

# Summary of WFPC2 SM97 Plans

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## ABSTRACT

*We summarize WFPC2 activities and calibrations planned for the second Service Mission in early 1997.*

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## 1. Introduction

The second HST Service Mission is planned for early 1997 (SM97). During this mission STIS, NICMOS, a new FGS, and a Solid State Recorder will be installed. While no astronaut activities are planned for WFPC2, it is still of the utmost importance to ensure that neither astronaut activities, nor contaminations from new instruments, damage or otherwise alter the performance of WFPC2. Hence an aggressive plan of WFPC2 contamination control and calibration is anticipated during the Service Mission and in the Orbital Verification that will follow (SMOV). Herein we outline the goals of the WFPC2 SMOV activities, describe specific proposals which implement these activities and the data analyses which are anticipated.

In an effort to minimize photo-polymerization of contaminants, the HST will be held in a Bright Earth Avoidance (BEA) orientation during the first 10 days after HST release, with the intention of preventing bright UV light from reaching the HST focal plane area. This orientation places severe restrictions on the targets available, and hence we include extensive discussion of BEA targets.

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1. Copies of this report may be obtained from the Science Support Division, Space Telescope Science Institute, 3700 San Martin Drive, Baltimore MD 21218, by e-mail to [help@stsci.edu](mailto:help@stsci.edu), by anonymous FTP to [stsci.edu](ftp://stsci.edu) directory [instrument\\_news/WFPC2](ftp://stsci.edu/instrument_news/WFPC2), and by WWW at <http://www.stsci.edu/instruments.html>

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## 2. Goals of the WFPC2 SM97 Plan

The main goals of the SM97 plan are firstly, protecting the health and safety of WFPC2 immediately after the service mission, and secondly, evaluating and calibrating any significant changes in the instrument performance.

### 2.1 Instrument Health and Safety

The first area of health and safety concern, is contamination of the WFPC2 pick-off mirror (POM). The POM is fully exposed to the focal plane / hub area of HST, and no direct mechanical protection is possible. The WF/PC-1 experience further heightens concerns in this area; upon return to Earth, the WF/PC-1 POM was found to be severely contaminated and completely opaque to Lyman  $\alpha$  light.

The primary source of damage to the POM is photo-polymerization of molecular contaminants deposited on the mirror surface. Hence, the strategy to protect the POM is to reduce both sources of molecular contamination and the exposure of the POM to UV light during and immediately after the service mission. Both STIS and NICMOS have been constructed to minimize outgassing of molecular contamination. They are thought to be cleaner than both WFPC2 and COSTAR. In addition, the FGS replacement is thought to be cleaner than COSTAR. Hence the supply of molecular contaminants during SM97 should be lower than during the first service mission. Sources of UV light will be minimized by requiring that the OTA axis remain 2 degrees or more from the bright Earth during the service mission, and for approximately 10 days after HST release (bright Earth avoidance or BEA). This 2 degree avoidance angle is sufficient to ensure that Earth light does not strike the WFPC2 POM.

In an effort to evaluate such contamination, the Lyman  $\alpha$  throughput will be measured at several times in the weeks immediately following HST release (see “Lyman  $\alpha$  Throughput Check” proposal number 7018 in Section 3). This wavelength was chosen, since evidence of contamination would first appear in the far-UV. If contamination is detected, the duration of BEA could be extended to provide further protection, though this might have a significant impact on the SMOV plans of all instruments.

The second area of health and safety concern is contamination of the cold (-88 °C) CCD windows (or field-flatteners). Some contamination of these optics is always present during normal operation of WFPC2. Typically, contaminants build-up slowly on the CCD windows at a rate corresponding to a 30% per month decline in the F170W throughput. Approximately once per month the contaminants are removed by a “decontamination procedure where the CCD windows are warmed to +20 °C for 6 hours. The primary concern here is to avoid deposition of contaminants which would not be removed by this standard decontamination procedure. It is felt that this can be done by avoiding contamination growth rates which exceed the normal experience (30% per month decline in the F170W throughput).

Several actions are planned to minimize contamination of the cold optics:

(1) WFPC2 will be placed in a “protect safe mode” during and immediately after servic-

ing. In this mode the shutter is closed, and a seldom used F785LP filter is placed in the beam, to minimize the influx of contaminants from the HST hub area. In addition, the thermo-electric coolers (TECs) are turned off.

(2) The shutter-open time will be minimized during the first month after HST release by prohibiting WFPC2 parallel observations. In addition, a modified decontamination (PROTECT DECON) will be used where in the shutter is closed and F785LP is placed in the beam, again to minimize the influx of contaminants during the typical 6 hour procedure. (The “standard” decontamination [STANDARD DECON] encourages contaminants to leave WFPC2 by placing the shutter open and clearing the filter wheel.)

(3) The initial cool-down of WFPC2 after HST release will be accomplished in two steps, with an initial ~48 hour period at an intermediate temperature of -43 °C, followed by cooling to the normal operating temperature of -88 °C. Most importantly, the F170W throughput will be monitored frequently after cool-down, to ensure the build-up rate does not exceed the nominal 30% per month decline in the F170W throughput (see “UV Monitor / Cool-down” proposal number 7016 in Section 3).

Finally, the basic health and safety of the instrument is monitored by obtaining standard sets of bias frames, dark frames, internal flats, and K-spot images during orbital verification (see “Internal Monitor” proposal number 7022 in Section 3). These are similar to the internal monitors executed throughout each Cycle. The goal here is primarily to look for unexpected changes in the instrument which result from the service mission.

Further discussion of health / safety issues can be found in various meeting minutes produced by the Contamination Working Group during late 1995.

