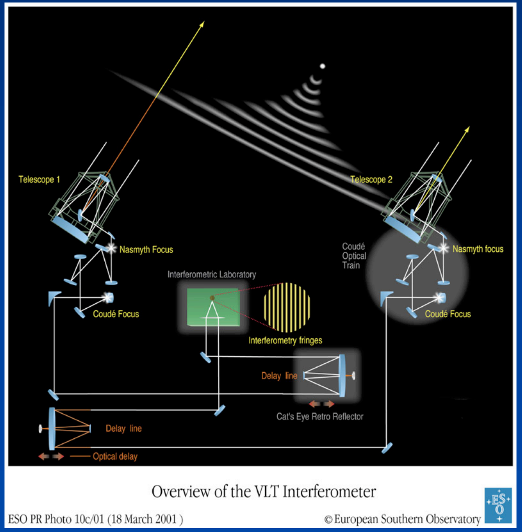
Dissecting MYSOs with MIR Interferometry



Overview of the VLT Interferometer

ESO PR Photo 10c/01 (18 March 2001)

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Motivation

- Knowledge about inner structure (<100 AU) of massive YSOs still limited
- Large distances to high-mass SFRs (on average) → high spatial resolution as prerequisite
- Often strongly embedded → go to longer λ, but conventional MIR imaging with restrictions
- ↳Overcome resolution limits of single-telescope imaging with MIR interferometry!

The input sample

- MIR-bright massive YSOs: unresolved by previous imaging with 4-m class telescopes
- In particular: BN-type objects (e.g., Henning et al. 1990)
  unusually bright already in K-band, but not (yet) associated with pronounced UCHII region
- Among them: disk candidates,
  in general: strong Silicate absorption near 10 µm

Programme details I

Our tool: MIDI @ VLTI

Aerial View of Paranal Observing Platform with VLTI Light Paths

ESO PR Photo 10f/01 (18 March 2001)

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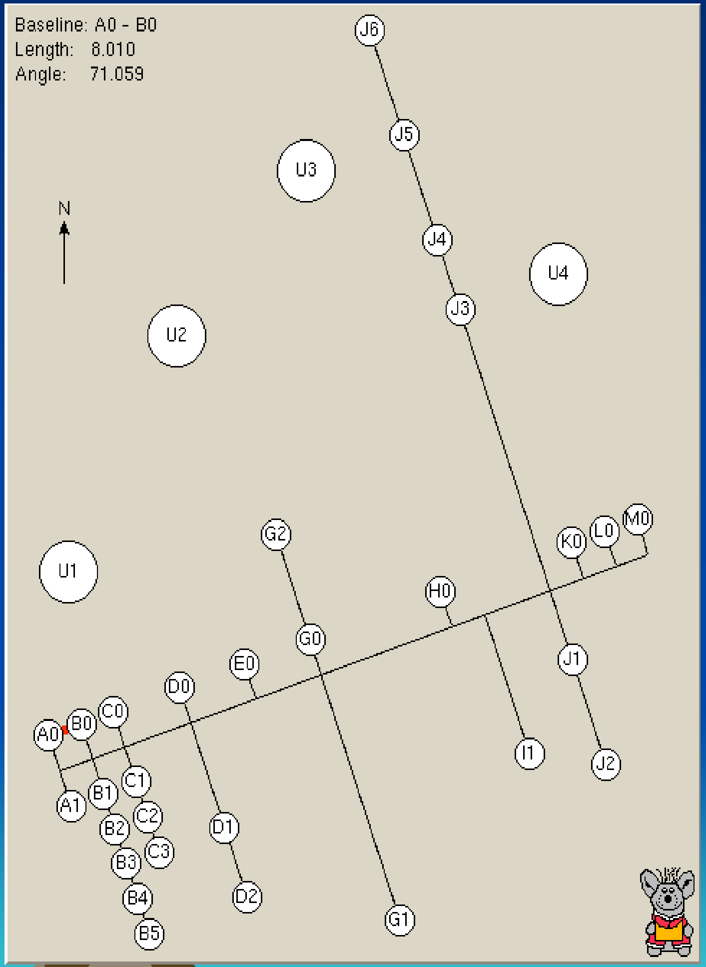


Baseline: A0 - B0
Length: 8.010
Angle: 71.059

Programme details II

- MIDI UT observations in every ESO semester from 2004 to 2006 (Guaranteed Time Programme)
- After an ambitious start: keep it simple!
  --> Prism as disperser (R = 30)
  --> „High-Sens“ mode
  (all light for the interferometric beams, photometry subsequently)
- Our main data reduction packages: EWS (Leiden) and MIA (MPIA/Leiden)

