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Analysis of June 2010 ATF TBT data

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TBT data at the j^{th} BPM following a **single** kick in the z plane ($z \equiv x, y$)

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

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

Twiss functions at BPM location:

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

$Z_j(Q_z) \equiv$ **Fourier component** of z_j

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

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

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 a constant a part

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

Amplitude fit:

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

The amplitude computation relies on a “reference” optics, but in first approximation the beta beating does not affect the amplitude fit.

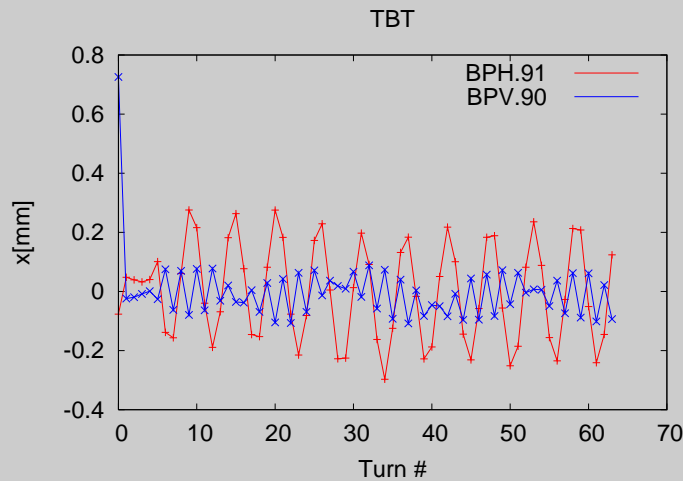
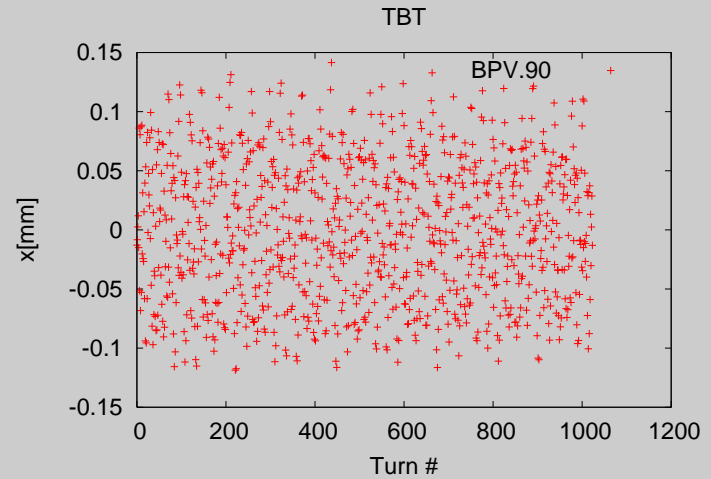
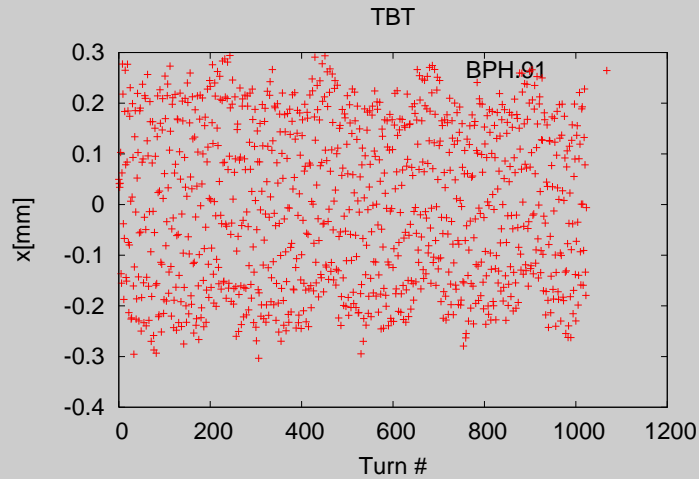
Friday June 4 18 TBT data have been recorded at ATF with the new BPM electronics.

- 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.

