Minutes of the 132th WP2 Meeting held on 02/10/2018

Participants: S. Antipov, G. Arduini, X. Buffat, R. Corsini, R. De Maria, D. Gamba, M. Giovannozzi, G. Iaddarola, S. Fartoukh, S. Kostoglou, N. Mounet, A. Oeftiger, Y. Papaphilippou, F. Plassard, K. Skoufaris, G. Sterbini, R. Tomas, F. Van Der Veken

AGENDA:

1 GENERAL INFORMATION (G. ARDUINI)

The minutes of the previous meeting have been circulated and will be reviewed at the following, 133rd meeting.

2 FLAT OPTICS FOR (HL-)LHC (S. FARTOUKH)

For the normal HL-LHC assumptions the integrated yearly luminosity is between 250 and 320 fb^{-1} for 5x10^{34} (Standard OP scenario) and 7.5x10^{34} (Ultimate) levelled luminosity. The HL-LHC baseline 250 fb^{-1} is achieved for a virtual luminosity of 16.9x10^{34}, whereas for a flat optics a similar yearly luminosity can be achieved for a smaller virtual luminosity in Run III. Overall, it seems inefficient to design the machine for a virtual luminosity more than 250% of the levelled luminosity.

A scan of virtual luminosity reach vs β* reveals that the flat optics gives room for increasing the levelled luminosity to a level of 10^{35}. Without the crab cavities (CCs) the virtual luminosity saturates at 8.5x10^{34} for round optics while it can be further increased to 15x10^{34} for the flat optics. With CCs the limits are 17.2x10^{34} for the round and 25.2x10^{34} for the flat optics.

Concerning the data quality, the flat optics allows keeping the pileup below 1.5 evt/mm (within 50% of the baseline) without the crab cavities, while for the round one the pileup density exceeds 2.0 evt/mm as one goes through the squeeze. With the flat optics one can increase the β^* aspect ratio while keeping the normalized crossing angle constant.

A long range beam-beam correction (BBLR) is important to achieve a 10 σ crossing angle (i.e. 280 μrad for a β^* ratio 40/10 cm). The correction can be done either with a wire or with octupoles. The wire can act on all the driving terms and provides and efficient compensation up to a β^* aspect ratio of 4 and a normalized crossing angle of 9.7 σ. Octupoles correct only the 4th order driving term, the current needed critically depends on β^*, bunch intensity, and the effectiveness of the telescope ATS. At a β^* aspect ratio > 4, the octupole current is at the limit or exceeds the hardware limit, even with the telescopic index above the strict minimum required to build the optics: without the CCs 1210 A (for the Standard) – 1480 A (for the Ultimate) needed; with CC 390 - 470 A needed for min telescopic index. The figures reduce for the maximum telescopic index, but without the current need without the crab cavities still exceeds 570 A.

The highlights of MDs show a demonstration of the first train collisions with flat optics with 60 bunches of 10^{11} ppb. A naïve scaling suggests a luminosity of 2.5×10^{34} for 2548 colliding bunches of 1.15×10^{11} ppb. The BBLR MD with negative polarity octupoles showed that the mitigation is necessary in order to achieve a good beam lifetime. With the long-range interaction compensated the lifetime stayed at the burnoff limit – around 20 h.

- **Riccardo** raised a question if the 10^{35} luminosity is being discussed. **Rogelio** suggested the coming Annual Meeting could be a good place to open a discussion. **Gianluigi** suggested emphasizing that the flat optics with CCs could help pushing the integrated luminosity towards ultimate and beyond.
- **Rogelio** questioned the need to couple the flat optics with BBLR. **Stéphane** pointed out the BBLR either with a wire or with octupoles is a key ingredient. **Riccardo** asked if one would still chose flat optics without the crab cavities. **Stéphane** replied one needs to look at the MD results. **Riccardo** asked if there is a target for the pileup density. **Rogelio** replied there is currently no such target.
- During a discussion on the achievable β^*, **Riccardo** pointed out that the calculation does not account for the for triplet tolerances, in particular for the β-beating, which is assumed to be up to 20% in the HL-LHC baseline and stressed that this assumption has to be explicitly mentioned. **Stéphane** pointed out that in MDs, and in general the β-beating has never been negative at the IP (inducing smaller β^*), i.e. positive in the triplet (increased β_{max}), especially for telescopic optics, and therefore should not be counted twice for the β^* reach. He further insisted that the main reason preventing the 10 cm β^* reach in HL-LHC is not so much the tolerances for optics distortion but mainly the relaxed collimation and machine protection hierarchy compared to the Run II settings, for which there are ingredients for improvement. **Stéphane** emphasized the way the tolerances changed significantly over the past years, allowing to lower the margins, hence it makes sense to compare the physical limitations (coming from the aperture restrictions and optics feasibility), leaving the tolerances aside. **Riccardo** noted that the 10 cm β^* seems optimistic, while the baseline 15 cm ultimate β^* is the one that can surely be provided. **Gianluigi** summarized it has to be mentioned explicitly that what is studied is not the baseline, it also needs to be said the protected aperture in the LHC design was smaller, the tolerances have improved based on experience. For HL-LHC the assumptions for the tolerances have been based on the LHC experience (e.g. for orbit) but given the increasing difficulties in the optics measurement and correction going to smaller β^* the tolerance on beta beating has not been reduced.

