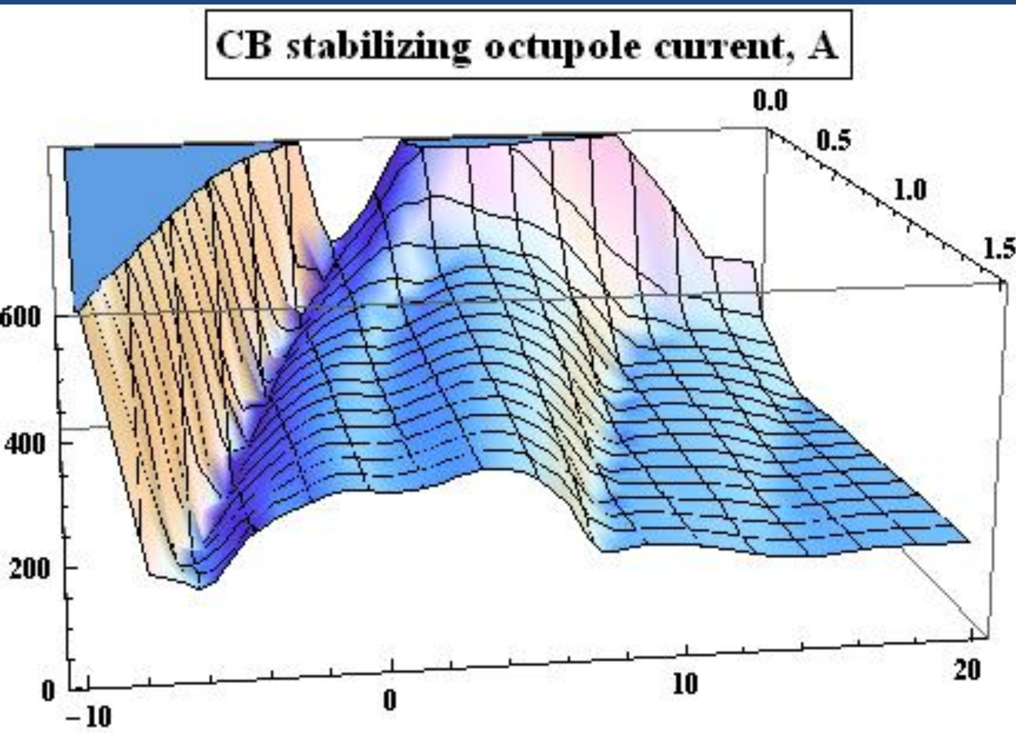
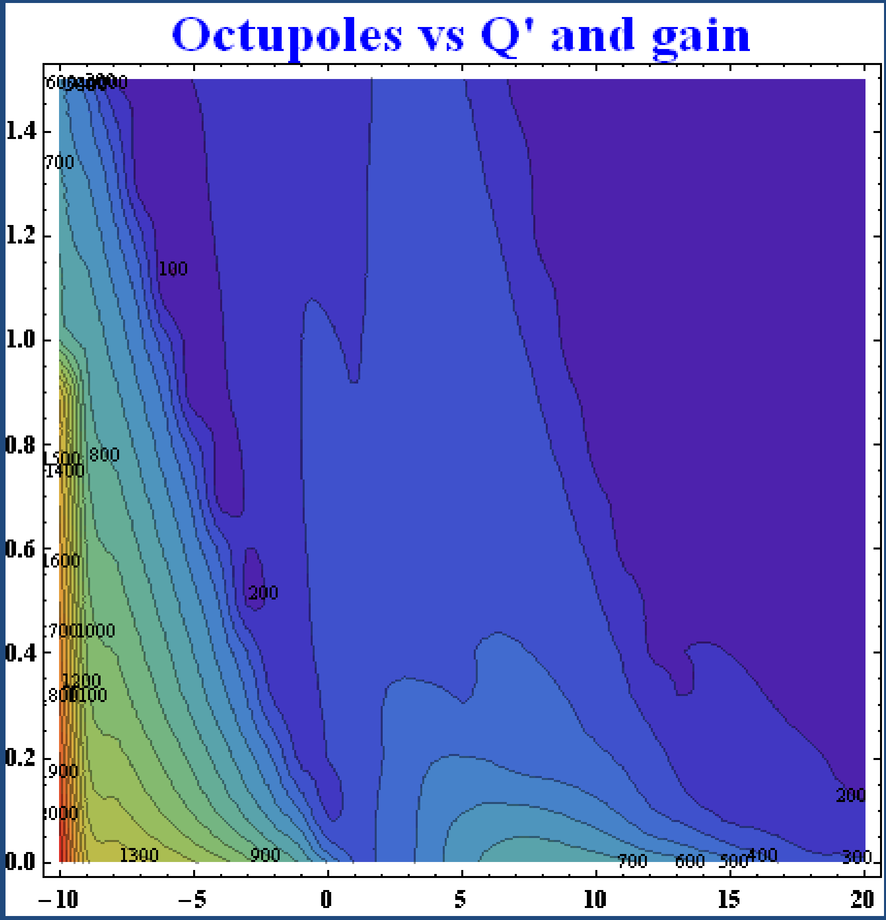
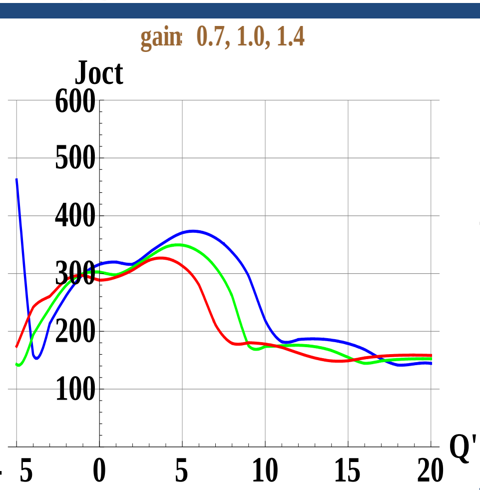
ADT Suppression of Coherent Beam-Beam

