$\{\beta,\ D_x\}$ Beat Correction @LHC/RHIC

R. Calaga, R. Tomás

Ack: M. Giovannozzi, Y. Papaphilippou, M. Bai (RHIC AC Dipole Data)

LCU Meeting, Nov 5, 2007

LHC Simulations

- Realistic magnetic errors from MADX error tables
- Observables

  $\Delta\vec{\phi}_x,\ \Delta\vec{\phi}_y$: Indep. of BPM Calibration (FFT, SVD)

  $\Delta\vec{D}_x$: Calibration Dependent - $\pm 4\%$ (Rad. Steering)

- Specifications:

$$\left\{\frac{\Delta\beta_x}{\beta_x},\ \frac{\Delta\beta_y}{\beta_y}\right\}_{peak} < 15\% \quad \text{[Rep.501]}$$

$$\left|\frac{\Delta D_x}{\sqrt{\beta_x}}\right|_{RMS} < 0.013\sqrt{m} \quad \text{[Rep. 501]}$$

- BPM Resolution: 200μm (TBT Data)
- $\sim$160 Variables (beam 1 or 2):

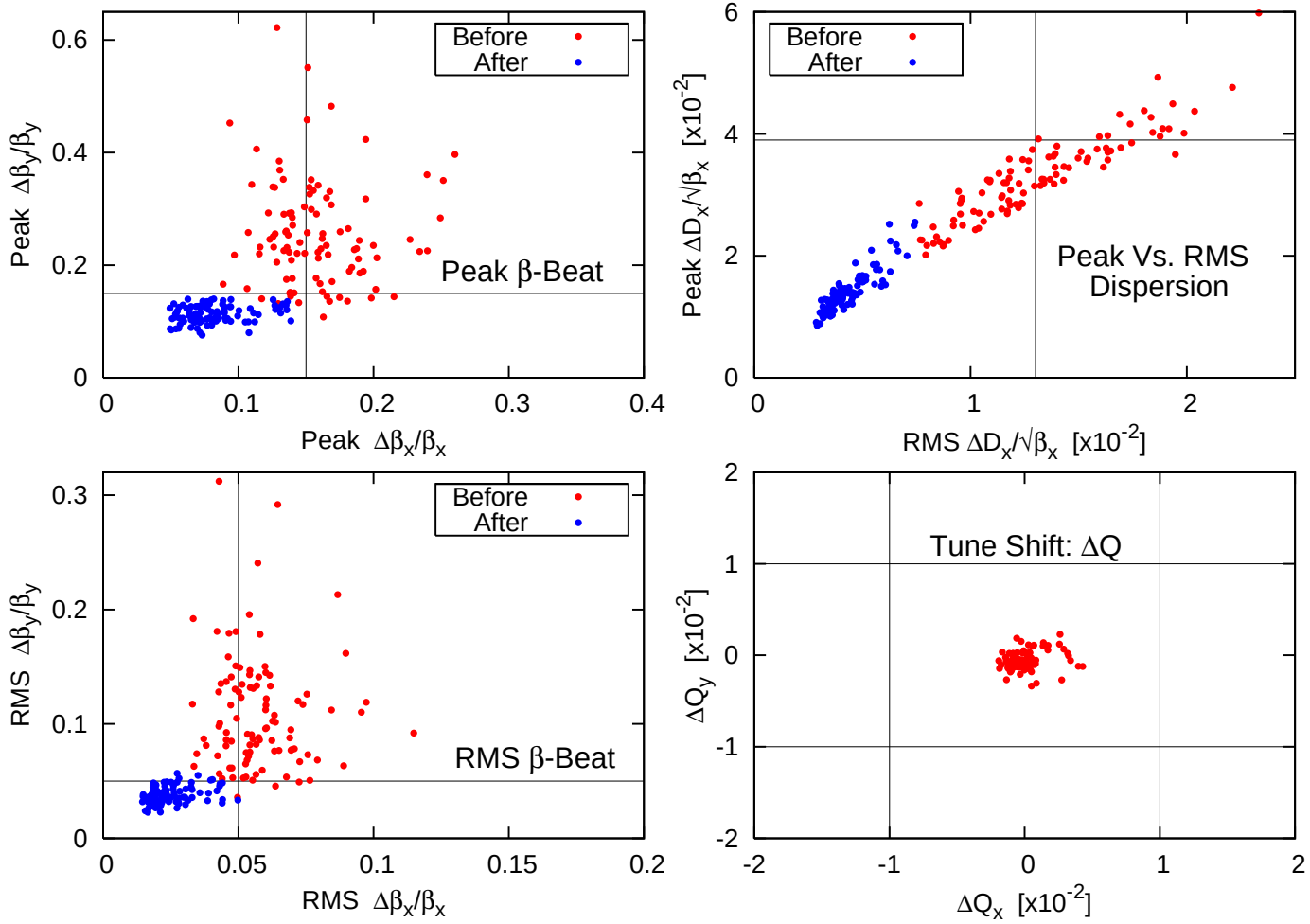
$$\vec{k}_1\text{: } \{\text{KQ[4-10], KQX, KQF, KQD, KQT, } \cdots\}$$

- Correction:

$$\Delta\vec{k}_1 = -R^{-1}\left[\Delta\vec{\phi}_{(x,y)},\ \Delta\vec{D}_x/\sqrt{\beta_x},\ \Delta Q_x,\ \Delta Q_y\right]^T$$

