# Meeting of LIU SPS-BD WG on 15.06.2017

Present

Theodoros Argyropoulos, Thomas Roland Kaltenbacher, Patrick Kramer, Joel Repond, Christine Vollinger, Elias Metral, Danilo Quartullo, Hannes Bartosik, Alexandre Lasheen, Giovanni Rumolo, Thomas Bohl, Nasrin Nasresfahani, Giulia Papotti, David Amorim, Markus Schwarz

Agenda

1. Minutes and actions – E. Shaposhnikova
2. Space charge studies with protons for ions – H. Bartosik
3. Beam losses in simulations and recent MDs – M. Schwarz
4. Evaluation of the optimized 628 MHz coupler – N. Nasresfahani, P. Kramer
5. Review of the SPS impedance model – T. Kaltenbacher

Actions

* Analysis of the Coast MD in Q20 and Q26 (J. Repond).
* Study the problem of the definition of the separatrix for a time dependent Hamiltonian.
* Use bunch profiles after rotation in the PS for the losses simulations.
* 6th of July: technical stop 🡪 measurements before the removal of the soft clamps.
* Evaluate the differences between 3 and 4 sections (N. Nasresfahani, P. Kramer).
* Assess the natural spread of the HOMs between the 3 and 4 sections cavities (N. Nasresfahani, P. Kramer)s
1. **–** **Minutes and actions – E. Shaposhnikova**

Review of the actions from last time.

* Decision about the shield of the QF vacuum flanges in the short straight section and the sliding RF fingers has been taken during the SSS QF shield Review. The shield with the RF fingers continues to be used.
* Concerning the Coast MD in Q20/Q26, the data has been taken. Analysis pending (Joël).
* Questions about the HOM of the 200 MHz cavities in longitudinal and transverse plan will be addressed during this session.
	+ Remaining question: How much reduction of transverse 938 MHz damping is possible? Damping by a factor two for the moment, could be difficult to damp less.

**2 – Space charge studies with protons for ions – H. Bartosik**

The future working point in tune diagram for the ions in Q20 has not been much studied in operation yet. Measurements have been taken using a single proton bunch with high brightness to mimic the larger space charge of the ions. Scanning the area around the working point for ions, a new potentially harmful resonances has been found.

* Ions: lower intensity but lower energy 🡪 more space charge, tune spread larger.
* MD done at the end of 2016.
* Observed: significant beam degradation on the long plateau for ions and not much experiment in their optimal operation area.
* A sextupole kicker has been added to excite the vertical third order resonance close to the working point.
* The closer to the resonance, the more the losses are pronounced.
	+ Emittance reduction when operate on the line (violent losses).
* Beam response as expected from periodic resonance crossing (synchrotron motion and space charge).
* Unexpected behavior for Qx larger than 20.39.
	+ Another resonance is crossed at Qx = 20.40.
	+ Two candidates.
		- 5th order systematic resonance (not suppressed by the symmetry of the machine) 🡪 excited by the b5 component of the dipole magnets.
		- 10th order resonance driven by non-linearity of space charge potential (appears clearly in simulation with space charge only).
* **E. Shaposhnikova**: Try with lower intensity to lower the space charge effects.
	+ **H. Bartosik**: It has been tried but the result is not clear for the moment.

**3 – Beam losses in simulations and recent MDs– M. Schwarz**

This talk gives an update on the MDs and simulations concerning the injection losses.

* Simulations:
	+ 72 bunches spaced by 25ns.
	+ Injected at the center of the RF bucket.
	+ Gaussian bunch profile with a length of 3.6 ns (4 sigma).
	+ Feedback mimicked by an impedance reduction factor proportional to the impedance of the RF cavity (ZRF) and a strength exponentially increasing with a time constant of 3 turns.
	+ Feed-forward not included.
* Losses are computed by evaluating the separatrix and checking how many particles are inside.
	+ **E. Shaposhnikova**: For a time dependent potential, the separatrix is not well defined.
	+ **T. Argyropoulos**: The motion should be slow enough to keep the usual definition.
	+ **Action**: evaluate this problem.
* The shape of the losses along the batch correspond to the one observed in measurements in 2016.
	+ Unexplained 15% offset starting from the first bunch.
	+ **E. Shaposhnikova**: The rotated bunches from the PS should be used, not Gaussian.
* **E. Shaposhnikova**: could this offset comes from transverse effects?
	+ There is no longitudinal impedance in the model that lasts 23 μs.
	+ Geometrical losses (bunch shape coming from the PS)?
		- **A Lasheen**: cannot explain 15%. The MD was not totally successful, this measurement should be done again.
		- **H. Bartosik**: The data presented here is the profile sum, uncaptured beam still appears on the (DC) BCT.
		- **T. Bohl**: Such high amount of losses cannot be trusted. Something went wrong.
* Observations from MDs last week:
	+ Measurements of the cavity voltage at injection 🡪 the feedback reacts over 3 turns in the four cavities.
	+ The pattern of the losses along the batch does not appear anymore.
* The induced voltage in simulation decreases to 20% of its maximum value with the feedback correction whereas the measurement shows a decrease to 10%.
	+ **E. Shaposhnikova**: The plot of the induced voltage shows that the losses are defined during the first 40 turns (~ half synchrotron period).
* Next steps.
	+ Use bunch profile after rotation in the PS.
	+ Include feed-forward.
	+ Use a feedback based on the beam signal.
* **E. Shaposhnikova**: In measurement we should use a small ramp to 30 GeV to clean the uncaptured beam.

