Apex Meeting 2006

Skew Chromaticity in RHIC

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Skew Chromaticity

Eigen-tunes from coupling:

$$\nu_{\pm}=\frac{1}{2}\{\nu_x+\nu_y\pm\sqrt{(\nu_x-\nu_y)^2+|\boldsymbol{q}|^2}\} \qquad \Delta Q_{min}=|\boldsymbol{q}|$$

Off-momentum behavior:

$$\nu_x\rightarrow\nu_x+\xi_x\delta \qquad \nu_y\rightarrow\nu_y+\xi_y\delta \qquad \boldsymbol{q}\rightarrow\boldsymbol{q}+\boldsymbol{k}\delta$$

$$\nu_{\pm}(\delta)=\frac{1}{2}\{(\nu_x+\nu_y)+(\xi_x+\xi_y)\delta\pm\sqrt{[(\nu_x-\nu_y)+(\xi_x-\xi_y)\delta]^2+[\boldsymbol{q}+\boldsymbol{k}\delta]^2}\}$$

$$minimum(\Delta Q_{min})\approx|\boldsymbol{k}|\frac{\sigma_p}{p} \qquad \Delta Q_{min}^2\rightarrow|\boldsymbol{q}|^2+2\boldsymbol{q}\cdot\boldsymbol{k}\delta+|\boldsymbol{k}|^2\delta^2$$

Stability conjecture (G. P. Goderre, S. Peggs, et al, "Head Tail Stability and Linear Coupling in the Tevatron", IEEE Part. Accel Conf (1991)):

$$0<\xi_{\pm}=\frac{d\nu_{\pm}}{d\delta}$$

BBQ – Tune with Coupling

- Tune is measured with Base Band Tune meter
- The system was enhanced to measure X-Y coupling
- Take a Tune-Coupling measurement at different beam momenta
  - Fit eigen-tunes, skews to a polynomial
  - Calculate uncoupled tunes

Chromaticity Application

RhicChromaticity

File Setup Help

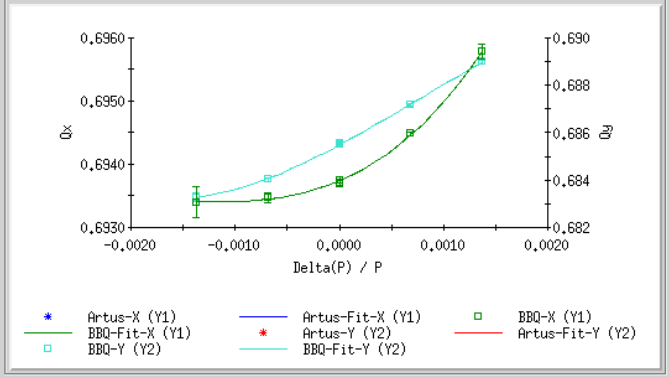
Acquisition	Tune-meter	Single Shot	Stop	Steer Max [mm]	Steps	Ring	State
Single Shot	BBQ	Measure	Stop	1.5	5	Both	-- Ready --
Ring	Stone	Brho [T-m]	RF State	RF Freq	Collimator	Gap Cleaner	Rebucket
Blue	pp35::store	334.28311	Hold	28149440	Out	Off	Off
Yellow	pp35::store	334.28311	Hold	28149440	Out	Off	Off

