Fermilab

http://www.fnal.gov

Analysis of June 2010 ATF TBT data

Eliana GIANFELICE

eliana@fnal.gov

TBT data at the jth BPM following a single kick in the z plane ($z \equiv x, y$)

$$z_n^{(j)} = \frac{1}{2}\sqrt{\beta_z^{(j)}} A_z e^{i(\mu_z + 2\pi Q_z n)} + c.c.$$

with $\quad n \equiv$ turn number $\quad A_z = |A_z|e^{i\delta_z} \equiv$ constant of motion

Twiss functions at BPM location:

$$\beta_z^{(j)} = |Z_j(Q_z)|^2 / |A_z|^2 \qquad \mu_z^{(j)} = \arg\left(Z_j\right) - \delta_z$$

$$Z_j(Q_z) \equiv \text{Fourier component of } z_j$$

$$|A_z| = \sqrt{\beta_z^{(k)}} \Theta_k \qquad \Theta_k \equiv \text{kick}$$

$$\delta_z = -\mu_z^{(k)} + (2m+1)\frac{\pi}{2}$$

The *actual* optics being unknown, the phase advance is known a part for an additive constant and the β function values are known a constant factor a part.

The phase advance is defined *anyway* a constant a part

$$\mu_z(s) \equiv \int_{s_0}^{s} \frac{ds'}{\beta_z(s')}$$

Amplitude fit:

$$|A_z|^2 = \frac{\sum_j 1/\beta_z^{0(j)}}{\sum_j 1/|Z_j(Q_z))|^2} \qquad \beta_z^{0(j)} \equiv \textit{unperturbed} \ \beta \text{ function at BPM } \#j$$

The amplitude computation relies on a "reference" optics. The convenience of this expression is that the beta beating does not affect the amplitude fit if $Q = Q^0$ (and the sampling is sensible).

Friday June 4 18 TBT data have been recorded at ATF with the new BPM electronics.

- 9 files refer to injection data

- 9 have been obtained by kicking in *both* planes simultaneously.

The total number of BPMs is 96. The BP.47 is still wired to the old system.

The number of turns recorded per BPM is 1024.