## **2.2 Calibration Verification**

The second major objective is to identify, and correct for, any major changes which occur in WFPC2 calibration as a result of the Service Mission. To this end, there are proposals which test the status of the WFPC2 focus and PSF, the photometric calibration, and the flat field calibration (see appropriate proposals in Section 3).

The goal of SMOV calibration is not necessarily to return to the same calibration accuracy which was present before SMOV, but rather to calibrate out major changes so that most science can proceed. The scope of SMOV is limited, due largely to a desire for an early return to normal science operations. Hence, it may not be possible to generate corrections for all possible changes based solely on the SMOV data. For example, a change in the “super darks” might require fifty or more dark frames to fully correct, but the SMOV calibrations include only 25 darks. In the event of a major change in dark calibration, these 25 SMOV darks would provide sufficient calibration for most science images until a better calibration could be derived from Cycle 6/7 calibration data.

## **2.3 Formal Requirements**

Formal requirements for WFPC2 SMOV activities are set forth in Appendix F “Mission

Operations Functional Requirements ...” of the SMO-1000 document, Revision C, August 25, 1995 (sometimes referred to as the “Level III Requirements”). These establish a minimum requirement, as follows:

#### F.2.5.1 WFPC2 Requirements:

The following two assumptions apply at to WFPC2 at the point of HST release: (1) WFPC2 in PROTECT-SAFE mode; and (2) The WFPC2 shutter is closed with the F785LP filter in place.

##### F.2.5.1.1 Engineering Activation and Check-out Requirements:

F.2.5.1.1.1 After release, the instrument shall undergo an active decontamination procedure of 24 (TBD) hours. In the interval between release and the start of the decontamination procedure, the shutter shall remain closed and the TECs shall remain off.

F.2.5.1.1.2 If an FGS is replaced during the servicing mission, a TBD contamination management plan shall be carried out.

F.2.5.1.1.3 Upon completion of the decontamination procedure and upon approval of STScI, the instrument shall be cooled to its nominal operating temperature and the AFMs shall be reset.

F.2.5.1.1.4 Following TEC turn-on, a standard UV stellar monitor shall be scheduled at least twice during the first week and, starting with the second week, at a declining frequency for the duration of SMOV as part of the WFPC2 Cycle 6/7 calibration program. (STScI will use the UV monitor to determine whether the instrument remains at its operating temperature or undergoes further decontamination.)

F.2.5.1.1.5 A short-wavelength (approximately Lyman  $\alpha$ ) stellar observation shall be performed.

##### F.2.5.1.2 Science Verification Requirements

F.2.5.1.2.1 The baseline instrumental performance and optical alignment of WFPC2 shall be measured from a initial set of PSF measurements, photometric calibrations and internal calibrations (dark frames, bias frames, K-spot images, and internal flat fields). Subsequent to this initial set of measurement, all WFPC2 calibrations will be performed as part of the Cycle 6/7 WFPC2 calibration program.

### **3. Calibration Proposals**

The WFPC2 SMOV activities and calibrations are carried out by eight proposals summarized in Table 1. In addition, there is a pre-SMOV proposal (7211) which obtains baseline data on special calibrators which are needed during the Bright Earth Avoidance (BEA) phase of SMOV (see Section 5).

**Table 1: WFPC2 SMOV Proposals**

<b>ID</b>	<b>Proposal Title</b>	<b>SMOV Activity ID</b>	<b>Formal Requirements</b>	<b>Execution Method</b>	<b>Time (hours)</b>	<b>External Pointed Orbits</b>
7211	Pre-SM97 UV Baseline Observations	(Cycle 6)	-	SMS	4	6
7015	Protect Safe Mode to Operate; Decon	WFPC2-01	F.2.5.1.1.1 F.2.5.1.1.2	Real Time	12	0
7016	SM97 UV Monitor & Cool Down	WFPC2-02	F.2.5.1.1.3 F.2.5.1.1.4	Real Time / SMS	16	19
7017	SMOV Focus Check	WFPC2-03	F.2.5.1.2.1	SMS	3	3
7018	Lyman $\alpha$ Throughput Check	WFPC2-04	F.2.5.1.1.5	SMS	~3	~3
7019	Flat Field Check	WFPC2-CAL01	F.2.5.1.2.1	SMS	11	0
7020	Relative Photometric Check	WFPC2-CAL02	F.2.5.1.2.1	SMS	3	4
7021	PSF Verification	WFPC2-CAL03	F.2.5.1.2.1	SMS	3	4
7022	Internal Monitor	WFPC2-CAL04	F.2.5.1.2.1	SMS	18	0
Totals					~68	~39

We now briefly summarize each proposal; complete up-to-date copies of each proposal are available through the usual PRESTO WWW page.

**Proposal ID 7211: WFPC2 Pre-SM97 UV Baseline Observations**

**Purpose:** Obtain baseline photometric data for five UV bright stars which will give complete coverage during BEA phase of SMOV. Test viability of special UV calibrators.

**Description:** Take far UV images of special BEA calibrator stars, essentially duplicating SMOV exposures in 7016 and 7018. One orbit each on targets GRW+70D5824 (included as check), WD0134+833, WD0214+568, WD0310-688, WD1042-690, and WD2126+734. During each 1 orbit visit exposure are made on PC1 with gain 15 using single CCD readout in filters F555W, F122M, F122M+F130LP, F160BW, F160BW+F130LP, and F170W. A single exposure is made on WF3 in F122M, if schedulable in single orbit.

**Contingency:** If observations fail, re-observe before SM97.

**Analysis:** Combine images to remove cosmic rays; perform aperture photometry. Measure F122M, F160BW, and F170W throughputs; use +F130LP data to make corrections for redleaks. Quick-look is needed within 3 days of observations to check for failure; full analysis within 7 days after observation.

