Recent improvements in TOPOS

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TOPOS is the digital Tune, Orbit and POSition measurement system which is currently under operation at GSI SIS-18 [1]. TOPOS provides bunch-by-bunch position from all 12 beam position monitors (BPMs) during the full acceleration cycle. It can also provide digitized raw BPM signal from all 48 pick-up electrodes (4 per BPM) at 125 MSa/s for ≈ 300 ms. TOPOS is designed to operate under a high dynamic range (90 dB) of beam currents in SIS-18.

TOPOS has been extensively utilized for SIS-18 optimisation and operation as well as for studying beam dynamics [2, 3, 4] in the past years. The widespread usage of TOPOS brought out the following technical issues:

1. An amplifier gain dependent closed orbit position variation of up-to 2 mm was observed as shown in Fig. 1 for 20 and 30 dB gains.
2. Erroneous position data for periods much longer than the set acquisition time was acquired by TOPOS system. This occured randomly for several BPMs.
3. Beam-based bunch detection for short bunches (with $< 7-8$ ADC samples) failed during the high energy proton beam operation.

Several beam-based tests were performed with TOPOS in response to the recurring operational issues mentioned above. The conclusions as well as the resulting upgrades to the TOPOS are reported in the next section.

Tests and Conclusion

Amplification dependent position variation was suspected to be an error in the present position calculation algorithm (i.e. weighted mean) due to its reliance on a complicated baseline restoration procedure described in [5]. Therefore, an alternate and simpler method for position calculation based on regression fitting was implemented. Figure 1 shows the comparison of the calculated horizontal position along the acceleration ramp between both algorithms. The amplifier gain dependence of beam position remains the same irrespective of the algorithms used. A small systematic bias (≤ 0.1 mm) between the positions calculated by both algorithms is due to the difference in their noise suppression characteristics. On further investigation it was found, that the calibration of the distinct amplifier chains connected to the 4 BPM electrodes were performed by a fixed amplitude signal generator. This calibration configuration allowed calibration only in a small range of amplification (i.e 10 to 20 dB). A new front-end electronics will be installed in SIS-18 where a calibration method based on varying input amplitude will be used to correct this error.

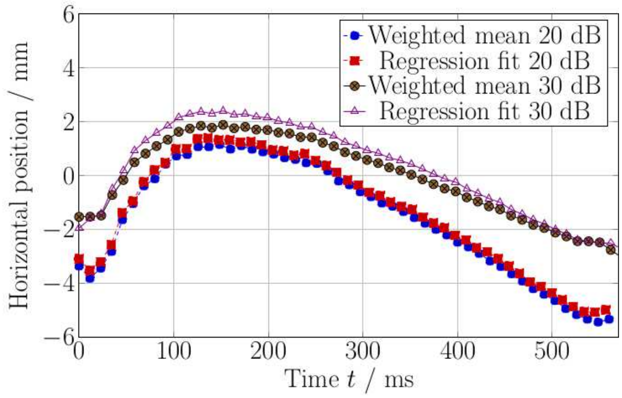

Figure 1: Comparison of measured horizontal beam position during the acceleration at two separate gain settings with both algorithms.

The problem with the erroneous acquisition length was related to the storage of the RF synchronous time-stamp generated for each bunch in the Libera FPGA. The error occurred when the time-stamp was not reset after the measurement cycle was finished. This happened in special conditions such as, when the end of measurement cycle coincided with the read strobe signal responsible for reading and clearing the time-stamp. This issue is resolved.

The issue of short bunch detection was studied by applying FPGA simulations. It was found that the bunch detection worked well for Gaussian shaped bunches with a sufficiently high amplitude even for a bunch length down to three samples. Offline simulations with recorded beam data with short bunches (upto 6 samples) also worked fine. Thus, the problem could not be reproduced during the investigations and is probably linked to the erroneous acquisition length issue.

References

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