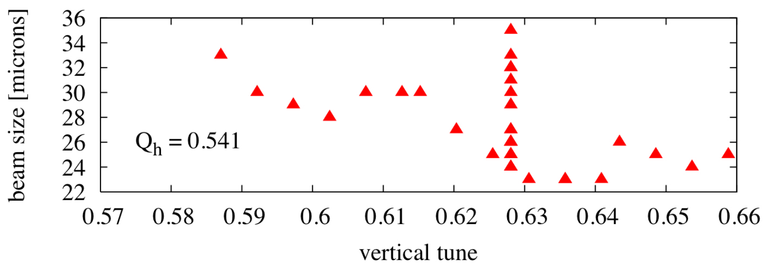
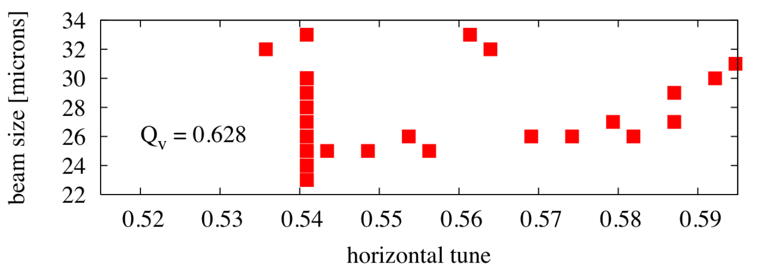
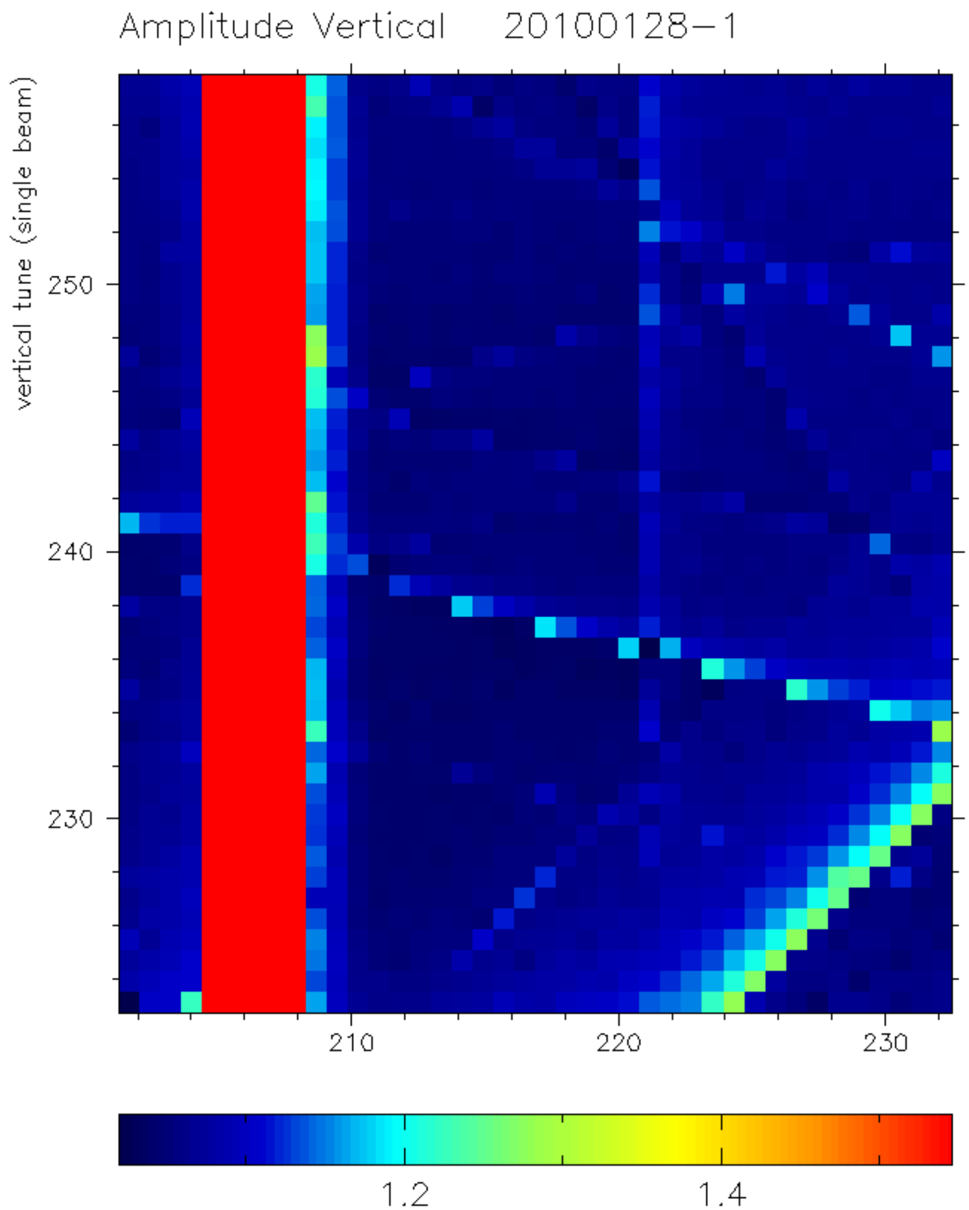
Tune scan of vertical beam size

