



## **BPM/Quadrupole Offset Measurements of 26 March 2024**

**The alignment measurements for the BPMs in the south arc date from early 2023.**

**The measurement of 35W on 28 February 2024 suffered from one bad phase measurement.**

**There was some hope that X5D and 44E would be newly available, but the quad centering code complained of “bad data.”**

**Also obtained repeatability data for 32E to see effect of beta functions compared to the earlier measurements at 18E.**

**Performed the “Shanks test” to isolate the contribution of the phase measurement and optimization repeatability.**

## **BPM Recalibration Study with Updated Offset Values**

**How stable are the BPM/Quadrupole offset values?**

Jim Crittenden

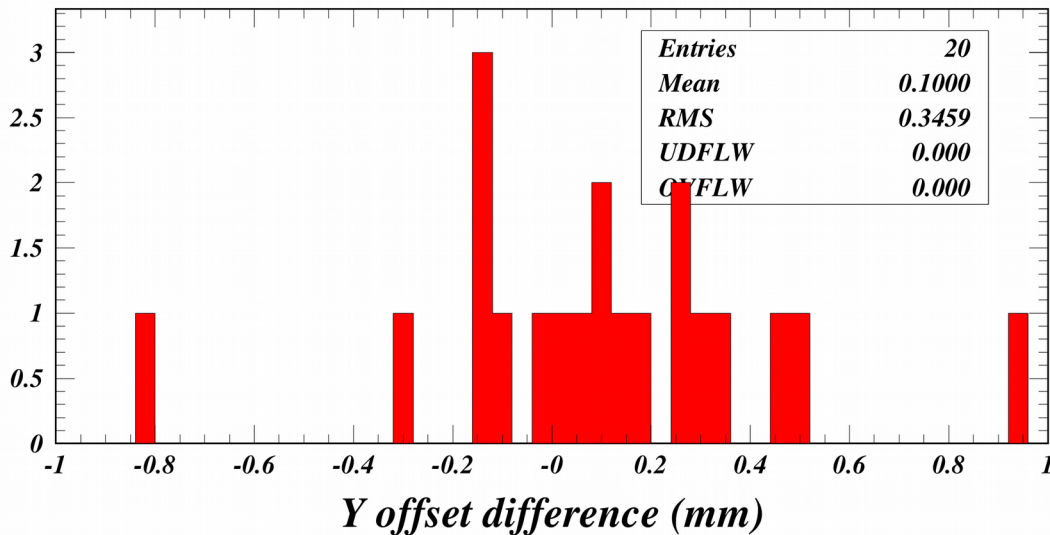
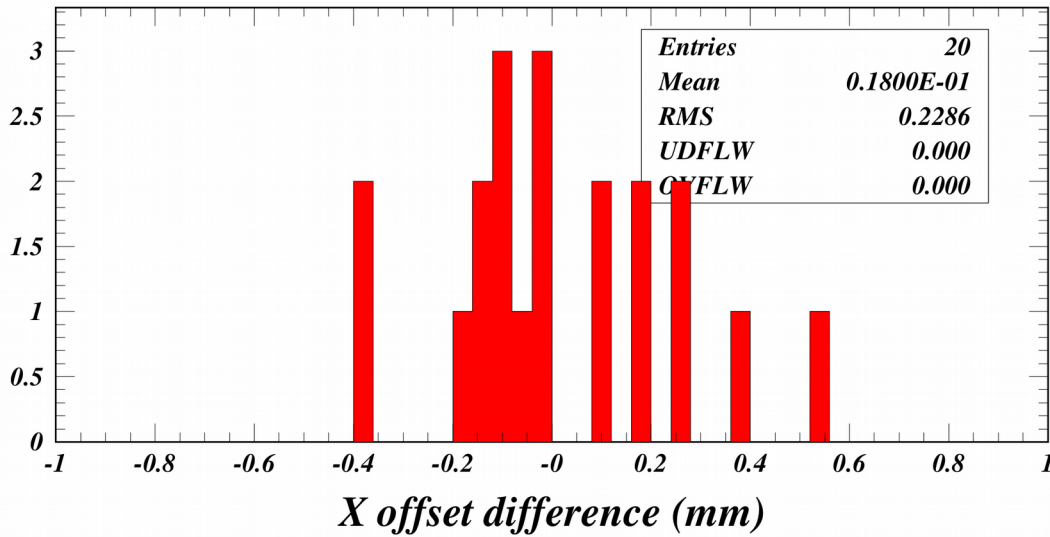
CESR Accelerator Group Meeting

