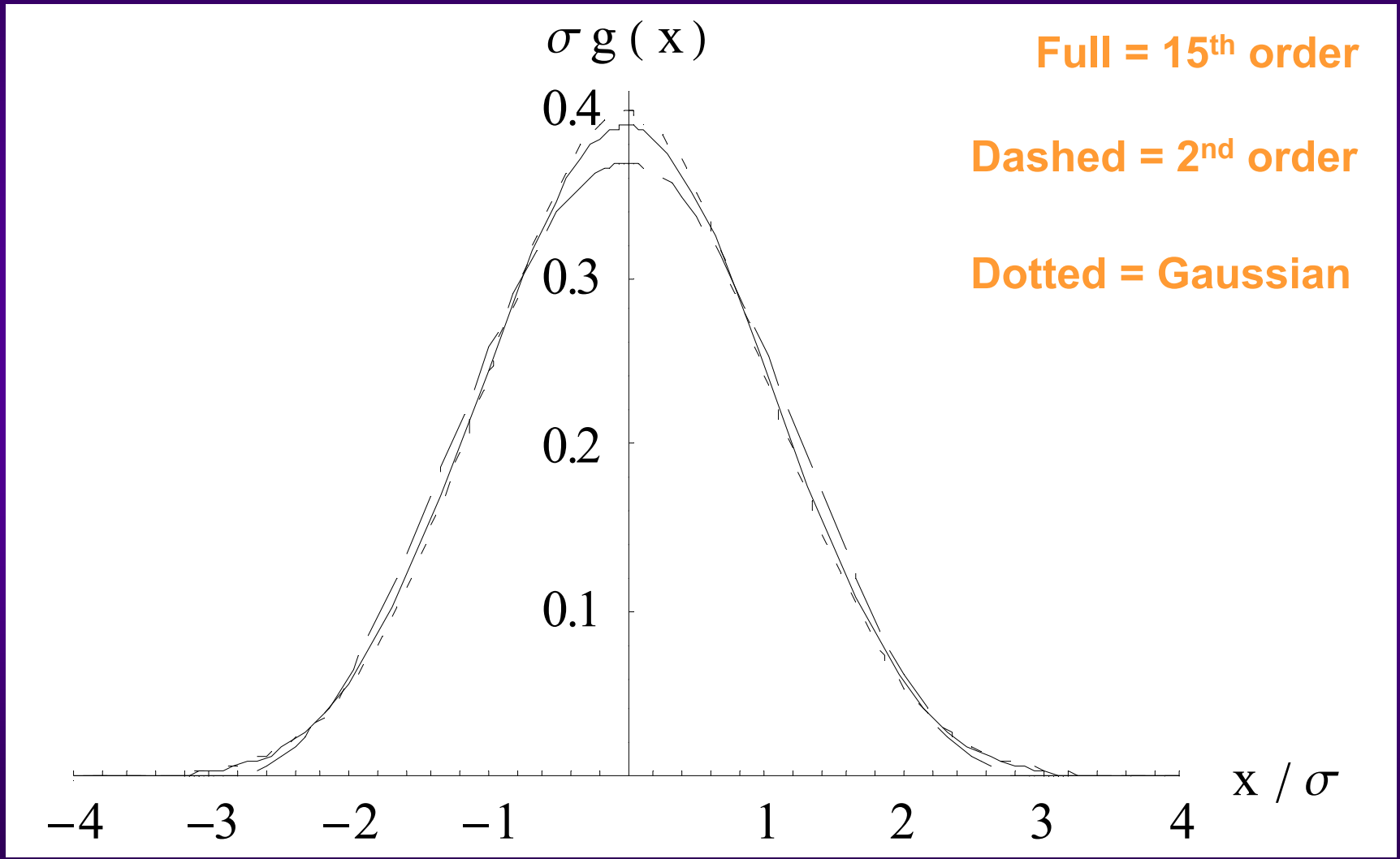
STABILITY DIAGRAM FOR A BEAM COLLIMATED AT 6 SIGMAS

E. Metral and A. Verdier

- **2nd order distribution function = quasi-parabolic distribution of Berg-Ruggiero ⇒ Extends to 3.2 σ in transverse plane ⇒ Underestimates beam stability (if the beam goes to 6 σ)**
- **Gaussian distribution function ⇒ Extends to infinity in transverse plane ⇒ Overestimates beam stability**
- **15th order distribution function ⇒ Extends to 6 σ in transverse plane ⇒ Consistent with the collimator settings**