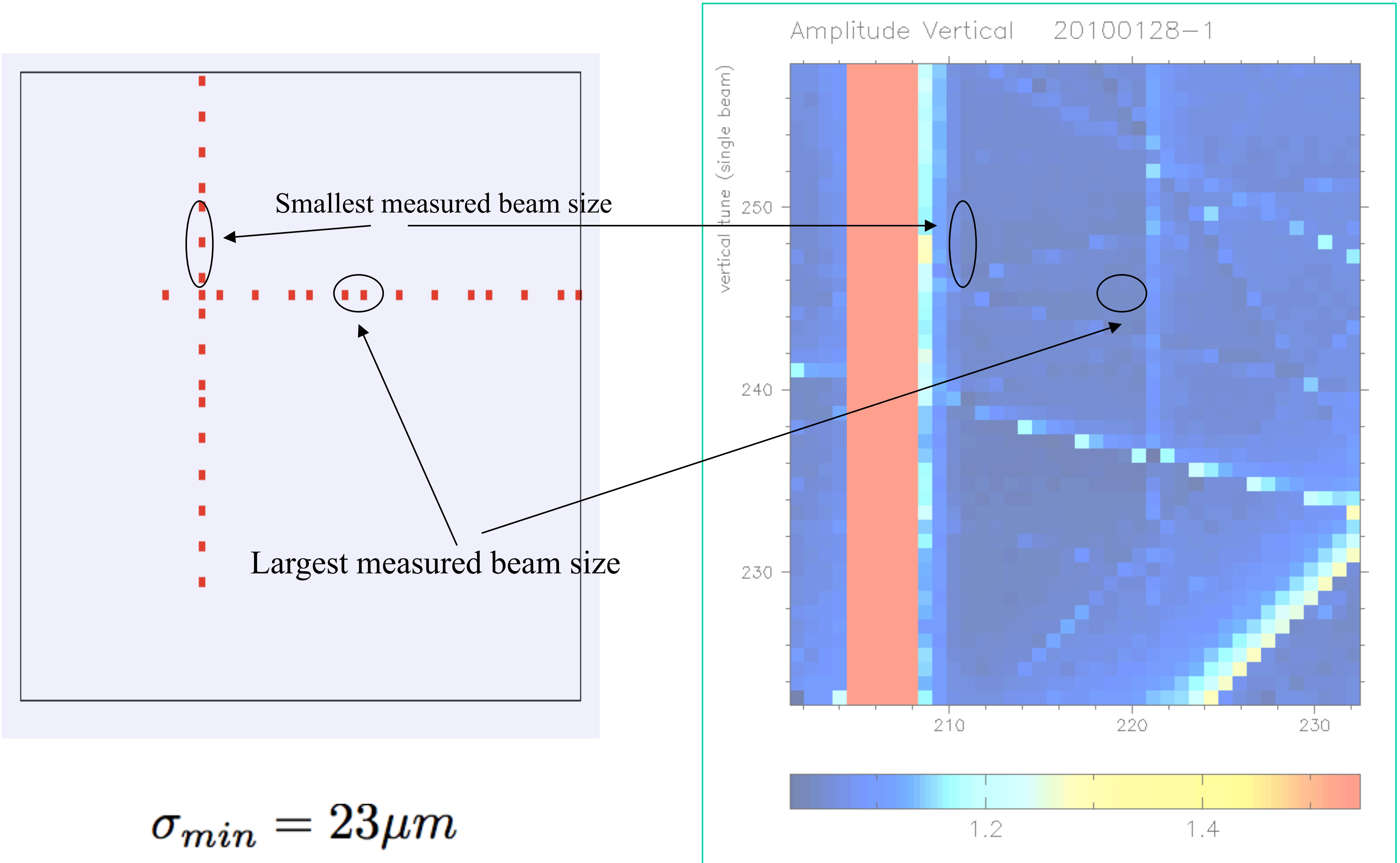
December 22, 2009







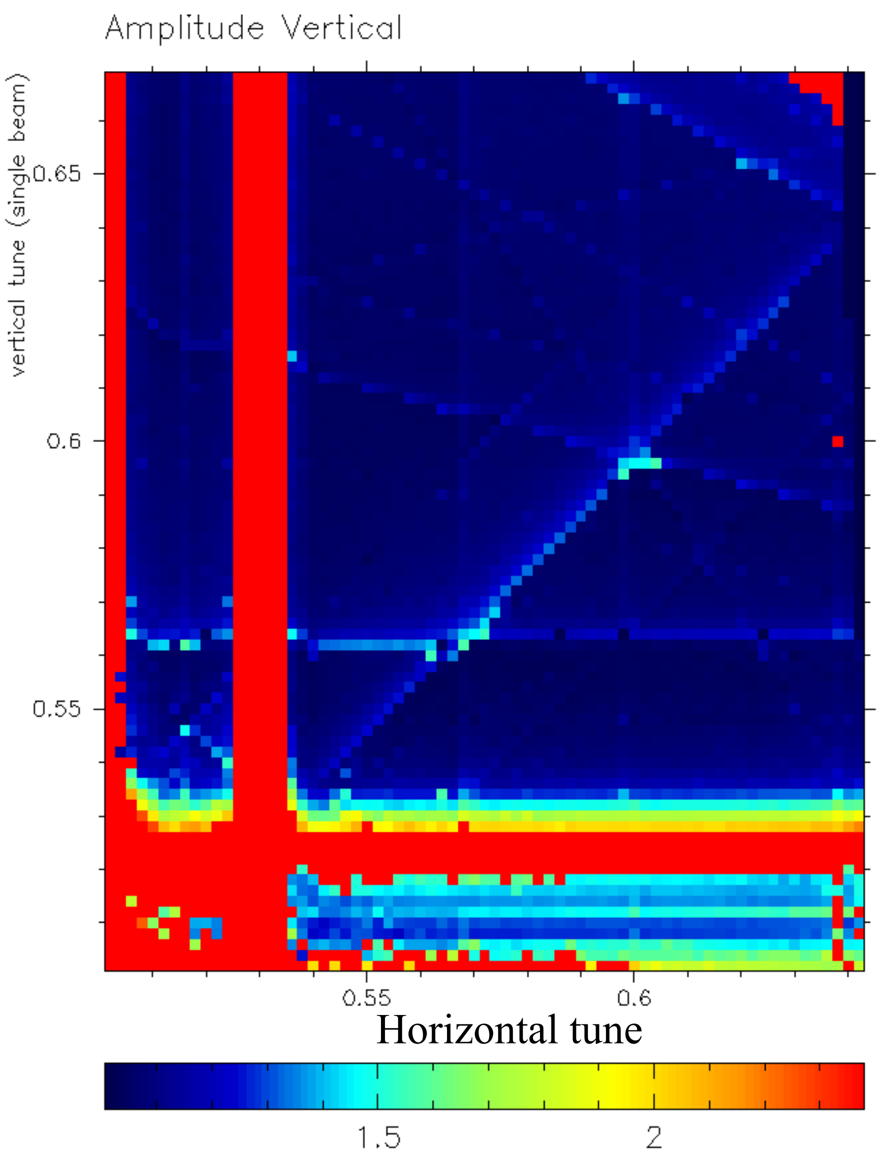
X-ray beam size monitor
Gives turn by turn beam size



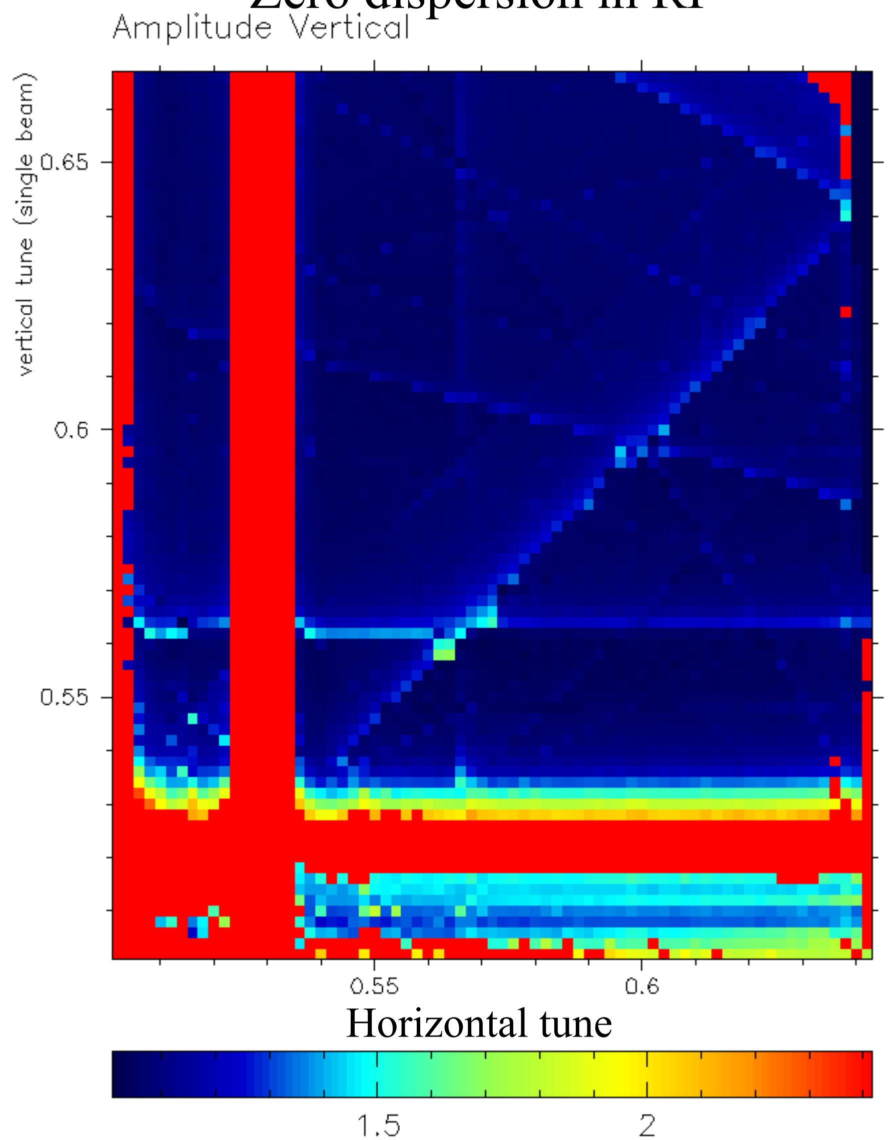
$$\sigma_{min} = 23\mu m$$
$$\epsilon_v = 32pm$$

