Tutorial T-10
Amber Data Reduction (practical point of view)

EuroSummer School

Observation and data reduction with the Very Large Telescope Interferometer

Goutelas, France
June 4-16, 2006

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LAOG/JMMC
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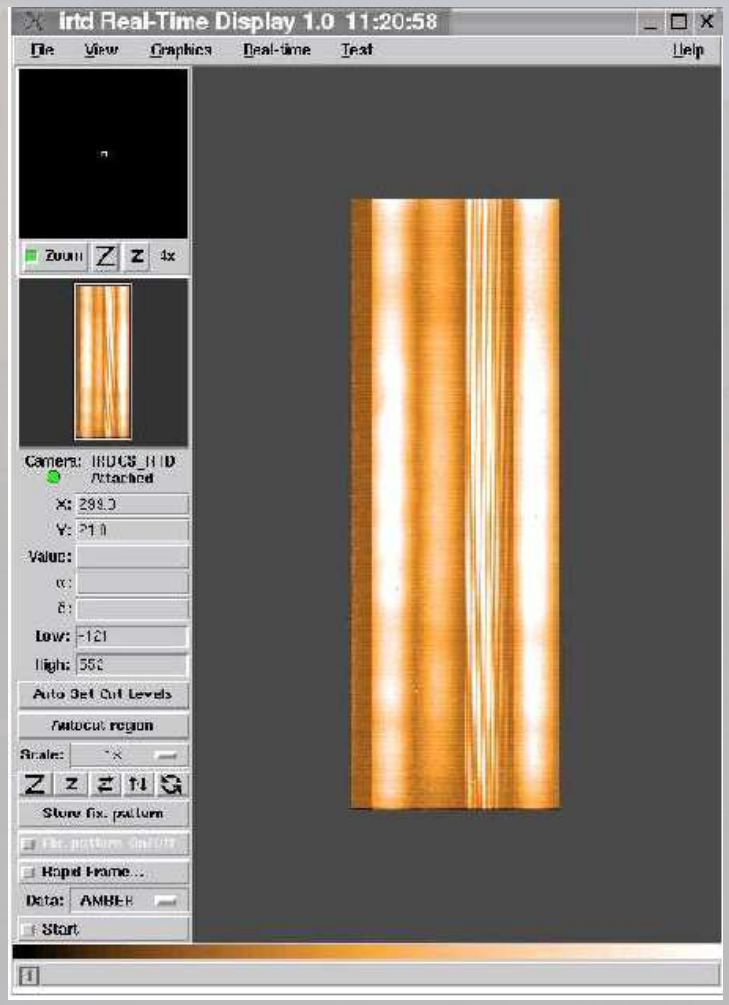
AMBER DATA REDUCTION OVERVIEW

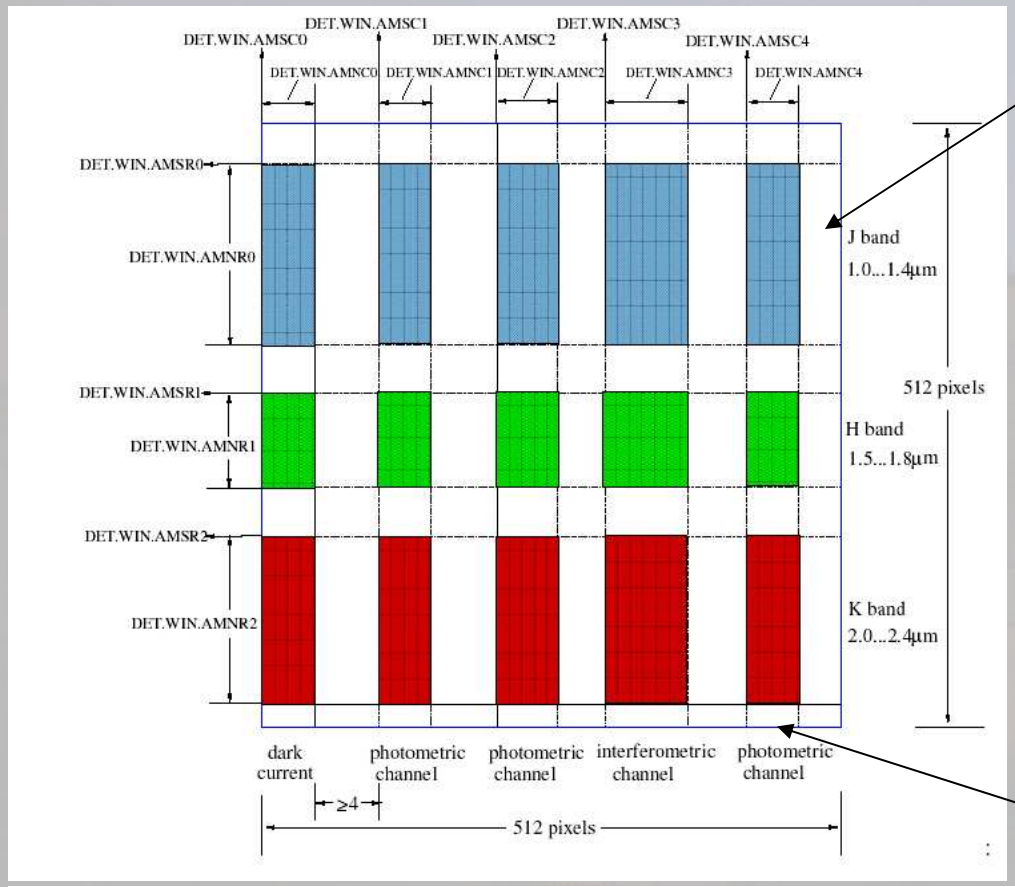
AMBER paradigm: ***spatially coded, spectrally dispersed, photometrically monitored, fringes.***

