CHAPTER 1:

Quick Reference Guide

In this chapter. . .

Hint: The synphot task obsmode can be used to quickly look up legal completions of a given obsmode. For example, to determine the available set of central wavelengths for the G230m grating for STIS, one may type `obsmode stis,g230m`

Hint: The synphot task modeinfo can be used to quickly look up additional information about legal keywords for each instrument. For example, one may type `modeinfo stis` ***to obtain a list and brief discussion of available keywords.***

1.1 Current Instruments

This section describes the keywords available for the science instruments installed on HST as of January, 2005: the Advanced Camera for Surveys (ACS), the Fine Guidance Sensor (FGS), the Near Infrared Camera and Multi-Object Spectrograph (NICMOS), the Space Telescope Imaging Spectrograph (STIS), and the Wide Field Planetary Camera 2 (WFPC2).

1.1.1 ACS

The ACS keywords consist of a list of detectors, filters, and extraction apertures. The coronagraphic mode may be used only with the HRC detector.

Table 1.1: ACS Keywords

Detectors	hrc sbc wfc1 wfc2
Filters for wfc	pol_uv f475w f502n f550m f555w f606w f625w f658n f775w f850lp f892n pol_v f435w f660n f814w
Filters for hrc	pol_uv f475w f502n f550m f555w f606w f625w f658n f775w f850lp f892n pol_v f220w f250w f330w f344n f435w f660n f814w
Filters for sbc	f122m f115lp f125lp f140lp f150lp f165lp
Ramp filters for wfc	fr388n# fr423n# fr462n# fr459m# fr647m# fr914m# fr505n# fr551n# fr601n# fr656n# fr716n# fr782n# fr853n# fr931n# fr1016n#
Ramp filters for hrc	f122m# f115lp# f125lp# f140lp# f150lp# f165lp#
Dispersers for wfc	g800l
Dispersers for hrc	g800l pr200l
Dispersers for sbc	pr110l pr130l
Encircled energy radius values	aper#0.0, aper#0.1, aper#0.2, aper#0.3, aper#0.4, aper#0.5, aper#0.6, aper#0.8, aper#1.0, aper#1.5, aper#2.0, aper#4.0
Other	coron

1.1.2 FGS

The FGS instrument keywords consist of a list of filters plus a coordinate axis. Some of the filter names are aliases for other filters. "astroclear" is an alias for "F605W", "clear" is an alias for "F583W", "red" is an alias for "F650W", and "yellow" is an alias for "F550W". One example of an FGS observation mode string would be "`FGS,F583W,Y`".

Table 1.2: FGS Keywords

Filter	f550w (yellow) f583w (clear) f605w (astroclear) f650w (red) nd5 pupil
Axis	x y

1.1.3 NICMOS

The NICMOS keywords consist of a list of filters, grisms, polarizers, and detectors. Both the filter name and camera number are required in the observation mode. (The detector keyword `tacq` is another way to specify detector 2.) The `dn` keyword is used to divide throughputs by the analog-to-digital converter (ADC) gain ratio, which transforms results from units of electrons to data numbers (DNs). For thermal calculations, all component keywords except the detector may be parameterized for temperature.

Table 1.3: NICMOS keywords

Detectors	1 2 3 tacq
Filters for Camera 1	blank f090m f095n f097n f108n f110m f110w f113n f140w f145m f160w f164n f165m f166n f170m f187n f190n pol0s pol120s pol240s
Filters for Camera 2	blank f100w f160w f165m f171m f180m f187n f187w f190n f204m f205w f207m f212n f215n f216n f222m f237m pol0l pol120l pol240l
Filters for Camera 3	blank f108n f110w f113n f150w f160w f164n f166n f175w f187n f190n f196n f200n f212n f215n f222m f240m g096 g141 g206
ADC gain	dn dqe
Thermal components	spider primary pads hole sec edge bend1 reimag pupil image para1 para2 bend dewar cmask

1.1.4 STIS

The available keywords for STIS include filters, apertures, gratings, central wavelengths, and ADC gains. Each grating or imaging mirror can be used with only one of the three STIS detectors (CCD, NUVMAMA, or FUVMAMA); specifying the grating automatically determines the detector. If no central wavelength is specified, results will be calculated for the entire bandpass of the grating. The ADC gain keywords only apply to the STIS CCD modes and are used to convert results from units of electrons to DNs.

