46th Meeting of the HL-LHC Technical Coordination Committee – 22/02/2018

Participants: C. Adorisio, M. Alcaide León, G. Arduini, V. Baglin, A. Ballarino, R. Bruce, R. Calaga, O. Capatina, S. Claudet, R. De Maria, D. Delikaris, B. Delille, B. Di Girolamo, P. Fessia, S. Gilardoni, N. Grada, P. Martinez Urios, M. Martino, R. Martins, T. Otto, Y. Papaphilippou, M. Pojer, L. Rossi, F. Sanchez Galan, J. Serrano, M. Sitko, L. Tavian, J. - P. Tock, R. Tomas, S. Yammine, M. Zerlauth (chair).
Excused: A. Apollonio, O. Brüning, R. Jones, S. Redaelli.

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

In the absence of O. Brüning, M. Zerlauth opened the meeting by reviewing the minutes of the last TCC. The actions were reviewed. In particular, and in preparation of the upcoming C&S review, in the TCC of the 8th of March, the different options currently still ongoing within the HL project will be addressed, with their principal mission, impact in performance, timetable, plan and a priority rating from a project point of view. In this respect, L. Rossi sent an e-mail to the WP leaders. In addition, I. Bejar Alonso will remind the current baseline and review the ECRs currently under approval, with deadline for the approval of any additional ECR to be implemented during LS2 being the end of March.
M. Zerlauth proceeded to a review of the agenda of the meeting.

Main project follow-ups from Chamonix, L. Rossi - slides

L. Rossi presents a report highlighting the main points from Chamonix 2018 to be further followed-up by the project. Session 4 addressed HL-LHC equipment development, apart from the crab-cavity (CC) and 11 T-dipole (discussed in session 6). Regarding the IR magnets, the point mentioned regarding the reproducibility of the performance of 11 T Nb_3Sn dipole model was resolved since Chamonix, but there is still quite a lot of work to have a solid understanding. For the cold powering, it is important to stress that the 100 kA MgB_2 wire is a complete new design. It was underlined that no major show-stopper is found, but some R&D needed, with an important milestone being the testing of a 60 m long demonstrator system by the end of 2018. A. Ballarino clarifies that the full circuit will be indeed tested by the end of the year. A special talk was given by A. Devred regarding the cold-powering options, where the copper variant was found not viable anymore at this point in time, whereas the NbTi option is still possible but requires some design study and R&D, in particular for the very high dI/dt expected during magnet quenches. This is indeed further stressing the importance to have everything studied by 2018 for MgB_2, especially in case of problems, so that there is enough time to modify the baseline to the other variant without a major impact on the overall project schedule. Regarding heat deposition, it was shown that all elements can withstand ultimate performance, and a further 10 % reduction in dose was provided by the crossing angle variation proposed by WP2. Regarding collimation it is important to highlight the very good performance of the low-impedance collimators. In addition, crystal collimation performance with ions was proven in first MDs to be very good. S. Fartoukh presented the excellent performance of ATS during 2018, and highlighted the important MDs during 2018, in particular flat optics and round optics with large telescopic index and high-bunch intensity for e-cloud studies. G. Arduini pointed out that it seems that there is not much to be gained with respect to electron cloud. Following the question of L. Rossi regarding the use of round or flat optics during LHC Run III, G. Arduini answered that this will be decided after the results of the MDs during 2018.

Session 5 addressed HL-LHC open issues and options. In particular, the integrated luminosity performance was recovered for both nominal and ultimate with an efficiency hypothesis of 50% but with much less margin. The presentation of G. Iadarola addressed the difference in heat loads among sectors, which is not compatible with the HL-LHC beam requirements. Thereby, the identification in the present LHC of the source and its suppression is fundamental. If not, this will have an impact on the beam train composition and luminosity. The low-β* correction strategy, as presented by R. Tomás, is very robust but a further improvement is required for HL-LHC. Very good results were presented regarding the experimental demonstration of BBLR compensation with the DC wire demonstrators. L. Rossi recalls the answer of Y. Papaphilippou to the question of the CMAC chairman, that, at present, an engineering solution for a solid wire has not being found yet and that a lot of R&D work is necessary during this year for proving the viability of this option. Regarding the matching section, Option A (based on remote alignment) is assumed to become the baseline. It has to be reviewed however in more detail with respect to extra cost and interface issues of the different systems, e.g. vacuum, cryogenics but also radiation. Indeed, P. Fessia showed that fully remote alignment is better but the radiation resistance should be further demonstrated. The hollow e-lens will be proposed to become part of the HL- LHC baseline, and an endorsement by the following C&S review will be important, as the ballpark cost of around 10 MCHF is significant.

