Turn-by-turn measurement at the ATF damping ring

Y. Renier ,Y. Papaphilippou, R. Garcia

ECFA LC2013
28 of May 2013

Headlines

Introduction

Analysis with Sussix and GetLLM

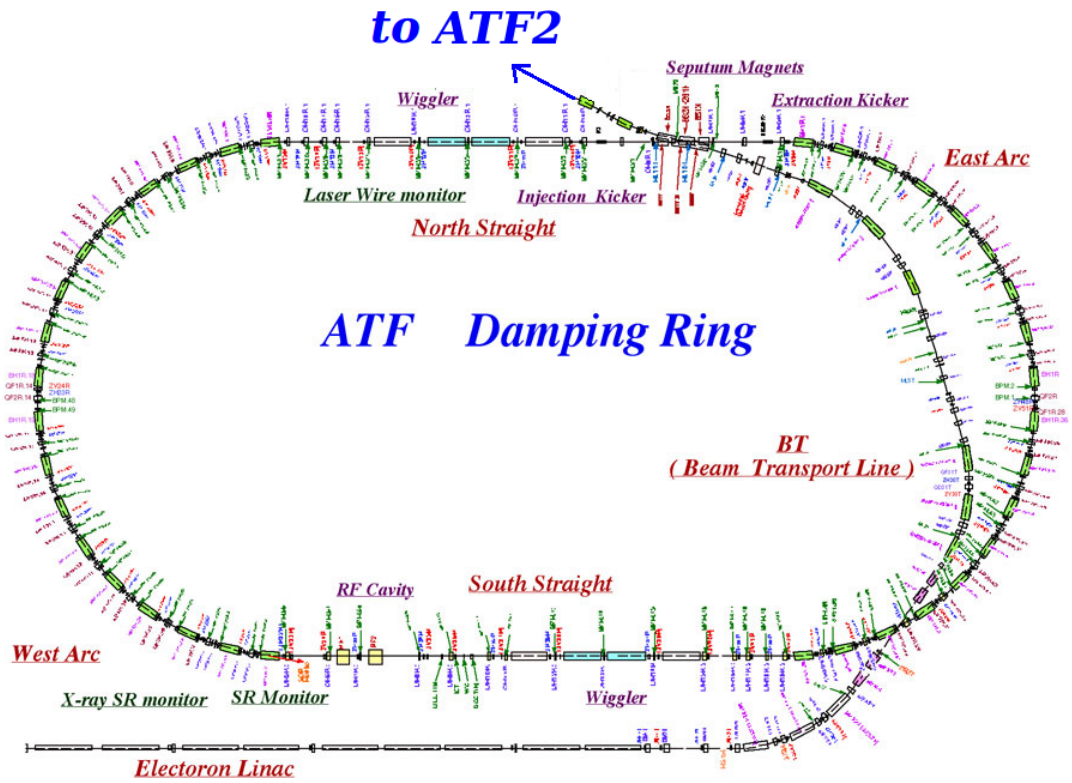
Measurement

Analysis combining BPMs with NAFF

Conclusion and prospects

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

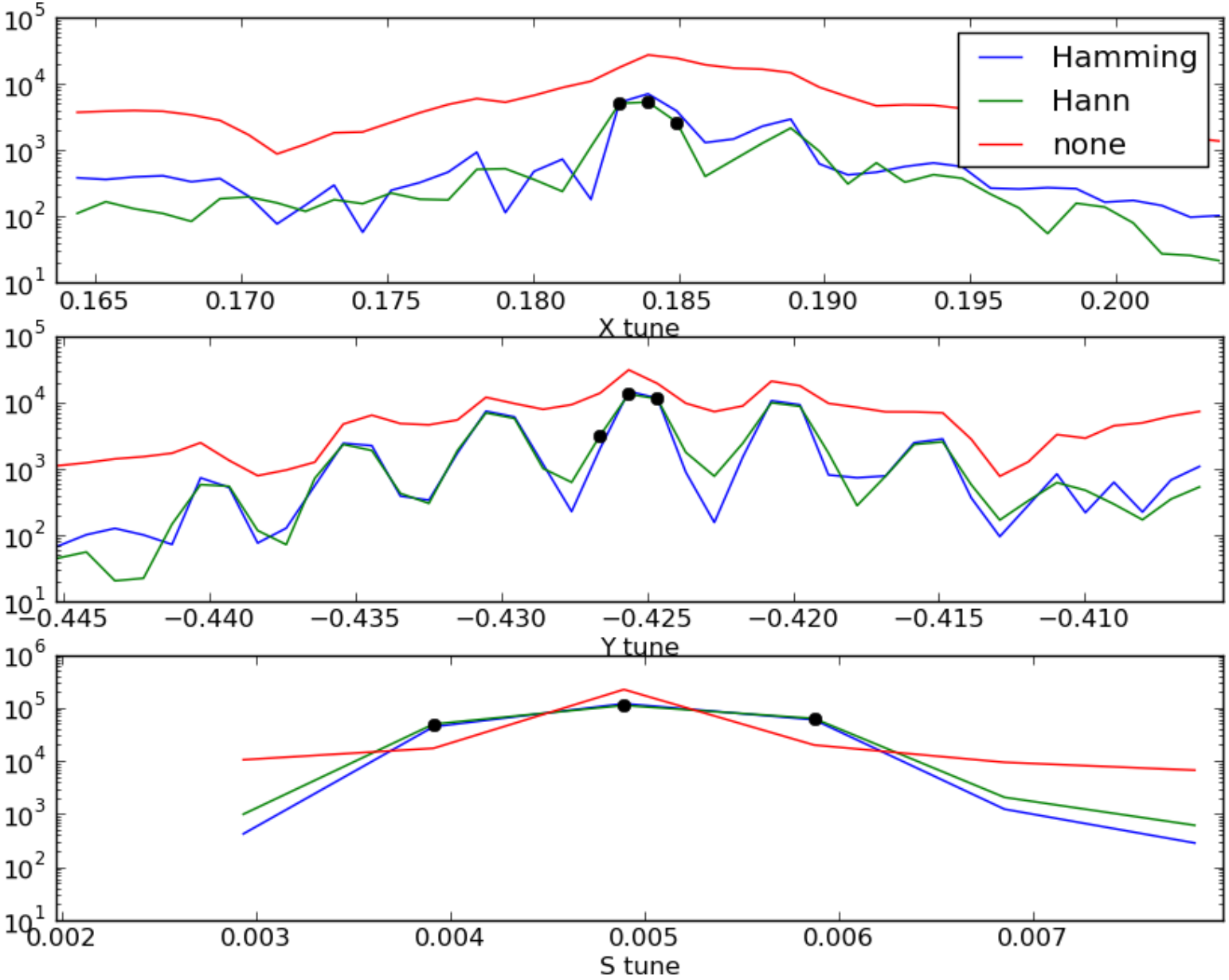
Analysis

Analyzing each BPM individually