Programme details III

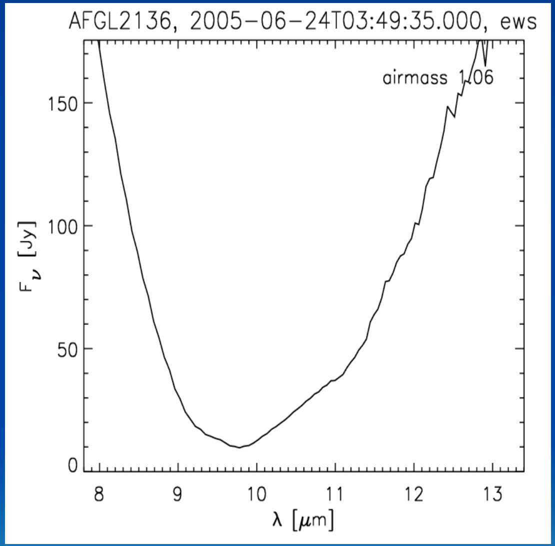
- Attempts to observe ***13 sources***
- Fringes found for ***9 sources***

- **No fringes** for:
  GGD27-ILL (faintness/technical?),
  Orion SC3 (partly resolved/faint),
  Herschel 36 SE (partly resolved/faint) --> but acquisition images included in Goto et al. (2006)
  GM24 IRS3 (strong but complex/extended):
  see poster by Mauricio Tapia

Observational Intricacies

- General trend: low visibilities (1 – 20 %), effect increased due to silicate absorption

(see spectrum of AFGL2136) __



- Massive star-forming regions
  --> high optical extinction
  --> optical stars faint and far
  away from target
  Major problem for MIDI AT observations!

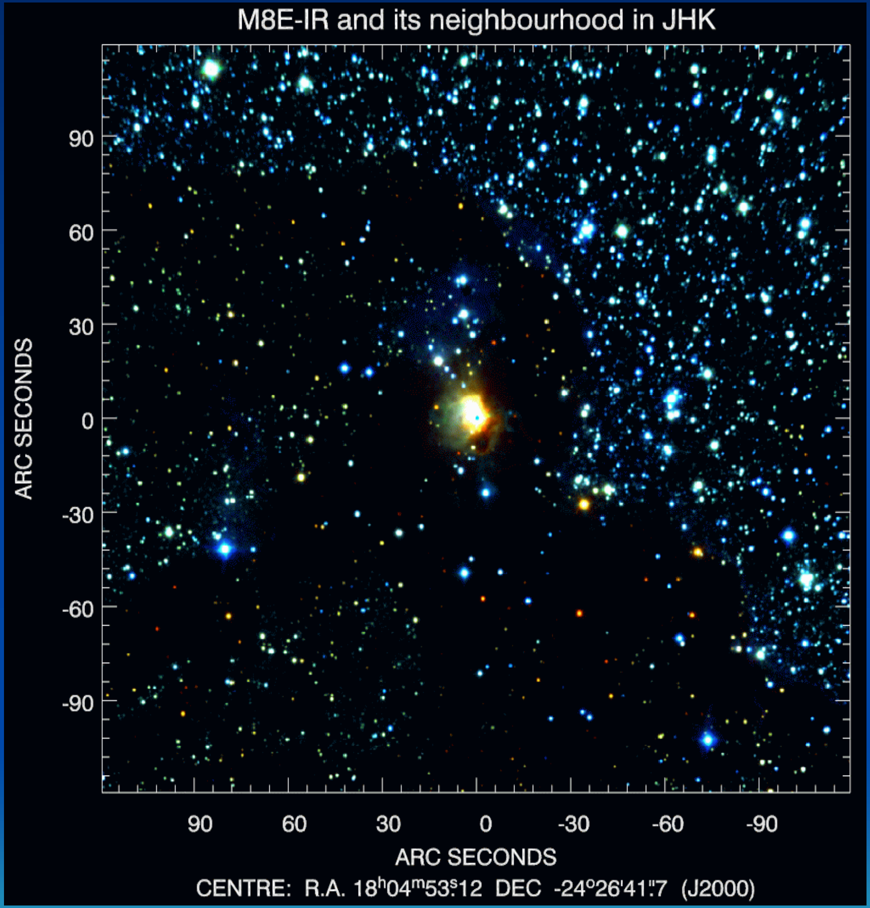
Programme details IV

Two examples, where progress could be reached:

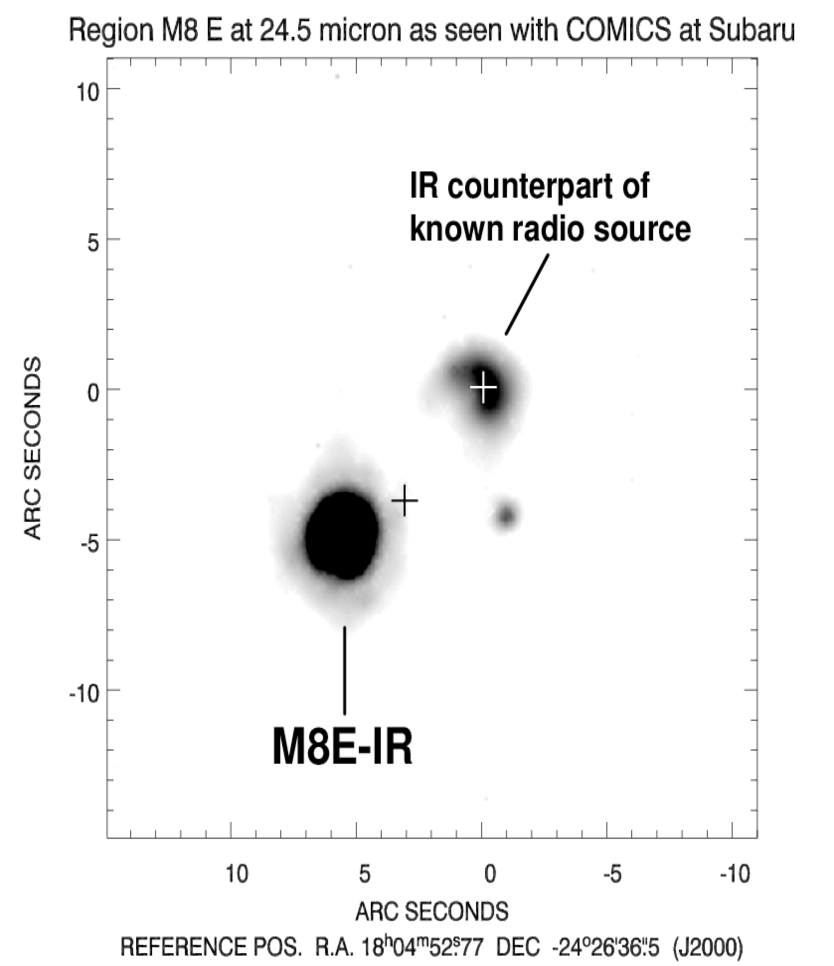
- **M8E-IR** : 7 visibilities with U2-U3, U3-U4,
  U1-U2, U1-U3

