LHC Studies Working Group

Notes from the meeting held on 16th August 2011

The meeting was dedicated to the review of the preparation for the LHC MD#3, which will take place from August 24th to 29th. The slides can be found at the following link: https://indico.cern.ch/conferenceDisplay.py?confId=150363

R. Assmann could not be present at the meeting but notified the LSWG via email that "he will present the results of the first two MD blocks to the CMAC. Any input is welcome and should be sent before Thursday morning. Input should be restricted to major messages that people want to have presented. Powerpoint digestible info is preferred. He cannot present full summaries and must extract the major info. He will then try to distribute a draft by Friday midday for comments and feedback."

F. Zimmermann opened the meeting by showing the list of MD requests, indicating the time allocated for each request that has already been scheduled. He also presented the list of MD notes. The notes for the following MDs are still missing:
- Investigation on CODs (performed in MD#1);
- IR3 combined cleaning test at 3.5TeV (performed in MD#2);
- Improving LHC collimator set up at 3.5TeV (performed in MD#2);
- R2E MD (performed in MD#2);

The "Quench margin at injection" MD published the note shortly before the meeting. Additionally, F. Zimmermann presented two possible schedules for MD#3, the choice of which will depend on the amount of time dedicated to the 1m beta* commissioning. The use of floating MD time could be considered to both keep the scheduled MDs and include the squeeze commissioning. The final schedule will be circulated when available. M. Ferro-Luzzi pointed out that given the recent cryo stop and the 1 shift allocated for the 90m optics, it would preferable not to reduce further the physics time before the TS. He added that it is nevertheless crucial to verify any possible showstoppers for the 1m beta* before the TS so that the path is clear for the restart after the TS. M. Ferro-Luzzi stressed the importance of combining the fills scheduled for after the TS ramp-up with the 1m beta* ramp up, so as to minimize the time required. F. Zimmermann added that the possible Alice polarity change should be taken into account in the scheduling, M. Ferro-Luzzi agreed. B. Goddard pointed out that the start of the 25ns injection MD at 4 am is inconvenient; E. Shaposhnikova added that the 25ns beam should be set up during the day, so that all required experts are available. This was checked after the meeting with G. Rumolo, Injector MD Coordinator, who agreed that the beam can be set up in the injectors during daytime, when the LHC will be performing "aperture" and "1m beta* squeeze" MDs.
The presentation of "aperture measurements" could not be carried out due to the absence of the speaker, the slides can be consulted on the Indico webpage.

1. Beam-beam MDs (X. Buffat)

The head-on MD consists of colliding two very high intensity bunches per ring (>2e11ppb in <2um, RF and ADT should be set up accordingly) at high energy (nominal sequence), to verify the dependence of the losses and lifetime dips observed at injection on the physical beam size. Working point optimizations are performed and

possible coherent motions are observed. The ADT pickups and the experiments luminometers are needed during the MD. Given that the beams are used for high pile-up (μ) data taking for the experiments, the minimum brightness required was asked for, and also for how long "stable beams" should be declared. M. Ferro-Luzzi answered that now μ_{avg}~10, so with 1m beta* μ_{avg}~15, and at least μ>25 is required in the MD. Data taking for 1 hour is sufficient. M. Ferro-Luzzi also pointed out that the high pile-up data taking is less urgent than the 1m beta* setup, so the dedicated fill for data taking can be postponed to a later time in the p+ run. P. Baudrenghien suggested that the settings for RF LL and ADT for very high intensity beams should be stored in a beam process, so that operations could change them without the need for an expert intervention.
The long range MD repeats what had been carried out in MD#2 while using 2 36-b trains per ring so to have collisions in all IPs. The crossing angle is reduced in steps and the TCTs move accordingly: this caused the MD to be classified MP type C, and the EDMS document is under approval. The luminometers from the experiments and the ADT pickups are required for this MD.

