SINGLE BUNCH DYNAMICS

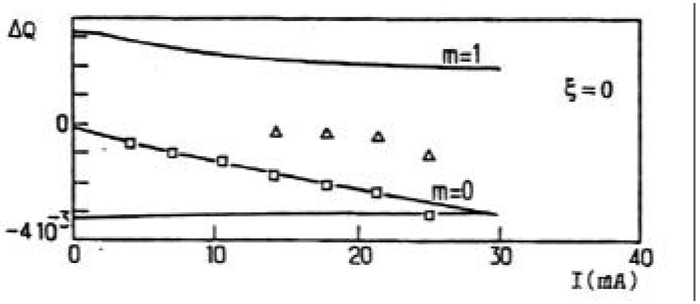
☞ Transverse Mode Coupling Instability

One RF system 100 MHZ

❖ *Experiment with x = 0 : The instability occurs at 30 mA.*

For weak current (<15 mA), we observe only one betatron frequency the m=0 dipole mode which shifts with current.

The fit of its tune variation ⇨ $Z_T = 0{,}3\ M\Omega/m$. *The simulation with MOSES code (Fr = 2,5 GHZ) is in good agreement with the experimental instability threshold.*

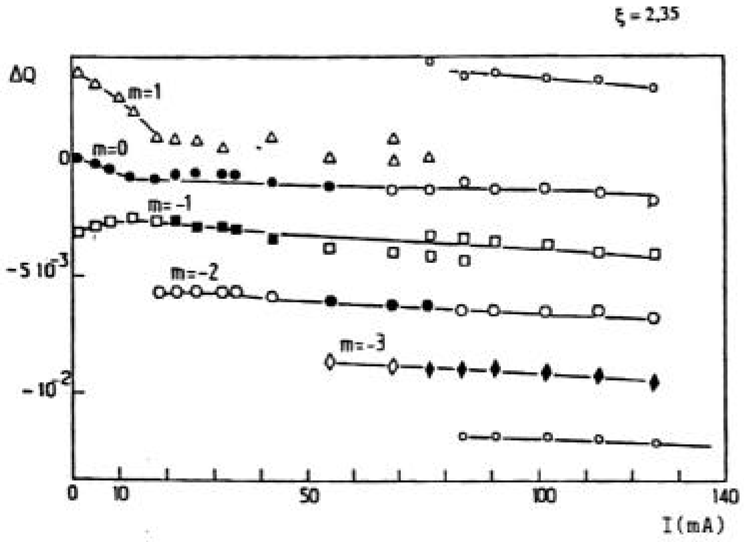


- *Experiment with x = 2,35 : No instability up to 150 mA.*

  For weak current and large chromaticity, satellites appear on each side of the initial betatron frequency. They are separated by approximately synchrotron frequency Qs.

  When I↗ the amplitude of the response at the first frequency decreases, some satellites may become more important than the initial frequency.

The transverse modes 0 and -1 which merge at 30 mA for low chromaticity remain well separated making the instability disappear.



Simulation with MOSES code

- **Broad band resonator model Z_T = 0,3 MΩ/m Fr = 2,5 GHz**
- **Bunch mode spectrum**

For low current and x = 0 response to 1,2 MHz excitation is zero for m = ± 1

For I = 100 mA and x = 6 response is very large for m = ± 1 and almost zero for m = 0.

For ξ = 0 the convolution of imaginary Z_T and the spectrum h_0 is important ⇨ the shift ΔQ is large.

For ξ = 6 the convolution of imaginary Z_T and the spectrum h_0 is small ⇨ the shift ΔQ is small.The convergence of the modes 0 and -1 occurs for 110 mA.

For ξ = 8 the modes 0 and -1 remain well separated up to 150 mA.

The calculations with MOSES are in good agreement for the mode coupling instability threshold at ξ = 0 but experimentally the chromaticity value to push away the instability is much lower.

