

Table of Contents

Preface: How to Use this Handbook	xvii
<i>Handbook Structure</i>	xvii
<i>Handbook Updates</i>	xix
<i>Typographic Conventions</i>	xx
Visual Cues	xx
Keystrokes	xx
Comments	xx

Part I: Introduction to HST Data

Chapter 1 Getting HST Data	1-1
<i>Archive Overview</i>	1-1
Accessing the Archive	1-2
Registering to Retrieve Hubble Data	1-3
Authorization to Retrieve Proprietary Data	1-3
Archive Documentation and Help	1-3
Getting Your Data Quickly	1-4
<i>Getting Data with StarView</i>	1-4
Welcome Screen	1-5
Command Usage and Screen Interaction	1-5
Searching the Catalog	1-6
Retrieving Datasets From the Archive	1-12
Exiting StarView	1-17
Transferring Your Data with FTP	1-17
Running StarView via Remote Access	1-18
<i>Identifying Calibration Reference Files</i>	1-19
<i>Reading HST Data Tapes</i>	1-22
Loading Packages	1-22
Mounting the Tape	1-23

Setting File Format	1-23
Using strfits	1-23

Updated March 1998, v. 3.1

Chapter 2 HST File Formats	2-1
<i>Historical Perspective</i>	2-2
<i>FITS File Format</i>	2-3
Working with FITS Image Extensions.....	2-4
Working with FITS Table Extensions.....	2-7
<i>GEIS File Format</i>	2-10
Converting FITS to GEIS	2-11
GEIS Data Groups.....	2-11
Working with GEIS Files	2-11

Chapter 3 STSDAS Basics	3-1
<i>Navigating STSDAS</i>	3-1
STSDAS Structure	3-2
Packages of General Interest	3-2
<i>Displaying HST Images</i>	3-4
The display Task.....	3-4
Working with Image Sections	3-7
<i>Analyzing HST Images</i>	3-8
Basic Astrometry.....	3-9
Examining and Manipulating Image Data	3-10
Working with STIS and NICMOS Imsets	3-12
Photometry	3-15
<i>Displaying HST Spectra</i>	3-17
FOS and GHRS Spectra.....	3-17
STIS Spectra	3-18
Producing Hardcopy	3-19
<i>Analyzing HST Spectra</i>	3-21
Preparing FOS and GHRS Data.....	3-21
Preparing STIS Spectra for Analysis	3-23
General Tasks for Spectra.....	3-25

STSDAS fitting Package	3-29
specfit	3-32
<i>References</i>	3-32
Available from STScI	3-32
Available from NOAO	3-32
Other References Cited in This Chapter	3-33

Part II: FOC

Chapter 4 FOC Instrument Overview	4-1
<i>Spatial Resolution and PSF</i>	4-2
<i>Filters</i>	4-4
<i>Formats & Fields of View</i>	4-4
<i>Sensitivity</i>	4-5
<i>Polarization & Spectroscopy</i>	4-6
<i>What to Expect</i>	4-7
 Chapter 5 FOC Data Structures	5-1
<i>File Suffixes</i>	5-1
<i>Header Keywords</i>	5-2
<i>Relationship to Proposed Observations</i>	5-7
<i>Paper Products</i>	5-10
 Chapter 6 FOC Calibration	6-1
<i>FOC Pipeline Processing</i>	6-1
<i>FOC Calibration Switches</i>	6-2
Dezooming of Zoomed Images (PIXCORR)	6-2
Absolute Sensitivity Correction (WAVCORR)	6-3
Geometric Correction (GEOCORR)	6-5
Flatfield Correction (UNICORR)	6-7
<i>Reasons to Recalibrate</i>	6-8
Absolute Sensitivity Keywords	6-8

Flatfields	6-9
Geometric Correction Files	6-9
Improved Pipeline Algorithms	6-10
User Calibrations	6-10
<i>How to Recalibrate</i>	6-10

