

# Status of the machine studies

APC meeting, 23/11/07

## 1) Studies in the longitudinal plane (E. Chapochnikova, 17/10)

- We could not have 4 batches at 450 GeV with nominal voltage of 7 MV.
- Problems with V damper, setting-up till 18:30
- Measurements of controlled emittance blow-up as a function of noise settings (central frequency and bandwidth) and the 800 MHz phase relative to the 200 MHz. The emittance blow-up obtained was less uniform along the batch than in the previous MD with similar settings. Strong dependence of final bunch lengths on the 800 MHz phase was observed.
- To continue scanning in multidimensional parameter space for the best settings. Needs to be done also as a function of beam intensity.

## 2) Test of gamma transition doublet power converter with noise (S. Gilardoni, 25/10)

- Oasis could not be available all the time. Expert had to fix triggering problem.
- Data analysis

## 3) Trimming of MTE beam on 1bp (S. Gilardoni, 26/10)

- Q-meter seems to work for non linear chromaticity measurement. Capture established with small intensity per island, probably due to too small emittance from booster. This is due to the use of the MD3 from booster in H2 and not a specific and prepared user.

## 4) Acceleration of up to 4 bunches to 450 GeV/c (T. Bohl, 29/10)

- New low level set-up for new cycle. Optimisation of low level for 4 bunches injected (first time). Confirmation that h/w change of Friday last week proved beneficial for the transmission of all bunches and especially for the 2nd, 3rd and 4th bunch. Further transmission optimisation by RF voltage programme adaptation.
- Several firmware improvements concerning the Slave DDS - modification of synchronisation loop - study of capture loss (evtl. use of very short bunches from PS, inject on synthesiser) - test of injection damping - acceleration with synchro loop - reference measurements.
- No new requirement, just the old one for about 10-12hrs during the next dedicated I-LHC MD and for parallel MD time before.

## 5) Ion beam in coast at 17 GeV/c/charge to study space charge effects + IBS (Django, 30/10)

- All injectors performed well during the whole MD session; few breakdowns.
- It took a while to get the transverse dampers off as the remote control did not work and we had to call the piquet.
- Measurements of longitudinal and transverse beam profiles, total beam currents and individual bunch currents at various timings after injection, with H and V tune scans, and intensity variations.
- Detailed analysis underway; correlation of measurement times between devices is a challenge.

## 6) Fast extraction of ion beams in TT60 (Django, 30/10)

- Kickers prepulse not available.
- It was decided to postpone the test to daytime during the next MD, after no other beam is needed, in order not to perturb the last days of LHC proton MDs.
- Prepare extraction kicker prepulse for ion beam for the last session on 12-13/11/2007.

## 7) RF studies on ions in the SPS (T. Bohl, 06/11)

- Improved low level h/w was not yet ready for installation in FC.

## 8) Abort gap cleaning tests in the SPS in view of LHC (W. Hofle, 05/11)

- The situation with a water leak in T2 was unclear (intervention time to be used for SPS access), hence we got no beam before 10:00. Furthermore we had smaller interruptions until 11:30 because of other interventions. Due to problems on our side we actually started to measure not before 13:30. The decision was made to stay with single bunch for the rest of the MD, which then was very constantly available.
- (0) It would be good if the BLM system [SPS and future LHC] (fast acquisition, every 40 microseconds) would have a built in timing system to trigger the acquisition. Currently this system only triggers on thresholds and in order to synchronize the BLM acquisition and the damper action we had to use an old cable link between BA2 and BA1 via CCC. Setting-up this link and the BLM triggering took a good deal of the morning.

(1) Large horizontal orbit oscillations (max +/-8mm, RMS 3mm) which seemed to be caused or influenced by switching on the octupoles. (2) Operation or certain measurements rely on the presence of Jörg Wenninger in the control room (thanks again Jörg!). (3) WireScanner measurement is cumbersome.

- We measured >99.5% "beam cleaning" efficiency using optimized excitation programs on the transverse dampers in the presence of chromaticity and/or non-linearities (octupoles). The LHC-type BLM on the TIDV in the SPS was a very helpful tool to record detailed loss rates. The measurement results are in agreement with previous simulations, details have to be worked out offline (data analysis). They will serve as input for detailed studies of the LHC.

- Next steps: Detailed analysis of the data + simulations for LHC.

- New requirements: LHC ready! MDs in LHC with a single bunch (if LHC available in 2008), if LHC not available: more measurements in SPS if necessary.