0.0%

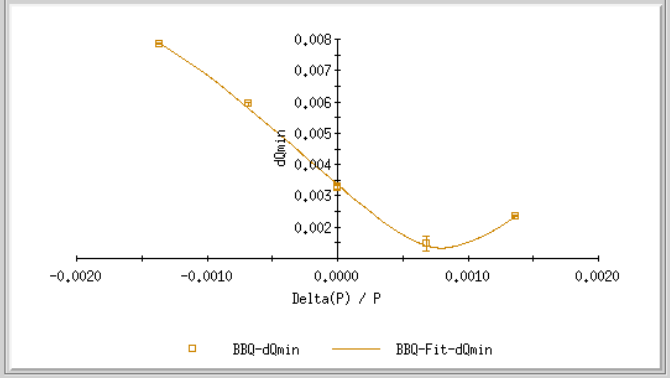
Blue Yellow

Stone	Date	Time	Brho [T-m]	Gamma	Circ [m]	GammaT	Order
pp35::store	May 31 2006	00:58:00	334.283	106.813	3833.845181	23.5967	3
Chromaticity	Corr	Tune	+-Sigma	Chrom[1]	+-Sigma	Chrom[2]	+-Sigma
Artus-H (Eigen)	0	-999	-999	0	0	0	0
Artus-V (Eigen)	0	-999	-999	0	0	0	0
BBQ-H (Eigen)	0.999615	0.693742	1.63223e-05	0.693998	0.0184808	457.231	20.5145
BBQ-V (Eigen)	0.999816	0.685479	2.57888e-05	2.36618	0.0291991	341.127	32.4125
BBQ-H (Set)	0.999906	0.693381	1.2645e-05	1.43917	0.0143172	88.3236	15.8928
BBQ-V (Set)	0.999928	0.68584	1.21914e-05	1.62128	0.0138036	708.49	15.3226
BBQ-H (Skew)	0.999842	0.000812642	2.72737e-05	-2.85253	0.0308804	289.872	34.2787
BBQ-V (Skew)	0.999476	-0.00325533	5.8194e-05	2.96783	0.0658896	398.064	73.1406
	Raw Data...	Correction...	Analysis...	Dispersion...	Chrom-Time...	Tune Above	

