Update on Long-range Instabilities

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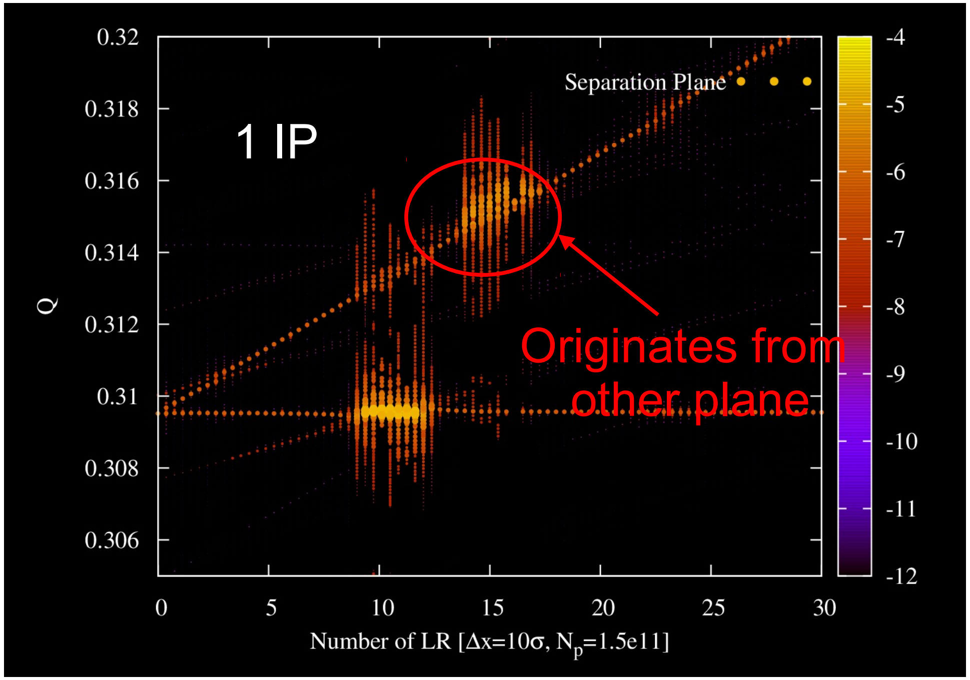
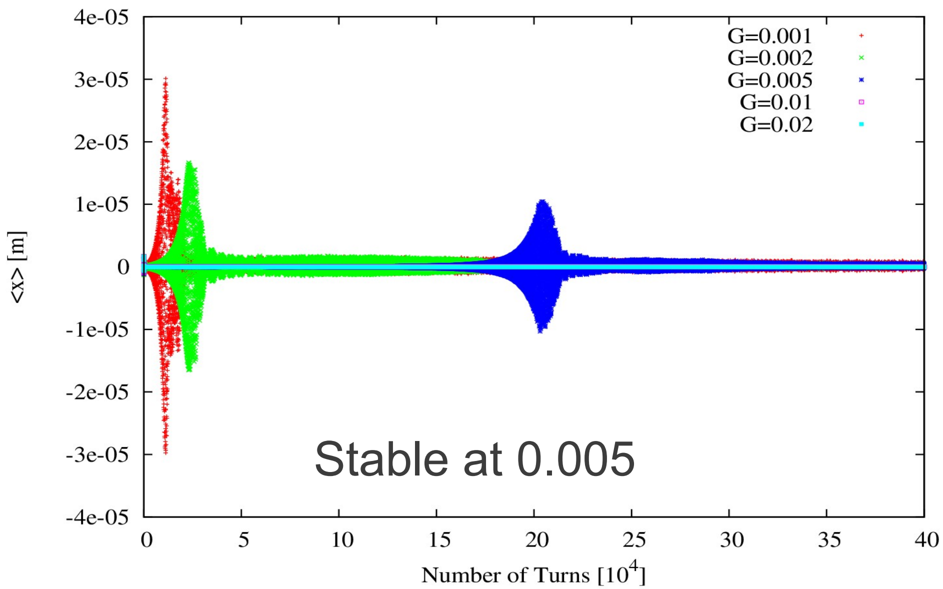
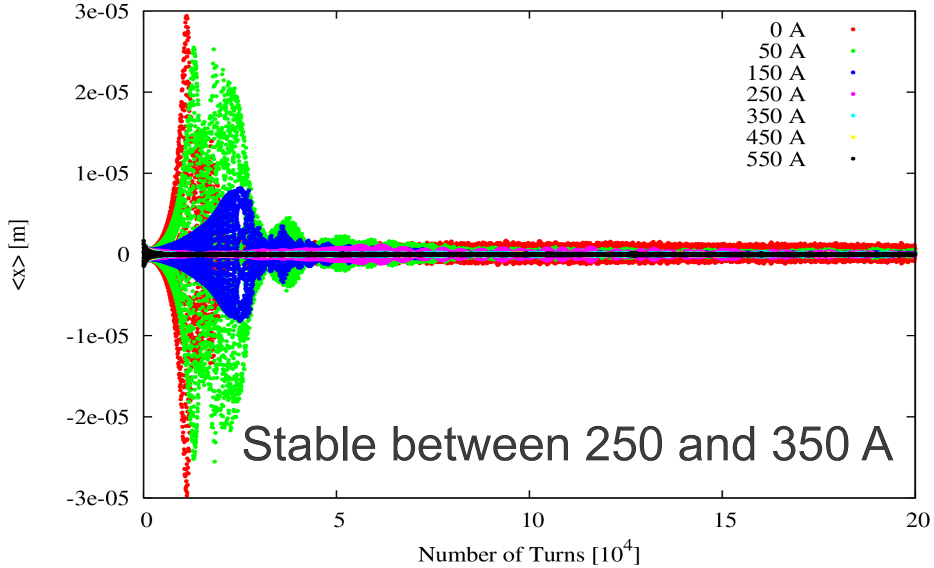
Thanks to X. Buffat and N. Mounet

