Performance demonstration of the non-intercepting Bunch Shape Monitor at UNILAC *

B. Zwicker[1,2], *C. Dorn*[1], *P. Forck*[1,2], *O. Kester*[1,2], *and T. Sieber*[1]
[1]GSI, Darmstadt, Germany; [2]IAP, Frankfurt, Germany

A non-invasive Bunch Shape Monitor (BSM) is foreseen to determine the longitudinal bunch structure with a phase resolution of 1.0°, with respect to the 325 MHz acceleration frequency of the FAIR p-LINAC [1]. It is intended to ensure proper longitudinal matching of the accelerating structures. The presented device is based on the creation of secondary electrons by the ion beam passing a section of high local nitrogen pressure. The secondary electrons are accelerated by an external driving potential towards a time-resolved imaging system [2].

Beam-based Measurements

The non-invasive Bunch Shape Monitor (BSM) has been tested at the UNILAC with several ion beams at 11.4 MeV/u and beam currents in the range from 0.08 to 1 mA. Extensive parameter studies have been executed in 2014. Various parts of the hardware were modified in 2013 and the improved functionality of the device has been clearly demonstrated [3]. For the applied beam settings the BSM is able to obtain profiles down to 250 ps rms with a resolution of 34 ps [4]. As expected, non-Gaussian profiles have been obtained.

By using a single gap resonator (SGR) as a rebuncher longitudinal profile changes have been investigated. This matching is confirmed with a phase probe, while the applied power to the SGR is varied. For the beam tests the ER10 has been used, which implies a distance of 55 m to the location of the BSM (TK5 DK1). The focal length of the ER10 has been varied over several tens of meters to ensure the transmission of the focal point through the location of BSM.

In dependence of the focal length the obtained profile rms widths are depicted in Figure 1. The applied voltage has been varied from 0.53 MV to a feasible maximum of 1.0 MV. The focal length f depends on the applied electric gap voltage U_0 to $U_0 \propto 1$ / f. The BSM is able to detect differences even with a small step size of 0.012 MV. For a value of 0.87 MV the minimum is obtained. From linear beam optics a parabolic dependence of the square of the rms width is expected. For better visualization the rms width is depicted, which should match the square root of this parabola fit. Besides width variation, the bunch shape itself changes and reveals a rather complex composition. This is a hint, as expected, of a distorted phase space distribution of the beam due to the IH-structure's KONUS dynamics. It is foreseen to determine an approximated longitudinal emittance with this measurement by using the parabolic fit parameters for σ^2 over 1/f.

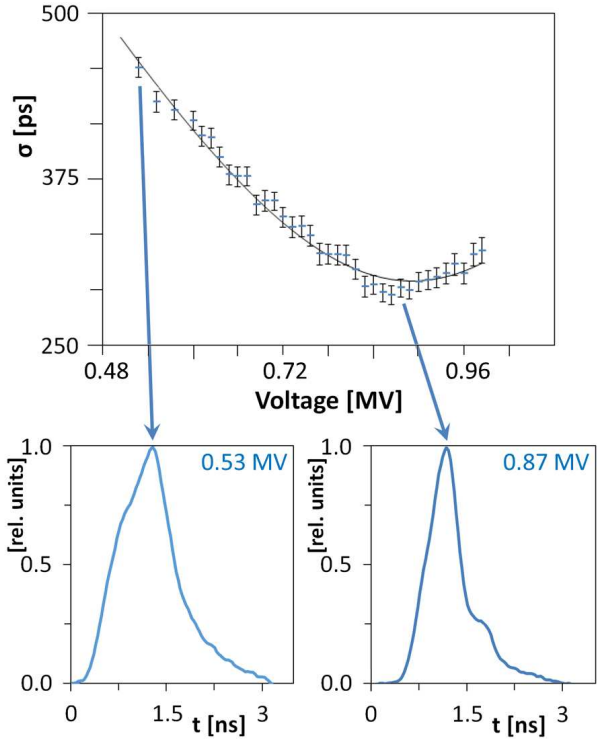

Figure 1: Longitudinal profile widths (rms width of a single Gaussian fit) in dependence of the focal length of single gap resonator ER10. Below are two bunch shapes depicted for different focal length. A non-Gaussian shape is visible. Setting: U^{28+} at 11.4 MeV / u, I = 0.5 mA , τ = 95 μs, p = $5 \cdot 10^{-6}$ mbar, P = 25 W, 16 averages.

References

[1] L. Groening et al., LINAC'12, Tel-Aviv, THPB034, p. 927

[2] P. Forck et al., DIPAC'05, Lyon, p. 48

[3] B. Zwicker et al., IBIC'13, Oxford, MOPC36

[4] B. Zwicker et al., IBIC'14, Monterey, TUDP07

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