BPM Calibration for GMp/DVCS experiments`

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On behalf of the DVCS Collaboration

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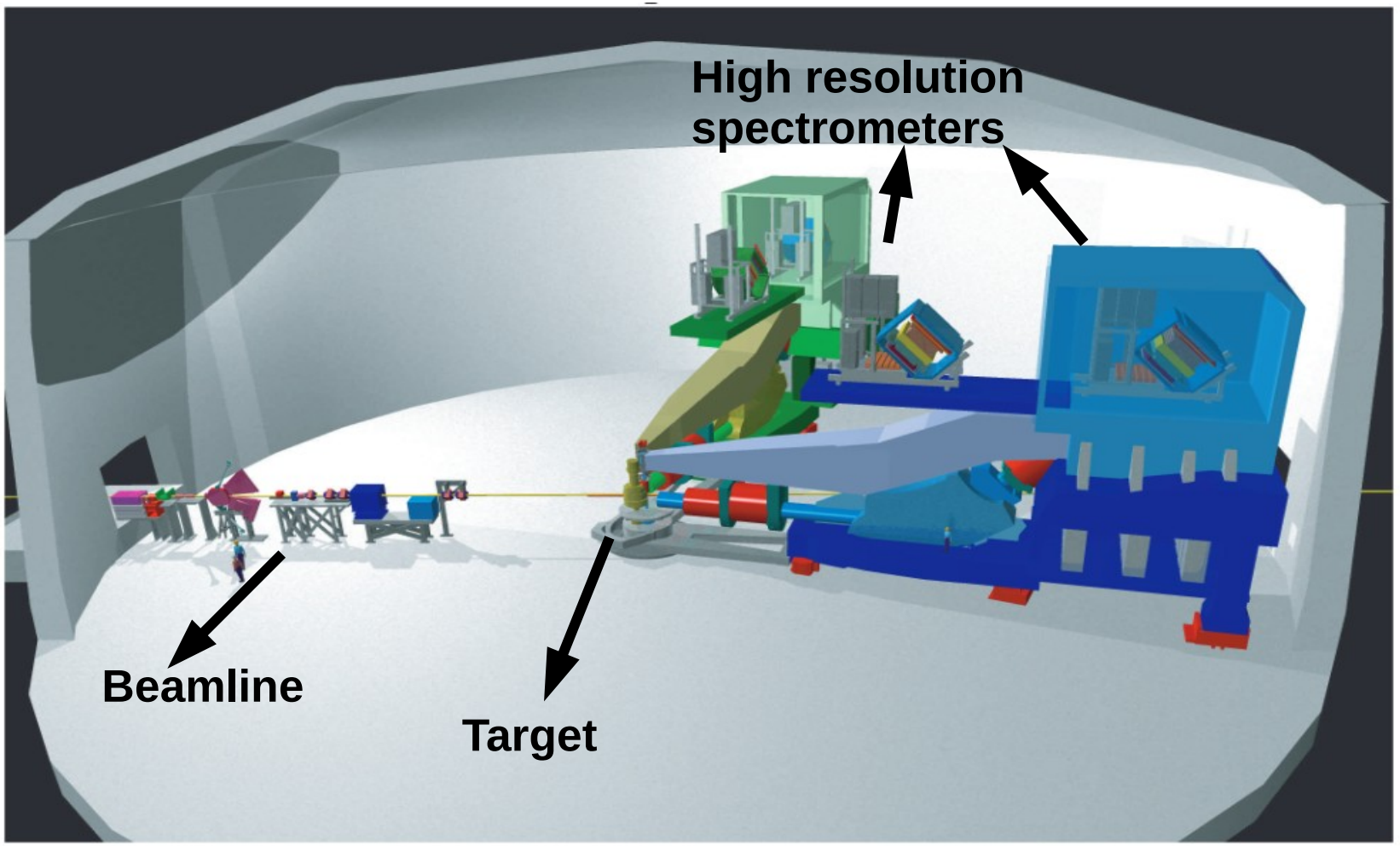
Outline

- Motivation
- Hall A beamline and coordinate systems
- Beam position monitoring instruments
- BPM calibrations and results
- Conclusions

