LHC Beam Operation Committee

Notes from the meeting held on 6th March 2012

List of Participants

1. LHCb Vertical Crossing Angle (Reyes Alemany Fernandez)

R. Alemany summarized the reasons for switching the external crossing angle in IP8 to the vertical plane. She presented three possible methods of implementation:

- Method 1: reduce vertical separation -> separate beams horizontally -> build up vertical crossing angle and remove horizontal crossing angle.
- Method 2: reduce vertical separation -> build up vertical crossing angle -> separate beam horizontally -> remove horizontal crossing angle.
- Method 3: build up vertical crossing angle -> remove horizontal crossing angle -> separate horizontally and vertically.

R. Alemany showed that for all three methods the **same TCT settings for both LHCb spectrometer polarities can be used (orbit difference <1σ)**. Nevertheless, the TCTs will have to follow the orbit changes during the switch of the crossing plane. For all methods, the beam separation at the first 50ns parasitic encounter is always >10σ. Method 2 assures also for the first 25ns parasitic encounter >8σ separation (compared to only ≈3σ for method 1).

The time estimate for switching the crossing plane is 3-4 minutes. The switching could be done after the squeeze of IP8 to 3m and in parallel to the last squeeze step of IP1 and IP5.

R. Alemany pointed out that if there is sufficient aperture margin, the best solution would be to start from injection with vertical crossing in IP8. Otherwise method 2 is proposed.

Discussion:

S. Redaelli pointed out that 1σ orbit difference at the TCTs between both LHCb spectrometer polarities is not negligible and that the TCT margins should be confirmed with beam. J. Wenninger stressed that different TCT settings for both LHCb spectrometer polarities would result in an unacceptable overhead.

Amendment: The computed orbit difference at the TCTs between the two LHCb spectrometer polarities for a leveling position of the beams corresponding to x=42 µm, y=100 µm, ext. horizontal crossing angle = 0 and vertical crossing angle = 100 µrad (method 2) is **0.26σ.**

J. Wenninger asked if the nominal emittance is assumed for the calculations. R. Alemany answered that for all calculations 3.5µm·rad emittance is assumed.

J. Wenninger reminded that the option to have a vertical crossing angle at injection would affect the injection protection collimators. Thus, **the aperture should be measured** very early and a decision on this option should be taken **before set-up of the injection protection collimators.**

G. Arduini asked if the current circuit limitations are taken into account for the calculation of the settings. J. Wenninger answered that this was not done yet, but it is assumed that there is no limitation for the proposed methods.

M. Lamont and J. Wenninger suggested to switch the crossing plane in IP8 after the squeeze in IP1 and IP5 is finished in order to decouple the beam processes.

The LBOC proposes to do an early aperture measurement (IP8, 450GeV). If possible, a vertical crossing angle should be used in IP8 throughout the full cycle. Otherwise, the crossing angle plane should be switched after the squeeze in all IPs is finished by using method 2.

2. Ramping Faster (Mike Lamont)

M. Lamont explained that the energy ramp functions consist of a **parabolic** ramp start (to ensure voltage continuity) followed by an **exponential** segment (to minimize magnetic field errors), a **linear** segment (determined by maximum ramp rate of main dipole circuits) and a **parabolic** round off at the end (to ensure voltage continuity). He pointed out that the magnetic field errors that motivate the exponential segment turned out to be negligible.

M. Lamont elaborated on the parameterization of the ramp functions and explained that it has three free parameters.

M. Lamont showed that with design parameters the ramp duration would be 1095s (4 TeV). **With the parameters used in 2011, the ramp duration would be 760s** (no chromaticity decay plateau at flat top). He presented two scenarios based on **more aggressive parameters, by which the ramp duration could be reduced down to 632s**.

M. Lamont elaborated on the snapback and its compensation. He pointed out that the snapback is not completely compensated by the spool pieces but that the chromaticity correction sextupoles are used as well. A faster ramp rates gives larger decay and snapback, but the way in which the linear part is reached (i.e. length of the parabolic part) has no influence. The parabolic part was kept very slow to have a small ramp rate during the snapback, easing the control and correction.

M. Lamont concluded that by a more aggressive parabolic start of the energy ramp, its duration could be reduced by a couple of minutes. Limiting aspects might be the b3 correction, the accuracy of the chromaticity measurements, the bandwidth of the tune feedback and the RF system.

3. b3 Decay at 4 TeV Measured at SM18 (Nicholas Aquilina)

N. Aquilina elaborated on the double exponential decay model of the b3 and pointed out that it has three parameters of which one is fixed.

