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Very Large Telescope

Paranal Science Operations

MIDI Template Manual

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List of Abbreviations

CS	Constraint Set
ESO	European Southern Observatory
LST	Local Sidereal Time
MACAO	Multi-Application Curvature wavefront sensor Adaptive Optics
MIDI	MID-infrared Interferometric instrument
OB	Observation Block
OD	Observation Description
OPC	Observation Program Committee
OPD	Optical Path Difference
OT	Observation Toolkit
PAF	PArameter File
P2PP	Phase-2 Proposal Preparation
SM	Service Mode
STRAP	System for Tip-tilr removal with Avalanche Photodiodes
TSF	Template Signature File
USD	User Support Department
UT	Unit Telescope
VLT	Very Large Telescope
VLTI	Very Large Telescope Interferometer

1 INTRODUCTION

1.1 Scope

This document describes the **templates** for the MIDI mid-infrared instrument of the VLT Interferometer. Like for all the VLT instruments, observations with MIDI are carried out with **observation blocks** (OBs). The OBs must be written by the user during Phase-2 preparation with the P2PP tool. An OB consists of a set of information 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 manual requires the user to already have an insight of MIDI operation, as described in the "MIDI User Manual", that can be downloaded from:

> `http://www.eso.org/sci/facilities/paranal/instruments/midi/doc/`

For the installation of the P2PP tool, see:

> `http://www.eso.org/observing/p2pp/P2PP-tool.html`

Note: the MIDI-specific templates will be downloaded by the P2PP tool.

For service mode observations, it is important to read the MIDI-specific service mode instructions given on the webpage:

> `http://www.eso.org/observing/p2pp/MIDI/MIDI-P2PP.html`

This page gives suggestions for OB edition with P2PP (name, constraint set), as well as the requirements for the "readme" file and for the finding charts.

1.2 Contact information

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

1.3 Period of validity of this manual

This manual only applies for observations with MIDI in ESO Period 84, starting 1 October 2009 and ending 31 March 2010.

1.4 Acknowledgements

The Editor of this manual thanks all the members of the ESO VLTI Group (Paranal), of the ESO Telescope Division (Garching) and of the ESO Data Management and Operations Division (Garching) for their input and comments. The Editor would also like to thank all the users which have brought comments and suggested corrections of this manual, through the ESO User Support Group.

1.5 Glossary

- **Constraint Set (CS)**
  List of requirements for the conditions of the observation that is given inside an OB. OBs are only executed under this set of minimum conditions.

- **Observation Block (OB)**
  An Observation Block is the smallest schedulable entity for the VLT. It consists in a sequence of Templates. Usually, one Observation Block include one target acquisition and one or several templates for exposures.

- **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-I)**
  The Phase-I begins right after the Call-for-Proposal (CfP) 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`

- **Phase-2 Proposal Preparation (P2PP)**
  Once proposals have been approved by the ESO Observation Program Commitee (OPC), users are notified and the Phase-2 begins. In this phase, users are requested to prepare their accepted proposals in the form of OBs, and to submit them by Internet (in case of service mode). The software tool used to build OBs is called the P2PP tool. It is distributed by ESO, and can be installed on the personal computer of the user. See:

  `http://www.eso.org/sci/observing/phase2.html`.

- **Service Mode (SM)**
  In service mode (opposite of the "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 send 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.

1.6 Modifications for P84

No changes to the MIDI templates with respect to the previous period.

2 MIDI TEMPLATES

2.1 Observing modes

As indicated in the "MIDI User Manual", the following setup of MIDI will be offered for P84. This setup can be summarized as follows:

- Acquisition possible with any of the MIDI filters.

- Fourier mode (long scan) fringe exposures.

- Dispersed fringes (0.56-arcsec on-sky slit), or non-dispersed fringes with very long scans (field/astrometry).

- Dispersive element: either NaCl prism ($R = 30$) or KRS5 grism ($R = 230$).

