LHC-Beam Commissioning Working Group

Notes from the meeting held on
29 June 2010

Present: Carmen Alabau, Markus Albert, Ralph Assmann, Roger Bailey, Wolfgang Bartmann, Philippe Baudrenghien, Chiara Bracco, Pierre Charrue, Guy Crockford, Bernd Dehning, Laurent Deniau, Lene Drosdal, Massimilano Ferro-Luzzi, Brennan Goddard, Per Hagen, Lars Jensen, John Jowett, Verena Kain, Mike Lamont, Aurelien Marsili, Malika Meddahi, Giulia Papotti, Mario Pereira, Laurette Ponce, Bruno Puccio, Mariusz Sapinski, Frank Schmidt, Rüdiger Schmidt, Elena Shaposhnikova, Ralph Steinhagen, Ezio Todesco, Rogelio Tomas, Daniel Valuch, Walter Venturini Delsolaro, Simon White, Uli Wienands, Frank Zimmermann.

Excused: Gianluigi Arduini, Reyes Alemany, Tobias Baer, Chandra Bhat, Oliver Brüning, Helmut Burkhardt, Andy Butterworth, Rama Calaga, Ed Ciapala, Octavio Dominguez, Stephane Fartoukh, Kajetan Fuchsberger, Marek Gasior, Rossano Giachino, Massimo Giovannozzi, Werner Herr, Wolfgang Höfle, Eva Barbara Holzer, Delphine Jacquet, Thibaut Lefevre, Yngue Levinsen, Alick Macpherson, Ryoichi Miyamoto, Gabriel Mueller, Lasse Normann, Mirko Pojer, Stefano Redaelli, Stefan Roesler, Adriana Rossi, Andrzej Siemko, Katarina Sigerud, Matteo Solfaroli, Marek Strzelczyk, Jan Uythoven, Glenn Vanbavinckhove, Jörg Wenninger, Daniel Wollmann.

1- Comments and follow-ups from last meetings

- Daniel Valuch: RF transverse damper synchronisation: a patch is ready and was successfully tested without beam. Will be tested with beams as soon as LHC is refilled, using few injections. If the tests are successful, the patch will be deployed on all 8 ADT units and declared operational.
- Wolfgang Bartmann: BPMS: In the BIC overview panel, left and right definitions of the P6 BPMS are not the same as defined in YASP. To be changed in the BIC window. Action: **Bruno Puccio + Lars Jensen**.
- New sequence to drive all the new settings: new beam process available and used. New sequence: in progress. **Mike Lamont**.

2- Beam observations and measurements over the last 2 weeks

Injection and beam dumping systems – Brennan Goddard (slides)

Beam dump system status: The hardware system reliability is much better since the various fixes performed in last 2 TS. Concerning the energy tracking, the MSD Transfer function still presents some small inconsistencies (10-20 mm on TDE) - being checked. The synchronization looks fine for the moment – need to revisit after injection adjustments. On the instrumentation side, the BLMs with filters in P6 work well – much improved analysis of tests. Some discussions are scheduled on displaying/logging data from filtered monitors. Concerning the qualification tests, the MPS tests are all finished for this intensity, the apertures are all measured and the interlock BPMs was re-centered and dumps were successfully checked from extreme positions.
Dump Protection: the initial setup from collimation work was performed 1 week ago. No anomalies or difficulties reported. The 3.5 TeV TCDQ retraction wrt TCGS B1/B2 0.5/1.0 σ ("safe side" for B2). The asynchronous beam dumps at 3.5 TeV and 450 GeV are finished (for 3.5 m β^* colliding beams), and dumps from on axis, and from SIS interlock limit (~3 σ

offset) were performed. The SIS is active at 2.0 mm (1.5 mm now?) for orbit ↔ TCSG/TCDQ. A cross-check of TCP/TCSG shows only very systematic error (<80 μm). From the loss maps, the measurements are very close to expectations. The losses in P6 with the nominal 25ns beam will increase by ~1200. This needs more detailed analysis to predict how much of the arc will quench.

Left over bump in P6? From the timber data, it is clear that the measurements made last Friday were done with bumps of different strengths than the ones found yesterday and that the bumps were indeed put back to zero at the end of the studies. It is seen that these correctors were activated again for a reason which is to be understood.

Injection – preparation for higher intensity: list of work to be done

Cleanup of TL steering (4-8 h)

- Many accumulated corrections, trajectory changed through TCDIs
- Frequent beam losses above threshold at injection (losses on TCDIs) – with 10 bunches circulating will hit this (no masking…)
- Remove all and start afresh
- Test new procedure for injection oscillation correction (or no correction if e OK with damper)

Revisit injection protection (8-12 h)

- Sort out TDIs (measure B1, apply corrections for both, test)
- Re-setup of TCDIs around new trajectory if needed
- Verification of protection level (TCDIs, TCLIs, TDI) with simulated TL failure cases (not urgent – need once >4 bunches injected together)

Multibunch injection (~8 h)

- Sequencing and injection mechanics for required filling pattern(s)
- Losses with multibunch injection (BLMs, TCDIs, stability, …)
- Checks of diagnostics (BI, IQC, …)
- Verify AGK functionality with extreme bunches

Other (more urgent) items (2-4 h)

- Complete injection-related MP checks
- Quantify emittance preservation at injection with 1e11

Other (less urgent) items

- Measurement of B1/B2 MKI waveform
- Fine adjustment of MKI kick lengths, & AGK adjustments
- Verification of injection aperture through MSI with ‘golden’ trajectory and ‘orbit’
- Study of injection matching and emittance preservation

