Bpm study
-- to check beam position

Jie Liu

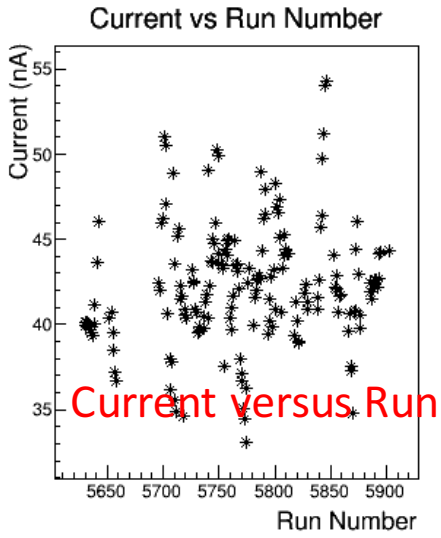
12/14/2016

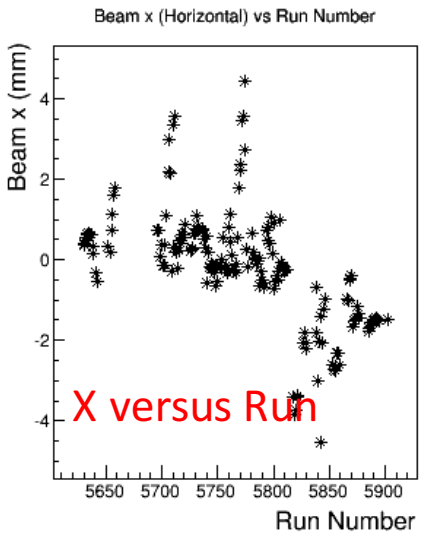
BPM pedestal Study

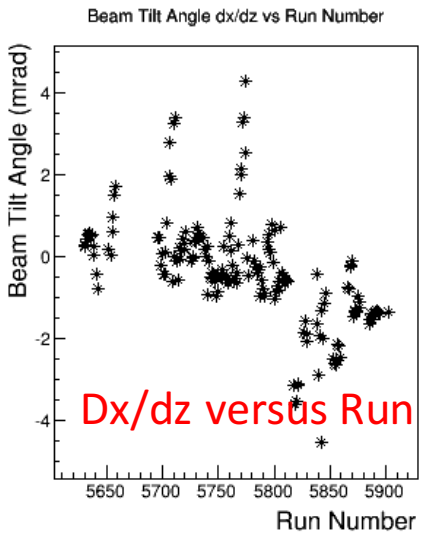
- Goal: To help resolve the yields drift problems
- Today
  - Current Status Summary

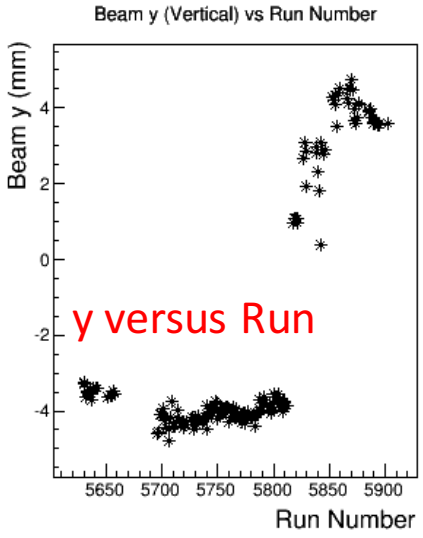
Recall Beam Position Issue

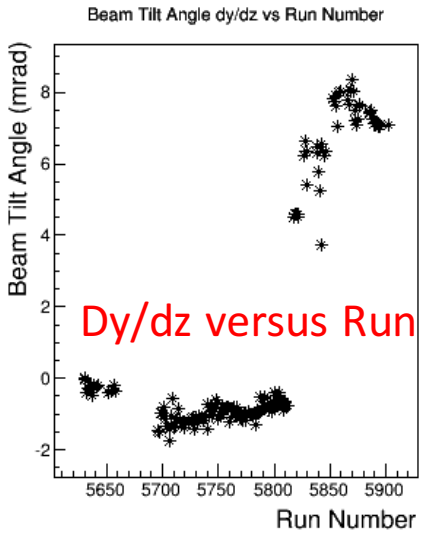
Energy 2254 GeV -- beam information at target versus Run Number







