THPAB173

# FUNDAMENTAL STUDY ON ELECTROMAGNETIC CHARACTERISTICS of HALF-WAVE RESONATOR for 200 MeV ENERGY UPGRADE of KOMAC PROTON LINAC

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# Abstract

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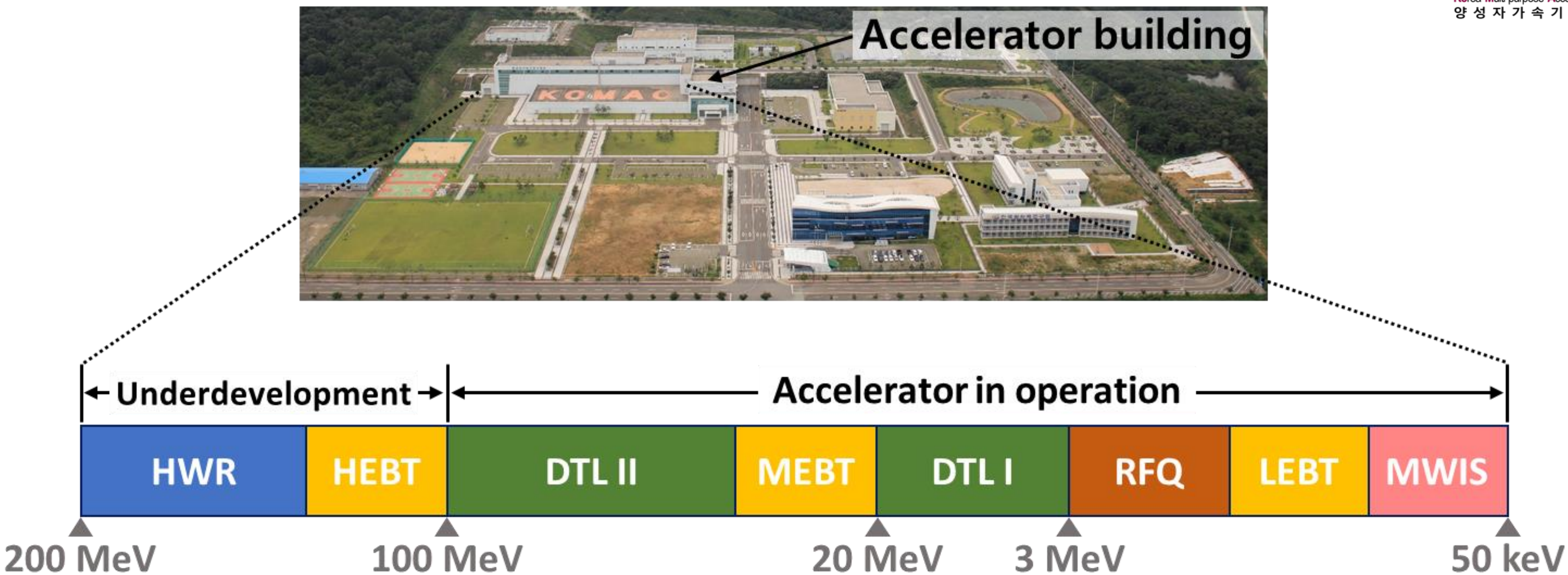
A superconducting linac has been developed at Korea Multi-purpose Accelerator Complex (KOMAC). A goal of the SRF linac is to increase proton beam energy from 100 MeV to 200 MeV. 350 MHz half-wave resonator (HWR) should provide 3.6 MV accelerating voltage to achieve the energy upgrade. An electromagnetic (EM) analysis on the parametrically designed HWR cavity was conducted. The cavity design was optimized to reduce a peak electric field and a peak magnetic field while satisfying the required accelerating voltage. In addition, a mechanical-EM coupled simulation was conducted to estimate a helium pressure sensitivity. Also, Lorentz force detuning was simulated. The cavity and a helium jacket design was optimized to minimize the frequency detuning due to the helium pressure and Lorentz force. The helium sensitivity is 1.7 Hz/mbar, and the Lorentz force detuning coefficient is -3.37 $Hz/(MV/m)^2$.

