Minutes of the HL-LHC WP2 Task 2.4

6th (VIDYO) meeting on Wednesday 22/01/2014 (11:00-12:30, 6/R-018)

Task 2.4 members: Alexey Burov (AB), Alessandro Drago (AD), Alessandro Gallo (AG), Andrea Mostacci (AM), Alessandro Vivoli (AV), Benoit Salvant (BS), Bruno Spataro (BrunoS), David Alesini (DA), Deepa Angal-kalinin (DAK), Elias Metral (EM), Elena Shaposhnikova (ES), Fabio Marcellini (FM), Fritz Caspers (FC), Frank Zimmermann (FZ), Gianluigi Arduini (GA), Giovanni Rumolo (GR), Hugo Alistair Day (HAD), John Jowett (JJ), Kevin Li (KL), Luigi Palumbo (LP), Mauro Migliorati (MM), Michel Martini (MM), Mikhail Zobov (MZ), Nicolas Mounet (NM), Oliver Boine-Frankenheim (OBF), Olga Zagorodnova (OZ), Oscar Frasciello (OF), Paul Goergen (PG), Rainer Wanzenberg (RW), Uwe Niedermayer (UN), Wolfgang Hofle (WH).

Present/Excused: AB, **AD (through VIDYO)**, AG, AM, AV, **BS**, BrunoS, DA, DAK, **EM**, ES, FM, FC, FZ, **GA**, GR, HAD, JJ, **KL**, LP, MM, MichelM, MZ, **NM**, OBF, **OZ (through VIDYO)**, **OF (through VIDYO)**, PG, **RW (through VIDYO)**, UN, WH.

1) General information (EliasM):

- Restart of the Task2.4 meetings after last year devoted to build a first impedance model for HL-LHC => 1st VIDYO meeting today.

- The HL-LHC impedance model is available on the left of the Task 2.4 web page (https://espace.cern.ch/HiLumi/WP2/task4/SitePages/Home.aspx) and the direct link is http://impedance.web.cern.ch/impedance/HLLHC.htm.

- Reminder: No error bar studies and no safety factor included so far.

- As already discussed before Christmas, the idea is to freeze the impedance model as it is now and split the activities in 2:

    1) Take this model as input and make all the intensity limitations studies

        a) Vs. chromaticity, transverse damper gain, Landau octupoles etc.

        b) Study of the effect of a 2nd RF system, starting with 800 MHz as first priority but then also 200 MHz, which has been recently proposed.

        c) Interplay with beam-beam,

d) Etc. => Any other idea of things which need to be studied in detail?

=> Milestone on 01/05/2014 on first intensity limitations (with current impedance model).

2) Some people will continue and work on the impedance model (and the error bars), which we will update after the milestone of May

- If significant changes in the impedance model => Redo all the intensity limitations estimates during summer to be ready for the final report on 01/11/2014.

- Reminder on the Workshop on "Electromagnetic Wake Fields and Impedances in Particle Accelerators", Erice (Sicily, Italy), 23-29/04/2014 => Web site: https://indico.cern.ch/conferenceDisplay.py?confId=287930.

- In parallel, the e-cloud studies should continue for the

1) Cold elements of the matching section in IR1 and 5 (for which if needed we can still consider mitigation measures like coating and/or clearing electrodes as for the triplets),

2) Cold D1s (in the future we will have single bore, superconducting D1 magnets in all experimental IRs: 1 and 5 but also 2 and 8).

2) First estimates of the intensity limitations from HL-LHC transverse impedance (NicolasM): pdf

- NicolasM reminded first the changes of the HL-LHC transverse impedance with respect to the LHC one. The round optics with beta* = 15 cm has been assumed => This corresponds to the case at the end of the betatron squeeze.

- The horizontal single-bunch growth rate vs. Q' at a fixed intensity of 1.5E11 p/b and in the presence of a perfect transverse damper (with a damping time of 50 turns) for a linear bucket, the dipolar impedance only and without Landau damping, has been computed for both the HL-LHC (7 TeV) case and the typical 2012 LHC (4 TeV) case. The main conclusions are that:

1) The analytical code DELPHI (developed by NicolasM) and the tracking simulation code HEADTAIL give very similar results.

2) LHC in 2012 and HL-LHC give very similar results.

3) Both cases seem very stable for positive chromaticities, with the HL-LHC case even more stable.

- OscarF made the comment that one should try and make a comparison between HEADTAIL and DELPHI for the case of a nonlinear bucket. NicolasM answered that it is not possible for the moment.

- The same analysis has also been done for the multi-bunch case (with the 50 ns bunch spacing) and the main conclusions were quite similar as the ones for the single-bunch case.

> => It is worth mentioning that some observations made in the LHC in 2012 went into this direction as in some cases only ~ 20 A in the Landau octupoles were sufficient to stabilize the beam at the end of the squeeze with a chromaticity of ~ + 5 units. The beam became unstable only when we reduced the Landau octupoles current down to 0 (see first point of slide 6 of https://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=200145). This has to be confirmed (see Action 1 below).

- In the absence of transverse damper, the multi-bunch growth rate vs. Q' reveals again a very similar behavior between LHC in 2012 and HL-LHC, with very similar values for Q' = 0 and Q' = 15. For other chromaticities, one or the other can be slightly more critical.

- The TMCI (Transverse Mode-Coupling Instability) intensity threshold has also been looked at for the case of a single bunch, without transverse damper and for Q' = 0 (with the same assumptions as before: absence of Landau damping, linear bucket and dipolar impedance only). The main conclusions are that:

> 1) DELPHI and HEADTAIL give similar results.
>
> 2) LHC in 2012 and HL-LHC give similar results, with a slightly higher intensity threshold for HL-LHC of ~ 4E11 p/b. This confirms the result obtained by S. White on slide 5 of https://indico.cern.ch/getFile.py/access?contribId=59&sessionId=11&resId=0&materialId=slides&confId=269322.
>
> - What about the TMCI intensity threshold in the presence of the transverse damper and for positive chromaticities? Can this be a problem or should we forget about it (see Action 2 below)?

