LHC-Beam Commissioning Working Group

Notes from the meeting held on
25 August 2009

Present: Ralph Assmann, Tobias Bär, Oliver Brüning, Helmut Burkhardt, Massimiliano Ferro-Luzzi, Kajetan Fuchsberger, Rossano Giachino, Massimo Giovannozzi, Brennan Goddard, Eugenia Hatziangeli, Hitomi Ikeda, Delphine Jacquet, Lars Jensen, John Jowett, Verena Kain, Mike Lamont (chair), Alick Macpherson, Malika Meddahi, Gabriel Mueller, Bruno Puccio, Stefano Redaelli, Stefan Roesler, Frank Schmidt, Wojtek Sliwinski, Marek Strzelczyk, Ezio Todesco, Jan Uythoven, Walter Venturini Delsolaro, Jörg Wenninger, Simon White, Marco Zanetti, Frank Zimmermann.

Excused: Roger Bailey, Ralph Steinhagen.

1. Comments and actions from the last minutes

None.

2. News from LMC – Mike Lamont (slides)

The minutes, written by Frank Zimmermann are available here.
Conclusion: Operation at 7 TeV c.m. with a dipole energy extraction time of 50s. During this time, monitor carefully all quenches to gain additional information. Then operate at 9 - 10 TeV c.m.

Integrated luminosity at 3.5 TeV:

Month	Comment	Turn around time	Availability	Max number bunches	Protons/Bunch	% nom. intensity	Min beta*	Peak Luminosity $cm^{-2}s^{-1}$	Integrated Luminosity	events/X
1	Beam commissioning								First collisions	
2	Pilot physics, partial squeeze, gentle increase in bunch intensity, 40%	Long	Low	43	3×10^{10}		4 m	8.6×10^{29}	100 - 200 nb^{-1}	
3		5	40%	43	5×10^{10}		4 m	2.4×10^{30}	~ 1 pb^{-1}	
4		5	40%	156	5×10^{10}	2.5	2 m	1.7×10^{31}	~9 pb^{-1}	
5a	No crossing angle - could at this stage push intensity see 5b	5	40%	156	7×10^{10}	3.3	2 m	3.4×10^{31}	~18 pb^{-1}	0.8
5b	No crossing angle - squeezing to beta* = 1m at this stage would double these lumi numbers (and the pile-up)	5	40%	156	10×10^{10}	3.3	2 m	6.9×10^{31}	~36 pb^{-1}	1.6
6	50 ns - nominal crossing angle - aperture restricts squeezing further	5	40%	144	7×10^{10}	6.7	2-3 m	3.1×10^{31}	~16 pb^{-1}	
7	50 ns	5	40%	288	7×10^{10}	4.5	2-3 m	8.6×10^{31}	~32 pb^{-1}	
8	50 ns*	5	40%	432	7×10^{10}	9.3	2-3 m	9.2×10^{31}	~48 pb^{-1}	
9	50 ns*	5	40%	432	9×10^{10}	11.5*	2-3 m	1.5×10^{32}	~80 pb^{-1}	
10		5	40%	432	9×10^{10}	11.5*	2-3 m	1.5×10^{32}	~80 pb^{-1}	
								TOTAL	~ 300 pb^{-1}	

And with a possible shift to higher energy:

Month	Comment	Turn around time	Energy [TeV]	Max number bunches	Protons/Bunch	% nom. intensity	Min beta*	Peak Luminosity $cm^{-2}s^{-1}$	Integrated Luminosity	events/X
1	Beam commissioning								First collisions	
2	Pilot physics, partial squeeze, gentle increase in bunch intensity, avaialbility low	Long	3.5	43	3×10^{10}		4 m	8.6×10^{29}	100 - 200 nb^{-1}	
3		5	3.5	43	5×10^{10}		4 m	2.4×10^{30}	~ 1 pb^{-1}	
4		5	3.5	156	5×10^{10}	2.5	2 m	1.7×10^{31}	~9 pb^{-1}	
5a	No crossing angle - could at this stage push intensity see 5b	5	3.5	156	7×10^{10}	3.4	2 m	3.4×10^{31}	~18 pb^{-1}	0.8
5b	No crossing angle - squeezing to beta* = 1m at this stage would double these lumi numbers (and the pile-up)	5	3.5	156	10×10^{10}	4.8	2 m	6.9×10^{31}	~36 pb^{-1}	1.6
6	Possible shift to higher energy - would anticipate ~4 weeks to reestablish physics follow by a fairly gentle increase back up in intensity.	Would aim to first provide a period of physics at the higher energy (4.5 TeV, say) without crossing angle, this could be followed by a move to 50 ns with a limited number of bunches. Note that the total intensity limit will go down with the move to higher energy.								
7	4 - 5 TeV (5 TeV luminosity quoted - doesn't make too much difference). No crossing angle.	5	4 -5	156	7×10^{10}	3.4	2 m	4.9×10^{31}	~26 pb^{-1}	
8	50 ns - nominal crossing angle - aperture restricts squeezing further - note limited complement of bunches.	5	4 -5	144	7×10^{10}	3.1	2 m	4.4×10^{31}	~23 pb^{-1}	
9	50 ns	5	4 -5	288	7×10^{10}	6.2	2 m	8.8×10^{31}	~46 pb^{-1}	
10	50 ns*	5	4 -5	432	7×10^{10}	9.4	2 m	1.3×10^{32}	~69 pb^{-1}	
(11)	50 ns*	5	4 -5	432	9×10^{10}	11.5*	2 m	2.1×10^{32}	~110 pb^{-1}	