2. Long bunch studies (E. Shaposhnikova)

E. Shaposhnikova reminded the audience that longer bunches are beneficial for beam stability, IBS growth times, heating and multipacting, but shorter bunches are preferable for capture and single beam lifetime. The choice of an optimum bunch length should be balanced among the different phenomena. The limit is set for a 4σ bunch length of about 1.75ns, where losses out of the bucket start to appear. The first part of the MD is spent at the flat bottom with observations of 50ns spaced beams with different injected longitudinal emittance (0.7eVs, and 0.5eVs operational). In the second part of the MD, 8 nominal bunches are ramped: the emittance blow up target is set to 1.0ns, additional blow up is performed on the flat top modulated at f_{rev}. This single bunch blow up needs to be tested before the MD at 450GeV and for this 2 hours at injection are requested (1h to fill, 1h to excite and observe). At the end of the coast the total voltage is reduced to 6MV (SIS interlock at 8.5MV to be masked). P. Baudrenghien pointed out that the abort gap monitor calibration factor should be changed, J.J. Gras suggested to address the request to A. Boccardi.

3. Beam Instrumentation MD (J. J. Gras)

During the BI MD many activities are carried out in parallel: deployment of new BPM firmware to improve the Signal-to-Noise Ratio (SNR); comparison of synchronous and asynchronous orbit acquisitions; investigation of crosstalk in striplines; quantification of fBCT system A improvements done during the last TS; measurement of fBCT response to bunch intensity; studies on the Schottky; response of abort gap monitor after RF off (data lost in MD#2 due to logging problem); test of algorithms for background subtraction for the wire scanners (to solve the noise problem on the b1 measurement); studies for the BSRT working point; comparison BSRT vs WS (b1 3.5TeV unlucky so far in MD#1 and #2); dependence of BGI SNR on intensity and gas pressure; calibration of direct dump BLMs in IP6. Additionally some time is planned for emittance blow up dependence on chromaticity. The MD time is divided in 7 periods: Inj&Dump for direct dump BLMs; scraping studies for BCT (WS, BSRT, BGI in the shadow); BPM studies with RF cogging; abort gap filling with RF off (SBF needed, RF interlock masked); studies with orbit bumps; 30 minutes to observe emittance blow up dependence on chromaticity; 1 ramp for WS-BSRT comparison (12 single bunches, 6 with emittance <2um and 6 with >3um).

4. Collimator setup for beta*=1m (R. Bruce)

The goal of the MD is to qualify the tight collimator settings which are needed to squeeze IP1 and 5 to beta*=1m (TCPs at 4 nominal σ to protect the TCTs, TCPs/TCSs/TCTs tighter to each other). The steps required to setup the collimators are presented. One nominal bunch per ring is ramped, while the collimators follow new ramp functions to end up at tight settings, the squeeze to 1m is performed (half crossing angle=100urad). The TCTs are realigned around the collision orbit. Finally loss maps are performed (betatron and off momentum; also an asynchronous dump if time allows). Before the MD an EoF study with tight collimator settings should verify whether the beam remains stable with the collimators closer in, proving the feasibility of beta* 1m for physics purposes. E. Metral commented that issues from impedance are not expected (while octupoles are in use), but the movement of the collimators to 4s as EoF might cause enough losses to cause a beam dump. It was pointed out that smaller emittance is worse from the point of view of impedance, so EoF is probably more likely to be stable than the start of fill. G. Papotti suggested to first try this as EoF; in case no problems are observed, one could try another test again at the beginning of the fill. M. Ferro-Luzzi pointed out that the use of MD time is not efficient for the second test, as in case the machine is not available the time is lost; he suggested scheduling this phase after the TS; R. Bruce agreed. Before the MD the optics should be commissioned and the beta-beating corrected; the collimator ramp functions and thresholds are being prepared. G. Papotti asked what the difference is to the collimator studies carried out in MD#1, R. Bruce answered that the proposed tight settings are the ones validated during that MD for primaries and secondaries. B. Dehning asked what the criteria for the failure of the EoF study is, R. Bruce answered big losses or beam stability issues. F. Zimmermann pointed out that it should be verified that there are no problems with the orbit feedback for the tight collimator settings.

