

LHC-Beam Commissioning Working Group

Notes from the meeting held on 8 December 2009

Present: Maria Alabau, Roger Bailey, Tobias Bär, Helmut Burkhardt, Andy Butterworth, Rama Calaga, Octavio Dominguez, Kajetan Fuchsberger, Eliana Gianfelice, Massimo Giovannozzi, Per Hagen, Eugenia Hatziangeli, Eva Barbara Holzer, Lars Jensen, John Jowett, Verena Kain, Mike Lamont (chair), Yngve Levinsen, Malika Meddahi, Gabriel Mueller, Gulia Papotti, Mario Pereira, Laurette Ponce, Bruno Puccio, Frank Schmidt, Rüdiger Schmidt, Katarina Sigerud, Marek Strzelczyk, Yipeng Sun, Ezio Todesco, Rogelio Tomas, Jan Uythoven, Glenn Vanbavinckhove, Walter Venturini Delsolaro, Simon White, Frank Zimmermann.

Excused: Brennan Goddard, Stefan Roesler.

1. Comments

None.

2. News from LMC – Mike Lamont

Summary notes from previous LMC meetings, written by Brennan Goddard or Frank Zimmermann, are available [here](#). Items discussed:

- Progress with beam;
- RF;
- Collimation;
- Power convertor tracking;
- Resources for QPs connector repair;
- Planning for 6 kA commissioning. General planning was shown for January 2010, very tight, all LHC work would finish on 4th February. Therefore, the LHC beam commissioning would restart at the earliest on 8th February. The CMS water leak problem might also require slightly more time for the repair, going beyond the foreseen 4th February. The injectors are planned to re-start right away on 5th February.

3. Week 49 LHC beam commissioning

Overall beam commissioning status: Mike Lamont ([link](#), check week49)

Mike Lamont went through the summary of the LHC activities which took place in week 49. The amount of beam commissioning work done is highly impressive. First “stable beams” were declared on Sunday 6th December at 7:00 am, beam colliding at 450 GeV, 4x4.

Lars Jensen: if we get more intensity, then commissioning of the abort gap monitor could continue with the undulator at 200A.

Barbara Holzer: BLM work is not yet finished, MPS is not complete. Test with pseudo “quench” magnets to be done.

Jorg Wenninger’s list of MPS tests to be updated with the items not yet done and mandatory for the higher intensity run.

List of issues shown ([link](#), check “commissioning issues”)

Massimo Giovannozzi: Beta beat measurements indicated field errors originating from the triplet magnets of IP2 and IP8. This was discussed at the FiDel meeting and possible error of powering is being investigated. *Noted after the meeting: From Massimo Giovannozzi: The powering issue was identified together with Walter and Mike: the trim power converter in Q1 is not at zero (as it should) in IP2/8.*

B1 TCDQ: Stefano reported losses during injection. Tbc.

Eugenia Hatziangeli: Proxys and JMS: all problems were linked to the Mega bytes of infos being sent by the BLM systems. This is being investigated, temporary solutions are deployed, and a more robust solution is being worked on for the long term. Proxy of page 1 has been split out to this problem and is therefore robustly functioning.

Beam transfer systems – Jan Uythoven for Brennan Goddard ([slides](#))

Much work has been done over the week 49:

- Finished off LBDS synchronisation & checked with beam: adjusted and checked for B1 and B2 - all OK
- First TDI and TCLIA/B setups around orbit:
 - Worked well with beam edge defined at 5.7σ by collimation system
 - TDI jaws look 'asymmetric', with real position ~ 2 mm lower than read back by the sensors
 - Beam well-centred on adjacent BTV
 - Explains some of the problems with high losses/BCM readings
- Checked losses on TDI & IR8 for MKI off/over-injecting
 - Do not understand loss peak on MQXA (Q3) R8
 - 2-3 TDI BLMs above threshold for 40/80 us windows
- Measured local aperture with closed bumps in IR6 for B1 and B2:
 - Checked horizontal aperture carefully at TCDS, TCDQM, MSDC and MKD, as far as possible with bumps through the region
 - Looks as expected with respect to physical aperture model
 - Differences are due to emittances assumed
 - Will re-measure with better definition of circulating beam 'edge' if needed
- Dump checks from golden orbit (trajectory, losses, extraction with 14/15 MKD kickers):
 - Extracted beam trajectory looks very good for both beams
 - Maybe 7-8 mm vertical error at the TDE for both beams (total MSD strength could be about $11 \mu\text{rad}$ too weak – not an issue)
 - Could dump without losses with ± 1.666 MKD for B1, $+1.333$ and -1.666 MKD for B2
 - Very good result for the dump channel aperture
- Tests of injection and matching with xing/sep bumps on (see Werner Herr's presentation)
- Injection kicker rough timing in:
 - Both beam roughly timed in
 - Adjusted with OASIS signals
 - Checked beam injected OK with acceptable oscillations
 - Need to adjust fine timing to fit full SPS batch (not urgent) and to allow configuration of abort gap keeper (urgent). Will use waveform data taken during sector tests, with cross-check
- Firmware upgrade to fix TSU asynchronous dump, plus testing:
 - Problem found which was causing $\sim 2\%$ of asynchronous dumps
 - Dump request coincident with DRF clock
 - Firmware upgrade made and deployed Friday
 - Tested with repeated dumps for both beams
 - Total of about 300 shared between the systems
 - No asynchronous dumps seen since

