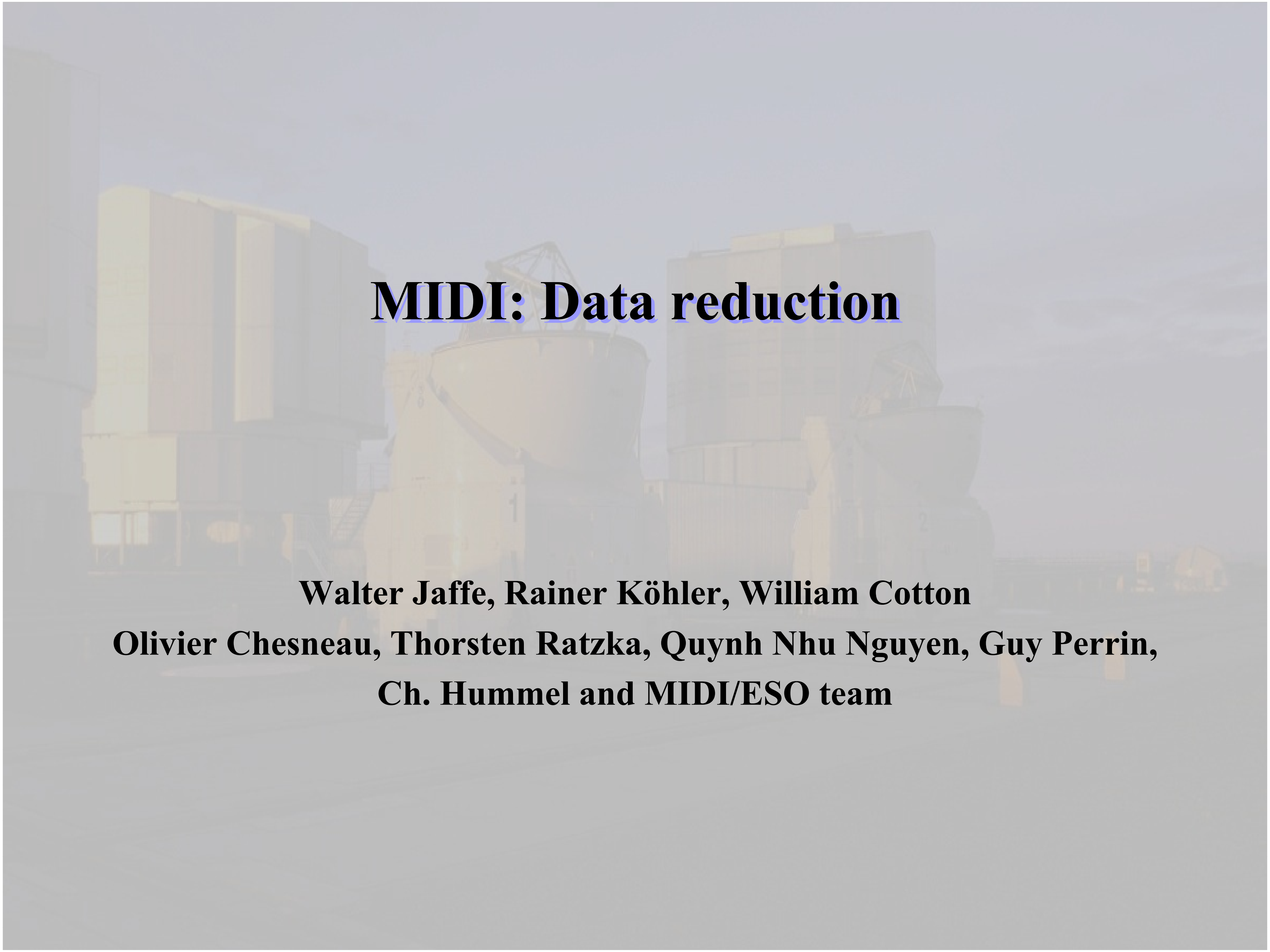


MIDI: Data reduction

Walter Jaffe, Rainer Köhler, William Cotton

Olivier Chesneau, Thorsten Ratzka, Quynh Nhu Nguyen, Guy Perrin,

Ch. Hummel and MIDI/ESO team

Where getting information?

Web sites:

http://www.mpia-hd.mpg.de/MIDI/ (Mostly MIA package)
http://www.strw.leidenuniv.nl/~koehler/MIA+EWS-Manual/
http://www.sc.eso.org/~chummel/midi/midi.html
http://www.mariotti.fr/data_processing_midi.htm (Meudon package)

Calibrating spectra:

http://www.iso.esac.esa.int/users/expl_lib/ISO/wwwcal/isoprep/cohen/templates/

Documents:

Thorsten Ratzka thesis (take care 200 Mega, PS file…)
http://www.ub.uni-heidelberg.de/archiv/5516
MIDI/ESO User manual

Choosing and inspecting data

ESO Data

We will use for this tutorial the GTO (Garanteed Time Obsesrvations) data obtained with MIDI for the Herbig star AB Aur and some calibrators.

Below are the typical amount of data you can expect with MIDI.

MIDI.2003-06-15T09:26:17.000.fits.Z	HD10380 C	Acquisition	20 MB
MIDI.2003-06-15T09:37:19.000.fits.Z	HD10380 C	FringeTrack	110 MB
MIDI.2003-06-15T09:38:35.451.fits.Z	HD10380 C	FringeTrack (continuation)	110 MB
MIDI.2003-06-15T09:39:51.901.fits.Z	HD10380 C	FringeTrack (continuation)	106 MB
MIDI.2003-06-15T09:43:00.000.fits.Z	HD10380 C	Photometry (A)	52 MB
MIDI.2003-06-15T09:44:52.000.fits.Z	HD10380 C	Photometry (B)	52 MB
MIDI.2003-06-15T10:00:09.000.fits.Z	NGC1068S	Acquisition	30 MB
MIDI.2003-06-15T10:04:07.000.fits.Z	NGC1068S	FringeTrack	111 MB
MIDI.2003-06-15T10:05:23.451.fits.Z	NGC1068S	FringeTrack (continuation)	111 MB
MIDI.2003-06-15T10:06:39.901.fits.Z	NGC1068	S	FringeTrack
(continuation)107 MB MIDI.2003-06-15T10:12:40.000.fits.Z	NGC1068S	Photometry (A)	
52 MB			
MIDI.2003-06-15T10:14:32.000.fits.Z	NGC1068S	Photometry (B)	52 MB

Choosing and inspecting data

make_midi_log,'<path>',LOGBOOK='<target>/filename.log'

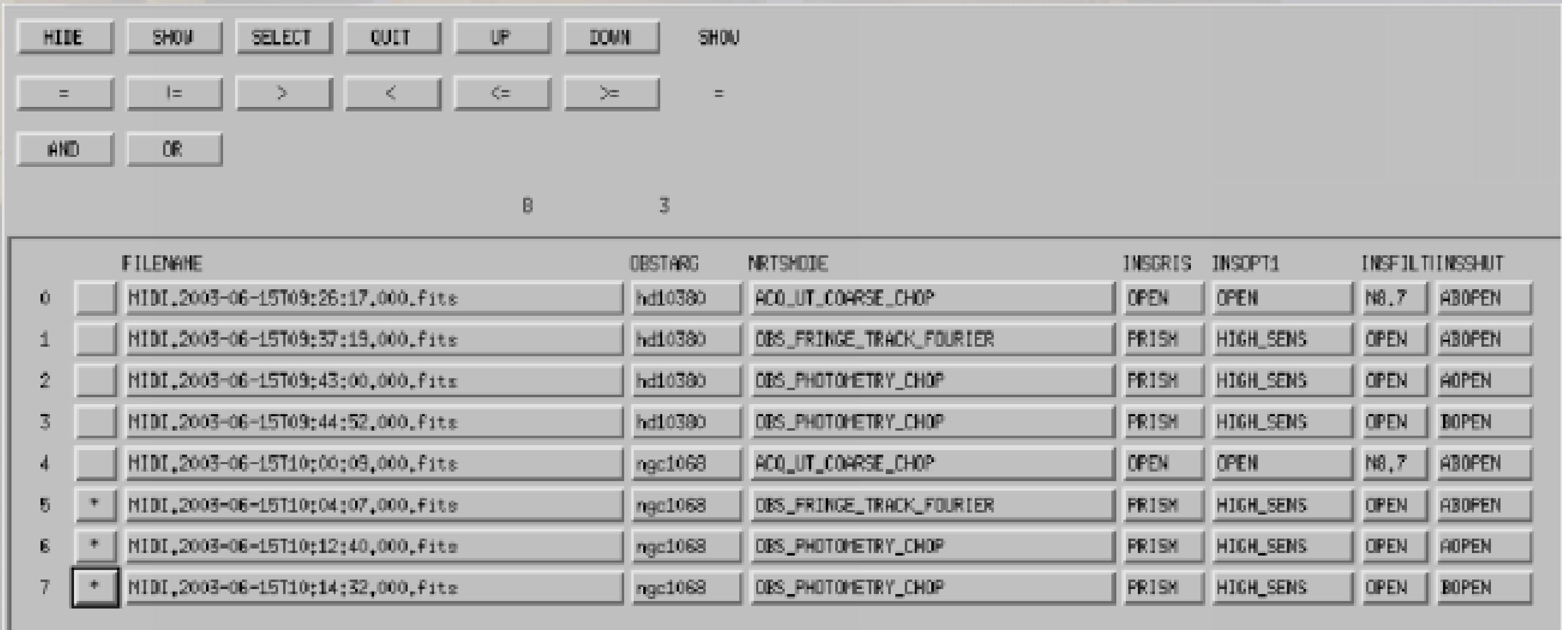
files=midigui(dir='<path>') ("Gorgonzola")