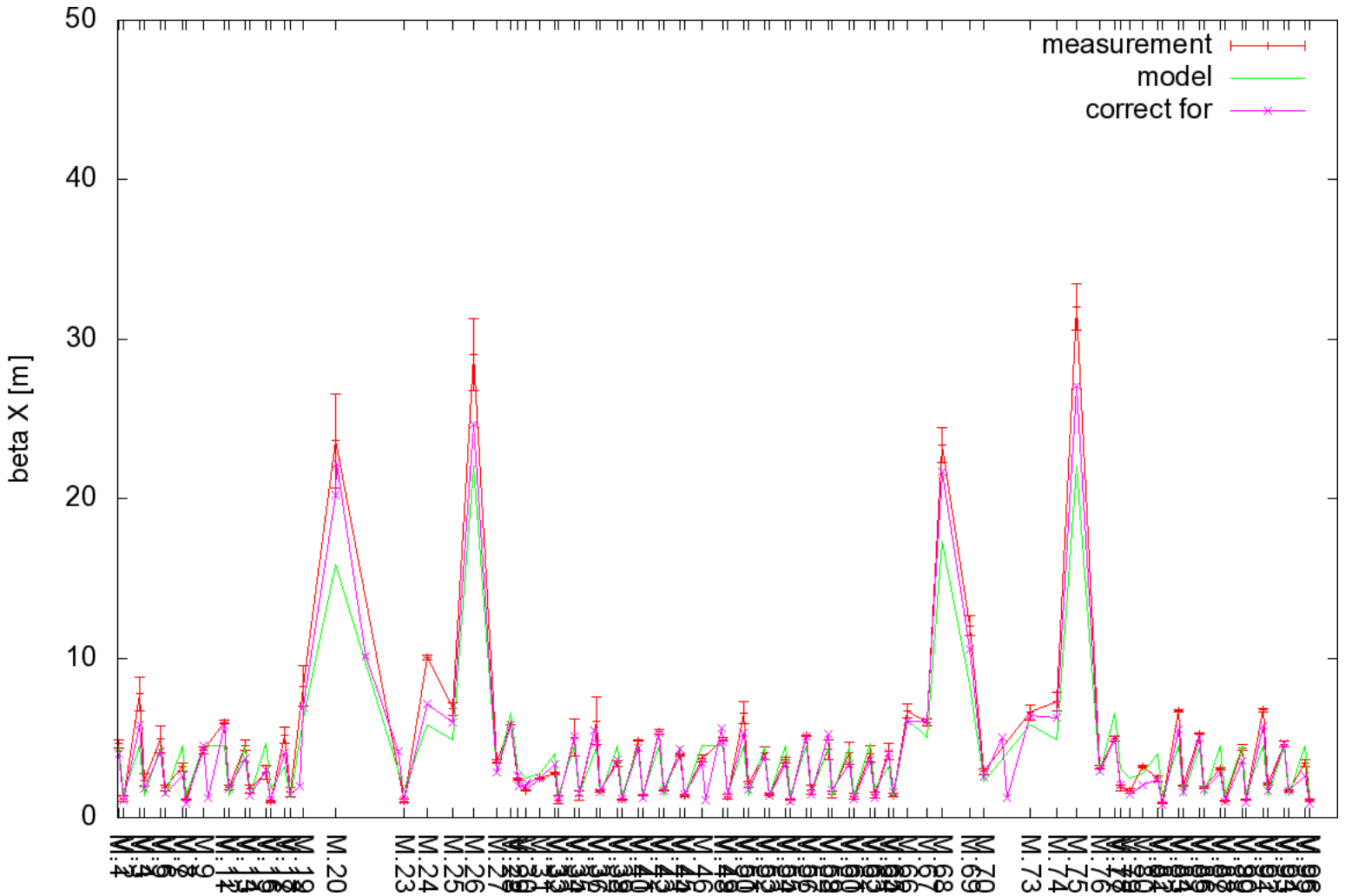
- Tunes measurement with FFT (windows to reduce noise influence)
- with sussix or NAFF, measure resonances (amplitude and phase) for:
  - in horizontal plane: $(1,0)_h$, $(0,1)_h$, $(2,0)_h$ and $(3,0)_h$
  - in vertical plane: $(0,1)_v$, $(1,0)_v$, $(1,1)_v$
- From resonance measurements, with getLLM 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

