10 Hz GOFB real-time system calibration

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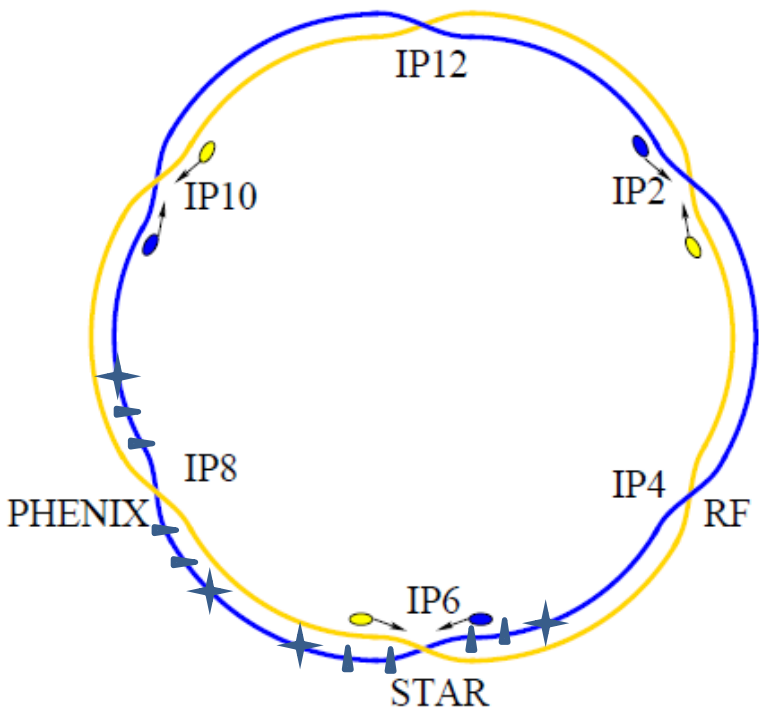
Outline

1. Background
2. Why need calibration?
3. What’s been done?
4. What’s the plan?

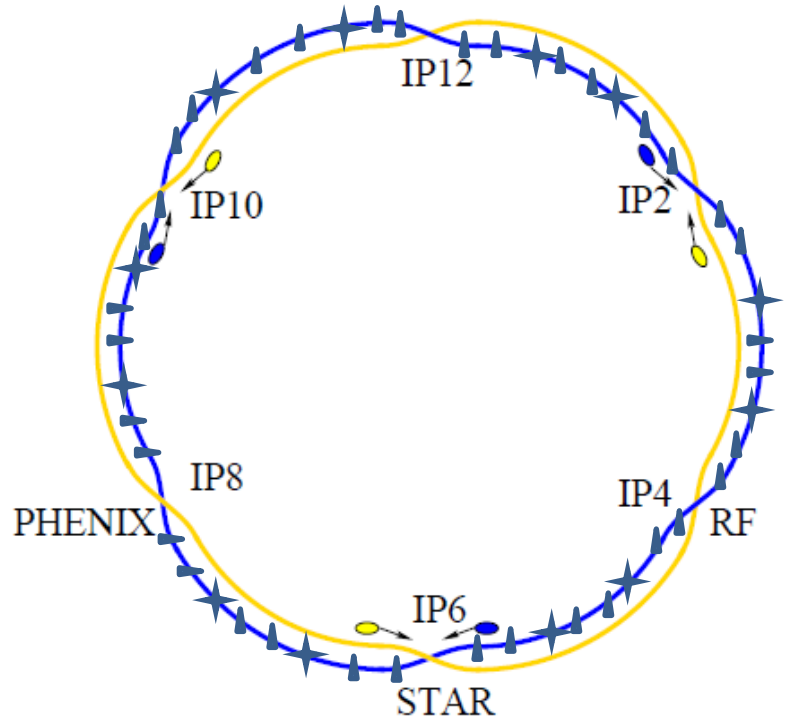
Background:

Intro to 10 Hz GOFB

The purpose of the 10 Hz global orbit feedback system is to correct the 10 Hz horizontal beam perturbations in both rings that are suspected to be caused by triplet magnet vibrations



Run-10



Run-11

corrector BPM

4 BPMs/IR, 2 BPMs/arc, 1 corrector/triplet

Orbit response matrix

Orbit response matrix R is the closed-loop transfer function which correlates corrector strength and horizontal position measured by a beam position monitor

$$\begin{pmatrix} \Delta x_1 \\ \Delta x_2 \\ \dots \\ \Delta x_{36} \end{pmatrix} = \begin{pmatrix} R_{1,1} & R_{1,2} & \dots & R_{1,12} \\ R_{2,1} & R_{2,2} & \dots & R_{2,12} \\ \dots & \dots & \dots & \dots \\ R_{36,1} & R_{36,2} & \dots & R_{36,12} \end{pmatrix} \begin{pmatrix} \Delta\theta_1 \\ \Delta\theta_2 \\ \dots \\ \Delta\theta_{12} \end{pmatrix}$$

Singular value decomposition (SVD) algorithm is used to compute the required corrector strength:

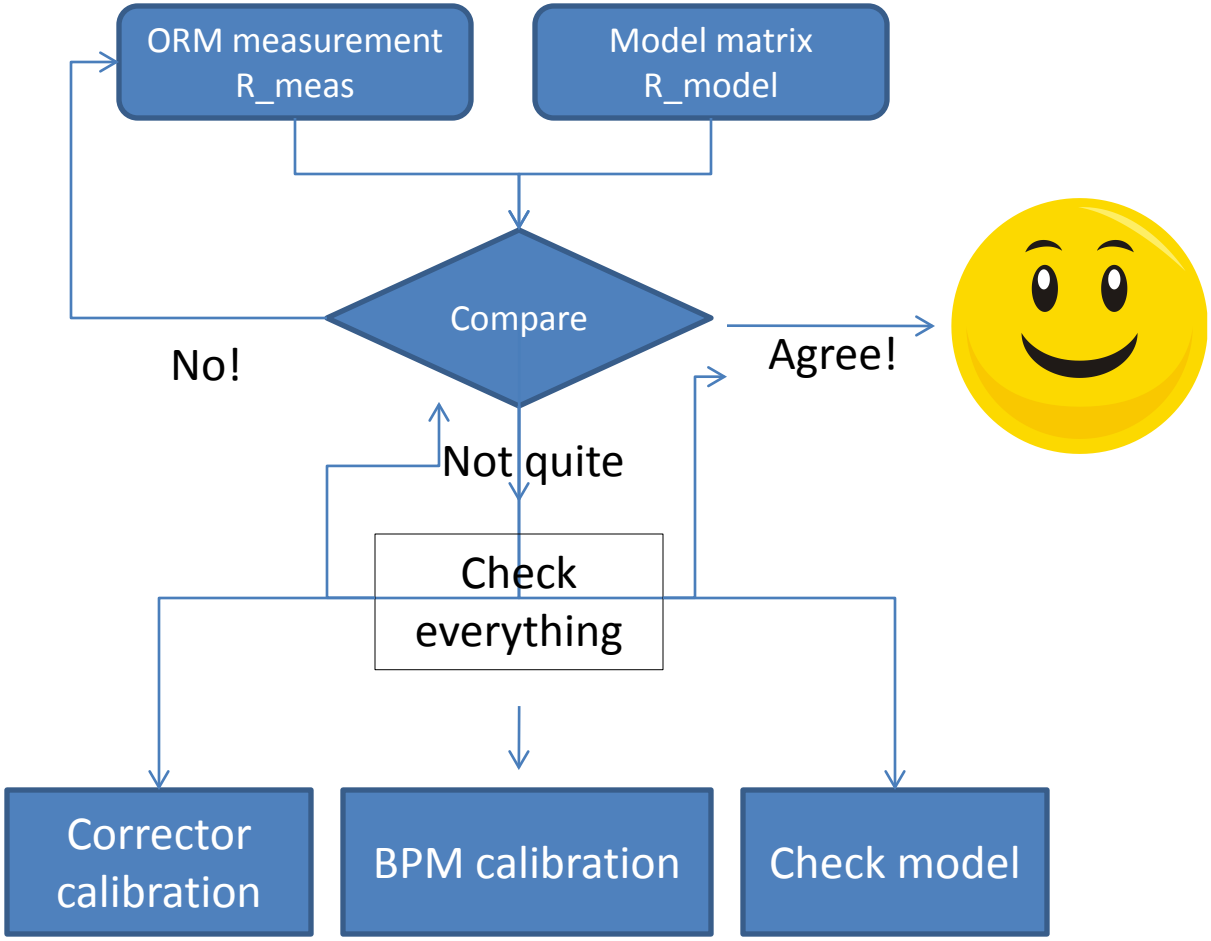
$$\Delta x = R\Delta\theta$$

$$\Delta x = USV'\Delta\theta$$

$$\Delta\theta = VS^{-1}U'\Delta x$$

Why calibration?

