Contributed talk WEOAC03 (12 + 3 min, 14 slides)

TRANSVERSE IMPEDANCE OF LHC COLLIMATORS

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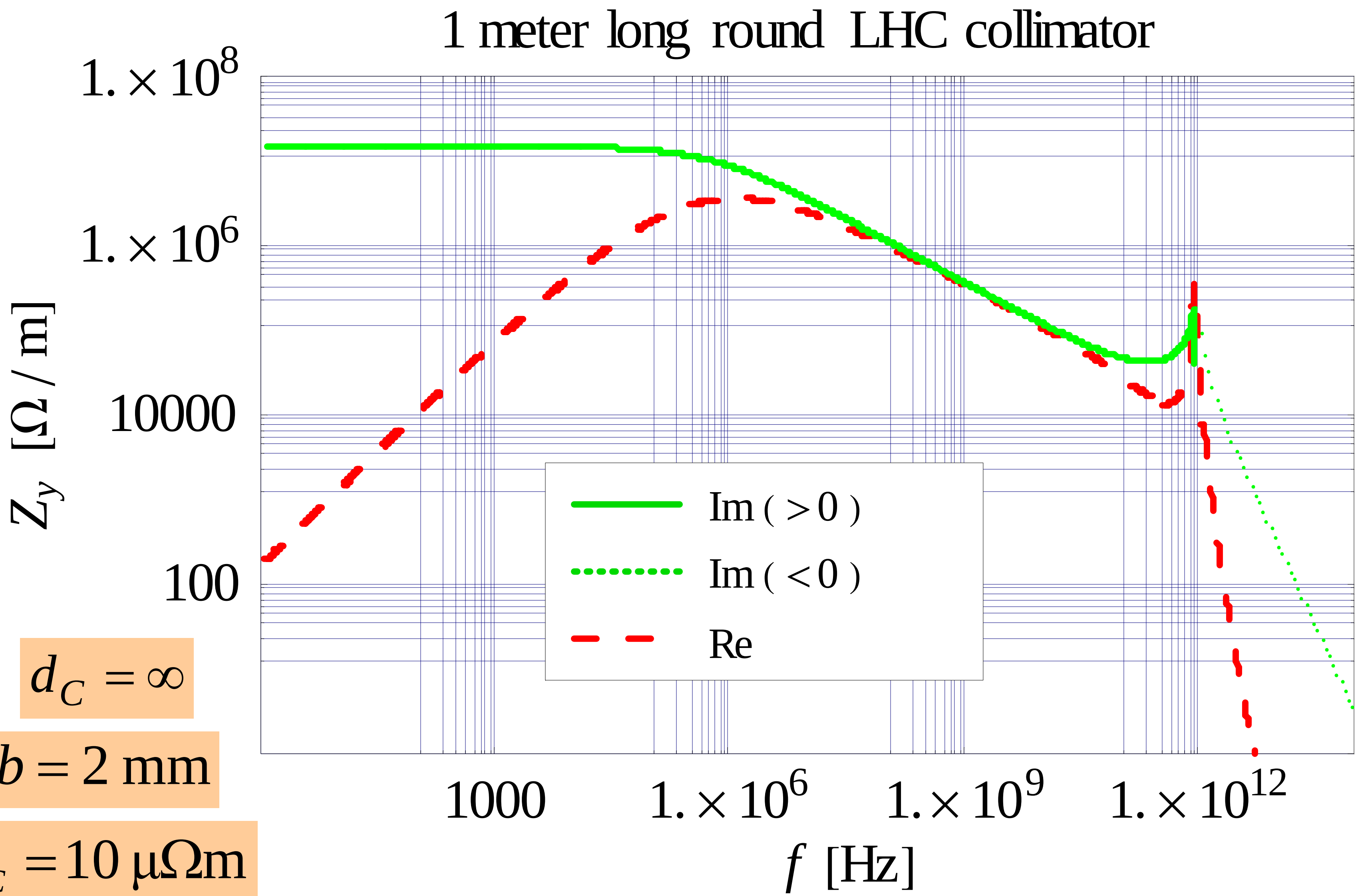
ZOTTER2005'S THEORY (1/2)

- **Valid for a circular beam pipe of infinite length**
  - **Any number of layers**
  - **Any beam velocity**
  - **Any frequency** $\Rightarrow$ **Unification of 3 regimes: low, intermediate and high**
  - **Any σ (conductivity), ε (permittivity) and μ (permeability)**

- **Zotter2005's formula compared to**
  - **Burov-Lebedev2002**
  - **Tsutsui2003 (theory + HFSS simulations but only above 1 MHz!)**
  - **Vos2003**
  - **Al-Khateeb_*et_al.*2006**
  - **Bane1991 (high-frequency)**
  - **Henry-Napoly1991**