Cta_2085mev_20090516 Q_z=0.066=25.7kHz

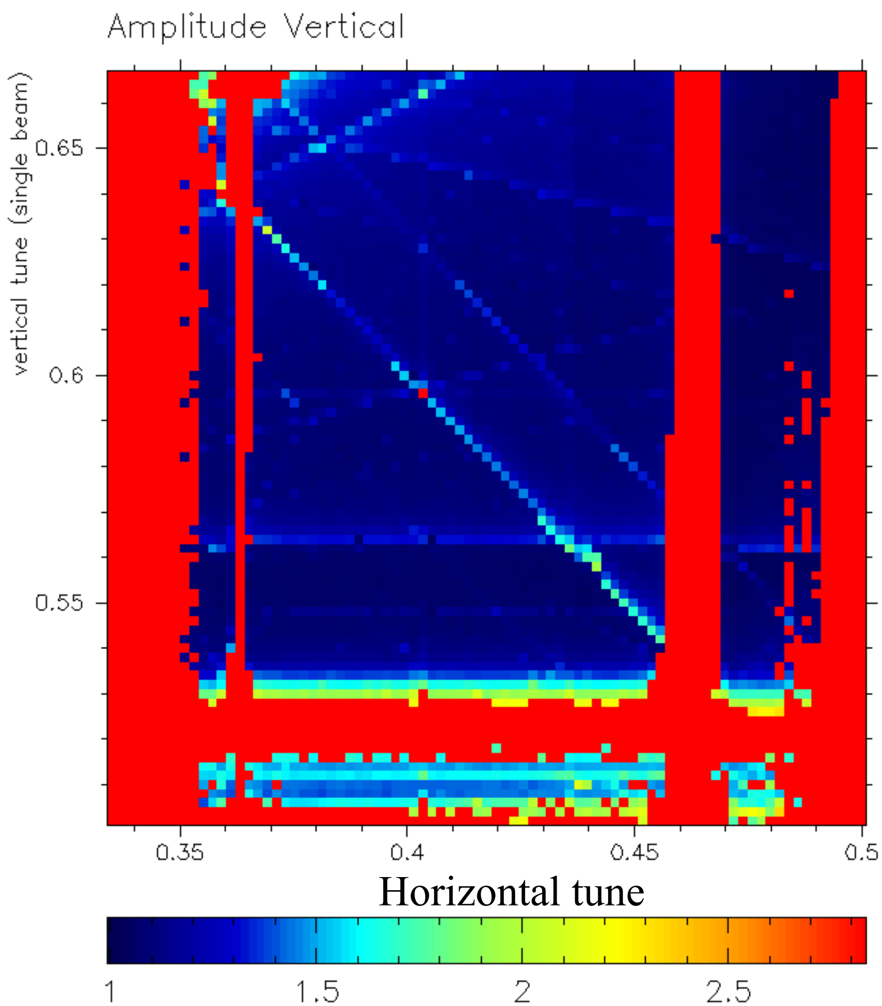
nominal



Zero dispersion in RF

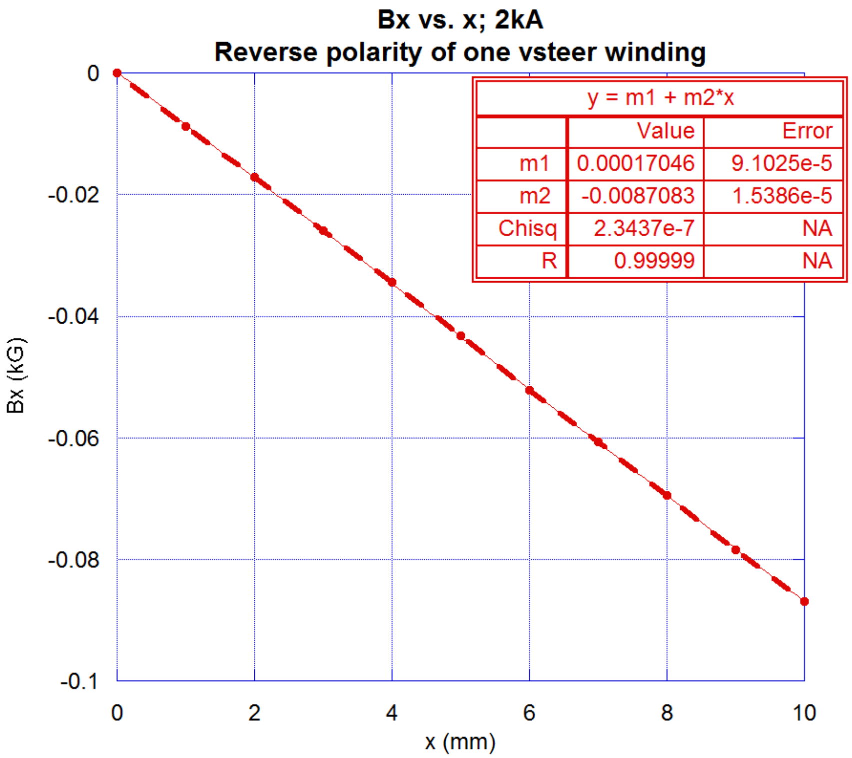


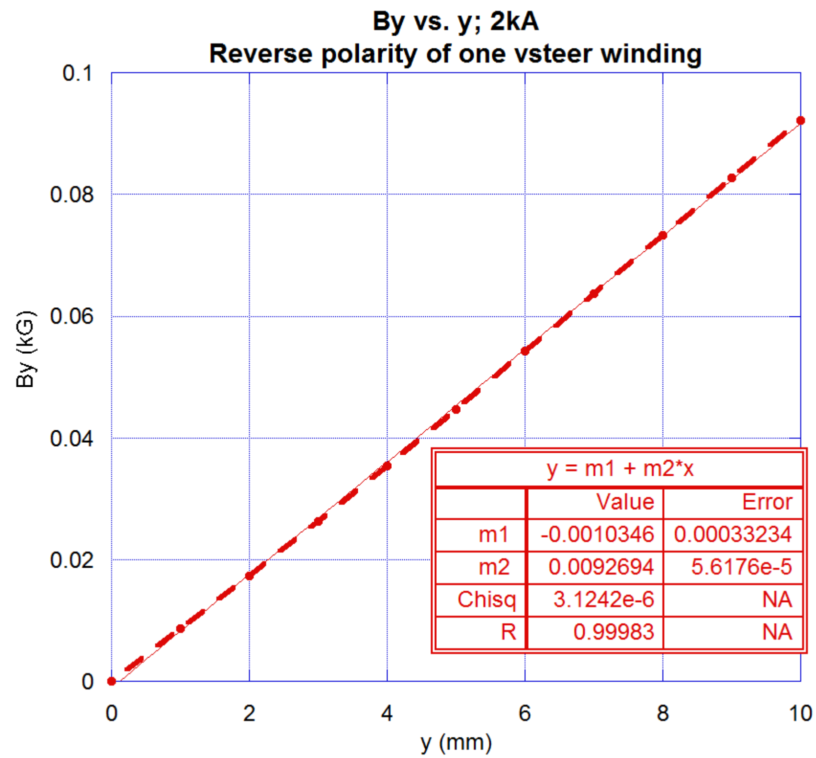
$Q_h<0.5$



Amplitude Vertical
vertical tune (single beam)
0.65
0.6
0.55
0.35
0.4
0.45
0.5
Horizontal tune
1
1.5
2
2.5

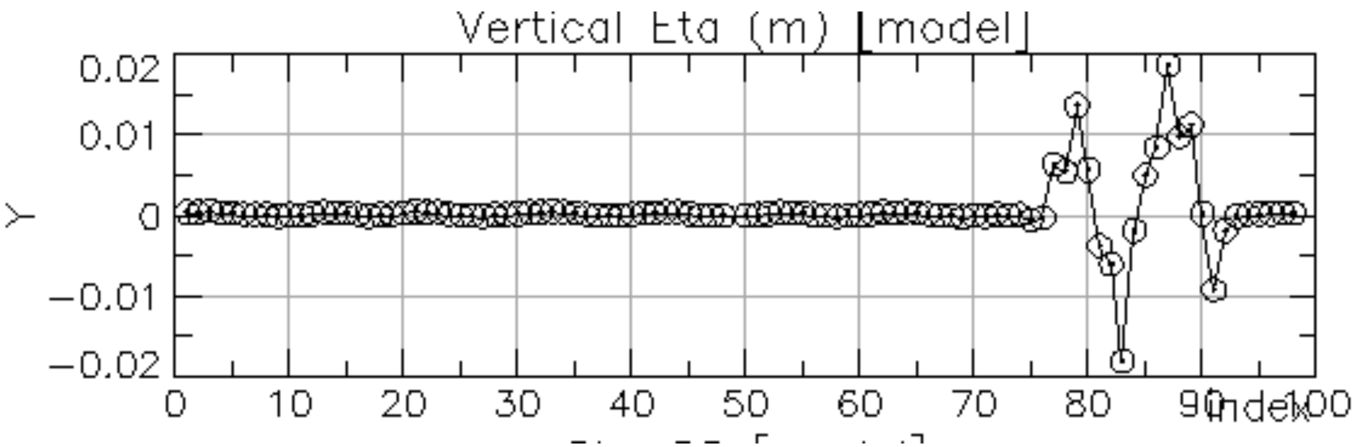
Reverse sextupole steering windings - skew quads



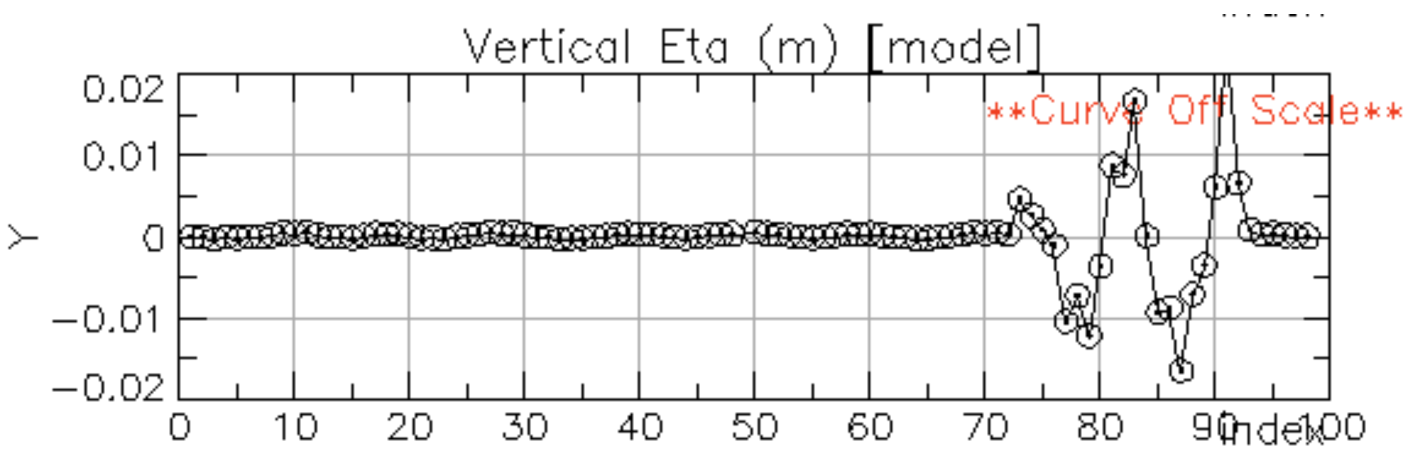


Skew quad k~0.002/m^2 @ 14A

Closed dispersion/coupling bumps

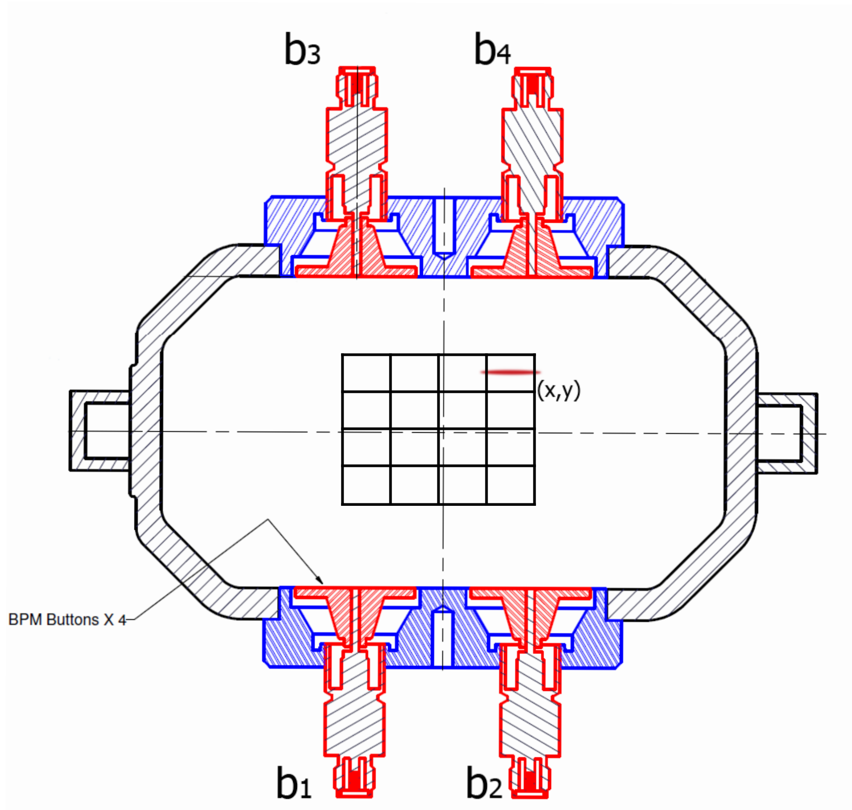


η_y at 18-19



η'_y at 18-19

Gain mapping



Signal at each button depends on bunch current (*k*) and position (*x,y*)

