MIDI: the mid-infrared instrument on the VLTI
Some experiences during the project

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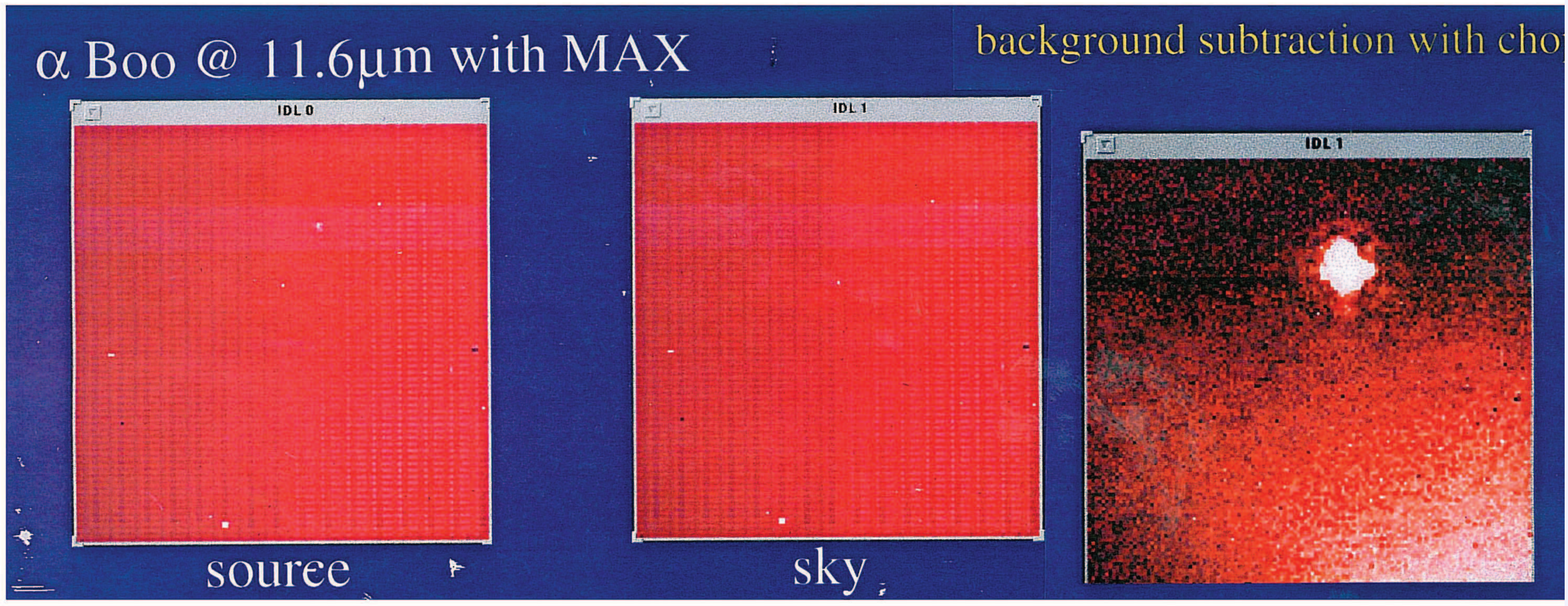
example for a 10 μm measurement (on UKIRT, 3.8m)

8-13 μm background: 1.3x10^{11} photons/Airy disk = 4x10^{8} e^{-} in 20 ms

star: 815 Jy, N = -3.3 mag, hard to see on the left exposure



- extra needs for this MIDI instrument difficult to argue
  (more UT GTO time asked for, larger than 10 cm siderostats needed) **(-)**

COMMISSIONING: new instruments also commission the system

(one MIDI example: active optics motions lead to fringe loss)

- cooperation ESO-instrument team, solution oriented, is essential
  (as opposed to formalism-oriented)

  went quite well along the project, beyond PAC up to now ++

- participation of ESO colleague in instrument team for setup and testing

  transparent for both sides +++

MIDI CONCEPT: simple and safe

cold optics in dewar, warm optics in front of dewar

simple $\Rightarrow$ sensitive: **+**

– no 5 μm channel
– only two-telescope combination
– no AT/UT combination
– simultaneous photometry by pure choice
– 20 μm later ($\rightarrow$ never)

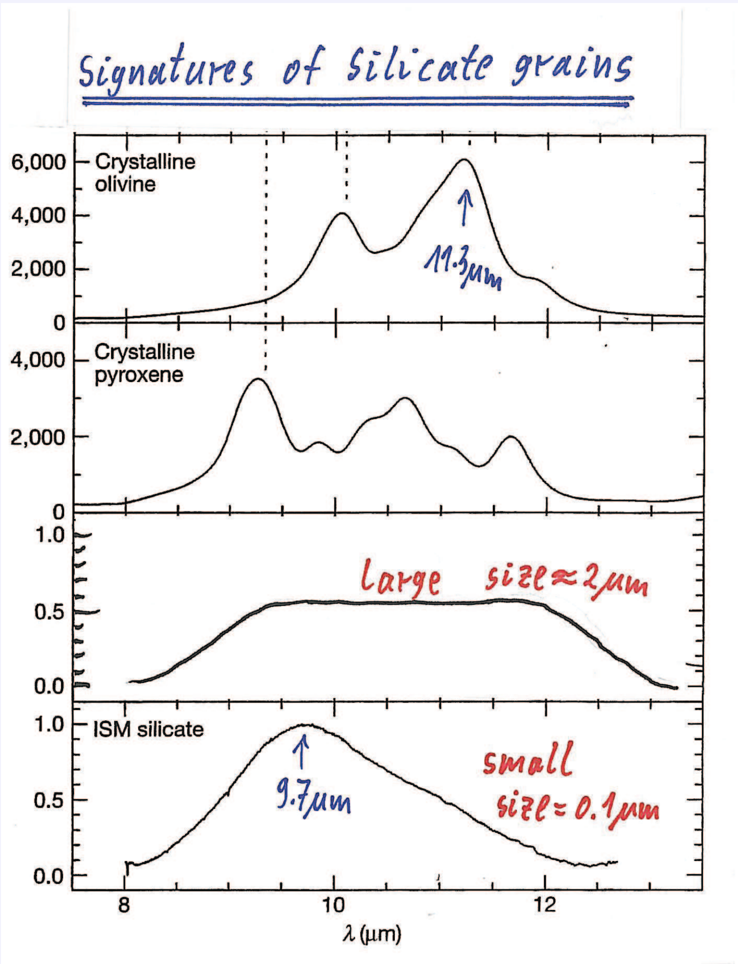
safe (redundant) **+ +**

– fringe following to $\pm$ a couple of λ as fallback solution in case no fringe tracking available
– extra optical path for fiber optics