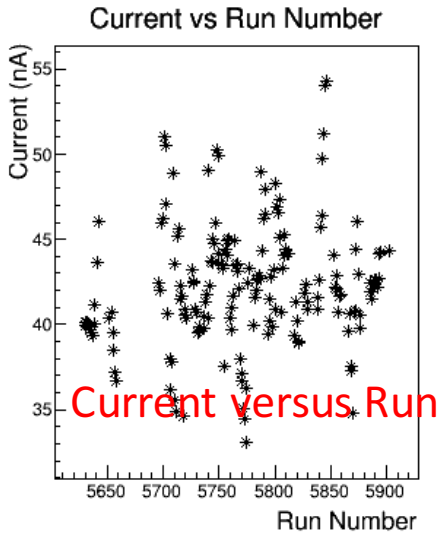


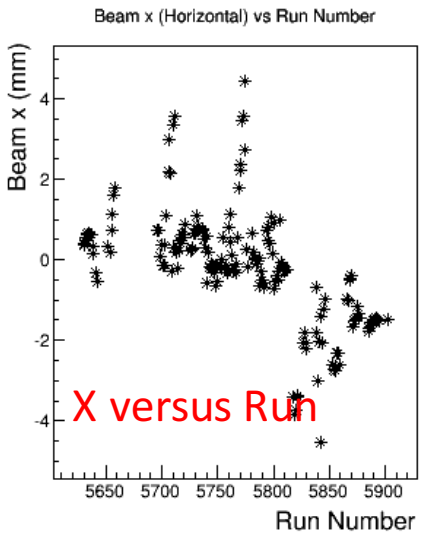


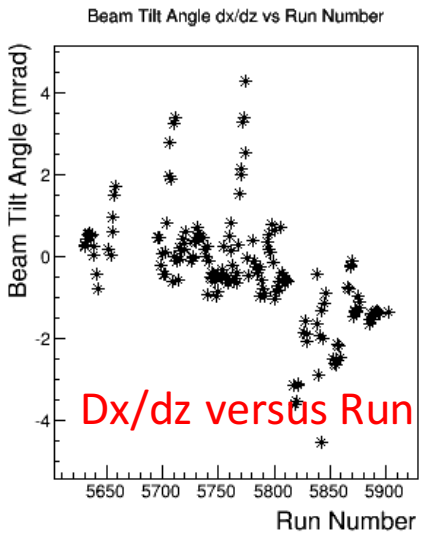
Use Pengjia's database

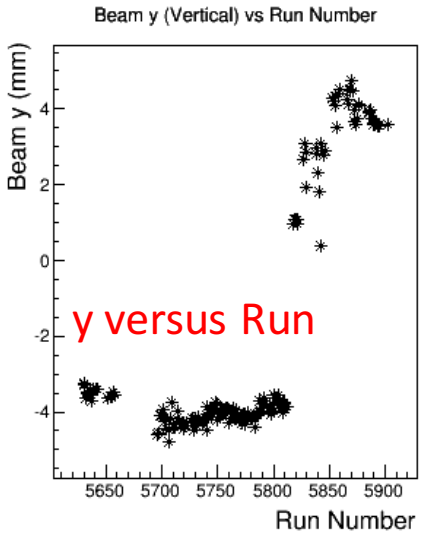
Recall Beam Position Issue

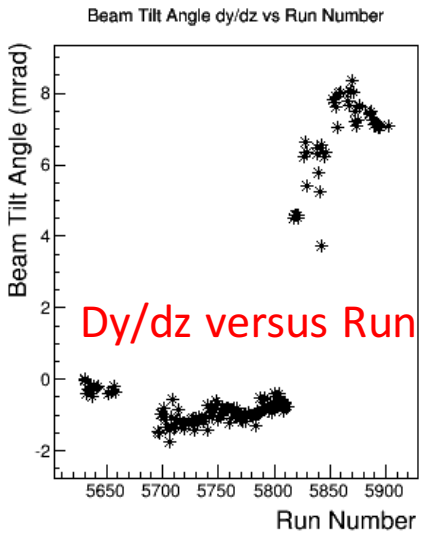
Energy 2254 GeV -- beam information at target versus Run Number









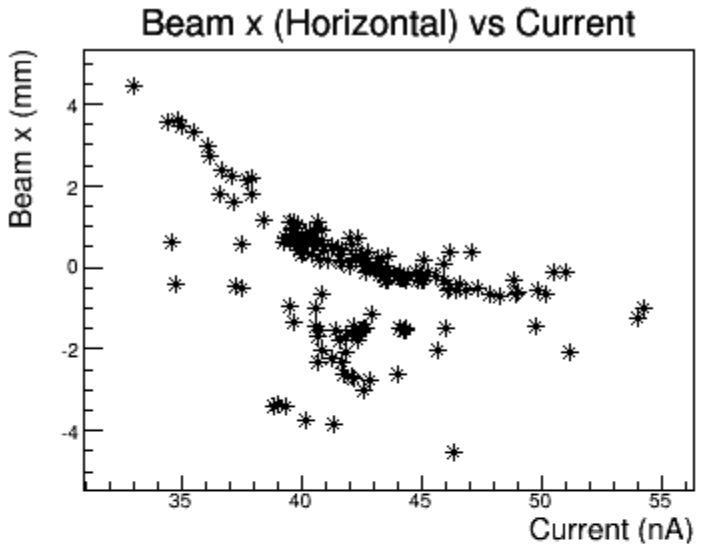


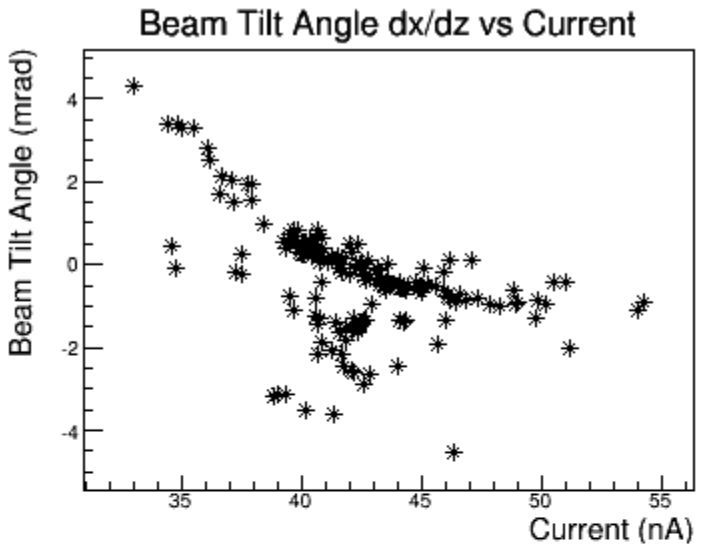
Use Pengjia's database

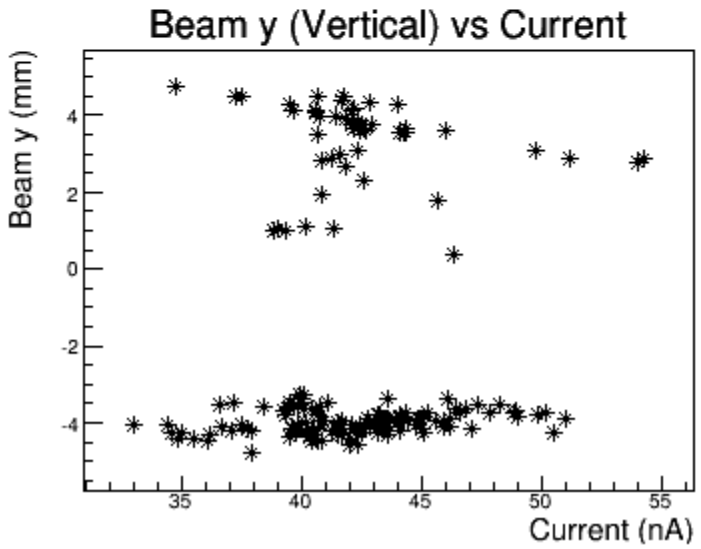
If plot the beam information
Versus current