$$B_1 = kf(x,y)$$

$$B_1 \approx k\left(f(0,0) + \frac{\partial f}{\partial x}x + \frac{\partial f}{\partial y}y + \frac{1}{2}\frac{\partial^2 f}{\partial x^2}x^2 + \frac{1}{2}\frac{\partial^2 f}{\partial y^2}y^2 + \frac{\partial^2 f}{\partial x \partial y}xy + \ldots\right)$$

$$B_1 \approx k(c_0 + c_1 x + c_2 y + c_3 x^2 + c_4 y^2 + c_5 xy)$$

Signals on the four buttons are related by symmetry

$$B_2 = kf(-x,y)$$
$$B_3 = kf(x,-y)$$
$$B_4 = kf(-x,y)$$

Combining sums and differences we find the following relationship, good to second order

$$B_1 - B_2 - B_3 + B_4 = \frac{1}{k}\left(\frac{c_5}{c_1 c_2}\right)(B_1 - B_2 + B_3 - B_4)(B_1 + B_2 - B_3 - B_4)$$

$$B(+--+) = \frac{c}{k}B(+-+-)B(++--)$$

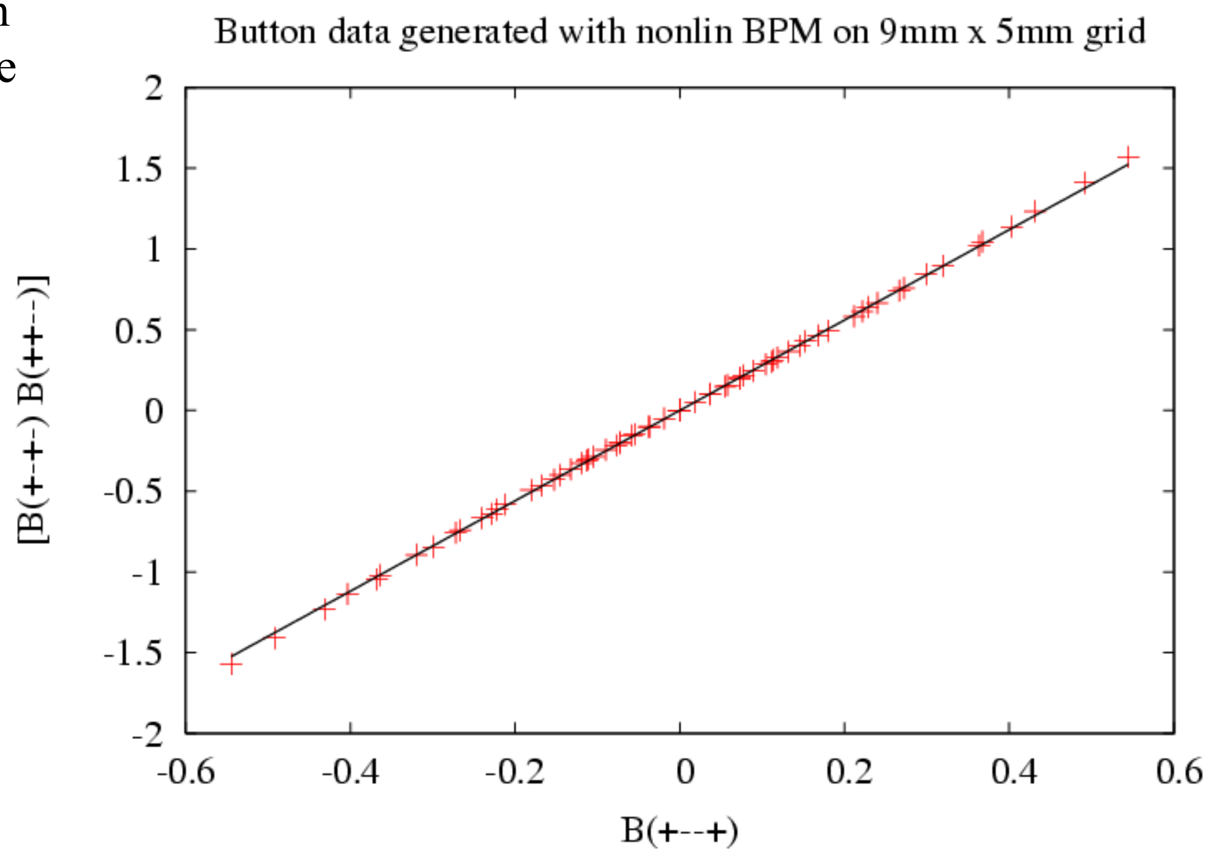
Simulation

$$B(+--+) = \frac{c}{k}B(+-+-)B(++--)$$

Using a map that reproduces the "exact" dependence of the button signals on the bunch positions we generate B_1,B_2,B_3,B_4 for each of 45 points on a 9mm x 5mm grid

In first order *c=0,* and therefore B(+--+) = 0. Evidently the first order approximation is not very good enough this range.

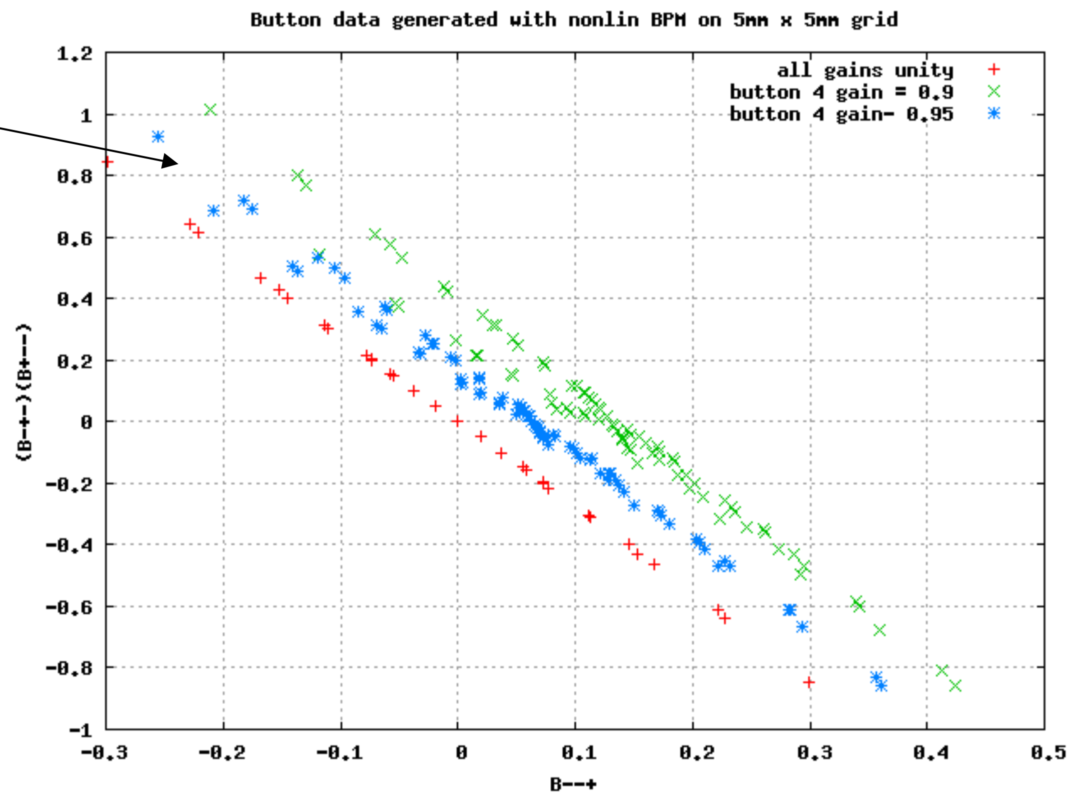
The small deviations from the straight line at large amplitudes is a measure of the higher than second order contributions.



