MSWG Meeting #14, 28-Sept-2018

Present:

F. Asvesta, M. Barnes, H. Bartosik, M. Carla, J.F. Comblin, D. Cotte, V. Forte, M. Fraser, K .Hanke, V. Kain, A. Huschauer, M. Kaitatzi, E. Koukovini Platia, A. Lasheen, T. Lefevre, A. Santamaria Garcia, F. Velotti, C. Zannini

Agenda:

Link to the Indico Event:

- Approval of minutes – Karel Cornelis/Hannes Bartosik
- Status of operational Beams – Machine supervisors
- Main presentations:
    - Horizontal instability studies at 160 MeV mimicking the future injection energy in the PSB – Eirini Koukovini Platia
    - Transverse optimization of LHC beams in the PS - Alexander Huschauer

Status of operational Beams

PSB – Jean-Francois Comblin

Good machine availability considering ITS2. OP beams are OK and LHCMD went smoothly. Wire-scanner replacement in TS delayed due to leaking vacuum valves. Next week priority for MD's in the PSB will be given to the reference measurements to be taken before the end of the run and LS2.

PS – Matthew Fraser

Again, good availability but some issues on start-up after ITS2, which were listed. The PFW circuit PR.WFNP trips on LHC beams after ITS2 and the ramp rate on LHC cycles has had to be reduced to prevent this issue. Investigations on-going and root cause not understood. Double timings for extraction septum has been implemented to test the double-bunch TOF cycle, extraction bumper timings still to be added.

HiRadMat 16b LHC25 beam is ready for SPS. Satellites were observed in front of the dedicated n-TOF bunch, investigations and optimisation is on-going in collaboration with n-TOF.

A list of on-going MD's was presented and it was reported that first turn-by-turn injection SEM grid profile measurements were made quickly today as the machine restarted from an access.

SPS – Francesco Velotti

Good availability, with the only main downtime in the SPS due to an MBE in TT20; most problems were caused by the injectors. During ITS2 the octupoles were reconfigured to reduce the second-order chromaticity on Q20. Since ITS2 the highest intensity (ppp) was extracted this year to North Area with COSE on the operational beam. Many dedicated MD's for slow extraction were carried out on Wednesday with octupoles, crystal shadowing on the ZS, correction of spill noise ripple using the digital control on the main quadrupoles, as well as set-up for the BDF faculty with the short (1.2 s flat-top) SHiP/BDF cycle.

The SHiP/BDF target test will continue next week in parallel to the crystal shadowing MD's.

High intensity LHC MD's were carried out, with instabilities observed from 1.8e11 ppb and stabilised up to 2.0e11 p/b with chromaticity and octupoles.

Main presentations:

Horizontal instability studies at 160 MeV mimicking the future injection energy in the PSB – Eirini Koukovini Platia

Above a certain energy in the PSB a horizontal instability develops from an unknown source causing transverse coherent oscillations and significant beam loss requiring the Transverse Feedback (TFB) to suppress it. These studies were motivated in view of the higher intensities after LIU and by the increase in the injection energy to 160 MeV at which this instability is observed to start for certain tunes. The measurement campaign presented was carried out on a constant energy plateau of 160 MeV, probing the working point and instability onset for different beam intensity and chromaticity. To distinguish the instability from resonance crossing, measurements were done with the TFB on and off. The measurement set-up and procedure were detailed at length before the results were presented systematically. The horizontal instability appears for a range of tunes between QH = 4.21 and 4.30 with maximum losses at QH = 4.26. The situation is worse for natural chromaticity with maximum losses up to 100%. The growth rate was shown to increase linearly with intensity, as expected from theory, before the head-tail signal was presented at 600e10. No visible trend in the rise times was observed with chromaticity scans for horizontal tune QH = 4.26 but rise times seem to increase for certain sextupole strengths once the tune is moved away from the critical tune. The TFB is therefore imperative. A test showed the RF cavities C02, C04, C16 are not the driving source of the horizontal instability. The beam coupling impedance due to unmatched terminations of the extraction kicker is the suspected source and PyHEADTAIL simulations as well as the semi-analytical code DELPHI reproduce nicely the onset of the instability if one considers the impedance as narrow-band resonator peaked at 1.7 MHz. However, simulations predict higher order nodes in the head-tail instability than observed in the machine. The next steps for understanding the instability with simulations were outlined before an MD to change the termination of the extraction kicker at the end of the run was proposed to check any effect on the instability.