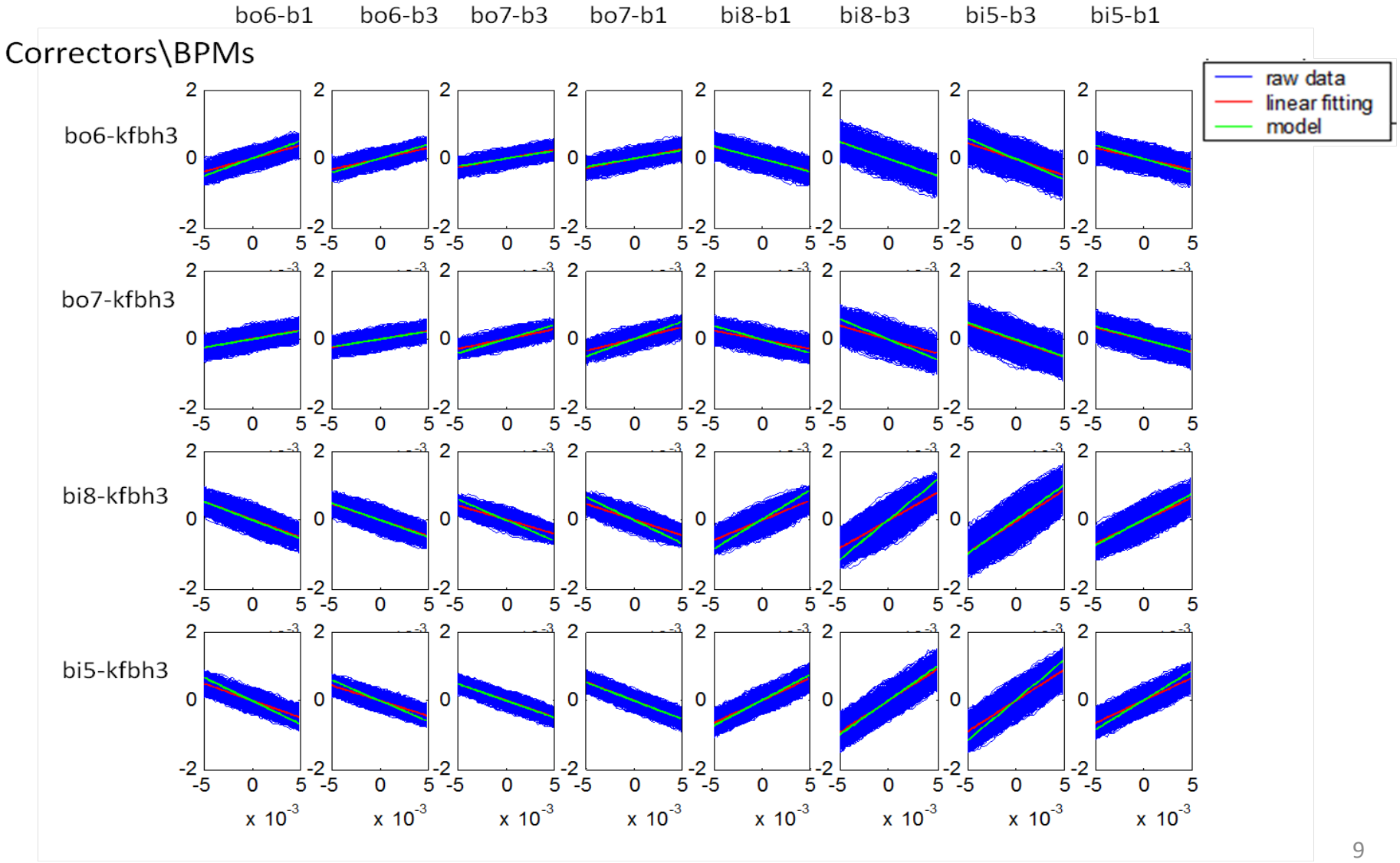
Why need calibration?



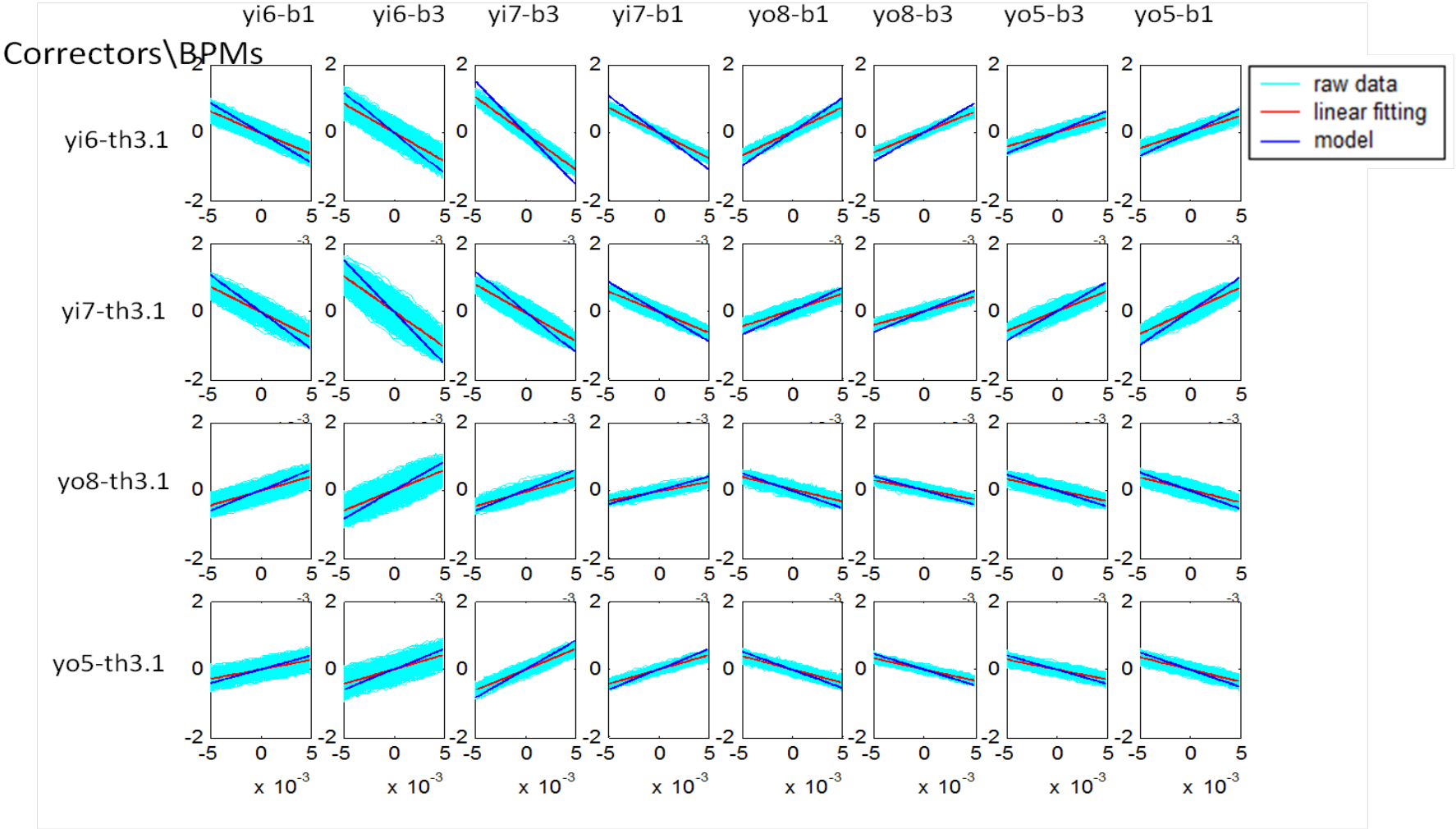
R_meas (avoids errors in BPM and corrector calibrations and in the optical model) is supposed to make GOFB perform better!

