**Transverse stability - Pending actions after 23/08/2019 => Answers with XavierB and NicolasM + comments in red during the meeting**

1. **From action 24/10/2015:** Estimate the Laslett tune shifts and benchmark with measurements. **Action: Elias.** Some experimental studies were reported by Massimo (see IPAC paper http://accelconf.web.cern.ch/AccelConf/IPAC2015/papers/tupty043.pdf ). But need estimate although **low priority**.

   **=> Some estimates were computed by Sergey Antipov using L. Vos formula (following paper from F. Zimmermann at IPAC19) and NHTVS, giving a maximum tune shift along the train between 6.7 $10^{-4}$ and $10^{-3}$ (depending on the filling scheme), for HL-LHC in the full upgrade scenario. Should be presented/discussed at some HSC meeting => Should be discussed/presented at some WP2 meeting.**

Maximum tune shift along the train due to impedance
Estimates based on the work of L. Vos

$$\Delta Q_{full} = \frac{1}{4\pi Q}\frac{R}{E/e}Z_{\perp}I_b$$

| Machine | LHC – L. Vos | LHC – L. Vos | LHC - 2017 | LHC - 2017 | HL-LHC | HL-LHC | HE-LHC | HE-LHC |
|---|---|---|---|---|---|---|---|---|
| Cycle state | Injection | Flat-top | Injection | Flat-top | Injection | Flat-top | Injection | Flat-top |
| Energy, GeV | 450 | 7000 | 450 | 6500 | 450 | 7000 | 1300 | 13500 |
| Intensity, ppb | $1.05\times10^{11}$ | $1.05\times10^{11}$ | $1.05\times10^{11}$ | $1.05\times10^{11}$ | $2.3\times10^{11}$ | $2.3\times10^{11}$ | $2.2\times10^{11}$ | $2.2\times10^{11}$ |
| Current full, A | 0.67 | 0.67 | 0.67 | 0.67 | 1.47 | 1.47 | 1.4 | 1.4 |
| Imp, MΩ/m | 52 | 116 | 100 | 900 | 100 | 800 | 250 | 2000 |
| **Tune shift full** | **$4.6\times10^{-4}$** | **$6.7\times10^{-5}$** | **$8.8\times10^{-4}$** | **$5.5\times10^{-4}$** | **$1.9\times10^{-3}$** | **$1.0\times10^{-3}$** | **$1.6\times10^{-3}$** | **$1.2\times10^{-3}$** |

NHT est. for LHC 2017: $6.2\times10^{-4}$ 2015: $4.4\times10^{-4}$ 2017 R3: $4.6\times10^{-4}$ 2017 8b4e: $4.2\times10^{-4}$ HL-LHC: $1.0\times10^{-3}$ HL-LHC R3: $7.3\times10^{-4}$ HL-LHC 8b4e: $6.7\times10^{-4}$

2. **Pending actions on the operational scenario**:
   a. Update stability requirements taken into account DA and coupling correction constraints, include latest information on Crab Cavity HOM impedance, compare positive and negative octupole polarities**.** Both postLS2 and full upgrade scenarios should be considered and possible intensity limitations should be provided.

      **=> WP2 talk "Update on the operational scenario taking into account of the constraints on coupling" on 17/09/2019 (XavierB and NikosK).**

3. From WP2 meeting on 22/5/2018 (https://indico.cern.ch/event/726043/ ) – **Q4-2019**
   a. ACTION (Xavier): Estimate the effect of crab cavity noise on stability (both dipole modes and head-tail modes). It is important to understand the impact to make sure that the use of crab cavities does not bring any negative effect.

      **=> Theoretical estimates for dipole noise should be available by the end of the year, the extension to crab cavity amplitude noise (i.e. with a head-tail component) should follow in 2020. In the OP scenario, the CCs are switched on once in collision, so should be no pb for stability (to be checked nevertheless).**

      **=> The goal of Gianluigi is to collect all the info linked to noise (which is both important for emittance growth and beam stability) and put them in a table**

**=> Will be done by GuidoS.**

b. ACTION (Elias, Xavier): to summarize the stability threshold measurements without damper in the LHC.