Eigen Tune vs Momentum



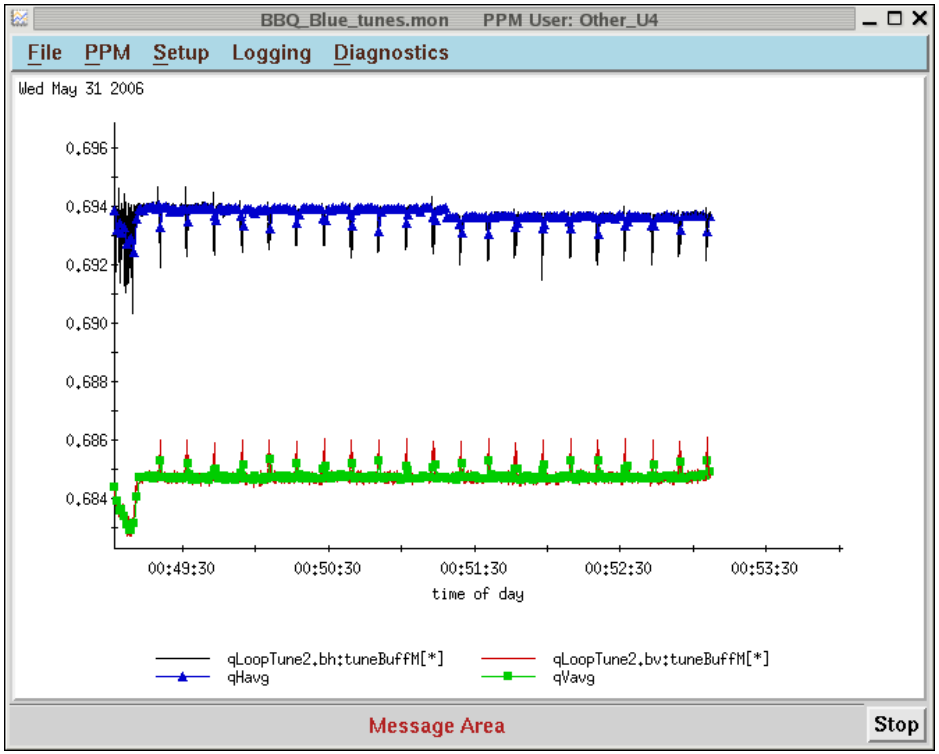
dQmin vs Momentum



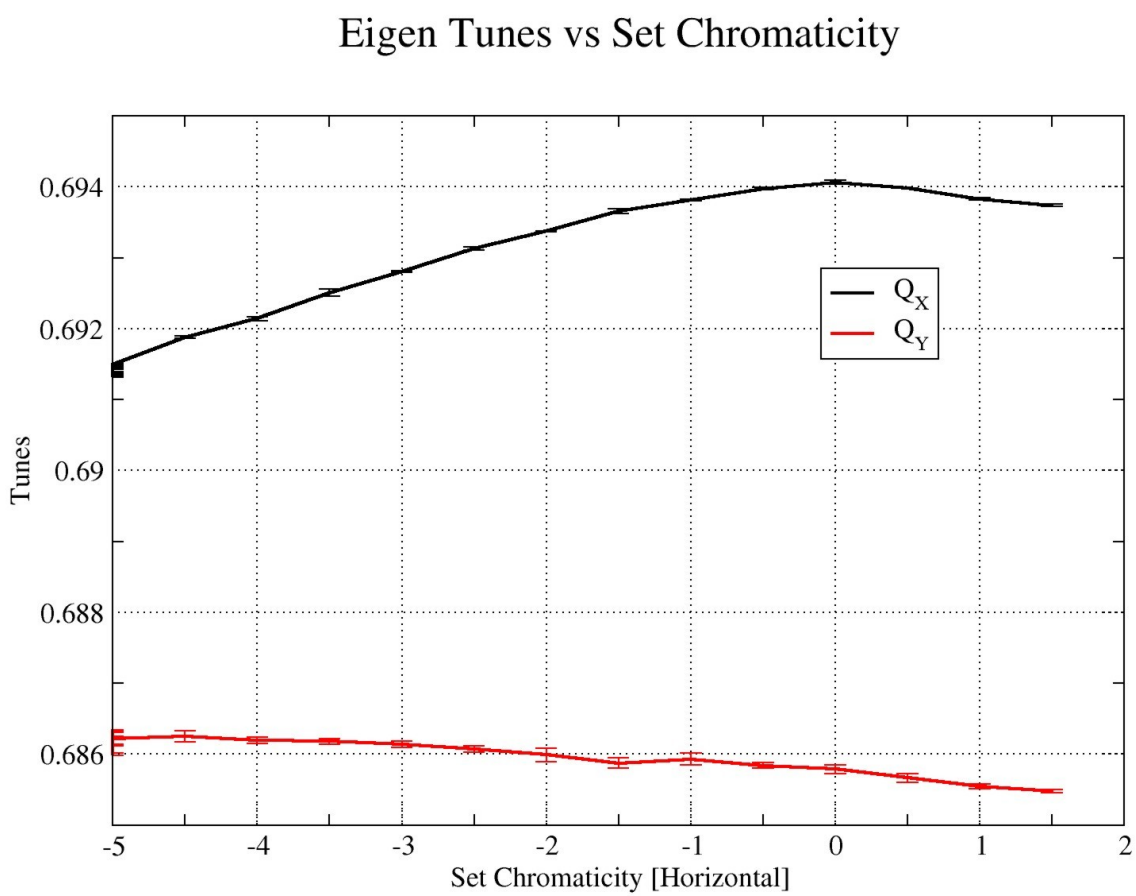
Inform -- Number of Blue BPMs: 334
Inform -- Number of Yellow BPMs: 334

