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JMMC

MIDI

DATA REDUCTION SOFTWARE

USER'S MANUAL

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		•					

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1 INTRODUCTION

1.1 Purpose

The purpose of this handbook is to provide all information necessary for the installation and use of the MIDI data reduction software, developed by the Paris Observatory / LESIA based group of the JMMC.

1.2 <u>Reference document</u>

- [1] VLTI Data Interface Control Document, Version 1.0, VLT-SPE-ESO-15000-2764/1.0, May 2004
- [2] A Data Exchange Standard for Optical (Visible/IR) Interferometry, Release 5, First Version: 10 January 2001, Last Update: 7 April 2003, Prepared by NPOI and COAST

1.3 <u>Abbreviations and acronyms</u>

MIDIMID-infrared InstrumentVLTIVery Large Telescope InterferometerJMMCJean-Marie Mariotti CenterLESIALaboratoire d'Etudes Spatiales et d'Instrumentation en
Astrophysique

1.4 <u>Typographical conventions</u>

ASCII	American Standard Code for Information Interchange
DRS_MIDI	MIDI Data Reduction Software
FITS	Flexible Image Transport System
IDL	Interactive Data Language
IDLDE	Interactive Data Language Development Environment
PSD	Power Spectral Density (Power Spectrum)
OI_FITS	Optical Interferometry Flexible Image Transport System

2 **DESCRIPTION**

2.1 General

DRS_MIDI is an IDL Widget-based program which includes three parts:

- The control and browsing of the MIDI data files in FITS format
- The computation of fringe contrasts
- The computation of the visibilities

2.2 Controlling the data files

The control of the MIDI data files allows one to list their contents: headers and data (without any processing). The contents of these files are described in [1].

2.3 Computation of fringe contrasts (Reduction of the data)

This part pertains to the computation, for each fringe data FITS file from a list selected by the user, of the factor of contrast for all wavelengths. The results are recorded in standard FITS files (and not MIDI standard) whose names are identical to the names of the data files, except that MIDI is replaced by FRGE.

 Example:
 Data file
 : MIDI.2004-06-08T05_32_18.660.fits

 Reduced file
 : FRGE.2004-06-08T05_32_18.660.fits

In this part, the OI_FITS files (OIF1*.fits for the first method of the visibilities computation and OIF2*.fits for the second one) are recorded in the same folder as the fringe files. Theirs OI_VIS2 table will be completed by the "Visibilities Computation" part and the new files will be recorded in the "Save Visibilities Directory".

2.3.1 Selection of the MIDI data files:

This step consists in selecting the files containing the fringes, i.e. the files corresponding to «OBS_FRINGE_TRACK_FOURIER» or/and «OBS_FRINGE_TRACK_DISPERSED».

2.3.2 Research of the files of photometry:

With each fringe file are associated two data files of photometry (one for each telescope). These files are selected as follows:

- the acquisition time is the closest to the fringe file's

- one file pertains to the open output A, while the other to the open output B

2.3.3 Checking the photometry files and the calibrators:

With the sky background it is difficult to extract the position of the source on the detector by inspecting the flux only in the tracking files (note that during the tracking, no chopping is applied at the moment. Hence the photometric files are used to define the location of the source on the detector and to compute a mask to extract the fringes. It is necessary to check the time consistency of the files: for instance if two photometry acquisitions were made before and after the fringe acquisition, both the AOPEN and BOPEN photometry files may be used. In this case, the hours of photometry are very different. To avoid such a case, a test over the acquisition hours is carried out.

2.3.4 Detector masking and photometry computation:

The photometry files are used to mask out the detector patches free of interferometric signals (computation of the mask). Photometry data contain observations on the sky (OFFSOURCE) and source (ONSOURCE). The target signal is extracted by substracting the ONSOURCE signal from the OFFSOURCE one acquired at a chopping rate between 0.5 and 2Hz generally.

Three methods of mask calculation are proposed by the software:

- *Fix Mask:* the position of the maximum signal is found for each pixel (i.e. each wavelength), for AOPEN (telescope 1) et BOPEN (telescope 2). Then the mean of these two values is computed to define the position of the fringe mask. This mask is 1 in the chosen region and 0 outside, the size of the mask, is predefined.
- *Rectangular Mask*: this method returns a mask determined by the area where the value of the signal is higher than a threshold, then a filtering by median in order to eliminate the irregularities due to noise is applied.
- Gaussian Mask:a 1D gaussian is fitted at each pixel (i.e. wavelength λ). A
low order polynomial function is fitted to follow the change
of FWHM(λ) and MAX(λ). A gaussian mask is computed
by creating gaussian at slowly evolving position of
maximum and FWHM.