Agreed: This preparatory work for >1e12 circulating and multi-bunch injection will start next week. To be scheduled in next week LHC beam commissioning planning: **Roger Bailey + Malika Meddahi**

Optics measurements – Rogelio Tomas (slides)

Rogelio Tomas reported on beta beat measurements performed at 9 m and 3.5m (below 20% for H plane and 30% in V plane, for both beams). Subtraction of these two measurements indicates that during the squeeze the vertical beta changes by 15% (beam 1) to 20% (beam2).
Measurements of the beta at the IPs were performed and results presented. An important vertical beta miss-match is measured in IR2. For more accurate measurements and error bars, a better IR BPM calibration is needed (beam based? Vertex data?).
A very good correction, with moderate errors in the proposed quadrupoles, has been found to correct IR8 local errors, beam 1. Optics errors are not visible in Dx,y, the model is in very good agreement with the measurements. The BPM calibration problem in turn-by-turn mode is under investigation.
A solution has also been found to correct for the IR8 local errors for beam2.

In summary, a distributed correction was calculated (more distributed than the correction at 2m which was only using 2 magnets). The triplet correction looks very correct and the amplitude of the corrections better than with the correction with only 2 magnets.
Next steps:

- Correcting at beta*=3.5m seems to be reasonable to do, although the beta beat is at max 30%
- Need to find corrections for IR1 and IR2
- Make suitable knobs (to cancel tune drifts)
- Test the corrections: ready to do so in the next couple days.

Agreed proposal: as all the protection devices are now set up with this un-corrected -but acceptable- optics, it is proposed to continue the luminosity operation with the current uncorrected optics. The tests of these corrections could then be done when moving on to a new 10A/s cycle commissioning, which would in any case require new protection device setting up and qualification.

Update on collimation– Ralph Assmann (slides)

Ralph Assmann gave a summary of the high intensity collimation set-up work performed at 3.5 TeV.

- Orbit and optics are different for 3.5 TeV and physics conditions, compared to injection. This requires a new beam-based collimation setup.
  - Setup at 3.5 TeV involves 76 collimators, covering the two beams and x, y, skew and off-momentum phase space.
  - Tertiary collimators have to be set up for three conditions due to change of setup in experimental areas (squeeze, separation, crossing angle, …).
- Had to perform 108 collimator setups at 3.5 TeV.
  - Each setup takes 15 min ➔ 27 hours of beam time at 3.5 TeV required.
  - Reduced by factor 2 by doing both beams in parallel.
  - Losses of time due to beam efficiency. Several beam dumps due to loss of 0.1% of intensity, when touching halo.
- In the end took ~30 h of beam time with single bunch of 1e11 p at 3.5 TeV. Time distributed over 10 days with ~1 collimation shift per day.
- Finally, setup of smooth ramp functions including interlock thresholds.

The method used and the associated error were described. Ratio of the calibrated beam size over the expected beam size was shown. Some collimators show behavior to be followed up (alignment?). Gap offsets were shown for both beams. The collimator settings overview was summarized for all collimator families and for the different optics sets.
Qualification of the collimator set-up was successfully done and the performance of the system was as expected.
In summary and outlook:
The system performs as expected so far. There are some minor issues to follow up. The LHC collimation system is ready for several MJ. It is expected that present setup remains valid into September. However, it does require regular monitoring of performance (loss maps at end of fill). A monitoring during a stable running period will allow determining more precise performance reach with this setup (collimator stability, machine reproducibility, beam drifts,…). Then, in September the collimation system will be adapted for bunch trains and establish readiness for the 2010 goal of 30 MJ.

Beam losses during stable beam operation: Beam 2 vertical blow up was observed during stable beam operation, together with very quick losses observed. All losses were at collimators: no risk for damage! Ralph Assmann explained that the losses correspond to a factor 25 below the threshold for 3.5 TeV and loss rate of 6.3e10 p/s. From these data, and with the present beam stability, it is concluded that we can push the intensity by a factor ~25 before hitting the BLM threshold in SC magnets.

To Note:

- Assumes that BLM thresholds are accurate for 3.5 TeV.
- More severe loss rates in shorter time bins (fast loss spikes).
- Expect to gain factor ~3 in efficiency with tight settings (not possible now). However, also much higher impedance.

To Do: These losses remain to be understood in any case! The next fills will be observed and it was proposed to follow this up at the next LHC Beam Commissioning meeting. **Action: Werner Herr**

Beam jumps for the 2 fill – Massimiliano Ferro-Luzzi (slides)

The losses are very different between bunches and affect mainly beam 2. At one occasion the losses happened during a luminosity scan. The luminosity region parameters show a jump in vertical sigma.

Factor 1.7 missing in the Wire Scan emittance measurements to match the results from the experiments: **Follow-up: BI.**

24x24 with mutibunch injection – Giulia Papotti (slide)

Motivation: 24+24 would take a long time to inject, so it is clearer interesting to inject 2/3/4 bunches per injection.
From the filling scheme, Giulia Papotti reminded that 2/3/4 bunches can be grouped into batches, with the advantage of requiring only one pattern from SPS and then inject in different buckets. SPS is indeed ready with a multi injection cycle -flexibility on number of injections and bunches.
A filling scheme is available. Now the consequences on the other systems can be evaluated and actually tested as of next week.

3- A.O.B,

Verena Kain: state machine needed: requirements + implementation: **Action: OP + Pierre Charrue**

Elena Shaposhnikova: Last night there were perfect beams brought up at 3.5TeV, even without the emittance blow up. Should have kept the beams instead of dumping them. **Elena Shaposhnikova** will summarize the beam parameters which are considered acceptable.

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

Next meeting: **6 July 2010,** 15:30, 874-1-01.

Malika Meddahi