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Very Large Telescope

Paranal Science Operations

MATISSE Template Manual

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Contents

1 Introduction

1.1 Scope

This document describes the observing templates for MATISSE, the second generation VLTI mid-infrared instrument. As for all the VLT instruments, observations with MATISSE are carried out with observation blocks (OBs). The OBs must be defined by the user during Phase-2 preparation with the p2 web pages. An OB consists of a constraint set and several templates that describe the target acquisition and the observation sequence. For some templates, the user has to indicate the values of keywords (parameters).

This Template Manual requires the user to have some basic understanding of the MATISSE instrument. If you are a first time user, we recommend to read the MATISSE User Manual and web pages that can be accessed from:

http://www.eso.org/sci/facilities/paranal/instruments/matisse.html

The OBs are prepared with the web application p2. The web interface is available at: http://www.eso.org/p2

Also visiting observers at Paranal are asked to prepare their observations with this web-based application. OBs created or changed through p2 will be directly recorded in ESO's database and immediately become available at the telescope on Paranal.

Finally, the VLTI manual povides all the information which is not instrument specfic (e.g. AT configuration, limiting magnitudes for the Auxiliary Telescopes etc.) that one needs to prepare VLTI observations: VLTI User Manual

1.2 MATISSE brief description

MATISSE is a four-beam interferometric combiner that can operate in the L, M, and N bands simultaneously (i.e. from 3 to 13μm). It can work with either the four UTs or ATs. It is composed of three main parts: the warm optics table (WOP), the L-and-M-bands cryostat and the N band cryostat. After a dichroics located on the WOP, MATISSE can be seen as two separated instruments working simulateanously (and synchronised). The L&M and the N arms differ in a few points. The most important are:

Spectral resolutions:

- In the L&M bands: LOW (R=30), MED (R=500), HIGH (R=950) and HIGH+ (R$\sim$5000).
- In the N band: LOW (R=30) and HIGH (R=220).

Detectors:

- The L&M bands cryostat is equipped with a 2048x2048 pixels HAWAII-2RG detector (identical to the science detector of GRAVITY)
- N band cryostat is equiped with a 1024x1024 pixels AQUARIUS detector (identical to VISIR detector)

After being spatially filtered by pinholes or slits (in service mode only one pinhole is offered), the light of the four beams is combined in the focal plane and spectrally dispersed. This produces the typical X-lambda fringe pattern, similar to AMBER. However, in order to efficiently remove background contamination and reduce cross-talk between the fringe peaks, an optical path difference (OPD) modulation is applied on the four beams during observation.

Before the combination, beam splitters can take a part of the flux and redirect it into photometric channels. As these devices are movable, each arm can operate in two different modes:

- SI-PHOT (SImulatenaous PHOTometry): with the beam splitters, the photometric calibration of the fringes is then done during fringe observation.
- HI-SENS (HIgh SENSitivity): In that mode, the beam splitters are removed and all photons are sent to the interferometric channel. Subsequent photometry exposures, closing the shutters one by one, are needed to evaluate the beams absolute photometry.

Currently MATISSE is only offered in a so-called HYBRID mode, where the L&M arm operates in SI-PHOT and the N band in HI-SENS.

1.3 Contact information

In case of questions or suggestions related to Phase-2 preparation, please contact the ESO User Support Department (usd-help@eso.org).

1.4 Period of validity of this manual

This manual is valid for observations with MATISSE during P103 and may be revised for P104 and beyond.
In particular, not all modes are fully commissioned for P103.

- M-band observations are not offered in P103
- L-band HIGH+ resolution is not offered in P103
- N-band HIGH resolution is not offered in P103

1.5 ESO observation glossary

- **Constraint Set (CS)**
  List of requirements for the conditions of the observation that is given inside an OB. OBs are only executed if conditions meet or exceed these requirements.
- **Observation Block (OB)**
  An Observation Block is the smallest schedulable entity for the VLT. It consists of a sequence of Templates. Usually, one Observation Block includes one target acquisition template and one or several observation templates.
- **Observation Description (OD)**
  A sequence of templates used to specify the observing sequences within one or more OBs.

- **Observation Toolkit (OT)**
  Tool used to create queues of OBs for later scheduling and possible execution (service mode).

