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FLATS: SBC DATA FROM THERMAL VACUUM TESTING

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ABSTRACT

The Advanced Camera for Surveys (ACS) has three detectors: a large and a small format CCD (WFC and HRC), and a 1024x1024 MAMA Solar Blind Channel (SBC). During the Thermal Vacuum testing at GSFC in 1999 March, flats with S/N=100 per pixel were obtained for the six SBC filters and two prisms. The pixel-to-pixel P-flats are independent of wavelength to <1%. Because of a temperature dependence in the structure of the flats, the use of these flats to reduce flight data may cause a residual Moire pattern with an amplitude of a few percent in the worst region of the SBC.

1. Introduction

During the 1999 March thermal vacuum test of ACS, the Stimulus for Ultraviolet Flat Fields (STUFF) apparatus was used to provide external flat field illumination of the SBC channel. STUFF was developed by Doug Leviton of GSFC. The primary illumination mode is a PtNe emission line lamp, which shines on a micro-mirror array that directs the beam down the ACS optical axis. An alternate external light source is a sheet of Spectralon that is also illuminated by a PtNe lamp. The micro-mirror array directs much of the light toward ACS and is much brighter than the more widely diffused Spectralon mode. Since neither STUFF illumination is a high fidelity simulation of the OTA, the low frequency spatial response of the SBC MAMA detector must be removed to make pixel-to-pixel P-flats, according to the prescription of Bohlin, et al. (1999).

Since future vacuum testing time is restricted and since the internal deuterium SBC flat field lamp has a limited lifetime, the existing set of external STUFF flats will probably be used to reduce the initial flight science data. The internal lamp will be used to monitor changes and to confirm the STUFF P-flats. The currently installed SBC MAMA detector is the flight unit, STF7. On-orbit observations of starfields will determine the low frequency L-flat variations of the SBC flat fields (Bohlin, et al. 1999).

Many instruments require some sort of reference file for describing the geometric distortion, yet a single format has not yet been developed that satisfies each instrument’s needs. The description of the geometric distortion can take many different forms, ranging from images of pixel area variations to polynomial fits. One common element shared by all the instruments is the Science Instrument Aperture File (SIAF) which contains descriptions of the distorted and undistorted aperture positions. The conversion between distorted and undistorted positions in the SIAF is controlled by a polynomial fit performed by the instrument teams. This commonality provides the basis for generating a small and simple reference file which can be used by any instrument to describe the detector’s geometric distortion using the same fitting method.

2. Results

Flat field exposures have been obtained for the SBC during thermal vacuum testing at GSFC. The ACS IDT has stored these images in an on-line database and has assigned a unique entry number to each image. Data of P-flat quality exist for all six SBC filters and the two SBC prisms, as summarized in Table 1. There are 10 observation sets with the external STUFF illumination, each of which consists of 10-12 one hour exposures to accumulate ~10,000 counts/px. The F140LP set is repeated with the same micro-mirror setup, while the F115LP is repeated with the Spectralon light source. Each set of flats is added and reduced per (Bohlin, et al. 1999). The appearance of these 10 flats is similar, except for some blemishes on F165LP and F115LP. The prisms do not illuminate the SBC beyond column 850 (see Figures 1-2). The ’pawprints’ on the F165LP filter and similar fainter features on F115LP are caused by dust particles, which are illuminated at a different angle by the four segments of the micro-mirror array. A cleaning of the F165LP filter is planned, but repeats of the STUFF flats are currently not scheduled for the next thermal vacuum run. During ground tests under nitrogen purge, more flat field exposures in F165LP may be possible.

Figure 3 is the ratio of the F115LP flat of 1999 on day 67 to the F122M flat. Two or three weak pawprint signatures of dust are present in the F115LP flat, while the small-scale, low-level streaks extending in the direction from top

left to bottom right are typical of all the SBC flat field ratios. The large-scale, low-level patches of bright and dark in Figure 3 are worse for comparisons of the medium width F122M filter to a broader band longpass filter than for comparisons of one longpass filter with another longpass filter. The multi-layer F122M interference filter may be less uniform at larger scales than the uncoated, crystaline longpass filters.
Table 2 characterizes the P-flats and quantifies their differences for sub-images from the pixel range (590:690,490:590), which avoids the shadow of the vertical repeller wire and the horizontal rows 599:604 that are affected by the bad anode. The individual flats are compared to the broadband F115LP P-flat taken on 1999 day 67. The Poisson counting statistics, the actual one sigma rms scatter, the intrinsic rms variation, and the minimum and maximum are tabulated for each flat. The Poisson scatter is removed from the ’Actual sigma’ to calculate the ’Sigma Flat’, which is the intrinsic rms variation of the flat itself. The RATIO section of Table 2 shows the result of correcting each numerator flat by the F115LP denominator flat, where the Poisson statistics are the numerator and denominator Poisson statistics combined in quadrature. The ’Actual sigma’ entries are the standard deviations within the ratio sub-images. The residuals in the bottom row of Table 2 result from the removal of the Poisson rms from the actual rms and indicate the difference between the F115LP P-flat and the other flats indicated at the top of each column. These residuals are all less than ~0.5%, except for the wavelength extremes at F122M and F165LP and except for the prisms, which have a different angle of illumination and a different position for the repeller wire shadow. The residual of 0.9% for the low S/N internal flat in the column IN99069 is poorly determined but suggests that high S/N flats with the internal lamp will agree with the external STUFF flats to better than 1%.

