RHIC BBA Measurement & BPM offset Installation

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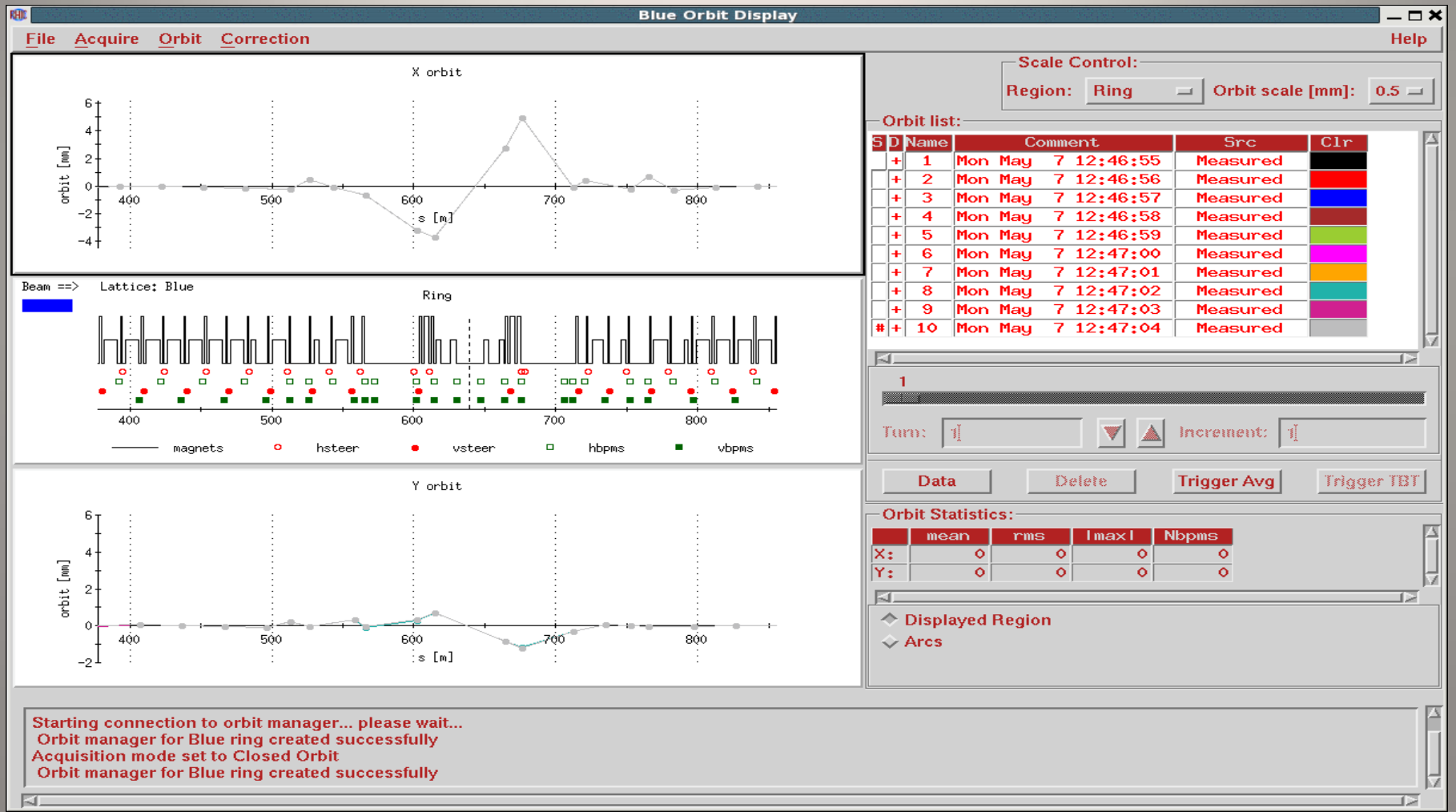
Basic Procedure for BPM offset installation

The basic procedure we followed:

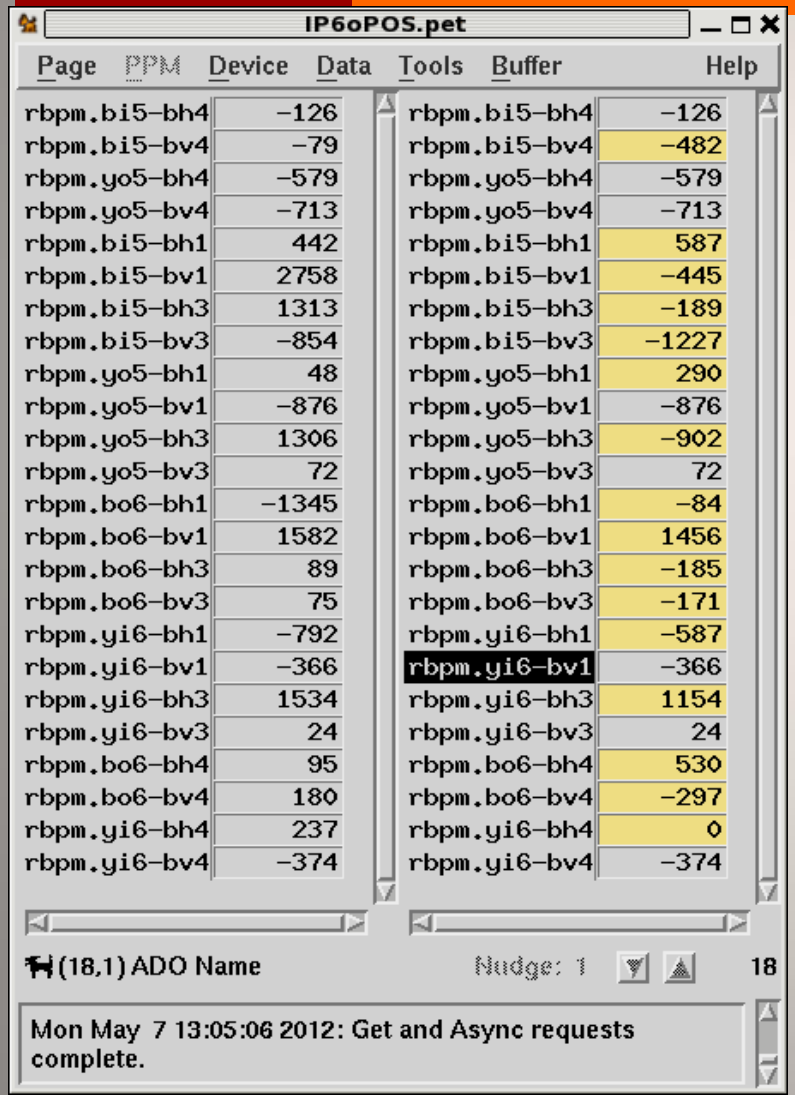
1) Pulse LISA
2) Turn off 10hz feedback
3) Orbit feedback
4) Save a goal orbit (to fall back to if screw things up, or at least make a note of what the current goals are.)
5) Turned off automatic orbit corrections.
6) Change BPMs using a script or by hand
7) Capture orbit, make goal
8) Turn 10Hz feedback back on
9) Turn LISA back on

Blue orbit before BPM offset installation

æ 12:47:cp Large horizontal blue orbit at 8 o'clock.