What’s been done:

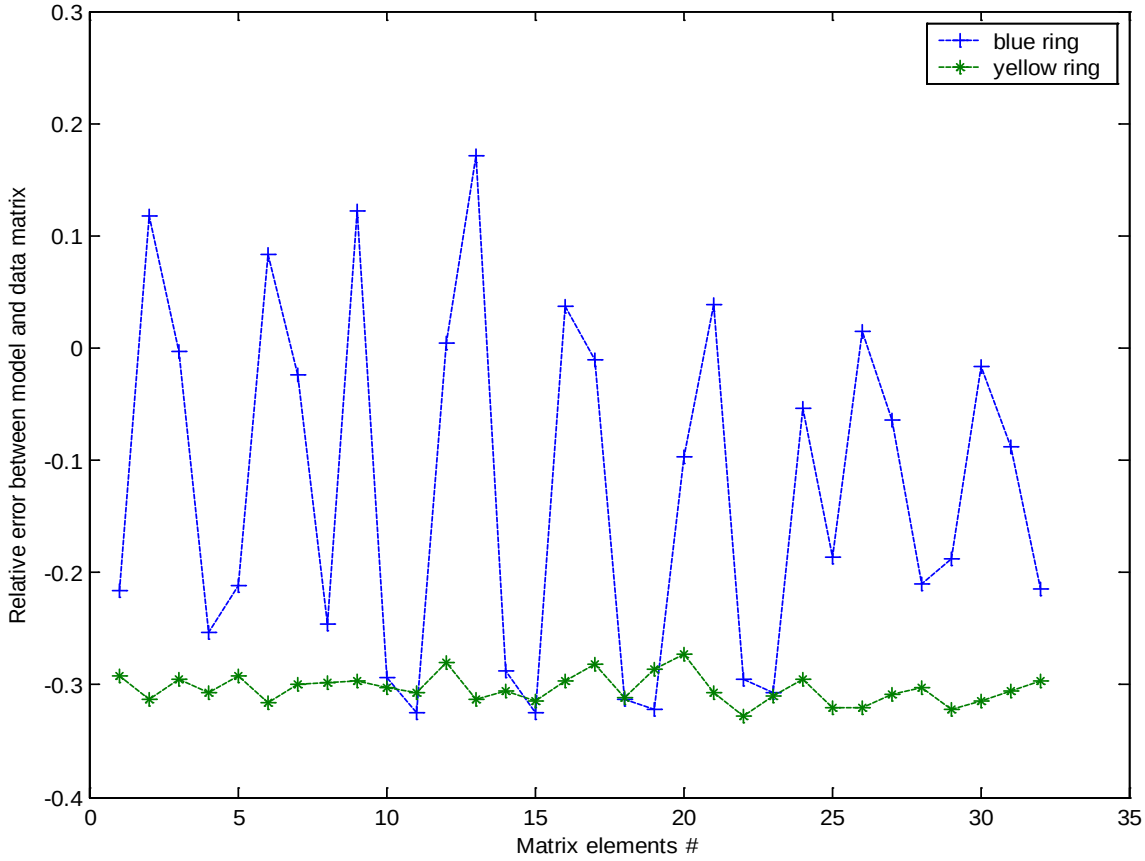
R_meas vs. R_model for blue



R_meas vs. R_model for yellow

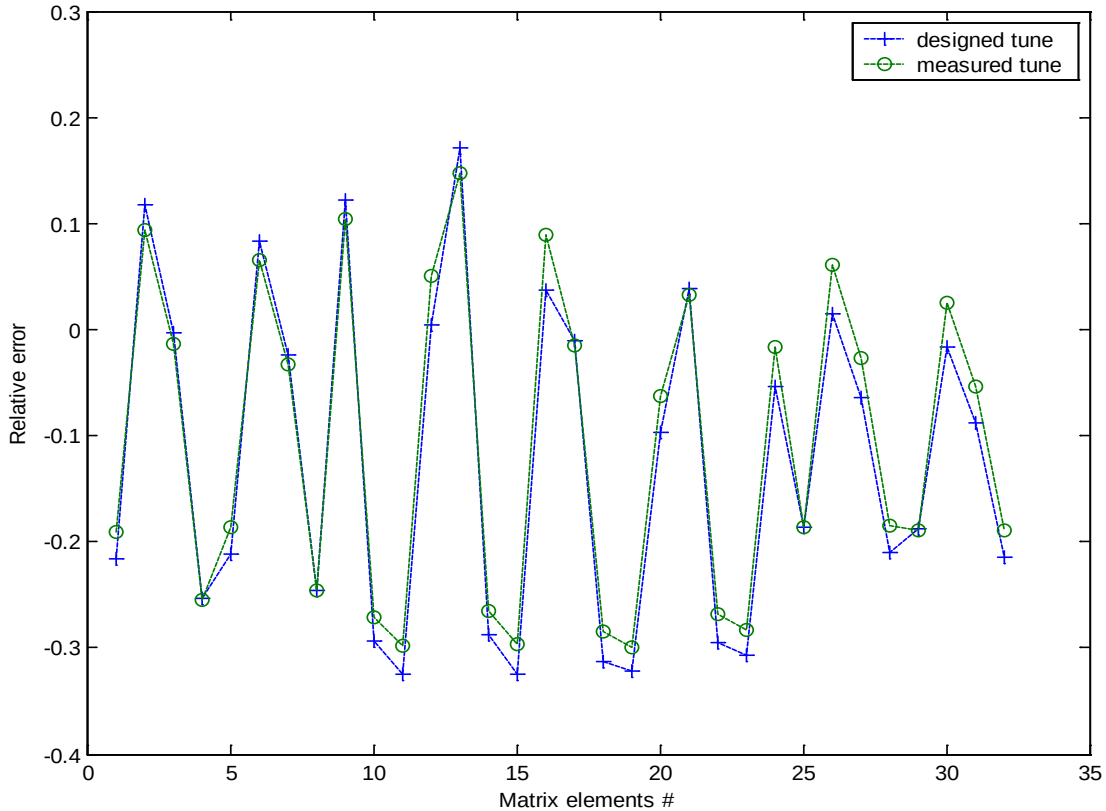


Relative errors



