# Low-mass YSOs with MIDI

László Mosoni
Konkoly Observatory
Budapest, Hungary

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# Projects

MPIA: Ch. Leinert, Th. Ratzka, S. Wolf. Th. Henning

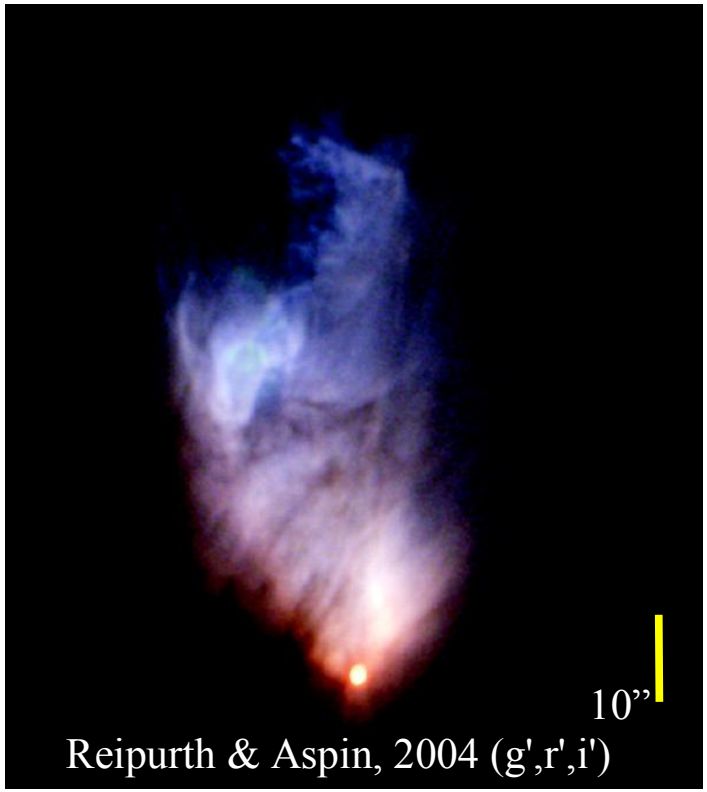
Leiden: A. Juhász

Konkoly: N. Sipos, K. Gabányi, P. Ábrahám

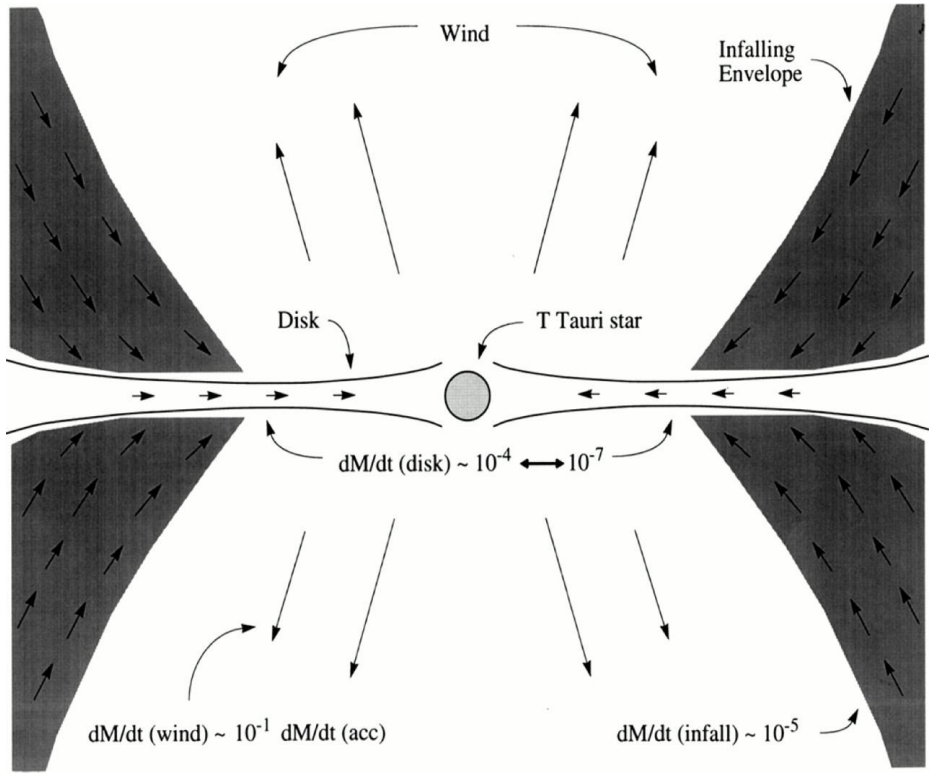
- radiative transfer modeling of selected objects (V1647 Ori, V883 Ori, AK Sco)
- study of DG Tau
- most GTO objects

  + MATISSE (Dutch-connection, MPIA/cryo)

