2.1 GHz Warm RF Cavity for LEReC

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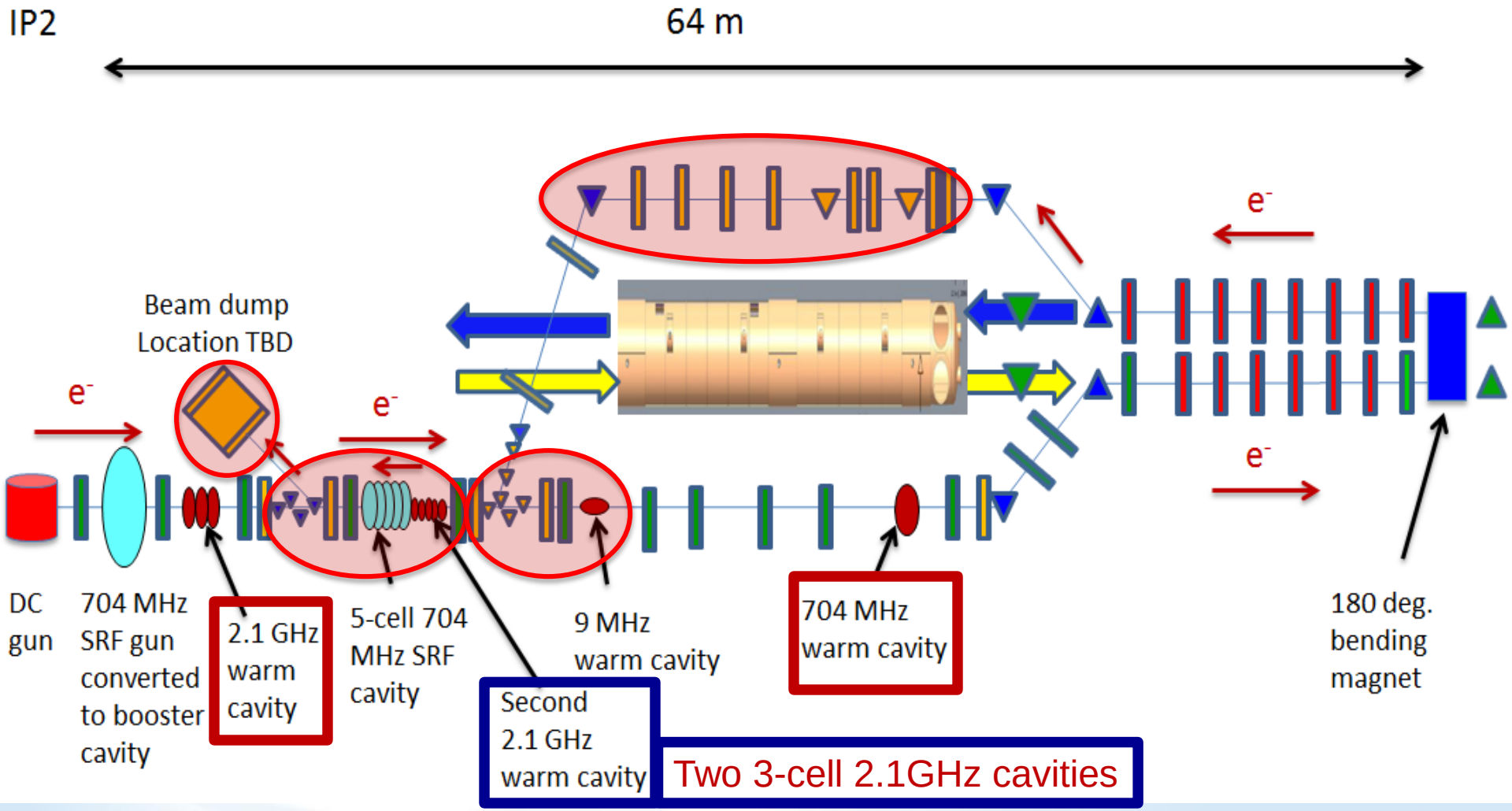
Outline

