58th Meeting of the HL-LHC Technical Coordination Committee – 20/09/2018

Participants: C. Adorisio, A. Apollonio, G. Arduini, V. Baglin, A. Ballarino, F. Bertinelli, R. Bruce, C. Bracco, M. Brugger, O. Brüning (chair), R. Calaga, S. Chemli, S. Claudet, R. De Maria, B. Delille, A. Devred, B. Di Girolamo, P. Fessia, M. Freitas Mendes, J. Gascon, S. Gilardoni, M. Giovannozzi, B. Goddard, A. Lechner, M. Martino, E. Metral, T. Otto, Y. Papaphilippou, D. Perini, M. Pojer, S. Redaelli, F. Rodriguez Mateos, A. Rossi, L. Rossi, F. Savary, L. Tavian, E. Todesco, R. Tomas Garcia, D. Wollmann, C. Wiesner.
Excused: M. Zerlauth.

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

The minutes of the previous meeting were approved without further comments. There were no particular actions. O. Brüning proceeded with the presentation of today's agenda.

Proposal to remove the 120A circuits from the superconducting link + Q1 trim solution – A. Ballarino - slides

A. Ballarino presented a proposal for a change of the current baseline regarding the removal of the 120 A and 200 A cables from the SC link and to replace them by normal conducting powering. The proposed change allows WP6a to resolve technical difficulties in the SC link design (fragility of the smaller wires) and offers several additional advantages, namely the simplification of the cabling process, the replacement of the gas cooled high-temperature current leads with conduction cooled ones, the elimination of the associated protection equipment for super-conducting part of the circuit, the reduction of the number of electrical splices and the simplification of the DFH cryostat. All these changes result in the increase of the reliability of the electrical circuit during operation.
For WP3, the integration of the 120 A and 200 A current leads in the corrector package cryostat is feasible with some extra cost but at the same time, the proposed new solution features also a cost reduction due to the interconnections' work. Following the question of L.Rossi, A. Ballarino answered that the cost refers to the four-lead assemblies as already present in LHC.
For WP9, the integration is also feasible, with some cost saving for equipment and operation.
Regarding WP6b, two possibilities were studied. Case A refers to the positioning of the power convertors (PC) in the UR with no extra cost. Answering the question of L. Rossi, M. Martino explained that this refers only to the PC cost, as the cabling is part of WP17. Case B refers to the position of radiation-hard PCs in the UL of LHC, with some extra cost. This cost includes the four sides of P1 and P5 plus the spares. M. Martino explained that the string test does not need a radiation-hard PC and in any case, the final convertor will not be ready for the string test.
Regarding WP7, the integration is feasible and there is some cost reduction for case A.
For WP17, case B is preferable as the cost impact is smaller and existing infrastructure (cable trays) is used, whereas for case A, the DC cable has to pass inside the vertical shaft and its cross section would need to be increased. Furthermore, the discussions at the TCC underlined

that solution A imposes additional cooling and ventilation needs for the normal conducting cables, that are not yet part of the installation work. Given the current baseline design of the URs, Solution A therefore does not seem to be a viable option at this stage.
For WP15, case A imposes the need of including in the planning the installation of cables, whereas for case B a provision of 25 kCHF/point is included in the cost, in case of need.
Finally a cost evaluation is given, with the main reduction coming from WP6a with a total reduction of 100 kCHF/point. Following the question of L. Rossi for the need of energy extraction for 200 A, D. Wollmann answered positively.
L. Tavian remarks that there is a net saving of 150 kCHF with a conduction cooled cable for case A. A. Ballarino points out that operation and provision are not included in this estimate. Regarding the question of L. Rossi on the cost of electricity, M. Martino answered that this is in the noise of the estimate.
In conclusion, the proposal is feasible and MCF recommended to go ahead with case B as confirmed by F. Rodriguez Mateos, who added that the main problem of case A is the uncertainty for the impact in cooling and ventilation of the shaft. P. Fessia stressed that there is actually no place in LHC for active cooling and the space in the vertical shaft is limited.

