MIDI scientific and technical observing modes

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ABSTRACT

The first science instrument for the Very Large Telescope Interferometer (VLTI), the Mid-infrared instrument MIDI, will be commissioned in November 2002 with anticipated first fringe during that commissioning run on the 40-cm Siderostats and the 8.2-meter Unit Telescopes. In this paper we describe scientific and technical observing modes (also referred to as observation procedures) developed for MIDI and discuss in detail how an observing run with the instrument is planned.

MIDI is built by a consortium lead by the Max Planck Institute for Astronomy (MPIA Heidelberg), with contributions from among others ASTRON (Dwingeloo, The Netherlands), Leiden Observatory, University of Amsterdam, Paris Observatory, University of Groningen, the Kiepenheuer-Institut für Sonnenpysik at Freiburg, Thüringer Landessternwarte Tautenburg, and the Observatoire de la Côte d'Azur.

Keywords: Optical interferometer, infrared instrumentation, observation mode, VLTI, MIDI

1. INTRODUCTION

The **V**ery **L**arge **T**elescope **I**nterferometer (VLTI) is entering a phase in which significant amount of scientific output is expected. The 2-micron 2-way beam-combiner, the **V**LTI **In**terferometry **C**ommissioning **I**nstrument (VINCI), is commissioned. The 10-micron 2-way beam-combiner **Mid-I**nfrared instrument (MIDI) and the 2-micron 3-way **A**stronomical **M**ulti **Be**am **R**ecombiner (AMBER) will be commissioned in November 2002, and summer 2003 respectively. In this paper we discuss the scientific and technical observation modes developed for MIDI as they are implemented in September 2002.

The observing modes are a set of pre-defined modes, which has been developed for the instrument and is supported by the consortium. Additional modes may be added in the future after evaluation of the instrument performance on site during the commissioning runs. At the time of writing this paper, the technical observing modes are used in the laboratory in Heidelberg to test the instrument and are tested extensively. The acquisition, science, and calibration observing modes have been developed, but their performance can only be tested once MIDI is operational at Paranal. We expect that these observing modes will evolve during the next year and reach a stable level of performance when MIDI becomes available as a general user instrument to the scientific community (fall 2003).

We will first introduce MIDI by briefly discussing the science drivers for developing this instrument, followed by a short description of the hardware and software architecture of the instrument. This main body of the paper will discuss the observing modes available to acquire the science source and the related science and technical observing modes to obtain the data requested. Calibration is an essential factor in the performance of this instrument; therefore we discuss some dedicated calibration observation modes available to the astronomer, and technical (calibration) observation modes available only to the instrument operator. Finally a discussion and conclusion is presented on the observing modes available for MIDI as it stands in September 2002.

2. SCIENCE DRIVERS

In many cases our understanding of astrophysical processes would greatly benefit from a detailed knowledge of spatial structures on sub-arcsecond scale. Research fields which could benefit from high resolution optical astronomical instruments are among others the formation and evolution of circumstellar disks around young stellar objects and the formation of planetary systems, fundamental astrophysics of stars by measuring stellar diameters and proper motions (kinematics), mass-loss phenomena forming shells and disks around evolved stars, and the inner structures of Active Galactic Nuclei [1].

For a focus on circumstellar matter, there is a strong need for an instrument that operates at the emission peak of circumstellar matter with a temperature of a few hundred Kelvin and which operates at an angular resolution at least an order of magnitude better than existing instruments ($\theta << 0.1$ arcsec). MIDI on the VLTI fulfills these requirements.

3. HARDWARE

MIDI is the 10-micron, 2-way pupil-plane beam-combiner for the VLT Interferometer. MIDI has been built by an international consortium lead by the Max Planck Institute for Astronomy in Heidelberg (Project scientist: Ch. Leinert, Project Manager: U. Graser). The cold bench (at about 35 Kelvin) containing the cold stop, spatial filters, beam-combiner, dispersive elements, broad-band and narrow-band filters has been built by ASTRON (A. Glazenborg, J-W. Pel). The Raytheon detector in the cold bench is cooled to 10 K. The software efforts are managed by the University of Leiden (W. Jaffe) with the largest contributions by the Heidelberg (R. Mathar, U. Neumann, C. Storz) group and a smaller contribution by the Leiden group (W. Jaffe, J. de Jong, D. Hartmann, I. Percheron, and E.J. Bakker) and NRAO (B. Cotton). The Paris Observatory (G. Perrin) contributes to the off-line data reduction and provides the R&D on the single-mode fiber and eventually the single-mode fiber for MIDI when available. The limiting magnitude for MIDI will be in the range of N=3 to 4 for an unresolved source using the Unit Telescopes. This limit is dictated by the ability to fringe track and will mostly depend on the behavior of the background and on our ability to subtract it from the data. With an external fringe tracker, there is no limit, in principle, on the length of the integration, objects as dim as N=10 will be measurable in reasonable short observations times. For resolved sources, these numbers will depend on the source characteristics and the performance of MIDI integrated in the VLTI infrastructure. For details we refer to [2].