**4 – Evaluation of the optimized 628 MHz coupler – N. Nasresfahani, P. Kramer**

The macroparticle simulations show that the 630 MHz HOM of the 200 MHz cavities is critical for beam stability and must be decreased by a factor 3. The way to achieve this factor is not yet clear. This talk gives an update on the actual knowledge.

* Optimization started from single cell because the size of the problem with 4 sections is too heavy in simulation.
* Single cell.
	+ The couplers break the mode in two other close modes.
		- One is well coupled to the probe, the other not.
	+ Playing with the length of the coupler a reduction by a factor 2.6 in the peak value of the impedance is achievable.
* 4 sections.
	+ Other modes appear, not considered in single cell 🡪 the probe is not optimized for these modes.
	+ The reduction factor decreases to 1.6.
	+ Idea: go back to single cell and optimize the coupler for the new modes.
	+ There is a difference between one section and four sections 🡪 we cannot rely on simulations of a single section only.
* Idea to optimize the probe: approximate couplers by equivalent circuit at 628 MHz (the mode not affected by present coupler).
	+ First approximation presented to compute the power evacuated by the probe.
	+ Different ways to increase this power.
		- Increase the current 🡪 increase the length, more surface.
		- Increase the probe capacitance.
		- Decrease the load.
	+ How to increase the capacitance?
		- Add an inductance in the circuit.
		- Use a lambda/4 transformer.
	+ By increasing the capacitance, a factor 3 reduction in single cell seems feasible.
* **E. Shaposhnikova**: Which reduction factor can we guarantee for the moment?
	+ **N. Nasresfahani**: 1.5 could be achieved.
* **E. Shaposhnikova**: Do you expect a big difference between 3 and 4 sections?
	+ **N. Nasresfahani**: Big difference between 1 and 4 sections 🡪 there will be a difference.
		- **Action**: It has to be assessed.
* **T. Bohl**: What is the tolerance between the simulations and reality?
	+ **N. Nasresfahani**: The equivalent circuit is modeled based on the impedance of the cavity which is measured. We do not expect big difference after LS2.
* **E. Shaposhnikova**: Depending on the natural spread of the cavities, a smaller reduction factor would be necessary.
	+ **Action**: Assess the natural spread between the 3 and 4 sections.

**5 – Review of the SPS impedance model– T. Kaltenbacher**

Last update on the SPS impedance model. Present different simulations results not shown before.

* QF-QF (no bellow) vacuum flange model 🡪 discrepancy w.r.t. J. Varela results.
	+ The high frequency mode (above 4 GHz) is totally different between the two models.
		- Above cut-off, should not be harmful for the beam.
	+ N. Nasresfahani: Q value from Wakefield and Eigen mode simulations cannot be the same, only the peak (Rsh) must be the same. Wakefield simulations give you the loaded Q value whereas the Eigen mode solver gives the unloaded Q. See the reference:

T. Suzuki, On The Coupling Impedance Of A Resonant Cavity,
  IEEE Trans. Nucl. Sci. 28(1981)2566, doi:10.1109/TNS.1981.4331758

* + Further studies are needed.
* Gasket gap filling gives good results in impedance reduction and can be easily installed on various flanges.
* We still don’t know how many unshielded pumping ports are in the machine.
* VVSF fast vacuum valve.
	+ Injection.
	+ 2 items in the SPS, should be confirmed.
	+ Further simulations needed to confirm the impedance.
* LHC-BGI
	+ Removed from the LHC because of heating issues.
	+ Currently two devices in the SPS.
	+ NEG coating? 🡪 Must be checked.
	+ Further studies needed.

Minutes written by J. Repond