- **Proposal Preparation and Submission (Phase 1)**
  The Phase 1 begins right after the CfP (Call-for-Proposals) and ends at the deadline for CfP. During this period the potential users are invited to prepare and submit scientific proposals. For more information, see:
  http://www.eso.org/sci/observing/phase1.html

- **Observation Preparation (Phase 2)**
  Once proposals have been approved by the ESO Observation Program Committee (OPC) and scheduled, users are notified and the Phase 2 begins. In this phase, users are requested to prepare their accepted proposals in the form of OBs using the p2 web application. See:
  https://www.eso.org/sci/observing/phase2.html.

- **Service Mode (SM)**
  In service mode (in contrast to "Visitor-Mode"), the observations are carried out by the ESO Paranal Science-Operation staff (PSO) alone. Observations can be done at any time during the period, depending on the CS given by the user. OBs are put into a queue schedule in OT which later sends OBs to the instrument.

- **Template**
  A template is a sequence of operations to be executed by the instrument. The observation software of an instrument dispatches commands written in templates not only to instrument modules that control its motors and the detector, but also to the telescopes and VLTI sub-systems.

- **Template signature file (TSF)**
  File which contains template input parameters.

- **Visitor Mode (VM)**
  The classic observation mode. The user is on-site to supervise his/her program execution, to directly analyse the data and to take real-time decisions if necessary.

2 The acquisition template

The first template in an OB must be an acquisition template which contains the information to point the telescope at a source and sets up the VLTI and instrument for observation. MATISSE only has one acquisition template named **MATISSE_image_acq**.

2.1 Template sequence

The sequence of the acquisition template is the following:

- Telescopes are slewed to the target.

- The target is acquired, coudé guiding is performed either on the target or on an off-axis guide star.
- Adaptive optics system are optimized and their loops are closed
- Delay lines are preset to offer enough delay range for the interferometric observation.
- Lab guiding loop (i.e. stabilisation of the beams in the interferometric laboratory) is closed using the IRIS VLTI sub-system.

When the VLTI is ready, MATISSE can perform additionnal verifications which are optional:

- The target can be acquired by MATISSE to check the MATISSE-VLTI alignment. As the VLTI-MATISSE is very stable, this is currently only done once per night, on the first star acquired with the instrument. The night astronomer verifies the instrument, and, if needed (which rarely happens), change the IRIS reference pixel to align it with MATISSE.
- Though the quality of the pupils in the VLTI lab are checked at the begining of the night using IRIS, MATISSE also offers an option to verify its pupils internally. This feature is mainly used for technical troubleshooting and is not offered, neither in service nor in visitor mode.
- Finally, a fringe search can be done during the acquisition template. As the VLTI delay line model is now very stable and MATISSE offers a reasonable coherence length even in the L-band low resolution mode (i.e. of the order of 10μm) this step is usually only done once per night, during the first acquisition with MATISSE.

Performing MATISSE image acquisition, pupil check, and fringe search is the responsability of the VLTI night astronomer and is not offered as a user parameter in service mode.

2.2 Execution time

MATISSE acquisition template execution times range between 4 min if only the VLTI preset is done to about 15 minutes if pupil check with IRIS and image acquisition and fringe search with MATISSE are performed. In p2 the execution time is set to 10 min.

2.3 NAOMI and MACAO guiding

On the Unit Telescopes, adaptive optics correction is provided either by MACAO in the optical or by CIAO in the infrared, both located in the coudé focus of the telescopes. However, MATISSE is currently not offered with CIAO so that only MACAO can be used on the UTs. Details on MACAO and CIAO can be found in the VLTI User Manual.

MACAO (Multi-Application Curvature Adaptive Optics) is a 60 elements curvature adaptive optic system working in the visible. It has the following requirements:

- The guide star must be fainter than V = 1^m and brighter than V = 16^m. Note that the Strehl drops significantly with a coudé guide star fainter than the 13-14th magnitude.

- The guide star must be within a radius of 57.5 arcsec from the science target.

From P103 on, the Auxiliary Telescopes guide by means of the New Adaptive Optics Module for Interferometry (NAOMI). NAOMI is a low-order Shack-Hartman system operating in the visible which replaces the previous STRAP tip-tilt guiding. Installation and commissioning of 4 NAOMI modules took place between September and November 2018. As NAOMI commissioning is under way, refer to the VLTI User Manual for the most recent values.

