

Bpm study

-- check beam position

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BPM pedestal Study

□ Goal: To help resolve the yields drift problems

□ Today

- Study the jump - calibrated position changed while yields not change

Recall BPM Calibration

□ The calculation of beam position (pengjia technote):

$$x_b = \frac{(A_+ - A_{+ped} + b_+) - g_x(A_- - A_{-ped} + b_-)}{(A_+ - A_{+ped} + b_+) + g_x(A_- - A_{-ped} + b_-)}$$

$$x = Rx_b \left(\frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)$$

$$y = Ry_b \left(\frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)$$



Beam pos



$$x_{BPMrealBPM} = c_0 + c_1x + c_2y$$

$$y_{BPMrealBPM} = c'_0 + c'_1x + c'_2y$$

- A_+, A_- : bpm raw signal for + and - channel
- A_{+ped}, A_{-ped} : bpm pedestal for + and - channel
- b_+, b_- : offset, calibration constant
- $g_x, c_0, c_1, c_2, c'_0, c'_1, c'_2$: calibration constant

Recall BPM Calibration

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$$x = Rx_b \left(\frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)$$

$$y = Ry_b \left(\frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)$$



Beam pos



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- A_+, A_- : bpm raw signal for + and - channel
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□ Today

- What will happen if total offset $b_{tot+} = b_+ - A_{+ped}, b_{tot-} = b_- - A_{-ped}$ not constant
- Show total offset did change

Math

□ The calculation of beam position (pengjia technote):

$$x_b = \frac{(A_+ - A_{+ped} + b_+) - g_x(A_- - A_{-ped} + b_-)}{(A_+ - A_{+ped} + b_+) + g_x(A_- - A_{-ped} + b_-)}$$

□ We can write the above formula as

$$x_b = \frac{[f(A_+) - b_{tot+}] - g_x[f(A_-) - b_{tot-}]}{[f(A_+) - b_{tot+}] + g_x[f(A_-) - b_{tot-}]}$$

Here $f(A_+) = k_+ * current + b_{real+}$, $f(A_-) = k_- * current + b_{real-}$, k_+, k_- relates to position response

➤ If $b_{tot+} \neq b_{real+}$ or $b_{tot-} \neq b_{real-}$ (wrong offset in formula)

$x_b = h(current, b_{tot+}, b_{real+}, b_{tot-}, b_{real-}, k_+, k_-, g_x)$ dependent on current and other factors.

➤ If $b_{tot+} = b_{real+}$ and $b_{tot-} = b_{real-}$ (right offset in formula)

$x_b = h(k_+, k_-, g_x)$ NOT dependent on current

- A_+, A_- : bpm raw signal for + and - channel
- A_{+ped}, A_{-ped} : bpm pedestal for + and - channel
- b_+, b_- : offset, calibration constant
- $g_x, c_0, c_1, c_2, c'_0, c'_1, c'_2$: calibration constant