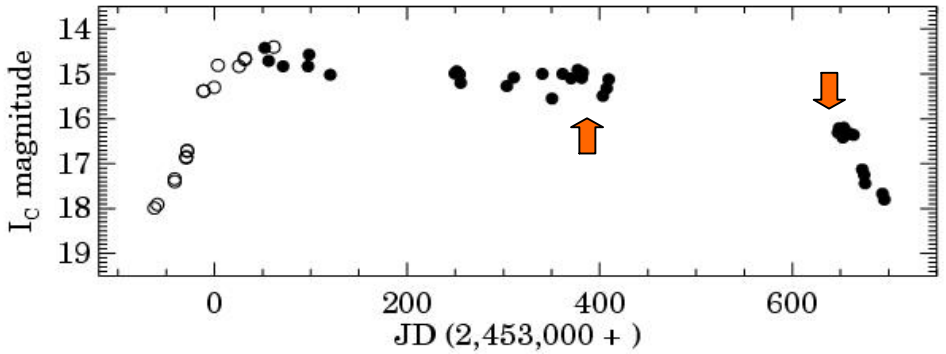
# Dynamics in V1647 Ori



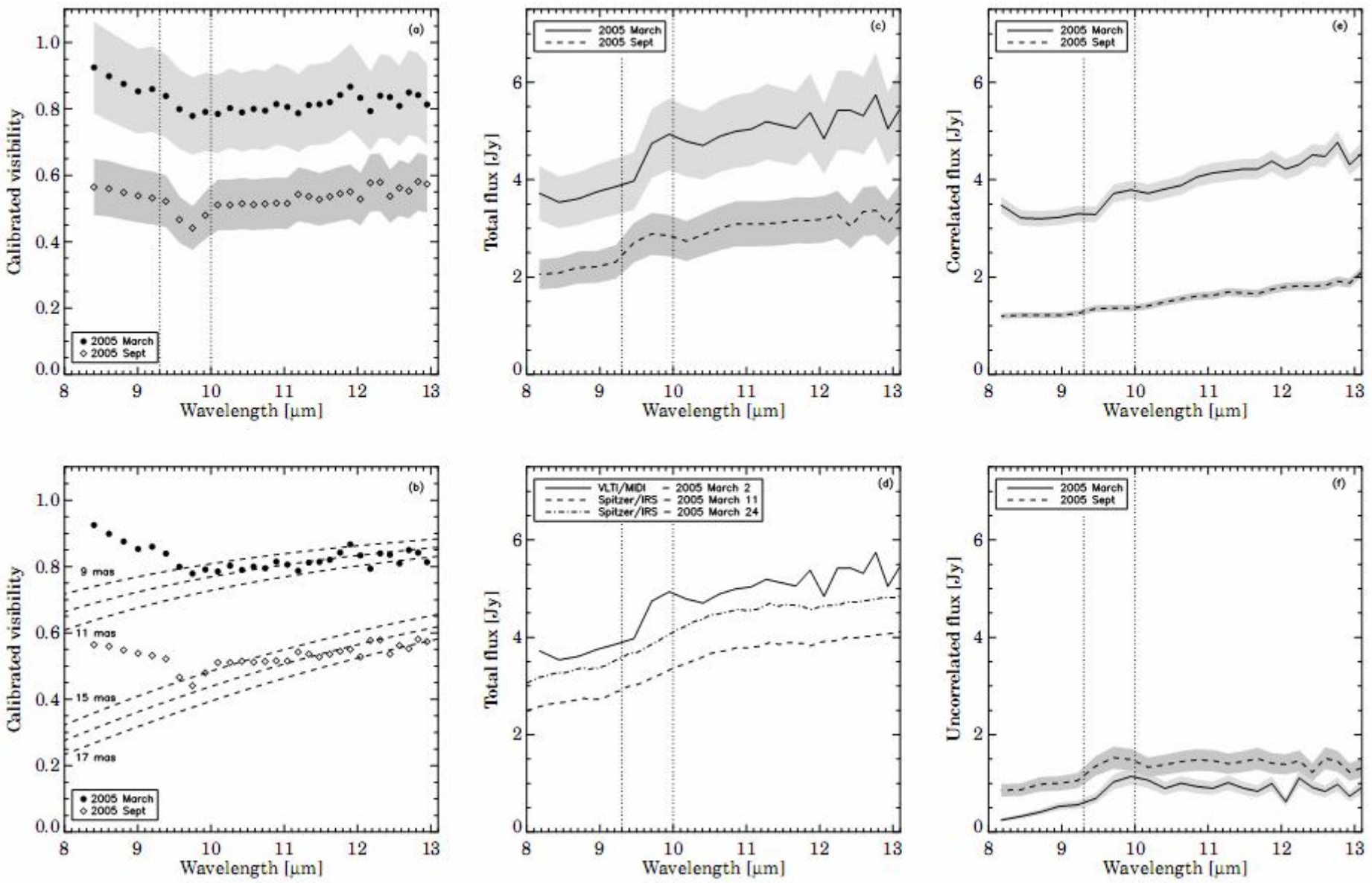
Reipurth & Aspin, 2004 (g',r',i')



Hartmann & Kenyon 1996



outburst 2003-2005




1. faded 2. more extended

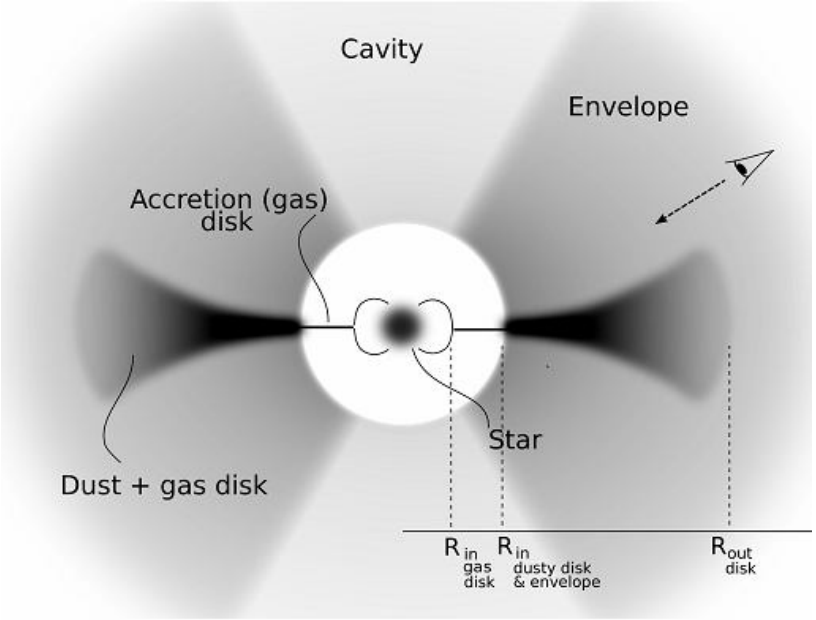
Mosoni, Sipos et al. 2013

RT modeling w MC3D (S. Wolf)

- SEDs: 5 epochs
- MIDI: 2 epochs

1. reference epoch (SED+MIDI)

| Parameters | Final model |
|---|---|
| **Stellar parameters** | |
| Temperature ($T_{star}$) | 3800 K |
| Mass ($M_{star}$) | 0.8 $M_\odot$ |
| Radius ($R_{star}$) | 3.25 $R_\odot$ |
| Interstellar visual extinction ($A_V$) | 0 mag |
| **Circumstellar disk parameters** | |
| *Inner radius of dusty disk* ($R_{in,disk}$) | 0.7 AU |
| Outer radius of dusty disk ($R_{out,disk}$) | 500 AU |
| *Scale height at 100 AU* ($H_0$) | 15 AU |
| *Flaring index* ($\beta$) | 1.2 |
| *Exponent of radial density profile* ($\alpha_{disk}$) | −1.75 |
| Total mass of disk and envelope ($M$) | 0.045 $M_\odot$ |
| Distance ($d$) | 400 pc |
| Inclination ($\vartheta$) | 60 ° |
| **Circumstellar envelope parameters** | |
| *Inner radius of dusty envelope* ($R_{in,env}$) | 0.7 AU |
| Outer radius of dusty envelope ($R_{out,env}$) | 3000 AU |
| Exponent of radial density profile ($\alpha_{env}$) | −1.5 |
| **Parameters for the accretion** | |
| *Accretion rate* ($\dot{M}$) | $3.5\times10^{-6}$ $M_\odot yr^{-1}$ |
| Magnetic truncation radius ($R_{trunc}$) | 5 $R_{star}$ |
| Temperature of the hot spot ($T_{spot}$) | 6500 K |

