Libera Brilliance Single Pass testing at FLASH

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1 Introduction - General Test Description

Various measurements were performed at the FLASH facility in Hamburg. The measurements were performed in different sections of the linac on three different types of sensors. The FLASH injector striplines have a diameter of 34 mm and a geometrical coefficient k = ~ 14 mm. Both are orthogonally mounted, one before and one after the first chicane. Gun buttons are mounted in the first part of the linac, after the gun (orthogonally positioned), their geometrical coefficients are k = ~ 9 mm. The 11ACC7 button is orthogonally mounted in the last part of the FLASH injector; it has a larger diameter ~ 78 mm. The Libera Brilliance single Pass geometrical coefficients during the measurements were set to the default value – 10 mm. The figures in the report were plotted directly from the Libera Brilliance Single Pass acquisition. For the rms calculation, the real sensor coefficients were applied to the results.

BEAM PARAMETERS:
- Micropulse frequency: 1 MHz
- Macropulse frequency: 10 Hz
- No. of bunches in Macropulse: 10 - 30
- Bunch Charge: 0.55 nC

The current Libera Brilliance single Pass software was adapted for the averaging of various number of bunch information's, in certain case this means that two consecutive bunches in the bunch train were averaged, consecutively for 30 bunches long train 15 position and charge information were acquired for each bunch train. The data was observed in a GUI. Figure 1 shows part of a 30 bunches long train.
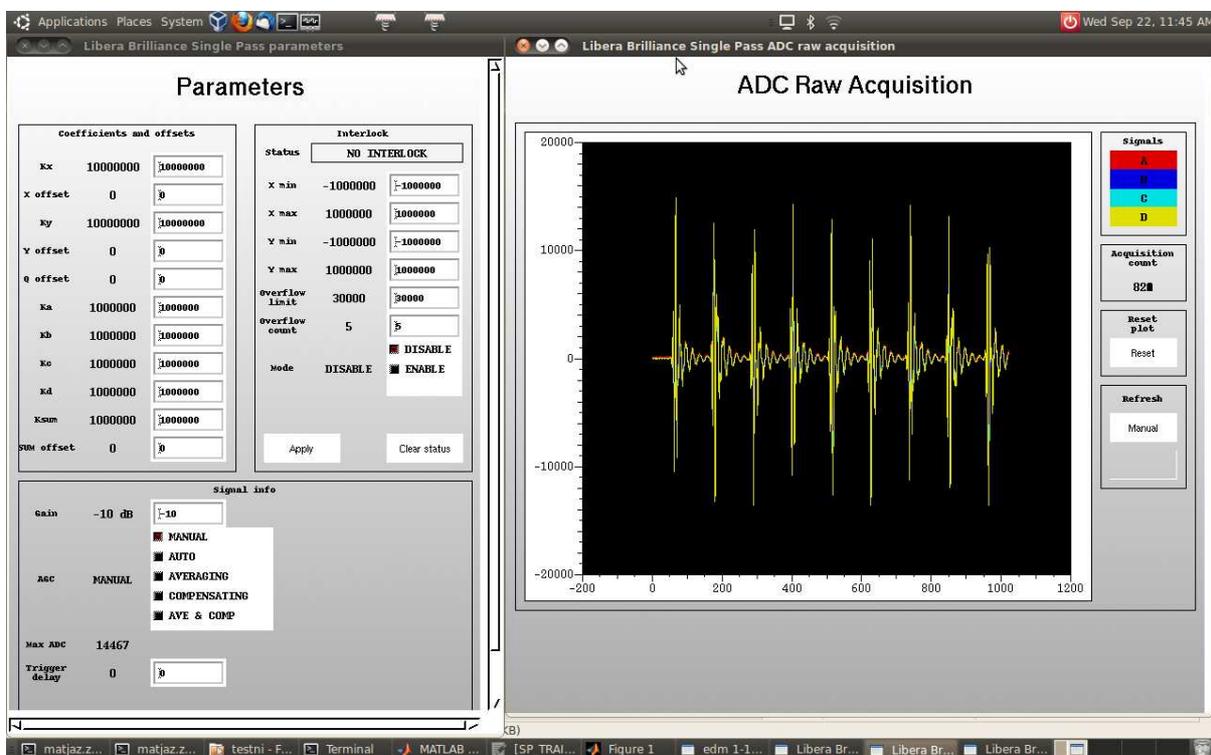

Figure 1: GUI - RAW data

The acquisition for one bunch train is shown below. The part marked with red color contains the information of train containing 30 bunches. Each line contains the averaged information of two bunches. The values respectively mean: Va, Vb, Vc, Vd, SUM, Not used, X [nm], Y[nm], STATUS, Bunch batch counter, Bunch train counter. The Va, Vb, Vc and Vd mean the amplitudes of four input channels in arbitrary units. The same means for the SUM signal which is the sum of the four amplitudes and represents the Charge in arbitrary units.

