THP089

Development of Superconducting RF Double Spoke Cavity at IHEP

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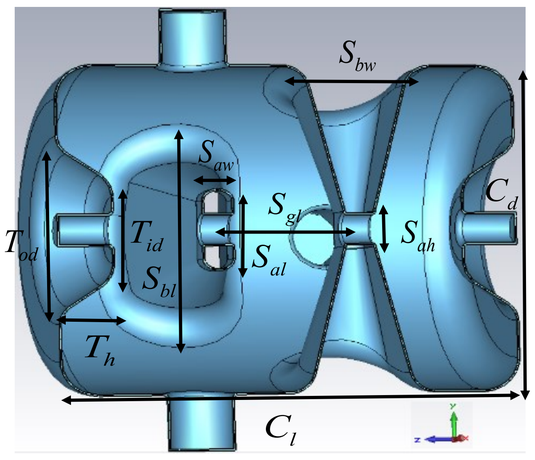
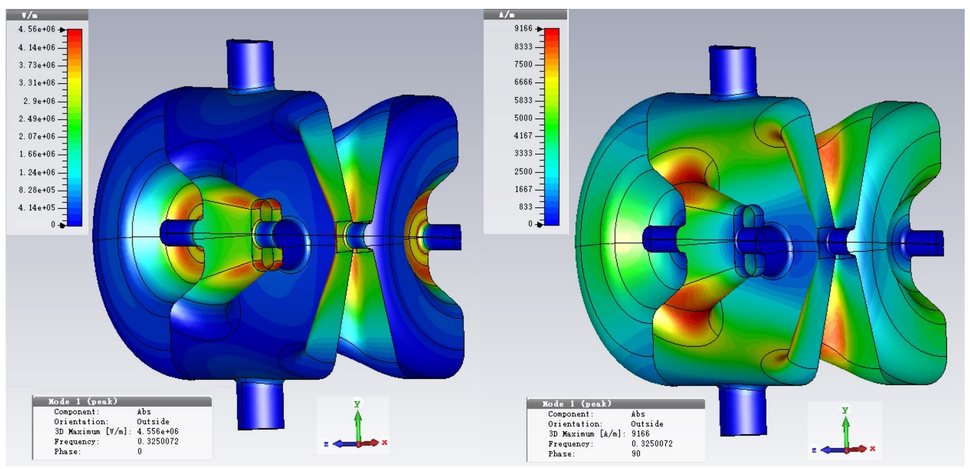
Introduction

The China Spallation Neutron Source (CSNS) is designed to produce spallation neutrons. CSNS upgrade is planned to increase beam power by inserting a SRF linac after drift tube linac (DTL). The SRF linac will accelerate peak proton beam of 40mA up to 303MeV, and double spoke cavity is adopted for the SRF linac medium β section. IHEP is developing a 325MHz double spoke cavity at β0 of 0.5 for the CSNS SRF linac.

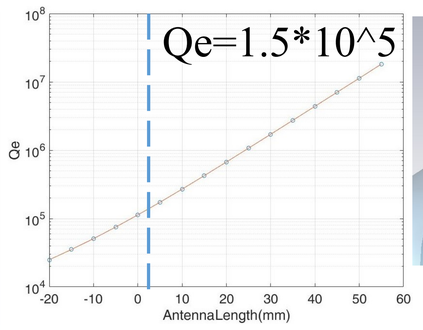
Spoke cavity evolves from half-wave resonator (HWR) operating in TEM mode. Compared with HWR, Multi-gap structure is possible in spoke cavity, which saves longitudinal space and increase the real-estate gradient. Compared with elliptical cavity, the spoke structure has higher shunt impedance, meanwhile, it is mechanically more stable and exhibit a stable field profile due to the high cell-to-cell coupling[1]. Thus spoke double spoke cavity is a preferred candidate for medium β application.

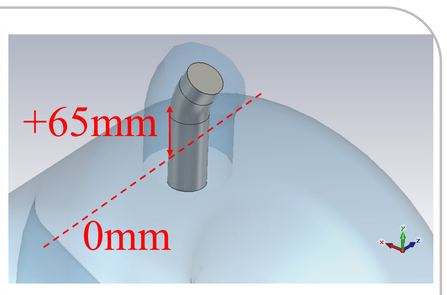
Electromagnetic Design





E-field distribution H-field distribution





Winding coupling port and Qext versus antenna length

- Shape of Spoke pillar was racetrack to minimize Epeak/Eacc and Bpeak/Eacc;
- There are mainly 11 geometry parameters to optimize the double spoke cavity;
- Cavity length = 729mm, Cavity diameter = 560mm;

Description	Results
Frequency (MHz)	325
R-aperture (mm)	50
Epk/Eacc	3.4
Bpk/Eacc (mT/(MV/m)	8.67
G*R/Q (Ω ²)	5.08e4