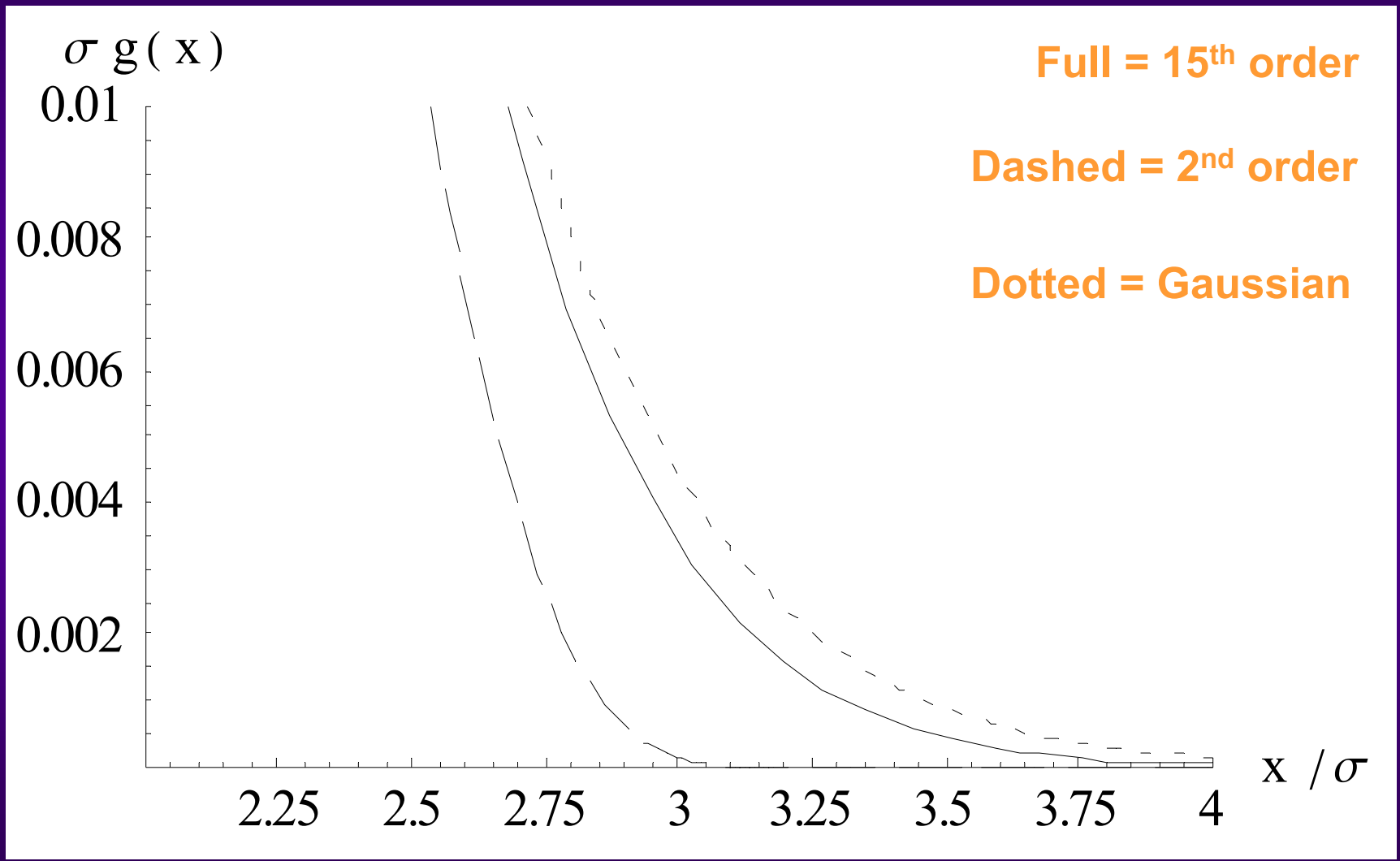
Stability diagram (maximum octupoles) for the LHC at top energy (1/4)

