Injection Efficiency Monitoring with Libera Brilliance Single Pass

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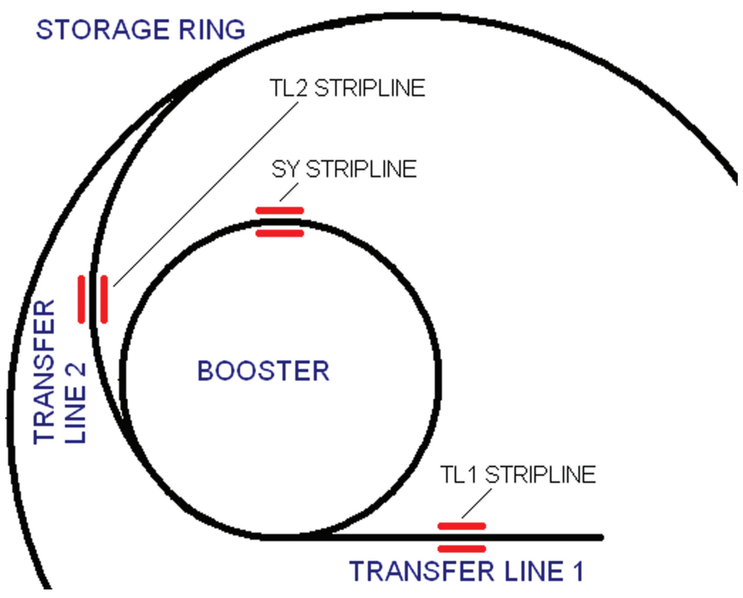
Abstract

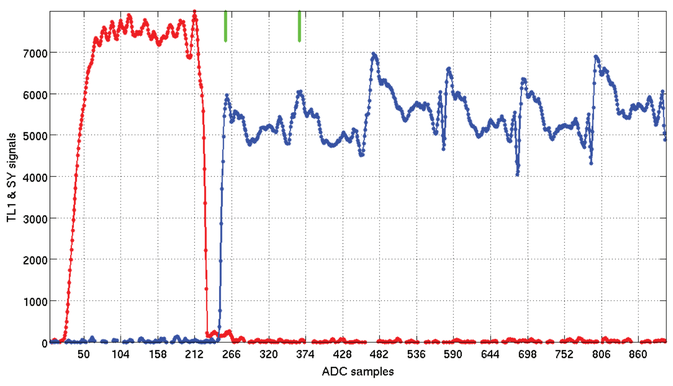
Libera Brilliance Single Pass is a standard device for single pass position measurements. Initially, the device was intended for beam position monitoring at injector system for the FEL machines, this was afterwards followed by the idea of using it on transfer lines on 3rd generation light sources. The device can be used on pickup buttons and on striplines. The measurement principles and results of Libera Brilliance Single Pass at ESRF, as beam-charge monitor and injection-efficiency monitor, are presented.

Setup

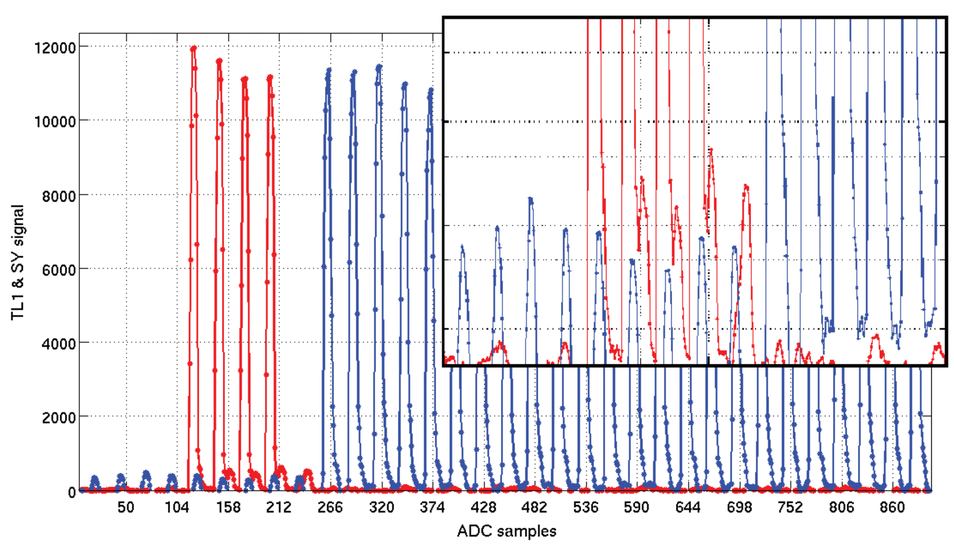


Test setup: measurements were performed in the ESRF injection system, where 3 Libera Brilliance Single Pass units are installed. The three units were connected to the striplines which are installed on the transfer line from the linac to the booster (TL1), booster (SY) and the transfer line from the booster to the storage ring (TL2).

