# LHC Studies Working Group
## Notes from the meeting held on 19th July 2011

The meeting was dedicated to the presentation of the draft schedule for the LHC MD#3, which will take place from August 24th to 29th. Additionally, the presentations on results for "combined cleaning", "transverse beam distribution" and "R2E" MDs took place as they had been postponed from the previous meeting (the slides can be found at the Indico link of the previous meeting: https://indico.cern.ch/conferenceDisplay.py?confId=146925 ). R. Assmann also reminded about the MD note deadline, only few had notes already been uploaded.

### 1. Combined cleaning and faster collimator setup (A. Rossi)

The IR3 collimators were setup for combined momentum and betatron cleaning; this setup is motivated by possible R2E needs (to relocate losses from IR7 to IR3), by shorter setup time and by reduced impedance. For this test, the horizontal (H) and skew (S) collimators in IR7 were opened to 18-24 $\sigma$, while the vertical collimators were left at nominal positions (no V collimators are available in IR3). H loss maps were performed at the flat top. The loss pattern showed some anomalies: high losses at the TCSG.A5L3.B2 (higher than at the primary, which could be explained by showers or hierarchy breakdown) and high leaks at the TCTVs in R1 and R8. Original SixTrack predictions show a correct hierarchy and much better cleaning efficiency in the other IRs. Additional simulations were performed after the MD and overlapping results from hierarchy breakdown and sheet beam hitting both collimators with highest losses could only partly reproduce the observations (better match in IR7 but not in IR3). Further studies are needed to reproduce the observations. Additional Fluka simulations including showers could also improve the understanding. The off momentum loss maps could not be performed.
During the same MD, the routines and software developed for a faster collimator setup were tested. The "pattern recognition of optimal loss spikes" worked well (52 cases ok versus 1 not ok) and will be used as a standard technique in the next setups. The tool for the "automatic identification of the collimator aligned to the beam during parallel setup" was not tested during the MD but only after the TS, and was also ok. The b1 and b2 IR3 collimators were setup in about 15 minutes/collimator (including the reference TCP setup). Additionally, the setting stability was better than 135 um with respect to the 08/03/2011 campaign, apart from one TCSG.
W. Hofle asked to which emittance one $\sigma$ corresponds, A. Rossi and R. Assmann answered that it is 3.75 um at 3.5 TeV in simulation, 3.5 um in the machine; at injection the sigma measured by realigning the collimators can be used. S. Fartoukh wondered what the theoretical basis for these studies is, given that the phase advance in IR3 is completely different from IR7, and given the scatter in V coming from the interaction with the primaries. A. Rossi confirmed that for the V plane, collimators would need to be installed. R. Assmann added that this setup worked with an inefficiency of 3e-4, a factor 10 worse than IR7, so the setup would be a fallback solution only in case of R2E problems, and reminded that in IR3 tungsten collimators are installed including a vertical one (3 H and 1 V). S. Fartoukh added that his concern was that the optics in IR3 and 7 could be improved if the constraints imposed by the

collimators could be released. R. Assmann concluded that this setup will not be studied further as no installation for combined cleaning is foreseen for LS1.

## 2. Beam distribution in the LHC (F. Burkart)

During the MD time the following was performed: one full scraping in H, V and S for both beams and one V fast scraping for both beams (collimator jaw at full speed). The calibration factors between BLM loss signal and actual intensity loss was calculated, resulting in 1.1e12 p/Gy to 1.9e12 p/Gy depending on beam and plane. The losses versus jaw position were plotted to look at the tails of the beam distribution. Preliminary results show that the sum of two Gaussian distributions can be fitted to the measurement. A microphone signal analysis of the scraping was also done. Two microphones are installed at approx 1.5 m from the primaries in pt 7 (TCPB and D). Spikes in the signal were observed coinciding with the scraping and are induced by radiation. The amplitude of this signal (fft bin amplitude at the revolution frequency) is linear with the loss signal, and no beam induced sound was observed during the scraping. The microphone corresponding to the TCPB (downstream) was more sensitive to the BLM signal. Given that the high sample rates allow the spectral analysis to be done up to 100 kHz, the analysis should be redone for high sample rate BLM data. D. Deboy added that the purpose of the test was to verify if the scraping could generate any audible signal, in particular to find an intensity threshold. R. Schmidt pointed out that the signal cannot be from a shock wave, and that in order to get BLM capture data from the PM files, probe bunches of up to 3e10 could be sent onto the collimators. D. Deboy answered that that was already done. R. Assmann reminded that the purpose of these studies is to perform damage detection, and that more tests are planned in the HiRadMat facility.