**Special Requirements:** Must execute 5 +/- 2 days after a decontamination, so as to duplicate contamination conditions in Cycle 6 proposal 6936 (UV Throughput and Lyman  $\alpha$  Verification), and be similar to SM97 proposal 7018. Must execute prior to 30 Dec. 1996 to allow reduction of data, and possible re-observation before SM97 if problems arise. Under current schedule, these observations will execute on ~16 Nov. and ~14 Dec. 1996.

**Accuracy:** Measure F170W throughput to 3% or better accuracy. Measure Lyman  $\alpha$  throughput to 5% - 10% accuracy (limited by redleak corrections).

**Products:** Pre-SM97 count levels for BEA targets.

**Telescope Resources:** 6 orbits pointed time.

**Human Resources:** 2 weeks FTE. Quick-look is needed within 3 days of observations; full analysis within 7 days after observation. Observations planned for ~16 Nov. and ~14 Dec. 1996.

**Proposal ID 7015: WFPC2 Transition to Hold and Decon**

**Purpose:** Transition WFPC2 to operate and perform initial decontamination.

**Description:** WFPC2 mechanisms are powered-up for first time after Service Mission. Initial decontamination is performed during COSTAR DOB deploy. A PROTECT DECON is used where the shutter is closed, filter F785LP is in place, and TECs are off; this attempts to minimize influx of contaminants into WFPC2 during COSTAR DOB deploy.

**Contingency:** If WFPC2 fails to re-start, assess situation and try again.

**Analysis:** None.

**Special Requirements:** Timing is linked to COSTAR DOB deploy.

**Telescope Resources:** no pointed time; approx. 12 hours non-pointed time.

**Human Resources:** ~1 day engineering support.

**Proposal ID 7016: WFPC2 SM97 UV Monitor and Cool Down Procedure**

**Purpose:** Perform initial cool down of WFPC2 CCDs to operating temperature with frequent monitoring of F170W throughput using standard stars.

**Description:** This proposal handles cool down of the WFPC2 CCDs to  $-88^{\circ}\text{C}$  with frequent monitoring of contamination via standard star observations in F170W. The cool down is performed in two steps, with a  $\sim 2$  day period at  $-43^{\circ}\text{C}$  and return to decon, before proceeding to  $-88^{\circ}\text{C}$ . Each one-orbit visit consists of F170W and F555W standard star observations, as well as a pair of INTFLATS at F555W. The standard star observations are made on each CCD; two exposures are always made to aid cosmic-ray removal.

The cool down and visits are scheduled as shown in Table 2. As this proposal starts during the Bright Earth Avoidance (BEA) phase of SMOV, one or more BEA targets are used for the early visits (BD+75D325, GRW+70D5824, G191-B2B, WD0134+833, WD0214+568, WD0310-688, WD1042-690, or WD2126+734). Under the current plan BEA should end around visit 24, and hence there is a transition to target GRW+70D5824 for remaining visits (or Feige 110, if unavailable) which have more complete pre-SMOV data.

**Table 2: Scheduling of UV Monitor Visits**

Visit	CCD Temp ( $^{\circ}\text{C}$ )	When	Target
1	-43		BEA UV star
2	-43	visit 1 + 48 hours	BEA UV star
10	-88	visit 2 + 12-24 hours	BEA UV star
12	-88	visit 10 + 3hours	BEA UV star
14	-88	visit 10 + 6 hours	BEA UV star
16	-88	visit 10 + 12 hours	BEA UV star
18	-88	visit 10 + 24 hours	BEA UV star
20	-88	visit 10 + 36 hours	BEA UV star
22	-88	visit 10 + 48 hours	BEA UV star
24	-88	visit 10 + 72 hours	BEA UV star
25	-88	visit 24 + 0-6 hours	GRW+70D5824
26	-88	visit 10 + 96 hours	GRW+70D5824
28	-88	visit 10 + 7 days	GRW+70D5824
30	-88	visit 10 +10 days	GRW+70D5824

**Table 2: Scheduling of UV Monitor Visits**

Visit	CCD Temp (°C)	When	Target
32	-88	visit 10 + 14 days	GRW+70D5824
34	-88	visit 10 + 17 days	GRW+70D5824
36	-88	visit 10 + 21 days	GRW+70D5824
38	-88	visit 10 + 24 days	GRW+70D5824
40	-88	visit 10 + 28 days	GRW+70D5824

If at any point during execution of this proposal, the F170W contamination growth rate exceeds 30% throughput loss in 1 month, WFPC2 will be transitioned to PROTECT DECON (shutter closed, MECH power supply off, F785LP in, TECs off) until the situation can be assessed. When it is felt safe to resume WFPC2 operations, this proposal will be executed again from the beginning starting on the next available SMS.

**Contingency:** If early visit(s) fail or contamination too rapid (>30% F170W throughput loss / month), transition WFPC2 to PROTECT DECON. Restart proposal from beginning on next available SMS. Single failures of later visits are tolerable, provided contamination rate appears low.

**Analysis:** Combine images to remove cosmic rays; perform aperture photometry. Check that rate of F170W throughput decline is always 30%/month or less. Check for any changes in F555W photometry or in F555W INTFLATS vs. pre-SM97 data.

Data for visits 10, 12, and 14 must be reduced within ~1 hour of receipt. Visits 16, 18, and 20 need data reduced within about 6 hours of receipt. Other visits need data reduced within ~24 hours of receipt.