4. SOFTWARE

MIDI software is largely developed according to ESO standards [3] with some deviations due to the special nature of MIDI. An overview of MIDI software is presented in Figure 1 and can best be described as follows.

In the preparation phase the astronomer can use SimVLTI [4] to compute the expected visibility based on the selected baseline, time of observation, and characteristics of the science source, or use the ESO VLTI Visibility Calculator (VisCalc). Additional tools are available to predict the exposure time for a given signal-to-noise ratio. The expected visibility and the expected exposure time are sufficient to prepare the observations with ‘‘**P**hase **2** **P**roposal **P**reparation’’ (P2PP, Figure 2). The astronomer fills in template signature files using the P2PP interface at his office location and as a result fully defines the observing mode for MIDI at Paranal in that manner. The result of P2PP is an **O**bservation **B**lock **D**escription (OBD), which is imported in the **B**roker of **O**bservations **B**locks (BOB, Figure 3). In general P2PP runs at the astronomers office location, while BOB runs on the instrument workstation at Paranal.

Operations with MIDI at Paranal are started from BOB, which runs template sequencer scripts and sends the commands to MIDI **O**bservation **C**ontrol **S**ystem (MIDI-OCS). MIDI-OCS defines exposure schedules, monitors the MIDI subsystems, and communicates with the VLTI telescopes and VLTI delay lines. Commands are sent to the MIDI **I**nstrument **C**ontrol **S**ystem (ICS) and the MIDI **D**etector **C**ontrol **S**ystem (DCS). Whereas the latter compromises two parts: an adaptation of the **Ge**neric **IN**fra**R**ed **S**oftware system (GEIRS) and a data archiving and data quality analysis system referred to as the **N**ear-**R**eal **T**ime **S**ystem (NRTS). The status of the MIDI instrument can be monitored using the status panel GUI (Figure 4).

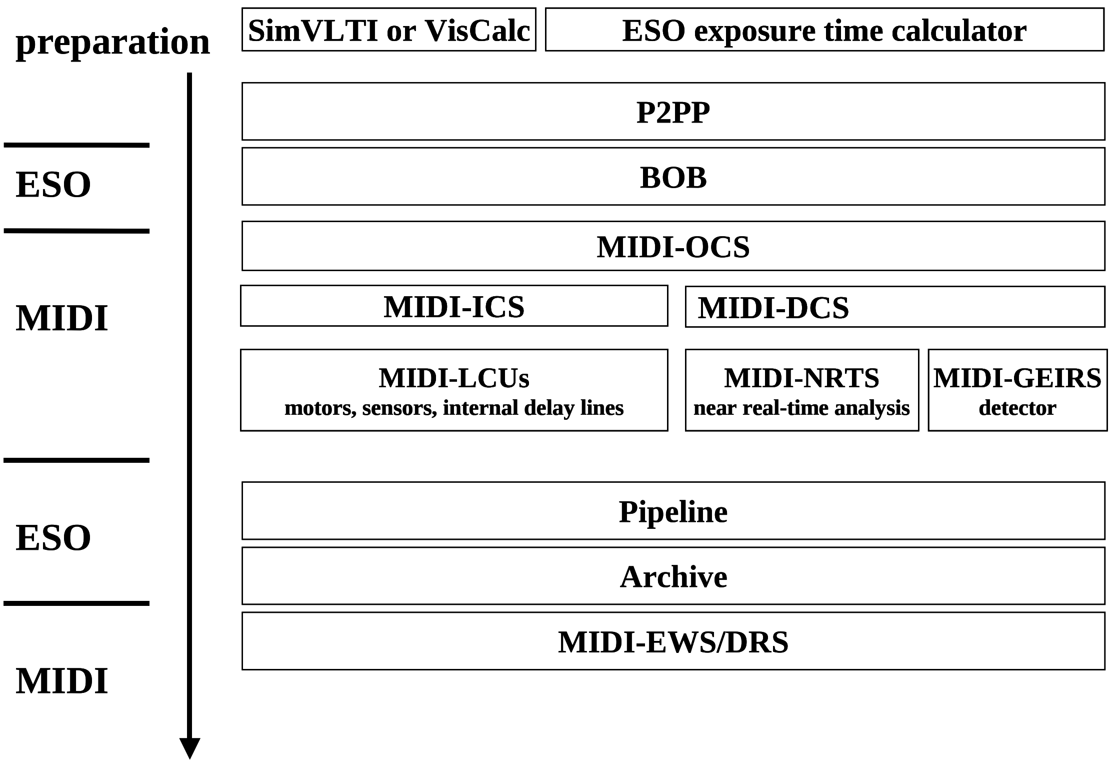


Figure 1: MIDI software structure. Commands are on a high level defined by the astronomer (through P2PP), and detailed out by underlying software modules, to reach the motors, sensors, detector and data analysis at the bottom.

