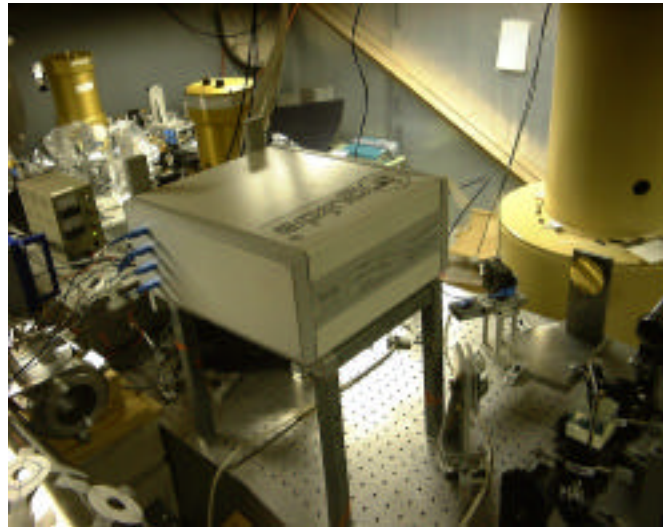


FLUOR software manual



IOTA



FLUOR

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1 Release notes

- 11 April 2000: first version

2 What to expect from this document

The purpose of these notes is to document the software enclosed in the "FLUOR environment" directory/folder. FLUOR is a fiber-based beam combiner currently in use at the IOTA interferometer. Its associated software package contains routines for:

- Preparing interferometric observations with IOTA
- Observing with the FLUOR instrument
- Obtaining calibrated visibilities from the raw FLUOR data

The current implementation of the software was first used in November 1999 and is referred to as the "Big Bang". The Big Bang was developed to accommodate for the fast scan unit, a faster acquisition computer, and to mimic as much as possible the behavior and data reduction philosophy of the VINCI commissioning instrument of the VLTI. It is still in a maturation phase so slight inconsistencies between the software and its documentation are to be expected.


3 What not to expect from this document

Nothing concerning hardware, electronics, optics, alignment notes etc... is covered here. See the IOTA and FLUOR Web sites for related documentation.

The "FLUOR environment" software package contains routines for reducing data obtained with the previous implementation of FLUOR (in operation from October 1995 to May 1999) but they are not documented here. Catalogs and data obtained with the older implementation of FLUOR are not compatible with the Big Bang routines (although a translator exists for the catalogs, and a data format translator is in the works).

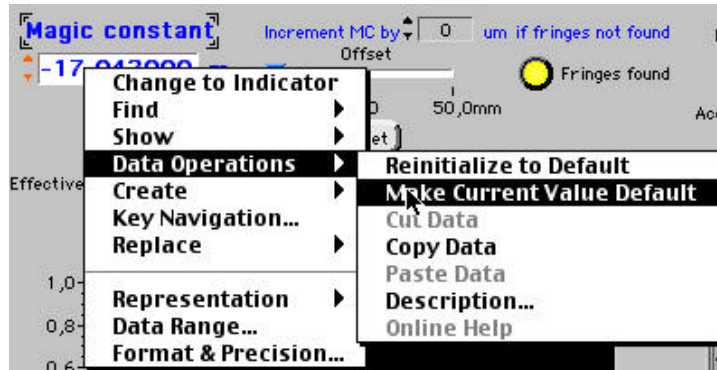
4 A crash course in LabVIEW

All FLUOR software is written using National Instrument's LabVIEW graphical language for instrumentation and data analysis (<http://www.ni.com/labview/what.htm>). A minimum of ease with that environment is necessary in order to operate the programs. A LabVIEW tutorial is available on the IOTA site (??, TBC). Here's the bare minimum to know in order to operate LabVIEW:

- A program is called a Virtual Instrument, or VI for short. It indeed employs the metaphor of a virtual electronics instrument, with a front panel containing controls and indicators, and a graphical code which looks like an electronics diagram;
- An control has a double arrow  and is used to input parameters: its numerical value can be modified by the user. An indicator has no such arrows

Effective scan OPD range 0,171 mm => 400 useful frames and is used to display output parameters. Its numerical value cannot be changed while the VI is running. There are, however, exceptions to this general rule;

- It is possible to set a given value of a control or indicator as a default by Command (Apple key)-clicking on it when the VI is not running. This calls a contextual menu as shown in this example:



- The upper left of the front panel contains four important buttons (but the programmer may elect to hide any of these), from left to right:



- "Run": the arrow becomes black when the VI is running;
- "Continuous run": to loop the VI indefinitely;
- "Stop": greyed out here since the VI is not running;
- "Pause".
- LV is a compiled language. A VI is compiled the first time it is run after a modification.
- When a VI is modified, an asterisk appears in its title bar, such as **FLUOR Observing Software ***. LV is quite fussy about what "modifying a VI" means. It can simply be that it was confused with the file paths to the sub-VIs (if the routine were copied from another volume, for example), or the default data values have been modified. When prompted with the Save Changes? window (upon closing a VI), it is possible to see what these changes were ("Explain..." button). Do not hesitate to save if you know you have not substantially modified the VI.



- LV saves data into datalog files, which have a programmer definable, but very rigid, format. Datalog files are incremental and data are always appended to the existing file: it is not possible, within LV, to erase data saved in a file.
- A big warning: **never modify a VI name, or position in the file hierarchy, while the LV environment is open.** This may cause a fatal crash of the machine and loss of the VI.

5 Reference documents

5.1 PhD thesis

The most complete descriptions of FLUOR are to be found in the following PhD thesis of the Université Paris 7 – Denis Diderot (in French):

- Guy Perrin, 1996, "Une unité de recombinaison à fibres pour l'interféromètre IOTA. Application à l'étude des étoiles de type tardif."
- Bertrand Mennesson, 1999, "Interférométrie stellaire dans l'infrarouge thermique: observations d'environnements circumstellaires par optique guidée monomode et contributions à la mission spatiale DARWIN".
- Cyril Ruilier, 1999, "Filtrage modal et recombinaison de grands télescopes. Contributions à l'instrument FLUOR".

5.2 Web sites

The following Web sites contain useful information and further documentation:

- The IOTA Web site: <http://cfa-www.harvard.edu/cfa/oir/IOTA/>
- The FLUOR Web site: <http://despa.obspm.fr/fluor/>

5.3 Papers

The most recent (although already quite outdated) paper in English describing the FLUOR system in general can be found in:

- Coudé du Foresto, V., G. Perrin, et al. (1998). The FLUOR fibered instrument at the IOTA interferometer. In *Astronomical Interferometry*, SPIE 3350 (Kona), pp 856–863.

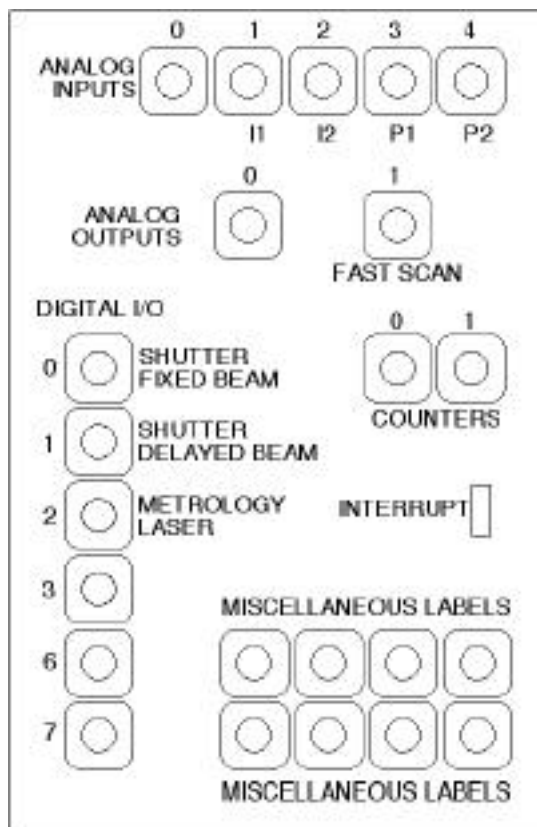
Two refereed papers describe in detail the data reduction procedure and the error bar management in FLUOR:

- Coudé du Foresto, V., S. Ridgway, et al. (1997). "Deriving object visibilities from interferograms obtained with a fiber stellar interferometer." *Astronomy and Astrophysics Supplement Series* 121: 379–392.
- Perrin, G., V. Coudé du Foresto, et al. (1998). "Extension of the effective temperature scale of giants to types later than M6." *Astronomy and Astrophysics* 331: 619–626.

6 FLUOR control system architecture

6.1 Computer hardware

FLUOR is controlled by a single computer (Macintosh G3 Blue/White, 400MHz, 256Mo RAM) equipped with a PCI-MIO-16E4 general purpose board (digital I/O, analog I/O, counter/timers) from National Instrument. The board is connected to an interface box (see picture below) which is documented elsewhere (blue booklet, called "FLUOR Interface", available on the IOTA site). In the FLUOR G3 there is also a PCI-DIO-32HS board for digital handshake communications with the NICMOS Pentium.



6.2 Overview of hardware control

6.2.1 Telescopes control

The FLUOR G3 does not control the IOTA telescopes, and does not communicate with the telescope computers. Therefore it has no knowledge of the pointing/tracking status and all information regarding the source must be entered separately on the FLUOR and IOTA telescope computers.

6.2.2 Short delay control

The short delay is controlled via the counters of the PCI-MIO-16E4 board. Pulse trains are generated by the counters, conditioned by the interface box (which can route the pulses either to the short or the long delay), and sent to the delay line control electronics.

WARNING: The short delay should be the source of constant attention and there are a few caveats concerning its operation:

- The delay line has no encoder so that the software has to maintain a count register to know its position. If the position is unknown for some reason (when the software is launched, for example) a homing/register initialization routine has to be run.
- Even if the software thinks it knows the position of the short delay, that position corresponds to the true carriage location only if all pulses and direction bits generated by the board have been transmitted correctly to the motor.
- Pulses are generated as infinite trains (whose frequency is regularly updated to reflect velocity changes) by the counters. The CPU has to access the counters in order to stop them, and it does it each time it is deemed necessary . This is the case, for example, when the acquisition program is stopped in a normal way (and also for most of the stops generated by an error condition). But if the software is crashed, the pulse train is not necessarily stopped and the delay line carriage might keep running, possibly into the hardware limits.
- Pulse trains can be monitored on the oscilloscope (picture??) or the pulse counter (picture??). In case of a runaway pulse train, the safest solution is to use the "panic" (interrupt) switch on the interface box.
- Another visual feedback is the oscilloscope display of the delay line servo (Picture, details??).

6.2.3 Long delay control

Although the hardware capability exists to control the long delay, this is no longer supported by the FLUOR software. Currently the long delay is controlled directly from its dedicated IOTA computer, and after each motion its new position is to be entered manually in the FLUOR software.

6.2.4 Chopping

There are two options to measure the background with FLUOR:

- Close shutters located on the FLUOR table (one shutter per beam, "fixed" and "delayed"). The shutters are controlled via TTL signals accessible from the interface box. This option works well in the K' band, where within the beam étendue accepted by the fibers, the sky emission cannot be distinguished from the shutters emission, as long as the observations are carried out at least 45mn after sunset or before sunrise.

