MSWG Meeting #15, 19-October-2018

Present:

F. Asvesta, M. Barnes, H. Bartosik, M. Carla, K. Cornelis, H. Damerau, M. Delrieux, V. Forte, M. Fraser, K. Hanke, K. Hirosawa, W. Hofle, A. Huschauer, M. Kaitatzi, E. Koukovini Platia, A. Lasheen, B. Mikulec, T. Prebibaj, G. Rumolo, F. Tecker

Agenda:

Link to the Indico Event:

- Approval of minutes – Karel Cornelis/Hannes Bartosik
- Status of operational Beams – Machine supervisors
- Main presentations:
  - Space charge studies in the PS – Foteini Asvesta
  - Longitudinal instability studies for Landau cavities in the PS – Alexandre Lasheen

The minutes from the last two meetings were approved.

Status of operational Beams

PSB – Bettina Mikulec

Exceptionally good running for the PSB with a few non-blocking faults for the Finemet cavity affecting R4 on ISOLDE, which is currently being followed up by the specialist. Special beams have already been prepared for the LHC MD4 run next week, including the 8b4e. Only the different emittance versions of the LHCINDIV beams still need to be followed up over the weekend. Most reference measurements have been completed with only a few still outstanding. Good news with the advancement of the TFB commissioning with >900e10 p that could be accelerated on ring 3 (ISOLDE). A detailed list of MDs was presented.

H. Bartosik asked if both TFB systems can be used PPM. **B. Mikulec** explained that currently all OP users are using the old system, and only a single MD user on the new system. A mini-reliability run on ISOLDE is foreseen before the end of the run.

An issue with a high intensity LHC MD beam is now resolved and was probably induced during cloning.

PS – Heiko Damerau

No major problems for the PS with 94% availability for the last 3 weeks. A list of OP issues was outlined with emphasis on the PFW trips: MD users should be aware that old LHC cycles will need their ramp-down rate reducing to avoid tripping the PFW's. For information, the WS68H wire is broken. The TOF bunch rotation has been optimised to reduce pre-pulses (probably satellites in front of the main bunch) observed by the experiments. A list of beams prepared for MD studies was presented along with details of on-going transverse and longitudinal MD's.

K. Cornelis asked for motivation behind the barrier bucket studies **H. Damerau** explained that a barrier bucket might be able to produce a gap in the line density of the coasting beam during MTE extraction to reduce the losses on the TPS15 and 16 as the beam is swept over the septum blade. **A. Huschauer** started a discussion on the impact on capture in SPS, which will need detailed studies to following up.

SPS – Hannes Bartosik

Good availability also for the SPS. The high-beta run was completed successfully with VdM beams and preparation of LHC MD beams on-going. The 8b4e at 1.6e11 ppb has been set-up with ZS removed from operation. The 4x 12b at 2e11 ppb set-up is on-going with longitudinal stability issues (feedforward OFF, helps transmission). Ion cycle preparation is on-going. SFTPRO POT history was presented. Some MD highlights were presented, including 1 MV in both crab cavities to show transparency and higher intensity MD's looking at HOM behaviour and beam loading. High intensity LHC MD's showed stabilisation of a horizontal instability with 4x 48b (>2e11 ppp) using higher chromaticity and octupoles, profiting from the recent octupole recabling.

Main presentations:

Space charge studies in the PS – Foteini Asvesta

The studies in the presentation were motivated by the limitations facing LIU parameters with the large space-charge induced tune spread on the injection plateau and the need to understand the interplay of space-charge with resonances during the long time the beam is stored waiting for the second batch to be injected. Of relevance are the vertical integer (QV = 6), third-order (QV = 6.33) and fourth-order (QV = 6.25) resonances, where an 8^{th} order structural resonance driven by space charge is observed. The direct and indirect interaction of space charge with resonances was described in detail, in particular, resonance crossing in the indirect case (for low and high brightness) and computation of the Resonant Driving Terms (RDT) in the direct case. To perform studies of the direct effect, the third-integer resonance had to be compensated and the process by which this was achieved was explained in detail. For the 8^{th} order structural resonances all the coupling resonances were also explained: 2QH + 6QV, 4QH + 4QV, 6QH + 2QV, 8QH, 4QH – 4QV. The MD studies performing static tune scans were presented using a single INDIV bunch (45e10 ppb for low and 90e10 ppb for high brightness) from ring 3 to probe space-charge induced resonances and tune spread on known resonances. The behaviour of the 8th order structural resonances 8QV and 2QH + 6QV were studied in terms of losses along the flat-bottom. The measured loss response as the resonance is scanned was presented and explained in detail. The 3QV resonance is strongly excited in the PS and it was observed that the fourth-order 2QH + 2QV resonance is also excited, consistent with recent studies of **M. Kaitatz**. To complement the measurements simulation studies were presented employing a non-linear model of the PS in MADX and tracking in PyORBIT using PTC with the space charge kick calculated for a bi-Gaussian distribution using the Bassetti Erskine formula to save computation power. The simulations including space charge qualitatively agree with the measurements, but it seems that non-linear components in the lattice are missing. The next steps for further study were briefly outlined.