- Layout of the LEReC linac
- Description of 2.1 GHz warm RF system
- Summary

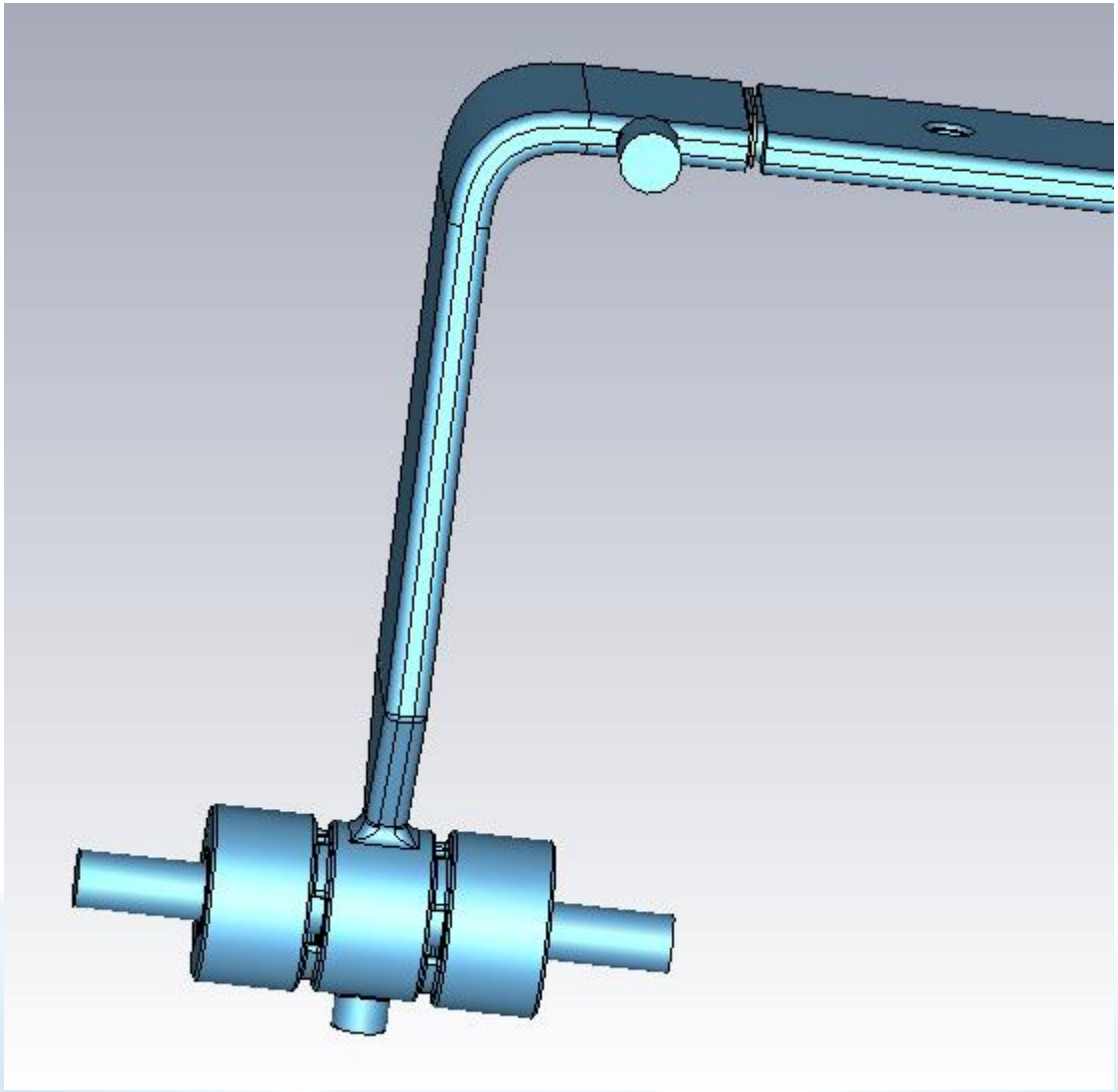
LEReC layout



Parameters

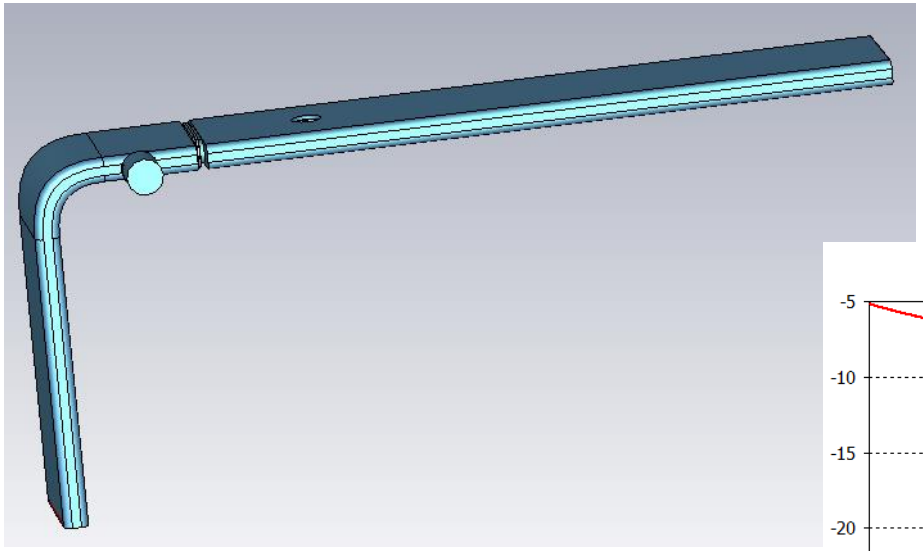
	Phase I	Phase II
Frequency	2.1107 GHz	
Beam pipe ID [inch]	1.37	
# of cells	3	
Voltage [kV]	200	250
R/Q [Ohm]	480	
G [Ohm]	170	
Q0	14100	
Pcav [kW]	5.92	9.25
RF power [kW]	10	20

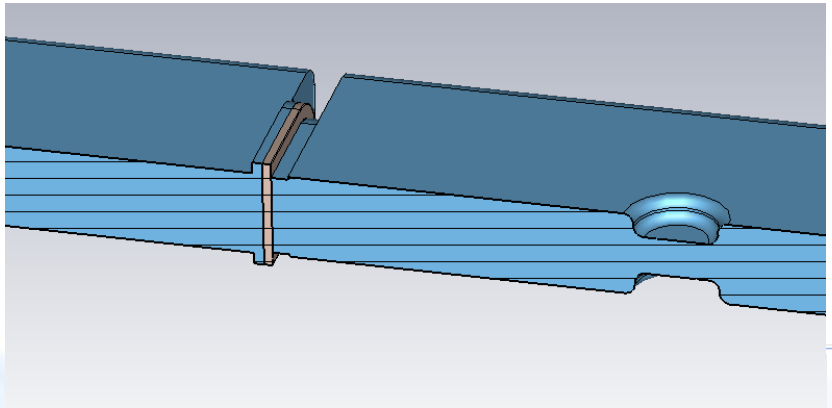
2.1 GHz warm cavity: 3cell



- Machining accuracy 0.005”.
- Added stubs near RF window for a better match at 2.1 GHz (window originally designed for 1.5 GHz)