10 April 2024



# BPM offset measurement changes since early 2023

*Change in SA BPM offsets on 26 March 2024*



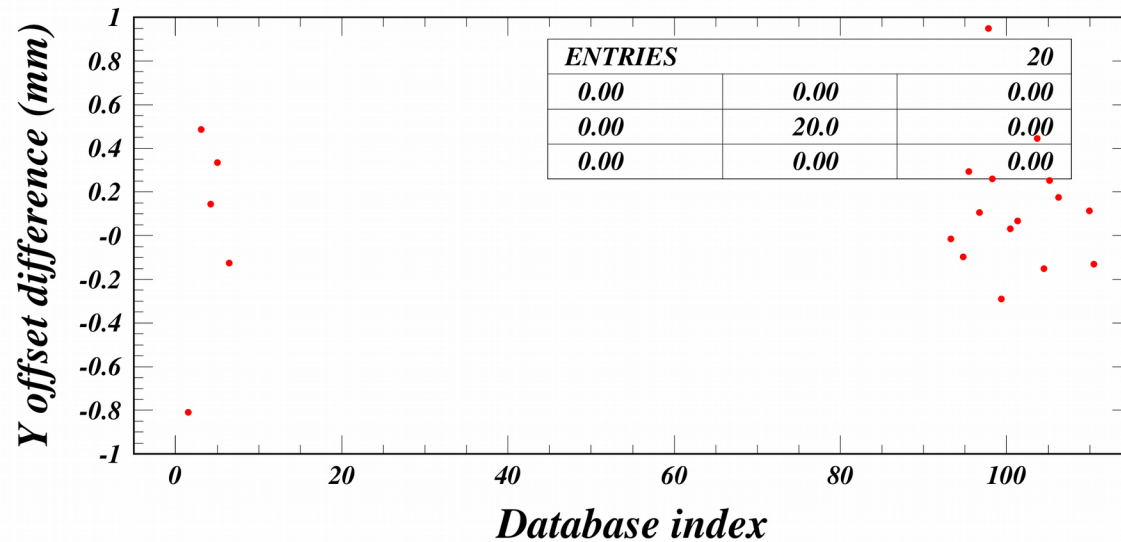
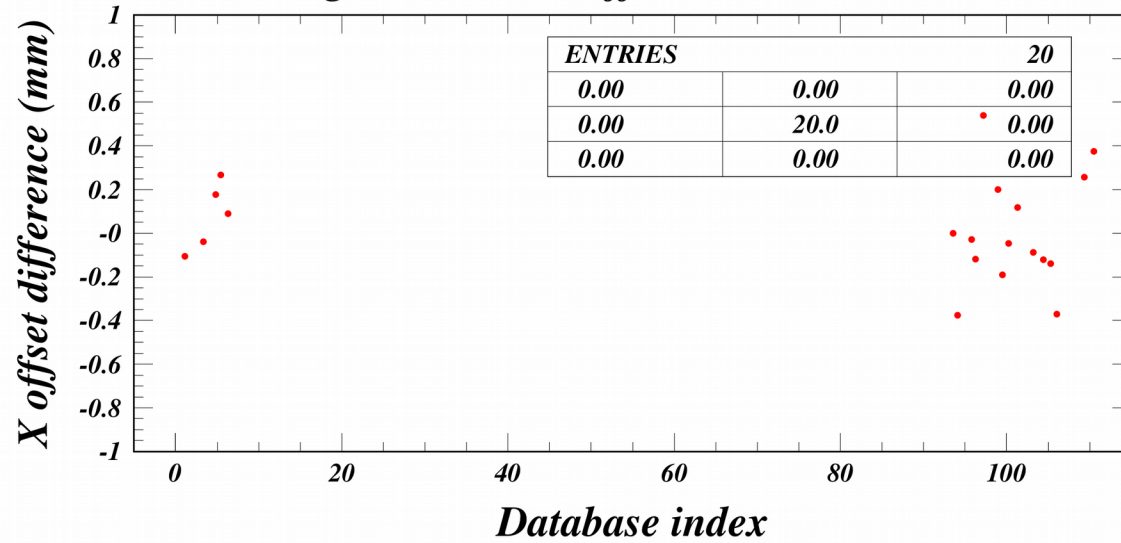
Changes of hundreds of microns are much larger than our single-shot orbit measurement accuracy of about ten microns.

