RHIC AC Dipole Driven Linear Optics Measurement/Correction

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APEX Workshop 2007

Outline

- Summary of RUN2007 linear optics experiments
  - phase response matrix
  - advantage of ac dipole driven optics measurements and corrections
    - effect of secondary driving term and correction
- Plan for gradient error correction
  - Goal and plan

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Phase Response Matrix

- Preliminary data analysis using PRM(Phase response matrix) was done to identify the location of the trim quad error

$$\Delta\psi = \frac{1}{4\sin(2\pi Q)} \sum_{i}^{nquad} \Delta k l_i \beta_i \{ \sin(2\pi Q) + \sin(2\psi_i - 2\pi Q) + sign(\psi - \psi_i)[\sin(2\pi Q) + \sin(2|\psi - \psi_i| - 2\pi Q)] \}$$

$$(\Delta\psi)_{nbpm} = (M)_{nbpmxnquad} (\Delta k_i)_{nquad}$$

$$(\Delta k_i)_{nquad} = (M)^{-1}_{nbpmxnquad} (\Delta\psi)_{nbpm}$$

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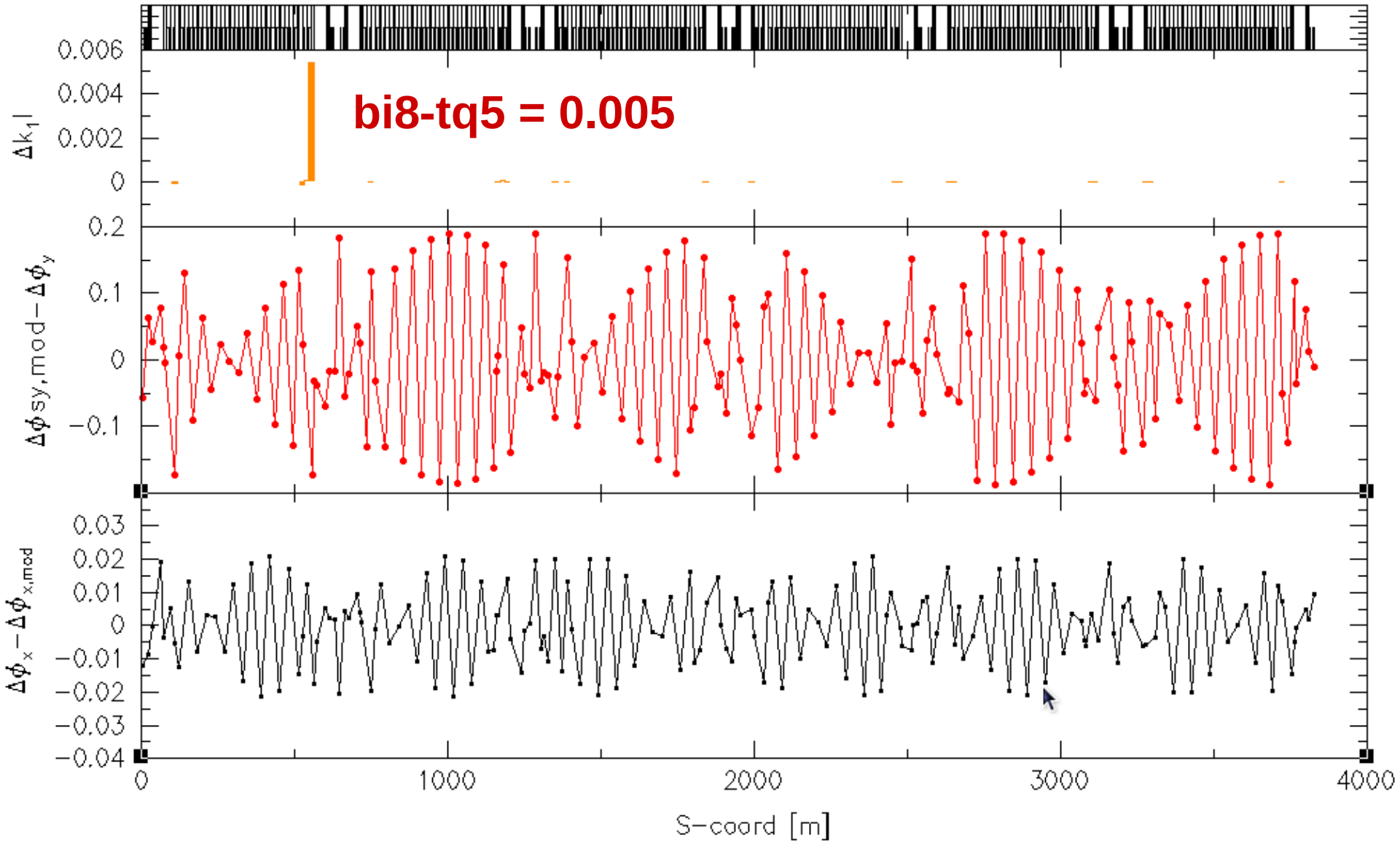
Simulation


