LHC-Beam Commissioning Working Group

Notes from the meeting held on
19 October 2010

Present: Carmen Alabau, Reyes Alemany, Ralph Assmann, Tobias Baer, Wolfgang Bartmann, Chiara Bracco, Oliver Brüning, Andy Butterworth, Marco Calviani. Christian Carli, Pierre Charrue, Lene Drosdal, Massimilano Ferro-Luzzi, Brennan Goddard, Werner Herr, Wolfgang Höfle, Bernhard Holzer, Christoph Kurfürst Delphine Jacquet, Lars Jensen, John Jowett, Verena Kain, Mike Lamont, Yngve Levinsen, Ewen Maclean, Malika Meddahi, Tom Mertens, Ryoichi Miyamoto, Gabriel Mueller, Eduardo Nebot, Annika Nordt, Lasse Normann, Giulia Papotti, Mario Pereira, Tatiana Pieloni, Laurette Ponce, Agnieszka Priebe, Bruno Puccio, Stefano Redaelli, Mariusz Sapinski, Katarina Sigerud, Matteo Solfaroli, Ralph Steinhagen, Marek Strzelczyk, Ezio Todesco, Rogelio Tomas, Glenn Vanbavinckhove, Jörg Wenninger,.

Excused: Markus Albert, Nicholas Aquilina, Gianluigi Arduini, Roger Bailey, Philippe Baudrenghien, Giulia Bellodi, Chandra Bhat, Andrea Boccardi, Roderik Bruce, Xavier Buffat, Florian Burkart, Helmut Burkhardt, Rama Calaga, Marija Cauchi, Guy Crockford, Octavio Dominguez, Stephane Fartoukh, Ed Ciapala, Riccardo De Maria, Bernd Dehning, Laurent Deniau, Kajetan Fuchsberger, Marek Gasior, Rossano Giachino, Massimo Giovannozzi, Jean-Jacques Gras, Per Hagen, Eva Barbara Holzer, Witold Kozanecki, Emanuele Laface, Thibaut Lefevre, Alick Macpherson, Django Manglunki, Aurelien Marsili, Valerie Montabonnet, Kazuhito Ohmo, Mirko Pojer, Stefan Roesler, Federico Roncarolo, Adriana Rossi, Frank Schmidt, Rüdiger Schmidt, Elena Shaposhnikova, Andrzej Siemko, Benjamin Todd, Jan Uythoven, Gianluca Valentino, Walter Venturini Delsolaro, Daniel Valuch, Simon White, Uli Wienands, Daniel Wollmann, Marco Zanetti, Markus Zerlauth, Frank Zimmermann

1- Comments and Follow-up from the last minutes

John Jowett and Christian Carli: (slides): C. Carli discussed intermediate filling patterns for the 2010 heavy ion run. The aim is to devise the LHC ion filling patterns with a number of bunches somewhere between 2 bunches/ring (during first setting up) and the one with >100 bunches for higher luminosity.Two (amongst many possibilities) proposals for LHC ion filling patterns with about 20 bunches per ring and regular spacing (apart gaps for abort gap and non- colliding bunches) were presented. Collision schedules for all experiments were developed, together with the filling sequence. Few batches from the 140/128/120 bunches/ring scheme were also presented and completed with the collision schedule and filling sequence.

Django Manglunki: Following the request of M. ferro-Luzzi to inject 16 ion bunches in the SPS instead of 4, beam time has been accorded to study the feasibility –tomorrow 8:00 – 18:00 (slides). However due to central timing incompatibility, the maximum number of injections will be 11. In short, all known showstoppers have been eliminated and tomorrow's MD will allow to see if the bunches survive the long injection flat bottom

Joerg Wenninger: the BLM UFO discussed at the last LHC BC meeting should not be considered as a protection issue as it indeed dumped the beams.

