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Notes on STIS Vacuum Alignment Procedure

Note that details of the procedure are still being finalized, so things may change a little bit still. This document will be updated accordingly.

GENERAL COMMENTS:

Mama Overlight Protection

We will be using the band 1 MAMA detector in a variety of observing configurations, many of which have not been tested previously (particularly in vacuum, where the throughput will be higher than it has been in the nitrogen purge testing). There are aperture/lamp/mode combinations that can grossly exceed MAMA safe operating limits (e.g. large aperture exposures in low dispersion or imaging modes). *Avoidance of overlight illumination is critical.* Although the MAMA automatic shutdown protections for global rate violations will be operating (both the direct hardware and event monitor versions), we do not want to be banging the detector high voltage off unnecessarily in this test.

Local rate monitoring with the flight software will not be active for this test. We will have real-time feedback on the MAMA illumination via the oscilloscope display of valid events and GSE monitoring of the valid event rate. Actions can be taken in response to visually alarming event distributions that have not tripped the global protections, but again, we do not want to be cycling the high voltage unnecessarily. Therefore, the following points should be kept in mind:

1. *We will keep global count rates below 300,000 cts/sec and local count rates below 25 cts/sec/pixel (low-res pixel) for this test.*

2. *No motions of the slit wheel or MSM may be made with both the MAMA on and an unblocked lamp turned on.* In other words, for FFUSS exposures, the lamp will be blocked during STIS mechanism motions; for IM calibration subsystem exposures, either the lamps will be off or the CIM will be out of the beam during STIS mechanism motions.

3. *The general strategy will be to "creep up" on the final observing configuration by starting in a "guaranteed safe" configuration, observing the count rate, and then figuring out what the optimal safe setup will be.* For example, external lamp observations will start with high ND values in the FFUSS optical system, which will then be decreased as count rates permit. IM lamp exposures in previously unobserved modes will be made through small slits (sometimes with ND filters); from the count rates seen there, the optimal safe combination of slit size and ND filter will be determined for the final exposure.

4. *Before lamps are unblocked or turned on, explicit confirmation that we have reached the desired observing configuration is required (i.e. telemetry confirmation for STIS hardware, verbal confirmation of GSE setups by the operators).* We do not want to be done in by a typo in the slit wheel or MSM commanding, or by a failure of the mechanism to reach the commanded position.

5. *Before each set of exposures, we need an agreed upon response to modest overlights that have not tripped the global protection, but appear to be undesirable based on the GSE and oscilloscope monitoring.* For example, for FFUSS exposures, the quickest safe response is probably to block the lamp or turn it off. For internal STIS exposures, the quickest safe response is probably to command the lamp off. But there may be situations in which we do need to safe the MAMA high voltage. *This needs to be discussed with MAMA and SITS operators.*

6. *Specific ND values have been chosen for installation on the slit wheel in support of this test; those values and their slit assignments are listed in the Vacuum Alignment Procedure.* Do not use the "nominal slit-ND combinations" listed in the STIS CEI spec or older Ball SERs.

7. *Avoid viewing the turn-on spikes of the Krypton lamp in the IM system and the Pt lamp when run at its 1 mA setting (because it actually turns on at 10 mA and then switches down).* Except when we are explicitly calibrating the turn-on behavior (through small slits in timetag mode), we will turn on these lamps with the CIM out of the beam and then move the CIM into the beam to take the exposure.

<u>Priorities</u>

The nominal procedure goes through an extensive sequence of band 1 observations; for all of these it is highly desirable to have data taken in vacuum. However, if time pressures prevent us from completing the entire nominal procedure, there are portions of the procedure that are more crucial than others. These are:

a) Band 1 throughput (123.6 nm and 147 nm). This is the only opportunity we will have to confirm the vacuum UV throughput before final vacuum testing in the summer. The vacuum UV wavelengths are the most susceptible to contamination; obtaining explicit confirmation that the STIS throughput is as expected at these wavelengths is very important.

b) Cal subsystem throughput measurements (both the continuum and Pt lamps). Observations of the krypton count rates in a variety of modes will be used to determine the final complement of ND filters to be mounted on the slit wheel and in front of the lamp itself. Pt lamp observations are needed so that safe, effective wavecal configurations/exposure times can be determined for all band 1 modes.

