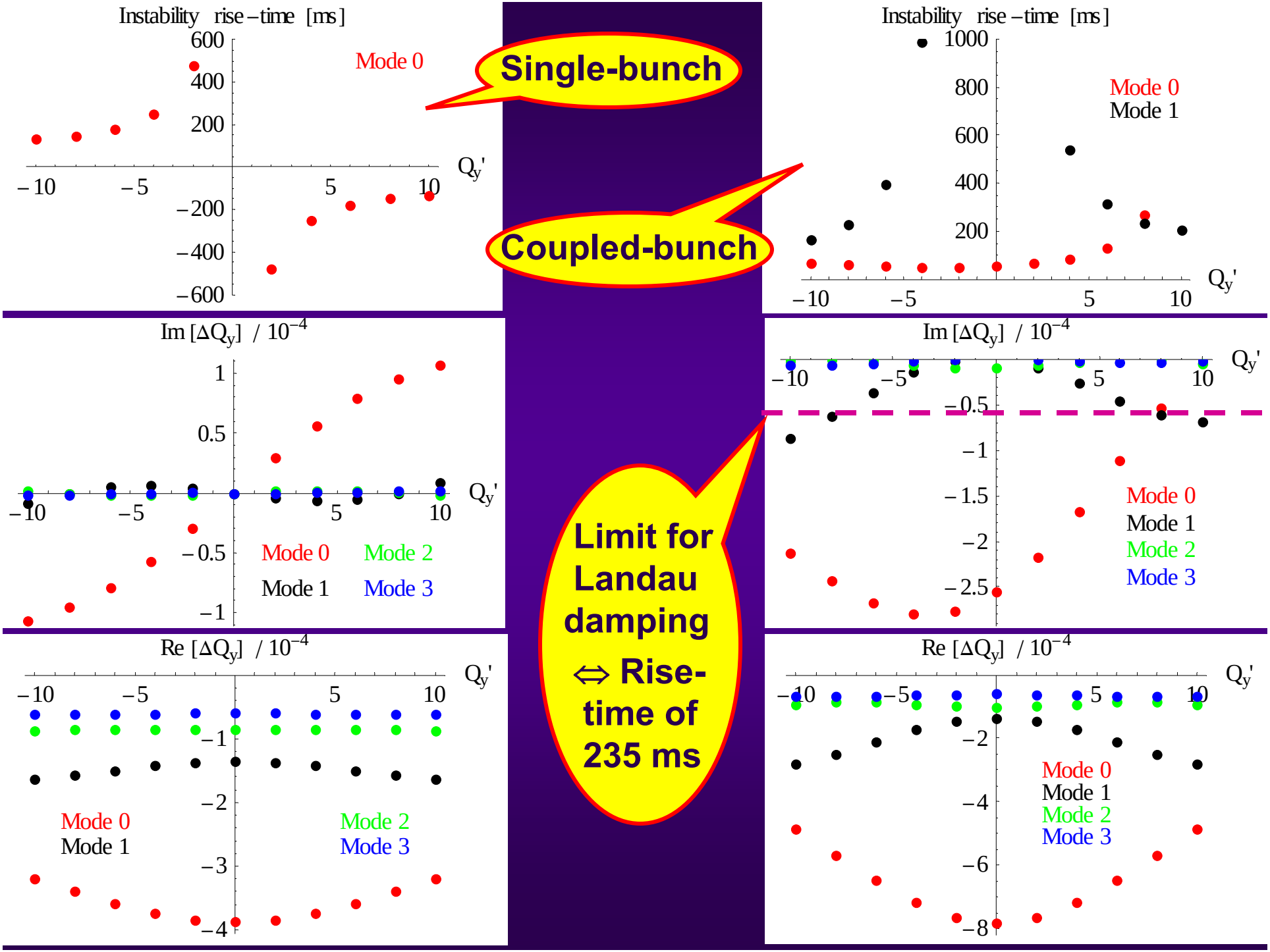
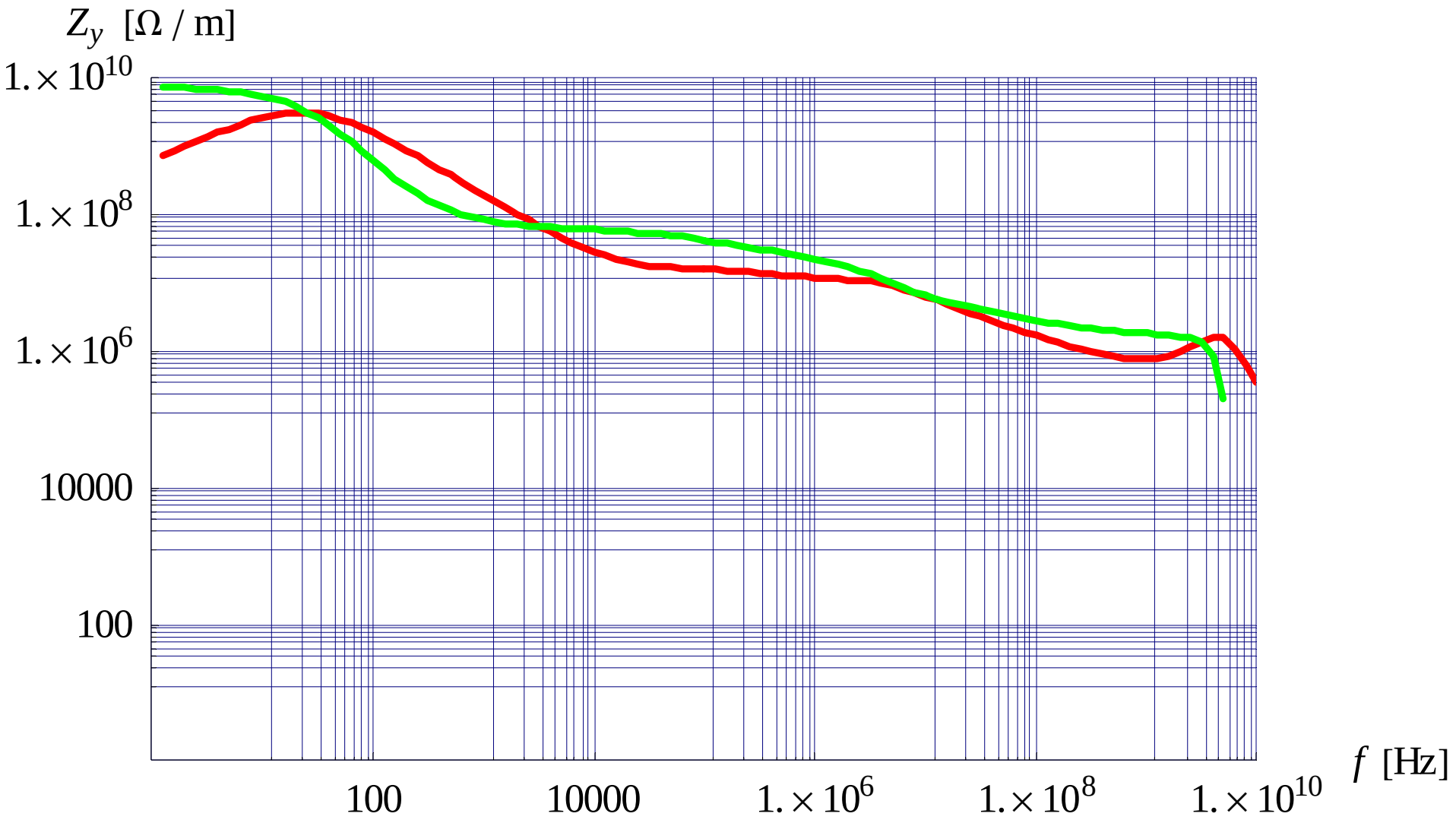
SINGLE-BUNCH AND COUPLED-BUNCH INSTABILITY AT LHC INJECTION VS. CHROMATICITY

