LANDAU OCTUPOLES POLARITY

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=> Follow-up of my LMC talk on 13/06/12, MDs and LMC talk from StephaneF on 11/07/12 (where it was recommended to change the sign of the octupoles)

- **4 main (urgent) questions we wanted to answer first (during MDs with 1 beam)**
- **Where do we want to go? Why change the sign of the octupoles?**
- **Our plan**
- **EOF yesterday (WE 01/08/12)**
- **Situation of the tune footprint viewer (there was an action)**

4 MAIN (URGENT) QUESTIONS WE WANTED TO ANSWER

- 1) What are the chromaticities?

=> Better knowledge vs. Landau octupoles' current. Measurements done 3 times and similar results obtained. Meas. from JorgW

- 2) Are the impedances (much) bigger than expected?

=> Within a factor ~ 2

- 3) Why do we need such a high octupoles' current in operation (~ 450 A, out of 550 A max, whereas we predicted much less)? => Of significant importance for the future operation at 7 TeV…

=> Seems not due to a single beam => Interplay with beam-beam (effect of negative chromas? high ADT gain?)?

- 4) Why is the ADT gain so high (i.e. damping time so fast as the predicted, and measured, instability rise-times are much slower)?

=> Seems not due to a single beam => Interplay with beam-beam (past hump or external excitations? effect of negative chromas?)?

WHERE DO WE WANT TO GO? (1/2)

- Several possibilities to stabilize/destabilize the beams (with chromas, octupoles, ADT and beam-beam)
- Goal: Find the best combination to have a very robust solution (where we have margins for all parameters) with sufficiently low octupoles' current (< ~ 250 A) not to be limited when we will go to 7 TeV

WHERE DO WE WANT TO GO? (2/2)

- Reduce the chromaticities (still > 0) as much as we can => ~ 1-2 units proposed (if possible to keep them positive, otherwise we should run with higher values)
- Reduce to ADT gain to what is (thought to be) needed => Much less
  - Remark 1: Due to the very high gain of the ADT, head-tail modes have to be treated together and first estimates (from AlexeyB and NicolasM) seem to indicate (to be confirmed) that in this case a higher chromaticity would be required (~ 5-6 units)
  - Remark 2: With this high gain, the TMCI intensity threshold could be pushed up (to be confirmed and kept in mind for the future)

  => All this study to be finalized, and meanwhile we would like to work with the lowest ADT gain (and thus lowest chroma and oct.)
- Reduce the octupoles' current to what is needed => Much less and change the sign (see next slide)

WHY CHANGE THE SIGN OF THE OCTUPOLES? (1/4)

- 1) + sign (in the LOF): To avoid situations with bunches having very small tune spread for landau damping (due to partial compensation between octupoles' effect and BBHO and/or BBLR) => When separation is reduced (BBLR) or when the beams are put in collision or in coast for some particular bunches (with emittance growth etc.)

