



# **MIDI: an overview**

**2010 VLT School**

*Observation and data reduction with the Very Large Telescope Interferometer*

**Porquerolles, France**

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Contents: Olivier Chesneau

Observatoire de la Côte d'Azur, F

Presentation: Tijl Verhoelst

KULeuven, B

# MIDI, what is it?

MIDI: MID-infrared Interferometric Instrument

MIDI concept presented in 1997, first fringes in 2003

Offered to the community in 2004

Spectral dispersion, 30 et 230, accuracy 5-15%, 2 telescopes

Consortium:

D: Max-Planck Institut für Astronomie: Heidelberg

PI: Christoph Leiner, PM: Uwe Grase

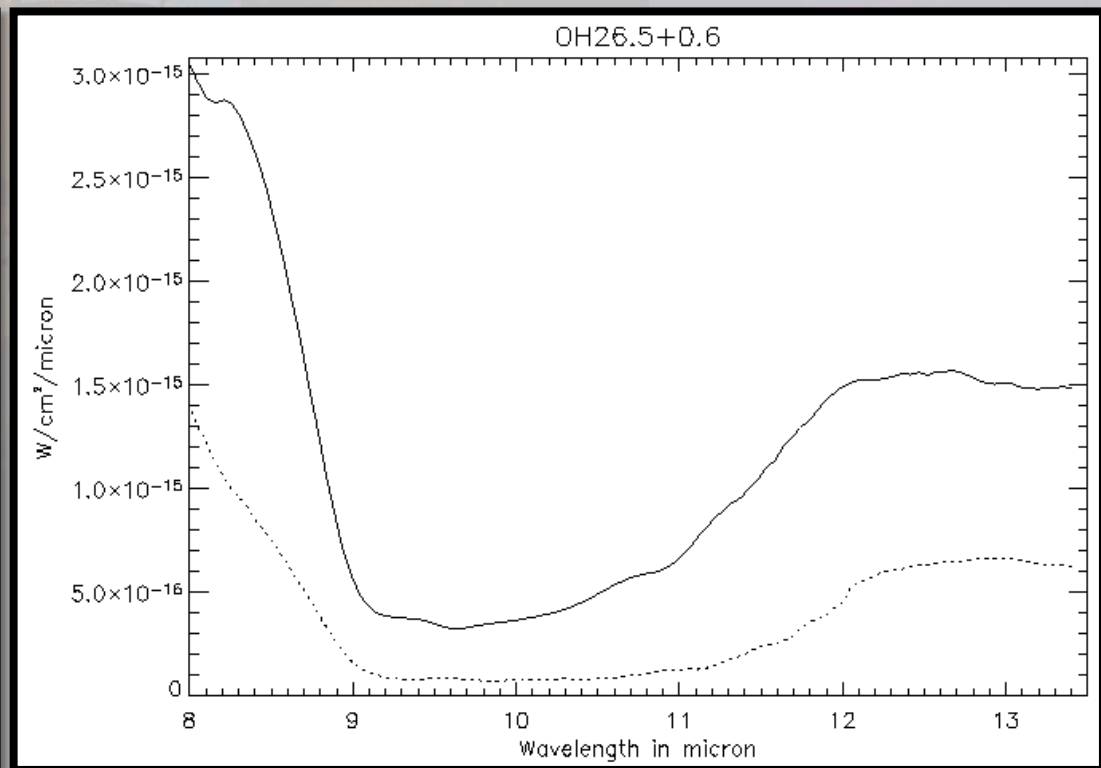
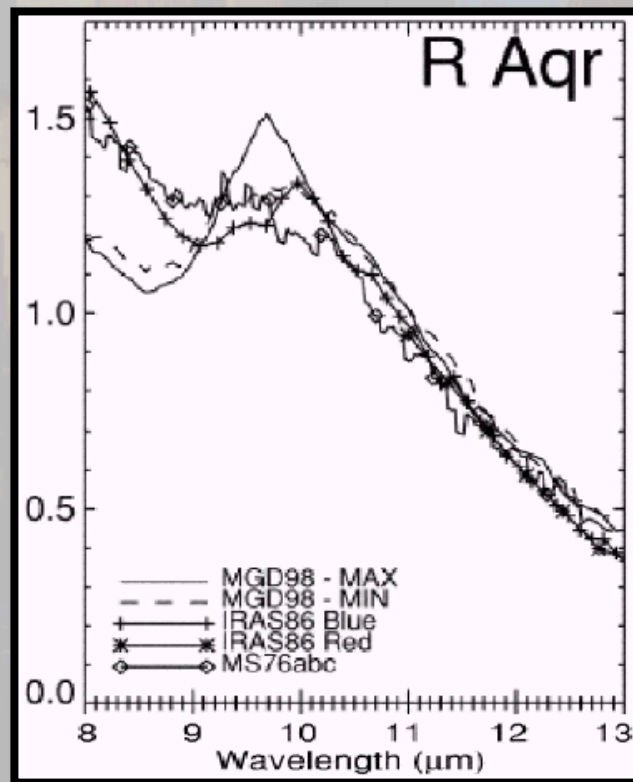
Nl: Leiden Observatory, ASTRON (Dwingeloo)

D: Kiepenheuer-Institut Friburg,

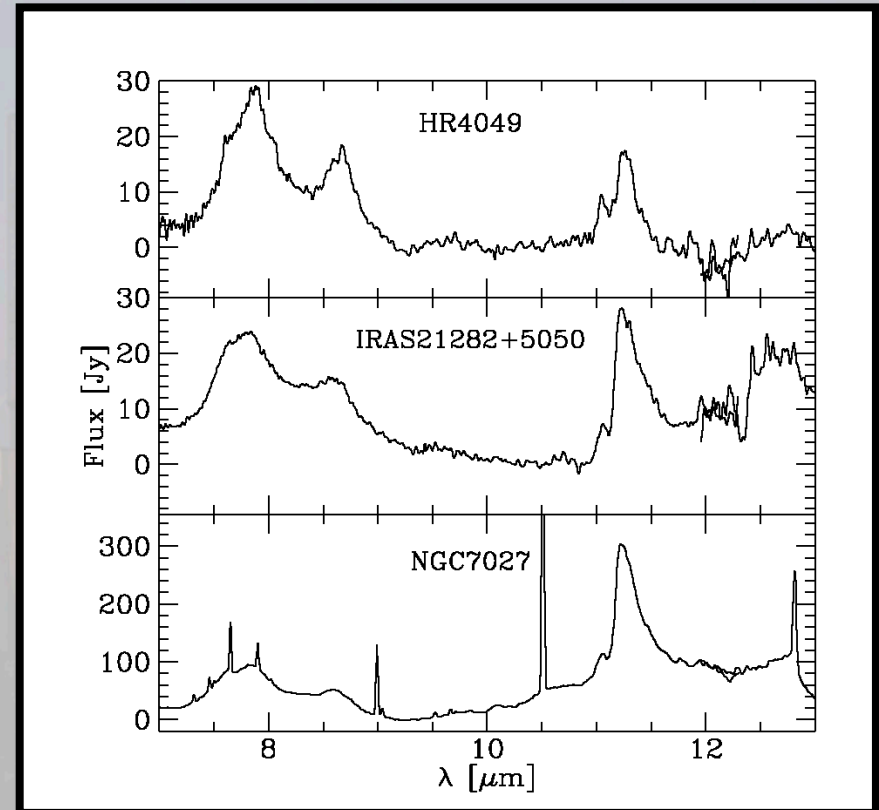
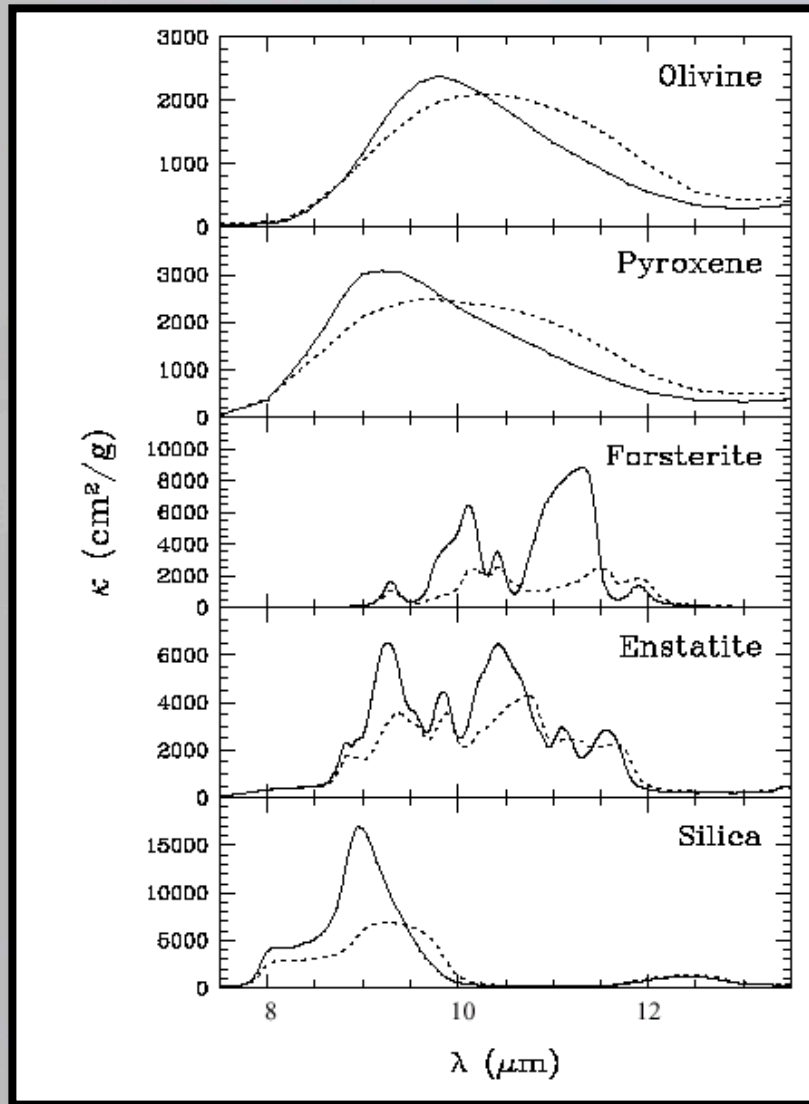
F: Meudon Observatory and Côte d'Azur Observatory

## MIDI, why was it built?

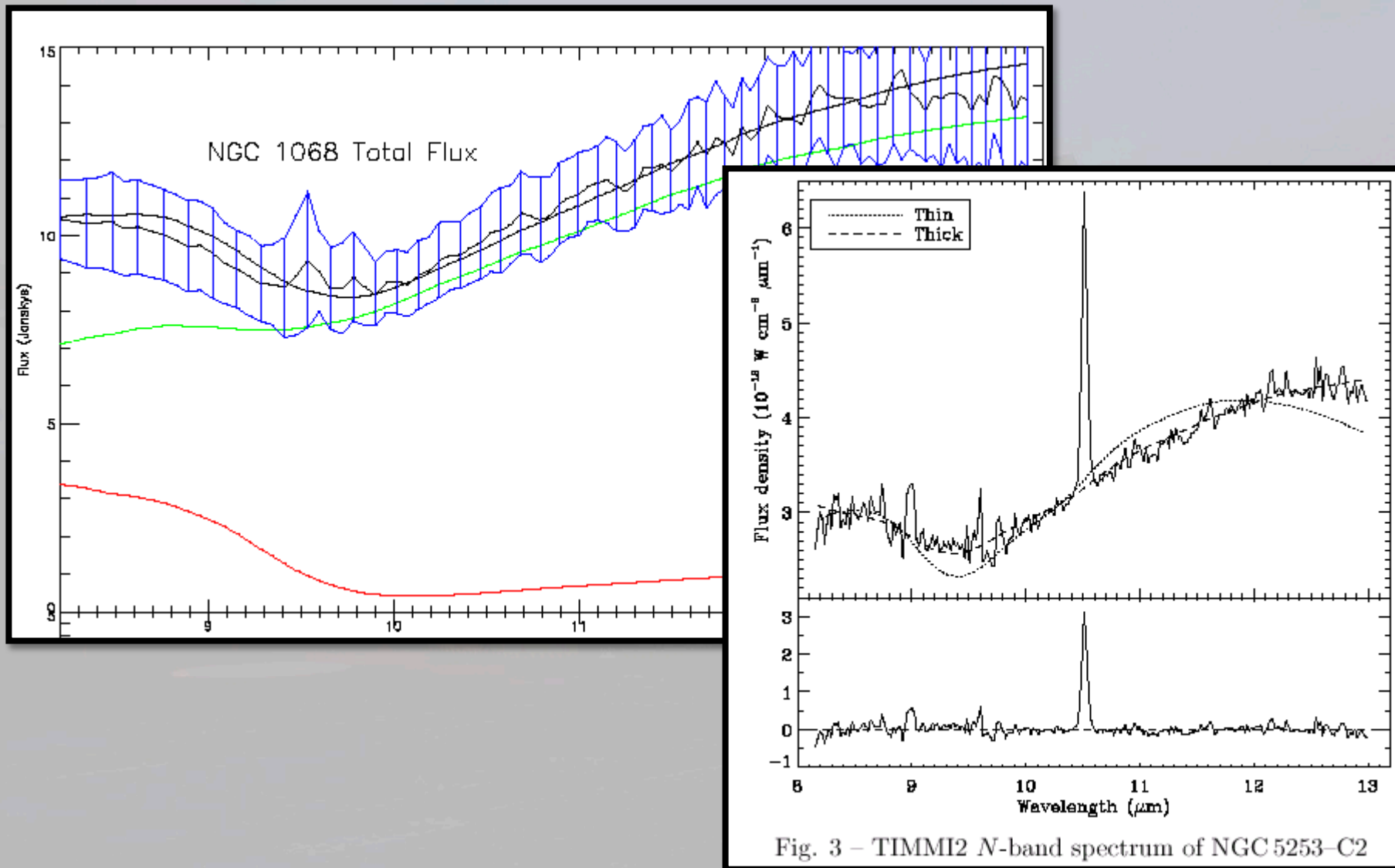
To study **compact dusty objects**: young stars with protoplanetary disks, old stars with circumstellar matter, extreme stars with mass loss, AGN,...



# MIDI, why was it built?



# MIDI, why was it built?



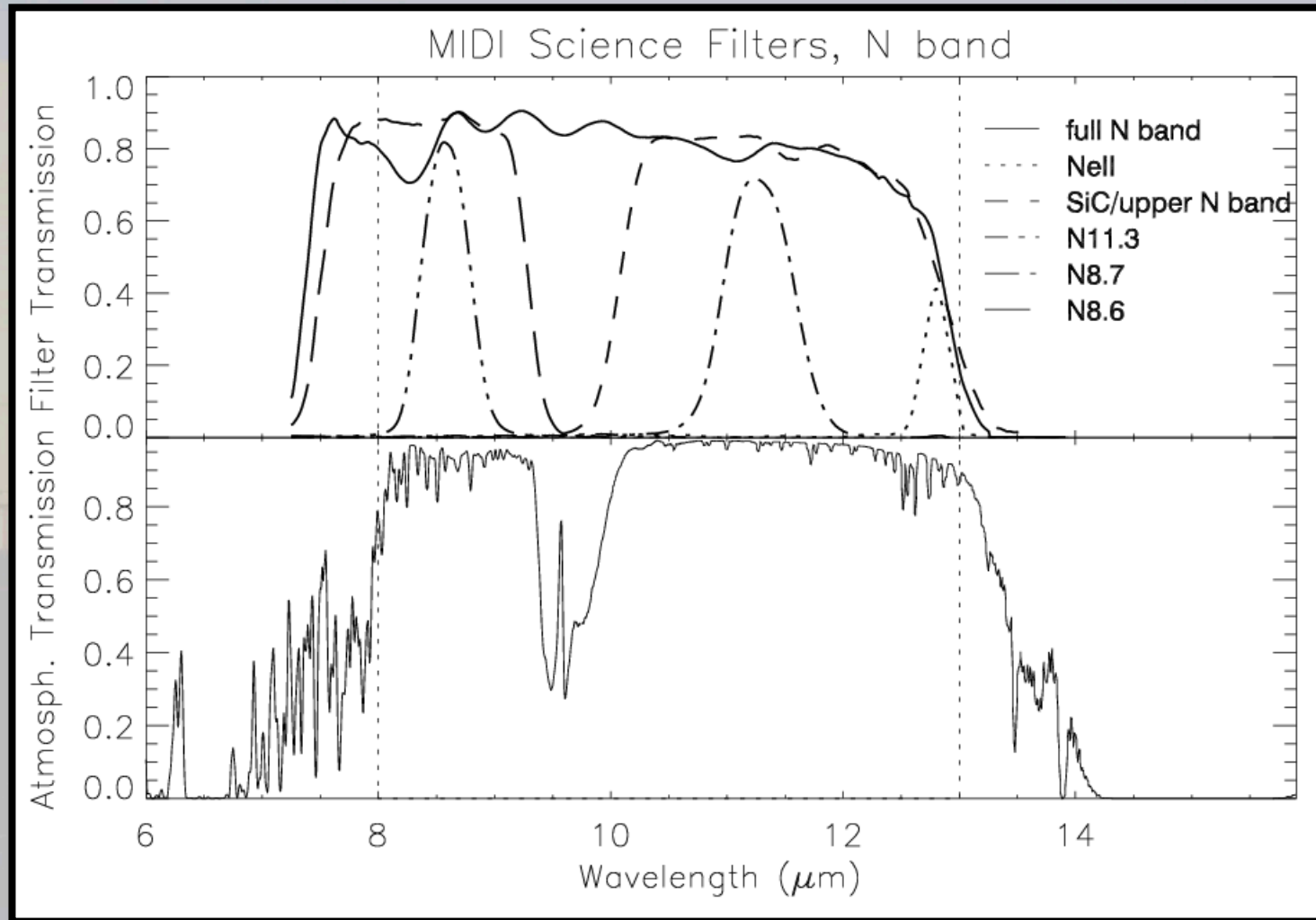
# Working in Mid-IR: the **Good**, the Bad, and the Ugly

**Table 4.1:** Characteristic parameters for different wavelengths, a zenith distance of  $\zeta = 0^\circ$ , a wind speed of  $v = 10 \text{ ms}^{-1}$ , and a telescope diameter of  $D = 4 \text{ m}$ .

