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Very Large Telescope
Paranal Science Operations
ISAAC User Manual

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1 Introduction

1.1 ISAAC

ISAAC is an IR (1 – 5 μm) imager and spectrograph that lies at the Nasmyth B focus of UT1. It has two arms, one equipped with a 1024 ×1024 Hawaii Rockwell array, and the other with a 1024 × 1024 InSb Aladdin array from Santa Barbara Research Center. The Hawaii arm is used at short wavelengths (1 – 2.5 μm). Prior to P70, the Aladdin arm was used exclusively at long wavelengths (3– 5 μm). From P70 onward this arm is also offered for JHK imaging.

ISAAC has several modes: imaging and spectroscopy in both SW and LW, and imaging polarimetry in SW only. All modes are offered for both Service and Visitor Programs. Target acquisitions, observations and calibrations are done via templates. A number of calibrations are regularly performed by ESO for general use (Calibration Plan). Finally, data reduction pipelines are available for most modes of the instrument.

Important additional information, to consult before preparing Phase I or Phase II proposals, can be found at the following URLs:

- http://www.eso.org/instruments/isaac
- http://www.eso.org/proposals
- http://www.eso.org/observing/p2pp
- http://www.eso.org/observing/p2pp/ISAAC/ISAAC-P2PP.html

1.2 Reminders

See http://www.eso.org/observing/p2pp/ISAAC/ISAAC-P2PP.html for recent reminders.

1.3 Content of this manual

This User Manual is organized as follows:

Section 2 describes the optical layout, the offered modes, the detectors, the control software, and the templates of ISAAC.

Section 3 gives an overview of observing in IR.

Section 4 presents some general features of observing at the VLT, and section 5 introduces observing with ISAAC.

Section 6 gives a cookbook of the ISAAC templates, and has a discussion of overhead calculation.

Sections 7 to section 11 give details of the different ISAAC instrument modes.

Finally, the appendices present a detailed description of the templates (appendix A), the filter curves (appendix B) and a list of acronyms (appendix D). The standard star lists previously in the appendices are now available from the http://www.eso.org/instruments/isaac.

1.4 Contact

Should you have any questions regarding the operation of ISAAC, the point of contact is the User Support Group (usg-help@eso.org) in Garching. Questions related to the visitor

mode (VM) observations should be addressed to the Paranal Science Operation (PSO) team (`pso@eso.org`).

2 ISAAC. Infrared Spectrometer and Array Camera

2.1 Optical Layout

Figure 1 shows the ISAAC optical layout.

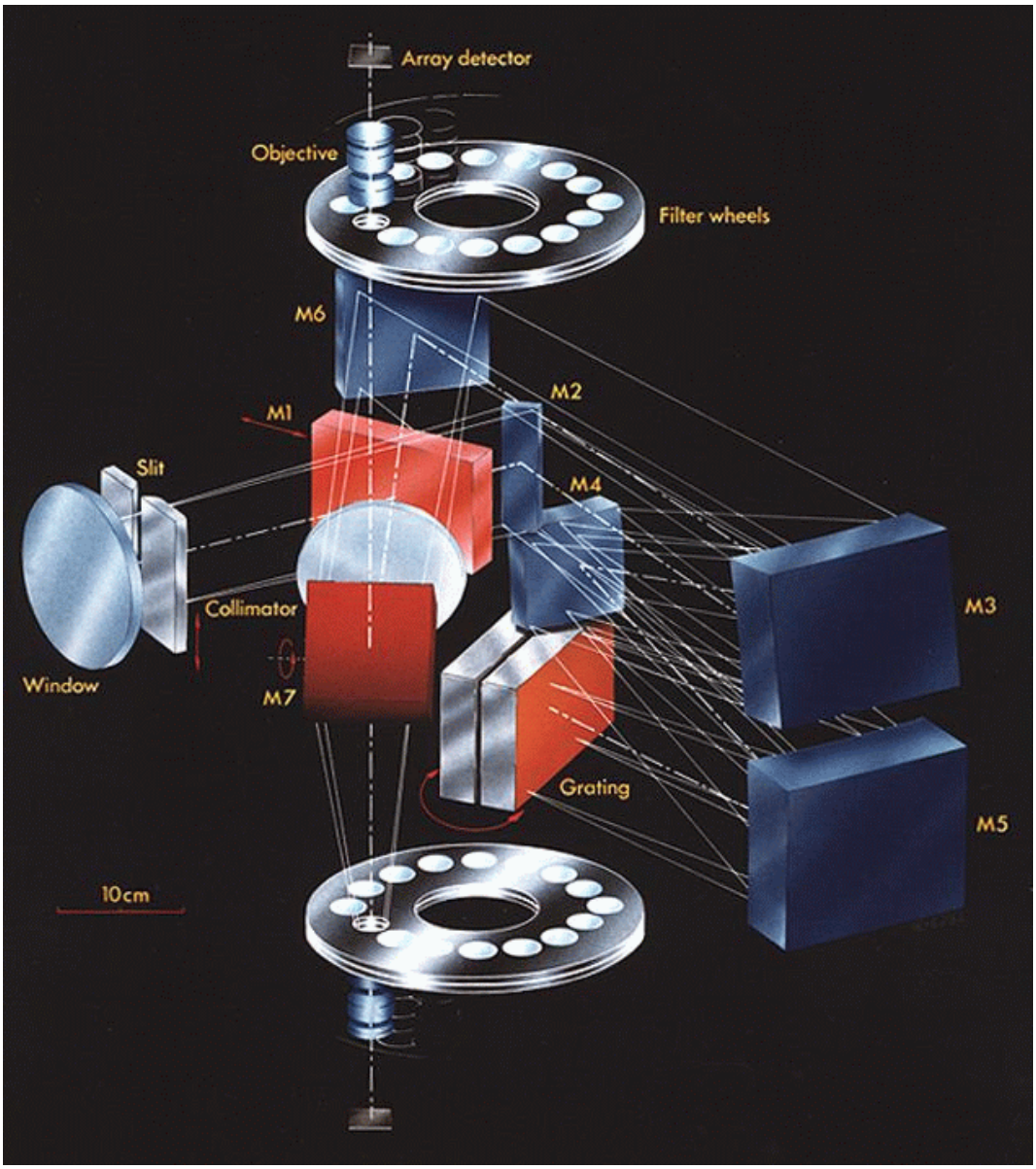


Figure 1: ISAAC Optical Layout.

In imaging mode, light enters the entrance window on the left hand side of the figure (the slit is then out of the beam). The Telescope Focal Plane is $\sim$ 80 mm behind the entrance window. The Mode Selector Mirror (M1) directs the light to the collimator and the collimated beam is sent to the M7 mirror which selects between the Hawaii (SW) and Aladdin (mostly LW, but also JHK imaging) arms. The collimated beam is then imaged onto the detector by the objective in place on the Hawaii or Aladdin arm. There are two filter wheels just in front of the objective wheels.

Table 1: ISAAC Imaging Modes

Mode	Array	Spectral Range	Pixel Scale (arcsec)	Maximum Field Of View (arcsec^2)	Detector Size (pixels)
SWI1	Hawaii	0.98 – 2.5 μm	0.1484	152 × 152	1024 × 1024
LWI3[1] [3]	Aladdin	1.1 – 5.1 μm	0.1478	151 × 151	1024 × 1024
LWI4[2]	Aladdin	3.0 – 5.1 μm	0.0709	73 × 73	1024 × 1024

[1] LWI3 is used for J+Block, H, Ks, NB_3.21 and NB_3.28 imaging without chopping, and for acquisition of LW spectroscopic targets.
[2] LWI4 is used for LW imaging with chopping (L, NB_M, NB_3.21, NB_3.28, NB_3.80 and NB_4.07)
[3] The LWI3 objective setup is used also by the new Burst and FastJitter modes which, therefore, have the same pixel scale and maximum FoV. However, in Burst and FastJitter modes the detector can be hardware windowed to FoV as small as 4.7x4.7 arcsec^2 (i.e.32x32 pixels).

In spectroscopy, M1 is retracted and light is diverted by M2 onto the 3 mirror collimator (M3, M4 and M5). Light then reaches the grating in Littrow mode, and is reflected back to M6 via the 3 mirror collimator. An intermediate spectrum is formed on M6, which is conjugated with the slit plane. The rest of the optical path is identical to the imaging path.

2.2 Imaging Modes

The characteristics of the imaging modes are summarized in table 1 and they are described in greater detail in Sections 7, 8 and 12.

The filters available in SWI1, LWI3 and LWI4 modes are listed in tables 2 and 3. Note that the filter central wavelengths are field dependent (this is a general characteristic of filters, due to the variation of the incidence angle on the filter across the field of view). The effect is $\sim$ 0.3% of the central wavelength in some NB filters in K, which represents a significant fraction of the bandwidth of these filters.

2.2.1 Comparison of JHK imaging in Hawaii and Aladdin arms

Due to technical problems in P69 it was necessary to transfer some SW observations to the Aladdin arm. Although the technical problems are now fixed, we have decided to keep, and offer, the possibility of JHK imaging with the Aladdin arm. Note however that, as yet, we have little experience with JHK Aladdin observations, and in particular have not yet clarified some issues regarding flat fielding and photometric accuracy. For these reasons we strongly suggest that users carry out SW imaging observations with the Hawaii arm.

The main cause of concern for Aladdin JHK observations is the photometric accuracy. In test observations we find a difference, which we do not currently understand, of up to 0.1 mag (rms) between Hawaii and Aladdin magnitudes of the same field. (For JHK imaging with the Hawaii we achieve a photometric accuracy of 5% or better). In addition the Aladdin array is intrinsically more non-linear.

The Aladdin JHK images are more complicated to flat field, because the flat field contains scattered light and also a central light concentration. In some cases we have found that flat fielding can actually decrease the photometric accuracy of the observation. Without illumi-

Table 2: SW Imaging: filters. See appendix B for the filter curves.

Name	Line	Central wavelength[1] (μm)	Width (μm)	Width (%)
Filters available with the Hawaii				
SZ[2]		1.06	0.13	13
Js		1.24	0.16	13
J[3]		1.25	0.29	23
H		1.65	0.30	18
Ks		2.16	0.27	13
NB 1.06[4]		1.06	0.01	.94
NB 1.08	He I	1.08	0.016	1.5
NB 1.19[4]		1.19	0.01	0.8
NB 1.21		1.21	0.018	1.5
NB 1.26	Fe II	1.26	0.019	1.5
NB 1.28	Pβ	1.28	0.019	1.5
NB 1.64	Fe II	1.64	0.025	1.5
NB 1.71		1.71	0.026	1.5
NB 2.07	He I	2.07	0.026	1.5
NB 2.09		2.09	0.02	1.0
NB 2.13	H2 S1	2.13	0.028	1.3
NB 2.17	Brγ	2.17	0.028	1.3
NB 2.19		2.19	0.03	1.3
NB 2.25		2.25	0.03	1.3
NB 2.29		2.29	0.03	1.3
NB 2.34	CO	2.34	0.03	1.3
Filters available with the Aladdin				
J+Block	Same as Hawaii + blocking filter[5] with mean transmission of 75%			
H	Same as Hawaii			
Ks	Same as Hawaii			

[1] The central wavelength varies slightly across the field of view.
[2] This filter is primarily used as an order sorting filter, however, it can be used for imaging as well. [3] This filter has leaks in the K band and the atmosphere defines the red edge of the filter. For accurate photometry the Js filter is recommended.
[4] The narrow band 1.06μm and 1.19μm filters correspond to regions of low OH emission and, therefore, enhanced sensitivity.
[5] The blocking filter is to prevent red leaks.

Table 3: LW Imaging: filters. See appendix B for the filter curves.

Name	Line	Central wavelength[1] (μm)	Width (μm)	Width (%)
L[2]		3.78	0.58	15
NB M		4.66	0.10	2
NB 3.21		3.21	0.05	1.6
NB 3.28	PAH	3.28	0.05	1.6
NB 3.80		3.80	0.06	1.6
NB 4.07	Brα	4.07	0.07	1.7

[1] the central wavelength varies slightly across the field of view.
[2] the ESO L filter is centered at 3.8μm and is closer to L' filter (Bessell and Brett, 1988) than it is to the original Johnson L filter.

Table 4: ISAAC Spectroscopic Modes [1]

Mode	Array	Spectral Range	Pixel Scale (arcsec)	Resolution for 1 arcsec slit
SWS1-LR	Hawaii	0.98 – 2.5 μm	0.147	$\sim$ 500
SWS1-MR	Hawaii	0.98 – 2.5 μm	0.147	$\sim$ 3000
LWS3-LR	Aladdin	3.0 – 5.1 μm	0.147	$\sim$ 400
LWS3-MR	Aladdin	3.0 – 5.1 μm	0.147	$\sim$ 2500

[1] See Sections 9 and 10 for more detailed information.

nation corrections the flat fielding accuracy is ≈3%, improving to ≈1.5% with illumination corrections. (The corresponding values for the Hawaii are ≈2% without and ≈1% with illumination corrections).

Ks images taken with the Aladdin contain scattered LW light (observed as circular arcs) which is probably due to the open filter position which is immediately adjacent. The scattered light is removed by normal IR sky subtraction techniques, however sky subtraction is still better with the Hawaii.

The main advantage of JHK Aladdin observations is that they are much more efficient due to the negligible readout time. This can mean a significant reduction in overheads for users with short DITs. This also means that the minimum DIT is reduced compared to the Hawaii (0.3447s compared to 1.77(3.55) s). The Aladdin arm also has higher throughput than the Hawaii arm (in tests SW imaging with the Aladdin reached ≈0.15 mag fainter than with the Hawaii in the same exposure time).

In summary, users who require very short integration times, or who do not require such accurate photometry may be interested in using the Aladdin arm for JHK observations, however most users will probably want to use the Hawaii arm.

2.3 Spectroscopic Modes

ISAAC is equipped with 2 gratings, for Low and Medium Resolution (LR and MR respectively) spectroscopy, 6 slits, and order sorting filters for each spectroscopic band.

The main characteristics of the spectroscopic modes of ISAAC are summarized in table 4. Slits, with widths ranging from 0.3 to 2 arcsec (see table 5), are available.

The 0.8" slit has two defects on the slit which produce regions of reduced transmission in the spectra. Figure 2 shows a plot of the transmission along the slit. The two defects, at 93 and 688 pixels from the bottom of the slit, are clearly seen. It is recommended that observers choose nod throws that avoid using these parts of the slit. This limits the usable length of the 0.8" slit to ≈1.5 arcmin.

A calibration unit allows calibration lamps to be used for both wavelength calibration and flat fielding (in spectroscopy only). The lamps used for wavelength calibration are Xenon and Argon.

Special acquisition templates are used for the spectroscopic modes, in order to ensure that objects are properly acquired in the slits.

The spectroscopic arm of ISAAC involves additional mirrors which cause the spatial axis (the vertical one) to be flipped with respect to imaging.

Table 6 shows the correspondence between wavelength range, grating order, filter, and spectral resolution in the LR and MR modes. The order is automatically set by the templates, and

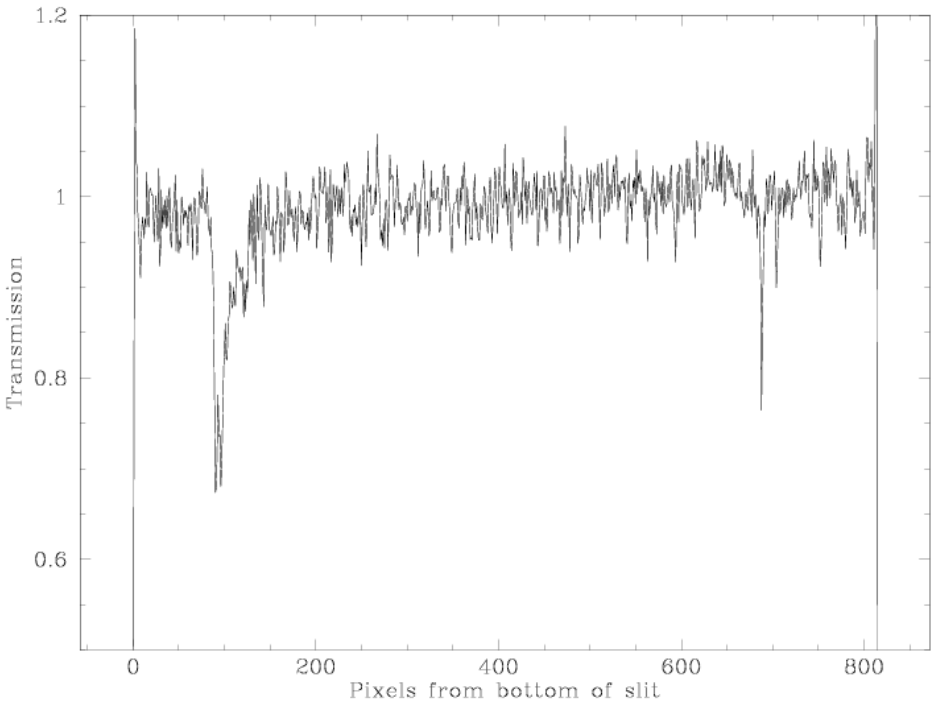


Figure 2: Transmission along 0.8" slit showing two slit defects

Table 5: ISAAC slits

Slit width (arcsec)	Slit Height (arcsec)
0.3	120
0.6	120
0.8	120[1]
1.0	120
1.5	120
2.0	120

[1] Defects on the slit limit the usable length to ≈90 arcsec.

the user only needs to define the central wavelength of the observations.

2.4 Polarimetric Mode

ISAAC offers SW imaging polarimetry in the Hawaii arm. A Wollaston prism in one of the two filter wheels splits the incoming parallel beam into two beams which are perpendicularly polarized. The beams are separated by ∼ 21 arcseconds. Thus an image taken with the Wollaston prism will contain two images of every object. To avoid sources overlapping, a special mask, consisting of alternating opaque and transmitting strips (24 arc seconds ∼20 arc seconds, respectively), is inserted at the focal plane. Thus, in a single exposure, at least half the field will be missing, so three exposures, with telescope offsets in between, are required to image one field (see Section A.7.5 for more details).

The Wollaston prism is not achromatic, so the exact separation between the two beams is a function of wavelength. In J, the separation is 22.5 arcseconds, while in Ks, the separation is 21 arcseconds. The beam separation is also a function of position: from the top to the bottom of the image, the separation varies by ∼ 3 pixels.

Table 6: Wavelength range, order, filter, spectral coverage ($\Delta\lambda$) and spectral resolutions for the SWS1 and LWS3 LR and MR modes. See appendix B for the filter curves.

Wavelength Range (μm)	Order	Filter	LR $\Delta\lambda$ (μm)	LR R(0.3")/R(0.6")/R(0.8")/R(1")/R(1.5")/R(2")	MR $\Delta\lambda$ (μm)	MR R(0.3")/R(0.6")/R(0.8")/R(1")/R(1.5")/R(2")
SWS1						
0.98 – 1.1	5	SZ	full	1800/900/750/550/420/270	0.046	11500/5700/5000/3400/2700/1700
1.1 – 1.4	4	J	full	1700/860/730/500/390/250	0.059	10500/5200/4700/3100/2500/1500
1.4 – 1.82	3	SH	full	1600/840/690/500/380/250	0.079	10000/5100/4500/3000/2400/1500
1.82 – 2.5	2	SK	full	1500/750/600/450/330/200	0.122	8900/4400/3900/2600/2100/1300
LWS3						
2.55 – 4.2	1	SL	full	1200/600/480/360/270/180	0.255	6700/3300/2600/2000/1500/1000
4.45 – 5.1	1	M	full	1600/800/650/500/370/250	0.237	10000/5000/4000/3000/2300/1500

Table 7: ISAAC Polarimetric Mode

Mode	Spectral Range	Pixel Scale (arcsec)	Field Of View (arcsec^2)	Detector Size (pixels)
SWP1	0.98 – 2.5 μm	0.1484	3 × 20 × 150	1024 × 1024

To measure the Stokes parameters and hence the degree and position angle of polarization a second set of images with the Wollaston prism rotated 45 degrees with respect to the first pair are required. The rotation is done by rotating the entire instrument. The Stokes parameters are then determined as follows.

$$I = i(90) + i(0) = i(45) + i(135)$$

$$Q = i(0) - i(90)$$

$$U = i(45) - i(135)$$

where $i(\alpha)$ is the intensity of the source which transmits light that is polarized at angle α. We have assumed that the rotator is at a position angle of 0 degrees for the first measurement. This need not be the case. The degree of polarization and the polarization angle are given by;

$$P = \frac{\sqrt{U^2 + Q^2}}{I}$$

$$\theta = 0.5 \tan^{-1}\frac{U}{Q}$$

To derive the correct value of θ, attention needs to be paid to the signs of U and Q.

This algorithm neglects instrumental polarization. Preliminary measurements with ISAAC indicate that the instrument polarization is 1.5%. As this is partially caused by the tertiary mirror, the vector defining the instrument induced polarization will rotate relative to the sky. A method to eliminate the instrumental polarization is outlined by Sperello di Serego Alighieri (1989, Proceedings of 1st ESO/ST-ECF Data Analysis Workshop).

Table 7 shows the main characteristics of the Polarimetric Mode of ISAAC.

The filters available in the Polarimetric Mode are a subset of the filters available in imaging (the Wollaston prism is on one of the two filter wheels, making the filters on this wheel unavailable). Available filters in SWP1 mode are listed in table 8.

Table 8: SW Polarimetry: filters. See appendix B for the filter curves.

Name	Central wavelength[1] (μm)	Width (μm)	Width (%)
SZ[2]	1.06	0.13	13
Js	1.24	0.16	13
J [3]	1.25	0.29	23
H	1.65	0.30	18
Ks	2.16	0.27	13
NB 1.06[4]	1.06	0.01	.94
NB 1.19[4]	1.19	0.01	0.8
NB 2.09	2.09	0.02	1.0
NB 2.19	2.19	0.03	1.3

[1] The central wavelength varies slightly across the field of view.
[2] This filter is primarily used as an order sorting filter, however, it can be used for imaging as well. [3] This filter has leaks in the K band and the atmosphere defines the red edge of the filter. For accurate photometry the Js filter is recommended.
[4] The narrow band 1.06μm and 1.19μm filters correspond to regions of low OH emission and, therefore, enhanced sensitivity.

2.5 Detectors and Acquisition System

Characteristics
The detectors are an Hawaii 1024 × 1024 array from Rockwell used for SW observations, and a 1024 × 1024 Santa Barbara Research Center (SBRC) Aladdin array used mainly for LW observations but also for JHK imaging (from P70 onward). They are controlled by the ESO-IRACE controller. The main characteristics of the detectors are summarized in table 9.

DIT and NDIT
The IRACE controller controls the detector front end electronics and manages pre-processing of the data before transferring it to the workstation. The pre-processor, among other tasks, averages the `NDIT` individual `DIT` integrations. This significantly lowers the data rate between the IRACE controller and the instrument workstation were the images are finally stored on disk, particularly for L band imaging where the `DIT` is only a hundred milliseconds. Note that **the number of counts in the images always correspond to** `DIT`, not to the total integration time (i.e. `DIT` × `NDIT`).

Readout Modes
The offered readout modes with the Hawaii are Double Correlated Read (DCR) and Non Destructive Read (NDR). The offered readout modes with the Aladdin are Uncorrelated Read (UCR), Double Correlated Read with High Bias (DCR-HB) and Double Correlated Read with Low Bias (DCR-LB).

DCR first resets the array and then performs two reads, one at the beginning, and one at the end, after DIT seconds of integration. The difference between these two reads is the image.

NDR first resets the array and then non-destructively reads the array N+1 times during the DIT seconds of integration, where N depends on the DIT and is set by the software. Longer DITs will result in more reads. For each pixel a line is fit to the N reads (the first read is discarded), and the slope of the fit gives the pixel value in the image.

The readout modes are **not** parameters defined by the users. The readout mode is automatically set according to the instrument mode. Table 10 lists the detector modes that are assigned to instrument modes / configurations.

LW observation modes

Chopping is the default mode of operation for LW observations; it is not used for SW observations. Chopping is achieved by synchronizing the detector with the secondary mirror of the telescope (M2), and by subtracting the images from the respective beams. The result of a chopped image is therefore a background subtracted image with positive and negative images. It is described in more detail in Section 5.6. We deliver the two half cycle frames for each chopped image (ie an ON frame and an OFF frame, both averaged over the number of chop cycles). These data are stored in a cube.

For LW narrow-band imaging observations below 3.5 microns and for MR spectroscopic observations, it is possible to get reasonable sky subtraction without resorting to chopping. We have provided 6 observing templates, 2 acquisition templates and 2 calibration templates that can be used to jitter and nod the telescope without chopping. These templates are identical to those used for SW imaging in the Hawaii arm. The advantages of jittering and nodding over chopping are twofold. Firstly, the overheads are less and, secondly, there are no negative images, so that, unlike when chopping, the whole field of view becomes available for science. For all LW broad-band and LR spectroscopic observations, chopping is the only offered mode.

Windowing

Windowing is **not** offered for either SW or LW observations. However, in some cases (acquisition frames in the L band and some LW calibrations), windowing may be used, but this is automatically setup and transparent to the user.

Minimum `DIT`

Table 11 indicates the minimum integration times for the Hawaii and Aladdin arrays, which limit the magnitude of the stars to be used for e.g. photometric calibration.

In the Hawaii array the minimum DIT has alternated in the past between 3.55 and 1.77s. This is due to changing the detector read speed to reduce the amplitude of the odd-even column effect. The current value of the minimum DIT in the Hawaii array can be found `http://www.eso.org/instruments/isaac/oddevencol.html`.

For service mode observations with the Hawaii array the allowed minimum DIT is 3.55s. Users requiring shorter DITs should consider using the Aladdin array (see Section 2.2.1).

Note that DIT/NDIT are not template parameters for the LW templates where chopping is used. They are hard-coded in the templates.

Features

ISAAC suffers from a number of features that are discussed in the ISAAC data reduction guide and in the ISAAC web pages. Users are encouraged to consult these documents before submitting an ISAAC proposal and to assess carefully how these features may affect their scientific goals.

For example, the Hawaii SW detector suffers from 'electrical ghosts' along detector lines which are somehow proportional to the intensity integrated along the lines. A procedure (`ghost`) to partially get rid of these features when reducing the data has been implemented in the `http://www.eso.org/projects/aot/eclipse/` data reduction package (not longer supported – Note that the new pipeline, `http://www.eso.org/observing/cpl/esorex.html` does not offer any more such a recipe).

Table 9: ISAAC detectors

Detector	Format (pixels)	Pixel Size (μm)	Q.E.	RON (e^-)	Gain (e^-/ADU)	Well capacity (e^-)
Hawaii	1024 × 1024	18.5	0.65	$\sim$ 10	4.6	200,000
Aladdin	1024 × 1024	27	0.8	$\sim$ 40	7.8 (DCR-HB,UCR)	290,000
					8.7 (DCR-LB)	170,000

Table 10: ISAAC detector readout modes

Instrument mode / configuration	Detector readout mode
Hawaii	
Hawaii SW Imaging (SWI1)	Double Correlated (DCR)
Hawaii SW Spectroscopy (SWS1)	Non Destructive Read (NDR)
Aladdin with chopping	
Aladdin LW Imaging (LWI4: L, M NB)	Uncorrelated (UCR)
Aladdin LW Imaging (LWI4: NB 3.21, 3.28, 3.80, 4.07)	Double Correlated High Bias (DCR-HB)
Aladdin LW Spectroscopy (LWS3-MR and LR L band)	Double Correlated High Bias (DCR-HB)
Aladdin LW Spectroscopy (LWS3-LR: M band)	Uncorrelated (UCR)
Aladdin without chopping	
Aladdin SW Imaging (LWI3: J+Block, H, Ks)	Double Correlated Low Bias (DCR-LB)
Aladdin LW Imaging (LWI3: NB 3.21, NB 3.28)	Double Correlated High Bias (DCR-HB)
Aladdin LW Spectroscopy (LWS3-MR)	Double Correlated Low Bias (DCR-LB)

Table 11: Minimum `DIT` for the Hawaii and Aladdin Arrays

Detector	Readout Mode	Minimum `DIT` (s)
Hawaii (SW)	DCR and NDR	1.77/3.55
Aladdin (LW)	DCR-LB	0.3447
Aladdin (LW)	DCR-HB	0.2771[1]
Aladdin (LW)	UCR	0.1073

[1] For NB_3.21 & NB_3.28 non-chopping observations with this mode the minimum DIT is 0.3447s

3 Observing in the NIR

3.1 Atmospheric Transmission

The transmission of the Earth's atmosphere from 0.8 to 5.1 μm is shown in Figures 3 and 4, and overplotted are the transmission curves of most of the filters available in ISAAC. The J, H, K, L and M bands correspond to the main transmission windows. All bands, particularly, J, L, and M, are also affected by atmospheric absorption within the band. The amount of telluric absorption varies with zenith distance and the amount of precipitable water vapor (PWV).

3.2 Background Emission

There are two regimes in the sky background emission. Below $\sim$ 2.2 μm, the sky emission is dominated by OH emission, taking place at an altitude of $\sim$ 80 km. Detailed sky spectra with OH line identifications are available on the http://www.eso.org/instruments/isaac

Beyond 2.2μm, the thermal background dominates. The thermal background consists of atmospheric and telescope emission. An overall telescope emissivity of 17% has been recently measured.

Between the OH lines in J and H, the background is very low, and has been measured to be $\sim$ 0.1 to 0.15 e^-/s during dark conditions. It is a sensitive function of the Moon phase and the distance to the Moon. Even with `DIT` values of 900s, the performance in MR spectroscopy is limited by the readout noise of the detector and not by the shot noise from the sky continuum. Longer integration times are possible, but lead to very poor cosmetics (hot pixels and cosmic rays), see Section 9.

3.3 Imaging

Jitter

Because of the high sky brightness in the IR, its rapid variability, detector cosmetics and detector instabilities, accurate sky subtraction is essential and this requires special attention and procedures. The standard practice is to resort to the `jitter` technique (also called shift-and-add), and all ISAAC SW (and some LW) imaging templates make use of it.

When the field is uncrowded, sky frames can be estimated from the object frames themselves. In practice, a running sky is built from the $\sim$ 5 frames that were taken immediately before and after the frame from which the sky is being estimated. All sky subtracted frames are then co-added with adequate shifts to form the final image.

When the field is crowded or the object extended (i.e. covering a large fraction of the array), the sky has to be sampled away from the object, resulting in a loss of efficiency for the observations, which can amount to 50% of the time if the sky has to be sampled as frequently as the object. In this case, all the 'object' and 'sky' positions are 'jittered' between themselves.

