30th Meeting of the HL-LHC Technical Coordination Committee – 08/06/2017

Participants: C. Adorisio, A. Apollonio, G. Arduini, L. Bottura, R. Bruce, O. Brüning (chair), R. Calaga, O. Capatina, F. Cerutti, R. De Maria, S. Fartoukh, D. Delikaris, P. Fessia, R. Garcia Alia, M. Giovannozzi, J.M. Jimenez, R. Jones, A. Lechner, H. Mainaud Durand, E. Metral, M. Modena, Y. Papaphilippou, S. Redaelli, G. Riddone, L. Rossi, F. Sanchez Galan, M. Zerlauth.

Excused: J. Jowett, M. Gourber Pace, D. Wollmann.

The slides of all presentations can be found on the website and Indico pages of the TCC:

HL-LHC TCC homepage: https://espace.cern.ch/HiLumi/TCC/Default/Home.aspx

Indico link: https://indico.cern.ch/event/638356/

O. Brüning recalled the actions and decisions from the 29th HL-TCC.

- For the executive summary from the circuit review, the decision was taken to accept all recommendations given by the review panel. In particular O. Brüning mentioned that the decision concerning the removal of the Q2a trim needs to be explicitly mentioned in the minutes.
- Concerning the overview of collimation changes, the new naming conventions will be distributed for comments. P. Fessia mentioned that the new naming is not yet approved. S. Redaelli commented that this version of the naming was a proposal of the LHC baseline team (A.L.Perrot, S.Chemli), but modifications are still possible in case of confusions. This should be finalized by the end of the month; O. Brüning proposed to include a table in the HL-LHC TCC page explaining the logic for the adopted naming convention.
- Concerning the energy deposition studies on Q5 during an asynchronous dump, F. Cerutti and A. Lechner mentioned that results will be available within 2-3 weeks.

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Update on optics constraints for injection and dump protection elements (C. Bracco - slides)

C. Bracco recalled the main optics constraints presented on 4/8/2016 at the HL-LHC TCC. O. Brüning asked what are the assumptions for beam parameters when calculating the energy deposition in the protection elements. A. Lechner explained that the worst case is assumed, namely BCMS emittances and no emittance growth during the fill.

C. Bracco mentioned that the TCDQ movement during the squeeze should be unidirectional for ensuring the required alignment precision, as changes of direction compromise the reproducibility of the alignment. Moreover a redesign of the BETS would be required to implement the β* check and allow changing the TCDQ position at fixed energy.

C. Bracco reminded about the assumptions for the studies and stressed that results are based on analytical calculations, a final validation will require more detailed particle tracking simulations.

C. Bracco presented the results of the calculation of the optics constraints for the phase advance between MKDs and TCT at the end of the squeeze, accounting also for non-zero dispersion at the TCDQ (having an effect of 4-5°). She also presented the effect of the TCDQ retraction on the 'forbidden' zone of phase advance. This enlarges by 3° per 0.5 σ retraction (for a 3.5 mm mrad normalised emittance).

C. Bracco reminded that to evaluate the effect of settings and optics on energy density in the TCDQ, the type-2 erratic was considered (worst case scenario) for a gap of 3 mm. Mechanical stresses still need to be evaluated, but they might be close to the limits. Accounting also for orbit drifts, optics errors and dispersion offsets, C. Bracco recommended a minimum allowed TCDQ gap of 4.9 mm.

R. De Maria commented that for flat optics at the end of the squeeze limiting the β_x to 500-600 m might be a problem, this aspect needs to be further studied. He added that for dispersion 2 m is a significant margin, some gain could therefore be possible. C. Bracco agreed and mentioned that results are based only on the centre of the orbit, without accounting for the full phase space.

C. Bracco listed several options for positioning the TCDQ during squeeze. O. Brüning asked whether squeezing during the ramp would help in this respect. R. De Maria explained that it doesn't help, due to the exploitation of luminosity levelling. R. Bruce and S. Fartoukh mentioned that during the telescopic squeeze the position of the TCT is constant, so no problems are expected for the TCT. C. Bracco clarified that these considerations apply for the case of an asynchronous dump, for losses on TCP and TCSG in IR7. Concerning the possibility to perform the telescopic squeeze during the ramp, S. Fartoukh commented that is should not be excluded.