To check what is stored in the variable files just type

print,files

or

print,files[i]

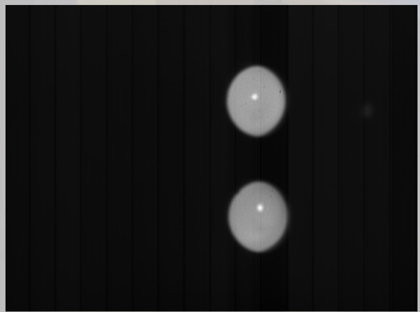


		FILENAME	OBSTARG	NRTSMODE	INSGRIS	INSOPT1	INSFILT	INSSHUT
0		MIDI.2003-06-15T09:26:17.000.fits	hd10380	ACQ_UT_COARSE_CHOP	OPEN	OPEN	N8.7	ABOPEN
1		MIDI.2003-06-15T09:37:19.000.fits	hd10380	OBS_FRINGE_TRACK_FOURIER	PRISM	HIGH_SENS	OPEN	ABOPEN
2		MIDI.2003-06-15T09:43:00.000.fits	hd10380	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	AOPEN
3		MIDI.2003-06-15T09:44:52.000.fits	hd10380	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	BOPEN
4		MIDI.2003-06-15T10:00:09.000.fits	ngc1068	ACQ_UT_COARSE_CHOP	OPEN	OPEN	N8.7	ABOPEN
5	*	MIDI.2003-06-15T10:04:07.000.fits	ngc1068	OBS_FRINGE_TRACK_FOURIER	PRISM	HIGH_SENS	OPEN	ABOPEN
6	*	MIDI.2003-06-15T10:12:40.000.fits	ngc1068	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	AOPEN
7	*	MIDI.2003-06-15T10:14:32.000.fits	ngc1068	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	BOPEN

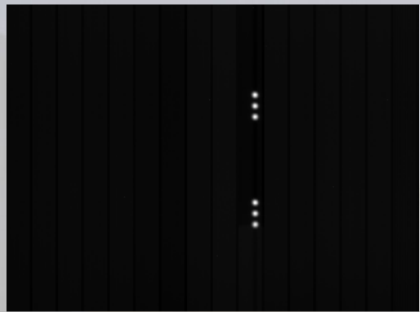
MIDI - Detector

Detector: 320 x 230 pixels

Acquisition (Field Camera)



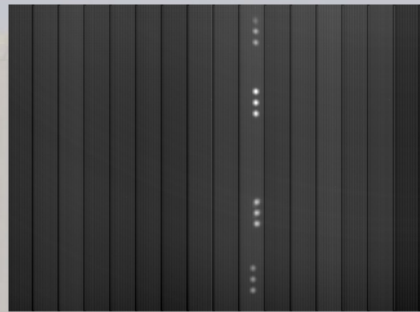
High-Sens Mode



I1

I2

Sci-Phot Mode



PA

I1

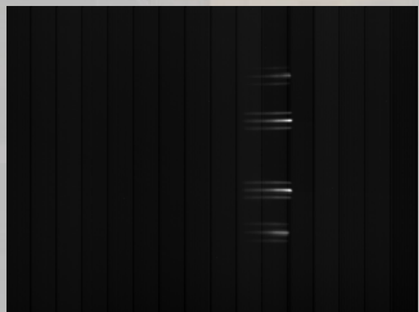
I2

PB

Typical exposure time: 4ms
2-4 subarrays: 69 x 62 pixels

70% Interferom., 30% Photom.

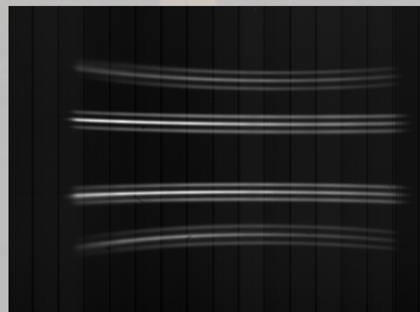
Dispersion with Prism



2-4 subarrays:
171 x 40: prism
261 x 40: grism

λ= 8 - 13.5μm, R = ~ 25
Typical exposure time: 15-20 ms

Dispersion with Grism



λ= 8 -13.75 μm, R = 230
Typical exposure time: 30-40 ms

Acquisition images

OirGetData

Start "Gorgonzola" by typing

```
calfile=midigui(dir='<path>')
acq=oirgetdata(calfile[0])
```

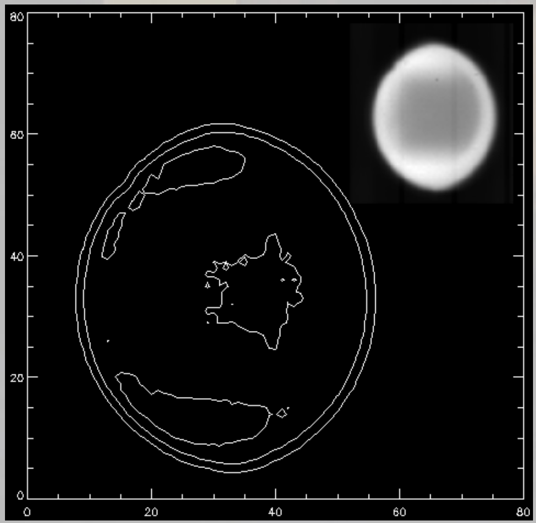
With `tvscl,acq[100].data1`

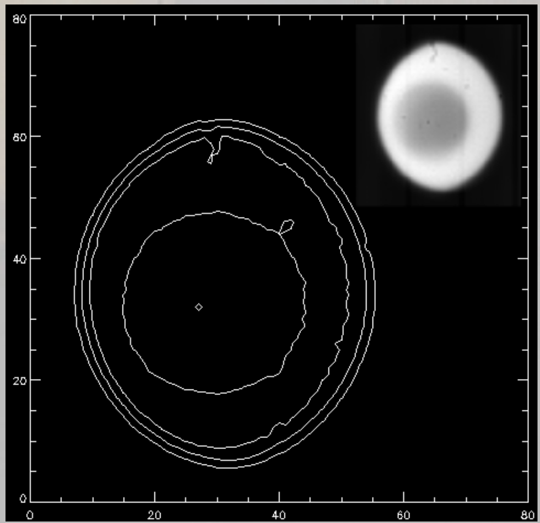
the 100th frame of beam B (data1) is displayed. Since each real pixel on the detector is shown as one pixel on your monitor, it's a good idea to magnify the image, e.g. by a factor 5:

```
tvsclm,acq[100].data1,5
```

Try also e.g. a contour plot with

```
contour,acq[100].data1
```





Problem of FOV!!
(Field-Of-View)

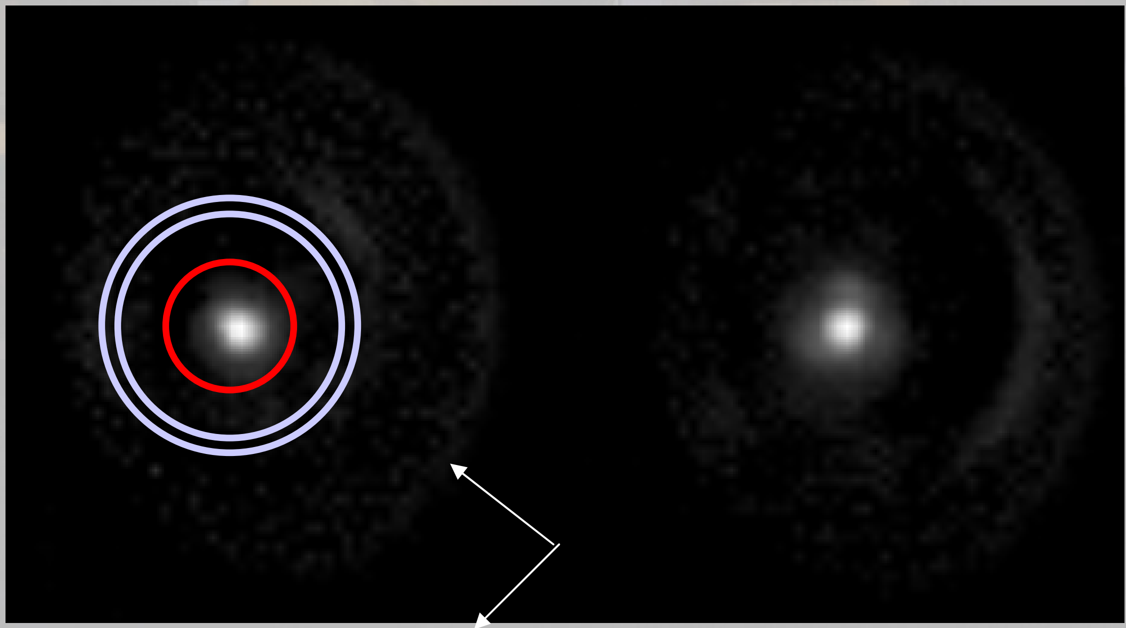
Acquisition images

Photometry with Chop_Nod_Phot

The flux from the source is hidden in the overwhelming background that dominates observations in the mid-infrared. To overcome this, the background has to be determined immediately after a certain number of frames with the source have been taken. This is done by observing with the telescope a nearby part of the sky ("chopping").Whether a exposure is taken on the sky or on the source is given in the fitsheader belonging to that frame.