The sixth session addressed issues on infrastructure, test facilities and the 11-T dipole. Regarding the SPS CC test, there was very good progress and most of the remaining issues have been addressed. S. Claudet reported the latest news: some non-conformities were fixed, and cool down started down to 80 K, following to the Liquid He part for the following day. The connection to the cold box for cooling to 4 K will be done in two to three weeks (i.e. before Easter). D. Delikaris added that the important milestone of the connection of the 8 m transfer line used for the cool down will be done next week after the authorisation is given. O. Capatina also reported that the RF connection was done, insulation vacuum started to be pumped and the table tested. L. Rossi congratulated the different teams for the hard work to address the last remaining issues especially regarding leaks in a timely manner. Moving back to the presentation, L. Rossi mentioned that for the CE works, the bids were opened and the signing of the contract will be done in the third week of March. He reminded that this is the single most important contract in HL-LHC. Excavations are starting in July, and two pits will be completed by the end of the year, as clarified by L. Tavian. Regarding the 11-T dipole, nominal performance was not achieved by the time of the Chamonix workshop, but now this is solved, with jump above ultimate. A decision should be also made regarding the coating of the matching section. Good news from cryogenics were also reported for P4, with a new baseline based on an upgrade of the existing plant. L. Rossi concluded that there was not strong recommendation from the CMAC and asked for any further comments. In this respect, M. Zerlauth highlighted the presentation of A. Apollonio during the last session on the full energy exploitation study, highlighting that the still open options should not only be addressed for their potential performance increase, but also for additional operational complexity, as failures of these devices will impact the overall machine availability. Following as well the CMAC recommendation from Chamonix, A. Apollonio will soon contact the equipment owners to launch the inclusion of the CCs, e-lenses, etc., into the availability models. L. Rossi agreed and added that we have to make sure that all elements are compatible with ultimate luminosity and ultimate energy operation. Following the question of R. Calaga on the various options, L. Rossi answered that they will be discussed during the next TCC.

Recommendation for electrical protection and safety in HL-LHC underground areas, T. Otto - slides

T. Otto introduced the context of the presentation, which addresses the protection of personnel accessing the machine. A review of the electrical hazards is further given. The Ingression Protection (IP) rating is a two-digit classification of electrical hazards, from 0 (no protection) to high protection. The first digit is for protection against solid devices and the second is for water. After the question of L. Rossi regarding the maximum level, T. Otto answers that it is most probably 7. The philosophy followed for HL-LHC is the same as in the present LHC, where, IP2 (no accidental contact with fingers) and IP3 (no contact with a screw-driver) are considered for low and high voltage respectively. In line with the French standard NF-C18-510, the conductors and metallic parts are not considered to be "nu sous tension". After a question of L. Rossi, T. Otto answers that low voltage and high voltage correspond to below 1 kV and 1.5 kV (for AC and DC, respectively).

Regarding electrical protection against dripping water (condensation, overflow, leaks), there are two options. First, conformity to level IPX1 should be assured. Then, case by case solutions shall be implemented, taking the environment and space into consideration. P. Fessia reminds that at present, protective equipment is not fully specified for all HW, and it may impact integration. Regarding special systems, i.e. non-standard equipment with no IP rating, e.g. 18 kA supplies, sc triplet magnets, current leads, RF equipment, need a dedicated risk assessment. A. Ballarino mentions that already some work is on-going and presented for the current leads. M. Martino points out that the 10 kA power convertors should be also considered special equipment, as they foresee internal energy storage and, depending on the connection technology, additional risks may occur.

