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LHC MD1087

CONTROLLED LONGITUDINAL EMITTANCE BLOW-UP WITH SHORT BUNCHES

Abstract

This note summarises the detailed programme proposed for “Controlled longitudinal emittance blow-up with short bunches”. The goal of this MD is to study the stability and convergence of the operational blow-up during the acceleration ramp with a reduced target bunch length.

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1. INTRODUCTION

In 2015, the target bunch length for the controlled emittance blow-up had been reduced to 0.9 ns during the ramp. As a result, a bifurcation of bunch lengths was observed [1]; some bunches remained significantly shorter and some significantly longer than the target length.

Subsequently, in 2016 operation, a shorter bunch length at arrival to flat top was desired. The target bunch length has been reduced from 1.25 ns to 1.1 ns from one fill to another in steps of 50 ps. Until the target of 1.15 ns, the spread between minimum and maximum bunch length along the bunch train stayed approximately the same. With 1.1 ns, some bunches started to deviate from the mean and the spread between minimum and maximum bunch length increased from 200 ps to 600 ps. This has been mitigated by keeping the target at 1.25 ns in the first 800 s of the ramp [2], thus keeping the beam more stable, and lowering the target length only afterwards.

Presently, the bifurcation of bunch lengths cannot be reproduced in simulations although there are some theories to explain observations. Both for near-future operation as well as for HL-LHC parameters the stability of the bunches during the controlled emittance blow-up is indispensable and has to be studied, so that measures can be taken to ensure that the blow-up scheme will remain converging also in the future.

2. DETAILED STEPS TO BE TAKEN BEFORE, DURING AND AFTER THE MD

2.1 PREPARATION OF THE MD

As a preparation, only the blow-up parameters have to be changed for the ramp: the target bunch length and the bunch length feedback. Otherwise a few batches with operational parameters are required, which are to be accelerated to 6.5 TeV.

Optional: prepare different batches to have different intensities and/or emittances

2.2 STEPS TO BE TAKEN DURING THE MD

1. Prepare the modified blow-up: lower the target bunch length on both beams and disable the bunch length feedback on one beam
2. Measure bunch profiles and peak-detected Schottky spectra for reference
3. Inject either a few (up to five) batches with nominal intensity and emittance in each beam, or optionally, inject up to 20 single bunches of 0.45 eVs longitudinal emittance and variable intensity in the range $(0.5-2.5) \times 10^{11}$ ppb (the intensity to be varied in the PSB, the emittance of 0.45 eVs to be achieved by controlled blow-up in the SPS).
4. Measure again bunch profiles and peak-detected Schottky spectra after blow-up
5. If bunches are stable and not blown up too much, synchrotron frequency measurements (MD232) can be performed at flat top

2.3 RECOVERY AFTER THE MD

Recover operational settings for the controlled emittance blow-up. Recover operational beam parameters in the injectors, should they be changed during the MD.

3. RISKS

The only difference compared to an operational ramp will be that the blow-up target bunch length will be lowered so that some bunches will be at the limit of stability during the ramp. As a consequence, the bunch length target may not be met by all bunches; some bunches might be shorter and some longer than the target. Should off-momentum losses occur during the ramp, the lost particles will be absorbed at the off-momentum collimators, so abort gap cleaning is not necessary.

4. REFERENCES

- [1] J. Esteban Muller et al., LHC Longitudinal Single-Bunch Stability Threshold, CERN-ACC-NOTE-2016-0001, 2016, <https://cds.cern.ch/record/2119854>
- [2] H. Timko et al., RF EoF MD1279 Bunch Flattening in Physics, LSWG meeting No. 14, 2nd August 2016, <https://indico.cern.ch/event/557533/>