$\Longrightarrow$ **Similar results obtained in the low-frequency regime**



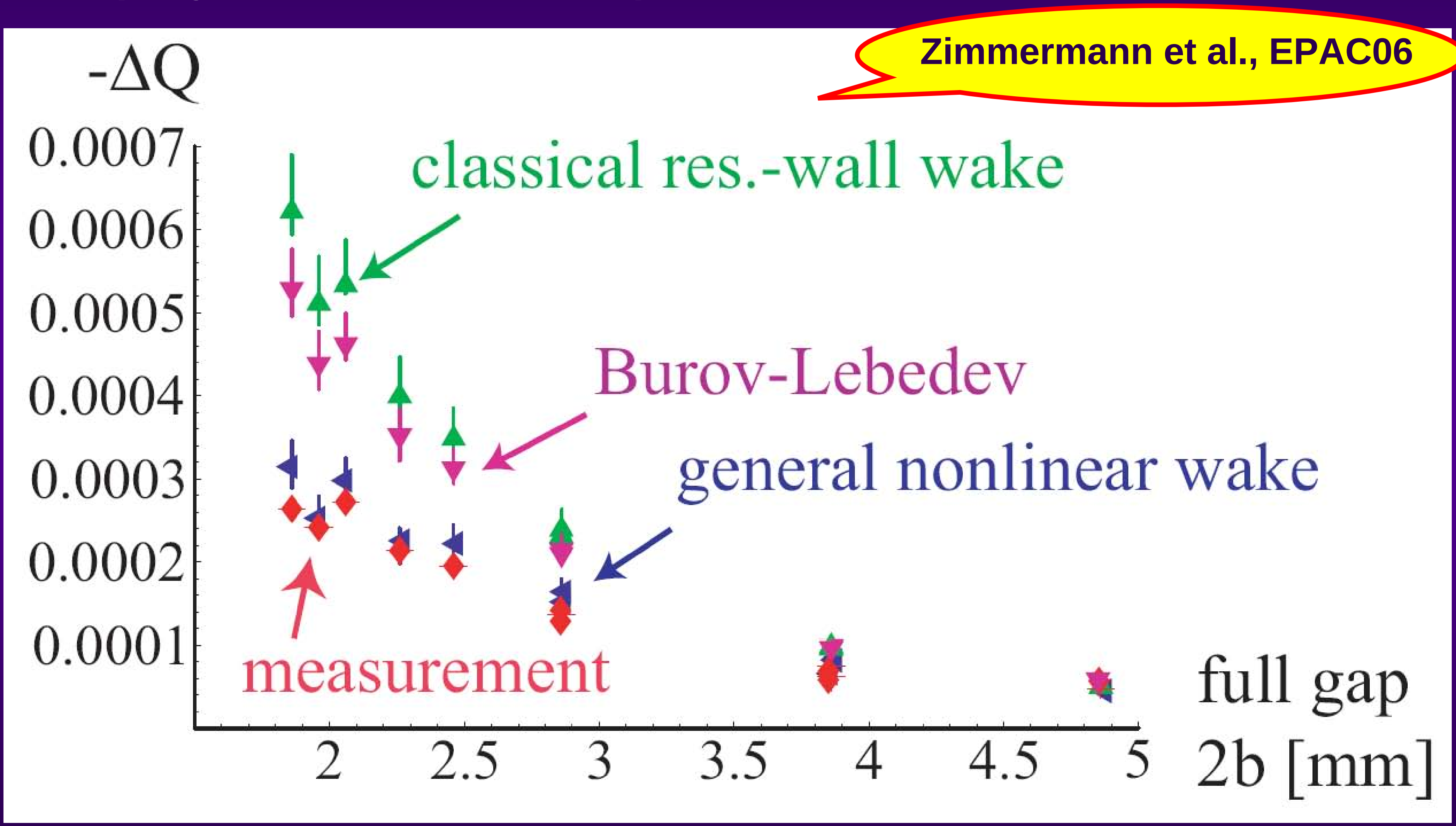
$d_C = \infty$

$b = 2$ mm

$\rho_C = 10$ μΩm

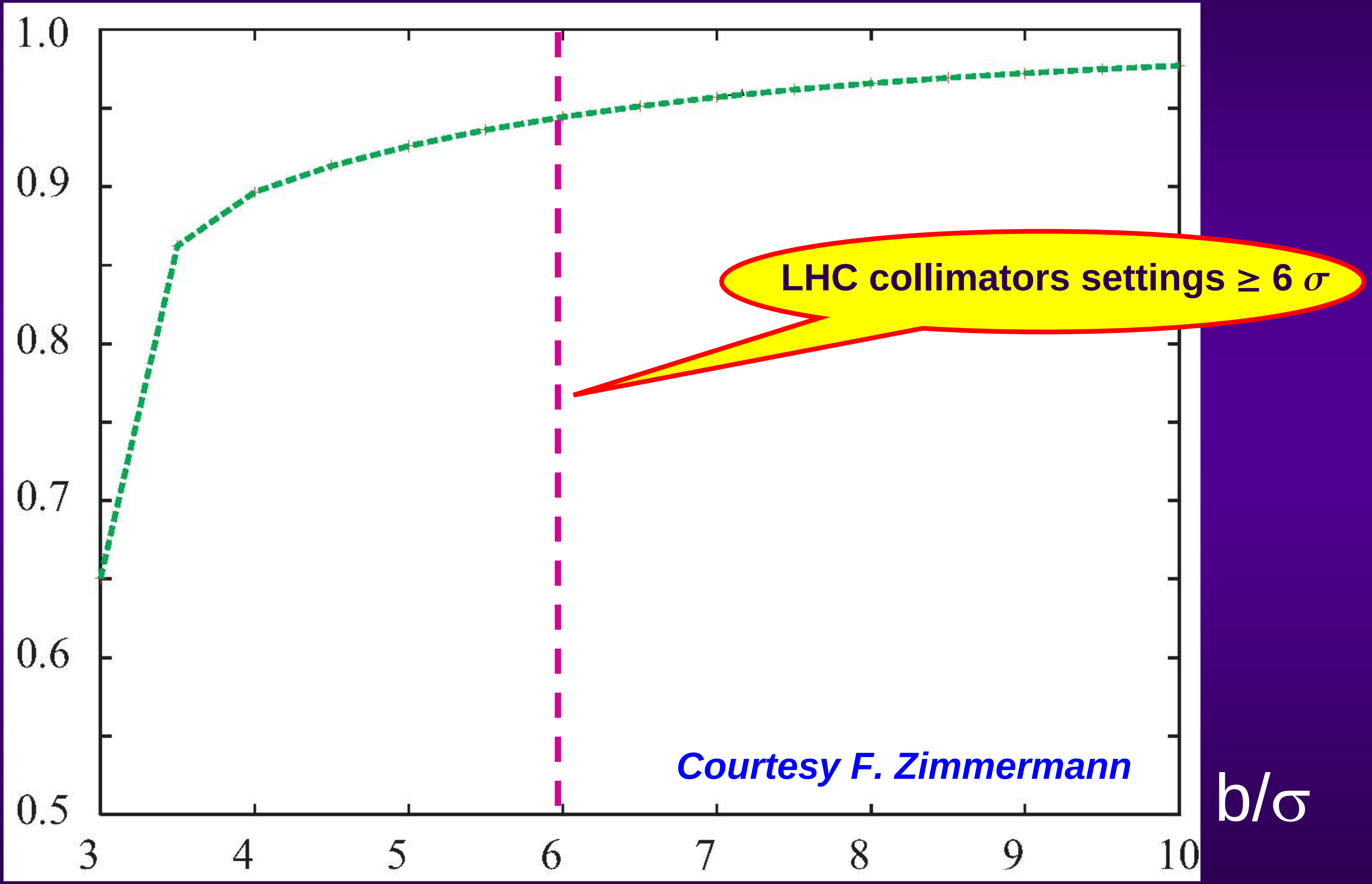