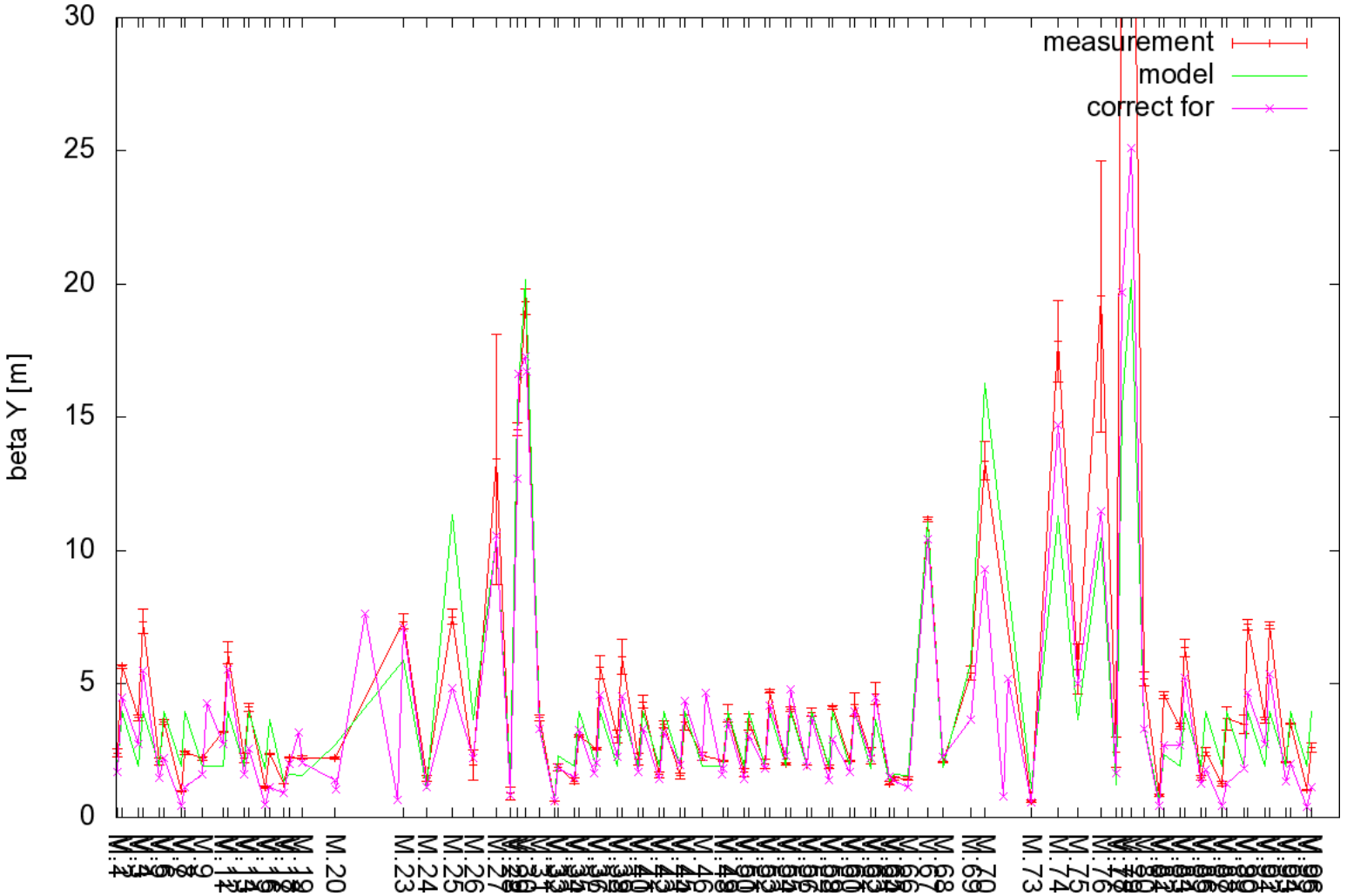
Approximative tunes with windowed FFT



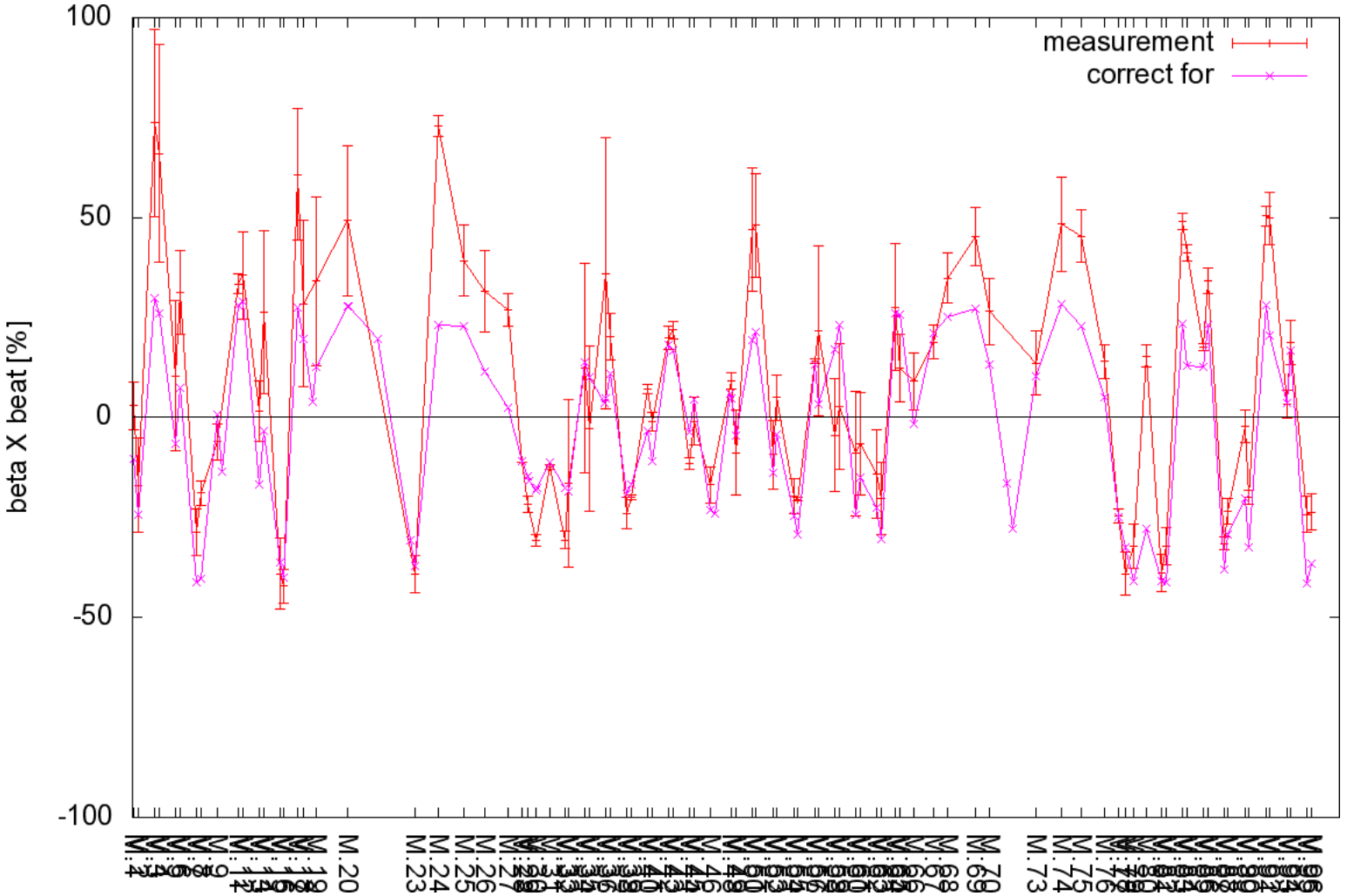
β_x function measurement