- Insert slightly wedged windows in front of the star tracker mirrors, so that they track a position which is offset by several arcseconds from the star. The translation stage that supports the windows (picture??) is controlled by the FLUOR G3 via a serial interface. This solution is adopted for L band observations, but switching on-source/off-source takes more time (1 second) and currently it is not possible to switch each beam individually.

6.2.5 Data acquisition

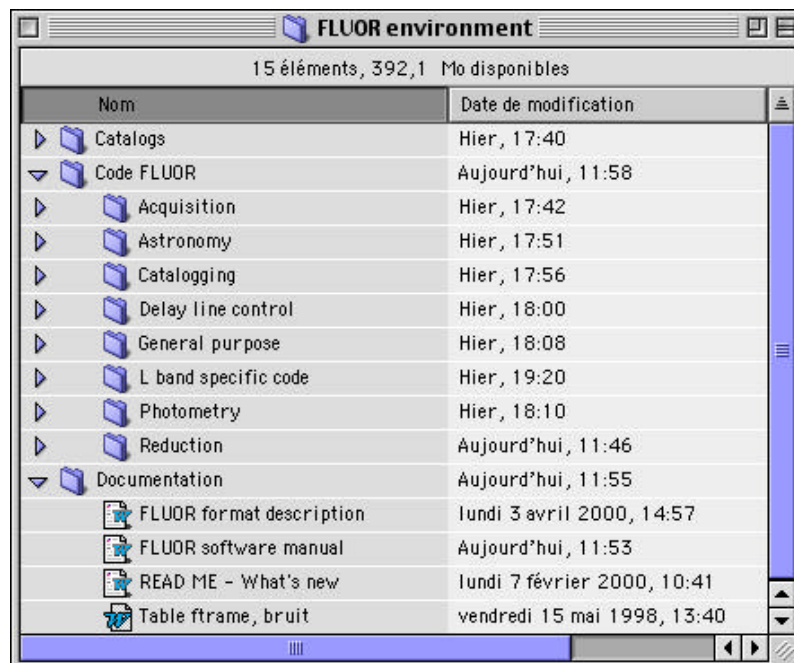
There are two ways of acquiring data with FLUOR:

- In the K' band, a NICMOS camera is read out by a Pentium and the data are transmitted to the FLUOR G3 via the fast DIO link. The IOTA NICMOS camera was developed by Rafael Millan-Gabet and the Pentium software documentation is available on the site (Web site also??). Note that the Pentium also has a software (q_read) to provide a full frame readout mode for output fibers alignment.
- In the L band, InSb photometers are used and the analog signals pass through a filter/amplifier (picture??) before being digitized by the PCI-MIO-16E4 board.


7 Software structure

7.1 Installing/upgrading the software

The FLUOR software, and related files, is distributed in the form of a folder called "FLUOR environment".



To install or update the software:

- Make sure no other version of "FLUOR environment" is on the hard disk, because LabVIEW does not like to see homonymous files on the same hard disk. If you want to backup a previous version of the code, you should compress it first (by dropping the "FLUOR environment" folder icon onto the DropStuff icon , for example), save the compressed version into the "FLUOR code backup folder" and trash the uncompressed version.

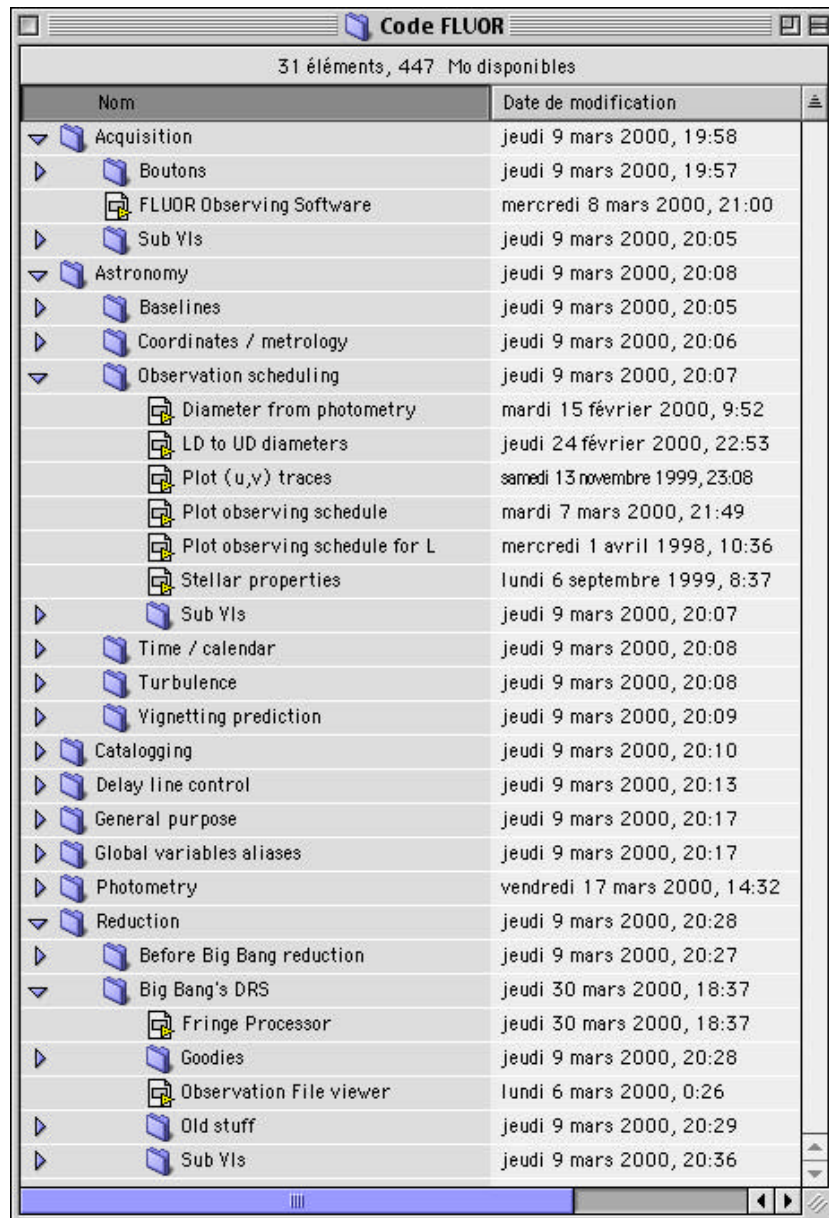
- If the newer version of the distribution is compressed, it appears as the following:



FLUOR environment 00_04_10.sit

Double-click on the icon to uncompress it.

- If they do not already exist, create on the desktop an alias of the most frequent top-level (user called) routines (see picture below for the path):
 - Plot observing schedule: used to prepare observations with IOTA, indicates which objects can be observed, and when, based on a catalog and a set of filters;
 - FLUOR Observing Software: the main VI to be launched to carry out observations with FLUOR and produce raw data;
 - Fringe processor: pipeline to compute and save raw visibilities from the raw data;
 - Observation File viewer: interactive VI to compute calibrated visibilities from fringe processed files, or display selected data.
- Open the "READ ME - What's new" file for the latest information and release date.



7.2 Portability notes

LabVIEW exists for many platforms, and the FLUOR software should in principle be readily useable on a PC or Unix workstation equipped with that environment. Here's the procedure to install the FLUOR environment on a PC with LabVIEW :

- Download and install Aladdin Expander for Win'95/98/NT, available at <http://www.aladdinsys.com/expander>.
- Drag and drop the stuffed FLUOR file into Aladdin Expander and select a directory in which the environment will be expanded.

To launch a VI, simply double-click on its icon and select LabVIEW as the application to use with. Note that when you close the VI for the first time, you will be asked for saving

the changes. Simply click on "Yes to All" to allow LabVIEW to save the recompiled files, taking into account the conversion from the MacOS platform.

8 Data structure

8.1 Data hierarchy

The FLUOR data are quite strongly structured and the following hierarchy applies:

Frame < Scan < Batch < Observing Block < Observing File.

- Frame (1D array): a collection of 4 numbers corresponding to instantaneous intensity values for each of the four outputs of the instrument: I1 and I2 (complementary interferometric outputs) and PA and PB (photometric outputs for telescopes A and B);
- Scan (2D array): a collection of (typically 256) frames which form an uninterrupted time sequence;
- Batch (3D array): a collection of scans. In a standard complete observation, 4 types of batches are acquired sequentially:
 - Off-source batch 1 (typically 25 scans): background acquisition. Either the shutters are closed or the fibers look off the star, and the fast scan unit is not active;
 - Single beams batches: these are used to compute the relative gain matrix (also called the kappa matrix) between PA, PB and I1, I2. They include:
 - Fixed beam only batch (typically 25 scans): only the fiber in the fixed beam looks at the star; the other fiber is off-source. The fast scan unit is not active;
 - Delay beam only batch (typically 25 scans): only the fiber in the delayed beam looks at the star; the other fiber is off-source. The fast scan unit is not active;
 - On-source batch (typically 100–500 scans): both fibers look at the star and the fast scan unit is active. This is when the fringes are expected to be recorded;
 - Off-source batch 2 (again): background acquisition again, for typically 100 scans.
 - Observing Block (OB for short): the smallest self-consistent data unit (able to produce raw visibilities), corresponding to a complete single observation of a single source. It has the form of a LabVIEW cluster (equivalent to a structure in C) containing different types of information (see the document "FLUOR format description" for details):
 - Raw data zone:
 - The four batches: on-source, off-source, fixed beam only and delayed beam only
 - Header type information: source catalog entry cluster, IOTA and instrument setup, acquisition parameters, etc...

- On-source scan-specific header information: an 1D array of clusters containing the header type information that varies with each on-source scan, such as the time, source altitude and azimuth, (u,v) coordinates, short delay velocity, etc...
- Fringe processed data zone:
 - Two (one for each interferometric output) 1D arrays containing the uncalibrated visibilities (squared moduli μ^2 of the coherence factor)
 - Header type information with the data reduction parameters
 - A provision for storing the corrected interferograms into two dedicated batches (3D arrays) exists but is not used yet.
- Observation File (OF for short): a collection of OBs, saved as a LabVIEW datalog file, containing (ideally) alternate observations of calibrators and science targets. From the analysis of the calibrators in an Observation File the time evolution of the transfer function can be computed, and then the calibrated visibilities (and associated error bars) can be derived for the science targets. It is therefore important that the OF be consistent (contains data acquired with the same setup, ie under conditions that should yield the same transfer function) and be extensive (contains all data acquired with a given setup). The motto here is "One setup, One night, One file". Saving each OB to individual files does not prevent proper data reduction, but makes it much more cumbersome.
- The final result of FLUOR's data acquisition and reduction pipeline is a text file called Observation File report, which contains in spreadsheet form the calibrated visibilities for the whole observing session corresponding to the OF, and the history of the transfer function evolution.

