S-Band Cavity BPM readout electronics for the ELI-NP Gamma Beam System

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The ELI-NP electron beam characteristics

The ELI-NP accelerator facility employs a warm C-band electron LINAC [1]. At every injection, up to 32 electron bunches are accelerated and delivered to two interaction points (IP) with energies of 280MeV and 720MeV. The beam structure at the interaction point is represented in Figure 1.

Figure 1: Electron beam structure at the interaction point

The Cavity BPM pickup and readout electronics

To align the beam with the laser at the IP, the position of each bunch should be measured with µm resolution, in the range of ±1mm. Because of this, low-Q cavity BPMs will be installed immediately before and after the IPs. These are the BPM16 cavities used at PSI [2], consisting of one reference cavity and one position cavity, with quality factor Q=40 and a resonant frequency of 3.284GHz.

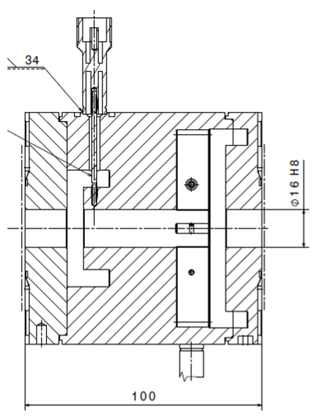

Figure 2: BPM16 Cavity.

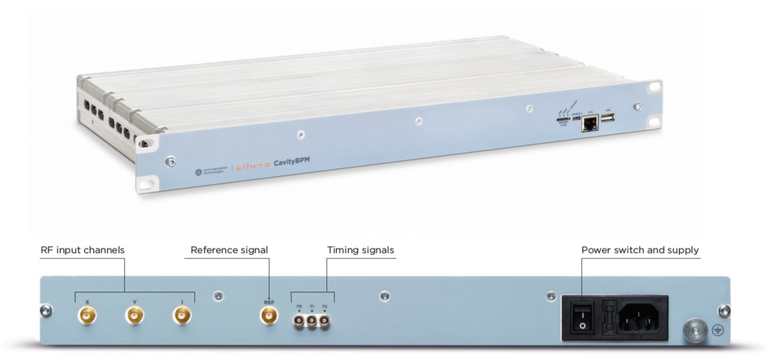

Figure 3: Cavity BPM readout electronics.

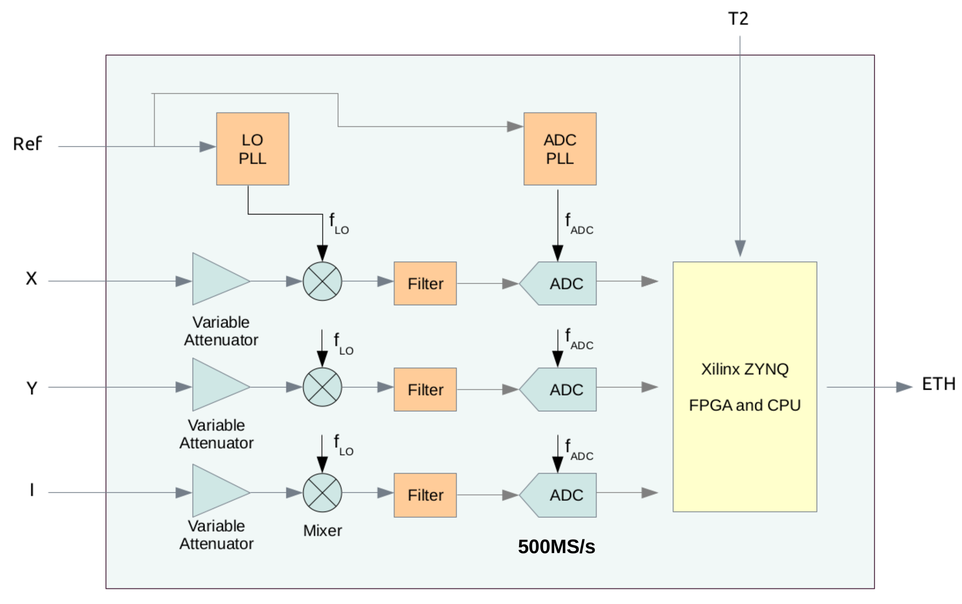

Figure 4: Block diagram of the electronics front-end.