bi8-tq5 = 0.005
$\Delta k_1 l$
0.006
0.004
0.002
0
$\Delta\phi_{sy,mod} - \Delta\phi_y$
0.2
0.1
0
−0.1
$\Delta\phi_x - \Delta\phi_{x,mod}$
0.03
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
0
1000
2000
3000
4000
S−coord [m]

Effect of secondary driving term

- secondary driving term – feature of driven oscillation

$$x_i(s) = \frac{B_{acd} L}{4B\rho \sin\left(\pi\left(Q_{acd} - Q_x\right)\right)} \beta_{acd} \sqrt{\beta(s)} \cos(2\pi Q_{\mathrm{acd}} i + \Delta\psi(s) + \pi(Q_{\mathrm{acd}} - Q_x) + \chi_{\mathrm{acd}})$$
$$+ \frac{B_{acd} L}{4B\rho \sin\left(\pi\left(1 - Q_{acd} - Q_x\right)\right)} \beta_{acd} \sqrt{\beta(s)} \cos(2\pi(1 - Q_{\mathrm{acd}}) i + \Delta\psi(s) + \pi((1 - Q_{\mathrm{acd}}) - Q_x) - \chi_{\mathrm{acd}})$$

- This effect causes an additional beta beat as if an localized quadrupole error as Ryoichi from FNAL pointed out.
- This effect is very sensitive to the working point. For RHIC current working point, this artificial beta beat is about 6% peak
- For RHIC near integer working point at (0.92, 0.93), this effect is close to 15% peak