Discussion:

E. Koukovini Platia explained to **K. Cornelis** that the simulations producing the 8 node headtail instability were carried out with the measured chromaticity but with a very simplified resonator. It is intended to build up a more sophisticated impedance model and investigate the behaviour of the instability in simulation.

T. Lefevre asked by how much the termination of the kicker will be changed. At the moment it is open, and it will be matched to 25 Ohms. **M. Barnes** clarified that the circuit is open at the switch end of the cable. **C. Zannini** pointed out that the spectrum looks like it is coupling to the coaxial cable of the kicker. **M. Barnes** pointed out an interesting paper from KEK terminating coaxial cable with diodes to solve the problem with coupling to the beam.

V. Forte mentioned the choice of tune in the studies was far from the expected operational values. **H. Bartosik** pointed out that it would be best not to be limited in the working point and **E. Metral** stressed that the source should be suppressed, especially if a likely source has been identified.

Transverse optimization of LHC beams in the PS - Alexander Huschauer

The LIU project relies on bunches with large longitudinal emittance to decrease the space charge tune shift. To achieve this, we will need to correct the chromatic tune spread with ideally zero chromaticity on the injection plateau. To complicate matters this requires an uncoupled machine and the use of the TFB to combat head-tail instabilities on the flat bottom. The history of chromaticity correction was presented including an attempt with new sextupole magnets, however unacceptably high resonance excitation and losses on the operational BCMS beam were observed. As a result, the PFW are used at low energy in 3 current mode (CM) to approach close to zero chromaticity. The machine is decoupled with skew quadrupoles and the tune is held constant along the injection plateau to simplify the TFB operation by keeping a fixed frequency using the low energy quads. The gain is adjusted along the plateau, high at injection to damp injection oscillation and low throughout. The TFB is used in the horizontal plane only and is critical to operation; turning off the TFB results in almost compete beam loss. Since LHC fill 7123 the TFB has been use in operation in this way with good reliability, demonstrating an important step towards the LIU era for LHC beams in the PS. Emittance measurements with the wire-scanner indicate slightly smaller (≈ 10%) emittance in the PS but no clear evidence of a gain in luminosity in the LHC was seen, to be followed up. The next steps were outlined including chromaticity correction with the PFW in 5 CM.

The recent progress with the set-up of high intensity beams was presented with intensities reaching the LIU goal of 2.6e11 ppb at PS extraction, profiting from longitudinal upgrades that are now in place including the Finemet coupled-bunch feedback, multi-harmonic feedbacks for the high-frequency cavities and one 40 MHz cavity working as a Landau cavity 170 ms after transition. The difficulties and how they were overcome, namely beam loss, to attain the 5% LIU loss budget were briefly detailed. The stability of the high intensity LHC-type beams was improved by optimisation of the transverse setup. A vertical instability observed was also seen in the beginning of the year on the operational LHC cycles. This important optimisation allowed for significant progress to be made in the longitudinal plane and made systematic longitudinal studies possible with the improved reproducibility of the cycle. As a next step the high intensity beam needs migrating to work with lower chromaticity.

Discussion:

E. Metral explained the trick used in the past to introduce coupling with skew quads to stabilise the beam at injection, which was done at the time because there was no TFB available. Removing the coupling and using TFB allows more freedom nowadays to adjust tunes and chromaticity etc. and optimise the cycle.

V. Kain asked how the PFW and knobs to control the tune and chromaticity are now in LSA. **A. Huschauer** explained that not all PFW matrices are in LSA yet but one for both the 3 and 5CM are. In the future, more will be added to help operational flexibility.