**Meeting of LIU SPS-BD WG on 22/03/2012**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Chandra Bhat, Thomas Bohl, Fritz Caspers, Heiko Damerau, Roland Garoby, Simone Gillardoni, Michael Holz, Giovanni Iadarola, Juan Esteban Muller, Steve Hancock, Yannis Papaphilippou, Giovanni Rumolo, Benoit Salvant, Elena Shaposhnikova, Helga Timkó, Joachim Tuckmantel;

**Excused:** Gianluigi Arduini

**Presentations:**

**Helga Timkó: Update on PS-SPS transfer studies**

In 2011 MD studies it was observed that increasing the voltage of the 80 MHz cavity in the PS during the bunch rotation 2011 does not improve transmission to the SPS flat top. The transmission seems to depend strongly on the longitudinal emittance rather than the bunch length at injection. The experimental observations were reproduced with very good agreement (within 1%) when including around 10% longitudinal emittance blow-up on the PS flat top. It was also shown that capturing the beam is not improved by increasing the injection voltage in the SPS due to the long tails of the longitudinal particle distribution delivered by the PS, as found also experimentally.

* *The fraction of particles in the long tails of the distribution corresponds roughly to the losses. However, part of the bunch might also be captured in the neighboring buckets. A quantitative characterization of the tails should be obtained from the simulations.*

Optimization studies were performed for different settings for the bunch rotation parameters, namely the timings of the 40 MHz and 80 MHz cavities, and the voltage settings for different number of cavities. According to the simulations, an improvement of the transmission by about 1% can be expected by optimizing the timing of 40 MHz cavity and 2% of 80 MHz cavities. Further improvement by about 2% in transmission is achieved when using two 40 MHz and three 80 MHz cavities instead of only a single 40 MHz and two 80 MHz cavities. This allows decreasing the population of the long tails, which results in the desired improvement of the capture process. Injection errors of the order of 200 ps do not significantly increase the capture losses. The effect of different voltage settings for the 200 MHz cavities in the SPS at capture was also simulated. Injection with 3 MV results in the best capture but leads to larger losses at the start of the ramp as the bunch fills the bucket. Better transmission is found when injecting at 2 MV. The simulations cannot explain why raising the voltage on the flat bottom to 3 MV after capture with 2 MV improves the total transmission as compared with 2 MV constant. This might be explained when intensity effects are included, to be checked in future simulation studies.

* *The 200 ps injection errors in the SPS are considered to be close to observations in the machine, although they seem optimistic at first. These errors are not to be confused with the bunch-to-bunch phase jitter of the order of 100 ps measured in the PS. What is important here is the synchronization between PS and SPS. The phase loop in the SPS corrects the longitudinal bunch displacement, but this cannot be done simultaneously for all bunches due to beam loading.*
* *Although not desirable for beam stability in the PS and the SPS, it is expected that a smaller longitudinal emittance would result in better capture in the SPS.*
* *The Q20 optics should be simulated in future studies when intensity effects are included in the simulations. This is of particular interest since 2011 MD studies showed that the scaling the optimal settings for Q26 does not result in the best transmission with the Q20 optics. This might be related to the fact that the relative effect of beam induced voltage and beam loading are smaller in Q20, as this optics requires naturally larger RF voltages.*
* *The experimental results were obtained by averaging over a large number of cycles (~30). This is necessary due to the large spread in the measured transmission from cycle to cycle.*

**Thomas Bohl: Q20 for CNGS**

Some aspects related to transition crossing of fixed target beams in the Q20 optics were studied. Due to the lower transition energy, transition will be crossed earlier in the cycle and therefore with a smaller dB/dt. This is not favorable, as it results in a larger non-adiabatic time and therefore transition crossing becomes more critical. Furthermore, the beam loading angle is much larger at transition since the required RF frequency is much further away from the central frequency of the travelling wave cavities.

* *The dB/dt can probably not be increased compared to the present magnetic cycle due to limitations of the required voltage in the power supplies for the main magnets. The RF voltage itself might also be a limitation.*
* *In principle the RF central frequency of the travelling wave cavities could be retuned to the lower value at transition crossing in Q20, but this would be a huge effort, as it requires a large number of stamps to be retuned.*
* *Increasing the extraction energy from the PS might allow injecting fixed target beams above transition. The feasibility is not obvious however. Furthermore, the multi-turn extraction (MTE) would not be possible due to limitations of the corresponding magnetic elements.*
* *The reasons for considering the Q20 optics also for fixed target beams are mainly operational advantages of having a single optics for all beams in the SPS. Furthermore, higher beam stability is expected above transition. The overall performance of fixed target beams with the Q20 optics needs to be addressed in machine studies.*

**Benoit Salvant: Impedance studies in 2012**

Impedance studies in 2011 were devoted mainly to the TMCI threshold in the Q20 optics. Some measurements on transverse tune shift with intensity and impedance localization were performed. For 2012 it is planned to measure again the transverse tune shift with intensity to serve as a reference before LS1. It will be tried to reproduce the difference in the effective impedance between the two different optics (Q20 vs. Q26) observed in 2011. It is also expected that the sign of the horizontal tune shift will be flipped in 2012 after the shielding of the MKE kickers in the 2011/2012 winter shutdown. Further attempts on impedance localization will be done with the support of BI for optimizing the settings of the MOPOS system. In fact the limited number of BPMs available in the turn-by-turn mode was the main limitation for the measurements in 2011. It is envisaged to use the scraper several times within the cycle for measuring different intensities with the same longitudinal beam parameters. A new configuration of the tune kickers allows exciting the beam up to four times per cycle. Finally the growth rate for different chromaticity settings will be studied.