8.2 Global variables

During an acquisition sequence, all data and parameters are maintained in the computer RAM under the form of LabVIEW global variables. Global variables enable any VI to access the information without the need for an explicit call. They are transferred to a file only at the end of an completed observation, when the Observation Block is saved. This approach was adopted in order to enable fast data acquisition, but the down side is that all data are lost if the observation is aborted.

Global variables are grouped into global variable VIs, and for debugging purposes these VIs can be checked to know what the computer believes the status of the instrument is.

The following global variables VIs (to be found in Code FLUOR:Acquisition:SubVIs) contain the information related to data acquisition:

The screenshot shows a window titled "Global variables" with a status bar indicating "7 éléments, 392,4 Mo disponibles". The window contains a table with two columns: "Nom" and "Date de modification".

Nom	Date de modification
DAQ memory register	samedi 20 novembre 1999, 23:16
Global FLUOR/IOTA	vendredi 25 février 2000, 15:54
Global Select and Save	jeudi 11 février 1999, 2:34
Global status acquisition	vendredi 25 février 2000, 15:19
Global variables to OB	Aujourd'hui, 17:01
OB to global variables	Aujourd'hui, 17:01
Scan parameters memory register	vendredi 25 février 2000, 18:30

"Global FLUOR/IOTA", "Global Select and Save" and "Global status acquisition" are bona fide LV global variables. "DAQ memory register" is a specific VI that contains the data batches and is emptied each time an OB is written to file or an observation is aborted. "Scan parameters memory register" is also a specific VI containing the on-source scan-specific header information and is emptied each time an OB is written to file or an observation is aborted.

There are two global variables related to the delay line control (to be found in Code FLUOR: Delay line control): "Global active delay line" is a boolean that controls whether the pulses are directed to the short or the long delay line connector out of the interface box (it exists only for historical reasons and is always maintained to True (SD) now that the Short Delay is the only delay line controlled by the FLUOR G3), while "Global status SD" contains what the computer believes is the current short delay position, velocity etc...

8.3 From/to global variables to/from an OB cluster

The VI "Global variables to OB" is used to collect all relevant data and parameter information and convert it into an OB cluster (which can subsequently be saved to an OF file). The VI "OB to global variables" loads the relevant global variables with the values found into the input OB cluster (which is usually retrieved from an OF file). With this technique, when the software reads an OB from an Observation File, it is able to emulate the state in which it was when the data were acquired.

9 Data flow in FLUOR

As a reminder, an OB contains two types of data (and associated header-type information): the raw data (interferograms) and the fringe processed data (raw visibilities).

- The raw data are collected by the "FLUOR Observing Software" (FLUOR OS for short, located in the Code FLUOR:Acquisition folder) during an observation, displayed for quick-look analysis by the "Observation Block viewer" (in the Code FLUOR:Reduction:Big Bang's DRS:Sub VIs folder) which offers the option to save it into

an OF. For real time analysis, raw visibilities are calculated in a "quick and dirty" fashion within the FLUOR Observing Software but are not saved;

- A number crunching routine called "Fringe Processor" (in the Code FLUOR:Reduction:Big Bang's DRS folder) properly computes the raw visibilities, and saves both raw and fringe processed data into a new OF called a fringe processed file. The name of the fringe processed file is usually the original OF's name with the appendix ".fp".



- The fringe processed file can then be analyzed with the "Observation File viewer" which will produce the Observation File report. From within the OF viewer it is possible to call the Observation Block viewer to further investigate a specific OB, remove unwanted scans and/or save the OB into a new OF.

Therefore, in principle at least, the production of calibrated visibilities can be performed without human intervention (pipeline reduction), if the calibrator information has been properly recorded during acquisition. The pipeline is able to eliminate by itself certain categories of corrupted data. However, during the February 2000 run it was found that the variety of data corruption is so vast (see the Museum of Horrors below) that it was necessary to manually look at each OB, remove some (and sometimes all) scans, and build from these new OBs clean OF files, suitable for pipeline processing.

10 Observation preparation

10.1 Tools

There are a number of observation preparation tools that are located in the Code FLUOR:Astronomy:Observation scheduling folder. They will be detailed in a forthcoming version of this manual.

7 éléments, 391,9 Mo disponibles	
Nom	Date de modification
Diameter from photometry	mardi 15 février 2000, 9:52
LD to UD diameters	jeudi 24 février 2000, 22:53
Plot (u,v) traces	samedi 13 novembre 1999, 23:08
Plot observing schedule	samedi 26 février 2000, 1:43
Plot observing schedule for L	mercredi 1 avril 1998, 10:36
Stellar properties	lundi 6 septembre 1999, 8:37
Sub Vls	Hier, 17:51

10.2 Cataloging

FLUOR catalogs are recorded as LabVIEW datalog files. Each catalog entry is a cluster containing the star coordinates, HD and HR numbers, calibrator status, magnitudes, spectral type, estimated diameter and a free zone for comments. This information is used at different stages:

- The coordinates (in format hh.mmssss and dd.mmssss) for fringe location;
- The K magnitude is used within the OB viewer to determine the "magnitude limit" (an indicator of the overall photometric efficiency of the system);
- The estimated diameter is used by FLUOR OS to determine the expected visibility and, if the source is a calibrator, by the OF viewer to determine the transfer function;
- The calibrator boolean is used by the OF viewer and determines whether a transfer function estimate or the calibrated visibility has to be determined from the raw visibility

Catalog file *(dialog box if empty)*
 Leonard:FLUOR environment :Catalogs :K calibrators catalog

Add entry **Edit catalog** **Save changes**

Select source
 51 Ori 104

Source

51 Ori Calibrator
 Selected source

HD **37984** HR **1963**

Coordinates (h.mmss) for Epoch 2000,00

Right Ascension 5,422866 Declination 1,282879

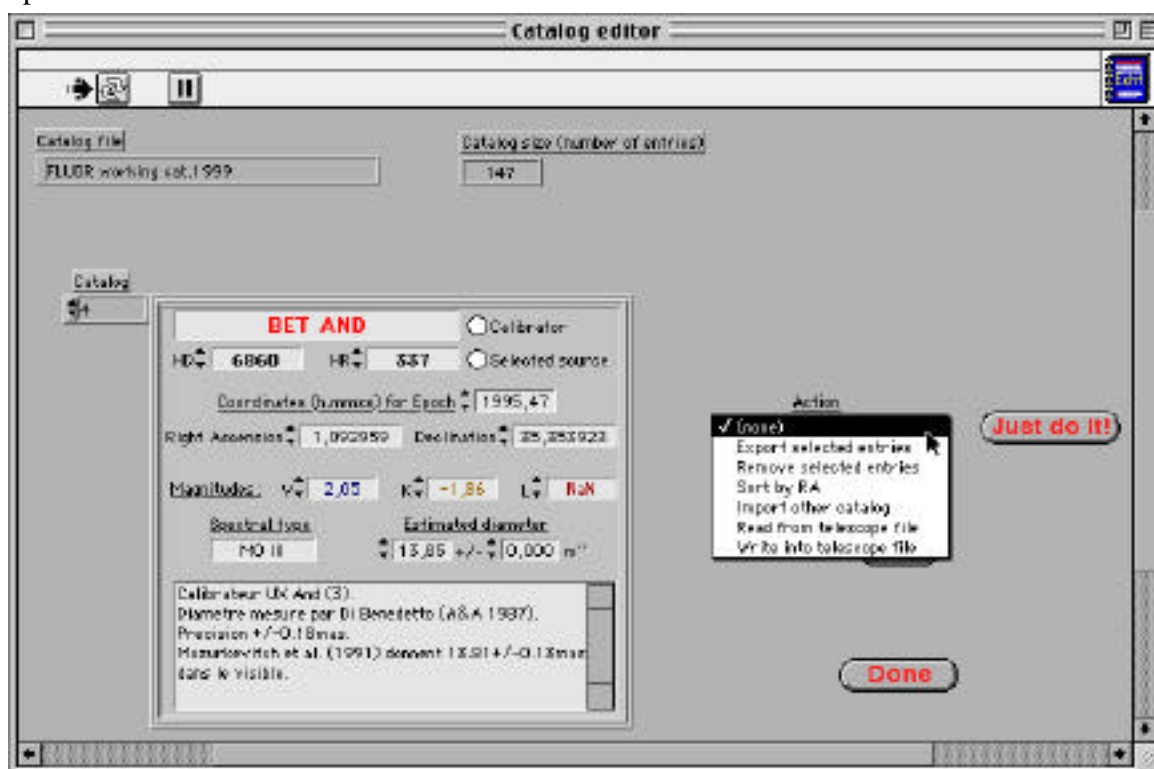
Magnitudes: V **5,24** K **2,09** L **2,03**

Spectral type **K1 III** Estimated diameter **1,87 +/- 0,021 m"**

The simplest way to modify or add an entry into a FLUOR catalog is to write directly into the source cluster from the FLUOR OS. When a source entry is modified, two buttons appear: Add entry (appends the modified record to the catalog file) or Save changes (replace the original source record with the modified record). To select an other catalog file, stop the FLUOR OS, empty the Catalog file field on the front panel, and launch the OS again. A navigation window will appear which is used to select the desired catalog file.

10.2.1 The catalog editor

The Edit catalog button on the OS front panel is permanently displayed and calls the "Catalog editor" VI (in the Code FLUOR:Cataloging folder). This VI can also be called as a top-level VI. In that case, when it is launched it displays a navigation window from which an existing catalog file can be selected, or a new one can be created. Because of an obscure bug, currently the dialog file is displayed only when the VI is run for the first time after LV is open.



Apart from modifying/adding entries to the cluster, the catalog editor can be used to sort the entries by right ascension, and read/write from/to a text file which in principle is understandable by the telescopes control software. The fields are determined by the position of the characters in the file, according to the following example (one logical line per source entry):

name	ra	dec	epoch	mura	mudec	v	k	sp	
DEL AND	00:39:19,7	30:51:39,7	2000	0,0	0,00	3,50	0,44	K3 III	0
4,25 mas prog. binaire spectro, p									
ALF CAS	00:40:16,5	56:30:32,3	1995	0,0	0,00	2,23	-0,25	K0 III	1
5,33 mas Calibrateur de R Cas.									