Discussion

M. Martino stressed that the proposal to move the 120 A/200 A power convertors in UL is transparent and the system is fully redundant. P. Fessia confirmed that with respect of integration this is feasible, although the proposed solution adds a complication, with three different installations and layouts to deal with in four symmetric locations and a more complex planning.
F. Rodriguez Mateos pointed out that the ECR is written and ready to be circulated by the end of the week. O. Brüning stressed that it would be good to take the decision on the SC link modification by the annual meeting. L. Tavian stressed that only Option A has no radiation issues and thereby fits to the HL-LHC upgrade goal of providing more accessibility for the new hardware. Option B does not have this feature and then the HL-LHC goal for more accessibility of equipment during operation would be lost in this case. M. Martino explained that only two (UL14 and 16) among the four locations have really a radiation issue. In any case, this slight disadvantage is mitigated by having redundant PCs, which reduces the implications of radiation on the machine reliability. However, the issue of limited accessibility remains valid.
Following the question of O. Brüning regarding the decision, F. Rodriguez Mateos stressed that the TCC should decide. But in his opinion there is only one proposal (case B) due to the cooling/ventilation problem in the shaft for case A. L. Rossi felt that although the proposal is acceptable, there is nothing compelling. A. Devred disagreed, as the list of advantages for the SC link is quite important and the system becomes simpler and cheaper. Following the remark by O. Brüning that case A looks like it is not a real option, A. Ballarino pointed out that it is an option but the study from CV is missing and will not be ready within the next few months.

Action: P. Fessia should report back to the TCC with alternative options for placing the 120 A and 200 A power converters in locations that are accessible during operation.

Finally A. Ballarino mentions that the Q1a k-modulation Trim is part of WP3. The powering is local with CLIQ powering leads.

e-lens powering scheme, D. Perini - slides

D. Perini gave an update on the e-lens powering scheme. This is a small hollow cylindric beam of electrons with a central hole opening of 1.8 mm of diameter for interaction with the proton beam halo over a length of 3 m, at injection and collision. Thereby, the size of the ring has to be adapted to the beam size. Following the question of L. Rossi, regarding the possibility to

only use it at flat top, G. Arduini answered that the motivation is to remove the halo at low energy, so as not to have loss spikes at high energy.
As the available space in IR4 is limited, the design is rather compact. The proposal asks in total for two lenses plus one complete spare. The e-lens features a system of SC solenoids cooled at 4.5 K which are used to control the electron beam size and guide its trajectory. The two central solenoids have a field of 5 T and inner bore of 180 mm, whereas the solenoid close to the gun is used to tune the electron ring size and its field varies from 0.2 to 4 T. The size of the electron beam is determined by the cathodes and can be shaped by the applied field along its trajectory. Two additional small solenoids guide the electron beam from the gun to the main beam axis and from the beam axis to the collector after interaction with the proton beam halo.
The magnet configuration includes therefore a total of five solenoids and a few dipole correctors. The need of quadrupoles and the final number of dipole corrector magnets is presently still under study. It is important to finalize the configuration for deciding the number of circuits. A. Rossi mentioned that based on recent simulation from the BINP collaborators, corrector magnets are needed at the gun and at the exit bend to correct the main solenoid misalignment. Following a question of O. Brüning, F. Rodriguez Mateos stressed that there are a lot of open points for MCF, e.g. regarding current ratings, dI/dt's, protection, busbars, etc. D. Perini clarified that only the quadrupole parameters (normal and skew) are not yet specified, and A. Rossi added that it may be possible to use only dipoles. The other open point corresponds to the vacuum chamber diameter, with 180 mm being the nominal value, but there is possibility to reduce it further. Following a question of O. Brüning regarding the technical readiness of the design and recommendation, D. Perini answered that it is possible to reduce this diameter and in any case, the CAD model is parametric. S. Claudet stressed that for example the thermal shield is not scalable. D. Perini answered that with split solenoids at 5 T and inner bore of 180 mm diameter, energy extraction is still needed. For a reduced 160 mm bore, the energy stored is decreased in the solenoids by about 25%. This may still require energy extraction but the situation will be more comfortable.
The next step in priority is to fill the specification table and finalise the study for the reduced aperture.
O. Brüning stressed that it is important to finalise the parameters by the annual meeting. He reminded that the e-lens is considered to be part of an in-kind contribution and a collaborator expressed interest for this. It is thus important that the design is sufficiently solid for making an offer for an external contribution. It would be a pity to get an external commitment for a given design and to have to inform the partner only at a later stage that the agreed design is not acceptable for CERN. Regarding circuit protection, D. Wollmann said that WP7 needs indeed the input parameters to proceed with the simulations, and the approach will be to use existing solutions. M. Martino said that also for the power convertors, the idea is to reuse existing designs for HL-LHC, as much as possible. He added though that even if the circuit parameters are given today, there is no manpower to finalise all specifications by the annual meeting and he would like to have a more realistic deadline. S. Redaelli added that as the e-lens is not baseline, it is difficult to get the required resources from the CERN teams. He thought that it is not necessary to address all points but also rely on the collaborator for finalizing the design. O. Brüning agreed with the principle but stressed that the MCF approval is mandatory. He clarified that this is a full in-kind contribution to CERN specs, as the management did not accept this extra 5 MCHF. A. Rossi mentioned that when meeting BINP colleagues, it was agreed to go ahead with the present design and allow CERN to refine it. S. Claudet reminded that it is important for CERN to be able to operate the built HW.
L. Rossi pointed out that there is some flexibility, as the collaborator needs the green light in order to ask for the budget from national resources. They can commit to a final design in a year. The idea would be to put some specifications with margins and then adapt them when