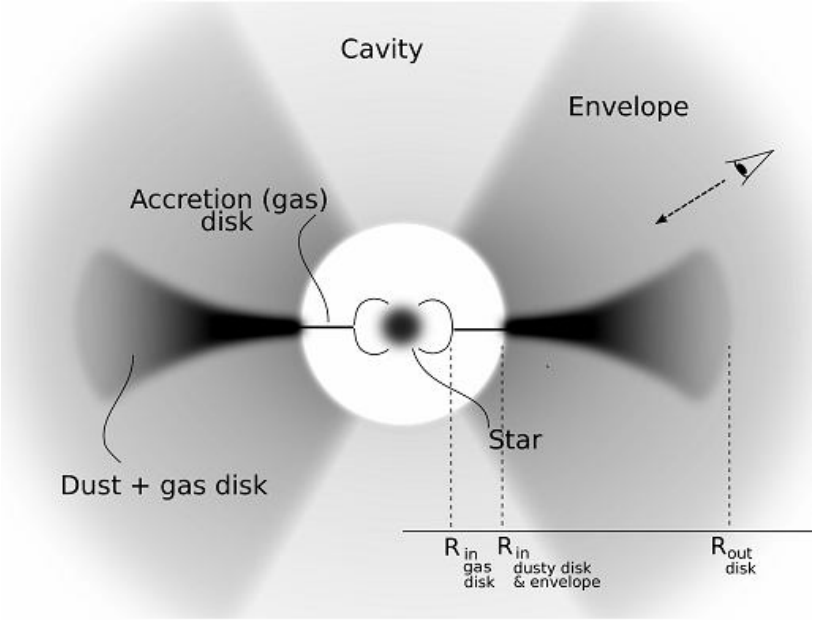


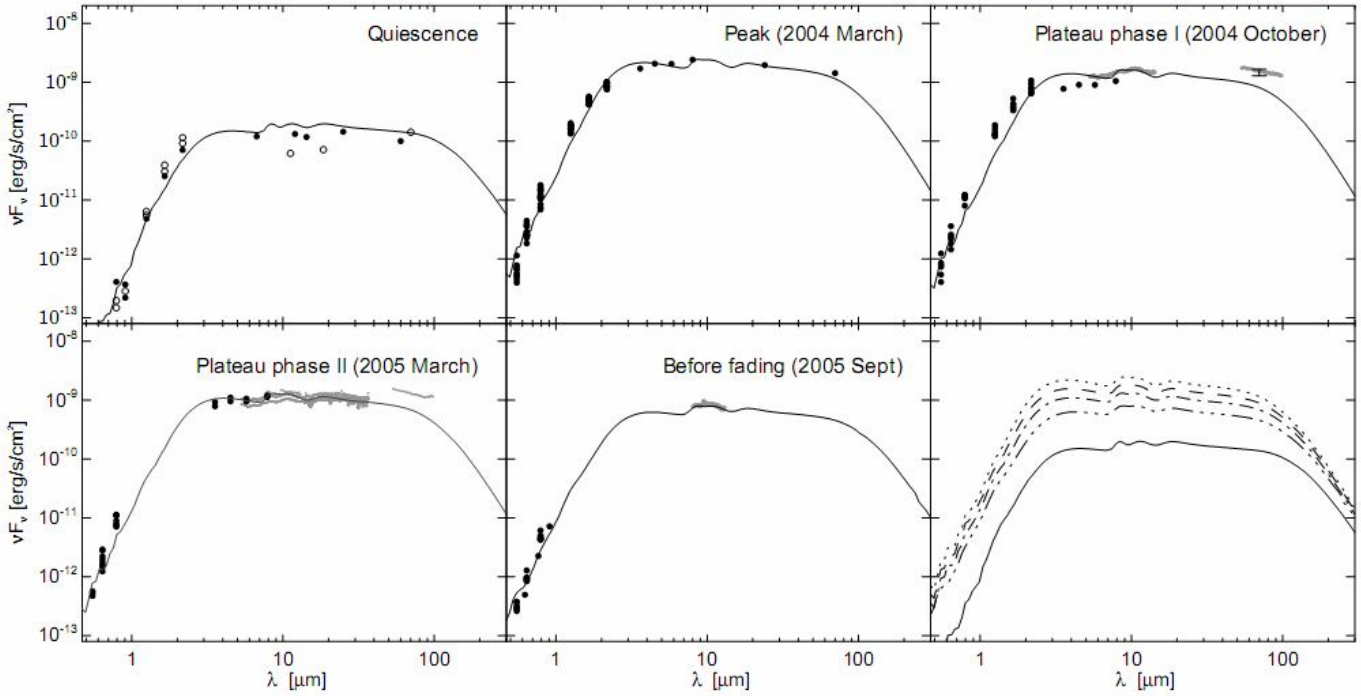

„typical" disk & envelope parameters

RT modeling w MC3D (S. Wolf)

- SEDs: 5 epochs
- MIDI: 2 epochs

1. reference epoch (SED+MIDI)
2. all SEDs



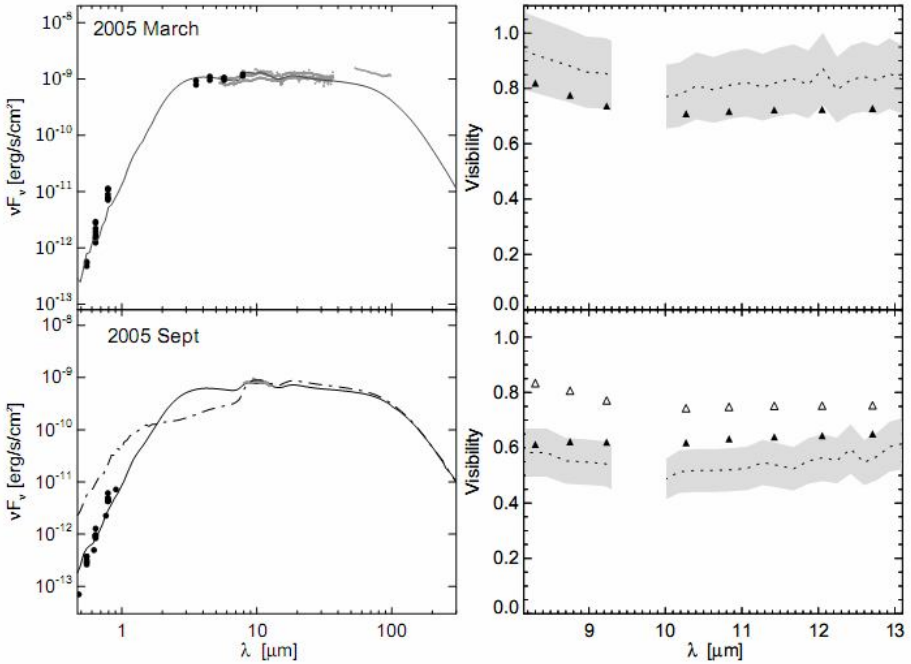



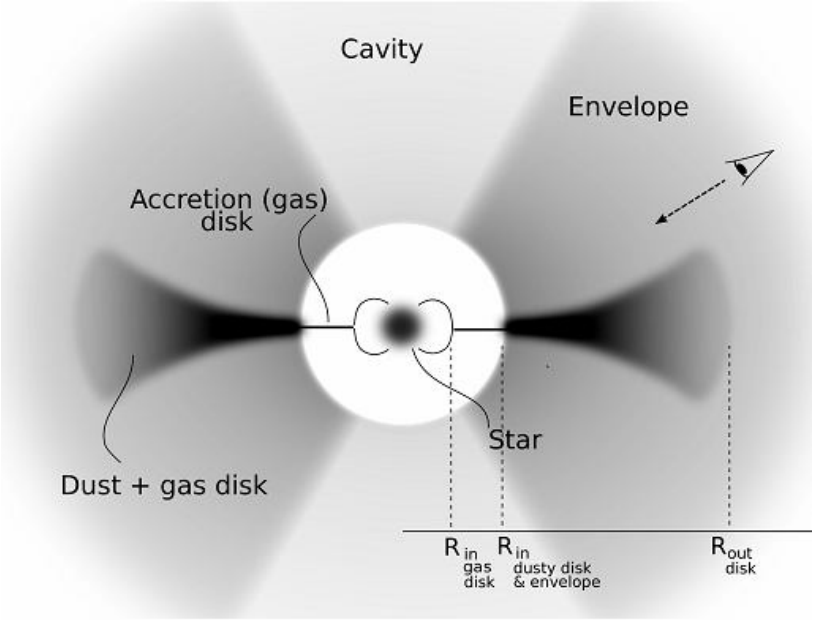

accretion rate changes during the outburst

RT modeling w MC3D (S. Wolf)

- SEDs: 5 epochs
- MIDI: 2 epochs

1. reference epoch (SED+MIDI)
2. all SEDs
3. 2nd MIDI data




| Parameters | 2004 | | 2005 | | 2003/06 |
|---|---|---|---|---|---|
| | Mar | Oct | Mar | Sept | quiescent |
| $\dot{M}$ ($M_\odot yr^{-1} \times 10^{-6}$) | 7.0 | 5.5 | 3.5 | 1.6 | 0.3 |
| $R_{in,disk}$ (AU) | 0.7 | 0.7 | 0.7 | 0.7 | 0.5 |
| $R_{in,env}$ (AU) | 0.7 | 0.7 | 0.7 | 3.0 | 0.5 |
| $A_V$ (mag) | 18.9 | 18.9 | 18.9 | 11.5 | 23.4 |

