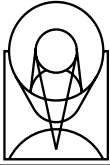


Cycle 15+16 WFPC2 Calibration Plan

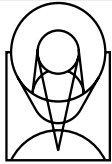
Overall Goals:

- Monitor & maintain WFPC2 health & safety.
- Maintain calibration accuracies for science modes currently used.
- Closeout calibrations to increase the value of the WFPC2 scientific legacy.



Notes / Issues:

- Since SM4 date uncertain, we plan for 24 months of monitor observations -- allows 6+ months contingency before new proposals would be needed.
- May be difficult to calibrate any unusual modes proposed by GOs in Cycle 16 -- not enough time for new calibration phase II, target visibility issues, etc.
- Special APT version is needed for observations after Dec. 2007 -- we have already lost 1 week troubleshooting APT problems.
- Will run close on 10/13 phase II deadline for routine proposals (APT issues, short-staffed).



Recent History of WFPC2 Usage

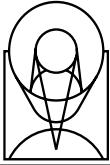
- Cycles 12 - 15: prime science orbits relatively low.
- Parallel observing is dominant mode.

WFPC2 Science Program Usage	Cycle 12	Cycle 13	Cycle 14	Cycle 15
Primary Orbits	56	21	50	50
Coordinated Parallel Orbits	381	890	752	1023
Pure Parallel Orbits	844			

WFPC2 Calibration Program Usage	Cycle 12		Cycle 13		Cycle 14		Cycle 15+16	
	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.
Monitors: decons, darks, internals, flats, photometry, CTE	12	1677	13	582	11	552	19	1104
Special / Close-Out Calibrations	13	4	2		6		68	276
Reserve (Unexpected Items)	2		2		2		2	
Total	25	1681	17	582	19	552	89	1380

WFPC2 Cycle 15+16 Routine Calibration Summary

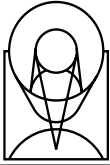
ID	Proposal Title (PI)	Frequency	Estimated Time (orbits)		Scheduling Required	Analysis Resources (FTE yrs)	Products	Accuracy Required	Notes
			“External”	“Internal”					
11022	WFPC2 Decons & Associated Observations (Biretta)	Decons every 45d - 60d	12	188	every 45d - 60d	0.1	CDBS, Inst Hbk, Synphot, WWW reports	1-2%	Decons, photometric monitor, internals, UV throughput, VISFLATS and UVFLATS.
11023, 11070	Standard Darks (Part 1 & Part 2) (Biretta)	weekly, except decon week		528	once every 7 days, except decon wk.	0.2	CDBS	1 e-/hr	CDBS updates and weekly WWW hot pixel lists.
11024	Internal Monitor (Biretta)	weekly, except decon week		88	once every 7 days, except decon week	0.1	CDBS	0.8e-/pix	BIAS, INTFLATS in F555W for gain and throughput stability measurements
11027	Visible Earth Flats (Gonzaga)	continuous		100	mid-to-late	0.3	CDBS	0.3%	F502N only (time dependence only)
11028	UV Earth Flats (Gonzaga)	continuous		40	mid-to-late	0.1	CDBS	0.3%	F255W only
11029	INTFLAT & VISFLAT Sweeps, Filter Rotation Monitor (Gonzaga)	1/year		160	mid-cycle	0.2	TIR	0.3%	Flats in all the filters, both gain settings & both shutters.
11025	CTE Monitor (Biretta)	1/year	4		mid-to-late	0.2	ISR	0.03 mag	Continue CTE monitor
11026	Photometric Monitor (Biretta)	1/cycle	3		mid-cycle	0.2	ISR, Synphot	1%	GRW+70d5824 in filter/chip combinations used for science in Cycle 15
	~10% reserve		2						Placeholder for unexpected items.
TOTAL TIME (including all executions)			21	1104		1.4			



Cycle 15+16 WFPC2 Routine Programs

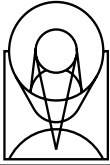
WFPC2 Cycle 15+16 Decontaminations (ID=11022; PI=Biretta)

- Decontaminations every 45 - 60 days (synchronized with target).
- Monitor F170W in all 4 chips each decon when target available.
- Additional UV & blue filters cycling among the different chips to fill orbit.
- Cost: 12 external orbits, 188 internal orbits.



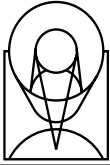
WFPC2 Cycle 15+16 Standard Darks (ID=11023&11070; PI=Biretta)

- Six 1800s exposures / week (5 with clocks off, 1 with clocks on).
- Used for weekly CDBS darks (hot pixels, superdark).
- Not scheduled during Decon weeks (those are in Decon proposal).
- Need is driven by ~week timescale for hot pixel growth.
- Cost: 528 internal exposures.