# Proton Linac at KOMAC






- **Design baseline SRF linac**
  - 36 HWR cavities for additional 100 MeV acceleration
  - Accelerating voltage : 3.6 MV
  - Optimum beta : 0.56
  - 9 cryomodules(4 HWRs/cryomodule)
  - Optimized using GenLinWin code

# Electromagnetic Analysis on Parametrically Designed HWR

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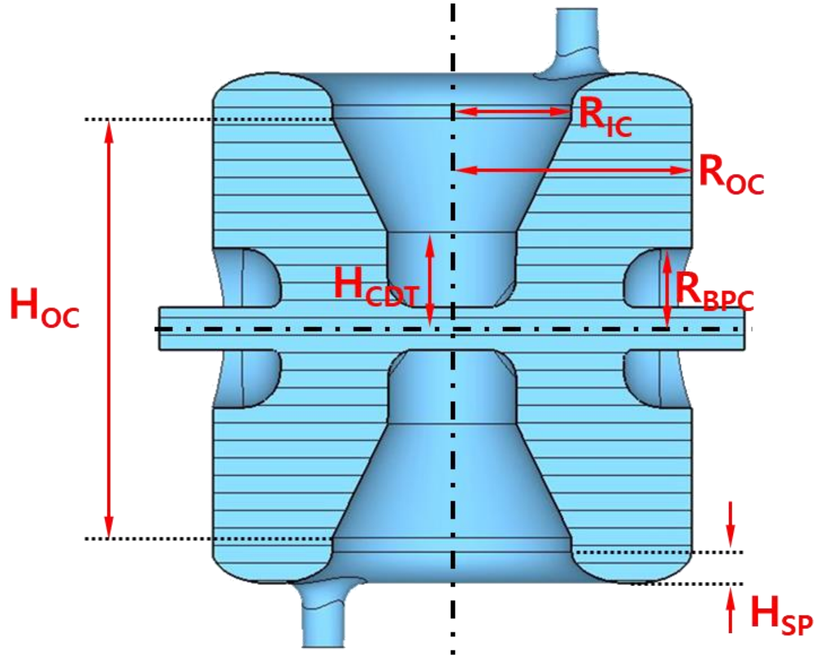
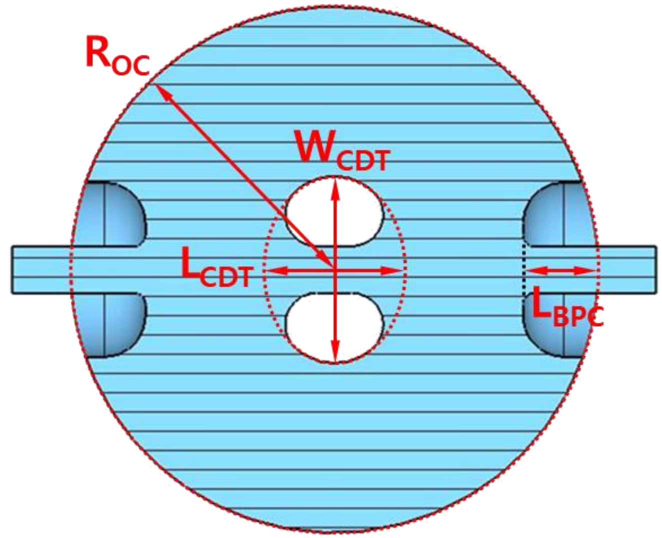
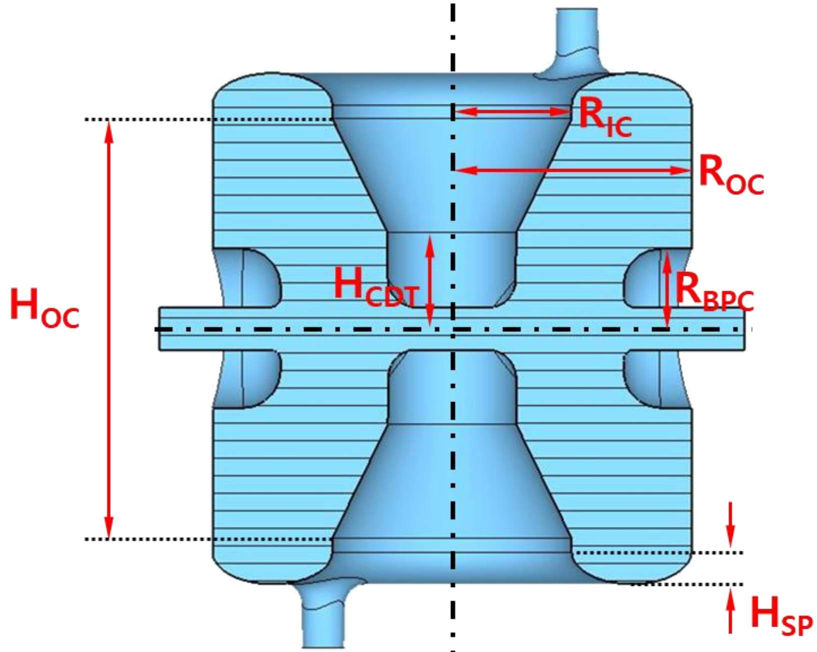


