MSWG Meeting #11, 18-August-2017

Present: F. Caspers, K. Cornelis, H. Damerau, V. Forte, M. Fraser, L. Gatignon, A. Gerbershagen, A. Lasheen, G. Papotti, C. Rossi, G. Rumolo, E. Senes, L. Stoel, F. Velotti, P. Zisopoulos

The minutes of the last meeting were approved. The request for higher intensity on SFTPRO is not imminent, with probably 2 more weeks of advance, but a small increase of increase approximately 20E11 ppp will be requested from next Wednesday.

Agenda:

Link to the Indico Event:

- Approval of minutes – Karel Cornelis
- Main presentations:
  - Studies on slow extraction losses in LSS2 – Linda Stoel
- MD updates:
  - PS 80 MHz cavity impedance measurements – Alexandre Lasheen

Status of Operational Beams:

PSB – Gian Piero Di Giovanni

All operational beams available and within the requested specifications, however an instability in the intensity of the beam from Linac2 since 12 August has caused issues. The Linac2 RF team is following up the issue and although it is presently much improved they will report to the FOM next week. The observed ripple on the QDE has been suppressed after an intervention. During the intervention the R2V WS was reset and the hotspot around BHZ52 was measured and shown to be generated in R2. **S. Albright** has prepared the BCMS 1.5 eVs beam starting from the LHC25 standard cycle. The expected improvement in brightness in the H plane was only observed and full deconvolution of the dispersive component, which changed the measured emittance by about 50%.

H. Damerau asked if the intensity fluctuations are normally observed, but the rate of "normal" occurrence has never been looked into in detail.

PS – Heiko Damerau

Operational beams are in a good state, with multi-harmonic RF sources being propagated gradually on to the operational beams. The LHC was filled with BCMS beam including the constant bucket area RF function during the ramp to the intermediate flat-top, removing a source of transverse emittance blow-up. A list of MD news was presented with a highlight that LHC25 beam with good longitudinal quality at >1.8E11 ppb with coupled-bunch feedback was sent to the SPS for Q22 studies. The 64V WS is now broken and 85V is being used. The upgrade of the RF beam control and new multi-harmonic RF sources was explained in detail.

Any MD beam cloned from LHCPROBE or INDIV will need migrating; as well as SFTPRO/MTE, EAST and TOF. Migration takes about 1 hour with checking: see users denoted "_MHS". A procedure will be made so that the OP team can do it, but it remains to be seen how difficult this is in practice **H. Damerau** recommends that MD users re-clone from OP beams that are already migrated: if this is not possible discuss directly with him before migrating.

SPS – Karel Cornelis

Operational beams OK, with a better 200 MHz structure (by chance) since the PS RF beam control migrated to the new MHS. Smooth running of AWAKE with some issue on the missing pre-pulse for MKE4 due to FMCM issues. A big effort was made from BI to improve the bunch-by-bunch WS emittance measurements. A sinking quadrupole in 523 was verified during a stop; the quad was blocked so it won't drop further and will be corrected during a future stop.

Recent MDs included LHC Q22 optics, SHiP cycle with extraction assisted with damper noise and also tests on the high bandwidth damper.

Main presentations:

Studies on slow extraction losses in LSS2 – Linda Stoel

The concept of resonant slow extraction was outlined, along with the associated extraction hardware focused on the electrostatic septum, which directly impinges the extracted beam inducing activation of the accelerator. A historical summary of the activation measured next to the ZS in the 30-hour RP survey shows that in 2015 the extraction efficiency was poor. Improvements were needed to bring down the activation levels for the future POT requested by the North Area, not only in 2017 but especially with the SPS Beam Dump Facility (BDF) proposal. In 2016, regular re-alignments of the ZS managed to control the activation (per proton) at the ZS but a hotspot was observed on the downstream TPST during the end of the run RP survey. In 2017, the beam loss levels at the TPST were closely followed during the ZS re-alignments. Another issue with the relative alignment of the ZS2 anode and cathode (gap for extracted beam) was identified in June as the machine operated at very high intensity, increasing the normalised loss levels, probably because the beam heated the device. The vacuum degradation and an increase in spark rate was observe on ZS2. After investigations, the loss levels at high duty factor were reduced by over a factor of 2 by retracting the cathode and realigning the ZS. It appears the cathode of ZS2 was touching the extracted beam and at high duty cycle this induced a significant increase in the loss per proton compared to low duty cycle operation. In addition, the gaps of the upstream ZS tanks were opened to give more margin to the extracted beam, whilst they were closed downstream to maintain the deflection for a constant operational voltage of -220 kV. The normalised loss levels in the LSS2 extraction channel, as measured on the BLMs, are now stable and have been for 2 months, consistent with historical data available back to 2007.