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/*********************************************************************************/
25250488 22458007 24390136 27783691 6020796 0 184585 -1061303 0x0004 12 1334
25249511 22452148 24348144 27659667 6030284 0 174624 -1064129 0x0004 13 1334
25112304 22354980 24258789 27668945 5988491 0 174443 -1055734 0x0004 14 1334
25151367 22383789 24275390 29046386 5951354 0 153837 -1082997 0x0004 0 1335
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25676757 22733886 24809570 28138671 5957495 0 185624 -1097846 0x0004 2 1335
25502929 22583007 24579101 28111816 5950540 0 175703 -1092358 0x0004 3 1335
25461914 22589355 24565917 28118652 5923851 0 177202 -1090506 0x0004 4 1335
25409179 22541015 24583984 27974609 5929439 0 160248 -1095822 0x0004 5 1335
25330566 22481445 24472656 27956542 6189889 0 178221 -1092925 0x0004 6 1335
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24925292 22089843 24098144 27411132 5976325 0 156348 -1089793 0x0004 13 1335
24803710 22040039 24019042 27451171 5960551 0 168822 -1090028 0x0004 14 1335
24866699 22063964 24019042 30330078 5931185 0 211451 -1084703 0x0004 0 1336
27690917 24396972 26320800 29703125 5904904 0 284179 -1076601 0x0004 1 1336
27246582 23900878 25692382 29529296 5898763 0 308220 -1081750 0x0004 2 1336
/*********************************************************************************/
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2   Measurements on Stripline BPM with Train Length 30 Bunches

2.1   Measurements at STRIPLINE-BPM 2UBC2

The stripline 2UBC2 is located after the first chicane in the FLASH injector. The diameter is 34 mm. The bunch charge during the test was 0.55 nC, which resulted in 3 Vpp (centered beam) on the stripline output. The figures below depict the X and Y plane acquisition of concatenated 665 bunch trains. It can be observed that the beam position in this part of the Linac is pretty unstable, there can be observed larger variations in position between different bunch trains in both planes. Considering the sensor geometrical coefficients ~ 14 mm, the beam position rms was: Xrms = 73.4 um, Yrms = 25.8 um.
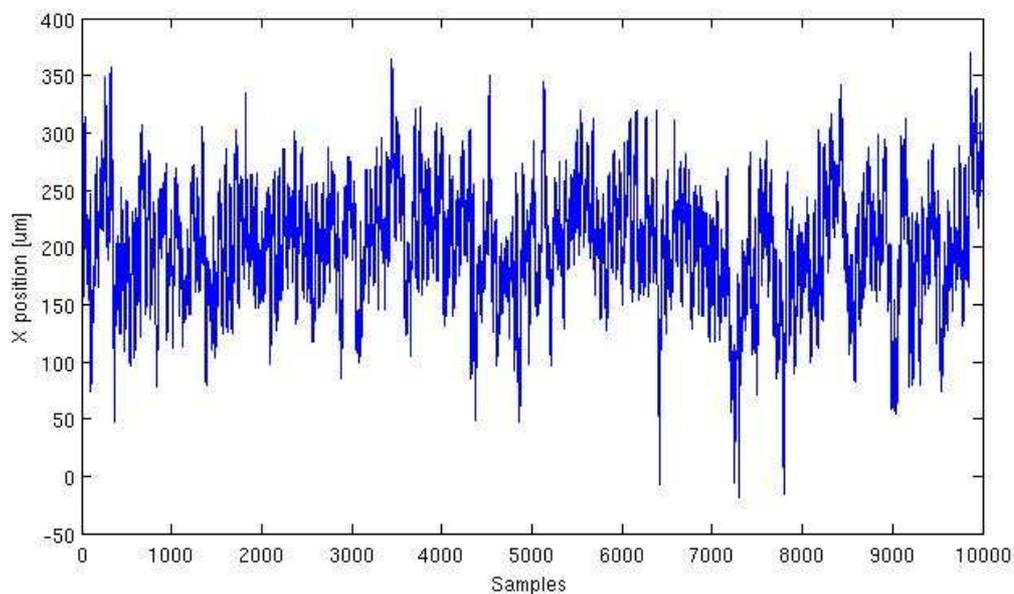
Figure 2: Concatenated acquisition of 665 bunch trains – X plane
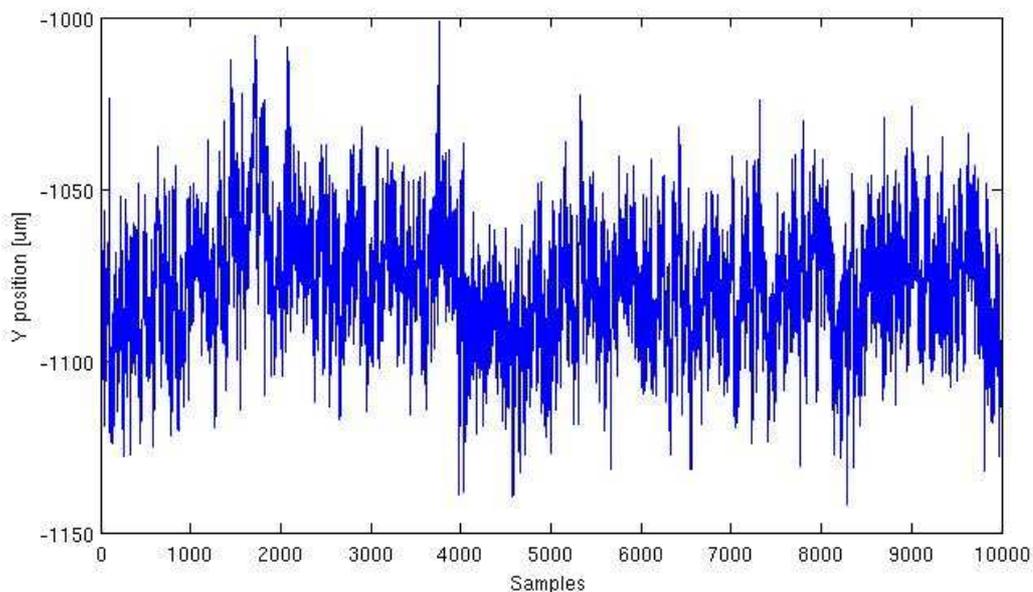