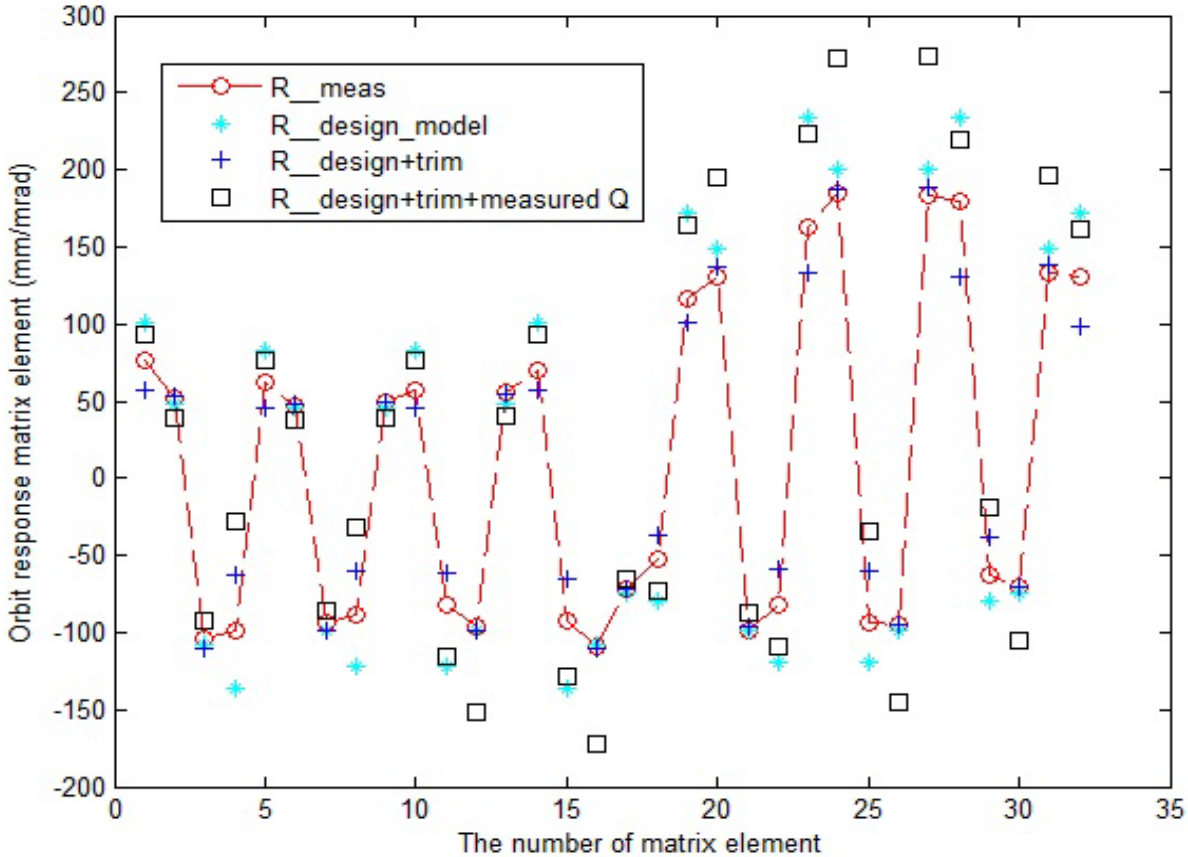
Random errors in blue is suspected from model (see later slides); systematic negative errors in yellow seems like from scaling factor for BPMs or correctors (not confirmed yet).