Blue orbit before BPM offset installation



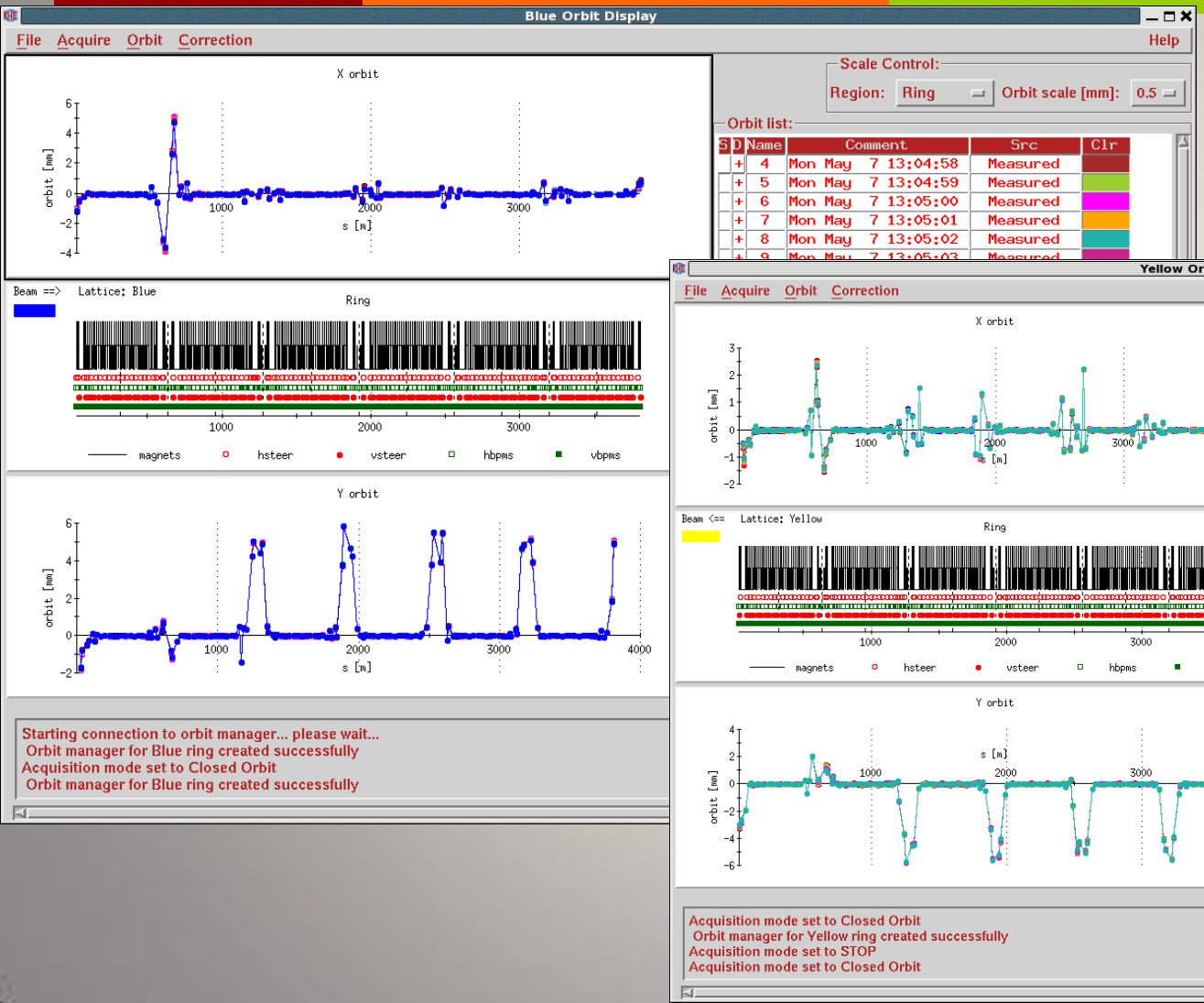
rbpm.bi5-bh4	-126	rbpm.bi5-bh4	-126
rbpm.bi5-bv4	-79	rbpm.bi5-bv4	-482
rbpm.yo5-bh4	-579	rbpm.yo5-bh4	-579
rbpm.yo5-bv4	-713	rbpm.yo5-bv4	-713
rbpm.bi5-bh1	442	rbpm.bi5-bh1	587
rbpm.bi5-bv1	2758	rbpm.bi5-bv1	-445
rbpm.bi5-bh3	1313	rbpm.bi5-bh3	-189
rbpm.bi5-bv3	-854	rbpm.bi5-bv3	-1227
rbpm.yo5-bh1	48	rbpm.yo5-bh1	290
rbpm.yo5-bv1	-876	rbpm.yo5-bv1	-876
rbpm.yo5-bh3	1306	rbpm.yo5-bh3	-902
rbpm.yo5-bv3	72	rbpm.yo5-bv3	72
rbpm.bo6-bh1	-1345	rbpm.bo6-bh1	-84
rbpm.bo6-bv1	1582	rbpm.bo6-bv1	1456
rbpm.bo6-bh3	89	rbpm.bo6-bh3	-185
rbpm.bo6-bv3	75	rbpm.bo6-bv3	-171
rbpm.yi6-bh1	-792	rbpm.yi6-bh1	-587
rbpm.yi6-bv1	-366	rbpm.yi6-bv1	-366
rbpm.yi6-bh3	1534	rbpm.yi6-bh3	1154
rbpm.yi6-bv3	24	rbpm.yi6-bv3	24
rbpm.bo6-bh4	95	rbpm.bo6-bh4	530
rbpm.bo6-bv4	180	rbpm.bo6-bv4	-297
rbpm.yi6-bh4	237	rbpm.yi6-bh4	0
rbpm.yi6-bv4	-374	rbpm.yi6-bv4	-374

