PHENIX Technical Note

Measurement of the Transverse Beam Position in PHENIX Using the RHIC Beam Position Monitors

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Abstract

The RHIC Beam Position Monitors are designed to measure the transverse position of the beams to a precision of around 10 μ. Average position measurements are logged by RHIC periodically, and these measurements could be useful to determine the collision point in PHENIX more accurately. Data from Run 3 for d-Au and pp collisions were extracted from the RHIC database and averaged through a PHENIX run. The beam position was found to be internally consistent to about 120 μ, and was compared with independent measurements from PHENIX.

1 Beam Position Monitors

The Beam Position Monitor system in RHIC has been described in the literature. [1–4] There are BPM's in each of the DX magnets just outside the PHENIX IR, at $z = \pm 8.3$m from the collision point. Data are analyzed in real time by DSP's to give average beam positions which are then logged periodically by the RHIC control system.

2 Access to BPM Data

Logged RHIC data can be accessed and displayed by the LogView application (conventionally run by PHENIX users on acnsun65.pbn.bnl.gov), but for the purpose of studying all the logged data from many RHIC fills and PHENIX runs, the command line tool exportLoggerData [5] was found to be more convenient.

A Perl script was developed that extracted BPM data for the time of the PHENIX run. First, the start time and duration of the PHENIX runs were

Run	Start Run	End Run	Total Runs	Good Runs
dAu	63474	80312	1733	230
pp	83478	92446	1239	319

Table 1: Runs examined in this analysis. The Start and End Runs are PHENIX run numbers used which resulted in the total number of runs listed under Total Runs. Runs where the BPM data satisfied the cuts described in the text are counted in the column labeled Good Runs.

determined from the MySQL runcontrol database. The start time and duration of runs of partition "Big" with more than 10k events which were logged were selected. (Runs in which the ending time was recorded as 0 were excluded, but this only eliminated about 10 runs in each data set.)

The mean and RMS of each of the eight BPM measurements (horizontal and vertical measurements of the blue and yellow beam north (8 o'clock) and south (7 o'clock) of the collision point) were calculated during the time of the PHENIX run. The position of the beam at $z = 0$ was calculated as

$$x_{blue} = \frac{\text{blue-g7-bhx+blue-g8-bhx}}{2} \tag{1}$$

$$x_{yellow} = \frac{\text{yellow-g7-bhx+yellow-g8-bhx}}{2} \tag{2}$$

$$y_{blue} = \frac{\text{blue-g7-bvx+blue-g8-bvx}}{2} \tag{3}$$

$$y_{yellow} = \frac{\text{yellow-g7-bvx+yellow-g8-bvx}}{2} \tag{4}$$

The list of runs extracted from the runcontrol database was fed to another script (runbpm.pl) which was used to call readbpm.pl. The means and sigmas of the four measured positions was recorded to a file with the script readbpm.pl. The ASCII files are copied from the acnsun65 to PHENIX computers, and the position data are inserted into an SQL database for easy access by Root macros.

3 BPM Data Reduction

The BPM data exhibit a number of pathologies which make the position measurement too poor to use. An example of bad data from RHIC fill 3055 in the dAu run is shown in Figure 1. There are periods of missing data, and drifting positions. This led to a number of rudimentary cuts which were applied to the BPM data which address problems with the data as logged. The

- For many PHENIX runs, there are not enough logged position measurements to make a reasonable estimate of the beam position. Measurements were generally logged every five minutes or so, but for some runs there was no logged data, and some PHENIX runs were short enough so that there were insufficient measurements in the course of the run. In principle,