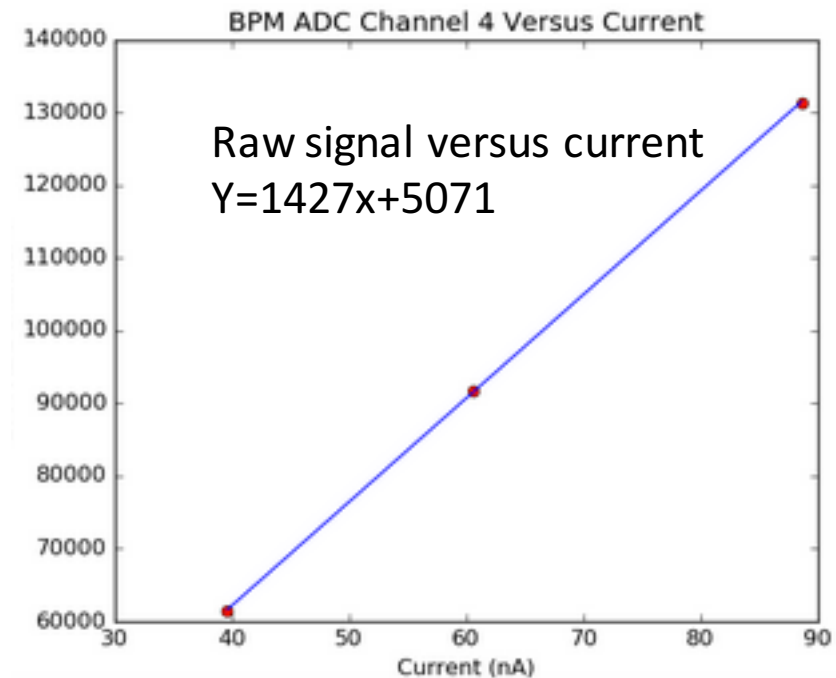
How to get offset b_+ , b_-

- One possibility is to check with harp scan runs
- same bpm gain settings, same position, with different current