Note that for both UT and AT, the V magnitude (faintest, if variable)of the coudé guide star should be given in the keyword **"GS mag in V"** of the acqusition template.

As MACAO and NAOMI are the default guiding system for the UTs and ATs respectively, the **"Guiding Type"** should be be set to DEFAULT. Note that it is also equivalent to ADAPT_OPT for MATISSE.

2.4 List of user parameters

MATISSE acquisition template contains only three parameters in addition of the standard VLT/VLTI parameters.

L band flux in Jy
The object estimated L band flux. The users can find such flux, for instance, in the WISE all sky catalog. This parameter is used by the observation template to set-up the real-time fringe coherencing parameters.

N band flux in Jy
The object estimated L band flux in Jansky. The users can find such flux, for instance, in the WISE all sky catalog or in the IRAS catalog. This parameter is used by the observation template to set-up the real-time fringe coherencing parameters.

K band magnitude
The object estimated K band magnitude. This is used by the IRIS lab-guiding system.

Differential tracking in RA
Differential tracking in RA in arcsecs per second.

Differential tracking in DEC
Differential tracking in DEC in arcsecs per second.

RA of guide star if COU guide star is SETUPFILE
Right Ascension of the coudé guide star. This keyword should only be specified if the keyword **COU guide star** is set to SETUPFILE.

DEC of guide star if COU guide star is SETUPFILE
Declination of the coudé guide star. This keyword should only be specified if the keyword **COU guide star** is set to SETUPFILE.

Epoch
Epoch of the coordinates of the coudé guide star if it is different from the science target. Usually 2000.

Equinox
Equinox of the coordinates of the coudé guide star if it is different from the science target. Usually 2000.

COU guide star
This keyword is used to tell the system which source shall be used for coudé guiding, either: SCIENCE if the target is used for the guiding, or SETUPFILE if an off-axis star will be used. In that case, the coudé guide star coordinates need to be specified.

Off-axis Coude Proper motion Alpha
Alpha coordinate of the proper motion of the coudé guide star in arcsec/year. This should only be specified if the keyword **COU guide star** is set to SETUPFILE.

Off-axis Coude Proper motion Delta
Delta coordinate of the proper motion of the coudé guide star in arcsec/year. This should only be specified if the keyword **COU guide star** is set to SETUPFILE.

Guiding Type
This keyword defines the type of coudé guiding to be used. The default setting (i.e. DEFAULT) , implies that, for the ATs, NAOMI or, for the UTs, MACAO will be used. Is it equivalent to ADAPT-OPT. MATISSE is currently not offered with CIAO, the infrared adaptive optic system installed on the UTs.

GS mag in V
coudé guide star visual magnitude. This should always be specified. In the case of a variable star the faintest magnitude should be given.

2.5 List of all template parameters accessible during observation

Here we list all template parameters including those that cannot be defined by the user in p2, but can be modified at the time of observation.

3 The observation template

Following the acquistion template, the user has to include in the OB one or more observation templates. For P103 MATISSE offers only one observation template: the HYBRID observation template named **MATISSE_hyb_obs**.

This template defines an observation in HYBRID mode, where the L&M-band arm observes with the beam splitter in SI-PHOT mode and the N-band arm without the beam splitter in HI-SENS mode.