E. Métral

- **Impedances considered**
  - **All collimators (TDI "correctly treated")**
  - **Beam Screen and Warm Pipe**
  - **Broad-Band impedance (Q = 1, fr = 5 GHz, Ry = 1.34 MΩ/m)**
  - **MQW (2mm Cu) and MBW (2mm Cu)**
- **Burov-Lebedev formalism considered**

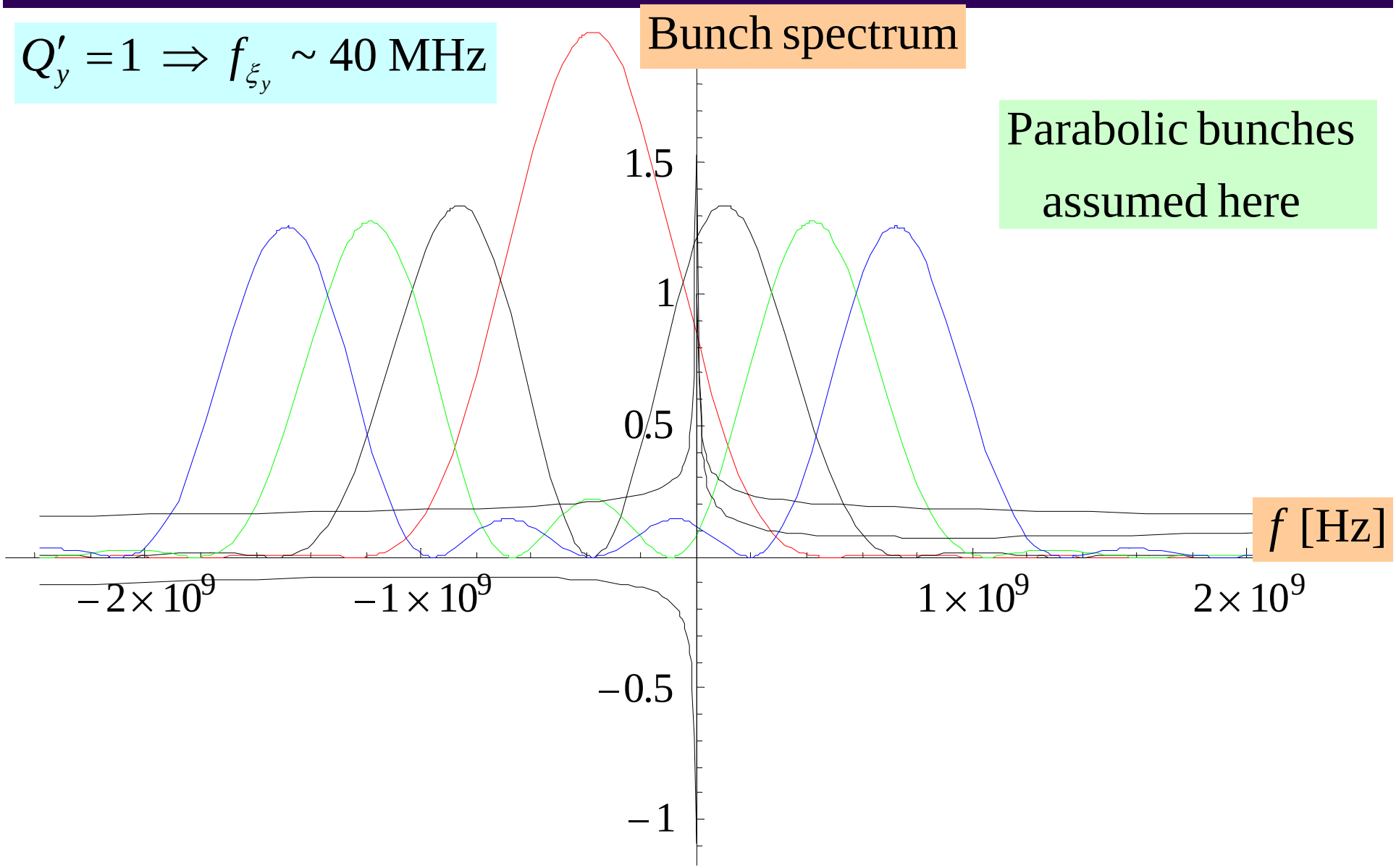

Instability rise–time [ms]
Mode 0
Single-bunch
Coupled-bunch
Instability rise–time [ms]
Mode 0
Mode 1
Im [ΔQy] / 10−4
Mode 0
Mode 2
Mode 1
Mode 3
Limit for Landau damping ⇔ Rise-time of 235 ms
Im [ΔQy] / 10−4
Mode 0
Mode 1
Mode 2
Mode 3
Re [ΔQy] / 10−4
Mode 0
Mode 1
Mode 2
Mode 3
Re [ΔQy] / 10−4
Mode 0
Mode 1
Mode 2
Mode 3
Qy'