In summary, P-flats for the ACS SBC are independent of wavelength to better than 0.5% per pixel in most cases and to <1% rms in all cases. Consequently, seven STUFF flats for the filters are summed to make a SBC superflat. The F165LP is excluded from the superflat sum because of the dust pawprint signatures, which have a typical depth of <2-3%. If the F165LP cannot be cleaned before flight, a separate flat is required; however, OTA illumination should show a more symmetric blemish instead of a pawprint. The two prism flats are summed to make one prism flat, which should be appropriate for SBC pipeline data reduction along with the filter superflat. The filter superflat is illustrated in Figure 4, while the prism flat appearance does not differ from the individual prism flat of Figure 2. For a cut across the detector, Figure 5 illustrates the actual rms structure in the filter superflat along with the Poisson statistical uncertainty of ~0.4%. The intrinsic rms structure of the STF7 MAMA in Figure 5 and in Table 2 is in agreement with the global average "high frequency component of the fixed pattern noise" of 5.9% as measured by Argabright (1996).

For STIS, the MAMA flats are also wavelength independent to better than 1% (Bohlin et al. 1997, Kaiser et al. 1998).

The data quality flags in the third extension of the flat file are zero, except that the unusable edges, corners and rows 599:604 are flagged as 240, while the flag for the repeller wire region is 174, as for the STIS MAMAs.

3. WHY DO THE SBC P-FLATS REPRODUCE TO ONLY ~0.5%?

Even though the typical residual difference of ~0.5% among the SBC P-flats may not limit many science programs, the source of the limitation is investigated by comparing flats obtained at filter wheel positions that are offset from the normal position by one step (148 microns). In particular, the F140LP and F115LP repeats are composed of the three separate step positions, as indicated in Table 2. Detailed intercomparison of the three steps with each other and with the earlier baseline show subtle differences in the appearance of the ratio images; but all the residuals are in the range 0.4-0.7%, that is typical of the last row of Table 2, EXCEPT for one case: The ratio of the F115LP Spectralon flats at the plus 1 and minus 1 positions agree to within a 1σ uncertainty in the mean of 0.04%! For this section, the ratio image is divided into 8x8 blocks; and the residual rms scatter is computed for the 16384 pixels in each 128x128 px box. The quoted residuals are the average of the residuals for the interior 36 boxes, while the uncertainties in these means are the rms scatter among the 36 residuals divided by the square root of 36.

Why do the +1 and -1 F115LP step positions agree so much better than the rest of flats? For example, the comparable difference in the F140LP micro-mirror array flats at the plus 1 and minus 1 positions is 0.46% +- 0.02; and even in the case of the F140LP position 0 on 99Mar5 vs. position 0 on 99Mar9 with the same temperature to 1.3C, the rms is 0.39%.

The clue to the above mystery is in the temperature column of Table 1. All the data were obtained at temperatures in the 31-33C range, except for the F115LP Spectralon data. Step 0 images, 5808-5811, have an average temperature of 34.4C, step +1 images, 5812-5814 are at 36.2C, and step -1 images, 5815-5817, are at 37.2. Even though the micro-mirror illumination of the tilted filters limits repeatability to ~0.4% rms, the more diffuse Spectralon illumination could produce flats that are more independent of step position and wavelength.

However, temperature differences as large as the 1.8C and 2.6C between the Spectralon step 0 and the plus and minus step positions might cause the observed rms differences of 0.45% +- 0.02% and 0.42% +- 0.03%, respectively. With only a 1.0C difference between the Spectralon +1 and -1 positions, the effect of temperature is no longer important. Comparisons among the first four images 5808-5811 at step 0 shows that a discrete internal event occurred in the SBC MAMA during the rapid thermal changes of the first set of four exposures at step 0. In particular, a Moire pattern is visible in the 5810/5811 ratio image, which suggest that the microchannel plate shifted slightly with respect to the MAMA anode array in this time frame.

4. GOALS FOR THE NEXT THERMAL VACUUM TESTS

Because of the limited lifetime of the internal deuterium lamp on the SBC, one internal P-flat with 10000 counts per 2x2 px resolution element must suffice. Probably, the F125LP should be used for this internal flat, unless a different filter will be more commonly used for science imaging. However, because of the pawprint signature in the existing F165LP flat, an internal and a Spectralon F165LP P-flat would help bound the uncertainty in the appearance of the dust blemishes for true OTA f/24 illumination. If STUFF illumination is available, a variety of Spectralon flats would answer the question of whether the small-scale, low-level streaks at 45 degrees can be attributed to the micro-mirror array or not. Also, P-flats at the expected on-orbit operating temperatures of 35-40C would quantify the uncertainty due to changes in the SBC P-flats with temperature. The comparision of the averages of the step -1 F115LP images 5815-5817 at 37C with the earlier baseline at 31C differ in the 128x128 px boxes by up to 1σ = 1% per px in the lower left hand corner of the SBC, where the the Moire Pattern is the strongest. On the finer scale, the Moire fringes have peak to valley amplitudes of a few percent.

References

Argabright, V. 1996, Ball Systems Engineering Report, SER STIS-MAMA-080.