- **M17 SW IRS1** : 3 visibilities with U2-U3, U3-U4,
  U1-U2

One prime target: M8E-IR

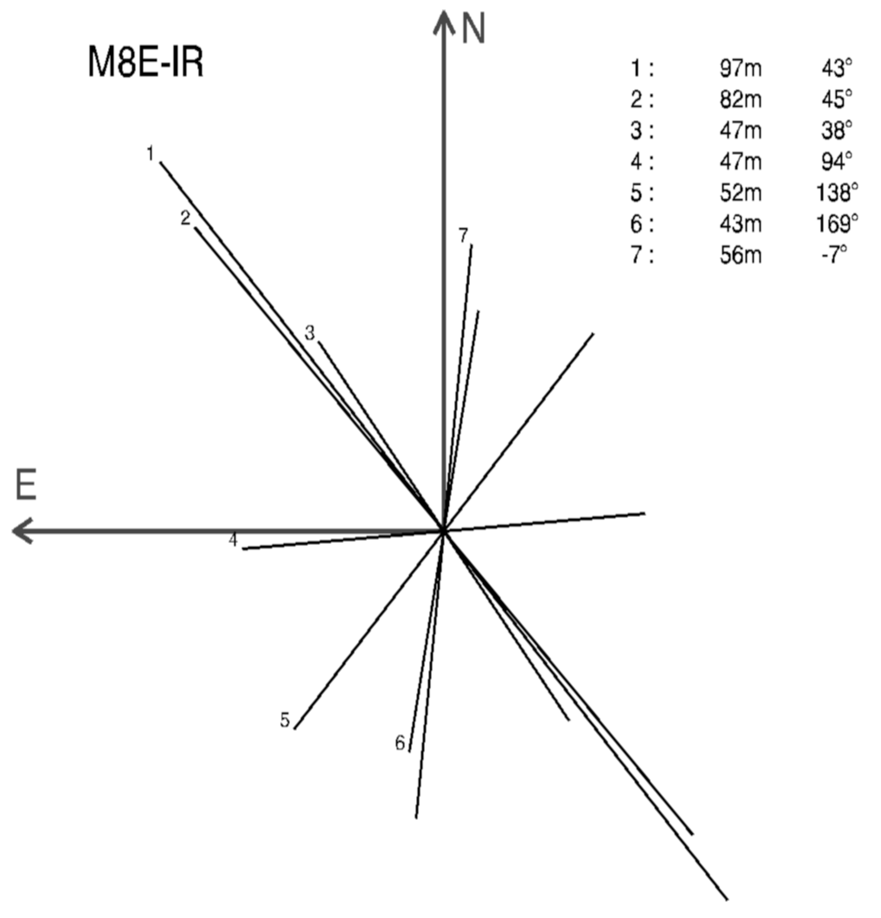


M8E-IR and surroundings with NTT/SofI



Subaru/COMICS: M8E-IR at 24.5 µm

A massive disk candidate: M8E-IR



1 :	97m	43°
2 :	82m	45°
3 :	47m	38°
4 :	47m	94°
5 :	52m	138°
6 :	43m	169°
7 :	56m	-7°

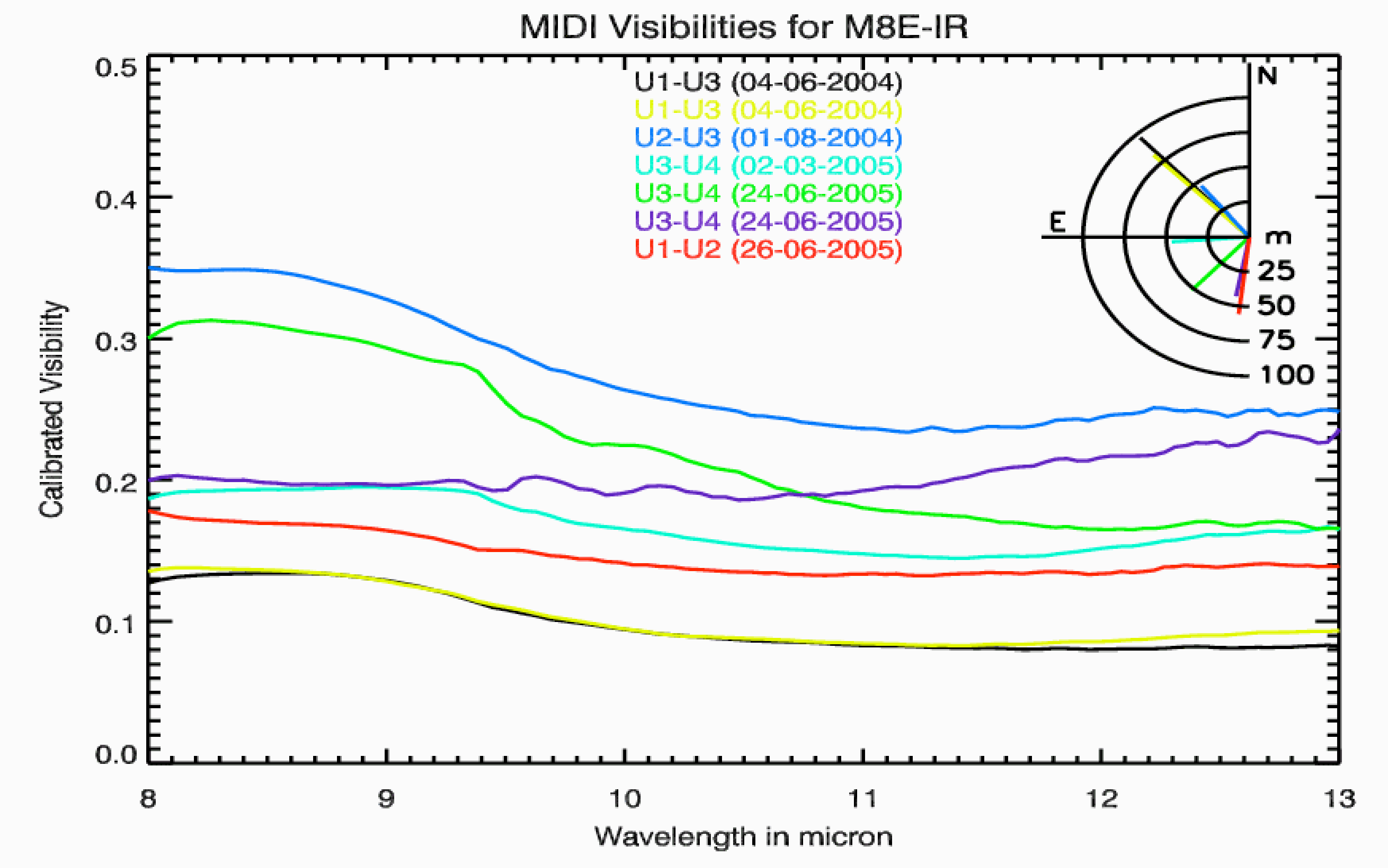
Distribution of projected baselines for the UT observations of M8E-IR

