MI BPM TBT Analysis 12/07/2005   Bob Webber

Import the data
12/5/05

Turn-by-Turn Data from prototype MI BPM system at MI40

Horizontal BPM 412
using only linear BPM scaling of 20.2mm
(see beams-doc #1978)

Three sets of data at injection 2048 turns each with injection occuring about "turn" #27

tbt1 and tbt2 are "normal" injections

tbtbig includes intentional injection mis-steering

tbt1 :=

	0	1	2
0	0	-5.9141	18.1078
1	1	3.1719	94.1874
2	2	3.5188	54.4253
3	3	-5.49	24.5648
4	4	-1.4008	26.582
5	5	3.7124	37.3223
6	6	-16.7092	62.3237

tbt2 :=

	0	1	2
0	0	12.12	25
1	1	-7.8521	39.9374
2	2	4.3119	57.1421
3	3	-7.2684	67.0779
4	4	-12.2889	52.0788
5	5	6.8998	67.1018
6	6	-6.0089	40.4615

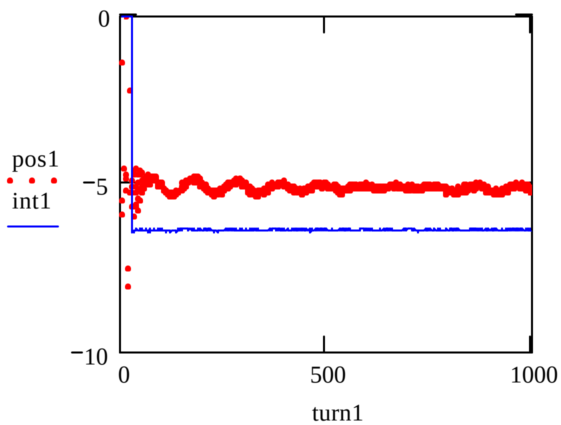
tbtbig :=

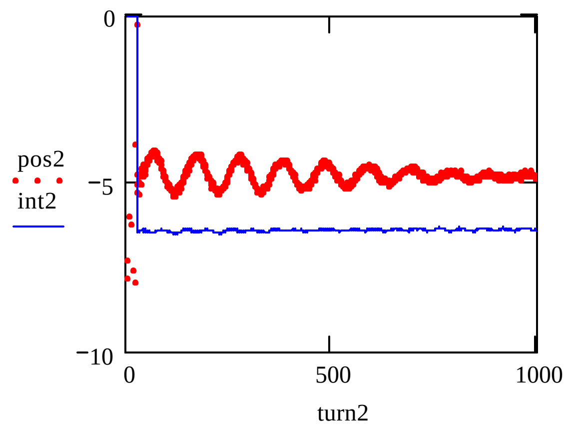
	0	1	2
0	0	4.7356	11.6832
1	1	-4.6065	82.9469
2	2	4.009	56.0728
3	3	-2.8981	78.3182
4	4	-9.8744	93.0012
5	5	-12.2911	41.1833
6	6	2.781	33.7696

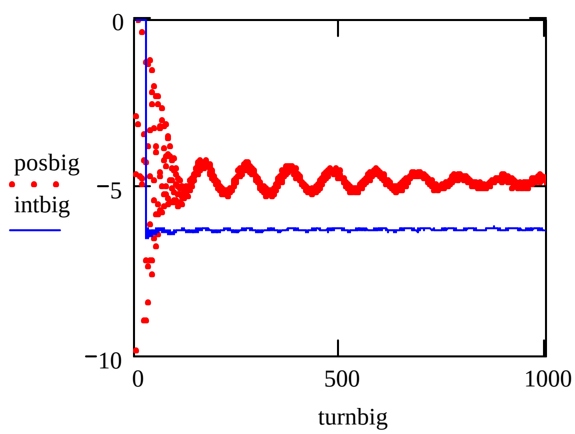
$pos1 := tbt1^{\langle 1 \rangle}$ $\quad$ $turn1 := tbt1^{\langle 0 \rangle}$ $\quad$ $int1 := \frac{tbt1^{\langle 2 \rangle}}{-2000}$

