**Meeting of LIU SPS-BD WG on 19/09/2013**

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

**Agenda:**

1. Follow-up of the SPS vacuum flanges: measurements and simulations – J. E. Varela
2. Latest results of simulations with HEADTAIL – H. Timko
3. Update on the SPS impedance: ZS PMs and BPMs – B. Salvant

**Presentations:**

**1. Jose Varela Campelo: Follow-up of the SPS vacuum flanges**

Simulations of the QF-MBA, QF-QF (with and without bellow) and BPH-QF type flanges were performed. The QF-QF type flanges have the highest shunt impedance (Rsh) and quality factor (Q) of all flanges simulated up to now. The damping resistors are not included in the simulations yet. The information about the presence of damping resistors for the QF-QF flanges cannot be found in the layout drawings and is therefore presently under investigation by the vacuum group.

The effect of the short damping resistor on the impedance was studied by measuring the resonance frequency and unloaded Q of the available test bellow with and without damping resistor installed. The measurements were compared with simulations, where a realistic model of the damping resistor based on an Alumina ring with resistive coating of 100 μm thickness was used. The damping resistor reduces the Q of the bellow/flange by about a factor 10. The measured frequency shift with the resistor installed is smaller than in the simulation. Therefore the properties of the damping resistor in the simulation, such as the relative permittivity and conductivity, were varied for fitting the material properties (the blue and red curves in the graph correspond to different conductivities, the green line represents the measured values).

Accurate information about the presence of the damping resistors in all the bellows of the SPS is needed for establishing the SPS impedance model. However, opening all the 2000 flanges for inspection is not feasible and radiography is too expensive to be applied to all bellows in the machine (more than 1kCHF per flange).

*For the moment the strategy is to inspect all the flanges/bellows that have to be opened for maintenance anyhow.*

*As a general rule, the damping resistors should be installed (or put back in place if missing) in all the bellows/flanges that need to be opened, replaced or newly installed.*

*The effect of missing damping resistors on the global SPS impedance can be studied in the simulations by comparing different situations, for example: a) all damping resistors are installed, b) half of them missing, c) all of them missing; the impact on the impedance would give an idea how important the presence of the damping resistors is.*

The next step in the search for impedance sources concerns the study of other elements of the machine, which could have large impedance. These are for example the 37 unshielded pumping ports, which have special geometry and were thus not part of the shielding campaign in the past. Furthermore, ensembles with cavity like configurations could have potentially high impedance, for example the BPCR, the arrangement around the BCT, or the different types of vacuum valves. These objects need to be simulated together with their respective surrounding elements. Further investigation is also needed for the WSB vacuum valve: the adjacent bellow and the pumping port were shielded, but later the WSB was installed in between and it is unclear if the shielding of the bellow and the pumping port was left inside. If it was left inside, this ensemble could have high impedance as the shielding would be interrupted by the vacuum valve. Another source for the 1.4 GHz resonance in the longitudinal impedance could be pumping port shields that were not installed properly. It was proposed to address this experimentally by putting an SMA probe inside the ‘blade hole’ and measuring in reflection. The sensitivity of the measurement setup for detecting a misplaced shielding needs to be studied in simulations and with laboratory samples.

*It will be difficult to perform the measurement of the pumping port shields in the machine due to mechanical constraints. If a study on a laboratory sample shows already that the leaking frequency is not in the interested range (i.e. around 1.4 GHz), then the measurements of the pumping port shielding has less priority. The impact of non-conformities (e.g. RF fingers hanging inside the aperture) of the shielded pumping ports can also be studied in simulations.*

*Up to now, no missing shielding was found in the machine, but there have been cases where the RF fingers were not in the correct place.*

Further measurements will be performed on a new test setup with MBA-MBA type flanges. The studies on the damping resistors are ongoing.