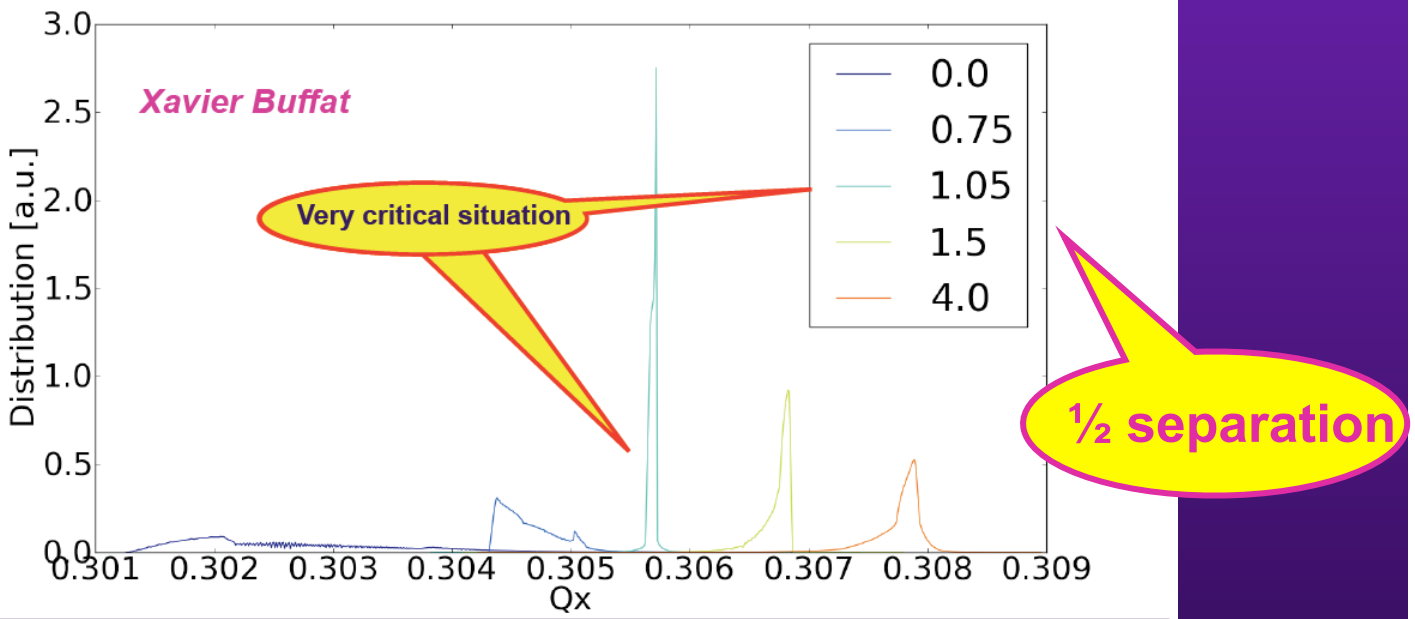
=> Much safer to operate with + sign where both effects (octupoles and beam-beam) add (but we said in the past "all consequences to be investigated in detail")

WHY CHANGE THE SIGN OF THE OCTUPOLES? (2/4)

- StephaneF recovered (during his LMC talk on 11/07) the same results obtained by the beam-beam team during the collision process, which is good and gives even more confidence => We all agree that there could be critical points (but then depend on the time of the different processes)!

2 TYPES OF INSTABILITIES RECENTLY OBSERVED (5/6)

- Horizontal tune distribution for an IP8 private bunch, with current octupoles



Elias Métral, LMC, 13/06/2012 19/21

WHY CHANGE THE SIGN OF THE OCTUPOLES? (3/4)

- I could not show all the plots the last time but the corresponding plots were (looking also at why instabilities in H and not V)