A routine called chop_nod_phot makes use of this keyword. The routine is started just by typing

```
chop_nod_phot,calfile[0]
```



Aperture Photometry of
MIDI.2003-06-15T09:26:17.000.fits

----

rA= 5 : rB= 5

Flux (photons) - error - Sky - error
MIDI Beam B: 2.8368597e+08 - 747517.64 - 68528.595 - 63923.805

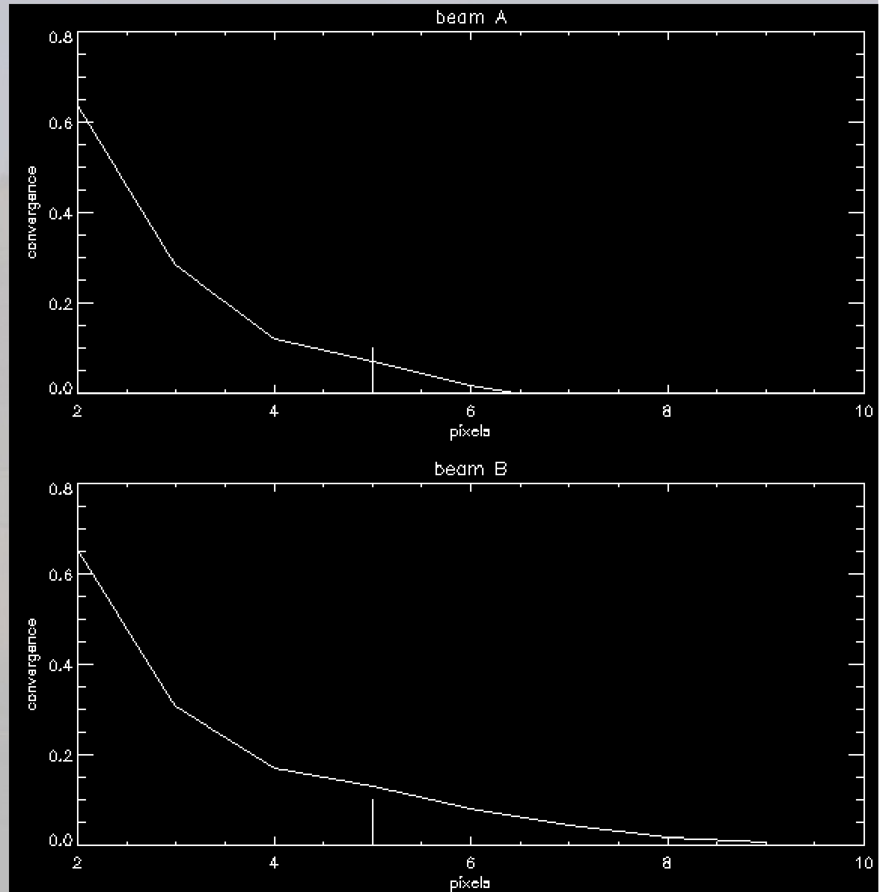
MIDI Beam A: 1.7577727e+08 - 865017.33 - 80041.702 - 76718.819

----

rA= 6 : rB= 6

Flux (photons) - error - Sky - error
MIDI Beam B: 3.0853491e+08 - 940967.04 - 68528.595 - 63923.805

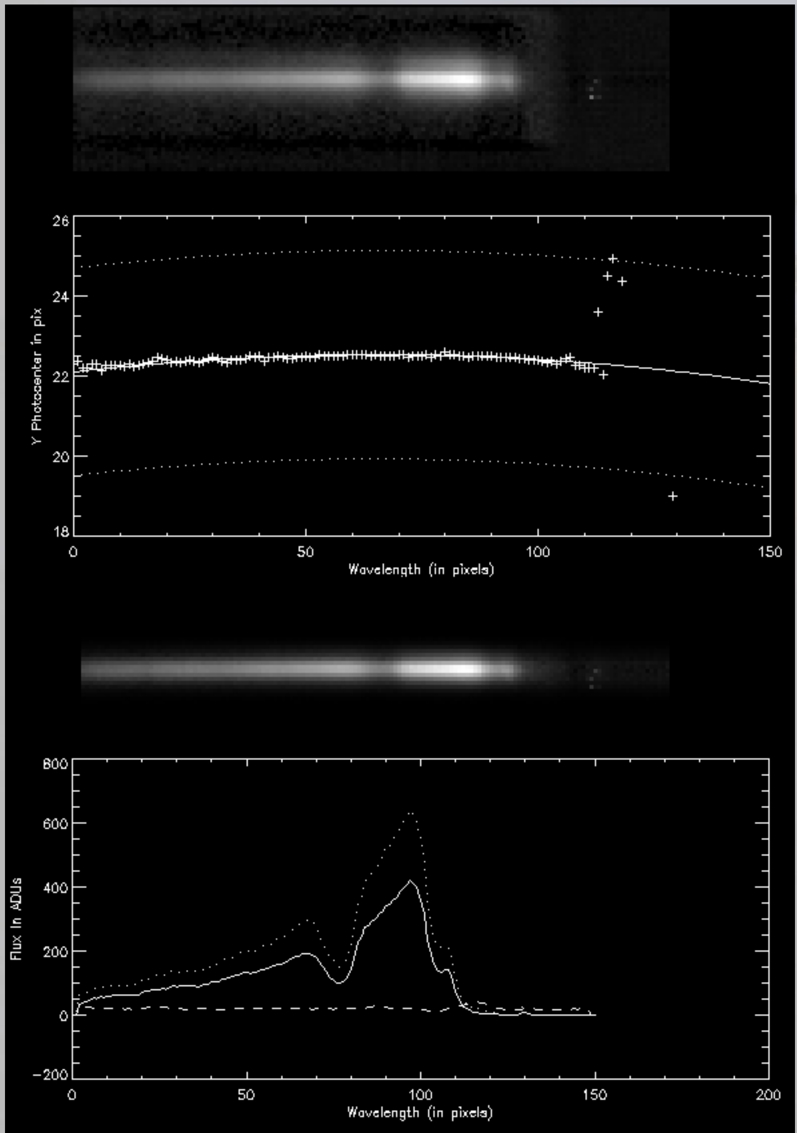
MIDI Beam A: 1.8071686e+08 - 1101247.1 - 80041.702 - 76718.819



All output is written to an ascii file within the newly created subfolder
'<path>/PHOTOMETRY'

Spectroscopy

Spectroscopy with Chop_Nod_Disp



A similar routine exists for dispersed data. It is called chop_nod_disp.

chop_nod_disp,calfile[2]

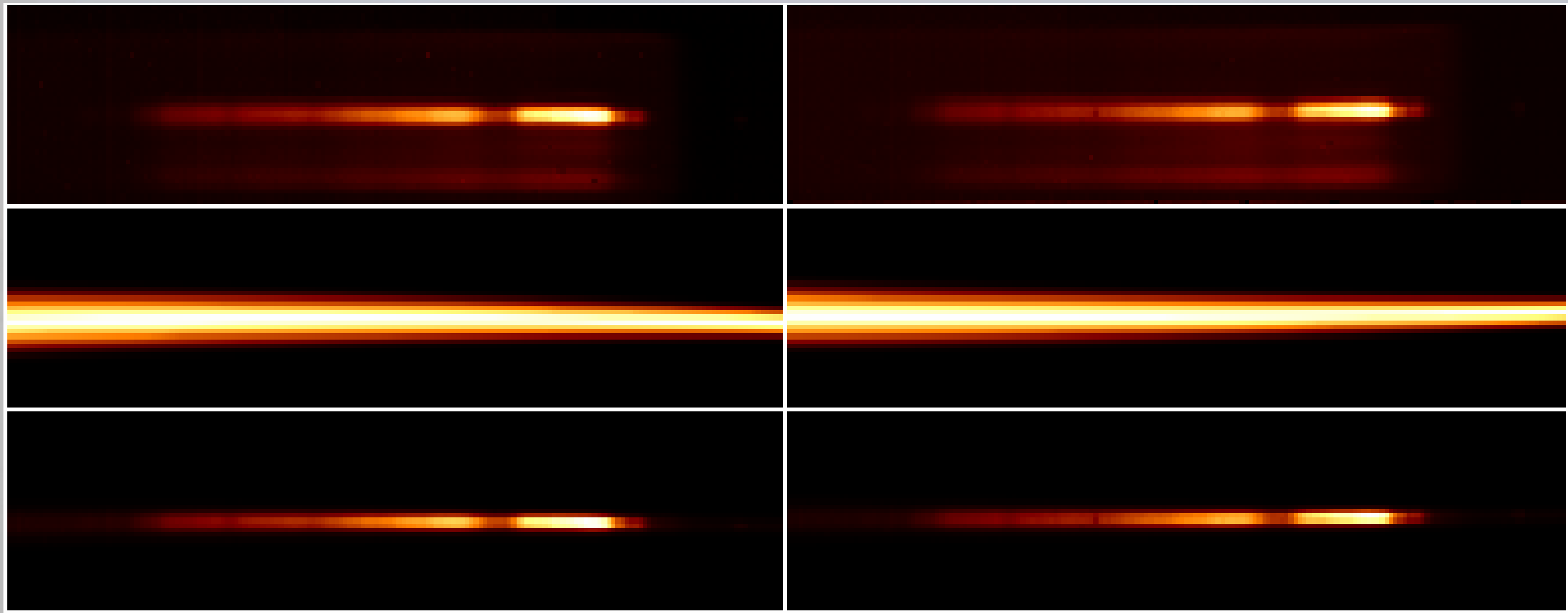
Options

- WIDTH=w, width of 1D-gaussian relative to width of fit (by default 1.0)
- TRACE_ORDER=o, order of polynopmial used to fit position (by default 2)
- FWHM_ORDER=o, order of polynopmial used to fit FWHM (by default 1)
- BEFORE=b, number of frames to skip before chop (by default 1)
- AFTER=a, number of frames to skip after chop (by default 1)
- /SILENT , tells routine to be non interactive