studies and specifications are finalised. It is important though to know if there are no resources to do this in a year, e.g. because of the manpower engagements during LS2. In that case, the project has to make this clear to the management. O. Brüning concluded that the HW should clearly state if it is impossible to have specifications for the e-lens within a year. In any case, where possible, one should use specifications from existing LHC equipment (e.g. power converter) and it is understood that the external contributions would have to be built according to the CERN specifications.

HL-LHC optics version V1.4 – R. de Maria - slides

R. De Maria started by giving a summary of the changes between optics V1.3 and V1.4. Regarding the present layout in IR1 and IR5, the main changes, already presented in Chamonix 2018, are two instead of four crab-cavities (CC), the reuse of the Q4 and Q5 cold masses and the full deployment of remote alignment enabling the realignment of IP shift and orbit flattening, and thereby reducing the need for orbit correctors. Further changes are being addressed with integration and will be included in a future version.
The CC angle is reduced from 380 µrad to 375 µrad due to Q4-Q5 displacement. The CC angle can be increased if Q7 (double MQM) could function in higher then nominal current. It would be thus desirable to test this magnet up to ultimate current. Following a question of L. Rossi, M. Pojer replied that this magnet is not yet planned to be tested to ultimate current but stated that such a test could be included. O. Brüning proposes to endorse this request for testing of Q7 in the TCC and ask to present this request to the LMC for approval.

Decision: The TCC endorses and recommends to the LMC that the Q7 magnets of IR1 and 5 are tested up to ultimate current.