Mechanical Design

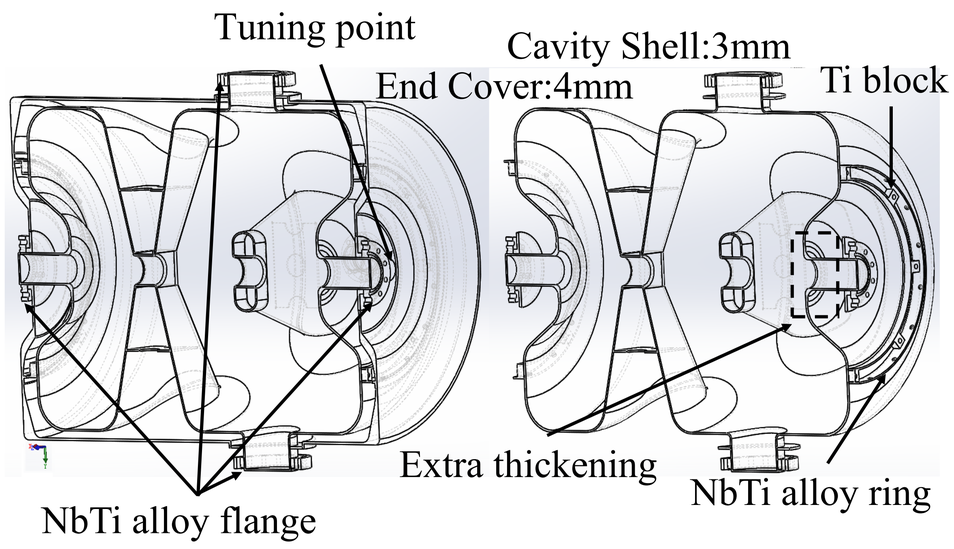
Mechanical performance of the cavity was optimized with COMSOL.

- Minimizing He pressure sensitivity (df/dp);
- The cavity will not plastically deform in any possible boundary condition during post processing, testing, and operation;
- The lowest intrinsic vibration frequency is above 100Hz;

Boundary conditions for stress analyses

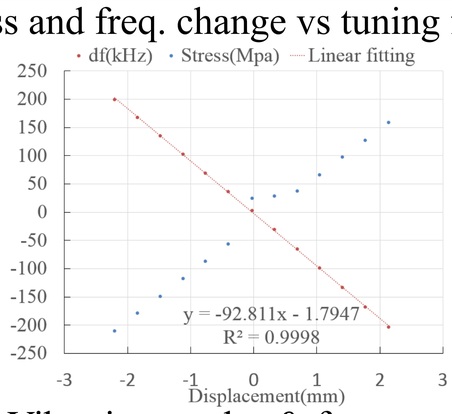
	In	HeV	Out	BP
Leak check	Vac.	1 atm	1 atm	Free
Cooling down	Vac.	1 atm	Vac.	Free
Tuning(4K)	Vac.	1 atm	Vac.	Free+Push

*HeV is short for helium vessel, and BP is for beam pipe

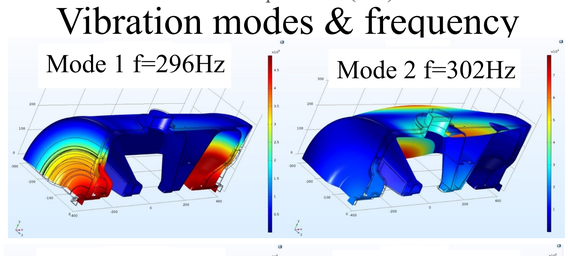


Description	Results
df/dP (Hz/mbar)	3.35
LFD factor (Hz/(MV/m)^2)	-10.9
Tuning sensitivity (kHz/mm)	93
Cavity rigidity (kHz/kN)	16.78

