LHC-Beam Commissioning Working Group

Notes from the meeting held on
1 December 2009

Present: Masamitsu Aiba, Ralph Assmann, Roger Bailey, Tobias Bär, Wolfgang Bartmann, Jean-Claude Bau, Oliver Brüning, Helmut Burkhardt, Andy Butterworth, Rama Calaga, Massimiliano Ferro-Luzzi, Kajetan Fuchsberger, Eliana Gianfelice, Brennan Goddard, Hitomi Ikeda, Rhodri Jones, John Jowett, Verena Kain, Ioan Kozsar, Mike Lamont (chair), Yngve Levinsen, Malika Meddahi, Mario Pereira, Bruno Puccio, Stefan Roesler, Frank Schmidt, Rüdiger Schmidt, Katarina Sigerud, Ralph Steinhagen, Rogelio Tomas, Glenn Vanbavinckhove, Jörg Wenninger, Simon White, Daniel Wollmann, Frank Zimmermann.

Excused: Massimo Giovannozzi, Eugenia Hatziangeli, Lars Jensen, Jan Uythoven.

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. Some of the items discussed:

- Updates on progress with beam
- Expected snapback with 1.2 TeV ramp
- Work plan for TN security
- Summary of splice mapping
- Cryogenic work over Christmas

3. Week 48 LHC beam commissioning

Overall beam commissioning status: Roger Bailey (slides)

- Both beams in pretty good shape at 450 GeV
  - RF : Both beams synchronised and with RF phase locked (some stability issues), Lifetimes 10-50 hours (collimators out)
  - Dispersion excellent
  - Energy matching done
  - Orbit remarkably stable: Reference orbit B1 and B2 using common correctors
  - Tune, coupling and chromaticity measurement and correction working
  - Pre-cycle working and gives reproducible Q Q' coupling
  - Solenoids on and compensated (orbit ALICE, coupling CMS)
- Ramp
  - Beams ramped to 1.18 TeV, orbits rather stable, tune excursions

- BI systems commissioning well advanced (Q measurement, BPM, BLM, wire scanners …) and ongoing
  - BPM in capture mode
  - phased in horizontal and vertical MKQA tune kicker for B1 and B2
  - measured and corrected PLL beam transfer function for B1 and B2 system (tbc)
  - Undulator RU.L4 ON at 50 A:

        - no effect on orbit/tune (Beam 2) ➔ but not sufficient to see synch light ➔ HW commissioning to be continued
- Beam dump studies well advanced
  - Synchronisation checked. B2 OK, B1 kick too late by about 1ms
  - Aperture scanned for B1 extraction channel
  - Apertures look similar to those obtained for B2
  - Physical apertures seem OK on both planes
- Collimation
  - IR3, IR7 to nominal settings (primary aperture about 5.7 sigma)
  - Dump protection IR6 set up
  - TCT's not touched (IR1 looked at) at +-15 mm around +-15-25 sigma
- Kick response campaign almost finished
  - B1 finished (some possible corrector polarity errors L3 and L7)
  - B2 missing 2 sectors
  - Missing triplet correctors
- Aperture measurements underway
  - Beam 1 H - losses mainly in 6 - possible restriction in 6R2, 6R8
  - Beam 2 V - several loss locations, mostly in S78
- Beta-beating studies underway (measurement and correction)
- Machine protection program started but lots to do for stable beams

The list of issues was given (see slides). They were as well summarized in:
Mike Lamont: Chromaticity: Horizontal trims of -16 bringing the chromaticity down to 7 or 8. Why so large? Tunes: very close to nominal values.