BBQ – Tune with Coupling

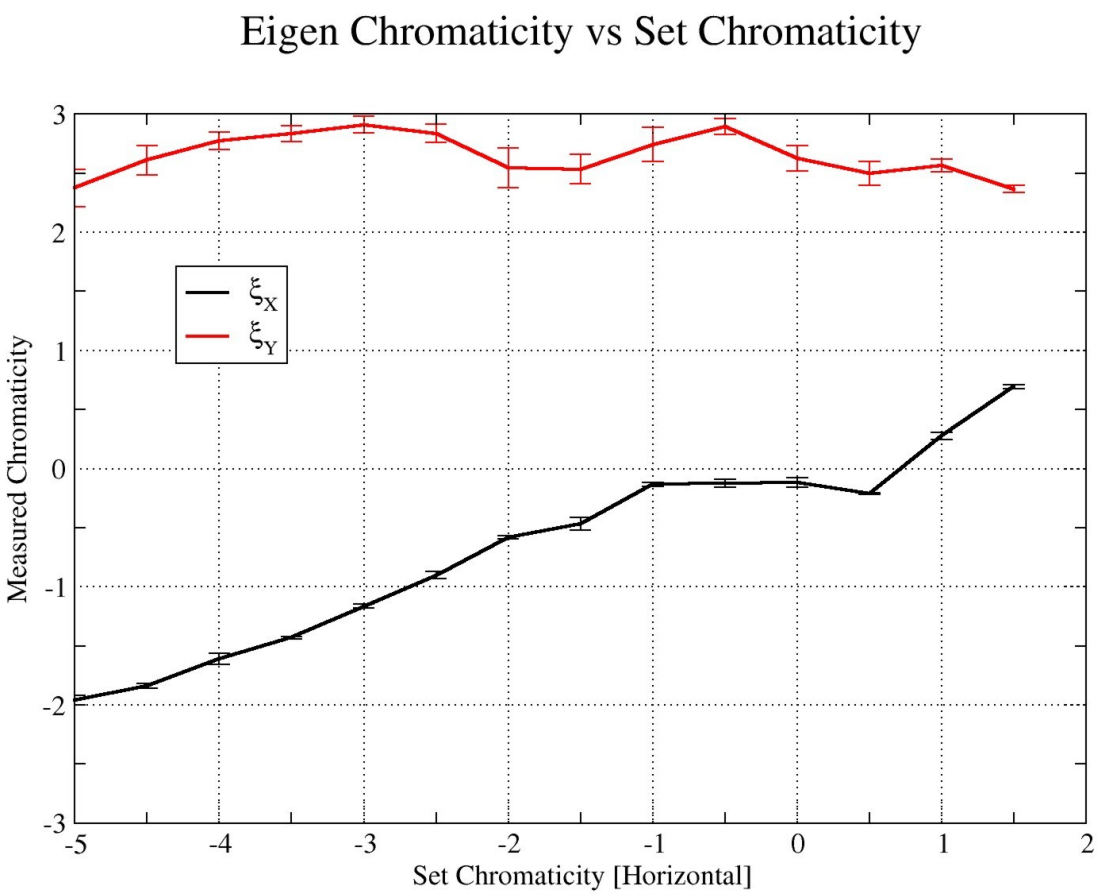
- BBQ is sensitive to noise
- Beam-Beam interactions causing the spikes
- Matched momenta changes in both rings eliminated the beam-beam interaction