It is essential that both of these blocks be completed during the vacuum portion of the testing. Alignment/focus issues can in principle be addressed in nitrogen purge testing, but it is better

to get this data in vacuum as well (no wavelength holes)

High Resolution vs. Low Resolution Analysis

We need to decide what we are doing with regard to high-res vs. low-res readouts for the MAMA data. Are we going to be evaluating resolution performance with high-res readouts rather than rebinning to low-res? If so, we will need to get a decent high-res flat field for this detector, as it will be mated to different electronics than it was for the old flat field images that we have on file. This will have to be done with external lamps if we decide to do so; we do not want to run the internal lamps that long.

Internal Cal Lamp Usage

The internal cal lamps are extremely susceptible to contamination, especially the krypton lamp, whose enormous VUV flux can polymerize contaminating material onto the lamp window. It is therefore desirable to minimize the use of these lamps, as STIS will not have been in vacuum very long and will not have had much time to outgas. We therefore have put most of the cal lamp tests (krypton especially) near the end of the procedure, though we must bear in mind the high priority of completing those measurements within the time available (see above). We also have laid out a procedure in which relatively brief exposures are taken to determine the count rates and basic spectral distribution in various modes, but we do not intend at this time to take high S/N flats with the internal lamps.

Proper Stray Light Shutter Usage

All exposures should be taken with the echelle blocker and mode isolation shutter in the proper positions for the mode in use (echelle blocker in front of the band 1 echelles except when echelle observations are being made, modes 1.3 and 1.4; mode isolation shutter "up" except when mode 1.1, 1.6, or 1.6f observations are being made). We should be gathering this unique data set in as close to a flight-like configuration as possible.

Stray Light/Vignetting

Though the test procedure and these notes will not explicitly comment on stray light and vignetting in every section of the procedure, these are important issues to be kept in mind for every exposure that is taken. Data loggers/data analysts should be on the lookout for any unexpected features in the images indicative of unwanted reflections, scattering, etc. and for any signs of rolloff in the exposures before the edge of the field is reached.

COMMENTS ON SPECIFIC PROCEDURE SECTIONS

8.1 Band 1 Optical Throughput (Kr line lamp)

Purpose: This test is conducted using a krypton line lamp in the GSE, not the flight IM lamp. The purpose is to compare the count rate in the bright krypton lines (mostly 123.6 nm, but a

second line may be present at 116.5 nm) in the various STIS modes with the rate observed with a calibrated reference detector. These data will provide a measurement of the absolute efficiency of the STIS modes at these short VUV wavelengths where contamination is a critical issue, and where accurate throughput data can not be obtained in a nitrogen purge.

Setup: The test setup will project the image of a small pinhole (100 micron diameter) in the FFUSS onto the STIS focal plane, with a large aperture in place at the slit wheel. That spot will be magnified by a factor of approximately 3-3.6, to produce a spot in the detector of 300-360 microns diameter, i.e. 12-15 pixel diameter. In dispersed modes, two such images are expected, one at 123.6 nm (brighter) and a much weaker one at 116.5 nm.

Test conductor: For the unfiltered exposures, keep the rate below 3,000 cts/sec in the MAMA spot; take a long enough exposure to obtain 100,000 cts in the line. For the SrF2 exposure, we are trying to measure or derive an upper limit to a very small expected transmission, so get a good healthy rate on the PMT while keeping the MAMA count rate within safety limits.

Note that we take the filter exposures in the Mode 1.1 configuration rather than Mode 1.6f. This permits us to confirm that we are measuring the transmission of the filter at 123.6 nm and are not being misled by some weak lamp emission at other wavelengths.

Data analyst: Just need to extract the total count rates above background for any lines seen. Compare with the reference photomultiplier count rate and its efficiency to derive the STIS efficiency. Multiple lines confuse the issue, but it is expected that the 123.6 line will strongly dominate the total signal and that a good 123.6 nm efficiency will be derivable.

Results: Compare with efficiency estimates generated by Phil Plait from component level testing and flag any unexpected results.