Figure 3: Concatenated acquisition of 665 bunch trains – Y plane

The corresponding four amplitudes (Va, Vb, Vc and Vd) of few concatenated bunch trains are depicted in Fig. 4. One can observe that each bunch train starts with higher charge that decreases over the time.
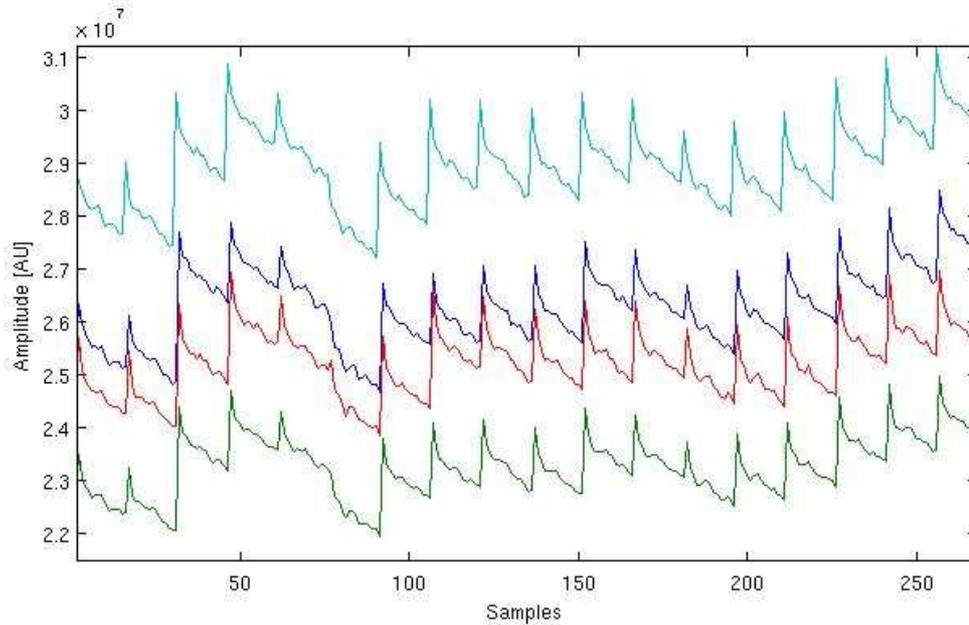

Figure 4: Charge [arbitrary units] ~ Amplitudes of few concatenated bunch trains

If we look at the bunch trains in more detail, we can observe that there is a quite stable beam within the individual bunch trains, but there are noticeable variations among consecutive train positions. The variation on X position can be observed on the figure below which is a zoomed acquisition from figure 2. Similar, but less intense variations were observed on the Y plane.
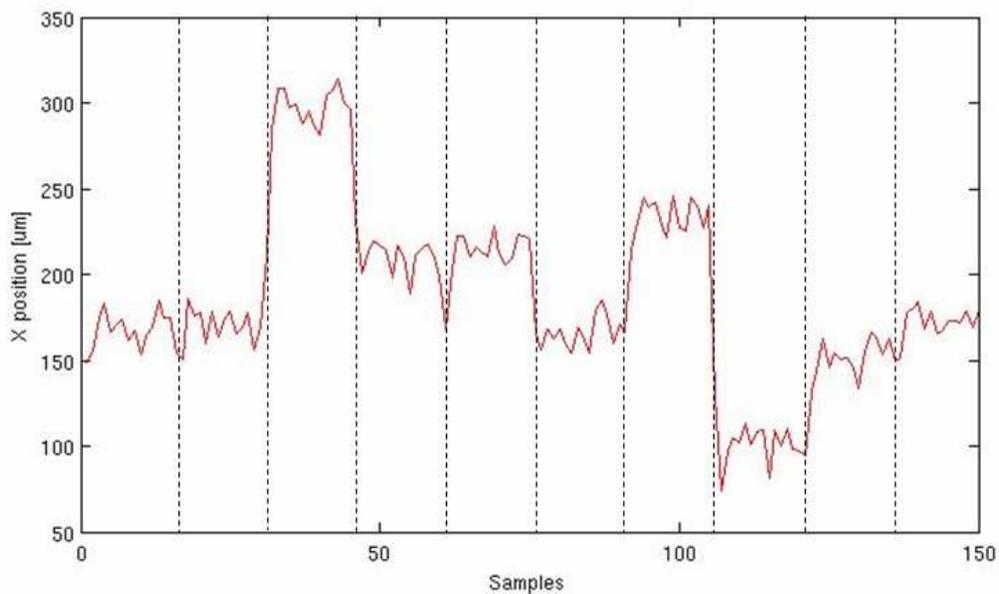
Figure 5: Noticeable variations among consecutive train positions after the first chicane – X plane