Chapter 7 FOC Error Sources..... 7-1

<i>Overview of FOC Characteristics</i>	7-1
<i>Nonlinearity</i>	7-2
<i>Geometric Correction</i>	7-4
<i>Flatfield Residuals</i>	7-5
Border Effects	7-5
Video and Digitizing Defects	7-7
Reseau Marks, Scratches, and Blemishes	7-8
Pattern Noise	7-8
Large Scale Variations	7-9
Time Variability	7-9
Format-Dependent Effects	7-9
<i>Format-Dependent Sensitivity</i>	7-10
<i>Background</i>	7-11
Detector Background	7-11
Geocoronal Emission Lines	7-12
Zodiacal Light and Diffuse Galactic Background	7-12
Scattered Stray Light	7-12
<i>Filter Induced Image Shifts</i>	7-13
<i>Errors in Absolute Photometry (f/96)</i>	7-14
<i>Absolute Sensitivity of the f/48 Detector</i>	7-15

Chapter 8 FOC Data Analysis..... 8-1

<i>Photometry</i>	8-1
Point Spread Function	8-2
Photometric Accuracy	8-3
<i>Astrometry</i>	8-6
<i>Polarimetry</i>	8-7

<i>Objective-Prism Spectroscopy</i>	8-10
<i>Long-Slit Spectroscopy</i>	8-14
Tribulations of the f/48 Spectrograph.....	8-15
Reduction of f/48 Spectra	8-16
Accuracy of f/48 Spectroscopy	8-16
<i>Summary of FOC Accuracies</i>	8-17

Part III: FGS

Chapter 9 FGS Overview	9-1
<i>FGS Capabilities</i>	9-2
<i>FGS Design</i>	9-3
FGS Optics	9-3
FGS Aperture.....	9-6
S-curves.....	9-8
FGS 1R.....	9-13
<i>FGS Control</i>	9-15
<i>Target Acquisition and Tracking</i>	9-16
Search	9-17
CoarseTrack	9-17
FineLock	9-18
<i>Transfer Scans</i>	9-21
<i>FGS Guiding</i>	9-21
<i>FGS Astrometry</i>	9-22
<i>Astrometry with FGS 3</i>	9-23

Chapter 10 FGS Data Structures	10-1
<i>Engineering Telemetry Data</i>	10-1
<i>FGS Astrometry Files</i>	10-2
<i>Relationship to Phase II Request</i>	10-6

<i>Jitter Files</i>	10-6
<i>SMS Support Data</i>	10-7

Chapter 11 FGS Calibration 11-1

<i>The Visit</i>	11-1
<i>Initial Data Processing</i>	11-2
<i>POSITION Mode Pipeline</i>	11-3
Position Mode Observations	11-3
Processing Individual Observations	11-4
Assembling the Visit	11-5
<i>TRANSFER Mode Pipeline</i>	11-7
TRANSFER Mode Dataset	11-7
Mapping TRANSFER Mode to POSITION Mode	11-7
Limitations of the TRANSFER Mode Pipeline	11-8
<i>POSITION Mode Pipeline Output</i>	11-8

Chapter 12 FGS Error Sources 13

<i>Levels of POSITION Mode Errors</i>	13
<i>Observation-Level POSITION Errors</i>	14
Rotation Angle Errors	14
Centroiding Errors	14
Locating Interferometric Null	17
Optical Field Angle Distortion	19
Lateral Color Error	20
Cross Filter Effect	21
Differential Velocity Aberration	22
Lever Arm Length and Offset Angle	22
<i>Visit-Level POSITION Errors</i>	23
POSITION Mode De-jittering Errors	23
Drift Correction Errors	24
<i>Field-Level POSITION Errors</i>	25
<i>TRANSFER Mode Errors</i>	26

Chapter 13 FGS Data Analysis	29
<i>Analyzing Individual Observations</i>	<i>29</i>
<i>Plate Overlays.....</i>	<i>31</i>
<i>Resolving Structure with TRANSFER Mode</i>	<i>33</i>
FGS Response to a Binary	34
TRANSFER Mode Data Reduction.....	37
Uncertainties in TRANSFER Mode Data	38

Part IV: NICMOS

Updated March 1998, v. 3.1

Chapter 14 NICMOS Instrument

Overview.....	14-1
<i>Instrument Overview.....</i>	<i>14-1</i>
<i>Detector Readout Modes</i>	<i>14-2</i>
MULTIACCUM.....	14-3
ACCUM.....	14-4
BRIGHTOBJ	14-4
RAMP	14-5

