LHC Beam Operation Committee

Notes from the meeting held on 22nd February 2011

1. Comments from Jorg - J. Wenninger

Gianluigi Arduini has accepted to be deputy chairman of the LHC Beam Operation Committee. Minutes of the meetings will be posted on the webpage under minutes and an e-mail will be sent for info when available.

2. Crossing Angles – W. Herr (slides)

Werner presented the main constrains to decide which crossing angle to apply at injection and top energy and gave his recommendation on how to proceed for this 2011 run.
The main considerations to decide about crossing angles are:

- **Beam-Beam**: the crossing angle should be as large as possible, with this one sets lower limits on the β^*_{Inj} needed to have adequate separation at the different parasitic encounters.
- **Aperture:** should be as small as possible and this sets upper limits to the β^*_{Inj} choice.
- **Operation:** the choice should make operation simple if possible, like keeping it constant during cycle, deciding on the magnets to be used or not like the MCBXs etc.
- **Other considerations:** magnets in IP2 and IP8 (field strength and polarity), solenoids (in other experiments small effects) and the sign of the crossing angle in IP5 and IP8.

To determine the crossing angle at Injection essential inputs are the beam **emittances**, **bunch spacing** and **β^*_{Inj}**.
The nominal angle of ±170 μrad was defined in 1999 assuming nominal emittances (3.75 μm), nominal aperture (n1 > 7) and for a bunch spacing of 25 ns for a β^*_{Inj} of 18 m.
With the present LHC layout β^*_{Inj} = 11 m at IP1 and IP5 the minimum separation at the beam-beam parasitic encounters is of 9.5 σ with a ± 170 μrad crossing with nominal emittances of 3.75 μm. Reducing the crossing angles to ±140 μrad provides the same minimum separation assuming beam emittance of 2.7 μm, which is what was available last year.
Since it is planned to inject for testing also the 25 ns beams and for this configuration only nominal emittance are guaranteed by the injectors then the ±170 μrad crossing only can assure a 9.5 σ minimum separation at injection.
PROS-CONS of the ±170 μrad crossing angle:
PRO: works for nominal emittances and 25 ns bunch spacing
PRO: For smaller emittances gives larger separations and for long-range interactions this will result in a positive effect.
CONS: Requires more aperture

CONS: Requires ramping down at top energy

PROS-CONS of the ±120/±140 μrad crossing angles:
PRO: works for smaller emittances
PRO: could keep same value during whole cycle
CONS: Requires smaller emittances for the 25ns beams
CONS: problems for IP8 does not allow polarity sweep

RECOMMENDATION:
Werner recommends to start with the ±170 μrad crossing angle as a safer bet since we do not yet know the effects of long range beam-beam interactions moreover gives a possibility of scrubbing or testing with the 25 ns beams.
Nevertheless in case long range will not be a limiting factor for 50 and 75 ns beams then could result in overkill for operation while a reduced crossing can relax aperture margins. Moreover a reduced crossing angle of ±140 μrad allows keeping the same crossing for the full machine cycle. Another additional simplification is that at 3.5 TeV we can also avoid using the MCBXs which makes things easier for operation. We start with them on to have margin on the Q4 aperture then a solution can be found with the MCBXs off.

3. HWC summary with list of remaining issues/non-conformities - M. Pojer (slides)

Mirko presented a summary of the HardWare Commissioning carried out over these last 3 weeks and presented only electrical non-conformities which are relevant for the LHC operation. Mirko showed the definitive planning of the HWC respect to the November plan and showed how against any believe the team managed to test all sectors in 10 full days. He confirmed that no NEW non-conformities were found. He showed the impressive work of the last 3 weeks of powering tests of the HWC team 1565 over the 11572 circuits were commissioned resulting in 6000 test steps over 3 weeks. Respect to last year some non-conformities have been fixed and circuits validated leaving behind only 7 circuits (listed in a summary table) with really problematic cases but RCBXH3.L5 which can be repaired in short time if needed, but last year we run without it so no repair required now. Another limitation to notice is that the RQT13.L7B1 showed an increase in resistance therefore the powering limit has been fixed to 50 A but should not be a problem for operation since last year it has been used only up to 2-3 A.

