TLEP: effect of cavity impedance for operation at high current and low energy

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Outline

- TLEP: one of the scenarios for a possible high-energy electron-positron collider.
- 80 km circumference.
- Most critical version: ”low” energy TLEP-Z
  - 45.5 GeV / beam,
  - 2625 bunches / beam,
  - 1.18 A / beam,
- LEP (in particular LEP2) was limited by TMCI (transverse mode coupling instability), due to cavities impedance

→ need to study TMCI for TLEP, with particular emphasis on feedback.

What about LEP TMCI ?

- Impedance model: two broad-band resonators (RF cavities + unshielded bellows), the rest is relatively small [G. Sabbi, 1995].

  → experimental tune shifts and TMCI threshold (from a simple formula) well reproduced,

  → final threshold a bit less than 1mA.

- Transverse feedback:
  - First idea: reactive feedback (prevent mode 0 to shift down and coupled with mode 1) → found rather ineffective (5-10 % increase in threshold) despite several trials [Danilov-Perevedentsev 1993, Sabbi 1996, Brandt et al 1995],
  - Another idea: resistive feedback, first found ineffective [Ruth 1983], but finally thought to be a good option with a possible increase by a factor ~5 of the threshold [Karliner-Popov 2005]. Tried at VEPP-4 (Novossibirsk) with success, but not at LEP.

How are we going to study this ?

- Using a new code made up of a set of old methods

→ DELPHI (for Discrete Expansion over Laguerre Polynomials and Headtail modes),

→ based on a resolution of Sacherer integral equation (Chao eq. 6.179),

→ using a decomposition over Laguerre polynomials of the radial function (idea from Besnier 1974, used then by Y. Chin in code MOSES - 1985),

→ eigenvalue system,

→ including azimuthal & radial modes, and mode coupling (like MOSES),

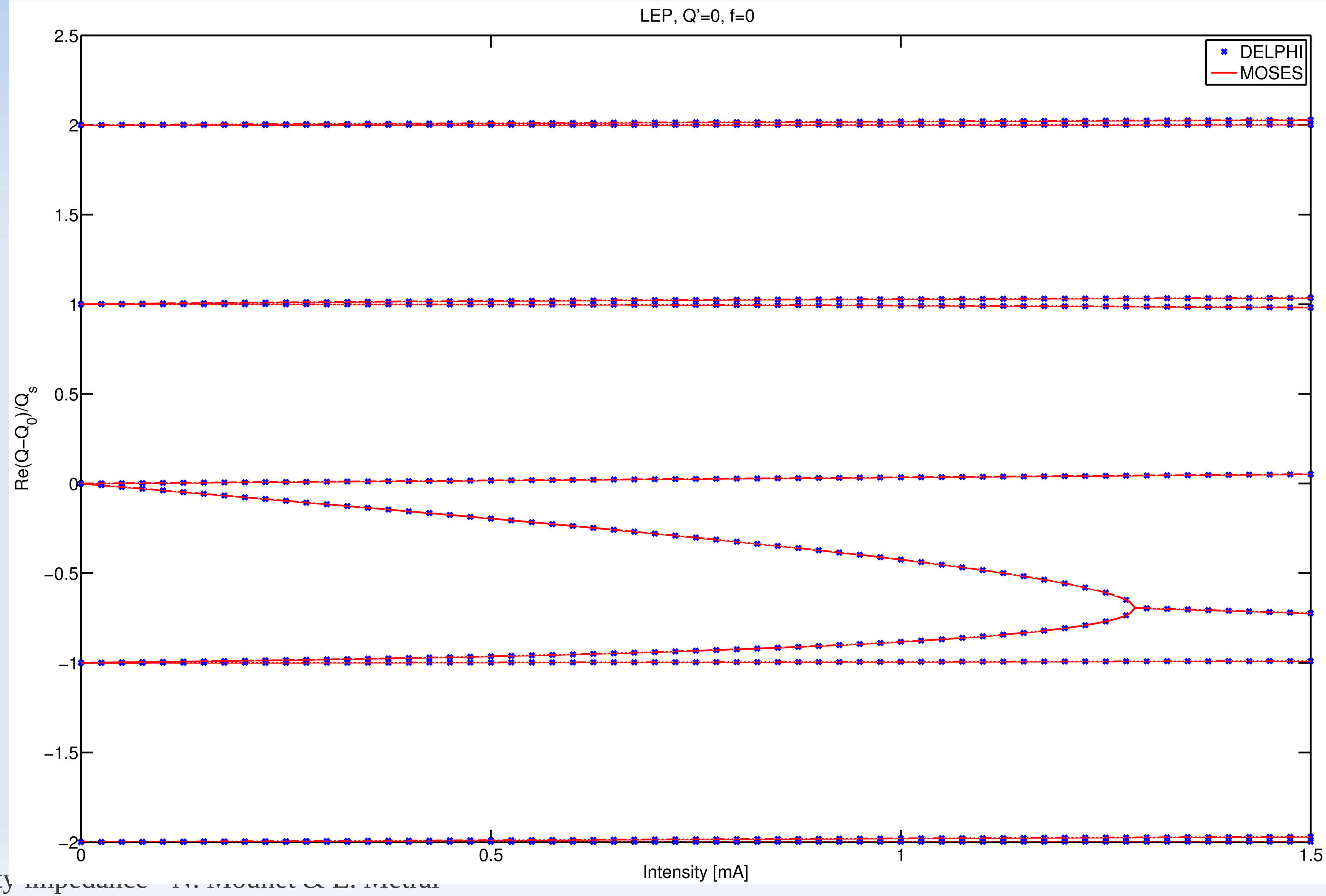
→ including generalization to any kind of impedance, multibunch effects and damper (either bunch-by-bunch or from a ”damper impedance”) (unlike MOSES),

