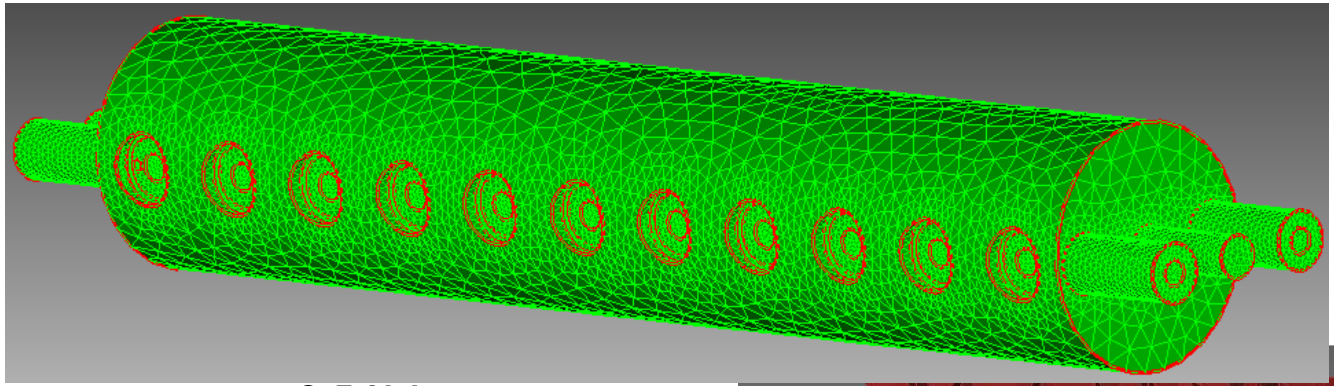
200MHz TWC: Transverse impedance and influence of 938MHz-coupler

Content

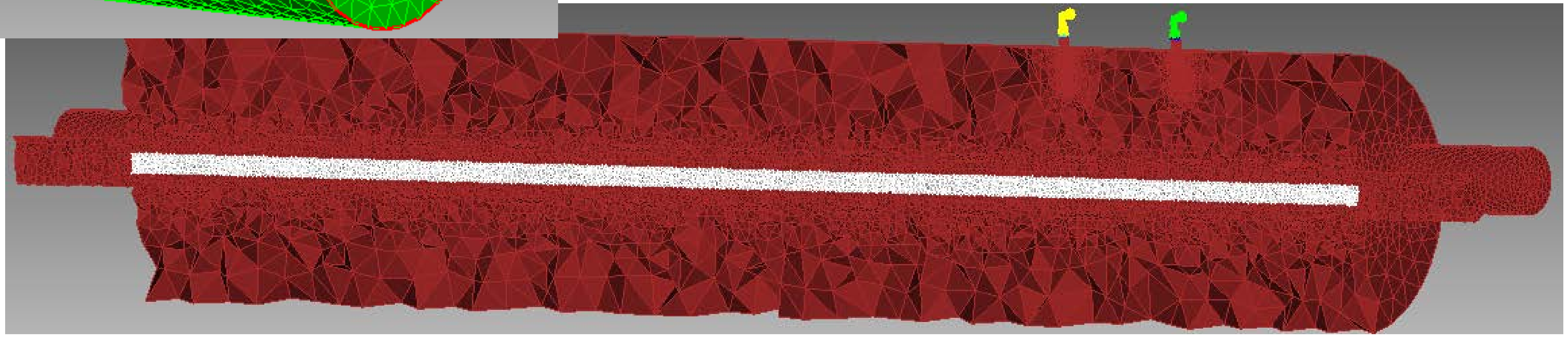
- Influence of 938MHz-coupler on HOMs (long. & transv.)
  - 1-section Eigenmode simulations (ACE3P)
- Influence of 628MHz-coupler on 938MHz HOM
  - Single-cell simulations (CST)
- Transverse impedance results for 4-section cavity

Eigenmode – Models & mesh

- Comparison: 1section+FPC & 1section+FPC+938-coupler
- Coarser mesh as in wake simulations is sufficient
- Perfectly matching boundaries on FPCs and beam pipes