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Table 1. ACS prelaunch data catalog

ENTRY	FILENAME	OBSTYPE	DATE-OBS	EXP TIME	DE-TEC-TOR	STIMULUS	ENVIRON	MGLOBAL	FILTER3	SBC TEMP	LAMP	FW3 POS
4806	CSIJ99064061442_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263709.9	F140LP	31.0	PtNe #1	1440
4807	CSIJ99064071835_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263382.9	F140LP	31.0	PtNe #1	1440
4808	CSIJ99064082112_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263380.1	F140LP	31.9	PtNe #1	1440
4809	CSIJ99064092409_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263392.0	F140LP	31.9	PtNe #1	1440
4810	CSIJ99064102613_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263431.4	F140LP	32.4	PtNe #1	1440
4811	CSIJ99064112826_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263451.8	F140LP	32.4	PtNe #1	1440
4812	CSIJ99064123250_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263496.3	F140LP	32.8	PtNe #1	1440
4813	CSIJ99064134954_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263516.2	F140LP	32.8	PtNe #1	1440
4814	CSIJ99064145614_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263543.2	F140LP	33.2	PtNe #1	1440
4815	CSIJ99064155849_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263566.9	F140LP	33.2	PtNe #1	1440
4816	CSIJ99064170115_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	263603.2	F140LP	33.2	PtNe #1	1440
4818	CSIJ99064183350_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	259685.1	F165LP	33.2	PtNe #1	2520
4819	CSIJ99064200959_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	258942.7	F165LP	31.5	PtNe #1	2520
4820	CSIJ99064211158_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	258479.8	F165LP	31.5	PtNe #1	2520
4821	CSIJ99064221552_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	258378.5	F165LP	31.0	PtNe #1	2520
4822	CSIJ99064232507_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	266557.9	F165LP	31.5	PtNe #1	2520
4823	CSIJ99065002851_1	EXTERNAL	05/03/99	3600.0	SBC	STUFF	VACUUM	266464.2	F165LP	31.0	PtNe #1	2520
4825	CSIJ99065014429_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	266404.3	F165LP	31.0	PtNe #1	2520
4826	CSIJ99065024652_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	266386.9	F165LP	31.0	PtNe #1	2520
4827	CSIJ99065035355_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	266376.1	F165LP	31.0	PtNe #1	2520
4828	CSIJ99065045959_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	266361.9	F165LP	31.0	PtNe #1	2520
4831	CSIJ99065075051_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	273266.1	F122M	31.0	PtNe #1	2880
4833	CSIJ99065094414_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	245468.7	F122M	31.0	PtNe #1	2880
4834	CSIJ99065104623_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	245895.9	F122M	31.0	PtNe #1	2880
4835	CSIJ99065114915_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	246530.4	F122M	31.0	PtNe #1	2880
4836	CSIJ99065125148_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	247342.4	F122M	31.0	PtNe #1	2880
4837	CSIJ99065135414_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	247430.4	F122M	31.0	PtNe #1	2880
4838	CSIJ99065145609_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	247511.1	F122M	31.0	PtNe #1	2880
4839	CSIJ99065155750_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	247534.8	F122M	31.0	PtNe #1	2880
4840	CSIJ99065165948_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	265696.7	F122M	31.0	PtNe #1	2880
4841	CSIJ99065180203_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	268009.8	F122M	31.0	PtNe #1	2880
4842	CSIJ99065190347_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	267897.0	F122M	31.0	PtNe #1	2880

4843	CSIJ99065200539_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	267755.8	F122M	31.0	PtNe #1	2880
4845	CSIJ99065223145_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	258077.9	F150LP	31.0	PtNe #1	1800
4846	CSIJ99065233656_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	267205.4	F150LP	31.0	PtNe #1	1800
4847	CSIJ99066003904_1	EXTERNAL	06/03/99	3600.0	SBC	STUFF	VACUUM	267361.2	F150LP	31.0	PtNe #1	1800
4848	CSIJ99066014043_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267295.7	F150LP	31.0	PtNe #1	1800
4849	CSIJ99066024245_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267285.1	F150LP	31.0	PtNe #1	1800
4850	CSIJ99066034509_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267293.3	F150LP	31.0	PtNe #1	1800
4851	CSIJ99066044706_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267306.0	F150LP	31.0	PtNe #1	1800
4852	CSIJ99066054939_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267360.8	F150LP	31.0	PtNe #1	1800
4853	CSIJ99066065215_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267394.9	F150LP	31.0	PtNe #1	1800
4854	CSIJ99066075147_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267423.2	F150LP	31.0	PtNe #1	1800
4855	CSIJ99066082737_1	EXTERNAL	07/03/99	2000.0	SBC	STUFF	VACUUM	267464.5	F150LP	31.0	PtNe #1	1800
4864	CSIJ99066115127_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	257002.0	F125LP	31.0	PtNe #1	720
4865	CSIJ99066125450_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	262280.8	F125LP	31.0	PtNe #1	720
4866	CSIJ99066135704_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	255679.6	F125LP	31.0	PtNe #1	720
4867	CSIJ99066145840_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	255871.3	F125LP	31.0	PtNe #1	720
4868	CSIJ99066160110_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	266183.6	F125LP	31.0	PtNe #1	720
4869	CSIJ99066181954_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	266780.6	F125LP	31.0	PtNe #1	720
4870	CSIJ99066193950_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	266931.7	F125LP	31.0	PtNe #1	720
4871	CSIJ99066204226_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267017.3	F125LP	31.0	PtNe #1	720
4872	CSIJ99066214428_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267116.0	F125LP	31.0	PtNe #1	720
4873	CSIJ99066224617_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267192.1	F125LP	31.0	PtNe #1	720
4874	CSIJ99066234845_1	EXTERNAL	07/03/99	3600.0	SBC	STUFF	VACUUM	267273.2	F125LP	31.0	PtNe #1	720
4877	CSIJ99067021956_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	268116.1	F115LP	31.0	PtNe #1	360
4878	CSIJ99067032355_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	268352.2	F115LP	31.0	PtNe #1	360
4879	CSIJ99067042605_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	268611.1	F115LP	31.0	PtNe #1	360
4880	CSIJ99067052916_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	268748.9	F115LP	31.0	PtNe #1	360
4881	CSIJ99067063105_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	268881.8	F115LP	31.0	PtNe #1	360
4882	CSIJ99067073309_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	268941.6	F115LP	31.0	PtNe #1	360
4883	CSIJ99067083623_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	269024.1	F115LP	31.0	PtNe #1	360
4884	CSIJ99067093827_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	269090.8	F115LP	31.0	PtNe #1	360
4885	CSIJ99067104013_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	269138.8	F115LP	31.0	PtNe #1	360
4886	CSIJ99067114216_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	269212.6	F115LP	31.0	PtNe #1	360
4887	CSIJ99067121913_1	EXTERNAL	08/03/99	2000.0	SBC	STUFF	VACUUM	269242.8	F115LP	31.0	PtNe #1	360
4890	CSIJ99067144719_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	248846.7	PR130L	31.0	PtNe #1	3600
4891	CSIJ99067154905_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247706.0	PR130L	31.0	PtNe #1	3600