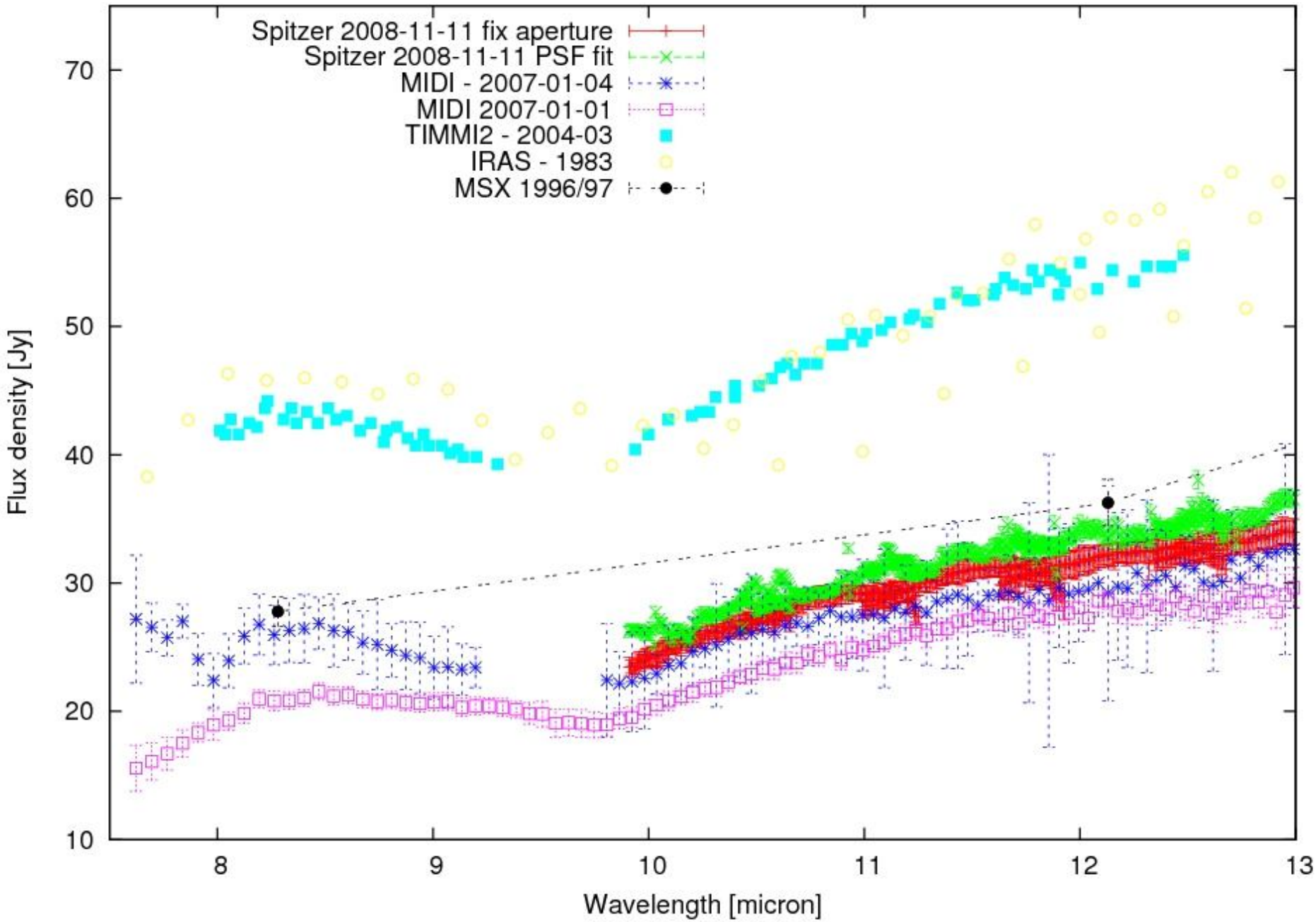
inner radius of dust envelope increased 0.7 AU -> 3.0 AU

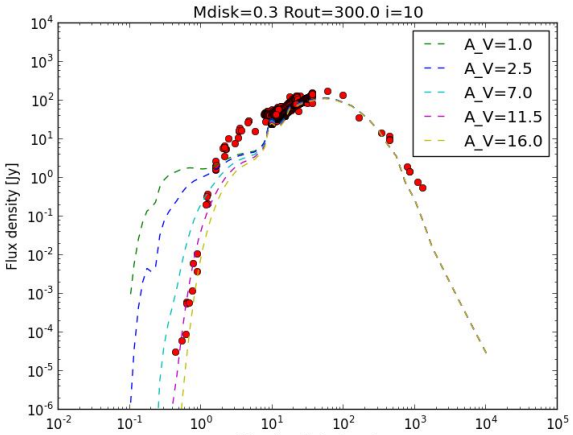
- blown-up cavity
- disappearing warm halo
- out-of-equlibrium system

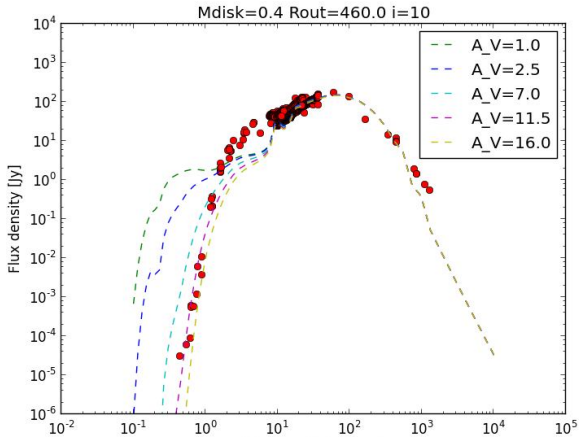
# Other eruptive YSOs with MIDI

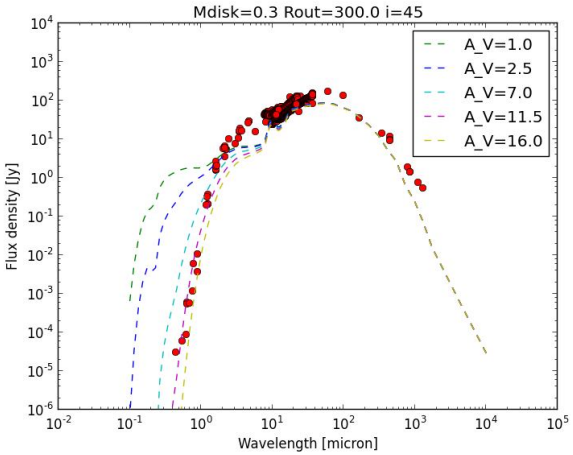
- FU Ori (GTO, Quanz et al. 2006)
- Z CMa (GTO)
- V346 Nor (PI: S. Kraus)
- V883 Ori (PI: S. Quanz 2006)
  - similar to eruptives (FUor)
  - observations 2007 Jan. (U2-U3: 44m, U3-U4: 55m)
  - RT modeling with RADMC (PIs: K. Gabányi & A. Juhász) – grid
  - 200 $L_{sun}$: stellar or accretion? MIDI cannot distinguish

