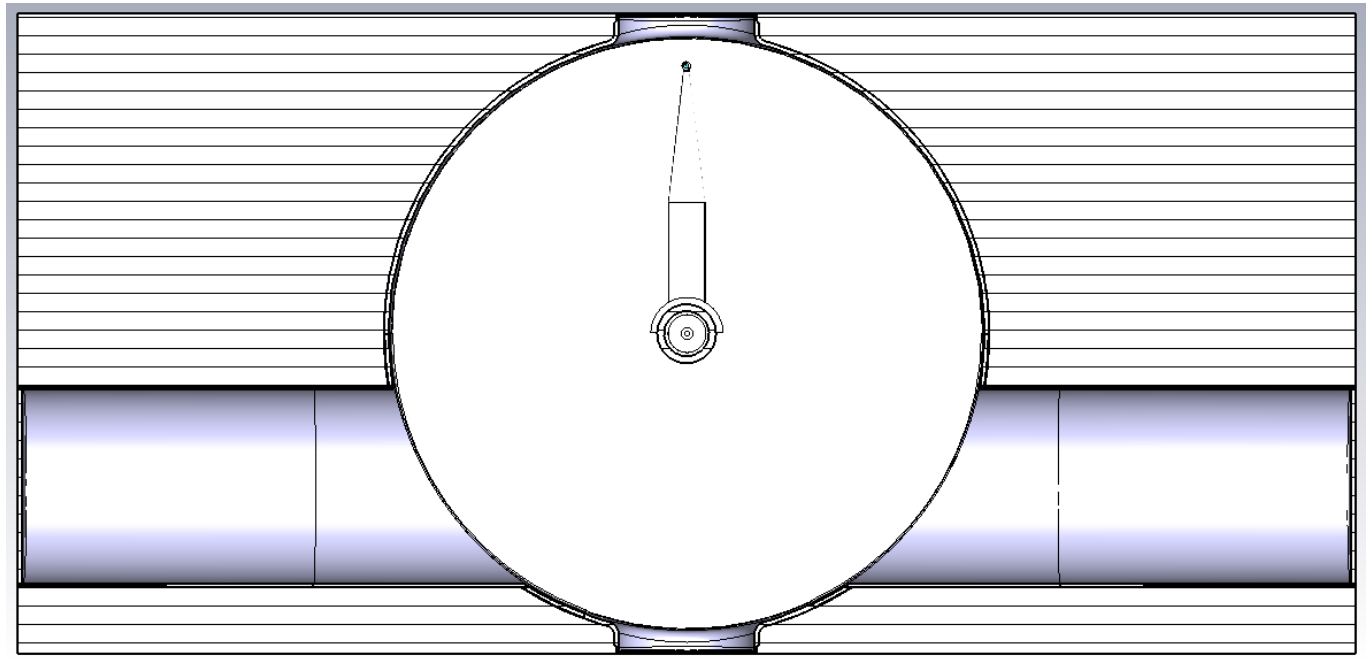
https://indico.cern.ch/event/616762/

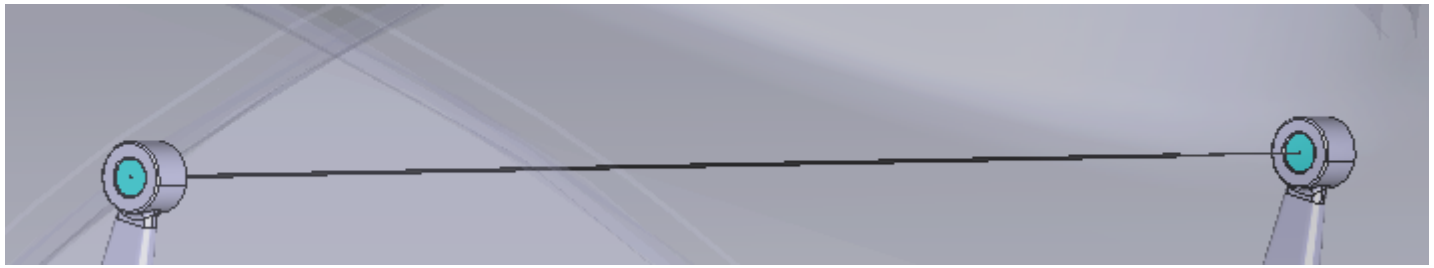


→ First mode power loss is hardly on the wire, and does not change as much with bunch length
→ With such high Q (>2000), hard to explain that mode for all scanners hits the beam spectrum lines at the same time (Deltaf~300 kHz)

4

Wire Scanner with Macor and C-wire





- Macor with $\epsilon = 6$ is used in the gap between the carbon wire and the fork.
- The carbon wire is modelled as a lossy metal with a conductivity of 9000 S/m.
- The resonance becomes much broader than steel wire due to lower Q value.

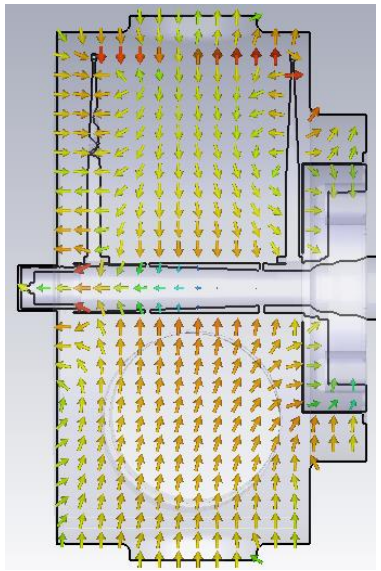
Frequency (Multiple Modes) : 0.78579166
Q-Factor (Perturbation) (Multiple Modes) : 278.5439
R over Q beta=1 (Multiple Modes) : 26.184434
Shunt Impedance (Pertubation) beta=1 (Multiple Modes) : 7293.5145