Each mask (i.e. one for each telescope) is then applied to the photometry. The photometry is computed as follows:

 $Photometry = \sqrt{PhotometryA * PhotometryB}$

2.3.5 Computation of the Power Spectrum:

The power spectrum is calculated from the difference between the two interferometric outputs (the two outputs are complementary). It is a very efficient way to remove the background and any sources of noise, but this method is limited by the quality of the beam splitter. A fringe peak is detected, a correction of the background noise is applied by fitting of the noise at various frequencies in Fourier plane and the integral of the peak provide the correlated flux in counts unit (ADUs).

Three methods of calculation of the background are available:Constant:the minimum of the signal is takenEdges:the average of the edges values of the PSD is takenHistogram:the histogram of the PSD allows one to define the
background pixels and to take their average value

2.3.6 Computation of raw visibilities (fringe contrasts):

The fringe power is the integral of the calibrated power spectrum. The power spectrum is windowed to improve the signal-to-noise ratio.

The squared coherence factor is the ration of the power to the squared photometry:

$$\mu^2 = \frac{Power}{Photometry^2}$$

2.3.7 Recording of the results:

The results are recorded in FITS files. These files contain a primary recording and 7 extensions.

Primary: (*Extension* = θ)

Header: the whole information necessary to the computation of the transfer functions and the visibilities such as: name of the data file, name of the files of photometry, date of observation, name of the object, UTC, LST, projected bases, U, V, azimuth, name of the mask applied, diameter and associated error (for the calibrators)...

T / Written by IDL: Mon Dec 13 13:13:31 2004

```
Data: no data.
```

Here is an example of the primary header of a file: SIMPLE = T / Written by IDL:

```
-32 /
       BITPIX =
                                                                   2 /
      NAXIS
      NAXIS1
                      =
                                                               151 /
      NAXIS2 =
                                                                71 /
                      = '2004-12-13'
      DATE
                                                                       / Creation date (CCYY-MM-DD) of FITS header
                                                                  Т /
       EXTEND =
       TFILE = 'E:/Data/2003/11-08\MIDI.2003-11-08T05_27_58.000.fits' /Target filename
                    = 'E:\Data\2003\11-08\MIDI.2003-11-08T05_32_06.000.fits' /AOPEN filename
= 'E:\Data\2003\11-08\MIDI.2003-11-08T05_34_29.000.fits' /BOPEN filename
       AOPEN
       BOPEN
       DATE_OBS= '2003-11-08T05:27:58.00' /Date of observation
     TARGET = 'hd39400 ' /Target name

CALCODE = 'C ' /C-calibrator, S-Source

RAEPP = 88.110224 /Right Ascension (decimal degree)

DECEPP = 1.8550700 /Declination (decimal degree)

EQUINOX = 2000.00 /

DIAMETER= 2.25000 /Diameter (m)

DIAM_ERR= 0.120000 /Diameter com

      DIAM_BIRG
      0.120000 / Diameter error (m)

      TIME_OBS= '25645:27:58.0000'
      /Observation time

      BEGINTIM=
      52951.228 /

      ENDTIME =
      52951.229 /

      UTC =
      19669.000 /UTC at start (decimal sec)

      LST =
      14050.560 /Local Sideral Time at start (decimal sec)

      PBASE =
      36.712655 /Projected baseline (m)

      TEL10 =
      -44.9146 /Telescopes coordonates

      TEL11 =
      -66.1831 /

      TEL210 =
      -14.8937 /

      TEL211 =
      -30.4893 /

      TEL212 =
      0.000247539 /

      BLENGTH =
      46.6401 /Baseline length (m)

      INCLIN =
      -0.011243479 /Baseline Inclination (decimal degree)

      AZIMUTH =
      30.795986 /Azimuth (decimal degree)

      PARALAT =
      -24.6279 /Site Latitude (decimal degree)

      PARALONG=
      -70.4048 /Site longitude (decimal degree)

      U =
      18.796243 /U (m)

      V =
      31.536016 /V (m)

      MODE_ID = 'PRISM '
      /Mode ID

      SHIFTWIN=
      150 /Detector Window shift

       TIME_OBS= '25645:27:58.0000' /Observation time
                                                               150 /Detector Window shift
       SHIFTWIN=
       FIL_ORG = 'E:\Data/2003/11-08\MIDI.2003-11-08T05_27_58.000.fits' /Data file
       END
Extension 1 (EXTNAME = MEANDSP): average power spectrum.
Extension 2 (EXTNAME = DSP): Power spectrum on all scans.
Extension 3 (EXTNAME = PHOTO): Photometry acquisitions.
Extension 4 (EXTNAME = MASK): Mask.
       With header USE MASK giving the name of the mask (either FIX, or
       RECTANGULAR, or GAUSSIAN)
Extension 5 (EXTNAME = MU2): squared factor of contrast (\mu^2) computed for each
scan.
Extension 6 (EXTNAME = WAVELENGTH): wavelength.
Extension 7 (EXTNAME = DIFF_PHASE): differential phases.
```

Extension 8 (EXTNAME = DATA_UT): Acquired data for image centering.

This information is recorded for data reduction quality check. This check can be carried out in «Computation of the visibilities» section.

2.4 <u>Computation of the visibilities</u>

This part allows to compute the transfer functions, the visibilities, along with their errors, and to display the results obtained.

Computations are carried out on the whole list of contrast files (FRGE*.fits) selected by the user.

For each source file, a search of the closest calibrator files is carried out.

Computations include:

For calibrators, the transfer function based on the contrast estimate and diameter input.

For sources, the estimate of the transfer function, either by interpolating the transfer functions of the two calibrators bracketing the source (1st method), or by calculating the average transfer function of all the calibrators belonging to the same night selected by the user (2nd method).

The visibility of the source is:

$$Visibility = \frac{Contrast}{TF}$$

More exactly, the (Co-Transfer Function)², i.e. $1/TF^2$, is computed and multiplied to the (Contrast Factor)² to yield the (Visibility)²:

$$(Visibility)^2 = (Co_TF)^2 \times \mu^2$$

These values can be recorded in files, either in FITS format, or in ASCII format. The files of results of the first method have the name RESU*.fits or RESU*.asci and those of the second method have the name MEAN*.fits or MEAN*.asci.

The FITS files contain a binary table with 7 columns:

Column 1: wavelengths

Column 2: (Co-Transfer Function)²

Column 3: $Error(CoTF)^2$

Column 4: $(Visibility)^2$

Column 5: $Error(Visibility)^2$.

Column 6: (Average_FactorContrast)²

Column 7: Error(Average_FactorContrast)²

as well as the headers giving information on the dimensions of the table of results, the name of the object, the date of observation, the projected baseline, the azimuth, U, V, names of the calibrators and their times, ...

This same information is recorded in the ASCII files.

The OI_FITS files (described in [1]) can be recorded:

The filename is OIF1*.fits for the first method.

The filename is OIF2*.fits for the second method.

These files contain:

- an OI_ARRAY table.

- an OI_TARGET table.

- an data table OI_VIS2 that refers to an OI_WAVELENGTH table.

3 USER'S GUIDE

3.1 <u>Prerequisite</u>

The MIDI Data Reduction Software needs that either *IDL runtime* (version 5.6, 6.0 or 6.1) or *IDL Virtual Machine* (version 6.1) is installed on your computer to operate.

The IDL Virtual Machine can be freely downloaded on http://www.rsinc.com/idlvm.

3.2 Installation

The software can be downloaded on <u>http://mariotti.fr</u> in the *Data Processing* section. You must download the software corresponding to the version of your IDL.

After download, the first step consists to unpack the .tgz file using either the Unix/MacOS command, as shown below:

% tar -xzvf drs_midi-IDLv<IDL-Version>.tgz

or the WinZip or PowerArchiver tool on Windows.

3.3 Startup

To run the Software using *IDL runtime*, go into the created directory, start IDL and restore the software using the command:

IDL> RESTORE, 'drs_midi.sav'

And to start it:

IDL> drs_midi

To run the Software using *IDL Virtual Machine*, go into the created directory, start directly IDL using the following command:

% idl -vm=drs_midi.sav

The main widget software pops up:

🎒 MIDI - DR5 main me	nu	_					
			Abou				
Data Midi Directory	C:\DATA\031108\	Browse					
Save Contrasts Directory	C:\RESULTS\031108\	Browse					
Save Visibilities Directory	C:\RESULTS\031108\	Browse					
[MIDI DATA CONTROL						
	Select MIDI FITS Files						
	MIDI FITS DISPLAYER						
	Control UT Files						
			_				
	MAKE LOGBOOK (All Data Files) File Name : logbook.txt						
Save in Directory	C:\RESULTS\031108\	Browse					
	Make LOGBOOK						
CONTRASTS Computation VISIBILITIES Computation							
EXII							

For *Data Midi Directory*: select the path of the folder containing the data files FITS. For *Save Contrasts Directory*: select the path of the folder where the files resulting from the computation of contrasts will be recorded.

For *Save Visibilities Directory* select the path of the folder where the files resulting from the Computation of the visibilities will be recorded.

For *Save in Directory* (Make LogBook): select the path of the folder where the file logbook.txt will be recorded. This file contains information pertaining to all the data directory (*Data Midi Directory*) files: file names, object names, observation modes (Prism or Grism and High_sens or Sci_phot), NRTS mode (Obs_Fringe_Track_Fourier, Act_UT_Coarse_Chop, Obs_Photometry_Chop, ...), Shutter name (ABOEN, AOPEN, BOPEN), diameter, exposure time, ...

These folders must be created before any use. Make sure that writing permissions are enabled.

It is preferable that the path of the data folder does not comprise the string « MIDI » and those with the folders of the reduced files and visibilities, «FRGE », « RESU » and «MEAN ». Such a case would be extremely confusing for the automatic research procedures.

🏥 Go	rgonz	ola									
			10	4							
			Show o	nly selected file	es	Show all list					
					Show	v all list					
				L	JP List	DOWN List					
				Se	lect all files	s of this criteria					
					SEL	ECT					
		FILENAME		OBJECT	NRTSMC	IDE	INSOPT1	INSGRIS	INSSHUT	EXPTIME	
0		MIDI.2003-11-08T05_24_16.000.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	64.640000	
1		MIDI.2003-11-08T05_25_32.451.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	31.360000	
2		MIDI.2003-11-08T05_27_58.000.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	64.624000	
3		MIDI.2003-11-08T05_29_14.431.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	31.360000	
4	×	MIDI.2003-11-08T06_11_07.000.fits		alfori	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	48.480000	
5	×	MIDI.2003-11-08T06_12_07.290.fits		alfori	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	47.520000	
6	×	MIDI.2003-11-08T06_15_09.000.fits		alfori	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	40.400000	
7	×	MIDI.2003-11-08T06_16_01.207.fits		alfori	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	39.600000	
8		MIDI.2003-11-08T06_40_55.000.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	64.640000	
9		MIDI.2003-11-08T06_42_11.451.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	63.360000	

SELECT MIDI FITS FILES

The selection of the files is done, either by checking the choices one by one, or by desired type. Example: to select all of the ALFORI files, it is suitable to click on a box «ALFORI » then to click on «Select all files of this criteria». The same shortcut is available for all the types of desired files (OBS_FRINGE_TRACK_FOURIER, PRISM, ABOPEN, ...).

MIDI FITS DISPLAYER

FITS MONITEUR		
FILE View File	🛍 IDL	_ 🗆 🗙
Close File	C:\Data\031108\MIDI.2003-11-08T05_24_16 C:\Data\031108\MIDI.2003-11-08T05_25_32 C:\Data\031108\MIDI.2003-11-08T05_27_58	5.000.fits 2.451.fits 2.000.6ts
Exit	C:\Data\031108\MIDI.2003-11-08T05_29_14 C:\Data\031108\MIDI.2003-11-08T05_29_14	.431.fits .000.fits
	C:\Data\031108\MIDI.2003-11-08T06_12_07 C:\Data\031108\MIDI.2003-11-08T06_15_09 C:\Data\031108\MIDI.2003-11-08T06_16_01	7.290.fits 0.000.fits 207.fits
	C:\Data\031108\MIDI.2003-11-08T06_40_55 C:\Data\031108\MIDI.2003-11-08T06_42_11	.000.fits .451.fits

Select a file to visualize its principal headers and its data by clicking on the buttons *HEADER* and *TABLE* (Caution: since some data can be heavy to load the use should be restricted to header visualization):



Example: file C:\Data\031108\MIDI.2003-11-08T06_11_07.100.fits

- Header for ARRAY_GEOMETRY:

🎒 H	IEADER - ARR	AY_GEOMETRY		X			
	Close						
		ARRAY_GEOM	ETRY				
		Keyword	Value				
	0	XTENSION	BINTABLE	binary table extension			
	1	BITPIX	8	8-bit bytes			
	2	NAXIS	2	2-dimensional binary table			
	3	NAXIS1	48	width of table in bytes			
	4	NAXIS2	2	number of rows in table			
	5	PCOUNT	0	size of special data area			
	6	GCOUNT	1	one data group (required key			
	7	TFIELDS	6	number of fields in each row			
	8	EXTNAME	ARRAY_GEOMETRY	Auto Added Keyword			
	9	ORIGIN	ESO-PARANAL	Auto Added Keyword			
	10	DATE	2003-11-08T06:12:35	Auto Added Keyword			
	11	TELESCOP	ESO-VLTI-U23	Auto Added Keyword 💌			
		•		Þ			

- Table for ARRAY_GEOMETRY:

1	TABLE - ARRAY_GEOMETRY							
				ARRAY	_GEOMETRY			
								_
		TEL_NAME	STA_NAME	STA_INDEX	DIAMETER	STAXYZ	MNTSTA	
		S	S	I	F	D	I	
					m	m		
							1	
		Extend	Extend	Extend	Extend	Extend	Extend	
	1	UT3	03	33	8.00000	-44.914583	0	
	2	UT2	U2	32	8.00000	-14.893744	0	
l								

S CONTROL UT FILES

Control ACQ_UT Data					
Select MIDI File : C:\DATA\031108\MIDI.2003-11	I-08T06_15_09.000.fits	•			
L	JT File selected for your MIDI file	¢			
C:\DATA\031108\\MIDI.2003-11-08T06_02_43.00	10.fits				
Select UT File : C:\DATA\031108\\MIDI.2003-1	1-08T06_00_42.000.fits	•			
	Display UT				
	Source Position:				
Data1,X= 29 Y= 32 Data2,X= 30 Y= 32					
	Delete All Plots				
	Close				

This widget allows one to know which UT file is associated with a given data file, and to visualize the positions of the source:



Scontrasts Computation (see 3.4.1)

This widget pertains to the factors of contrast Computation.

CONTRASTS computation	_ _ _ _ _
Compute MASK : 💿 Fix 🔿 Rectangular 🔿 Gau	ssian
ADVICE: The FIX mask is very	efficient
COMPUTATION	
Control Computed Files	5
Close	

VISIBILITIES COMPUTATION (SEE 3.4.2)

This widget calculates the visibilities.

IVISIBILITIES Computation				
Visibilities F Calibrators / Target	iles Display ts Files modification			
1st METHOD : Visibilities computation by Calibrators'interpolation Select Targets Files MODIFICATION Modify Target [Calibrators] Modify List Calibrators Compute VISIBILITIES Display Results	2nd METHOD : Visibilities computation with Mean Transfert Function Select Targets Files MODIFICATION Modify List Calibrators Compute VISIBILITIES Display Results			
Close				

3.4 Data reduction

3.4.1 Computation of contrasts

CONTRASTS compu	tation	-D×
Compute MASK : 💿 F	ix 🔿 Rectangular 🔿 Gaussian	
	ADVICE: The FIX mask is very efficient	
	COMPUTATION	
	Control Computed Files	
	Close	

The Computation of contrast consists in:

- a) Determining from the photometry files a mask to isolate the part which contains data. Three options of mask are proposed: Fix, Rectangular and Gaussian (the mask which returns good results with almost all data is the "Fix" one).
- b) Applying the mask to the photometry files to extract the photometry values.
- c) Calculating the power spectrum of the fringes signal pertaining to the area defined by the mask.
- d) Calculating the factor of contrast by normalizing the power spectrum by photometry.

The results will be recorded in the FITS files whose names are deduced from the names of the MIDI data files by replacing MIDI by FRGE. The contents of these files can be visualized in the section "*VISIBILITIES Computation*", as described below.

First of all, it is necessary to choose a mask, then to click on "Computation". The list of MIDI data files contained in the Data Midi Directory with the OBS_FRINGE_TRACK_FOURIER or/and OBS_FRINGE_TRACK_DISPERSED flag appears:

🎒 Gor	gonz	ola									
			10	10)						
			Show or	nly selected file	es l	Show all list	1				
					Show	all list					
				L	JP List	DOWN List					
					loot all files	of this criteria					
			_	36	SEL						
				ODUECT			INCODT1	INCODIC	NCCUUT	EVETIME	
0	×	MIDI.2003-11-08T05_24_16.000.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	64.640000	
1	×	MIDI.2003-11-08T05_25_32.451.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	31.360000	-
2	×	MIDI.2003-11-08T05_27_58.000.fits		hd39400	OBS_FR	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	64.624000	-
3	×	MIDI.2003-11-08T05_29_14.431.fits		hd39400	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	31.360000	
4	×	MIDI.2003-11-08T06_11_07.000.fits		alfori	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	48.480000	
5	×	MIDI.2003-11-08T06_12_07.290.fits		alfori	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	47.520000	
6	×	MIDI.2003-11-08T06_15_09.000.fits		alfori	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	40.400000	
7	×	MIDI.2003-11-08T06_16_01.207.fits		alfori	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	39.600000	
8	×	MIDI.2003-11-08T06_40_55.000.fits		hd39400	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	64.640000	
9	*	MIDI.2003-11-08T06_42_11.451.fits		hd39400	OBS_FRI	INGE_TRACK_FOURIER	HIGH_SENS	PRISM	ABOPEN	63.360000	

For this example (we only have the OBS_FRINGE_TRACK_FOURIER files), check the **OBS_FRINGE_TRACK_FOURIER** files for the sources and the calibrators to be processed to select them (left-hand column) or all the files of this type by checking an **OBS_FRINGE_TRACK_FOURIER** box, then click on **«Select all files of this criteria**». Complete the selection by checking on **«Select**».

The program carries out the first step which consists in recovering all the parameters necessary to the reduction and seeking the associated files of photometry automatically.

A window appears indicating the source names (Target) and the acquisition times of photometry files associated with AOPEN and BOPEN:

🗂 IDL								<u>_ ×</u>
Target hd39400 hd39400 hd39400 alfori alfori alfori alfori hd39400 hd39400	Target Time 05_24_16.00 05_25_32.45 05_27_58.00 05_29_14.43 06_11_07.00 06_12_07.29 06_15_09.00 06_16_01.20 06_40_55.00 06_42_11.45	AOPEN 0 05_32_00 1 05_32_00 0 05_32_00 0 05_32_00 0 06_19_22 0 06_19_22 0 06_19_22 0 06_19_22 0 06_19_22 0 06_45_53 1 06_45_53	Time 5.000 5.000 5.000 2.000 2.000 2.000 2.000 3.000 3.000	BOPEN Tim 05_34_29.00 05_34_29.00 05_34_29.00 05_34_29.00 06_21_29.00 06_21_29.00 06_21_29.00 06_21_29.00 06_48_03.00 06_48_03.00	e Code 0 S 0 S 0 S 0 S 0 S 0 S 0 S 0 S	Diameter 2.250 2.250 2.250 0.000 0.000 0.000 0.000 2.250 2.250	Diam_Err 0.120000 0.120000 0.120000 0.000000 0.000000 0.000000 0.000000	
	L L		Mod	lify PHOTOME	TY files			
				Select	TARC	GET		
		0	05_24	_16.000	hd39400	<u>▲</u>		
		1	05_25	_32.451	hd39400			
		2	05_27	_58.000	hd39400			
		3	05_29	_14.431	hd39400	_		
			•			•		
		A0pen A0	IPEN T	ime 💌 BOp	en BOPEN	Time 💌		
				OK				

It is mandatory to check the consistency between the source file and the photometry files AOPEN and BOPEN. A time difference larger than 2 or 3 minutes (this criterion can be adjusted by the user) between AOPEN and BOPEN indicates a probable bad choice. It is possible to manually select the photometry files associated with a given source: boxes AOPEN and BOPEN propose the list of the possible photometry files for this source.

At this stage, all files are marked as sources (S). The columns Diameter and Error_Diameter display the diameter estimate for the sources which were indexed as possible calibrators in the associated data base. It is possible to redefine the calibrators thereafter.

Blank lines can appear. This indicates that Computations could not be carried out because some photometry files are missing.

The next steps of the processing are automatic and lead to the recording of the fringe files in the folder **Save Contrasts Directory**.

During the processing, so messages can appear, indicating that the chosen mask is not valid for some of the files and suggest, once the computation is over, to select another mask for these files.

Scontrol Computed Files

Control state of Fringe Computation		
C:\Data\031108\\MIDI.2003-11-08T05_24_16.000.fits	hd39400 FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T05_25_32.451.fits	hd39400 FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T05_27_58.000.fits	hd39400 FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T05_29_14.431.fits	hd39400 FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T06_11_07.000.fits	alfori FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T06_12_07.290.fits	alfori FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T06_15_09.000.fits	alfori FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T06_16_01.207.fits	alfori FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T06_40_55.000.fits	hd39400 FIX	Computed
C:\Data\031108\\MIDI.2003-11-08T06_42_11.451.fits	hd39400 FIX	Computed

This widget shows which files have been reduced (indicated by «Computed»).

3.4.2 Computation of the visibilities

Clicking in the principal menu on the VISIBILITIES Computation button launches the computation of visibilities widget:



This part relates only to the reduced files recorded in the folder *Save Contrasts Directory*, and does not use the raw data of the *Data Midi Directory* any more.

At this stage, two methods of computation are available:

First method: makes an interpolation of the transfer functions of the two calibrators bracketing the source.

<u>Second method</u>: calculates the average transfer function of all the calibrators belonging to the same night chosen in the list by the user.

It is compulsory to carry out computations in the order of the Widget IDL buttons, i.e. from top to bottom, as will be reminded by error messages.

VISIBILITIES FILES DISPLAY



The file selection window shows up:



This widget allows to visualize the contents of the reduced files (FRGE*.fits), i.e.:

- The factor of contrast as a function of wavelength:



- The mask:



- The photometry:



- The differential phase:



- The histogram of the PSD for a given wavelength selected by the cursor:





- The average PSD on an observation:



- The average PSD for a given wavelength selected by the cursor:





- The name of the photometry files associated with a given source and the ACQ_UT_COARSE_CHOP file preceding the source:





Scalibrators/Targets Files Modification

Controlling and choosing the calibrators:



In this widget, one can:

- Redefine which are the sources and calibrators (At the beginning, by default, all the files are in the column SOURCE. It is up to the user to modify them: either Source, or Calibrator, or Removed).
- If some source files or calibrator files are of poor quality, they can be removed by *Remove Source* or *Remove Calibrator* (and also recovered as a source or calibrator by *Recall Calibrator* or *Recall Source*).
- Trace the transfer functions of the calibrators to assess their quality and record them in the FITS or ASCII files. The name of these files is deduced from the names of files FRGE by replacing FRGE by TSFR.
- Record the (Co_TF)² computed for each scan in the FITS or ASCII files. The name of these files is deduced from the names of files FRGE by replacing FRGE by COTF.

The modifications made at this stage are recorded in the FRGE files, therefore the selection of the sources and calibrators is recorded and remembered even after quitting the session.

SELECT TARGETS FILES

🎒 Gor	gonz	zola					
			4	4	1		
						1	
			Show	only selected fi	les	Show all list	
					Sho	w all list	
					UP List	DOWN List	
					oloot all file	e of this oritoria	
					elect all file		
					SE	LECT	
_		FILENAME		TARGET			
0		FRGE.2003-11-08T06_11_07.000.fits		alfori			
1		FRGE.2003-11-08T06_12_07.290.fits		alfori			
2		FRGE.2003-11-08T06_15_09.000.fits		alfori			
3		FRGE.2003-11-08T06_16_01.207.fits		alfori			

It is necessary to select the sources for which visibilities are to be computed.

Source States (Calibrators)

Once the sources are selected, another window pops up with the list of the sources and the calibrators associated with each of these sources.



The automatic calibrator research procedure selects for each source the first calibrator preceding it and the first following it, if they exist. The procedure works even if there is only one calibrator regardless of its acquisition time (before or after the source). The user can change the associated calibrators by selecting a source and then by choosing in the lists of calibrators 1 and 2 which are to be used or removed («null» meaning the corresponding calibrator will not be used).

Solution States And St

MODIFY LIS	T CALIBRATOR				_ _ 				
	C = Calibrators, S = Sources, R = Removed								
Here, you	can modify the value of calibrators' diameter or err_diameter. These no	ew values	will be used to compu	ute the visibilities					
Target	File	Code	Diameter	Err Diameter					
hd39400 hd39400 hd39400 alfori alfori alfori alfori hd39400 hd39400	C:\Results\031108\FRGE.2003-11-08T05_24_16.000.fits C:\Results\031108\FRGE.2003-11-08T05_25_32.451.fits C:\Results\031108\FRGE.2003-11-08T05_27_58.000.fits C:\Results\031108\FRGE.2003-11-08T05_11_07.000.fits C:\Results\031108\FRGE.2003-11-08T06_11_07.000.fits C:\Results\031108\FRGE.2003-11-08T06_15_09.000.fits C:\Results\031108\FRGE.2003-11-08T06_15_09.000.fits C:\Results\031108\FRGE.2003-11-08T06_15_09.000.fits C:\Results\031108\FRGE.2003-11-08T06_5_00.207.fits C:\Results\031108\FRGE.2003-11-08T06_40_55.000.fits C:\Results\031108\FRGE.2003-11-08T06_42_11.451.fits	บบบบดดดดบบ	2.25000 2.25000 2.25000 0.000000 0.000000 0.000000 0.000000 0.000000	0.120000 0.120000 0.120000 0.000000 0.000000 0.000000 0.000000					
	ОК								

Here, it is possible to modify the value of the diameters of the calibrators and their errors. These modifications are taken into account in the following steps to calculate the visibilities.

Scompute Visibilities

The computation of the visibilities is done without graphic interfaces. The program will inform by a message that the computation is finished.

S DISPLAY RESULTS

The box *Display Results* can display the results of the computations thanks to the following widget:



The user can:

- List the parameters corresponding to the various sources/calibrators (*Select Parameter*): baseline, list of sources, list of calibrators, projected baseline, U, V coordinates, ...

🎒 DR5 MIDI Report Analysis	
Spatial Frequency U V (in meters) hd39400 5:29:14.432 18.950502, 31.539421	Select Parameter Spatial Frequency List Parameter hd39400 05_29_14.431 alfori 06_11_07.000
	Object: alfori 06_12_07.290 alfori 06_15_09.000 Transfert Function Plot OPlot Transfert Function
	Select Visibility Contrast List Values SAVING
	Save on ASCII File Save on FITS File Save on OL_FITS File
₹ 	Delete plots Close

- Plot the transfer function, visibility and contrast for the sources as well as for the calibrators which were processed. Here is the example of the Source ALFORI 06_11_07.000:
 - \Rightarrow Select the object: click on ALFORI 06_11_07.000
 - \Rightarrow Select the layout desired then click on *Plot*



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It is possible to superimpose the layouts of the same type (click on *Oplot*), for example: visibility for all the sources, in order to compare the results obtained.

- List the preceding values (or a selection of these values) with the corresponding error bars:

🎒 DRS N	1IDI Report a	Analysis						
alfori 20)03-11-08T06:1	1:07.000						
Wavelend	ath Cot Transf2	Err Trans2	Visib2 E	rr Visib2 Me	an Fc2 Err	Mfc2		Select Parameter Spatial Hequency
13.4133	-NaN	-NaN	-NaN -I	NaN -N	aN NaN	1		List Parameter
13.3765	i -NaN	NaN	-NaN -I	VaN -N	laN -NaM	1		
13.3394	1.771277	0.012223	0.061081	0.000653	0.034484	0.000131		hd39400 05_29_14.431
13.3019	2.016315	0.043243	0.072435	0.001622	0.035924	0.000034		alfori 06 11 07 000
13.2642	2.121438	0.015021	0.075686	0.000571	0.035677	0.000016		
13.2261	2.194164	0.081212	0.074133	0.002811	0.033787	0.000031		Ubject: alfori U6_12_07.290
13.1878	2.145962	0.039318	0.071214	0.001371	0.033185	0.000031		alfori 06_15_09.000 🛛 🖵
13.1491	1.896636	0.023659	0.063174	0.000920	0.033309	0.000070		
13.1101	1.824182	0.029222	0.050050	0.001250	0.032924	0.000158		
13.0708	i 1.934012	0.023489	0.055170	0.000984	0.032662	0.000112		Transfert Eurotion
10.0012	1.752304	0.010131	0.0000000	0.000330	0.031241	0.000007		
12.3313	2 000172	0.024030	0.061427	0.000004	0.032027	0.000017		Plot OPlot
12.3311	2.000173	0.003610	0.063036	0.000185	0.031343	0.000032		
12.3100	1 900065	0.017522	0.054355	0.0000007	0.030480	0.000138		
12.0030	1 892967	0.034636	0.058261	0.0001100	0.030778	0.000004		
12 7872	1 937084	0.018116	0.054458	0.000599	0.028113	0.000046		I I ransfert Function
12 7454	1 828648	0.024489	0.050489	0.000801	0.027610	830000 0		
12,7034	1.843067	0.010871	0.049203	0.000324	0.026696	0.000018		Select 🗹 Visibility
12,6610	1.877121	0.009989	0.051840	0.000430	0.027617	0.000082		
12,6183	2.012220	0.011775	0.056925	0.001086	0.028290	0.000374		🖌 🗹 Contrast
12.5754	1.925206	0.024587	0.053600	0.000941	0.027841	0.000133		
12.5321	1.909579	0.028828	0.051517	0.000803	0.026978	0.000013		List Values
12.4885	1.760536	0.003986	0.047160	0.000202	0.026787	0.000054		
12.4446	1.927825	0.009914	0.050650	0.000467	0.026273	0.000107		
12.4004	1.814933	0.003675	0.047610	0.000281	0.026233	0.000102		SAVING
12.3558	1.871432	0.004541	0.050115	0.000281	0.026779	0.000085		Save on ASCILEIle Cave on ELTS File
12.3110	1.860828	0.009613	0.047725	0.000356	0.025647	0.000059		
12.2659	1.858920	0.005325	0.044039	0.000303	0.023691	0.000095		Save on OL EITS File
12.2204	1.916053	0.021679	0.045176	0.000544	0.023577	0.000017		
12.1747	1.790760	0.016914	0.042431	0.000443	0.023695	0.000024		
12.1286	1.744709	0.017666	0.041310	0.000593	0.023677	0.000100		Delete plots
12.0823	1.864165	0.006569	0.040899	0.000310	0.021939	0.000089		
12.0356	1.803363	0.018363	0.038531	0.000862	0.021288	0.000260	النے	Claus
						<u> </u>		Liose

- Record the preceding values (or a choice of these values) :
 - 1. in a FITS or ASCII file whose name is derived by replacing FRGE in the fringe file name by RESU (for the first method) and by MEAN (for the second method).
 - 2. in a OI_FITS file whose name is derived by replacing FRGE in the fringe file name by OIF1 (for the first method) and by OIF2 (for the second method).

Caution:

The layouts are:

- Transfer function
- Visibility
- Contrast

The FITS or ASCII record files contain:

- (Co- Transfer Function)²
- $Error(CoTF)^2$
- $\overline{}$ (Visibility)²
- $\overline{}$ Error(Visibility)²
- (Average_FactorContrast)²
- Error(Average_FactorContrast)²

The OI_FITS files (OIF1*.fits for the first method, OIF2*.fits for the second method) contain:

Primary (Extension = 0) Extension = 1, EXTNAME = 'OI_ARRAY' Extension = 2, EXTNAME = 'OI_TARGET' Extension = 3, EXTNAME = 'OI_WAVELENGTH' Extension = 4, EXTNAME = 'OI_VIS2'

For the moment, the MIDI data do not enable us to have certain values for the OI_TARGET table:

RA_ERR	:	Error in RA at mean equinox (degrees)
DEC_ERR	:	Error in DEC at mean equinox (degrees)
SYSVEL	:	Systemic radial velocity (meters per second)
VELTYP	:	Reference for radial velocity ('LSR', 'GEOCENTR', etc.)
VELDEF	:	Definition of radial velocity ('OPTICAL', 'RADIO')
PMRA	:	Proper motion in RA (degrees per year)
PMDEC	:	Proper motion in DEC (degrees per year)
PMRA_ERR	:	Error of proper motion in RA (degrees per year)
PMDEC_ERR	:	Error of proper motion in DEC (degrees per year)
PARALLAX	:	Parallax (degrees)
PARA_ERR	:	Error in parallax (degrees)
SPECTYP	:	Spectral type

Thus by default, they are set to zero or "".