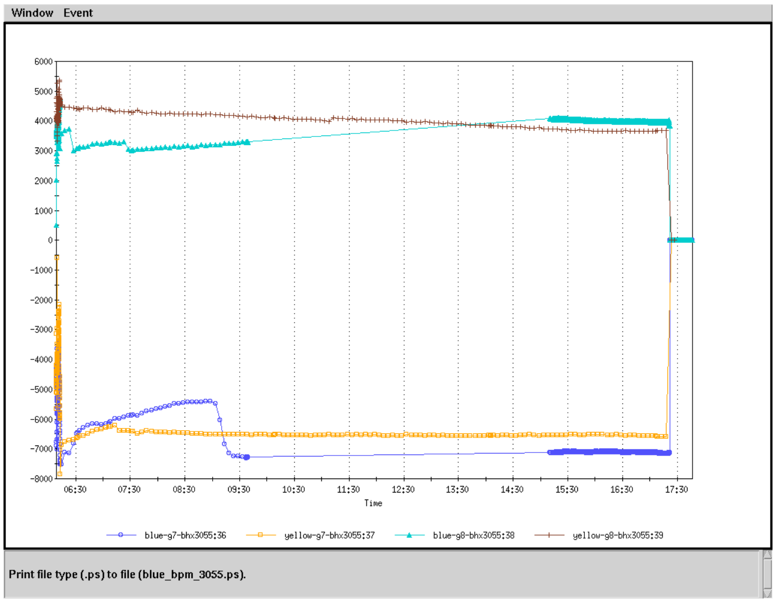

Figure 1: Blue BPM data from RHIC fill 3055 from LogView.

one could recover some of that position information by relying on other measurements during a fill, but this was not attempted and may not actually yield many more reliable measurements. Runs in which any of the eight BPM's had less than three logged measurements were eliminated. For the dAu run, this eliminated 70% of the runs, while for the pp run, it eliminated about 56%.

- Runs in which the RMS deviation of any one of the measured positions was large were eliminated. For well behaved runs, the measured positions are quite stable, but there are a substantial number of runs in which one or more the measurements drift during the course of the run. A run in which the RMS deviation of any of the four measurements is greater than 0.01 cm (100 microns) is eliminated. This eliminates about 15% of the dAu runs and slightly more, about 17%, of the pp runs. This does not appear to be movement of the beams, since often only one BPM exhibits the drift.

- A small fraction of the runs (around 1-2%) are eliminated because the measurements are identically 0.

After applying these cuts, the correlation between the measurements of the position of the blue and yellow beams is shown in Figure 3 for the dAu run and Figure 5 for the pp run. Each point corresponds to an average position measurement from all the BPM measurments logged during the course of the run, subject to the requirements described above. The beams are clearly in collision,

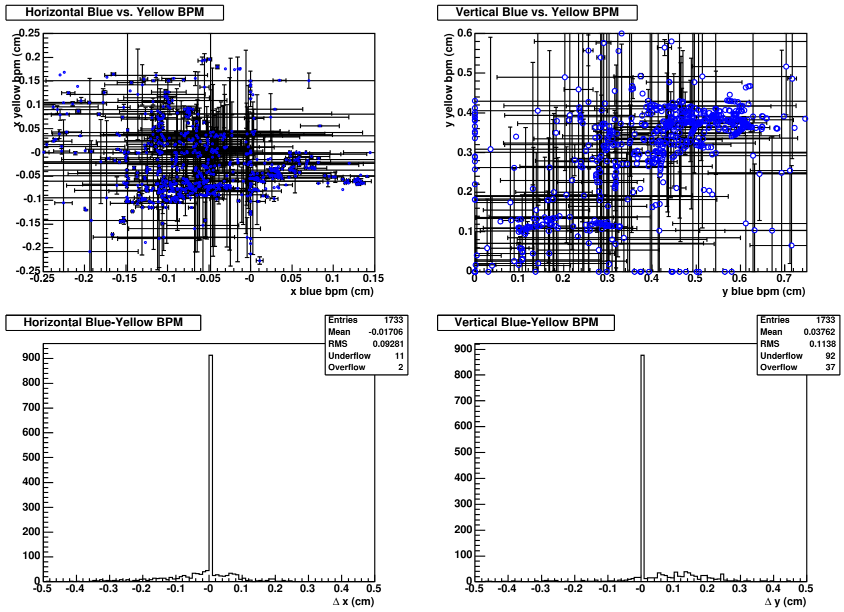

Figure 2: All position measurements from the dAu run. The upper graphs show the correlation between the positions measured by the blue and yellow BPM's, while the lower plots are the differences between the positions. The error bars are the sigmas of the measurements.

BPM	x (cm)	y (cm)
7 o'clock	-0.59	-0.38
8 o'clock	0.31	-0.13

Table 2: Transverse position of the BPM's in the RHIC coordinate system as measured by the RHIC survey.

since a substantial number of events were recorded by PHENIX during these runs. Table 2 shows the BPM survey data from RHIC [6]. During PHENIX operation, the Central Magnet is generally not moved, so measurements based on the Beam-Beam counters are likely to be stable throughout the run. The East and West Carriages are thought to return to their position to about ± 0.05 cm [7].

