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MD 2935: 16L2 solenoid tests

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Summary

This MD allowed confirming that the solenoid installed in 16L2 during Technical Stop 2 (TS2 2017) could be held responsible for the performance improvement observed after TS2.

The MD was performed on 30th November 2017 in parallel with MD#2889 [1] and the procedure was adjusted for both MDs to profit as much as possible of the available time.

Contents

1 Introduction and MD goal

Recurrent beam dumps perturbed the operation of the LHC in the summer months of 2017. These unexpected beam dumps were triggered by fast beam losses that built up in the cryogenic beam vacuum at the half-cell 16 left of LHC-IP2 and were detected at that location and in the collimation insertions. There had been several converging signs that electrons were part of the mechanism that led to these so-called “16L2 events” [2].

Before Technical Stop 2 (TS2) in 2017, increasing the bunch intensity above 1.15 10^{11} p/b for 1800 bunches with the 8b4e scheme systematically triggered a beam dump. After installing and operating a solenoid at 55 A around the 16L2 interconnect during TS2 [3], there was a clear improvement: there were less loss spikes and one could inject up to 1.26 10^{11} p/b without beam dumps [4].

It was not possible to perform tests with the solenoid switched off during operation. This MD was proposed to switch off this 16L2 solenoid for a typical operational LHC fill to check that indeed the solenoid can be held responsible for this performance improvement.

2 Procedure and beam conditions

The nominal procedure for LHC fill was followed for fill number 6442. The main features of this fill compared to standard operational fills that took place before this MD period are:

- The 16L2 solenoid was switched off.
- The CMS solenoid unexpectedly tripped during transfer line steering (fill 6441 at 23:27) during ramp down.
- The bunch intensity spread was larger than usual but there was no time to reinject due to time lost because of injection issues and CMS magnet trip.
- The range of bunch intensities at flat top was chosen between 1.17e11 p/b (limit that triggered events before TS2) and 1.26e11 p/b (limit that did not trigger events after TS2, e.g. fill 6255). In view of the impossibility to refill for a second ramp, the intensity had to be chosen close to the maximum of the range, in order to maximize chances to obtain a dump with blown up bunches for MD#2889, since no dump had occurred during the fill at injection. The average intensity at injection turned out to be close to the maximum of the range, but was assumed low enough as (1) there would be losses before flat top and (2) time was running out due to injection issues followed by the CMS magnet trip. Indeed losses reduced intensity to 1.24e11 p/b in both beams shortly after the start of the ramp. Clearly, a bunch intensity of 1.2e11 p/b or lower would have been preferable for the sake of this MD alone.