NRTS receives both the raw data from GEIRS and the scheduling information (delay lines, piezo etc.) from one **L**ocal **C**ontrol **U**nit (LCU), merges this information in FITS files, and forwards the data to the Observation Software for later submission to the online archive and off-line reduction within the ‘‘pipeline’’. The pipeline is non-interactive. To allow the astronomer to inspect and reduce the raw data in greater details, the off-line reduction package **E**xpert **W**orkbench **S**tation (EWS) and the **D**ata **R**eduction **S**ystem (DRS) will be available to compute visibilities from the raw archived data.

Table 1: overview of available MIDI observing modes.

1 Source acquisition modes	**3 Calibration modes**
1.1 Preset	3.1 Wavelength
1.2 Coarse	3.2 Instrument Transfer Function
1.3 Fine	3.3 Background rejection
2 Science modes	**4 Technical modes**
2.1 Photometry	4.1 Black screen
2.2 Spectro-photometry	4.2 Focus
2.3 Non-dispersed Fourier fringe tracking	4.3 Generic
2.4 Dispersed Fourier fringe tracking	4.4 Laser
2.5 External fringe tracking	4.5 Self test
	4.6 Pupil image

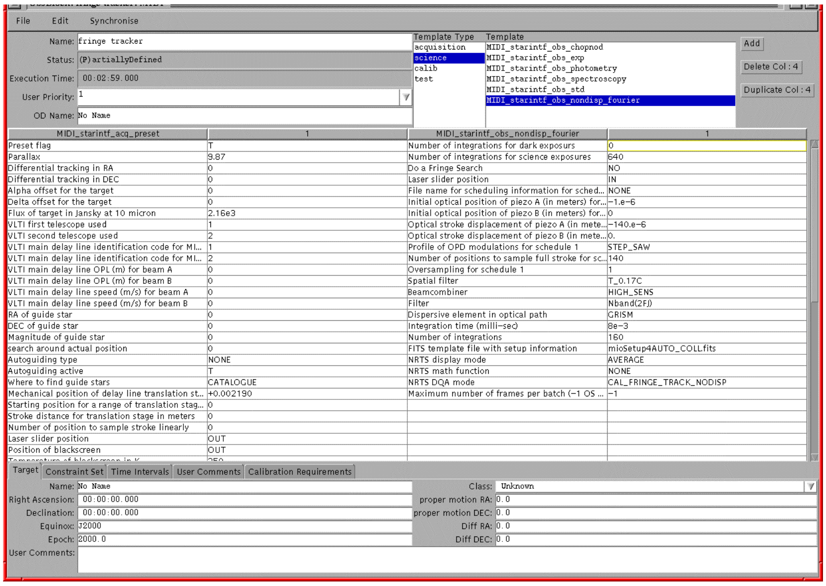
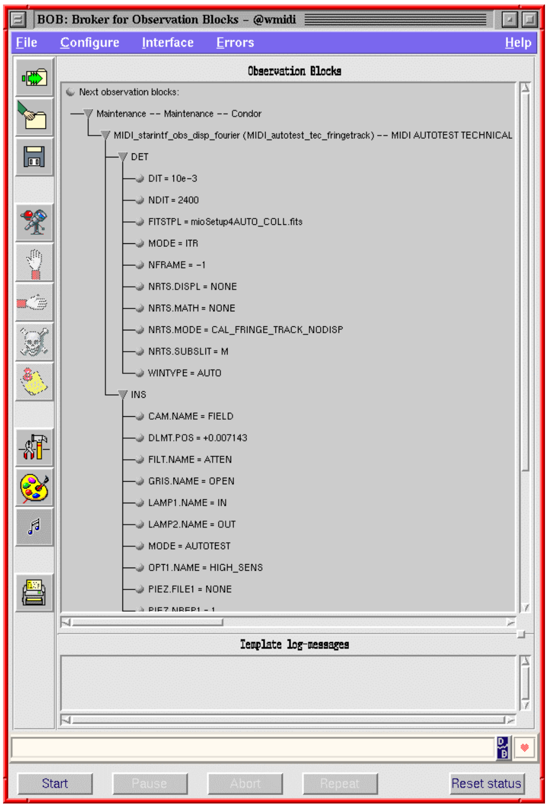