In the dAu run shown in Figure 3, the horizontal measurements from the blue and yellow beam seems to have some structure which could be variability of the position sensitivity of one of the measurements; it appears that the position sensitivity of one or the other BPM can be half or twice the other, as seen by two apparent slopes in the upper left plot and the bifurcated difference distribution in the lower left. The vertical measurement does not appear to exhibit this

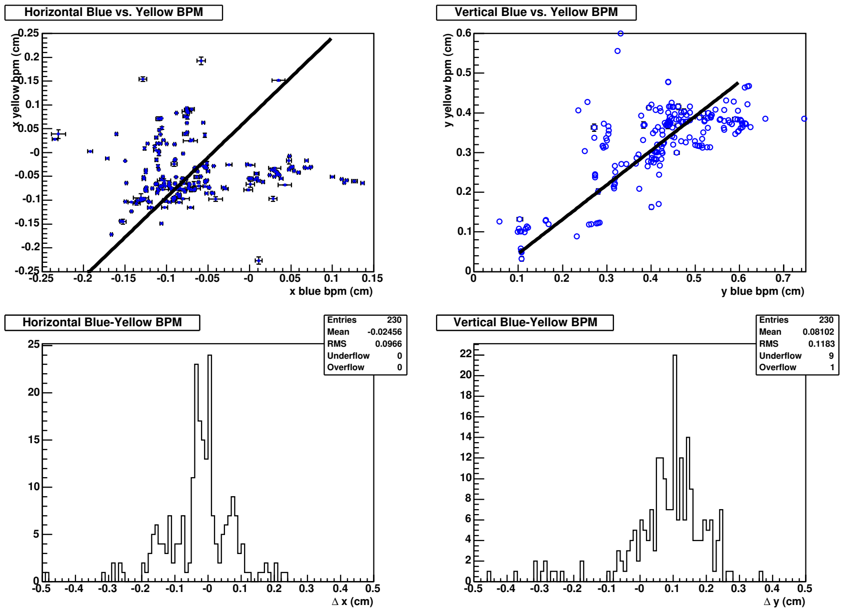

Figure 3: Position measurements from the dAu run satisfying the requirements discussed in the text.

effect, although the broad difference distribution may mask it. The distribution of the sigmas for the BPM's is show in Figure 4; note that the cut was at 0.01 cm. Note that there is more dispersion in the horizontal or bend plane than in the vertical plane, which is probably consistent with the beam physics. After all the cuts, about 13% of the runs have a position measured.

Position measurements from pp run are shown in Figure 5. The positions are generally more stable and self-consistent than during the dAu run. The Gaussian fit to the difference between the horizontal positions measured by blue and yellow BPM's has a mean of -0.032 cm and a sigma of 0.016 cm, so if the meaurements are comparable in precision, one could expect about 120 μ resolution.

4 Comparison with PHENIX Measurements

For 36 PHENIX runs in the dAu run, the beam position has been estimated from measurements with the PHENIX detector and compared to the BPM measurements. Measurements from the blue and yellow BPM's are shown in Figure 6. Of the 36 runs, 12 had BPM measurements that satisfied the quality cuts.

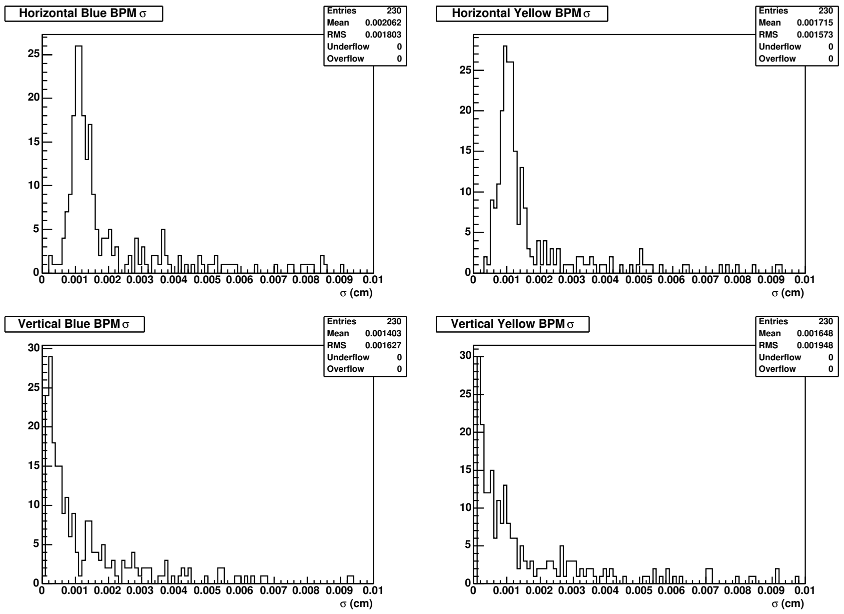

Figure 4: Sigmas of the measurements from the dAu run satisfying the requirements discussed in the text.