Global impedance



Bunch spectrum (Q_y' = -10) + Impedance

$$Q'_y = 1 \Rightarrow f_{\xi_y} \sim 40 \text{ MHz}$$

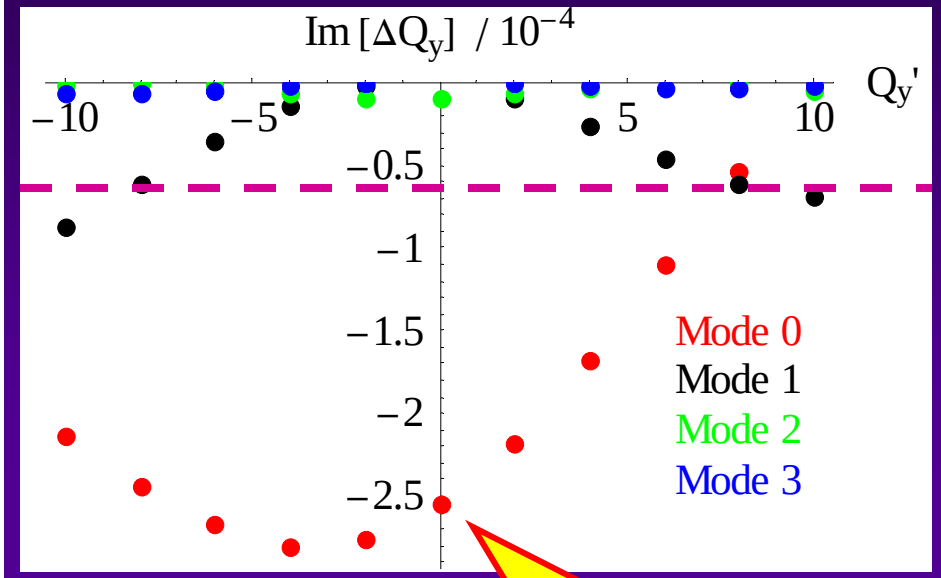


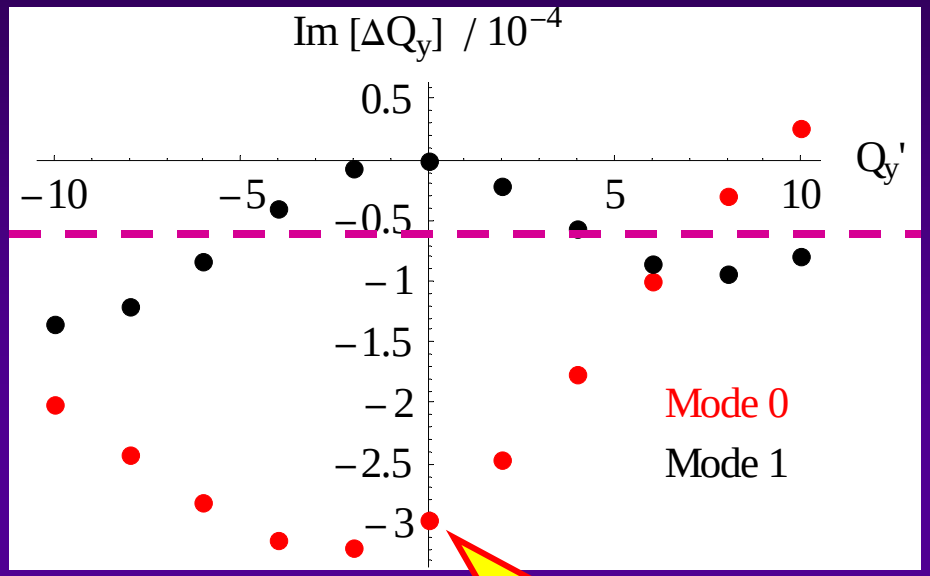
Value of the "effective impedances" (classical times 16) at 8 kHz and 20 MHz in MΩ/m to compare with the Design Report (DR)

	8 kHz		20 MHz	
	EM	DR	EM	DR
Collimators (without TDI)	-4.6+52.8j	-7.6+74j	18.5j	33j
TDI	-0.2+7.3j	-	0.4j	-0.5+3j
Beam screen	-22.8+8.6j	-29.5+8.6j	2.1j	-1.5+0.5j
BB	1.34j	1.34j	1.34j	1.34j
Warm pipe	-1.4+1.6j	-3.5+2.9j (pipe +etc.)	0.2j	-0.2+0.2j (pipe +etc.)
MQW (2 mm Cu)	-1.3+1.5j	-4.3+4.8j	0.2j	-0.3+0.3j
MBW (2 mm SS)	-0.2+0.3j	-0.6+0.6j	0.04j	-0.05+0.05j

Note that in the DR Vos used Vos' formula whereas BL formula is used here (see other talk, where these formulae are compared)

Comparison between Parabolic and Gaussian bunches for the coupled-bunch instability





Rise-time ~ 55 ms (~27 ms in the DR)

Rise-time ~ 45 ms

- **Note that the real impedance will be "slightly" larger as some equipments have been neglected…**
- **The limit for Landau damping is computed here assuming an amplitude detuning budget of 2×10^{-3} at 6σ**

- In Chapter 4 of the LHC DR (Optics and Single Particle Dynamics) it is written (page 74):

  "The operational margins for the chromaticity are based on collective instabilities and the operational experience in existing hadron storage rings. Stability of the collective effects requires positive chromaticity values and operational experience chromaticity values smaller than 5 units yielding a target chromaticity of 2 units with an operational margin of $\delta Q' = \pm 2$"