Super ACO

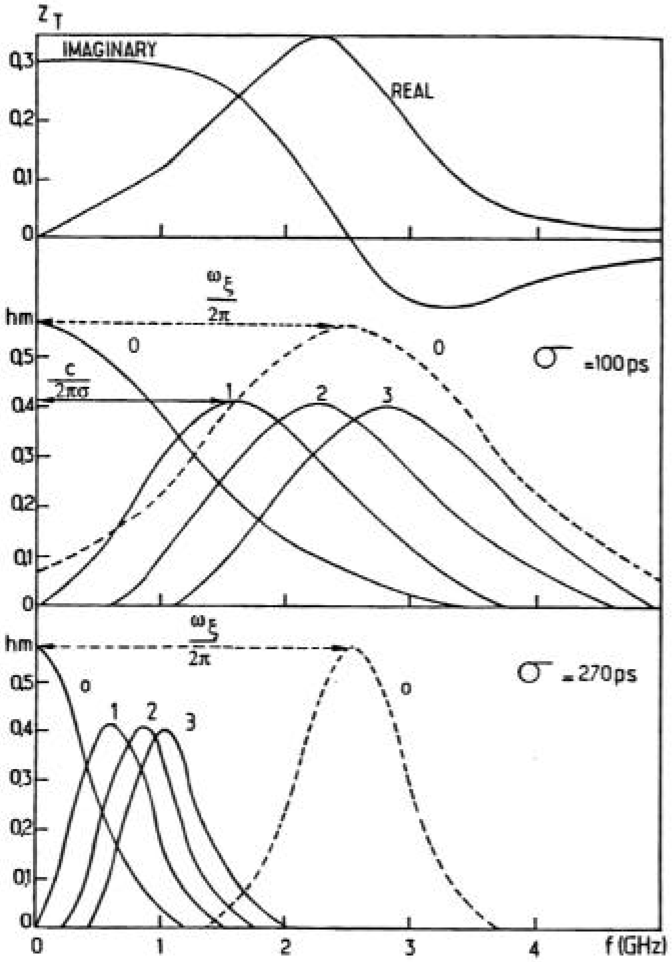
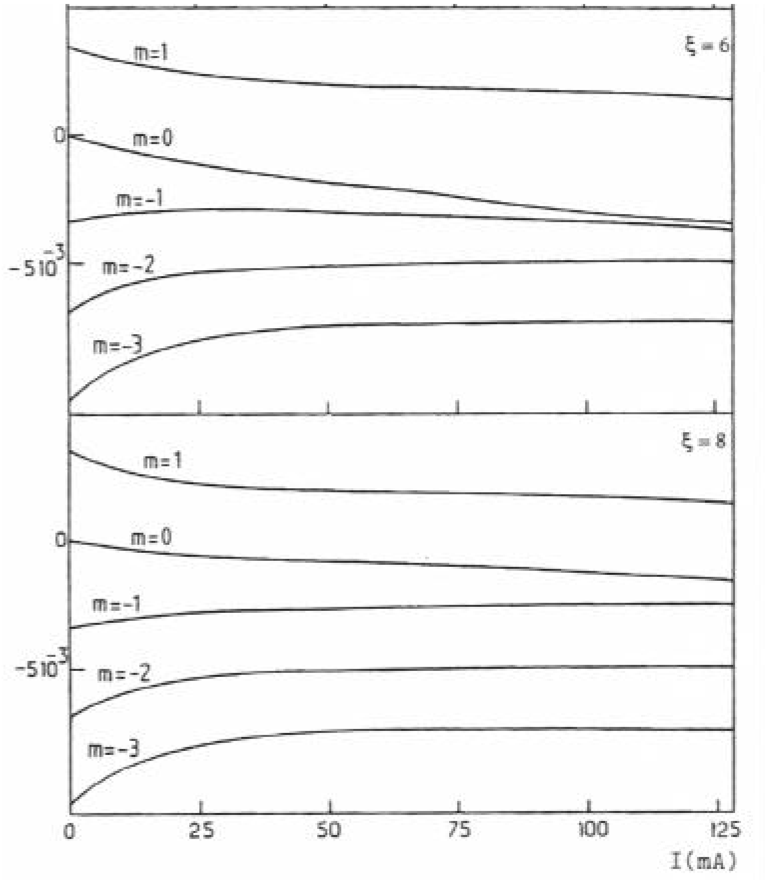


Fig. 3 : Impedance (broad band resonator model) and mode spectrum envelop for 2 different bunch currents.



Theoretical mode frequency variation for 3 different chromaticities.

Super ACO

TWO RF system 100 MHz+ 500 MHz

Bunch length have been shortened by factors between 2 and 3.5.

In these conditions we observe again the merging of the modes 0 and -1 for 30 mA/bunch.