Tune effect



No big difference between designed tune and measured tune (measured for same fill, but not at exact same time as ORM measurement).

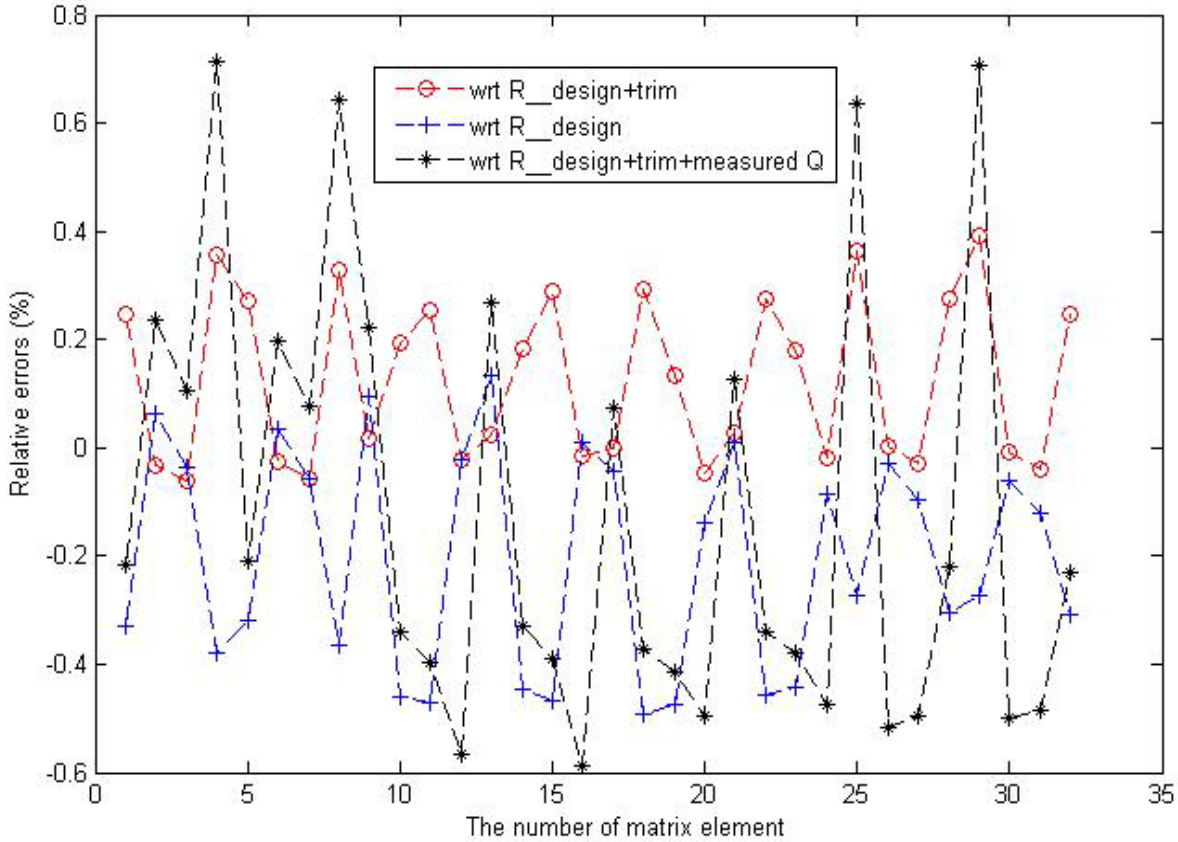
ORMs from different model



Design + trim model results in a matrix quite different from that from design model