→ not including Landau damping (MOSES has this possibility).

Benchmarks

- DELPHI vs MOSES, for single-bunch TMCI without damper (LEP RF cavities modelled as a broadband resonator):

Real, part, Q'=0



Benchmarks

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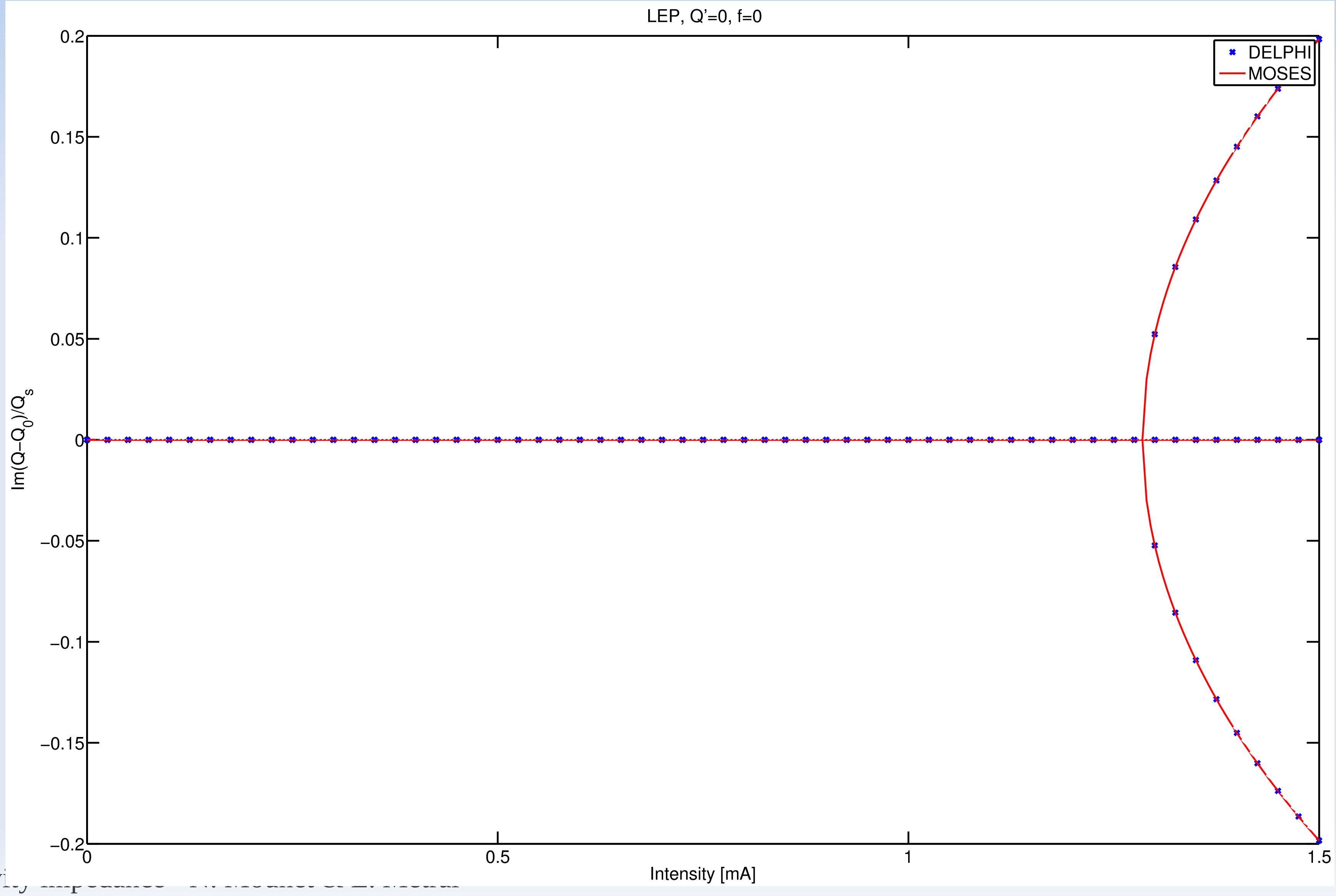
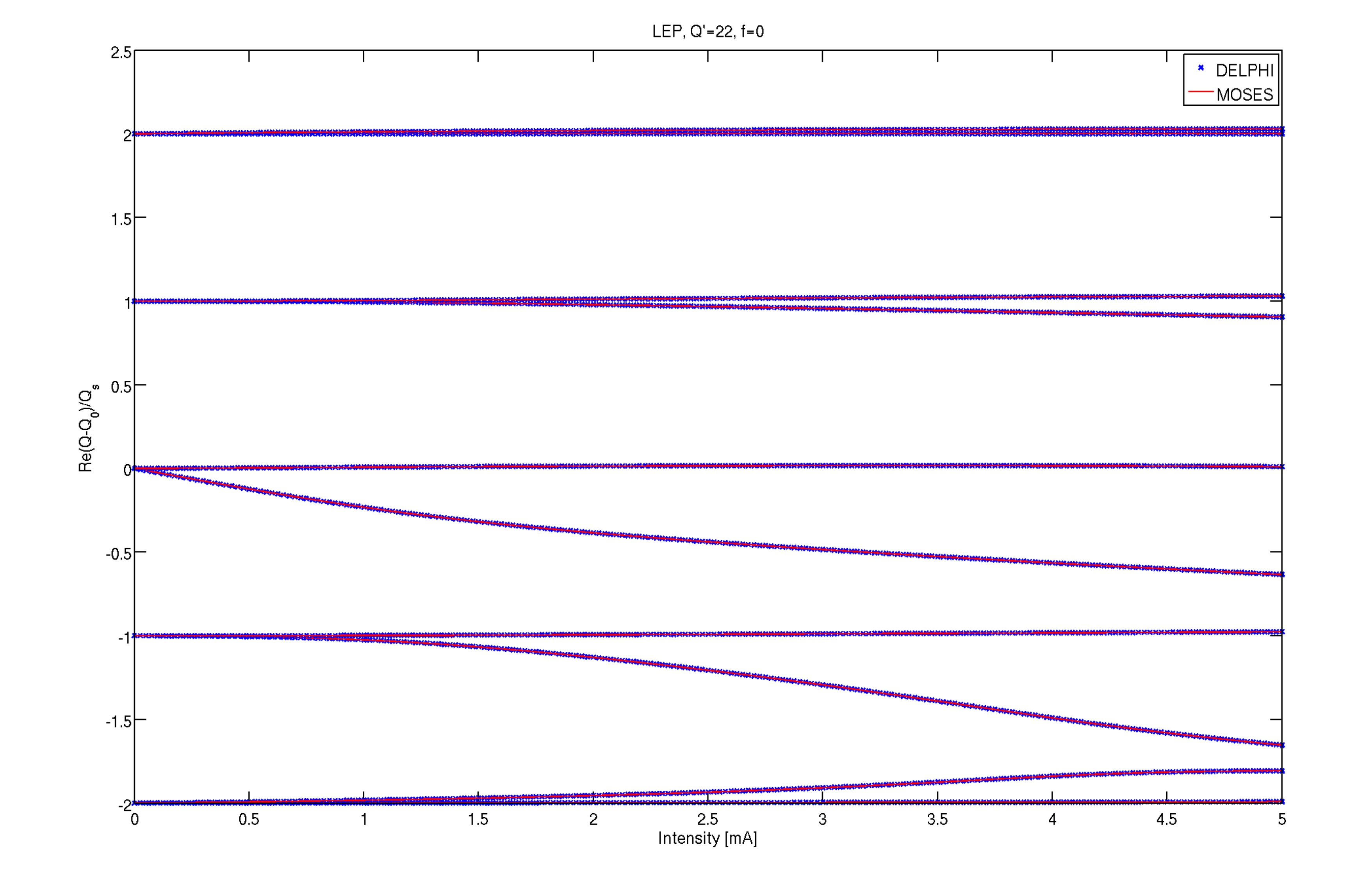
Imag. Part, Q'=0



