LHC-Beam Commissioning Working Group

Notes from the meeting held on
3 August 2010

Present: Nicholas Aquilina, Gianluigi Arduini, Tobias Baer, Wolfgang Bartmann, Chandra Bhat, Oliver Brüning, Rama Calaga, Guy Crockford, Bernd Dehning, Lene Drosdal, Massimilano Ferro-Luzzi, Per Hagen, Werner Herr, Wolfgang Höfle, Eva Barbara Holzer, John Jowett, Mike Lamont, Malika Meddahi, Elias Metral, Eduardo Nebot, Giulia Papotti, Tatiana Pieloni, Mirko Pojer, Stefan Roesler, Elena Shaposhnikova, Rüdiger Schmidt, Katarina Sigerud, Matteo Solfaroli, Ralph Steinhagen, Marek Strzelczyk, Ezio Todesco, Rogelio Tomas, Jan Uythoven, Daniel Valuch, Walter Venturini Delsolaro, Jörg Wenninger, Uli Wienands, Simon White, Daniel Wollmann.

Excused: Carmen Alabau, Markus Albert, Reyes Alemany, Ralph Assmann, Roger Bailey, Philippe Baudrenghien, Chiara Bracco, Roderik Bruce, Xavier Buffat, Helmut Burkhardt, Andy Butterworth, Pierre Charrue, Ed Ciapala, Riccardo De Maria, Laurent Deniau, Octavio Dominguez, Stephane Fartoukh, Kajetan Fuchsberger, Marek Gasior, Rossano Giachino, Massimo Giovannozzi, Brennan Goddard, Jean-Jacques Gras, Delphine Jacquet, Lars Jensen, Verena Kain, Emanuele Laface, Thibaut Lefevre, Yngue Levinsen, Ewen Maclean, Alick Macpherson Aurelien Marsili, Ryoichi Miyamoto, Valerie Montabonnet, Gabriel Mueller, Lasse Normann, Mario Pereira, Bruno Puccio, Laurette Ponce, Stefano Redaelli, Adriana Rossi, Mariusz Sapinski, Andrzej Siemko, Frank Schmidt, Glenn Vanbavinckhove, Markus Zerlauth, Frank Zimmermann.

1- Comments and Follow-up from the the last minutes (slides)

- New access procedure now under approval : Follow-up: Markus Zerlauth
- Sequencer: run through bug (one of them) caught server side. Break on dummy tasks inserted into sub-sequences. Checklist application in use –looks good
- Orbit and Tune-FB revalidation- Ralph Steinhagen (email): Main problem during last week end was probably related to the fact that the OFC crashed during the ramp and was not fully re-initialised afterwards. In case the OFC crashes (all FBs stop and trims as displayed in BI-QP GUI go to zero), a procedure is recommended and available in the LHC-OP elog. Mitigations for this problem are already underway.
- Reference orbit at stable beams – In progress - Jörg Wenninger.
  Orbit changes wrt June ref. in basically all low-beta IRs:
  - Always positive (both planes and beams)!
  - In most cases corrections would require suspiciously huge trims.
  - Triplet Wire Positioning System does not indicate significant movements.

  Orbit at TCTs drifted significantly in some IRs wrt June references.
  - Most prominently in ALICE, TCTH B2 (~ 2 sigma).
  - Large H orbit deviations around ALICE IR can be cleaned, but to become ‘permanent’ need to change the procedure (settings organization) to move from end of squeeze to collisions.
  - TCT alignment check in physics to be done.
- Un-bunched beam at injection: MD will be organized to quantify the losses. Follow-up: Brennan Goddard in collaboration with Elena Shaposhnikova
- Head-tail monitor status to be checked: Ralph Steinhagen**.**
- Marek Strzelczyk re-generated the ramp settings for the RCD circuit – to fix a bug introduced while implementing a2& a3 corrections -the present settings of MCD

were a factor two lower than requirements, i.e. around 60 A at injection instead of 120 A.