#### **9) RF studies on ions in the SPS (T. Bohl, 07/11)**

- No usable beam in the afternoon.

- Vacuum problem in the PS

- Test of firmware upgrade of Slave DDS during the morning showed improvement and a new bug was found (will be fixed for next MD).

- Next step: Fix firmware.

#### **10) Transverse Impedance with Intensity (R. Calaga, 02/11)**

- Problem encountered: BPM gain settings with intensity. Did realize the additional attenuators in ARC 3-4 which had to be 10dB more than the others and the total intensity setting should be less than ~8000.

- Under Analysis.

#### **11) Check the dispersion matching of LHC beam in the SPS at injection, with the new optics of Oct'07 (E. Benedetto, 11/11)**

- LHCPILOT used. Varied the beam momentum at extraction from the PS (Delta B inj ~ +/-30G corresponding to +/-5kHz on the 200MHz frequency) and recorded beam position at the BPM in TT2-TT10-1stTurnSPS with the Passerelle. Measurements with bunch rotation on (couldn't switch it off -? too low intensity).

- 1) In the SPS RF application (-> to vary B injection or Bucket selector) you should enter the beam type (i.e. LHCPILOT) and not the user !!!(i.e. MD1): it took some time to find it out. 2) BPMOPOS\_6 not acquiring, BPMOPOS\_4 server was not reachable at the end of the MD. 3) Great help from Heiko who spent Friday afternoon to check the tuning of the RF cavities (to avoid calling the experts in the week-end) and came on Sunday @ lunch time to check the RF cavities and the synchronization with the SPS for me.

- With the new optics in operation since Oct'07 (QKE58 definitely removed) the dispersion is well matched at the injection in the SPS and the mismatch factor [Arduini, Raimondi, SL-Note-99-022 SLI] is  $J \sim 1.02$ , assuming nominal LHCbeam with  $Ex^* = 3\mu\text{m}$ ,  $dp/p = 1.1e-3$  (1sigma). Dispersion measured at the beginning of TT2 is  $Dx0 = 2.73\text{m}$ ,  $Dxp0 = 0.230$  (with uncertainties due to BPMOPOS4 and 6 not acquiring and no measurements with OTRs and SEMwires in TT2-TT10)

=> Study finished.

#### **12) Ion studies (Django, 12-13/11)**

- On LEIR, the RF team has successfully installed the new hardware over the week-end. It is now in production. The beam has been used in the LINAC, LEIR and PS over the week-end under the surveillance of the SPS team.

- Dedicated ion MD in the SPS started at 8:00 on Monday 12/11. Ions started to be injected at 10:00. The RF team worked all day to try and accelerate the beam to 450 Z GeV/c. In parallel, extraction conditions for TT60 were being set up. As soon as the beam reached 450 Z GeV/c, extraction was enabled and the extracted beam was observed on the TT60 screens just before 17:00.

- The rest of the evening was devoted to trying to accelerate the beam through transition without the radial loop, to ease the synchronization, but these attempts were unsuccessful.

- At Midnight the collimation/BLM MD started, first at low energy. At 3:00 the 270 Z GeV/c coastable cycle was reloaded, and the collimation MD went on at 270 Z GeV/c until beam stop.

- Since less than 25% of the nominal bunch intensity came out of the PS due to the bad vacuum, some parts of the foreseen MD programme had to be dropped (IBS, space charge).

#### **13) Low-intensity limit with the nominal (72 bunches) LHC beam (PSB&PS people, 07/11)**

- Intensity change on LHC25A&B in the PSB to eject 15E10p/ring, i.e. to divide the intensity by a factor 10 (BI.SIEVE IN - Intensity/5 and Vertical Shavers IN - Intensity/2). Note that the bunch shape of the ring1 and the intensity was not good and stable.
- The intensity on LHC25 in the PS was decreased accordingly. Some optimization was required in both longitudinal and transverse planes. The transverse emittances (rms, norm) near extraction were ~ 1.9 and 1.3 micrometers. Note that tails larger than for the Gaussian were also observed".

**14) IPM (J. Koopman, 07-08/11)**

- Horizontal profiles measured along the cycle with the IPMH on both SFTPRO1 on 07/11 and LHC25NS on 08/11 (to see the also the effect of the controlled transverse blow-up for the ecloud studies).
- The camera of the IPMV seems to be dead...
- => A summary of the 2007 results will be presented at the APC to be held on 07/12.