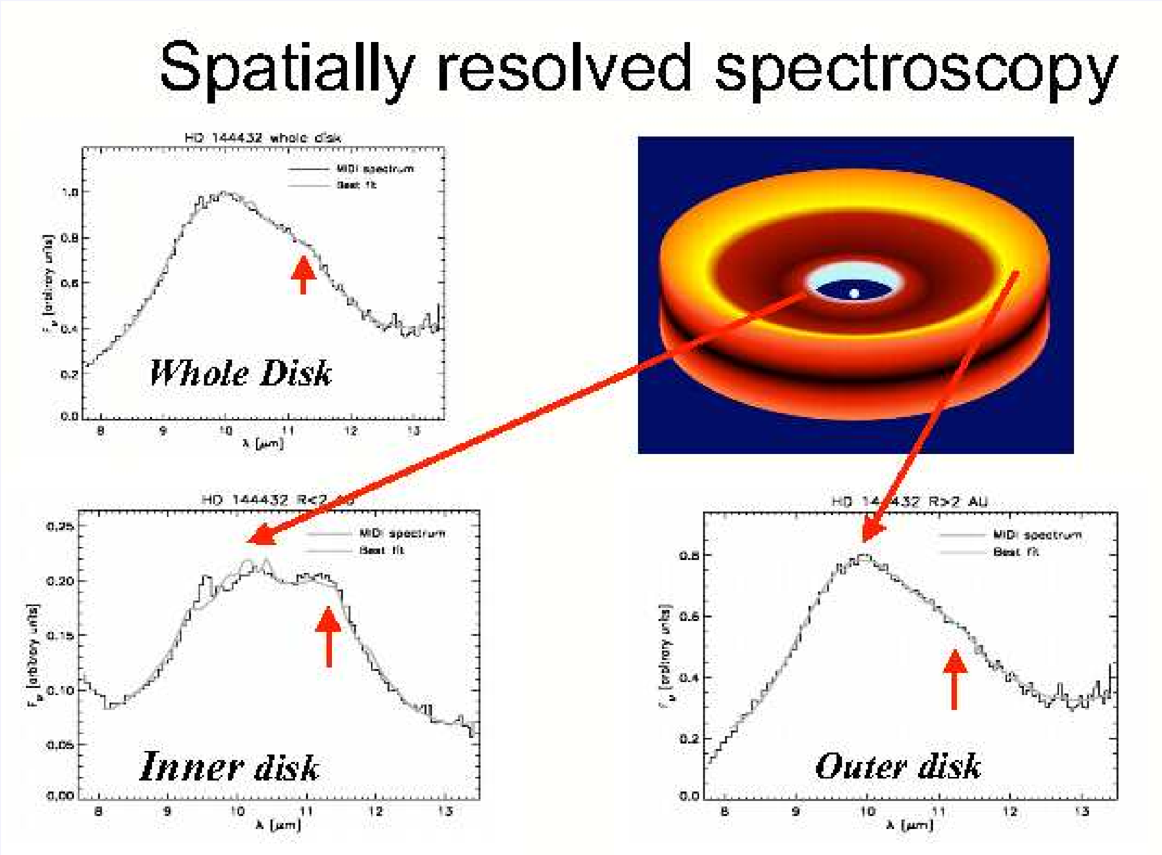
Selected observations

Dust evolution in (the young) Herbig Ae stars

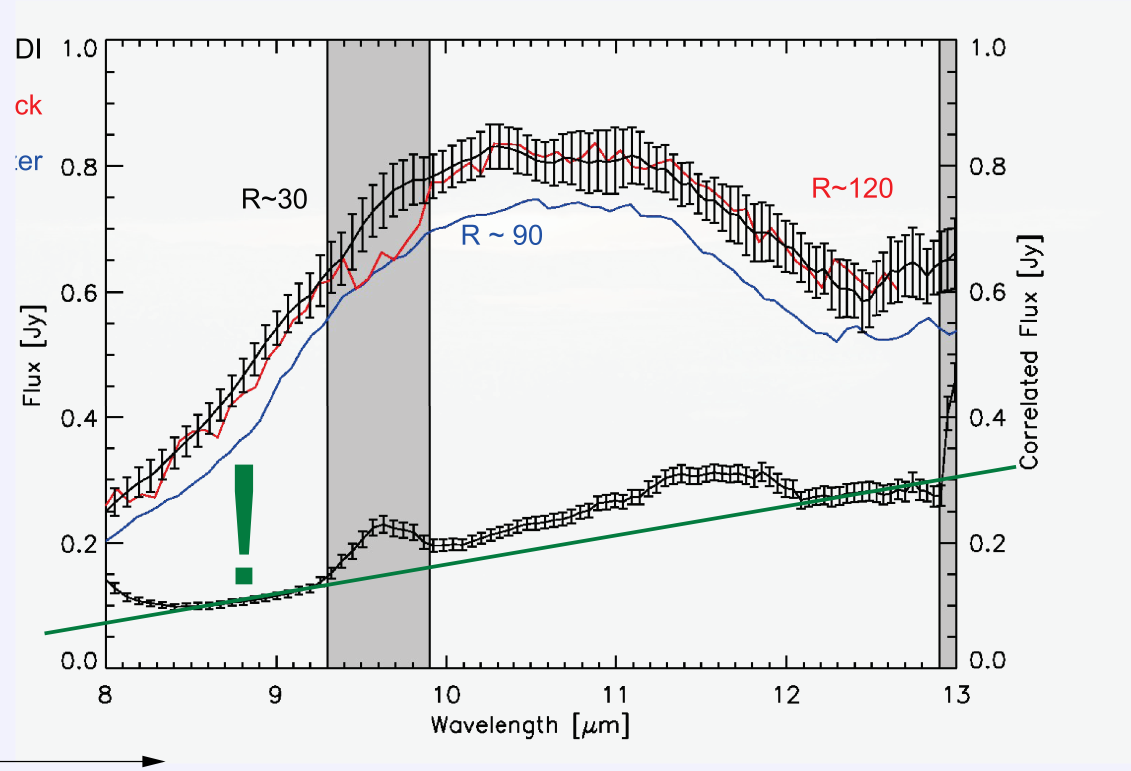
(Grain properties vary with R)