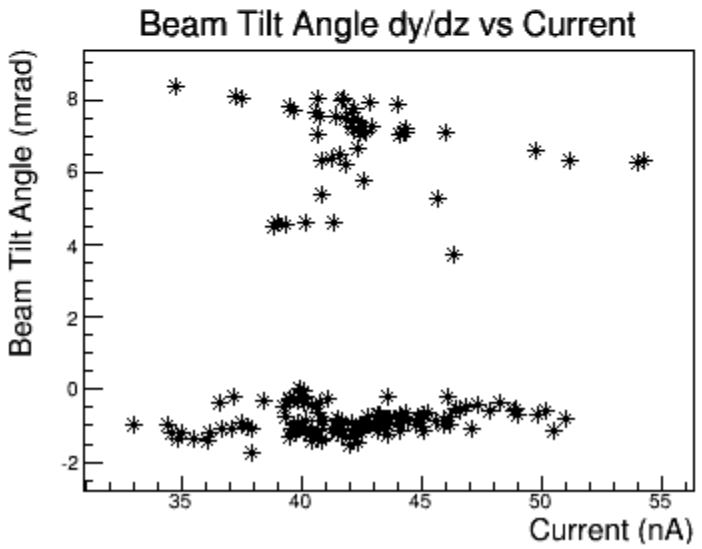
Recall Beam Position Issue

Energy 2254 GeV -- beam information versus Current









Two issues to check

- Current dependence
- Suddenly jumps

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

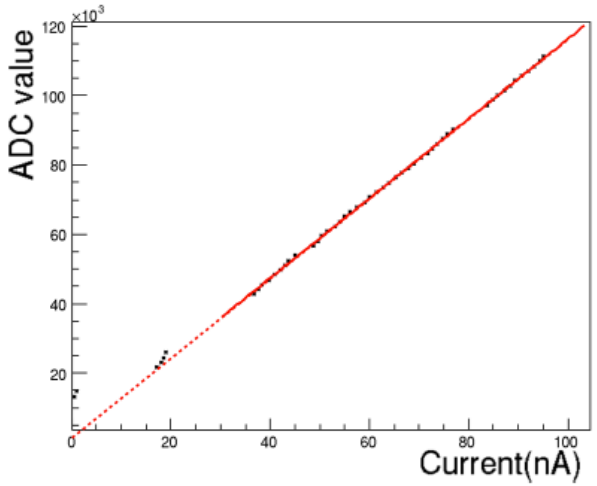
$$x_{BPMreal_{BPM}} = c_0 + c_1 x + c_2 y$$

$$y_{BPMreal_{BPM}} = c_0' + c_1' x + c_2' y$$

- 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

❑ To get the offset b

Consider the unlinear response of bpm



ADC value of BPM raw signal ($A - A_{ped}$) V.S. beam current

Recall Beam Position Issue

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From Pengjia <zhupengjia@gmail.com>

Subject **Re: [g2p_ana] Question BPM calibration** 4/27/16, 12:53

To Alexandre Camsonne <camsonne@jlab.org>, g2p_ana <g2p_ana@jlab.org>

Hi Alex,
No we didn't (we did in auto gain mode, but they are useless). We did several calibration runs on different beam current (50-100nA) on May.3, and I used them to remove the current dependency (the constant b in my paper). But seems the constant in this current range does not work well for runs with curr<40nA for BPM B (A is much better), We can try to use the runs to fit again with stable yields and stable BPM A pos to fix the current dependency for BPM B (if the we assume the real pos is stable if with stable yields and stable BPM A pos), although I thought It is dangerous since I need to use the updated b to fit other constants with the same calibration runs, even if the current of the calibration runs is not in that current range. I've updated the BPM B constants for 5T long (5706-5812) for Jie, at least there is no current dependency for those runs. If the results matched the simulated yields then we can try another settings.

Pengjia

2016-04-27 22:34 GMT+08:00 Alexandre Camsonne <camsonne@jlab.org>:

> Hi Pengjia,
>
> did we take bull's eye scan at different current ?
> (I thought we did at lower currents)
>
> I guess at low current we are more sensitive to pedestal value and noise.
>
> Alexandre

From Pengjia's email:

- Calibration runs on different beam current (50-100nA) on May 3 (run 5490)

New

- Use the stable yields and stable BPMA runs to remove the current dependence
- Use the new offset, put in the old calibration runs to do a new calibration

However, For 5T longitudinal

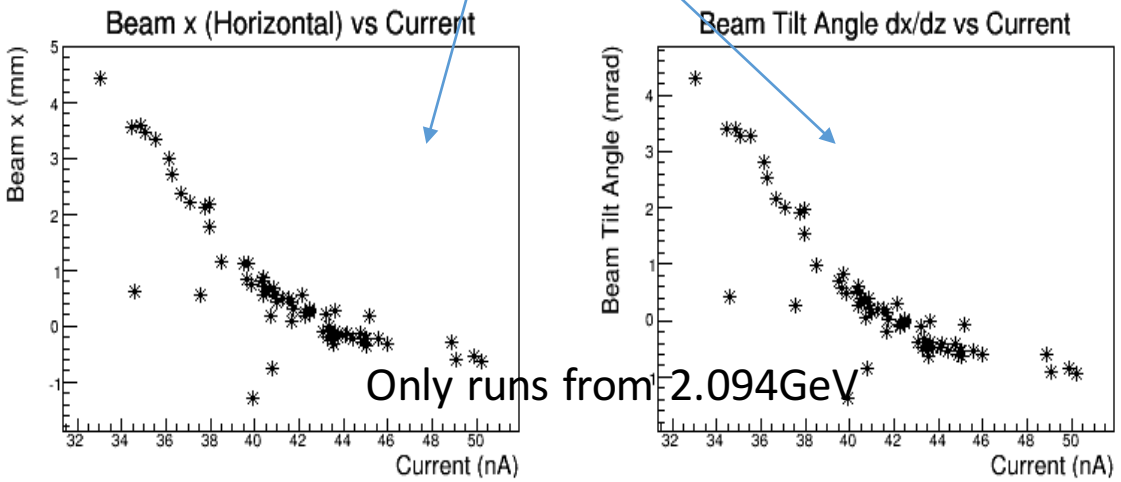
- Only 3% data took >50nA for 5T
- 15% data took within 45nA to 50nA
- 60% data took within 40nA to 45nA
- 22% data took below 40nA

Ebeam=2.2GeV, momentum 2.049GeV, Longitudinal 5T
new database after remove current dependence

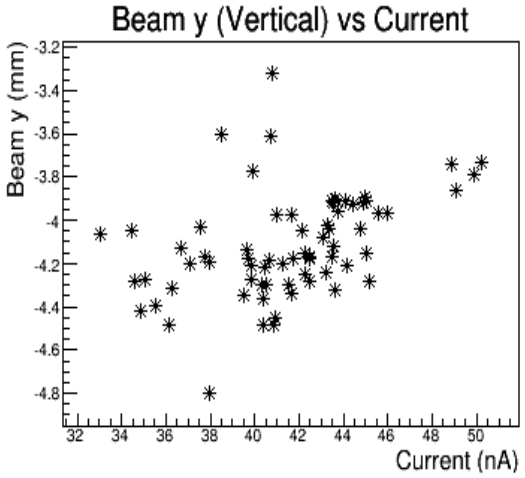
choose the runs without yields to correct