Latest schedule: First LHC beam is tentatively scheduled for middle of week 47 (~18th November).
Mid-October would be the earliest time for the injection tests of beam 1.
TI 2 / TI 8 are still scheduled for 25 to 29 September, ending at 7:00 am on Tuesday 29 September.

3. Dry Run news – Verena Kain (activity tracking link and slides)

Summary of the activities, week by week, as sent by OP team in charge:

W32: Beam dump beam 1 and follow ups - Incorporation, RBAC strict, Fidel …
LBDS1 armed successfully with the sequencer. Tested the beam dump triggers by operator switch, timing and energy tracking errors.
Inject & Dump: could run for the first time the inject and dump sequence for beam 1, with programmed dumps 0, 1 and 2 turns after injection. This was done with LHC as master, injection kicker pulsing and LBDS armed. Very nice results because last year this had been done only for B2.
FiDeL: Tested FiDeL corrections for the compensation of the B3 and B5 current decays. Snap-back corrections for the ramp are available however they could not be tested for the converters in SIM_VS because some correctors exceed the Imax. Marek is following this up. A demo was setup with the FiDeL team and the future tests and setting validation were agreed.
Squeeze: Repeated tests for all points with all relevant PC's. Problems to check the IP2 settings because the HW limits are still in place from the commissioning of June. The issue of the HW values needs to be addresses in order to be able to test in simulation mode the LSA settings for powering levels above Phase-1 powering. Problem of first-point-mismatch if incorporation is done after actual trim performed in a stopping point of the squeeze (Stefano and Greg will follow this up).

Incorporation: Tested the final version of the incorporation also for incorporation into points within the beam process, which failed last week. Tried for stopping points of the squeeze beam process. Incorporation rules worked as expected.
SoftStart: routinely performed for both beams. A few erratic faults on the first attempts to condition the kickers. Then all fine. Prepared a sequences for running daily the SoftStart of both injection kickers, as requested by the kicker team to train the conditioning.

W33: DIP handshake with the experiments (LHCf, LHCb, ALICE, ATLAS & CMS) tested for the injection, adjust and beam dump phases. The sequence of tested messages/tasks can be found in the tracking list link.
Tested as well with ATLAS and LHCb: safe_stable_beam, movable_allowed_in SMP flags and post mortem event. Found a cable exchanged in the LHCb movable devices input at the BIC: now fixed. ATLAS and LHCb see the flags going from false to true and viceversa.
Post-mortem events were sent and LHCb receives them right, but ATLAS has an issue: when the SAFE_BEAM_FLAG at the SMP receiver is TRUE, they don't see the post-mortem event: being followed up**.** Details:
https://espace.cern.ch/mddb/Activity%20Tracking%20Tool/Activity%20Tracking%20Welcome.aspx?View={593B6E53-F6F9-4485-8646-E7E683D0F681}&SelectedID=44

W34: Inject and dump beam 1 and 2, Circulate and dump beam 1 and 2.
LBDS and BIC armed properly with the sequences, MKI B1 and B2 pulsing properly. In general was very successful, we found the following issues to be followed up:
LBDS:
a. MCS checks still failing due to inconsistency between DB and hardware.
b. XPOC still failing as references are not up-to-date.
c. Fixed displays: vacuum still not working. Ring fast BCTs do not show their XPOC values there, but the 1 Hz continuous data.
d. LBDS (MKBs) were not in condition to be ramped. Postponed.