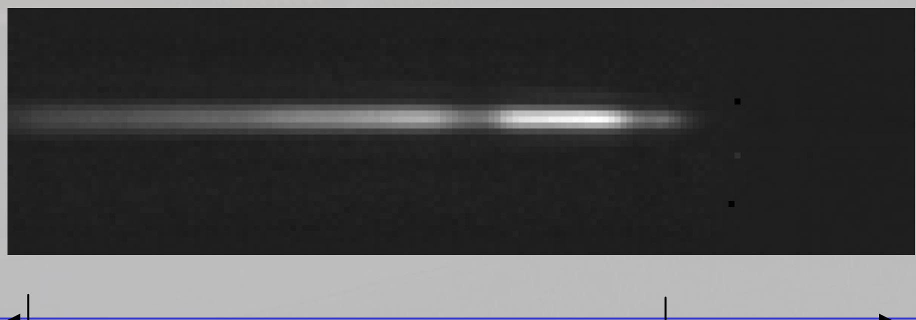
OUTPUT: an ascii file in the directory PHOTOMETRY

Can be read by the command: readphot, filename

Critical points: the masks!



Chopped spectrum



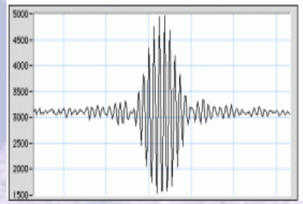
Steps to create a mask from photometric data

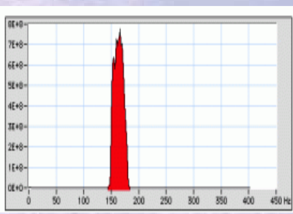
1. columnwise median smoothing to remove badpixels
2. columnwise one-dimensional Gaussian fit (centres marked by diamonds)
3. fit to the photo centres (solid line) with a second order polynomial
4. fit to the FWHMs of the Gaussians (dotted lines) with a first order polynomial

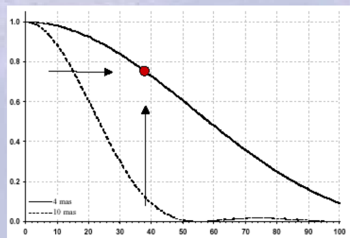
MIDI – Detecting fringes and measuring visibility

Without Dispersion

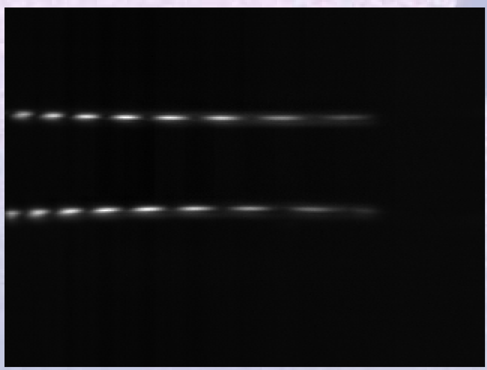
MIA/Meudon Package: Fourier-Method:
called also ‘incoherent’ method
Need: temporal scanning, zero fringe