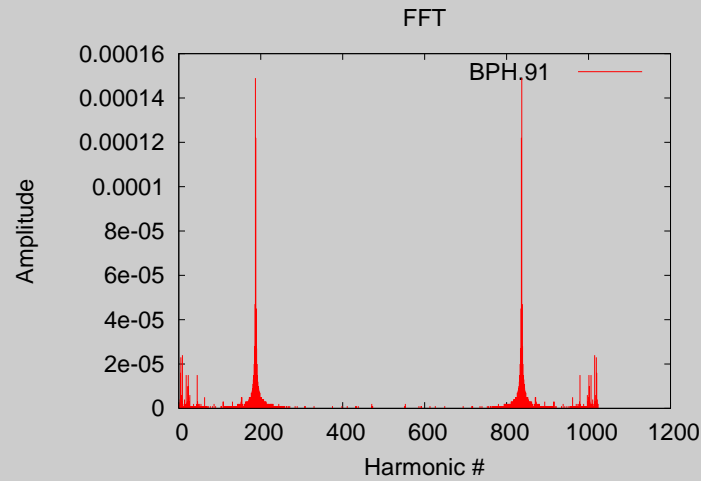


$$\beta_x^0 = 1.6 \text{ m @ BPH.91}$$

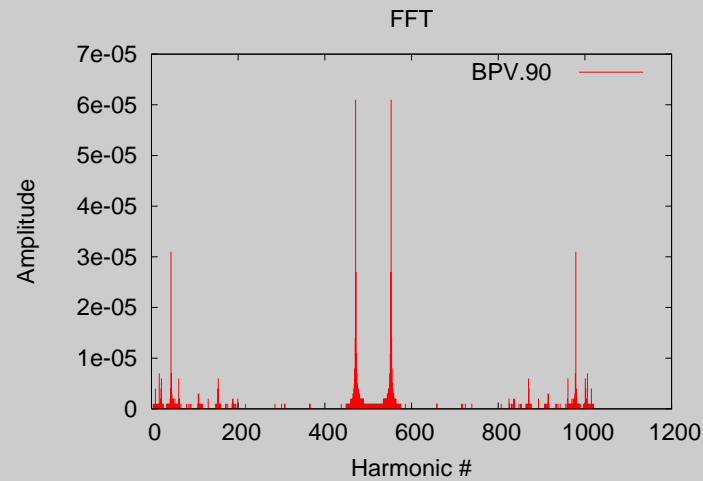
$$\beta_y^0 = 2.0 \text{ m @ BPV.90}$$

Oscillation amplitude is rather small and is not damped:
small chromaticity?

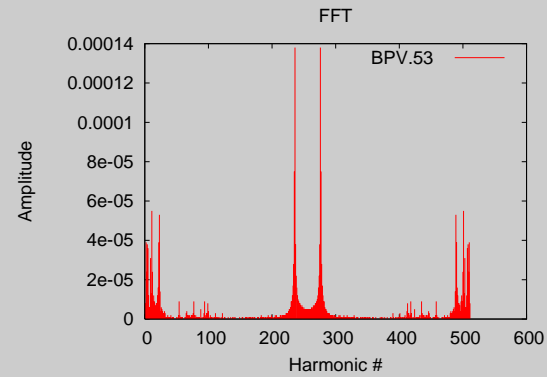
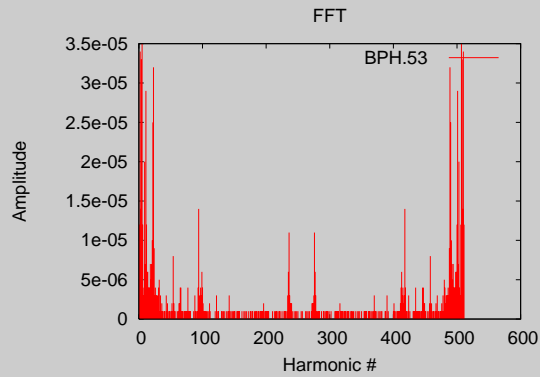
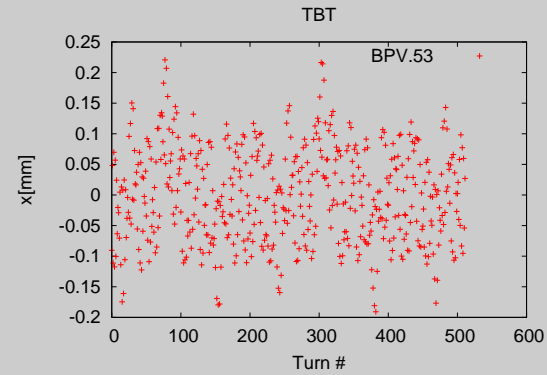
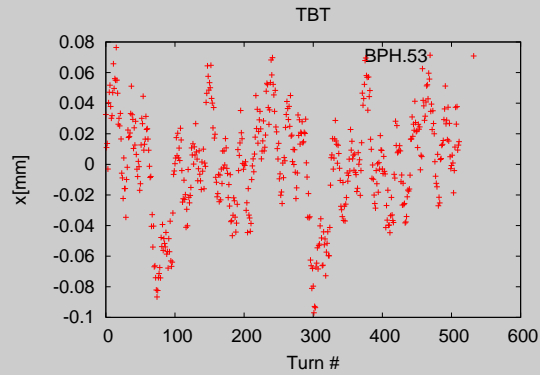
Kick in the vertical plane is a factor 2.4 weaker.