- **fringes** ... on an infrared Hawaii Camera:
- camera readout mode
- camera windowing, readout timing
- camera readout noise, bad pixels, flat, etc...
- **spectrally dispersed** ... needs spectral calibration
- wavelength calibration
- **spatially coded** ... needs spatial coding calibration:
- the P2VM

• fringes ...


irtd Real-Time Display 1.0 11:20:58
File
View
Graphics
Real-time
Text
Help
Zoom
1x
Camera:
Attached
X: 288.0
Y: 21.0
Value:
α:
β:
Low: -121
High: 552
Auto Set Cut Levels
Autocut region
Scale:
Store fix. pattern
Rapid Frame...
Data:
AMBER
Start

... on an infrared Hawaii Camera:

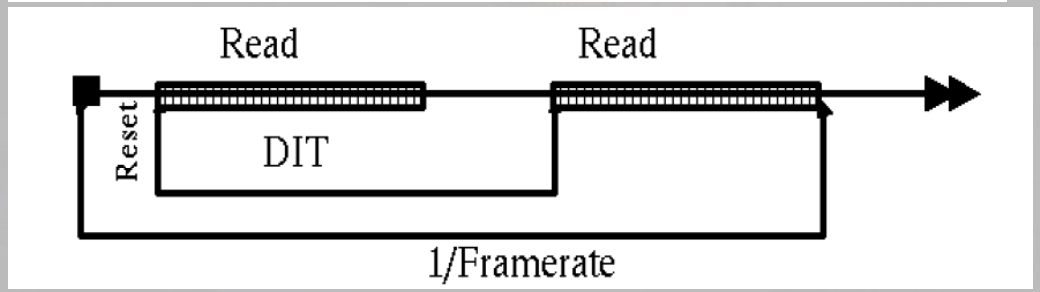


« row »

« channel »

The camera is ALWAYS illuminated (NO shutter)

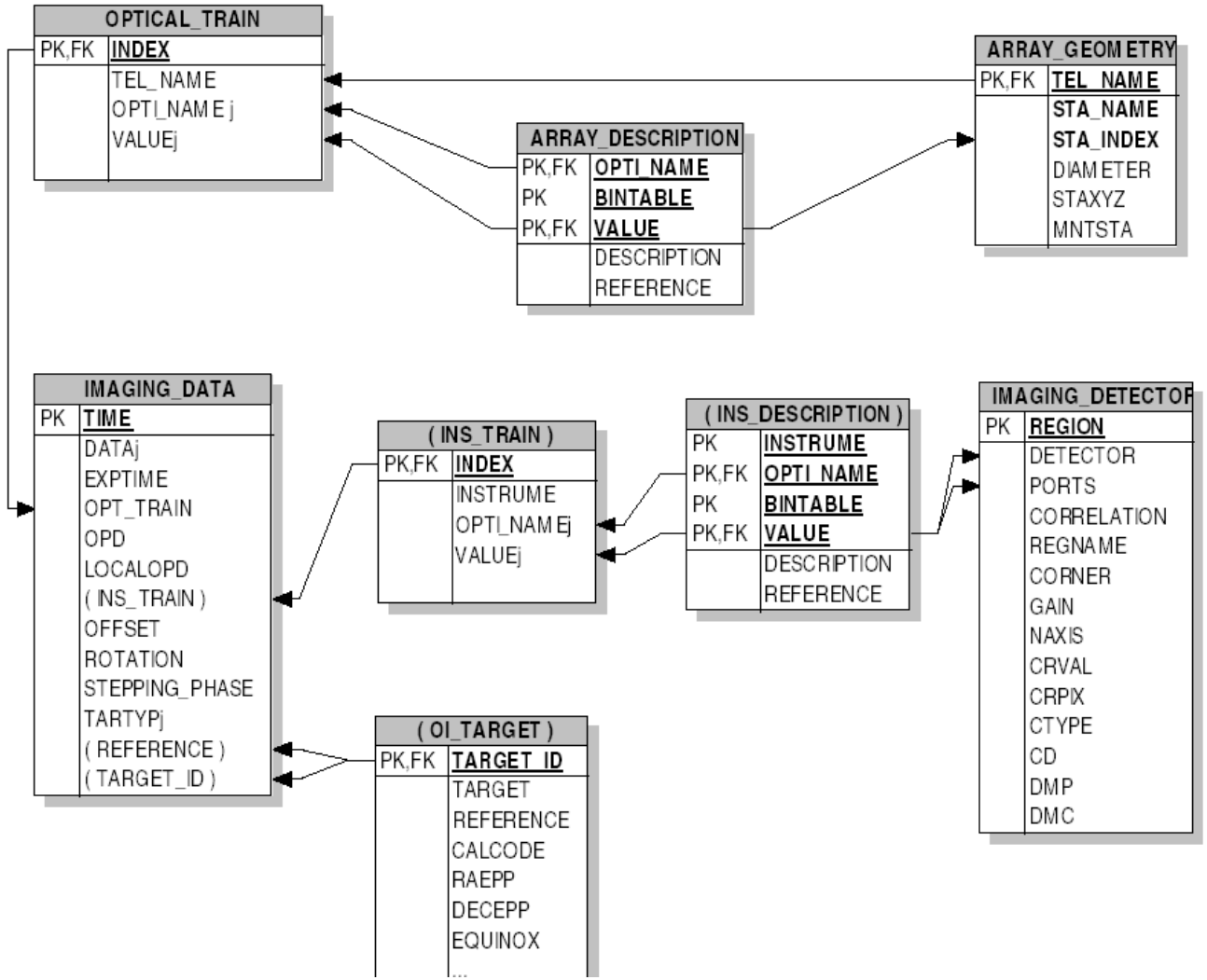
The camera is divided in (max 3) ROWS of (4 or 5) , regions: Dark, P1 , P2, I [, P3]