- MCBCY settings: at 7 TeV: not enough strength! - already powered at 50 A at 3.5TeV.
- Massimo Giovannozzi (email): At injection the MCO are used to compensate the b4 in the dipoles. The actual b4 is smaller than the target value and hence it might be left un-compensated. The magnetisation effect (leading to under/over correction) should not be a problem, as it was tested in the past (numerical simulations) that the overall correction can be re-distributed globally in the ring without affecting the DA. Hence, as long as globally the strength of the MCOs compensates the b4 in the dipoles is fine. At top energy, Ezio Todesco confirmed that the b4 in the dipoles is essentially the same as at injection. This means that there should be no issue in using the MCOs. It is well-known that the MCOs run out of strength at some point and the b4 will be left uncompensated, anyway. This would generate yet more detuning with amplitude that would be beneficial for stabilising the beam. Therefore, the current situation is fine. A test with MCOs switched off (but after a degaussing cycle) could be also made, checking the beam behaviour in terms of lifetime, emittance growth and instabilities.
- New beam process defined by Mike Lamont -avoid jumping back to the end of squeeze settings after the collisions procedure. Will be tried tonight.
- Intensity switching – Kajetan Fuchsberger: automatic switch of the BPM gain, ready – to be tested in operation. Question: will it happen that low intensity bunches are injected on purpose, while there are already high intensity bunches circulating? This case is not yet covered: The current version simply switches according to the next injected bunch intensity and does not care about the circulating intensities.
- 3 ms losses: Bernd Dehning: 2 events observed. Rüdiger Schmidt : Similar events like these ones have already been seen but losses were not reaching the thresholds. Losses are also observed at the collimators, not only at the area where the BLM caught them first. Must be explained. Loss of particles very far in the tails. Which mechanism would lead to these losses, in a few turns? Resonances: doubtable.
- IBS: John Jowett said that the difference between the IBS growth rates given in the parameters note and the ones estimated from luminosity growth over several hours are likely due to the RF voltage being much lower, uncertainties in the initial estimated emittances and the fact that IBS slows down quickly as the emittance grows. Elena Shaposhnikova: clear measurements to be taken (with all beam parameters measured).
- Collimator state checks: implemented and checked (Stefano Redaelli).

2- LHC beam commissioning: progress and issues – round table

Monday morning summary of Week 30 (report from Roger Bailey and Jörg Wenninger): (slides)

- No physics in the week-end after technical stop.
- Problems to ramp nominal bunches - Significant chromaticity changes in the ramp due to 10 A/s ramp rate for ramp-down and pre-cycle.
- Monday to Wednesday were used to re-establish good ramps and squeezes and perform verifications of optics and collimation.
- Stable beams with 13b / beam re-established Wednesday at 22:30 - Tricky to establish collisions in ALICE.

- First fill with 25b / beam: Thursday late evening - Peak L seen just after colliding ~2.8E30 $cm^{-2}s^{-1}$ - In STABLE BEAMS peak L ~2.6E30 $cm^{-2}s^{-1}$ - TOTEM RPs at 30/25 sigma (H/V) – 1.2 MJ.

- To note:
  - Optics measurements show excellent reproducibility
  - Since the introduction of the 10 A/s ramp, much larger orbit variations are observed fill to fill at injection in the horizontal plane – signature of random b1 error - 0.3-0.6 mm RMS
  - Validation of collimation setup for stable beams was performed on 28.07. This is the first validation since collimators were set up one month ago! Loss maps were OK even though B1 vertical showed a rather high peak on a TCT in IR2. To be redone this week with nominal conditions.
  - No dedicated dump setup validation could be done. Post-mortem data analysis using the losses from beam in the abort gap indicates no anomaly. Proper validation to be done this week.
  - MPP: Accumulated 171 dumps above 450 GeV. In all cases the MPS reacted correctly, even for yet un-explained events. There are 2 events where the cause is not understood, on July 7th (BLM IR7) and July 30th (BLM IR5). Common features:
    - Loss at cold element – 'bypass' collimation (loss too fast…)
    - Loss time scale ~2 milliseconds ~20 turns.
    - Loss after a bending section (DS IR7, D1 IR5).
    - Orbit and trajectory stable.

    Event July 30th:
    - All PC currents rock stable – no trims etc.
    - Orbit stable to few microns, trajectory to few tens of microns (resolution!).

Week 31 (Gianluigi Arduini and Oliver Brüning) - Main aims of the week:

- Consolidation of stable beam operation with 25 bunches of 1e11
- Achieve 1 pb^{-1} total integrated luminosity at 3.5 TeV

Reminders:

1- Jan Uythoven: when there is no beam in the machine for some time, re-run all the required checks before re-injecting.

2- Mike Lamont: do not be inventive with the amount of beam energy which is now in the machine. If there is any doubt then dump the beams and re-inject.

Bunch-by-bunch beam losses and collision patterns: Giulia Papotti and Werner Herr (slides).

Fill 1251: Losses start when beams are put into collisions (as expected!), the witness bunches do not experience losses. The families of losses do depend on the collision pattern. Beam 1 loses more intensity than beam 2.

