# Meeting of LIU SPS-BD WG on 13.02.2018

Present

Patrick Kramer, Joël Repond, Hannes Bartosik, Markus Schwarz, Christine Vollinger, Giulia Papotti, Thomas Bohl, Alexandre Lasheen, Ezgi Sunar, Nasrin Nasresfahani, Danilo Quartullo, Wolfgang Hofle, David Amorim, Michele Carla’, Heiko Damerau, Rama Calaga, Mario Stefan Beck, Aaron Farricker.

Agenda

1. Verification of HOM-mitigation by measurements on one section – P. Kramer
2. Measurements on 4-section cavities in SPS tunnel – N. Nasresfahani
3. First slip-stacking simulations with BLonD – D. Quartullo
4. Simulations of instabilities during ramp – J. Repond

Actions

* **M. Beck**: News on MKE impedance model should be presented at a next meeting.
* **P. Kramer**: Measurements of effect on the fundamental passband of the new 3-section HOM damping scheme.
* **N. Nasresfahani**: Study the possibility to use the new coupler design to replace all existing 630 MHz HOM couplers.
* **D. Quartullo**: Slip-stacking with intensity effects.

**1 – Verification of HOM-mitigation by measurements on one section – P. Kramer**

The efficiency of the new 630 MHz HOM (longitudinal) damping scheme for the 3-section cavity has been proven in electromagnetic simulations. Addition of new RF couplers on the top ports of the cavity pushes the electrical field to the bottom. Perturbations are added inside the pumping ports to change the field pattern and suppress the modes degrading beam stability. Even if a 3-section cavity is not yet available for measurements, the efficiency of the scheme can be tested in a single-section. This talk presents the result of this measurements.

* Simulations with new probes and perturbations on the bottom of the cavity show a factor two reduction for the maximum shunt impedance in the band (compared to what is used in beam dynamics simulations).
  + Simulations with ACE3P and CST agree.
* The perturbation (stem) is clipped in the grid of the pumping port. The port is still available for its original purpose.
* The mode needing reduction in the 3-section cavity does not exist in the 1-section.
  + A mode with similar characteristics has been found in simulation.
* Transmission measurements confirm the efficiency of the damping scheme at frequencies where the reduction is wanted.
  + However, partial agreement between simulations and measurements in R/Q for other modes in the 630 MHz passband.
* Concerning the fundamental passband a frequency shift of 18 kHz is expected from simulations of the 3-section cavity.
  + Measurements not possible since the fundamental power couplers were not installed on the 1-section cavity.
  + Wake simulations suggest no significant impact.
  + **H. Bartosik**: Are the measurements of the fundamental passband planned?
    - **P. Kramer**: Measurements should be done this year.
  + **W. Hofle**: Does the perturbation has an effect on the transverse modes?
    - **P. Kramer**: This is not studied yet.
    - **A. Farricker**: No perturbation is expected in the transverse plan.
    - **H. Bartosik**: This can be checked in simulation.
      * **P. Kramer**: We focused on longitudinal impedance until now.
      * **D. Amorim**: Studies of the 915 MHz transverse HOM have shown that below a shunt impedance of 10 GΩ/m the effect of the HOM on beam stability is insignificant.

**2 – Measurements on 4-section cavities in SPS tunnel – N. Nasresfahani**

Eight news couplers have been installed during last YETS in cavity 2 (4-section). Cavity voltage measurements with beam before the installation of the new damping scheme show a clear excitation for frequencies between 628 MHz and 630 MHz. The performances of the new couplers need assessment. This talk presents transmission measurements with and without load on new couplers to estimate their efficiency.

* Transmission measurements show a clear reduction of the modes for which the new probes were expected to act.
  + Impedance seen by the beam cannot be extracted from these measurements.
* Measurements agree with predictions in simulation.
* No effect on the fundamental passband.
  + Measurements from different probes (individual field probes) show no effect in the 200 MHz passband.
* **H. Bartosik**: Can we do measurements with the beam?
  + **N. Nasresfahani**: Have been done last year. Show clear excitations in the frequency range 628-630 MHz. Will be done again this year to see the reduction.
* **N. Nasresfahani**: The new couplers perform well. The existing couplers could be replaced 🡪 possibly better performance which would allow to have free ports on the top of the cavity.
  + **H. Bartosik**: Studies needed.

**3 – First slip-stacking simulations with BLonD – D. Quartullo**

The baseline scheme for the production of an HL-LHC ion beam in the SPS requires momentum slip-stacking to reduce bunch spacing and double the number of bunches in the LHC. This scheme cannot be tested before RF upgrade (LS2) and backup scenario are developed in parallel. However, particle simulations suggest the feasibility of the slip-stacking in the SPS with bunch rotation before extraction to the LHC to meet the HL-LHC beam parameters.