The READOUT mode used is DOUBLE-CORRELATED

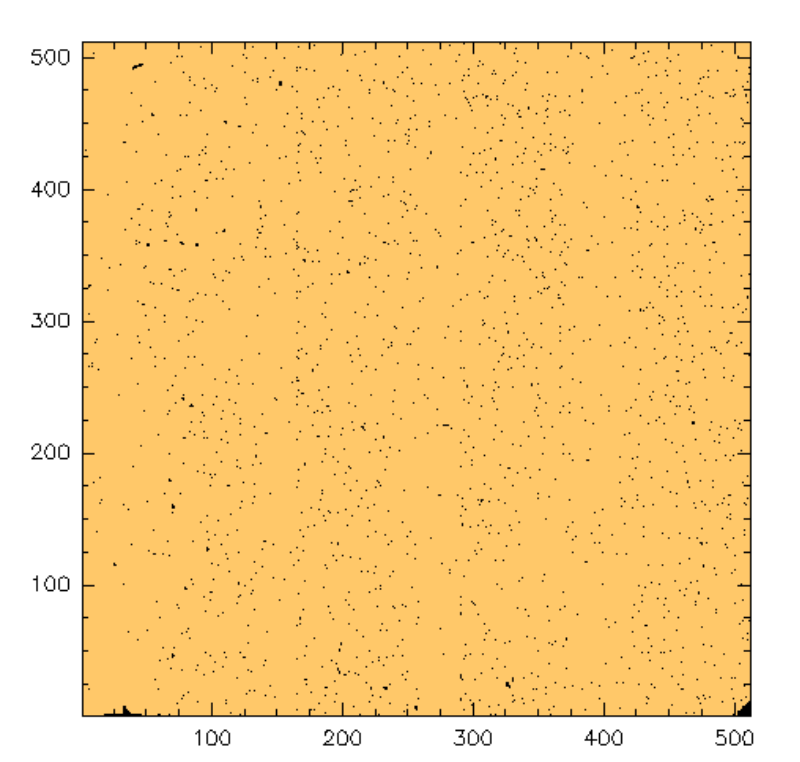
The NDIT camera readouts of duration "DIT" are saved in a raw data fits file containing several Tables. This is the basic product of AMBER

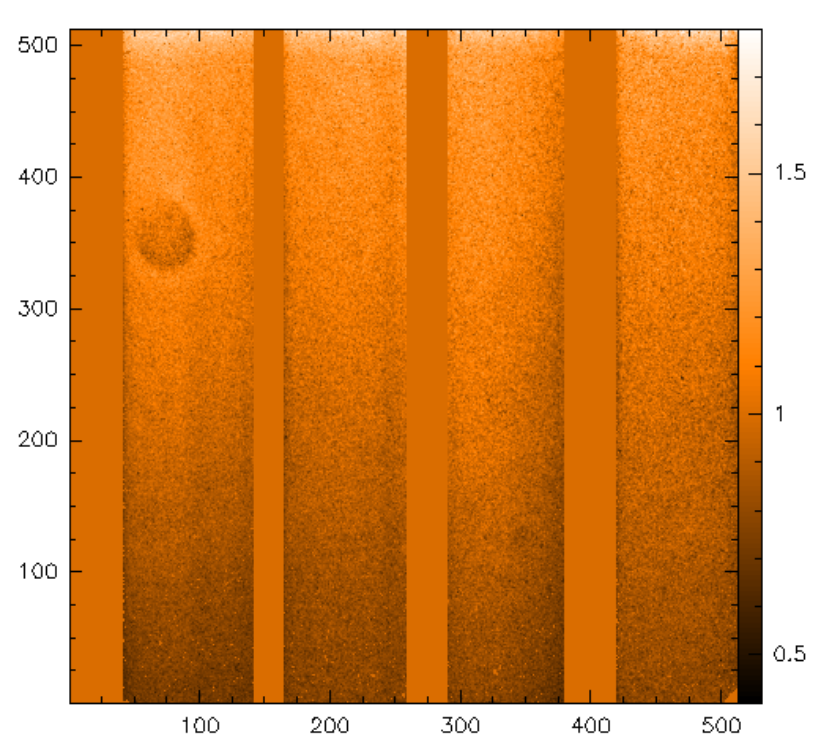
RAW DATA Fits file: sequence of FITS Tables,described in ESO Doc. No.: VLT-SPE-ESO-15000-2764



(a supplementary table, AMBER_WAVELENGTH, contains the spectral calibration)