A more detailed explanation can be found http://www.eso.org/projects/dfs/papers/jitter99/

Chopping

This technique is reserved for the Aladdin arm above 3 μm, and it consists of moving the

secondary mirror of the telescope (M2) once every few seconds. The typical throw is about 20 arcseconds. Therefore, in most circumstances, the images corresponding to the two beams have some overlap. An essential requirement of this technique is to combine chopping with telescope nodding (i.e. offsetting in the direction opposite to that of the chop). The chopped images usually leave strong residuals on the detector, that are due to the different optical paths of the two beams. These residuals subtract well between two chopped images taken with a telescope nod in between. In addition, chopping and nodding may be combined with jittering, i.e. the telescope is slightly offset between nod cycles.

Photometric Calibration

Because the strong IR atmospheric absorption varies with airmass and water vapor content (see section 3.1) in a slightly non-linear manner, accurate photometric calibration is more difficult in the IR than in the visible. An accuracy of 1% can be obtained during stable nights, provided that standard stars are observed frequently and with the same airmass as the object. Standard stars have to be observed at least twice with a telescope offset in between, allowing for the sky to be subtracted. A list of photometric standard stars is provided in appendix C.1. The observatory maintains a list of standard star OBs which visiting astronomers can use.

Flat fielding

The VLT domes are not equipped with calibration screens, so dome flats are not possible. In imaging, twilight flats are for the time being the only possibility offered to ISAAC observers. Regular twilight flat fields are taken by the ISAAC operation staff as part of the Calibration Plan, and are made available through the ESO archive. ISAAC does have a calibration unit, equipped with a tungsten lamp; however, the unit is adequate for spectroscopic flat fields only.

3.4 Spectroscopy

Nodding

The classical technique in spectroscopy is to observe object(s) at two or more positions along the slit. The sky is effectively removed by subtracting one frame from the other, registering the two beams and then subtracting again. This process is sometimes called double subtraction. If the field is crowded, or if the object is extended, then a blank sky may be necessary, and, in this case, the double subtraction is done slightly differently.

Spectrophotometric Calibration

Calibration of spectroscopic data in the IR is a complicated procedure that requires care. It is generally done in three steps. The first step removes telluric features, with what is commonly called a telluric standard; the second step removes the spectral features of the telluric standard that are imprinted onto the science spectrum because of the first step; and the third step sets the absolute scale with what one may call a spectroscopic standard. In general the spectroscopic standard and the telluric standard are the same star, but this does not need to be the case.

The most prominent feature in IR spectra are the telluric lines of the Earth's Atmosphere. Unfortunately, many of the telluric lines do not scale linearly with airmass, so it is necessary to observe a standard at the same airmass and with the same instrument setup as that used for of the science target. Furthermore, the strength of the telluric lines varies with time, so it is also necessary to observe the standard soon after or soon before the science target.

The spectrum of the telluric standard is divided directly into that of the science target. Ideally, the spectrum of the telluric standard should be known, so that features belonging to it can be removed. However, this is never the case, so one has to use standards in which the spectrum

is approximately known.

Within the observatory's calibration plans, we use either hot stars (main sequence B0-B4 stars) or solar analogs as telluric standards and, generally, these stars are selected from the Hipparcos Catalog. The spectra of hot stars, those hotter than B4, are relatively featureless and are well fitted by blackbody curves. So, by knowing the spectral type of the star, one uses a blackbody curve with the appropriate temperature to fit the continuum of the standard. The spectra of stars that are cooler than A0 start to have many more features and cannot be fitted with a blackbody curve for wavelengths below 1.6 microns.

Unfortunately, hot stars do contain some features, usually lines of hydrogen and helium, that can be difficult to remove. If the region around the hydrogen and helium lines are of interest, then one can also observe a late type star, which should have weak hydrogen and helium lines. This star is then used to correct for the helium and hydrogen absorption in the spectrum of the hot star. Some hot stars also have emission lines or are in dusty regions. These stars should be avoided. The V-I colour of the star can be used as an indicator of dust. For stars hotter than A0, it should be negative. And lastly, hot stars tend to lie near the galactic plane, so there may be situations where there are no nearby hot stars.

Solar analogs, (for the purpose of removing telluric features) are stars with spectral type G0V to G4V. These standards have many absorption lines in the IR, particularly in the J band. The features can be removed by dividing by the solar spectrum that has been degraded to the resolution of the observations. This can be a bit tricky with ISAAC as the spectral resolution is variable.

In addition to hot stars and solar analogs, IR astronomers have used other stellar types as telluric standards. For example, F dwarfs are commonly used.

We would like users to think carefully about which star is best for their program. Although the observatory will automatically observe a telluric standard for service programs, we cannot guarantee that we will make the best choice, as this depends on the science users wish to do. If you think that a specific spectral type suits your program better than others, we recommend that you submit calibration OBs.

The observatory selects telluric standards from four catalogs: the IRIS Photometric Standards, the MSSSO photometric standards, a composite list of bright spectroscopic standards and the Hipparcos Catalog. The majority of the standards come from the Hipparcos Catalog. Although, the Hipparcos Catalog is an excellent source of telluric standards for ISAAC, most of the stars in the catalog do not have IR magnitudes, which means that IR magnitudes have to be inferred from the spectral type. Such an extrapolation leads to an uncertainty of 5-20% in the absolute flux calibration. If users wish to have a more certain absolute flux calibration, they should provide their own standards.

For absolute calibration, slit losses have to be estimated. This is usually a difficult task, as the spectroscopic standard (which is usually the telluric standard) and the program object may not be positioned at exactly the same place in the slit. If the object is a point source, it can be assumed that the slit losses for the standard and the program object are the same. If the program object is not a point source, the slit losses have to be estimated on the basis of its morphology. If your observations need an estimate of the slit losses and/or accurate flux calibration, we recommend that you explicitly asks in your README file that the telluric standard is observed also with the $2''$ slit or in slit-less mode.

Alternatively, if the broad-band magnitudes of the object are known, the absolute flux calibration can be derived by convolving the measured spectrum with the broad-band filter curves. In this case, the IR magnitude of the standard is irrelevant, only the spectral type is important.

This works at Low Resolution but not at Medium Resolution where the spectral coverage is smaller than the filter bandwidth.

Locating spectra

Because ISAAC uses two different optical paths in imaging and spectroscopy, the formats in imaging and spectroscopy are different. E.g. if an object is along the slit at pixel Y_{img}, its position along the slit in spectroscopy is Y_{spec}. Note for instance that the vertical axis is flipped between imaging and spectroscopy. The relationship Y_{spec} = function(Y_{img}) is calibrated and maintained by ESO (http://www.eso.org/observing/dfo/quality/ISAAC/qc/qc_IS_startrace.html).

At the end of each acquisition (see appendix A), the image that is displayed on the RTD, which usually consists of a moderately deep sky subtracted image, is dumped to disk. The locations of the slits are accurately known, so it is always possible to know exactly what was observed from the acquisition images.

For faint objects, it is not always easy to locate the spectrum on the spectroscopic images. **It is strongly recommended, to the extent this is possible, to orient the field so as to have a moderately bright object in the slit simultaneously with the program object.** This allows one to monitor slit losses during a long exposure, while providing an extra means of locating the object spectrum through its position relative to this reference object. The bright object can also be used as a secondary standard for the removal of telluric lines.

Wavelength calibration

As mentioned in section 2.3, ISAAC is equipped with a calibration unit allowing one to take arc spectra of Xenon and Argon. However, it is standard practice to use the OH lines for wavelength calibration. The technique works very well at medium spectral resolution below 2.2μm. At low resolution, the lines are too highly blended, but can still be used for a zero point correction from a calibration performed with the arc lamps. Detailed sky spectra with OH line identifications are available on the http://www.eso.org/instruments/isaac

Above 2.2 μm, the OH lines are very weak and cannot be used, so arc spectra should be used. Telluric features can also be used.

Above 4.2 μm, Xenon and Argon lines are too faint to be observed. Although it is possible to use the grating in 3rd order to do the wavelength calibration, the calibration is not very accurate. An alternative method is to use the numerous telluric features. This has been tested for MR and LR spectroscopy and has proved to be as accurate as using the arcs.

3.5 Influence of the Moon

The Moon is usually not a problem in the IR. In Broad Band SW and LW imaging, most of SW Narrow Band imaging, LW Narrow Band imaging, SWS-LR spectroscopy, LWS-LR and LWS-MR spectroscopy, moonlight does not significantly affect the background. There is therefore no point in requesting gray or dark time for programs that involve these modes.

However, the moonlight contributes to the sky background when observing between the OH lines in J and H, i.e. NB imaging in J in the low background NB filters (NB 1.06, NB 1.19), and SWS-MR spectroscopy in J and H. Measurements done during an eclipse of the Moon showed that at more than $\sim 70^o$ from the Moon, the sky background remains approximately constant, regardless of the phase. Typically, when ultimate performances are sought in MR spectroscopy below 2.0 μm, it is advisable to constrain the distance to the Moon to be above 50-70°, while the Fractional Lunar Illumination can remain relatively unconstrained (< 0.7).

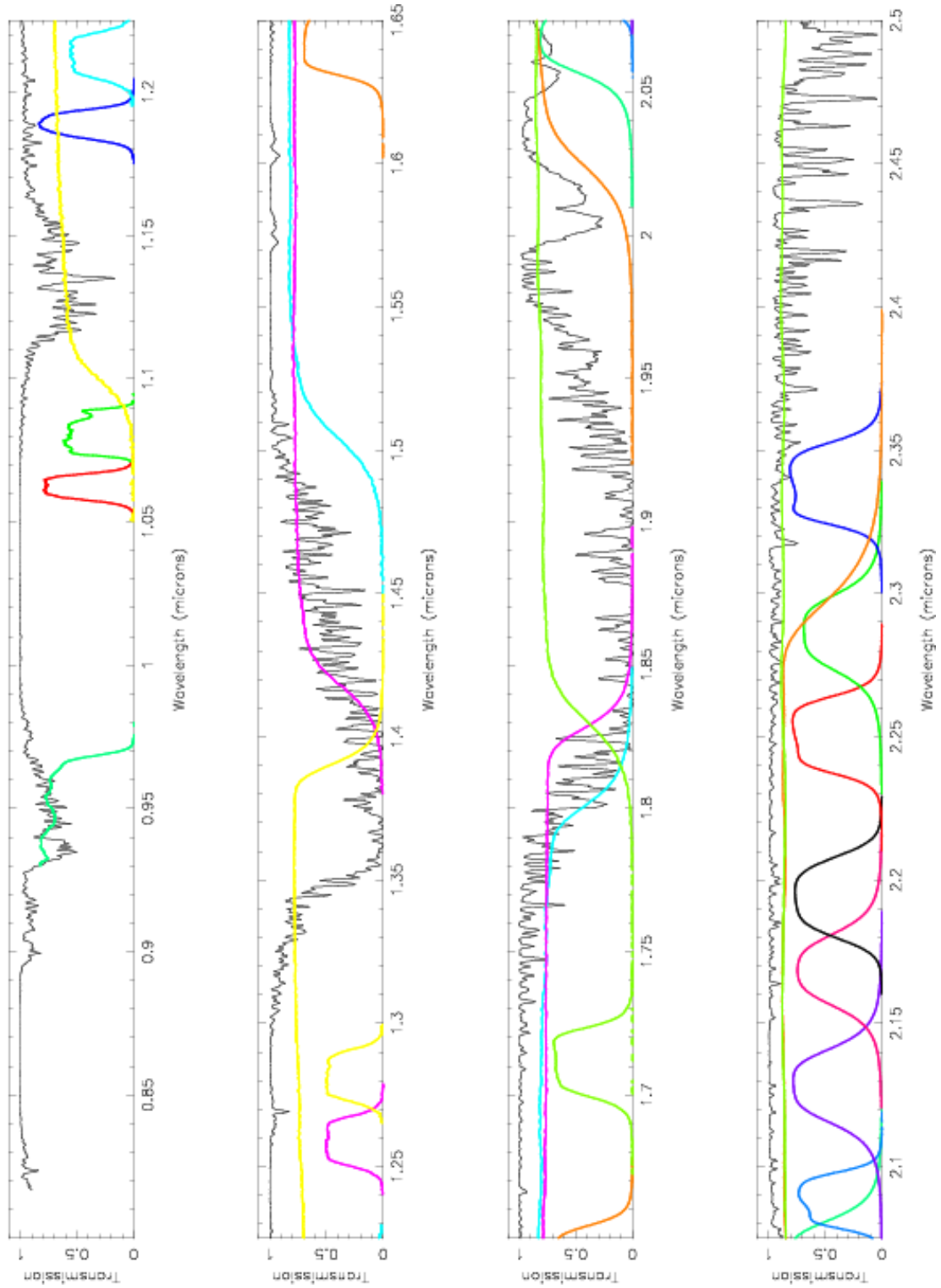


Figure 3: Atmospheric Transmission spectrum in the SW region. Most of the SW filter transmission curves are overplotted. The atmospheric spectrum is represented here with a FWHM of 8 Å. The atmospheric spectrum is a model corresponding to the typical situation at Paranal. The Narrow Band Filters can be easily identified through the central wavelength of their response curves. In green is part of the Z filter (not offered since P70), in yellow the J filter, in magenta the SH filter, in blue the H filter, in green the SK filter, and in orange the Ks filter.

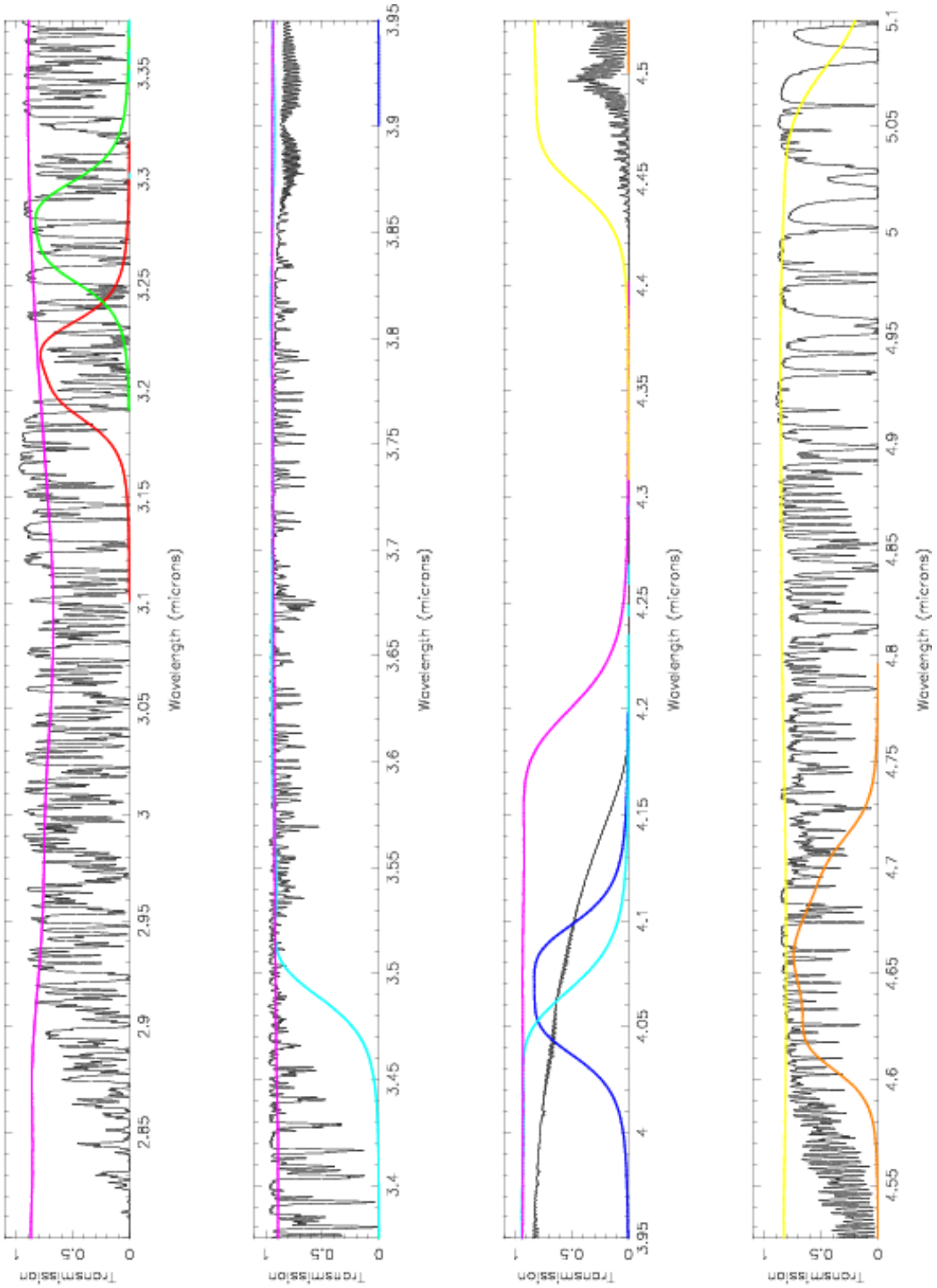


Figure 4: Atmospheric Transmission spectrum in the LW region. Most of the LW filter transmission curves are overplotted. The atmospheric spectrum is represented here with a FWHM of 2.5 Å. The atmospheric spectrum is a model corresponding to the typical situation at Paranal. The Narrow Band Filters can be easily identified through the central wavelength of their response curves. In magenta is the SL filter (the absorption dip at 3.1 μm is not real), in blue the L filter, in yellow the M filter.

4 Observing at the VLT

4.1 Visitor Mode Operations

Visitors arrive on Paranal 2 days ahead of their observing run and receive support from Paranal Science Operations (PSO) to prepare their OBs. Users are requested to read the P2PP and ISAAC User Manuals before arriving. During the night, users do not have direct interaction with the instrument and the telescope. The execution of their OBs is undertaken by the Telescope Instrument Operator and/or the nighttime support astronomer.

Visitors should be aware that at least part of the twilight will be used by the observatory according to the instrument calibration plan. This usually consists in twilight flat fields and low airmass SW photometric standards. For spectroscopic observations in VM, the observatory will not automatically take telluric standards, although they are essential in removing telluric features and calibrating the data. Visitors should think carefully about which telluric standards they should observe and observatory staff will help them make the right choice. A brief overview of spectrophotometric calibration, which includes the removal of telluric features, is give in Sec. 3.4.

Back-up programs
Even though Paranal is an excellent site, bad weather can occur. Therefore visitors should request backup programs in their telescope time proposal, particularly if their main targets are in the North, where, on some occasions, it is not possible to point the telescope because of strong wind.

Dealing with the moon
If the object is very close to the moon (less than 20 degrees away), moonlight can prevent the telescope active optics system from working. The effect is difficult to predict and quantify as it depends on too many parameters. Just changing the guide star often solves the problem. Visitors are encouraged to carefully check their target positions with respect to the Moon at the time of their scheduled observations. Backup targets are recommended whenever possible, and users are encouraged to contact ESO in case of severe conflict (i.e. when the distance to the Moon is smaller than 30 °).

4.2 The Telescope

Telescope Focus
This is a burden of the past. In fact, the telescope cannot be defocused. For standard stars, we can degrade the IQ by using a calibrated solution for the optics, since standards are often too bright for the VLT. However, this procedure is not offered for science targets.

Telescope control
Most interactions with the telescope consist of telescope presets for acquisition, telescope offsets during observations, and M2 chopping in LW observations. Small offsets (i.e. less than 1 arcminute) are usually completed in 10 to 15 seconds of time.

The guide star is used for field stabilization and optimizing the performance of the optics (active optics). The active optics system runs continuously, even when the telescope does an offset. During the offset, the guide star is lost for the duration of the offset. Consequently, offsetting the telescope too frequently can result in a significant loss of signal for the active optics and degraded performance. This has the following important operational consequence: **The minimum time between telescope offsets must be at least one minute. Ob-**

servations not complying with this rule will be rejected by the operation staff at the time of execution.

Note that this rule does **not** apply to standard stars (imaging or spectroscopy), since some image degradation can usually be tolerated. Provided that the previous rule is followed, the control of the telescope active optics is totally transparent to the users.

Other important facts are:

- the offsetting accuracy of the telescope is 0.1 arcsec RMS as long as the same guide star is used when offsetting. Offsets larger than a few arc minutes may involve a guide star change and in such a case the offsetting accuracy is less.
- defocusing the telescope is not an operational procedure.
- Scanning along the slit in spectroscopy during one exposure is **not** supported.

Guide Stars

Guide stars are automatically found by the Telescope Control System, and the users do not have to worry about finding them.

When small telescope offsets are used (a few arcseconds to a few arcminutes), the telescope keeps the same guide star (this depends in practice on the position of the guide star in the Nasmyth field of view). The offset accuracy is then excellent, at the level of $\sim$ 0.1 arcsecond.

However, if large telescope offsets are used, the guide star changes. The telescope will not resume guiding automatically, and the operator will be prompted to resume guiding. More importantly, after changing guide stars the telescope may not come back to precisely the same position. This is a potential problem when doing spectroscopy of extended objects. This particular problem will be dealt with by the operator during such observations, by ensuring that the same guide stars are used when the telescope returns back to the object.

Flexures and tracking stability The flexure of ISAAC at the detector plane is very small, around 0.5 pixel over a full instrument rotation. In most circumstances, the image stability of both telescope and instrument is so good that there is usually no need to reacquire the target during long integrations, up to two hours, in spectroscopy. This is not the case when crossing the meridian near Zenith, and it is advised not to schedule trans meridian observations on fields with Zenith distances lower than $\sim 10^{o}$. For such fields, it is advised to do e.g. standard star observations during the $\pm$ 15 minutes surrounding the transit.

5 Observing with ISAAC

5.1 Observation Software

OS is the high level software controlling the instrument. It has its own GUI which allows one to access all instrument parameters. Figure 5 shows the ISAAC OS GUI. The users only use templates to control the instrument, and therefore have no direct interaction with OS. However, the OS GUI is useful for the visitors as a status display panel, displaying all information from instrument, detector and telescope.

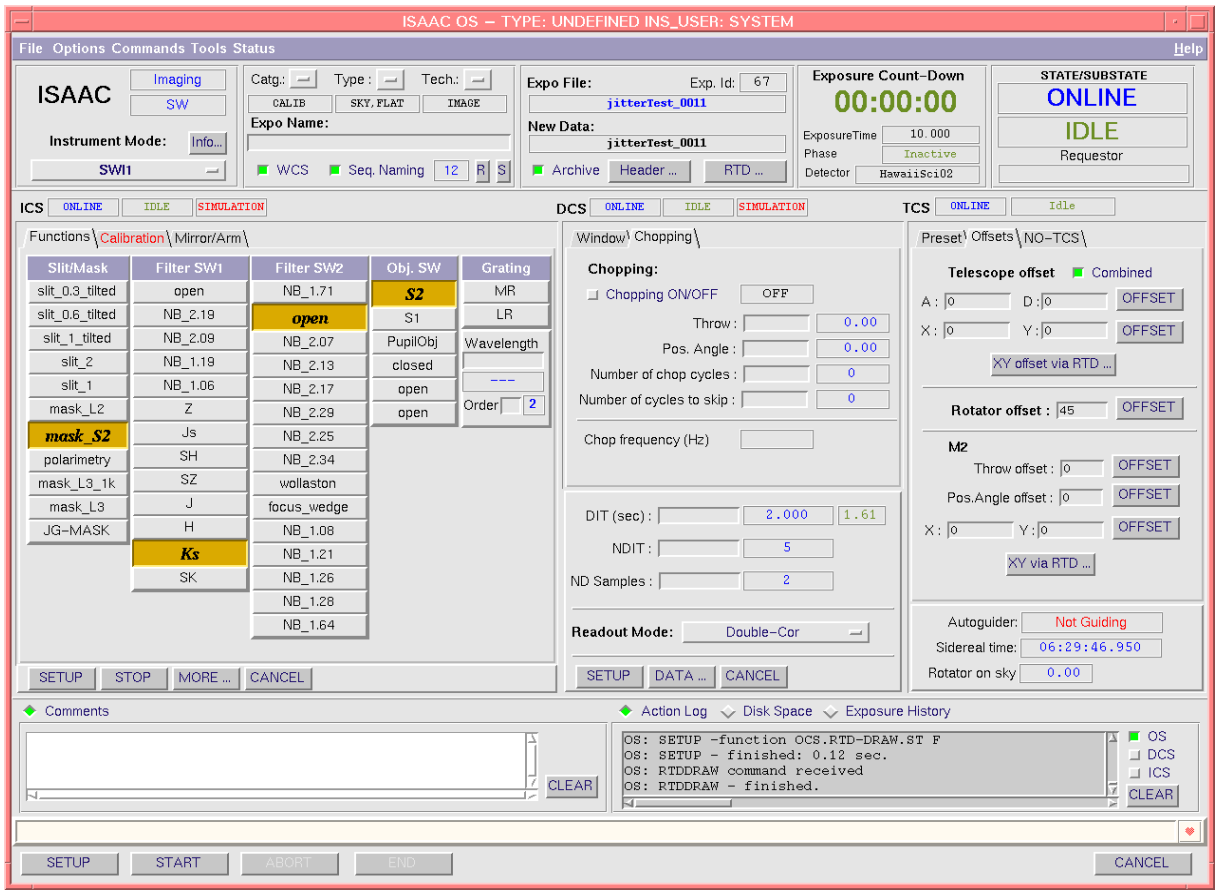


Figure 5: OS Graphical User Interface. Left panel: instrument control. Middle panel: detector control. Right panel: telescope control.

5.2 The Real Time Display (RTD)

The Real Time Display is central to observing with ISAAC. Like a video camera, every frame taken by the detector is continuously displayed on the RTD. It is important to realize that the continuous display of images on the RTD is not related to saving the data to disk. An image is stored to disk only if the adequate action is taken to do so, i.e. when a 'Start Exposure' is sent. This is what the templates do.

The RTD provides a number of tools for measuring statistics, measuring the position and FWHM of objects in the field, and for storing an image to be subtracted from incoming

images. This latter tool is referred to as `store a fixed pattern`, and is very frequently used during acquisition, quality control, etc.

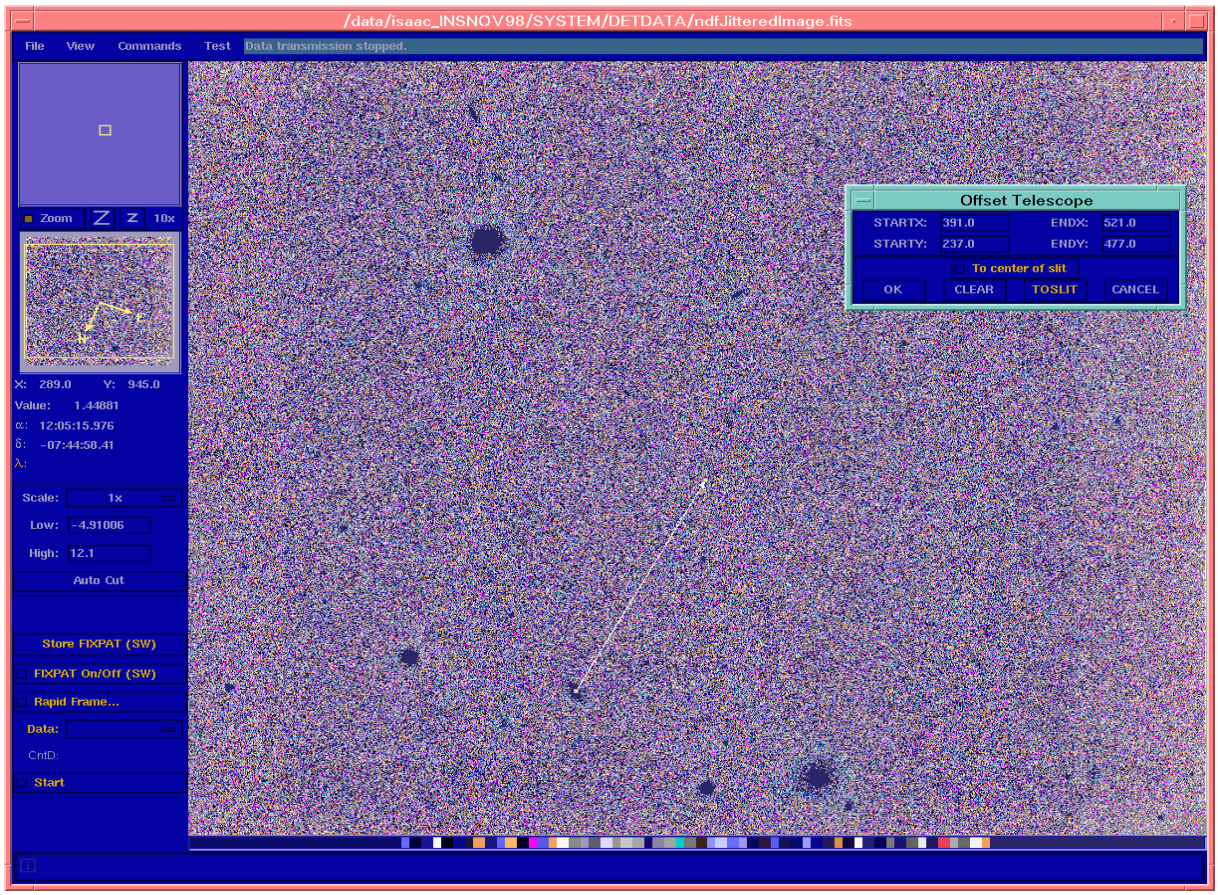


Figure 6: Real Time Display.

5.3 Target Acquisition

5.3.1 Imaging

The pointing accuracy of the VLT is very good, and usually a blind preset to the field is sufficient in imaging (the templates for the Hawaii and Aladdin arms are `ISAACSW_img_acq_Preset` and `ISAACLW_img_acq_Preset` respectively). If users would like a finer pointing, so as to position an object in a particular region of the detector, they should use `ISAACSW_img_acq_MoveToPixel` for the Hawaii arm, and `ISAACLW_img_acq_MoveToPixel` (if chopping) or `ISAACLW_img_acq_MoveToPixNoChop` (non-chopping) for the Aladdin arm. These templates provide interactive tools such as arrows to define telescope offsets (see figure 6). Use of the finer pointing acquisition templates should be accompanied by precise instructions in the Phase II README file.

Observers in service mode shall provide, together with their OBs, all necessary information regarding the centering of the field if they have special requirements.

5.3.2 SW Spectroscopy

Blind centering of objects in the slits based on coordinates is not supported. Neither the pointing accuracy of the telescope, nor the coordinate accuracy of most targets would guarantee that the objects go straight into the slit.