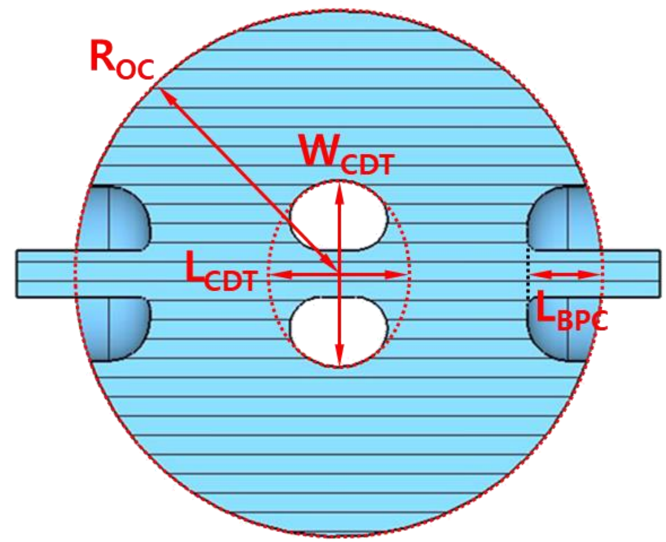




- **Parametrically Design HWR**
  - Frequency : 350 MHz
  - Conical inner conductor, elliptical cross-section central drift tube (CDT)
  - Radius of outer conductor ($R_{OC}$), lengths of CDT ($L_{CDT}$) and beam port cup ($L_{BPC}$) were guided by accelerator baseline.
  - Beam aperture : 40 mm
  - CST MWS