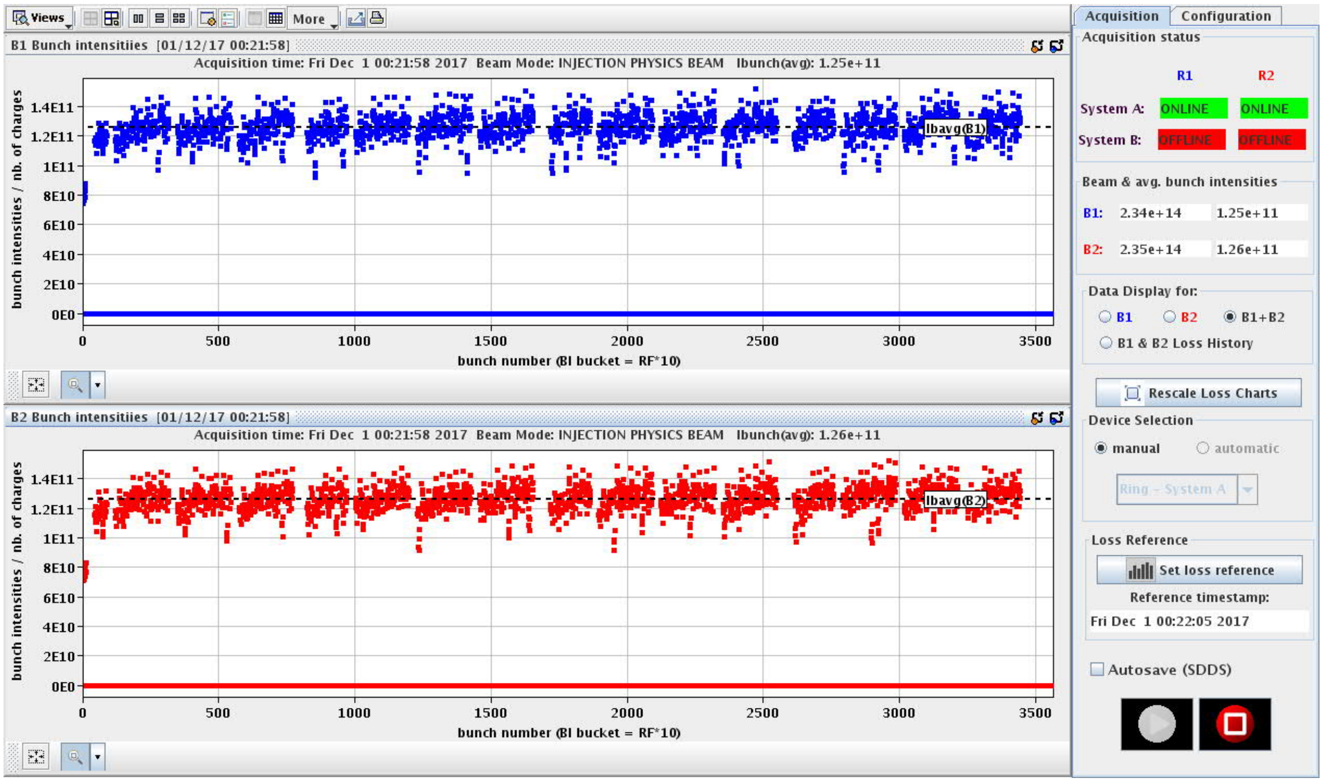
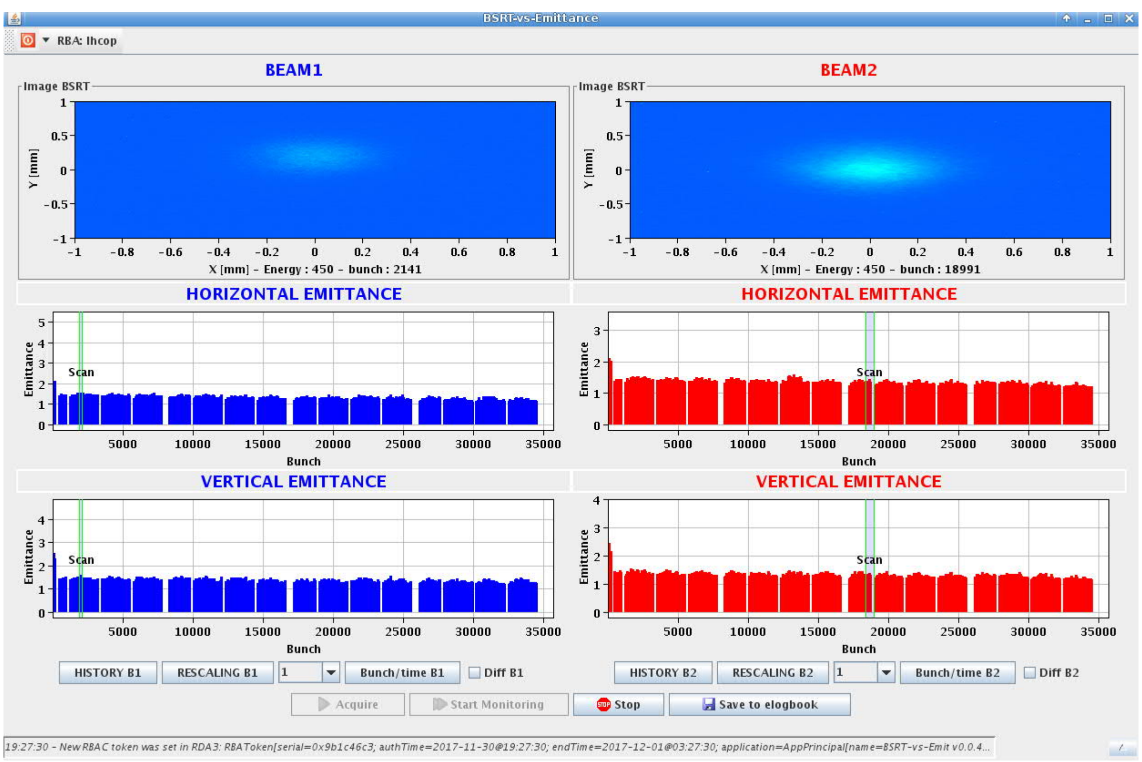


