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WFC3/IR: Time Dependency - of Linear Geometric Distortion

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Abstract

Over eight years, the globular cluster Omega Centauri (ω Cen) has been observed with the WFC3/IR F160W filter to examine the linear terms of the WFC3/IR distortion solution and temporal variations of the astrometric scale. We used the DrizzlePac/TweakReg software package to perform linear transformations between X and Y positions with respect to a reference image, the first observation in calibartion program 11928, calculating the shift, scale, rotation, and skew. We conclude that the WFC3/IR detector exhibits a scatter of << 0.1 pixels over eight year time span and the geometric distortion appears to be stable with a change of less than 0.1 pixels (0.013 arcsecs), and shows no evidence of significant temporal variation.

1. Introduction

The geometric distortion is a critical calibration that is necessary for astrometric measurements. Understanding geometric distortion is important for measuring accurate positions, parallaxes, and proper motions. The focal plane of the WFC3/IR camera is tilted by ~21 degrees with respect to the incoming light which distorts the images by ~4.5 arcsecs (~35 pixels). The WFC3/IR general geometric distortion is represented by a 4^{th} order polynomial as described in Kozhurina-Platais et al., 2009. The calculated geometric distortion coefficients were converted into the format of a reference file called the Instrument Distortion Coefficients Table (IDCTAB) and are used to correct images for distortion in the WFC3 calibration pipeline (*calwf3 3.4*) and STSDAS DrizzlePac software packages. Significant variation in the linear terms over time can impact the accuracy of the geometric distortion correction, resulting in blurred images, and distort the under-sampled Point Spread Function (PSF).

For example, ACS/WFC a similar instrument to WFC3, was installed in 2002 and the linear terms of the geometric distortion changed monotonically over 16 years. From 2002-2007, the size of the change is noticeable, reaching a ~15 mas (~0.3 ACS pixels, Anderson, 2007, Kozhurina-Platais, 2015) difference from the 2002 based distortion solution. DrizzlePac, the current software used to align and combine HST images, requires an accuracy of the distortion solution to be < 0.1 pixels. If larger, the drizzled HST images will have poor alignment. Some linear terms of the ACS/WFC geometric distortion show a strong correlation with the HST roll angle (PA_V3) (Kozhurina-Platais, 2015). Therefore, it is necessary to monitor WFC3/IR geometric distortion for variation in the linear terms as a function of time and HST roll-angle (PA_V3). In 2012, the linear parts of WFC3/UVIS and IR geometric distortion were analyzed over a 2-year time span. The analysis concluded that the WFC3/UVIS and IR geometric distortion were stable and shows no evidence of secular changes (Kozhurina-Platais, 2012). In this report, we present the analysis and results of the WFC3/IR time dependence of the linear geometric distortion over the 8-year time span, using the DrizzlePac/TweakReg software package.

2. Observations

Observations of ω Cen were taken with the F160W filter in the WFC3/IR channel for the geometric distortion calibration programs (11928, 12353, 12714, 13570, 14550). We used over 8-years of observations to examine the time-dependency of the WFC3/IR geometric distortion for a total of 80 images. The images were taken with the same pointing (POSTARG) but various HST roll-angles (PA_V3). The POSTARG for proposals 11928 and 12353 were commanded for ±34 arcsecs and ±60 arcsecs, respectively. Frames with the same pointing and orientation would cancel out systematic errors in the geometric distortion; the distortion-corrected frames with different pointings and orientations would reveal systematic residuals in the X and Y positions. All images were calibrated through the WFC3 calibration pipeline (*calwf3 3.4*). A list of the filename, date of observation, velocity aberration (VAFACTOR), PA_V3, POSTARG1, POSTARG2 and Proposal ID is located in Table 1 in the Appendix.

3. Data Reduction using DrizzlePac/TweakReg

3.1 DrizzlePac/TweakReg

DrizzlePac is the software package used to align and combine HST images. The task in DrizzlePac that performs the astrometric transformations between HST images is called TweakReg. TweakReg performs a linear transformation (See Eq. 1 and Eq. 2) between the two coordinate systems, finds the X and Y positions, and solves for the shift, scale, skew and rotation. TweakReg uses similar parameters to IRAF/DAOFIND and IRAF/XYXYMATCH. Typically, the user will set an image or a catalog as the reference and selects a list of files as input images. The user can then set various parameters for the reference frame and input frames for finding sources. For detailed information about DrizzlePac and TweakReg, see the DrizzlePac Handbook. We set the first image (ibcj01ttq_flt.fits) from CAL 11928 with a POSTARG of 0.0 arcsecs as the reference frame and all other images as input frames.