Motivation

- Shift in vertical beam position cause change in spectrometer momentum
- The scattering angle at vertex depends on beam direction, which in turns depends on the beam position measurements

Hall beamline transport

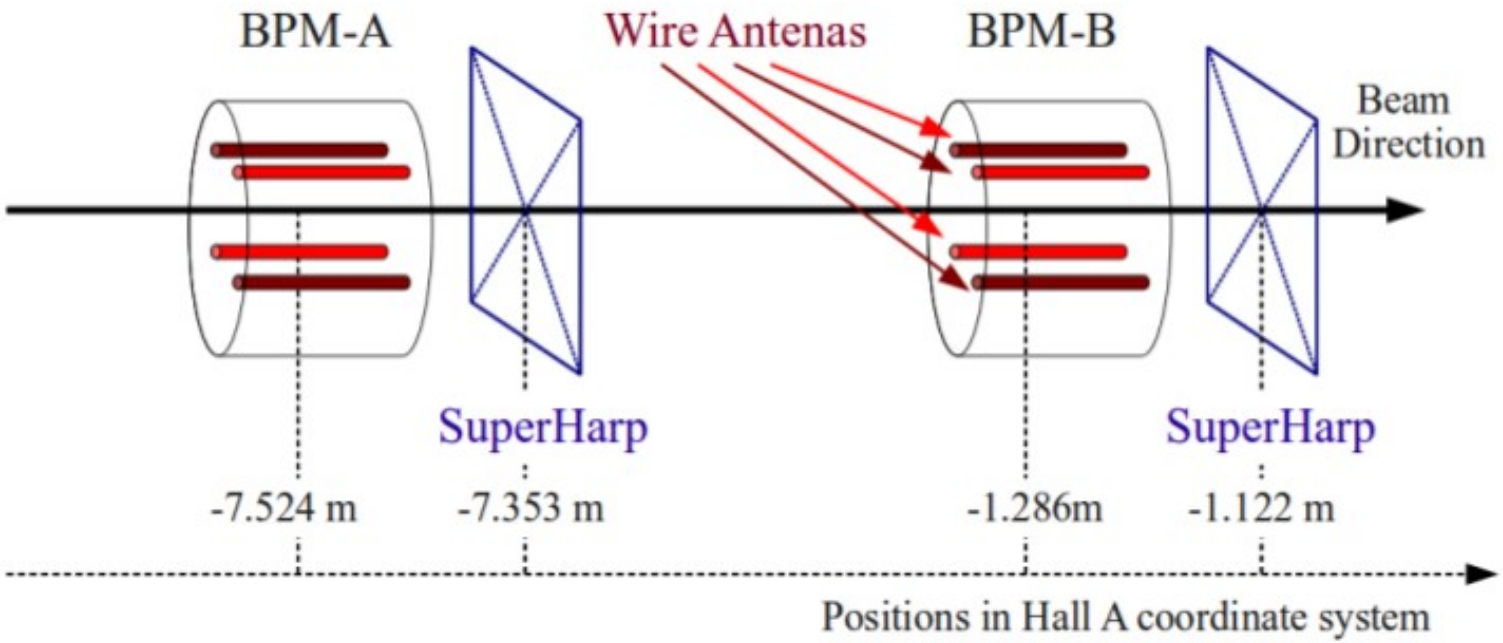


Hall A Beam Position Monitors

- Two BPMs provides non destructive measurements when beam is present in the hall
- Each BPM consists of a cylindrical cavity housing of four wires (X_p, X_m, Y_p and Y_m)
- The relative beam positions X' and Y' along the axis of the wires is given by:

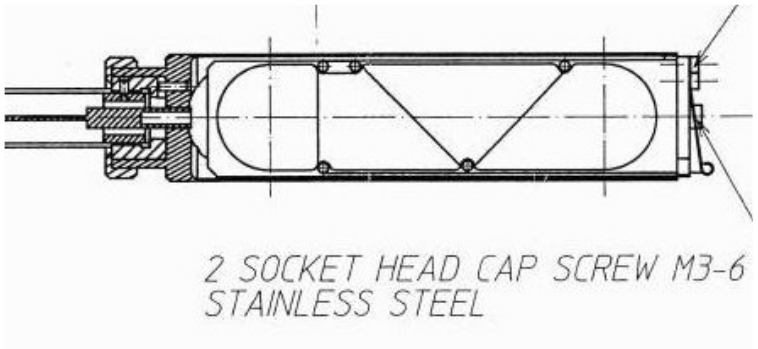
$$X' = k\,\frac{(X_p - X_m)}{(X_p + X_m)},\quad Y' = k\,\frac{(Y_p - Y_m)}{(Y_p + Y_m)}$$

