**Meeting of LIU SPS-BD WG on 09/10/2014**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Fritz Caspers, Juan Esteban Müller, Giovanni Iadarola, Verena Kain, Alexandre Lasheen, Danilo Quartullo, Giovanni Rumolo, Benoit Salvant, Elena Shaposhnikova, Mauro Taborelli, Helga Timko, Jose Varela Campelo, Carlo Zannini;

**Agenda:**

1. Benchmarking the SPS impedance model: Headtail growth rates – C. Zannini
2. Update on reduction of the SPS vacuum flanges impedance – J. Varela Campelo
3. Short update on the SPS MD planning – G. Rumolo

Elena gave a short summary of the LIU SPS presentations in the Chamonix workshop

* Interesting options for further increasing the SPS performance were presented
  + Q22 optics for reducing required RF power during the ramp
  + 80 bunch scheme for increasing number of colliding bunches in LHC
  + Impedance reduction of flanges for increasing longitudinal instability threshold
  + Bunch rotation at flat top to allow transfer of larger longitudinal emittance to LHC
* It became clear that RF power limitations along the ramp will require to reduce the ramp rate for LHC beams even after the LIU RF upgrade

1. **C. Zannini – Benchmarking the SPS impedance model: Headtail growth rates**

The benchmarking of the latest SPS transverse impedance model with various measurements was presented.

* Using the analytical formula for the mode 0 coherent tune shift, the SPS transverse impedance model can reproduce more than 90% of the measured vertical coherent tune shift in the Q20 optics. As predicted by the model there is practically no tune shift measured in the horizontal plane. The bunch length in the measurements was kept close to the normal operational conditions for LHC beams (about 3 ns). Future measurements could be done with different bunch lengths to study the effective impedance as function of frequency. Furthermore the tune shift obtained in HEADTAIL simulations should be compared to the measurements (this would be interesting because in longitudinal the results are different for analytical calculations and for macroparticle simulations).
* The measured TMCI threshold as a function of longitudinal emittance at injection is well reproduced in HEADTAIL simulations, for both the Q26 and the Q20 optics. The characteristics of the measured intra-bunch motion are observed also in the simulations.
* The latest benchmark was done using the measurements of the mode 0 growth rate for different values of negative chromaticity at injection energy (above transition). The growth rate was determined from the evolution of the amplitude of the mode 0 peak in the FFT of the vertical centroid position. They were compared with the analytical formula of the growth rate using the real part of the effective dipole impedance of the model, and with HEADTAIL simulations. In the Q20 case, both agree within 15-20% with the measurements. Also the pattern of the intra-bunch motion agrees between measurements and HEADTAIL. In the Q26 case, even better agreement within 10% is obtained between the HEADTAIL simulation and the measurement for the full range of chromatic frequencies up to 1.8 GHz. The analytical formula shows significant discrepancy and this needs to be further investigated. One of the possible reasons could be that the formula is based on Gaussian distributions with single harmonic RF while the measurements were done in double harmonic (with 1:10 voltage ratio).

1. **J. Varela Campelo – Update on reduction of the SPS vacuum flanges impedance**

The status of the studies on the impedance reduction was presented.

* The high-impedance SPS flanges have been categorized into 2 groups. Group I consists of those flanges having MBA or QF beam pipes attached. Those flanges having QD beam pipes attached constitute Group II. The former group is responsible of the 1.4GHz resonance. The later, of the 1.8 and 2.5GHz resonances.
* In principle, partial shielding can only be applied to the flanges belonging to Group I. Mainly, due to space limitations
  + A shield consisting of an array of wires can reduce the R/Q of the 1.4GHz resonance by factor 5-8. Bead-pull measurements of a hand-made wire array shield confirm the simulated R/Q reduction.
  + A shield made of a thin metallic sheet gives a factor 5-12 reduction of R/Q at 1.4 GHz, as shown in simulations and measurements. Different scenarios where there are imperfect contacts between the flange and the vacuum flange are currently under study. The cases covered so far do not show significant impedance increase with respect to the shielded case. Potential issues could arise from transverse movements of the bellow resulting in the shield going into the aperture of the machine (mechanical studies needed).
  + The aforementioned reduction factors include modifying the side that does not have bellows to reduce the gap between flanges. Without this modification the R/Q reduction factor would be 3-4 and 3-6, for the wire and thin sheet shields respectively. The mechanical implementation of this gap reduction needs to be addressed.
  + Any combination of both types of shields (horizontal sheet and vertical wires, metallic strips…) will also significantly reduce the impedance of the vacuum flanges. Conceptually, these hybrid cases are the same as a wire array or a metallic sheet. Many of these cases have already been assessed. This freedom degree can be used to address mechanical requirements.
  + EN-MME and TE-VSC should now be involved for the initial phase of design studies. Brennan Goddard is already in contact with them.
  + The cost for modifying the ~200 Group I flanges would be about 250 kCHF.
* A complete redesign of all flanges is also an option:
  + Most effective for impedance reduction: up to a factor 20 in R/Q at 1.4 GHz for Group I flanges. Further impedance reduction might be achieved by optimizing the vacuum seal of the circular flanges.
  + The exchange of flanges with the new design would concern the BPHs as well as the Quadrupoles and sextupoles/octupoles in short straight sections.
  + Also the transverse impedance needs to be addressed and studied carefully.
  + It should also be studied if the ceramic coating in flanges is necessary or if it could be avoided by slightly redesigning the grounding cables. The ceramic coating is expensive and difficult to produce.
  + The criticality with respect to fatigue caused by mechanical stress needs to be taken into account (e.g. for elliptical bellows).
  + The costs for producing and exchanging all the ~550 flanges (both Group I and II) would be on the order of 3 MCHF.
* The decision about the impedance reduction campaign during LS2 needs to be taken in 2015 since it requires a long preparation time.

1. **G. Rumolo – Short update on the SPS MD planning**

A summary of the dedicated MD of week 41 was presented. In parallel to aperture measurements on the SFTPRO cycle, up to 72 bunches of the 25 ns LHC beam were accelerated to 110 GeV. No emittance blow-up along the train was observed with bunch-by-bunch wire scan measurements on flat bottom. The last few hours were dedicated to instability measurements during acceleration of 12 bunches.

Conclusions from the first SPS MDs in 2014:

* Having a scrubbing run right after the startup (as foreseen in the original planning) is not a good idea: it would not be very efficient due to vacuum limitations coming from critical machine elements (kickers, ZS, …), which prevent at this stage the injection of long LHC trains (only up to 48 bunches accelerated to flat top for now!).
* LHC beams still require tuning in the PS

Minutes written by Hannes Bartosik