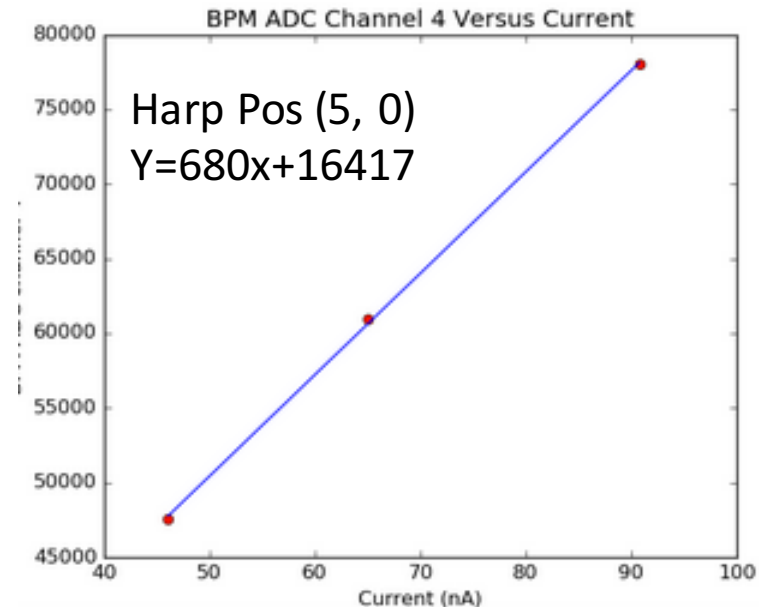
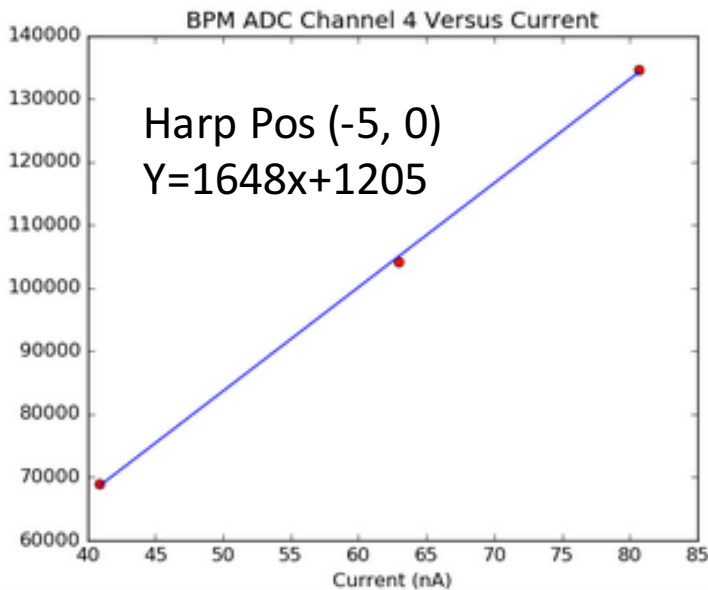
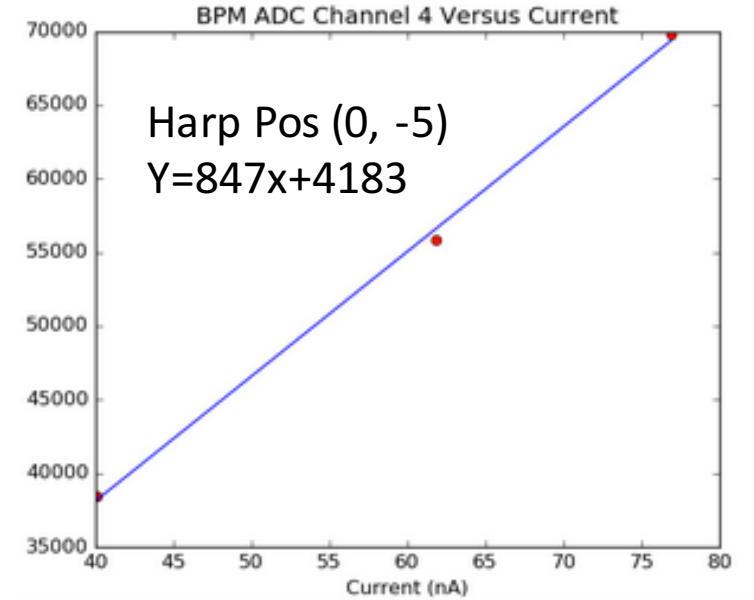
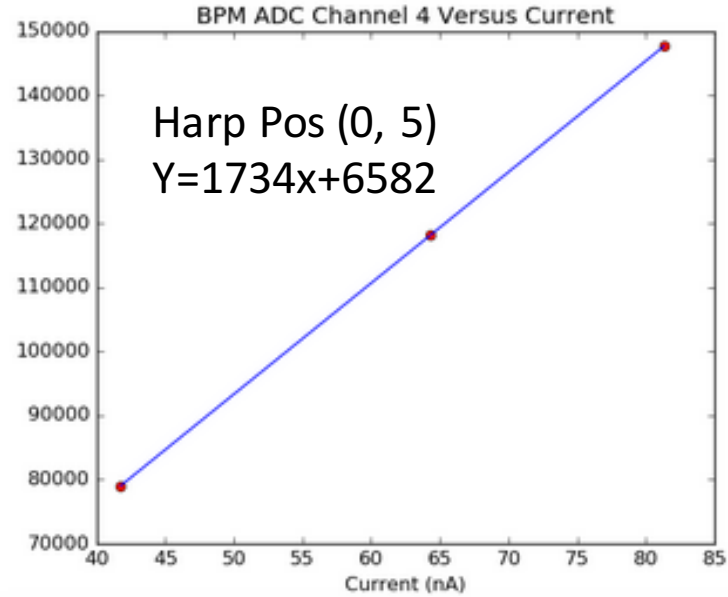
