RHIC Beam Experiments Workshop

Chromaticity

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Chromaticity

- Introduction
- Classical Method
  - Second order chromaticities
- PLL Radial Wiggle Method
  - Measuring chromaticity during the ramp
- Phase Modulation Method (R. Jones)
- Head - Tail Method (R. Jones)

Introduction

- Chromaticity models tune variations with momentum
- Momentum variations causes radial beam shifts
- α is the momentum compaction factor
- γ_T is the gamma-transition
  - *Obtainable from the modeling engine*

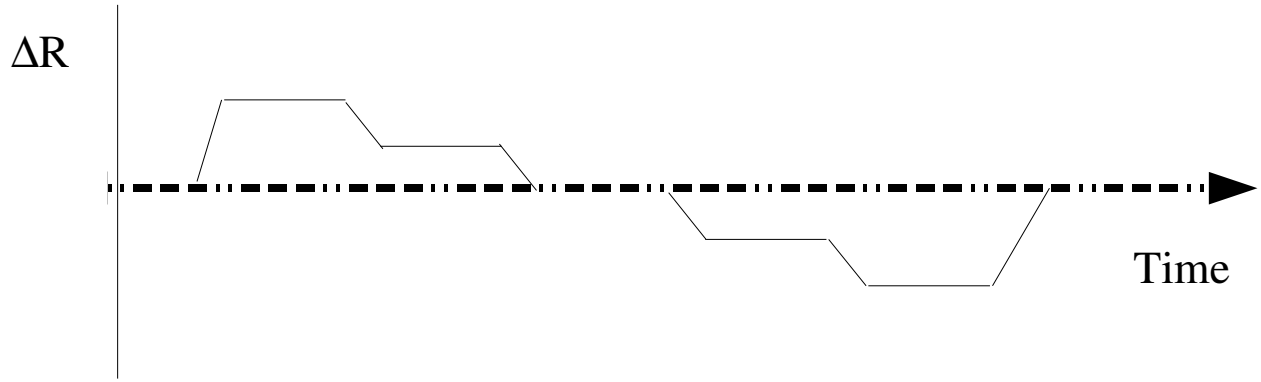
$$\Delta\nu = \xi_1 \frac{\Delta p}{p} + \xi_2 \left(\frac{\Delta p}{p}\right)^2 + \xi_3 \left(\frac{\Delta p}{p}\right)^3 + \cdots$$

$$\frac{\Delta R}{R} = \alpha \frac{\Delta p}{p}$$

$$\alpha = \frac{1}{\gamma_T^2}$$

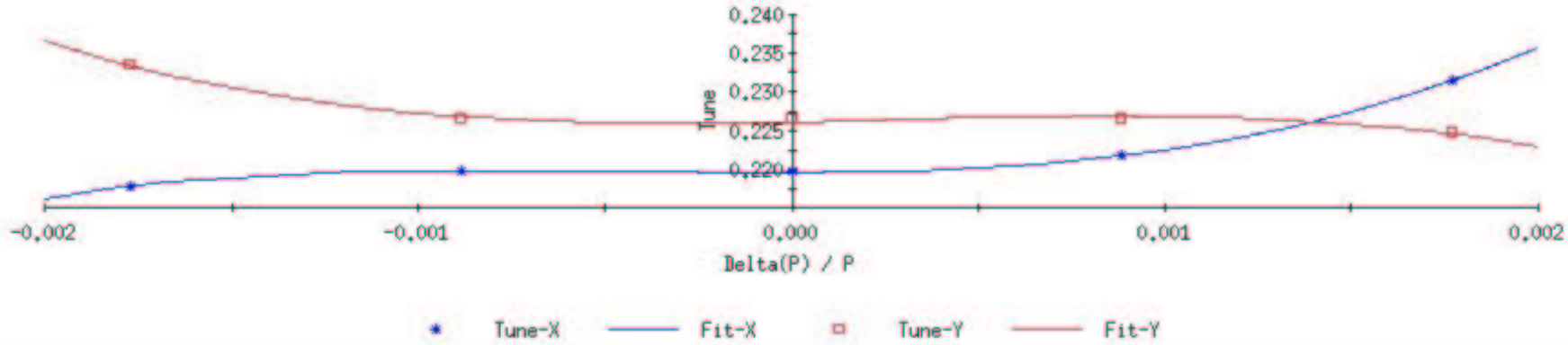
Classical Method

- Find chromaticity at a fixed energy using **Artus** or **PLL** to measure the tunes
- Change the radial shift in steps, $\approx 2mm$ max typically
- Fit tunes vs momentum to a polynomial
- This is a destructive measurement



