Status of the machine studies

APC meeting, 14/11/08

0) General comment: Few hours were sometimes lost for the preparation of the supercycles. We already discussed that this should be done during the preceding shift. How can we improve it?

1) Setting-up MD4 cycle in the PS with long (~ 25 ns at 4 sigmas) bunches for SPS impedance meas. (H. Damerau)

- The beam phase loop shows an offset at very low RF voltages (10 MHz cavities) which deteriorates the stability of the synchronization. With 10^11 ppb, a high frequency structure is sometimes seen on the bunch. This indicates that this beam might also be useful for longitudinal impedance studies in the PS.
- The cascade for a controlled RF voltage reduction to either 20 kV or 4 kV (one single cavity) has been programmed on the MD4 user and tested with beam. The synchronization with the SPS takes place at a constant RF voltage of 80 kV which is followed by an iso-adiabatic descent to the final voltage, reached ~15 ms before extraction. The 4 sigma bunch length at extraction is either ~20 ns (20 kV at extraction, symmetric bunch) or ~28 ns (4 kV at extraction, slightly asymmetric bunch).

2) Reference measurements on LHC25 in the PS (effect of fast feedback of 40/80 MHz cavities) (H. Damerau)

- All three 80 MHz cavities must be switched on for the measurements to be compared to last year's results; but the 80 MHz cavity in SS89 could not be switched on during the MD.
- Thanks to Michele Morvillo who investigated the cavity problem, it became clear that an access would have been necessary to make the cavity operational again. The access could not been performed during the MD.
- Measurements of different configurations with the remaining two 80 MHz cavities have been recorded. Without analysis of the acquired data it is unfortunately not possible to state if the effect of bunch lengthening towards the end of the batch (as observed last year) could be measured. In any case, the results obtained so far will unfortunately not be comparable to those of last year due to the problem with cavity C80-89.
- Next steps: To be decided if the cavity can be repaired during an access before the end of the run. If this is the case, the large part of the measurements must be repeated to finally compare them to last year's results. This comparison would be very interesting since the impedance reduction feedbacks (fast loops in the tunnel) of the cavities had been adjusted differently for the run of this year.

=> Another MD was done few days after.

3) Inject in the SPS the PS LHC75 and MD3 (LHC50ns) beam with re-bucketing to SPS derived buckets instead of using a fine synchro, to see if this improves the situation (H. Damerau)

- LHC-type beams with 75 ns and 50 ns bunch spacing have been injected into the SPS using two different synchronization schemes: (a) Operational scheme using coarse (h1) and fine (h84) synchronization loops in the PS and (b) new scheme using coarse synchronization (h1) and re-bucketing with an RF-voltage at h84 directly derived from the SPS frev and fRF. Systematic measurements for comparison of the schemes have been recorded in PS and SPS for both beams.
- Next steps: Depending on the results of the MD (after data analysis), a prototype electronics to test the scheme with an LHC25 beam might be prepared and the new scheme might replace the fine synchronization of LHC 50 ns and 75 ns variants for next year's run.

4) Beam position interlocks studies (J. Wenninger)

- MD went well $\Longrightarrow$ Preliminary conclusions:
  - The old system (based on MOPOS) is very precise (but slow) and reproducible for all the beams (25, 50 and 75 ns), which is good news.
  - The new system stars to work but some few things still need to be looked at.

5) Study of the SPS impedance with long bunches (B. Salvant)

- The bunch was not as long as expected.
- RF rephasing + LINAC intervention + other minor issues took quite some time off the MD. Also the headtail monitor in the vertical plane, an important monitor for the MD with short bunches we also planned to perform that day, was disconnected.
- An intensity scan with long bunches was performed and bunch parameters were saved, in particular the bunch longitudinal and vertical signals from the wideband pickup in the Faraday cage. Preliminary analysis produced the longitudinal and transverse frequency spectra. The main contributions are between 10 to 500 MHz. A signal at ~100 MHz is visible in the vertical plane after a few turns, and is not seen in the longitudinal plane. This could be due to coupling with chromaticity or impedance. Data still to be analysed in detail.