In case of injection failures, studies on energy deposition in the TDIS indicate that with HL beams and the current version of the optics, the stresses in graphite could be at the material limit, it would therefore be highly desirable to increase the β function in this location.

S. Fartoukh asked what is foreseen after LS2 to cope with the problem of the minimum allowed β at the TCDQ in case a non-telescopic optics will be used. C. Bracco commented that this could have a direct impact on the allowed bunch intensity after LS2. A. Lechner mentioned that this would not be the only limitation, as it is known that the LHC dump could also be damaged in case of a double MKB erratic. A. Lechner proposed coming back to the HL-LHC TCC in late summer/autumn with more details on the beam dump studies and with the results of the ANSYS simulations for the TCDQ stress levels.

ACTION: A. Lechner will give an update on the beam dump studies and on the results of the ANSYS simulations for the TCDQ stress levels (end of summer/autumn).

O. Brüning suggested making the optics parameters available either in the TCC webpage or in the optics webpage. R. De Maria commented that he will publish the parameters on the optics page.

ACTION: R. De Maria should publish the new optics constraints and parameters in the HL-LHC optics page.

Review of MQW and MBW lifetime taking into account results from the dosimeters during the 2016 run (P. Fessia - slides)

P. Fessia stressed that the scaling shown in the presentation only applies to the cleaning insertions (not to IP1 and IP5). He recalled the progress of the analysis from 2013, profiting in 2015 and 2016 from dosimeter readings, which highlighted doses below expectations. For lifetime calculations in 2016 it was decided to conservatively assume a scaling of the dose with an estimated loss-to-luminosity ratio. Thanks to the combination of the 2016 dosimeter readings and the results from FLUKA models, it

was quantified that the 2016 vs 2015 dose ratios calculated with the luminosity scaling were more than a factor 3 above the measured values.

G. Arduini commented that in 2016 the use of BCMS beams yielded more luminosity for the same intensity and that the beam lifetime is burn-off dominated after 2 h in collisions (therefore after 2 hours most of the losses should occur at the IRs), so these factors should also be considered.

P. Fessia presented the dose scaling based on the integrated intensity for IR3 and IR7, showing much better results than the luminosity scaling (slides 11-12).

T. Otto asked about the uncertainty on dosimeter measurements. P. Fessia explained that it cannot be excluded that it's up to a factor 2, but it should in reality be much better than this.

P. Fessia illustrated the new procedure for dose estimates, based on the integrated intensity. Considering the projected integrated intensity for the LHC up to the HL-LHC era, a reduction of the doses between a factor 5 and 10 with respect to old estimates is expected. It is assumed to have maximum LIU intensity during Run 3 and that ultimate HL-LHC integrated luminosity will be reached by having three additional years of HL-LHC run.

P. Fessia presented the expected material safety margins according to the new dose estimates in both IR3 and IR7. The lowest margin is for MQWA.E5 in IR3, for which a probably conservative factor 2 margin is estimated. Following these considerations, P. Fessia proposed revising the plans for activities after LS2, which at the moment foresee the production of 4 sets of radiation-hard coils for MBW. It is instead proposed, following a discussion and agreement with D. Tommasini and E. Todesco, to invest instead in tooling for opening these magnets in case of need. No change in the plans is proposed in the period going up to LS2, including the installation of shielding in IP3 and IP7 (studies ongoing) and the removal of MQWA.E5 in IP7, with the recovery of two spares. For MQW it is also proposed not to procure additional magnets or coils. In this case, the possibility of sorting magnets or working on an alternative to suppress MQW trims (proposal under development) could also be considered.

L. Bottura recalled that MQWs were sorted in point 3, so re-shuffling of the magnets could be possible in LS3, but with some constraints. M. Giovannozzi confirmed this is the case and stated that this possibility will be verified once a proposal will be available. P. Fessia stressed that is a remote possibility, to be adopted just in case the dose increases significantly more than expected and no spares are available.

S. Fartoukh asked whether a change in the location of the highest dose in the magnets was observed between 2015 and 2016. P. Fessia replied that no change was observed,

which is clear from the plot of the normalized dose in slide 8. S. Fartoukh stressed that the loss pattern depends on optics and phase advance between IPs and collimators. This implies that when ATS optics will be implemented for HL-LHC then the loss pattern will become more stable, potentially having an impact on the accumulated dose.