13:11: New and old (yellow highlighting) orbPositionOffsetS values.

Blue orbit before BPM offset installation

Time: May 7 2012
Time: 12:55-13:03

Blue orbit before BPM offset installation



Orbit while running feedback after installation of new offsets.

Goal of this BBA Session

1. Verify the BBA results from the previous measurements (last APEX and/or last two years);
2. Obtain BBA measurements on other BPMs;
3. Test a possibly more thorough BBA measurement procedure and compare the results to that of previous BBA measurement. The procedure is to do BBA systematically on all the measurable quad/BPM in IR one-by-one from upstream to downstream: (a) Starting BBA measurement from Q4trim/BPM4 pair upstream of IP; (b) use 3 correctors to put the beam through the center of Q4trim found through step (a); (c) move on to BBA measurement on Q3/BPM3 and Q1/BPM1; (d) move the beam to the center of Q1 before moving on to the Q1/BPM1 on the other side of IP…
4. Test possible strategy for beam alignment (optimum beam path) through IR (Q4-Q3-Q2-Q1-Q1-Q2-Q3-Q4) by iteration through the following steps: (a) BBA measurements in the section (6 BPMs, horizontal and vertical) and find the correction to BPMs; (b) include the BPM corrections into a target orbit; c) apply orbit feedback to move the beam as close to the targeted orbit as possible. Then repeat (a) to (c) to see if the result converges.

Procedure of this BBA Session

The BBA results in ROUND 0:

(a) Install the offsets based on the best results from previous BBA sessions.
(b) Use liveFeedback to send the orbit at all BPMs in IR6 to zero mm (or, as close as Feedback could make it) before starting Round 1.

For each measurement in ROUND 1:

(a) Took a BBA measurement on the 1st quad upstream of IR;
(b) installed the offset into the BPM;
(c) run liveFeedback for ~10 seconds to re-zero beam on those BPMs using the newly installed orbPositionOffsetS value;
(d) On the next BPM downstream, repeat steps (a) to (c).