Transverse beam profiles

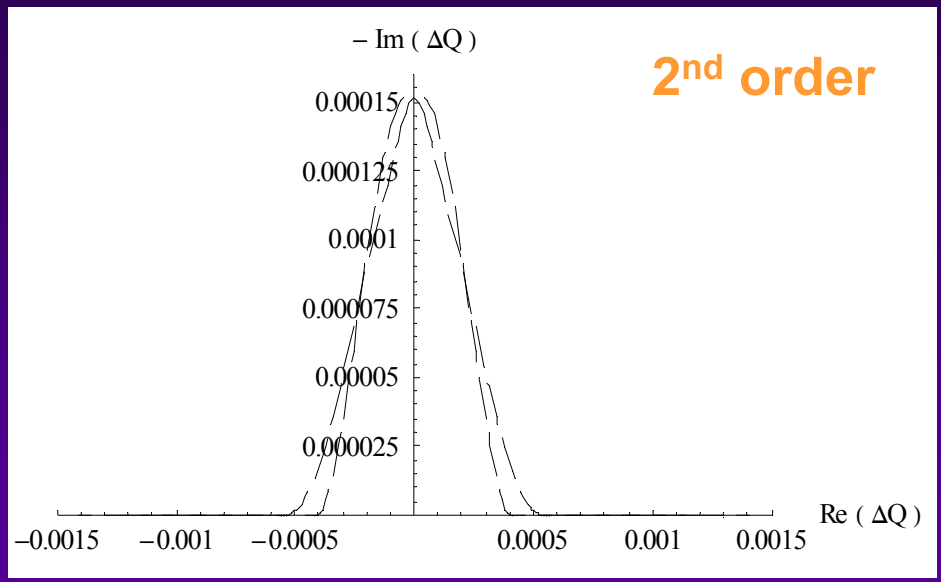


Stability diagram (maximum octupoles) for the LHC at top energy (2/4)

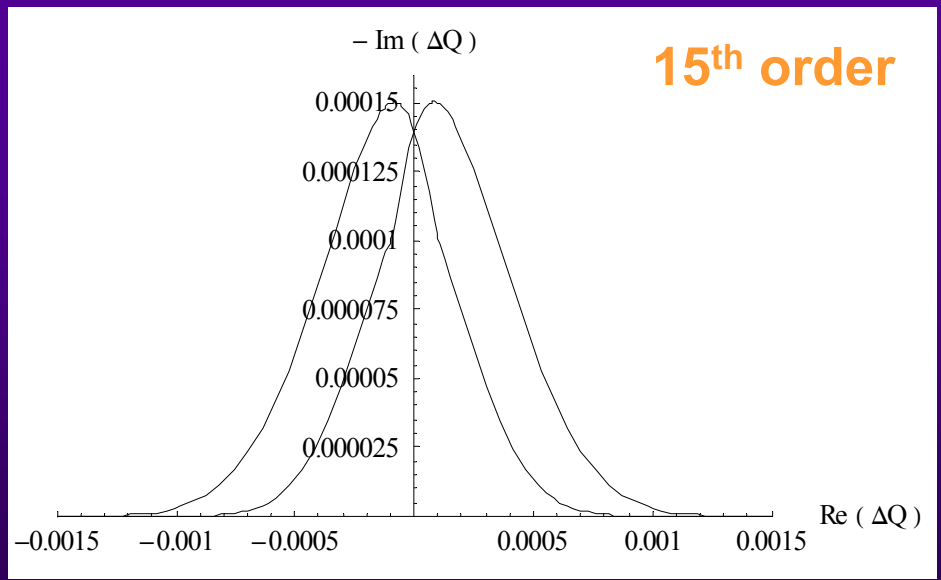
Zoom of the tails of the transverse beam profiles



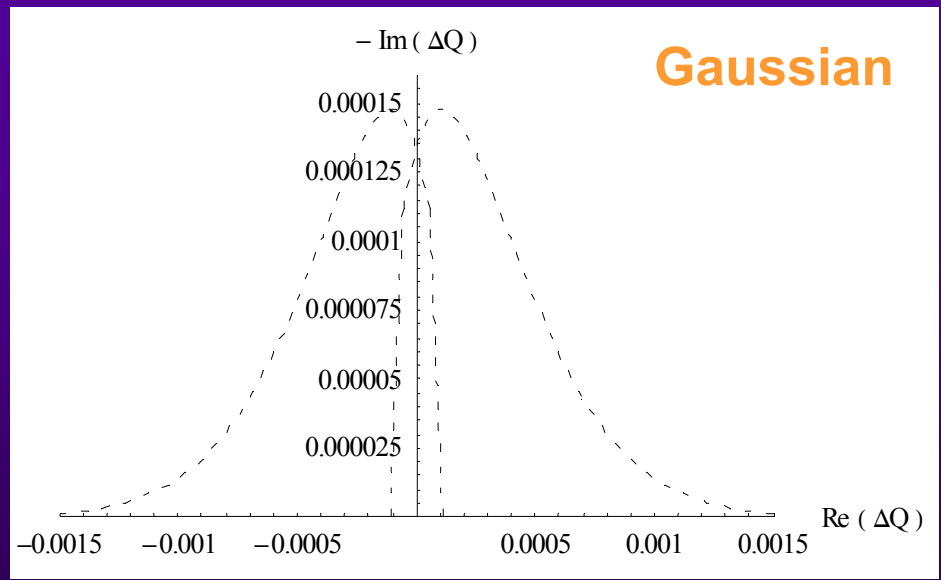
Stability diagram (maximum octupoles) for the LHC at top energy (3/4)



