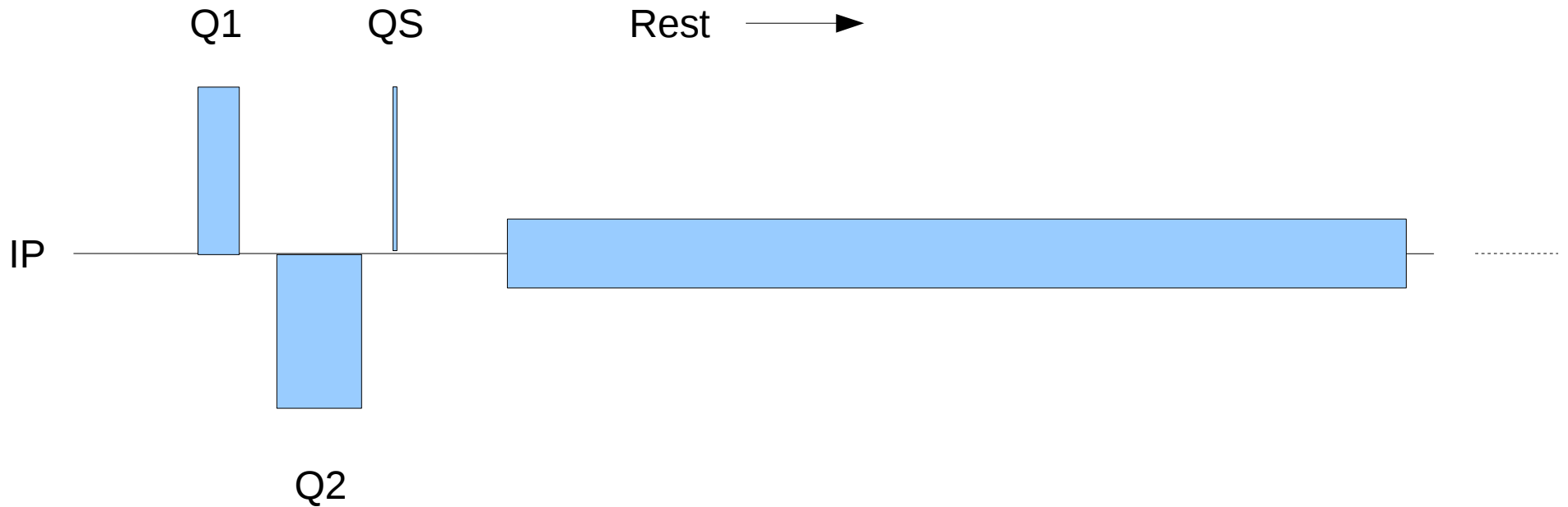


Measure Twiss and Coupling



- Varied 6 quadrupoles for each measurement
- Got 21 tune/coupling measurements
- Solve for 10 unknowns for the twiss and coupling matrix

10 parameters:

$$[\mu_x, \alpha_x, \beta_x, \mu_y, \alpha_y, \beta_y, a, b, c, d]$$

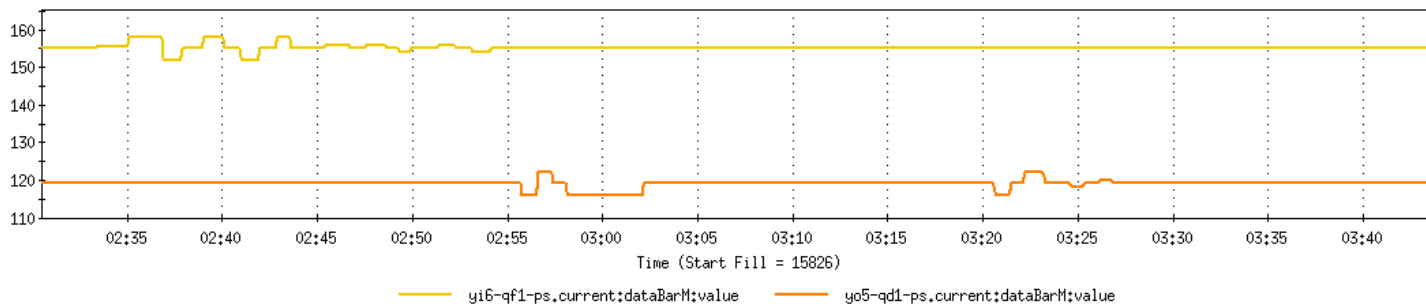
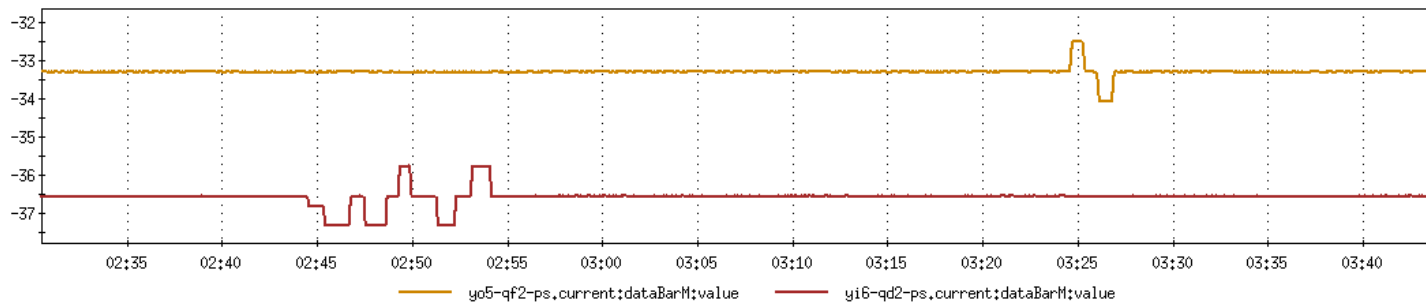
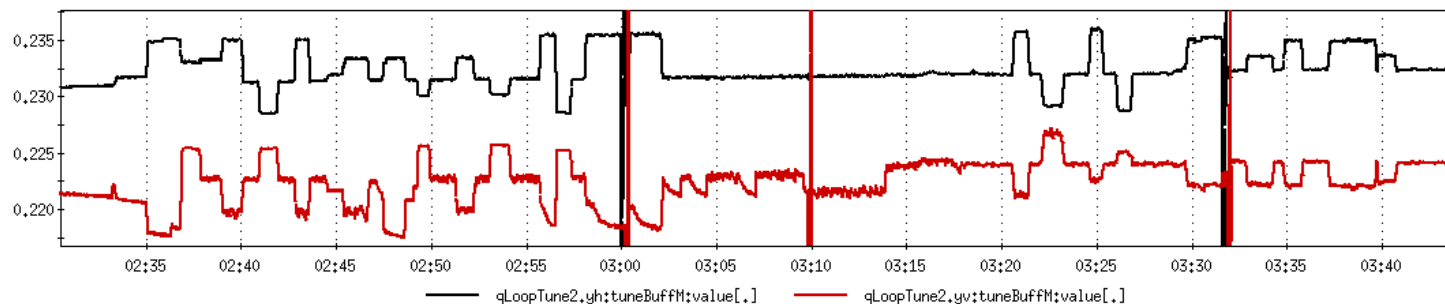
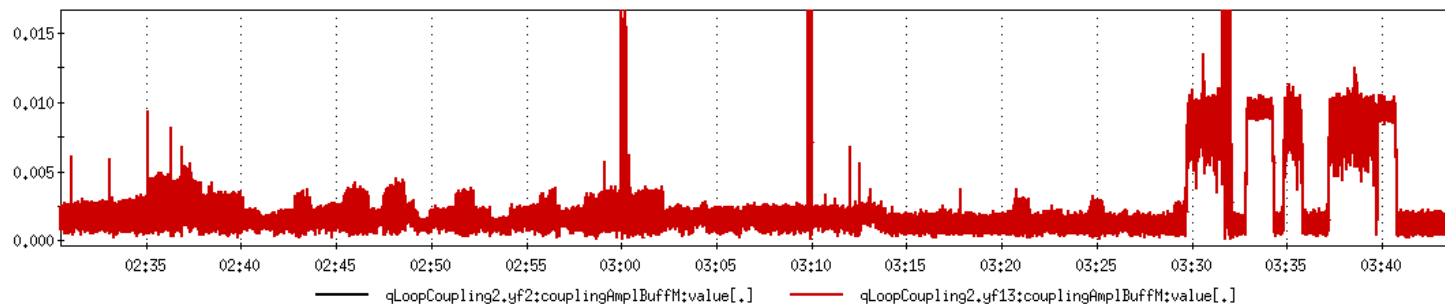
The eigen-tunes from the transfer matrix:

$$Q_{\pm} = \text{Tune}_{\pm}(\mathbf{T}) = \frac{1}{2\pi} \arccos\left(\frac{1}{2}(\text{Tr}(\mathbf{A}) + \text{Tr}(\mathbf{D}))\right) \pm \sqrt{\frac{1}{4}(\text{Tr}(\mathbf{A}) - \text{Tr}(\mathbf{D}))^2 + \det(\bar{\mathbf{B}} + \mathbf{C})}$$

The ΔQ_{min} from the transfer matrix:

$$\Delta Q_{min} = \text{DtuneMin}(\mathbf{T}) = \frac{\sqrt{\det(\bar{\mathbf{B}} + \mathbf{C})}}{\pi[\sin(2\pi Q_+) + \sin(2\pi Q_-)]}$$

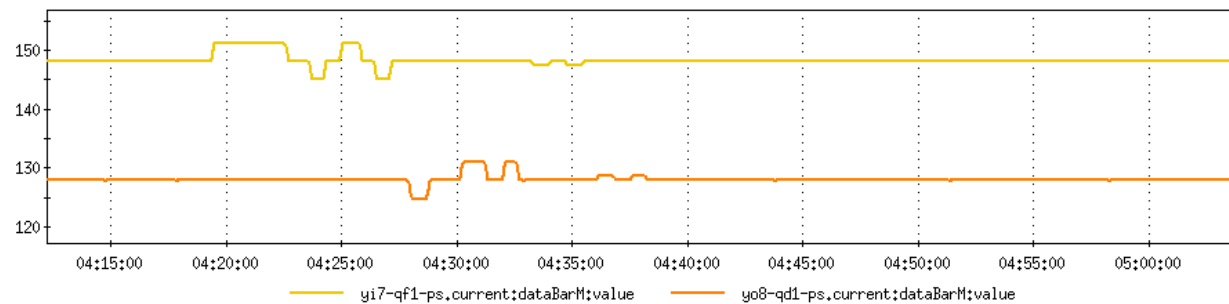
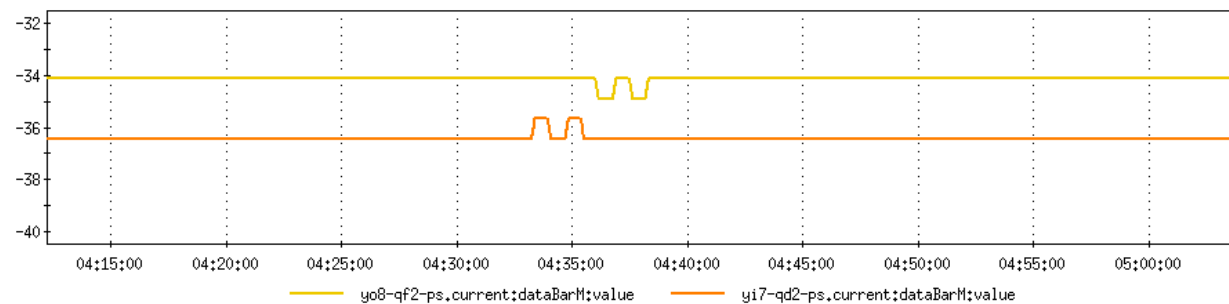
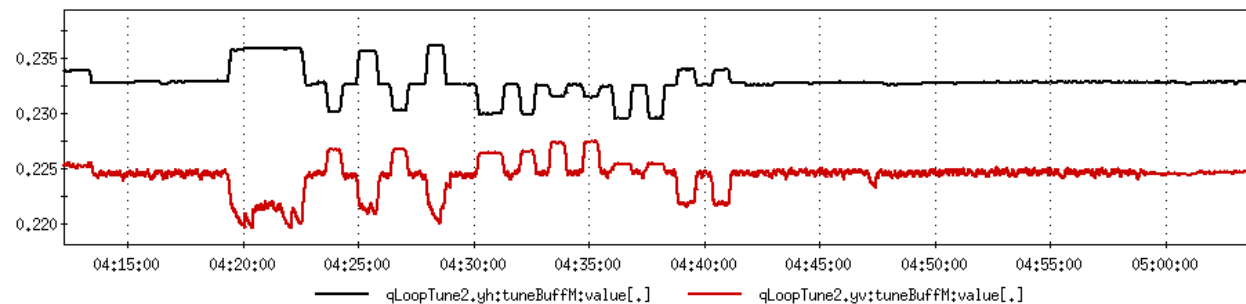
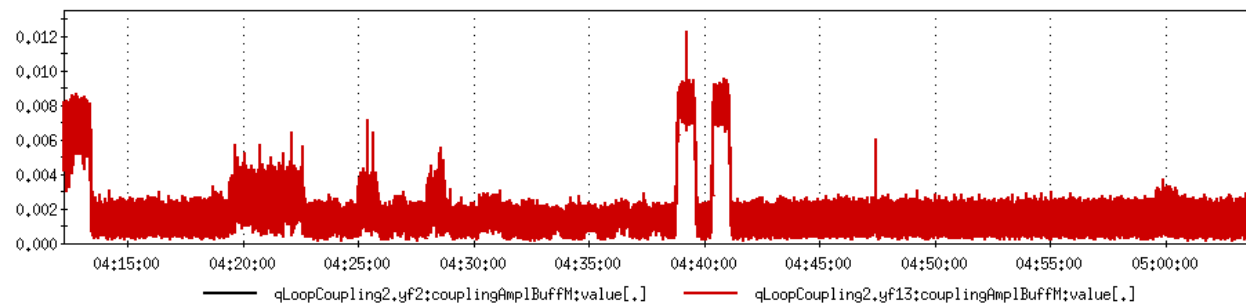
BBQ measures the eigen-tunes and the ΔQ_{min} . Using the above equations, we solve for the 10 parameters that describe the transfer matrix T .