Benchmarks

- DELPHI vs MOSES, for single-bunch TMCI without damper (LEP RF cavities modelled as a broadband resonator):

Real, part, Q'=22



Benchmarks

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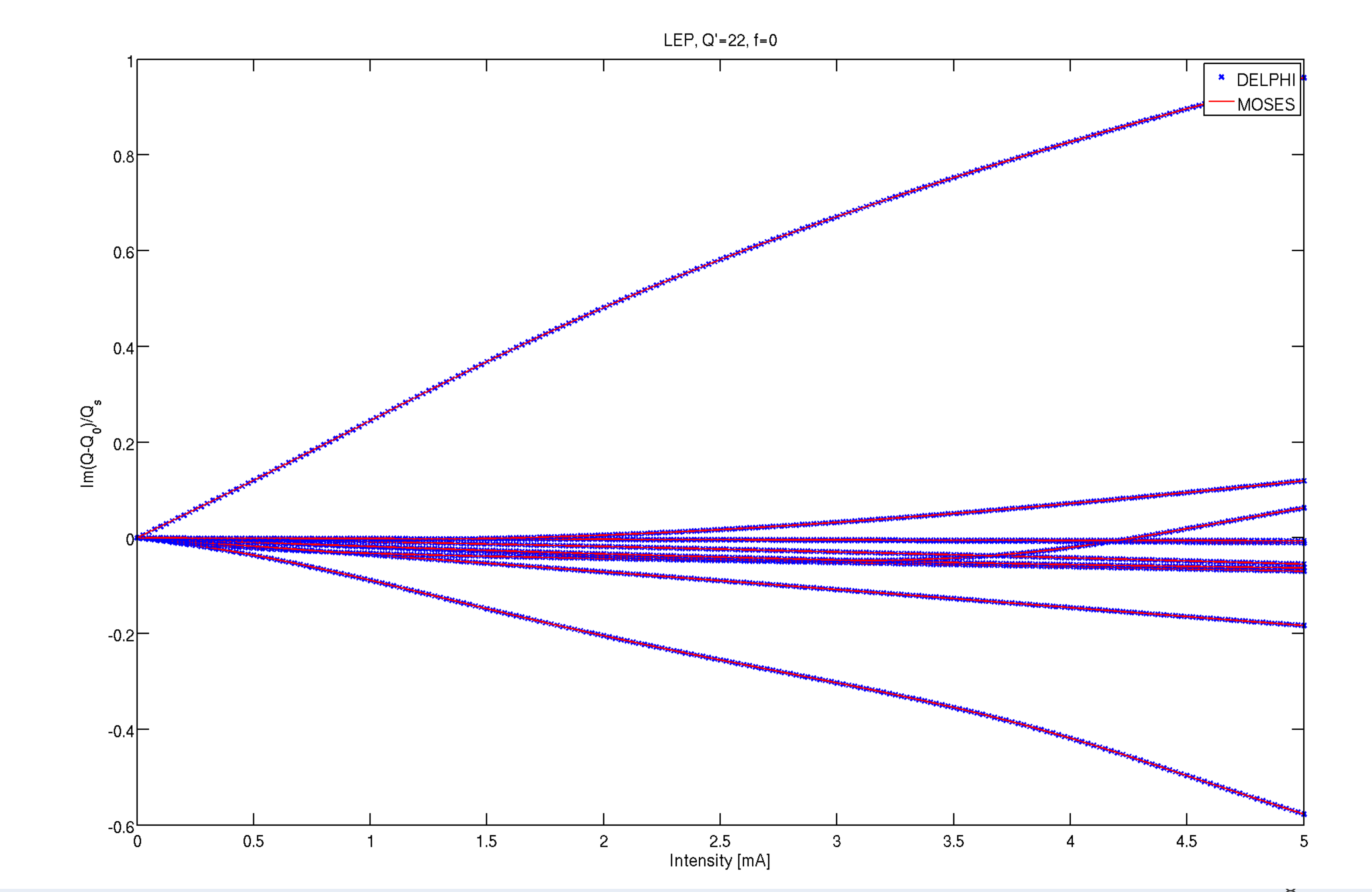
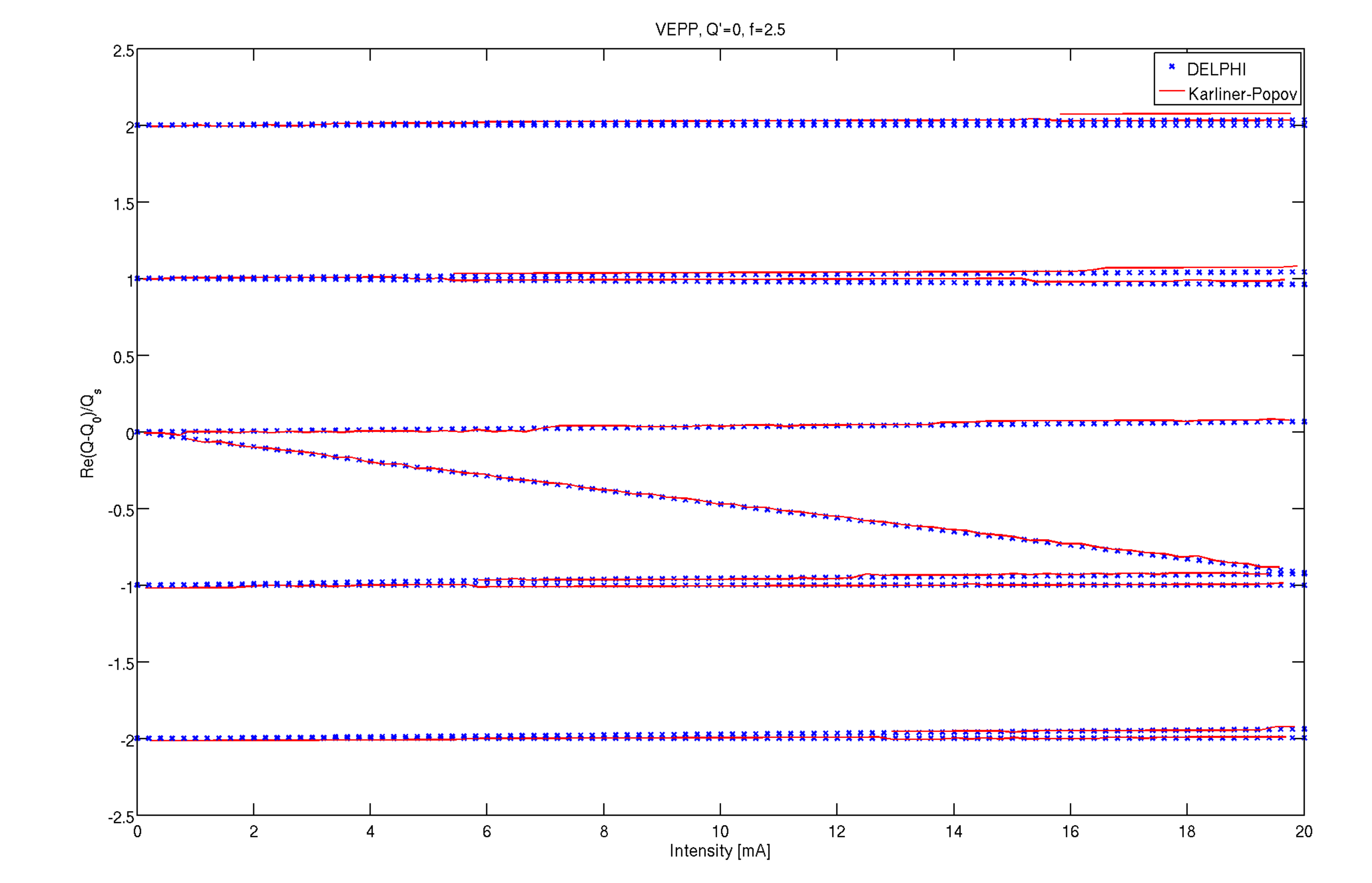
Imag. Part, Q'=22