Reminder



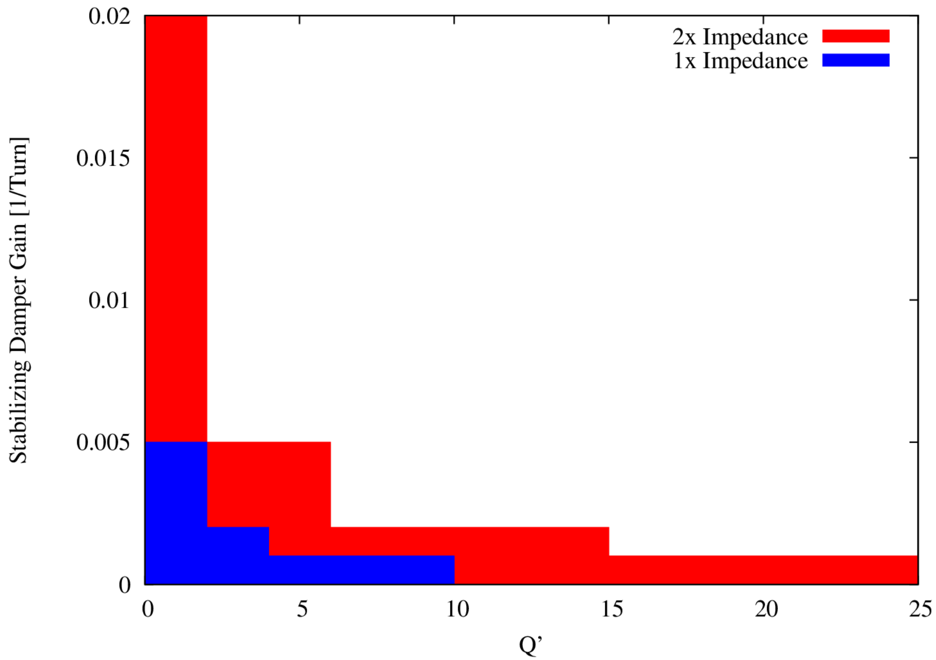




→ Mode -1 couples with σ-mode leading to strong instability
→ Damper is efficient only at high gain
→ Octupoles have stabilizing effect (realized G=0.001 in this case)