$pos2 := tbt2^{\langle 1 \rangle}$ $\quad$ $turn2 := tbt2^{\langle 0 \rangle}$ $\quad$ $int2 := \frac{tbt2^{\langle 2 \rangle}}{-2000}$

$posbig := tbtbig^{\langle 1 \rangle}$ $\quad$ $turnbig := tbtbig^{\langle 0 \rangle}$ $\quad$ $intbig := \frac{tbtbig^{\langle 2 \rangle}}{-2000}$







Plot the first 1000 points of position and sum from each data set

First turn with beam is index 26 or 27

$$\text{frev} := \frac{52.811 \cdot 10^6}{588}$$

$$\text{lenfft} := 1024 \qquad m := 0 .. \frac{\text{lenfft}}{2} \qquad \text{tune}_m := \frac{m}{\text{lenfft}} \qquad \text{freq}_m := \text{tune}_m \cdot \text{frev}$$

$\text{fftdat1} := \text{submatrix}(\text{pos1}, 27, 26 + \text{lenfft}, 0, 0)$

$\text{int1fftdat} := \text{submatrix}(\text{int1}, 27, 26 + \text{lenfft}, 0, 0)$

$\text{fftdat2} := \text{submatrix}(\text{pos2}, 27, 26 + \text{lenfft}, 0, 0)$

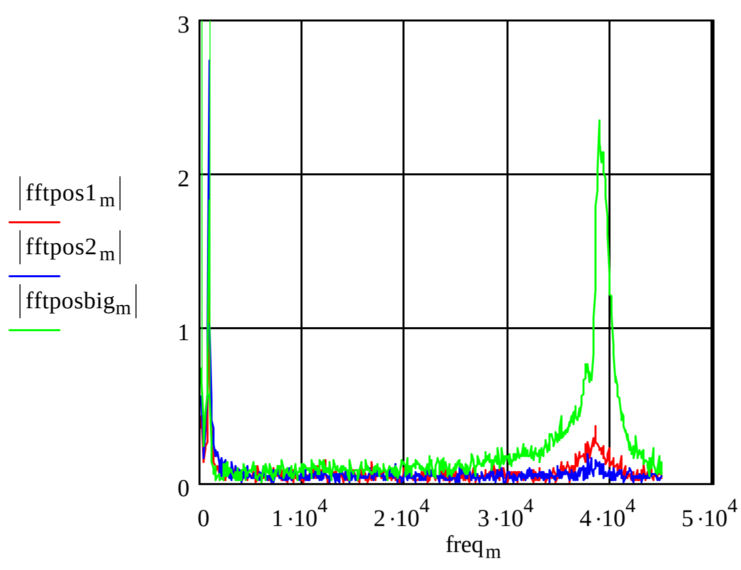
$\text{int2fftdat} := \text{submatrix}(\text{int2}, 27, 26 + \text{lenfft}, 0, 0)$

$\text{fftdatbig} := \text{submatrix}(\text{posbig}, 27, 26 + \text{lenfft}, 0, 0)$

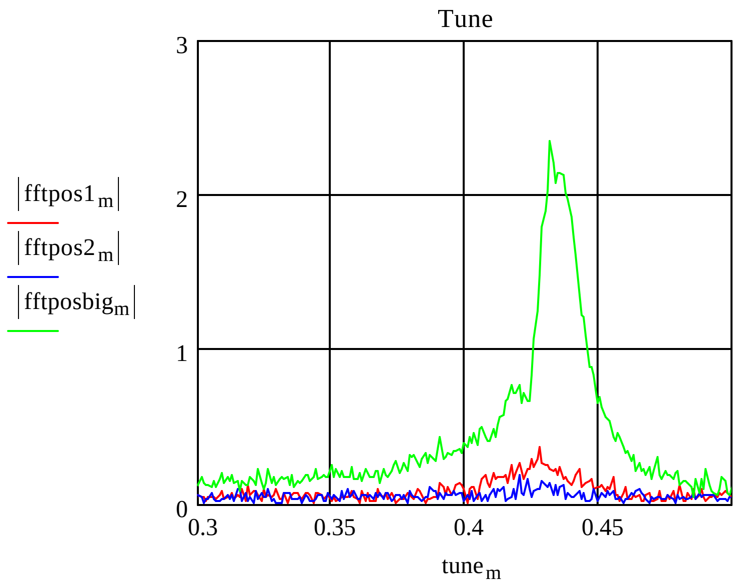
$\text{intbigfftdat} := \text{submatrix}(\text{intbig}, 27, 26 + \text{lenfft}, 0, 0)$