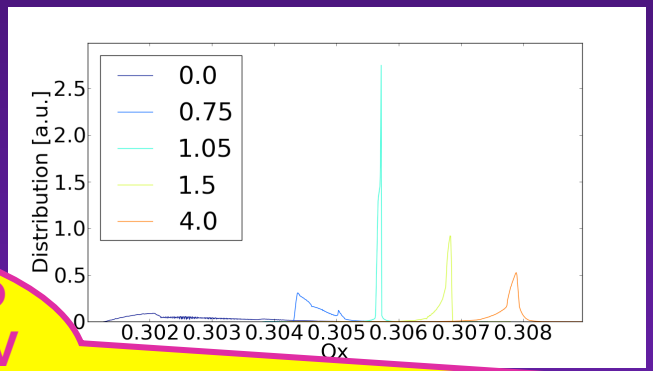
Xavier Buffat

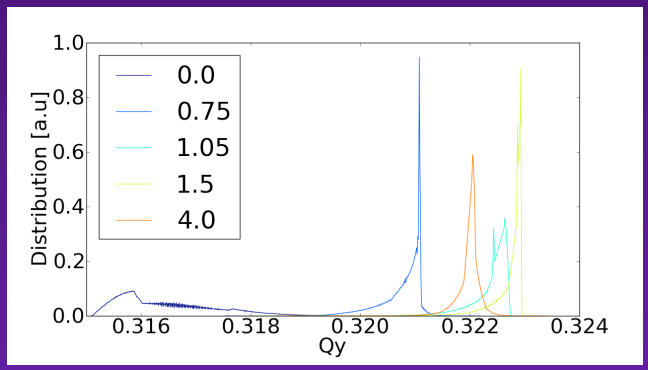
< 0 sign

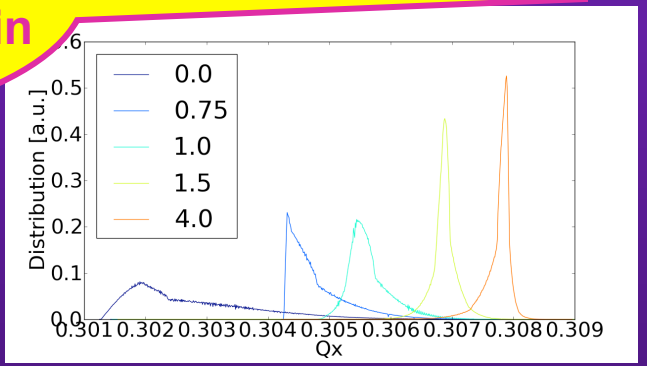
Was "1 possibility" to try and explain the H/V asymmetry observed in instabilities

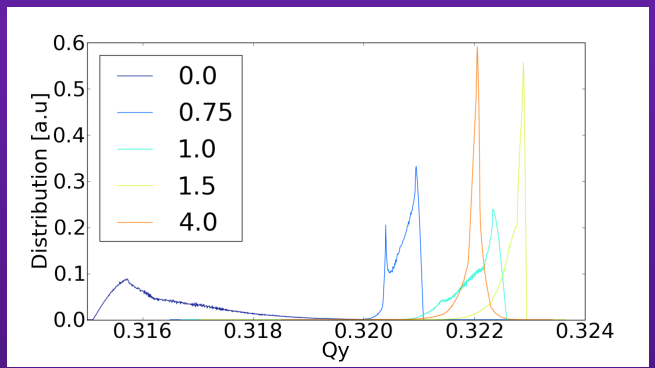
0 sign

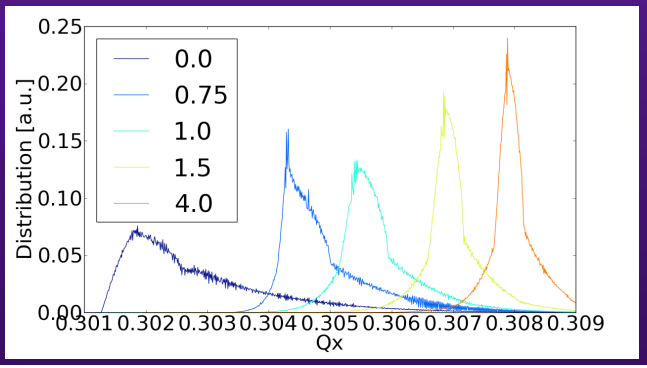
> 0 sign

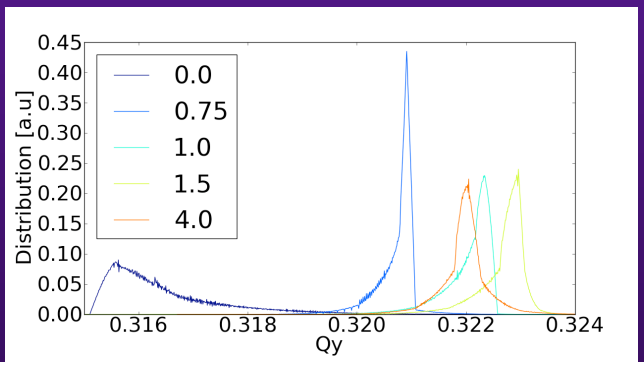












WHY CHANGE THE SIGN OF THE OCTUPOLES? (4/4)

- Next step (of our plan) => Plot the modified (by beam-beam) stability diagram and the modified (by ADT) complex tune shift on it to see what happens for all types of bunches to see if/when we can explain the instabilities by this mechanism