→ Done only for Q'=0 and 1x nominal impedance

Chromaticity and higher impedance



→ Scan chromaticity for different damper gains, octupole current set to 0A

→ Large error bars – step in G: 0.02/0.01 0.005/0.002/0.001/0.0

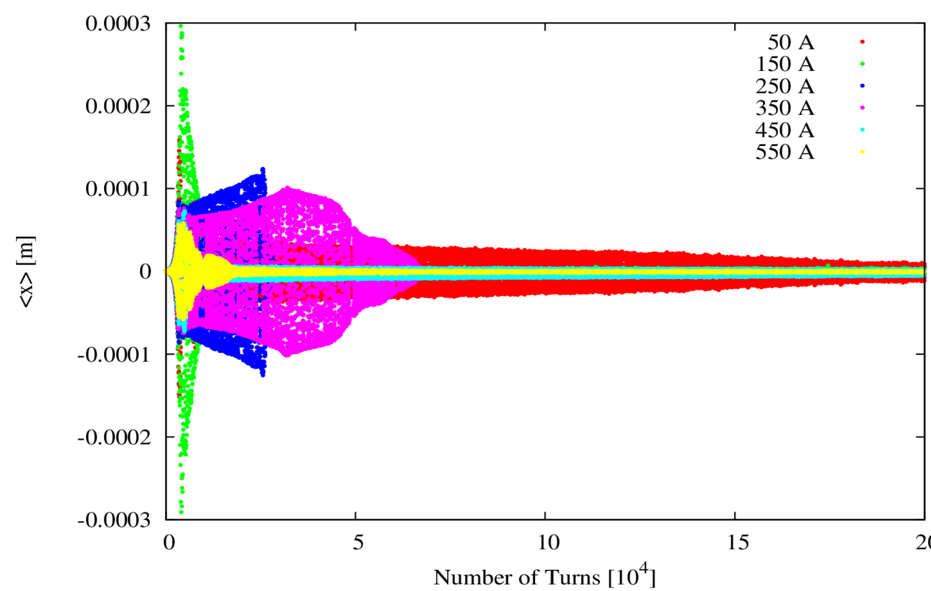
→ High chromaticity and gain cures the Instability