In addition to the aperture names as given in Table 1.4, synphot will recognize aperture names as given in the format used for phase 2 proposals. For example, the aperture name "52X0.05" is equivalent to the aperture "s52x005" listed in the table.

For important additional details about specifying STIS obsmodes, see Section 3.2, “Specifying STIS observation modes,” on page 20.

As of January, 2005, STIS is in safe mode due to the failure of the Side 2 power supply in August 2004 (Side 1 had failed in 2001). It is unknown whether STIS can be returned to operability.

Table 1.4: STIS keywords

Filters	25mama 50ccd 50coron f25ciii f25cn182 f25cn270 f25lya f25mgii f25nd3 f25nd5 f25ndq1 f25ndq2 f25ndq3 f25ndq4 f25qtz f25srf2 f28x50lp f28x50oii f28x50oiii
Apertures	s005x29 s005x31nda s005x31ndb s009x29 s01x003 s01x006 s01x009 s01x02 s02x005nd s02x006 s02x006fpa s02x006fpb s02x006fpc s02x006fpd s02x006fpe s02x009 s02x02 s02x02fpa s02x02fpb s02x02fpc s02x02fpd s02x02fpe s02x05 s02x29 s03x005nd s03x006 s03x009 s03x02 s05x05 s10x006 s10x02 s2x2 s31x005nda s31x005ndb s31x005ndc s36x005n45 s36x005p45 s36x06n45 s36x06p45 s52x005 s52x01 s52x02 s52x05 s52x2 s6x006 s6x02 s6x05 s6x6
Gratings	e140h e140hb e140m e140mb e230h e230m g140l g140lb g140m g140mb g230l g230lb g230m g230mb g430l g430m g750l g750m prism x140 x140m x230 x230h
Mirrors	acq ccd fuvmama nuvmama
Central wavelengths	all c1687 c1769 c1851 c1933 c2014 c2095 c2176 c2257 c2338 c2419 c2499 c2579 c2659 c2739 c2818 c2898 c2977 c3055 c3134 i1884 i2600 i2800 i2828 c1713 c1854 c1995 c2135 c2276 c2416 c2557 c2697 c2836 c2976 c3115 i2794 c1978 c2707 i2124 i2269 i2415 i2561 c1763 c2013 c2263 c2513 c2762 c3012 i1813 i1863 i1913 i1963 i2063 i2113 i2163 i2213 i2313 i2363 i2413 i2463 i2563 i2613 i2663 i2713 i2812 i2862 i2912 i2962 c3165 c3423 c3680 c3936 c4194 c4451 c4706 c4961 c5216 c5471 i3305 i3843 i4781 i5093 c1173 c1222 c1272 c1321 c1371 c1420 c1470 c1518 c1567 c1616 c1665 c1714 i1218 i1387 i1400 i1540 i1550 i1640 c1425 c1234 c1416 c1598 i1271 i1307 i1343 i1380 i1453 i1489 i1526 i1562 c7751 c8975 c10363 c10871 c5734 c6252 c6768 c7283 c7795 c8311 c8825 c9336 c9851 i6094 i6581 i8561 i9286 i9806
ADC Gains	a2d1 a2d2 a2d3 a2d4
Modified Julian Date	mjd#

1.1.5 WFPC2

The WFPC2 keywords consist of a list of detectors, filters, and miscellaneous keywords. The miscellaneous keywords include the ADC gain keywords `a2d7` and `a2d15`, which convert results from units of electrons to data numbers (DNs); `cal`, which accounts for the flat-field response; `lrf#`, which is used for the linear ramp filters; and `cont#`, which accounts for changes in throughput between decontamination events (see Chapter 2:Parameterized Keywords for more details on the latter two).

The WFPC2 has twelve filter wheels, each of which has five positions, including a clear position. Detector 1 is the PC chip; detectors 2 through 4 are the Wide Field chips. If a detector is not specified, the default is #4. A typical WFPC2 observation mode string would be "`WFPC2,F450W,2`".