0.54M



0.65M

“mesh-creator” on-axis

Eigenmode – Impedance calculations

- Usual definition for longitudinal R/Q (circuit Ohms)

$$\frac{R}{Q} = \frac{V_{\parallel}^2}{\omega U} = \frac{|\int_0^L E_z(r=0) e^{-j\frac{\omega}{c}z} dz|^2}{2\omega U} \quad [\Omega]$$

Integration on beam-axis

- Transverse parameters calculated with Panofsky-Wenzel

$$\left(\frac{R}{Q}\right)_{\perp} = \frac{V_{\perp}^2}{\omega U} = \frac{|\int_0^L E_z(r=r_0) e^{-j\frac{\omega}{c}z} dz|^2}{\left(\frac{\omega}{c} r_o\right)^2 \omega U} \quad [\Omega]$$

Integration at offset

$$Z_{\perp}(\omega) = \frac{\omega}{2c} \, Q \, \frac{R}{Q} \perp \quad [\Omega/\mathrm{m}]$$

Circuit Ohms

Influence of 938-coupler on 620MHz range

- Longitudinal impedance

1section+FPC				1section+FPC+938HOM			
f [MHz]	Q	$R/Q_{\|\|}$ [Ω]	$R_{\|\|}$ [kΩ]	f [MHz]	Q	$R/Q_{\|\|}$ [Ω]	$R_{\|\|}$ [kΩ]
627.5	34500	15.6	538	627.8	33900	19.8	671
630.9	34750	46.8	1627	630.3	36380	5.3	193
632.2	38950	20.2	787	631.4	34000	40.5	1377
				634.8	37482	12.5	469
635.3	42650	6.4	273	635.9	43600	2	87.2

Mode breakup

The 938MHz coupler has a significant influence on the 628MHz modes

Influence of 938-coupler on transv. HOMs

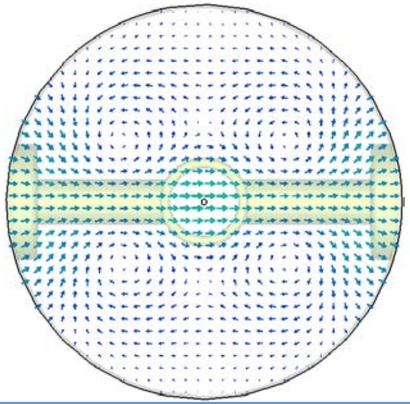
1section+FPC				1section+FPC+938HOM			
f [MHz]	Q	R/Qx [Ω]	Rx [MΩ/m]	f [MHz]	Q	R/Qx [Ω]	Rx [MΩ/m]
462.0	37200	394	71.0	462.2	37000	395	70.8
939.27	58500	83.8	48.2	938.9	42980	55.6	23.5
940.35	63600	30.4	19.1	940.0	46568	23.4	10.7

