704MHz Warm RF Cavity for LEReC

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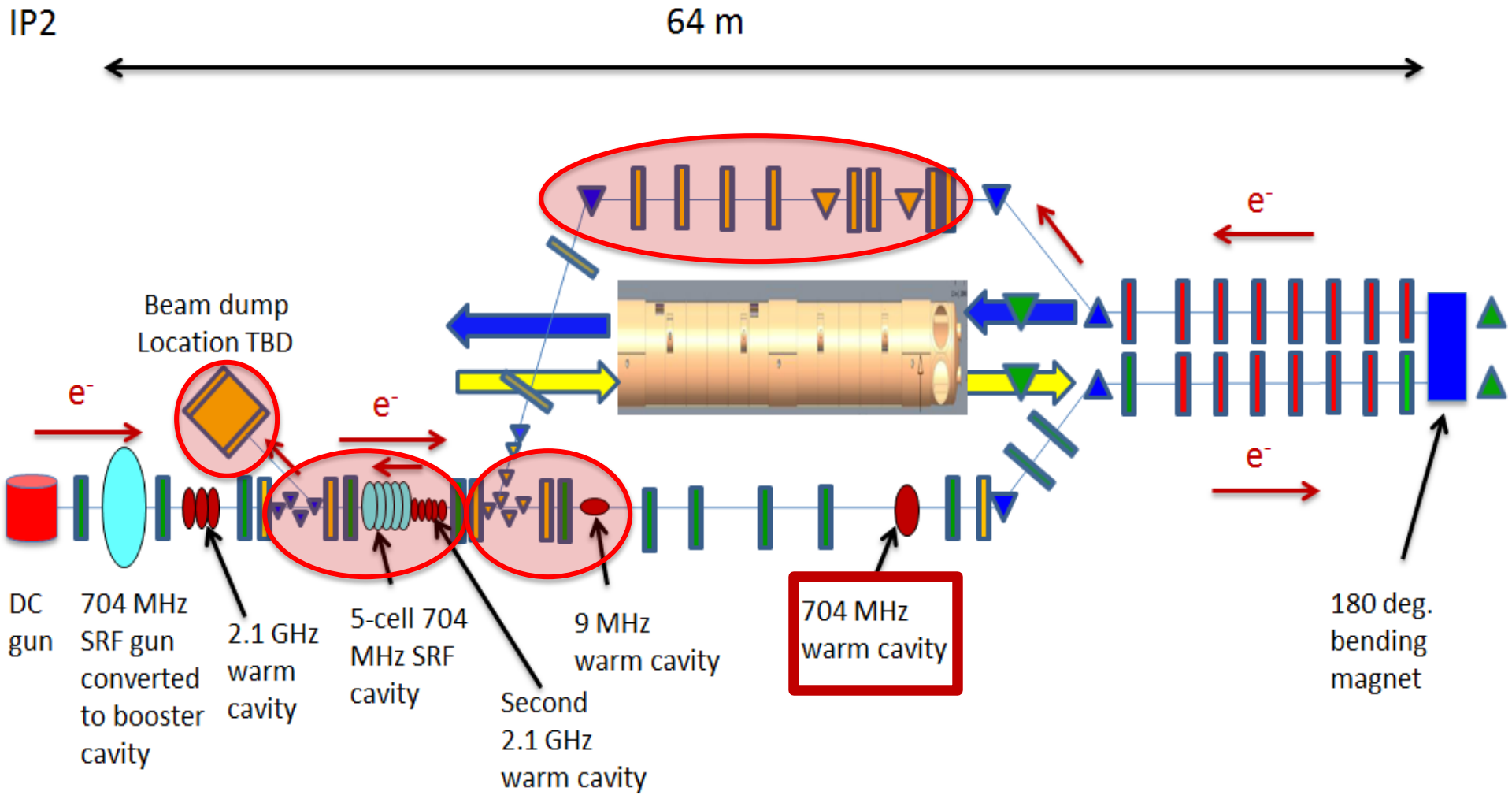
Outline

- Layout of the LEReC linac
- Description of 704 MHz warm RF system
  - Parameters
  - Bare Cavity
  - Vacuum Port
  - FPC Coupler
  - Tuner
  - Error Analysis
  - HOM
- Summary