MEASUREMENT 1 (1/2)

- **Coherent tune shift from a LHC prototype collimator at the SPS (single bunch at 270 GeV/c) in 2004**



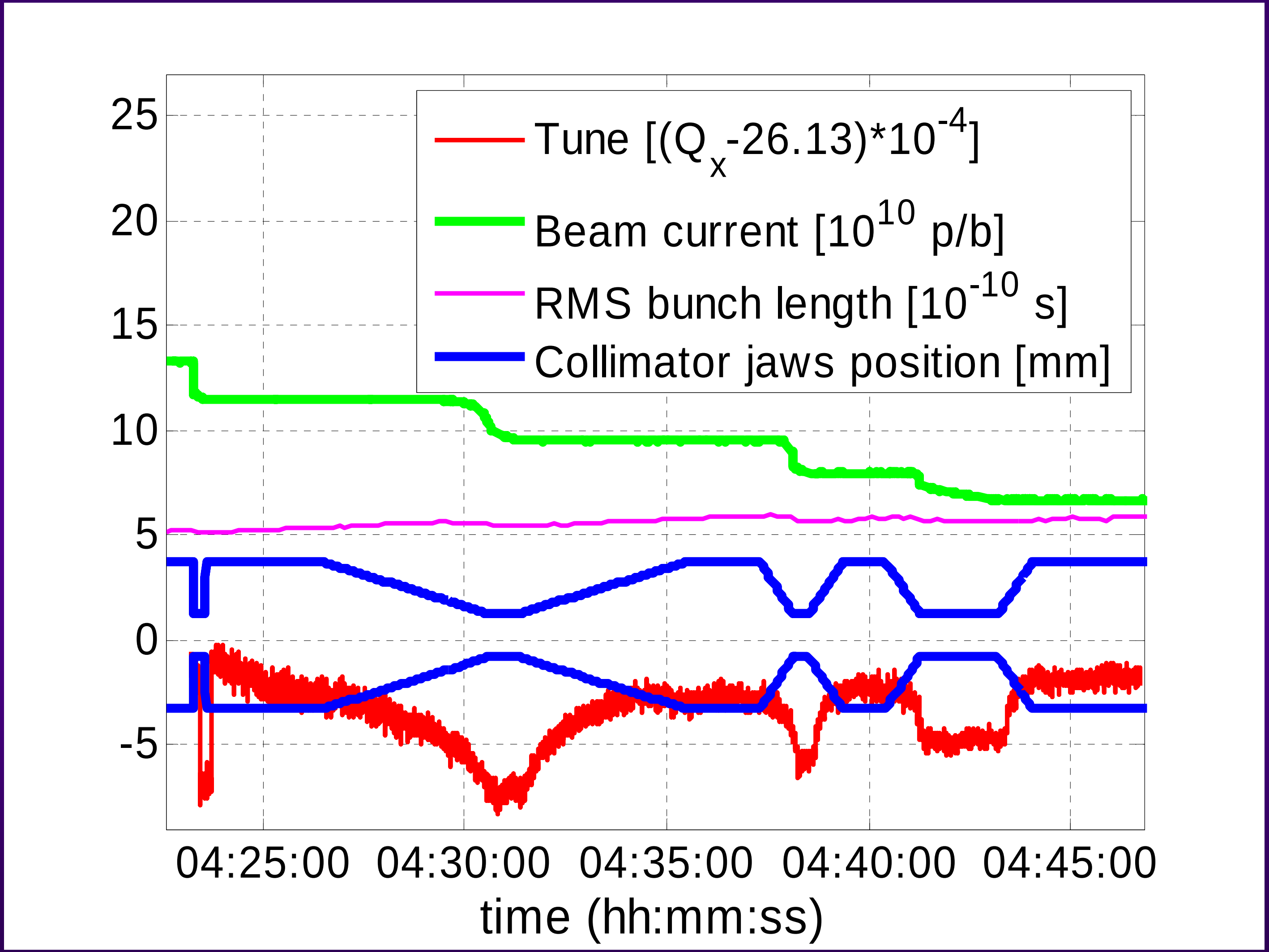
MEASUREMENT 1 (2/2)

