2002 HST Calibration Workshop
Space Telescope Science Institute, 2002
S. Arribas, A. Koekemoer, and B. Whitmore, eds.

The Accuracy of WFPC2 Photometric Zeropoints

Inge Heyer, Marin Richardson, Brad Whitmore, Lori Lubin

Space Telescope Science Institute, Baltimore, MD 21218

Abstract. The accuracy of WFPC2 photometric zeropoints is examined using two methods. The first approach compares the zeropoints from five sources: Holtzman (1995), the *HST Data Handbook* (1995 and 2002 versions), and Dolphin (both 2000 and 2002 versions). We find the mean scatter between the different studies to be: 0.043 mag for F336W, 0.034 mag for F439W, 0.016 mag for F555W, and 0.018 mag for F814W.

The second approach is a comparison of WFPC2 observations of NGC2419 with ground-based photometry from Stetson (from his website) and Saha et al. (private communication). The tentative agreement between these comparisons is similar to the historical zeropoint comparisons. Hence we conclude that the true uncertainty of WFPC2 zeropoints is currently about 0.02–0.03 magnitudes. Since Poisson statistics would predict that 1% absolute accuracy should be attainable, we conclude that there are still systematic error sources which have not yet been identified.

1. Goals and Approach

The ultimate goal of this project is to determine if 1% absolute photometry is possible using WFPC2. In principle this should be attainable, as evidenced by the fact that the short-term rms in our photometric monitoring observations for the primary broadband filters are $< 1\%$. The challenge is to: 1) understand the various systematic errors well enough (e.g., CTE loss, variable focus, geometric distortion, etc.) and 2) match the zeropoints to existing standards with enough precision to make this possible. In this poster we address the second issue by examining the accuracy of WFPC2 photometric zeropoints using two methods.

The first approach compares the zeropoints from five sources: Holtzman (1995), *HST Data Handbook* (1995), *HST Data Handbook* (2002), Dolphin (2000), and Dolphin (2002). See Whitmore (2003) for a discussion and a figure. These five studies use largely independent methods to determine zeropoints (e.g., the *Data Handbook* uses a single photometric monitoring star and SYNPHOT while Dolphin uses ground-based photometry of Omega Cen and NGC 2419). Hence the resulting scatter provides an empirical estimate of the true uncertainty.

The second approach is a comparison of WFPC2 observations of NGC 2419 with ground-based photometry from Stetson (2002; from his website) and Saha et al. (2002; private communication). The resulting scatter between these two determinations, along with the historical scatter outlined above, provides our best estimate of the true uncertainty in the WFPC2 zeropoints. A weighted combination of all determinations will eventually be used to determine new WFPC2 zeropoints for the F336W, F439W, F555W, F675W, and F814W filters. At present, we have results for F555W and F814W.

Caveat: The current results should be considered **tentative**, pending some additional checks. Please refer to the *Instrument Science Report* (when completed) and the WFPC2 WWW site for the final values.

Table 1. Averaged Means and Mean Residuals of the Zeropoint Deltas

Filter	Chip	Sample Size[a]	Stetson's Averaged Mean	Stetson's Mean Residual	Sample Size[a]	Saha's Averaged Mean	Saha's Mean Residual
F555W	PC1	22	−0.0087	0.0303	10	−0.0229	0.0412
	WF2	29	0.0106	0.0412	13	0.0010	0.0293
	WF3	32	−0.0083	0.0403	13	−0.0025	0.0321
	WF4	16	−0.0048	0.0270	12	−0.0264	0.0531
F814W	PC1	46	−0.0197	0.0346	8	−0.0708	0.0394
	WF2	64	−0.0255	0.0374	16	−0.0573	0.0304
	WF3	68	−0.0310	0.0306	14	−0.0654	0.0269
	WF4	48	−0.0143	0.0313	11	−0.0746	0.0414

[a] 'Sample' refers to different datasets observed between 1995 and 2002. Each sample typically consists of 5–20 stars.

2. Data Reduction

The images were first multiplied by a geometric distortion correction image, since we are doing point-source rather than surface photometry. Aperture photometry was performed on each dataset using a $0.5''$ radius, and the values were corrected to infinity by subtracting 0.1 magnitudes (Holtzman 1995). Very bright stars and very faint stars were trimmed from the sample, due to suspected saturation and excessive noise, respectively. Searches were then performed to identify stars that matched stars from Stetson's (2002; WWW site) data files. The Dolphin (2002) CTE correction and the Holtzman color transformations were applied. The sample was further trimmed by applying graduated isolation criteria with a limit approximating a 4-magnitude difference at $5''$ distance. Finally, plots were produced for each dataset showing the magnitude and $V - I$ versus the delta between the observed magnitude (using the *Data Handbook* 2002 zeropoint) and the comparison study.

3. Results

We present the results of our examination for the target NGC 2419 in the filters F555W and F814W. Table 1 shows the averaged means and mean residuals of the deltas of the zeropoints for each filter and chip.

Figures 1–4 show the mean as a function of exposure time and observation date (in MJD) for F555W and F814W. The circles show the results from the comparison with Stetson's stars, and the triangles show the results from the comparison with Saha's stars.

4. Conclusions

1. The true uncertainty in the current WFPC2 zeropoints, as judged by either the historical zeropoints (see Figure 3 in Whitmore 2003) or comparisons of *HST* observations of NGC 2419 with ground-based photometry is about 0.02 mag for F555W and F814W, and about 0.03–0.04 mag for F439W and F336W. The F814W comparison with Saha (2002) appears to be slightly worse.