**=> Only one test at flat top during Run 2, it was reported at Evian 2019 showing a discrepancy by a factor 4 w.r.t. the model. The threshold measurements of Run 1 are not representative due to the known uncertainty on coupling…**

c. Gianluigi inquired about the progress on understanding how the beam distribution and stability diagram are changed due to noise and whether non-linearities (e.g. octupoles) can enhance the changes.

**=> The latest developments will be presented by SondreF at the MCBI workshop in Zermatt (23 to 27/09/2019). Nonlinearities are indeed a key component of the mechanism.**

d. Scaling of latency vs. octupole current and impedance to be studied

**=> Scaling laws based on tracking simulations were described at the HL-LHC collaboration meeting 2018. The theoretical developments mentioned above should shed more light on these aspects. Moreover, a time domain Vlasov solver is being developed by N. Mounet to understand the impact of nonlinearities (chromaticity & octupoles) on instability latency time (talk at ABP group information meeting on 19/09/2019).**

**4.** Shall we increase the crossing angle during ramp and squeeze up to collision to reduce the compensation of the octupole spread by the long range? **– Q2-2019**

**=> An increase of the crossing angle to 295 murad combined with an increase of the beta* to 64 cm for the start of collision relaxes the stability requirements to those of the non-colliding bunches (i.e. the effect of beam-beam interactions becomes negligible, as mentioned at the WP2 meeting on 17/09/19).**

**5.** Define tolerances on bunch-to-bunch population and emittance (also H/V differences) from stability considerations. At least we should get an idea based on the known phenomena (beam-beam and impedance, for example) – **Q2-2019**

**=> There is no issue with bunch-to-bunch variation as long as the single bunch brightness does not exceed the design one.**

6. From WP2 meeting on 29/1/2019 (https://indico.cern.ch/event/788818/ ):
   a. Analysis of the stability and heat load in the presence of the crab cavity HOM should be repeated also for the 8b4e beam and possibly for hybrid schemes.

**=> Possible issues are just for heat load: to be moved to "Impedance actions".**

7. From WP2 meeting on 16/4/2019 (https://indico.cern.ch/event/804350/ ): continue the studies to determine the dependence of the stability limits on the longitudinal distribution at low chromaticity (**Action: Elias**)

   **=> A detailed study using the circulant matrix model could be launched in 2020, that could be benchmarked using the results of AdrianO and/or another similar study using DELPHI. The effect of noise also in this situation will be studied in the future.**

8. From WP2 meeting on 2/7/2019 (https://indico.cern.ch/event/826475/ ):
   a. Estimate the effect of electron cloud, impedance and beam-beam on crabbing

      **=> Not quantified yet. These effects should be small, low priority.**

9. From WP2 meeting on 9/7/2019 (https://indico.cern.ch/event/831847/ ):
   a. Examine whether the growth rates of the observed instabilities are consistent with models

      **=> Giacomo compared the measured and modelled growth rates for an MD in 2017 and XavierB presented the results at Evian 2017. No significant discrepancy was found. In principle, this could be repeated for 2018 MDs.**

   b. Identify what measurements need to be performed in Run3 based on the present experience and what diagnostics is required by the end of 2019

      **=> This has not been started yet. We can make a list of 'standard measurements' by the end of the year based on the experience in Run 2. We should nevertheless give ourselves the time to understand if other types of experiments could be designed to better probe the different parts of the impedance (2020) => The goal would be to try and do this before the end of the year in particular if we have particular requests for new measurements etc. to be sure that BI etc. have sufficient time to implement possible requests from our side. As discussed, this should be done also in parallel to the critical review of the LHCIM (which was discussed during a LHCIM meeting), which will soon be discussed at HSC and then with Gianluigi. Finally, we could/should discuss it also with OP (LBOC) to have their feedback and have then all the inputs to prepare very well Run 3.**