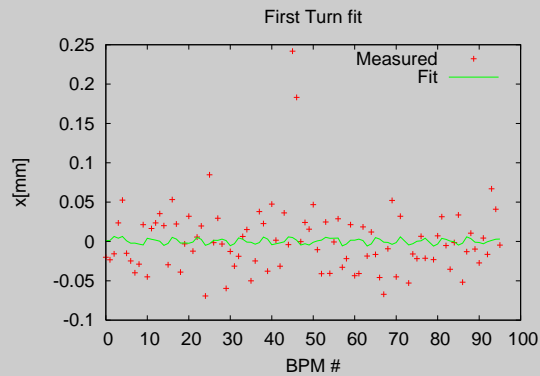
Tunes: 0.1831
0.5398
Small coupling between
planes.



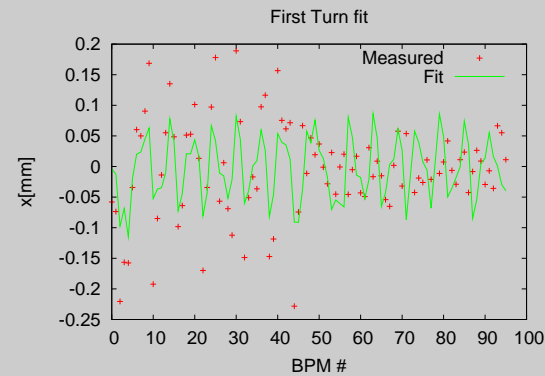
BPM.53 seems not working in the horizontal plane.



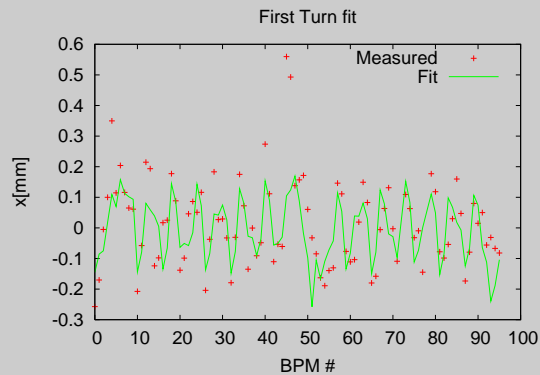
Same disease in all files.