Name	description	range	default
DET1.READ.CURNAME	Frame mode for L detector	SCI-FAST-SPEED SCI-SLOW-SPEED	SCI-SLOW-SPEED
SEQ.ACQ.ST	Do image acquisition	T F	F
SEQ.FLUX.L	L band flux in Jy	-	-
SEQ.FLUX.N	N band flux in Jy	-	-
SEQ.MAG.K	K-band magnitude	-	-
SEQ.FS.DET1.DIT	Integration time for fringe-search, L-band	-	0.111
SEQ.FS.INS.DIL.NAME	Dispersive element for fringe-search, L-band	HIGH+ HIGH MED LOW	MED
SEQ.FS.INS.DIN.NAME	Dispersive element for fringe-search, N-band	LOW HIGH	LOW
SEQ.FS.INS.SFL.NAME	Spatial filter for fringe-search, L-band	1.00 1.50 2.00 0.66x5.5 1.50x5.5 2.50x5.5	1.5
SEQ.FS.INS.SFN.NAME	Spatial filter for fringe-search, N-band	1.50 2.00 2.50 1.00x5 1.50x5 2.00x5	2.0
SEQ.FS.SKY.DURATION	Duration of sky exposure for fringe-search	1..60	15
SEQ.FS.ST	Do fringe-search	T F	F
SEQ.OSF.AUTO	Automatic execution of OSF scripts?	T F	T
SEQ.PRESET.ST	Preset VLTI ?	T F	T
SEQ.SKY.OFFS.ALPHA	sky offset, right-ascension	-	1
SEQ.SKY.OFFS.DELTA	sky offset, declination	-	15
SEQ.TRACK.BAND	Master-band controlling the VLTI delay-lines	L N	L
SEQ.CHOP.ST	Use telescope chopping	F T	T
TEL.TARG.ALPHA	Target RA	ra	0
TEL.TARG.DELTA	Target DEC	dec	0
TEL.TARG.EQUINOX	Target Equinox	-2000..3000	2000
TEL.TARG.ADDVELALPHA	Differential tracking in RA	-15..15	0
TEL.TARG.ADDVELDELTA	Differential tracking in DEC	-15..15	0
TEL.TARG.PMA	Proper motion in RA (”yr)	-500..500	0
TEL.TARG.PMD	Proper motion in DEC (”/yr)	-500..500	0
TEL.GS1.ALPHA	RA of guide star	ra	0
TEL.GS1.DELTA	DEC of guide star	dec	0
TEL.GS1.MAG	Magnitude of guide star	0..25	0
TEL.CHOP.FREQ	Chopping frequency (Hz)	-	0.5
TEL.CHOP.POSANG	Azimuth angle of chopping	0..360	0
TEL.CHOP.PVRATIO	Star/sky dwell ratio	1	1
TEL.CHOP.THROW	Amplitude angle of chopping	0..4.5	4.5
COU.AG.ALPHA	RA of guide star if COU guide star is SETUPFILE	ra	0
COU.AG.DELTA	DEC of guide star if COU guide star is SETUPFILE	dec	0
COU.AG.EPOCH	Epoch	-2000..3000	2000
COU.AG.EQUINOX	Equinox	-2000..3000	2000
COU.AG.GSSOURCE	COU guide star	NONE SETUPFILE SCIENCE	SCIENCE
COU.AG.PMA	Off-axis coude Proper Motion Alpha	-10..10	0
COU.AG.PMD	Off-axis coude Proper Motion Delta	-10..10	0
COU.AG.TYPE	Guiding Type	DEFAULT NONE ADAPT_OPT	DEFAULT
COU.GS.MAG	GS mag in V	0..25	0
DEL.FT.SENSOR	Fringe tracker sensor	MATISSE NONE	MATISSE

Table 1: Comprehensive list of template parameters accessible during observation

In the following subsection we describe the different observing configurations (instrumental and detector setting).

3.1 Observing configurations

Table 2 summarizes MATISSE instrumental and detector configurations available for observation. Note that not all values are offered in service mode and that some are even unavailable in P103 in visitor mode.

3.1.1 Spatial filtering

In each cryostat, spatial filtering is done by pinholes or slits mounted on a motorized wheel. The possible settings are given in Table 2. The pinholes diameters and slit widths varies from 1.0 to 2.0 λ/D in L&M and 1.5 to 2.5 λ/D in N. All slits have a length of 5 λ/D.

Note that, in service mode, the spatial filtering configuration is fixed to pinholes of λ/D in L&M and 1.5λ/D in N.

