Using TBT data at ATF DR

Purposes:

- Fast optics measurement
- Optics modeling
- Betatron Coupling correction

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The Fourier analysis of TBT data has been first applied at LEP in 1992 as a tool for measuring the *uncoupled linear optics*.

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

$$z_n^j = \frac{1}{2}\sqrt{\beta_z^j}\,e^{i\Phi_z^j} A_z e^{iQ_z(\theta_j + 2\pi n)} + c.c.$$

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

$\Phi_z \equiv \mu_z - Q_z\theta$ (periodic phase function)

Twiss functions:

$$\beta_z^j = |Z_j(Q_z)|^2 / A_z^2 \qquad \mu_z^j = \arg\,(Z_j) - \delta_z$$

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

Amplitude fit:

$$|A_z|^2 = \frac{\sum_j 1/\beta_z^{0j}}{\sum_j 1/|Z_j(Q_z))|^2}$$

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

The Fourier analysis of the coupled oscillation gives information on the machine coupling. Preliminary simulations show that

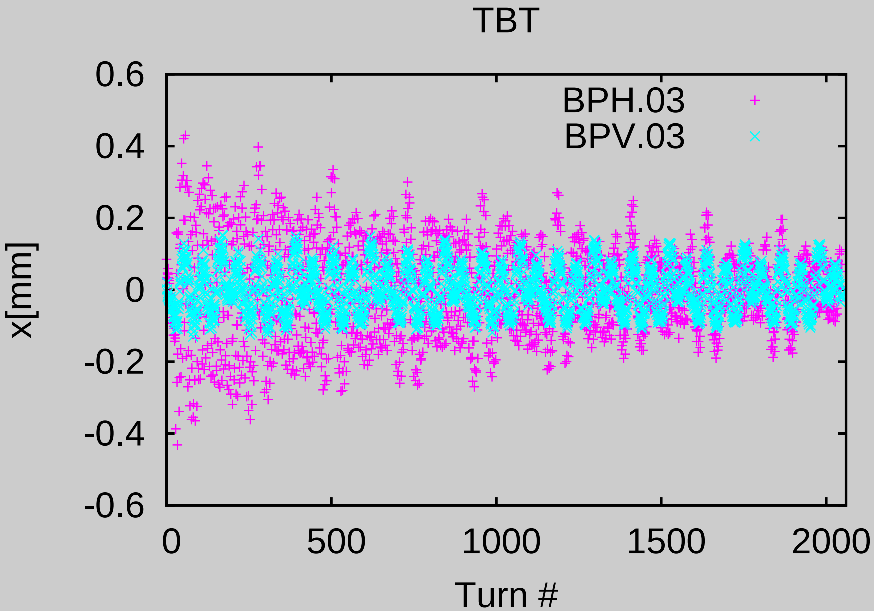
- the simultaneous correction of betatron coupling and spurious vertical dispersion looks very promising for attaining the small vertical emittance at ATF
- even with only 20 BPMs we should be able to see the effect of the skew quadrupoles on the coupling functions and eventually correct the machine linear coupling.

However for localizing coupling sources as well as for modeling the machine a larger number of observation points (BPMs) is needed