The on-going effort to develop beam dynamic simulation tools to understand the extraction process were outlined, with the pycollimate scattering routine combined with MADX tracking to qualitatively reproduce the measured loss profile as the downstream position of the ZS girder is moved. The proposed dynamic bump concept was explained and proposed MDs outlined, along with the passive

diffuser. The improvement in losses at the ZS has been demonstrated in two independent simulation routines: simple semi-analytical scattering and pycollimate/MADX.

Future MDs will continue to test future loss mitigation proposals being followed up in the SLAWG.

Discussion:

A. Gerbershagen asked about the impact of a diffuser on the beam emittance. **M. Fraser** explained that the scattering induced will move losses away from the ZS and elsewhere and increase the tail on the extracted beam; there is no magic solution. However, these tails are very similar to those induced by scattering on the ZS wire array itself anyway, and the vast majority of the scattered beam will be extracted into the transfer line and out of the machine. The diffuser will likely be combined with a collimation stage in the transfer line, if the scattered beam can't itself be transferred to the experimental target. A local, dedicated and shielded absorber is far preferred than the sensitive extraction equipment: last year 3 ZS tanks were exchanged and the teams involved were exposed to the radioactivity on the ZS induced by the extraction process.

MD updates:

PS 80 MHz cavity impedance measurements (beam-based) – Alexandre Lasheen

80 MHz structure due to the impedance of the cavities installed in the ring has been observed on the LHC beam at intensities above 1.6E11 ppb during the h = 42 to 84 splitting, causing emittance blow-up. For large intensity, the longitudinal emittance blow-up is critical for transfer to the SPS (large losses). In order to attain a reliable beam coupling impedance model for the 80 MHz cavities, beam-based measurements were carried out. The onset of beam profile modulation at 80 MHz was observed at flat-top and with the RF voltage of the 10 MHz cavities reduced, where the effect was significant with two 80 MHz cavity gaps open. The dependence on the number of bunches was investigated and the 80 MHz peak was observable for >9 bunches. Theoretical impedance models were presented and numerical simulations using BLonD code with the present impedance model were presented. It was not possible to reproduce the onset of the instability as a function of the number of bunches for the present model. A factor of 2 (for 21 bunches) to 3 (for 12 bunches) is necessary to reproduce the peak measured at 80 MHz.

Other beam measurements of the impedance made in the past have revealed that some resistive impedance may be missing from the present impedance model in the > 80 MHz region. These measurements could be repeated in the future. The next step is to measure the RF voltage in the gaps with a spectrum analyser to evaluate the impedance and compare with the present results to confirm or not that the 80 MHz impedance is larger than expected, using a beam-based calibration of the cavity probe signal.

Discussion:

K. Cornelis asked if the measurements were done with the feedback on. **C. Rossi** explained that a priori the feedback was on and the bias voltage for the anode should have been at its maximum level, however, beam measurements should be done again checking these points to make sure of the conditions under which the measurements were done.

The uncertainty in the calibration of the cavity voltage probe was discussed. **H. Damerau** explained that the tomoscope can be used to make a beam-based calibration of the cavity's absolute voltage seen by the beam. With a proper calibration it is hoped to measure directly the impedance seen by the beam.

F. Caspers recommends that the R/Q definition is explicitly clarified and defined, e.g. if it includes transit time factor or not. Such misunderstandings can account for significant factors and may be responsible for the report discrepancies.