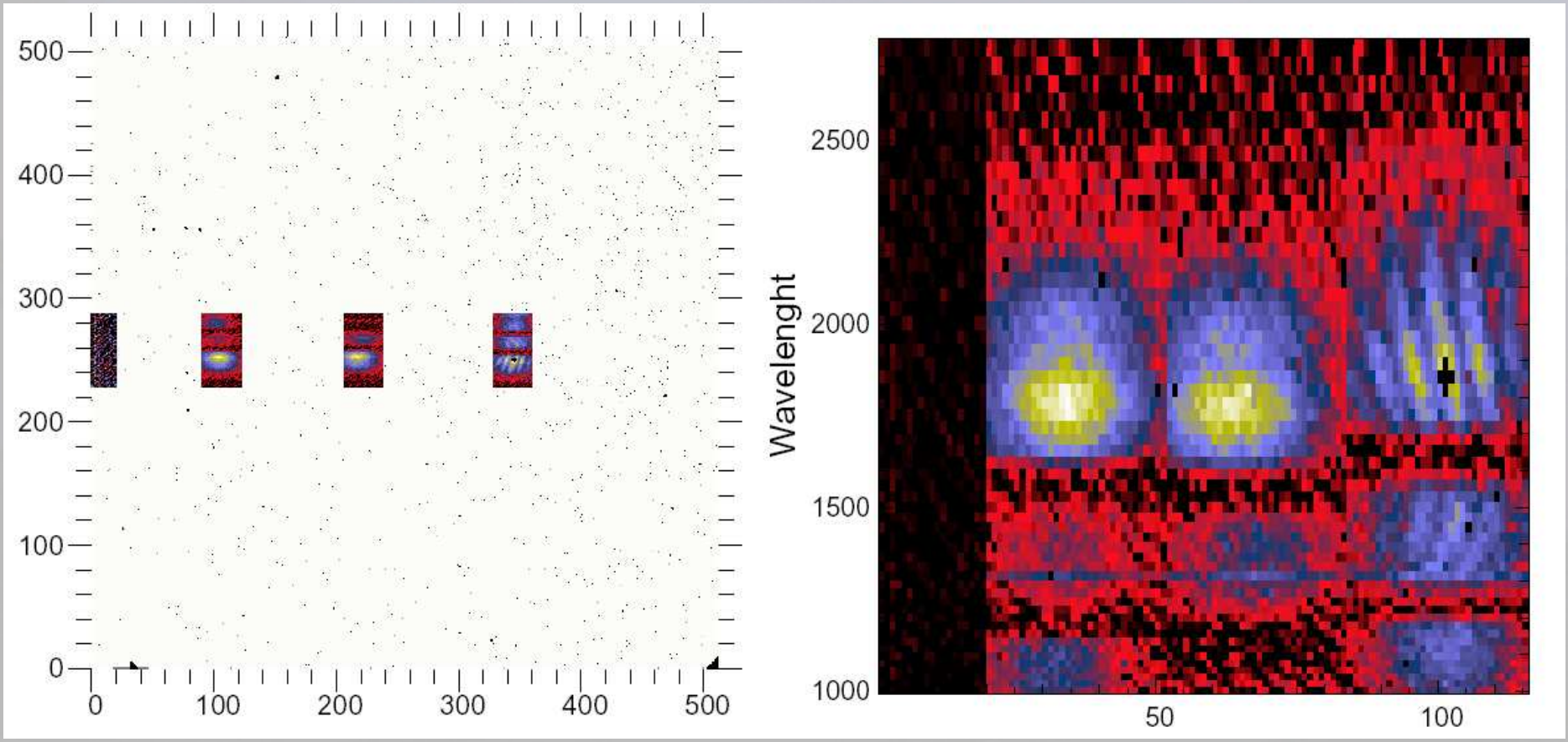
- camera readout noise, bad pixels, flat, etc...





1. Bad Pixels -> “Bad Pixel Map” File
2. BIAS depends on the illumination of the camera and EXPOSURE TIME –> “Dark” Files
3. Relative pixel-to-pixel gain -> “Flat Field Map” File

. spectrally dispersed …



…displacement of photometric « channels » - CALIBRATE – 3 or 4 Files
…accurate wavelength calibration of the Interferometric « channel »? NO