If we want to take full advantage of the orbit measurement precision, we will need to understand the contributions to these changes.



# BPM offset measurement changes since early 2023

*Change in SA BPM offsets on 26 March 2024*

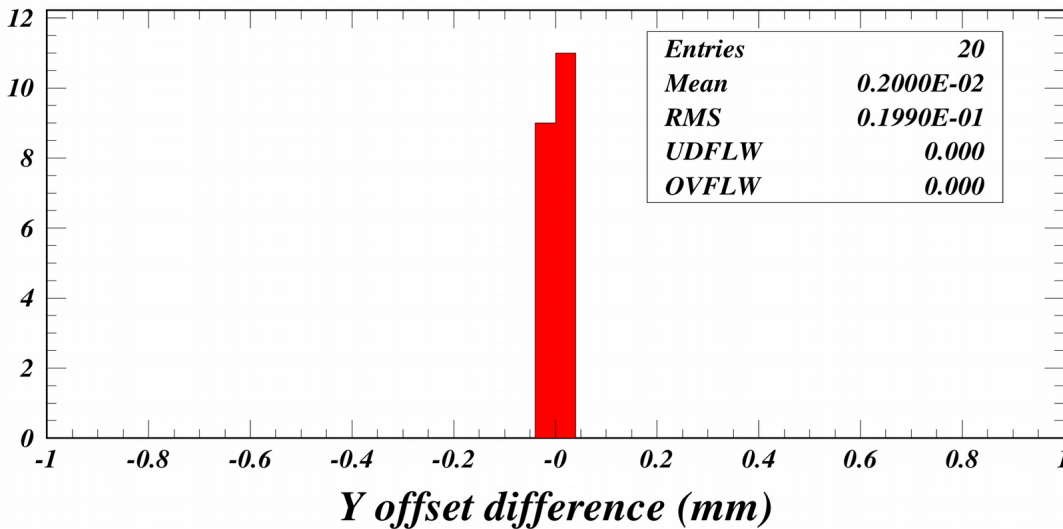
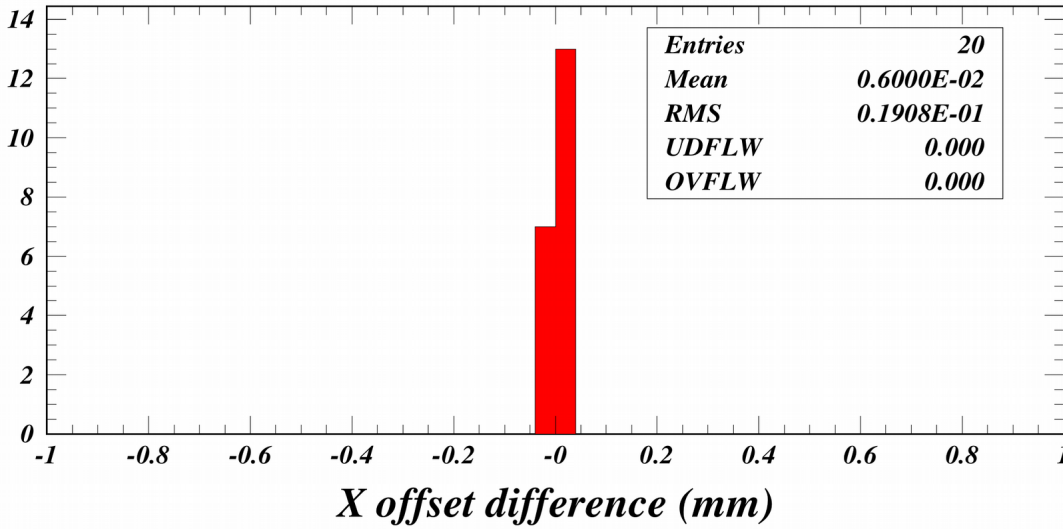