The recommendation regarding access for electrical works in the underground area imposes lock out of circuits. The type and amount of works during operation and commissioning is limited (for TS and shut-downs) and proper procedures are needed.

Discussion

L. Rossi asks the category risks and access limitation during a TS in the presence of helium, and T. Otto answers that this will be addressed by the next presentation. M. Zerlauth stresses that people need indeed to access underground areas during the normal run, for interventions. T. Otto gives as example the RF equipment, i.e. tuning the cavities. R. Calaga explains that this depends on the various accelerators, but in general a certain number of operations can be done from the surface but some necessitate access.

Estimation of cryogenic MCI in HL-LHC underground area, T. Otto - slides

T. Otto presented considerations of risks from release of helium, with the help of N. Grada. There are four major failure modes, short/arc and/or quench in the triplet magnets leading to rupture of cryostat, short/arc in the DFX and/or heater failure, short/arc in the SC link or loss of insulation vacuum in SC Link. Following a question by A. Ballarino, T. Otto explains that the rupture of the plug may be harmless but a quench in the magnet side may be a hazard. The most conservative values for the He content and both SC options have been considered and should be further consolidated. A cross section of the UR gallery is shown with the ventilation operating with air handling units mixing the air, i.e. taking fresh air from the surface and exchange air every 40 min, and a smoke extraction system which can handle 18000 m^3/h. During the first failure, 200 kg of helium at pressure of 17 bar will be going out to the DFX, thereby the safety device for the DFX should be able to handle this. The second failure involving a quench of the MgB_2 cable is similar to the fourth failure corresponding to loss of insulation vacuum. A. Ballarino thinks that a quench from a short will be detected, preventing the insulation vacuum loss. P. Fessia clarifies that this is true for a short without an arc. T. Otto explains that this is similar to the third failure scenario considered, which indeed leads to a loss of insulation vacuum. In that case, there is a difference in the flow between the MgB_2 and NbTi (2 versus 4.5 kg/s). The assumptions for the time evolution after a loss of insulation vacuum are based on past estimations and it is shown that the release takes a few sec. A. Ballarino mentions that similar calculations have been performed recently, showing that the event is quite short, with a limited turbulent zone. The helium behavior into the tunnel is further described. The helium mixes with air within a turbulent zone. Knowing the amount of He, the amount of Oxygen can be estimated in the well mixed He-air zone. For MgB_2, there is 24 % of oxygen, but for NbTi it is 18.2 %, therefore very close to the 18 % limit defined for personnel safety. An example of simulations for the SPS CC test is shown, where within 2 s the oxygen content reduces to 8 % at the release location but, at 5 m of distance, it is already at 14% Oxygen. M. Zerlauth mentions that the biocell training indicates that – if a person find him/herself in the immediate vicinity of a leak - one is advised to first move away of the release and then put on the mask. The conclusions and further steps are finally given, with a series of future work for WP6a, safety and WP9.

Discussion

L. Rossi asks about the recommendation for stopping the ventilation system during a helium release. T. Otto answers that this is just an idea, not a recommendation. L. Rossi asks about the documentation of the findings and the timeline. T. Otto answers that a document will be circulated but there is some additional work to be done by WP6a. A. Ballarino clarifies that three months will be needed to finalise the work but this should not prevent the document from being drafted.

Action: M. Zerlauth suggests to come back to the TCC at the beginning of summer for an update of the studies.