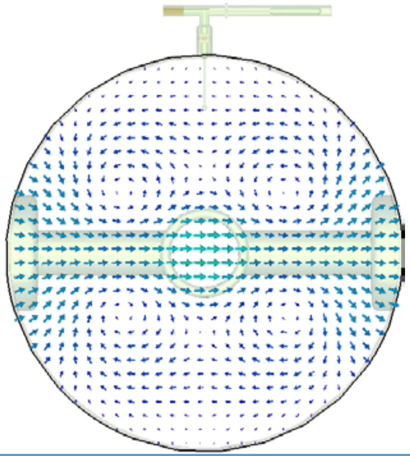
No impact on 460MHz mode

Impedances of 938MHz modes are halved

Influence of 628-coupler on 938MHz HOM

- Single-cell simulations with pA=60°



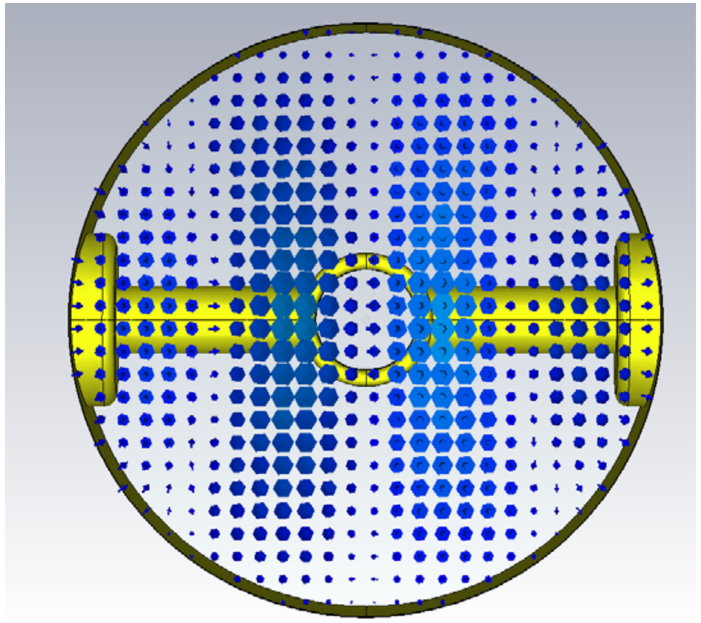


single-cell			single-cell+628-coupler		
f [MHz]	Q	Vz@Δx=1cm [kV]	f [MHz]	Q	Vz@Δx=1cm [kV]
939.8	62120	6.55	939.8	61420	6.2

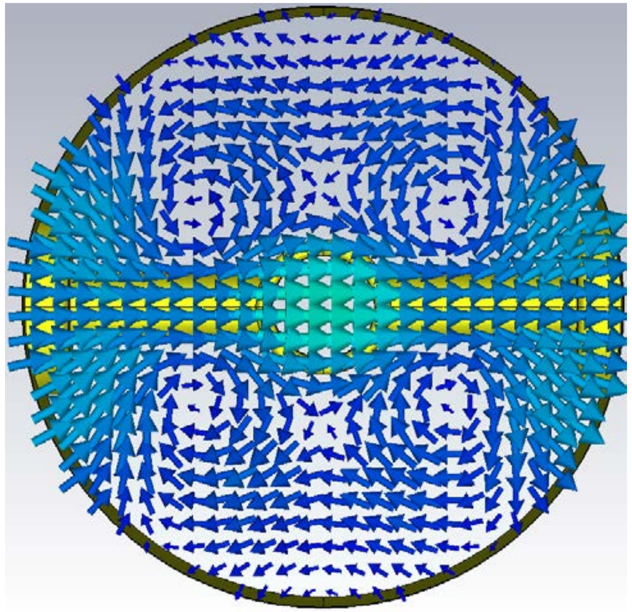
➡ Absence of influence can also be seen at the field profile…

Influence of 628-coupler on 938MHz HOM

- Electric field profile



t=0



t=T/4

f= 939.6 MHz

No influence of 628-coupler on 938MHz mode!

Transverse results for 4-section cavity

- Eigenmode simulation for 4 section cavity

4section+FPC			
f [MHz]	Q	R/Qx [Ω]	Rx [MΩ/m]
461.8	37200	1971	698
939.4	63000	205	127
940.2	62780	90.5	56

→ Comparison with other results

Transverse results for 4-section cavity

- Measurements and simulations

	Freq (MHz)	Zx (4*11 cell)
[1]	938	70 MΩ/m (Q=61000)
Wakefield CST	937.45	4*28=112MΩ/m
Eigenmode ACE3P	939.4	127 MΩ/m

[1] R. J. Laukner and T. R. P Linnecar, “The transverse coupled bunch mode instability at 940 MHz in the SPS” SPS improvement report No. 186 (1979)