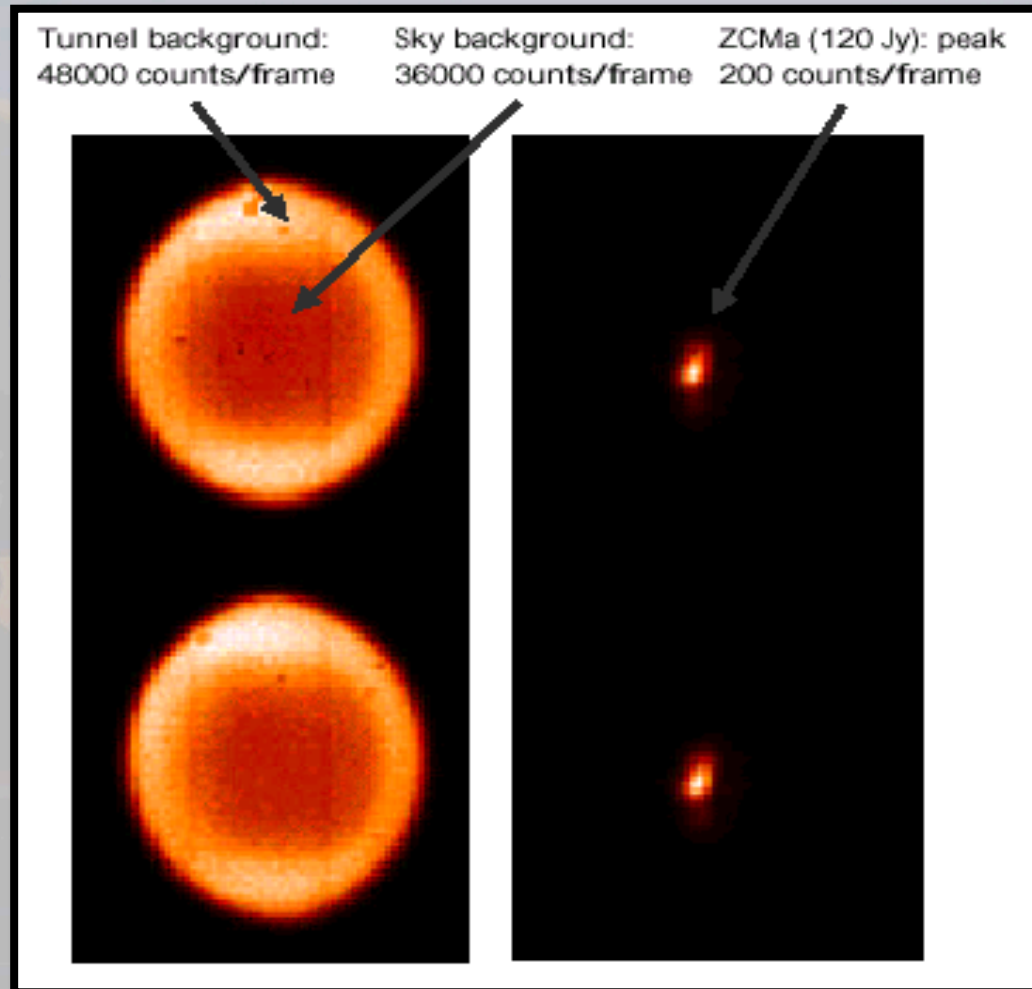
		$0.55 \mu\text{m}$	$2.2 \mu\text{m}$	$10 \mu\text{m}$
Fried paramter	$r_0$	10 cm	60 cm	$\approx 4 \text{ m}$
seeing limit	$\lambda r_0^{-1}$	$1.1''$	$0.76''$	$0.52''$
coherence time	$r_0 v^{-1}$	10 ms	60 ms	400 ms
diffraction limit	$\lambda D^{-1}$	$0.028''$	$0.11''$	$0.52''$

The Mid-IR is *easier* for interferometry because the individual images are (close to) **diffraction limited**, and the **coherence time is long**

