Minutes of the LHC Beam Operation Committee

7th May 2024

Indico

Participants: H. Bartosik, E. Bravin, R. Bruce, X. Buffat, C. Hernalsteen, U. Kar, S. Kostoglou, A. Lechner, B. Lindstrom, S. Morales, D. Nisbet, T. Persson, S. Redaelli, G. Trad, J. Wanczyk, J. Wenninger, D. Wollman, C. Young

Participants (Zoom): F. Alessio, D. Alves, R. Bruce, R. Cai, E. Calvo, R. De Maria, K. Dewhurst, J. Dilly, Y. Dutheil, P. Dyrcz, I. Efthymiopoulos, M. Gasior, L. Giacomal, M. Gonzalves Berges, P. Hermes, M. Hostettler, M. Lamont, D. Lazic, L. Mether, D. Mirarchi, M. Monikowska, N. Mounet, Y. Papaphillipou, G. Papotti, M. Pojer, V. Rodin, A. Rossi, B. Salvachua, B. Salvant, L. Salvatore Esposito, G. Smirnov, R. Tomas, N. Triantafyllou, M. Trzebin, J. Uythoven, F. Van Der Veken, A. Vella, C. Zamantzes

J. Wenninger presented a summary of the observation of hierarchy breakage at β^* 33-30cm. The effect is present only when both beams are present with sufficiently high intensity. The loss patterns indicate mostly vertical losses in B2. All loss maps performed are OK. There is no significant offset shown by the BPM. The breakage is seen with 400b or higher. The bunch by bunch lifetime derived from losses at the primary collimators measured by dBLM show an inversion at 33cm, i.e. bunches experiencing more long-range beam-beam interactions loss more than others for $\beta^* > 33$cm, but lose less below. When reaching 30cm there are no longer any losses observed at TCP by the dedicated dBLM. There is a delay observed between the reaching of the matched point and the reduction of losses on the TCP measured by the dBLM. Effectively the lifetime does not improve indicating that the beam losses have moved to another location. Increasing further the strength of the octupoles tend to reduce the hierarchy breakage, while reducing its strength and inverting the polarity tend to worsen it. Increasing the crossing angle in IR1 or decreasing it in IR5 improved the hierarchy. Two fills accidentally reached 33cm since first observations of breakage, yet the breakage was no longer observed. During the coronograph MD featuring low intensity beams, the hierarchy margin was reduced by 1σ and no breakage was observed, confirming that the single beam setup is good. Optics measurements do not exhibit deviation further than 5% from the model which cannot explain the observations. Bunch-by-bunch orbits driven by long-range beam-beam interactions as well as β-beating due to beam-beam, even at large amplitude can explain reductions of the hierarchy by fractions of a σ.

- Y. Papaphillipou asked whether bunch-by-bunch orbits were measured. J. Wenninger answered that bunch-by-bunch measurements from normal BPMs are biased by the trains structure due to the acquisition electronics and therefore cannot be used. S. Kostoglou added that the ADTObsBox exhibit a pattern that looks qualitatively like beam-beam, but it does not follow the intensity decay, it could therefore be an artifact of the measurement.
- Y. Papaphillipou suggested moving one jaw at a time to verify the alignment.
- Y. Papaphillipou asked about the impact of electron cloud. X. Buffat reported rough estimates by K. Paraschou suggesting that both the orbit effect and the β-beating are too weak to explain the breakage, yet the uncertainties are large due to the unknown on the SEY.
- Y. Papaphillipou asked whether an octupoles reversal could be done. J. Wenninger answered that it was already done. The negative polarity (positive knob value) tends to degrade further the hierarchy.

- D. Mirarchi proposed removing the angular alignment since it was changed w.r.t. last year. S. Redaelli said that, since loss maps are good, there shouldn't be any impact. In addition, such a test would require significant amount of time to revalidate the cycle with these settings. J. Wenninger suggested to rather move the jaw angles during end of fill tests during which offsets are varied as well. D. Mirarchi said that the margin was measured at 1σ without angular alignment and improved to 1.5σ thanks to the angular alignment.
- X. Buffat mentioned that we should not focus on changes from last year since there were signs of breakage already next year. D. Mirarchi corrected that this information was erroneous, in fact there was no such sign in previous years.
- R. Tomas highlighted that horizontal β-beating from beam-beam gives 10% in the bad direction.
- R. Tomas proposed to change the polarity of the crossing angle in IR1 which was changed since last year.
- G. Trad said that we should define a minimal setup, maybe featuring a single train in each beam, with which we allow hierarchy breakage in order to make tests. J. Wenninger suggested to try after the VdMs to have this minimal setup and go straight to 30cm and check for breakage. C. Young mentioned that the current plan is to switch to BCMS after the VdMs.