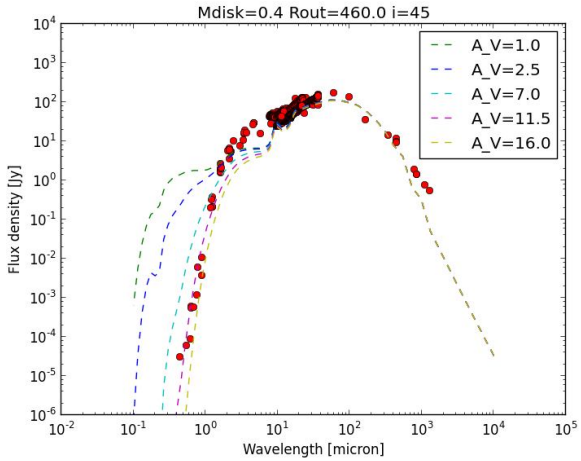
# V883 Ori

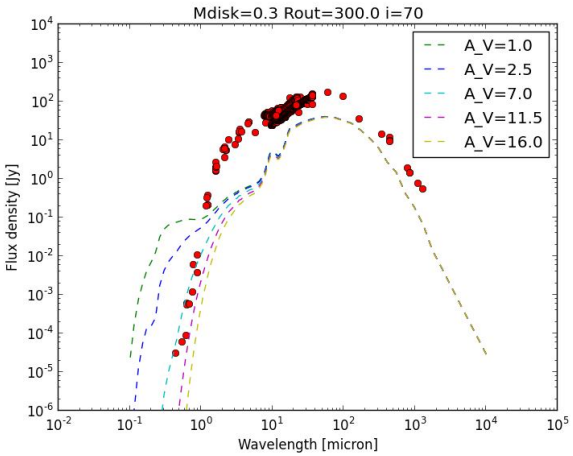

Spitzer 2008-11-11 fix aperture
Spitzer 2008-11-11 PSF fit
MIDI - 2007-01-04
MIDI 2007-01-01
TIMMI2 - 2004-03
IRAS - 1983
MSX 1996/97
Flux density [Jy]
Wavelength [micron]
10
20
30
40
50
60
70
8
9
10
11
12
13