6) Last Long Injector MD in week45

- RF studies: studies of beam stability in a double RF system (E. Shaposhnikova)
    - Perfect conditions
    - We observed fast and slow (time scale of minutes) instability in a double RF system of the SPS for different voltages and operation modes of the 800 MHz RF system (bunch lengthening and shortening correspondingly). We also investigated the role of phase loop by putting it on different bunches (1st and 3rd) and of other RF loops.
    - Next steps: The same type of conditions (coast) next year to continue these studies.
- Matching monitors' study in the SPS (E. Benedetto)
    - Problems of the server of the CIS main power supply (called piquet PO) made us start with 2h delay.
    - We had very good beam conditions, found correct timing for the camera, ready to take measurements, but the fast camera start giving noisy acquisitions (radiation? over-heated?). Decided an access to reboot the camera. Camera OK. Problems with the timing. Solved. Beam unstable form the PS: extraction was changing form shot to shot and we had large oscillations at injection, which could not be cured since were varying form shot to shot. Investigations in the PS, even if many other activities were going on in that Island (but, as agreed, we were not the user with higher priority any longer). Finally the camera stopped giving any signal of life (radiation? heat? what else? it happened also last time in August. BI is investigating). Either ask for another access to reboot the camera, either to remove it. Since it was already 12h30, the MD was supposed to finish by 15h, and the beam was not stable, we decided to remove it.
    - We took some measurements anyway. Most likely useful, even if corrupted -> to be cleaned up and analyzed. But we could not complete the planned MD: 1) measurements with the current optics DONE! 2) artificially introduce mismatch in the optics NO! 3) go to higher chromaticity to see if there is an effect on the beam shape(to crosscheck measurements of last year), NO!
    - Next steps: 1) Analyze data. 2) Decide what to do and how to proceed next time in order not to waste precious MD time.
- InCA (S. Deghaye) => The validation of the new control architecture has been done and next year it will be the construction phase.
- Continuous beta-beat measurement using BBQ-type detectors, BTF measurements, continuous head-tail tests using diode-based acquisition system (R. Steinhagen)
    - Beam and machine conditions were satisfactory.
    - Problems: MPS recovering problems (~2h), corrector/RF trims of the old MUGEF system needed to be fixed to work during coast (thanks to Michel only 2 hours), Wednesday: tardy CPS super-cycle setup (change multi to single bunch operation) during OP crew change (lost 2 hours), lost another 2 hours due to IT maintenance on the CCR routers and switches that brought large parts of the CO server infrastructure down (2h), total time lost: ~ 10 hours (50% efficiency)
    - A) beta-beat: We could show that our proposed system is capable of tracking the values of the betatron function at three LHC-type pickups in the SPS with better than a degree resolution corresponding to a beta-beat resolution of about 1% while using off-resonance excitation only. The continuous tracking could also be used to show SPS inherent lattice drifts in the order of 1 to 2%.
    B) Scanned the BTF as a function of Q', octupole strength, dp/p shift scanning speed. Initial results showed the expected results seen in previous years (e.g. tune width being proportional to Q'), further detailed analysis pending.
    C) Continuous head-tail and quadrupolar pick-up: analysis pending (FNAL/CERN collaboration)
    - Next step: results and further will be presented/discussed during the coming APC meeting (21. November)
    - New requirements: We likely will need some additional MD's with coasting beam at 270 GeV.
- Scraper MD on tail repopulation (H. Burkhardt)
    - 1.5h lost in recover after previous MD, mains, off - piquet intervention. 0.5h lost with software - time inconsistencies.
    - Needed hack to fake timing to get scraper and BCT working in coast.
    - Only 2h remained for actual measurements
    - We had to skip the idea to get a second coast with different intensity and beam size.
    - Scraper control technically ok.
    - Confirmed strong repopulation only in horizontal plane. Beam shape measured including tails by scraping plus wirescanner.
    - Next steps: See if halo repopulation changes with intensity and bunch length - for which we had no time left this time. More detailed non-gaussian tail measurements.

- New requirements: Nothing fundamentally new needed - mainly time (beam and manpower).

- Study of beam losses and beam lifetime with different settings of the LHC collimator prototype in LSS5 (S. Redaelli)
  - Coasting beam of the requested intensity was available reliably throughout the allocated MD time. Just lost one coast due to a spurious interlock (lost about ~30 min).
  - Beam-based alignment of the collimator jaws was achieved. Attempts to adjust also the collimator jaw angles were carried out (off-line analysis ongoing). Measurements of beam lifetime reduction as a function of the collimator settings were performed with great detail and are being investigated. Good sets of data obtained with the LHC-type BLM: "Post-mortem" and "capture" buffers as designed for the LHC were set-up and worked reliably. Variation of beam loss patterns as a function of RF settings performed and analysis under investigation.
  - Next steps: Depending on the LHC activity, we would like to continue this type of studies next year.
  - New requirements: Higher intensities (only had time to work with 12 bunches this time).
- Frequency spectrum of beam losses at LHC and SPS collimators (B. Holzer) => Perfect beam conditions and data to be analyzed.

