	JMMC-MAN-2100-0002 Revision 10.0 Date: 17/09/2007

JMMC

ASPRO-VLTI User's Manual

Authors:
Gaspard Duchêne <Gaspard.Duchene@obs.ujf-grenoble.fr> — LAOG/JMMC
Gilles Duvert <Gilles.Duvert@obs.ujf-grenoble.fr> — LAOG/JMMC
Daniel Bonneau <Daniel.Bonneau@obs-azur.fr> — OCA/JMMC
Olivier Chesneau <Olivier.Chesneau@obs-azur.fr> — OCA/JMMC

Author: Gaspard Duchêne Institute: LAOG/JMMC	Signature: SUBMITTED Date: 17/03/2007
Approved by: Gérard Zins Institute: LAOG/JMMC	Signature: APPROVED Date: 17/09/2007
Released by: Gilles Duvert Institute: LAOG/JMMC	Signature: RELEASED Date: 17/09/2007

Change record

Revision	Date	Authors	Sections/Pages affected
	Remarks		
1.0	01/03/2005	G. Duchêne	all
	User's Manual for preparation of observations during P75		
2.0	18/03/2005	G. Duchêne	all
	User's Manual for preparation of observations during P76		
3.0	13/09/2005	G. Duchêne	all
	User's Manual for preparation of observations during P76 and P77		
4.0	20/02/2006	G. Duchêne	25-end
	Updated for SearchCal 3.3		
5.0	16/03/2006	G. Duchêne	all
	User's Manual for preparation of observations during P77 and P78		
6.0	02/05/2006	G. Duchêne	Appendix A
	New version of SearchCal software		
7.0	14/09/2006	G. Duchêne	all
	User's Manual for preparation of observations during P78 and P79		
8.0	12/03/2007	G. Duchêne	all
	User's Manual for preparation of observations during P79 and P80		
9.0	15/03/2007	S. Cètre	Appendix A
	Updated description of variability flags displayed in SearchCal GUI		
10.0	17/09/2007	G. Duchêne	all
	User's Manual for preparation of observations during P80 and P81		

Table of contents

List of Tables

List of Figures

1 Introduction

1.1 Object

This document describes the usage of **ASPRO-VLTI**, a software derived from the JMMC general software for preparing interferometric observations, **ASPRO**. **ASPRO-VLTI** allows users to simulate VLTI observations with the setups offered by ESO for Period 80 and 81.

1.2 Reference documents

[1] JMMC-MAN-2100-0001, Revision 6.0, **ASPRO** User's Manual

1.3 Abbreviations and acronyms

AMBER	Astronomical Multi Beam Recombiner
ASPRO	Astronomical Software to PrepaRe Observations
AT	Auxiliary Telescope
CDS	Centre de Données astronomiques de Strasbourg
CHARA	Center for High Angular Resolution Astronomy
COAST	Cambridge Optical Aperture Synthesis Telescope
DFT	Discrete Fourier Transform
ESO	European Southern Observatory
ETC	Exposure Time Calculator
FAQ	Frequently Asked Questions
FITS	Flexible Image Transport System
FWHM	Full Width at Half-Maximum
GI2T	Grand Interféromètre à 2 Télescopes
GILDAS	Grenoble Image and Line Data Analysis System
GUI	Graphic User Interface
IOTA	Infrared Optical Telescope Array
IRAM	Institut de RadioAstronomie Millimétrique
JMMC	Jean-Marie Mariotti Center
MIDI	MID-infrared Instrument
PDF	Portable Document Format
PS	PostScript
PTI	Palomar Testbed Interferometer
RMS	Root Mean Square
SIMBAD	Set of Identifications, Measurements and Bibliography for Astronomical Data
UT	Unit Telescope
VLTI	Very Large Telescope Interferometer
XML	eXtensible Markup Language

2 Overview

2.1 Brief functional description

ASPRO-VLTI is designed to allow effortless usage by any astronomer; in particular, no detailed knowledge of optical interferometry is required. The only prior information that the user should provide is the instrument he/she would like to use and the physical properties of his/her target. **ASPRO-VLTI** provides tools to determine the optimal VLTI configuration and interferometric calibrators to achieve the user's astrophysical goals. The optimization is performed through estimating synthetic interferometric observables (visibilities) as well as through fitting theoretical models on these quantities. The fitting process takes into account the measurement errors of the interferometric signal based on the instrument's ETC.

ASPRO-VLTI is organized as a suite of four main successive modules (see Fig. 1), which are briefly presented below and described in more details later in Sect. 3. The four modules are:

- **OBJECT**: to define the target properties (name, coordinates, photometry and model of its geometry);
- **OBSERVATIONAL SETUP**: to define the VLTI configuration to be used in the observations; this includes defining both the telescope array and the instrumental setup;
- **UV PLOTS**: to calculate and plot interferometric observables and their associated uncertainties;
- **FIT MODEL**: to fit parametric models to the synthetic interferometric signal that are created by the **UV PLOTS** module.

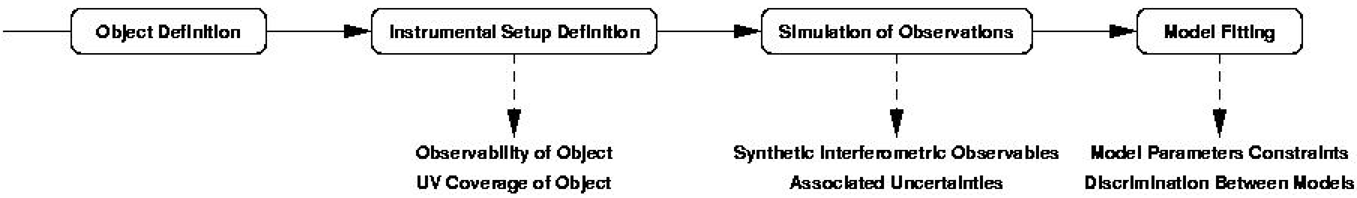


Figure 1: Outline of the usage of **ASPRO-VLTI**. Users go through each of these four main modules and obtain some quantitative results indicated below each module.

The UV coverage of the object with VLTI is provided by the **OBSERVATIONAL SETUP** module. With the **UV PLOTS** module, the user can readily estimate if observing the target in the requested configuration will yield visibilities that are accurately measurable and that vary significantly as a function of time, for instance. The **FIT MODEL** module allows the user to estimate whether the observations would yield tight constraints on the geometrical model of the source, possibly leading to the exclusion of some models, for instance. In addition to these outputs, **ASPRO-VLTI** also provides a tool to search for adequate interferometric calibrators; the user is provided with a list of objects, along with a number of relevant properties, from which the most appropriate ones can be selected.

2.2 System requirements

ASPRO-VLTI is run remotely through the JMMC website. It is normally run as a `Java2 applet`, which requires Java 1.5 at least as well as the appropriate `Java plug-in`. If it is not installed, please install the J2SE Runtime Environment (see `http://java.sun.com`).

ASPRO-VLTI can be used in *anonymous* or *authenticated* mode. Authenticated mode permits to exchange files with the server and retrieve previously stored user preferences and files. When launching **ASPRO-VLTI** anonymously, the user connects to one of the 16 **ASPRO-VLTI** *visitor accounts* available. If all accounts are already being used, the application will not start and the user must try again later. All connections use one TCP port in the range 50000-52500. In case of systematic failure to start the application, the user must check that he/she is not working in front of a firewall that blocks part of this port range.

An alternative method to start **ASPRO-VLTI** is to launch it as a `Java Webstart` application, also available from the JMMC website. This only requires the installation of `Java Runtime Tool Kit` on the user's computer, also available from `http://java.sun.com`.

The **ASPRO-VLTI** GUI has been created by JMMC based on Java and XML technologies. The use of the GUI should be totally transparent to the user; if necessary, a document describing the basic principles of the XML-based GUI is available from the JMMC website. Additional information on how to set up your computer to use Java properly can be found at `http://www.mariotti.fr/java_infos.htm`.

3 Using ASPRO-VLTI

This section describes how to launch the **ASPRO** package and to use **ASPRO-VLTI**, which is a part of this package. If problems occur while running **ASPRO-VLTI**, check here for possible errors in selecting options or providing information to the software. Furthermore, right-clicking (`<CTRL>`-click for Macintosh users) on a variable/parameter name in any panel brings up a brief explanation of its nature and possible values. In addition, use the `Help` buttons available in each **ASPRO-VLTI** panel. If no solution to a problem can be found there, please send an email to the JMMC User Support group (`user-support@mariotti.ujf-grenoble.fr`) with a detailed description of the problem (including input parameters and error messages appearing in the LOG window, if any).

Each of the **OBJECT**, **OBSERVATIONAL SETUP**, **UV PLOTS** and **FIT MODEL** panels, which are described below, contains a `CLOSE` button to dismiss it. However, navigation between modules of **ASPRO-VLTI** should normally be performed with the `Proceed to ...` and `Back to...` buttons, a method which ensures that the four main modules of **ASPRO-VLTI** are used in the appropriate order.

Note ***ASPRO-VLTI*** *generates several files as commands are executed and uses them in other modules. The naming convention of these files, which can be retrieved by the user from his/her* ***ASPRO-VLTI*** *account, is automatic and cannot be modified by the user.*

3.1 Launching the ASPRO package

3.1.1 The launcher applet

Figure 2: The **Application Applet** window for anonymous (*left*) and personal account (*right*) login to **ASPRO-VLTI**.

To start a new **ASPRO-VLTI** session, click on the `Start the Application Launcher Applet` icon/link in the **ASPRO** webpage. If the appropriate `Java2 applet` is installed (see Sect. 2.2), an **Application Applet** window will appear on the user's screen (see left part of Fig. 2). Select **Help** under the **?** menu for a basic description of the usage of the applet. Note that, at this stage, **ASPRO-VLTI** has not yet been started; the Java applet has only initiated a new "session", from which it is possible to start the entire suite of JMMC softwares, including **ASPRO-VLTI**.

3.1.2 Anonymous vs. authenticated login on the ASPRO server

The user can decide to launch **ASPRO-VLTI** either anonymously (default option offered by the **Application Applet** window) or using a pre-defined username. First- or one-time **ASPRO-VLTI** users can usually accommodate using the anonymous login option. For frequent **ASPRO-VLTI** users and/or for repeated use of some custom input/setup files, the use of a personal account is usually more appropriate. Note that it is not possible to upload files (such as FITS files representing object models) to the JMMC servers using anonymous login, nor is it possible to retrieve files created or used during previous use of **ASPRO-VLTI**. It is however possible to save any plot generated by **ASPRO-VLTI** as a PS or PDF file with either type of login.

3.1.3 Setting a personal account on the ASPRO server

Setting a personal account can be done simply by subscribing to the `aspro-users` mailing list. After sending an email to `sympa@mariotti.ujf-grenoble.fr` (with `sub aspro-users` in the subject line), the user will receive a confirmation email containing his/her username and password. These are the entries to provide in the **Application Applet** window after checking the *Start application using my account informations* box (see right part of Fig. 2).

3.1.4 Starting the ASPRO package

To start the entire **ASPRO** package, which includes **ASPRO-VLTI**, either anonymously or after logging in with a valid username/password combination (do not forget to click on the `Login` button once after filling the username and password fields), simply select **ASPRO** in the **Start** menu of the **Application Applet**.

When **ASPRO-VLTI** is launched, one or two new tab(s) appear in the **Application Applet** window: **ASPRO** and, if the user has used an authenticated login, **File Management** (see Fig. 3). The **ASPRO** tab should indicate that **ASPRO-VLTI** is now running.

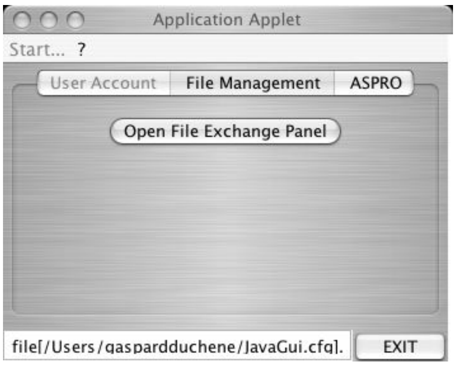


Figure 3: The new tabs appearing in the **Application Applet** window after **ASPRO-VLTI** has been launched.

3.1.5 Uploading and downloading files to/from the ASPRO server

If the user has started the application with an authenticated login, the `Open File Exchange Panel` button in the **File Management** tab allows him/her to upload/download files from his/her personal **ASPRO-**

VLTI account. Clicking on this button opens a **File Exchange** window (see left part of Fig. 4) that lists all files currently present on the user's account (it is empty when the account has just been created). Checking the *Enable File Management* box opens a second sub-panel in the **File Exchange** window (see right part of Fig. 4) that lists and allows to browse the files and directories present on the user's personal computer. To upload a file on the JMMC servers, highlight the file in the **Local File System** sub-panel and click on the [<] button; the file should appear in the **Remote File System** sub-panel. Reversely, to download a file from the JMMC servers, select the file and click on the [>] button after selecting the appropriate download directory. Click on the `Cancel` button in the **Remote File System** sub-panel to dismiss the **File exchange** window.

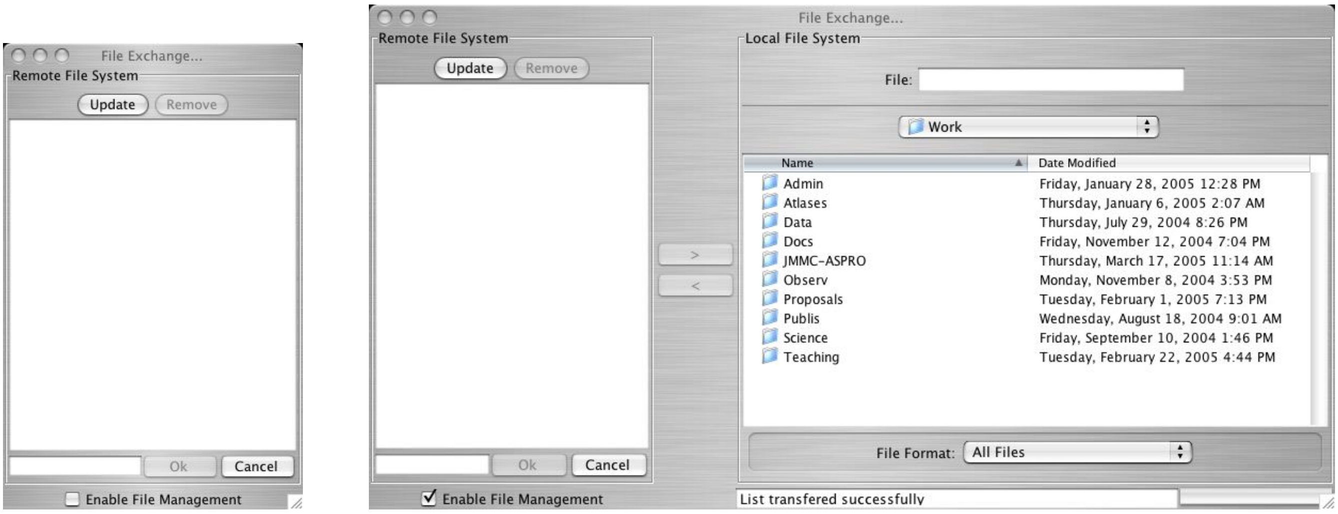


Figure 4: The **File Exchange** windows to upload and download files from a personal **ASPRO-VLTI** account.

3.2 The ASPRO package

Once the user has launched the **ASPRO** package, he is presented with two GUI windows (see Fig. 5): the graphic window, in which plots will be presented when running **ASPRO-VLTI**, and the start-up control window. At this stage, the start-up control window contains only a **Choose** menu, from which the user actually selects the JMMC software he wants to use for this session. The possible choices are:

- **AMBER, Periods 80-81**
- **MIDI, Periods 80-81**
- **Full ASPRO Interface**

The first two choices represent the specific versions of **ASPRO-VLTI** available for preparing observations for Period 81 with either instrument. Note that the technical details of both AMBER and MIDI instruments are the same for Periods 80 and 81. The appearance and usage of **ASPRO-VLTI** is essentially the same for both versions, with only minor details varying from one to the other (such as the instrument sensitivities or the observing wavelength). In the remainder of this document, we describe the usage of **MIDI, Periods 80-81**, and only explicitly discuss the specificities of other versions when needed.

The **Full ASPRO Interface** choices starts up the wider-scope **ASPRO** software, which allows simulations of observations with other interferometers (CHARA, COAST, IOTA) as well as configuration of VLTI with MIDI and AMBER that are not available for Period 81 and with future VLTI instruments allowing observations with 4-, 6- and 8-telescope arrays. This version of the software is not described here; a specific Users' Manual is available from JMMC.

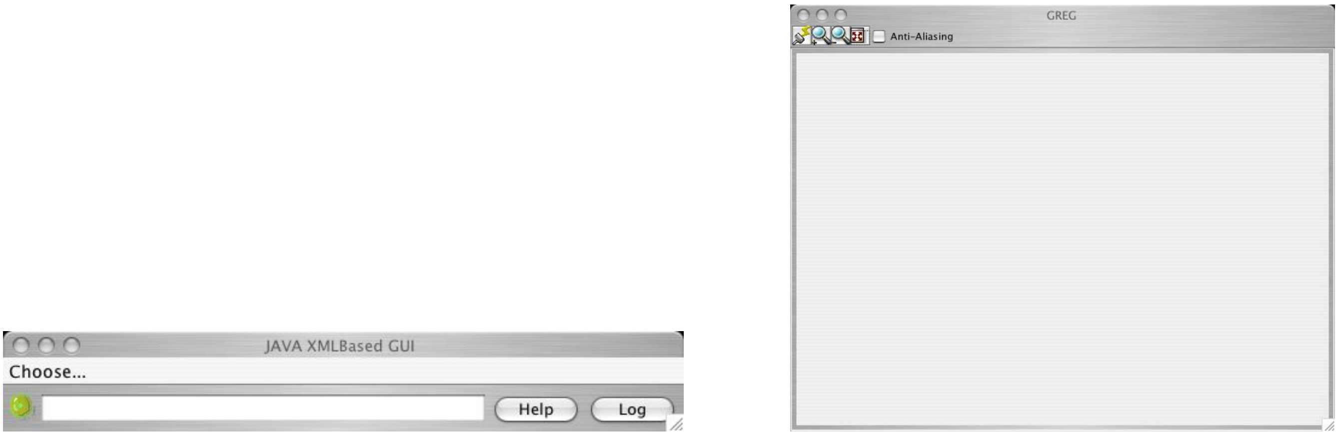


Figure 5: The two GUI windows that are automatically opened upon launching the **ASPRO** package: the start-up control window (*top*) and the graphical window (*bottom left*).

3.3 First contact with ASPRO-VLTI

Once a specific version of **ASPRO-VLTI** has been selected, the main control window offers seven menus (see Fig. 6). The **EXIT** menu allows to quit **ASPRO-VLTI**. The **OBJECT**, **OBSERVATIONAL SETUP**, **UV PLOTS** and **FIT MODEL** menus allow the user to enter the four main modules constituting **ASPRO-VLTI** (see Fig. 1). The **PLOT** and **MISC** modules offer several helpful commands that can be used at any time while running **ASPRO-VLTI**. All menus are described in more detail in the remainder of this document.

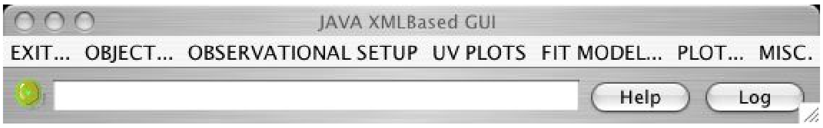


Figure 6: The appearance of the main control window GUI once the user has selected a version **ASPRO-VLTI**.

In addition to these main menus, the main control window contains an `Help` button and a button to open the LOG window in which **ASPRO-VLTI** prints out messages as it executes commands. The content of the LOG window can be useful while troubleshooting. To the left of these two buttons is a white-background window in which **ASPRO-VLTI** provides short statements about its status while running commands; it is usually empty when the software is idle. Finally, to the left of this window is a roundish icon whose color indicates **ASPRO-VLTI** status: when it is green, the software is up and running and waiting for commands from the user; when it is orange, it is executing a command; when it is red, the software has run into an error and stopped. *Commands can only be executed when this icon is green.* If it is orange, wait for the command to be completed. If it is red (or stuck on orange for at least a couple of minutes), try using (a few times if necessary) **Exit From Error Loop** in the **MISC** menu (see Sect. 3.10.5). If this is not enough to restore a normal running state for **ASPRO-VLTI**, then there has been a severe crash; it is then recommended to quit **ASPRO-VLTI** and restart if from scratch. If the same problem occurs repeatedly, checking the content of the LOG window may provide an indication of the nature of the problem.

The buttons located in the top left corner of the graphical window represent the following, from left to right:

– **Refresh Plot** redraws the last plot requested in case of problem;

– **Zoom In** increases the zoom factor and provides scrolling bars to move around in the plot;

– **Zoom Out** decreases the zoom factor;

– **Toggle Scrolling Bars On and Off** adjusts the window size to the current zoom while removing the scrolling bars;

– the *Anti-Aliasing* option can be used for improving the quality of the graphical display on your computer screen.

3.4 EXIT menu

The only command under the **EXIT** menu, **Exit From ASPRO-MIDI_UT** quits the **ASPRO-VLTI** software after confirmation in a pop-up window. After the software is shut down (the GUI windows are dismissed), the **Application Applet** window remains in the user's screen, but the **ASPRO** tab has now disappeared. The configuration of the applet window is identical to its status after the user has first started the applet (see Fig. 2); in particular, if the user had logged in with his/her personal account information, he/she has been automatically logged out. Clicking on the `EXIT` button terminates the current **ASPRO-VLTI** session.

3.5 OBJECT menu

This menu brings up the first main module constituting **ASPRO-VLTI**: the object definition module. Here, the user must provide all properties that define the interferometric target: its name, coordinates, brightness and a model of its geometry. The coordinates of the object can be entered by hand (see Sect. 3.5.1) or retrieved from the CDS database (see Sect. 3.5.2). Also, **ASPRO-VLTI** provides a tool to find the most appropriate calibrators for a given scientific target, taking into account the required accuracy on the visibilities (see Sect. 3.5.3).

3.5.1 Manual Object Entry

Selecting **Manual Object Entry** under the **OBJECT** menu brings up the **All About My Source** panel illustrated in the left part of Fig. 7.

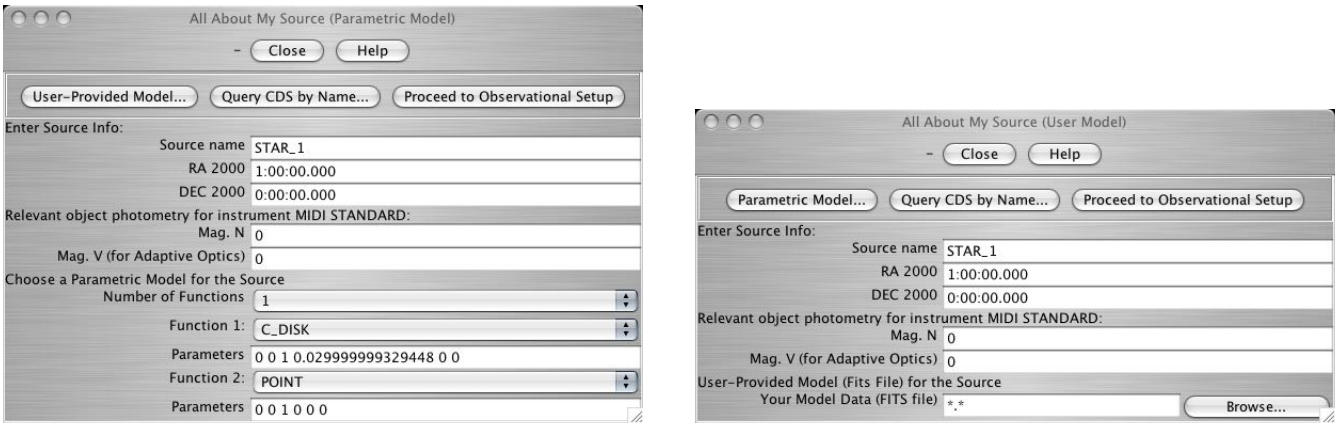


Figure 7: The **All About My Source** panel opened by the **Manual Object Entry** menu in the case of a parametric model of the source (default, *left*) and of a user-provided FITS model (*right*).

In the upper half of the panel, the user must provide the target name (*Source Name*, with no more than 24 characters and no embedded `<space>`; use `<underscore>` instead), its J2000 coordinates (*RA 2000* and *DEC 2000*; format should be `HH:MM:SS.SSS` and `DD:MM:SS.SSS`) and its N/JHK band magnitude (*Mag.*

Table 1: List of available analytical models and the parameters that describe them.

Name	Description	Par. 1	Par. 2	Par. 3	Par. 4	Par. 5	Par. 6
Point	Point Source (Dirac function)	$\Delta\alpha$	$\Delta\delta$	F_ν	–	–	–
C_Gauss	Circularly symmetric Gaussian distribution	$\Delta\alpha$	$\Delta\delta$	F_ν	$D^{1/2}$	–	–
E_Gauss	Elliptical Gaussian distribution	$\Delta\alpha$	$\Delta\delta$	F_ν	$D_M^{1/2}$	$D_m^{1/2}$	θ
C_Disk	Circular disk (a.k.a. uniform disk)	$\Delta\alpha$	$\Delta\delta$	F_ν	D	–	–
E_Disk	Elliptical uniform disk (i.e., inclined **C_Disk**)	$\Delta\alpha$	$\Delta\delta$	F_ν	D_M	D_m	θ
Ring	Uniform ring with finite width	$\Delta\alpha$	$\Delta\delta$	F_ν	D_i	D_o	–
U_Ring	Unresolved (infinitely narrow) ring	$\Delta\alpha$	$\Delta\delta$	F_ν	D	–	–
Exp	Exponential brightness distribution	$\Delta\alpha$	$\Delta\delta$	F_ν	$D^{1/2}$	–	–
Power-2	$1/r^2$ brightness distribution	$\Delta\alpha$	$\Delta\delta$	F_ν	$D^{1/2}$	–	–
Power-3	$1/r^3$ brightness distribution	$\Delta\alpha$	$\Delta\delta$	F_ν	$D^{1/2}$	–	–
LD_Disk	Limb-darkened disk (resolved star)	$\Delta\alpha$	$\Delta\delta$	F_ν	D	C_U	C_V
Binary	Binary point source	$\Delta\alpha$	$\Delta\delta$	F_ν	FR	ρ	θ

N/Mag. J/H/K), the relevant filter(s) for MIDI/AMBER observations. In addition, on the case of AMBER observations, the H band magnitude is required in order to assess the usability of FINITO. If the brightness of the object is below the minimum required by ESO[1] for observations during Period 81, a warning window will pop-up when proceeding to the **OBSERVATIONAL SETUP** module. In addition, the V band magnitude of the object is requested as the interferometer is fed by an adaptive optics system using an optical wave-front sensor. The coordinates of the object can also be retrieved from the CDS database by clicking on the `Query CDS By Name` button (see Sect. 3.5.2).

In the bottom half of the panel, the user must define the geometrical model of the target. The default option to do this is to select one or the weighted sum of two simple parametric models for which the Fourier Transform can be calculated analytically. This choice is provided with the *Number of Function* scroll-down menu. The list of functions, along with the appropriate sets of parameters can be found in Table 1. Provide the name of the desired functions (*Function 1* and *Function 2*) and their associated parameters (*Parameters*). **Important:** *Be sure to provide 6 parameters for each function, even though less parameters are needed to describe some of them; fill in the list with* `0`*s if necessary.*

The first two parameters for all models, $\Delta\alpha$ and $\Delta\delta$, represent the angular offset from the coordinate center (i.e., the values entered for *RA 2000* and *Dec 2000*). This is useful when using a model that sums two parametric functions that represent spatially-separated components of the object; for one-function models, these parameters should be set to `0 0`. F_ν represents the normalized flux associated to the model: when

[1] Note that the minimum brightness indicated by ESO applies to the *correlated flux* of the object, i.e., basically the product of the object *total flux* by its interferometric visibility. Since the visibilities are only calculated in the **UV PLOTS** module, only the *total flux* can be tested against the required minimum brightness at this stage. Remember however that if the object visibility is $V = 0.25$ (e.g., 25%), then its correlated flux is about 1.5 mag fainter than its total flux, for instance.

using only one analytical model, set this to `1`, and when using the sum of two models, make sure that $F_{\nu,1} + F_{\nu,2} = 1$. D and $D^{1/2}$ represent the diameter and FWHM of the model, respectively. The subscripts M and m indicate the major and minor axis, respectively, whereas i and o indicate the inner and outer diameters. θ is the position angle of the major axis (models `E_Gauss` and `E_Disk`) or of the binary system (model `Binary`). Finally, FR is the flux ratio of the binary and C_U and C_V are the coefficients defining the limb-darkening profile. This profile is defined such that the Fourier Transform of the limb-darkened disk is:

$$G(u, v) = [a\ (J_1(x)/x) + 1.253\ b\ (J_3(x)/x) + 2\ c\ (J_2(x)/x^2)]\ /\ s$$

where $x = \pi D(u^2 + v^2)$, $J_1(x)$ and $J_2(x)$ are Bessel functions, $J_3(x) = \sqrt{0.637/x}\ (\sin x\ /x - \cos x)$, $a = 1 - C_U - C_V$, $b = C_U + 2C_V$, $c = -C_V$ and $s = a/2 + b/3 + c/4$.

All angular distances must be given in arcseconds (even though milli-arcseconds usually is a more natural unit for optical interferometry). The position angle is expressed in degrees (following the usual astronomical convention, i.e., measured East from North).

If none of the parametric models adequately describe the geometry of the target, the user can decide to use a FITS file instead, for which **ASPRO-VLTI** can calculate the Fourier Transform using a DFT. This can be done by clicking on the `User-Provided Model` button, which brings a new **All About My Source** panel (see right part of Fig. 7). The top part of the panel is unchanged and previously entered information (source name, coordinates and magnitude) is still present. Only the bottom part has changed and now contains a single entry (*Your Model Data*) in which the user indicates his/her FITS model (see the adequate format below). Either indicate the file name or, if it has not yet been uploaded on the user's personal **ASPRO-VLTI** account, click on the `Browse` button, which opens the **Select One File** window, whose use is much similar to that of the **File Exchange** window described in Sect. 3.1.5 (in case of anonymous login to **ASPRO-VLTI**, the user must upload his/her files at every login since they cannot be stored on the server). Once the FITS file is uploaded, highlight it in the **Remote File System** sub-panel and click on `Ok` to validate the choice; the upload window is automatically dismissed and the filename now appears in the *Your Model Data* entry of the **All About My Source** panel. If the user has no adequate FITS file, click on the `Parametric Model` and select a parametric model from the available list instead.

The user-provided FITS file should have 2 or 3 dimensions. The third dimension, if present, represents independent spectral channel. This capability is not yet fully implemented in **ASPRO-VLTI** and the software currently processes only the first slice of an input datacube. The two spatial dimensions must have the same number of pixel (i.e., square image). The FITS file header must contain a certain type of information so that **ASPRO-VLTI** can deal with it properly. In particular, the pixel scale must be provided. Here is a possible beginning for a valid FITS file header:

```
NAXIS   =                    2 /2 minimum!
NAXIS1  =                  512 /size 1st axis
NAXIS2  =                  512 /size 2nd axis
CRVAL1  =  0.0000000000000E+00 / center is at 0
CRPIX1  =  0.2560000000000E+03 / reference pixel is 256 in Alpha
CDELT1  = -0.4848136811095E-09 / increment is 0.0001" in radians,
                               / and 'astronomy oriented (negative)'
CRVAL2  =  0.0000000000000E+00 / center is at 0
CRPIX2  =  0.2560000000000E+03 / reference pixel is 256 in Delta
CDELT2  =  0.4848136811095E-09 / increment is 0.0001" in radians.
```

In this example, the "coordinate center" (i.e., the point where the object coordinates apply) is located at the center of the 512×512 image, and each pixel is 0.1 milli-arcsecond (or 0.48×10^{-9} radian) on the side.

Once the object has been entirely defined, click on the `Proceed to Observational Setup` button to move on to the second main module of **ASPRO-VLTI**, **UV PLOTS** (see Sect. 3.6).

3.5.2 Get CDS Object By Name

Selecting **Get CDS Object By Name** under the **OBJECT** menu or clicking on the `Query CDS By Name` button in the **Manual Object Entry** panel brings up the **Get Source Coordinates** panel (see Fig. 8). Enter a case-insensitive target name (*Enter CDS Source Name*, with no more than 24 characters and no embedded `<space>`; use `<underscore>` instead) and click on the `GO` button. If the requested object name is not resolved by SIMBAD, a pop-up window presents an error message; click on `GO` and enter a new object name, or click on `CLOSE` and select **Manual Object Entry** in the **OBJECT** menu. If the object name was resolved by SIMBAD, the panel is dismissed and an **All About My Source** panel appears with the coordinates retrieved from CDS. The object name cannot be modified in this panel, but its coordinates can be. Because of possible errors in the CDS database, it is recommended to check that the coordinates are correct and, if necessary, to modify them.

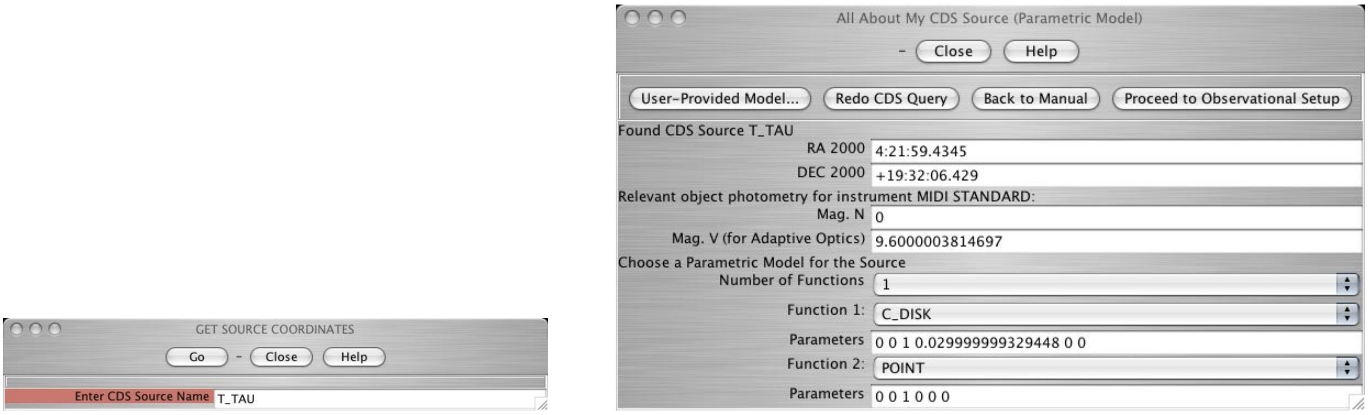


Figure 8: The **Get Source Coordinates** panel opened by the **Get CDS Object By Name** menu (*left*) and the resulting **All About My Source** panel (*right*).

The remainder of the object definition process is identical to that described in Sect. 3.5.1 and is not repeated here.

3.5.3 Calibrator(s)

Selecting **Calibrator(s)** in the **OBJECT** menu brings up the **Search Calibrators** panel (see Fig. 9). The basic principle of this tool is to provide the user with a list of stars that can be considered as "good" interferometric calibrators. These calibrators must fulfill a number of conditions, that include: proximity to the target, similar brightness as the target and well-defined radius (hence visibility). A more detailed description of the methods used by this piece of software is provided in Appendix A.

Calibrators are search for around the last target that has been defined by the user in the **OBJECT** menu[2]. The user must provide the desired *Observing Wavelength* (between 8 and 13 μm for MIDI observations and between 1.8 and 2.5 μm for AMBER observations) to calculate the calibrators' properties at the relevant wavelength. The scientific target brightness (*Science Object Magnitude in Search Band*) is carried over from the object definition panel; it is used by the software to search for calibrators of appropriate brightness for MIDI observations. For AMBER observations, the user must specify the range of magnitudes for the calibrators (*Magnitudes min & max to search*, entered as two real numbers separated by a `<space>` character). Then, a first set of selection criteria must be provided by the user concerning the distance to the object within which calibrators should be searched for (the default values are considered a good default

[2] The definition of a new object is only validated once the user clicks on the `Proceed to Observational Setup` button. If the defined does not appear in the proposed list of targets, repeat the object definition step and make sure to click on that button.

choice). Finally, the *max baseline used* is indicated to the user; if no array configuration has been selected yet, then a default value is provided. Once the search criteria are selected, click on the `GO` button to start the search.

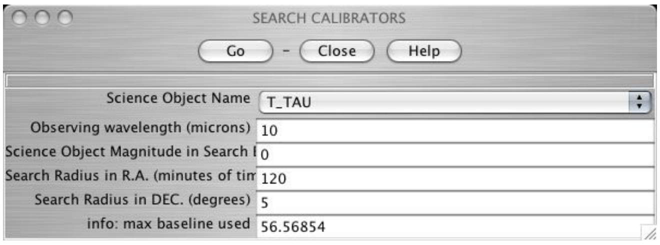


Figure 9: The **Search Calibrators** panel opened by the **Calibrator(s)** menu.

Once the search is over, the results are presented in a new window illustrated in Fig. 10. A detailed description of the window presenting the results and of the available methods to refine the search for the most appropriate calibrators is presented in Appendix A.

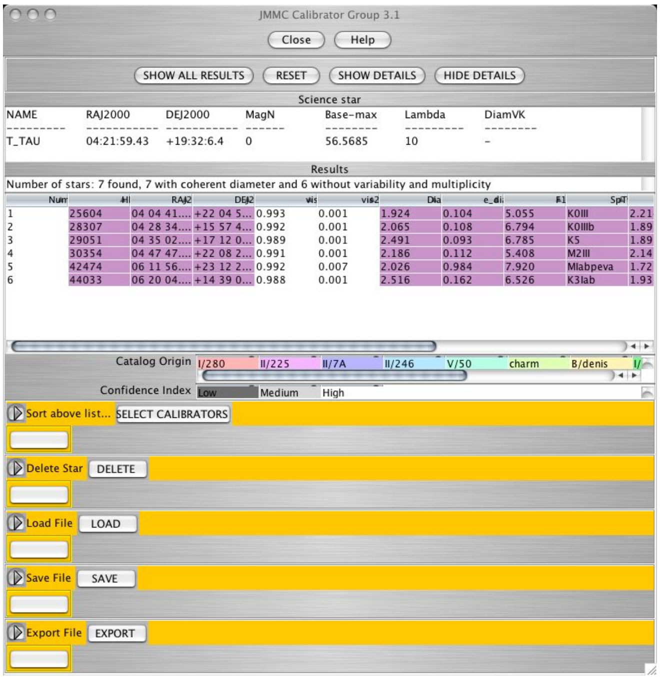


Figure 10: The window presenting the results of the Search Calibrators tool.

Once the user has retrieve a calibrator list or has confirmed that good calibrators are available for his/her target, both panels can be dismissed by clicking on the `CLOSE` buttons.

3.6 OBSERVATIONAL SETUP menu

The **Observational Setup** menu brings up the **Setup For Observation** panel (see left part of Fig. 11) in which the user indicates its intended instrumental setup. Clicking on the `Help on MIDI/AMBER` downloads the instrument-specific pages from ESO's Call for Proposals which contain the offered instrumental configurations for Period 81.

The default assumption is that the target will be followed during its entire transit as long as it remains at an elevation of at least 30 degrees, with the ESO-specified default observing frequency. These choices can be modified in the **Less Used Observing Constraints** sub-panel (see below). To check the actual observability of a target at a certain date, click on the `Source Observability` button. This brings up the **Observability** panel illustrated in the left part of Fig. 12. The user must enter the *Min. Elevation* (in degrees) above which he/she plans on observing the previously defined target and the *Date* to be tested (format should be `DD-MMM-YYYY` using decimal numbers for days and years and English 3-letter abbreviation for months). The telescope stations which have been defined in the **Setup For Observation** panel is reminded but cannot be changed in this panel. If the *Time-stamp DL Availability Zones* box is checked, the earliest and latest time at which the limited range of the delay lines will allow observation of the target. Once all parameters have been set, click on the `GO` button. The **Observability** panel will be dismissed, the **Setup For Observation** panel brought back, and a new plot will appear in the graphical window (see right part of Fig. 12). The horizontal axis represents time (local standard time and universal time are indicated on the top and bottom axes, respectively). Also indicated around the plot are the Moon phase (as a percentage of illumination) and brightness (apparent magnitude) the date of observations and reminder of the VLT coordinates. The night- and twilight-periods are indicated with dark and light shades of gray; the white are is day-time. The black horizontal segment indicates the period of the day during which the target is above the requested minimum elevation whereas the red segment indicates the period during which the VLTI delay lines allow observation of the target. Normally, with current VLTI technical information, it is be always possible to observe the target through its transit. This tool is therefore more appropriate to determine whether the entire transit occurs during night-time.

To determine the actual UV coverage of his/her proposed observations, the user must first provide the wavelength of interest (*Wavelength*, between 7 and 15 μm for MIDI and 1.46 and 2.54 μm for AMBER; values outside these ranges are rejected and a default value is automatically selected). Note that, with both MIDI and AMBER, a large wavelength range is covered with a single observation; however, plots created by **ASPRO-VLTI** apply to a single wavelength, which can be selected to be that of a spectral feature of interest, for instance. The user then specifies the VLTI baselines to be used (*Telescopes Configuration*). The checked *Reset Frame* box means that only the current array configuration is calculated. Unchecking this box and requesting a second set of telescopes results in the combination of the two arrays in a single "observation". The object magnitude (*Star magnitude in Band N*) cannot be modified in this module; if necessary, click on the `Back To Source Def` button to go back to the **OBJECT** module and modify the target brightness. The instrumental configuration must then be selected: for MIDI observations, the user must choose the *Beam Combiner* (`High_Sens` or `Sci_Phot`) and the *Spectrograph* (`Prism` or `Grism`); for AMBER observations, the user must select the *Spectral Resolution* (`High`, `Medium` or `Low`).

Once all parameters are set, click on the `GO (Show/Add UV Tracks)` button to visualize the UV coverage resulting from the requested setup (see right part of Fig. 11). The module of the Fourier Transform of the object model (i.e., the interferometric visibility) is automatically underplotted on a linear stretch, which provides a visual indication of the relevance of the selected setup. In the example given in Fig. 11, the selected UV coverage appears to sample a range of visibilities, from relatively high to low values. If the UV coverage appears inappropriate for the object model, the telescope stations and/or wavelength of interest can be modified and the UV coverage recalculated. Once a satisfactory coverage has been found, click on the `Proceed to Visibility Panel` button to reach the next main module of **ASPRO-VLTI**, **UV PLOTS** (see Sect. 3.7). Note that **ASPRO-VLTI** refuses to move on to the next module if the `GO (Show/Add UV Tracks)` button has not been clicked after the last modification of the instrumental setup.

If the default type of observation, i.e., following the target for an entire transit at elevations above 30 degrees with a pre-defined frequency, does not match the user's goal/intention, click on the arrow in the **Less Used Observing Constraints** sub-panel to open it and make some modifications (see left part of Fig. 13). There, it is possible to change the minimum and maximum hour angles (*Hour Angle Start* and *Hour Angle End*) and elevations (*Min. Elev. To Plot* and *Max. Elev. To Plot*). Only observations that satisfy both the hour angle and elevation requests are plotted. In addition, the user can changed the *Observing frequency* if longer or more sparse observations than the default, ESO-specified, frequency are required. Once new values of these parameters have been entered, click on the `Click Here to Validate Entries` to record

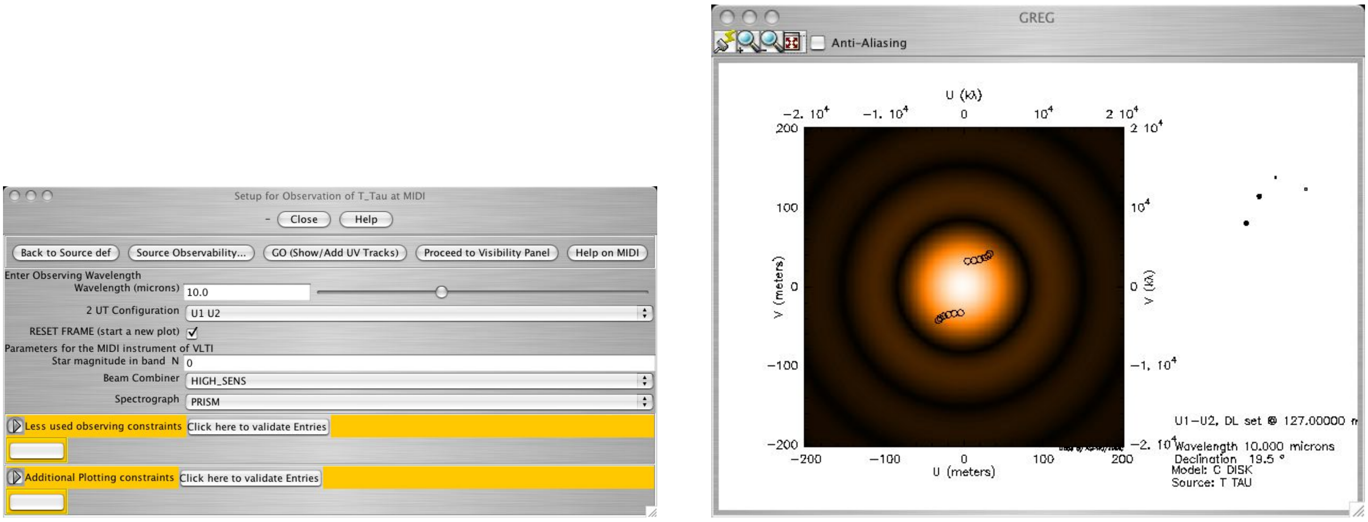


Figure 11: The default **Setup For Observation** panel (*left*) and the resulting UV coverage plot for a **E_Gauss** model (*right*).

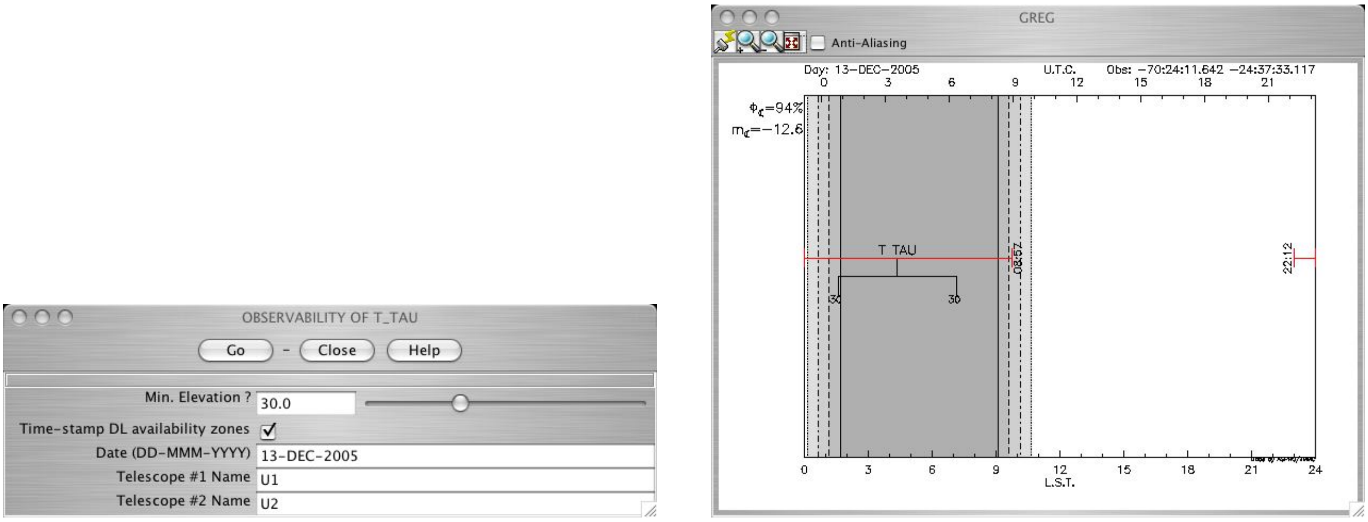


Figure 12: The **Observability** panel (*left*) and the resulting time coverage plot (*right*).

them and then repeat the UV coverage calculation by clicking on the `GO (Show/Add UV Tracks)` button. Click again on the arrow to dismiss the **Less Used Observing Constraints** sub-panel.

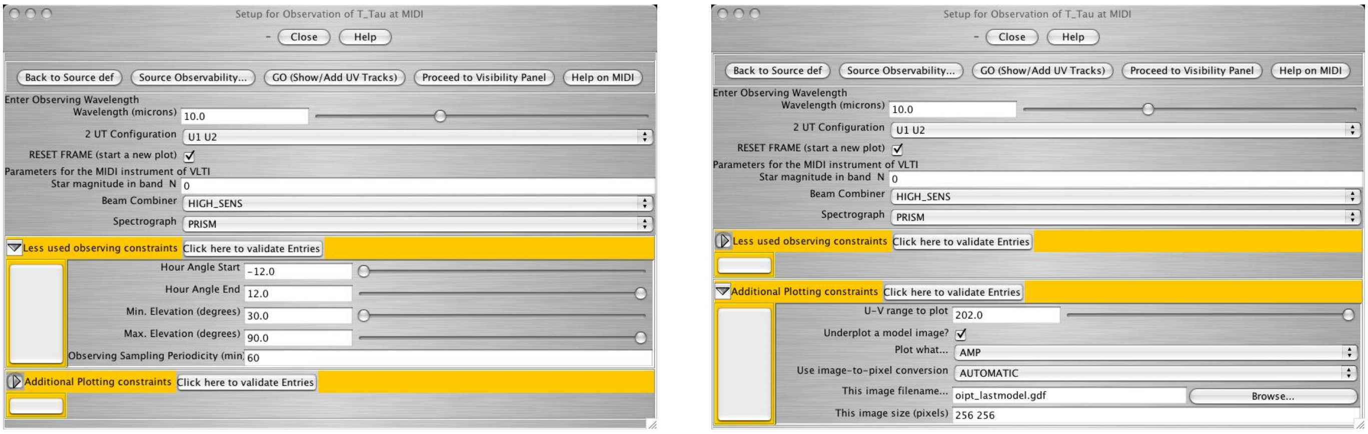


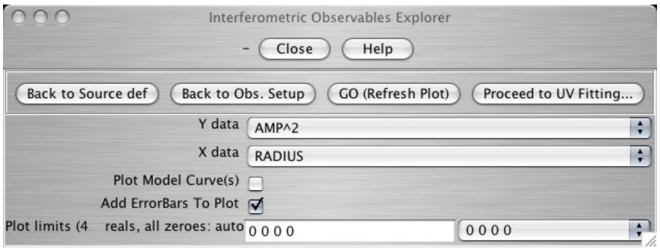
Figure 13: The **Setup For Observation** panel with the **Less Used Observing Constraints** (*left*) and **Additional Plotting Constraints** (*right*) sub-panels.

It is also possible to change the default plotting options by clicking on the arrow in the **Additional Plotting Constraints** sub-panel (see right part of Fig. 13). For instance, it is possible to modify the size of the UV plot to produce (*U-V range to plot*), to remove the Fourier Transform of the object model by unchecking the *Underplot a Model Image* box or to change the quantity to be plotted (*Plot What*: visibility amplitude, phase or any derivative with respect to the model parameters) and the color scale stretch (*Use Image-to-Pixel Conversion*, `linear` - which is default -, `logarithmic` or `equalization`). The name of the output file to store the image in GILDAS format (*This Image Filename*) and its size (*This Image Size*) can also be modified by the user. Once new values of these parameters have been entered, click on the `Click Here to Validate Entries` to record them and then repeat the UV coverage calculation. Click again on the arrow to dismiss the **Additional Plotting Constraints** sub-panel.

3.7 UV PLOTS menu

This menu brings up the **Interferometric Observables Explorer** panel (see left part of Fig. 14) in which plots of the synthetic visibilities and other interferometric quantities can be created. The Fourier Transform of the model, which has been calculated in the **OBJECT** module, is sampled at the UV points determined by the array and instrument setup defined in the **OBSERVATIONAL SETUP** module.

Since the target and the instrumental setup are defined in the previous modules, there is little to choose here, and a default plot (see right part of Fig. 14) appears at the same time as the panel appears on the user's screen. The user can decide which quantities to plot (*X data* and *Y data* for the horizontal and vertical axis, respectively); the possible choices are listed in Table 2 along with a brief description. Selecting `V` for *Y data* and `U` for *X data* will produce a plot very much similar to the one obtained at the end of the **OBSERVATIONAL SETUP** module. Checking the *Add Errorbars to Plot* box enables uncertainties to be plotted (they are automatically calculated by **ASPRO-VLTI** based on the object brightness with an instrument-specific ETC). The limits of the plot along both axes (*Plot limits*; X_{min} X_{max} Y_{min} Y_{max} in that order) can either be chosen by the user or automatically computed (which is achieved with the default `0 0 0 0` selection). The user can also choose to check the *Plot Model Curve* box which superimposes on the calculated visibilities, the theoretical visibilities as a (set of) continuous red curve(s). If the model is axisymmetric, only one curve appears when plotting **AMP^2** as a function of **RADIUS**; if the model is non-axisymmetric or when plotting quantities as a function of **ANGLE**, numerous curves appear, corresponding to different position angles or radii in the Fourier domain.



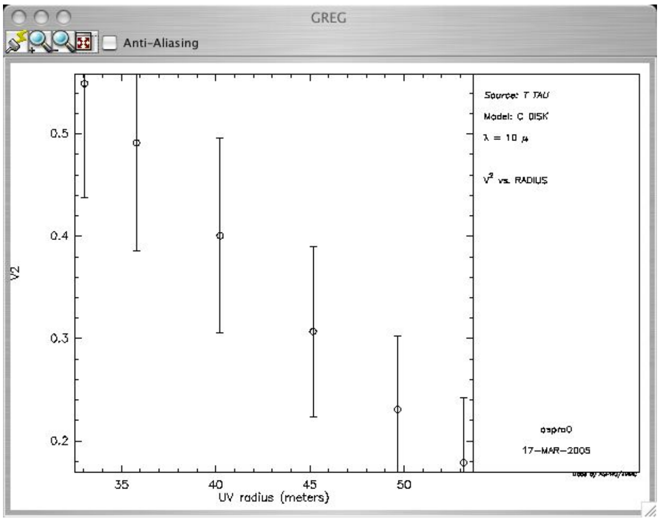


Figure 14: The **Interferometric Observables Explorer** panel (*left*) and a visibility plot (*right*).

If the plotted visibilities (or other quantities) appear unsatisfactory to the user, for instance because they do not change enough with time or because they are too small to be confidently measured, click on the `Back to Obs. Setup` button to return to the **OBSERVATIONAL SETUP** module and try another instrumental configuration. Otherwise, the user can click on the `Proceed to UV Fitting` button to try to fit the synthetic visibilities with parametric models and to estimate the resulting parameter uncertainties.

3.8 FIT MODEL menu

In this menu, the user can fit the synthetic visibilities created by the **UV PLOTS** module with parametric models in order to estimate the constraints provided by the proposed observations on the geometry of the object. At any time, the user can return to any of the other three main **ASPRO-VLTI** modules by clicking on the `Back to ...` buttons.

3.8.1 Fit UV Data

This menu brings up the **MIDI_UT UV Fit Control Panel** (see left part of Fig. 15), which is also automatically opened when the user click on the `Proceed to UV Fitting` button in the **Interferometric Observables Explorer** panel. The user only needs to define the parametric model to be fit, which can be one or the weighted sum of two simple parametric models. Use *Number of Functions*, *Function 1*, *Function 2* and *Parameters* in the same way as in defining the object model (see Sect. 3.5.1). In addition, the user can provide a range of possible values for the model parameters (*Starting Range*) and a number of (evenly-spaced) values to test throughout that range (*Numb. of Starts*; `-1` means that the parameter is fixed to its prescribed value and `0` provides an automatic fit). If a variable is not fixed, then the value listed in *Parameters* (and the *Starting Range* around them) is a (series of) first guess(es) from which the iterative fitting process starts.

In this fitting process, the fit is actually not performed on the synthetic visibilities created in the **UV PLOTS** module but rather on a noise-added dataset: a random quantity is added to each simulated visibility based on its associated uncertainties (assuming a Gaussian distribution for the uncertainties). Therefore, the fitting process never recovers exactly (i.e., with infinite accuracy) the original model parameters. This also means that repeating the fitting process yields different results every single time because of the random treatment of uncertainties. Making a series of ∼ 10 fits and calculating the standard deviation of the resulting parameters can therefore provide a secondary estimate of the uncertainty on the model parameters, which should be close to the one provided by a single fit. This fitting approach is in principle a close match to the actual observing and analysis processes that would be conducted by the user on actual datasets and should therefore provide a good estimate of the constraint on the models provided by the proposed observations.

Table 2: Quantities that can be selected to plot the results of the simulated observations.

Variable	Description
U	Fourier coordinate corresponding to the East-West axis
V	Fourier coordinate corresponding to the North-South axis
ANGLE	Position angle in the Fourier plane
RADIUS	Radius in the Fourier plane
AMP	Amplitude (visibility $\|V\|$) of the Fourier Transform of the model
AMP^2	Squared amplitude ($\|V^2\|$) of the Fourier Transform of the model
PHASE	Phase ($\Phi(V)$) of the Fourier Transform of the model
REAL	Real part ($Re(V)$) of the Fourier Transform of the model
IMAG	Imaginary part ($Im(V)$) of the Fourier Transform of the model
SIG_V2	Uncertainty on the squared visibility ($\sigma(\|V^2\|)$)
TIME	Time of observation
DATE	Date of observation
SCAN	Sequential number of scan
NUMBER	Sequential number of observation

Clicking on the `GO (Perform Fit)` button launches the fit and a **Result** window that presents the results of the fit automatically appears (see right part of Fig. 15). At the bottom of that window, the result of the fit is summarized as follows, with one line per model parameter:

`Model_Name Variable_Name Best_Fit ( Uncertainty )`

If the parameter was held fixed, the `Uncertainty` entry reads `fixed` instead of a numerical value. In the example presented in the top right part of Fig. 15, an **E_Disk** function, with three free parameters (FWHM along the semi-major and semi-minor axes and position angle), was fitted to a synthetic set of visibilities created with a **C_Disk** function. The result window indicates that both axes (which should in principle be equal) are only poorly recovered and the position angle is obviously not at all constrained. This can be interpreted as evidence that the actual geometry of the source is not elongated in a particular direction, prompting the user to try fitting a **C_Disk** function, rather. The result of this second fit, which has only one free parameter (FWHM), gives a satisfactory 30.8±0.3 milli-arcsecond result, whereas the input model was constructed using a value of 30 milli-arcsecond.

The quality of the fit can be estimated with the RMS residual flux value indicated just above the best fit parameters values in the **Result** window. In the example above, using a **C_Gauss** function rather than a **C_Disk** function gives a residual standard deviation almost twice as large, suggesting that the **C_Gauss**

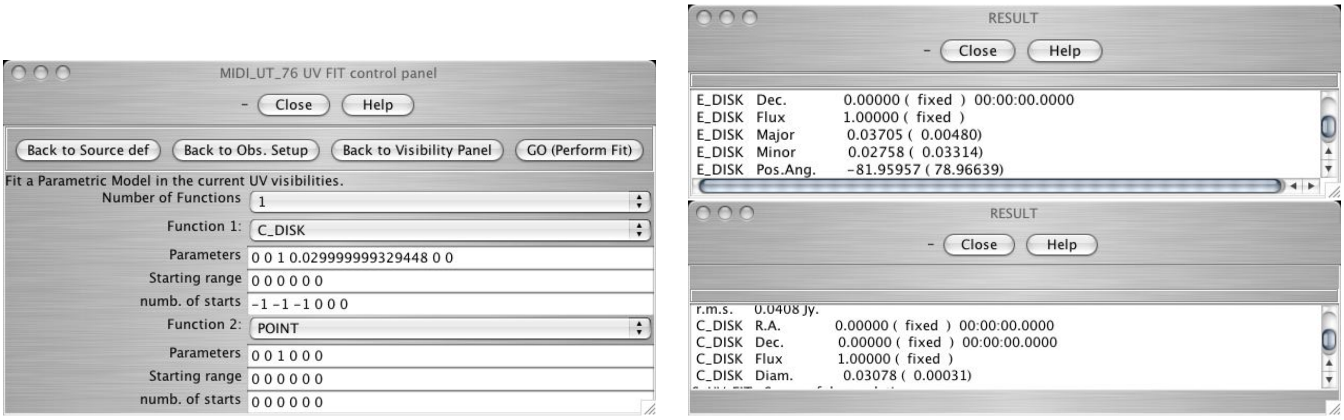


Figure 15: UV fit control panel (*left*) and result windows (*right*) for the **Fit UV Data** procedure for two different models fitted to the same synthetic dataset.

model is an unlikely fit to the synthetic visibilities. Once again, because of the random process included in the fitting process, it is strongly recommended to run the fit a number of times and to average the values of the residual RMS, for instance.

3.8.2 Model Parameter Errors Calculator

This menu provides an alternative, though not realistic, method to fit a parametric model on the synthetic visibilities created in the **UV PLOTS** module. Its usage is almost identical as that of the **MIDI_UT UV Fit Control Panel** panel (see Sect. 3.8.1), except for the absence of the *Starting Range* and for the fact that the *Numb. of Starts* entries is replaced by *Masked Parameters*. This can only take values of `0` (free parameter) or `1` (fixed parameter). The fit is performed iteratively from the initial guess (*Parameters* entries) in a way that does not take into account the visibility uncertainties. It is therefore not representative of an actual observation/analysis procedure and should not be considered as a strong result by the user. We strongly recommend using the **Fit UV Data** menu rather.

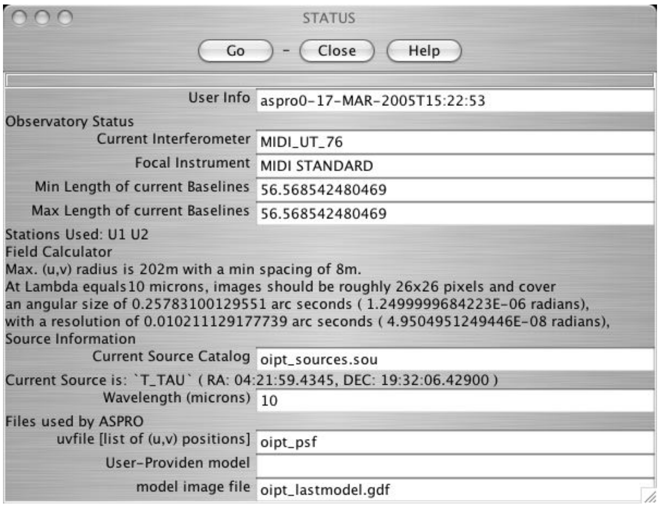
3.9 PLOT menu

Selecting **Show Plot in Browser (PS/PDF File)** under the **PLOT** menu creates a PS/PDF file containing the current content of the **ASPRO-VLTI** graphic window. The file is automatically displayed by the user's browser and, simultaneously, stored in the user's **ASPRO-VLTI** account where it can later be retrieved.

3.10 MISC menu

3.10.1 Show Current Setup

This menu opens a **Status** window in which the basic properties of the observation being simulated are summarized (see left part of Fig. 16). The information provided includes the interferometer, instrument, array configuration, current object, wavelength and name of a few key files for **ASPRO-VLTI**. No modifications to the setup can be performed from this panel; it is exclusively informative but provides an overview of what has been selected by the user so far. Note that many variables have default values, so that no parameter presents an empty field even at the time **ASPRO-VLTI** is launched (the only exception being *Model File*, which represent the name of the user-provided FITS model of the object). Click on `CLOSE` after reviewing the parameters (the panel will be automatically dismissed once another module is opened).



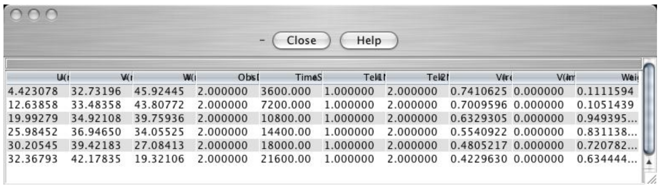


Figure 16: Current setup panel (*left*) and UV table listing (*right*) obtained from the **MISC** menu.

3.10.2 Plot Current Interferometer Setup

Selecting this options results in a new plot that represents a sketch of the selected interferometer along with the name of the offered stations.

3.10.3 Reset Marker Size

Selecting this option forces **ASPRO-VLTI** to use the default, dot-like, markers when plots are created. This overrides the selection of **Use Big Markers**.

3.10.4 Use Big Markers

Selecting this option forces **ASPRO-VLTI** to use larger markers when creating plots. This can be useful when plotting visibilities with their uncertainties, for instance, since the errorbar is as large as the default, dot-like, marker and it is therefore sometimes difficult to determine from the plot the actual visibilities. There is only one "big" marker size; selecting repeatedly this option will not increase the marker size every time. This can be overridden by selecting **Reset Marker Size**.

3.10.5 Exit From Error Loop

Selecting this option forces the command interpreter to return to its default idle status (i.e., green icon in the main GUI window) without executing the remainder of an aborted command. This is to be used when **ASPRO-VLTI** is stuck with a red or fixed orange icon in the main GUI window; in the latter case, check in the LOG window that the last output is indeed an error message. In some cases, it may be necessary to select this option several times consecutively to unwind the command stack.

3.10.6 Ignore Error

Selecting this option forces the command interpreter to ignore (step over) the current error and to try to complete the remainder of the command. This usually does not solve problems but it may be useful in some specific cases. We strongly recommend using **Exit From Error Loop** and analyzing the error message(s) in LOG window (check for missing files, unproper parameter selection, ...), instead.

3.10.7 List UV Table Content

Selecting this option displays in a pop-up window the current content of the UV table corresponding to the observations simulated by **ASPRO-VLTI** (see right part of Fig. 16). The file contains one line per measurement and per individual baseline. Each line contains the UVW projected baseline coordinates, a dummy observation date, the time since the beginning of observations (in seconds), the code for the two telescope stations, the real and imaginary part of the complex visibility and its weight (i.e., its uncertainty). A text file (`uvtable.txt`) containing the same information is automatically stored in the user's **ASPRO-VLTI** account; the user can then retrieve it and use custom plotting routines to create different plots than those provided by **ASPRO-VLTI**.

A SearchCalibrators Tool

A.1 Goals

SEARCH CALIBRATOR builds a dynamical catalogue of stars with all useful information for the selection of the calibrators most adapted to the requirement of the astrophysical program.

A.2 Method

Two methods are used, one specific for the N band (e.g., the MIDI instrument of ESO), one used for the VJHK bands (suitable for the AMBER instrument in J,H and K).

A.2.1 N-Band case

Definition of calibrator field The maximum angular distance (in RA and DEC) of calibrators from the object is given by the user.

Flux constraints Three cases are considered for the range of magnitude of the calibrators following the object brightness (see Table 3).

F_{obj} (Jy)	$[F_{min} - F_{max}]$	[mag N_{min} – mag N_{max}]
<10	[5 – 20]	[2.2 – 0.7]
[10 – 100]	[5 – 50]	[2.2 – -0.3]
>100	[5 – 100]	[2.2 – -1.0]

Table 3: Magnitude Search Range vs. Flux of Object.

List of possible calibrators The program finds the possible calibrators in the list of mid infrared interferometric calibration sources established by van Boekel et al. (2005) . The result is a list of stars with known parameters in astrometry (equatorial and galactic positions, proper motion, parallax), spectral classification, photometry as well as indication of variability and multiplicity and computed value of the measured angular diameter. For each calibrator, the squared visibility (V^2_{cal} , ΔV^2_{cal}) is computed as function of the angular diameter, wavelength and maximum baseline.

A.2.2 Other Bands

Definition of calibrator field The search is based upon user-specified criteria of angular distance and magnitude around the Scientific Object.

List of possible calibrators The program sends a request to the CDS database using "scenarios" based upon the selected photometric band (K). The result is a list of stars with known parameters in astrometry (equatorial and galactic positions, proper motion, parallax), spectral classification, photometry (Johnson magnitudes) as well as indication of variability and multiplicity and known value of the measured angular diameter. For each star, the angular diameter is computed using a surface brightness method and color index calibration using V magnitude and (B-V), (V-R) and (V-K) color index. For each star, the squared visibility (V^2_{cal} , ΔV^2_{cal}) is computed as function of the angular diameter, wavelength and maximum baseline.

Post processing of the calibrators A coherence test of the photometry is done by comparison of the computed diameters from the different color index. The star is rejected if one of the computed diameter differs more than 2σ from the mean value.

A.3 Further selection of the calibrators

It is possible, once the list of calibrators has been constructed, to refine the choice of the calibrators using several selection criteria:

- field size around the science object
- object–calibrator magnitude difference
- spectral type and luminosity class
- accuracy on the calibrator visibility
- information regarding the calibrator variability and multiplicity

A.4 Results of the SearchCalibrators tool

Once the CDS request is answered, a Result Panel pops up (fig. 17).

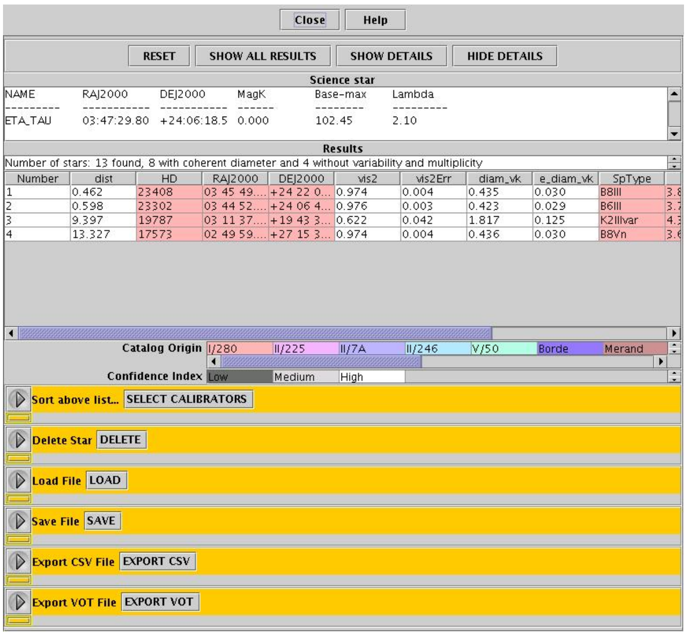


Figure 17: Result Panel

A.4.1 Initial selection

The panel consists in three sections, the Science Star window, the Results window and a set of subpanels allowing a refinement of the selection of the calibrators based on various selection parameters.

The **Science Star window** shows the parameters of the Science object: name, position (RA, DEC), N magnitude and maximum baseline, computed angular diameter (K Band).

The **Results window** shows the list of the calibrators without any indication of variability or multiplicity. Only some selected parameters are given (see table 5 for JHK results, 4 for N-Band results), unless the `SHOW DETAILS` button has been activated. By clicking on the name of the column and dragging the column, it is possible to personalize their order.

The top border of the panel presents 4 buttons:

`RESET` : button to show the full list of the potential calibrators.

`SHOW ALL RESULTS` button to display the full list of the potential calibrators, including those which are variable, multiple of that have inconsistent diameters (which are excluded from the default list).

`SHOW DETAILS` button to display the full list of measurements returned by the program. All available parameters are given in Tables 6 and 7 for N and JHK band search respectively).

`HIDE DETAILS` button to display only the principal measurements returned by the program. Only some selected parameters are given (Tables 5 and 4).

The lower part of the panel is a set of selection tools used to refine the list of calibrators and load/save results.

SELECT CALIBRATORS is described below in sect.A.4.2.

DELETE to delete a star of the list. Click the arrow, enter the number of the line to be suppressed, click the **DELETE** button.

LOAD to load a result saved as a file. Click the arrow, enter the name of the File (name.scl), click the **LOAD** button.