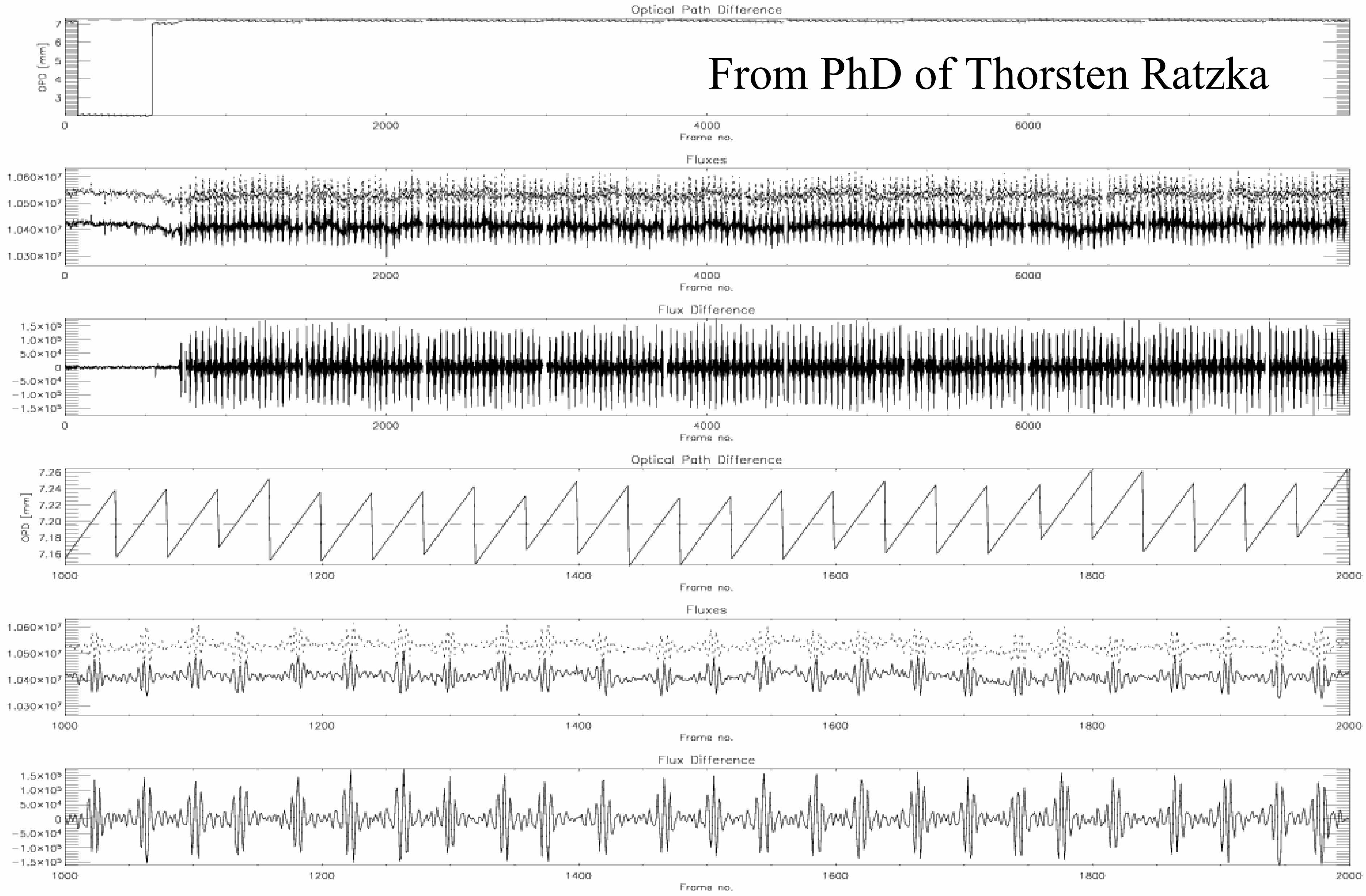




Dispersion with Grism
„Channeled Spectrum“

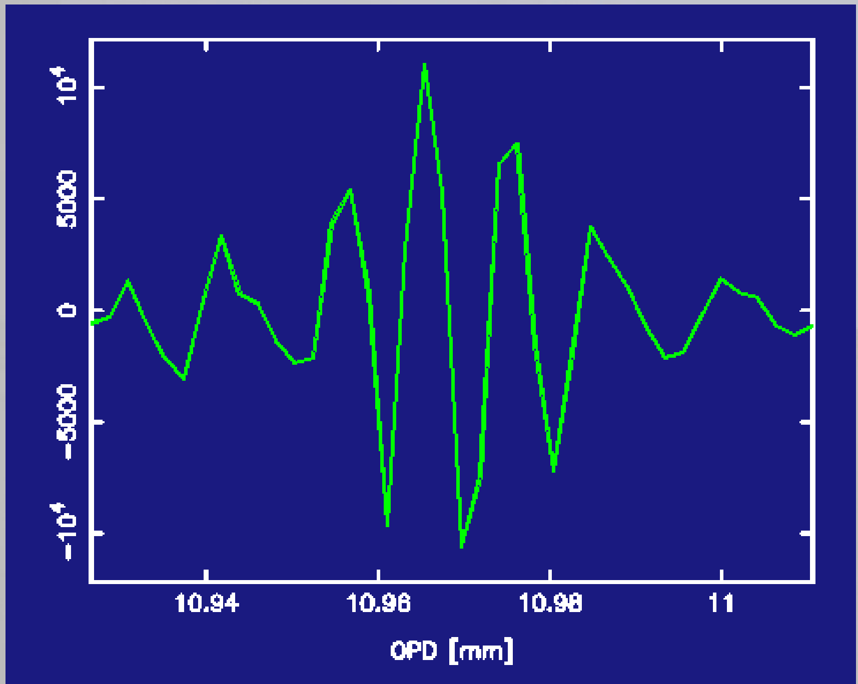


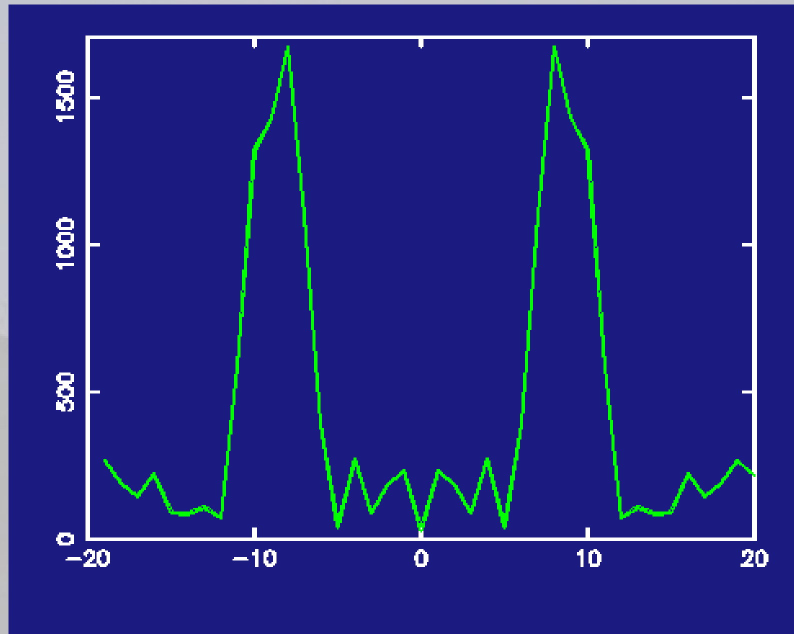
EWS: Channeled Spectrum-Method: called also ‘coherent’ me
Need: dispersion and avoid the zero fringe



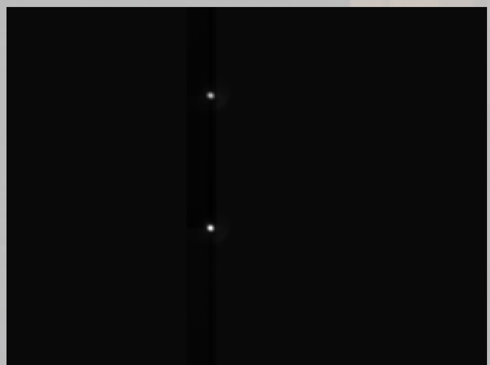
From PhD of Thorsten Ratzka

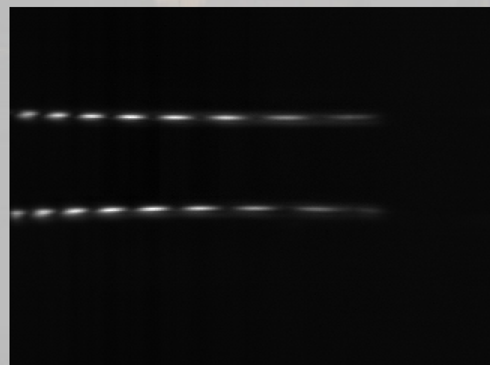
MIA and Meudon package: Fourier methods





PSD of the interferogramm





Fourier-Algorithm: the steps in MIA soft

Compression: collapse of flux within the mask in 1D : F(λ),

Flux difference: I2-I1 (first order clean-out, from 2 window 1 data set)

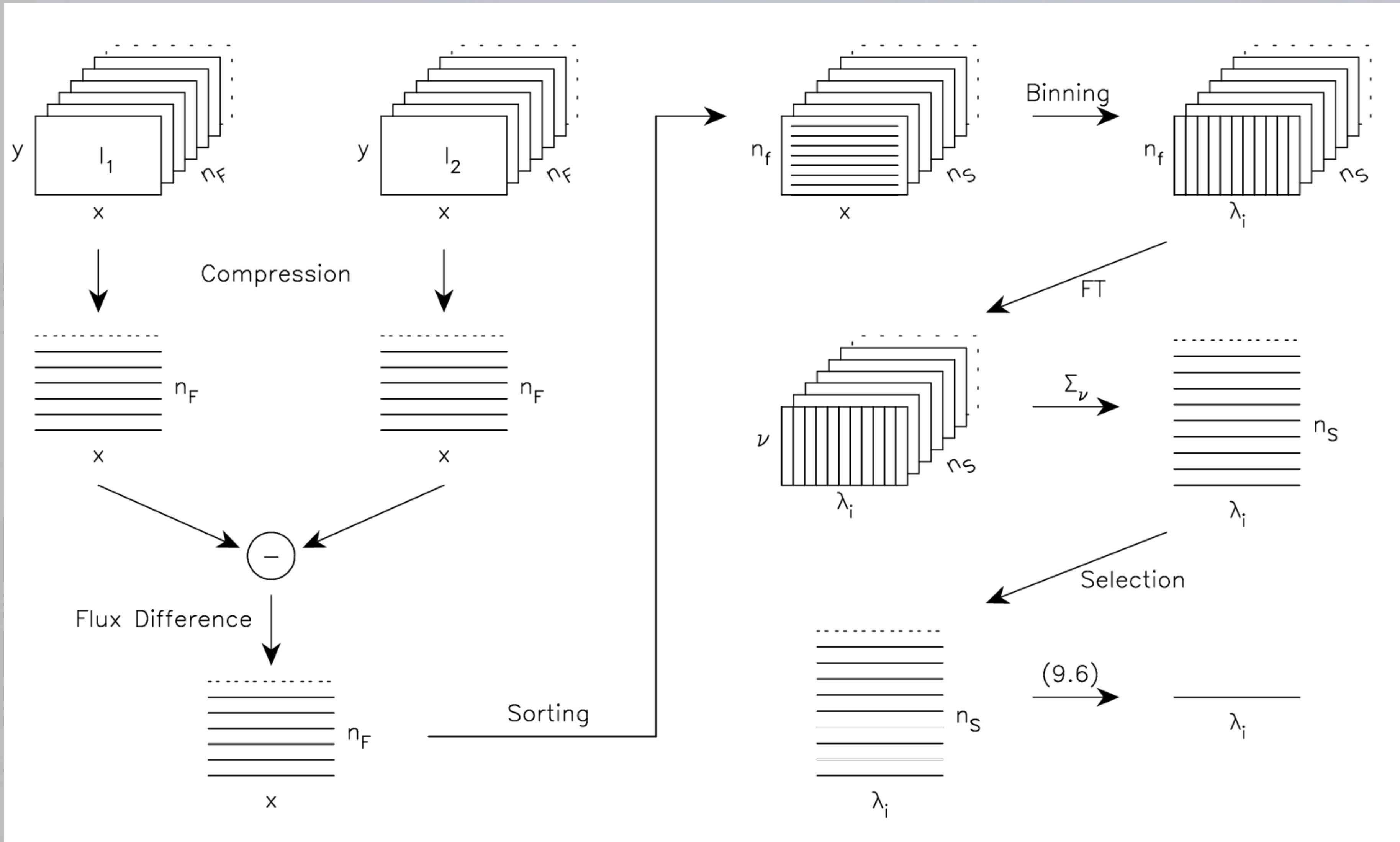
Sorting frames into scans: create an array of n_s scan and of n_f frames (typically 200 scans at least, 40 frames per scan)

λ- Binning: adapt the spectral resolution to the source SNR (user's decision)

Selection of good fringes (scans): this step is critical (user's decision)
+Noise correction

An instrumental visibility is provided, corrected by the known size of the source for the calibrator.

