Turn-by-turn BPM data analysis from the ATF damping ring

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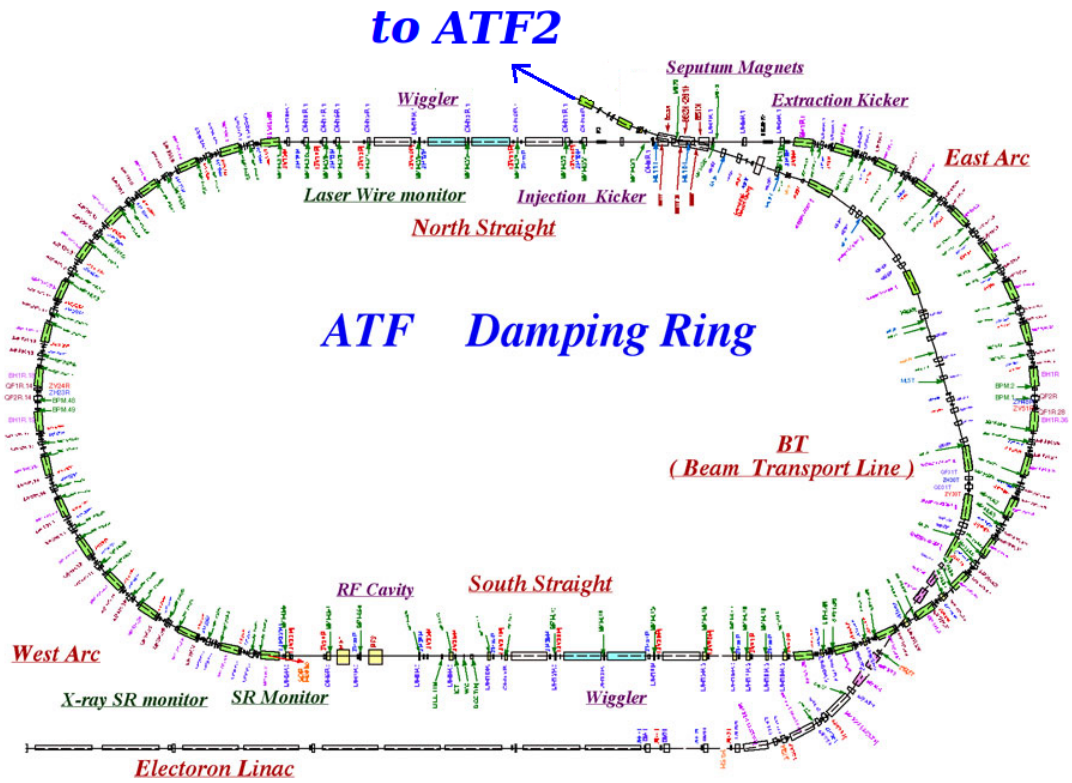
ATF2 Project Meeting
23 of January 2013

Headlines

Headlines

ATF Damping Ring at KEK



Parameter	Nominal value
ϵ_x	1.0×10^{-9}rad.m
ϵ_y	1.0×10^{-11}rad.m
Circumference	138m
Energy	1.3GeV
Intensity	$1.10^{10} e^-$

Turn by Turn Analysis

Motivation

- 96 new BPMs installed capable of turn by turn measurement.
- Few μm resolution.
- Fast measurement of β functions, coupling, ...
- Combine BPMs data to get tune measurement over few turns.

The Data

- Obtained in December 2012.
- Low intensity (may impact resolution)
- Parasitic measurements, no dispersion measurement.
- Injection data, exciter not used.

Headlines

Analysis

Analyzing each BPM individually

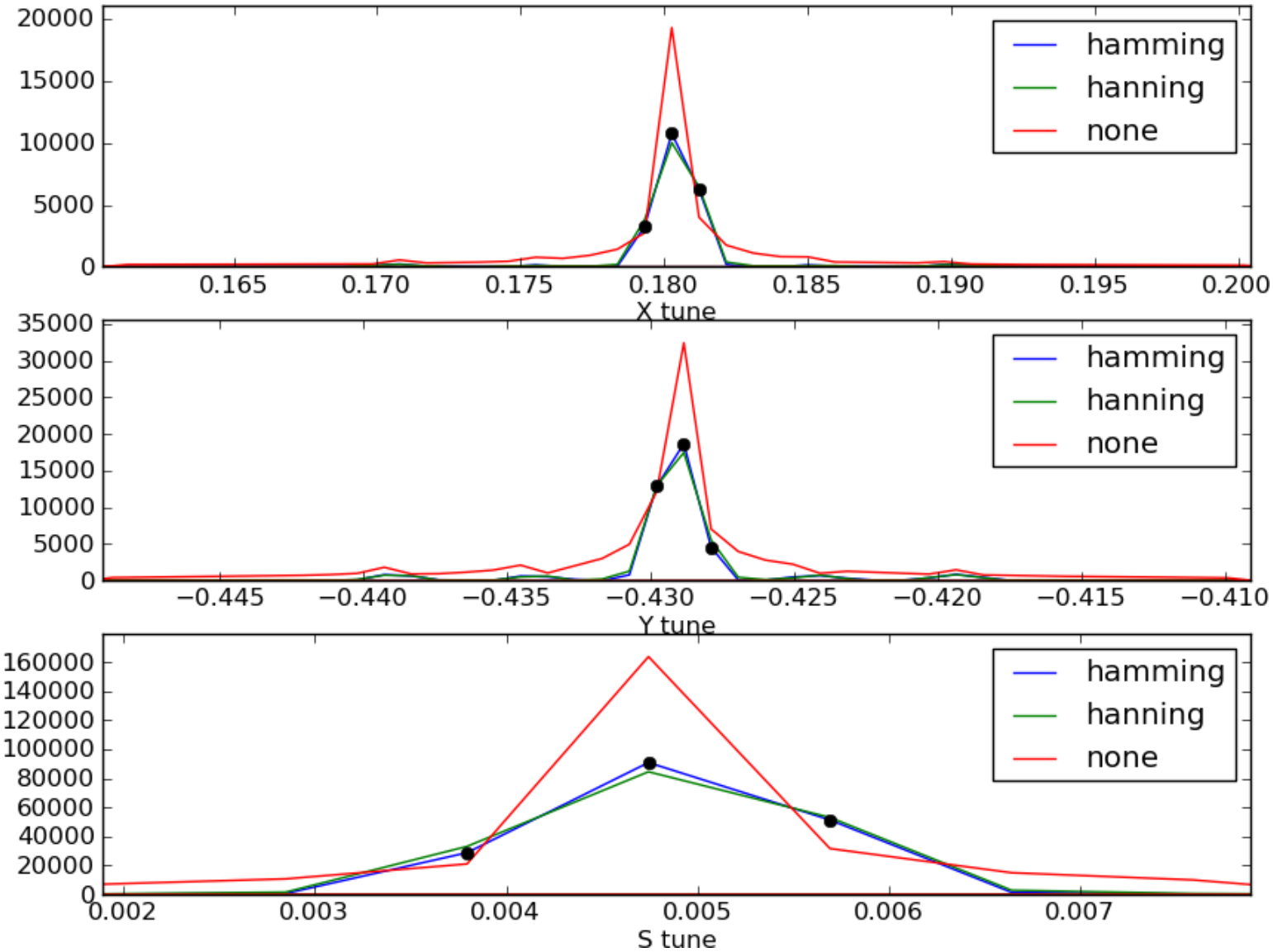
- Tunes measurement with FFT (windows to reduce noise influence)
- with sussix or NAFF, measure resonances (amplitude and phase) for:
  - in horizontal plane: $(1,0)_h$, $(0,1)_h$, $(2,0)_h$ and $(3,0)_h$
  - in vertical plane: $(0,1)_v$, $(1,0)_v$, $(1,1)_v$
- From resonance measurements, with getLLM we get:
  - Twiss functions from amplitudes or phases.
  - Coupling measurement.
  - f_{3000} (sextupoles induced resonances).
- Match model for experimental tunes, then compute response matrices.
- From β beating, phase mismatch and coupling, corrections are computed (based on response matrices).

Headlines

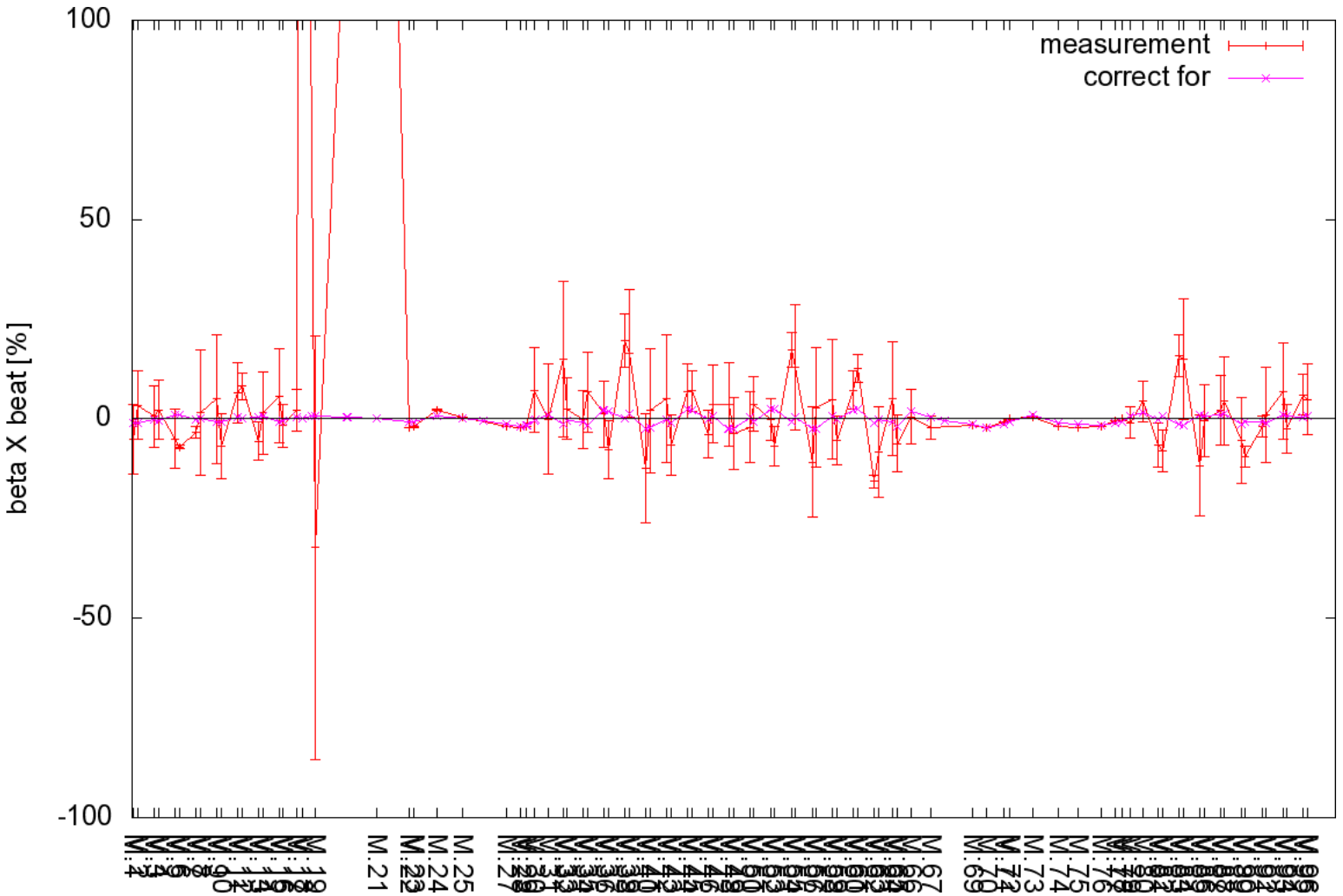
Simulation parameters

- Perfect MADX lattice.
- Tracking for 1056 turns with MADX PTC.
- Injection at $x = 50\mu$m, $y = 50\mu$m and $t = 0.04$m to get about same tunes amplitudes as experimentally.