# Electromagnetic Analysis on Parametrically Designed HWR





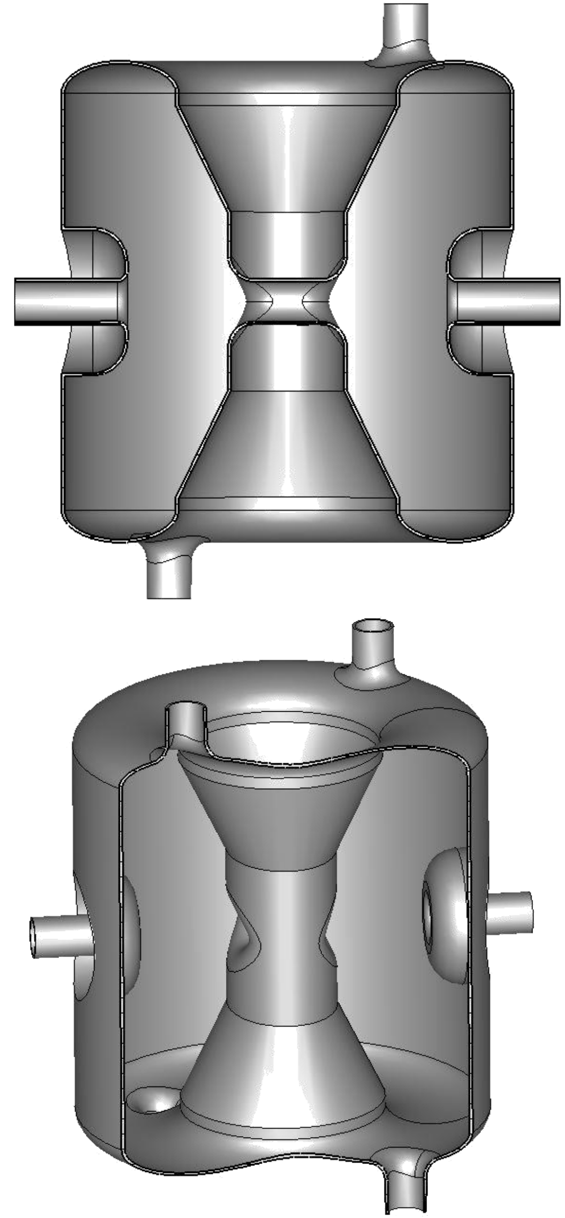




- **Parametrically Design HWR**
  - Design optimization to reduce peak electric and magnetic field while satisfying optimum beta and accelerating voltage.
  - EM analysis on HWR designed by various combinations of optimization parameters such as radius of inner conductor ($R_{IC}$), width of CDT ($W_{CDT}$), height of CDT ($W_{CDT}$), height of short plate($H_{SP}$), radius of BPC ($R_{BPC}$) and radii of fillets of CDT, BPC and rinsing ports.

# Figure of Merit



| Parameter | Unit | KOMAC HWR |
|---|---|---|
| Frequency | MHz | 350 |
| Optimum beta | - | 0.56 |
| Stored energy | J | 23.1 |
| $V_{acc}$ | MV | 3.6 |
| $V_0$ | MV | 4.1 |
| $E_{acc}$ | MV/m | 7.5 |
| $E_0$ | MV/m | 8.6 |
| $E_{pk}$ | MV/m | 29.1 |
| $B_{pk}$ | mT | 61.7 |
| $E_{pk}$ / $E_{acc}$ | - | 3.9 |
| $B_{pk}$ / $E_{acc}$ | mT/(MV/m) | 8.2 |
| R/Q | ohm | 256.6 |
| G | ohm | 116.1 |
| $Q_0$ (@Rs=20 nΩ) | - | 5.81E+9 |



# EM-Mechanical Coupled Analysis

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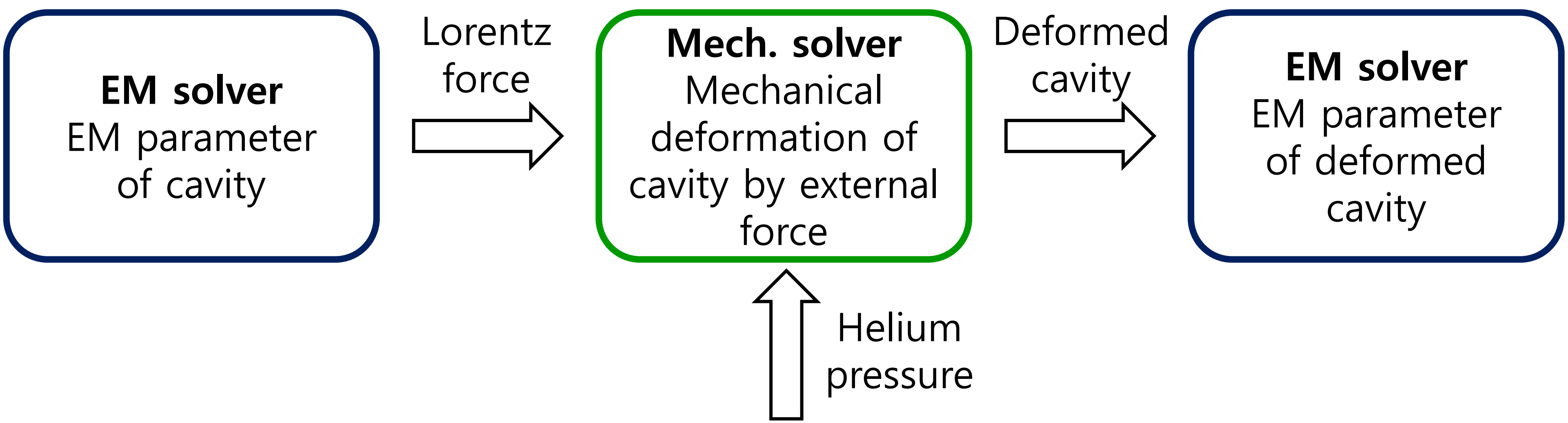
- Mechanical simulation to quantify deformation of cavity by external force
- EM simulation to quantify frequency detuning by deformation of cavity
- Estimation of a helium pressure sensitivity and Lorentz force detuning
- HWR and helium jacket design optimization for minimizing frequency detuning
- CST Studio Suite (Structural Mechanics & Eigenmode solver)