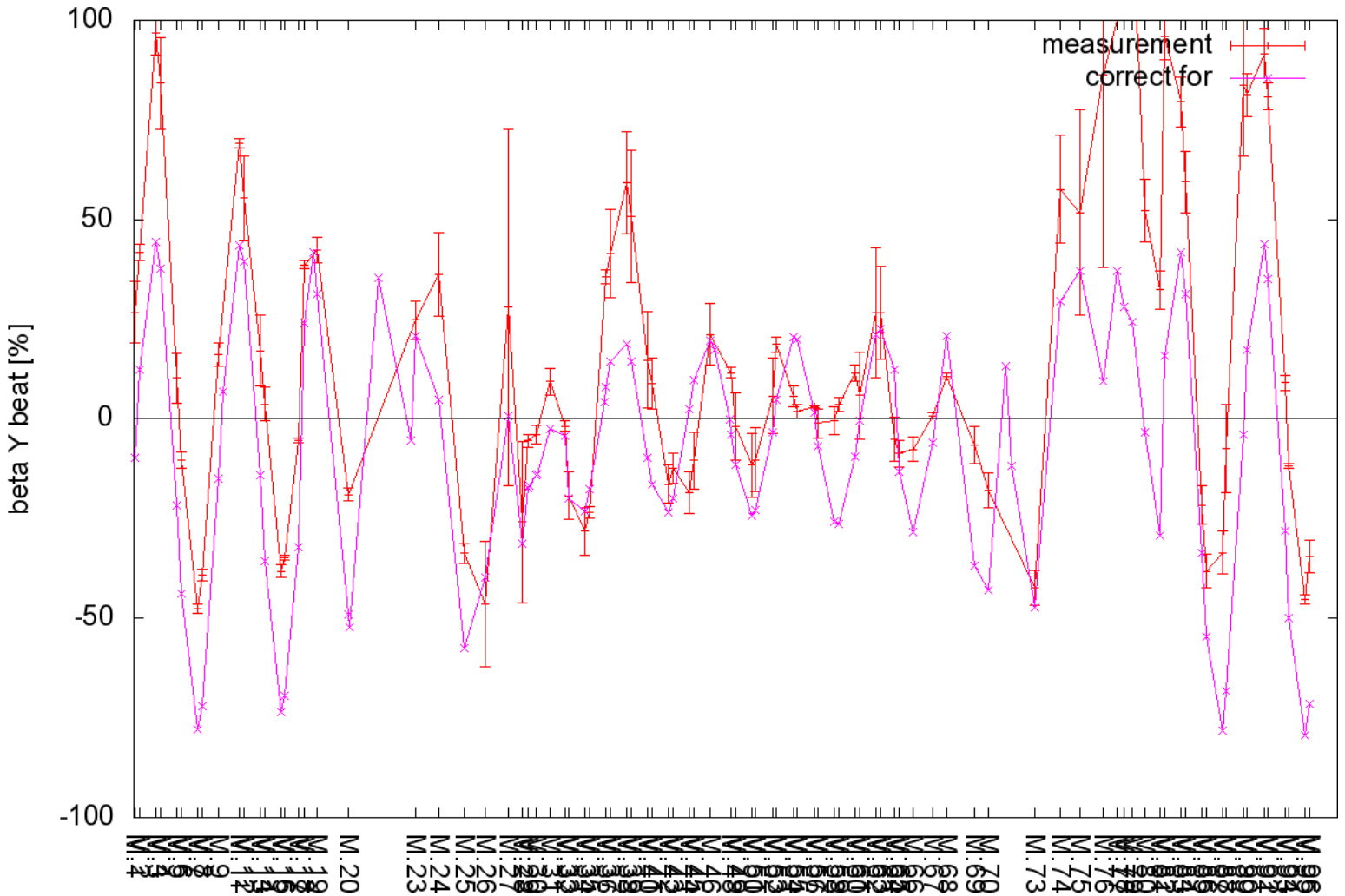
β_y function measurement



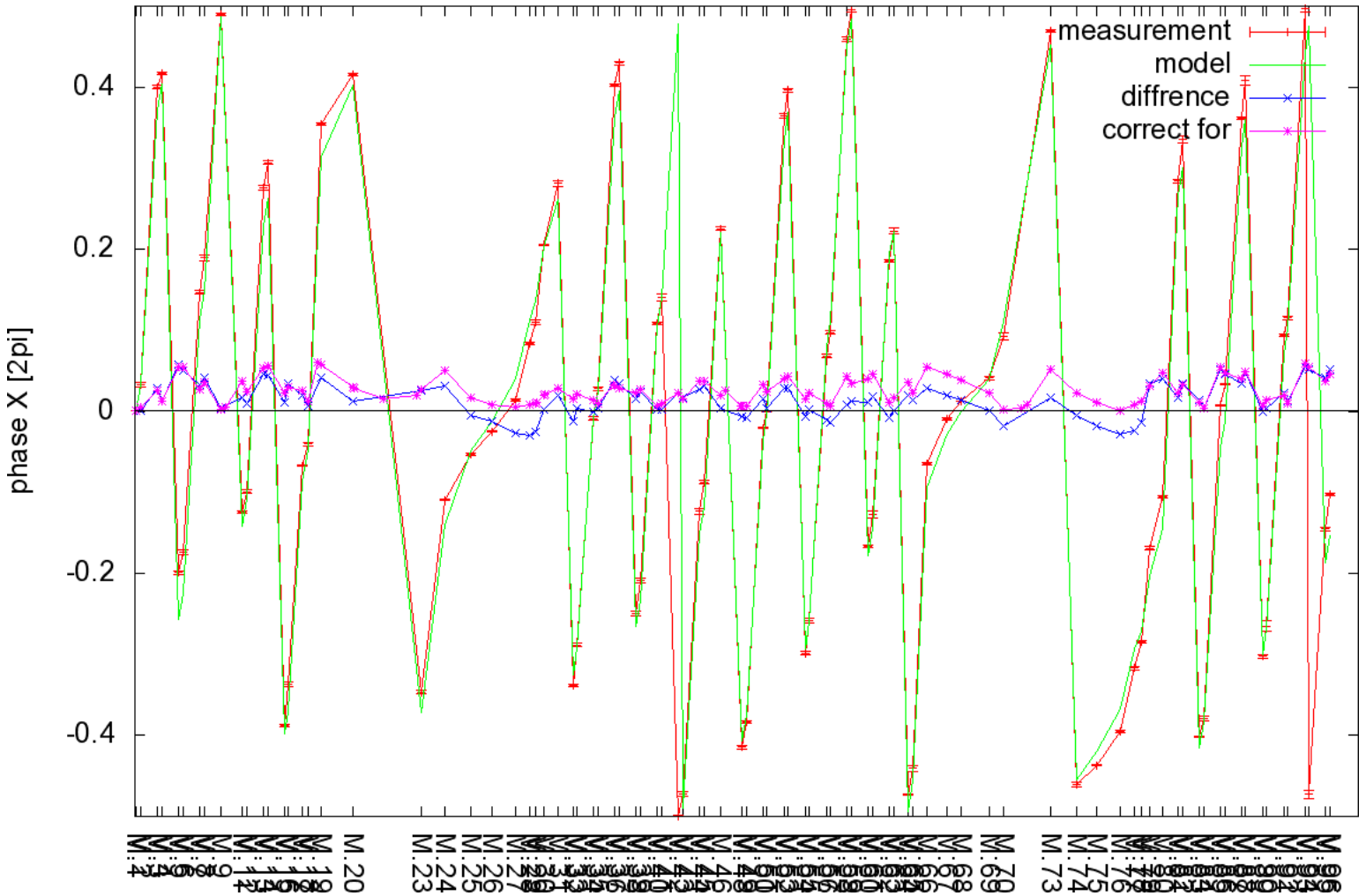
β_x beating measurement



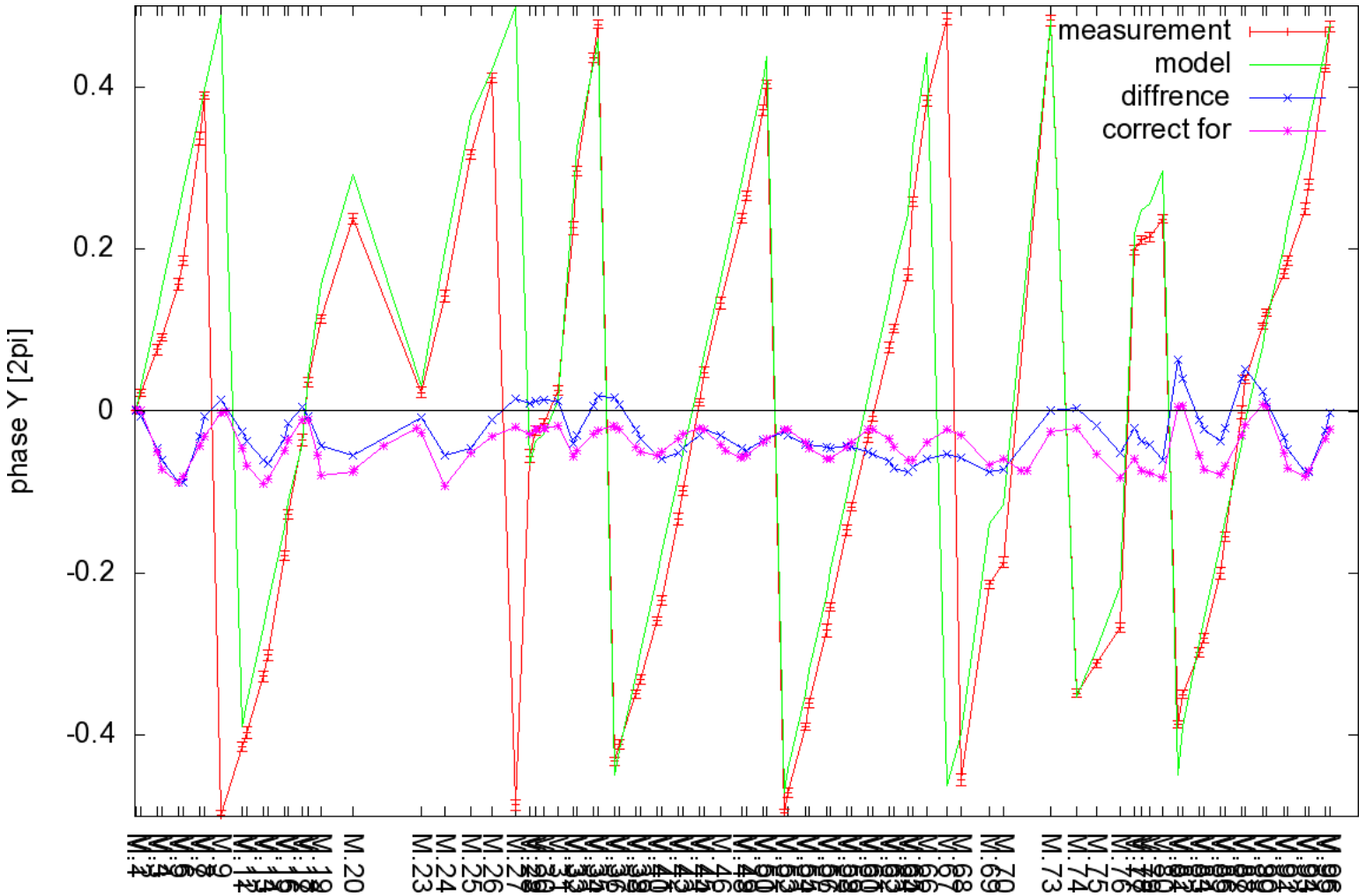
