DEVELOPMENT OF A FDT-CAVITY*

K. Kühnel, A. Schempp
Institut für Angewandte Physik, Johann Wolfgang Goethe-Universität,
Robert-Mayer-Straße 2-4, D-60325 Frankfurt am Main, Germany

Abstract

The acceleration efficiency of RFQs is going down with higher particle energies. To achieve a better focussing at higher energies the RFQ principle is combined with a drift tube cavity. In a Focussing Drift Tube (FDT) cavity this is done by adding small electrodes with quadrupole symmetry to the accelerating gaps of a $\beta\lambda/2$-spiral loaded cavity. This type of cavity is planned to be used as a booster for the new RFQ-injector for COSY at FZ Jülich [1].

1 INTRODUCTION

A field of work at IAP since the 1970s has been the development of spiral loaded cavities. These cavities feature a high efficiency, a very compact design and a big variety of possible applications.

They are often used as postaccelerators for adjusting the final energy of the beam or as buncher cavities. Compared to other designs these structures have the advantage of a small size. Futhermore they can easily be tuned to the required resonance frequency by adjusting the spiral length [2].

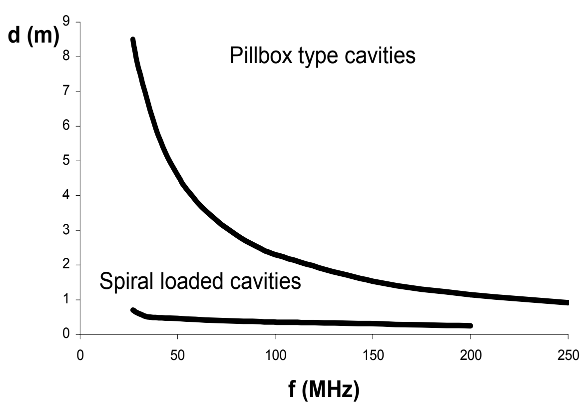

Fig. 1: cavity diameter over resonance frequency

A further improvement can be made by adding a focussing field component in the accelerating gap. This is done with small quadrupol electrodes which are mounted on the edges of the drift tubes. Figure 2 shows a schematic drawing of a gap with mounted quadrupoles. The geometry was created with MAFIA [3]. The electric field components calculated with the electrostatic solver are shown in figure 3.

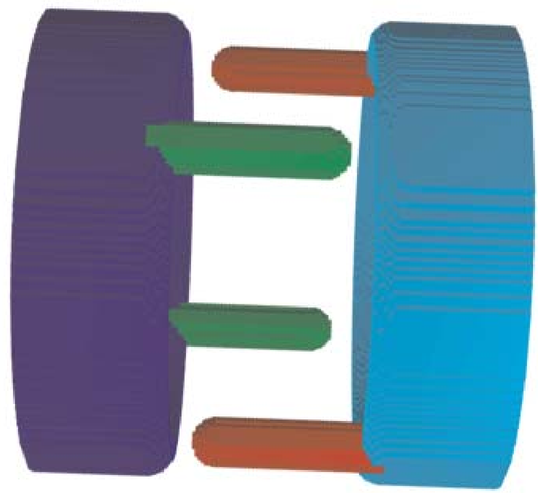

Fig. 2: schematic drawing of a accelerating gap with quadrupole electrodes.