Analysis of Data

Tune vs. Momentum



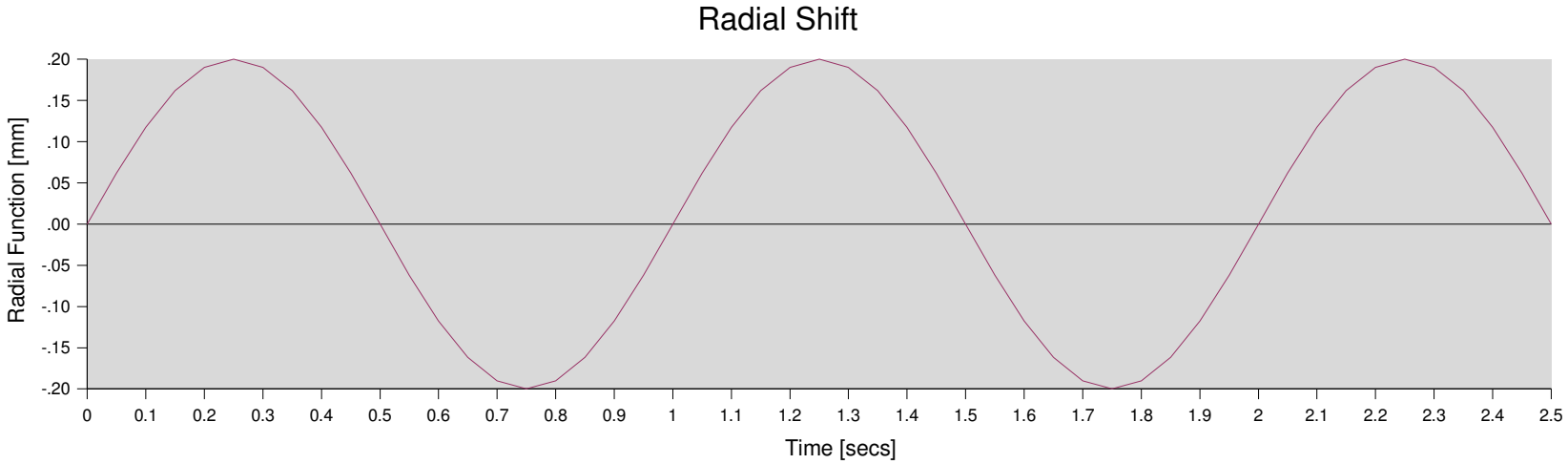
Row	Delta(p)/p	PLL X	Tune X #1	Tune X #2	Select	PLL Y	Tune Y #1	Tune Y #2	Select
1	-0.00176963	-1.65281e-06	0.217773	0.210938	Peak 1	-1.65281e-06	0.233398	0.226562	Peak 1
2	-0.000884815	-1.65281e-06	0.219727	0.226562	Peak 1	-1.65281e-06	0.226562	0.233398	Peak 1
3	0	-1.65281e-06	0.219727	0.227539	Peak 1	-1.65281e-06	0.226562	0.219727	Peak 1
4	0.000884815	-1.65281e-06	0.22168	0.229492	Peak 1	-1.65281e-06	0.226562	0.219727	Peak 1
5	0.00176963	-1.65281e-06	0.231445	0.223633	Peak 1	-1.65281e-06	0.224609	0.231445	Peak 1
0	0	0	0	0	Peak 1	0	0	0	Peak 1
0	0	0	0	0	Peak 1	0	0	0	Peak 1
0	0	0	0	0	Peak 1	0	0	0	Peak 1
0	0	0	0	0	Peak 1	0	0	0	Peak 1
0	0	0	0	0	Peak 1	0	0	0	Peak 1

	Corr	Tune	+-Sigma	Chrom[1]	+-Sigma	Chrom[2]	+-Sigma
Horizontal	0.999768	0.219559	0.000104399	0.183949	0.0834312	1603.76	79.6915
Vertical	0.996273	0.226144	0.000260997	0.827768	0.208578	890.978	199.229