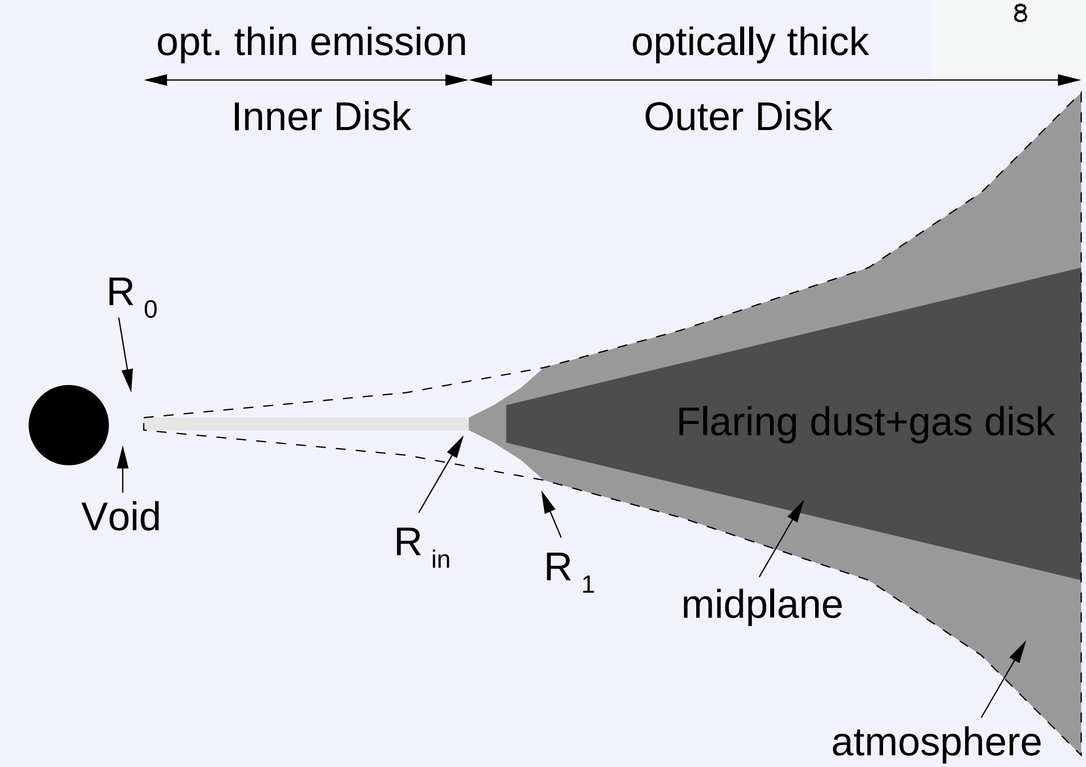


HD 144432



TW Hya – size
of inner hole





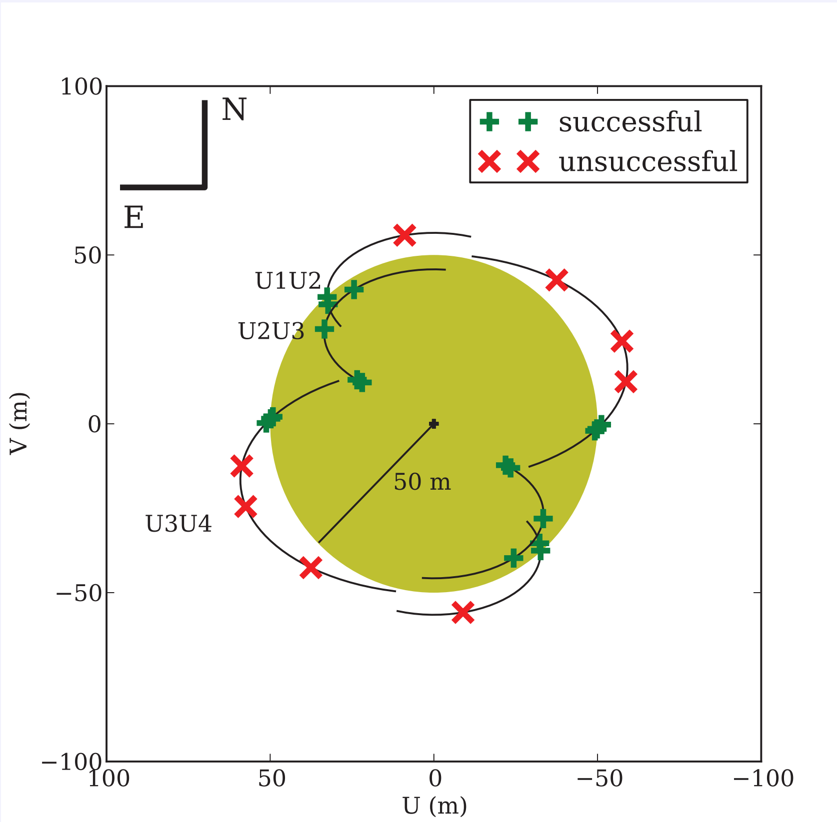
in 2002: R_{in} = 3 AU
(mm image, Calvet et al.)

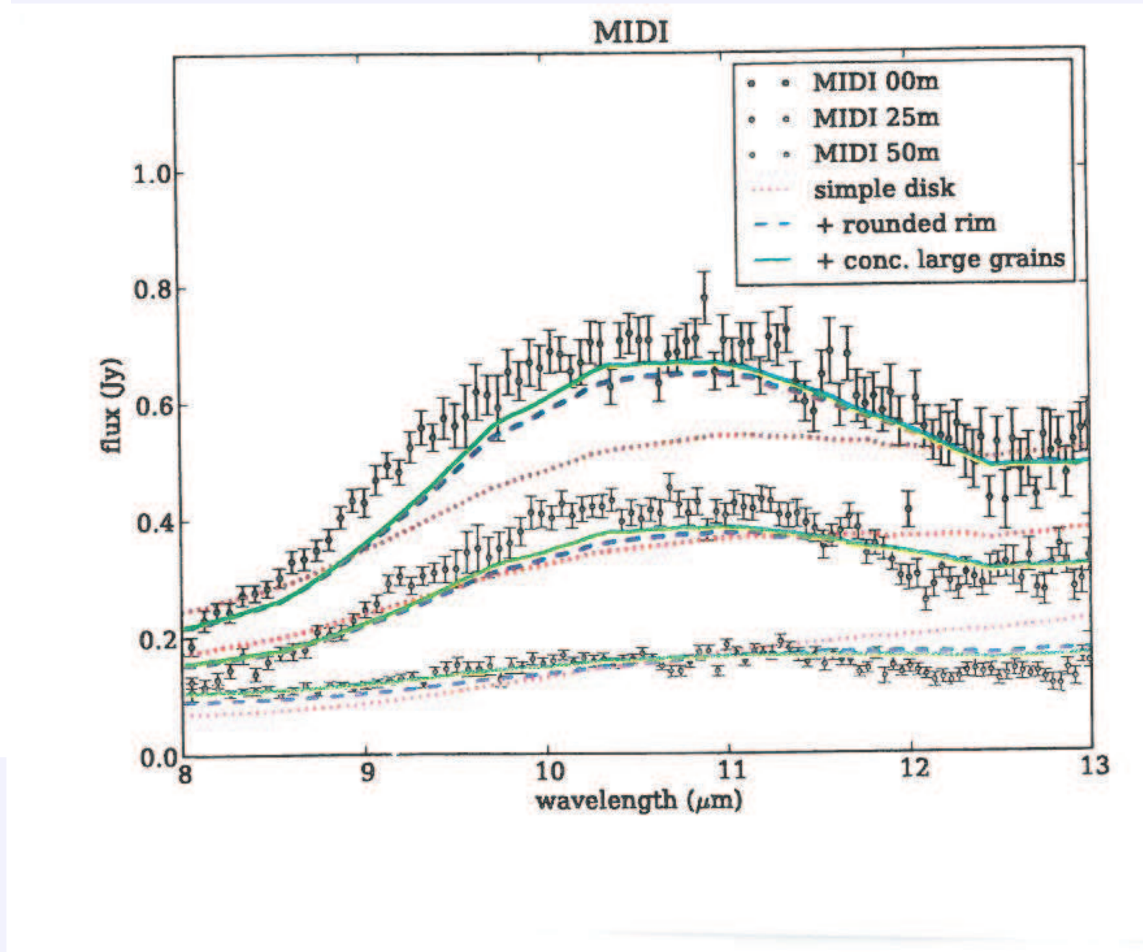
$\Rightarrow$ R_{in} (2007) = 0.5 AU
(MIDI, 10μm, Ratzka et al.)

