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

- Current versus Run
- X versus Run
- Dy/dz versus Run

If plot the beam information
Versus current

Use Pengjia’s database
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):

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

\[
x = R_x b \left( \frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)
\]

\[
y = R_y b \left( \frac{1}{x_b^2 + y_b^2} - \frac{1}{\sqrt{x_b^2 + y_b^2}} \sqrt{\frac{1}{x_b^2 + y_b^2} - 1} \right)
\]

- \(A_+, A_-\): 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 nonlinear response of bpm

![Graph showing ADC value of BPM raw signal vs. beam current](image_url)
Recall Beam Position Issue

From Pengjia’s email:
- Calibration runs on different beam current (50-100nA) on May 3 (run 5490)
- 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

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
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

Using the new database

Only runs from 2.094GeV
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

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%

Use Pengjia’s database
**Ebeam=2.2GeV, momentum 1.886GeV, Longitudinal 5T - 1st type jump**

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<th>BPMA y (mm)</th>
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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 -2.8mm; y jump 2.4mm
Theta jump 5.5mrad; phi jump -2.3mrad
Data Yields within 1% for the momentum setting
Usually 1mm (1mrad) shift change yields ~3%
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
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This table use the same pedestal (from run 5816)
BPMA pos no jumps????
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

BPMA Database
BPMB Database for run 5485-5816

```
avail run period:5485-5488,5490-5491,5494,5498-5499,5503-5504,5510-5511,5514,5519-5520,
5528-5529,5523,5532,5537,5544,5554-5561,5564-5566,5681,5690-5812
avail curr(nA):88 75
target z position(mm,support multi):-14.135 0 14.135 -10.81 -13.6271 -12.5476
pedestal peak:932.455078 26819.394531 37714.996094 12536.925781
offset:-8641.000000 -20161.000000 -27858.000000 -9902.000000
bpm a.x,y,z:0.033272652288621 1.096324079373919 0.029047078500277
bpm a.x,y,z:0.048720993507263 1.20292041282734 0.078819129281960
tval:0.0739224 0.0863825
bpm x err:0.130851 0.019434 0.022899
bpm y err:0.146220 0.021511 0.025433
```

Calibration constant:

Offset: $b$ offset
Gx, gy: relative gain

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

A, b, c: linear effect

$$x_{BPM \text{real}_BPM} = c_0 + c_1 x + c_2 y$$

$$y_{BPM \text{real}_BPM} = c'_0 + c'_1 x + c'_2 y$$

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:932.455078 26819.394531 37714.996094 12536.925781
offset:-12325 -15779 -10565 -7666
bpm a.x,y,z:0.033272652288621 1.096324079373919 0.029047078500277
bpm a.x,y,z:0.048720993507263 1.20292041282734 0.078819129281960
tval:0.0739224 0.0863825
bpm x err:0.130851 0.019434 0.022899
bpm y err:0.146220 0.021511 0.025433
```
BPMB Database for run current around 37nA

BPMB Database for run current around 42nA
Ebeam=2.2GeV, momentum 1.469GeV, Longitudinal 5T – 2\textsuperscript{nd} type jump

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?