# MSWG Meeting #17, 30-Nov-2018

***Present:***

A. Alekou, M-E. Angoletta, F. Asvesta, H. Bartosik, F. Bertin, D. Cotte, K. Cornelis, H. Damerau, G-P. Di Giovanni, V. Forte, M. Fraser, K. Hanke, A. Huschauer, V. Kain, M. Kaitatzi, G. Kotzian, E. Koukovini Platia, A. Lasheen, T. Lefevre, T. Prebibaj, C. Rossi, F. Tamura, F. Tecker, F. Velotti. M Vadai, C. Zannini, P. Zisopoulos

***Agenda:***

Link to the Indico Event:

- Approval of minutes – Hannes Bartosik and Karel Cornelis
- Status of operational Beams – Machine supervisors
- Main presentations:
    - Barrier buckets with Finemet cavity in the PS – Mihaly Vidai
- MD updates
    - PS injection studies: turn-by-turn measurements after injection – Vincenzo Forte
    - Source of horizontal instability in the PSB – Eirini Koukovini Platia

The minutes from the last meeting were approved.

Status of operational Beams

PS – Klaus Hanke

The PS is running with very good availability. Access and investigations required for C76 but the problem was eventually found to be a short circuit on a cable which could be fixed without further access. There were some issues for a new destination to send partially stripped ions to AWAKE.

SPS – Verena Kain

A 24h UA9 run was carried out before LHC MD's and crystal extraction MD's carried on in parallel to NA physics without interruption. AWAKE destination in LEIR needed a timing upgrade followed by extraction issues that were finally fixed. The oven refill went ahead yesterday. SFTION run at 380 Z GeV and for LHC ions record luminosity was achieved with 75 ns scheme, 14 injections.

Main presentations:

Barrier buckets with Finemet cavity in the PS – Mihaly Vadai

As part of a PhD project "Beam Loss Reduction by Barrier Buckets in the CERN Accelerator Complex" recent beam tests showed the feasibility of making an abort gap for the kickers' rising field on Multi Turn Extraction (MTE) in the PS using the Finemet cavity. The motivation and application of barrier buckets to reduce the losses during MTE were explained before the concept of barrier buckets introduced. The existing Finemet system was used along with parts of the existing beam synchronous sine / cosine generator firmware (PS Multi-harmonic Source – MHS) to make a prototype system for tests. The prototype hardware, firmware and software solution were discussed to create a beam synchronous, arbitrary waveform generator. First beam tests were presented at injection energy in the PS. The voltage of the Finemet system is not high enough to make a matched injection but on the injection plateau it was possible to adiabatically manipulate a bunch from an isolated bucket to a long-stretched barrier bucket and back again, almost recovering the beam quality before the manipulation with low losses, which are still to be understood. The process was very sensitive to asymmetries in the voltage applied to each end of the bucket, even at a sub-percent level. Tests investigating the adiabaticity of the process were presented. The presentation finished by showing the beam tests made at high energy (14GeV/c) on the MTE cycle. With limited time at flat-top to carry out the barrier bucket manipulations the barrier voltage was ramped as the voltage of the main harmonic was still on and being reduced. It was possible to keep a gap between select bunches of the main harmonic as the beam de-bunched inside the barrier bucket, producing a quasi-constant line density inside the barrier bucket. The gap could be kept across a wide range of intensities ranging from 0.4 to 2.2e13 ppp. Significant beam loss reduction at extraction in the PS was demonstrated when the gap was synchronised with the extraction. The synchronisation only works with PS internal RF signals and there is no synchronisation yet with the SPS due to the low voltage. Further work is required to solve the problem of synchronising with the SPS.

***Discussion:***

**K. Cornelis** asked how important the symmetry of the barrier voltage actually is. **M. Vadai** explained that it seemed to be much more severe at low intensity than at high intensity (an empirical result). At close to operational conditions and higher intensities it was not such a problem. It still needs to be understood how the intensity affects this scheme.

**M. Vadai** explained that they didn't try to inject into the barrier bucket but changed the injection phase to see when the beam would reflect. **H. Damerau** clarified that for bunched injection with large emittance one needs much higher voltages compared to those available in the PS Finemet system. He suggests this could be attempted in the PSB. **K. Cornelis** stated that this was tried 20 years ago in the SPS, but it did not work.