The changes in the BPM offsets are not obviously related their locations.



# One iteration in the measurement of the BPM offsets

## Change in SA BPM offsets after one iteration



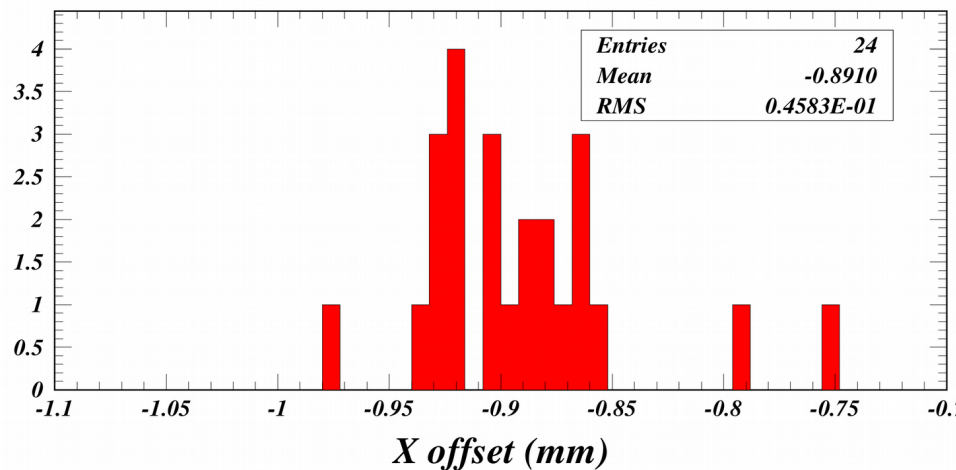
The offset calculation relies on the offsets used in the orbit calculations, so convergence needs to be tested. This is the result.

A single iteration results in an acceptable convergence to 20 microns.