2.1 GHz warm cavity: stub





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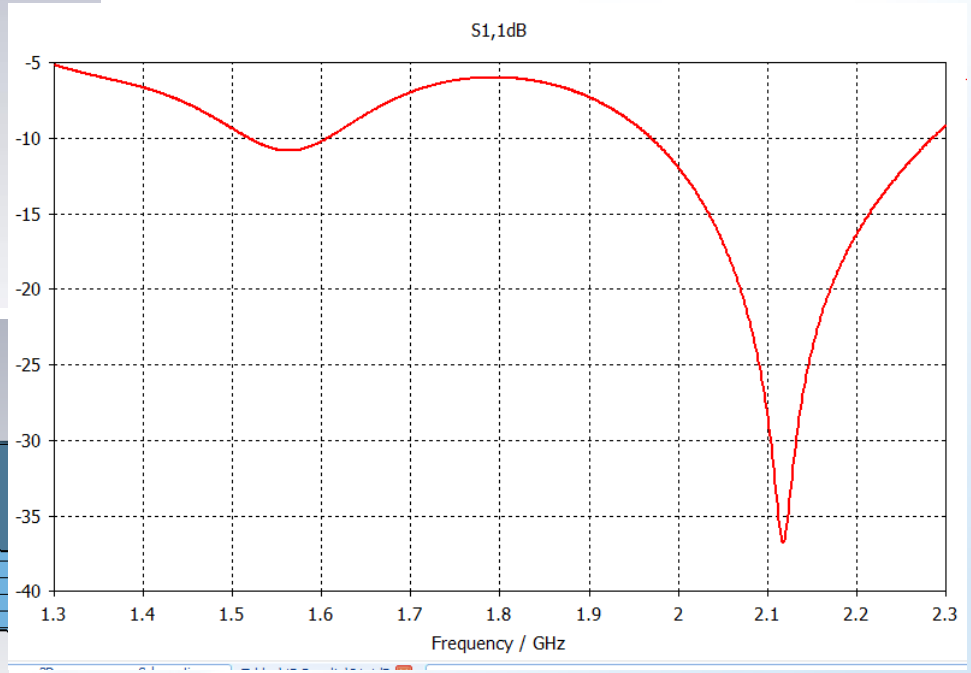
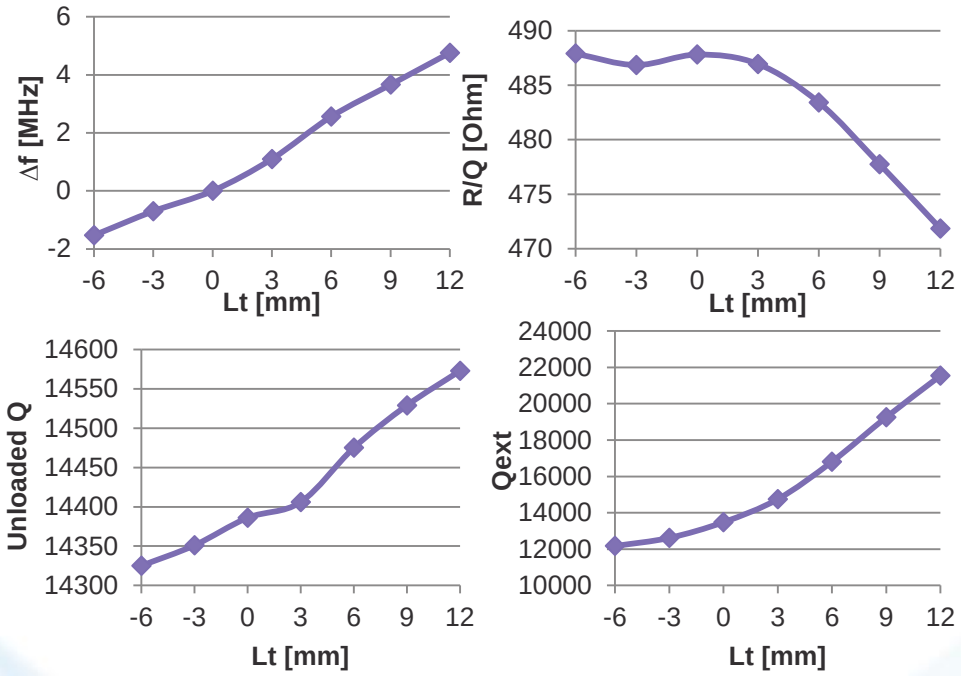


