
CERN

“Incoherent” actions for HL-LHC WP2

Y. Papaphilippou

with contributions of G. Arduini, O. Brüning, R. de Maria, **S. Fartoukh**, G. Iadarola, **N. Karastathis**, **D. Pellegrini**, A. Poyet, L. Rossi, K. Skoufaris, **G. Sterbini**, R. Tomas

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"Incoherent" actions and timeline

- Emittance blow-up in the HL-LHC era
- Impact of Noise
- BBLR compensation for HL-LHC (flat optics)
- Incoherent e-cloud (see Gianni's presentation)
- SPS CC test
- Beam-beam weak strong actions
- Status of beam-beam simulation tools
- **Prioritization** to be established

Emittance blow-up

- Evaluate **blow-up** observed in LHC and provide estimates for HL-LHC (Presentation at the Annual Meeting 2018):
  - Evaluate emittance blow-up at beginning and at end of the trains to distinguish relative contribution of electron cloud and establish the other remaining sources of blow-up.
  - Already work done by Stefania, to be concluded for 2018 (and also run II in general) by **beginning of 2019 (Evian)**
- From 7/6/2016: In the machine, the vertical emittance growth observed at injection during **Run 1** is not explained and it **looks smaller** in **2016** (effect of the new working point?).
  - Emittance estimates of run1 at injection, mostly from wire scan measurements of first injected trains (and not always)
  - Knowledge of machine settings is not always available (e.g. ADT,…)
  - Proposal to **focus on runII data**
- Work to be done:
  - Understand the existing extra emittance blow-up through the cycle based on Run II data -> **end of 2019**

Emittance blow-up

- In the model of the luminosity evolution include effect of **elastic scattering and diffraction** so to have the possibility to consider the inelastic cross section (instead of the total for burn-off) and include the impact on **transverse distribution** of the elastic scattering and diffractive scattering by appropriate differential cross sections. Can the elastic scattering and diffraction explain the slow blow-up that we observe during fills? Analysis of the **high pile-up MD**? Can we say anything about the luminosity evolution and on the blow-up? What was the expected dynamic aperture?
  - The elastic scattering emittance growth part is included in the model since early 2016 (from "Where all the protons go?", M. Lamont LBOC 2/2/2016, see Fanouria's presentation and paper in Evian 2016)
  - The impact is **an order of magnitude smaller** then the observed emittance growth
- **Work to be done**
  - Include elastic and diffrative part **in SIRE** for observing the impact on distributions (not expected to be important, growth rate in the shadow of radiation damping) -> **mid-2019**
  - Analysis of high-pile-up MD -> **Beginning/mid 2019 (Evian)**
  - Analysis of high intensity MDs -> **Beginning/mid 2019 (Evian)**

Impact of noise

- Crab cavities
  - Effect of crab cavity noise throughout the cycle before going in collision and in collision
    - PhD thesis of Natalia -> **results by end 2019** (including SPS measurement analysis, model benchmarking, projections for HL-LHC)
- Power converters
  - Presentation at the WP2 meeting on 4/9/2018 and at the annual meeting 2018 on observations on power converter noise. Measurements are ongoing including ObsBox to quantify the possible effect of main bends active filters on noise close to the betatron frequency:
    - a. Dependence on the phase advance IP1/5. Can we determine which sectors are mostly active?
    - b. Issue with the ramp dependence that does not fit with the observations for the moment
  - Need to update the estimations on the impact of noise on DA, lifetime and blow-up/tail generation with and without beam-beam on the basis of the tables produced by EPC. The evaluation should include flat optics.
  - Work to be done:
    - Active filter measurements applied during MD4, phase dependence to be evaluated -> **beginning 2019**
    - Update on impact of noise on DA, lifetime and blow-up -> **mid 2019**

Impact of noise

- Electron lens
  - Effect of noise induced by electron lens and specification of the maximum acceptable noise updating numbers provided by M. Fitterer at HL-LHC annual meeting in November 2016 and at IPAC'17. Need to update the numbers in particular in collision. Need to answer by Spring 2019.
  - **Work to be done**: Evaluate the impact of e-lens noise on DA (SIXTRACK model?) -> difficult to keep deadline for **Spring 2019** (need to address luck of **resources**)
- Vibrations
  - Follow-up of the low frequency noise experiments and comparison with simulations
  - Work to be done -> **end of 2019** (need to address luck of **resources**)