Fourier-Algorithm: the steps in MIA soft



EWS algorithm: group delay method

EWS is based on the analysis of the dispersed fringe pattern,

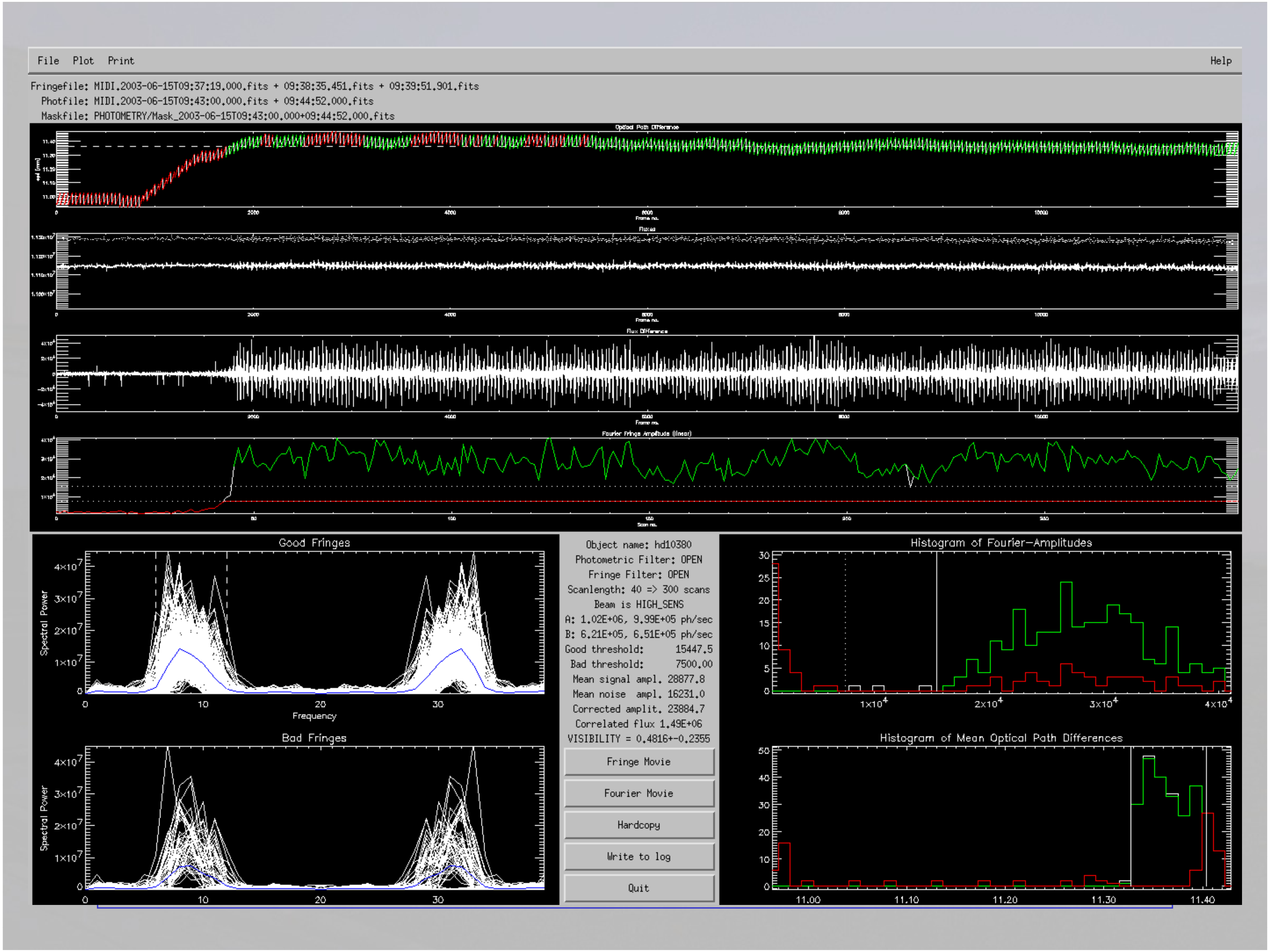
A scan demodulation is performed (scan not needed for this method)

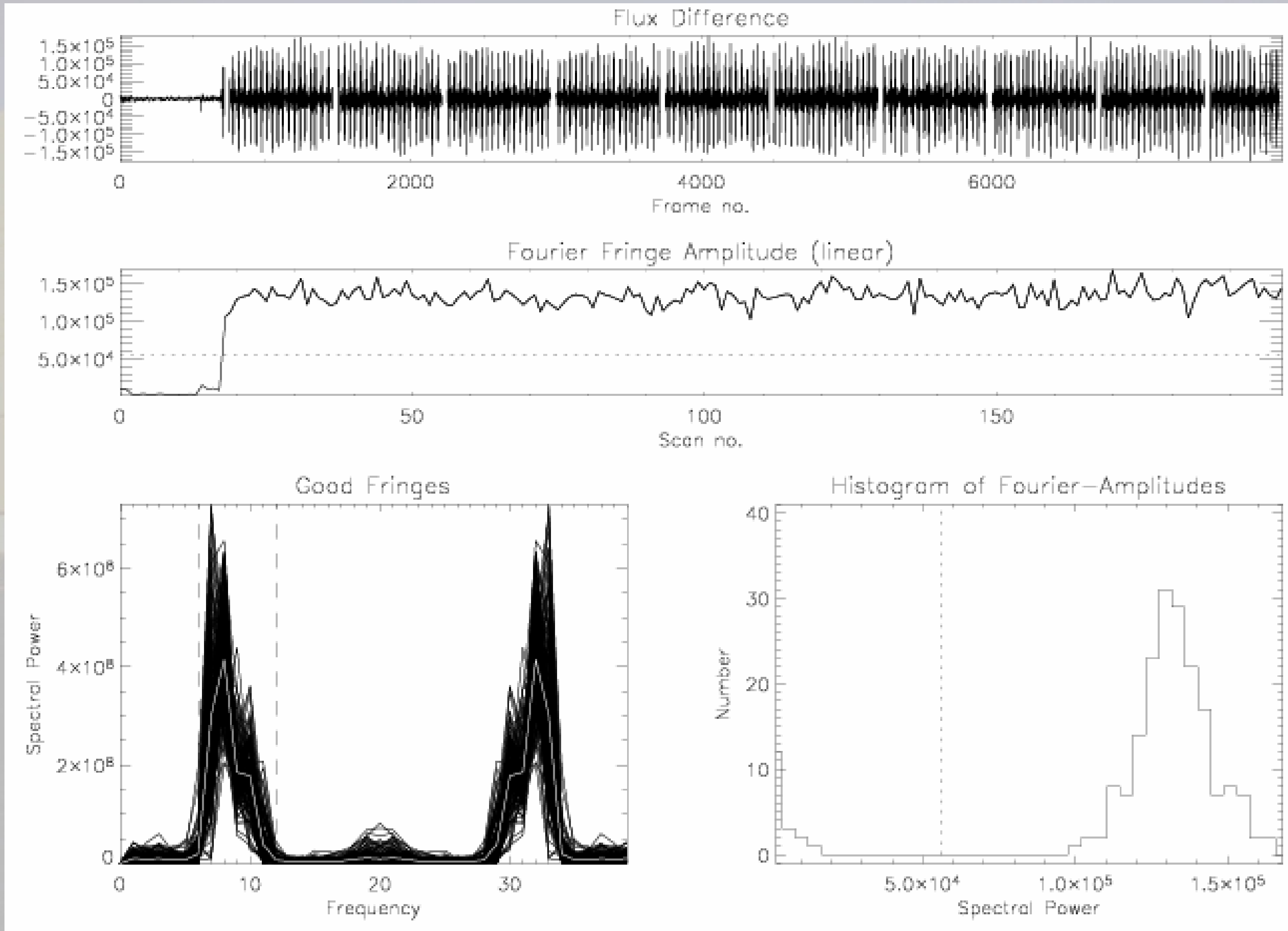
A piston (group delay) is computed

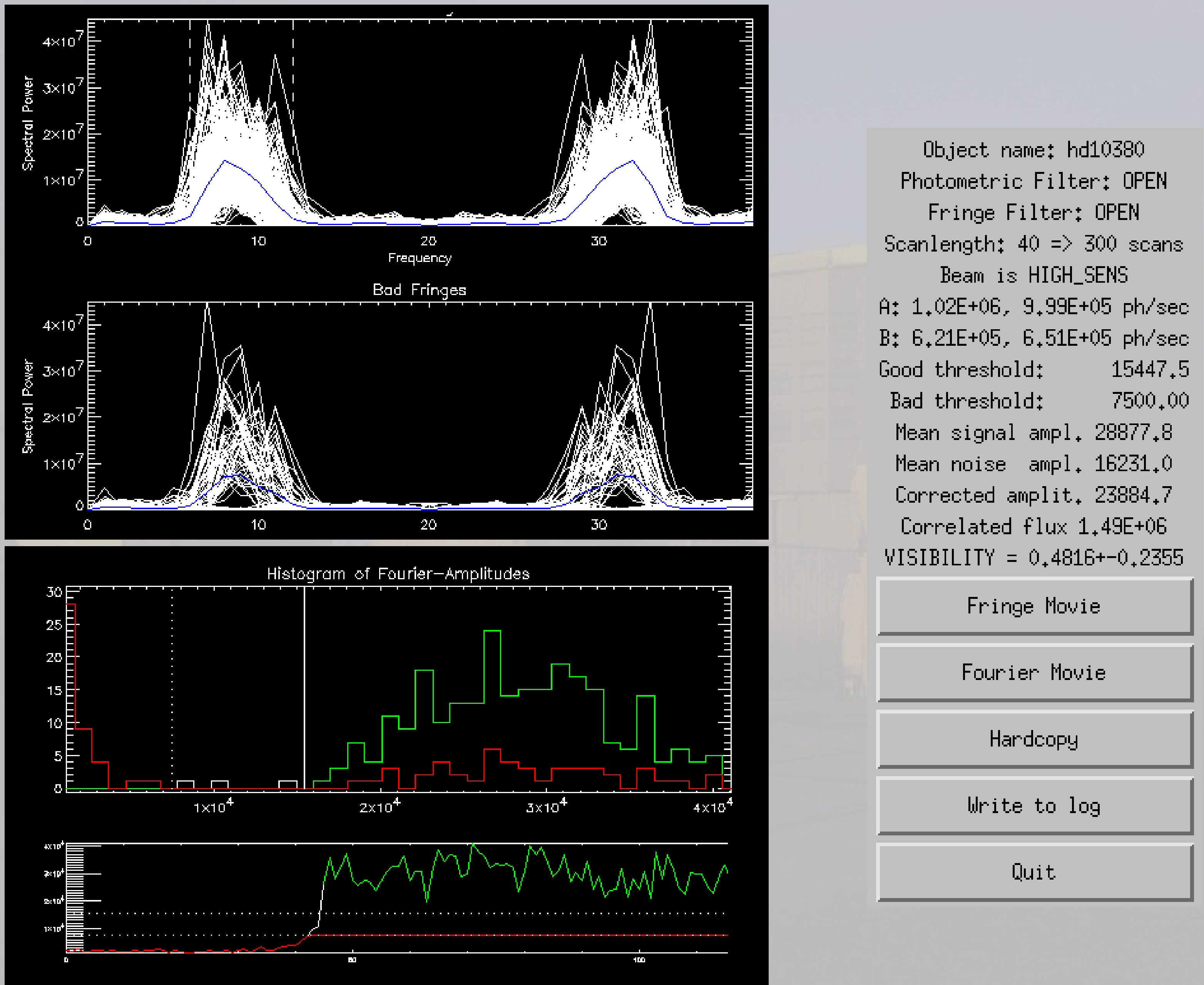
The piston-corrected dispersed patterns are co-added