- **Stéphane** had to leave for another meeting. The participants are welcome to send their comments or questions regarding the talk directly to him via email.

ACTION (Stéphane): Modify the talk, taking into account the comments: compress the presentation, emphasize the assumptions made, and focusing on the potential for a further push of the luminosity.

3 EFFECT OF CIVIL ENGINEERING WORK ON LHC AND IMPLICATIONS FOR HL-LHC (D. GAMBA)

Davide presented a draft of his talk for the Annual Meeting. Some results are preliminary and show the work in progress. The key assumptions made are (1) uncorrelated ground motion along the whole machine, which leads to (2) low frequency closed orbit variation. Both LHC and HL-LHC parameters are studied. The scope of this work is limited to the transverse plane only.

Estimates show that the HL-LHC will be about 2 times more sensitive to ground vibrations than LHC. The most sensitive quadrupoles are the triplets in IP1/5. For LHC the ground motion is predicted to amount to around 1% luminosity reduction, which means ~2% for HL-LHC via scaling.

Ground motion spectral data is taken from geophones installed at IP1, 5 and on the surface. Oscillations of the order of 1 µm shows up readily the instrumentation. The data is logged and can be used to issue warnings. An example of system usage – on 30.08.18 a warning from EN-MME stopped the excavation works: the ground motion caused by the works produced a noise that exceeded the stop level in the frequency range around 20 Hz.

Some activity has been logged in Oct-Nov 2017 and during 2018; the data suggests an impact of the order of 1% on the luminosity, as expected. In the example fills 6757 and 6919 luminosity decrease and beam losses were observed that are correlated with the ground motion. From the noise levels the expected luminosity loss is around 1%, consistent with the logged luminosity data. CMS seems more sensitive to ground motion than ATLAS. A few 10^{-5} losses have been measured, an investigation to correlate them with orbit jitter at collimators is under way.

- Regarding the assumptions made for the estimates, **Gianluigi** asked if the motion is assumed to be uncorrelated for different magnets. **Roberto** confirmed, noting that measurements show that the correlation length is shorter than the distance between the quadrupoles of the triplet. **Roberto** also mentioned that since an uncorrelated motion is assumed, the directionality of the sensors is irrelevant. **Riccardo** asked if the impact of the motion in the crossing over plane on the luminosity is taken into account. **Davide** replied that for the luminosity loss it only matters what happens in that IP, therefore motion in only one plane is assumed. **Gianluigi** suggested making an explicit list of assumptions made and summarize the results in a plot showing expectations towards observations
- **Gianluigi** asked why the frequencies around 10 Hz seem more critical than the others. **Davide** replied they are close to the resonance of the triplet. **Sergey** suggested showing the integrated effect of ground motion instead of many lines for different bands for the luminosity loss plots. **Roberto** mentioned there is only one band that is really relevant due to amplification of the magnet – it is 20-40 Hz.

- **Rogelio** inquired why the luminosity scale is different between CMS and ATLAS. **Davide** replied the absolute value is irrelevant, it is the shift that is important. **Gianluigi** suggested emphasizing this fact.
- **Gianluigi** inquired if it is possible to have an automated trigger for data logging on geophone events. **Xavier** suggested Tom Levens would be the person to talk to.
- **Gianluigi** inquired if the maximum acceptable triplet transfer function for HL-LHC can be estimated. **Roberto** replied one needs to make an assumption on the excitation spectrum. Maybe it is possible to take a typical excitation spectrum from the observation data. For the Annual Meeting, **Gianluigi** requested compressing the talk and focusing on the main message: the model (rough as it is) explains the experimental data to a decent precision, an important element of the model is the amplification factor, it needs to be measured to obtain predictions for HL-LHC.
- **Rogelio** asked if the tune can change as a result of the ground motion. **Davide** replied the sensitivity needs to be checked. **Rogelio** suggested providing the data on the tune jumps under investigation.

ACTION (Davide): Investigate what type of instruments it is possible to collect data from on a geophone trigger.

ACTION (Davide, Roberto): Estimate the maximum acceptable triplet transfer functions for HL-LHC.

ACTION (Davide, Rogelio): Check the possibility of an effect of ground motion on the tune.

ACTION (Davide): Modify the presentation accounting for the comments.

4 ROUND TABLE

Riccardo presented the functional specification for the HL-LHC BPMs at the WP 13. A small working group will be created after the Annual Meeting. Within six months it is foreseen to converge on the BPM design.