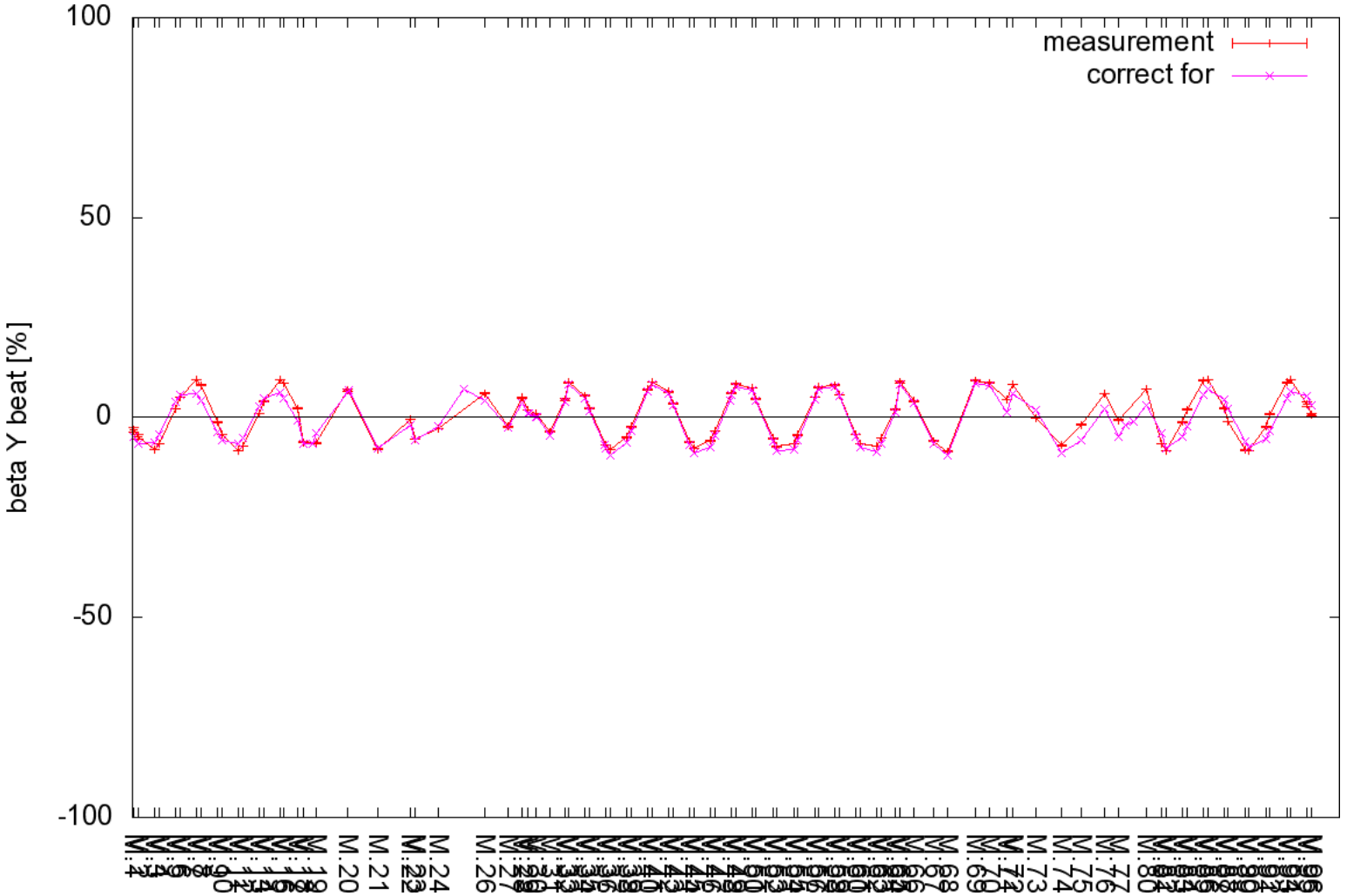
Approximative tunes with windowed FFT



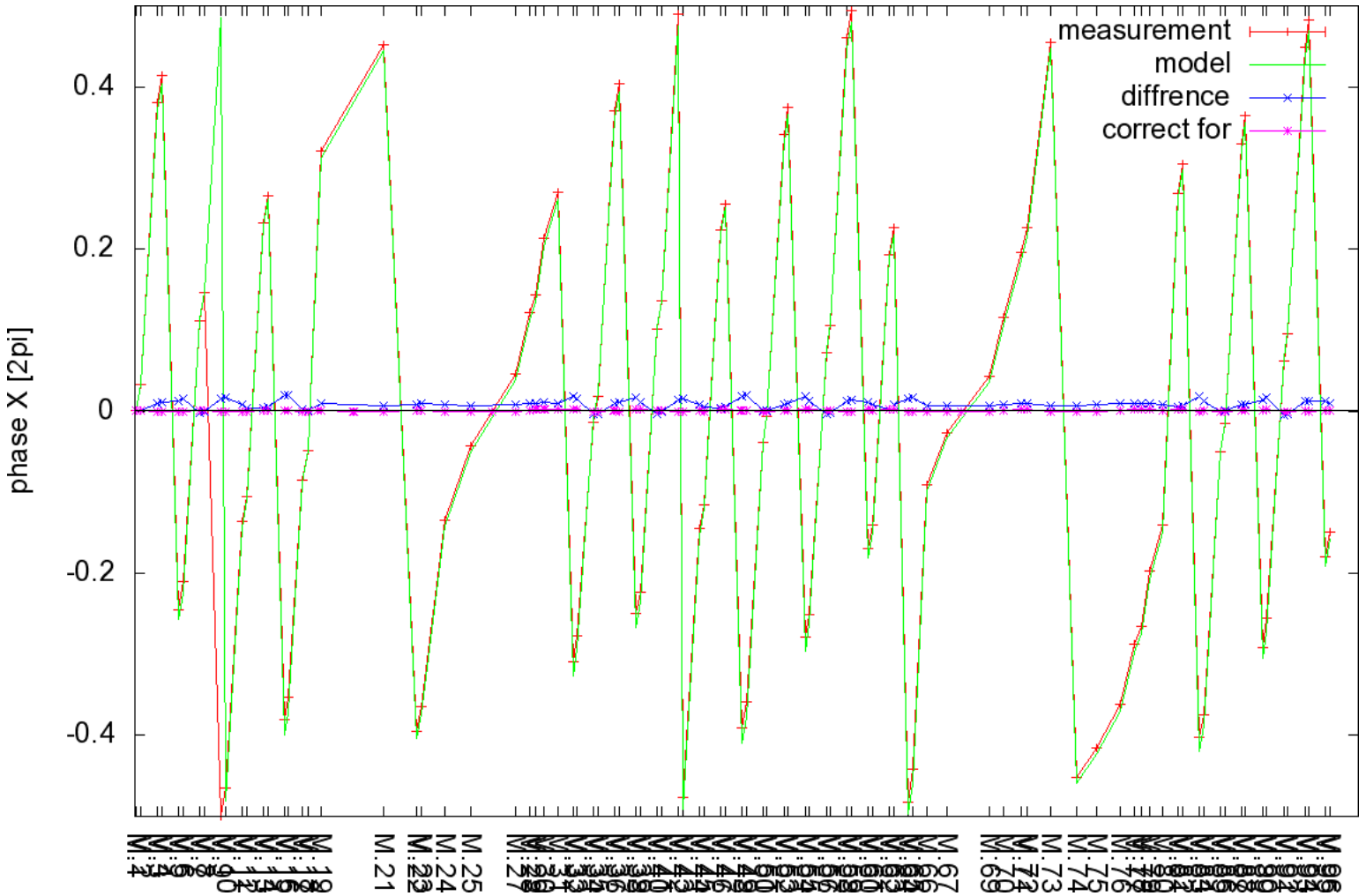
β_x beating measurement



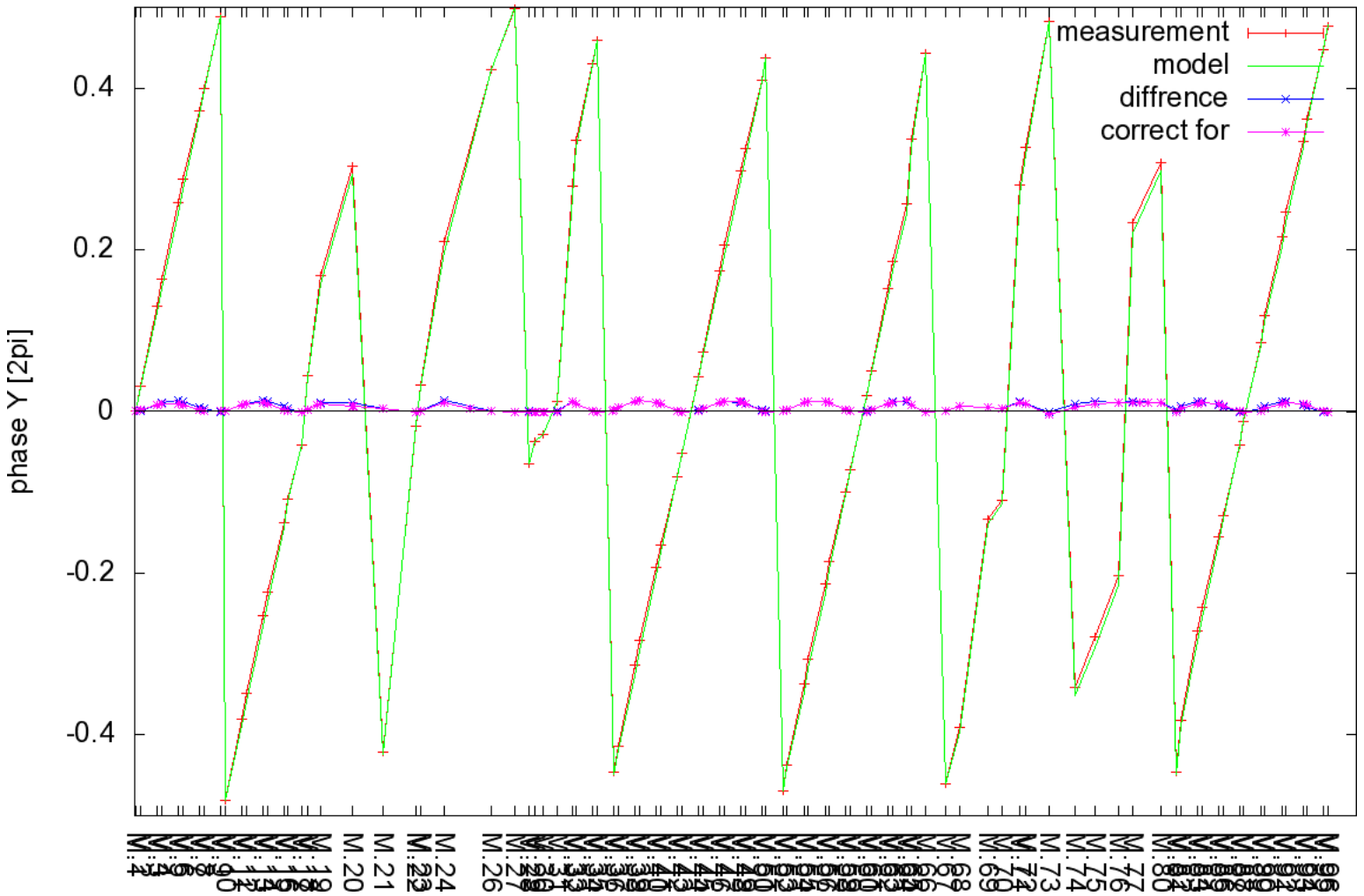
β_y beating measurement



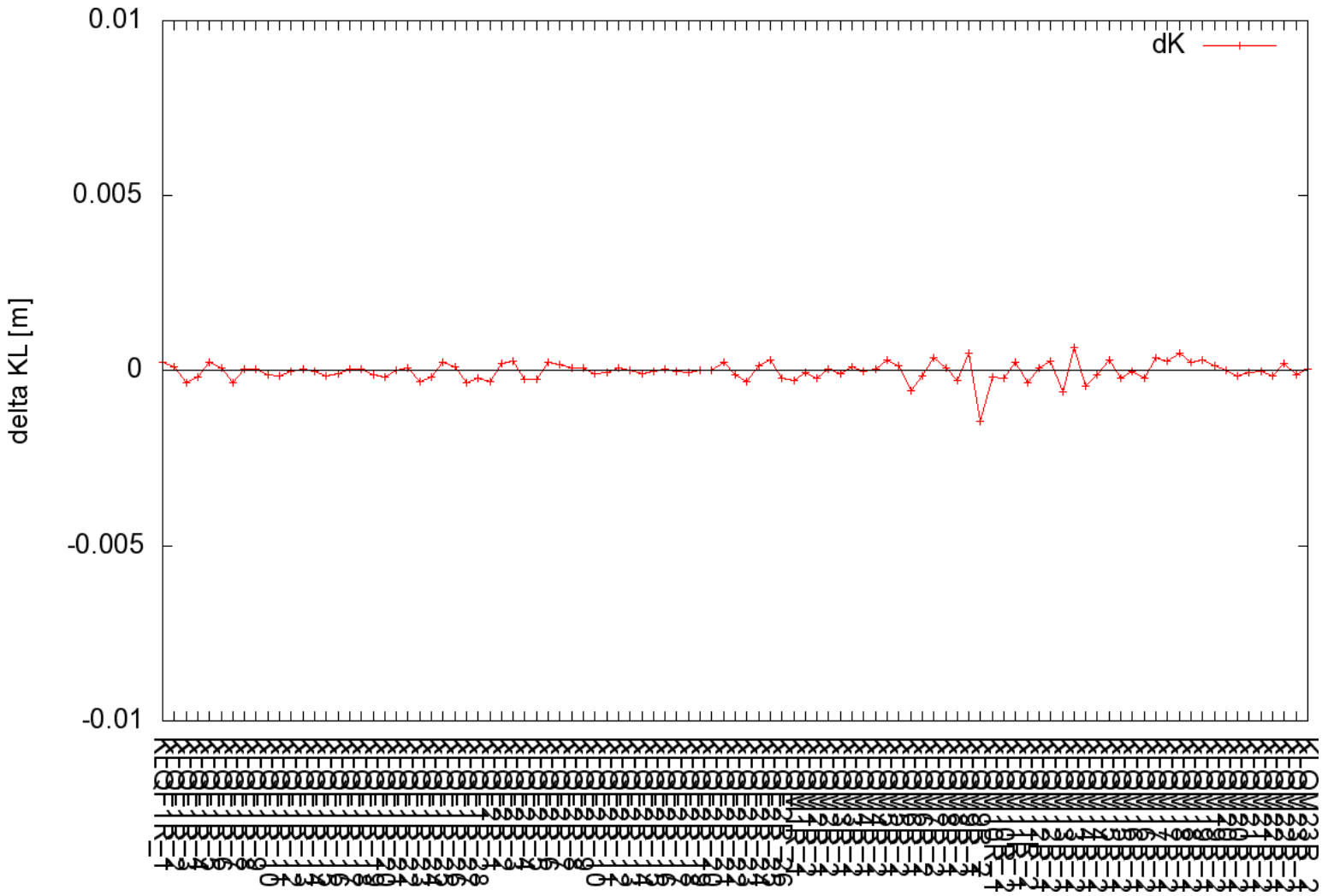
ϕ_x measurement



ϕ_y measurement



Correction