Results from the BBA Analysis

from 1Hz BPM reading of all BPMs in all arcs

↓beam↓		ROUND 0			ROUND 1		
↓dir↓		oPosOffS [um]	BBA Result [um]	oPosOffS [um]	oPosOffS [um]	BBA Result [um]	oPosOffS [um]
bi5-b4	HOR	-126	0	-126	-126	-63	-63
	VER	-482	0	-482	-482	-403	-79
bi5-b3	HOR	-189	-1535	1346	1346	33	1313
	VER	-1227	-373	-854	-854		-854
bi5-b1	HOR	587	222	365	365	-77	442
	VER	-445	-811	366	366	91	275
bo6-b1	HOR	-84	1134	-1218	-1218	127	-1345
	VER	1456	-79	1535	1535	-47	1582
bo6-b3	HOR	-185	-544	359	359	270	89
	VER	-171	-232	61	61	-14	75
bo6-b4	HOR	530	0	530	530	435	95
	VER	-297	0	-297	-297	-477	180
yi6-b4	HOR	0	0	0	0	-237	237
	VER	-374	0	-374	-374		-374
yi6-b3	HOR	1154	-217	1371	1371	-163	1534
	VER	24	0	24	24		24
yi6-b1	HOR	-587	81	-668	-668	124	-792
	VER	-366	-295	-71	-71		-71
yo5-b1	HOR	290	242	48	48		48
	VER	-876	-474	-402	-402		-402
yo5-b3	HOR	-902	-2208	1306	1306		1306
	VER	72	0	72	72		72
yo5-b4	HOR	-579	0	-579	-579		-579
	VER	-713	0	-713	-713		-713