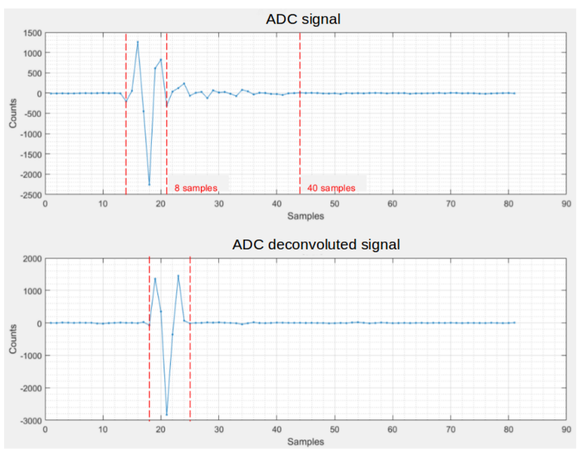

Figure 5: ADC data and ADC deconvoluted data.

$$V_{X,n} = \sqrt{\sum_{nth\ bunch\ window} x_i^2}$$

$$V_{X,n} = \alpha_{X,ATT_X} 10^{\frac{ATT_X}{20}} V_{X,n}$$

$$|X_n| = k_{XI,setup} \frac{S_{I,cavity}}{S_{X,cavity}} \frac{V_{X,n}}{V_{I,n}}$$

Laboratory setup and measures

INFN-LNF provided a laboratory setup to simulate the output signal from a CavityBPM, using the same BPM16 cavity which will be installed in the machine.

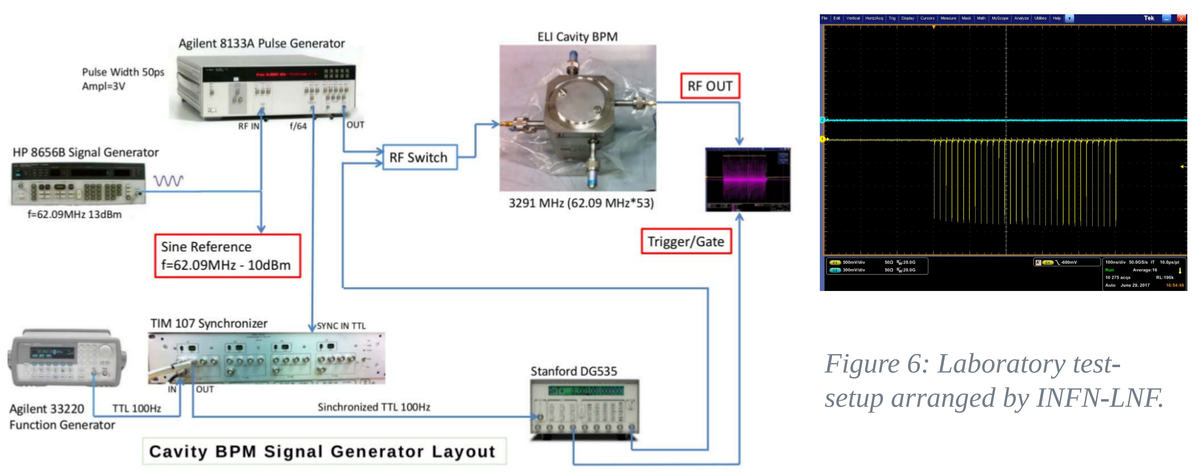

Figure 6: Laboratory test-setup arranged by INFN-LNF.

