Minutes of the HL-LHC WP2 Task 2.4

18th (VIDYO) meeting on Wednesday 10/12/2014 (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), Nicolo Biancacci (NB), 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, AG, AM, AV, **BS**, BrunoS, DA, DAK, **EM**, ES, FM, FC, FZ, **GA**, GR, HAD, JJ, **KL**, LP, MM, MichelM, MZ, NM, **NB**, OBF, OZ, OF, PG, RW, UN, WH, **JuanEM**, **AlexejG, RamaC, ErkJ**.

1) General information (EliasM):

- Summary of actions from last HiLumi workshop in KEK:

  - LHC impedance model presented by NicoloB is now within a factor ~ 1.5. However, it is worth remembering that in this model the resistivity of the CFC collimators is assumed to be 5 μΩm as mentioned in some measurement paper (note that I used 10 μΩm in the past). However, it seems that the average of the resistivity distribution lays more around ~ 7 μΩm (final value to be used still to be confirmed by Alessandro Bertarelli). We will update the impedance model with this value (7 μΩm), which should then decrease the discrepancy factor to a factor ~ 1.3. To be followed up but it seems that we are converging…

  - Concerning the important subject of the impedance of the Crab Cavities (CC, to be discussed in some detail today), we need to try and answer to the following questions:

    - BNL vs. ODU/SLAC: which one is better wrt impedance issues?

    - Are we sure of our results? How can we convince ourselves first and then our RF colleagues? => Try and re-do the same

analysis using only 1 mode but at different resonant frequencies, from 100 MHz till 2 GHz, by step of 100 MHz, to show the frequency dependence (question raised by ElenaS at the workshop). Compare Sacherer / Laclare (analytical formulae) to DELPHI (Vlasov solver) for any chromaticity but without transverse damper. Study the effect of the transverse damper with DELPHI.

- Would the situation be better for low chromaticity, say Q' ~ 2? Would the situation be better for a higher transverse damper gain, corresponding say to 20 turns?

- HEADTAIL (tracking) code simulations with a single bunch for any Q' and any damper => Can we confirm the DELPHI result? What about multi-bunch effects?

- What are our most precise estimates for the maximum values of R and R / Q?

- Let's assume the HOMs of different Crab Cavities are well separated, what would be our most precise estimates for the maximum values of R and R / Q?

- Considering the previous scenario, at which beta* should we collide to reach single-beam stability?

- Is the solution not to damp any HOM? In this case, what should be the maximum width of a HOM? But, as the HOMs of the different Crab Cavities are expected to be well separated, is this really feasible?

- RamaC raised at the workshop the issue of the EM simulations in time vs. frequency domain. BenoitS studied this carefully in the past and I also showed a plot at the workshop. Is it OK or do we need more studies?

- Would the use of a 800 MHz RF system be of any help here?

- Could some Q" help us here? Which values should be reached to be helpful?

- What about the nonlinear multipoles of the Crab Cavities?

- To be able to compare the Crab Cavities modes to HOMs from other equipment, what is the effect of the HOMs of

    - the normal RF cavities?

    - the experimental areas?

    - the TCTP mode?

- Everything near the high beta region

- Etc.

- Summary of our main (collective effects) messages at last KEK workshop and first discussion about operational scenarios for HL-LHC => https://indico.cern.ch/event/354507/contribution/4/material/slides/0.pdf.

- List of actions from GianluigiA for the WP2 => https://indico.cern.ch/event/354507/contribution/3/material/slides/1.pdf.
Please have a look and contact me in case of any issue with the subjects, deadlines etc.

2) Follow-up of the impedance of the Crab Cavities by KevinL, NicoloB and BenoitS:

1) KevinL: https://indico.cern.ch/event/354942/contribution/0/material/slides/0.pdf

Update of the single-bunch stability limit with HEADTAIL (HL-LHC impedance model, chromaticity, octupoles, transverse damper, without and with a double RF system – including a phase error between the 2 RF systems)

- To analyse all the simulation results, KevinL automatized the fits (which are now reliable, even if not perfect yet).

- The new result, since the HiLumi workshop where I presented some results from KevinL, is that with the BLM mode, the intensity threshold (for Q' ~ 15, + 550 A in the octupoles and the transverse damper with a damping time of 50 turns) is ~ 16E11 p/b (it was said > 7E11 p/b at the workshop as higher intensity values were not scanned yet). As a reminder, the intensity threshold for the BSM mode is ~ 3.2E11 p/b and the intensity threshold with a single harmonic system is ~ 3.9E11 p/b. Therefore, a factor 4 increase in the intensity threshold is predicted with a double RF system in BLM, compared to a single RF system, which is a huge improvement!