$\text{fftpos1} := \text{fft}(\text{fftdat1}) \qquad \text{fftpos2} := \text{fft}(\text{fftdat2}) \qquad \text{fftposbig} := \text{fft}(\text{fftdatbig})$

$\text{fftint1} := \text{fft}(\text{int1fftdat}) \qquad \text{fftint2} := \text{fft}(\text{int2fftdat}) \qquad \text{fftintbig} := \text{fft}(\text{intbigfftdat})$



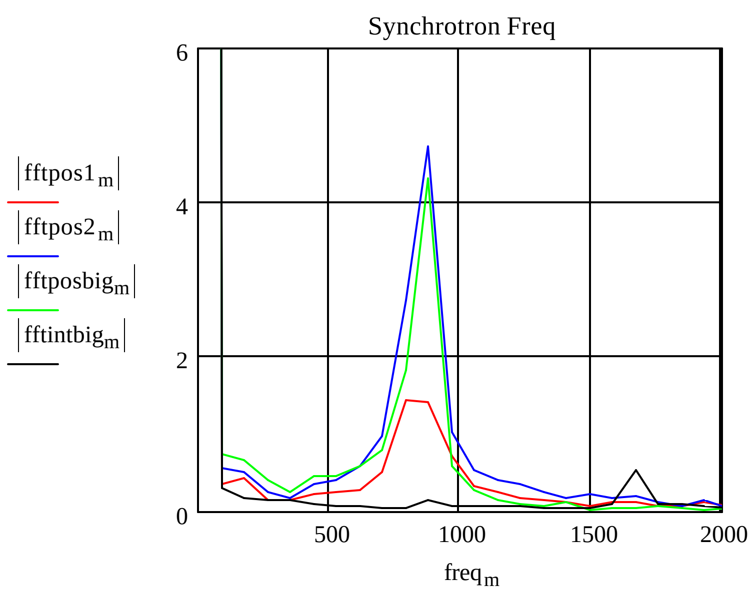
FFT the data
x axis is real frequency



FFT the data

Top plot: x axis is fractional turn, showing betatron tune

Bottom plot: x axis is real frequency showing synchrotron frequency

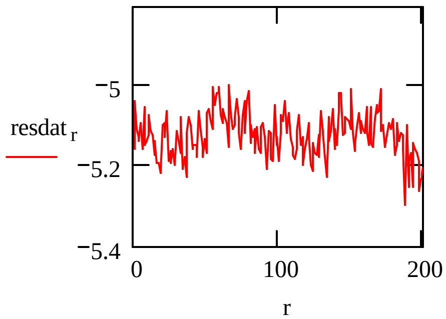


$resdat := submatrix(pos1, 600, 799, 0, 0)$

$r := 0..199$

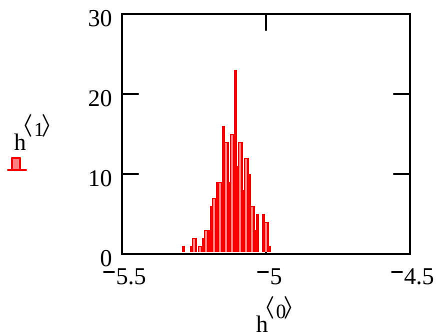
Look at BPM resolution

Histogram pos1 data for 200 points during 'quiet' time



$nbins := 100$ $\quad binn := 0..nbins - 1$ $\quad bins_{binn} := -5.5 + \frac{binn}{nbins} \cdot 1$