Early disk claim by Simon et al. (1985) on the basis of lunar occultation data,

Prediction of small disk

(6 – 25 milli-arcsec projected size)

A massive disk candidate: M8E-IR



One prime target: M8E-IR

Very first ansatz: assume Gaussian intensity distribution for the source

Then: visibility $V(u) = \exp(-3.56\, u^2\, FWHM^2)$
with $u = B/\_$

Example: V = 0.2 @ _=12 μm for 50 m projected baseline

_ FWHM = 33 mas (≈ 50 AU for d = 1.5 kpc)

We find sizes of 20-25 mas (8.5 μm) and 32-38 mas (12 μm)

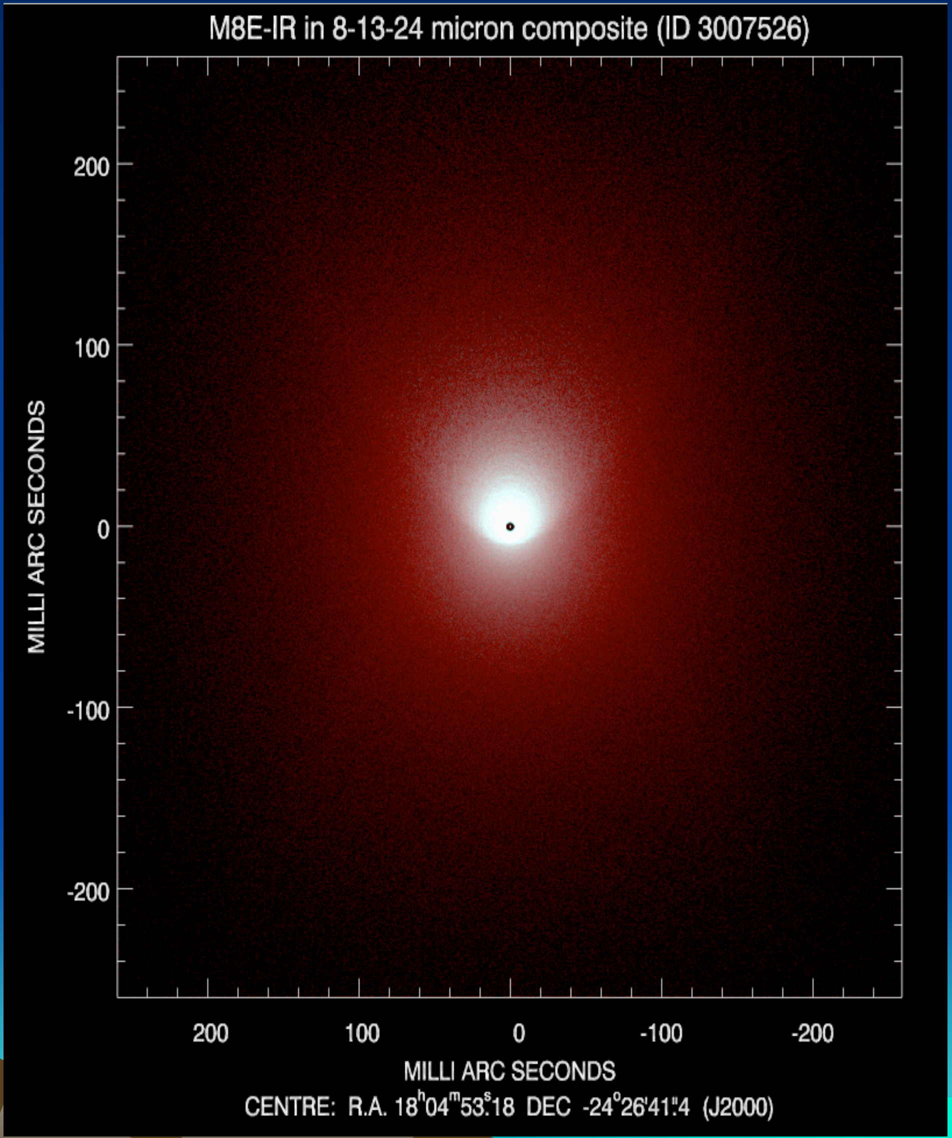
But: simple ansatz not the best match to disk intensity distribution ... radiative transfer modelling