N. Aquilina explained that measurements with PELP (Parabolic-Exponential-Linear-Parabolic) ramps were done in SM18 up to 3.5 TeV, 4 TeV, 6.5 TeV and 7 TeV. Moreover, a special measurement for a ramp up to 4 TeV with a faster parabolic and exponential segment (fast PELP presented by M. Lamont) was done. Additionally, a series measurement (different cycle) was done to determine the representativeness of the test magnets.

N. Aquilina concluded from the series measurement the test magnets are indeed representative LHC magnets. He showed that **the measured decay amplitude for 4 TeV is 20% larger than for 3.5 TeV (14% expected).**

Discussion

E. Todesco clarified that for the fast PELP measurements an actual pre-cycle was used, which does in fact not include a fast PELP. Thus, the measurements are the same as the slow PELP measurements.

E. Todesco pointed out that **the measured change in decay amplitude should be included in the b3 compensation model.** The measured 20% increase corresponds to about 3 units of chromaticity.

R. Steinhagen pointed out that the snapback is limited to the first 20s, but that the ramp rate is still very low then. He suggested a more aggressive parabolic and exponential ramp after 20s. E. Todesco underlined that this seems feasible and stated that the slow PELP was originally proposed for an expected decay amplitude of 2 units (for 7 TeV). Since in current operation only ≈0.4 units are observed, a faster PELP would be possible.

J. Wenninger pointed out that changing the ramp functions has (apart from the need of new tune and chromaticity corrections) very little overhead.

The LBOC proposes to start with the ramp as in 2011 as the expected gain is marginal. Measurements with a bare ramp should be repeated and correction of the snap-back with the sextupole spool pieces improved.

4. Tune Behaviour During Injection and Ramp (Nicholas Aquilina)

N. Aquilina explained the double exponential decay model of the tune. He presented an analysis of the bare tune behavior based on tune measurements from 2011 operation. He showed that during injection, there is **no obvious dependence of the tune decay amplitude on the powering history**. On average, **the bare tune at injection is off by +0.035/-0.07 (H/V) units** w.r.t. nominal values. **The tune decay is about 0.01 units within the first hour after injection** with same values in both horizontal and vertical plane, suggesting that it is due to the main quadrupoles. This corresponds to 1-2 units decay in the MQ transfer function, in agreement with measurements.

N. Aquilina showed that at the beginning of the ramp **a snapback-like effect on the tune** with an amplitude of about 0.01 units is observable. **Throughout the ramp the horizontal bare tune decreases and the vertical bare tune increases by about 0.06/0.05 (H/V) units.**

Discussion

J. Wenninger asked if the bare tune change during the ramp could be due to a b1 error. E. Todesco replied that this cannot be the case because the horizontal and vertical tune changes have opposite signs. He pointed out that this effect should not be due to an error of the main quadrupole model.

F. Schmidt pointed out that in the PTC model with all imperfections a similar tune change during the ramp is observable. The modeled tune change has about half the amplitude of the observed bare tune change.

5. MPS Commissioning for 2012 run (Markus Zerlauth)

Markus Zerlauth gave an overview over the status and the planning of the machine protection tests for 2012:

The **magnet interlock** tests are mainly completed. Almost all LHC **FMCMs** are already tested without beam. For the FMCMs at RD1 and RD34 **end of fill tests** during beam commissioning and the intensity ramp-up are planned with fully squeezed beams at 0.6m.

The new hardware **SMP-GMT** cross-checker remains disabled for the beginning of 2012 (but already connected to the BIS) and will be made active after some initial commissioning during TS1.

The tests related to the **collimation** system are mostly standard commissioning tests. The tests are well advanced apart from IP2 and IP8 due to the ongoing MKI/VAC activities.

BLM system checks are mainly related to a firmware change and new acquisition modes. Large scale high voltage modulation tests are ongoing. Several tests with probe beams at injection are envisaged to assure the capability of each BLM crate to dump the beam (**2-3 hours**).

LBDS and **injection protection** tests without beam but with closed beam permit loops are foreseen. The testing of the new TSU firmware requires **several hours of 'circulate and dump'**.

Most **SIS** tests are done parasitically. About **2-4 hours beam time** are needed for the usual cross-checks.

Discussion

R. Alemany asked what the SMP-GMT cross-checker is. M. Zerlauth explained that it is a hardware cross-check that verifies the consistency between the safe machine parameters and the values broadcasted by the timing system. A similar consistency check is done by the software interlock system as well.

B. Dehning asked what the SIS limit on the RB circuits is. J. Wenninger replied that the SIS does a full energy consistency check of all main bend circuits.

Upcoming meetings:

Tuesday, 13st March 2012 15:30 in 874-1-011: LBOC

Reported by Tobias Baer