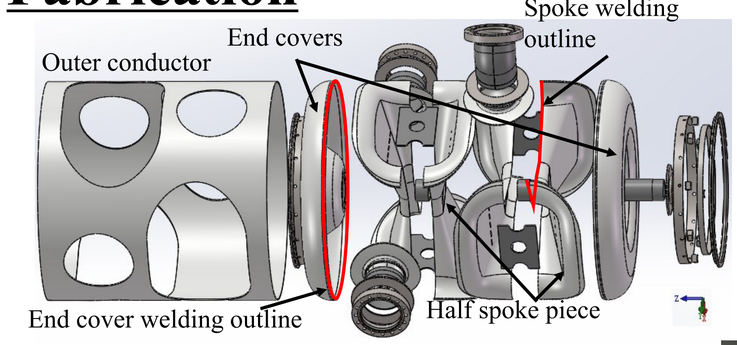
Stress and freq. change vs tuning force



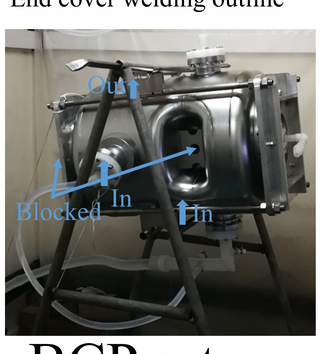
Vibration modes & frequency



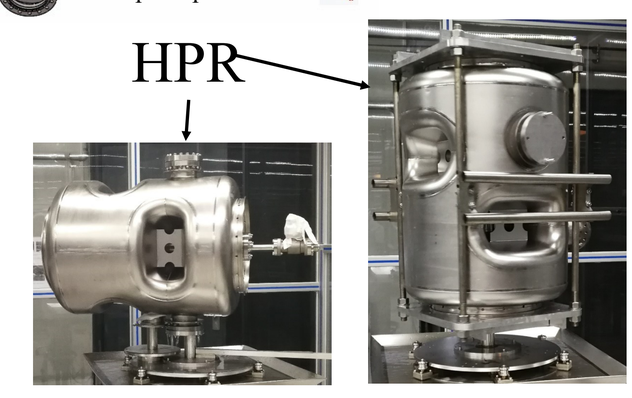
Fabrication



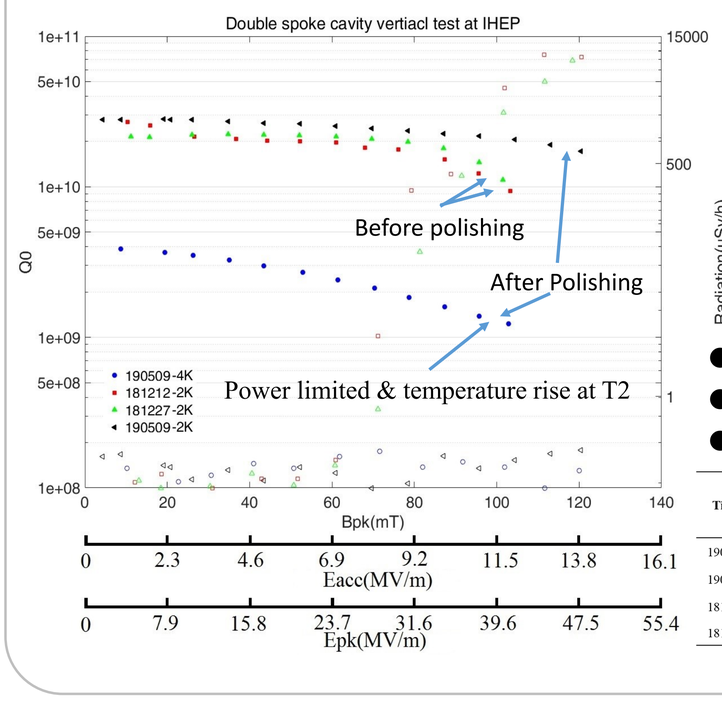
Fabrication parts

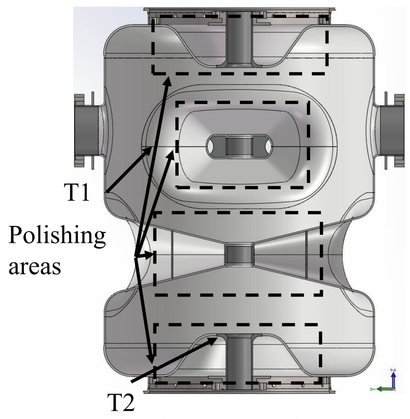


BCP setup



Test Results





- 600 mesh grinding wheels was used;
- 30-50um of material surface was removed;
- BCP 40minutes and HPR 9h

Time	T	Q0	Eacc = 9MV/m Ep (MV/m)	Bp (mT)	Radiation (μSv/h)	Highest Gradient Eacc (MV/m)	Q0	Ep (MV/m)	Bp (mT)	Radiation (μSv/h)
190509	4K	1.85*10^9	30.6	78.3	0.17	11.8	1.23*10^9	40.1	102.7	0.14
190509	2K	2.36*10^10			0.10	13.8	1.71*10^10	46.9	120.0	0.25
181212	2K	1.77*10^10			419.13	11.9	9.4*10^9	40.5	103.5	8763.72
181227	2K	1.99*10^10			389.01	11.7	1.11*10^10	39.8	101.8	7937.48

Conclusion

Another surface treatment such as surface defect inspection in high-magnetic field region and barrel polishing is ongoing. After this round of surface treatment, the cavity is planned to vertical test again on September 2019.

Reference :

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