Simulations of a quadrupolar pick-up at GSI SIS-18*

Joel Alain Tsemo Kamga†[1], *Wolfgang F.O. Müller*[1], *and Thomas Weiland*[1]
[1]Technische Universität Darmstadt, Institut für Theorie Elektromagnetischer Felder (TEMF), Schlossgartenstrasse 8, 64289 Darmstadt, Germany

Introduction

This report presents the simulation results for an asymmetrical capacitive pick-up installed at GSI SIS-18. In the past, it was used as BPM (Beam Position Monitor) and is planned to be used for measuring the transverse beam size oscillations at SIS-18. The main goal of this project consists in estimating the properties of the pick-up and evaluating its usage as a quadrupole signal monitor. Due to the fact that the bunch for the SIS-18 operation is long compared to the pick-up electrode, first simulations have been performed with the electrostatic solver of the simulation software CST EM Studio to estimate the pick-up properties [1]. Now, to study the pick-up behavior in the frequency range of insterest for GSI, some simulations have been performed using the PIC solver of CST PS (Particle Studio) [2] and the results are presented in this report.

Simulations and Results

The pick-up design used for the simulations is shown below in Fig. 1

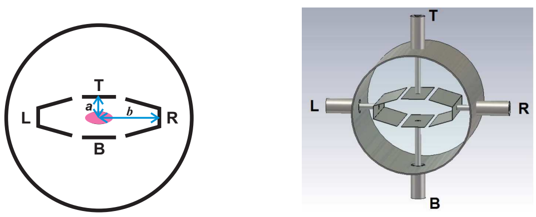

Figure 1: **Left**: front view of the pick-up design, b = 100.3 mm, a = 35.3 mm; **right**: perspective view of the pick-up from CST PS.

The quadrupolar signal Ξ for the traditional diff-over-sum method is given by $(U_R+U_L-U_T-U_B)/(U_R+U_L+U_T+U_B)$, where U_R, U_L, U_T and U_B are the amplitudes of the FFT signal voltages induced on the respective pick-up plates. Since the frequency range of interest for a typical SIS-18 opetration is between 10 kHz and 10 MHz, a high terminating resistor of 1 MΩ was connected at the output of each electrode to obtain a low 3 dB cutoff frequency of the plate. The simulation was carried out, as mentioned in the introduction, using CST PS, with a PIC solver in the frequency range of DC $\leq f \leq$ 200 MHz.

On the above diagram in Fig. 2, one can see that, the greater the horizontal beam size σ_x, the greater the quadrupolar signal in the whole frequency range, as expected. Furthermore, one can see that, in the frequency range of interest (10 kHz $\cdots$ 10 MHz) the quadrupolar signal is almost constant; the maximal deviation of $\Xi(f)$ (10 kHz $\leq f \leq$ 10 MHz) from the value of Ξ at 10 MHz is in the order of around 0.21%. The lower picture in the above figure shows the quadrupolar signal at 10 MHz for different values of σ_x/σ_y. One can state a good agreement between both solvers; the maximal relative deviation of the PIC solver results from the electrostatic ones is around 0.4%.

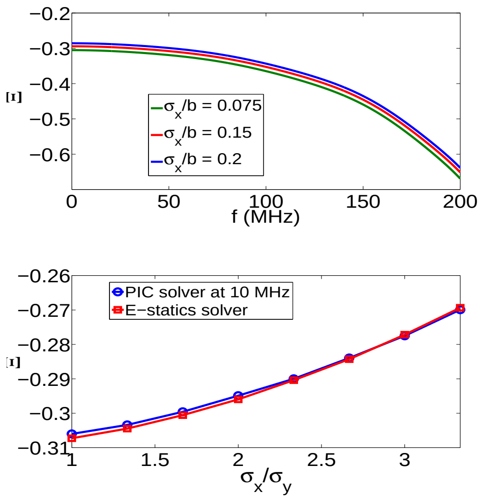

Figure 2: Quadrupolar signal Ξ for a centred beam; **above**: Ξ as a function of frequency; **below**: Ξ as a function of the horizontal beam size σ_x; σ_y/b = 0.075, b = 100.3 mm

Conclusions

The simulations for an asymmetrical pick-up have been investigated in this project. One has seen that, in the frequency range of interest for GSI, the pick-up behaves capacitiv. Moreover, there was a good agreement between the PIC und electrostatic results. In conclusion, one can say that, for beams, whose longitudinal extent is much larger that the electrode length, the pick-up properties, like for instance the sensitivity, can be estimated very good electrostatically; this has the advantage that the simulation time is very low compared to that of the PIC solver.

References

[1] Joel A. Tsemo Kamga, et al., *GSI Scientific Report 2013*.
[2] CST AG, "CST Particle STUDIO", ww.cst.com

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† tsemo@temf.tu-darmstadt.de

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