→ For 2x impedance and chromaticity up to 2 still unstable even at G=0.02

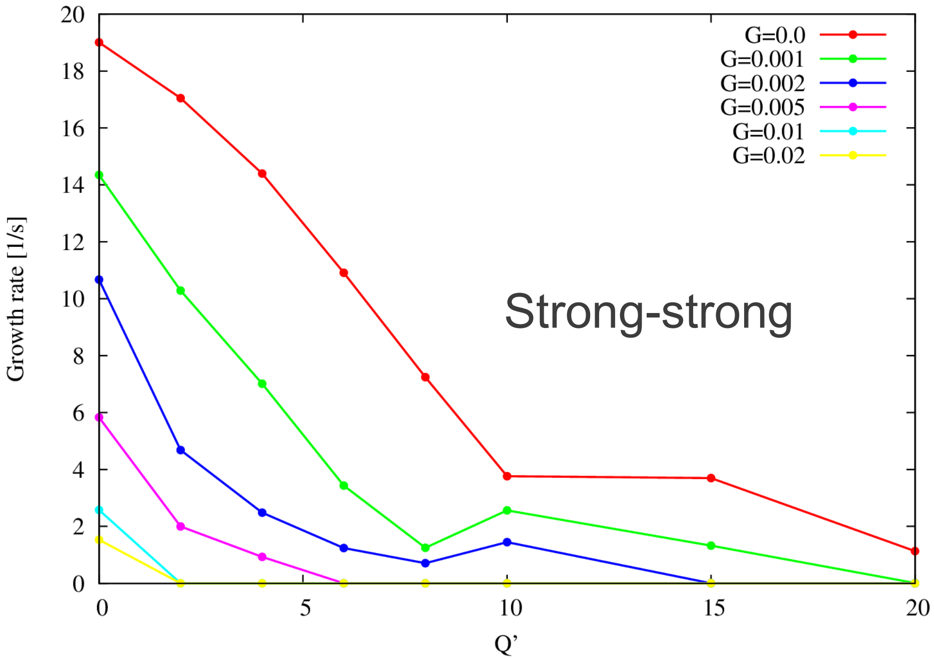
→ Try to stabilize with octupoles only

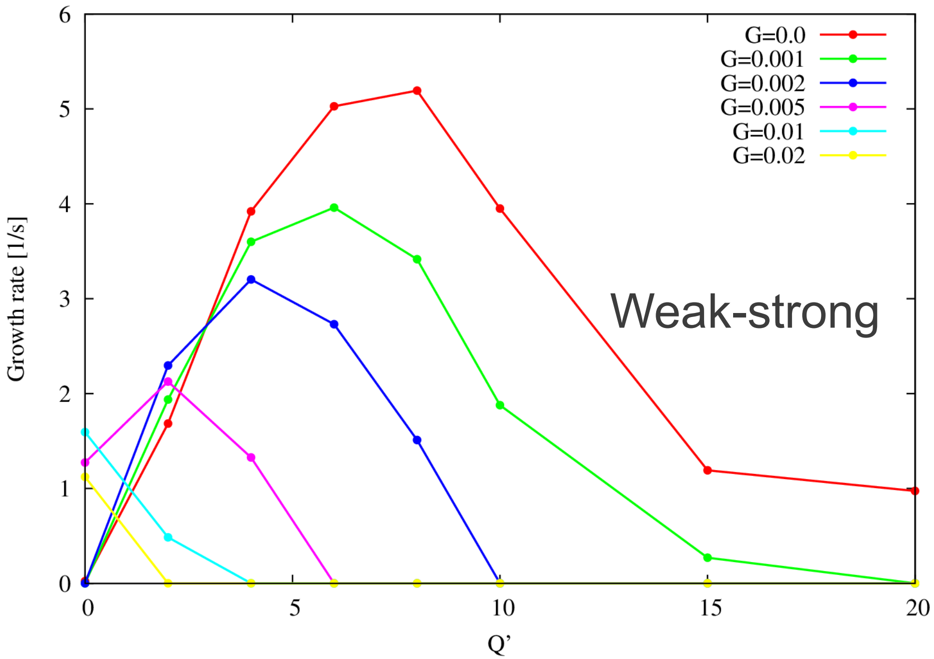
→ With 2x nominal impedance it was not possible to stabilize the beams even at full octupoles current

→ Rise-time depends decreases with current



Growth rate



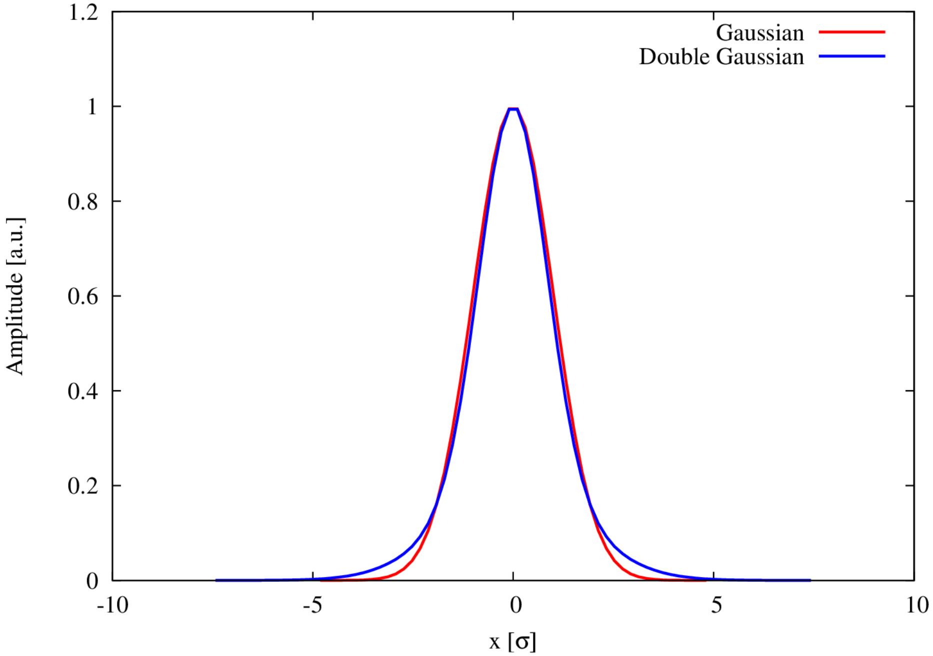


→ Comparison between strong-strong (tune spread+coherent modes) and weak strong (tune spread only) for the same beam parameters – tune spread ~200A of octupoles

