Minutes of the 75th WP2 Meeting held on 23/08/2016

Participants: M. Alcaide, G. Arduini, N. Biancacci, O. Brüning, X. Buffat, R. Calaga, L. Carver, R. De Maria, P. Fessia, D. Gamba, W. Höfle, G. Iadarola, K. Li, E. Métral, D. Pellegrini, R. Tomas.

Minutes, Follow-up of Actions, General Information (G. Arduini)

Minutes have been approved with a comment from Benoit asking to specify that no forward physics for the HL-LHC implies that no roman pot will be installed in the machine and therefore they are not included in the impedance budget.

Rama and Wolfgang clarified that spectrum analyser for continuous beam spectrum monitoring is present, Wolfgang will check if automatic logging will be restored.

Expected performance of the HL-LHC transverse feedback (W. Hofle)

Wolfgang presented the improvements expected for the ADT in the future. The performance features are kick strength, signal to noise ratio (SNR), bandwidth and damping time. They have been also discussed in a workshop in Valencia in 2006.

During Run 2, ADT have been consolidated, additional pick-ups connected, new VME boards built to combine 4 pick-ups per plane/beam and disentangle gain for feedback from cleaning blow-up, new A/D. The combination of 4 pickups allows to be more insensitive to tune changes (the present system uses previous turns) at the cost of redundancy. It is also planned to have a system that combines both benefits.

New algorithms could give potential improvements in the feedback performance and diagnostic. The Observation box is under exploitation and will continue to be supported.

The BPM will benefit from large beta function and small dispersion. Riccardo clarified that with ATS the beta of one side increases naturally for low β^*, although in general one has some freedom also on the other side at flat top regardless of the ATS setting.

Also kickers will benefit from large beta functions. Kick strengths is not necessarily linked with damping time, since gain can be increased when damping noise sources without saturating kick strength. Abort gap cleaning would benefit from larger β function at flat top. Riccardo clarified that it is possible to change β function also in the kicker region with or without ATS optics provided nearby equipment accepts β function variation during the cycle.

Tetrodes need to be maintained and in the long term, if no manufacturer will be able to provide this equipment in the time scale of the HL-LHC, solid state amplifier and tunnel space will be needed.

The original layout has a reserved space for the ADT upgrade. Wolfgang clarified that this has to be meant as any transverse damping equipment.

Presently the noise level is 2 μm, and the target is 0.5 μm for the HL-LHC.

Bandwidth is the most critical figure. The system naturally has lower gain with frequency but the bandwidth can be increased digitally at the expense of a lower gain at low frequency. The system is not optimal for single bunches in a train getting unstable. If the damping time is too small (< 10 turns) the feedback might become unstable.

Gianluigi asked if one can simulate multi bunch with intra bunch motion and feedback in HEADTAIL. Kevin replied that is not available and only rigid multi-bunch motion is available in the multibunch version of HEADTAIL or for single bunches in HEADTAIL where a realistic model of the High Bandwidth Feedback has been implemented. Other tools include NestedHeadTail and DELPHI but these do not include a realistic model of a feedback. Gianluigi noted that the development of a multi-bunch simulation code should be pursued profiting of parallelization.

In summary the injection damping time is about 10 turns at the center of the batch and about half at the edges of the batch with the standard bandwidth. With enhanced bandwidth settings, damping is flat over the bunch, but achievable damping times are lower (about 40 turns). For the damping of an instability of a single bunch with the standard bandwidth settings the center of the bunch is more critical then the edges, while for enhanced bandwidth settings there is no difference along the batch.

Rogelio asked if an excitations can be applied to one bunch or all bunches for diagnostics while keeping the damping functionality. Wolfgang replied that is possible in principle, although for a 20 MHz excitation one has to expect larger damping time.

In summary bandwidth for multi-bunch modes is the most critical figure, SNR is critical for crab cavity and potential improvements exists, kick strength is sufficient. Consolidation and obsolescence might be an issue.