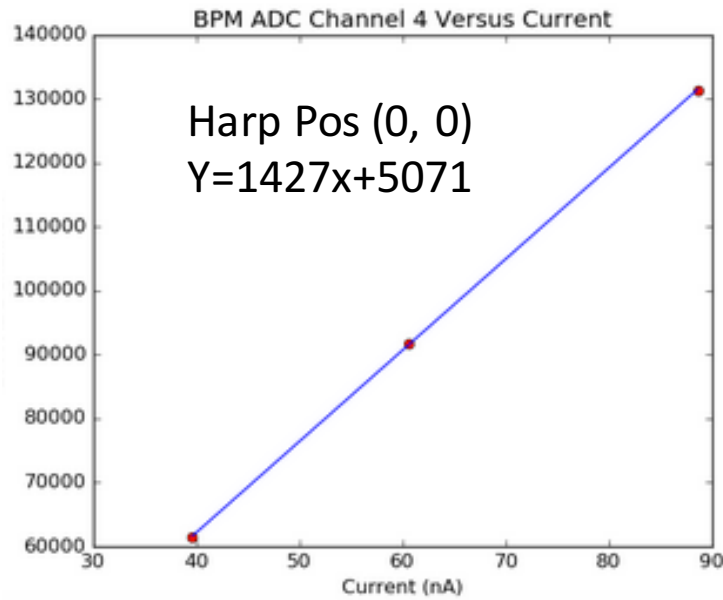
Run Number	Harp pos Setting (x, y) mm	Current setting (nA)	Real Current (nA)
5490	(0, 0)	100	88.59
5491	(0, 0)	75	60.56
5494	(0, 0)	50	39.59