# Helium Jacket Design and He Pressure Sensitivity

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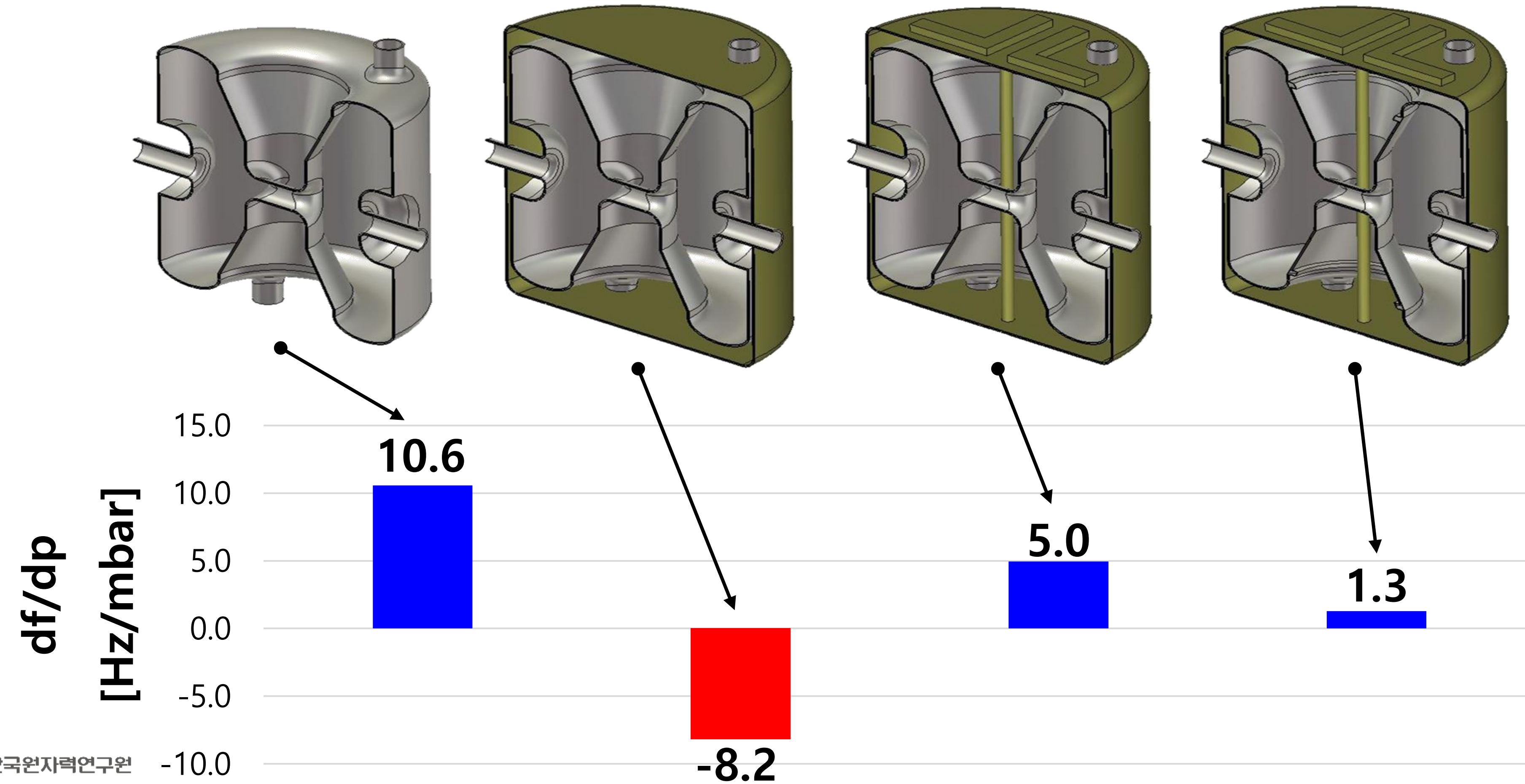
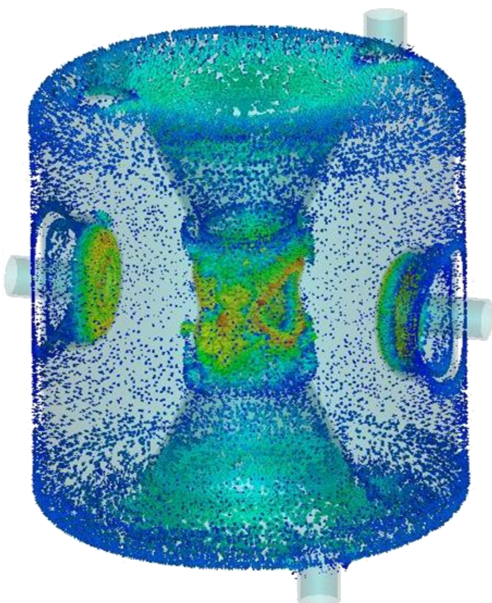
- Fixed beam port condition
- Cylindrical titanium helium jacket
- Reinforced helium jacket to reduce deformation of flat ends
- Stiffening rib on conical inner conductor