Figure 1: Bunch-by-bunch intensities after the last injection.

- Bunches were blown up in both beams and both planes for MD#2889 (see Fig. 2).



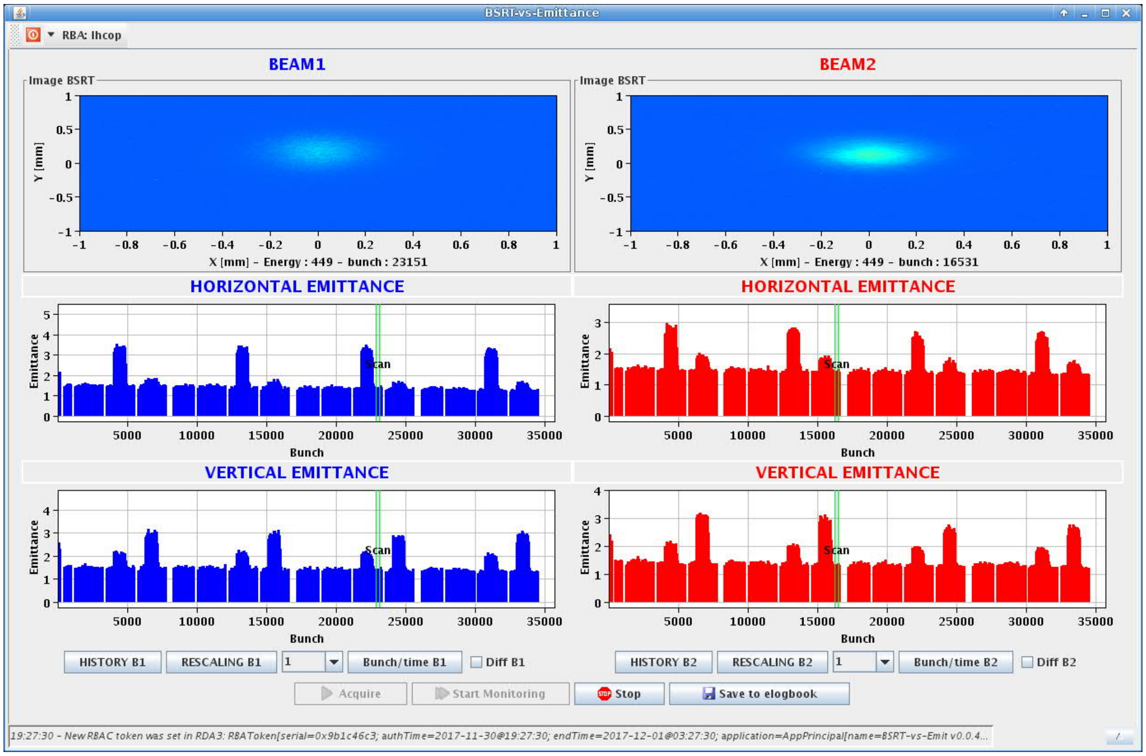


Figure 2: Horizontal and vertical emittances as measured by the BSRT before (top) and after (below) the blow up performed for the UFO studies of MD#2889.