new, combined modeling
(Menu et al. A&A 2014)

TW Hya revisited – measurements

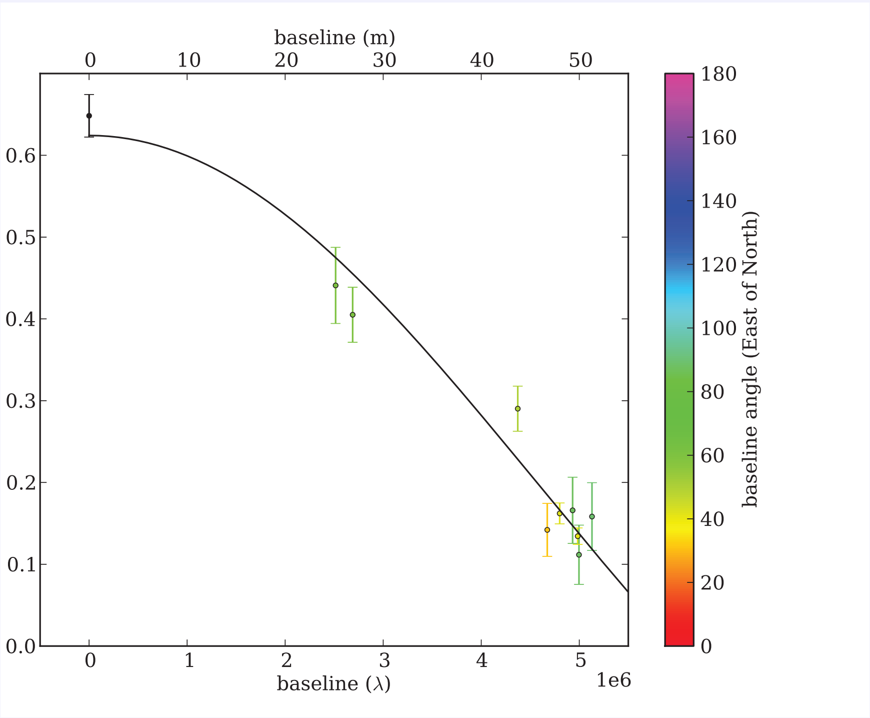
(Menu et al. 2014)

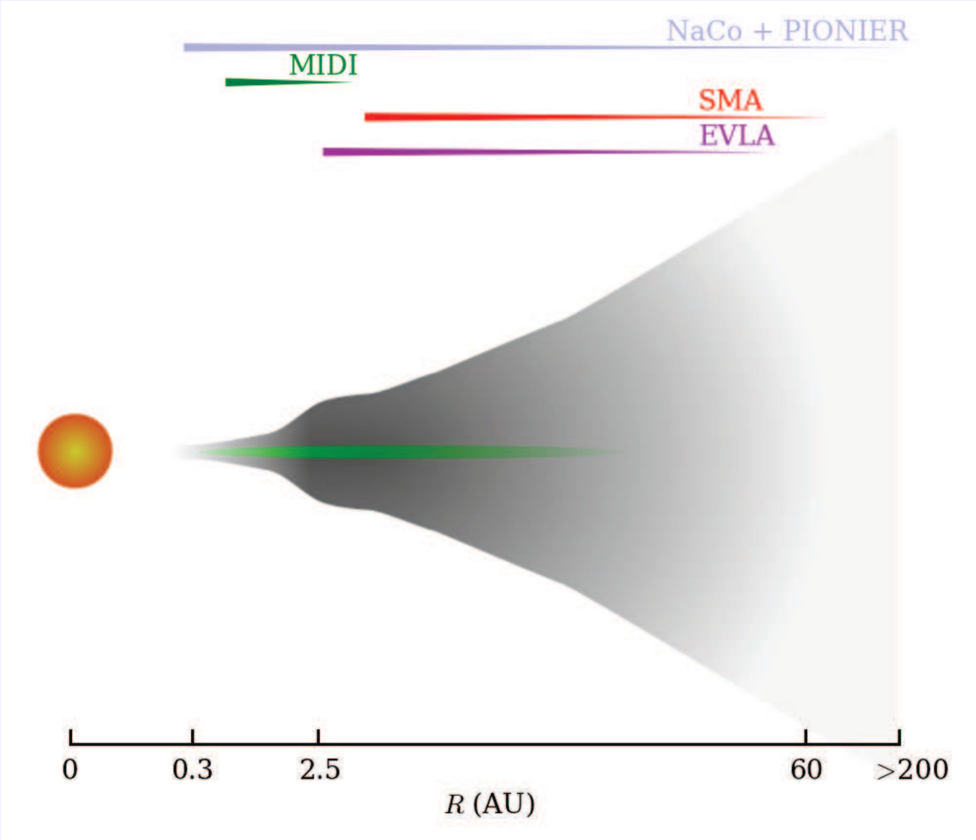




TW Hya revisited – results

(Menu et al. 2014)