Table 1.5: WFPC2 keywords

Detectors	1 2 3 4
Miscellaneous	a2d7 a2d15 cal cont#
Filter Wheel 1	f122m f157w f160bw f953n
Filter Wheel 2	f130lp f165lp f785lp f850lp
Filter Wheel 3	f336w f410m f467m f547m
Filter Wheel 4	f439w f569w f675w f791w
Filter Wheel 5	f343n f375n f390n f437n
Filter Wheel 6	f469n f487n f502n f588n
Filter Wheel 7	f631n f656n f658n f673n
Filter Wheel 8	f170w f185w f218w f255w
Filter Wheel 9	f300w f380w f555w f622w
Filter Wheel 10	f450w f606w f702w f814w
Filter Wheel 11	f1042m fqunv fqunv33 fqch4n fqch4n33 fqch4n15 fqch4p15 polq polq_par polq_perp polqn33 polqn18 polqp15
Filter Wheel 12	lrf#

1.2 Non-HST Filter Systems

In addition to the HST instrument components, the graph table also supports various standard filter system passbands. The passband keyword string consists of the name of the system plus the passband name. An example of a passband observation mode string would be "`COUSINS,I`". If no system name is given for any of the UBVRIJHK bands, the defaults are Johnson UBV, Cousins RI, and Bessell JHK. For example, "v - r" will result in Johnson V minus Cousins R.

For a more detailed description of these filter systems, see Section 3.3, “Non-HST Photometric Systems,” on page 21

Table 1.6: Non-HST Filter Systems

System	ans baum bessell cousins johnson kpno landolt sdss steward stromgren walraven
ANS Bands	1550 1550n 1800 2200 2500 3300
Baum Bands	f336w f439w f547m f555w f569w f606w f622w f675w f702w f725lp f785lp f791w f814w f850lp f1042m
Bessell Bands	J H K
Cousins Bands	R I
ESO Bands	
Johnson Bands	U B V R I J K
KPNO Bands	J H K
Landolt Bands	U B V R I (= Johnson UBV + Cousins RI)
SDSS Bands	u g r i z
Steward Bands	J H K
Stromgren Bands	u v b y
Walraven Bands	V B L U W

1.3 Retired Instruments

The instruments which have previously flown on HST but have been replaced by more modern detectors are included here for completeness.

The complete list of allowed component names that represent the telescope, COSTAR, and science instruments is:

- Telescope: ota noota
- COSTAR: costar nocostar
- Instruments: acs fgs foc fos hrs hsp nicmos pc stis wf wfc wfc3 wfpc wfpc2

As of September 1993, the default modes for the Telescope and COSTAR components were "ota" and "nocostar", respectively. Soon after COSTAR was installed in the telescope, the default mode was changed to "costar" for original instruments. Once the second-generation instruments were installed, with their built-in optical corrections, the default mode for "costar" or "nocostar" became instrument-specific. Note that for the WF/PC-1 instrument the names "wf", "wfc", and "wfpc" are all equivalent and correspond to the WFC mode of the WF/PC-1 instrument.

1.3.1 FOC

The FOC keywords consist of a list of detectors, filters, and miscellaneous keywords. The f/48 has two filter wheels and the f/96 detector has four filter wheels. Some of the filters have aliases. "fuvop" is an alias for PRISM1, "nuvop" is an alias for PRISM2, "fopcd" is an alias for PRISM3, "g450m" is an alias for F305LP, "g225m" is an alias for F220W, and "g150m" is an alias for F140W. The miscellaneous keywords include the COSTAR and the occulting fingers. An example of an FOC observation mode string would be "`FOC,COSTAR,F/96,F410M`"

Table 1.7: FOC Keywords

Detector	f/48 f/96 f/288 spec
f/48 Wheel 1	f140w (g130m) f150w (g150m) f175w f195w f220w (g225m) f305lp (g450m) prism3 (fopcd) (grat-prism)
f/48 Wheel 2	f130lp f180lp f275w f342w f430w prism1 (fuvop) prism2 (nuvop)
f/96 Wheel 1	f600m f630m f2nd f4nd f6nd f8nd pol0 pol0_par pol0_per pol0_unp pol60 pol60_par pol60_per pol60_unp pol120 pol120_par pol120_per pol120_unp prism1 (fuvop) prism2 (nuvop)
f/96 Wheel 2	f140w f175w f220w f275w f320w f342w f370lp f430w f480lp f486n f501n
f/96 Wheel 3	f120m f130m f140m f152m f165w f170m f190m f195w f210m f231m f1nd
f/96 Wheel 4	f130lp f253m f278m f307m f346m f372m f410m f437m f470m f502m f550m
f/48 Image Formats	x48n256 x48n256d x48n512 x48nlrg x48zlrg x48zrec
f/96 Image Formats	x96n128 x96n256 x96n512 x96nlrg x96z512 x96zlrg
Spectral Order	order1 order2 order3 order4
Occulting Fingers	occ0p23 occ0p4 occ0p8
Detector Formats	x48n256 x48n256d x48n512 x48nlrg x48zlrg x48zrec x96n128 x96n256 x96n512 x96z512 x96nlrg x96zlrg

