

Minutes of the HL-LHC WP2 Task 2.4

**21th (VIDYO) meeting on Wednesday 25/03/2015
(11:00-12:30, 18/3-008)**

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**, **TatianaP**, **Na Wang**.

1) General information (EliasM):

- See actions / follow-up last meeting:

- For single-bunch, a R/Q of 27 kOhm/m (for all the Crab Cavities) has been shown to have an important effect on the rise-time (\sim factor 2 compared to the rest of the machine with CFC collimators and $\beta^* = 15$ cm) and should therefore be reduced. The limit given at the KEK workshop was few kOhm/m \Rightarrow Let's study this in more in detail, see below the next steps:

a) Update the HL-LHC impedance model with Mo-Gr collimators in IP7.

b) Plot the single-bunch growth-rate vs. intensity with DELPHI and HEADTAIL.

c) Add the CC impedances (the few important modes from the real cavities \Rightarrow i.e. several resonator impedances) and plot the growth-rate vs. intensity for a β^* of 45 cm (and not 15 as we will collide at 45 cm for ultimate performance in HL-LHC)

d) see the results... and conclude...

- Do the same thing for LOF $>$ and LOF $<$ 0 as the latter sign should be

able to be used => To be (fully) confirmed by TatianaP and RiccardoDM in the future.

- Ideally, we should consider a $Q' = + 3$ units (and not ~ 15 units based on the 2012 experience).

- CerdicG sent an update of the new (back-up) RF fingers. He reduced the size of the small cavity => To be followed up.

- Benoit mentioned that Na was looking at the impact of the quadrupolar impedance on beam stability

- Some info about Landau damping (and references as requested) and effect of quadrupolar impedance can be found here: http://ab-abp-rlc.web.cern.ch/ab-abp-rlc/Meetings/2006/2006.09.19/ReviewOfSomeLandauDampingResults_19-09-06.pdf

- SC can be seen as a quadrupolar impedance depending on J_x and J_y .

- One should extend the theory to a “real” quadrupolar impedance depending on z . In fact one should try and solve a dispersion equation close to the Eq. (1) of <http://cds.cern.ch/record/739960/files/ab-2004-025.pdf> => See also the paper from Bill Ng where he in fact included the z -dependence for the space charge tune spread: Eq. (5.3) from <http://lss.fnal.gov/archive/2008/conf/fermilab-conf-08-410-ad.pdf>.

- See also: http://ab-abp-rlc.web.cern.ch/ab-abp-rlc/Meetings/2003/2003.09.26/StabilityDiagramAndTuneShift_26_09_03.tif.

2) DELPHI studies on HOM driven growth rates and CB spectrum for crab cavities (NicoloB): <https://indico.cern.ch/event/383042/contribution/1/material/slides/0.pdf>

- 2 topics treated

a) Study of the effect of overlapping modes on beam stability,

b) HOM frequency spread Vs CB spectrum.

a) Study of the effect of overlapping modes on beam stability

- Study of the instability growth rate driven by a transverse HOM with $R_s = 1.6 M\Omega/m$ per crab cavity, $Q = 1000$ and variable frequency. This means a total R_s of $\approx 1.3 G\Omega/m$ for 16 cavities at $\beta_y = 3600$ m.

- DELPHI has been compared to Sacherer's formula using both sinusoidal and Gaussian modes, without and with damper, and for $Q' = 0, 5, 10$ and 15 .

- Conclusions:

- DELPHI and Sacherer modes seems to be generally in good agreement for $Q' = 0$.

- Sinusoidal modes are more appropriate for describing the CB instability rise time for mode $m > 1$ with respect to the Gaussian ones (as discussed already in the past, see for instance: <http://cds.cern.ch/record/1051102/files/ab-2007-032.pdf>).

- The effect of damper seems to be different with respect to chromaticity. Increasing $Q' = 0$ the modes with $m > 0$ start to be damped.

- Next step : HEADTAIL simulations could help in order to understand this effect.

- Reminder: all the studies performed above have been done in multi-bunch => To be redone 1st in single-bunch to be able to compare with single-bunch HEADTAIL.

b) HOM frequency spread Vs CB spectrum

- Fixing the coupled-bunch mode number (n), the lines are spaced by $Mf_{\text{rev}} \approx 40$ MHz and shifted by $Q_0 f_{\text{rev}}$.

- Varying the coupled-bunch mode number (n), the lines spaced by $f_{\text{rev}} \approx 11$ kHz.

=> The HOM bandwidth is overlapping in most of the cases the CB lines and we should consider the worst case of mode overlapping with CB lines.

- However (next step): we should try and look into more detail to what happens if we have 2 close but separated HOMs hitting 2 different coupled-bunch modes.

- Furthermore, one should also try and zoom on the picture of slide 12 to see what happens close to a resonance.

3) HL-LHC operational scenario: Beam- beam considerations on table parameters (TatianaP et al.): <https://indico.cern.ch/event/383042/contribution/3/material/slides/1.pdf>

- TatianaP concluded that the proposed values of parallel separations (2 mm at injection and 0.75 at top energy) are fine vs. BB effects. In fact these values are historical (from the design of the LHC). The starting point was a separation of +/- 0.5 mm at the end of the ramp at 7 TeV, which gives a separation of +/- 2 mm at injection to get the same normalized separation (scaling with the square root of the energy) to have no tune change during the ramp. It was checked that +/- 2 mm at injection and +/- 0.75 mm at top energy are fine for beam-beam effects but these values are not the most optimized

ones).

- In fact it would be even better to keep the 2 mm separation at flat-top to reduce the stability diagram reduction from BBLR in the case of $\text{LOF} < 0$.

4) Next meeting

- The next (22th) VIDYO meeting will be announced in due time.

Minutes by EliasM, 30/03/2015.