

DEVELOPMENT OF A NORMAL CONDUCTING CH-DTL*

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Abstract

The normal conducting "Crossbar H-Type" (CH) accelerating structure is a good candidate for pulsed, high intensity linacs application, covering the energy range from 3 to 100 MeV. H Mode cavities are outstanding in the low-beta range with respect to shunt impedance, high acceleration fields, and compact design: that's why we propose to base the 70 mA, 70 MeV, 352 MHz proton linac for the GSI FAIR project on that structure. The actual design consists of 11 CH-DTL's with a total length of around 20 m. Latest results from beam dynamics optimisation will be discussed. Moreover, this paper describes the CH-DTL cavity design with emphasis on the optimisation with Microwave Studio and on the achieved progress in the development of mechanical design concepts. A stainless steel multicell model cavity is presently fabricated by our institute in collaboration with GSI, in order to investigate manufacturing and assembly details. Based on this experience, the design of a CH prototype power cavity will be optimised.

BEAM DYNAMICS INVESTIGATION

Compared to previous design results for the GSI FAIR facility Proton Linac [1], the RFQ-DTL matching section (MEBT) has been modified, according to a new RFQ output particle distribution at energy of 3 MeV and with a current higher than 70 mA.

The Proposed MEBT Section

The MEBT section (represented in Fig.1) must provide efficient matching between the RFQ and the first CH tank and also provides some free space for the beam diagnostics devices like phase probes, profile monitors or current transformer: for this reason the proposed scheme includes some free space followed by a single quadrupole lens, a short rebuncher and, finally, a triplet system that leads the beam into the first CH module. Nevertheless this first stage of acceleration is still under investigation: it could be happen that more free space is needed and this could consider influence the transversal behaviour of the beam. Preliminary results have shown that, for a drift

length higher than 15 cm the initial singlet could be replaced by a doublet quadrupole system in order to provide transversal stability and symmetry of the beam.

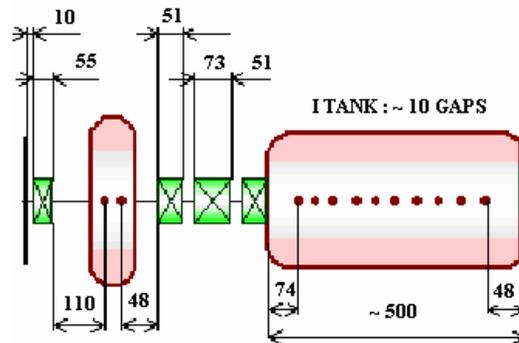


Figure 1: A schematic overview of the MEBT section showing the rebuncher and the first tank.

The Overall Design

After the rebuncher 10 tanks (for a total length of ~20 meters) will be needed to get the final energy of 70 MeV within the beam requirements for the injection into the SIS Synchrotron [1].

Each tank corresponds to a KONUS [2] period and will be fed by its own 352 MHz Klystron with a maximum power of 1.1 MW: to keep the total power consumption per cavity (energy absorbed by the beam + loss due to the electrical resistance) below this number the effective shunt impedance has been optimised and a value of 35 MΩ/m seems feasible at 70 MeV [3].

Finally a new concept for the hosting of the quadrupole triplets between each tank has been developed and it will be described in the next section.

The main CH parameters are summarized in Table 1 while Figures 2 and 3 show, respectively, the transverse envelopes and the input and output projection emittance cluster plots.

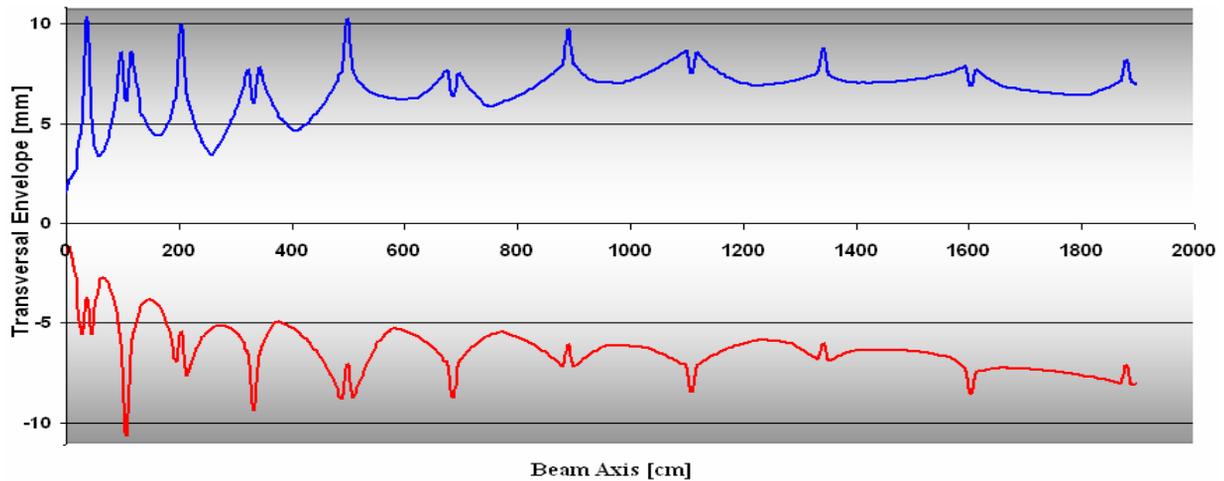


Figure 2: The 100 % transversal beam envelope.