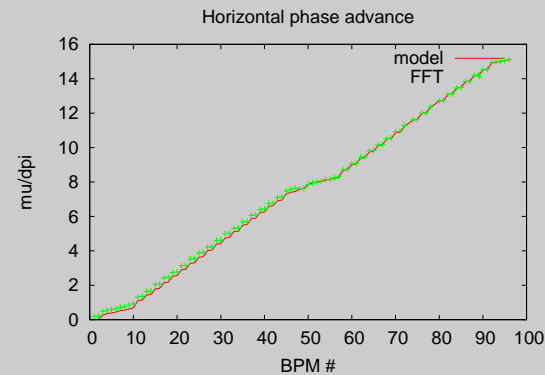
4th turn after trigger
No kick yet



5th turn after trigger
First BPM half see kicked beam



All BPM see kicked beam, but poor fit:
order may be wrong..

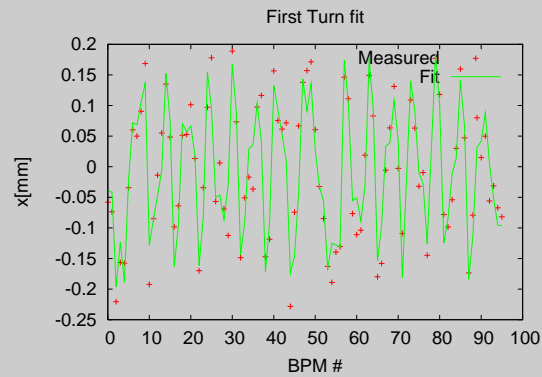


6th turn after trigger:
order is wrong!

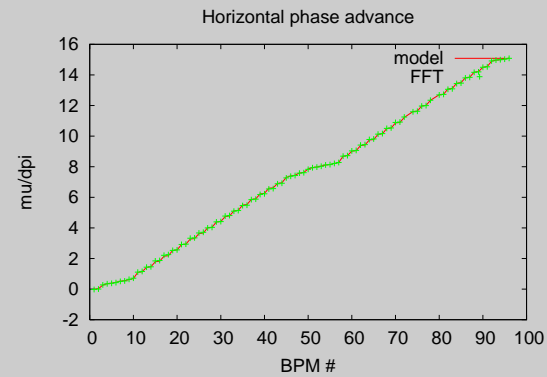
Apply a shift of the data

| | x | y |
|--------|----|----|
| BPM.71 | -1 | -1 |
| BPM.72 | -1 | -1 |
| BPM.73 | -1 | -1 |
| | “ | ” |
| BPM.96 | -1 | -1 |
| BPM.01 | -1 | -1 |
| | “ | ” |
| BPM.21 | -1 | -1 |

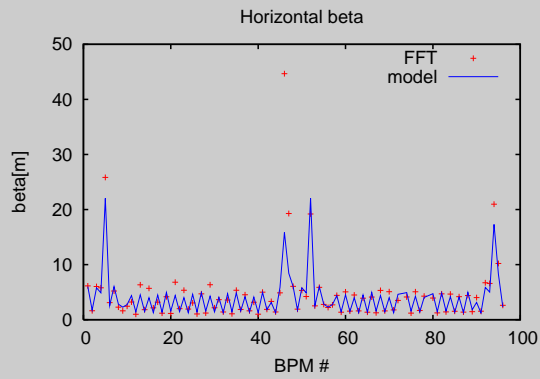
A shift of $+1$ for all the other BPMs would be equivalent. I verified that these shifts apply to *all* data sets.