It is mandatory to use the `ISAACSW_img_acq_MoveToSlit` or `ISAACSW_img_acq_MoveToSlitrrm` acquisition template in all SW spectroscopic program OBs and to use the same slit in both the acquisition and observing templates.

This template provides interactive tools to rotate the field and / or make telescope offsets to center objects into the selected slit which is overlaid on the RTD. It can also be used to place two objects in the slit without having to precompute the position angle. Service mode users requiring the rotation angle to be found in this way should make this clear in the finding chart and README, and identify which stars to use.

OBs for which target acquisition cannot be completed within a few minutes of time will not be executed. Acquisition can be done either on the target itself or on reference targets. The object used for acquisition has to be brighter than approximately 17-18th magnitude in the IR when acquisition is done with the near IR Broad Band filters (J, H or Ks). Exceptions will be tolerated for moving targets, and special situations to be evaluated on a case by case basis.

When the science target is fainter than the above quoted magnitude, the procedure for acquisition should rely on reference objects which are brighter than this limit. These reference objects can either be positioned in the slit together with the target by defining the appropriate position angle on sky (the recommended procedure), or be used for initial centering on slit, followed by a blind offset to move the target into the slit. The `ISAACSW_img_acq_MoveToSlit` template allows one to define relative offsets from the reference star.

These reference objects should be stars or point-like objects. Blind offsets from a reference object should be limited to approximately 1 arcminute. Offsets that are too large could cause the TCS to change the guide star, which would result in a less accurate acquisition. Experience has shown that the offsets from the reference star are often inaccurately defined. For example, if the offsets are computed from a previously taken ISAAC image, the distortion at the edges of the field can affect the accuracy of the offsets if one has assumed a constant plate scale. Also, users tend to choose the brightest object in the field, which can be far from the target. Fainter reference objects, still bright enough to satisfy the limits mentioned above, are often closer to the target and make much better choices. To minimize offset errors, users should use reference objects that are as close as possible to the target, rather than trying to use the brightest reference objects.

It is recommended to position a reference object in the slit together with the target, so one can determine the position of the target on the spectral image. It also allows one to monitor the image quality (across the spectrum) and to monitor the flux through the slit, etc.

In service mode, it is mandatory that all the relevant information is given in advance to the operation staff. This information should consist of:

- Finding charts, with clear definition of the field orientation and of the scale
- Overlay of the slit
- Clear identification of the object
- Clear identification of the reference object to be used for preliminary slit centering.

- The offset to be applied between the reference and the target. This offset has to be entered in the ISAACSW_img_acq_MoveToSlit template.

See http://www.eso.org/observing/p2pp/ for more detailed information on the format of the finding charts and README files to be provided at the time of OB submission. **Should this detailed information be missing, the observations will not be scheduled**.

5.3.3 LW spectroscopy

The same interactive tools available in ISAACSW_img_acq_MoveToSlit are provided in the ISAACLW_img_acq_MoveToSlit and ISAACLW_img_acq_MoveToSlitNoChop templates. Although the subsequent spectroscopic observations are at long wavelengths (>3μm), short wavelength broad band filters (J, H and Ks) are available for object acquisition. It is believed that most of the targets will be acquired more easily in these SW filters than in the LW filters. If the ISAACLW_img_acq_MoveToSlit acquisition template is used then chopping is set by default, even if SW filters are used during the acquisition.

A defect on the objective in the Aladdin arm produces a patch of lower counts in the bottom left quadrant of the array. In order to avoid the subsequent spectra being at the same position on the array as this patch, objects are acquired ≈150 pixels away from the center of the slit.

5.3.4 Rapid Response Mode (RRM)

The rapid-response mode (RRM), offered from P74, allows approved RRM programs to automatically trigger target-of-opportunity (ToO) observations.
Please see http://www.eso.org/observing/p2pp/rrm.html for more information about RRM.
To facilitate the RRM two new acquisition templates are provided,
ISAACSW_img_acq_Presetrrm and ISAACSW_img_acq_MoveToSlitrrm . It is required that any RRM OB contains one of these acquisition templates. The templates are essentially identical to the ISAACSW_img_acq_Preset and ISAACSW_img_acq_MoveToSlit templates, but contain fewer parameters. See Section 5.4 for brightness limits applied to RRM observations.

5.3.5 Burst mode and Lunar occultation

Starting from period 79, we are offering a new observing mode capable to deliver ultra fast photometry (down to the order of a few millisecond) for short time intervals. See Section 12 or the link http://www.eso.org/instruments/isaac/news/burst_fastjitter.html for a description of the mode.

The mode has been originally implemented for lunar occultations (LOs) which are short and time critical events. We have also created a new acquisition template which is particularly suitable to LO observations. The template, ISAACLW_img_acq_FastPhot, can be used only in combination with the observing template ISAACLW_img_obs_FastPhot. On the contrary the observing template ISAACLW_img_obs_FastPhot can be alternatively combined with others LW imaging acquisition templates in no-chopping mode (i.e. ISAACLW_img_acq_Preset and ISAACLW_img_acq_MoveToPixNoChop), as needed.

The ISAACLW_img_acq_FastPhot template minimizes the time for the target acquisition by skipping active optics corrections (good image quality is not critical to LO observations). It is suitable for the acquisition of very bright targets as it allows the use of the windowed detector. The user is recommended to provide accurate and correct targets coordinates as the template,

though allowing to refine the centering of the target, will not allow to check the field of view (particularly in the case of very small window). The Finding Chart is not required for this specific template.

See Section A.9.6 for a description of the template parameters.

5.4 Maximum Brightness of Observable Targets

Direct imaging of very bright objects in the Hawaii arm results in residual images that can last up to several hours due to persistence effects in the Hawaii. In service mode, this problem can affect subsequent observations of other programs. In visitor mode, and provided that the nights are not shared, the potential problems related to the persistence effects are left to the responsibility of the user. We have less experience with the effect of bright stars on the Aladdin array. Hence we request that users follow the same SW imaging rules as with the Hawaii.

Note: RRM observations will be turned down if the field contains objects brighter than 9th magnitude in J, H or K. This is done in order to protect the array from remnant-effects and changes in the gain properties resulting from saturation. As the field and OB contents is not known *a priori*, a general rule must be applied to all ISAAC RRM observations. The brightness of field stars will be checked automatically with the final release of the 2MASS catalog. See Sections 5.4.1 and 5.4.2 for more information on general brightness limits in service mode.

Note 2: When using the ISAACLW_img_acq_FastPhot template and the Burst/FastJitter mode, the maximum brightness of the observable target depend on the minimum DIT that is possible for the selected mode (Burst or FastJitter) and on the detector windowing. For the moment it should be extrapolated by using the ETC.

In no case targets brighter than 3 mag will be observed (any filter).

5.4.1 SW Imaging - Aladdin and Hawaii

Observations involving fields with objects brighter than 11th magnitude (BB imaging) or 8th magnitude (NB imaging) cannot be guaranteed in service mode and in shared visitor nights. ESO reserves the right to lower the overall priority of the OB in question in service, and not to execute the observations in shared visitor nights.

Imaging observations not compliant with these limits must be approved via submission of a http://www.eso.org/observing/p2pp/ServiceMode.html#Waiver. If the waiver is approved, this should be stated in the README file, along with an estimate of the brightest object in the field of view. ESO will try to devise strategies so that the observations can be done, for example, scheduling the observations for the end of the night or scheduling other imaging OBs after the observations in question.

5.4.2 SW Spectroscopy

Table 12 indicates the filter settings that must be used when acquiring targets. This depends on the brightness of the sources in the instrument field of view during a spectroscopic acquisition. Note that this typically applies not only to standard stars, but also to science fields when there are bright objects in the field of view.

Table 12: Acquisition filters versus target magnitude

IR Magnitude	Filters to use
> 11	Any
>8 and <11	Any Narrow Band filter
>6 and <8	Two close Narrow Band Filters on each filter wheel.
	E.g. NB_2.19 on filter wheel 1 and NB_2.17 on filter wheel 2
<6	Two distant Narrow Band Filters on each filter wheel
	E.g. NB_2.09 on filter wheel 1, and NB_2.17 on filter wheel 2

Important note: when the bright object in the field of view is not the target to center on slit, the target may become too faint to see due to the use of the Narrow Band Filter(s). In this case (see Sec. 5.3), offsets from a reference star should be used.

5.4.3 LW Imaging and Spectroscopy

For NB_3.21 and NB_3.28 non chopping observations the maximum brightness is L=5. Users who wish to observe brighter stars in these filters should use chopping.

For LW spectroscopy, objects brighter than 4th magnitude should be acquired with the NB filters.

5.5 Night Flat fields and arcs

Due to non-reproducibility effects involving the grating and the slit, there are usually slight differences between flats and arcs taken at different times. As flats and arcs are taken the day after the observations, this can limit the accuracy at which spectroscopic data can be flat fielded and wavelength calibrated. To circumvent this, special templates have been created to allow flat fields or arcs to be taken at the end of the spectroscopic templates without moving the grating or slit wheel (`ISAACLW_spec_cal_NightCalib` for LW, `ISAACSW_spec_cal_NightCalib` for SW). If used, these templates must be attached at the end of each spectroscopic template. They are not autonomous; they must not be used on their own.

It is believed that the flat field non-reproducibility problem only affects observations at high signal-to-noise ratio (S/N >100). It is therefore recommended that users use the night time calibration templates if they want high signal-to-noise data. In this case, one should also take night time flats for the telluric standards. As this is not part of the ISAAC calibration plan users will have to provide the appropriate OBs. To get the highest signal-to-noise ratio one should set the nod throws of the telluric standard and the science target to be the same.

Observers who do not wish to obtain such high signal-to-noise data **(this applies to most observations done with ISAAC)** can safely ignore the night time flat field calibrations.

Requesting night time arcs is usually not necessary for observations below 2.2μm, since the OH lines provide an in situ wavelength calibration. Above 2.2 microns there are few OH lines, but there are many telluric features and they can either be used as in situ wavelength calibration or as a means of determining the wavelength offset for observations calibrated with the daytime arcs.

Little experience has been obtained with similar problems in the LW arm. However, the same template has been created for the LW channel, in case users feel they need accurate flat fields or arcs. Note that the arcs should usually not be necessary, since the sky leaves plenty of telluric features for wavelength calibration.

In the M band, it is not possible to do accurate wavelength calibration with the arc spectra. Although we do provide an arc that is taken with the grating in third order the telluric features should prove to be more accurate.

5.6 Chopping

For LW broad band imaging and LW LR spectroscopy, chopping is the only offered mode. For other LW instrument setups, the user can choose not to use chopping. The basic characteristics and definitions of chopping are:

- The chopping throw is distance between the two beams. The maximum chop throw is 30 arcsec.
- The chopping angle can be defined with reference to the SKY or to the DETECTOR (see appendix A.3).
- Guiding can be achieved on both beams, provided that the throw is approximately less than 20 arcseconds, which corresponds to the field of view of the guide probe. If the throw is greater than this, guiding will be performed on only the central (ON) beam. This will result in significantly poorer image quality in the OFF beam. **Thus we generally recommend that the chopping throw be kept to 20 arc seconds or less.**
- The chopping frequency is automatically defined in the templates and is based on the instrument mode in use. It typically varies between 0.1 and 0.5 Hz.
- Chopping is always associated with nodding in the opposite direction of the chop. The nodding frequency is also automatically defined in the templates to give optimum performance for each instrument mode.
- The detector acquisition system is synchronized in a transparent way with the M2 chopping.
- One chop cycle corresponds to one ON-OFF cycle, i.e. one period of the M2 chopping motion. Only the acquisition frame is saved on disk as the subtracted ON–OFF image.
- Several chop cycles can be averaged by the pre-processor to deliver only one image. This is referred to as the `Number of chop cycles ?` in the template parameters and applies only to acquisition templates. For the observing templates, this parameter is automatically set.
- **LW chopping data** From P69 onward, we have delivered the two half cycle frames for each chopped image (i.e. an ON frame and an OFF frame, both averaged over the number of chop cycles). These data are stored in a cube. There is one cube, containing these two half cycle frames, for each chopped image. This change is transparent at the template level for the user. The pipeline has been updated accordingly.

  The subtracted image ON-OFF image can still be displayed on the RTD but is not saved on disk. Storing the half-cycle frames allows checking of the sky background levels to operate the detector at the optimum level ranges, and easier application of the non-linearity corrections during data reduction. The format of the data issued from non-chopping templates are un-changed.

- DIT and NDIT are not parameters of the LW chopping templates, as they are automatically set to the optimal values imposed by the chopping frequency and saturation levels.

5.7 Calibration Plans

The calibrations that the observatory takes are discussed in detail in sections 7 to 11. Users are requested to read these sections carefully.

The time spent doing these calibrations is not charged to the user.

If the user wishes to do calibrations that are not specifically mentioned or if the user wishes to do calibrations in excess of those specified in the calibration plan, then users must submit the OBs to do these calibrations together with precise instructions in the README file. The time spent doing these calibrations will be charged to the user.

5.8 Pipelines

It is our long term aim to produce pipelines that reduce ISAAC data accurately. At this point in time, this is not the case and experienced observers will be able to do better than the pipeline. Thus we recommend that users use pipeline products as a means of quickly assessing the data. The pipeline recipes and their limitations are discussed in more detail in the http://www.eso.org/instruments/isaac/#Documentation.

See Sections 7 to 11 for details of the pipelines associated with each template. For the templates supported by the pipeline, service observers will receive reduced data processed by the pipeline in Garching by the Quality Control Group. Visitors will have direct access to the data processed automatically on line. Note however that in the latter case the data are not calibrated (e.g. flat fielded) as they are in Garching for service observations. Visitors can save the pipeline reduced data for themselves. Pipeline reduced data are not part of the data package they receive at the end of their run.

The ISAAC pipeline is based on the eclipse library, which can be downloaded from
http://www.eso.org/projects/aot/eclipse/

Table 13: Aladdin Templates: cookbook

Action	Template(s) to use
Acquisition	
Simple telescope preset	ISAACLW_img_acq_Preset
Preset telescope and center field with chopping	ISAACLW_img_acq_MoveToPixel
Preset telescope and center field without chopping	ISAACLW_img_acq_MoveToPixNoChop
Preset telescope and center filed without chopping and without AO	ISAACLW_img_acq_FastPhot
Preset telescope and center object(s) in slit with chopping	ISAACLW_img_acq_MoveToSlit
Preset telescope and center object(s) in slit without chopping	ISAACLW_img_acq_MoveToSlitNoChop
Imaging	
Imaging with chopping and nodding	ISAACLW_img_obs_AutoChopNod
Imaging without chopping (J+Block, H, Ks and narrow band imaging below 3.5 μm)	ISAACLW_img_obs_AutoJitter ISAACLW_img_obs_AutoJitterOffset ISAACLW_img_obs_GenericOffset ISAACLW_img_obs_FixedSkyOffset
Fast Photometry (J+Block, H, Ks): Burst or FastJitter	ISAACLW_img_obs_FastPhot
Spectroscopy	
Spectroscopy with chopping and nodding	ISAACLW_spec_obs_AutoChopNod
MR spectroscopy without chopping	ISAACLW_spec_obs_AutoNodOnSlit ISAACLW_spec_obs_GenericOffset
Standard Stars	
Standard Star (imaging - with chopping)	ISAACLW_img_cal_AutoChopNod
Standard Star (imaging - without chopping)	ISAACLW_img_cal_GenericOffset
Standard Star (spectroscopy - with chopping)	ISAACLW_spec_cal_AutoChopNod
Standard Star (spectroscopy - without chopping)	ISAACLW_spec_cal_AutoNodOnSlit ISAACLW_spec_cal_GenericOffset
Spectroscopic Night Time Calibration	
Night time flat fields and / or arcs	ISAACLW_spec_cal_NightCalib

The allowed imaging acquisition templates for subsequent science observations have changed since P70. The simple preset (ISAACLW_img_acq_Preset) can be used for any subsequent imaging observation. The chopping preset (ISAACLW_img_acq_MoveToPixel) can only be used for subsequent imaging observations with chopping and the non-chopping preset (ISAACLW_img_acq_MoveToPixNoChop) can only be used for subsequent imaging observations without chopping.

6 Template cookbook and overhead calculations

6.1 Templates: General description and summary

The instrument, detector and telescope are controlled by Observing Blocks (OBs), which are made up of templates. Templates are divided into three categories: acquisition, observation and calibration.

Usually, OBs consist of an acquisition template and one or more observation templates for science frames, and one or more calibration templates for calibration frames.

One (and only one) acquisition template is allowed in an OB, and therefore only one preset on sky. It is not possible, for example, to group in the same OB, observation templates on the science object and calibration templates on a standard star.

Tables 13 and 14 provide a short summary of the templates currently offered. These templates should cover most needs.

Should observers who have observing time with ISAAC consider that these templates do not

Table 14: Hawaii Templates: cookbook

Action	**Template(s) to use**
Acquisition	
Simple telescope preset same for RRM	`ISAACSW_img_acq_Preset` `ISAACSW_img_acq_Presetrrm`
Preset telescope and center field	`ISAACSW_img_acq_MoveToPixel`
Preset telescope and center object(s) in slit (spectroscopy) same for RRM	`ISAACSW_img_acq_MoveToSlit` `ISAACSW_img_acq_MoveToSlitrrm`
Preset telescope and center field (polarimetry)	`ISAACSW_img_acq_Polarimetry`
Imaging	
Imaging of uncrowded fields	`ISAACSW_img_obs_AutoJitter`

Imaging of extended objects or crowded fields	`ISAACSW_img_obs_AutoJitterOffset`
	`ISAACSW_img_obs_GenericOffset`
	`ISAACSW_img_obs_FixedSkyOffset`

Imaging requiring special telescope offset sequences	`ISAACSW_img_obs_GenericOffset`
Imaging Polarimetry	`ISAACSW_img_obs_Polarimetry`
Spectroscopy	
Spectroscopy of point–like or moderately extended objects	`ISAACSW_spec_obs_AutoNodOnSlit`
Spectroscopy of extended objects (i.e. wider than $\sim$ 1 arcminute), or complex sequences of slit positions	`ISAACSW_spec_obs_GenericOffset`
Standard Stars	
Standard Star (imaging)	`ISAACSW_img_cal_GenericOffset`
Standard Star (polarimetry)	`ISAACSW_img_cal_Polarimetry`
Standard Star (spectroscopy)	`ISAACSW_spec_cal_AutoNodOnSlit` `ISAACSW_spec_cal_GenericOffset`
Spectroscopic Night Time Calibration	
Night time flat fields and / or arcs	`ISAACSW_spec_cal_NightCalib`

cover their needs, they must contact the User Support Group (usg-help@eso.org) well before the observations start.

The template parameters are extensively described in appendix A for Phase II Preparation.

Note: calibration templates dealing with darks, flats and arcs are not available in the ISAAC Instrument Package for P2PP. All the required calibrations are executed by the Operation Staff at the end of the night according to the setups that were used during the night. The only calibrations that can be taken at night, if desired, are spectroscopic flat fields and arcs taken with the ISAACSW_spec_cal_NightCalib or ISAACLW_spec_cal_NightCalib templates (see Section 5.5).

6.2 Overheads

Since Period 65, overheads are charged to the users. Special care should therefore be taken when estimating the overheads.

The execution time report produced by P2PP computes the overheads according to the rules given in this manual. Users, especially those in service mode, should check it to make sure that the overheads have been taken into account.

Preset operations

The overhead for preset and acquisition depends on the template, as shown in Table 15. These times include the telescope preset, closing the active optics loop and acquiring the target if necessary.

Hawaii overheads

During the execution of an Observation Template, most of the overheads come from frequent telescope offsets inherent to IR observations. One should allow for approximately 15 seconds of time for the telescope to offset (a few arcseconds) and for the next exposure to start. A strict minimum of 1 minute per telescope position (including overheads) is mandatory, in order to maintain image quality (see Section 4).

Another source of overheads is the detector read time, which lasts approximately 2.3/4.1 [1] seconds per DIT for Hawaii imaging observations and 4.0/7.6 seconds per DIT for Hawaii spectroscopic observations. The overheads then depend on the nature of the observations. In Ks imaging for instance, DIT is typically 15s. Assuming NDIT = 6, the elapsed time between 2 consecutive exposures, including one telescope offset, is therefore $\sim 6 \times (15 + 4.1) + 15 =$ 130 seconds, corresponding to overheads of about 44% (in case of a readout of 2.3 seconds, the overheads are of the order of 30%). Shorter DITs will accordingly increase the overheads. In medium resolution spectroscopy in J or H, the DIT can be as high as 15 minutes, leading to readout time limited overheads of 2% only.

Aladdin overheads

For the templates that involve chopping the overheads are given as a fraction of total integration time. For imaging this fraction is 40% and for spectroscopy the overheads are 30%.

The Aladdin templates that do not involve chopping (used for J+Block, H, Ks, NB_3.21 & NB_3.28 imaging and LW MR spectroscopy) are more efficient. The overheads come from instrument setups, telescope presets, object acquisitions and telescope offsets. The overhead

[1] For service mode observations a read time of 4.1s should be assumed. The Hawaii read time has alternated between these two values, because of changes in the chip read-speed made to reduce the amplitude of the odd-even column effect. Refer to the ISAAC web pages (http://www.eso.org/instruments/isaac/#Documentation) - for the current value.

Table 15: Overheads

Channel	Operation	Time (minutes)	Comment
Both	Full Preset & acquisition		varies with acq template
	`ISAACSW_img_acq_Preset`	6	times incl. active optics
	`ISAACSW_img_acq_Presetrrm`	6	
	`ISAACLW_img_acq_Preset`	6	
	`ISAACSW_img_acq_MoveToPixel`	7	
	`ISAACSW_img_acq_Polarimetry`	7	
	`ISAACLW_img_acq_MoveToPixNoChop`	7	
	`ISAACLW_img_acq_MoveToPixel`	7	
	ISAACLW_img_acq_FastPhot	5	(max - depending on tel offset)
	`ISAACSW_img_acq_MoveToSlit`	10	
	`ISAACSW_img_acq_MoveToSlitrrm`	10	
	`ISAACLW_img_acq_MoveToSlitNoChop`	10	
	`ISAACLW_img_acq_MoveToSlit`	10	
Both	Instrument Setup, Spectroscopy	2	Average
Both	Instrument Setup, Imaging	0.5	Average
Both	Instrument Setup per additional (after the 1st) template in the same OB	1	Average
Both	Telescope Offset	0.25	Average
Hw imaging	Detector readout (per DIT)	0.04/0.07[1]	Approximately
Al nochop imaging	Detector readout (per DIT)	Negligible	
Hw spectroscopy	Detector readout (per DIT)	0.07/0.13[1]	Approximately
Al nochop spectroscopy	Detector readout (per DIT)	Negligible	
Al (LW)	Imaging with chopping	40%[2]	
Al (LW)	Spectroscopy with chopping	30%	
Both	Night time flat	4	For one on-off pair
Both	Night time arc	3	For one on-off pair

[1] Depends on read speed - see text
[2] Global overheads in percent should be used for LW chopping observations

Table 16: Overheads – Example 1 – SW: Imaging with the Hawaii

Template parameters	
Acquisition Template	`ISAACSW_img_acq_Preset`
Observation Template	`ISAACSW_img_obs_AutoJitter`
`DIT`	10 (seconds)
`NDIT`	10
`Number of Exposures`	36
Execution time (minutes)	
Preset	6.0
Instrument setup	0.5
int time + detector overhead	(0.167 + 0.07) × 10 (`NDIT`) × 36
Telescope offsets	0.25 × 36
Total	101 minutes for 60 minutes of integration

from detector readout is negligible. Assuming DIT=0.4 seconds and NDIT=150, the elapsed time between two consecutive exposures is $\sim 0.4 \times (150) + 15 = 75$ seconds, corresponding to overheads of about 25%.

Table 15 provides some generic values for the main operations involved during operations. They should be used when computing the ISAAC overheads.

In the new Fast Photometry observing modes, the overheads dominate the total execution time (assuming a DIT of few millisec). They increase with the requested NDIT (i.e. the size of the data cube to be created/delivered), and they also depend on the selected mode (Burst or FastJitter). In particular, they increase parabolically in the case of the Burst mode and linearly in the case of the FastJitter one (see Figure 7).

Some examples (tables 16 to 21) are given below to illustrate how to compute overheads with ISAAC.

Table 17: Overheads – Example 2 – SW: Imaging with the Aladdin

Template parameters	
Acquisition Template	`ISAACLW_img_acq_Preset`
Observation Template	`ISAACLW_img_obs_AutoJitter`
`DIT`	10 (seconds)
`NDIT`	10
`Number of Exposures`	36
Execution time (minutes)	
Preset	6.0
Instrument setup	0.5
int time + detector overhead	0.167 × 10 (`NDIT`) × 36
Telescope offsets	0.25 × 36
Total	76 minutes for 60 minutes of integration

Table 18: Overheads – Example 3 – SW: Standard star in spectroscopy

Template parameters	
Acquisition Template	`ISAACSW_img_acq_MoveToSlit`
Observation Template	`ISAACSW_spec_cal_AutoNodOnSlit`
`DIT`	20 (seconds)
`NDIT`	3
`Number of AB or BA cycles`	1
`NINT`	1
`Return to Origin`	T
Night time Calibration Template	`ISAACSW_spec_cal_NightCalib`
`Flatfield at end of template`	T
`Arc at end of template`	T
Execution time (minutes)	
Preset & Acquisition	10.0
Instrument setup	2.0
int time + detector overhead:	(0.33 + 0.13) × 3 (NDIT) × 2 (1 AB cycle)
Telescope offsets	0.75 (3 telescope offsets)
Flat field	4
Arc	3
Total	22.5 minutes for 2 minutes of integration

Table 19: Overheads – Example 4 – SW: Spectroscopy of fainter object

Template parameters	
Acquisition Template	`ISAACSW_img_acq_MoveToSlit`
Observation Template	`ISAACSW_spec_obs_AutoNodOnSlit`
`DIT`	300 (seconds)
`NDIT`	1
`Number of AB or BA cycles`	6
`NINT`	1
`Return to Origin`	T
Night time Calibration Template	`ISAACSW_spec_cal_NightCalib`
`Flatfield at end of template`	T
`Arc at end of template`	F
Execution time (minutes)	
Preset	10.0
Instrument setup	2.0
int time + detector overhead:	(5 + 0.13) × 1 (NDIT) × 12 (6 AB cycles)
Telescope offsets	0.25 × 8 (8 offsets for 6 cycles)
Flat field	4
Total	79.5 minutes for 60 minutes of integration

Table 20: Overheads – Example 5 – LW: Imaging with chopping L band

Template parameters	
Acquisition Template	`ISAACLW_img_acq_Preset`
Observation Template	`ISAACLW_img_obs_AutoChopNod`
`Integration time (minutes)`	60
Execution time (minutes)	
Preset	6.0
Instrument setup	0.5
Integration time	60
Global overheads	40% × 60
Total	90.5 minutes for 60 minutes of integration

Table 21: Overheads – Example 6 – LW: Spectroscopy with chopping

Template parameters	
Acquisition Template	`ISAACLW_img_acq_MoveToSlit`
Observation Template	`ISAACLW_spec_obs_AutoChopNod`
`Integration time (minutes)`	60
Execution time (minutes)	
Preset	10.0
Instrument setup	2.0
Integration time	60
Global overheads	30% × 60
Total	90 minutes for 60 minutes of integration

Table 22: Overheads – Example 7 – LW: Spectroscopy without chopping

Template parameters	
Acquisition Template	`ISAACLW_img_acq_MoveToSlitNoChop`
Observation Template	`ISAACLW_spec_obs_AutoNodOnSlit`
`DIT`	0.4 (seconds)
`NDIT`	150
`Number of AB or BA cycles`	30
`NINT`	1
`Return to Origin`	T
Execution time (minutes)	
Preset	10.0
Instrument setup	2.0
int time	60.0
Telescope offsets	15.25 (61 telescope offsets)
Total	87.25 minutes for 60 minutes of integration

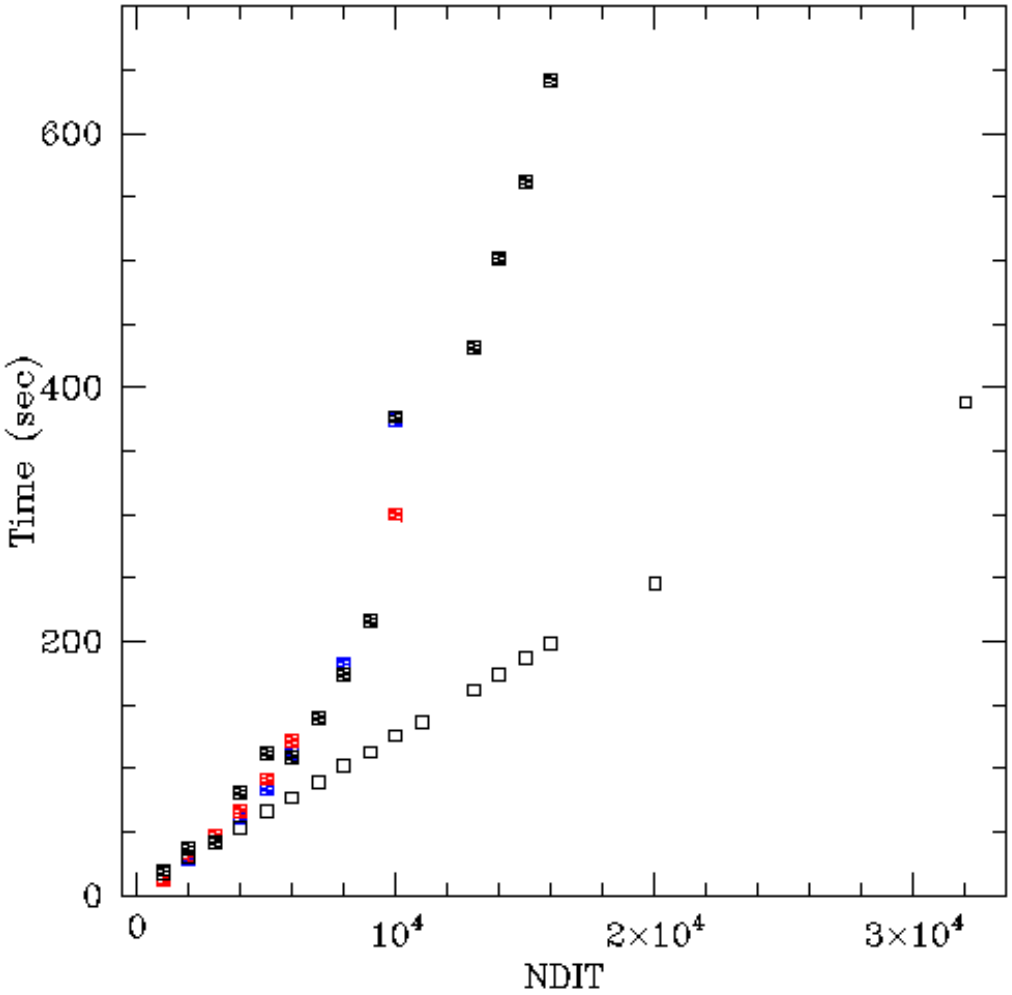


Figure 7: Execution times of the ISAACLW_img_acq_FastPhot template depending on the the data cube size and the selected mode (Burst or FastJitter). Filled squares are for Burst mode executions (black is for window=32x32 and DIT=3.2ms; blue is for window=32x32 and DIT=5ms; red is for window=64x64 and DIT=6.4ms). Empty squares are for the FastJitter mode executions (window=32x32 and DIT=12 ms).

