Nonlinear Chromaticity

The contribution to the Hamiltonian due to the octupoles:

$$\Delta H = [\frac{1}{4}x^4 - \frac{3}{2}x^2 y^2 + \frac{1}{4}y^4] b_3$$

From the following:

$$x = \sqrt{2\beta_x J_x}\cos(\phi_x) + \eta_x \delta \qquad y = \sqrt{2\beta_y J_y}\cos(\phi_y) + \eta_y \delta \qquad \Delta\nu_{x(y)} = \frac{1}{2\pi}\oint \frac{\partial H}{\partial J_{x(y)}} ds$$

The tune spread can be found:

$$\Delta\nu_x = \frac{1}{2\pi}[\frac{3}{4}J_x\langle\beta_x^2 b_3\rangle + \frac{3}{2}\langle\beta_x(\eta_x^2 - \eta_y^2)b_3\rangle\delta^2 - \frac{3}{2}J_y\langle\beta_x\beta_y b_3\rangle]$$

$$\Delta\nu_y = \frac{1}{2\pi}[\frac{3}{4}J_y\langle\beta_y^2 b_3\rangle + \frac{3}{2}\langle\beta_y(\eta_y^2 - \eta_x^2)b_3\rangle\delta^2 - \frac{3}{2}J_x\langle\beta_x\beta_y b_3\rangle]$$

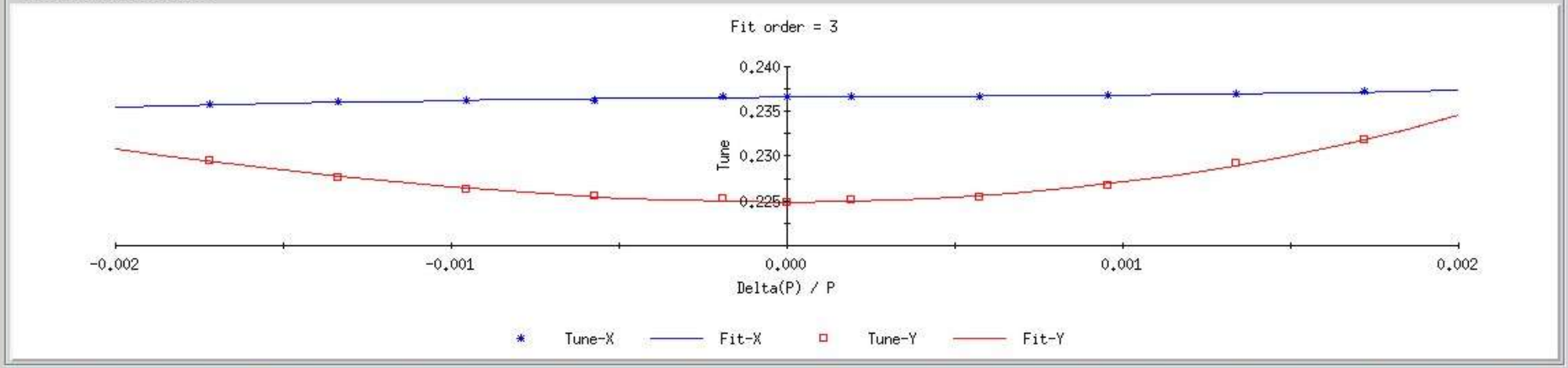
Nonlinear Chromaticity

Four families of octupoles for momnetum and amplitude detuning.
Assume $J = J_x = J_y$ to reduce the system to four familes

Chrom2x	165.94	11.71	2.39	0.3	b-octf-disp
Chrom2y	-37.03	-47.41	-0.58	-0.47	b-octd-disp
dQx	388.47	-288.51	134.82	-105.93	b-octf-nodisp
dQy	-278.41	339.16	-111.4	127.57	b-octd-nodisp
b-octf-disp	6.7415E-3	1.6485E-3	-3.8430E-4	-3.2912E-4	Chrom2x
b-octd-disp	-5.0015E-3	-2.2807E-2	-2.1888E-4	-2.5341E-4	Chrom2y
b-octf-nodisp	-2.5872E-2	-9.8336E-3	2.5025E-2	2.0806E-2	dQx
b-octd-nodisp	5.4180E-3	5.5643E-2	2.1595E-2	2.5961E-2	dQy

Analysis of Data -- Yellow ring -- Wed Jan 07, 2004 00:44:32

Tune vs. Momentum

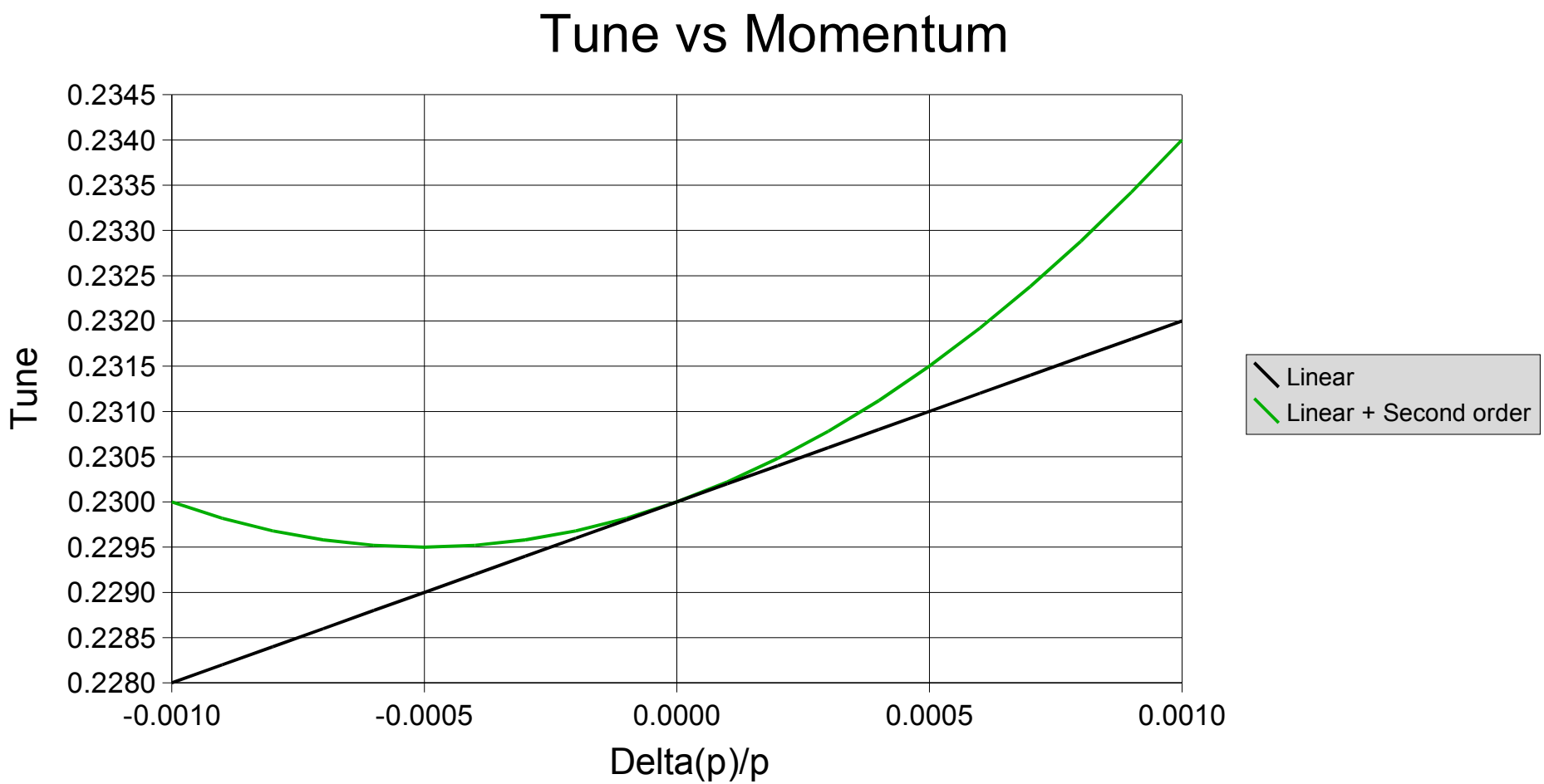


Row	Delta(p)/p	PLL X	+- Sigma	Tune X #1	Tune X #2	Select	PLL Y	+- Sigma	Tune Y #1	Tune Y #2	Sel
1	-0.00171857	0.235724	1.6446e-05	0.233398	0.225586	PLL	0.229526	0.000234243	0.225586	0.232422	P
2	-0.00133686	0.236026	0.000134588	0.233398	0.225586	PLL	0.227655	8.48944e-05	0.225586	0.219727	P
3	-0.000954283	0.236194	3.64387e-05	0.233398	0.222656	PLL	0.226289	6.01458e-05	0.225586	0.219727	P
4	-0.00057257	0.236215	3.58784e-05	0.233398	0.239258	PLL	0.225481	2.21892e-05	0.220703	0.226562	P
5	-0.000189997	0.236679	3.24337e-05	0.233398	0.223633	PLL	0.225232	1.55031e-05	0.22168	0.227539	P
6	0	0.236694	1.81041e-05	0.233398	0.225586	PLL	0.224796	3.83848e-05	0.222656	0.228516	P
7	0.000190857	0.236673	4.72662e-05	0.233398	0.239258	PLL	0.225039	7.26861e-05	0.222656	0.216797	P
8	0.000573429	0.236687	2.96285e-05	0.234375	0.240234	PLL	0.225448	2.79985e-05	0.227539	0.22168	P
9	0.000955143	0.23674	6.51716e-05	0.234375	0.227539	PLL	0.226715	6.26681e-05	0.228516	0.222656	P
10	0.00133772	0.236944	3.31231e-05	0.234375	0.228516	PLL	0.229153	7.73592e-05	0.229492	0.222656	P
11	0.00171943	0.237194	3.79174e-05	0.235352	0.241211	PLL	0.231836	5.04111e-05	0.230469	0.224609	P

	Corr	Tune	+-Sigma	Chrom[1]	+-Sigma	Chrom[2]	+-Sigma	Chrom[3]	+-Sigma
Horizontal	0.976348	0.236583	3.36492e-05	0.264218	0.0321648	-53.4223	31.4851	52985.6	36028.9
Vertical	0.99781	0.224878	5.43421e-05	0.0437105	0.0519449	1952.77	50.8472	224538	58185.1

Set Peak #1 | Set PLL | Close

Nonlinear Chromaticity



Nonlinear Chromaticity

Case	Oct – disp		Oct – nodisp		Measured		Predicted	
	F	D	F	D	X	Y	X	Y
0	0	0	0	0	-53	1953	-53	1953
1	2	0	0	0	-3	1739	279	1879
2	2	-1	0	0	-144	1670	267	1926
3	4	-1	0	0	13	1445	599	1852
4	4	-1	0	2	-15	1802	600	1851
5	4	0	-1	-4	102	1696	607	1806
6	4	2	-1	-4	486	1575	631	1713
7	4	4	-1	-4	1029	1481	654	1618

Nonlinear Chromaticity

- Changed the second order chromaticity with octupoles
  - *Measurements similar to predicted values*
- Octupoles not strong enough for full correction
- All instrumentation performed nicely
- Future:
  - *Blue -Yellow sign differences*
  - *Use orbit bumps on octupoles to verify field direction*
  - *Make measurement in Blue ring*