# Meeting of LIU SPS-BD WG on 17.08.2017

Present

Elena Shaposhnikova, Rama Calaga, Eric Montesinos, Patrick Kramer, Joel Repond, Alexandre Lasheen, Giovanni Rumolo, Giovanni Rumolo, Thomas Bohl, Fritz Caspers, Nasrin Nesresfahani, Aaron Farricker, Giulia Papotti, David Amorim, M. Schwarz, Marcin Patecki, Michele Carla, Angela Saa Hernandez

Agenda

1. New 628 MHz coupler; the design procedure and evaluation – N. Nasresfahani
2. Review of the SPS impedance model – A. Farricker
3. Measured beam losses in Q20 and Q22 cycles – M. Schwarz
4. Measured instability thresholds during ramp – J. Repond
5. Future instability thresholds in simulations with beam loading limitation – J. Repond

Actions and follow-up

* **N. Nasresfahani, P. Kramer**: Give to E. Montesinos the mechanical drawing of the new coupler to analyze the feasibility.
* **N. Nasresfahani, P. Kramer**: Study the new couplers in the SPS cavity 2 and the 3 sections.
* Prototype of the new coupler to measure in the two sections cavity in the workshop.
* **J. Repond**: Study the 200 MHz main impedance during acceleration regarding instabilities. Simulations on flat top with further damping of the main 200 MHz harmonic.
* **J. Repond**: A prototype of the new HOM coupler could be installed on cavity 1 during YETS. Verify in simulations if it is possible to observe any effect on beam stability to prove the efficiency of the probe.

1. **New 628 MHz coupler; the design procedure and evaluation – N. Nasresfahani**

The damping of the 630 MHz HOM of the 200 MHz SPS RF cavities is necessary to ensure the stability of the future high intensity HL-LHC proton beam. This talk presents the last results concerning the HOMs study and the design of a new coupler which could damp further the modes.

* The original design of the coupler was based on a single section.
  + Good performance in the range 628.5-631.5 MHz.
  + Main contributions to the impedance in 4 sections do not exist in single section 🡪 undamped by current coupler.
* Design of a new coupler which captures the electric field of the undamped mode.
  + Single cell simulations show an effect on the mode 🡪 damping in 4 sections expected.
  + Transverse 938 MHz HOM couplers have no negative effect on these modes.
  + Simulation using the SPS 200 MHZ cavity 1 (4 sections) shows a reduction by a factor 3.3 of the shunt impedance.
  + New coupler has no negative effect on the fundamental passband.
* Next step:
  + Study the second 4 sections cavity (location of the couplers different).
  + Study the 3 sections cavities.
* **E. Shaposhnikova**: Does these undamped modes exist in the 3 sections cavities?
  + **N. Nasresfahani**: The high Q mode in the 4 sections cannot exist in the 3 sections (nor in the 5 sections). The lowest Q exists and the coupler will have an effect.
* **E. Montesinos**: The mechanical drawing file should be provided to study the feasibility. A 3D printed version could maybe be installed during the next YETS. No problem to install it during LS2.
* **P. Kramer**: The same modes exist in the two sections cavities (symmetric), would it be possible to measure the efficiency of the coupler using the two sections cavity currently in the workshop?
  + **E. Montesinos**: The cavity will not move before October/November. If a prototype is available, the measurement can be done.
* **E. Shaposhnikova**: If the damping is less effective in the 3 sections cavities, can a total damping by a factor more than two still be obtained?
  + **N. Nasresfahani**: The coupler can still be optimized by adding a few centimeters to the rod 🡪 more margin available.
* **N. Nasresfahani**: The loop design discarded because negative effect on the fundamental passband.

**2 Review of the SPS impedance model – A. Farricker**

The beam measurements suggest some missing impedance in the current SPS impedance model. This talk gives a review of what is in the model and what can be missing.

* Main elements dominating the overall impedance in the SPS:
  + Traveling wave cavities.
  + Kicker magnets.
  + Vacuum flanges.
* Currently 900 components included in the model.
  + 600 are vacuum elements.
  + Vacuum report suggests 1009 changes in cross-section 🡪 significant number of possible missing elements in the model.
* Synchrotron frequency shift measurements and simulations exhibit a missing impedance which could sit around 350 MHz.
  + Unlikely to be caused by purely geometric shape unknown but more likely by an element containing a material with high permittivity or a port which is unshielded.
* **F. Casper**s: Different possibilities:
  + The permittivity of the ferrite elements is often neglected in simulations.
  + The external circuitry around the isolated flanges exhibits resonances around 200/300 MHz.

