MSWG Meeting #18, 14-Dec-2018

Present:

S. Albright, M-E. Angoletta, F. Asvesta, H. Bartosik, N. Biancacci, M. Carla, K. Cornelis, H. Damerau, M. Fraser, A. Huschauer, V. Kain, M. Kaitatzi, T. Lefevre, T. Prebibaj, A. Saa Hernandez, F. Tecker, M Vadai, F. Velotti, C. Zannini

Agenda:

Link to the Indico Event:

- Approval of minutes – Hannes Bartosik and Karel Cornelis
- Status of operational Beams – Machine supervisors
- Main presentations:
    - Overview of the LEIR performance during the ion run – Nicolo Biancacci
- MD updates
    - Overview of MD studies in LEIR – Angela Saa Hernandez

The minutes from the last meeting were approved.

Main presentations:

LEIR performance during the ion run – Nicolo Biancacci

The presentation was started with the news that this year was a record with up to 10.9e10 charges extracted from LEIR. An overview of LEIR performance was given for the NOMINAL beams with 100 and 75 ns bunch spacings, respectively. The data was analysed statistically and presented for approximately 90 LHC fills. An on-going refinedThe LEIR extracted intensity was dependent on the Linac3 current and machine injection efficiency. For most of the run the linac current was at 30 uA and LEIR comfortably achieved the future requested LIU performance. Different aspects of the cycle were discussed in detail including (i) injection and transmission and (ii) capture and acceleration. A good injection efficiency was observed but with a large jitter where optimisers and equalizers were tested and deployed. The efficiency through capture and acceleration varied from 95 to 80% depending on the accumulated intensity, with strong sensitivity on the electron gun voltage and revolution frequency. The lessons learnt through the year were described including (i) hysteresis of ETL.DHN10 (aircoil corrector), (ii) IPM perturbing orbit and full voltage, (iii) H instabilities arising from excessive cooling in H plane, (iv) stripper foil degradation and (v) injection energy drifts from Linac3. The presentation was summarised with an overview of the lessons learnt and next steps to implement improvements for smoother operation. It was emphasised that the early start-up of the machine in June was very important for training the LEIR team and preparing well for the run.

Discussion:

H. Bartosik clarified that the data presented was only from LHC fills and pointed out that no variation should be observed from the PS stray field, which should be constant and reproducible for LHC filling. **N. Biancacci** acknowledged that the source of the injection jitter needs to be investigated further.

N. Biancacci confirmed to **T. Lefevre** that "excessive cooling" means that the beam becomes too small before becoming unstable. **T. Lefevre** ask if there is no other way to control the cooling instead of going into the cooler with a strong angle. **N. Biancacci** explained that one can manipulate the relative beam sizes in H and V to control this too and control the cooling. This is something that will be further studied in simulation during LS2. **A. Saa Hernandez** pointed out that a lot of data was taken with cooling maps and will be presented in the next talk. **H. Bartosik** explained the cooling issue: one needs to cool sufficiently fast to be ready for the next injection but as one accumulates one does not want to cool so hard as the accumulated beam size can become very small; it's a trade-off. On the other hand, on the EARLY cycle, being a short 1-injection cycle, the cooling rate is boosted setting the ions and electrons trajectories aligned in the cooler section.

H. Bartosik recommended that efficiency of the different injections in the cycle is checked as function of time to see if there is correlation or causal effect with trims influencing the stability. In addition, compensation of the IPM should be studied further.

Overview of MD studies in LEIR – Angela Saa Hernandez

An overview of the MD schedule and motivation for the studies was used to introduce the talk. The first studies presented investigated the interplay between cooling and heating effects in LEIR, i.e. electron cooling vs. IBS, space-charge, scattering on residual gas etc. The cooling force was measured using the momentum variation of the ion beam, reproducing well simulations of the process using the RFtrack code. Systematic studies characterising the cooling behaviour as a function of the position and angle in the cooler were shown for different e-beam current and transverse beam profiles, which allowed for the preparation of beams with desired properties. Simulations are on-going to understand both IBS and space charge, separately. The behaviour of IBS was well understood at low intensity but at higher intensities the emittance blow-up depended strong on the working point, above a threshold intensity, implying that space charge dominates for certain tunes and intensities. In this context, systematic measurements exploring losses and emittance at different working points were presented, with a resonance at QY = 2.66 being identified as the cause of vertical emittance blow-up and beam losses. Compensation of this resonance up with given sextupole settings found could compensate losses by up to 90% when crossing the resonance dynamically. Tests probing different ideas to reduce losses and emittance blow up were presented, including attempts to accelerate ions without RF on a slowly ramping injection plateau using the e-cooler and cooling bunched beams. Although acceleration could be achieved no improvement of the emittance was observed and cooling bunched beams yield no immediate benefits either. The source of a fast, vertical instability was found and cured, and attributed to unterminated equipment in the ring. Horizontal instabilities were investigated further. Finally, the development of optimisation tools was reported and proof of principle test presented showing optimisation of the automated optimisation of the cycle with Powell and Reinforcement learning methods. The presentation was summarised with a LEIR team happy with a successful 2018 ion run.

Discussion:

K. Cornelis asked if we conclude that when the tune is set correctly, LEIR is entirely IBS limited? Yes,for coasting beam but for bunched beams the tune spread is increased, creating a large tune footprint in the tune diagram. Indeed, if far from resonance and low intensity then IBS is the dominating source of blow-up but closer to resonances and, even with only moderate intensities, then space-charge plays an important role. **K. Cornelis** asked if there any other ideas for acceleration without RF capture. Indeed, one could consider phase displacement acceleration and accelerating between an bucket by sweeping the RF frequency (last time at ISR at CERN). The available RF voltage would need discussing here. Even ideas using a betatron were discussed.

T. Lefevre brought up the future of LEIR tune kicker moving into LS2 and post-LS2. As in many machines the tune kicker is being used in very different ways than just for tune measurements. Although BI are still responsible for this, their expertise for the higher voltages needed to make the tune kickers strong enough to measure the machine optics make is difficult for the HV expertise of BI to keep following. It was suggested that discussions should be opened with ABT about how to transfer responsibility in view of the changing kicker requirements. **H. Bartosik** added that in the PSB already started this year with turn-by-turn BPM optics measurements and measurements will follow in LEIR in the future: a suitable kicker/exciter will be needed. **T. Lefevre** proposes that the LEIR requirements are written down next year and a strategy is discussed and agreed early next year.

T. Lefevre also discussed dedicated diagnostics for cooling. Indeed, LEIR would benefit from diagnostics giving information on the electron properties, namely on the position of electron beam and physical overlap of the two beams. The electron lens project in the LHC was discussed along with related instrumentation. **H. Bartosik** pointed out that there are references to e-beam modulation and other useful instrumentation possibilities with the existing cool. It would be a good idea to look into this and see what can be renovated or revived; a list will be drawn up.