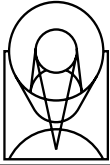
WFPC2 Cycle 15+16 Internal Monitor (ID=11024; PI=Biretta)

- Monitor the health of the camera electronics (bias level, gain stability, flat).
- Scheduled once / week, except for Decon weeks (are in Decon proposal).
- Each week: 4 BIAS frames, 2 INTFLATs at Gain=7 and Gain=15.
- Provides data for bi-annual superbias in CDBS.
- Cost: 88 internal orbits.



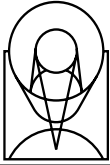
WFPC2 Cycle 15+16 Visible Earth Flats (ID=11027; PI=Gonzaga)

- Time-dependent changes are predominantly monochromatic (Koekemoer et al. 2001).
- Monitor only single visible filter, F502N.
- Combine and used to update filter flats in CDBS.
- Cost: 100 internal orbits.



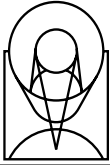
WFPC2 Cycle 15+16 UV Earth Flats (ID=11028; PI=Gonzaga)

- Monitor potential UV throughput changes across the field caused by contaminants.
- Monitor single UV filter, F255W.
- Cost: 40 internal orbits.



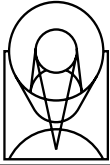
WFPC2 Cycle 15 INTFLAT & VISFLAT Sweeps (ID=11029; PI=Gonzaga)

- Monitor WFPC2 pixel-to-pixel flat field response: INTFLAT and VISFLAT exposures in F555W.
- Monitor WFPC2 linearity using F555W INTFLAT exposures at variety of exposure times, using both gains and both shutters A & B.
- Obtain INTFLAT exposures through entire standard filter set (31 filters).
- Check repeatability of filter wheel positioning (past issue): VISFLAT and EARTHFLAT exposures in 4 linear ramp filters (by themselves for VISFLATS; crossed with narrow-band filters for the Earthflats).
- *Execute INTFLATs only during ACS anneals to avoid scattered light.*
- Total cost: 160 internal orbits (includes earthflat occultations).



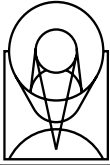
WFPC2 Cycle 15+16 CTE Monitor (ID=11025; PI=Biretta)

- Monitor CTE degradation; better characterize long-vs-short anomaly.
- Standard monitor, execute once per year.
- Omega Cen in F814W and F555W, in WF2 & WF4, gain 7 and some gain 15.
- Include high S/N Long vs. Short test for uncrowded field.
- Total cost: 4 external orbits.



WFPC2 Cycle 15+16 Photometric Monitor (ID=11026; PI=Biretta)

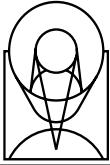
- Observe the WFPC2 standard star GRW+70d5824 in a range of filter/chip combinations that are used by GOs in Cycle 15.
- Include additional filter/chip combinations from standard photometric set that are not explicitly requested by GOs.
- Verify photometric stability to 1-2%, and update the photometric zeropoints in SYNPHOT, if necessary.
- Cost: 3 external orbits.



WFPC2 Closeout Calibrations

Overall Goals:

- Enhance value of WFPC2 archival legacy.
- Provide final data on long-term changes in calibration.
- Provide additional data in areas with known calibration deficiencies.
- Attempt new types of calibration.
- Provide continuity between WFPC2 and current / future HST instruments.
- Support post-mission ground calibrations of the instrument.



WFPC2 Closeout Calibrations (cont.)

Cost of program:

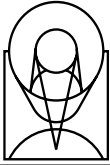
- 68 external orbits (0.3% of total WFPC2 science orbits).
- 276 internal orbits.

Notes / Issues:

- Phase II proposal schedule: external programs ready ~ January 2007; internal programs ready ~ March 2007.
- Unclear whether resources exist to analyze closeout data -- take data anyway, since unique opportunity goes away at SM4.
- Currently no contingency orbits in closeout program; add 10% = 7 orbits?