Benchmarks

- DELPHI vs Karliner-Popov, for single-bunch TMCI with damper (VEPP-4, broadband resonator):

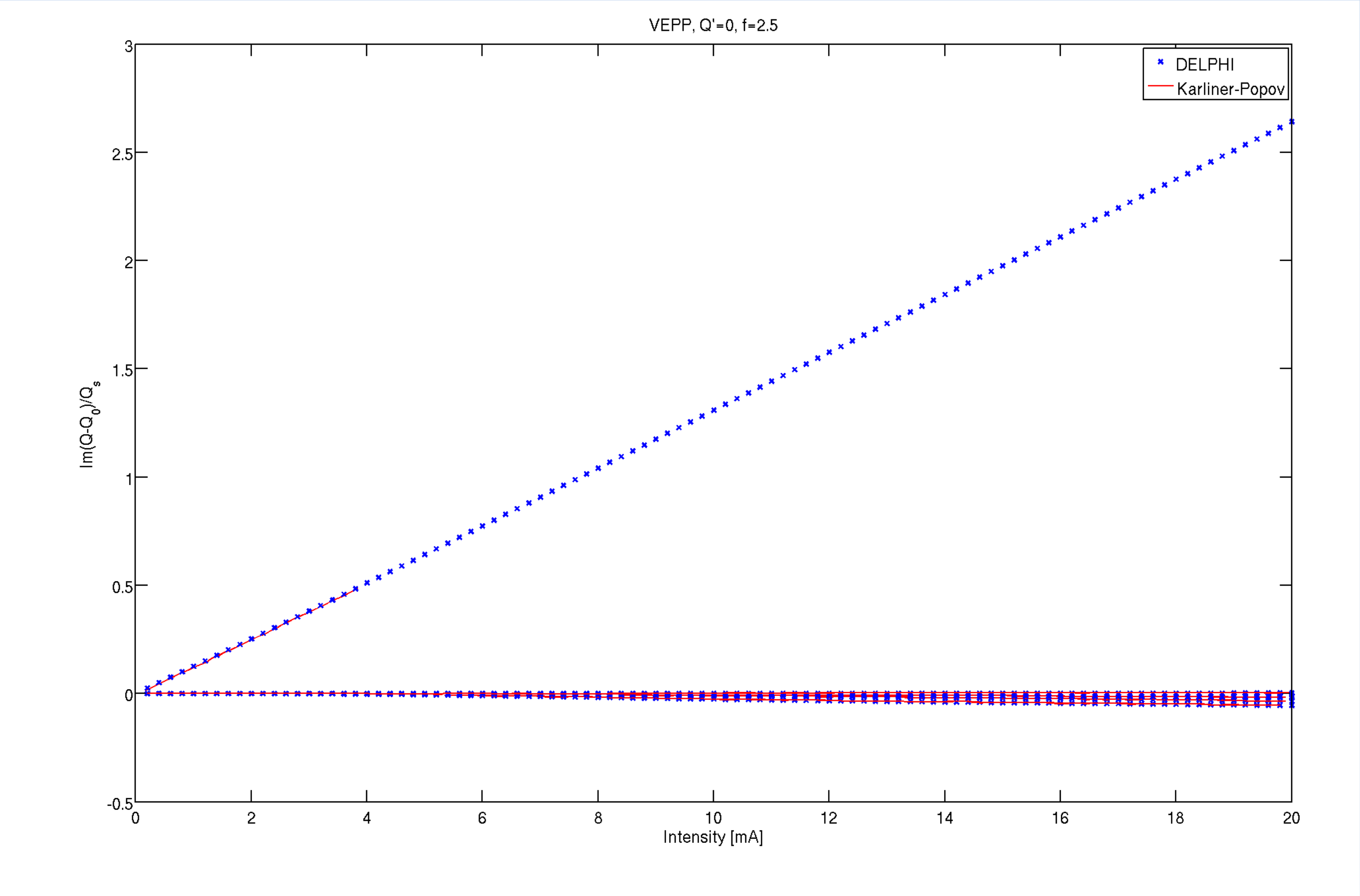
Real, part, Q'=0



Benchmarks

- DELPHI vs Karliner-Popov, for single-bunch TMCI with damper (VEPP-4, broadband resonator):