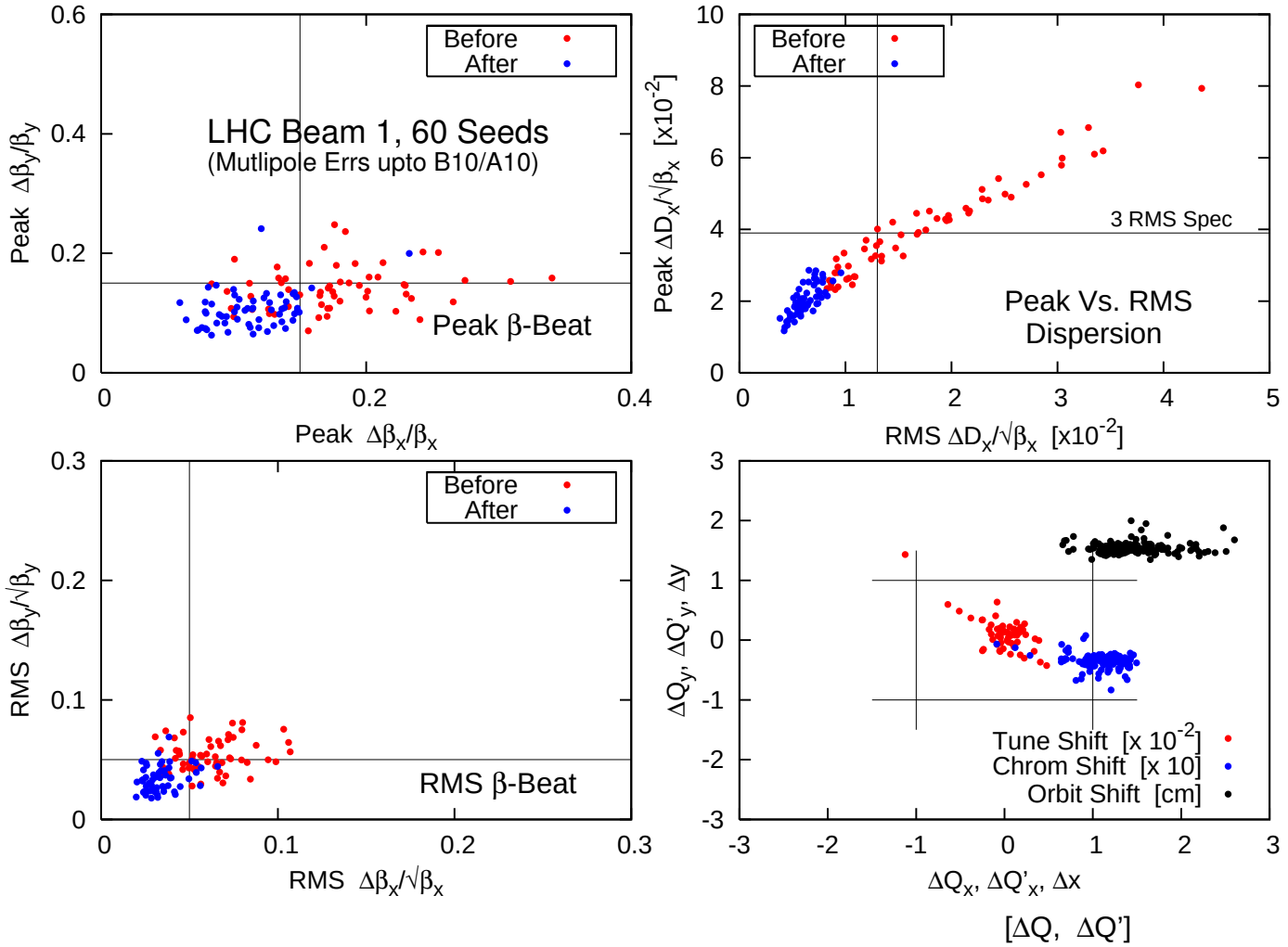
$$\Delta\vec{k}_1 = \left[(R^T W R)^{-1} R^T W\right]\vec{b}$$

$\{\beta,\ D_x\}$ Correction (2006 Status, Beam 2)



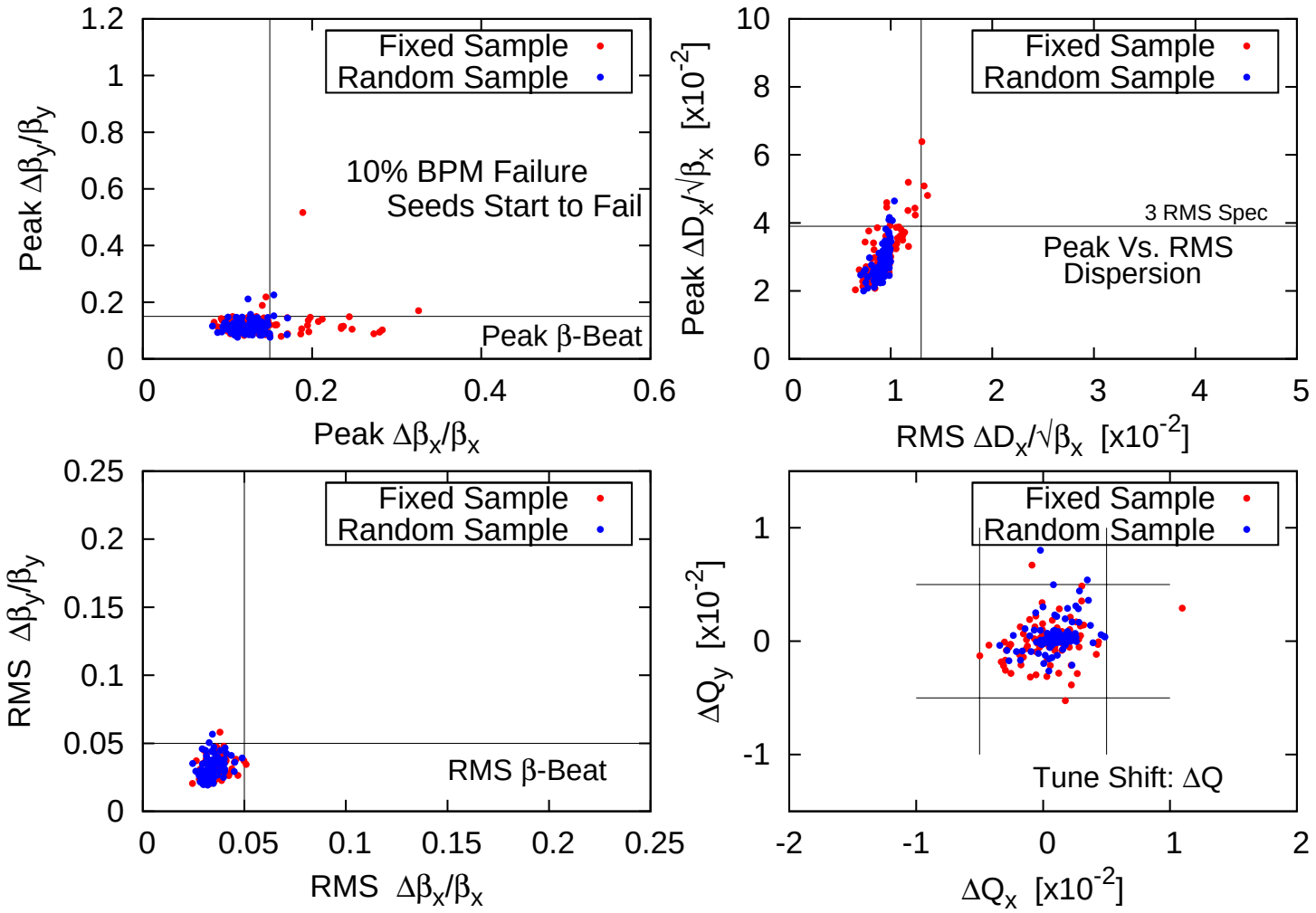
- B1/A1 = 0, all higher orders included (Errors: 80% measured & as installed, 20% extrapolated)
- Additonal 2mm random sextupole misalignments + 5 units random B2