In the following analysis the BPMs are ordered from the first BPM after the kicker, namely BPM.71.
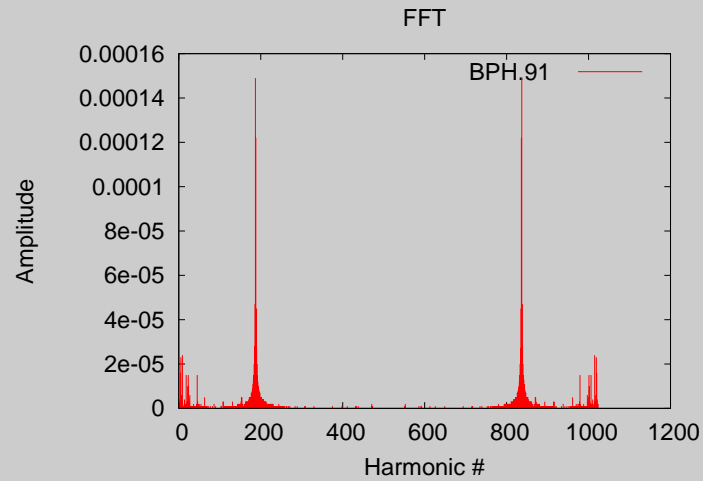
TBT_kick499775_9.txt
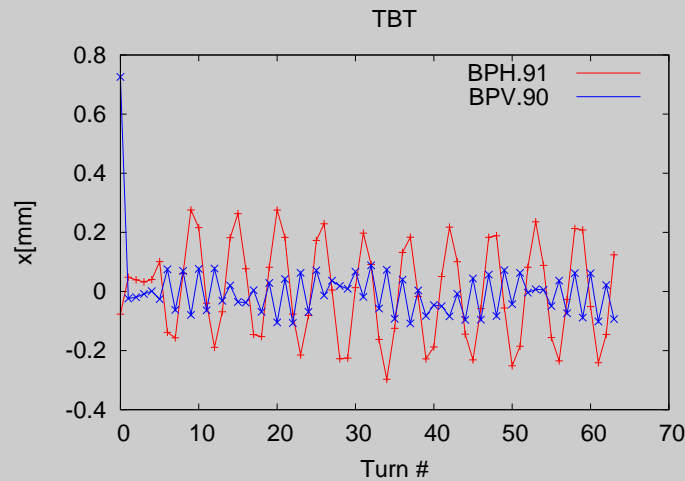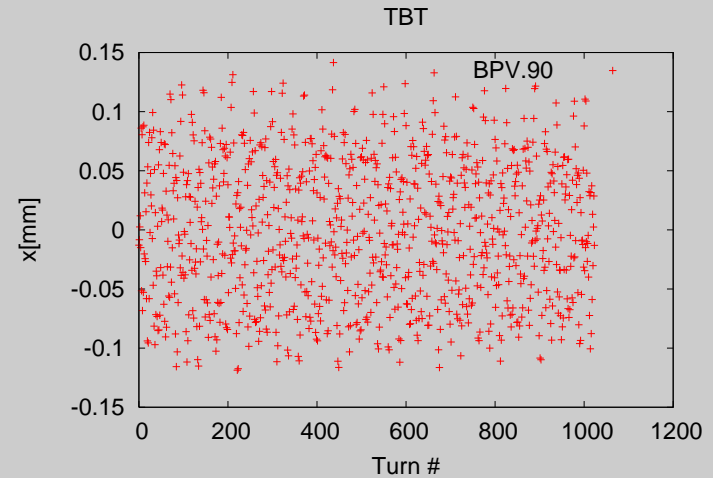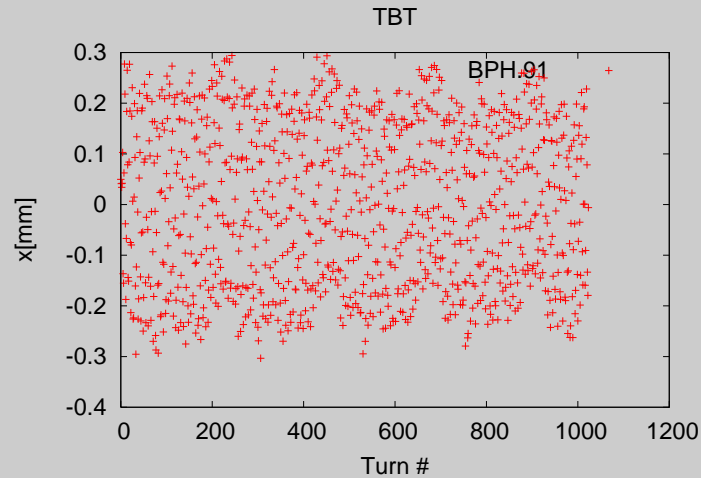
$$\beta_x^0 = 1.6 \text{ m @ BPH.91}$$
$$\beta_y^0 = 2.0 \text{ m @ BPV.90}$$