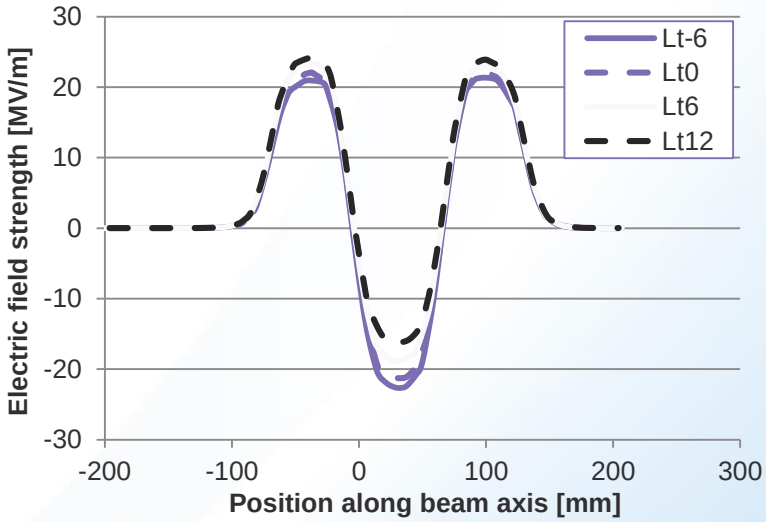
2.1 GHz warm cavity: tuner

RF performance for different tuner insertion

Lt[mm]	Δf [MHz]	Q0	Qext	R/Q [ohm]
-6	-1.530	14325	12168	487.89
0	0.000	14386	13481	487.81
6	2.560	14475	16808	483.42
12	4.758	14573	21540	471.85

Simulation results at different tuners' penetrations: frequency shift, R/Q at $\beta = 1$, Q_0, and the FPC's external Q.

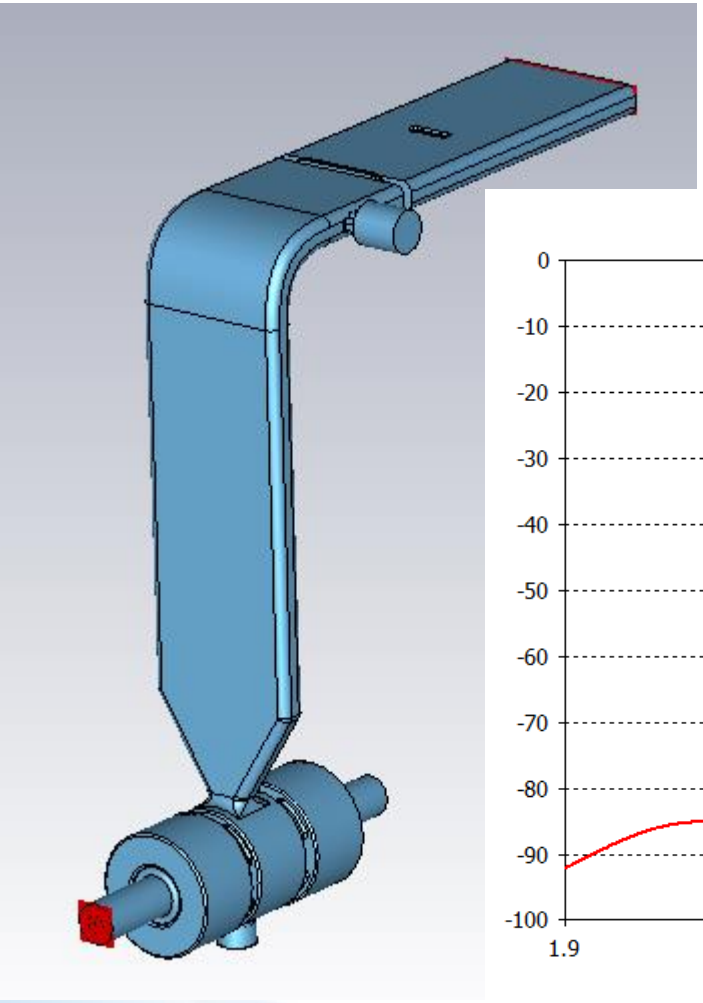




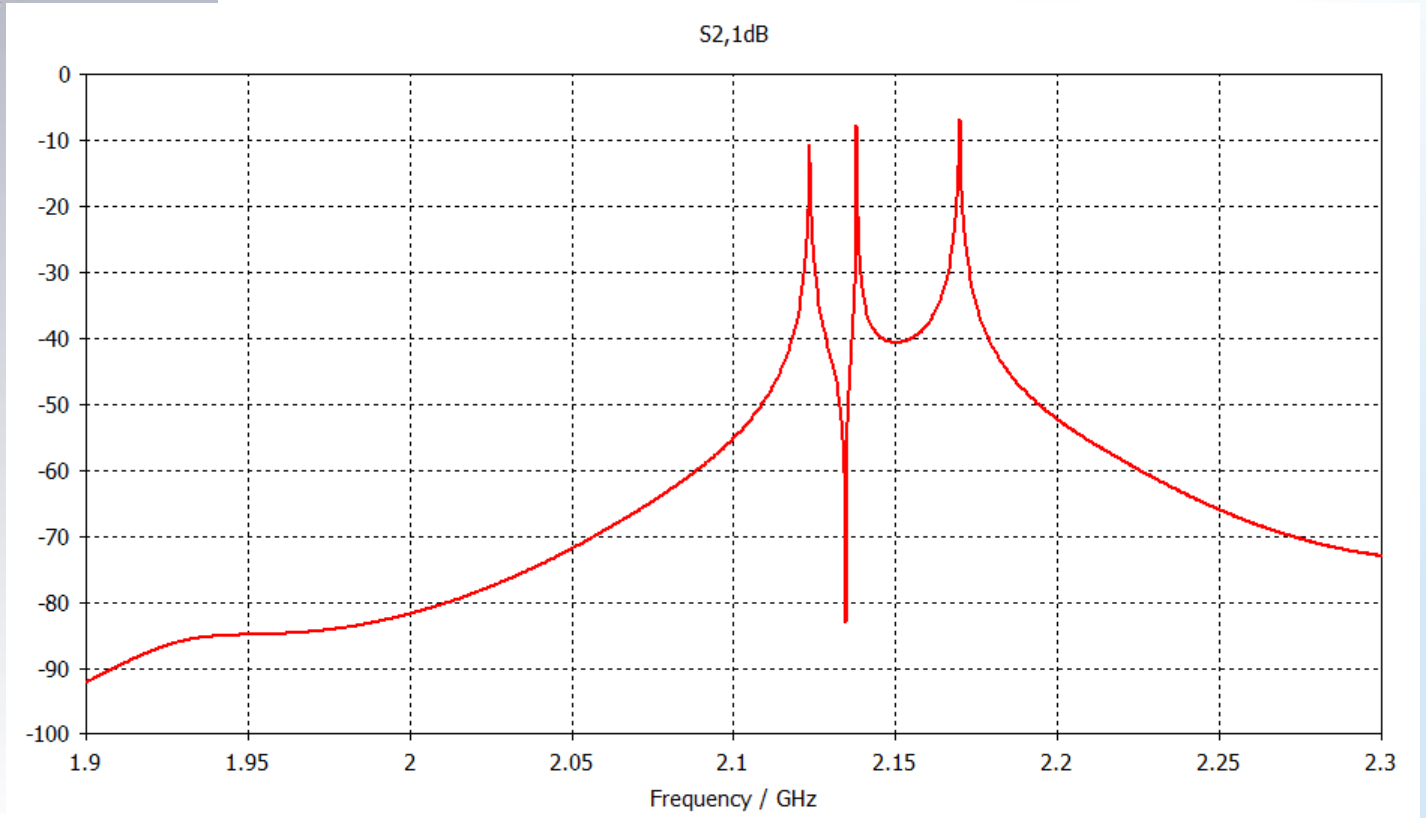
We can reduce the tuning range based on what we actually need.