LEReC layout



Parameters

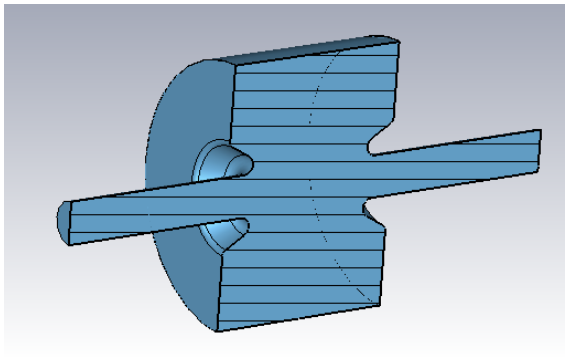
Frequency [MHz]	703.567	
Beam pipe ID [inch]	1.875	
# of cells	1	
Voltage [kV]	250	430
R/Q [Ohm]	250	
Q0	26200*	
Pcav [kW]	9.6	28.3
RF power [kW]	20	50

*After considering the 1.3 factor on the surface resistance due to surface roughness.

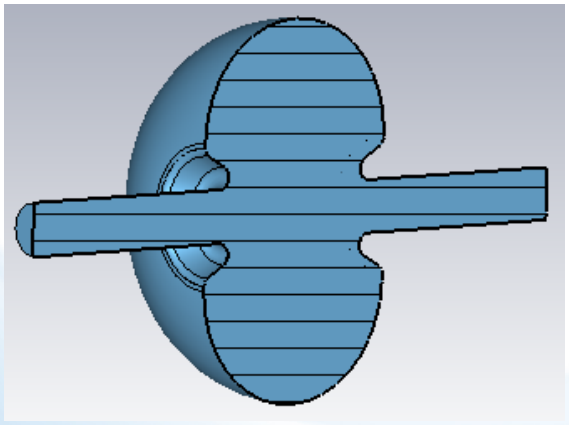
Bare Cavity

- Fix the following parameters: beam pipe diameter, cavity length (half lambda), fundamental resonant frequency f_0, and adjust the following parameters: nose cone depth (scan) and cavity radius (adjust to meet f_0). Find the best nose cone depth for above two shapes.
- Use the results above as a baseline, scan different elliptical blending and adjust cavity radius to meet f_0. Get an optimized elliptical blending, and then further scan the nose cone depth and cavity length to get an optimized cavity shape.