Note that the spectroscopic capabilities, and hence the related keywords spec, order1, order2, order3, and order4, are only available for the f/48 camera. Furthermore, the occ0p23 keyword is only available with the f/48 camera, and the occ0p4 and occ0p8 keywords are only available with the f/96 camera.

The x48* and x96* keywords are used to account for the known dependency of DQE on the detector format (see the FOC Instrument Handbook for more details). These keywords invoke throughput tables that contain the (wavelength-independent) relative sensitivities for each format, where the 512x512 format (x48n512 and x96n512) is set to 1.0. The associations between formats and synphot keywords is listed in Table 1.7

Table 1.8: FOC Detector Format Keywords

Camera	Synphot Keyword	Camera Format
f/96	x96n128	128 x 128
	x96n256	256 x 256
	x96n512	512 x 512
	x96z512	512z x 512
	x96zlrg	512z x 1024
f/48	x48n256	256 x 256
	x48n512	512 x 512
	x48zrec	256z x 1024
	x48nlrg	512 x 1024
	x48zlrg	512z x 1024

1.3.2 FOS

The FOS keywords consist of a list of detectors, apertures, gratings, and polarimeter waveplates and waveplate position angles. The waveplate keywords indicate whether waveplate A or B is being used and the angle of the waveplate. An example of an FOS observation mode string would be "`FOS,BLUE,G160L`".

Table 1.9: FOS Keywords

Detectors	blue red
Apertures	0.3 0.5 1.0 4.3 0.1-pair 0.25-pair 0.5-pair 1.0-pair upper lower 0.25x2.0 0.7x2.0-bar 2.0-bar blank fail-safe
Gratings	g130h g190h g270h g400h g570h g780h g160l g650l mirror prism order0
Waveplates	pol0-a pol0-b pol22.5-a pol22.5-b pol45-a pol45-b pol67.5-a pol67.5-b pol90-a pol90-b pol112.5-a pol112.5-b pol135-a pol135-b pol157.5-a pol157.5-b pol180-a pol180-b pol202.5-a pol202.5-b pol235-a pol235-b pol257.5-a pol257.5-b pol270-a pol270-b pol292.5-a pol292.5-b pol315-a pol315-b pol337.5-a pol337.5-b
COSTAR	costar nocostar

The upper and lower aperture keywords are only recognized when used in conjunction with one of the paired apertures, e.g., "`FOS,BLUE,G130H,UPPER,1.0-PAIR`". The order0 keyword is only available in conjunction with the g160l grating and the blue detector. The waveplate keyword syntax is POLpa-wp, where pa is the position angle in degrees, and wp is the A or B waveplate.

1.3.3 HRS

The HRS keywords consist of a list of detectors, apertures, gratings or mirrors, and Echelle mode orders. The Echelle mode orders are used with the keywords ECHA and ECHB. Orders 18 to 33 are valid with Echelle mode B, while orders 33 to 53 are valid with Echelle mode A. An example of a typical HRS abbreviation mode string would be "`HRS,LSA,G160M`"

Table 1.10: HRS Keywords

Apertures	lsa ssa
Gratings	echa echb g140l g140m g160m g200m g270m
Mirrors	a1 a2 n1 n2
Echelle Orders	18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 all
COSTAR	costar nocostar

1.3.4 HSP

The HSP keywords consist of a list of detectors, filters, apertures, and beams. The beams refer to the two beams that come out of the beam splitter. Not all apertures can be used with all detectors. Refer to the HSP Instrument Handbook for further information. The polarization detector also has angle and type keywords. An example of an HSP observation mode string would be "`HSP,UV1,F220W,C`".