→ At low chromaticity and/or low gain the pictures are significantly different and coherent modes clearly degrade the situation

→ Both cases at stable at high gain and chromaticity – difficult to compare – this cannot explain what is observed in the machine

Non Gaussian tails

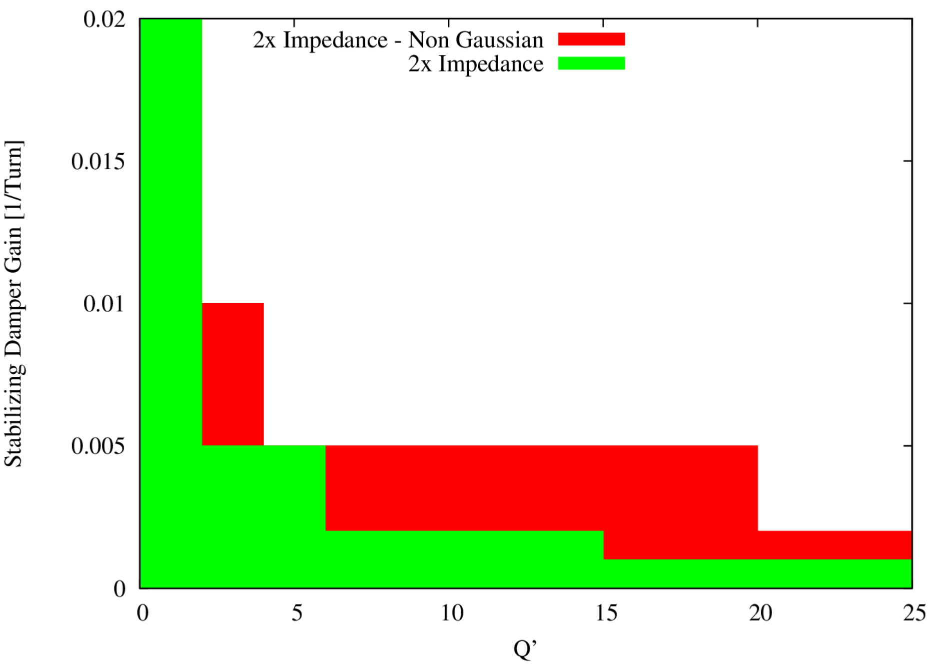


→ Generate double Gaussian distribution