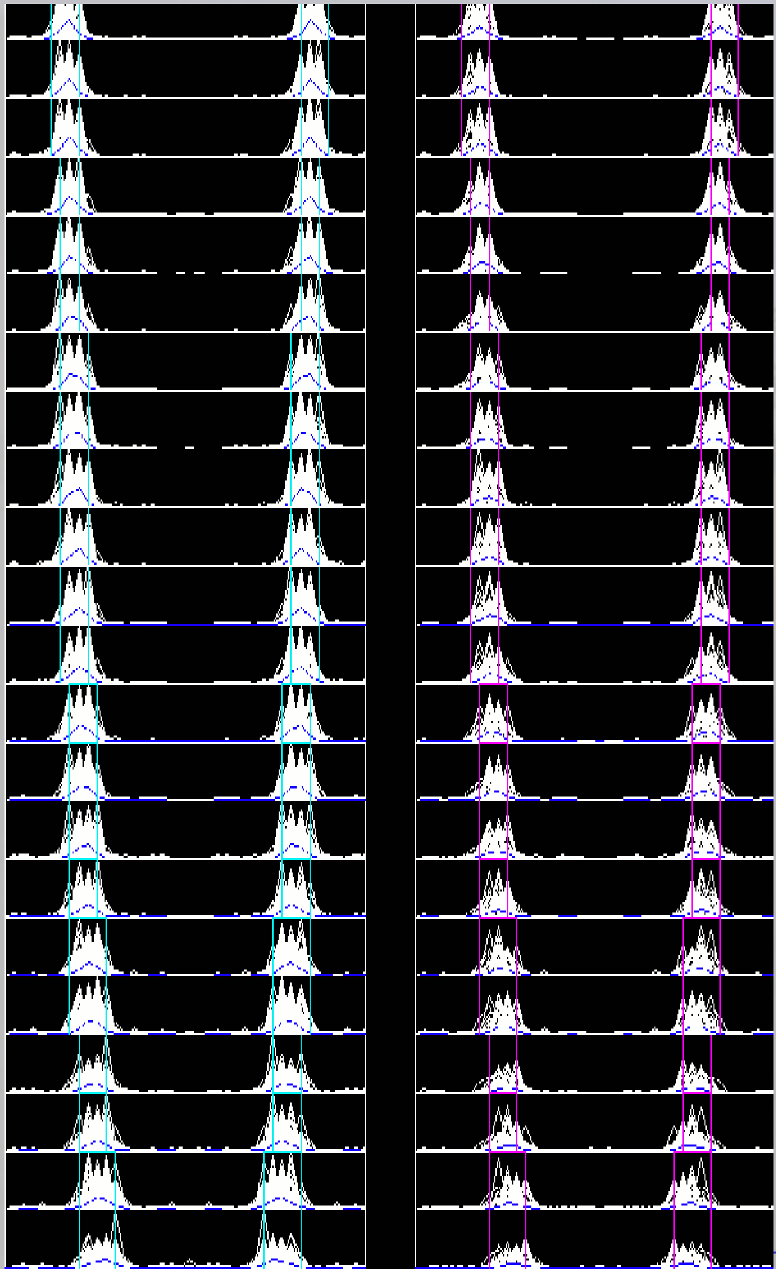
This method has the great advantage to protect the differential phase of the spectrally dispersed signal

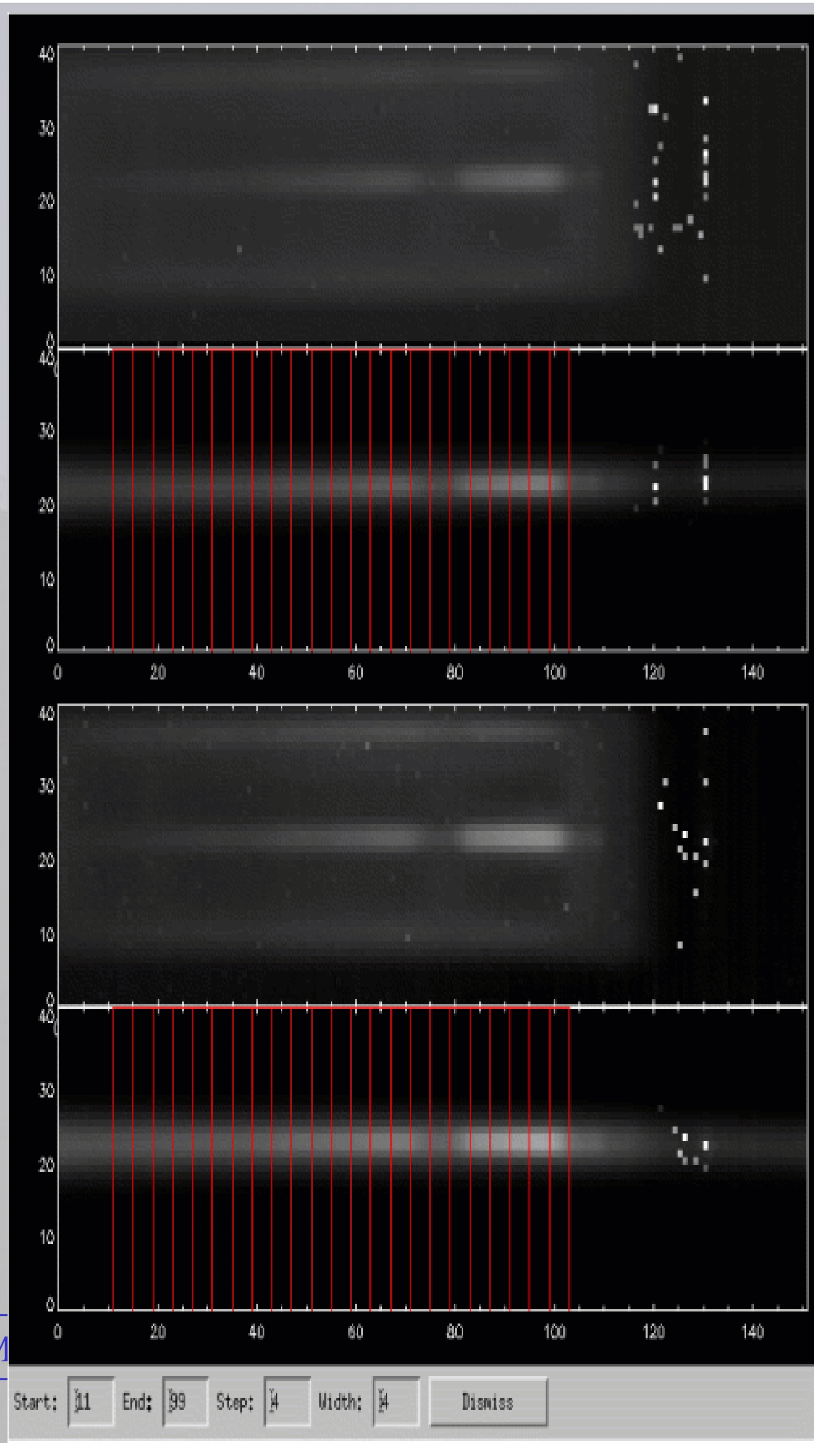
For a full manual of EWS:
http://www.strw.leidenuniv.nl/~koehler/MIA+EWS-Manual/


File Plot Print
Help
Fringefile: MIDI.2003-06-15T09:37:19.000.fits + 09:38:35.451.fits + 09:39:51.901.fits
Photfile: MIDI.2003-06-15T09:43:00.000.fits + 09:44:52.000.fits
Maskfile: PHOTOMETRY/Mask_2003-06-15T09:43:00.000+09:44:52.000.fits
Good Fringes
Spectral Power
Frequency
Bad Fringes
Object name: hd10380
Photometric Filter: OPEN
Fringe Filter: OPEN
Scanlength: 40 => 300 scans
Beam is HIGH_SENS
A: 1.02E+06, 9.99E+05 ph/sec
B: 6.21E+05, 6.51E+05 ph/sec
Good threshold: 15447.5
Bad threshold: 7500.00
Mean signal ampl. 28877.8
Mean noise ampl. 16231.0
Corrected amplit. 23884.7
Correlated flux 1.49E+06
VISIBILITY = 0.4816+-0.2355
Fringe Movie
Fourier Movie
Hardcopy
Write to log
Quit
Histogram of Fourier-Amplitudes
Histogram of Mean Optical Path Differences