Figure 2: **P2PP panel for MIDI.**



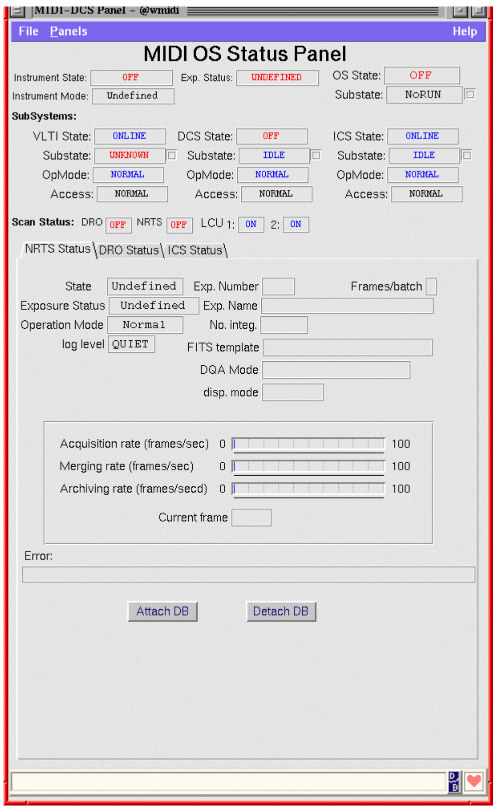


Figure 3: **left: BOB panel for MIDI.**

Figure 4: **right: MIDI subsystem status panel.**

5. OBSERVING MODES

In this paper we discuss the available observing modes: source acquisition, science, calibration, and technical. An overview of the modes currently available is presented in Table 1.

6. SOURCE ACQUISITION OBSERVING MODES

The objective of the acquisition modes to acquire the source on the MIDI detector with as few as possible optical element in the optical path. The source acquisition is divided in three steps, which must all be passed, in the order listed.

- Preset source acquisition: point the telescopes to the user-provided source position.
- Coarse source acquisition: position the source in the center of the field of view, on a pre-defined pixel location. If needed mosaic around the preset position to find the science source on the MIDI detector.
- Fine source acquisition: insert a small pinhole and maximize throughput by building a mosaic of pointing positions.

6.1. PRESET SOURCE ACQUISITION OBSERVING MODE

The first phase is the pointing of the telescopes at the nominal position of the source. The light of the star passes through the delay tunnel, enters MIDI, and is being detected by the MIDI detector. Using the visible light the source is centered on the optical axis of the telescopes. The main objectives of this observing mode are:

- Select the two telescopes that will be used.
- Select the appropriate delay line configuration and position the delay lines.
- Point the two telescopes to the user-provided coordinates of the source.
- Start blind tracking.
- Start chopping and nodding if requested.

6.2. COARSE SOURCE ACQUISITION OBSERVING MODE

The second phase is acquisition of the source by the MIDI instrument using a simple configuration of the instrument setup (with as few optical elements in the optical path). The main objectives of this mode are:

- To acquire the source within the full field of view of MIDI.
- To point the two telescopes such that for each of the telescopes the science light falls on a pre-defined pixel of the MIDI detector.

The three telescope types available (Siderostats, Unit Telescopes, and Auxiliary Telescopes) have all their different characteristics. Because of these different features (see Table 2), which are of particular importance to obtain a background image, the three-telescope systems will each have their own coarse source acquisition mode. For example the U.T. and A.T. allow chopping to correct for the thermal background, and the strap unit for fine pointing. For the Siderostats, nodding must be used to correct for the thermal background.

Table 2: characteristics of different telescope types.

Capability	Unit Telescope	Auxiliary Telescope	Siderostats
Adaptive optics	Yes	No	No
Chopping	Yes	Yes	No
Strap (Tip-Tilt)	Yes	Yes	No

6.3. FINE SOURCE ACQUISITION OBSERVING MODE

The third phase of source acquisition is inserting a pinhole in the optical path and scanning around the current coordinates to obtain maximum throughput and maximize the signal on the MIDI detector for each telescope separately. The main objectives of this mode are:

- To acquire the source on the MIDI detector and to obtain maximum throughput by scanning over the source.
- Remember the telescope parameters for later use.

The three telescope types available are all different (Table 2). Because of these different features, which are of particular importance to obtain a background image, the three-telescope systems will each have their own fine source acquisition mode.

7. SCIENTIFIC OBSERVING MODES

The scientific observing modes for MIDI can be divided in two categories: those in which light accepted by a spatial filter is spectrally dispersed and wavelength dependent fringes are detected, and those in which the interference is observed directly in the image plane (if requested with a filter in the optical path). In both cases the MIDI piezo provides modulation of the signal and allows fringe tracking by the NRTS system. Fringe finding and tracking is obtained by combining the optical path length differences introduced in the system by the VLTI main delay lines, the MIDI translation stage, and the two MIDI piezos. Fringe finding and tracking is done on-line for which a number of alternative fringe finding algorithms are implemented in the MIDI software. Typical integration times per frame (a single readout of the detector electronics) is 5 milliseconds, set by saturation of the detector due to the thermal background radiation. Whereas an exposure is defined as an integer number of consecutive frames.