**15) BBLR (J. Wenninger, 09/11)**

- All the studies of the last proton dedicated MD (the additional one we asked for) were successful, except this one, which was judged to have the lowest priority and was therefore put at the end of the long MD. Less than 2 hours were devoted to it, which revealed to be not sufficient.
- We measured the V emittance in the SPS (2.5 micrometers for nominal intensity with 12 bunches on 2 batches). Then we put the sieve and re-measured in the SPS and found ~ 1.2, which is strange as it should not change the emittance => I informed K. Hanke, who then performed some measurements, which confirmed that the transverse emittance is reduced when using the sieve (although not by a huge factor).

**16) Study of the 75 ns beam (G. Arduini, 31/10)**

- Many orbits were taken the same day, i.e. with more or less the same conditions, for both 25 ns and 75 ns beams.
- It is not possible (for the moment?) to compare with data stored several years ago due to a change in the formats (not readable anymore by the program).
- => A summary of the 2007 comparison between the 25 ns and 75 ns beams will be presented at the APC to be held on 07/12.

**17) TMCI studies at SPS injection (B. Salvant, 04/11)**

- After adjustment similar to the one used in the past, nothing was observed in long., while the instability in V was recovered for ~ 1.2E11 p/b (nothing in H).
- Threshold in xiv ~ 0.5, and threshold in intensity ~ 0.7E11 p/b => To be analysed in more detail...
- Many data taken while the intensity was scanned using the vertical shavers in the PSB, for 2 settings of octupoles (maximizing the decoherence time).

**18) Study of the effect of energy (and transverse beam emittances) on the electron cloud vertical fast instability at 55 GeV/c (G. Rumolo, 08/11)**

- Transverse emittance blow-ups were done using the transverse damper + octupoles.
- Data to be analysed in detail, but it seemed clear in the CCC (observations on many cycles) that the beam was (reproducibly) stabilised with the larger transverse emittances, which would go in the same direction as the predictions from Giovanni.

**19) Long 5BP LHC cycle in the PS, with rotating machine but simulating its absence (Y. Papaphilippou, 13/11)**

- It was a test without beam and other users present in the supercycle, thus easy to achieve the requested conditions.
- Problems: a) Absence of the Bdot sampler signal which was recovered by using OASIS. b) 1hour interruption due to access in the PS for radiation measurements. c) The MD was resumed around 18:30 after having lost the ability to further reset the Main Power supply.
- Current results: a) Smoothing of the Bdot to a limit sustained by the magnet. b) Setting up of the PFWs and 8-loop. c) Setting up of 10MHz cavities GFA. d) Listing all potential timing and instrumentation parameter inconstancies with respect to a 5BP cycle.
- Next steps: a) Communicate to RF colleagues the current Bdot status and understand if it is acceptable. b) Modify a series of maximum values in timing parameters to cover the whole cycle (BI, CO). c) Test and optimize the cycle with beam and without the rotating machine.
- New requirements: A dedicated MD may be needed.

**20) Ion loss map studies using LHC collimator in the SPS (R. Bruce, 13/11)**

- We had lower intensity due to the PS dump vacuum leak. The life time of the beam in coast at injection energy was very short (~ a few supercycles).
- We took data for loss maps for coasting beam at 270 GeV/c equivalent. The loss patterns are qualitatively similar to earlier results, but now the larger amount of data gives us the necessary statistics and at a higher energy.

#### **21) Rephasing of the LHC proton beam in the SPS before transfer to the LHC (P. Baudrenghien, 08/11)**

- The rephasing is controlled by an application program running in a VME CPU and interfacing with various electronics: the existing Frequency Program (generating the reference RF) and a new VME module on charge of measuring SPS-LHC revolution pulse delay and SPS-LHC RF phase difference. This equipment is not operational yet.
- Current results: 1) The application program (real-time task under LynxOS and triggered by the timing) is now reacting in a fixed time (not the case in last MD). This now gives a good measurement of the SPS beam position with respect to the LHC revolution reference. 2) At 270 GeV/c we applied a frequency bump of amplitude 400 Hz @ 200 MHz to simulate the rendez-vous with an LHC at a small frequency offset (~ 2 mm radial displacement in the SPS). With 4 MV RF voltage we have seen no loss or emittance blow-up (~0.6 eVs). 3) We moved the SPS beam by 15 ns with respect to the pseudo-LHC reference by applying a short 400 Hz bump (frequency rise, plateau, frequency fall). Again no loss or emittance blow-up.
- Next steps: The hardware must be made reliable. For this we have a test set-up in the lab and will make it much more robust for next year start-up. MD time is needed at the beginning of run 2008 to make the equipment operational for filling the LHC. In the longer term (as LHC calls for more intensity injected) the issue of making the 800 MHz track the 200 MHz during rephasing must be addressed.
- New requirements: MD time is needed at the beginning of run 2008 to make the method fully operational. (We can work with any LHC type beam, even pilot. Concerning the cycle we need some acceleration but can rephase at any energy).