M8E-IR: Radiative transfer modelling II

SED fitting with Robitaille Online Tool: Full 2D models with disk + envelope

Best-fitting models give small disk (< 100 AU radius !) and low inclination (i = 18°) plus larger envelope

Subsequent RT imaging with underlying Whitney code: 3-colour composite from 8, 13, and 24 micron



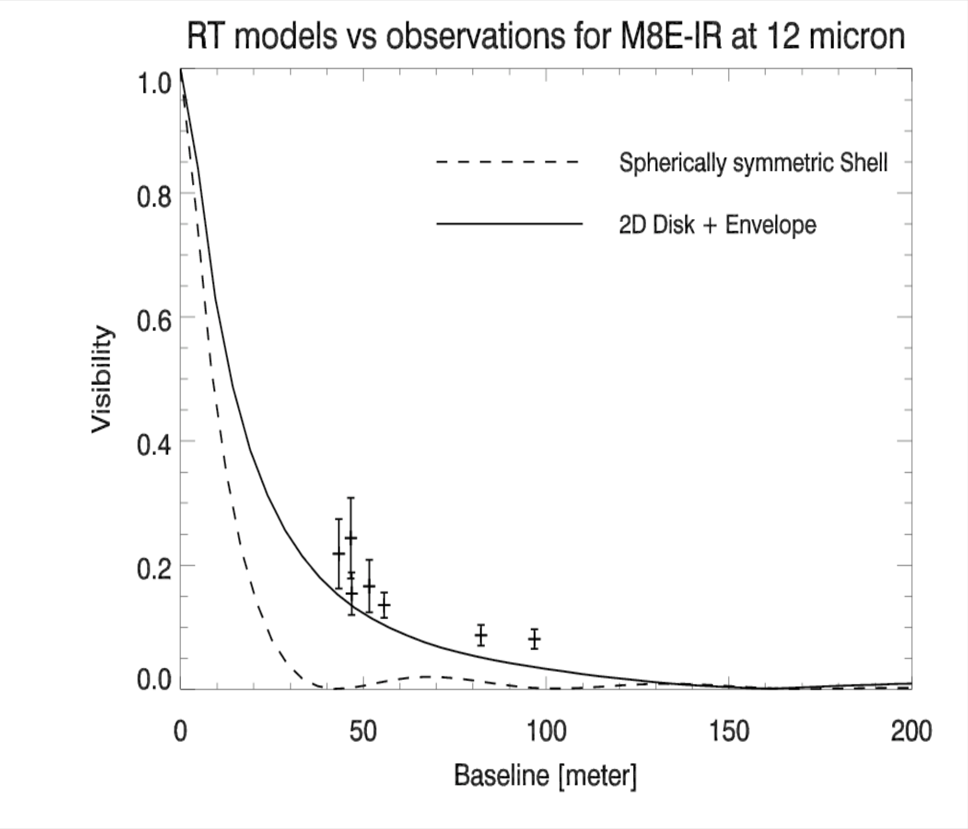
The crucial comparison

Visibilities vs spatial frequencies (in units of the projected baseline length)

Cut through the spatial frequency spectra of the models (curves) and comparison with MIDI measurements (plus signs)