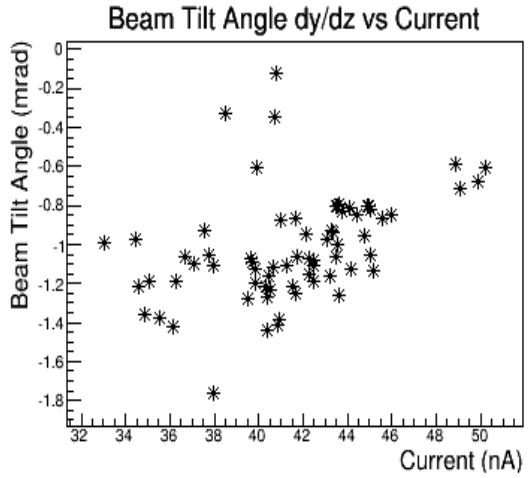
Each mark stands for one run in the plot

Using the old database

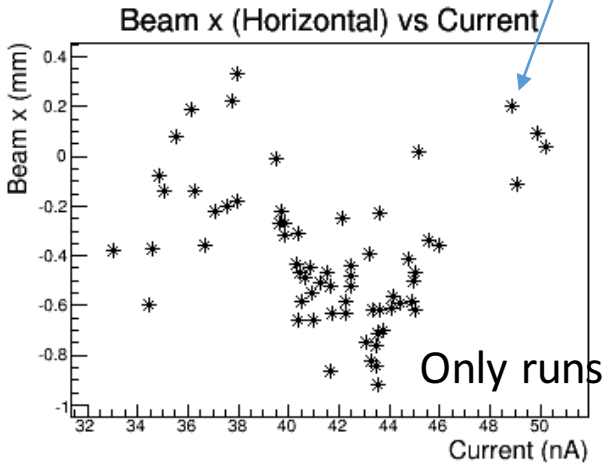


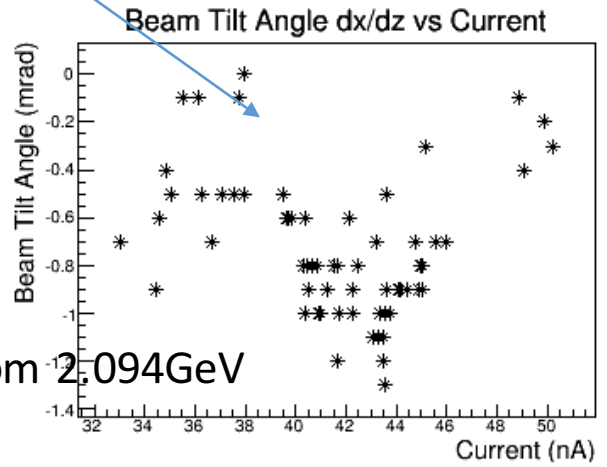
Only runs from 2.094GeV





Using the new database





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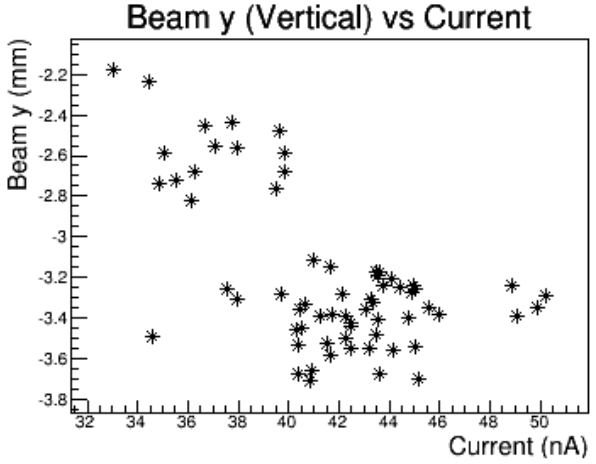
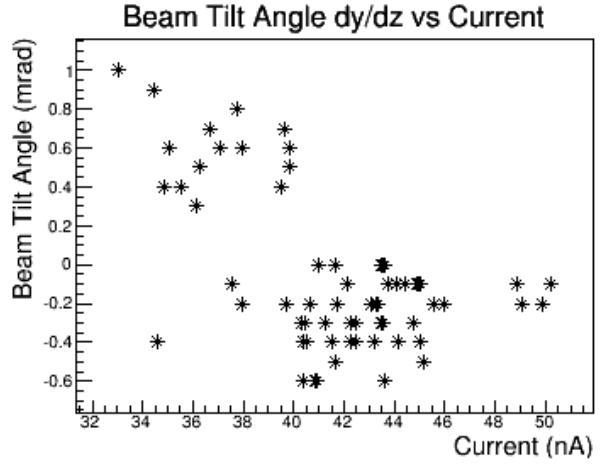
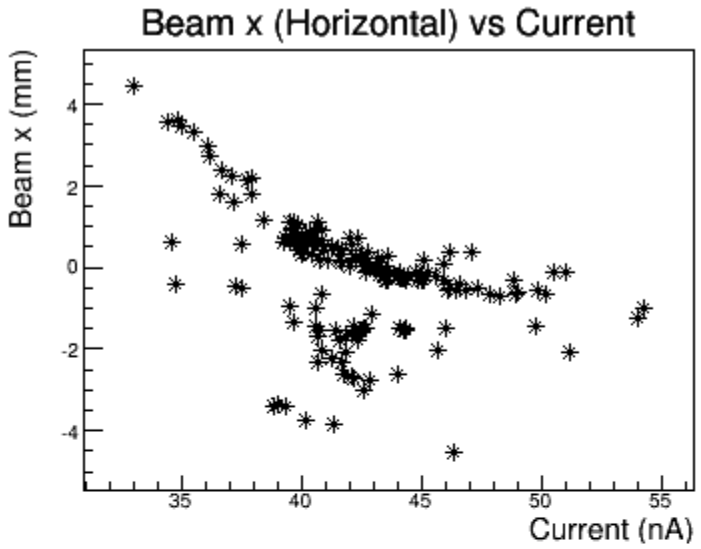
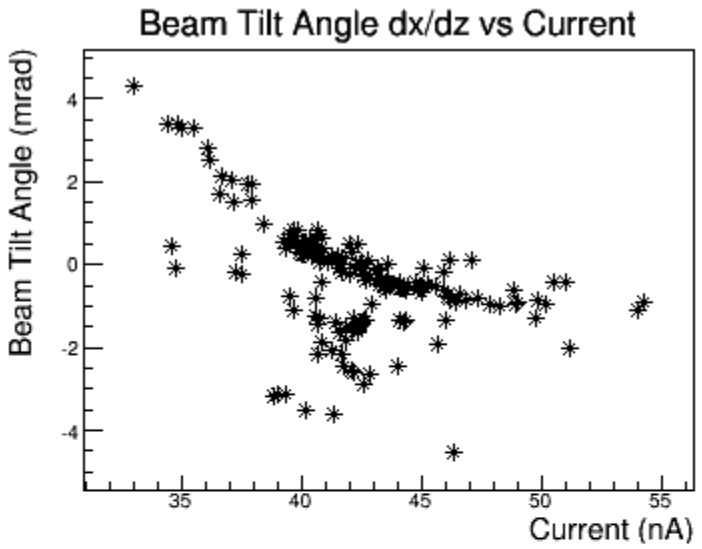


