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RF design of 324 MHz superconducting (SC) CH cavity for 0.21 beta.

K Taletskiy[1], D Surkov[1] and M Gusarova[2]

[1] Student, NRNU "MEPhI", Moscow, Russia
[2] Docent, PhD, NRNU "MEPhI", Moscow, Russia

E-mail: kirill.taletski@gmail.com

Abstract. The results of RF optimizations for 324 MHz SC cross-bar H-mode (CH) cavity for 0.21 beta are presented. Maximum surface electric field of 36 MV/m and a corresponding effective accelerating gradient of 7 MV/m have been achieved.

1. Introduction

Currently planned project of the new linac injector for Nuclotron-NICA (Figure 1) demand high-gradient SC cavities for medium energy range [1]. The most types of superconducting cavities developed for $\beta \leq 0.5$ have less than 4 cells. But in many cases the RF linac efficiency can be increased significantly by the use of multicell cavities. The possibility of using the five-gap accelerating CH resonator is considered in this paper.

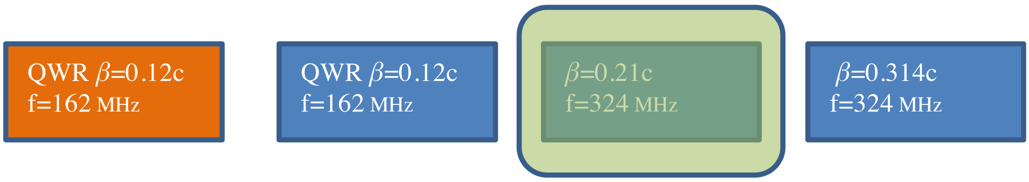

Figure 1. Schematic layout of the new linac injector for the Nuclotron-NICA.

2. Time transition factor optimization.

Optimization of the TTF increases efficiency of acceleration in given structure. The TTF analysis of two-gap cavity proposed in [2] shows that only one value of period length d (for defined accelerating gap width g) corresponds to maximum TTF value. Similar analytical approach was applied to find $d(g)$ dependence that leads to maximum TTF value. The obtained dependence can be sufficiently described by second-order polynomial. It is presented on Figure 2.

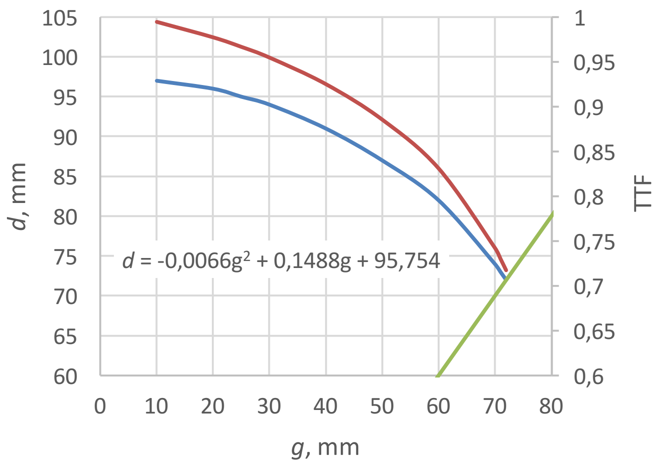

Figure 2. Optimal period length d (blue) and corresponding TTF (red) vs. gap length g. Green line limits $g < d$ set of values, which has no physical meaning.

3. Single period model optimization.

Once TTF was optimized the next step was to develop single period geometry to minimize peak surface electric and magnetic fields ratios (E_P/E_{ACC} and B_P/E_{ACC}). Firstly, drift tubes geometry was optimized as the maximums of electric field were concentrated on it. Figure 3 and Figure 4 show the main geometrical parameters that were used for optimization.

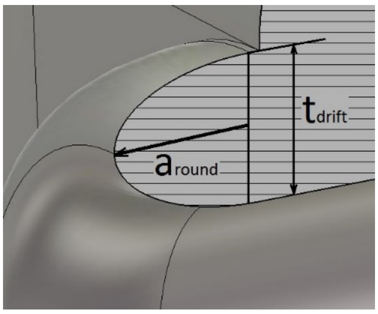

Figure 3. Schematical layout of a drift tube geometry.

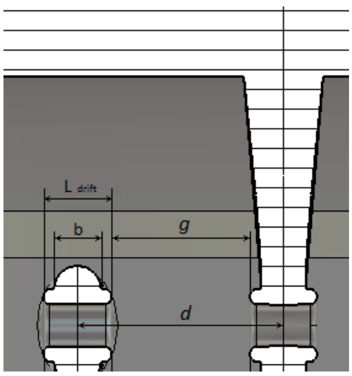

Figure 4. Schematical layout of a two-gap periodic model.

Three major types of drift tube geometries were investigated (Figure 5). As it may be seen from Figure 6 decreasing l_{DRIFT}/b ratio allows to lower relative peak electric field E_P/E_{ACC} down to 7.