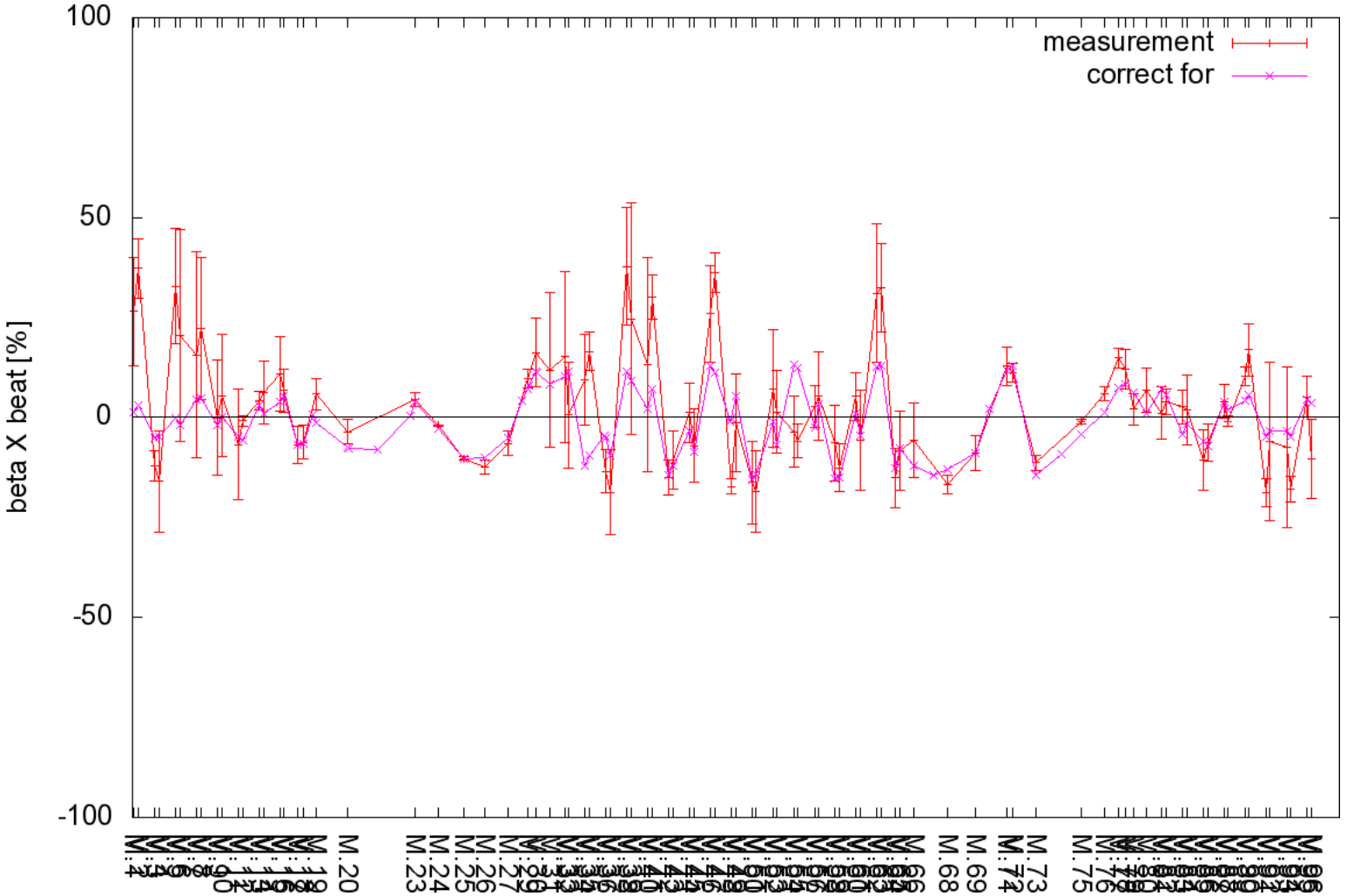


Headlines

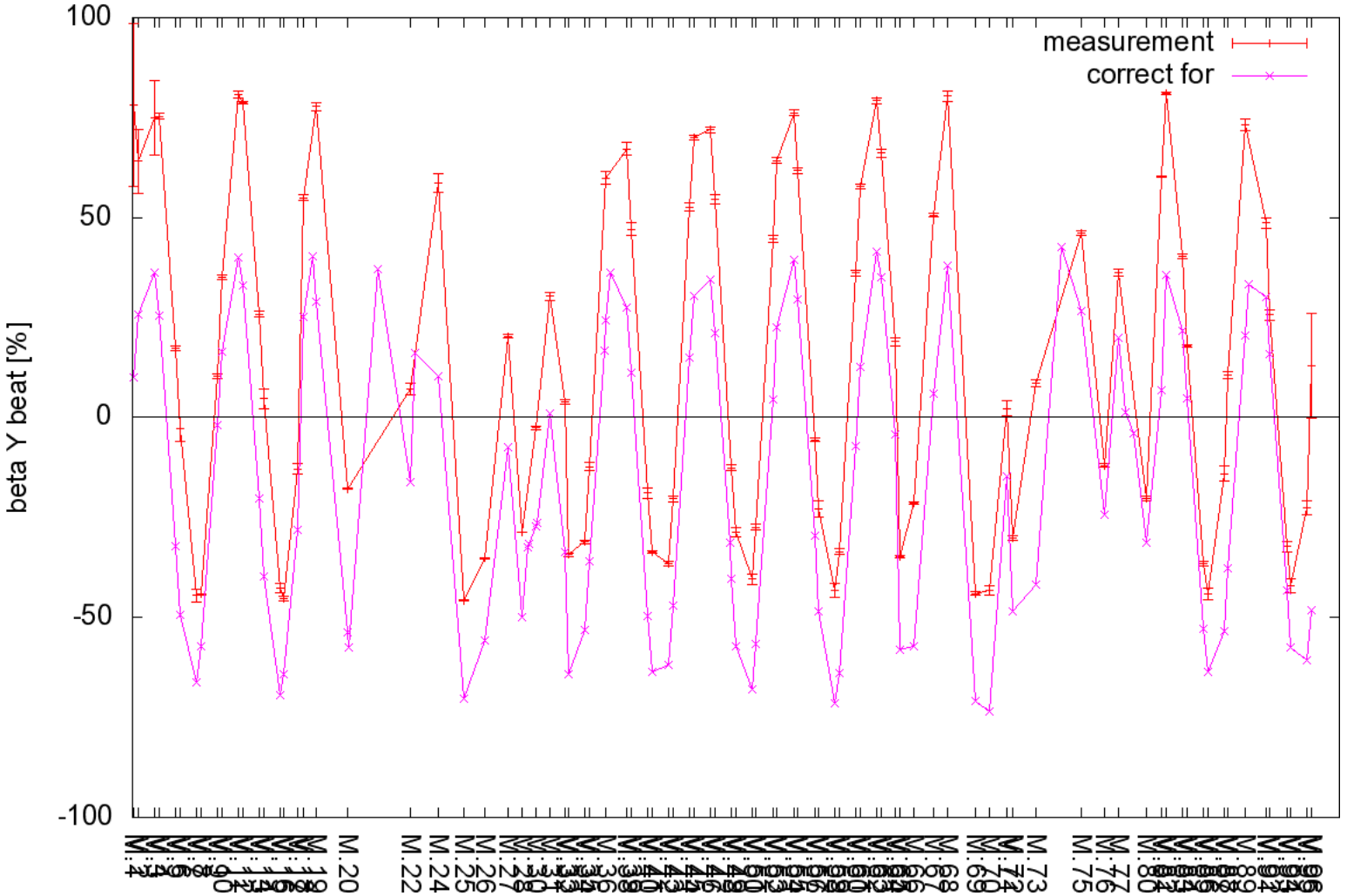
Simulation parameters with 1 mismatched quadrupole

- KLQF1R_1 set to nominal $+0.1$m.
- Tracking for 1056 turns with MADX PTC.
- Injection at $x = 50\mu$m, $y = 50\mu$m and $t = 0.04$m to get about same tunes amplitudes as experimentally.