→ Field computed with Poisson solver, no assumption on distribution

→ x coordinates rescaled to keep rms constant

→ 20% of the particles in 2nd Gaussian with 2x nominal σ

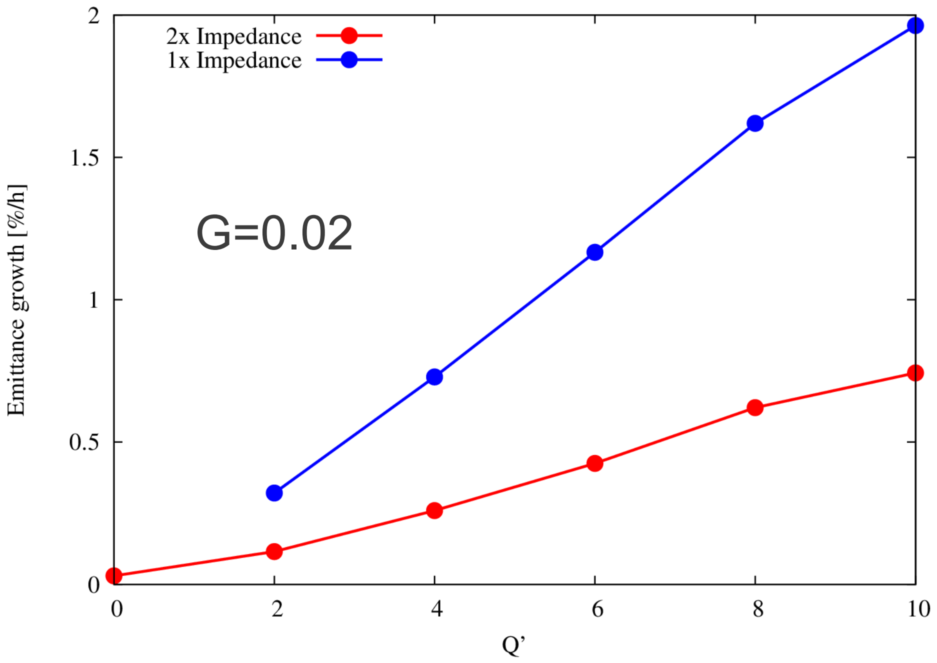


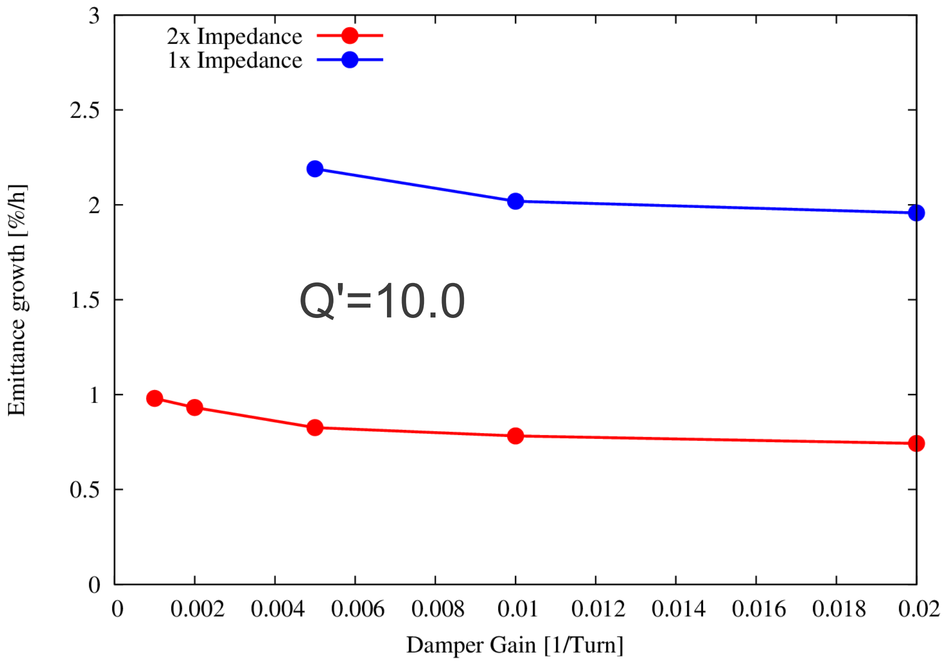
→ Adding more particles in the tails clearly degrades the situation

→ Even at very high chromaticity the gain required to stabilize the beams is higher than 0.005