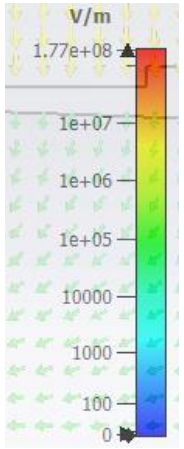
Q-Factor Calculation

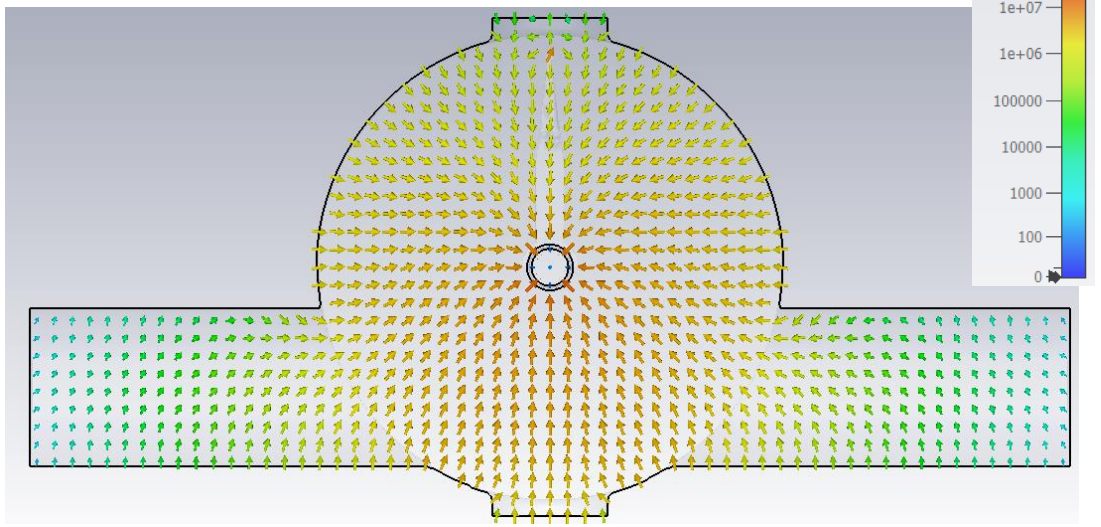
H-Field data: Mode 3

Material/Solid	Conductivity	Mu	Loss/W	Loss/%	Q
Cond. Enclosure	5.8000e+07	1	0.0000e+00	0	
st_steel	1.3500e+06	1	2.1735e+06	12.3	2.2732e+03
SPSCarbonWire	9.0000e+03	1	1.5565e+07	87.7	3.1744e+02
PEC	5.8000e+07	1	0.0000e+00	0	
Sum			1.7738e+07		2.7854e+02

Wire Scanner with Macor and C-wire

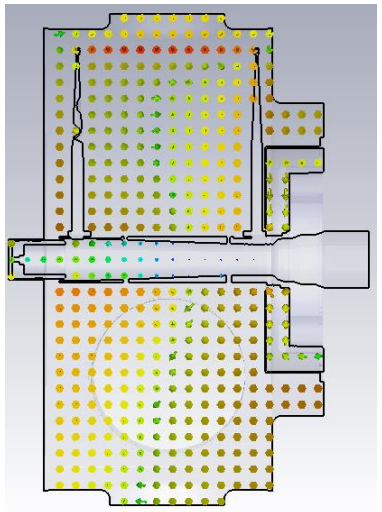


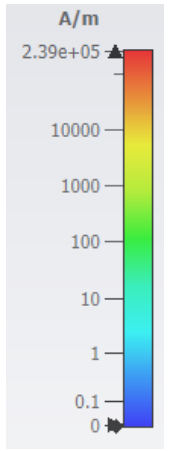


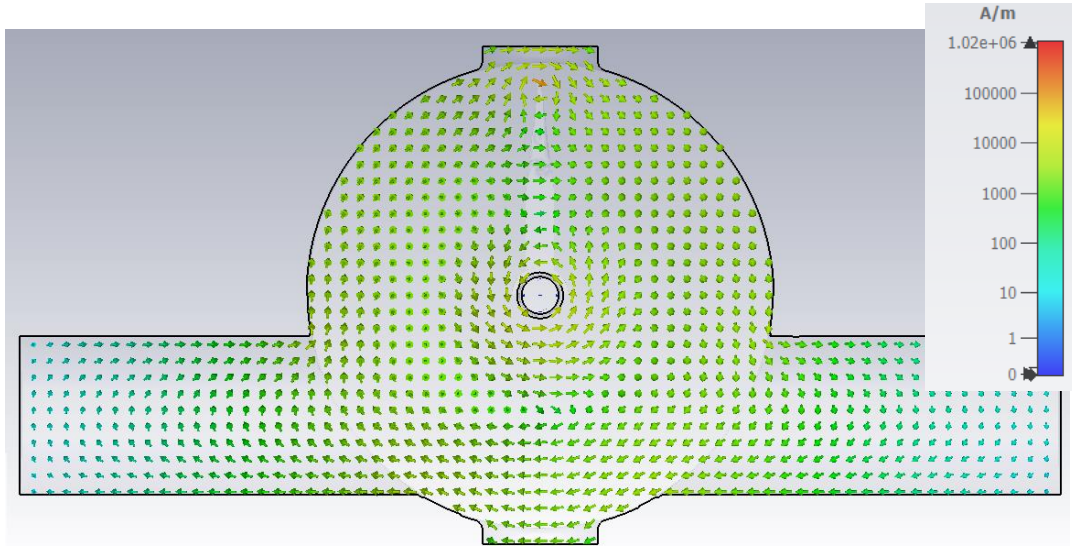


Mode 3 E-Field

Frequency	0.785792 GHz
Phase	0 °
Cross section	A
Cutplane at Z	-0.000 mm
Maximum on Plane (Plot)	1.77017e+08 V/m
Maximum (Plot)	1.25279e+09 V/m