Nonlinear correction vs. gap (round beam)



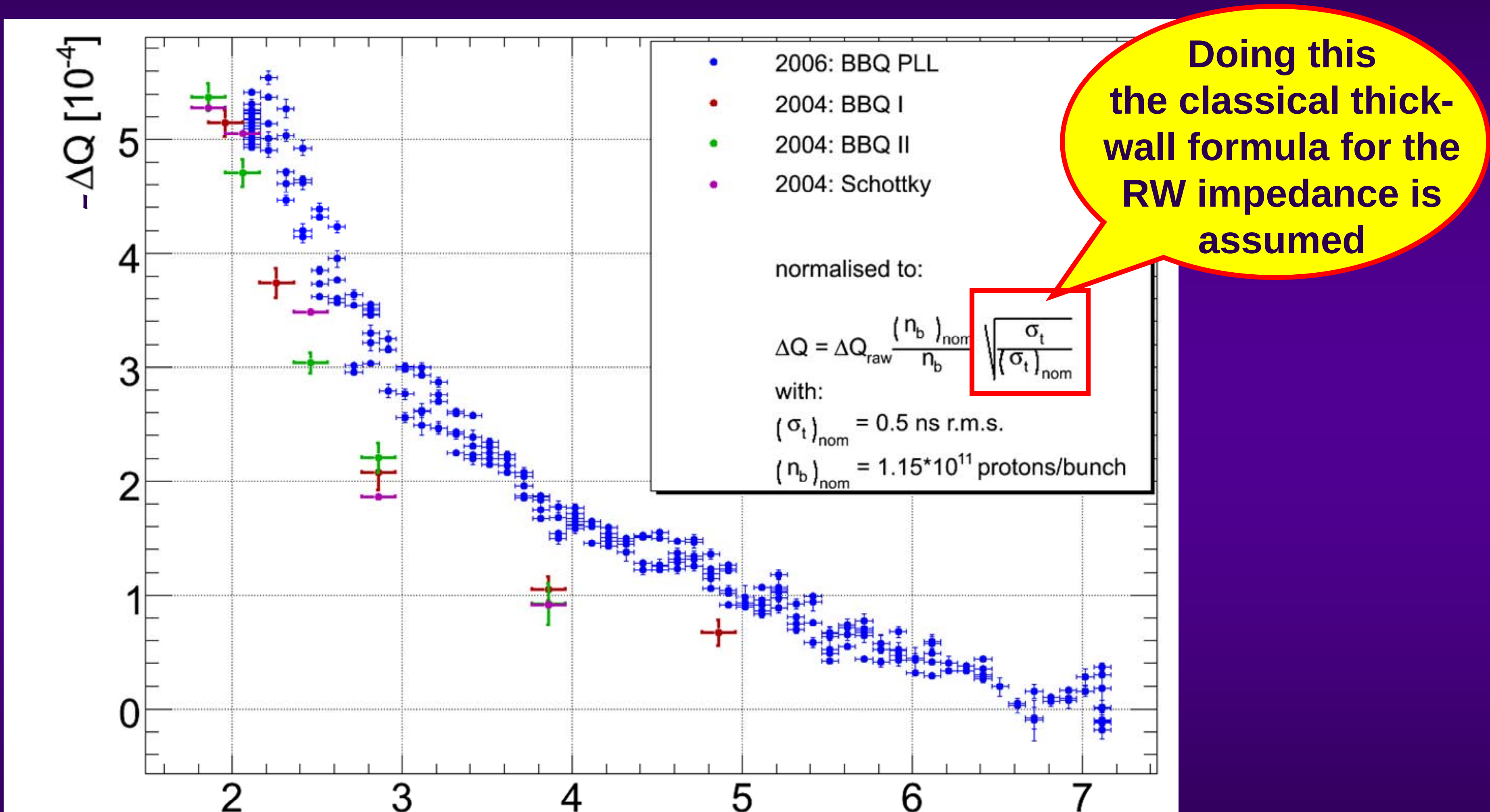
MEASUREMENT 2 (1/2)

- **Coherent tune shift from a LHC prototype collimator at the SPS (single bunch at 270 GeV/c) in 2006**



