

HL-LHC OPERATIONAL SCENARIO

**E. Métral, N. Biancacci, K. Li, T. Pieloni, B. Salvant, C. Tambasco
and Tasks 2.4 and 2.5**

- ◆ **Follow-up from KEK => Where are we?**
- ◆ **Current proposed operational scenario**

FOLLOW-UP FROM KEK => WHERE ARE WE? (1/4)

- ◆ **To reach single-beam transverse stability, it is necessary to**
 - Coat new Molybdenum-Graphite (Mo-Gr) collimators with 5 μm of Molybdenum
 - Still decrease (a lot) the impedance of the Crab Cavities => Task 2.4 meeting next week (<https://indico.cern.ch/event/354942/>)
 - Keep a good control of the impedance (at large β , new eq., etc.)
- ◆ **Single-beam stability relies on**
 - Transverse damper @ 50 turns => Ongoing studies. **Do we need 10-20 turns?**
 - Chromaticity control: from 2012 experience => $Q' \approx + 15$ at high energy, **BUT still needs to be optimized => 2015-16 experience important!)** => **Important to have a good control from OP**
 - Landau octupoles: **LOF = + 590 A @ 7 TeV** (i.e. maximum value)

FOLLOW-UP FROM KEK => WHERE ARE WE? (2/4)

- ◆ **For luminosity leveling reason => β^* leveling: Collide (@ $\beta^* \approx 70$ cm) & Squeeze (down to 15 cm)**
 - Thanks to β^* leveling, we have a lot of margin for beam-beam (with nominal Xing angle of 590 μ rad) and we could optimize / reduce the Xing => Needs then for instance less CC
 - If β^* leveling does not work or the pile-up in experiments can be considerably increased, this should be very tight
- ◆ **In stable beam, both the octupoles and chromaticity should be reduced for DA (lifetime) reason => What about non-colliding bunches required by the experiments?**
 - Might prevent from reducing chromaticity and octupoles once in collision => Reduce integrated luminosity
 - Might be lost if collision is required for beam / bunch stability => beam dumps?

FOLLOW-UP FROM KEK => WHERE ARE WE? (3/4)

◆ Other important issues to be studied

- Exact value of octupoles to be used at injection? => 6.5 A in 2012 with 50 ns (24 A with 25 ns and e-cloud), what about 2015 (=> 2015-16 experience important!)? What about HL-LHC? => Impact on DA? => Studies with OCT + SC + BBLR + EC? + ...
- Beam stability in the presence of e-cloud in the quadrupoles? => Was it already an issue in 2012?...
- What if we miss some Landau damping?
 - Q'' values which could help? => Is this feasible by the optics team?
 - Collide & Squeeze earlier (~ few m?)
 - ✧ Still with LOF > 0?
 - ✧ With LOF < 0?
 - Use some RFQs?
 - Use a 800 MHz RF cavity? In BLM? What about impedance?

FOLLOW-UP FROM KEK => WHERE ARE WE? (4/4)

- Some beam-beam studies during the betatron squeeze have been performed using a Xing angle scan. These are being re-done with all the optics steps now available
- Until now, the stability diagrams in the squeeze in the presence of both octupoles and BBLR were studied assuming the ATS effect since 2 m => Ongoing studies on it
- Effect of the particles distribution: Gaussian assumed...
- Be careful when removing tails => Impact on Landau damping...
- IP2/8 under study to define a leveling scenario to be in the shadow of IP1/5
 - IP2 => // separation
 - IP8 => // separation or β^* leveling (large β needed in this case, i.e. large Xing angle)
- Heat-loads from e-cloud, RF heating, etc.

HL-LHC OPERATIONAL SCENARIO (1/7)

- ◆ **There is no possible operational scenario with the current impedances of the CC and non-colliding bunches required by the experiments**
- ◆ **Without non-colliding bunches, beam stability might be reached with Collide (@ β^* of few m \Rightarrow 11 m, i.e. at FT?) & Squeeze**
- ◆ **Without non-colliding bunches and without CC (or with CC with a much reduced impedance \Rightarrow \sim 2 orders of magnitude?), the currently proposed operational scenario is**

HL-LHC OPERATIONAL SCENARIO (2/7)

◆ INJECTION

- ADT @ 50 turns
- $Q' \approx + 3$
- LOF $\approx + 10-20$ A
- Half // separation = 2 mm
- Xing angle = 590 μ rad

HL-LHC OPERATIONAL SCENARIO (3/7)

◆ RAMP

- ADT @ 50 turns
- $Q' \approx +3$
- LOF current scaled with energy (as in 2012 to reach maximum value of + 590 A at 7 TeV)
- Half // separation = 2 mm
- Xing angle = 590 μ rad

HL-LHC OPERATIONAL SCENARIO (4/7)

◆ FT

- ADT @ 50 turns
- $Q' \approx + 15$
- LOF = + 590 A
- Half // separation = 0.75 mm
- Xing angle = 590 μ rad

HL-LHC OPERATIONAL SCENARIO (5/7)

- ◆ **SQUEEZE until $\beta^* = 70$ cm (for luminosity leveling reason)**
 - ADT @ 50 turns
 - $Q' \approx + 15$
 - LOF = + 590 A
 - Half // separation = 0.75 mm
 - Xing angle = 590 μ rad

HL-LHC OPERATIONAL SCENARIO (6/7)

- ◆ **COLLIDE @ $\beta^* = 70$ cm (for luminosity leveling reason)**
 - ADT @ 50 turns
 - $Q' \approx + 15$
 - LOF = + 590 A
 - // separation = 0 mm
 - Xing angle = 590 μ rad

HL-LHC OPERATIONAL SCENARIO (7/7)

- ◆ **STABLE BEAM & β^* leveling until 15 cm => See plots from RiccardoDM**
 - **ADT @ 50 turns => Reduce it as much as possible...**
 - **$Q' \approx + 15$ => Reduce it as much as possible (~ 2?)...**
 - **LOF = + 590 A => Reduce it as much as possible...**
 - **// separation = 0 mm**
 - **Xing angle = 590 μ rad**