4892	CSIJ99067165043_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247436.2	PR130L	31.0	PtNe #1	3600
4893	CSIJ99067175217_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247309.2	PR130L	31.0	PtNe #1	3600
4894	CSIJ99067185347_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247242.5	PR130L	31.0	PtNe #1	3600
4895	CSIJ99067195604_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247189.5	PR130L	31.0	PtNe #1	3600
4896	CSIJ99067205945_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247174.2	PR130L	31.0	PtNe #1	3600
4897	CSIJ99067220345_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247165.6	PR130L	31.0	PtNe #1	3600
4898	CSIJ99067230616_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247163.2	PR130L	31.0	PtNe #1	3600
4899	CSIJ99068000910_1	EXTERNAL	08/03/99	3600.0	SBC	STUFF	VACUUM	247183.0	PR130L	31.0	PtNe #1	3600
4902	CSIJ99068024612_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250696.2	PR110L	31.0	PtNe #1	3960
4903	CSIJ99068034806_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250678.1	PR110L	31.0	PtNe #1	3960
4904	CSIJ99068045242_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250815.6	PR110L	31.0	PtNe #1	3960
4905	CSIJ99068060358_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250852.5	PR110L	31.0	PtNe #1	3960
4906	CSIJ99068070620_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250852.4	PR110L	31.0	PtNe #1	3960
4907	CSIJ99068080754_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250850.8	PR110L	31.0	PtNe #1	3960
4908	CSIJ99068090940_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250829.1	PR110L	31.0	PtNe #1	3960
4909	CSIJ99068101118_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250844.5	PR110L	31.0	PtNe #1	3960
4910	CSIJ99068111247_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	250861.6	PR110L	31.0	PtNe #1	3960
4911	CSIJ99068115527_1	EXTERNAL	09/03/99	2000.0	SBC	STUFF	VACUUM	250871.4	PR110L	31.0	PtNe #1	3960
4913	CSIJ99068141443_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	261175.3	F140LP	31.0	PtNe #1	1440
4914	CSIJ99068152450_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	259450.4	F140LP	31.0	PtNe #1	1440
4915	CSIJ99068162725_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	259132.5	F140LP	31.0	PtNe #1	1440
4916	CSIJ99068172933_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262550.0	F140LP	31.0	PtNe #1	1440
4917	CSIJ99068183731_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262548.8	F140LP	31.0	PtNe #1	1441
4918	CSIJ99068193920_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262511.4	F140LP	30.6	PtNe #1	1441
4919	CSIJ99068204202_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262524.9	F140LP	30.6	PtNe #1	1441
4920	CSIJ99068214703_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262524.4	F140LP	30.6	PtNe #1	1439
4921	CSIJ99068224918_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262545.7	F140LP	30.6	PtNe #1	1439
4922	CSIJ99068235112_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262563.9	F140LP	30.6	PtNe #1	1439
4923	CSIJ99069005310_1	EXTERNAL	09/03/99	3600.0	SBC	STUFF	VACUUM	262604.7	F140LP	30.6	PtNe #1	1439
4963	CSIJ99069142033_1	INTERNAL	10/03/99	1000.0	SBC	NONE	VACUUM	61193.0	F115LP	30.6		360
4964	CSIJ99069143837_1	INTERNAL	10/03/99	1000.0	SBC	NONE	VACUUM	61030.1	F115LP	31.0		360
4965	CSIJ99069145808_1	INTERNAL	10/03/99	1000.0	SBC	NONE	VACUUM	60879.2	F115LP	31.0		360
4966	CSIJ99069151646_1	INTERNAL	10/03/99	1000.0	SBC	NONE	VACUUM	60718.6	F115LP	31.0		360
4967	CSIJ99069153556_1	INTERNAL	10/03/99	1000.0	SBC	NONE	VACUUM	60582.9	F115LP	31.0		360
5808	CSIJ99072170559_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	268491.8	F115LP	33.2	PtNe #2	360
5809	CSIJ99072180810_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	265548.7	F115LP	34.1	PtNe #2	360