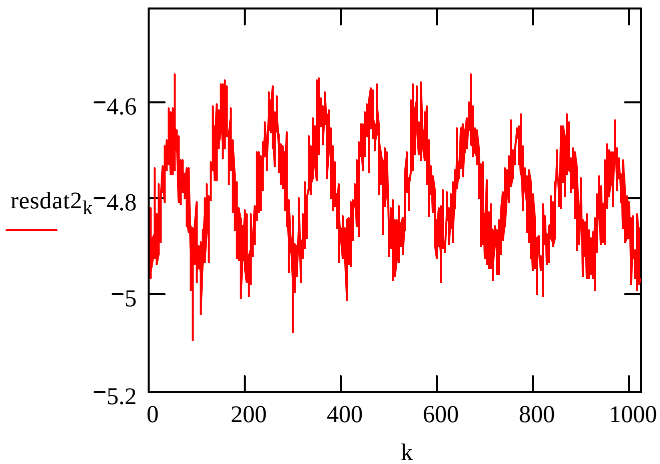
$h := histogram(bins, resdat)$



resdat2 := submatrix(pos2, 1024, 2047, 0, 0)   resturn2 := submatrix(turn2, 1025, 2047, 0, 0)

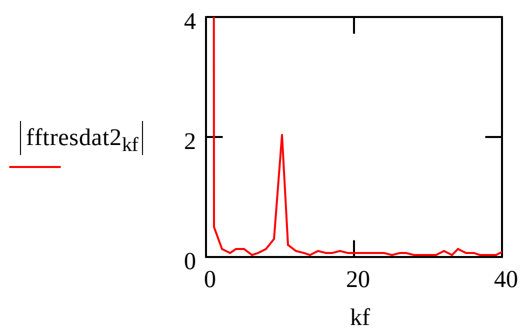
k := 0.. 1023   kf := 0.. 512

fftresdat2 := fft(resdat2) $fftresdat2_0 = -153.192$



Try different approach to estimating resolution

FFT pos1 data for last 1024 turns



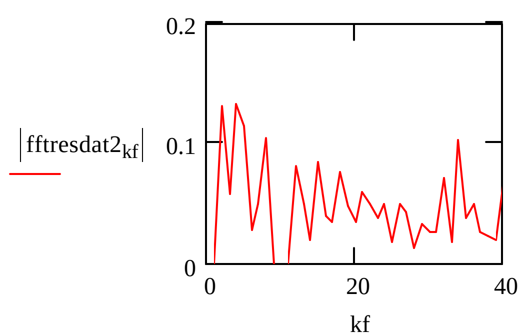
Filter out known beam motion:

Zero amplitudes at zero frequency, lowest non-zero frequency, at synchrotron frequency and one point either side

$fftresdat2_0 := 0$ $fftresdat2_{10} := 0$

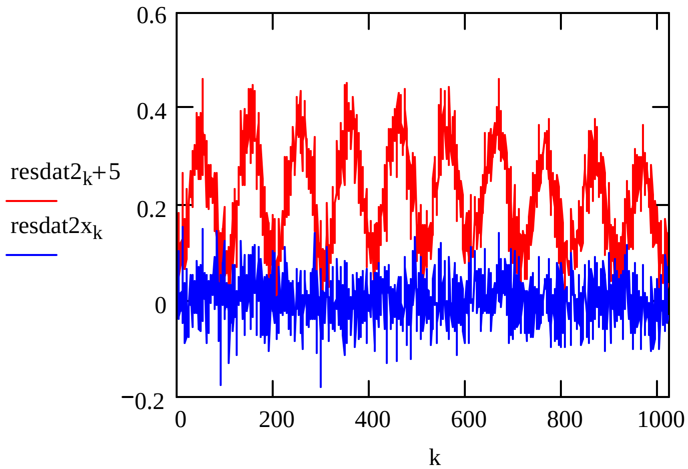
$fftresdat2_1 := 0$ $fftresdat2_{11} := 0$

$fftresdat2_9 := 0$



Resultant low end of spectrum

$resdat2x := ifft(fftresdat2)$ $\qquad$ $rows(resdat2x) = 1.024 \times 10^3$



Plot original data and "filtered" data

$stdev(resdat2x) = 0.051$

Rms of filtered data shows resolution to be 51 microns

$nbins := 100$ $\qquad$ $binn := 0..\, nbins - 1$

$$bins_{binn} := -0.5 + \frac{binn}{nbins} \cdot 1$$

Histogram of "filtered" data

$h := histogram(bins, resdat2x)$