Prelim: $\{\beta,\ D_x\}$ Corr (2007, Beam 1)



- All Multipole errors upto B10/A10 (Errors: 100% measured & as installed)
- No additional misalignments added, no orbit correction

$\{\beta,\ D_x\}$ Corr (10% BPM Failure)

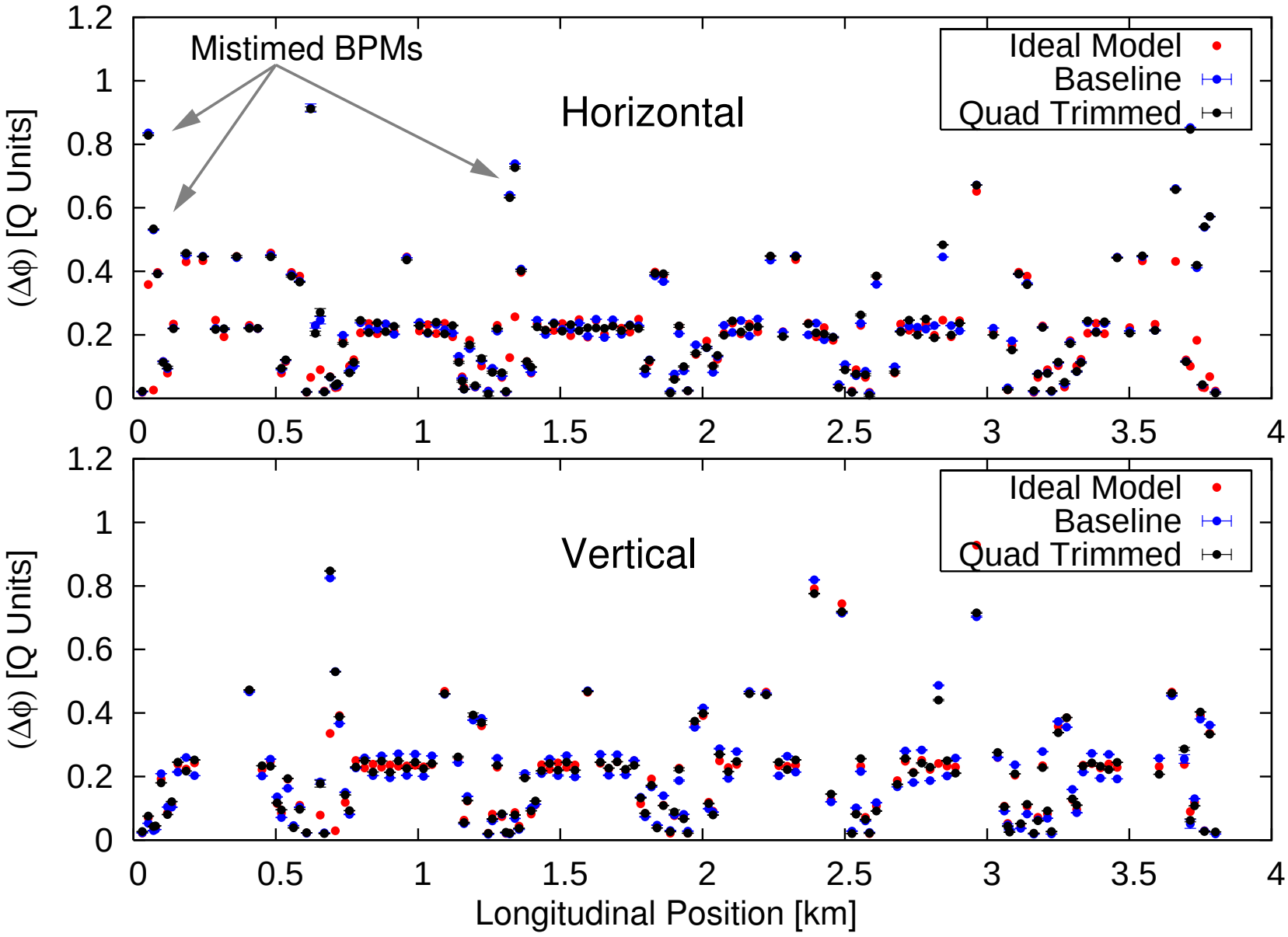


- Some seed fail for 10% BPM failure (many seeds fail for 20%)
- Failure Tolerance $<$ 10% for effective correction