7 Short Wavelength Imaging (Hawaii - SWI1 & Aladdin - LWI3)

7.1 Characteristics

See Section 2.2 for a description of this mode. JHK imaging is possible with the Aladdin as well as the Hawaii. See section 2.2.1 for a comparison of these two modes. For most users JHK imaging with the Hawaii will be superior.

7.2 Recommended DITs and NDITs

Table 23 gives some recommended values for DIT and NDIT×DIT. These values are a compromise between being background limited and maximizing efficiency, while limiting the exposure level to below $\approx 10,000/5,000$ ADU (Hawaii/Aladdin), and not staring at the same position for too long. It is important that the sky is sampled frequently and many times. Users should err on the side of having too many sky frames rather than too few.

Exposure levels can be derived by using the http://www.eso.org/observing/etc/.

Table 23: Recommended DIT (in seconds) and NDIT ranges for mode SWI1 & LWI3.

	J/Js/J+Block	H	Ks	NB filters in J	NB filters in H and K
DIT(seconds)	30–45[1]	10–12[1]	10–15	60–120	50–100
NDIT× DIT(seconds)	60-180	60-120	60-120[2]	180-300	120-300

[1] For visitor mode programs the ranges for the Js and H filters are 30–60 and 10–15 seconds respectively. (If the observations are to be done at the beginning of the night when the background in these filters is high, then DITs at the lower end of the range should be used).

[2] For K-band observations of objects that are crossing the meridian near Zenith (within 10 degrees of Zenith), it is better to use NDIT× DIT that is nearer to the lower bounds of the recommended range. This will result in better sky subtraction.

7.3 Calibration Plan

According to the observatory's calibration plan, in SM we provide the following calibrations:

- Twilight Flat Fields in all filters, as they are used. Note that due to the limited number of narrow bands (NB) which can be observed during twilight (i.e. one), each science OB is restricted to include at most two NB filters.
- Nightly zero points in the Hawaii Js, J, H and Ks filters using a low airmass standard star. On a semi-regular basis we also take a photometric standard star at high airmass in the same filters. Typically both the low and the high airmass standard are taken during twilight. In VM only the low airmass standard will be taken. Note that for the Aladdin J+Block, H and Ks filters (SWLW), zero-points will be taken only in those nights when these filters are used. In any case the zero points are aimed at providing photometric calibration accurate to $\sim$ 5%/10% (Hawaii/Aladdin). Should users need higher accuracy, they should provide OBs for standards close to the object, that will be

executed either immediately before or after their observations. In this case, the time spent doing these observations will be charged to the user. Zero points in all other filters (in particular NB filters) are not supported by the calibration plan, and users should prepare the necessary OBs.

- The observatory does not measure the extinction every night. Instead, the observatory has calculated the average extinction for the J, Js, H and Ks filters with the Hawaii detector since the start of operations. See http://www.eso.org/instruments/isaac/imaging_standards.html#Extinction. Extinction coefficients for the SW broad band filters in the Aladdin detector have not been determined yet.

- Every 3-6 month or after an intervention on the instrument the observatory takes illumination frames for the illumination correction. This frames are taken only in photometric conditions and serve to determine large scale difference between the true flat field and the twilight sky flat field. These are determined in the Aladdin and the Hawaii for Js, J, J+Block, H and Ks only.

- Detector darks, taken during the following morning for any DIT used at night.

7.4 Pipeline

All `AutoJitter` and `AutoJitterOffset` templates are supported by the pipeline. `ISAACLW_img_obs_GenericOffset` is not supported. `ISAACSW_img_obs_GenericOffset` is only partly supported - sequences of observations with offsets larger than the field of view (mosaicing) are not reduced by the pipeline. The SWI1 and LWI3 pipelines also calculate zero points and the read out noise, and create master twilight flats and master dark frames.

See http://www.eso.org/projects/dfs/papers/jitter98/ for a description of the pipeline algorithm. This pipeline has been used successfully since the start of the operations.

7.5 Performance

The user should refer to the ETC for estimating the performance of this mode http://www.eso.org/observing/etc/

8 Long Wavelength Imaging (LWI3 and LWI4)

8.1 Characteristics

See Section 2.2 for a description of this mode.

Chopping is essential for observations with wavelengths $> 3.5\mu$m, and can be used for all LW observations. Chopping will always give a better sky subtraction. For more information about chopping see Section 5.6. The imaging mode for observations with chopping is LWI4. The chopping templates produce a data cube for each nod position, which contains the two half-cycle frames.

For the narrow band 3.21 and 3.28 μm filters, non-chopping observations can also be used. The imaging mode for NB_3.21 and NB_3.28 non-chopping observations is LWI3.

8.2 Recommended `DIT`s and `NDIT`s

For observations that use chopping, `DIT` and `NDIT` are not parameters; they are automatically set by the templates and depend on the filter.

For observations without chopping the optimal DIT values are given in Table 24. NDIT should be set so that the total exposure at any one position is one minute.

Table 24: LW detector settings for imaging

Mode and filter	DIT (seconds)
LWI3 3.21 μm filter	0.35 to 0.7
LWI3 3.28 μm filter	0.35 to 0.5

8.3 Calibration Plan

Supported calibrations are:

- Sky flats (taken at three different airmasses) in all filters used during a night.
- Zero points of the night in the L and M_NB filters whenever they are used at night. These zero points aim to provide photometric calibration to an accuracy of $\sim 10\%$. Users requiring higher accuracy should provide OBs that will be executed either immediately before or after their observations. In this case, the time spent doing these observations will be charged to the user. Narrow band filter zero points are not supported by the calibration plan, and should be explicitly requested and prepared by the users.
- Darks frames for any DIT and readout mode used at night are taken during the following day.

8.4 Pipeline

Chopping and most non-chopping observations are supported by the pipeline. The `ISAACLW_img_obs_GenericOffset` template is not supported.

8.5 Performance

The user should refer to the ETC for estimating the performance of this mode http://www.eso.org/observing/etc/

9 Short Wavelength Spectroscopy 1 (SWS1)

9.1 Characteristics

See Section 2.3 for a description of the mode.

9.2 Recommended DITs and NDITs

ISAAC has always suffered from electronic pickup which could occasionally dominate the readout noise. The work around was to use recommended DITs which were observed to have small or insignificant pickup noise. However, a recent intervention (Feb 2006) on the Infrared Array Control Electronic (IRACE) cabinet, has solved the problem. By replacing a fan, the well known pickup noise at 51Hz has been eliminated and only a weak residual pickup noise at 75 and 152 Hz can be observed through a power spectrum analysis. Therefore, there are no longer particular limitations on the choice of the DIT values. Reappearance of pickup noise will be posted on the http://www.eso.org/instruments/isaac/ which we suggest to check at the moment of your OB preparation. In case, a thumbnail rule would be to select a DIT value which is not multiple of the pickup frequency, i.e. avoid DIT=n/f sec, where f is the frequency of the pickup noise and n is an integer number. Additionally, it will be possible to remove the pickup noise at the reduction stage (see http://www.eso.org/instruments/isaac/doc/drg/html/drg.html).

Even with exposures as long as 900s, the performance of MR spectroscopy between the OH lines in the J or H bands is readout noise limited. It is therefore advisable to integrate for the longest possible time, but the very high density of hot pixels and cosmic rays can seriously limit the data quality if the integrations are too long. These bad pixels and cosmic rays are better removed when combining a large number of images. The best compromise between data integrity and readout noise is difficult to find, and somehow depends on the program. It is advised to choose DITs of $\sim$ [10-15] minutes in J, H and K band (below 2.2 μm) medium resolution spectroscopy, and smaller values above 2.2 μm in K band medium resolution spectroscopy.

If the total duration of the observation is short (i.e. one single OB lasting less than one hour), it is advisable to reduce the DIT to say 5 minutes or so and increase the number of exposures and telescope positions at which data is obtained. This will make it easier to properly reject bad pixels.

If, on the other hand, the total duration of the observation is long (i.e. several OBs, each lasting 1 hr or so), then it is advisable to increase the exposure time to 10-15 minutes. Then, by combining all the images from all OBs, one will be able to adequately remove bad pixels. In this case, it is recommended to place the object at different positions along the slit. The easiest way to do this is to give the different OBs slightly different values for the Nod Throw Along Slit parameter (see Section A.8.1).

The ISAACSW_spec_obs_AutoNodOnSlit template provides the possibility of storing individual frames at each telescope position (NINT). It is therefore preferable to use a high NINT, rather than a high NDIT.

At Low Resolution, the noise is essentially limited everywhere by the photon noise from the OH lines after $\sim$ 1 minute of integration. Therefore, DITs of a few minutes (e.g. from 1 to 3) are adequate. It is then advisable to offset the telescope as many times as possible during the execution of the template.

Table 25: Recommended range for DIT (in seconds) and NDIT for SWS1-LR and SWS1-MR modes.

	LR	MR
DIT(recommended)	60–200	300–900
NDIT	1	1

9.3 Calibration Plan

For the LR grating, **only four grating settings, that correspond to 1.06, 1.25, 1.65 and 2.2 μm** are supported. Users should not use any other central wavelength in LR mode. In LR mode, telluric standards, spectroscopic flats and arcs will only be taken at the supported wavelengths.

The guarantee calibrations in SM are:

- LR and MR Telluric Standard Stars according to the night time observations. The telluric standard is taken at similar airmass than the science observations: the observatory guarantees that the airmass difference between the standard and science target is $\leq$0.2 airmasses. The standard will be observed with the slit that was used during the observations. Starting from period 77 we do not observe any more the telluric standard with the 2″ slit. Therefore the users should explicitly required it within their README files, should they need it. Note that starting from period 78 the time for such an observation will be charged to the user.

  The stars are generally chosen from the Hipparcos catalog and are either hot stars (spectral type B0V to B4V) or solar type stars (spectral types G0V to G4V). These calibrations are taken so that telluric features can be removed from science spectra. They can also be used for flux calibration with a relative accuracy of 5-10% and an absolute accuracy of 5-20%. A detailed discussion on this topic is given in Sec. 3.4.

  Should users need more accurate results or require telluric standards of a particular spectral type, they should provide the corresponding OBs and detailed instructions. **The spectroscopic standard star templates (e.g. _cal_) must be used to prepare these OBs**. In this case, the time executing the OBs will be charged to the user and the observatory will not observe a separate telluric standard.

- Darks are taken on the following morning for any DIT value used during the night.

- Spectroscopic screen flats are taken on the following morning for any set-up used during the night.

- Wavelength calibrations are taken on the following morning for any set-up used at night.

- Star traces are taken every 3-6 month or after an instrument intervention to trace the spectra at different positions along the slit and provide the co-ordinate transformation between imaging and spectroscopy. They are archived for both the LR and MR modes and can be downloaded from the archive.eso.org.

9.4 Pipeline

The AutoNodOnSlit templates are supported by the pipeline. The GenericOffset templates are not supported by the pipeline. Further details are given in the http://www.eso.org/

instruments/isaac/doc/drg/html/drg.html.

9.5 Performance

The user should refer to the ETC for estimating the performance of this mode http://www.eso.org/observing/etc/

10 Long Wavelength Spectroscopy 3 (LWS3)

10.1 Characteristics

See Section 2.3 for a description of the mode.

Chopping is essential for LR observations, and can be used for all observations. For more information about chopping see Section 5.6. The chopping templates produce a data cube for each nod position, which contains the two half-cycle frames.

For MR observations, non-chopping observations can also be taken.

10.2 Recommended DITs and NDITs

For observations that use chopping, DIT and NDIT are not parameters; they are automatically set in the templates based on the instrument mode in use.

For non-chopping observations the optimal DIT values are between 0.35 and 5 seconds. NDIT should be set so that the total exposure at any one position is between one and a few minutes. Users should note that some spectral regions in the M band will saturate the detector with the minimum integration time. More detailed information is provided on the http://www.eso.org/instruments/isaac/.

10.3 Calibration Plan

For the LR grating, **only two grating settings, that correspond to 3.55 and 4.75 μm** are supported. Users should not use any other central wavelength in LR mode. In LR mode, telluric standards, spectroscopic flats and arcs will only be taken at the supported wavelengths.

The calibration provided by the instrument calibration plan are the following:

- LR and MR Telluric Standard Stars according to the night time observations. The telluric standard is taken at similar airmass than the science observations: the observatory guarantees that the airmass difference between the standard and science target is $\leq$0.2 airmasses. The standard will be observed with the slit that was used during the observations. Starting from period 77 we do not observe any more the telluric standard with the 2″ slit. Therefore the users should explicitly required it within their README files, should they need it. Note that starting from period 78 the time for such an observation will be charged to the user.

  The stars are generally chosen from the Hipparcos catalog and are either hot stars (spectral type B0V to B4V) or solar type stars (spectral types G0V to G4V). These calibrations are taken so that telluric features can be removed from science spectra. They can also be used for flux calibration with a relative accuracy of 5-10% and an absolute accuracy of 5-20%. A detailed discussion on this topic is given in Sec. 3.4.

  Should users need more accurate results or require telluric standards of a particular spectral type, they should provide the corresponding OBs and detailed instructions. **The spectroscopic standard star templates (e.g. _cal_) must be used to prepare these OBs**. In this case, the time executing the OBs will be charged to the user and the observatory will not observe a separate telluric standard.

- Darks. Darks are taken at the end of each night with the `DIT` values and readout mode used during the night.
- Spectroscopic Flats corresponding to the set-ups used during the night are taken by the operation staff the next day.
- LR arcs. LR arcs are taken in the L band. In M, it is not possible to take arcs with the grating in the 1st order, so they are taken with the grating in 3rd order. However, the accuracy is poorer than using the telluric features themselves, which are ubiquitous in M band spectra.
- MR arcs. Arcs, corresponding to the setups used during a night, are taken by the daytime astronomer during the following day. As in LR, arcs are taken with the grating in 1st order for L and with the grating in 3rd order for M. Alternatively, the ubiquitous telluric features can be used. This has been tested for all spectroscopic modes, and has proved to be as accurate as using the arcs.
- Star traces are taken every 3-6 months or after an instrument intervention to trace the spectra at different positions along the slit and provide the co-ordinate transformation between imaging and spectroscopy. They are archived for both the LR and MR modes.

10.4 Pipeline

All chopping and most non-chopping templates are supported. The `GenericOffset` templates are not supported.

10.5 Performance

The user should refer to the ETC for estimating the performance of this mode (http://www.eso.org/observing/etc/).

11 Short Wavelength Polarimetry 1 (SWP1)

11.1 Characteristics

See Section 2.4 for a description of this mode.

11.2 Recommended `DIT`s and `NDIT`s

Since light is divided in two by the Wollaston prism, the `DIT` values used in the SWI1 mode (see Section 7) should be doubled.

11.3 Calibration Plan

This mode is not really supported within the ISAAC Calibration Plan.

The normal twilight flat fields without the Wollaston can be used to flat field the data and this are the only calibration provided by the observatory. If the user need a polarimetric standard or so, he/she must provide the OBs and the time will be charged to him/her.

11.4 Pipeline

This mode is not supported by a pipeline.

11.5 Performance

This mode is not supported by an ETC. However, the performance can be confidently estimated from the imaging case (see section 7) by considering that the light from the object and from the sky is divided into two by the Wollaston. To reach a given limiting magnitude in the background limited case therefore requires twice the time required in imaging.

12 Aladdin Fast Photometry: Burst and FastJitter modes

Starting from Period 79, two new imaging modes are offered: the Burst mode and the FastJitter mode. They are intended for fast relative photometry, from a few ms to a few tenths of ms. Originally implemented (and tested) for lunar occultations, they are suitable for any fast variable phenomena where time resolution is a must.

12.1 Characteristics

Imaging is possible in three SW filters: J+Block, H and Ks, using the Aladdin array (located in the ISAAC's LW arm). Hardware windowing of the array allows very short DITs. The Burst and FastJitter modes are offered both in VM and in SM.

The two modes differ only in the way an image is processed and transferred from IRACE (InfraRed Array Control Electronics) to the instrument workstation. This difference affects the technical capabilities of each mode. Specifically:

- The shortest DITs possible are 3.2 ms (Burst mode) and 12ms (FastJitter) with the smallest window size of 32x32 pixels (corresponding to a 4.7"x4.7" FOV).
- The readout mode is Double Correlated Read (Reset-Read-Read): in this mode, each image, or DIT unit, is made of two reads. The data are stored in single fits files, each containing a data cube:
  - The Burst mode produces a data cube comprised of single reads, which have to be combined two by two to reconstruct an image (DIT). A script which allows image reconstruction is available. For the smallest window, the size of the data cube is therefore 32x32x2xNDIT.
  - The FastJitter mode usually produces a data cube of DITs (i.e. already reconstructed images). For the smallest window the size of the data cube is therefore 32x32xNDIT.
- In Burst mode the telescope is staring at the target for the duration of the integration (INT=NDITxDIT) and only one data cube is produced. In FastJitter mode, the telescope can jitter in the sky and several data cubes can be produced within one template.
- In Burst mode it is possible to set the absolute time on which the observation has to be centered. For example, if one wants to observe an event at time T and sets a total integration of 60 seconds, the template will start to collect data at time=T-30 and end at T+30.

Both modes are subject to some limitations:

- The data cube can contain a maximum of 32000 planes (frames), i.e. the maximum NDIT is 16000 in Burst mode and 32000 in Fast Jitter mode.
- The maximum data cube size is 262Mb. Once the window size has been selected, this limits the number of frames/reads and vice versa.

Table 26: Hardware windowing characteristic in Burst and FastJitter mode.

			Burst mode	FastJitter mode		
Window Size [pxs]	StartX=StartY [pxs]	Field of View ["]	min DIT [ms]	max NDIT	min DIT [ms]	max NDIT
32x32	497	4.7x4.7	3.2	16000	12	32000
64x64	481	9.5x9.5	6.4	15991	12	16000
128x128	449	19x19	14	3998	14	4000
256x256	385	38x38	37	999	37	1000
512x512	257	75x75	106	249	106	250

A summary table with the hardware windowing characteristic is given in Table 26.

The detector characteristics are the same as for SW imaging with the LW array (see the User's Manual). The maximum and minimum observable magnitudes can roughly be estimated through the ETC by scaling the obtained counts to the actual DIT.

Table 27 reports some technical information for the Burst mode.

Table 28 reports some technical information for the FastJitter mode.

12.2 Calibration Plan

For both modes we provide a set of windowed darks taken with the same DIT of the science template and windowed twilights flats taken with the same filters combination as in the science template.

12.3 Pipeline

Burst and FastJitter observations are not pipeline supported. However, the same recipes that process standard darks and twilight flats can deal with the windowed frames as well.

Note that, in the case of the Burst mode, it is necessary to reconstruct the images. We are in the process to include the script for the reconstruction of the Burst mode data cubes into the ISAAC pipeline.

Table 27: Burst mode technical info. Note that the reported execution times are just indicative and may vary depending on the net connection.

Window Size [pxs]	DIT [ms]	NDIT	N. Frames	Execution time [s]	Data cube Size [Mb]
32x32	3.2	1000	2000	20	4.1
32x32	3.2	2000	4000	37	8.2
32x32	3.2	3000	6000	42	12.3
32x32	3.2	4000	8000	81	16.4
32x32	3.2	5000	10000	112	20.5
32x32	3.2	6000	12000	109	24.6
32x32	3.2	7000	14000	139	28.7
32x32	3.2	8000	16000	174	32.8
32x32	3.2	9000	18000	216	36.9
32x32	3.2	10000	20000	377	41.0
32x32	3.2	13000	26000	431	53.3
32x32	3.2	14000	28000	495-501	57.4
32x32	3.2	15000	30000	562	61.5
32x32	3.2	16000	32000	636-642	65.6
32x32	4.0	7000	14000	143	28.7
32x32	4.5	6000	12000	114	24.6
32x32	5.0	1000	2000	20	4.1
32x32	5.0	2000	4000	29	8.2
32x32	5.0	3000	6000	42	12.3
32x32	5.0	4000	8000	61	16.4
32x32	5.0	5000	10000	84	20.5
32x32	5.0	6000	12000	112	24.6
32x32	5.0	8000	16000	183	32.8
32x32	5.0	10000	20000	374	41.0
32x32	6.0	7000	14000	143	28.7
64x64	6.4	1000	2000	12	16.4
64x64	6.4	2000	4000	31	32.8
64x64	6.4	3000	6000	47	49.2
64x64	6.4	4000	8000	67	65.6
64x64	6.4	5000	10000	92	82.0
64x64	6.4	6000	12000	122	98.4
64x64	6.4	10000	20000	270-300	163.9

Table 28: FastJitter mode technical info. Note that the reported execution times are just indicative and may vary depending on the net connection.

Window Size [pxs]	DIT [ms]	NDIT	N. Frames	Execution time [s]	Data cube Size [Mb]
32x32	12	1000	1000	18	4.1
32x32	12	2000	2000	30	8.2
32x32	12	3000	3000	41	12.3
32x32	12	4000	4000	54	16.4
32x32	12	5000	5000	66	20.5
32x32	12	6000	6000	77	24.6
32x32	12	7000	7000	89	28.7
32x32	12	8000	8000	102	32.8
32x32	12	9000	9000	113	36.9
32x32	12	10000	10000	126	41.0
32x32	12	11000	11000	137	45.0
32x32	12	13000	13000	162	53.3
32x32	12	14000	14000	174	57.4
32x32	12	15000	15000	187	61.5
32x32	12	16000	16000	198	65.6
32x32	12	20000	20000	246	82.0
32x32	12	32000	32000	388	131.1
64x64	12	16000	16000	199	262.2
128x128	14	4000	4000	114	262.2
256x256	37	1000	1000	37	262.2

A Template description

A.1 General remarks and reminders - how to avoid common sources of error.

- Only parameters specific to ISAAC are described. The description of other parameters can be found in the http://www.eso.org/observing/p2pp
- We **strongly** recommend that you consult the http://www.eso.org/instruments/isaac/ for the latest information.
- Templates using the Aladdin and templates using the Hawaii must not be mixed in the same OB.
- All SW spectroscopic OBs must use the `ISAACSW_img_acq_MoveToSlit` or `ISAACSW_img_acq_MoveToSlitrrm` template for acquisition and all LW spectroscopic OBs must use either the `ISAACLW_img_acq_MoveToSlit` or `ISAACLW_img_acq_MoveToSlitNoChop` templates.
- The SW polarimetric OBs must use the `ISAACSW_img_acq_Polarimetry` template for acquisition.
- LW imaging chopping templates must use either `ISAACLW_img_acq_Preset` or `ISAACLW_img_acq_MoveToPixel` for acquisition, and LW imaging no-chopping templates must use either `ISAACLW_img_acq_Preset` or `ISAACLW_img_acq_MoveToPixNoChop`.
- In those templates where 2 filters have to be defined (`SW Filter wheel 1` and `SW Filter wheel 2`, or `LW Filter wheel 1` and `LW Filter wheel 2`), it is essential that at least one filter be set. This includes acquisition templates.
- The slit that is chosen in the acquisition template and the slit that will be used subsequently in the observation template must be the same.
- If imaging and spectroscopic templates are combined in one OB, it is required that the imaging template follows the spectroscopic template.
- It is possible to submit a single OB which comprises several observing descriptions, for example, to observe a single target with different filters.
- Night time calibration templates are not autonomous. They must follow a spectroscopic observation. Furthermore, they only calibrate the wavelength setting that is used in the preceding template and not the wavelength settings in all preceding templates.
- Some targets we are asked to observe saturate the detectors with the minimum DIT. Please pay close attention to source brightnesses to ensure that this does not happen!
- Use the verify button in P2PP - this checks that individual parameters are within the defined ranges, and also runs scripts to check the global logic of an OB.
- With the exception of standards, the minimum amount of time between telescope offsets is one minute.

- Remember that, for short wavelength imaging, objects brighter than 11th magnitude must be justified in the README file.
- Ensure that the correct set of filters are used when acquiring bright targets for SW spectroscopy. See Section 5.4.
- Ensure that spectra do not overlap when offsetting the telescope or nodding the secondary. In particular, make sure that jitter width is smaller than the nod throw.
- Observation templates that use chopping should only be calibrated with calibration templates that use chopping. Likewise, observation templates that do not use chopping should only be calibrated with calibration templates that do not use chopping.
- For observations that use chopping, the bias voltage of the array is set so that the well depth is large. This leads to a very large number of hot pixels, whose flux is changing on the timescale of a few seconds. Thus it is very important in long exposures to set `Jitter Box Width` to some non zero value, so that these hot pixels can be removed.
- When doing a blind offset from a bright reference object to a faint target, the co-ordinates of the reference object are the ones that should go into the acquisition template.

A.2 Orientation conventions and definitions

- East is to the right (X^+) of the images for zero position angle.
- North is to the bottom (Y^-) of the images for a zero position angle.
- Position angle on sky. This angle is measured in the standard way, i.e. it is positive from North to East. Note that the opposite is true for FORS1.
- The slits are oriented along detector columns (y axis on the figures). In fact there is a small angle which ensures that night sky lines and arc lines are vertical. This angle is totally transparent to the user.
- The Y axis between images and spectra is flipped.

See figure 8 for illustrations of the orientation convention.

A.3 Chopping conventions and definitions

- `Chop Throw (arcsec) ?`. This is the throw of the chopping (in arcsec). The formal allowed range is 10-30 arcseconds; **however, we strongly recommend that the throw is kept to 20 arcseconds or less**. If the chop throw is between 20 and 30 arcsec, guiding is only possible on one beam, leading to a deterioration of the image quality due to intermittent loss of AO corrections.
- `Chop Position Angle ?`. This is the chopping position angle in degrees. If the `Chop Angle Coordinate ?` is set to SKY, then the chopping will be in sky coordinates. The convention is that 0 degree will result in chopping to the South, i.e. the OFF beam will be to the South of the ON beam (negative and positive images respectively on the acquisition images), and that the angle of the chop is defined from North to West. The

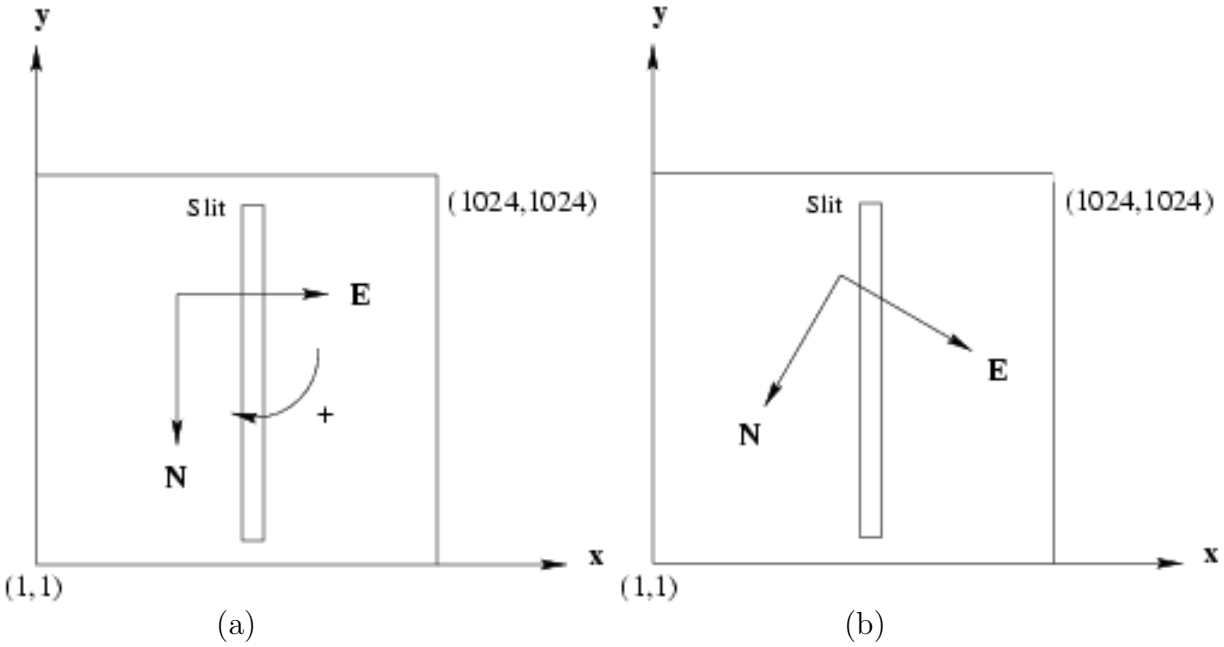


Figure 8: Orientation convention for images, including acquisition images. (a): Field orientation on detector at 0° rotation angle on sky, (b): Field orientation at 30° rotation angle on sky. The slit position is overlaid. In spectra, the Y axis is flipped. The circular arrow indicates the direction the field will rotate after a positive position angle is applied.

direction of the chop on the array depends on the position angle of the instrument on the sky.

If the `Chop Angle Coordinate ?` is set to DETECTOR, the chopping will be in detector coordinates. The convention is that chopping will be along the X^+ axis if `Chop Position Angle ?` is set to 0°, and to the Y^+ axis if `Chop Position Angle ?` is set to 90°. This is independent of the position angle of the instrument on the sky.

- `Chop Angle Coordinate ?`. Either SKY or DETECTOR.

See figure 9 for an illustration of the chopping orientation conventions.

A.4 Offset conventions and definitions

The templates make extensive use of telescope offsets. In some templates the offsets are set automatically (e.g. `ISAACSW_img_obs_AutoJitter`), but in others the offsets have to be entered manually as lists. In this latter case, the convention is that offsets are **relative**. E.g, the following list of offsets:

`RA offset list (arcsec)` 0 10 -10 20 -20

will result in a first image at initial position in RA, telescope offset 10 arcsec East for the second, telescope offset 10 arcsec West for the third image (.i.e the telescope is back to the initial position), etc.