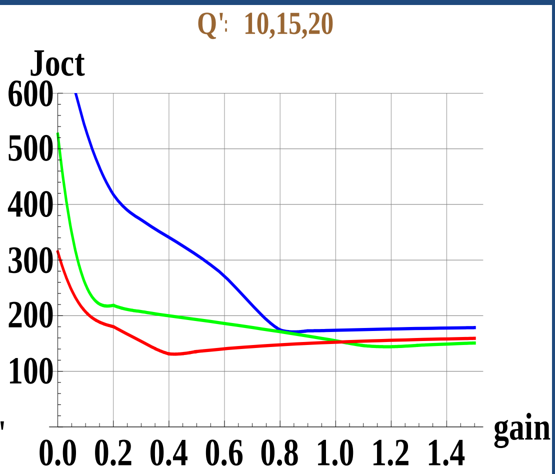
A. Burov, Oct 29/2012

2⊗(SB and CB Imp), MO>0, no beam-beam:





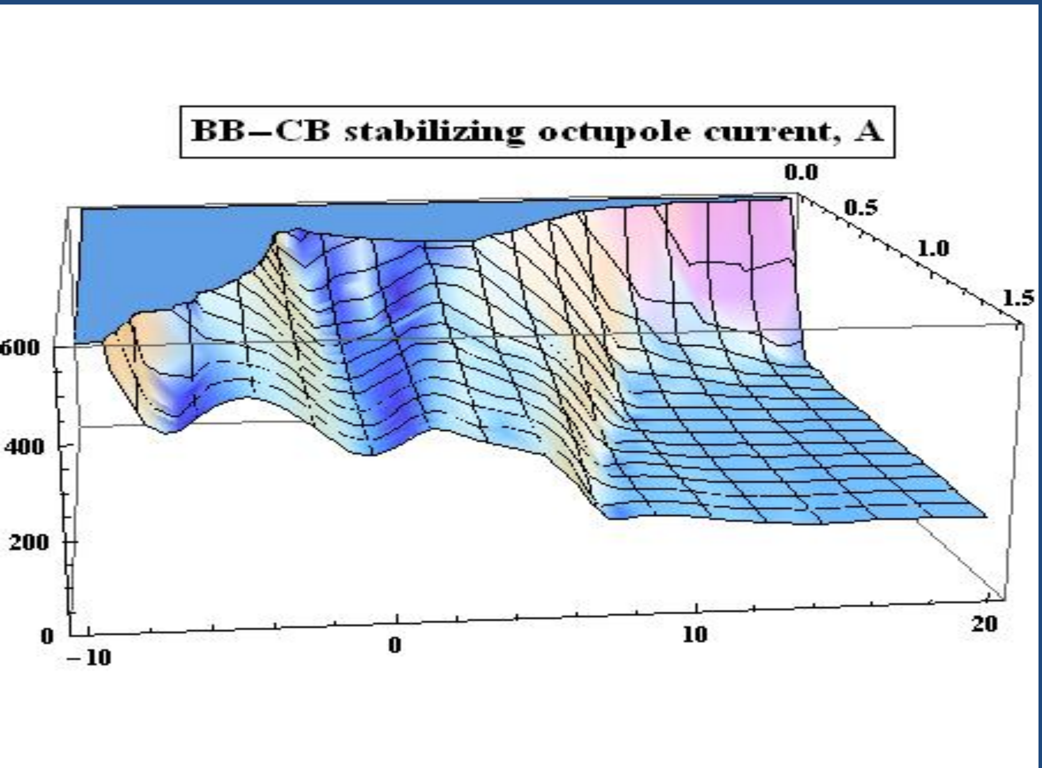


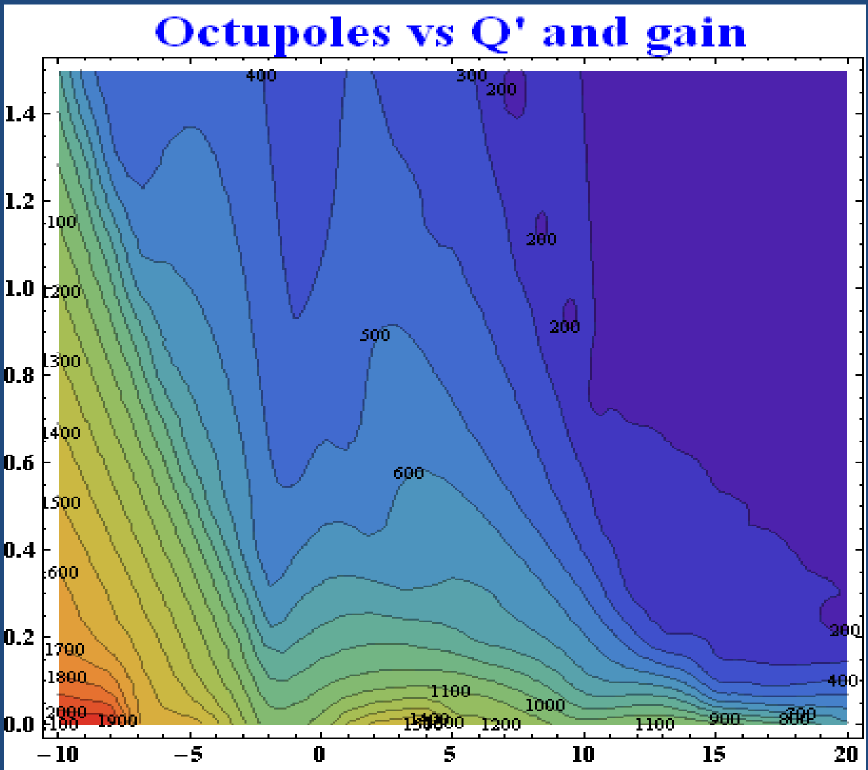