Simulation with gain errors

$$B(+--+) = \frac{c}{k}B(+-+-)B(++--)$$

Introduce gain errors



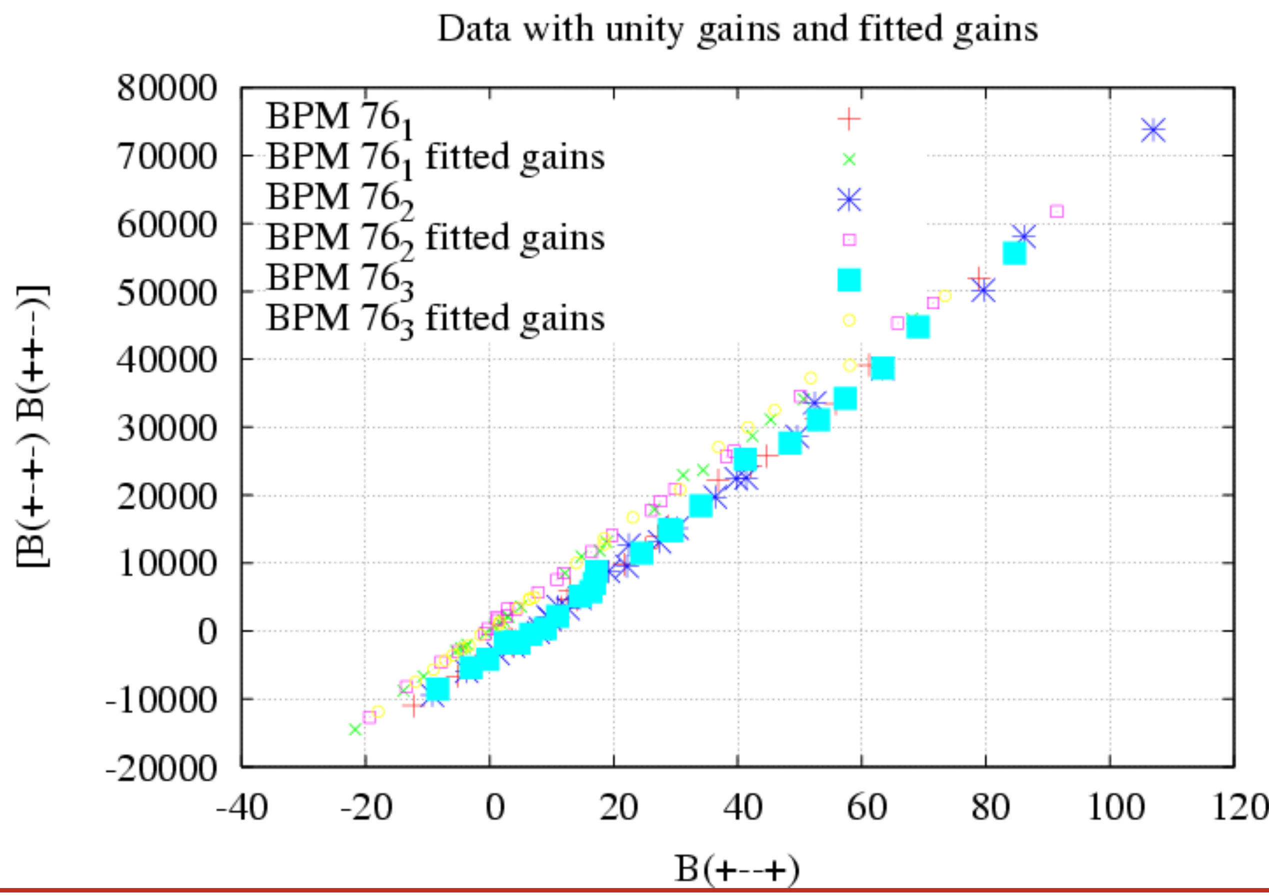
Zero offset, nonlinearity, and multi - valued relationship i n is a measure of gain errors.

Orbit data collected on a grid

To fit for gains

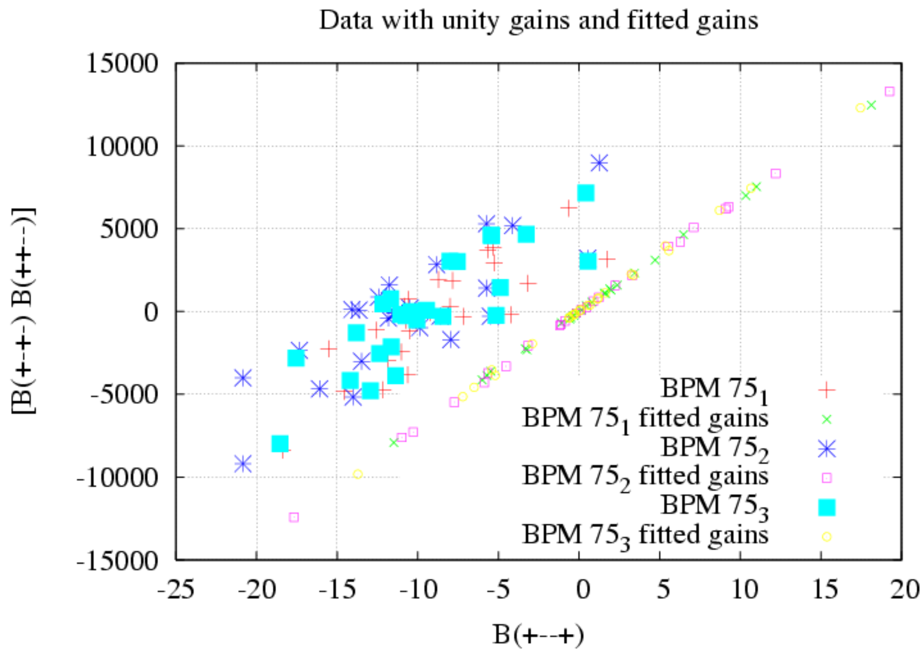
Fix g_1=1, and minimize with respect to g_2,g_3,g_4,c

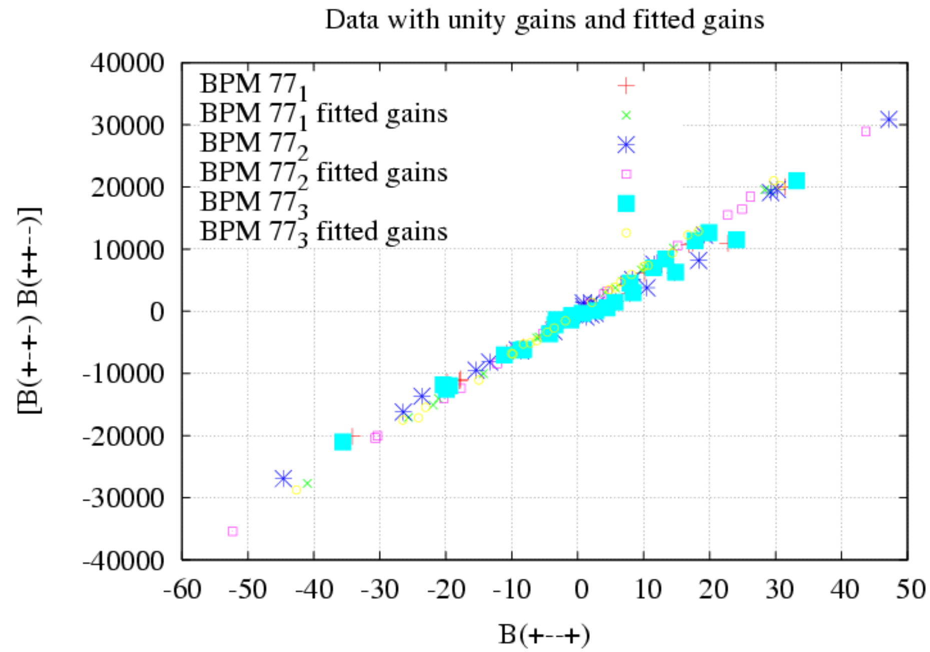
$$\sum_i \left[(g_1 B_1^i - g_2 B_2^i - g_3 B_3^i + g_4 B_4^i) - \frac{c}{I}(g_1 B_1^i - g_2 B_2^i + g_3 B_3^i - g_4 B_4^i)(g_1 B_1^i + g_2 B_2^i - g_3 B_3^i - g_4 B_4^i)\right]^2$$



