Transverse coherent instabilities in the LHC and HL-LHC: from understanding to predictions

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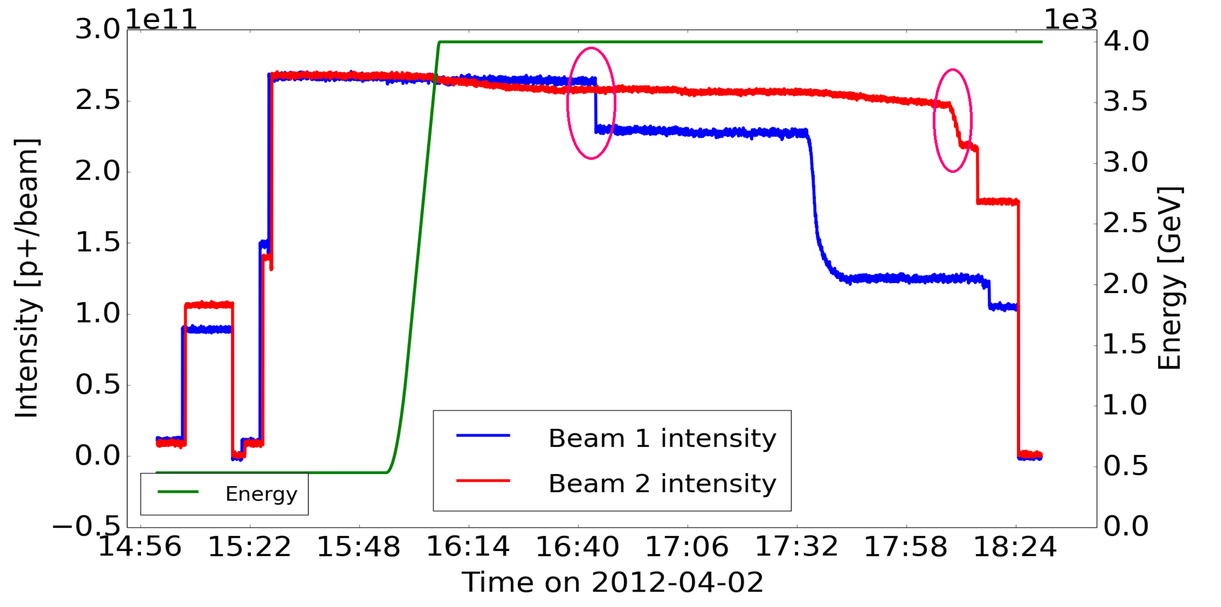
ABSTRACT

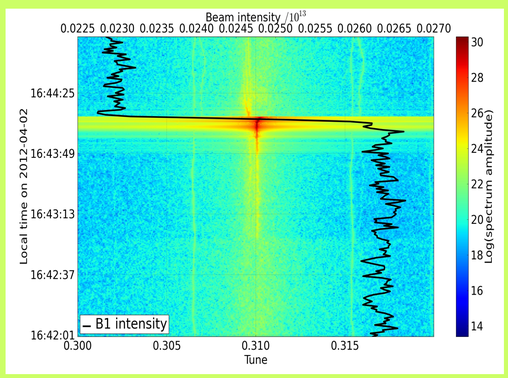
Transverse collective instabilities are one of the most important limitations to achieve the highest luminosities in the LHC and have been regularly observed during the LHC Run I.
A complete understanding of the observed instabilities requires simulations/theories as close as possible to reality. This will then allow predictions for the future operation of the LHC as well as for HL-LHC.

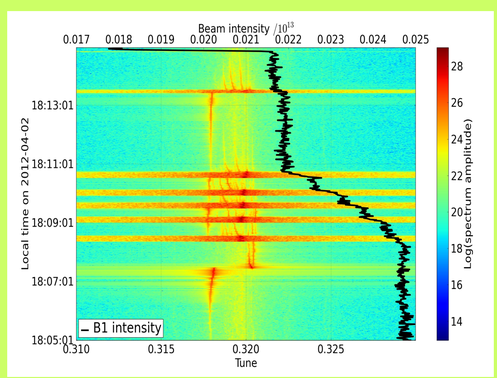
OBSERVATION

In 2012, in LHC were observed some single-bunch instabilities during normal operation, which can be studied with HEADTAIL simulations. For instance, the instability on 2nd of April, during the collimator's "loss maps".

