BUNCH PATTERN BY-3 IN PEP-II*

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Abstract

After a long 4-month down time where additional RF was installed and heating problems addressed, the PEP-II B-factory should be capable of delivering about 1.5 times the currents. This can only be done by going to more bunches from a full by-4 pattern to either a partly filled by-3 or by-2 pattern. The by-2 pattern has parasitic crossings, so the by-3 pattern is the next candidate. Heating issues from the different higher order modes, especially in the longitudinal and transverse feedback structures are a concern. Effects from an electron cloud seem to be still visible in the by-3 and by-2 pattern.

1 INTRODUCTION

Figure 1 shows a typical by-3 bunch pattern with short bunch trains of 10 bunches out of 12. We fill up to bucket number 3400 out of 3492 giving us about 940 bunches. The details in the pattern are mostly caused by electron cloud effects (or possibly phase transients). The train length, the beginning after the abort gap, the first bunches of the train, and the timing for the beam position monitors (BPMs) have to be carefully chosen.

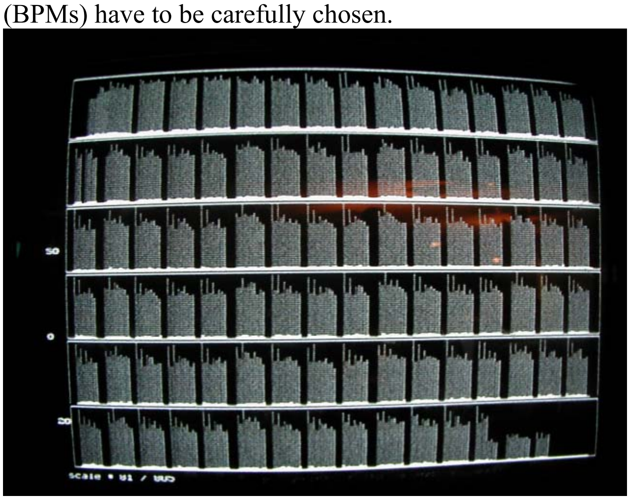

Figure 1: Luminosity per bunch for typical by-3 pattern.

When we first switched from the by-4 to the by-3 pattern excessive vacuum activity was observed which scrubbed out after a few days (Fig. 2, top).

2 PATTERN DETAILS

2.1 Train Length

The initial switch went to a full by-3 pattern, then the number of bunches got reduced by moving to trains of 30 out of 32 and then trains of 28 giving about 1000 bunches (Fig. 2, bottom). With 28 or later 26 bunches in a train the luminosity dropped down about 15% over that length, making shorter bunches more attractive. So we went to 9 and 10 bunches out of 12 keeping the number about constant (see Fig. 1). Even shorter bunch trains of 5 out of 6 (see Fig. 3) were not successful, since the luminosity was 5% lower, probably caused by too many "first" bunches in a train.

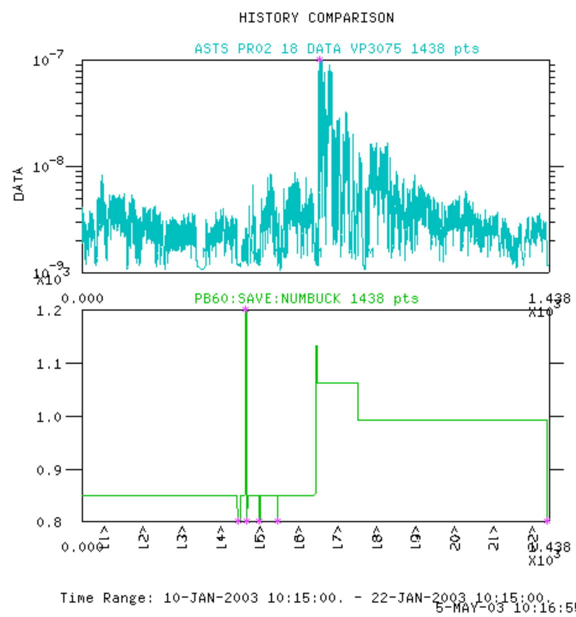

Figure 2: Pressure activity (top, in Torr) and number of bunches (bottom) when going from by-4 to a by-3 pattern.