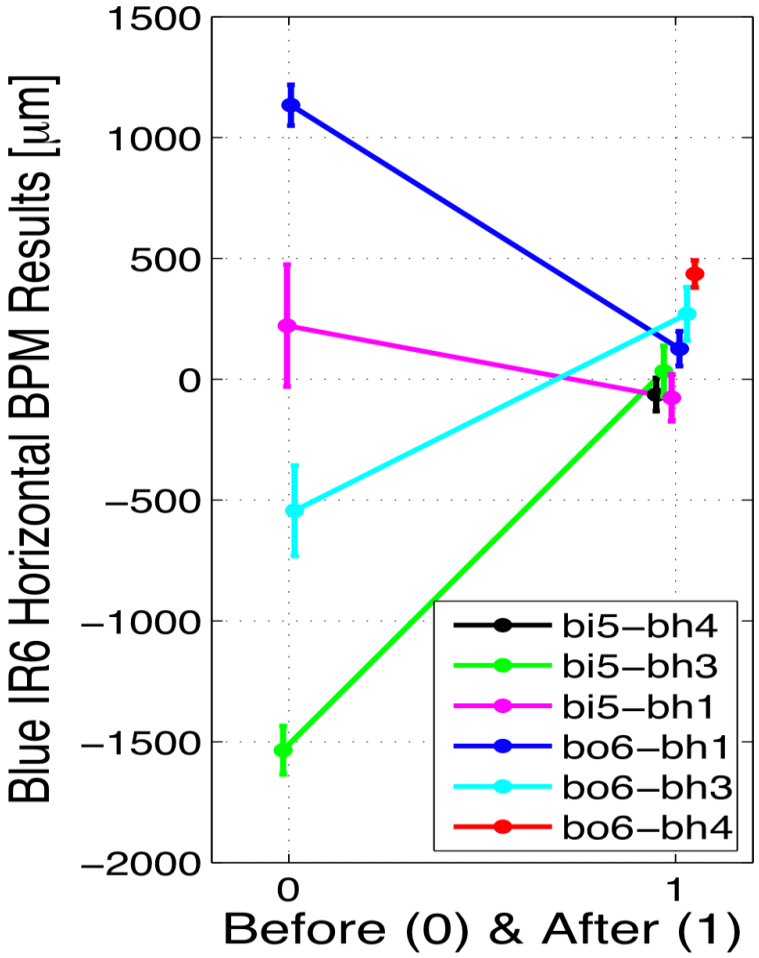
Results from the BBA Analysis

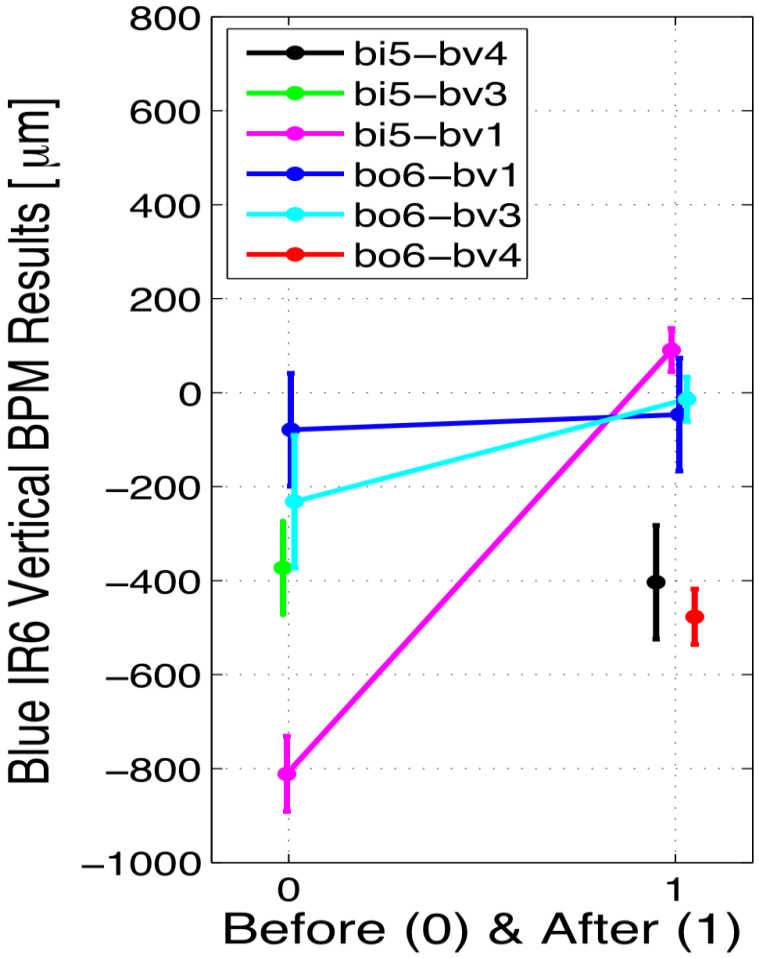
Complete list of the BBA measurements during APEX 5/2/2012

BPM	QUAD	DATE and TIME	Res. [mm]	Err [μm]
bi5-bh4	bi5-tq4	5/2/2012 10:12:07	-0.0306	65
bi5-bh4	bi5-tq4	5/2/2012 10:37:48	-0.0632	69
bi5-bh3	bi5-qf3	5/2/2012 10:42:44	0.0331	105
yi6-bh4	yi6-tq4	5/2/2012 10:52:29	-0.2369	121
yi6-bh3	yi6-qf3	5/2/2012 10:58:24	-0.1636	98
yi6-bh1	yi6-qf1	5/2/2012 11:03:53	0.1242	52
bi5-bh1	bi5-qf1	5/2/2012 11:04:18	-0.0765	97
bo6-bh1	bo6-qd1	5/2/2012 11:14:33	0.1264	72
bo6-bh3	bo6-qd3	5/2/2012 11:19:48	0.2704	110
bo6-bh4	bo6-tq4	5/2/2012 11:25:09	0.436	56
bi5-bv4	bi5-tq4	5/2/2012 11:30:23	-0.4035	121
bi5-bv1	bi5-qf1	5/2/2012 11:42:34	0.0905	46
bo6-bv1	bo6-qd1	5/2/2012 11:48:26	-0.0466	120
bo6-bv3	bo6-qd3	5/2/2012 11:53:23	-0.0139	47
bo6-bv4	bo6-tq4	5/2/2012 11:57:59	-0.477	59