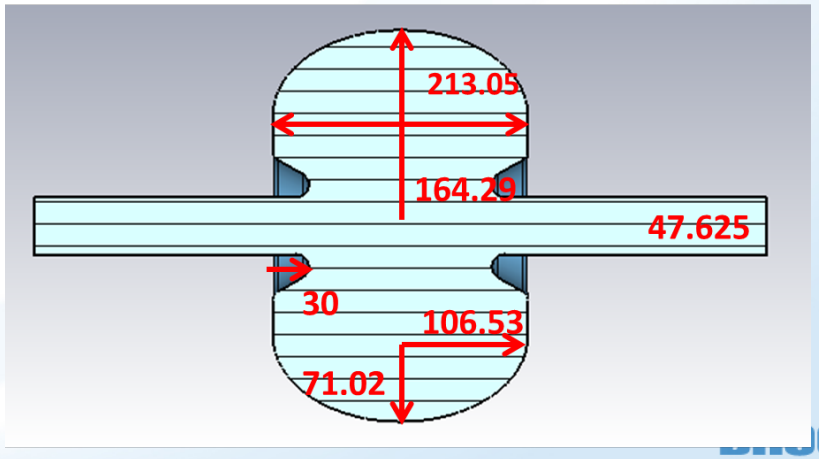
Pillbox cavity with nose cone



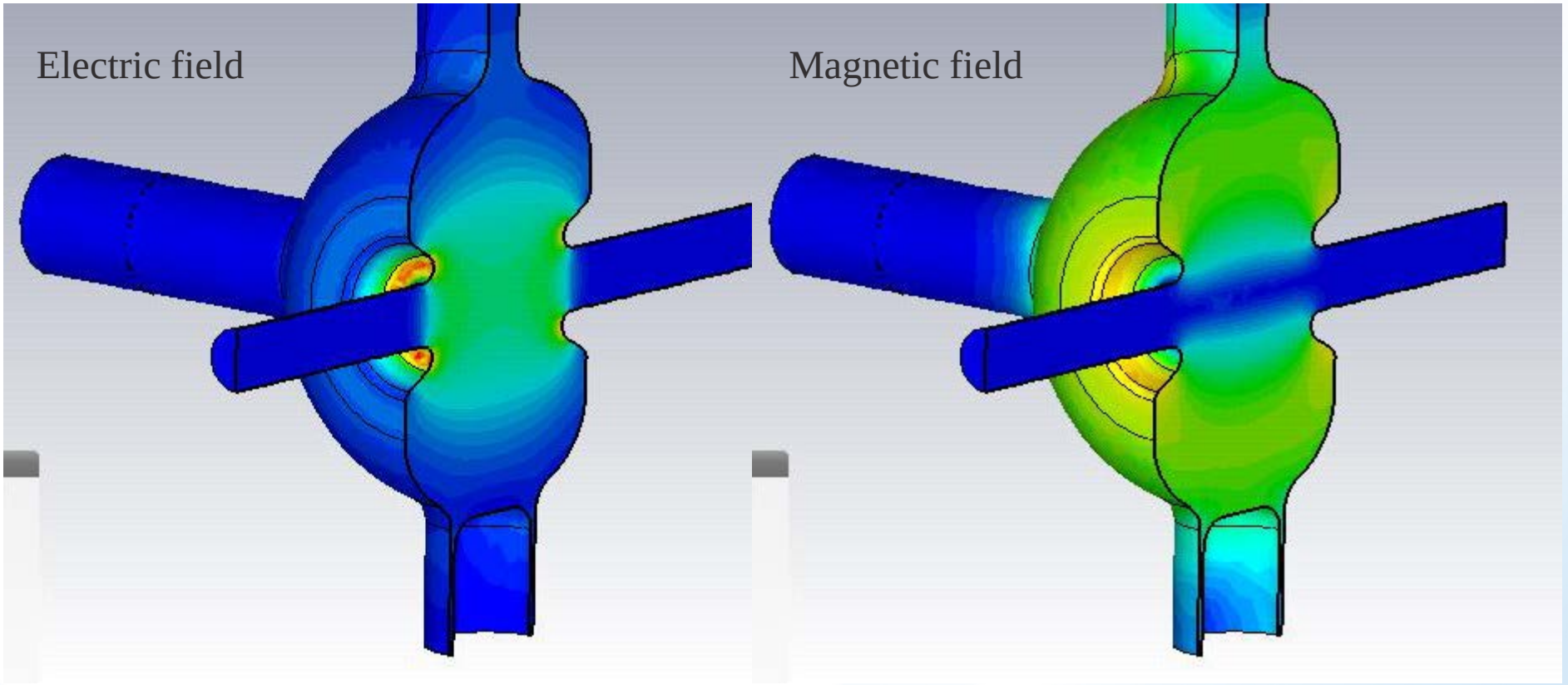
PEP-II toroid cavity



Elliptical cavity

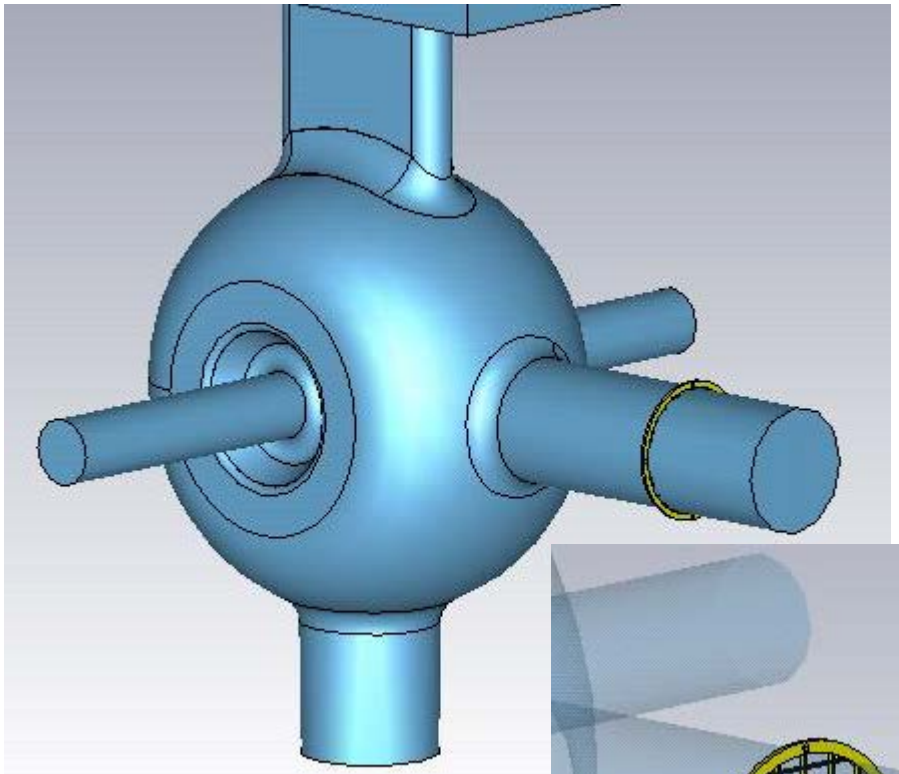


