LHC Studies Working Group
Notes from the meeting held on 3rd April 2012

The meeting was dedicated to the detailed presentations of the studies scheduled for MD#1 (20-22 April). The slides can be found at the following link: https://indico.cern.ch/conferenceDisplay.py?confId=184509

R. Assmann presented the draft schedule, summarized in the following (stressing that it might have to be adjusted according to commissioning progress and issues arising):

- Friday:
  - 06:00 – 07:00: end of fill study (tune scan, levelling, …);
  - 09:00 – 12:00: 450 GeV: Longitudinal impedance;
  - 12:00 – 18:00: 450 GeV → 4 TeV: ADT (incl. fast blow up test);
  - 20:00 – 02:00: 450 GeV: BI (FBCT and BPM's);
- Saturday:
  - 04:00 – 12:00: 450 GeV → 4 TeV: Collimation;
  - 14:00 – 22:00: 450 GeV: Injection: loss limitations towards nominal intensity;
  - 00:00 – 08:00: 450 GeV → 4 TeV: Aperture at the triplets;
- Sunday:
  - 10:00 – 18:00: 450 GeV: RF batch by batch blow up;
  - 18:00 – 23:00: 450 GeV → 4 TeV: BI (emittance cross calibration);
  - 01:00 – 06:00: 450 GeV → 4 TeV: ADT (tune compatibility).

G. Arduini asked about the scheduling of studies on emittance blow up. R. Assmann replied that data will be taken during the BI and ADT studies, and that it had to be taken into account that the emittance measurement experts would be away for most of the MD period. E. Metral confirmed that impedance studies would be carried out in parallel to the collimator MD. R. Assmann added that a parallel movement of many collimators could for example be performed. F. Zimmermann suggested that data for longitudinal impedance (phase shift) be gathered in parallel. E. Metral commented that the subject had already been discussed with E. Shaposhnikova.
Presentations by the MD teams followed, detailing each study.

1. Injection: beam losses towards nominal intensity (C. Bracco)

This study concentrates on injection losses when injecting up to nominal intensity, aiming at verifying whether enough shielding and mitigation measures are in place. In particular, losses from the longitudinal plane and on the transfer lines (with new Little Ionization Chambers, LICs, installed) will be investigated. The required beam is 25 ns spaced, 1.05e11 ppb, 2.5-3 μm emittance, with heavy SPS scraping (>10%). At the LHC, RF and ADT should be setup for 25 ns spaced beams, the chromaticity probably needs to be set high (Q'~15 units) to be able to store the beam. The MD plan includes steering with 12 bunch trains (including, if required, opening the TCDIs to +/- 5 σ) and then increasing the number of bunches up to 288 bunch trains. Additionally, the latest version of the TCDI setting-up software tool is to be verified. E. Shaposhnikova pointed out that at LHC injection energy the beam is longitudinally stable, and losses should be studied rather as lifetime problems or capture losses. E. Shaposhnikova also suggested studying the case of low voltage at SPS extraction and the sensitivity of the LHC to longer bunches at injection (useful in the framework of SPS Q20 optics). J. Wenninger pointed out that electron cloud is likely to be the most limiting factor for storing 288 bunch trains. M. Lamont recalled that the LHC scrubbing run is so far postponed to

after Easter, but might also be postponed to a later period in the year: the decision is to be taken at a later stage. W. Hofle pointed out that it should be made sure that the intensity per bunch is not at the limit of two different ADT operating ranges. R. Assmann suggested the ADT to be setup for up to 1.4e11 ppb.

2. Batch-by-batch blow up (P. Baudrenghien)

The new longitudinal blow up allows batch-per-batch blow up at injection and keeps the bunch shape more Gaussian during the ramp (this should reduce heating). Recent observations indicate a stability issue in the last part of the ramp (e.g. quadrupolar oscillations). Thus, the allocated MD time (8 hours at injection) aims at implementing the new batch-by-batch blow up, measuring the bunch profile produced by the blow up and measuring the effect of the main phase loop with blow up. It is likely that the RF injection sequencer will be deployed only at a later stage.

3. Longitudinal impedance (E. Shaposhnikova)

The knowledge of the LHC impedance is important for both beam stability and heating of different elements in the ring (e.g. the heat load from electron cloud can be found from the synchronous phase error, so far taking into account the effect of beam loading, but not yet of the resistive impedance). The model of the LHC resistive impedance has not yet been confirmed with beam. The effective impedance of a few devices can be estimated from the synchronous phase shift of single bunches with varied intensity and length. In very preliminary experimental studies during 2011, a significant deviation was observed from the prediction based on existing impedance models, but only small ranges in bunch length and intensity were covered, and more data is needed. The MD is performed at injection energy with 8 bunches per ring injected with variable longitudinal emittance and intensity (through SPS controlled emittance blow up and scraping), and measurements of the phase shift are taken. E. Metral asked about combining transverse and longitudinal impedance measurements in the collimation and/or RF MDs, E. Shaposhnikova agreed that both impedance teams should participate in both MDs. F. Zimmermann asked whether the beam characteristics are different in the two MDs, E. Shaposhnikova replied positively, highlighting the added value of having different bunch lengths during the RF MD. R. Assmann recalled that at the flat top the movement of the collimators is more effective in studying impedance effects as the jaws can be closed more (in mm) as the beam size is smaller. E. Metral recalled the 2011 measurements on the loss of Landau damping, wondering how they compare to the predictions. E. Shaposhnikova replied that in 2011 the phase loop was on (even though with different settings during the studies), while for the comparison with the theory the best configuration is a ramp with the phase loop open. A study of the phase shift with variable emittance and intensity during the energy ramp is desirable but not enough time is allocated during MD#1.