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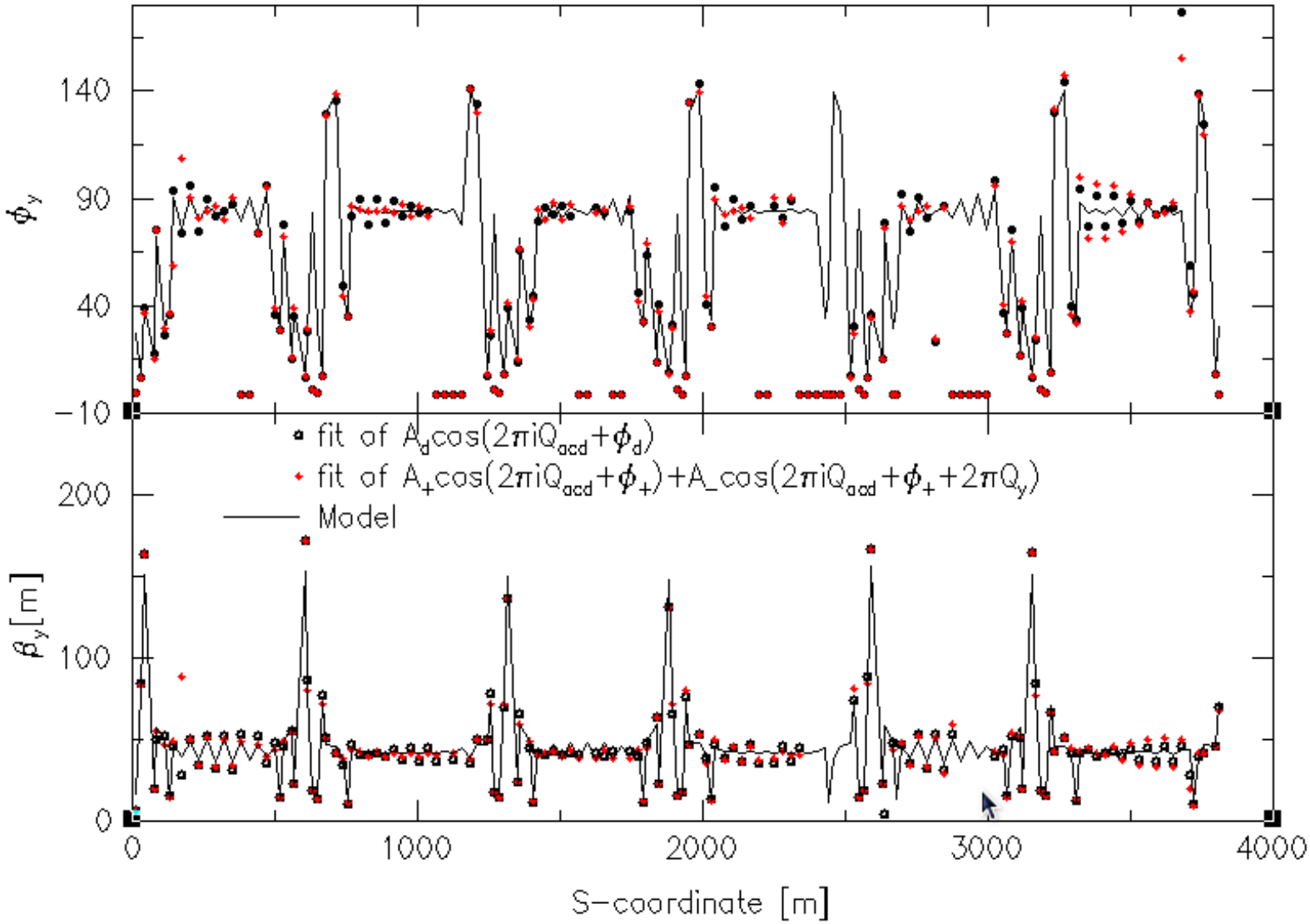
Effect of secondary driving term



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Beam Experiment on Gradient Error

- Injection optics were measured with and without an artificial quad error at
  - bi6-tq6
  - bi8-tq5

- Data were independently analyzed by Mei and Rama/Rogelio.
  - Both algorithms identified the quad error correctly
  - However, the results are not in perfect agreement in terms of amplitude of the quad error