Have to cross-check with bunch length variation during the fill. Average bunch length is getting smaller for beam 1, starting at the time the beams are put into collisions.

Fill 1256: short fill!

Fill 1257: Losses started only after luminosity scan, as at the beginning the beams were not colliding (orbit problems).

Fill 1258: beam 1 has extremely high losses.

These results point to a worse working point for beam 1 than beam 2, probably due to the applied tune split.

Suggestion: swap the tunes for one beam (0.31,0.32) vs (0.32,0.31) which would implicitly include tune split!

To note: ADT damper system was on during these fill. Still some fine tuning to be done. Mirko Pojer: ADT was switch on/off in collisions and no change was observed in tunes and lifetime.

3- Multi-Bunch injection – Malika Meddahi (slides)

On Tuesday 27 July, TCDIH.29050 was readjusted around the trajectory (corrected to the previous reference). However the trajectory changed again, and it was decided on Friday 29 July to save a new reference trajectory, which took care of the SPS orbit change -after the TS and the change of SPS magnets- and the injection oscillations into the LHC, but which was different at the location of the downstream end of TI 2. Therefore the TCDIH.29050 and TCDIH29205 were re-adjusted around the beam center and 4 bunch injection successfully tried for both beam 1 and beam 2, up to 24+1 bunches / beam. The losses on the BLMs were below thresholds, and therefore 4 bunch injection declared ready for OP, to be used and monitor carefully to accumulate information in view of increasing the number of injected bunches. Reminder: sensitive LHC BLMs are exposed to losses on TCDI injection protection collimators. Strategy for reducing the losses:

- Reduction of losses on TCDIs: SPS scraping, tight control of SPS beam parameters; Trajectory control: autopilot, systematic steering, improvement of septa ripple, more BPMs; Relax settings from 4.5s …. Need validation tests!
- Improvement of setup and diagnostic tools - Automatic TCDI scans, trajectories into IQC, …
- Shielding the most critical BLMs - Addition of local shielding at TCDIs, Move BLMs to other side of cryostat?
- Reduce BLM sensitivity - Optimise thresholds (to max) for affected BLMs (MPP), 'Injection sunglasses' for some monitors (long term)
- The situation at present is fine, but we should make sure that it will still be OK when we move to trains of bunches, for which we should certainly make some measurements.
- Quantify uncaptured beam seen: measurement and tests needed - the losses are from beam grazing the TDI, which make it difficult to calibrate the loss signal against a known number of protons swept. Needs some dedicated study (e.g. debunching a pilot bunch at 450 GeV for long enough to get a uniform distribution around the LHC, then firing the injection kicker, to see the loss response. And compare this with the dump thresholds to see what the max uncaptured beam can be in p+/m). Is it really capture losses? Saw signs of beam being lost from the bucket over 30 minutes on Tues, which would indicate it's rather continuous losses. Elena Shaposhnikova has pointed out that for present beams few things can be investigated which should decrease tails in longitudinal distribution of injected bunches (no emittance blow-up in the SPS and even some voltage dip during acceleration). Another possibility is to increase capture voltage in LHC which nevertheless probably would require more time for adjustments.

Conclusions: Injection system is ready for 24+1 bunch operation. The coming 4 weeks are crucial to get experience in view of increasing the number of injected bunches per SPS-to-LHC injection.
Wolfgang Höfle: SPS procedure to be also written to reliably measure the beam emittance with the WS.

4- Planning for bringing in bunch trains – Mike Lamont (slides)

A total of ~8 shifts is estimated to commissioning the crossing angle operation from the injection to Physics phases. Consensus: more like a week of commissioning is required.

Squeezing to 2-2-2-2 m (if any) would require ~3 shifts (no contingency). As squeezing to 3.5-10-3.5-3.5 m would add to ~6 shifts preparation (no contingency) - special case for LHCb where 2 different polarities require different external crossing angles. Also at injection there is a huge crossing angle from the LHCb spectrometer (~2 mrad). This rules

out one polarity at full field so either need to stay at full field and skip polarity change or ramp dipole with energy (needs commissioning time).

John Jowett: ALICE: there is an interest in using the external crossing angle to minimise the net crossing angle at the IP, certainly for the heavy-ion run, but also for p-p.

Raph Steinhagen: should profit of this commissioning time to introduce the 10A/s ramp rate.

Daily 8:30 HWC meeting in the CCC conference room (09:00 at weekends).

Next meeting: **10 August 2010,** 15:30, 874-1-01.

Malika Meddahi