Fitted gains = 1,0.95,0.96,0.97

Orbit data collected on a grid



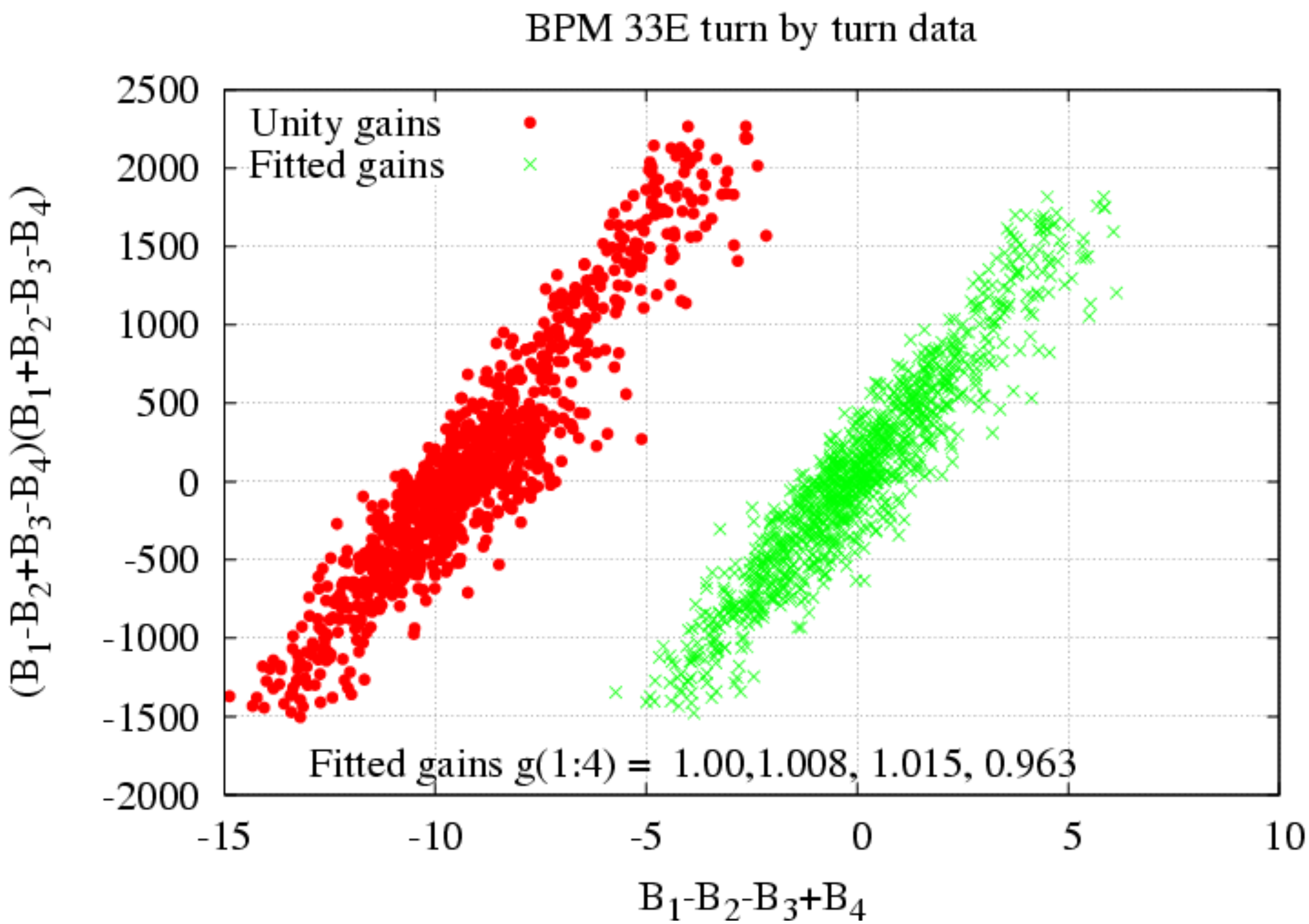


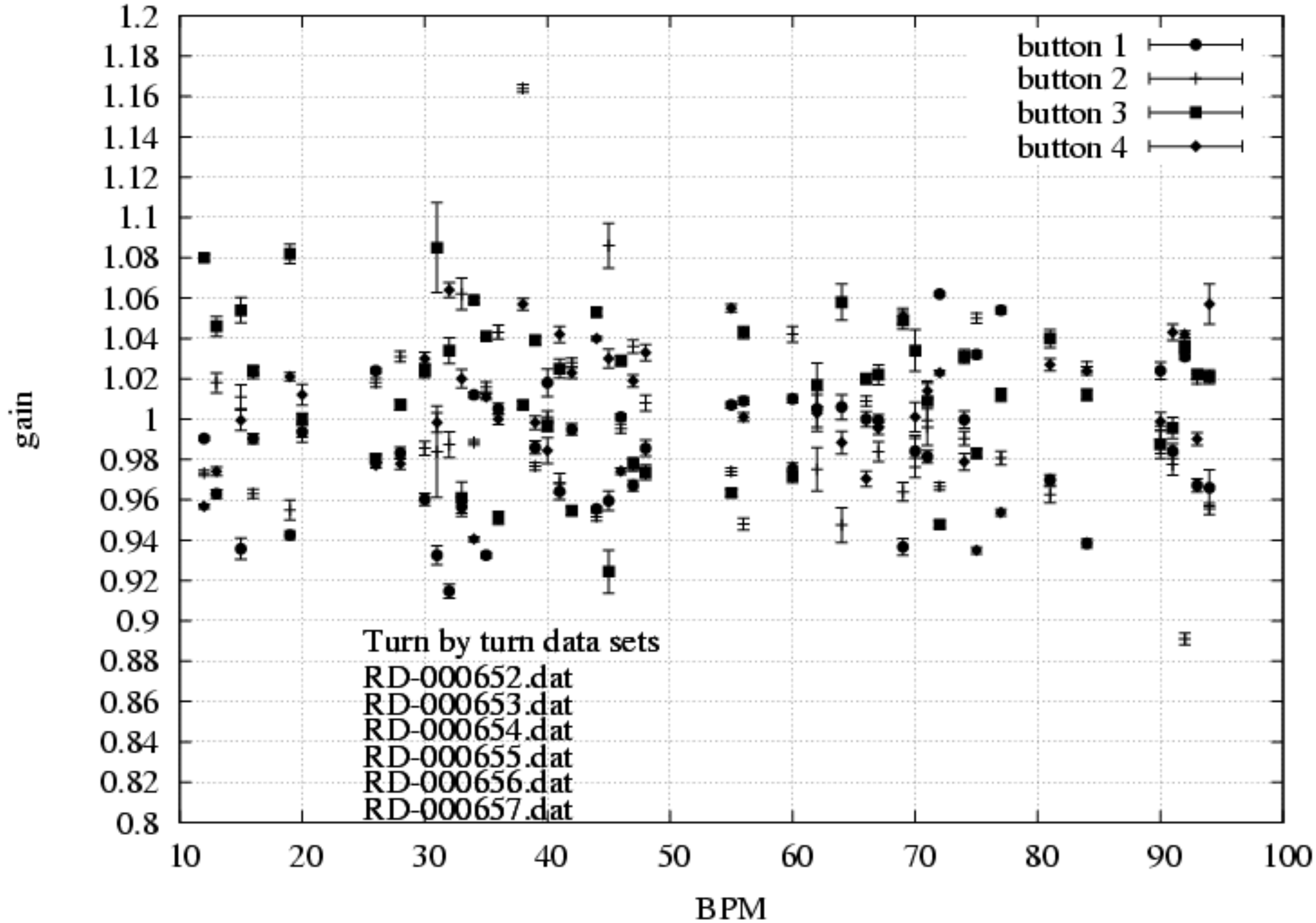
BPM 75 -
fitted gain = 1,1.02,0.96,0.91

BPM 77 -
fitted gain = 1,0.92,0.96,0.9

Fit typically reduces χ^2 by two orders of magnitude

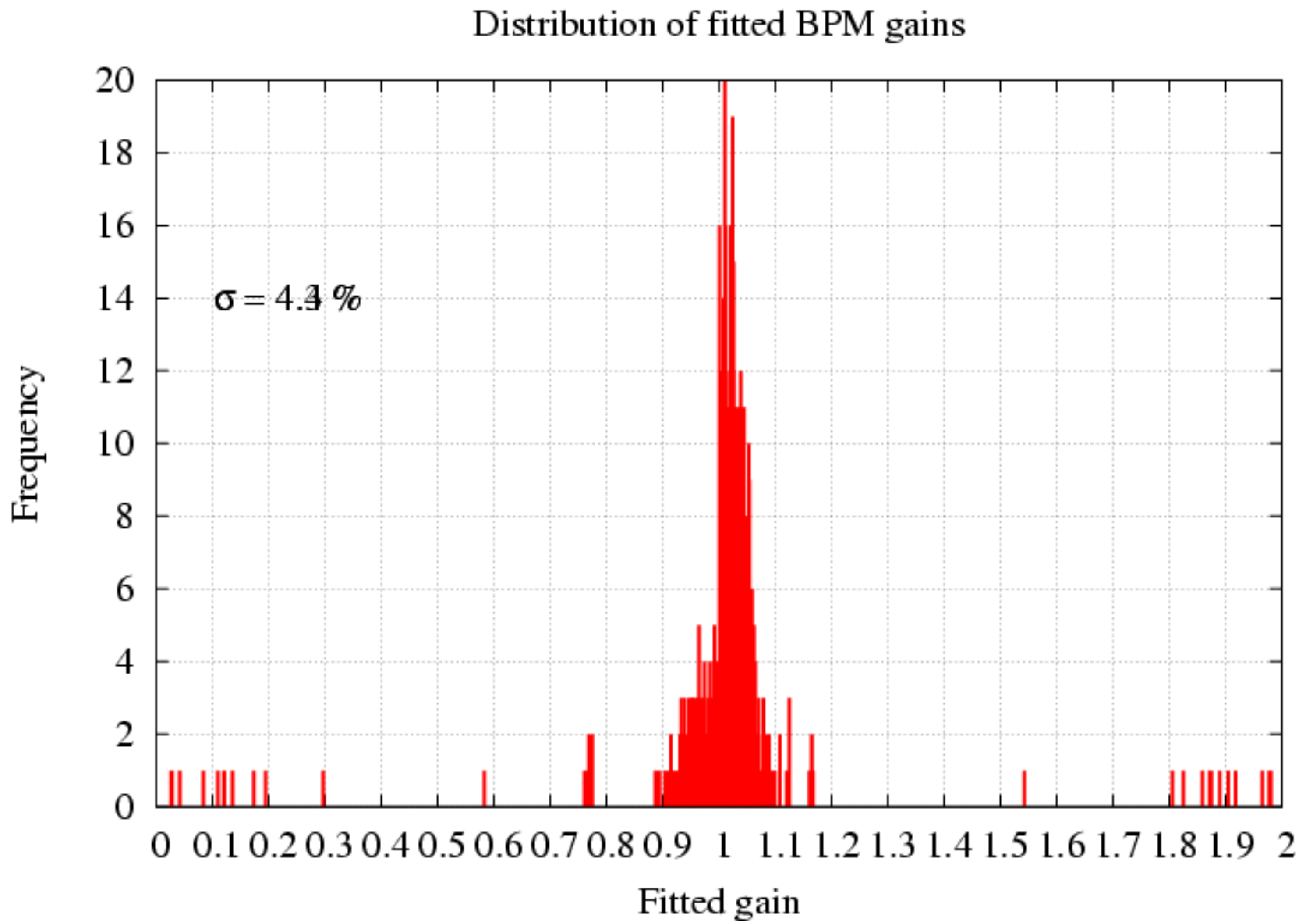
Turn by turn data, December 10, 2009





Average gains computed for 6 turn by turn data sets

Error bar is the standard deviation of the 6



Fitted gains from 6 turn by turn data sets, RD-000652, 653, 654, 655, 656, 657
Normalized so that average at each BPM of 4 gains is unity
Standard deviation, eliminating all points with gain errors greater than 50% is σ =4.3%