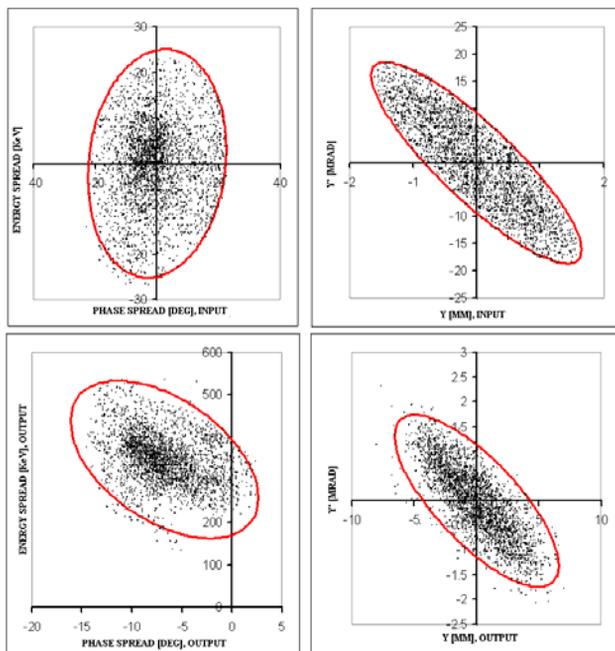


Figure 3: Transverse and longitudinal particle distribution at the entrance and at the exit of the CH-DTL.

Table 1: The main parameters of the CH-DTL

CH Parameters	INPUT	OUTPUT
Energy [MeV]	3	70
Current [mA]	95.7	95.7
ϵ_{tr} (98 % norm)	1.2266	2.9033
ϵ_{tr} (RMS)	0.23768	0.37551
ϵ_{long} (98 % norm)	4.4252	12.058
ϵ_{long} (RMS)	0.6752	1.4244
No. of Tanks	10	
No. of gaps per tank	10 - 17	
Total Length [meter]	~ 20	

MECHANICAL DEVELOPMENT

There is still a lack in experience with this novel type of accelerator: for this reason we decided to build a cold model to test the fabrication steps and to find out technical solutions for the future prototype cavity.

Our model consists of 8 identical cells corresponding to a beta value of 0.09 ($\beta\lambda/2 = 45$ mm) which, according to beam dynamics simulation, would be the length of the last gap in the first module. In a first step Microwave Studio[®] was used to optimize cavity parameters such as shunt impedance and voltage distributions: comparison between different geometries for the stems were carried out both at the low and high energy front side and, finally a conical solution for the stems was adopted. The dimensions were finally optimised to take into account the space needed for the water cooling system and to ensure for the whole structure a good mechanical stability.

As already discussed in [4], the stems will be welded in the outer wall while the massive copper half drift tubes will be press-fit into the stainless steel stems: this technique is expected to ensure both excellent RF contacts and mechanical stability. At the moment no screws are foreseen inside the cavity with the aim to improve the electrical properties of the cavity.

One of the main advantages of the new CH-DTL, also according to the experience on the superconducting model [5], is the capability to get flatness of the field distribution: this is especially important in the ends cell to approximate the H_{211} mode as close as possible to the H_{210} ; in the IH cavity (H_{110} mode), for instance, this is obtained by large undercuts in the base girders to enlarge the magnetic inductance at the cavity ends. In our case, since no girder is present in the cavity, one way is to increase the length of the first and last half tubes: if the radius of these half tubes is also enlarged, this drift space can be used to host one part of the quadrupole lens or a diagnostics device. For our model we tested the distribution of the field obtained for a end cell length of 8, 10 and 12 cm, respectively, and the results are shown in Fig.4 where it is possible to see how good flatness of the

electric field and voltage distribution can be achieved simply by using this technique: further improvement can, of course, be obtained by changing the drift tube length inside the desired gap.

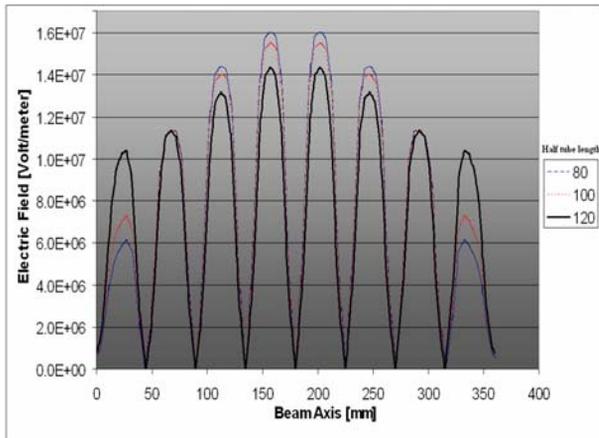


Figure 4: The field distribution for different value of the end half tube length.

But this design will not be only helpful for the cavity tuning, it will carry also great advantages concerning the mechanical assemblage: hosting the lenses and the diagnostics inside the end cells will permit to save considerable quantity of space resulting in a huge reduction of the total size of the linac. Each tank will be fed by its own generator and will be strictly integrated with the following one, resulting in a very compact structure considerably improving the CH-DTL capabilities. Least, the reduction of the drift space

between one tank and the following one will also be useful concerning the particles transport.

CONCLUSION

A compact design of a dedicated Proton Linac, based on H-mode cavities (CH) for the FAIR facility at GSI was presented. Preliminary beam dynamics simulations show that the beam could be transported from 3 to 70 MeV within the requirements for the SIS Injection. A new design for the cavity ends cell, which will considerably improve the CH-DTL capabilities, was described.

According to this design a cold model is under construction at the IAP in order to test key steps in production and assemblage.

REFERENCES

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Figure 5: Overview of the proposed design for the CH-DTL: the large end cells will host the quadrupole lenses and the beam diagnostics while the massive copper drift tubes (shown here in white) will be press-fit into the stainless steel stems