Table 1.11: HSP Keywords

Detectors	pmt pol uv1 uv2 vis
POL Filters	f160lp f216m f237m f277m f327m
UV1 Filters	f122m f135w f140lp f145m f152m f184w f218m f220w f240w f248m f278n prism
UV2 Filters	f122m f140lp f145m f152m f160lp f179m f184w f218m f248m f262m f278n f284m prism
· VIS Filters	f160lp f184w f240w f262m f355m f400lp f419n f450w f551w f620w prism
Relay mirror	norelay relay
Apertures	a b c d e f h j s t
Beams	blue red
Polarization Angles	0 45 90 135
Polarization Types	ext ord par per

1.3.5 WF/PC-1

The WF/PC-1 keywords consist of a list of filters, detectors, and miscellaneous keywords. The miscellaneous keywords include `baum`, which accounts for the Baum spot; `dn`, which converts units from electrons to data numbers (DNs); `cal`, which accounts for the flat-field correction; and `cont#`, which accounts for changes in sensitivity between decontamination events (see section 2.2).

The WF/PC-1 has twelve independently positionable filter wheels, each of which has five positions, including a clear position. Detectors 1 through 4 correspond to the Wide Field camera, while 5 through 8 are the Planetary camera. A typical WF/PC-1 observation mode string would be "`WFPC,F550W,4,DN`".

Table 1.12: WFPC1 keywords

Instrument	wfpc, wfc, wf (all equivalent), pc
Detectors	1 2 3 4 5 6 7 8
Miscellaneous	baum dn cal cont#
Filter Wheel 1	f673n f8nd g450 g800
Filter Wheel 2	f122m f336w f439w g200 g200m2
Filter Wheel 3	pol0 pol60 pol120 f1083n
Filter Wheel 4	f157w f194w f230w f284w
Filter Wheel 5	f569w f658n f675w f791w
Filter Wheel 6	f631n f656n f664n f702w
Filter Wheel 7	f375n f437n f502n f588n
Filter Wheel 8	f368m f413m f492m f622w
Filter Wheel 9	f547m f555w f648m f718m
Filter Wheel 10	f785lp f814w f875m f1042m
Filter Wheel 11	f128lp f469n f487n f517n
Filter Wheel 12	f606w f725lp f850lp f889n

The detector specifications 1 through 4 are valid only when used in conjunction with the wf, wfc, or wfpc instrument keywords, and detectors 5 through 8 are only valid when used with the pc keyword. If a detector number is not specified, the default detector for WF is #2, and the default for PC is #6

CHAPTER 2:

Parameterized Keywords

In this chapter. . .

Parameterized keywords are generally used to access throughput tables for which the throughput is a function of some other variable in addition to wavelength. The syntax for a parameterized keyword is `keyword#value`, where value is a numeric (integer or float) value for the keyword to take. The hash sign # indicates to synphot that a parameterized keyword is being used.

Parameterized throughput tables contain several throughput columns, each for a specified value of the parameterized component. The user may specify an arbitrary value, however, and synphot will linearly interpolate between the two closest values. If no parameterized keyword is used in the obsmode, a default value will be used.

2.1 Ramp filters (WFPC2, ACS)

2.1.1 WFPC2

Filter wheel 12 contains four linearly variable narrowband ramp filters, which together cover a total wavelength range of 3700 to 9800 Å. The FWHM of the throughput at a given wavelength is typically about 1% of the central wavelength. The ramp filters have been implemented as a parameterized component in synphot. To use the ramp filters in simulations, use the keyword syntax `lrf#wwww`, where wwww is the central wavelength, in Angstroms, that you desire, e.g., obsmode="`wfpc2,3,lrf#4861`".

2.1.2 ACS

Fifteen ramp filters are available for use with the WFC detector, and six are available for use with the HRC detectors. To use the ramp filters in simulations, use the keyword syntax `ffff#wwww`, where ffff specifies the filter and wwww specifies the central wavlength, in Angstroms, that you desire, e.g., obsmode="`acs,wfc,fr388n#3880`".

2.2 Contamination (WFPC1, WFPC2)

The `cont#` keyword references a "parameterized" component throughput table. In this case, the extra variable is the Modified Julian Date and is used to account for the gradual decline in throughput between decontamination events, as well as the sudden increase in throughput immediately after a decontamination.

For WFPC1, data exists for 48384.0 < MJD < 49329.0 (8 May 1991 to 8 December 1993), in intervals of 20-30 days.

For WFPC2, data currently exists from MJD 49347.0 onwards (26 December 1993), in intervals of approximately 30 days.

The **synphot** expression evaluator interpolates between the dates for which data exists in the table to arrive at an estimate of the throughput on the requested date.