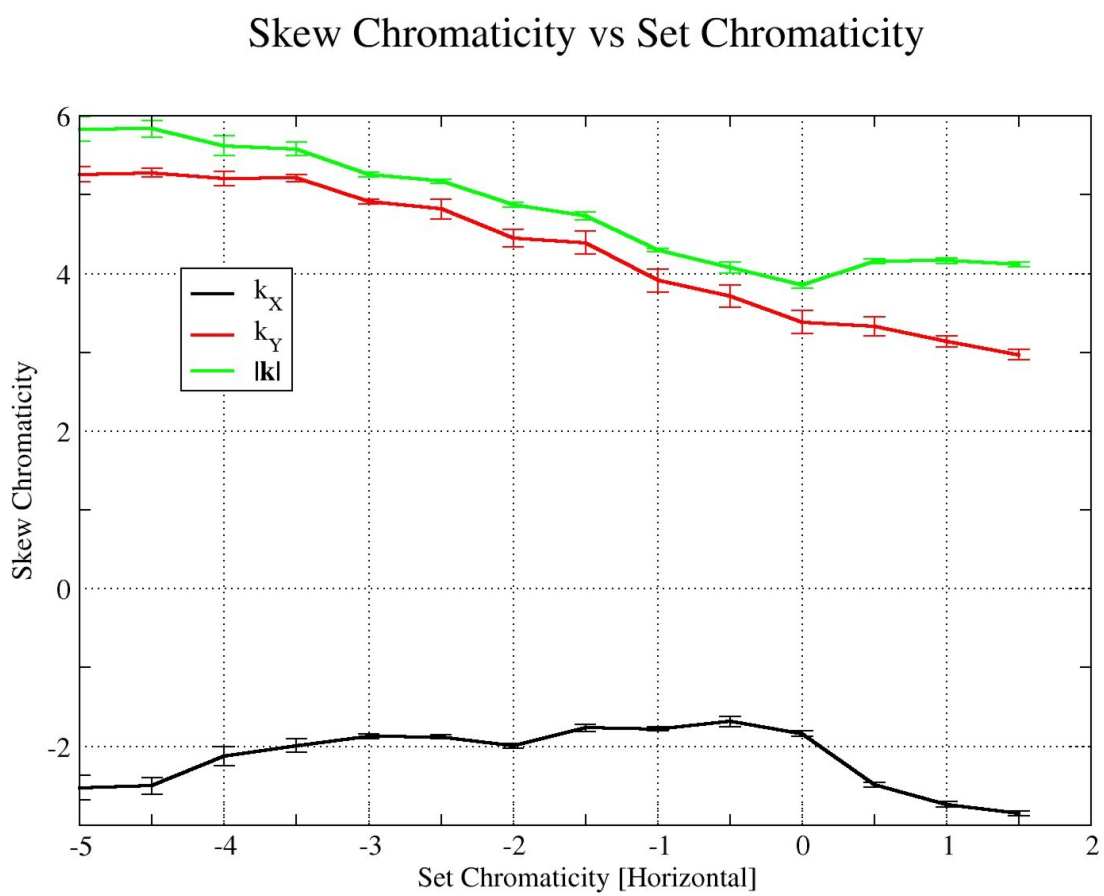
Measure vs Set Chromaticity



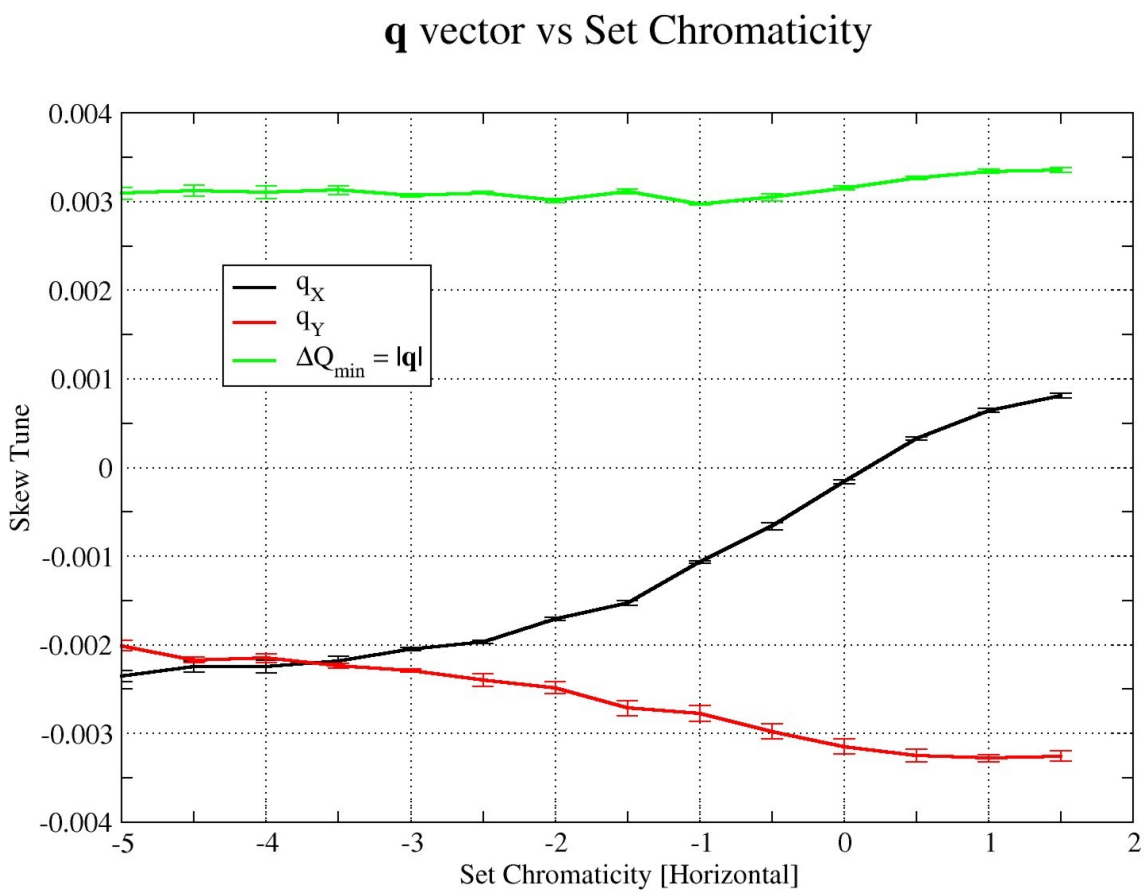
Measure vs Set Chromaticity



Measure vs Set Chromaticity

