





**“Incoherent” effects actions
for HL-LHC WP2
([link](#))**

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"Incoherent" effects actions and prioritisation

1. SPS crab cavity tests
 2. Status of BB WS simulation tools
 3. BBLR compensation for HL-LHC
 4. BB-WS and noise for flat optics
 5. Noise effects and emittance-BU in the HL-LHC
 6. BB weak strong actions
- **Prioritization** and **work-load sharing** to be established

SPS crab cavity tests

- Perform further analysis and present the measurement results of **b3 multipoles**.
- Define and **use common units of multipole** strength that are used in beam dynamics and RF groups
- **Disentangle the contributions from non-linearities** in the SPS. Plan a reference measurement of the impact of the feed-down of octupoles and sextupoles in the SPS without crab cavities before repeating the a3 measurement with crab cavities ON.)

→ **Present and document in a note the findings before the end of 2019 (Michele)**

Status of beam-beam WS simulation tools

- Test a the B2 mask (B4) with BB → **End of 2019 (Guido)**.
Use the the mask by F. Van der Veken.
- Perform simulations on Beam 4 with beam-beam, to assess possible asymmetry in DA → **Q1 2020 (Guido)**.
- Define tolerances on BBB population and emittance (also H/V differences) from BB considerations → **This will require development of new tools. Longer term action.**
- Inclusion of orbit effects in the beam-beam simulations → **Longer term action.**
- Evaluate the possibility to simulate beam-beam effects with other colliding species with SIXTRACK → **The tools are be available. Need to test the mask. Discuss with J. Jowett to inherit tools developed in the past for benchmarking. End of 2020.**

BBLR compensation for HL-LHC

- **Flat optics simulations** should be performed for the configurations (by R. Tomas) and documented in a note (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. Evaluate the improvement on performance of a scenario with round optics and wire (w and w/o CCs).
Lower priority - to be revised in 2020.
- Evaluate **the impact of the wire on lifetime**.
Lower priority to be revised in 2020.
- Present reliable **HW solutions to HL-LHC project**.
End 2019 (outcome of [HL-LHC Wire Compensation?](#))

BB-WS and noise for flat optics

- **Performance for the flat optics with CC** should be analyzed once the round optics studies are completed → **Longer term action: Update end of 2020**
- 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 for flat optics → **Longer term action, Update end of 2020**

Noise effects and emittance blow-up (I)

Emittance blow-up

- 1. 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? → **End 2019**
- 2. Include elastic and diffractive part and effect of burn-off in SIRE for observing the impact on distributions (not expected to be important, growth rate in the shadow of radiation damping) → **Lower priority. To be discussed whether other options exist**

Impact of noise

- Crab cavities Studies ongoing with PhD student → **Natalia, timeline 2020-2021**
- Effect of crab cavity noise throughout the cycle before going in collision and in collision. **Q4-2019**. During the WP2 meeting on 29/1/2019 (<https://indico.cern.ch/event/788818/>) the issue of the non perfect counterphasing (5 degrees error) and uncertainty on the voltage (10%) have been raised. The impact on the beam at injection assuming 0.25 MV/ cavity should be studied with beam-beam.
- Power converters Presentation at the WP2 meeting on [4/9/2018](#) and at the [annual meeting 2018](#) on observations on power converter noise. Presentation by S. Kostoglou at the HL-TCC on [13/12/2018](#) → **To be continued 2020**
 - a. Issue with the ramp dependence that does not fit with the observations for the moment (under investigation) – **Not understood yet**
 - 2. Specification of power converter noise from DA simulations with beam-beam. Summarize in a note. → **Q1 2020**

Noise effects and emittance blow-up (II)

Vibrations and noise

- Follow-up of the low frequency noise (vibrations) experiments and comparison with simulations → **Q4 2020**
- In general we should define a table with the various expected source of noise, their characteristics, their origin and mitigation measures. → **Guido to prepare this table and keep it up-to-date. Longer term follow-up.**

This should include

- Cold mass vibrations
- Beam screen vibrations
- Power converters (including the effect of the load (magnets) and beam screens)
- Transverse feedback
- Electron lens: electron current noise, modulation and corresponding kicks
- Crab cavities
- The impact on DA and on emittance blow-up and halo generation should be studied → ?

Beam-beam weak strong actions (I)

- Effect of Crab cavities field quality: Maximum allowed RF multipoles for crab cavities should be defined.
 1. The latest tables of the field quality presented by Rama and Jamie should be used (sent to Emilia with e-mail dated 21/08/2019) → **They are now used**
 2. Nominal scenario with H-crossing in IP1 should be studied → **This is now used as default**
 3. Verify the time evolution of the DA to get an insight on the long-term DA behaviour->?
 4. Impact on operation of b2 multipoles and tolerance on their maximum value to allow operation of crab cavities in one IR only → **End of 2019 including beam-beam effects.**
 5. Determine any possible limitation on the crabbing non-closure taking into account of field quality in the insertions and arcs. Do we have to set a limit on the non-closure for crab cavity form DA considerations? → **lower priority**
- 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 → **End of 2019 with available information.**
- Define the Δp 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 D_p/p used so far and one corresponding to the D_p/p providing the weighted (on the momentum distribution) average DA. Similar study should be done with beam-beam → **Lower priority.**

Beam-beam weak strong actions (II)

- 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
→ **Note being finalized.**
 - Include the effect of field errors and coupling (see specs in the operational scenario – see also discussion at WP2 meeting on [20/08/2019](#)). 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? This should be checked. Where do we start to see the effect of field quality? What is the margin we have for field quality? → **Q4 2019**
 - The pros and cons of operating below or above the coupling resonance all through the cycle should be evaluated with a reasonable distance determined by realistic values of the coupling compensation to be provided by the OMC team. → **End 2019**
 - Need to verify the impact of the different classes of PACMAN bunches. **This has been presented. Yannis could you please provide the link to presentation/paper**
- Investigate whether HO or long range are the main limitation for HL-LHC. It appears that we are dominated by long range the addition of LHCb at high luminosity does not appear to reduce further DA. Done. → **Being documented in a note.**

Beam-beam weak strong actions (III)

- 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. → **It will be clarified in the note being written by Nikos.**
- 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? → **Lower priority. Excluded from other considerations (stability)?**
- Can we run simulations for lead ion beams. Can we accept a half crossing angle at IP2 of 100 μ rad for the 25 ns beam? → **Lower priority**





BACKUP SLIDES



Concluding remarks

- Over **50 actions** ranging from **simple scaling** to **full scale simulations** and long term studies
- Addressed a **large fraction** of them with available resources
- **Difficult to fulfill** all tasks (even with prioritization) taking into account the past, present and, in particular, future man-power.
- Some **filtering** is **necessary** on the generation and follow-up of these actions (hopefully through present meeting)