# Working in Mid-IR: the Good, the **Bad**, and the Ugly

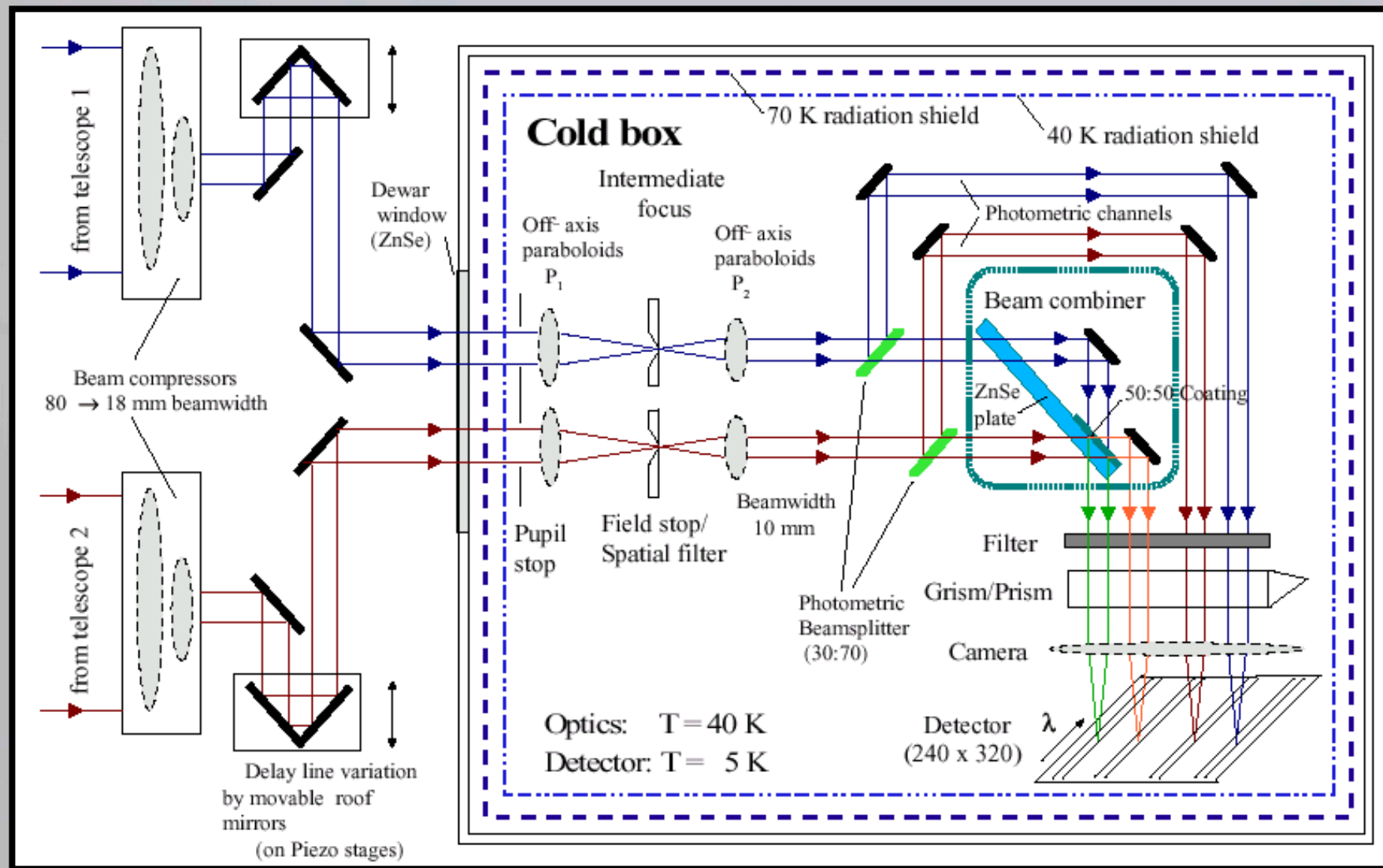


# Working in Mid-IR: the Good, the Bad, and the Ugly

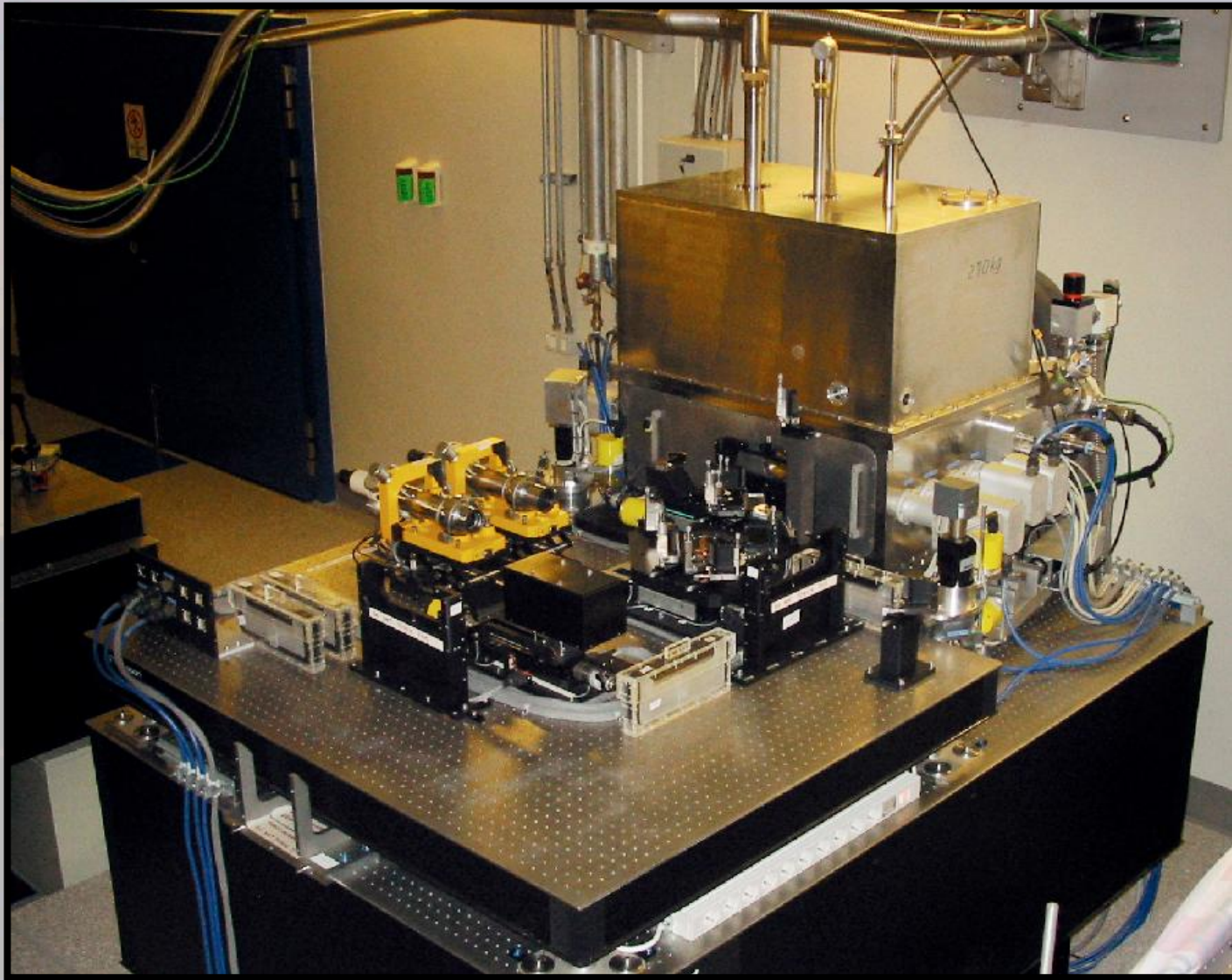




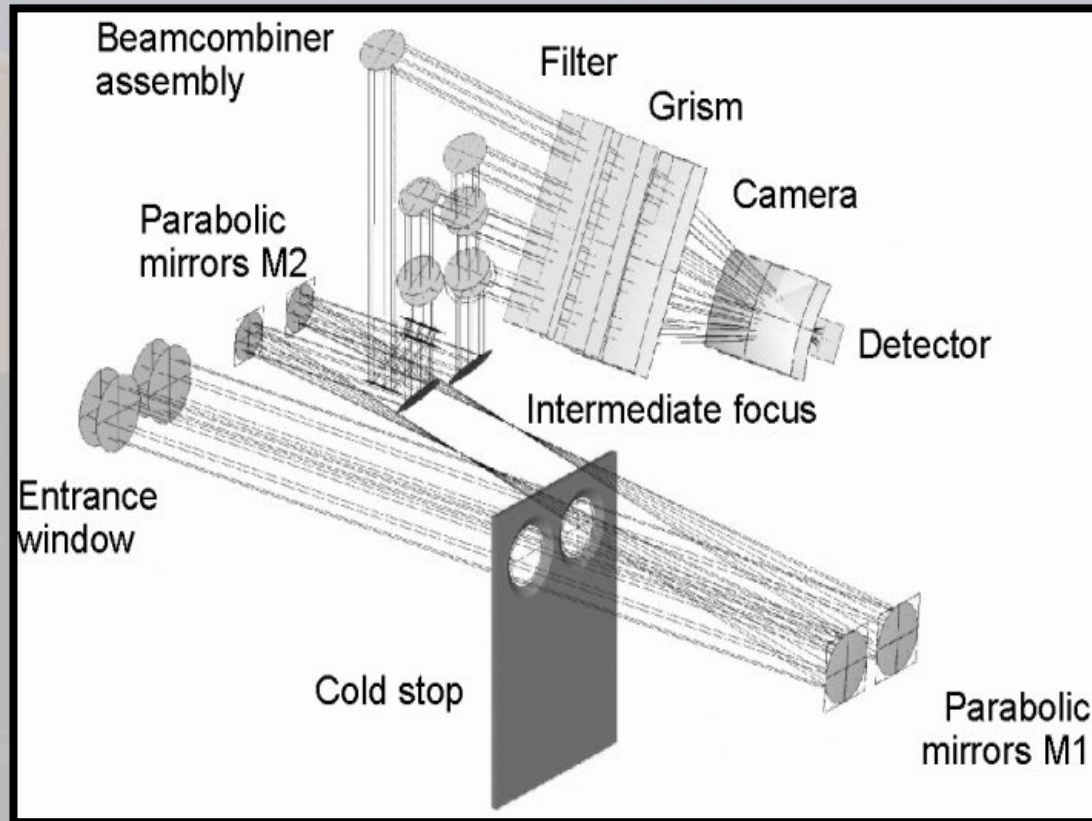
# MIDI: the instrument



## MIDI: the instrument



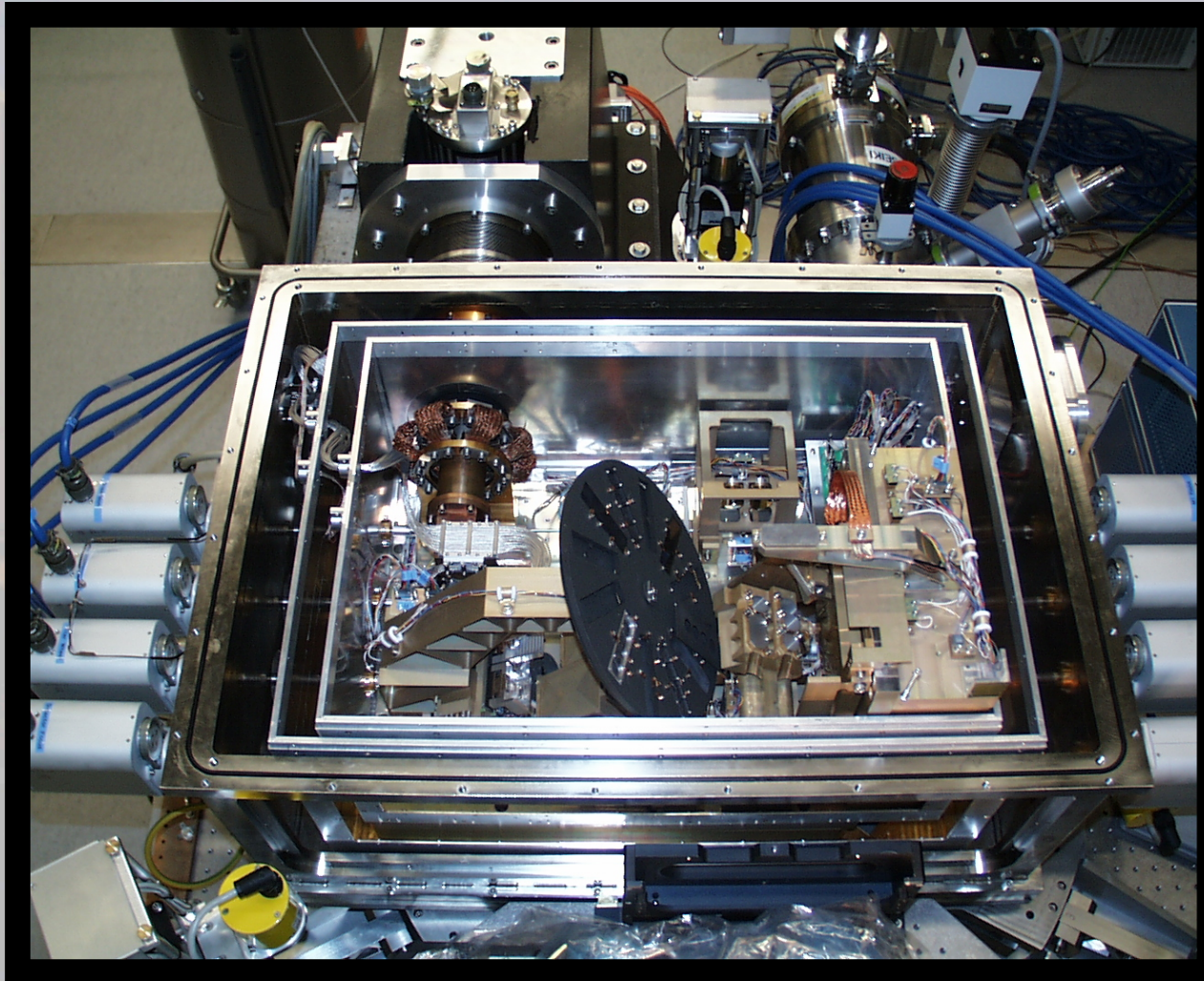
# MIDI: the instrument



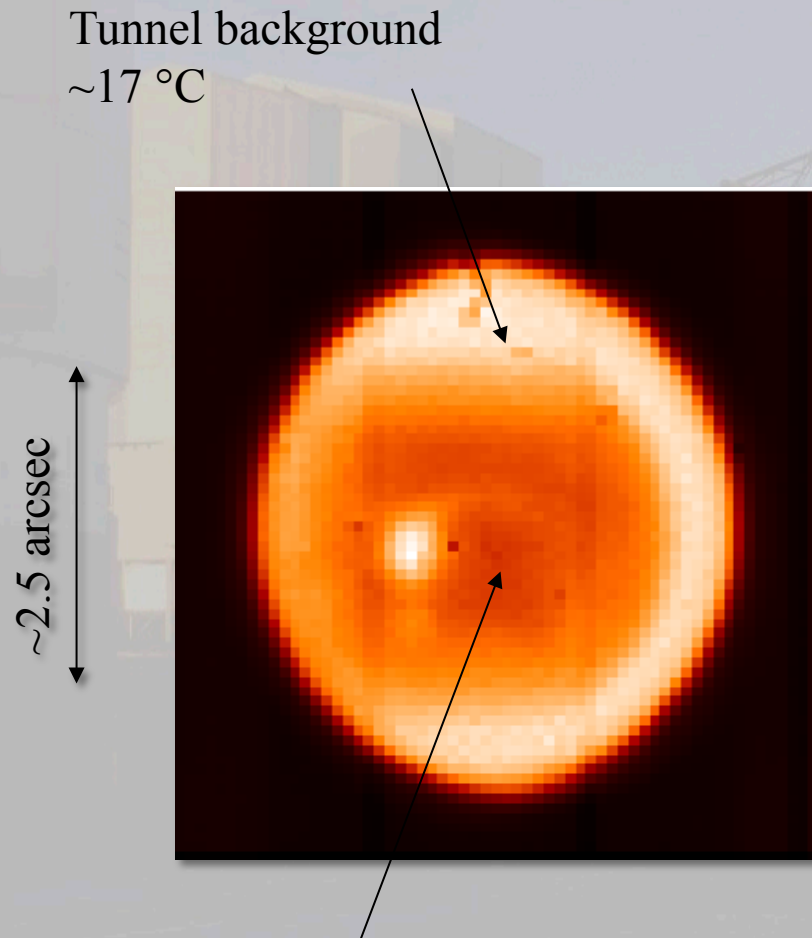
Inside the dewar



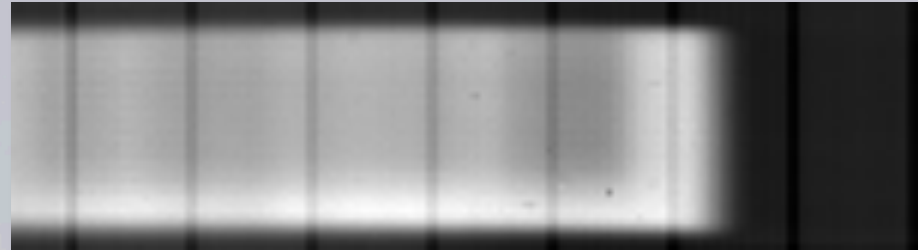
# MIDI: the instrument



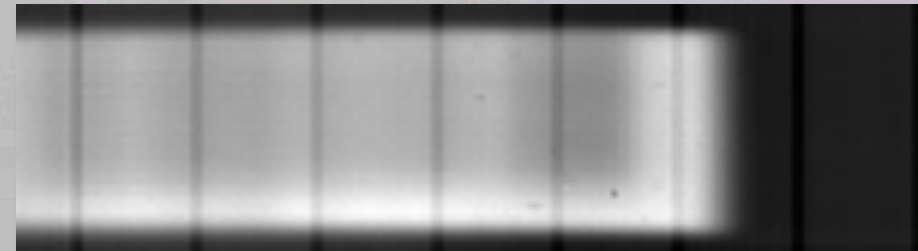
# What does MIDI see?



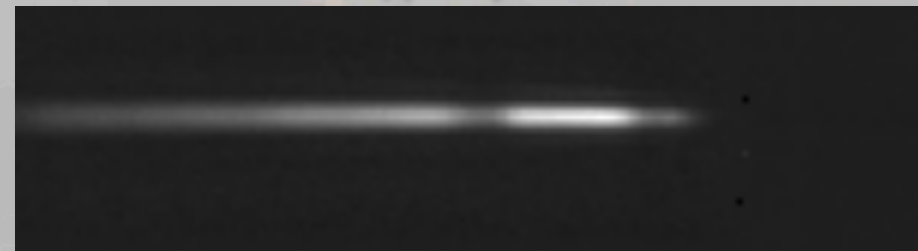
Sky exposure



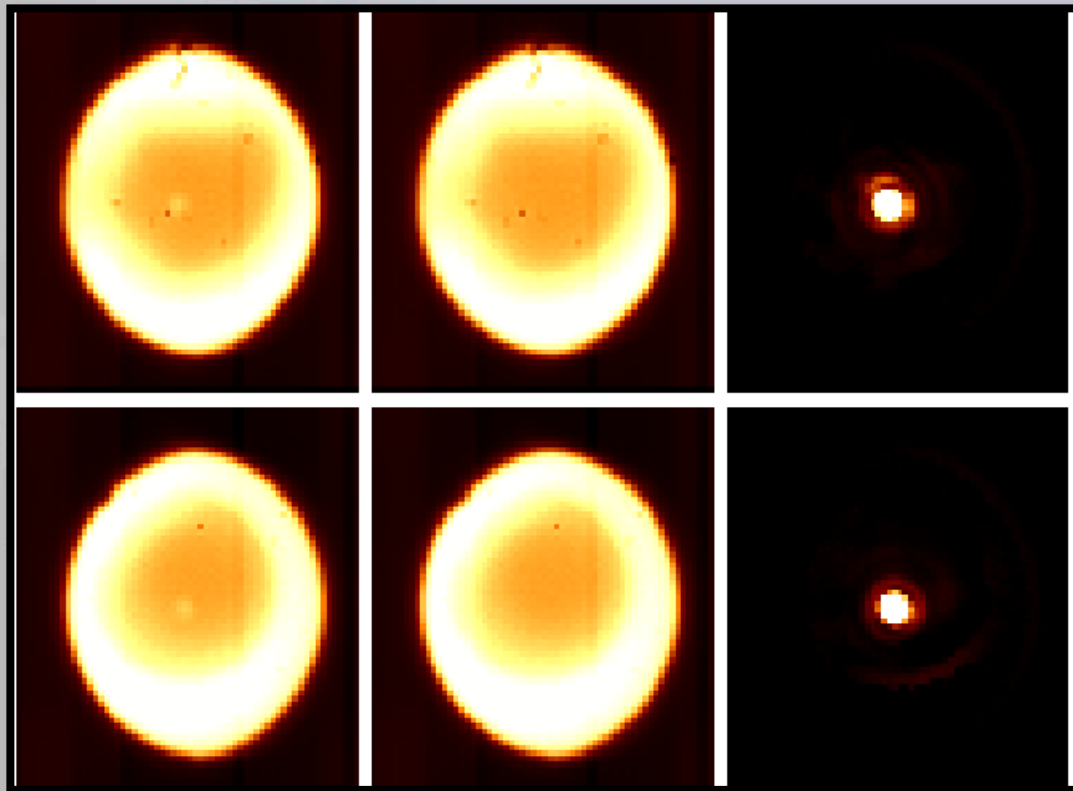
On source exposure



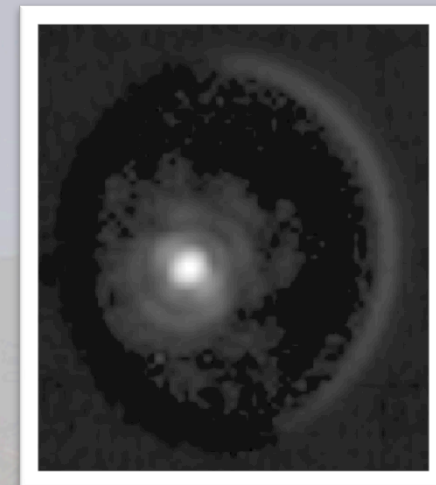
Chopped spectrum



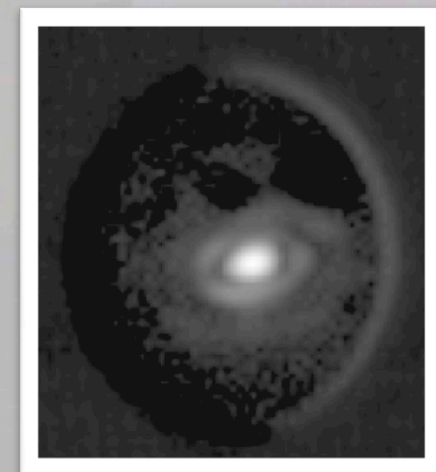
## What does MIDI see?



Z CMa

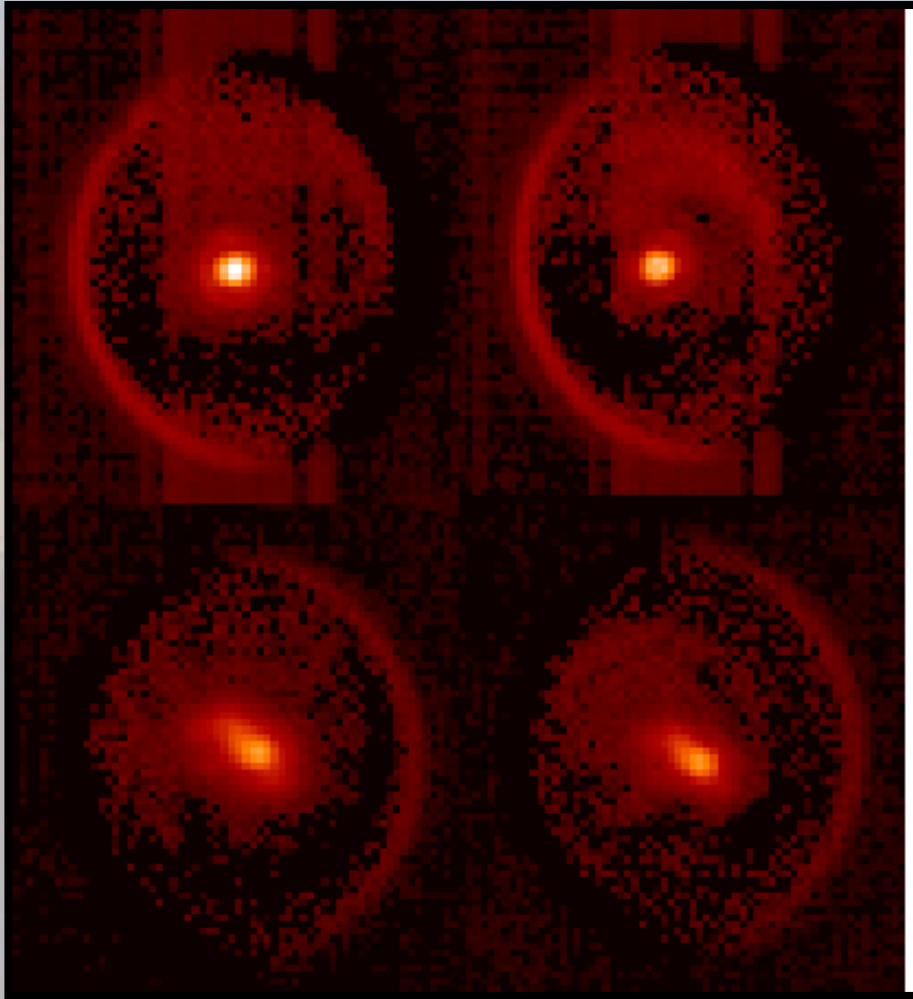


Z Cma:  $I^{1/4}$  in Beam B



Z CMa:  $I^{1/4}$  in Beam A

## What does MIDI see? **A caution!**



Calibrator

NGC 1068



# Two Observing Modes

## HIGH-SENS: the High Sensitivity mode:

Fringe tracking: exclusively on the source, no chopping

2 windows

Photometry of telescope A: shutter B, beam combiner inserted, chopping

2 windows located at the same place in the detector

Advantage: simple data sets in the same detector position

Drawback: Photometry performed at 2-5 minutes intervals. The accuracy on the visibility is typically 7-15% under good to medium atmospheric conditions,

## SCI-PHOT: the high accuracy mode

Fringe tracking: chopping working at a frequency which is an integer multiple of the scanning frequency

4 windows: 2 interferometric, 2 photometric

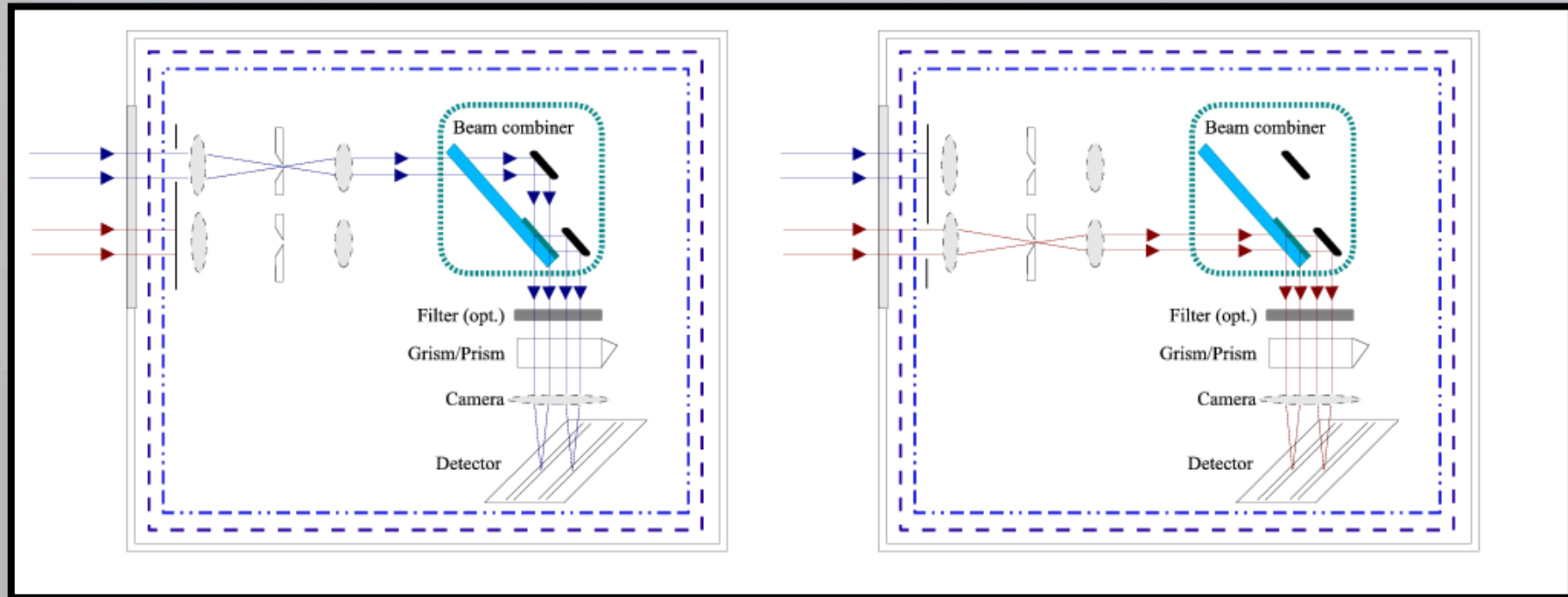
Advantage: simultaneous photometry

Drawbacks: chopping simultaneously with scanning, heavy real time control  
: distorsion of the photometric beams, added detector noise

Unknown: coupling coefficients: is MIDI stable?



# HIGH-SENS: delayed photometric calibration

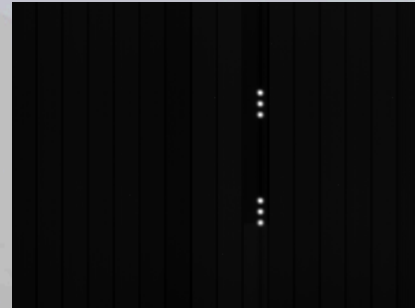
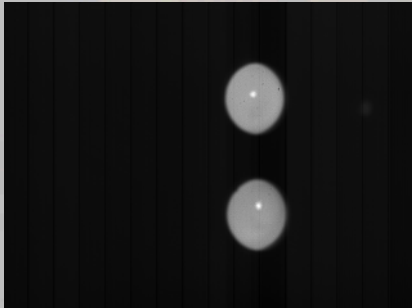


TIP: separate photometry is also useful for SCI-PHOT observations of faint sources

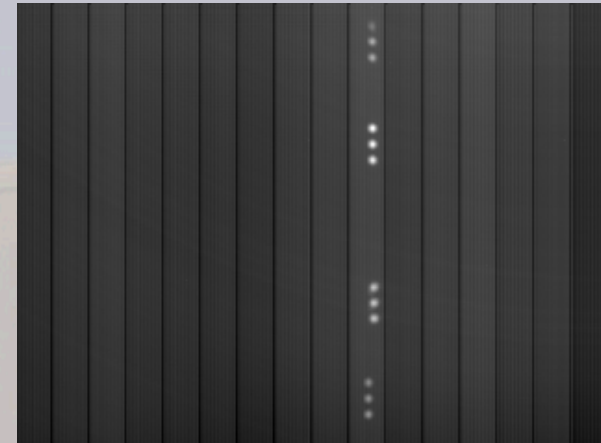
# What do we see on the MIDI detector?

Detector: 320 x 240 pixels

Acquisition (Field Camera)    High-Sens Mode

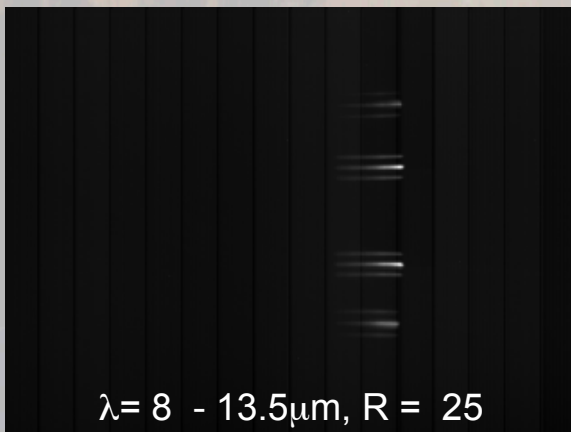


Typical exposure time: 4ms



70% Interfero., 30% Phot.

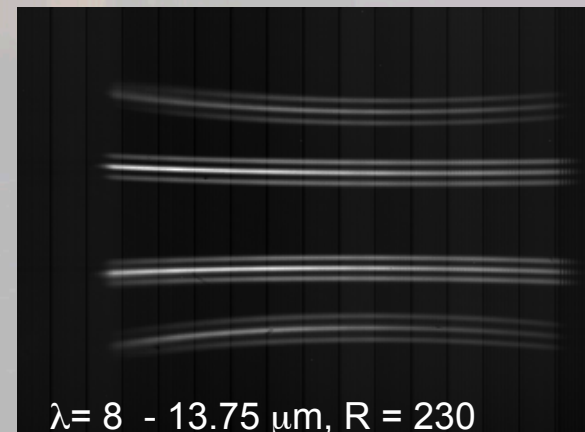
Dispersion with Prism



$\lambda = 8 - 13.5 \mu\text{m}$ ,  $R = 25$

Typical exposure time: 15-20 ms

Dispersion with Grism



$\lambda = 8 - 13.75 \mu\text{m}$ ,  $R = 230$

Typical exposure time: 30-40 ms

## What do we see on the MIDI detector?

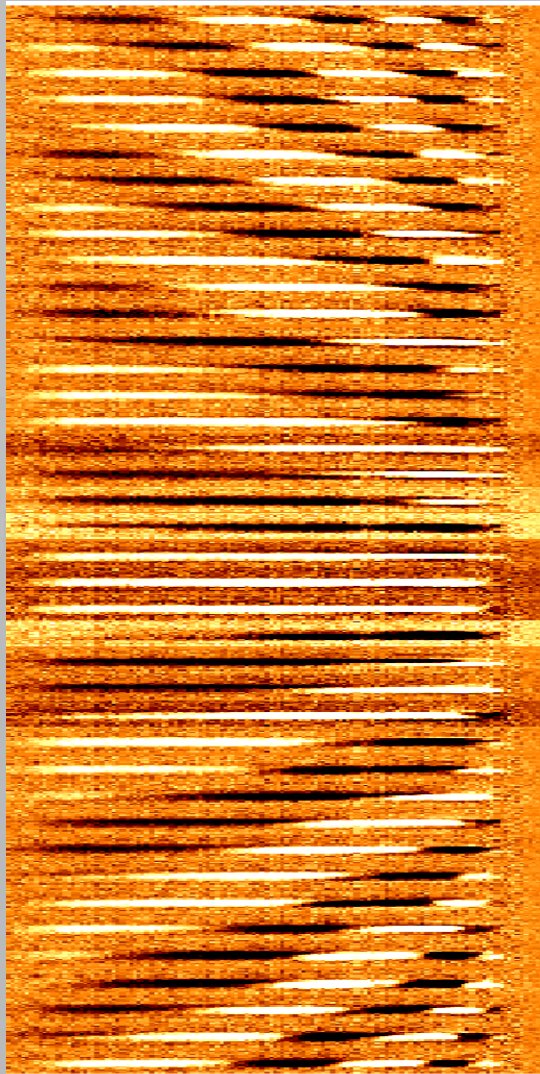
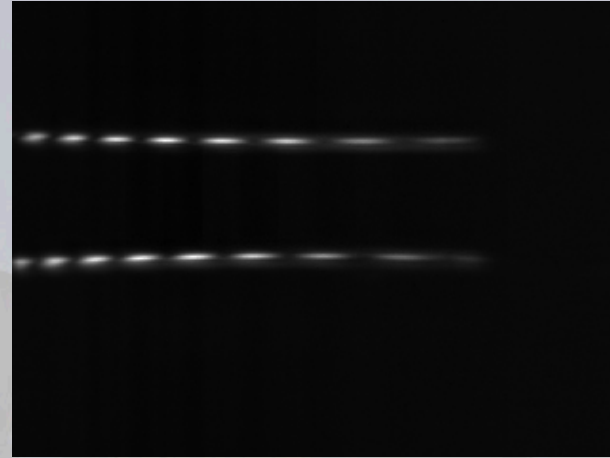


Figure courtesy of Thorsten Ratzka

——→ Limit of the scan

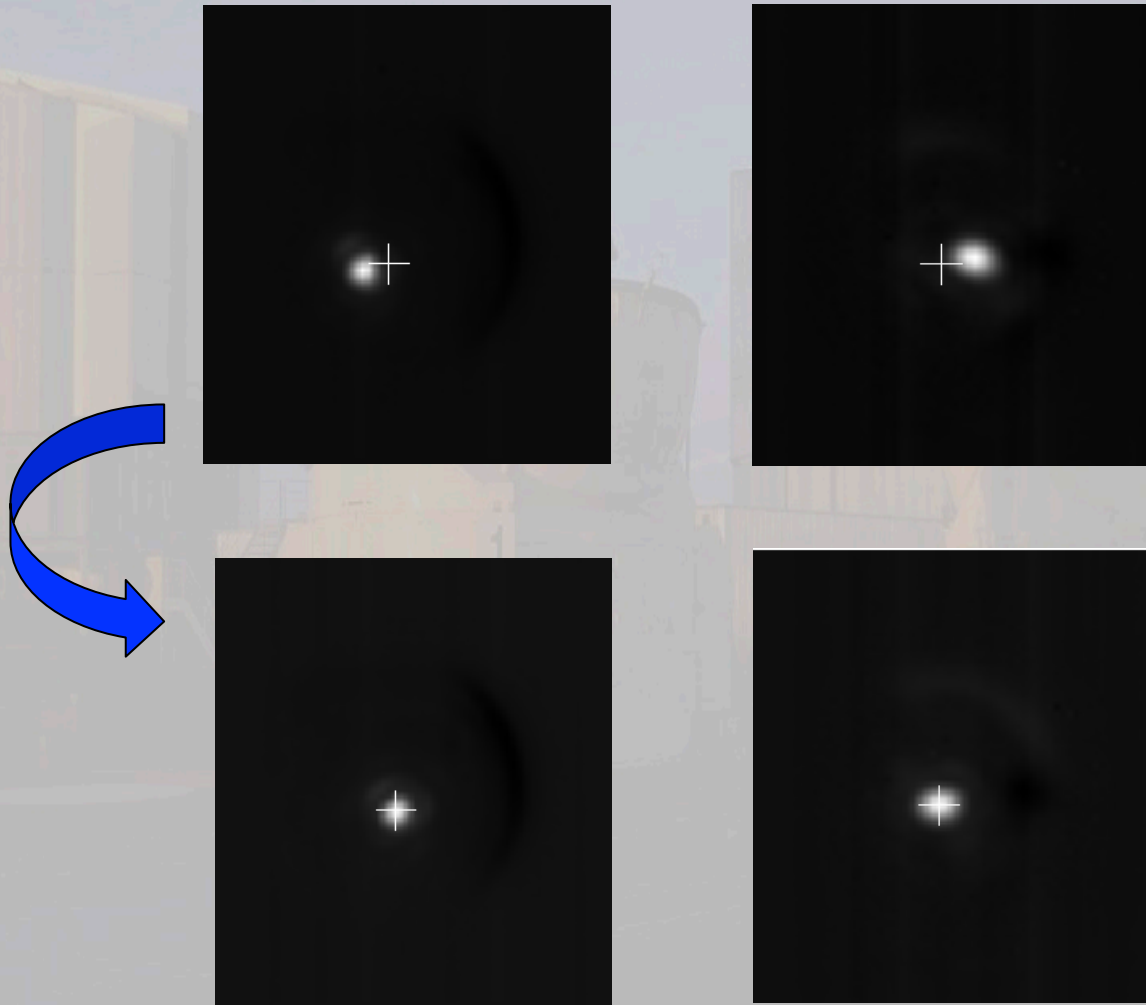


——→ Zero OPD: white fringe at all wavelengths

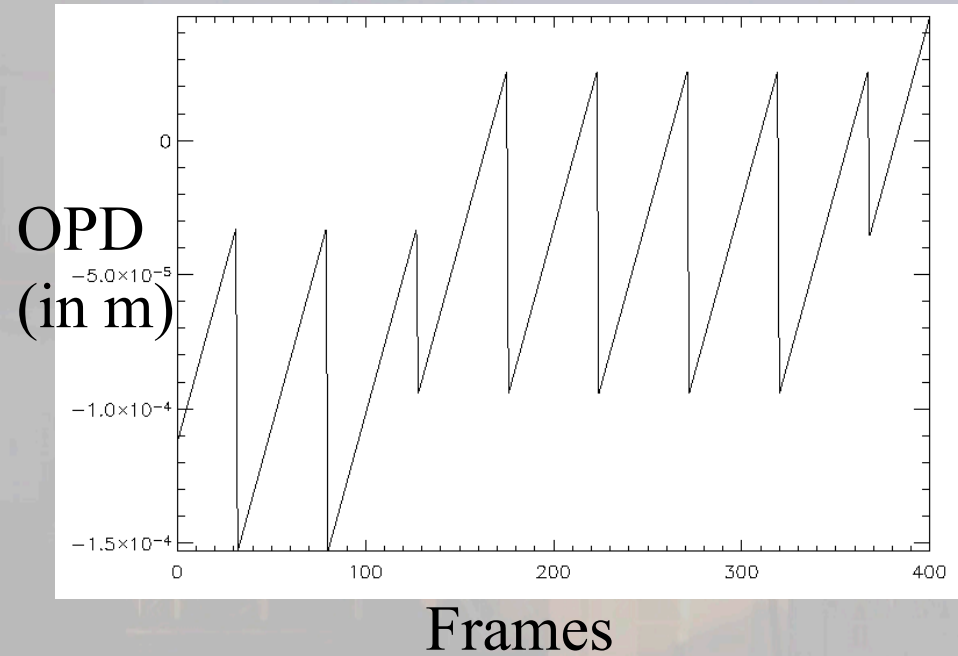
## A MIDI observation from A to Z

- Acquisition and fine acquisition
  - Fringe search
  - Fringe track
- (Photometry A and B)
- All of this for the calibrator

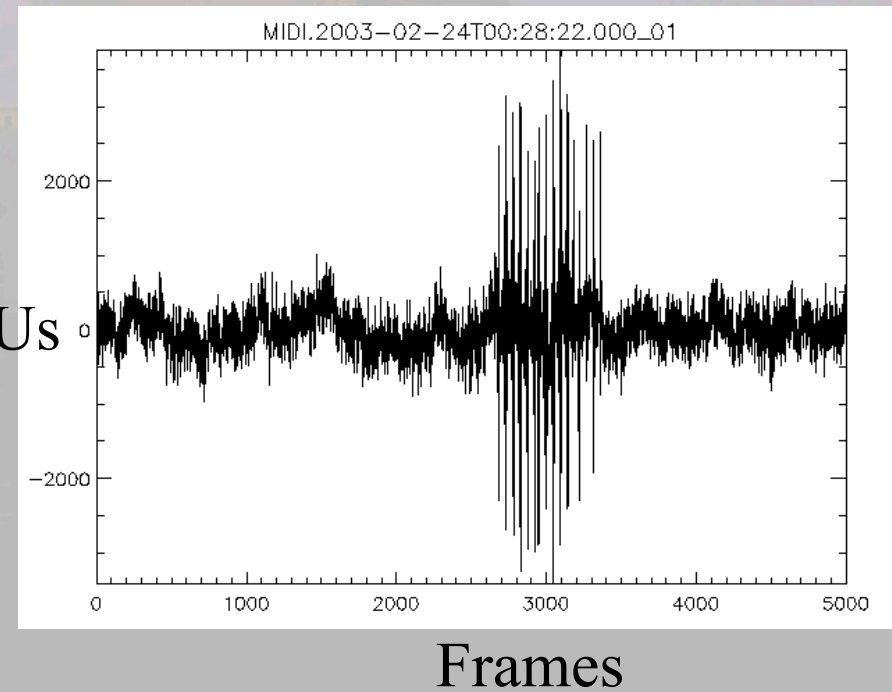
# 1: Source Acquisition



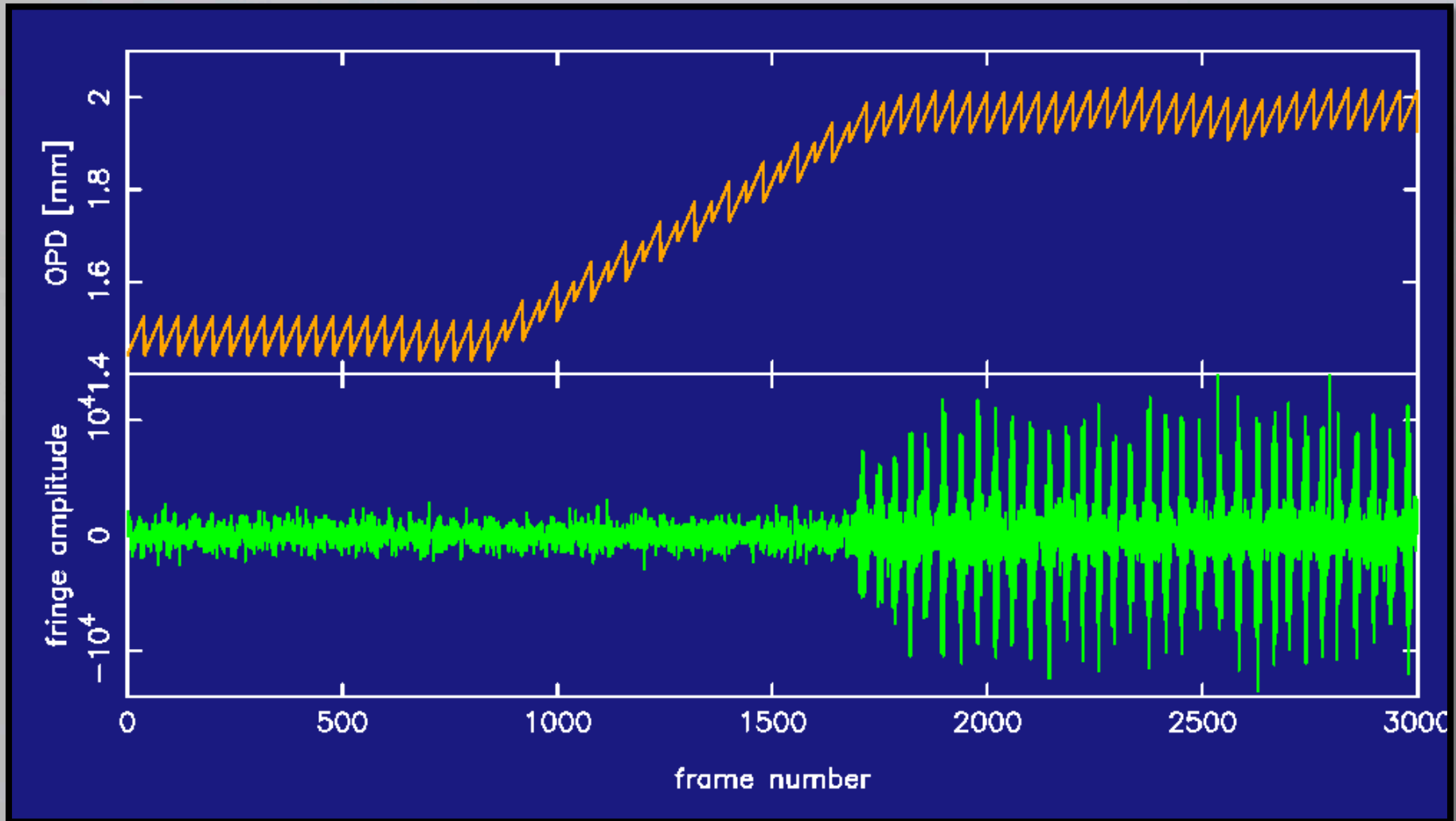
## 2: Fringe Search



ADUs



### 3: Fringe Track





# Preparing Observations: Observing Block creation with p2pp

P2PP V.2.13.1 082.D-0179(B)/SM/MIDI

New
 Duplicate
 Verify
 View
 Attach FC
 Readme
 p2pp-submit
 Period
All
No CCS
AppServer

**Folders**

- 074.D-0601(A)/SM/MIDI
- 074.D-0601(B)/SM/SOFT
- 076.D-0107(A)/SM/VISIR
- 077.D-0061(A)/SM/MIDI
- 077.D-0061(B)/SM/MIDI
- 077.D-0061(C)/SM/MIDI
- 077.D-0061(D)/SM/MIDI
- 077.D-0061(E)/SM/MIDI
- 077.D-0061(F)/SM/MIDI
- 078.D-0112(A)/SM/MIDI
- 078.D-0112(B)/SM/MIDI
- 078.D-0112(C)/SM/MIDI
- 080.D-0059(A)/VM/MIDI
- 080.D-0059(B)/VM/MIDI
- 080.D-0059(C)/VM/MIDI
- 080.D-0059(D)/VM/AMBER
- 081.D-0616(A)/SM/VISIR
- 082.D-0179(B)/SM/MIDI**
- 084.D-0009(A)/VM/MIDI
- 084.D-0009(B)/VM/MIDI
- 084.D-0009(C)/VM/MIDI
- 380.D-0630(A)/SM/VISIR

**Summaries**

**ObsBlock** **CalBlock**

Name	DbaseId	Status	Target	OD	CS	Acquisition	FindingCharts	...
SCI_Beturus_15m	0	(P)artiallyD...	Beturus	No Name	Short_Baseline	MIDI_starintf_acq	(0)	



# Preparing Observations: Observing Block creation with p2pp

ObsBlock: SCI\_Beturus\_15m: MIDI

Name: SCI\_Beturus\_15m

Status: (P)artiallyDefined

\* Execution Time: 00:00:00.000

User Priority: 1

OD Name: No Name

User Comments:

Instrument Comments : name of associated OB of the SCI/CAL pair

CAL\_HD11111\_15m

Template Type	Template
acquisition	MIDI_starintf_obs_field
science	MIDI_starintf_obs_fringe
calib	
test	

Add

Delete Col : 4

Duplicate Col : 4

Recalc ExecTime

MIDI_starintf_acq	1	MIDI_starintf_obs_fringe	1
Correlated magnitude (Jy)	15	Number of frames per photometry exp...	4000
Magnitude in H-band	2	Fringe tracking at zero OPD	<input checked="" type="checkbox"/>
Uncorrelated magnitude (Jy)	20	Angle of chopping	0
Angle of chopping	0	Amplitude of chopping	15
Amplitude of chopping	15	Dispersive element	PRISM
Filter	N8.7	Beamcombiner	HIGH_SENS
Coude guide star alpha	0.		
Coude guide star delta	0.		
Coude guide star type	SCIENCE		
Coude guide star magnitude in V	12.		
Science or calibrator	SCIENCE		

Target    Constraint Set    Time Intervals    Sidereal Time    Calibration Requirements

Name: Beturus

Class: Unknown

Right Ascension: 00:00:00.000

Declination: 00:00:00.000

Equinox: 2000

Epoch: 2000.0

proper motion RA: 0.000000

proper motion DEC: 0.000000

Diff RA: 0.000000

Diff DEC: 0.000000

# Preparing Observations: Observing Block creation with p2pp

ObsBlock: SCI\_Beturus\_15m: MIDI

Name: SCI\_Beturus\_15m  
Status: (P)artiallyDefined  
\* Execution Time: 00:00:00.000  
User Priority: 1  
OD Name: No Name

Template Type    Template

acquisition	MIDI_starintf_obs_field
<b>science</b>	<b>MIDI_starintf_obs_fringe</b>
calib	
test	

Add  
Delete Col : 4  
Duplicate Col : 4  
Recalc ExecTime

User Comments:

Instrument Comments : name of associated OB of the SCI/CAL pair  
CAL\_HD11111\_15m

MIDI_starintf_acq	1	MIDI_starintf_obs_fringe	1
Correlated magnitude (Jy)	15	Number of frames per photometry exp...	4000
Magnitude in H-band	2	Fringe tracking at zero OPD	<input checked="" type="checkbox"/>
Uncorrelated magnitude (Jy)	20	Angle of chopping	0
Angle of chopping	0	Amplitude of chopping	15
Amplitude of chopping	15	Dispersive element	PRISM
Filter	N8.7	Beamcombiner	HIGH_SENS
Coude guide star alpha	0.		
Coude guide star delta	0.		
Coude guide star type	SCIENCE		
Coude guide star magnitude in V	12.		
Science or calibrator	SCIENCE		

Target    Constraint Set    Time Intervals    Sidereal Time    Calibration Requirements

Name: Short\_Baseline  
Baseline: UT2-UT3  
Sky Transparency: Photometric

# Reducing and calibrating MIDI observations

**Walter Jaffe  
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William Cotton  
Olivier Chesneau  
Thorsten Ratzka  
Quynh Nhu Nguyen  
Guy Perrin  
Christian Hummel  
MIDI/ESO team**

Where can one get started?


- <http://www.strw.leidenuniv.nl/~koehler/MIA+EWS-Manual> (http://mia at the school)
- <http://www.ub.uni-heidelberg.de/archiv/5516> : Thorsten Ratzka's PhD thesis
- The ESO webpages: <http://www.eso.org/sci/facilities/paranal/instruments/midi/>
- Christian Hummel's homepage: <http://www.eso.org/~chummel/midi/midi.html>

# Reducing and calibrating MIDI observations

MIA+EWS - The Friendly Manual


file:///Users/tijl/Resources/Manuals/MIA\_EWS/MIA+EWS-Manual/index.html google.be

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## MIA+EWS

### MIDI Data Reduction Software



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  3. [Walter's User Guide](#)
9. [Sci Phot mode](#)
10. [The results of MIA and EWS differ - Panic!](#)
11. [MIDI File Formats](#)

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#### Acknowledgements

This manual is based on a tutorial for MIA written by Thorsten Ratzka (MPIA), and documents on EWS originally written by Walter Jaffe (Sterrewacht Leiden), which were modified and extended by Christian A. Hummel (ESO) with help from Markus Schoeller (ESO) and members of the MIDI consortium. The version you see here

# Reducing and calibrating MIDI observations: File sizes

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	NGC1068 S	Acquisition	30 MB
MIDI.2003-06-15T10:04:07.000.fits.Z	NGC1068 S	FringeTrack	111 MB
MIDI.2003-06-15T10:05:23.451.fits.Z	NGC1068 S	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	NGC1068 S	Photometry (A)	
52 MB			
MIDI.2003-06-15T10:14:32.000.fits.Z	NGC1068 S	Photometry (B)	
52 MB			

# Reducing and calibrating MIDI observations: Selecting data

```
Mia:> files=midigui(dir='<path>')
```

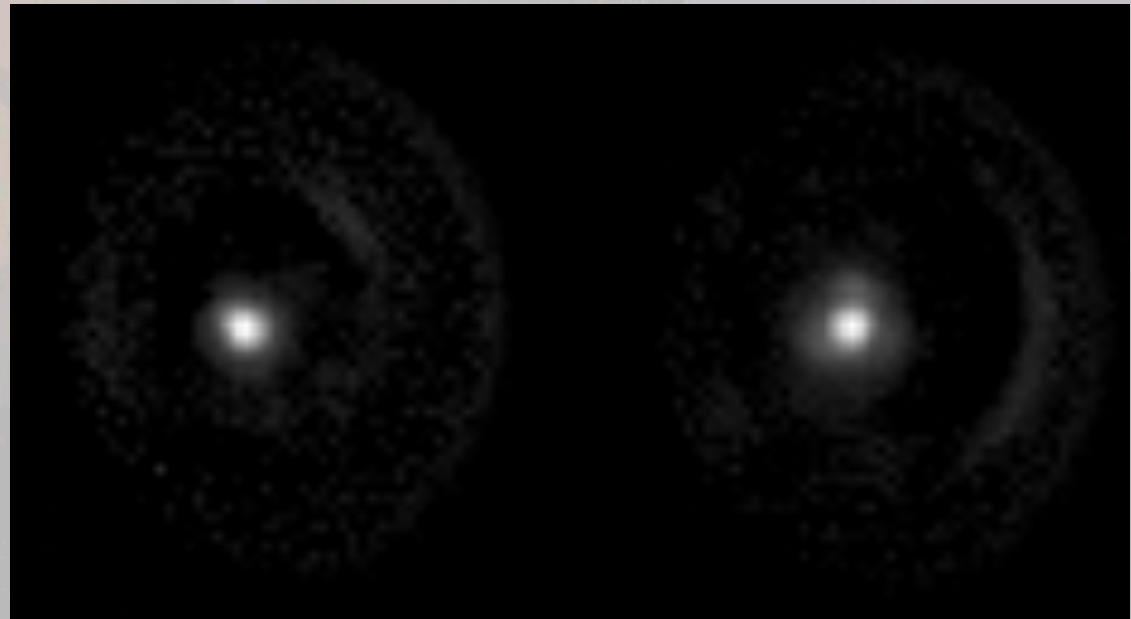
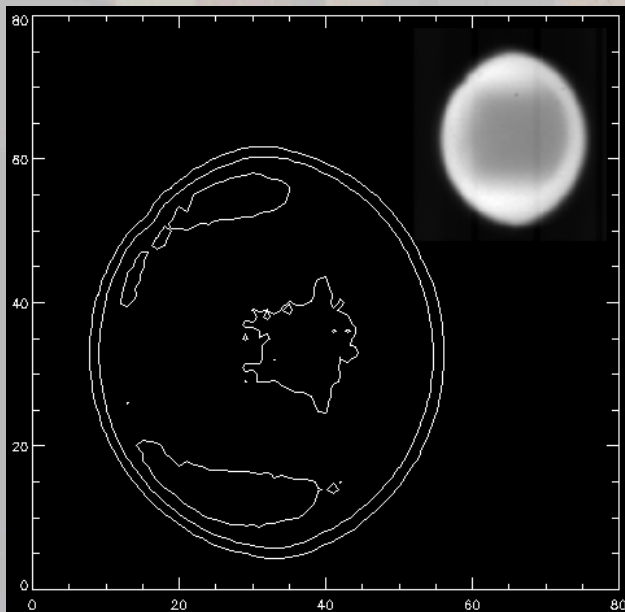
<div> <div>HIDE SHOW SELECT QUIT UP DOWN SHOW</div> <div>= != &gt; &lt; &lt;= &gt;= =</div> <div>AND OR</div> </div>							
B 3							
	FILENAME	OBSTARC	NRTSHDIE	INSGRIS	INSOPT1	INSGFILTINGSHUT	
0	<input type="checkbox"/> MIDI_2003-06-15T09:26:17.000.fits	hd10380	ACQ_UT_COARSE_CHOP	OPEN	OPEN	N0,7	ABOPEN
1	<input type="checkbox"/> MIDI_2003-06-15T09:37:19.000.fits	hd10380	OBS_FRINGE_TRACK_FOURIER	PRISM	HIGH_SENS	OPEN	ABOPEN
2	<input type="checkbox"/> MIDI_2003-06-15T09:43:00.000.fits	hd10380	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	ABOPEN
3	<input type="checkbox"/> MIDI_2003-06-15T09:44:52.000.fits	hd10380	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	ABOPEN
4	<input type="checkbox"/> MIDI_2003-06-15T10:00:09.000.fits	ngc1068	ACQ_UT_COARSE_CHOP	OPEN	OPEN	N0,7	ABOPEN
5	<input checked="" type="checkbox"/> MIDI_2003-06-15T10:04:07.000.fits	ngc1068	OBS_FRINGE_TRACK_FOURIER	PRISM	HIGH_SENS	OPEN	ABOPEN
6	<input checked="" type="checkbox"/> MIDI_2003-06-15T10:12:40.000.fits	ngc1068	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	ABOPEN
7	<input checked="" type="checkbox"/> MIDI_2003-06-15T10:14:32.000.fits	ngc1068	OBS_PHOTOMETRY_CHOP	PRISM	HIGH_SENS	OPEN	ABOPEN

```
Mia:> print, files[i]
```



# Reducing and calibrating MIDI observations: Acquisition images

```
Mia:> acq=oirgetdata(files[0])  
Mia:> tvsclm,acq[100].data1,5;show 101th frame  
Mia:> contour,acq[100].data1,nlevels=20  
Mia:> chop_nod_phot,files[0]
```



# Reducing and calibrating MIDI observations: Acquisition images

-----  
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  
-----

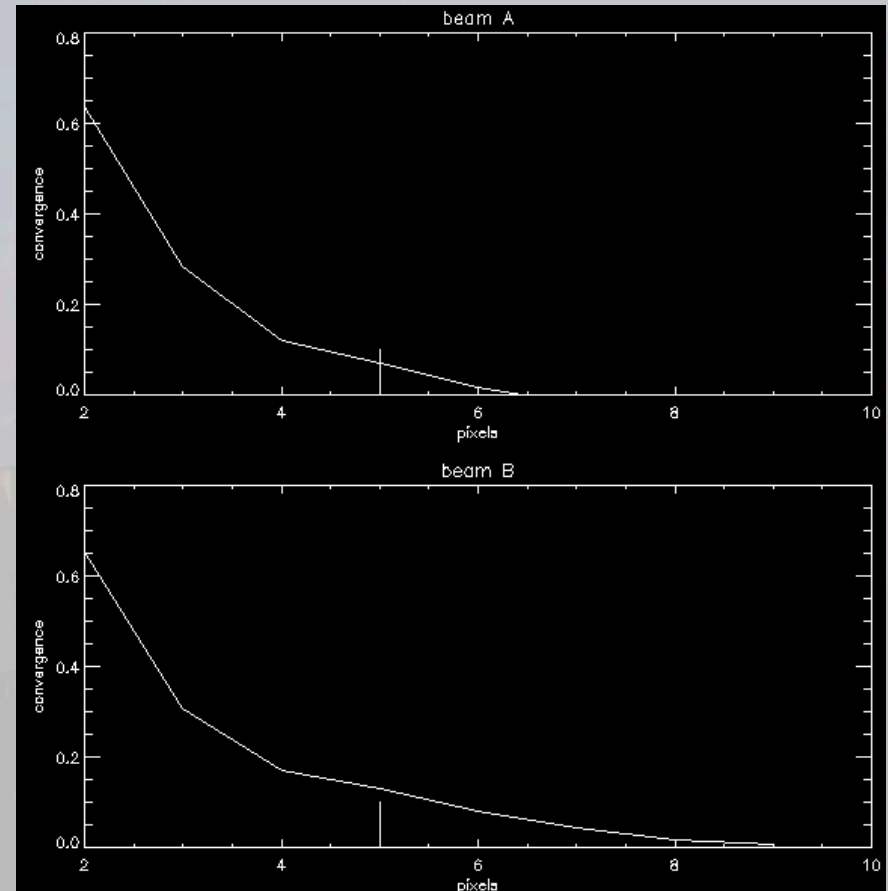
MIDI Beam A: 1.7577727e+08 - 865017.33 - 80041.702 - 76718.819  
-----

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'





