Beam Diagnostics for Measurement of longitudinal Beam Properties at UNILAC

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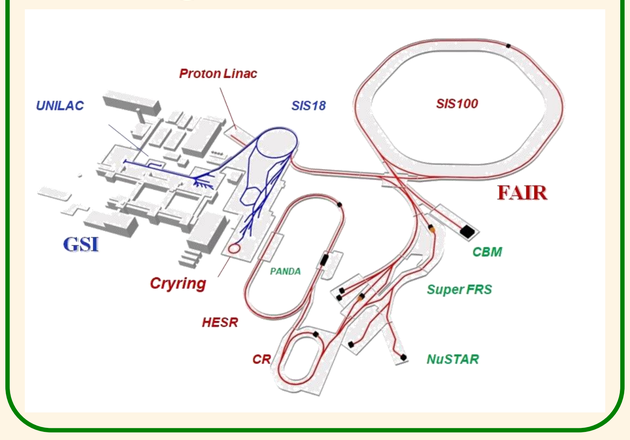
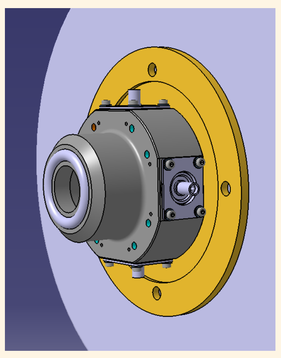
Abstract

During recent beamtimes at GSI we have used various diagnostics devices for characterization of the longitudinal properties of the UNILAC beam. Beam Position Monitors (BPM), Secondary Electron Emission Grids (SEM-Grids) - originally developed for the FAIR proton Linac - have been employed as well as a Feschenko Type Bunch Shape Monitor (BSM) to measure beam displacement behind dispersive sections in combination with bunch lengths and shape to derive longitudinal emittance. We present the diagnostics tools and explain the basic measurement principle.