Gianluigi asked if the filling pattern can be included in the ADT response, in particular for 8b+4e. Wolfgang replied that it could be beneficial although it is difficult to implement it reliably. If the bunch pattern is stable, it is easier to implement specific software optimization. In case of doublet there is no need for changes provided it is sufficient to dump the centroid of the doublet.

Rogelio asked what would be needed to make the damper working close to half integer (e.g. .47-.46). Wolfgang replied that no modifications might be required although damping times might be longer.

<u>Do we need a Wide-Band Transverse Feedback in the LHC/HL-LHC (K. Li)</u>

Kevin addressed the question of the needs of a wideband feedback system for LHC and HL-LHC by reviewing the expected instabilities from impedance and electron cloud, the performance achieved by the demonstrator system installed in the SPS and finally some specifications for a potential system.

The feedback system is operationally complex and will need experts to run. Besides damping it also gives many additional potentially useful functions (e.g. control emittance of single bunches).

Present impedance models and simulations predict that the available stabilization means (Landau octupoles and ADT) should be sufficient to ensure beam stability for HL-LHC. Present e-cloud models predict that operating the HL-LHC with the 8b+4e scheme is compatible with the available cooling capacity. On the other hand, the present experience with LHC does not allow us yet to conclude that we will be able to operate HL-LHC with the nominal beam due to limitations in the available cryo power.

The instability simulations with the impedance models shows single bunch instabilities with a frequency spectrum ranging from 0.5 up to 1.5 GHz. Simulations show that, using a one-pole-roll of transfer function to limit the bandwidth, already low cut-off frequencies around just 500 MHz are sufficient to stabilize the beam due to the very low gains required as a result of the very slow instability rise times (> 60000 turns).

The e-cloud instabilities appear to be stabilized from chromaticity. The stabilizing effectiveness of a high bandwidth feedback will be studied in this context. Simulations so far show that e-cloud instabilities feature a coherent bunch centroid motion in the horizontal plane and are mitigated by the conventional transverse damper, whereas they show intra-bunch motion in the vertical plane. Gianni clarified that this simulations are potentially compatible with the instabilities observed in the machine.

The demonstrator system installed and tested in the SPS shows that the concept works in practice. The specifications scaled to LHC are within reach.

In conclusion the theoretical models predict that a wide bandwidth feedback is not needed, although these models are not completely describing the instabilities observed in the present machine.

Oliver observed that the unexplained instabilities are nevertheless stabilized. The point is whether the instabilities could be a problem, when beam parameters are scaled to HL-LHC. Kevin replied that the present understanding does not allow a robust scaling.

Kevin presented a comparison between active feedback and RF-quadrupoles. The active feedback offers additional functionalities and flexibilities that, however, come with an increased operational complexity as compared to the RF-quadrupole. Oliver argued whether the functionalities are proven to be needed. The cost of the two systems is not known yet. Gianluigi noted that a wide-band feedback would be necessary if we have a situation in which the heat load due to electron cloud is compatible with the cryogenic power but the beam is not stable. He also added that electron cloud instabilities are better controlled by chromaticity and therefore an RFQ likely would not be an efficient means to control beam stability in the presence of electron cloud. In this case a wide-band feedback would provide a better solution.

Gianluigi asked whether 2GHz is really needed since of the simulation show effectiveness at lower frequency. Elias reminded that Q" overlaps in functionality with the RFQ.

Xavier asked how the noise would scale because this appears to be an issue. Wolfgang replied that for a full bandwidth system the noise would be high, however if one designs a band-by-band approach, than noise would be much smaller as the bands are only 40 MHz wide.

Annual Meeting Program (R. Tomas)

Rogelio presented an update of the HiLumi annual meeting program. The program is available on Indico. Invitation list is not approved yet. Optimization on the schedule of the parallel session are still possible. Rama and Elias agreed that the topic of crab cavity impedance does not need to be addressed.

Reported by Gianluigi, Riccardo and Rogelio.