- 2) + sign: More current needed for the stability diagram but i) we should have enough margin and ii) we could rely on the core particles and not the tails (which is maybe better / more robust…)
- 3) + sign: Are we sure this will solve the issue at the end of the squeeze (where the beams are separated by ~ 30 sigmas)? Analyses ongoing => See also talk by TatianaP at last LBOC
- 4) + sign: Should find the octupole current needed with this sign to stabilize 1 beam (with the "correct" low chromas and low ADT gain) and then change the sign from injection and adjust the chromas => Would need fills with 1 beam or try to do this only at high energy (crossing 0)… => Take some time and need to be well prepared

OUR PLAN (1/2)

- Plan discussed in particular with GianluigiA, MikeL, JorgW, BernhardH
- Check that we have the sign of the octupoles we think (ABP) => Done and we have what we think (MassimoG)
- Reproduce the tune footprints with both polarity of the octupoles DURING THE SQUEEZE (ongoing, optics files needed => They are available)
- Before any change of polarity of the octupoles we need to verify the lifetime in collision with opposite polarity
  - 1st EOF study done yesterday (see later)
- Put the octupoles current to the same value (still negative sign). For the moment – 475 A for B1 and – 509 A for B2 => Put both at – 475 A (next fill)
- The chromaticity during the squeeze and in adjust needs to be re-measured (particularly for B2H) and possibly corrected to re-establish conditions similar to before the technical stop => Correct them to ~ 1-2 units

OUR PLAN (2/2)

- Reduce the gain of the damper (at least during end of ramp and squeeze initially) by factor 2/4/10…?
- In parallel of the verifications of the feasibility of running with opposite polarity of the octupoles a few EOF (or SOF?) fill tests will have to be done to optimize the strength of the octupoles and possibly the working point that might have to be changed and to set the corresponding chromas

EOF STUDY OF YESTERDAY (WE 01/08/12) (1/4)

- With TatianaP, AlexeyB, EnricoB, GuyC, GianluigiA, BarbaraH, GeorgesT…
- Goal: study the effect of the opposite sign in the Landau octupoles in collision and separated beams, as this sign could lead to some lifetime degradation (larger tune footprint) and instabilities (depending on the current)
  - Initial luminosity of ~2E33 for IP1&5
  - Bunch intensities of ~1E11 p/b
  - Transverse emittances of ~ 3.5 microm (from luminosity)
  - Chromas should be at ~1.5-2 units in both planes both beams (according to recent measurements and trims)

$\Delta Q_{\text{oct}} \propto \varepsilon_n$ + effect of impedance proportional to bunch intensity

$$\Delta Q_{\text{BBHO}} \propto \frac{N_b}{\varepsilon_n}$$

$$\Delta Q_{\text{BBLR}} \propto N_b \, \varepsilon_n$$

EOF STUDY OF YESTERDAY (WE 01/08/12) (2/4)

- 1st study: Beams in collision and we changed the octupoles current by steps starting from the initial case (from physics): -475 A for B1 and -509 A for B2: -220 A, -100 A, +100 A, +200 A, +300 A, +400 A, +500 A
  - In every step, the chromas were trimmed (approximately) based on past (linear) measurements of the chroma dependence on octupoles' current
  - Essentially no change of lifetime (some dips observed at the time of the changes and then recovering) except for the last 2 steps were the lifetime was certainly worse => To be checked but could be what we were looking for (due to larger wings in the tune footprint)
  - Furthermore, some effect on the bunch length (steeper slope in bunch shortening) was also observed which should be studied in detail

EOF STUDY OF YESTERDAY (WE 01/08/12) (3/4)