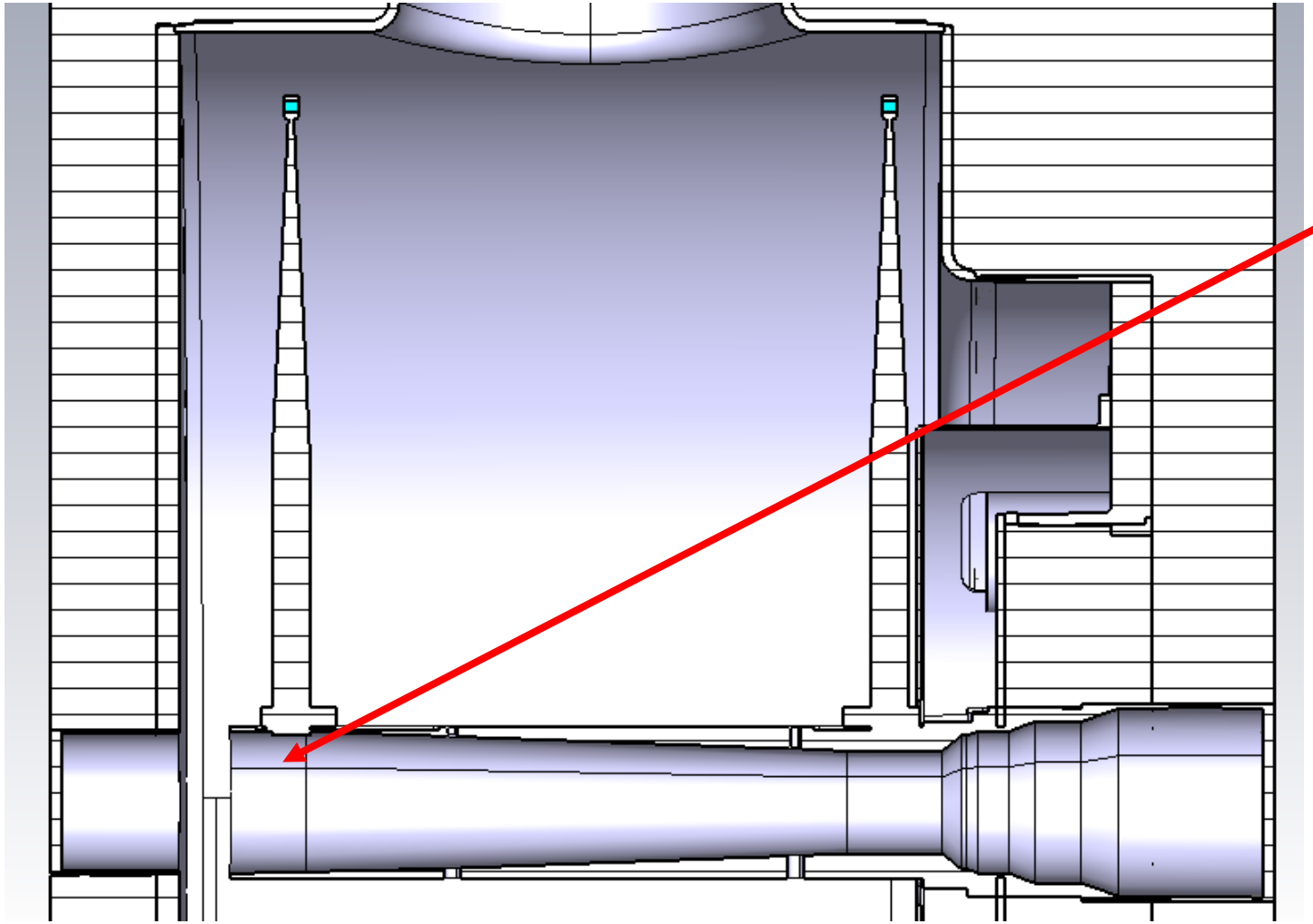


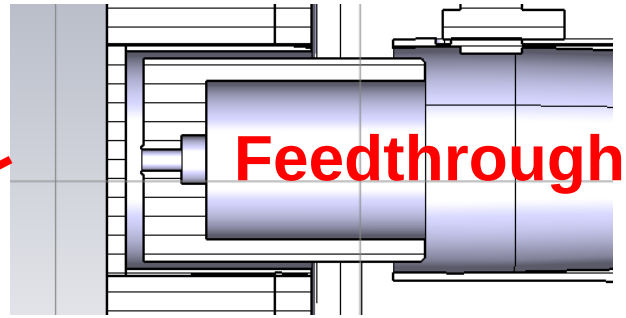


Mode 3 H-Field

Frequency	0.785792 GHz
Phase	90 °
Cross section	A
Cutplane at X	0.000 mm
Maximum on Plane (Plot)	1.16894e+06 A/m
Maximum (Plot)	2.2511e+06 A/m

Mitigation option - No Feedthrough

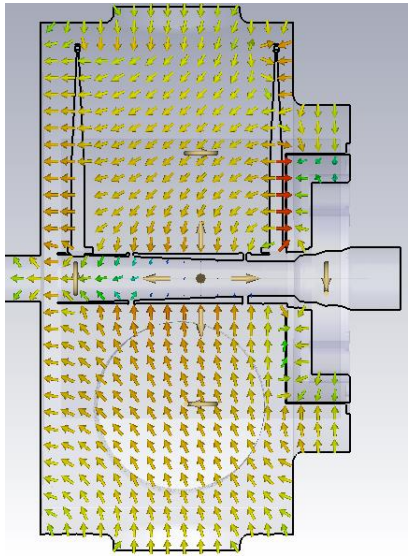


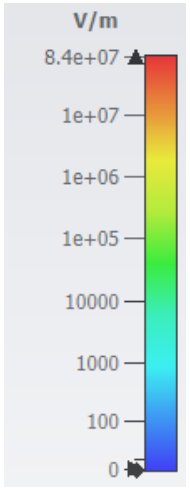


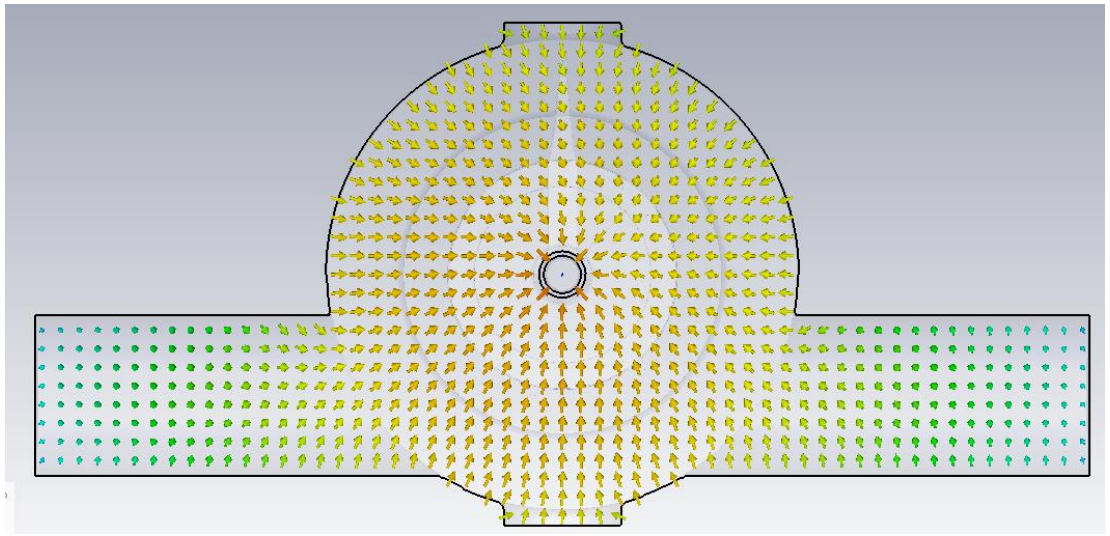
- This is how the Wire Scanners exist in the SPS and the lab.
- Absence of feedthrough was not known by impedance team when these simulations where done, so all mitigation options should be compared to the “Macor and C-wire” model on slide 4.
- Simulations can be repeated with the feedthrough removed.