The Offset: 5071

- Will it be a constant?
compare the offset got from different position



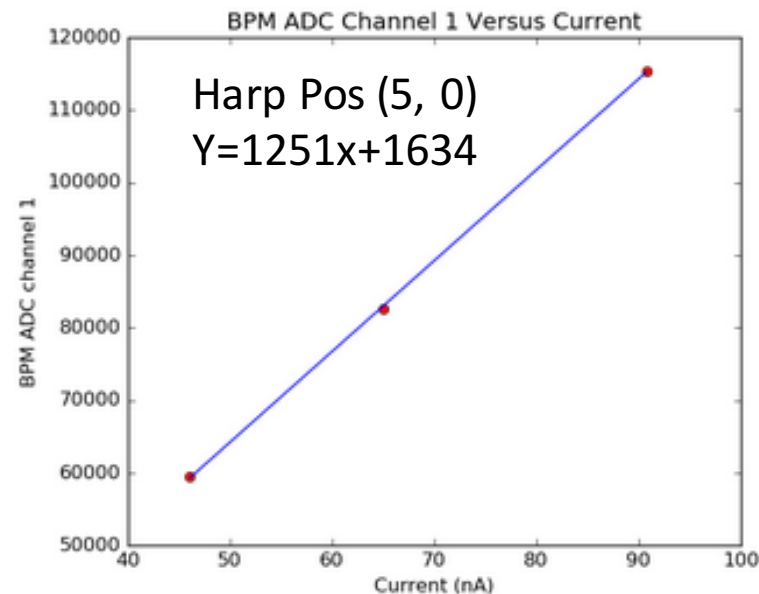
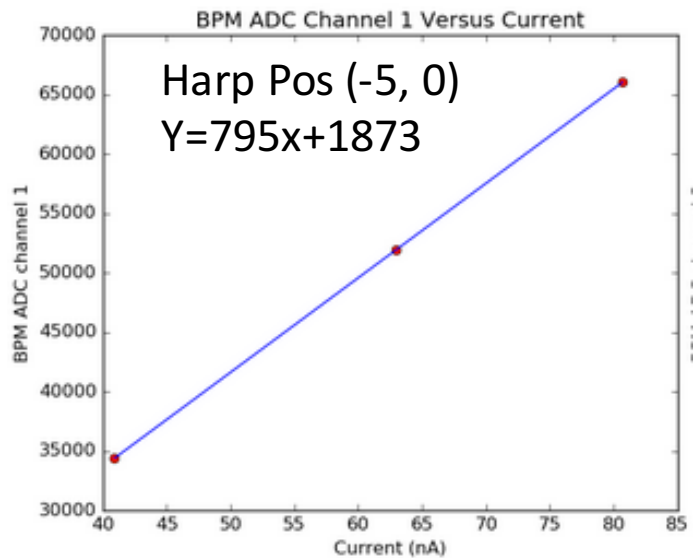
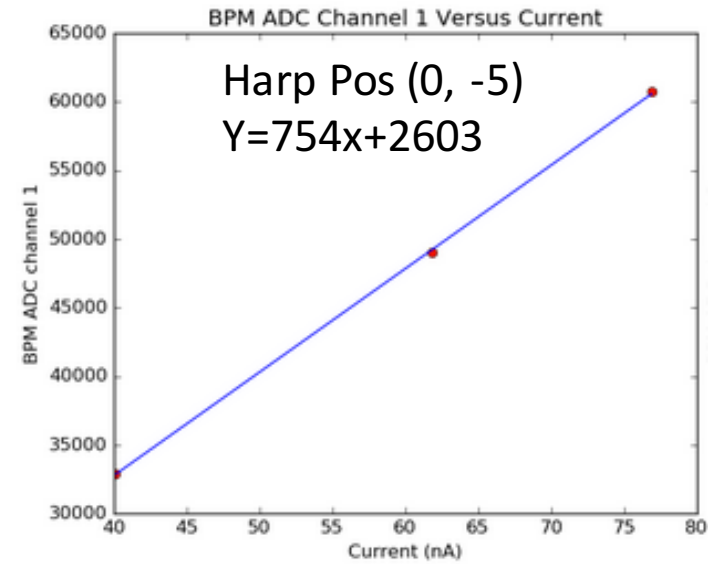
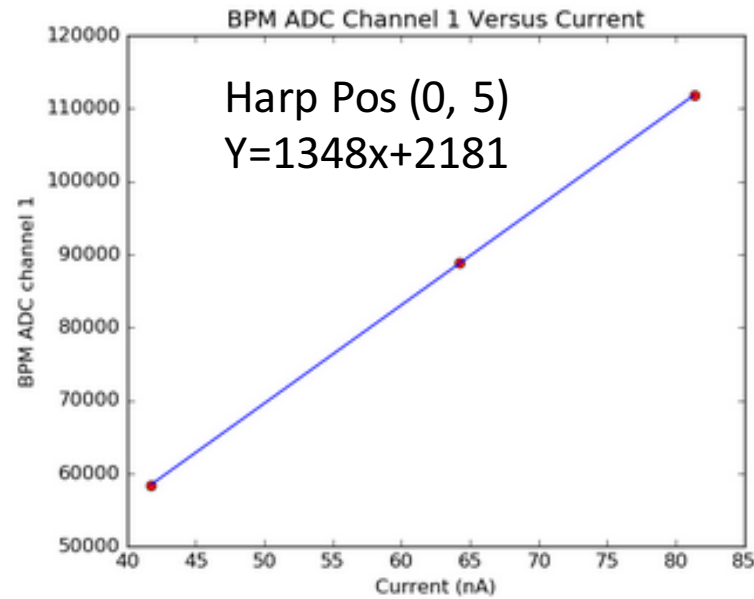
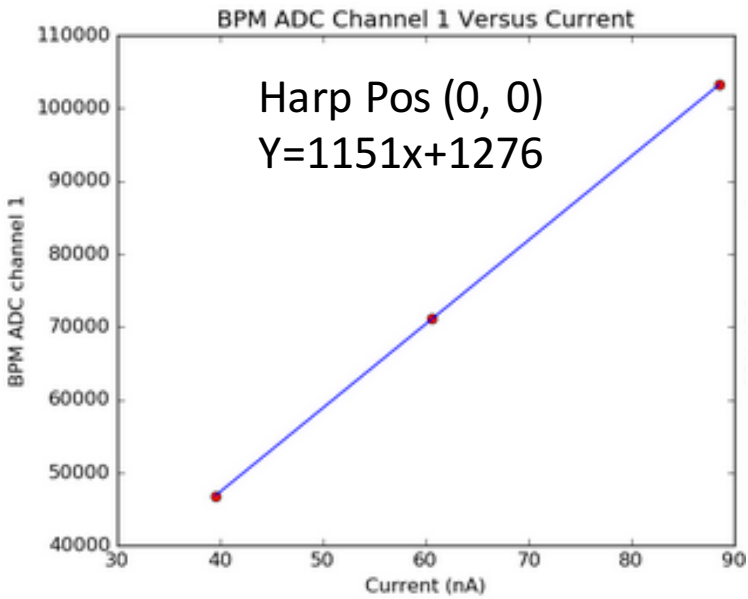
Fitting Offset for Channel 4 (BPMA)



