PEAK FIELD OPTIMIZATION FOR THE SUPERCONDUCTING CH STRUCTURE*

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Abstract

The Cross-Bar H-type (CH) cavity is a multi-gap drift tube structure operated in the H_{21} mode. This structure is studied at the IAP Frankfurt extensively since several years. Based on detailed numerical simulations a 19 cell prototype cavity from bulk Nb was realised in cooperation with ACCEL Instruments GmbH. After successful experiments with the superconducting prototype cavity and voltage gains up to 3.8MV, detailed numerical simulations with CST MicroWave Studio have been performed. The goal was to improve the geometry against field emission. As a result, peak fields were efficiently reduced by larger g/L ratios, and by increased outer drift tube diameters. An overall peak field reduction of 20% against the present layout seems feasible.

SUPERCONDUCTING (SC) CH-PROTOTYPE

In sc cavities there is no cooling problem when compared to cw operated rt (room temperature) linacs. In general, sc linacs can be operated at higher gradients above a certain duty factor.

Figure 1: The sc 352 MHZ CH prototype

On the other hand, at low duty factors and high beam currents rt structures are preferable in many cases. This is especially true for rt structures with high shunt impedance like IH and CH-structures at low and medium beam energies. To demonstrate the capabilites of the superconducting CH-DTL, a CH prototype has been developed. The cavity production started in 2003, the completed cavity was delivered in March 2005 [2] and meanwhile several cold tests have been performed [3].

frequency [MHz]	352
beta	0.1
R_a/Q [kΩ]	3.18
E_{peak}/E_a	5.21 **
B_{peak}/E_a [mT/MV/m]	5.76 **
cavity length [m]	1.048
gaps	19
aperture diameter [mm]	25
tank diameter [m]	0.28
stem width a [mm]	12.5
stem width b [mm]	20

Table 1: Parameters of the prototype cavity (**active length) (a and b see fig. 2)

PEAK FIELD OPTIMIZATION

For the optimization of the magnetic and electric peak fields, we performed detailed simulations with CST MicroWave Studio. The main parameters which influence the peak fields, are the geometry of the stems (fig. 2), the thickness of the drifttubes and the gap lengths.

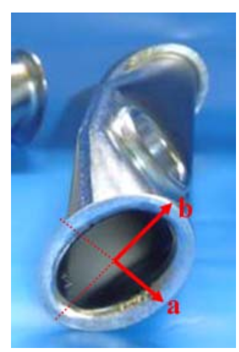

Figure 2: Stem of a s.c. CH-Cavity.

Variation of the stem geometry

The overall geometry of the stems was varied to minimize the peak fields. Especially, the stem width in both directions a and b was varied. A widening of the stems along b led to a reduction of the peak fields as shown by fig.3. If the stem width a is close to the stem width at the drifttube the magnetic peak fields are increasing locally (fig.4).

* Work supported by GSI, EU, BMBF contr. no. 06F134I

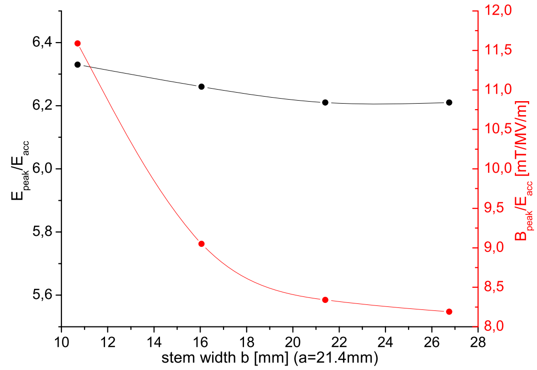

Figure 3: Electric and magnetic peak fields in dependence of the stem width b.

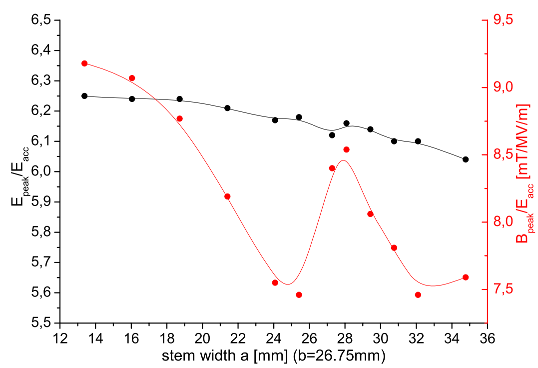

Figure 4: Electric and magnetic peak fields in dependence of the stem width a.

Variation of the drifttube thickness

The electric peak fields occur at the drifttube ends. To minimize these fields the drifttube thickness was changed. Figure 7 shows a drifttube with a thickness $R_2 - R_1 = 5mm$ like used for the prototype. In figure 8 you can see, that the electric fields on the surface will become about 10% smaller, when the thickness of the drifttubes is increased to 11 mm.

Figure 6 shows the electric fields on path along the aperture radius of the drifttubes in beam direction. The influence of a larger wall thickness is clearly shown at each drifttube end region.

Variation of the gap length

The next point was to minimize the electric peak fields by changing the ratio g/L. Fig.10 shows the electric field strength distribution along path y (fig.9). In fig.11 one can see, that it is possible to reduce the electric peak fields by 17% if the gap is enlarged from 13.9 mm to 23.9 mm at constant period length.

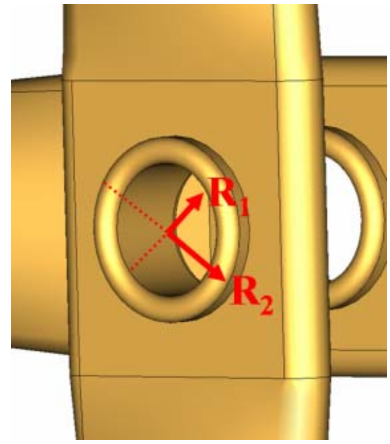

Figure 5: Drifttube of a s.c. CH-cavity

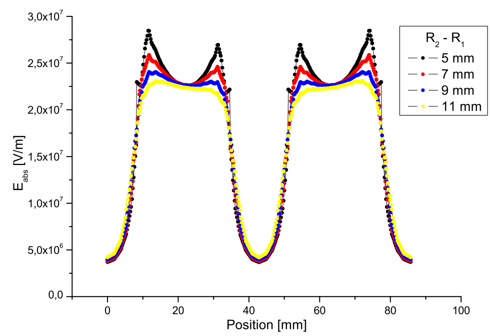

Figure 6: Electric fields at the apertur of the drifttube for different drifttube thicknesses

OUTLOOK

Measurements at the prototype reached an effective voltage of 3.8 MV for the given geometry. These is some evidence of a limitation by local field emission [3]. By optimization of the geometry, it is possible to reduce the peak fields by about 20%. So it should be possible to reach considerally higher effective voltages by further geometry optimizations and by further cavity surface treatment.

REFERENCES

[1] http://www.cst.com

[2] H. Podlech, H. Deitinghoff, H. Klein, H. Liebermann, U. Ratzinger, A. Sauer, Test of the Superconducting CH-Structure, Proceeding of the PAC 2005, Knoxville, TN, USA

[3] H. Podlech, H. Klein, H. Liebermann, U. Ratzinger, A. Sauer, First Cryogenic Tests of the Superconducting CH-structure, these proceedings

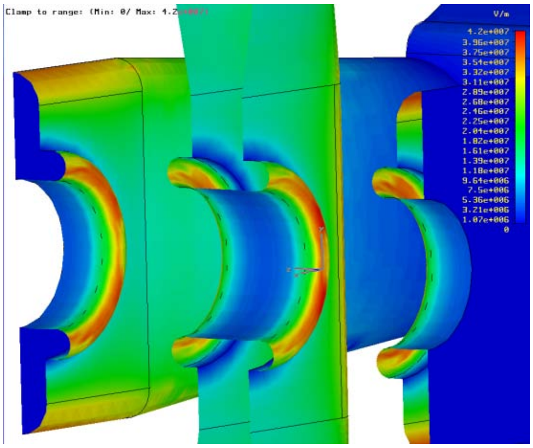

Figure 7: Electric field strength on the surface of a drifttube with a thickness of 5mm

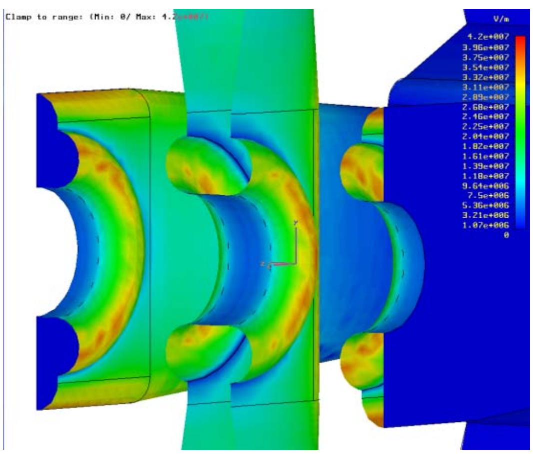

Figure 8: Electric field strength on the surface of a drifttube with a thickness of 11mm

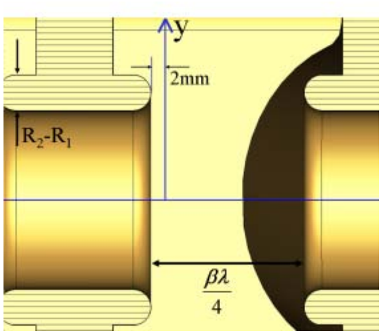

Figure 9: Geometry of a CH gap

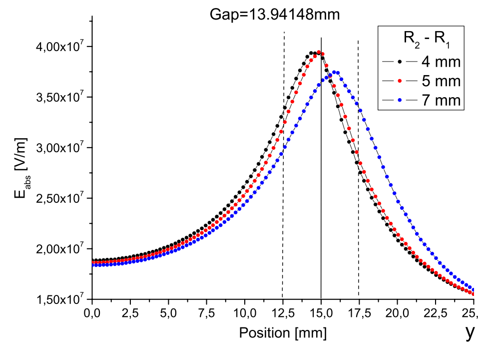

Figure 10: Electric field strength distribution along the path y (fig.9). Variation of drift tube thickness

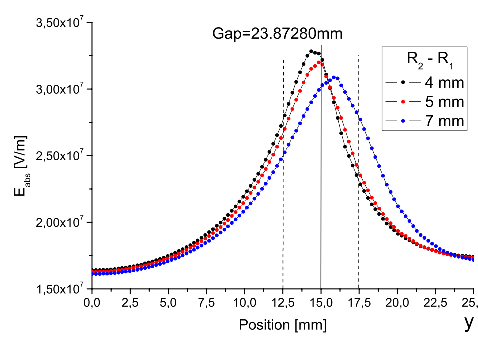

Figure 11: Electric field strength distribution along the path y (fig.9). Variation of drift tube thickness