## 3. R2E MD (M. Calviani)

The purpose of the R2E MD was to evaluate the R factor (i.e. the ratio between thermal neutron fluence and High Energy Hadron, HEH, fluence) for tunnel locations, to check the radiation level gradient along the MBC dipole, to check the ratio between BLM dose and RadMon counts and to study the gradient between the BLM locations and below the dipole equipment (factor 3 difference expected from FLUKA for the same longitudinal location). The knowledge of the R factor will reduce the uncertainties in the radiation level estimates for the SEU issue during LHC operation. A -24 mm orbit bump was created in C14R2, and probes were continuously injected in beam 1 (I&D, one injection every ~45 s). The R factor is deduced by the combined use of two RadMons operated at different voltages. It was measured to be 1.4 below the MB/MQ interconnect (as expected from previous measurement in the LHC during standard lumi operation), and ~10 below the MBC (it seems thermal neutrons contribute more than expected, probably due to the very well localized bump). By the end of the MD, the integrated HEH fluence was 1e9 HEH/cm2 below the MBC and MQ interconnect and 1.6e7 HEH/cm2 below the MBC (almost 2 orders of magnitude reduction in ~11 m). In this configuration 8 QPS PM events were generated. In two occasions a +24 mm bump was applied in the same location: once the QPS detected a “quenchino” (quench heaters fired, PM generated), the second time no trip occurred over 10 minutes and several I&D sequences. The BLM rates vs RadMon counts evaluation seems to confirm

the factor difference 3 (evaluated with FLUKA calculations) in terms of dose between beam axis and tunnel floor. Also the 1 count/mGy ratio – extracted by comparing the RadMon and BLM signals during 2010 - seems to be confirmed (preliminary results). A possible BLM left/right asymmetry is also being analysed. S. Redaelli reminded that the aperture is symmetric but the orbit is not, so it should be evaluated how far into the aperture the shots went, rather than only looking at the relative orbit bump value. S. Fartoukh asked whether similar tests were planned also in the V plane, and M. Calviani replied that probably not, as the results were sufficient.

## 4. RF MD requests (T. Mastoridis)

The studies on the longitudinal stability (single bunch instability driven by broadband impedance) should be continued as the phenomenon will intensify at higher bunch intensities. An easy fix in case of sudden problems could be an increase of the bunch length, but the understanding of the phenomenon and its intensity threshold should be improved. R. Assmann pointed out that there seem to be no urgency, so the MD could be scheduled in MD#4. The 1-turn (1-T) feedback helps reduce the transient beam loading and effective cavity impedance, increases the stability margin for longitudinal coupled bunch instabilities and allows reliable operation at higher beam currents. During the last technical stop the hardware was installed, now beam time should be allocated for beam commissioning. Rephasing of p bunches at 3.5 TeV was tested once in 2010 but losses and lifetime dips were observed. It should be tested again as part of the p/Pb feasibility study.

## 5. First draft schedule of LHC MD#3 (R. Assmann)

R. Assmann presented the draft schedule for MD#3, which can be found here: https://espace.cern.ch/lhc-md/Shared%20Documents/2011%20MD%20Schedules/LHC_MD3_v3.pptx
The schedule includes: long range (6h) and head-on beam-beam (8h), followed by data taking with highest pileup (TBC, 4h); studies on long bunch length (8h), beam blow up with ADT (6h); aperture measurements (8h), check of the feasibility of the squeeze to 1m (8h); 25 ns studies (8h), UFO studies (8h), SPS Q20 extraction and LHC injection (8h); beam instrumentation (8h); large Piwinski angle (8h); p-Pb tests (8h); quench test at 3.5 TeV (8h).
B. Gorini commented that for the experiments' data taking, 2 hours of stable beams might be sufficient, and added that more than 1 bunch per IP would be preferable. W. Hofle commented that he will need to check with the RF colleagues in which MDs they are involved to make sure that the workload is not excessive. He added that for the "long bunches" MD, software needs to be developed. It was commented that the aperture MD might profit from the results of the ADT blow up MD, so it should be scheduled afterwards. W. Hofle questioned the need for the 25 ns MD, as it might not be operationally needed in 2011 and 2012 (not so much time is needed for RF and ADT setup), especially at the expense of the understanding of 50 ns. B. Gorini reminded that the experiments might be interested in a test run with 25 ns spaced beams in 2011. F. Roncarolo hoped that the BI MD could be carried out in the first part of the MD so to allow more time for data analysis before the technical stop (TS) when hardware problems could be addressed. Time for the 1 m optics was allocated to verify the feasibility beforehand and so to allow to possibly implement it in the machine

