

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

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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 interest 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

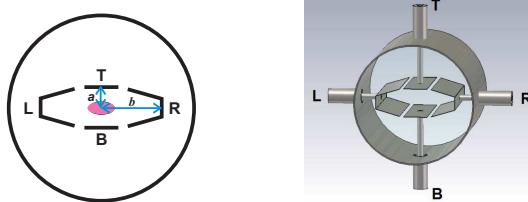


Figure 1: **Left:** front view of the pick-up design, $b = 100.3$ mm, $a = 35.3$ mm; **right:** perspective view of the pick-up from CST PS.

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 operation is between 10 kHz and 10 MHz, a high terminating resistor of $1 \text{ M}\Omega$ 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 $\text{DC} \leq f \leq 200 \text{ MHz}$.

On the above diagram in Fig. 2, one can see that, the greater the horizontal beam size σ_x , the greater the

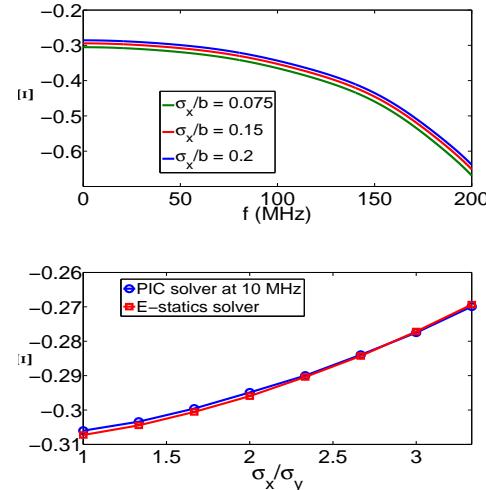


Figure 2: Quadrupolar signal Ξ for a centred beam; **above:** Ξ as a function of frequency; **below:** Ξ as a function of the horizontal beam size σ_x ; $\sigma_y/b = 0.075$, $b = 100.3$ mm

quadrupolar signal in the whole frequency range, as expected. Furthermore, one can see that, in the frequency range of interest ($10 \text{ kHz} \dots 10 \text{ MHz}$) the quadrupolar signal is almost constant; the maximal deviation of $\Xi(f)$ ($10 \text{ kHz} \leq f \leq 10 \text{ MHz}$) 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%.

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 capacitive. Moreover, there was a good agreement between the PIC and electrostatic results. In conclusion, one can say that, for beams, whose longitudinal extent is much larger than 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”, www.cst.com

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