7) Transverse feedback in the PS (A. Blas)

- The goal here was to try and stabilize the horizontal single-bunch resistive-wall instability on the long injection flat-bottom (nominal LHC cycle) with the transverse feedback instead of linear coupling. If this can be done, then the idea would be to increase the chromaticity from ~ -1 to ~ -0.1 (the predicted instability should be more violent!) and one could may be hope to reduce the slow incoherent losses observed for several years on the long injection flat-bottom. Another application of the transverse feedback could be to try and stabilize the high-energy instability which sometimes re-appeared this year with the nominal LHC beam.
- When the beam was taken on 07/11, there were ~ 40% beam losses on the long injection flat bottom. This was reduced to ~ 15-20% when the vertical orbit was corrected (even if the improvement of the orbit was barely visible!). One could never reduce the losses less than ~ 10% (obtained on 11/11) on the injection flat bottom. Furthermore, it was observed that the vertical profile had large tails, and that these tails were already present in the PSB.
- Stabilization was succeeded, but sometimes the instability re-appeared (later on the injection flat bottom). Reminder: Fine phase settings using the BTF and fine PU gain settings (to use the ADC dynamic range without saturation) have not been carried out yet. This fine tuning will be done next year.
- We tried to increase the horizontal chromaticity by ~+0.6. It seemed the instability was in fact less violent (but we had slow losses…). To be followed up next year.

8) New digital beam control in the PSB (M.E. Angoletta)

- The tests done this year in the PSB with the new digital beam control have been extremely successful, as the beam results were excellent and we managed to do everything that was on our (ambitious) “To Do” list for 2008.
- The system was integrated within the control infrastructure and relied on the front-end software developed for LEIR; as a consequence, no changes in the frontend part (namely our many RTTs) were needed for these tests. A dedicated PSB user was devoted to us, where the beam was sent to the beam dump: this allowed us to control a typical LHC intensity beam. The intensity range used for most of the tests was of the order of 1-2E12 protons per ring.
- The system captured, accelerated and extracted the beam on the PSB ring 4, by controlling the CO2 and CO4 RF systems. I would like to underline that controlling the CO4 RF system was an absolute first for the digital BC, and was an essential, important step forward.
- The bunch splitting was also achieved with the digital beam control for the first time, requiring the phase loop at harmonic 2 to be implemented, as well as feedback control of the phase of the CO4 cavity with respect to the CO2 cavity.
- The bunches at extraction were very short (~ 105 ns), with a typical extracted number of particles of about 1-2E12 protons.
- Next step (from W. Hofle): Migration to a full digital beam control system in the booster in the near future…

9) Acceleration of an LHC-type multi-bunch beam with the real cavity return summation signal, instead of the normally used synthesized cavity return (H. Damerau)

- The delay of the real cavity return sum was found to be longer than the delay of the beam signal path. Some extra delay (300 ns) had to be installed in the signal patch of the beam pick-up, requiring a complete readjustment of the beam control.

- An TSTLHC25 beam (48 bunches) has been successfully accelerated using the real cavity return vector sum signal instead of a synthesized cavity return. The switch-over to the high-energy part of the beam control and the bunch splittings could be adjusted correctly and intensity changes (20% <-> 100% nominal) have been tested. The intensity dependence of the h21 phase loop offset and the h21 cavity return signal remained similar to the normal configuration (using the synthesized cavity return). It can thus be concluded that the intensity dependence of the beam control observed is not due to a phase shift between the synthesized cavity return used for the phase loop and the gap voltage in the cavities.

10) Generation of flat bunches in a double harmonic h21/h42 bucket at flat-top energy in the PS, including electron cloud measurements by Edgar Mahner and Fritz Caspers (H. Damerau)

- The voltage program for the 20 MHz (h42) cavity could not be started before ~ C2256. This was found to be due to the trigger time of frequency and phase loop window discriminators (protection) and has then been bridged for the MD.
- Flat bunches (18 bunches at h21) have been observed according to simulations by Chandra Bhat (visitor from Fermilab) and were found to be stable during the ~170 ms from their generation to ejection. No electron cloud effects were seen with these bunches.