All the work of the HWC team is documented and published: EDMS DOC No. 1113965.

Finally Mirko addressed the case of the 120 A correctors of the ITs. The cooling of these circuits has been problematic since the beginning. Already last year many circuits had to be super-locked and have never been used so far but this year we might need some of them when going to low β* in particular the RCSXs (info from M. Giovannozzi and R. Tomas). Mirko suggests to condemn all the 120 A circuits of the DFBXs (32 circuits in total) but the RCSXs.

Comments:

It is agreed to condemn from OP all the 120 A circuits since they will not be used this year. They should be super-locked and valves blocked for the cryo.
Jorg pointed the need this year of the RQT13.L7B1 but we will need them at 2-3 A powering so should be ok. Mirko commented that 2 extra powering checks are planned for this.
Markus Zerlauth mentioned that also the RCBYV5.L4B2 was locked last year. Mirko said it has been commissioned to 50 A.
Jorg and Rudiger Schmidt suggested to check this. Maybe the lock comes from last year commissioning. To be followed up by the HWC team.

4. Automatic tune and b3 compensation at injection -N. Aquilina (slides)

Nicholas presented an analysis of the decay of the tune and chromaticity during the injection plateau. Data comes from the last year run and a comparison to the first 2011 LHC ramp had been also shown. A statistic evaluation of the time spent at injection current of 757.2 A shows a peak around 1-2 hours. During this time a clear decay in tune Q and Chromaticity Q' is observed.

In 2010 the decay has been corrected manually by the OP crew applying the necessary trims. A plot shows the dynamics of the manual correction: in blue the decay of Q as measured by the BBQ system and in red the trims applied with the QTD and QTF circuits in operation to bring back the tune to nominal value 0.28.

To analyse the parameters of the decay at injection one needs the total decay during the full injection plateau and this is obtained by subtracting the trim contributions from the measured values of tune and chromaticity. While for the tune measurements and trims are easily available, for Q' measurements are obtained going through the logbooks (as done by Venturini) while the trims are obtained either from the logbook or from the MSF/MSD currents. To the total Q and Q' decay during the injection plateau, Nicholas applied the known empirical double exponential model for the decay to all available 2010 injection plateau between 3rd Sept to 31st Oct 2010. It is worth noticing that the horizontal tune sits around 0.31 for both beams (only 0.03 a part from nominal) while the vertical one is far away from the nominal by 0.1 units. Moreover, a systematic difference is visible between beam 1 and beam 2. Based on last year statistics an average correction is proposed for the tune decay to implement in FiDeL following the double exponential model for the decay of the Q at injection. The analysis of the Q' decay at injection also defines an average correction which Nicholas proposes to implement in FiDeL, substituting the values coming from the SM18 modeling since the latest were obtained from a nominal LHC cycle with flat top current of 12 kA and a ramp-rate of 50 A/s which is not the case today (6 kA I_{FT} and 10 A/s linear ramp-rate). The total Q' decay amplitude at injection is as expected around 20 units (approximately 0.5 units of b_3). For completeness the values in the FiDeL database are also shown.

Last Sunday 20th February 2011 the first ramp has been tried in the LHC and the measured Q and Q' were compared to last year's statistics. Both Q and Q' decays seem to be much faster than last year. It is not clear what is happening, more measurements are required for the analysis.

Another important ingredient for this type of analysis is the pre-cycling of sectors, in particularly when some sectors are pre-cycled individually. The decay starts as soon as the magnets current is set to injection value and depends also on the pre-cycling conditions. While one sector is pre-cycling, the others that are at waiting at injection current have all the multipoles decaying. Different sectors contribute differently to the decay phenomenon and example of how this effect can appear in measurements is shown. Ideally all sectors should be pre-cycled together for reproducibility.

Conclusions:

For Q, from last year data a tune decay of approximately 0.04 units is visible during injection. The decay has been modeled and an **average correction is suggested** for implementation in FiDeL to avoid manual trims by OP.

For Q', from analysis of last year runs seems the decay of b_3 is slower but of the predicted (from SM18 measurements) amplitude during injection. An average correction based on the analysis is proposed. **A modeling of the initial part of the decay as soon as possible after setting the machine to injection current will help understanding what is happening. Important: inject the beams as fast as possible to catch the first part of decay with Q' measurements on the beam**.