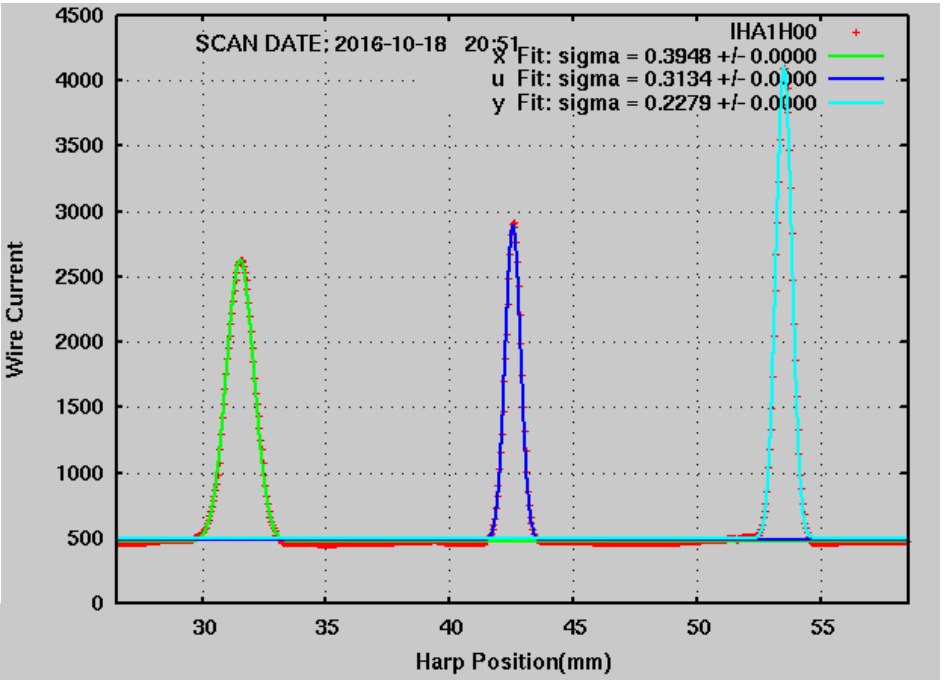
Where, κ = 0.01887



Harp scanners

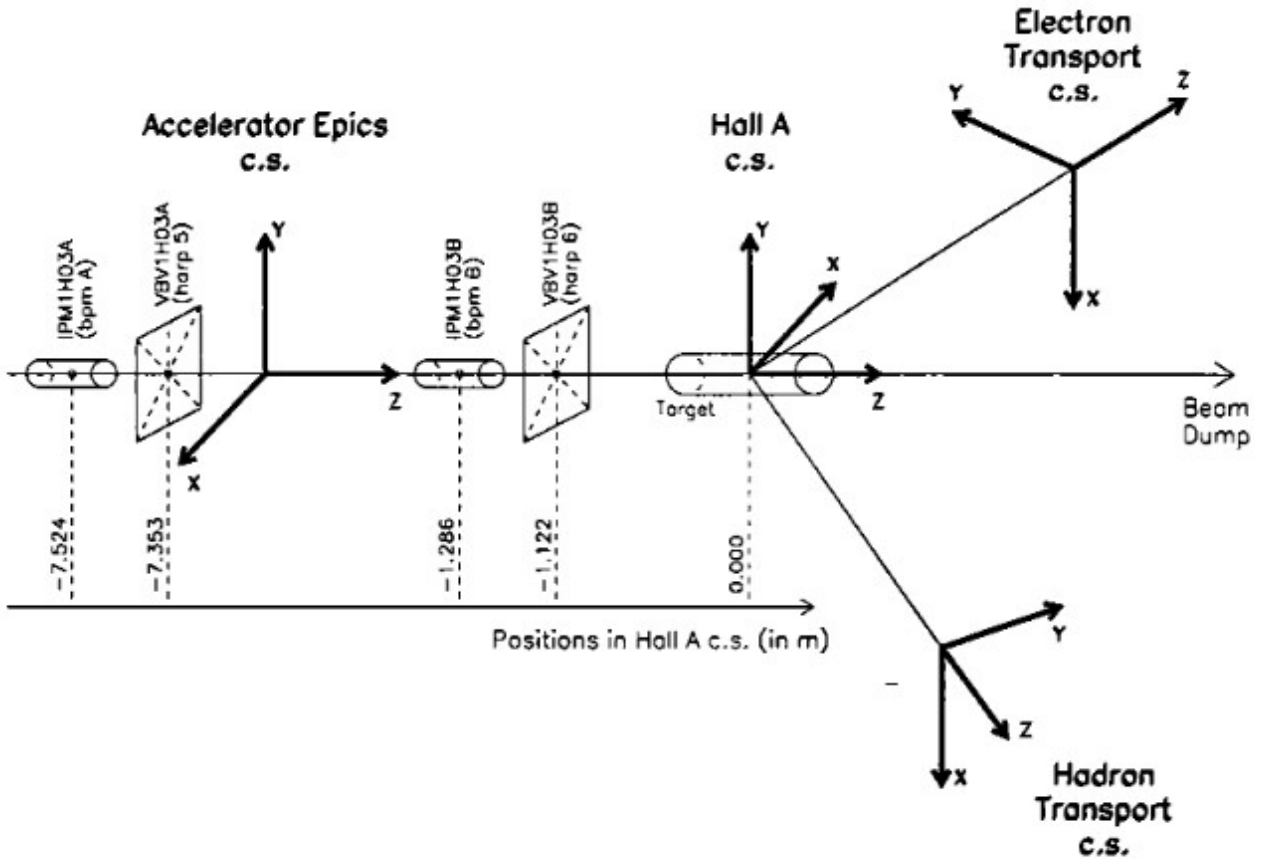
- Harps provides an invasive measurement of the beam position
- Consists of three wires: the first into the beam is vertical and the next two are at 45° to the vertical
- They operates by moving differently oriented wires across a low current beam and reading out the induced wire signals