profiting from the post-TS intensity ramp-up. S. Fartoukh proposed the ATS pre-squeeze as a possible alternative that would allow correcting the chromatic aberrations which at 1 m might become a problem, R. Assmann suggested the discussion to be postponed to Evian, for the 2012 run. S. Redaelli added that it is mandatory for the remaining 2011 run to minimize the changes from the present configuration in order to maximize the integrated luminosity. In response to a question from J. Jowett, S. Redaelli confirmed that it would be easy to do a roll-back to 1.5 m should this turn out to be necessary in the set-up for the ion run. S. Redaelli reminded that the aperture measurements might reveal higher available aperture which would allow squeezing the beta-star even further, and added that matched optics files already exist for 1 m. Concerning the Q20 optics, W. Bartmann confirmed that extraction to the TEDs will be performed beforehand so to reduce the time needed at the LHC, and stressed that injection and capture of high-brightness bunches with low losses and emittance conservation are the decisive part. B. Gorini questioned the necessity for the Large Piwinski Angle MD, which is a development for a much longer timescale. R. Assmann responded that this MD could also bring shorter-term benefits. S. Redaelli reminded the importance of the combined ramp and squeeze MD, which might come too late if scheduled during MD#4, and questioned why the feasibility of the 1 m optics was scheduled in MD time rather than in physics time. R. Assmann answered that the MD time is allocated in order to verify the feasibility of MP and collimator constraints.

A list of operational developments has also been put in place, to group subjects that should be studied outside of MD time for operational improvements. To date, the list includes: tight collimator settings and their feasibility with respect to impedance and beam instabilities (2h, EoF); 1 m optics checks with and without beam (4+8h); 1-T feedback commissioning (8h).
R. Assmann explained that the tight collimator settings would be tried by moving in all primaries, secondaries and TCSG (not tungsten collimators as they would risk to be damaged) at the end of a physics fill, and observing whether the beam becomes unstable. W. Hofle commented that colliding beams have additional tune spread and that makes them more stable. R. Schmidt replied that EoF is already a good check, especially in case the settings do not work already then, but expressed concerns about the low number of recent programmed dumps. S. Fartoukh added that in an EoF the emittance would be bigger, granting extra Landau damping. R. Assmann disagreed and stated that smaller emittances are favorable in this case, and added that the experiment could also be performed before the declaration of stable beams, and by retracting the collimators at the end of the experiment, the advantage being the possibility to avoid the overhead necessary in case of dedicated studies. S. Redaelli reminded that the beams cannot be separated back after physics. The 1 m optics checks without beam should profit from periods of machine unavailability (e.g. localized cryo problem).

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

Giulia Papotti

## List of participants

| | | |
|---|---|---|
| ASSMANN | Ralph Wolfgang | BE-ABP-LCU |
| BAER | Tobias | BE-OP-LHC |
| BARTMANN | Wolfgang | TE-ABT-BTP |
| BRUCE | Roderik | BE-ABP-LCU |
| BRUGGER | Markus | EN-STI |
| BURKART | Florian | BE-ABP-LCU |
| CALAGA | Rama | BE-ABP-LCU |
| CALVIANI | Marco | EN-STI-EET |
| CIAPALA | Edmond | BE-RF |
| DE MARIA | Riccardo | BE-ABP-LCU |
| DEBOY | Daniel | BE-ABP-LCU |
| DEHNING | Bernd | BE-BI-BL |
| FARTOUKH | Stephane | BE-ABP-LCU |
| FOX | John | BE-RF |
| GORINI | Benedetto | PH-ADT-DT |
| HOFLE | Wolfgang | BE-RF-FB |
| JOWETT | John | BE-ABP-LCU |
| MACLEAN | Ewen Hamish | BE-ABP-LCU |
| MASTORIDIS | Themistoklis | BE-RF |
| NEBOT DEL BUSTO | Eduardo | BE-BI-BL |
| PAPOTTI | Giulia | BE-OP-LHC |
| POJER | Mirko | BE-OP-LHC |
| REDAELLI | Stefano | BE-OP-LHC |
| RONCAROLO | Federico | BE-BI-PM |
| ROSSI | Adriana | BE-ABP-LCU |
| SAPINSKI | Mariusz Gracjan | BE-BI-BL |
| SCHMIDT | Frank | BE-ABP-ICE |
| SCHMIDT | Rudiger | TE-MPE-PE |
| SOLFAROLI CAMILLOCCI | Matteo | BE-OP-LHC |
| TODESCO | Ezio | TE-MSC-MDA |
| TOMAS GARCIA | Rogelio | BE-ABP-CC3 |
| TUCKMANTEL | Joachim | BE-RF-BR |
| VANBAVINCKHOVE | Glenn | BE-ABP-LCU |
| VENTURINI DELSOLARO | Walter | BE-OP-LHC |
| WOLLMANN | Daniel | BE-ABP-LCU |
| ZERLAUTH | Markus | TE-MPE-MI |