Sometimes, offsets may be defined in detector coordinates. In that case, a positive offset in X will move the image to the right (X^+) (the telescope offset is therefore in the opposite

direction).

All offsets are given in arcseconds, even the offsets that are defined in detector coordinates. Therefore, an offset of +10 in X will move the object 10 arcsec to the right of the image.

Reminder: the minimum time between telescope offsets is 1 minute.

A.5 File names

The names of the FITS files produced are fixed for each template, and have names of the format (ROOT)_(nnnn)_(ext).fits, where (ROOT) depends on the template used and is given in Table 29, (nnnn) is a 4 digit incremental number and (ext) is a possible extension (e.g. CUBE1 for LW observations, and SAMPLE or DIT for the Burst and FastJitter observations, respectively).

Table 29: FITS files names

Template	(ROOT)
ISAACSW_img_obs_AutoJitter	ISAAC_SWI_SCI
ISAACSW_img_obs_AutoJitterOffset	
ISAACSW_img_obs_GenericOffset	
ISAACSW_img_obs_Polarimetry	ISAAC_SWP_SCI
ISAACSW_spec_obs_AutoNodOnSlit	ISAAC_SWS_SCI
ISAACSW_spec_obs_GenericOffset	
ISAACSW_img_cal_GenericOffset	ISAAC_SWI_STD
ISAACSW_spec_cal_AutoNodOnSlit	ISAAC_SWS_STD
ISAACSW_img_cal_Polarimetry	ISAAC_SWP_STD
ISAACSW_spec_cal_NightCalib	ISAAC_SWS_NIGHTCALIB
ISAACLW_img_obs_AutoChopNod	ISAAC_LWI_SCI
ISAACLW_img_obs_AutoJitter	
ISAACLW_img_obs_AutoJitterOffset	
ISAACLW_img_obs_GenericOffset	
ISAACLW_img_obs_FastPhot (Burst mode)	ISAAC_LWI_SCI_nnnn_SAMPLE_
ISAACLW_img_obs_FastPhot (FastJitter mode)	ISAAC_LWI_SCI_nnnn_DIT_
ISAACLW_spec_obs_AutoChopNod	ISAAC_LWS_SCI
ISAACLW_spec_obs_AutoNodOnSlit	
ISAACLW_spec_obs_GenericOffset	
ISAACLW_img_cal_AutoChopNod	ISAAC_LWI_STD
ISAACLW_img_cal_GenericOffset	
ISAACLW_spec_cal_AutoChopNod	ISAAC_LWS_STD
ISAACLW_spec_cal_AutoNodOnSlit	
ISAACLW_spec_cal_NightCalib	ISAAC_LWS_NIGHTCALIB

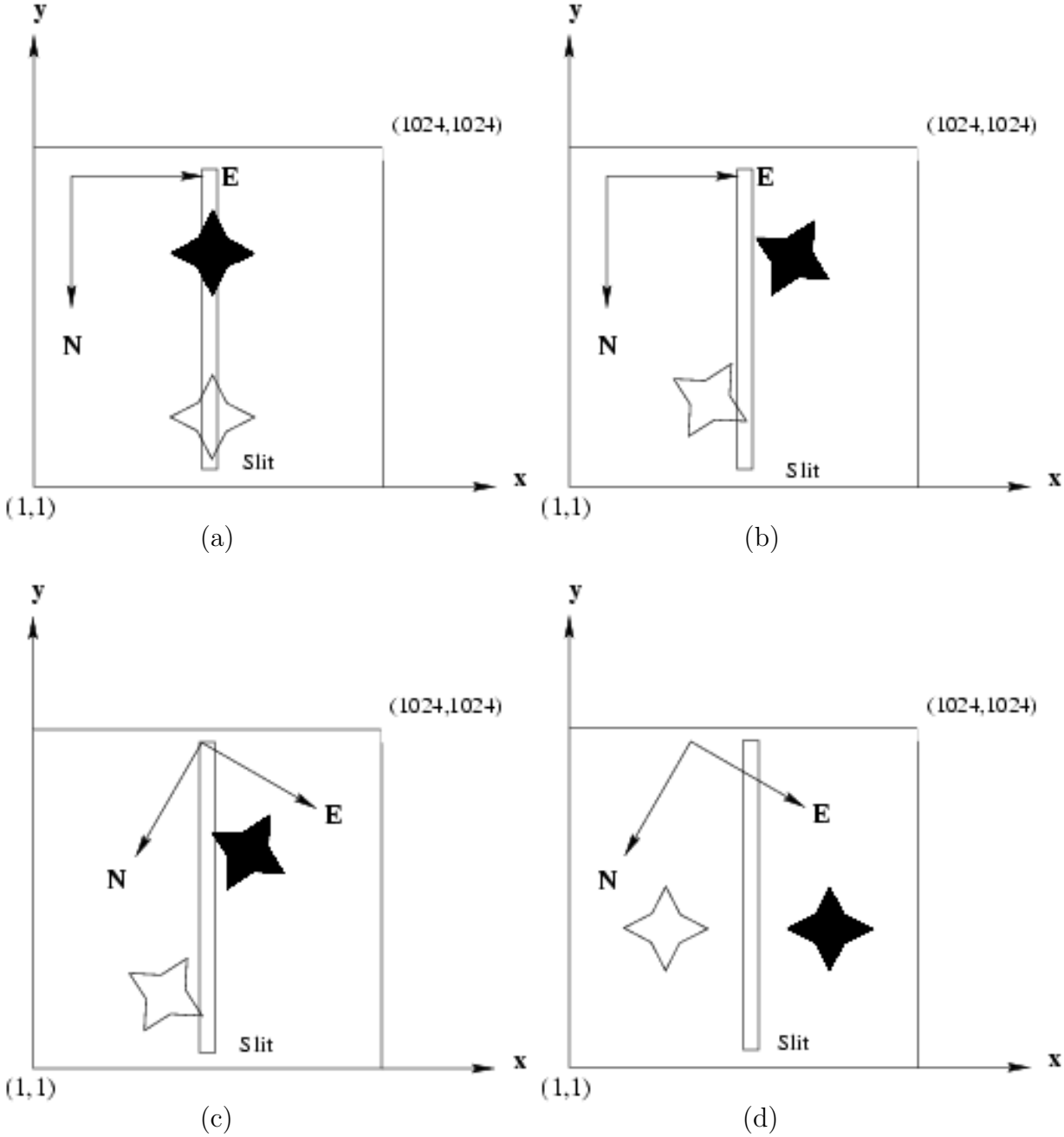


Figure 9: Chopping orientation convention. The star image in white is positive, the star image in black is negative.
(a): 0° rotation on sky. 0° chopping angle for SKY chopping coordinates, or 90° chopping angle for DETECTOR coordinates.
(b): 0° rotation on sky. 30° chopping angle for SKY chopping coordinates, or 60° chopping angle for DETECTOR coordinates.
(c): 30° rotation on sky. 0° chopping angle for SKY chopping coordinates, or 60° chopping angle for DETECTOR coordinates.
(d): 30° rotation on sky. 60° chopping angle for SKY chopping coordinates, or 0° chopping angle for DETECTOR coordinates.

A.6 Hawaii Acquisition Templates

A.6.1 Introduction

Telescope presets can only be done via acquisition templates. Telescope presets move the telescope to the requested coordinates and allow the telescope operator to select a guide star and start active optics. Additionally, these templates set up the detector and the instrument. Conversely, observation templates only deal with telescope offsets, and not with telescope presets. In general, acquisition templates dump an image to disk; only the `ISAACSW_img_acq_Preset` template does not. These dumped images are aimed at keeping track of the field position and orientation before starting the observation.

All Hawaii acquisition templates use the SWI1 mode.

See also sections 5.3, 7 and 9 for more information on target acquisition and on the Hawaii imaging and spectroscopic modes.

In general, it is not necessary for the acquisition and the subsequent observation templates to have the same `DIT` and `NDIT`. However, not doing so, may lead to unnecessary overhead.

A.6.2 `ISAACSW_img_acq_Preset`

This template does a simple telescope preset. It is the easiest template to use when objects can be easily identified against the sky background. An identical version for RRM observations is available (see Section A.6.3). It should **NOT** be used for subsequent spectroscopic observations and it should not be used if the user wants a pointing accuracy that is better than few arcsec.

The instrument parameters can be set to values used in the subsequent imaging template, so that the instrument will be already set at the start of this template. This will save time.

Table 30 describes the parameters of this template.

Table 30: Parameters of `ISAACSW_img_acq_Preset`

P2PP label	Keyword	Default	Description
`DIT`	`DET DIT`	–	Detector Integration Time (secs)
`NDIT`	`DET NDIT`	–	Number of `DIT`s
`Add Velocity Alpha` [1]	`TEL TARG ADDVELALPHA`	0	Additional tracking vel. in RA
`Add Velocity Delta` [1]	`TEL TARG ADDVELDELTA`	0	Additional tracking vel. in DEC
Position Angle on Sky (Deg)	`TEL ROT OFFANGLE`	0	Position angle ([+-]DDD.TTT)
`SW Filter wheel 1`	`INS FILT1 NAME`	–	Filter wheel 1
`SW Filter wheel 2`	`INS FILT2 NAME`	–	Filter wheel 2
`Equinox`	`TEL.TARG.EQUINOX`	2000	Equinox expressed as yr from -2000 to 3000
`Epoch`	`TEL.TARG.EPOCH`	2000	Epoch expressed as yr from -2000 to 3000
`Proper Motion Alpha`	`TEL.TARG.PMA`	0.	proper motion in “/yr from -10 to 10
`Proper Motion Delta`	`TEL.TARG.PMD`	0.	proper motion in “/yr from -10 to 10

[1] In arcsec/sec

No RTD image is dumped on disk at the end of this template.

A.6.3 ISAACSW_img_acq_Presetrrm

This template is functionally identical to ISAACSW_img_acq_Preset apart from having fewer parameters (see Table 31) and is intended for acquisition of RRM imaging OBs.

Table 31: Parameters of ISAACSW_img_acq_Presetrrm

P2PP label	Keyword	Default	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in "/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in "/yr from -10 to 10

A.6.4 ISAACSW_img_acq_MoveToPixel

This template presets the telescope and allows the operator to interactively center the field. In visitor mode, the interactive part of the template will be executed by the instrument operator under the supervision of the visiting astronomer. In service mode, it is mandatory that users send detailed information for the field centering (see Section 5.3).

In general, one should not put the object at the very center of the array. One should aim to place it a few tens of pixels away.

In order for objects to be clearly seen, one fixed pattern image is acquired in an offset position defined by the Alpha offset (arcsec) and Delta offset (arcsec) parameters. This image is then subtracted from all images that are subsequently displayed on the RTD. The telescope first goes to the offset position, the operator is prompted to store a fixed pattern, and when stored the telescope moves to the preset position. The image displayed on the RTD then displays an image of the field minus the fixed pattern. The integration time for these acquisition images is defined by the DIT and NDIT parameters, and should be set according to the guidelines discussed in section 7.

At this point in time the user can change DIT and NDIT. If the user changes these values, the telescope offsets again and the user is required to store another fixed pattern before the telescope returns to the nominal position. This loop can continue until the user has identified the target.

The observer is then prompted to define an offset. This is simply done by drawing an arrow on the screen with the left hand button of the mouse. At this point a window, which lists the pixel co-ordinates at the start and the end of the arrow, will appear (see figure 6). The user can either accept the offsets, cancel, or edit the co-ordinates directly. If the offsets are accepted, the telescope offsets by the desired amount. Finally, the user is given the possibility to redraw the arrow for refining the position of the object if necessary. Once the user is satisfied, the template finishes.

If the "Preset Telescope ?" parameter is set to "F", then the telescope will not move. This can be useful in visitor mode to use the functionality of the template without presetting the telescope.

The interactive pop-up windows are usually displayed *before* new images have arrived on the RTD. Therefore, users are strongly advised to carefully check that a new image has arrived

before clicking on these windows (e.g. for storing a fixed pattern, for changing the DIT and NDIT).

Table 32: Parameters of ISAACSW_img_acq_MoveToPixel

P2PP label	Keyword	Default	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Alpha offset (arcsec)	TEL TARG OFFSETALPHA	10	RA offset (arcsec)
Delta offset (arcsec)	TEL TARG OFFSETDELTA	10	DEC offset (arsec)
Add Velocity Alpha [1]	TEL TARG ADDVELALPHA	0	Additional tracking vel. in RA
Add Velocity Delta [1]	TEL TARG ADDVELDELTA	0	Additional tracking vel. in DEC
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in “/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in “/yr from -10 to 10

[1] In arcsec/sec

The image displayed on RTD at the end of the template is dumped on disk.

A.6.5 ISAACSW_img_acq_MoveToSlit

All SW spectroscopy OBs must make use of this template for target acquisition. The only exception is for RRM observations, for which ISAACSW_img_acq_MoveToSlitrrm(see Section A.6.6) must be used instead. See also section 5.3 and 5.4 for more specific information regarding slit acquisition.

This template is very similar to the ISAACSW_img_acq_MoveToPixel template.

A drawing of the selected slit (defined with the Slit ? parameter) is displayed on the RTD and is superimposed on the image of the field. The centering of the target or reference objects is then done interactively with the tool described in appendix A.6.4. In most cases, users will use the option to move the selected object to the centre of the slit.

The template also allows one to place two objects into the slit without the requirement of calculating the position angle beforehand.

There is no way of checking if the slit that is chosen in the acquisition template and the slit that will be used subsequently in the observation template are the same. It is, therefore, of utmost importance that users ensure that they are identical.

Users should also ensure that the correct set of filters are used when acquiring bright targets. See Section 5.4.

The Alpha offset from Ref Star and Delta offset from Ref Star parameters allow the user to define a telescope offset when the acquisition is made on reference objects. That is, once the reference object has been acquired and centered in the slit, the offsets defined here will offset the telescope so as to bring the desired target into the slit.

These offsets should not be confused with the Alpha offset (arcsec) and Delta offset (arcsec) offsets, which are used to define a 'sky' reference for the first telescope position in order to subtract a fixed pattern.

Table 33: Parameters of ISAACSW_img_acq_MoveToSlit

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Alpha offset from Ref Star	SEQ REF OFFSETALPHA	0	Offset from Ref. Star (arcsec)
Delta offset from Ref Star	SEQ REF OFFSETDELTA	0	Offset from Ref. Star (arcsec)
Alpha offset (arcsec)	TEL TARG OFFSETALPHA	10	RA offset (arcsec)
Delta offset (arcsec)	TEL TARG OFFSETDELTA	10	DEC offset (arsec)
Add Velocity Alpha [1]	TEL TARG ADDVELALPHA	0	Additional tracking vel. in RA
Add Velocity Delta [1]	TEL TARG ADDVELDELTA	0	Additional tracking vel. in DEC
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2
Slit ?	INS SLIT	–	Slit (e.g. slit_1)
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in "/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in "/yr from -10 to 10

[1] In arcsec/sec

The image displayed on RTD at the end of the template is dumped on disk.

A.6.6 ISAACSW_img_acq_MoveToSlitrrm

This template is functionally identical to ISAACSW_img_acq_MoveToSlit apart from having fewer available parameters (see Table 34) and is intended for acquisition of RRM spectroscopy OBs.

Table 34: Parameters of ISAACSW_img_acq_MoveToSlit

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2
Slit ?	INS SLIT	–	Slit (e.g. slit_1)
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in "/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in "/yr from -10 to 10

A.6.7 ISAACSW_img_acq_Polarimetry

All SW polarimetric OBs must use this template for target acquisition.

This template is very similar to the ISAACSW_img_acq_MoveToPixel template. The polarimetric mask is displayed on the RTD and is superimposed on the image of the field. Therefore, the offset can be defined so as to properly position the object into the transparent region of the mask. The template has been coded so that the field of view will rotate around pixel (x,y)=(512,540). If the aim of the user is to measure the polarisation of a single target, as opposed to measuring the polarisation in the entire field, it is recommended that the target is placed on or close to this pixel. Otherwise the target may move behind the mask after the field is rotated. Service Mode users should make it clear where they wish their target to be placed.

Table 35: Parameters of ISAACSW_img_acq_Polarimetry

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Alpha offset (arcsec)	TEL TARG OFFSETALPHA	10	RA offset (arcsec)
Delta offset (arcsec)	TEL TARG OFFSETDELTA	10	DEC offset (arsec)
Add Velocity Alpha [1]	TEL TARG ADDVELALPHA	0	Additional tracking vel. in RA
Add Velocity Delta [1]	TEL TARG ADDVELDELTA	0	Additional tracking vel. in DEC
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in "/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in "/yr from -10 to 10

[1] In arcsec/sec

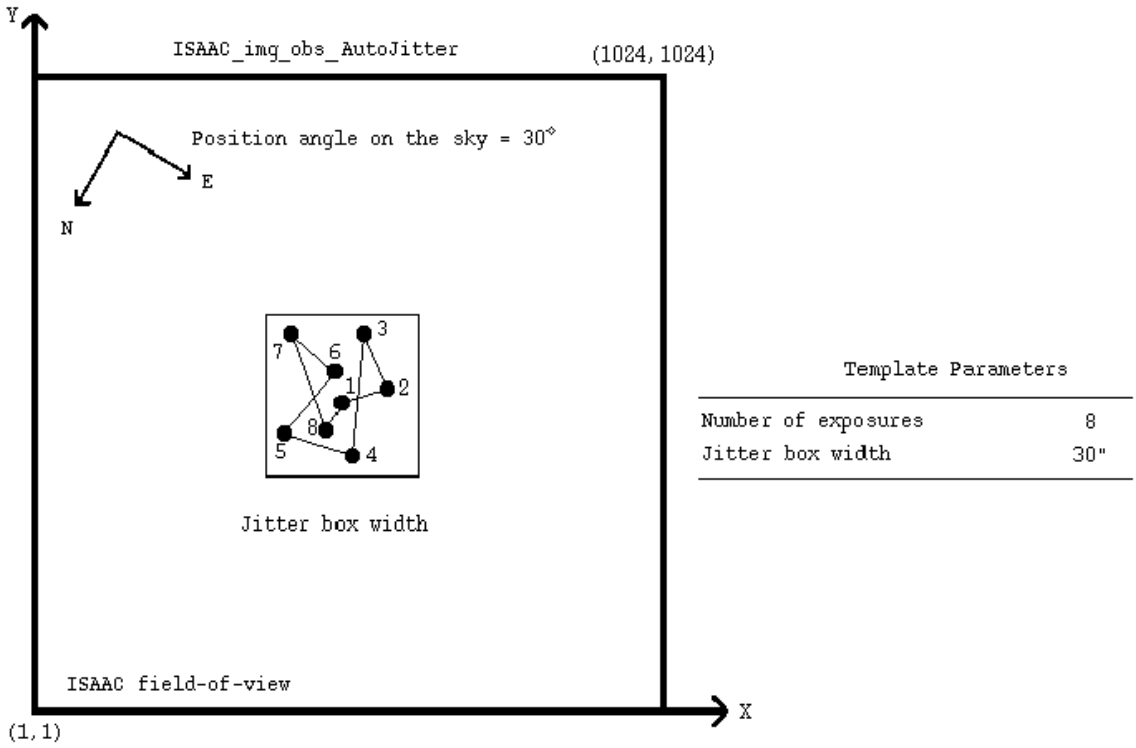


Figure 10: Illustration of the `ISAACSW_img_obs_AutoJitter` template. The black dots represent the position of a star, which was originally at the center of the field.

A.7 Hawaii Imaging Templates

All Hawaii Imaging templates use the SWI1 mode, except the `ISAACSW_img_acq_Polarimetry` template which uses the SWP1 mode. For more information, see section 7.

A.7.1 `ISAACSW_img_obs_AutoJitter`

This template offsets the telescope between exposures according to a random pattern of offsets automatically determined within the template. It is ideal for long integrations on empty fields, and does not require a long list of offsets to be defined.

Table 36: Parameters of `ISAACSW_img_obs_AutoJitter`

P2PP label	Keyword	Default	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Number of Exposures	SEQ NEXPO	–	Number of exposures
Jitter Box Width	SEQ JITTER WIDTH	–	Random offset box size (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin
SW Filter wheel 1	INS FILT1 NAME	–	Filter name in wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter name in wheel 2

Figure A.7.1 illustrates what the template does.

The offsets are distributed randomly within a box whose size is defined by the parameter "`Jitter Box Width`" (in arc seconds), with the condition that the distance between any two

points in a series of ten values is greater than a certain minimum. This is intentionally done to ensure that the 5 frames before and after any frame are spatially not too close and can be safely used for creating skies without residual objects for sky subtraction.

The value of the "`Jitter Box Width`" parameter corresponds to the **full width** of the box in which the offsets are generated. Defining too wide a box may lead to poor image overlap. Conversely, too small a value may lead to poor sky subtraction near extended objects. A value of $\sim$ 30 arcsec or less is adequate for empty fields. The minimum value is set to 10 arcsec.

By construction, there is no telescope offset before the first exposure. If the parameter "`Return to Origin`" is set to true (T), the telescope moves back to its original position at the end of the template. If not, the telescope is not moved.

The total **integration** time (excluding overheads) is defined, in seconds, by:

`DIT` $\times$ `NDIT` $\times$ `Number of Exposures`

A.7.2 ISAACSW_img_obs_AutoJitterOffset

This template moves the telescope alternatively between 'object' and 'sky' positions. The 'object' positions of the telescope are randomly distributed around the object (initial telescope position) and within a box whose dimensions are set by the parameter "`Jitter Box Width`" (in arcsec). The minimum value for this parameter is 10 arcsec.

The 'sky' positions are at a constant distance (defined by the parameter "`Sky Offset Throw`") from the original telescope position, but at an angle randomly distributed between 0 and 360 degrees (i.e. the 'sky' exposures are distributed on a circle surrounding the initial telescope position).

Table 37: Parameters of `ISAACSW_img_obs_AutoJitterOffset`

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Jitter Box Width	SEQ JITTER WIDTH	–	Random offset box width (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin
Sky Offset Throw	SEQ SKYTHROW	–	Sky Throw (arcsec)
Rotate Pupil	SEQ ROTPUPIL	T	Pupil rotation compensation
Number of AB or BA cycles	SEQ NABCYCLES	–	Number of AB or BA cycles
NDIT for the OBJECT positions	SEQ NDIT OBJECT	–	NDIT used on OBJECT positions
NDIT for the SKY positions	SEQ NDIT SKY	–	NDIT used on SKY positions
SW Filter wheel 1	INS FILT1 NAME	–	Filter name in wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter name in wheel 2

Figure A.7.2 illustrates what the template does.

By default, there is no telescope offset before the first exposure. If the parameter "`Return to Origin`" is set to true (T), the telescope moves back to its original position at the end of the template. If not, the telescope is not moved.

The `Number of AB or BA cycles` defines the number of OBJECT-SKY or SKY-OBJECT cycles to be executed.

These cycles are executed in ABBA sequences. E.g. if `Number of AB or BA cycles` is set to 3, 6 exposures will be taken in an ABBAAB sequence.

The template provides the possibility of rotating the instrument between object and sky frames so that pupil ghosts can be minimised (all object frames have the same position angle on sky). The technique has proved to be efficient with SOFI. It is the default configuration with ISAAC.

In addition, the template provides the flexibility to adjust the number of `NDIT` subintegrations for the OBJECT and SKY frames. `NDIT for the OBJECT positions` defines the number of subintegrations on the object, and `NDIT for the SKY positions` defines the number of subintegrations on the sky.

The total **integration** time (excluding overheads) is defined, in seconds, by:
`DIT` × (`NDIT for the OBJECT positions` + `NDIT for the SKY positions`) × `Number of AB or BA cycles`.

Thus, the total integration time on the sky and on the object can be adjusted so that the S/N on the object is optimised. Remember that the "1 minute per telescope position rule" means here that both (`DIT` × `NDIT for the OBJECT positions` plus overheads) and (`DIT`× `NDIT for the SKY positions` plus overheads) shall each exceed one minute of time.

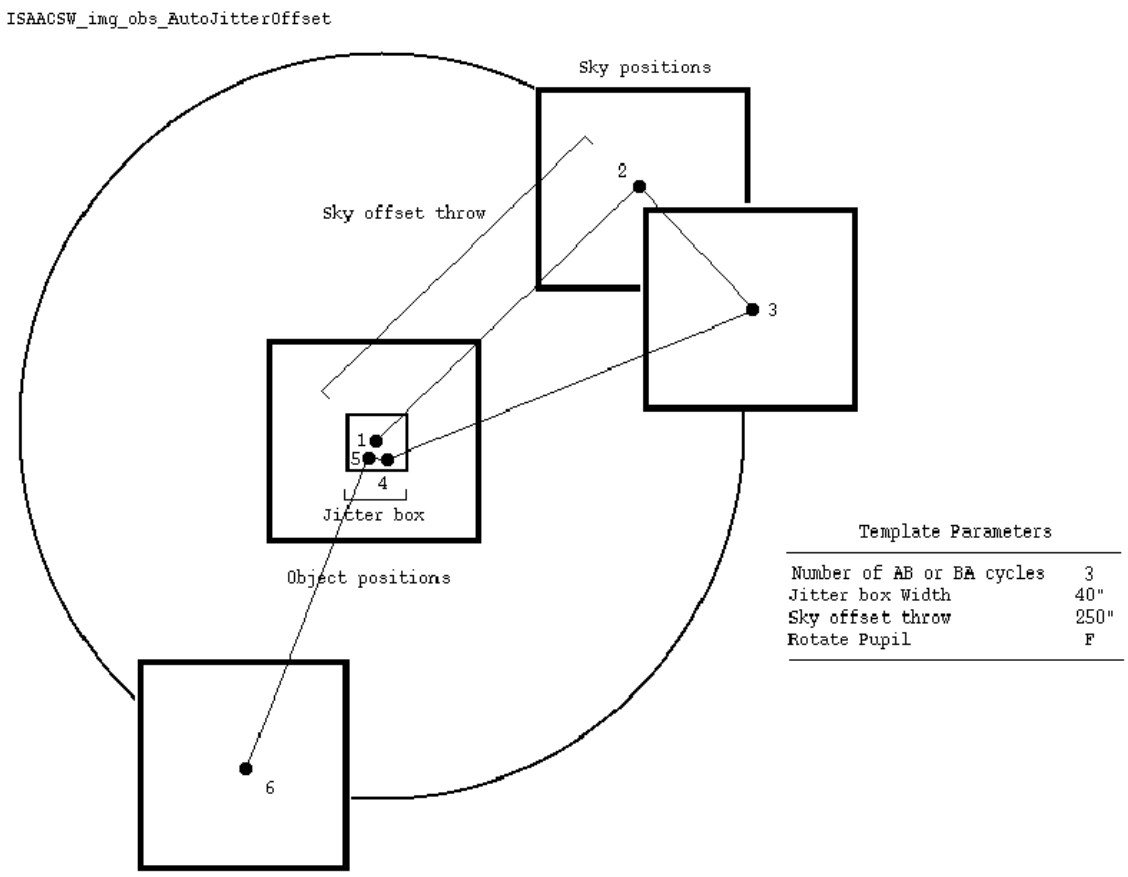


Figure 11: Illustration of the `ISAACSW_img_obs_AutoJitterOffset` template. The black dots in the central square represent the position of a star, which was originally at the center of the field. The other squares represent the position of the SKY frames.

A.7.3 ISAACSW_img_obs_FixedSkyOffset

This template moves the telescope alternatively between 'object' and 'sky' positions. The 'object' positions of the telescope are randomly distributed around the object (initial telescope position) and within a box whose dimensions are set by the parameter "Jitter Box Width" (in arcsec). The minimum value for this parameter is 10 arcsec.

The 'sky' positions are also randomly distributed around a fixed offset position (defined by the parameters "Sky Offset in Alpha" and "Sky Offset in Delta") from the original (object) telescope position. The box dimensions of the random 'sky' positions are set by the parameter "Jitter Box Width" (i.e. the 'sky' exposures are distributed in a box offset from the initial telescope position).

Table 38: Parameters of ISAACSW_img_obs_FixedSkyOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Jitter Box Width	SEQ JITTER WIDTH	–	Random offset box width (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin
Sky Offset in Alpha	SEQ SKYOFFSET ALPHA	–	Sky Offset in Alpha (arcsec)
Sky Offset in Delta	SEQ SKYOFFSET DELTA	–	Sky Offset in Delta (arcsec)
Rotate Pupil	SEQ ROTPUPIL	T	Pupil rotation compensation
Number of AB or BA cycles	SEQ NABCYCLES	–	Number of AB or BA cycles
NDIT for the OBJECT positions	SEQ NDIT OBJECT	–	NDIT used on OBJECT positions
NDIT for the SKY positions	SEQ NDIT SKY	–	NDIT used on SKY positions
SW Filter wheel 1	INS FILT1 NAME	–	Filter name in wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter name in wheel 2

Figure 12 illustrates what the template does.

By default, there is no telescope offset before the first exposure. If the parameter "Return to Origin" is set to true (T), the telescope moves back to its original position at the end of the template. If not, the telescope is not moved.

The Number of AB or BA cycles defines the number of OBJECT-SKY or SKY-OBJECT cycles to be executed.

These cycles are executed in ABBA sequences. E.g. if Number of AB or BA cycles is set to 3, 6 exposures will be taken in an ABBAAB sequence.