Stuff We Need:

1. We need calibration data on the PMT + pickoff mirror efficiency from Ball at 116.5, 123.6, and 147 nm.

2. Phil: we need a printout of your predictions for the STIS slit-to-detector efficiency at 116.5, 123.6, and 147 nm in all Band 1 modes.

8.2 <u>Band 1 Optical Throughput (Xe line lamp)</u>

Purpose: Same as for the krypton lamp, except we are now measuring the efficiency of the STIS band 1 modes at 147 nm (the bright peak of xenon lamp emission).

Setup, Test Conductor, Data Analyst: Same as above, but with xenon lamp in the SRS illumination system. Expect a bright “line” near 147 nm, but with significant continuum intensity in the vicinity.

8.3 Band 1 Focus and Wavelength Position Tests (Unscanned Positions)

Purpose: These observations will be used to refine the MSM pointing table (to center the format in the spatial and spectral directions) and to evaluate the resolution performance of the spectroscopic and imaging modes.

Setup: We will be filling the STIS long slits for these measurements, and therefore can not have a pinhole at the FFUSS entrance aperture. The chamber must be brought up to air to remove this pinhole, unfortunately, and then cycled back to vacuum for the remainder of the test. Both external and internal Pt lamps will be used for this test sequence.

Test conductor: For basic pointing information, use the external Pt lamp, even if the slit illumination is not complete or particularly uniform, as long as some spatial reference (e.g. long slit fiducial, or separate exposure through short slit) is available to indicate the pointing in the spatial direction. Pointing determination does not require very deep exposures.

If we derive the necessary pointing corrections quickly and can update the MSM encoder positions, we can run through a corrected set of pointings during this sequence to verify that the updated MSM values do center the format as desired. Once the format is properly centered, the other kind of data we want to get is an exposure that does fill the entire long slit well for first order or imaging modes, in order to provide data on the resolution performance over the full field.

Such exposures may require use of the IM system Pt lamp, as the FFUSS illumination is not likely to fill the long slits adequately. Use the nominal, approximately 2-pixel wide, slit for these resolution measurements. Verify using small slits first that the IM system can be safely viewed in the long slit mode without violating MAMA count rate limits.

Data analyst:

1. Calculate the offsets of the observed spectral images from their nominal positions.

First order and imaging modes:

> In the spatial direction, the inside edges of the occulting bars should be symmetrically placed on the format for modes 1.1 and 1.2. For cross-dispersed modes 1.7x3 and 1.7x4, the slits have no occulting bars, but slit 51 is shorter than the length of the detector; the edges of the slit should be centered on the detector. For mode 1.6 and 1.6f, the image of small slit 21 should be centered on the detector format.
>
> Spectral offsets should be determined by fitting the wavelength scale of the observed spectrum and comparing the central wavelength with the nominal central wavelength. Alternatively, the data analysts may prepare nominal spectral maps for the various settings, using predicted positions of various Pt lamp lines, for direct correlation against the observed spectra.

Echelle modes:

> The observed wavelength map can be compared with Terry Beck's nominal predictions to derive an estimated offset. Blaze centering can be evaluated by taking ratios of the same line seen in consecutive echelle orders and fitting the observed ratio vs. the expected ratio for lines in that position on the detector.

2. Measure image tilts (rolls); plot line center over full range of field angles, position of spatial feature (i.e. edge of fiducial) over full range of wavelengths.

3. Measure the resolution performance over the full wavelength range and full field of the spectral formats.

First order and imaging modes:

> Measure line widths (FWHM), generate line profiles for a number of lines spanning the full wavelength range of the image, at spatial positions spanning the full field of view of the modes (e.g. every 100 low-res pixels or so). If lines are tilted with respect to detector columns/rows, make sure extractions for line profile fits are not broadened artificially by the tilt (i.e. keep the number of columns/rows in the extraction low or actually extract properly along the tilted image).

Echelle modes:

> Measure FWHM for a large number of lines over the entire spectral format.

Stuff We Need:

1. We need a table for all the modes, providing the scaling between offsets in pixels or angstroms and the corresponding delta elevation and azimuth angles. The scaling is derived from the nominal dispersions, focal lengths, plate scales, and diffraction angles of the modes. I will prepare this table.