Increasing the vertical chromaticity from 2.5 to 4 leads to a sudden separation of the 2 lines and a calming of the instability.

☞ Longitudinal behaviour

One RF system 100 MHz

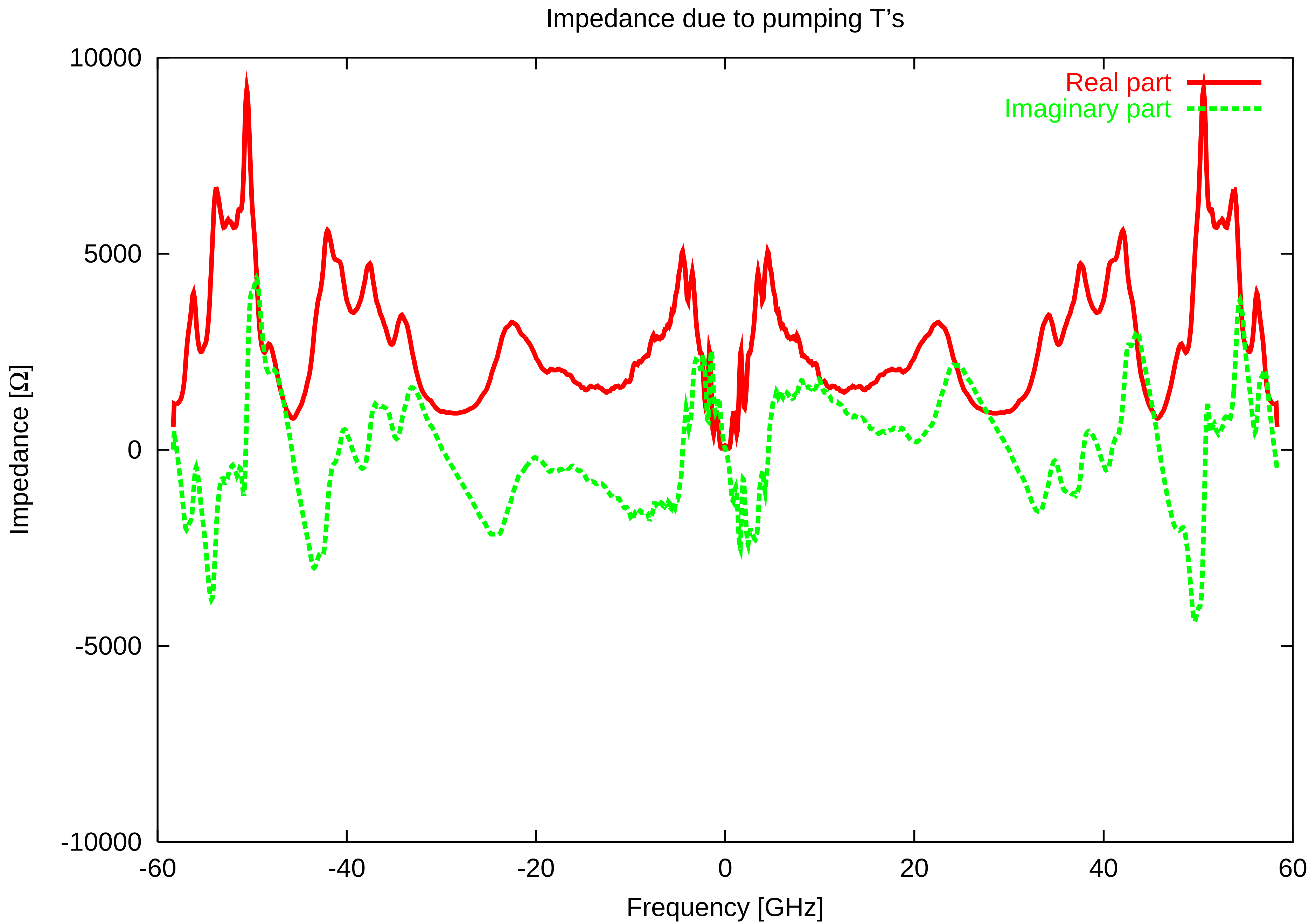
Different measurements (with different methods) were made along the machine life :

- *1989 Fit BB resonator BBI : Z/n =2.8 W ; Fr = 2.5 GHz*
- *1999 Fit BB resonator with tracking code (F. Orsini):*

