**Meeting of LIU SPS-BD WG on 27/03/2014**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Thomas Bohl, Fritz Caspers, Heiko Damerau, Juan Esteban Muller, Jose Ferreira Somoza, Roland Garoby, Wolfgang Höfle, Alexandre Lasheen, Kevin Li, Danilo Quartullo, Benoit Salvant, Elena Shaposhnikova, Helga Timko, Jose Varela Campelo, Carlo Zannini;

**Excused:** Gianluigi Arduini, Giovanni Rumolo, Giovanni Iadarola

**Agenda:**

1. Stripline kicker for HBFS: beam coupling impedance calculations – Carlo Zannini
2. SPS longitudinal impedance Simulations & Measurements update – Jose Varela Campelo
3. Simulations of the synchrotron frequency shift – Alexandre Lasheen
4. **Carlo Zannini: Stripline kicker for HBFS: beam coupling impedance calculations**

The stripline kickers for the high bandwidth feedback system will be installed in position 321 of the SPS, which is presently an empty drift of about 6.5 m with a large circular vacuum chamber of 156 mm diameter. The impedance for different integration options of two kicker modules has been studied. The lengths of the kicker modules and the connecting bellows/flanges are still to be optimized. The connection of the kicker modules to the adjacent large circular vacuum chamber will consist of circular bellows, while the interconnection of the two kicker modules can be either a circular bellow or an elliptical bellow.

* *The elliptical bellow considered here is provided by Eric Montesinos. Wolfgang and Eric need to check with the vacuum group if there would be spare bellows of this type available (the policy is to install only bellows for which spares are available).*

Compared to the reference case without flange in between the two kicker modules, the longitudinal impedance with a circular bellow inserted shows a strong broadband resonance with Z ≈ 4.5 kOhm at around 1.6 GHz. With an elliptical bellow in between the kicker modules there is only a very small step transition in the horizontal plane and a slightly bigger transition in the vertical plane and the longitudinal impedance is very close to the case without flange. In this case the longitudinal impedance is practically independent of the bellow length and thus is caused only by the kicker itself. In the transverse plane, the elliptical bellow creates some impedance for example due to a resonant mode of the transition piece. Nevertheless, the effective vertical impedance for 2 stripline kicker modules is expected to be only 0.1% of the total SPS vertical impedance, which would be acceptable.

* *In the presented simulations, insulating flanges are not taken into account yet, i.e. all flanges are assumed to be conducting.*
* *From the high bandwidth feedback project point of view, the main priority is to have a working kicker installed before the end of LS1. If possible, the elliptical bellow will be used for minimizing the longitudinal impedance. In case the elliptical bellow cannot be used right away, a circular bellow could be installed for the moment but the elliptical bellows need to be prepared for installation during a winter stop. The possibility of using insulating flanges will be looked into at a later stage. Damping resistors will be installed in the interconnect between the large diameter vacuum chamber and the first kicker module.*

**2. Jose Varela Campelo: SPS longitudinal impedance Simulations & Measurements update**

The present SPS impedance model for the longitudinal plane contains the travelling wave cavities, BPMs, the different types of flanges and the kickers. In the impedance calculations of the flanges the damping resistors have not been included yet but it was assumed that they halve the Q of the enamelled flanges. Further studies and measurements will be performed for assessing the effect of the different types of damping resistors (long and short) on the Q of the different types of enamelled flanges more accurately. The longitudinal impedance of the kickers is based on 3D CST particle studio simulations. For the purpose of beam dynamics simulations, a broadband resonator model fitted to these simulations is used.

* *Since experimental data for the ferrite in the kicker magnets is available only up to 2 GHz, an extrapolation of the ferrite behavior is used in the CST simulations at higher frequencies. This is the reason why the fitted broadband resonator model was used for beam dynamics simulations. A more accurate behavior of kickers at frequencies up to 3 GHz can be obtained from the analytical Tsutsui model.*

The total impedance of the 2013 longitudinal impedance model is dominated by the resonances of the travelling wave cavities and of the flanges. The largest contributors to the R/Q, which determines the microwave instability threshold, are the kickers and cavities. The imaginary(Z)/n of the present model is dominated by the vacuum flanges but there is some information missing about the contributions from the kickers. Space charge and the low frequency resonance of the enameled flanges are not yet taken into account.

The impedance model has been improved recently by means of detailed simulations and measurements of the different types of flanges and step transitions. Furthermore, the impedance calculations of the travelling wave cavities have been refined by taking into account the frequency dependence of the group velocity in the analytical expressions of G. Dome. Bead-Pull measurements have been performed for characterizing one of the 200 MHz cavities (in Standing Wave Mode). A benchmark with simulations shows good agreement. Ongoing efforts include the assessment of the impact of the damping resistors on the Q of enamelled flanges and other cavity like objects. It seems that the damping resistors in enamelled flanges are not very effective. Simulations of vacuum valves and unshielded pumping ports are also in preparation.

* *Measurements of the 800 MHz cavity have not been performed yet. However, the Bead-Pull measurement setup used for the 200 MHz cavity can be adapted easily to the 800 MHz cavity.*

**3. Alexandre Lasheen: Simulations of the synchrotron frequency shift**

Simulations of the synchrotron frequency shift with intensity as measured in the SPS after injection in a mismatched RF bucket were performed with HEADTAIL. The longitudinal impedance of the SPS is thereby modeled by broadband resonators accounting for contributions from the cavities, flanges, BPMs and kickers. Gaussian and parabolic distributions have been used in the simulations and the obtained synchrotron frequency shift as function of the average bunch length depends strongly on the initial bunch distribution. For large longitudinal emittance relatively good agreement with the measurement is obtained with the parabolic distribution.

* *First simulations with a more realistic bunch distribution, i.e. taking into account the bunch rotation in the PS, were not matching the experimental data. Further studies are ongoing and the updated impedance model will be used in future simulations.*

An estimation of the missing impedance was obtained by adding a single broad band resonator to the impedance model. The experimental data with small longitudinal emittance can be reproduced by adding a resonator at 3 GHz with a shunt impedance of 0.7 MOhm and a Q of 1. In this case a imaginary(Z)/n of about 1 Ohm would be missing (assuming Z/n constant).

* *The missing contribution to Z/n could come from the step transitions and from resistive wall and space charge.*
* *Measurements of the synchrotron frequency shift with intensity could also be performed at high energy in order to reduce the effect of space charge and thus disentangle the different contributions. A fast RF voltage rise is now possible in the SPS due to modifications of the LLRF that are made for AWAKE.*

Minutes written by Hannes Bartosik