INITIAL TESTS OF NEW ELECTRON AND PHOTON BEAM POSITION MONITOR ELECTRONICS AT ADVANCED PHOTON SOURCE

P. Leban, Instrumentation Technologies, Solkan, Slovenia
G. Decker, APS, ANL, Argonne, IL 60439,U.S.A.

Abstract

Measurements were done at Advanced Photon Source in sector 35 with Libera Brilliance+, connected to S35A:P0 and S35B:P0 buttons. The photon beam position was measured downstream of the 35-ID source point using Libera Photon in horizontal/vertical configuration. Top-up injections were recorded simultaneously on both units, providing details about the electron and photon beam motions before, during and after injection in storage ring and beamline. FFT spectrums were compared from current bsp-100 bpm (APS made) electronics and both new instruments.

This article discusses the calibration procedure for electron and photon beam position monitors and results of measurements.

TEST SETUP

The diagnostics arrangement for the 35-ID section is shown in Figure 1. The Libera Brilliance+ processors were connected to the S35B:P0 (processor #1) and S36A:P0 (processor #2) BPM stations. These stations were mounted on a high vacuum chamber of diagnostics undulator. The Bergoz BPMs were mounted on the large-aperture vacuum chambers upstream and downstream of the 35-ID insertion device straight section (S35B:P1 and S36A:P1) [1]. The Libera Photon processor was connected to the S35ID:P1 blade sensors, measuring horizontal and vertical position.

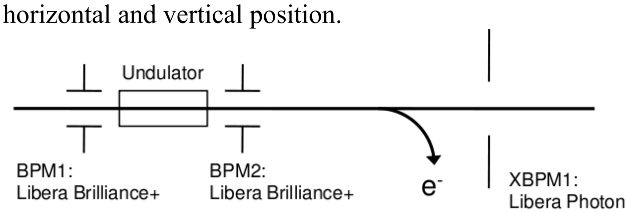

Figure 1: Test setup.

None of the Libera processors above were calibrated to the ring model. The sensitivity parameters of the buttons for Libera Brilliance+ were:

Sx=1 / kx = 0.36 / mm → kx = 2.778 mm

Sy=1 / ky = 0.1464 / mm → ky = 6.831 mm

Calibration of the Libera Photon was one of the topics, discussed in this paper.

MEASUREMENTS

Calibration of the XBPM

We used the local angle bump and changed the electron BPM setpoints upstream and downstream of the source point to antisymmetric fashion. Since the response matrix being used by the orbit control feedback was square, it forced the in-loop BPMs to track their setpoints exactly.

Position of the photon beam is calculated using delta/SUM formula, which contains also gain parameters and offsets to calibrate the reading to the other subsystems.

The challenge was to set the gain parameters for S35ID:P1 where Libera Photon was to be attached to. In the beginning, we used in-house XBPM system to read the position and compare the data with electron BPMs. The displacement of the electron beam was detected with Libera Brilliance+ processor #2 and then correlated to the photon beam measured at S35ID:P1 location.

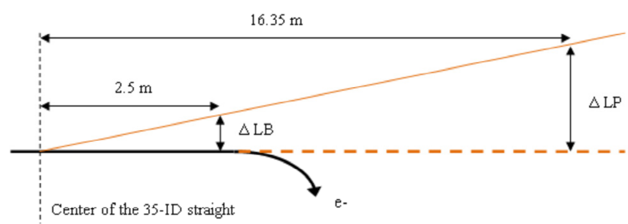

Figure 2: Calculating the displacement of the beam at S35ID:P1 location.

For gain parameter calculation, the geometry presented in Figure 2 was used. Libera Brilliance+ processor #2, marked as "LB" is located at 2.5 meters downstream from the center of the 35-ID straight, XBPM1 station P1 is at 16.35 meters and is marked as "LP".

Calculated slope for P1 is:

$$\frac{\Delta LB}{2.5\ m} = \frac{\Delta LP}{16.35\ m}$$

$$\Delta LP = \frac{16.35}{2.5} \times \Delta LB = 6.54\ \times \Delta LB$$

The beam was bumped in the horizontal and vertical directions. The data on stations was acquired. The most interesting data were ΔLB (at S36A:P0) and ΔLP (at S35ID:P1) which were then used to calculate the slope of the beam. Fitting was done using sddspfit tool [2]. Measured values were:-4.334 for horizontal and 6.507 for vertical. Final gain values were (expected / measured):

$$P1\_x = \frac{6.54}{-4.334} = -1.509$$

$$P1\_y = \frac{6.54}{6.507} = 1.006$$

These values were then finally loaded to Libera Photon, which we hooked up to S35ID:P1 blades. We repeated beam bumps, first in the vertical direction and then in the horizontal direction. The gap was fixed at 15 mm. Figure 3 and Figure 4 show the results taken with Libera Photon. While doing the vertical beam bump, a small amount of correlated horizontal variation is seen. The amount of vertical variation during the horizontal beam bump is much less.