11 Observation

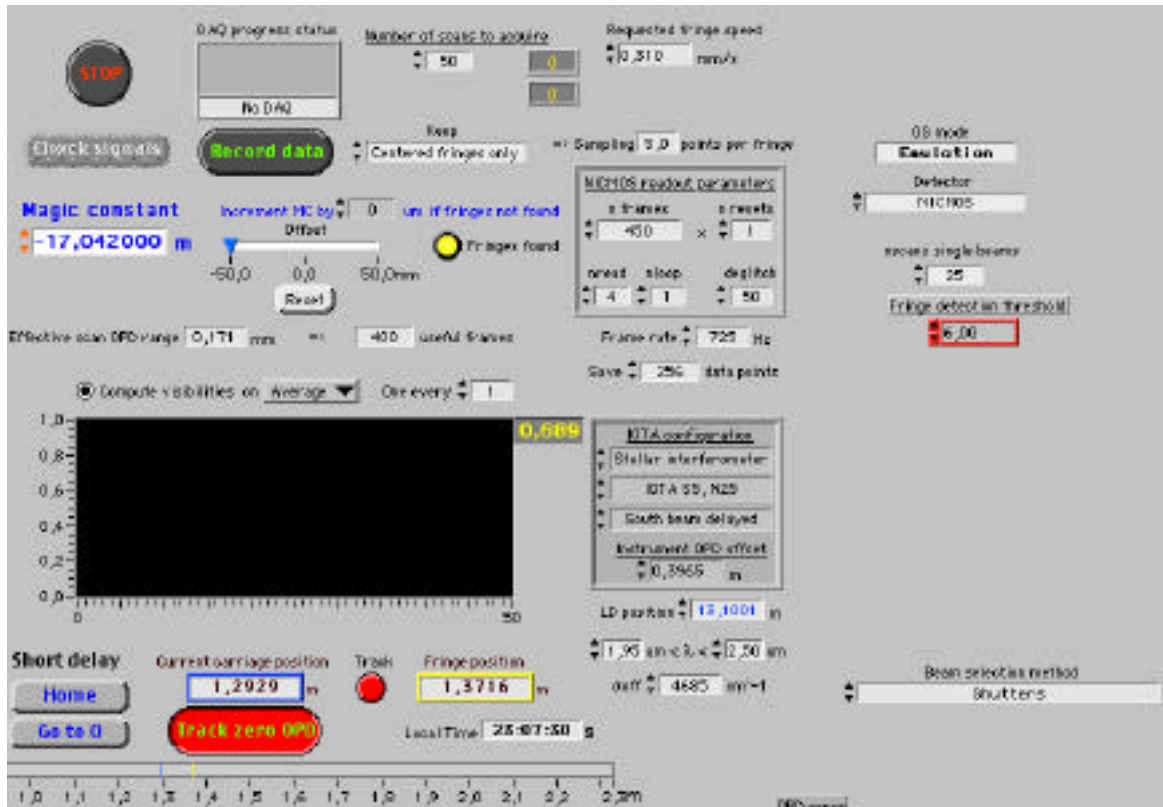
Observations are carried out through the FLUOR Observation Software. The main panel is used to adjust setup parameters and launch data acquisition, and provides access to two important auxiliary panels (corresponding each to a sub-VI):

- Signal check: a virtual oscilloscope, providing real-time intensity signals and shutter control used to optimize the stellar injection into the fibers;
- Observation Block viewer: called after a completed acquisition to display the raw data for quick-look analysis, and possibly save them into an OF.

11.1 FLUOR OS

When FLUOR OS is open, it launches automatically and displays several dialog boxes:

- Select a catalog file (if run for first time or catalog filename empty)
- Choose OS mode: FLUOR control or Emulation. Emulation is a mode which enables to carry out dummy observations off-line (data are retrieved randomly from a real data set);
- In FLUOR control mode and if the short delay has not been initialized, a checklist appears before the short delay is homed and initialized.

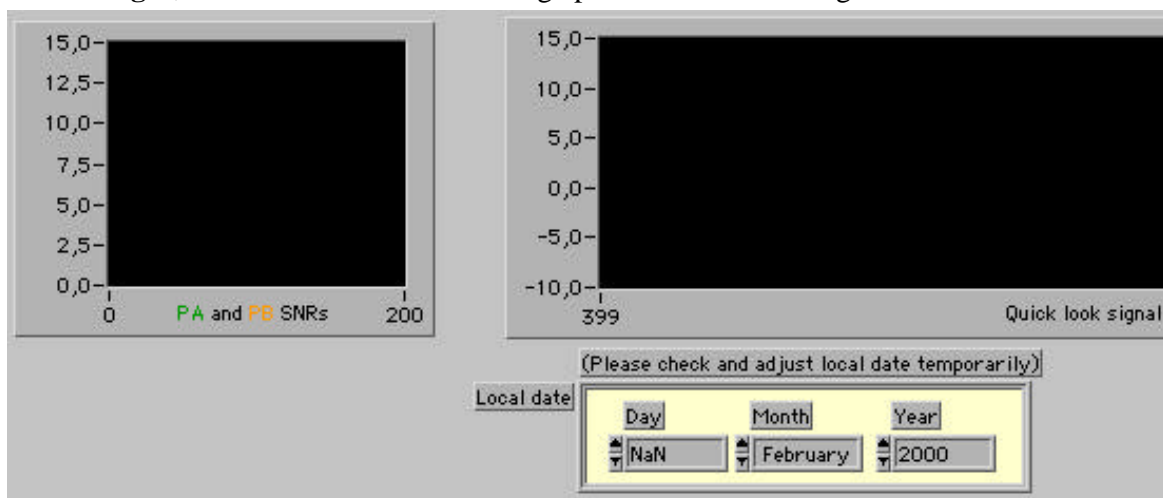


11.1.1 FLUOR OS setup parameters

Use the FLUOR OS front panel to setup the observation parameters:

- Detector menu: choose NICMOS, and forget about Photometers which is used for the L band, implies a different set of acquisition parameters and is not documented here;
- nscan single beams: number of scans in the fixed beam only and delayed beam only batches. Should be set to at least 25 or it will have an impact on the fringe visibility error bar;
- Fringe detection threshold: number of sigmas away from the mean for a point in the filtered signal to be declared as a "fringe". The centroid of the fringe packet is then computed as the median of the abscissae of all fringes detected. Under normal conditions the noise statistics are Gaussian and with a threshold of 5 or 6 the number of false alarms is only a few percents. If the threshold has to be raised above 8 for the false alarms to be not too common, then the fringe frequency window is probably contaminated by photometric fluctuations and visibility measurements are likely to be biased;
- Baseline and beam delayed menus are self explanatory;
- Beam selection method: Shutters for 'K' band observations, Star trackers (not fully operational yet) for L band observations.
- Requested fringe speed: the desired OPD velocity. The combination of OPD velocity and frame rate should yield a sampling of 5 points per fringe;
- NICMOS readout parameters: nread and nloop determine the frame rate (and the frame rate control blinks if either nread or nloop have been changed). The total number of frames acquired is nframes x nresets. The first ndeglitch frames are thrown away, and if nreset > 1, after each reset the ndglitch frames that follow are replaced by interpolated values. **Therefore it is not possible to acquire science grade data with nreset>1.** The number of "useful frames" (acquisition window) is (nframes x nresets) - ndeglitch.
- Frame rate is to be set manually. Obviously, changing nread, nloop and hence the frame rate generates a new setup and the data need to be recorded in a different OF;
- The number of data points to save is smaller than the number of useful frames in the acquisition window. The program selects a save window centered around the fringe packet and chunks out the rest. If the fringe packet is too near one edge of the acquisition window then the save window might not contain a centered interferogram, which would lead to biased visibility estimates. It is possible to activate a "keep centered fringes only" option to prevent such scans to be saved but, to reduce the likelihood of this event, the length of the acquisition window needs to be substantially larger (at least 30 pixels) than the length of the save window. For the fringe processing routine to work, **the number of saved data points must be a power of 2** (256 is fine in most cases). Under extreme circumstances, for a very bright star with a very low visibility, a 150--170 points acquisition window can be chosen, with 128 points saved, but this should be considered as a new setup and the data should be saved in a specific OF.

- IOTA configuration menu: only Stellar Interferometer is working at the moment, choosing Autocoll the fringe velocity is not right;
- Baseline selector menu and beam delayed menu are self-explanatory;
- Instrument OPD offset is to be kept for FLUOR at 0.3965m. This parameter is used to enable the operation of different instruments (with different OPDs) with the software;
- LD position: position of the long delay, to be entered manually;
- Minimum and maximum wavelengths: λ_{\min} and λ_{\max} determine in which frequency range the fringes are searched (from $v_{\text{fringes}}/\lambda_{\max}$ to $v_{\text{fringes}}/\lambda_{\min}$). If, for some reasons, one has doubts about v_{fringes} or the frame rate, it is possible to enlarge the frequency range in which the fringes are searched by modifying λ_{\min} and λ_{\max} .
- The effective wave number k_{eff} is used to compute the spatial frequency;
- Number of scans to acquire: number of scans to acquire in the on-source batch. This is not necessarily the number of scans that will be transferred to the Observing Block, since not all scans are saved;
- Which scans are transferred to the OB depends on the status of the Keep menu: all scans, all fringes, or centered fringes only.
- Magic constant: officially, the South beam - North beam OPD for a star at zenith and when both short and long delay lines are at their home positions, and the instrument OPD offset is null. In practice, *the* number in which are also folded all instrumental errors and that makes it possible to see the fringes. Each IOTA configuration has its own canonical magic constant. Modifying the magic constant is equivalent to sending an offset to the short delay when it tracks;
- MC increment when fringes not found. A useful feature to search for fringes in a wide range of OPDs (10mm can be searched in a few minutes). This number is reset to zero as soon as fringes have been detected in a scan.
- Local date: this control has been introduced as a temporary kludge to work around a bug in LabVIEW. The date in local time **should be manually entered, and changed after midnight**, otherwise the calculated fringe position will be wrong.

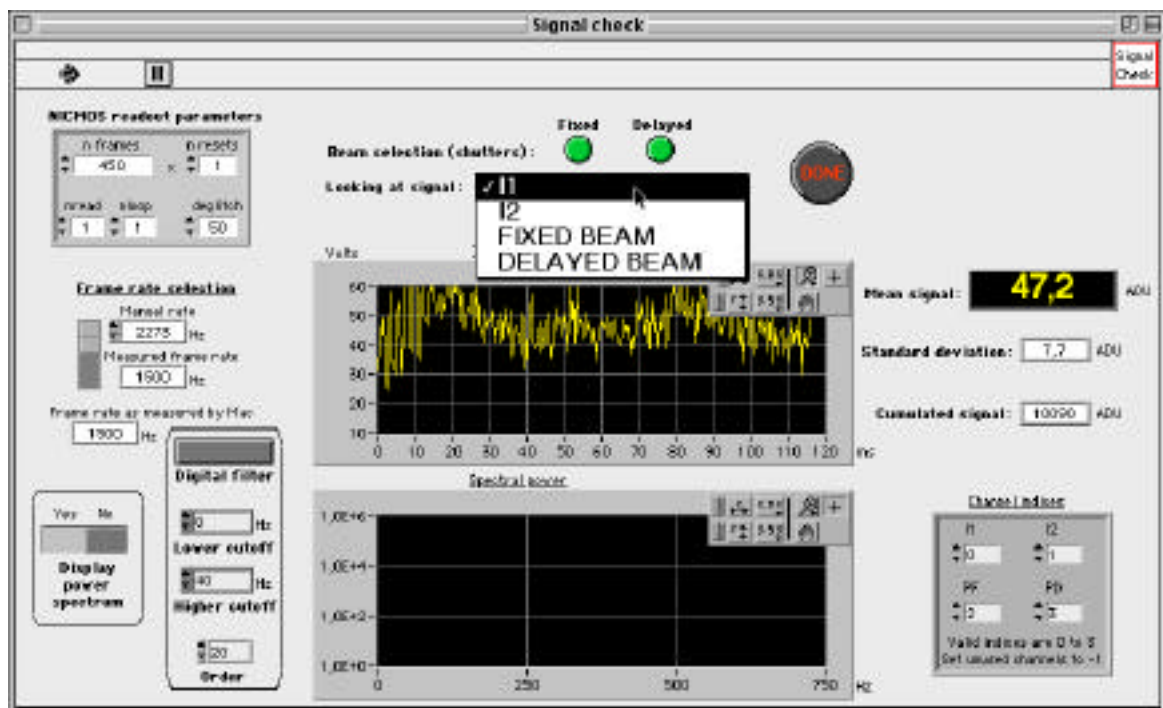


11.1.2 FLUOR OS action buttons

The following buttons trigger various actions:

- Add entry, Edit catalog and Save changes: see the Cataloging section above;
- Short delay home: rehome and index the short delay counters. When homing the software displays the number of pulses (expressed in distance) until it reaches the home signal, which is useful to diagnose problems with the short delay line;
- Go to 0: send the delay line to where the computer believes its home (zero) position is;
- Track zero OPD: send pulses to the short delay so that it tracks the zero OPD. When the short delay reaches the zero OPD position and velocity, the Track boolean turns green. This condition has to be met for on-source data to be acquired;
- Record data: triggers a data acquisition sequence, with successively off-source, fixed beam only, delayed beam only, on-source and off-sources again batches. Once the sequence is finished, the Observation Block viewer is called;
- Check signals: calls the Signal check VI;
- Stop: performs a "clean stop" (stopping all pulses first) and stops the FLUOR OS VI. Note that the standard "hard stop" button on the top left part of the window has been removed.

