650MHZ ELLIPTICAL CAVITIES IN IMP FOR CIADS PROJECT*

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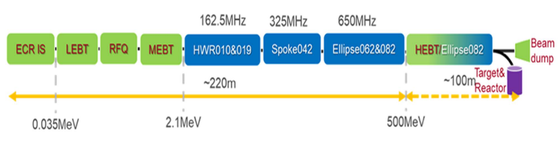
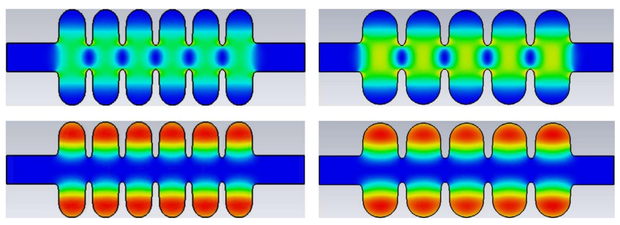
Abstract

650MHz multi-cell superconducting elliptical cavities with optimum beta equal to 0.62 and 0.82 were adopted in the driver linac of Chinese initiative Accelerator Driven Subcritical System (CiADS) to accelerate the 10 mA proton beam from 175 MeV up to 500 MeV, with the possibility to upgrade the energy to 1 GeV and higher. Mechanical design and optimization of the niobium cavity-titanium helium vessel assembly will be summarized in this paper. Vertical test results of three single cell prototype cavities will also be discussed, with comparisons with the simulation values.

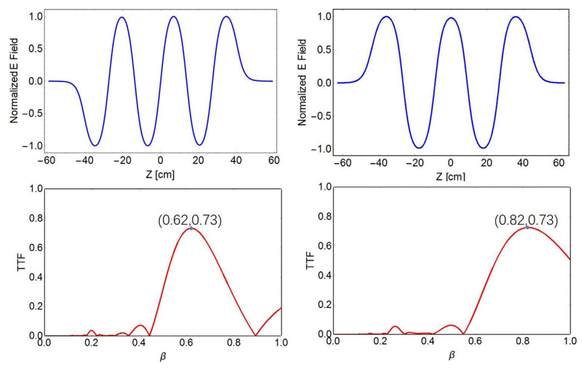
Introduction

Chinese initiative Accelerator Driven Subcritical System (CiADS) is a Multi-MW proton source for energy generation and nuclear waste transmutation. The driver superconducting linac is composed of three categories of superconducting cavities, 162.5MHz half-wavelength resonators (HWR) with optimum beta equal to 0.10 and 0.19, 325 MHz double spoke resonators (DSR) with optimum beta equal to 0.42, and 650 MHz elliptical cavities with optimum beta equal to 0.62 (Ellip.062) and 0.82 (Ellip.082)



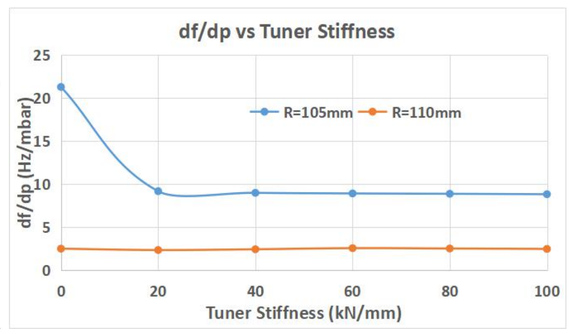


Parameter	Ellip.062	Ellip.082
β_{opt}	0.62	0.82
Number of cells	6	5
E_{pk}/E_{acc}	2.78	2.14
B_{pk}/E_{acc}(mT/(MV/m))	4.83	4.04
R/Q (Ω)	330	491
G (Ω)	188	231
Cell-to-cell coupling	1.54%	1.00%
Effective length (m)	0.821	0.896
Flange to flange distance (m)	1.22	1.22
E_{pk} @ operation (MV/m)	29	29
E_{acc} @operation (MV/m)	11.86	16.60
B_{pk} @ operation (mT)	50.38	54.75
V_{acc} @ operation (MV)	8.56	12.15
Estimated surface resistance (nΩ)	17.57	17.57
Cryogenic losses per cavity at 2K (W)	20.76	22.59
Cavity number per cryomodule	4	4
Cavity number required for CiADS 500 MeV linac	40	24

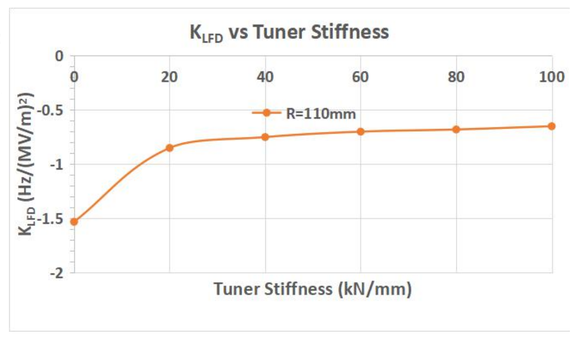


Stiffening Ribs Optimization and Stress analysis

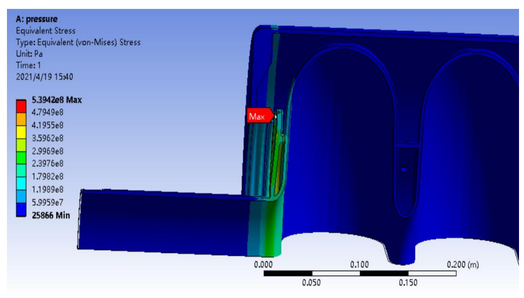
Position of the stiffening ribs between adjacent cells were optimized to minimize the Lorentz Force Detuning (K_{LFD}) and the frequency sensitivity to pressure fluctuation (df/dp).



df/dp and K_{LFD} with different tuner stiffness were calculated. The expected tuner stiffness is larger than 40 kN/mm.

