PROTOTYPE CONSTRUCTION OF A COUPLED CH-DTL PROTON LINAC FOR FAIR

R. Brodhage*, U. Ratzinger, H. Podlech, S. Minaev, R. Tiede,
IAP, Goethe University, Frankfurt am Main, Germany
G. Clemente, L. Groening, GSI, Darmstadt, Germany

Abstract

For the research program with cooled antiprotons at FAIR a dedicated 70MeV, 35mA (70mA optionally) proton injector is needed.
The main acceleration of this room temperature injector will be provided by six coupled CH-cavities operated at 325MHz. [2]
Each cavity will be powered by a 3 MW klystron (6 in total). For the second acceleration unit from 11.7 to 24.3 MeV measurements on a 1:2 scaled model are performed. This tank is now under construction and will be used for RF power tests at GSI. The RF power test installations are underway.
The overall injector design and the status of the first power cavity are presented in this paper.

INTRODUCTION

The proton linac for FAIR is mechanically grouped in two tanks, each having a length of about 10m. Based on the actual design the two tanks will consist of 3 coupled CH-cavities each. Between both tanks there will be a diagnostics section with an additional rebuncher inside.
Further investigations have started to find out whether a alternative layout of the 2nd section of the proton linac could be an improvement. In that case, three simple CH cavities without a coupling cell would be used, reducing the high energy triplet lens number by three. This paper will focus on the actual design, because a decision on this topic is not yet made.

THE COUPLED PROTOTYPE CAVITY

The prototype cavity corresponds to the second coupled cavity in the first section of the injector. The low energy part consists of 13 gaps, followed by the coupling cell and by the 14 gap high energy part. The whole cavity has an inner length of about 2.8m and an inner diameter of about 375mm.
The coupling cell has a length of $2\beta\lambda$ and hosts the focusing triplet lens within one large drift tube. The intertank sections will also house triplet lenses as well as beam diagnostics. They mechanically connect neighboured cavities.

* brodhage@iap.uni-frankfurt.de

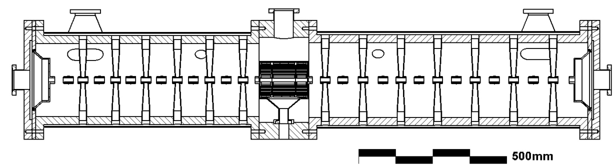

Figure 1: Cross-sectional view of coupled cavity no. 2.

Table 1: Parameters of the CH Prototype Cavity

no. of gaps	13 + 14 = 27
frequency [MHz]	325.2
energy range [MeV]	11.7 - 24.3
beam loading [kW]	882.6
heat loss [MW]	1.35
total power [MW]	2.2
Q_0-value	15300
effective shunt impedance [MΩ/m]	60
average E_0T [MV/m]	6.4 - 5.8
Kilpatrick factor	2.0
coupling constant [%]	0.3
aperture [mm]	20
total inner length [mm]	2800

MECHANICAL DESIGN

Intertank Unit

The concept based on two 10m long tanks leads to very tight tolerances with respect to the surface orientation of the tank flanges as well as with respect to the transverse alignment against the beam axis. To control mechanical deformations by gravity or stress the linac will be placed on a rail system with flexible supports - as practiced at the GSI Unilac. Alternatively, each tank could be mounted precisely on a robust support and then be aligned via a 3-point adjusting device with respect to the beam axis.
The neighboured cavities will be connected by an intertank unit. It consists of a quadrupole triplet housed in a drift tube and mounted into a rectangular massive frame which provides the end flanges for the neighboured cavities at the same time. No bellow connection along the beam line is foreseen in that concept within each 10m section.