2.3 Modified Julian Date (STIS)

The `mjd` keyword applies only to the MAMA grating and imaging modes (the MJD keyword has not yet been implemented in **synphot** for the MAMA echelle modes) and is used to handle the time dependent sensitivity of the FUV and NUV MAMAs. To use this capability in simulations, include the string `mjd#ddddd` in your obsmode specification, where ddddd is the desired MJD value (which can be given as either an integer or real value).

For example, to get the efficiency on MJD 49486, use "`mjd#49486`" as part of your obsmode string. When specifying the `mjd` keyword in command line input to synphot, it may be necessary to enclose the obsmode string in quotes to ensure that the synphot expression evaluator properly interprets the obsmode string.

The **synphot** expression evaluator interpolates between the dates for which data exists in the table to arrive at an estimate of the throughput on the requested date. The default is to use the latest set of throughput values without any extrapolation. The values are expected to be updated approximately yearly, so the default result should not differ by more than 2 percent from those that use the current date.

2.4 Encircled energy (ACS)

In April 2003, a new capability was introduced in synphot for use with the Advanced Camera for Surveys (ACS) imaging modes. This functionality is new to **synphot** and is currently only available for ACS. Users are now able to specify a circular aperture (radius in arcsec) to calculate the source counts within this aperture. If no aperture is defined (or if a 4.0 arcsec radius is specified), synphot calculates the total number of counts in an infinite aperture.

This makes **synphot** more flexible and accurate, particularly in cases such as red targets that are observed at long wavelengths. At wavelengths greater than 7500 A (HRC) and about 9000 A (WFC) ACS CCD observations are affected by a red halo due to light scattered off the CCD substrate. An increasing fraction of the light as a function of wavelength is scattered from the center of the PSF into the wings. This problem affects particularly the very broad z-band F850LP filter, for which the encircled energy depends on the underlying spectral energy distribution the most.

In the currently available APT ETC, the treatment of such an effect has been ameliorated but not solved. In fact, the encircled energy fraction is at the effective wavelength which takes into account the source spectral distribution. This fraction is then multiplied by the source counts. (The effective wavelength is the weighted average of the system throughput AND source flux distribution integrated over wavelength, that is,

$$\frac{\int f_\lambda P_\lambda \lambda^2 \, d\lambda}{\int f_\lambda P_\lambda \lambda \, d\lambda}$$

where P_λ is the (dimensionless) passband throughput, and f_λ is the source flux distribution.

However, this does not account for the variation in enclosed energy with wavelength.As a consequence, to obtain correct estimated count rates for red targets, observers are advised to use the **synphot** package in IRAF/STSDAS for which this proper integration over wavelength has now been incorporated for encircled energy.

To quantify this new **synphot** capability, we compare APT ETC results with synphot for a set of different spectral energy distributions and the observation mode WFC,F850LP. In the following table, the spectral type is listed in the first column. The fraction of light with respect to the total integrated to infinity is listed in the other two columns, for the ETC and synphot calculations respectively. These values are derived for a 0.2 arcsec radius aperture for the ETC and synphot calculations.

Sp. Type	ETC	synphot
O	0.76	0.74
M	0.71	0.7
L	0.69	0.68
T	0.61	0.6

The ETC results are off by up to 3% (O star), 2% (M and L stars), and 1% (T star). If this small effect is relevant to particular observations, then the **synphot** software package can be used.

A new keyword has been implemented to call for the encircled energy tables. The keyword is "`aper`". The user is allowed to select an aperture (radius in arcsec) and indicate this value by typing "`aper#value`". Currently, the following apertures are supported: every tenth of arcsec between 0. and .6 arcsec, 0.8, 1., 1.5, 2. and 4. arcsec. When calling "`aper#0`" the user will obtain the number of counts in the brightest pixel, i.e. the peak counts of the source centered at that pixel.

Arbitrary aperture sizes are also permitted but are not recommended, because **synphot** provides only a linear interpolation between supported apertures, which is a poor approximation, especially at small apertures.

A typical obsmode would now read: `acs,wfc1,aper#0.2,f850lp`.

From the cl command line such an obsmode should be entered within quotes, or **synphot** complains:
cl> calcphot "`acs,wfc1,aper#0.2,f850lp`"

GOs can always "epar" the program they want to run, or use Pyraf instead of cl. Users can also provide their own input spectrum, which must be in the same format as the user-provided spectrum for the ETC. The file should be placed in the directory from which **synphot** is run. Please refer to the ETC help pages for more specific information about this format.

