PRELIMINARY STUDIES FOR TOP-UP OPERATIONS AT THE AUSTRALIAN SYNCHROTRON

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Abstract

The Australian Synchrotron is now a fully commissioned synchrotron light source providing beam for users [1]. With the facility now fully operational, the next major advancement in machine operations will be top-up mode. The advantages of running in a dynamic top-up mode are well documented by other third generation light sources (see for examples references [2, 3, 4]) ; in broad terms it leads to a better quality beam for some users, and better experimental results. An overview will be given of the top-up runs that have been conducted and the instrumentation that was used. It has been demonstrated that top-up operation is possible, however improvements in injection efficiency and beam stability during injection are required before this can become a routine mode of operation.

BACKGROUND

All contracts issued for construction of the Australian Synchrotron contained the requirement that the system delivered would not prevent top-up operation. However, there was no special requirements for the demonstration of top-up operation and it has not been specifically requested by the user community. Now that user runs are routinely conducted, it is time to look to the future possibilities of top-up operations. In order to demonstrate that top-up is feasible a machine studies run was successfully conducted but there are still improvements which need to be made before this can become a routine mode of operation.

REQUIREMENTS FOR TOP-UP

The main requirements for successful implementation of Top-Up Mode are:

- High injection efficiency,
- Low beam motion during injection,
- Good timing system and synchronization,
- Accurate diagnostic methods, especially real-time fill pattern measurements.

SQUARE-UP MODE

Experience with top-up mode at the SLS shows that it is important for beam stability to have an even fill pattern[5]. Pattern injection cannot provide the necessary fill pattern by itself. A dynamic top-up mode run after the initial fill

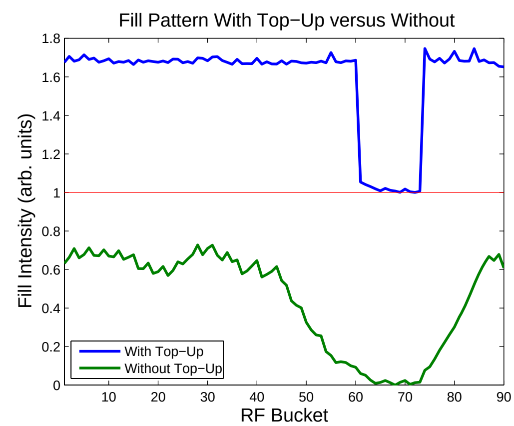

Figure 1: A sample pattern fill (lower graph), topped up and squared off using an intensity targeted injection protocol. The value of squared fill (upper graph) has been increased by 1.0 point for ease of comparison.

can even out the fill pattern quickly and maintain an even pattern using periodic, intensity targeted injections. To monitor the fill pattern in real-time, a fill pattern monitor (FPM) on the optical diagnostic beamline is used[6]. The FPM provides an vector of emitted light intensities for the stored electron bunches. When the stored current is below a preset threshold, the designated "filled" RF buckets are sorted according to intensity and the bucket with the lowest measured emitted light intensity is chosen for injection. The protocol is repeated until the stored current is over the threshold. Figure 1 shows the resulting fill pattern after top-up operations. The standard deviation of the measured light intensity of the filled buckets drops dramatically when the top-up protocol is used to dynamical alter the fill pattern, as shown by Figure 2.

CAMSHAFT MODE

In camshaft mode, a single bucket in a region of empty buckets is chosen and filled to a higher current than the others (see Figure 3). Time resolved experiments can be gated using the single bucket, removing multi-bunch contributions to the experiment. Camshaft mode was successfully injected and measured using the FPM.

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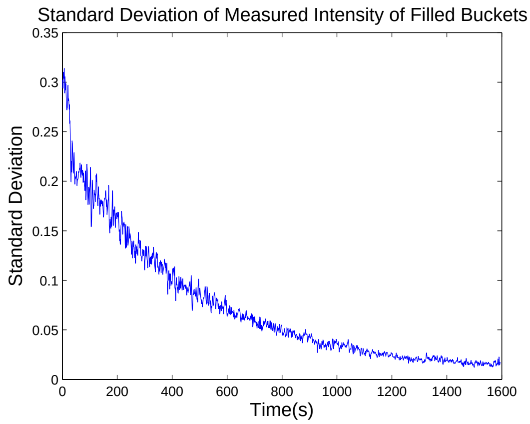

Figure 2: The standard deviation of the filled buckets over time during an intensity targeted dynamic top-up run.