5810	CSIJ99072190938_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	264621.8	F115LP	34.6	PtNe #2	360
5811	CSIJ99072201116_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	266643.0	F115LP	35.5	PtNe #2	360
5812	CSIJ99072211735_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	264568.1	F115LP	36.0	PtNe #2	361
5813	CSIJ99072222006_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	262713.2	F115LP	36.0	PtNe #2	361
5814	CSIJ99072232143_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	261048.2	F115LP	36.5	PtNe #2	361
5815	CSIJ99073002707_1	EXTERNAL	13/03/99	3600.0	SBC	STUFF	VACUUM	259441.9	F115LP	37.0	PtNe #2	359
5816	CSIJ99073014643_1	EXTERNAL	14/03/99	3600.0	SBC	STUFF	VACUUM	257557.1	F115LP	37.0	PtNe #2	359
5817	CSIJ99073024849_1	EXTERNAL	14/03/99	3600.0	SBC	STUFF	VACUUM	256149.4	F115LP	37.5	PtNe #2	359

Table 2. STATISTICS OF THE FLAT FIELD IMAGES

	F122M EX99065	F125LP EX99066	F140LP EX99064	F140LP EX99068	F150LP EX99065	F165LP EX99064	F115LP EX99072	F115LP IN99069	PR110L EX99068	PR130L EX99067
NUMERATOR			(1)				(1,2)	(3)		
Poisson(%)	0.93	0.96	0.95	0.96	1.00	0.99	1.08	5.80	0.99	1.00
Actual sigma(%)	6.27	6.00	5.84	5.93	5.88	5.64	6.01	8.22	6.06	6.00
Sigma Flat(%)	6.20	5.92	5.76	5.85	5.79	5.56	5.91	5.83	5.97	5.92
Minimum	0.71	0.71	0.71	0.72	0.72	0.72	0.71	0.70	0.71	0.71
Maximum	1.27	1.25	1.23	1.25	1.24	1.23	1.26	1.34	1.24	1.27

	F115LP EX99067
DENOMINATOR	
Poisson(%)	0.97
Actual sigma(%)	6.04
Sigma Flat(%)	5.96
Minimum	0.71
Maximum	1.27

RATIO

	F122M EX99065	F125LP EX99066	F140LP EX99064	F140LP EX99068	F150LP EX99065	F165LP EX99064	F115LP EX99072	F115LP IN99069	PR110L EX99068	PR130L EX99067
Poisson(%)	1.34	1.36	1.36	1.36	1.39	1.38	1.45	5.88	1.38	1.39
Actual sigma(%)	1.48	1.39	1.46	1.46	1.47	1.58	1.54	5.95	1.56	1.52
Resid. sigma(%)	0.64	0.29	0.53	0.51	0.49	0.76	0.52	0.90	0.73	0.63

NOTES:

1. Includes the normal filter position, as well as plus and minus one filter step positions.
2. STUFF Spectralon diffuser used.
3. Internal lamp with few counts.