- They are routinely surveyed with respect to hall coordinate system





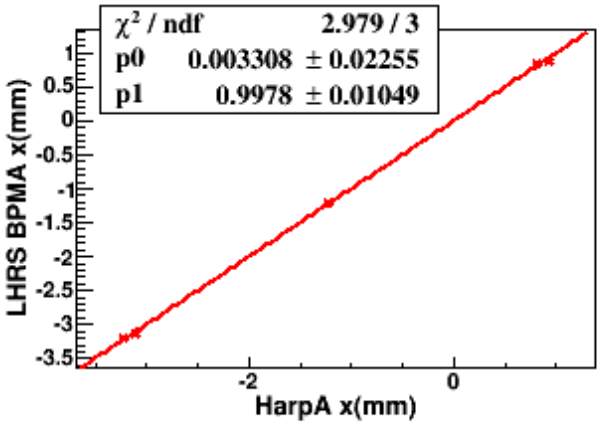
EPICS and hall coordinate system

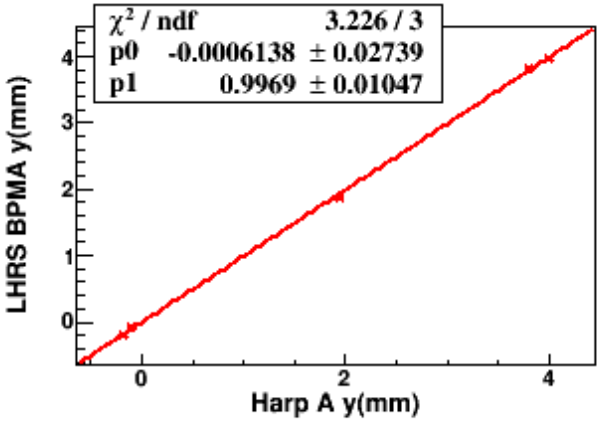
- Accelerator coordinate system are left handed system where all EPICS information are given
- Hall coordinates are right handed where all the survey information are given