7.1. PHOTOMETRY SCIENTIFIC OBSERVING MODE

This objective of this mode is to measure the total (uncorrelated) strength of the signal from a celestial source in instrumental units (counts/sec.) in non-spectrometric mode. A dispersing element may be used, but the reported flux is integrated over all measured channels. The mode will measure, as specified, either the geometric mean of the signals from the two telescopes (default), the arithmetic mean, or both. The main objective of this measurement is to provide a normalization value for the measured visibilities. The mode can be applied before or after the interferometric measurements when the photometry is not being measured with the photometric channels. This type of measurement is then less accurate in following the time dependence of the photometry (due to variations in Strehl ratio and scintillation), but may have advantages in simplicity or sensitivity.

The main objectives of this mode are:

- Obtain the actual source brightness and compare this with an initial estimate to see if the instrument is working well and the source is in fact the expected one.

- To measure the relative strength between the signals in the output beams of the beam-combiner for each arm of the interferometer (the κ coefficients). If only one shutter is open (one arm of the interferometer is used), the light is split by the beam-combiner in two channels (I_1 and I_2 non-interfered) without the photometric plates in the optical path, or four channels (P_A, I_1, I_2, and P_B non-interferometric, with only stray light in the other photometric channel).

- Correlated flux: calibrate the correlated flux between the two arms of the interferometer.

7.2. SPECTRO-PHOTOMETRY SCIENTIFIC OBSERVING MODE

For the most part photometric and spectro-photometry observing modes are very similar: the difference is the presence of a dispersing element or not. The reduction is also rather similar: spectro-photometric observation mode observations are photometric except that one computes a solution at each wavelength instead of for all wavelengths together. Spectroscopic measurements (dispersed) can be analyzed in photometric mode by ignoring the wavelength information. In addition to the objectives listed for photometry observing mode, the spectro-photometry observing mode has the additional objectives:

- To provide an estimate of the source spectrum that can be used to optimize tracking and visibility estimating algorithms.

- To provide a calibration for the spectrally dispersed fringe tracking mode (the κ coefficients as function of wavelength).

7.3. NON-DISPERSED FOURIER FRINGE TRACKING SCIENTIFIC OBSERVING MODE

The non-dispersed Fourier fringe track mode serves to locate the fringe pattern by scanning the MIDI **O**ptical **P**ath **D**ifference (OPD) through a range expected to contain the zero-OPD and monitoring whether a significant fringe packet can be detected. This mode uses the whole MIDI wavelength band (8-12 micron), with the possibility to limit the effective bandwidth using a filter. Once the fringe packet is detected it will be tracked by the online software (NRTS), which will display plots of the packet on-line. The mode involves two major variations: phase and group delay tracking (coherent and incoherent integration).

PHASE TRACKING

For coherent integration or phase tracking mode the fringe can be detected and actively tracked in a period of τ_0. The objective of the fringe finding mode is to actually locate the fringe, to an accuracy of better than λ and then track the position with this accuracy. In this mode MIDI initially acquires the fringe OPD by scanning small segments of OPD space (typically over about 5λ). If the fringe is not detected, the process is repeated on an adjacent OPD region. Once a positive detection has been made, MIDI goes into fringe tracking mode, in which the fringe position within the scanned region is repeatedly found and used to re-center the OPD offset for the following scan.

GROUP DELAY TRACKING

In incoherent integration or group delay mode the signal is assumed too weak to detect in this time and the fringe cannot be effectively tracked because it moves by more than λ in the time it takes to detect it. The objective of this mode is to establish a range in which the fringe can be found with a high probability. Then the fringe estimation process will integrate the fringe power in these regions over a longer time in order to estimate the visibility. Thus the fringe finding algorithm can only effectively establish the instrumental OPD offset; it is too slow/inefficient to establish the atmospheric offset because this changes faster than it can be determined. The total effective width of the OPD distribution, essentially the outer scale of the OPD wander, can be determined by this method, but it is much more efficient to measure it using coherent tracking on a bright calibration object.

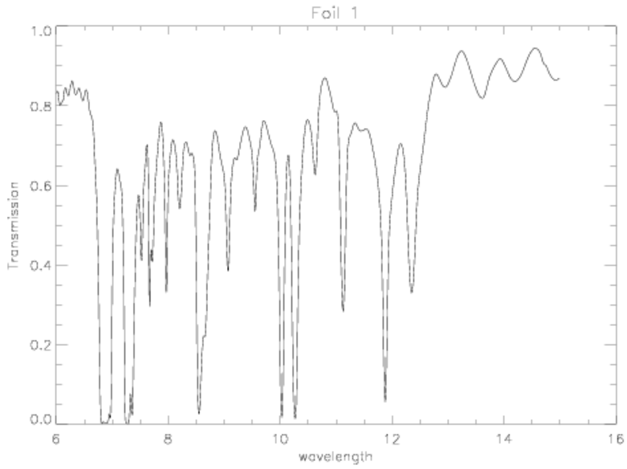


Figure 5: an example of an absorption spectrum from a foil present in the MIDI filter wheel.

Thus in group delay tracking mode the entire possible spread of the OPD range (instrumental and atmospheric) is scanned repeatedly and the fringe power is accumulated as a function of OPD. After many repetitions this will generate a histogram of the likelihood of finding the fringe in various parts of the OPD range. If this is significant in a limited sub-range of the initial OPD region, NRTS estimates this sub-range and limits future scans to the region in which it has determined with high confidence that the fringe exists. Continued application of this estimation procedure during subsequent data acquisition can detect possible drifts in this OPD due to modeling errors.

7.4. DISPERSED FOURIER FRINGE TRACKING SCIENTIFIC OBSERVING MODE

MIDI has been designed to work with a dispersive element. The prism provides a spectral resolution between 20 to 30, whereas the grism provides a spectral resolution of 230. If no dispersive element is placed in the optical path of the system, the two interferometric channels, I_1 and I_2, both are detected on several pixels each. In the case of a dispersive element the 8 to 12 micron band is spread over an elongated strip on the detector (banana shape). More advanced fringe tracking algorithms can be applied in this case.

The dispersed Fourier fringe track observing mode serves to locate the fringe pattern by scanning the MIDI OPD over a specified range to search for a detectable fringe in the spectrum of the source. Once the fringe packet is detected it will be tracked by the online software (NRTS), which will display plots of the detected fringe. The MIDI piezo modulates the OPD centered around the computed zero OPD position. This observing mode is similar to the non-dispersed Fourier fringe track mode and allows for phase tracking and group delay tracking (coherent and incoherent integration modes respectively). In the spectrally dispersed mode, calibration of the visibility will require to divide the spectrum by the spectro-photometry. The calibration is either obtained through running the spectro-photometry observing mode on the same source, or using the photometric channels of the beam-combiner.

7.5. EXTERNAL FRINGE TRACKING SCIENTIFIC OBSERVING MODE

Once the dual feed phase referenced VLTI facility PRIMA [5], or fringe tracker FINITO [6] will be available, fringe finding and tracking can be accomplished externally from MIDI, and allowing for coherent integration of the MIDI detector signal even for very low signals. This mode of observing can be in dispersed or non-dispersed mode.

8. CALIBRATION OBSERVING MODES

A number of calibration modes can be distinguished. Most important are the instrument calibration through the observation of a calibrator source; the other important calibration is the correction for thermal background radiation.

8.1. WAVELENGTH CALIBRATION OBSERVING MODE

The prism with a low resolution between 20 and 30 and the grism with a relative high resolution of 230 can be calibrated through fitting of spectral features from the foils present in the MIDI filter wheel (Figure 5). The MIDI filter wheel currently offers two foils. The main objectives of this mode are

- Wavelength calibration of MIDI in all dispersed modes.
- A time monitoring of this calibration.

The result of the calibration is the mean wavelength or frequency as a function of pixel position on the detector for each MIDI beam (P_A, P_B, I_1, I_2). The wavelength variation with pixel number will be expressed as a polynomial expansion and encoded in the coordinate distortion matrices in the image detector tables in the data. The wavelength spread per pixel will be expressed as a Gaussian width. This mode should be applied as a MIDI check each night. It is expected that the only significant change from night to night will be small zero-point displacements caused by movement of the pinhole slider. Beyond this the MIDI cold environment is supposed to be stable, and that the mode will be mainly used to detect a slow evolution.

8.2. INSTRUMENT TRANSFER FUNCTION CALIBRATION OBSERVING MODE

The most important calibration is the one of measuring the visibility of a calibrator of known visibility, and to determine the instrument transfer function from this. This instrument transfer function must then be applied to the science source in order to compute the absolute visibility from the measured un-calibrated visibility. Observations with MIDI are structured in sequences referred to as **M**ultiple **O**bject **S**ingle **O**bservation **B**locks (MOSOB). Such a sequence contains a visibility measurement of a calibrator, a science source, and second calibrator. This scheme of observation is defined in two phases. The first phase, the calibrators (one or two) and the science source are all three acquired and accurate coordinates and telescope configuration settings are determined for these sources for the specific telescope condition and instrument configuration. The telescope configuration is stored for later use. The second phase is fringe tracking on the two calibrators and science source. Source acquisition can be fast since the stored telescope configuration is used and this puts the source at exactly the required position on the MIDI detector.

8.3. BACKGROUND REJECTION CALIBRATION OBSERVING MODE

One of the greatest challenges faced by MIDI is the correction for the thermal background (both from the atmosphere and from the telescope optical train). MIDI offers at least two methods to correct for the thermal background. These modes will be referred to as "**virtual chopping**" and "**real chopping and nodding**". Both modes will be available to the astronomer. The use of chopping and nodding leads for each chop or nod to a loss of the fringe. The fringe of the source has to be reacquired when the telescope chops or nods back to the science source. An alternative approach is to apply virtual chopping and correct for the background through interpolation of the background signals from two additional pinholes on both sides of the science pinhole.