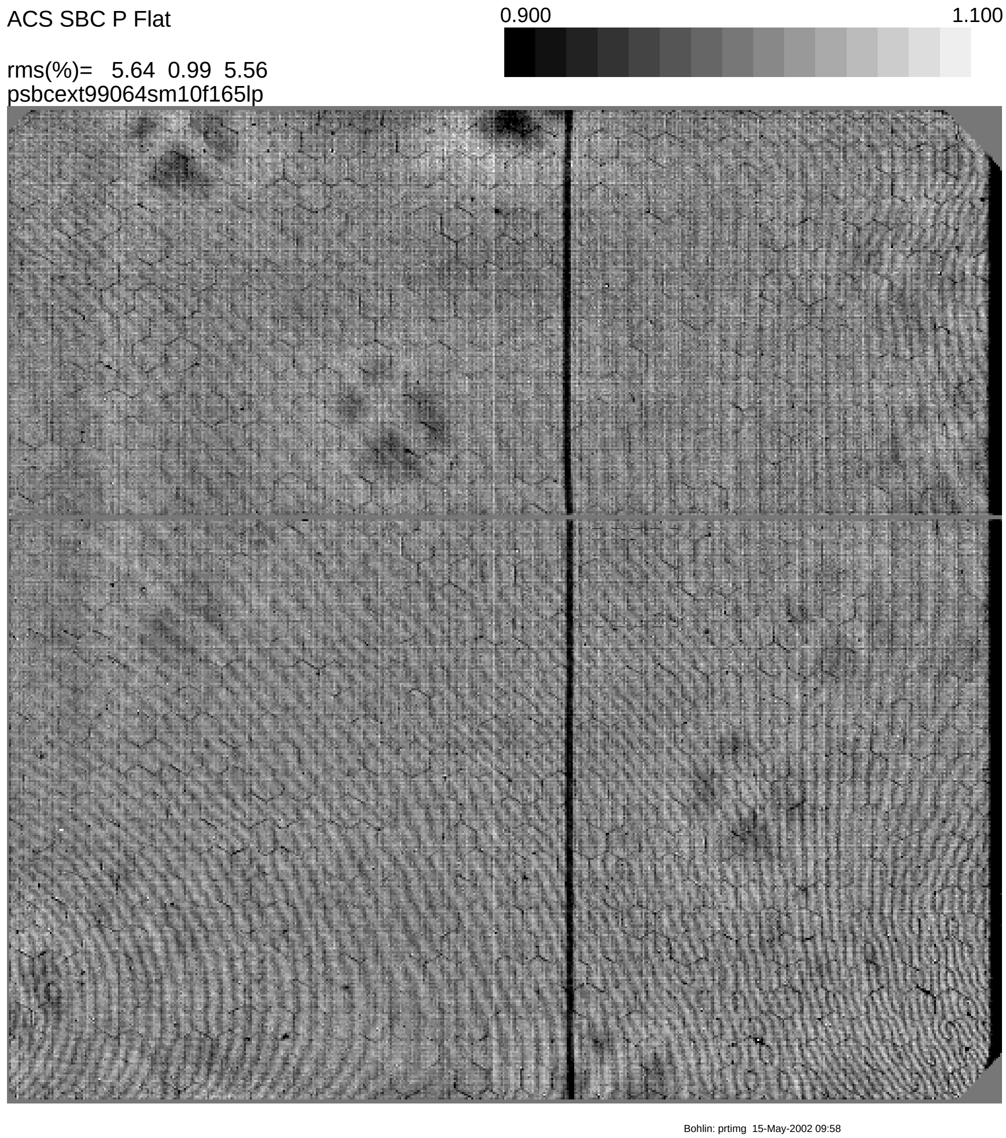

Figure 1: SBC P-flat derived from external STUFF illumination through the F165W filter. The image stretch is from 0.9 to 1.1, as indicated by the reference gray scale at the top. The various cosmetic features are a Moire pattern from interference of the micro-channel plate pores with the MAMA anode array, a hexagonal structure from the bundles of micro-channel plate pores, a vertical and horizontal streakiness from the variation in sensitivity of the MAMA anodes, and a few ’pawprint’ signatures of dust on the filter. The horizontal gray strip at rows 599:604 is a region lacking in sensitivity because of a bad anode and has been set to unity. Small regions in the corners of the detector are vignetted by a mask in front the MAMA. The vertical black streak is the shadow of the repeller wire, which reduces the sensitivity behind the wire by ~10%. The orientation of the flat is in the GO science coordinate frame.

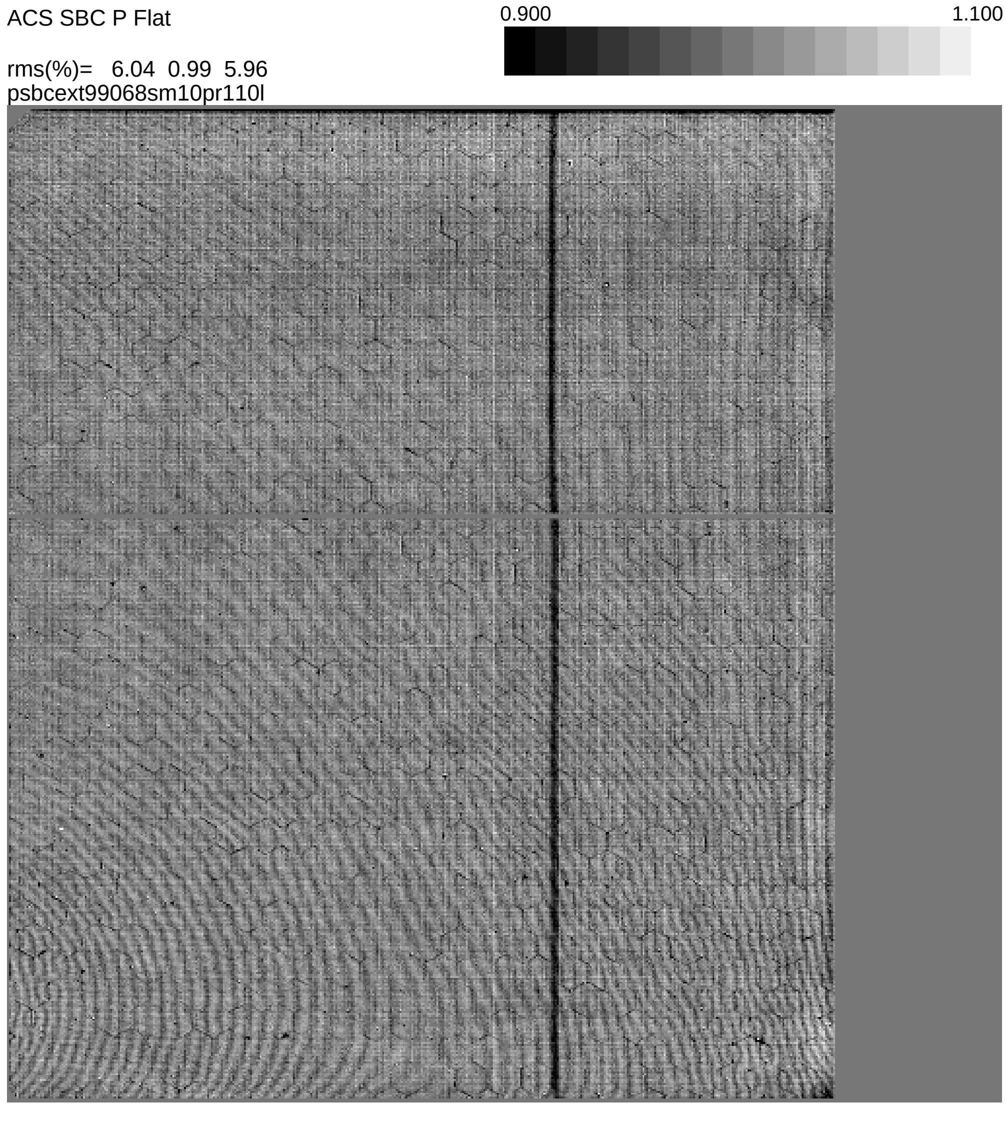

Figure 2: As for Figure 1, except for the prism PR110L. the unit gray region beyond column 850 is not illuminated in a prism exposure.