Inject and dump beam 1 looping nicely:
a. The maximum of the number of turns is still limited by the automatic PM enable.
b. For the time being did not manage to inject on every cycle (40 s long super cycle in the SPS). There is still some margin (remove conservative "sleeps" in sequence). Could gain at least 10 s.

Inject and dump beam 2: always get an IPOC error: on synchro and delay; may be a cabling issue. Programmed dump, circulate and dump, and any other dump is fine.
Circulate and dump looping nicely: Should speed it up as well.
SIS:
a. Could not test the SIS logic because the INJ_B1_PERMIT and INJ_B2_PERMIT are not connected to the injection master BIC and the slave BICs are disabled on the injection masters. Postponed
b. BTVs issues in the SIS: As clarified by Lars Jensen, the RBAC issue has already been dealt with by adding a specific rule allowing SIS to access without needing the CMW proxy.
c. SIS additional issue: it does not recognize the mode "circulate & dump" as an injection mode and never gives the injection permit in mode circulate & dump.

Dumped events still not coming out automatically. Did not manage to disentangle the dumped events from the post-mortem events. And the PM events MUST NOT come out while we are hardware commissioning. In the mean time the BIC cables to the timing system are disconnected. Will have to test during the machine check-out.
Alternate Injection:
a. Serious issues with the re-phasing. Cannot re-phase anymore if we are running alternating filling schemes. Even when the frequencies are the same for both beams.
b. Even more: for beam 2 only (not alternating, but e.g. inject & dump on continuous) if there is no request for some time, the re-phasing will never recover again.

https://espace.cern.ch/mddb/Activity%20Tracking%20Tool/Activity%20Tracking%20Welcome.aspx?View={593B6E53-F6F9-4485-8646-E7E683D0F681}&SelectedID=45

W35: Interlocked BPM, BCTS VMCS, Incorporation, Squeeze, IQC next version, BIC-RBAC, I to IREF filtering.
https://espace.cern.ch/mddb/Activity%20Tracking%20Tool/Activity%20Tracking%20Welcome.aspx?View={593B6E53-F6F9-4485-8646-E7E683D0F681}&SelectedID=46

Upcoming dry runs:

- Week 35: BCTs, virtual critical settings, I2Iref filtering, incorporation, IQC, re-phasing (Friday), regular softstart MKI, squeeze stop points
- Week 36: Fidel (calculate ramp corrections), follow-up (Logging RF,...), regular softstart MKI, incorporation through hypercycle; hardware group and PC settings
- Week 37: IQC virtual critical settings, Injection sequencer connected to real IQC, IQC tasks in sequencer, hardware group and PC settings, XPOC BI, hardware groups and PC settings; Monday/Tuesday: Transverse damper/Abort gap cleaning;
- Week 38: LHC RF for ions, re-phasing with injection kickers??? SIS task for IQC, hardware groups and PC settings, Transverse damper/Abort gap cleaning
- Week 39: TI 8/TI 2 Test interleaved, ions, full IQC, hardware groups and PC settings, AC Dipole
- Week 40: Feedbacks

Mike Lamont congratulates the OP team for this continuous excellent preparatory work.

4. Update on LHC field model activities and critical issues – Ezio Todesco (slides)

Ezio Todesco gave the status report of FiDel activities. Contents of the talks: Reminder of the structure, What has been done since 2008 run and Critical issues and future activities.

The new structure implemented in 2009 allowed reducing the total number of people involved in the project and increasing their percentage. Most of the staff dedicated to magnet analysis is within one group, one section, and only staff members are in charge of the data. Bi-monthly meetings are being held -minutes at www.cern.ch/fidel
Each magnet family has a custodian (staff member) who evaluates the parameters from the measurements, follow-up specific issues, writes the documentation and is able to go back to data and perform analysis if needed.

What has been done since the 2008 run?

2008: TF of all magnets plus field harmonics of MB

2009:
FiDeL parameters of all field harmonics - Penetration component added, complete review of correctors carried out, MB to review and to update 3-4.