  Z/n = 8 W ; Fr = 10 GHz

Two RF system 100 MHz + 500 MHz (shortening mode)

- *1998 FFT based tracking code (impedance of pumping T's) G. Flynn*
- *"longitudinal characterisation (bunch lengthening and energy spread widening) with one or two RF cavities on Super ACO"LEL team reported by G. Denino.*



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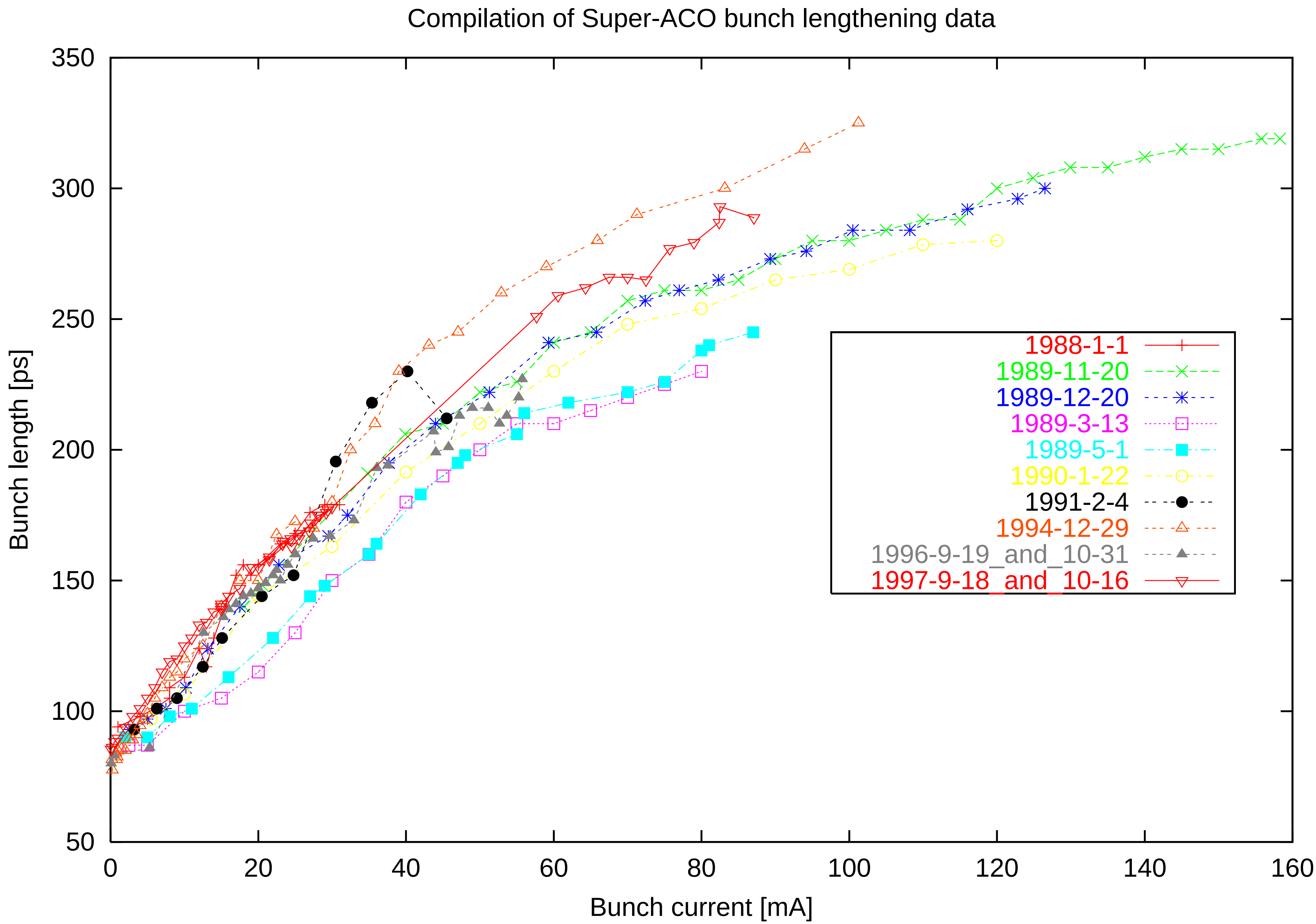

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