Accelerating component of the electric field on beam axis for 3-cell cavity at 1Joule stored energy, with tuner penetrations to be -6, 0, 6, and 12 mm.

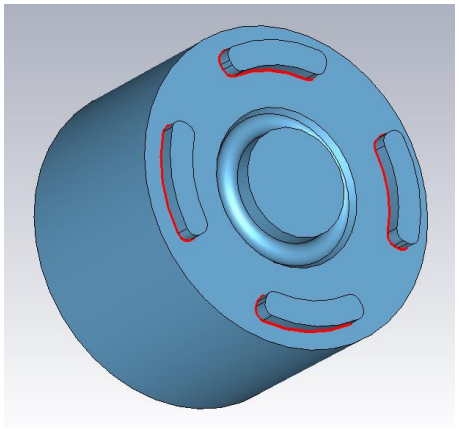
2.1 GHz warm cavity: SOM



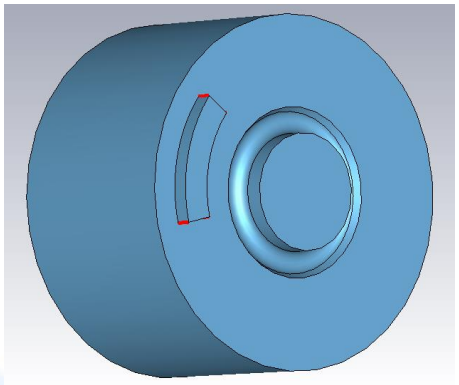
Working mode has the lowest frequency, and the next SOM is 15 MHz away.