**Special Requirements:** Tape recorder dumps are needed immediately after visits 10, 12, and 14, so as to allow rapid checking for contamination after CCDs cooled to -88 degrees.

**Accuracy:** Measure F170W throughput to 3% or better accuracy.

**Products:** Throughput decline rates for F170W in each CCD. ISR.

**Telescope Resources:** 19 orbits pointed time.

**Human Resources:** 8 weeks FTE. Data for visits 10, 12, and 14 must be reduced within ~1 hour of receipt. Visits 16, 18, and 20 need data reduced within about 6 hours of receipt. Other visits need data reduced within ~24 hours of receipt. Will require some 24 hour support and weekend support from SSD. Probably need 3 people to effectively handle 24 hour support periods.

**Computing Resources:** Requires 24 hour, 100% reliable computing during execution of visits 10 - 22 (approx. 5 day period). Computing support required 24 hours per day during

this time. Daily weekend computing support required during rest of proposal.

**Real-Time Requirements:** Data from visits 10, 12, and 14 must be available within 1 hour of observation. Must be able to uplink real-time commands to WFPC2 to override SMS and force transition to PROTECT DECON if contamination rate is too high. Will need 24 hour OPUS support during execution of visits 10 - 24, and daily uplink opportunities after that.

## **Proposal ID 7017: WFPC2 SMOV Focus Check**

**Purpose:** Check for post-SM focus anomalies. Update value for SMOV desorption focus move on 1 March 1996, if needed.

**Description:** Observations are made of a star in PC1 in F555W with various position dithers over one orbit. This sequence is then repeated over 2 more orbits spread over a total of ~18 hours so as to sample variety of possible breathing effects. Single CCD reads are used.

Observations occur during Bright Earth Avoidance. Current version (15 Oct 1996) uses and early set of BEA targets including S121-E, WD1057+719, L145-141, L151-81, WD1647+591, AGK+81D266, WD0002+729, BD+75D325, GRW+70D5824, G191-B2B. We may want to revise to use BEA targets in Section 5 (BD+75D325, GRW+70D5824, G191-B2B, WD0134+833, WD0214+568, WD0310-688, WD1042-690, and WD2126+734).

**Contingency:** Use only extrapolated pre-SMOV focus data for focus move.

**Analysis:** Perform phase-retrieval analysis on images to measure WFPC focus position using normal focus monitor software. Compare with extrapolated pre-SMOV focus positions, and determine focus move for SMOV desorption focus move. Data must be reduced within ~1 day of observation, since focus move is schedule about 3 days after last observation.

**Special Requirements:** Normal operation at -88°C for at least 12 hours prior to execution, to allow thermal equilibrium of WFPC2 optical bench. We will need the temperatures of light shield sensors T307 to T310, so that we can correct for breathing. Need data available within ~6 hours of observation.

**Accuracy:** Measure WFPC2 focus position to ~1 micron accuracy (equivalent OTA secondary mirror position).

**Products:** Updated focus value for SMOV desorption focus move. ISR.

**Telescope Resources:** 3 orbits pointed time.

**Human Resources:** 1 week FTE. Data must be reduced within ~1 day of observation, since focus move is schedule about 3 days after last observation. Two people are required to provide intensive support.

**Real-time Requirements:** Access to OPUS monitor pages is needed during observations to allow recording of light shield temperatures. WFPC2 data must be available within ~6 hours of observation.

## **Proposal ID 7018: WFPC2 SMOV Lyman $\alpha$ Check**

**Purpose:** Measure far-UV contamination of pick-off mirror.

**Description:** Observations are made of a UV-bright star at three epochs so as to measure any far-UV (Lyman- $\alpha$ ) throughput decrease due to contamination of the WFPC2 pick-off mirror. Observations are made in far-UV filters F122M and F160BW, as well as F555W. Images are also taken with the UV filters crossed with F130LP, so as to isolate counts contributed by redleak in F122M and F160BW. Pre-SMOV data will be compared with each of the SMOV epochs, so as to measure any throughput decrease occurring as a result of SMOV. Single CCD reads are used with gain 15.

The first visit occurs during Bright Earth Avoidance. To ensure consistency of data, all three visits are made on one BEA target. Visits are scheduled within  $\sim 1$  day after first three SMOV decons to minimize effects from contamination on CCD windows. Possible targets are BD+75D325, GRW+70D5824, G191-B2B, WD0134+833, WD0214+568, WD0310-688, WD1042-690, and WD2126+734.

If large change is seen in far-UV throughput, some consideration should be given to extending BEA or minimizing activities which might cause contamination.

**Analysis:** Combine images to remove cosmic rays; perform aperture photometry. Measure F122M, F160BW, and F170W throughputs; use +F130LP data to make corrections for redleaks. Data must be reduced within  $\sim 3$  days of observation.

**Special Requirements:** Normal operation at  $-88^{\circ}\text{C}$ . Should be scheduled within  $\sim 1$  day after decontaminations.

**Accuracy:** Measure Lyman  $\alpha$  throughput to 5% - 10% accuracy (limited by redleak corrections).

**Products:** Far-UV throughput. ISR.

**Telescope Resources:** 3 orbits pointed time.

**Human Resources:** 2 weeks FTE. Data must be reduced within  $\sim 3$  days of observation.

## **Proposal ID 7019: WFPC2 SMOV Flat Field Check**

**Purpose:** Verify that flat field is unchanged at ~1% level.

**Description:** Take 120 Earthflats in F502N to check OTA+WFPC2 flat field. Also INTFLATS will be taken in filters F336W, F439W, F555W, F675W, F814W, and F502N to provide a quick check for wavelength-dependent effects; four are taken in each filter at gain 7, except for F555W where four are taken in each gain. VISFLATS are taken in F336W, F502N, F555W, F675W, and F814W (two each) to test for wavelength-dependent effects in calibration-channel optics. Observations will begin after CCDs are operating at -88C and after Bright Earth Avoidance ends, and will extend over several weeks. Ideally, execution would begin about 12 days after HST release (after the "protect" decon which occurs ~10 days after HST release), and execute over next 4 to 6 weeks.