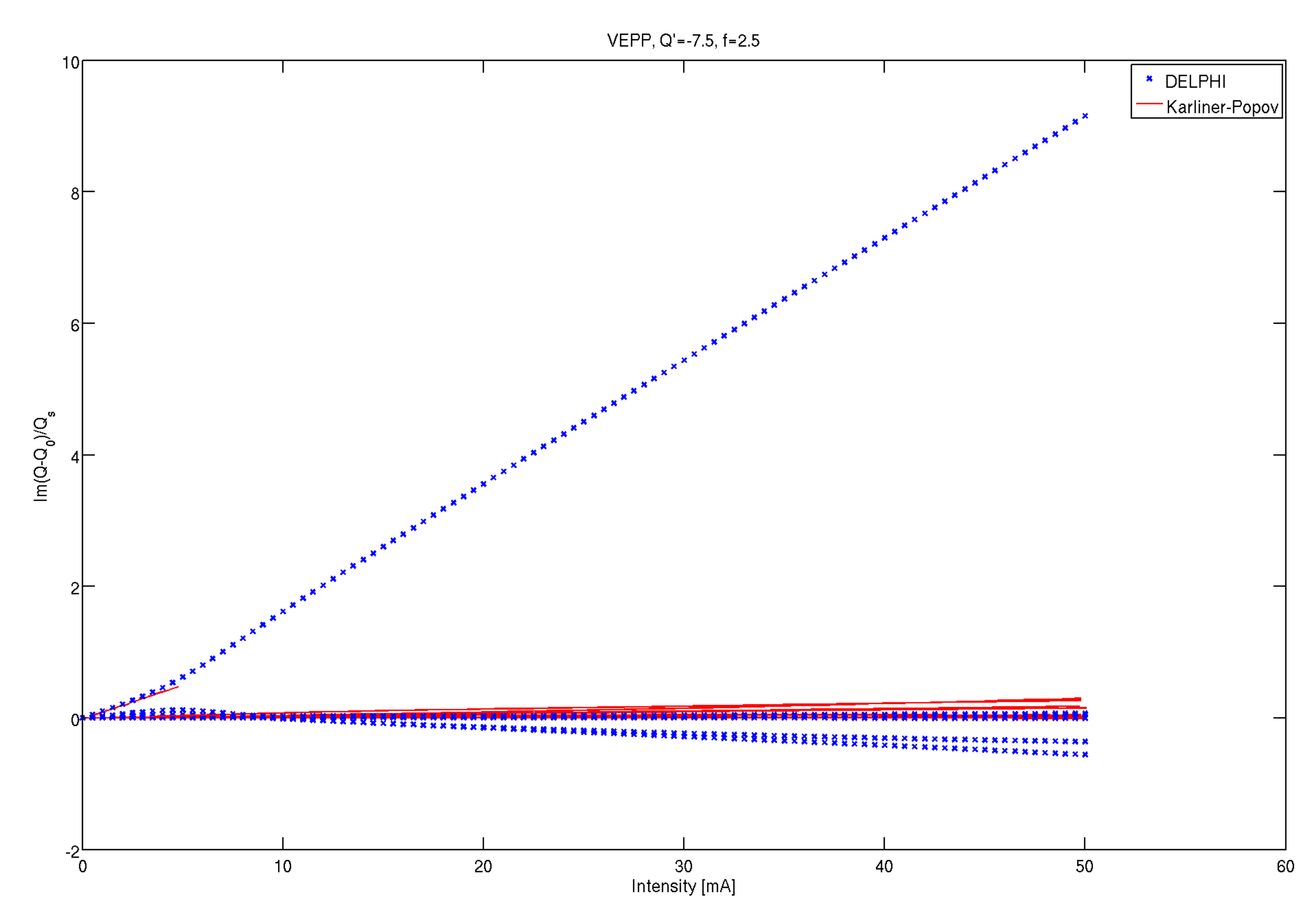
Imag. Part, Q'=0



Benchmarks, but...