2nd order

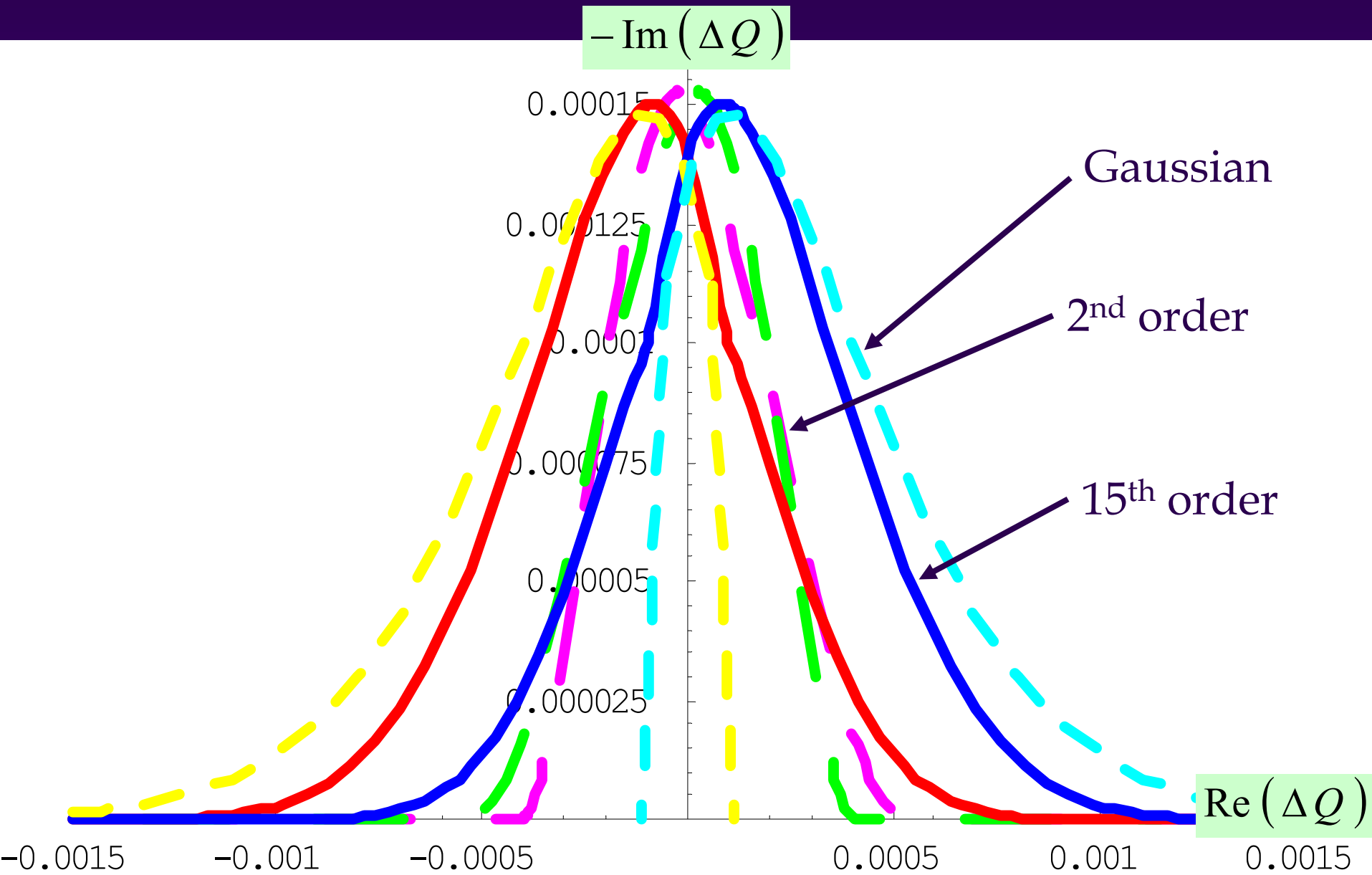


15th order



Gaussian

Stability diagram (maximum octupoles) for the LHC at top energy (4/4)