- **spatially coded** ... the P2VM: 5 (2T) or 9 (3T) files

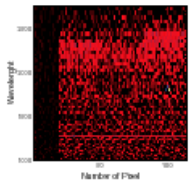
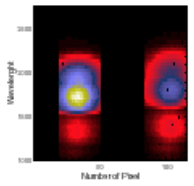
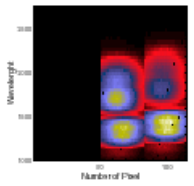
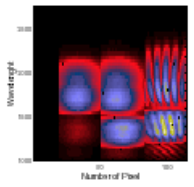
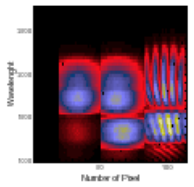
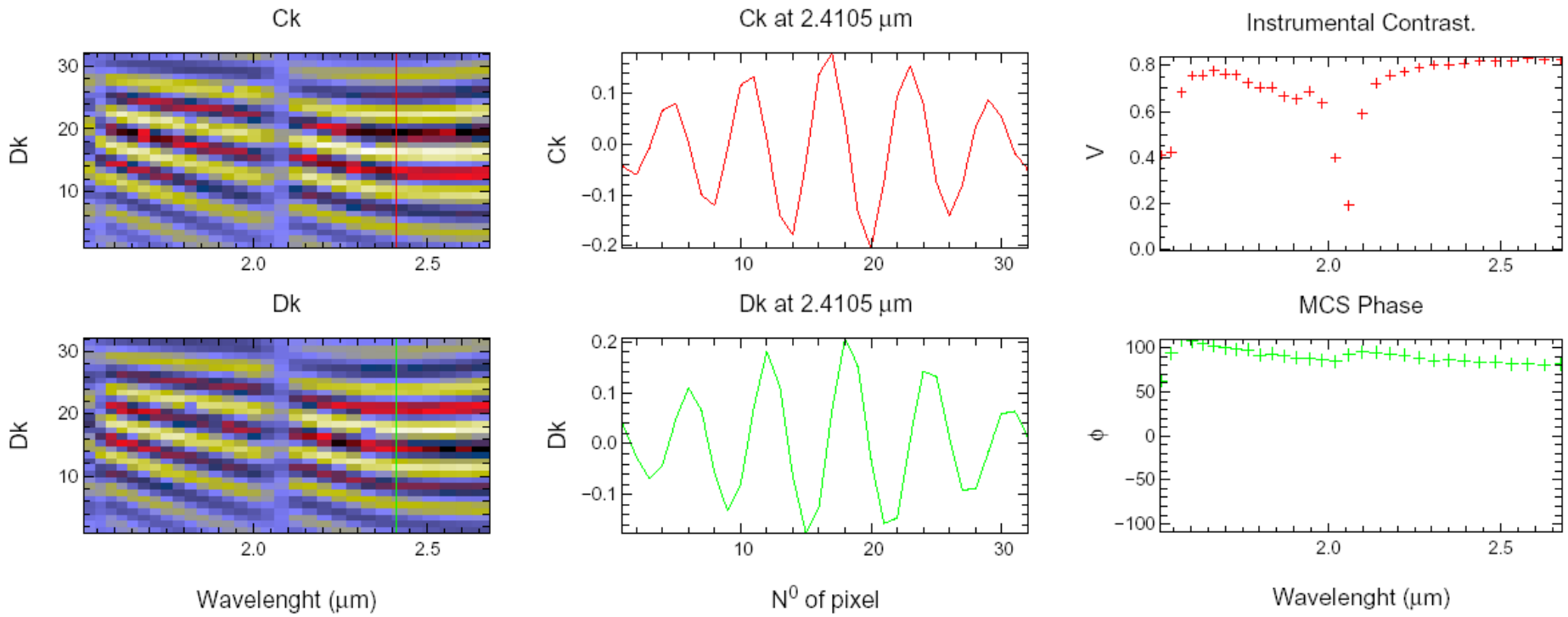
Shutter 1	Shutter 2	Shutter 3	Delaying plate	file Name	figure
Close	Close	Close	No Delay	AMBER_3TSTD_CAL_0001.fits	
Open	Close	Close	No Delay	AMBER_3TSTD_CAL_0002.fits	
Close	Open	Close	No Delay	AMBER_3TSTD_CAL_0003.fits	
Open	Open	Close	No Delay	AMBER_3TSTD_CAL_0004.fits	
Open	Open	Close	1/2 Delayed	AMBER_3TSTD_CAL_0005.fits	

