LAYOUT OF THE BPM SYSTEM FOR P-LINAC AT FAIR AND THE DIGITAL METHODS FOR BEAM POSITION AND PHASE MONITORING

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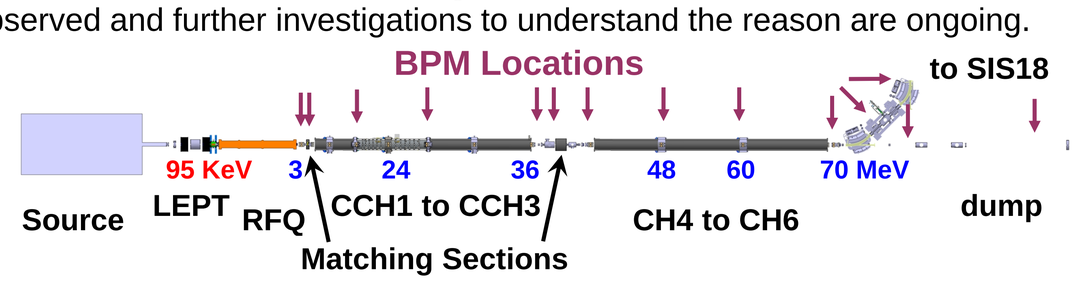
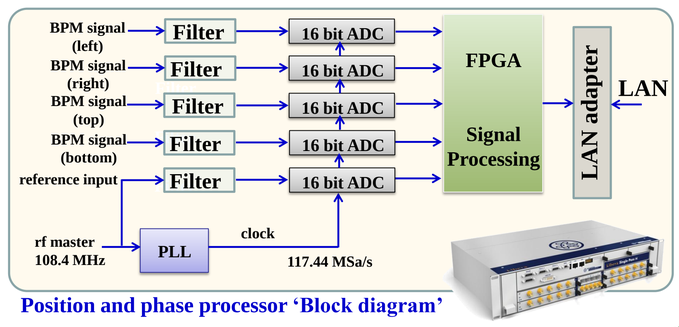
Abstract

At the planned Proton LINAC at the FAIR facility four-fold button Beam Position Monitor (BPM) will be installed at 14 locations along the LINAC. Four of these BPMs will be mounted only about 40 mm upstream of the CH cavities. The coupling of the rf accelerating field to those BPMs was numerically investigated. The properties of a digital I/Q demodulation scheme were characterized by detailed lab-based tests. The performance was investigated by a 80 µA Ca^{10+} beam at 1.4 MeV / u at GSI UNILAC for beam position and phase determination. The I/Q phase results were compared to a time-domain approach as well as successive FFT calculation. A significant deviation between the methods were observed and further investigations to understand the reason are ongoing.



The Digital Method for Beam Position and Phase Monitoring Tested at GSI

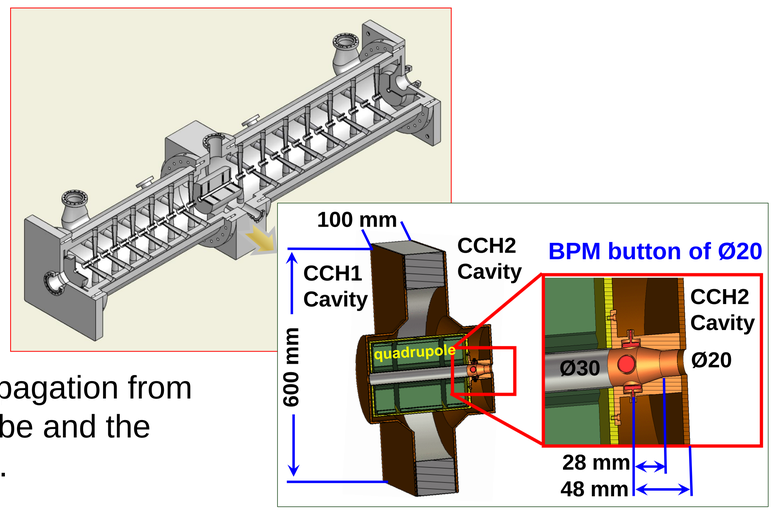
- Sampling rate 117.440 MSa/s.
- High resolution ADC (16 bit nominal).
- Digital I/Q de-modulation → amplitude & phase.
- Output of 1 µs time steps: Position x & y, phase, plate voltages.