2.1 GHz warm cavity: EM field

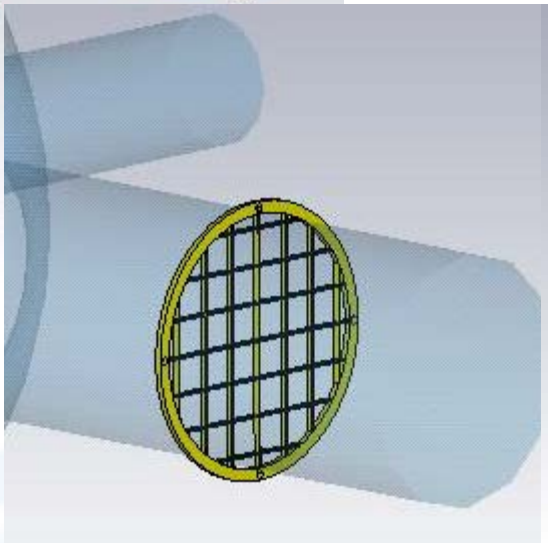


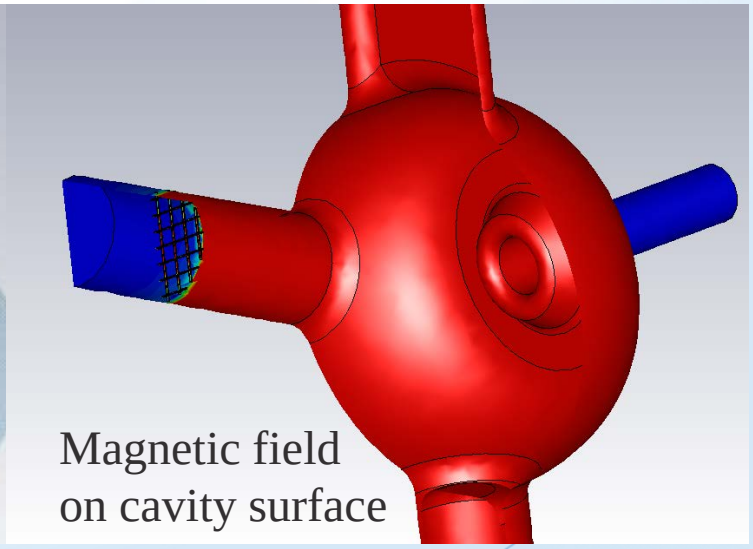
For 430 kV:
Peak electric field 8.1 MV/m, Peak magnetic field 9.4 mT