2- LHC beam commissioning: progress and issues – Mike Lamont

Monday morning summary of Week 40 - slides from Mike Lamont and Gianluigi Arduini
And short summary from Mike Lamont (slides)
To note:

- Mission accomplished! Peak luminosity reached ~1.48e32 in stable beams
- Very uncommon UFO on beam 1 close to BSRT in pt4 (just above threshold)
- VdM scans : done – Excellent collaboration from ABP and BI, with the OP crews
- Abort Gap cleaning: abort gap cleaning was successfully performed on both beams. Machine protection issue: Check that if the cleaning is not done at the right location it's caught by the interlock system -by interlocked BPM or BLM signal. Abort Gap cleaning currently not usable at the same time with QV-BBQ reading - To be cured. Cleaning to be used in regular injection for physics fills. Was done on Monday evening, with no anomalous observation made. To be continued.
- RF noise induced diffusion – noise generation will be reviewed. Data being analysed.
- PLL commissioning continued last night- very encouraging results. To be continued. It remains to be seen how much emittance blow-up is caused by the continuous excitation as it appears that a factor 2 in beam size was observed.

3- Updates on the injection– Verena Kain (slides)

The injection investigations and re-setting-up work performed last week were summarized by Verena Kain. Verena Kain reminded the chronology of the events, the understanding of the observations and the cures applied. Last Friday large losses were measured during the injection process of beam 1. Loss pattern at the location of the MSI magnets revealed a "non-standard" loss distribution, with a peak at the entrance of the MSIA (second set of MSI) and not anymore at the entrance of the first set, at the MSIB. This was investigated and traced to an obstacle – RF fingers- which has moved into the injected beam trajectory, generating large losses in the downstream part of the beam line and caught by the LHC BLM. A beam scan was performed to assess the remaining aperture at the MSI and a magnetic bump calculated and applied at that location to "avoid" the obstacle and considerably reduce the beam losses. The regular loss hierarchy along the injection line was successfully re-established. This injection bump was also matched at the LHC beam entrance, on the H and V orbits, in order to diminish the injection oscillations. These provisional patches allowed to successfully injected the beams for Physics operation.
Unfortunately the situation degraded three days later again (RF fingers sinking more into the beam pipe), leading to further deviate the transfer line trajectory, by adjusting the injection and LHC bumps. But at this stage no further aperture margin was available to compensate further aperture reduction.
Longitudinal losses: the injection is extremely sensitive to capture losses in the LHC – debunched beam is swept onto TDI during the injection and several mitigation measures are in progress and being followed up by Brennan Goddard in a working group addressing this particular concern. Some of the solutions examined are: threshold level, relaxed sensitivity of critical BLMs, BLM sunglasses, injection cleaning with the transverse damper à la abort gap cleaning and shielding. Sources of longitudinal losses from the injectors are also being tracked. On Thursday evening, losses on the TCTVB were a factor 3 higher than normal. This was finally understood to be a combination of satellite bunches coming from the SPS and un-captured beam in the LHC. There was a problem due to the SPS 800 MHz not locking onto the frequency for many hours –diagnostics to be added, SPS surveillance needed and to use signals provided by LHCb.
On saturday afternoon, one of the PS 80 MHz cavities was off during injection, creating showers on the TCTs (V and H). On Sunday night again, showers on the TCTs were

measured, and several attempted fills failed. Again more diagnostics are needed along the chain.
To note:

- Abort Gap keeper: allowed bucket number changed: 31140
- Inject the pilot not in the first injection bucket – would avoid losing it when over-injection fails
- Giulia Papotti clarified that the pickup used for the BQMSPS, a wall current monitor, is not well suited to detect un-captured beam. Checks are already in place to verify the bunch lengths at SPS injection, unfortunately the thresholds are at the moment pushed so high as to make the check ineffective (threshold at 4.7 ns for a 5 ns bucket).