Updated March 1998, v. 3.1

Chapter 15 NICMOS Data Structures

<i>NICMOS Data Files</i>	<i>15-1</i>
File Name Suffixes.....	15-2
Science Data Files.....	15-3
Auxiliary Data Files	15-9
<i>Header Keywords.....</i>	<i>15-10</i>
<i>Working with NICMOS Files</i>	<i>15-15</i>
<i>From the Phase II Proposal to Your Data</i>	<i>15-21</i>
<i>Paper Products</i>	<i>15-22</i>

Chapter 16 NICMOS Calibration	16-1
<i>Pipeline Processing</i>	16-1
<i>NICMOS Calibration Software</i>	16-2
The Calibration Pipeline	16-2
Grism Spectroscopy	16-3
<i>Basic Data Reduction: calnica</i>	16-3
<i>Mosaicing: Calnicb</i>	16-10
Input Files	16-11
Output Files	16-12
Processing	16-13
<i>Grism Data Reduction: Calnicc</i>	16-16
Input Files	16-16
Output Files	16-16
Processing	16-18
<i>Recalibration</i>	16-21
Why Recalibrate?	16-21
Recalibrating the Data	16-22
Calculating Absolute Sensitivity	16-24
 Chapter 17 NICMOS Error Sources	 17-1
<i>Flatfield Errors</i>	17-1
Thermal-Vacuum versus On-Orbit Flatfields	17-1
Characteristics and Uncertainties of Flatfields	17-2
Color Dependence of Flatfields	17-6
<i>Dark Current Subtraction Errors</i>	17-7
Dark Current Pedestal	17-7
Synthetic MULTIACCUM Darks	17-8
Uncertainties in the Synthetic Darks	17-10
<i>Instrument Artifacts</i>	17-11
Non-Zero Zeroth Read Correction for Bright Sources	17-11
Effects of Overexposure and the “Mr. Staypuft” Anomaly	17-11
Vignetting	17-12
Amplifier Glow	17-12

Intra-Pixel Sensitivity Variations	17-13
Hot Pixels, Cold Pixels, and Grot.....	17-13
<i>Cosmic Rays</i>	17-14
<i>Calibration Goals</i>	17-14

Chapter 18 NICMOS Data Analysis..... 18-1

<i>STSDAS Software</i>	18-1
<i>Photometric Calibrations</i>	18-2
Units for NICMOS Photometry.....	18-3
Fluxes and Magnitude Zeropoints	18-3
Photometric Corrections	18-4
Magnitudes and Photometric Systems Transformations.....	18-8
Absolute Photometry for Emission Line Filters	18-9
Absolute Spectrophotometry with NICMOS Grisms	18-10
<i>PSF Subtraction</i>	18-11
<i>Analysis of Polarization Images</i>	18-12
Introduction	18-12
Theory.....	18-13
A Useful Script for Polarization Analysis.....	18-14

Part V: STIS

Updated March 1998, v. 3.1

Chapter 19 STIS Overview..... 19-1

<i>Instrument Capabilities and Design</i>	19-1
<i>Basic Instrument Operations</i>	19-4

Updated March 1998, v. 3.1

Chapter 20 STIS Data Structures 20-1

<i>Overview</i>	20-1
<i>STIS File Structures</i>	20-2

STIS FITS Image Extension Files.....	20-2
Tabular Storage of STIS Data	20-5
<i>Types of STIS Files</i>	20-6
Understanding Associations	20-6
<i>Headers, Keywords, and Relationship to Phase II</i>	20-9
<i>Error and Data Quality Arrays</i>	20-13
The Error Array	20-14
Data Quality Flagging	20-14
<i>STIS Paper Products</i>	20-15

Updated March 1998, v. 3.1

Chapter 21 STIS Calibration	21-1
<i>Pipeline Processing Overview</i>	21-1
<i>Structure of calstis</i>	21-3
<i>Data Flow Through calstis</i>	21-9
<i>Descriptions of Calibration Steps</i>	21-15
<i>Recalibration of STIS Data</i>	21-29
Mechanics of Full Recalibration.....	21-30
Rerunning Subsets of the Calibration Pipeline	21-33
<i>Updates to calstis</i>	21-35