**2. Helga Timko: Latest results from simulations of intensity effects in the SPS**

A code-to-code benchmark between HEADTAIL, ESME and the code of Theodoros Argyropoulos shows an agreement within 10% between all of them, as for example when comparing the spectra of de-bunching beams over the full frequency range.

Compared to the studies presented in the last meeting, the impedance model of the BPMs and the ZS were updated and a preliminary impedance model of the flanges is included. The effect of the damping resistors in the flanges is modeled by reducing the Q of the corresponding resonator at 1.4 GHz by a factor 10. The simulated de-bunching spectrum shows a reduction of the peak at 1.4 GHz compared to the simulation without damping resistor. This peak is appearing again when removing the impedance of the BPMs and the ZS. This can be understood from the fact that the BPMs and the ZS have resonances in the frequency range between 1-2 GHz, which smear out the spectrum and damp the peak at 1.4 GHz. By removing these resonances from the total impedance, the peak at 1.4 GHz becomes thus more pronounced.

The sensitivity of the simulated spectrum on the different bunch distributions (as measured in the PS for lower bunch intensity) was studied in simulations without BPMs and ZS impedance but with damping resistors in the flanges. For matching the de-bunching spectrum measured in the SPS, the R/Q of the damping resistors have to be slightly increased and about 15% higher Rsh at 1.4 GHz is needed in the model. It seems that only a narrow band of R/Q values is compatible with the experimental observations. The uncertainties in the model and in the measurements (due to varying intensity for example) are still too high to pin down exactly the source of the resonance at 1.4 GHz. Further effort needs to be put in the elimination of these uncertainties.

The question if the bunch lengthening observed during MDs at high energy can be explained by microwave instability and with the present impedance model will be subject of further studies. Furthermore the single bunch (and coupled bunch) instability thresholds in the simulation will be benchmarked with existing measurements.

*If the observed bunch lengthening is due to the microwave instability, it should become more critical with increasing energy. It was proposed to compare the measured bunch profiles along the ramp with simulations in order to see if blow-up occurred during the cycle.*

*Measuring a single flange does not allow to obtain the distribution of Rsh and R/Q of all the flanges (variation from flange to flange due to mechanical tolerances, scratches on the enamel, thickness of the coating, conductivity of stainless steel, contact resistance, …). A big uncertainty of the impedance could be due to the actual variation of the length of the bellows in the machine, since there can be a large difference between individual bellows. These uncertainties can be addressed in simulations by studying the sensitivity of the results on the variation of the simulation parameters for getting an idea of the possible range of R/Q.*

**3. Benoit Salvant: Update on ZS transitions**

An updated model of the transitions (pumping modules) between the ZS septa tanks was presented, which contains now the correct type of stainless steel and a more realistic geometry. The new calculations demonstrate that the impedance was previously overestimated due to the simplifications of the geometry. The new model includes the plates on either side of the pumping module. Although they act as partial shielding, fields can escape and in fact most of the resonant modes observed in the simulations seem to be created by these plates. The two strongest modes have a shunt impedance of about 65 kΩ at 0.54 GHz and 1.05 GHz, respectively, with a Q of about 2500. These values correspond to a single pumping module and there are about 7 of these devices installed in the SPS. The damping resistor installed in the center of the module has only minor impact on these resonances, as it is placed at a location where the electromagnetic fields are weak. The effect of the resistive coating of the damping resistors was not taken into account yet. Further convergence studies of the simulation results are needed due to the complexity of the structure.

*If needed, measurements of the transition piece could be redone together with TE/ABT. However, the measurements have to be performed on the full ensemble of pumping module together with the adjacent ZS tanks (which is not available as mockup in the lab) in order to yield the relevant impedance of the structure.*

*Due to the high Q factor found in the simulations, the ZS could be one of the main sources for the longitudinal coupled bunch instability observed in measurements. Therefore the ZS impedance needs to be further investigated by simulating the complete ZS ensemble together with the pumping module.*

Minutes written by Hannes Bartosik