2.2 First Bunch in Train

The first bunch in a train has often a different lifetime in the Low Energy Ring (LER). This can be easily seen as less bunch current at the end of a coast, when the overall current decayed from 1700 mA to 1300 mA or about –25% while the first bunches lose 40%. It is a difference when there are 2 or 3 bunch spaces free (3 worse), but there is also a difference when there is only one bunch missing (as in all cases of Fig. 3), but there is another gap close by.

A gap causes the LER bunch to be less blown up in x from less electron cloud, which gives it less beam-beam tune shift causing it to be more near a resonance and having therefore less lifetime [1]. There are two successful ways to improve this situation at different times. To increase the tune spread a lower charge in the LER train's first bunch can help its lifetime, since it loses charge anyway faster. Sometimes the opposite is true and less HER current in the first bunches helps.

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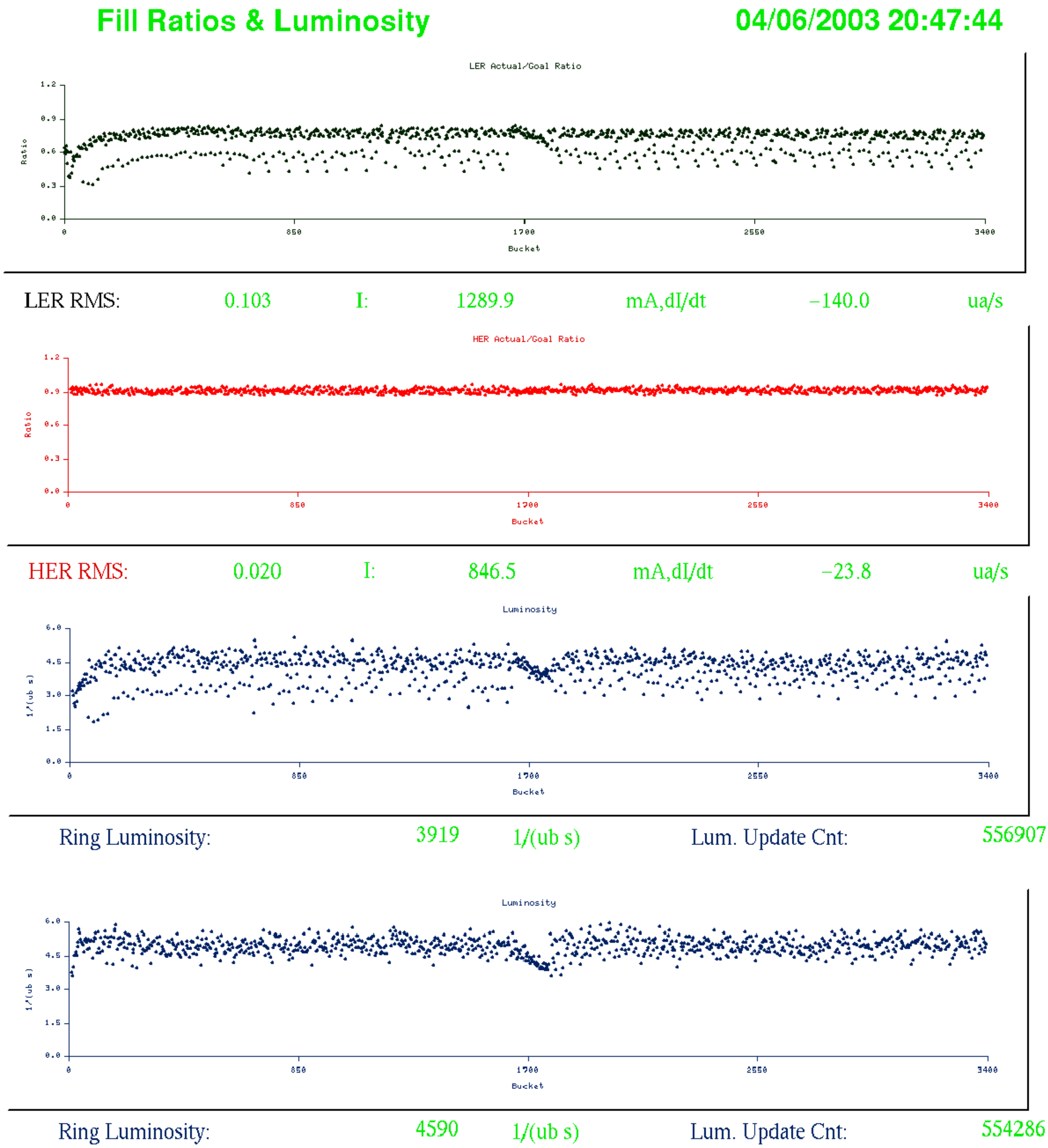

