MD PRIORITIES FOR RUN 2

J. Uythoven, G. Papotti, R. Tomas
CERN, Geneva, Switzerland

Abstract

The Machine Development studies performed during 2015 are briefly revisited, with the aim to be able to identify the topics that can be considered finished and the topics that will need further attention in Run 2. New topics for 2016 are also pointed out, resulting in a rough outline of the MDs foreseen for 2016. The organisational experience of the 2015 MDs is also presented and suggestions for further improvements for the coming years are made.

MACHINE DEVELOPMENT IN 2015

MD requests

In 2015 there were 3 MD blocks of 5 days each. This are 4 days less than the number of MD days originally planned, due to the additional hardware commissioning tests that needed to be performed coming out of the Long Shutdown 1.

In 2015 there were in total 92 MD requests of which 50 MDs were scheduled and 43 actually took place. In December 2015 only 9 MD notes were published as CERN-ACC-NOTE-2015-XXXX. The aim is that the MD notes are written down in the two months following the MD and that they give a first analysis of the data.

Fig. 1 shows the distribution of requested MDs in hours. In total 821 hours were requested while 296 hours of MDs actually took place (effective time, excluding time for rampdown etc.), including 25 hours for ion MDs. From the figure it can be seen that the collimation MDs form the largest group, followed by collective effect studies and optics studies on a third place. In relative terms the collimation and beam instrumentation studies obtained more time for their studies than the fraction of time they asked for.

It is also possible to classify the MD studies concerning their focus. This is done in Fig. 2: 18 % of the studies are closely related to operation and for this reason should ideally have taken place as operational development. This mainly considers the studies for beam instrumentation and collimation. The largest block, 56 %, concerns 2016 operation and beyond with as main contributors the studies related to the optics of $\beta^* = 40$ cm, collimation and beam instrumentation. The MDs which present studies for the longer time scale projects, like HL-LHC, represent 19 % of the MDs. These include quench tests and vibration studies.

Organisation

The organisation of the MDs consisted of the following steps: submission of the MDs before a given deadline for each MD block, by using the website [1]; LHC Studies Working Group Meetings (LSWG) to discuss a first selection of submitted MDs, indicatively 4 weeks before the MD block [2]; approval of the proposed MD schedule by the LHC Machine Committee, 2 weeks before the MD block; deadline for MD procedures of the selected MDs; a restricted Machine Protection Panel (rMPP) meeting in which a selection of MDs were discussed in detail followed by formal approval in EDMS; the actual MD block followed by another LSWG meeting in which a presentation of the first results was made. Finally the MDs have been written up as ATS notes, at least many of them.

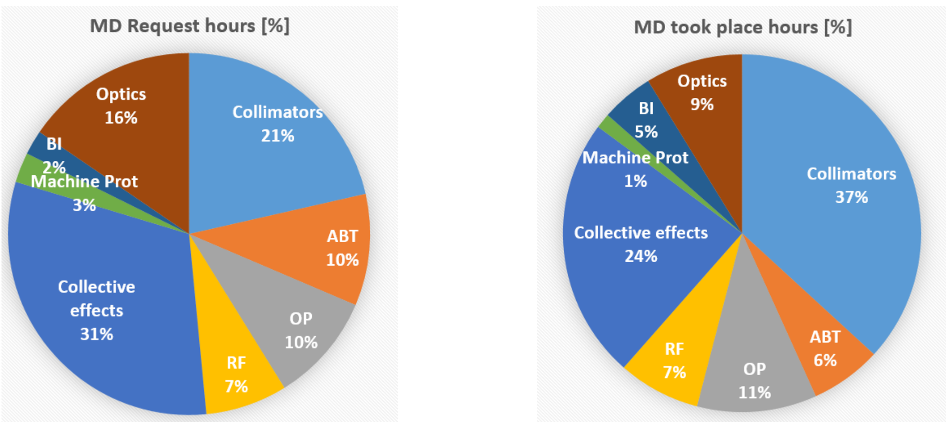

Figure 1: Classification of 2015 MD requests compared to the classification of the MDs that actually took place.