**Analysis:** The F502N Earthflats will be flattened with pipeline flats; ones which are too bright or dark, or with streaks stronger than ~3% peak-to-peak will be discarded. The remaining ones combined with STREAKFLAT, and examined for agreement with previous flats in this filter. If necessary, a correction image will be generated and used to update the calibration flats for the pipeline. The INFLATs and VISFLATs will be combined to remove cosmic rays, and compared against Cycle 6 data from proposals 6906 and 6907.

**Special Requirements:** Normal operation at -88°C.

**Accuracy:** Measure any changes in flat field to ~1% accuracy.

**Products:** Revised calibration flat fields, if necessary. ISR.

**Telescope Resources:** No pointed time; ~11 hours non-pointed time.

**Human Resources:** 2 weeks FTE for simple reduction. An additional 4 weeks FTE if large changes are seen and necessary to update calibration flats. A quick-look at the data should be made within a day or two of receipt of first images to verify no serious problems or gross changes in flat field. A full analysis should be completed within 4 weeks of WFPC2 SMOV end (about 8 weeks after HST release).

## **Proposal ID 7020: WFPC2 SMOV Relative Photometry Check**

**Purpose:** Verify that photometry is unchanged at 1% to 2% level.

**Description:** A UV standard star is exposed in a wide range of filters (F160BW, F170W, F185W, F218W, F255W, F300W, F336W, F439W, F555W, F675W, and F814W) in each CCD (one orbit per CCD). Single CCD readouts are used. One target is selected from GRW+70D5824, G191-B2B, and FEIGE110.

This should run after bright Earth avoidance is suspended, preferably 1 to 3 days after the “protect decon” which executes ~10 days after HST release.

**Analysis:** Aperture photometry is performed on the images. Results are compared with similar pre-SMOV data in Cycle 6 proposal 6902.

**Special Requirements:** Normal operation at -88°C.

**Accuracy:** Measure any changes in photometry to 1% to 2% accuracy.

**Products:** Photometric monitoring plots. Revised photometric calibration, if necessary. ISR.

**Telescope Resources:** 4 orbits pointed time.

**Human Resources:** 1 week FTE for simple reduction. An additional 2 weeks FTE if update required to SYNPHOT tables. Full analysis needed within 8 weeks of HST release.

## **Proposal ID 7021: WFPC2 SMOV PSF Verification**

**Purpose:** Verify that PSF is unchanged across field-of-view.

**Description:** Omega Cen field is used to observe PSF throughout WFPC2 field of view in F555W. Exposure times of 40s and 100s (with gain = 15) are used to increase dynamic range. A spatial scan is performed over a 4x4 grid on the CCD using 0.375 arcsec offsets. The effective step size is 0.025 arcsec, which should give critically sampled PSF over most the field of view. Based partially on cycle 4 program 5575, and cycle 5 program 6193 which used a similar field. The proposal also allows a check for subpixel phase effects on the integrated photometry.

**Analysis:** Extract PSFs and assemble critically sampled “composite” PSF using dither software. Compare against pre-SMOV PSFs.

**Special Requirements:** Normal operation at -88°C. Data volume may be a problem, and require special tape recorder handling.

**Accuracy:** Measure any changes in PSF to 5% to 10% accuracy.

**Products:** Update PSF library. Also updates to TIM and TinyTIM, if needed. ISR.

**Telescope Resources:** 4 orbits pointed time.

**Human Resources:** 2 weeks FTE for simple reduction. An additional 2 weeks FTE if update required to TIM or TinyTIM models. Full analysis needed with 8 weeks of HST release.

## **Proposal ID 7022: WFPC2 SM97 Internal Monitor**

**Purpose:** Verify no change in basic instrument health and internal calibrations.

**Description:** A variety of internal exposures are obtained in order to provide a monitor of the integrity of the CCD camera electronics in both bays (gain 7 and gain 15), a test for quantum efficiency in the CCDs, an internal check on the alignment of the WFPC2 optical chain, and a monitor for possible buildup of contaminants on the CCD windows.

The internal observations consist of: 2 F555W INTFLATs and biases each at gain=7 and gain=15; 2 kspot images optimized to WF and PC, respectively. Also 5 dark frames of 1500 sec. each. The entire set should be run weekly, on a non-interference basis. Proposal should start as soon as WFPC2 is operational with CCDs at  $-43^{\circ}\text{C}$ , and run twice weekly. Darks are omitted from visits at  $-43^{\circ}\text{C}$ .

**Analysis:** Combine frames to remove cosmic rays. Compare with similar pre-SMOV images. Update calibration reference files if large changes are seen.

**Special Requirements:** None.

**Accuracy:** Measure any changes in bias and dark frames to  $\sim 1.4$  electrons per pixel. Measure any changes in INTFLAT to  $\sim 1\%$  accuracy.

**Products:** Update bias and dark reference files, if large changes are seen. ISR.

**Telescope Resources:** no pointed time; 18 hours non-pointed time.

**Human Resources:** 2 weeks FTE for simple reduction. An additional 2 weeks FTE if update required to calibration reference files. Full analysis needed within 8 weeks of HST release.

#### **4. Time Line for WFPC2 SMOV Activities**

Table 4 below summarizes the timing of the WFPC2 SMOV activities, assuming a nominal HST release date of 2/20. We briefly note some features of this schedule.