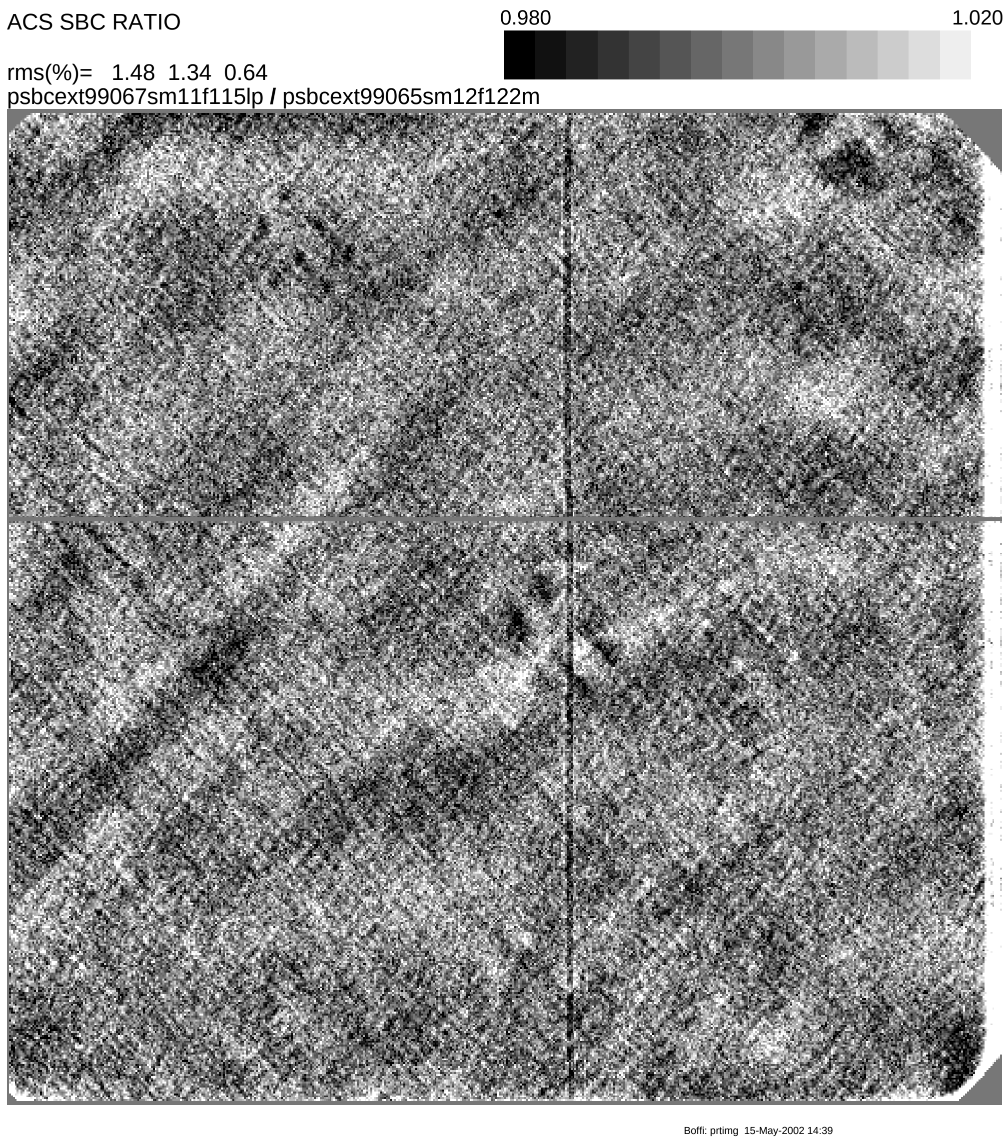

Figure 3: Ratio of the F115LP flat of 1999, day 67 to the F122M flat with a stretch from 0.98 to 1.02. The various weak cosmetic features are discused in the text.