Comments:
On the pre-cycling of all sectors: Ezio made clear that for reproducibility if one magnet fails then all of the same kind should be pre-cycled. This is important if one wants to make good use of the forward corrections. Mirko mentioned that in this way one increases the risk on the circuits. Ezio mentioned there is a document on the pre-cycle strategy to follow when a failure occurs. **Action for Ezio:** provide OP an EXCEL FILE with a list of circuits to pre-cycle when a failure occur.

Jorg asked about the decay at 3.5 TeV we need to know to apply forward compensation. Ezio said that seems consistent with expectation from energy scaling around a tenth of the injection decay (4 units).

5. Update from the LHC start-up –J. Wenninger

Jorg mentioned that ramp and squeeze with pilot bunch were successfully commissioned during these last days of LHC commissioning. The squeeze procedure worked well down to 1.5 meters β*. They will inject nominal bunch after the cryo stop and then commission the bumps, make aperture measurements globally and locally then move to the collimator settings.

Jorg showed the beam availabilities (slides) from the injectors as agreed in an external meeting between the LBOC and the injectors representatives. The only new respect to the planning is that the 25 ns beam will be available already by next week because needed for PS and SPS scrubbing runs. A summary table of the LHC required beams with deadlines for PSB, PS and SPS is also available.

Comments:
R. Assman said why not commissioning squeeze and ramp with nominal bunch? Jorg said they lost 90% of the beam on the ramp they will move to nominal as soon as they will get through it in better conditions since the feedbacks have to still been tuned.

6. Early 2011 needs from the expts –M. Ferro Luzzi (slides)

Massi presented the early 2011 run requests from the experiments (agreed at the LPC) concerning the operational strategies to follow questions from the experiments to define their strategies.

- **Lumi production**:

Concerning the squeeze strategies: two options were suggested by Stefano at the last LBOC meeting (minutes), a 3 m option (option A) and a 6-3 m option (option B) squeeze independent for IP8. The LPC agrees to the proposed option of squeeze in IP1&5 and IP8 down to 1.5 m and 3 m in one go (first option). No time should be spent on extra β* options for IP8, for the moment it is assumed that the separation leveling technique will be successful. Depending on the results of leveling two possible scenarios could arise:

  - Leveling does not work:
    for option A : need to commission a full beam process with time cost 20h + 16h/value
    for option B: squeeze functions already validated just have to stop earlier. Time cost for TCTs setting needed for new β* 16 h/value + 8 h of initial invested time
  - Leveling works:
    for option A: already there ZERO time
    for option B: 12 h of beam time by the end of 2011 + 8 h of initial invested time

Concerning table of beam parameters: Massi highlighted the important parameters at top energy and on which they want some flexibility.

The experiments assume nominal intensities (1.15×10^{11} p/bch) and low transverse emittance (2.5 μm) as initial values to go for a full 900 bunches beam. Later it is expected to push N/ε_N to larger values.

β* at IP2 defined at 10 m but should be smaller for Ions. The crossing angle in IP2 requires 2 settings for the TCTs even if β* at 10 m. The crossing angle at IP8 assumes small emittances, and the LHCb magnet can stay on at full field all the time.

Operation IP8 with V separation of 0-2 σ they want to have reference orbit excursions of 1 σ in V-plane.

Operation IP2 with H separation 3-5 σ they want to be able to have 4 σ excursions of reference orbit in H-plane.

Concerning Scans during luminosity production:

Mini/scans optimization at start of fill: the experiments propose to optimize first H plane of IPs 1-5-8 then optimize IPs 1-2-5 in V plane and start leveling in IP8 V-plane, followed by leveling in IP2 H-plane.

Leveling procedure: first it will be done manually for target L_{avg} required by LHCb and Alice. Later an automated procedure will be implemented based on the measured luminosity, maintaining the level constants within 5-10%. The rate of adjustments is less than 2 times per hour (for a 10h luminosity lifetime a reduction of 10% is expected over 1 hour time this means 1 adjustment per hour required).