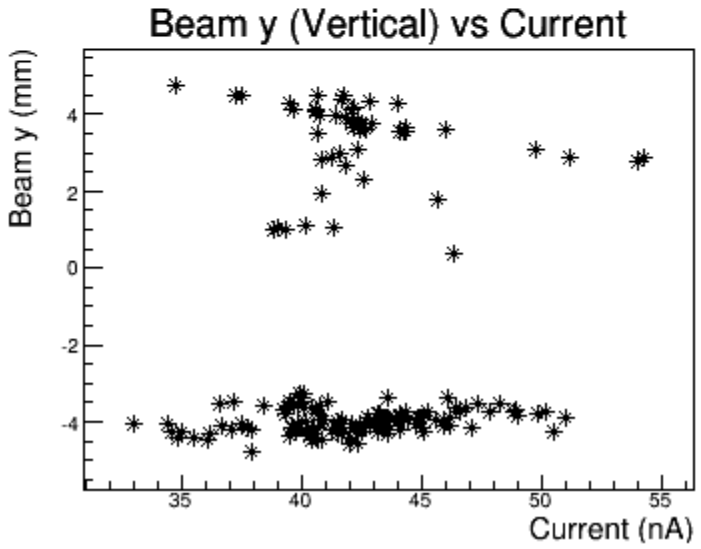


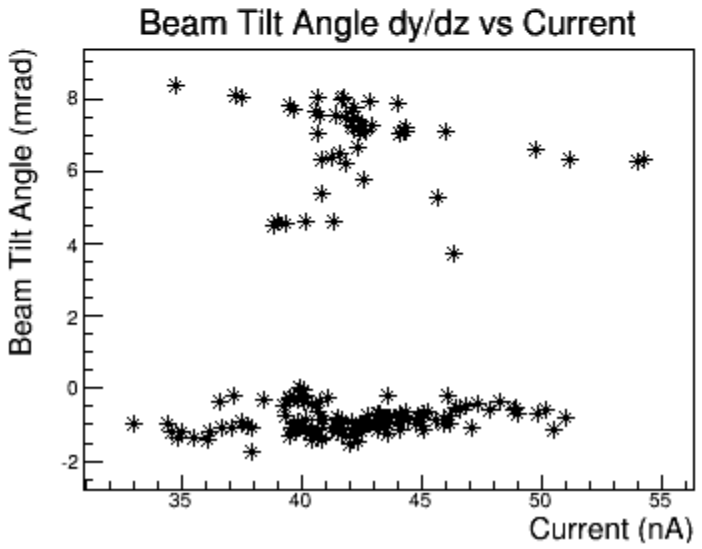
Recall Beam Position Issue

Energy 2254 GeV -- beam information versus Current









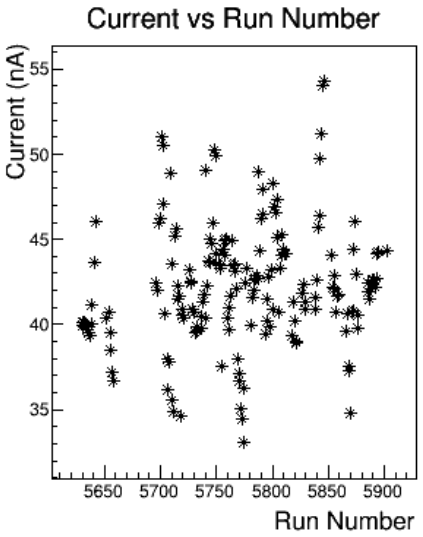
Use Pengjia's database

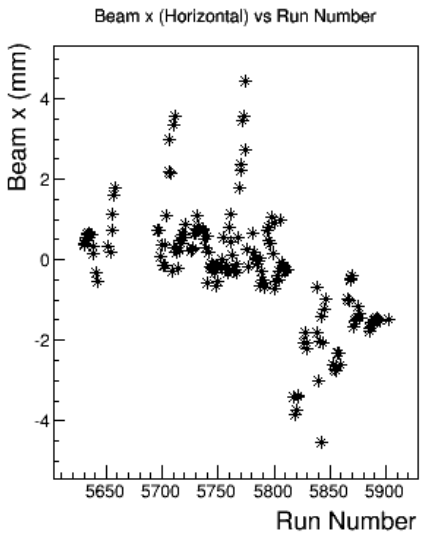
Two issues to check

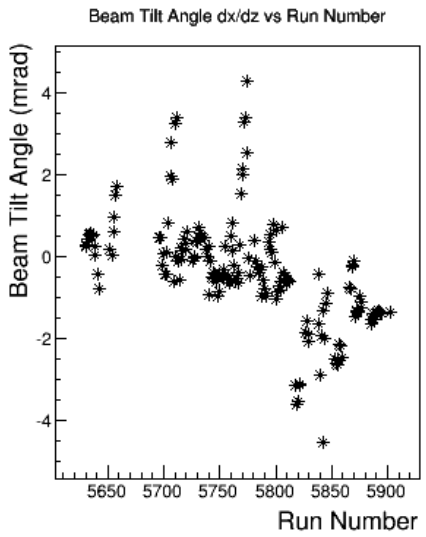
- Current dependence
- Suddenly jumps

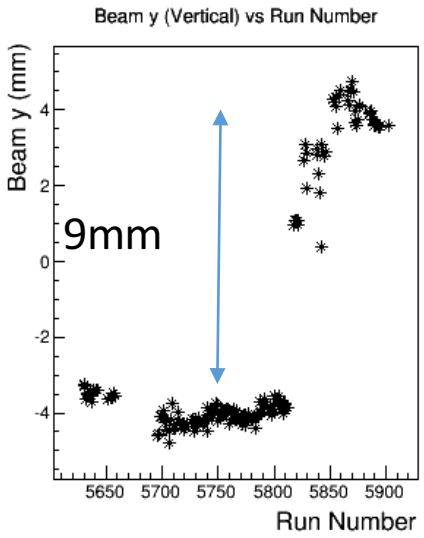
Recall Beam Position Issue

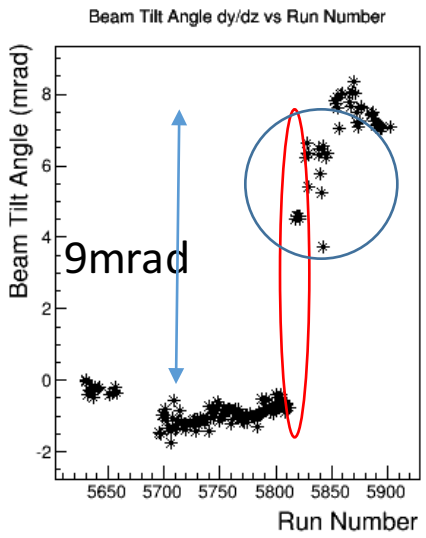
Energy 2254 GeV -- beam information versus Run Number