It is essential that the X and Y positions are as accurate as possible to look for systematic residuals. TweakReg computes the X and Y residuals (DX, DY) and outputs the values in **flt_catalog.match* file. We plot the residuals as a function of the X and Y positions (Figure 1) for each input image to identify the systematic residuals in the X and Y positions. We use a 5th order polynomial fit as a visual guide to look for any systematic errors in the residuals which is represented by the green line, a flat line at 0.0 pixels is an indication of low to no systematic error in the residuals. Above the plot is the corresponding root-mean-square (RMS) of the solutions in X and Y, filter name, and the numbers of stars used in the linear solution between images. On average, TweakReg matched ~2720 sources between the reference image and the input images and found an average of ~0.07pix and ~0.06pix for X and Y RMS, respectively.

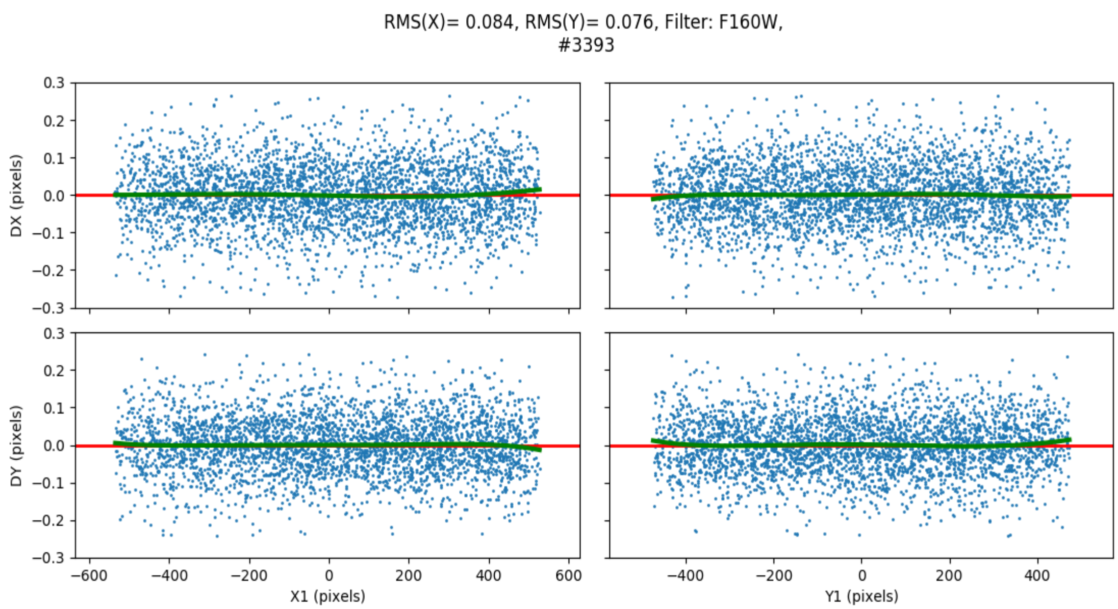

Figure 1:*Plot of the X and Y residuals (DX, DY) as a function of X and Y reference positions (X1, Y1) for image ido706fcq_flt.fits using the WFC3/IR image (ibcj01ttq_flt.fits) as the reference frame. The green line represents a 5th order polynomial fit and is an indication that there are no positional systematic errors. Above the plot is the corresponding RMS of the solutions in X and Y, filter name, and the number of stars used in the linear solution between images. The units are in WFC3/IR pixels.*

3.2 Gaia Data Release 2

We attempted to use Gaia Data Release 2 (DR2) in the vicinity of ω Cen as a reference catalog (Gaia Collaboration et al., 2016a; Gaia Collaboration et al. 2016b). The precision of Gaia would have provided a more accurate calculation of the time dependent distortion in the WFC3/IR channel. All Gaia sources in Data Release 2 from the Gaia Archive Core System located at European Space Agency (ESA) Center, were retrieved within 0.5 degree of the reference point in the vicinity of ω Cen. A recently developed procedure to align HST images with Gaia in TweakReg (Bajaj, 2017) has been used here as a starting pointing. Unfortunately, the number of stars that overlap with Gaia and the WFC3/IR input images were < 300 stars. Due to the low number of stars that overlap, the statistics using Gaia as a reference frame would not have been reliable for this analysis. As explained previously, we plotted the X and Y residuals as a function of X and Y positions for the input frames (Figure 2). Unlike Figure 1, the 5th order polynomial fit indicates positional systematic errors due to the low number of stars; this furthers our reason to use the WFC3/IR image as a reference frame over Gaia DR2 for this analysis.