Set Peak #1 | Set PLL | Close

PLL Radial Wiggle Method

- Apply ±0.2*mm* sine function to the radial steering



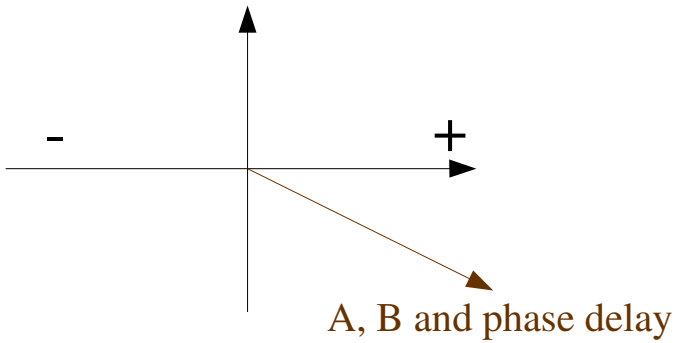
- Measure the tunes with the PLL tune-meter
  - With/Without tune feedback
  - While tune feedback on, error signals provide scaled and delayed tunes
- Accumulate the measurements using data sliding techniques

PLL Radial Wiggle Method

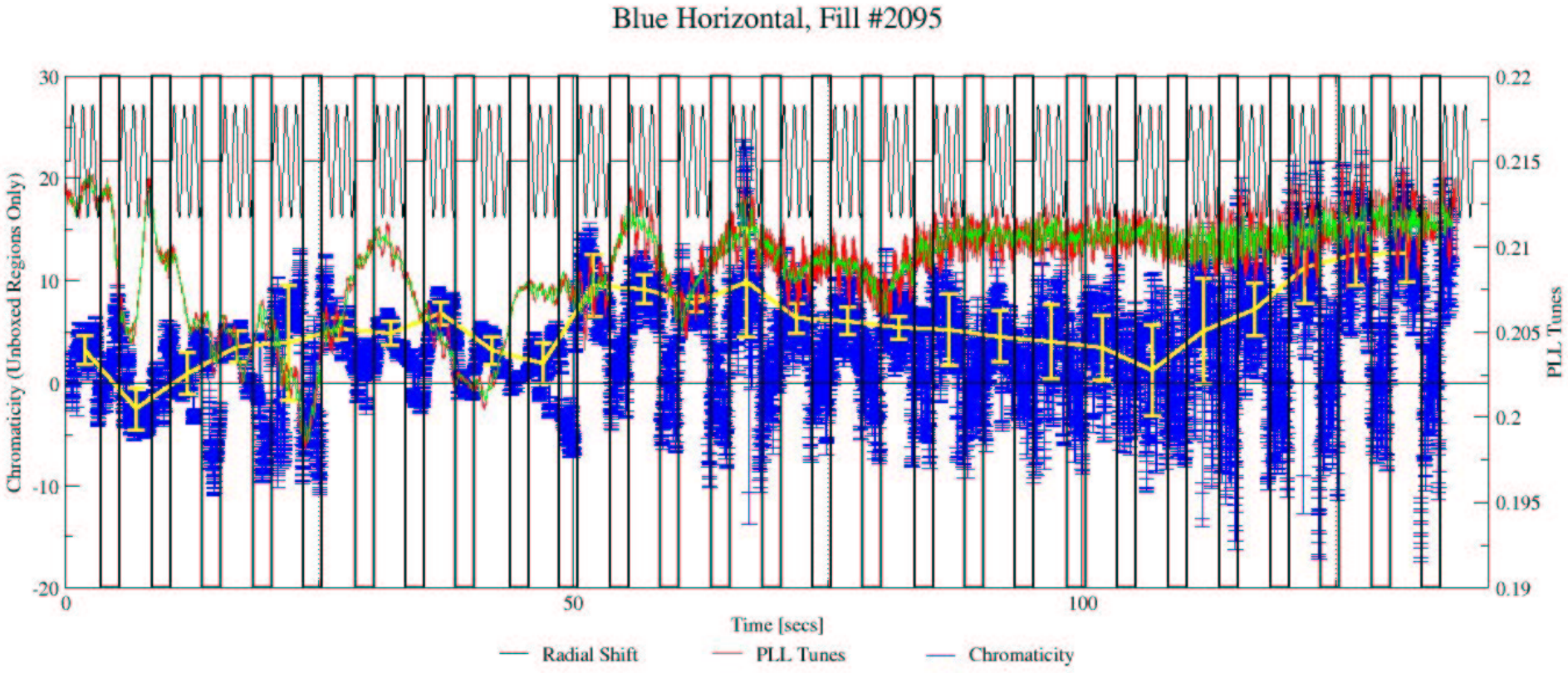
- Fit the measured tunes to the following function with ω at $1Hz$
- With linear regression, find the coefficients A, B, C, D and E and their standard deviations
- Chromaticity is found from the coefficients A and B
- The sign can be determined from the phase angle between A and B including any phase delays

