HST CALIBRATION WORKSHOP 2005

EVENT PROGRAM

OCTOBER 26–28, 2005

SPACE TELESCOPE
SCIENCE INSTITUTE
3700 San Martin Drive
Baltimore, MD 21218

Local Organizing Committee:

Santiago Arribas
John Biretta
Linda Dressel
Paul Goudfrooij (Chair)
Tony Keyes
Jessica Kim Quijano
Anton Koekemoer
John MacKenty
Dixie Shipley
Marco Sirianni

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Workshop Agenda

Tuesday, October 25, 2005	
5:00 - 7:00	**Evening Reception & Registration** Cash bar available.

Wednesday, October 26, 2005	
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SPECTROGRAPHS 1 *Chair: Gerard Kriss*	
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9:25 - 9:40	STIS First-Order Spectroscopic Flux Calibration *Charles Proffitt*
9:40 - 10:00	The HST/STIS Next Generation Spectral Library *Michael Gregg*
10:00 - 10:20	STIS Calibration Enhancement: Implementation of Model Based Techniques for Wavelength Calibration and Charge Transfer Inefficiency *Paul Bristow*
10:20 - 10:40	Correcting STIS CCD Spectra for CTE Loss *Paul Goudfrooij*
10:40 - 11:00	**Coffee-Break/Poster Session**
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12:20 - 12:40	Mid-UV Spectral Templates from STIS Data: Impact of Echelle-Mode Flux Uncertainties *Ruth Peterson*
12:40 - 1:00	STIS Calibration Enhancement: Dispersion Solutions Based on a Physical Instrument Model *Florian Kerber*
1:00 - 2:00	**Lunch**

P3-7
NICMOS Performance in the Two-Gyro Mode

Sangeeta Malhotra, san@stsci.edu
Space Telescope Science Institute

NICMOS performance was tested under the Two-Gyro Mode with regards to the point spread function, dither performance and coronagraphy. We will summarize these results.

P3-8
NIRSpec Pipeline Concept: A High Level Description

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European Space Agency

NIRSpec is a multi-object spectrograph (up to ~ 100 objects) with a field of view of 10 $arcmin^2$ and a detector response covering nearly a factor of 10 in wavelength, from 0.6 through to 5 micron. It will be employed on JWST, a segmented off-axis telescope in deep space. The combination of all these factors results in a number of unique challenges for the calibration of the NIRSpec instrument. In this paper, we outline the many challenges and present a high-level concept of the NIRSpec pipeline data reduction sequence. We address the calibration products and reference files needed for the pipeline to work in an automated fashion.

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3:15 - 3:30	FGS Astrometry in Two-Gyro Mode *Edmund Nelan*
3:30 - 3:45	The Optical Field Angle Distortion Calibration of HST Fine Guidance Sensors 1R and 3 *Edmund Nelan*
3:45 - 4:05	**Coffee-Break/Poster Session**
	HST SOFTWARE, ARCHIVE & VIRTUAL OBSERVATORY *Chair: Tony Keyes*
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4:20 - 4:40	The HST Archive *Richard L. White*
4:40 - 5:05	Where Will PyRAF Lead Us? The Future of Data Analysis Software at STScI *Perry Greenfield*
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5:30 - 6:30	**DISCUSSION: Spectrographs/CTE** *Lead: Paul Goudfrooij*

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9:30 - 10:00	Modeling and Correcting the Time-Dependent ACS PSF for Weak Lensing *Jason Rhodes*
10:00 - 10:20	The Photometric Calibration of ACS *Marco Sirianni*

10:20 - 10:40	ACS Stellar Photometry with DOLPHOT *Andrew Dolphin*
10:40 - 11:00	**Coffee-Break/Poster Session**
11:00 - 11:20	Calibration of the ACS Emission-Line Filters *Robert O'Dell*
11:20 - 11:45	Slitless Spectroscopy with the Advanced Camera for Surveys *Martin Kümmel*
11:45 - 12:05	Selection and Characterization of "Interesting" Grism Spectra *Gerhardt Meurer*
12:05 - 12:25	Distortion in the WFC Camera *Jay Anderson*
12:25 - 12:50	**2-minute Slide Poster Presentations**
12:50 - 2:00	**Lunch**
IMAGERS 2 *Chair: John MacKenty*	
2:00 - 2:20	ACS Flatfield Update and New SBC L-flats *Jennifer Mack*
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2:35 - 3:00	WFPC2 Status and Calibration *John Biretta*
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ANALYSIS OF DITHERED, UNDERSAMPLED DATA *Chair: Kailash Sahu*	
3:45 - 4:05	Finding Stars in Undersampled ACS Images *Harvey Richer*
4:05 - 4:25	MultiDrizzle Overview and Future Plans *Anton Koekemoer*
4:25 - 4:55	Band-limited Imaging from Undersampled Data *Andrew Fruchter*
4:55 - 5:25	Obtaining Nyquist-sampled Data from Undersampled Images *Tod Lauer*
5:30 - 6:30	**DISCUSSION: Dithering/Undersampled** *Lead: Anton Koekemoer*

WORKSHOP DINNER	
7:30	Cash bar
8:00	Dinner

intrapixel sensitivity. In the end we present the formula to correct this intrapixel sensitivity.

P3-4

New NICMOS Readout Sequences

Chun Xu, chunxu@stsci.edu
Space Telescope Science Institute

On June 12, 2005, 4 new NICMOS multi-accum sequences (SPARS4, SPARS16, SPARS32, SPARS128) were implemented. Observations with these 4 new sequences are carried out (Prop-10721) and the data are analyzed. The observed dark currents are well matched by the dark current model used in the present pipeline. Since these new sequences have equal delta time except for the first few readouts, the data could be better reduced as far as shading is concerned. The users are encouraged to try these new observation modes.

P3-5

Using MultiDrizzle with NICMOS Data

Louis Bergeron, bergeron@stsci.edu
Space Telescope Science Institute

A working example of using the new MultiDrizzle package for NICMOS dithered image combination.

P3-6

Removing Post-SAA Persistence in NICMOS Data

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Space Telescope Science Institute

A general concern with NICMOS images is the issue of "persistence", or residual charge from bright sources and cosmic rays that remain trapped in pixels and is gradually released during subsequent exposures. This is particularly noticeable after HST transits of the South Atlantic Anomaly (SAA), where the cosmic ray rate is so high that their residual flux contributes a significant noise component to many subsequent exposures. We describe the "SAAclean" script which can be run on post-SAA NICMOS images to identify the amount of charge in each pixel that can be attributed to persistent flux from SAA cosmic rays, and applies a correction based on an SAA persistence model to remove this flux from the data. This script has so far been tested on a variety of NICMOS data, and this represents the first delivery of this script in the PyRAF/STSDAS environment to the HST observer community.

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astrometric field, spectrophotometric standard stars, and photometric standard fields.

POSTER SESSION 3

P3-1
NICMOS Calibration Plans

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We will describe the NICMOS Calibration Plans performed since the completion of the Servicing Mission and On-orbit Verification program (SMOV-3B), with special emphasis in those for Cycles 12 through 14. We will present the generic objectives pursued with these plans, and the specific programs involved.

P3-2
Temperature Control of the HST/NICMOS Dewar: Impact on Calibrations

Tommy Wiklind, wiklind@stsci.edu
Space Telescope Science Institute/European Space Agency

We describe the method for temperature control and on-orbit performance of the NICMOS instrument on the HST. A low and steady temperature of the NICMOS dewar is essential for sensitive near-infrared observations. Small variations of the temperature will have an impact on the sensitivity of the detectors. The NICMOS dewar is presently controlled by the NICMOS Cooling System (NCS) and operated at a higher temperature than in the pre-NCS period 1997-1998. The method of temperature control of the NICMOS dewar, the implications for the calibrations and a comparison between pre- and post-NCS performance will be presented.