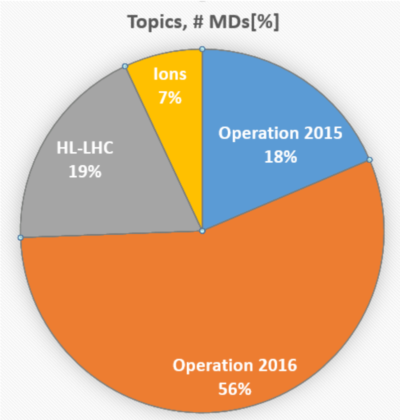

Figure 2: Classification of MDs considering their focus.

Machine availability

The first MD block (20 - 25 July 2015) had a rather low availability of 50 % due to several machine problems. Some of the MDs were reshuffled to be able to advance on higher priority MDs. The second MD block from 26 to 31 August started late due to an extension of the Van der Meer scans and a water problem in the machine. This resulted in the first two MDs not taking place during this MD block, but the first MD was recovered as a floating MD and the second one took place during the intensity ramp-up. The overall availability of the second block was excellent with 88 % availability and all MDs taking place.

The third and last MD block took place from 4 to 9 November 2015 and had an average availability of 75 %. Some MDs could not take place or were only partly successful.

Besides the studies in the designated MD blocks, there have been end-of-fill MDs, which are often far more time efficient than regular MDs if the studies require the standard physics machine conditions with large beam intensities. A typical example of this are RF stability studies.

One MD was moved towards a floating MD. This can also be time efficient from an MD user point of view, almost guaranteed to have 100 % availability when experts are around, however it was proven hard to schedule in 2015. How disruptive the floating MDs are for physics operation is an interesting point of discussion.

MD HIGHLIGHTS

This write-up is only very brief on the MD highlights. They have been referred to by many other contributions in this year's Evian workshop, which is a direct recognition of their usefulness. Some of the highlights are:

- Fully probed β^* = 40 cm optics which is ready to be exploited for 2016 operation [3, 4, 5, 6];
- Ramp and squeeze commissioned, and already used for the 2.51 TeV run [7];
- β^* levelling and collide & squeeze fully demonstrated with low beam intensities [8, 9];
- Crystal channelling observed at 6.5 TeV;
- Quenching magnets with ions is easier than quenching magnets with protons [10, 11];
- Longitudinal bunch flattening developed and operational;
- Development of new beam instrumentation, especially the DOROS, BTF, BCTF (Integrating Current Transformer and Wall Current Transformer), Schottky and diamond BLMs [12, 13,14, 15];
- Achieved beam-beam tune shifts of 0.04 [16].
- Instability threshold tracked during 2015 and observed to have improved with scrubbing [17, 18].

MDS IN 2016 AND BEYOND

For 2016 it is foreseen to have 4 MD blocks of 5 days each plus 2 days of floating MD, not including the ion MDs. This needs to be compared to 15 days of MDs in 2015. A special LSWG is organised on 18th January 2016 [19] to trigger the right MD requests that will make the difference in the LHC, HL-LHC and future colliders. The different groups will be asked to give the approximate list of priorities of their studies. Prime candidates for the 2016 MDs are the ATS optics, further studies of crystal collimation and studies of collimation with one jaw only to reduce the beam impedance. Other studies consist of flat optics, injection of trains of 80 bunches from the PS, beta-beating correction on colliding beams (to be done with larger beam intensities) and study of snapback effects for very low magnetic fields by operating the LHC at 225 GeV.

Existing MD paths will be continued in 2016. They consist of studies of collective effects, emittance conservation of the small BCMS beams and their blow-up over the cycle. This is related to further impedance studies and studies of RF instabilities. Quench limits remain to be confirmed with protons and beam instrumentation is continuously being developed and improved. Beam transfer studies include the losses at injection with diamond BLMs, the verification of injection of 288 bunches and measurements of kicker waveforms.

On the other hand, some 2015 MD paths have matured in an operational state and do not require further studies in MD time or by their nature should not be part of the MD programme. Examples are ramp & squeeze, β^* levelling, RF bunch lengthening, BSRT calibration, scrubbing and scrubbing checks. The special run with β^* = 2.5 km foreseen in 2016 and the required preparations should be part of operational development.

There were three ion MDs in 2015 and also 2016 is expected to have a certain number of ions MDs: crystal collimation at top energy; collimation quench tests, proton–lead performance limits and strategies to minimise losses in operation by using larger BFPP bumps, IR7 bumps and TCP jaw movement. These studies should appear explicitly on the 2016 schedule, which is presently not the case.