Chapter 22 STIS Error Sources	22-1
<i>Calibration Goals</i>	22-1
<i>Calibration Accuracy Resources</i>	22-3
<i>Factors Limiting Flux and Wavelength Accuracy</i>	22-5
Flux Accuracy	22-5
Wavelength and Spatial Accuracies	22-6

Updated March 1998, v. 3.1

Chapter 23 STIS Data Analysis	23-1
<i>Data Reduction Applications</i>	23-1

<i>STIS-Specific Reduction and Analysis Tasks</i>	23-2
<i>Working with Two Dimensional Extracted Spectra</i>	23-3
Sensitivity Units and Conversions	23-3
Wavelength and Spatial Information.....	23-5
<i>TIME-TAG Data</i>	23-6
<i>Target Acquisition Data</i>	23-8

Part VI: WFPC2

Chapter 24 WFPC2 Instrument Overview	24-1
---	------

Chapter 25 WFPC2 Data Structures	25-1
<i>Data Files and Suffixes</i>	25-1
<i>Header Keywords</i>	25-3
<i>Correlating Phase II Exposures with Data Files</i>	25-8
<i>WFPC2 Paper Products</i>	25-10

Chapter 26 WFPC2 Calibration	26-1
<i>Overview of Pipeline Calibration</i>	26-3
<i>Standard Pipeline Calibration</i>	26-5
Calibration Files	26-6
Calibration Steps	26-7
<i>Recalibration</i>	26-10
Why and When to Recalibrate	26-10
Assembling the Calibration Files	26-13
Setting Calibration Switches	26-13
<i>Post-Pipeline Calibration</i>	26-15
Warm Pixels.....	26-16
Removing Cosmic Rays from Co-aligned Images	26-20
Charge Traps.....	26-22

Chapter 27 WFPC2 Error Sources	27-1
<i>Bias Subtraction Error</i>	27-2
<i>Flatfield Correction Errors</i>	27-2
<i>Dark Current Subtraction Errors</i>	27-3
Electronic Dark Current	27-3
Dark Glow	27-4
<i>Image Anomalies</i>	27-5
Bias Jumps	27-5
Residual Images	27-6
PC1 Stray Light	27-10
Other Anomalies	27-11

Updated March 1998, v. 3.1

Chapter 28 WFPC2 Data Analysis	28-1
<i>Photometric Zero Point</i>	28-2
Photometric Systems Used for WFPC2 Data	28-2
Determining the Zero Point	28-4
<i>Photometric Corrections</i>	28-6
Time-Dependent Corrections	28-6
Position-Dependent Corrections	28-11
Other Photometric Corrections	28-13
An Example of Photometry with WFPC2	28-15
<i>Polarimetry</i>	28-16
<i>Astrometry</i>	28-18
<i>Dithering</i>	28-19
<i>Accuracy of WFPC2 results</i>	28-24
References	28-25

Appendixes

Appendix A IRAF Primer	A-1
<i>Initiating IRAF</i>	A-1
Setting Up IRAF	A-2
Starting and Stopping an IRAF Session	A-3
<i>IRAF Basics</i>	A-4
Loading Packages	A-4
Running Tasks	A-5
Getting Help	A-6
Setting Parameters	A-8
Setting Environment Variables	A-10
File Management	A-11
Troubleshooting	A-13
<i>Getting IRAF and STSDAS</i>	A-13
Retrieving the IRAF and STSDAS Software	A-14
Getting the Synphot Database	A-15
Extracting the synphot Unix Tar Files	A-15
 <i>Updated March 1998, v. 3.1</i>	
Appendix B HST File Names	B-1
 Appendix C Observation Logs	C-1
<i>Observation Log Files</i>	C-1
<i>Retrieving Observation Logs</i>	C-8
<i>Using Observation Logs</i>	C-9
Guiding Mode	C-9
Guide Star Acquisition Failure	C-10
Moving Targets and Spatial Scans	C-11
High Jitter	C-11
 Appendix E Resources on the Internet	E-1

Glossary F-1

Index IX-1