#### **22) Non-linear chromaticity measurements in order to establish the 5-CM PFW matrices (R. Steerenberg, 2007 run)**

- Several attempts were made during the year.
- The operations team have setup cycles/beams with flat tops at different energies for the measurements, which are archived and can be re-used.
- The PFW power converters were unstable (large ripple) until 30 August. The tune measurement did not work properly when  $dR > \text{few mm}$  until 30 October.
- 3 out of the about 9 matrices are measured. Two seem to be correct the 3rd remains to be analyzed.
- Next steps: Continue.
- New requirements: Beam time in parallel and working tune measurement.

#### **23) Setting-up of high intensity CNGS beam (R. Steerenberg, September 2007, in parallel)**

- The absence of the PFW matrices made it more difficult. The tune measurement did not always work correctly especially for long bunches (like CNGS high intensity).
- We accelerated 3E13, but only extracted it with a fast extraction, not with a CT (high losses).
- Next year we have to provide the CNGS beam again.
- New requirements: working tune measurement and complete PFW matrices.

#### **24) Study of the LHC BLM System (C. Zamantzas, 08/11)**

- With the new configuration of the timing system the collimation movement trigger was not transmitted at either the front-end or the processing card. Efforts have been made to set the threshold levels at values that would trigger only at needed for observation cases.
- Several acquisitions have been made that managed to collect data for the channels connected to Ionisation chambers. Nevertheless, not even one acquisition was possible for those with Secondary Emission Monitors nor a pseudo-synchronised acquisition for all processing cards.
- Next steps: Work with the timing experts on solving this problem and repeat the study.

#### **25) Study of the LHC BLM System (C. Zamantzas, 12/11)**

- The reply from the timing experts was that the 'exotic' configuration of the timing system to simulate 'LHC timing' would need a significant effort to make it work. The collimation movement trigger was not transmitted always at the front-end or the processing card. We resorted back to triggering through threshold levels at values or manual (for the SEMs).

- Current results: Several 'clean' acquisitions have been made that managed to collect data for the channels connected to Ionisation chambers (ICs). There were a few acquisitions taken for the Secondary Emission Monitors (SEMs) too, by using the manual trigger. In this MD all acquisitions for the ICs were managed to be pseudo-synchronised which are expected to give comparable results on the study of different filter responses. In addition, in this configuration a prototype of the Combiner card was present in the system. Even though we didn't focus too much on testing several of its functions with beam (mainly because of the limited time) we have clearly seen correct registering of the beam dump triggers sent by the threshold comparator and uninterrupted and error free energy transmission. Finally, at the end of the MD (and without beam) we have successfully tested the high voltage modulation (which will be part of the automatic test procedure for the BLM system).

- Next steps: Work with the timing experts on adding 'real' LHC timing at BA5. Work with the collimation experts on the automatic Beam Based Alignment. (In that case we would be able to test the final system early next year (2008) independent and before the LHC start-up).

**26) Dynamic vacuum effects due to ion losses in the PS (M. Benedikt, 13/11)**

- Measurement data evaluation ongoing.

**27) Measurements of quadrupole synchrotron frequency shift with intensity (E. Chapochnikova, 01/11)**

- We were not able to have constant longitudinal beam parameters (length and emittance simultaneously) which are necessary for reliable results.

- Too large longitudinal emittance and its dependence on intensity.

- We can reproduce closely results of 2006 and 2007 measurements depending on bunch production scheme used in the injector chain.

- Next step: Repeat these measurements in 2008.

- New requirements: Use different beam production scheme in PSB-PS, probably  $h=2$  in PSB - to be discussed.

**28) Beam stability studies in a double RF system (E. Chapochnikova, 08-09/11)**

- Problem: Injection phase variation.

- Results to be analysed.

- Next steps: More coasts with different conditions next year.