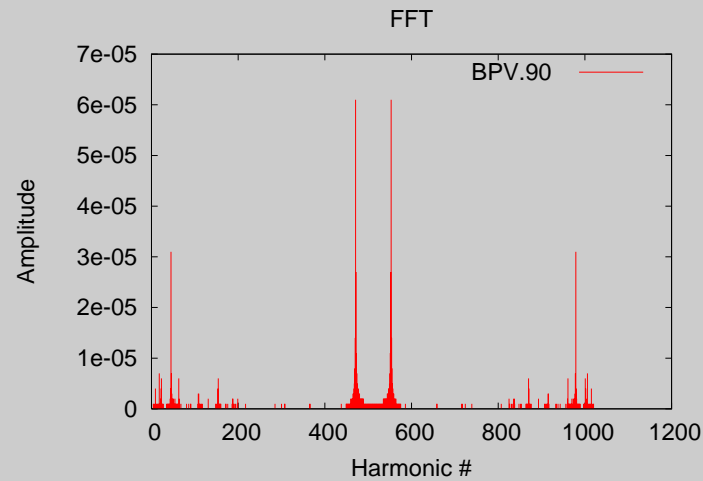Oscillation amplitude is rather small and is not damped: small chromaticity?
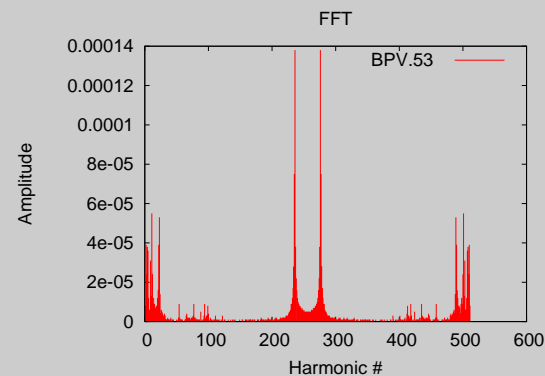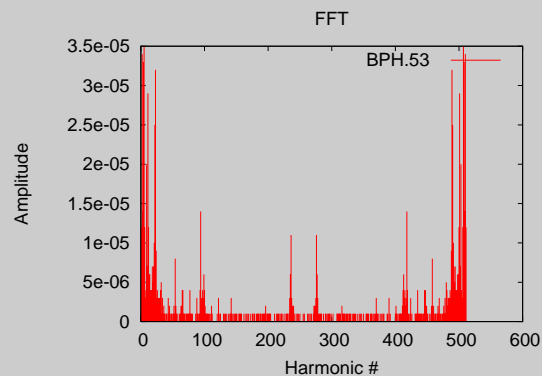
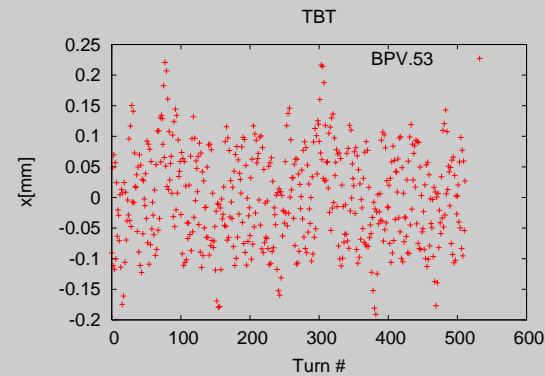Kick in the vertical plane is a factor 2.4 weaker.
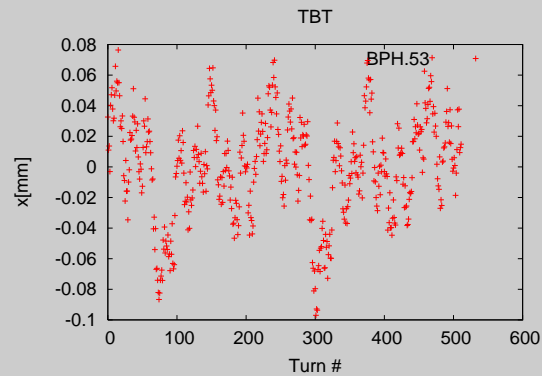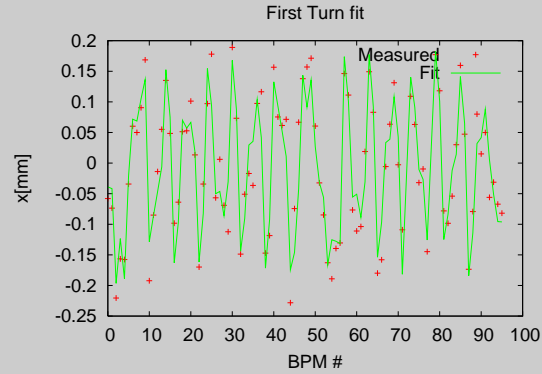
Tunes: 0.1831
        0.5398
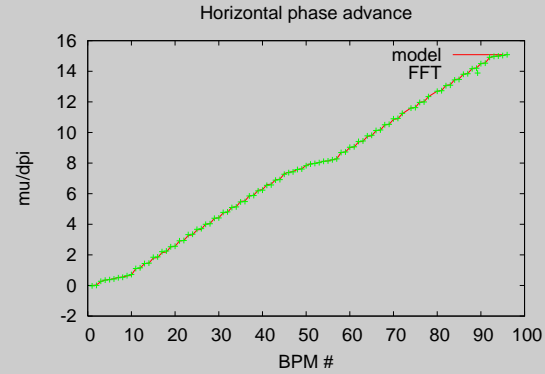Small coupling between
planes.