This offset has a very strong position Dependence

Harp pos setting (x, y) mm	Offset
(0, 0)	5071
(0, 5)	6582
(0, -5)	4183
(-5, 0)	1205
(5, 0)	16417

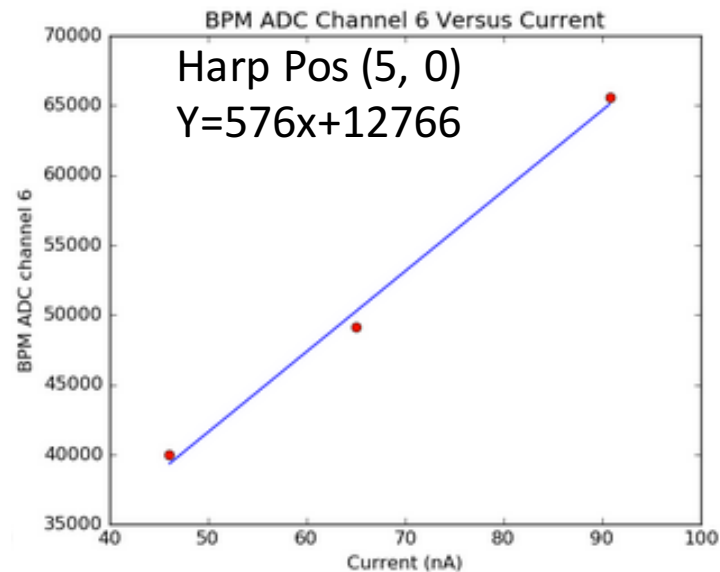
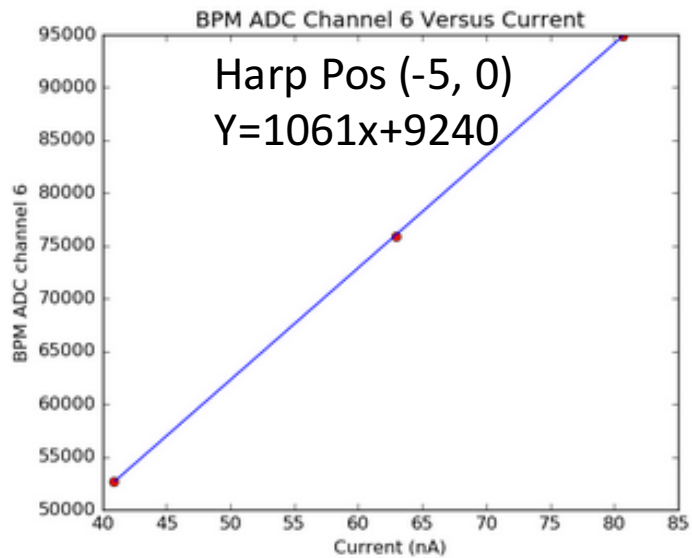
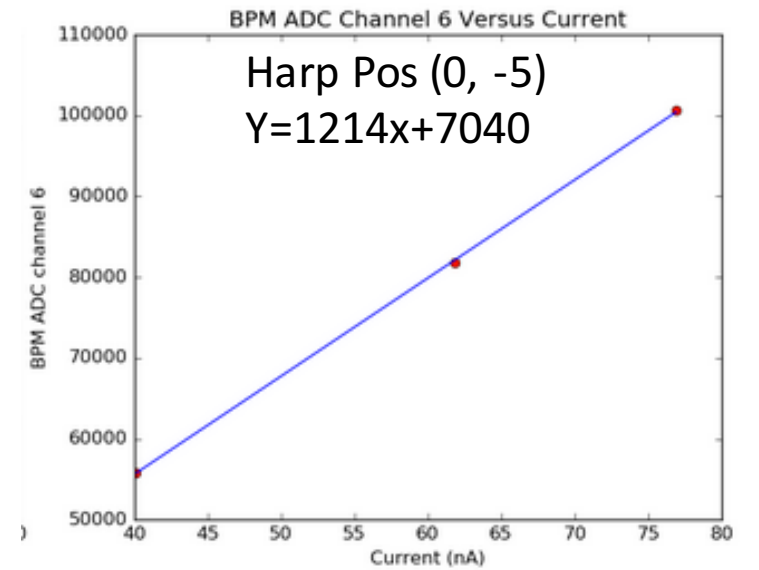
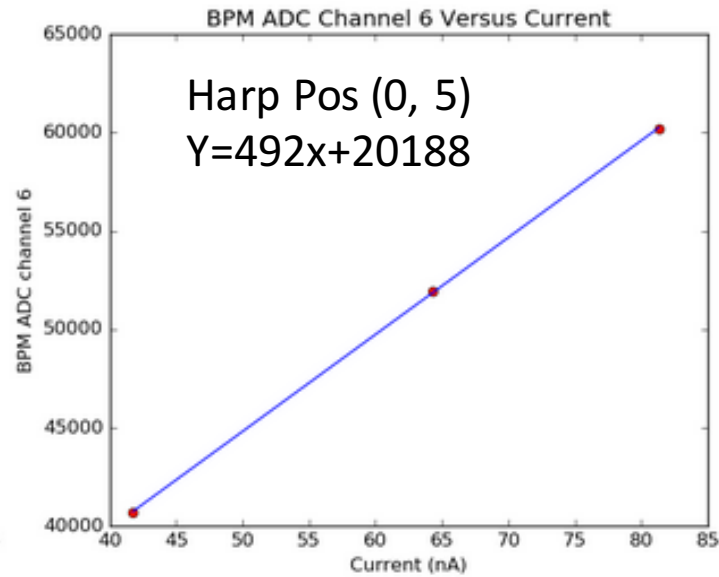
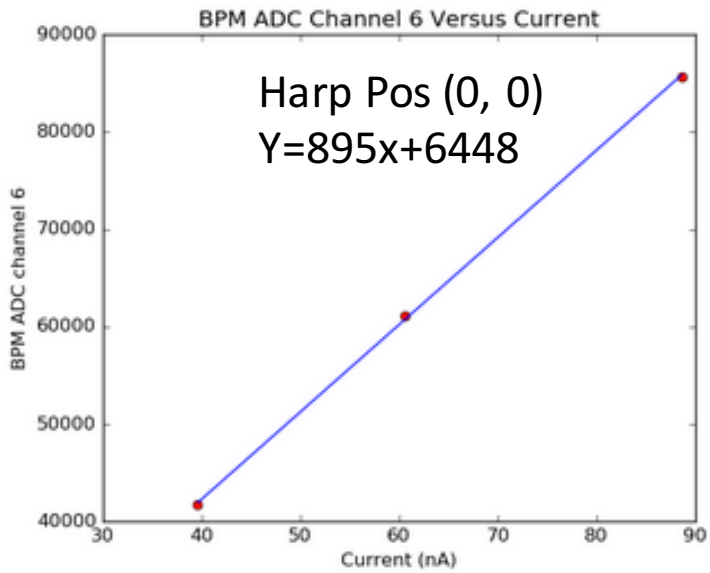
Fitting Offset for Channel 1 (BPMA)