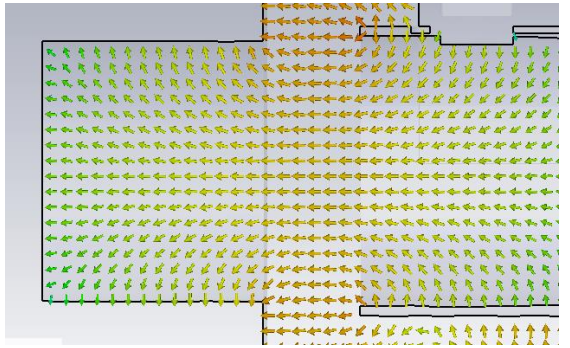
Frequency (Multiple Modes) : 0.80666401
Q-Factor (Perturbation) (Multiple Modes) : 1233.1603
R over Q beta=1 (Multiple Modes) : 16.640295
Shunt Impedance (Pertubation) beta=1 (Multiple Modes)_no_offset : 20762.207

Mitigation option - No Feedthrough



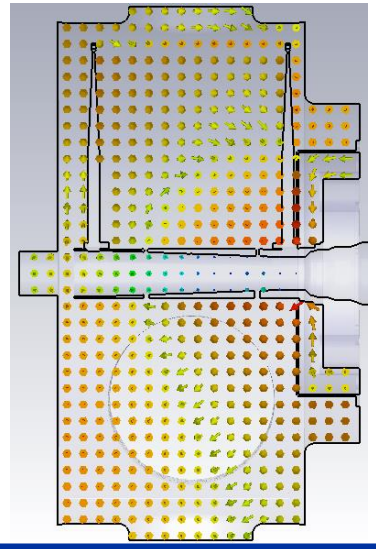


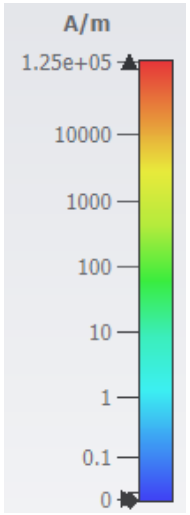


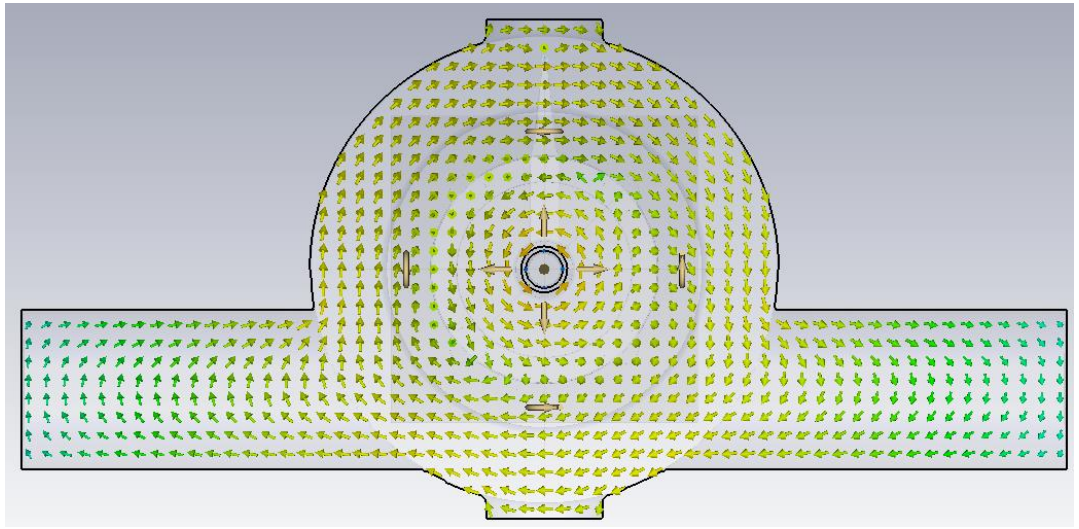


Mode 1 E-Field

Frequency	0.806664 GHz
Phase	0 °
Cross section	A
Cutplane at Z	-0.000 mm
Maximum on Plane (Plot)	8.39639e+07 V/m
Maximum (Plot)	7.55192e+08 V/m



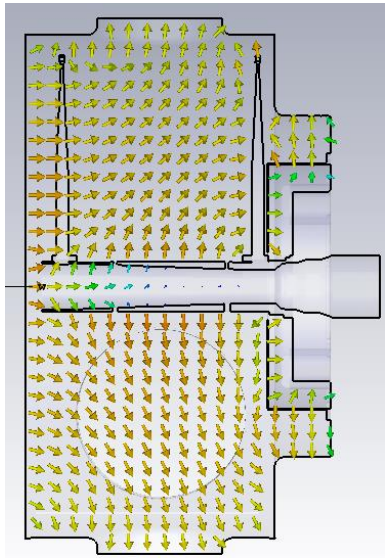


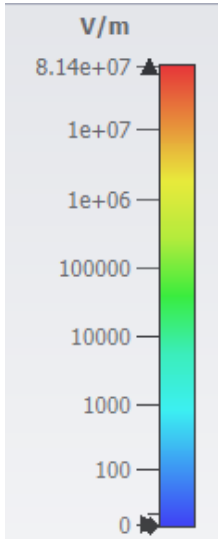


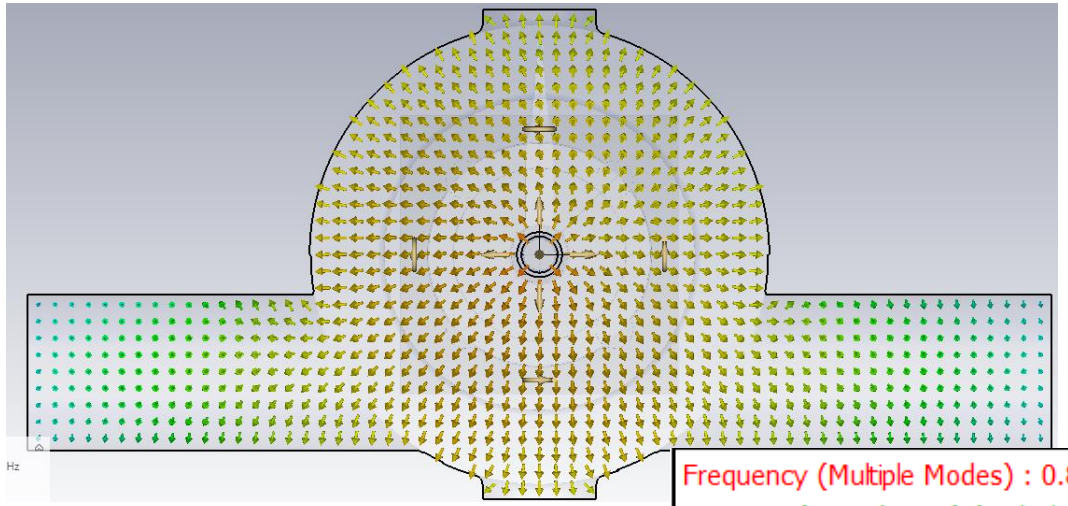
Mode 1 H-Field

Frequency	0.806664 GHz
Phase	90 °
Cross section	A
Cutplane at Z	-0.000 mm
Maximum on Plane (Plot)	125128 A/m
Maximum (Plot)	505138 A/m