2. The short-term rms scatter would predict that an accuracy of 1% should be attainable. The fact that the true uncertainty is currently about 0.02–0.03 magnitudes indicates that there are as yet unidentified error sources.

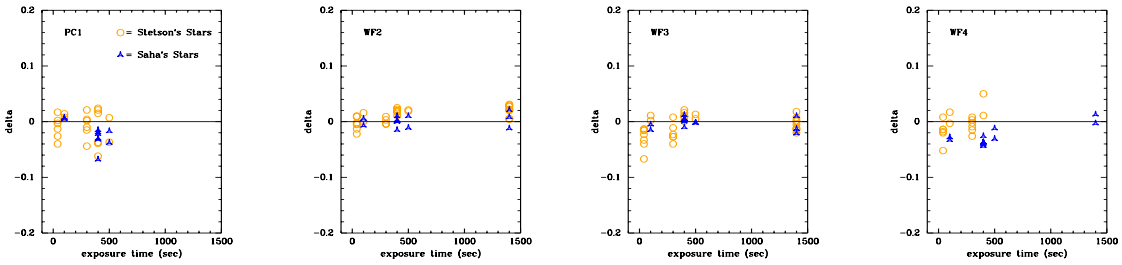

Figure 1. Delta vs. Exposure Time for F555W.

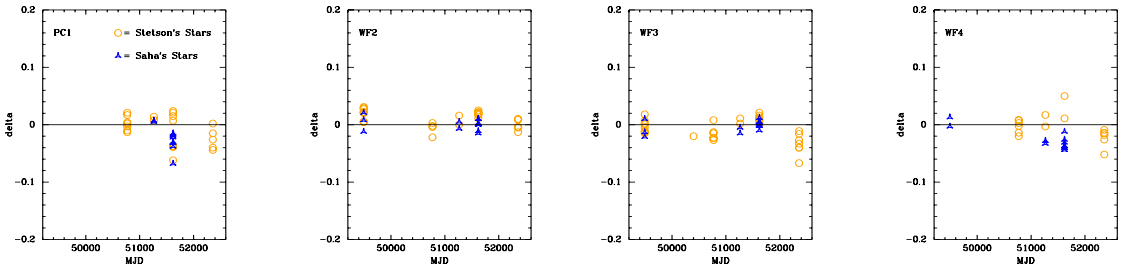

Figure 2. Delta vs. Observation Date for F555W.

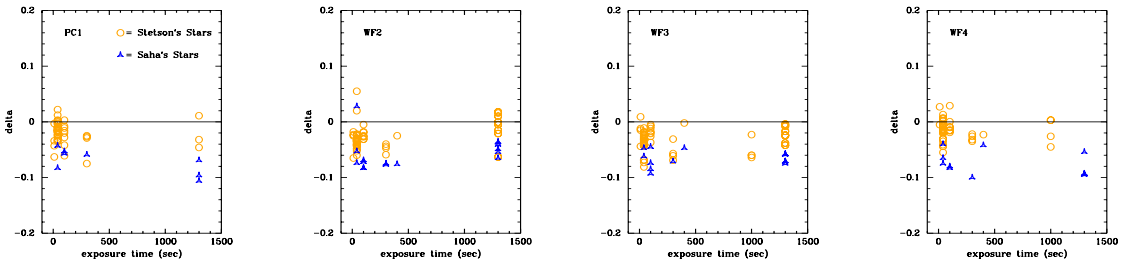

Figure 3. Delta vs. Exposure Time for F814W.

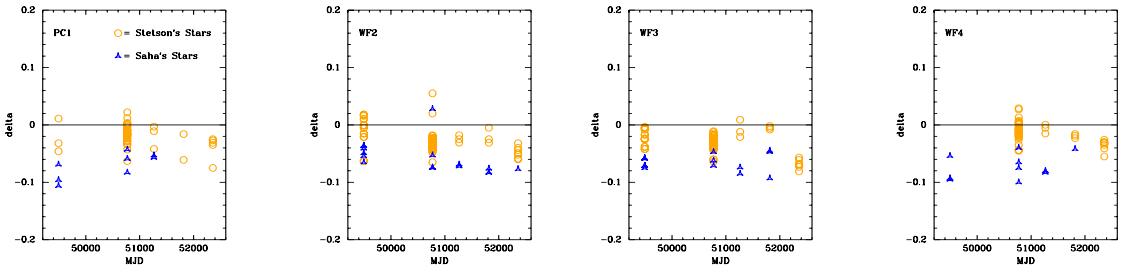

Figure 4. Delta vs. Observation Date for F814W.

3. While there appear to be some possible trends in the zeropoint deltas versus exposure time and time of observation, the lack of agreement in these trends for the different filters suggests that the underlying source of the error is still unknown.

4. Results of the various methods used here will be averaged together to produce new values for the zeropoints. These will be included in a WFPC2 Instrument Science Report and on the WFPC2 WWW site at a future date.

References

Baggett, S. ed., *HST Data Handbook (WFPC2)*, Version 4.0, October 2002 (Baltimore: STScI)

Dolphin, A. E. 2000, PASP, 112, 1397

Dolphin, A. E. 2002, http://www.noao.edu/staff/dolphin/wfpc2_calib/

Holtzman, J., et al. 1995, PASP, 107, 1065

Leitherer, C. ed.,*HST Data Handbook*, Version 2.0, December 1995 (Baltimore: STScI)

Saha, A. 2002, (private communication)

Stetson, P. 2002, http://cadcwww.dao.nrc.ca/cadcbin/wdb/astrocat/stetson/query/

Whitmore, B. 2003, this volume, **??**