# LHC Studies Working Group

## Notes from the meeting held on 18 January 2016

https://indico.cern.ch/event/464617/

**Introduction (R. Tomas Garcia)**

R. Tomas introduced the scope of the meeting: having a first look at the MD priorities for 2016 and beyond. The 2016 schedule foresees 22 days of MDs. 14 out of 41 2015 MD notes are still missing. Ion MD notes are due by 18 February.

**ATS MD (S. Fartoukh)**

The ATS optics should be validated for use in HL-LHC. It has been demonstrated in Run 1 with low intensity beams until beta* 10 cm. The main difficulty with the first generation of ATS optics was the $\pi/2$ phase advance between the MKD and several TCTs. This limitation was recently cured and the new ATS optics will feature phase advances close to 0 and 180 degrees, up to within +/-40 degrees between the MKD and the TCTs, for both beams, both IR1 and IR5, and all beta* from 2 m to 10 cm. A plan for implementing the ATS optics (new generation) in the LHC as HL-LHC test bench includes: ~8-9 shifts in 2016 for the pre-squeezed optics (including validation with a train of 36 nominal bunches, but not including the flat optics, which is lower priority for the moment); >4 shifts in 2017-18 to gain experience with the ATS telescopic optics, possibly including an intensity ramp-up.

J. Wenninger commented that 2 shifts/block (4 MD blocks are present in the 2016 LHC schedule) will be the minimum needed.

**Linear and non-linear optics MDs (M. Giovannozzi)**

M. Giovannozzi underlined different aims of the MDs: from understanding the present (2016 run), preparing the medium term (Run 2), building the long term (HL-LHC). Ballistic optics was proven successful in 2015 and it is assumed it should be carried out during 2016 beam commissioning. The need for a 2-2.5 km optics should be addressed well in advance as there are intrinsic difficulties expected, to be determined if this will be done in operational time or if MD time will be required. The presented studies include studies of linear optics (linear coupling, different optics for injection and collisions), studies of non-linear optics (measurement of natural chromaticity, b3, b4, b5, non-linear coupling at injection and non-linear chromaticity and detuning with amplitude at the flat top, studies of non-linear errors in the IRs, measurement of dynamic aperture), and background studies (from synchrotron radiation versus controlled pressure rise). A prioritization is given on the last slide.

R. Tomas asked about the two options for flat optics, with standard optics and ATS. M. Giovannozzi replied that it will depend on the choices for the ATS optics: if ATS will be operational earlier, then the priority of this MD will decrease, while if ATS will be used later, then this flat optics could be a valid alternative for production.

**Collective coherent effects MDs (E. Metral)**

The impedance of the new TDIs can be measured already during beam commissioning, as well as BTF calibrations. Scrubbing is not included during MD time. Studies in parallel with physics include the stability limits for the non-colliding bunches and the optimization of the working point. Studies on beam instability include the further study of the transverse instability threshold at high energy. The single bunch stability should be studied with respect to linear coupling, Q'', Q', MO, ADT settings and TCSGs positions. Concerning e-cloud, the working point could be optimized at injection and the dependence on beam parameters for HL-LHC could be looked into. On the beam-beam side, studies are the BFT to study Landau damping and diffusion, and the beam stability with a transverse offset.
After a question by G. Papotti, E. Metral clarified that in MD time the tunes might be swapped (e-cloud gives a different tune spread in dipoles and quadrupoles).

**Luminosity and beam-beam (Y. Papaphilippou)**
Beam-beam MDs are divided into long-range effects and compensation, head-on and noise (high and low frequency) effects, effects linked with optics (Q' variation with LR and beta-beating driven by beam-beam). The long-range limits should be probed already during beam commissioning for the operational scenario, while ultimate 25 ns or BCMS beams should be tried when available. The MD proposals include a proof of compensation of long-range effects with the DC wires embedded in TCTs to be installed in 2017 and 2018. On luminosity, the evolution of beam distributions through the cycle and the observation of single beam parameters should be studied (also concerning their stability). The stability of the IP1h OP scans should be followed up and the impact of longitudinal profiles can be studied as an end-of-fill study. A table of priorities is given at the end.
J. Wenninger pointed out that the optics should not be commissioned already in 2016 if the wire compensators are installed only in 2017-18, as it will need to be redone anyway. Y. Papapilipphou commented that the same optics can be re-used also for triplet corrections studies. As these MDs require a lot of time, any early experience is welcome. He also added that this optics would be the lowest priority of the optics presented previously. J. Wenninger pointed out that anyway a full campaign of optics commissioning is required. There was general agreement on the need to follow a strategy based on which optics is operational (ATS or traditional).

**Collimation MDs (S. Redaelli)**
The collimator requests are divided into: operational aspects (including improvement of the collimator alignment, possibly aperture measurements, probing the beam halo), requests on beta* reach (which will depend on the choice for 2016), requests on impedance studies and requests for HL-LHC (e.g. quench limits, and studies of collimators with wires). Note that in 2017 a low impedance collimator will be installed (TCSPM), and it will require dedicated, high priority MDs. Crystal MDs are also desired, e.g. to measure channeling with Pb ions (machine not available when scheduled in 2015).
R. Tomas asked about the multi-bunch halo importance. S. Redaelli commented that, in the absence of dedicated instrumentation, this is the most precise

method available, already used in 2015 (while the immediate importance for performance might be lower).

**Ion MDs (J. Jowett)**
J. Jowett pointed out that the species and energy for the 2016 run are not yet decided, and this has an impact on the MD choices. Note that no dedicated time is reserved for ion MDs in the LHC schedule. Some possible subjects for studies are: BFPP studies (if more data is needed, possibly another quench test), asymmetric TCP settings, an absolute calibration of the LHC energy (requiring p-Pb and Pb-p runs), and unequal beam sizes in collision. Emittance and intensity evolution of non-colliding bunches might be studied in parallel with physics, as for protons. Ion beams could be ready earlier, e.g. in the summer.
S. Redaelli pointed out that anticipating some of the MDs with respect to the ion run might have a big impact on MD time because of the preparation time required.