11.2 Signal check



The signal check VI is used to help optimize the stellar flux into the fibers. Beam selection is performed by clicking on the Fixed and Delayed booleans to activate the relevant shutters.

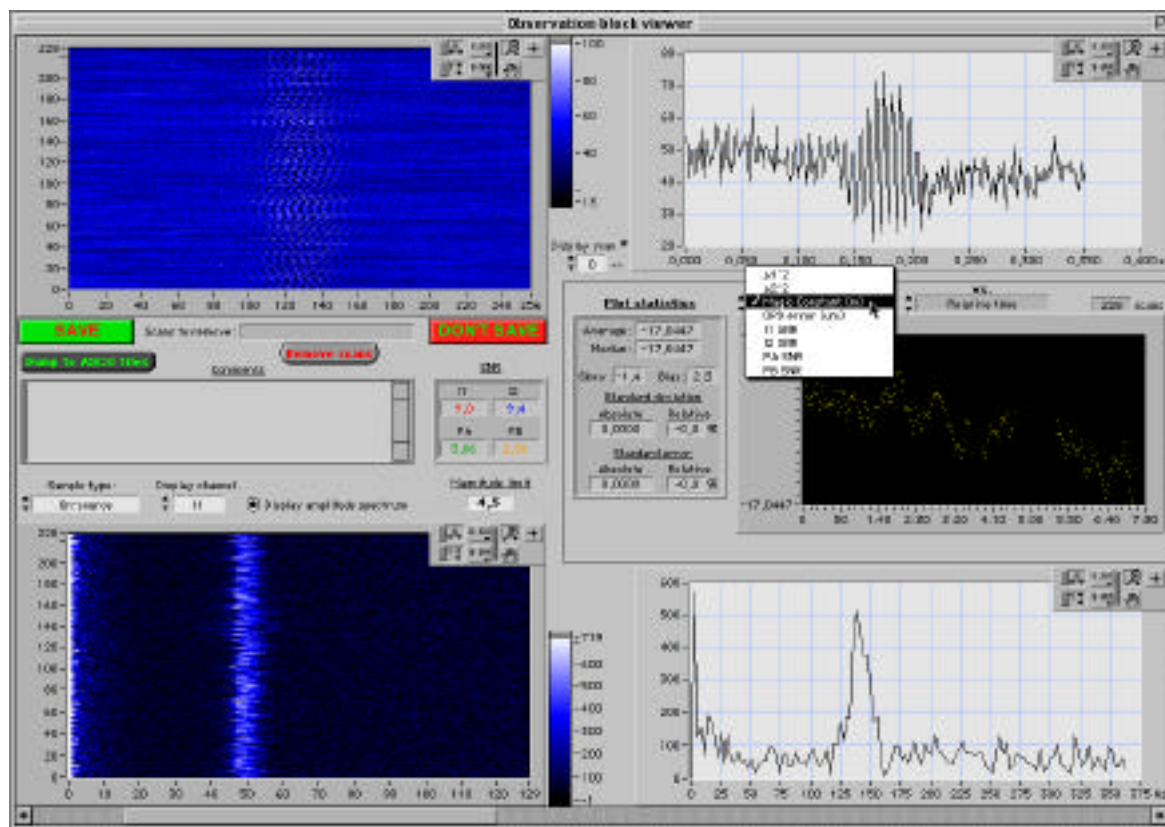
The signal check VI can also be used to estimate the frame rate. The measured frame rate is estimated by the time lapsed for the acquisition, as measured by the Pentium, and is all the more accurate as the total number of frames is large. However, if the total number of frames (nframes x nresets) is larger than 7000, the FLUOR G3 and the Pentium freeze and a reboot of both machines is required.

The NICMOS readout parameters can be changed in the Signal Check routine without any consequence on the FLUOR OS setup.

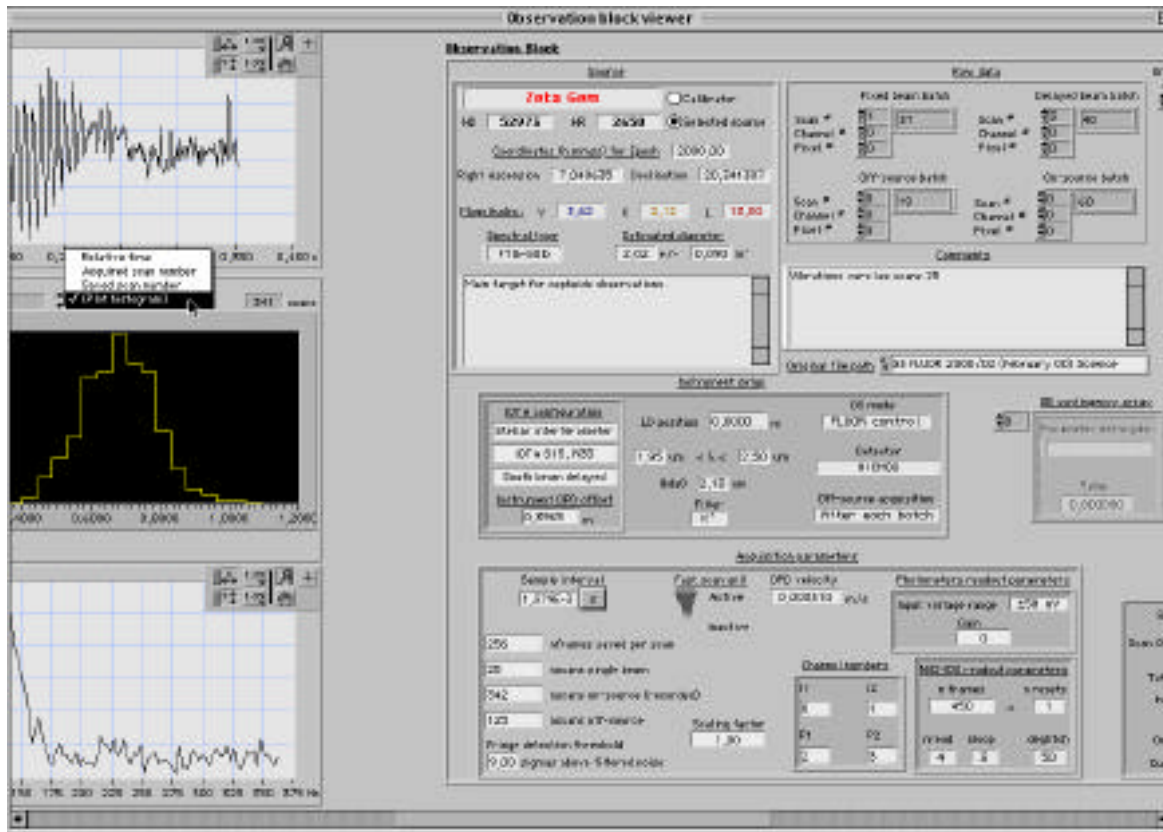
The Frame rate selection boolean determines which value of the frame rate is used for the display scale of the time sequence and the spectrum. If measured frame rate is chosen, that scale will change each time the measured frame rate value is updated. It is usually more convenient to adopt a fixed, manually set frame rate.

Finally , another purpose of the signal check VI is to optimize the acquisition length in order to avoid saturation. When the cumulated signal between two consecutive resets is larger than 53000 ADUs, saturation is declared and the VI beeps (with a tone all the higher as the saturation is large). The same beeps might also occur during data acquisition within a batch from the FLUOR OS. In that case, the scan is not transferred to the OB.

11.3 Observation Block viewer



The OB viewer is a two-screen wide VI with interactive graphical displays of the OB data in the left part, and a numeric display of the OB cluster in the right part.



In the graphical zone, the two blue graphs on the left are waterfall display of the time sequences (upper graph) and associated amplitude spectra (lower graph). To improve the refresh rate, the Display amplitude spectrum boolean can be turned off. The horizontal scale for these graphs is in pixels, while the vertical scale is the saved scan number. Which signal is displayed is selected via the Sample type and Display channel menus.

The two black and white graphs on the right are plots of a particular scan which is selected via the Display scan # control. The horizontal scale there is in seconds for the time sequence, and in Hertz for the amplitude spectrum.

The middle black display (yellow dots) on the right is used to plot some scan related parameters (including the raw squared visibilities μ^2 if the data have been fringe processed) as a function of either relative time, acquired scan number, saved scan number, or to plot the histogram of that parameter. If there are any 4-sigma outliers, their list appears in red below the plot.



The statistics of the plotted parameter are also summarized numerically. They are self explanatory except for:

- Bias = (average - median)/(standard error)
- Skew is the ratio of the third order moment of the distribution to the standard deviation of the third order moment of a set of random points (with the same number of points) issued from a Gaussian distribution.

When the parameter displayed is a raw visibility, two additional numbers appear:

- Piston noise/total noise: the amount of correlation between the measured raw visibilities at the two interferometric outputs;
- Correlated magnitude: the magnitude of the correlated flux (photometric flux x raw visibility).

The SNR numbers are the ratio of the average value for the batch to the noise rms of that channel. The Magnitude limit is the magnitude which would yield a SNR of 1 on I1 and I2. It does not necessarily correspond the actual magnitude limit of the instrument (although it comes fairly close if the raw visibility is high), but gives an overall indication of the photometric performance and is a good diagnosis tool to detect transmission problems such as vignetting.

It is possible to remove specified scans (because they are corrupted for example) from a batch. Simply type in a string with the corresponding saved scan numbers in the Scans to remove indicator (this is one case where it is possible to write into an indicator), and click on the Remove scans button. The numbers need not necessarily be sorted, and a range can be declared with a double dash. For example, the string "4 2 8--10" will remove scans 2, 4, 8, 9 and 10. Because the scan removal feature is not fully proofed yet, it is advised to use it only for off-line data (when the OB viewer is called by the OF viewer).