3.1.2 Beam splitter: the HI-SENS and SI-PHOT modes

Thanks to movable beam splitters installed in each cryostat, each arm of MATISSE can record simultaneous photometry or not. The modes with and without this photometery are name

Device	Possible values L&M bands	Possible values N band	comments
Spatial Filter	1, **1.5**, 2.0 λ/D 1x5, 1.5x5, 2.0x5 λ/D	1.5,**2.0**, 2.5 λ/D 1.5x5, 2.0x5, 2.5x5 λ/D	Holes or Slits. Fixed to bold value in service
Beam Splitter	HI-SENS (Out) **SI-PHOT** (In)	**HI-SENS** (Out) SI-PHOT (In)	Fixed to bold value in service
Spectral Filter	LM, L, and M	OPEN	Automatically set depending on central wavelength λ_0
Spectral Disp.	LOW (R=30) MED (R=502) HIGH (R=502) HIGH+ (R=502))*	LOW (R=30) HIGH (R=230)*	Set by users
Frame Mode	SCI-FAST-SPEED SCI-SLOW-SPEED	SCI-HIGH-GAIN	For L&M band depends on the target brightness
DIT	0.011s / 0.02s / 0.075s 0.111s, 0.250s /0.500s	0.02s / 0.075s	see section 3.1.5

Table 2: MATISSE instrumental and detector configurations available for observation.
* Note that HIGH spectral resolution in N band and HIGH+ in L&M are not offered in P103.

SI-PHOT (SImultaneous-PHOTometry) and HI-SENS (HIgh SENSitivity).

In P103, MATISSE is only offered in a so-called HYBRID mode where the L&M band arm operates in SI-PHOT mode and the N-band in HI-SENS.

3.1.3 Frame rate modes in L&M band

Unlike the AQUARIUS detector used for the N-band, the L&M-bands HAWAII-2RG detector is offered in two frame-modes for science observations:

- SCI-SLOW-SPEED: Full frame detector readout in 1.38s (shorter when windowed)
- SCI-FAST-SPEED: Full frame detector readout in only 0.078s (shorter when windowed)

The major difference between the two modes is the detector read-out noise which is 6 times higher in the SCI-FAST-SPEED mode. For that reason, most objects should be observed in SCI-SLOW-SPEED.

The SCI-FAST-SPEED mode is only offered for the brightest targets, and should only be used for targets that would saturate the detector using the minimum DITs offered in SCI-SLOW-SPEED.

For example, in LOW spectral resolution, the windows including the full L&M bands can be read in 0.011s in SCI-FAST-SPEED mode and 0.111s in SCI-SLOW-SPEED mode. Using the SCI-FAST-SPEED mode allows to observe stars 10 times brighter than the saturation limit in SCI-SLOW-SPEED mode.

The saturation limit for all offered mode is given in Table 4 (i.e. column Max Flux).

Note that the science target and the calibrators must be observed with the same frame-mode and DIT, so that faint calibrators should be avoided for very bright science targets that require observation in SCI-FAST-SPEED mode.

3.1.4 Spectral resolution and wavelength coverage in L&M bands

In LOW spectral resolution DITs are set to cover the full L, M or L&M bands for both the SCI-SLOW-SPEED and SCI-FAST-SPEED modes:

- L&M bands (2.85-5.0μm): 0.020s in SCI-FAST-SPEED (minimum DIT of 0.011s is not offered in service mode)
- L&M bands (2.85-5.0μm): 0.111s in SCI-SLOW-SPEED (not offered in service for P103)
- L band only (2.85-4.2μm): 0.075s in SCI-SLOW-SPEED
- M band only (4.0-5.0μm): 0.075s in SCI-SLOW-SPEED (not offered in service for P103)

To observe either in the L or M band, the user needs to set the λ_0 (i.e. "**Central Wavelength for the L&M band**") template parameter. If λ_0 >4.2, observation will be carried out in the M band (not offered for P103), if it is smaller, the observation will be performed in L band.

In MED spectral resolution, the SCI-FAST-SPEED mode offers the full spectral coverage of the L&M bands, and in HIGH resolution, of either the L or M band. As for the LOW spectral resolution, the user only needs to set the λ_0 parameter to a value greater than 4.2 to enable M band observation in HIGH resolution. Note that M band observation are not offered in service mode for P103.

In SCI-SLOW-SPEED, the standard DIT offered for service mode observation, i.e. 0.111s, only allows to cover roughly 0.16μm in MED resolution, and 0.08μm in HIGH resolution. In these modes, the observing spectral window will be centered on λ_0. For instance, to observe the Brα line at 4.05μm, the user should use $\lambda_0 = 4.05$ in the template.

If the user wants to observe several spectral windows in either MED and HIGH resolution, she can concatenate several observation templates with various values of λ_0 in the same OB (visitor mode only).