2. One person on each shift needs to know how to run the MSM pointing program, so that new encoder values can be calculated for the new elevation-azimuth targets calculated for each mode. Susan Downey should provide instruction on this task.

3. Chuck Bowers needs to instruct people on other shifts in how to do the "line ratio" method of determining the blaze centering.

4. We need Jeff Valenti's code for automatically fitting line profiles of features at a variety of field positions and generating plots of line profiles, resolution maps, etc.

8.4 <u>MSM and Slit Wheel Repeatability Test</u>

This test needs to be performed earlier than here in the sequence, preferably during an N2 run-through of the procedure, and certainly ahead of Section 8.3.

Purpose: Alignment data taken in February indicated poor repeatability of the spectral format for supposedly identical MSM and slit wheel positional readouts, well beyond the nominal pointing non-repeatability for those mechanisms. Before taking a lot of "final alignment" data, we have to confirm that these mechanisms and their readouts are working properly and repeatably.

Joe has laid out a brief test here involving a limited amount of cycling among MSM positions without moving the slit and then among slit positions without moving the MSM.

Test Conductor: Exposures need only to be deep enough to permit the positions of several features in the image format to be located precisely, for comparison with repeat observations at the same nominal pointing.

Data Analyst: For each exposure that will be repeated, measure the position of several such distinctive features. Calculate the shifts in pixels for these features for each set of repeated observations.

8.5 Band 1 Scan Positions

This is essentially the same as section 8.3 (and presumably will be done consecutively, once the repeatability test is properly located in the flow). The same goals of determining pointing offsets, calculating new encoder goals, and measuring image quality apply, but now for all the scanned positions of the scanned modes.

New Features in This Section: Once proper pointing of mode 1.4 has been achieved, we will take several exposures with the mono-isotopic Pt lamp to probe the achievable resolution of this mode:

a) with slit 20 (0.09 arcsec wide -- corresponding to 2 pixels slit width)

b) with slit 19 (0.063 arcsec wide -- corresponding to 1.3 pixels slit width)

c) with slit 19 and the repeller off, for evaluation of how much difference the repeller makes

d) with slit 30 (0.025 arcsec wide -- the "Jenkins" slit) and the repeller off, for evaluation of what is the absolute limit of resolution that STIS can achieve. (Do I hear 150,000?)

8. 6 Band 1 Image Quality Over Field of View

Purpose: Measure the image quality of the 1.6 camera mode over its entire field of view.

This will be done by putting the 6 x 6 arcsec slit in position at the slit wheel (corresponding to roughly 250 x 250 pixels on the detector) and using slightly off-nominal tilts of the MSM to project the image of that slit into the edges and corners of the detector format.

Test Conductor: With a count rate limit of 300,000 cts/sec, we will be limited to < 5 cts/pixel/sec over the slit image (somewhere between 0.5 and 5 if the FFUSS provides factor of 10 steps in ND throughput). Try to get hundreds of cts/pixel in each image.

Data Analyst: Measure the edge resolution at a number of positions in the field (at least every 200 low-res pixels or so). *Don L.: What is the best method for quantitatively characterizing this edge resolution?*

Stuff We Need:

1. Chuck Bowers or Dave Michika: confirmation that the small tilts we will be putting into the MSM pointing do not significantly change the ray-traces at the different points in the field we will be probing, i.e. that what we are measuring is representative of the resolution over the field with the MSM at its nominal pointing.

8.7 <u>Cal Subsystem (IM) Throughput</u>

Purpose: There are several broad goals of the testing to be carried out with the IM system krypton, deuterium, and Pt lamps:

a) Finalize the ND filter values to be installed at the slit wheel "cal slits" and in front of the continuum lamps.

b) Determine whether special procedures are required to prevent lamp turnon spikes from over-illuminating the MAMA detectors.

c) Augment the Pt lamp line list at band 1 wavelengths and measure the actual irradiances at both the 10 and 1 mA current settings, as a guide for planning automatic and engineering wavecals for ground and on-orbit use.

These goals are to be accomplished with as low a usage of the internal lamps as is practical. The nominal procedure calls for approximately 2 hours of run time for the krypton lamp, which is the one most vulnerable to contamination.