TL1 - Booster efficiency

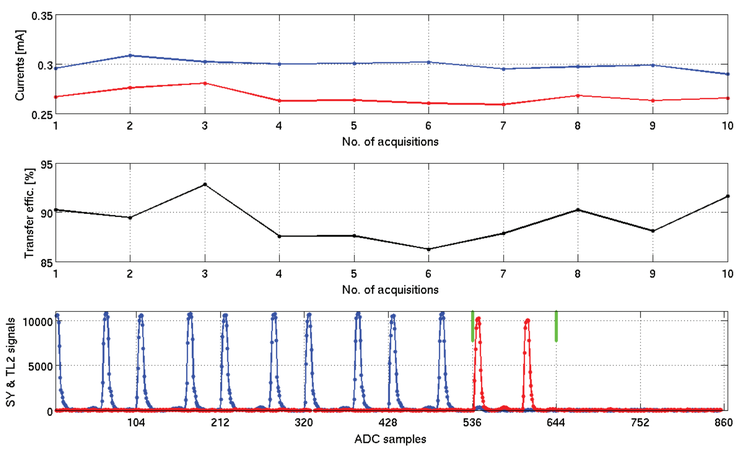


Injection of long pulse from TL1 (red) to booster (blue) at 1.1 mA. Booster revolution period can be easily observed. The excesive length of the pulse from TL1 can be seen.

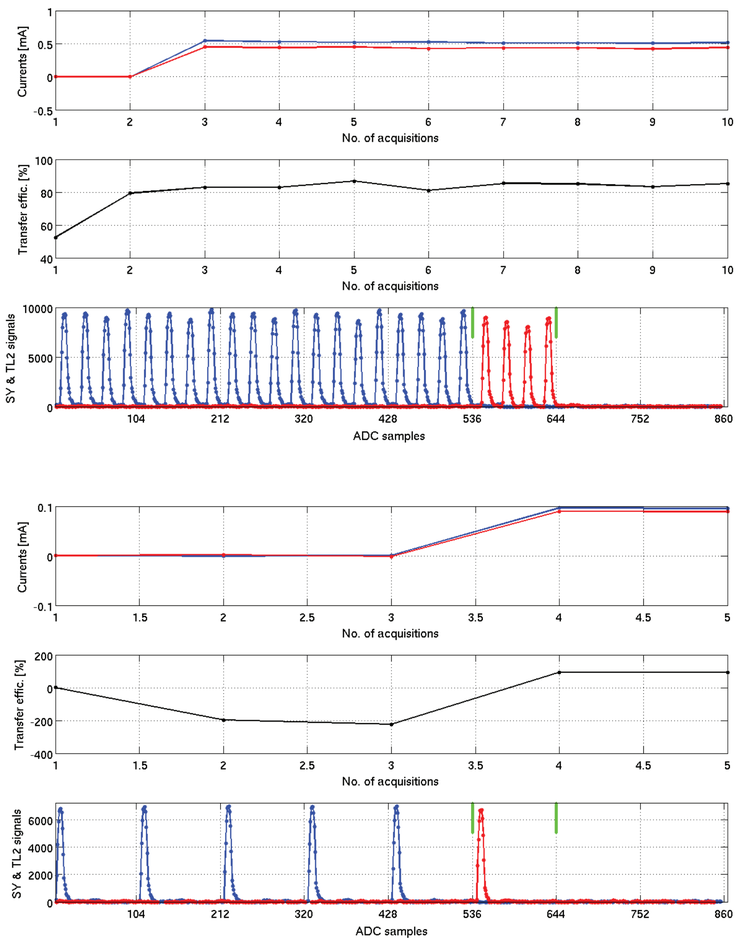


Injection of four bunches from TL1 (red) into the booster (blue), zoom at upper right. In the case above, bunches are not completely ejected from the booster, a small fraction of them surviving until the next injection. New bunches from TL1 overlap with small bunches from the previous cycle. This phenomenon was appearing randomly, and needs to be further investigated.