WFPC2 Closeout Calibration Summary

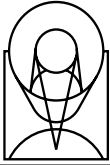
ID	Proposal Title	Frequency	Estimated Time (orbits)		Scheduling Required	Analysis Resources (FTE yrs)	Products	Accuracy Required	Notes
			“External”	“Internal”					
11030	WF4 Anomaly	as needed	2	54	as needed	0.7	CDBS, IHB, WWW reports	1-2%	Two additional WFPC2 temperature adjustments to keep WF4 CCD functioning, if needed.
11031	CTE & Background Dependence	once	16		mid-to-late	0.2	ISR, IHB	0.03 mag	Evaluate CTE corrections near mission end.
11032	CTE Extended Targets	once	8		mid-to-late	0.13	ISR, IHB	0.03 mag	Evaluate extended target CTE near mission end.
11033	Full Moon Earth Flats	continuous		200	mid-to-late	0.3	CDBS, ISR	0.3%	Test / improve broadband flats.
11034	Photometric Closeout	once	4		mid-to-late	0.13	CDBS, ISR	1%	Filters not calibrated recently.
11035	Photometric Zero Points	once	8		mid-to-late	0.3	CDBS, ISR	1%	Final cross-calibration vs. ACS
11036	Red Leaks	once	6		mid-to-late	0.2	CDBS, ISR, Synphot	1%	Improve calibration.
11037	Red Filters	once	4		mid-to-late	0.13	CDBS, ISR, Synphot	1%	Cross-calibrate WF3 CCD vs ACS.
11038	Narrow-Band and Ramp Filters	once	10	20	mid-to-late	0.2	CDBS, ISR, Synphot	1%	Check for long-term changes in bandpasses.
11039	Polarizers	once	2	2	mid-to-late	0.2	CDBS, ISR, Synphot	3%	Check for changes in polarizer performance.
11040	Geometric Distortion	once	8		mid-to-late	0.3	CDBS, ISR	0.05"	Better astrometry in red and blue; skew terms.
TOTAL TIME (including all executions)			68	276		2.8			



WFPC2 Closeout Programs

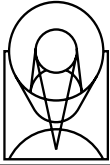
WFPC2 Closeout: WF4 Anomaly (ID=11030; PI=Biretta)

- Keep WF4 alive so can be used for closeout and GO observations.
- Perform possibly two additional temperature adjustments.
- Internal flats & biases to check bias level and photometry post-adjustment.
- K-spots to check camera optical alignment at new temperature.
- Omega Cen to check PSF.
- Essentially a copy of program 10779.
- Cost: 2 external orbits, 54 internal orbits.



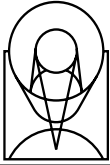
WFPC2 Closeout: CTE and Background Dependence (ID=11031; PI=Biretta)

- CTE monitor during recent Cycles depended on measuring small differences in photometry between WF2 and WF4, but WF4 has been sick since ~2002.
- Instead directly measure CTE on each CCD.
- Images of star cluster at two ORIENTS 180 degrees apart.
- CTE depends critically on background illumination, but this dependence not measured since Cycle 10.
- Make new measurements of background dependence.
- Omega Cen images in various filters and various levels of preflash.
- Repeats portions of programs 7603, 8447, 8821, & 9254.
- Cost: 16 external orbits.



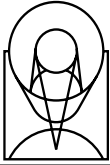
WFPC2 Closeout: CTE for Extended Target (ID=11032; PI=Biretta)

- Measure extended target CTE near mission end when effect is largest.
- Image galaxy in each CCD with two ORIENTS 180 degrees apart.
- Effectively repeats portions of program 8456.
- Cost: 8 external orbits



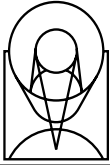
WFPC2 Closeout: Full Moon Earth Flats (ID=11033; PI=Biretta)

- Current broad band filter flats are combination of ground Thermal Vacuum flats and on-orbit narrow band Earth flats.
- This method leaves some concern about ground test illumination vs. HST on-orbit illumination, and concern that narrow band filter flats are not completely applicable to broad band filters.
- Better option would be to directly take broad band filter flats on-orbit.
- Issue is finding suitable uniform target on-orbit with correct brightness.
- Earth when illuminated by full moon provides correct brightness.
- Propose F600W and F814W Earth flats taken near time of full moon (300s exposure produces about 1800DN at gain 7 in F606W).
- Attempt few-orbit pilot observation early in Cycle 15.
- Cost: 200 internal orbits. Requires extra work by schedulers.



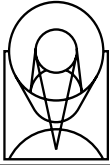
WFPC2 Closeout: Photometric Calibration (ID=11034; PI=Biretta)

- Observe WFPC2 standard star GRW+70d5824 in all filter / CCD combinations not recently calibrated in monitor program.
- Measures all filters for long-term changes in throughput.
- Provides useful comparison data for post-mission ground calibration of filters.
- Cost: 4 external orbits



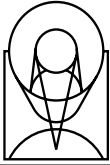
WFPC2 Closeout: Photometric Zero Points (ID=11035; PI=Biretta)

- Observe the 47 Tuc and NGC 2419 to obtain final calibration of zero points in primary broad band filters.
- Also provides final cross-calibration between WFPC2 and ACS.
- Will improve zero points of blue filters, where errors of 3% to 4% are seen.
- Repeats portions of proposal 9061.
- Cost: 8 external orbits.