Flux Difference
1.5×10⁵
1.0×10⁵
5.0×10⁴
0
−5.0×10⁴
−1.0×10⁵
−1.5×10⁵
0
2000
4000
6000
Frame no.
Fourier Fringe Amplitude (linear)
1.5×10⁵
1.0×10⁵
5.0×10⁴
0
50
100
150
Scan no.
Good Fringes
Spectral Power
6×10⁸
4×10⁸
2×10⁸
0
0
10
20
30
Frequency
Histogram of Fourier−Amplitudes
Number
40
30
20
10
0
5.0×10⁴
1.0×10⁵
1.5×10⁵
Spectral Power


Spectral Power
Frequency
Bad Fringes
Histogram of Fourier–Amplitudes
Object name: hd10380
Photometric Filter: OPEN
Fringe Filter: OPEN
Scanlength: 40 => 300 scans
Beam is HIGH_SENS
A: 1.02E+06, 9.99E+05 ph/sec
B: 6.21E+05, 6.51E+05 ph/sec
Good threshold: 15447.5
Bad threshold: 7500.00
Mean signal ampl. 28877.8
Mean noise ampl. 16231.0
Corrected amplit. 23884.7
Correlated flux 1.49E+06
VISIBILITY = 0.4816+-0.2355
Fringe Movie
Fourier Movie
Hardcopy
Write to log
Quit




0
20
40
60
80
100
120
140
Start: 11
End: 99
Step: 4
Width: 4
Dismiss

Correcting for the finite size of the calibrator

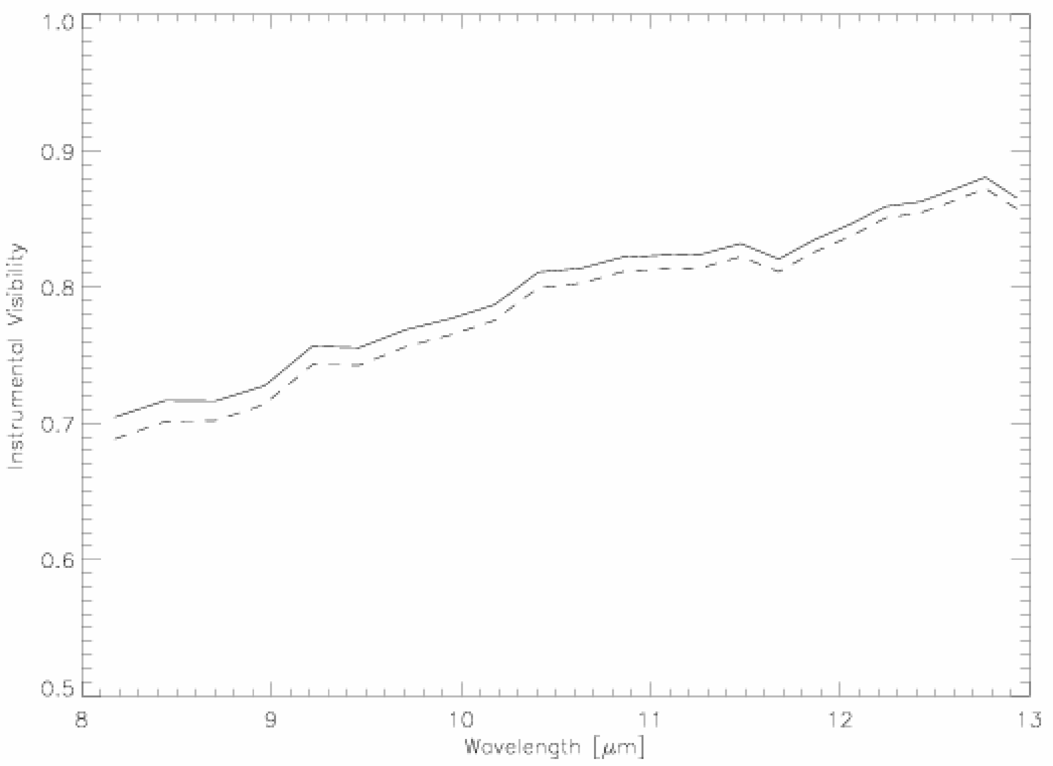
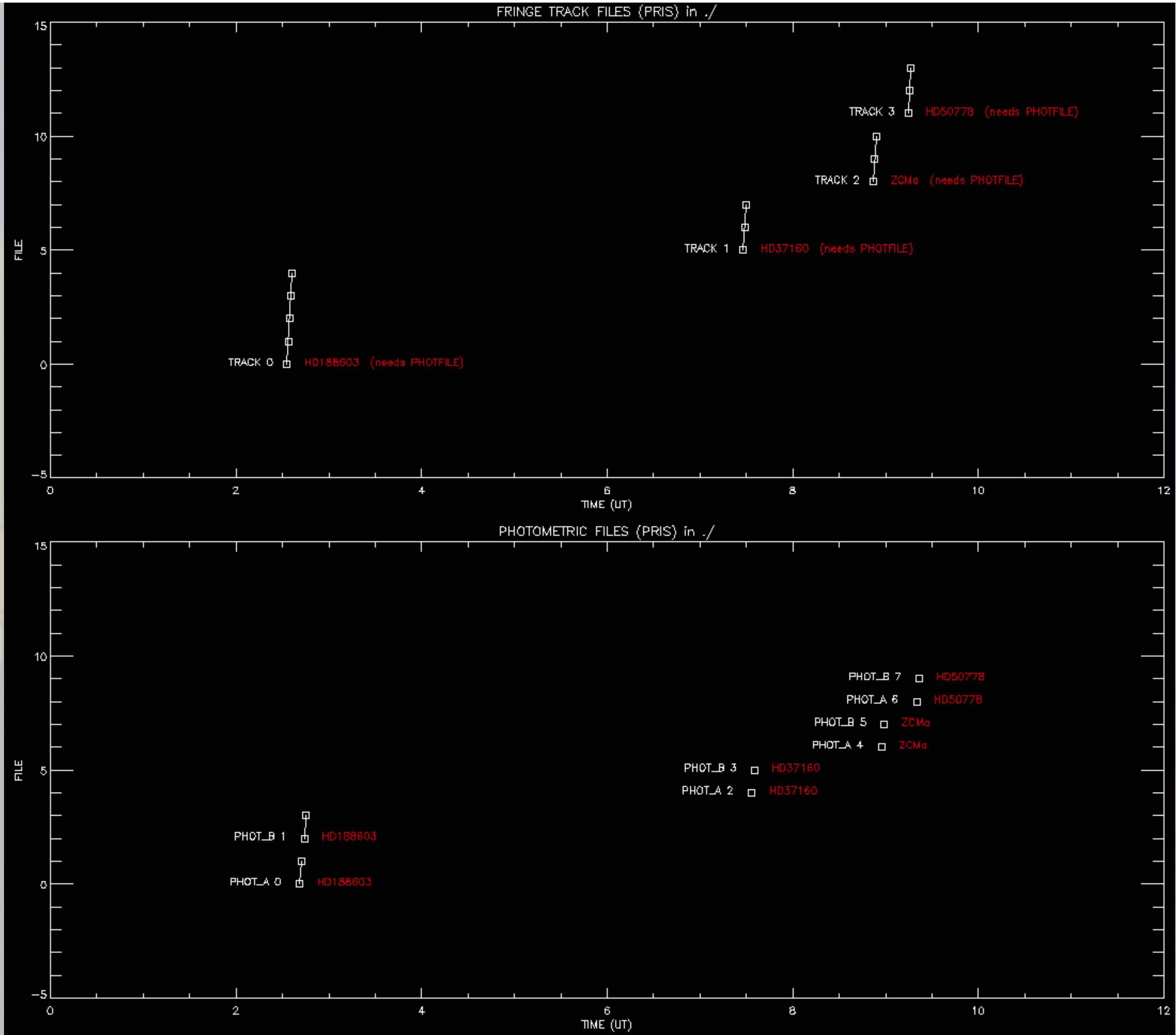


Figure 9.22: The raw visibility (dashed) of HD 50778 and the instrumental visibility (solid) derived from it.

From PhD of Thorsten Ratzka


FRINGE TRACK FILES (PRIS) in ./
TRACK 0
HD188603 (needs PHOTFILE)
TRACK 1
HD37160 (needs PHOTFILE)
TRACK 2
ZCMa (needs PHOTFILE)
TRACK 3
HD50778 (needs PHOTFILE)
FILE
TIME (UT)
PHOTOMETRIC FILES (PRIS) in ./
PHOT_A 0
HD188603
PHOT_B 1
HD188603
PHOT_A 2
HD37160
PHOT_B 3
HD37160
PHOT_A 4
ZCMa
PHOT_B 5
ZCMa
PHOT_A 6
HD50778
PHOT_B 7
HD50778
FILE
TIME (UT)

A new mode: Sci_phot

- Mode offered in P76, yet not fully commisionned,
- Mode intended to be more accurate to the High_Sens one,
- A version of MIA and EWS is under test: more complex data reductions: detector effect and distortion to take into account
- some assumptions on the instrument coupling coeficients under tests,
- The data are good in any case: we have to learn how to reduce them at best,

New telescopes: The difficult qualification of ATs with MIDI

- First observations with ATs during P76,
- Bad data quality when observations performed without VCMs: the FOV is as large as the PSF
  - Difficult pointing,
  - Photometric calibration almost impossible,
  - The instrument is very dependant to vibrations…
- Data acquired with VCMs are better but an adaptation of existing softwares seems requested: the ration FOV/PSF is much lower than with UTs:
  - UTs: PSF~300mas, FOV~4.5’’
  - ATs: PSF~1300mas, FOV~6’’