List of commissioning issues: see slides of Roger Bailer and table of Mike Lamont, regularly updated at link under “commissioning issues”

Beam transfer systems - Brennan Goddard (slides)

LBDS synchronisation:
- Adjusted roughly last Tuesday according to OASIS data
- Saturday & today, varied RF bucket number and compared measured BTV position with theoretical form
  - B2 looks to be well-adjusted, bucket 1 where we expect it
  - B1 has about 600 buckets error – 1.5 μs adjusted today in tunnel
- Discrepancy with synch BPM and MKD on OASIS not understood

LBDS asynchronous dump:
- Occurring slightly more frequently than 1 per year at present…
- One cause (w/o beam) was RF re-synch procedure
  - Was causing both TSU PLLs to unlock at the same time, after which only recourse is asynch dump
  - Investigated for 2 hours this morning but could not reproduce this – only got synch dumps. But RF has improved their re-synch sequence and procedure in the meantime.
  - Will continue to try to provoke and understand this failure mode, as points to weakness in the system
- Seen one ‘intrinsic’ asynchronous dump from the retriggering system – analysing.

Dump protection setting-up and test:
- Performed with collimation setting-up tests
  - Inversion in TCDQ.B2 movement sense – sorting this helped
- Beam-based alignment worked reasonably well for B1 and B2
  - Set TCSG and TCDQ to 7 and 8 sigma respectively
- Another asynch dump test for B2

  - Left beam to debunch for much longer (~50 minutes)
  - Losses only on TCDS, TCDQ and TCP in P7. Nothing in IR5…
  - Factor 1e3 between IR6 and IR7 losses

Dump aperture:

- Scans of all phases in I&D turn1 for B1 extracted
- Find between 5 and 11 sigma clear aperture (until onset of losses) using a beam with nominal horizontal emittance
  - Agrees with expected physical opening and alignment
- Circulating beam – IR6 aperture limit from last night's measurement (as expected - largest betax in ring at Q4/Q5)
  - Detailed checks with local bumps started – continue tomorrow
- Extracted with varying numbers of MKD – looks like +/-2 MKD range
- Cross-checks to make from 'golden' orbit – tomorrow

Injection issues / work:

- Sort out losses and alignment questions on TDI P8 - tomorrow
- Issue of MKI not pulsing occasionally
  - One reason was MKI logic which ABT understand and will change – for present procedure to pulse once before injecting beam should solve…(?)
  - Were missing timing events sometimes: -1000 ms or 'next ring injection" event on occasion. Now appears to be understood (final check needed).
  - Should go through diagnostics tools with the shift crews
- Synchronisation of injection kicker pulse to bucket 1 to do
- First global injection protection setup to 'golden' orbit – to schedule
- Optimisation of injection steering to 'golden' orbit with bumps etc on
- IQC sometimes missing one kicker waveform
- IQC needs LHC BQM for bucket number…
- Asynchronous dumps – under investigation
- Bucket 1 / LBDS synchronisation to recheck with beam
- Checks of trajectory from golden orbit
- Systematic circulating beam aperture checks in IR6
- Interlocking (direct BLM, inltk BPM) checks, deployment
- XPOC deployment with BLMs
- TCDQ LVDTs
  - Still giving strange readings on occasion
  - Mechanical issue. Will try to change in shutdown
- Abort gap keeper to deploy (needs MKI and MKD synched in)
- Abort gap cleaning tests to make with damper
- Ramping - Programmed dumps for B2 and B1 at 0.65, 0.90 and 1.17 TeV (B2 OK for 1.17 TeV!)

Beta beat measurements - Rogelio Tomas (slides)

Beam 2 beta beating, as measured on Monday 23 Nov, was shown. These data were taken before the first ramp -magnetic state not perfectly known. Results were rather good. The new data taken on Sunday 29 November, after pre-cycling, show large differences, which seem to originate at around s=1km.

Beam 1 beta beating shows only small changes with respect to the data taken at different days.

Local correction in IP2 for beam 2 was applied, worked very nicely, and would still need re-iteration in the horizontal plane. It is noted that the correction applied, with ktqx2.l/r2 is large and other possible sources should be envisaged, which would be more realistic from the magnetic point of view.