P3-3
NICMOS IntraPixel Sensitivity

Chun Xu, chunxu@stsci.edu
Space Telescope Science Institute

We present here the new measurements of the NICMOS (Camera 3) intrapixel sensitivity after the installation of the cryo-cooler in Cycle 11. We find a 27% decrease in the intrapixel sensitivity from Cycle 7 to Cycle 11 for both the J (F110W) and K (F160W) bands. The decrease in the intrapixel sensitivity could not be attributed to the change of the PSF as the latter is less than 5%. We also discuss a possible cause for the decrease of the

Friday, October 28, 2005	
8:30 - 9:00	**Breakfast**
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9:30 - 9:50	A Study of NICMOS Non-linearity *Bahram Mobasher*
9:50 - 10:10	NICMOS Calibration Challenges in the Ultra Deep Field *Rodger Thompson*
10:10 - 10:35	Temperature and Bias Variation and Measurement in the NICMOS Detectors *Louis Bergeron*
10:35 - 10:50	**2-minute Slide Poster Presentations**
10:50 - 11:10	**Coffee-Break/Poster Session**
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11:35 - 11:55	Differential NICMOS Spectrophotometry at High Signal-to-Noise *Ronald Gilliland*
11:55 - 12:10	NIC3 FOM Dithered Observations of the Orion Nebula *Louis Bergeron*
12:10 - 12:35	HST Observations in Support of JWST Calibration *James Rhoads*
12:35 - 12:40	Closing remarks
12:40 - 12:50	**Recess to grab lunch**
12:50 - 1:50	**LUNCH/SPLINTER SESSION: Imagers** *Lead: Massimo Stiavelli*

SPECTROGRAPHS 1
Wednesday, 9:05am - 1:00pm

Review and Status of STIS Closeout
Paul Goudfrooij, goudfroo@stsci.edu
Space Telescope Science Institute

The huge archive of STIS observations constitutes a unique source of spectroscopic data in the UV and spatially-resolved spectroscopic data at UV and optical wavelengths. To enable the astronomical community to take full advantage of the quality of archival STIS data, the STIS team has put together a close-out plan for STIS support. The main goal of this plan is to render the full archive of STIS data in a calibration status suitable for performing high-level and high-accuracy science before STIS support at STScI is phased out. In addition, we intend to implement software improvements as well as enhancements related to the retrieval of STIS data from the HST archive. Here we present the major activities in the overall STIS closeout plan as well as an overview of the timeline.

STIS First-Order Spectroscopic Flux Calibration
Charles Proffitt, proffitt@stsci.edu
Space Telescope Science Institute/Computer Sciences Corporation

During the operational lifetime of STIS, the primary emphasis of throughput measurements was the accurate determination of broad band point source fluxes observed using the low dispersion modes at the center of the 52X2 aperture, including measurement of time-dependent changes in sensitivity. We will review the current status and accuracy of this primary flux calibration, and discuss the remaining instrumental and model dependant uncertainties for both low and medium dispersion first-order modes.

The HST/STIS Next Generation Spectral Library
Michael Gregg, gregg@igpp.ucllnl.org
University of California, Davis and Lawrence Livermore National Lab

During Cycles 10, 12, and 13, we obtained STIS G230LB, G430L, and G750L spectra of 378 bright stars covering a wide range in abundance, effective temperature, and luminosity. This HST/STIS Next Generation Spectral Library was scheduled to reach its goal of 600 targets by the end of Cycle 13 when STIS came to an untimely end. Even at 2/3 complete, the library significantly improves the sampling of stellar atmosphere parameter space compared to most other spectral libraries by including the near-UV

Differential NICMOS Spectrophotometry at High Signal-to-Noise
Ronald Gilliland, gillil@stsci.edu
Space Telescope Science Institute

Transiting extra-solar planets present an opportunity for probing atmospheric conditions and constituents by taking advantage of different apparent radii, hence transit depth as a function of wavelength. Strong near-IR bands should support detection of water vapor via G141 spectroscopy of the bright star HD 209458 (H=6.13) by comparing in- and out-of-transit ratios of in- and out-of-band spectral intensity ratios. I will discuss calibration and science observations in which analyses are aimed at reaching the 1 part in 10,000 level, or better, for spectral diagnostics using NICMOS with grism-based spectroscopy.

NIC3 FOM Dithered Observations of the Orion Nebula
Louis Bergeron, bergeron@stsci.edu
Space Telescope Science Institute

The HST Treasury program 10246 used the ACS WFC to survey a large portion of the Orion nebula cluster. In parallel with the ACS, NIC3 observations in F110W and F160W were also taken. In order to cover the largest area possible, the NICMOS Field Offset Mirror (FOM) was used for dithering. The original ground-system FOM offset limits were changed from a radius of 26" (relative to the mechanism 0.0) to ± ~26" along each axis, allowing FOM offsets to the corners of its safe operational range. The known severe vignetting from the forward instrument enclosure bulkhead and spatially varying image quality with FOM offset position must be dealt with to maximize the useful observed image area and ensure proper photometric calibration. Results of these calibration issues are discussed.

HST Observations in Support of JWST Calibration
James Rhoads, rhoads@stsci.edu
Space Telescope Science Institute

The James Webb Space Telescope will be NASA's flagship observatory in the next decade, and will be a worthy successor to the Hubble and Spitzer Space Telescopes. I will outline plans for HST observations of JWST calibration targets. Such observations will help ensure the best possible calibration of JWST by using the unique capabilities of HST. They will also facilitate studies that combine data from two or more of HST, Spitzer, and JWST. I will summarize the motivation and planning for observations of an

Polarimetry with NICMOS

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Space Science Institute

NICMOS cameras 1 and 2 (43 and 76 mas/pixel, respectively) each carry a set of three polarizing elements to provide high sensitivity observations of linearly polarized light. The polarizers are band-pass-limited and provide mid-band diffraction-limited imaging in camera 1 at 0.8 - 1.3 microns, and in camera 2 at 1.9-2.1 microns.

The NICMOS design specified that the intra-camera primary axis angles of the polarizers to be differentially offset by 120 degrees and with identical polarizing efficiency and transmittance. While this ideal concept was not strictly achieved, accurate polarimetry in both cameras, over their full (11" and 19.2" square) fields of view was enabled through ground and on-orbit calibration of the as-built and HST-integrated systems.

The Cycle 7 & 7N calibration program enabled and demonstrated excellent imaging polarimetric performance with uncertainties in measured polarization fractions < app. 1%. After the installation of the NICMOS Cooling System (NCS), the polarimetric calibration was re-established in Cycle 11, resulting in systemic performance comparable to (or better than) Cycle 7 & 7N.

The NCS era NICMOS performance inspired the development of an earlier conceived, but non-implemented, observing mode combining high contrast coronagraphic imaging and polarimetry in camera 2. This mode was functionally tested in the Cycle 7 GTO program (observing the edge-on debris disk of beta Pic), but without a detailed characterization of the instrumental polarization induced by the coronagraph, proper data calibration was not possible. To remedy this shortfall and to enable a new and powerful capability for NICMOS, we successfully executed a program to calibrate and commission the "Coronagraphic Polarimetry" mode in NICMOS in Cycle 13, and the mode was made available for GO use in Cycle 14.

We will discuss the data reduction and calibration of direct and coronagraphic NICMOS polarimetry, and will present early results from programs illustrating the capability. Importantly, NICMOS coronagraphic polarimetry provides unique access to polarized emission near bright targets over a range of spatial scales intermediate between direct polarimetry and ground-based coronagraphic polarimetry using adaptive optics.

and significant numbers of metal poor and super-solar abundance stars. Numerous calibration challenges have been encountered, some expected, some not; these arise from the use of the E1 aperture location, non-standard wavelength calibration, and, most significantly, the serious contamination of the near-UV spectra by red light. Maximizing the utility of the library depends directly on overcoming or at least minimizing these problems, especially correcting the UV spectra.

STIS Calibration Enhancement: Implementation of Model Based Techniques for Wavelength Calibration and Charge Transfer Inefficiency

Paul Bristow, bristowp@eso.org
Space Telescope European Coordinating Facility

The Instrument Physical Modelling Group at the Space Telescope European Coordinating Facility is investigating areas of STIS data calibration which can be enhanced by replacing existing empirical solutions with physical models. A major area of development has been wavelength calibration. We find that, with a simple optical model of the spectrograph and an accurate description of the instrument configuration, we are able to predict the distribution of wavelengths on the detector more accurately than can be achieved with the standard empirical solution. Consequently we have developed optimisation techniques which derive the instrument configuration required by the model from existing calibration data. I will present an example of the improvement in wavelength calibration that is possible and outline the steps required to apply the model to real data.

A further application of physical modelling is in the area of charge transfer efficiency. We have developed a model of CCD readout based upon existing charge transfer theory and laboratory results. I will describe our approach to this problem for STIS, its strengths and weaknesses and relevance to other HST instruments.