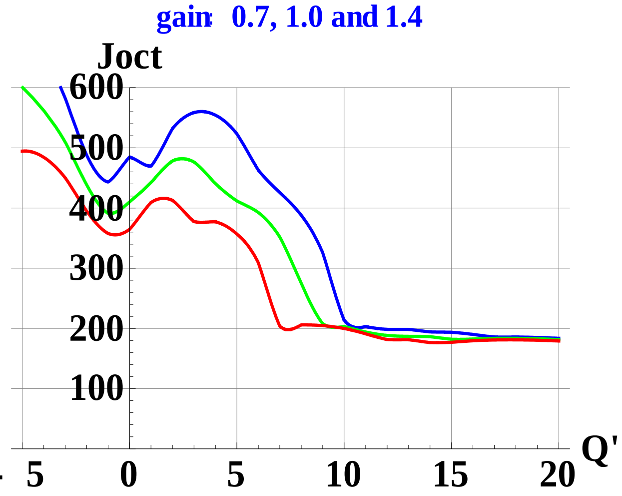
Gain is in Qs units.

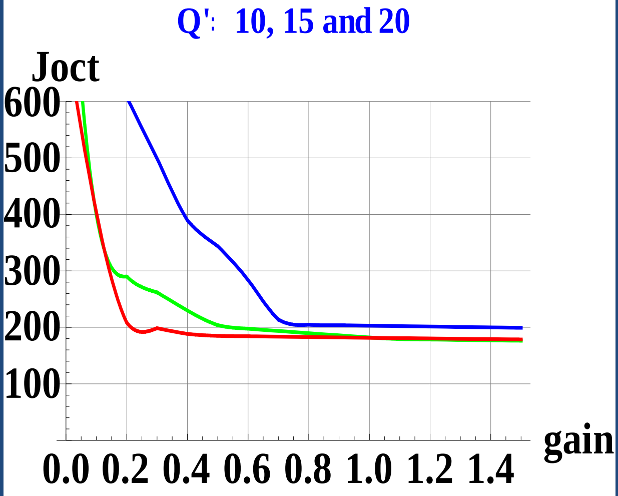
Gain=1 is equivalent to 70 turns of the damping time.