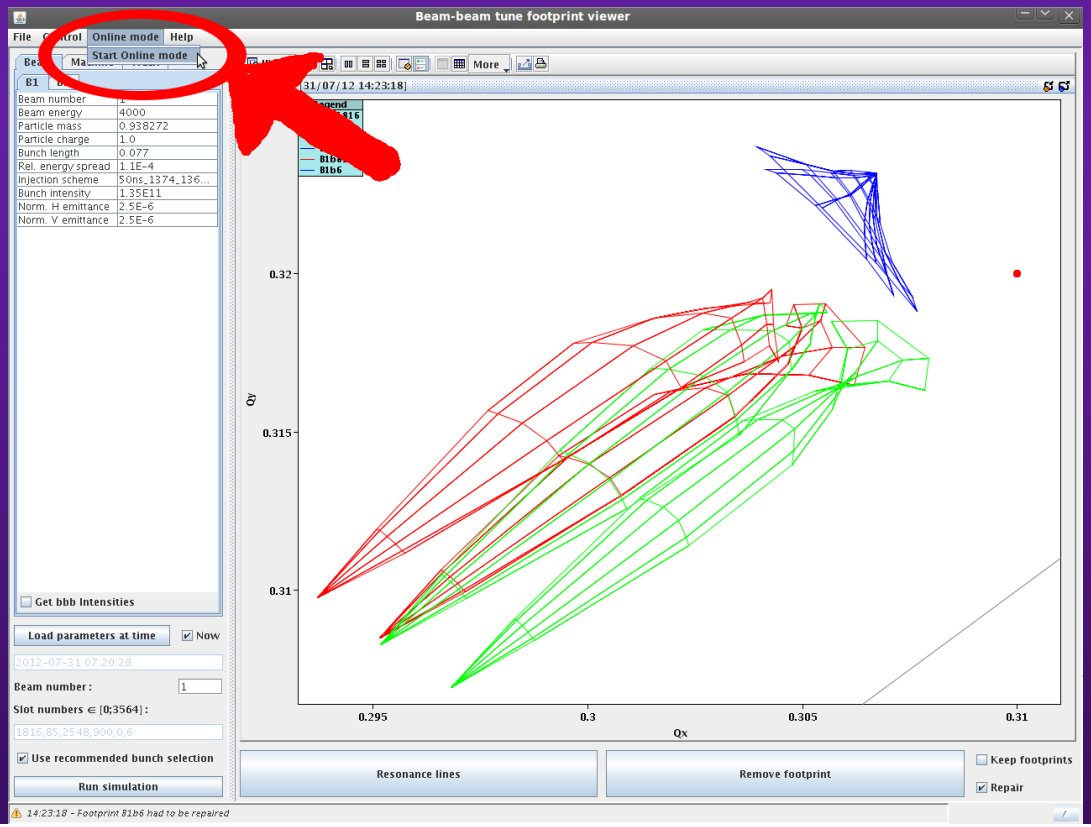
- 2nd study: +150 A octupoles (with chromas trimmed)
  - Then separated IP1&5 by steps of 0.5 sigmas from 0 till 4 sigmas => No (big) pb
  - Then separated in IP8 from 0 till 4 sigmas => No (big) pb
- 3rd study: +50 A octupoles (with chromas trimmed)
  - Experiments still separated => No (big) pb
  - IP1 & IP5 & IP8 back in collision in 1 step => No (big) pb seen and the IP1&5 lumi was ~ 1.8E33, also after re-optimization. (Reminder: was ~2E33 at the start of the study)

EOF STUDY OF YESTERDAY (WE 01/08/12) (4/4)

- 4th study: Reduced octupoles' current to 0 A (with no chromas trimmed)
  - No (big) pb
  - Then separated IP1&5&8 to 4 sigmas in 1 step => No (big) pb
  - Finally, did some steps in chromas:
    - Delta of +5 in both planes both beams => Dip (as usual) and then it tried to come back but the final lifetime was reduced
    - Delta of -10 (i.e. - 5 compared to the initial situation) done at 11:25 => Dip (as usual) and then it came back to a lifetime even better. However, 4 minutes later we started to see some activities/instabilities on the 6 IP8 bunches. To be studied in detail

TUNE FOOTPRINT VIEWER (1/3)