Two events are strongly tied to activities on other instruments. The initial DECON on 2/23 must occur during the COSTAR DOB deploy; the essentially sets the start of WFPC2 SMOV activities. Secondly, the normal OTA desorption focus move is schedule for 3/1. This cannot be significantly delayed without impacting optical fine alignments on other instruments.

Science observations begin 7 days after release, but UV science and parallel observations are initially prohibited. UV science is prohibited, since the contamination state is likely to be anomalous due to the two-step cool down procedure, and possibly due to out-gassing from other instruments. Hence the normal corrections for contamination are likely to be incorrect. UV science is started approx. 3 days later after the PROTECT DECON.

WFPC2 parallels are prohibited during the first ~40 days after release, so as to minimize the WFPC2 shutter-open time, especially while other instruments are operating.

The Cycle 6 monitor programs are slowly phased-in starting about 3 weeks after HST release.

Figures 1 and 2 illustrate the approximate manpower requirements before and during SMOV.

**Table 3: WFPC2 SMOV Activity Timeline**

1997 Day	Activity	Proposal ID	Comments
2/20	HST RELEASE		(WFPC2 IN PROTECT SAFEMODE)
2/23	WFPC2 TO HOLD; WFPC2 TO OPERATE	7015	
	PROTECT DECON	7015	SHUTTER CLOSED, F785LP, TEC OFF (COSTAR DOB DEPLOY)
2/24	COOL DOWN: -43°C	7016	
	UV MONITOR: 0	7016	UV STAR, F170W, FINE LOCK
	INTERNAL MONITOR	7022	BIAS, INTFLAT, K-SPOT
2/26	UV MONITOR: +48 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
2/27	COOL DOWN: -88°C	7016	
	UV MONITOR: 0	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	INTERNAL MONITOR	7022	BIAS, DARK, INTFLAT, K-SPOT
	UV MONITOR: +3 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	UV MONITOR: +6 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	FOCUS CHECK #1	7017	UV STAR, F555W, PC 1, FINE LOCK
	LYMAN $\alpha$ CHECK #1	7018	UV STAR, F122M, F160BW, F130LP
	UV MONITOR: +12 HRS	7016	UV STAR, F170W, FINE LOCK
	<b>* SCIENCE START *</b>		NO UV, NO PARALLELS
	FOCUS CHECK #2	7017	UV STAR, F555W, PC 1, FINE LOCK

**Table 3: WFPC2 SMOV Activity Timeline (cont.)**

Date	Activity		Comments
2/27	UV MONITOR: +18 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	FOCUS CHECK #3	7017	UV STAR, F555W, PC 1, FINE LOCK
	UV MONITOR: +24 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
2/28	UV MONITOR: +36 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	UV MONITOR: +48 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
3/1 fixed	OTA DESORPTION FOCUS MOVE		USE SMOV FOCUS CHECK RESULTS; IF PROBLEMS USE PRE-SMOV FOCUS EXTRAPOLATION
	UV MONITOR: +72 HRS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	INTERNAL MONITOR	7022	BIAS, DARK, INTFLAT, K-SPOT
3/2	UV MONITOR: +96 HRS	7016	(END BEA)
3/2	PROTECT DECON		SHUTTER CLOSED, F785LP IN
	LYMAN $\alpha$ CHECK #2	7108	UV STAR, F122M, F160BW, +/- F130LP
3/3	UV MONITOR: +5 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON
	<i>* UV SCIENCE START *</i>		
	START FLAT FIELD CHECK	7019	EARTH FLATS IN F502N; INFLATS AND VISFLATS
	START PSF CHECK	7021	STD STAR, STAR FIELD, F555W
	START PHOTOM CHECK	7020	STD STAR, ALL CCDs
3/6	INTERNAL MONITOR	7022	BIAS, DARK, INTFLAT, K-SPOT

**Table 3: WFPC2 SMOV Activity Timeline (cont.)**

Date	Activity	Proposal ID	Comments	Contingency
3/7	UV MONITOR: +8 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
3/11	UV MONITOR: +12 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
	INTERNAL MONITOR	7022	BIAS, DARK, INTFLAT, K-SPOT	
3/13	START CYCLE 6 MONITORS		PHASE -IN INTERNAL, VISFLAT, DARK, PHOTOM MONITORS	
3/14	UV MONITOR: +15 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
3/18	UV MONITOR: +19 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
	INTERNAL MONITOR	7022	BIAS, DARK, INTFLAT, K-SPOT	
3/21	UV MONITOR: +22 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
3/25	UV MONITOR: +26 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
3/28	UV MONITOR: +29 DAYS	7016	CONTAM RATE <30% LOSS / MONTH? NO: RETURN TO PROTECT DECON	
3/30	STANDARD DECON		SHUTTER OPEN, NO FILTER	
	LYMAN $\alpha$ CHECK #3	7018	UV STAR, F122M, F160BW, F130LP	
	<i>* END WFPC2 SMOV *</i>		START PARALLEL SCIENCE	

