# Meeting of LIU SPS-BD WG on 03.11.2016

Present

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Agenda

1. Models of LLRF and beam loading measurements – P. Baudrenghien/T. Mastoridis
2. Beam loading for 8b4e vs nominal 25 ns – MD data – T. Bohl
3. Losses for 8b4e vs nominal 25 ns – H. Bartosik
4. EOY talk – E. Shaposhnikova
5. **– Models of LLRF and beam loading measurements – P. Baudrenghien/T. Mastoridis**

Feedback section uses model-based simulations of the feedback low-level RF loop (Simulink) in order to drive specifications for post-LS2 era. This presentation shows the model capability of reproduction of the actual measurements but the goal is to have requirements for future design of the hardware and not to understand the present situation.

* Historically the SPS was design for low intensity.
  + Feedback response time much longer than one turn 🡪 no effect on transient beam loading or coupled bunch instabilities.
  + One turn delay feedback then installed to sustain the 0.6 eVs for the LHC.
  + Design done to decrease impedance as much as possible.
* Model in frequency domain
  + Study the stability margins of control loops.
  + Tool to optimize the setup.
  + Understand limitations.
* Model in time domain
  + Study RF/beam interactions.
  + Give specifications for the new design.
  + Study the 200/800 MHz alignment.
* Regarding transient beam-loading, transfer function of FB contains combs at revolution frequency and at one and two times the synchrotron frequency. The phase of the open loop gain is zero degree.
* Possible to compensate the second side lobe.
* The cavity model uses an analytical formula 🡪 needs alignment with the real cavity.
* The hardware is relatively versatile, a change of optic (Q20 to Q22) could be handled.
* Answer from last meeting question: Gain not limited by one turn delay feedback.
* In frequency domain, single-station model is complete in Matlab. In time domain, the Simulink version includes all components from frequency domain.
* E. Shaposhnikova: Two main question for beam stability.
  + - Impedance seen by the beam after feedback loop?
    - Reasons of actual uncaptured losses at FB?
  + Our main concern is the prediction of beam stability in future. If we do not understand present situation, impossible to ensure stability for HL-LHC.
  + P. Baudrenghien: The purpose of the model is to design the new electronic, not understand the actual machine. All the RF system will be replaced until 2020.
  + E. Shaposhnikova: In parallel to future design, present situation should be study. Impossible to simulate beam dynamics without specifications from the feedback section.
  + P. Baudrenghien: Main focus of FB section is the reduction of transient beam loading and impedance at the fundamental.
* Next step: investigate beam loading effect along the batch (as function of LLRF parameters).
* E. Shaposhnikova: Only feedback gives effects on losses. Increase in gain increases the losses (can reach 25%). Analyzed bunch by bunch, the losses are increasing along the batch and then saturate.
* A person has to take care of this issue. Necessary to obtain specifications for actual transient beam-loading and impedance reduction from LLRF and to translate them into beam dynamics simulations (Joël, new fellow?)

**2 – Beam loading for 8b4e vs nominal 25 ns – MD data – T. Bohl**

In the last meeting, power and voltage measurements after injection was presented for the 25 ns batch used for the LHC filling. The same kind of data is presented here for the 8be4 configuration, repeated 6 times, which is known to limit the e-cloud effect. The beam-loading compensation is even worse in this case. Moreover, not only a lack of power introduces uncompensated beam-loading but also a lack of bandwidth.

* Reference concerning feedback and feed-forward: Chamonix 2001.
* Voltage compensation smaller for the head and the tail and the beam. Edge bunches suffer more in 8b4e.
* Power to compensate beam loading higher than for the 25 ns beam.
* P. Baudrenghien: Compensation rather high, why the bunch is so mismatched?
  + S shape from the PS, voltage available not sufficient during rotation.
  + SPS FB: voltage increase 🡪 satellites created; voltage decrease 🡪 uncaptured losses increase.
  + Quadrupolar damper could help?
  + Second rotation in SPS could help?
* Peak power much higher in 8b4e (transient at the head and the tail). Not better in steady state situation.
* 4 sections cavity: available power sufficient but uncompensated beam-loading still present (8b4e).
  + Comes from bandwidth limitation. 8b4e introduces 3MHz transient beam-loading, feedback limited to 1MHz (the transmitter limits the bandwidth).
* Lack of bandwidth or power produces uncompensated beam loading.
* Beam loading compensation worse for 8b4e than nominal 25ns.
* Keep in mind: Gaps are not good for fixed target experiments.

**3 –Losses for 8b4e vs nominal 25 ns – H. Bartosik**

Losses latest results for 8b4e versus 25 ns batches. E-cloud effect not dominant. Losses higher for 8b4e. The mechanism behind the losses is still not fully understood.

* Losses higher for 8b4e (FB and ramp) 🡪 reaching 20%.
* Losses more important for the first of the height bunches.
* E. Shaposhnikova: Present situation not limited by RF power, no e-cloud but already 20% losses 🡪 in future need more than 2.75 10^11 ppb at injection.
* P. Baudrenghien: losses continue all along the batch and during all the run 🡪 cannot come from a transient process.
* Future losses specifications: 7% from scrapping. Understanding of the actual losses mechanism is needed. Not sustainable for HL-LHC intensity.

Actions

* Necessary to obtain specifications for actual transient beam-loading and impedance reduction from LLRF and to translate them into beam dynamics simulations (Joël, new fellow?)

Minutes written by J. Repond