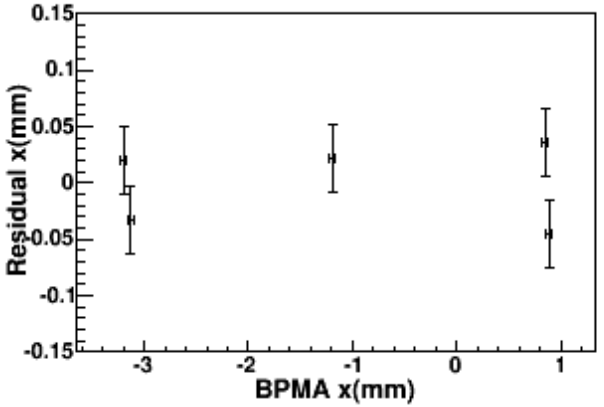


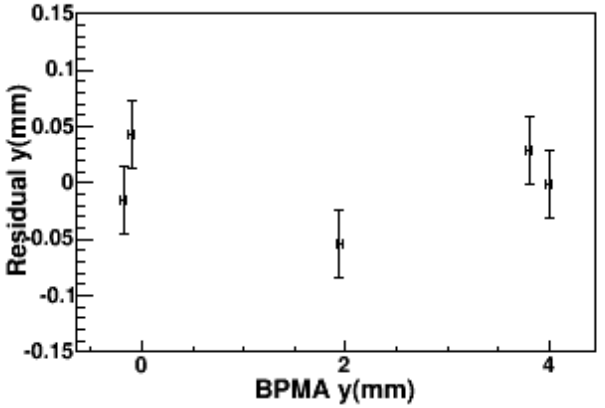
BPM calibration

- Idea is to convert the relative beam position from BPM to the absolute positions in hall coordinate system using positions determined by the harp scan.
- Need to find the calibration constants that give positions at BPM close to positions from harps.
- Estimated uncertainty on beam position is ~0.03 mm









BPM Relative coordinates(x',y')

Hall coordinates (x,y)

$$\begin{pmatrix} x \\ y \end{pmatrix}_{Abso} = \begin{pmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{pmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix} + \begin{pmatrix} x_{of} \\ y_{of} \end{pmatrix}$$

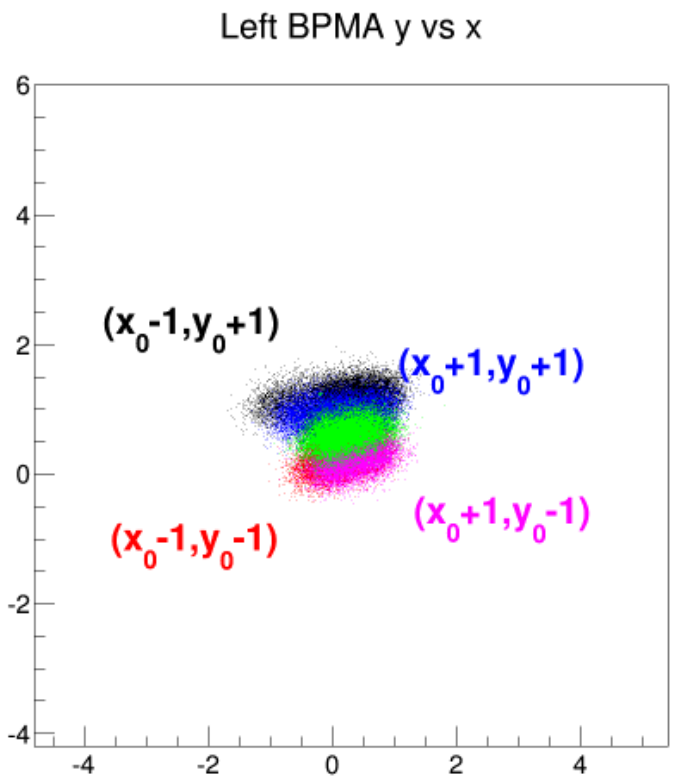
- It is an over tuned system (have 5 harp positions). So we use least square method to calculate the constants