There are three ways to exit the OB viewer (the standard "stop" button is hidden out):

- Click on the Save button: a dialog box appears to select (or create) an OF file in which to save the OB, including the Comments that can be written from the OB viewer;
- Click on the Dump to ASCII file button: a dialog box appears to generate a set of spreadsheet-type ASCII files from the OB raw data (with very limited header information);
- Click on the Don't Save button, and return to the calling VI with no further action.

12 Data reduction

Reminder: the data flow in FLUOR is the following:

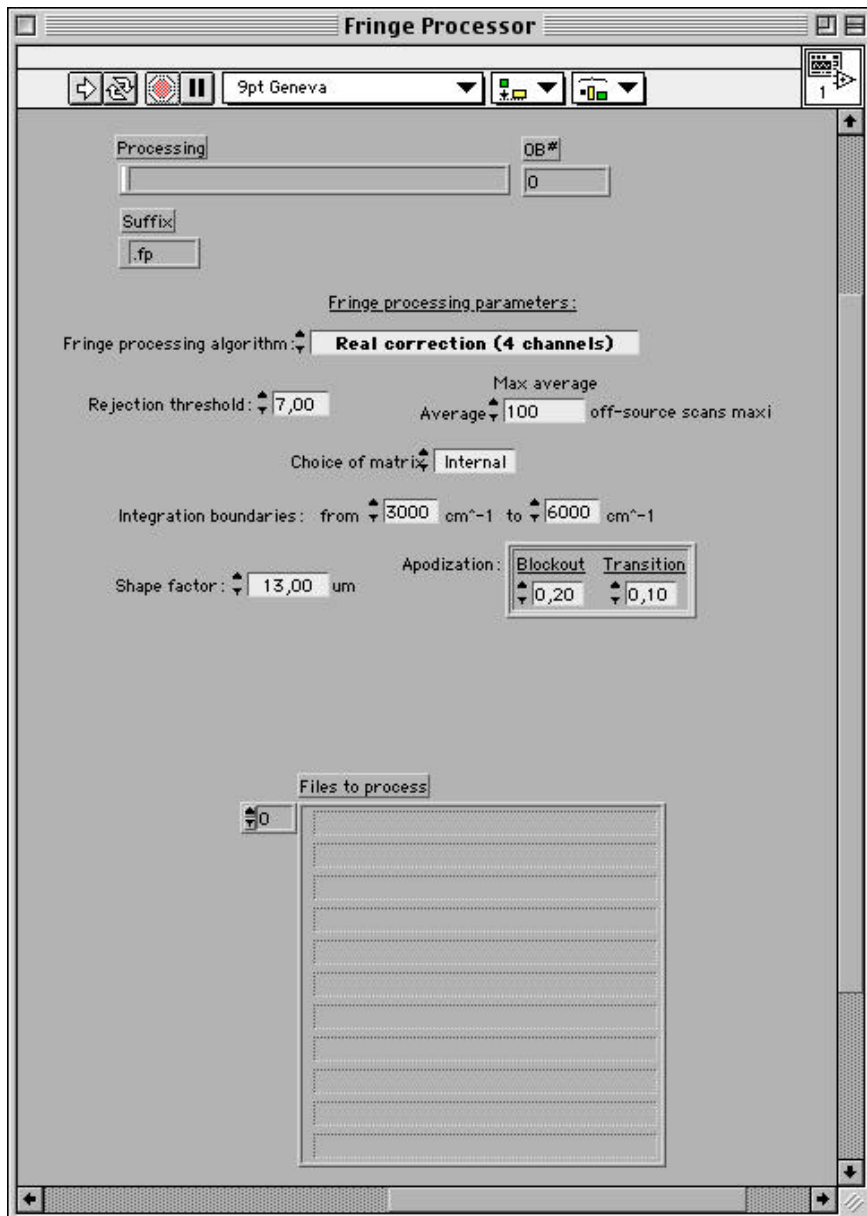
i/ Collect raw data with the FLUOR OS and save them into Observation Files (which do not contain raw visibilities);

ii/ With the Fringe Processor, compute the raw visibilities and save them with the raw data into completed (fringe processed) OFs;

iii/ Use the OF viewer to analyze an OF, view specific OBs, and produce calibrated visibilities, which can be saved into an OF report.

It is very important to perform steps ii/ and iii/ as soon as possible after the observation (maybe the next afternoon), since many problems can be diagnosed only from fully reduced data and calibrated visibilities.

12.1 Fringe Processor



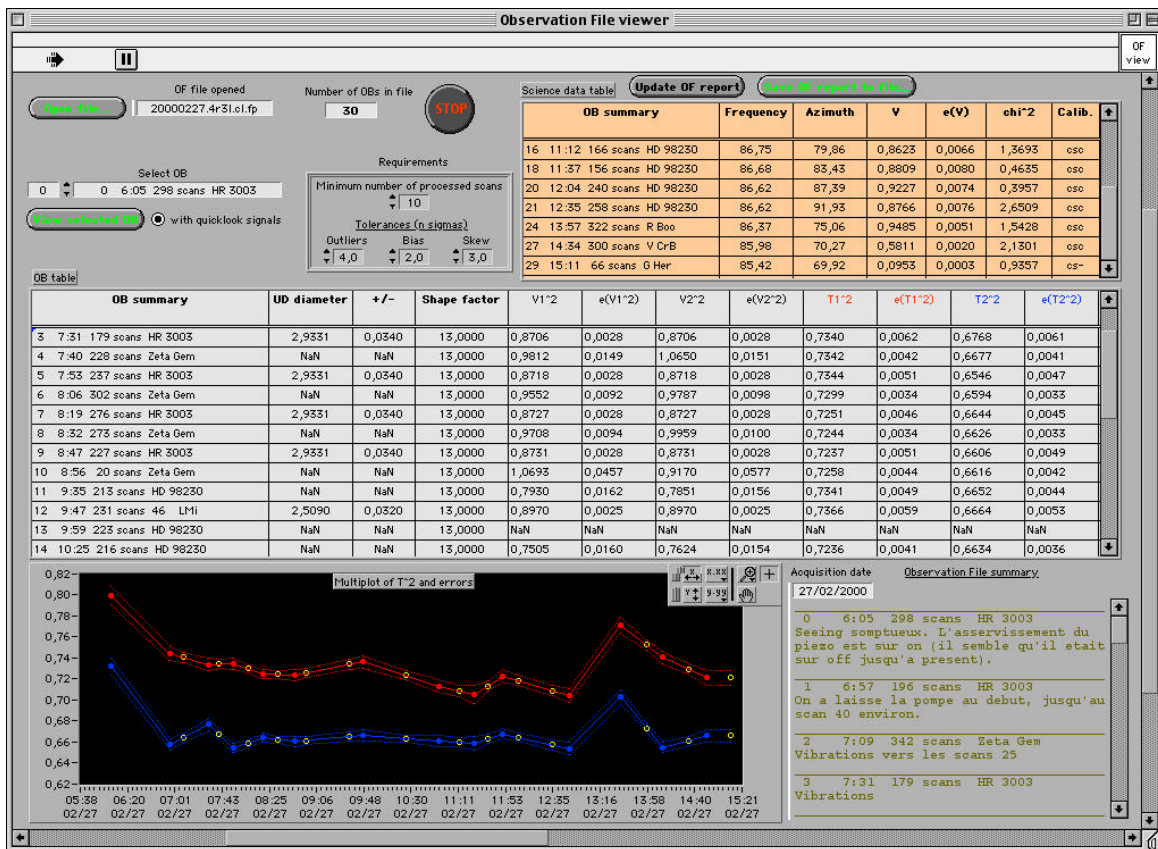
The fringe processor is a number crunching routine and its interface is very limited. To run it, simply click on the white arrow button on the upper left corner. When the dialog window appears, navigate through the Finder to the folder in which are located the OFs to be reduced, and click on the "Select Folder" button. The run arrow becomes black until the

reduction is finished. It takes less time to fully fringe process a good night's worth of data, than for the observer to sleep...

The data reduction parameters are described in detail in the paper “Deriving object visibilities from interferograms obtained with a fiber stellar interferometer.” A&A SS **121**: 379–392. Their default values are good for full K' band observations.

12.2 Observation File viewer

12.2.1 Observation File viewer description



The OF viewer has four main displays (the details of error bars management and transfer function interpolation can be found in A&A **331**: 619–626):

- The science data table (in yellow at the upper right of the window): contains the calibrated visibility (not squared) for all science targets, consolidated from the two interferometric channels, with the overall error bar and a Chi² (the result should probably be discarded if the Chi² > 3). Another indicator of the overall quality is the calibration code: "csc" if the science target was bracketed with two calibrators, "-sc" if the calibrator was observed only after the science target, and "cs-" if the calibrator was observed only before the science target.

- The OB table: lists all OBs, whether they correspond to a calibrator or a science target:
 - For calibrator targets, the UD diameter and its error are collected by default from the source catalog entry recorded with the data. From this diameter is derived an expected visibility (the same for both channels), and the transfer function is estimated by $T^2 = \mu^2 / V^2$;
 - Science targets are identified with NaN (Not a Number) in their diameter fields. In that case the values for the transfer functions in each channel are interpolated, and the calibrated squared visibility is estimated by $V^2 = \mu^2 / T^2$.
- The multiplot of T^2 and errors, a graphical representation of the time evolution of the transfer function for each channel. Science target OBs are represented in this time sequence by a yellow circle.
- The Observation File summary, an automated log of the OF containing OB times, number of scans, targets, and comments as introduced in the OB viewer.

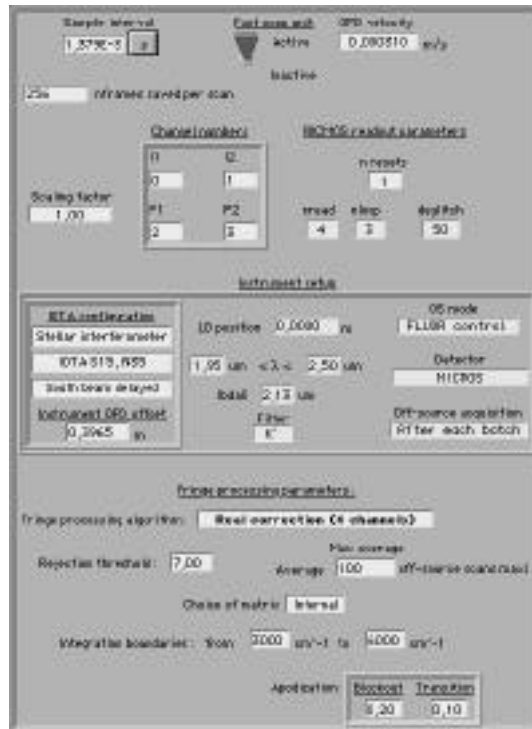
There is also a Requirement cluster that contains a set of statistical tests on the data. If a given OB fails these tests, its corresponding line in the OB table is filled with NaNs. The tests are:

- Minimum number of processed scans in the OB: not all scans are processed by the Fringe processor. A scan is not processed if the minimum SNR value of the photometric signals is so low that the division becomes numerically unstable;
- Maximum allowable values for the bias and the skew of the raw visibility distributions in any of the two channels;
- Maximum allowable value for an outlier in the distribution of raw visibilities: outliers are removed recursively until there is none left, before averaging the raw visibility distribution to produce a raw visibility estimate.