- DELPHI vs Karliner-Popov, for single-bunch TMCI with damper (VEPP-4, broadband resonator):

Imag, part, Q'=-7.5



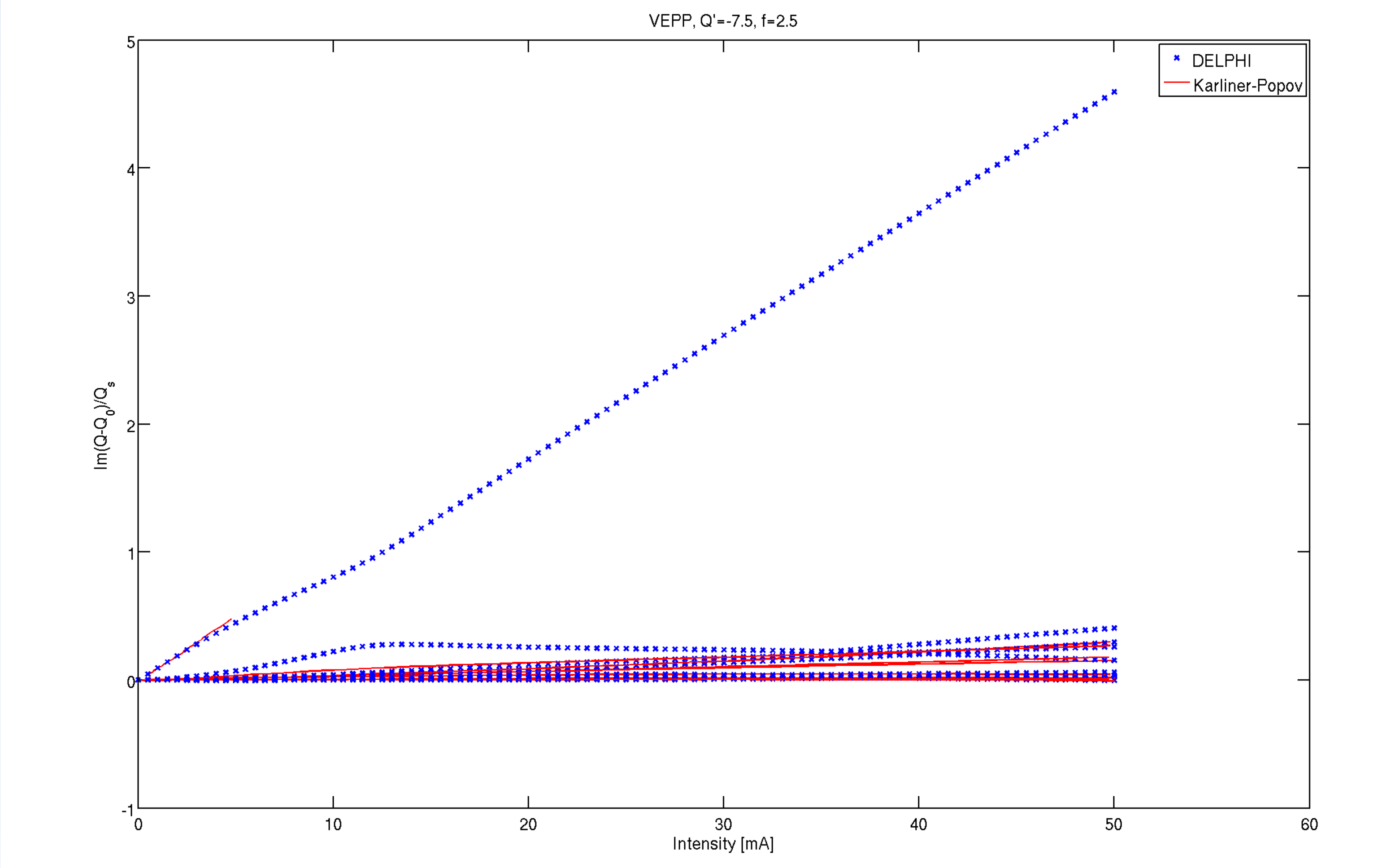
Karliner-Popov is more stable ...

With Karliner-Popov non-ideal damper

- Up to now the damper was bunch-by-bunch in DELPHI, but Karliner-Popov has a more sophisticated damper model (bandwidth, and effect of kicker and pickup finite lengths). Trying to play with their damper-impedance (exact parameters unfortunately not available...), one can get:

Imag. Part, Q'=-7.5

Better but still not exactly this...



More to come...

- No wonder that the benchmark works so well in most cases: the 3 codes have exactly the same principles (Laguerre polynomials decomposition).
- I chose the same number of radial modes and azimuthal modes for these benchmarks, but DELPHI is actually testing the convergence w.r.t. The number of modes. This could well have a significant impact.
- More results coming (LEP, then TLEP with 700 MHZ cavity impedance from R. Calaga + resistive wall)....