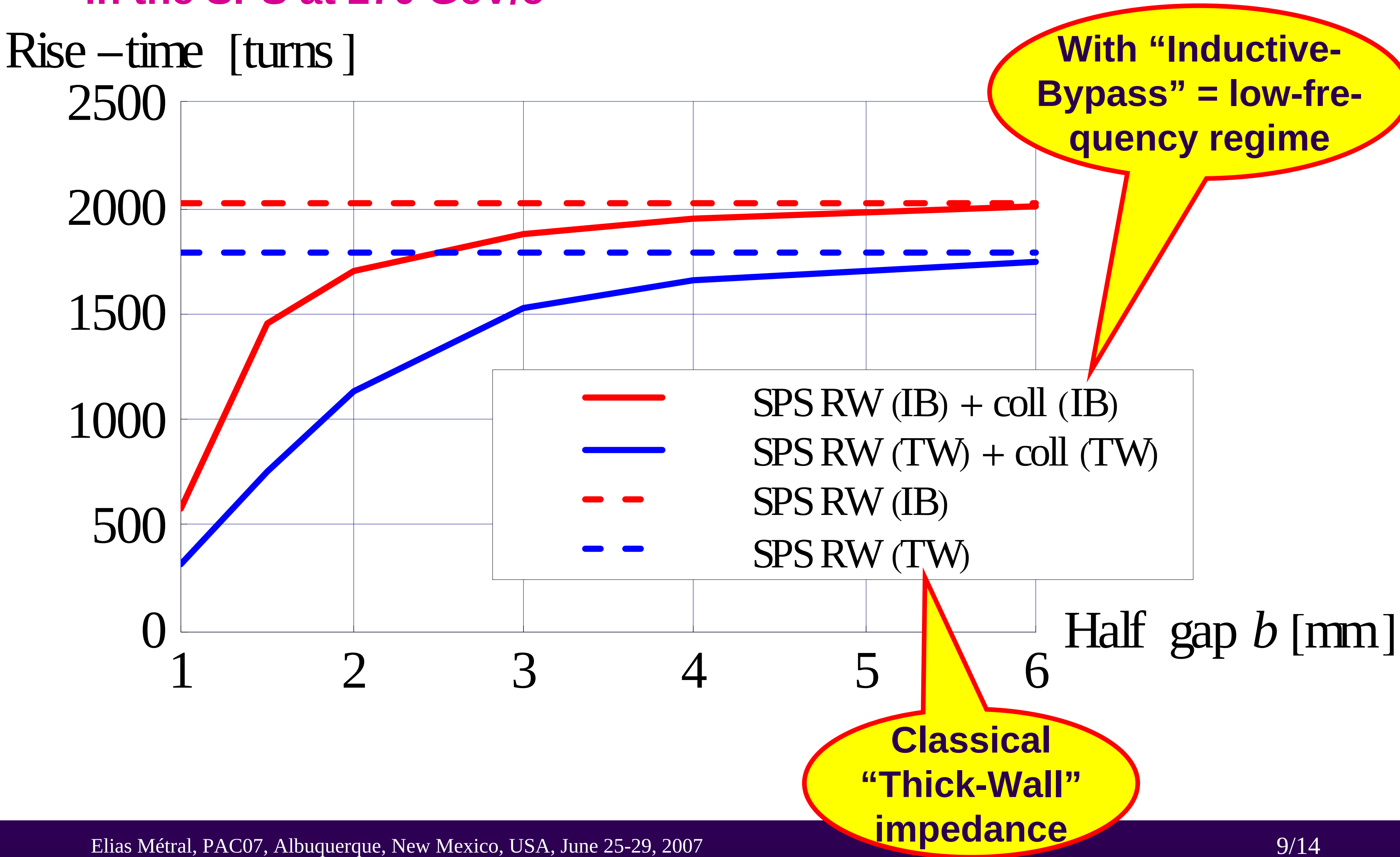
MEASUREMENT 2 (2/2)