Hysteresis: As illustrated on page 7, during the squeeze, in some MQM the current decreases and the other branch of the hysteresis should be followed. LSA in 2009 had only one branch, giving for Q6.ip5 an error of 35 units at β^*=0.55 m. Neglecting this effect is not dramatic, but has some impact on the beam (estimates from Massimo Giovannozzi). This is already modelled in the FiDeL equations -it is enough to change the sign of the DC magnetization.
Decision: LSA should be able to switch from one branch to the other one according to dI/dt: Implemented in July 2009 (Marek Strzelczyk), to be checked, aim at having the possibility to switch off this option.
Other types of hysteresis: Spool pieces (MCS, MCDO) have decreasing currents during injection plateau, due to decay, and then they cross zero current during ramp. Neglecting

the hysteresis has a negligible impact on the beam. Marginal for the sextupole spool pieces

Hysteresis – other cases:

1- Lattice sextupoles MS: i- Work at very low current (6 and 10 A); ii- At 6 A hysteresis gives 7% difference in TF, iii- since one corrects 90 units, neglecting this, gives 6 units of uncorrected chromaticity - Proper pre-cycle is needed to place the magnet on the right hysteresis branch; the DC magnetization component should be added to the model -remark by Walter Venturini.
2- Some correctors (orbit correctors, MQT, MQS, …) have no nominal settings and can work around zero current. This effect is deemed to be not important and is neglected for the first phases of commissioning. Case of MQT was discussed widely, additional measurements in progress.

Penetration component: Some MQM and MQY operate below the penetration field. A penetration component with two parameters has been added to the FiDeL equations -proposed by W. Venturini Delsolaro- so the model now fits also this behaviour. Neglecting this component would have given non-negligible beta-beating -estimates of Massimo Giovannozzi.

Database: FiDeL parameters are stored in Oracle database. Database active in the final form since May 2009 (L. Deniau, P. Hagen, based on the work of R. Wolf). Easy access to check all parameters.

Documentation: The information relative to each magnet family is given in a report -to be published as LHC Project Note. 250 pages of documentation are already available on the FiDeL web site: http://www.cern.ch/fidel

Future activities and critical points: Complete the documentation, Validation LSA vs FiDeL, Correction of decay and snapback: tracking test, Pre-cycle prescriptions.

Tracking tests:

Tracking test campaigns have been carried out in 2007-2008.

B_1/B_2 tracking test: one dipole and one quadrupole powered together – during the ramp, one checks the stability of the tune, the ratio between B_1 and B_2 - success!

B_3 tracking test: a dipole ramped with b_3 spool pieces – one integral b_3 measured to checks the validity of the local correction -Point of view of the beam: needed correction is 0.05 units – obtained correction: 0.3 units

Point of view of the magnet: i- Injection current (geometric+persistent) about -8 units, 0.2 units left (correction works at 98% - good), ii- Decay: about 0.6-1 unit, 0.2 units left (correction works at 65-80%), iii- Snapback: about 0.6-1 unit, 0.2-0.4 units left (correction works at about 50% - bad). iii - During the ramp: variation of about 7 units reduced to 0.3 units, (correction works at 95% - not bad). Still a lot to understand.

New tracking test are being done in SM18 and results are expected for September.

Ramp rate: All SM18 measurements had been done at 50 A/s ramp rate, different from nominal – strong impact on decay and snapback. Rescaling of all measurements to operational conditions is delicate.

Database of pre-cycles:

R. Wolf created an Oracle DB in 2007-2008 with optimized pre-cycles based on FiDeL activities and LEP experience. LSA has an Oracle DB of pre-cycles used in the LHC sequencer: this was used during the successful 2008 run. A synchronization between the two is needed.

For the 3.5 TeV run:

All efforts should be done to reduce as much as possible the pre-cycle time (nearly 2 h for the MB in the DB of Rob) taking advantage of the reduced energy. MB ramp will last 550 s instead of 1000 s.

Decay proportional to flat top energy → **at 3.5 TeV we should have half of the decay**.

It was further clarified that:
- The 3.5 TeV run will require a precycle up to 3.5 TeV instead of 7 TeV;
- According to the measurements, with this pre cycle, the decay should be reduced;
- 3.5 TeV is already out of the DC magnetization zone so the static model has the same features of 7 TeV;
- Therefore there should be no particular issues for a 3.5 TeV run.

Ezio Todesco will address in a future meeting the required magnet cycling after a beam abort.

5. TI 2 / TI 8 beam tests of week 39 - Malika Meddahi & Rossano Giachino

Rossano Giachino confirmed the beam test dates: from Friday 25 September 18:00 to Tuesday 29 September 7:00 am.

Jörg Wenninger proposed to benefit from the tests to switch on the LHC injection elements – downstream of the TEDs. Despite the fact the LHCb team won't be present, it should be made sure that LHCb gives the beam permit signal.

The programme of the beam tests was presented by Malika Meddahi.

To note: LHCb would like 8hrs of proton beam onto the TEDs at a later stage.

Next meeting

Tuesday 1st September 2009, 15:30, 874-1-011. Agenda will be sent in due time.

Malika Meddahi.