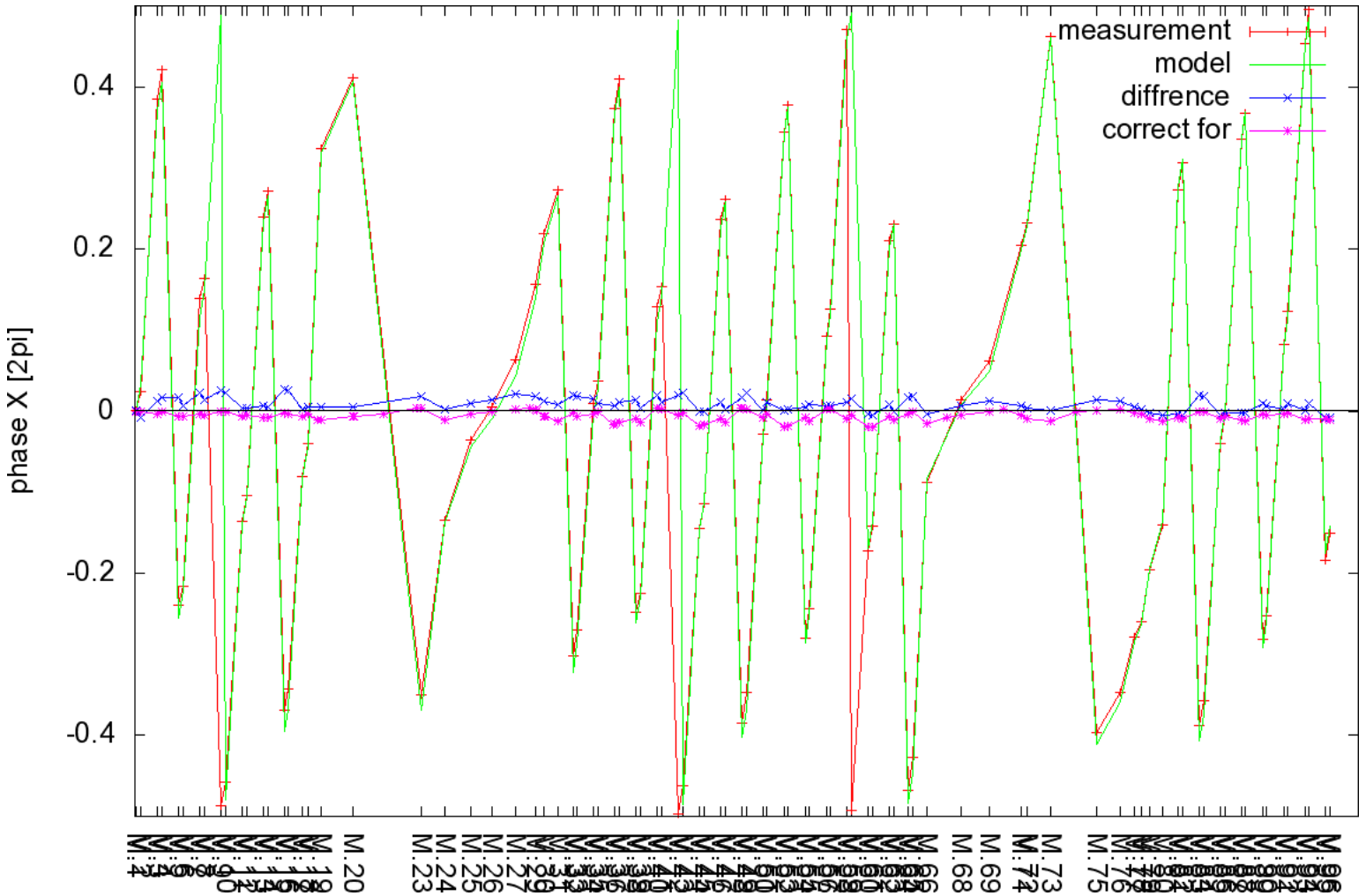
β_x beating measurement



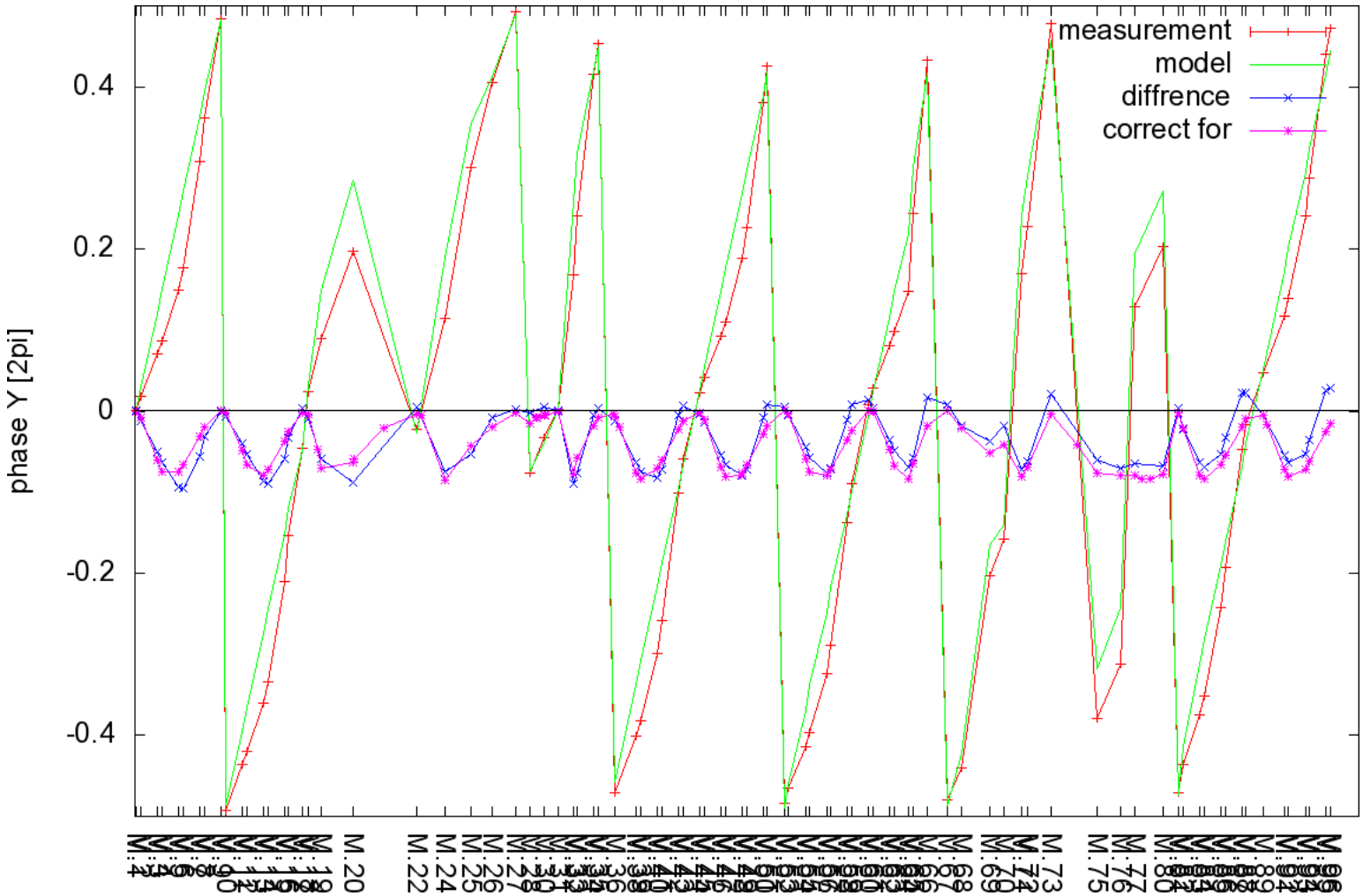
β_y beating measurement



ϕ_x measurement



ϕ_y measurement



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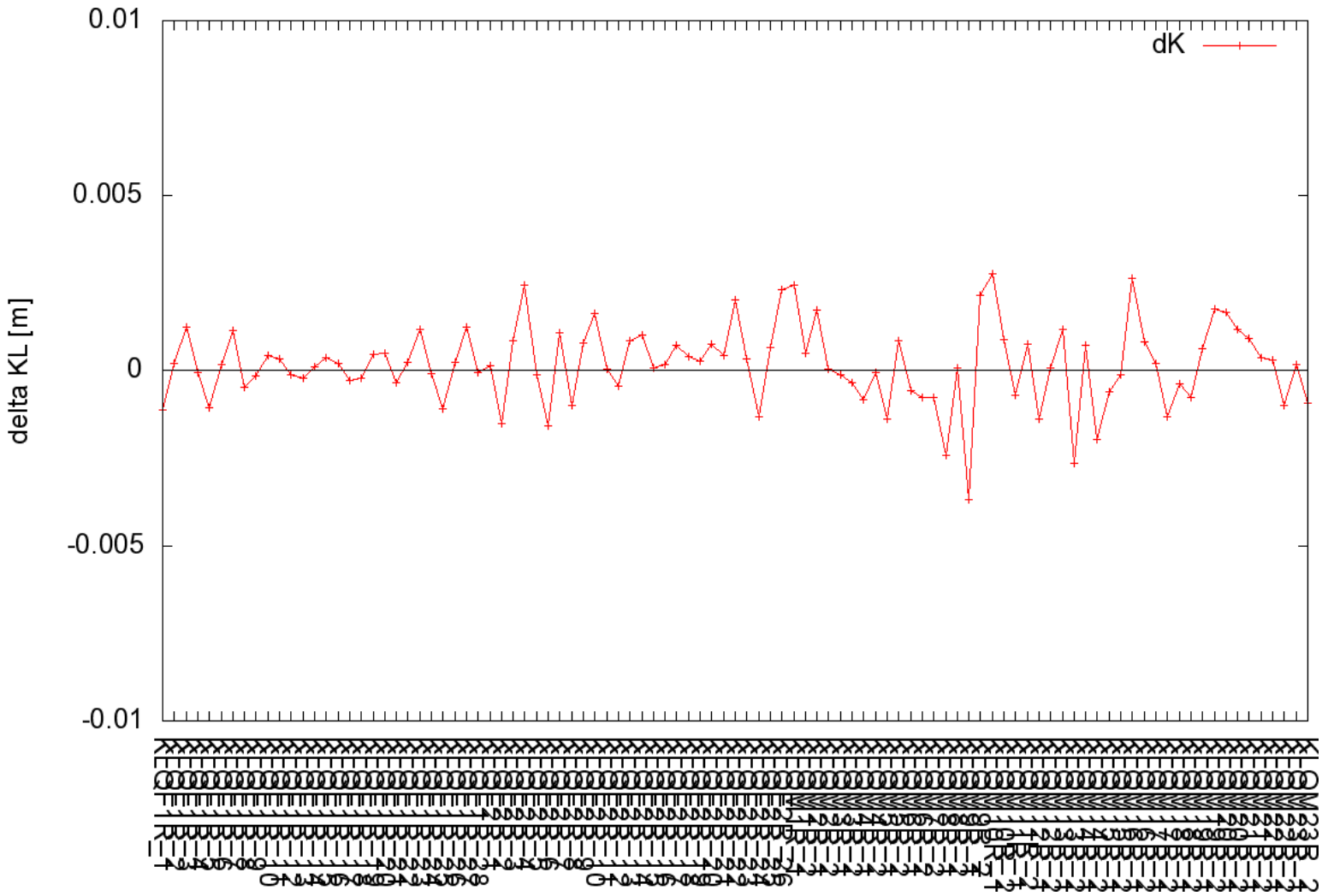
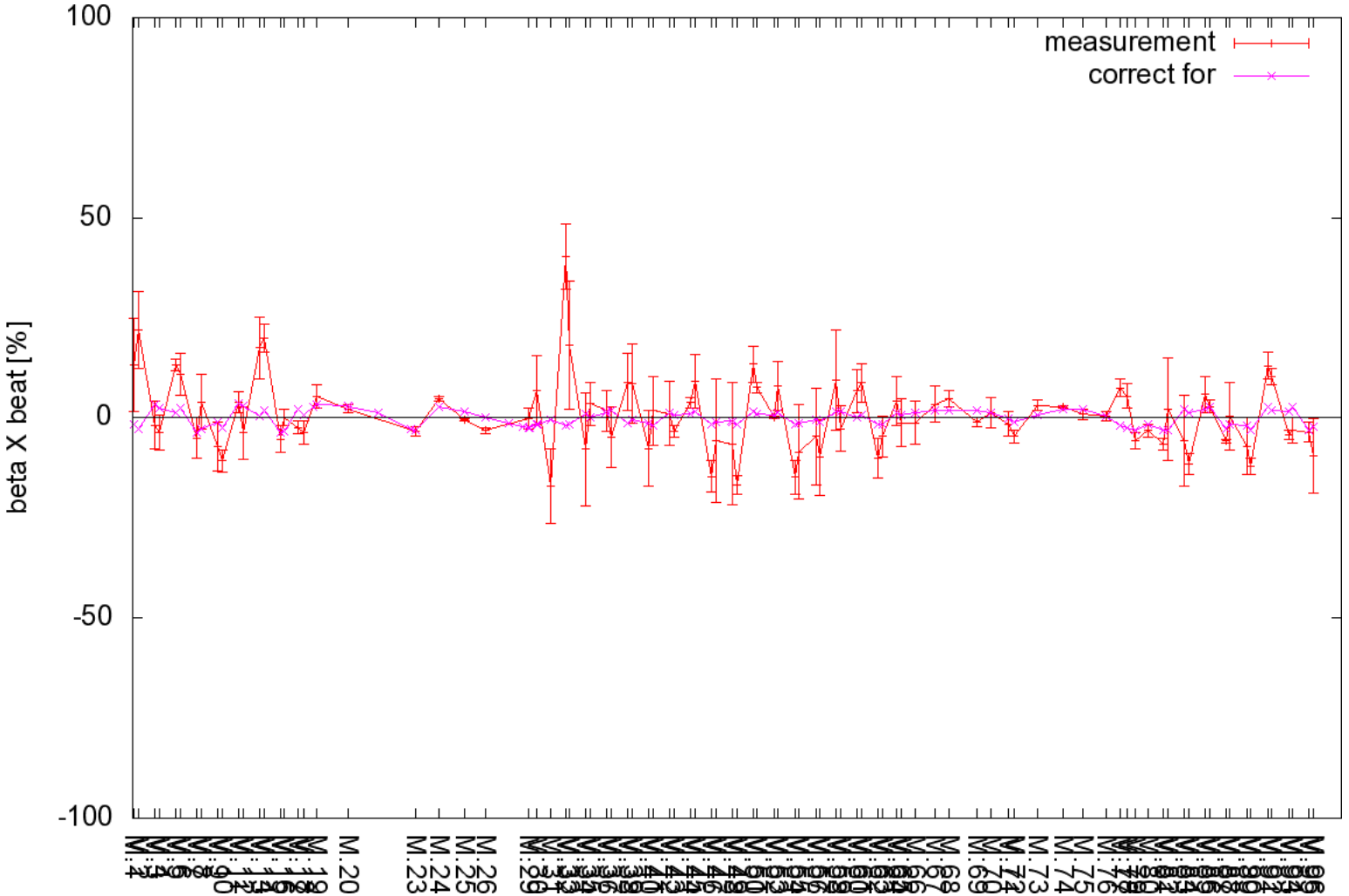


Headlines

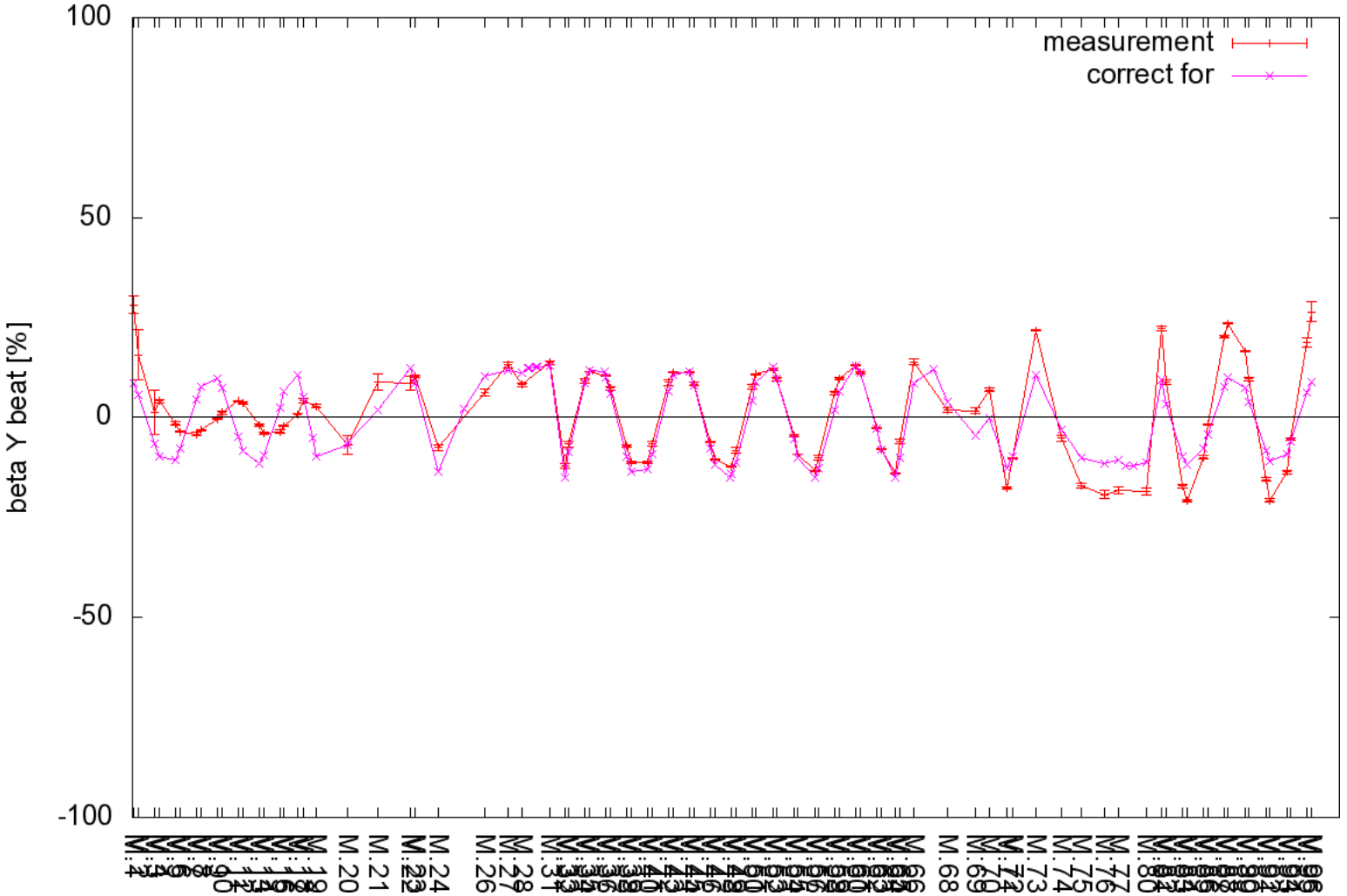
Simulation parameters with 1 mismatched quadrupole and correction

- KLQF1R_1 set to nominal $+0.1$m.
- Apply correction computed previously.
- Tracking for 1056 turns with MADX PTC.
- Injection at $x = 50\mu$m, $y = 50\mu$m and $z = 0.04$m to get about same tunes amplitudes as experimentally.