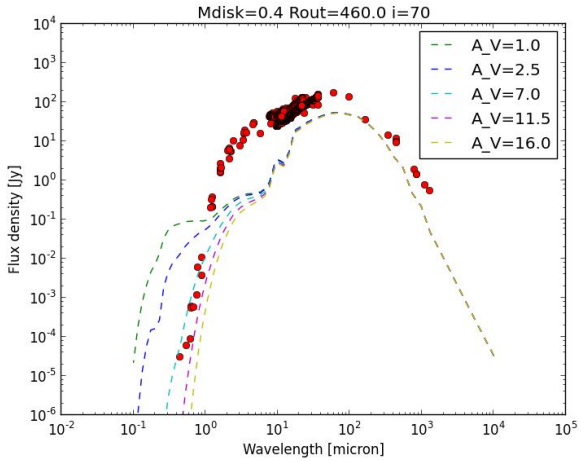


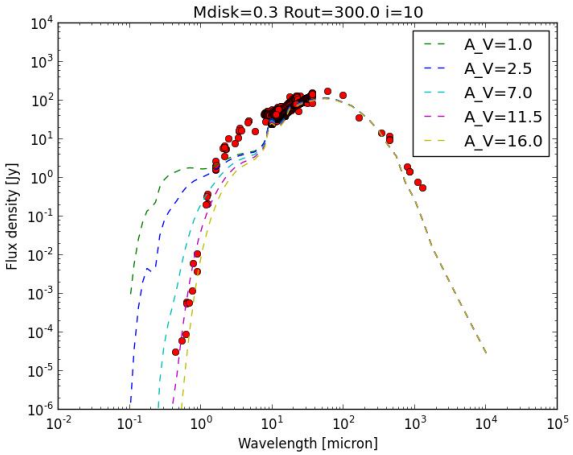

# V883 Ori

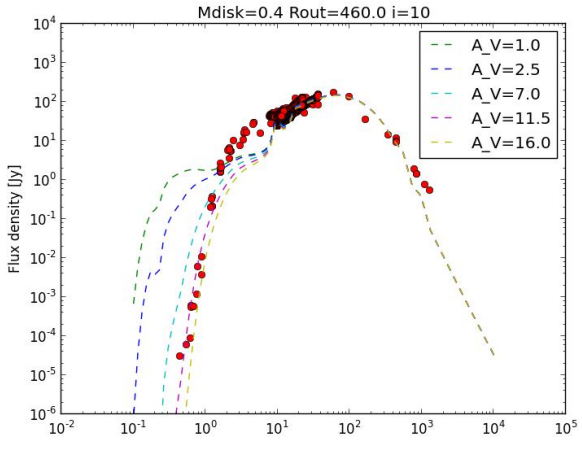
left: 0.3M, 300AU

right: 0.4M, 460AU

i=30, 45, 70 deg

# V883 Ori


Mdisk=0.3 Rout=300.0 i=10
A_V=1.0
A_V=2.5
A_V=7.0
A_V=11.5
A_V=16.0
Flux density [Jy]
Wavelength [micron]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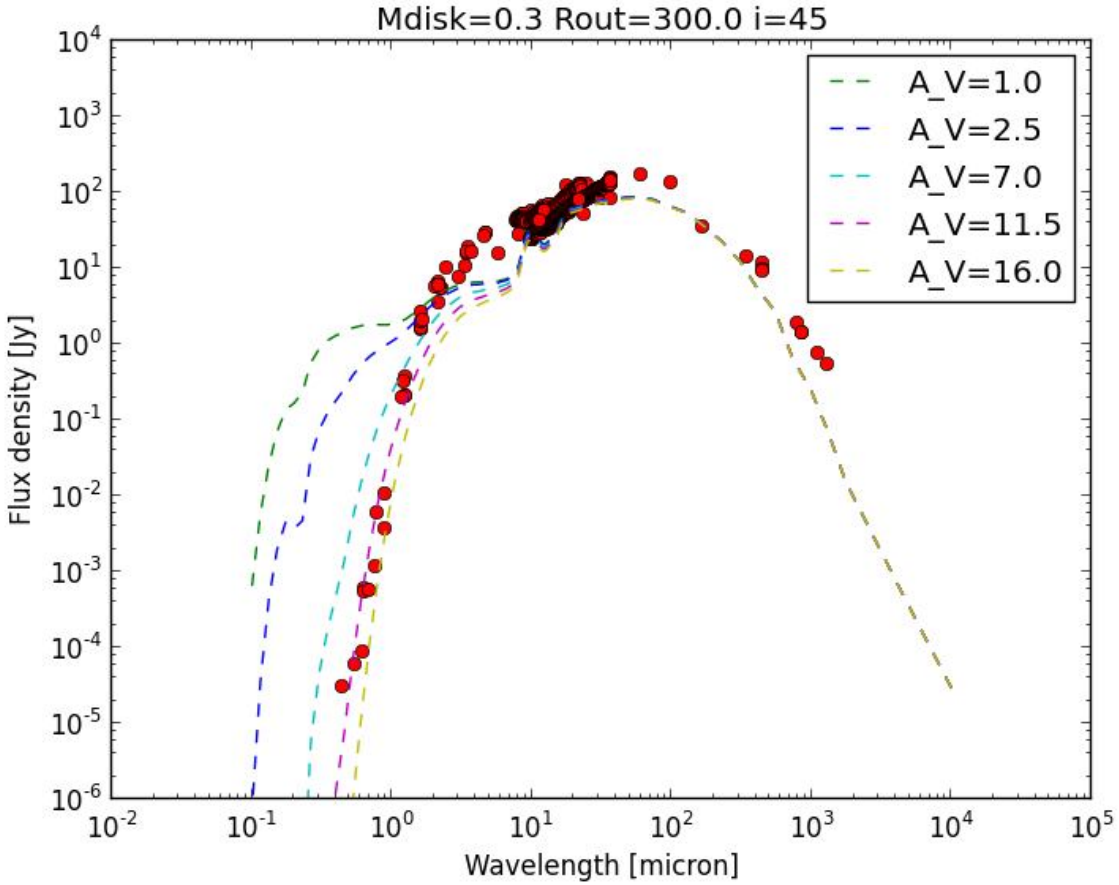
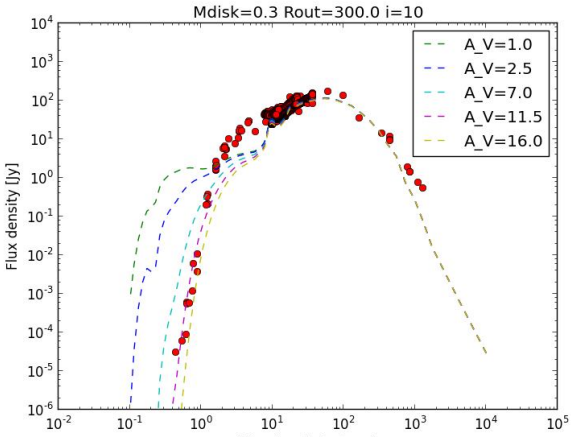
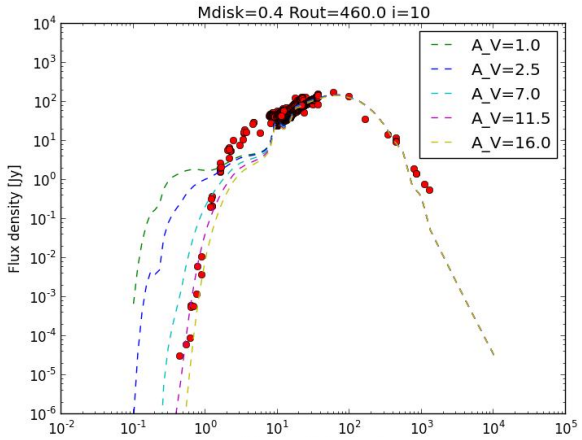
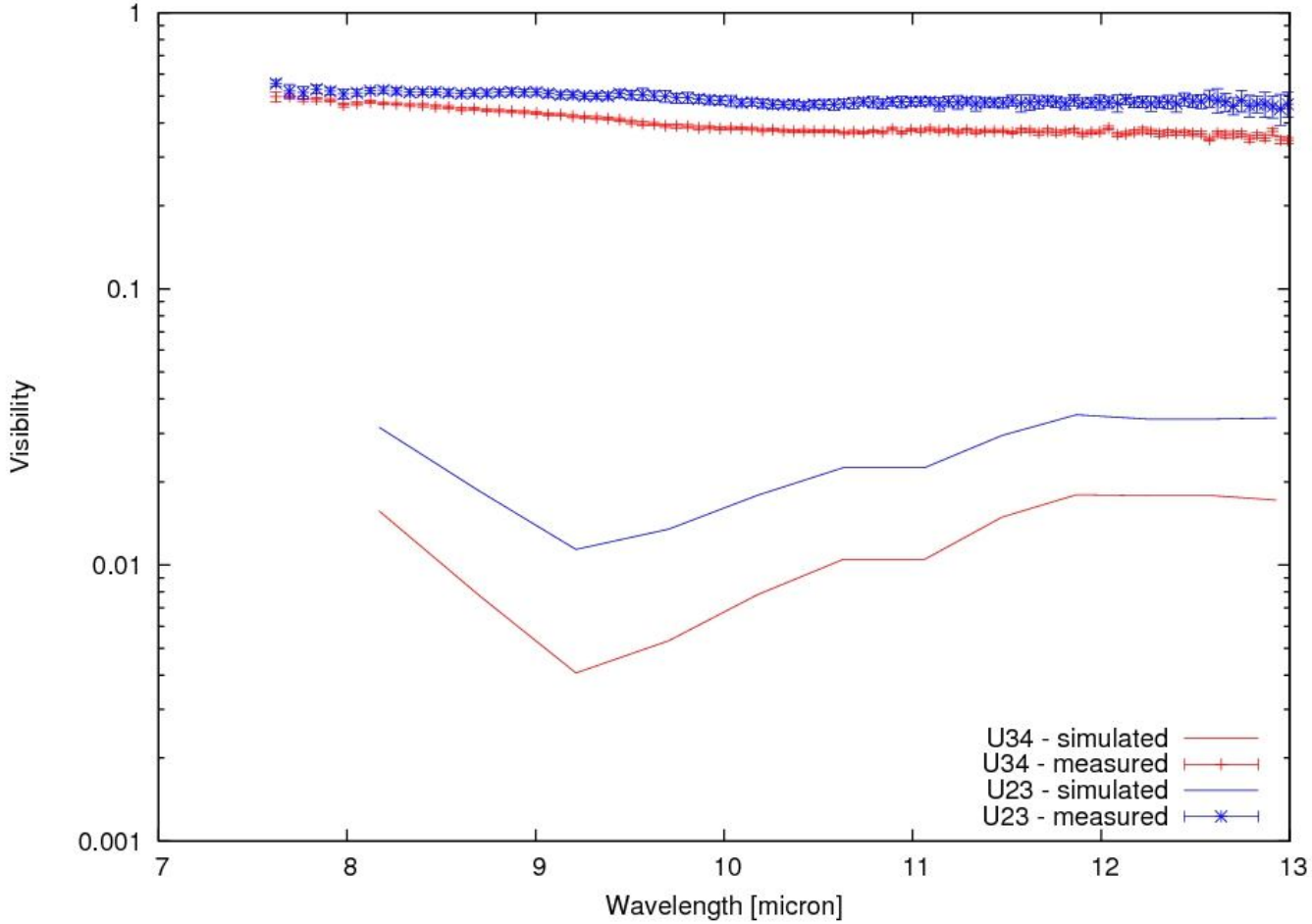
A_V=1.0
A_V=2.5
A_V=7.0
A_V=11.5
A_V=16.0
Flux density [Jy]


Mdisk=0.3 Rout=300.0 i=45
A_V=1.0
A_V=2.5
A_V=7.0
A_V=11.5
A_V=16.0
Flux density [Jy]
Wavelength [micron]

