**Meeting of LIU SPS-BD WG on 27/02/2014**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Michael Bodendorfer, Thomas Bohl, Fritz Caspers, Heiko Damerau, Thibault Ferrand, Eva Barbara Holzer, Aleandre Lasheen, Django Manglunki, Juan Esteban Muller, Wolfgang Höfle, Kevin Li, Yannis Papaphilippou, Danilo Quartullo, Giovanni Rumolo, Benoit Salvant, Elena Shaposhnikova, Jose Varela Campelo, Carlo Zannini;

**Agenda:**

1. Momentum slip-stacking of the I-LHC beam in the SPS – Theodoros Argyropoulos
2. Bunch parameters of the 50 ns LHC type beam for the Q26 and Q20 optics in 2012 – Thomas Bohl
3. Update of the SPS transverse impedance model – Carlo Zannini
4. SPS wire scanner prototype – Benoit Salvant
5. **Theodoros: Momentum slip-stacking of the I-LHC beam in the SPS**

Compared to the studies presented in the last LIU SPS-BD meeting, the case of slip stacking at 300 GeV/c/u has been investigated in order to minimize the amount of uncaptured beam transferred to the LHC. The simulations start already at the stage where the two batches are longitudinally interleaved with maximum separation in momentum and the two RF systems are in phase. The capture voltage and the capture time have been optimized for minimizing losses and emittance blow-up. In the best case, losses on the percent level and a longitudinal emittance of about 0.35 eVs/A are obtained when starting from 0.125 eVs/A (i.e. emittance blow-up by almost a factor 3).

Simulations were also performed for the acceleration of this beam to flat top in order to study the achievable beam parameters at extraction. In Q20, the bunch length is quite long (about 1.9 ns) even with the high RF voltage that will become available after the SPS RF power upgrade. Bunch rotation might be required for transfer to the LHC. In simulations with the Q26 optics the bunch length at extraction would be ok with the usual adiabatic bunch compression after the RF upgrade, as the RF voltage is more effective in Q26.

* *For transverse beam dynamics (for example space charge and intra beam scattering) it would be preferred to use the Q20 optics but then the bunch length at extraction could be an issue in particular since imperfections are not considered in the simulations. In case bunch rotation would be used, the maximum momentum spread compatible with the transfer line aperture needs to be studied.*

1. **Thomas: Bunch parameters of the 50 ns LHC type beam for the Q26 and Q20 optics in 2012**

An analysis of the longitudinal bunch parameters of the operational 50 ns beam in 2012 with the Q26 and the Q20 optics was presented. The average beam parameters per fill of the LHC have been computed. Although the comparison of the performance of the two optics is difficult due to the variation of the machine parameters along the year, a few observations can be made:

* The bunch length at injection is correlated with the intensity at injection due to the beam preparation in the PS. As the stability in the PS was marginal in the period with high intensity, high peak values of the bunch length at SPS injection were observed in some cases.
* A clear improvement of the bunch length at SPS extraction (in terms of mean and max) was achieved in the Q26 optics at the end of August after the adjustment of the longitudinal damper at injection, which improved beam stability up to flat top.
* In periods of good machine setup, the bunch length at extraction was smaller in Q26 (about 1.45 ns) compared to Q20 (about 1.55 ns). Although in this case the beam would be expected to be more stable in Q20, the bunch length standard deviation, which indicates beam stability, was similar in the two optics. However, the intensity was slightly higher in Q20. Furthermore, it could be that in the Q20 optics the applied controlled longitudinal emittance blow-up was larger than what was required for beam stability. This needs to be investigated further during operation in the future.
* While in the period with Q26 the bunch length at SPS injection was increasing linearly with intensity, a large spread was observed in the Q20 optics even though the intensity was not varying much. Thus the beam conditions out of the PS were also varying quite a lot during the run …

