31st Meeting of the HL-LHC Technical Committee

Participants: A.Apollonio, G.Arduini, V.Baglin, O.Bruning (Chair), R.Calaga, R. De Maria, B.Delille, P.Ferracin, J.Gascon, B.Di Girolamo, M.Fraser, M.Giovannozzi, R.Jones, T.Lefevre, A.Lechner, T.Otto, Y.Papaphilippou, G.De Rijk, A.Rossi, L.Rossi, L.Tavian, R.Van Weelderen, S.Weisz, D.Wollmann, M.Zerlauth.

Excused: C.Adorisio, V.Baglin, M.Bernardini, F.Bertinelli, S.Baird, L.Bottura, P.Fessia, J.Jowett, M.Lamont.

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

HL-LHC PLC/TC homepage: https://espace.cern.ch/HiLumi/PLC/default.aspx

Indico link: https://indico.cern.ch/event/461411/

O.Brüning opened the meeting highlighting the main actions, as reported in the minutes of the 30th TC. There was an action for a follow up of the radiation dose tests at BNL, regarding the longevity of new collimator materials. A.Rossi mentioned that new measurements are presently carried out at BNL, and the results could be reported by next February. A.Lechner added that in parallel FLUKA simulations studies are being performed to better understand the measurements outcome.

O.Brüning proceeded by introducing today's agenda and AOBs.

Injection considerations for HL-LHC optics, C.Bracco – slides

C.Bracco started the presentation by stressing that the studies were mainly conducted by F.Vellotti, who was not available to give this presentation. After a reminder of the LHC injection system composition, C.Bracco describes the injection protection devices, namely the TDI located at 90deg. vertical phase advance downstream of the MKI, for protection against kicker failures and the TCLIA/B for protection of particles escaping the TDI, due to phase advance errors and showers. The TDI is a 4 m absorber with two vertical jaws and a nominal aperture of 6.8 σ, whereas the TCLIA/B are 1m-long and the present operational half-gaps are 6.8 and 8.3 σ, respectively. The TDI will be upgraded already in LS2, as it will have to withstand the LHC beams following the LIU upgrades towards nominal and ultimate beam intensity and brilliance; the upgrade will be such to be valid as well for the more optimistic HL-LHC beam parameters. It will be composed of three blocks: two made from graphite and 1 with high-Z material (aluminum and copper). The last block's aperture is opened 2 additional mm for avoiding direct impact.

For the simulations, the HLLHC v1.1 optics is used and nominal crossing and separation

schemes at IR2 and IR8. The nominal MKI deflection angle is assumed to be 0.85 mrad. Its strength can vary from 0 to 125% for affecting the injected beam and 0 to 100% (nominal strength) for the circulating beam, with the note that above 20% of the strength, almost the whole beam will be lost on the TDI, due to the high impact parameter. M.Zerlauth asks for the origin of the 25% excess kick. J.Uythoven answers that the additional 25% represents a failure of the last kicker resulting in a reflection which will for this kicker amplify the kick strength to 200% due to e.g. a flashover.

The beam envelope is tracked with MADX and a new routine allowing the interaction with collimators (PYcollimate), for the different MKI strengths (11% of the nominal for beam 1 and 9.5% for beam 2) and three scenarios with respect to the collimator gaps: Scenario 0, with nominal half-gaps of 6.8 σ_y; Scenario 1, with TDIs opened at one extra σ (7.8 σ_y) and finally; all collimator half-gaps at 7.8 σ_y (scenario 2). All studies are done for a normalized emittance of 1.37 mm.mrad, which corresponds to the worst case scenario for damage (BCMS beam). The loss maps for all three scenarios clearly show that, within one turn, most of the impact of the escaping particles is towards IR7 for both beam 1 and beam 2. Some of the halo escapes towards the arc. The maximum amplitude escaping the protection system with intensities above the safe beam flag ($5x10^{11}$p) is 7 σ_y in the vertical plane. In the horizontal plane, there is an unlucky phase advance that the beam core could escape completely the TL collimation system. The maximum amplitude escaping the TL collimators with intensities above the safe beam flag is 7.4 σ_x (as compared to the minimum magnet aperture of 9.07 σ). Including tolerances (1.5 + 1.5 σ for orbit and injection oscillations, 10% beta-beat and dispersion beat of 40 %), results in a total of 10.3 σ_y and 11.05 σ_x. In conclusion, the current settings of the injection protection elements guarantee the loss localization in the injection region in case of MKI failure. Extra simulations are necessary for evaluating the impact of the escaping halo on the TCLIB due to the high load.