Conclusions

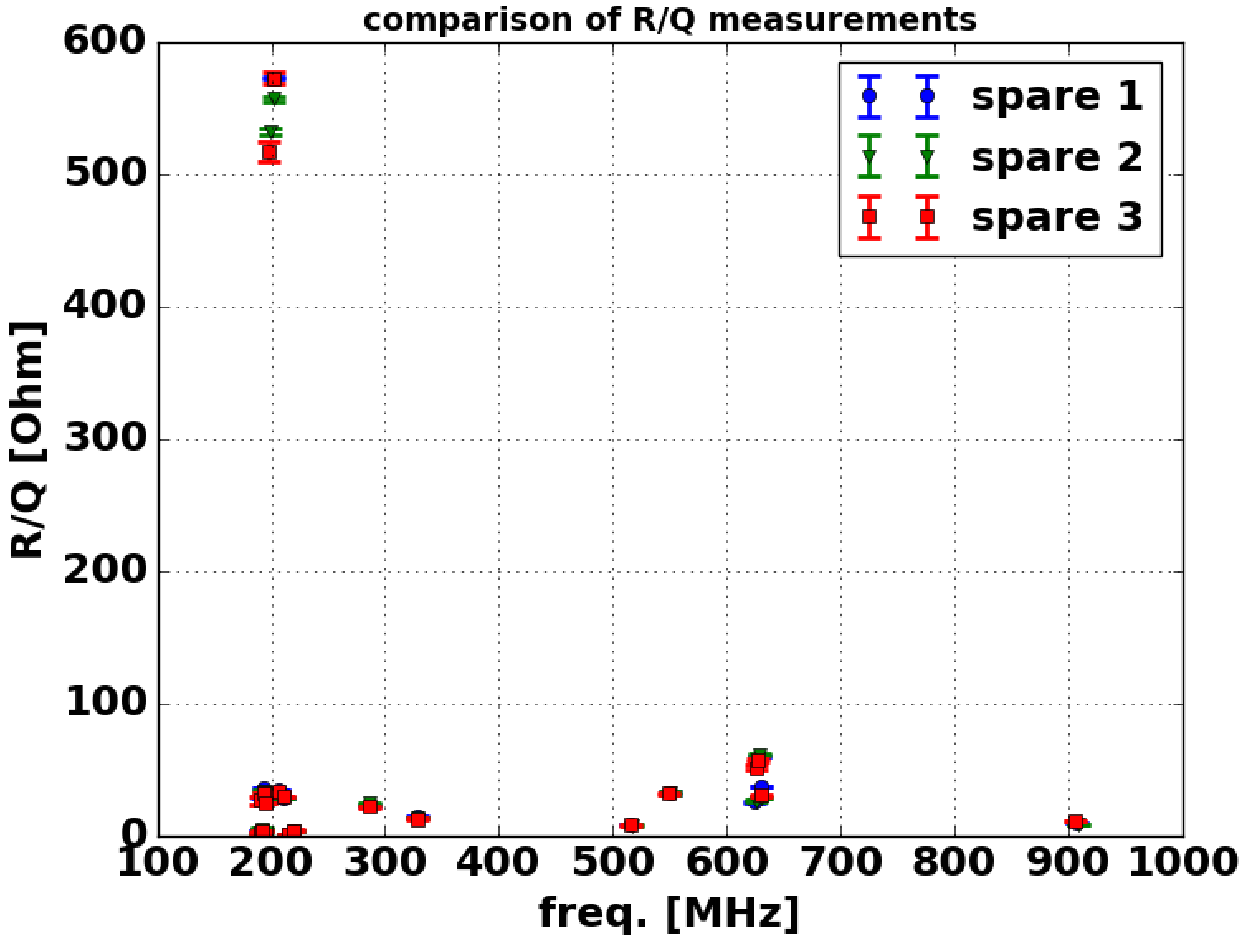
- Influence of 938-coupler on 620MHz range
- No influence of 628-coupler on 938MHz mode
- Impedance estimates for 460MHz and 938MHz modes have been given

