Week 17 & 18

Beam set up on the low gamma transition cycle (Q20) (H. Bartosik, et al.)

We were able to take some beam with the Q20 optics, already during last week. On Wednesday and Thursday, some basic optimization on the LHCFast3 (Q20) was done, including orbit correction (<3mm rms in horizontal and < 2mm rms vertical) and the adjustment of the tunes along the ramp with a single bunch intensity of about 1.6e11 ppb. The octupoles were switched off without measurable impact on the beam intensity along the cycle. The RF voltage program was redone, starting from 0.45 eVs constant bucket area. As usually done for LHCFast cycles, the voltage program is modified towards the end of the ramp to a constant value until extraction. Changing the voltage at injection (between 2 and 4.5 MV) showed very little effect on the capture losses. In general, for intensities 1.2-1.6e11 ppb only small losses along the cycle (<4% from injection to extraction) were observed on the BCT after these optimizations. Chromaticity was set by hand to positive along the cycle, however a more thorough optimization is needed. Thursday night, Stephane prepared a copy of the LHC_1Inj_FB60_FT835_2011_V1 cycle (slow ramp) with the Q20 optics called LHC_1Inj_FB60_FT835_Q20_2011_V1 and successfully accelerated single bunches up to flat top. On Friday, the radial steering of 6mm needed to stabilize the beam in the second half of the cycle could be removed after adjusting the vertical chromaticity. It seems that feed-down effects due to the large orbit offset from the radial steering allowed to correct chromaticity and therefore stabilize the beam. Basic optimization of the orbit and the tunes were performed also for this cycle. Apart from the usual losses of the uncaptured beam at the beginning of the ramp, only small losses were observed along the ramp. However, further optimization is needed for the chromaticity and the voltage program (the latter is a pure copy of the Q26 cycle). On Friday evening, a batch of 12 bunches with nominal intensity was accelerated up to flat top without any losses. A test was made together with Thomas and Elena in order to understand the beam losses observed in the nominal cycle when applying a negative radial steering (final part of the ramp or the flat top) of about 2mm. The same phenomenon was reproduced with the new Q20 cycle. It is not yet conclusive if this is an instability or some loss due to mis-steering of the beam. No loss of this kind was observed for large radial steering in the LHCFast cycle with the nominal Q26 optics (not tried yet for Q20). Injection matching studiesin week 18 to try to improve the matching from TT10 into the SPS did not show any significant improvement in terms of the injected beam quality.

Controlled longitudinal emittance blow up studies in preparation for the LHc MD (T. Bohl, J. Tuckmantel)

For the LHCFAST cycle good BUP settings had been found to obtain bunch lengths between 1.3~ns and 2.1~ns (0.4~eVs and 0.9~eVs of longitudinal emittance). Also for the cycle with the standard LHC cycle ramp good BUP settings had been found. As the BUP time was 1~s longer in this case, it was easier to find settings for a stable and reproducible result at flat top. Finally the required beam had been delivered to LHC 2011-05-05.

Longitudinal instabilities at flat top caused by radial steering (T. Bohl, E. Shaposhnikova)

Check presence of longitudinal instability at end of acceleration ramp as function of radial steering:

- CY: LHCFAST_L7200_2009_V5, fast ramp: not observed
- CY: LHC_50ns_S_2011_V1, standard ramp: observed (as earlier)
- CY: LHC_1inj_FB60_FT835_2011_V1, standard ramp: observed
- CY: LHC_1Inj_FB60_FT835_Q20_2011_V1, standard ramp: observed

Measurements on instability at flat top using a fast and standard ramp seem (!) to indicate that the instability is not observed with fast ramp but with the standard ramp cycle. As a number of parameters like TWC800 on/off, controlled long. emittance blow-up on/off, RF voltage programmes (bucket filling factor), intensities etc., have to considered the comparison of the data acquired with the various cycles is not yet fully analysed.