The specific measurements that we need to get in this vacuum test period in order to satisfy these goals include:

a) Measure the krypton lamp count rates and spectral shapes for the highest and lowest rate settings in the "normal dispersion" modes. This entails measurements in mode 1.1 (highest count rate) and mode 1.2 (at its faintest long wavelength settings).

b) Measure the krypton lamp count rates and spectral shapes for the highest and lowest rate settings in the “cross dispersion” modes. This entails measurements in mode 1.7x3 (highest count rate) and mode 1.7x4 (at its faintest long wavelength setting).

c) Using MAMA timetag mode, measure the count rate vs. time after turnon for the krypton, deuterium, and Pt lamps.

d) Obtain fairly deep Pt lamp exposures in mode 1.1 (to get a more complete band 1 line list) and in mode 1.3 (to get a spectrum with enough resolution to separate blends and permit modelling of the wavecal spectra in mode 1.2).

e) Determine whether the Pt lamp at its 1 mA setting can be used for flat-fielding in the any of the mode 1.6f filtered imaging modes.

Test Conductor: After checking the lamp count rates in small or ND filtered slits, go to the highest count rate safe slit configuration available, in order to get the maximum S/N and most sensitive coverage of the faint portions of the spectrum in the brief exposure times available.

For time tag exposure planning, bear in mind that the buffer memory can hold < 4 million timetag events, so keep the expected count rate * exposure time product well below that. An expected steady state rate of a few thousand per second would probably be about right--we could tolerate an enormously brighter turnon spike without MAMA safing or damage, but would have
enough count rate to get good time resolution on the rate. At that sort of rate, a few minute exposure is no problem.

The diciest part of the test will be the camera mode exposures with the Pt lamp. We will need to VERY carefully examine the mode 1.1 spectra and scale from that what the expected rates per pixel would be through the various filters. The filters for which the predictions are comfortably safe should be tried to confirm that they work. We don’t want to try this for the first time in thermal vac or on orbit. And it is not that difficult, just takes caution and careful checking of the calculations.

Data Analyst: For flat field exposures, extract count rate per pixel vs. wavelength for the various exposures. Divide by the transmission of the ND filter used for that exposure to derive a predicted count rate for a 0.050" clear slit. We will then multiply that by the various available ND filter transmissions to identify the lowest ND value that could be used while staying under the 300,000 cts/sec goal.

For Pt lamp spectra, extract the wavelength-calibrated spectrum, extract count rates in the various lines and compare with Phil and Don’s predictions to derive new irradiances for the various lines. For previously untabulated lines, we will need a calculation of predicted rates per irradiance, which can then be rescaled.

Phil and Don’s programs can then be used to fold the Pt line irradiances through the camera +

filter modes as well.

Stuff We Need:

1. Count rate predictions for the various lamps in the various modes -- these have already been done, just need to have them on hand so that people know about what to expect out of each setup.

2. The cal lamp count rate calculating programs so that new predictions can be made based on observed Pt lamp spectra.

3. Timetag mode data analysis routines to plot count rate vs. time for the lamp turnon exposures.

8.8 Echelle Cross Disperser Scans for Blaze Evaluation

Purpose: The echelle mode spectra are not well centered with respect to the echelle blaze (and appear to have moved in the case of 1.4 compared with data taken in October). The purpose of this test is to try to separate the effects of small tilt errors in the echelle mounting vs. small pointing errors in the MSM pointing of the cross-disperser in order to determine which of these has placed the echelle blaze peak off-center on the detector.

Chuck Bowers has devised a scan of the cross-disperser in the elevation direction (i.e. along the echelle orders rather than in the cross-dispersion direction). By observing the count rates in various lines as a function of this scan angle, we hope to see lines moving along the echelle ripple function but then start to be vignetted. The hope is to find a cross-disperser tilt in the elevation direction in which the blaze is well centered, and there is also no vignetting. If no such solution is found, tweaks to the echelle tilt could be necessary; it would be good to avoid these if possible.

Data Analysis: Chuck will figure out what he wants done to analyze this data.

8.9 Band 1 Selected Retests to Verify MSM Pointing Corrections

Same type of data as earlier sections, just with updated MSM pointing tables. Verify proper centering of the formats in spatial and spectral directions.