Mitigation option - No Feedthrough, filled opening

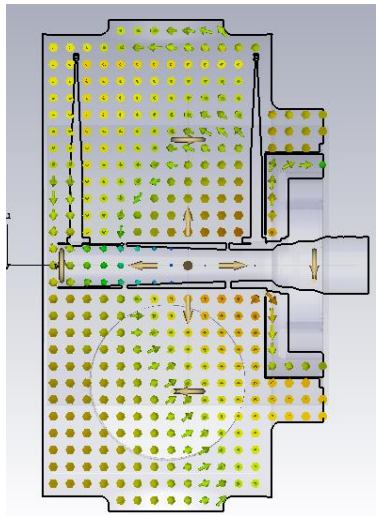


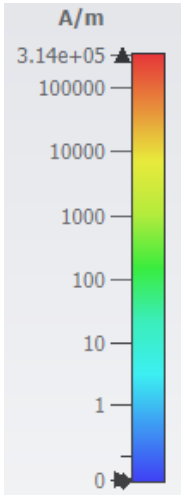


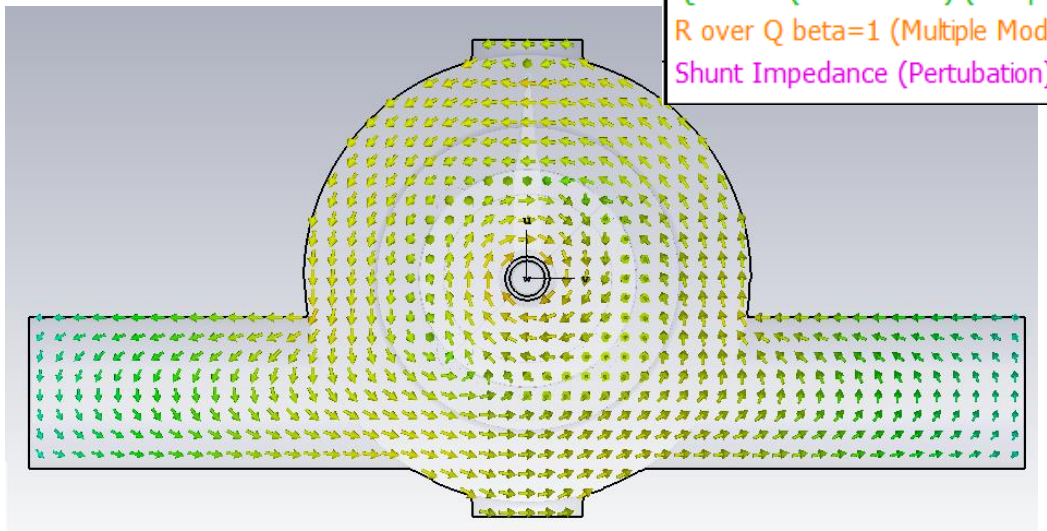


Mode 1 E-Field

Frequency	0.806847 GHz
Phase	0 °
Cross section	A
Cutplane at Z	-0.000 mm
Maximum on Plane (Plot)	8.13886e+07 V/m
Maximum (Plot)	8.01108e+08 V/m





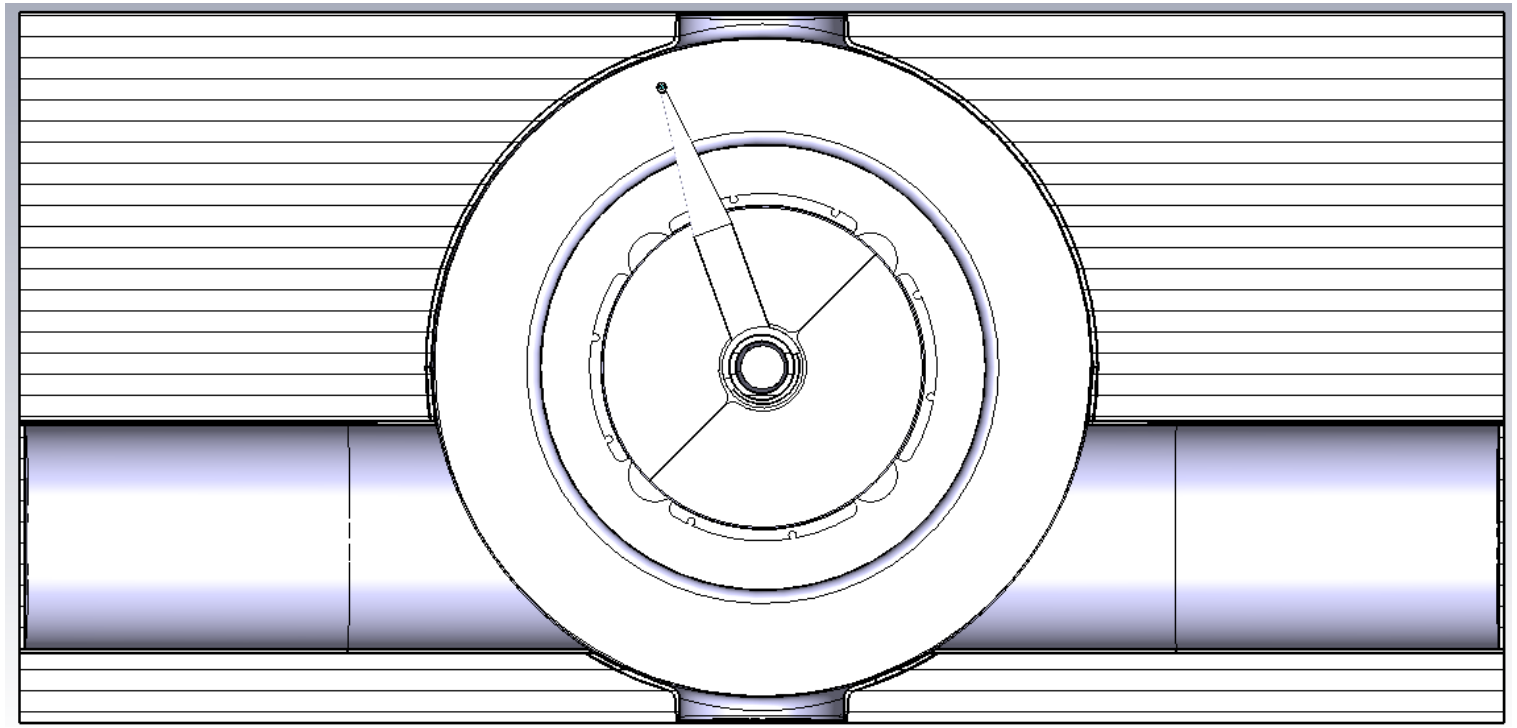


Frequency (Multiple Modes) : 0.80684698
Q-Factor (Perturbation) (Multiple Modes) : 1180.0938
R over Q beta=1 (Multiple Modes) : 16.993361
Shunt Impedance (Pertubation) beta=1 (Multiple Modes)_no_offset : 20295.564