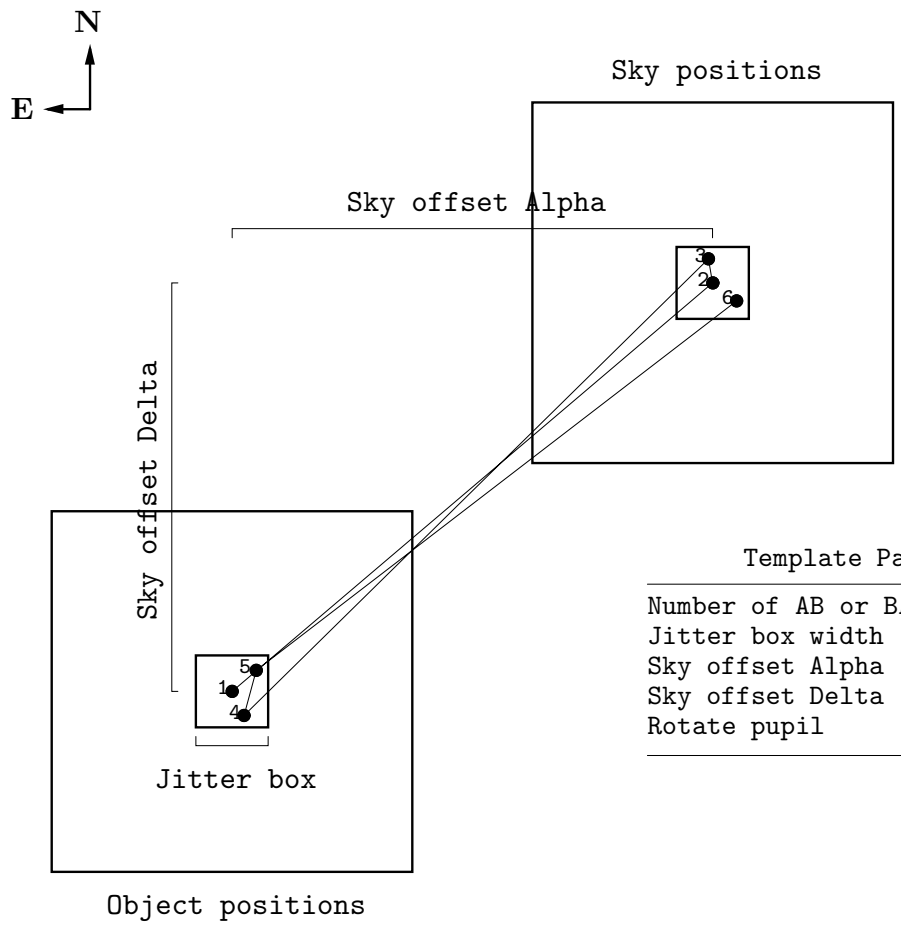
The template provides the possibility of rotating the instrument between object and sky frames so that pupil ghosts can be minimised (all object frames have the same position angle on sky). The technique has proved to be efficient with SOFI. It is the default configuration with ISAAC.

In addition, the template provides the flexibility to adjust the number of NDIT subintegrations for the OBJECT and SKY frames. NDIT for the OBJECT positions defines the number of subintegrations on the object, and NDIT for the SKY positions defines the number of subintegrations on the sky.

The total **integration** time (excluding overheads) is defined, in seconds, by:
DIT × (NDIT for the OBJECT positions + NDIT for the SKY positions) × Number of AB or BA cycles.

Thus, the total integration time on the sky and on the object can be adjusted so that the S/N on the object is optimised. Remember that the "1 minute per telescope position rule" means here that both (DIT × NDIT for the OBJECT positions plus overheads) and (DIT× NDIT for the SKY positions plus overheads) shall each exceed one minute of time.

ISAACSW_img_obs_FixedSkyOffset



Template Parameters

Number of AB or BA cycles	3
Jitter box width	30″
Sky offset Alpha	-200″
Sky offset Delta	170″
Rotate pupil	F

Figure 12: Illustration of the ISAACSW_img_obs_FixedSkyOffset template. The black dots in the central square represent the position of a star, which was originally at the center of the field. The other square represents the mean position of the SKY frames.

A.7.4 ISAACSW_img_obs_GenericOffset

This template is for imaging and has the flexibility to do any sequence of telescope offsets, either in detector or sky coordinates.

Table 39: Parameters of ISAACSW_img_obs_GenericOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Number of Exposures	SEQ NEXPO	–	Number of exposures
List of NDIT	SEQ NDIT LIST	–	NDIT List
Return to Origin	SEQ RETURN	T	Return to Origin Flag
Obs Type (O or S)	SEQ OBSTYPE LIST	–	Observation type list (S or O)
List of offsets (X or RA)	SEQ OFFSET1 LIST	–	X or RA offset list (arcsec)
List of offsets (Y or DEC)	SEQ OFFSET2 LIST	–	Y or DEC offset list (arcsec)
Offset Coordinates ?	SEQ OFFSET COORDS	–	SKY or DETECTOR coords ?
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2

Figure 13 and 14 illustrate what the template does.

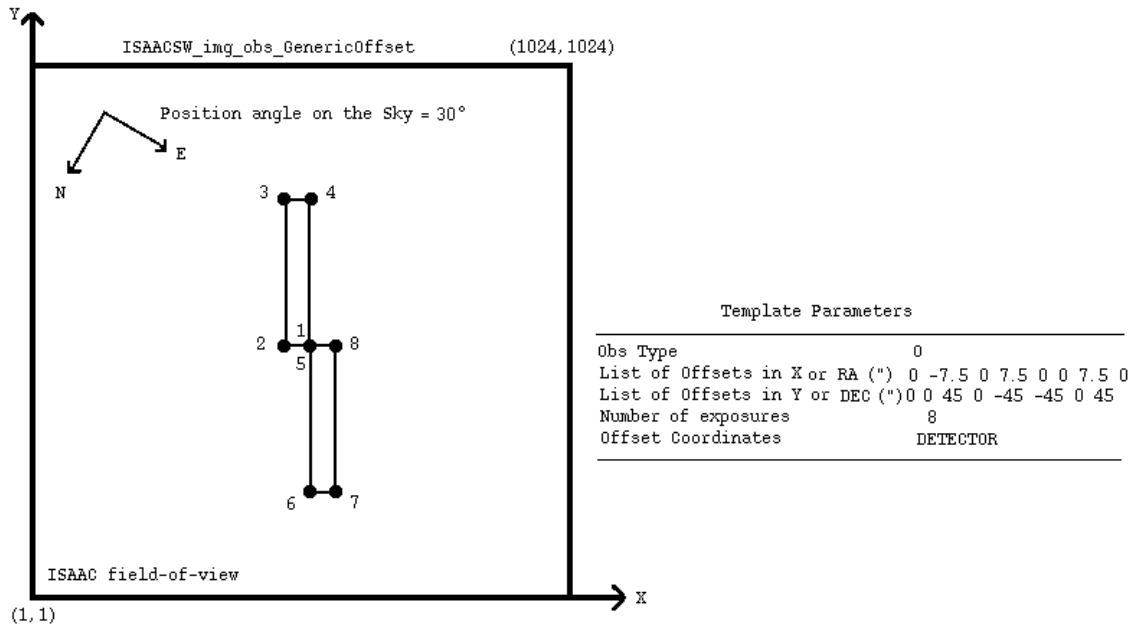


Figure 13: Illustration of the ISAACSW_img_obs_GenericOffset template. The black dots represent the position of a star, which was originally at the center of the field. In this example, Offset Coordinates ? is set to DETECTOR, and the stars (not the telescope) are moved in X and Y according to the list of offsets.

Telescope offsets are defined as lists with the parameters List of offsets (X or RA) and List of offsets (Y or DEC). The offsets are *relative* to the previous position, in RA and DEC or in X and Y depending on the Offset Coordinates ? parameter, and they are defined in *arcsec*.

Additionally, the observation type can be defined for each image, and is entered as a list in the parameter "Obs Type (O or S)." O stands for Object and assigns the DPR TYPE header keyword to OBJECT. S stands for Sky and assigns the DPR TYPE header keyword to SKY.

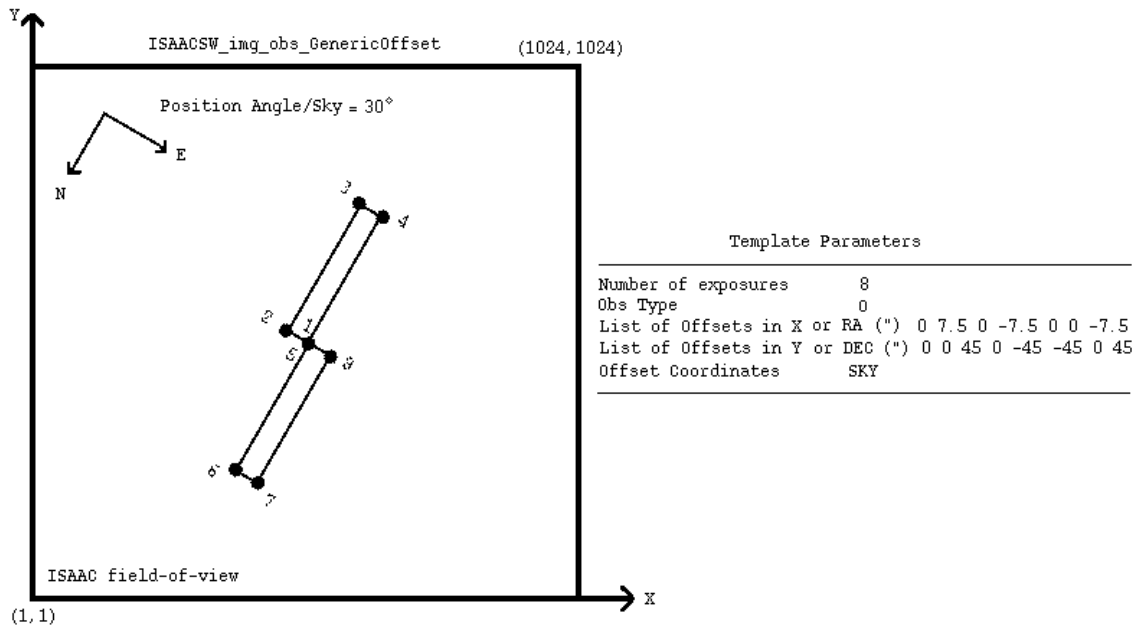


Figure 14: Illustration of the `ISAACSW_img_obs_GenericOffset` template. The black dots represent the position of a star, which was originally at the center of the field. In this example, `Offset Coordinates ?` is set to SKY, and the telescope is moved in RA and DEC according to the list of offsets (the stars move in the opposite direction).

The total number of exposures is defined in the parameter "`Number of Exposures`." This number can be different from the number of elements in the aforementioned lists. Lists do not need to have the same length. If the number of exposures is larger than the number of elements in a list, the list is restarted from the beginning as many times as needed until the correct number of frames have been acquired.

The lists can have any length; however, having lists of different lengths can become extremely confusing. It is good practice to use lists of equal length or lists with only one value if one parameter is not changed.

At the end of the template, the telescope is returned to the original position if the parameter "`Return to Origin`" is set to true (T). If not, the telescope is not moved at the end of the template.

The total **integration** time is defined, in seconds, by:

$$\mathtt{DIT} \times \sum_{1}^{\mathtt{NumberofExposures}} \mathtt{NDIT}(i)$$

where `NDIT`(i) are the elements of the `List of NDIT`.

A.7.5 ISAACSW_img_obs_Polarimetry

This template is used for imaging polarimetry.

Telescope offsets are defined with the parameters "X offset list (arcsec)" and "Y offset list (arcsec)" and are defined along detector *rows* and *columns*, so that users can move the object easily along the strips of the polarimetric mask (which are along detector columns).

A list of rotator offsets is defined with the parameter "Rotator Offset list". The rotator offsets are **relative** to the current rotator position.

All the spatial offsets are performed for **each** rotator offset. At the end of the sequence of spatial offsets at one rotator position, the telescope is returned to its original spatial position.

The parameter Number of Exposures gives the number of exposures at each rotator position. The offsets in X offset list (arcsec) and Y offset list (arcsec) will be repeated until SEQ NEXPO exposures have been taken. Note that the telescope is only returned to its original spatial position after Number of Exposures exposures. Be very careful if the lengths of X offset list (arcsec) and Y offset list (arcsec) are not equal to the number of exposures. If the cumulative offset at the end of the list is not equal to zero it is easy to inadvertently move the object behind the polarimetry mask.

At the end of the template the rotator offset can optionally be returned to the value at the beginning of that template by setting "Return to original rotator position" to true (T) (note that this option only returns the rotator to its original position at the end of the entire template).

With this scheme, it is possible for the user to sample the object and sky as desired for a sequence of rotator positions within one template. At least two different orientations, separated by 45 degrees, are required for computing the Stoke's parameters. The most likely situation will be to set the "Rotator Offset list" parameter to 0 45. The template has been coded so the rotation occurs about the center of the mask, which is approximately at (x,y)=(512,540).

To image the entire field of view at one position angle, one must take great care with the spatial offsets. The opaque and transmiting parts of the mask have slightly different widths (24 arc seconds for the opaque ones and 20 arcseconds for the transmiting ones). Thus three exposures with offsets of about 15 arcseconds in between the exposures are needed to cover the whole field.

Figure 15 illustrates what the template does.

Only the filters in filter wheel 1 are available for this template.

Table 40: Parameters of ISAACSW_img_obs_Polarimetry

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Number of Exposures	SEQ NEXPO	–	Number of exposures at each rotator position
X offset list (arcsec)	SEQ OFFSETX LIST	–	X offset list (arcsec)
Y offset list (arcsec)	SEQ OFFSETX LIST	–	Y offset list (arcsec)
Rotator Offset list	SEQ ROT OFFLIST	0	Rotator offset list (degrees)
Return to original rotator position	SEQ RETROTOFF	T	Return to original rotator position Flag
SW Filter wheel 1	INS FILT1 NAME	–	Filter name in wheel 1

The total **integration** time (excluding overheads) is defined, in seconds, by:

DIT × NDIT × Number of Exposures× number of rotator offsets

A.7.6 ISAACSW_img_cal_GenericOffset

This template is used for imaging standards and is similar to the ISAACSW_img_obs_GenericOffset template (appendix A.7.4), with the difference that the offsets are defined in detector coordinates.

This template should be used by all SWI1 users requesting calibrations beyond the ones provided by the Calibration Plan of this mode.

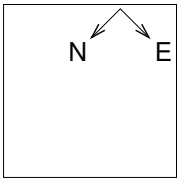
Table 41: Parameters of ISAACSW_img_cal_GenericOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Number of Exposures	SEQ NEXPO	–	Number of exposures
Return to Origin	SEQ RETURN	–	Return to Origin Flag
X offset list (arcsec)	SEQ OFFSETX LIST	–	X offset list (arcsec)
Y offset list (arcsec)	SEQ OFFSETY LIST	–	Y offset list (arcsec)
SW Filter wheel 1	INS FILT1 NAME	–	Filter wheel 1
SW Filter wheel 2	INS FILT2 NAME	–	Filter wheel 2

A.7.7 ISAACSW_img_cal_Polarimetry

This template is used for standard star observations in SW polarimetry. It is strictly equivalent to the ISAACSW_img_obs_Polarimetry template, with the only difference that some DPR keywords in the FITS headers of the images are set to different values allowing pipeline processing and archiving. The user is referred to the description of the ISAACSW_img_obs_Polarimetry template for the description of the parameters.

Acquisition template:
Angle on Sky (deg) 45



Observation template parameters:

Number of exposures	9
X Offset List (")	–15 15 15 0 –15 –15 0 15 15
Y Offset List (")	–30 0 0 30 0 0 30 0 0
Rotator Offset List	0 45

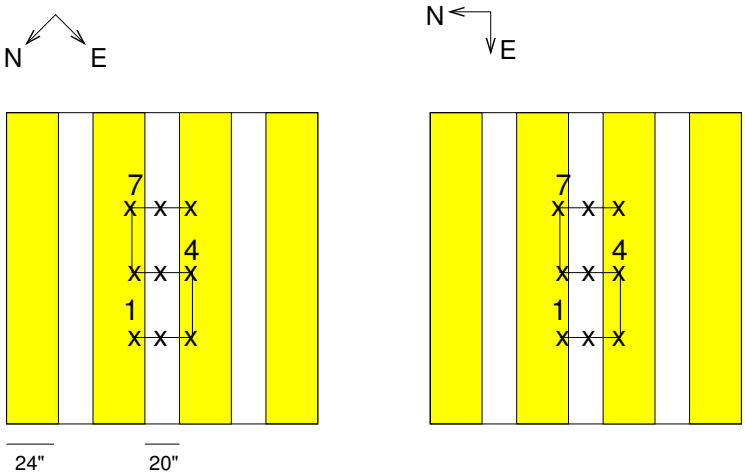


Figure 15: Illustration of the `ISAACSW_img_obs_Polarimetry` template. The rotator angle set in the acquisition image is 45 degrees. The crosses represent the position of a star, which was originally at the center of the field. With this sequence, the entire field of view would be imaged, first at position angle of 45 degrees and then with 90 degrees.

A.8 Hawaii Spectroscopy templates

A.8.1 ISAACSW_spec_obs_AutoNodOnSlit

This template nods the telescope between two positions (A and B) along the slit. A cycle is a pair of AB or BA observations. Cycles are repeated on ABBA sequences. E.g. 3 cycles correspond to an ABBAAB sequence, 4 cycles correspond to an ABBAABBA sequence, etc.

Table 42: Parameters of ISAACSW_spec_obs_AutoNodOnSlit

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Jitter Box Width	SEQ JITTER WIDTH	–	Jitter box width (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin flag
Nod Throw Along Slit	SEQ NODTHROW	–	Throw of the nod (arcsec)
Number of AB or BA cycles	SEQ NABCYCLES	–	Number of AB or BA cycles
NINT	SEQ NINT	–	Number of frames at each position
Instrument Mode	INS MODE	–	Instrument Mode
Slit ?	INS SLIT	–	Which slit ? (e.g. slit_1)
Central Wavelength (microns)	INS GRAT WLEN	–	Central Wavelength (microns) ?

Figure 16 illustrates what the template does.

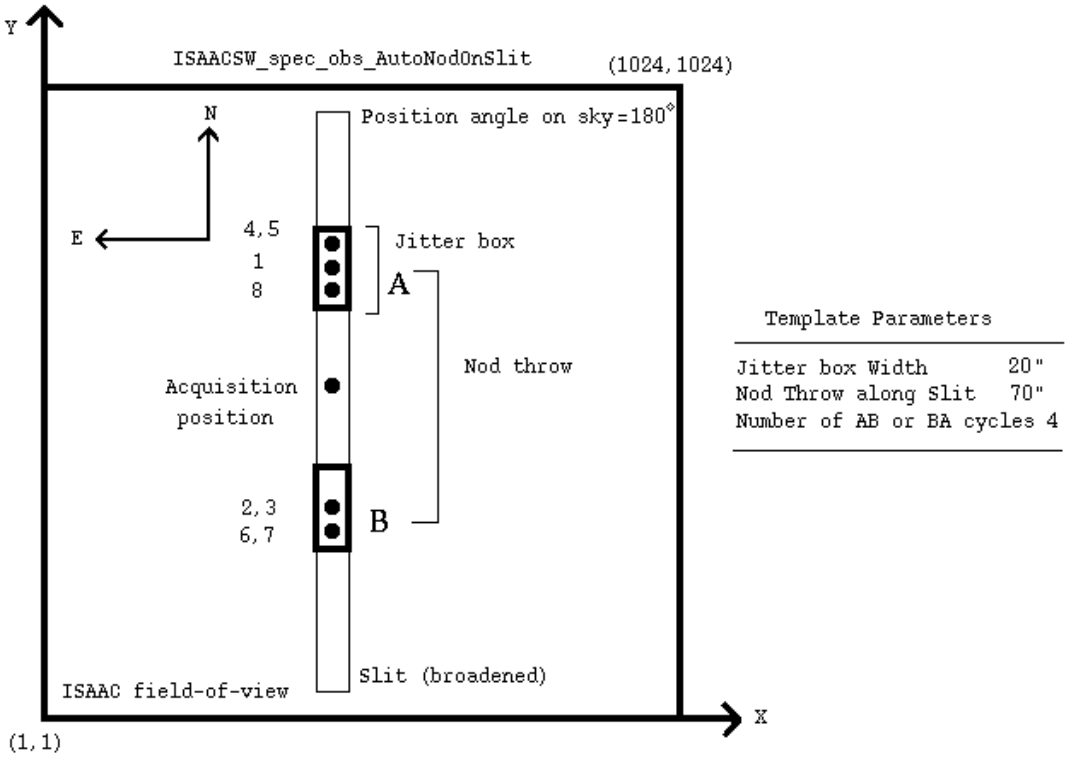


Figure 16: Illustration of the ISAACSW_spec_obs_AutoNodOnSlit template. The black dots represent the different positions of a star originally at the center of the slit. Note that the template starts with a telescope offset to move the star to one end of the nod along the slit.

The mean size of the nod is defined by parameter Nod Throw Along Slit (in arcsec). The first exposure (A) is taken after offsetting the object along the slit by $-\frac{\texttt{NodThrowAlongSlit}}{2}$ arcsec.

The second exposure (B) is therefore $+\frac{\texttt{NodThrowAlongSlit}}{2}$ arcsec from the initial position along the slit.

In addition to nodding, random offsets can be added in the *middle* of a cycle. A sequence of 6 cycles with jittering will result in the following sequence:

$$A(B+\epsilon_1)(B+\epsilon_1)(A+\epsilon_2)(A+\epsilon_2)(B+\epsilon_3)(B+\epsilon_3)(A+\epsilon_4)\ (A+\epsilon_4)(B+\epsilon_5)(B+\epsilon_5)(A+\epsilon_6)$$

where ϵ_n are random offsets. In general, ϵ_n should be much smaller than the nod throw.

The random offsets are generated inside an interval defined by the parameter "`Jitter Box Width`" (in arcsec). Offsets are randomly distributed between $-\frac{\texttt{JitterBoxWidth}}{2}$ and $+\frac{\texttt{JitterBoxWidth}}{2}$. **It is strongly recommended to define some non-zero value for the `Jitter Box Width` parameter**, as this allows one to get several images with the spectra lying at different positions on the detector. However, it should be smaller that the `Nod Throw Along Slit` , otherwise spectra on either side of the throw could overlap.

To better exploit the jittering facility offered by this template, it is also recommended to define `Number of AB or BA cycles` to some value higher than e.g. 4 or 5 so as to get several AB pairs of images with the spectra lying at different positions across the array.

If the parameter "`Jitter Box Width`" is set to zero, then the template will just nod between A and B.

At the end of the template, the telescope returns to the original position if the parameter "`Return to Origin`" is set to true (T). If not, the telescope is not moved at the end of the template.

Users of the SWS1-LR mode are requested to set the central wavelength to one of the following values: 1.06, 1.25, 1.65 or 2.20. Other values are not supported by the calibration plan (see section 9).

The `NINT` parameter defines the number of frames stored per A or B position. If e.g. `DIT` = 120s, `NDIT` = 1, `NINT` = 8, 8 images will be stored for each position. If in addition `Number of AB or BA cycles` is set to 2, the template will deliver in total 32 images, 8 for the first A position, 16 for the B position, and 8 for the second A position. The total integration time (excluding overheads) is 64 minutes.

Note: in the case where there are several OBs using this template on the same target (for several hours of integration on the same target), it is recommended to modify the `Nod Throw Along Slit` parameter by a few arcseconds between each OB. This is for the following reason: the acquisition is always done at the same position on the array (i.e. center of the slit). Therefore, different executions of the same template will position the targets at the same positions along the slit, and the spectra will fall at the same positions along on the detector. Therefore, even if you define some non-zero value for the `Jitter Box Width` parameter, it is recommended to give the `Nod Throw Along Slit` parameter different values between OBs so as to get the spectra at different positions across the array.

When defining the nod throw, users are requested to ensure that other objects in the slit do not cause the spectra to overlap when the throw is executed.

The total number of frames correspond to the product:
`Number of AB or BA cycles` $\times$ `NINT` $\times$ 2.

The total **integration** time (excluding overheads) is defined, in seconds, by:

DIT × NDIT × NINT × 2 × Number of AB or BA cycles

A.8.2 ISAACSW_spec_obs_GenericOffset

This template is for spectroscopy and has the flexibility to allow any sequence of telescope offsets. It is essentially intended for programs requiring large offsets (off the slit), or slit scanning across one object.

Table 43: Parameters of ISAACSW_spec_obs_GenericOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Number of Exposures	SEQ NEXPO	–	Number of exposures
Return to Origin	SEQ RETURN	T	Return to Origin flag
X offset list (arcsec)	SEQ OFFSETX LIST	–	X offset list (arcsec)
Y offset list (arcsec)	SEQ OFFSETY LIST	–	Y offset list (arcsec)
Obs Type (O or S)	SEQ OBSTYPE LIST	–	List of observation types (S or O)
Instrument Mode	INS MODE	–	Instrument Mode
Slit ?	INS SLIT	–	Long Slit
Central Wavelength (microns)	INS GRAT WLEN	–	Central Wavelength (microns) ?

Figure 17 illustrates what the template does.

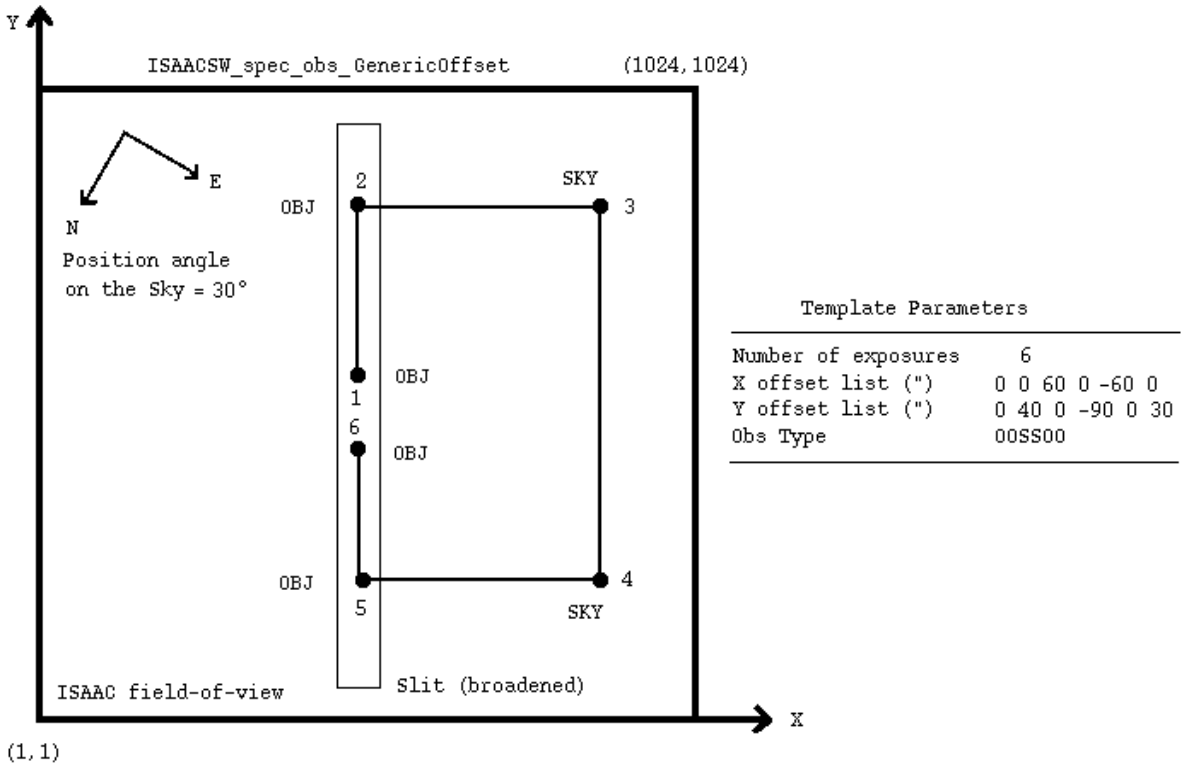


Figure 17: Illustration of the ISAACSW_spec_obs_GenericOffset template. The black dots represent the position of a star moved according to the lists of offsets in X and Y, irrespective of the position angle on sky.

Telescope offsets are defined as lists with the "X offset list (arcsec)" and "Y offset list (arcsec)" parameters. Telescope offsets are *relative*, defined along detector lines (X)

and columns (Y), and are in arcsec. Offsets in Y are along the slit, offsets in X are perpendicular to the slit.

With large combined offsets, the guide probe may not be able to follow the same guide star. In such a case, the guiding system will automatically find another star, but not resume guiding. A pop up window will instruct the operator to resume guiding. If the guide star has changed during an offset, the accuray of the offset will be poorer than the offset would have been if the same guide star had been used. This will only occur when offseting from object to sky. On the return offset, the operator will make sure that the original guide star is reselected so that pointing accuray is maintained while on the object.

Additionally, the observation type can be defined for each image, and entered as a list (`Obs Type (O or S)`). `O` stands for `Object` and assigns the `DPR TYPE` to OBJECT. `S` stands for `Sky` and assigns the `DPR TYPE` header keyword to SKY.

This template allows slit scanning across an object by defining a list of offsets in the X direction.

At the end of the template, the telescope returns to the original position if the parameter "`Return to Origin`" is set to true (T). If not, the telescope is not moved at the end of the template.

The lists can have any length; however having lists of different lengths can become extremely confusing. It is good practice to use lists of equal length or lists with only one value when one parameter remains constant.

The total **integration** time (exluding overheads) is defined, in seconds, by:

`DIT` × `NDIT` × `Number of Exposures`

A.8.3 `ISAACSW_spec_cal_AutoNodOnSlit` & `ISAACSW_spec_cal_GenericOffset`

These templates are used for standard star observations in spectroscopy at SW. They are strictly equivalent to the `ISAACSW_spec_obs_AutoNodOnSlit` and `ISAACSW_spec_obs_GenericOffset` templates in the definition of the parameters. The user is referred to the description of these templates for the description of the parameters (appendix A.8.1 & A.8.2).

These templates must be used by SWS1-MR and SWS1-LR users requesting calibrations beyond the ones provided by the Calibration Plan of this mode.

The differences with `ISAACSW_spec_obs_AutoNodOnSlit` & `ISAACSW_spec_obs_GenericOffset` are:

1. some DPR keywords in the FITS headers of the images are set to different values allowing pipeline processing and archiving.

2. In the list of available slits (`Slit ?` parameter), a `slitless` slit can be selected for observation of the standard star in a slitless mode for absolute spectrophotometric calibration. Note that the `Nod Throw Along Slit` parameter when selecting the `slitless` **must** be < 20 arcsec. Note also that this particular 'slit' is not offered in the list of available slits in the `ISAACSW_img_acq_MoveToSlit` template. Any slit can be defined for the acquisition when `slitless` is selected in the present template.

A.8.4 `ISAACSW_spec_cal_NightCalib`

This template allows one to take night time calibrations after the `ISAACSW_spec_obs_AutoNodOnSlit`, `ISAACSW_spec_obs_GenericOffset` and `ISAACSW_spec_cal_AutoNodOnSlit` templates. See

section 5.5 for more information regarding the need for night time calibrations.

This template is not autonomous. It must follow a spectroscopic observation. Furthermore, it only calibrates the wavelength setting that is used in the preceding template and not the wavelength settings in all preceding templates.

Table 44: Parameters of `ISAACSW_spec_cal_NightCalib`

P2PP label	Keyword	Def.	Description
`Flatfield at end of template`	`SEQ FLATFIELD`	T	Night flat field at end of template ?
`Arc at end of template`	`SEQ ARC`	F	Night arc at end of template ?