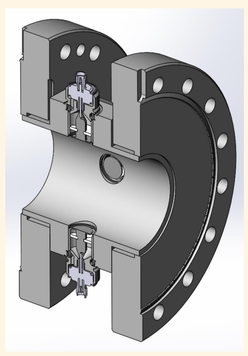
FAIR @ GSI



BPM Mechanical Design

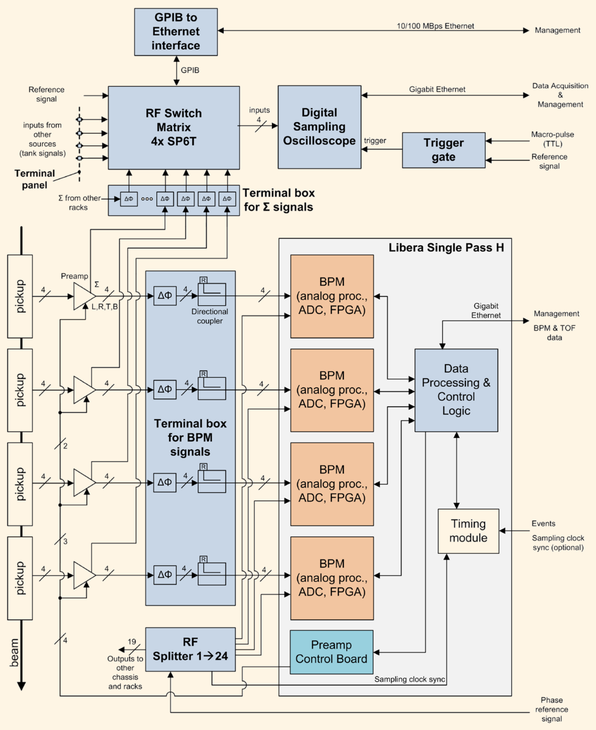


„inter Tank“ type, mounted to triplet

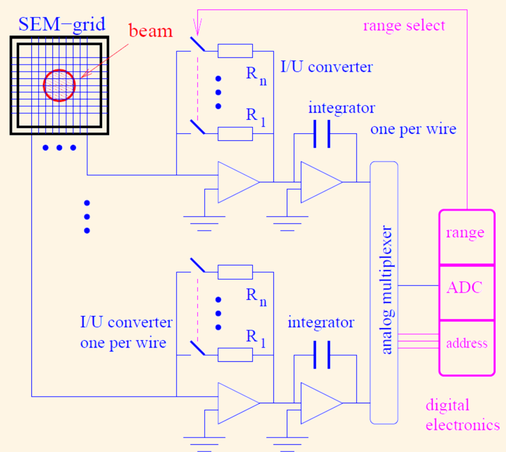


„beamline“ type

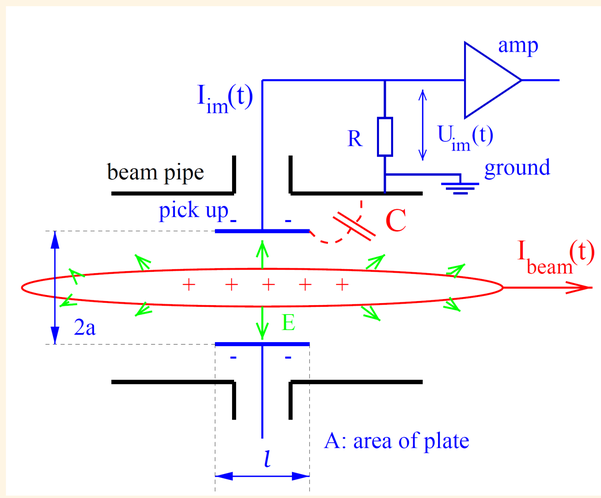
BPM Electronics System LSPH



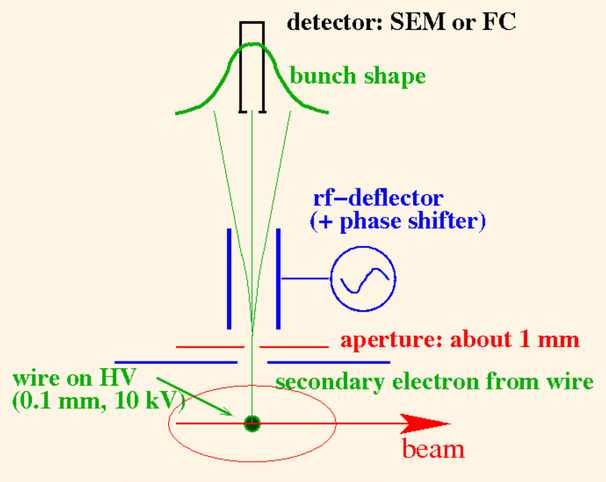
Operation Principle



SEM Profile Grids and typical Electronics



Beam Position Monitors

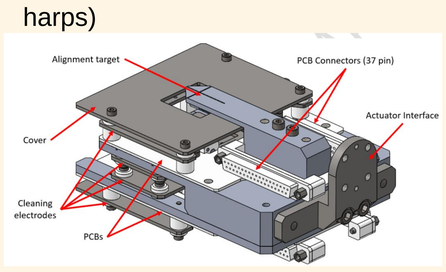


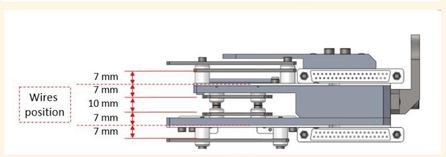
Bunch Shape Monitor

SEM Grid Design

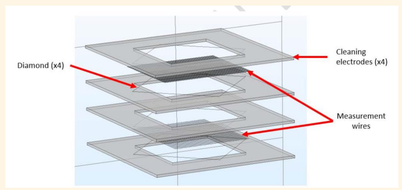
SEM Grids designed by PROACTIVE:

- Design based on PCB in combination with mech. stretching system
- 0.1 mm wires, 0.5 mm wire pitch
- detector area 32 x 32 mm
- used for beam alignment/operation and emittance measurement (grids and harps)



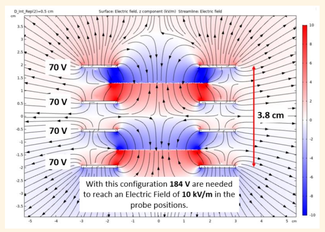


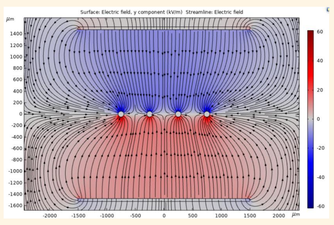
Harp Simulations



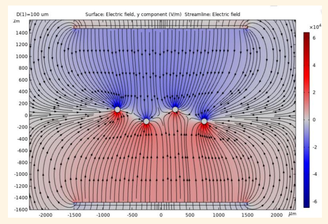
Model to study the filed configuration for different wire / grid geometries

Optimization with respect to highest possible gradient at most compact setup and lowest applied voltage. 10kV/m required to bend electrons away from neighbouring wires