Eight bunch trains on the same graph are ploted on the below figure. Average bunch train X position rms was 14 um (9 um – 24 um).
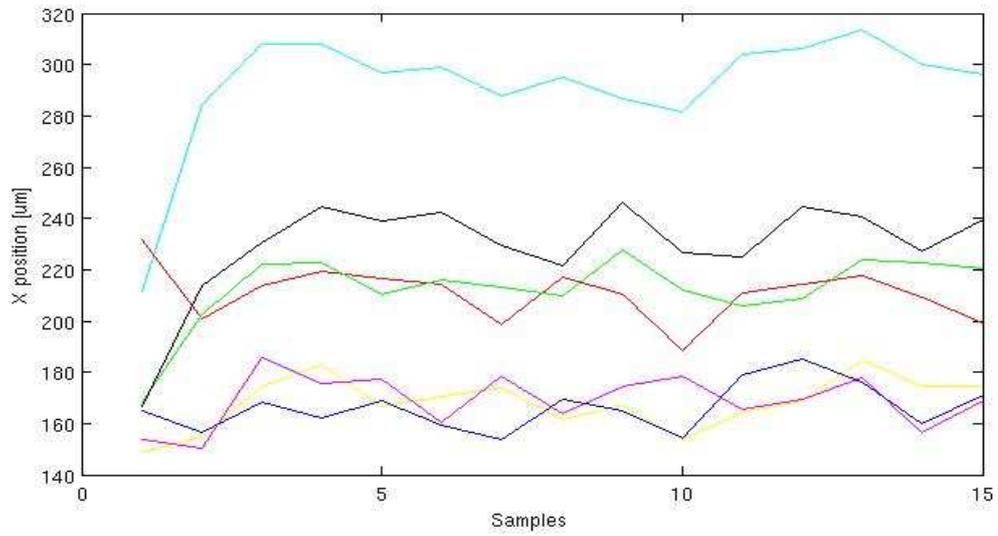

Figure 6: Eight consecutive bunch trains

3   Measurements on Button and Stripline BPMs with Train Length 10 bunches

3.1 Measurements at BUTTON 1-BPM GUN

The button 1 GUN is located after the gun in the FLASH injector. Bunch charge during the operation was 0.55 nC, what resulted as 450 mVpp on the button output. Two bunches information was averaged into one data output, what means 5 position information's per bunch train. The figures below depict the concatenated acquisition of 200 bunch trains. Considering the sensor geometrical coefficients ~ 9 mm, the beam position rms was: Xrms = 10.9 um, Yrms = 11.1 um.
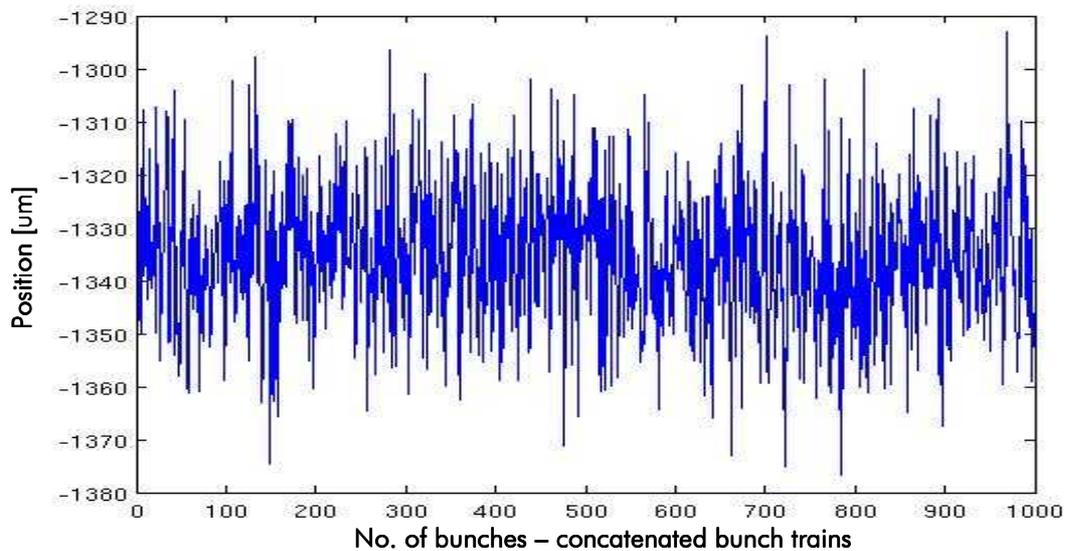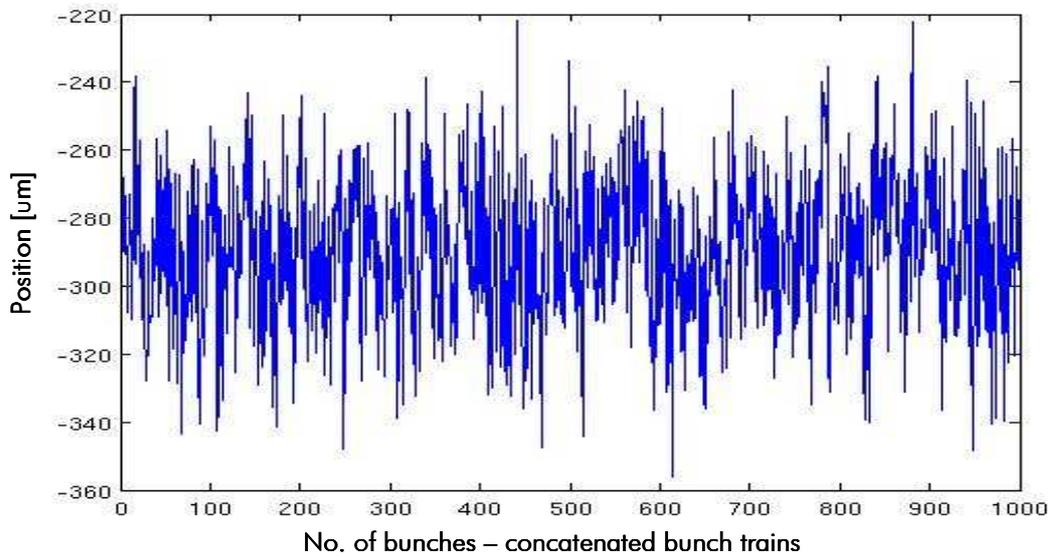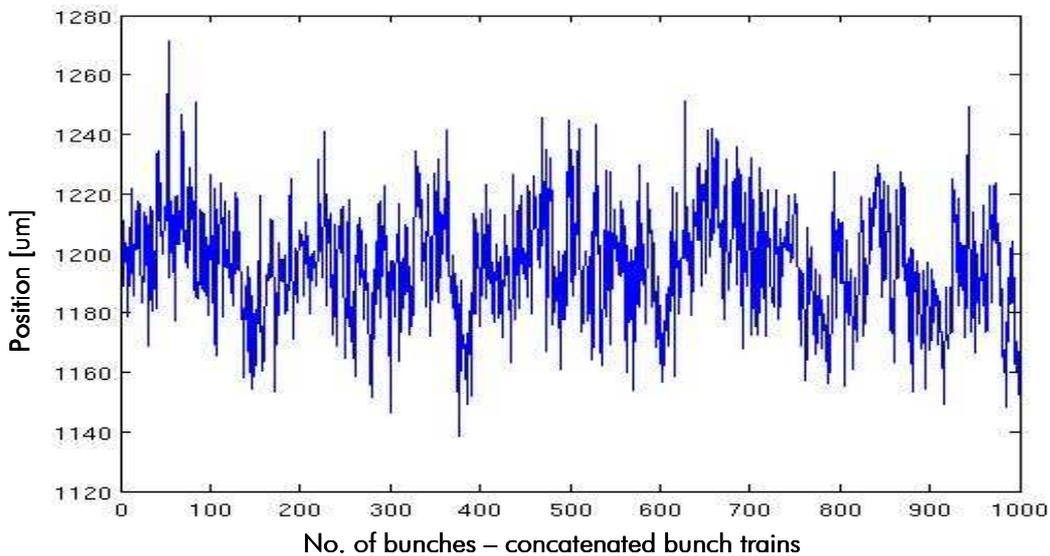

Figure 7: X position
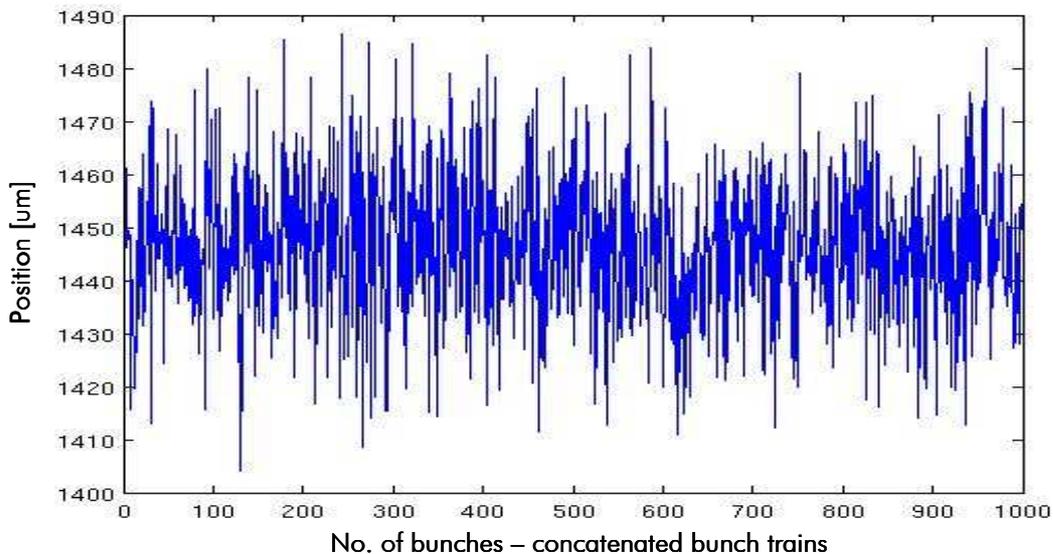
Figure 8: Y position

3.2 Measurements at BUTTON-BPM 3 GUN

The button 3 GUN is located after the 1 GUN in the FLASH injector. Bunch charge during the operation was 0.55 nC, resulting in 450 mVpp on the button output. Two bunches information was averaged into one data output, what means 5 position information per bunch train. The figures below depict the concatenated acquisition of 200 bunch trains. Considering the sensor geometrical coefficients $\sim$ 9 mm, the beam position rms was: Xrms = 17.5 um, Yrms = 15.1 um.