Geometry that corresponds to $l_{DRIFT}/b = 1$ (i. e. with no “door knops”) was considered to be the most effective.

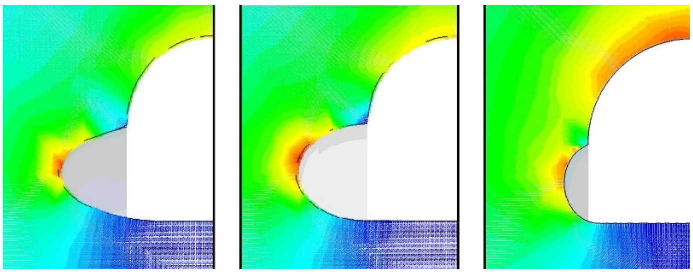

Figure 5. Three major types of drift tube geometries ($k = a_{round}/t_{drift}$): $k > 1$ (left), $k = 1$ (middle), $k < 1$ (rigth).

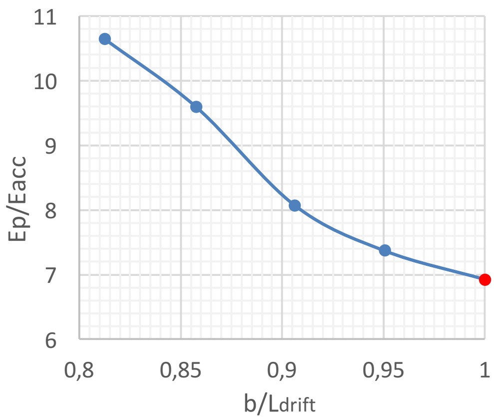

Figure 6. Relative surface peak field vs. b/L_{DRIFT} ratio.

4. Full cavity model tuning

The main challenge of finite structure optimization is the end-cells geometry design. As was proposed in [3] inclined geometry of the end bars helps to tune end-cells to work frequency. Figure 7 shows end cells design concept proposed in [3] with its main parameters used for tuning. Surface electric and magnetic field distributions of the CH cavity are presented on Figure 8. The parameters of tuned cavity are shown in Table 1.

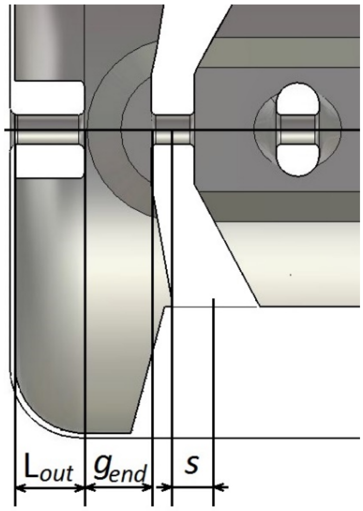

Figure 7. Schematic layout of the end-cell geometry.

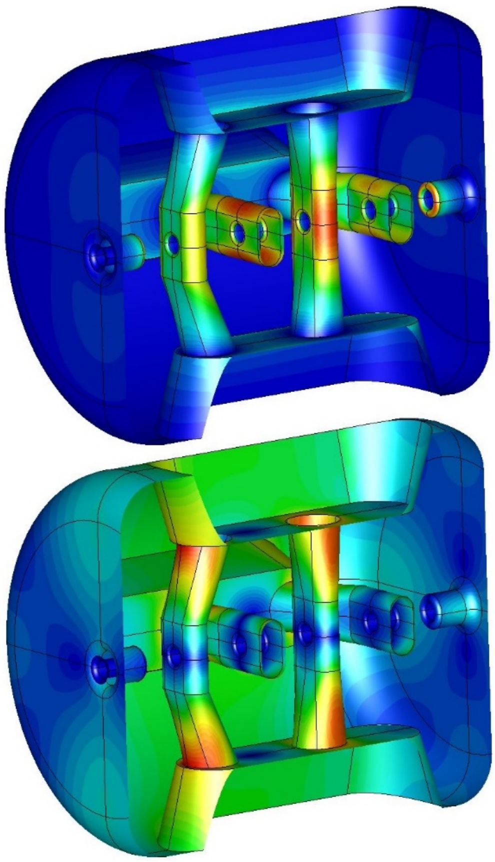

Figure 8. Surface electric (top) and magnetic (bottom) fields in CH resonator.

Table 1. The geometry and RF parameters of tuned CH cavity.

β	0.21
Frequency [MHz]	324
Length [mm]	500
Radius [mm]	204
$\mathbf{E_p/E_a}$	5.1
$\mathbf{B_p/E_a}$ **[mT/(MV/m)]**	7.5
G [Ω]	84
$\mathbf{R_a/Q_0}$	615

5. Conclusion

We presented the RF design of the superconducting CH cavity intended for the proposed proton and deuteron injector for the NICA project. The electromagnetic optimization was performed to show that desired effective accelerating gradient of 7 MV/m can been achieved with this type of cavity.

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