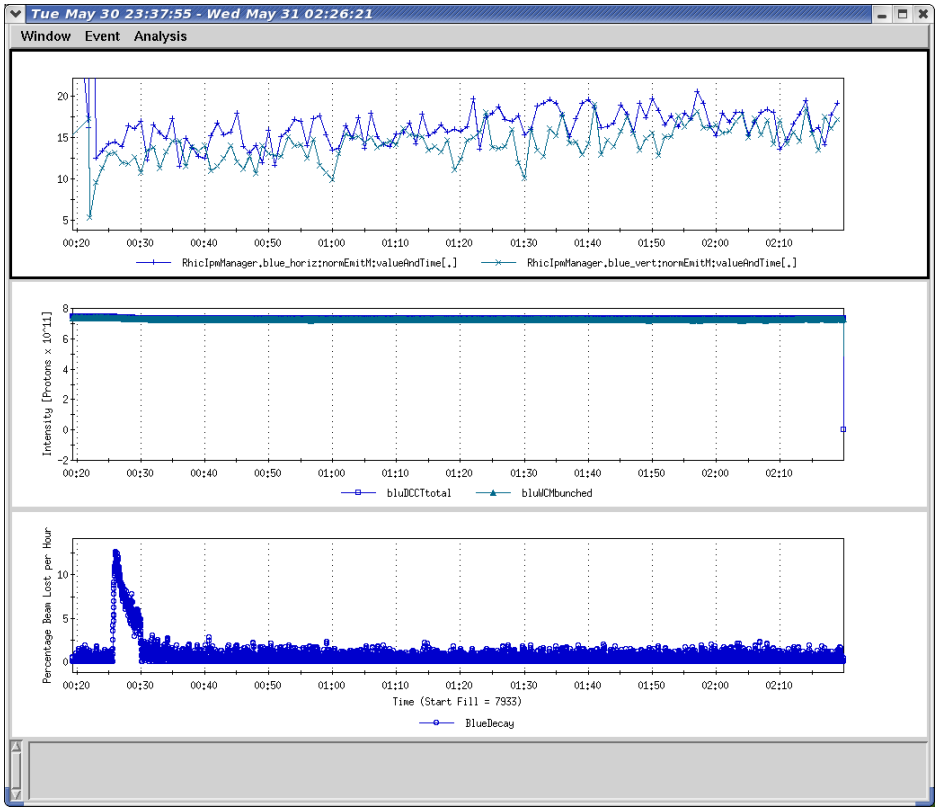


Measure vs Set Chromaticity



Stability

- Emittance
- Intensity
- Beam Decay
- No loss from Beam decay was observed even though the chromaticity became negative