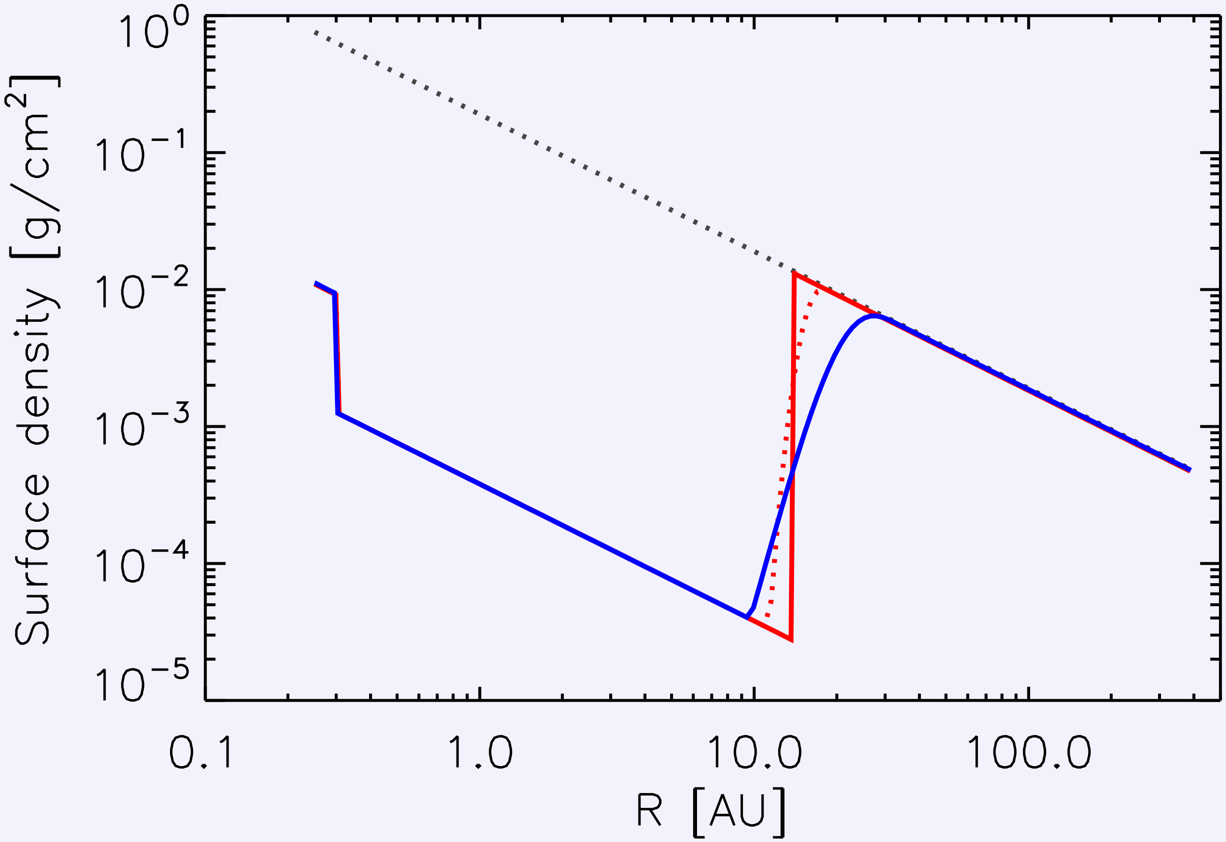


HD 100546 – inferring a companion mass

from details of spatial distribution

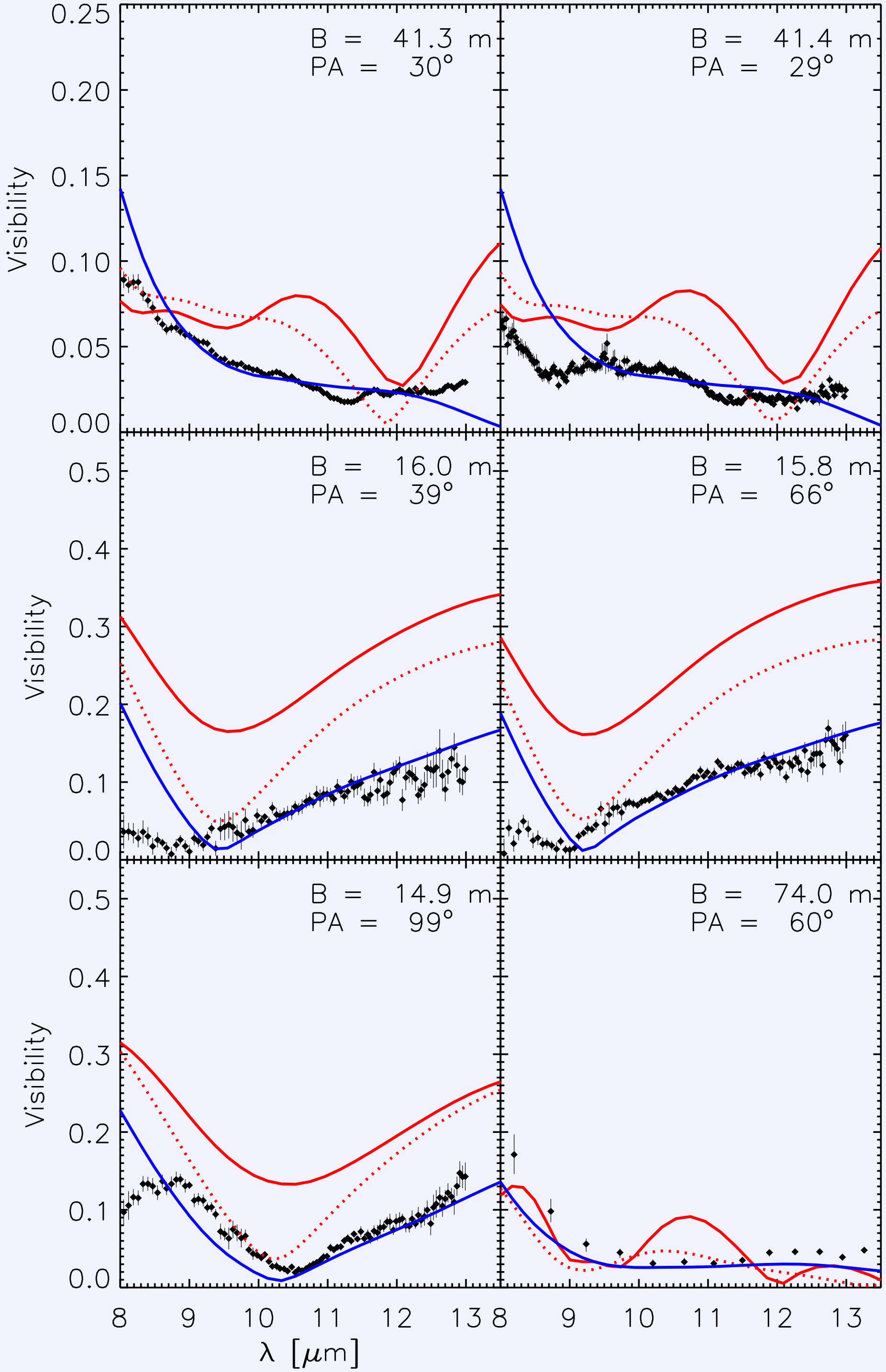
(Mulders et al. A&A 2013, Panic et al. A&A 2012)

gap in transitional disk $\rightarrow$ probably “planet” > 1 M$_J$



– surface density profile for outer disk edge depends on “planet” mass

– rounder walls for higher “planet” mass (Fargo code)



HD 100546 – result

UT baselines 40m, 70m
AT baselines 15m

– visibilities request
round edge (blue)

– best fit mass: 60 M_J
($\Rightarrow$ a brown dwarf)