Figure 1. Schedule of pre-SMOV Work

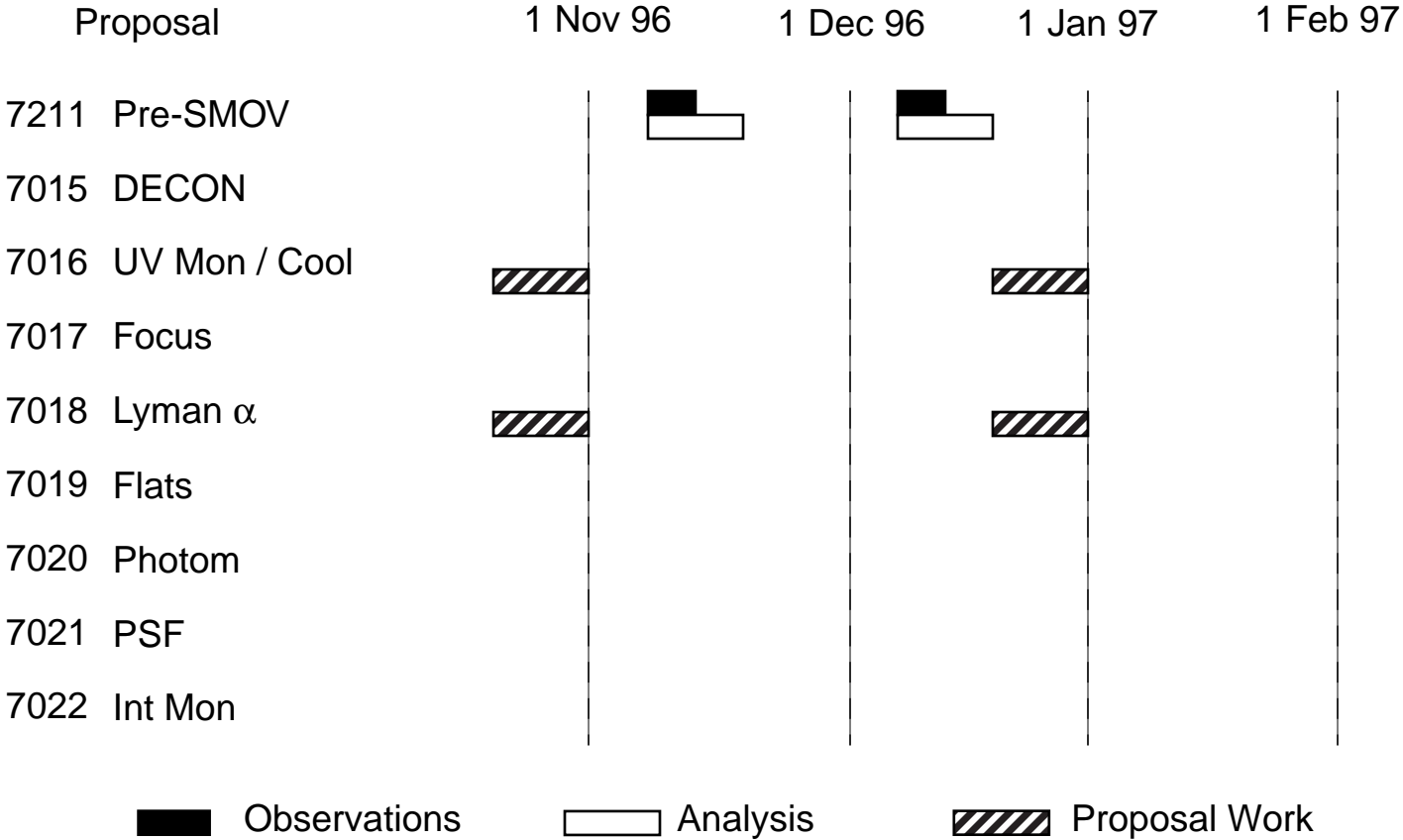
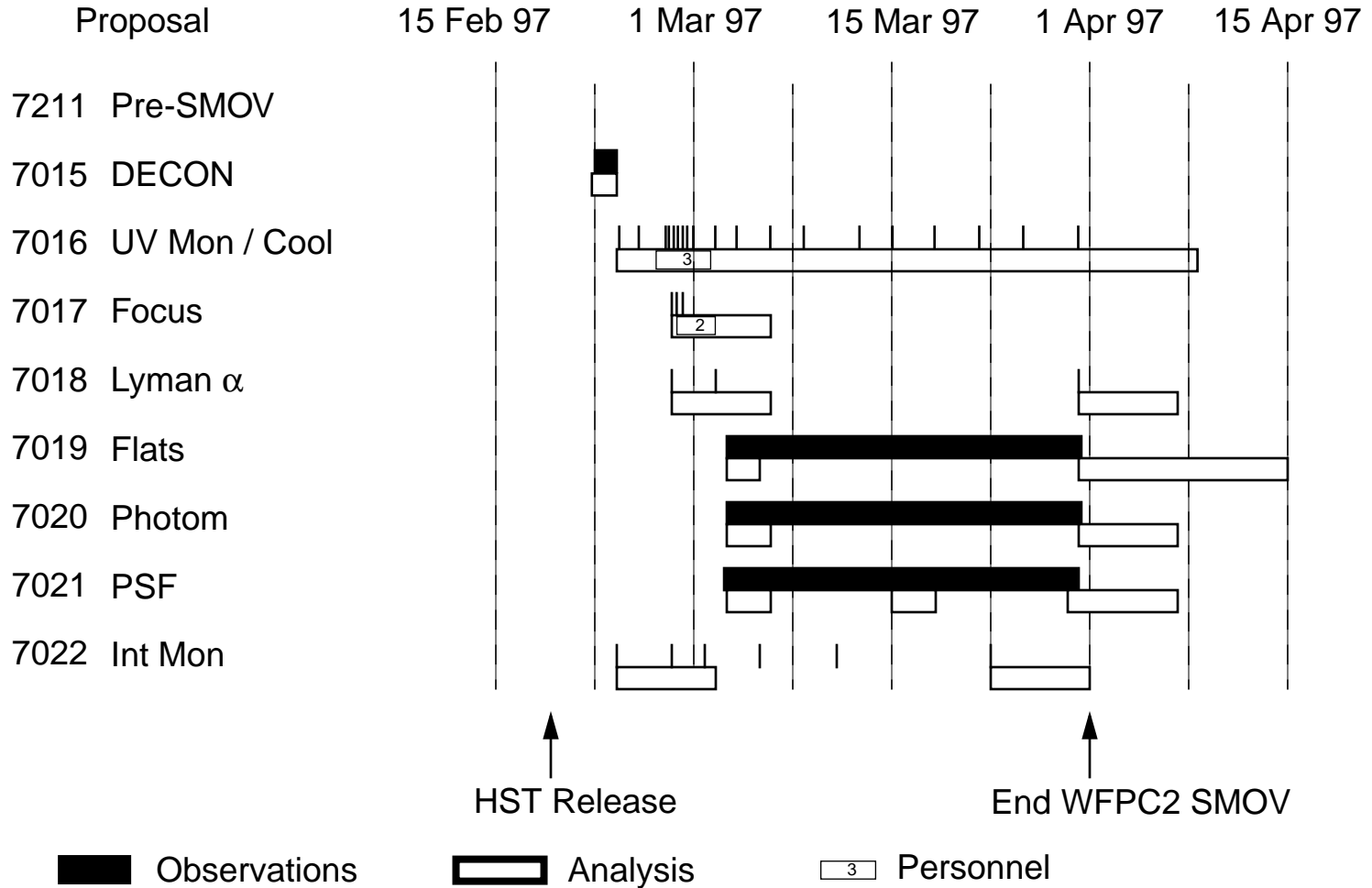