- Setup of dump protection and tests with asynchronous dumps: done: Comparison of alignment results between beam-based gap and nominal gap:
 - TDI: O.K for both beams
 - TCSG and TCDQ for beam 1 to be checked (beta beat to check at this location for TCSG– may have changed- and suspect alignment error from mechanical sense inversion for TCDQ).
- Injection of multiple bunches:
 - 4 bunch injection sequences worked after timing in MKI
 - Need to be aware that injecting near to abort gap needs consideration
 - bunch is always at the head of the injection kicker pulse
 - may need to reorder some injection sequences, especially with ‘trailing pilot’
 - may need to change order of injection for some bunches.
 - Setting up of TCDIs and TCLIA/Bs to do
 - Losses on TCDQ/TCSG for B1 – (more) checks to make
 - Improvements to IQC ergonomics being made
 - BQM information for IQC to be made operational
- Extraction checks for multiple bunches
 - Checks of trajectory and losses made
 - Both beam extracted correctly
 - No losses in extraction channel
 - Bunches where they should be on TDE and on sweep
 - Still to check Bucket1 and Bucket 3444 extracted together

Finally the list of remaining work to be done was shown (see slides), and part of it was already being worked on in the CCC during the meeting.

Beta beat measurements - Rogelio Tomas ([slides](#))

Beam 1 beta beating changes with pre-cycling was shown: slight difference - 5% only- in the vertical plane.

Beam 1 dipole b2 correction: it was corrected with the arc QTFs and QTDs as predicted from the magnetic measurements. Action-Phase analysis confirms the b2 correction (plot showing the horizontal phase advance, before and after b2 correction of the dipole).

B2 correction: *Added the meeting: Form Massimo Giovannozzi: The scripts can be found in the toolkit of the V6.503 (prepared by Thys) as:*

- *Apply_b2_errors.madx*
- *MQT_b2_corr.madx*
- *Job.make_mqs_knobs.madx*

Note that injection, tune, chromaticity and coupling corrections will have to be re-tuned.

Predicted correction in IR8 and measured correction was shown. Correction is good, although not perfect.

IR8 corrections:

- .Many solutions exist distributing errors between 50 and 100 units among some triplet quads
- The on-line correction was not optimal
- Further iterations are required
- Correction impact on beam 2 not probed
- Feedback from E. Todesco: Try same errors in all Q2s and same errors in all Q1s and Q3s
- Feedback from W. Venturini: possible source might be the (unforeseen) re-distribution of current within the triplet quads.

Beam 1 beta beating after b2, IR8 and IR 2 corrections: Large errors remain in IP7 (horizontal) and IR3 (vertical).

IR7 and IR3 corrections:

- Correction failed in Beam1 V plane but Beam2 correction was OK
- Other solutions involve changes of Q6R7 to the 1% level (could this be due to not pre-cycling Q6?)
- Further understanding/tests required
- Situation in IR3 is even worse since no solution has been found using MQW4, 5 for both beams (use Q6?)

Summary:

- Stability ~5% beta beat in 4 days (but caution)
- Dipole b2 in perfect agreement with magnetic measurements (also confirmed during injection tests!)
- IR2 and IR8 triplets take corrections in the range of 50-100 units
- IR3 and IR7 contain the largest remaining errors (MQWs, Q6?)

LHC separation and crossing bumps – Malika Meddahi for Werner Herr ([slides](#))

Aim of the tests:

- Commission bumps and crossing angle. Reminder: bumps are required for larger intensities.
 - Check correct setup of knobs for operation (size, polarities etc.)
 - Check closure of bumps
 - Evaluate effect on dispersion
- Inject on nominal configuration
- In parallel: check all luminosity scan knobs (Simon White)

Procedure: Switch on separation bumps one by one, first at +/-0.5 mm, then increase to nominal +/-2 mm. Compare with theoretical bumps and check non-closure and the possible source (correction). Repeat the same for crossing angles. Measure dispersion for each step.

Measurements: The difference orbit to the reference orbit (no bumps) was shown after switching IP2 horizontal separation bump. The non closure was small for both beams (0.3mm rms, including the separation bumps), and could be corrected with 1 corrector, excited below 5 μ rad. Same exercise was done for IP8, switching on the separation bump in the vertical plane to nominal (2 mm). The observations were the same as for IP2.

After switching on all separation and crossing angle bumps, the bump closure was still rather good without any correction applied and the bumps follow the theoretical model.

Both separation and crossing angle use MCBX. When both are switch on, no obvious cross talk was observed.

Small hysteresis effect was measured, before and after switching all bumps on.

Walter Venturi: would be interesting to only switch off the separation bumps leaving the crossing angle on, to simulate the physics conditions during collisions and check again the hysteresis effects.

Beam1 and beam 2 injection were done in the LHC with all bumps switched on and the injection was clean, without noticeable losses measured on the BLMs.

Dispersion measurements have been taken for the different bump configuration and with the injection of B1 and B2. Analysis is on-going.

Possible improvement: the knob values are in mm and μ rad, which require the exact knowledge of the sign and the values. Would be interesting to establish some nominal knob for initial settings and trim as needed.

4- Planning for the next few days – Mike Lamont.

Link to the beam commissioning programme [link](#) under “commissioning plans for 2009”.

Main objective: to increase the intensity to 2-3-e10 per bunch, in order to provide to the experiments the requested number of events. If time allows: continue ramp tests and provide collisions at 1.2 TeV.

5. A.O.B

Daily 8:30 & 17:00 meetings in the CCC conference room.

Please come at the 17:00 meeting to defend the measurements you need to do before the end of the run.

The first LHC beam commissioning workshop will take place on 19-20 January 2010. Location is still to be decided. More details will follow in the next days.

Next meeting: **January 2010**, 15:30, 874-1-01. Date and agenda will be sent in due time.
No meeting on 15 December.

Malika Meddahi.