Figure 3: Special by-3 pattern with short trains of 5 bunches out of 6 (till bucket 585), and then every 4th train the middle of the 5 bunches is removed. A straight by-3 part is around bucket 1700±70. The top shows the LER bunch current after coasting for 45 min, next is the HER current with no change and the luminosity. The bottom shows the initial luminosity, when the currents were flat, indicating a drop induced by the electron cloud.

2.3 First Bunches after Abort Gap

The problem gets of course more serious after the abort gap where all or most the electron cloud should be gone. Here helps a longer current ramp from 70 to 100% [2,3], or we tried to "preload" the chamber with an electron cloud by filling a few bunches in the LER before the first colliding bunch. In Fig. 4 six bunches are filled before the colliding bunches. This help only a little, but when we filled every bucket (by-1) instead of a by-3 distance, the next colliding bunches were stable. Later we had to reduce this line density to a by-2 distance since the longitudinal feedback system had trouble to keep these bunches stable. We probably still need to increase the number of not colliding LER bunches.

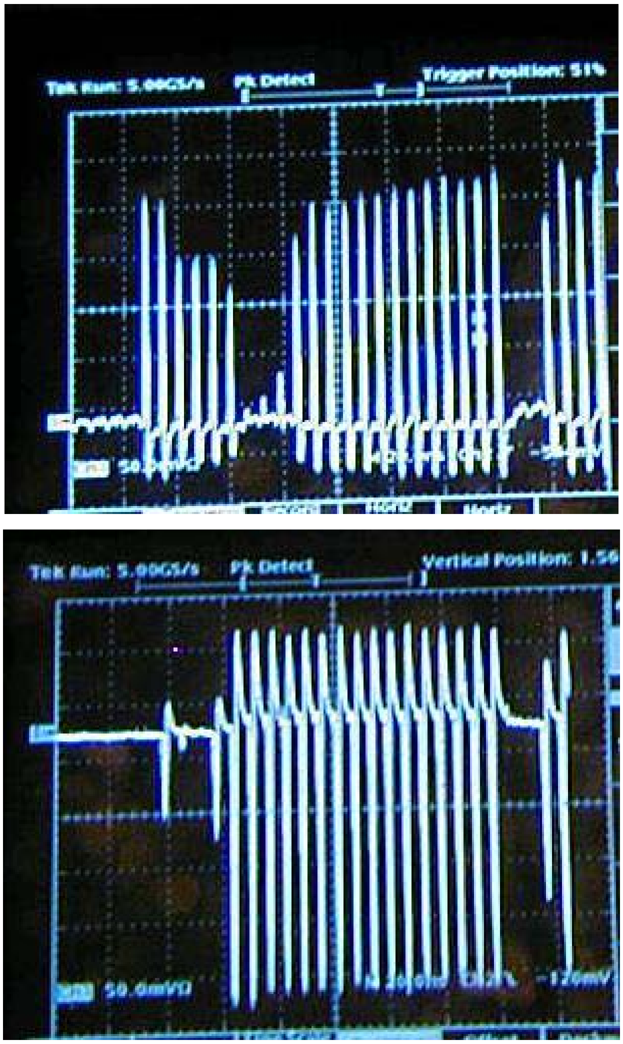

Figure 4: BPM intensity signals of first few bunches in LER (top) and HER (bottom), (20ns/div).