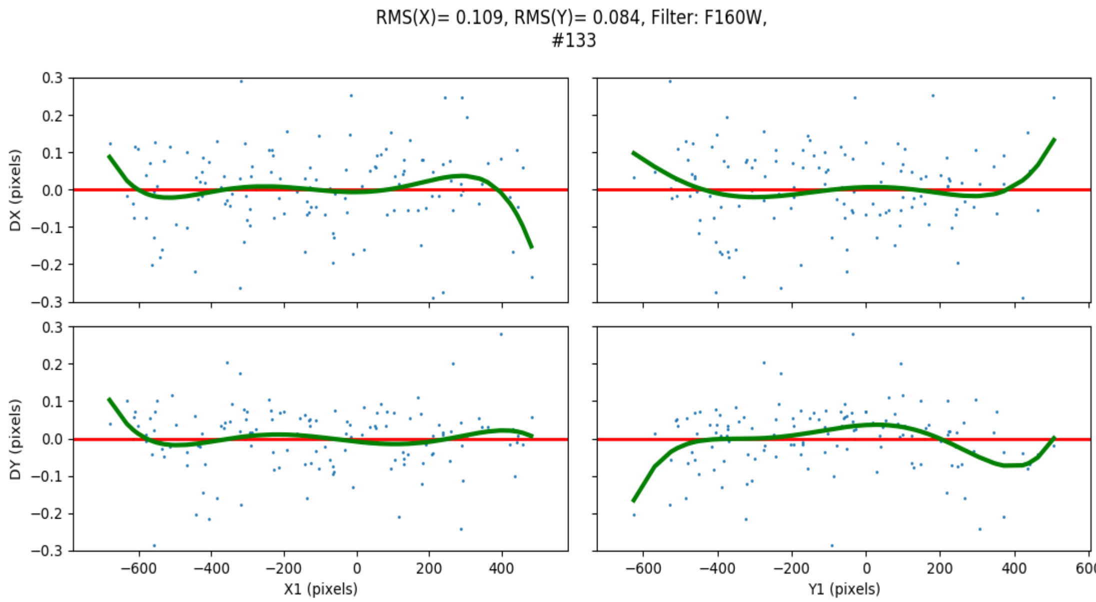

Figure 2: *Plot of the X and Y residuals (DX, DY) as a function of X and Y reference positions (X1, Y1) for image ido706fcq_flt.fits using the Gaia DR2 as the reference catalog. The green represents a 5th order polynomial fit and is an indication that there are positional systematic errors due to the low number of stars. Above the plot are the corresponding RMS of the solutions in X and Y, filter name, and the number of stars used in the linear solution between images. The units are in WFC3/IR pixels.*

3.3 DrizzlePac/TweakReg Equations

TweakReg performs the linear transformation between two coordinate systems. The following equation are used to do this transformation:

$$\boldsymbol{U = P_2 + P_0X + P_1Y} \qquad (1)$$
$$\boldsymbol{V = Q_2 + Q_0X + Q_1Y} \qquad (2)$$

where U and V are the positions of the reference system (ibcj01ttq_flt.fits, the first observations of ω Cen with POSTARG 0:0 in IR) as rectangular coordinates. The input frames' positions (X, Y) were measured and corrected for the distortion. The (X, Y) positions were solved into the reference frame (U, V) in a linear 3x2 parameter transformation. P_2 and Q_2 are the constant terms and represent the offset between the two systems. Parameters P_0, P_1, Q_0, Q_1 represent the linear terms, such as scale in X and Y and rotation in X and Y.

The X and Y scale between the two coordinate systems were calculated with the following equations in TweakReg:

$$Scale_x = \sqrt{P_0^2 + Q_0^2} \qquad (3)$$

$$Scale_y = \sqrt{P_1^2 + Q_1^2} \qquad (4)$$

The plate-scale is the general scale of the detector, and TweakReg uses the following calculation:

$$Plate\text{-}Scale = \sqrt{P_0 Q_1 - P_1 Q_0} \qquad (5)$$

The following equations define the rotation angle in the X-direction and rotation angle in Y-direction:

$$Rotation_x = \tan^{-1}\left(-\frac{P_0}{Q_0}\right) \qquad (6)$$

$$Rotation_y = \tan^{-1}\left(\frac{P_1}{Q_1}\right) \qquad (7)$$

Finally, the global skew is the non-orthogonality between the two principle axes and can be calculated by taking the difference of the X and Y rotations as seen below:

$$Global\ Skew = Rotation_x - Rotation_y \qquad (8)$$

4. Data Analysis

The linear terms in the general transformation between two coordinate systems, corrected for geometric distortion, provide insight of the accuracy of the distortion solution. Variation in the X and Y scale can impact the accuracy of geometric distortion correction. To search for significant variations over time and a correlation to the orbit of HST, we plotted the values of the X and Y scale, plate-scale, skew and RMS of solution in X and Y as a function of time (DATE-OBS) and HST roll angle (PA_V3). The X and Y scale, RMS, and rotation values were computed in TweakReg and logged in the output file *tweakreg.log*. However, TweakReg does not provide the calculated error for the linear terms.