Figure 9: X position

Figure 10: Y position

3.3 Measurements at STRIPLINE-BPM 2UBC2

The stripline 2UBC2 is located after the first chicane in the FLASH injector. Bunch charge during the operation was 0.55 nC, what resulted as 3 Vpp on the stripline output. Considering the sensor geometrical coefficients ~ 14 mm, the beam position rms was: Xrms = 56.2 um, Yrms = 17.5 um.
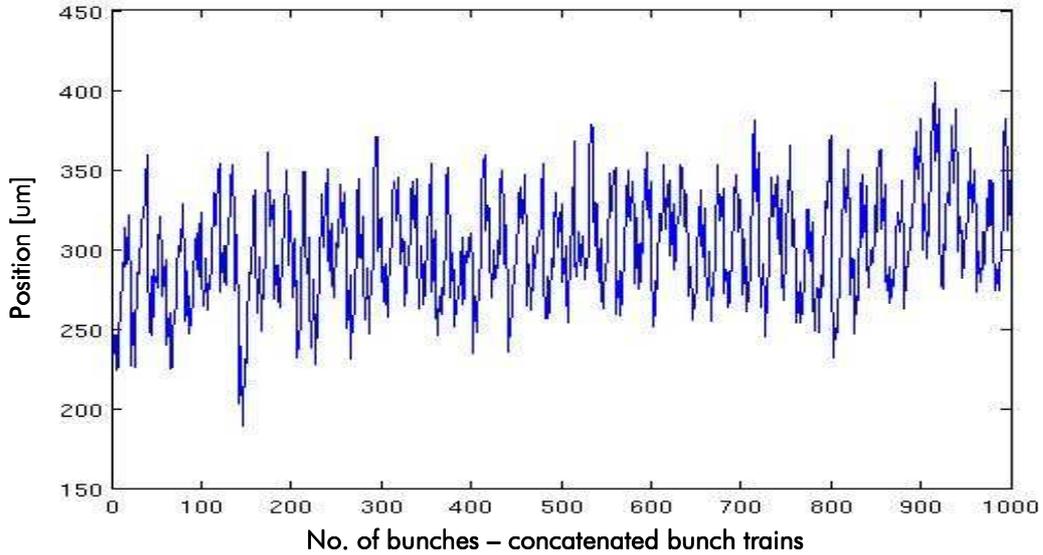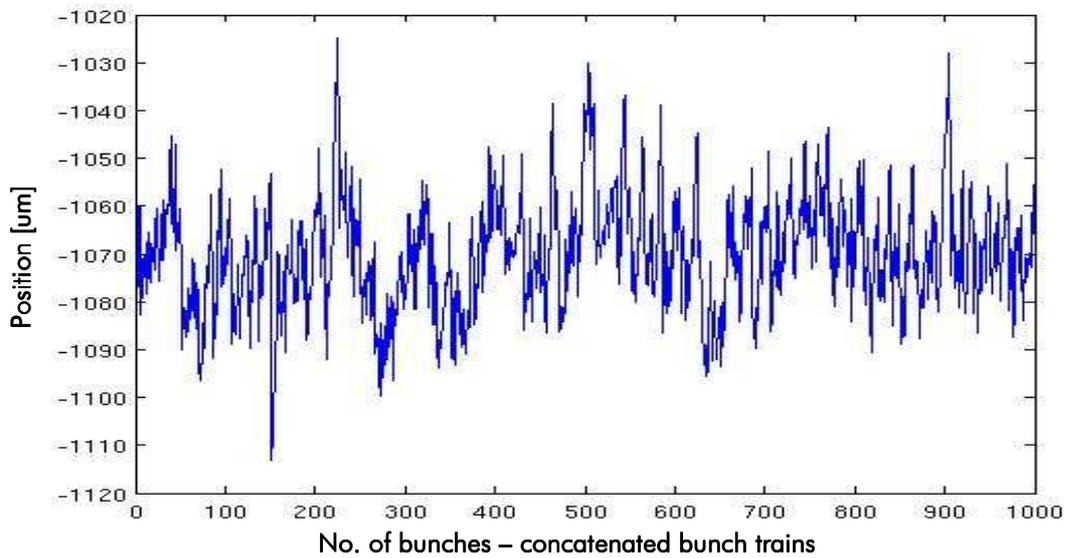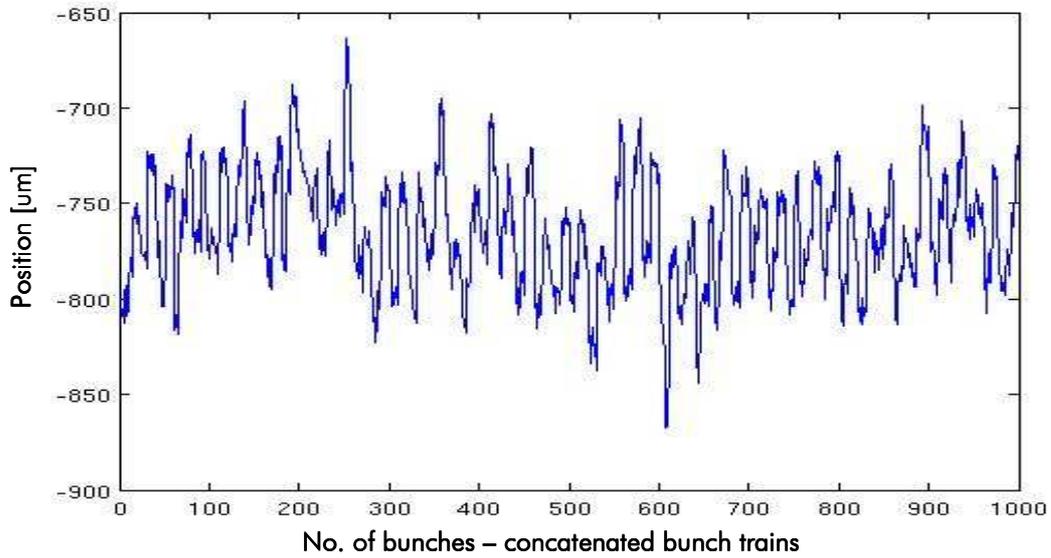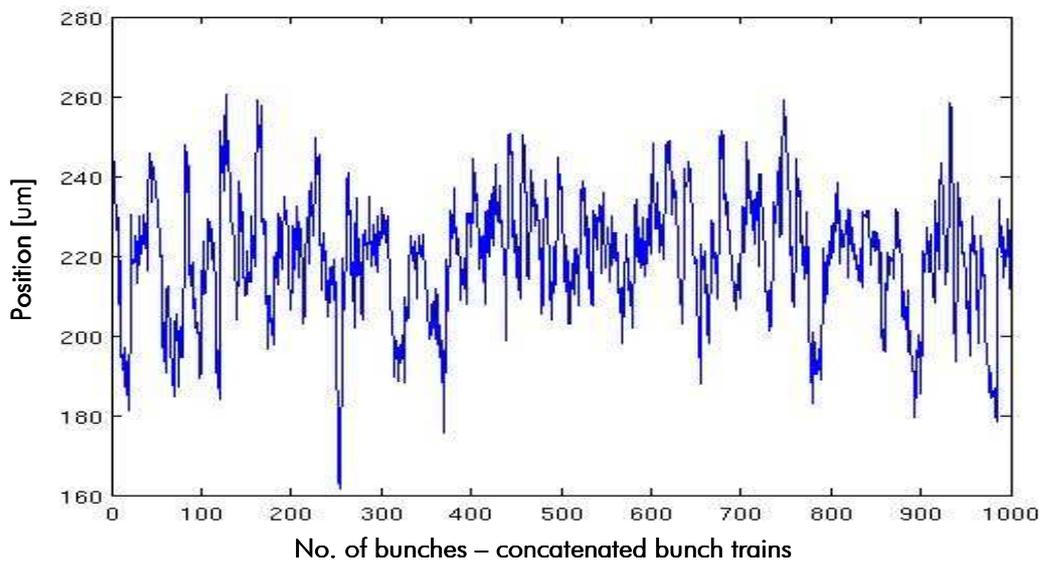

Figure 11: X position

Figure 12: Y position

3.4 Measurements at STRIPLINE-BPM 1DBC2

The stripline 1DBC2 is located after the 2UBC2 in the FLASH injector. Bunch charge during the operation was 0.55 nC, what resulted as 3 Vpp on the stripline output. Considering the sensor geometrical coefficients ~ 14 mm, the beam position rms was: Xrms = 35.1 um, Yrms = 20.7 um.