Figure 3. Complete calibration sequence for 2 telescopes

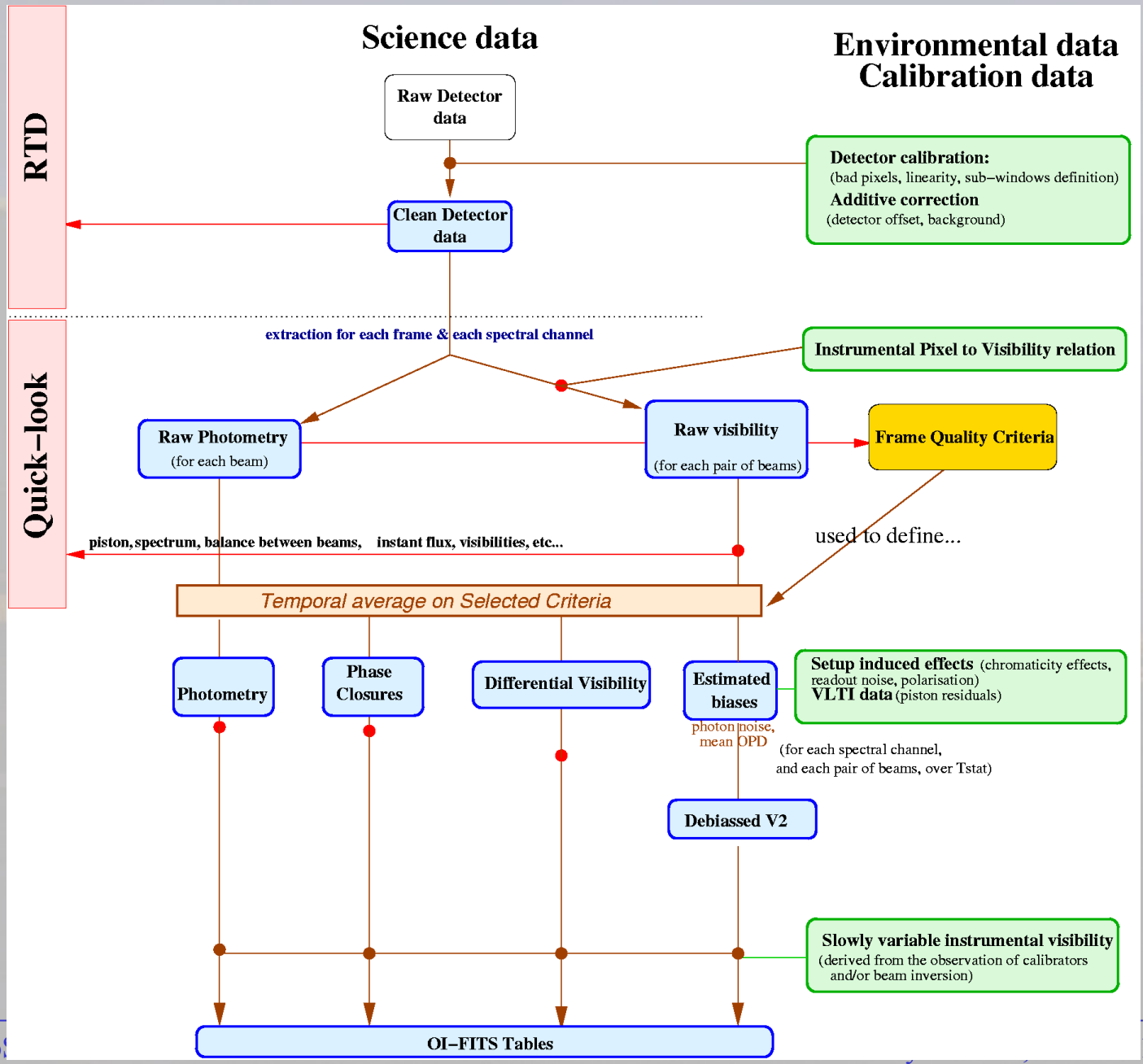
Shutters and P2VM calibration files

Step	Shutter 1	Shutter 2	Shutter 3	Phase γ_0	DPR key
1	Open	Closed	Closed	NO	2P2V, 3P2V
2	Closed	Open	Closed	NO	2P2V, 3P2V
3	Open	Open	Closed	NO	2P2V, 3P2V
4	Open	Open	Closed	YES	2P2V, 3P2V
5	Closed	Closed	Open	NO	3P2V
6	Open	Closed	Open	NO	3P2V
7	Open	Closed	Open	YES	3P2V
8	Closed	Open	Open	NO	3P2V
9	Closed	Open	Open	YES	3P2V

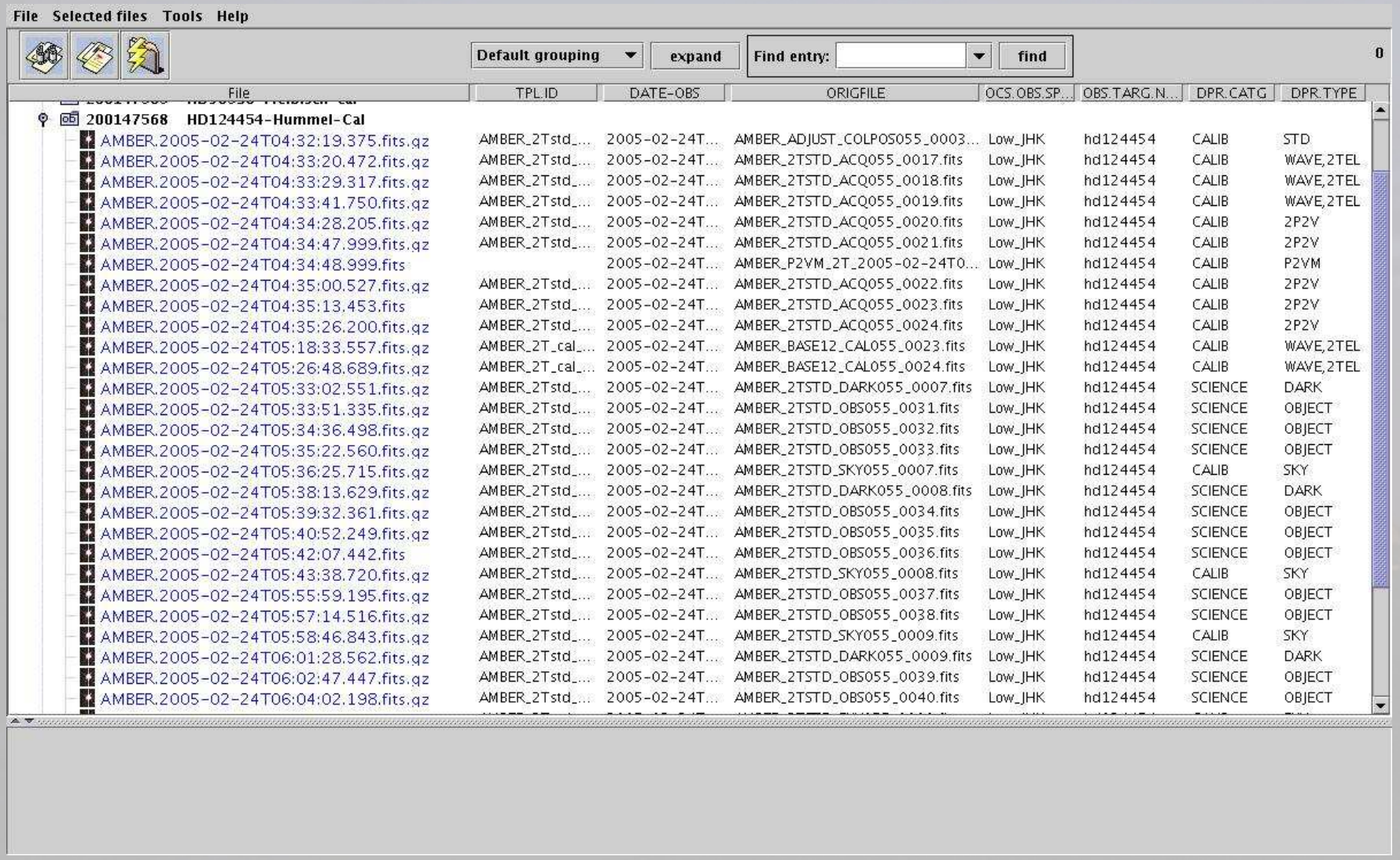
the P2VM:
the « carrying waves: Ck and Dk»