3.1.5 Summary of offered modes in P103

The two tables below summarize of MATISSE offered modes for P103 (both for visitor and service mode observations).

For N-band, the user only needs to set the spectral resolution parameter and the other parameters will be computed by the template accordingly.

Spectral mode	Frame-mode	DIT (s)	Spectral band (μm)	Offered in Service
LOW	SCI-HIGH-GAIN	0.020	8 - 13	**Yes**
HIGH	SCI-HIGH-GAIN	0.075	8 - 13	No

Table 3: N-band offered configurations for P103 in service and visitor mode

For the L&M bands arm, the user needs to provide: the spectral resolution, the detector frame-mode, the DIT, and the central wavelength of observation λ_0.

Spectral mode	Frame-mode	DIT (s)	Spectral band (μm)	Min /Max Flux (Jy) ATs	UTs	Offered in Service
LOW	SCI-FAST-SPEED	0.011	2.85 - 5.0	200 / 16000	40 / 800	No
	SCI-FAST-SPEED	0.020	2.85 - 5.0	100 / 8000	20 / 400	**Yes**
	SCI-SLOW-SPEED	0.111	2.85 - 5.0	3 / 2000	0.5 / 100	No
	SCI-SLOW-SPEED	0.075	2.85 - 4.2	3 / 1600	0.5 / 80	**Yes**
	SCI-SLOW-SPEED	0.075	4.00 - 5.0	3 / 2000	0.5 / 100	No
MED	SCI-FAST-SPEED	0.075	2.85 - 5.0	150 / -	15 / 5000	**Yes**
	SCI-SLOW-SPEED	0.111	$\lambda_0 \pm 0.08$	20 / -	2 / 3000	**Yes**
	SCI-SLOW-SPEED	0.250	$\lambda_0 \pm 0.18$	20 / -	2 / 1500	No
	SCI-SLOW-SPEED	0.500	$\lambda_0 \pm 0.36$	20 / -	2 / 700	No
HIGH	SCI-FAST-SPEED	0.075	2.85 - 4.2	500 / -	50 / 10000	**Yes**
	SCI-FAST-SPEED	0.075	4.0 - 5.0	500 / -	50 / 10000	No
	SCI-SLOW-SPEED	0.111	$\lambda_0 \pm 0.04$	75 / -	8 / 6000	**Yes**
	SCI-SLOW-SPEED	0.250	$\lambda_0 \pm 0.09$	20 / -	8 / 3000	No
	SCI-SLOW-SPEED	0.500	$\lambda_0 \pm 0.18$	20 / -	8 / 1500	No

Table 4: L&M-bands arm offered configurations for P103 in service and visitor mode

3.2 Template sequence

Here we describe the MATISSE observing sequence for the HYBRID mode, which is the only mode offered for P103.

The observation starts with two 30s sky exposures: one recorded with both Beam Communiting Devices (i.e. BCD, see section 3.2.1 for more details) in OUT position and a second one with both in IN position. The sky offsets α and δ are users parameters that should be modifiied only for very extended object. The sky exposures are recored simultaneously on both detectors.

The instrument then records a series of fringe exposures simultaneously on both detectors. Each exposure lasts 60s and the total number of exposures is 4 times the **Number of exposure cycles** specified in the template by the user.

Each cycle consists on 4 exposures taken with different BCDs positions: IN-IN, IN-OUT, OUT-IN, and OUT-OUT. In service mode, the standard number of cycles is 1 in LOW and MED resolutions and 2 for HIGH resolution.

After the fringe sequence, the template can perform a photometry sequence if the template parameter **Do photometry sequence** is set to "T". This sequence is necessary to compute visibilities in the N-band (see section 3.2.2 for more details). The photometry sequence consists of a four-shutters sequence performed twice, with two BCDs positions (IN-IN and OUT-OUT). Each of the 8 exposure is 60s.

The photometry sequence is performed using chopping. The chopping parameters are fixed in service mode (0.5Hz and 4.5" stroke in the North-South direction).

During the N-band photometry sequence the L&M band detector records a chopped fringe exposure, that will be treated by the pipeline to provide additional L&M band data.

3.2.1 About the Beam Commuting Devices (BCD)

The BCDs are two identical devices that allow to commute the beams two by two. BCD1 commutes beams 3&4, and BCD2 beams 1&2. They each have two positions: OUT where the beams are not commuted, and IN where beams are commuted.