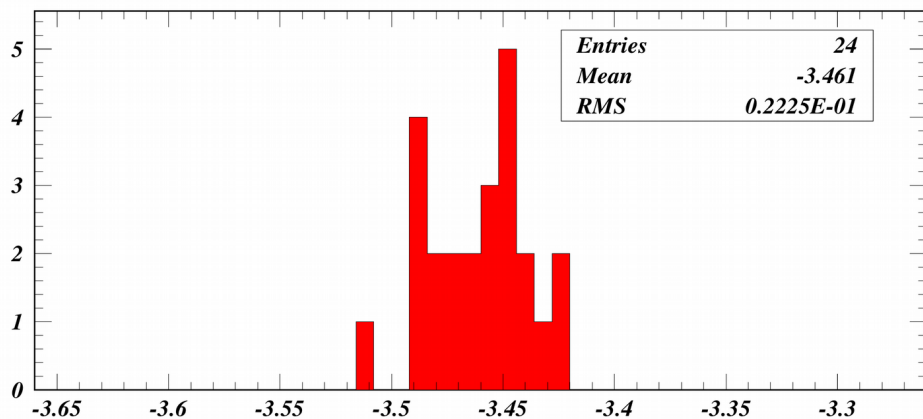


# Repeatability test for BPM 32E

26 March 2024 32E: + - 4 kHz



*X offset (mm)*



*Y offset (mm)*

## Summary of BPM/quadrupole offset measurements at 18E and 32E

### 2 March 2024 18E (Beta X/Y = 38.8/1.8 m)

Tune change X:  $\pm 4$  kHz Y:  $\pm 0.2$  kHz

X offset: N=10 avg =  $-0.200 \pm 0.007$  rms =  $0.023 \pm 0.007$  mm

Y offset: N=10 avg =  $0.231 \pm 0.014$  rms =  $0.046 \pm 0.014$  mm

Tune change X:  $\pm 8$  kHz Y:  $\pm 0.4$  kHz

X offset: N=10 avg =  $-0.212 \pm 0.004$  rms =  $0.011 \pm 0.004$  mm

Y offset: N=10 avg =  $0.307 \pm 0.014$  rms =  $0.043 \pm 0.014$  mm

### 19 March 2024 18E (Beta X/Y = 38.8/1.8 m)

Tune change X:  $\pm 4$  kHz Y:  $\pm 0.2$  kHz

X offset: N=53 avg =  $-0.167 \pm 0.002$  rms =  $0.017 \pm 0.002$  mm

Y offset: N=53 avg =  $0.308 \pm 0.008$  rms =  $0.060 \pm 0.008$  mm

Tune change X:  $\pm 6$  kHz Y:  $\pm 0.3$  kHz

X offset: N=9 avg =  $-0.15 \pm 0.01$  rms =  $0.023 \pm 0.01$  mm

Y offset: N=9 avg =  $0.34 \pm 0.01$  rms =  $0.029 \pm 0.01$  mm

### 26 March 2024 32E (Beta X/Y = 19.3/12.5 m)

Tune change X:  $\pm 4.1$  kHz Y:  $\pm 2.7$  kHz

X offset: N=24 avg =  $-0.891 \pm 0.009$  rms =  $0.045 \pm 0.009$  mm

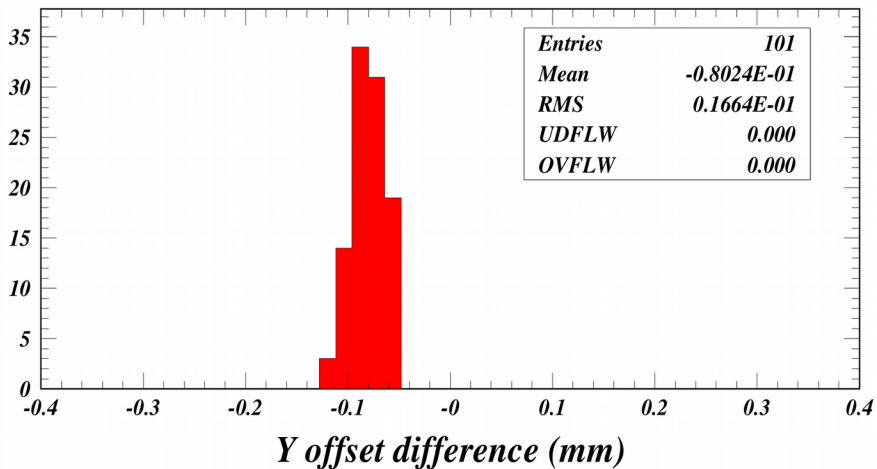
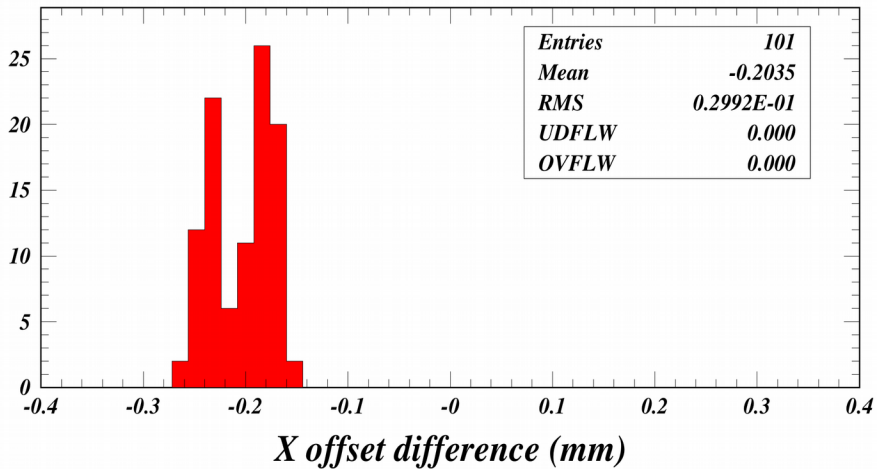
Y offset: N=24 avg =  $-3.461 \pm 0.004$  rms =  $0.022 \pm 0.004$  mm

The X and Y offsets for the default tune range are repeatable at the 10-60 micron level.