On beam 1, the IP 2 local correction applied worked very well for the vertical plane, and would as well require iteration in H plane.

These first results are excellent: 5 arcs with H and V beta beating below 20 % after correction.

Predicted IP7 local correction: Beam 1 done in rush. The correction applied seems large wrt to magnetic model. Correction sign was mistaken, but with the "anticorrection" looks excellent.

Next steps:
- Correct with right signs in IP7
- Iterate in IP2
- Correct IP8
- Investigate IP3, which remains unclear
- Commission the global correction

SPS-LHC Energy matching – Jörg Wenninger (slides)

The strategy for energy matching was recalled:
- Center the closed orbit in the LHC using the RF frequency.
- Center the first turn by adapting the SPS momentum at extraction.

Note that this strategy cannot correct for small differences between the 2 rings – to be corrected at a later stage using orbit correctors…

Closed orbits (c.o.) and first turn (F.T.) before the energy matching were shown for both beams and the c.o. and F.T. errors for B1 and B2 in dp/p and dr given.
Step1: LHC energy matching: Change the LHC RF frequency to center the c.o. and get a feedback on the F.T. Both c.o. were centered within: $dp/p \approx \pm 10^{-5}$ and $dr \approx \pm 30$ μm
Step 2: Correct the F.T. error. The change of frequency to center the c.o. changes the energy at extraction of the SPS and therefore the beam position on the F.T. Results of the F.T. after energy matching show that B2 T.T. is centered and Beam 1 has a residual offset of $dp/p \approx -1.3 \pm 10^{-4}$ and $dr \approx \pm 0.18$ mm.
The transfer lines after energy matching are now at 450.73 GeV
The table of the energy offsets by sector after E-matching was shown and the largest offsets are -0.27 per mill in sector 56 / beam1 and +0.32 per mill in sector 78 / beam2.

Energy matching summary:
- Frequency change to center the closed orbit.
- B field change at extraction from the SPS to center the first turn

To note: Orbit change during the CMS solenoid ramp up: the orbit difference CMS ON – CMS OFF was shown. It indicates a dp/p error change by ~ 0.1 per mill. Indeed, ramp up coincided with large tidal change – good agreement! Tidal swing corresponds to ~ 15 Hz.

Orbit evolution ramp 1 and 2 – **Jörg Wenninger** (slides)
The orbit evolution through ramps 1 and 3 were shown for beam 1. Drifts: rms: 0.4-0.5 mm, mean ~ 10's microns with a large difference between the two ramps in the horizontal plane, on a time scale of about a minute (pre-cycle?).
The orbit differences inj-1040 GeV are being analysed for the two ramps. Look similar but not identical. More detailed work to continue.

LHC beam 1 and beam 2 ramp evolution - Ralph Steinhagen (slides)

LHC beam 1 and beam 2 ramp evolution was shown for the case of the third ramp: Tunes, beam intensity and energy were shown as a function of time through the ramp. The losses are clearly seen as the beam goes through resonances.

Right at the start of the ramp, small losses are observed. Then, the beam lifetime is increasing when ramping up, and losses on collimators are decreasing (Rüdiger Schmidt: do tail scrapping happen at the beginning of the ramp? Or is it more a slow diffusion process and how will it evolve with more intensity?).
To note: Tune resolution not better than 1e-4, and seems to be better with the larger energy.

Losses during the first ramp – Ralph Assmann.

BLM beam losses recorded during the first ramp were shown by Raph Assmann. Movie available in \\cern.ch\dfs\Users\d\dwollman\Public\loss_maps. Analysis is continuing for the other ramps.

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

Link to the beam commissioning programme link under "commissioning plans for 2009"

Jörg Wenninger: as the intensity is slowly increasing, BLM thresholds should progressively be moved to "un-masked".

6. A.O.B

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

Next meeting : **Tuesday 8th December 2009**, 15:30, 874-1-011. Agenda will be sent in due time.

Malika Meddahi.