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STATUS AND FIRST MEASUREMENT RESULTS FOR A HIGH GRADIENT CH-CAVITY *

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Abstract

The pulsed linac activity aims on compact designs and on a considerable increase of the voltage gain per meter. A high gradient CH – cavity operated at 325 MHz was developed and successfully built at IAP – Frankfurt. The mean effective accelerating field for this cavity is about 13.3 MV/m at β = 0.164. The results might influence the rebuilt and a later energy upgrade of the UNILAC – Alvarez section. Another motivation is the development of an efficient pulsed ion accelerator for significantly higher energies like 60 AMeV. The new GSI 3 MW Thales klystron test stand will be used for the cavity RF power tests. Detailed studies on two different types of copper plating can be performed on this cavity. The first measurement results of the frequency and the on axis electric field for this cavity will be presented.

INTRODUCTION

Conventional DTL's are limited in maximum field gain by thick walled drift tubes which are housing the focusing elements. Such geometries cause bigger parallel surfaces around the gaps which are loaded by high electric field levels. This leads to an increase of the stored field energies as well as the risk of spark damages on the cavity surfaces. Consequently, this results in reduced operable field levels.

Separated function DTL technology and strategies for a minimization of the consequences from transverse rf defocusing have been developed during the last decades of heavy ion linac development.

On the other hand, the combination between slim drift tubes and KONUS beam dynamics, in H – mode cavities allows to increase the effective field gain well above 10 MV/m. This has been tested successfully at CERN Linac 3, where the field gradient reached 10.7 MV/m at 1 ms pulse length and at low beam energy [1].

H – mode cavities profit very much from slim drift tubes (see Fig. 1), as they concentrate the electric field on the drift tube structure. Thus, the stored energy is reduced efficiently by a small outer drift tube diameter, reducing surface damages in case of sparking.

The development of CH – cavities towards a high field gradient [2-4] will be the main topic of this paper.

This aspect is important for cases, where a compact linac for low duty factor applications is needed. Also, for high current operation the high field acceleration provides the needed longitudinal focusing forces.

One main motivation of this work is to prepare the rebuilt and a later energy upgrade of the UNILAC – Alvarez section. Another motivation is the development of an efficient and compact ion accelerator for significantly higher energies for facilities like medical hospitals where available space is quite limited.

CH – CAVITY FABRICATION

A high gradient, 7 gap CH – cavity has been developed and successfully built at IAP – Frankfurt and was fabricated at NTG, Gleisbau, Germany [2-5]. This cavity (Fig. 1) is expected to have a mean effective field gradient of about 13.3 MV/m at β = 0.164.

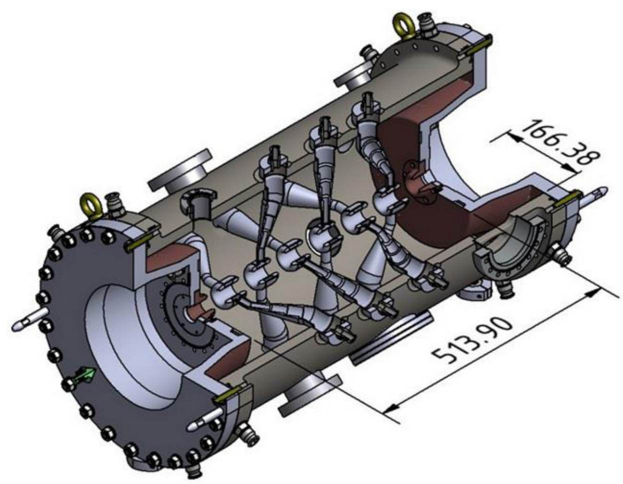

Figure 1: A 3D schematic view of the CH – cavity.

Table 1: Main Parameters of the High Field CH – cavity

Number of Gaps	7
Frequency (MHz)	325.2
Voltage Gain (MV)	6
Eff. Accel. Length (mm)	513.90
Mean eff. Accel. Field (MV/m)	13.3
Power Loss (MW)	1.76
Q_0 – value	12500
Effective Shunt impedance (MΩ/m)	52.15
Beam Aperture (mm)	27

The central part is a "monolithic" stainless steel element, where the drift tube structure was welded into a massive cylindrical tank. The drift tube stems with drift tubes are directly water cooled, the outer cylinder has eight cooling channels in longitudinal direction. The end plates have one cooling channel each, the quadrupole triplets will be positioned in the accessible outer volumes. Metal gaskets will be used at each bolted joint. Figure 2 shows the cavity tank, stems, end flanges and the massive drift tubes.