The RMS widths are not always smaller for larger beta (larger tune change).



Change in offsets for 100 phase file pairs for 32E (2/28/2024--3/26/2024)



## Recalibration using 100 phase file pairs for BPM 32E

The offset file in use on 26 March is now named `offset.bpm.20240329`. It was also used for these recalibrations.

The offset values for BPM 32E in this file are

$$X_{\text{offset}} = -3.41 \text{ mm} \quad Y_{\text{offset}} = -0.72 \text{ mm}$$

The Q32E settings used for these recalibrations were 22593 cu and 20615 cu, corresponding to a horizontal tune change of  $\pm 4.068$  kHz around 224.760 kHz and a vertical tune change of  $\pm 2.220$  kHz around 244.642 kHz.

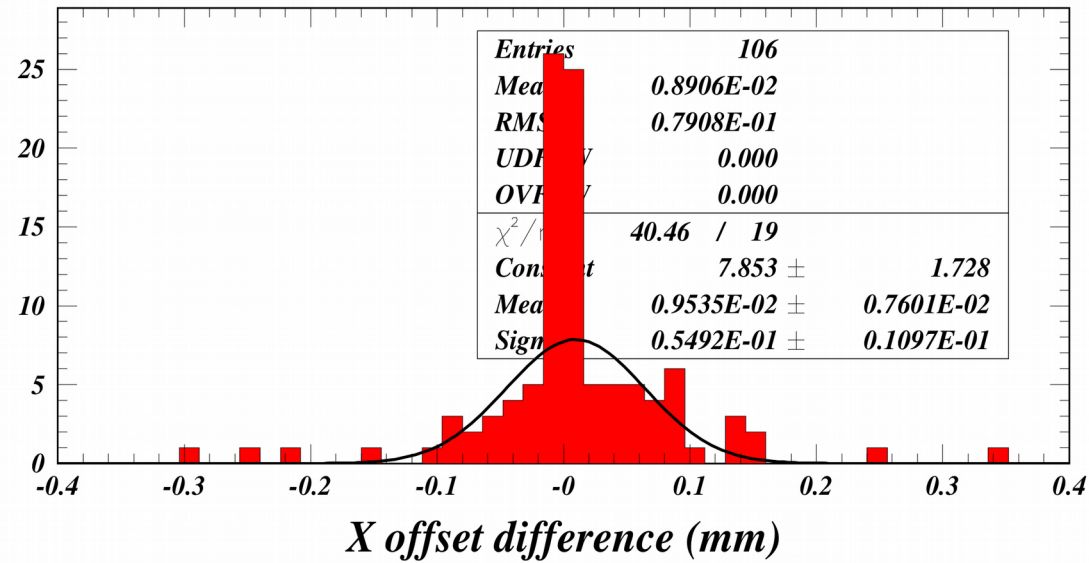
The orbit kicks are -26.9 microradians in X and 8.9 microradians in Y.

Repeatability is found to be 30 microns in X and 17 microns in Y. This is a significant contribution to the overall repeatability of 45 microns in X and 22 microns in Y.

The odd double-peak structure in X is not correlated with phase file number (i.e. time).