Figure 3 shows the X and Y scale values as a function of date of observation (DATE-OBS) and HST roll-angle. The X and Y scale shows a decrease of < 0.001 pixels (1.3e-4 arcsecs) over an 8-year period. The change in the X and Y scale is insignificant over time and shows no evidence of major scatter. The scale terms show no clear correlation to the PA_V3.

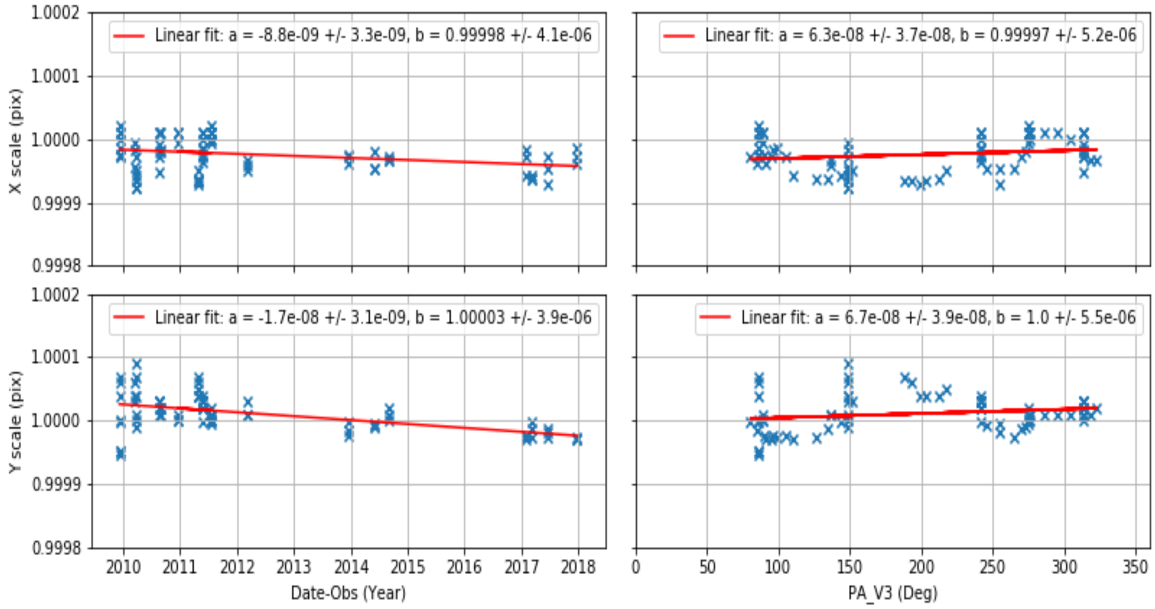

Figure 3: *Plot of the X and Y scale as a function of time and HST roll-angle. The blue crosses represent the calculated scale values in units of WFC3/IR pixels for each image. The red line represents the linear fit of data, where a and b in the legend represent the slope and y-intercept.*

In Figure 4, the computed plate-scale (Eq. 5) shows a result similar to the X and Y scale with a decrease << 1% over an 8-year time frame and shows no clear dependency with the HST roll-angle. Velocity aberration can contribute to the scale change in the WFC3/IR images. The velocity aberration is a known effect and can be found in the science extension for all images under the keyword VAFACTOR. TweakReg accounts for the VAFACTOR in its computation, thus all images are velocity aberration free. The gradual change over time is possibly due to breathing, which takes place on orbital time-scales and causes small changes in the focus and PSF shape.