Quick update about aC coating during LS2, V. Baglin - slides

V. Baglin gives a short update on the strategy for aC coating during LS2. First, the present baseline is presented. After several discussions and the recommendations following the

Chamonix workshop, a new baseline is being proposed with coating of four magnets, namely Q6 and Q5, right of 2 and left of 8. Between LS2 and LS3, the present baseline is kept but includes now as well the coating of the dipole, quadrupole and CP's electron shields located behind the pumping slots and interconnections of triplets region in LSS1 & 5 (20 in total). L. Rossi asks whether the new type of RF finger can be coated and if LESS could be used for the full RF finger. V. Baglin answers that this needs to be further studied. He comments on the in-situ and ex-situ coatings during LS3, including the Q5 and Q4 in IR1 and 5, recovered from the LHC. L. Rossi asks if Q5 will be taken out of the tunnel. G. Arduini points out that interventions on the beam screens are needed and R. De Maria further clarifies that rotation of the beam screen on both apertures is required for Q5, whereas for Q4 only the beam screen in one aperture needs to be rotated in the present configuration, but anyhow the magnets have to be moved. V. Baglin concludes that a further study needs to be done for the impact on cost and manpower. D. Delikaris points out that the recommendation by the heat load task force was to coat Q6, whereas Q5 is further away and the impact from synchrotron radiation can be decoupled. L. Rossi agrees that this is true based on the difference of heat load but it is important also to understand the phenomenon. V. Baglin agrees and this is why it was asked at some point to coat Q5 during this shut-down. L. Rossi stresses that if the project agrees, most probably LMC will accept this. M. Zerlauth adds that an ECR has first to be prepared. He further asks if a potential EYETS between LS2 and LS3 can used to reduce the work load for LS3. V. Baglin answers that this may be possible, in particular for the matching section. On a question concerning the need to coat also the beam screen of LSS4 and 6 G. Arduini replies that there are no strong arguments for this, as these are adjacent to the sectors with the lowest load and to point 5 where the cryogenics is going to be upgraded. He further asks if it is possible during LS2 to install the magnets to be changed (around 20 dipoles and a few quadrupoles) with a coated beam screen, thereby having 20 times 15 m of the machine coated. L. Rossi thinks that this is a good point and V. Baglin answers that he will follow it up. M. Pojer further asks to consider the coating of magnets close to the ones that are moved.

Update on LESS activity, M. Sitko - slides

M. Sitko presents the motivation for LESS coating, where the laser treatment modifies the morphological properties of the surface. This is a collaboration of CERN with the University of Dundee and STFC. The very first step was the laser treatment for COLDEX (round shape) and then its adaptation for the LHC beam screens (racetrack shape), which are much more difficult for adapting the laser properties due to the focusing of the spot at a varying distance. The components of the treatment system include a green light laser and a beam delivery system, feeding the laser light into the fiber. The last element is a small robot, with a length of 15 cm, developed by General Electric and the Un. of Dundee, allowing in-situ treatment. The accuracy of longitudinal steps of the robot are found to be below 7 µm and moving along the beam screen is ensured by using movable clumps. After a question of M. Zerlauth, M. Sitko clarifies that 7 µm correspond to the accuracy of the structure. B. Di Girolamo points out that the SEY changes with distance. After a question of G. Arduini, B. Di Girolamo clarifies that if the laser grooves are too sparsely spaced, they need to be deeper, which might become an issue for the 50 µm copper coating. G. Arduini further asks if these are transversal grooves and B. Di Girolamo answers positively and adds that there are thoughts for parallel grooves as well, taking the light from a reflector. G. Arduini suggests that, for the dipoles, the critical surfaces to be coated are only the top and bottom. B. Di Girolamo stresses that the fiber can be also engineered for having the proper light distribution. The accuracy of the movement was verified to be quite good and a video is shown with the laser treatment set-up and process. After a question of L. Rossi on the speed of the treatment, M. Sitko answers that it depends on parameters but it is typically 10 cm/hour. L. Rossi points out that a speed of 1-2 m/h is desirable in case coating is at some point considered at a larger extent for the whole LHC arcs. B. Di Girolamo explains that, with a powerful laser, the beam could be split into two fibers. The next steps include the laser parameters' optimization, taking into account the geometry of the beam screen and the experience gained with respect to groove depth versus best SEY. The nitrogen flow is a quite important parameter as well, and the treatment of 700 mm of beam screen will be used to further refine the parameters. The final step is the treatment of a 2.2 m-long beam screen. After a question of M. Zerlauth, B. Di Girolamo answers that a new date for the review of LESS has not been decided yet.

The next TCC meeting will take place on the 8th of March 2018.