* *The idea of using the scraper for producing different intensities with constant longitudinal parameters within the cycle seems also interesting for longitudinal measurements.*
* *In addition to the tune kicker also the transverse feedback can be used to excite the beam.*
* *Although many dedicated MDs will be devoted to the Q20 optics, impedance measurements need to be done also for the nominal optics.*
* *Another possibility of impedance localization is to use orbit bumps in high impedance locations (in the kickers for example). Measuring the leakage of the bump for different intensities allows measuring impedance. On the other hand a dynamic effect can also be observed when varying the excursion of the orbit bump along the flat bottom.*
* *It was mentioned that instability was observed for large values of radial displacement along the ramp. This instability is observed only for one direction of radial steering. The reason is unclear and should be addressed in machine studies in 2012.*

**Elena Shaposhnikova: Longitudinal impedance of SPS**

The main known contributions to the different parts of the longitudinal impedance are due to the travelling wave cavities, kickers and higher order modes in the 200 MHz cavities. Beam measurements in the past clearly show the evolution of the impedance due to the installation of equipment or impedance reduction measures during the last years. The measurement of the impedance is in general difficult due to the large spread of the beam parameters. Measurements of the synchrotron frequency shift with intensity can be explained reasonably well with the impedance model. The major contributions to the reactive part of the impedance are nowadays coming from the MKE kickers. Also the real part of the impedance measured from the synchronous phase shift with intensity agrees with the predictions from the model. However, the data analysis is complicated by the dependence of the distribution and bunch length on intensity. A further reduction of the real part of the impedance is expected due to the serigraphy of the MKE kickers.

* *The timeline of MKE kicker serigraphy is as follows:*
  + *Run 2006: 9 non serigraphed MKEs*
  + *Run 2007: 6.5 non serigraphed MKEs + 1.5 serigraphed MKEs*
  + *Run 2008: 6.5 non serigraphed MKEs + 1.5 serigraphed MKEs*
  + *Run 2009: 5 non serigraphed MKEs +  3 serigraphed MKEs*
  + *Run 2010: 5 non serigraphed MKEs + 3 serigraphed MKEs*
  + *Run 2011: 3 non serigraphed MKEs + 5 serigraphed MKEs*
  + *Run 2012: 1 non serigraphed MKE + 7 serigraphed MKEs*
  + *Run 2014:                                             8 serigraphed MKEs*

The measurements on bunch lengthening have quite a large scatter. In particular measurements from different years are not directly comparable due to different initial bunch lengths. After shielding the pumping ports the microwave instability in the SPS with bunch intensities of about 1.5x1010 was not observed any more. Some small peaks in the unstable bunch spectrum of very long bunches at around 1.4 GHz seem to appear again for intensities of around 1x1011p/b nowadays. It is not clear what is driving the peaks at 1.4 GHz. It might be interesting to study the bunch spectrum with the Q20 optics, as a lower gamma transition optics proved already in 1998 mitigation of the microwave instability. Although the single bunch impedance effects are well predicted by the identified impedance sources, the multi bunch effects are still to be explained. In fact, the instability along the ramp cannot be clearly identified as coupled bunch instability. However it is caused by a multi bunch effect, as it depends not only on the longitudinal emittance of the individual bunch but also on the bunch spacing. In the present understanding the observed instability is caused by loss of Landau damping due to the reactive part of the impedance. It is not clear if it is really the narrow-band impedance that is driving this instability.

The serigraphy of three kickers since the last measurements of the longitudinal impedance should be clearly observed in 2012 measurements. In addition to impedance measurements the studies in 2012 will concentrate on understanding the mechanism and the source of the multi bunch instability, which remains the main intensity limitation for LHC beams in the longitudinal plane.

**Hannes Bartosik and Giovanni Iadarola: Schedule for the scrubbing run**

The schedule for the scrubbing run was presented, including a table with the key persons required for the different tasks of setup and the various measurements. Monday will be devoted to setup. After a short access on Tuesday morning the first measurements could start with different beam conditions. In the afternoon the beam quality should be studied with coasting beam. Wednesday is dedicated to the e-cloud measurements under stable conditions. Thursday is reserved for high intensity studies. Final measurements characterizing the status of the liners after the scrubbing and beam quality studies will be done on Friday, the last day of the scrubbing period.

The next SPSU BD meeting is scheduled for April 19th

* Preliminary agenda
  + Open action: Q20 for ions (Yannis Papaphilippou)
  + Beam observations during the scrubbing run (Hannes Bartosik)
  + Update on transverse impedance budget (Benoit Salvant)

Minutes written by Hannes Bartosik