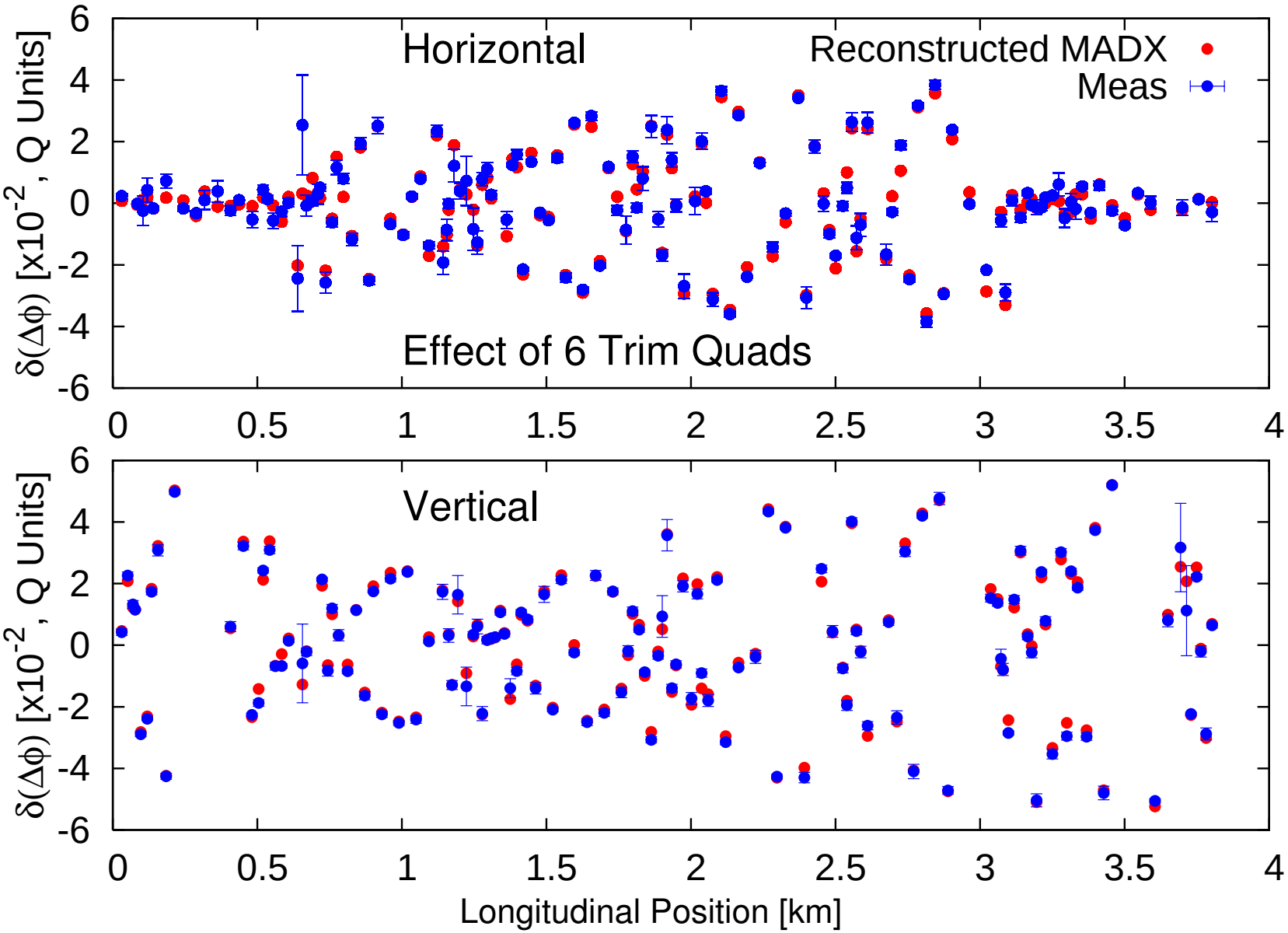
RHIC Measurements

Kicked & AC Dipole Exps

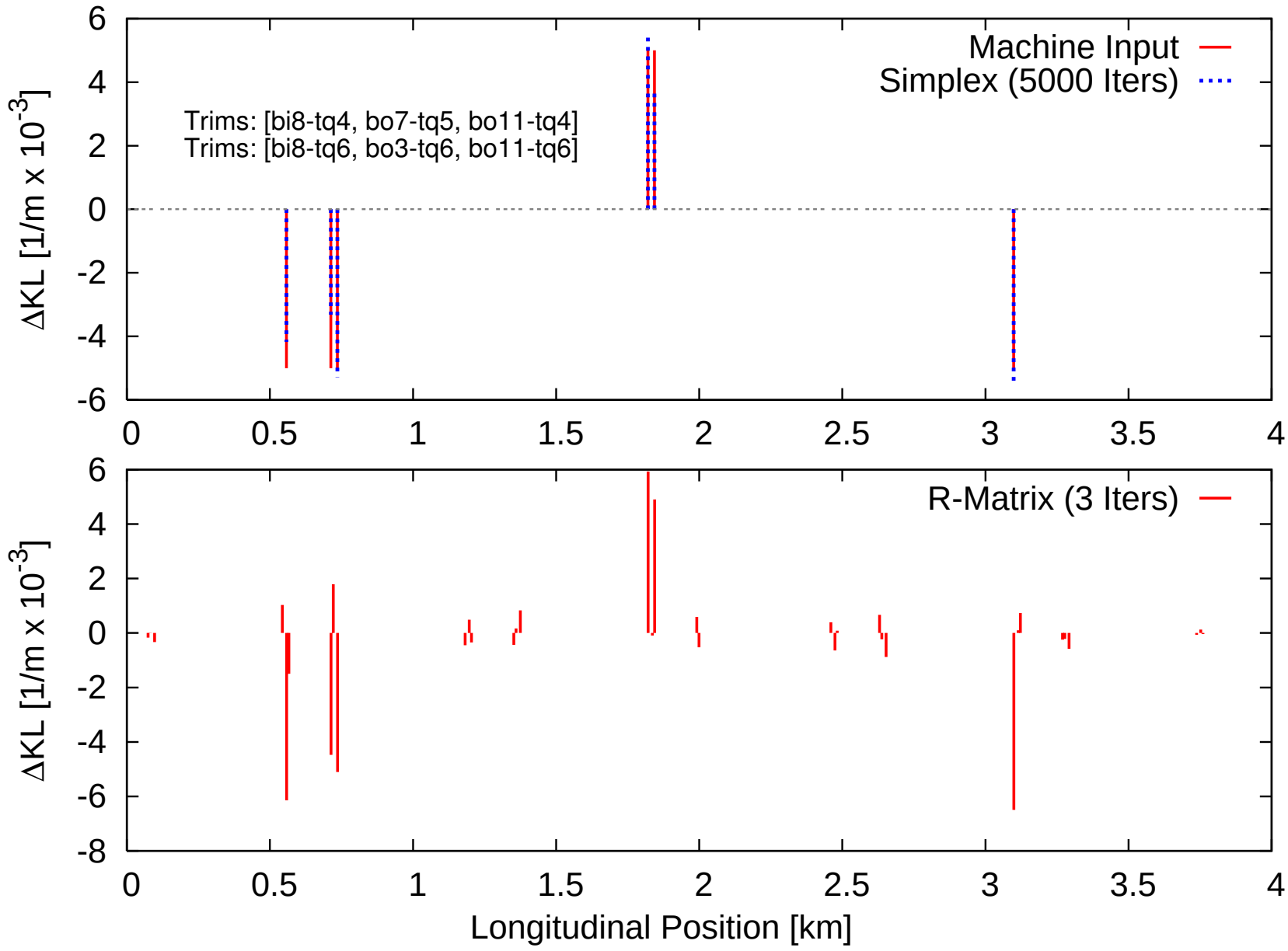