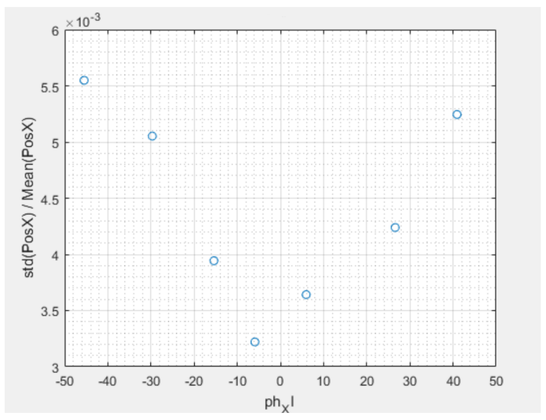

Figure 7: Performance in single-bunch mode.

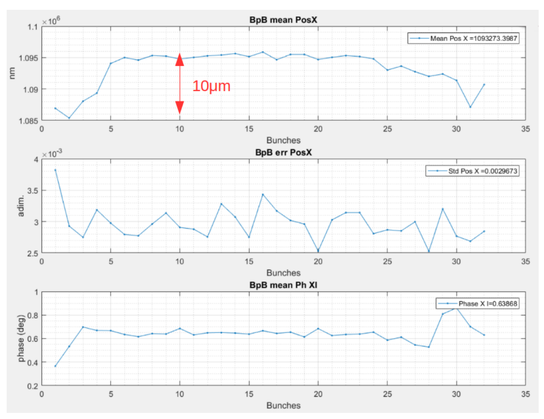

Figure 8: Performance in multi-bunch mode.

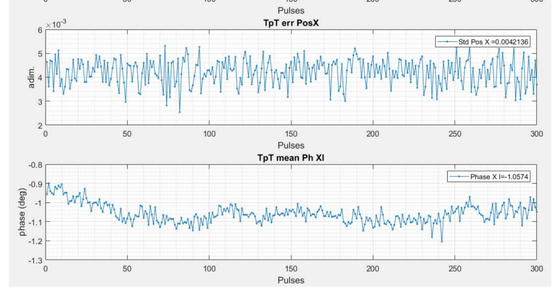

Figure 9-10: Long term stability measured over 48h.

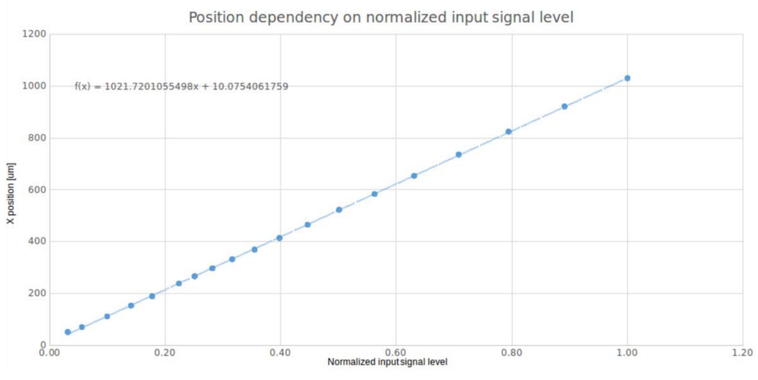

Figure 11: Characterization of the linearity of the front-end with external variable attenuators.

Conclusions

The results from the measurements are in line with the expectations. The RMS position resolution is within 5µm for a position range of ±1mm. This was achieved despite of the non-ideal input signals (high insertion loss of the cavity, pulse amplitude fluctuations and correlated noise at the instrument input).The deconvolution filter concept has been validated with individual and multiple-bunch sequences. The long term stability and linearity are excellent.
Still there are some aspects to be understood, in particular the influence of the phase difference between the input channels on the position resolution. Measurements on the real machine will help to clarify this aspect.

References

[1] L. Serafini *et al.*, "*Technical Design Report EuroGammaS proposal for the ELI-NP Gamma beam System*", July 14th, 2014.
[2] F. Marcellini et al., "Design of cavity BPM pickups for SwissFEL", in Proc. IBIC2012, Tsukuba, Japan,2012.

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