Position and phase processor 'Block diagram'

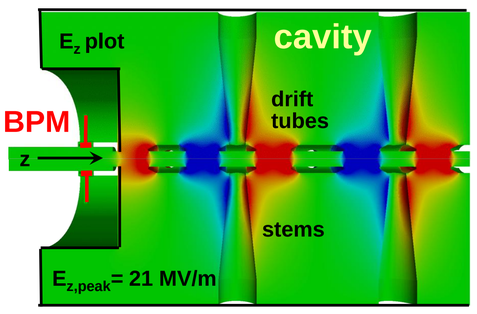
Simulation of rf coupling to BPM in the proton LINAC (rf-Leakage)

- At four locations the BPMs will be an integral part of the inter-tank section between the CCH and CH cavities mounted within an evacuated housing.
- Simulation of rf field propagation from the cavity into the beam tube and the BPM's co-axial signal path.



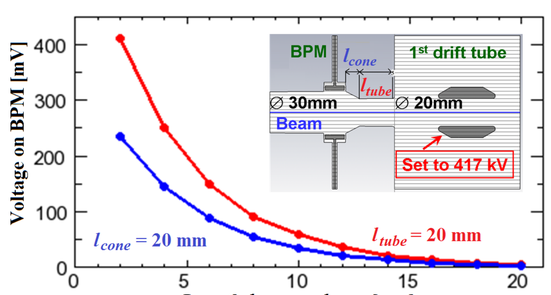
Method 1

- Eigen-value solver (frequency domain). i.e. realistic simulation of field propagation.
- The solution is obtained with a parallel implementation of the Jacobi-Davidson algorithm (Recent development at TEMF, Tech. Uni. Darmstadt (not part of CST)).
- Large CPU-time required.



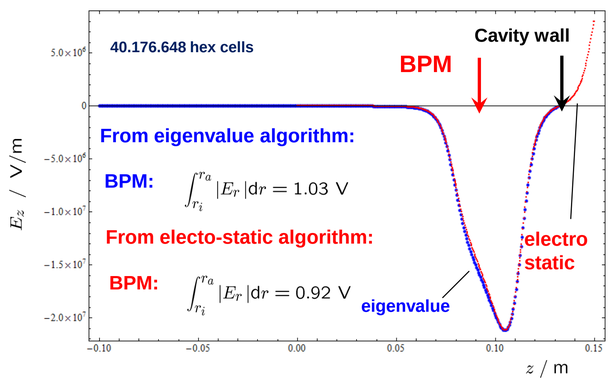
Method 2

- Electro-static solver, i.e. only static field with drift tube set on scaled value.
- The solution can be approximated by a simple electro-static approach with an appropriate, static potential of the closest drift tube in the CCH cavity.
- Fast calculations.



Results

- Induced voltage of ~ 1 V at 325 MHz
  i.e. as large as signal voltage.
- BPM has to be shielded.
- Suppression of voltage down to 5 mV for ltube + lcone = 40 mm → sufficient shielding.



Beam-based experiment at GSI UNILAC

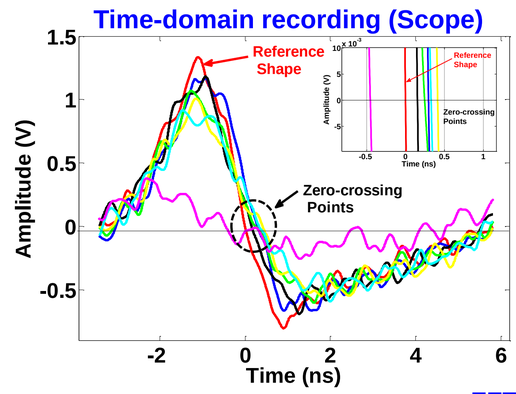
at GSI UNILAC with a Ca^{10+}, the performance of Libera SPH is tested. A single BPM was used to detect the beam position and to act as a "Bunch arrival monitor" for phase determination.