Correcting STIS CCD Spectra for CTE Loss

Paul Goudfrooij, goudfroo@stsci.edu
Space Telescope Science Institute

Since the installation of STIS onto HST in Feb 1997, radiation damage to the CCD (primarily due to high energy protons encountered in crossings of the South Atlantic Anomaly) has caused a degradation of its Charge Transfer Efficiency (CTE) which is becoming worse with time. In the 2002 version of the HST Calibration Workshop, we reviewed the empirical calibration tests developed to measure the CTE performance of the STIS CCD in imaging mode, and used the results of those tests to derive a functional form of the

CTE loss per pixel transfer along the parallel register as a function of time, object signal level, and background level. However, spectroscopic data involve a charge structure on the CCD that is inherently different from that of direct imaging, and hence they require a separate correction. Here we present the determination of the functional form of the CTE loss per pixel in SPECTROSCOPIC mode from a variety of calibration data. Differences with results of the CCD readout model-based approach (see Invited talk by P. Bristow) are pointed out and discussed.

Some Neglected Pixel Problems

Kris Davidson, kd@etacar.umn.edu
University of Minnesota

Certain types of instrumental data degradation have usually been ignored in the past because they are inconspicuous in image displays. These typically result from marginal sampling (pixel widths greater than about 1/3 the PSF's FWHM), non-uniform focus, etc. Though subtle, they affect measurements. Some of these effects were critical for the Treasury Program on Eta Carinae, because we needed the best spatial resolution attainable with the HST/STIS, with broad wavelength coverage. Most STIS/CCD users seeking high spatial resolution had experienced serious difficulties, largely because the available software did not include special techniques to compensate for marginal sampling. Here I sketch some of the techniques we have developed for the Eta Car program. We recommend the same general methods for image data obtained with a variety of instruments.

Four specific difficulties noted here include (1) fundamental variations of the PSF due to marginal sampling; (2) robust identification of bad pixels independent of "CR-SPLIT" tests; (3) artifacts in STIS/CCD spectroscopy; and (4) splicing multiple wavelength intervals despite a focus variation across the detector. The first of these is particularly interesting because it is mathematically more difficult than one might have expected.

Spectral Extraction of Extended Sources using Wavelet Interpolation

Paul Barrett, pebarrett@gmail.com
The Johns Hopkins University

Spatially-resolved spectroscopic investigations of extended sources using STIS, such as galactic black hole mass measurements and chemistry in spatially resolved structures around Eta Carinae, use a narrow extraction width (1-2 pixels wide) to minimize source confusion. However, the combination of the finite pixel size of the CCD and the slight tilt of the spectrum cause problems for the CALSTIS extraction algorithm, resulting in

NICMOS observations in the Hubble Ultra Deep Field provide particular challenges. Effects that are either subtle or negligible in other observations can become prominent effects when observing very faint objects over long time periods. The special techniques used in the data processing of the NICMOS UDF observations will be reviewed along with recommendations on NICMOS observing techniques for future faint field observations.

Temperature and Bias Variation and Measurement in the NICMOS Detectors

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Space Telescope Science Institute

The NICMOS detectors on HST are extremely sensitive to changes in operating temperature and supply voltage. These temperature and voltage variations affect quantum efficiency and bias in ways that limit overall sensitivity and make calibration difficult. Several factors influence the operating temperature including the NCS set-point and control law, aft-shroud environment, spacecraft attitude history, and operational duty-cycle of the detectors themselves. In addition, changes on the main HST bus voltage that provides the instrument power can be seen as variations in the detector bias at very low levels. Detector readout timing variations also play a role in the measured detector bias.

Precise measurement of the NICMOS temperature and voltage variations at the location of the detectors is highly desirable for accurate calibration of science data. The detectors themselves, being large diodes, can be used to measure the temperature by correlating changes in the measured bias against a known temperature reference and correcting for any voltage-induced variations. Voltage variations seen in the engineering telemetry (the HST main bus voltage) are shown to be propagated through to the NICMOS detectors. In addition, a fortuitous property of the detector readout timing can also be used to measure the voltage variations directly without the engineering telemetry. Temperature measurement precision in the 5-10mK range is possible using the temperature-from-bias technique. Voltage-induced bias changes from the HST main bus propagated into the NICMOS instrument may be the driver behind the long-standing bias jump or "pedestal" problem, and telemetry or self-measured voltage changes could provide the solution.

INFRARED IMAGERS
Friday, 9:00am – 12:35pm

NICMOS Status

Roelof de Jong, dejong@stsci.edu
Space Telescope Science Institute

I will give an overview of the current status of NICMOS. I will highlight some of the changes that have occurred now that NICMOS has been working at a different temperature over the last three years after the cryo-cooler was installed. Improvements to the data reduction pipeline that have been made will be presented, as well as some of the upgrades to expect in the near future. I will present how the new photometric calibration constants were derived. I conclude with the discovery of a flux rate dependent non-linearity in NICMOS data, what we have done to investigate its cause, and what we are doing to characterize it.

A Study of NICMOS Non-linearity

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Space Telescope Science Institute

Observations of standard stars with NICMOS grism (G096), when compared with the same standards taken with STIS (G750L), show a disagreement over the wavelength range 0.8 to 1 micron. Further comparison with ACS F850LP data confirms this non-linearity to be due to NICMOS in the sense that fainter stars in NICMOS appear too faint relative to a brighter normalisation. We investigate this over a wide magnitude range by compiling samples of stars (spanning $8 < J < 17$) and galaxies (spanning $17 < J < 25$), with available data with both NICMOS (F110W and F160W) and ground-based JH bands. We find no difference between the NICMOS F160W and ground-based H-band. However, in the case of F110W and J-band filters, when allowing for differences in filter response functions, we find a trend at the bright-end ($J< 17$), confirming slight non-linearity. This is interpreted as being due to trapping and difference in exposure times between the bright and faint objects. We conclude that most of the observations will not be affected by this as the source count rates are sufficiently high so that the fraction of charge lost to traps is negligible.

NICMOS Calibration Challenges in the Ultra Deep Field

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Steward Observatory, University of Arizona

spectra having a scalloped pattern (i.e., aliasing). A wavelet interpolation algorithm is presented that nearly eliminates aliasing, while conserving flux. This algorithm is being implemented as an STSDAS task.

Improving the Rectification of Spectral Images

Linda Dressel, dressel@stsci.edu
Space Telescope Science Institute

Single rows in STIS rectified spectral images are being analyzed in science programs where the highest obtainable spatial resolution is needed. I will discuss two problems that have limited the accuracy of the rectified spectral images produced by the STScI pipeline: (1) the changing tilts of the spectral traces across the detector have not been taken into account, and (2) interpolation between rows of spectral images which are undersampled in the cross-dispersion direction has produced substantial artifacts in single rows of the rectified images. To address these problems, post-pipeline software is being developed to produce contemporary traces from stellar exposures, and the time evolution of traces is being characterized so that it can be incorporated into trace reference files. A technique of iteratively subdividing pixels in the cross-dispersion direction, using area interpolation instead of point interpolation, is being developed for a calibration routine which will produce substantially improved rectified images. Preliminary results of the use of these new techniques will be presented here.

Towards a Comprehensive Sensitivity Calibration of the STIS Echelle Modes

Alessandra Aloisi, aloisi@stsci.edu
Space Telescope Science Institute/European Space Agency

I will present the state of the art of the final sensitivity calibration for all the STIS spectroscopic Echelle modes. This includes 1) the derivation of a new absolute sensitivity for all primary settings, 2) the determination of an on-orbit absolute sensitivity calibration for all secondary settings, 3) a quantification of sensitivity variations as a function of time, and 4) a characterization of the Echelle blaze function (shape and shift) versus time and location on the detector (e.g., changes due to the monthly offset). I will quantify the improvements in terms of flux accuracies, and I will give an overview of the tools implemented into the pipeline in order to take all the above mentioned issues correctly into account when calibrating STIS Echelle data.