- Beam combiner: either "HIGH_SENS" (no photometric channels, more sensitive) or "SCI_PHOT" (photometric channels, more accurate).

- No filter for fringe exposure.

- Self fringe tracking (coherencing at 1 to 2 Hz).

- Photometry exposures (beam A only then beam B only) after each fringe exposure in "HIGH_SENS". In "SCI_PHOT", such exposures are taken as a rule as well to enable a "pseudo-HIGH_SENS" reduction, but striclty speaking are required only on one bight object or calibrator during the night, in order to compute the splitting ratios.

Hence, the number of templates for P84 is minimal: one template for preset, acquisition and fringe search, and one template for fringe observation. Moreover, because of the policy adopted by ESO for observations with MIDI in service mode (one calibrated visibility point every hour, whatever the correlated magnitude of the science target is) and visitor mode (one calibrated visibility point every 1.5 hour if the uncorrelated flux is between 1 and 2 Jy at 12 μm, one calibrated visibility point every hour otherwise), the number of keywords to be set by the user is very limited.

2.2 The acquisition template

According to P2PP rules, the first template in an OB must be an acquisition template. In the case of MIDI, the name of this template is: *MIDI_starintf_acq*.

The sequence of this template starts by a "preset": the target coordinates (α, δ) are sent to the telescopes and the delay lines, so they can slew to the position corresponding to the target coordinate at preset time. Once the telescopes are tracking and Coudé-guiding, the target should be seen in the FOV of MIDI in imaging mode with a user-selected spectral filter. To ensure beam interference, the images from both beams must be overlapped. This is done by several iterations of the sequence: exposure, star centroid measurement, then offsets calculated and sent to the telescope to bring the star image on a reference pixel of the detector.

It is possible to have, as a guide star at the Coudé foci, an object different from the science target. The requirements are:

- The guide star must be brighter than $V = 17$ (MACAO is used for Coudé guiding) on the UTs, $V = 13.5$ on the ATs (STRAP is used for Coudé guiding).

- The guide star must be within a radius of 1 arcmin from the science target. If the visible magnitude of the guide star is between 12 and 13.5 (AT case), or between 15 and 17 (UT case), and if the distance between the target and the guide star is larger than 45 arcsec, a warning will be issued.

It is interesting to notice that the mean isoplanatic angle at Paranal is a little more than 2 arcsec at $\lambda = 0.6$ μm. This would scale to 1 arcmin at $\lambda = 10$ μm. Hence, using a guide star with the above conditions allows correction of the science target image.

Because of the need for background subtraction, MIDI requires chopping of the secondary mirrors of the UTs. The chopping is used for acquisition exposures (to reach beam overlap), and later in the observation template for photometry exposures (see next Sect. 2.3). The user has the possibility to set the off-source polar coordinates (angle and radius) relative to the on-source position, in the case that an object in the vicinity of the source would appear in the field of view for default off-source coordinates, biasing the background subtraction.

The template parameters for the guide star must be set by the user with P2PP (see Sect. 2.4.1).

If no possible guide star exists, the acquisition can however be done without Coudé guiding, but only in the case of the UTs. In this case, the `COU.AG.GSSOURCE` keyword has to be set to "NONE". Note that in this acquisition mode, the data quality strongly depends on the seeing (see MIDI PPRS webpage).

2.3   The observation template

This template is the second and the last one in any MIDI OB description for P84. It is either the normal dispersed-fringe template, or the field/astrometry template.

Interferograms are recorded in "Fourier" mode in a "fringe exposure". In this mode, the length of each scan (linear OPD modulation over the time) is nominally $8 \times \bar{\lambda}$, where $\bar{\lambda}$ corresponds to the central wavelength of the MIDI spectral window: around 10.3 μm.

The interferogram results from the subtraction of the two interferometric channels of MIDI (which are π-phase-shifted). The number of scans, i.e. interferograms, is not set by the user, according to the policy of Period 84 (see MIDI user manual).

