# 232nd HiLumi WP2 Meeting

## Tuesday 14th January 2025, 14:00 – 16:00

| | |
|---|---|
| *Chair:* | Nicolas Mounet |
| *Speakers:* | Hannes Bartosik, Georges Trad, Thomas Pugnat, Sofia Kostoglou |
| *Participants:* | Yannis Angelis, Chiara Antuono, Hannes Bartosik, Xavier Buffat, Riccardo De Maria, Joschua Dilly, Massimo Giovannozzi, Wolfgang Höfle, Dobrin Kaltchev, Sofia Kostoglou, Lotta Mether, Nicolas Mounet, T. Pugnat, Giovanni Rumolo, Benoit Salvant, Kyriacos Skoufaris, Matteo Solfaroli, Rogelio Tomas, Georges Trad, Michail Zampetakis, Carlo Zannini; |

## AGENDA



## MEETING ACTIONS

**WP2:** MD requests should be placed to check different aspects of using the LIU beams, the 4x72 injection, the 8b4e for collision and the hybrid as the fallback for e-cloud issues.

**Georges et al**: To contact HL-LHC detector coordinators to clarify detector availability or needs in the first year.

# 1. STATUS OF LIU BEAMS AND OPTIONS IN THE INJECTORS (HANNES BARTOSIK)

Focus during 2024 was put in reducing the transverse tails for the operational BCMS beam to values very close to q=1 (basically Gaussian) in the PS. In the SPS, brightness is within 15% of the LIU target for the LHC operational beams. In the LHC tails improved during the year. 5x36 filling scheme tested in preparation for 2025 operation. Both in LHC and SPS injection plateaus, emittance growth is observed.

Concerning the LIU beams, intensity at 450 GeV was demonstrated in 2024 (4x72). At PS extraction q=1.11 after scraping was reached for 4x48 BCMS. Standard beam (4x48) reached an emittance of 2.4 um while target was 2.1 um. Tails are slightly larger than for BCMS. In summary, BCMS has a brightness within 10% and Standard (4x48) within 15%.

Discussion:

- **Nicolas** asks if it is more convenient to reduce the time at flat bottom in the SPS than in the LHC. **Hannes** replies that this conclusion is not so straight forward. Final direction points to minimize the number of injections in the LHC.
- **Sofia** clarifies that out of the ~0.6 um/h blow-up measured in LHC injection, 0.2 um/h is unexplained.
- **Georges** asks what is counteracting IBS in the SPS. **Hannes** replies that this is simply a threshold effect from space-charge.
- Injected beams with low q come from large injection offsets.
- **Rogelio** asks if standard beam 4x72 would be ready for injection tests and 8b4e for beam-beam MDs. **Hannes** replies that these beams should be available for MDs with LIU intensity and actually early MD requests would be highly appreciated to prepare these beams (**Action**: MD requests from **WP2**).
- **Nicolas** asks about the hybrid beam. **Hannes** replies that the hybrid would still have the challenge of equalizing both beams but this is doable and could be motivated by MDs. Higher than LIU intensity is being explored.
- **Hannes** clarified that emittances shown on the summary table are measured in the SPS after scraping. **Rogelio** asked about data in the LHC. **Sofia** checked on-line that the emittance was 2.14 um for 2x48 and B1. To be tested in 2025 MDs for more beams.

# 2. PREPARATION OF CHAMONIX TALK: COMMISSIONING THE HL-LHC (GEORGES TRAD)

**Georges** presents a sketch of his presentation for Chamonix along with questions to be discussed during this preparation discussion.

Discussion:

- **Sofia** asks about the absence of ion run in 2030 and **Georges** confirms that this has been decided to be removed and it is already displayed in the LHC long term schedule webpage. This makes the proton intensity ramp-up in physics up to $1.8 \times 10^{11}$ ppb much more affordable in the first year.
- **Riccardo** comments positively on the alternative plan proposed by **Georges** where top energy activities are interleaved from the start of commissioning and there is no need for the ideal IP shift in the first year. This is also partly motivated by the new information that experiments might need 2030 for the detector commissioning.
- **Georges** asks about advancing beta* steps to first year in case the detectors would be in commissioning mode. **Rogelio** asked if this information came from HL-LHC detectors coordinators (**F. Hartmann** and **B. Gorini**), however this was not the case. For the Chamonix presentation it would be very important to clarify this (**Action**: **Georges**) as this was not the message passed in the past.
- **Matteo** comments that the new 29 days should also help for detector commissioning tasks.
- **Rogelio** asks about messages hardware-wise. **Georges** mentions that hardware commissioning should be smooth thanks to the IT string and that activities for the new circuits have already started. **Rogelio** comments that it would be nice if some messages concerning new features of the hardware would be presented (no need to be detailed).

