Minutes of the 71st WP2 Meeting held on 28/06/2016

Participants: G. Arduini, X. Buffat, F. Van Der Veken, J. Jowett, E. Métral, L. Medina, G. Sterbini, B. Salvant, G. Iadarola, Y. Papaphilippou, D. Pellegrini, R. Tomas.

Minutes, Follow-up of Actions, General Information (Gianluigi)

Minutes have been approved without comments.

John proposed $\beta^* = 1.5$ m for p-Pb in LHCb for the 2016 run, so that this value can become a reference for the HL-LHC operation. This needs to be discussed with the coordination committee. The point has already been raised with Lucio.

Gianluigi has contacted Oliver concerning the definition of the nominal bunch length. This will be discussed initially between WP2 and WP4. Elias is in contact with E. Shaposhnikova. A dedicated meeting will be organized together with WP4.

Updates on the operational scenarios (specifying parameters like required chromaticity and octupole strength) are going to be provided **by Elias and Yannis** by the end of September. These should take into account the lessons learned on the LHC so far and spelling out the possible assumptions (e.g. presence or not of electron cloud in the dipoles).

Rogelio is following-up with Ezio the issue of the magnetic flux jumps seen in the 11T dipoles and triplets. This behaviour is observed not only below the injection field strength, but also at higher fields. We need to understand the tolerance to main field errors but we need information on the impact on and higher order multipoles as well.

The presentation of Frederik has been updated to include the parameters considered for the simulations.

Elias raised the attention to the studies performed by Tatiana et al. on the possibility of using octupoles to compensate long-range beam-beam long in HL-LHC and suggested to organize a presentation from Tatiana in a future WP2 meeting. Gianluigi noted that the magnetic errors should be included as well in the studies and asked that these studies be presented in the beam-beam studies working group first.

Gianluigi briefly summarized the presentation given by Lucio at the last HL-TCC: the HL-LHC project has been approved. A series of modifications to the baseline have been identified to keep the cost within the approved envelope of 950 MCHF with a limited reduction in performance. Among them:

- Only two crab cavities per IP per beam per side will be installed;
- The replacement of Q4 with a MQYY will be postponed and initially Q4 will be equipped with a MQY magnet;
- Some cost reduction measures have been identified for the triplets (e.g. laminations);
- The review of the powering of the triplet has entailed some cost reductions

In general, all the systems will be designed for nominal performance and possible performance beyond nominal will only come from engineering margins. The reduction of the cost of the civil engineering resulting from the above modifications is being evaluated.

Gianluigi reminded that the reduction in performance resulting by halving the number of crab cavities is limited as initially the number of crab cavities considered in the nominal scheme was larger (by one unit) as compared to the minimum required to obtain the full compensation of the nominal crossing angle with the nominal voltage. The margin was initially foreseen to compensate for the potential limitations on the maximum voltage and to leave open the option of the crab crossing for pile-up density reduction. The above modifications will imply a reduction of the integrated luminosity if a limit on the maximum pile-up density is imposed demanding for levelling based on pile-up and pile-up density. The total reduction in integrated luminosity in this case is of the order of 10% as compared to the previous nominal scenario that was also assuming tighter tolerances and therefore larger beam clearance for the beam in the triplet.

The reduction of Q4 aperture affects particularly the minimum β^* achievable with flat optics. The SPS crab cavity tests and the tests of a wire long-range beam-beam compensation already planned will continue as initially scheduled.

During the HL-TCC meeting, WP2 confirmed that there is no need to change the position of Q6.

A solution has been found for the integration of a BPM between Q1 and Q2 in a position sufficiently distant from a long-range encounter permitting to have accurate reading of the beam position. Now all the BPMs in the triplet area are conforming to the requirements and the initially redundant BPM located in the experimental cavern will be removed simplifying considerably the integration in that area.

Heat load estimates for the Long Straight Sections of the HL-LHC (G. Iadarola)

The aim of the presentation is to review the estimates of the beam-induced heat loads in all the sectors and to pin point potential bottlenecks and the needs concerning the coating of the beam screens.

Beam-induced heat loads are dominated by electron cloud and impedance contributions. The contribution of synchrotron radiation should be small, but it would be important to know whether there are potential 'hot spots'. Elias noted that Roberto Kersevan has made estimations of the heat load due to synchrotron radiation. They have been presented at IPAC14 and IPAC15. Gianluigi noted that it would be important to ask Roberto to present at one of the WP2 meetings.

Gianni did detailed evaluations for all the beam screens. The impedance contributions take into account beam screen temperature, magneto-resistance and weld resistivity.

A database of simulations has been built as a function of the following parameters:

- bunch population
- SEY
- various field configurations

Rather conservative but realistic assumptions on the beam parameters have been made for the HL-LHC beam parameters. Based on the 2015/16 experience it has been assumed that electron cloud saturation occurs on each train after 30 bunches. Gianluigi asked whether this source of uncertainty could be lifted by simulating a full LHC turn. Gianni replied that for the time being the detailed SEY model is the main source of uncertainty and additional laboratory measurements would be very useful.

Gianni prepared an additional summary document providing the expected contributions to heat load due two electro cloud for two values of the SEY of 1.1 (maximum value expected for a-C coated surfaces) and 1.3 (minimum value of the SEY expected for scrubbed surfaces). The expected current value of the SEY lies between 1.3 and 1.4 when the measured heat load is compared with the expected values of the heat load as a function of the SEY for quadrupoles, dipoles and different beam screens in the LHC. An issue with octagon apertures in the MADX files was spotted and corrected. Gianni set up a mostly automated procedure to scan various components.

The study has revealed the following main points:

- The heat load in dipole correctors is not negligible;
- Heat load due to electron cloud is the main source of heat load for SEY=1.3
- The heat load in a-C coated surfaces in the straight sections reduces by at least an order of magnitude the heat load due to electron cloud.
- The impact of the bunch length on heat load is expected to be small.

The matching sections around the four experiments are the most critical areas. While new cryogenic plants are going to be installed around IP1 and IP5, no upgrade is foreseen for IP2 and IP8. Coating of the beam screens of the elements of the matching section is recommended. Gianluigi noted that the values should be transmitted to S. Claudet for their feedback. **Action: Gianni.** He also noted that it might not be desirable to coat elements close to the injection kickers. Gianni noted that a strategy for the scrubbing and intensity ramp up would have to be defined and noted that hybrid schemes could be used for that.

Gianni noted that there is presently a discrepancy between the HL-LHC Q5 magnet length in point 6 and the present length of the cryostat in point 6. Gianluigi replied that so far it was foreseen to install an additional MQY for each of the two Q5 magnets in IP6 but this option has now been abandoned as the MQY magnets in IP6 will be operated to 1.9 K (the need for that is still to be confirmed in particular with the increased β*). The present baseline foresees a single MQY for each of the Q5 magnets in IP6.

Gianluigi concluded that, pending confirmation from WP9 coating of the triplets and matching section beam screens will be required in all the experimental interaction regions.

Reported by Dario, Gianluigi and Rogelio.