Comparison between 2004 and 2006



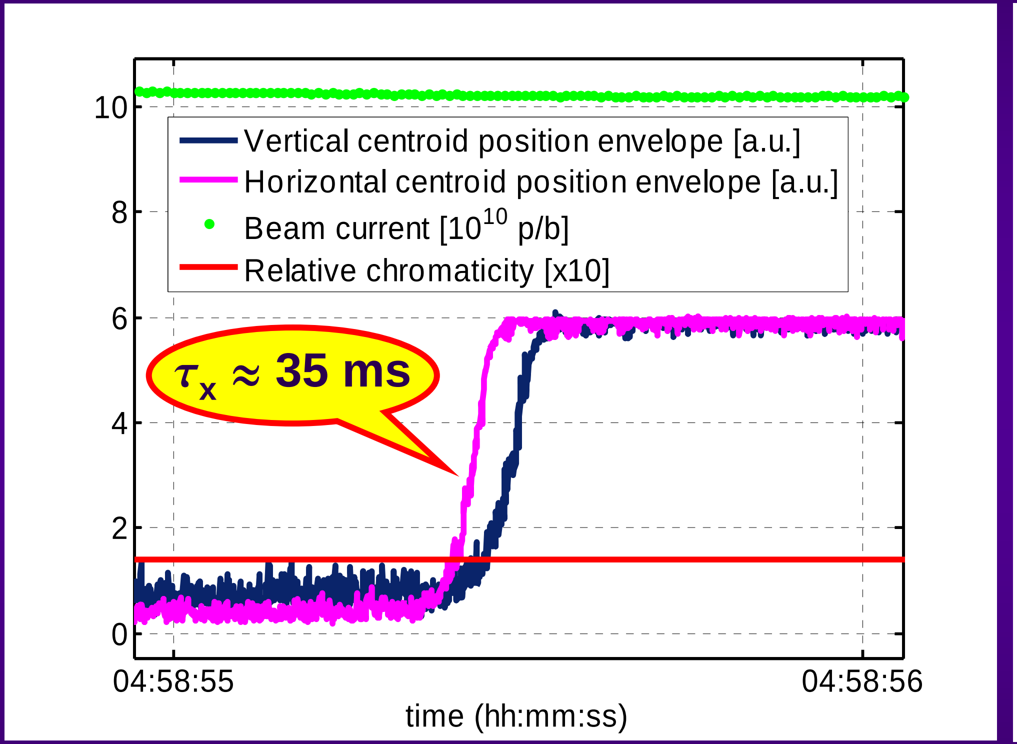
Courtesy R. Steinhagen

- **Predicted instability rise-time with a batch of 72 nominal bunches in the SPS at 270 GeV/c**

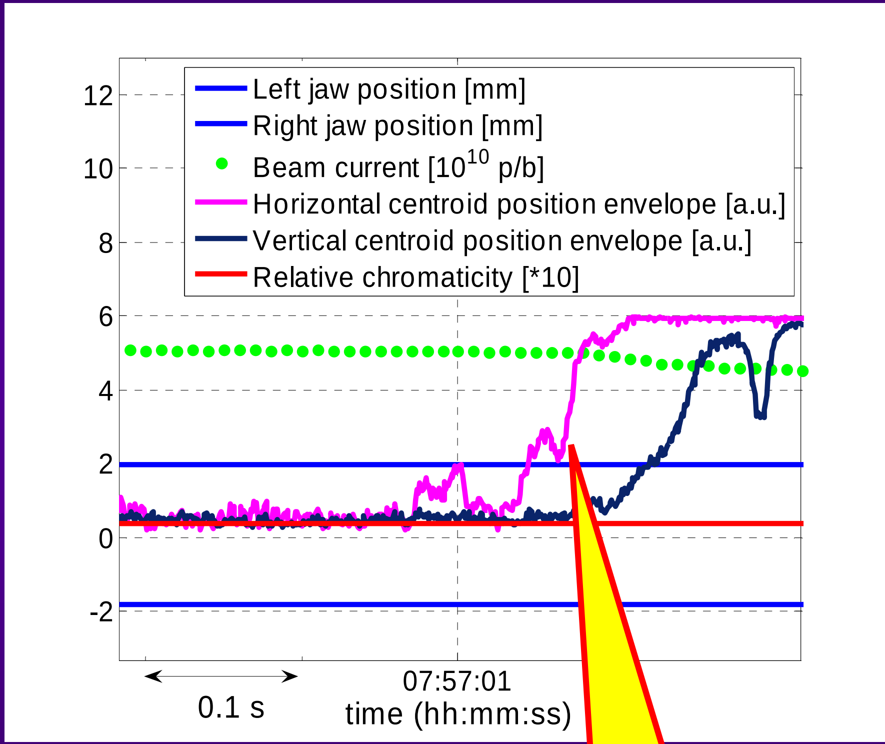


MEASUREMENT 3 (2/2)

Collimator OUT (± 30 mm)



Collimator IN (± 2 mm)



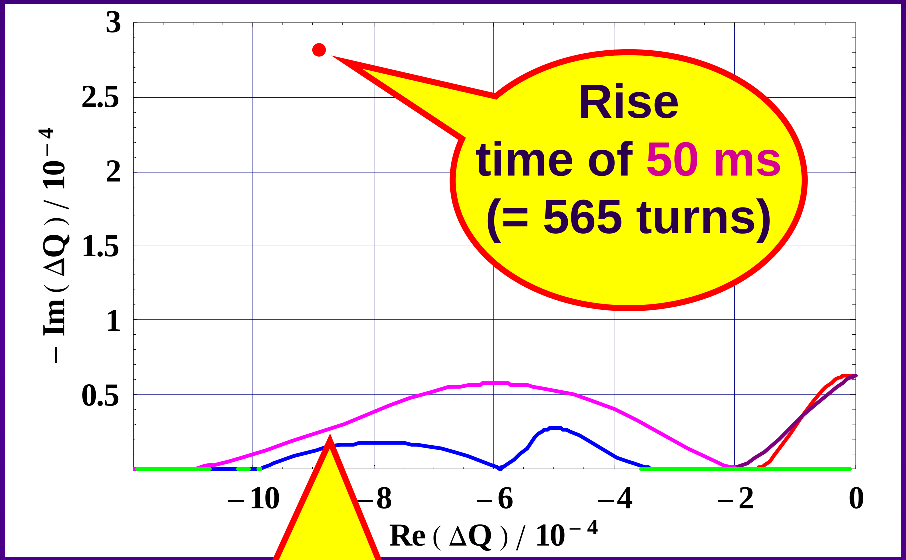
$T_{rev}^{SPS} \approx 23\ \mu s$

$\tau_x \in$ **[12, 32 ms]**

STABILITY DIAGRAM (1/3)

- **Nominal case (25 ns bunch spacing and nominal intensity)**

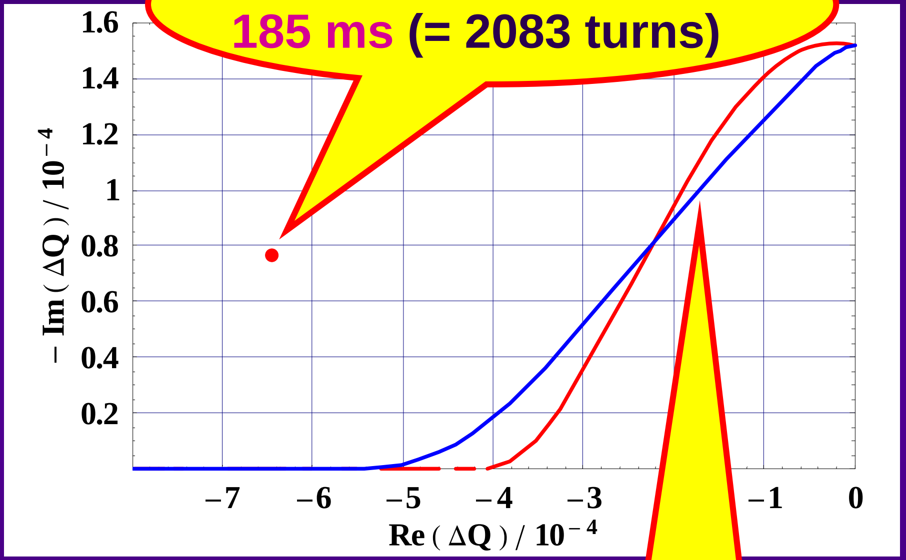
INJECTION



From nonlinearities + space charge (2D)

⟹ Will be damped by feedback

TOP ENERGY



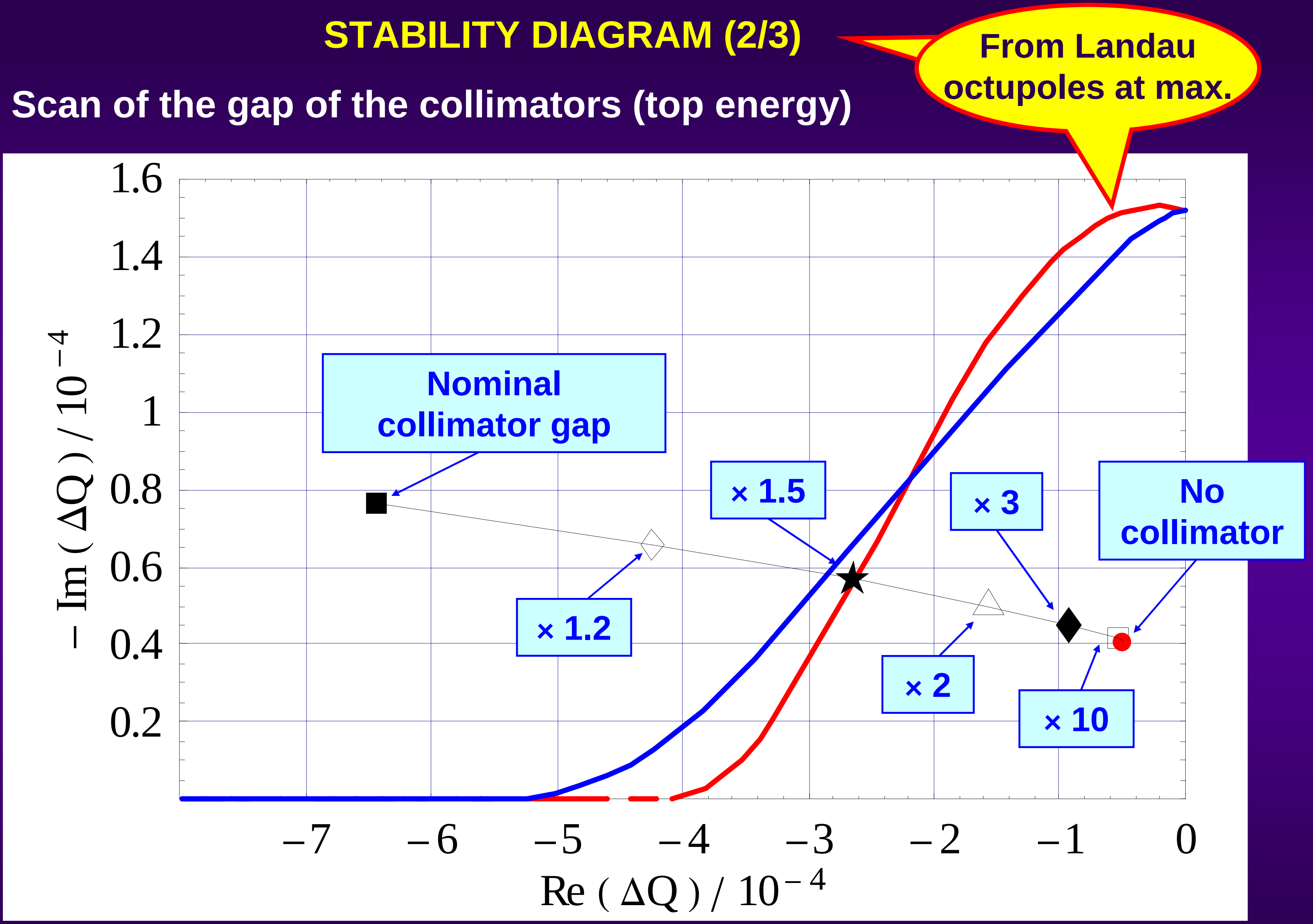
From Landau octupoles at max.