5 Conclusion

Some convenient tools have been developed to access the logged BPM data at RHIC. For this analysis, and perhaps others, it is more convenient to access logged RHIC data directly than by reading logged CDEV records, since data are logged outside of PHENIX data taking, and so beam conditions before and after a data taking run can be examined, and there is no client-server failure mode which can prevent data from being logged.

The Beam Position Monitor data appears to be capable of measuring the transverse position at the interaction point to a precsion of about 100 μ, particularly in view of several improvements planned for Run 4 which should reduce the noise on teh analog signals, and improve the stability of the measurement. It would be useful to monitor the BPM data during the run to see if the promised stability can be obtained.

Further study is needed to determine whether the position measured by the BPM's is a useful refinement to the position measured with the PHENIX detector. Higher statistics measurements from data taken in Run 3 would be interesting to compare, but given the known instabilities in the BPM's in Run 3, are probably better done with new data.

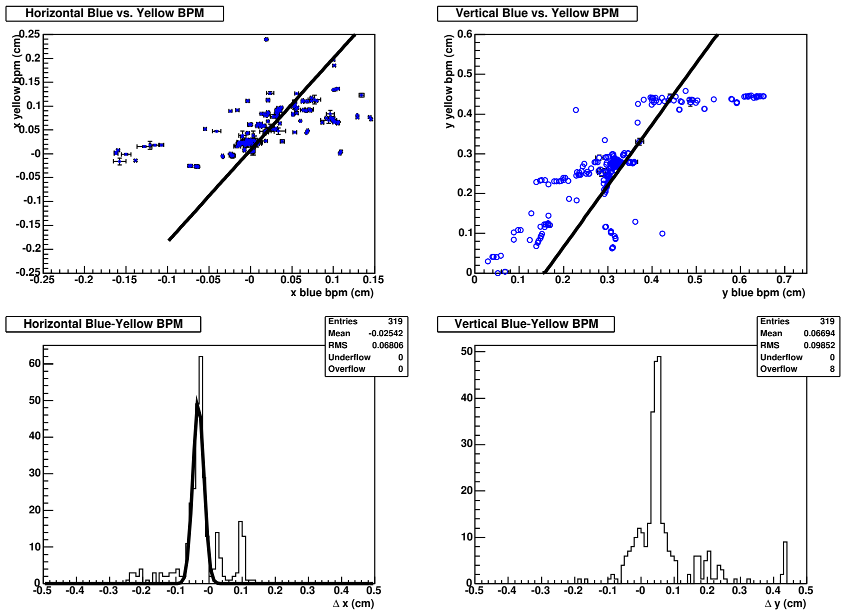

Figure 5: Position measurements from the pp run satisfying the requirements discussed in the text. The superimposed Gaussian fit has a mean of -0.032 cm and a sigma of 0.016 cm.

6 Acknowledgments

Angelika Drees and Todd Satogata in the Collider-Accelerator Department explained in detail to me how the Beam Position Monitors were set up and how to access the data from them. This work could not have been done without them. Tom Hemmick and Sean Leckey provided the PHENIX transverse position measurements. This work would not have been done without them.

References

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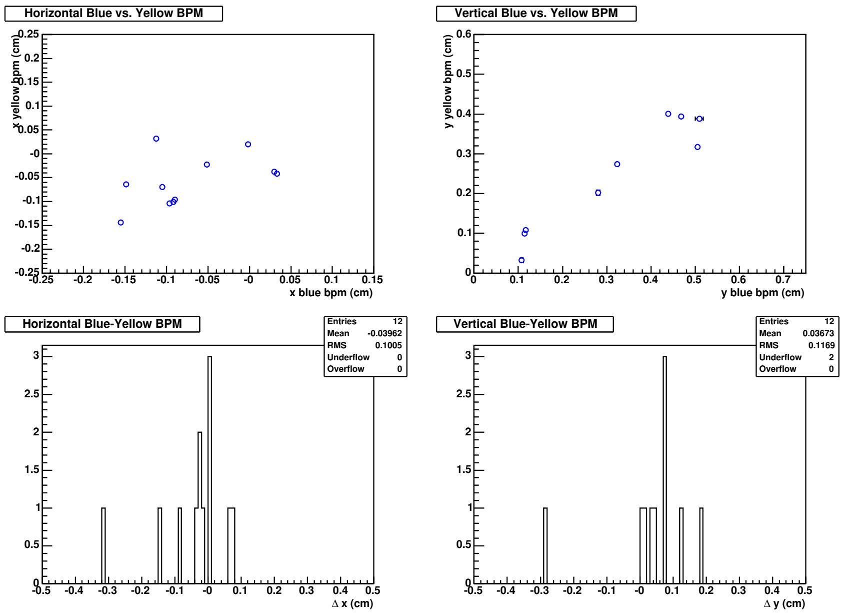

Figure 6: Position measurements from the dAu run satisfying the requirements discussed in the text and a measured position by PHENIX.