Mid-UV Spectral Templates from STIS Data: Impact of Echelle-Mode Flux Uncertainties

Ruth Peterson, peterson@ucolick.org
University of California Observatories/Lick and Astrophysical Advances

Echelle-mode fluxes allow a direct test of whether a theoretical stellar spectrum whose line strengths match an observed high-resolution spectrum also reproduces the stellar angular diameter. We discuss particular cases, notably the standard F4IV star Procyon whose mass and angular diameter have been independently determined. In this case, a reduction from 10% to 2% in flux uncertainties would strongly constrain whether stellar-evolutionary tracks can reproduce the parameters of this mildly-evolved star.

In practice, the bulk of STIS first-order spectroscopic observations used apertures smaller than the 52X2, and in recent years a substantial fraction of observations were done at the E1 aperture positions, which were placed closer to the readout to minimize CTI losses. Analysis has now shown that additional grating dependent throughput corrections are needed for these smaller apertures, and vignetting corrections are needed for observations done at non-central positions on the detector, including those observations done at the E1 positions. These corrections can amount to several percent, and failure to include them can result in flux inconsistencies between observations done with different gratings or apertures. Once these corrections are applied, the flux calibration of well centered observations done using the commonly used 52X0.2 aperture should agree with the primary wide aperture calibration to better than 2%.

STIS Calibration Enhancement: Dispersion Solutions Based on a Physical Instrument Model

Florian Kerber, fkerber@eso.org
Space Telescope European Coordinating Facility

The Space Telescope European Coordinating Facility (ST-ECF) embarked on the STIS Calibration (STIS-CE) effort as part of the extension of the Memorandum of Understanding between NASA and ESA for the Hubble Space Telescope (HST). The work was done by the ST-ECF's Instrument Physical Modeling Group (IPMG) in collaboration with the STScI's STIS Team.

Traditionally, calibration of spectrographs is done by empirical methods, e.g. a wavelength dispersion solution is derived by applying a polynomial fit to the emission line spectrum of a calibration exposure. In the model-based approach we make full use of the engineering information used to build the instrument. Our approach comprises a ray trace model describing the geometry of the optical elements and the software needed to compare the

baseline for re-running MultiDrizzle off-line using customized parameters, if required for certain scientific applications. I will review the current status of MultiDrizzle and describe plans for future related pipeline enhancements.

Band-limited Imaging from Undersampled Data

Andrew Fruchter, fruchter@stsci.edu
Space Telescope Science Institute

Over the past decade "Drizzle" has become a de facto standard for the combination of HST images. However, the drizzle algorithm was developed with small, faint, partially-resolved sources in mind, and is not the best possible algorithm for high signal-to-noise unresolved objects. Here, a new method for creating band-limited images from undersampled data is presented. The method uses a drizzled image as a first-order approximation and then rapidly converges toward a band-limited image which fits the data given the statistical weighting provided by the drizzled image. This method eliminates the small high-frequency artifacts that can be introduced by drizzling. The method works well in the presence of geometric distortion, and can easily handle cosmic rays, bad pixels, or other missing data. It can combine images taken with random dithers, though the number of dithers required to obtain a good final image depends in part on the quality of the dither placements.

Obtaining Nyquist-sampled Data from Undersampled Images

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National Optical Astronomical Observatory

Undersampled images, such as those produced by the HST WFPC-2, misrepresent fine-scale structure intrinsic to the astronomical sources being imaged. Analyzing such images is difficult on scales close to their resolution limits and may produce erroneous results. A set of "dithered" images of an astronomical source generally contains more information about its structure than any single undersampled image, however, and may permit reconstruction of a "super-image" with Nyquist sampling. I present a tutorial on a method of image reconstruction that builds a Nyquist super-image from a complex linear combination of the Fourier transforms of a set of undersampled dithered images. This method works by algebraically eliminating the high-order satellites in the periodic transforms of the aliased images. The reconstructed image is an exact representation of the data set with no loss of resolution at the Nyquist scale. The algorithm is directly derived from the theoretical properties of aliased images and involves no arbitrary parameters, requiring only that the dithers are purely translational and constant in pixel space over the domain of the object of interest.

a ~160 x 160 arcsec field of view with 0.039 arcsec pixels, with a rich assortment of broad, medium, and narrowband filters and a UV grism. The IR channel (800-1700nm) incorporates a HgCdTe array with 1014 x 1014 imaging pixels, covering a field of ~130 x 130 arcsec at 0.130 arcsec sampling, also with a sizable complement of filters and grisms. The combination offers HST major advances in near-UV and near-IR imaging.

During 2004 the instrument was fully integrated and underwent a substantial suite of end-to-end characterization and calibration tests, both in ambient and thermal-vacuum conditions. We report here on some of the primary results of those calibrations (basic throughput, resolution, noise levels, etc., demonstrating the surveying speed advantages offered by the instrument) as well as investigations of particular issues such as filter ghosts, inter-channel crosstalk, etc. We also report on the status of improved IR detector arrays that are currently being tested as replacements for the current flight unit.

ANALYSIS OF DITHERED, UNDERSAMPLED DATA

Thursday, 3:45 – 5:25pm

Finding Stars in Undersampled ACS Images

Harvey Richer, richer@astro.ubc.ca
University of British Columbia

We present a new method of finding stars in undersampled ACS images. The algorithm produces hands off clean stellar finding lists that are largely devoid of galaxies, lumps on diffraction spikes and saturation streaks, cosmic rays and other artifacts.

MultiDrizzle Overview and Future Plans

Anton Koekemoer, koekemoe@stsci.edu
Space Telescope Science Institute

The MultiDrizzle program provides a powerful, unified interface to the various steps involves in registering, cleaning and combining dithered HST data using the "drizzle" software. MultiDrizzle can be run on ACS, WFPC2, NICMOS and STIS imaging data in a single step, with default parameters chosen to provide good results for the majority of datasets if standard recommended dithering patterns were followed. Alternatively, the various parameters can be adjusted and specific steps can be run one at a time for additional flexibility, if desired for certain scientific applications. MultiDrizzle has also been incorporated into the HST OTFR pipeline for ACS data, thereby allowing automatic delivery of cleaned, combined data that can be used directly for science in many cases, or alternatively used as a

performance of the instrument as determined by the model with actual calibration data. We then use an optimizer tool which finds, for any given observation, the actual configuration of the instrument. With this method we can close the loop between model description and actual observations resulting in a high fidelity calibration of the instrument. For STIS we have completed the dispersion solution of the high resolution Echelle modes and have demonstrated that all central wavelengths of E140H can be properly described by changing only two parameters of the cross-disperser. An integral part of our approach is the provision of high quality input data: in the case of STIS our work - in collaboration with the Atomic Spectroscopy Group at NIST - on the output of the calibration lamps has remedied a long-standing shortcoming of the calibration. Wavelength calibration of all HST spectrographs has been based on the line list produced by Reader et al. [1] using a Pt-Ne lamp, STIS uses a Pt/Cr-Ne lamp; the addition of Cr is especially significant in the near UV where up to 90 % of the observed lines are Cr but without established wavelength standards they could not be used. Details of these aspects of STIS-CE are also discussed in two posters.

Our new dispersion solution based on an instrument model and using the new Pt/Cr-Ne line list [2] has been successfully applied to scientific data. We give an example (Echelle mode E140H) that illustrates the improvement in the achievable wavelength accuracy in particular the improved agreement between overlap regions from different orders.

[1] J. Reader, N. Acquista, C. J. Sansonetti, and J. E. Sansonetti, ApJS 72, 831 (1990).
[2] C.J. Sansonetti, F. Kerber, J. Reader, M.R. Rosa, ApJS 153, 555 (2004)

SPECTROGRAPHS 2

Wednesday, 2:00 - 2:55pm

NUV-MAMA Prism Calibration

Jesús Maíz Apellániz, jmaiz@stsci.edu
Space Telescope Science Institute

A flux calibration for the STIS NUV-MAMA objective prism that yields a precision of 1% rms in the 1300-3000 Å range with respect to the first-order modes G140L and G230L will be presented. I will also discuss MULTISPEC, a code for the automatic extraction of multiple spectra from slitless exposures that was designed with the STIS objective prism in mind and that was used for its flux calibration.

Results from the Calibration of the Cosmic Origins Spectrograph

James Green, jgreen@casa.colorado.edu
University of Colorado

The Cosmic Origins Spectrograph (COS) had a full thermal-vacuum calibration run in summer 2003, and will undergo another full calibration in 2006 in anticipation of a late 2007 launch. We present the instrument performance and scientific capabilities from the 2003 calibration, plus the results of periodic monitoring of instrument performance since that time.