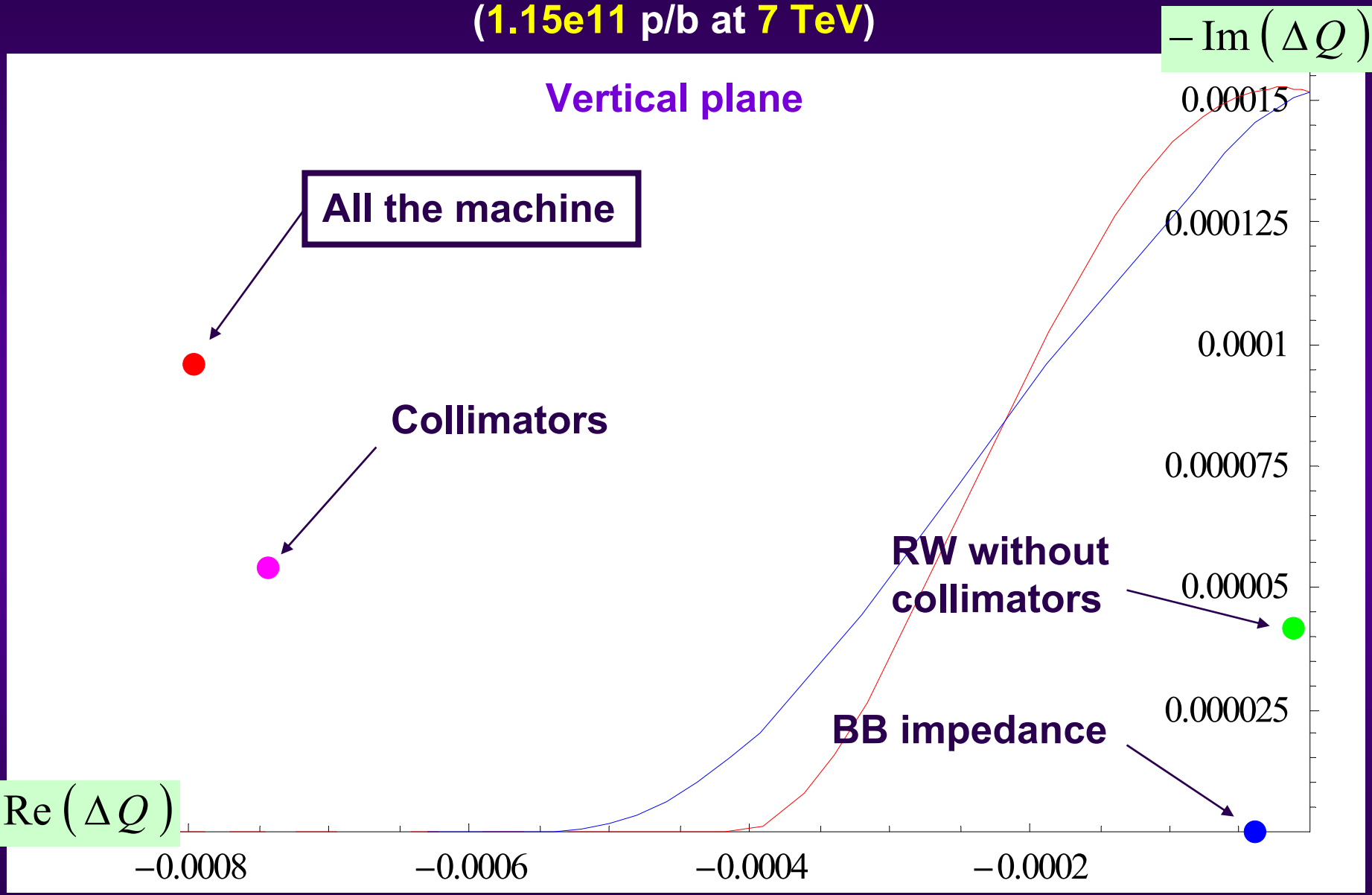


Results with the 2nd order distribution function

Stability diagram and coherent tune shift for the nominal LHC beam taking into account