**OP MDs (J. Wenninger)**
Many OP MDs are semi-parasitic and embedded in operation: e.g. OP scans, studies of non-colliding bunches, a trial of defender bunches for the UFOs, and parameter scans once in stable configuration. Other MDs require dedicated time: use of the MCBXs in the OFB (too disruptive to the OFB to be done in operation), surviving 60 A orbit corrector failures (might be important depending on SEU rates), studies on the dynamic magnetic field change. An MD for FCC-ee aims at studying the vertical dispersion and targeting a correction to the 1 mm level.
S. Fartoukh asked whether there is no more beta* leveling studies. J. Wenninger replied that he will work on DOROS BPMs data in the shadow before requiring more dedicated time. After a comment by S. Fartoukh, J. Wenninger confirmed that more tests and simulations are required on the subject of the correction of the vertical dispersion. R. Tomas added that the improved measurements of the snapback could possibly be done in parallel with e.g. ATS optics ramp developments.

**RF MDs (J. Esteban Muller)**
Most requests are standing from 2015. MD 249 on voltage phase modulation is the highest priority, in view of increasing the bunch intensity. MD 1087, on the controlled emittance blow up, is also important and derived from observations done during 2015 MDs. On bunch shaping (MD 373), big progress was made, but the question remains of how close to the stability limit these bunches are. This could be done also during operation or commissioning. MD 376 was scheduled in 2015 but the machine was not available at the time of the MD. Studies on impedance evaluation and the longitudinal damper studies have lower priority. New MDs are the optimization of the LLRF with beam (at present the optimization is done without beam, so it should be repeated with beam in view of HL-LHC) and the measurement of the HOM of the 400 MHz cavities (to follow parasitic measurements during commissioning). The first two MDs are the most important.

**BI MDs (E. Bravin)**

The BSRT needs ~6 h of effective time at 6.5 TeV, mostly to verify the advantage of using 250 nm light. Halo studies are also foreseen to characterize the coronagraph (beam 2 only, from MD2 on). Wire scanner performance concerning linearity, saturation, calibration are also important. BBQ studies include the Q' measurement with small and slow radial modulation and the calibration of the BBQ using standard and DOROS BPMs. BPM studies include investigating the absolute scale using bumps and the test of new electronics for the interlock BPMs (requires scraping, from MD3 on). Using the DOROS BPMs, the coupling can be studied with small transverse excitations. Also the DOROS directivity can be assessed using RF cogging. Dedicated time is required also for the Schottky and MIM systems.
J. Uythoven asked about the priorities of the MDs. E. Bravin replied that priorities have not yet been discussed within the group and will be communicated. J. Wenninger added that the BPMs could be studied during the commissioning. He also added that many time requests seem short.

**ABT MDs (C. Bracco)**
Measurements of TDI impedance with single bunches should be done during commissioning. Other measurements of TDI and TCDQ impedance can be done in MD time (medium priority). TCDQ-TCT retraction and losses during asynchronous beam dump can be done during commissioning for the nominal beta*. MD 905, on injection losses with the diamond BLMs, should be continued: a new MD request is already available (MD 1077, high priority). The injection of 80 25 ns bunches could be studied in parallel with the study of the MKI waveform (pulse length and ripple definition, high priority). MD 287 is medium priority; MD 273, 274 are low priority.
After a question by S. Fartoukh on the MKI MD, C. Bracco replied the main observable is injection oscillations and studies should involve the ADT team. R. Tomas asked when the 80 25 ns bunches will be available from the injectors. C. Bracco replied that they were already available in 2015, but they could not be injected due to the TDI limitation.

**MPE MDs (M. Valette)**
MD 67 aims at validating the aperture margins in the triplet. Another MD aims at calibrating the diamond BLMs in IP6 (possibly requiring higher abort gap population than other studies). A third MD aims at measuring the effect of a D1 powering failure on the beam.
S. Fartoukh commented that the D1 will be superconducting for HL-LHC, so the MD might be less important for HL-LHC. R. Tomas commented on the high priority of MD 67: it should be cross-checked with the latest version of the ATS optics. S. Redaelli stressed the importance of the validation method, regardless of which optics it is applied to.

**FCC MD (M. Solfaroli)**
Two MDs are proposed in the scope of FCC studies. Different ramps are tried with pilot beams for a faster snapback, plus a shorter parabolic round-off or higher dI/dt (PELP to PPLP, where P stands for parabolic, E for exponential, L for linear segments of the FGC function). A second MD is being studied to try and inject into the LHC at a lower energy (e.g. 225 GeV), recommendation from the

recent FCC Injection Energy Review. On the side, this would help improving the understanding of the magnetic model and snapback. This test requires major changes in the SPS and LHC interlocks and would require several days. An alternative could be to inject at 450 GeV but then decelerate to 225 GeV.
S. Redaelli asked about the impact on MP of the test, given that it requires only pilot beams. M. Solfaroli and J. Wenninger pointed out that the MD requires dismantling much of the SPS and LHC interlock chains, so the recovery from the MD should be most properly handled. After a comment by R. de Maria and S. Fartoukh, it was agreed that this MD should be verified with power converter people and optics teams. R. Tomas pointed out that if the study happens, then many others should profit, e.g. studies of magnet field quality. The MD could possibly be scheduled at the end of the 2016 or 2017 run (a major amount of time is required to recover from the MD, so the MD should be ideally be schedule just before a YETS).

Reported by G. Papotti.