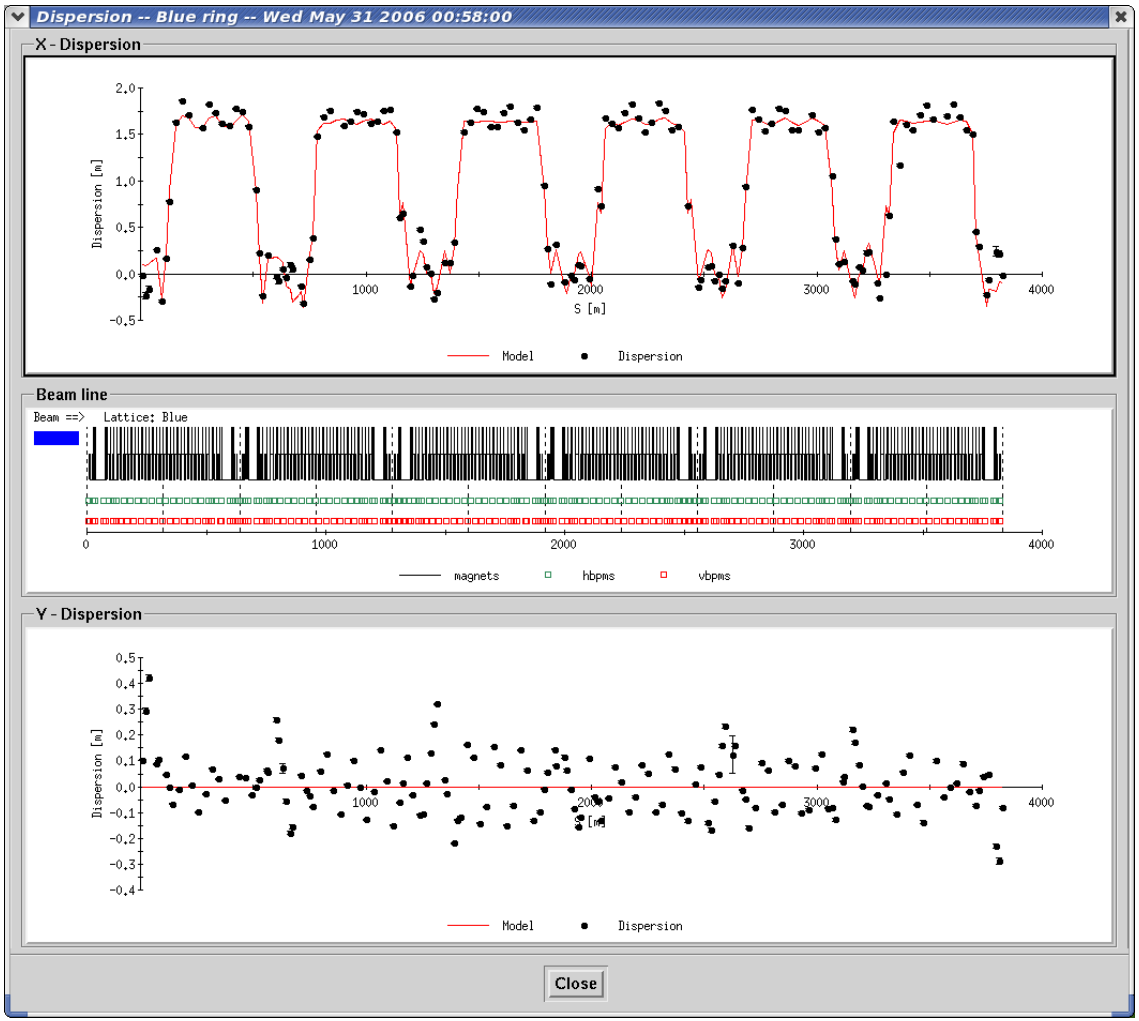


Dispersion

- Dispersion
  - Horizontal at Q_F
  - Vertical at Q_D

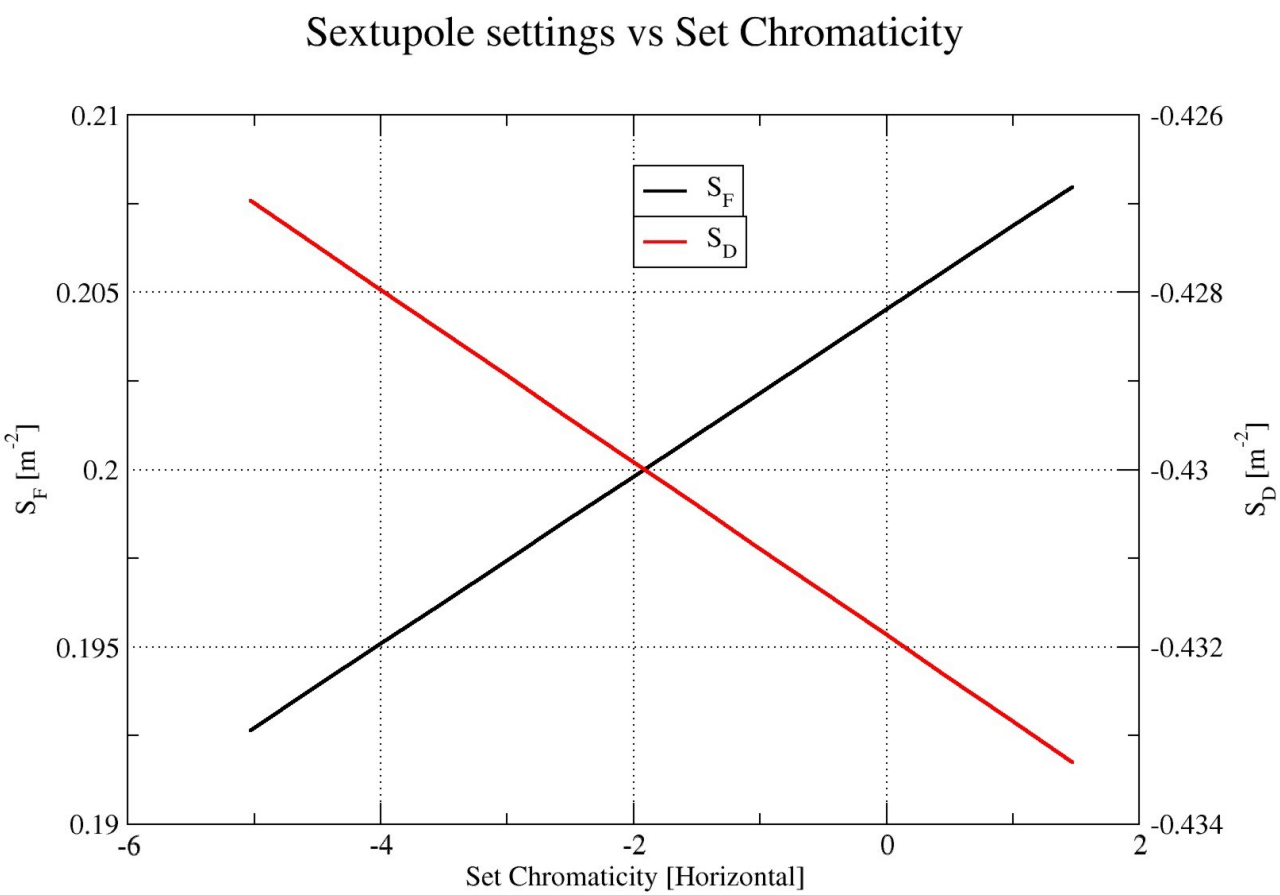
$$|k_i| = \frac{B_2}{\pi} D_y \sqrt{\beta_x \beta_y}$$

$$\Delta |k_i| = A \Delta S_F + B \Delta S_D$$



S. Peggs and G. F. Dell, "Skew Chromaticity", RHIC/AP/57 (1995)

Sextupole Strengths



Results

- Averaged vertical dispersion = 3.02*mm* for S_D
- Average over $(\beta_x\beta_y)^{1/2}$ = 22.158*m* for S_D
- As set chromaticity becomes more negative
  - S_F and S_D tend toward zero
- The measured |**k**| may be explained if averaged vertical dispersion on S_F are negative and is 65 times larger → -0.2*m*?

Summary

- Described the tools to measure the skew chromaticity
- Made measurements while changing the Sextupoles
- Failed to reproduce the stability condition seen at the Tevatron
- Under some extreme numbers, I could explain the variation of |**k**| with the sextupoles.