Study of the (single-bunch) effect of an additional HOM (as discussed during the HiLumi workshop, to study the effect of the modes of the Crab Cavities) with HEADTAIL and comparison with previous results with DELPHI

- Single harmonic, linear, RF system, Q' ~ 15, octupoles with + 550 A and transverse damper with damping time of 50 turns.
- Used classical HL-LHC impedance wake table + the additional HOM (800 MHz, 1.4 GΩ / m with a Q of 1000) => Done in PyHEADTAIL by simply concatenating a resonator wake to the existing wake fields.
- The results are:
    - Excellent agreement found with DELPHI and the previous conclusions from DELPHI are thus confirmed (growth rate,

effect of HOM damping, etc.).

- In particular, the additional mode leads to a factor ~ 2 increase in the instability growth rate.

2) NicoloB: https://indico.cern.ch/event/354942/contribution/0/material/slides/2.pdf

NicoloB compared the transverse HOMs from the BNL CC (assuming the same frequency for the HOMs of the different CC) and the HOMs from RF and experiments, weighted by the betatron function => The difference is clearly visible.

NicoloB then studied in some detail the additional HOM mentioned above to look at the possible overlap with the coupled-bunch lines and at the effect of a shift of the HOM frequency on the instability growth rate, comparing for instance the (full) Sacherer formula to a simplified formula (with only 1 line), etc.

- In particular, it can be shown that the effect of the frequency of the HOM on the instability growth rate, is "quite small" (for the values we are discussing, as mentioned during the workshop). Indeed, for frequencies < 800 MHz, the instability growth rate is always (larger) within a factor ~ 2-3, and for frequencies > 800 MHz, it is always (smaller) within a factor ~ 2-3 (until 2 GHz).

Next steps:

- Redo the DELPHI simulations (only, as confirmed by HEADTAIL) with Mo-GR collimators + CC (instead of CFC collimators + CC done until now) to estimate better the maximum allowed values for R and R/Q of the CC.
- Study of the effect of the damper with DELPHI.
- Update of the BNL HOM tables, etc. Consider the 8 CC well separated in frequency => These tables should be sent / confirmed by RamaC and ErkJ (as for instance ErkJ mentioned during the meeting that the work on the HOM damping seems not finalized).
- Where are then the new limits with the previous assumption?
- Pay attention to all the (old and new) equipment at large beta functions => As we mentioned already in the past, for instance with the new BPMs to be installed…
- Etc.

3) BenoitS: https://indico.cern.ch/event/354942/contribution/0/material/paper/0.pptx

BenoitS presented additional results from DELPHI considering the additional HOM discussed before. In this study, Q is kept constant (to 1000) and R is decreased (during the HiLumi workshop, the results of a HOM damping was discussed, i.e. assuming R/Q constant)

- Even with R/100, we still have a 50% increase in growth rate compared with the HL-LHC impedance (where CFC collimators

are used => Should be updated with the HL-LHC impedance model considering Mo-Gr collimators) without this mode for 3654 bunches. However, for single bunch stability, it would be sufficient.

- Performing a scan in frequency of the HOM is not easy (reliable yet) with DELPHI as all the CB modes are not considered (to gain some computational time) and the mode can be missed in some cases (in particular at low frequency when the width of the resonance decreases) => To be finalized but it seems that, for the reliable frequencies scanned, the expected "small" effect of the frequency (see discussion above) is confirmed. However, here is addition to what was discussed above, the transverse damper is IN which modifies the head-tail modes, etc., and more detailed studies should be performed.

2 comments from ErkJ:

- If I am not mistaken (to be checked / confirmed by ErkJ): "An impedance of 1 kΩ/m with a transverse displacement of 1 mm gives 1 V (for 1 A). This value seems very small to him and he has hard time to believe that this can do something bad to the beam (and, in particular, there should be many equipment with such a value in the LHC)" => One should thus try and explain our results following this approach, comparing for instance the transverse kick factor with the one from other (known) equipment.

- Which experiments could be done, for instance with the ATS optics, to reveal the huge impedance effect due to the beta function?

3) AOB (EliasM) => Slides from Alexey Burov (from FNAL): https://indico.cern.ch/event/354942/contribution/2/material/slides/0.pdf

I asked in parallel to Alexey Burov his predictions with his NHTVS code if one would add to the current impedance model a HOM at 800 MHz of 1.4 GΩ/m and Q of 1000. I added his slides on the site after the meeting. His conclusions are:

- To have a reasonable safety, the shunt impedance must be reduced at least 30 times.

- The alternative solution is a narrow-band damper at this mode location (and of course at the locations of any other HOM like that).

4) Next meeting

- The next (19th) VIDYO meeting will take place in 2015 and the agenda will be announced in due time.

Minutes by EliasM, 06/01/2015.