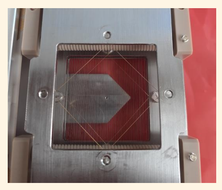


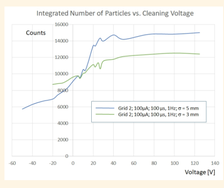
Standard co-planar wire arrangement



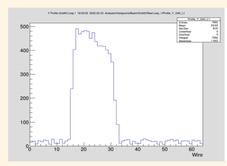
Alternative setup to avoid field free region between wires

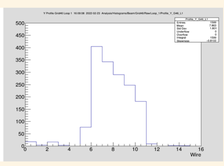
SEM Grid Acceptance Tests



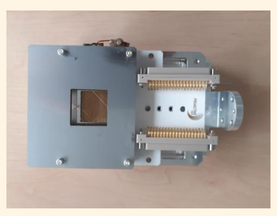


Cleaning electrode → Voltage optimization



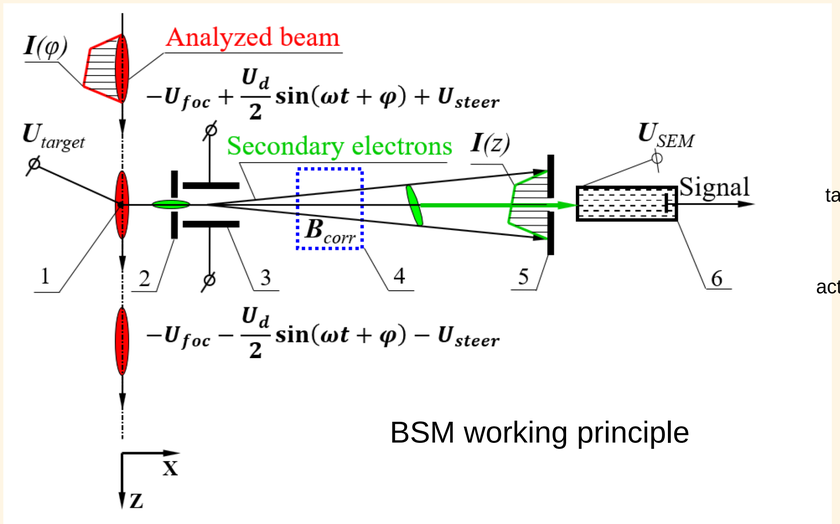


Comparison pLinac grid (left), UNILAC grid (right)

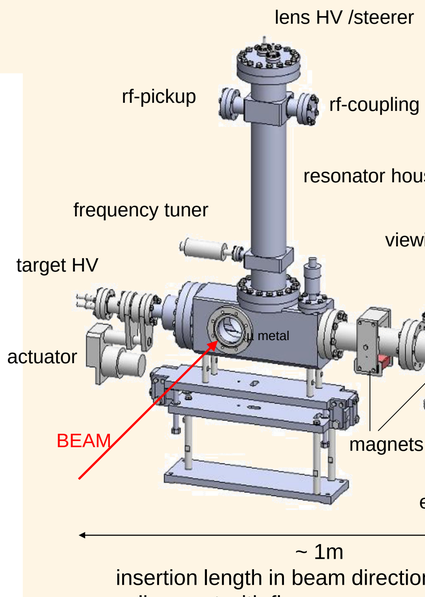


SEM Grids ready for Operation

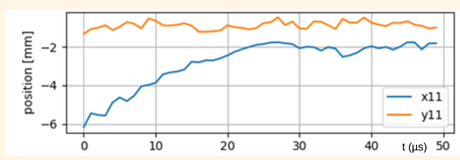
BSM - Bunch Shape Monitor (Feschenko)



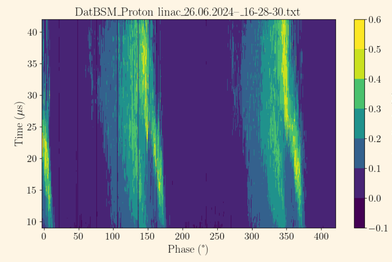
BSM working principle



insertion length in beam direction: 129 mm
alignment with flange accuracy sufficient

