DESIGN OF A COMPACT SUPERCONDUCTING CRAB-CAVITY FOR LHC USING NB-ON-CU-COATING TECHNIQUE

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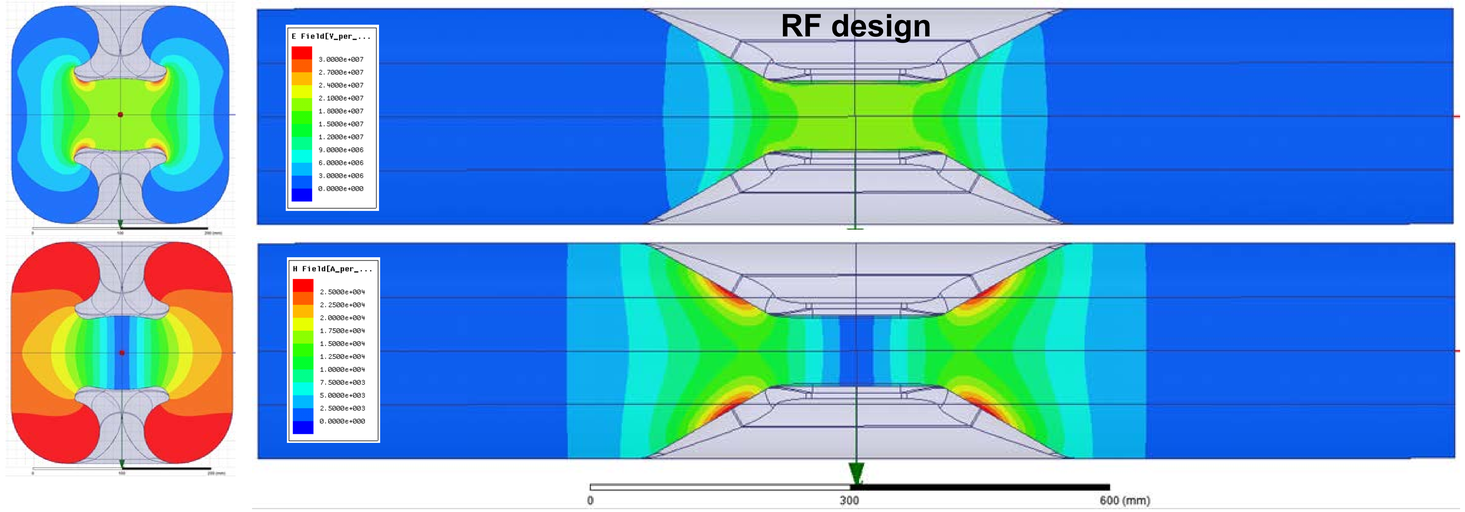
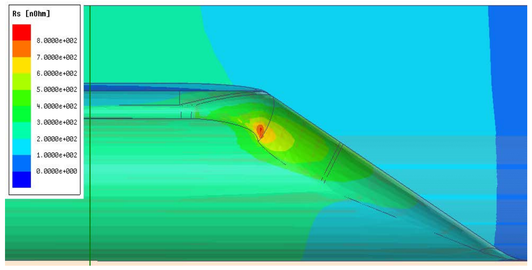
Abstract

The design of a compact superconducting crab-cavity for LHC using Nb-on-Cu-coating technique is presented. The cavity shape is based on the ridged waveguide resonator with wide open apertures to provide access to the inner surface of the cavity for coating. It also provides natural damping for HOMs and rather low longitudinal and transverse impedances. The results of the cavity shape optimization taking into account RF performance, coating, and thermo-mechanical considerations, as well as the design and fabrication plans of the first prototype for coating and cold tests are presented.

RF design



Electric (top) and magnetic (bottom) field distributions in the transverse plane and in the cavity kick plane are presented for deflecting voltage of 3 MV

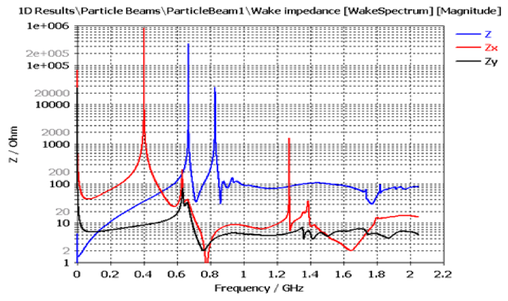


Surface resistance and losses

Typically, this surface resistance Nb-on-Cu-coating at 4.5 K shows a non-linear dependence on the surface magnetic field B_s which can be fitted by an exponential function based on the measurements done for the LHC main RF system cavities:

$$R_s^{LHC}[n\Omega] = 54.7 + 19.0\exp(54B_s[T]) \quad (1)$$

Surface resistance distribution of Nb-on-Cu-coating on the cavity walls at 3 MV obtained from Eq. (1).