First turn fit after shifting data



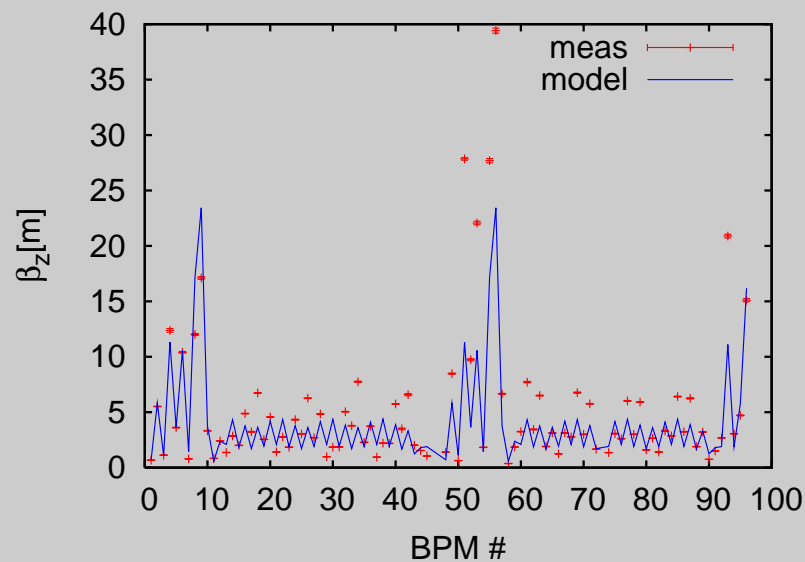
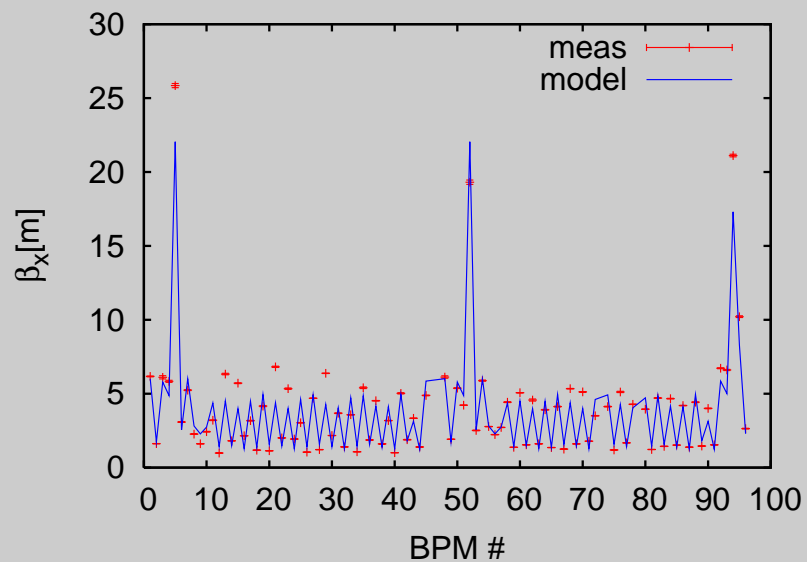
Phase advance after shifting data



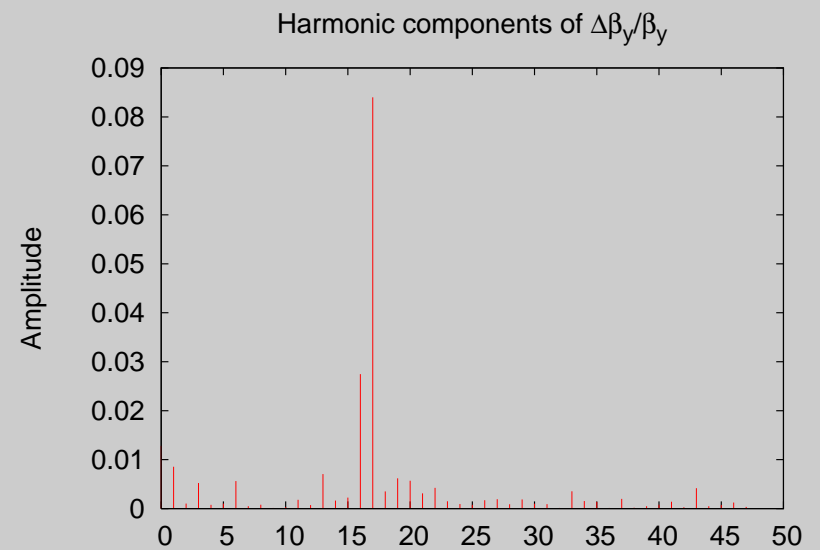
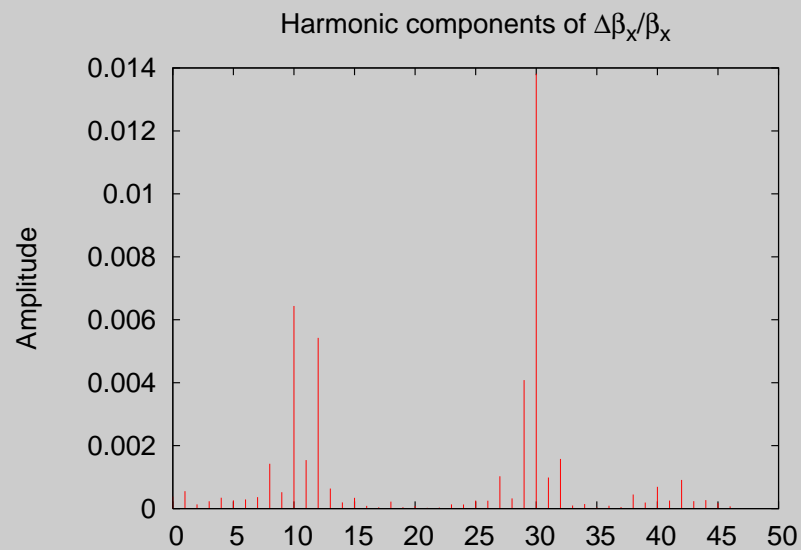
$$\beta_x$$