Data from December 19, 2009

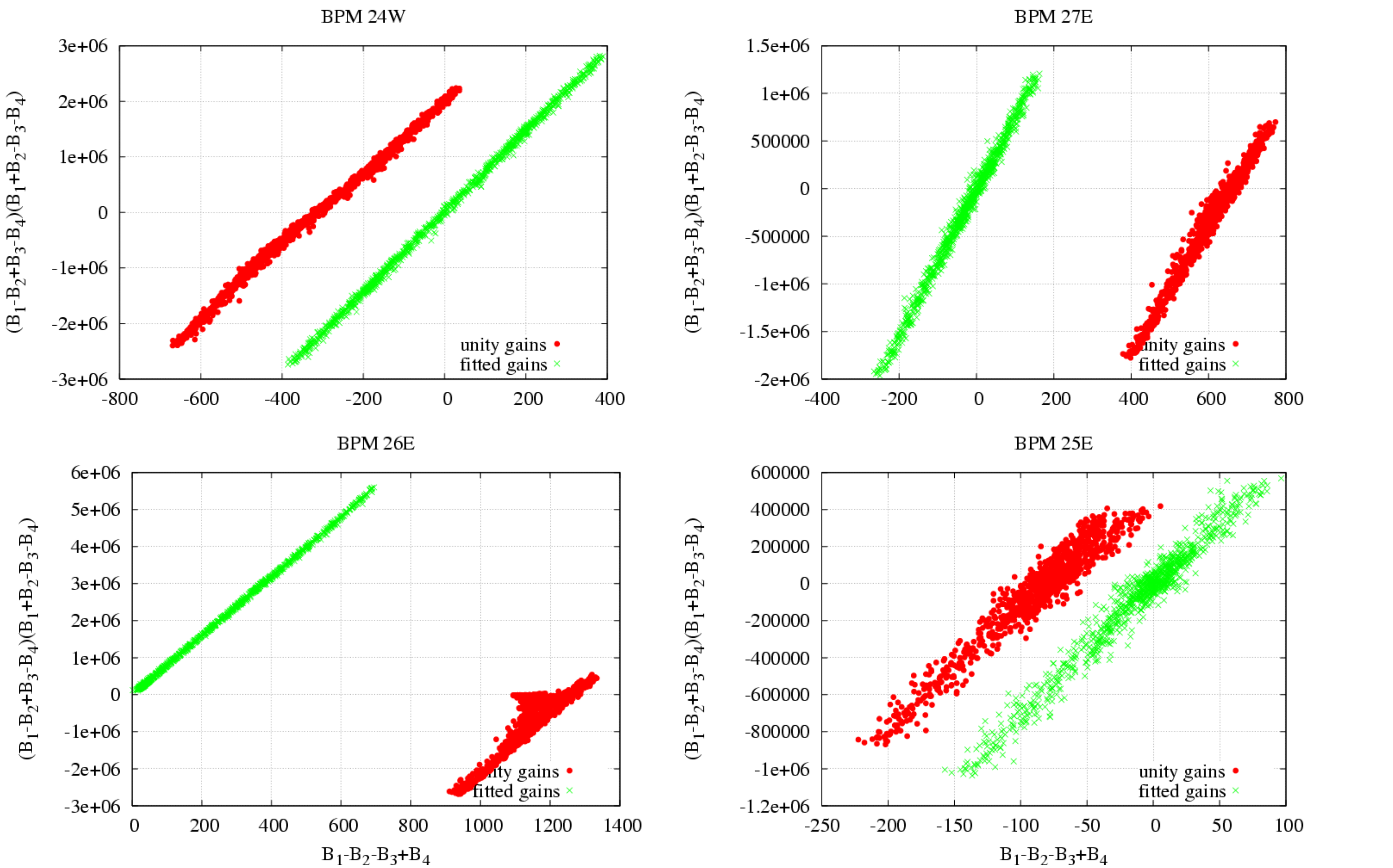
Turn by turn data RD-000908.dat, RD-000909.dat

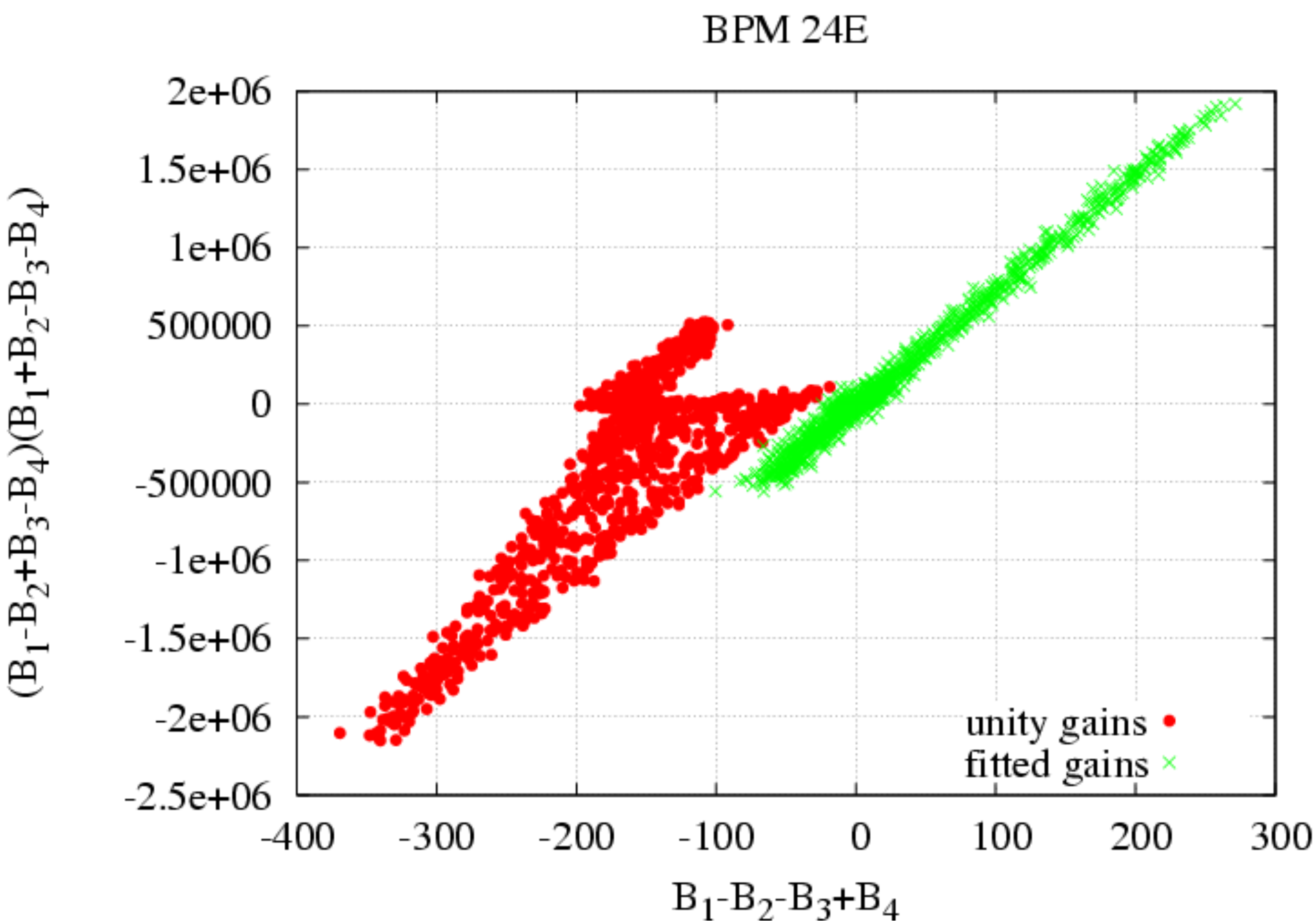
Immediately followed by
measurement of phase.8607
and ac_eta.165