Results from the BBA Analysis

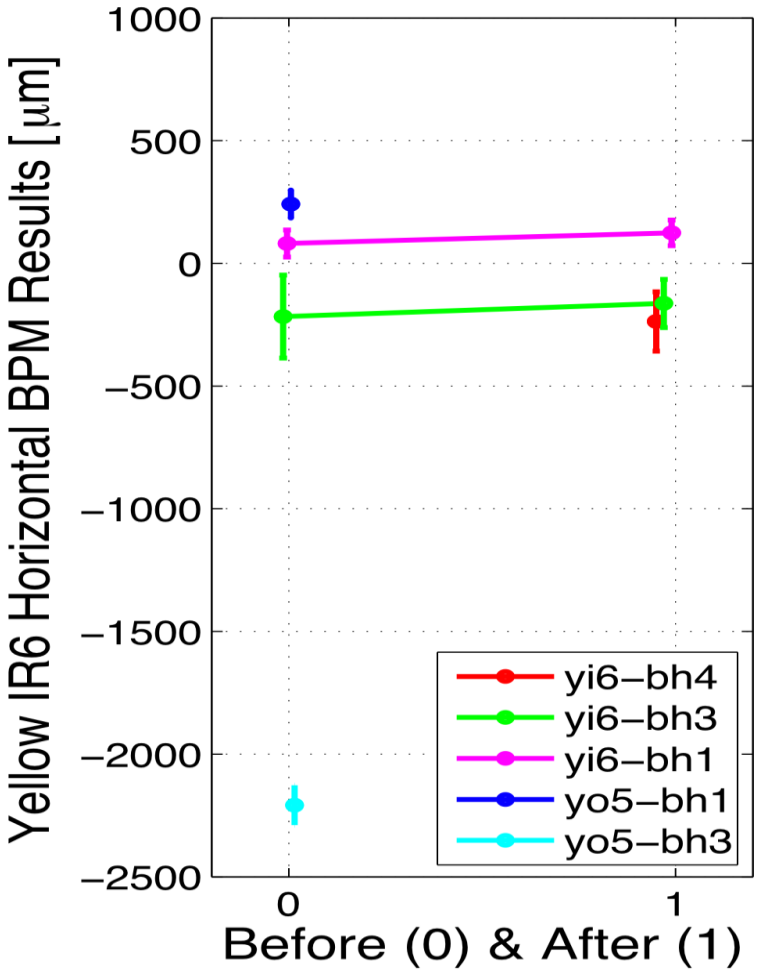
Blue IR6 BPM results (APEX 5/2/2012, bi5-bv3 not working)