β_y beating measurement



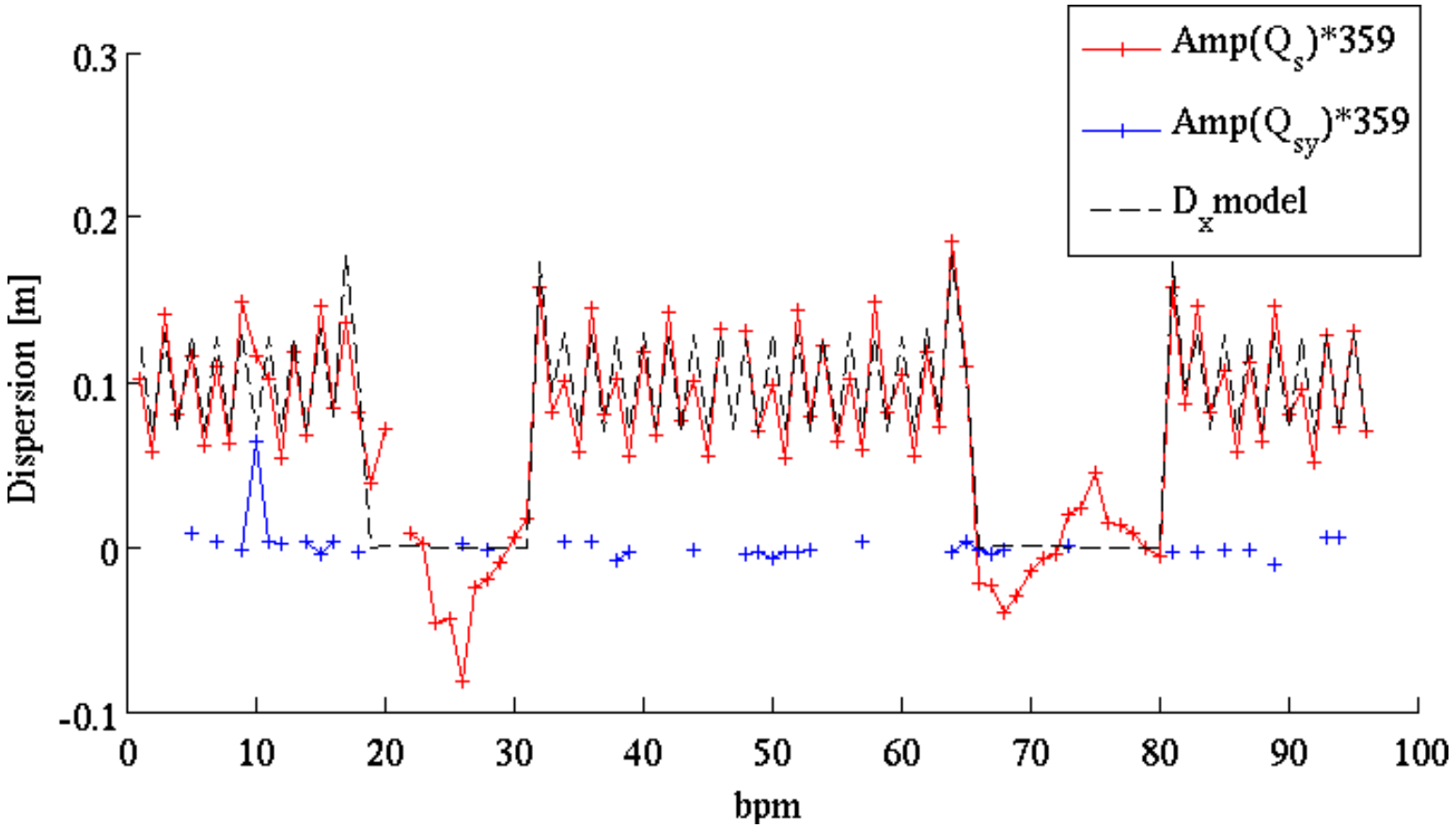
ϕ_x measurement



ϕ_y measurement

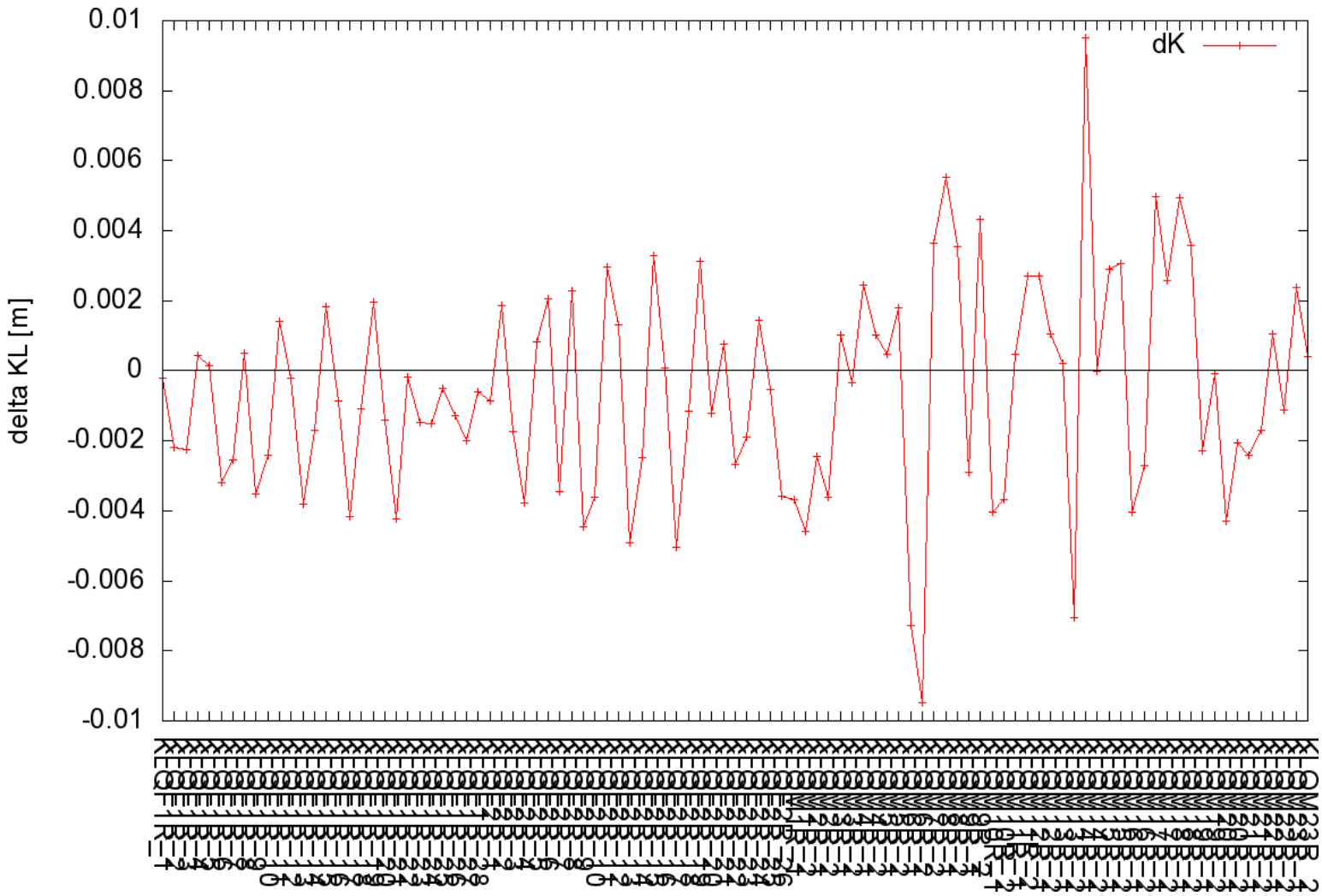


D_x measurement (done with NAFF)