Figure 2. Schedule of SMOV Work



## **5. Data Analysis Teams**

We will organize data analysis efforts by teams, with one team assigned to each proposal, as below. Semi-weekly meetings will be held involving entire group.

Oversight, coordination, communications: Biretta, Baggett, Whitmore

UV Monitor / Cool-Down (7016): Stiavelli, Baggett, Gonzaga, Mutchler

Focus Check (7017): Casertano, Suchkov

Lyman-Alpha Check (7018): O'Dea, Baggett

Flat Field Check (7019): Biretta, Wiggs

Photometry Check (7020): Whitmore, Heyer

PSF Check (7021): Fruchter, McMaster

Internal Monitor (7022): Stiavelli, Mutchler

## 6. Targets for Bright Earth Avoidance

During the first ~10 days following HST release, the spacecraft will be held in a Bright Earth Avoidance (BEA) orientation. This severely limits the region of the sky which is accessible, and requires special targets to facilitate early calibrations (i.e. UV Monitor / Cool Down, Focus Check, and Lyman  $\alpha$  proposals).

The accessible sky region at any one time during BEA is the region within 22 degrees of the HST orbit pole, which is placed at ~61.5 degrees Declination. Also since the orbit precesses with a 56.1 day period, any one target is only visible for a maximum period of about 2 weeks. Table 4 gives rough target accessibility periods as a function of Declination. Targets between about  $-52^\circ$  and  $+28^\circ$  Declination are also impacted by solar avoidance during the nominal SMOV period.

**Table 4: Accessibility periods for targets as function of Declination.**

Absolute Value Target Declination	Accessibility Period (days)
$52^\circ$	11.5 (solar avoidance)
$59^\circ$	14
$64^\circ$	15
$70^\circ$	15.5
$75^\circ$	15
$81^\circ$	9

Since launch delays may impact the SMOV schedule, it is necessary to have a series of targets so that one or more targets are always visible. Table 5 lists the targets we have selected to meet this criteria. Several are usual HST calibrators, with the remainder being taken from the IUE spectral survey of white dwarf stars by Wegner and Swanson (1991). We have chosen mostly DA3 white dwarfs, since this is the spectral class of the WFPC2 calibrator GRW+70D5824.

**Table 5: Targets for Bright Earth Avoidance Calibrations**

Target	R.A. (J2000)	Declination (J2000)	V	B-V	Spectral Class	1997 Days Accessible	Source
WD0310-688	03H 10M 30.39S	-68D 36' 05.3"	11.38	+0.04	DA3	52-68, 108-124, 164-180	WEGNER & SWANSON 1991
GRW+70D5824	13H 38M 51.77S	70D 17' 8.5"	12.77	-0.09	DA3	63-79, 119-135, 175-191	BOHLIN, ET AL., 1990
BD+75D325	8H 10M 49.31S	74D 57' 57.50"	9.52	-0.34	O5p	76-91, 132-147, 188-203	BOHLIN, ET AL., 1990
G191-B2B	05H 05M 30.62S	52D 49' 54.0	11.78	-0.33	DA0	85-97, [141-153, 197-200 solar avoidance], 201-209	BOHLIN, ET AL., 1990
WD0214+568	02H 17M 33.15S	57D 06' 47.1"	13.68	-0.12	DA3	90-103, [146-159 solar avoidance], 202-215	WEGNER & SWANSON 1991
WD0134+833	01H 41M 30.32S	83D 34' 57.7"	13.17	-0.17	DA3	91-99, 147-155, 203-211	WEGNER & SWANSON 1991
WD1042-690	10H 44M 11.59S	-69D 18' 18.8"	13.09	-0.04	DA3	96-113, 152-169, 208-225	WEGNER & SWANSON 1991
WD2126+734	21H 26M 57.48S	73D 38' 45.7"	13.09	0.02	DA4	101-116, 157-172, 213- 228	WEGNER & SWANSON 1991

## **7. References**

Bohlin, et al., (1990) Ap.J. 73, 413.

Wegner & Swanson (1991), Ap.J.Supp. 75, 507.