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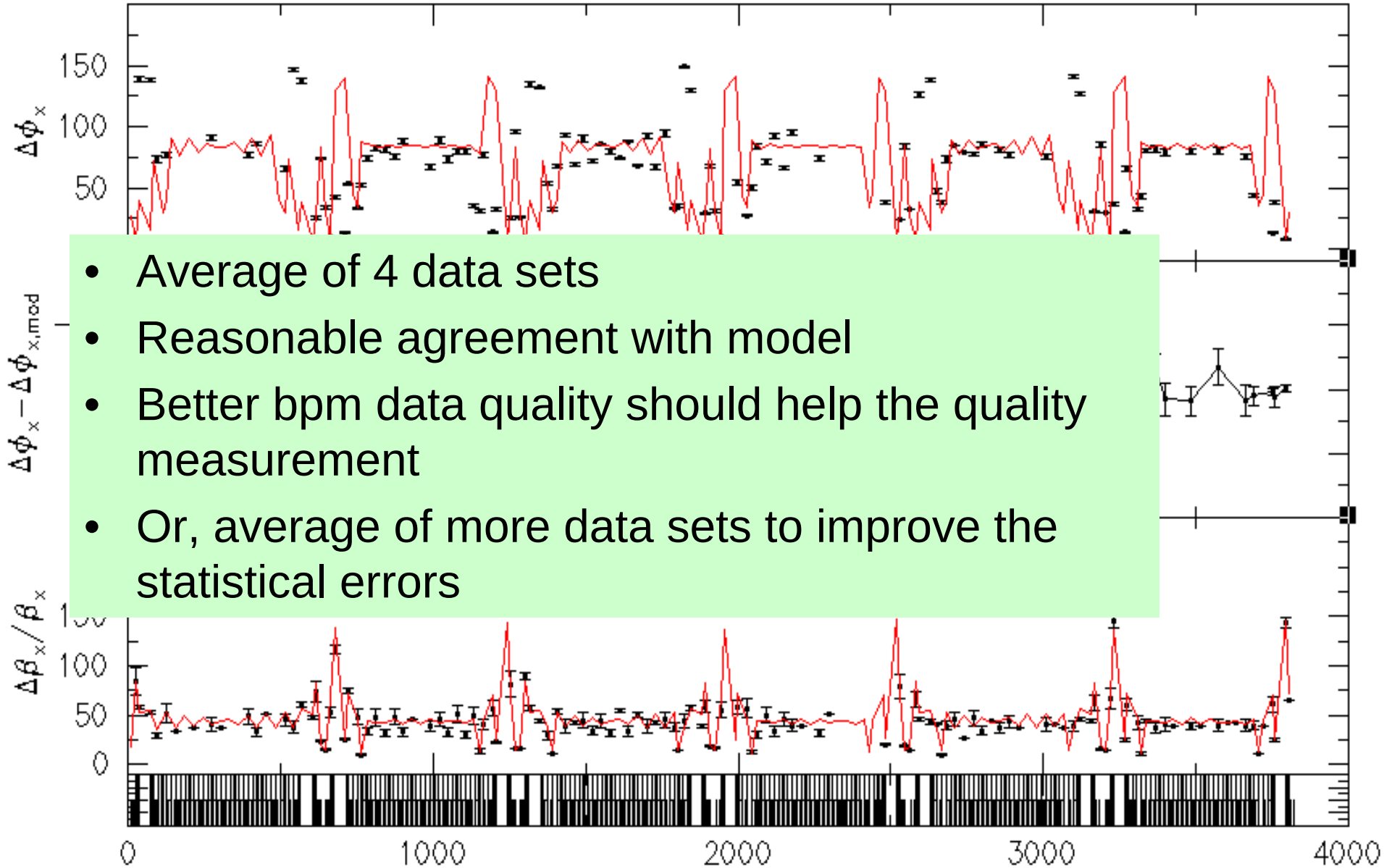
