# LHC-Beam Commissioning Working Group

Notes from the meeting held on
**13 July 2010**

Present: Carmen Alabau, Nicholas Aquilina, Gianluigi Arduini, Roger Bailey, Chandra Bhat, Philippe Baudrenghien, Chiara Bracco, Roderik Bruce, Xavier Buffat, Rama Calaga, Pierre Charrue, Ed Ciapala, Bernd Dehning, Riccardo De Maria, Massimilano Ferro-Luzzi, Massimo Giovannozzi, Brennan Goddard, Jean-Jacqyues Gras, Werner Herr, Bernhard Holzer, Eva Barbara Holzer, Bernard Jeanneret, John Jowett, Witold Kozanecki, Christoph Kurfuerst, Emanuele Laface, Mike Lamont, Yngue Levinsen, Ewen Maclean, Aurelien Marsili, Malika Meddahi, Elias Metral, Ryoichi Miyamoto, Valerie Montabonnet, Gabriel Mueller, Giulia Papotti, Mario Pereira, Mirko Pojer, Bruno Puccio, Mariusz Sapinski, Frank Schmidt, Rüdiger Schmidt, Andrzej Siemko, Katarina Sigerud, Marek Strzelczyk, Ezio Todesco, Rogelio Tomas, Walter Venturini Delsolaro, Jörg Wenninger, Uli Wienands, Daniel Wollmann.

Excused: Markus Albert, Reyes Alemany, Ralph Assmann, Tobias Baer, Wolfgang Bartmann,Oliver Brüning, Helmut Burkhardt, Andy Butterworth, Guy Crockford, Laurent Deniau, Octavio Dominguez, Lene Drosdal, Stephane Fartoukh, Kajetan Fuchsberger, Marek Gasior, Rossano Giachino, Per Hagen, Wolfgang Höfle, Delphine Jacquet, Lars Jensen, Verena Kain, Thibaut Lefevre, Alick Macpherson, Lasse Normann, Laurette Ponce, Stefano Redaelli, Stefan Roesler, Adriana Rossi, Elena Shaposhnikova, Matteo Solfaroli, Ralph Steinhagen, Jan Uythoven, Daniel Valuch, Glenn Vanbavinckhove, Frank Zimmermann.

## 1- Comments on the last minutes

None.

## 2- LHC beam commissioning: progress and issues – Roger Bailey - Malika Meddahi (slides)

Besides providing luminosity operation, the goals of the week 27 were to complete the work needed for the injection of more than 1e12p per beam. This is reported in details in Chiara Bracco's presentation. During week 27, observations and more understanding of the sudden beam losses during collisions were also performed – see Werner Herr's presentation.

To note:

- Multi-bunch controlled longitudinal blow-up – Thomas Bohl, Joachim Tueckmantel, Urs Wehrle.

4 single nominal bunches were injected into the SPS, 2.4 s apart, bunch spacing was 2 us, I_bunch ~1e11 at injection. Optimisation of the controlled longitudinal emittance blow-up was done and at 450 GeV, with 7.0 MV, the bunch length was between 1.3 - 1.85 ns, corresponding to longitudinal emittance of about 0.40 - 0.75 eVs. For better optimization, the TWC 800 MHz is required (this will be a new operational requirement) and more beam time is needed for optimisation.

- SPS transverse blow-up with transverse damper - Wolfgang Höfle.

Octupoles are used in combination with an excitation by the damper around the tune frequency (small frequency modulation). The system was tuned for providing emittances of ~3 – 3. 5um in H and V for both beams.

- Preparation of LHC multi-bunch injection is in progress in the SPS – **OP**.

- Horizontal scraping of the SPS beam is to be done before beam transfer into the LHC. Was first used over last week end in injection studies and later on for LHC physics filling.
- ADT has been successfully tested during EOF with the goal to be switched on all along stable beams. Wolfgang Höfle, Daniel Valuch, Maarten Schokker.
- De-bunching on beam 1 linked to RF noise : Philippe Baudrenghien found that it was due to one of the clock (380 MHz) produced by a Phase Lock Loop which was not locking anymore on beam 1 and generating bursts of noise in the loop. It was re-tuned and will be monitored periodically.
- RF bucket problem: software fixed, will be deployed as soon as LHC is back at 450 GeV – **Philippe Baudrenghien**.
- Consolidation of BI equipment has been performed.
- Orbit-wise: **Jörg Wenninger**. i) To establish absolute reference orbit with stable beam configuration. ii) In YASP: when changing LHCb polarity, evaluate the possibility to implement in YASP the correction of the orbit leakage using LHCb compensator magnets. This would avoid the mistake to use orbit or MCBX correctors. But also need to understand why the orbit is not close anymore.