Use Pengjia's database

How to deal with beam jumps here:

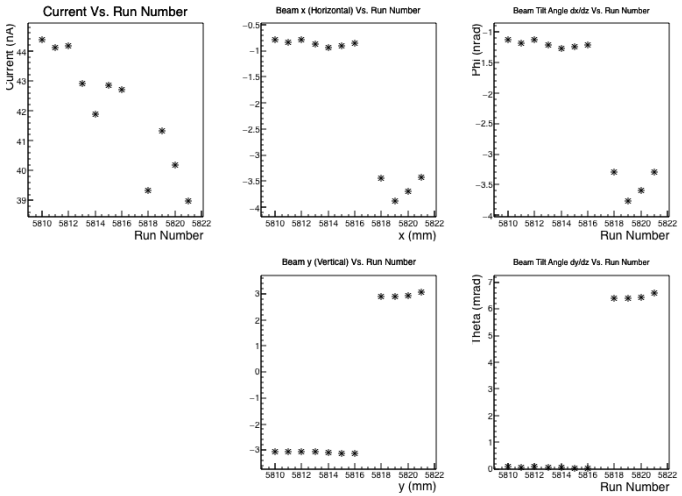
Two types of beam position jumps

a) Red circle part (after adding the carbon cover, run 5816), jump about 5mm or 5mrad? But yields no change

b) Blue circle part (run 5838-5851, continuous taking data, position jump back and forth, spread 3mm or 3mrad)
yields change within 3%

Ebeam=2.2GeV, momentum 1.886GeV, Longitudinal 5T – 1st type jump

run	materialID	Momentum	current/nA	yield(use 6mm Raster cut)	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)
5809	17	1.8857	44.07	1	-1.39	-2.35	-1.23	-2.57	-0.9	-1.23	-3.11	0.04
5810	17	1.8857	44.39	1.005	-1.37	-2.34	-1.19	-2.57	-0.78	-1.12	-3.05	0.08
5811	17	1.8857	44.12	1.003	-1.37	-2.34	-1.2	-2.56	-0.84	-1.18	-3.06	0.06
5812	17	1.8857	44.17	1.001	-1.37	-2.35	-1.18	-2.57	-0.78	-1.12	-3.05	0.08
5813	17	1.8857	42.92	0.997	-1.36	-2.34	-1.2	-2.56	-0.87	-1.21	-3.07	0.05
5814	17	1.8857	41.89	1.01	-1.39	-2.34	-1.24	-2.56	-0.94	-1.27	-3.09	0.05
5815	17	1.8857	42.84	1.005	-1.39	-2.35	-1.23	-2.58	-0.9	-1.24	-3.11	0.03
5816	17	1.8857	42.72	1.004	-1.36	-2.37	-1.2	-2.59	-0.85	-1.21	-3.11	0.03
5818	17	1.8857	39.35	1.002	-1.86	-2.02	-1.31	-0.64	-3.45	-3.3	2.89	6.4
5819	17	1.8857	41.33	1.006	-1.84	-2.02	-1.39	-0.57	-3.87	-3.76	2.89	6.39
5820	17	1.8857	40.19	1.005	-1.84	-2.02	-1.35	-0.59	-3.7	-3.59	2.93	6.43
5821	17	1.8857	39	1.021	-1.84	-2.02	-1.27	-0.59	-3.42	-3.29	3.08	6.59
5822	17	1.8857	38.88	1.006	-1.86	-2.02	-1.3	-0.61	-3.47	-3.33	2.99	6.51