Evaluation of spare sections

Comparison

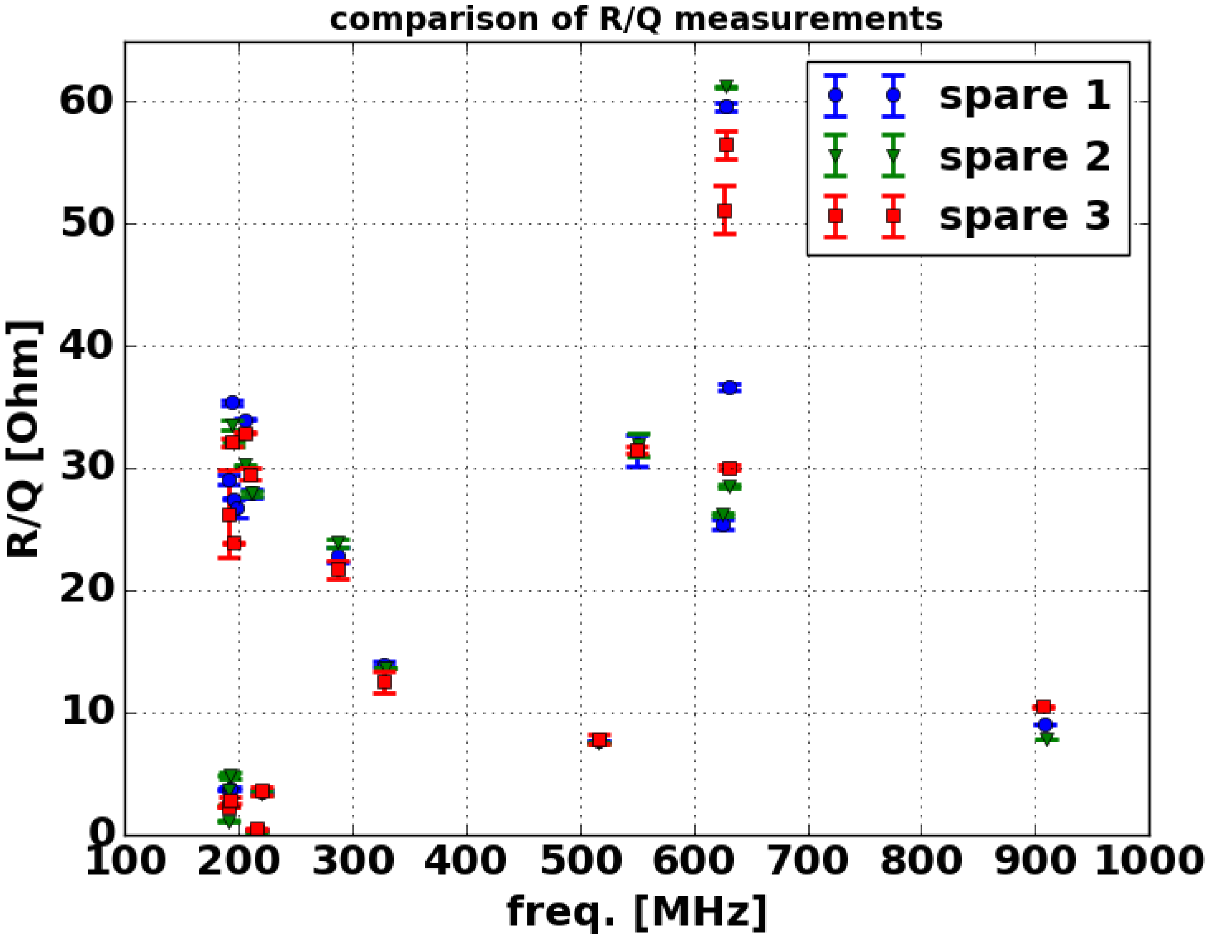
Comparison R/Q

- Error bars result from 3 traces only, but statistics were done for reliability (see next slide)



Comparison R/Q

- Error bars result from 3 traces only, but statistics were done for reliability (see next slide)



⇒ R/Q-values of the 3 spares agree very well!

⇒ No influence of different stem lengths?

Statistics - Reliability of the results

- Setup 1, 50 Traces

freq. [MHz]	R/Q [Ω]	std_R/Q [Ω]	rsd_R/Q [%]
202.20	570.37	3.279	0.57
628.27	59.12	0.27	0.46
907.62	8.98	0.05	0.56