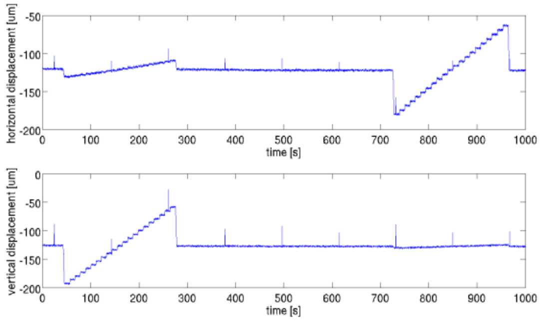

Figure 3:Vertical and horizontal angle bumps.

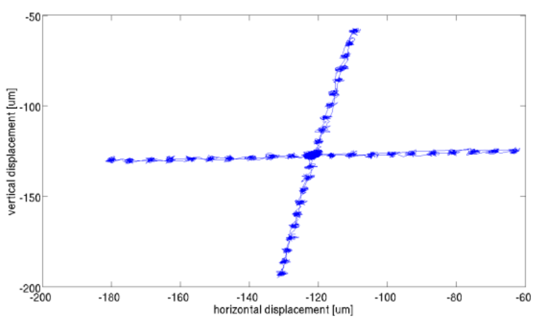

Figure 4: Beam bump presented as XY plot.

Blade sensors provide horizontal and vertical position of the photon beam. Libera Photon was configured for such sensor configuration. As currents from the blades were normally between 1 – 2 μA, Libera Photon was set to Range 4 (< 2 μA) but was working in the Automatic Range Control mode just in case.

Measurement Resolution and Noise Spectrum

The measurement resolution of Libera Brilliance+ was evaluated on the fast stream at 10 kHz data rate and turn-by-turn data buffers in the top-up operation mode and the real-time feedback turned OFF. Libera Brilliance+ processor #2 was working in the Automatic gain control mode with longterm drift compensation (crossbar switch) turned ON. The APS FPGA-based BPM receiver (BSP-100) was temporarily connected to the S35B:P0 BPM station and was working in routine configuration. Results are as presented in Table 1. The RMS value of the turn-by-turn data on BSP-100 is lower on the vertical direction, probably because of smaller beta function.

Table 1: Measurement Resolution (RMS) on 10 kHz Data Stream and Turn-By-Turn Data

	10 kHz data stream		**Turn-by-turn data**	
Instrument	**Horiz.**	**Vert.**	**Horiz.**	**Vert.**
Libera Brilliance+	4.7 μm	2.9 μm	6.0 μm	2.7 μm
BSP-100	5.7 μm	2.1 μm	5.9 μm	n/a

The noise spectrum was checked on the turn-by-turn data buffers. The crossbar switching was turned OFF on Libera Brilliance+. The BSP-100 was set to horizontal reading only (no 0/180 switching). The data buffers of 262144 turns were collected from both systems and compared for position RMS and noise spectrum. Results are presented in Table 1.

The noise spectrum of both instruments fit very well (Figure 5). The data from Libera Photon was added to the same plot. The data rate is not turn-by-turn but 10 kHz so the comparison is not fair. However, all spectrums fit in every detail. The synchrotron motion line was seen at ~1800 Hz.

Integrated noise plot on Figure 6 shows that majority of noise is introduced in the 0 – 100 Hz frequency range, the strongest components are 60 Hz and its subharmonics.

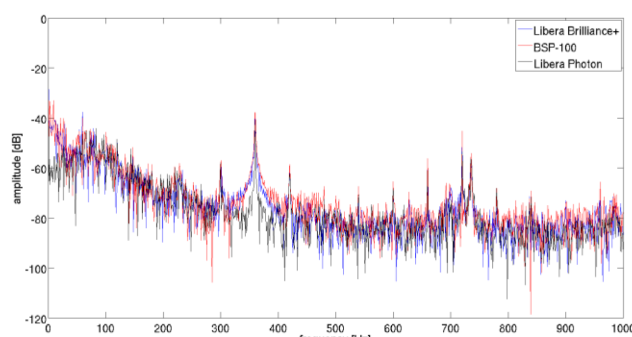

Figure 5: Noise spectrum of three beam position monitors.

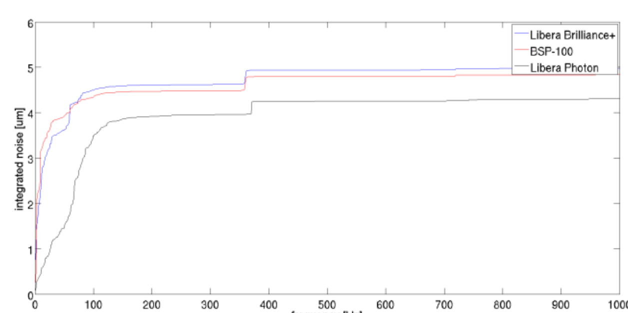

Figure 6: Integrated noise.