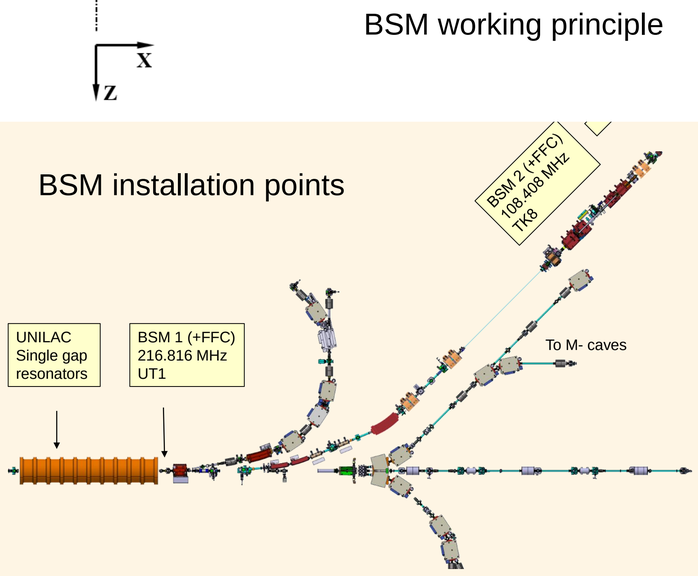


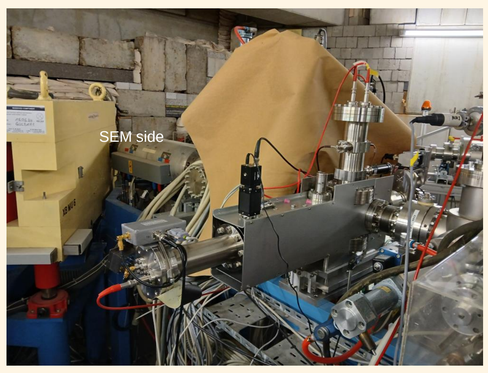
pLinac BPM test Feb. 2022 in X2
(8.6 MeV, 200µA protons)

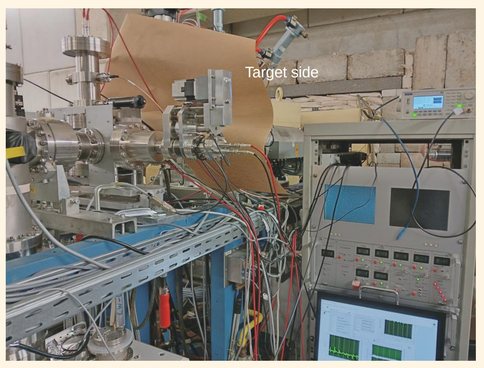


Beam: U^{28+}, 11.4 MeV/u, 50µs, 1Hz, ~150µA

BSM installation points





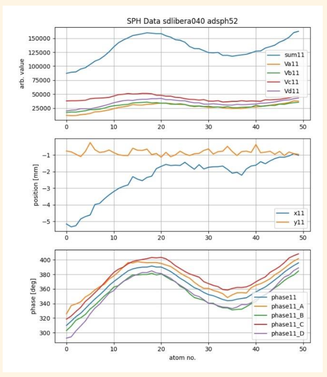


Experimental Setup for Bunch Measurements at UNILAC

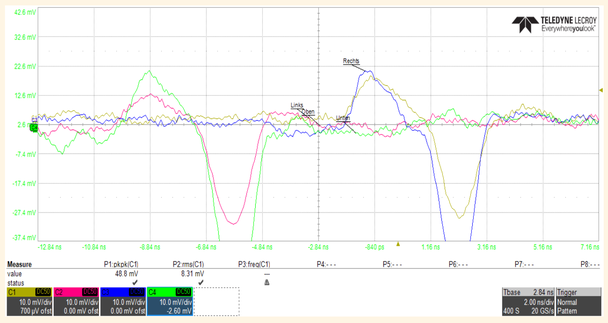
BPM Test Measurements

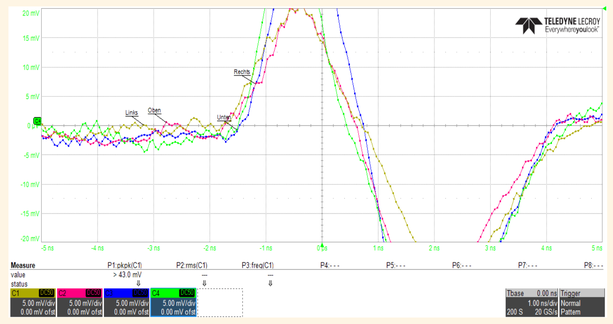
Test setup at UNILAC

BPM electronics racks



Position and phase from LSPH





Position (left) and phase (right) measurement with scope directly at BPM preamplifier