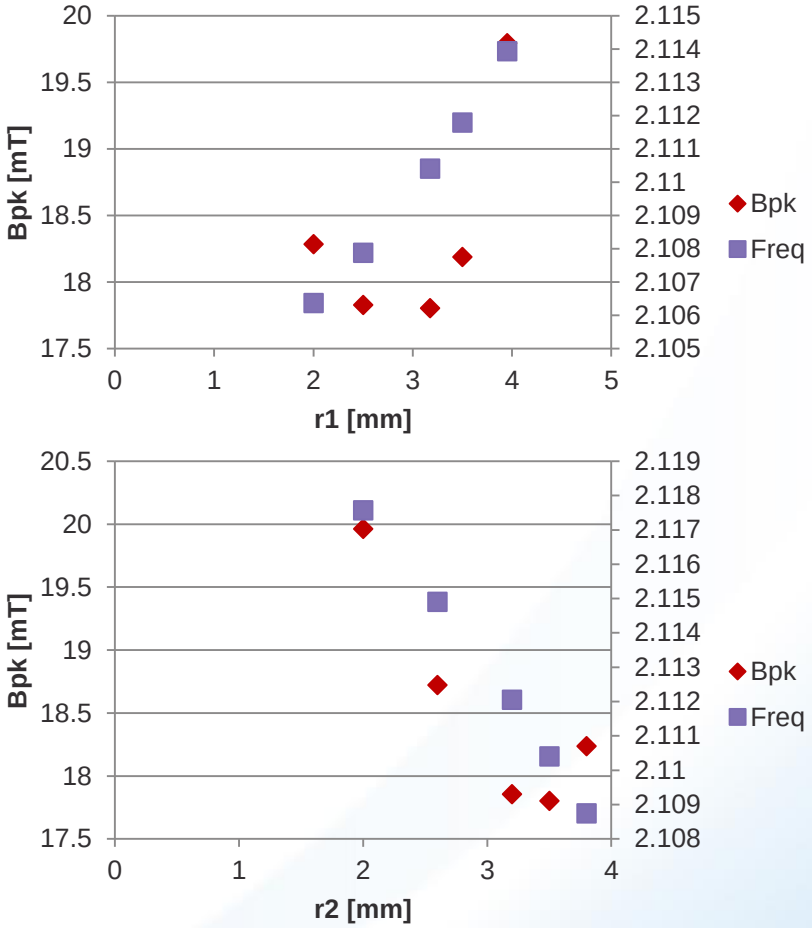
2.1 GHz warm cavity: Bpk



Blending on red curves: r2

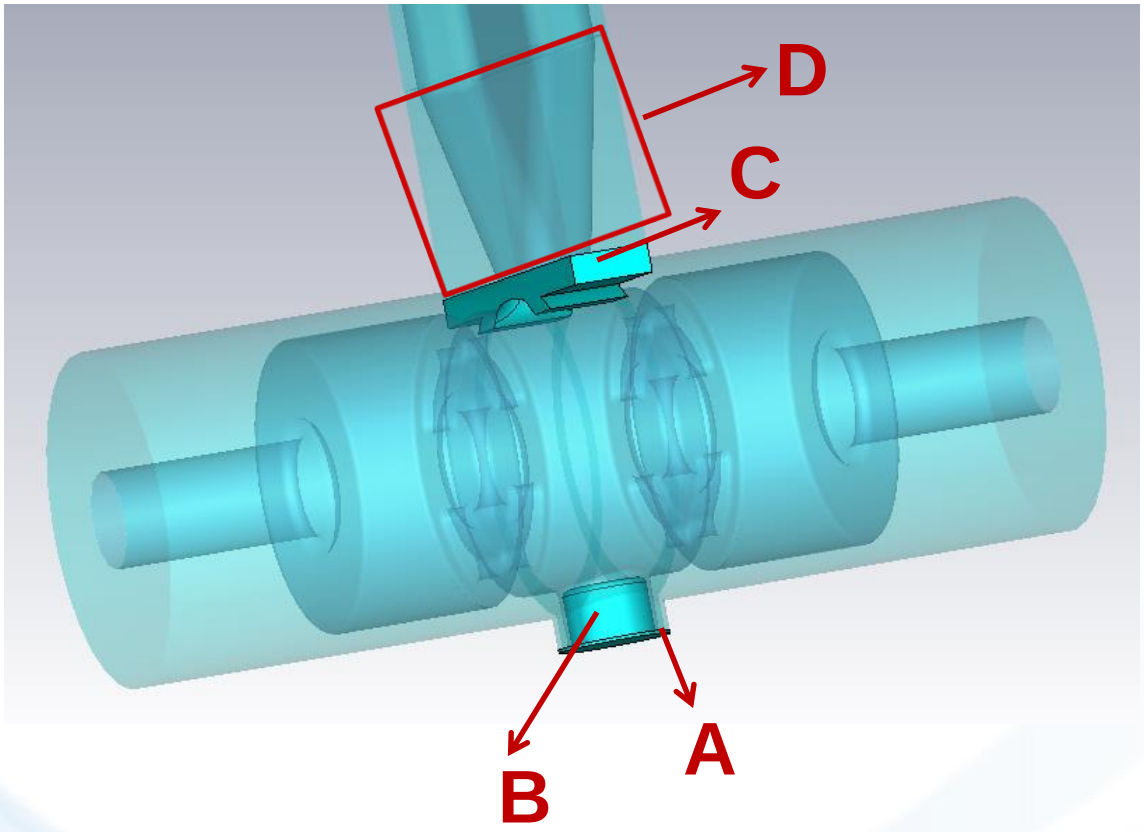


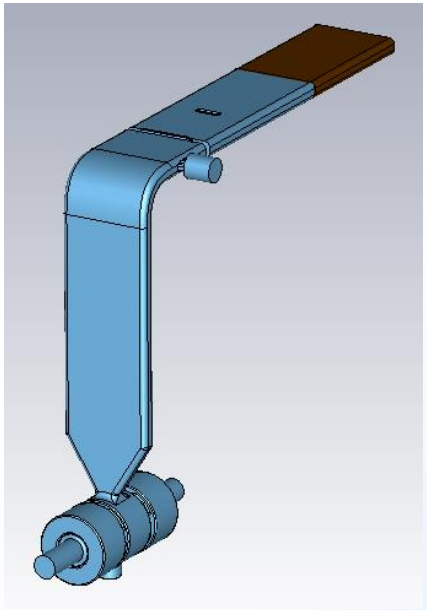
Blending on red curves: r1



Keep r1 at 3.175mm, change r2 from 2mm to 3.5mm, Bpk reduces to 90%. Cavity radii (both end cells and center cell) need to be changed to compensate the frequency change (needs to be done).