SAVE to save in a file all the information of the list of calibrators. Click the arrow, enter the name of the File (name.scl), click the **SAVE** button. Retrieving this file is possible within the File Exchange Panel (see sect. **??**)

EXPORT CSV to save in a file the list of calibrators as displayed in the results window. Click the arrow, enter the name of the File (name.csv), click the **EXPORT** button. Retrieving this file is possible within the File Exchange Panel (see sect. **??**)

EXPORT VOT to save in a file the list of calibrators as displayed in the results window in the VOTable format[3]. Click the arrow, enter the name of the File (name.vot), click the **EXPORT** button. Retrieving this file is possible within the File Exchange Panel (see sect. **??**)

A.4.2 Refining the selection

To refine the selection, do:

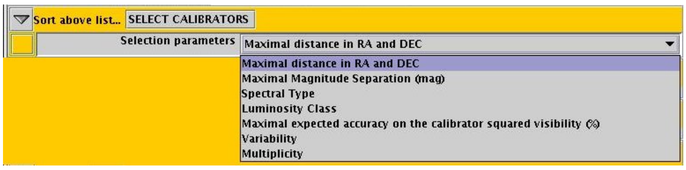


Figure 18: Refining the selection

Click on the arrow left of **SELECT CALIBRATORS** to open the list of selection parameters (fig. 18)

Select the parameter

[3]See `http://www.ivoa.net/Documents/latest/VOT.html` for more information about this format

Click on **SELECT CALIBRATORS** button to open a specific choice panel...
Enter the value of the selection parameter
Click on `OK` button to start the selection
The new result is displayed in the "Result" window.

Click the `RESET` button to return the previous result.

1. Field around the Science Object

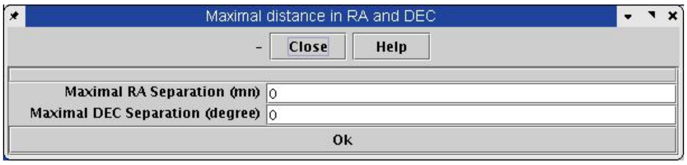


Figure 19: Field Selection Tool

2. Maximum magnitude difference (Science Object - Calibrator)

Figure 20: Maximum magnitude difference Selection Tool

3. Spectral Types (Temperature class) of the Calibrators

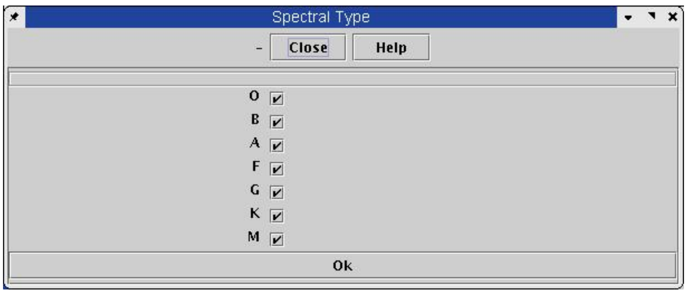


Figure 21: Spectral Types Selection Tool

4. Luminosity class of the calibrators

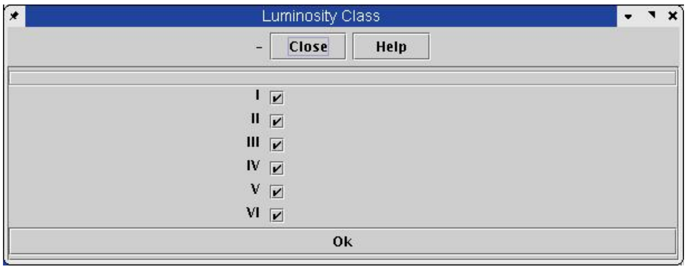


Figure 22: Luminosity class Selection Tool

5. Maximal expected accuracy on the calibrator visibility ($\Delta V_{cal}^2/V_{cal}^2$ in %)

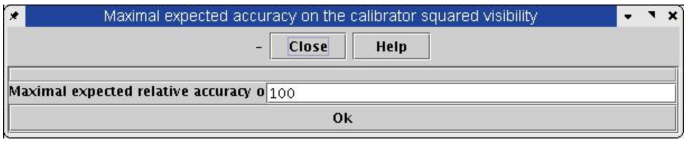


Figure 23: Maximal expected accuracy Selection Tool

6. Variability

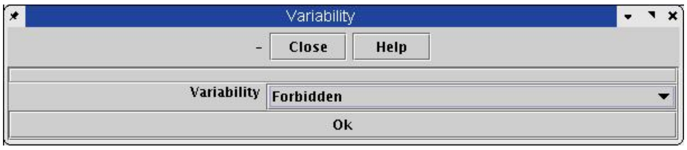


Figure 24: Variability Selection Tool

7. Multiplicity

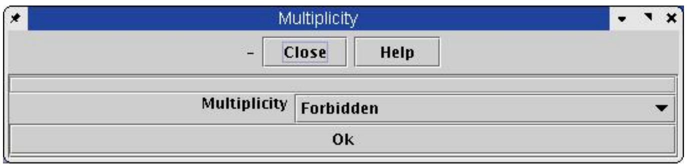


Figure 25: Multiplicity Selection Tool

A.5 Description of columns in the Search Calibrator result panel

A.5.1 Short list column description, N-Band case

Table 4: Short list column description, N-Band case

Col. Num.	Identifier	Explanation
1	Number	entry index
2	dist	calibrator–object angular distance in degrees
3	HD	HD number
4	RAJ2000	right ascension J2000
5	DEJ2000	declination J2000
6	vis2	squared visibility V_{cal}^2
7	vis2Err	estimated error on V_{cal}^2
8	Dia12	computed angular diameter in band.
9	e_Dia12	error on the angular diameter.
10	F12	mid-infrared flux (Jy) at 12μm.
11	SpType	MK spectral type
12	N	N magnitude computed from F12 using the relation $Nmag = 4.1 - 2.5\log(F_{12\mu}/0.89)$.
13 to 16	vis2 (λ) and vis2Err(λ)	computed visibility and estimates error for the limits of the N band (λ 8μm and λ 13μm).

A.5.2 Short list column description, JHK-Band case

Table 5: Short list column description, JHK Bands case

Col. Num.	Identifier	Explanation
1	Number	entry index
2	dist	calibrator–object angular distance in degrees
3	HD	HD number
4	RAJ2000	right ascension J2000
5	DEJ2000	declination J2000
6	vis2	squared visibility V_{cal}^2
7	ErrVis2	estimated error on V_{cal}^2
8	diam_vk	estimated ϕ_{VK} from the (V,(V-K)) calibration
9	e_diam_vk	estaimted error on ϕ_{VK}
10	SpType	MK spectral type
11	V	mag V
12	J	mag J
13	H	mag H
14	K	mag K

A.5.3 Full table description, N-Band case

Table 6: Column description, N-Band case

Col. Num.	Identifier	Explanation
1	Number	index
2	dist	calibrator–object angular distance in degrees
3	HD	identification by HD number
4	RAJ2000	right ascension J2000
5	DEJ2000	dclinaison J2000
6	vis2	computed squared visibility V_{cal}^2
7	vis2Err	estimated error on V_{cal}^2
8	Dia12	computed angular diameter at 12μm.
9	e_Dia12	error on the angular diameter.
10	orig	source of the IR flux IRAS or MSX.
11	F12	mid-infrared flux (Jy) at (12(m.
12	e_F12	relative error on F12 (%)
13	SpType	MK spectral type
14	N	N magnitude computed from F12 using the relation $Nmag = 4.1 - 2.5\log(F_{12\mu}/0.89)$.
15 to 18	vis2 (λ) and vis2Err(λ)	computed visibility and estimates error for the limits of the N band (λ 8μm and λ 13μm).
19	Calib	c for stars selected as spectro-photometric calibrators.
20	Mflag	indication of binarity (angular separation ¡ 2") from Hipparcos catalog.
21	Vflag	indication of variability from SIMBAD (SB or eclipsing B);
22	V	V magnitude.
23	H	H magnitude.
24	plx	trigonometric parallaxes
25	e_plx	error on plx
26	pmRA	proper motion in RA.
27	pmDE	proper motion in DE.
28	A_V	visible interstellar absorption.
29	Chi2	Chi2 value for the model fitting of spectro-photometric data.
230	SpTyp_Teff	spectral type from adopted modelling effective temperature.

A.5.4 Full table description, JHK-Band case

Table 7: Column description JHK bands case

Col. Num.	Identifier	Explanation
1	Number	index
2	dist	calibrator–object angular distance in degrees
Computed squared visibility from measured angular diameter or computed ϕ_{vk} diameter		
3	vis2	computed squared visibility V^2_{cal}
4	vis2Err	estimated error on V^2_{cal}
Estimated photometric angular diameters		
5	diam_bv	diameter ϕ_{bv} from (V,(B-V)) calibration
6	diam_vf	diameter ϕ_{vr} from (V,(V-R)) calibration
7	diam_vk	diameter ϕ_{vk} from (V,(V-K)) calibration
8	e_diam_vk	estimated error on ϕ_{vk}
Identificators		
9	HIP	HIP number
10	HD	HD number
11	DM	DM number
Astrometric data		
12	RAJ2000	right ascension J2000
13	DEJ2000	declination J2000
14	pmDec	proper motion in declination
15	pmRA	proper motion in right ascension
16	plx	trigonometric parallax
Spectral Class		
17	SpType	MK spectral type
Variability - Multiplicity		
18	VarFlag1	Known variability from GCVS/NSV • G : variable known in the General Catalog of Varaible Stars • N : variable known in the New Suspected Variable catalog
19	VarFlag2	Variability in Tycho-1: • U : apparent variablity in the Tycho data, may be due to duplicity • V : strong evidence of intrinsic variability • W : suspected intrinsic variability
20	VarFlag3	Variability type : • C : no variability detected (”constant”) • D : duplicity-induced variability • M : possibly micro-variable (amplitude ¡ 0.03 mag) • P : periodic variable • R : V-I color index was revised due to variability analysis • U : unsolved variable which does not fall in the other categories
21	MFlag	Multiplicity Flag
Galactic coordinates		
22	GLAT	galactic latitude
23	GLON	galactic longitude

Col. Num.	Identifier	Explanation
Radial velocity		
24	RadVel	radial velocity (km/s)
25	RotVel	rotation velocity v sini (km/s)
Measured angular diameter from CHARM (Richichi and Percheron, 2002)		
26	LD	limb darkened disc diameter (mas)
27	e_LD	error on limb darkened disc diameter (mas)
28	UD	uniform disc diameter (mas)
29	e_UD	error on uniform disc diameter (mas)
30	Meth	method of measurement
31	lambda	wavelength
Computed angular diameter from Catalogue of calibrators stars for LBSI (Bord et al., 2002)		
32	UDDK	uniform disc diameter in K band (mas)
33	e_UDDK	error on uniform disc diameter (mas)
Photometry		
34–43	B, V, ..., N	Johnson's magnitudes U, B,V, R, I, J, H, K, L, M, N
Photometry corrected for interstellar absorption		
44	A_V	visual interstellar absorption