$$2A_{Q_s} = D_x \frac{\Delta E}{E} \tag{1}$$

Correction



Headlines

Basics

Combining BPMs

- Classical analysis : Fourier transform of

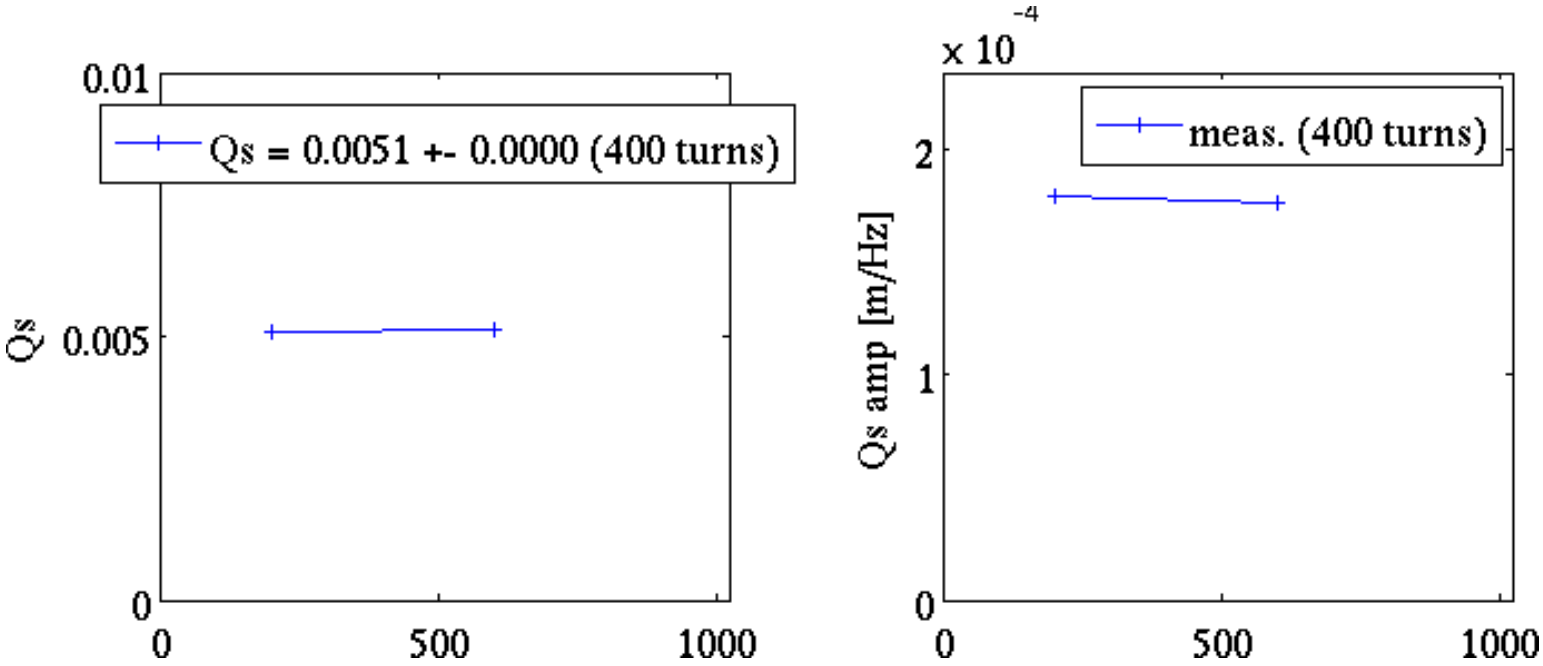
$$\begin{pmatrix} X_{BPM1}(turn\ 1) \\ \vdots \\ X_{BPM1}(turn\ 100) \end{pmatrix}$$

- 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 !