To note:

- Loss of communication with a BIC – **Bruno Puccio**: trace to a problem with a FESA class, resulting in the connection to CMW being interrupted. Will be solved next week during the Technical stop. To be kept in mind: BIC interlock process is purely hardware and completely independent of the monitoring communication, LHC safety is still ensured. If communication is lost, the principle risk is that no PM data will be returned from the blocked controller following a beam dump. At this moment, a simple reboot of the effected front-ends restores correct operation of the BIC FESA class, and the front-end reconnects to CMW. It is important to note that the reboot does not break the beam-permit loops and the beam operation won't be stopped if a reboot is performed with beam permit true.
- De-bunching at 450 GeV – Brennan Goddard said that there had been cases where with circulating beams (7 or 8 bunches), the MKIs were firing with no beam from the SPS. Losses were observed on the TDI, even though no beam was extracted from the SPS. It seems to point to un-captured beam which the kicker is sweeping across the TDI. Investigation: **Philippe Baudrenghien**.
- MKIs not firing at injection: Follow-up. **Etienne Carlier**.

**3- Injection and transfer line studies** – Chiara Bracco (slides)

Much work was performed in week 27 in view of injecting more than 1e12p/beam. Chiara Bracco presented the details of checks, optimisations and setting-ups which were successfully performed.

- Data taken concerning the TDI positioning are being analysed;
- Emittance measurements in SPS, TLs and LHC proved to be consistent: ~3um everywhere (normalized). A blowup of the individual bunches on the flat bottom has been observed, which depends on the time the bunch has been circulating and which affects B2 V the most (about 1 um/h);
- TI 2 collimator tail scan: transverse blowup is giving large tails in H, with about 2% of the beam outside 4.5 sigmas. Horizontal beam scraping will be needed in the SPS if this cannot be improved;
- TI 2 and TI 8 steering by cleaning unnecessary corrections, TCDI collimators re-centered around new trajectory. One BPM with inversed polarity in H and V has been identified - **Lars Jensen**;

- Injected 13 nominal bunches per beam via filling sequence. Very clean injections (with the scraping ON in the SPS) and no problems to run through sequence with BLMs unmasked;
- Over injection of both beams with 7e9 pilot gave losses on the TCTVB which are above threshold – being addressed;
- Multibunch setting up in the SPS for about 3 hours, but a bit more work is needed (orbit, transverse, settings) before injection into LHC. Took the beam to the end of TI 2 and got trajectory with large excursions - will wait for SPS tidy up before continuing;

In conclusion: The injection systems are ready for 12 nominal bunches.

To note:

- Screens of the beam dump lines have also been added to the screen application (Fabio Follin – Verena Kain). They will provide an important complement of the emittance measurement checks through the SPS to the LHC.
- Should make sure that the correctors in the TLs cannot be changed to guarantee a safe injection into the LHC.
- SPS scrapers: are now considered to be operational.

## 4- Updates on beam observations during stable beams – Werner Herr (slides)

Werner Herr presented a 2nd follow up of the sudden beam losses observed during stable beam operation.

He reminded us that the only observations last week have been made on a new scheme with 10 bunches, i.e. with a maximum number of 2 collisions per bunch.

An observation during the night 8/9 July showed a loss on beam 1 and it was observed that the first 4 bunches of beam 1 were lost in sequence.

On one of the slide Werner presented, the losses are correlated with the current in an orbit corrector used to separate the beams in ALICE to reduce the luminosity. The losses are clearly correlated with this separation procedure. Only bunches colliding in IP1 and IP5 suffered from this loss.

In another fill with 12 bunches from 13.7. (this morning) a loss was observed after a luminosity scan in IP1.

He re-iterated on the point that any manipulation on colliding strong beams can potentially cause problems. The losses observed are clearly related to beam-beam effects and a strong coherent signal during the losses is always visible. Werner reminded us that such modes are always present but are only visible when they suffer from an excitation and in the absence of Landau damping. It was speculated what can be the origin of such an excitation and/or loss of damping.

Werner Herr proposed a few tests to further investigate the problem.

Priority should be to understand the measured tune spectra and he emphasized the need for a bunch by bunch tune diagnostics.

Another recommendation was to minimize the number of luminosity scans during stable beam operation until the problem is understood and/or solved.

To note:

- Moving the orbits during the luminosity scan in one IP: this will affect all bunches, through orbit separation. It's a transient, difficult to observe on the BPMSW
- Avoid changing any of the parameters in presence of strong beam-beam effects, in particular moving beams against each other.
- LHC does have many b-b coherent modes, always present but there are not observed unless excited or if Landau damping is lost.
- Lose landau damping if either incoherent spectrum or coherent frequency moves towards each other.
- May try to have bucket 1 bunch not colliding in ATLAS and CMS.
- May try for 10 bunch scheme to switch off the external crossing angle.