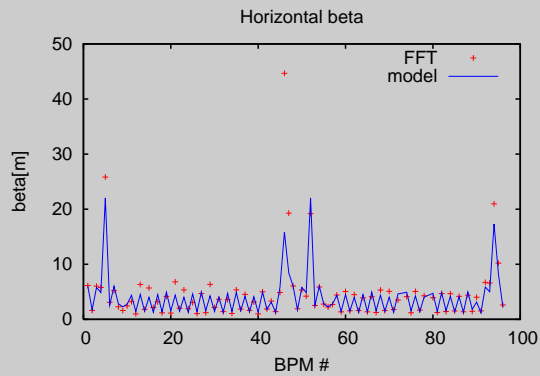# BPM.53 seems not working properly in the horizontal plane.

The spectrum of the horizontal TBT shows a peak at about the horizontal tune (.184 instead of .183) but also a large line corresponding to the vertical one. Same disease is present in all files.
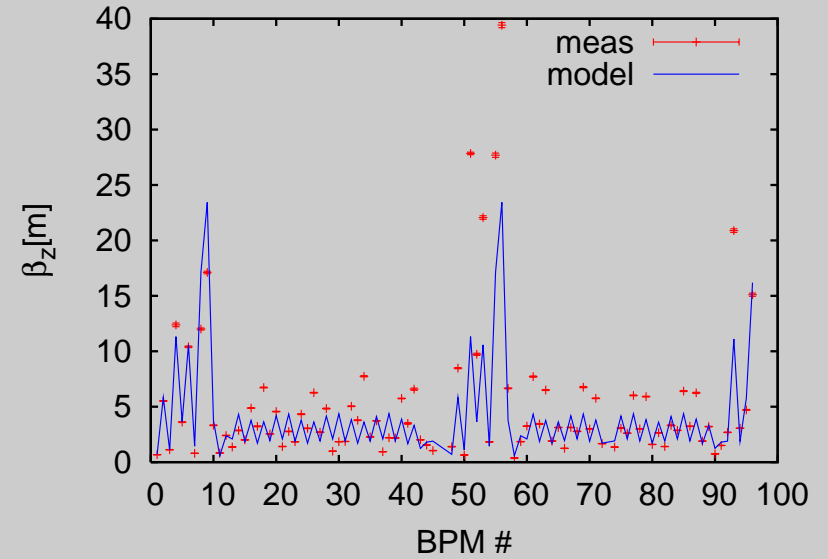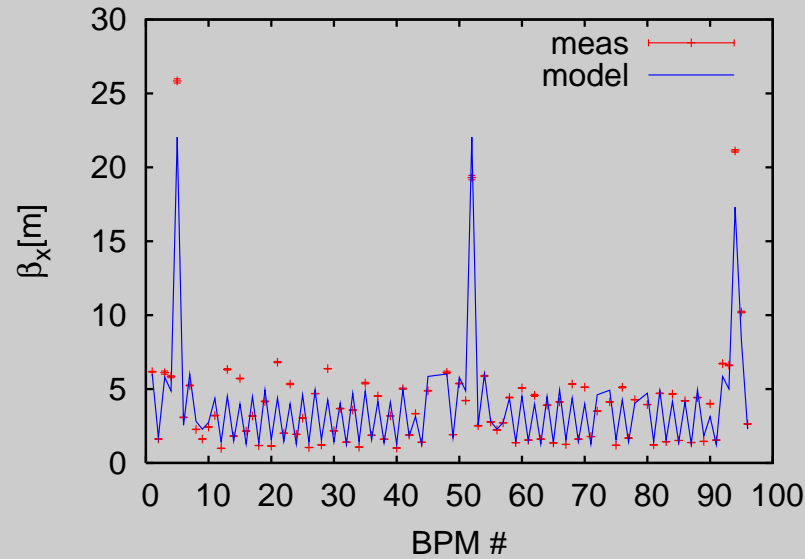
First turn fit

