MAFIA Simulations of the REX-ISOLDE IH-Structure and Frequency Tuning

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Contrary to similar devices the IH-structure of the REX-ISOLDE LINAC [1] is able to vary the exit energy of the particles by changing the gap voltage distribution. This is achieved by placing one of the two capacitive plungers, the low energy plunger (NE) respectively, so close to the beam axis, that the gap voltages between the drifttubes are significantly changed via capacitive influence; a situation one usually wants to avoid, but which comes handy here. The detuning of the resonator is compensated then by moving the massive plunger at the high energy side (HE) further away from the drifttubes [2].

Since the plungers of the IH-Structure not only serve to adjust the frequency of the IH-eigenmode ($TE_{(1,1,1)}$ Mode) to the required frequency of 101.28 MHz, but also to determine the gap voltage distribution, the range of positioning the plungers is very limited and precise design of the resonator is mandatory. Furthermore the eigenmode frequencies of the two plungers (NE,HE), the innner tank triplet (Q) and the IH-eigenmode ($H_{(1,1,1)}$) depend on the positions of the plungers (fig. 1). If the eigenmode fequencies are to close together mode mixing occures and the gap voltage distribution is seriously disturbed.

Due to the circumstances mentioned above, discrepancies of eigenmodes and gap voltage distribution between design calculations and the resonator actually built must not exceed +/- 1%. Otherwise the frequency of the resonator can not be adjusted by changing the positions of the plungers.

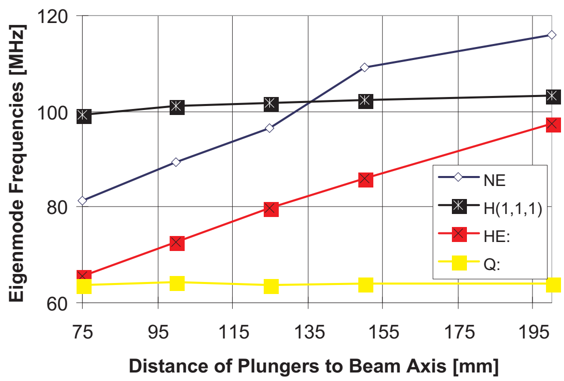

Fig. 1: Calculated development of the first four eigenmodes in dependence on the position of the capacitive plungers. Both plungers have the same distance to the beam axis. Positions, where the low energy mode (NE) is close to the tuner mode ($H_{(1,1,1)}$), must be avoided.

In order to examine the different eigenmodes and the gap voltage distribution calculations using the program MAFIA, which is based on the finite integration theorie (FIT), had been compared to measurements on an 1:2 model.

These measurements showed that the results of the MAFIA calculations varied about 3-4% from the measured values. Because MAFIA is merely a one-to-one translation of Maxwell's equations to a grid space [3], which results in highly accurate calculations of the electromagnetic fields, the accuracy depends mostly on the quality of the virtual model. Since the electromagnetic field of the IH-Structure is concentrated on the axis and the field strength depends mainly on the capacity of the drifttubes, even a small difference between the model and the IH-structure will cause discrepancies that are not tolerable. The same is valid for the 1:2 model, which turned out to be not good enough on scale to guarantee the required accuracy.

In MAFIA a good agreement of model and the real object can either be achieved by optimizing the mesh or by increasing the number of meshcells, but a rough estimate shows that it would be necessary to increase the number of meshcells at least 200 times to achieve a significantly better resolution compared to the optimized mesh and this would require about 40000 times more cpu time.

Since the frequency of the resonant mode mainly depends on the volume of the resonator, it was decided to built the resonator according to the calculations, but with oversized flanges on the halfshells, which increases the resonators volume and directly results in a lower resonant mode. The frequency of the IH-mode could then be raised again by milling down the flanges.

Because of the fact that the error of the MAFIA calculations is entirely systematical an accuracy of +/- 0.2% could be achieved to estimate the eigenmode frequencies by extrapolating the difference between MAFIA calculations and actual values (fig. 2) and the correct size of the flanges could be determined.

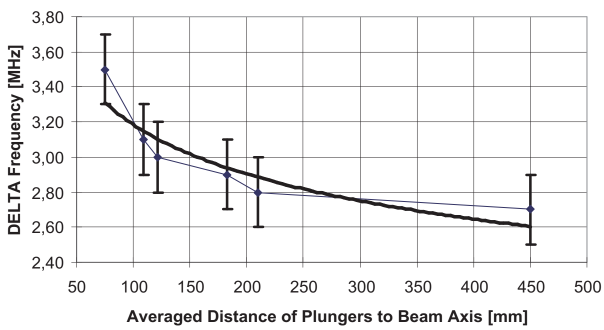

Fig. 2: Discrepancy between MAFIA calculations and measurements in dependence on the averraged distance to the beam axis. The thick line is the estimated difference between the MAFIA calculations using an optimised mesh and measurements at the IH-Structure. For the estimate it was assumed that both plungers have the same distance to the beam axis. The datapoints are measurements taken at NTG (Nov. 17th 1998) with different combinations of plunger positions.

References

[1] O. Kester, Jahresbericht 1997, p. 77
[2] B. Keil, diploma thesis, LMU München, 1997
[3] The MAFIA Collaboration, Documentation, Theorie, 1994