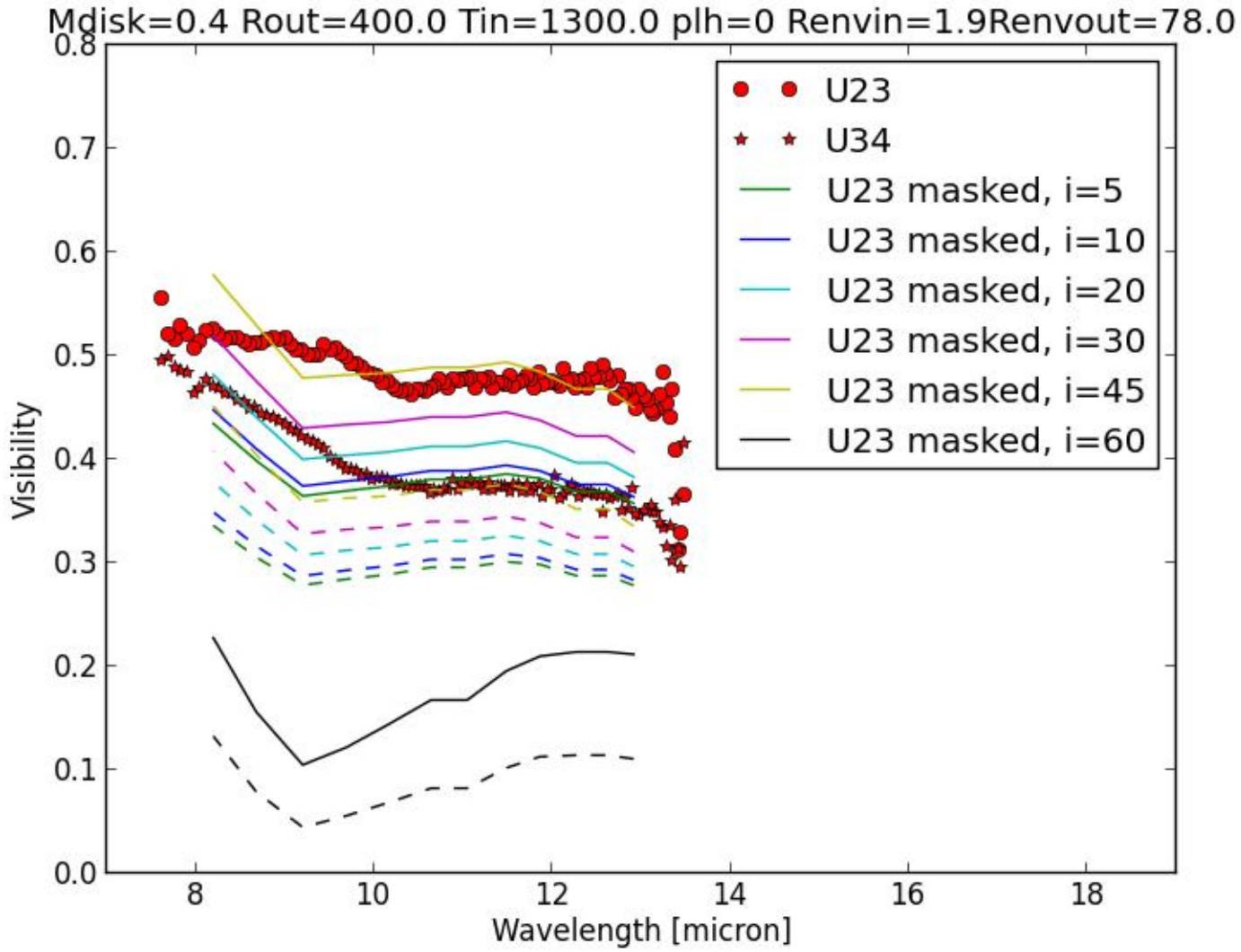
# V883 Ori


Mdisk=0.3 Rout=300.0 i=10
A_V=1.0
A_V=2.5
A_V=7.0
A_V=11.5
A_V=16.0
Flux density [Jy]


Mdisk=0.4 Rout=460.0 i=10
A_V=1.0
A_V=2.5
A_V=7.0
A_V=11.5
A_V=16.0
Flux density [Jy]


Visibility
Wavelength [micron]
U34 - simulated
U34 - measured
U23 - simulated
U23 - measured

# V883 Ori



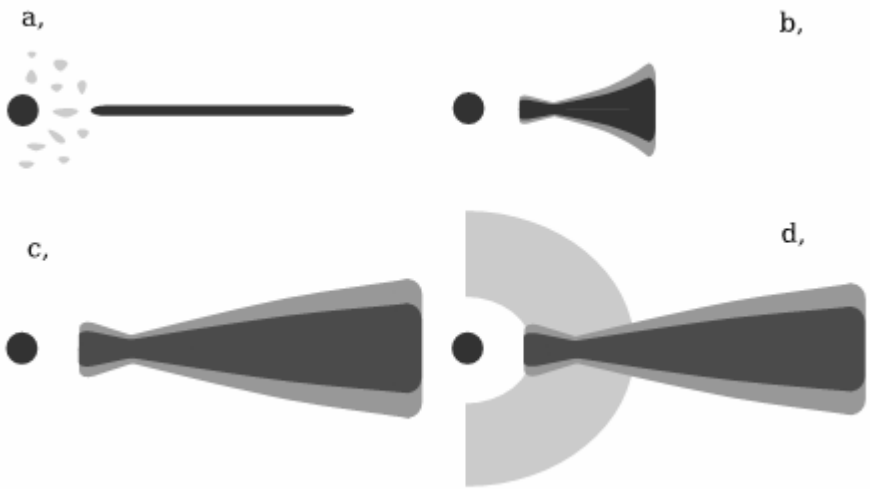

1. final conclusions from this run, 2. larger grid

# AK Sco

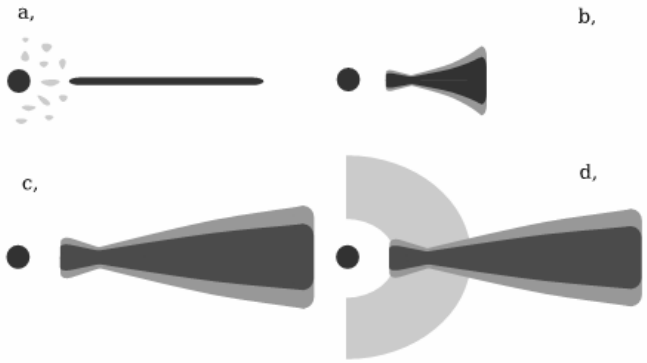
- binary (2 x F5V), a*sini=0.14AU (i~60deg),
  $\varepsilon = 0.55$, d = 145pc (Alencar+ 2003)
- MIDI GTO

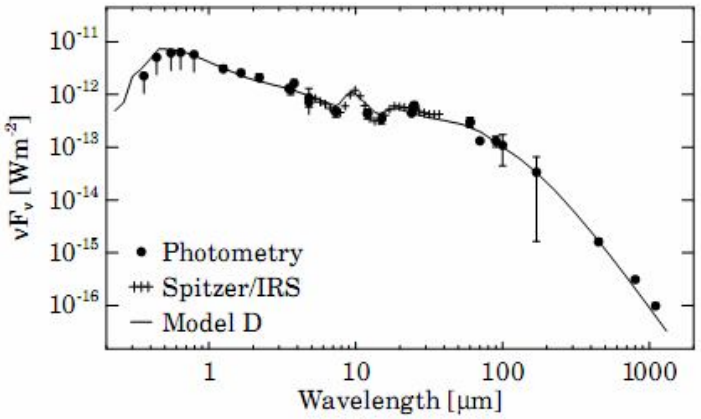
| VLTI baseline | Observing date | Projected baseline Length [m] | P.A. [deg] |
|---|---|---|---|
| U1 – U2 | 2005-05-29 03:09 - 03:38 | 56.4 | 13.6 |
| U1 – U3 | 2005-05-29 06:56 - 07:25 | 91.8 | 45.6 |
| U3 – U4 | 2005-05-30 02:26 - 03:15 | 55.2 | 93.3 |
| U3 – U4 | 2005-05-30 08:38 - 09:18 | 54.6 | 151.5 |

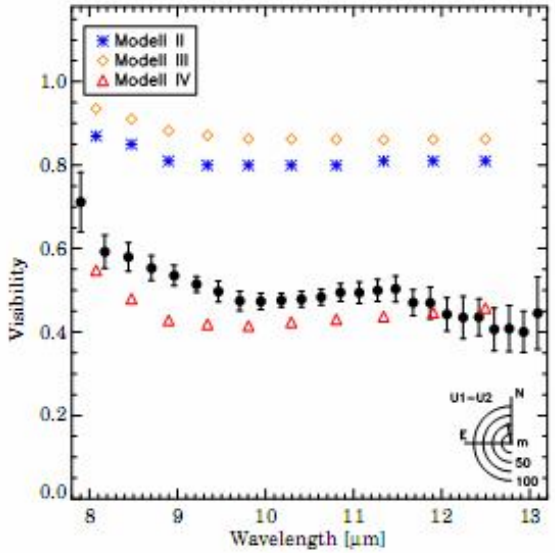
- RT modeling
  (A. Juhász)

