LHC Studies Working Group

Notes from the meeting held on 29 May 2012

The meeting was dedicated to the preparation of MD#2 (19-24 June 2012). The slides can be found at: https://indico.cern.ch/conferenceDisplay.py?confId=192559
High beta* and MKI UFO MDs were not presented due to the unavailability of team members.

1. Large Piwinski Angle (F. Zimmermann)

The Piwinski angle is defined as the product between the half crossing angle (e.g. H plane), the longitudinal beam size and the inverse of the transverse beam size (e.g. H plane). The higher the Piwinski angle is, the smaller the luminosity. The MD is performed by colliding long, high brightness bunches at injection energy (with collision tunes) and changing the IP8 spectrometer strength in steps. Losses, luminosity at LHC, ATLAS and CMS, and intensity lifetimes are monitored during the variation of the Piwinski angle. Simulations by K. Ohmi are available for comparison, which predict a large effect of a nonz-zero Piwinski angle on the luminosity lifetime. The tertiary collimators in IP8 might need to be adjusted or kept at intermediate settings (setup beam flag needs to be true). J. Jowett asked why the test is not performed in IP2. F. Zimmermann answered that IP8 provides the largest crossing angle (purely in H). E. Shapochnikova suggested also the concurrent observation of reference bunches. F. Zimmermann pointed out the 5e11 p/ring total intensity limitation which had to be respected in order to be able to profit from the setup beam flag. E. Shapochnikova also suggested the use of longitudinal blow up at the LHC flat bottom to get as long bunches as possible.

2. Longitudinal dynamics study (E. Chapochnikova)

The purpose of this MD is to measure the LHC impedance (the longitudinal resistive part from the stable phase shift, the longitudinal reactive part from the peak detected Schottky, the transverse reactive part from the betatron tune shift); the loss of Landau damping as a function of bunch length and intensity; and the transverse emittance evolution as a function of intensity and bunch length. Two fills are planned at 450 GeV with the phase loop open, one with bunches with constant longitudinal emittance and variable intensities, and one with bunches with constant intensity and variable longitudinal emittances. One ramp is also planned, with bunches of constant intensity and transverse emittance and variable longitudinal emittance, with the phase loop open (only during the ramp). T. Mastoridis pointed out that an effect from the 50 Hz frequency lines could be seen on some ramps during commissioning. So he suggested opening the phase loop after the 50 Hz crossing. E. Shapochnikova answered that this will be taken into account as the 50 Hz lines can even drill holes into the particle distribution. J. Jowett suggested paying attention to IBS effects (growing bunch length and possible losses). V. Kain replied that no particular losses had been observed in previous blow-up studies.

3. Long-range with high intensity (T. Pieloni)

The MD aims at studying the long-range limits with 50 ns trains with the highest possible intensity per bunch (e.g. 1.7e11 ppb) and determining the minimum required separation by reducing the crossing angle in steps (TCTs to be moved accordingly). The octupole strength can be reduced at the end of the MD to the values found in the octupole instability threshold MD (if carried out beforehand). Intensity lifetime, losses and emittances are observed and these data will be used to define the limits. The beam-beam team also supports the EoF tune scan (suggested to move along the tune diagonal and stay a few minutes per step, a clean tune measurement before the dump is needed) and the leveling by beta* (as an alternative to levelling by separation which results in a reduction of Landau damping for separations of ~1.5-2 σ). J. Wenninger pointed out that it might be challenging to get to 1.7e11 ppb. N. Mounet asked to clarify which collimators are moved during the reduction of crossing angle. It was confirmed that these were only the tertiaries in IP1 and 5. F. Zimmermann asked how much time would be needed to include the octupole strength scan. T. Pieloni replied that the test would be quick, the value would be directly trimmed around the value found in the single-beam octupole MD.

4. Levelling with beta* (S. Redaelli)

During this MD the feasibility of levelling the luminosity with beta* is tested, i.e. whether it is feasible to squeeze the beams while in collisions (from beta* 3 m to 0.6 m, in steps). Only IP1 and 5 are involved in the test (the beams will remain separated in IP2 and 8). Collisions will be established or readjusted at every step and the luminosity change will be verified against the expectations. The TCTs in IP1 and 5 will be manually moved, while other collimators will stay at standard end-of-ramp settings. Crossing angle settings will remain unchanged. After successful completion of this MD, the natural continuation involves repeating the exercise with bunch trains to observe long-range effects. G. Papotti recalled that due to the use of 2/3 nominal bunches, there should be no requirements from Machine Protection. J. Wenninger added that a MP document is required for the second part of the MD dedicated to beam-beam studies, but it is unlikely that the MD will get that far in the first 8 hours. G. Papotti asked whether the MD could be shortened by e.g. 2 hours. J. Wenninger replied that in 8 hours a second ramp could be performed to verify the cycle reproducibility.