Data Reduction Layout



Sequence of observations:



*A dedicated library, **amdlib**, is pivotal for both observation & data reduction.*

It is used at the time of observation to find fringes, etc…

All the steps for data reduction are available as functions in the amdlib library.

These functions can be called from external programs, but amdlib provides also command-line programs to perform the data reduction.

Each raw data file (including those used to obtain calibration files such as the P2VM) must be calibrated for camera cosmetics.

Internally each calibrated file is converted to a simpler structure, called ScienceData:

-The temporal sequence of 2D Interferograms, untouched.

- Each 2D photometric channel is replaced by a 1D photometry vector (1 instantaneous photometry per beam and per wavelength), and associated errors.

A P2VM must be obtained before any Science Data;
The P2VM File is computed by the amdlib command **`amdlibComputeP2vm`**
Using the 5- or 9- calibration files obtained on the internal source of AMBER

```
Usage: amdlibComputeP2vm [-s o1,o2,o3] badPixelMap flatFieldMap dark file1
... file9 p2vmFile
    or
       amdlibComputeP2vm [-s o1,o2,o3] badPixelMap flatFieldMap dark file1
... file4 p2vmFile
       where o1,o2... is a comma-separated list of shifts for the 2 or 3
photometric channels
```

The DATA necessary to get visibilities on a Science Object are:

- RAW DATA on a Science Object (AMBER_XXX_OBS_YYY)
- Associated Pixel Bias Map (aka DARK)
- [eventually an associated SKY]
- The P2VM in use at time of the observation.

The command amdlibExtractVis does the complete sequence of calibration and visibility, etc., computation using the P2VM, and produces an OI_FITS file:

```
Usage: amdlibExtractVis [-f] [-s] [-b num] [-p PHASOR|PHASE][-e
STATISTIC|THEORIC] badPixelMap flatFieldMap p2vm dark sky input
output
Options: -f to force the use of another P2VM
         -s split OI-FITS; one file per band
         -b 'num' to average (bin) over 'num' frames
         -p PHASOR or PHASE (default) for piston algorithm
         -e THEORIC or STATISTIC (default) for error bars estimation
         -c FRG or FLUX criterion for frame selection
         -r ratio for frame selection
```

A number of programs already call amdlib and provide and interface to it:

-ammYorick, a Yorick implementation by F. Millour (et al).
- a scripting interface in the ESO's gasgano file sorter (to be used this evening)
- The ESO pipeline, now to be delivered with a flexible workflow bench, "taverna" and the gasgano interface (next september).
-The Final OI_FITS product can be read and used by many generalist data visualisation programs (IDL, gildas, etc…)

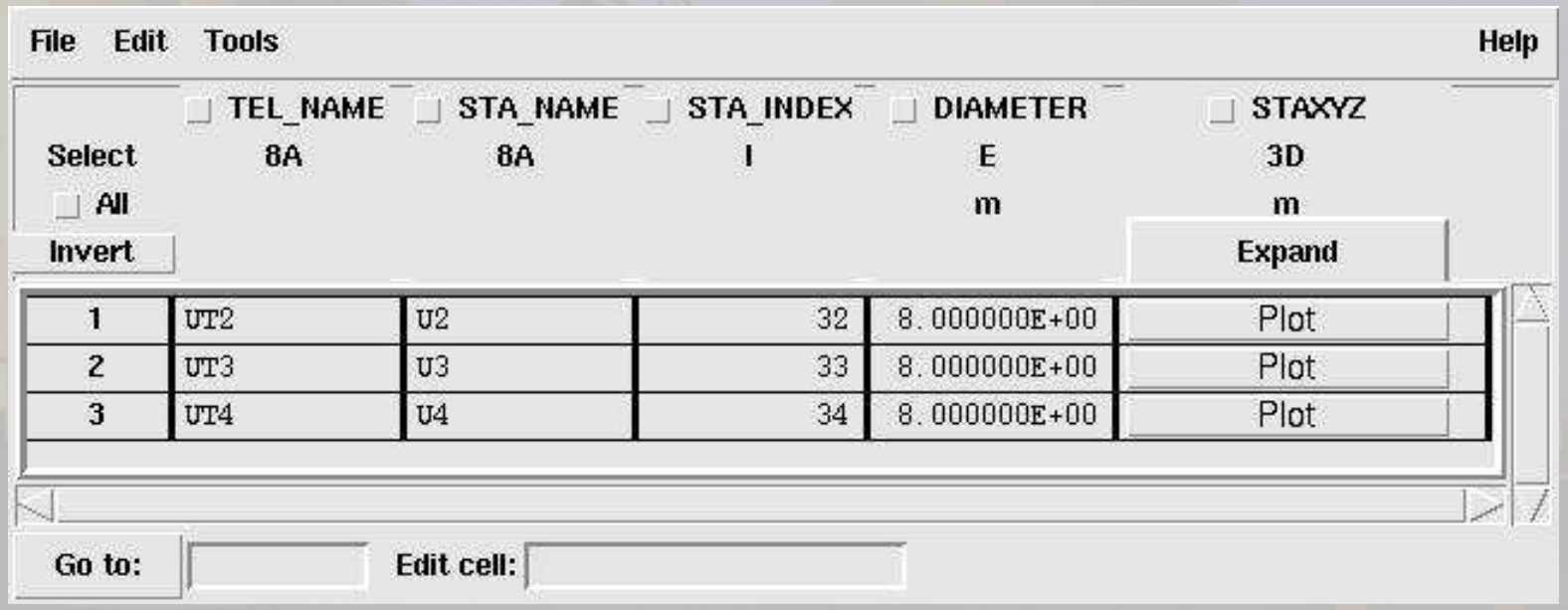
OI_FITS Product:

Normalized by the IAU commission and published. (Pauls, T. A.; Young, J. S.; Cotton, W. D.; Monnier, J. D., "A Data Exchange Standard for Optical (Visible/IR) Interferometry", 2005, The Publications of the Astronomical Society of the Pacific, Volume 117, Issue 837, pp. 1255-1262.). Has a number of Extensions:

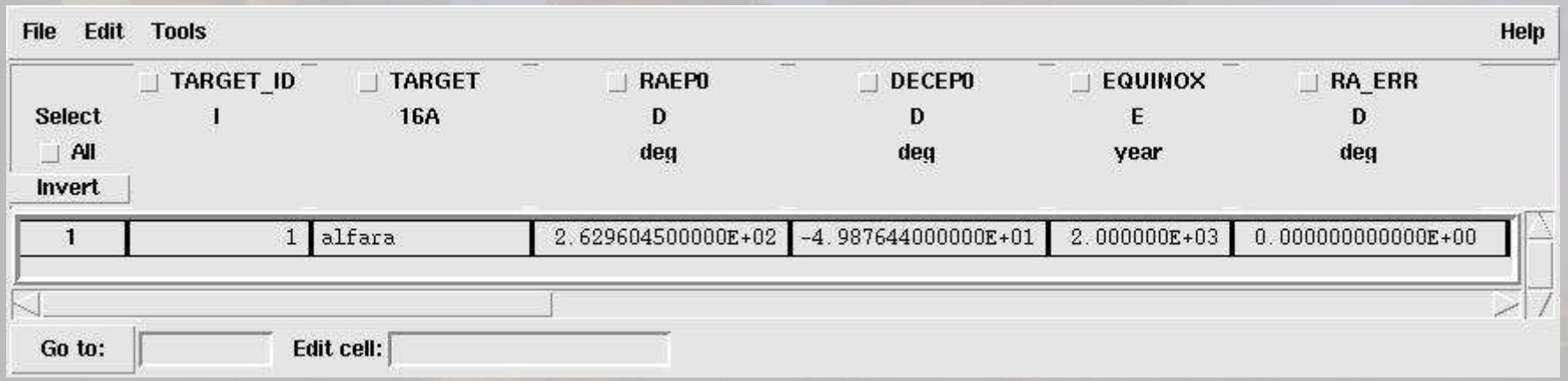
File Edit Tools Help

Index	Extension	Type	Dimension	View				
0	Primary	Image	0	Header	Image		Table	
1	OI_ARRAY	Binary	5 cols X 3 rows	Header	Hist	Plot	All	Sele
2	OI_TARGET	Binary	17 cols X 1 rows	Header	Hist	Plot	All	Sele
3	OI_WAVELENGTH	Binary	2 cols X 158 rows	Header	Hist	Plot	All	Sele
4	OI_VIS	Binary	14 cols X 1500 rows	Header	Hist	Plot	All	Sele
5	OI_VIS2	Binary	10 cols X 1500 rows	Header	Hist	Plot	All	Sele
6	OI_T3	Binary	14 cols X 500 rows	Header	Hist	Plot	All	Sele
7	AMBER_DATA	Binary	16 cols X 1500 rows	Header	Hist	Plot	All	Sele

OI-ARRAY Table



OI-TARGET Table:



OI_WAVELENGTH TABLE

File Edit Tools Help

Select	EFF_WAVE	EFF_BAND
All	E	E
Invert	m	m
1	2.106147E-06	6.829834E-10
2	2.106830E-06	6.829834E-10
3	2.107513E-06	6.829834E-10
4	2.108196E-06	6.828613E-10
5	2.108879E-06	6.828613E-10
6	2.109562E-06	6.829834E-10
7	2.110245E-06	6.829834E-10
8	2.110927E-06	6.828613E-10
9	2.111610E-06	6.828613E-10
10	2.112293E-06	6.828613E-10
11	2.112976E-06	6.828613E-10
12	2.113659E-06	6.828613E-10
13	2.114342E-06	6.828613E-10

Go to: Edit cell: