Chromaticity shift induced by misalignment of Landau Octupole Magnets

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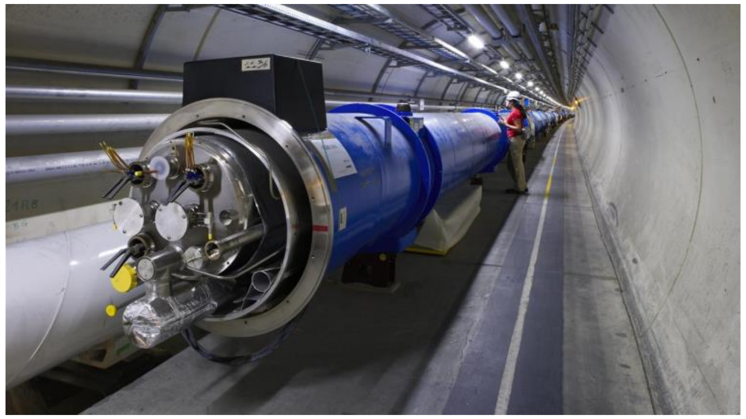
LHC



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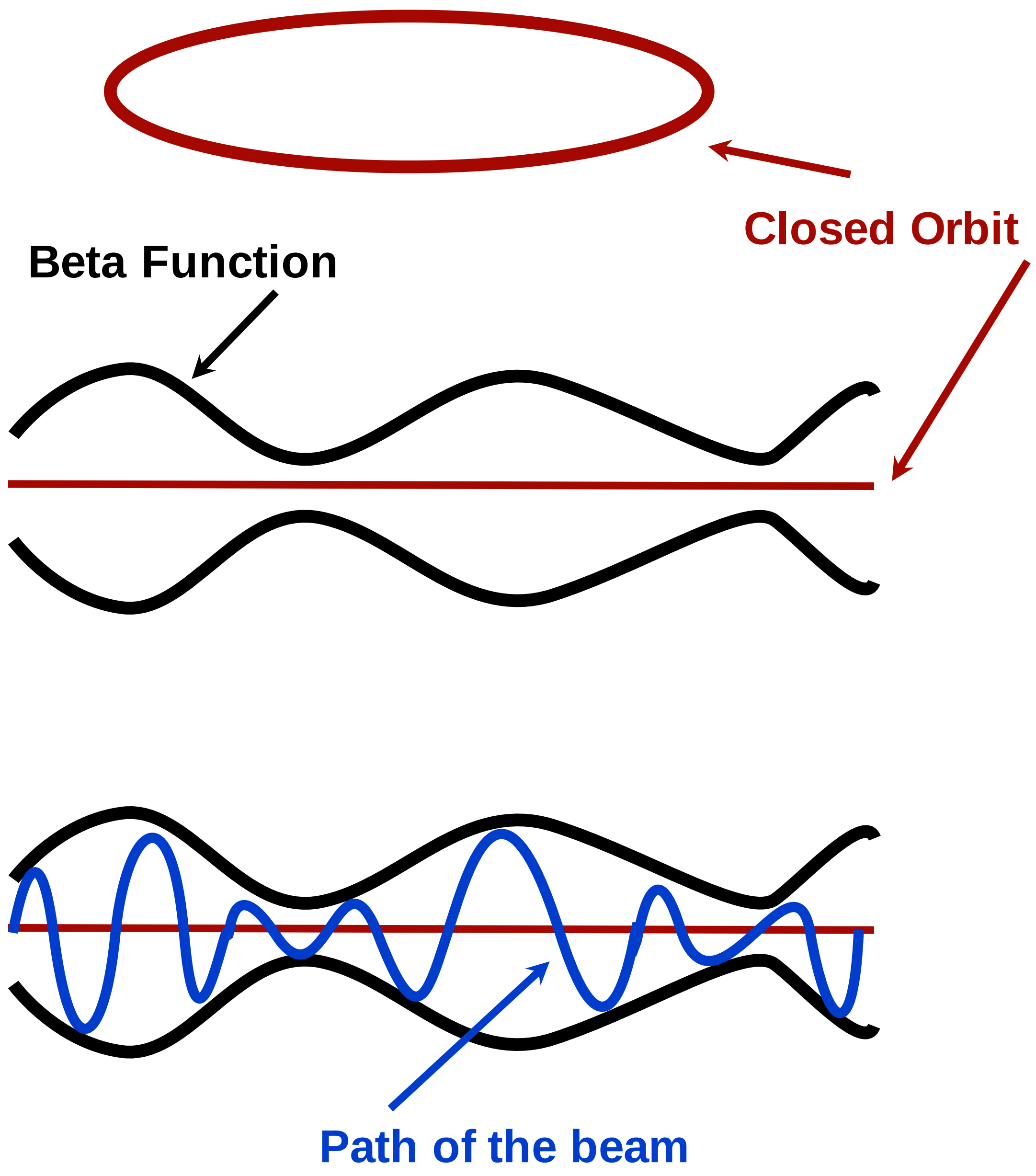
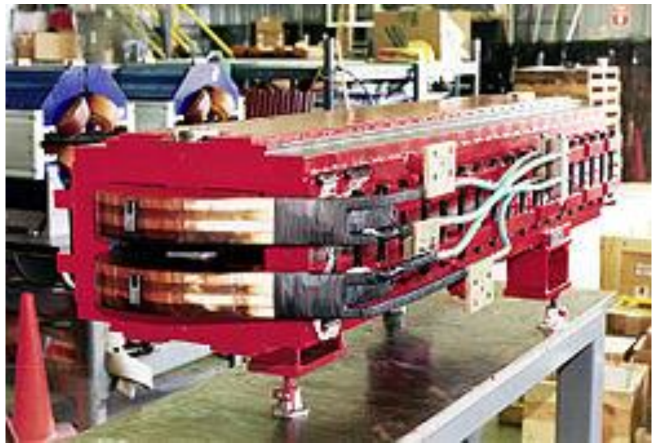
Basic Accelerator Optics

- Closed Orbit - path the beam follows around the accelerator. Can be distorted from the ideal path.
- The actual beam oscillates around the closed orbit with varying amplitude. The Beta function determines the amplitude.
- The tune, Q, is the number of betatron oscillations per revolution.
- Chromaticity: Q' = dQ/(dp/p)
- Chromaticity helps dampen instabilities in the beam
- Want a small positive value. (LHC: Q' ~ 2)



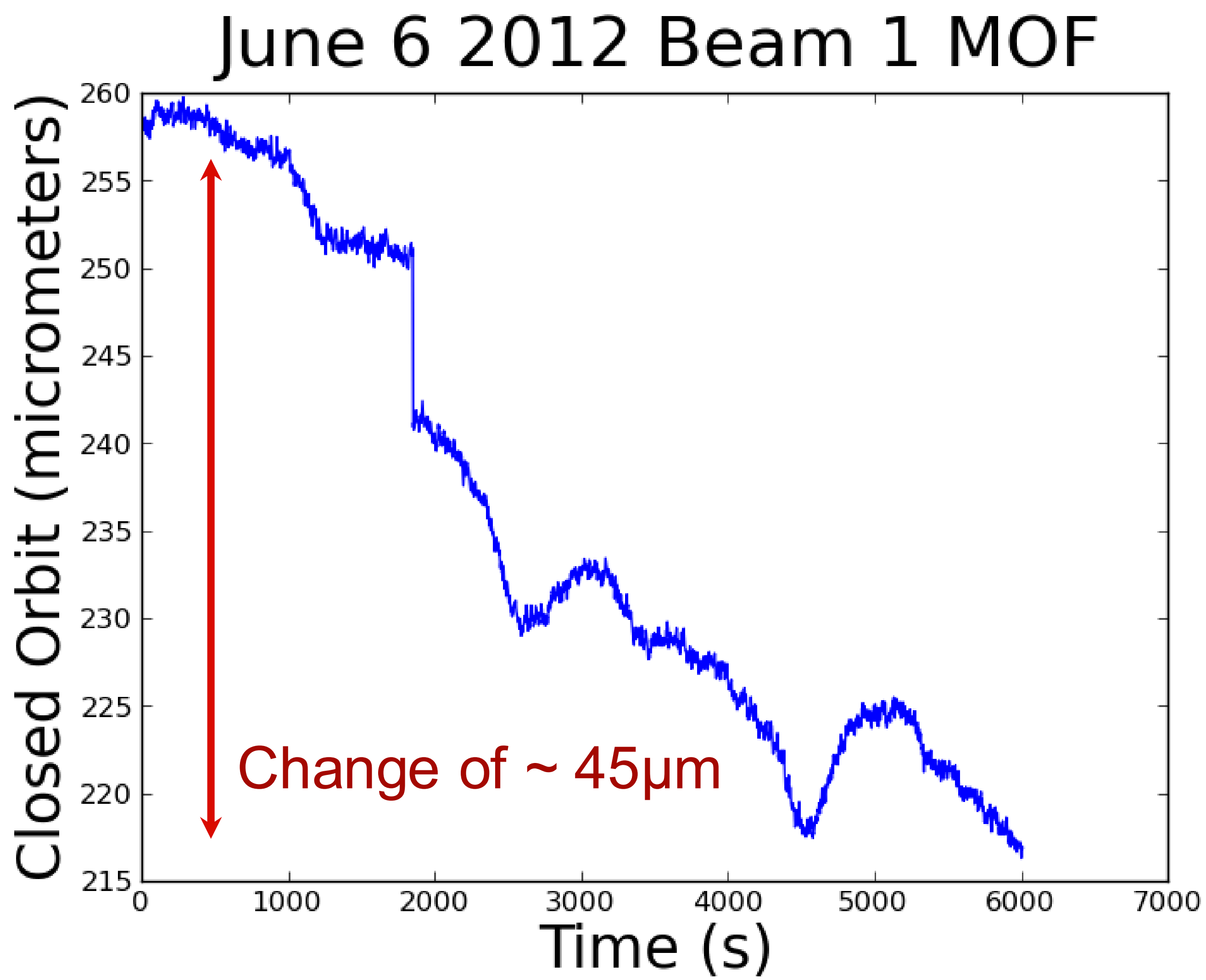
Magnets

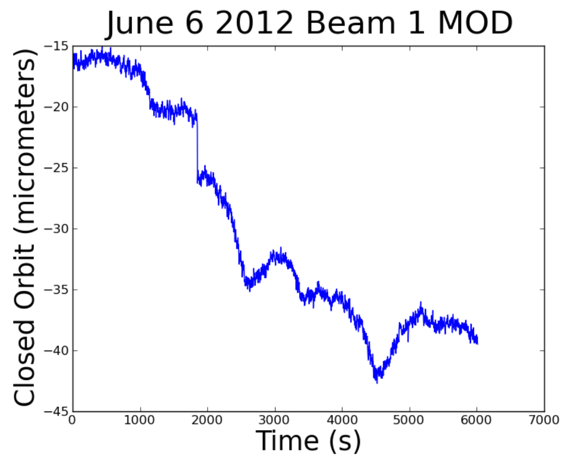
- Dipole Magnets Steer the beam
- Quadrupoles focus the beam
  - Determine Beta Function and Tune
- Sextupoles correct the chromatically
- Octupoles are used to damp other instabilities.
  - In particular, strong Landau octupoles are used for Amplitude Detuning



My Project: Chromaticity induced by misalignment of Landau Octupoles

- A misaligned multipole will cause the beam to experience lower order fields. This is called "feed down."
- In particular, a misaligned octupole will cause the beam to experience a sextupole field.
- Sextupoles change chromaticity
- My project - Measure systematic misalignment of octupoles and study resulting chromaticity shifts.





A closed orbit shift of 45 μm corresponds to a Q' shift of 0.8 units. A 40% change!

$$\boldsymbol{H_0} = \frac{1}{2}p_X^2 + \frac{1}{2}p_y^2 + \frac{1}{2}K(\theta)_x^2 - \frac{1}{2}K(\theta)_y^2$$

$$\boldsymbol{H_n} = \frac{q}{p}Re[\frac{1}{n}\left(B_n(s) + iA_n(s)\right)(x+iy)^n]$$

$$\boldsymbol{H_n} = \frac{q}{p}B_n(s)\frac{1}{n}Re[(x+iy)^n]$$

$$H_3 = \frac{q}{p}\frac{1}{3}B_3\ Re[(x+iy)^3]$$

$$H_4 = \frac{q}{p}\frac{1}{4}B_4\ Re[(x+iy)^4]$$

$$\boldsymbol{H_4} \propto \frac{1}{4} Re[x+iy]^4$$

$$\boldsymbol{H_4} \propto x^4 - 6x^2y^2 + y^4$$

$$x \;\rightarrow x - \delta x$$

$$\boldsymbol{H'_4} \propto (x-\delta x)^4 - 6(x-\delta x)^2 y^2 + y^4$$

$$H_4' \propto \; H_4 + [-4(x-\delta x)^3 + 12(x-\delta x)y^2]\delta x + \; \mathcal{O}$$

$$= H_4 - 4[(x - \delta x)^3 + 3(x - \delta x)y^2]\delta x$$

$$H_3 \propto x^3 - 3xy^2$$

$$H_3 = \frac{q}{p}\frac{1}{3}B_3\, Re[(x + iy)^3]$$

$$= H_4 - 4[\, Re[(x - \delta x) + iy]^3 \delta x$$

$$H'_4 = \frac{q}{p}\frac{1}{4}B_4(\, Re[(x + iy)^4] - 4Re[(x + iy)^3]\delta x\,)$$

$$H_4' = H_4 + H_{4\to 3}$$

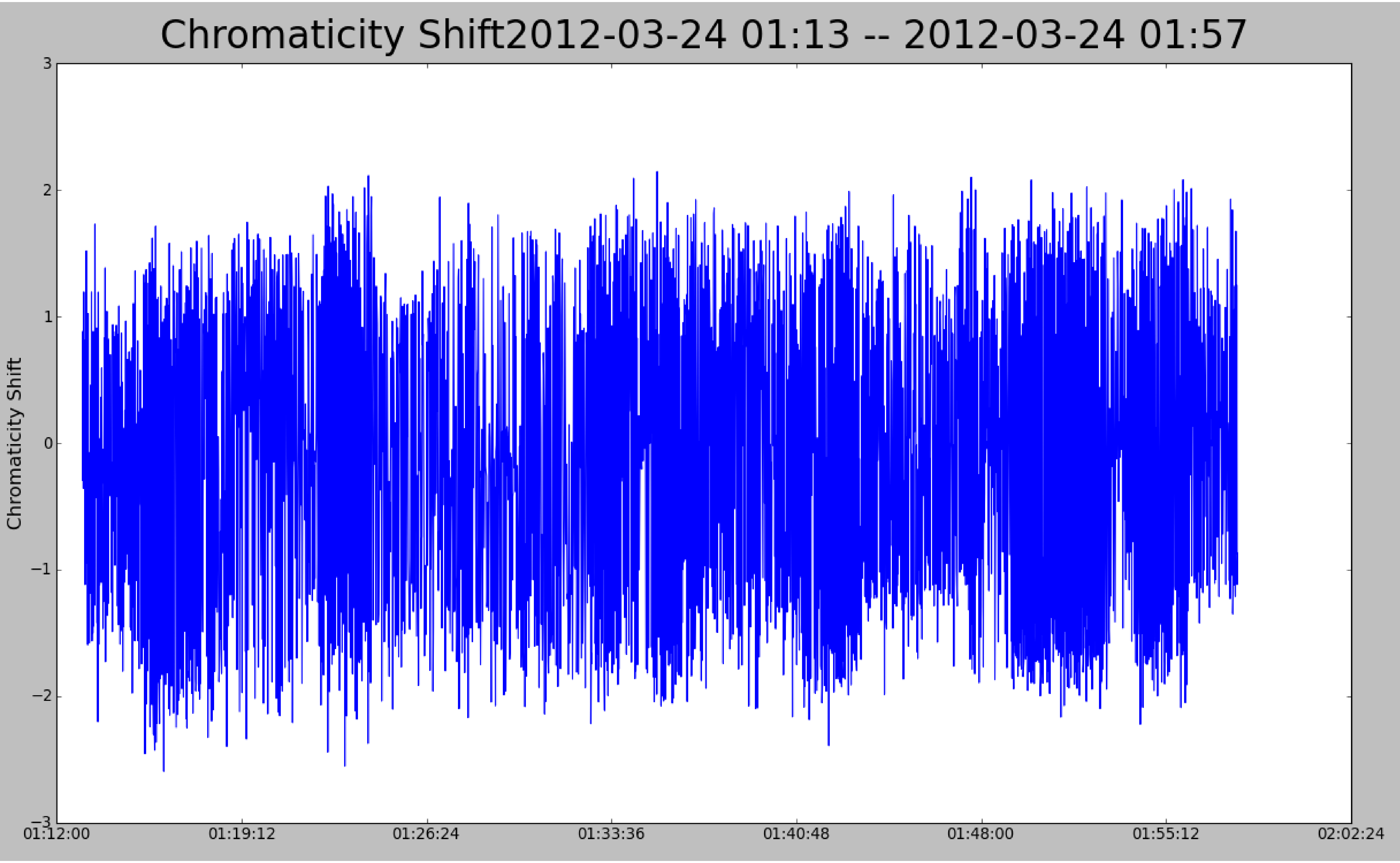
$$\Delta Q'_x = \frac{1}{4\pi}\beta_x(s)D_x(s)k_3 l$$

$$\Delta Q'_y = \frac{-1}{4\pi}\beta_y(s)D_x(s)k_3 l$$

$$k_3 \rightarrow -k_4 \delta x$$

$$\Delta Q'_x = \sum_s \frac{-1}{4\pi}\beta_x(s)D_x(s)k_4 l\ \delta x$$

$$\Delta Q'_y = \sum_s \frac{1}{4\pi}\beta_y(s)D_{x(s)}k_4 l\ \delta x$$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0
−1
−2
−3
01:12:00
01:19:12
01:26:24
01:33:36
01:40:48
01:48:00
01:55:12
02:02:24

Adventures

More