5. Octupole instability threshold (N. Mounet)

A number of recent unprogrammed dumps due to beam instability might be due to the loss of Landau damping of headtail modes. This is inconsistent with the current impedance model as the operational value for the octupole current should be abundantly sufficient to guarantee beam stability. An additional issue is that the power converters would not be able to reach the equivalent current values required for damping at 7 TeV (by scaling the present operational values). This MD aims at testing the minimum octupole current needed for single beam stability (1380 bunches per ring at a time, squeezed, with ADT on, reducing the octupole current in steps until instabilities or losses develop). An additional 8 hours of MD time are requested to perform 4 fills, 1 per beam with 2 units of chromaticity, and 1 per beam with -5 units of chromaticity (negative chromaticity should automatically damp all headtail modes except for mode 0 for which the ADT is effective). E. Metral suggested asking at the LMC for the additional MD time and scheduling this MD before the beam-beam MD in order to apply possible findings. G. Papotti pointed out that a careful control of chromaticity to 2 units might require a dedicated ramp. She also suggested to inject 12 bunches in the other ring for aiding the orbit feedback. E. Shapochnikova and F. Zimmermann suggested a careful measurement of the chromaticity and of the total tune shift at the flat top. N. Mounet confirmed that at present neither the total tune shift nor the impedance had been measured at the flat top. R. Calaga recalled that measuring the tune shift with the tune kicker for 8 single bunches at injection during MD#1 proved difficult due to instrumentation issues. V. Kain added that all the 8 bunches could not be measured due to the memory buffer length, but suggested preparing the kicker settings in advance for MD#2. F. Zimmermann suggested using the 12 bunches to measure the tune shift with current by scraping. G. Papotti and F. Zimmermann asked whether delaying part of the study to the floating MD could be feasible. E. Metral replied that results from one beam would already be useful.

6. Aperture (R. Bruce)

It was recalled that triplet aperture measurements are necessary to verify the margins for operation at a given beta*. This MD targets the measurement of both sides of the aperture (by inversion of the crossing angle) and the explanation of the finding of the bottleneck in the wrong IP/plane during previous measurements. The measurement procedure was recalled: after blowing up the emittance with the transverse damper, the local TCT is opened in steps until the losses move from the collimator to the aperture (the collimator gap indicates the $N\sigma$). J. Jowett suggested measuring also IP2, but R. Bruce replied that not enough time is available. S. Redaelli stated that he preferred to measure the IP2 aperture during the squeeze commissioning foreseen for the start of the ion run. He added that the bottleneck found in 2011 could not be explained during the shutdown inspection. So he could hardly imagine for it to be improved. It was pointed out that the allocated MD slot was difficult for the MD team due to team members' unavailability. Given the late stage of the planning, a better slot for the MD team could not be found and the MD was postponed to a later stage.

7. Collimation (impedance, nominal settings) (B. Salvachua)

This MD combines different studies. The 7 TeV settings (in mm) are tested, implying the closure of the secondaries from 6.3 mm to 5.1 mm and of the tertiaries from 8.3 mm to 7.6 mm compared to the present 4 TeV settings. Then several collimators in IR7-IR3 are moved in and out for impedance measurements. Finally loss maps are performed. In parallel, losses acquired with standard BLMs and diamond detectors are compared for a bunch-by-bunch study of fast losses. G. Papotti recalled that the time necessary for a rampdown must be included before the ADT fast losses MD.

8. Fast losses with ADT (A. Priebe)

This MD is in preparation of the quench test foreseen for the end of the 2012 run and aims at qualifying the ADT as a tool for inducing fast beam losses (1 ms timescale). In particular, it is planned to check the impact of the phase advance between the ADT and the primary collimators on excitation and loss efficiency and the time structure of the losses. Probes are excited for both rings and planes to generate losses on the outside of the cold mass. An asymmetric positioning of the primary collimator jaws will be tested, to ensure the generation of losses on one side only of the aperture. The MD consists of two phases: first the critical loss location is found by applying a small gain and inverted feedback sign to the ADT (at this location the BLM monitor factor might be increased), secondly the excitation is applied at maximum gain and the post-mortem data is collected. At the end of the MD, care will be taken that the collimators are back at their original positions and that the BLM monitor factors are back to the original values. G. Papotti asked whether the test will be performed at both injection and flat top energy. A. Priebe replied that this question is being discussed with MPP.