Mode 1 H-Field

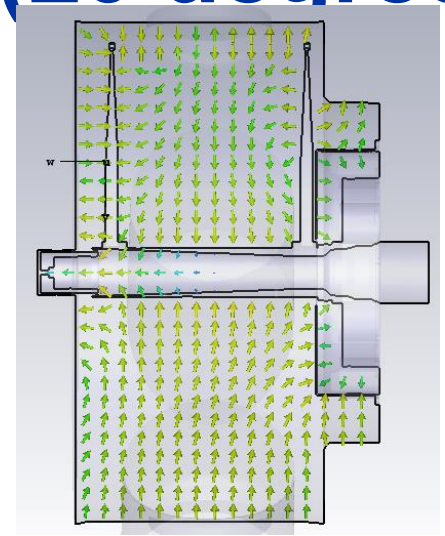
Frequency	0.806847 GHz
Phase	90 °
Cross section	A
Cutplane at Z	-0.000 mm
Maximum on Plane (Plot)	124801 A/m
Maximum (Plot)	562139 A/m

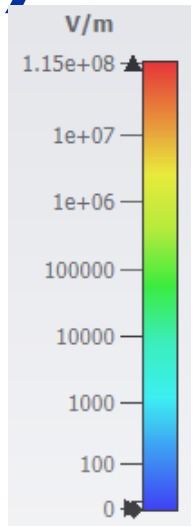
Mitigation option - Changed fork parking position (20 degrees)

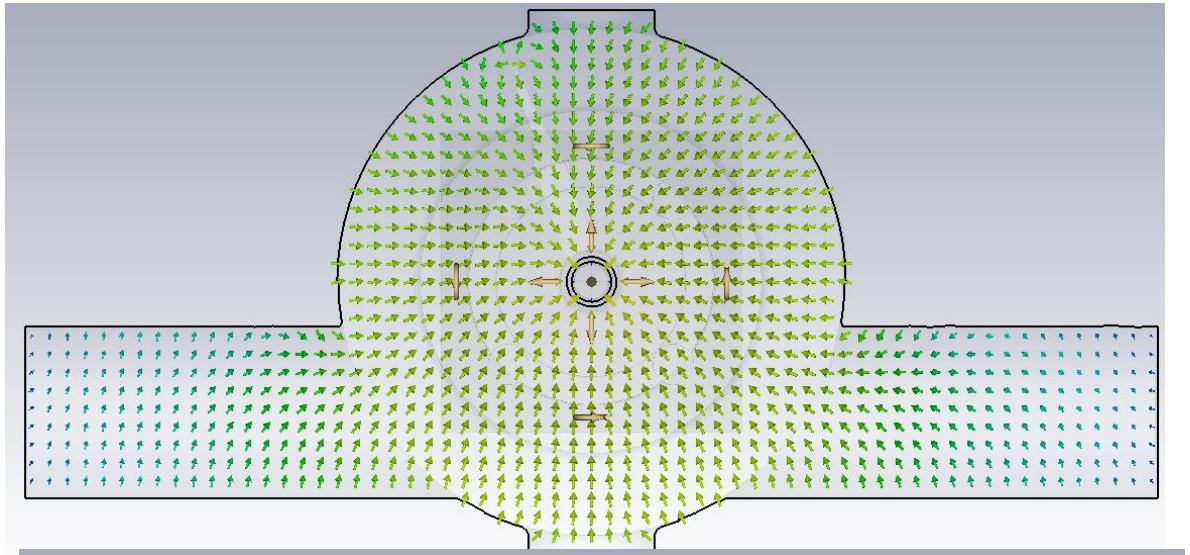


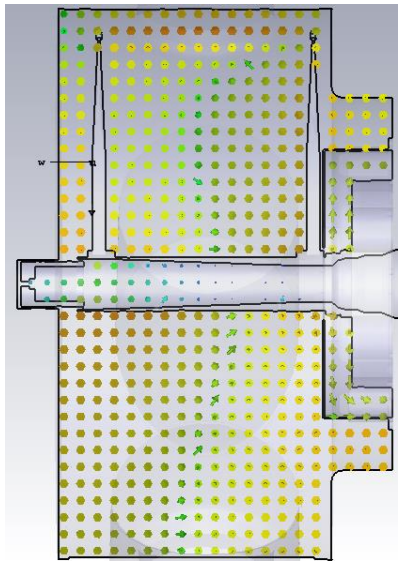
Frequency (Multiple Modes) : 0.78623528
Q-Factor (Perturbation) (Multiple Modes) : 171.68042
R over Q beta=1 (Multiple Modes) : 25.946698
Shunt Impedance (Pertubation) beta=1 (Multiple Modes)_no_offset : 4509.5881

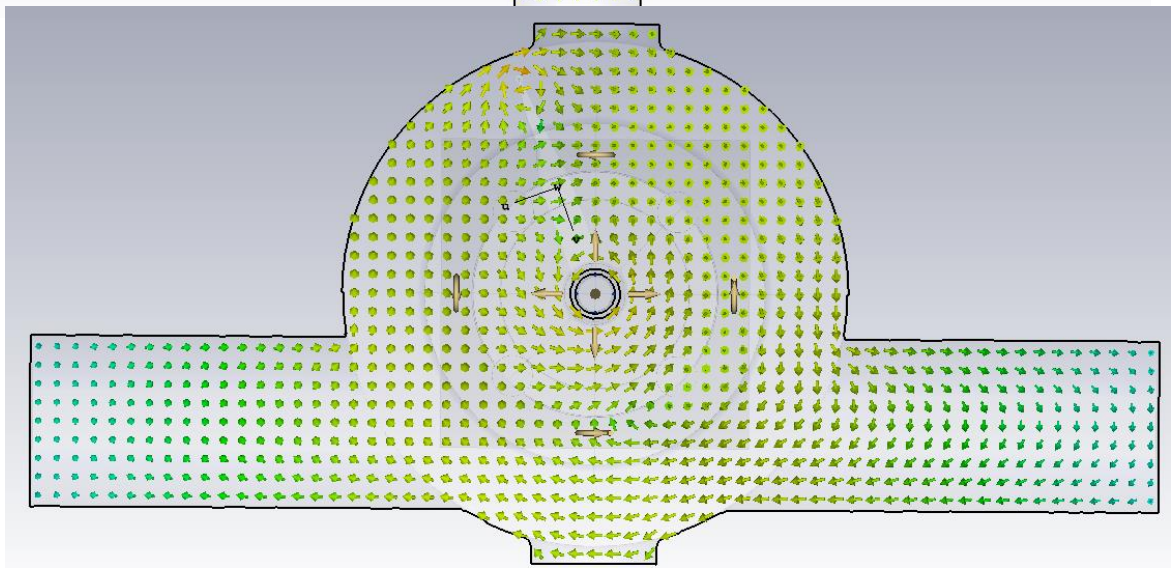
Mitigation option - Changed fork parking position (20 degrees)