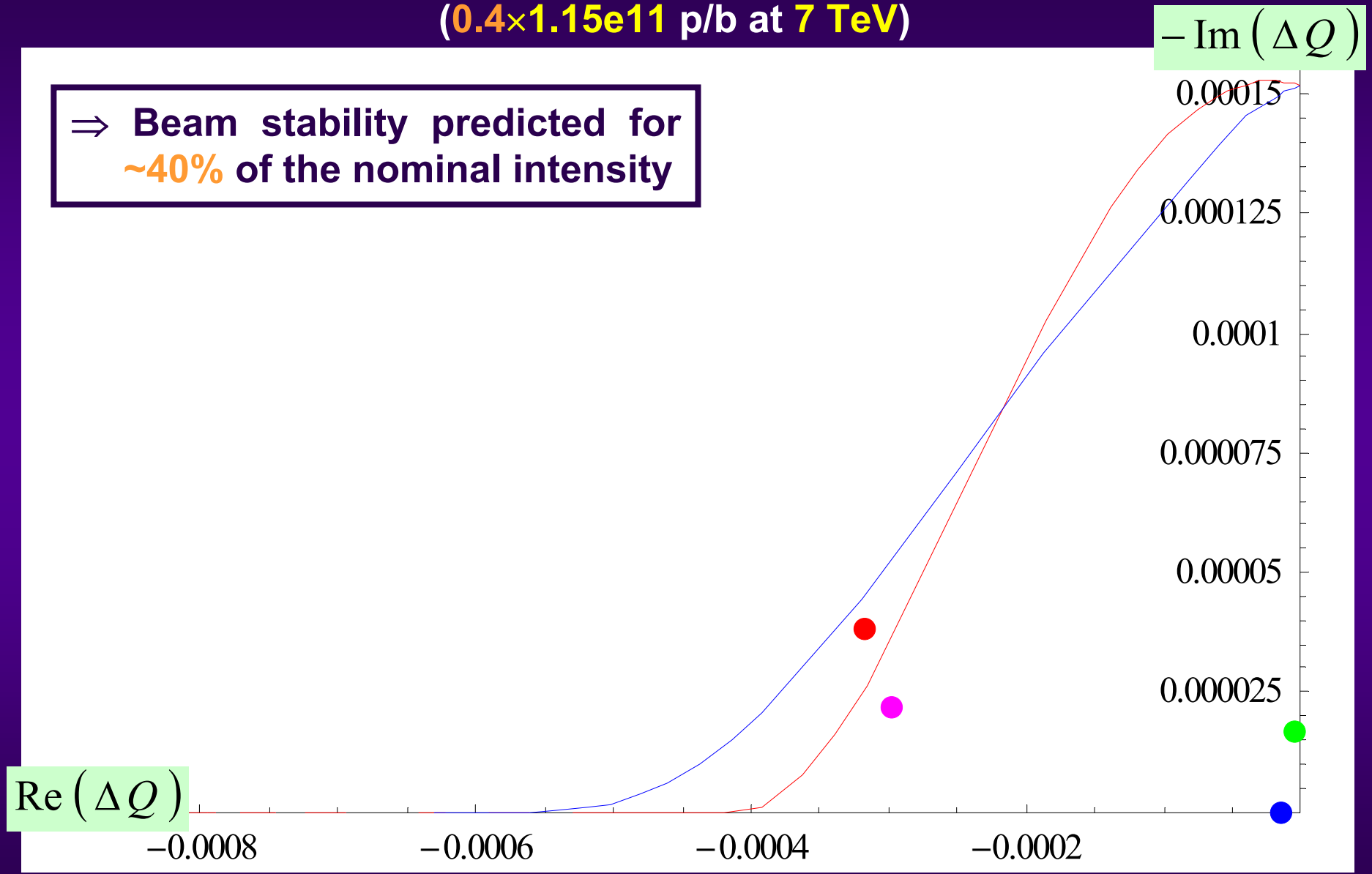
- **All the collimators (IR7 v26top6n1b1 and IR3 from June 2003)**
- **The Resistive-Wall (RW) impedance from the rest of the machine (i.e. without collimators)**
- **The Broad-Band (BB) impedance**

Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0 (1.15e11 p/b at 7 TeV)



Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0 (0.4×1.15e11 p/b at 7 TeV)