A triple pinhole can be inserted in the optical path of MIDI. The science light passes through the central pinhole and produces a signal at the two interferometric output channels I_1 and I_2. On both sides there is an additional pinhole, which only contains background radiation. In the **virtual chopping mode**, the MIDI software determines the background radiation from the two outer pinholes, which only contain the background radiation and interpolates to compute the background level at the position of the science source.

Advanced observing modes for MIDI are foreseen after the instrument performance is demonstrated at Paranal. Among the performance modes under discussion are improved rejection of the background radiation and water vapor effects by developing dedicated nodding and chopping modes. Together with internal fringe tracking by MIDI these modes are rather complicated since a chop and a nod also means that the fringe is lost. When the mirror returns to the science source, the fringe has to be reacquired.

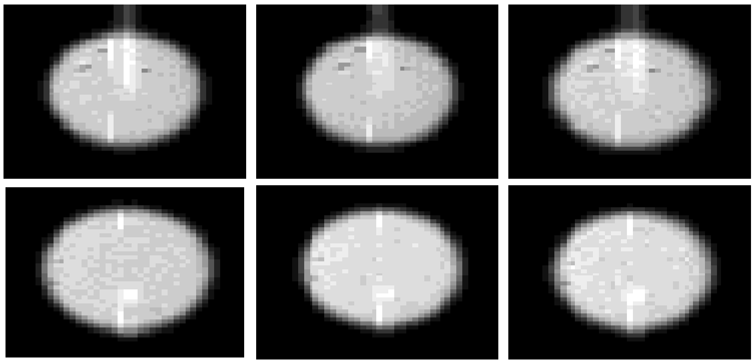


Figure 6: full field of MIDI for three shutter positions (AOPEN, BOPEN, and ABOPEN) for the two interferometric channels (I_1 and I_2 upper and lower row respectively).

9. TECHNICAL OBSERVING MODES

Technical observing modes are in general not accessible to the astronomer, but are important tools to monitor the performance of the instrument and to optimize the instrument settings (focus, detector etc.).

9.1. BLACK SCREEN TECHNICAL OBSERVING MODE

MIDI is equipped with a device called a black screen. The black screen provides two beams of uncorrelated flux from a blackbody at a given temperature. Each beam corresponds to an arm of the interferometer. The black screen can be used to verify the transmission of each arm of the interferometer and can be used as a diagnostic for a number of instrumental parameters. The main objectives for this mode are to monitor changes in:

- Overall sensitivity of the instrument for a default and an optional user-defined instrument configuration.
- The alignment of the pinholes as imaged on the detector.
- Characterization of illuminated detector characteristics, e.g. "dark" counts, dead pixels, relative individual pixel gain.

This mode will normally be run in a standard setup (i.e. fixed filter, disperser, camera) during daylight each evening before observing starts to verify the integrity of the instrument and to provide a standard monitoring protocol that can be followed over the life of the instrument. It can also be re-run with setups that cover the configurations to be used that night. Figure 6 presents an example of the full illuminated field of view of the two interferometric channels I_1 and I_2 (top and bottom row). The sequence from left to right corresponds to three different shutter positions: only beam A open, only beam B open, and beams A and B open.

9.2. FOCUS TECHNICAL OBSERVING MODE

The objective of the focus mode is to determine the best detector focus position for the instrument configuration specified. The light source used is the external laser. For a configuration in which the beam-combiner is open this results in two laser spots without interference. MIDI has two devices, which allow focusing the instrument:

- Detector position: to focus the slit (and the source if present) on the detector.
- MIDI M1 mirror: to focus the source image on the slit.

Both positions can be measured to obtain the best instrument focus.

9.3. GENERIC TECHNICAL OBSERVING MODE

To give complete freedom to the engineers, instrument specialist, and the astronomer, a generic observing mode is available that allows the user the set all possible device settings. The main objectives of this mode are:

- To provide a tool to define an observing mode and repeat it at his/her convenience.
- To provide a maximum flexibility to run the instrument.

9.4. LASER TECHNICAL OBSERVING MODE

The laser observing mode covers a set of measurements and reductions executed with MIDI to measure several instrumental characteristics with the aid of the 10.6-micron CO_2 laser. The mode described here will be executed once or twice per cold period of the instrument, to monitor changes caused by a warm/cold cycle or other changes over periods of weeks to months. There are many characteristics that can be measured with the laser and there are both major and minor or incidental goals of this mode. The main objectives of this mode are:

- Check and monitor the movement and stability of the MIDI piezo delay system. The ultimate calibration of the piezos was established with an optical laser and will be repeated as needed, hopefully only at intervals of several years. With the technique described here we will monitor changes in the relation between commanded and actual position for both arms of the delay system. To measure the hysteresis and repeatability of the positioning of the pizeos and the residual uncertainty (‘‘noise’’) after removal of all known calibrations.
- Calibrate the visibility contrast of the MIDI system using an almost perfectly coherent source. For various optical configurations of MIDI we will measure this contrast as a function of position on the detector.