This offset has a very strong position Dependence

Harp pos setting (x, y) mm	Offset
(0, 0)	1275
(0, 5)	2181
(0, -5)	2603
(-5,0)	1873
(5,0)	1634

Fitting Offset for Channel 6 (BPMB)



This offset has a very strong position Dependence

Harp pos setting (x, y) mm	Offset
(0, 0)	6448
(0, 5)	20188
(0, -5)	7040
(-5, 0)	9240
(5, 0)	12766

Recall BPM Calibration again

□ The calculation of beam position (pengjia technote):

- Got the offset b for each channel from the setting (0,0)mm only
- And then fit the calibration constants use 50nA current setting (but different position((0,0), (0,-5), (0,5), (-5,0), (5,0))

$$x_b = \frac{(A_+ - A_{+ped} + b_+) - g_x(A_- - A_{-ped} + b_-)}{(A_+ - A_{+ped} + b_+) + g_x(A_- - A_{-ped} + b_-)}$$

$$x = Rx_b \left(\frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)$$

$$y = Ry_b \left(\frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)$$



Beam pos



$$x_{BPMreal_{BPM}} = c_0 + c_1x + c_2y$$

$$y_{BPMreal_{BPM}} = c'_0 + c'_1x + c'_2y$$

- A_+, A_- : bpm raw signal for + and - channel
- A_{+ped}, A_{-ped} : bpm pedestal for + and - channel
- b_+, b_- : offset, calibration constant
- $g_x, c_0, c_1, c_2, c'_0, c'_1, c'_2$: calibration constant

□ At this stage, we know

- Offset changed for different beam position scan, eg, (0,0) versus (0, -5) mm
- If offset not exactly for the run, will introduce the current dependent effect
- Calibration only done for current, this assumed current dependence removed, but not actually true

□ How large is the current dependence effects?