4. Fast beam losses with ADT (A. Priebe)

The aim of this MD is to verify if and how UFO-like losses (in the ms timescale) can be generated by the transverse damper in view of a possible quench test at the end of the run. A 2-hour study can be performed at injection, or a full program including a ramp is

possible if 6 hours are available. The influence of different phase advances on the losses is studied, and an asymmetric placement of collimator jaws is desirable to get one-sided losses (which is more similar to beam losses leading to quenches). In the longer term, the possibility of creating steady state losses should also be looked into (1 minute timescale). M. Sapinski pointed out that at 4 TeV care should be taken to have losses on one beam only and avoid dumping both beams at the same time. D. Wollmann and J. Wenninger pointed out that a probe bunch might not be sufficient to create steady state losses. M. Sapinski recalled that losses with a duration of tens of seconds were already achieved by means of the ADT, A. Priebe added that a feedback on the BLM system could be used to keep the losses constant. It was decided that 2 hours would be sufficient for this first test. More time might be allocated in the future based on requests and results. M. Sapinski added that more time would be requested in a later MD session to allow studies at 4 TeV. R. Assmann, F. Zimmermann and J. Wenninger suggested an MPP document to be written for this MD, both for injection and flat top energy (also in preparation for other possible sessions, it is not guaranteed that the losses would be at the collimators for all possible phase advances).

5. ADT studies (W. Hofle)

Two slots are reserved during MD#1 for ADT studies (6 hours + 5 hours, of which 2 hours are shared for the UFO-type loss studies). The Friday slot is divided in two parts: initially, the effect of "injection" and "prepare ramp" ADT gains on emittance evolution is observed (damping times are also checked with the Q-kicker; machine in nominal state apart from the ADT). The second part of the Friday slot is dedicated to testing the bunch-by-bunch modulation of the damper gain (new feature, added for 2012 by D. Valuch): different bunches are set with different gains (one bunch with zero gain), damping times are verified and emittance evolution checked at injection and during the ramp. During the Sunday night slot, the gain modulation is used and the effect on the BBQ signals is studied in collaboration with the BI experts. Two ramps are scheduled to quantify the difference on the BBQ signal of the different leading bunch intensities: one bunch out of 8 has no damping in both ramps and 20% more intensity in one of the ramps. This goes in the direction of investigating the possibility of getting the tune signal from the 12 leading bunches, or the need for a gated BBQ. Offline analysis of the MD data will provide information on the feasibility of a tune measurement from the ADT pickup data. F. Zimmermann asked why the extra intensity is needed on the bunch that is not damped. R. Steinhagen answered that in this way the bunch dominates the BBQ signal; a proper BBQ gating is being prototyped at the moment and could be available only after LS1 if found necessary and resources are allocated. R. Steinhagen also recalled that the chromaticity is at times negative during the ramp, so the ADT is necessary (with some gain) to damp the m=0 headtail mode.

6. Beam instrumentation developments (F. Roncarolo)

Two slots are allocated to BI developments during MD#1. On Friday, some BPMs are checked for non-linearities (with H/V grids and bumps); k-modulation of triplet BPMs, BPMSW phasing and checks of sequencer are performed. J. Wenninger clarified that the phasing is to be performed during commissioning only for the BPMWF. BCT and

fBCT are compared during a scraping exercise (e.g. for dI/dt). During the Sunday slot, the commissioning of the matching monitor is continued (injection offset scan to verify filamentation, verification that the blow up from the screens is negligible, check of the detector response with intensity). Next, for the BSRT and BGI the plan is to take data with closed orbit bumps. For the BSRT, the measurements are compared to the WS for different emittances (ADT blow up required). For the BGI, data is to be collected with inverted polarity (collection of ions instead of electrons, access required before the MD for the inversion). Note that many of the items are scheduled during commissioning and might have already been performed at the time of the MD. W. Hofle asked for a clarification on a past elogbook comment concerning the ADT blow up; he also suggested to increase the octupole current to have more tune spread for a more efficient blow up. F. Roncarolo explained that it seemed that losses were faster than the emittance blow up, and this was possibly due to a non-optimum setting of the ADT system; ideally the presence of the experts could help tweaking the settings to generate a range of beam sizes for calibration with the wire scanners. R. Assmann stressed the importance of the emittance cross-calibration, and advised this to be performed first, before the matching monitor commissioning.

7. Collimation studies (G. Valentino)

The software tool for the automatic collimator alignment based on a BLM feedback allowed an improvement in the setup time at the flat top (from 28 hours in 2010 and 18 in 2011, to 7.5 in 2012). Still, the pattern recognition of loss spikes can be further improved at the flat top. Additionally, beam instabilities were observed during the 2012 commissioning when many collimators were close to the beam during the alignment campaign. The MD comprises one part at injection energy, mainly to perform collimator alignment with an improved loss spike recognition algorithm. The second part is at flat top energy and includes further checks on the alignment of the TCPs in pt 3, a test of the improved loss spike recognition algorithm (particularly in H) and a study of tune shift and possible instabilities with tight collimator settings (with different octupole currents, ADT and QFB on and off).

Nobody from the **aperture MD** team could present the plans for the MD, so R. Assmann summarized the study. Some of the findings during commissioning were found to be puzzling, so MD time is allocated for further data collection. In particular, the aperture bottleneck for B2H at β^*=0.6 m was found in Q3.R1 instead of the expected IR5. Moreover the systematic errors of the measurement should be addressed: so far only one side of the aperture was measured, while the full diameter and the offset of the aperture should be verified.

The date of the next meeting is yet to be defined, invitations and agenda will be sent in due time.

Giulia Papotti

List of participants

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