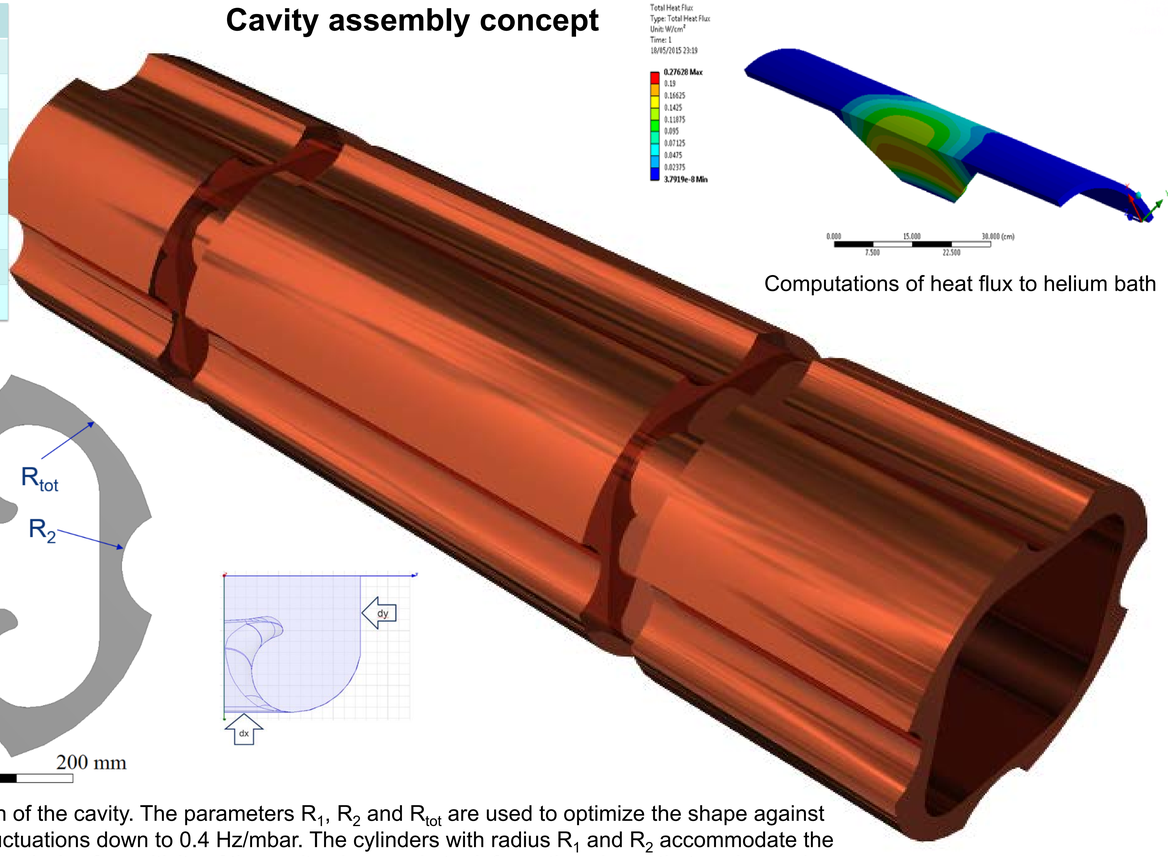


Beam coupling impedances

Beam coupling impedance: longitudinal (blue) and transverse dipolar with an offset of 10 mm both in the plane of kick (red) and in the other plane (black). The smooth 30-degree tapers and the large cross-section beam pipes provides naturally efficient HOM damping and rather low beam coupling impedance. The longitudinal loss factor of 0.035 V/pC; the dipole kick factor in the kick plane of 3.5 V/pC/m and the dipolar kick factor in the other plane of 0.3 V/pC/m.

RF parameters	
f [MHz]	400
R/Q=V_x^2/ωU [Ω]	343
Q_0(3MV)[10^8]	4.3
P_0(3MV)[W]	57
E_s^{max}(3MV)[MV/m]	45
B_s^{max} (3MV)[mT]	68
b_3(10MV)[mT/m]	-89
b_5(10MV)[kT/m^3]	-1.4

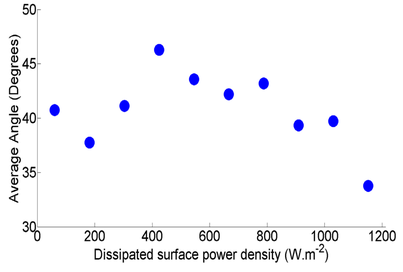
Cavity assembly concept



Transverse cross-section of the cavity. The parameters R_1, R_2 and R_{tot} are used to optimize the shape against sensitivity to pressure fluctuations down to 0.4 Hz/mbar. The cylinders with radius R_1 and R_2 accommodate the second beam axis. The analysis of sensitivity of the cavity eigenmode to deformation shows that, a change in the distance between the ridges (dx) produces -2.1 kHz/μm while a change in the side (dy) results in 1 kHz/μm.

Computations of heat flux to helium bath

Nb-coating simulations



Averaged angular distribution of sputtered atoms impinging on the cavity wall correlated to the dissipated surface power density

Possible cathode configuration with seven cathode rods of niobium