A.9 Aladdin acquisition Templates

A.9.1 Introduction

Telescope presets can only be done via acquisition templates. Telescope presets move the telescope to the requested coordinates and allow the telescope operator to select a guide star and start active optics. Additionally, these templates set up the detector and the instrument. Conversely, observation templates only deal with telescope offsets, and not with telescope presets. In general, acquisition templates dump an image to disk; only the `ISAACLW_img_acq_Preset` template does not. These dumped images are aimed at keeping track of the field position and orientation before starting the observation.

The acquisition templates to use depend upon the subsequent observation. For imaging, the simple preset (`ISAACLW_img_acq_Preset`) can be used for any subsequent observation. The chopping preset (`ISAACLW_img_acq_MoveToPixel`) can only be used for subsequent imaging observations with chopping and the non-chopping preset (`ISAACLW_img_acq_MoveToPixNoChop`) can only be used for subsequent imaging observations without chopping. For spectroscopy, observations using chopping must use `ISAACLW_img_acq_MoveToSlit` for acquisition. Non-chopping observations can use either `ISAACLW_img_acq_MoveToSlit` or `ISAACLW_img_acq_MoveToSlitNoChop`.

A.9.2 `ISAACLW_img_acq_Preset`

This template does a simple telescope preset. It is the easiest when a pointing accuracy of a few arcsec is enough for the purposes of the program. It should **NOT** be used for subsequent spectroscopic observations.

No light reaches the detector during this template, to avoid accidental imaging of warm objects as the telescope is presetting. Consequently an image of the field will not be seen on the RTD when this template is used.

Table 45 describes the parameters of this template.

Table 45: Parameters of `ISAACLW_img_acq_Preset`

P2PP label	Keyword	Default	Description
`Add Velocity Alpha` [1]	`TEL TARG ADDVELALPHA`	0	Additional tracking vel. in RA
`Add Velocity Delta` [1]	`TEL TARG ADDVELDELTA`	0	Additional tracking vel. in DEC
`Angle on Sky (deg)`	`TEL ROT OFFANGLE`	0	Position angle ([+-]DDD.TTT)
`Equinox`	`TEL.TARG.EQUINOX`	2000	Equinox expressed as yr from -2000 to 3000
`Epoch`	`TEL.TARG.EPOCH`	2000	Epoch expressed as yr from -2000 to 3000
`Proper Motion Alpha`	`TEL.TARG.PMA`	0.	proper motion in "/yr from -10 to 10
`Proper Motion Delta`	`TEL.TARG.PMD`	0.	proper motion in "/yr from -10 to 10

[1] In arcsec/sec

No RTD image is dumped on disk at the end of this template.

A.9.3 `ISAACLW_img_acq_MoveToPixel`

The instrument mode for this template is LWI4. The template uses chopping and can only be used to acquire targets for subsequent LW imaging observations that use chopping.

This template presets the telescope and allows the operator to interactively center the field. In visitor mode, the interactive part of the template will be executed by the instrument operator

under the supervision of the visiting astronomer. In service mode, it is mandatory that the users send detailed information for target acquisition.

The chopping parameters to be defined are:

- `Chop Throw (arcsec) ?`. This is the throw of the chopping (in arcsec), it is limited to the [10–30] arcsec range. A chop throw of <20 arcsec is recommended.
- `Number of Chop Cycles ?`. This is the number of chop cycles to be averaged in the acquisition system preprocessor. The higher the value, the better the detection limit, but the longer the acquisition time. One chop cycle will typically last between 2 to 10 seconds, depending on chopping frequency. The minimum number of chop cycles is 1. This parameter may be adjusted by the operation staff at execution time if the object is too faint.
- `Chop Position Angle ?`. See section A.2
- `Chop Angle Coordinate ?`. Either SKY or DETECTOR.

After completion of the preset, the instrument and detector are set.

The observer is then prompted to define an offset. This is simply done by drawing an arrow on the screen with the left hand button of the mouse. If the offset is accepted, the telescope offsets by the desired amount. Finally, there is the possibility to redraw the arrow for refining the position of the object if necessary. Once the user is satisfied, the template finishes.

The "`Preset Telescope ?`" parameter, if set to "F", allows to use the functionality of the template without presetting the telescope.

It is possible in this template to use the J+Block, H or Ks filters, which are likely to allow an easier identification of the field (these filters are not available for the subsequent observation templates).

Table 46: Parameters of `ISAACLW_img_acq_MoveToPixel`

P2PP label	Keyword	Default	Description
`Preset Telescope ?`	`SEQ PRESET`	T	Preset telescope
`Chop Throw (arcsec) ?`	`SEQ CHOP THROW`	–	M2 Chop Throw (arcsec)
`Number of Chop Cycles ?`	`SEQ CHOP NCYCLES`	–	Number of chop cycles
`Chop Position Angle ?`	`SEQ CHOP POSANG`	–	Chop Position angle (deg)
`Chop Angle Coordinate ?`	`SEQ CHOP COORDS`	–	SKY or DETECTOR coords ?
`Add Velocity Alpha` [1]	`TEL TARG ADDVELALPHA`	0	Additional tracking vel. in RA
`Add Velocity Delta` [1]	`TEL TARG ADDVELDELTA`	0	Additional tracking vel. in DEC
`Angle on Sky (deg)`	`TEL ROT OFFANGLE`	0	Position angle ([+-]DDD.TTT)
`Equinox`	`TEL.TARG.EQUINOX`	2000	Equinox expressed as yr from -2000 to 3000
`Epoch`	`TEL.TARG.EPOCH`	2000	Epoch expressed as yr from -2000 to 3000
`Proper Motion Alpha`	`TEL.TARG.PMA`	0.	proper motion in "/yr from -10 to 10
`Proper Motion Delta`	`TEL.TARG.PMD`	0.	proper motion in "/yr from -10 to 10
`LW Filter wheel 1`	`INS FILT3 NAME`	–	Filter wheel 1
`LW Filter wheel 2`	`INS FILT4 NAME`	–	Filter wheel 2

[1] In arcsec/sec

At the end of the template, the image displayed on the RTD (consisting of `Number of Chop Cycles ?` chopped images) is dumped on disk.

A.9.4 ISAACLW_img_acq_MoveToSlit

All LW spectroscopy OBs that use chopping must use this template for target acquisition.

This template presets the telescope and allows the operator to interactively center objects into the selected slit. In visitor mode, the interactive part of the template will be executed by the night operator based on the indications provided by the user. In service mode, it is mandatory that the users send detailed information for centering the object into the slit.

The instrument mode for this template is LWI3, which is not an offered imaging mode. Consequently, the detector may have to be windowed, down to a field of view of $\sim$ 1 arcmin, if the acquisition filter is either L or narrow band M. Therefore, acquisitions involving objects separated by more than 1 arcmin should be acquired with either the narrow band LW or SW filters.

This template uses chopping. All LW spectroscopic templates that use chopping should use this template. The template can also be used for LW spectroscopic templates that do not use chopping, although we recommend that the `ISAACLW_img_acq_MoveToSlitNoChop` template is used for acquiring such targets.

The chopping parameters to be defined are:

- `Chop Throw (arcsec) ?`. This is the throw of the chopping (in arcsec), it is limited to the [10–30] arcsec range. A chop throw of <20 arcsec is recommended.
- `Number of Chop Cycles ?`. This is the number of chop cycles to be averaged in the acquisition system preprocessor. The higher the value, the better the detection limit, but the longer the integration time. One chop cycle will typically last 2 to 10 seconds of time, depending on chopping frequency. The minimum number of chop cycles is 1. This parameter may be adjusted by the operation staff at execution time if the object is too faint.
- `ChopNod PARA of PERP to Slit ?`. This parameter allows the user to define chopping as either parallel or perpendicular to the slit. If set to PARA, the object will be continuously in the slit.

After completion of the preset, the instrument and detector are set.

The observer is then prompted to either define an offset to the slit (a drawing of which is overlaid on the RTD), or to rotate the field by clicking on two objects. Offsetting is simply done by drawing an arrow on the screen with the left hand button of the mouse. If the offset is accepted, the telescope offsets by the desired amount. Finally, the user is given the possibility of refining the position of the object. Once the user is satisfied, the template finishes.

An identical iteration loop is performed for rotating the field by clicking on 2 objects. These 2 objects will be centered in the slit.

If the "`Preset Telescope ?`" parameter is set to "F", then the telescope will not move. This can be useful in visitor mode to use the functionality of the template without presetting the telescope.

It is possible in this template to use the J+Block, H or Ks filters, which are likely to allow an easier identification of the field (these filters are not available for the subsequent observation templates).

The `Alpha offset from Ref Star` and `Delta offset from Ref Star` parameters allow the user to define a telescope offset when the acquisition is made on reference objects. That is, once the reference object has been acquired and centered in the slit, the offsets defined here will offset the telescope so as to bring the desired target into the slit.

Table 47: Parameters of `ISAACLW_img_acq_MoveToSlit`

P2PP label	Keyword	Default	Description
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Alpha offset from Ref Star	SEQ REF OFFSETALPHA	0	Offset from Ref. Star (arcsec)
Delta offset from Ref Star	SEQ REF OFFSETDELTA	0	Offset from Ref. Star (arcsec)
Chop Throw (arcsec) ?	SEQ CHOP THROW	–	M2 Chop Throw (arcsec)
Number of Chop Cycles ?	SEQ CHOP NCYCLES	–	Number of chop cycles
ChopNod PARA of PERP to Slit ?	SEQ CHOP SPEC	–	Chopping along or perp. to slit ?
Add Velocity Alpha [1]	TEL TARG ADDVELALPHA	0	Additional tracking vel. in RA
Add Velocity Delta [1]	TEL TARG ADDVELDELTA	0	Additional tracking vel. in DEC
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in ″/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in ″/yr from -10 to 10
LW Filter wheel 1	INS FILT3 NAME	–	Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter wheel 2
Slit ?	INS SLIT	–	Long Slit (e.g. slit_1)

[1] In arcsec/sec

At the end of the template, the image displayed on the RTD (consisting of `Number of Chop Cycles ?` chopped images) is dumped on disk.

A.9.5 `ISAACLW_img_acq_MoveToPixNoChop`

The instrument mode for this template is LWI3. This template does not use chopping and can only be used to acquire targets for subsequent imaging observations that do not use chopping (i.e. using J+Block, H, Ks, NB_3.21 or NB_3.28). Acquisition using LW broad band filters is allowed, however in this case the detector may have to be windowed down to a field of view of $\sim$ 1 arcmin to avoid saturation.

The template presets the telescope and allows the operator to interactively center the field.

This template is functionally identical to the `ISAACSW_img_acq_MoveToPixel` template, so users should refer to Sec. A.6.4 for details.

A.9.6 ISAACLW_img_acq_FastPhot

As specified in Section 5.3.5 the template can be used only in combination with the ISAACLW_img_obs_FastPhot. The acquisition is interactive as it allow the instrument operator to center the target by applying small offsets. The template, however, does not check nor wait for active optics or ONECAL corrections. It allows windowing of the detector (which is recommended in case of very bright target) thus very short DIT values.

We suggest to set always DIT= minimum DIT (see Table 26 for the minimum DIT values which correspond to each windowing), and to select a DIT NDIT combination such that their product is $\sim$0.5-1 sec. We also suggest to set the same detector windowing and the

Table 48: Parameters of ISAACLW_img_acq_MoveToPixNoChop

P2PP label	Keyword	Default	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Alpha offset (arcsec)	TEL TARG OFFSETALPHA	10	RA offset (arcsec)
Delta offset (arcsec)	TEL TARG OFFSETDELTA	10	DEC offset (arsec)
Add Velocity Alpha [1]	TEL TARG ADDVELALPHA	0	Additional tracking vel. in RA
Add Velocity Delta [1]	TEL TARG ADDVELDELTA	0	Additional tracking vel. in DEC
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in "/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in "/yr from -10 to 10
LW Filter wheel 1	INS FILT3 NAME	–	LW Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	LW Filter wheel 2

[1] In arcsec/sec

same filters combination as in the following science template thus to minimize the number of instrument setups and therefore the overheads. **In all cases the instrument set up should be carefully checked and selected on the basis of the target magnitude.**

Table 49: Parameters of ISAACLW_img_acq_FastPhot

P2PP label	Keyword	Default	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
WINX	DET.WIN.NX	1024	number of coulmn
WINY	DET.WIN.NY	1024	number of lines
STARTY	DET.WIN.STARTX	1	first column of window
STARTY	DET.WIN.STARTY	1	first row of window
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
LW Filter wheel 1	INS FILT3 NAME	-	LW Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	-	LW Filter wheel 2

A.9.7 ISAACLW_img_acq_MoveToSlitNoChop

The template presets the telescope and allows the operator to interactively center objects into the selected slit. The instrument mode for this template is LWI3, which is not offered for L and NB_M imaging. Consequently, the detector may have to be windowed, down to a field of view of $\sim$ 1 arcmin, if the acquisition filter is either L or narrow band M. Therefore, acquisitions involving objects separated by more than 1 arcmin should be acquired with either the narrow band LW or the SW filters.

This template does not use chopping. It should not be used to acquire targets if the subsequent LW spectroscopic template uses chopping.

This template is functionally identical to the ISAACSW_img_acq_MoveToSlit template, so users should refer to Sec. A.6.5 for details.

Table 50: Parameters of ISAACLW_img_acq_MoveToSlitNoChop

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Preset Telescope ?	SEQ PRESET	T	Preset telescope
Alpha offset from Ref Star	SEQ REF OFFSETALPHA	0	Offset from Ref. Star (arcsec)
Delta offset from Ref Star	SEQ REF OFFSETDELTA	0	Offset from Ref. Star (arcsec)
Alpha offset (arcsec)	TEL TARG OFFSETALPHA	10	RA offset (arcsec)
Delta offset (arcsec)	TEL TARG OFFSETDELTA	10	DEC offset (arsec)
Add Velocity Alpha [1]	TEL TARG ADDVELALPHA	0	Additional tracking vel. in RA
Add Velocity Delta [1]	TEL TARG ADDVELDELTA	0	Additional tracking vel. in DEC
Angle on Sky (deg)	TEL ROT OFFANGLE	0	Position angle ([+-]DDD.TTT)
Equinox	TEL.TARG.EQUINOX	2000	Equinox expressed as yr from -2000 to 3000
Epoch	TEL.TARG.EPOCH	2000	Epoch expressed as yr from -2000 to 3000
Proper Motion Alpha	TEL.TARG.PMA	0.	proper motion in "/yr from -10 to 10
Proper Motion Delta	TEL.TARG.PMD	0.	proper motion in "/yr from -10 to 10
LW Filter wheel 1	INS FILT3 NAME	–	LW Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	LW Filter wheel 2
Slit ?	INS SLIT	–	Slit (e.g. slit_1)

[1] In arcsec/sec

A.10 Aladdin Observation and Calibration Templates - With Chopping

Chopping and Nodding The Aladdin templates are divided into those that use chopping (LW) and those that do not (SW & LW). Chopping can be used for all LW observations (>3μm). It is the only mode of operations for imaging in L and M, and LR spectroscopy.

The Aladdin templates that use chopping are listed in Table 51.

Table 51: Aladdin templates that use chopping

P2PP Template Name
ISAACLW_img_obs_AutoChopNod
ISAACLW_spec_obs_AutoChopNod
ISAACLW_img_cal_AutoChopNod
ISAACLW_spec_cal_AutoChopNod

If an observation is done with chopping, then the calibration should be done with chopping as well. **Do not mix observing templates that use chopping with calibration templates that don't and vice versa.**

Chopping is always combined with telescope nodding. This is illustrated on figure 18.

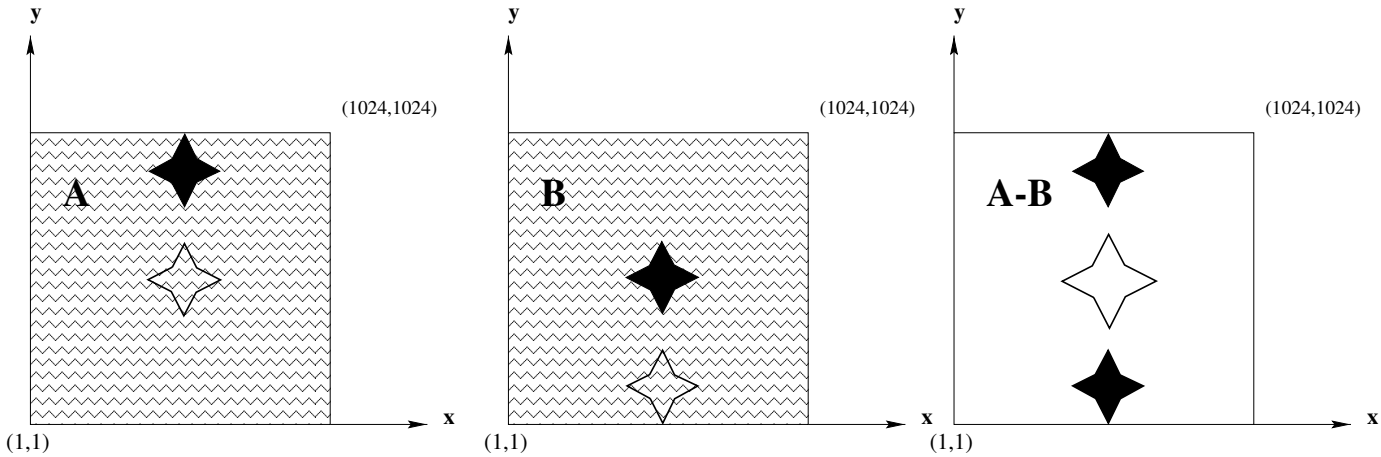


Figure 18: Combination of chopping and nodding in the opposite direction. On the left is a schematic of a chopped image (so-called position A), with one star image positive (in white) and one star image negative (in black). The chop throw is assumed here to be smaller than the field size. In the central figure, the telescope has been nodded to the B position, in the opposite direction of the chop. There are background residuals on both A and B chopped images. Subtracting the B from A (right image) provides an image free of background residuals, with a central positive image twice as bright as the 2 negative images.

For observations that use chopping, the bias voltage of the array is set so that the well depth is large. This leads to a very large number of hot pixels, whose flux is changing on the timescale of a few seconds. Thus it is very important in long exposures to set `Jitter Box Width` to some non zero value, so that these hot pixels can be removed.

A.10.1 ISAACLW_img_obs_AutoChopNod

This template combines chopping and telescope nodding. The number of nodding cycles is referred to as `Number of AB or BA cycles` and one cycle, commonly called an AB cycle,

consists of two exposures, one at each end of the nod. Additionally, it is possible to jitter between ABBA cycles, but not between AB or BA cycles. The amount of jitter between ABBA cycles is defined by the `Jitter Box Width` parameter (in arcseconds). For the removal of hot pixels it is essential that `Jitter Box Width` be set to a non zero value.

The orientation of the chopping is defined with the `Chop Position Angle ?` parameter. This parameter can be defined in terms of SKY or DETECTOR coordinates with the `Chop/Nodding Coordinate ?` parameter (see section A.3).

The parameters dealing with chopping and nodding are:

- `Integration time (minutes)`. This parameter allows one to define the total **integration** time, excluding overheads. See section 6.2 for how to compute the overheads. The number of chop and nod cycles will be determined automatically in the template.
- `Chop Throw (arcsec) ?`. This is the chopping throw (in arcsec), it is limited to the [10–30] arcsec range. However, we strongly recommend that users limit the throw to 20 arcseconds or less.
- `Chop Position Angle ?`. See section A.2. This parameter can be defined in either SKY or DETECTOR coordinates.
- `Chop/Nodding Coordinate ?`. Either SKY or DETECTOR. Depending on which value is selected, the chopping angle will be defined either on sky or relatively to the detectors rows and columns. The nodding is 'slaved' to the direction of the chopping.

If the parameter "`Return to Origin`" is set to true (T), the telescope moves back to its original position at the end of the template. If not, the telescope is not moved.

Table 52: Parameters of `ISAACLW_img_obs_AutoChopNod`

P2PP label	Keyword	Default	Description
`Observation Category`	`SEQ.CATG`	`SCIENCE`	Observation category (science or preimaging)
`Integration time (minutes)`	`SEQ.TIME`	–	Integration time (minutes)
`Jitter Box Width`	`SEQ JITTER WIDTH`	–	Random offset box size (arcsec)
`Return to Origin`	`SEQ RETURN`	T	Return to Origin
`Chop Throw (arcsec) ?`	`SEQ CHOP THROW`	–	M2 Chop Throw (arcsec)
`Chop Position Angle ?`	`SEQ CHOP POSANG`	–	Chop Position angle (deg)
`Chop/Nodding Coordinate ?`	`SEQ CHOPNOD COORDS`	–	SKY or DETECTOR coords ?
`LW Filter wheel 1`	`INS FILT3 NAME`	–	Filter wheel 1
`LW Filter wheel 2`	`INS FILT4 NAME`	–	Filter wheel 2

The total integration time (excluding overheads) is defined in minutes. In general, the user will get slightly more or slightly less time that what was specified in the OB. This is because the `DIT` is set so that the detector does not saturate, the number of `NDIT`s is set by the chopping frequency and the number of cycles is set so that approximately one minute is spent at each end of the nod.

To compute the actual integration time from the information provided in the FITS header you need to compute

`DIT` × `NDIT` × 2 × `Number of cycles`× `Number of AB or BA cycles`× 2.

Depending on the chop throw and whether or not the object is within the field of view in both chop positions, the total integration time on the object may be reduced by a factor 2.

A.10.2 ISAACLW_spec_obs_AutoChopNod

This template combines chopping and telescope nodding. The number of nodding cycles is referred to as the `Number of AB or BA cycles` and one cycle, commonly called an AB or BA cycle, consists of two exposures, one at each end of the nod. Additionally, it is possible to jitter between ABBA cycles, but not between AB or BA cycles. The amount of jitter between ABBA cycles is defined by the `Jitter Box Width` parameter (in arcseconds). For the removal of hot pixels it is essential that `Jitter Box Width` be set to a non zero value.

Chopping, and therefore nodding, can be either along the slit, or perpendicular to it (`ChopNod PARA of PERP to Slit ?` parameter). It is important to realize that if it perpendicular to the slit, only half the integration time will be spent on target.

The parameters dealing with chopping and nodding are:

- `Integration time (minutes)`. This parameter allows one to define the total **integration** time, excluding overheads. See section 6.2 for how to compute the overheads. The `DIT`, `NDIT`, and the number of chop and nod cycles will be determined automatically.
- `Chop Throw (arcsec) ?`. This is the chopping throw (in arcsec), it is limited to the [10–30] arcsec range. However, we strongly recommend that users limit the throw to 20 arcseconds or less.
- `ChopNod PARA of PERP to Slit ?`. Either PARA if chopping is done along the slit, or PERP if perpendicular to it. Nodding will always be done parallel to the chopping.

The first exposure is done without initially offsetting the telescope. The first image (A) is a chopped, subtracted image, the second image (B) is taken with the telescope offset in the opposite direction to the chop, etc.

Users of the LWS3-LR mode are requested to set the central wavelength to one of the following values: 3.55 or 4.75 μm. Other values are not supported by the calibration plan (see section 10).

If the parameter "`Return to Origin`" is set to true (T), the telescope moves back to its original position at the end of the template. If not, the telescope is not moved.

Table 53: Parameters of `ISAACLW_spec_obs_AutoChopNod`

P2PP label	Keyword	Default	Description
`Jitter Box Width`	`SEQ JITTER WIDTH`	–	Random offset box size (arcsec)
`Return to Origin`	`SEQ RETURN`	T	Return to Origin
`Chop Throw (arcsec) ?`	`SEQ CHOP THROW`	–	M2 Chop Throw (arcsec)
`ChopNod PARA of PERP to Slit ?`	`SEQ CHOP SPEC`	–	Chopping along or perp. to slit ?
`Integration time (minutes)`	`SEQ.TIME`	–	Integration time (minutes)
`Instrument Mode`	`INS MODE`	–	Instrument Mode
`Central Wavelength (microns)`	`INS GRAT WLEN`	–	Central Wavelength (microns) ?
`Slit ?`	`INS SLIT`	–	Which slit ? (e.g. slit_1)

The total integration time (excluding overheads) is defined in minutes. In general, the user will get slightly more or slightly less time that what was specified in the OB. This is because the `DIT` is set so that the detector does not saturate, the number of `NDIT`s is set by the chopping frequency and the number of cycles is set so that approximately one minute is spent at each end of the nod.

To compute the actual integration time from the information provided in the FITS header, you need to compute

`DIT` × `NDIT` × 2 × `Number of cycles`× `Number of AB or BA cycles`× 2.

Note again that if chopping / nodding is done in the direction perpendicular to the slit, only half of this time will be spent on target.

A.10.3 ISAACLW_img_cal_AutoChopNod

This template is used for standard star observations in imaging. It should only be used to calibrate observations that were taken with the Aladdin templates that use chopping. It is strictly equivalent to the `ISAACLW_img_obs_AutoChopNod` template, with the only difference that some DPR keywords in the FITS header of the images are set to different values. This allows pipeline processing, archiving and quality control. The user is referred to the description of the `ISAACLW_img_obs_AutoChopNod` template for the description of the parameters.

This template should not be used to calibrate observations that were taken with Aladdin templates that do not use chopping.

A.10.4 ISAACLW_spec_cal_AutoChopNod

This template is used for standard star observations in spectroscopy. It should only be used to calibrate observations that were taken with the Aladdin templates that use chopping. It is strictly equivalent to the `ISAACLW_spec_obs_AutoChopNod` template, with the only difference that some DPR keywords in the FITS header of the images are set to different values. This allows pipeline processing, archiving and quality control. The user is referred to the description of the `ISAACLW_spec_obs_AutoChopNod` template for the description of the parameters. **This template must be used by users requesting calibrations beyond the ones provided by the Calibration Plan of this mode**.

This template should not be used to calibrate observations that were taken with Aladdin templates that do not use chopping.

A.10.5 ISAACLW_spec_cal_NightCalib

This template allows one to take night time calibrations right after any Aladdin spectroscopic template. See section 5.5 for more information regarding the need for night time calibrations.

This template is not autonomous. It must follow a spectroscopic observation. Furthermore, it only calibrates the wavelength setting that is used in the preceding template and not the wavelength settings in all preceding templates.

Table 54: Parameters of `ISAACLW_spec_cal_NightCalib`

P2PP label	Keyword	Def.	Description
`Flatfield at end of template`	`SEQ FLATFIELD`	T	Night flat field at end of template ?
`Arc at end of template`	`SEQ ARC`	F	Night arc at end of template ?

A.11 Aladdin Observation and Calibration Templates - Without chopping

For some modes, one can take data in the Aladdin arm without chopping. These modes are broadband imaging with the J+Block, H & Ks filters, NB imaging with the NB 3.21 and NB 3.28 filters, and MR spectroscopy at all wavelengths.

The Aladdin templates that do not use chopping are listed in Table 55.

Table 55: Aladdin templates that do not use chopping

P2PP Template Name
ISAACLW_img_obs_AutoJitter
ISAACLW_img_obs_AutoJitterOffset
ISAACLW_img_obs_FixedSkyOffset
ISAACLW_img_obs_GenericOffset
ISAACLW_spec_obs_AutoNodOnSlit
ISAACLW_spec_obs_GenericOffset
ISAACLW_img_cal_GenericOffset
ISAACLW_spec_cal_AutoNodOnSlit

If an observation is done without chopping, then the calibration should also be done without chopping. **Do not mix observing templates that do not use chopping with calibration templates that do and vice versa.**

A.11.1 ISAACLW_img_obs_AutoJitter

This template works in an identical manner to ISAACSW_img_obs_AutoJitter. Please refer to Sec. A.7.1 for a description of what the template does.

This mode is available for imaging with the J+Block, H & Ks broadband filters and 3.21 and 3.28 narrow band filters only.

Table 56: Parameters of ISAACLW_img_obs_AutoJitter

P2PP label	Keyword	Default	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Number of Exposures	SEQ NEXPO	–	Number of exposures
Jitter Box Width	SEQ JITTER WIDTH	–	Random offset box size (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin
LW Filter wheel 1	INS FILT3 NAME	–	Filter name in wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter name in wheel 2

A.11.2 ISAACLW_img_obs_AutoJitterOffset

This template works in an identical manner to ISAACSW_img_obs_AutoJitterOffset. Please refer to Sec. A.7.2 for a description of what the template does.

This mode is available for imaging with the J+Block, H & Ks broadband filters and 3.21 and 3.28 narrow band filters only.

Table 57: Parameters of ISAACLW_img_obs_AutoJitterOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Jitter Box Width	SEQ JITTER WIDTH	–	Random offset box width (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin
Sky Offset Throw	SEQ SKYTHROW	–	Sky Throw (arcsec)
Rotate Pupil	SEQ ROTPUPIL	T	Pupil rotation compensation
Number of AB or BA cycles	SEQ NABCYCLES	–	Number of AB or BA cycles
NDIT for the OBJECT positions	SEQ NDIT OBJECT	–	NDIT used on OBJECT positions
NDIT for the SKY positions	SEQ NDIT SKY	–	NDIT used on SKY positions
LW Filter wheel 1	INS FILT3 NAME	–	Filter name in wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter name in wheel 2

A.11.3 ISAACLW_img_obs_FixedSkyOffset

This template works in an identical manner to ISAACSW_img_obs_FixedSkyOffset. Please refer to Sec. A.7.3 for a description of what the template does.

This mode is available for imaging with the J+Block, H & Ks broadband filters and 3.21 and 3.28 narrow band filters only.

Table 58: Parameters of ISAACLW_img_obs_FixedSkyOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Jitter Box Width	SEQ JITTER WIDTH	–	Random offset box width (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin
Sky Offset in Alpha	SEQ SKYOFFSET ALPHA	–	Sky Offset in Alpha (arcsec)
Sky Offset in Delta	SEQ SKYOFFSET DELTA	–	Sky Offset in Delta (arcsec)
Rotate Pupil	SEQ ROTPUPIL	T	Pupil rotation compensation
Number of AB or BA cycles	SEQ NABCYCLES	–	Number of AB or BA cycles
NDIT for the OBJECT positions	SEQ NDIT OBJECT	–	NDIT used on OBJECT positions
NDIT for the SKY positions	SEQ NDIT SKY	–	NDIT used on SKY positions
LW Filter wheel 1	INS FILT3 NAME	–	Filter name in wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter name in wheel 2

A.11.4 ISAACLW_img_obs_GenericOffset

This template works in an identical manner to ISAACSW_img_obs_GenericOffset. Please refer to Sec. A.7.4 for a description of what the template does.