- The effect of both the nonlinear RF bucket and the quadrupolar impedance terms on the TMCI intensity threshold has also been studied with HEADTAIL for the case of the HL-LHC (with the same assumptions as before), and this resulted in a reduction of the intensity threshold by ~ 25%, with a new intensity threshold of ~ 3E11 p/b.

> - This decrease should be fully understood (see Action 3 below). BenoitS suggested checking also the evolution of the bunch length.
>
> - The TMCI should also be studied at injection, ideally including also the space charge effect, which can play an important role (see Action 4 below).

- What about the non-perfect behavior of the transverse damper, including for

instance a limit in the detection of the centroid motion (at ~ the microm level)? Some preliminary analyses by XavierB seem to indicate that it could lead to some instabilities (see Action 5 below).

- Discussing about the implementation of a wide-band transverse damper in HEADTAIL (which has been done for a single bunch by KevinL) for multi-bunch operation, the issue is the parallelization, which needs to be thought about in detail.

- GianluigiA reminded us that in case of computing power limitations, we should raise our hand and some possibilities could be found through collaborations. There is for instance a cluster in Bologne. LennyR from EPFL is also always willing to help. RainerW commented that DESY is involved in the LHC experiments and that we could contact them if needed. However, it is thought that we first need to optimize our codes before asking for such services.

- GianluigiA asked about the effect of the geometric component of the collimators in the LHC impedance model. It has been said in the past that a factor ~ 2 is missing in our impedance model to explain the measured coherent tune shifts. Including the geometric component of the collimators, what is the remaining disagreement factor? NicolasM answered that ~ 20-25% could be explained by the geometric collimators => To be done in detail (see Action 6 below).

- As concerns the effect of a 2nd RF system, KevinL started some first simulations with HEADTAIL (where a 2nd RF system is already included) but he got some puzzling results for the moment, which have to be understood better before moving ahead with more involved simulations (see Action 7 below). Reminder: both modes should be studied (BL = Bunch Lengthening and BS = Bunch Shortening), knowing that for several reasons (RF heating, pile-up density) BL might be preferred.

- What about longitudinal collective effects with 1 and 2 RF systems (see Action 8 below).

- Do we have some news in the e-cloud studies (see Action 9 below)?

- RainerW asked whether some impedance work should be performed for ALICE and/or LHCb. It was mentioned that some other equipment might be more urgent (see Action 10 below).

- GianluigiA mentioned the possibility in the future to organize a joint meeting between WP2 and WP4 to discuss all the possible issues / parameters etc. linked to crab cavities. GianluigiA asked also whether there was a need to organize any other joint meeting if there were some points where we are missing information.

- Concerning the future MD requests for LHC, it is worth mentioning that GianluigiA has been appointed as new LHC MD coordinator (with Jan Uythoven) and that they can start to collect all the requests. However, the

LHC first has to restart and 2015 might be devoted to intensity increase. The first question to answer is: what can be measured during the start-up phase? Then, some MDs could take place to prepare for what will be needed in 2016 and 2017 and then also for HL-LHC.

- It will be good also at some point to estimate the effect of a Molybdenum coating on the secondary collimators on the beam stability (see Action 11 below).

3) Actions

- Action 1 (NicolasM): Confirm that for both the LHC and HL-LHC beam stability could be reached with almost no Landau damping (as ~ observed during some MDs => Continue also the LHC data analyses).

- Action 2 (NicolasM): What about the TMCI intensity threshold in the presence of the transverse damper and for positive chromaticities? Can this be a problem or should we forget about it?

- Action 3 (NicolasM): Try and understand why the nonlinear RF bucket and the quadrupolar terms of the impedance decrease the TMCI intensity threshold from ~ 4E11 p/b to ~ 3E11 p/b (without transverse damper and for zero chromaticity).

- Action 4 (NicolasM): What about the TMCI at injection? Space charge could also play an important role.

- Action 5 (NicolasM): What about the non-perfect behavior of the transverse damper (in HEADTAIL), including for instance a limit in the detection of the centroid motion (at ~ the microm level)? Some preliminary analyses by XavierB (done with COMBI) seem to indicate that it could lead to some instabilities.

- Action 6 (NicolasM): It has been said in the past that a factor ~ 2 is missing in our impedance model to explain the measured coherent tune shifts. Including the geometric component of the collimators, what is the remaining disagreement factor?

- Action 7 (KevinL): Check that the 2nd RF system in HEADTAIL is working as it should to be able then to perform detailed beam instabilities studies in the presence of 2 RF systems (400 and 800 MHz, and then 400 and 200 MHz).

- Action 8 (ElenaS): What about longitudinal collective effects with 1 and 2 RF systems (400 and 800 MHz, 400 and 200 MHz)?

- Action 9 (GiovanniR): Do we have some news in the e-cloud studies?

- Action 10 (BenoitS): RainerW asked whether some impedance work should be performed for ALICE and/or LHCb, but it was mentioned that some other equipment might be more urgent => What is the prioritized list of impedances which need to be study in more detail?

- Action 11 (NicolasM): Estimate the effect of a Molybdenum coating on the secondary collimators on the beam stability.

4) Next meeting

- The next (7th) VIDYO meeting will be announced in due time. Please don't hesitate to contact me in case you would like to present something.

Minutes by EliasM, 25/01/2014.