$$\nu(t) = A\sin(\omega t) + B\cos(\omega t) + Ct^2 + Dt + E$$

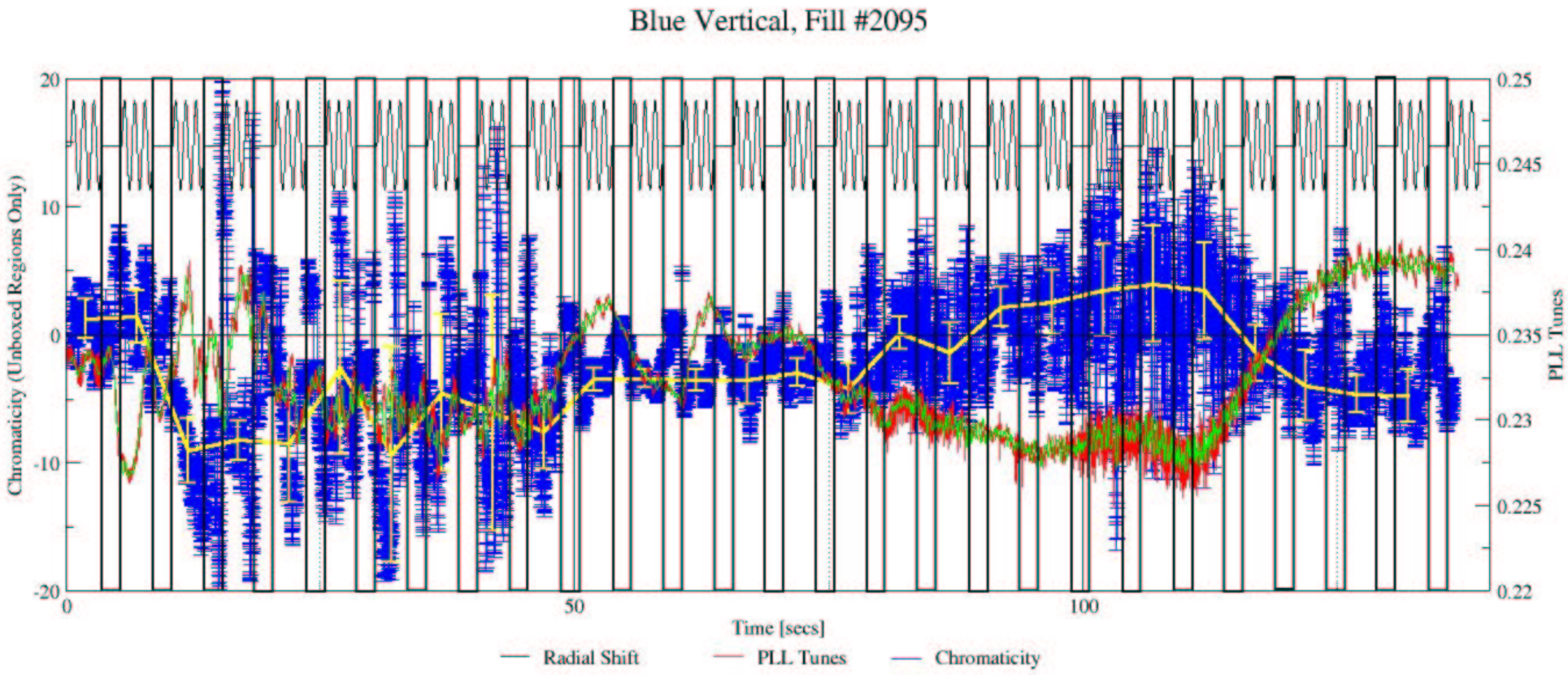
$$\xi = \pm\sqrt{A^2 + B^2}\,\frac{\alpha R}{\Delta R}$$



PLL Radial Wiggle Method



PLL Radial Wiggle Method



Plans

- Second order chromaticity measurements at fixed energy
- Measure chromaticity during ramping
  - PLL Radial Wiggle method
  - Head - Tail Method
  - Phase Modulation Method
  - Schottky Cavity
- Chromaticity feedback correction during ramping