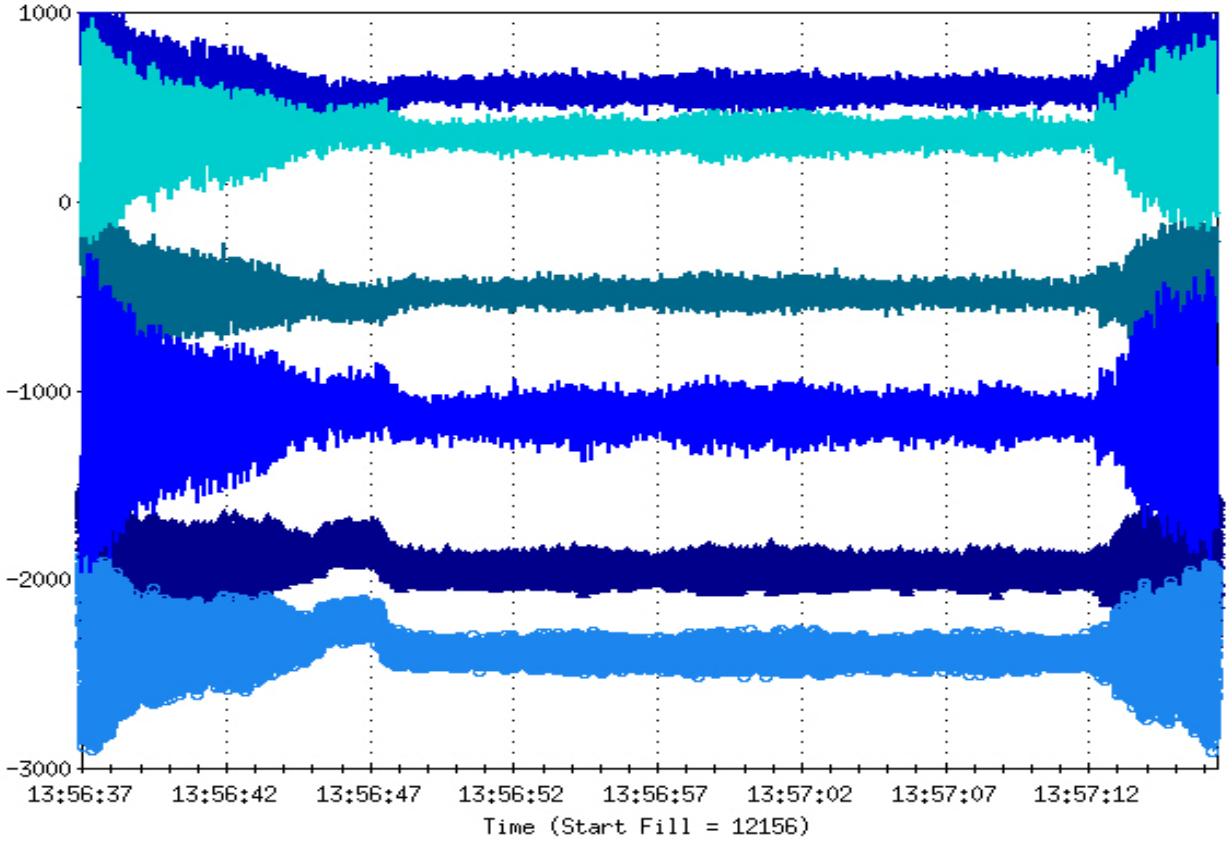
Q_design=31.2293, Q_design+trim=31.3158, Q_meas=31.2346

Relative errors wrt. different model

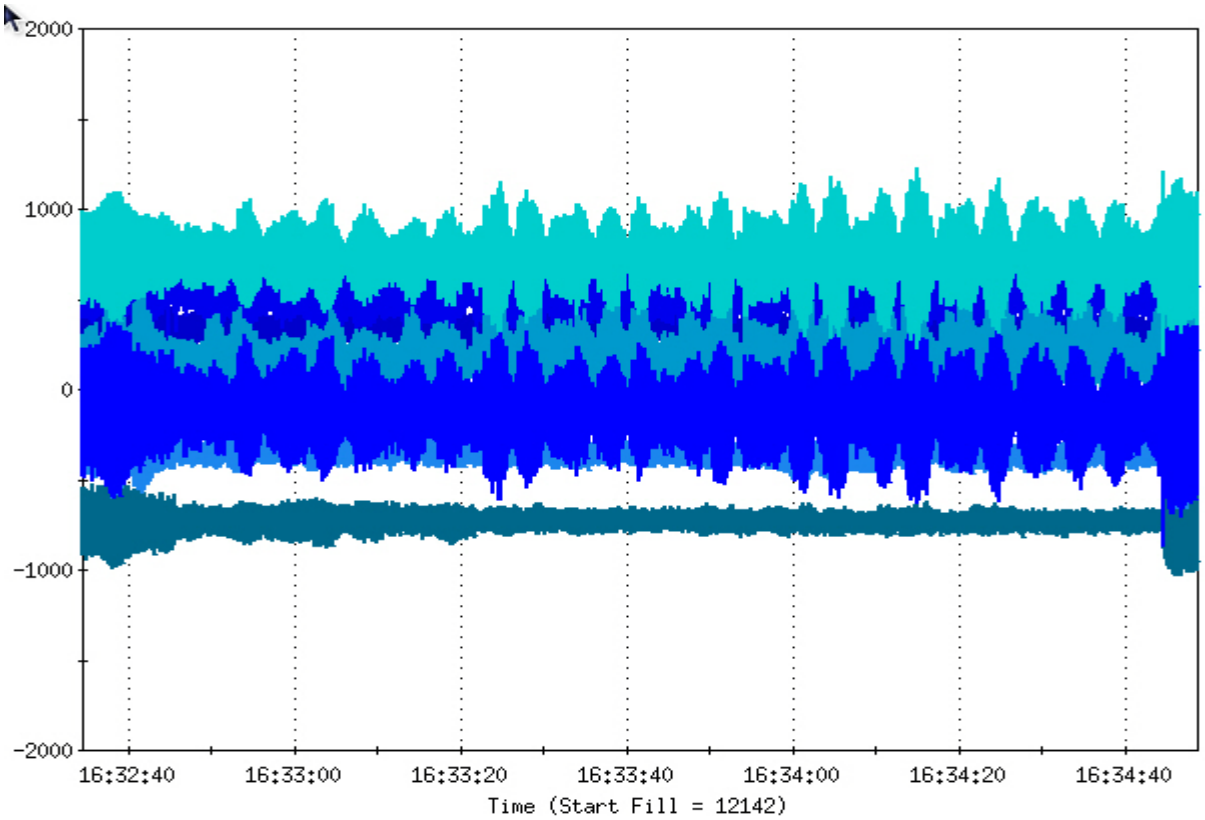


None of the models is close to measurement

GOFB at Au104 (100GeV)