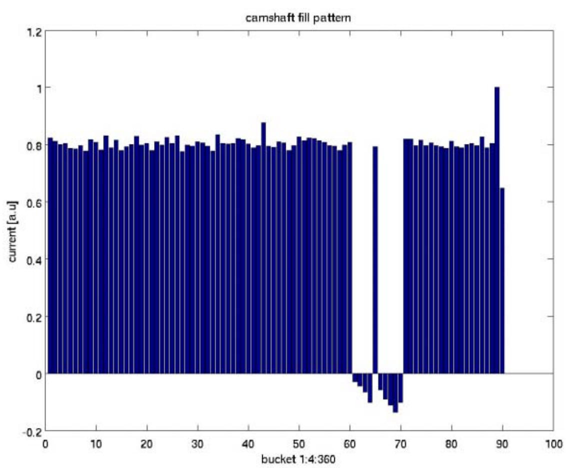

Figure 3: A successfully injected ”camshaft” fill pattern.

BUNCH PURITY

When users conduct time resolved experiments that are gated on a single high current bunch, the purity of this bunch is critical. With this in mind, a Bunch Purity Monitor (BPU) is being developed based on Reference [7]. Accurate bunch purity measurements require a diagnostic device with a high dynamic range. For the Australian Synchrotron, a Time-Correlated Single Photon Counting (TCSPC) system has been commissioned, using an avalanche photodiode (APD) and the Picoharp 300[8]. The Picoharp 300 uses a Time to Digital Converter (TDC) to measure the elapsed time between the start signal (the storage ring synchronization pulse) and the stop signal from the APD. The TDC then provides the digital timing value to address the built in histogrammer. Although this method provides a high dynamic range, in order to prevent pile-up in the measurements the synchrotron light must be heavily filtered and so the data acquisition must be taken over a time span of minutes to build up the histogram.

A preliminary bunch purity measurement has been made to test the BPU setup (see Figure 4). The acquisition time for this measurement was 10 minutes. A comparison between the BPU and the FPM is shown in Figure 5. Each of the result have been normalized to unity and the horizontal offset between the data sets have been removed. The mean absolute difference between the normalized values for the measured light intensities for each of the RF buckets is only 2.20%.

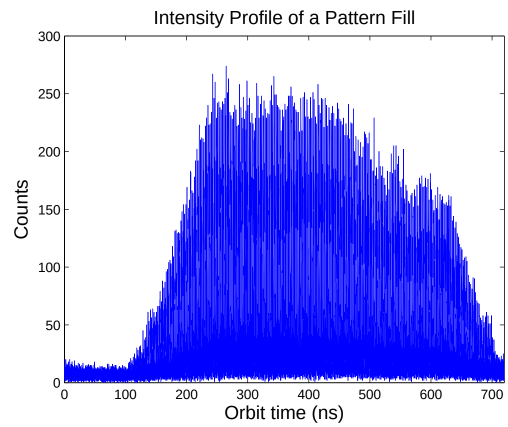

Figure 4: Stored electron beam intensity profile measured using the BPU setup.

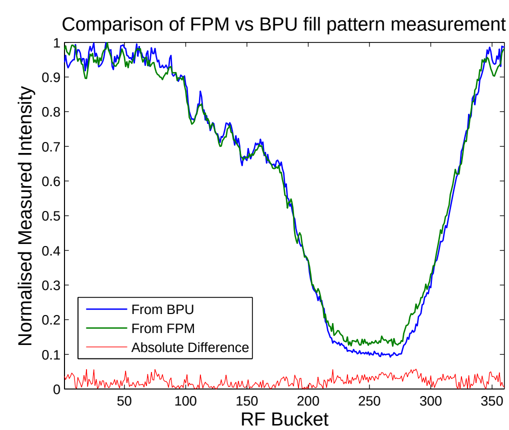

Figure 5: A comparison between the BPU and FPM on the measurement of fill pattern.

CONCLUSIONS

A dynamic Top-Up mode has been successfully designed and tested at the Australian Synchrotron. Using a real-time fill pattern measurement device, periodic targeted injections were used to square the fill. Preliminary bunch purity measurements have been undertaken using the newly commissioned bunch purity monitor and the initial results correlate well with the fill pattern monitor.

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