[5] http://www.agsrhichome.bnl.gov/Controls/doc/FillData/FillEventsTools.html

[6] This information was provided by Angelika Drees, private communication.

[7] This information was provided by Peter Kroon, private communication.

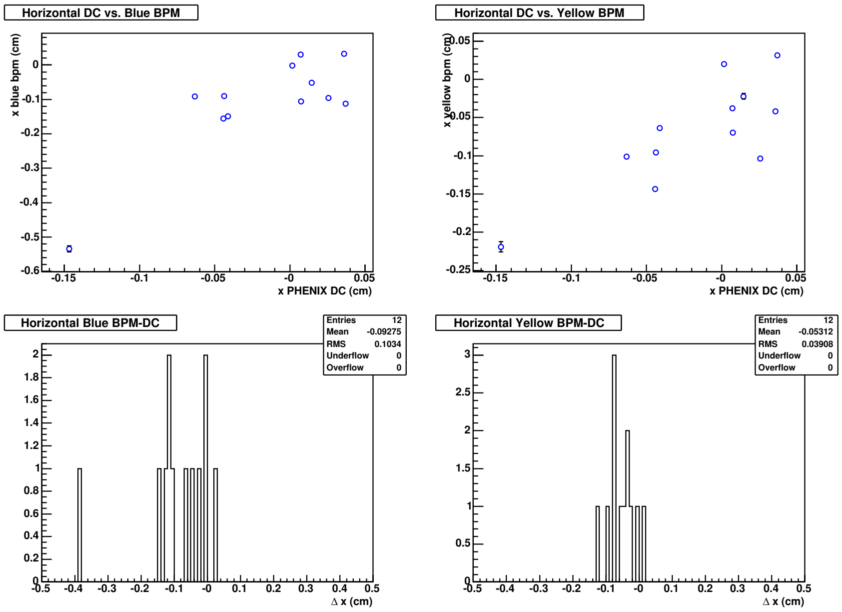

Figure 7: Comparison of measurement of the horizontal position by PHENIX with blue and yellow BPM's.

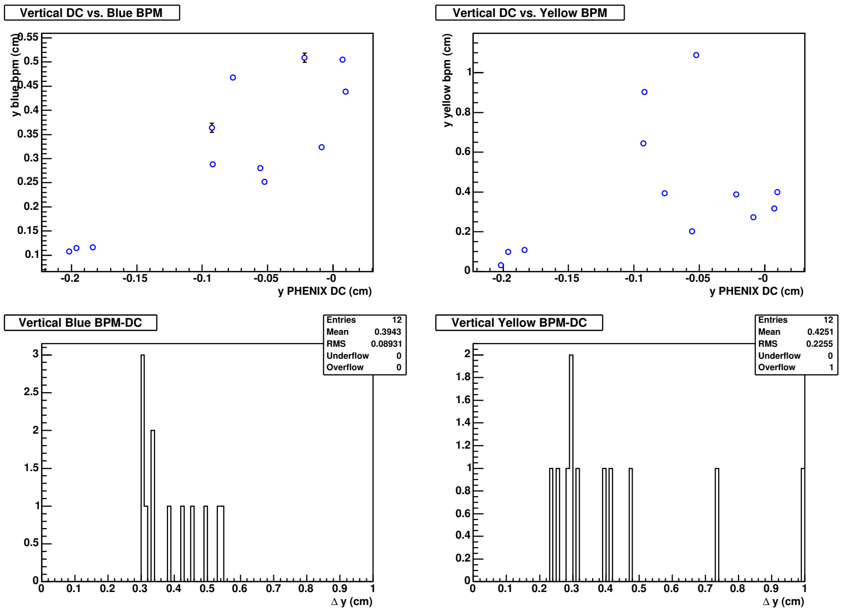

Figure 8: Comparison of measurement of the vertical position by PHENIX with blue and yellow BPM's.