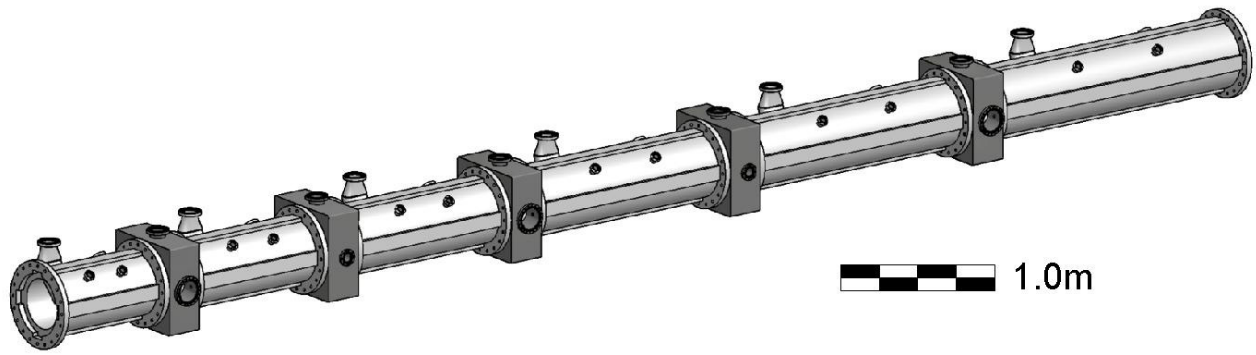

Figure 3: 3D - view of the first section of the proton linac.

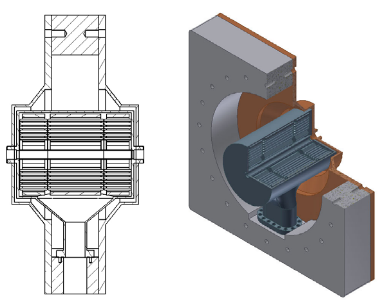

Figure 2: 3D - sketch and cut of the intertank section.

Coupling Cell with Beam Diagnostics

It is investigated, whether a capacitive 4-knob pickup probe could be integrated into the drift tube containing the quadrupole triplet. The technology of cavity internal lenses can be transfered from IH-cavites as built many times succesfully.
The coupling cell has four CF-flanges on the outer wall, which will be needed for:

a) incoupling loop c) plunger
b) vacuum pump d) quadrupole lens

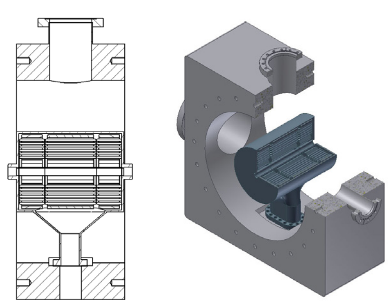

Figure 4: 3D - sketch and cut of the coupling cell.

Drift Tube Sections

It has been demonstrated successfully by a 8-cell prototype cavity [4] that the drift tube stems can be welded into the tank wall at the inner surface. To avoid large holes in the outer tank, special techniques were developed to integrate long drift tubes with modest transverse stem diameters. Additional care must be taken to limit longitudinal stress along the stem caused by temperature differences between tank wall and drift tube structure. Therefore the stems will have a bellow-like shape at the end to compensate the stress.
Whith respect to the cooling system a stem and drift tube geometry was developed which makes it possible to produce the stems in four single parts.
New welding techniques make it possible to weld the stems with very high precission.

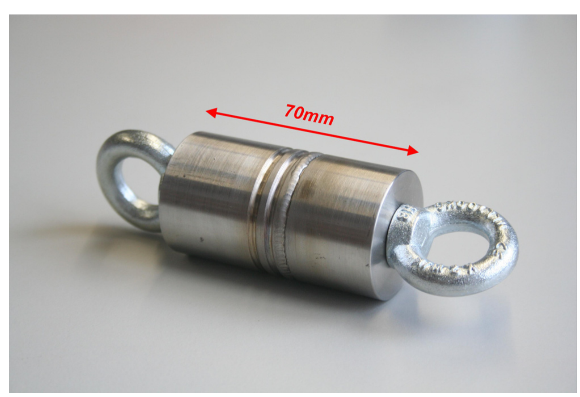

Figure 5: Prototype to test a stress relaxation concept used at the stem ends.

Cooling System

Because of the low duty cycle, investigations on the cooling system showed that it is possible to keep the whole cavity at moderate temperature with only eight cooling channels (20mm diameter) in the tank wall and at a wall thickness of 5mm along the stems.