– located at: 8-10 AU

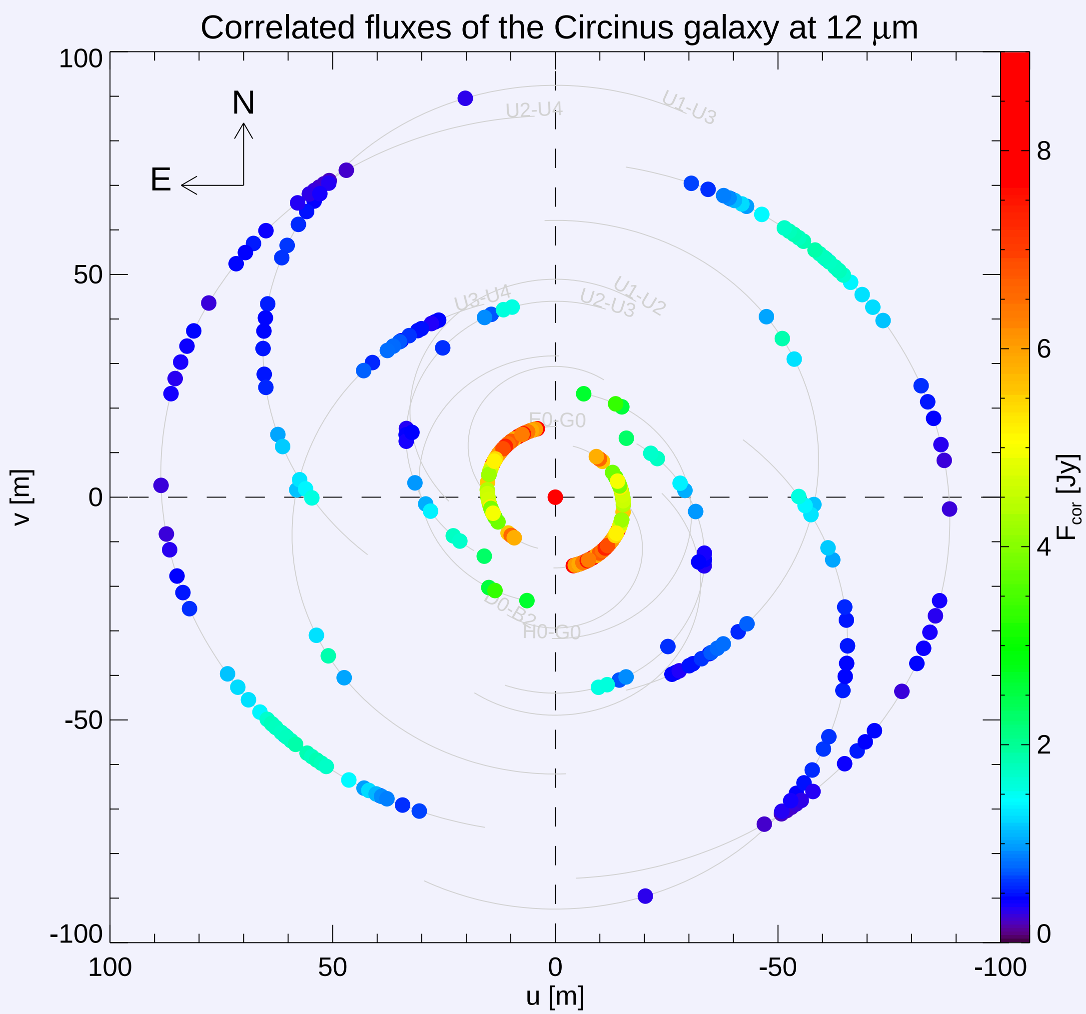
– viscosity α = 0.02
(high)

AGN – parametrized “images”

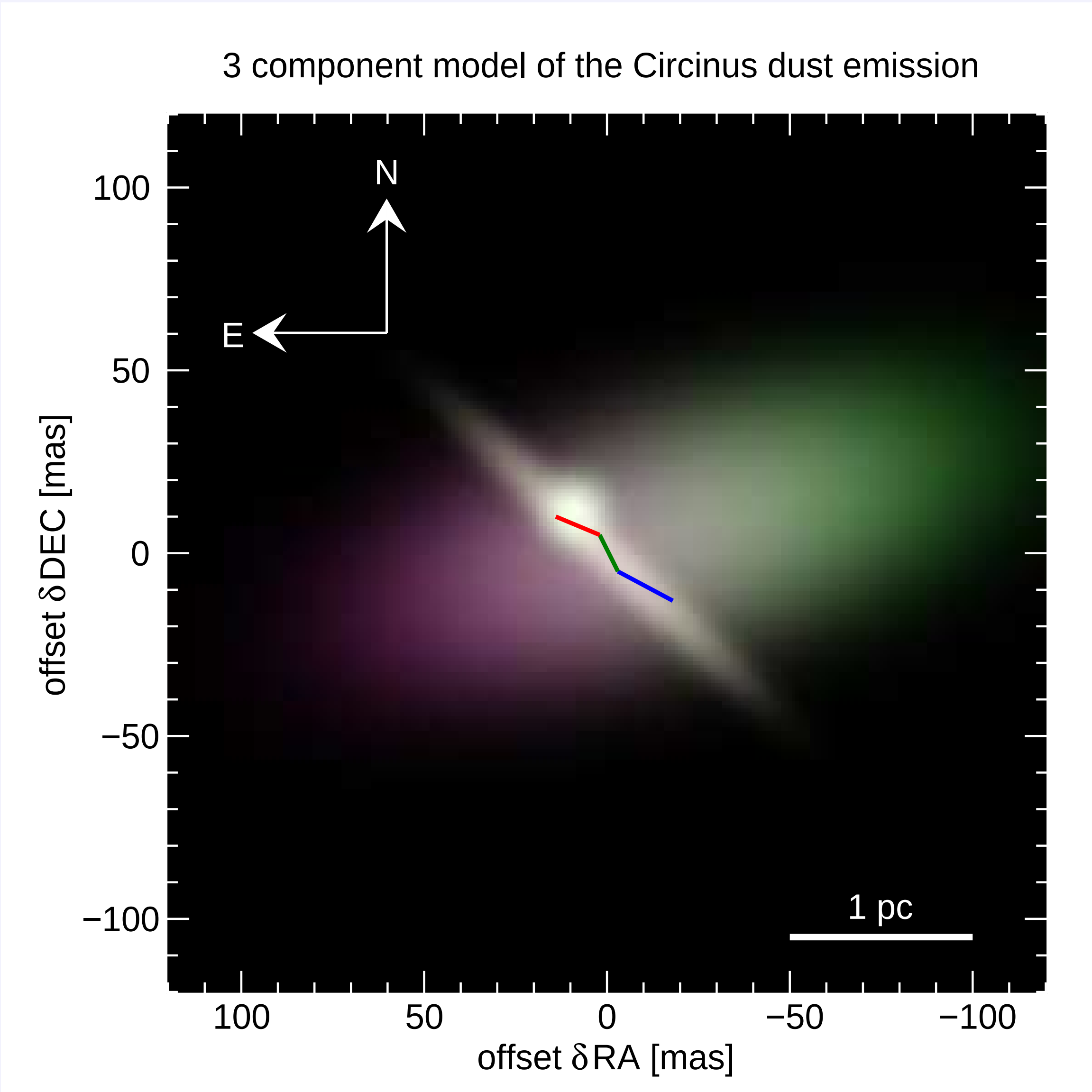
Circinus

UV coverage (UTs)

(Tristram et al. A&A 2014)



Circinus – 3-component “image”