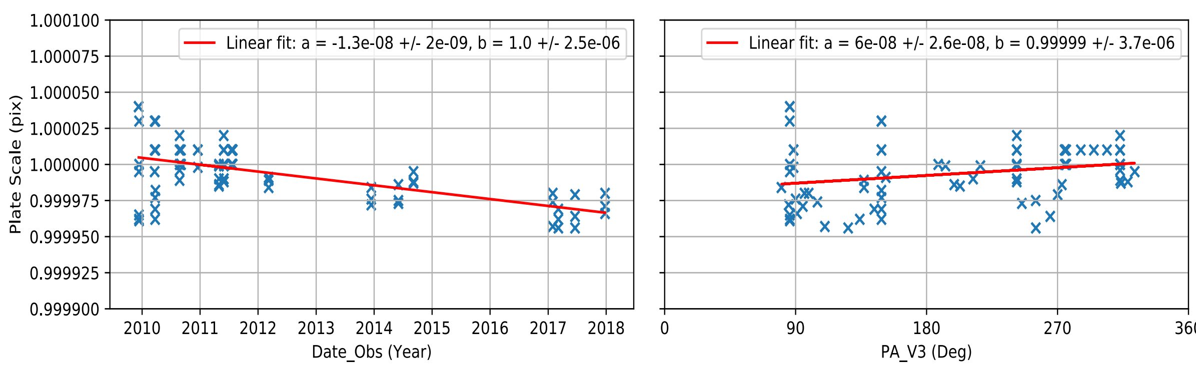

Figure 4: *Plot of the plate-scale as a function of time and HST roll-angle. The blue crosses represent the calculated plate-scale values in units of WFC3/IR pixels for each image. The red line represents the linear fit of data, where a and b in the legend represents the slope and y-intercept.*

To look for any changes in the linear parts of the distortion, the global skew as defined in Eq. 8, was computed in TweakReg. We scaled the skew term by 512 WFC3/IR pixels to represent the size of the effects at the edge of the IR image. Over the 8-year time span, the skew term has been consistent around zero, though there are considerable scatter of 0.01 pixels in the values (Fig 5). The scatter is due to the under-sampled PSF for the WFC3/IR detector and possible orbital breathing; however, the effects are minor and do not impose any significant variation in the skew. The skew term does not show any clear correlation to the PA_V3.

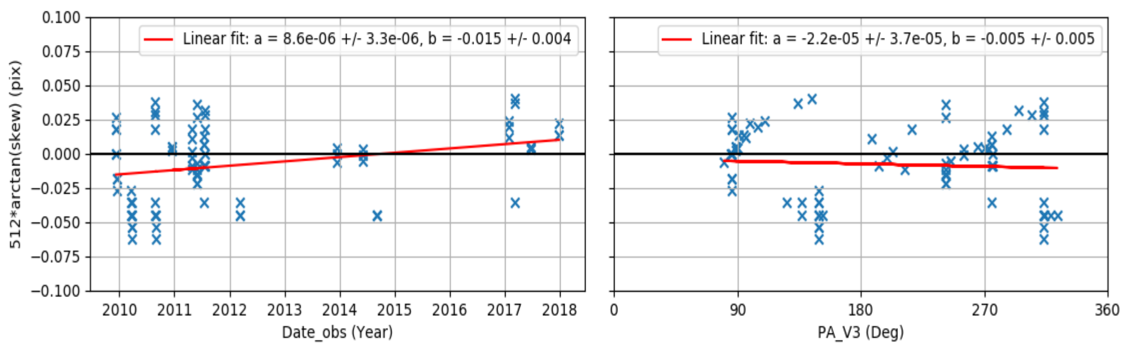

Figure 5: *Plot of the inverse tangent of the calculated skew term scaled by 512 WFC3/IR pixels as a function of time and HST roll-angle. The red line represents the linear fit of data where a and b in the legend represent the slope and y-intercept.*

5. Proper motion effect on X and Y RMS

The internal velocity dispersion of ω Cen in the proper motion is ~0.9 mas/year or 0.007 pix/year in IR pixels, which is possibly correlated with the increase in the X and Y residuals RMS over time. Figure 6 shows the change in the solutions of the RMS in X and Y. Over the 8 years time frame, we expect an increase of ~0.06 IR pixel in the X and Y RMS but only see an increase of ~0.02 for both X and Y RMS. The X and Y positions provided by the TweakReg task is not design for accurate and precise measurement of the centroid in severe under-sampled PSF images as in the case of WFC3/IR, because of that we assume that RMS of solutions is increasing with the velocity dispersion of ω Cen over time.