9.5. SELFTEST TECHNICAL OBSERVING MODE

An observing mode to test the integrity of the instrument and test if all subsystems are alive (sanity check). The main objectives to this mode are:

- Test if the subsystems can be setup (TCS, ICS, NRTS, GEIRS).
- Test if the detector can be read-out and data transferred to the archive.
- Test the availability of the online database.

9.6. PUPIL IMAGE TECHNICAL OBSERVING MODE

This observing mode allows to image the pupil plane (the cold stop of MIDI and the M1 mirror of the telescopes) in order to study the thermal background and to improve background rejection techniques. The main objectives to this mode are:

- To image the pupil plane and to obtain time series of its variability.
- To study the effects of chopping and internal modulation on the thermal background image.

10. DISCUSSION AND CONCLUSIONS

MIDI scientific observing modes are in a phase of definition and development (September 2002). The modes are defined as described and tested in the laboratory. The next phase is testing the theoretical concepts during commissioning. This will surely lead to major changes and improvements. This paper therefore only gives a status report on our current (September 2002) thoughts about the scientific observing modes, but the reader is advised to see if later papers are devoted to this topic, which might supersede this one.

Science observing modes for the astronomer are non-dispersed and dispersed Fourier fringe track with near real-time data quality analysis by NRTS and near real-time fringe tracking. These two science observing modes allow sufficient flexibility to conduct the majority of the science programs foreseen for MIDI. Additional modes may be developed after evaluation of the instrument performance during commissioning.

Major challenges for the MIDI scientific observing modes include:

- Decreasing the time overhead for source acquisition (which is currently believed to be 10 minutes for the Unit Telescopes).
- Chopping, nodding, internal modulation strategies for photometric measurements of total source flux (required to obtain accurate visibilities) given fluctuations in the thermal background of the atmosphere and the VLTI infrastructure.
- Corrections for fluctuations in the phase of interference due to atmospheric water vapor in homogeneities and humidity in the path of the delay lines and relay optics.

REFERENCES

1. *ESO Proc. ‘‘Science with the VLT Interferometer’’*, Springer-Verlag, F. Paresce Ed., 1996
2. Leinert, Ch., Graser, U., Waters, L.B., Perrin, G., Lopez, B., Coudé du Foresto, V., Glazenborg-Kluttig, A.W., de Haas, J.C, Herbst, T.M., Jaffe, W., Lena, P.J., Lenzen, R., le Poole, R.S., Ligori, S., Mundt, R., Pel, J-W., Porro, I.L., and von der Lühe, O., ‘‘10-µm interferometry on the VLTI with the MIDI instrument: a preview’’, *Proc. SPIE Vol. 4006*, pp. 43-53, Interferometry in Optical Astronomy, P.J. Lena, A. Quirrenbach Eds., 2000
3. Ballester, P., Chavan, A.M., Cotton, B., Coudé du Foresto, V., Glindemann, A., Guirao, C., Jaffe, W., Kervella, P., Longinotti, A., Percheron, I., Peron, M., Duc, T-P, Pirenne, B., Quinn, P.J., Richichi, A., Schöller, M., Wicenec, A.J., Wilhelm, R., Wittkowski, M., and Zampieri, S., ‘‘Data flow system for the very large telescope interferometer’’, *Proc. SPIE Vol. 4477*, pp. 225-233, Astronomical Data Analysis, J-Luc. Starck; F.D. Murtagh Eds. 2001
4. Feldt, M., and Lopez, B., ‘‘SimVLTI: a simulation tool for VLT instrument MIDI (and AMBER)’’, http://www.mpia.de/MIDI/SIMVLTI
5. Quirrenbach, A., Coudé du Foresto, V., Daigne, G., Hofmann, K.H., Hofmann, R., Lattanzi, M., Osterbart, R., le Poole, R.S., Queloz, D., Vakili, F., ‘‘PRIMA: study for a dual-beam instrument for the VLT Interferometer’’, *Proc. SPIE Vol. 3350*, pp. 807-817 Astronomical Interferometry, R.D. Reasenberg Ed., 1998
6. Gai, M., Corcione, L., Delage, L., Gardiol, D., Gennai, A., Lattanzi, M.G., Loreggia, D., Massone, G., Menardi, S., Reynaud, F., ‘‘The FINITO fringe sensor for VLTI’’, *ESO Proc. "Beyond Conventional Adaptive Optics"*, R. Ragazzoni, N. Hubin, S. Esposito eds., 2001

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