9. Injection and SPS Q20 optics (G. Vanbavinckove)

During this MD slot the tool for automatic set up of the TCDI is tested. Next, the influence of the SPS supercycle on injection losses is studied with 12/36 bunches and removing the CNGS cycle in front of LHC1. Lastly, the injection into the LHC of beams using Q20 optics in SPS and transfer lines is tried (new reference trajectories and steering). For this part, the extraction of Q20 beams up to the downstream TED should be completed before the start of the MD block. The MD planning foresees 8 hours of studies while 6 hours are allocated: an extension of 2 hours of the MD is requested. J. Wenninger pointed out that for the Q20 transfer some of the interlocks in the transfer lines have to be masked. Care is taken at the end of the MD to revert all operational settings.

10. Cavity phase modulation (T. Mastoridis)

The LHC RF system is currently setup to minimize the transient beam loading effects, but this scheme would required excessive klystron forward power for 25 ns beams (200 kW forward power would be the minimum requirement, but the klystrons saturate at 200 kW with the present DC parameters, allowing no operational margins). For beam currents above nominal, transient beam loading has to be accepted and the one-turn feedback is also needed for loop and beam stability. The voltage set point is then to be adapted for each bunch (proposed by D. Boussard in 1991). The MD aims at testing the algorithm to adapt the voltage set point over a turn ("feedforward" algorithm). This algorithm takes into account filling pattern and beam current. About 600 bunches at injection are required for the test. J. Wenninger stated that the MD is of MP class B. G. Papotti suggested BGI observations to be done parasitically. M. Sapinski added that 1 mm orbit bumps in Pt 4 might additionally be needed.

11. Scraping, diffusion and repopulation (G. Valentino)

The time evolution of beam losses in a collimator scan can give information on e.g. halo diffusion and population. During this MD, the measurements profit from the new 12.5 Hz BLM data for greater resolution and from a diffusion model developed by G.

Stancari for Tevatron data (the diffusion coefficient is used to predict the spike height). This study can also provide information on the BLM-to-intensity calibration factors. For this study, collimators other than the TCP in IR7 are to be retracted beyond the physical aperture (at 15 σ) to reduce the interference. The MD plans to insert the TCP in steps, and to then bring it back to the initial position and measure the halo repopulation.

12. Beam Instrumentation and ramp for emittance calibration (F. Roncarolo)

The list of desired BI studies was presented, but priorities are still to be defined. The list includes: matching monitor commissioning, BSRT versus wire scanner calibration, BGI calibration, tests of new software for the BCT/fBCT, calibration of the wall current monitor, BPM non-linearity studies and calibration.
The ramp aims at achieving an absolute calibration of the Wire Scanners, a WS-BSRT cross-calibration and at minimizing the uncertainty on the IR4 betas for emittance determination. Two nominal bunches with different emittances are ramped with coarse collimator settings. Closed orbit bumps are applied both at the flat bottom and at the flat top. If time allows the beams are brought into collisions and the emittances compared to the values expected from luminosity.

13. Dynamic aperture (F. Schmidt)

Dynamic aperture has never been determined experimentally to better than a factor 2. At the LHC it might be possible to get a better measurement thanks to the good knowledge of harmonics and misalignments, to the apparent little noise and to an aperture kicker strong enough for a direct measurement. Two MD teams work in parallel on the two rings. One team is to estimate the DA via the intensity evolution (based on an inverse logarithmic scaling law derived from tracking data). This is done by creating a Gaussian distribution (with the ADT) and following the intensity evolution with time using the MCOs to make the machine nonlinear. The other team looks also at detuning with amplitude and resonance driving terms. Systematic kicks are given with the aperture kicker (possibly also the AC-Dipole). Driving terms are studied (until 10 σ), and kicks are applied in steps beyond 10 σ until losses become relevant. Note that the collimators need to be opened to at least 12 σ. J. Jowett asked whether the non-linear chromaticity knobs had been previously tested. F. Schmidt replied positively.

Date for the next meeting to be decided, invitations and agenda will be sent in due time.

Giulia Papotti

List of participants

ARDUINI	Gianluigi	BE-ABP-LIS
BRUCE	Roderik	BE-ABP-LCU
BUFFAT	Xavier	BE-ABP-ICE
BUROV	Alexey	BE-ABP-ICE
CALAGA	Rama	BE-RF-BR
DE MARIA	Riccardo	BE-ABP-LCU
DEHNING	Bernd	BE-BI-BL
ESTEBAN MULLER	Juan	BE-RF-BR
JOWETT	John	BE-ABP-LCU
KAIN	Verena	BE-OP-LHC
MASTORIDIS	Themistoklis	BE-RF-FB
METRAL	Elias	BE-ABP-ICE
MOUNET	Nicolas	BE-ABP-ICE
PAPOTTI	Giulia	BE-OP-LHC
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VALENTINO	Gianluca	BE-ABP-LCU
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Excused: M. Giovannozzi.