– point source
– disk source
(⊥ ionization cone)
– extended emission
offset NE (phases ≠ 0)

Maser observations assumed to be centered on disk component

Phases in MIDI – available

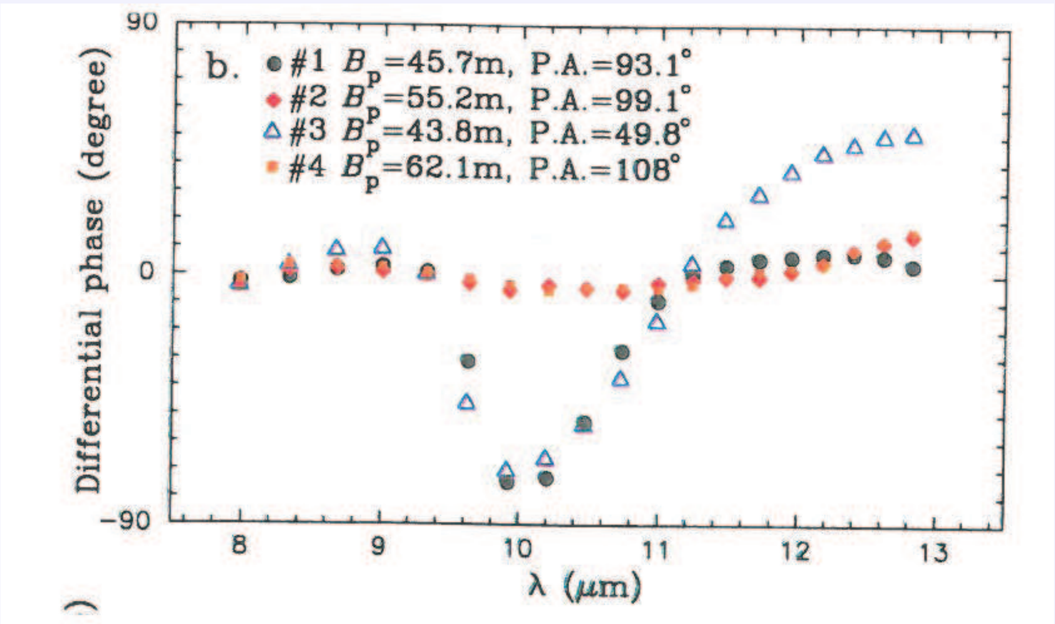
Fourier transform on object:

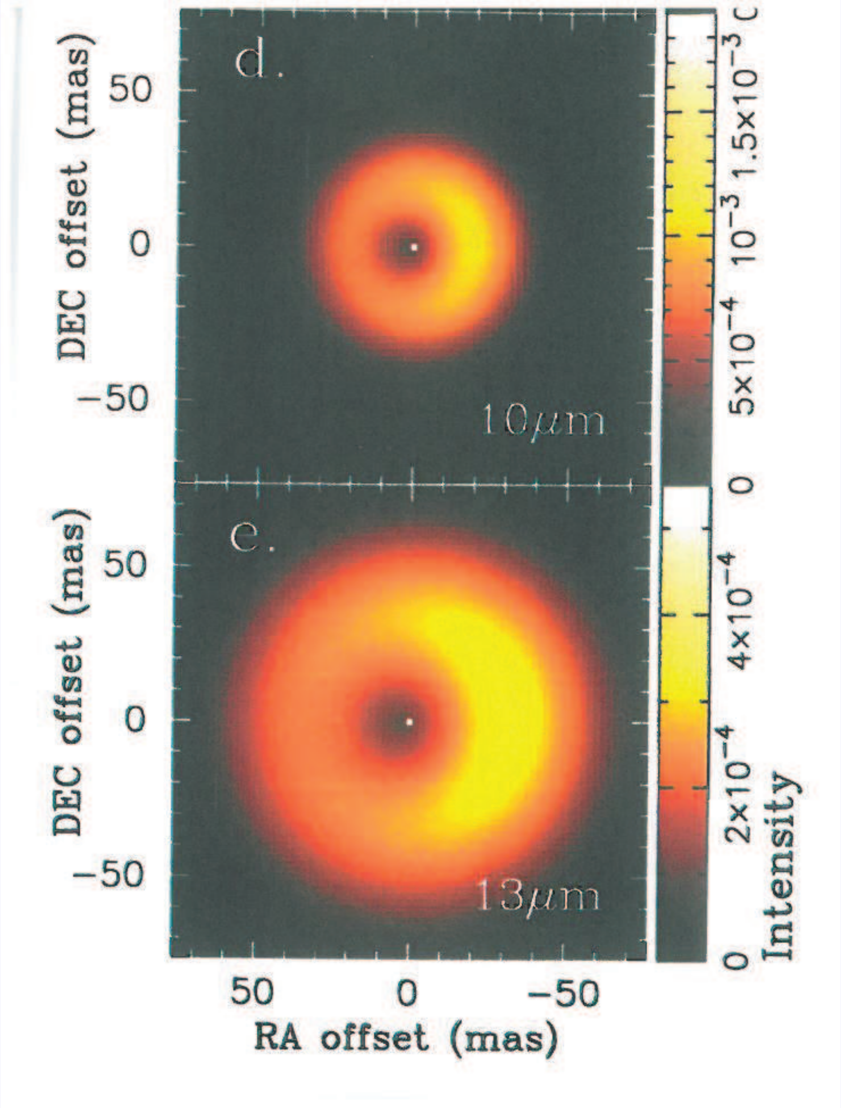
$F_\lambda(u) = A_\lambda(u) \cdot \exp(i\phi_\lambda(u))$, $u = B_{proj}/\lambda$

constant and linear terms removed

– longitudinal dispersion and position –

- (Ratzka et al. 2009 on T Tau, Appendix)





silicate carbon star BM Gem
→ circumcompanion disk
(Ohnaka et al. 2008)

After main observing period

Fringe tracking ⇒ improved sensitivity

- planned to arrive before instrument

  but FINITO late, not sufficiently sensitive (H band) **- -**

- last couple of years: FSU-A + MIDI on-axis

  successful cooperation: **(+) +**

  GTO + commissioning / left over technical time + software support

  ATs: substantial gain (x5)

  UTs: 50 mJy
  (1998 estimate was 400 mJy, N = 5 mag)