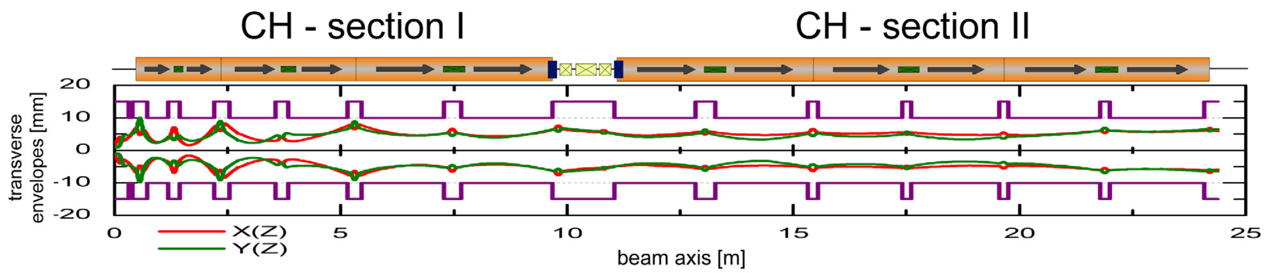

Figure 8: Schematic view of the proton linac with 99% beam envelopes.

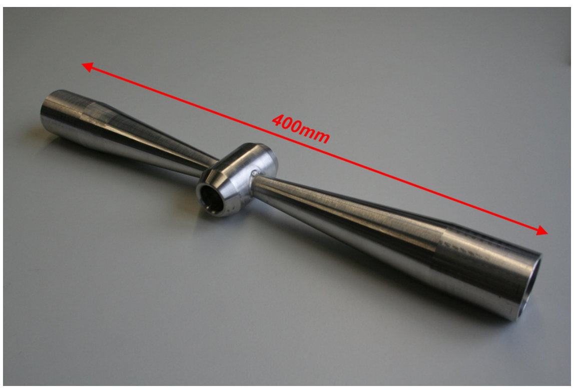

Figure 6: Prototype of a stem for cooling tests.

Figure 7: Milling of the outer cylindrical wall at one part of the prototype cavity and preparation for thrilling the longitudinal water cooling channels.

RF PROPERTIES AND TUNING

The coupling between an acceleration section and the coupling cell is accomplished by RF-fields around the coupling drift tube as well as by the gap capacity. The corresponding drift tube inside the coupling cell is charged oppositely at the ends in the mode of operation. This means, that it acts like an Alvarez type drift tube.
The coupling factor is around 0.3%. This means, the spacing between the 0-mode and the $\pi/2$-mode is about 1.3MHz, which seems to be sufficient. Possibilities for an increased mode separation are actually investigated at the rf model.
Concepts for fine tuning of the voltage distribution already during cavity fabrication with static tuners are studied as well as new concepts of dynamic tuners for the frequency regulation during operation. The results seem very promising.
The acceleration sections of the cavity contain no screwed connections. Therefore a Q-value within 5% of the theoretical value is expected. This was demonstrated successfully by the 8-cell prototype. [4]

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REFERENCES

[1] G. Clemente, H. Podlech, U. Ratzinger, R. Tiede, S. Minaev, "HIPPI-Relevant Activities at IAP-Frankfurt on the Development of the Room Temperature CH-DTL", CARE-Report-2008-014-HIPPI

[2] U. Ratzinger, G. Clemente, C. Commenda, H. Liebermann, H. Podlech, R. Tiede, W. Barth, L. Groening, "A 70MeV Proton linac for the FAIR facility based on CH cavities", proceedings of LINAC 06 - TH1004

[3] L. Groening, W. Barth, L. Dahl, W. Vinzenz S. Yaramyshev, G. Clemente, U. Ratyinger, A. Schempp, R. Tiede, "The 70MeV proton linacfor the Facility for Antiproton and Ion Research FAIR", Proceedings of LINAC 06 - MOP061

[4] G. Clemente, H. Podlech, R. Tiede, U. Ratzinger, L. Groening, S. Minaev, "Status of the 70MeV, 70mA CH Proton-DTL for FAIR", Proceedings of EPAC 2006