Exp I: Kicked ($\Delta\phi_{x,y}$, 6 Quads Trimmed)



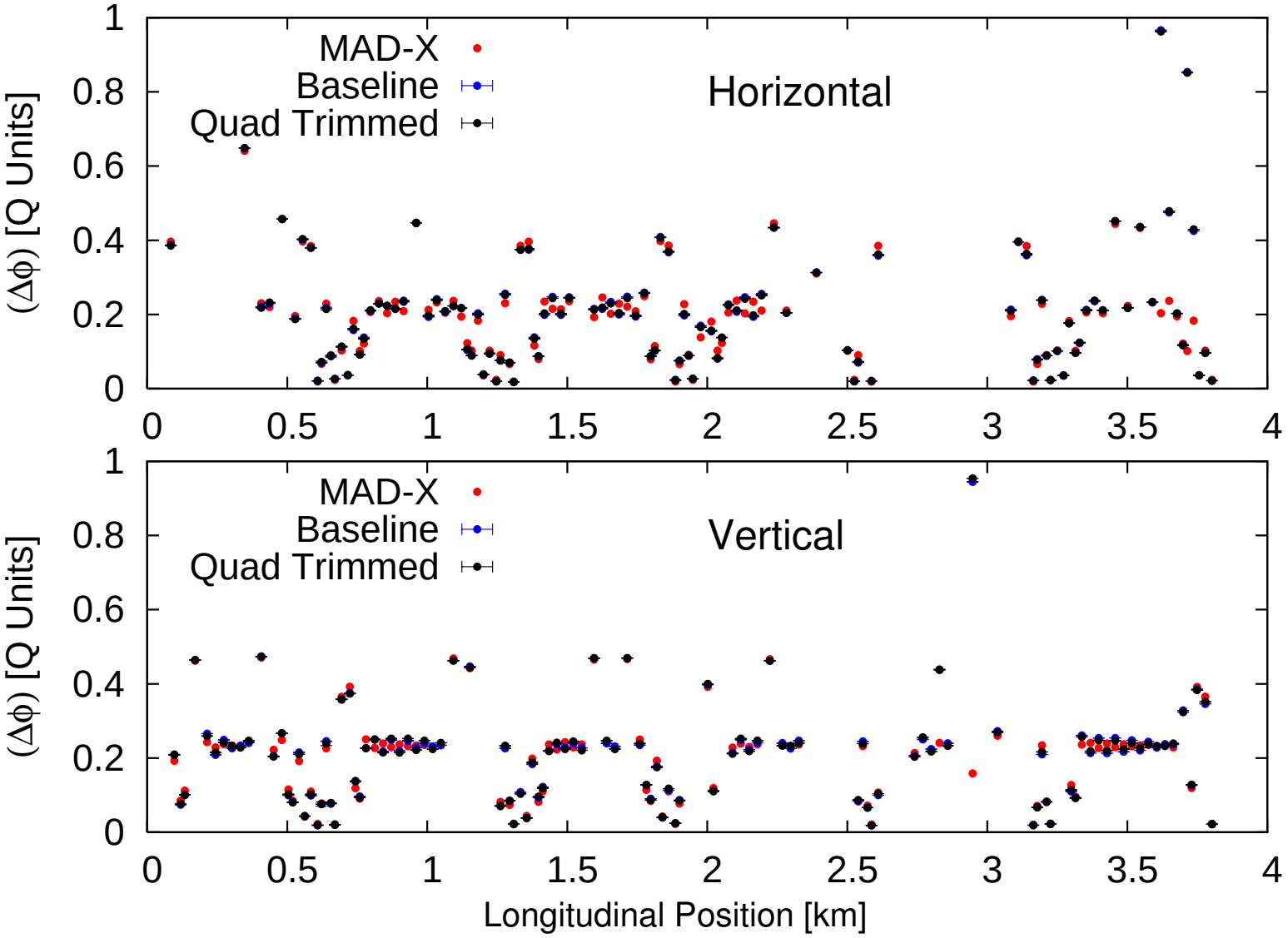
Exp I: Kicked ($\Delta\phi$-beat, Recons Machine)



