SIMULATIONS FOR A BUNCHER-CAVITY AT GSI

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Abstract

Buncher cavities can be used to bunch and rebunch or reaccelerate particle beams. A special form of these buncher cavities is a spiral structure. One of its main features is the easily adjustable frequency. A two-gap structure for the GSI has been simulated and will be build at the Institut für Angewandte Physik (IAP) at University of Frankfurt. This structure shall replace an existing buncher at GSI. It is designed to a frequency of 36 MHz. Also general simulations of spiral bunchers will be presented.

BUNCHER

A spiral structure can be applied to adjust a particle beam in the longitudinal direction, to bunch or reaccelerate it. In order to do so, it is typically placed between different accelerator units to ensure an ideal transition or at large beam ways to keep the bunch in a proper shape. The most simple variation of such a cavity is a $\lambda/4$ resonator. It is made of a drift tube, which is connected with the bottom plate over a spiral formed arm which can be turned without changing the orientation of the drift tube. It will always stay in the of the resonator . That simplifies the frequency adjustment enormously. While the arm is turned the induction changes and that causes a change of frequency. This effect can be increased by cutting the overlapping part. The longer the arm is, the lower is the frequency. For this reason the frequency of such a cavity is largely independent of its dimensions.

The structure is to be installed at GSI within the stripper section of UNILAC at 1,4 MeV/u. Its main purpose will be the bunching the beam from the 36 MHz section into the 108 MHz section. In order to do so there is a second buncher at 108 MHz. The spiral-structures will replace a four gap-structure built in 1999 which is shown in Fig. 1.

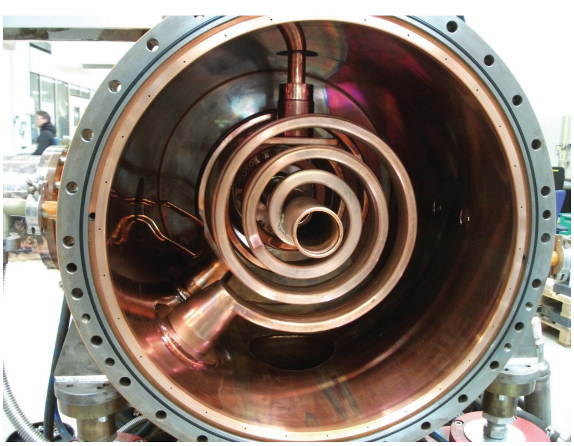

Figure 1: The original structure at GSI.

STRUCTURE SIMULATIONS

As mentioned before the resonance frequency of such a structure is depending on the length of the arm. To reach such a low frequency without getting stability issues or sparks a design-study was necessary. One of the key design principles was an archimedian twist of the arm, which was implemented in the final structure. This arm carries the middle drifttube. The other drift tubes are attached to the endplates of the tank. A first design study is shown in Fig. 2.

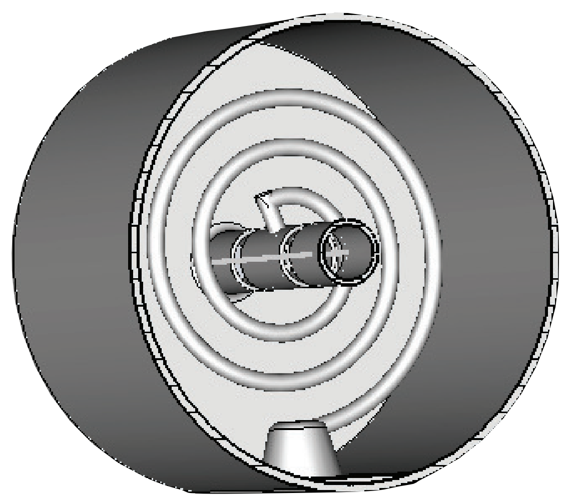

Figure 2: A first design study of the structure with 2,5 twists.

