Advanced CST simulations for the FAIR p-LINAC BPMs

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At the planned Proton LINAC of the FAIR facility, four-fold button Beam Position Monitors (BPM) will be installed at 14 locations along the 30 m long FAIR p-LINAC [1,2]. Depending on the location, the BPM design has to be optimized, taking into account an energy range from 3 MeV to 70 MeV, limited insertion length at 30 mm or 50 mm beam pipe aperture. Detailed simulations of the button parameters with the finite element code CST [3] have been executed including pickup capacitance, impedance matching characteristic in time and frequency-domain. Additionally, the signal shape modification with respect to beam parameters, namely beam velocity and bunch length, has been investigated.

Capacitance and Electrical Properties

The pickup capacitance and the electrical properties for different geometries were investigated. The model consists of an inner conductor connected to a button electrode shown in Figure.1.

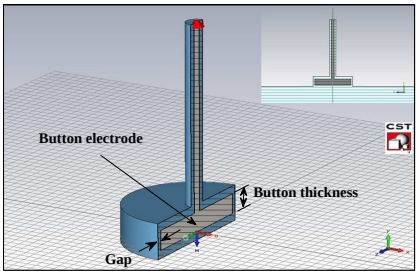

Figure 1: 3D model of the button pickup.

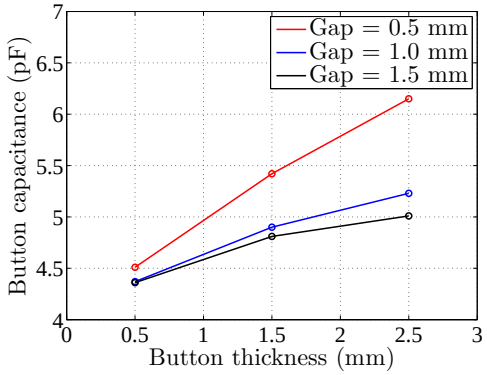

Figure 2: Pickup capacitance as a function of the button thickness calculated by CST Electrostatic Studio solver.

The button geometry has been modified by varying the button thickness and the gap between the button and the housing. The pickup capacitance for different button geometries is shown in Figure.2. A button thickness and gap size of 1 mm each results in a low capacitance, equivalent to high signal, and fits to the commercially available mechanical realization. The influence of further mechanical parameters on signal shape are discussed in [4] using CST Microwave Studio solver.

Bunch Length Investigations

CST Particle Studio was used to characterize the pickup signal width σ_s as a function of Gaussian bunch width σ_b at different beam velocities; β = 0.08, 0.27 and 0.37. The span of simulated bunch width starts from σ_b = 30 up to 960 ps.

The results show a linear relationship between the pickup signal and the bunch width down to a certain limit ($\sigma_b \approx 80$ ps) shown in Figure.3. Below this limit there is no change in the output signal width as the bunch width decreases further. Those limits (for each β value) are used to estimate the pickup signal and the required analogue band width for signal processing.

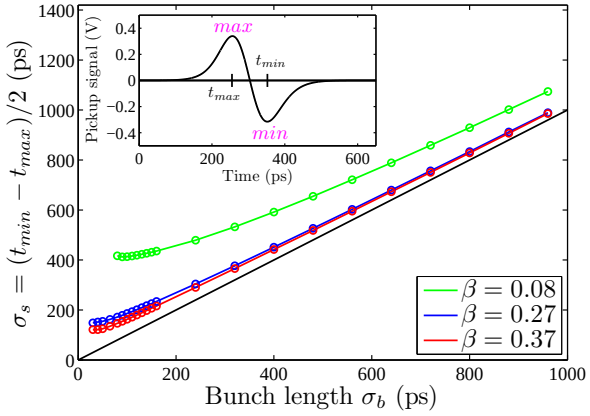

Figure 3: Relationship between bunch width σ_b and pickup signal width σ_s (σ_s calculated from the time difference between min and max values of the pickup signal).

References

[1] L. Groening et al., "Status of the FAIR 70 MeV Proton LINAC", LINAC'12, Tel-Aviv, p. 927 (2012).

[2] P. Forck et al., "Design of the BPM System for the FAIR Proton-LINAC", GSI scientific report 2010.

[3] https://www.cst.com/.

[4] M. Almalki, PhD Thesis, IAP University of Frankfurt, in preparation.

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