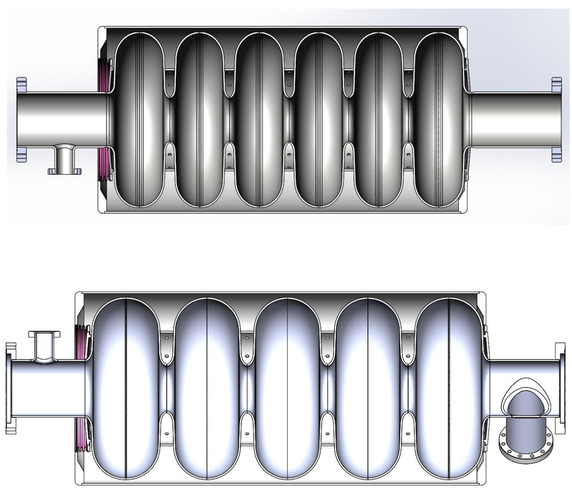


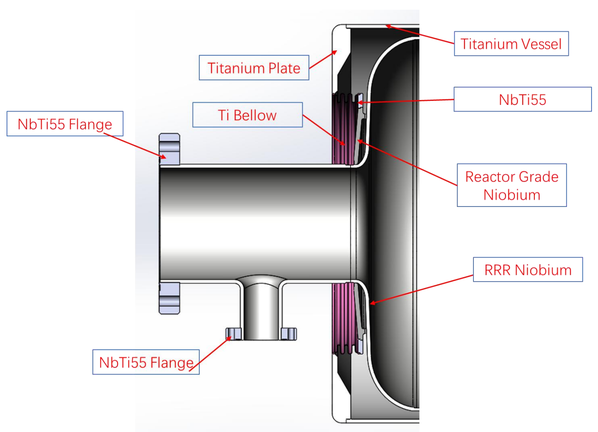
Stress analysis was done with gravity, cool down to 2 K, 2 mm tuner extension and 0.4 MPa helium pressure. Maximum stress is 539 MPa, which is located at the titanium bellow, and is safety below the yield strength of titanium at 2 K.



Cavity Assembly with Titanium Helium Vessel

Similar mechanical structure of the cavity-helium vessel-tuner-coupler assembly were adopted for both the six-cell Ellip.062 and five-cell Ellip.082 cavities due to their same cavity length and closed equator radius. Cavity will be made from 4 mm RRR300 Niobium sheets, while the stiffening ribs between cells and the end vessel plate connected to the beam pipe be made from 3 mm reactor grade niobium. Helium vessel is made from 4 mm Titanium with thicker end plate to get a better stiffness. NbTi55 was adopted to fabricate the flange, as well as the transit between niobium and titanium.

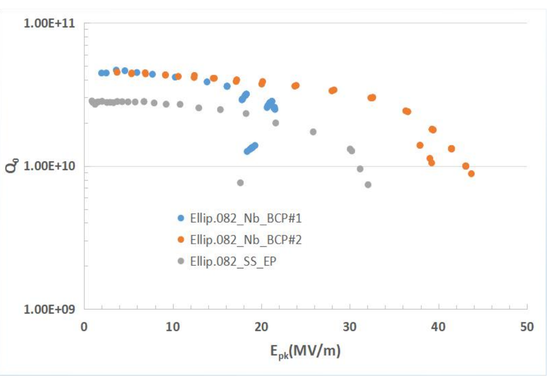




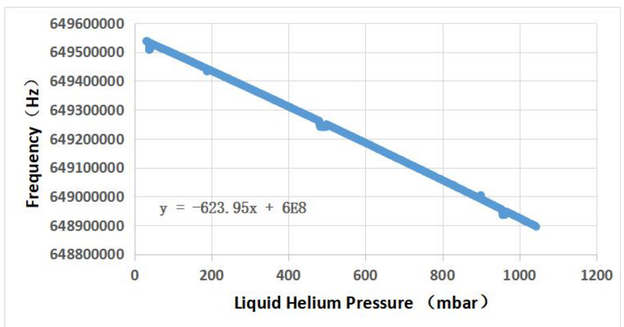
Single Cell Prototype Cavities

Three single cell niobium prototype cavities that constructed with end cells of Ellip.082 cavity were developed to explore the manufacture and post-processing technologies.

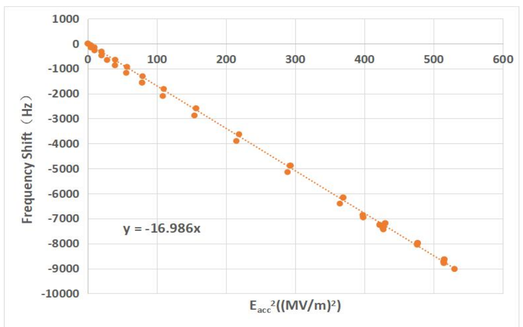
	df/dp (Hz/mbar)	K_{LFD} (Hz/(MV/m)²)
Measurement	-624	-17
Simulation	-606	-19



Vertical test results



df/dp measurement



K_{LFD} measurement

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