Beam energy	1.4 MeV/u
rf frequency	108.4 MHz
Pulse length	200 us
Beam current	~ 80 µA

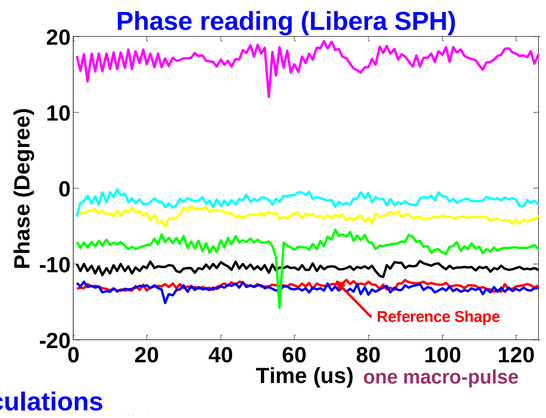
Purpose: Beam position and to characterize the dependence of beam arrival time on bunch shape.

Method: **The Libera SPH system** (117.44 MSa/s & 16 bit ADC) was evaluated and compared with a time-domain reading (zero-crossing) **by 10 GS/s scope** as well as successive **FFT calculations** from a single bunch and a stream of bunches (amp. & phase values at108.4 MHz).

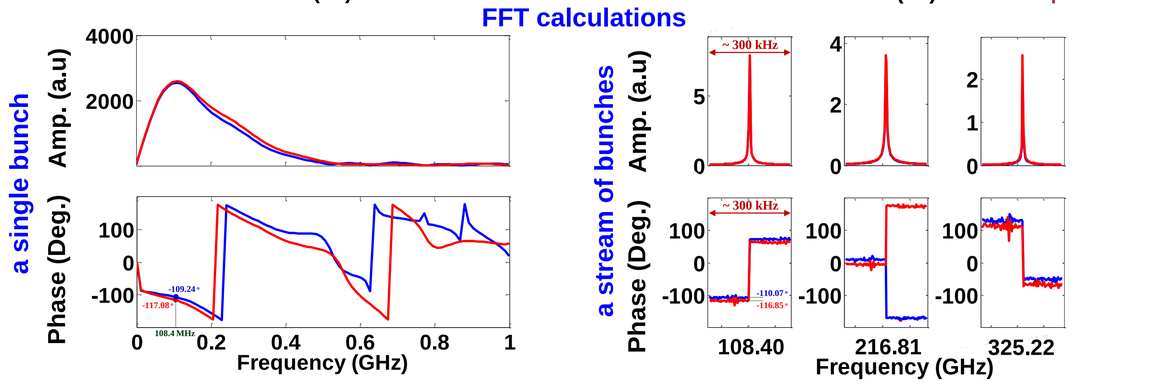
Time-domain recording (Scope)



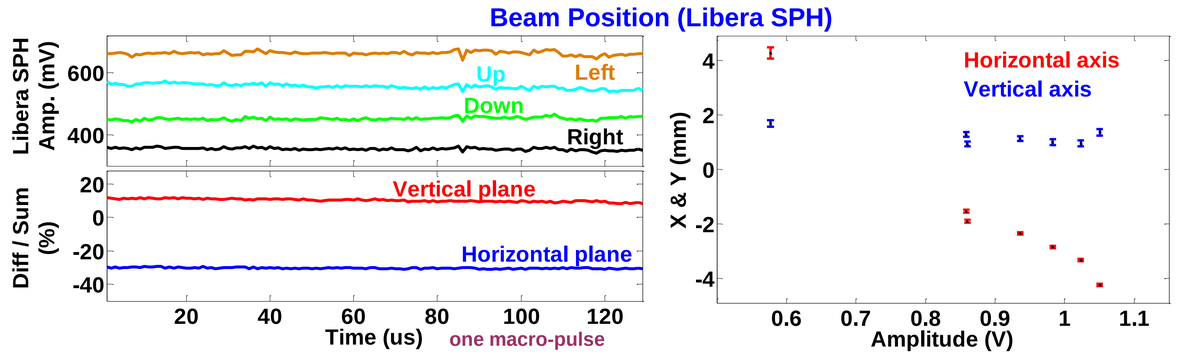
Phase reading (Libera SPH)



FFT calculations



Beam Position (Libera SPH)



Results:

Libera SPH

- Beam Position: suited
- Beam Phase: Some agreements with the time-domain & FFT calculation.

Remark: The FFT calculations are better matched to the time-domain evaluation.