**Meeting of LIU SPS-BD WG on 24/10/2013**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Thomas Bohl, Stephane Cettour-Cave, Juan Esteban Muller, Jose Ferreira Somoza, Giovanni Iadarola, Giovanni Rumolo, Benoit Salvant, Elena Shaposhnikova, Helga Timkó, Jose Varela Campelo, Carlo Zannini;

**Agenda:**

1. Short update on the SPS vacuum flanges – J. E. Varela Campelo
2. Latest results of simulations of the SPS impedance – H. Timko
3. SPS impedance reduction – E. Shaposhnikova

**Presentations:**

**1. Jose Varela Campelo: Short update on the SPS vacuum flanges**

The simulations of the flanges installed between the BPVs and the QD vacuum chambers were performed and added to the impedance inventory. The main resonance of these flanges is at around 1.21 GHz with a shunt impedance of around 600 kΩ and a quality factor Q of about 300.

The DC conductivity of the Nickel-Chrome layer on the damping resistors was measured in the lab through a DC measurement of the DC resistivity, yielding 15.7 S/m (while a conductivity of 10 S/m was assumed in previous simulations). Including the damping resistor with the measured conductivity value in the simulation of the test-bench setup of the bellow/flange yields excellent agreement with the measured resonance frequency and Q. The properties of the damping resistor are thus sufficiently benchmarked and calibrated for the simulation of other bellows/flanges with damping resistor.

*Jose Ferreira is preparing an inventory and survey of the different SPS flanges and their status with respect to the damping resistors. At present there exist about 20 spare damping resistors, but it seems there are many damping resistors missing in the machine. In order to be able to manufacture new damping resistors, their mechanical characteristics (dimension of coating, material, dimensions, type of ceramic, …) need to be specified as this information is presently not available. A summary of the work of the vacuum group on the flanges and damping resistors will be presented in one of the next LIU coordination meetings.*

*Whenever a flange is opened due to a future intervention and in case the damping resistor is missing, it should be installed and put in place. The problems is that sometimes the wire, which is supporting the damping resistor, is also not present in the bellow and so the damping resistor cannot be installed.*

**2. Helga Timko: Latest results of simulations of the SPS impedance**

The main sources of uncertainty in the simulations, like the longitudinal phase space distribution and the precise knowledge of the longitudinal impedance of the machine, were addressed systematically and the respective sensitivity of the simulations studied. For simplification, the impedance of the flanges is represented by a single broadband resonator. The impedance model of the kickers has also been updated (now the impedance is about 30% lower). In the HEADTAIL simulations the kickers are now represented by 8 resonators, which are fitted to the wake field obtained from the CST simulations. The impedance of the travelling wave cavities is based on analytical calculations performed by G. Dôme in 1977.

The measured de-bunching spectra were compared with HEADTAIL simulations for different longitudinal distributions. On one hand, the 6 distributions measured with the tomoscope in the PS at flat top (C1160, where the 10 MHz cavity has 73 kV) for an intensity of 6x1010 p/b were tracked with ESME up to the injection in the SPS. On the other hand the longitudinal distribution was reconstructed from the average longitudinal beam profile measured at SPS injection. Using the distribution reconstructed from the SPS measurements in the HEADTAIL simulation with the updated impedance model, the amplitude of the 1.4 GHz peak in the bunch spectrum grows too fast compared to the measurement and the peak at 200 MHz grows too slowly. Slightly better agreement with the experimental observations is achieved by superimposing a Gaussian distribution on the reconstructed longitudinal profile, which is justified by the fact that the tails of the measured distribution might be distorted by the limited bandwidth of the wall current monitor. An even better agreement between measurements and simulation is obtained when using the distributions measured with the tomoscope in the PS and tracking them up to SPS injection with ESME.

In the de-bunching spectrum measured in the SPS there are 200 MHz sidebands around the 1.4 GHz, which could be either related to actual impedance sources or simply to the modulation due to the overlap of the 1.4 GHz and the 200 MHz oscillations. The fact that the sidebands are not reproduced in the simulation could thus be due to an impedance source missing in the model, or to a wrong bunch distribution used in the simulation.

*It seems that the sidebands could be enhanced by an actual impedance, but come mainly from the fact that the 200 MHz and 1.4 GHz peaks have similar rise times in the measurements.*

The impedance of the simulated flanges is sufficient to explain the measured peak at 1.4 GHz in the de-bunching spectrum. The question if this impedance is harmful for the beam and if it can lead to microwave instability is still open. This will be addressed in further simulations using the improved impedance model with the goal of reproducing also the bunch lengthening observed during MDs in 2012. The main issue is that there are too many uncertainties the model.

*Simulations of single bunches with RF on (for reproducing the experimentally observed bunch lengthening) with the new impedance model are ongoing. Up to now they are performed using a matched distribution at flat top, i.e. not taking into account that the instability might have occurred already during the ramp.*

**3. Elena Shaposhnikova: SPS impedance reduction**

Longitudinal instabilities are the main limitation for future high intensity LHC beams in the SPS. As observed experimentally, the coupled bunch instability threshold scales with the total intensity per PS batch but is practically the same for one or more batches, i.e. the gap of 225 ns between batches is enough to decouple them. In addition, significant bunch lengthening was observed for high intensity single bunches during LHC and AWAKE MDs. Most likely the origin for these instabilities is a combination of broad band impedances, which are responsible for the microwave instability (bunch lengthening), and narrow band impedances with 150<Q/fr<700 for the coupled bunch instability.

*The resonance at 44 MHz introduced by the serigraphy of the MKE kickers with Q=11 would be a possible candidate for driving the coupled bunch instability. However, the instability was already observed before the serigraphy was applied and so it is most likely caused by another impedance source. Another candidate could be the impedance of the BPMs …*

The longitudinal emittance blow-up during the cycle (caused by the instability or required in order to achieve beam stability) could be a serious limitation for high intensity LHC beams. Before considering an impedance reduction program, all important impedance sources need to be identified and a good impedance model has to be established in order to be able to compare the relative contributions and decide which impedance needs to be reduced. The important next step in the studies is to reproduce and understand all single bunch as well as multi-bunch effects observed in the measurements.

Minutes written by Hannes Bartosik