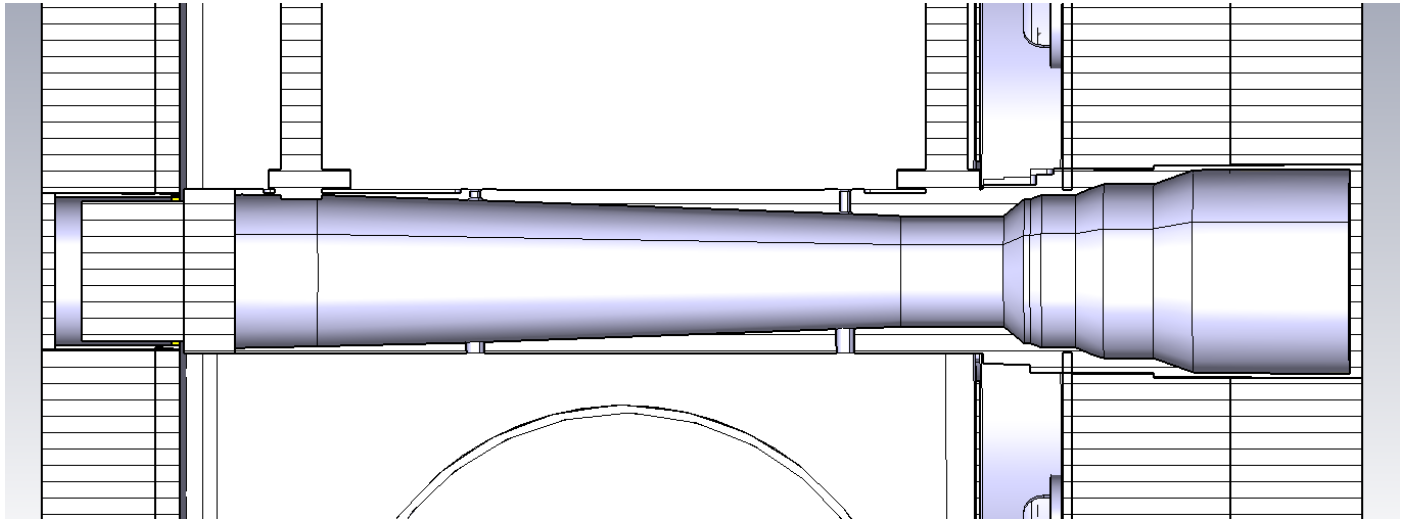
Mode 3 E-Field

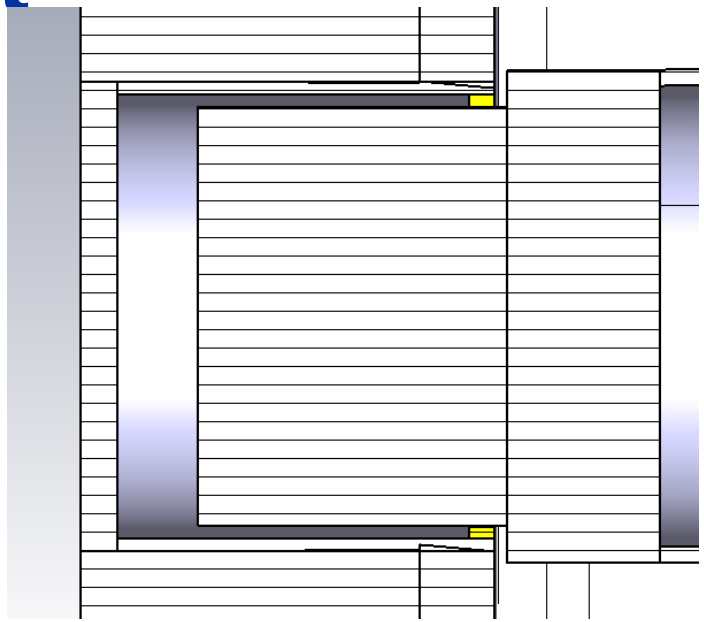
Frequency	0.786235 GHz
Phase	101.25 °
Cross section	A
Cutplane at X	0.000 mm
Maximum on Plane (Plot)	1.15044e+08 V/m
Maximum (Plot)	1.20555e+09 V/m

Mode 3 H-Field

Frequency	0.786235 GHz
Phase	101.25 °
Cross section	A
Cutplane at X	0.000 mm
Maximum on Plane (Plot)	1.83396e+06 A/m
Maximum (Plot)	3.21966e+06 A/m