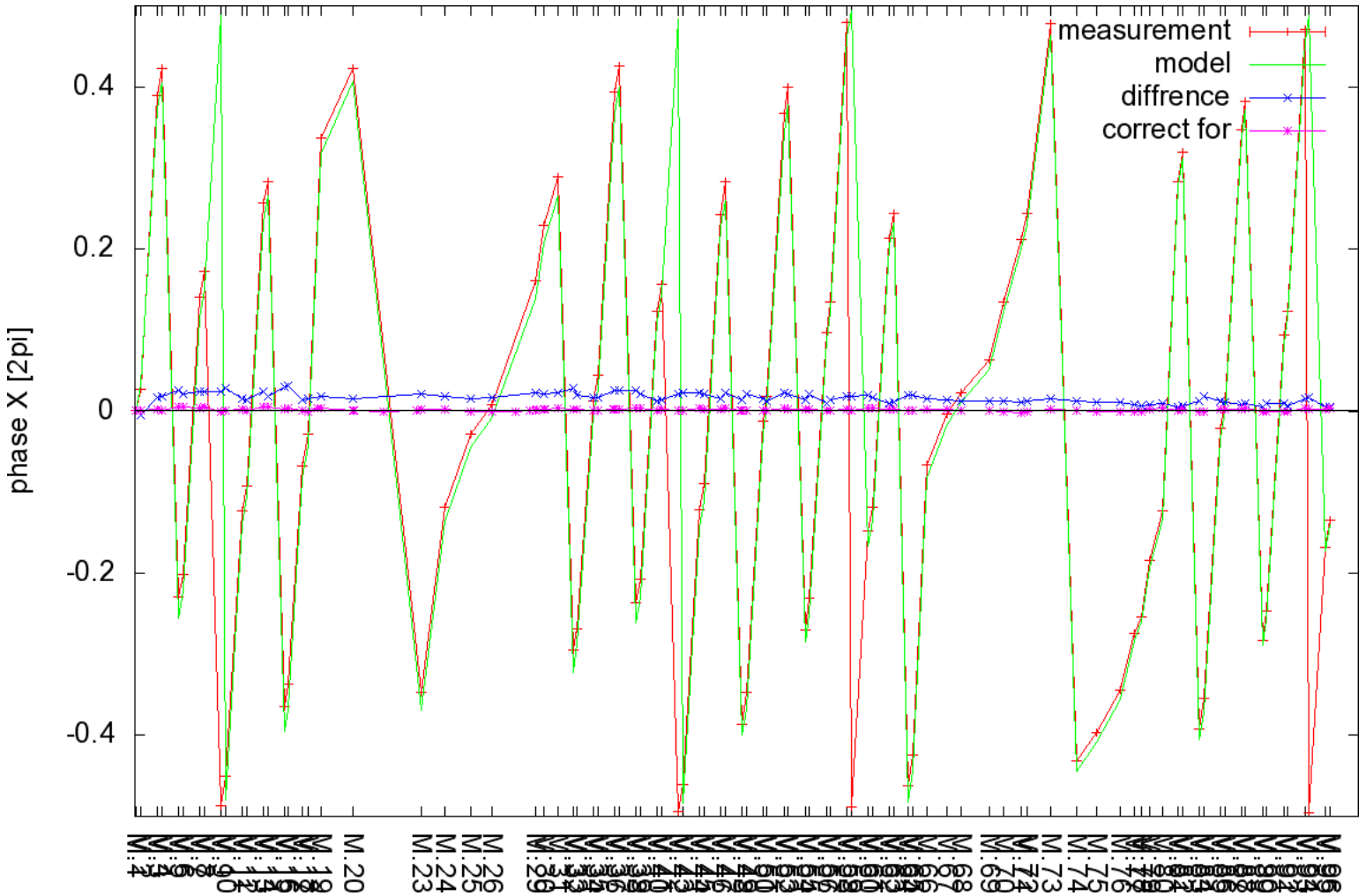
β_x beating measurement



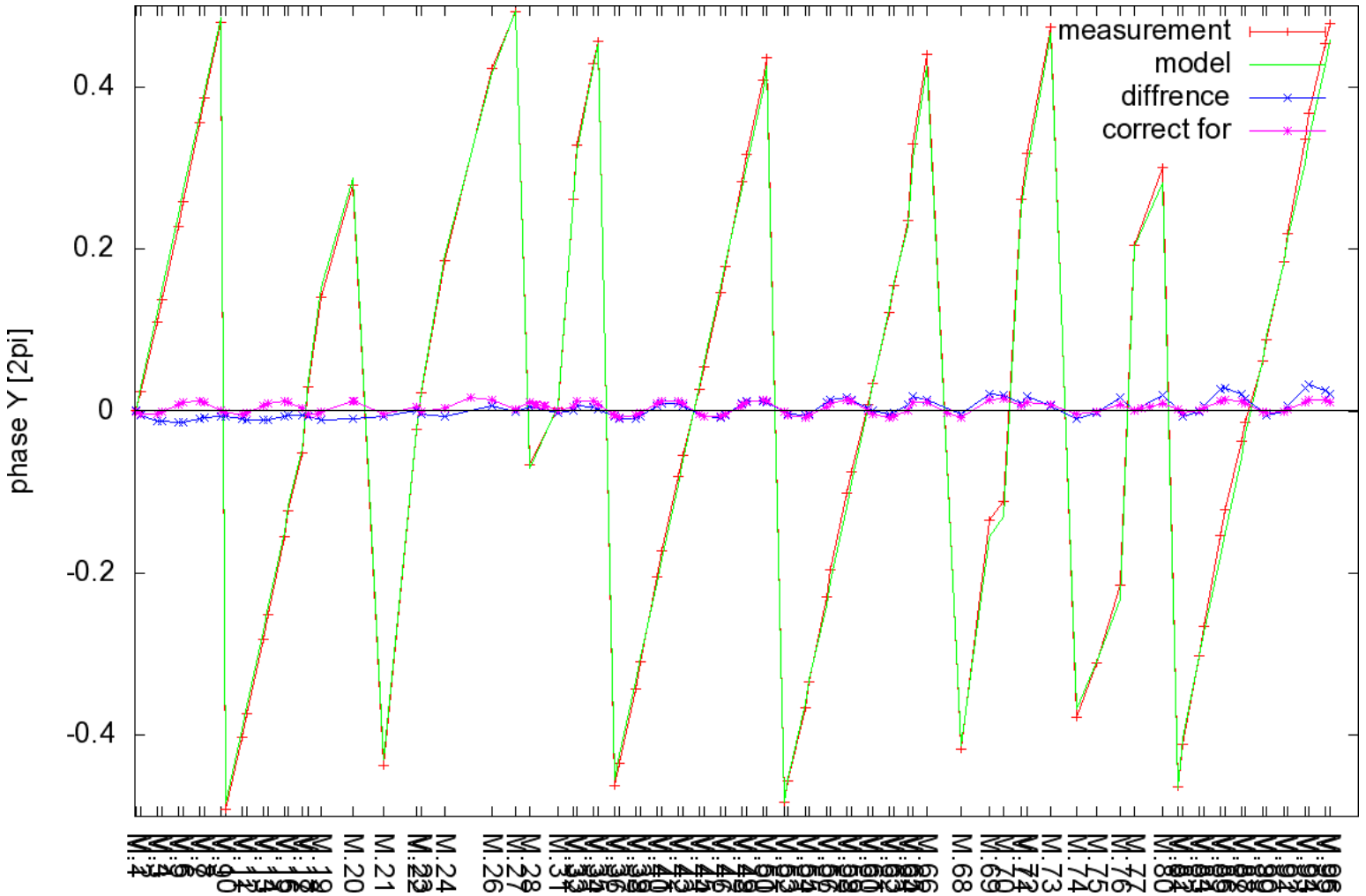
β_y beating measurement



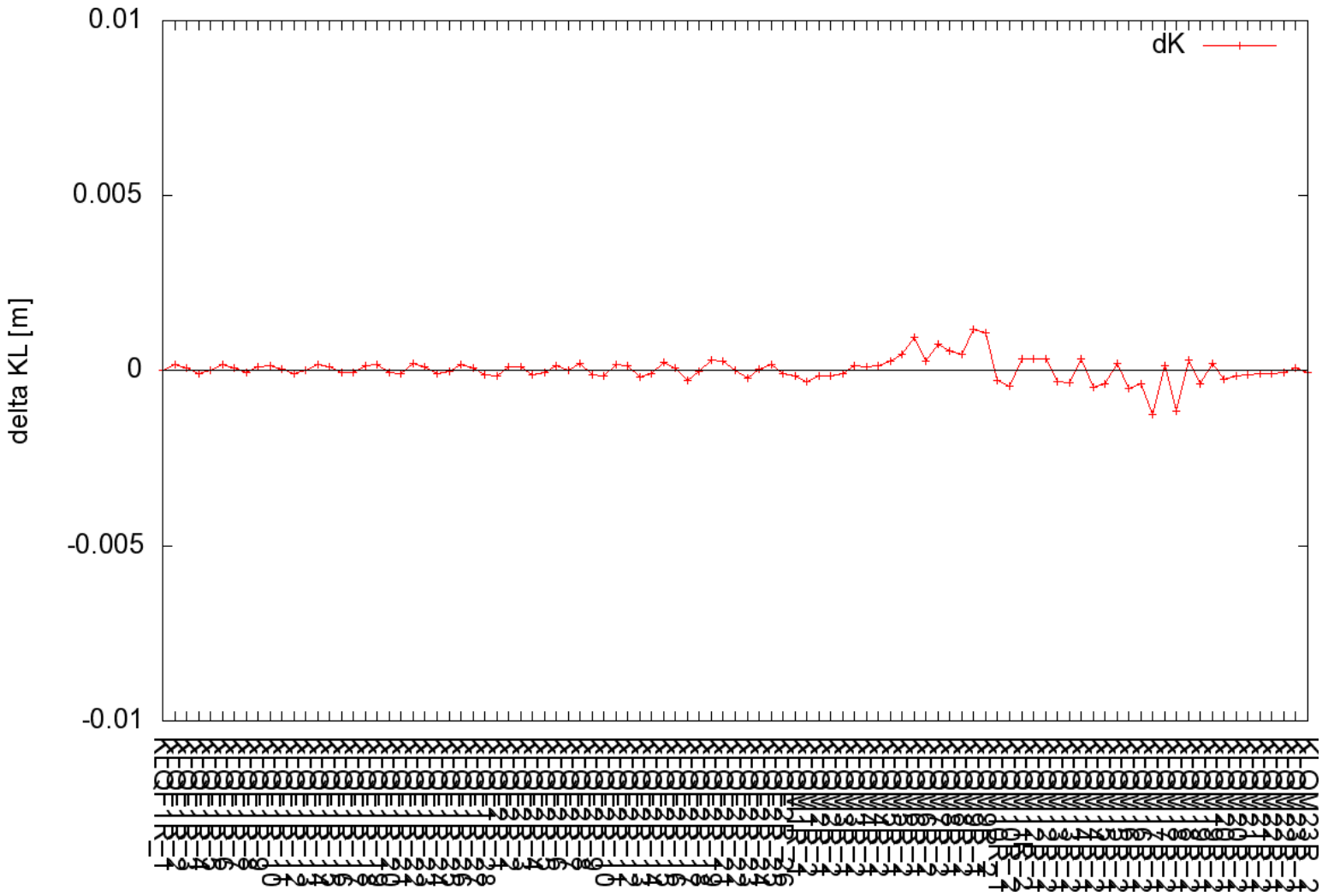
ϕ_x measurement



ϕ_y measurement



Correction



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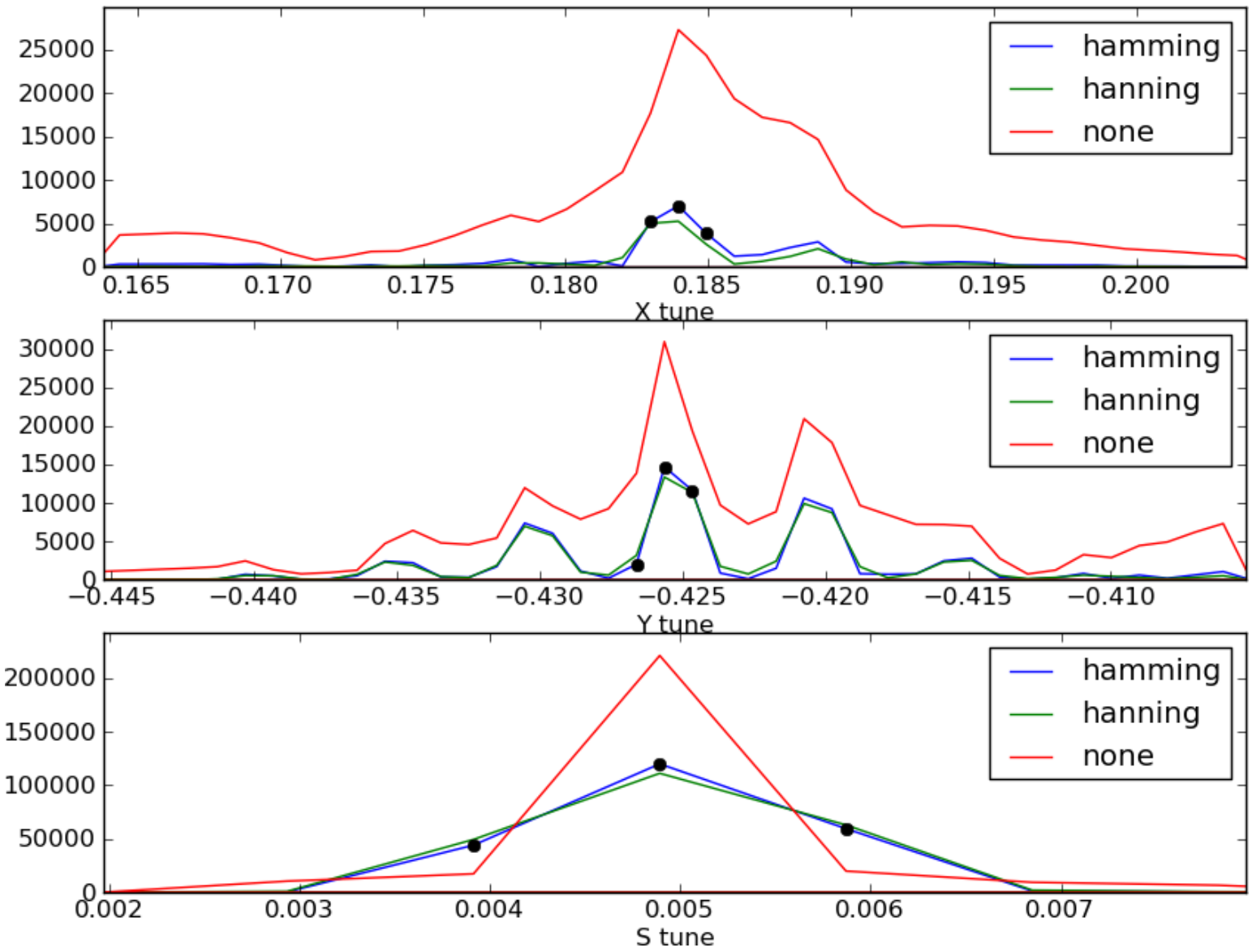
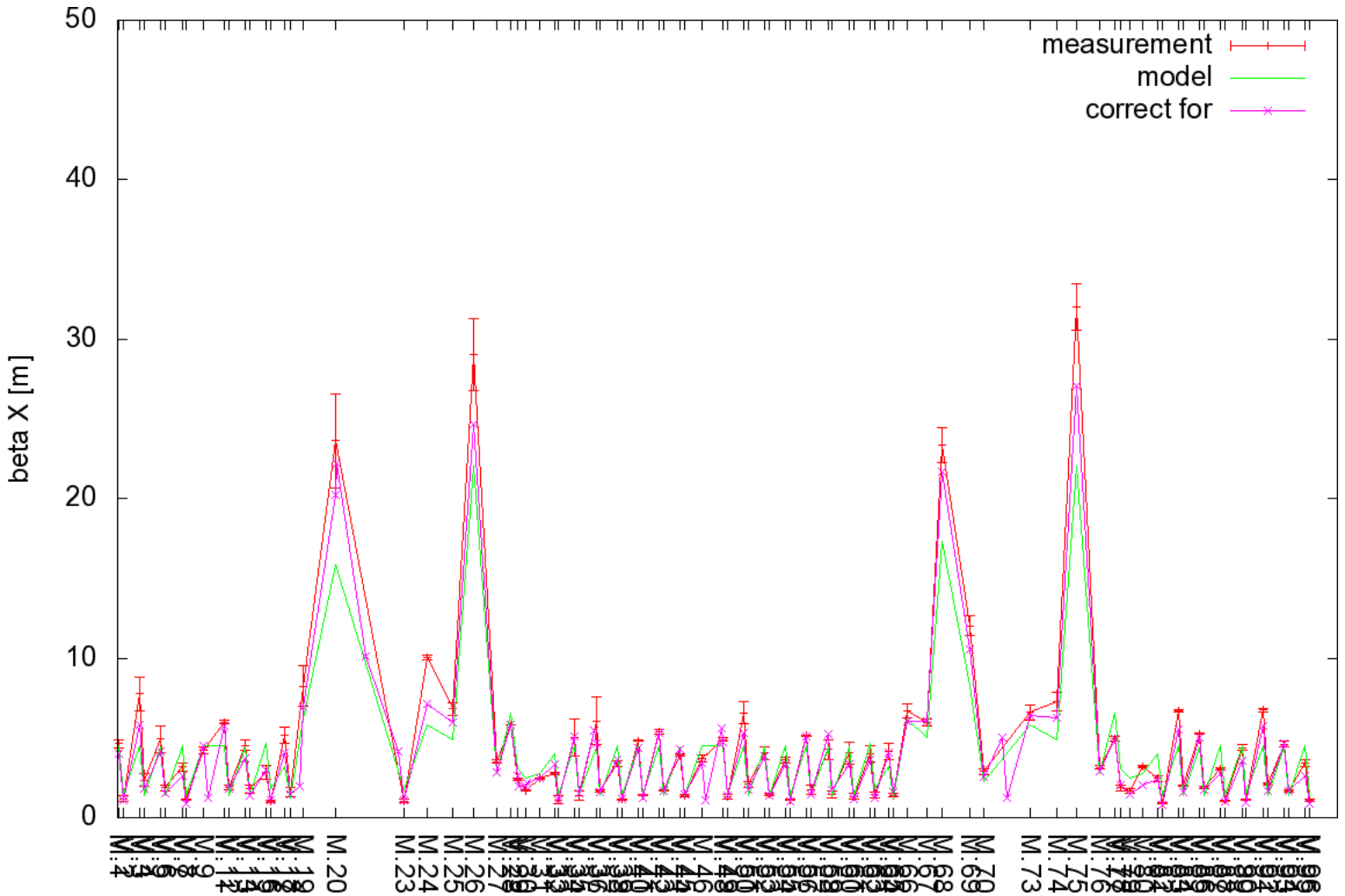
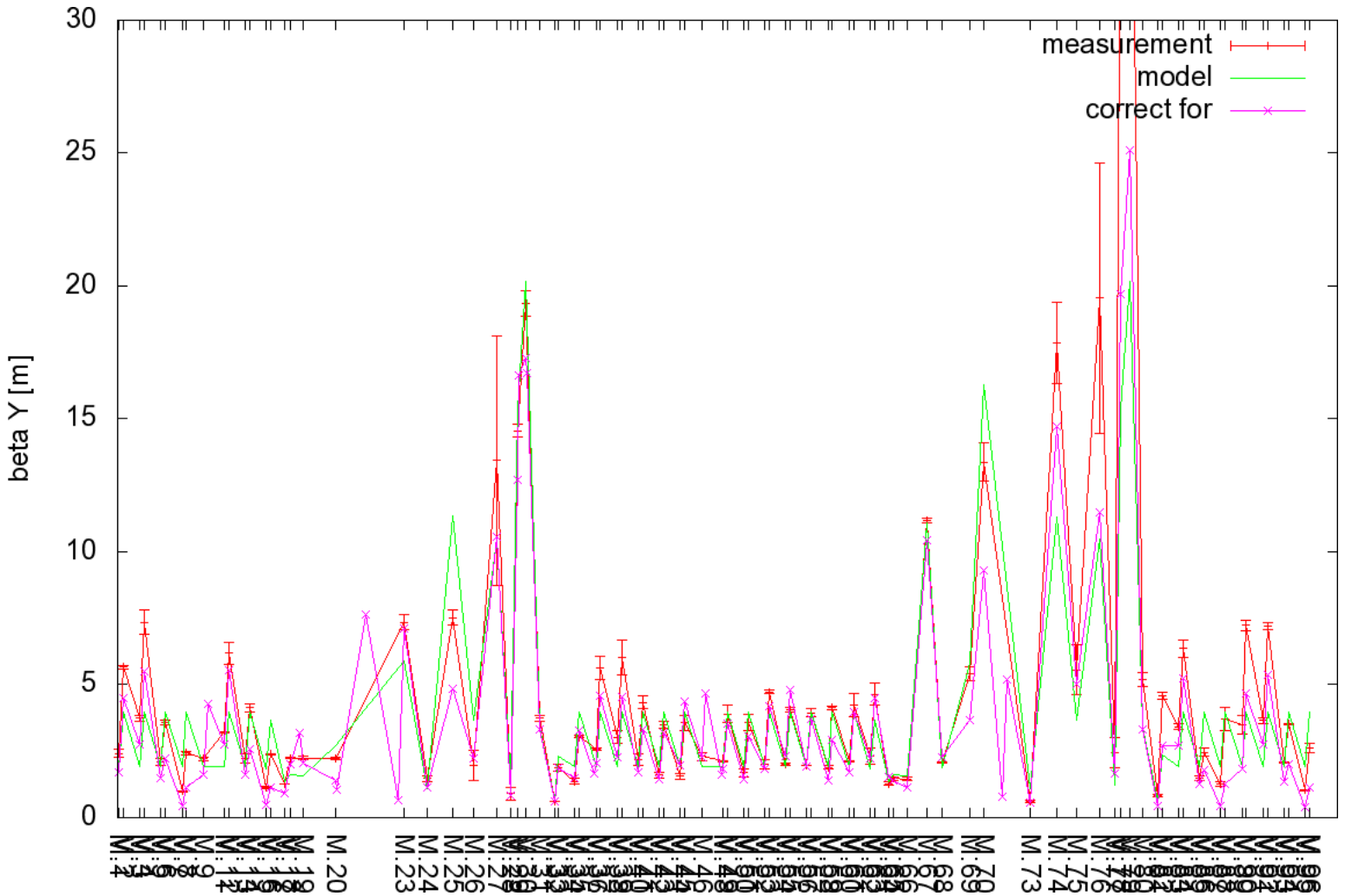
Approximative tunes with windowed FFT