**M. Vadai** explained to **G. Kotzian** that any waveform would do as barrier bucket so long as the time integral of the voltage (formula presented) is respected and the same on both sides. The function applied was not much different to sine, but low pass filtered, and even square pulses were attempted. The important point is to control the pulse shape down to zero and ensure it is flat in the pulse, i.e. any signal can be used as long as it is DC free.

**H. Bartosik** asked what would be needed to do this in LEIR with acceleration. It would be worth studying what we would gain if the first part of ramp is started with a very flat bunch (aim to get higher bunching factor). **H. Damerau** made it clear that accelerating with barrier buckets is very, very complicated. Experience at KEK has shown this.

**M. Vadai** explained to **G. Kotzian** that the barrier bucket amplitude ramped as a function, adiabatically.

PS injection studies: turn-by-turn measurements after injection – Vincenzo Forte

Recent multi-turn injection SEM grid measurements in the PS were presented from two MD sessions (not fully analysed yet) on 30th October and 7th November 2018. Two different transfer line optics were used on BCMS (0.9 eVs) cycles (TFB ON, low chroma, coupling corrected) using Ring 3 only (i) operational optics (ii) PPM re-matched, i.e. matched as best as possible whilst respecting PPM cycling of the transfer line. The dispersion was measured by momentum steering using the SEM grid and compared to measurements made on the BPM system, giving good agreement. From these measurements the energy matching could be inferred along with the level of oscillations from injection steering mismatch. Losses were observed due to the interaction of the beam with the grid. The RMS beam size was plotted turn-by-turn over the first 15 turns after injection and the beam size oscillation fitted with an analytic result derived by M. Benedikt and C. Carli et al. The frequency of the envelope oscillation indicates a dispersion dominated blow-up. The mismatch, assessed from the envelope oscillation, indicates an expected emittance blow-up after filamentation of 18% for the operational transfer line optics and only 2% for the re-matched optics. The relationship between the measured beating amplitude and RMS blow-up was explained at length. Very little mismatch was observed in the vertical plane for a tune of 6.25 but more measurements are still to be analysed at a tune further from the quarter-integer. A deliberately mismatched case was shown where the betatronic mismatch was comparable to the dispersive component, showing the expected doubling of the envelope oscillation frequency. The talk was concluded before a list of next steps in the analysis was given. It was clearly stated that brightness measurements taken with the re-matched optics would be very interesting to analyse in detail to see if the expected blow-up from the turn-by-turn data could be observed, especially for large longitudinal emittance beams.

***Discussion:***

**V. Forte** explained to **H. Bartosik** that the working point in these studies was QH = 6.21 and QY = 6.25. **V. Kain** sought clarification that with the matched optics one expects only 2% blow-up. Indeed, this is the case, and one would expect three times more blow-up for the 1.5 eVs beam. **V. Forte** is looking forward to seeing brightness curves for these beams and the re-matched optics.

Source of horizontal instability in the PSB – Eirini Koukovini Platia

Further investigations were recently made into the source of the horizontal head-tail instability in the PSB with a dedicated MD on the last morning of the proton run, extending it by a few hours to 1 pm on 12 November. To make the test using the Ring 3 extraction kicker (KFA14), its pulse forming lines were decoupled by removing the filter capacitance and the 5 Ω resistor and terminating the magnet instead with a matched load consisting of a 6.25 Ω resistor to closely match the characteristic impedance of the 4-cable system (kicker therefore not functional). As a result, no instability was observed even with the transverse feedback (TFB) off, clearly identifying the unmatched termination of the extraction kicker as the source of long-standing instability. Although the new TFB system should be able to cope with the instability in Run 3, options for kicker modifications are being considered and further studies are needed.

***Discussion:***

**H. Damerau** asked how the measurements were carried out in 2003 and would it be possible to do similar measurements on other kickers? Knowledge of the exact measurement procedure has since been lost. **E. Koukovini Platia** added that new measurements using a network analyser were taken on 12 November for the original and modified kicker configuration. **K. Cornelis** pointed out that similar measurements exist for LEIR and perhaps this could be followed up further.

**G. Kotzian** pointed out the third resonance in the impedance measurement from 2003 and asked if it is an issue**. E. Koukovini Platia** explained that it is at a high enough frequency not to cause issues within the energy range of the PSB, even after the LIU project upgrade where the PSB will accelerate beams up to 2 GeV.