The BCDs are used in standard MATISSE observation during the fringe exposure cycle. The full cycle consists of four exposures with the combination of the two BCD positions: OUT-OUT, IN-OUT, OUT-IN, and IN-IN.

As the BCDs are the first devices in MATISSE, commuting the beams allows to remove most instrumental effects, and significantly improves the closure and differential phase measurements.

3.2.2 Should I perform a photometry sequence?

The photometry is needed to compute visibility in the N-band. If no photometry is performed, only coherent fluxes can be computed by the MATISSE pipeline.

The VLTI/MIDI experience showed that, for faint objects, the photometry is the major source of noise and most users prefer to work with coherent flux only.

In Table 5 the sensitivity limit for coherent flux and visibility measurements are shown. For targets below the visibility-measurement sensitivity limit, the user should set the **Do photometry sequence** parameter to "F".

3.2.3 About MATISSE coherencing

Only one of the two bands (L or N) is used for coherencing during the fringe exposures. It is set by the "**Master band for the coherencing**" user parameter.

In most cases, the L-band should be chosen as the master band, because:

- The L-band sensitivity is higher than the N-band one. There is a factor of about ten in the fringe detection in L compared to N for the same flux.
- The stellar flux is usually higher in L. For a standard star there's a factor 8 in flux between the bands.

However, the N band might be chosen as master band if:

- the object is overresolved in the L-band (V<0.01)
- the object is highly reddened or has a very strong infrared excess (flux in N 10 times higher than flux in L).

If the user is not sure which band to use, L band should be selected and a note might be added as OB comment and in the readme file to let the operator decide when acuiring the target.

If N-band is chosen as the master-band, the chopped fringes acquired in the L&M bands during the N-band photometry sequence will be coherenced using the L-band.

3.3 Sensitivity

The target flux limits below are defined in such a way that the typical errors for:

- Low resolution observations will be better than 5 degrees on closure phase data and better than 10% on absolute visbilities
- Medium resolution obervation will be better than 10 degrees for closure phase data and better than 20% on absolute visbilities
- Attempting to obtain absolute calibrated quantities with high resolution is not recommended.
- The uncertainties of medium and high resolution observations will be about 1 degree on differential phases, and better than 10% on differential visibilities.

However, bad observing conditions do not only diminish the flux. If a science case is critically dependent on achieving the smallest possible error bars, it is strongly recommended to request good observing conditions regardless of the target brightness. Observations at seeing values worse than 1.2" are not recommended.

	AT		UT	
Setup	≤ 0.8", CLR	≤ 1.2", THN	≤ 0.8", CLR	≤ 1.2", THN
L-band LOW	3 Jy	5 Jy	0.5 Jy	1 Jy
L-band MED	20 Jy	30 Jy	2 Jy	3 Jy
L-band HIGH	75 Jy	115 Jy	8 Jy	12 Jy
N-band LOW, full visibilities	20 Jy	30 Jy	2 Jy	4 Jy
N-band LOW, corr. fluxes only	5 Jy	10 Jy	1 Jy	2 Jy

Table 5: MATISSE sensitivity for P103 for two seeing and sky transparency conditions.

3.4 Execution time

The total execution times of standard observation OBs are the following:

- 10 min in with L-band in LOW or MED (i.e. 1 cycle) without photometry sequence
- 15 min with L-band in HIGH (i.e. 2 exposures cycle) without photometry sequence
- 20 min in with L-band in LOW or MED (i.e. 1 cycle) with photometry sequence
- 25 min with L-band in HIGH (i.e. 2 cycle) with photometry sequence

3.5 List of user parameters

Frame mode for the L&M detector
Either SCI-FAST-SPEED or SCI-SLOW-SPEED (see section 3.1.3 for more information).

Integration time for the L&M detector
The detector integration time (DIT) in seconds for the Hawaii detector use in the L and M bands. The possible DITs depends on the detector frame mode. The current possible DITs are the following (bold for service mode): 0.011s, **0.020s**, **0.075s**, **0.111s**, 0.250s, 0.500s.