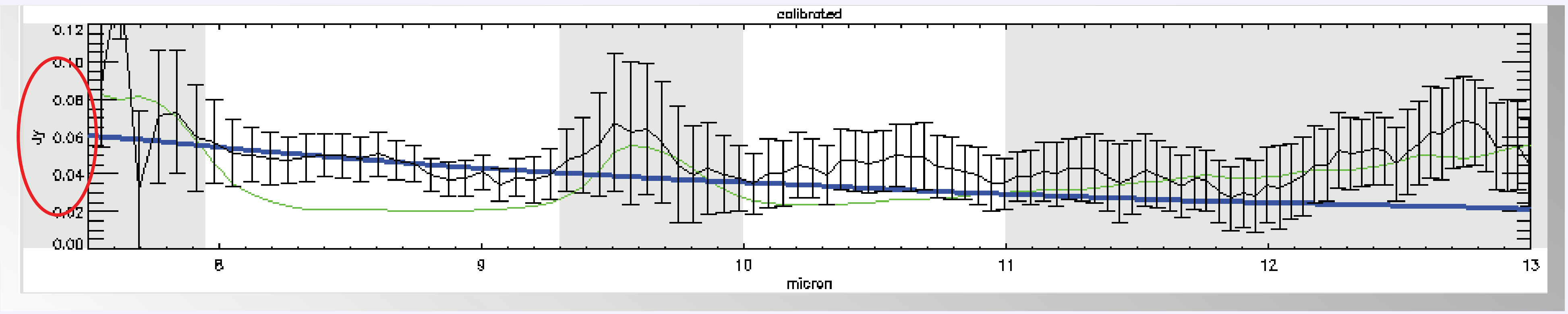
example: correlated flux measurement of 50 mJy source

– phase referencing by PRIMA FSU-A

– 3min exposure

– flux calibration in line with Wise satellite

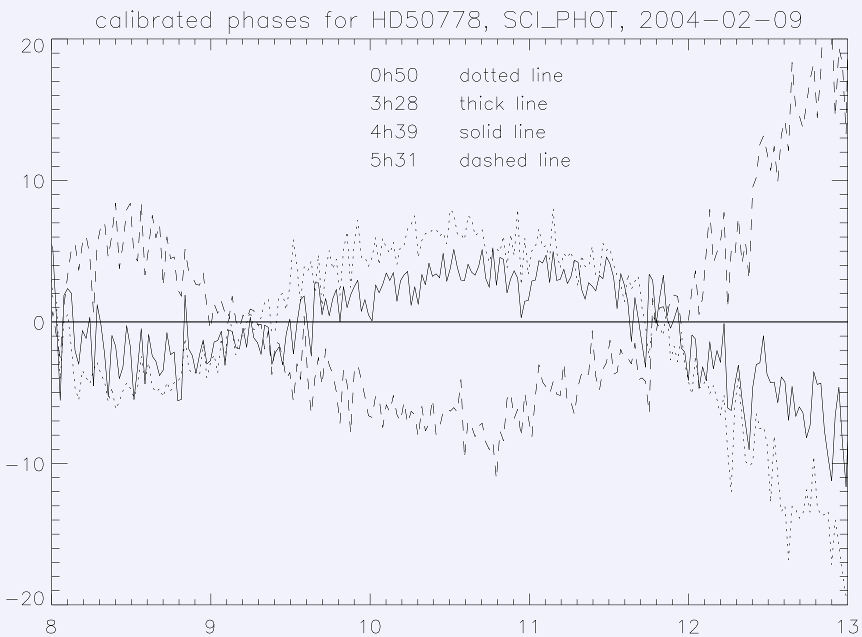
TYC 52582-2210-1



example: gain in accuracy of chromatic phase

no phase tracking

Δ_phase $\leq 5^\circ$



chromatic phases, 5h, bad conditions

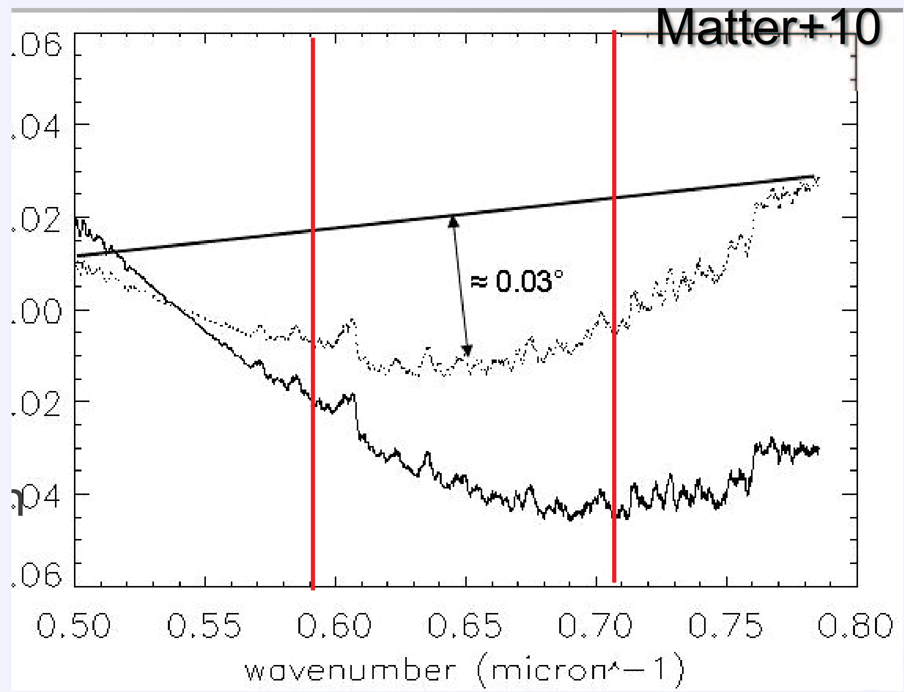
with phase tracking

Δ_phase $\leq 0.3^\circ$, 2 min on 10 Jy source

$\leq 1.5^\circ$, 1 Jy source

$\leq 0.050^\circ$, 10 Jy, binning 30 pixels

reaching substellar regime in 1 hour



Model prediction for Gliese 86

Pipeline, user support MIDI

- data reduction: MIA + EWS
  (V^2) + (V + chromatic phase)

– two independent approaches **+**

– steady improvement **(-) +**

–neither MIDAS-type documentation
nor HST-type support team **-**

future support:
– VLTI schools ?
– documentation ? **?**
– support center ?

MIDI science group

- organized by scientific projects +

  (as opposed to institute data rights)

- continuing over full GTO time (= lifetime of instrument) +
  - learning by exchange, planning improvements
  - contact address for ESO

- also ESO colleagues invited and participating +

Status of performance versus expectation – best so far

	promised 1998	April 2010	call for proposal	now
sensitivity PRISM				
–UTs	N=5mag, 0.4Jy	$\approx$ 0.2 Jy	0.5 Jy/1 Jy	50 mJy
–ATs	N=1.8mag, 8Jy	$\approx$ 6 Jy	10 Jy/20 Jy	500 mJy
accuracy PRISM	5%	5%-15%	better than 20%	
– photometric channels	2%	2%-4%	not mentioned	
– with spatial filter	1%	– N/A: no 10μm fibers available in time –		
phases	only with external referencing	higher order terms in EWS data reduction $<5^\circ$, $\pm1^\circ$ doable	not mentioned	$\leq 0.3^\circ \rightarrow \leq 0.05^\circ$

Summary of commented experiences

special 10 μm requests	(-)
commissioning cooperation continued beyond PAC	+
ESO colleague in instrument team	+
design for simplicity and independence	+
fringe tracking	- +
pipeline	?
science group	+