1.5 hours beam down (target anneal) between run 5816 and run 5818

Carbon cover added after run 5816

Calibrated Beam position Jump happened when beam back

X jump -2.6mm; y jump 6.0mm

Theta jump 6.37mrad; phi jump -1.8mrad

Data Yields within 1% for the momentum setting

Usually 1mm (1mrad) shift change yields ~3%

Ebeam=2.2GeV, momentum 1.886GeV, Longitudinal 5T – 1st type jump

Run	Current /nA	BPMA 1 Ped	BPMA 2 Ped	BPMA 3 Ped	BPMA 4 Ped	BPMB 1 Ped	BPMB 2 Ped	BPMB 3 Ped	BPMB 4 Ped	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)
5811	44.12	12958.9	10269.2	28438.7	20938.9	9690.3	24686.4	38748.7	13262.3	-1.37	-2.34	-1.2	-2.56	-0.84	-1.18	-3.06	0.06
5812	44.17	12958.9	10268.9	28439.8	20937.2	9690.7	24687.3	38744.7	13261.7	-1.37	-2.35	-1.18	-2.57	-0.78	-1.12	-3.05	0.08
5813	42.92	12959	10268.8	28440.4	20935.9	9690.6	24686.6	38742.3	13261.9	-1.36	-2.34	-1.2	-2.56	-0.87	-1.21	-3.07	0.05
5814	41.89	12959.1	10268.8	28440.6	20934.9	9690.3	24684.5	38741	13262.9	-1.39	-2.34	-1.24	-2.56	-0.94	-1.27	-3.09	0.05
5815	42.84	12959.1	10268.8	28440.8	20934	9689.9	24682.1	38740	13264	-1.39	-2.35	-1.23	-2.58	-0.9	-1.24	-3.11	0.03
5816	42.72	12959.2	10268.8	28441	20932.9	9689.5	24679.3	38739.3	13265.2	-1.36	-2.37	-1.2	-2.59	-0.85	-1.21	-3.11	0.03
5818	39.35	12412.3	11070	25768.7	21291.5	11193.8	23134.9	23097.8	12869	-1.86	-2.02	-1.31	-0.64	-3.45	-3.3	2.89	6.4
5819	41.33	12412.8	11070.5	25787.7	21304.2	11191.6	23135.4	23100.4	12872.8	-1.84	-2.02	-1.39	-0.57	-3.87	-3.76	2.89	6.39
5820	40.19	12413.3	11070.9	25803.9	21314.9	11189.8	23134.7	23103	12876.4	-1.84	-2.02	-1.35	-0.59	-3.7	-3.59	2.93	6.43
5821	39	12413.7	11071.3	25819.1	21325	11188.2	23132.6	23106.5	12880.6	-1.84	-2.02	-1.27	-0.59	-3.42	-3.29	3.08	6.59
5822	38.88	12413.8	11071.5	25823	21327.6	11187.8	23132.1	23107.4	12881.6	-1.86	-2.02	-1.3	-0.61	-3.47	-3.33	2.99	6.51
5823	38.95	12414.2	11071.8	25834.3	21335	11186.6	23130.5	23110	12884.6	-1.82	-2	-1.27	-0.6	-3.43	-3.29	2.99	6.46
5824	44.33	12414.2	11071.9	25836.5	21336.5	11186.4	23130.2	23110.5	12885.2	-1.81	-2.1	-1.4	-0.66	-3.91	-3.88	2.68	6.21
5825	45.06	12414.3	11072	25840.4	21339.1	11186	23129.7	23111.3	12886.3	-1.82	-2.07	-1.44	-0.61	-4.05	-3.99	2.74	6.25
5826	47.12	12414.4	11072.1	25843.8	21341.4	11185.6	23129.2	23112.1	12887.2	-1.78	-2.06	-1.4	-0.61	-3.99	-3.96	2.72	6.2
5827	41.87	12415.2	11072.9	25870.3	21359	11182.9	23125.8	23117.8	12894	-1.82	-2.04	-1.04	-0.73	-2.55	-2.41	3.1	6.61
5828	42.37	12415.8	11073.6	25892.6	21373.7	11181.8	23127.3	23115.5	12892.1	-1.83	-2.03	-0.9	-0.74	-2.08	-1.91	3.32	6.83
5829	40.86	12417.1	11075.4	25935.5	21402.6	11180	23135.5	23100.2	12877.7	-1.83	-2.03	-1.26	-0.69	-3.25	-3.12	2.78	6.28
5830	41.3	12418.1	11076.7	25967.6	21424.4	11178.6	23142	23090	12868.1	-1.82	-2.04	-1	-0.79	-2.3	-2.15	2.98	6.48

We saw big pedestal jumps for both BPMA and BPMB

BPMA x change from -1.36mm to -1.86mm, y change from -2.37mm to -2.02mm

Ebeam=2.2GeV, momentum 1.886GeV, Longitudinal 5T – 1st type jump

Run	Current /nA	BPMA 1 Ped	BPMA 2 Ped	BPMA 3 Ped	BPMA 4 Ped	BPMB 1 Ped	BPMB 2 Ped	BPMB 3 Ped	BPMB 4 Ped	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)
5811	44.12	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.34	-1.16	-2.64	-0.59	-0.93	-3.26	-0.15
5812	44.17	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.36	-2.35	-1.15	-2.65	-0.54	-0.88	-3.25	-0.13
5813	42.92	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.34	-1.17	-2.65	-0.61	-0.96	-3.27	-0.17
5814	41.89	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.38	-2.34	-1.2	-2.65	-0.68	-1.01	-3.3	-0.18
5815	42.84	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.38	-2.35	-1.2	-2.66	-0.66	-0.99	-3.32	-0.19
5816	42.72	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.37	-1.16	-2.68	-0.6	-0.96	-3.31	-0.19
5818	39.35	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.34	-2.34	-7.47	0.6	-26.08	-27.54	-5.72	-2.73
5819	41.33	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.33	-7.21	0.61	-25.29	-26.7	-5.21	-2.2
5820	40.19	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.33	-2.34	-7.35	0.62	-25.79	-27.24	-5.45	-2.45
5821	39	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.32	-2.34	-7.48	0.66	-26.28	-27.76	-5.61	-2.62
5822	38.88	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.33	-2.35	-7.56	0.64	-26.48	-27.96	-5.77	-2.78
5823	38.95	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.3	-2.33	-7.5	0.65	-26.35	-27.83	-5.73	-2.78
5824	44.33	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.39	-6.68	0.42	-23.43	-24.8	-4.62	-1.54
5825	45.06	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.37	-2.35	-6.64	0.46	-23.26	-24.58	-4.44	-1.36
5826	47.12	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.36	-2.33	-6.28	0.41	-22.07	-23.34	-3.97	-0.9
5827	41.87	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.34	-2.34	-6.52	0.41	-22.84	-24.15	-4.43	-1.38
5828	42.37	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.33	-6.26	0.39	-21.98	-23.25	-4.01	-0.95
5829	40.86	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.35	-2.33	-6.89	0.46	-24.02	-25.37	-5.03	-2.01
5830	41.3	12960.8	10273.7	28466.8	20890.4	9634.3	24319.8	38692.9	13401.6	-1.34	-2.34	-6.55	0.35	-22.83	-24.15	-4.68	-1.64

This table use the same pedestal (from run 5816)
BPMA pos no jumps????

BPMA Database

```
avail run period:5104-5338,5485-5488,5490-5491,5494,5498-5499,5503-5504,5510-5511,55
,5519-5520,5528-5529,5523,5532,5537,5544,5554-5561,5564-5660,5681,5690-6218
avail curr(nA):88 50
target z position(mm,support multi):-14.135 0 14.135 -10.81 -13.6271 -12.5476
pedestal peak:12982.098633 10318.531250 28632.167969 20933.537109
offset:-11101.000000 -7077.000000 -19830.000000 -15184.000000
bpma ar,gx,gy:34.924999999999997 1.024000000000000 0.987000000000000
fitorder:1 1
bpma x a,b,c:-0.067402468617895 -1.068032542963461 0.044955324295655
bpma y a,b,c:0.026272741909720 1.193521100852965 0.056804460364603
fval:0.1642982 0.1358930
bpma x err:0.124434 0.017438 0.021230
bpma y err:0.136093 0.019092 0.023323
```