# Reducing and calibrating MIDI observations: Photometry with dispersed data

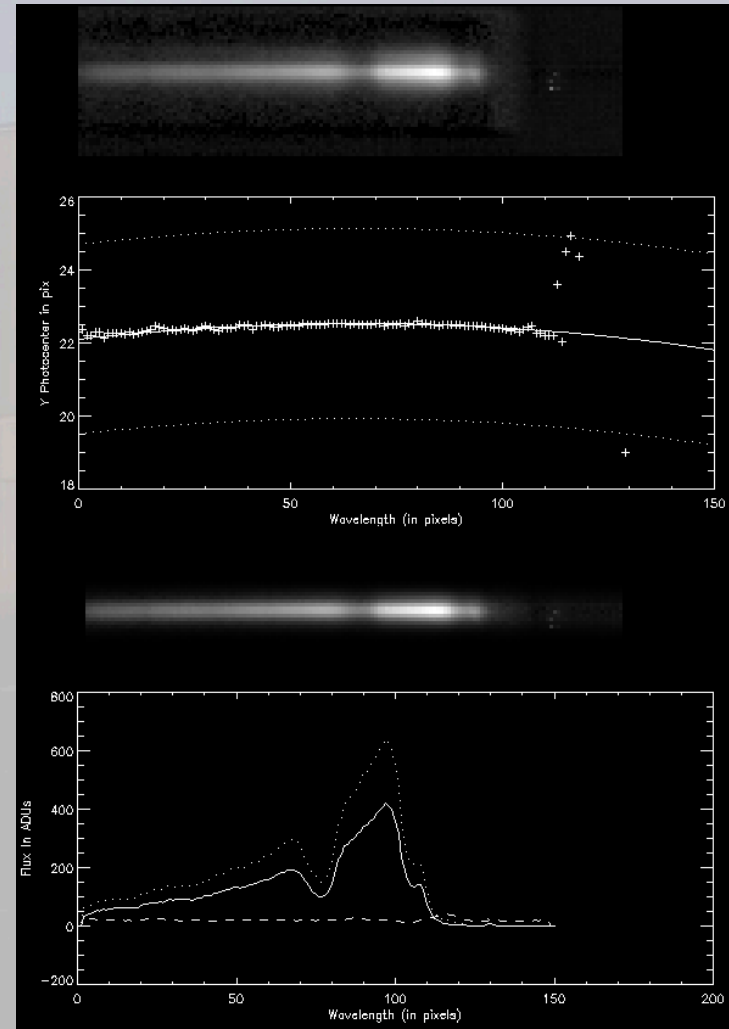
```
Mia:> chop_nod_disp,files[3]
```

## 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

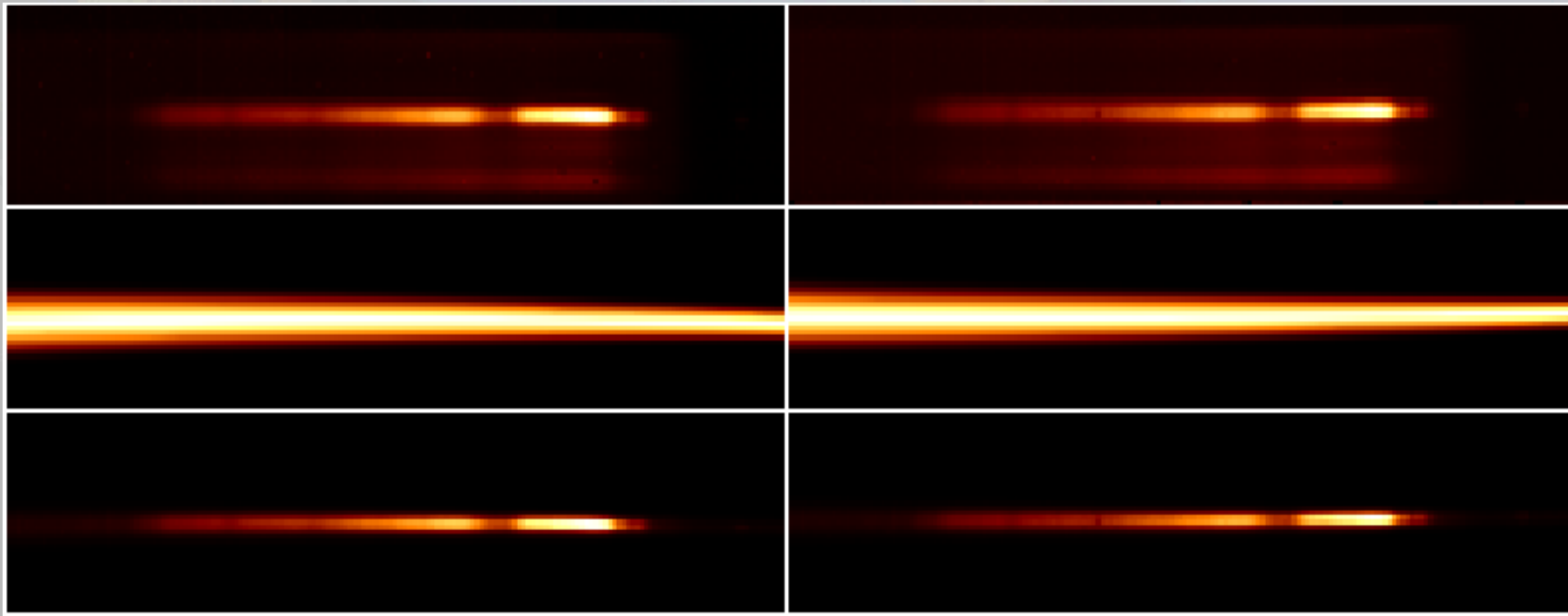
OUTPUT: an ascii file in the directory PHOTOMETRY

Can be read by the command: readphot, filename



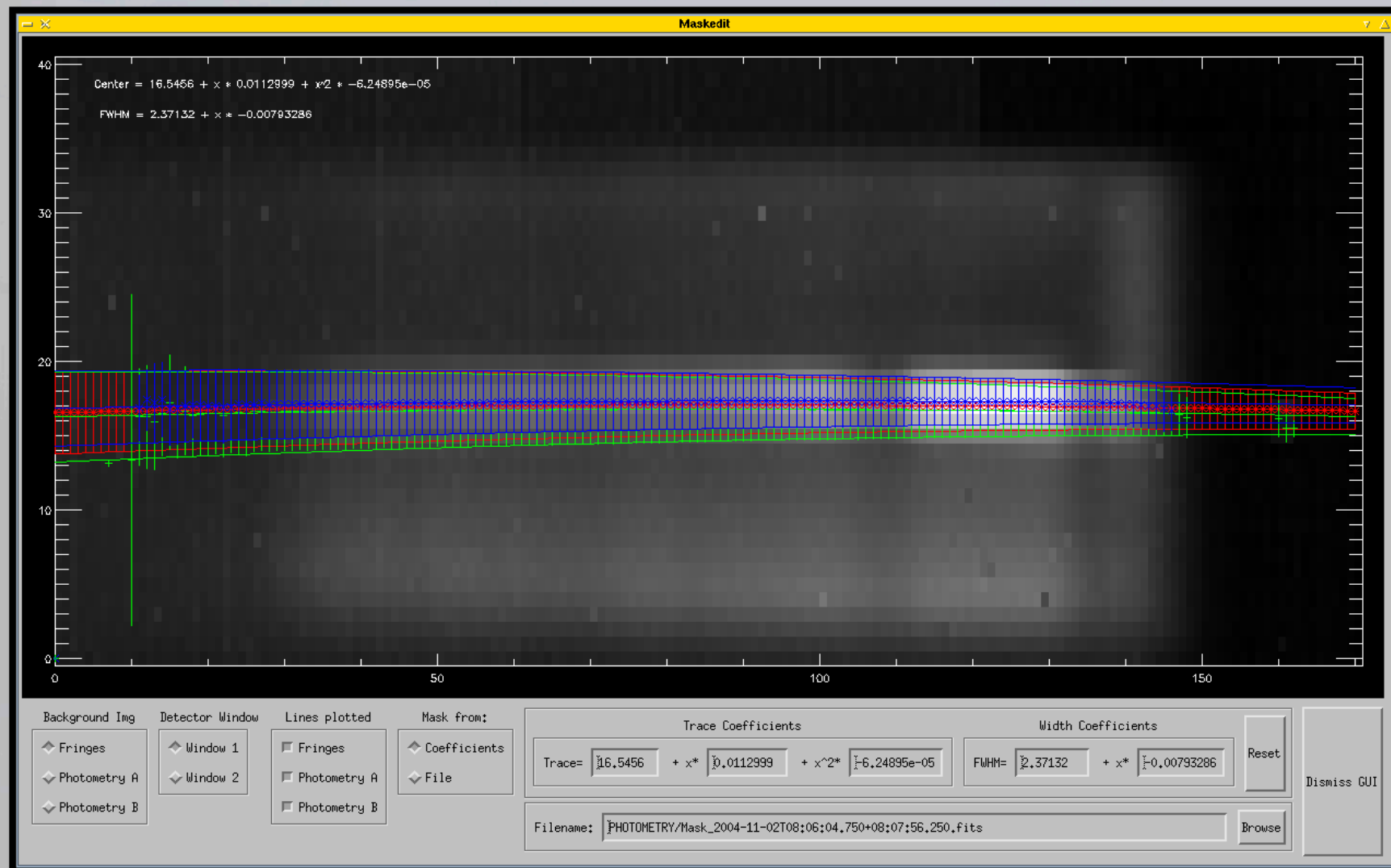
# Reducing and calibrating MIDI observations

## Intermezzo: the role of the masks



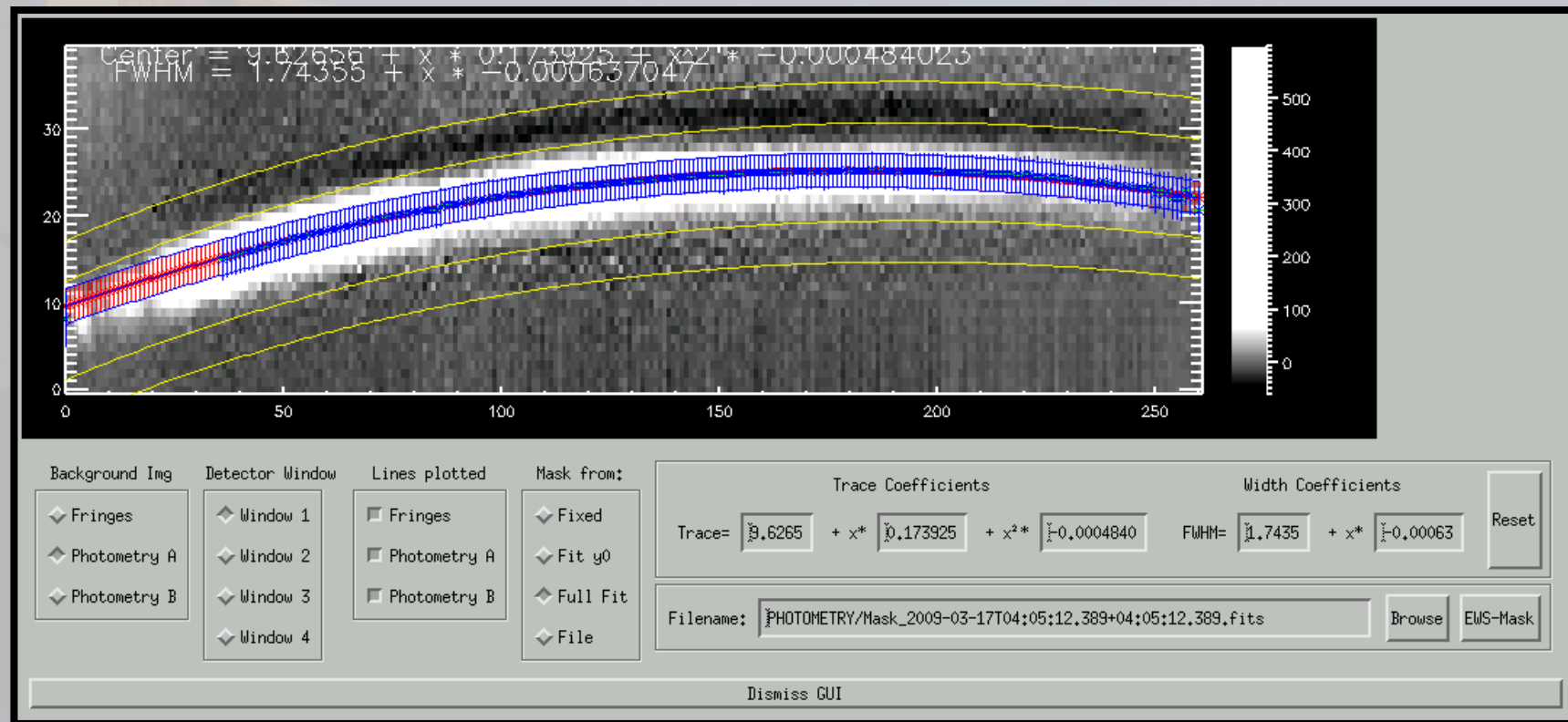
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## Intermezzo: the role of the masks



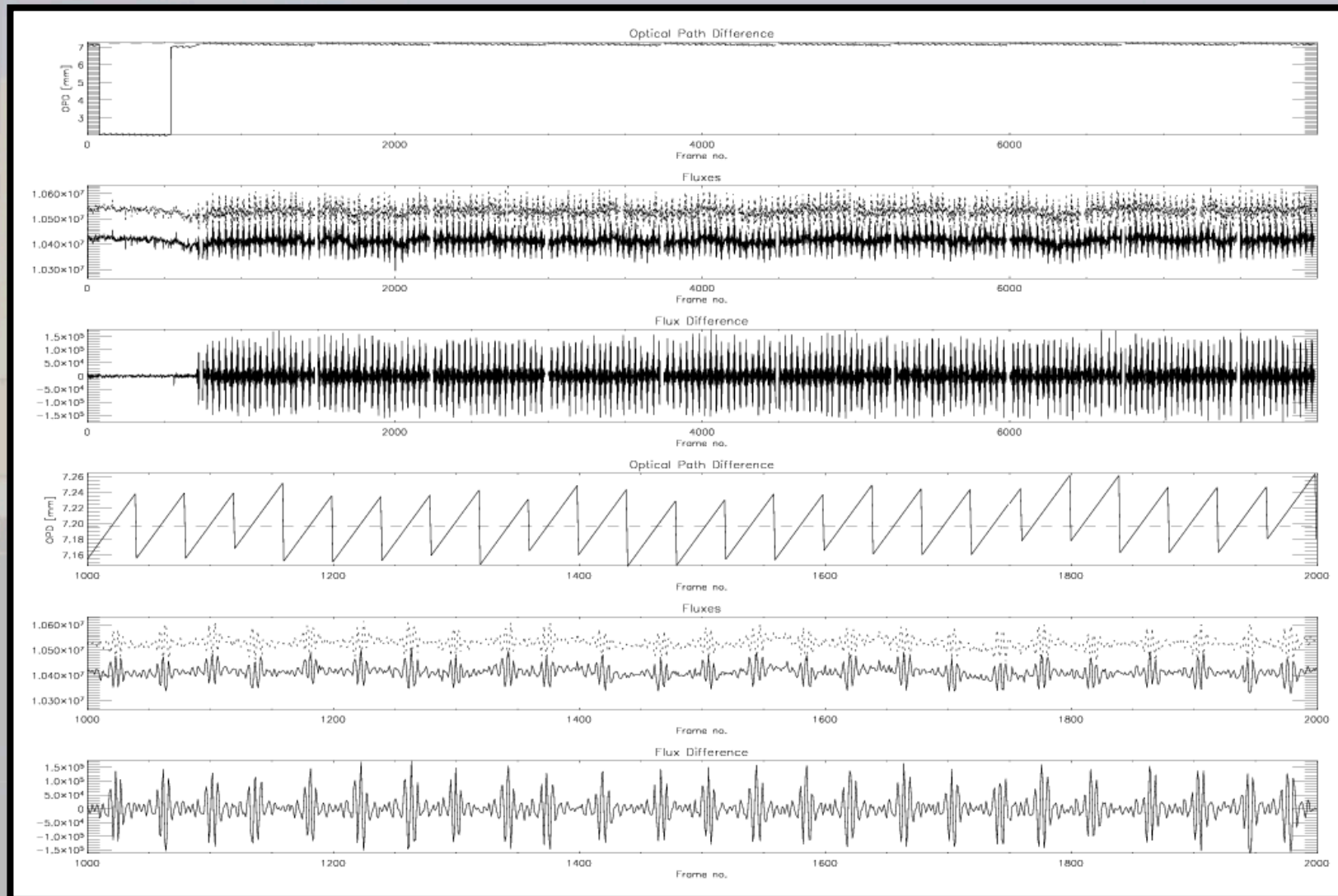
# Reducing and calibrating MIDI observations

## Intermezzo: the role of the masks



# Reducing and calibrating MIDI observations

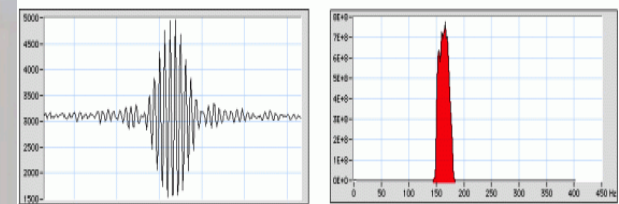
## Measuring the fringes



# Reducing and calibrating MIDI observations: Measuring the power in the fringes

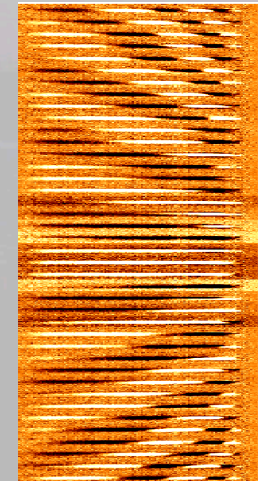
## Incoherent (MIA):