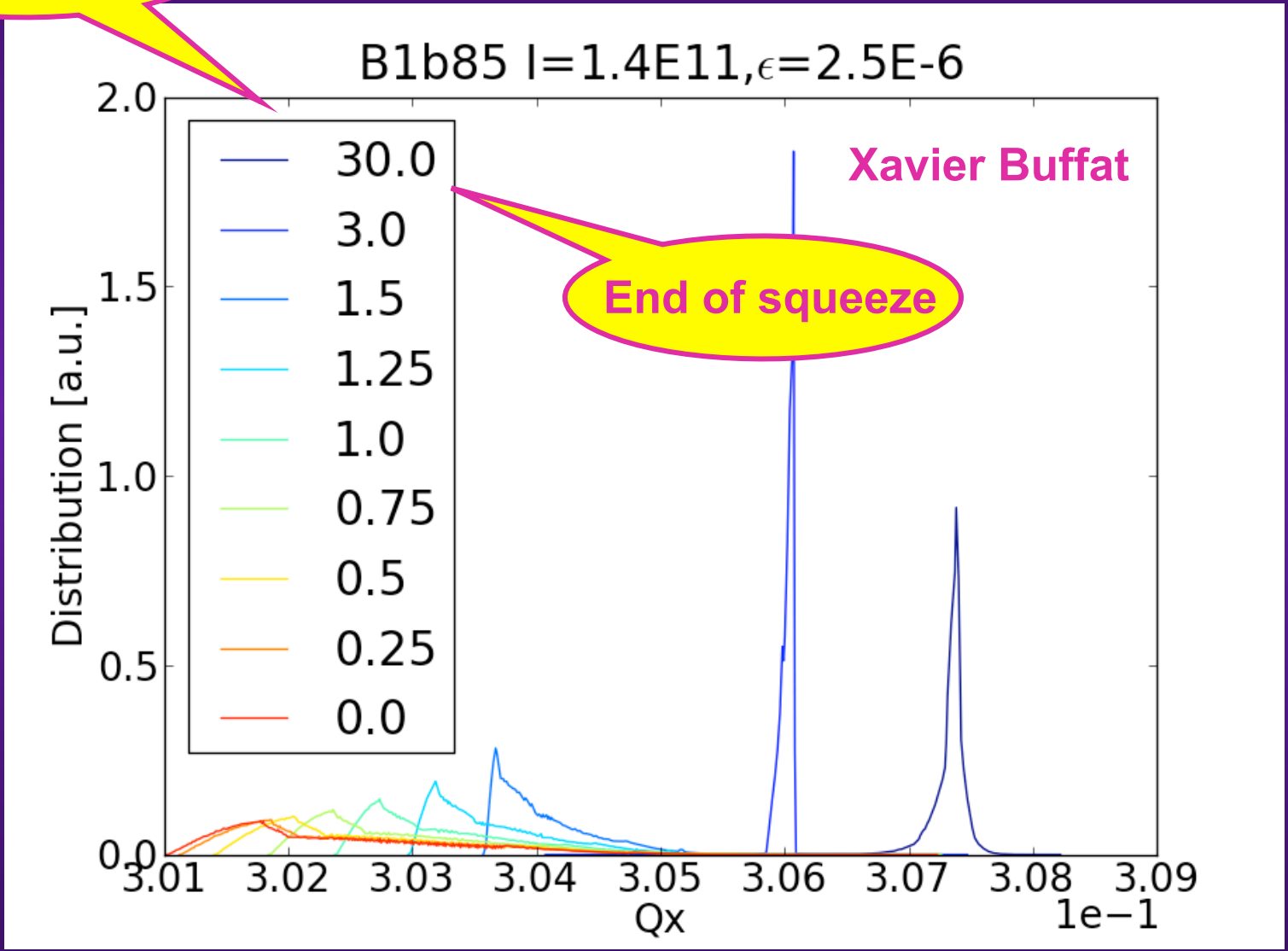
- **Online mode available (Xavier Buffat) => Fully automatized**
  - **Load from LSA**
  - **Only transverse emittances to be set by hand**
- **Ongoing discussions to have a remote machine (with Pierre Charrue)**
- **Could be released anytime (waiting for the remote machine)**



TUNE FOOTPRINT VIEWER (2/3)

- Some updated plots (for current situation)

Full separation



TUNE FOOTPRINT VIEWER (3/3)