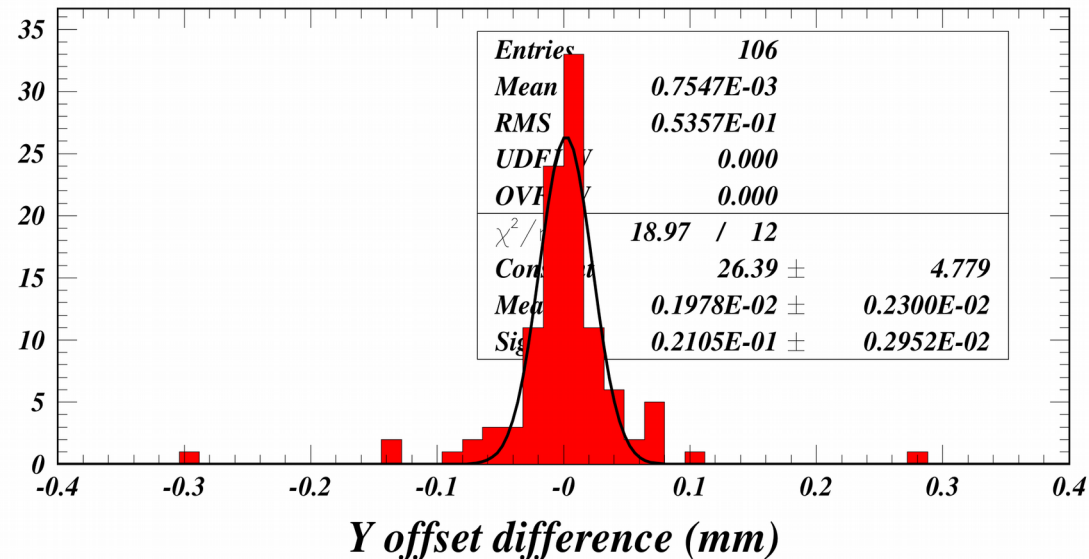


# BPM recalibration using phase files in current offset.bpm and current offset values



X rms (including outliers):

79 microns

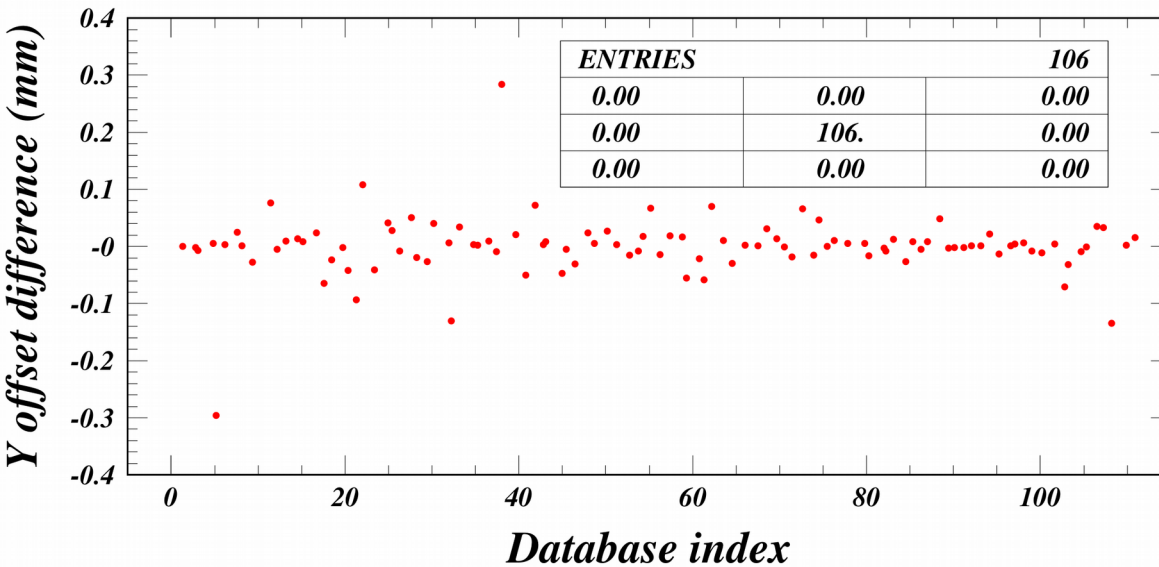
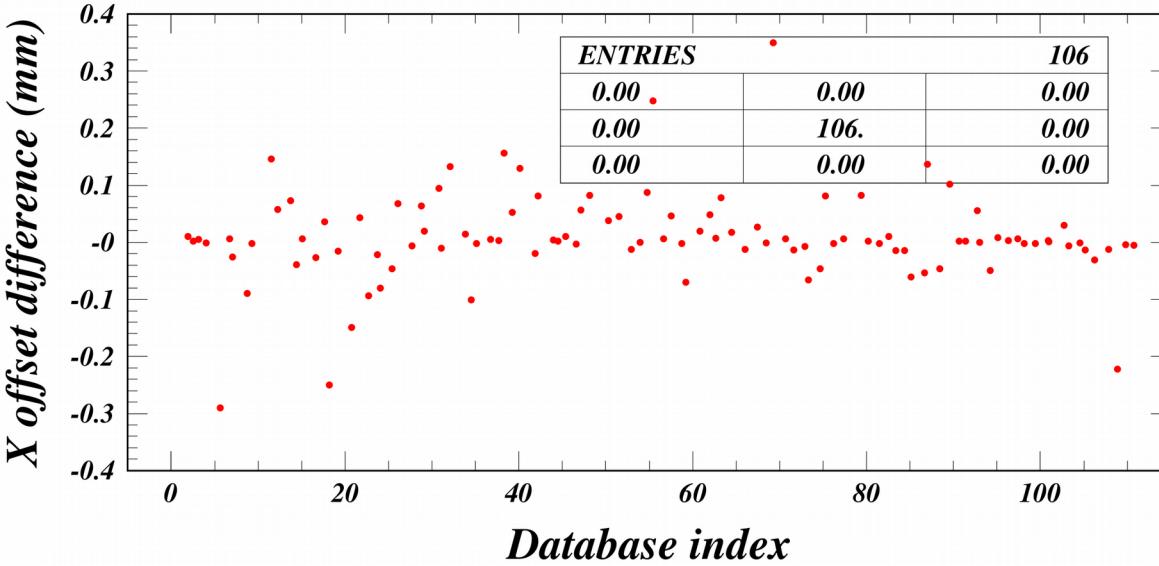