Mitigation option - Connected shaft

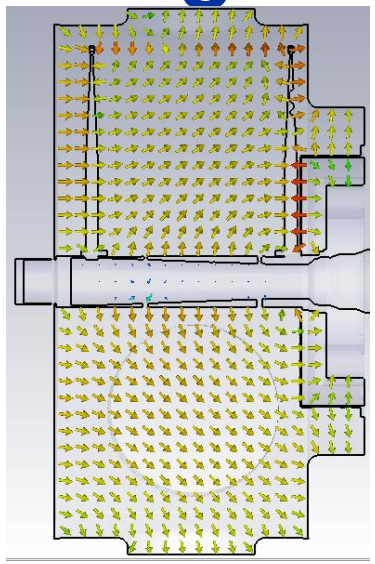


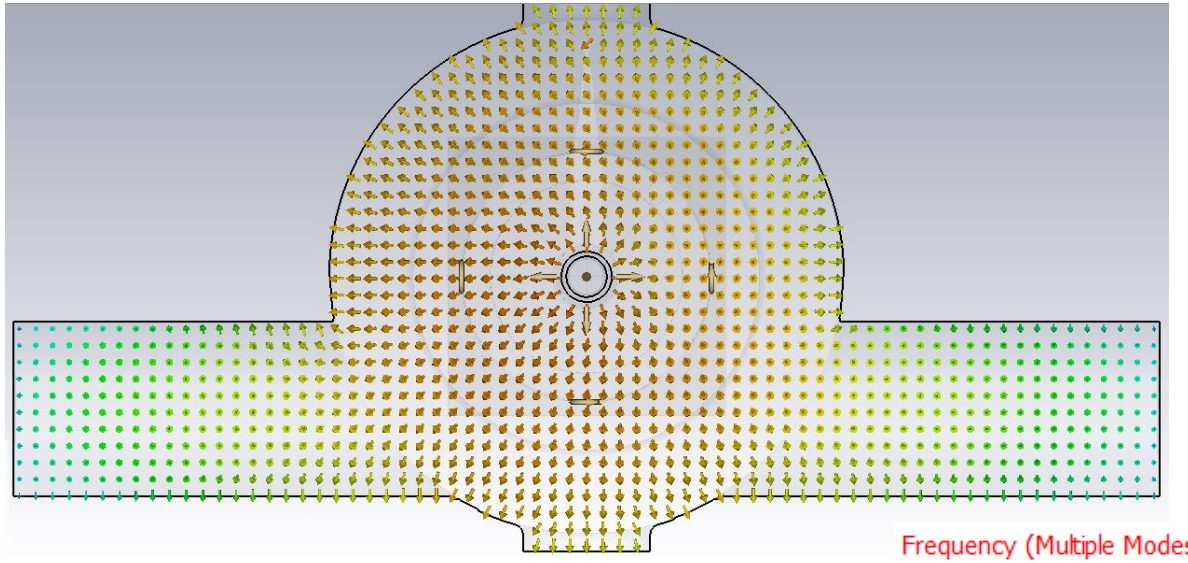


- Removed capacitive loading between the shaft end and the cavity in the tank wall by connecting via a steel part. A metal spring could be used to make electrical contact between shaft and the tank wall

Frequency (Multiple Modes) : 0.81187536
Q-Factor (Perturbation) (Multiple Modes) : 1343.0592
R over Q beta=1 (Multiple Modes) : 7.5761106
Shunt Impedance (Pertubation) beta=1 (Multiple Modes)_no_offset : 10236.613

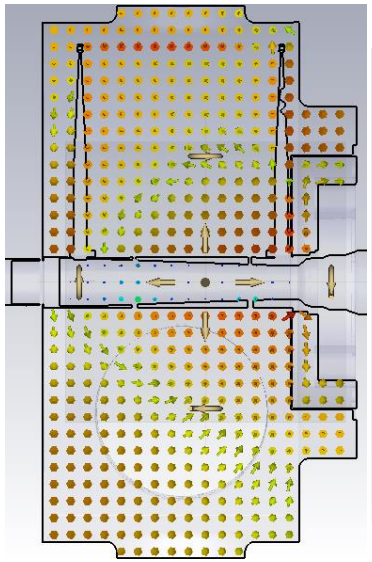
Mitigation option - Connected shaft

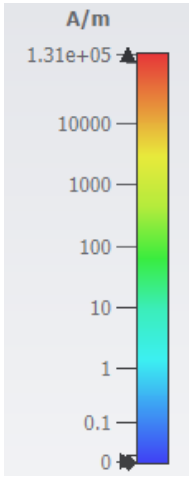




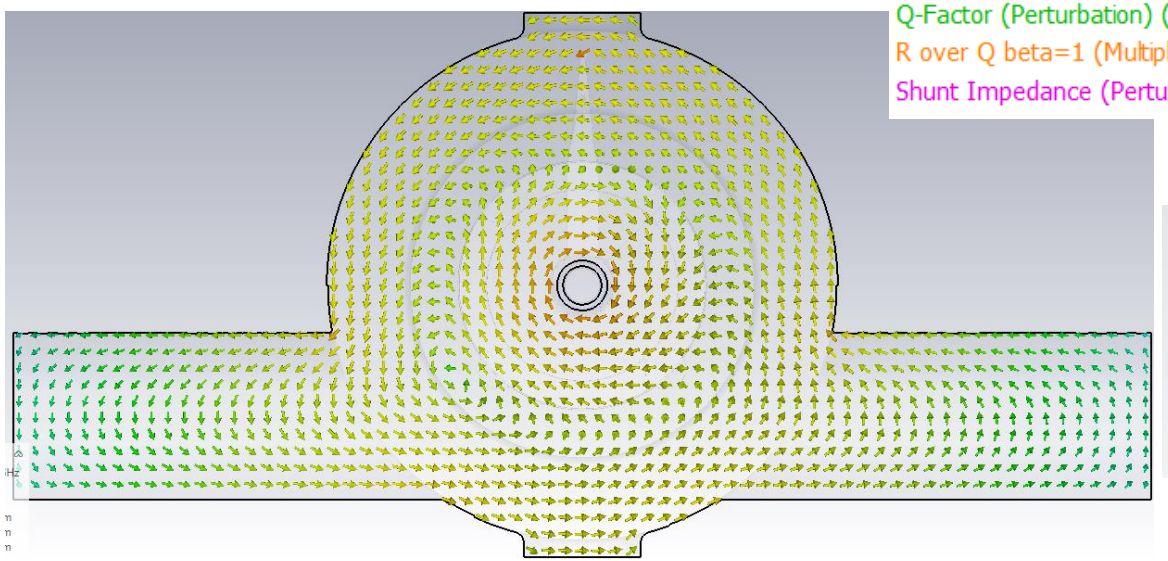
Mode 1 E-Field

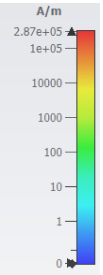
Frequency	0.811875 GHz
Phase	0 °
Cross section	A
Cutplane at X	0.000 mm
Maximum on Plane (Plot)	4.5249e+07 V/m
Maximum (Plot)	3.59789e+08 V/m





Frequency (Multiple Modes) : 0.81187536
Q-Factor (Perturbation) (Multiple Modes) : 1343.0592
R over Q beta=1 (Multiple Modes) : 7.5761106
Shunt Impedance (Pertubation) beta=1 (Multiple Modes)_no_offset : 10236.613





Mode 1 H-Field

Frequency	0.811875 GHz
Phase	90 °
Cross section	A
Cutplane at Z	-0.000 mm
Maximum on Plane (Plot)	130892 A/m
Maximum (Plot)	578538 A/m

Summary

Setup	f [GHz]	Zsh [Ω]	Q	R/Q [Ω]	Disp on wire [%]
Steel wire	0.783	21918	1671	12.94	
No forks, no wire	0.767	23502	2641	8.90	
Macor & C-wire	0.786	3646	279	13.09	87.7
No feedthrough	0.807	10381	1233	8.32	34
No feedthrough – filled opening	0.807	10148	1180	8.50	36.5
Fork rotated 20 deg	0.786	2255	171	12.97	92.3
Connected shaft	0.812	5118.3	1343	3.79	25.4

- Still to simulate/confirm results:
  - Isolated forks in Macor
  - Replace Macor by Vespel as isolated material.
  - Other arrangements of connecting the shaft to wall

2017 Model
Current Model
Updated Model as in SPS
Impedance mitigation options (feedthrough included)