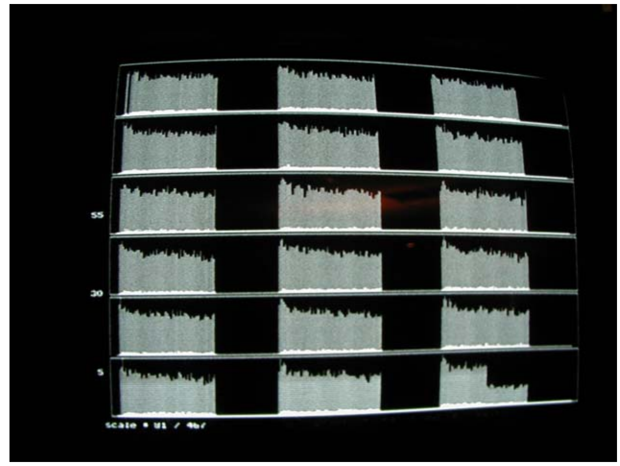

Figure 5: By-2 pattern with long trains show about a 25% luminosity drop.

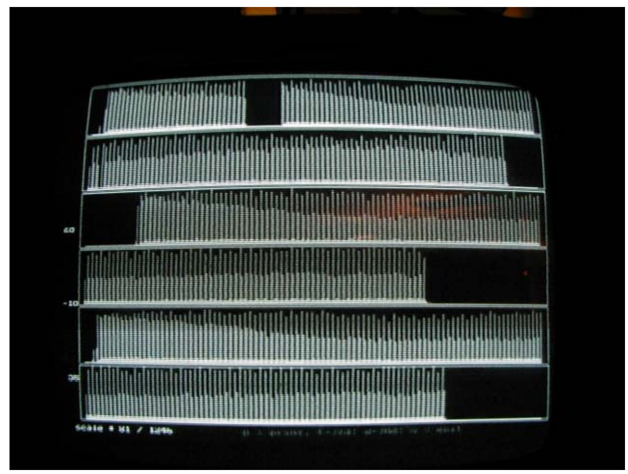

Figure 6: By-2 pattern with short "trains" (2,4,2,4…) shows only a luminosity loss for the second bunch.

2.4 Close to ½ Integer Tune

Recently we moved the x-tune close to the half integer (0.52) and achieved nearly a 20% luminosity improvement. Since then the behaviour is quite different the currents stay flat (except in the very front), while the luminosity at the end of a coast down shows a lower value of about 15%.

3 BY-2 PATTERN

Since we already see a 15% luminosity loss for long by-3 trains it might be necessary to look at a by-2 pattern before we reach a full by-3 pattern.

Two scenarios with very long trains of about 50 bunches, and very short "trains" of two bunches were studied. The first shows the typical 20-25% luminosity loss after the first few (5-10) bunches (Fig. 5), while the second case showed a very interesting behaviour (see Fig. 6). The first buckets of the duplets have the same high luminosity, while the luminosity of the second ones drops about 50% over 25 duplets, or 320 ns. Then it is constant except for after an empty bucket with number 585 (beginning of second row in Fig. 6). The luminosity slowly grows to nearly 75% before it starts dropping down again faster.

4 SUMMARY

Besides the rough number of buckets, gaps in the detailed pattern help to avoid the built-up of an electron cloud. But this causes different tunes, and therefore lifetimes or even beam loss. Most effects can be reduced by adjusting the size of the gaps and the intensity of the following bunch.

5 REFERENCES

[1] R.L. Holtzapple,et al., "Observation of Beam Size Flip-Flop in PEP-II", EPAC02, Paris, June 2002.

[2] F.-J. Decker et al., "Increasing the number of Bunches in PEP-II", EPAC02, Paris, June 2002.