Synchrotron Tunes Evolution

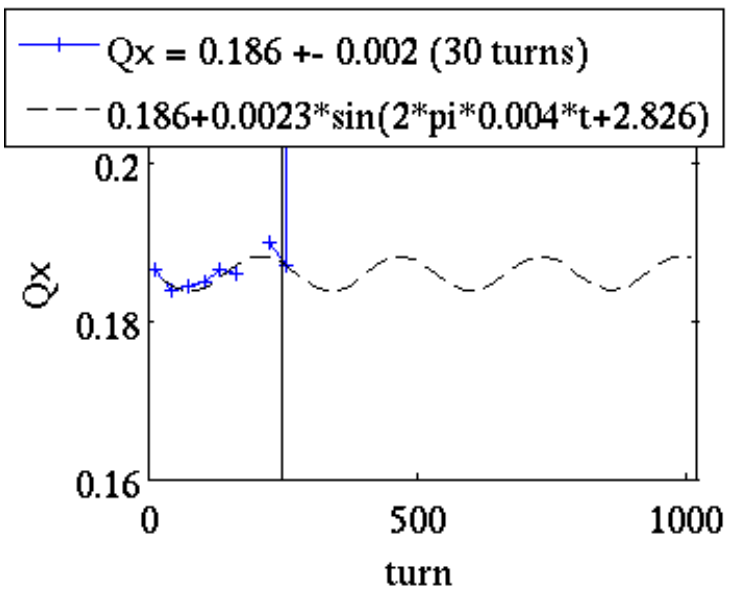


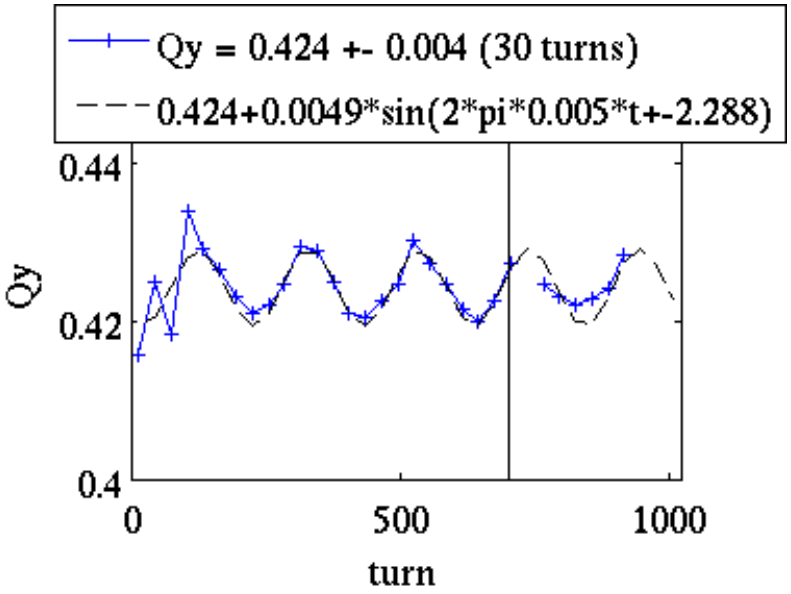
100 turns $\simeq$ 50ns

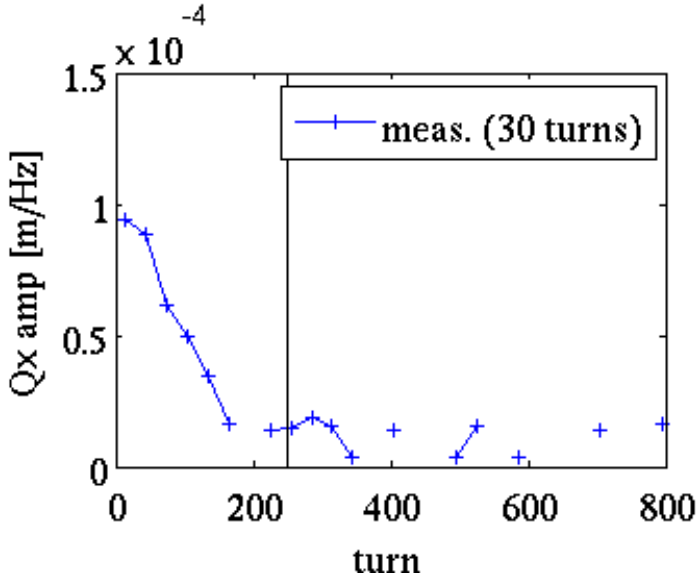
Remarks

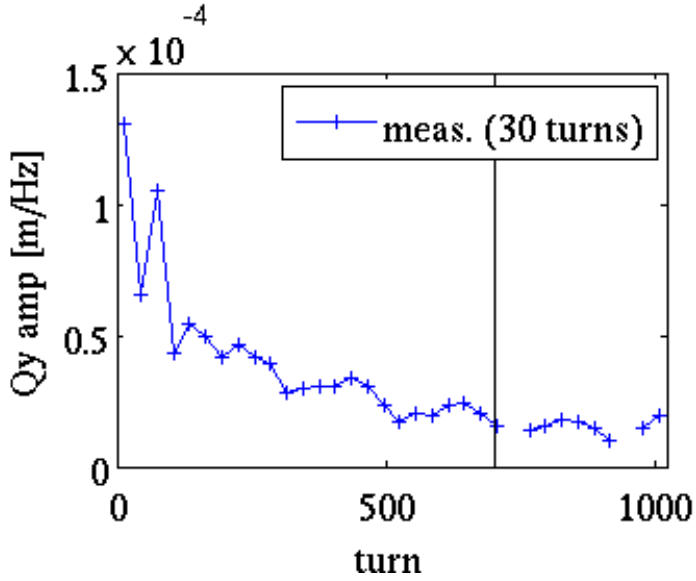
- Q_s has a low fractional tune (0.0051), at least 400 turns needed.
- Amplitude of the peak decrease slowly (Energy oscillations considered constant).

Tunes Evolution









100 turns $\simeq$ 50ns

Chromaticity Measurement

On the tune evolution measurement we get ΔQ_x and ΔQ_y as the factor in front of the sinus.
The definition of the chromaticity is :

$$\begin{aligned} Q'_x &= \frac{\Delta Q_x}{\frac{\Delta E}{E}} \\ Q'_y &= \frac{\Delta Q_y}{\frac{\Delta E}{E}} \end{aligned} \tag{2}$$

We measured :

$$\frac{\Delta E}{E} = 2 * \frac{A_{Qs}}{D_x} \tag{3}$$

So we got :

$$\begin{aligned} Q'_x &= \frac{\Delta Q_x}{2 * \frac{A_{Qs}}{D_x}} = 0.41 \\ Q'_y &= \frac{\Delta Q_y}{2 * \frac{A_{Qs}}{D_x}} 0.88 \end{aligned} \tag{4}$$

Headlines

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.
- Chromaticity measured from energy oscillation.

Prospects

- Try correction experimentally at ATF.
- Check chromatic measurements.
- Finalize coupling correction.