2.1 GHz warm cavity: power

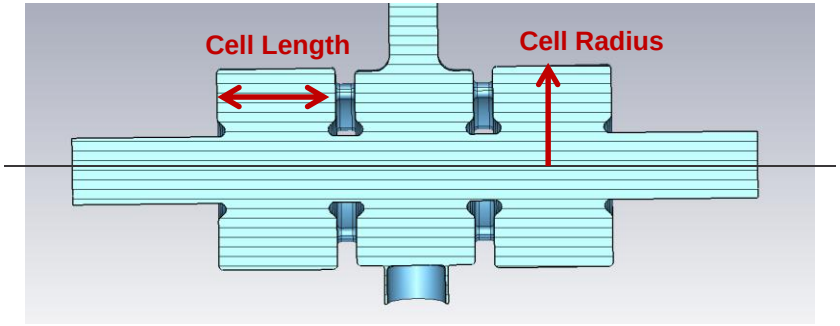


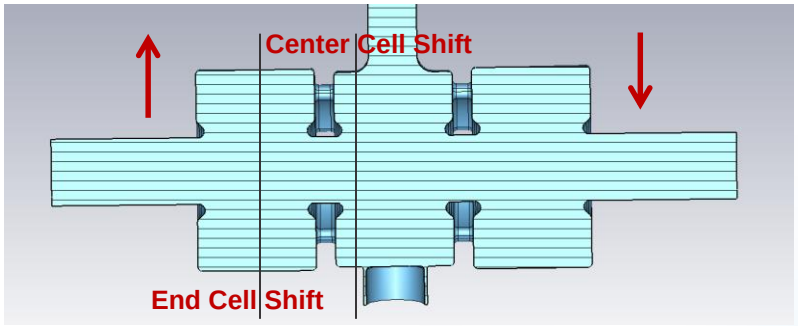


A: 1.3W
B: 62.6W (nominal position)
C: 96.9W
D: 10.3W
Above D: 0.288W/cm (x4)

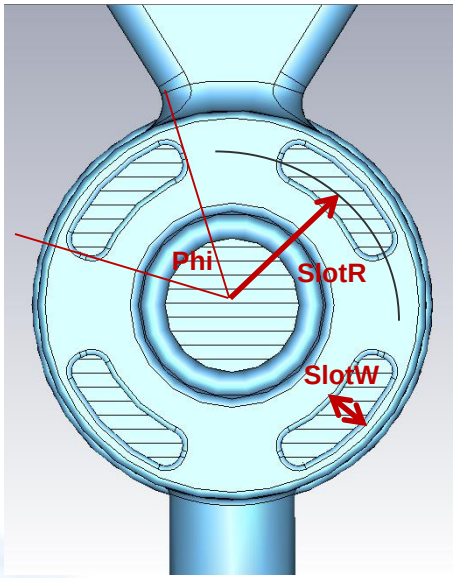
2.1 GHz warm cavity: error analysis

Cell length ±0.5mm, Δf ±0.3MHz, Qext about the same (<5%)
Cell radius ±0.1mm, Δf ∓1.3MHz, Qext ∓ 9.7% for center cell & ±6.7% for end cell





Cell shift +0.1mm, Δf -0.3MHz, Qext about the same

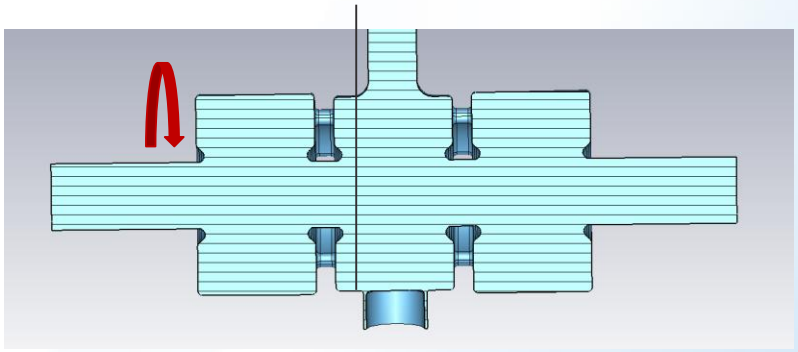


Phi ±1degree,
Δf ∓0.59MHz,
Qext about the same.

SlotR ±0.1mm,
Δf ∓0.10MHz,
Qext about the same.

SlotW ±0.1mm,
Δf ∓0.10MHz,
Qext about the same.