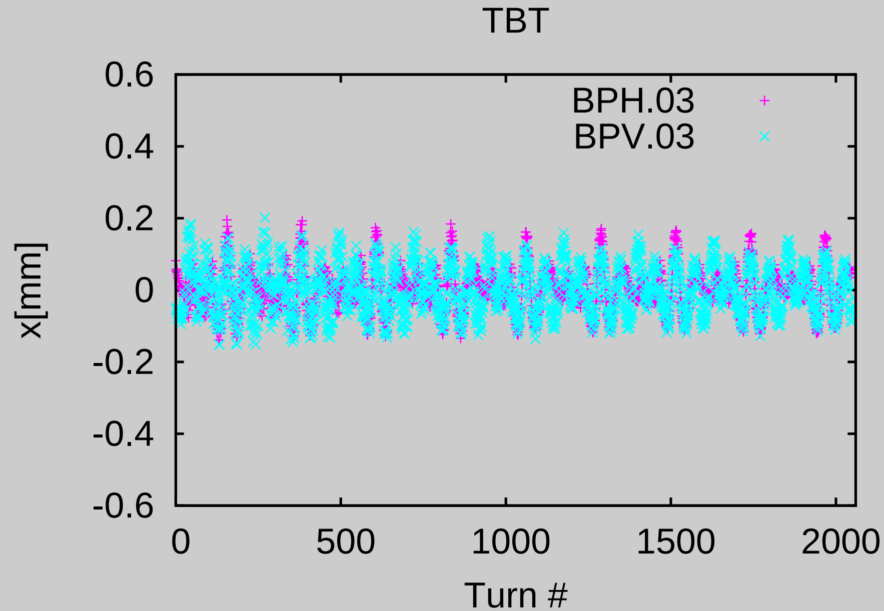
April 9, 2008 studies

April the 9th we had a "remote" shift. We analyse the BPM TBT data following a single kick. We have taken 2 sets of measurements kicking the beam horizontally and vertically