3. Results and discussion

A 16L2 event dumped the beams at 00:48:21.109 at 5.5 TeV (see Fig. 3 and 4). The dump could be attributed to a vertical instability that occurred on beam 1 from the loss pattern on collimators and bunch by bunch positions recorded at the transverse damper (ADT), see Fig. 5.

First spikes were observed on the UFO buster at 3.5 TeV in beam 1 and 4.7 TeV in beam 2.

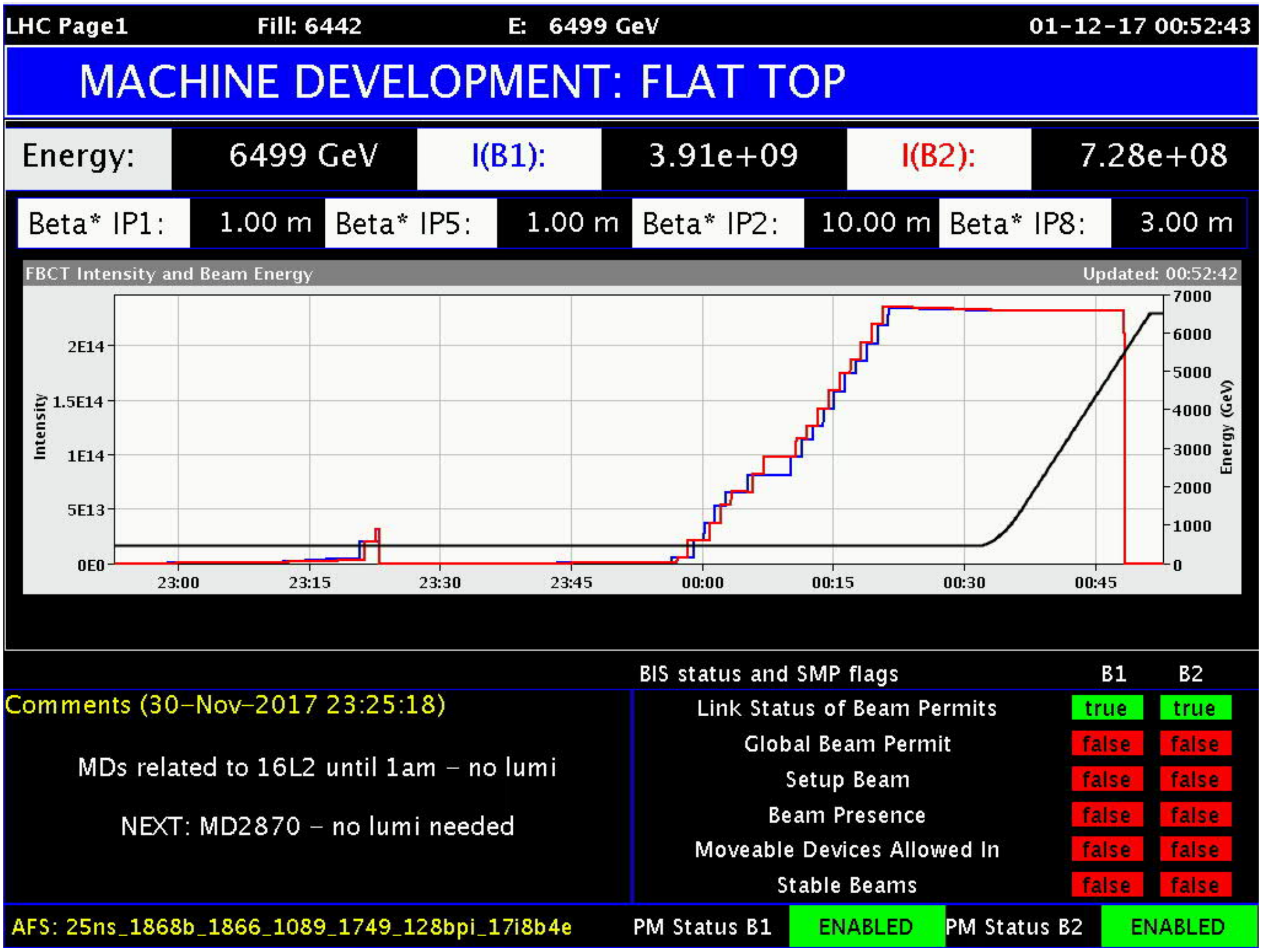


Figure 3: Snapshot of the LHC vistar that shows the beam dump.