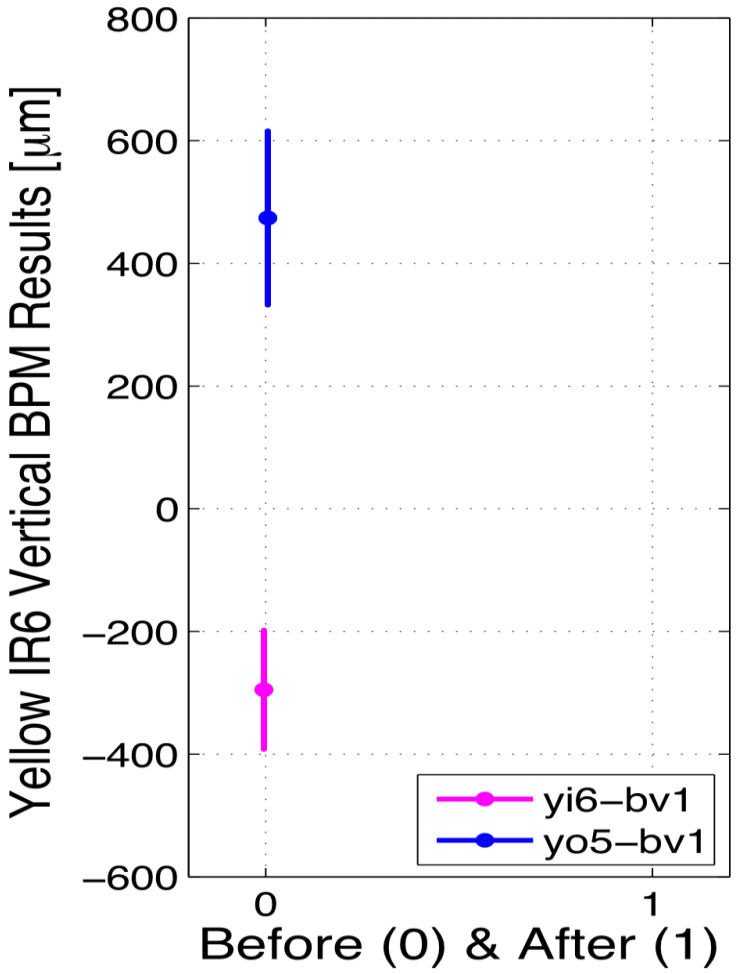




Results from the BBA Analysis

Yellow IR6 BPM results (APEX 5/2/2012, three measurements)





Results from the BBA Analysis

BPM yo5-bh3 (10 sets of measurements in 2 years)

BBA measurement run-time data file names	center [μm]	error [μm]
yo5-bh3_log_Wed_Mar__3_08:55:10_2010	-1996	377
yo5-bh3_log_Tue_Mar__9_23:21:13_2010	-2081	408
yo5-bh3_logQ1_Wed_Mar_21_19:03:46_2012	-2208	81
yo5-bh3_logQ1_Sun_Apr_22_09:50:07_2012	-2150	118
yo5-bh3_logQ1_Sun_Apr_22_09:56:57_2012	-1997	119
yo5-bh3_logQ1_Sun_Apr_22_10:00:26_2012	-2265	173
yo5-bh3_logQ1_Sun_Apr_22_10:04:24_2012	-1863	197
yo5-bh3_logQ1_Sun_Apr_22_11:56:37_2012	-2152	91
yo5-bh3_logQ1_Sun_Apr_22_12:01:54_2012	-2211	207
yo5-bh3_logQ1_Sun_Apr_22_12:06:47_2012	-2316	149
Average	-2124	192
Standard deviation	140	114

Conclusion

1. BBA on RHIC produce reliable results now.

2. There are some room for improvement
   (a) Systematic measurement
   (b) Iteration through measure-align-measure-align

3. Accuracy limitation: ~0.1 mm
   (a) Quads physical misalignment relative to each other
   (b) Limited correctors
   (c) repeatability under same machine settings

Quad Settings During BBA Measurements

pp12b-v2 at injection

Magnet Names	Length [m]	k [m-2]	kL [m-1]
Q1	1.44	0.0818	0.1178
Q2	3.4	-0.1887	-0.6416
Q3	2.1	0.1148	0.2411
tQ4	0.75	0.0378	0.0284
Q4	1.83	-0.1637	-0.2996
tQ5	0.75	0.0135	0.0101
tQ6	0.75	-0.0134	-0.01
Q7	0.95	0.0834	0.0792
Q8	1.13	-0.091	-0.1028
Q9	1.13	0.0891	0.1007

What we have learned from BBA measurement

1. Possible to develop nonconventional procedure to improve the accuracy/speed

   When the machine is reasonably stable BBA measurement can be performed by taking baselines (without changing the quad) for all beam-offset locations, then change quad once and take the measurement at the same set of offset locations. (It allows us to manipulate the offset in a nonconventional fashion in order to improve the accuracy/speed.)

2. A step towards streamline measurement: knowledge on measurement parameters

   A careful choice of beam-offset range and the amount of quad strength change in a given lattice can improve measurement accuracy without much sacrifice of beam lost. It was found the best beam-offset range is [-4.0 4.0]mm with quad strength change of -0.002 on Q1 or Q2 at injection.

3. A step towards automatic analysis: data requirement for reliable analysis

   Needs minimum 9 measurement points (4 on positive side and 4 on the negative side) to have confidence of good measurement since a line obtained from fitting 2 or 3 measurement points appears to be unreliable.

4. Knowledge on measurement accuracy vs. 1Hz BPM reading settle time

   The 3 seconds waiting time for the 1Hz BPM reading appears to be adequate. But the first/last measurement point (after a big step from/to the original setting) is bad in some of the measurements. The solution could be a 4-5 seconds waiting for the first and the last step.