Discussion

R.de Maria points out a likely typo in the tolerance for the dispersion variation, which should be 14% rather then 40 %. After the meeting, C.Bracco confirmed that in the simulations a value of 14 % is considered. In addition, the orbit tolerance should be equal to 4 mm. M.Giovannozzi stresses that the tolerances were reviewed at top energy and the same exercise should be done also for injection. G.Arduini adds that a similar document as for top energy should be issued, reviewing tolerances based on run1 experience for injection. O.Brüning stresses there should be a general agreement in the used tolerances and parameters. M.Zerlauth questions about the expected alignment tolerance of the new TDI, which for the present one is 1 σ. J.Uythoven answers that for the time being it is kept as it is, although the new device is expected to allow for more precise alignment. G.Arduini enquires to what the δ_p parameter of $0.6x10^{-3}$, corresponds. R.de Maria thinks that this is the maximum energy deviation, with the rms energy spread of $0.4x10^{-3}$ and an extra $0.2x10^{-3}$ for the energy error.

J.Uythoven requests that the optics should not undergo further major modifications as they would like to proceed with the design of the equipment. O.Brüning stresses that the only real constraint is the phase advance, beam sizes are secondary. C.Bracco mentions that the β-

function in the TDI should not be too small since this would translate into more strict requirements on the mechanical tolerances. R.de Maria answers that the optics is indeed quite fixed, but the presented simulations should be re-done with the latest HL optics version. L.Rossi asks why the design should be frozen at this point, as the delay of LS2 gives an extra year margin. J.Uythoven answers that for the nominal HL-LHC everything seems ok, but for very small emittances (i.e. BCMS beams), the damage limits may be tighter and this can only be settled after additional material tests. G.Arduini points out that, in any case, there is not a lot of liberty for changes right now as compared to the present HL-LHC optics, which also means that it will be difficult to fulfill any addition demands.

Finally, L.Rossi informed the TC that J.Uythoven is stepping down as a WP14 leader and C.Bracco is taking over. On this occasion, he thanks, on behalf of the whole project management, J.Uythoven for all the excellent - and very collaborative - work done in setting up and leading WP14.

Beam dump constraints on HL-LHC optics, M.Fraser – slides

M.Fraser introduces the LHC Beam Dump System (LBDS) by giving a schematic overview and further detailing the different protection devices. Initial studies have been made by A.Lechner (LMC of 15/07) for the LHC ultimate, nominal and BCMS of run2. Studies for HL-LHC in FLUKA and ANSYS have not yet been done due to the lack of resources. A.Lechner explains after a question of L.Rossi that the ANSYS simulations are quite heavy and they are under the responsibility of EN/STI. In fact, the team is quite busy with LIU work. J.Uythoven explains that the injection renovation was scheduled for LS2, whereas the dump work should be completed after LS3, so it is normal that until now, this was considered with lower priority.

The proposal is to study the worst case beam size at each location for HL-LHC v1.2 optics. By the end of June 2016, there will be completed studies, revealing if the present layout of IR6 is adequate or if there is need for replacing elements or additional protection (e.g. mask on Q5).

A type 2 erratic event is now considered, which allows very fast current jumps, for which the larger fraction of the beam can impact the TCDQ. This event although observed during high-voltage conditioning, never occurred with beam, and discussions are on-going with TE/ABT for mitigation measures.

Regarding the main dump block TDE and window, the run2 (BCMS) study revealed that intensity is more critical than emittance. The sweep speed is slower in the vertical direction and dilution failure scenarios become more critical. Presently, two horizontal and two vertical failures were considered. This may need reconsideration for HILUMI. L.Rossi asks if the emittance plays any role. A.Lechner replies that the intensity is the main driver, the different emittance scenarios differ by less than 2 %. G.Arduini asks whether there is a different dependence on emittance at 7 TeV with respect to 0.45 TeV. A.Lechner replies that this is mainly due to the different showers. L.Rossi wants to stress that it is important to study the dilution kicker failure scenarios and protection issues as a function of the energy, as the actual energy limit is not yet known for LHC.