Exp I: Reconstructed Trims, ΔKL (Kicked)

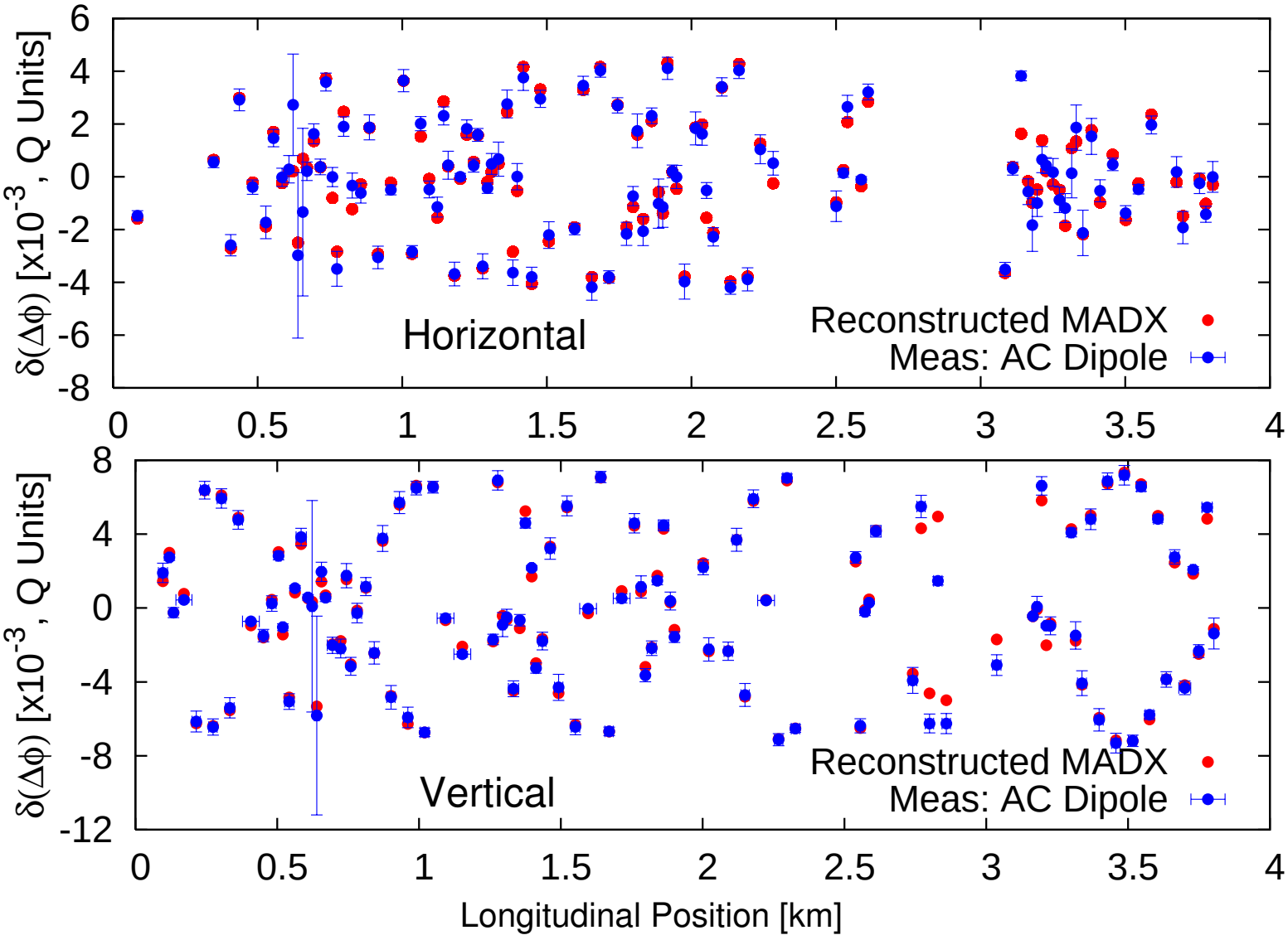


Exp II: AC Dipole (Initial ΔKL Unknown)