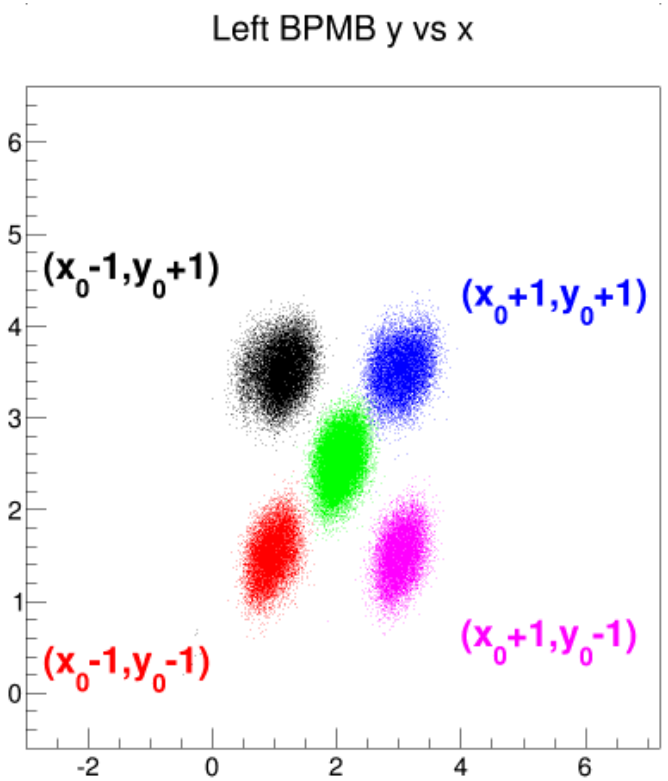
Calibrations for different run periods

Fall 2014 calibration: → Preliminary results of BPMB: https://logbooks.jlab.org/entry/3311886

→ The harp next to BPMA was not operational and bull's eye scans were overlapping with one another

→ No final BPM calibration





Calibrations for different run periods

Spring 2015 calibration:

LHRS

BPMA: -0.771611 0.834972 0.802278 0.787225 0.000859802 0.000368513

BPMB: -0.744433 0.765236 0.825768 0.774278 -0.000325983 0.00162295

RHRS:

BPMA: -0.661529 0.715392 0.680729 0.671765 0.000221095 0.0017538

BPMB: -0.789031 0.808909 0.872521 0.812793 -0.00026796 -0.000476752

Spring 2016 calibration:

LHRS

BPM A: -0.728829 0.760656 0.798555 0.746075 0.00138441 -0.000184231

BPM B: -0.751747 0.774562 0.823933 0.761607 0.000742791 -0.00128245

RHRS

BPM A: -0.73589 0.764353 0.805468 0.749956 0.00102968 0.00167268

BPM B: -0.75004 0.773907 0.826183 0.762423 0.000323344 -0.000890677

Calibrations for different run periods

Fall 2016 calibration (Oct):

LHRS

BPMA	-0.750796	0.723848	0.77656	0.72107	0.00143766	-6.81262e-06
BPMB	-0.624004	0.761298	0.659681	0.708074	0.000601645	-0.000985787

RHRS:

BPMA:	-0.759028	0.737819	0.787136	0.736787	0.00108179	0.0017238
BPMB:	-0.636638	0.768906	0.673286	0.716724	0.000252628	-0.000682291

LHRS Fall 2016 calibration (Dec):

→ Apparent position shift in the data-stream was found which followed the RF card replacement for BPM H04A

→ Addressed by new bull's eye scan

→ Analysis is still in progress due to harp encoder mismatch

Conclusion

- BPMs are calibrated at different run periods
- Beamline databases are updated with new calibrations for each run period
- Analysis of bull's eye scans for Dec 2016 run is in progress

Harp encoder

- The harp scan results in a text file consists of encoder positions and corresponding adc signals
- The encoder value needs to be translated to real world position
- The beam position is determined by the encoder positions where the peaks of the adc signals are

- Wires are moved across the beam path
- When beam hits the wire, a signal is detected by the PMT's positioned next to the scanner
- From the combination of size of the signal and the position of scanner beam position is determined