2⊗(SB and CB Imp), dQbb1=Qs, MO>0, dφ15=π



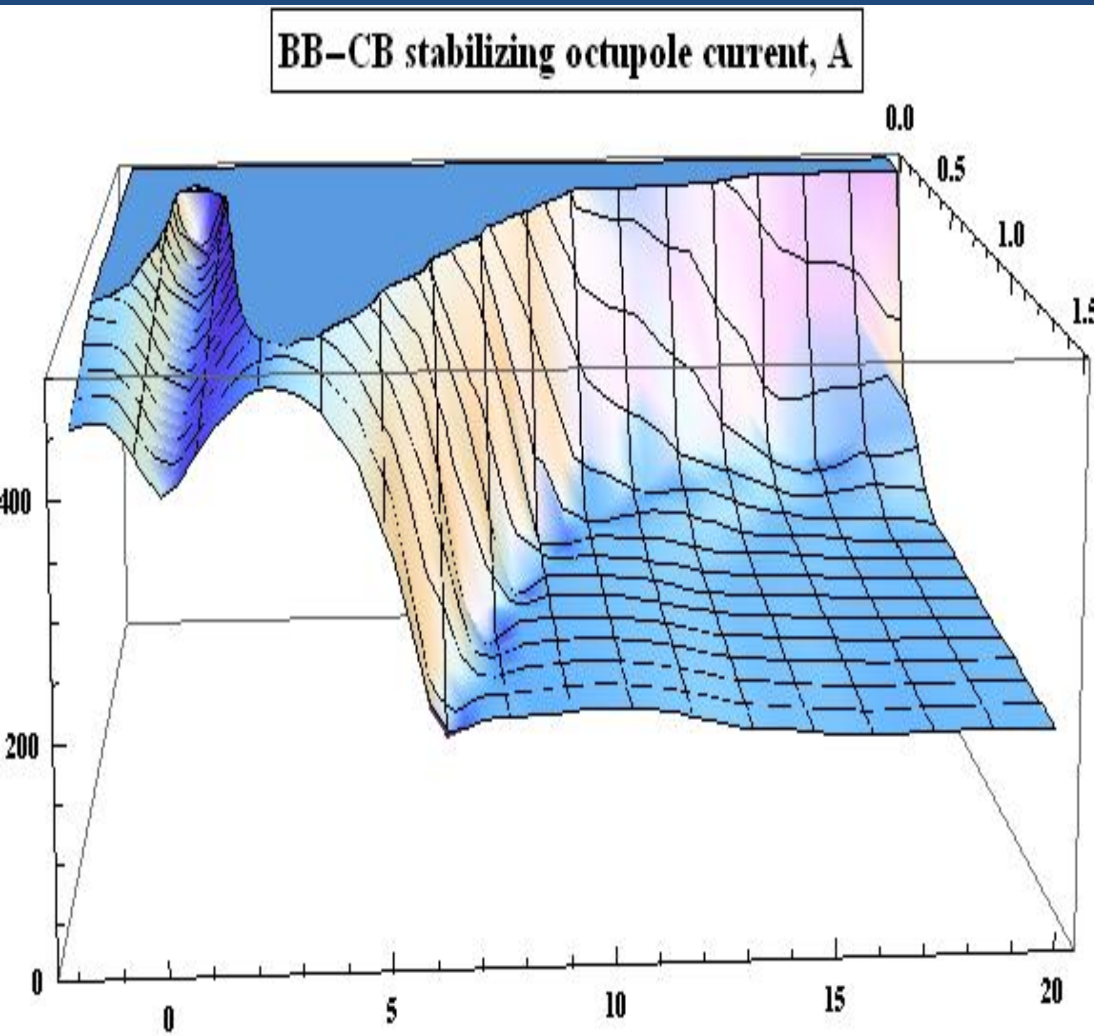


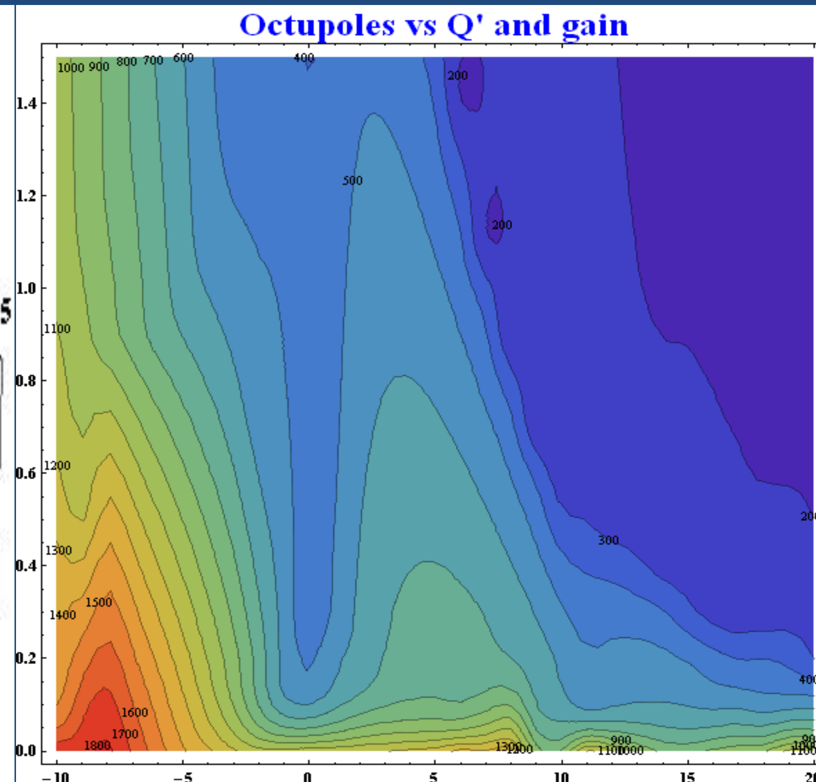


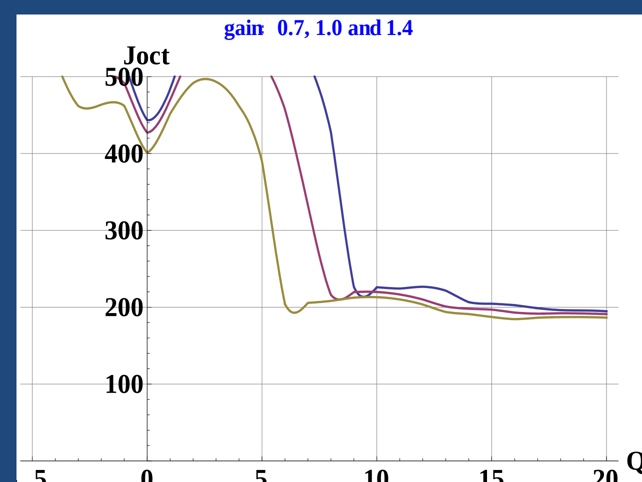


Total CBB tune shift=2Qs

2⊗(SB and CB Imp), dQbb1=4Qs, J>0, dφ15=π







Total CBB tune shift=8Qs,
but the plateau height is still the same.

Simple CBB model

Let $A_{1,2}$ be amplitudes of HT eigenmodes in beam 1 and 2. Due to BB, they become coupled:

$$\dot{A}_1 = -i\omega_c \dot{A}_1 - d\alpha A_1 - iq\alpha A_2 \; ;$$
$$\dot{A}_2 = -i\omega_c \dot{A}_2 - d\alpha A_2 - iq\alpha A_1 \; .$$

Here d and q are the damping rate and beam-beam tune shifts correspondingly, the parameter α reflects a weight of the center of mass in the amplitudes A. For mode=0, at chroma=0, $\alpha = 1$.

From here, the pi and sigma tune shifts follow:

$$\Omega = \omega_c - id\alpha \pm q\alpha \, .$$

Since the mode is unstable (otherwise we do not care) $d\alpha < \mathrm{Im}(\omega_c).$

After the squeeze $q/d \lesssim 1$, thus the CBB tune shift is as small as

$$q\alpha < \mathrm{Im}(\omega_c) q / d.$$

Conclusions

- Since the stability diagram is normally 3-10 times less sensitive to the real tune shift than to the imaginary, this gives a conservative estimation for the CBB role in the instability threshold:

$$\frac{\Delta I_{\text{CBB}}}{I} < 0.3\frac{q}{d}\,.$$

- The NHT plots above confirm this estimation. They also show that on the plateau the role of CBB is 2-4 times smaller.

- For the LHC, q/d~1, so at the plateau CBB may give not more than 10-15% increase of the octupole threshold (or the same reduction of the beam intensity threshold).

- Similarly, any two-beam impedance does not play a role unless it gives a tune shift much higher than gain, which at maximum =1.4Qs.

- The damper suppresses every coherent interaction based on a cross-talk between bunch centers of masses.