To compute the raw fringe visibility, exposures with one beam only must be taken before and after the fringe exposure. These two exposures (beam A only, then beam B only) are called "photometry exposures". They are performed by the observation template. Except for the shutter, the instrument optical configuration is exactly the same as the one used for the fringe exposure. The off-source polar coordinates corresponding to the chopping for photometry exposures are the ones defined by the user in *MIDI_starintf_acq*.

The observation template (recording interferograms by scanning, and then performing the two photometry exposures) is named *MIDI_starintf_obs_fringe*.

2.4   User keywords

In the following tables, we give for each template the keywords that have to be set by the user with the P2PP tool.

2.4.1   MIDI_starintf_acq

Keyword name	Description	Unit, format, possible values	Default value
INS.FILT.NAME	Filter used for acquisition	`\[ArIII\]` `\[SIV\]` `N11.3` `\[NeII\]` `N8.7` `SiC` `Nband` `OPEN`	`N8.7`
TEL.CHOP.POSANG	Angle of chopping on sky (see note)	degrees (0 = north, 90 = east)	0
TEL.CHOP.THROW	Amplitude of chopping on sky	arcsec	15
COU.AG.ALPHA	Right ascension of Coudé guide star	HH:MM:SS.SS (e.g.: 22:54:30.5 for 22 h 54 m 30.5 s)	0
COU.AG.DELTA	Declination of Coudé guide star	DD:MM:SS.SS (e.g.: -16:22:45.91 for -16° 22' 45.91")	0
COU.AG.GSSOURCE	Type of Coudé guiding	`SCIENCE`: no off-target guiding, other `COU..` keywords ignored `SETUPFILE`: off-target guiding, guide star used `NONE`: no Coudé guiding used	`SCIENCE`
COU.GS.MAG	Visual magnitude of either the target or its Coudé guide star (if the target is too faint for Coudé guiding)	m_V	12
DPR.CATG	Type of target	`SCIENCE`: target of scientific interest `CALIB`: calibrator star	`SCIENCE`
SEQ.UNCORR.IRFLUX	Uncorrelated flux at 12 μm	Jy	20
SEQ.CORR.IRFLUX	Correlated flux at 12 μm	Jy	15
SEQ.HMAG	Magnitude in H-band (1.6 μm) of the target	m_H	2

Notes:

- If you are not using an off-axis Coudé target, you MUST enter as value of `COU.GS.MAG` the visual magnitude of your target. The minimum allowed magnitude (i.e. maximum flux) is -1.0 with the UTs and -1.7 with the ATs.

- If the target or the off-axis guide star is a variable star, the magnitude of the star when it is at its maximum of brightness (i.e., the minimum magnitude) should be given for `COU.GS.MAG`, this to prevent the photodiodes of the Coudé detectors from being overilluminated for having set up an underestimated neutral density. Also, a comment should be added in the OB, specifying the magnitude interval of the star.

- If Coudé guiding cannot be used with the science target because it is too faint (`COU.AG.GSSOURCE=NONE`), the keyword `COU.AG.GSSOURCE` of the corresponding calibrator must also be set at `NONE` (to keep consistency in the observing conditions).

- Because a part of the MIDI observation software uses the Tcl language which performs a substitution of any expression between brackets (`[` and `]`), the narrow band filter names containing brackets have to use backslash (\) characters before bracket characters.

- If no off-axis guiding is used (`COU.AG.GSSOURCE=SCIENCE`), `COU.AG.ALPHA`, `COU.AG.DELTA`, and `COU.GS.MAG` can be left at zero.

- The angle of chopping on sky (`TEL.CHOP.POSANG`) corresponds to the direction on sky where the target is "moved", when the telescope is in off-source position. North corresponds to $+\delta$ and east to $+\alpha$ on the celestial sphere. Note that the chopping angle defined by the keyword is the opposite of the position angle (defined counter-clockwise from north to east on the celestial sphere). Hence, if `TEL.CHOP.POSANG=0` (north), the telescope position on sky will chop between the target and a position at south of the target. If `TEL.CHOP.POSANG=90` (west), the telescope position on sky will chop between the target and a position at east of the target. If `TEL.CHOP.POSANG=180` (south), the telescope position on sky will chop between the target and a position at north of the target. If `TEL.CHOP.POSANG=270` (east), the telescope position on sky will chop between the target and a position at west of the target.