h-kick

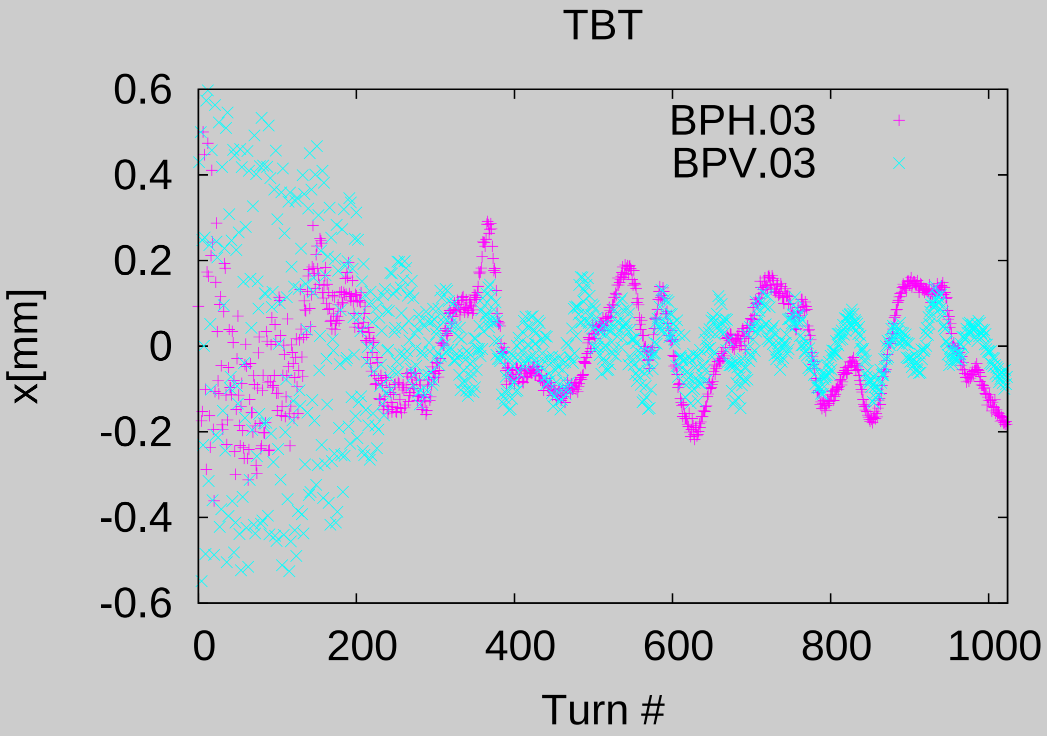


v-kick



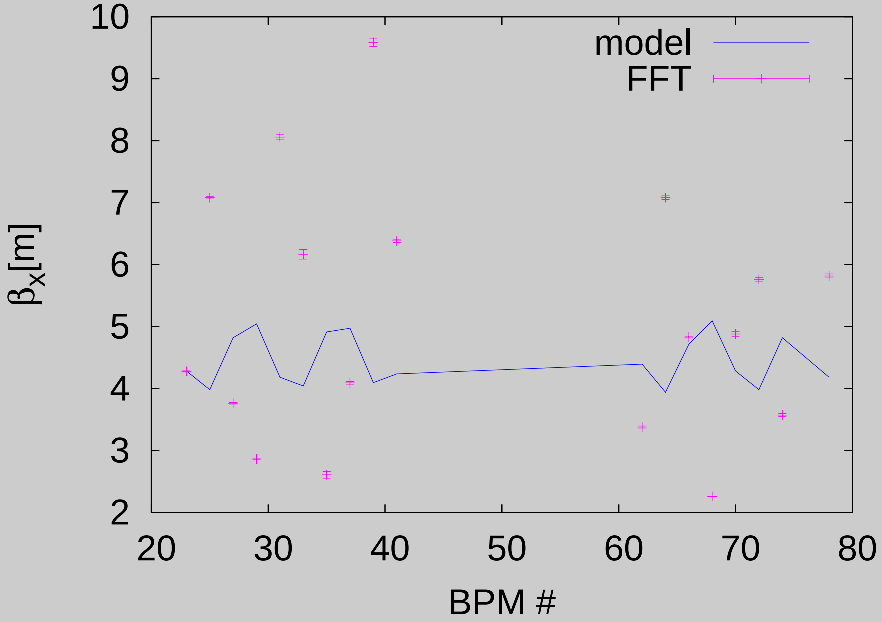
The coupling of the horizontal oscillation into the vertical plane is very weak. The poorness of the vertical data following the vertical kick is due to the fact that $\beta_y \simeq$ 0.5 m at the kicker location, ie 12 times smaller than β_x, and that β_y at the BPMs is $\simeq$2 m ie a factor 0.4 smaller than β_x).

Injection oscillations

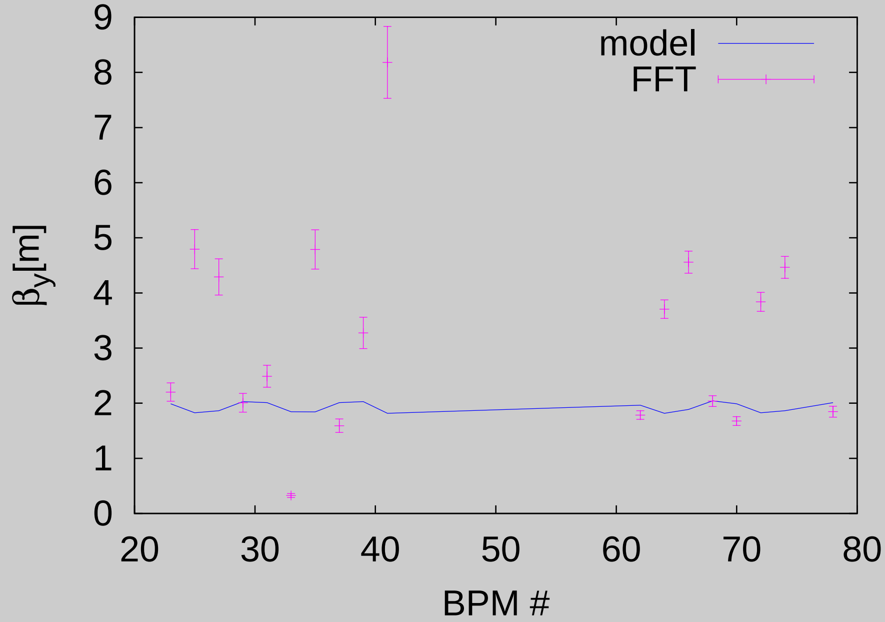


For the vertical plane we can rely for the moment only on injection data. As the oscillation lasts only some hundreds turns, the accuracy of the measurement is expected to be smaller than in the horizontal plane.

