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LHC MD4203

TCDQ LEVELLING MD AT 450 GEV WITH 3E11

Abstract

This note summarises the key objectives of the first TCDQ levelling MD (MD4203) which is scheduled to take place at the next MD block (2h slot in MD3-2018), including the motivation, basic description of the principle, present ad-hoc implementation, and foreseen procedures in order to rapidly demonstrate this new possible piece of orchestration. The connection with beta* levelling, and the different options of interlocking this new proposed beam manipulation will be addressed later on, and are not part of the present MD.

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0.2	xx	xx	

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1. INTRODUCTION AND MOTIVATIONS

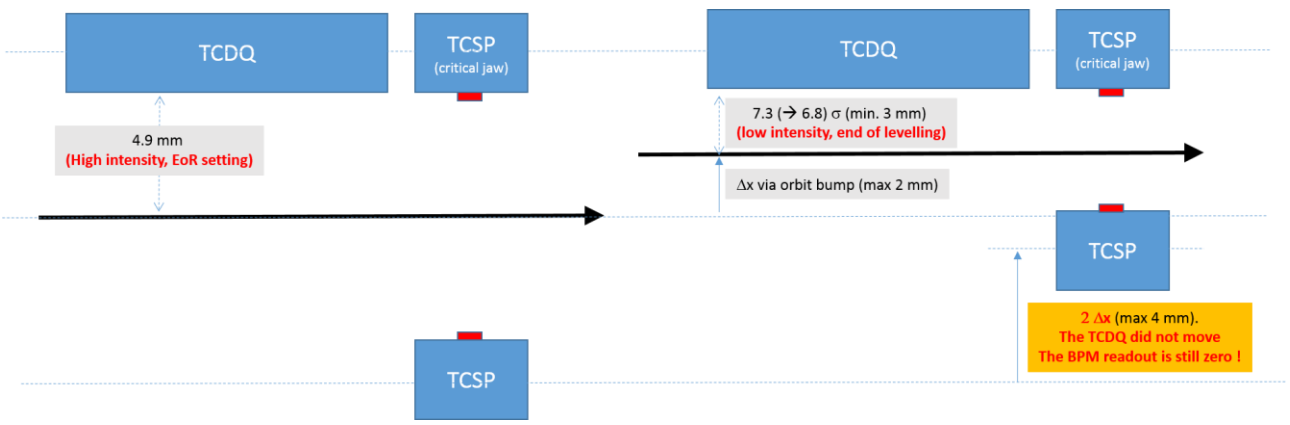
Within the framework of the LHC Upgrade studies, **high intensity (LIU) beams** have been recently found to drive hard constraints on the mm settings of the TCDQ in order to cope with specific failure scenarios [1]. This is in turn corresponds to normalised settings by up to 10 (collimation) sigma's for 7 TeV beam energy. Such large normalised settings for the TCDQ can be directly compared to the 7.3 σ TCDQ settings used in operation since 2017, which has been a **vital ingredient** for the beta* reach in Run II.

On the other hand, the above TCDQ constraints can in principle be alleviated together with the proton burn off in collision, continuously or by a few steps (to be decided later). Then, at lower beam intensity, this is exactly when the minimum possible protectable aperture needs to be further reduced, in order to enable a further squeeze of β^* and sustain the prescribed levelled luminosity.

Interlocked by the BETS, the TCDQ can presently not move as soon as the ramp is finished, and, in general, is preferred not to be moved for mechanical reasons, at least if movements in arbitrary direction are requested (as driven by ATS optics specificities, which adds complexity but is not the main justification for TCDQ levelling [2]). Assuming no taken action, and since the minimum possible beta* scales approximately with the squared of the available normalised aperture of the triplet, the degradation of the beta* reach can be as large as 50% in Run III compared to Run II [3]. Then, from a different perspective the potential beta* reach of for HL-LHC could be further improved by 1/3 with respect to the present baseline.
In order to preserve and further improve the beta* reach in Run III and HL-LHC, respectively, the requested dynamic range for the *effective* gap of the TCDQ during β* levelling amounts to about 2 mm in the worst case: typically from ~ 5 mm (value presently requested for the HL-LHC beam), down to ~ 3 mm (corresponding to a normalised setting of 7 σ, at a beam energy of 7 TeV, and with the horizontal β-function reduced by ~ 20% at the TCDQ for Beam2 after an aggressive flat tele-squeeze).