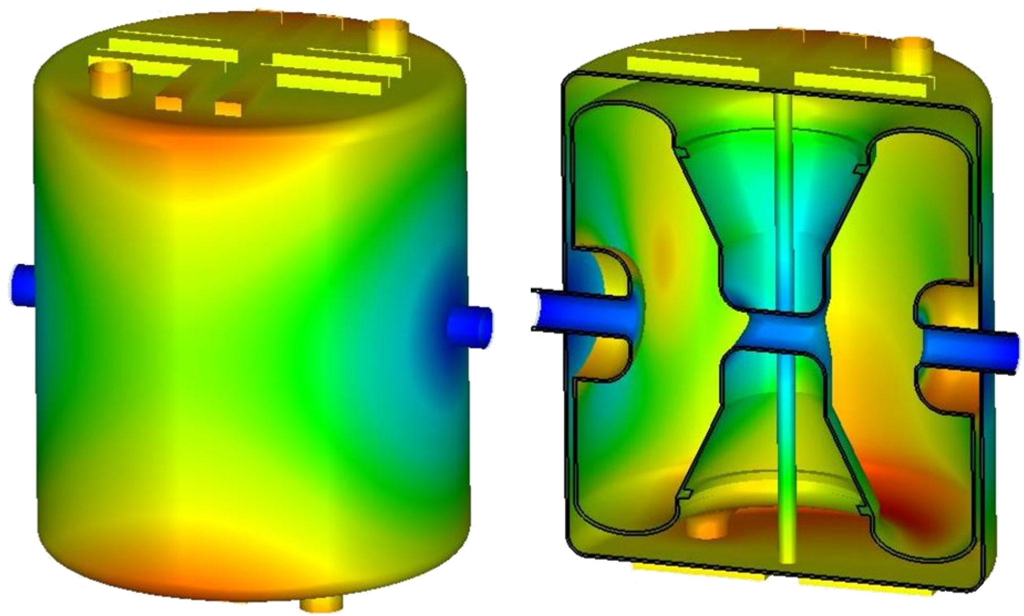


# Lorentz Force Detuning

- Lorentz force detuning is important in pulsed machine
- Fixed beam port condition



**Lorentz force on cavity**



**Displacement of cavity**

$$K_L = \frac{\Delta f}{(\Delta E_{acc})^2} = -3.37 \;\; [Hz/(MV/m)^2]$$

# Summary

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- KOMAC develops the SRF to increase the proton energy from 100 MeV to 200 MeV.
- EM analysis on the parametrically designed HWR was conducted and the design was optimized to reduce a peak electric and magnetic field while satisfying the accelerating voltage and the optimum beta.
- The helium pressure sensitivity and the Lorentz force detuning were estimated by the mechanical-EM coupled analysis. The helium sensitivity is 1.7 Hz/mbar, and the Lorentz force detuning coefficient is -3.37 $Hz/(MV/m)^2$.

# Future Work



- EM Analysis : Power coupler design
- Mechanical - EM Coupled Analysis : Tuner design
- Particle Simulation : Multipacting

# Thank You