Minutes of the 133th WP2 Meeting held on 09/10/2018

Participants: S. Antipov, G. Arduini, J. Coello De Portugal, I. Efthymiopoulos, M. Giovannozzi, G. Iaddarola, S. Fartoukh, N. Karastathis, S. Kostoglou, E. Métral, A. Oeftiger, Y. Papaphilippou, F. Plassard, A. Poyet, K. Skoufaris, G. Sterbini, R. Tomas, F. Van Der Veken

AGENDA:

1 GENERAL INFORMATION (G. ARDUINI)

The minutes of the 131st meeting have been approved. The minutes of the previous, 132nd meeting have been circulated and will be reviewed at the next meeting.

2 EXPERIMENTAL DATA QUALITY (R. TOMAS)

The goal of the talk is to provide an update on the experimental data quality. In 2017 a figure of merit has been defined - effective pile-up (PU) density, which allows estimating detector performance. In 2018 a Machine Report has been published summarizing the issue.

In general, the detector efficiency reduces with the PU density. The simulations of the effect for different physics cases have not been finalized yet. With a fine timing resolution CMS can reduce the dependence of charge isolation efficiency on the PU density. ATLAS does not have this problem due their design. For ATLAS the muon isolation efficiency reduces linearly with PU density.

For the baseline (round) optics the effective PU density is 0.79 with the Crab Cavities (CCs) and 1.55 without for the Nominal OP scenario and 1.2 (2.13) – for the Ultimate. A flat optics with CCs allows increasing the integrated luminosity by 2-4% while keeping the PU density at the same level as the round one. Without CCs the flat optics allows regaining the target luminosity figures: an integrated luminosity between 249 and 293 fb^{-1} is foreseen at an expense of a 20-30% PU density increase with respect to the baseline. A further improvement is possible with a wire or octupole beam-beam compensation.

Non-colliding bunches can differ from the colliding ones by intensity or emittance, if required for maximizing the integrated luminosity. There is no strong opposition to have different parameters.

A combined β^* and offset levelling scheme allows reducing the number of optics to commission by a factor of five. The scheme received no objections from the experiments. It is compatible with emittance scans, provided they are done one IP at a time in order not to compromise beam stability.

A large bunch-to-bunch luminosity variation has been measured both in ATLAS and CSM. The distribution is close to Normal with the rms spread of 7.5% in ATLAS and 8.7% in CMS. So far the detectors have been accounting for a $\pm 5\%$ flat distribution, which is an underestimate. While the larger spread is presently not a concern for the experiments is a potential issue to study.

- **Ilias** pointed out that instead of quoting different parameters one has to look at the luminosity and check at a real physics case – the PU can be more important that the PU density.
- **Rogelio** raised a question if a question about the flat optics becoming the baseline should be expected. **Gianluigi** replied that for the moment it remains an option, the flat optics can potentially boost the performance, but requires further research, in particular in beam-beam compensation and for that it would be good to see the results of the ongoing simulations. **Rogelio** pointed out that the flat optics can work without the compensation with a lower crossing angle. **Yannis** noted that while this is correct from the performance point of view, the irradiation of the triplet would likely go down. Roughly, a 10 μrad reduction of the angle leads to a 10% increase of the triplet lifetime.
- For the non-colliding bunches, **Elias** inquired what the conclusion is. **Rogelio** replied that on the experiments' side there is no strong opinion **Elias** pointed out that the presence of these bunches limits the flexibility in octupole and chromaticity settings. **Rogelio** proposed that the intensity of the bunches is reduced and emittance increase could also be brought to the table. **Gianluigi** raised a question is such a change is needed. **Ilias** commented that the experiments would prefer a lower intensity for compensating the background. **Rogelio** proposed a summarizing that in the present baseline a change of parameters of non-colliding bunches is not requires, but it may be useful in the future to win some margin.
- Regarding the luminosity variation, **Gianluigi** noted that the present assumption by the experiments would imply only a ±2.5% variation of bunch intensity for a constant emittance. In reality, the variation of bunch intensity is likely to be larger due to electron cloud. **Gianni** mentioned that the injectors provide a 10% variation of bunch intensity by design and asked if this tolerance should be tightened. **Elias** recalled that in the past the figures of 10% variation of bunch intensity and 20% for longitudinal and transverse emittance were given. **Rogelio** proposed checking the issue with the injectors.

ACTION (Rogelio): Highlight the issue of the larger luminosity variation and check the tolerances on beam intensity and emittance with the injectors.

3 EFFECTS OF FLUX JUMPS ON EMITTANCE BLOW-UP (J. COELLO DE PORTUGAL)

A flux jump is an unstable behavior exhibited by all type II SCs, it appears as a fast (of the order of tens of ms) error in the magnetic field. In LHC flux jumps happen in the first half of the Ramp. They produce random kicks on the beam impacting its emittance.

A simulation of the effect of flux jumps on beam emittance has been performed. It assumes only one IP – IP1 with all the quadrupoles equally likely to be affected by flux jumps. The magnitude of the field jump is assumed to be 30×10^{-6}, which corresponds to the highest jumps observed (at Injection). A 2.5 μm normalized emittance is assumed. The simulation results show the flux jumps are much more critical at a higher energy than at injection. In the worst case scenario - Vertical plane and 3.2 TeV energy less than 1000 jumps in the IP yields (to be divided by 12 if the effect is uncorrelated among quadrupoles of the triplet) a 1% emittance growth.