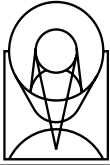
WFPC2 Closeout: Red-Leaks (ID=11036; PI=Biretta)

- UV filters including and blueward of F336W have significant red-leaks, but these have not been well-characterized.
- Time and spatial variations may also exist.
- Observe spectrophotometric standard stars in several CCDs and position off-sets.
- Similar to proposal 8814 but with multiple CCDs and field positions.
- Cost: 6 external orbits.



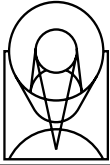
WFPC2 Closeout: Red Filters (ID=11037; PI=Biretta)

- Observe three red standard stars in far-red broad band filters (F785LP, F791W, F814W, F850LP, F1042M, etc.).
- Provides cross-calibration to ACS and WFC3.
- Verify SYNPHOT filter / detector curves.
- Similar observations were made in CCD PC1 in programs 10078 and 10366; here we repeat some of these in CCD WF3.
- Cost: 4 external orbits.



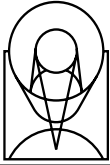
WFPC2 Closeout: Narrow Band and Ramp Filters (ID=11038; PI=Biretta)

- The central wavelengths and bandpasses of these filters are especially sensitive to long-term changes (e.g. desorption of the thin film layers).
- Internal flats of crossed pairs of narrow band and ramp filters to assess any relative changes in their properties.
- Observe standard stars and emission line nebulae (e.g. Orion) to assess changes in absolute calibration.
- Include emission line targets with accurate STIS spectrophotometry.
- Essentially repeats portions of proposals 8054, 8485, 8820, and 10080 near the mission end.
- Cost: 10 external orbits, 20 internal orbits.



WFPC2 Closeout: Polarization (ID=11039; PI=Biretta)

- Test for long-term changes in the polarizer filters.
- Observe unpolarized and polarized standard stars in each CCD and each POLQ filter quad.
- VISFLATS taken in several filters crossed with the POLQ to check for changes in the polarizer flats.
- Essentially repeats small portions of proposal 8453.
- Cost: 2 external orbits, 2 internal orbits.



WFPC2 Closeout: Geometric Distortion (ID=11040; PI=Biretta)

- Geometric properties of the camera may under go both slow evolution (e.g. desorption of the camera structures) and changes due to temperature adjustments made late in the mission (i.e. WF4 anomaly repair).
- Skew terms of the geometric solutions have never been well calibrated, since past observations were usually made at a single ORIENT.
- Observe standard Omega Cen astrometric field in F300W, F555W, and F814W at two roll angles 45 degrees apart for both large (between CCD) and small (fractional pixel) dithers.
- Effectively repeats proposal 6941 near mission end with two different roll angles.
- Cost: 8 external orbits.

Cycle 14 Calibration Status / Completion

ID	Proposal Title (PI)	Frequency	Estimated Time (orbits)		Completed	Notes
			“External”	“Internal”		
10744	WFPC2 Decons & Associated Observations (Biretta)	Decons every ~60d	6	94	71%	Decons, photometric monitor, internals, UV throughput, VISFLATS, UVFLATS. Runs through 23 Dec 2006. Throughput plots on WWW.
10745	Standard Darks (Kozhurina-Platais)	weekly, except decon week		264	75%	Runs through 31 Dec 2006. Weekly darks delivered to CDDBS.
10745	Internal Monitor (Biretta)	weekly, except decon week		44	70%	BIAS, F555W INTFLATS. Runs through 31 Dec 2006.
10749	Visible Earth Flats (Gonzaga)	continuous		50	100%	
10750	UV Earth Flats (Gonzaga)	continuous		20	100%	
10751	INTFLAT & VISFLAT Sweeps, Filter Rotation Monitor (Gonzaga)	1/cycle		80	100%	
10746	CTE Monitor (Biretta)	1/cycle	2+2		100%	
10747	Photometric Monitor & Closeout (Biretta)	1/cycle	3+4		100%	GRW+70d5824 in various filter/chip combinations.
10772	WF4 Anomaly Characterization (Biretta)	1/month	5	20	100%	GRW+70d5824 and VISFLATS in WF4.