2.5 Temperature specification (NICMOS)

With the release of STSDAS 3.0, support for thermal calculations was added to synphot with the new task **thermback**. At present, this capability has only been implemented for NICMOS. Additional keywords, including opaque but thermally emitting components of the OTA, were added, and all keywords except the detector keywords became parameterizable for temperature. Thus, to compute the thermal background assuming the primary mirror temperature is 290K, one would specify an obsmode `nicmos,3,f222m,primary#290.0`.

If no temperature value is specified, the default temperature for each component is used. The default temperature is stored as a header keyword (DEFT) in the thermal file for each component, which also contains the emissivity tables as a function of wavelength.

Most of the NICMOS optical elements are contained in the dewar, and are therefore at the same temperature. The software does not enforce this however: the user must specify the new temperature for each component individually. The keywords for the components located in the dewar are `reimag pupil image para1 para2 bend dewar cmask`.

CHAPTER 3:

Further Discussions

In this chapter. . .

More information about all the HST Science Instruments can be found in their respective Instrument and Data Handbooks.

3.1 WFPC2 Quad filters

Filter wheel 11 contains 3 specialized quadrant (quad) filters in which each quadrant corresponds to a facet of the pyramid, and therefore to a distinct camera relay. One quad filter, fquvn, contains four narrowband, redshifted [OII] filters. The second, fqch4n, contains four methane (CH4) band filters, and the third, polq, contains four polarizing elements. The instrument graph table is constructed so that distinct throughput values are automatically selected for a given quadrant of the fquvn and fqch4n filters based on the selected detector.

Note that all three of the quad filters were designed to map onto a four-faceted WFC configuration. However, in the final design of the instrument, with WF quadrant 1 replaced by the PC, it is necessary to rotate the quad filters by 33 in order to bring filter quadrant 1 into the WF 2 and 3 relays. In addition, partial rotations of 15 and +15 have been implemented for the methane (CH4) filter in order to bring two of its quadrants into the PC relay, and partial rotations of 18 and +15 have been implemented for the polarizer (pol) filter in order to allow observations with different polarization angles (see the WFPC2 Instrument Handbook for more details). Unique component keywords have been implemented in the instrument graph for the nominal and rotated positions of each of these filters. The nominal positions are designated as fquvn, fqch4n, and polq. The rotated positions are designated as fquvn33 (-33), fqch4n33 (-33), fqch4n15 (-15), fqch4p15 (+15), polqn33 (-33), polqn18 (-18), and polqp15 (+15).

3.2 Specifying STIS observation modes

In the STIS instrument, imaging mirrors and gratings are contained in the mode select mechanism (MSM) while filters and slits are in the aperture wheel. Each grating or imaging mirror is intended for use with only one of the three STIS detectors (CCD, NUVMAMA, or FUVMAMA).

In principle, any filter or slit (aperture) could be used with any grating or mirror, although in practice certain combinations are restricted or forbidden.

Since the slits and filters are in the same wheel, it is not possible to use both a slit and a filter at the same time. (Some small slits contain built in neutral density filters.)

The ADC gain keywords only apply to the STIS CCD modes and are used to convert results from units of electrons to DNs.

In a synphot observation mode string, specifying the grating automatically determines the detector used.

- If no aperture or filter is specified, the calculation is done for the clear aperture case. So the observation mode string `"stis,g430l"` is equivalent to either `"stis,ccd,g430l"` or `"stis,ccd,g430l,50ccd"`, (50CCD being the unobstructed full field aperture for the CCD detector).
- If the detector name is specified without a grating, e.g., `"stis,ccd,f28x50lp"`, it is assumed that an imaging mirror is being used.
- If no central wavelength is specified, e.g., `"stis,ccd,g430m,52X0.2"`, results for the entire bandpass of the instrument will be calculated, while if a central wavelength is included, e.g., `"stis,ccd,g430m,52X0.2,c4451"`, the calculation will be restricted to the actual wavelength range covered by that wavelength setting.

Each central wavelength is intended for use with a particular grating. See the STIS Instrument Handbook for a listing of which central wavelengths are allowed with each grating. The low order gratings, G140L, G230L, G230LB, G430L, and G750L have only one allowed setting and a central wavelength should not be specified in the observation mode string.