BBLR compensation

- Presentation of Sasha at the 45th WP2 TL meeting :
  - 1. compare wire performance in presently assigned position (between D1 and D2) and in a position between Q4 and Q5 with that considered for the study (at the crab cavity location).
  - 2. try to evaluate the dependence of the DA on the current of the wire for the studied configuration to see whether the considered value of 198 A×m lead to overcompensation and whether this has a negative impact in DA.
  - 3. optimize the working point.
- Evaluate the possible new position of the BBLR compensator in view of the layout changes and the availability of space close to the two remaining crab cavities.
- From Meeting on 1/9/2017:
  - Propose a realistic configuration using a material wire.
- The impact of the PACMAN orbit offsets should be considered for the wire compensations studies
- All these **actions should be closed** in light of the new simulation results of Kyriacos and his presentation in the HL-LHC annual meeting 2018:
  - The present **longitudinal position** of the wire is adequate for providing compensation and the **transverse distance** requirements can be relaxed, as they provide **2-3 σ DA improvement** with negative octupole and high chromaticity
  - **WP optimization**: the wire provides more margin in order to keep it constant during levelling
- **Work to be done**
  - Evaluate the impact of the wire on lifetime -> **beginning 2019**
  - Evaluate the improvement on performance of a scenario with round optics and wire (with/without CCs) -> **beginning 2019**
  - Evaluate possibility of BBLR compensation with existing wires in Run III -> **end of 2018**
  - Present reliable **HW solutions** to HL-LHC project -> **end 2019**

Flat optics

- Flat optics simulations should be performed for the configurations proposed by R. Tomas and documented in a paper describing the performance of nominal and alternative operational scenarios, simulations for the flat optics scenario presented at the Annual Meeting 2018 should be done also for nominal chromaticity (+15) and ultimate scenario.
- **Work to be done**
  - Evaluate impact of **high-chromaticity** in **flat optics** and/or **low chromaticity** in **round optics,** for consistency -> mid 2019

SPS Crab Cavity test

- From meeting on 12/9/2017: Experiments to measure the impact of crab cavity field quality in the SPS would be important.
- Presentations at WP2 meeting on 25/9/2018: Update on measurements of vacuum, a3 and RF multipoles measurements to be reported at future WP2 meeting and documented in a note.
- Effect of Crab cavities field quality: Maximum allowed RF multipoles for crab cavities should be defined. Take into account possible larger offsets (up to 5 mm) in the non crossing plane. Effect of b5 feed-down and effect of b3 and a3 should be evaluated (it has been shown that the b3 component has a strong impact on the SPS DA – see minutes of the WP2 meeting on 25/07/2017. Data on expected RF multipoles presented at the WP2 meeting on 25/09/2018. Simulations to be performed
- New DA simulations (with corrected bug in SIXTRACK CC ramping voltage) showed that multi-pole impact is much weaker -> Natalia can present them, even by **end of 2018**
- **Work to be done**:
  - Evaluate **a3** of CC from SPS measurements -> **beginning of 2019**
  - Impact of associated b3 and other multi-poles (including feed-down for CO offset) to HL-LHC **-> mid of 2019**
  - Documentation of SPS CC test and associated simulations **-> end 2019**

Beam-beam weak strong actions

- Following the presentation on the BPM calibrations on 20/11/2015. We should also define the required accuracy in the definition of the crossing angle.
  - This can be established (**very soon**) by imposing a tune-shift tolerance (~10^-4) between the alternating x-ing of IP1 and IP5
- Define the deltap to be used for DA simulations without and with beam-beam (see presentation on 31/7/2018.Two values should be quoted, those corresponding to the DA for the maximum Dp/p used so far and one corresponding to the Dp/p providing the weighted (on the momentum distribution) average DA. Similar study should be done with beam-beam.
  - Study already done for LHC, to be repeated for HL-LHC -> **beginning of 2019**
- Need to understand origin of the losses occurring on top of burn-off at the beginning of the physics fills.
  - A lot of work done from the observations point of view, simulations si