Central wavelength for the L&M bands
This parameter is used only in SCI-SLOW-SPEED mode where the whole detector cannot be read during one DIT. It specifies the central wavelength of the observing window. In LOW spectral resolution it is only used to specify whether the user wants to observe in the L or M band. However, the M band observation are not offered in service for P103. In MED resolution, the spectral window for the standard DIT of 0.111s is of the order of 0.16μm and in HIGH of 0.08μm. (See section 3.1.4 for more information).

Number of exposure cycles
This parameter determines the number of fringes exposures cycles. One exposure is one minute and a full cycle is made of 4 exposures (see section 3.2.1 for more information).

Do photometry sequence (T or F)
If set to "T", a chopped shutter sequence is performed after the fringes exposures in the N-band. During this 8 exposures sequence (4 exposures each in BCD IN-IN and OUT-OUT), the L-band arm records chopped fringe exposures. Note that this photometric exposure is mandatory to obtain visibilities in the N band. If set to "F" the MATISSE pipeline will only be able to deliver correlated flux in the N band. (See section 3.2.2 for more information).

Sky offset, right-ascension
Right ascension offset for the sky in arcseconds. Default is set to 1". This should only be modified in case of very extended object.

Sky offset, declination
Declination offset for the sky in arcseconds. Default is set to 15". This should only be modified in case of very extended object.

Master band for the coherencing (L or N)

Spectral band that will be used to perform the fringe coherencing. Possible values are "L" or "N". The default is L band as the SNR is usually higher on this band. This parameter can be changed at runtime by the night astronomer if coherencing can be better performed in the other band. (See section 3.2.3 for more information).

Spectral mode for the L&M bands

MATISSE offers four spectral resolutions in the L&M bands: LOW (R=30), MED (R=500), HIGH (R=950) and HIGH+ (R$\sim$5000). The HIGH+ mode is not offered for P103, neither in service nor in visitor mode.

Spectral mode for the N band

MATISSE offers two spectral resolution in the N band: LOW (R=30) and HIGH (R=220). The HIGH resolution is currently not offered in P103.

Observation type

SCIENCE for the science target and CALIB for the interferometric calibrators.

3.6 Comphrensive list of template parameters accessible during observation

Here we list all template parameters including those that cannot be defined by the user in p2, but can be modified at the time of observation.

Name	description	range	default
DET1.READ.CURNAME	Frame mode for L detector	SCI-FAST-SPEED SCI-SLOW-SPEED AUTO	SCI-SLOW-SPEED
DET1.DIT	Integration time for L-band	-	0.075
INS.DIL.NAME	Dispersive element in L-band	HIGH+ HIGH MED LOW	LOW
INS.DIN.NAME	Dispersive element in N-band	LOW HIGH	LOW
INS.SFL.NAME	Spatial filter in L-band	1.00 1.50 2.00 0.66x5.5 1.50x5.5 2.50x5.5	1.5
INS.SFN.NAME	Spatial filter in N-band	1.50 2.00 2.50 1.00x5 1.50x5 2.00x5	2.0
SEQ.DIL.WL0	Central wavelength of LM-band spectra	2.85 -5	3.5
SEQ.FRINGES.NCYCLES	Number fringe exposure cycles	-	1
SEQ.FRINGES.BCD.SEQ	BCD sequence	2STEPS 4STEPS	4STEPS
SEQ.OSF.AUTO	Automatic execution of OSF scripts?	T F	T
SEQ.SKY.OFFS.ALPHA	sky offset, right-ascension	-	1
SEQ.SKY.OFFS.DELTA	sky offset, declination	-	15
SEQ.CHOP.ST	Use telescope chopping	F T	T
SEQ.PHOTO.ST	Do photometry sequence	T F	T
SEQ.TRACK.BAND	Master-band controlling the VLTI delay-lines	L N	L
SEQ.TRACK.ST	SEQ.TRACK.ST	T F	T
TEL.CHOP.FREQ	Chopping frequency (Hz)	-	0.5
TEL.CHOP.POSANG	Azimuth angle of chopping	0..360	0
TEL.CHOP.PVRATIO	Star/sky dwell ratio	1	1
TEL.CHOP.THROW	Amplitude angle of chopping	0..4.5	4.5
DPR.CATG	Observation type	SCIENCE CALIB	CALIB

Table 6: Comphrensive list of template parameters accessible during observation