Vacuum Port



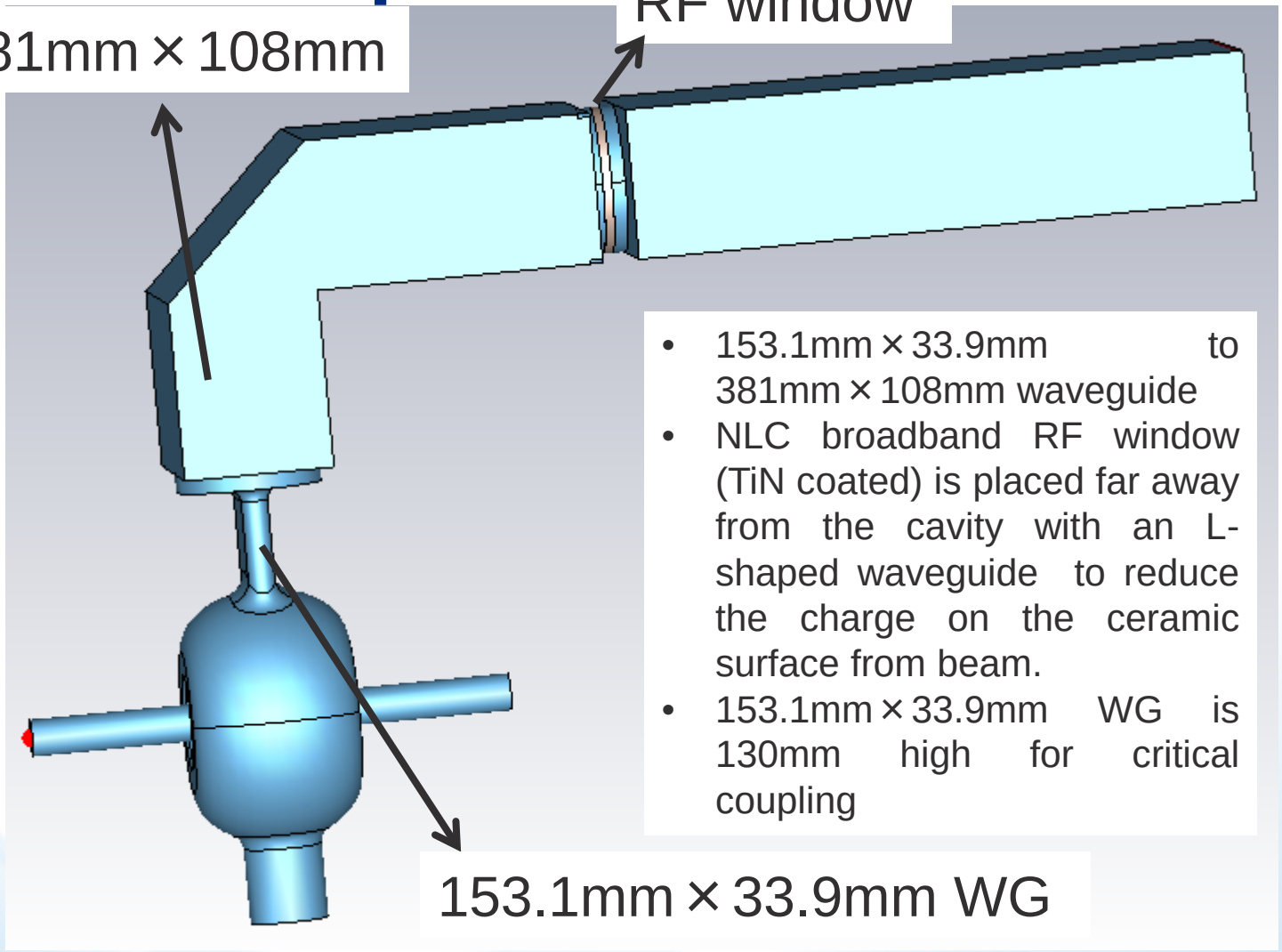
- 90mm diameter vacuum port (beam pipe ID 47.625mm)
- Gasket with mesh for RF shielding