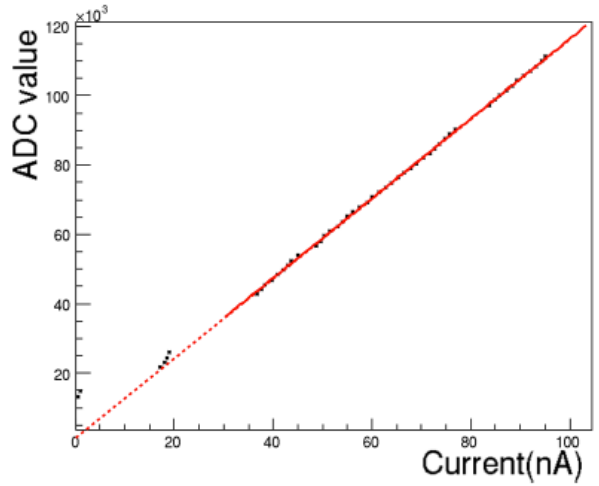
BPMA Database for run after 5104
Calibration runs from May 3rd 5490

The offset is b factor in the formula

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

The offset has a very big shift

How to deal with b factor:
b got from current dependence



ADC value of BPM raw signal $(A - A_{ped})$ V.S. beam current

BPMB Database

BPMB Database for run 5485-5816

```
avail run period:5485-5488,5490-5491,5494,5498-5499,5503-5504,5510-5511,5514,5519-5520,
5528-5529,5523,5532,5537,5544,5554-5561,5564-5660,5681,5690-5812
avail curr(nA):88 75
target z position(mm,support multi):-14.135 0 14.135 -10.81 -13.6271 -12.5476
pedestal peak:9932.455078 26819.394531 37714.996094 12536.925781
offset:-8641.000000 -20161.000000 -27858.000000 -9902.000000
bpmb ar,gx,gy:34.924999999999997 0.826000000000000 1.094000000000000
fitorder:1 1
bpmb x a,b,c:0.033272652288621 1.096324079373919 0.029047078500277
bpmb y a,b,c:0.048720993507263 1.202920412827341 -0.078819129281960
fval:0.0739224 0.0863825
bpmb x err:0.130851 0.019434 0.022899
bpmb y err:0.146220 0.021511 0.025433
```

BPMB Database for run 5817-5920

```
avail run period:5817-6218
avail curr(nA):88 50
target z position(mm,support multi):-14.135 0 14.135 -10.81 -13.6271 -12.5476
pedestal peak:9932.455078 26819.394531 37714.996094 12536.925781
offset:-12325 -15779 -10565 -7666
bpmb ar,gx,gy:34.924999999999997 0.826000000000000 1.094000000000000
fitorder:1 1
bpmb x a,b,c:0.033272652288621 1.096324079373919 0.029047078500277
bpmb y a,b,c:0.048720993507263 1.202920412827341 -0.078819129281960
fval:0.0739224 0.0863825
bpmb x err:0.130851 0.019434 0.022899
bpmb y err:0.146220 0.021511 0.025433
```

Calibration constant:

Offset: b offset

Gx, gy: relative gain

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

A,b,c: linear effect

$$x_{BPMreal_{BPM}} = c_0 + c_1 x + c_2 y$$
$$y_{BPMreal_{BPM}} = c'_0 + c'_1 x + c'_2 y$$

BPMB Database

BPMB Database for run current around 37nA

```
avail run period:5706,5707,5708,5711,5712,5731,5732,5733,5737,5769-5775
avail curr(nA):37
target z position(mm,support multi):-14.135 0 14.135 -10.81 -13.6271
pedestal peak:9932.568435 27050.689090 37947.382798 12518.264860
offset:-8162.9040398 -8491.82819061 -10430.1077895 -8697.99924469
bpmb ar,gx,gy:34.924999999999997 0.846000000000000 1.094000000000000
fitorder:1 1
bpmb x a,b,c:4.3911066313344387 0.8204690668785372 -0.025279685262359422
bpmb y a,b,c:-2.8271066612119728 1.0254900384464574 -0.044459016228853704
fval:0.7345050 1.0104276
bpmb x err:0.2 0.019434 0.022899
bpmb y err:0.2 0.021511 0.025433
```

BPMB Database for run current around 42nA

```
avail run period:5690-5705,5709-5710,5713-5730,5734-5736,5738-5768,5776-5816
avail curr(nA):42
target z position(mm,support multi):-14.135 0 14.135 -10.81 -13.6271
pedestal peak:9932.568435 27050.689090 37947.382798 12518.264860
offset:-7001.92140914 -11182.52819187 -19240.20734696 -7534.04559374
bpmb ar,gx,gy:34.924999999999997 0.846000000000000 1.094000000000000
fitorder:1 1
bpmb x a,b,c:1.7669720580957626 0.969356883774036 0.012141489078902175
bpmb y a,b,c:-1.7711933198053358 1.082135970322633 -0.07618325031862734
fval:0.7345050 1.0104276
bpmb x err:0.2 0.019434 0.022899
bpmb y err:0.2 0.021511 0.025433
```

Ebeam=2.2GeV, momentum 1.469GeV, Longitudinal 5T – 2nd type jump

run	materialID	Momentum	current/nA	yield(use 6mm Raster cut)	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)
5838	17	1.4684	40.88	1	-1.85	-2.03	-0.67	-1.08	-0.67	-0.42	2.8	6.31
5839	17	1.4684	41.61	0.992	-1.82	-2.04	-0.89	-0.87	-1.81	-1.63	2.97	6.48
5840	17	1.4684	42.59	0.993	-1.82	-2.03	-1.26	-0.84	-3	-2.87	2.32	5.78
5841	17	1.4684	45.7	0.977	-1.78	-2.06	-1.08	-1.12	-2.02	-1.9	1.8	5.24
5842	17	1.4684	46.39	0.973	-1.78	-2.06	-1.88	-1.08	-4.54	-4.54	0.37	3.74
5843	17	1.4684	49.78	0.966	-1.76	-2.06	-0.73	-0.9	-1.43	-1.3	3.09	6.57
5844	17	1.4684	51.21	0.969	-1.73	-2.07	-0.89	-0.86	-2.07	-2	2.88	6.34
5845	17	1.4684	54.02	0.969	-1.73	-2.08	-0.71	-1.02	-1.23	-1.12	2.79	6.25
5846	17	1.4684	54.27	0.985	-1.71	-2.09	-0.62	-1.03	-0.99	-0.89	2.88	6.33
5850	17	1.4684	45.98	0.973	-1.79	-2.05	-0.78	-0.79	-1.71	-1.56	3.37	6.87
5851	17	1.4684	43.05	0.983	-1.8	-2.02	-0.74	-0.63	-1.85	-1.68	3.91	7.42

1. a linear current dependence for BPMB x from run 5838 to 5842? Due to unstable BPMB?
2. almost no yields change from run 5842-5843, and BPMA just drift 0.02mm in x, the calibrated horizontal x jumped from -4.54mm to -1.43mm from run 5842 to 5843

- Beam jumps has two types.
- Any suggestions?