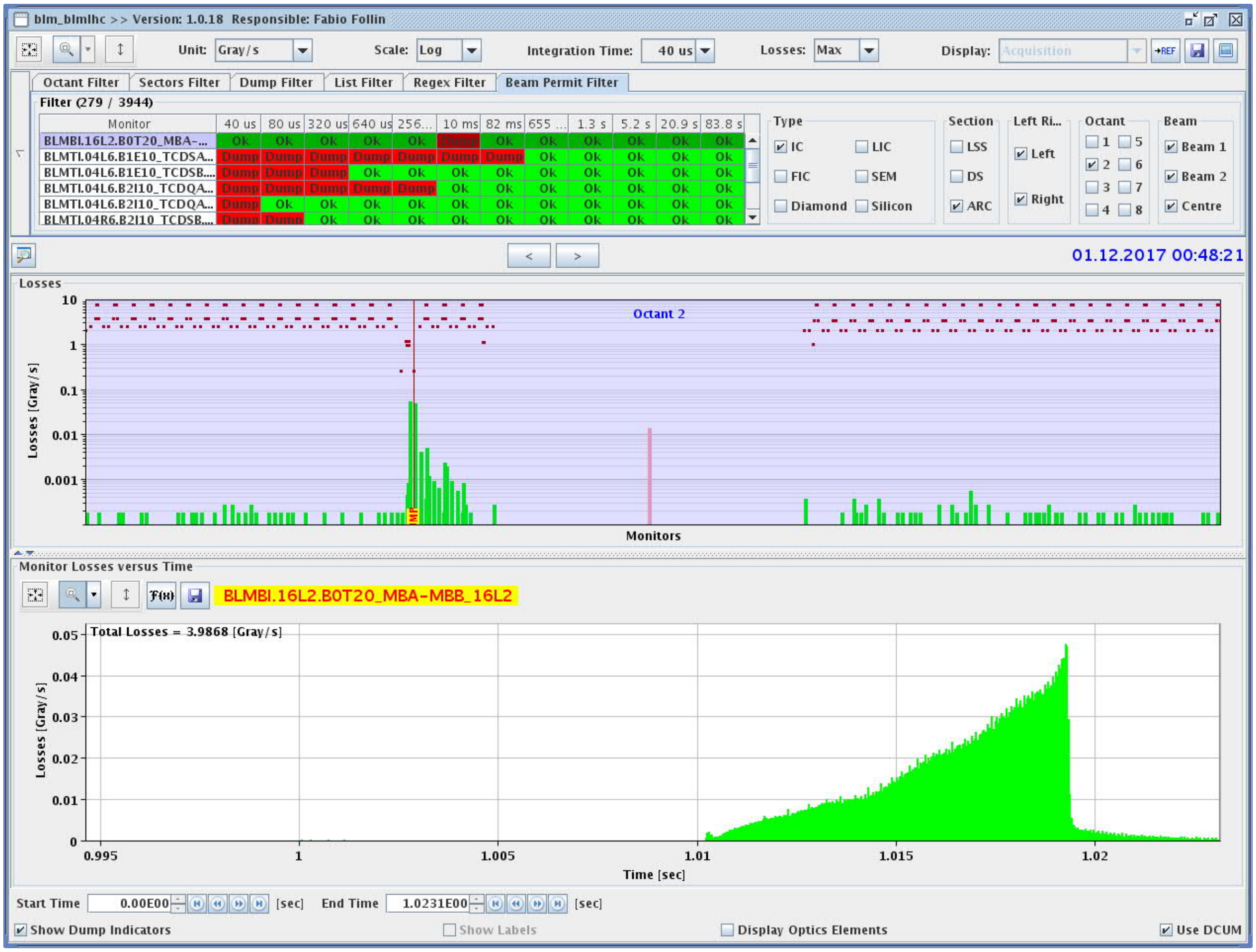


Figure 4: losses at one of the 16L2 BLMs presenting a characteristic fast loss pattern.