The default values of the requirements should be efficient under most circumstances. It is possible, however, to modify them if needed. It is also possible to change a calibrator diameter (and its uncertainty) in the OB table, or to transform a calibrator into a science target (by replacing its diameter and uncertainty values by NaN), or vice versa. Once the changes are made, click on the Update OF report button to see the revised displays. Once the displays are satisfying, click on the Save OF report to file... in order to generate an observation file report. The calibrated visibilities can then be read and archived in a spreadsheet program such as Excel, for example.

To view a specific OB with the OB viewer, select the OB with the Select OB menu, choose whether or not to compute the quick look signals, and click on the View selected OB button.

Another function of the OF viewer is to check the consistency of the instrument and data reduction setups throughout the Observing File. More specifically, the OF viewer checks that the following cluster is the same for all OBs in the OF, and if this is not the case, displays a warning message while opening the OF:



12.2.2 Sample observation file report:

FLUOR/IOTA

Report for Observation File: 20000219.4r41.clv.fp

Data acquired on: 19/02/2000

Report created on dimanche 9 avril 2000 at 16:50

SCIENCE TARGETS DATA REPORT

Name	HD	Date	Time	Freq. (arcsec ⁻¹)	Az. (deg)	V	e(V)	chi ²
		Calibration	Filter	lbda_eff (µm)	FP file	OB#		
Zeta Gem	HD0	19/02/2000	7:07	81,29	76,21	0,9800	0,0076	0,0043
	2,225	20000219.4r41.clv.fp	OB0					-sc K'
Zeta Gem	HD0	19/02/2000	7:59	80,54	83,84	0,9948	0,0058	0,2610
	2,225	20000219.4r41.clv.fp	OB2					csc K'

OB TABLE

OB summary	UD diameter	+/-	Shape factor	V1 ²	e(V1 ²)V2 ²	e(V2 ²)T1 ²
	e(T1 ²)T2 ²	e(T2 ²)				
0	7:07	130 scans	Zeta Gem	NaN	NaN	13,00000,9615
	0,0213	0,7289	0,0114	0,6714	0,0103	0,0217
1	7:35	283 scans	HD 49968	1,8700	0,0200	13,00000,9438
	0,0012	0,7289	0,0114	0,6714	0,0103	0,0012
2	7:59	409 scans	Zeta Gem	NaN	NaN	13,00000,9835
	0,0160	0,7071	0,0095	0,6442	0,0083	0,0169
3	8:39	234 scans	HD 49968	1,8700	0,0200	13,00000,9442
	0,0012	0,6725	0,0166	0,6011	0,0138	0,0012

13 Troubleshooting

13.1 Control signals

13.1.1 Piezo return

13.1.2 Pulses

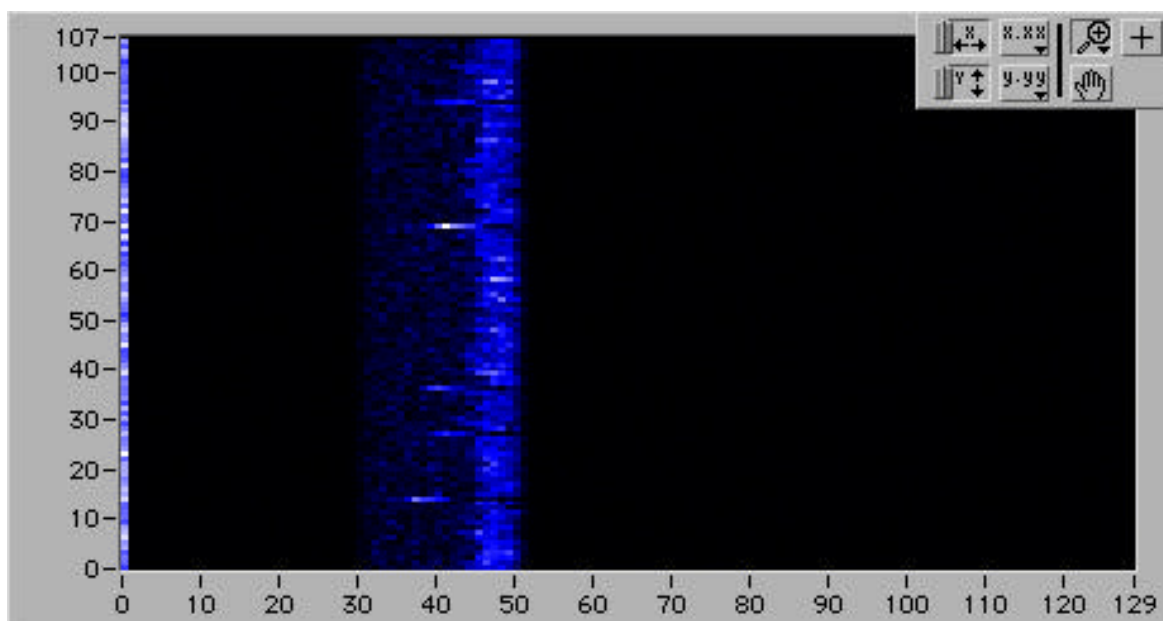
13.1.3 SD error signal

13.2 Museum of Horrors: examples of corrupted data

While acquiring data, watch out for these types of problems. Which does not mean that other types of data corruption cannot occur...

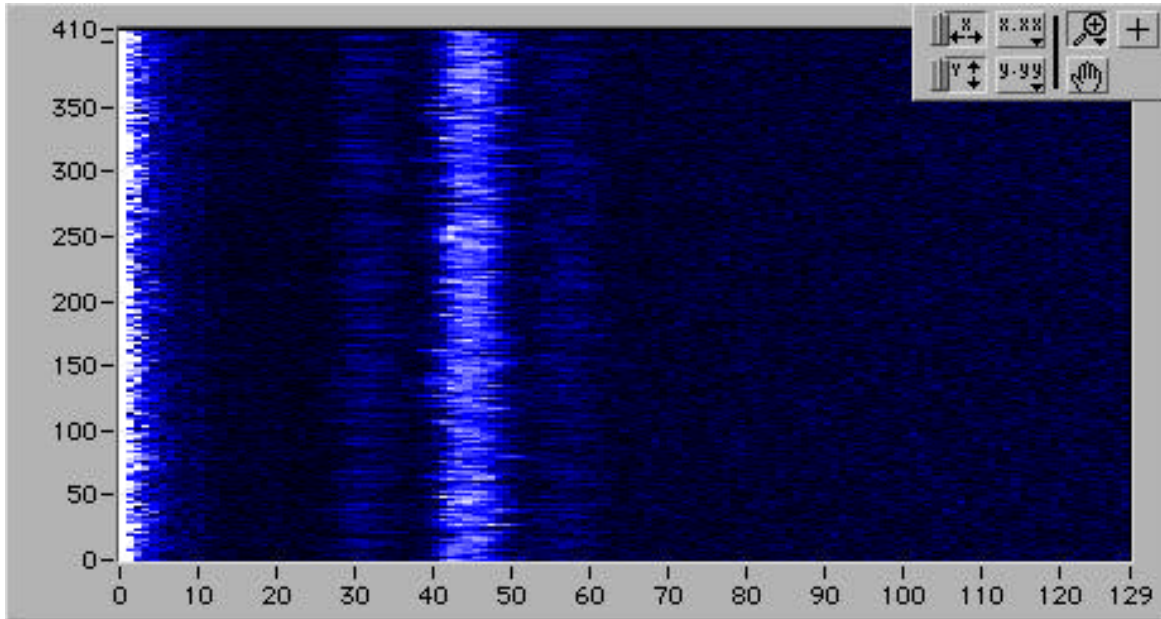
13.2.1 Wrong filtering window

In this waterfall display of the quick look signal spectral amplitude, the filtering window does not appear to be centered on the fringe frequency. The most likely explanation for this is that the declared frame rate is not the actual frame rate, or the declared f_{\min} and f_{\max} are not centered with respect to the actual effective wavelength. Another possibility is that the fringe speed is not what was requested, maybe because of a problem with the fast scan piezo or the short delay. If no solution is found, the easiest fix is to modify f_{\min} and f_{\max} to whatever values will work.



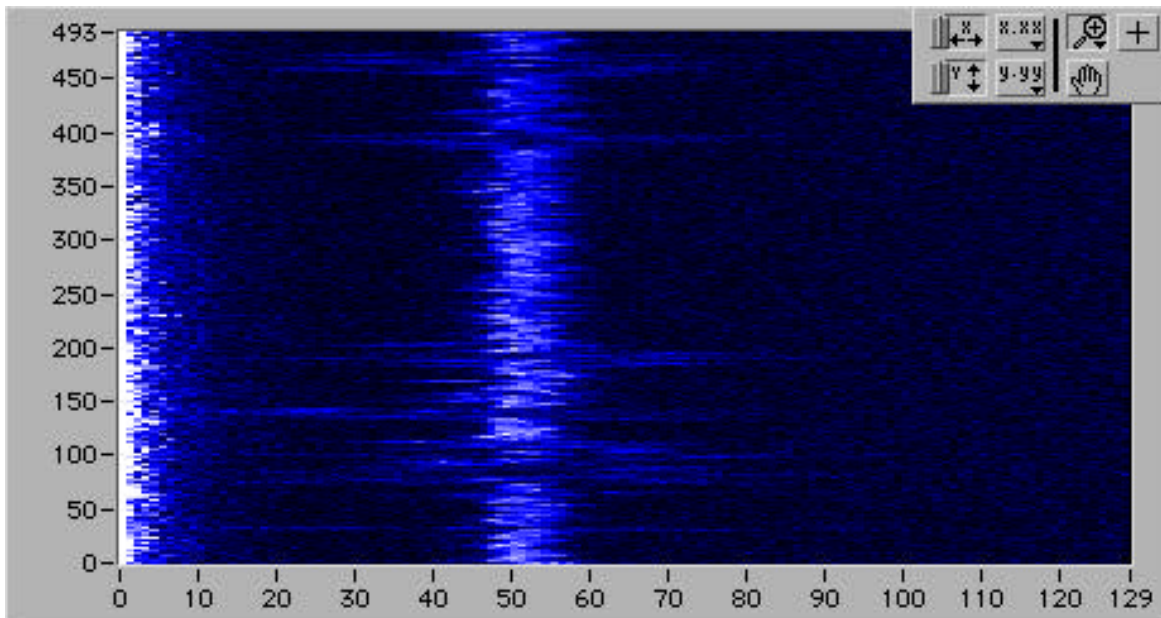
13.2.2 Longitudinal vibrations

A classic: sinusoidal OPD variations generate ghost replicas of the fringe spectral signature. The visibility calculation will be strongly biased.



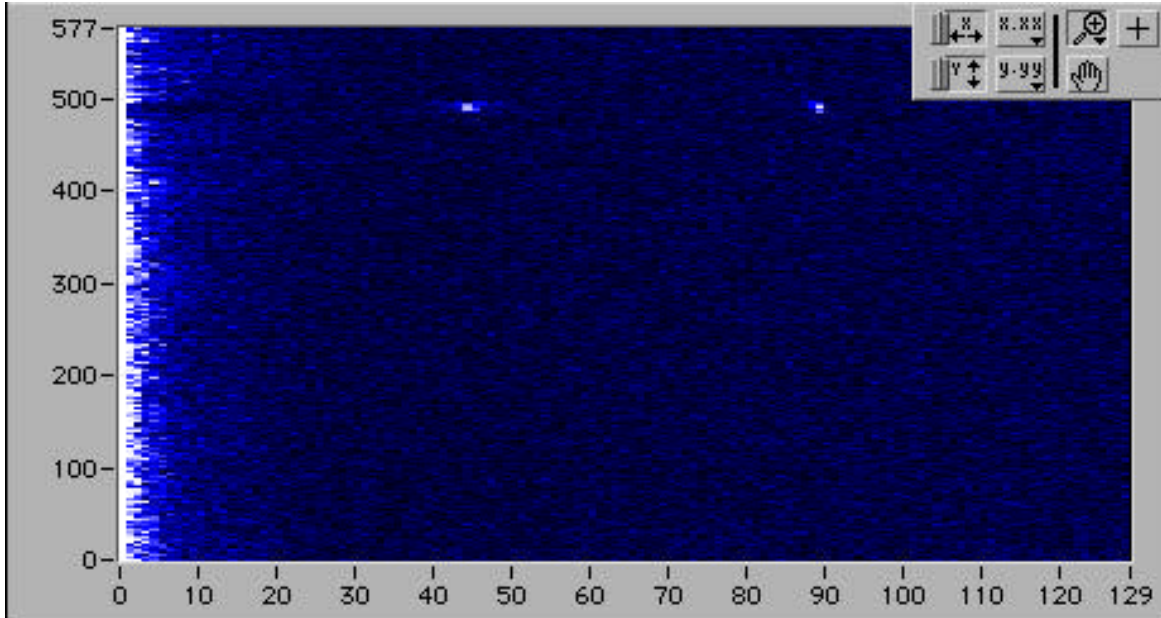
13.2.3 Generalized vibrations

This waterfall spectrum displays shows generalized vibrations that are believed to be somehow linked to the air line compressor. These have a catastrophic effect on visibilities calculations. It helps sometimes to interrupt observations while the compressor is running.



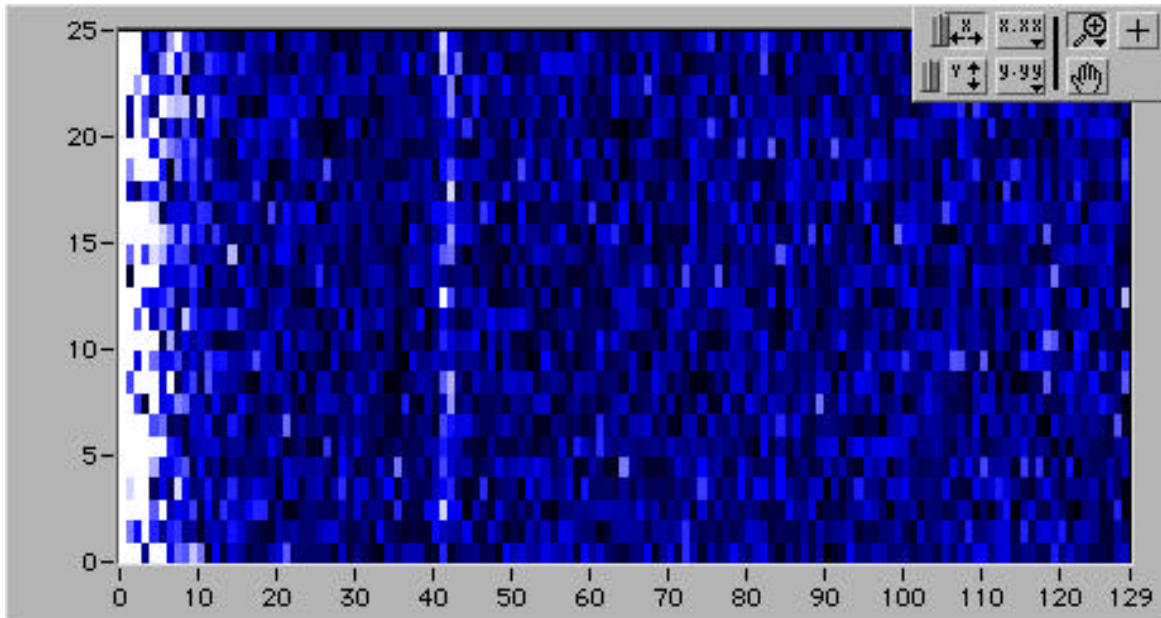
13.2.4 Monochromatic lateral vibrations

Nobody knows where these come from... (amplitude spectrum display). If these vibrations are limited in time, the corresponding scans do not pass the Requirement tests and they are ignored by the OF viewer.

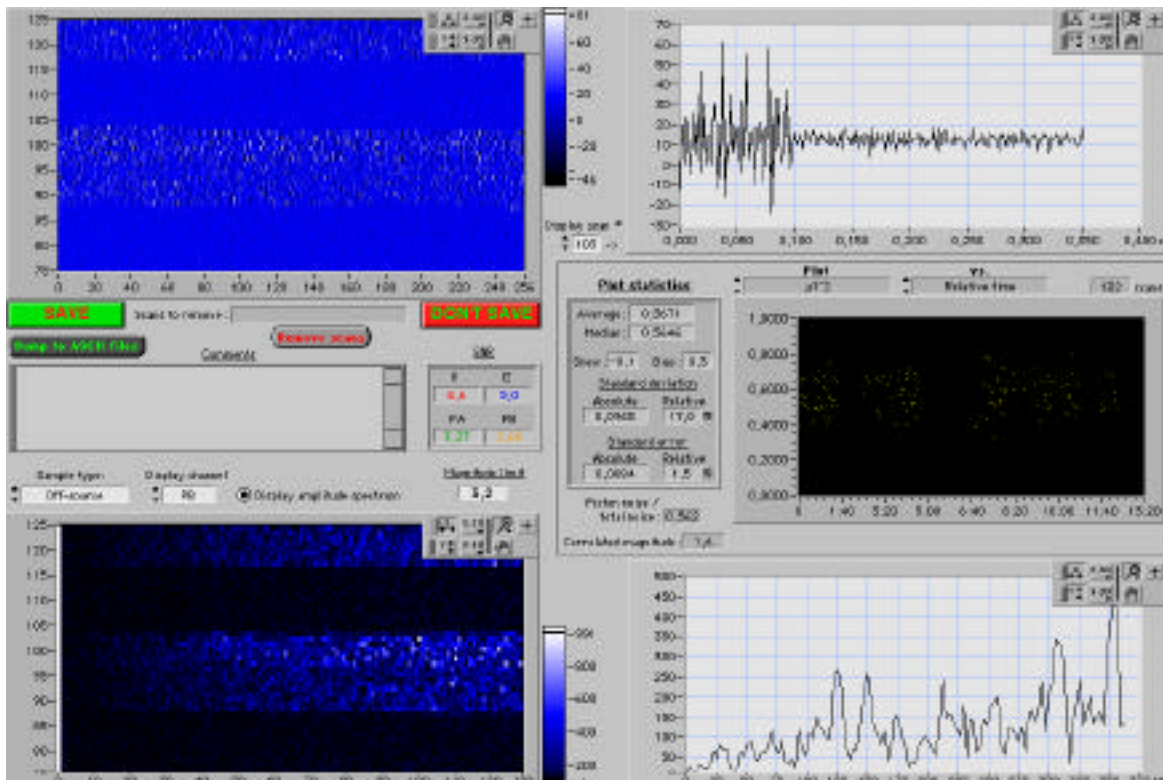


13.2.5 Pickup

This one appeared in the amplitude spectrum of one of the photometric signals:

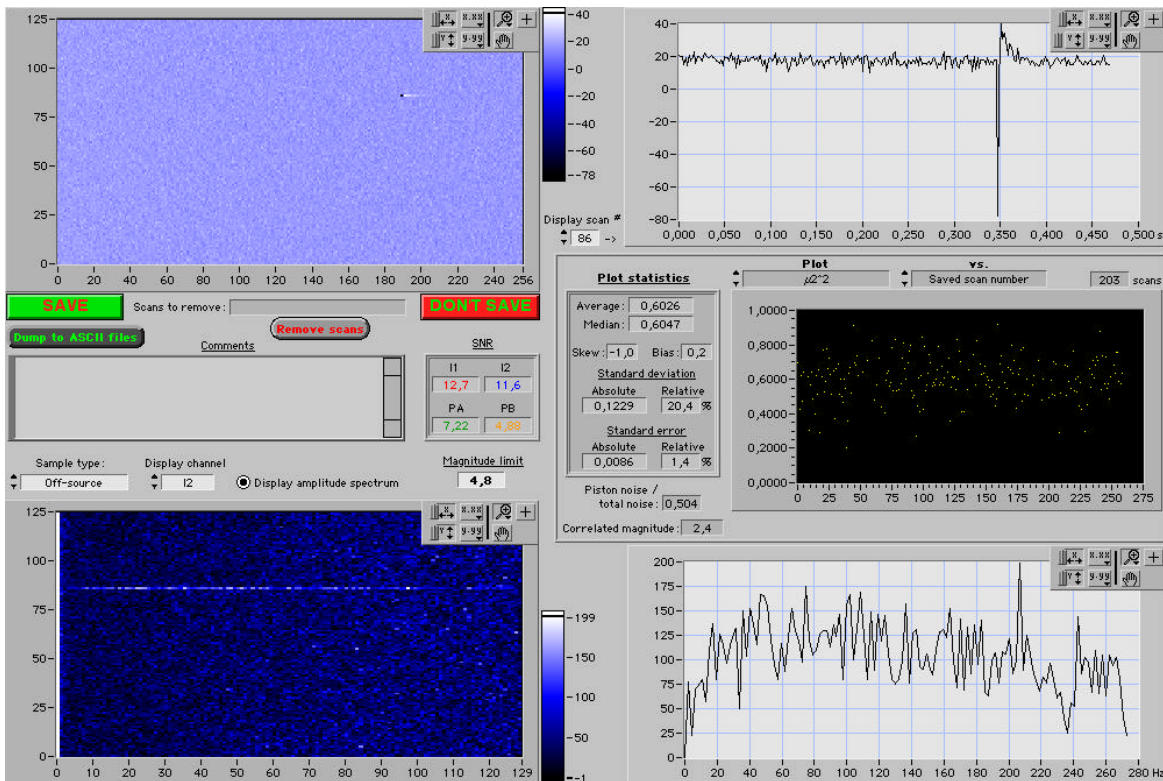


13.2.6 Sudden large noise increase in the camera



13.2.7 Spikes

Sometimes a spike appears in the data. This is not a big issue, since the data pipeline should be able to take care of it without too much trouble.



14 Known bugs, caveats and other gotchas

14.1 Piezo offset