- The values of `SEQ.CORR.IRFLUX` and `SEQ.UNCORR.IRFLUX` are used by the software to automatically adjust parameters like DIT. The value of `SEQ.UNCORR.IRFLUX` can be found for example in the IRAS catalog. The value of `SEQ.CORR.IRFLUX` = `SEQ.UNCORR.IRFLUX` × visibility can obviously only correspond to a rough estimation, since the visibility is what has to be determined by the observation !

- The value of `SEQ.HMAG` can be approximated from the visual magnitude m_V and the spectral type of the target, using the plot in the MIDI user manual.

2.4.2   MIDI_starintf_obs_fringe

Keyword name	Description	Unit, format, possible values	Default value
INS.GRIS.NAME	Dispersive element	PRISM GRISM	PRISM
INS.OPT1.NAME	Beam combiner	HIGH_SENS SCI_PHOT	HIGH_SENS
SEQ.ZEROTRACK	Tracking at zero OPD (yes/no ?)	T (yes, box checked) F (no, box unchecked)	T
SEQ.NFRAMES.PHOTOMETRY	Number of frames in each photometry exposure)	integer, ≤ 8000	4000
TEL.CHOP.POSANG	Angle of chopping on sky (see note)	degrees (0 = north, 90 = east)	0
TEL.CHOP.THROW	Amplitude of chopping on sky	arcsec	15
COU.AG.ALPHA	Right ascension of Coudé guide star	HH:MM:SS.SS (e.g.: 22:54:30.5 for 22 h 54 m 30.5 s)	0

Notes:

- If `SEQ.ZEROTRACK=T`, the fringes will be tracked around the zero-OPD of VLTI+MIDI. Otherwise, the fringes will be tracked at an OPD offset of 50 μm if `INS.GRIS.NAME=PRISM` and 100 μm if `INS.GRIS.NAME=GRISM`. We recommend however to use `SEQ.ZEROTRACK=T`.

- The value of `SEQ.NFRAMES.PHOTOMETRY` depends on the brightness in N-band of the target. Let L be the limiting flux of the requested mode and telescope type, it is recommended to use the following values:

  - 2000 for a brightness $\geq 10 \times L$.
  - 4000 for a a brightness $< 10 \times L$ and $\geq 2 \times L$.
  - 6000 for a brightness $< 2 \times L$.

  It is not advised to use systematically the maximum possible number of frames (8000) since it increases the time to take the photometry exposures, and the atmospheric transfer function may change meanwhile, biaising the computed visibility.

- In the observation template, `TEL.CHOP.POSANG` obeys to the same rule as in the acquisition template. Typically, a frame lasts 15 ms.

2.4.3   MIDI_starintf_obs_field

Keyword name	Description	Unit, format, possible values	Default value
INS.FILT.NAME	Filter used for the exposure	\[ArIII\] \[SIV\] N11.3 \[NeII\] N8.7 SiC Nband OPEN	N8.7
SEQ.NFRINGE.SCAN	Number of fringes per scan	12 to 200	12

Notes:

- The actual value of fringes per scan is 200 (2-mm scan) if SEQ.NFRINGE.SCAN is larger than 100, 100 (1-mm scan) if SEQ.NFRINGE.SCAN is between 29 and 100, and is really equal to SEQ.NFRINGE.SCAN if SEQ.NFRINGE.SCAN is betwwen 12 and 28.

2.4.4   Observation description

As mentioned in Sect. 2, only one OD is possible. It consists of one execution of either the template *MIDI_starintf_obs_fringe* or the template *MIDI_starintf_obs_field*. In the OB structure built with P2PP, this template must follow the acquisition template *MIDI_starintf_acq*.

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