1. **Carlo: Update of the SPS transverse impedance model**

The SPS transverse impedance model takes into account the wall impedance, the kickers, flanges, RF cavities and the BPMs. As predicted by the model and observed in measurements, the sum of horizontal driving and detuning terms is negative, which results in a positive tune shift with intensity. In the vertical plane, the model reproduces about 70% of the measured tune shift. Good candidates for the remaining impedance are cavity like objects and the step transitions between the different types of SPS vacuum chambers. Therefore an analytical model of the transverse broadband impedance of step transitions has been development in collaboration with Prof. Vaccaro. The broadband impedance depends only weakly on the length of the chamber around the step transition. Furthermore, for the main cavity like structures in the SPS the first resonant modes are above 1 GHz, while the bunch spectrum (for a Gaussian distribution) goes up to 600 MHz only. Therefore a good estimation of the broadband impedance contribution to the tune shift can be obtained. Including the step like transitions and the flanges in the impedance model results in an estimated vertical tune shift very close to the measurement. The next step is to generate the wake function for this extended impedance model and perform HEADTAIL simulations in order to compare the tune shift with the measurements and to study the impact on the TMCI instability.

* *Simulations of the transverse tune shift should be performed with a realistic bunch distribution in the longitudinal plane, as it can be quite different from Gaussian and this might play an important role in the tune shift estimation.*

The longitudinal broadband impedance of the step like transitions in the SPS has been estimated to be about Z/n = 1.1 Ohm (500 MHz).

* *In comparison, the measured effective impedance in the SPS is between 3 and 4 Ohm, so the step transitions could be a large part of the total longitudinal impedance.*

The impedance simulations of the septa, the wire scanners and non-standard transitions and valves are ongoing.

The impedance of the stripline kickers for the new high bandwidth feedback to be installed before the startup was studied. The structure consists of several modules, each of them containing a stripline kicker. The modules have an elliptical cross section and are connected through circular vacuum flanges and bellows. The transverse impedance of the simulated structure is small compared to the total SPS impedance. The longitudinal impedance is comparably high, where the low frequency part of the impedance spectrum is caused by the stripline kickers themselves and the higher frequency part is due to the flanges (and thus depends on the dimensions).

* *The presented impedance spectra correspond to 10 modules and in this case the longitudinal impedance is about 4 kOhm for Q=1 at 1.4 GHz. The aim for LS1 is to install 2 modules (thus 3 flanges instead of 11).*
* *As explained by Wolfgang, the vacuum chamber is optimized for aperture and for maximum kick strength. The requirement to be ready after LS1 constrains the flexibility for bellows and flanges. Limited time is the main issue for implementing better solutions.*
* *The impedance between 1 and 1.5 GHz is probably due to coupling between the stripline structure and the transitions. Wolfgang will contact the LARP collaborators to check the minimum distance between modules required for avoiding coupling between modules; Maybe the Enamel coating on the flanges can be omitted, then elliptical flanges become easier to produce;*
* *All mode couplers could be an option for reducing the impedance if the cavity like object (i.e. the flanges and bellows) cannot be avoided.*
* *Further studies are needed including bellows in the structure at the places where they will be in the actual design.*

1. **Benoit: SPS wire scanner prototype**

Most likely the prototype wirescanner tank will be installed in LS1 without the actual wire scanner. The presented Eigenmode simulations show resonances with high Q (typically more than 8000) but modest R/Q. In reality the Q should be lower (maybe 1000 instead of 8000).

* *If this is a temporary installation (since the impedance will change once the actual wire scanners will be in place), this impedance could be acceptable. 100k Ohm with a Q around 1000 is probably the limit.*
* *Since the Q is high but R/Q is not so high, the possibility of installing all mode couplers for reducing Q should be investigated.*

The SPS has many “ugly devices” from impedance point of view, such as flanges, transitions, bellows, and so on. In some cases, a device installed in the machine is not in the drawings and thus it is difficult to get an overview of all potentially critical items. It is proposed to survey the whole SPS half-cell by half-cell before the startup together with colleagues from vacuum, since many drawings are not up to date and identify objects that potentially have high impedance. Simulations were performed for a few generic structures (bare bellow transition and multiple transitions with bellows) indicating that shunt impedances of a few kOhm per transition might be reached.

* Xray scans could be performed in places where it is doubted that the damping resistors and the shieldings are installed.
* Colleagues from vacuum will be invited to the LIU SPS coordination meeting to define guidelines for the installation of damping resistors in flanges.

Minutes written by Hannes Bartosik