- Feedbacks (ADT) off
- After the end of the squeeze
- Focusing octupole current I_{oct} = -406 A







HEADTAIL SIMULATIONS

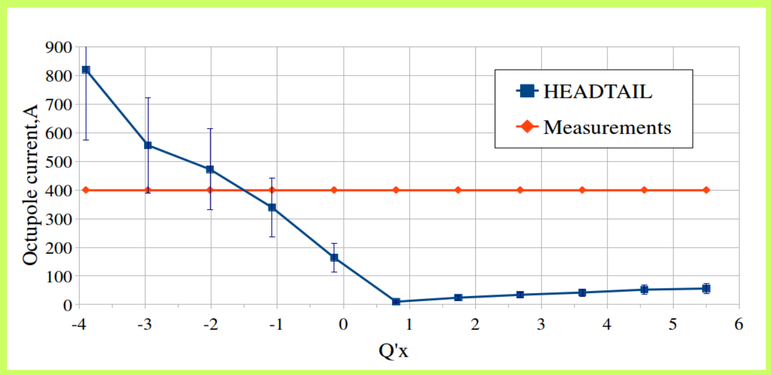
To check the accuracy of the LHC impedance model we chose to compare:

- the octupole current threshold from simulations and the octupole current in measurements;
- the bunch intensity in the measurements and the intensity needed in the simulations to obtain the same rise time as in the measurements (with the same octupole current).

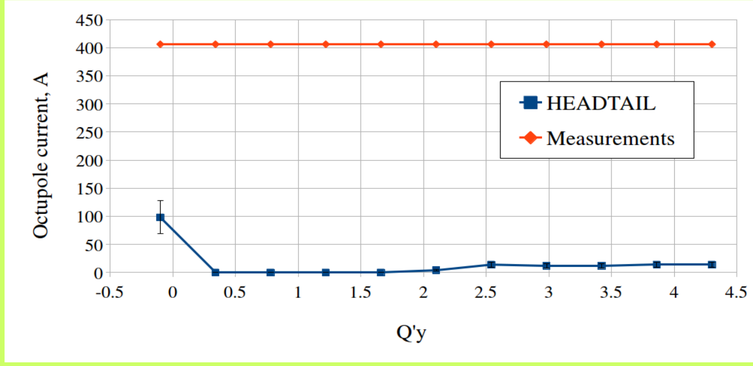
CONCLUSIONS

- The octupole current threshold found with HEADTAIL has a very large discrepancy compared to the octupole current in the measurements.
- From HEADTAIL simulations the stabilizing octupole current seems to be rather high for negative chromaticities and close to 0 A for positive chromaticities.
- The intensity, needed in the simulations to get the same rise time as in the measurements, in comparison with the measured intensities gives a discrepancy of factor 3 for positive chromaticities.
- Furthermore, having the chromaticity -2 in the measurements in beam 1 in the horizontal plane, the current LHC impedance model could explain the rise time observation.

Threshold octupole current

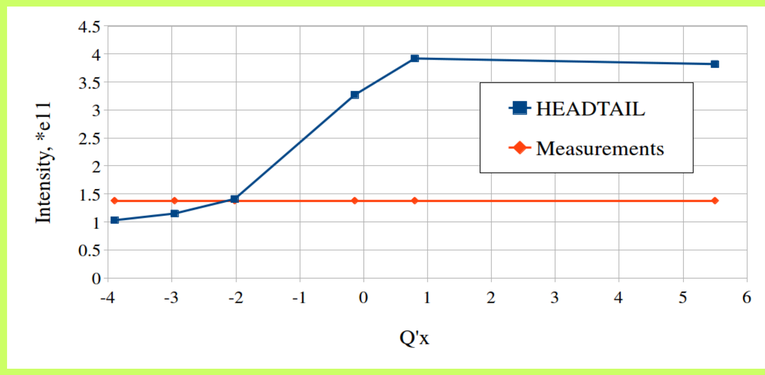


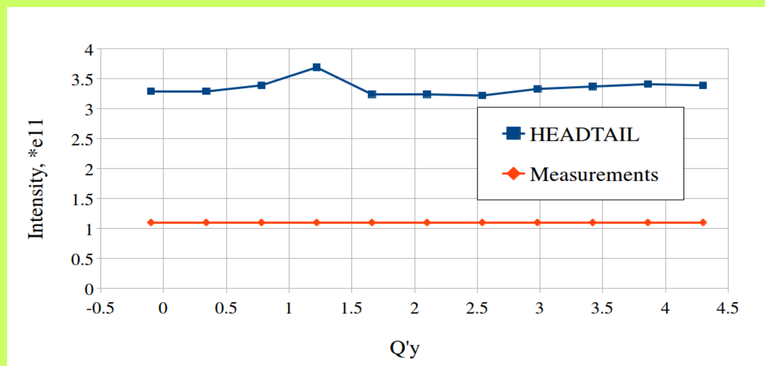
Beam 1 bunch 1, horizontal plane



Beam 2 bunch 2, vertical plane

Intensity scan





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