*Measure the power in the FT of each fringe scan,  
and add up these power measurements*



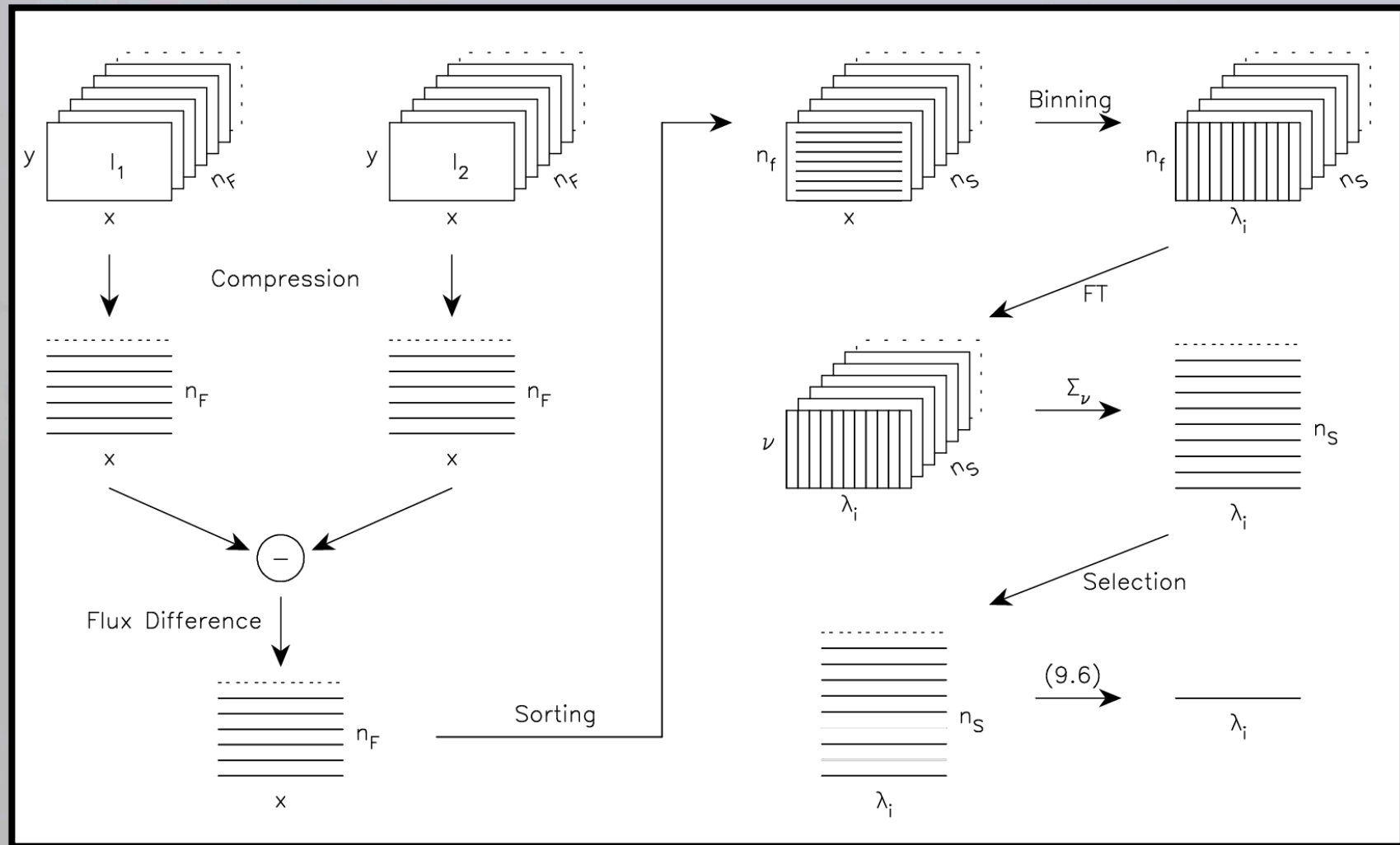
## Coherent (EWS):

*Use the dispersion, and the fact that we don't observe exactly at  
zero opd, to estimate the zero-opd location for each scan. Co-  
phase them, add them up, and then FT.*



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## Incoherent HIGH-SENS analysis

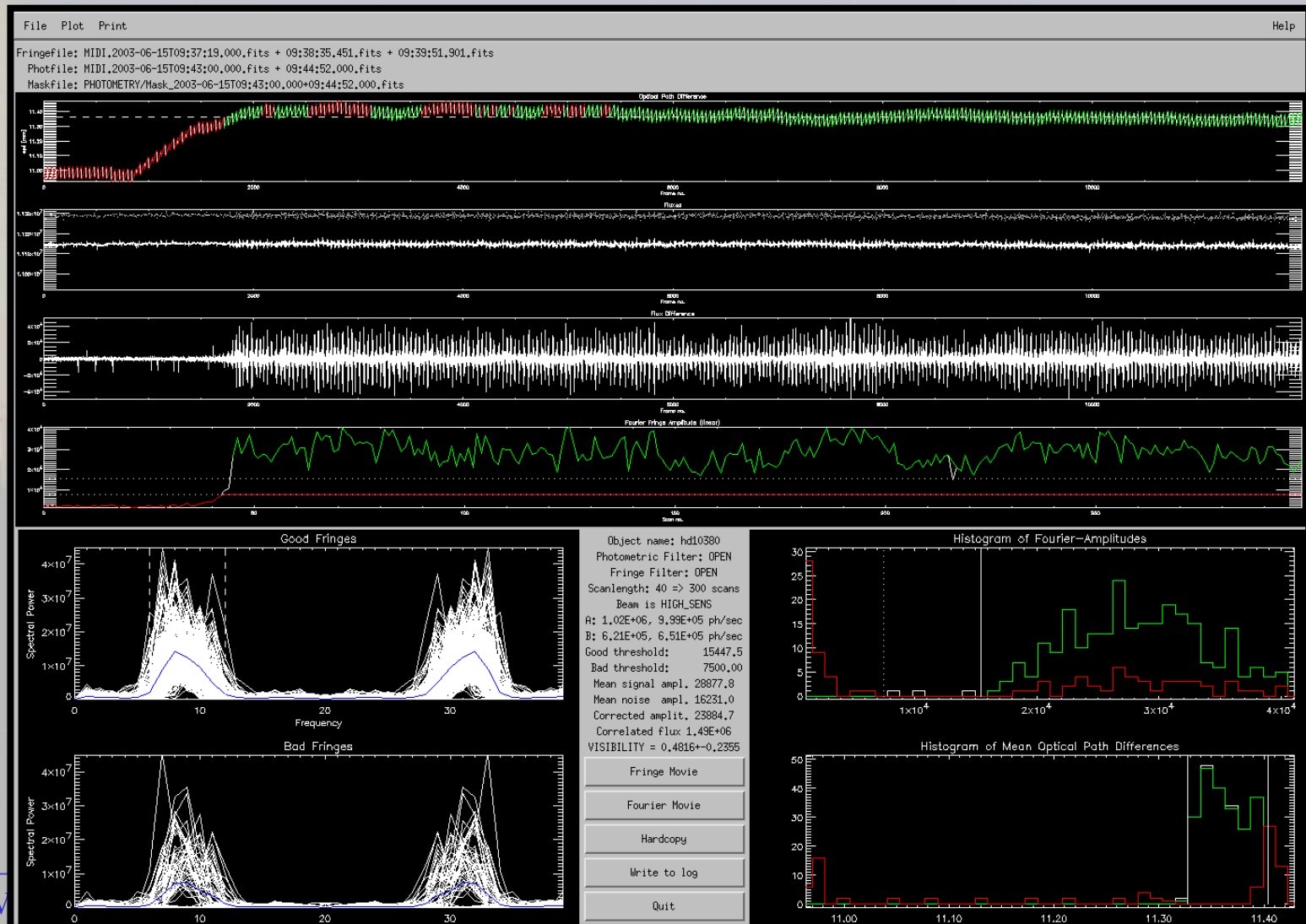




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## Incoherent HIGH-SENS analysis

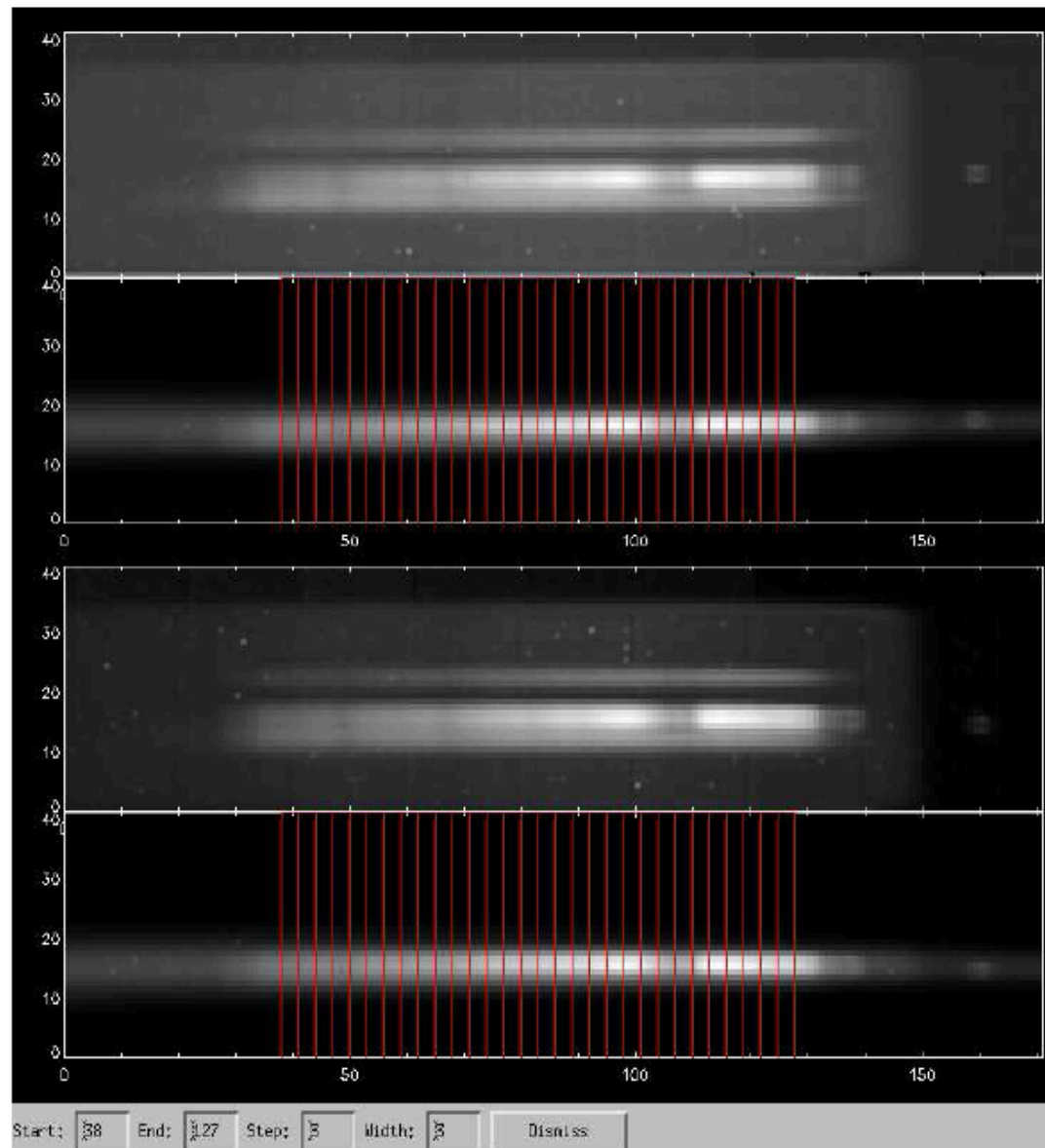
Mia:> *cal=xmdv(calfiles) & cal->gui,/tru*





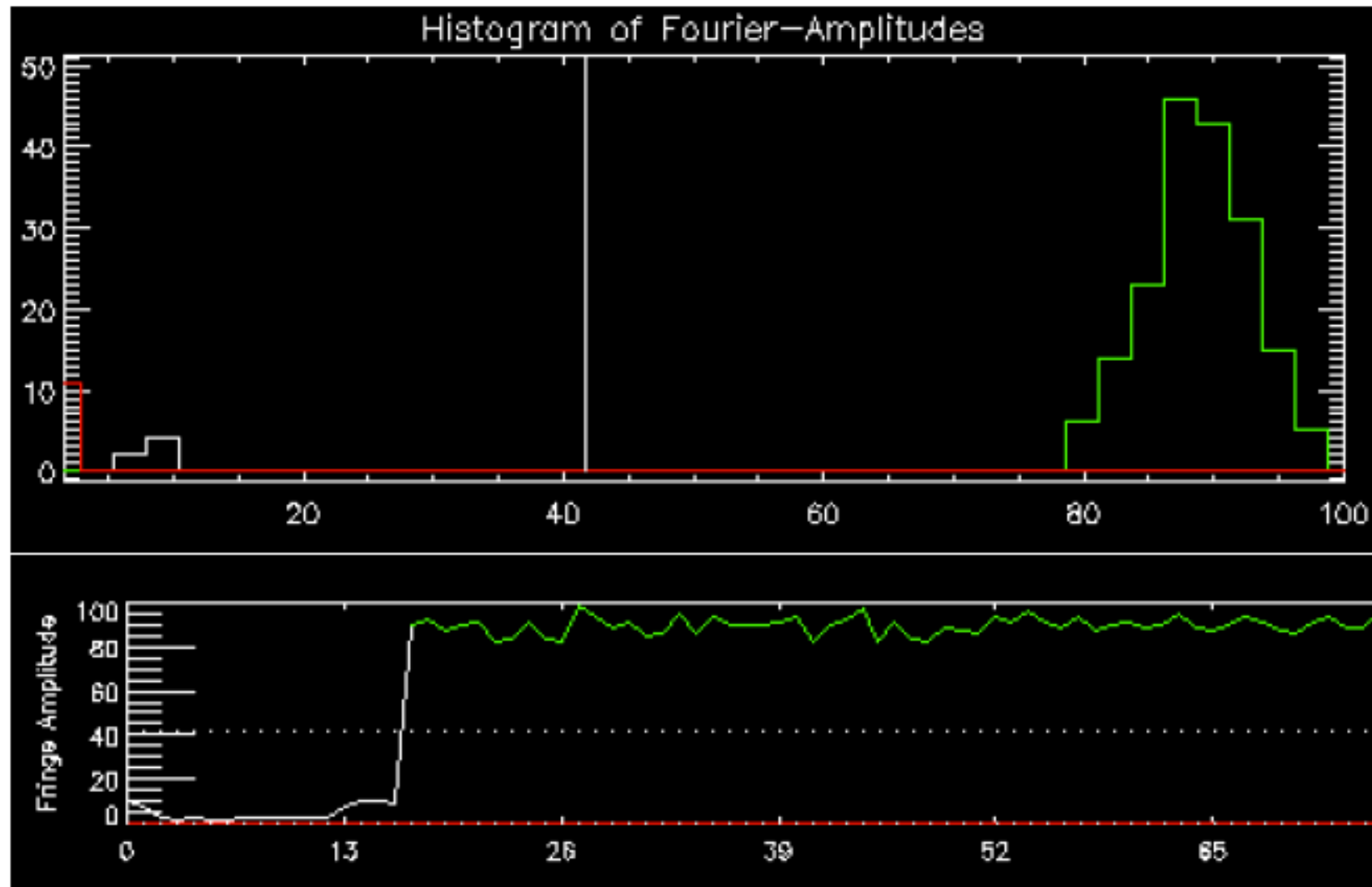
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## Incoherent HIGH-SENS analysis



