A Landau octupole puzzle

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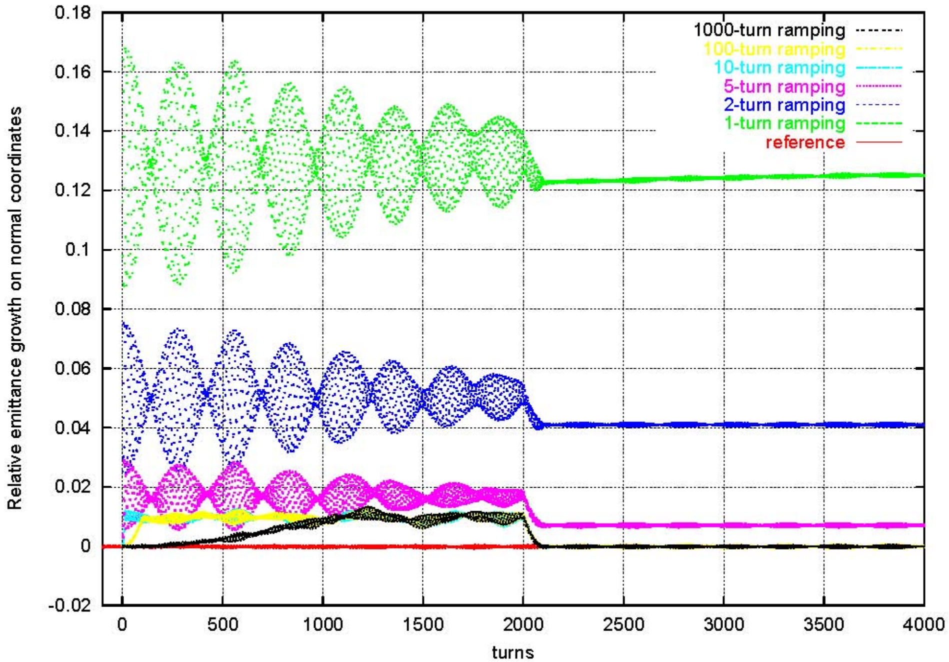
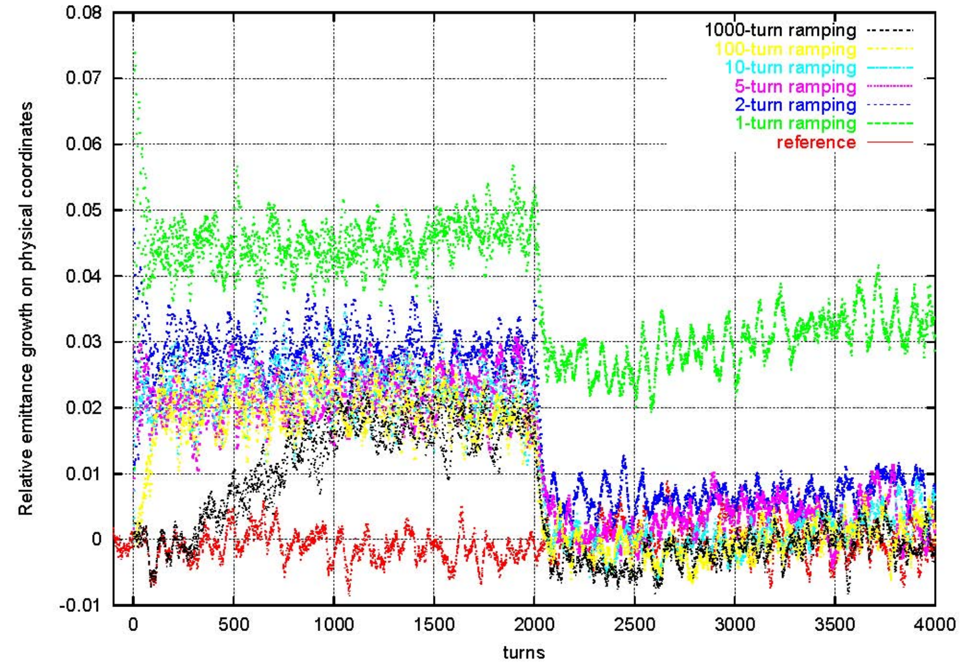
reminder: Akio Morita's crab-cavity ramping study



"nearly linear" machine



all Landau octupoles at K_3=100 m^{-4}

with octupoles emittance growth is ~3-4 times smaller?!?

what is the tune spread induced by octupoles?