- **Gianluigi** suggested assuming a more realistic smaller emittance that would be present in the beginning of the ramp, pointing out that the situation should become more critical; it is especially important for the BCMS beam. **Elias** recalled that for the BCMS beam the normalized transverse emittances are 1.8/1.7 (Hor./Ver.) μm at Injection and 1.9/1.7 in the beginning of the Ramp.
- **Gianluigi** inquired how likely the quoted 1000 flux jumps in an IP are. **Rogelio** replied it is hard to tell: first, there is no data how many flux jumps actually happen in the middle of the Ramp, second, the worst magnitude is assumed for all the jumps in the simulation. **Rogelio** suggested quoting a number of jumps per magnet that could be more intuitive for the experts. **Gianluigi** raised a question about the 11 T magnets. **Rogelio** replied they have not been studies yet, and suggested to do it. **Guido** asked whether a test to search for a correlation between a flux jump voltage and the magnet's magnetic field is planned. **Rogelio** answered that a similar test is ongoing in SM18.
- **Sergey** suggested cutting the amount of formulas in the slides. **Rogelio** supported the idea and proposed emphasizing on the main conclusion that follows from the equations – that the quadrupolar kick can be ignored.

ACTION (Jaime): Update the simulation results for the worst case scenario of the BCMS beam with a 1.7 μm normalized emittance

ACTION (Jaime): Extend the study to the 11 T magnets.

4 EXPERIMENTAL TESTS FOR BBLR COMPENSATION WITH WIRES IN THE LHC (G. STERBINI)

Guido began by demonstrating the principle of wire compensation. In theory, with only two symmetric wires one can compensate all the resonance driving terms. With realistic constraints on wire location and beam-wire distance, only a subset can be suppressed however. In LHC, a 1-m-long prototype is embedded in a jaw of a collimator. Due to the unideal location and constraints on beam-wire distance one can address only two Resonance Driving Terms (RDTs). The first order amplitude detuning terms (4,0) and (0,4) have been chosen for compensation. Tracking studies are needed for tuning of optimal position and current of the wire.

Results of five MDs are reported. First, a clear improvement of the lifetime is observed with 2 wires in IR5. Second, the initial testes with 4 wires (2 per IP) have been performed with a blow-up emittance. The results indicate that the situation with only IR1 wires ON is worse that with only IR5 because the location of the wires in IR1 is further away from the ideal. With a standard emittance the effect of wires on the beam lifetime is small but still visible. Then, a crossing angle variation has been studied. An improvement has been observed for half crossing angles from 130 to 150 μrad. Although the wires are optimized for 150 μrad, there was a clear effect in the suboptimal conditions. Finally, a compensation with trains has been tested for the first time. The signals from diamond Beam Loss Monitors (BLMs) were compatible with a reduction of losses on the BBLR bunches.

- **Stéphane** inquired why in the test with two wires in IR5 the witness bunch did not suffer. **Yannis** explained that the full BBLR compensation is not achieved in the experiment. **Guido** added that the inversion has only been observed with 4 wires, where there was a small negative effect on the head-on bunch.
- **Gianluigi** asked why in an MD the burnoff limit is never reached. **Stéphane** replied that the wire compensation technique has a limit due the 1/r nature of the field.

5 SIMULATION OF WIRE BBLR COMPENSATION IN HL-LHC (K. SKOUFARIS)

Long range beam-beam (BBLR) interaction can reduce the Dynamic Aperture (DA) when the beams are brought into collision, by more than 3 rms beam size (σ), according to numerical studies. It is therefore attractive to try compensating the BBLR. The idea of compensation with a wire comes from the fact that the field of a wire matches that of BBLR at large distances, above 2 σ. An extensive simulation campaign has been performed to identify potential benefits of wire compensation. The simulations focused on scanning the wire current and the wire transverse position to find the parameters giving the maximum gain in the DA. The most recent v1.3 HL-LHC optics and parameters from the OP Note were used for the study.

In all the scenarios an improvement of min or effective min DA is obtained with a wire distance as large as 10 σ and a wire current as low as 130 A, including the scenarios with suboptimal tunes and crossing angle, with and without the octupoles. The maximum improvement of around 1 σ in min DA is achieved for the 0 octupole current, while for the nominal one it seems to be lower.

- **Stephane** questioned the need for the full octupole current, considered in several scenarios, with the wire compensation in place. The reason is that the octupoles provide plenty of compensation already, especially with a large telescopic index, thus providing a bias for the wire compensation. The wire compensation, on the other hand, gives an additional knob to vary the octupole strength. **Kyriacos** agreed, pointing out that the parameters for the studies have been taken from the OP

Note. **Gianluigi** inquired if in that case one should we take the effect of the wire into account for the stability studies. **Elias** confirmed it would be proper.

- **Gianluigi** summarized that the gain from the wire compensation seems marginal. **Yannis** pointed out that the simulations show improvement even in non-optimal configurations and suggest one can push a bit the crossing angle, maybe 10% further. The scenario where the gain would be greater larger is the flat optics. **Rogelio** suggested that the results could be more conclusive for the Ultimate OP scenario. **Kyriacos** replied the simulations for the Ultimate scenario are running, he is looking forward to analyzing the data.

ACTION (Kyriacos): Update the results for the Ultimate OP scenario

6 ROUND TABLE

The next meeting will take place on Thursday, Oct. 11 at 14:00