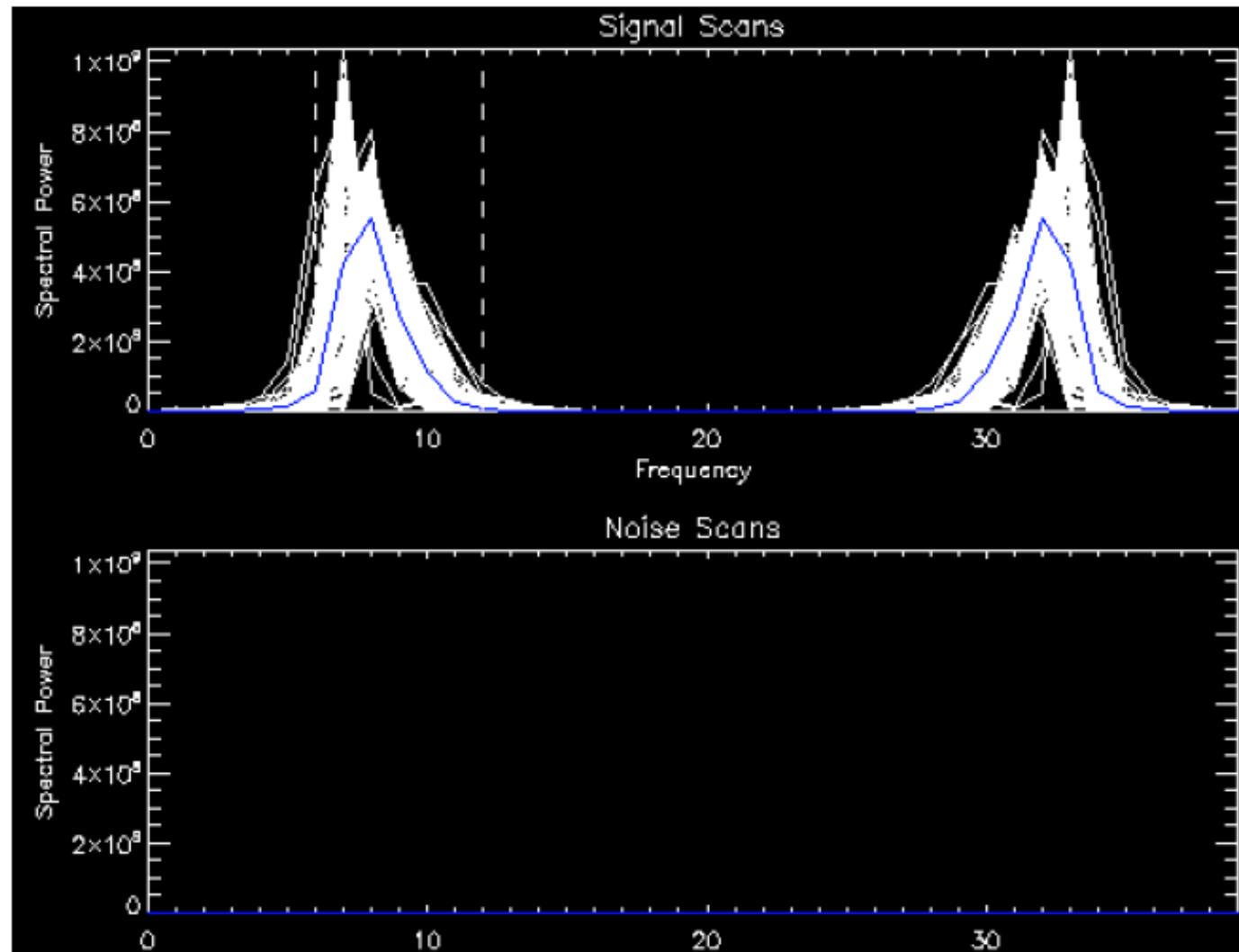
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## Incoherent HIGH-SENS analysis



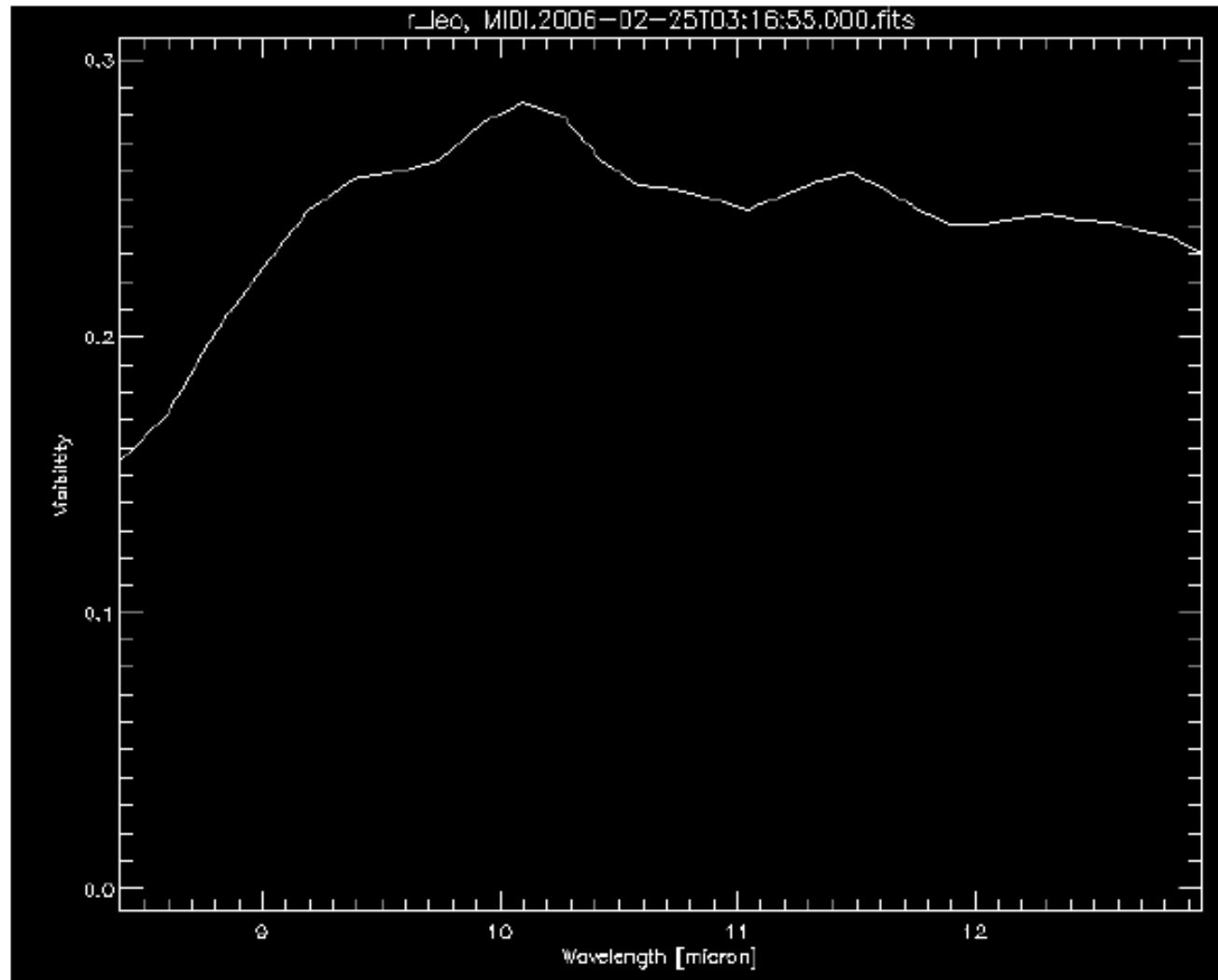
# Reducing and calibrating MIDI observations

## Incoherent HIGH-SENS analysis



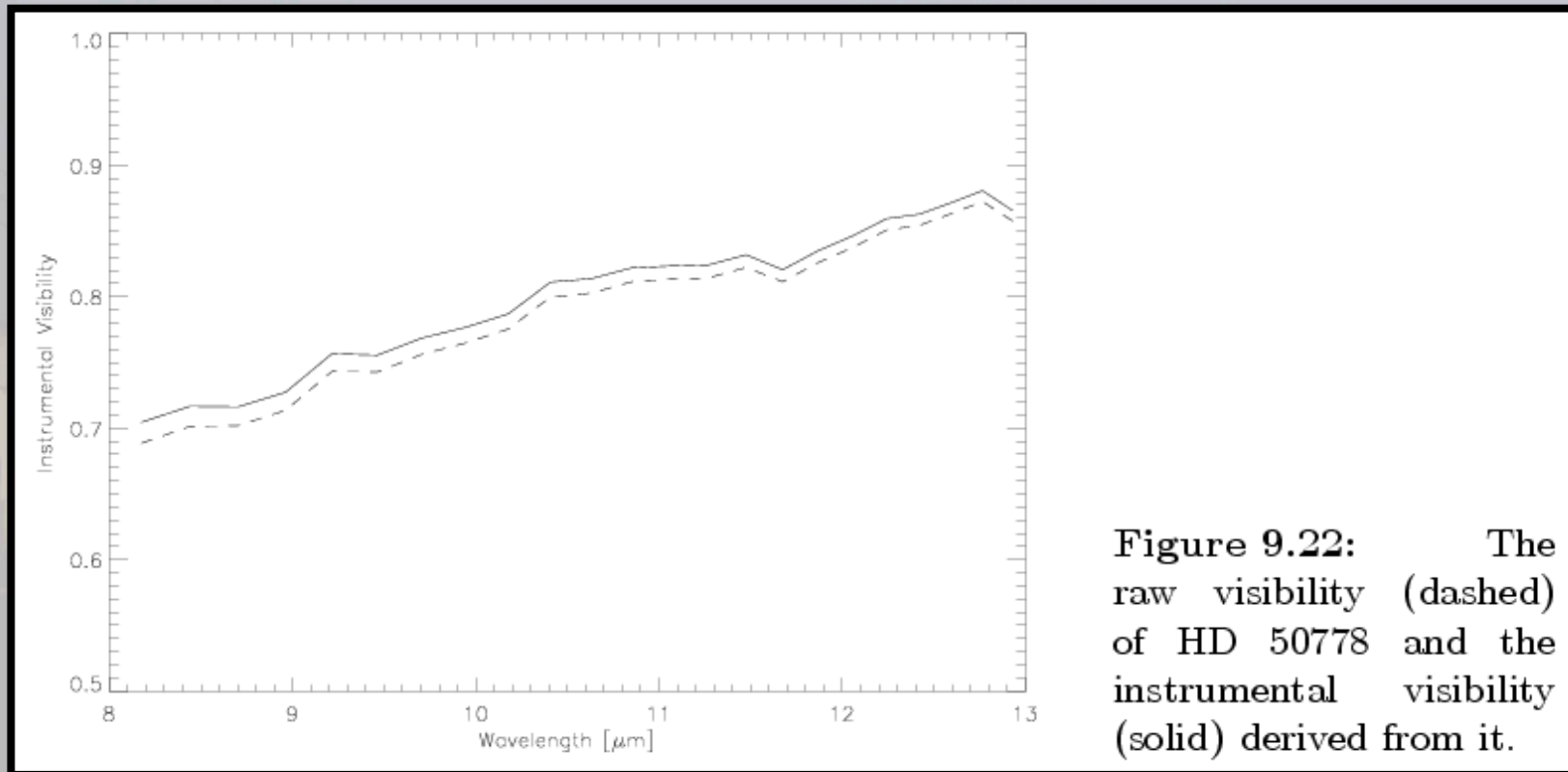
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## Incoherent HIGH-SENS analysis



# Reducing and calibrating MIDI observations

## Calibrating

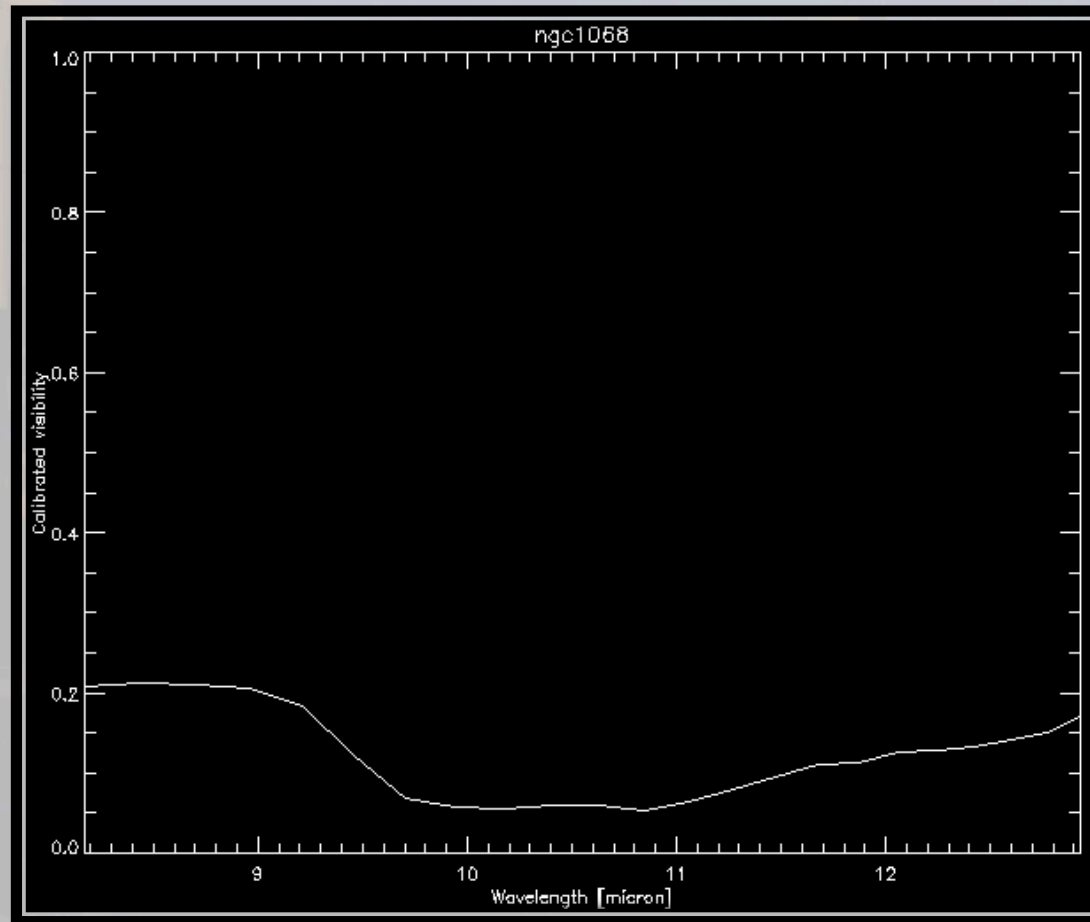


**Figure 9.22:** The raw visibility (dashed) of HD 50778 and the instrumental visibility (solid) derived from it.

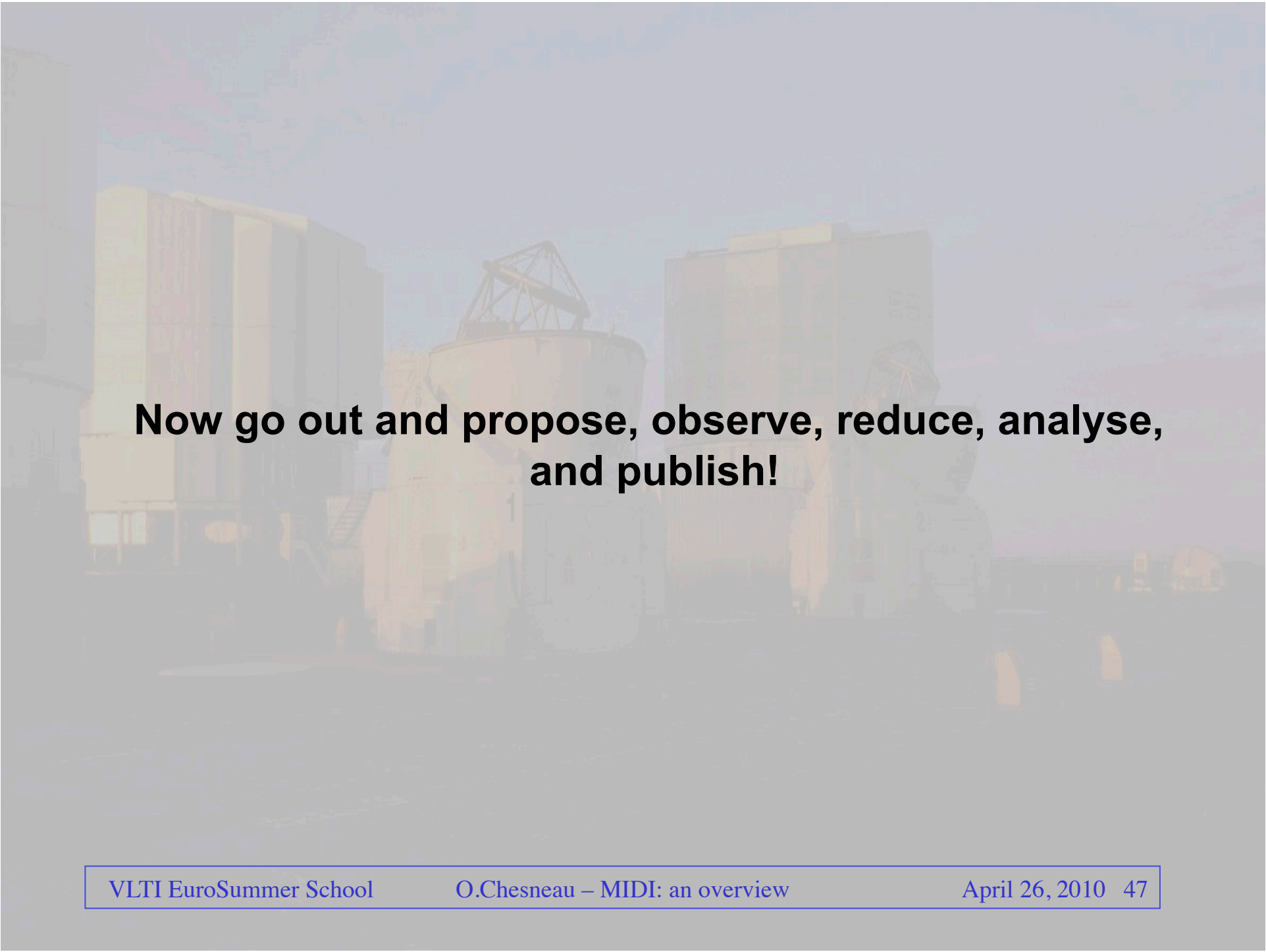
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## Calibrating

*Mia:> calvis = sci->calibratedvisi(cal,/VISPLOT)*







**Now go out and propose, observe, reduce, analyse,  
and publish!**