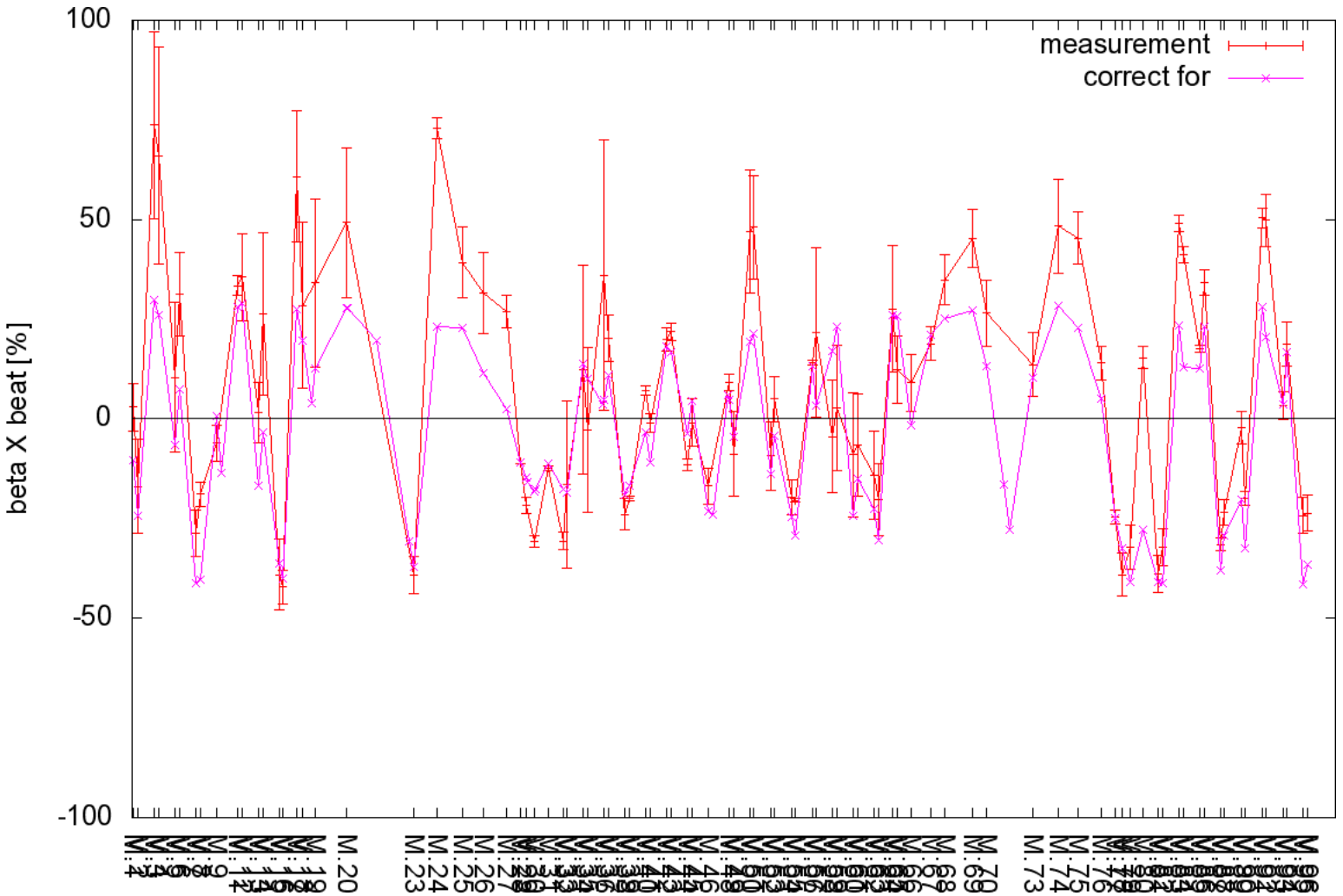
β_x function measurement



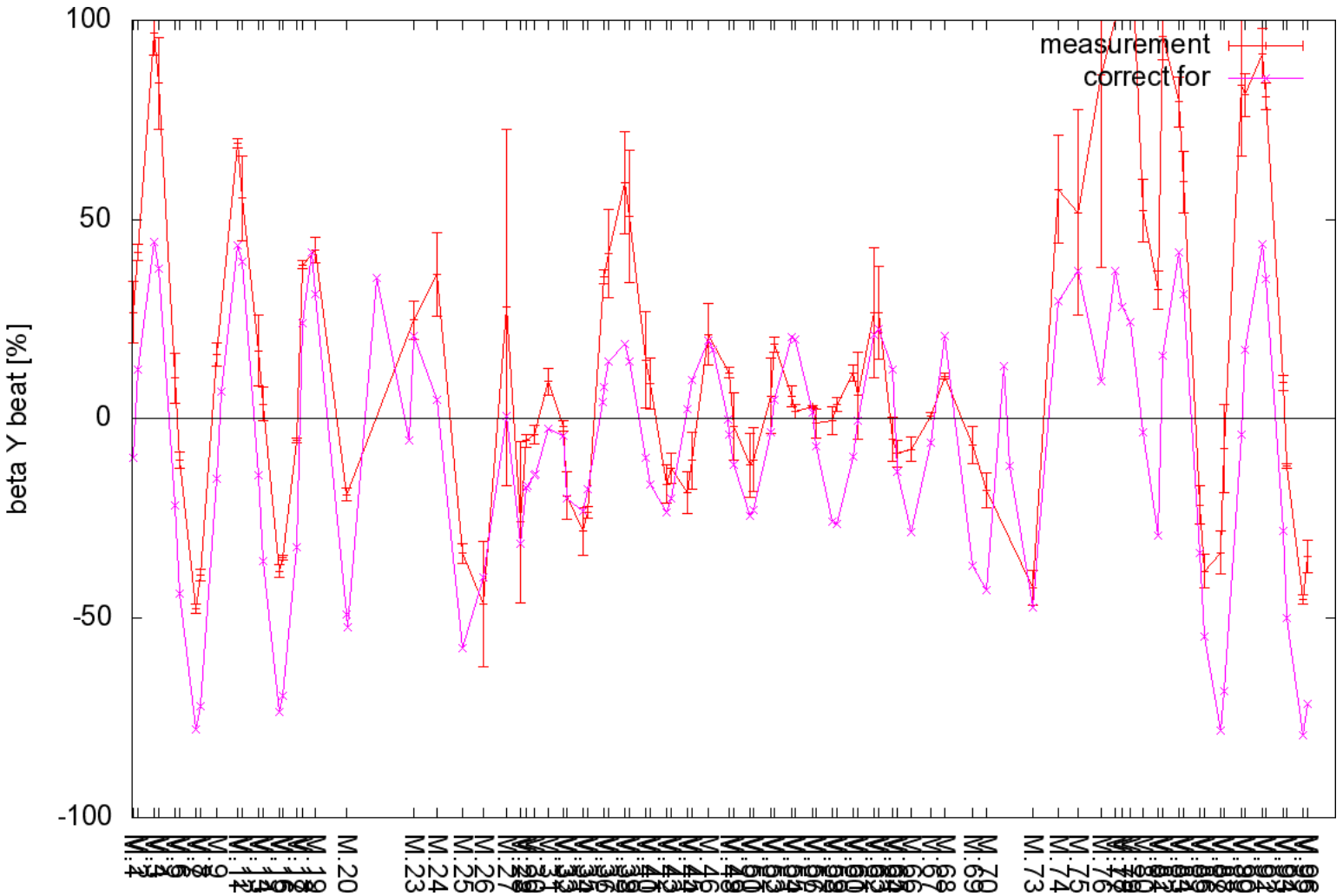
β_y function measurement



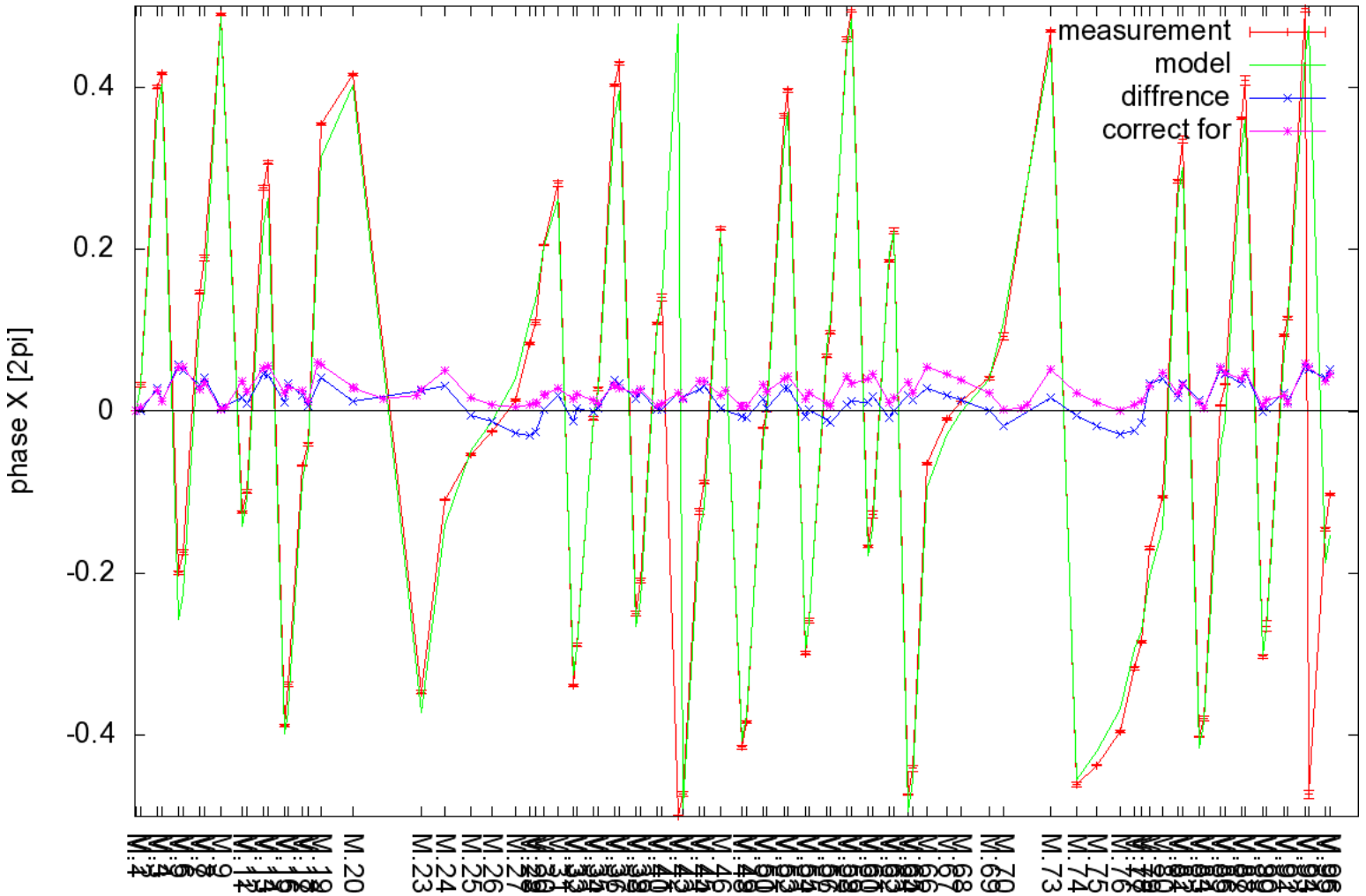
β_x beating measurement



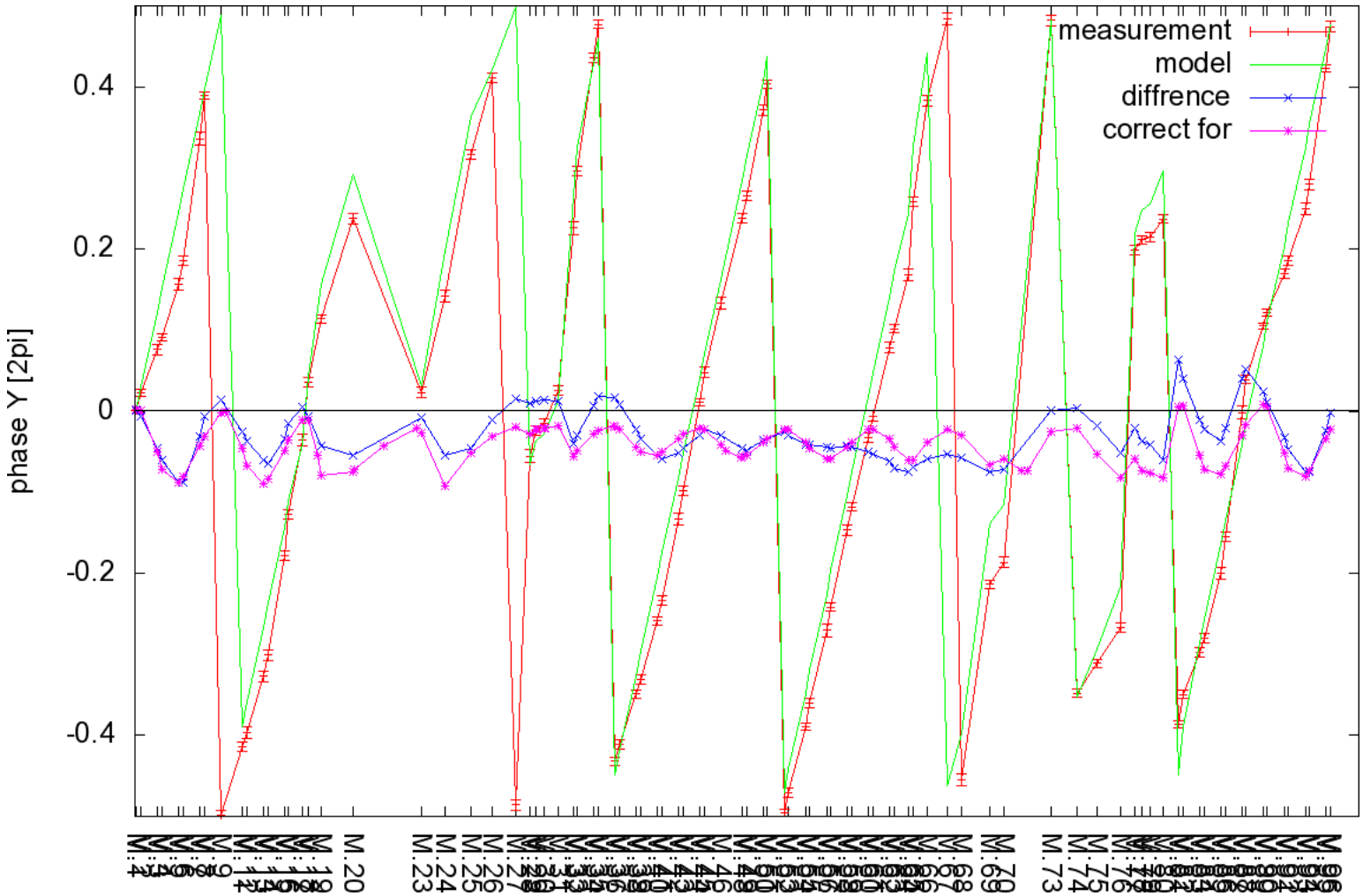
β_y beating measurement



ϕ_x measurement



ϕ_y measurement



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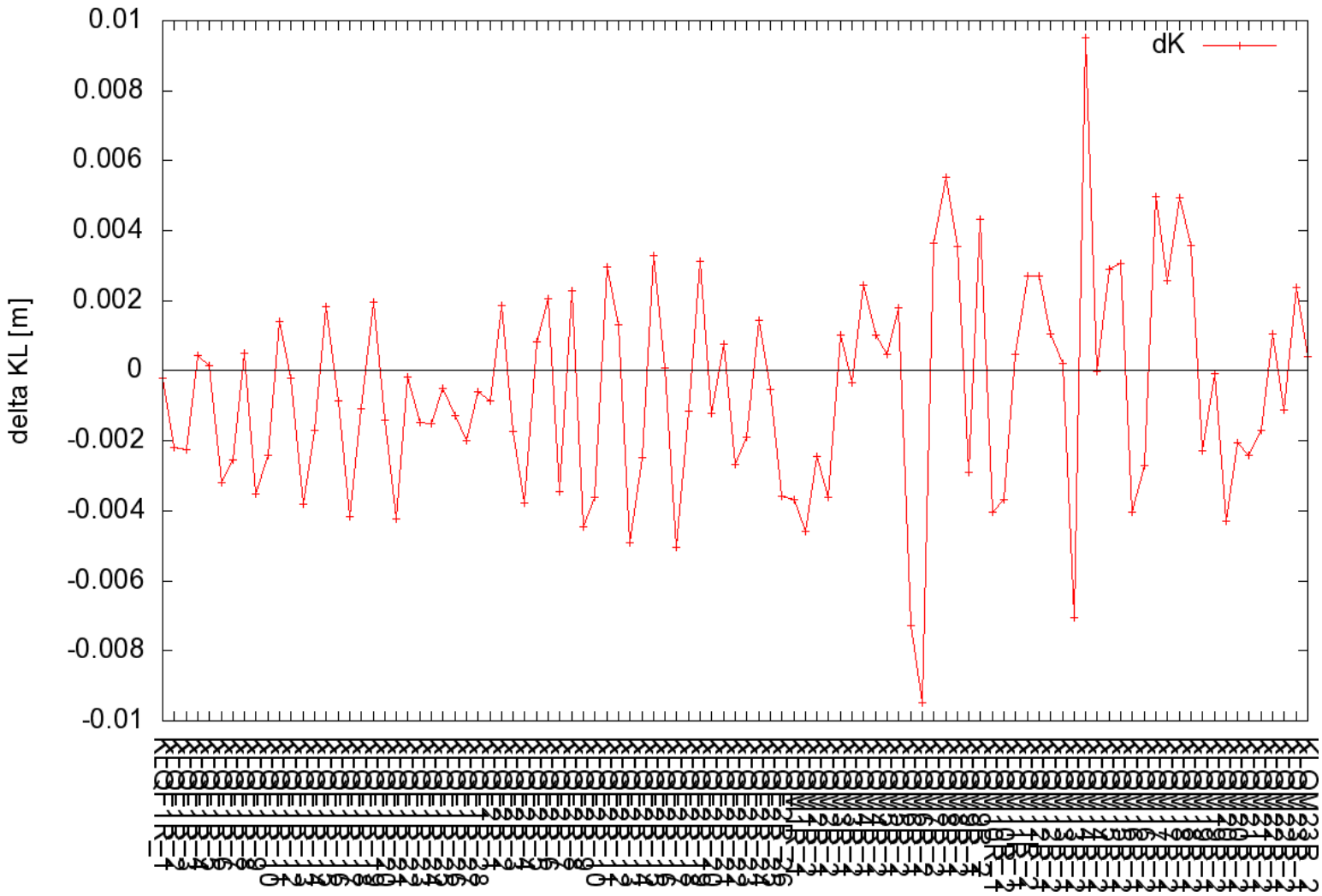


Headlines

Basics

Combining BPMs

- Classical analysis : Fourier transform of

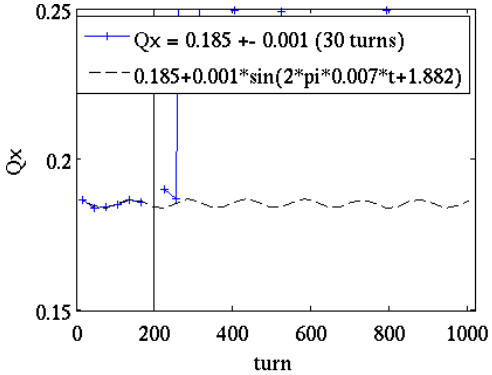
$$\begin{pmatrix} X_{BPM1}(turn\ 1) \\ \vdots \\ X_{BPM1}(turn\ 100) \end{pmatrix}$$

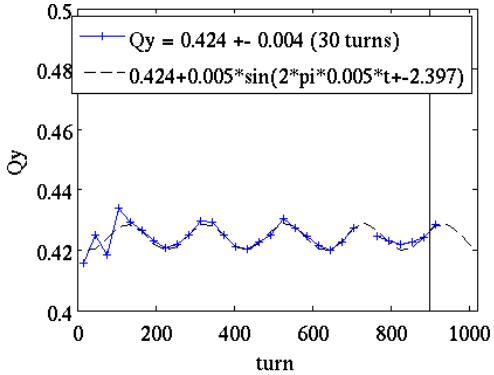
- Combining BPMs : the Fourier transform of

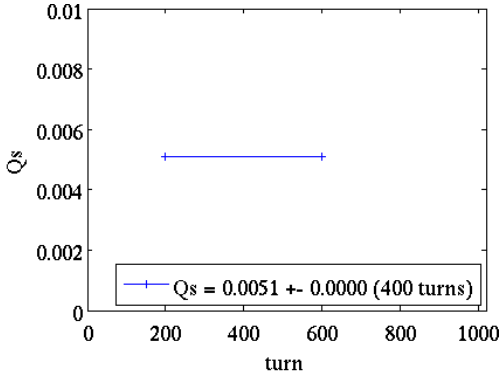
$$\begin{pmatrix} X_{BPM1}(turn\ 1) \\ \vdots \\ X_{BPM100}(turn\ 1) \end{pmatrix}$$

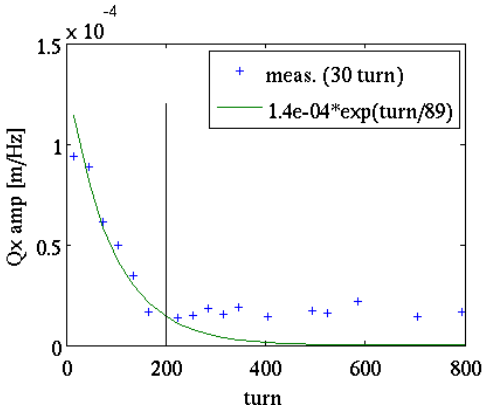
- f must be multiplied by the number of BPMs