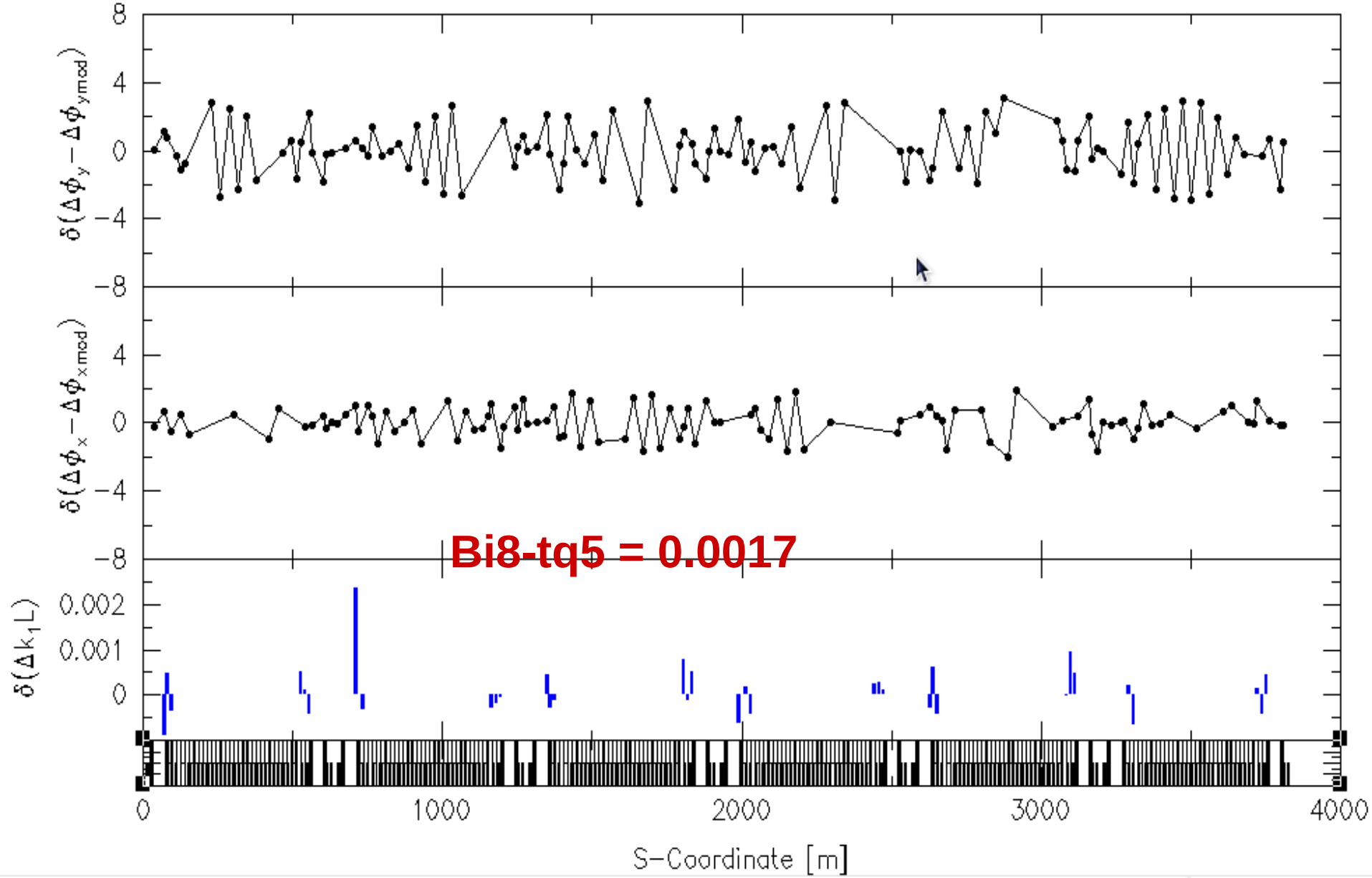
Injection H Optics