Regarding the TCDS, the main issues are the vertical beam size (horizontal sweep)

independent of the type of MKD erratic. For the TCDQ, the main issues are the re-triggering time, the vertical beam size and the overall beam intensity, in case of an asynchronous dump. In principle, the device could be moved with the squeeze but the interlocks should be upgraded, and there may be a horizontal beta optics constraint, as the intercepted intensity decreases exponentially with distance. This is OK for run2 (BCMS) with the TCDQ at 9.1 σ but it should be reviewed for HL-LHC.

O.Brüning asks if this is brightness dependent. A.Lechner answers that the plots are done for BCMS of run2 but they will be the same qualitatively for HL-LHC, simply scaled for the intensity.

Regarding the optics constraints, the Q4 gradient is fixed, as well as the horizontal phase advance of 90 deg. between MKD and TCDQ and the optics at the MKD. There are no studies yet for TCDQ, TCDS and TDE. A.Lechner thinks that these studies will be ready by June 2016.

In conclusion, FLUKA/ANSYS studies are ongoing to identify the limits of the protection devices in the dump area. Depending on results, analysis and discussion of mitigation scenarios, conclusions will be presented before the end of June next year. At present, and apart of the replacement of the TCDS, no other elements (nor the addition of dilution kickers) are in the WP14 baseline.

Discussion

L.Rossi asks when there will be an answer about the need for any additional dilution kicker. A.Lechner says that this will be also known by next June. O.Brüning asks if the optics is finalized. R.de Maria answers that they should be considered close to final, as during the last iteration, the changes accommodated made the optics already quite constrained. After the study, if one observable can be changed, there may be the possibility to accommodate it, but several changes can not be easily satisfied. G.Arduini adds that it is important to include the information concerning the optics with optimized phase advance studied by S. Fartoukh. The information concerning the value of the beta functions at the protection elements is needed to finalize the optics although as reminded by R. De Maria the tunabilty is very limited. O.Brüning asks if a decision for the two MQYs in Q5 should wait until next year. R.de Maria noted that doubling Q5 (two MQYs) is the option presently considered in the optics version HL-LHCv1.2.

Action: An update of the beam dump studies should be given by the end of next June.

Baseline Ion Parameters for HL-LHC, O.Bruning – document

O.Brüning presents the update of the ion parameters, which can be found in the PLC web-page. Now there are two columns, corresponding to the required parameters by HL-LHC and the ones reflecting the LIU baseline. There are also two additional rows with emittances at injection and collision and two rows for intensities, showing its degradation during the cycle. There is indeed a factor of two difference in the integrated luminosity. This is the basis to be discussed further in Chamonix for understanding of how to gain this missing factor of two. L.Rossi asks if the kicker upgrade in the SPS is included. O.Brüning answers that this should

not be the case, as it is not in the baseline. J.Uythoven agrees, but then the 50 ns bunch spacing in the SPS is not possible. This parameter should be reviewed. After the meeting, the list has been reviewed, updated and approved by S.Gilardoni, D.Manglunki and J.Jowett.

The TC members are invited to consult the updated table on the PLC webpage.

AOB

L.Rossi has a number of announcements: A second cost and schedule review will take place most likely between October 17th-19th 2016. Probably at the beginning of October, an ECFA meeting for the detector upgrade will take place. A review of all HL-LHC circuits will take place between 21-24 of March 2016. WP2 should be also involved for the specifications. A review of the 11 T dipole will take place on 4-8 of April 2016. It seems also that the LARP meeting will be moved with respect to the date announced during the HI-LUMI meeting of October. Most likely it will be on 18-20 of May at SLAC. On 23-24 of May, there will by a D1 review at KEK followed by a MQXF review, on 7-10 of June 2016.

Finally, L.Rossi will organize a discussion with all WP leaders and I.Bejar-Alonso, to renew the WPs description and mandate. On the 14th of January and during a common long (~3h) TC, the provisionary baseline should be confirmed along with a PBS review. This meeting should start earlier, e.g. at 14:30. M.Zerlauth reminded that the summary of the CC review by A.Yamamoto is also scheduled for this date.

Next TC on the 3rd of December.