Reasonable agreement of MIDI with general level of 2D model

MIDI data exclude 1D model



The Kleinman-Wright Object in M17 SW

2 R. Chini et al.: The nature of the KW object

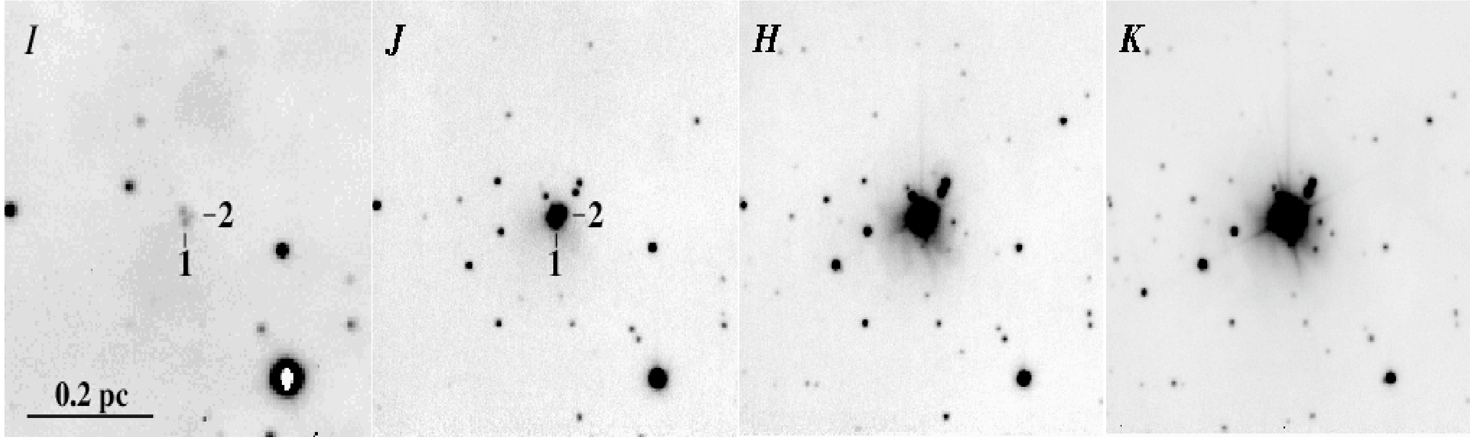
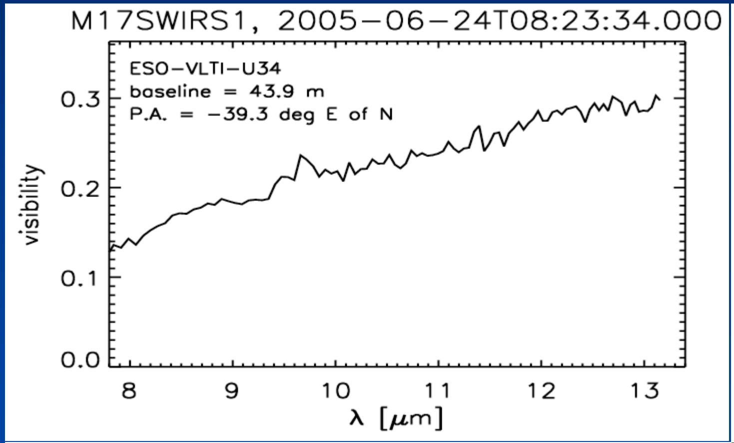
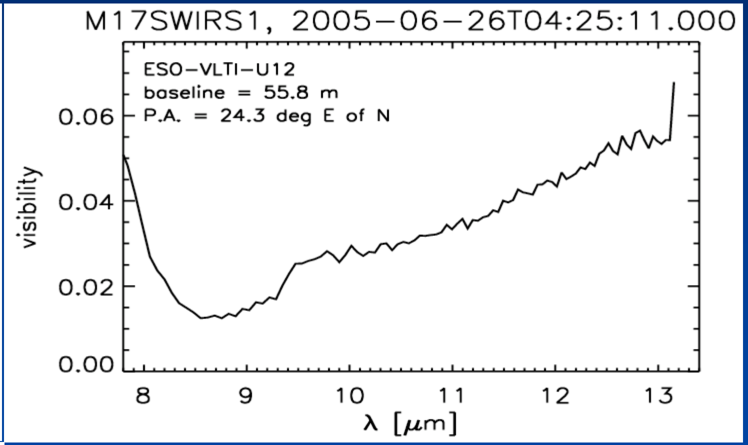


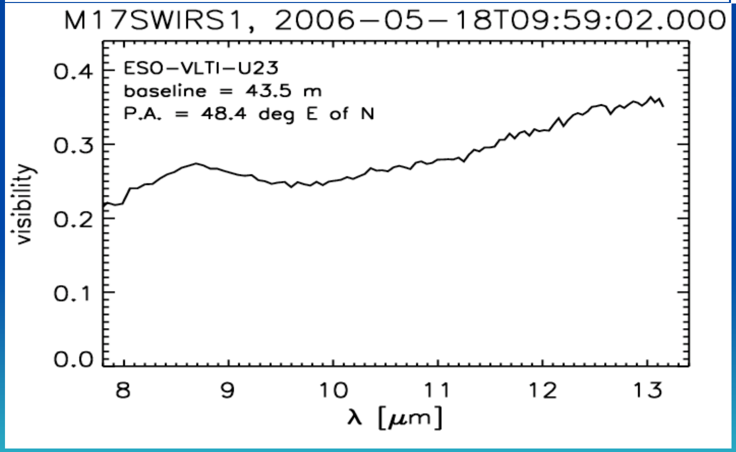
Fig. 1. *IJHK* images of the KW region. The KWO components, which could be resolved from *i* to K_s, are marked by numbers; the size of the displayed area is 55" × 55".

