**Meeting of LIU SPS-BD WG on 06/11/2014**

**Present:** Theodoros Argyropoulos, Hannes Bartosik, Heiko Damerau, Juan Esteban Müller, Alexandre Lasheen, Kevin Li, Giovanni Rumolo, Benoit Salvant, Elena Shaposhnikova, Jose Varela Campelo;

**Agenda:**

1. Impressions from the SPS scrubbing run – H. Bartosik
2. Longitudinal Microwave instability in a Multi- RF system – T. Argyropoulos
3. Synchrotron frequency shift as a probe of the SPS impedance – A. Lasheen
4. **H. Bartosik – Impressions from the SPS scrubbing run**

The SPS scrubbing run in Week 45 is going very well. The intensity of the nominal LHC beam was ramped up step by step to a maximum of 5 batches at the flat bottom.

* The main limitation is presently coming from the heating and the resulting outgassing of the MKP1 injection kicker. Both software and hardware vacuum interlock levels have been adapted in accordance with TE-ABT.
* A clear conditioning due to scrubbing is observed on both the pressure levels in the arcs and on the dedicated e-cloud monitors with Stainless Steel liners in MBA and MBB chambers.
* The transverse emittance of four batches of the nominal 25 ns beam was measured at around 2.5 um at flat bottom.
* The setup of the doublet scrubbing beam started during periods of cool-down of the MKP kicker. Some longitudinal emittance blow-up is needed in the PS to avoid instabilities due to the high intensity. The long bunches are slightly rotated before extraction to the SPS in order to optimize the capture efficiency (as predicted by Juan’s simulations).
* The setup of the doublet beam will be continued in the next days together with the acceleration of the nominal 25 ns beam.

1. **T. Argyropoulos – Longitudinal Microwave Instability in a Multi- RF system**

The present understanding of the longitudinal microwave instability in the SPS was presented.

* The longitudinal microwave instability results in a fast longitudinal emittance growth and thus bunch lengthening, as observed directly in machine studies with single bunches in 2014; a lower threshold was found in single RF compared to the SPS double RF in bunch shortening mode
* The 1.4 GHz resonance of the various SPS vacuum flanges is believed to cause the instability
* The scaling of the microwave instability threshold in a single RF system in BLonD simulations has been benchmarked with analytical models for a single resonator at 1.4 GHz in the narrowband and broadband regime
* Simulations at 450 GeV for a double RF system with fourth harmonic like in the SPS and a single resonator at 1.4 GHz show that the bunch shortening mode has a similar threshold as in a single RF system for small longitudinal emittances, but a lower threshold compared to single RF for large longitudinal emittances. This might be explained by the synchrotron frequency distribution.
* Single bunch simulations for the full SPS longitudinal impedance model using a particle distribution close to the measurement reproduce the experimental observations of bunch lengthening as function of intensity at 450 GeV. Indeed the vacuum flanges play an important role for the instability, since without the impedance of the vacuum flanges the instability threshold in the simulation increases by a factor 2. In multi-bunch simulations with 6 bunches the threshold for microwave instability is about half compared to single bunches, which is also in agreement with experimental observations.
* Larger RF voltage increases the instability threshold at flat top, but it was observed in measurements that during the ramp a lower voltage is better for beam stability. In some cases it seems that using only a single RF system would be better. To be investigated in further simulations and future MDs.

1. **A. Lasheen – Synchrotron frequency shift as a probe of the CERN SPS reactive impedance**

The quadrupole synchrotron frequency shift with intensity was measured as a function of bunch length and a non-monotonic behavior was observed. A simulation study was performed in order to understand this behavior.

* Simulations were performed with the longitudinal SPS impedance model (including longitudinal space charge) for different longitudinal line density functions (binomial distributions with different values of the distribution parameter n)
* The simulation results depend strongly on the longitudinal distribution considered. The measurements are best reproduced when using a parabolic line density in the simulations.
* An analytical analysis of the incoherent and coherent tune shift shows that for the parabolic distribution the capacitive impedance of the flanges can result in an effective inductive impedance due to shape of the bunch spectrum. For a Gaussian line density on the other hand, the effective impedance is a monotonic function of the bunch length (all contributions to the effective impedance are either inductive or capacitive).
* The understanding of the synchrotron frequency shift as function of bunch length is needed for optimizing the controlled longitudinal emittance blow-up with RF induced phase noise
* Future work will focus on a better understanding of the relative contribution from the incoherent and the coherent part of the measured tune shift as a function of bunch length, relying both on simulation studies and on additional measurements. Furthermore the space charge contribution will be singled out by performing measurements with different beam energies (for the measurements not at injection energy, quadrupole oscillations can be induced by a sudden RF voltage or phase jump).

Minutes written by Hannes Bartosik