3.3 Non-HST Photometric Systems

This section provides references and some further discussion on various non-HST photometric systems that are characterized in CDBS.

The ANS system is a set of ultraviolet filters used by the Astronomical Netherlands Satellite, described in van Duinene et al. (1975).

The Baum filter set is a set of 15 broadband and intermediate-band filters that are copies of some of the onboard WF/PC-1 filters and were used as part of a ground-based observing campaign to determine calibrations for the WF/PC-1 instrument. In order to match the response of the WF/PC-1 flight passbands as closely as possible, the throughputs for the Baum filters have been multiplied by the spectral response curve of the ground-based CCD (measured in the laboratory) and twice by the spectral reflectance of aluminum (see Harris et al., 1991, for details).

The Bessell JHK filter curves are taken from data in TableIV of Bessell and Brett (1988). These curves include mean atmospheric transmission equivalent to 1.2 air masses of a standard KPNO atmosphere.

The Cousins R and I throughputs are taken from Bessell (1983), TableAII.

The ESO band throughput tables were received from Jan Koornneef in 1990.

The throughput data for the Johnson UBV bands are the U3, B2, and V synthetic passband data of Buser and Kurucz (1978), while the Johnson RIJK throughputs are from Johnson (1965), TableA1.

The KPNO JHK filter curves are taken from tracings of the Simultaneous Quad Infrared Image Device (SQIID) filter set, which were provided by Richard Joyce (KPNO).

The Landolt photometric system is defined as the Johnson UBV bands plus the Cousins RI bands.

The Sloan Digital Sky Survey (SDSS) ugriz filter throughputs were provided by Sebastian Jester on behalf of the SDSS team. They are described in the Photometry White Paper by Gunn et al. (2001). See further discussion below. Figures showing the filter response can be seen at:

http://www.sdss.org/dr1/instruments/imager/index.html#filters.

The Steward Observatory JHK filter curves are from data provided by Marcia Rieke (Steward Observatory).

The filter throughputs for the Stromgren system are taken from Matsushima (1969).

The throughput data for the Walraven bands are from Lub and Pel (1977), Table 6.

3.3.1 Further detail on the SDSS filter curves

The throughput data for the SDSS ugriz bands give the system photon response to point sources of the 2.5m SDSS survey telescope, including extinction through an airmass of 1.3 at Apache Point Observatory (to which all SDSS photometry is referenced). Originally, the ugriz system was intended to be identical to the u'g'r'i'z' system described in Fukugita et al. (1996)and defined by the standard star system in Smith et al. (2002). However, in the course of processing the SDSS data, the unpleasant discovery was made that the filters in the 2.5m telescope have significantly different effective wavelengths from the filters in the USNO telescope, which was used to observe the u'g'r'i'z' standards (the difference originates from the USNO filters being exposed to ambient air, while the survey-telescope filters live in the vacuum of the survey camera). Therefore, it became necessary to distinguish between the primed and unprimed SDSS filter sets.

The response curves in r and i are slightly different for large extended sources (larger than about 80 pixels in size) because the extended infrared scattering wings in these bands, which do not affect the photometry of point sources, begin to be included. The modified curves are available from the SDSS web site:

http://www.sdss.org/dr3/instruments/imager/#filters.

The SDSS photometry is intended to be on the AB system (Oke & Gunn 1983), by which a magnitude 0 object should have the same counts as a source of Fnu = 3631 Jy (except that it used the so-called asinh magnitudes defined by Lupton, Gunn, & Szalay (1999) instead of conventional "Pogson" magnitudes). However, this is known not to be exactly true, such that the photometric zeropoints are slightly off the AB standard. The SDSS team continues to work to pin down these shifts. Their present estimate, based on comparison to the STIS standards of Bohlin, Dickinson, & Calzetti (2001) and confirmed by SDSS photometry and spectroscopy of fainter hot white dwarfs, is that the u band zeropoint is in error by 0.04 mag, u_AB = u_SDSS - 0.04 mag, and that g, r, and i are close to AB. These statements are certainly not precise to better than 0.01 mag. The z band zeropoint is not as certain at the time of this writing (Jan. 2005), but there is mild evidence that it may be shifted by about 0.02 mag in the sense z_AB = z_SDSS + 0.02 mag.

Further information about SDSS photometric calibration and the asinh magnitude system can be found at:

http://www.sdss.org/dr3/algorithms/fluxcal.html