Beam-beam weak strong actions

- Need to verify that the proposed operational scenario (CERN-ACC-NOTE-2018-0002) with negative octupoles is robust both for the nominal and ultimate scenarios from the point of view of DA including beam-beam effects and taking into account of PACMAN effects. Verify with respect to the two polarities of ALICE and LHCb -> **Mostly covered**
- Verification at injection (Requirements on crossing angle and separation at all points at injection from beam-beam considerations should be given). new working point should be considered -> **mid/end 2019**
- Ramp and squeeze and pre-squeeze/squeeze (define the minimum beta* achievable during the ramp and squeeze if larger than that indicated in the operational scenario) -> **partially covered** by Nikos during HL-LHC meeting 2018, remaining points by **mid 2019**
- Collision process and stable beams (provide the evolution of the crossing angle during the fill for the scenario with variable crossing angle, also after levelling, during the natural decay). Is the separation in ALICE/LHCb an issue? -> Need to establish the x-ing angle choice with wires (see previous slides)
- Include the effect of field errors and coupling (see specs in the operational scenario). In particular study the dependence on the a4 and b5 errors and determine DA for non-perfect correction by the triplet correctors and in the absence of triplet correctors. Do we see a saturation in the DA with increasing crossing angle as observed in the past -> **end 2019**
- From meeting on 12/6/2018: include the effect of the high telescopic index that might be required to stabilize the beam during the adjust process -> **covered** by Nikos during HL-LHC meeting 2018

Beam-beam weak strong actions

- Investigate whether HO or long range are the main limitation for HL-LHC
  - Partially done, part of the operational scenario refinement -> **mid 2019**
- · Impact of an increased b6 error on DA when beam-beam effects are included 12. From WP2 meeting on 31/7/2018, on 21/08/2018, on 4/9/2018 -> to be presented by **end 2018**
- DA simulations should be performed with the newly proposed telescopic indexes. Riccardo will provide the optics and Nikos will perform the DA simulations. Done and presented at the annual meeting 2018. The results of all the simulations (including positive polarity of the octupoles providing motivation to go to negative polarity) should be documented in a note by the **end of 2018.**
- Simulations with LHCb at high luminosity have been presented at the US-LARP meeting at SLAC on 19/5/2016, Presentation on 20/3/2018 and more recently at HL-LHC annual meeting 2018 to be cross-checked that this is consistent with the operational scenario -> to be done by **beginning of 2019**
- Need to verify the impact of the different classes of PACMAN bunches -> partially done by Kyriakos to be presented by **beginning of 2019**

Beam-beam weak strong actions

- Note on the minimum requirements on DA without and with beam-beam based on assumptions on lifetime. We should define a goal for lifetime when we are not in collision and when we are in collision. The DA aperture should be based on the nominal beam emittance. This should be written by Massimo and Yannis. The note should include benchmarks with the present LHC and the results of the MDs on DA and beam-beam.
  - Partially treated in Evian 2017 (Dario) and Chamonix 2018 -> note to written by mid **2019**
  - Better estimates based on simulations but more accurate model is needed (impact of e-cloud) -> **beginning of 2020**
- Need to individuate impact of power converter ripple and vibrations on DA and lifetime **without** beam-beam -> not strictly a beam-beam action…
- Define tolerances on bunch-to-bunch population and emittance (also H/V differences) from beam-beam considerations -> by **end of 2019**
- Can we exclude operation with a crossing angle at 45 degrees? Do we have simulations for that case? It could allow changing regularly the orientation to minimize radiation. Advantages/disadvantages for machine protection? Impact on field quality requirements? -> this is **not strictly beam-beam**, to evaluate with beam-beam simulations for BBLR compensation (crossing angle at 45 degrees) by **beginning of 2020**.

Status of beam-beam simulation tools

- From 20/3/2015: Are Beam 2/4 simulations possible
- Updated after meeting on 23/5/2017
- Points remaining:
  - Can we simulate ion-ion/proton-ion collisions, i.e. take into account the Z and A scalings?
  - Are the beta-beating and orbit distortion induced by beam-beam effects included in the strong/weak beams?
    - Beta-beta for the week beam is always included
- RF multipoles in SixTrack: is the implementation completed (doubts on simplecticity and inclusion of higher order multipoles) -> **already done**
- **Work to be done**:
  - Mask for beam2 with beam-beam to be tested -> **beginning of 2019**
  - Evaluate the possibility to simulate beam-beam effects with other colliding species with SIXTRACK -> **end of 2019**
  - Evaluate the impact of beta-beating for the strong beam -> **end of 2019**