Per slot

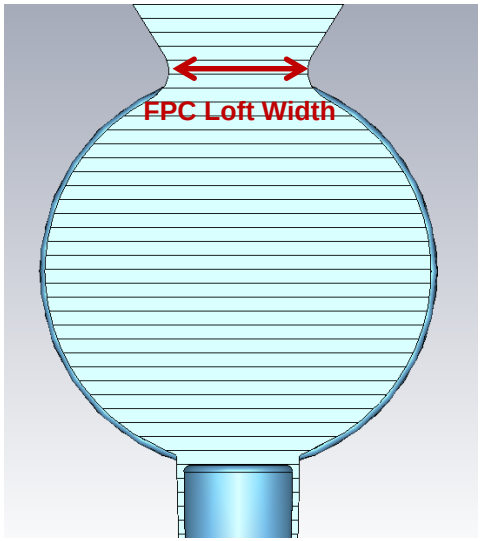


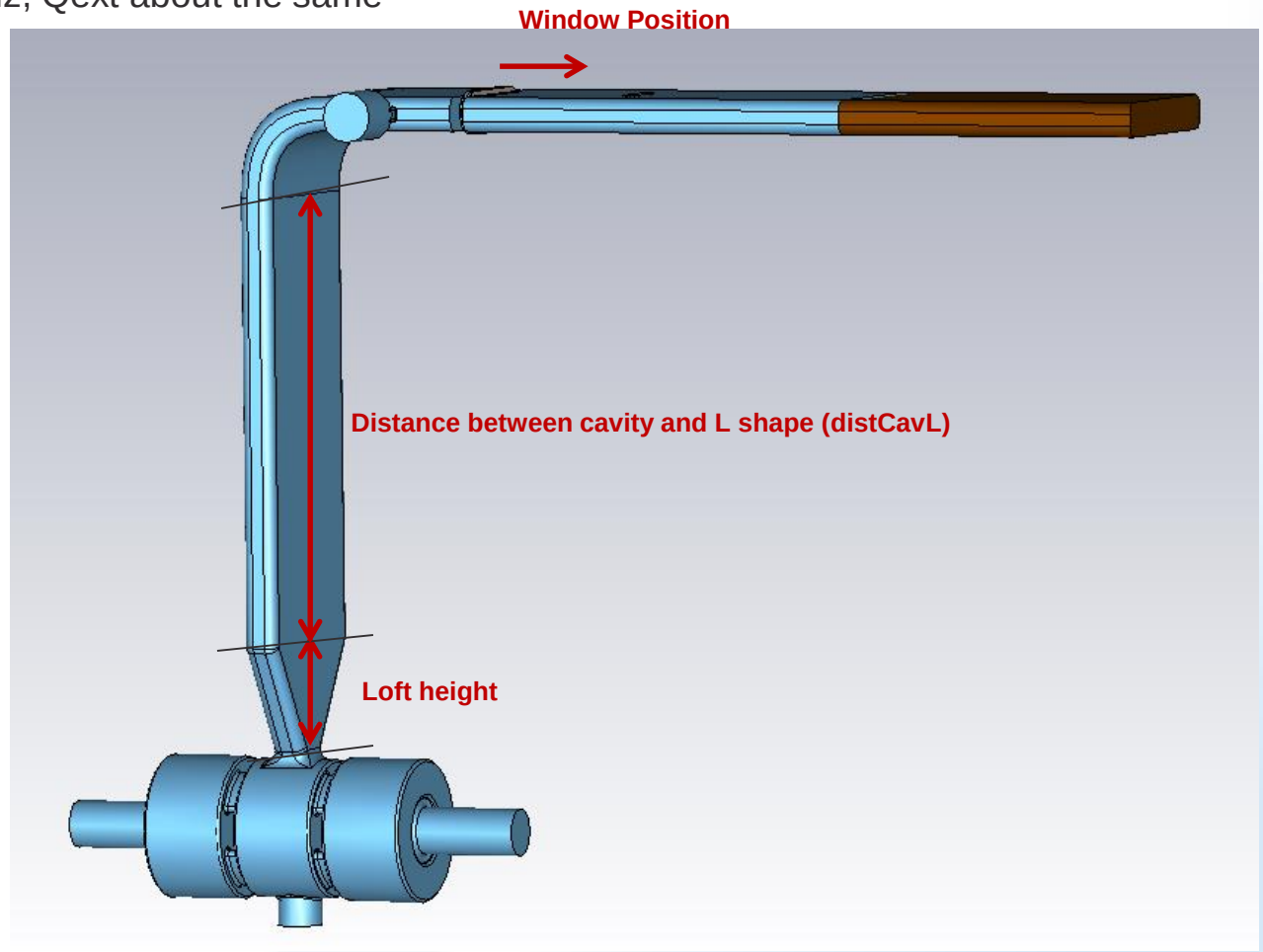
Coupling slot rotation

Coupling slot rotate 1degree, Δf -0.18MHz,
Qext about the same.

2.1 GHz warm cavity: error analysis (2)

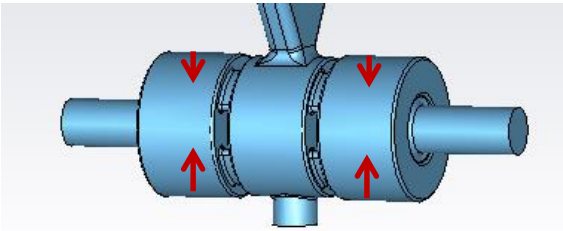
Loft width±0.1mm, Δf -0.05MHz, Qext about the same





Loft height ±0.5mm, Δf ±0.17MHz, Qext ±2.4%
distCavL±0.5mm, Δf -0.23MHz, Qext ±0.74%
Window position ±1mm, Δf -0.04MHz, Qext ±1.0%

2.1 GHz warm cavity: frequency compensation



- Machining errors: make the end cells smaller, assemble all components together, measure the frequency, trim the end cells so that frequency is closer to what we want. (May need a few iterations, and trim one cell at a time)
- End cell trimming error (0.005”) ±1.3MHz/cell, error caused by brazing -0.5MHz considering both 0.005” shift in alignment and 1degree rotation, and cavity temperature caused frequency shift (considering it might not work at 250kV), 0.5MHz from 0 to 250kV (to be confirmed by Cliff): fixed tuner/active tuner.
- Active tuner: -1.5~+2.5MHz, with -6~+6mm tuning range.
- Fixed tuner: 3/8” diameter, -0.07~+0.42MHz, with -5~+5mm tuning range. (4~6 of these tuners per cavity, 2~3 on each end cell)

Summary

- There will be two warm RF systems in LEReC: 704 MHz and 2.1 GHz cavities.

For the 2.1 GHz warm RF system:

- 3-cell cylindrical cavity with nose cones and coupling slots is designed, and is optimized on shunt impedance.
- FPC, vacuum port and gauge/arc detector port for FPC, tuner and Pickup coupler (Q_{ext} 10^8 to provide ~1W power at 200kV) are designed.
- A vacuum pump will be attached to the cavity using a Tee on one of the beam pipe.
- Cavity is fine tuned for field flatness.
- Cavity performance at different tuners' penetrations is evaluated.

Open questions:

- Eliminate the coupling slots and use center pipe for coupling? Simpler design, more uniform (but higher) heating, lower R/Q though.

Thank you!