O. Brüning suggested evaluating the effect of ATS optics, e-lenses and different collimators settings and materials on the conclusions, as the decision of stopping in-kind contributions is irreversible. P. Fessia commented that in case the doses are finally higher than estimated, then new coils could still be produced before LS3. In addition, tools for opening MQWs will be available. F. Cerutti commented that despite the change of optics, the dominating contribution for the loss pattern will still come from TCPs. S. Redaelli recalled that a change of the loss share between point 3 and point 7 has been observed in the past.

DECISION: The HL-LHC TCC endorses the modification of the baseline for warm magnets, based on the following points:

1- No production of coils or magnets for the MBW.

2- No production of coils or magnets for the MQW.

3- Acquisition of the capability and tool necessary to disassemble and reassemble MQW and MBW.

ACTION: release an ECR following the decision to modify the baseline for warm magnets.

Status of documents for DOE contribution (P. Ferracin - slides)

P. Ferracin gave an overview on the status of the documents for the DOE contribution. Two documents will be produced, one specifying functional requirements (divided in threshold requirements and objective requirements) and a second one specifying acceptance criteria.

The functional requirement specification for the magnets was circulated, and the first round of comments is completed. L. Rossi recommended adding also the department head to the approval list.

P. Ferracin presented the list of the threshold requirements. Concerning the radiation resistance threshold, 35 MGy should be quoted instead of 33 MGy. F. Cerutti confirmed that 35 MGy is the dose corresponding to the ultimate integrated luminosity of 4000 fb^{-1}.

Concerning voltage to ground, the threshold during operation is set to 670 V. Nevertheless, in the acceptance document also constraints related to ELQA tests should be included, i.e. 1.8 kV should be specified. L. Rossi suggested adding F. Rodriguez Mateos to the approval list.

L. Bottura commented on the target number of cycles (2000), stating this seems very low. Assuming 3 cycles per day and 200 days of operation per year already yields 600 cycles.

For the splice resistance requirements, L. Rossi commented that this will be essentially a measure of the quality of the welding.

O. Brüning asked how to demonstrate that the magnet will be able to survive 20 quenches. L. Rossi commented that this may be tested on the short model and at a later stage on the prototype.

O. Brüning encouraged the TCC members to give comments on the document that was circulated, this will be possible until the end of June (as also for the crab cavities document). L. Bottura pointed out that heat load conditions for operation are not specified. L. Rossi agreed this should be added.

P. Ferracin listed the other documents that are under work (FRS cold mass, FRS cryostat,…). For example these will include the specifications on how to interface the cold mass and the cryostat.

L. Rossi mentioned that for the material approval T. Otto should be added to the distribution list as safety representative of the project.

Crab cavities acceptance document (R. Calaga - slides)

R. Calaga presented the latest version of the document for dressed RFD cavities, already including comments from WP4 and the RF group.

L. Rossi already provided his comments on the document and these still have to be implemented. In particular, a scope contingency should always be included for collaborations with the US. The scope is to have 8 dressed cavities plus 2 spares. Some additional considerations should be added specifying requirements for integration in the cryostat and regarding transportation.

R. Calaga gave an overview of the parameters discussed in the document, all specified to be above nominal performance, with dedicated paragraphs explaining the choices of the thresholds.

O. Brüning asked whether mechanical tolerances are included in the document. R. Calaga explained that these are in the technical specifications (EDMS 1389669), to be

approved together with the functional specifications. L. Rossi added that the maximum voltage should be explicitly specified. R. Calaga mentioned that this was included at first (5 MV), but then it has been removed.

L. Rossi asked if there's any specification in terms of allowed number of quenches. R. Calaga mentioned that there's a voltage threshold of 4.1 MV ensuring that "hard quenches or strong field emission" will not occur. L. Rossi asked if it would be possible to specify a number for field emission. R. Calaga commented that the effects would be seen on the heat load, so this could be taken as a reference parameter.

O. Brüning recommended adding T. Otto in the approval list for materials and radiation tolerances.

AOBs

The next meeting will be on 22nd June, it will be chaired by M. Zerlauth.