1. Use turn by turn data to determine gains

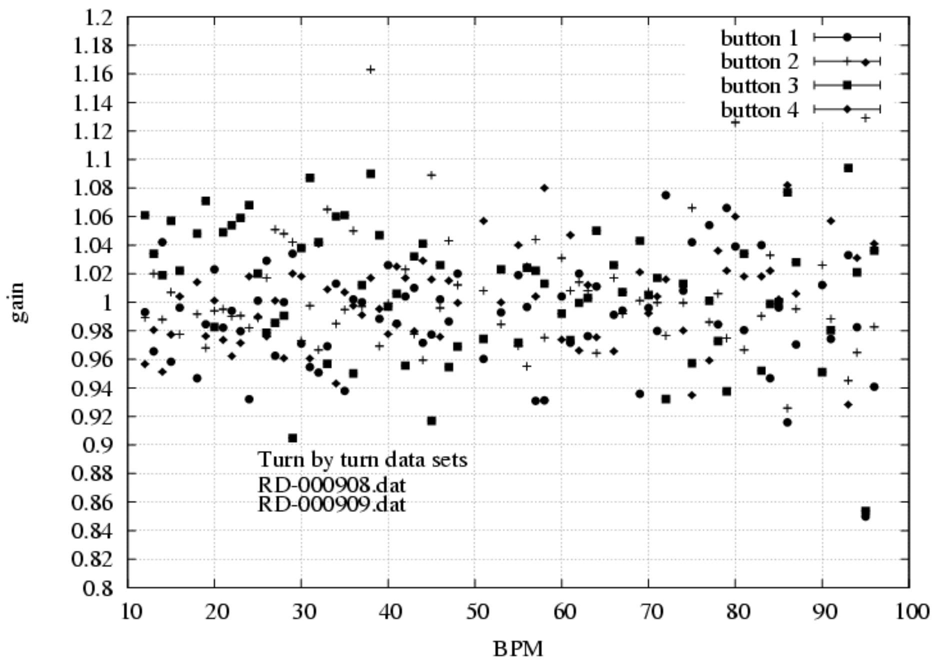
2. Use fitted gains to correct coupling and eta measurements

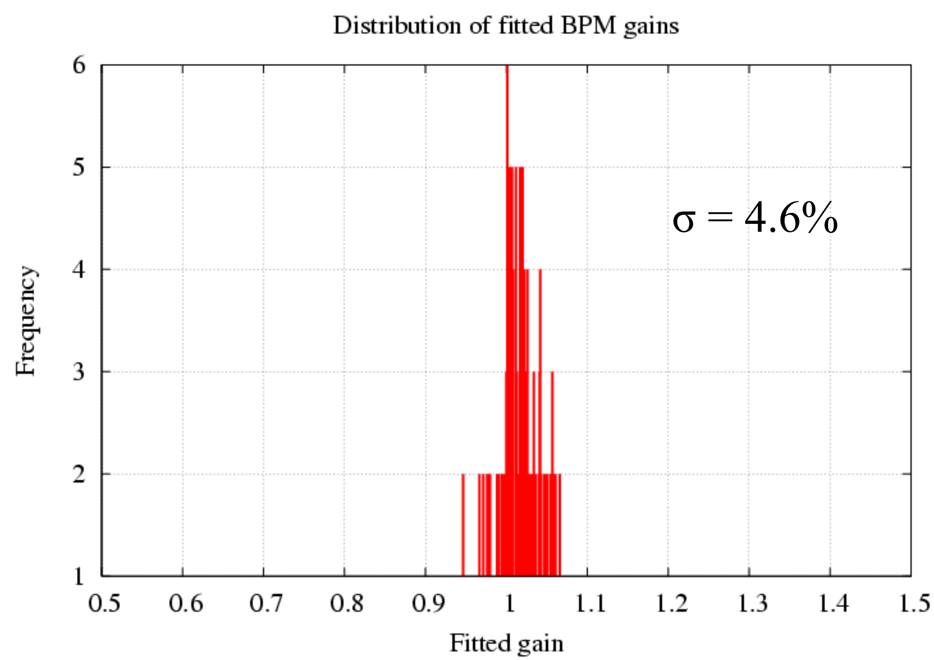
Examples of fits for various BPMs



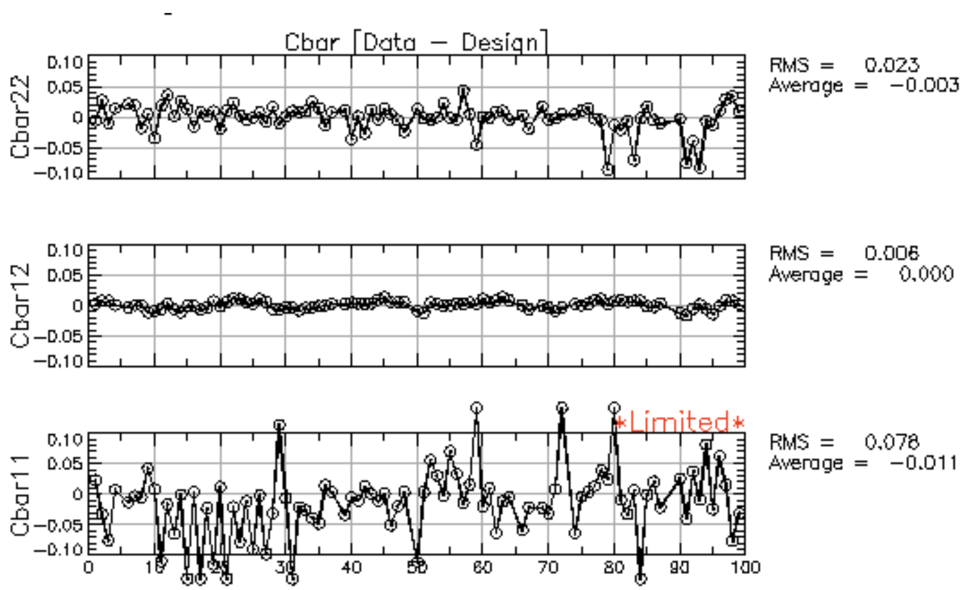

BPM 24E
2e+06
1.5e+06
1e+06
500000
0
-500000
-1e+06
-1.5e+06
-2e+06
-2.5e+06
-400
-300
-200
-100
0
100
200
300
(B1-B2+B3-B4)(B1+B2-B3-B4)
B1-B2-B3+B4
unity gains
fitted gains

Summary of fitted gains

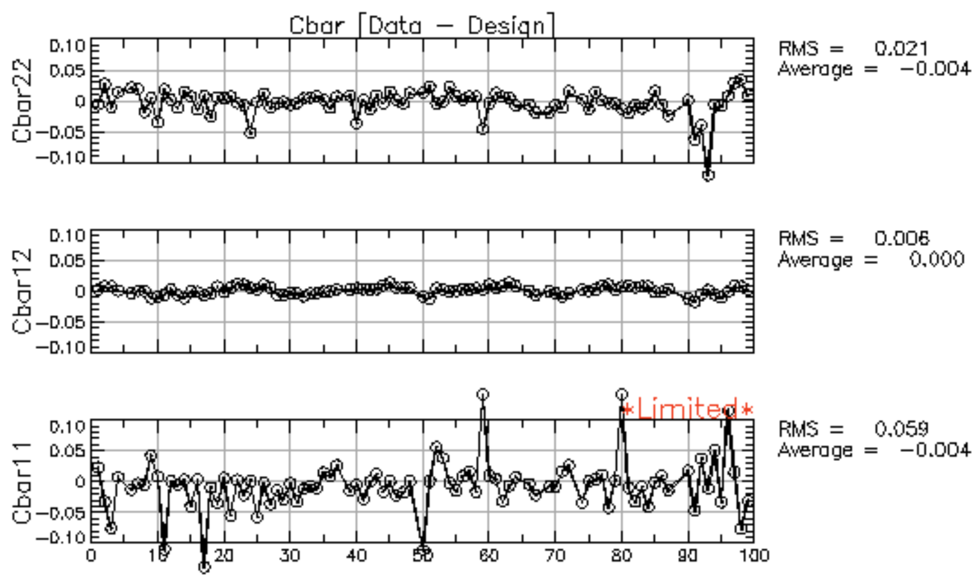




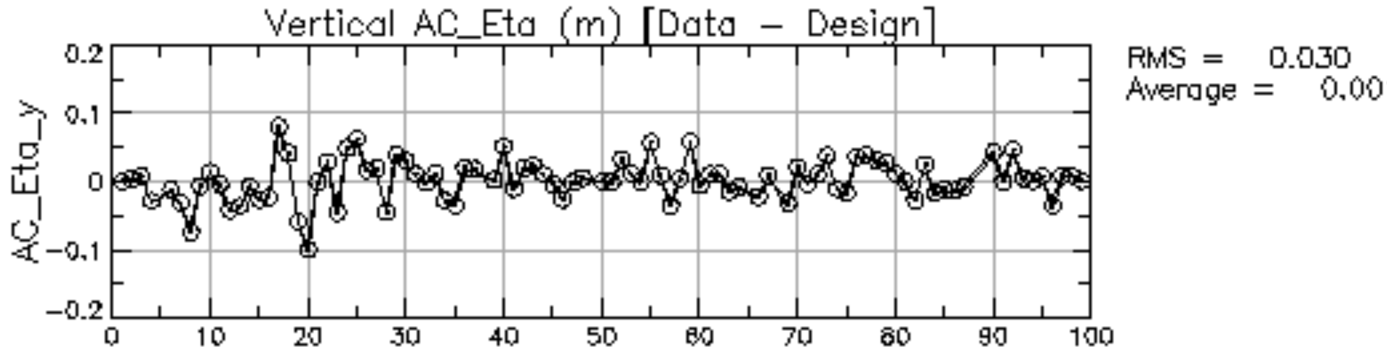
Coupling without
gain correction



Coupling with
gain correction



Dispersion without gain correction



Dispersion with gain correction