GOFB at Au107 (19.5GeV)



BPM measurements converge well at 6 o'clock, but not at 8 o'clock. This seems like Au107 model is off, for which we did the ORM measurement.

What’s the plan?

Plan for Run-11

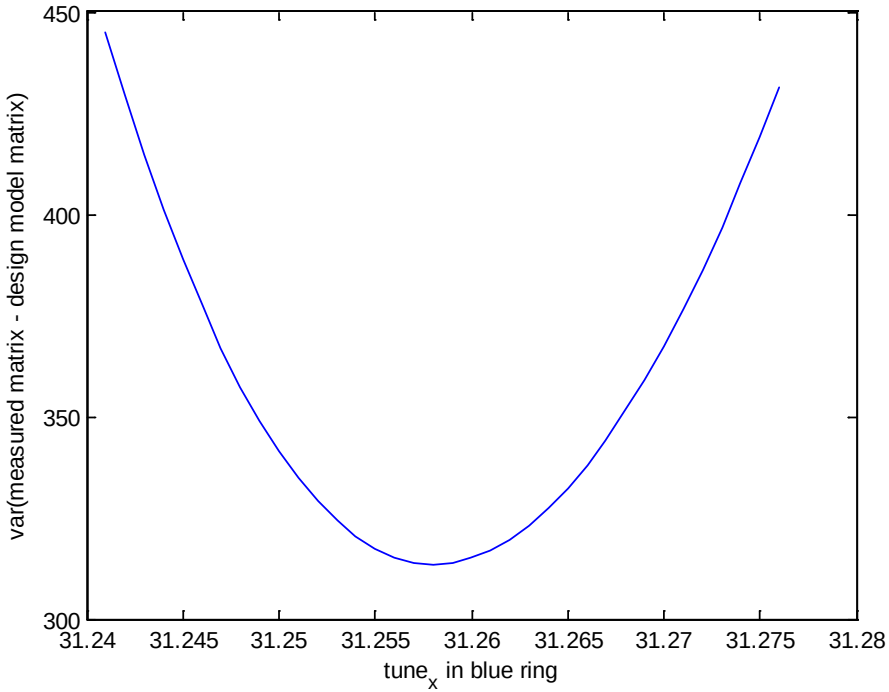
1. Develop automated acquisition of full response matrix using 12 correctors per accelerator
   - sequential excitation of correctors at single frequency
   - simultaneous excitation of correctors at different discrete frequencies

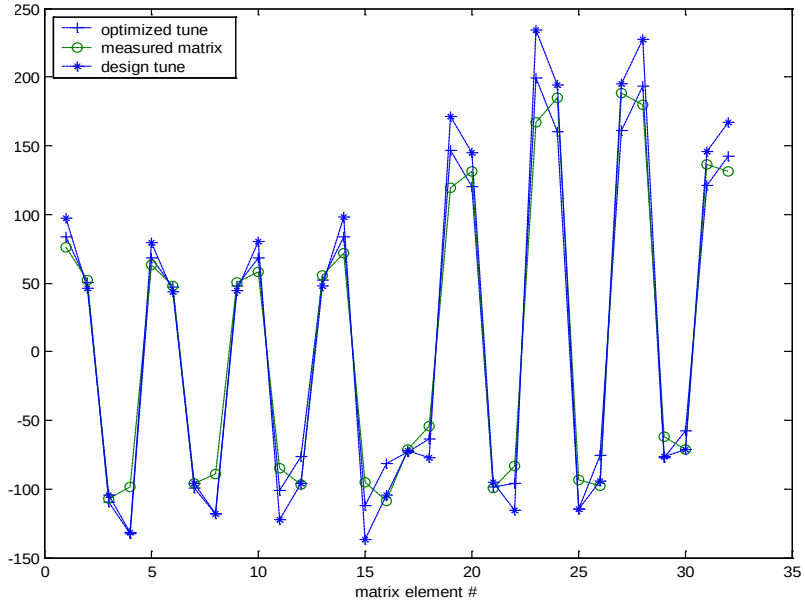
2. Develop codes (python) to
   - read online model, or
   - acquire data

   compute matrix, perform SVD, send reconstructed matrix elements to ML510

3. Compare the performance of GOFB using R_meas and R_model both with variable number of selected eigenvalues

Backup


var(measured matrix - design model matrix)
450
400
350
300
31.24
31.245
31.25
31.255
31.26
31.265
31.27
31.275
31.28
tune$_x$ in blue ring


optimized tune
measured matrix
design tune
250
200
150
100
50
0
-50
-100
-150
0
5
10
15
20
25
30
35
matrix element #