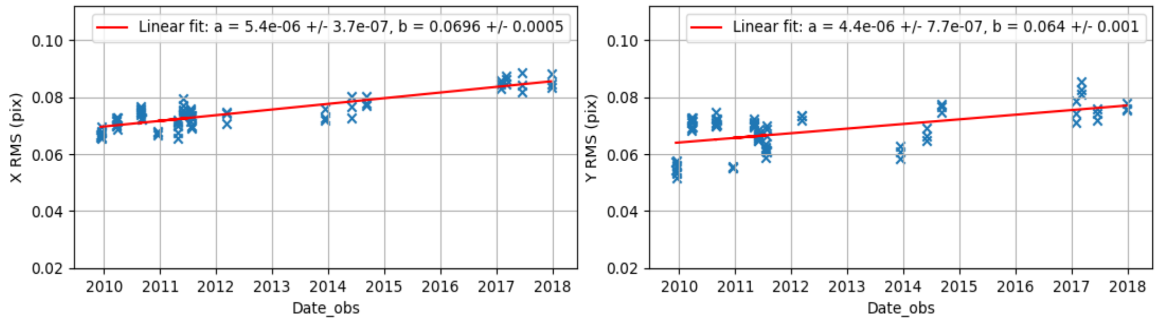

Figure 6: *Plot of the X and Y residuals RMS as a function of time. The units are in WFC3 IR pixels. The red line represents the linear fit of data, where a and b in the legend represent the slope and y-intercept, respectively.*

6. Conclusions

Observations of ω Cen through the F160W WFC3/IR filter have been used to examine the linear parts of the WFC3/IR geometric distortion. We used DrizzlePac/TweakReg to perform a linear transformation between a reference frame, the first observation of ω Cen in CAL-11928, and the input frames, the following observations over an 8-year time span. TweakReg then computed the scale, skew, shift and RMS of the 79 input images.

The calculated X and Y scale term for the input images shows that it is stable over time with a minor gradual decrease of < 1% over 8-years. The plate-scales were calculated from the X and Y scale (See Eq. 5) and show a < 1% decrease over time indicating that the WFC3/IR geometric distortion is stable. If the geometric distortion were changing over time, the scale terms would have sizeable temporal variations. The scale and plate-scale show no clear relation with HST roll-angle.

The skew terms, one of the remaining uncertainties in geometric distortion, shows a large scatter over the 8-year time frame. However, the spread of the effect of skew variations at the far edges of the detector is < 0.1 WFC3/IR pixel and can be considered as stable. From analysis done in 2012, the skew appears to linearly change over the short time interval of the orbital target visibility (Kozhurina-Platais, 2012). The skew variation is possibly related to the focus variation over an HST orbital time scale, known as orbital breathing. The WFC3/IR under-sampled PSFs can also be factors in the change in the skew term since the precision level of the geometric distortion mainly depends on the accuracy of the centering technique of the severely under-sampled IR PSF. The skew terms also show no clear relation with HST roll-angle.

The solution of the RMS in X and Y shows a gradual increase over the 8-year time span. The linear changes in RMS of solutions is possible due to the velocity dispersion in the proper motion of ω Cen, although it is difficult to make a strong interpretation because of inaccurate measurements of severe under-sampled IR PSF.

In conclusion, the WFC3/IR geometric distortion linear terms are stable with insignificant changes of <<1.0 pixel over 8-years and have no clear relation to HST roll-angle. We will continue to monitor the variation of the WFC3/IR geometric distortion over time.

7. Acknowledgments

We thank Warren Hack and Mihai Cara for their in-depth discussion about TweakReg computation. We are thankful to Catherine Martlin and Annalisa Calamida for careful reading of the early version of this report and valuable comments, which significantly improve and clarify the text.

8. References

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Gonzaga, S., Hack, W., Fruchter, A., Mack, J., eds. 2012, The DrizzlePac Handbook (Baltimore:STScI)

9. Appendix

Table 1:

Filename	Date of observation	VAFACTOR	PA_V3(Deg)	POSTARG1(")	POSTARG2(")	Proposal ID
ibcj01u3q_flt.fits	2009-12-10 00:00:00	1.000051172088	85.995468	0.0	-31.0	11928.0
ibcj01u9q_flt.fits	2009-12-10 00:00:00	1.000064144689	86.00219	34.0	-31.0	11928.0
ibcj02dhq_flt.fits	2009-12-12 00:00:00	1.000047711977	86.009308	34.0	0.0	11928.0
ibcj02drq_flt.fits	2009-12-12 00:00:00	1.000070495614	86.016418	34.0	31.0	11928.0
ibcj02dxq_flt.fits	2009-12-12 00:00:00	1.00004828571	86.009689	0.0	31.0	11928.0
ibcj03jxq_flt.fits	2009-12-13 00:00:00	1.000041668373	86.00296	-34.0	31.0	11928.0
ibcj03k7q_flt.fits	2009-12-13 00:00:00	1.000053320067	85.99585	-34.0	0.0	11928.0
ibcj03kdq_flt.fits	2009-12-13 00:00:00	1.000068127007	85.988739	-34.0	-31.0	11928.0
ibcj04jdq_flt.fits	2010-03-21 00:00:00	1.000048300468	149.001205	0.0	0.0	11928.0
ibcj04jnq_flt.fits	2010-03-21 00:00:00	1.000054566746	149.003403	0.0	-31.0	11928.0
ibcj04jtq_flt.fits	2010-03-21 00:00:00	1.000059095297	149.013397	34.0	-31.0	11928.0
ibcj05pfq_flt.fits	2010-03-24 00:00:00	1.000044609036	149.0112	34.0	0.0	11928.0
ibcj05ppq_flt.fits	2010-03-24 00:00:00	1.00005962178	149.009003	34.0	31.0	11928.0
ibcj05pvq_flt.fits	2010-03-24 00:00:00	1.000048984613	148.998993	0.0	31.0	11928.0
ibcj06z9q_flt.fits	2010-03-26 00:00:00	1.000046066694	148.988998	-34.0	31.0	11928.0
ibcj06zjq_flt.fits	2010-03-26 00:00:00	1.000048303994	148.991104	-34.0	0.0	11928.0
ibcj06zpq_flt.fits	2010-03-26 00:00:00	1.000057047817	148.993393	-34.0	-31.0	11928.0
ibcj07e0q_flt.fits	2010-09-03 00:00:00	0.9999303125999	312.998199	0.0	0.0	11928.0
ibcj07efq_flt.fits	2010-09-03 00:00:00	0.9999378601552	312.998596	0.0	-31.0	11928.0
ibcj07elq_flt.fits	2010-09-03 00:00:00	0.9999290517871	312.988312	34.0	-31.0	11928.0
ibcj08j0q_flt.fits	2010-08-25 00:00:00	0.9999150300647	312.987915	34.0	0.0	11928.0
ibcj08jfq_flt.fits	2010-08-25 00:00:00	0.9999246821354	312.987488	34.0	31.0	11928.0
ibcj08jmq_flt.fits	2010-08-25 00:00:00	0.9999324967693	312.997894	0.0	31.0	11928.0
ibcj09k8q_flt.fits	2010-08-25 00:00:00	0.9999153761794	313.008087	-34.0	31.0	11928.0
ibcj09kiq_flt.fits	2010-08-25 00:00:00	0.9999195355871	313.008514	-34.0	0.0	11928.0
ibcj09koq_flt.fits	2010-08-25 00:00:00	0.9999238732611	313.008911	-34.0	-31.0	11928.0
iblq01cjq_flt.fits	2011-05-30 00:00:00	0.9999577276003	241.997604	0.0	0.0	12340.0
iblq01cuq_flt.fits	2011-05-30 00:00:00	0.9999579738243	242.006607	0.0	-31.0	12340.0
iblq01d0q_flt.fits	2011-05-30 00:00:00	0.9999667291193	242.003693	34.0	-31.0	12340.0
iblq02k6q_flt.fits	2011-05-31 00:00:00	0.9999572603946	241.994705	34.0	0.0	12340.0
iblq02kgq_flt.fits	2011-05-31 00:00:00	0.9999567887554	241.985703	34.0	31.0	12340.0
iblq02kmq_flt.fits	2011-05-31 00:00:00	0.9999621569874	241.988602	0.0	31.0	12340.0
iblq03e5q_flt.fits	2011-05-30 00:00:00	0.9999541716323	241.991592	-34.0	31.0	12340.0
iblq03efq_flt.fits	2011-05-30 00:00:00	0.9999618629929	242.000595	-34.0	0.0	12340.0
iblq03elq_flt.fits	2011-05-30 00:00:00	0.9999546015769	242.009598	-34.0	-31.0	12340.0
iblq04pnq_flt.fits	2011-07-19 00:00:00	0.9999099690727	274.994202	60.0	-54.0	12340.0
iblq04pxq_flt.fits	2011-07-19 00:00:00	0.9999089065724	274.972992	60.0	54.0	12340.0
iblqa4q3q_flt.fits	2011-07-19 00:00:00	0.9999106583352	275.00061	-60.0	54.0	12340.0
iblqa4qdq_flt.fits	2011-07-19 00:00:00	0.999929787734	275.021912	-60.0	-54.0	12340.0
iblqa4qnq_flt.fits	2011-07-19 00:00:00	0.9999089712516	274.997406	0.0	0.0	12340.0
ibm502hkq_flt.fits	2010-12-18 00:00:00	1.000066417102	88.624634	0.0	0.0	12353.0
ibm502hrq_flt.fits	2010-12-18 00:00:00	1.000062760265	88.624634	0.0	0.0	12353.0
ibm502hxq_flt.fits	2010-12-18 00:00:00	1.000055054554	88.624634	0.0	0.0	12353.0
ibm509dyq_flt.fits	2011-04-30 00:00:00	1.000022935512	202.998795	0.0	0.0	12353.0
ibm510e0q_flt.fits	2011-04-30 00:00:00	0.9999993722021	211.998505	0.0	0.0	12353.0
ibm511e2q_flt.fits	2011-04-30 00:00:00	0.9999785615072	216.998306	0.0	0.0	12353.0
ibm512e4q_flt.fits	2011-04-30 00:00:00	1.000022851875	198.998993	0.0	0.0	12353.0
ibm513e6q_flt.fits	2011-04-30 00:00:00	1.0000004143	192.999207	0.0	0.0	12353.0
ibm514e8q_flt.fits	2011-04-30 00:00:00	0.999978800174	187.999496	0.0	0.0	12353.0
ibm515etq_flt.fits	2011-07-25 00:00:00	0.9999257097126	275.997406	0.0	0.0	12353.0
ibm515f0q_flt.fits	2011-07-25 00:00:00	0.9999162701361	275.997406	0.0	0.0	12353.0
ibm515f6q_flt.fits	2011-07-25 00:00:00	0.9999150618995	275.997406	0.0	0.0	12353.0
ibm520frq_flt.fits	2011-07-25 00:00:00	0.9999139642059	285.997498	0.0	0.0	12353.0
ibm521ftq_flt.fits	2011-07-25 00:00:00	0.9999199893044	294.997711	0.0	0.0	12353.0
ibm522fvq_flt.fits	2011-07-25 00:00:00	0.9999275113547	303.997894	0.0	0.0	12353.0
ibvj05yzq_flt.fits	2012-03-08 00:00:00	1.00007380031	137.001602	0.0	0.0	12714.0
ibvj06z1q_flt.fits	2012-03-08 00:00:00	1.000071065528	137.001602	0.0	0.0	12714.0
ibvj07z3q_flt.fits	2012-03-08 00:00:00	1.000056465633	152.001099	0.0	0.0	12714.0