R. De Maria further explained that there is some small additional gain in the CC angle by optics optimization and ordering of the CCs. It is not actually an integration issue but may be an equipment one. R. Calaga answered that swapping the modules does not seem to be a problem presently. S. Claudet added that this is not yet clear from the cryogenics point of view. L. Rossi stressed that if the gain is small, the change is not viable. O. Brüning suggested to study the implications and not to proceed at this stage unless the additional gain is found important.
The orbit corrector strength needs are detailed. After the clarification of R. De Maria that the design limit refers to the nominal strength, L. Rossi suggested to refer to it like nominal in order to differentiate it with ultimate (which may be indeed a design limit). He further asked if the D2 correctors are at their design limit and R. De Maria answered positively.
There are four non-conform MCBYs, maybe with an internal short, but there is at the moment still enough margin to recover the needed strength with other correctors. It would be important though to understand the origin of this problem. O. Brüning agreed that this is a important question to address for the lifetime of the LHC. L. Rossi stressed that this is part of consolidation. M. Pojer explained that it is not easy to understand, in particular if this is due to an internal short. The problem appears only on a fast discharge. Maybe, a replacement of the magnets can be foreseen, and G. Arduini agreed that this is a valid option. L. Rossi suggested that we should have a good reason to ask this to consolidation (M. Lamont).
A quick recap of aperture estimates is given, where margin is gained from the proposed new remote alignment. The aperture bottleneck is in the triplet and all other elements are in the shadow. Tolerances were further reviewed and WP8 and WP10 should evaluate if a reduction of TAXN aperture could improve the energy deposition. L. Rossi wondered if 2-3 mm reduction of aperture is really important, and G. Arduini answered that the sensitivity is not known.

R. De Maria added that in the case of the masks for the quadrupoles of the matching section the effect of few mm reduction was significant in terms of radiation.

ACTION: WP10 should evaluate if the proposed aperture reduction of TAXN could improve energy deposition.

There is new optics for Point 4 fulfilling all the needs for main instruments and presently checks are on-going from BI for the rest of the instrumentation. Further checks are also needed for the ADT.

ACTION: WP4 should evaluate if the proposed optics in Point 4 are compatible with the ADT parameters for HL-LHC.

Regarding the TCDQ at Point 6, a gap of 4.1 mm is needed to validate the optics. The minimum real gap of 3 mm corresponds to 2.2e11 ppb and A. Lechner confirmed that it can be lowered for reduced intensities. The dependence on emittance is quite weak. B. Goddard stressed that it is not clear if the interlock is feasible. Following the question of L. Rossi about the gain, R. De Maria answered that this impacts directly the β* reach. B. Goddard pointed out that this option should be carefully studied before it is endorsed. G. Arduini stressed that J. Wenninger did a similar study for the Working Group on running scenarios for Run3 and it seems that this option, although it requires studies, it may be possible.

ACTION: The TE-ABT group should study if the proposed TCDQ gap of 4.1 mm is viable.

Regarding the Q5 current in Point 6 and if tests are successful, the optics team asks to operate it very close to what has been achieved at 4.5 K. This magnet will be already tested at the end of the Run2. G. Arduini explained that this is quite close to the quench limit and there may reliability issues when losses occur in Q5, so a careful assessment is needed for not following the upgrade of the magnet to 1.9 K. R. De Maria further explained that this is in particular true for 7.5 TeV when the margin is reduced.
Regarding the optics parameter impact on the beam dump, the bottleneck is in the horizontal plane in IP5. For round optics, both H and V crossing are feasible, with V providing more margin in IP5. For flat optics, the H-crossing in IP5 is necessary. If this is chosen, the use of CCs with flat optics may be limited. Following a question of O. Brüning about the purpose of this scenario, R. De Maria answered that flat-optics with CC can be used in case of intensity limitations. There is also impact of crossing angle plane for forward physics and studies are on-going. G. Arduini asked R. Calaga if H/V crossing is possible for any point with respect to the CCs. R. Calaga answered that the strategy is to make the CC as identical as possible but observed that the design is not completely fixed. For example, spares could be exchangeable but extra equipment may still be required. P. Fessia asked about the timeline for this decision and approval, and L. Rossi answered that this is imminent, for accepting this optics as the baseline. He suggested that this is decided within the next six month, before the CC design is so advanced that further changes to the HW can not be applied.
O. Brüning suggested to approve the new optics for presenting them during the annual meeting, unless there are critical points to be addressed. P. Fessia remarks that the revision of cost and addition of remote alignment will not be ready that soon. O. Brüning stressed that it is anyhow important to approve the optics and get the required feedback for the annual meeting.

LHC dilution kicker flash-overs and impact to the HL-LHC upgrade plans and needs – C. Bracco

The presentation was postponed for the next meeting.

The next TCC meeting will take place on the 4th of October 2018.