→ Bunches at end of batches see lower gain, more impedance → could be consistent

Emittance



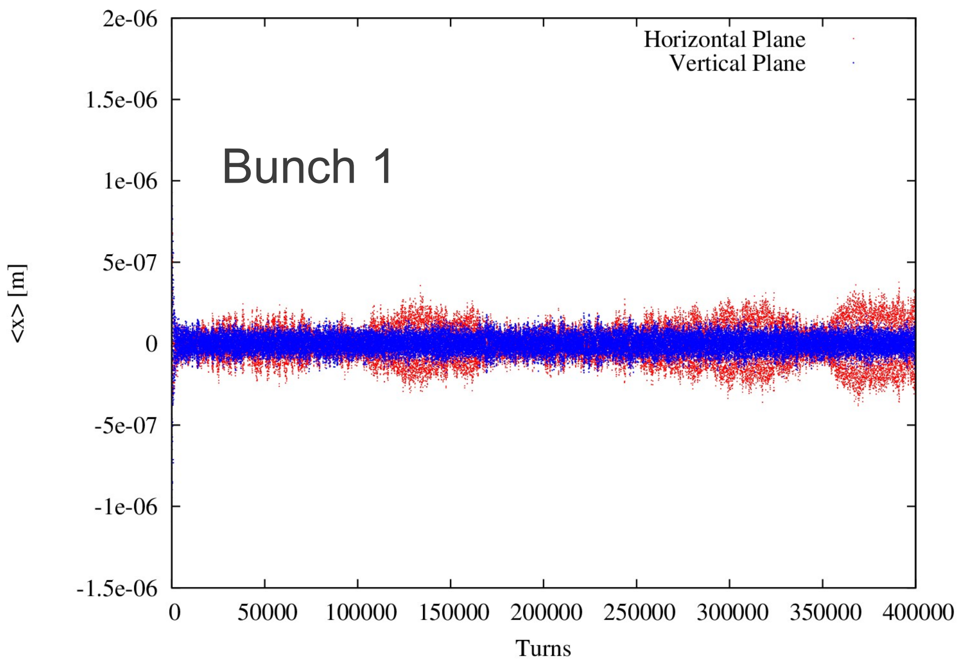


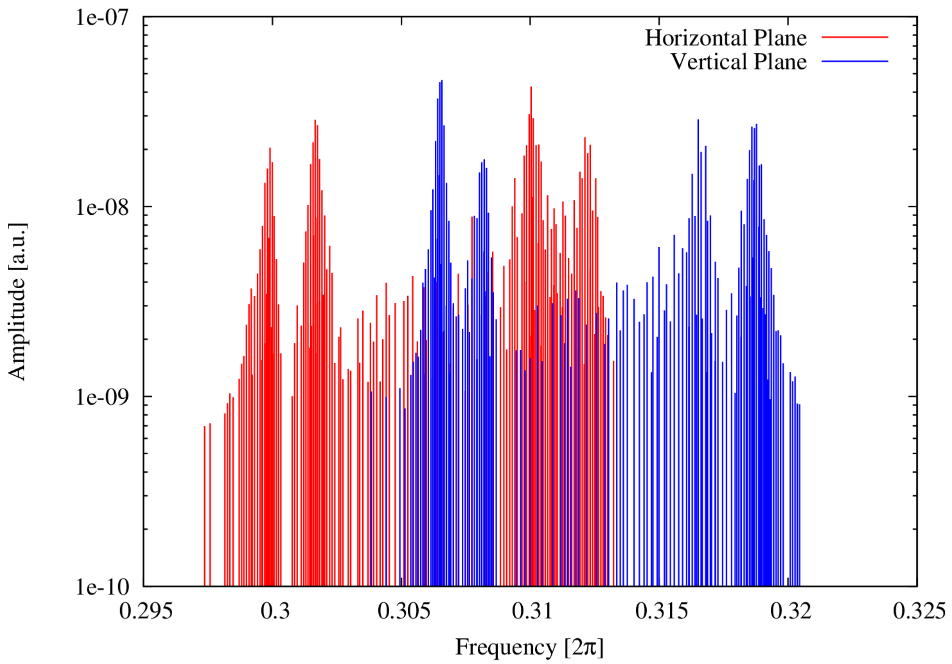
→ Strong dependency of emittance growth (or lifetime degradation, non losses in the code) with chromaticity – missing points means the beam is unstable

→ We should really make sure the chromaticity is reduced one colliding head-on as this could result in luminosity performance degradation

→ Damper has very little effect – slight improvement with higher gain, but in this case ideal damper: no noise besides statistical fluctuations

Head-on + long-range





→ Track 2x2 bunches such that each bunch has 10LR (lumped) + 1 HO – each bunch couples with a different counter rotating bunch for the LR and the HO

→ More modes present, LR modes still present – positive tune shift for horizontal and negative for vertical

→ Octupoles, damper gain and chromaticity set to 0, both planes look stable over 400000 turns

→ Full HO stabilizes the beams even without octupoles or damper

Summary

- Check the effect of doubled impedance: all gain thresholds increased, impossible to stabilize with octupoles only even at full current
- Assuming a perfectly Gaussian beam, high chromaticity and damper gain should provide stability → not consistent with observations
- Populating the tails has a detrimental effect and could compromise stability even for high gain and chromaticity: tails dynamics is difficult to model, studies ongoing
- High chromaticity could degrade lifetime, we should make sure it is significantly decreased once in physics
- A single head-on is sufficient to stabilize the beams without any octupoles or damper → goes in the direction of beta* leveling
- Results assuming non-Gaussian beams could be in qualitative agreement with observations: need to look at multi-bunch tracking for confirmation