POSTER SESSION 1

P1-1
Calibration and Interpretation of STIS Imaging Mode Fluxes

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Space Telescope Science Institute/Computer Sciences Corporation

While primarily a spectroscopic instrument, STIS also had a number of imaging modes, many of which provided unique capabilities, especially in the ultraviolet. However, most of the STIS imaging modes also had very wide, non-standard band-passes, making the calibration and interpretation of STIS imaging data especially challenging.

Here we describe the methods used to derive the adopted throughput curves, zero-points, and aperture corrections for these modes and also estimate the remaining uncertainties in these quantities.

The wide, non-standard band-passes of STIS imaging modes also present special challenges when comparing to observations in other photometric systems. To aid in interpretation, we present relations between STIS magnitudes and colors and those of other common photometric systems, with careful attention to the limitations of such transformations. We also discuss how to place STIS imaging observations in the context of the large area SDSS and GALEX surveys currently being conducted.

P1-2
Spectroscopic Point Spread Functions for Centered and Offset Targets

Linda Dressel, dressel@stsci.edu
Space Telescope Science Institute

Finely sampled observational spectroscopic point spread functions (PSFs) have been generated from exposures of stars made with commonly used combinations of first-order gratings and apertures. Lyot stops near the pupil plane of the G430L and G750L gratings block some scattered and diffracted light at the expense of reducing the throughput and broadening the PSF. For G750L, perpendicular-to-slit stepping patterns were performed across a star with the 52X0.1, 52X0.2, 52X0.1E1, 52X0.2E1 apertures to measure the

Pipeline Calibrations of ACS Data

Max Mutchler, mutchler@stsci.edu
Space Telescope Science Institute

Our strategies for collecting ACS calibration data, and converting it into reference files for use in the pipeline, have been continually evolving since the instrument was installed during Hubble Servicing Mission 3B in March of 2002. This talk provides an historical overview of basic ACS pipeline calibrations, including the impact that some of the more recent changes have on downstream data processing (e.g., drizzling).

The emphasis will be on bias and dark calibrations, but significant changes in other calibrations will also be mentioned. I will describe the expected detector degradations that these calibrations are designed to track and correct, and also some unexpected anomalies we have encountered, and the steps we have taken to ameliorate them.

WFPC2 Status and Calibration

John Biretta, biretta@stsci.edu
Space Telescope Science Institute

We review the current status of WFPC2 and its calibration, as well as future plans for special close-out calibrations prior to its eventual de-orbit. WFPC2 continues to perform flawlessly with very little change in its basic calibrations. Beginning in Cycle 14, decontaminations will be scheduled less frequently -- every 50 to 60 days -- to aid scheduling in two-gyro mode. Somewhat unexpectedly, the long-term increase in dark current appears to have slowed during recent years. New insights into CTE effects are discussed. Future plans for both routine calibration and special close-out projects are reviewed. We welcome input from the user community as to areas where the calibration should be improved prior to de-orbit, and invite community participation via the Calibration Outsource program.

Calibration Status and Results for Wide Field Camera 3

Randy Kimble, randy.a.kimble@nasa.gov
NASA Goddard Space Flight Center

Wide Field Camera 3 is a general purpose imager with broad wavelength coverage (200-1700 nm), currently in development for installation in place of WFPC2 in Servicing Mission 4.

The instrument features two channels. The UV/Visible (UVIS) channel (200-1000nm) is based on a two-CCD mosaic (4096 x 4096 pixels total), covering majority of the UVIS filters exhibit excellent performance consistent with or exceeding expectations, a subset show significant filter ghosts. Procurement of improved replacement filters is in progress and a summary of the characterization tests being performed on the new filters is presented. In the IR channel, while no filter ghosting was detected in any of the filters during thermal vacuum testing, the grisms were found to be installed incorrectly; they have been removed and will be reinstalled. In addition, due to the significantly improved response blueward of 800nm expected in the new substrate-removed IR detector (see Invited talk by R. Kimble), two IR filters originally constructed on a fused silica substrate are being remade using an IR grade substrate to block any visible light transmission. Tests of the new IR filters and preparations for the grism reinstallation are summarized.

P2-13
HST Temporal Optical Behavior - Observations & Models

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Co-authors: M. Lallo, R. B. Makidon, S. Casertano

While HST provides a stable stellar image relative to ground-based observatories, it features its own characteristic changes in the PSF it delivers to the Science Instruments. HST focus has been monitored and adjusted throughout the life of the observatory. More recently, the resolution and off-axis location of ACS/HRC have allowed us to accurately determine changes in coma and astigmatism as well. We present the basic modes and timescales of variations in these parameters; we discuss the extent of our modeling, and suggest the value of further examining with the community the effects on HST science observations.

IMAGERS 2
Thursday, 2:00 – 3:25pm

ACS Flatfield Update and New SBC L-flats

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Space Telescope Science Institute

We present an overview of the flatfields currently in use by the calibration pipeline. A recent comparison with sky flats obtained via observations of the bright Earth limb indicate that the CCD flats are accurate at the 1-2% level. New L-flats for the SBC detector have been derived using dithered star cluster observations. Large corrections to the existing flats are required at the 10-20% level, depending on wavelength. Using repeated observations over three years, we detect a loss in the absolute UV sensitivity of 2-3% per year.

spectroscopic PSF for an out-of-slit target, relevant to spectroscopic mapping observations. The observed spectroscopic PSFs have been compared to the predictions of Tiny Tim models, which were developed for slitless direct imaging. Models can easily be generated using no Lyot stop or using the Lyot stop parameters for the CCD mirror, similar to those for the G450L and G750L gratings. The on-target PSFs were generally well fit except for excess observed scattered light at very low levels. The observed offset-slit G750L fluxes were less than predicted, due in part to the differences between the PSF sampled in the slit plane and the PSF modeled on the detector. Observed and modeled PSFs for G750M (with no Lyot stop) and G750L (with a Lyot stop) at the same wavelength are compared.

P1-3
Improving the Spectral Resolution of HST Spectra via LSF Replacement

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University of Colorado - CASA

We present a post-pipeline calibration technique that shows promise in improving the spectral resolution of HST spectra by as much as 70%, while introducing less than a few percent noise to the continuum. This technique removes some of the spectral aberrations caused by the non-Gaussian “scattering wings” present in the line spread functions (LSFs) of many HST instrument+aperture+grating combinations. Our technique replaces the observed LSF with any other LSF, such as that of a smaller aperture or a delta function. In addition to improving single observations, this technique can also be used to place observations taken with different apertures onto a common reference frame (LSF) for increased signal-to-noise and spectral resolution.

P1-4
Spatially-resolved STIS Echelle Spectroscopy

Theodore Gull, Theodore.R.Gull@nasa.gov
NASA Goddard Space Flight Center

Combination of the HST near-diffraction-limited imagery in the Near Ultraviolet with the echelle high dispersion provides spatial information in complex systems. Binary star systems, stars with high mass loss and circumstellar material were observed with the STIS. A line-by-line extraction procedure was developed using the STIS GTO IDL software to provide spectral extractions within the aperture.

Examples will be provided using echelle data of Eta Carinae and its circumstellar structures known as the Weigelt condensations and neutral analogs. Foreground absorptions of the Homunculus and Little Homunculus prove to be mapable in both the echelle and CCD long slit data recorded over the 6 year period from 1998.0 to 2004.3.

P1-5

The Eta Carinae Treasury Project and the HST/STIS

John Martin, jmartin@astro.umn.edu
University of Minnesota

The HST Eta Carinae Treasury Project made extensive use of the HST/STIS from 1998 to the time of its failure in 2004. As the one of the most prolific users of that instrument, the Treasury Project used the cross-dispersed spatial resolution of the STIS as few projects did. We present several enhancements to the existing STIS data reduction methods that are applicable to non-Treasury Project data in the STIS archive.

P1-6

The Geometric Distortion of the STIS MAMAs and the ACS SBC

Jesús Maíz Apellániz, jmaiz@stsci.edu
Space Telescope Science Institute

I will discuss the current and future geometric distortion solutions for three HST detectors: the STIS NUV- and FUV-MAMAs and the ACS SBC. The solution for the NUV-MAMA was calculated based on an astrometric field obtained from WFPC2 observations. New solutions for all three detectors are planned based on HRC observations of two objects: the Scaled OB Association NGC 604 and the globular cluster NGC 6681.