LESSONS FROM 2015

The MD Webpage has proven to be very useful for collecting the MD requests, administration and the communication of the up-to-date MD schedule. All MDs had detailed procedures written which improved their efficiency. The procedures were available on dfs public folders. Changes in the procedures were not always uploaded back to the MD Webpages which in few cases created confusion with the operation teams.

The efficient collaboration with an OP contact person for each MD, which was probably taken more seriously during the first two MD blocks than the third, should be further strengthened for the 2016 MDs. One way will be to highlight the OP contact person in the LSWG meetings.

Some equipment checks could be carried out before the actual MD. Also here the OP contact person could share part of the responsibility.

The rMPP approval procedure of MDs that are considered risky for the machine, functioned well in 2015: no damage to the machine took place and no dangerous situations due to the MD programme were identified. All 50 MD procedures were available on dfs and 17 MD procedures went through an approval round in EDMS. At times the time between the procedure submission and the rMPP meeting was rather tight to allow a proper discussion between rMPP and the MD requesters. This should not be overlooked in 2016 as there are more MD blocks.

Special attention is to be given to end-of-fill MDs and studies to be done during physics time when normal operation is not possible due to partial machine unavailability. These studies should also be written down as procedures, be approved by rMPP when required, and be available on a 'standby list'.

The strategy not to have an MD priority and not to re-schedule MDs when the machine is not available worked well for the second and third MD block and it is foreseen to use the same strategy in 2016.

CONCLUSIONS

The Machine Development studies in 2015 were highly successful as is shown by the many presentation at this Evian workshop that referred to various MD results. The strategy for the 2016 studies will not be very different from 2015 and some important lessons learnt from the 2015 studies have been identified.

A good preparation of the MDs together with an OP contact person, detailed procedures, followed by rMPP approval if necessary will continue to be the default strategy. The demand for MD time is expected to remain high for the coming years.

REFERENCES

[1] MD website: https://md-coord.web.cern.ch.

[2] LHC Studies Working Group website: https://indico.cern.ch/category/3693/.

[3] A. Langner et al, LHC optics commissioning at beta* 40 cm and 60 cm CERN-ACC-NOTE-2015-0035.

[4] R. Bruce et al, Collimation with tighter TCTs at β^*=40 cm, CERN-ACC-NOTE-2015-0036.

[5] R. Bruce et al, IR aperture measurement at β^* = 40 cm CERN-ACC-NOTE-2015-0037.

[6] A. Mereghetti et al, β^*-Reach - IR7 Collimation Hierarchy Limit and Impedance CERN-ACC-NOTE-2016-000.

[7] J. Wenninger et al, First beam test of a combined ramp and squeeze at LHC CERN-ACC-NOTE-2015-0023.

[8] A. Gorzawski et al, Collide and Squeeze MD CERN-ACC-NOTE-2015-0043.

[9] A. Gorzawski et al, MD 239 on Collide and Squeeze (part 2) CERN-ACC-NOTE-2016-0018.

[10] B. Salvachua Ferrando et al, Collimation quench test with 6.5 TeV proton beams CERN-ACC-NOTE-2016-0015.

[11] C. Bracco et al., MD290: Q4 IP6 Quench Level, CERN-ACC-NOTE-2016-0028.

[12] D. Draskovic et al, Summary of LHC MD 369: DOROS vs WBTN in IR Stripline BPMs CERN-ACC-NOTE-2015-0029.

[13] M. Betz et al, Summary of LHC MD:377: Schottky pick-up CERN-ACC-NOTE-2015-0039.

[14] O. Stein et al, Injection quality measurements with diamond based particle detectors CERN-ACC-NOTE-2016-0021.

[15] M. Krupa et al, Summary of LHC MD 398: Verification of the dependence of the BCTF measurements on beam position and bunch length CERN-ACC-NOTE-2015-0031.

[16] J. Barranco Garcia et al, MD 402: Head-on limits. Separation levelling. CERN-ACC-NOTE-2016-0023

[17] L. Carver et al, MD 751: Train Instability Threshold CERN-ACC-NOTE-2016-0004.

[18] L. Carver et al, MD 754: Instability Threshold for Train with 25ns Spacing CERN-ACC-NOTE-2016-0022.

[19] Special LSWG on 18 January 2016 https://indico.cern.ch/event/464617/.