IP6

Vertical tune was noisier and less reproducible than horizontal tune.

Automated BTF measurements were on.



IP8

Vertical tune was noisier and less reproducible than horizontal tune.

Yellow Inner triplet (yi7) rolls were not measured.

Measurements: Yellow Ring IP6 Q1, Q2 and QS

Function (Before) = [-2.62116100e-06 -3.58777264e-02 3.60109371e-02 -1.83658181e-06
-1.92856807e-02 3.81554829e-02 -1.30163078e-06 4.35805426e-02
-4.98553601e-02 1.16454641e-02 -3.98050765e-02 3.16898052e-02
-1.97100512e-06 3.72458559e-02 -2.09194808e-02 -2.57760935e-06
4.33305573e-02 -5.01786710e-02 1.16543457e-02]

Penalty (sum of the squares) = 0.0178770409974

Iteration (Imdif) = 0 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 1 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 2 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 3 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 4 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 5 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 6 0.874924667463 0.877923472679 The relative error between two consecutive iterates is at most 0.000000

Function Evaluations = 435

Solution = [8.72004991e-03 **8.74924667e-01** -1.03166021e-02 **8.77923473e-01**
-8.46935693e-04 -1.39652835e+00 5.32397985e-01 1.04766189e-04]

Function (After) = [7.79780320e-05 -2.07899524e-02 2.04300303e-02 -3.17962163e-04
-1.25320216e-02 2.15998193e-02 -2.33097174e-04 1.99271310e-02
-2.70749616e-02 3.39405391e-03 -2.31813046e-02 1.74767945e-02
-3.20300714e-04 1.71238982e-02 -1.06926763e-02 3.90754846e-04
1.98508608e-02 -2.71926048e-02 3.39274379e-03]

Penalty (sum of the squares) = 0.00501067009717

0.155181854056 1.75219109794 -0.632781029064 0.0468220661034
-0.791244825486 0.13501689822 -0.0161423140734 0.644962648774
-0.645017410941 -0.0434763104943 0.144196926666 1.76474227525
0.0182821025393 0.63278780316 -0.784205082775 0.162586336658

Qx = 0.230685 Qy = 0.221611 Delta(Q)min^2 = 8.05991930114e-05

Measurements: Yellow Ring IP8 Q1, Q2 and QS

Function (Before) = [-2.06496900e-06 -3.84760341e-02 3.48330130e-02 -3.49311404e-06
4.58588765e-02 -2.08743301e-02 -2.77804625e-06 4.55978867e-02
-4.70679388e-02 1.17033646e-02 3.96109108e-02 -4.39010652e-02
-3.09056400e-06 1.98071769e-02 -4.43135568e-02 -1.53264400e-06
4.58289863e-02 -4.68687601e-02 1.16804412e-02]

Penalty (sum of the squares) = 0.0199497978457

Iteration (Imdif) = 0 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 1 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 2 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 3 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 4 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 5 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000
Iteration (Imdif) = 6 0.927703601863 0.919477307143 The relative error between two consecutive iterates is at most 0.000000

Function Evaluations = 412

Solution = [-1.34128463e-02 **9.27703602e-01** 1.31452232e-02 **9.19477307e-01**
-6.82648124e-04 1.94970973e+00 -6.55368271e-01 1.27702418e-03]

Function (After) = [6.69818681e-05 -1.82598116e-02 1.76551435e-02 -2.87593001e-04
2.06908688e-02 -8.16279599e-03 3.41699569e-04 1.95132442e-02
-1.58919353e-02 2.23374466e-03 1.74554502e-02 -1.89859285e-02
4.09041456e-04 7.28713852e-03 -1.79675477e-02 3.48575335e-04
1.96233835e-02 -1.58526821e-02 2.23032998e-03]

Penalty (sum of the squares) = 0.00346112325515

0.123029955591 2.19690828938 0.65377751212 -0.0441263791306
-0.6417123753 0.151218474017 0.0158127531087 -0.656317157474
0.656285922809 0.0450828745455 0.14259367913 2.18722924957
-0.0141737179898 -0.653719081692 -0.645303564209 0.118945022325
Qx = 0.224425 Qy = 0.232795 Delta(Q)min^2 = 6.90468371254e-05

Measure Twiss and Coupling

- Repeat the yellow measurement with better vertical tune measurements
- Two sets of measurements
 - With and without coupling
- Measure blue ring IPs