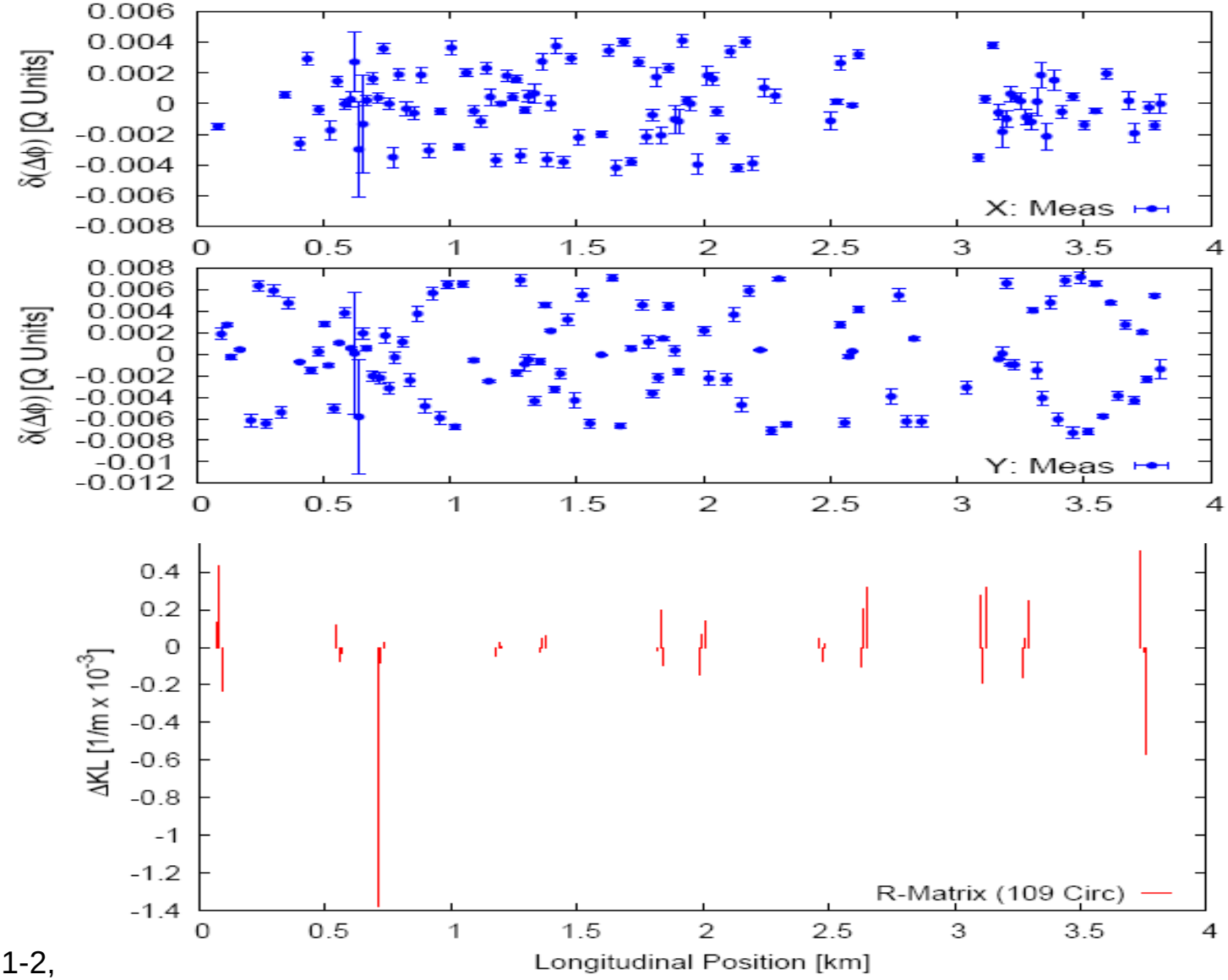


- Average of 4 data sets
- Reasonable agreement with model
- Better bpm data quality should help the quality measurement
- Or, average of more data sets to improve the statistical errors