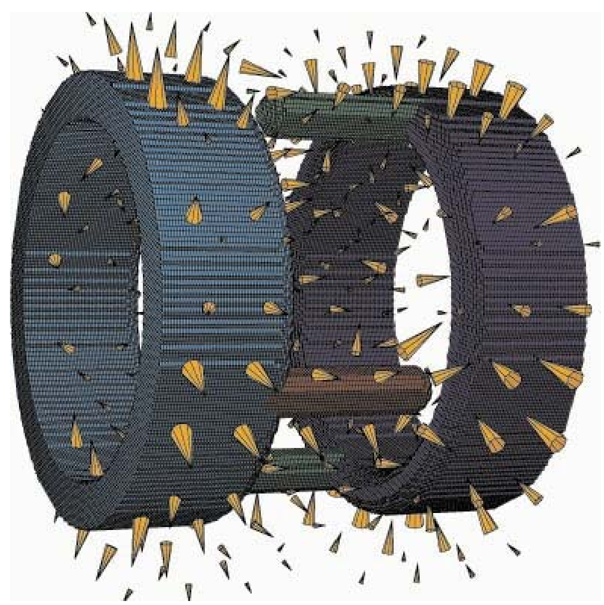

Fig. 3: three dimensional arrowplot of the electric field

2 SIMULATION USING PARMTEQ

To describe the combined function of an acceleration gap with quadrupole electrodes, PARMTEQ was used. Because it is not possible to decribe an accelerating gap which is also focussing the beam analytical, a new transport element was used [4]. This element transforms the beam through an arbitrary three dimensional potential distribution. The potential distribution is stored in a separate file which is generated by the method of successive relaxation. First of all the potential on the geometric structure is fixed in a 101*101*101 matrix. Then the algorithm provides a solution of the Laplace equation in the empty space between the electrodes. The time it takes to produce a good solution depends on the relaxation factor ω (~1.6) and the required precision of the solution. Figure 4 shows the transversal potential distribution on different cross sections through the calculated grid.

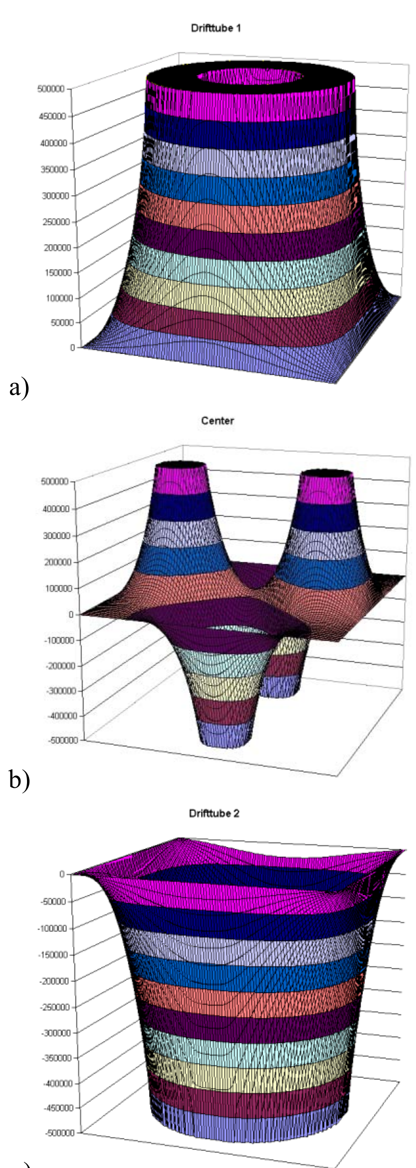

Fig. 4: Potential distribution on a cross section a) through first drift tube b) through the middle of the gap c) through second drift tube

The PARMTEQ simulations have been done with a deuteron beam with an energy of 2 MeV/u. A typical drift tube structure with an aperture of 20 mm and a gap width of 15 mm was used for comparison of the beam parameters. Into the gap electrodes with quadrupole geometry are added. The electrodes are aligned to provide a focussing field in x direction and a defocussing field in y direction. In the simulation a gap voltage of 1 MV was used. In an ideal drift tube this would correspond to an energy gain of 0.5 MeV/u. The simulations show that the energy gain in the FDT structure is slightly lower compared to a conventional drift tube. The difference of the energy stored in the field is used for the focussing quadrupole field. Figure 5 shows the beam data after the FDT structure in comparison to the beam data after a single drift tube shown in figure 6.