Instead of moving the TCDQ, moving the beam has been recently suggested [4]. It was then realised that: (i) the already existing TCDQ bump which is deployed for asynchronous dump test could a priori be re-used for this new functionality, and (ii) that moving the non-critical jaw of the TCSP in the same direction but by twice the bump amplitude (i.e. keeping fixed the critical jaw of the TCSP) could in principle "fake" the BPM-SiS interlock, since the beam would remain centred in the TCSP during this manipulation (see Fig. 1)

Figure 1: TCDQ levelling principle



2. OBJECTIVE FOR THE FIRST MD AND STRATEGY

The demonstration of the above beam manipulation is exactly the aim of the MD. After discussion with various experts, the usage/modification of the existing orchestration tool was however discarded at this stage. The alternative with a dedicated beam process and an ad-hoc sequence was preferred, which is presently under development [5]. This beam process is prepared with in mind horizontal bump excursions by up to +2/-2 mm at the TCDQ, in the outward/inward direction with respect to the ring center, and with the corresponding displacement for the non-critical jaw of the TCSP (twice the bump amplitude). This beam process is prepared to reset the situation at the end of it. It will be played in step of 0.25 mm or 0.50 mm (under discussion), at least for the first tries.

1 h of beam time (+1 h for recovery) is planned for this first MD. The MD will be run **at injection**,

(i) first with **probes** to debug any unexpected features in the new mechanics, masking the BPM interlock at Pt6 and enlarging (or masking) the TCSP limits,

(ii) and then with **set up beams** (1 or 2 nominal bunches per beam) in order to increase the DOROS resolution (un-masking the BPM-SiS interlock).

The outcome of the MD should be (i) a zero read-out from the TCSP-BPM (within some error bars which will assessed later on), and (ii) no interlock triggered over the full process (except related to the limits on the non-critical jaw of the TCSP).

3. BEAM & MACHINE CONDITIONS

The beam and machine conditions are summarized in Tab. 1.

Table 1: Basic beam and machine parameters during the MD

Beams required [1, 2, 1&2]	1&2
Beam energy	450 GeV
Bunch intensity [#p, #ions]	Pilot bunch (1E10) up to 3E11 (2 nominal)
Number of bunches	From 1 to a few pilots for fill #1, and 2 INDIVs for fill#2
Transv. emittance [m rad]	Not relevant
Bunch length [ns @ 4s]	Not relevant
Optics change [yes/no]	No (injection optics)
Orbit change [yes/no]	Yes: TCDQ bump
Interlocks [yes/no]	Yes: for the first try with probes (TCSP6 and BPM-SiS interlock at Pt6)
Collimation change [yes/no]	Yes: the non-critical jaw of the TCSP will move back and forth by twice the H orbit displacement at the TCDQ (max +/- 4 mm)
RF system change [yes/no]	No
Feedback changes [yes/no]	No
Octupole changes [yes/no]	No
What else will be changed ?	Nothing

4. REFERENCES & ACKNOWLEDGEMENTS FOR PREPARATION WORK

[1] C. Bracco et al., Update on optics constraints for injection and dump protection elements}, Presented at the 30th HL-LHC Technical Coordination Committee (TCC) meeting, 08/06/2017.

[2] S. Fartoukh et al., About Flat optics for the future operation of the LHC, CERN-ACC-2018-0018, 2018

[3] S. Fartoukh, LHC Cycle, Optics options (flat/round) with beta* reach in Run-III (with and without TCDQ levelling), Presented at the 4th LHC Run III configuration working group, 04/08/2018.

[4] P. Collier, Private comm., 2018.

[5] J. Wenninger and M. Pojer. Beam process and sequence for first demonstration of the TCDQ levelling principle, 2018.