* HL-LHC project aims at a doubling of the nominal peak luminosity of the ion beam.
  + 🡪 The number of bunches has to be doubled. This can be achieved by slip-stacking.
* Measurements cannot be done before RF upgrade (LS2).
* **W. Hofle**: Can we have a stability problem in transverse plan during the process?
  + **H. Bartosik**: For ions the transverse damper is active at flat bottom only.
* At which energy slip stacking should be performed?
  + At flat bottom: strong space-charge, intra-bunch scattering and RF noise.
  + At flat top: extra time needed for filamentation (smaller synchrotron frequency), uncaptured beam will be transferred to LHC.
  + An intermediate plateau at 300 GeV has been chosen to minimize space-charge and to have an energy smaller than then one at flat top where the intensity threshold is minimum.
* A new momentum program is designed with a plateau of 1.2 sec at 300 GeV.
  + **H. Bartosik**: The start of acceleration for the new momentum program seems quite aggressive, can we do it in operation?
    - **T. Bohl:** With ions in operation the acceleration is quite fast.
    - Should be studied.
* The voltage program is designed to keep a constant filling factor.
* The bunch length at flat top has to be reduced. The maximum voltage available is 15 MV. The two possible options are: bunch rotation or adiabatic bunch compression.
* Measurements from A. Lasheen exhibit big variations along the batch in intensity and bunch length at various point of the ramp.
* **W. Hofle**: Does the transverse size of the bunch matter during the process?
  + **H. Bartosik**: Studies needed, high energy.
* **H. Bartosik**: The maximum RF voltage amplitude during slip-stacking is predicted to be 0.62 MV. This value seems quite low.
  + **T. Argyropoulos**: This is what we compute. In reality the voltage will be higher because the emittance will be smaller than the one used in simulation (large tails).
* The Bunch compression with 15 MV will not be sufficient to reach HL-LHC parameters (Q20)
  + Bunch rotation needed.
* With Q22 and Q26 optics 🡪 less voltage needed but the process takes more time. Better results on flat top (losses and bunch length) with Q22/Q26 than Q20.
* **W. Hofle**: The choice of 300 GeV for the plateau should maybe be adjusted for the different optics.
  + **T. Argyropoulos**: We use the most stable region that we found in measurements. It can be refined now by simulations including intensity effects.
* Next step of the study: add intensity effects in simulation.
* **H. Bartosik**: When you changed the optic, did you change the length of the plateau?
  + **D. Quartullo**: The length of the plateau is the same for the three different optics but the maximum momentum is adjusted.
* **H. Bartosik**: The momentum aperture available (in simulation) has to be compared with measurements.
* **A. Lasheen**: To estimate more accurately the losses in the LHC, it would be important to take into account the real RF separatrix of the LHC and not only a 2.5 ns long cut like it is done now. The edges will be lost in the LHC.
* **H. Damerau**: Is it possible to test the injection to the LHC? Can we do bunch rotation at SPS flat top (AWAKE)?
  + 🡪 Ask beam control.
  + **A. Lasheen**: For awake a few microseconds is needed for the voltage to rise (1 turn assumed in simulation)
  + **W. Hofle**: It could be possible, to be checked with T. Bohl.
* **H. Bartosik, W.Hofle**: Is there beam measurements of ions after transition crossing?
  + **D. Quartullo**: Not yet.
* **W. Hofle**: Did you try a combination of bunch compression and bunch rotation?
  + **T. Argyropoulos, H. Damerau**: From experience, in general this combination makes the rotation less efficient.
* **H. Damerau**: Is it possible to blow-up artificially the beam and extract it to LHC to see if the tails are visible for LHC?
  + **G. Papotti**: BQM threshold on paper was 1.6-1.7 ns but now it is higher (2.1 ns).
  + **H. Damerau**: Can we arbitrarily increase the bunch emittance to check this?
* **H. Bartosik**: Do the latest results agree with studies done in the past?
  + **T. Argyropoulos**: Yes, mostly.

**4 – Simulations of instabilities during ramp – J. Repond**

Stability thresholds have been measured during acceleration cycle. Batches of 12 bunches have been used to enable acceleration with and without feedback in a single RF system. This talk presents the comparison of the measurements with simulations.

* Observations from measurements
  + Threshold is minimal on flat top.
  + Threshold exhibits no energy dependence when feedback is on.
  + Threshold weakly affected by longitudinal damper 🡪 can be neglected in simulation.
  + Instability observed on flat bottom for small bunch length (2.75 ns) and intensity larger than nominal ().
* The bunch length after filamentation is smaller for a batch of 12 bunches than 72 🡪 effect of phase-loop.
* It the case with feedback on the bunch length measured after capture increases with intensity.
  + Simulations show that the increase of bunch length remove the energy dependence of the threshold.
* Simulations and measurements are in agreement at the end of the ramp and flat top.
* Uncompensated beam-loading from feedback gives a bunch-to-bunch synchrotron frequency shift which improves stability.
* Difficulties to reproduce flat bottom instabilities.
  + Longer flat bottom in measurements than in simulations.
  + Bunch distribution different between simulations and operation (bunch rotation in PS).
* **H. Bartosik**: What are the key studies/measurements of this year regarding beam stability?
  + Understand the cause of flat bottom instability (single- and multi-batch).
  + Threshold for larger number of bunches (48) for impedance model benchmarking.
* **W. Hofle**: Can we investigate in simulation the gain of the feedback needed to improve sufficiently the stability?
  + It would be possible but we are not sure yet how to model accurately the effect of the feedback (on impedance) after LS2 in simulation.
* **H. Bartosik**: Is it possible to use an RF amplitude variation to profit from the stabilization effect of the bunch-to-bunch synchronous phase shift?
  + **T. Bohl**: Yes but it would be easier after LS2.
* **W. Hofle**: How the result of the simulations is modified if the bunch-to-bunch variations of intensity/bunch length is taken into account?
  + This is not studied yet. The first task was to understand the overall process before trying to reproduce the details.

Minutes written by J. Repond