Figure 13: X position

Figure 14: Y position

3.5 Measurements at BUTTON-BPM 11ACC7

The button 11ACC7 is located in the last part of the FLASH injector. Bunch charge during the operation was 0.55 nC.
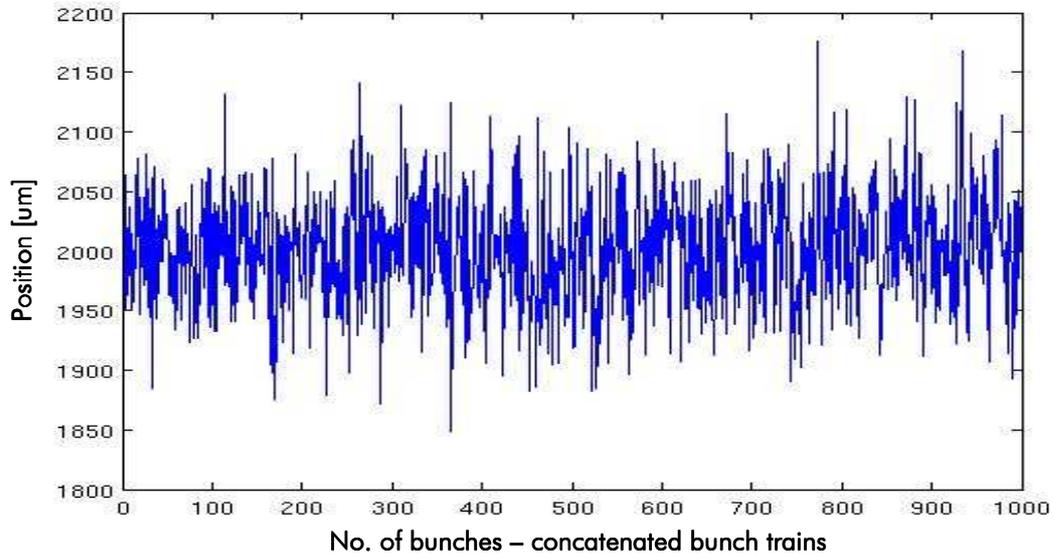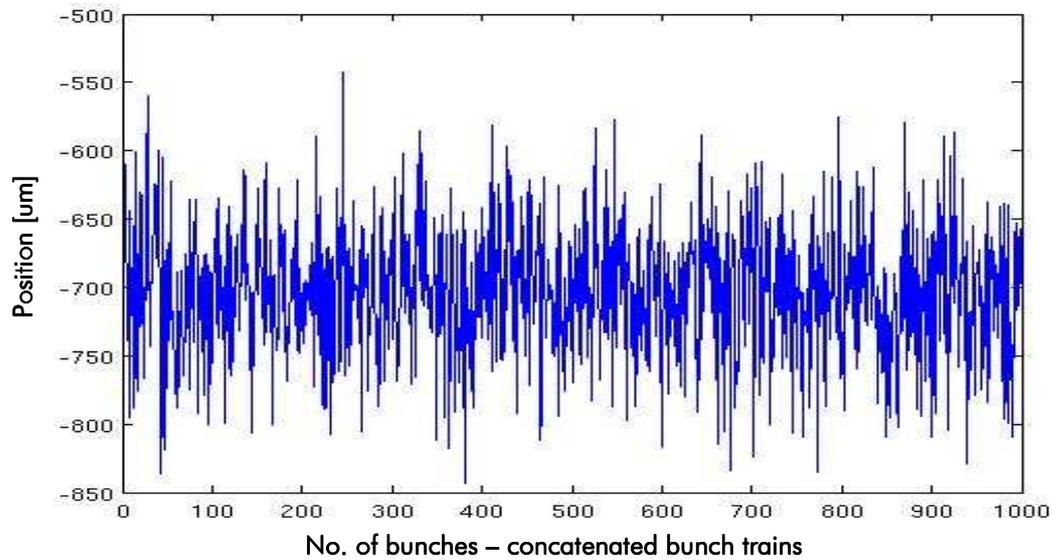

Figure 15: X position

Figure 16: Y position

4 Conclusion

The idea and implementation of the bunch-train position calculation algorithm in the Libera Brilliance Single Pass FPGA have been confirmed in practice to be a very efficient way to obtain true and pure bunch train position measurements. The measurements were performed in various sections of the LINAC on different types of stripline and button pick-up sensors. Tests confirmed that the instrument fulfils measurement requirements, providing very good results in terms of position resolution on both longer concatenated acquisitions and within individual bunch trains.

We would like to emphasize successful collaboration between users (Desy FLASH) and manufacturers of the instrument (Instrumentation Technologies).