Top-Up Injection Measurement

The injection trigger was split to all three instruments and was used to start the acquisition at every injection. BSP-100 was set to X only mode so only horizontal position was available. 262144 turns were acquired but only the interesting portions are presented in Figure 7 and Figure 8. The correlation between BSP-100 and Libera Brilliance+ is excellent.

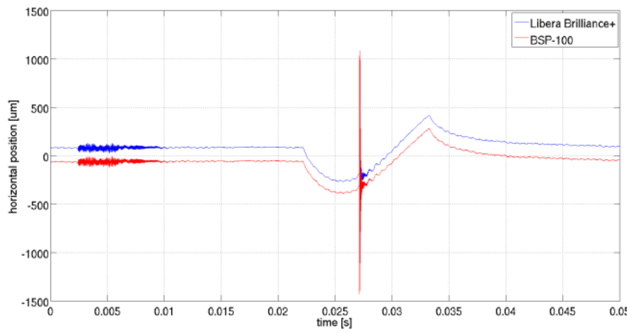

Figure 7: Top-up injection recorded by Libera Brilliance+ and BSP-100.

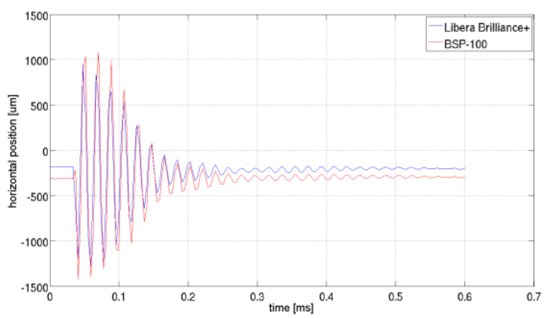

Figure 8: Detailed look at the injection transient during the top-up injection.

Then, the BSP-100 was replaced by Libera Brilliance+, processor #1. The injection was then recorded by two Libera Brilliance+ processors and Libera Photon in the front-end. The data from all three processors has exactly the same rate but some alignment against the acquisition trigger was necessary. For nicer presentation, certain offsets were applied to positions.

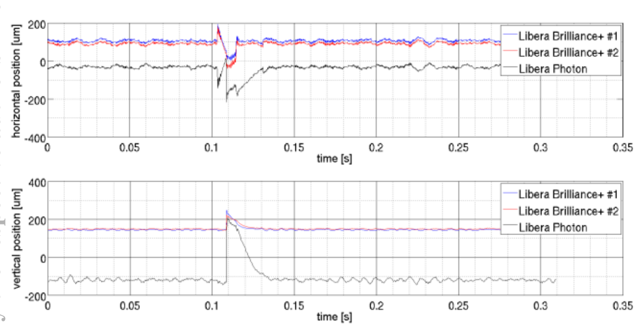

Figure 9: Top-up injection as seen in the photon beam.

There are at least three significant steps seen in the horizontal position of the photon beam (Figure 9). The step changes in the horizontal are probably changes made by fast feed forward correction trying to compensate the injection septum transients.

Figure 10 shows the absolute current reading from each of the blades. Mean current values were between 1 and 1.8 µA. The current increase due to the injection was measured to be up to 1.4 µA per blade and lasted approximately 30 ms.

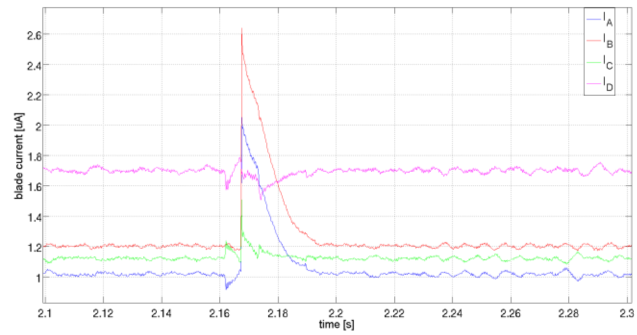

Figure 10: Absolute current reading from each of the blades.

CONCLUSION

The XBPM calibration was done quite fluently but with some effort for setting up the input channels correctly. The noise spectrum of Libera Brilliance+, Libera Photon and BSP-100 units fit very well in both directions. Having all instruments synchronized to the same injection trigger helped to make top-up injection acquisition easily. The injection was recorded in details. In the beamline, it was interesting to see the effect of the feed forward orbit correction on the photon beam in the horizontal direction.

This was the initial test of Libera Brilliance+ at APS. The unit was installed with the base application software, which offered a wide range of features, including all data buffers and streams. The EPICS server is linked to the latest software platform, Libera Base. This was one of the first tests in the real life environment and more functional and stability improvement opportunities of the EPICS server were identified. Those will be incorporated in the future updates.

REFERENCES

[1] O. Singh, et al.,“Comparative studies of RF beam position monitor technologies for NSLS-II”, DIPAC’09

[2] http://www.aps.anl.gov/