P1-7

COS: NUV and FUV Detector Flatfield Status

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University of Colorado - CASA

Current status of our knowledge of the flatfields for the Cosmic Origins Spectrograph (COS) is presented for both the Near Ultra-Violet (NUV) and Far Ultra-Violet (FUV) detectors. We present and discuss the construction algorithms of the flatfields, and explore their impact on the maximum achievable signal-to-noise of the two COS spectral channels.

P1-8

Correcting for Geometric Distortions on the COS FUV Detector

Stephane Beland, sbeland@colorado.edu
University of Colorado

The Cosmic Origins Spectrograph (COS) Far Ultraviolet (FUV) detector consists of microchannel plates (MCP) and time-delay anodes to provide

and flux- calibrations for the SBC (PR110L and PR130L) and HRC (PR200L) prisms, and discuss some caveats specific to slitless prism spectroscopy. Calibration and configuration files have been defined for the aXe package, allowing users to automatically extract calibrated ACS prism spectra in much the same way as for the G800L.

P2-10

ACS Solar Blind Channel Calibrations

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Space Telescope Science Institute

The ACS MAMA detector, also known as the Solar Blind Channel (SBC) is currently HST's principal detector in the far UV. WFPC2 does operate down to 1150Å with a wider field of view but at lower resolution and efficiency. Since the loss of STIS, more attention is now being paid to SBC calibration. New dark images have been supplied and the flat fields formerly measured on the ground have been refined. The prism modes have also been recently calibrated and an improved distortion correction is being prepared.

P2-11

WFC3 Ground Calibration and Data Processing

Howard Bushouse, bushouse@stsci.edu
Space Telescope Science Institute

The Wide Field Camera 3 (WFC3), scheduled to be installed on HST during the next servicing mission, has undergone extensive ground testing and characterization over the past 18 months. Results of these tests are available as Instrument Science Reports (ISRs) on the WFC3 web site and will be described in this presentation. Because the WFC3 UVIS and IR channels are very similar to the ACS WFC and NICMOS, respectively, the calibration pipeline processing will also be very similar and will be described.

P2-12

Characterization Tests of WFC3 Filters

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Co-authors: R. Boucarut, R. Telfer, J. Kim Quijano, M. Quijada, P. Arsenovic, T. Brown, M. Dailey, D. Figer, G. Hartig, B. Hilbert, R. Kimble, O. Lupie, J. MacKenty, T. Madison, M. Robberto, S. Rice, J. Shu, J. Townsend

The WFC3 instrument to be installed on HST during the next servicing mission consists of a UVIS and an IR channel. Each channel is allocated its own complement of filters: 48 elements for the UVIS (42 filters, 5 quads, and 1 UV grism) and 17 slots for the IR (15 filters and 2 grisms). While a

We discuss the processing, reduction steps, and calibration of imaging data acquired in two minor modes of ACS as part of the ACS GTO programs: HRC coronagraphy of the luminous quasar 3C 273 and imaging of nearby early-type galaxies through narrow-band and ramp filters. We show examples of the data at different stages of the analysis. The fully reduced and calibrated images reveal new morphological features, such as clumps and filaments of dust and ionized gas in the ISM of the galaxies, and an optical synchrotron knot in the jet of 3C 273 near its nucleus.

P2-8

Recent Developments of the ACS Spectral Extraction Software aXe

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The software package aXe provides comprehensive spectral extraction facilities for all the slitless modes of the ACS, covering the WFC grism, the HRC grism and prism, and the SBC prisms. The latest developments cover all ACS slitless modes leading to improved extraction, particularly for the most-used mode, the WFC with the G800L grism. Many thousands of spectra may be present on a single deep ACS WFC G800L image such that overlap of spectra is a significant nuisance. Two methods of estimating the contamination of any given spectrum by its near neighbors have been developed: one is based on the catalogue of objects on the direct image; another uses the flux information on multi-filter direct images. An improvement to the extracted spectra can also result from weighted extraction and the Horne optimal extraction algorithm has been implemented in aXe. A demonstrated small but significant improvement in signal-to-noise can be achieved. These new features will be available in aXe1.5 with the next STSDAS release.

P2-9

Calibration of ACS Prism Slitless Spectroscopy Modes

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Space Telescope European Coordinating Facility, European Southern Observatory

In addition to the G800L grism which provides slitless spectroscopy capability in the optical and near-IR, the Advanced Camera for Surveys is equipped with 3 prisms in the solar-blind and high resolution channels which together cover the 1150-3500 Å range. Following the demise of STIS the interest in using the ACS prisms has increased substantially, and new calibration programmes were undertaken in Cycle 13 in order to provide up-to-date wavelength- and flux calibrations. We present the new wavelength-

photon counting and imaging capabilities. The analog nature of the time-delay anode circuit, makes the computation of the centroid of a cloud of electrons susceptible to variations in the physical construction of the detector. This effect is seen as a distortion in images taken with the FUV detector. The final phases of the fabrication process of the FUV detector showed to have affected its characteristics sufficiently to make the initial geometric distortion maps unusable. A method has been developed during the calibration phase of COS to measure the new maps. This method uses the known spectral lines of a Platinum-Neon lamp to map the distortions across the FUV detector.

P1-9

Performance of the FOS and GHRS Pt/(Cr)-Ne Hollow-Cathode Lamps after their Return from Space and Comparison with Archival Data

Florian Kerber, fkerber@eso.org
Space Telescope European Coordinating Facility

The Space Telescope European Coordinating Facility (ST-ECF) and National Institute of Standards and Technology (NIST) are collaborating to study hollow cathode calibration lamps as used onboard the Hubble Space Telescope (HST).

As part of the STIS Calibration Enhancement Project we are trying to improve our understanding of the performance of hollow cathode lamps and the physical processes involved in their long term operation. The original flight lamps from the Faint Object Spectrograph (FOS) and the Goddard High Resolution Spectrograph (GHRS) are the only lamps that have ever been returned to Earth after extended operation in space. We have taken spectra of all four lamps using NIST's 10.7m normal incidence spectrograph and a Fourier transform spectrometer (FTS). These spectra, together with spectra archived from six years of on-orbit operations and some pre-launch spectra, provide a unique data set - covering a period of about 20 years - for studying aging effects in these lamps.

We have also documented the sensitivity of the lamp's performance to optical alignment in the case of lamps that use a MgF2 lens as entrance window. Our findings represent important lessons for the choice and design of calibration sources and their operation in future UV and optical spectrographs in space.

Acknowledgement: Funding for this project is provided by the European Space Agency (ESA). The FOS and GHRS lamps have been made available by the HST project, the Fiske Planetarium (Boulder, CO) and the National Air and Space Museum (Washington, DC).

P1-10

Characterization of Pt/Cr-Ne Hollow-Cathode Lamps for Wavelength Standards in Space Astronomy

Florian Kerber, fkerber@eso.org
Space Telescope European Coordinating Facility

The Space Telescope European Coordinating Facility (ST-ECF) and National Institute of Standards and Technology (NIST) are collaborating to study hollow cathode calibration lamps as used onboard the Hubble Space Telescope (HST). The project has two main components:

First, we have observed the spectra of Pt/Cr-Ne lamps to obtain wavelengths for all emission lines between 115 and 320 nm. The observations were made at NIST using the 10.7m normal incidence spectrograph and a Fourier transform spectrometer (FTS) optimized for the vacuum ultraviolet (UV) region. The spectral region corresponds to the Space Telescope Imaging Spectrograph (STIS) Echelle modes. Wavelength calibration of all HST spectrographs has been based on the line list produced by Reader et al. [1] using a Pt-Ne lamp, despite the fact that STIS and the Faint Object Spectrograph (FOS) use a Pt/Cr-Ne lamp. The addition of Cr is especially significant in the near UV where up to 90 % of the observed lines are Cr. However, published Cr wavelengths are not sufficiently accurate for the calibration of STIS or FOS. Our work has established accurate wavelengths for more than 5000 Cr lines. The uncertainty is 0.0020 Å (one standard deviation) for lines in the 115-180 nm region measured with the grating spectrograph and 0.0005 Å for the 180-320 nm region observed with the FTS. Wavelength accuracy for some Pt lines is limited by asymmetric line shapes due to unresolved hyperfine and isotope structure.

