**Meeting of LIU SPS-BD WG on 25/04/2013**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Thomas Bohl, Alexey Burov, Fritz Caspers, Heiko Damerau, Jose Ferreira Somoza, Juan Esteban Muller, Wolfgang Höfle, Giovanni Iadarola, Kevin Li, Benoit Salvant, Elena Shaposhnikova, Mauro Taborelli, Helga Timkó, Carlo Zannini;

**Presentations:**

**Hannes: Space charge in the SPS**

Transverse space charge effect for the LHC beams in the SPS is challenging because of the very long injection plateau and the required emittance preservation and small losses along the bunch train. For the LIU-project, the goal is to allow for a maximum of 10% emittance growth and 10% losses, including the losses at beginning of the ramp and due to the scraping before extraction to the LHC. The Q20 low gamma transition optics exhibits larger dispersion compared to the nominal optics for LHC beams and thus for the same beam parameters, the incoherent space charge tune spread is around 15% smaller.

Regarding the beam parameters of the 50 ns beams achieved at the end of 2012 with the Q20 optics in operational conditions, an incoherent tune shift of ΔQx/ΔQy~0.08/0.13 was obtained in routine LHC filling. During tests with the high brightness BCMS beam, an even larger tune shift of ΔQx/ΔQy~0.10/0.18 was achieved. Before sending this beam to the LHC, a tune scan was performed in the SPS with a single batch for studying space charge effects and optimizing the working point. For horizontal tunes smaller than Qx=20.14 or vertical tunes smaller than Qy=20.19, an emittance blow-up of the beam core due to crossing the integer resonances was observed, consistent with the estimated tune spread. Good emittance preservation was obtained for working points with higher fractional tunes. This was also demonstrated using the bunch-by-bunch feature of the wire scanners when injecting 3 batches. A small blow-up of the first two batches with respect to the third batch was observed for the working point Qx/Qy=20.13/20.19, while practically identical emittance behavior was achieved in the three batches by moving the working point to Qx/Qy=20.17/20.23. The beam transmission was usually around 93%. This experiment demonstrates that a space charge tune shift of ΔQy~0.18 on the long SPS injection plateau is not detrimental for the beam quality and the HL-LHC/LIU goal of ΔQy=0.20 seems to be in reach.

*It should not be forgotten that for higher space charge parameters, i.e. even larger tune shifts, also coherent instabilities might become a limitation.*

*In the SPS ppbar era, the 100 MHz RF system was installed for mitigating space charge effects and to increase the bucket area since the longitudinal emittance was blown-up. The present 800 MHz system used in bunch shortening mode is not helping for space charge and is also not the ideal choice for a higher harmonic system (400MHz or 600MHz would probably be better): its frequency was chosen since it provides a larger synchrotron tune spread for a given absolute voltage. The second harmonic cavity on the other hand would also help for better capture of the rotated bunches from the PS …*

**Theodoros: Longitudinal impedance identification**

The modulation of the bunch profile due to resonant impedance in the machine was observed with RF switched off and the line density was Fourier analyzed. Multiples of the 200 MHz resonance due to the main RF system are clearly visible in the spectrum. The low frequency part comes from the stable bunch spectrum. A clear peak at 1.4 GHz in recent measurements was already observed in previous measurements in 2001 and 2007. The growth time of the 1.4 GHz peak is different from the 200 MHz peak, so it is due to a different source and not just some higher harmonic. In comparison with the Q26 optics, this instability is observed in the Q20 optics for higher intensities (expected at 2.85 times higher intensities).

Simulations with the existing impedance model plus a resonator at 1.4 GHz with variable parameters were performed for reproducing the observations and thereby characterizing the impedance. Space charge was included in the simulation, but does not change much. Possible candidates for this impedance considered so far are HOMs of 200 MHz or 800 MHz cavities, or the Enamel flanges. Simulations of these enamel flanges performed by Benoit show a peak in the longitudinal impedance spectrum at 1.4 GHz, however the height of this peak is much lower than what is required for reproducing the beam measurements when injecting long bunches.

*Do we care about other vacuum flanges? What is the impedance if flanges are not isolating (enamel)?*

* + *The impedance of the normal flanges is very flat for the frequency range around 1.4 GHz*
  + *Normally there should be the RF shields for cross-section changes, but in reality around 10% of the shields are missing (were not installed) in the machine*
  + *There are no shields at the transition from elliptic to round chamber shapes*
  + *There are RF shields between all the dipoles (pumping ports shielding)*
  + *A round chamber (with transitions) with 160 mm diameter also has a resonance just below 1.5 GHz*

**Benoit: CST simulations of the enamel flanges**

Results from the first simulation campaign were already presented in the SPSU meeting on 12.5.2011 (where details on the geometry of the flanges can be found). In the simulations, the enamel coating is assumed to have a thickness of 0.2 mm (in reality it is between 0.2 mm and 0.4 mm). The flanges also have vetronite in the external part on both sides with a disk shape. Strong assumptions about the permittivity and the losses of the enamel coating have to be made in the simulations. Furthermore, the result depends a lot on the thickness of the isolator. For example, when removing completely the enamel, the spectrum shifts towards higher frequencies.

An idea of Fritz is to put a small ferrite ribbon between the isolated flanges and the clamp. Including this thin ferrite sheet in the CST model results in a strong reduction of the resonance at around 1.5 GHz in the longitudinal impedance spectrum (the impedance is now spread over a larger frequency range).

*Fritz wants to measure the impedance with different thicknesses of the ferrite ribbon in-situ, since the impedance depends also on the longitudinal gap between the two flanges.*

*Maybe other flanges should be studied a bit more carefully (some of them have vetronite and some do not, there is a variety of different configurations in the machine), ideally in combination with measurements. However, the usual wire method might not be suitable for objects, which are not continuously conducting on the outside.*

**Fritz: Considerations for the low-frequency impedance of enamel coated flanges in the PS, Booster and in the SPS**

In the SPS, the vacuum chambers around isolated flanges are grounded by cables in order to avoid eddy currents. Measuring the S11 reflection coefficient with a probe consisting of two pins across the isolated gaps, one can identify if the grounding is done properly. In this case an inductive impedance should be measured at low frequencies. If the grounding is missing, the capacitive impedance of the floating vacuum chambers would be measured.

*It is known that the grounding is missing or faulty in several places of the machine, but the exact status around the ring is not known. An inspection and corresponding correction measures will be done in LS1 by OP Group.*

*Fritz proposes to measure the S11 from outside the pipe and this might give reasonably well the impedance inside the vacuum chamber. In particular, he would like to measure an impedance reduction when inserting the aforementioned flexible ferrite ribbon with different thickness between the flanges and the clamp. However it is not clear if this kind of measurement would really yield the impedance relevant for the interaction with the beam since there are electromagnetic radiation and material losses. Therefore it would be good to think also about other measurement techniques in the laboratory for crosschecking the results.*

*Before doing any changes, i.e. installing for example these ferrite ribbons in all isolated flanges, it needs to be clear if these flanges are really responsible for the big part of the impedance that we are looking for, and that such a modification would solve the issue.*

Minutes written by Hannes Bartosik