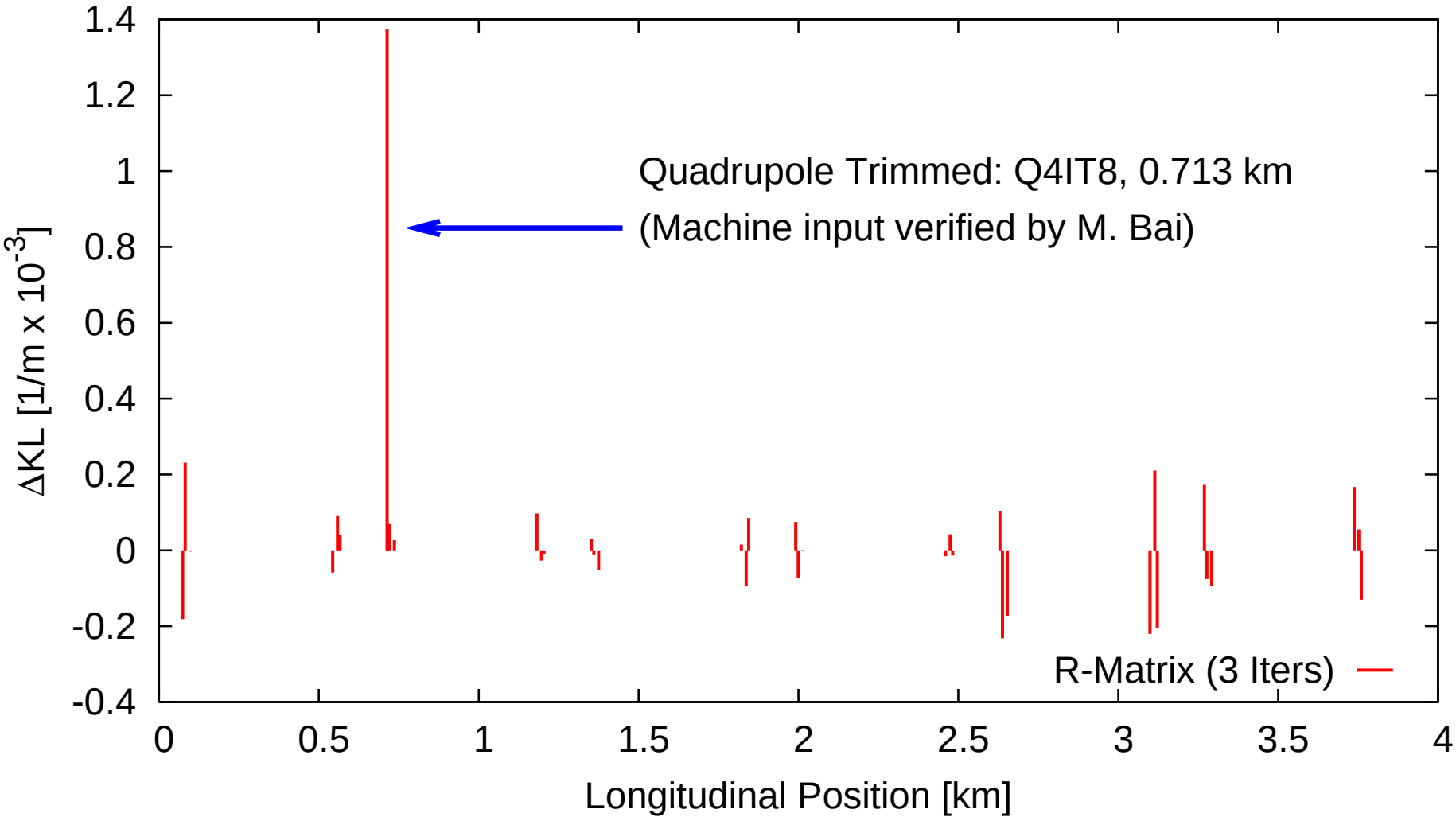
—— AC Dipole Data: Courtesy M. Bai

Exp II: AC Dipole ($\Delta\phi$-beat, Recons Machine)



—— AC Dipole Data: Courtesy M. Bai

Exp II: AC Dipole (Reconstructed ΔKL)