SURFACE ELECTRIC FIELD

The adaption of slim drift tubes for CH – cavity results in a very high sparking limit. The cavity geometry was

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designed for peak surface electric fields reaching up to 95 MV/m at very local spots on the 1 mm^2 – level.

Figure 2: Manufacturing process of the cavity. Top: CH – cavity cylindrical tank. Bottom: End drift tube (left), tank end flange (middle), drift tubes structure (right).

Figure 3 shows the maximum surface field on each drift tube versus the maximum on axis field for each gap. The electric and magnetic field distributions are shown in Fig.4.

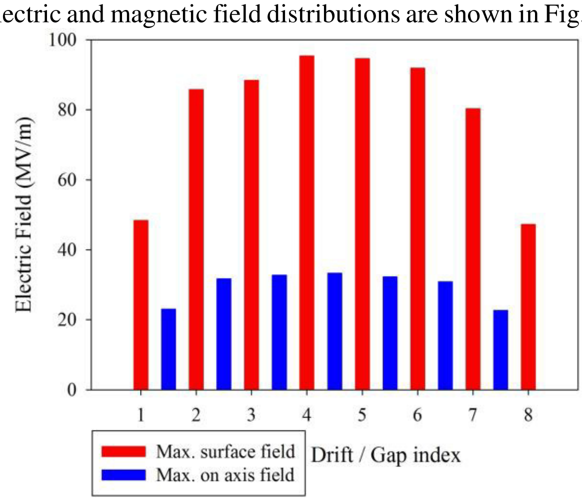

Figure 3: Maximum drift tube surface fields versus the maximum on axis gap fields.

Special care will be taken for the galvanic copper plating of the cavity. Two processes with different bath ingredients (high lustre and less lustre copper plating) will be tested against each other at high rf power levels. The main aspect in our case is the sparking limit, besides quality factor, vacuum and rest gas aspects.

CH – CAVITY MEASUREMENT

The cavity was successfully built and delivered to IAP - Frankfurt in December 2014. It was checked and prepared for the first measurements that were taking place in the end of January 2015, then it was sent directly to Galvano-T GmbH, Germany, for copper plating.

Frequency

The resonance frequency of the CH – cavity can be reached by varying the magnetically acting tuner positions within the cavity. At the absence of these tuners, one must get a frequency lower than the operated one.

The measured resonance frequency for the high gradient CH-cavity, is 323.617 MHz compared with 324.258 MHz in the CST simulation (Δf = 0.641 MHz) the difference is below 0.2%.

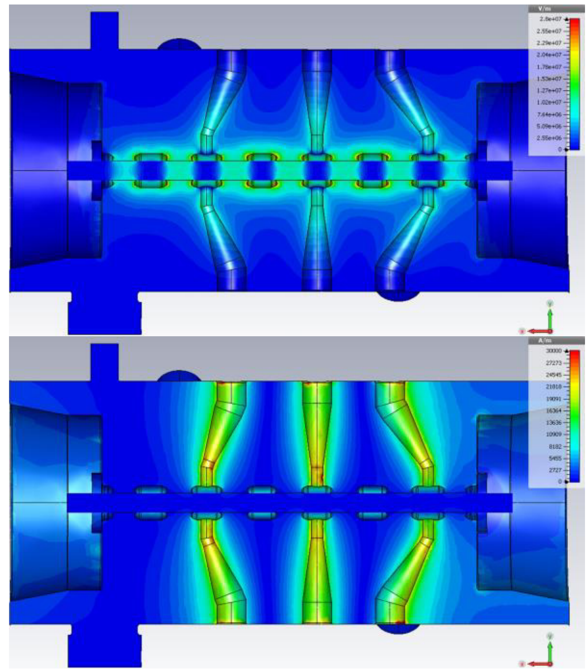

Figure 4: Electric (top) and magnetic (bottom) fields.

On Axis Electric Field

The on axis electric field was measured versus the position using the standard bead-perturbation technique. Figure 5 shows the normalized on axis electric filed of the cavity in comparison with the simulated one by CST. Possibly a non-perfect connection between the cavity tank and the end flanges, the field in the end gaps has some differences, while the other gaps are very well matched to the measurements.

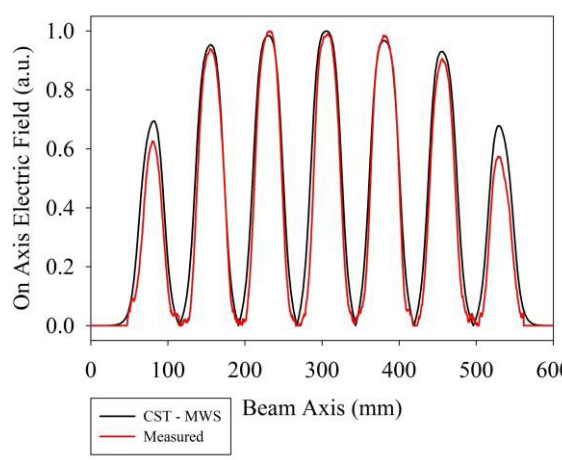

Figure 5: The measured on axis field compared with the simulated one by CST.