Phase advance

β_x

BPH.20 and BPH.21 seem to have a large calibration error

Averages over the 9 data set after taking out those two BPMs.


$$\Delta\beta_x/\beta_x \simeq 18 \text{ \% (85 BPMs)} \qquad \Delta\beta_y/\beta_y \simeq 22 \text{ \% (51 BPMs)}$$

nb: BPMs with $\Delta\beta/\beta > 40$ % were excluded from the average.

Harmonic analysis of the average $\Delta\beta/\beta$ shows large components at $h=30$ for the horizontal plane and $h=17$ for the vertical one, which correspond to $2 \times Q$ ($Q_x=15.18$, $Q_y=8.54$). Thus the beating is a *true* beating. The fact that it is larger in the vertical plane is likely due to the fact that the vertical tune is closer to a half integer than the horizontal one is to an integer.
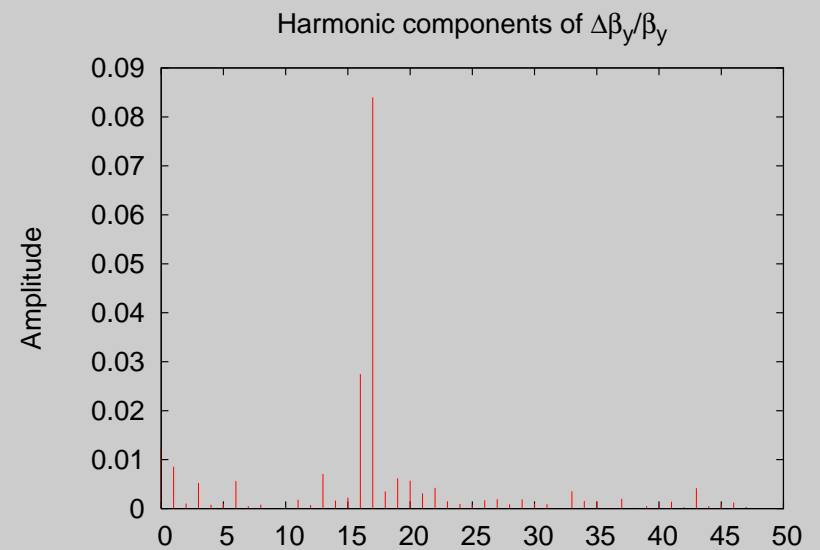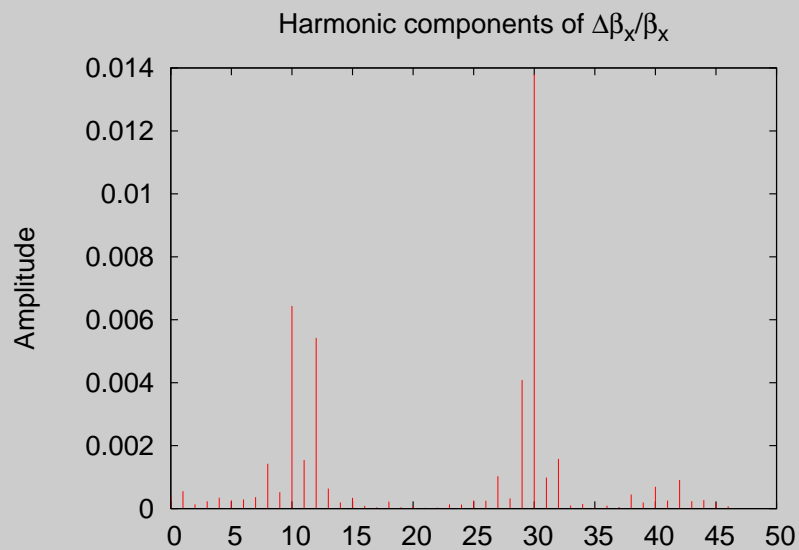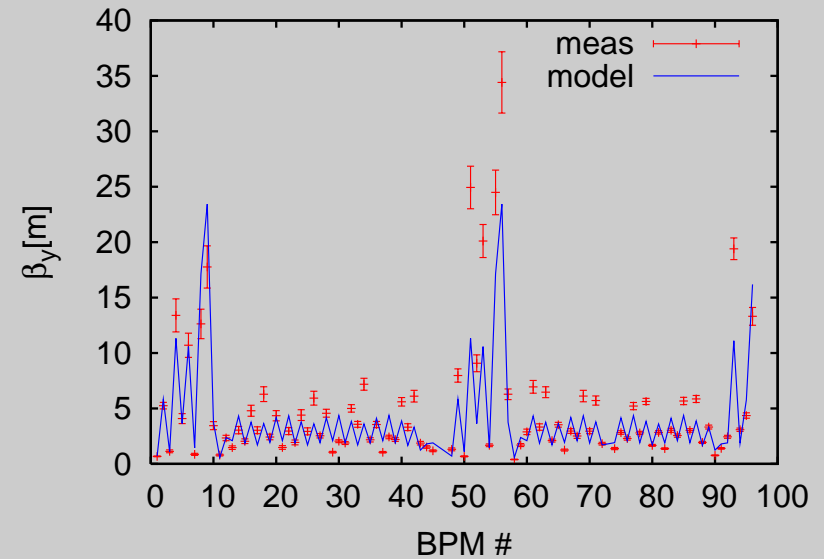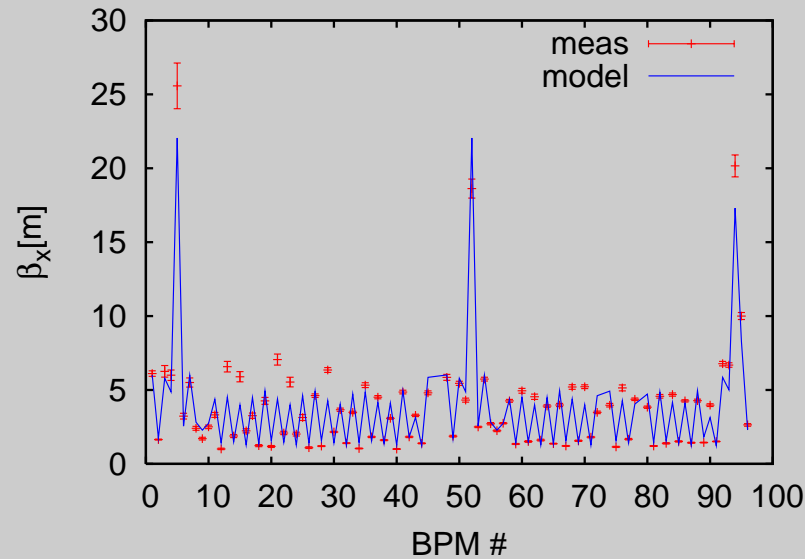
Injection data show large synchrotron oscillations in the horizontal plane.
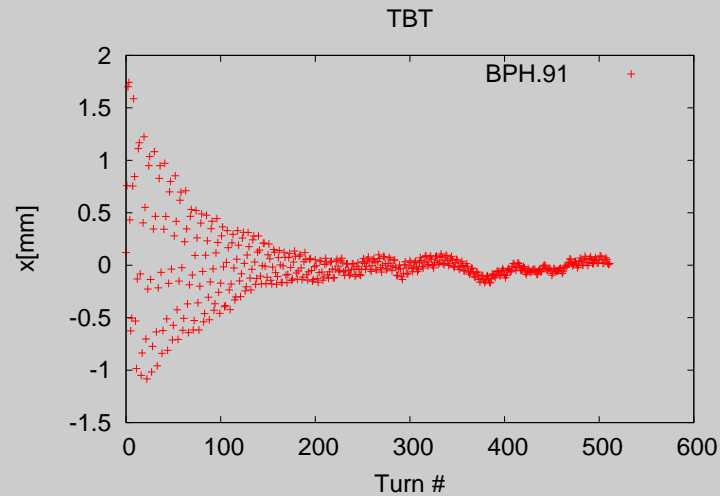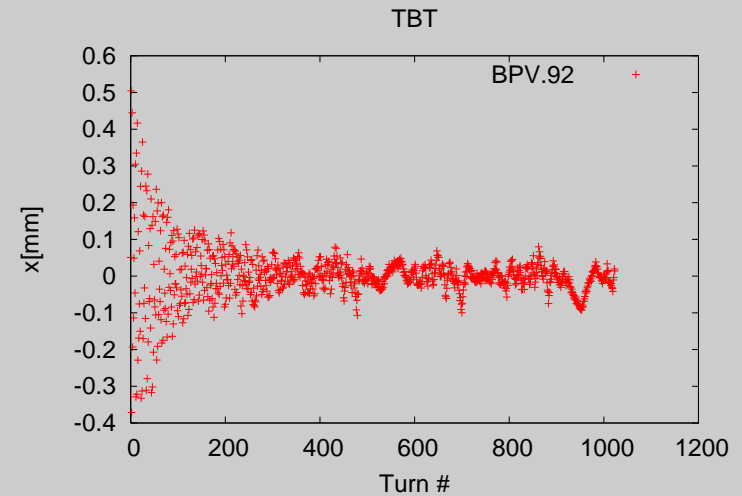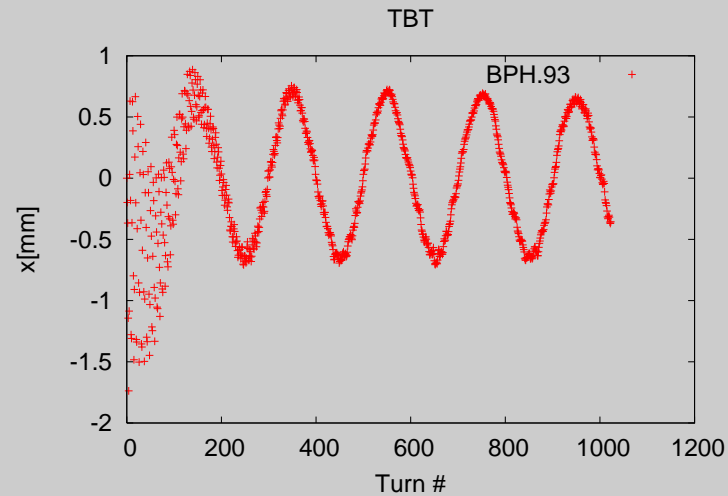
The synchrotron oscillation is fitted and subtracted from horizontal TBT data.

Averages over the 9 injection data set.

Results are very similar to those obtained with kicked data, the error bars are larger. The BPM.53, which was automatically excluded by the algorithm for kicked data ("bad tune"), it is not recognized as faulty for the injection data and initially screwed up all results.

Summary

- The analysis of the TBT data shows that

    - the broad-band measurement is in good shape

    - the machine optics is close to the model; there is some true beta beating, especially in the vertical plane.

- The strange behavior of BPM.53 (remarked also in the narrow band mode) must be investigated.

- BPM.20 and BPM.21 must be better calibrated, as it was expected.