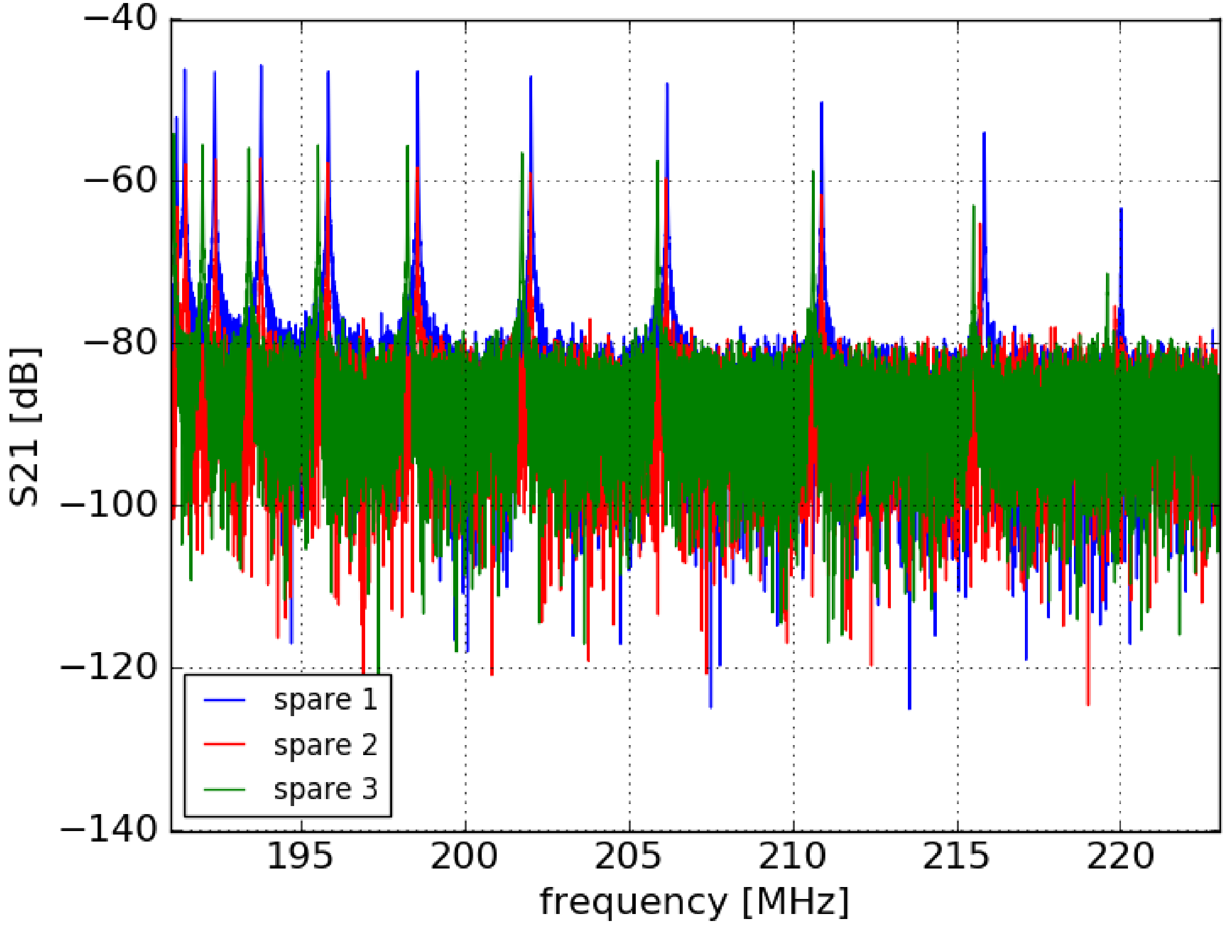
- Setup 2, 50 Traces (new centering, coupling, calibration)

freq. [MHz]	R/Q [Ω]	std_R/Q [Ω]	rsd_R/Q [%]
202.20	571.49	5.87	1.03
628.27	59.34	0.39	0.65
907.62	10.18	0.14	1.39

=> Beadpull setup should be reliable enough to draw above conclusion

SParameters in the FPB

- Is there a significant detuning of spare 3?



What would the tunnel sections look like?

Thanks

Statistics - Reliability of the results

- Setup 1, 50 Traces

freq. [MHz]	Q_0	std_Q_0	rsd_Q_0 [%]	R/Q [Ω]	std_R/Q [Ω]	rsd_R/Q [%]
202.20	14573	26.15	0.18	570.37	3.279	0.57
628.27	16117	27.04	0.17	59.12	0.27	0.46
907.62	20876	36.24	0.17	8.98	0.05	0.56

- Setup 2, 50 Traces (new centering, coupling, calibration)

freq. [MHz]	Q_0	std_Q_0	rsd_Q_0 [%]	R/Q [Ω]	std_R/Q [Ω]	rsd_R/Q [%]
202.20	14723	7.23	0.05	571.49	5.87	1.03
628.27	15884	21.18	0.13	59.34	0.39	0.65
907.62	23146	20.95	0.09	10.18	0.14	1.39