$\Rightarrow$ **Beam stability predicted for ~40% of the nominal intensity**

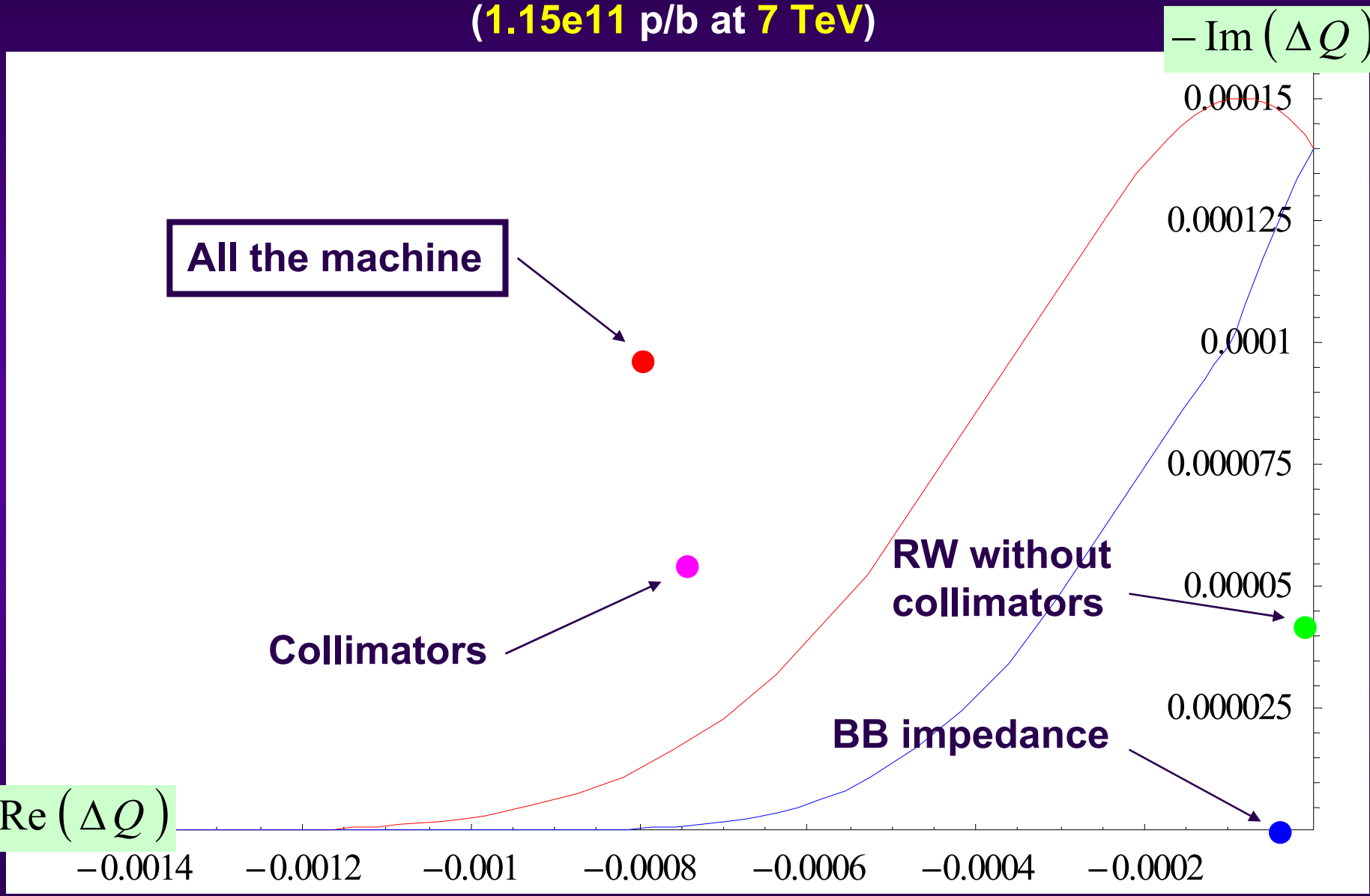


Results with the 15th order distribution function

Stability diagram and coherent tune shift for the nominal LHC beam taking into account