Y rms (including outliers):

54 microns



# BPM recalibration using phase files in current offset.bpm and current offset values



Locations of offset changes  
not concentrated in the SA.





# BPM recalibration using phase files in current offset.bpm and current offset values

## Worst Cases

Change > 0.2 mm

PAW > nt/sc 12 abs(dxoff)>0.2.or.abs(dyoff)>0.2 !!! db\_idx p1 p2 xoff yoff dxoff dyoff

Event	db_idx	p1	p2	xoff	yoff	dxoff	dyoff
4	108.	29694.	29695.	0.35	2.18	-0.221	-0.136
11	5.	33053.	33054.	0.74	1.9	-0.29	-0.297
23	18.	32301.	32302.	0.17	-1.84	-0.25	-0.024
43	38.	26067.	26068.	2.08	0.01	0.156	0.284
59	55.	28556.	28557.	1.57	0.09	0.247	0.066
72	69.	32460.	32461.	0.49	-0.03	0.349	0.013

==> 6 events satisfied the imposed cuts

## Entries in offset.bpm

X4D	108,	2.320,	0.570,	0.010,	0.010,	2023-02-23 09:41:29	p:29694	p:29695
X6C	5,	2.195,	1.027,	0.004,	0.010,	2024-03-26 19:10:03	p:33053	p:33054
18W	18,	-1.820,	0.420,	0.000,	0.010,	2024-02-28 17:04:21	p:32301	p:32302
38W	38,	-0.270,	1.920,	0.000,	0.000,	2020-10-21 18:10:22	p:26067	p:26068
44E	55,	0.020,	1.320,	0.000,	0.000,	2021-09-16 15:12:26	p:28556	p:28557
30E	69,	-0.040,	0.140,	0.000,	0.010,	2024-02-28 18:46:39	p:32460	p:32461

Should these new values be used?  
Look at BPM residuals in improved  
optimizations.