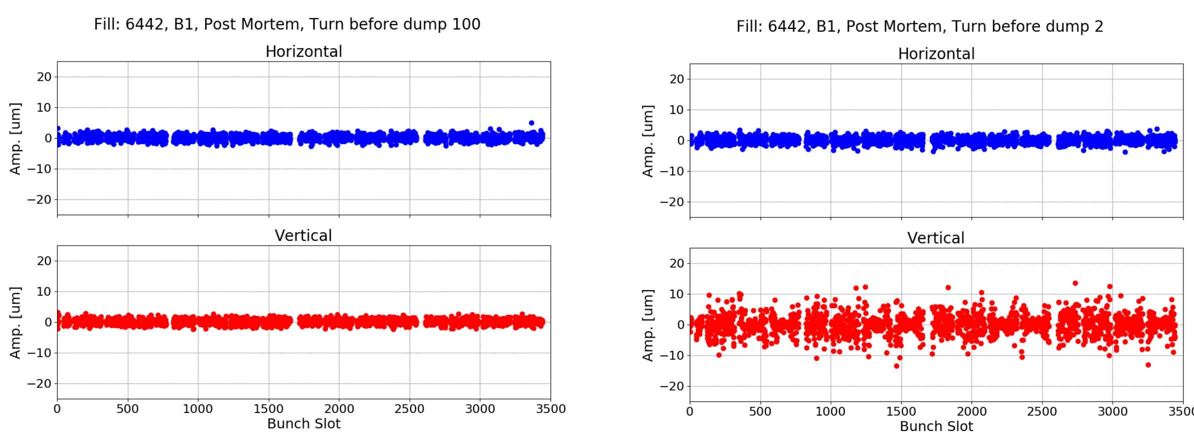


Figure 5: Beam 1 bunch positions 100 turns before the dump (left) and 2 turns before the dump (right). Horizontal positions (blue) are on top and vertical beam positions (red) are on the bottom. The vertical instability that triggered the dump can be attributed to beam 1.

As a conclusion, a ramp with a standard fill with less than 1.25e11 p/b generated a 16L2 event that dumped the beams when the 16L2 solenoid was switched off. There was no time to ramp up the intensity slowly as it was foreseen in the MD plan, and several parameters had to be different due to constraints imposed by the parallel MD and by operational issues during the MD: in particular, slightly larger bunch intensity spread, CMS solenoid that was down, and emittances of many bunches that were blown up on purpose. Nevertheless, this observation is another compelling evidence in favour of the beneficial impact of the solenoid on LHC operation after TS2.

4. Conclusion and Outlook

This MD allowed confirming that the solenoid installed in 16L2 during Technical Stop 2 (TS2 2017) could be held responsible for the performance improvement observed after TS2.

Both the solenoid and the dipole and quadrupole magnets around the 16L2 interconnect will be removed during the long shutdown 2.

Acknowledgments

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Figure 6: part of the MDs #2889 and #2935 participants. From left to right: B. Lindstrom, B. Salvant, E. Métral, Cristina Bahamonde Castro, M. Valette, D. Wollmann, L. Grob, M. Albert (the only one working as usual), A. Gorzawski, T. Levens, C. Yin Vallgren, H. Timko, L. Mether, D. Mirarchi. Thanks to Serge for taking the picture!

References

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[4] D. Mirarchi et al., "16L2 Post Mortem and lessons learnt", presented at the LHC Performance workshop 2018, Chamonix, Switzerland, 29/01/2018, https://indico.cern.ch/event/676124.