Set up of the high intensity 50ns beam (double batch from PSB) in the PS (H. Damerau, S. Hancock)

Longitudinally, the double-batch high-intensity 50 ns beam behaves very similarly to what had been observed during MDs with the single-batch beam in 2010. Up to transition energy, there are no issues since everything until then is identical to the 25ns beam with low intensity. Following transition crossing, coupled-bunch (CB) oscillations (as observed before) start off, but can be attenuated by the CB feedback (FB). On the flat-top however, the CBI increases and perturbs splitting and re-bucketing on the flat-top. Similar to last year with the single-batch variant, 1.9 10^11 ppb have been reached with slightly compromised longitudinal parameters (average bunch length at extraction ~ 4.2 ns, larger bunch-to-bunch intensity spread). Beyond that intensity, beam quality degrades quickly resulting in unstable, long bunches and strong satellites at 25 ns. Two issues remain to be looked into in more detail, which is why we would be interested in more parallel MD time in the PS with that beam:

- Are the coupled bunch-mode spectra the same as previously observed?
- What can be achieved with three 80 MHz cavities (as they were not available during setting up last week)?

The latter point is interesting since the results from first tests to transfer longitudinally larger bunches (~20% more long. emittance) to the SPS, but keeping their length at 4 ns, look promising.

Week 19 (long MD block)

Comparative electron cloud measurements with 25ns, 50ns double batch and single batch beams (T. Bohl, W. Hofle, H. Neupert, G. Rumolo, E. Shaposhnikova, D. Valuch, C. Yin-Vallgren)

The longitudinal plane and the transverse damper on the 25ns beam were set up during the first long MD day (Monday) with one or two batches. In the evening the number of injected batches was ramped to 4, and tunes and chromaticities were optimized for each injection so as to minimize the losses. Finally, 4 batches could be injected and accelerated in the SPS with losses below 4%. The transverse emittances were measured all along the cycle and also at flat top, showing values about 2.5um in both planes. It was discovered later that the wire scanners used for these measurements were gated only on the first half of the first batch, therefore these numbers will have to be confirmed in a later MD. Because of the MKE4 (Tank5) heating, the 4 batches injection was stopped and, instead, only 3 batches were injected with dump before acceleration. In these conditions, electron cloud measurements were taken for a dense grid of different values of clearing electrode voltage and magnetic field in the liners. The clearing electrode was found to be very effective in suppressing the electron cloud. On Wednesday, the 50ns beam with double injection from the PSB into the PS was taken by the SPS. Again the beam was optimized with 4 batches injected into the machine (intensity 1.4e11 ppb at flat top) and losses as low as 2-3% were established. The transverse emittances were measured to be 1.7um in both planes at flat top (with the same issue on gating as with the 25ns beam). While a significant electron cloud signal could still be measured with this beam on the bare StSt liner, the StSt liner equipped with clearing electrode seemed to have been more efficiently scrubbed, as no electron cloud signal was visible on it (and it was double-checked that the clearing electrode was grounded). In these conditions, the intensity per bunch was increased by ~15% and beams with 1.6e11 ppb could be injected and accelerated to the SPS flat top. However, the beams were longitudinally marginally stable, as the bunch length was often measured to be above 2ns at flat top. The longitudinal emittance blow up along the ramp will be optimized in a future MD for this type of beam. During the present MD, a good stabilization could be anyway achieved by having a longitudinal emittance blow up in the PS using the third 80 MHz cavity. Finally, the 50ns beam with single batch PSB/PS transfer was injected into the SPS with nominal intensities and up to 1.4e11 ppb. Transverse emittances were much larger (up to 3um per plane) and for the same intensity value, a lower electron cloud signal was observed on the StSt liner. This points to a dependence of the measured electron cloud on the beam transverse emittance, compatible with a situation in which the machine is running with a SEY very close to the threshold value for electron cloud formation.

Emittance growth studies on the Q20 cycle with long flat bottom (H. Bartosik, B. Salvant, et al.)

Single LHC-type bunches with intensities up to 3.5e11 p were injected into the SPS on a long flat bottom cycle, which had been previously set up. The purpose was to measure emittance growth along the 10.8s long flat bottom for different injected intensities, and the total transmission/emittance preservation along the full cycle (including the accelerating ramp). A part of the MD was devoted to optimizing the set up of the beam along this new cycle, then the emittance measurements took place. New plots of horizontal and vertical emittance versus the injected intensity have been produced, in which the further information on the total losses along the cycle is coded in the color of the points.