HL-LHC / LIU Joint Workshop, CERN 30-7-18, 30-03-2012 (14:00-15:00)

SUMMARY OF THE SESSION: Pros-Cons of 25 ns vs 50 ns

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- The discussions were triggered by showing the following five slides: https://indico.cern.ch/getFile.py/access?contribId=8&sessionId=2&resId=0&materialId=slides&confId=175259. To evaluate the pros and cons of the 25 ns scenario vs. 50 ns, we considered Oliver Bruning's set of beam parameters for HL-LHC (see for instance his Chamonix2012 paper: https://indico.cern.ch/getFile.py/access?contribId=52&sessionId=7&resId=7&materialId=paper&confId=164089 and today's update) and the LIU analyses presented by Brennan Goddard at Chamonix2012 (see https://indico.cern.ch/getFile.py/access?contribId=56&sessionId=7&resId=1&materialId=slides&confId=164089). The short summary of this session is the following:

  - The 25 ns is the preferred option provided that there are no electron cloud issues in the LHC (and in the SPS) and the number of events per crossing is limited to ~ 100 (as currently mentioned by the LHC experiments). In this case the luminosity can be leveled at 5E34 $cm^{-2}s^{-1}$. The 50 ns scheme proposed necessitates leveling the luminosity at 2.5E34 $cm^{-2}s^{-1}$, which leads to much longer fills, which can work only if the machine efficiency is considerably increased. The expected gain will anyhow, not totally compensate the decrease with respect to the 25 ns scenario. This consideration really means that the 50 ns beam can only be a/the back-up solution. In the injectors there is essentially one fundamental limit, which is space charge at PS injection. The "good news" are that: (i) no limit has been identified yet, (ii) the bunch length could be increased (the profile could be also flattened) and (iii) one could try and use a one-batch injection instead of two (with 48 bunches in total instead of 72) leading to only 8% less bunches in the LHC but with several potential gains, as discussed in the LHC Project Note 401 (http://cdsweb.cern.ch/record/1075485/files/project-note-401.pdf), such as less time spent as low energy (which can be better for space charge) and less potential electron cloud issues at high energy in the PS.

  - The 50 ns is a back-up solution in case of major problems with the electron cloud, if the machine is limited by the total current, or if the number of events per crossing can be increased. Furthermore, the 25 ns beam is limited at ~ 2.2E11 p/b due to the electron cloud heat load (and available cooling capacity), whereas the 50 ns beam has more potential. The TMCI (Transverse Mode-Coupling Instability) intensity threshold of ~ 3.5E11 p/b mentioned in Oliver Bruning's talk is for the nominal machine at 7 TeV/c with the nominal collimators' settings. This value should be updated for the new optics, which will be used during HL-LHC, with the upgraded collimators (with possible copper phase 2 collimators to reduce the impedance and maybe additional collimators), and with the real collimators' settings, which will be finally decided to have a sufficient cleaning efficiency. This means that this figure of ~ 3.5E11 p/b is not yet fixed and should be reviewed as it could be higher but also lower (see also

https://indico.cern.ch/getFile.py/access?contribId=17&sessionId=1&resId=0&materialId=slides&confId=138437 at the 1st LIU_HL-LHC Brainstorming meeting on 24/06/2011, where this subject was already raised).

- The two main subjects discussed during this session were the electron cloud issue for the 25 ns scenario and the pile-up / machine efficiency / leveling for the 50 ns one.

- For LIU there are now two scenarios (for both 25 ns and 50 ns): the "baseline" and the "stretch". The first cannot provide the required parameters for HL-LHC by a factor about two, whereas the second one almost meets the goals (within few percents).

- The above analysis was done in stationary conditions. In the comparison between the 25 ns and 50 ns scenarios, one should also take into account the "transient period" and the difficulty to reach these stationary conditions. In the case of the 25 ns beam a much longer time might be needed due to electron cloud.

- Frank Zimmermann considered a set of beam parameters different from the one used by Oliver Bruning, assuming that the machine is limited by the total current. In particular he assumed an intensity per bunch of only 1.73E11 p/b within 2.8 microm which should be feasible in the LIU baseline. The different sets of beam parameters used for HL-LHC should be reviewed to check the consistency between them and give a clearer picture to LIU. Oliver Bruning reminded us that if the total current limits the machine, then it is of course much better to go to a smaller number of bunches, and in particular to go to the 50 ns beam. Note that the Task 2.6 (intensity limitation from existing LHC hardware) of the HL-LHC Work Package 2 looks into this aspect.

- In favour of the 50 ns, Frank Zimmermann reminded us that from the past discussions he had with the physics coordinator the idea of the experiments was to be able to work with ~ 400 events per crossing, guaranteeing ~ 200-300 events per crossing. This subject should be followed up and clarified as it has a huge impact on the choice of the beam to use. This could really revive the 50 ns beam.

- All the discussions we had during the session clearly revealed the difficulty to discuss the integrated luminosity as many parameters are involved such as the number of days for physics, the turnaround time, the machine efficiency etc. To avoid these endless discussions it was proposed either to discuss only the peak luminosity or if we discuss the integrated luminosity we should all use the same assumptions.

- Miguel Jimenez mentioned that the LHC was designed for an ultimate intensity of 0.86 A/beam and above a total beam current of ~ 1 A, an ion instability (like in the ISR) could appear in case a feedback effect takes place in presence of a huge electron cloud activity.

- Laurent Tavian mentioned that initially only two IRs, 1 and 5, were considered for HL-LHC, whereas one now has to consider also points 2 and 8, which changes a bit the picture in particular for the cryogenics aspects. Furthermore, if the ions are running for some time one will have much less integrated luminosity as mentioned by Oliver Bruning as one month of ions considerably reduces the proton integrated luminosity.

- Roland Garoby asked if it is still useful to consider a small bunch spacing to optimize the scrubbing? The answer was yes as this is a logarithmic mechanism, which means that it takes a lot of time to get close to the asymptotic value. Scrubbing at 10 ns or 15 ns might be a good idea to run with 25 ns beams.

- Lucio Rossi asked on which subject(s) one would devote our energy to try and find solutions for HL-LHC:

  - Oliver Bruning mentioned mainly electron cloud.

  - Ralph Assmann said he is maybe less worried by electron cloud, as the LHC seems to scrub well, but more worried by beam-induced heating.

  - Elias Metral said that electron cloud and beam-induced heatings are indeed potential worries and the loss of Landau damping of mode m = - 1 is another one as one might be short in octupoles' strength. A possible solution could be to run with a slightly negative chromaticity as this should require (much) less octupoles to damp the mode m = -1 (which is what we want!) even if the mode m = 0 will be stronger, but we think that we have sufficient strength in the transverse damper. This will be tested during MDs in 2012 and hopefully will be proposed later for operation. Note that as concerns the beam-induced heating, a Task Force has been created to review all the LHC equipments with RF fingers to check the compatibility with ultimate and HL-LHC parameters. More information should be available in fall 2012. Finally, as already mentioned above the TMCI intensity threshold for HL-LHC is not yet really known as it will depend on the collimators which will be used. This will be studied in detail in the HL-LHC WP2 Task 2.4 (https://espace.cern.ch/HiLumi/WP2/task4/SitePages/Home.aspx).

- In general, lot of questions / comments came when comparing the parameters of the two scenarios 25 ns vs 50 ns giving the feeling that the boundary conditions and assumptions on possible improvements are not identical. An effort in that direction is highly desired.