ich804fzq_flt.fits	2013-12-14 00:00:00	1.000070708328	85.202637	0.0	0.0	13570.0
ich805g1q_flt.fits	2013-12-14 00:00:00	1.000060418438	90.002632	0.0	0.0	13570.0
ich806g3q_flt.fits	2013-12-14 00:00:00	1.000044525981	80.234871	0.0	0.0	13570.0
ich810jnq_flt.fits	2014-06-03 00:00:00	0.9999592722079	254.997406	0.0	0.0	13570.0
ich811jpq_flt.fits	2014-06-03 00:00:00	0.999949988844	272.997406	0.0	0.0	13570.0
ich812jlq_flt.fits	2014-06-03 00:00:00	0.9999643437763	245.497498	0.0	0.0	13570.0
ich816luq_flt.fits	2014-09-06 00:00:00	0.9999541542462	318.312897	0.0	0.0	13570.0
ich817lwq_flt.fits	2014-09-06 00:00:00	0.9999352233508	323.06311	0.0	0.0	13570.0
ich818lyq_flt.fits	2014-09-06 00:00:00	0.9999143321195	313.562714	0.0	0.0	13570.0
idcm04d1q_flt.fits	2017-01-30 00:00:00	1.000100229125	110.102402	0.0	0.0	14550.0
idcm05d3q_flt.fits	2017-01-30 00:00:00	1.000082887353	105.002502	0.0	0.0	14550.0
idcm06d5q_flt.fits	2017-01-30 00:00:00	1.000064522932	96.102592	0.0	0.0	14550.0
idcm10a8q_flt.fits	2017-03-06 00:00:00	1.000089855318	126.101997	0.0	0.0	14550.0
idcm11aeq_flt.fits	2017-03-06 00:00:00	1.00006873759	134.101807	0.0	0.0	14550.0
idcm12b0q_flt.fits	2017-03-06 00:00:00	1.000045099157	144.079407	0.0	0.0	14550.0
idcm16cpq_flt.fits	2017-06-19 00:00:00	0.9999613182002	255.097397	0.0	0.0	14550.0
idcm17crq_flt.fits	2017-06-19 00:00:00	0.9999386367755	264.997406	0.0	0.0	14550.0
idcm18ctq_flt.fits	2017-06-19 00:00:00	0.9999193221546	270.097412	0.0	0.0	14550.0
ido704f8q_flt.fits	2017-12-25 00:00:00	1.000083207819	91.002617	0.0	0.0	15000.0
ido705faq_flt.fits	2017-12-25 00:00:00	1.000069661047	95.002602	0.0	0.0	15000.0
ido706fcq_flt.fits	2017-12-25 00:00:00	1.000052558348	99.002563	0.0	0.0	15000.0