# 3. UPDATE ON SORTING OF MQXFB (THOMAS PUGNAT)

Set-up calibration and precision of the measurement of transfer function strongly affect the results from the assumed sorting strategy. Status of measurements (cold and warm) and uncertainty of the direct measurement of the extrapolation is presented. Three assumptions are presented: the *Predicted* beta-beating expected by the sorting, the *Realistic* beta-beating that can be expected at commissioning using the measurement-based Pair Calibration, and an *Optimistic* beta-beating when a more refined Pair Calibration is used. Three sorting scenarios are proposed in order to estimate the stability of the given magnets position: the 1st one does not consider the uncertainties while sorting, the others 2 do. One quadrupole already has a slot assignment. Systematic errors in the transfer function from the 2 different set-ups (CERN and USA) will be mitigated by cross-calibrations. In the realistic assumption, sorting shows no improvement in the beta-beating during commissioning as the Pair Calibration is based on the measurements. In the optimistic assumption, a net gain is observed considering a more accurate Pair Calibration used. Proposed slots for the different magnets are already given based on magnetic data. The second and third scenarios give similar results in terms of beta-beating, however slots allocations are different as the sorting considers the uncertainties from magnet measurements. The only consistent pairing is between MQXFB05 and MQXFB04 in A2L5 and B2L5, respectively.

Discussion:

- **Riccardo** asks for the possibility of considering other aspects for the sorting like coupling or mechanical data. Another option could be to use the transfer function measurements in the optics matching as a different mitigation than sorting. **Thomas** replies that this can be considered by selecting only the allowed permutations. This was done for previous studies (considering the development phase for example) but right now the only constraint is for MQXFB04 being in B2L5. **Massimo** replies that in principle all parameters could be used for sorting but given the data

quality and the time window options are unclear. As **Riccardo** remarks that re-matching could be done with 6 variables, **Thomas** points out that optics re-matching would be as the optimistic assumption presented.

- **Massimo** comments that the next step could be to propose the identified pair now and discuss the timeline with WP3.

# 4. PERFORMANCE UPDATES (SOFIA KOSTOGLOU)

**Sofia** presents performance estimates in different scenarios. Mind that this presentation is still considering an ion run in 2030. The scenarios consider: flat optics, various emittance evolution scenarios (CC noise, unknown sources), BCMS vs Standard, 90 mb vs 110 mb and combinations of them. The "Low tails" BCMS scenario means BCMS with 90 mb (same improvement would apply to Standard with 90mb; MDs at collisions are needed to identify loss mechanisms at LIU intensities). Baseline scenario gives 2236 $fb^{-1}$ (after the meeting, 2259 $fb^{-1}$ without ion run in 2030), which does not reach 2500 $fb^{-1}$ (about 500 $fb^{-1}$ from Run 1-3) because of the ion runs in Run 5. Flat optics gives 3.3% more luminosity. Different emittance mitigations give in the order of 1% more luminosity. Reducing losses to 90 mb increases lumi by about 5%. The impact of injectors' dedicated filling mode on emittance and luminosity is studied. The minimum injection time for 3x36 is 28 minutes, for 5x36 is 22 minutes, while for 4x72 is 16 minutes. Dedicated filling can reduce minimum injection time by 13-25% depending on the filling scheme. Impacts on luminosity from dedicated injection are moderate but reach about 1% increase. Yet, it is important to note that these estimates do not contain effects from debunching at injection. This mechanism is of great concern from experience in 2024 and its partial mitigation via dedicated filling should further contribute to increasing the integrated luminosity.

Putting together all possible improvements (90 mb, flat optics, CC noise feedback, dedicated filling, etc.) would yield about 10% more luminosity. It was noted that with all these improvements Run 1-5 luminosity would reach the HL-LHC goal of about 3000 $fb^{-1}$.

Discussion:

- **Riccardo** mentions that the integrated luminosity in higher pile-up scenarios would be more sensitive to flat optics or to any other improvement. This would be worth mentioning as detectors are designed for PU=200.
- **Rogelio** mentions that using the shown time reduction of injection time from dedicated mode applied to the turn-around-time of 2.5 h is unfair as 2.5 h includes 35 min of injection (allowing for some rejection of injections) and not the computed minimum time. To make comparisons the 35 min should be reduced (or increased) in the same proportion as the minimum injection times for the compared filling schemes, as rejected injections have the same length as successful ones, which would give increased benefits in emittance and luminosity.
- **Georges** mentioned that injection might be more inefficient with dedicated filling due to time needed for communications (failed injection, injection type). **Hannes** replied that this is under investigation and improvements are possible but the first approach is not to take the largest reduction but 6 s instead of 9 s.
- **Sofia** added that a turn-around-time of 2.5 h has been taken for all cases independently of the significant differences in minimum injection time. After the meeting it was agreed that these differences could be incorporated in future estimates.

- **Nicolas** asked for a clarification on the model and the impact of the CC noise on luminosity, which seems to be 1%. **Rogelio** mentions that Luis got 2% impact with the same growth formula (see Report). After the meeting **Sofia** checked that using as reference the case with IBS + SR gives 1.6% impact, more in agreement with the previous prediction.
- **Sofia** recalled that if the in-situ coating would not be sufficient and hybrid beams would be needed, a potential loss in luminosity of about 10% might be in place.

# 5. AoB

The next WP2 meeting will take place in one week.

*Reported by Rogelio Tomas*