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Tuning Concept

Figure 6 shows the tuner positions, while Fig. 7 displace their joint frequency tuning efficiency. In the next step, one needs to push the resonance frequency towards the operated frequency which is 325.224 MHz. This can be reached at tuner positions moved around 36.5 mm into the cavity.

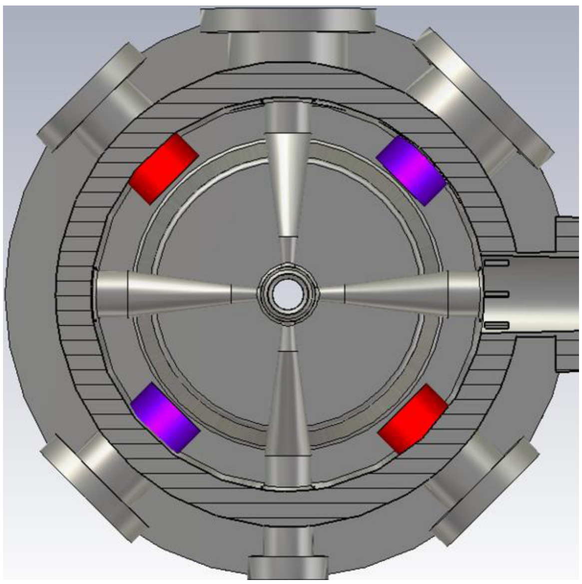

Figure 6: Magnetically acting tuner positions (in red at the cavity entrance, in magenta at the cavity end).

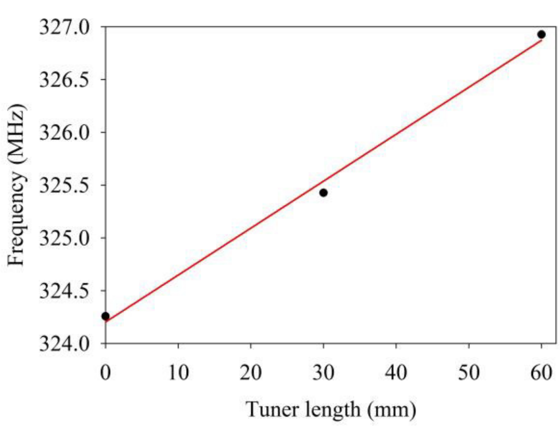

Figure 7: Tuner frequency shift vs the tuner position synchronous motion of all four plungers.

CONCLUSION AND OUTLOOK

The development of a CH – cavity towards high field gradients has been developed and successfully built at IAP – Frankfurt. The field gradient is expected to reach about 13.3 MV/m. This aspect is important for low duty applications. There are many pulsed beam linac projects aiming on compact designs. One class of facilities are medical hospitals where available space is quite restricted.

The first measurement performed on the CH – cavity shows good results with respect to the resonance frequency and field distributions in comparison with simulations.

A new generation of 1 MW high power solid state amplifiers and H- type cavities may allow for a significant cost and size reduction of future ion linacs in the energy range up to about 100 AMeV.

Detailed investigations on the two different types of copper plating can be performed on this cavity and detailed investigating by using the GSI high power 325 MHz test stand driven by a 3 MW klystron will be possible. The main aspect in our case is the high sparking limit. Currently, the cavity is copper plated at Galvano-T and expected to be delivered by May 2015.

The cavity operation at LN2 temperature seems promising at short pule lengths < 100µs and at low repetition rates of about 10 Hz. The possibilities of operating the cavity at LN2 temperature is under investigation. This seems promising at short pule lengths less than 100µs and at low repetition rates below 10 Hz.

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REFERENCES

[1] J. Broere et al., Proc. LINAC98, Chicago, USA, p. 771 (1998).

[2] A. Almomani et al., Phys. Rev. ST-AB 15, 051302 (2012).

[3] A. Almomani and U. Ratzinger, Proc. LINAC 14, Geneva, Switzerland, p. 208 (2014).

[4] A. Almomani and U. Ratzinger, Proc. IPAC 14, Dresden, Germany, p. 3229 (2014).

[5] A. Almomani and U. Ratzinger, Proc. IPAC 13, Shanghai, China, p. 3785 (2013).