5. 25ns beam injection setup (C. Bracco)

The injection of 25ns trains was set up during MD#2 only up to 24 bunches. In MD#3 trains of 72, 144 and possibly 288 bunches will be injected. Before the MD the beams should be set up in the SPS (1.1e11ppb, 3um) and extracted to the downstream TED. During the MD, time is allocated for the ADT setup, TL setup if required, observation of 24-b trains in the LHC for vacuum, losses, heat load and emittance blow up (to disentangle the effect of the ADT), injection of more bunches per batch. W. Hofle asked why they thought that the emittance blow up was due to the ADT, C. Bracco answered that the reasons for the blow up are being investigated, it will be verified whether the ADT can be ruled out as cause (at that time it was tset up for 50ns spaced beams). W. Hofle and D. Valuch explained that the settings for 25ns spacing grant damping also for 50ns spaced beams (with slightly less effective gain and longer damping time), while the inverse is not true. M. Ferro-Luzzi asked which emittances are available for the 25ns beams from the injectors, E. Metral answered 2-3um. M. Ferro-Luzzi asked whether 3um emittances are a problem for injection, C. Bracco answered that they are ok as long as the beams are well set up at the injectors (e.g. scraping). C. Bracco asked whether to speed up injection it would be possible to inject pilot and then directly 24 bunches, without stepping through the 12 at 50ns spacing, MPP to answer.

6. 25ns beam ecloud observations (E. Metral)

The goal of the MD is to study the effect of e-cloud with 25 ns beams (e.g. vacuum pressure rises, heat loads, coherent and incoherent effects, blow-up, losses, RF stable phase) together with the effectiveness of scrubbing. A first MD is scheduled in MD#3, another one is requested to proceed with the observation, with length to be determined after the first results. 25ns trains with >1.2e11ppb, small transverse emittance, ~1.5ns bunch length are requested. The first part of the MD plans injections with different filling schemes to constrain Secondary Electron Yield and Reflectivity (being prepared by O. Dominguez and F. Zimmermann). In the second part of the MD, several trains of 72 bunches with a bunch spacing of 925 ns in the LHC, up to ~ 1400 bunches, are injected. E. Shaposhnikova reminded that the RF total voltage has a very strong effect on e-cloud through the bunch length. G. Papotti reminded that the filling schemes should be created in the database before the start of the MD.

7. Large Piwinski Angle (F. Zimmermann)

The goal of this MD is to investigate the effect of a crossing angle on the head-on beam-beam limit for "Piwinski angles" approaching and exceeding a value of 1. The nominal LHC has a Piwinski angle of 0.64, which will further increase for emittances smaller than the design value. The HL-LHC considers Piwinski angles up to 2.5. A large Piwinski angle has historically been a problem in lepton colliders, e.g. at DORIS-I. Simulations by K. Ohmi for the LHC suggest a factor 10 reduction in beam-beam luminosity lifetime for the nominal Piwinski angle. Simulations have also been performed for various MD scenarios.This MD would inject two high-intensity low-emittance bunches per beam (e.g. 2.2e11, and 1.6 micron), with a total intensity staying below the safe beam limit of 5e11. One bunch of each beam would be made to collide in IPs1, 5 and 8, the other bunch only in IP8. The collisions are at injection energy with collision tunes. The crossing angle in IP8 would be reduced from 4 mrad to 0 by switching off the spectrometer with resulting change in the Piwinski angle at IP8 from about 1.5 to 0. The change in spectrometer strength may require an orbit correction. The beams are brought into collision at all three IPs. The collimators are left at their nominal injection settings in IR3, IR7 and IR6 and the symmetric "coarse" settings are used for the TCTs in IRs 1,5 and 8. The bunch length should be as large as possible, about 1.6 ns (4 sigma). Time permitting also a tune scan could be made. Luminosity information from LHCb (and also from CMS and ATLAS) would be desirable. FBCT readings, Schottky tune spectra, and BSRT emittances will be monitored in addition.
E. Shaposhnikova recalled that it is sufficient to use either long bunches from the SPS in a 6 MV capture voltage or to inject nominal bunch lengths in a lower capture

voltage, P. Baudrenghien suggested not to go below 3.5MV in order not to hit the hardware interlock.

8. p-p rephasing (Ph. Baudrenghien)

This MD is part of the feasibility checks for a p-Pb run. In such a run, $f_{RF,inj}$ is different to the two rings, but before physics the two f_{RF} are made identical and one ring will be rephased with respect to the other one. This procedure was tried in 2010, but resulted in significant losses and debunching, possibly due to the V_{TOT}=8MV, full buckets due to the long fill, or maybe due to too fast a frequency change. The MD is performed with 8 single pilot bunches (operational settings), ramped, and different steps of the rephasing at the flat top (with longitudinal and abort gap observations at every step). If time allows, a second fill is planned to try different rephasing speed and opposite rotating direction. M. Ferro-Luzzi asked which beam is to be moved for physics, P. Baudrenghien replied that normally b2 should be moved as the experiments prefer not to move b1 which is a reference.