This mode is available for imaging with the J+Block, H & Ks broadband filters and 3.21 and 3.28 narrow band filters only.

A.11.5 ISAACLW_img_obs_FastPhot

This template allow Fast Photometry either in Burst or FastJitter mode. In order to select one mode or the other the keyword DET.BURST.MODE should be set to T or F, respectively. For details about the difference between the two modes, please refer to Section 12. Other important keyword that need to be set in both modes are: the detector windowing (DET.WIN.NX and DET.WIN.NY), the DIT and the NDIT parameters.

Note that the JITTER.WIDTH parameter is ignored if BURST=T. Random telescope offsets (jitter) will be executed only in FastJitter mode if the number of exposure NEXPO is larger

Table 59: Parameters of ISAACLW_img_obs_GenericOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
Observation Category	SEQ.CATG	SCIENCE	Observation category (science or preimaging)
Number of Exposures	SEQ NEXPO	–	Number of exposures
List of NDIT	SEQ NDIT LIST	–	NDIT List
Return to Origin	SEQ RETURN	T	Return to Origin Flag
Obs Type (O or S)	SEQ OBSTYPE LIST	–	Observation type list (S or O)
List of offsets (X or RA)	SEQ OFFSET1 LIST	–	X or RA offset list (arcsec)
List of offsets (Y or DEC)	SEQ OFFSET2 LIST	–	Y or DEC offset list (arcsec)
Offset Coordinates ?	SEQ OFFSET COORDS	–	SKY or DETECTOR coords ?
LW Filter wheel 1	INS FILT3 NAME	–	Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter wheel 2

than 1. There is not jittering during the observation/creation of *a* data-cube.

The keywords EVENT.DATE and EVENT.TIME are ignored whenever BURST=F. On the contrary, in Burst mode, by setting the value 0 (default) no EVENT time is considered during the template execution and the exposure start as soon as the acquisition and the instrument set up have been completed.

Last, the keywords WIN.STARTX/Y cannot take any value. The window is alway centered in the Aladdin detector and is not possible to place it, say, in just one quadrant. Therefore, please refer to Table 26 to get the appropriate values for the selected window size.

Table 60: Parameters of ISAACLW_img_obs_FastPhot

P2PP label	Keyword	Def.	Description
BURST	DET.BURST.MODE	T	Toggle Burst mode
DIT	DET DIT	–	Detector Integration Time (secs)
List of NDIT	SEQ NDIT LIST	–	NDIT List
WINX	DET.WIN.NX	1024	number of column
WINY	DET.WIN.NY	1024	number of lines
STARTY	DET.WIN.STARTX	1-1024	first column of window
STARTY	DET.WIN.STARTY	1-1024	first row of window
EVENT DATE	EVENT.DATE	0	UT date of event: YYMMDD
EVENT TIME	EVENT.TIME	0	UT time of event: HHMMSS
Number of Exposures	SEQ NEXPO	–	Number of exposures
JITTERBOX	JITTER.WIDTH	–	Jitter Box Width
Return to Origin	SEQ RETURN	T	Return to Origin Flag
LW Filter wheel 1	INS FILT3 NAME	–	Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter wheel 2

Note 1: OB Naming Convention:

- FastJitter OBs (BURST=F) should start with the prefix 'FAST' in their name,
- Burst OBs (BURST=T) which **do not** make use of the EVENT keywords (EVENT.DATE=0 and EVENT.TIME=0) should start with the prefix 'BURST' in their name,
- Burst OBs (BURST=T) which make use of the EVENT keywords (EVENT.DATE=YYMMDD and EVENT.TIME=HHMMSS) need to include the time at which the science template (not the acquisition!) should start, i.e. the UT time of the EVENT time minus half the total exposure time. For example, let's assume that you are exposing for 30 sec in total and let's assume that your event occurs at UT date YYMMDD and UT time HHMMSS, then, your OB name should include the following prefix: BURSTUTYYMMDDHHMMss, where ss=SS-30/2=SS-15.

Note 2: OB requirements/Finding charts:
OBs making use of the acquisition template ISAAC_img_acq_Preset do not need an attached finding chart. It will be responsibility of the user to double check his/her coordinates.

A.11.6 ISAACLW_spec_obs_AutoNodOnSlit

This template works in an identical manner to ISAACSW_spec_obs_AutoNodOnSlit. Please refer to Sec. A.8.1 for a description of what the template does.
This mode is available for MR spectroscopy only.

Table 61: Parameters of ISAACLW_spec_obs_AutoNodOnSlit

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Jitter Box Width	SEQ JITTER WIDTH	–	Jitter box width (arcsec)
Return to Origin	SEQ RETURN	T	Return to Origin flag
Nod Throw Along Slit	SEQ NODTHROW	–	Throw of the nod (arcsec)
Number of AB or BA cycles	SEQ NABCYCLES	–	Number of AB or BA cycles
NINT	SEQ NINT	–	Number of frames at each position
Instrument Mode	INS MODE	–	Instrument Mode
Slit ?	INS SLIT	–	Which slit ? (e.g. slit_1)
Central Wavelength (microns)	INS GRAT WLEN	–	Central Wavelength (microns) ?

A.11.7 ISAACLW_spec_obs_GenericOffset

This template works in an identical manner to ISAACSW_spec_obs_GenericOffset. Please refer to Sec. A.8.2 for a description of what the template does.
This mode is available for MR spectroscopy only.

Table 62: Parameters of ISAACLW_spec_obs_GenericOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of sub-integrations
Number of Exposures	SEQ NEXPO	–	Number of exposures
Return to Origin	SEQ RETURN	T	Return to Origin flag
X offset list (arcsec)	SEQ OFFSETX LIST	–	X offset list (arcsec)
Y offset list (arcsec)	SEQ OFFSETY LIST	–	Y offset list (arcsec)
Obs Type (O or S)	SEQ OBSTYPE LIST	–	List of observation types (S or O)
Instrument Mode	INS MODE	–	Instrument Mode
Slit ?	INS SLIT	–	Long Slit
Central Wavelength (microns)	INS GRAT WLEN	–	Central Wavelength (microns) ?

A.11.8 ISAACLW_img_cal_GenericOffset

This template is used for standard star observations in imaging. It should only be used to calibrate observations that were taken with the Aladdin templates that do not use chopping. The template is very similar to ISAACLW_img_obs_GenericOffset, with the difference that the offsets are defined in detector coordinates.

Table 63: Parameters of ISAACLW_img_cal_GenericOffset

P2PP label	Keyword	Def.	Description
DIT	DET DIT	–	Detector Integration Time (secs)
NDIT	DET NDIT	–	Number of DITs
Number of Exposures	SEQ NEXPO	–	Number of exposures
Return to Origin	SEQ RETURN	–	Return to Origin Flag
X offset list (arcsec)	SEQ OFFSETX LIST	–	X offset list (arcsec)
Y offset list (arcsec)	SEQ OFFSETY LIST	–	Y offset list (arcsec)
LW Filter wheel 1	INS FILT3 NAME	–	Filter wheel 1
LW Filter wheel 2	INS FILT4 NAME	–	Filter wheel 2

A.11.9 ISAACLW_spec_cal_AutoNodOnSlit & ISAACLW_spec_cal_GenericOffset

These templates are used for standard star observations in spectroscopy. They should only be used to calibrate observations that were taken with the Aladdin templates that do not use chopping. They work in an identical manner to ISAACLW_spec_obs_AutoNodOnSlit & ISAACLW_spec_obs_GenericOffset. The only difference is that some keywords in the FITS headers are set to different values allowing pipeline processing and archiving.

These templates must be used by users requesting calibrations beyond the ones provided by the Calibration Plan of this mode.

A.11.10 ISAACLW_spec_cal_NightCalib

This template allows one to take night time calibrations right after any Aladdin spectroscopic template. See section 5.5 for more information regarding the need for night time calibrations.

This template is not autonomous. It must follow a spectroscopic observation. Furthermore, it only calibrates the wavelength setting that is used in the preceding template and not the wavelength settings in all preceding templates.

Table 64: Parameters of ISAACLW_spec_cal_NightCalib

P2PP label	Keyword	Def.	Description
Exposure Name	DET EXP NAME	1	Exposure Base filename
Flatfield at end of template	SEQ FLATFIELD	T	Night flat field at end of template ?
Arc at end of template	SEQ ARC	F	Night arc at end of template ?

B Filter curves

See the on-line version of the User Manual (http://www.eso.org/instruments/isaac) for transmission curves in ASCII format.

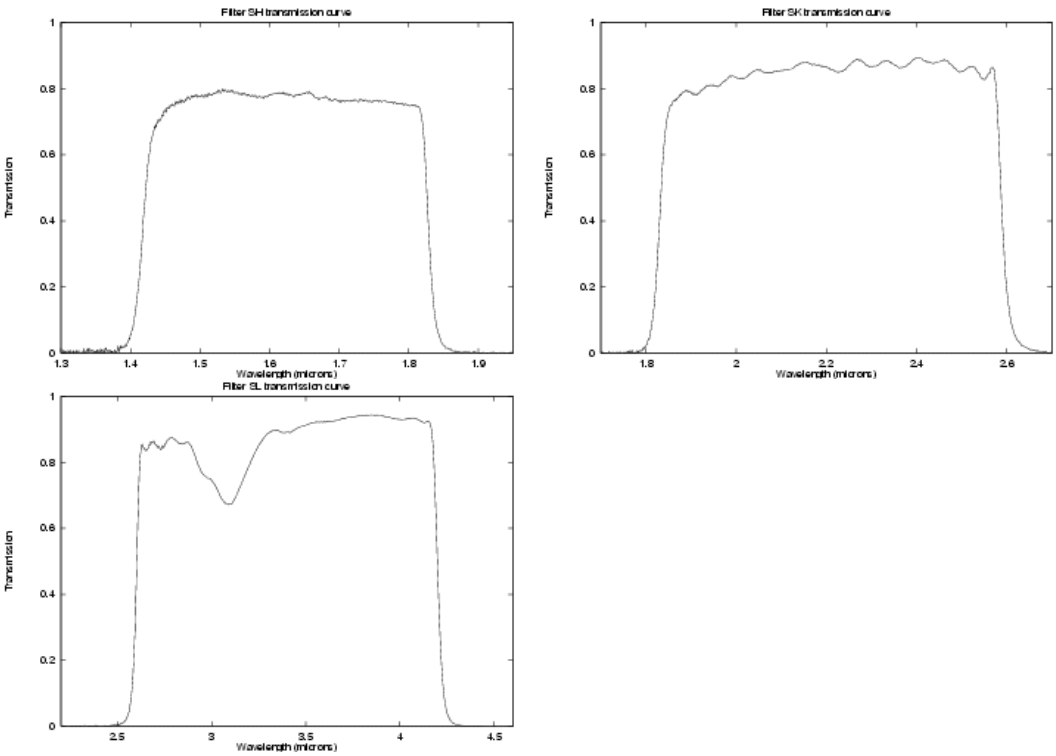


Figure 19: Filter curves for order sorting filters

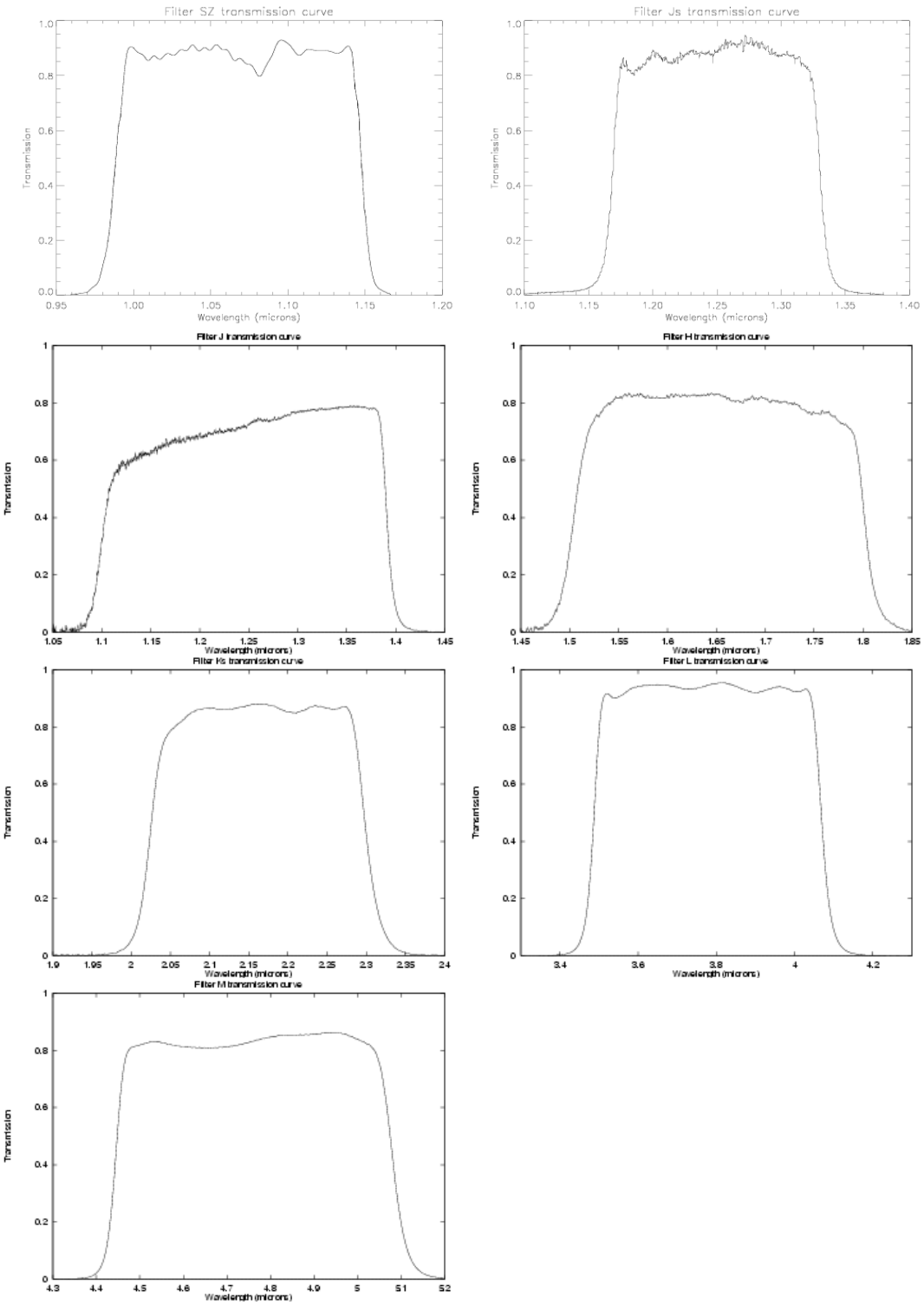


Figure 20: Filter curves for broad band filters

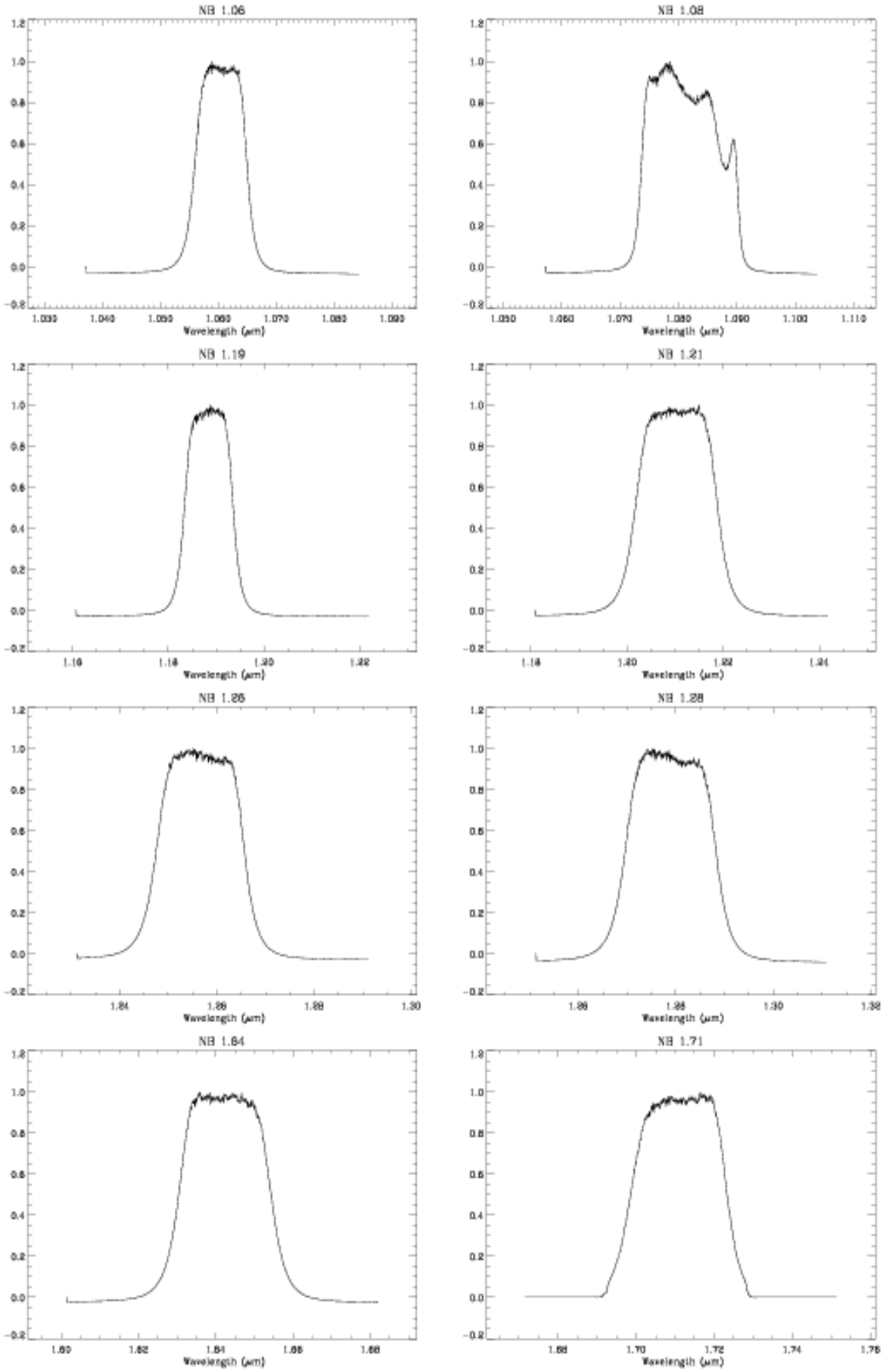


Figure 21: Narrow band filter curves

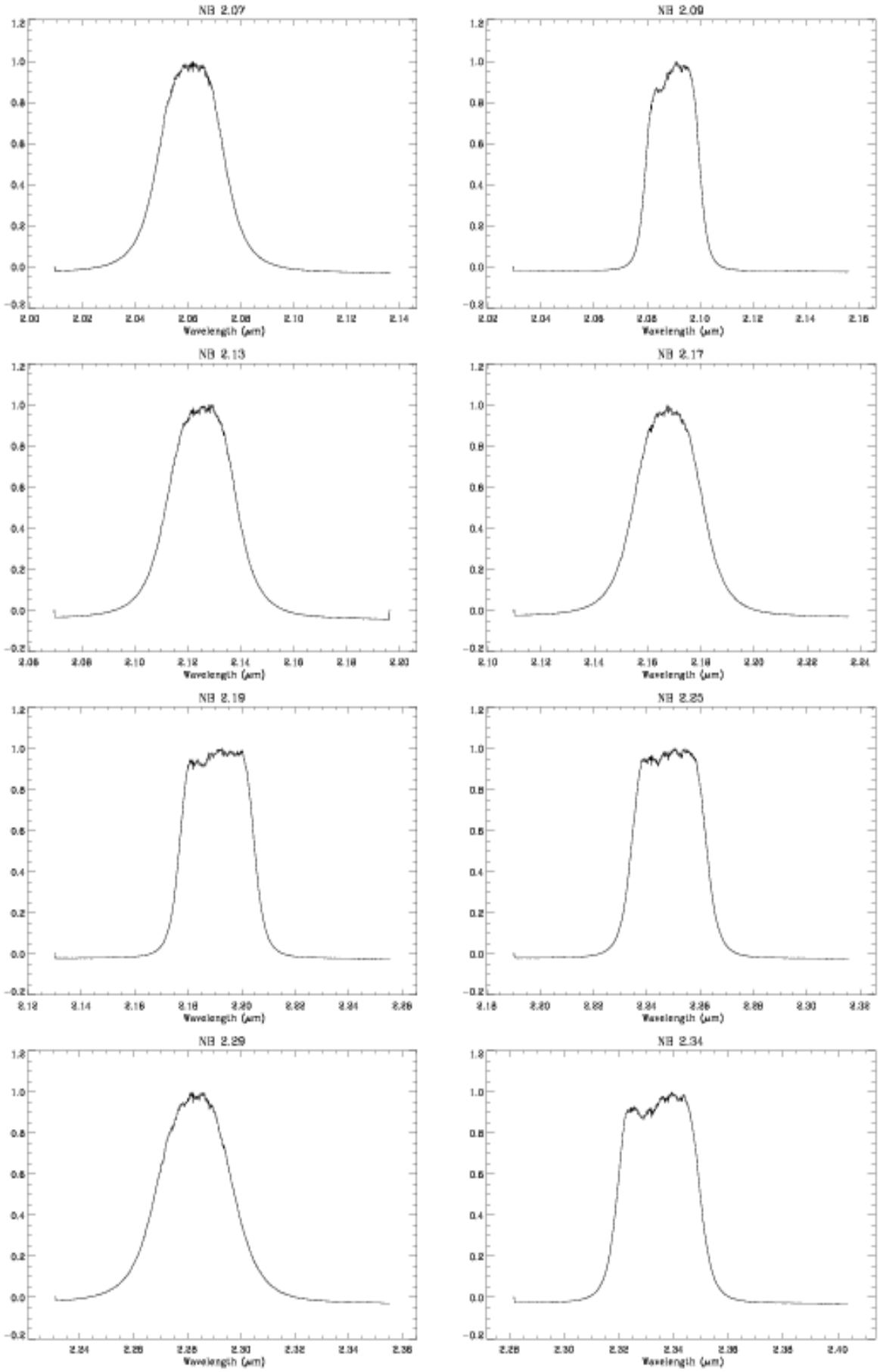


Figure 22: Narrow band filter curves

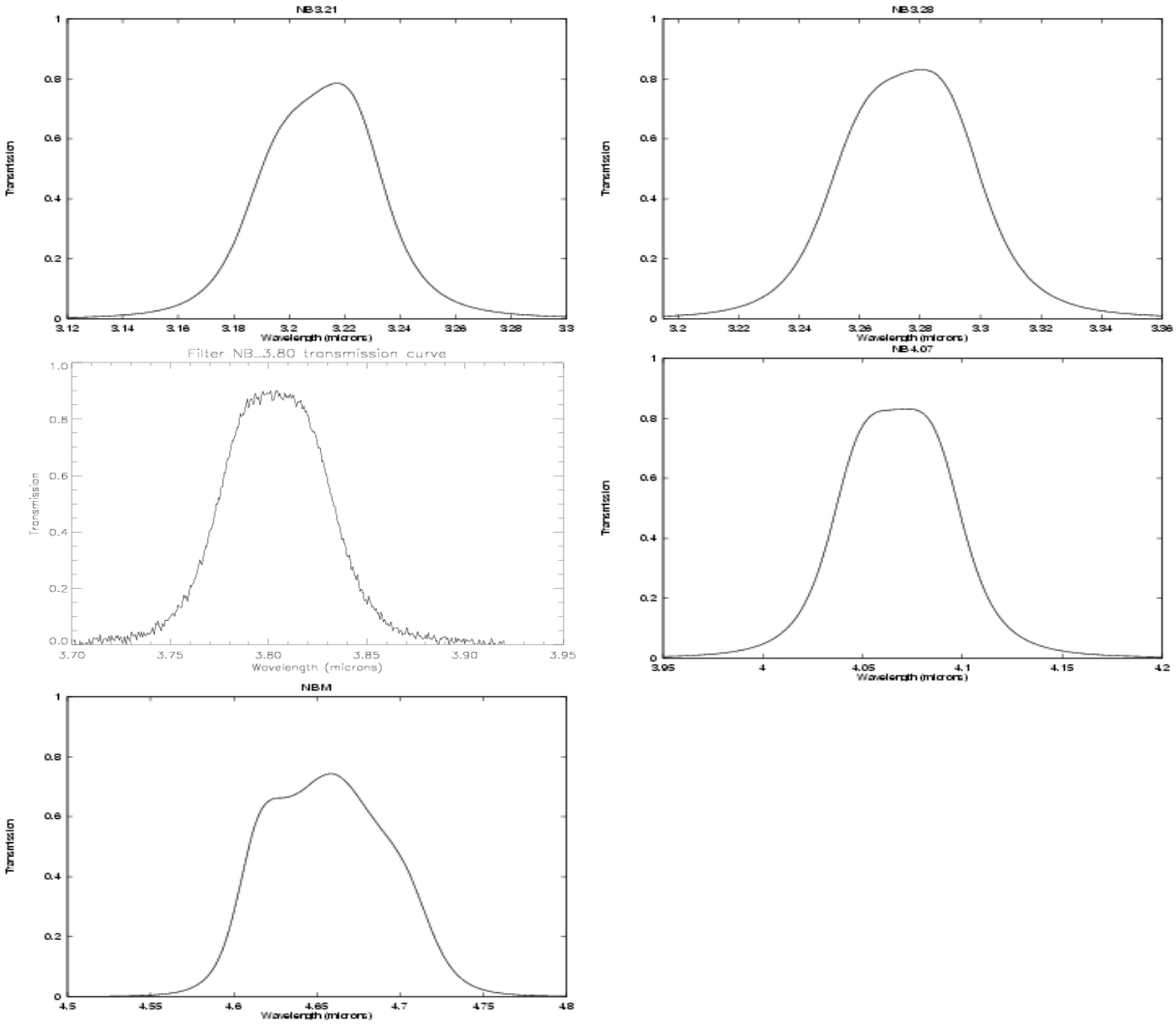


Figure 23: Narrow band filter curves

C Standard stars

See the http://www.eso.org/instruments/isaac, for a list of standard stars.

C.1 SW Photometric Standards

Only stars fainter than $K \sim 12$ mag should be used as standards to calibrate the broad band filters. A number of stars in the JHK Persson and UKIRT fundamental and extended lists are suitable. Note however that many stars in these lists are too bright and may saturate the detector, especially when the seeing is good.

C.2 SW Telluric Standards

Telluric standards are used to remove telluric absorption features. In most cases they can also be used for flux calibration. A more detailed discussion as to which stars are best to use is given in Sec. 3.4

We prefer to use very hot stars (earlier than type B4) or solar analogues. The Hipparcos catalogue is an excellent source for such stars. Many of the stars in the Hipparcos catalogue have IR magnitudes from either the 2MASS or DENIS IR surveys. See also section C.3 for more star lists.

The optimal magnitude ranges for SW LR and MR spectroscopic standards are K=7 to K=9 and K=5 to K=7 respectively. Stars brighter than this will saturate the detector.

C.3 Bright standards for LW imaging and spectroscopy.

This section mentions several standard star lists that can be used for LW observations, either for imaging or for spectroscopy. They can also be used for SW spectroscopy.

The optimal magnitude ranges for LR and MR spectroscopic standards are L=4 to L=6 and L=2 to L=4 respectively. For L band imaging, standards should be fainter than L=6 magnitude and for narrow band imaging, standards should be fainter than L=5.

- the MSSSO infrared photometric standards (McGregor 1994, PASP, 106, 508). Transformations from the Caltech system to the original MSSSO and AAO systems are given in McGregor (1994, PASP, 106, 508).
- the IR photometric data of ESO calibration stars (van der Bliek et al., 1996, A&AS, 119, 547).
- An extensive list of bright stars of known spectral type and magnitude taken from a variety of sources (MSSSO photometric standards, IRPS/FIGS G dwarfs spectroscopic standards, UKIRT spectroscopic standards, NASA Infrared Catalog, Bright Star Catalog) and have correspondingly uncertain photometric magnitudes. Photometric magnitudes in this list come from the following references: M = McGregor (1994, PASP, 106, 508), C = Carter (1990, MNRAS, 242, 1), B = Bouchet, Manfroid, & Schmider (1991, A&A Suppl., 91, 409), A = Allen & Cragg (1983, MNRAS, 203, 777). Stars with magnitudes listed but lacking a reference annotation are taken from the NASA Catalog, and their photometry should be considered uncertain at the ±0.05 mag level. Other stars lacking

measured photometric magnitudes should be used only as telluric standards to remove terrestrial absorption features; flux calibration should be obtained separately.

Important note: We had reports of incorrect visible magnitudes in this list. Users are encouraged to choose only standard stars for which the IR magnitude is available in the photometric band corresponding to their observations, and not to rely on the visible magnitude. The table will be corrected for the errors as time permits.

D Acronyms

ASM	Astronomical Site Monitor
BB	Broad Band
BOB	Broker for Observation Blocks
CCD	Charge Coupled Device
DCR	Double-Correlated Read
DCR-LB	Double-Correlated Read, Low Bias
DCR-HB	Double-Correlated Read, High Bias
DIT	Detector Integration Time
ETC	Exposure Time Calculator
GUI	Graphical User Interface
ISAAC	Infrared Spectrometer and Array Camera
LR	Low Resolution
LW	Long Wavelength
LWI	Long Wavelength Imaging
LWS	Long Wavelength Spectroscopy,
LWS-LR	Long Wavelength Spectroscopy - Low Resolution
LWS-MR	Long Wavelength Spectroscopy - Medium Resolution
MR	Medium Resolution
NB	Narrow Band
NDIT	Number of Detector Integration Time
NDR	Non Destructive Read
NINT	Number of integrations
NTT	New Technology Telescope
OB	Observation Block
OS	Observation Software
P2PP	Phase 2 Proposal Preparation
P70	ESO Observing Period 70
P71	ESO Observing Period 71
P72	ESO Observing Period 72
P74	ESO Observing Period 74
RRM	Rapid Response Mode
RTD	Real Time Display
SOFI	Son Of Isaac
SW	Short Wavelength
SWI	Short Wavelength Imaging
SWS	Short Wavelength Spectroscopy
SWS-LR	Short Wavelength Spectroscopy – Low Resolution
SWS-MR	Short Wavelength Spectroscopy – Medium Resolution
ToO	Target of Opportunity
UCR	Un-Correlated Read
UT	Unit Telescope
VLT	Very Large Telescope