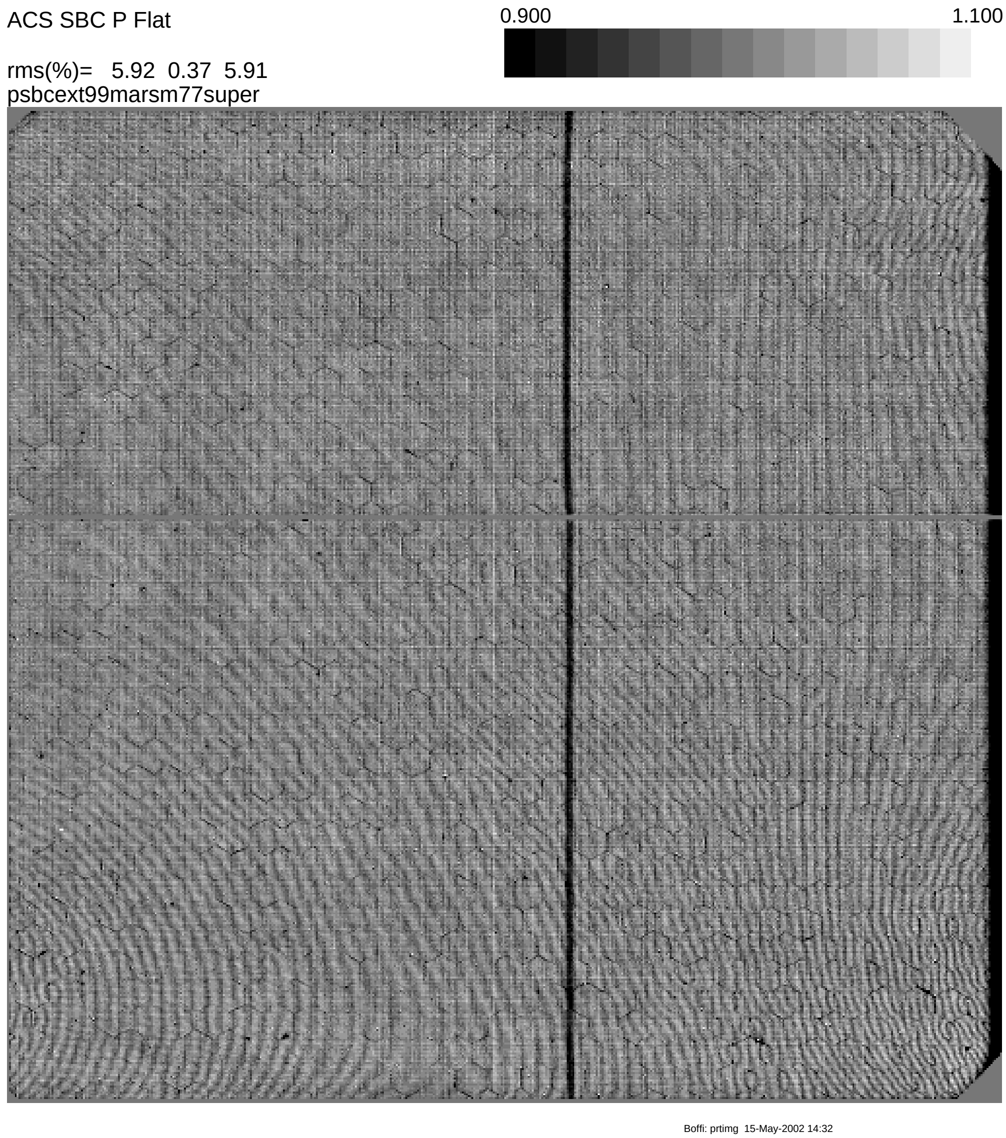

Figure 4: Superflat composed of the average of 7 separate filter flats with a total of 76 individual ~1 hour exposures.

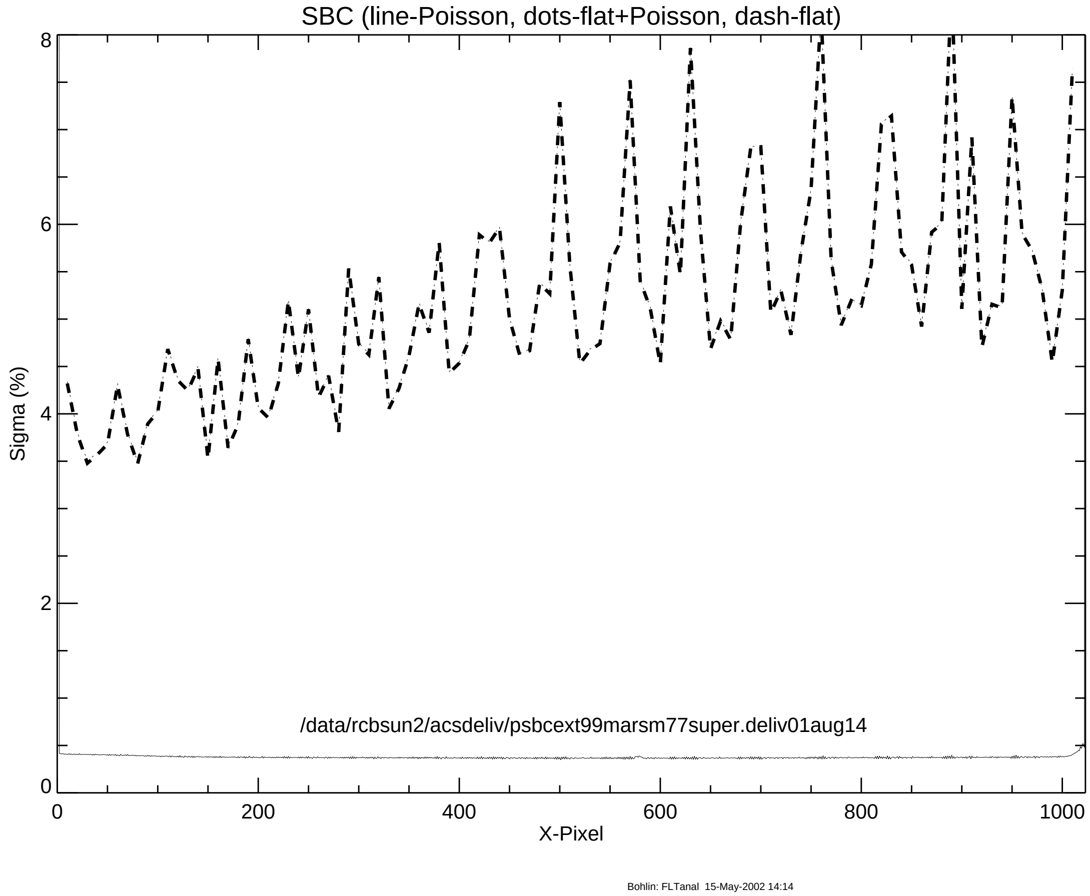

Figure 5: RMS structure in the filter superflat (dash-dot line). The solid line at the ~0.4% level represents the one-sigma Poisson uncertainty per pixel. The two curves represent the behavior of the SBC MAMA in the y-pixel range 450:550 as a function of x-pixel across the detector.