Frequency

To adjust the resonance frequency of a buncher with a spiral structure it is necessary to change the amount of windings of the spiral arm. To reach the low frequency of 36 MHz there have to be 2.5 windings. A structure with 100 MHz would have a quarter twist. Lowering the gapwith leads to a lower frequency. As a result of the simulation we find a change of 0.25 MHz per millimeter.

Stability

With such a long spiral configuration the risk of getting instabilities due to higher harmonics has to be minimized. Several radii of the arm were reviewed to reach a bigger

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stability. The stabilitiy increases with greater thickness of the arm. But due to the risk of sparks in-between arm and drift tube a diameter smaller than 30 mm is recommended (compare to Fig. 3).

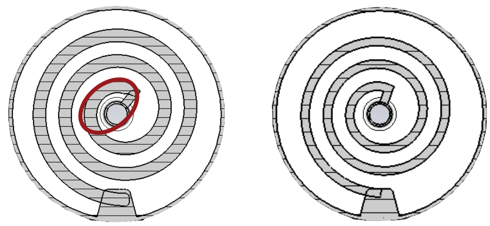

Figure 3: The difference of an 30 mm arm (left) to one with 20 mm (right). Note the very small space between drift tube and arm on the left example.

Base

The original configuration had a base of 95 mm height. Because of the small distance between gap and spiral arm a very high field density occured inbetween arm and base. This could induce sparks or instabilities. To avoid this effect the base was minimized to 75 mm as shown in Fig. 4.

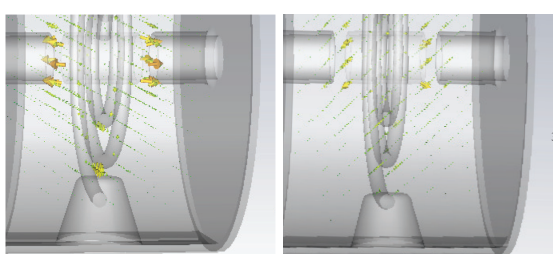

Figure 4: Comparison between the effects of a 95 mm base (left) and the chosen 75 mm base (right).

FIELD SIMULATIONS

The simulated field distribution is shown in Fig. 5. Depicted is the tangential component of the electrical field density on the beam axis as a function of the cavity length. The drifttubes are indicated as blue rectangles. One observes the peak maxima within the middle of each gap, which is in line with the expectations. With this data we could estimate the quality factor and shunt impedance. The expected quality factor will be around 4000 with an shunt impedance of 15 kΩm. Although this value seems low it is within the expected range for such a buncher-structure.

CONCLUSION AND OUTLOOK

The spiral-structure has been simulated and will be build this summer at IAP. The properties of the spiral-structure

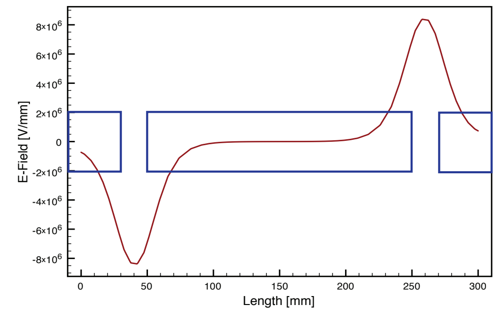

Figure 5: The tangential components of the electrical field depending on the resonator length.

are shown in Table 1. In late summer the structure is to be installed at GSI.

In addition several simulations regarding the general understanding of this type of buncher are to be made.

Table 1: Buncher Properties

Parameter	Simulation
Tank Diameter	500 mm
Tank length	300 mm
Drifttube radius	30 mm
Length central drift tube	200 mm
Gapwith	20 mm
Spiral arm	2.5 windings
Spiral arm diameter	20 mm
Frequency	36 MHz
Particle Energy	1.4 MeV/u
Quality Factor	4000
Shunt Impedance	15 kΩm

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