octupole strength

J.-P. Koutchouk, F. Ruggiero, **A Summary on Landau Octupoles for the LHC,** LHC-Project-Note-163, 1998:
144 octupoles, strength=62,000 T/m^3, length=32.8 cm
detuning $\Delta Q_{1\sigma}$=1.3x10^{-4}

LHC Design Report, Chapter 5:

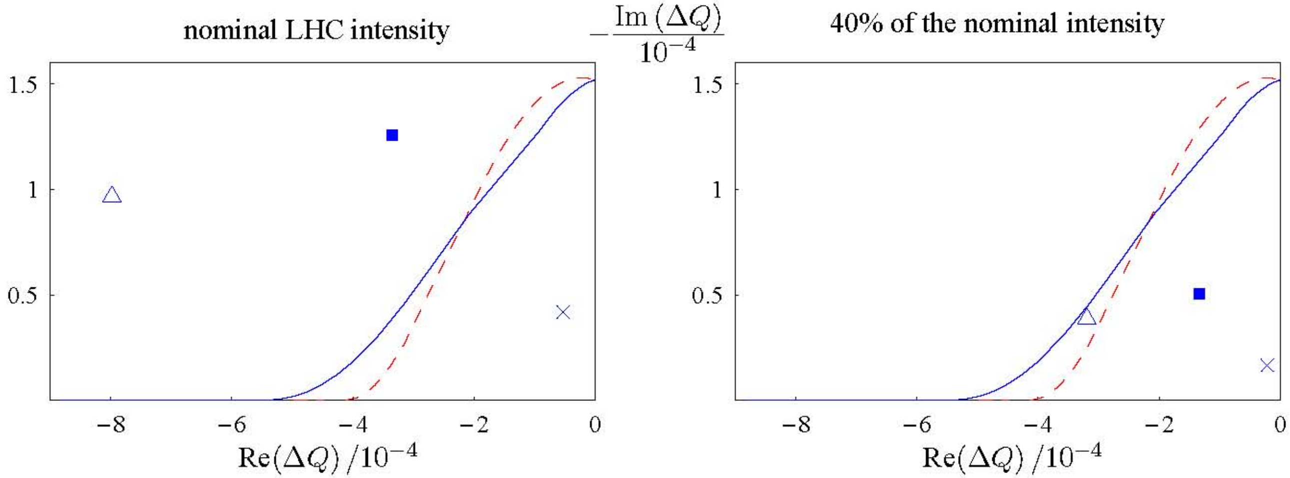


Figure 5.1: Stability limits for a detuning $\Delta Q_{1\sigma} = \pm 1.35 \times 10^{-4}$ and coherent tune shifts for the LHC at 7 TeV with squeezed optics and nominal LHC beam intensity (left) or 40% of the nominal intensity (right). The horizontal and vertical axes give the real part and minus the imaginary part, respectively, of the coherent tune shift for the most unstable coupled bunch rigid mode ($m = 0$): without collimators (cross), with copper coated graphite collimators (square), and with un-coated graphite collimators (triangle) at $\beta^* = 0.5\,\mathrm{m}$. The dashed (red) curve is the stability limit for maximum Landau octupole current with negative anharmonicity $a < 0$, the solid (blue) curve with positive anharmonicity $a > 0$.

I counted 168 Landau octupoles in LHC optics v. 6.5
nominal strength 63,000 Tm^{-3}
nominal field at 17 mm = 0.29 T
nominal current 550 A
magnetic length 32 cm

$K_{3,max}$ = 63,000 x (3!) / (3.356*7000) ~ 16.1 m^{-4}

I asked Akio to check tune shift at 1 sigma for K=100 m^{-4} using SAD:
$\Delta Q_x = 3.4\times10^{-4}$
$\Delta Q_y = 4.5\times10^{-4}$

Translated to the nominal octupole strength this would be
$\Delta Q_x = 5.4\times10^{-5}$
$\Delta Q_y = 7.2\times10^{-5}$
this is about half of the expected detuning!?!

Rogelio made independent check with MADX for K=10 m^{-4},
and confirmed the result of Akio

do we have less Landau damping than we thought? do we miss anything?

what is the definition of detuning at 1 σ?

in the note from J.-P. Koutchouk and F. Ruggiero
I find

$\Delta Q_{1\sigma} = 2\ \varepsilon$ DQDE

but maybe it should be

$\Delta Q_{1\sigma} = \varepsilon$ DQDE ?

do we use a consistent definition in the Landau damping calculations?