Mei's analysis



Rama's analysis



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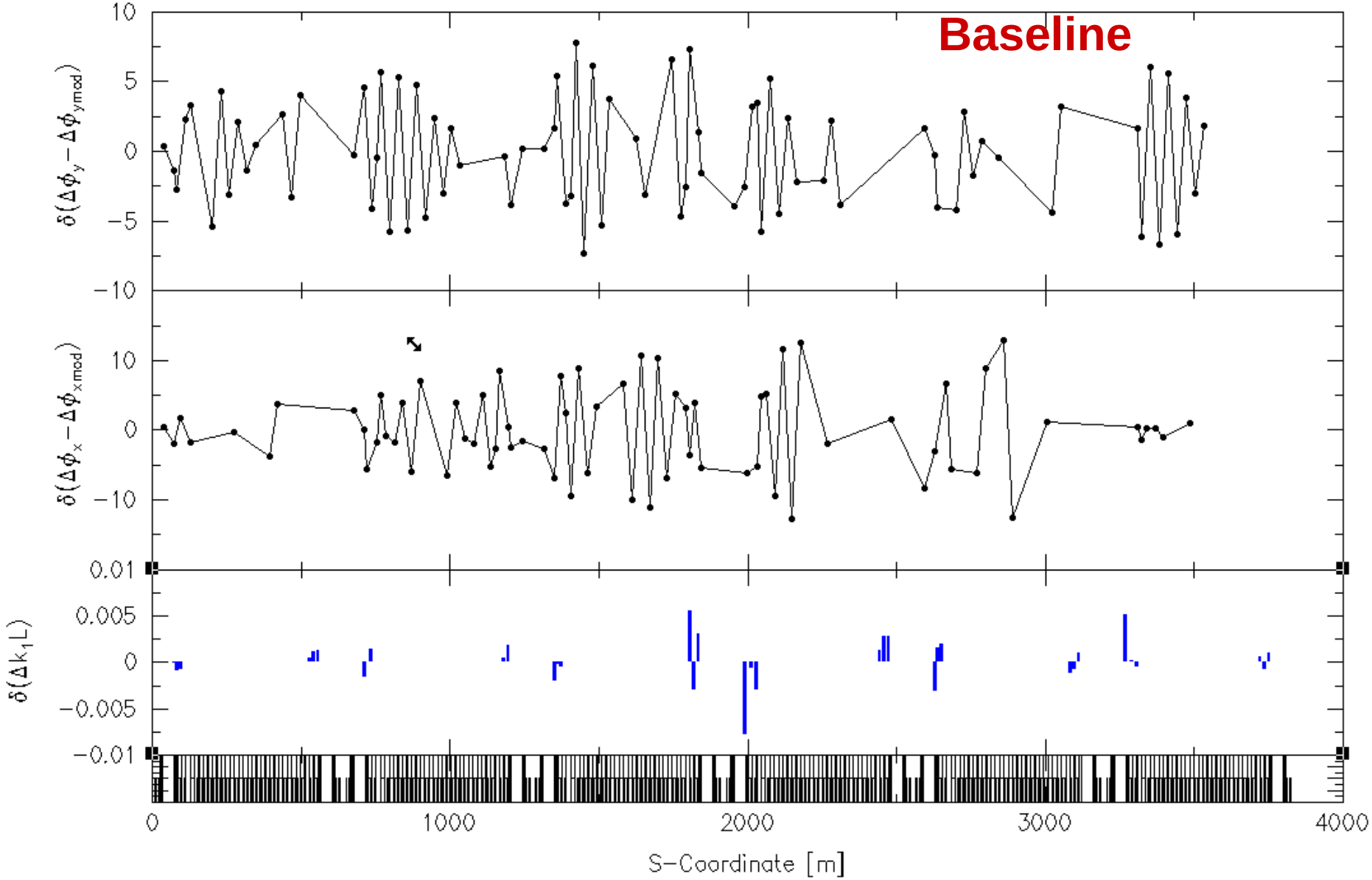
PRM analysis of baseline optics



Conclusions

- Proved the principle of PRM for linear optics correction. The data analysis also shows that it is critical to clean up the bpm turn by turn data

- The effect of secondary driving term is insignificant for the current RHIC working point

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Goals

- Goal:
  - Linear optics measurement:
    - Modify the existing RHIC ac dipole based linear optics application to suppress the secondary driving term effect which is critical for the new pp near-integer working point
  - Linear optics correction:
    - Can the PRM technique handle distributed gradient errors?
    - Are the existing trim quadrupoles enough for correcting beta-beat?
    - Test the PRM technique during the d-Au run
    - Commission the PRM for minimizing the beta-beat during the pp run

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Plans

- Plan:
  - Linear optics measurement, with the help from controls group
    - Enhance the function on clean up bpm turn by turn data
    - Average optics measurement by taking multiple ac dipole based optics data sets
    - Add PRM to the application
  - Linear optics correction:
    - Simulations to find out the tolerance on the noise of the bpm turn by turn data
    - Dedicated beam experiment with multiple quad error
  - Collaborate with Yiton Yan(SLAC) on applying MIA to RHIC linear optics correction

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