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

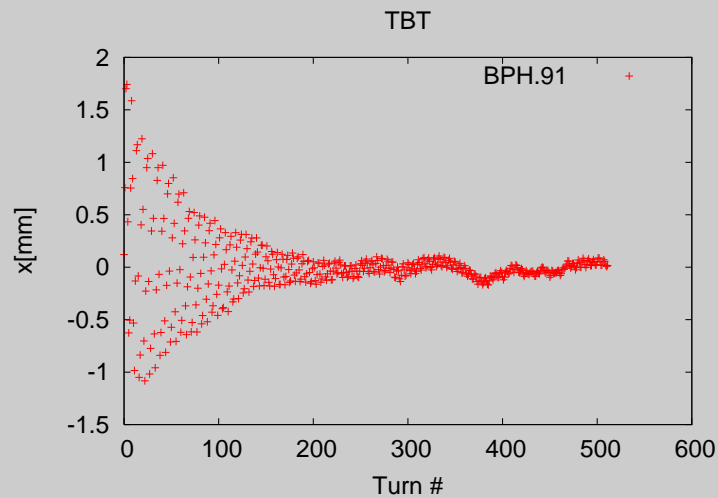
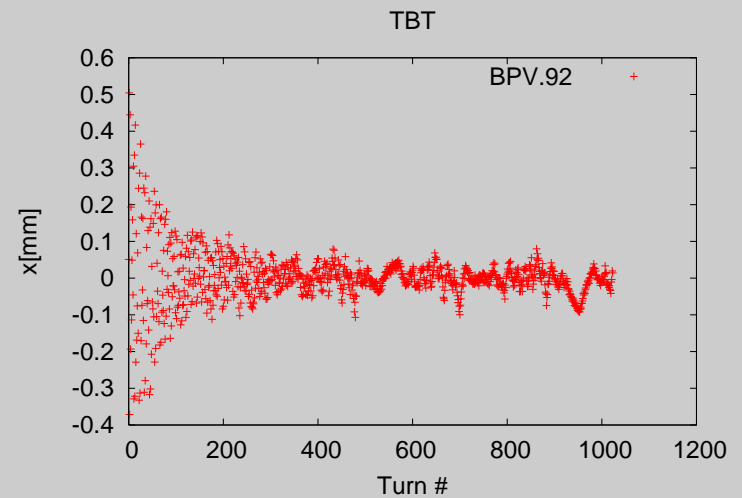
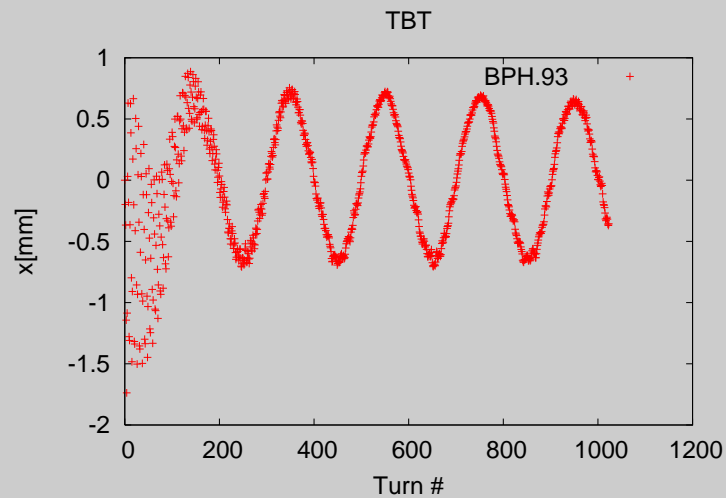
Averages over the 9 data set after taking out those two BPMs.