- We saw the beam position has the current dependence before.
- Tested with harp scan data

Tested with harp scan data

Harp scan Setting (x, y) mm	Run Number	Current (nA)	BPMA x (mm)	BPMA y (mm)	BPMB x (mm)	BPMB y (mm)	Horizontal tg_x (mm)	tg_phi=dx/dz (mrad)	Vertical tg_y (mm)	tg_theta=dy/dz (mrad)
(0,0)	5490	88.59	1.31	0.06	1.19	0.28	0.37	0.4	0.85	-0.12
	5491	60.56	1.11	0.12	1.17	0.19	0.95	0.44	0.79	0.68
	5494	39.59	1.42	0.02	1.27	0.27	0.36	0.36	0.87	-0.24

This is the setting to fit the offset

The offset is right, we did not see much current dependence

Tested with harp scan data

Harp scan Setting (x, y) mm	Run Number	Current (nA)	BPMA x (mm)	BPMA y (mm)	BPMB x (mm)	BPMB y (mm)	Horizontal tg_x (mm)	tg_phi=dx/dz (mrad)	Vertical tg_y (mm)	tg_theta=dy/dz (mrad)
(0,5)	5499	81.34	5.72	4.59	4.54	5.84	-0.07	-0.48	7.77	1.02
	5503	64.27	5.52	4.62	4.91	5.11	2.91	2.79	6.61	-0.06
	5504	41.74	4.65	4.72	4.63	3.63	6.72	7.49	2.97	-3.29

Although the harp position is the same, the calibrated position changed a lot

And the lower the current, the more the change, this can be derived from the formula

Harp scan Setting (x, y) mm	Run Number	Current (nA)	BPMA x (mm)	BPMA y (mm)	BPMB x (mm)	BPMB y (mm)	Horizontal tg_x (mm)	tg_phi=dx/dz (mrad)	Vertical tg_y (mm)	tg_theta =dy/dz (mrad)
(0,0)	5490	88.59	1.31	0.06	1.19	0.28	0.37	-0.12	0.85	0.4
	5491	60.56	1.11	0.12	1.17	0.19	0.95	0.68	0.79	0.44
	5494	39.59	1.42	0.02	1.27	0.27	0.36	-0.24	0.87	0.36
(0,-5)	5519	76.92	-7.85	-5.79	-6.79	-7.61	-2.41	-0.58	-10.96	-0.85
	5520	61.81	-7.98	-5.82	-6.27	-7.49	-0.89	1.07	-9.28	1.02
	5523	40.1	-7.69	-5.62	-4.87	-7.46	3.15	5.23	-7.37	2.66
(0,5)	5499	81.34	5.72	4.59	4.54	5.84	-0.07	-0.48	7.77	1.02
	5503	64.27	5.52	4.62	4.91	5.11	2.91	2.79	6.61	-0.06
	5504	41.74	4.65	4.72	4.63	3.63	6.72	7.49	2.97	-3.29
(-5,0)	5510	80.69	4.44	-7.35	6.08	-6.21	8.43	0.52	-1.45	1.15
	5511	62.93	4.99	-7.42	6.04	-6.32	7.35	-1.07	-2.73	-0.54
	5514	40.92	5.22	-7.47	6.03	-6.57	7.28	-1.35	-3.83	-1.82
(5,0)	5528	90.77	-8.43	5.79	-9.65	4.14	-11.56	-1.16	-1.13	1.3
	5529	65	-7.97	5.74	-8.51	3.9	-8.56	1.59	-0.4	1.76
	5532	46.11	-7.49	5.79	-8.99	2.94	-8.95	0.88	-5.21	-3.66

- The offset has a strong position dependence
- It caused the previous current dependence (we observed before)
- need redo calibration?
- Calculate the real position will be more complicated, do not know position first, the offset may also not know, especially if position slow drifting
- Any suggestions?