Second, we are attempting to better understand the performance of hollow cathode lamps and the physical processes involved in their long term operation. Among the issues we have studied is the dependence of the spectrum on lamp current and cumulative operating time. We have performed accelerated aging tests that simulate operations on STIS using newly made space qualified lamps. From these tests we have identified the increase in operating voltage (at a given current) as an obvious and the most easily measurable quantitative indicator for lamp aging.
Our new Pt/Cr-Ne line list has been successfully applied in the STIS Calibration Enhancement effort; hence these results lead directly to an improvement in the quality of scientific data obtained from existing HST spectrographs. Our findings also include important lessons for the operation of future UV and optical spectrographs in space.

Acknowledgement: Funding for this project is provided by the European Space Agency (ESA).

P2-5

Hot Pixel Growth in ACS CCDs

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We review our understanding of the nature of pixels that generate a dark current several times higher than normal pixels. On-orbit radiation damage is responsible for increasing the population of hot pixels with time. Monthly anneals mitigate the damage by sensibly reducing the number of hot pixels. Residual dark rate non-uniformity can impact the accuracy of the data reduction if not taken into account when planning the observations. We review the suggested strategies to mitigate this effect.

P2-6

Automated ACS Bias and Dark Reference File Production, and Improved Detector Trend Analysis

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Co-authors: M. Swam, M. Mutchler, and M. Sirianni

In the past two years, the production of ACS bias and dark calibration reference files has become almost completely automated. Building upon some code and lessons learned from the automated production of STIS reference files, the ACS bias and dark frames are automatically identified in the HST scheduling database and retrieved from the archive as soon as they are available on the ground. A number of formerly manual steps were also written in IRAF scripts, converted into PyRAF format, and strung together using the OPUS pipeline architecture. Routine collection of more and better image statistics has also been implemented, and these are now used in quality control along with inspection of the images. An archive of these statistics and the daily darks has been created, incorporating the files from each new biweekly period. At the same time, a series of scripts are run on the raw bias files and the daily darks to perform statistical analysis of read noise value, bias level, dark rate, and hot pixel population. The results are stored in databases that are used for longer-term trend analysis in order to better characterize the WFC and HRC cameras' performance and the effects of radiation damage, etc. as the detectors age.

P2-7

QSO Coronagraphy and Narrow-band+Ramp Imaging in the ACS GTO Programs

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The Johns Hopkins University

The results of ACS pointing stability tests are presented for the Two-Gyro Mode test conducted in February 2005, as well as the on-orbit check-out after the transition to Two-Gyro mode in August 2005. The goals of the ACS pointing stability analysis were to measure the accuracy with which HST can maintain a given position, as well as execute commanded offsets for POS TARGs and dither patterns. The results from these tests show that there is no significant difference in the quality of HST pointing as measured from these two-gyro tests, relative to the nominal HST behavior under three-gyro operations.

P2-3

ACS Charge Transfer Efficiency: Results from Internal Monitoring and Photometric Measurements

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We present charge transfer efficiency (CTE) measurements on ACS obtained both through internal and external photometric tests. Photometric losses from imperfect parallel CTE are worst for faint stars and low sky background. The measurements of photometric losses from imperfect parallel CTE in the WFC are consistent with the results of internal tests, and show a moderate increase with time. We provide formulae to correct for CTE losses for all flux levels, sky values, and times. We also present the plan for future CTE internal monitoring and external photometric tests on both the WFC and the HRC.

P2-4

Determination of the Charge Transfer Efficiency on Mosaic ACS Data

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Space Telescope Science Institute

All CCDs of the HST suffer a progressive degradation on their CTE, due to the partial loss of signal when charges are transferred down the chip during the readout phase. A detailed characterization of the CTE correction is now available for single exposure ACS images, nevertheless this characterization is often not directly usable. In fact, many programs require complex patterns to obtain a good compromise between hot pixels and CR removal, larger FoV and depth of the observations. Here we propose a simple procedure to determine the appropriate CTE correction for complex mosaic images, characterized by partial overlapping of the single exposures, among which a star can be affected from very different CTE values.

[1] J. Reader, N. Acquista, C. J. Sansonetti, and J. E. Sansonetti, ApJS 72, 831 (1990).

P1-11

Improving the Absolute Astrometry of ACS Data Using GSC-II

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Space Telescope Science Institute

We have used the new GSC-II to significantly improve the absolute astrometric accuracy of a large number of ACS datasets from the first years of ACS operations, reducing the initial levels of uncertainty (typically 1-2", or more in some cases) to an accuracy of about 0.3". There are typically enough GSC-II objects in the field of view of the ACS/WFC detectors to enable a robust solution to be determined by identifying the GSC-II objects and comparing their measured positions with those in the GSC-II. The resulting set of improved header coordinates are accurate enough to permit immediate multi-band comparisons between HST and data from other facilities and wavebands, from X-ray, mid-IR and radio through to data obtained with ground-based telescopes. The Institute has also begun planning to extend this work by including it in the automatic processing pipeline for ACS and eventually perhaps also for other HST instruments.

TWO-GYRO MODE AND FGS

Wednesday, 2:55 – 3:45pm

HST Two-Gyro Mode

Kenneth Sembach, sembach@stsci.edu
Space Telescope Science Institute

The Hubble Space Telescope was originally designed to use three rate-sensing gyroscopes to provide fine pointing control of the observatory during science observations. In order to conserve the lifetime of the HST gyros, one of the functioning gyros was turned off on 28 August 2005 and a new attitude control system that functions with only two gyros was activated. In this mode, two gyros used in combination with the Fine Guidance Sensors provide fine-pointing information during science observations. I will present an overview of the HST instrument performance in this mode and describe what, if any, impacts there may be on various types of science investigations.

FGS Astrometry in Two-Gyro Mode

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Space Telescope Science Institute

The FGS is used for astrometric measurements with accuracies that are typically good to 0.2 mas, as well as to resolve binary systems with separations that are less than HST's diffraction limit. One might expect some degradation of the instrument's scientific performance in two-gyro mode due to increased jitter of the observatory, but this has not been the case. By using the guide star centroids measured in the two guiding FGSs, the observatory's jitter can be modeled and removed from the astrometric observations. It turns out that under two-gyro operations, the structure of the jitter is more "organized" than it is in three gyro mode, so jitter removal is actually more robust in two-gyro mode. Unfortunately, the scheduling of observations is more problematic. Generally, an object can not be observed at both epochs of maximum parallax factor, so some loss of accuracy for parallax measurements may result.

The Optical Field Angle Distortion Calibration of HST Fine Guidance Sensors 1R and 3

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Space Telescope Science Institute

To date five OFAD (Optical Field Angle Distortion) calibrations have been performed with a star field in M35, four on FGS3 and one on FGS1, all analyzed by the Astrometry Science Team. We have recently completed an updated FGS1RFGS3 OFAD calibration. With our approximately 150 observations sets spanning 13 years we have recalculated the proper motions of the M35 stars, based upon McNamara's earlier proper motions catalog and incorporated these newly determined motions into a new OFAD calibration. The ongoing Long Term Stability Tests have also been analyzed and incorporated into these calibrations, which are time-dependent due to on-orbit changes in the FGS. Descriptions of these tests and the results of our OFAD modeling are given. Because all OFAD calibrations use the same star field, we calibrate FGS 1 and FGS 3 simultaneously. Past and future FGS astrometric science supported by these calibrations is briefly reviewed.

HST Software, Archive and Virtual Observatory

Wednesday, 4:05 – 5:25pm

The New GSC-II and its use for HST

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Space Telescope Science Institute

The second generation HST Guide Star Catalog (GSC-II) provides a significant improvement over the original GSC-I. It provides ICRS-based positions with improved accuracy for almost a billion objects as faint as J~21. This will become the default reference frame for HST observations

permits I will outline a technique for isolating the spectra of very compact sources, such as stars and supernovae, without the benefit of a contemporary direct image.

Distortion in the WFC Camera

Jay Anderson, jay@eeyore.rice.edu
Rice University

The material in this talk will come largely from the ISR I am putting together on the distortion solution for the WFC camera. Distortion in the WFC comes from three primary sources: (1) the off-axis optics of the telescope, (2) a small perturbation introduced by each filter, and (3) a small irregularity in the CCD with a pattern that repeats every 68.2667 columns. My solution addresses all three sources of distortion. I will describe how to access my solution and will also give advice on how best to use it. In addition, I will evaluate how breathing and secular variations introduce small additional distortions. Finally, I will present a software program, which I am making public, that measures point sources in WFC images using empirical PSFs that I have derived.