4- Analysis of the quench tests – Mariusz Sapinski (slides)

Mariusz Sapinski reminded the results from the past tests:

- All MB quenchinos
- All, except one, vertical losses
- All at injection energy
- All within the first turn
- All beam 1
- For fast vertical loss at injection energy it is easier to produce quenchino in MB than in MQ

The test campaign done at 450 GeV and 3.5 TeV was summarized:

- 450 GeV, on injections, fast loss, horizontal bump: no quench, but QPS crate got too much radiation –reset needed. Results were compared with simulation and about 1.6e9 protons were “missing” – possible leakage from BLM coverage, most likely in upstream MB, wrong simulations?
- 450 GeV, circulating beam 1, 1s loss, horizontal – signal at quench vs theoretical quench level is in very good agreement
- 450 GeV, circulating beam 2, vertical: MQ developed resistive zone, splice QPS dumped the current, quench heaters did not fire. Signal at quench and theoretical quench level showed that prediction was too optimistic by factor ~3
- 3.5 TeV, 10s loss: vertical bump, MQ quenched, 90% of the intensity were lost during 5.6s. Signal at quench compared to theoretical quench level shows that predictions are a factor 2 high

Conclusions:

- Fast transient tests at 450 GeV – no conclusive yet
- 1s quench test at 450 GeV - threshold too optimistic by a factor 3
- 5 s quench test at 3.5 TeV – threshold too optimistic by a factor 2
- These timescale are not limiting us – we need to investigate 1 ms timescale – wire scanner test
- QP3 code: more optimistic for UFO timescale.
- Analysis in progress - investigate where the protons went, Geant4 with focusing quadrupole, exercise QP3 code
- Preference for not changing the thresholds yet -based on vertical loss

To note: should perform the same measurement in the horizontal plane. Request made by Bernd Dehning for 3h beam time at 3.5 TeV for quench tests. Also a wire scan test would also provide additional important information.
UFOs does not provide us more infos as they have different source scenario (far away from the quench level).
Pending question: From the results (V plane), do we need to lower the threshold level for long time scales by a factor 3? Preference for analyzing the data and perform changes if confirmed during Christmas technical stop. Thresholds at the triplet to be checked again.

5- Beam-beam observations – Werner Herr – talk postponed to next week. – meeting running late

Werner Herr: One comment concerning the 50 ns bunch spacing: only useful test for b-b to be done with minimum 24b – 36b would also be O.K.

6- Analysis of tune & chromaticity reproducibility in the ramp – Ralph Steinhagen (slides)

Tune and chromaticity stability during the last 200 ramps were presented by Ralph Steinhagen. Main aim was to establish a quantitative estimate of the reliability and reproducibility.
The analysis of the last 200+ fills demonstrates that the LHC is/could be a fairly stable machine. Most dynamic/random variations were measured during the first 200 seconds (and compatible with the snap-back). It is proposed to change the gradual-out incorporation to reflect this.
Concerning the tune, systematic corrections of 0.06 units are done and there are about 0.06 units pp of variation at the start of ramp between fills which is believed to be correlated to the time spent at injection. A gradual-out within first 120 seconds improved significantly the reproducibility down to a few 10^{-3}. Feedback intercepted more than "random" snap-back perturbations.
Concerning the chromaticity some remaining measurement-vs-model errors are to be done. There are persistent currents of about 15 units missing and the snap-back is still large, up to 20 unit variation from fill to fill. The 'Decay' at 3.5 TeV is about ~ 6 units, ~ 1 unit/minute. They are not enough statistics to make a long-term assessment or on pathological cases (e.g. trip of sector, quench, partial pre-cycle…)
Work is on going on the analysis of all "lost ramps".
Where to find the data: logging data base, Online via BI-QP Fixed-Display.
Ezio Todesco: Tune: no decay – Q' decay at injection: measurements done by Mirko Pojer. Decay can be taken into account and correction implemented at injection (incl. difference between pre-cycle and ramp-down). Was agreed.

7- A.O.B –

Pierre Charrue asked that Jörg Wenninger and Rüdiger Schmidt propose an operational procedure on how to give SMP-THRESHOLD-EXPERT role in their absence. Pierre explained that following a change of plan for the LHC, he was called in the middle of the night by the EIC. Next time Pierre will need a confirmation before doing the change.

Evian LHC operation workshop will be held on 7-8-9 December. Invitations being sent out (Program)

Daily 8:30 HWC meeting in the CCC conference room (09:00 at weekends).
Next meeting: **26 October 2010,** 15:30, 874-1-01.

Malika Meddahi