- Phenomenon is mostly vertical (preliminary).
- Hump is typically a source which could excite coherent mode.
- 450 GeV; nothing such was observed. Could it be because of different phase advances between the IPs? Or because there were too few runs to observe such effects.
- Why does the bunch go shorter longitudinally when we observe such losses? Reduced longitudinally by 4% while transverse blow–up is 23% in vertical plane.
- Impedance of the machine plays a role? Yes. At injection the collimators are way out, however at top energy they are moved close to the beams.
- RHIC has observed b-b effects in strong regime. But they were not excited, as it is the case in the LHC from other excitation sources, such as the Hump.
- Could discriminate against coherent b-b mode by changing the tunes: could be done by swapping the tunes for example, but if it is excited by an outside source, then can only be damped by the ADT.
- Measuring tune bunch by bunch: head-tail monitor would be very useful at this stage. Could be triggered on the beam loss. Elias Metral said that for one of the observed instability, its rise time is ~10 s, so, for example, the monitor could be triggered every second. **Monitor status to be checked: Lars Jensen**.

**5- Updates on the Hump studies** – Gianluigi Arduini (slides)

Much work has been done by Gianluigi Arduini and his colleagues in order to analyse the data stored during the last weeks. Typical plots, taken through the ramp and the squeeze, of time vs. tunes were shown. Several lines are moving with time and all the frequency contents have been analysed for beam 2 vertical. Beside the vertical tune line, two main frequencies are seen, with their 2$^{nd}$ and 3$^{rd}$ harmonics. There is no evident dependence of the hump line frequencies vs. energy → it excludes high frequency exciting harmonics but not frequencies related to the RF one

Frequency sweep of the 8 kHz and 2, 4 and 6 harmonics: measurement campaign during TS is on-going to characterize the UPS noise and to identify possible locations with noisier UPSs.

The hump is with us all the time, but with different patterns more of less disturbing for the beam according to the amount of overlap with the tune. Correlation with events changing the structure is important (on going for some cases observed) and needs fixed display.

Momentum dependence during the ramp: Spectral density over a given band of frequency vs energy was shown. Average amplitude at 450 GeV excludes mechanical vibrations with constant amplitude (measured in the triplet).

Effect of the squeeze: none: rules out the hypothesis of a localised source in the insertions.

No evident effect (preliminary) of: RF cavity voltage distribution, MKI kickers, Beam screen cooling in the triplets (consistent with observations on the squeeze). Being further analyzed: Correlation of TI 2/TI 8 pulsing with low-frequency noise (~300 Hz)

To be done – Follow-up: **Gianluigi Arduini**:

- Fixed display and temporal correlation with other parameters – ongoing with Mario Pereira. Long term storage needed as well, at a rate of ~10s;
- Effect of orbit on RF → to rule out completely RF;
- Effect of GSM network and its surveillance (tentatively on Thu?);
- BLM signals and noise evaluation (ongoing with Mariusz Sapinski);
- First measurements with Schottky would help in the analysis;
- Noise map in the tunnel and spectral characterization of the UPS EM noise for the different models and understanding of possible failure modes;
- Sources of low frequency part of spectrum → EPC (MSD,MSI)

- Hump dumping (implies ADT noise reduction, which is in progress) – Wolfgang Höfle.

**6- Outcomes from the MPP review** – Rüdiger Schmidt - Jörg Wenninger (slide)

Rüdiger Schmidt summarised the outcome of the MP internal review which took place on 17-18 June 2010.
All details can be found in Rüdiger Schmidt 's slides.
To note:

- When "safety" is mentioned on the slides: it stresses the fact that this point should be considered with care in case of changes as it is directly linked to safety.
- Full tests to be done after critical equipment exchange during TS – Procedures after intervention are required.
- Interlock on the RF frequency to be activated.
- Tools for looking at BLMs as a function of time from logging data base.
- BETS is now unmasked.

List of critical items to be followed-up:

- Stable orbit
  - Orbit bumps can be dangerous, in particular in case of asynchronous beam dump and at injection of high intensity beam
  - Orbit non-conformities increase risk of damage, to be better understood…
- Coherence between machine status and collimator positions to be ensured (injection, flat-top, squeeze, physics, luminosity scans, ….)
  - Take into account possible failures, such as squeezing to wrong beta- function, failures in hardware systems, ….
  - Highly reliable sequences are required (sequencer + sequences)
  - Since the sequencer is not a SIL3 system: backup by SIS (beam dump or warning)
- Non-conformities due to machine protection tests
  - Un-masking SIS not to be forgotten – to be addressed
- Re-commissioning of protection systems after short technical stops
  - Every intervention on a protection system has some risks, procedures are required that determine what tests need to be performed
- Most important: stable running period for improvements
- Use the time before (much) higher intensity to sort out things
- Review with external participants planned for begin of September: are we ready to go to 30 MJ?
- SIS is not a safety system

Conclusion: No show stopper to operate with 12 nominal bunches/beam. And to review the situation after some experience with 12b operation, before going to 24 bunches.

**7. O.A.B**

None.

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

Next meeting: **20 July 2010,** 15:30, 874-1-01.

Malika Meddahi