high-frequency and mechanical basic analysis of conical half-wave resonator

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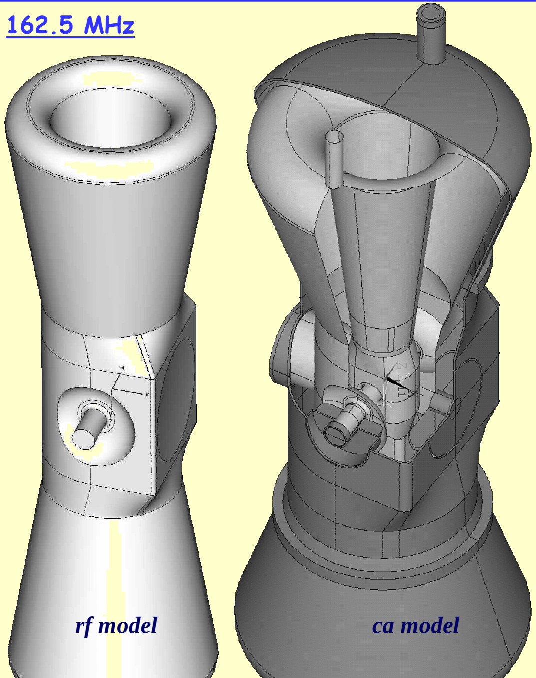
Abstract. ***A cylindrical Half-Wave length Resonator is a proved superconducting structure In the low energy part of accelerators. Accelerating efficiency in such resonator is limited by the peak RF magnetic field on the inner cavity surface. An enlargement of the dome cavity volume containing RF magnetic field reduces the cavity peak surface magnetic field. Additionally, this results in the power dissipation reduction.The paper reports results of cavity shape optimization and structural analyses of conical Half-Wave Resonators for beta=v/c=0.11 and two resonance frequencies 325 MHz and 162.5 MHz..***

162.5 MHz

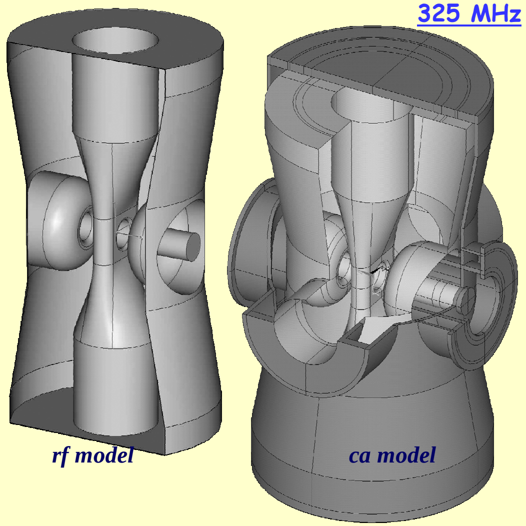


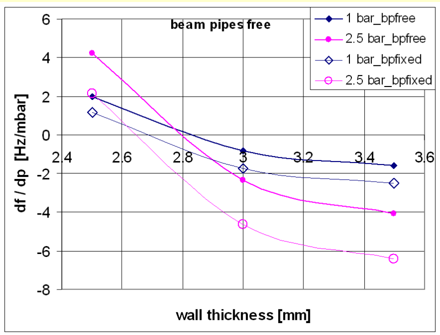
		hwr ifmif	chwr 2.0	chwr 1.5	ssr0 fnal	chwr 1.6	chwr 1.25
frequency	MHz	175	162.5	162.5	325	295	325
β = v/c		0.094	0.11	0.11	0.114	0.11	0.11
R_aperture	mm	20	15	15	15	15	15
$\beta\lambda$	mm	161.04	202.94	202.94	105.16	101.47	101.47
R_cavity	mm	90	90	90	91 **)	91	91
G	Ohm	28.55	36.76	29.32	50	56.35	53.66
R / Q	Ohm	107	114	101	108	121.8	114.5
E_{pk} / E_{acc} *)		4.42	5.32	5.37	5.63	4.58	4.71
B_{pk} / E_{acc} *)	mT/MV/m	10.12	7.08	8.44	6.92	5.33	6.07
B_{pk} / E_{pk}	mT/MV/m	2.29	1.33	1.57	1.23	1.17	1.23
tune	kHz/mm	-66	-74	-74		702	771
K_L	Hz/(MV/m)^2	-1.39		-1.2			-6.78