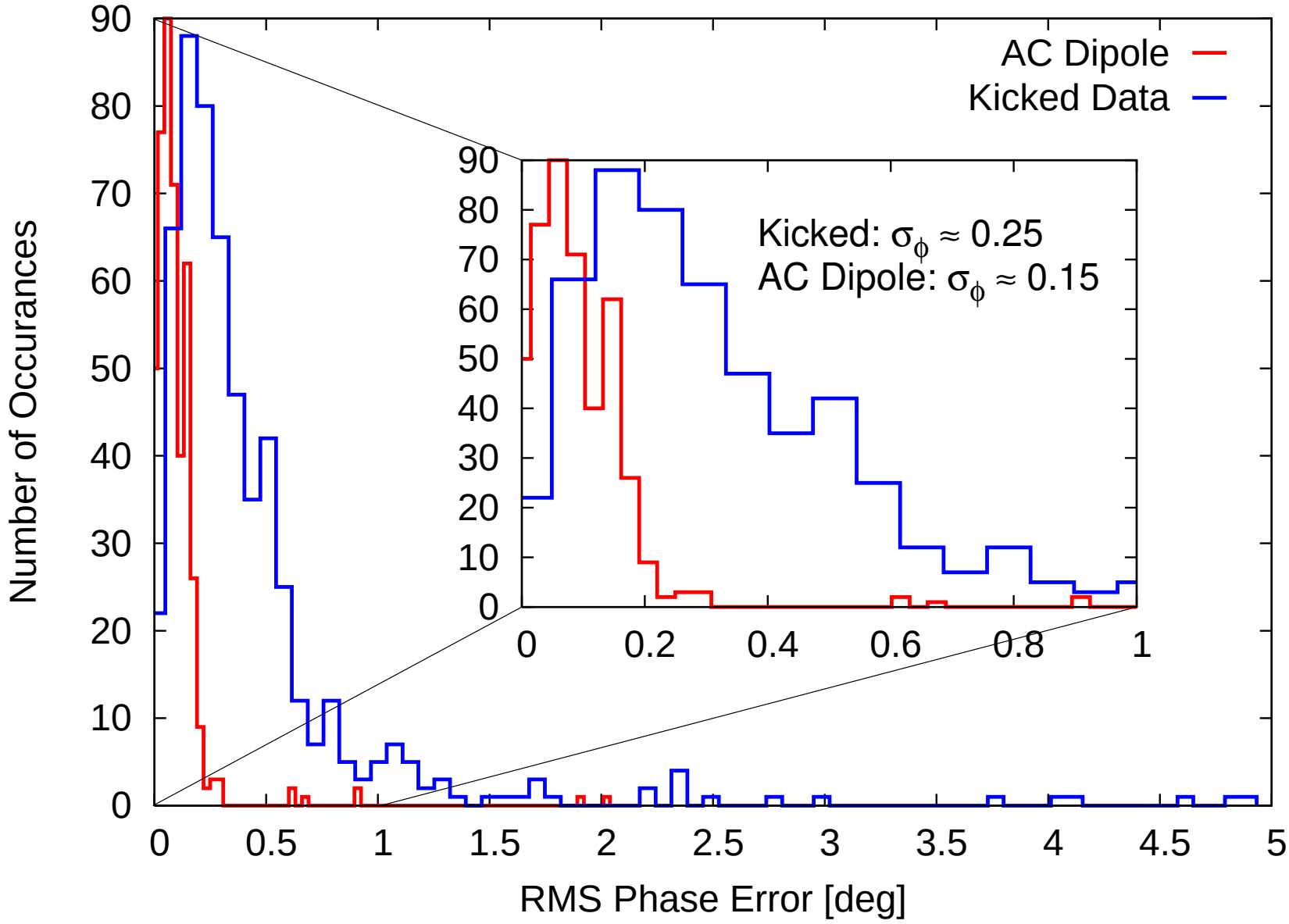


—— AC Dipole Data: Courtesy M. Bai

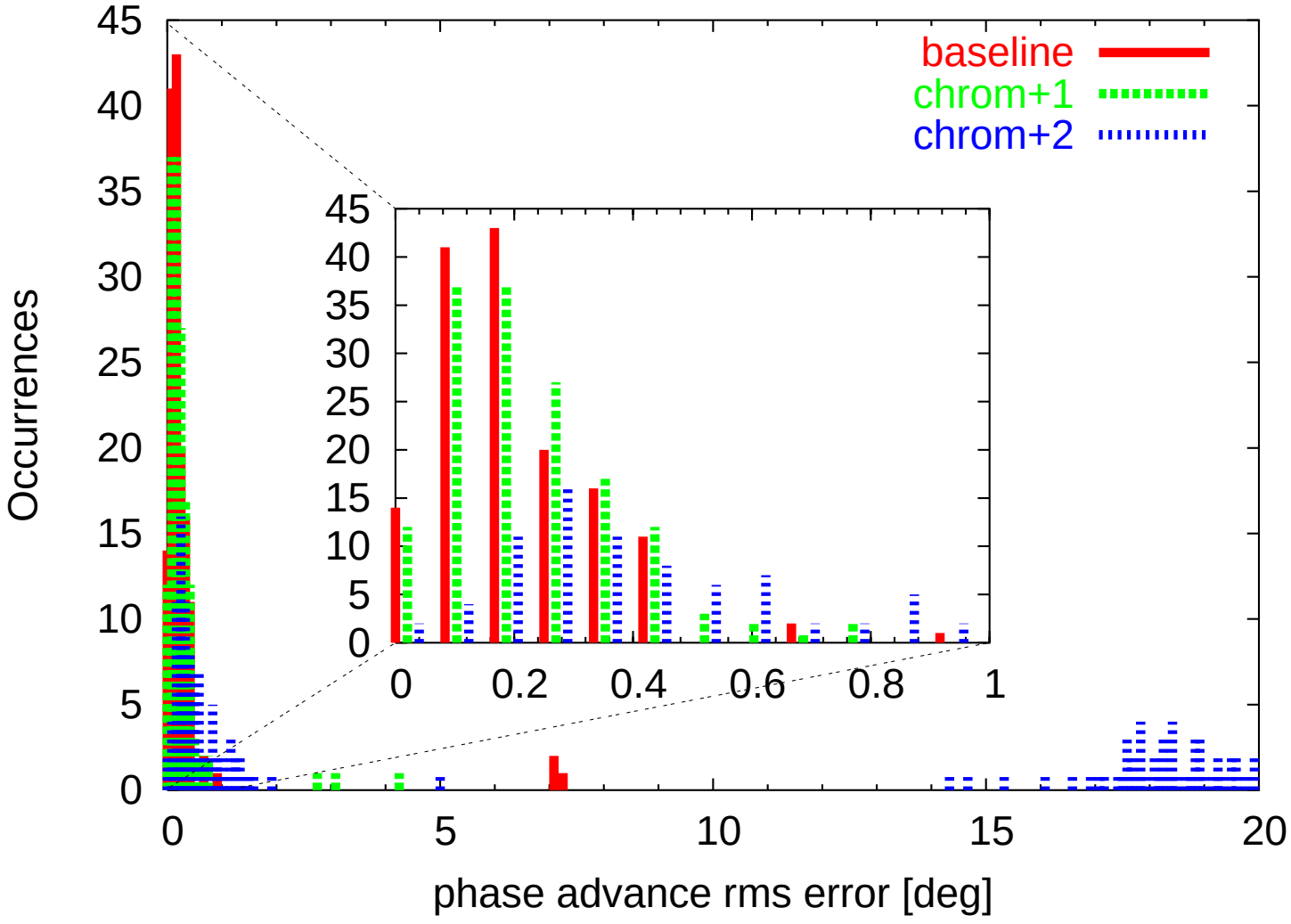
$\Delta\phi$ Measurement Err (σ_ϕ)

Kicked & AC Dipole Exps

Ph. Err (σ_ϕ), Low Chrom (Kicked & AC Dipole)



Ph. Err (σ_ϕ), Chromaticity Scan



- $\sigma_\phi \sim 0.25°$ for low chromaticity (baseline)
- $\sigma_\phi \gg 1.0°$ with larger chromaticity, correction difficult (PAC07)

Conclusions

- Requirements for Effective Corr:
  - Coherent Osc. ($\sim$ 400 turns, or AC Dipole) & Synchronized BPMs
  - Phase Err: $\sigma_\phi \ll 1^\circ$
  - Normalized Disp Err: $\left|\sigma_{D_x/\sqrt{\beta_x}}\right|_{rms} < 0.01\sqrt{m}$
  - Typically need 3-5 Iteration ($<$ 5 min/Iter), Reproducibility

- Application:
  - High level JAVA application (Glenn)
  - Run python scripts underneath (Robust & Well Tested)
  - Test final application to do online correction at RHIC (2008)

- Future Work:
  - Corr. via K-Modulation (114 Ind. Circ $\rightarrow \beta$'s)
  - Investigate discrepancies between Beam 1 & 2

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