🡪 Possible external source of impedance, external cables resonate.

* + The isolation of the flanges does more bad than good and should be removed.

**3 Measured beam losses in Q20 and Q22 cycles – M. Schwarz**

The mechanism resulting in losses on the SPS flat bottom is still not fully understood. This talk presents the latest measurement results in two different optics.

* Data acquired on the 2nd and 16th of August.
* Two types of losses:
  + Fast losses at injection, uncaptured beam.
  + Continuous losses along the flat bottom.
* Focus put on continuous losses (particles spilling out of the bucket).
* In Q20 and Q22 the losses are intensity dependent (higher losses for higher intensity).
* Loss rate higher with increased voltage on flat bottom.
* **E. Shaposhnikova**: An increase of voltage should decrease the loss rate if a RF noise is responsible of the particles spilling out of the bucket. The total losses at acceleration should not be affected.
  + Electron cloud?
* **G. Rumolo**: The BCT shows a slope too 🡪 this is not particles lost from the bucket, this is particles lost from the machine.
  + Unless a non-identified element in the ring scrapes the beam.
  + **E. Shaposhnikova**: The momentum aperture is small (factor two with momentum spread) and particles spilling out can be lost immediately.
* With and without tune kicker, continuous losses are comparable (same loss rate).
* Without intensity effects particles can still be lost from the bucket due to RF noise.
  + Higher voltage it should mitigate the loss rate.
  + Some improvements have been seen in Q26 optic by increasing the voltage (few percent).
  + Recaptured beam? 🡪 Not obvious.
* **R. Calaga**: Continuous on the long flat bottom 🡪 Coherent noise scraping the beam.
  + **E. Shaposhnikova**: If due to RF noise, it should not be intensity depend when normalized by intensity.
* **F. Caspers**: Oscillations of the trace of the intensity are not white noise 🡪 Fourier transform to see if there is any peaks.

**4 Measured instability threshold during ramp – J. Repond**

No clear coupled bunch modes driving the instability during acceleration were observed in the past. This talk presents the latest results of measurements using batches of 12 and 24 bunches studying the instability threshold in function of energy. The effect of the feedback is analyzed.

* Data acquired on the 12th of July 2017
* LHC 25 ns nominal cycle used
  + Q20
  + Single RF
  + Phase loop on, longitudinal damper on, feedforward on, feedback on/off, blow-up off.
  + Batches of 12 and 24 bunches with nominal emittance and varying intensities.
* The instability threshold is minimal on flat top.

🡪 Supports the analysis of the thresholds done on flat top.

* The coupled bunch instability behavior is observed without feedback.
* A batch of 24 bunches is more stable.

🡪 Bunch length of the batch of 12 bunches smaller.

🡪 Effect of the phase loop.

* Instability threshold higher with feedback on for 12 and 24 bunches.
  + 200 MHz impedance dominates during acceleration?

🡪 Simulations needed to confirm this hypothesis.

**5 Future instability thresholds in simulation with beam loading limitation – J. Repond**

The previous instability thresholds obtained on flat top were simulated assuming a 200 MHz voltage constant with intensity. More accurate threshold are presented in this talk, taking into account the limited power available. The maximum voltage in the cavity is function of the RF current and thus is intensity dependent.

* 10 MV at 200 MHz was assumed in the past for the post-LS2 scenario. Due to beam loading limitation, this voltage is available for intensities smaller than ppb only.
* Previous simulations were done again taking into account the beam loading limitation, for different batch configuration (48, 72, 80 bunches).
* Main observations:
  + The threshold flattens due to less voltage available at high intensity.
  + HOMs and QF thresholds close to each other.

🡪 Impedance reduction of both necessary.

* + Thresholds for 48, 72, 80 bunches similar.

🡪 No gain in stability to use BCMS beam.

* + HOMs damping by a factor 3 and shielding of the QF flanges ensure stability of the HL-LHC proton beam on the 0.5 s SPS flat top.
  + HOMs damping until a factor 4 improves the stability.
    - It has been observed that a damping by a factor 100 reduces the stability compared to a factor 3 due the broad-band nature of the resonator in this case.
* **P. Kramer**: If the impedance of the HOMs and the QF must be reduced together to observe a significant increase in stability threshold, will it be possible to measure an effect of the new 630 MHz coupler in the current configuration?
  + The effect of the HOMs damping alone is more important than the QF shielding alone but simulations are necessary to confirm the feasibility.

Minutes written by J. Repond