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.

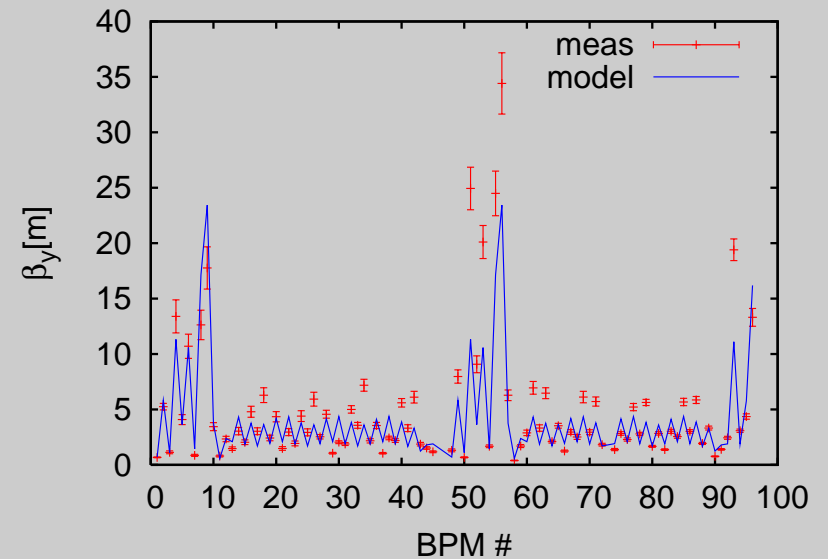
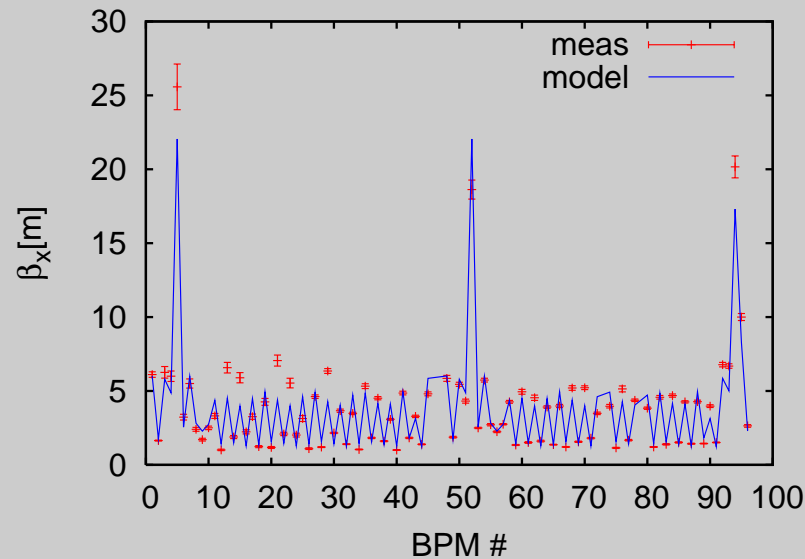


Injection data show large synchrotron oscillations



The synchrotron oscillation is fitted and subtracted.

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.