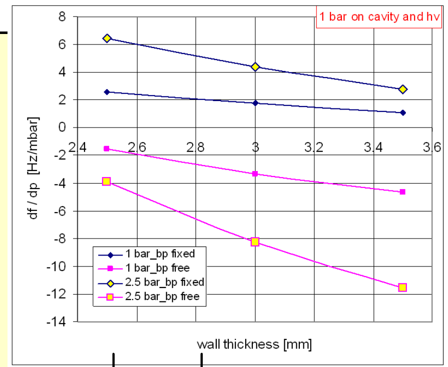
*) $L_{cav} = N_{gaps} * \beta\lambda/2$, where N_{gaps}=2 – number of gaps

**) cavity length along beam path

325 MHz



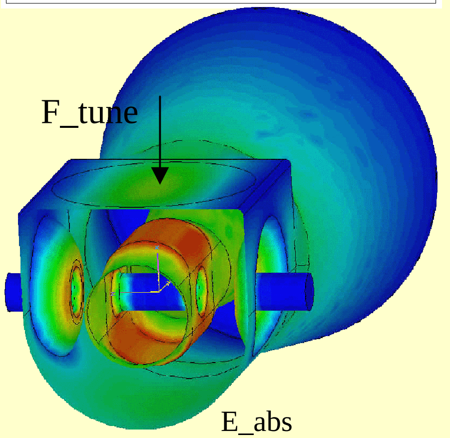


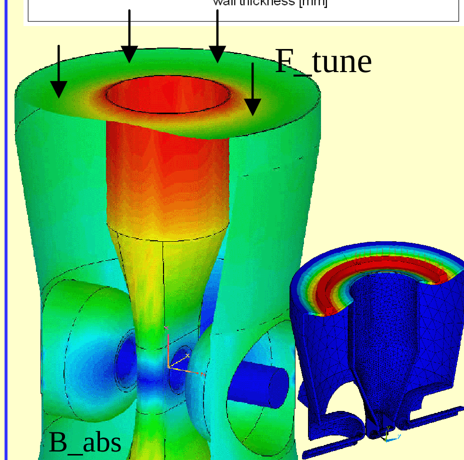


Design. ***The goal of cavity design is to develop a conceptual design of Half-Wave Resonator (HWR) that provides substantially lower the peak magnetic field by the same accelerating rate. Additionally, an alternative to the standard beam port deformations option for the cavity frequency adjustment should be developed.***

A straight circular IFMIF 175 MHz, β=0.094 half-wave resonator has been used as a basis for a 162.5 MHz, β=0.11 HWR developments. The cavity geometry has been modified to get the design frequency 162.5 MHz and β=0.11 and to minimize values of peak electrical and magnetic fields on the cavity surface relative to the accelerating electrical field on the cavity axes (B_{pk}/E_{acc} and E_{pk}/E_{acc}). The central part of the cavity is designed non-symmetrical with outer conductor plane surface that can be deformed to provide the resonance frequency adjustment.

A spoke cavity SSR0 design of FNAL Project X was the base for the development of cHWR for the resonance frequency 325 MHz and β=0.11. The dome geometry is kept straight since this place is considered as a tune plate.





Conclusions. ***The conical cavity can be effectively used in the range of resonance frequency of 150-175 MHz to reduce the peak value of magnetic field (B_{pk}/E_{acc}). Because of its big length the cavity volume enlargement in cHWR is made far from the beam path and does not affect overall accelerator length. The mechanical properties of cHWR are the same as by HWR and can be designed to reach complete compensation of microphonics within fabrication tolerances .***

In the range of around 350 MHz for the resonant frequencies, half-wave resonator and single spoke cavity do not differ much in RF parameters for any beta values. Since there is no accurate comparative investigation on the cost or complexity of cavity fabrications the choice of structure is based on the own Laboratory experience. The cavity inductance is growing with enlargement of magnetic field volume in cHWR. Since the cavity capacitance is defined mainly by accelerating gap geometry the length of cHWR should be reduce to target the required resonance frequency. To reach the noticeable reduction of B_{pk}/E_{acc} and power dissipation the cavity dome diameter should be substantially increased and height reduced. This results in cHWR geometry with increased overall length of the resonator to compare with straight cylindrical HWR.