Booster - TL2 efficiency



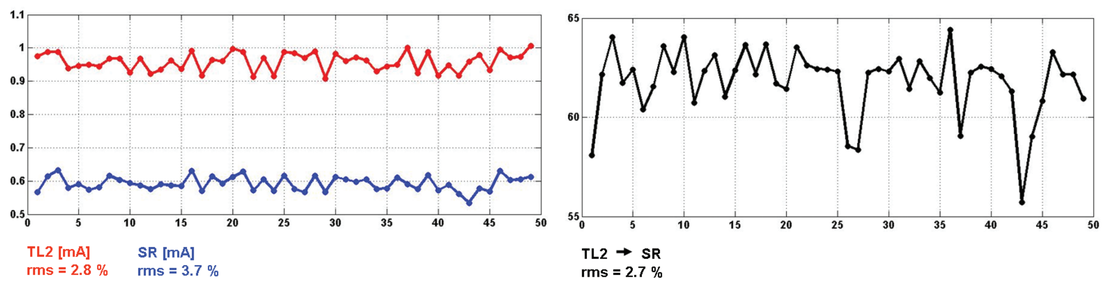
The lower graph is a snapshot of the injection, in blue are the two bunches circulating in the booster immediately before the injection, in red are the two bunches travelling through TL2. The two green lines show the ESRF booster revolution period. The upper graph shows calculated currents measured on the booster and transfer line 2 during the injection procedure through ten subsequent snapshots. From the ratio of these currents the injection efficiency can be calculated, see middle graph. We can observe that the mean efficiency during the injection was slightly under 90%.



The procedure is the same, four bunches are injected in this case.

Finally, injection of single bunch. The injection efficiency is in this case properly calculated for three last acquisitions only.

TL2 - Storage ring efficiency

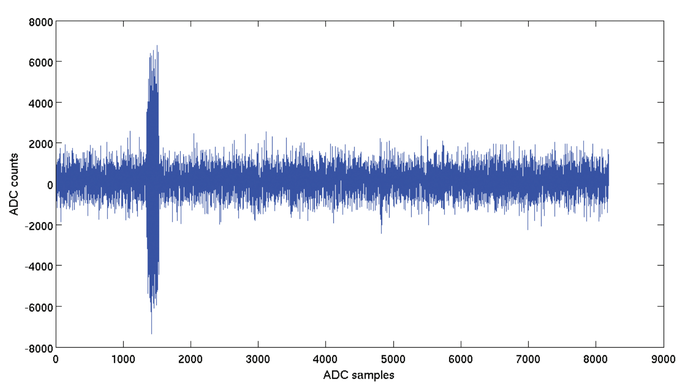


Red line shows the added current of each injection, as measured on stripline of TL2. At the same time (blue), the increase of the current after each injection was measured with regular Libera Brilliance devices, installed on pickup buttons on storage ring. The TL2 to storage ring efficiency (black, on right) is thus calculated in a very accurate way, with RMS of 2.7%

Comparison with existing current monitors

DCCT current reading [µA]	Libera BSP reading [µA]	attenuation setting [dB]
4200	5600	31
1100	2000	31
350	790	31
300	750	16
100	310	7
25	76	7
noise	35	7
noise	30	0

ESRF booster is equipped with the DCCT current monitor, its performace was compared to the Libera Brilliance Single Pass. In order to estimate the performances of it, measurement of current with long bunch pattern at different beam currents were performed. Libera Brilliance is very competitive, especially with low currents.



Signal to noise ratio at minimal booster current tested (~30 µA). The measurement is still reliable.

No. of injected bunches	DCCT current reading [µA]	Libera BSP reading [µA]	attenuation setting [dB]
2	200	280	31
2	90	142	31
2	90	125	22
4	360	510	31
4	180	250	31
4	180	220	22
1	100	158	31
1	50	72	31
1	50	78	22

To prove the Libera Brilliance Single Pass measurement repeatability and feasibility of measuring currents at different bunch patterns, the measurements were performed with two, four and single bunch patterns at different charges and different device attenuation setting. Slight dependence of the absolute current measurement on on-board attenuation was expected.

Conclusion

Libera Brilliance Single Pass has been shown to be an effective tool for monitoring the beam-charge losses during complete injection cycle (from TL1 to Storage Ring) at ESRF. The instrument provided excellent performance in terms of accuracy, resolution and reproducibility. Overall injection efficiency can easily be evaluated as a result. A significant result of the studies is that Libera Brilliance Single Pass is capable of measuring at very low beam current (below 0.05 mA stored ring in the booster) which is a factor 100 below nominal currents. It perfectly meets the requirements of the high-performance injection efficiency monitoring tool and offers better resolution and dynamic range than DCCT current monitors.

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