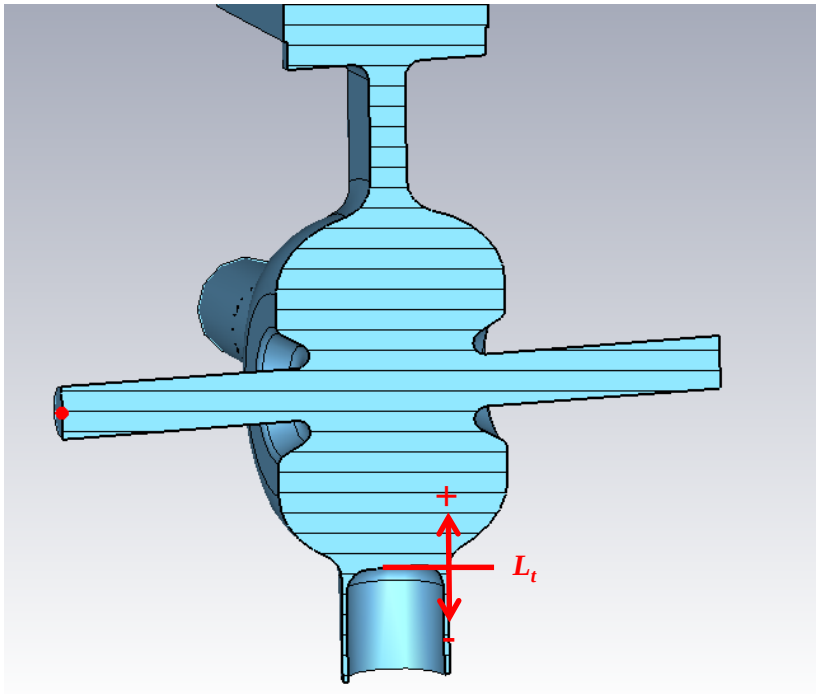
Magnetic field on cavity surface

FPC Coupler

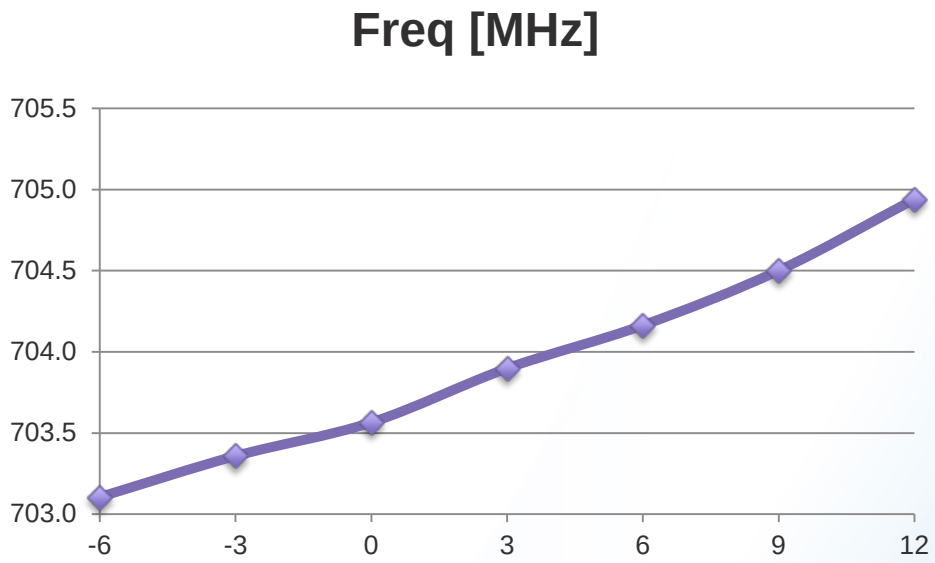


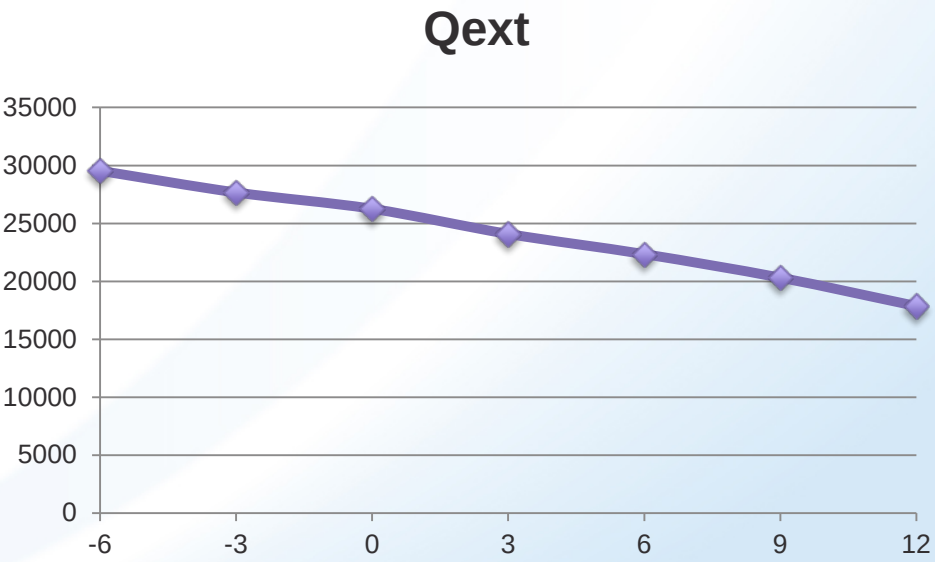
- 153.1mm × 33.9mm to 381mm × 108mm waveguide
- NLC broadband RF window (TiN coated) is placed far away from the cavity with an L-shaped waveguide to reduce the charge on the ceramic surface from beam.
- 153.1mm × 33.9mm WG is 130mm high for critical coupling

Tuner



With L_t changes from -6mm to 12mm
R/Q decreases 1%
Q0 decreases 3.5%
Frequency changes 2MHz