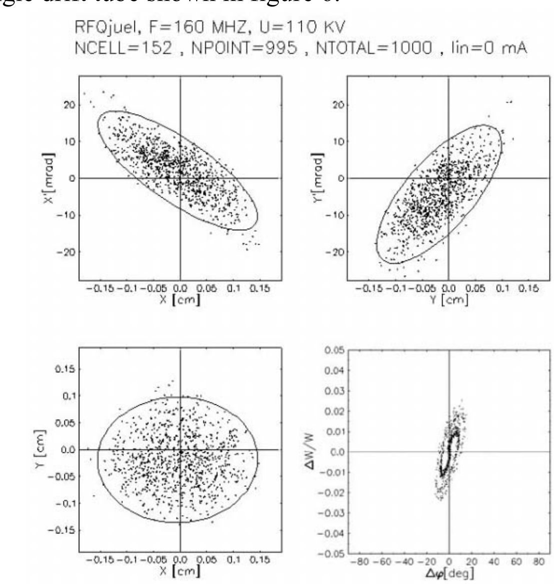

Fig. 5: Beam data after the FDT structure

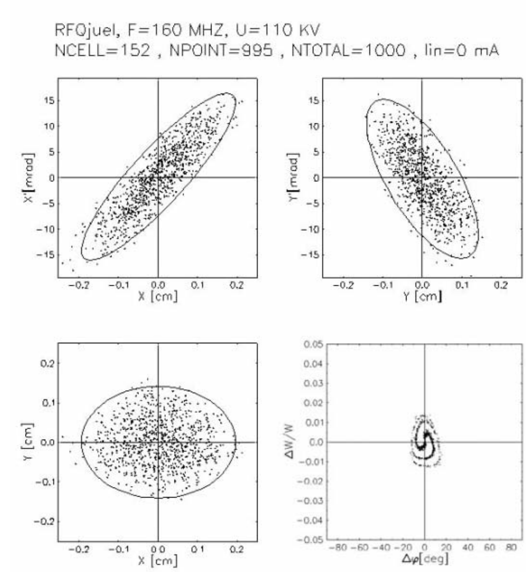

Fig. 6: beam data after an 1 MV accelerating gap

The focussing effect of the electrodes correspond to a quadrupole with the same voltage and the length of the overlapping electrodes.

3 DESIGN OF THE COSY BOOSTER

For the new RFQ-injector for COSY at FZ Jülich a booster is mounted directly on the RFQ. The booster accelerates the deuteron beam from 2 MeV/u to a final energy of 2.5 MeV/u. At the moment the booster is designed as a spiral loaded cavity with four gaps. Thus it contains two drift tubes mounted on spirals and one middle drift tube mounted on a short stem which is on ground potential.

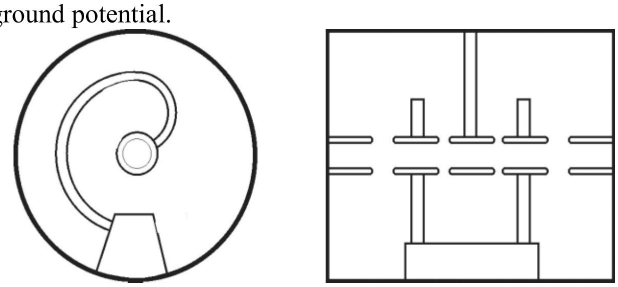

Fig. 7: Schematic drawing of the four gap spiral loaded cavity.

The structure with four gaps provides a voltage of 250 kV per gap. The symmetric distribution of the voltage over the four gap result in some advantages with the focussing electrodes.

4 CONCLUSIONS

The beam dynamic calculations with PARMTEQ showed that it is possible to add a focussing quadrupole component in the gap of a DTL. This provides an interesting option for very compact booster cavities if the space in the following beam line is limited. The FDT provides a good possibility to save the space and the expenses of additional quadrupol lenses. Another option for the future is the combination with an RFQ in the same tank. A similar construction with a DTL is used for the RFQ injector of the radiotherapy facility in Heidelberg [5].

At the moment a model structure of the four gap FDT is build at IAP to verify the calculated field distributions with bead pertubation mesurements before high power test on the structure can be conducted.

REFERENCES

[1] R. Tölle et al., “A Superconducting Injector LINAC for COSY”, Proc. EPAC 2002
[2] C.P. Welsch et al., „ Development of Rebunching Cavities at IAP“, Proc. LINAC 2000, 938
[3] T. Weiland, “User guide” MAFIA ver. 3.20
[4] A. Bechtold, “Erweiterung von PARMTEQ um ein Modul zur Berechnung der Teilchendynamik in einer frei wählbaren Potentialverteilung“ Int. Rep. Okt.2000
[5] A. Bechtold et al, “Design and Construction of an RFQ-Drifttube-Combination for a Medicine Synchrotron”, Proc. EPAC 2002