T. Persson reviewed optics measurements linked to IR7 during the commissioning. There are a few percent of β-beating in IR7 and 0.1 to 0.2 m dispersion errors. The dispersion varies by few cm between β^* of 45 and 30cm. The dispersion in the vertical plane at the secondary collimator is fairly high and measurements are even higher. The *on_disp* knob should have an impact on this dispersion. The exact impact on the aperture should be evaluated off-line. The ADT-AC dipole measurement with colliding beams suggest a 5% level of β beating due to beam-beam. Off-momentum β-beat is also in the order of a percent.

- D. Mirarchi highlighted that off-momentum loss maps did not show issues linked to dispersion.
- R. Tomas said that, with bad luck, the combination of dispersion, β-beat and beam-beam effect could add up to 1.5σ. X. Buffat mentioned that single beam test (coronograph MD) suggest that single beam effect can only account for 0.5 σ, since a reduction of the retraction by 1 σ remained OK.
- Y. Papaphillipou asked if dispersion was measured with beam-beam. J. Wenninger answered that it was not tried but could be done in the future.

D. Mirarchi mentioned that kicks of 0.5 (H) or 3.5 (V) μrad at the IT.L1 would reach TCS missing TCP. The bunch-by-bunch luminosity decay rates comparison between 36 and 30 cm exhibit a pattern which is comparable to vertical bunch-by-bunch orbit from PyTRAIN. This pattern is not visible in FBCT decay rate comparison, suggesting that losses in the last step are dominated by tail rather than core losses. It is not clear whether this obervsation can be linked to the hierarchy breakage. S. Kostoglou suggested to subtract the burn off losses to account for bunch-to-bunch brightness variations which are biasing the observables shown.

S. Morales presented an analysis of the decomposition of the losses through the cycle. Primary losses in the horizontal plane are observed at the start of collision. Later on during β^* levelling vertical losses at the

primary as well as primary losses on the TCSG also increase progressively. At 30cm the primary losses on the secondary exceed the ones on the primary collimators. The BLM thresholds at the TCSG.D4R7.B2 are based on HiRADMAT measurements, the threshold are now at 20% of the validated maximum loss rate.

- J. Wenninger concluded that, when planning tests, we should be protected against coating damage by BLMs for slow losses.
- B. Salvachua indicated that the number given by the decomposition gives the losses by primary losses at the secondary on top of those from the normal ones from primary collimators (red line on slide 10).
- B. Salvachua highlighted that the decomposition show primary impacts on the secondary during all the fill, yet they exceed the primary losses at the end of the squeeze only.
- A. Lechener said that, even though the situation seem safe for tests, it is not good for operation as primary losses on the secondary also load unnecessarily the collimators downstream.
- G. Trad highlighted that, in some fills, the primary losses on the primary collimators do not disappear when the secondary losses start to dominate unlike suggested by the disappearance of the signal of the dBLM.
- R. Bruce asked whether the decomposed losses reconstruct well the loss signals. S. Morales will check.

B. Lindstrom presented an analysis of collimator BPM and dBLM data. Collimator BPMs exhibit a slow drift at TCP of 0.5 σ over several fills. At the TCS a slow drift of 0.3 σ is observed. There is no systematic change in orbit through a fill.
dBLM show higher losses when reaching 30cm and decreasing crossing angle. The losses are reduced when turning on the wire. The bunches lacking IP8 exhibit less losses. In B2, losses at the dBLM decrease at 30cm. The dBLM normalised by the FBCT losses subtracting the burn off contribution (i.e. the signal corresponding to the losses that should hit the TCPs). Due to their locations, dBLM 1 should be dominated by vertical losses whereas dBLM 2 is impacted by losses in all collimators. Color tags on the plots are based on Daniele's assessment of BLM loss ratios, the validity of the hierarchy cannot be inferred from the plots. The bunch-by-bunch losses are influenced by missing collisions in IP2, as well as in IPs 1 and 5 (12b).

- B. Lindstrom suggested to move a dBLM at the center of IR7. S. Morales said that the current location was chosen for its fitness for both ion and proton operation. If it is moved for protons, it should be moved back for the ion run.
- G. Trad asked about the sensitivity of the amplified dBLM. B. Lindstrom said that the signals shown correspond to real losses, the noise is negligible.

R. Bruce reported that M. Trzebin requested to stop the roman pot 50 μm further away w.r.t. the present settings. S. Redaelli said that there is a drift of the LVDT that might be an artifact. It could be interesting to stay further out and monitor the situation while investigating whether the drift is real. S. Redaelli added that the pots are currently out, they can be brought in now.