$T_{rev}^{LHC} \approx 89\ \mu s$

⟹ Only ~ 50% of nominal beam intensity is stable

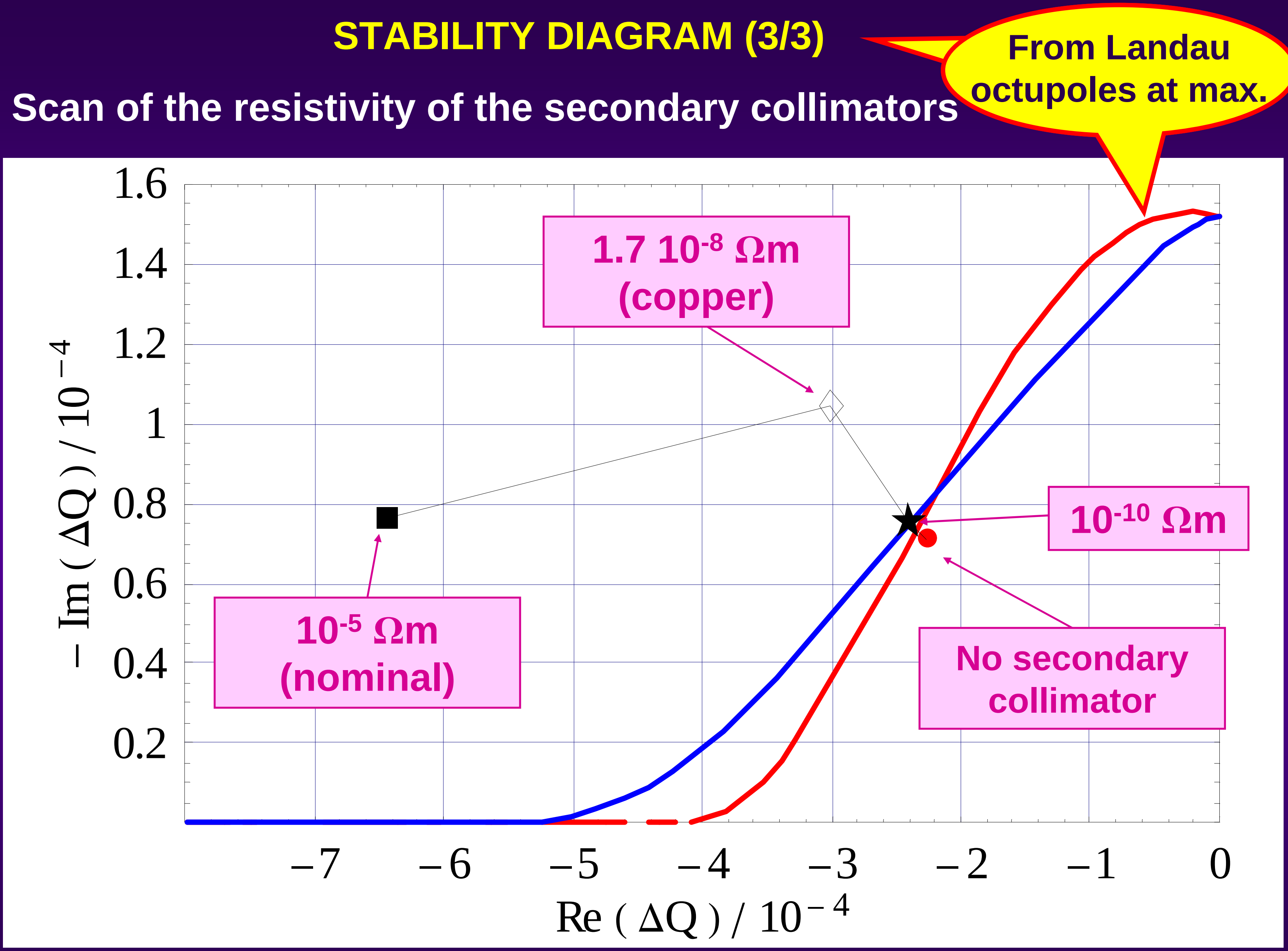
STABILITY DIAGRAM (2/3)

- **Scan of the gap of the collimators (top energy)**



STABILITY DIAGRAM (3/3)

- **Scan of the resistivity of the secondary collimators**



CONCLUSION

- Measurements performed so far are in agreement with our theoretical predictions but are not a proof of the low-frequency regime ($\leq \sim$ 1 MHz), which to our knowledge has neither been measured nor simulated

- Collimator bench measurements near 8 kHz are planned at CERN for the second half of the year

- Coupled-bunch instability in the LHC induced by the collimators
  - At injection $\Rightarrow$ Will be damped by a transverse feedback
  - At top energy $\Rightarrow$ Planned to be damped by Landau octupoles (ongoing studies)

- Estimated max. stable intensity $\Rightarrow$ < 50% of the nominal one

A good control of the tunes and chromaticities will be needed to increase the intensity