- Tune measured in few turns with 96 BPMs !

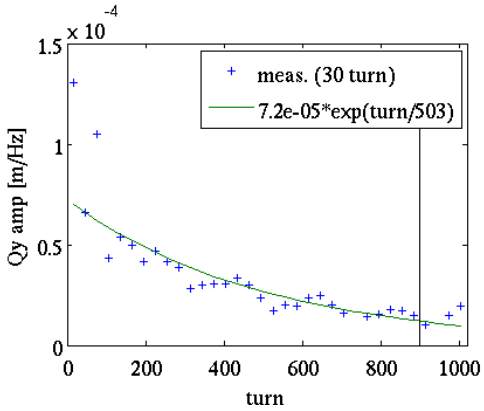
Tunes Evolution

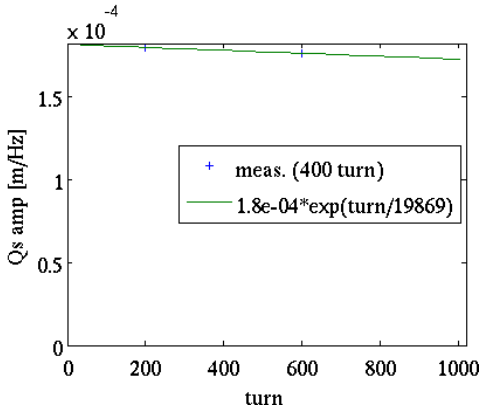












100 turns $\simeq$ 50ns

Headlines

Introduction

Analysis with Sussix and GetLLM

Example with simulated perfect lattice

Example with 1 mismatched quadrupole

Simulation results with computed correction

Measurement

Analysis combining BPMs

Conclusion and prospects

Conclusion & prospects

Conclusion

- Turn by turn data from ATF analyzed.
- Twiss functions measurements demonstrated.
- Correction of Twiss functions looks good.
- Tune measurement in about 30 turns possible.
- It shows evidence of chromaticity.

Prospects

- Convert from MADX strengths to magnet intensity.
- Apply correction at ATF.
- Make chromatic measurements.
- Finalize coupling correction.
- Use wiggling of tunes and/or sidebands for 1 shot chromaticity measurements.