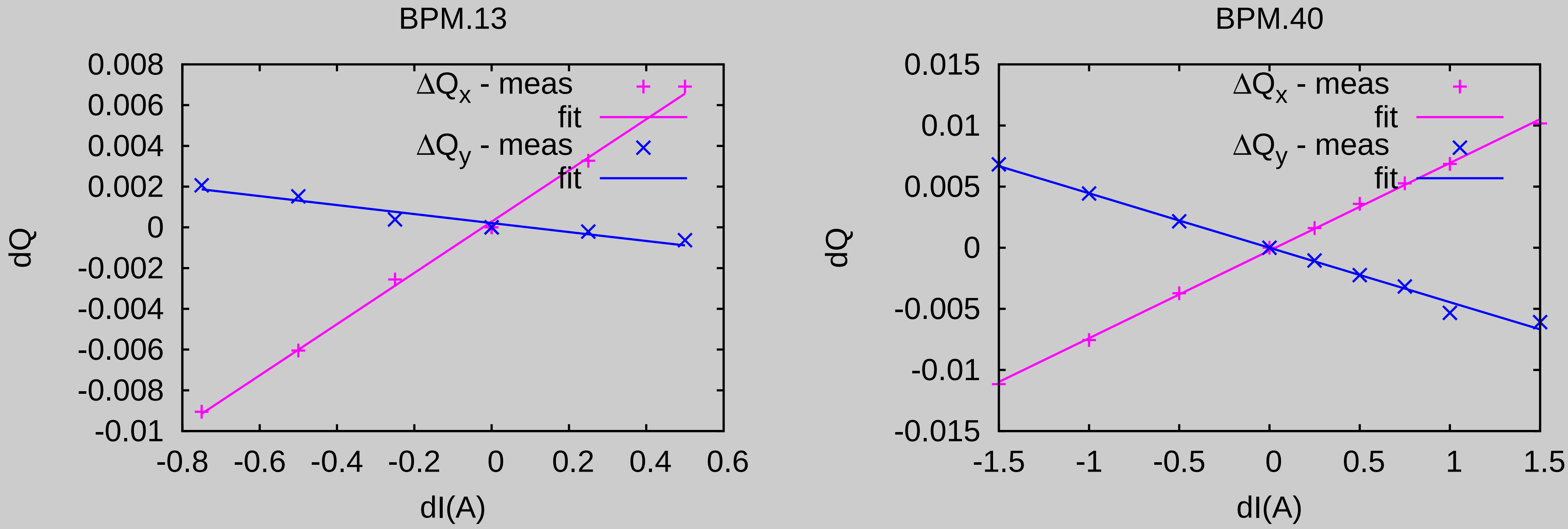
β_x (nominal reference optics)



β_y (nominal reference optics)

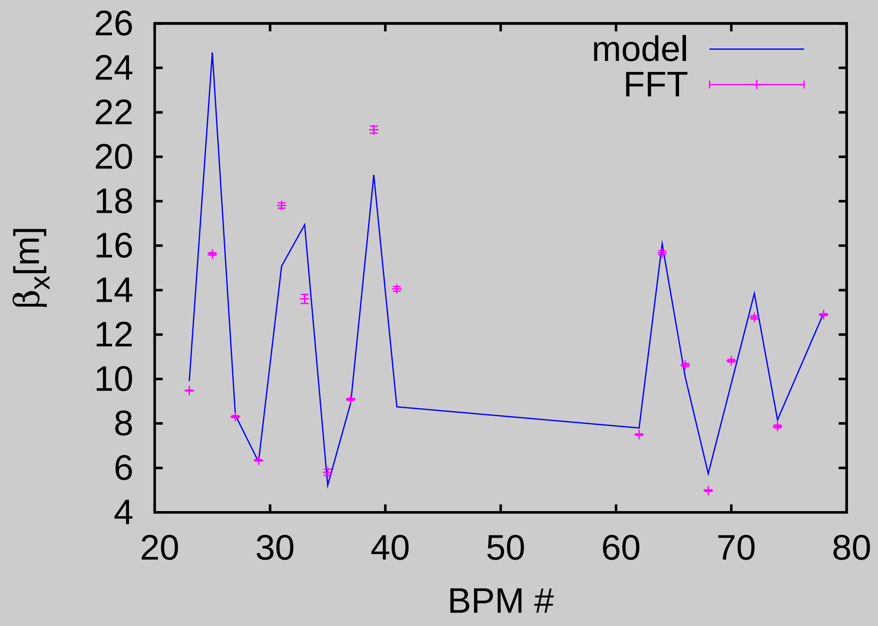


After observing such a large discrepancy with the model, the optics was measured at some BPM locations by changing the current of the trim quadrupoles.



These measurements showed also a large discrepancy with the model. Later on all the BPMs location were measured by the quadrupole method and those results used as reference optics for determining the oscillation amplitude.

β_x (measured reference optics)



β_y (measured reference optics)