Error Analysis

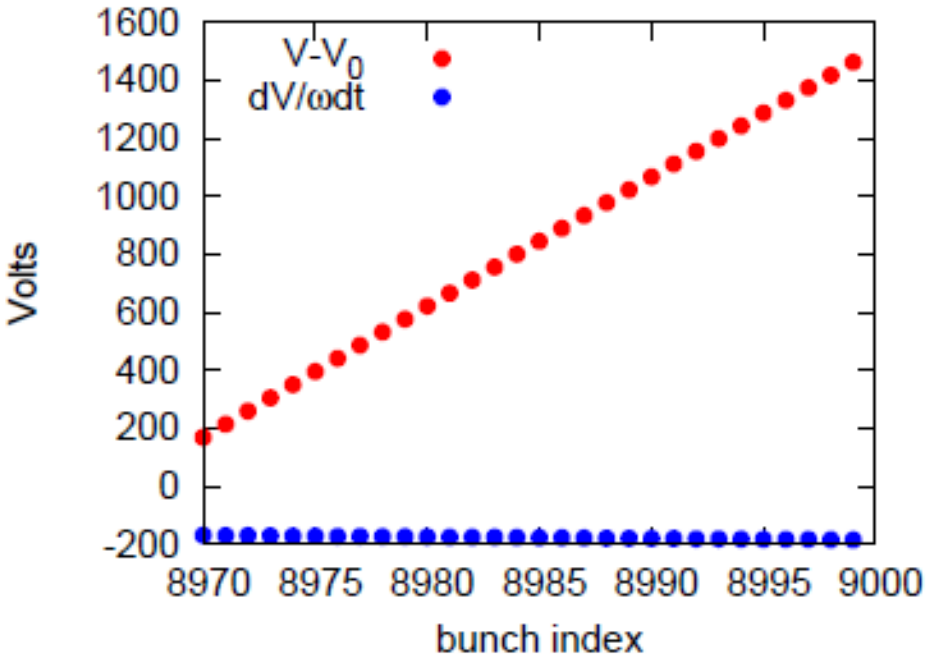
- The following errors were analyzed: Cavity length: ±0.5mm, Cavity radius: ±0.1mm, Coupling WG height: ±0.5mm, Ceramic window position: ±1mm, EBW of the cell: 0.2mm shift.
- Cavity quality factor Q0 and R/Q will not be affected by the above errors (<0.5% change).
- Frequency change: 0.57MHz/mm for cavity length, 4.2MHz/mm for cavity radius.
- FPC Qext change: 14.6%/mm for cavity length, 112%/mm for cavity radius, and 12.5%/mm for ceramic window position.
- -6~+12mm tuning with -0.5~+1.5MHz frequency range is not quite enough to compensate the above errors.
- Can we limit cavity radius error to ±0.05mm?

HOM

- A list of the HOM is generated up to 4 GHz.
- List will be provided to Dr. Blaskiewicz for HOM power calculation, and for impedance budget.

Freq [Hz]	Q0	Q0/1.3	R/Q [ohm]
7.038E+08	34217	26321	2.53E+02
9.679E+08	35521	27324	1.99E-02
9.703E+08	36660	28200	2.68E-03
1.050E+09	30479	23445	8.99E+01
1.056E+09	13669	10514	9.34E-01
1.173E+09	17944	13803	7.82E-02
1.193E+09	20209	15546	9.89E-06
1.199E+09	47953	36887	5.07E-02

Beam loading



beam loading voltage along the bunch train due to the combined effects of the accelerating cavity and the 704 MHz warm cavity, and the rf focusing due to the beam loading voltage.

- Just over 1.2 keV of energy loss which is +/- 3.e-4 dp/p
- The variation in dV/omega dt is about 15 volts along the bunch train so we do not need to worry about focusing variations.

Courtesy of Dr. Blaskiewicz

Summary

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

For the 704 MHz warm RF system:

- Elliptical cavity with nose cones is designed, and is optimized on shunt impedance.
- FPC, tuner and cavity vacuum port with mesh gasket for RF shielding are designed.
- Cavity performance at different tuners' penetrations is evaluated.
- Performed error analysis and HOM modes calculation.
- Beam loading calculated by Dr. Blaskiewicz.
- The 704 MHz RF design is about to finalize.

Things left behind…

- Vacuum port and gauge/arc detector port for FPC and pickup coupler (1 or 2?) will be designed.

Thank you!