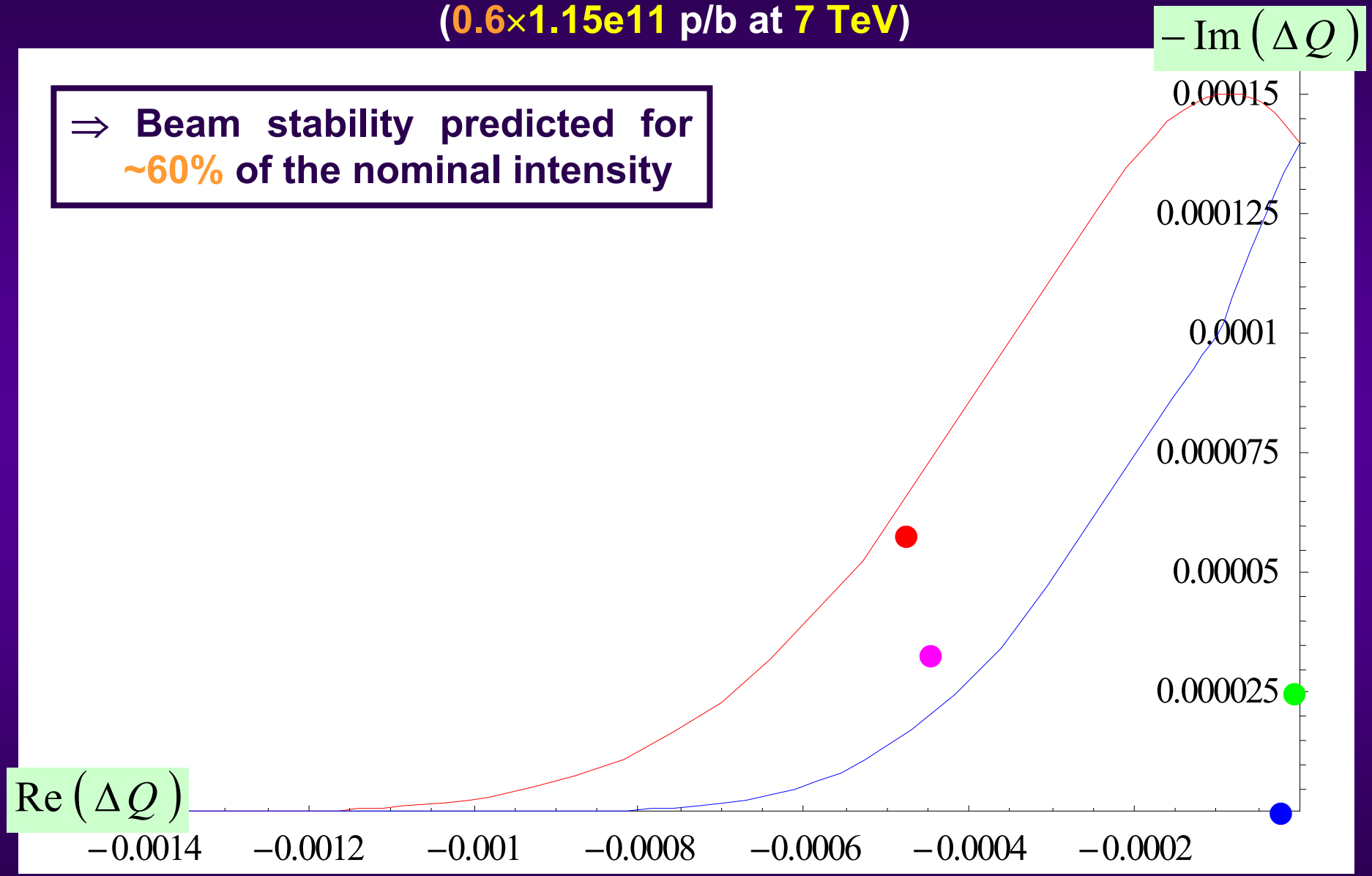
- **All the collimators (IR7 v26top6n1b1 and IR3 from June 2003)**
- **The Resistive-Wall (RW) impedance from the rest of the machine (i.e. without collimators)**
- **The Broad-Band (BB) impedance**

Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0 (1.15e11 p/b at 7 TeV)



Stability diagram (maximum octupoles) and collective tune shift for the most unstable coupled-bunch mode and head-tail mode 0 (0.6×1.15e11 p/b at 7 TeV)

$\Rightarrow$ **Beam stability predicted for ~60% of the nominal intensity**



Conclusion (1/2)

- The stability diagram for the 15th order distribution function lies between the ones already obtained with the 2nd order and Gaussian distributions (as expected !)

- A factor 2 is gained for the real part of the collective tune shift $\Rightarrow$ The new stability diagram improves the TOTEM beam stability by a factor 2 (as $|\mathrm{Re}(\Delta Q)|$ >> $|\mathrm{Im}(\Delta Q)|$)

- The case of a distribution with more populated tails than the Gaussian distribution will be presented next week (as it can happen in reality!)

Conclusion (2/2)

- **Shall we use this new stability diagram for beam stability analyses in the LHC at top energy ?**

  ⇒ **The presence or not of the high-amplitude tails in the distribution can substantially affect the amount of Landau damping. These stability diagrams should therefore be used with great care for beam stability analyses/predictions (as already mentioned by Berg-Ruggiero)**

  ⇒ **There is a slight improvement for the LHC beam stability : beam stability predicted for 60% of the intensity (with 15^{th} order) instead of 40% (with 2^{nd} order)**

  ⇒ **After discussion with Francesco, we keep the 2^{nd} order distribution for the baseline scenario (LHC design report), knowing that it could be somewhat conservative**