Discussion:

K. Cornelis asked how the non-linearities were introduced into the model for the PS. **F. Asvesta** explained that the higher-order multipoles were introduced from fits to measurements of non-linear chromaticity.

Longitudinal instability studies for Landau cavities in the PS – Alexander Lasheen

A quadrupolar coupled-bunch instability at about 4 × 2e11 ppb with small longitudinal emittance was introduced as a possible show-stopper for the LIU project, which motivated further investigation. To exacerbate the problem, the need for small longitudinal emittances to reduce losses at capture in the SPS was pointed out. Coupled-bunch mode spectra from the past were presented and recent measurements from 2018 of the quadrupolar spectrum were shown for measurements with a full machine at h = 21 and an intensity of 4 × 2.3e11 ppb on the flat-top, i.e. without the double splittings. Using this beam, it was possible to infer that neither the impedances of the 40 or 80 MHz cavities were the main drivers of the quadrupolar coupled-bunch instability by closing their gaps. The concept of Landau damping was introduced, using a spread of frequencies to supress resonant phenomena. In terms of longitudinal dynamics, this constitutes an increased spread of synchrotron frequencies with amplitude that a higher harmonic "Landau" cavity can provide. The recent tests carried out using an existing 40 MHz cavity (C40-78) in a Landau mode have demonstrated this stabilising effect, where the cavity was driven off resonance during acceleration, after transition, with a voltage ratio (compared to the 10 MHz system) of 10 - 15%. In such a configuration, the stability margin was increased beyond the LIU baseline; further optimisation (relative phase and voltage) is to be completed. Systematic parameter scans using the BlonD simulation code were carried out to try and understand the measured stability thresholds using the latest impedance model that is now missing only a few kickers and instrumentation devices. The simulations showed that, for the nominal emittance, the C40-78 would be expected to increase the instability threshold by a factor of 2. The simulation tool was used to specify suitable parameters (RF harmonic and voltage) for a dedicated Landau system capable of giving more than a factor 2 improvement of stability in intensity for the nominal emittance. Even though this solution works nicely, it was again emphasised that a dedicated Landau cavity could be necessary to reach lower longitudinal emittance and reduce the injection losses in the SPS.

Discussion:

K. Cornelis asked directly if we need a Landau cavity or not? **H. Damerau** explained that by using the existing cavities there is a time gap in the cycle after transition crossing that not is not "dampable" due to the changing and rising revolution frequency. In addition, with a dedicated Landau cavity we would have much more voltage margin. The question is, can we justify a dedicated system based on such results, which are quite successful! **K. Hanke** added that **M. Meddahi** will organise a review at the beginning of next year to help make this decision. With this in mind, **A. Lasheen** has already started to look at the stability margin needed to minimise losses at injection into the SPS. **H. Damerau** made another important point: for the present LIU scheme we assume that we already inject a large longitudinal emittance after LS2 which reduces the range that the longitudinal emittance can be modulated. **H. Damerau** clarified to **G. Rumolo** that there is no longer an upper limitation of 1 eVs to go through transition and that it can be passed at larger emittances.

W. Hofle asked for clarification that there is no clear contribution from the 80 MHz impedance to the quadrupolar instability. The solution to cure the impedance effects related to the 80 MHz cavities has been the multi-harmonic feedback. **H. Damerau** explained that the optimum for Landau damping is likely to be at a higher voltage than observed in the tests this year and the voltage is limited when the voltage programme rises for the final splitting because the phase of splitting and Landau damping are opposite.