Poster Session 2

P2-1
Analysis of ACS Data from the Two-Gyro Transition

Cheryl Pavlovsky, cherylp@stsci.edu
Space Telescope Science Institute

A summary of PSF stability and pointing accuracy results from data taken during the 2-gyro transition in August 2005 will be presented, along with a comparison of the August 2005 data to the February 2005 2-gyro test and 3-gyro data. Initial results show the PSF measurements agree with the previous 2-gyro test and 3-gyro data, FWHM (pixels): 2.036±0.039 compared to 3 gyro (Apr-Aug 2005) 2.031±0.040. Pointing data shows the total shift rms (milliarcsec) to be 2.08 during the August 2005 transition compared to 2.19 in 3-gyro mode. Final results including jitter, CVZ target, coronagraphy and moving target data and a discussion of any anomalies will be included.

P2-2
The Pointing Stability of ACS in Two-Gyro Mode

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results of this work allow an absolute calibration of the surface brightness of targets in the [OIII] 5007, HI 6563, and [NII] 6583 lines. It is essential that if accurate determination of the HI 6563 line is desired, one must make observations in both the F658N and F660N filters since the former can be strongly contaminated by [NII] emission.

Slitless Spectroscopy with the Advanced Camera for Surveys

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Space Telescope European Coordinating Facility

The Advanced Camera for Surveys (ACS) enables low resolution slitless spectroscopic imaging in the three channels. The most-used mode is grism imaging with the WFC (40Å/pixel), and the same grism also serves the HRC. In the far UV there are two prisms for the SBC and a prism for the HRC in the near-UV. An overview of the slitless spectroscopic mode of the ACS is presented together with the advantages of slitless spectroscopy from space. The methods and strategies developed to establish and maintain the wavelength and flux calibration for the different channels are outlined. Since many slitless spectra are recorded on one deep exposure, pipeline science quality extraction of spectra is a necessity. To reduce ACS slitless data the aXe spectral extraction software has been developed at the ST-ECF. aXe was designed to extract large numbers of ACS slitless spectra in an unsupervised way based on an input catalogue derived from a companion direct image. In order to handle dithered slitless spectra, drizzle, well-known in the imaging domain, has been applied. For ACS grism images, the aXedrizzle technique resamples 2D spectra from individual images to deep, rectified images before extracting the 1D spectra. aXe also provides tools for visual assessment of the extracted spectra and examples are presented.

Selection and Characterization of "Interesting" Grism Spectra

Gerhardt Meurer, meurer@pha.jhu.edu
The Johns Hopkins University

The G800L grism used in conjunction with the ACS WFC allows the detection of numerous emission line and other "interesting" sources in relatively shallow exposures of a few orbits. However, there are many complications in analysing the data, including geometric distortion, spatial variations in the wavelength solution, multiple orders, the wavelength variation of the flatfield, and source structure. I present some techniques to deal with these complications and efficiently find emission line galaxies. I show that the sources found are typically fainter than would be targeted by terrestrial 8+m class telescopes. Combined with multiple broad band photometry redshifts can be extracted to an accuracy of ~ 0.01. If time

starting in Cycle 15 and will reduce the absolute errors of the astrometry in the observation headers from 1-2" down to 0.3-0.5". In addition, the new astrometry can be used to improve the astrometric accuracy of archival HST data, and is also being incorporated into the Digitized Sky Survey (DSS) images.

The HST Archive

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Space Telescope Science Institute

Recent and planned enhancements to the Hubble and MAST archives will be described. Many of our new capabilities make use of the Virtual Observatory, including access to thousands of astronomical catalogs through VizieR, VO-compatible interfaces to MAST data holdings, and the ability to use Aladin to retrieve and display data from MAST and other archives. We are also beginning a new project to put all Hubble data online for instant access, which will enable new services (such as image cutouts at specified sky positions) and new data products (such as object catalogs from HST images.)

Where Will PyRAF Lead Us? The Future of Data Analysis Software at STScI

Perry Greenfield, perry@stsci.edu
Space Telescope Science Institute

PyRAF, which allows the running and scripting of IRAF tasks from Python, was just the first step in STScI's migration to a more flexible and productive data analysis software environment. The ultimate goal is to combine the best of the IRAF and IDL approaches to data analysis software into one environment, one where astronomers can find it easy to write software for, and software developers have sufficient tools and capabilities to handle writing general applications and pipelines. We are in the process of building the infrastructure to support these goals, and are well along in doing so. I will discuss the tools already developed, including PyRAF, numarray, PyFITS, numdisplay and matplotlib, as well as tools in development or that are planned. Finally, I'll review the applications that have been or are being developed and the implications for the user community of our move in this direction.

The National Virtual Observatory and HST

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Space Telescope Science Institute

In the past several years the National Virtual Observatory has progressed from concept to implementation. The NVO provides a suite of core applications for data discovery, multi-wavelength data comparison and analysis, and cross-correlation among large, distributed databases. These applications are layered on a suite of international standards developed by the International Virtual Observatory Alliance and provide access to astronomical catalogs, databases, and archives from data centers worldwide. The NVO provides new opportunities for comparison of HST data with data from other observatories and with theoretical models. Work has also begun on improvements to the HST archive to allow more immediate access to calibrated data and other high-level data products through the VO framework.

IMAGERS 1

Thursday, 9:00am – 12:50pm

ACS Calibration Status

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The Advanced Camera for Surveys is producing spectacular science results that require careful instrument calibration. This talk will provide an overview of recent calibration highlights and calibration plans for Cycle 14. It will also include plans for additional ACS calibrations relevant to understanding the temperatures dependencies of CCD quantum efficiency, charge transfer efficiency, and flat field precision. These latter tests have potential implications for the installation of the Aft Shroud Cooling System in Servicing Mission 4.

Modeling and Correcting the Time-Dependent ACS PSF for Weak Lensing

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Jet Propulsion Lab

The shapes of background galaxies are distorted by foreground dark matter in a process known as weak gravitational lensing. These distortions can be used to map out the foreground mass distribution, from cosmological scales down to the individual haloes of galaxies. Because extremely precise measurements of galaxy shapes are needed to detect weak lensing, any optical distortions and the Point Spread Function (PSF) must be modeled to a high level of accuracy. We have found that both the size and the shape of the ACS PSF vary significantly as a function of time. The variations are likely due to thermal expansions and contractions in HST that alter its effective focus. The effective focus for a given exposure is difficult to predict in advance. Using a modified version of the TinyTim program, we present a method to recover the effective focus using stars in an image, and to interpolate the PSF across the field. We correct the shapes of galaxies in the 2 square degree HST COSMOS survey, and show that the residual PSF contamination is sufficiently small to allow accurate weak lensing measurements. We discuss applications of this method to other weak lensing data sets taken with ACS.

The Photometric Calibration of ACS

Marco Sirianni, sirianni@stsci.edu
Space Telescope Science Institute/European Space Agency

During more than three years of on-orbit operation ACS has proven to be a very stable and repeatable instrument. Several calibration programs have been devoted to directly or indirectly improve the photometric calibration of ACS and our understanding of the most used observational modes has sensibly improved in the last couple of years. We discuss the current status of the photometric calibration of ACS in terms of accuracy of the absolute flux scale and linearity, and examine several possible sources of photometric errors.

ACS Stellar Photometry with DOLPHOT

Andrew Dolphin, adolphin@as.arizona.edu
Steward Observatory

A new stellar photometry package, DOLPHOT, is introduced. This package is based on HSTphot, and includes features for general use as well as an ACS-specific module that parallels the WFPC2-specific features of HSTphot: precomputed PSF libraries, zero points, transformations, and CTE corrections. I also present results from my zero point and CTE calibration projects.

Calibration of the ACS Emission-Line Filters

Robert O'Dell, cr.odell@vanderbilt.edu
Vanderbilt University

On-orbit calibration of the ACS emission-line filters F502N, F658N, and F660N have been made using a bright portion of the Orion Nebula as a reference source. This calibration is important because the conditions for pre-launch measurement of the filter profiles are not those in the ACS. The