9. MKI UFOs (C. Bracco)

The MD carries on with the studies that produce UFOs by pulsing the MKIs started in MD#2. This time both MKI2 and MKI8 are used, plus the tune kicker MKQ. The procedure for pulsing the single kickers is first verified with a fill of 12 pilots, then the MKQ is pulsed with 12 pilots in the machine. Then the machine is filled with 1236 bunches and the MKIs are pulsed (all 4, MKI-A or MKI-D only), then the MKQ is pulsed.

10. DS quench/loss test (A. Rossi)

A. Rossi reported for the collimator team. In particular the EDMS MPP document under approval is written by S. Redaelli and D. Wollmann and it establishes the procedure to be followed during the MD. The MD goal is to lose 500kW of beam 1 and beam 2 on the IP7 TCPs by crossing the 3rd integer tune resonance with about 32 nominal bunches per ring. A first ramp with fewer bunches is carried out to estimate the minimum number of bunches required to achieve the target losses. If time is available also the performance limitations with IR3 combined cleaning is measured. BLM threshold changes have to be applied to allow for the losses. For this reason the MD is classified of type C and the EDMS document approval is required before the MD can take place. Note that part of the procedure is also to ensure that the BLM system is restored to its operational settings after the end of the MD. G. Papotti and F. Zimmermann asked why time is allocated for the combined cleaning when it was said in a previous meeting that this would not be scheduled anymore. A. Rossi answered that the MD plan is tight and it is very unlikely the combined cleaning will be carried out. J. Jowett pointed out that a similar test and procedure should be carried out during the ion run. As no MD time is allocated after the start of the ion run, the study should be carried out in physics time or during floating MD time (to be saved until then).

11. Quench margin at injection (M. Solfaroli Camillocci)

During MD#2 investigations were carried out on the quench level for Q6.L8 and Q4.L6. For Q6.L8 a peak signal of 30mV in the quench detection system was observed, but the quench protection system was not triggered as the signal did not last longer than the discrimination time. Studies continue in MD#3 by repeating the same procedure (shooting beam on the closed TCLIB to generate losses), increasing the current in the magnet (the optics is then not at injection, but the machine is in Inj&Dump, so the beam does not need to circulate) and increasing if needed the probe intensity (2-3e10). If time allows, the orbit is modified by adding a bump in order to send the beam into the magnet, possibly changing the magnet current.

12. Controlled blow up with ADT (W. Hofle)

The MD time is to verify the possibility to use the ADT for performing controlled emittance blow up. One motivation is the use for transverse loss maps, to be able to reuse EoF physics beams instead of allocating dedicated fills. The specification is to lose the equivalent of one nominal bunch on a timescale of 1-10s. The use of time-gating allows targeting groups of bunches, similarly to the abort gap cleaning method (band pass noise around f_{rev}). The method is first tested on a filling with 10 probes to verify on which spacing the method can act. Then 6+6 properly spaced bunches (50ns) are used, to verify the impact on the bunches at the edges of the excited portion of the ring. Injection protection collimators are retracted, all others are in operational position. A similar technique can be used for aperture measurements: slow losses are created by diffusion from white noise (no time gating) all around the ring. Only 1 probe at flat bottom is planned for this test, all collimators are retracted to identify aperture bottlenecks. D. Valuch is working on creating noise on the FPGA, M. Jaussi on the FESA class and D. Jacquet on the LSA part. Less than one hour of beam time at injection is requested before the start of the MD to debug the system.

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

Giulia Papotti

List of participants

BAUDRENGHIEN	Philippe	BE-RF-FB
BRACCO	Chiara	TE-ABT-BTP
BRUCE	Roderik	BE-ABP-LCU
BUFFAT	Xavier	BE-ABP-ICE
DEHNING	Bernd	BE-BI-BL
FERRO-LUZZI	Massimiliano	PH-LBD
GODDARD	Brennan	TE-ABT-BTP
GRAS	Jean-Jacques	BE-BI
HOFLE	Wolfgang	BE-RF-FB
HOLZER	Bernhard	BE-ABP-LCU
JOWETT	John	BE-ABP-LCU
MASTORIDIS	Themistoklis	BE-RF
METRAL	Elias	BE-ABP-ICE
PAPOTTI	Giulia	BE-OP-LHC
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