Near-IR imaging from Chini et al. (2004)

The Kleinman-Wright Object in M17 SW







Our MIDI measurements:
Visibility level changes with baseline, but is always larger than 0.01 and reaches values of up to 0.3.

KWO models based on Robitaille Grid

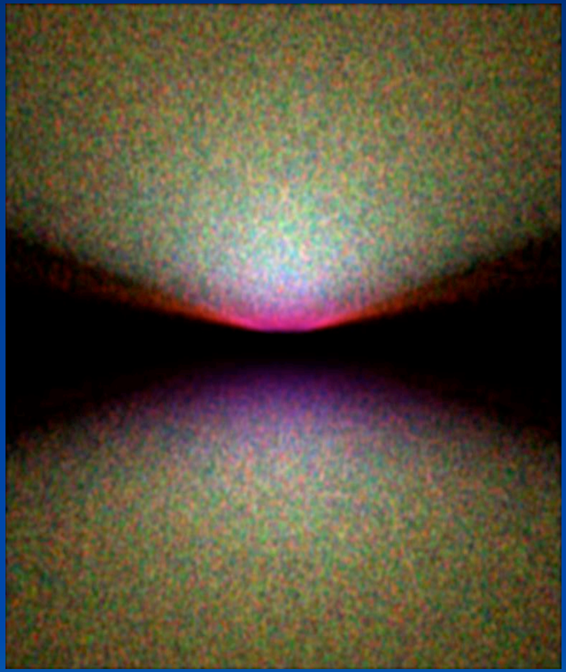
P.A. = 87°, M_{star} = 17.45 M_{sun}

P.A. = 63°, M_{star} = 7.92 M_{sun}

The two best-fitting RT models for KWO as 8-10-12 micron colour composites

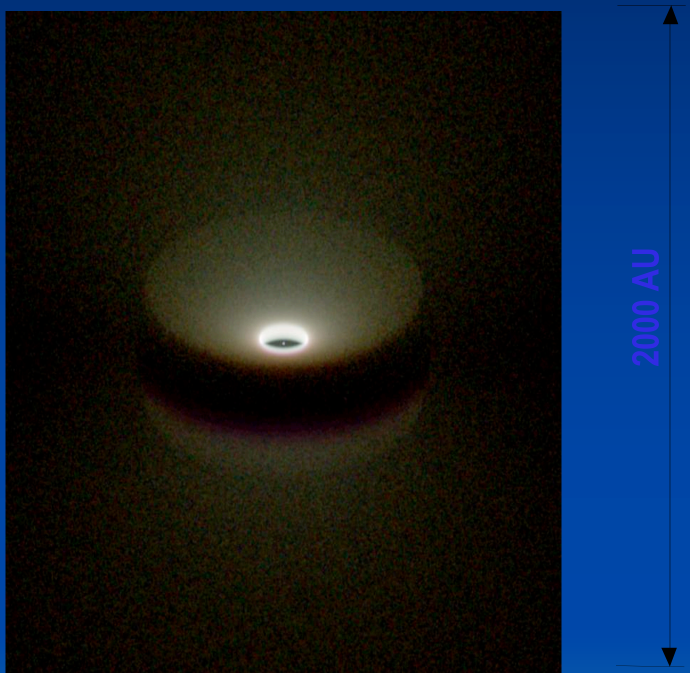
KWO models based on Robitaille Grid

P.A. = 87°, M_{star} = 17.45 M_{sun}



This model predicts visibilities of < 0.05 throughout contrary to the observations.

P.A. = 63°, M_{star} = 7.92 M_{sun}



This model predicts clearly higher visibilities in compliance with the observations.

Summary

- We have measured visibilities for 9 massive YSOs with MIDI. These objects are strongly resolved.
- Internal structures of 20 – 50 mas size exist.
- Interpretation not straight forward _ modelling!
- MIR interferometry as decisive tool to get complementary structure information:

Can break the SED-fitting degeneracy!