RECENT DEVELOPMENTS OF SUPERCONDUCTING CH-CAVITIES

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Abstract

The Crossbar-H-mode (CH)-structure which has been developed at the IAP in Frankfurt is a multi-cell drift tube structure for the efficient acceleration of low and medium energy protons and ions (see fig. 1) [1]. The superconducting low energy CH-prototype cavity (β=0.1, f=360 MHz) has reached gradients of up to 7 MV/m, corresponding to an effective voltage gain of 5.6 MV. This shows that high real estate gradients can be achieved in superconducting low energy multi-cell cavities. Additionally, microphonics and tuning measurements have been performed at room temperature and at 4K. Optimized cavity geometries for high power beam projects and designs for the construction of a new superconducting cavity will be presented.

CRYOGENIC TESTS OF THE SUPERCONDUCTING β=0.1 PROTOTYPE CAVITY

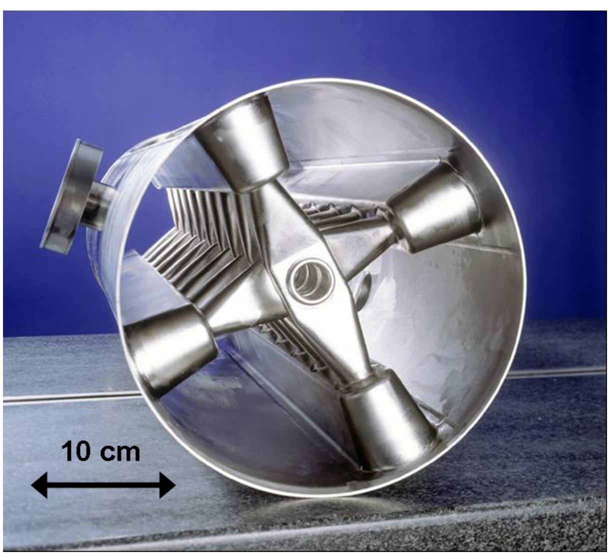

Figure 1: Superconducting 19-cell CH-cavity (β=0.1, f=360 MHz)(ACCEL).

Several tests have been performed in the Frankfurt cryogenic laboratory. After a new surface preparation performed at ACCEL including BCP and HPR gradients of 7 MV/m have been achieved (see fig. 2) [2]. This corresponds to an effecitve voltage of 5.6 MV. The cavity performance has been increased by about 50% compared to former measurements. Strong field emission activity could be reduced drastically. Especially an emission site close to the cavity center which has been identified using Thermo-Luminescence Dosemetry (TLD) could be removed [2].

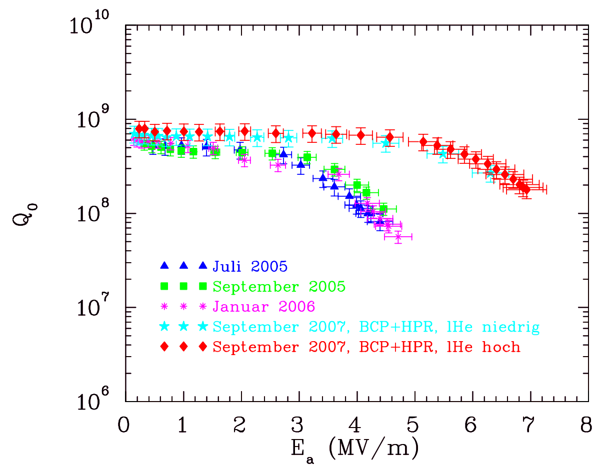

Figure 2: Measured Q-value versus the gradient. After a new surface preparation the cavity performance has been increased significantly by reducing field emission activity.

MICROPHONICS MEASUREMENTS

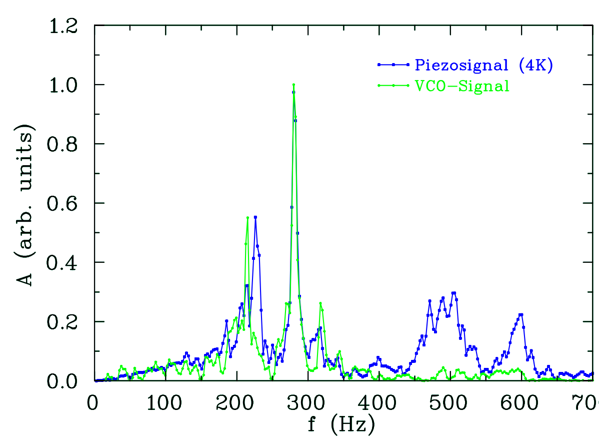

Figure 3: Microphonics spectrum measured with a piezo and the VCO-signal which is proportional to the cavity frequency deviation.

Cavity tests with a tuner system consisting of a slow tuner and a fast piezo tuner are under preparation. As a component test two piezos have been used in cryogenic environment to measure the microphonics spectrum and the signal of the voltage controlled oscillator (VCO) [3]. Two piezos have been attached to the cavity. One piezo was driven by a white noise to excite all mechanical modes of the cavity. The second piezo was used as sensor to detect the frequency variations caused by the microphonics. Additionally, the frequency spectrum of the VCO has been

measured. The VCO-signal is proportional to the deviation of the cavity frequency with respect to the master frequeny. Figure 3 shows the measured microphonics and the VCO-spectrum. Surprisingly, there are some mechanical modes which don't have an influence on the cavity frequency. In these cases there is a vanishing VCO-signal although there is a peak in the piezo signal.
At present the cavity is being prepared for tests in a horizontal cryostat which will be fully equipped with a slow and fast tuner system. Figure 4 shows the cryostat and a part of the tuner system with three piezos. The frequency shift will be done by pushing the end cells of the cavity. The changing end gap capacitance results in a change of the resonance frequency. Warm measurements have indicated a frequency shift of 400 kHz/mm [3].

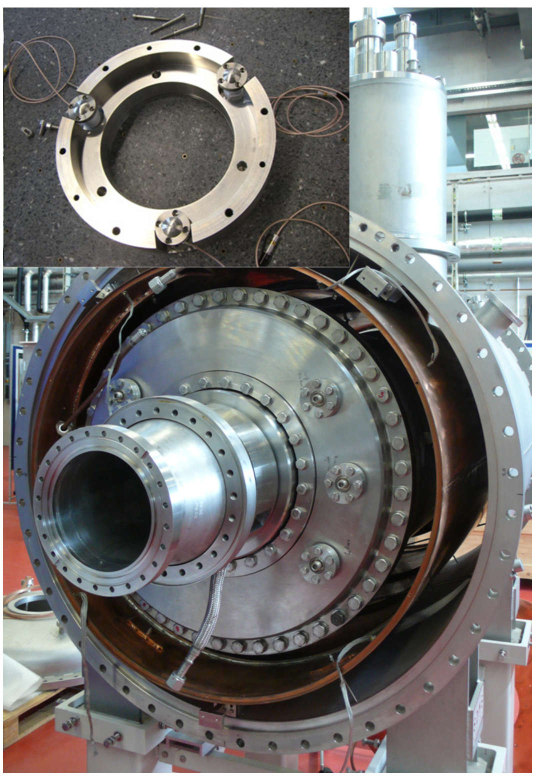

Figure 4: Horizontal cryostat are under preparation for the superconducting CH-cavity operated at fixed rf frequency with a tuner system for slow and fast tuning.

CH-CAVITIES FOR HIGH POWER APPLICATIONS

The superconducting CH-cavity is an excellent candidate for high power applications with high beam currents because it reduces the number of drift spaces between cavities significantly compared to conventional low-β ion linacs. Together with the KONUS beam dynamics which decreases the transverse rf defocusing and allows the development of long lens free sections this leads to high real estate gradients with moderate peak fields [1].

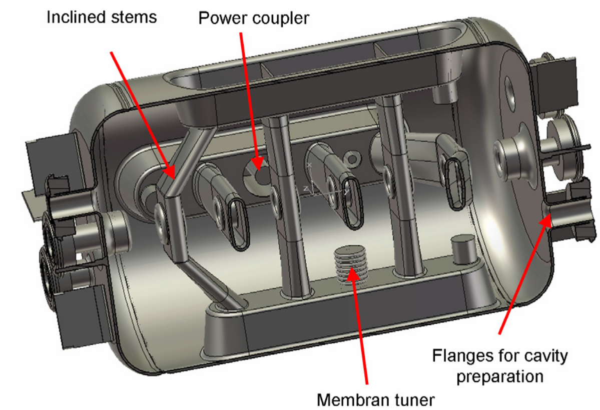

Figure 5: Layout of the superconducting 325 MHz, β=0.154 CH-cavity.

It is planned to build a superconducting CH-cavity optimized for high power applications. The girder and the stem geometry has been optimized to acommodate large power couplers between the stems (see fig. 5). For several projects as EUROTRANS or IFMIF an rf power per coupler of up to 250 kW is required [4].
Especially for high power applications the beam quality is a major issue to avoid beam losses and activation of accelerator components. It is advisable to reduce drift sections

Table 1: Parameters of the sc 325 MHz CH-cavity

f (MHz)	325.224
β	0.1585
L (m)	0.55
Aperture diameter (mm)	30
Accelerating cells	7
Tuner height (mm)	0-60
Tuner diameter (mm)	50

to a minimum. By the introduction of "inclined" stems the end cell length could be reduced significantly. This reduces the cavity length by about 20% without changing the voltage and peak fields.
A good surface preparation including effective high pressure rinsing is essential for high cavity performance. Therefore is has been decided to use four flanges for the preparation, one for each cavity quadrant. As a result, all surface areas will be reached during the rinsing process.
The tuning of the cavity will be done with capacitive tuners through the girder. This tuning concept has been proven already during the fabrication of the superconducting 360 MHz prototype cavity [2]. For the new cavity two different types of tuner are foressen. Cylindrical fixed tuners will be used for coarse voltage and frequency adjustment during fabrication. Additionally, two membran tuners are foressen with a tuning range of several hundred kHz. The advantage of these membran tuners is the minimiza-

tion of the required longitudinal space which would be necessary by using a tuner system pushing on the end cells. Figure 6 shows the simulated frequency shift by using two identical cylindrical tuners with a diameter of 50 mm.
The field distribution has been optimized by adjusting the ratio between the gap- and the cell length. Figure 7 shows the field distribution before and after the optimization. The 325 MHz cavity will be fully equipped with power couplers and helium vessel. It is envisaged to test the cavity with beam at the GSI UNILAC at the exit energy of 11.4 MeV. The frequency of the UNILAC is 108.408 MHz. The superconducting CH-cavity will be operated at the third harmonics of UNILAC.

To validate the electromagnetic simulations, a rt copper

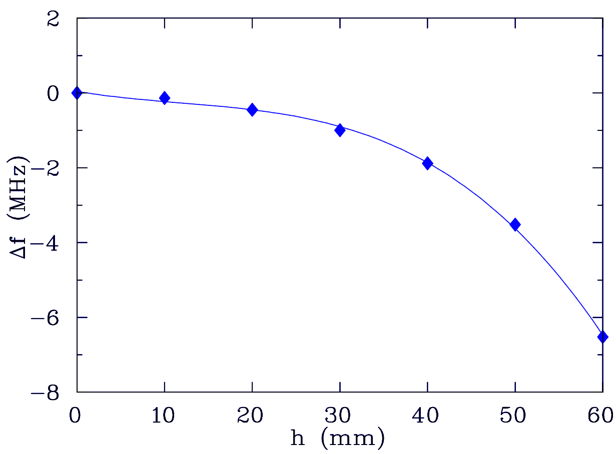

Figure 6: Tuning range of two tuners with a diameter of 50 mm.

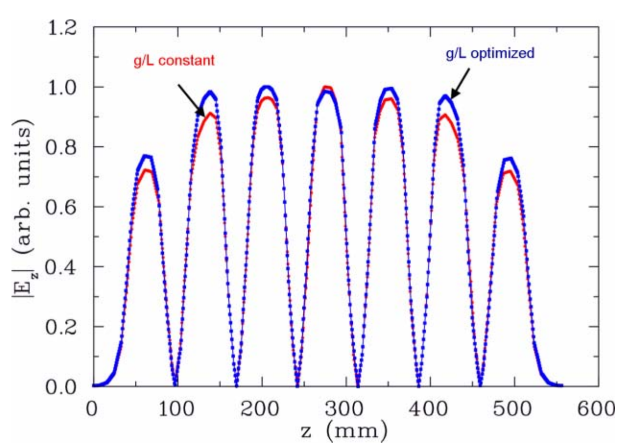

Figure 7: Distribution of the electric field (simulation) of the 325 MHz CH-cavity before and after the optimization.

model has been built (see fig. 8). It has a modular design to use it for different drift tubes array. The following list shows the geometrical parameters which can be changed:

- cell number
- cell length (β)

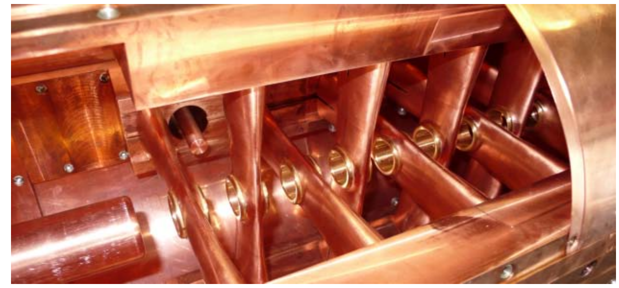

Figure 8: Photograph of the r.t. copper model to validate electrodyanmic simulations.

- cavity length
- drift tube length
- coupler size
- coupler position
- stem shape
- tuner position
- tuner size and shape

ACKNOWLEDGEMENT

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