Roman Pots: it is important that Roman Pots are set up for lumi production before the start of intensity ramp-up. They can have physics with few probe bunches placed in front of trains of nominal ones but this is possible only not for 900 bunches, as there is no space left in the filling scheme. Totem has a special request for small angles physics.
Questions from TOTEM/ALFA:
Action for Stefano: controls should be validated
Action for Ralph, Coll. Team and MPP: a detailed time plan of the beam-based alignment of the 24 Totem and 8 Alfa Pots should be provided as well as the nominal allowed RP positions in lumi production fills, including the reasons for the decision. For this year the experiments are assuming that 12 σ at the RP is feasible. Ralph said that this value is defined by the settings at the tertiary collimators at the TCTs. Last year Roman Pots were at 15 σ. A 12 σ setting is possible this year if we can still profit of a 3 σ gain that was there last year but everything depends on orbit stability etc. It has to be checked. Jorg said that to his knowledge they have never been settled below 18 σ last year. This should be checked and info provided to the RP teams.
Action for rMPP and Coll. Team: Totem requested a couple of hours with RPs at 5 σ from the beam. They can profit of a huge gain in acceptance for small scattering angles. Massi wants to know the intensity limits and in which conditions we can allow this. Ralph mentioned that to reduce to 5 σ at the RP we need to change back and forth the thresholds of the collimators. Last year they did it once to allow small angle physics. Jorg said this year to allow this regularly we will need settings and we will have to re-set the all interlock system. Rudiger suggested to find a solution as a special mode to make things transparent. The solution is not easy and a procedure should be defined by MPP.

Polarity change in IP2 and 8: LHCb and Alice will start with positive and negative (both solenoid and dipole) polarities, respectively. The external angle definition used by experiment is the one defined by Jorg at LPC 21-02-2011 presentation. Both LHCb and Alice wish to flip polarity every month. IR2 requires for this 2 different settings for the TCTs. Massi stressed the importance of the polarity flip for LHCb.
Action for collimation team: experiments want to know if by testing and defining the settings for one polarity one can extrapolate/predict settings for the opposite one based on the knowledge of collimation system and losses. Ralph answered no. The settings for both polarities have to be validated.

- **Physics run at 1.38 TeV energy per beam**

Massi highlighted the decisions taken at Chamonix 2011. ALICE requested Physics run at 1.38 TeV to record 50 M events to tape. This requires 35 hours of stable beams, and the expected setup time is 3 shifts. In the meantime also other experiments show interest. CMS wants as much luminosity as possible, Atlas would like to use a probe bunch and LHCb wants to flip polarity of the spectrometer if there is no extra time cost. A question from the experiment: Which is the maximum allowed intensity with zero extra time for set up. All experiments are also interested in Van der Merr scans in physics fills. Ezio commented to keep in mind a larger decay at 1.38 TeV.

- **Lumi calibration measurements**

For the limi calibration measurements the experiments will go for VdM scans at E-1.38 TeV and at 3.5 TeV. In lumi production this will be done with 50 to 100 nominal bunches during Mach-April. During the second half of the year VdM scansshould be done in special fills to get the best possible accuracy (2 %) with 20 isolated bunches. They require length scale calibration with range 4 σ and the VdM scan with range of 6 σ in both planes, with the possibility of a 3 σ displacement of both beams. In case of reference orbit displaced due to separation offset, they request to allow individual displacement of beams by 2-4 σ. Concerning the lumi scan at 1.38 TeV application they need an urgent modification of the length scale calibration scan protocol that Massi showed in detail with input parameters and procedure to be followed. Other non urgent requests have been presented.

Action for Collimation team and MPP Specify the allowed range for the scan in the case of fixed TCTs and in the case of co-moving TCTs. When will the co-moving TCTs be operational?

Action for Simon, Reyes and Fabio Modify the length scale calibration protocol for the 1.38 TeV scans. Reyes commented that a new protocol has been defined and documented; the doc is circulating for comments.

- **Filling Schemes**

Massi presented the filling schemes as requested by the experiments for the 75 ns bunch spacing up to around 900 bunches.

- **Scrubbing RUN**

Massi asked what should be the state of the spectrometer magnets during the scrubbing run. The experiments would like to have them on to acquire data. Gianluigi said it is not possible, we will require them to switch them off to make scrubbing more effective.