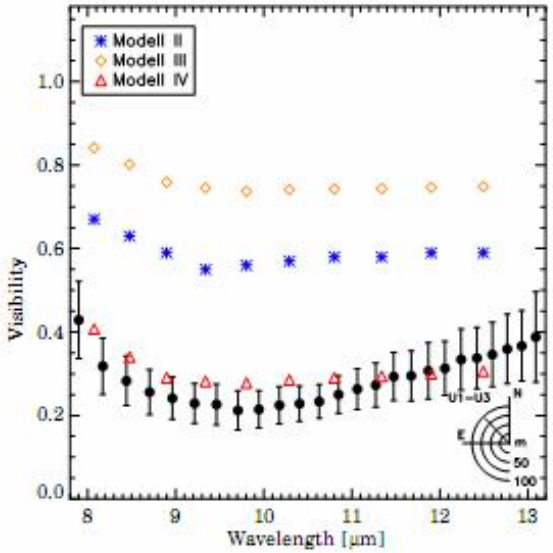


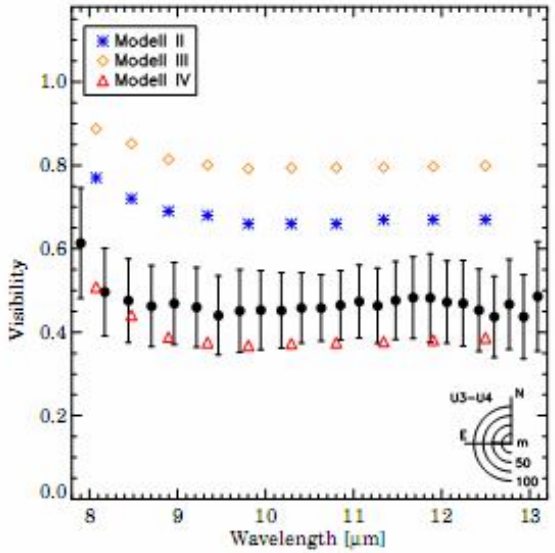
# AK Sco

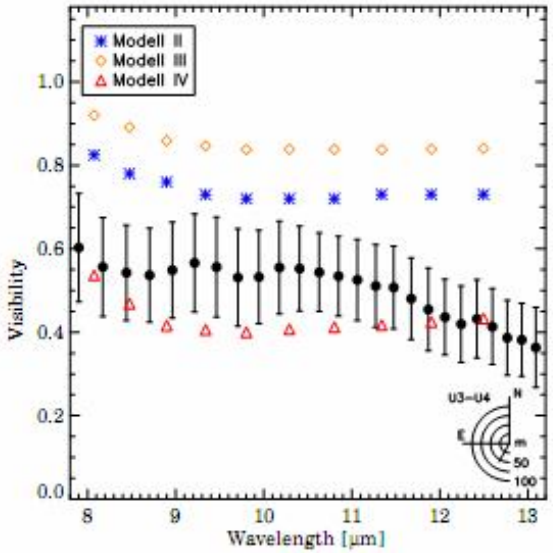



disk – halo degeneracy (+ EX Lupi?)

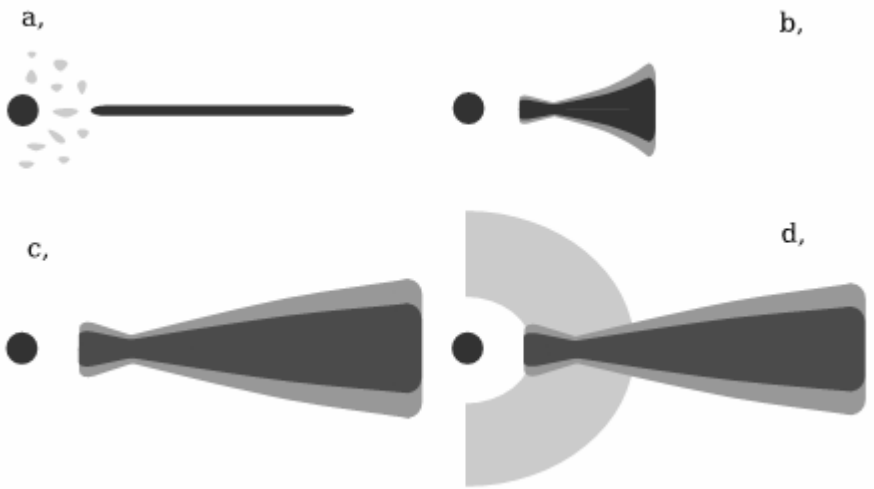
# AK Sco

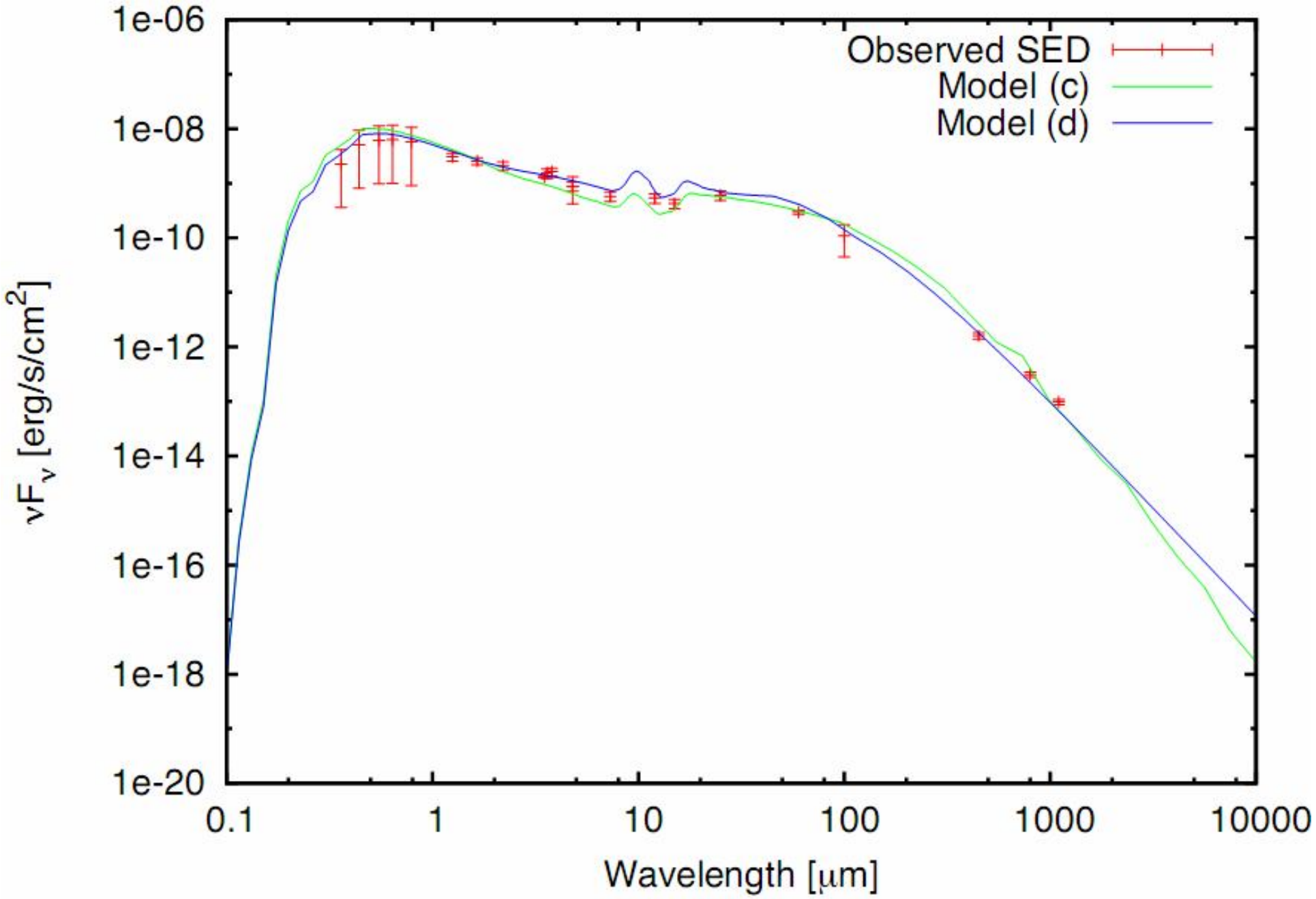
- binary (2 x F5V), a*sini=0.14AU (i~60deg),
  $\varepsilon = 0.55$, d = ~~145pc~~ 100pc

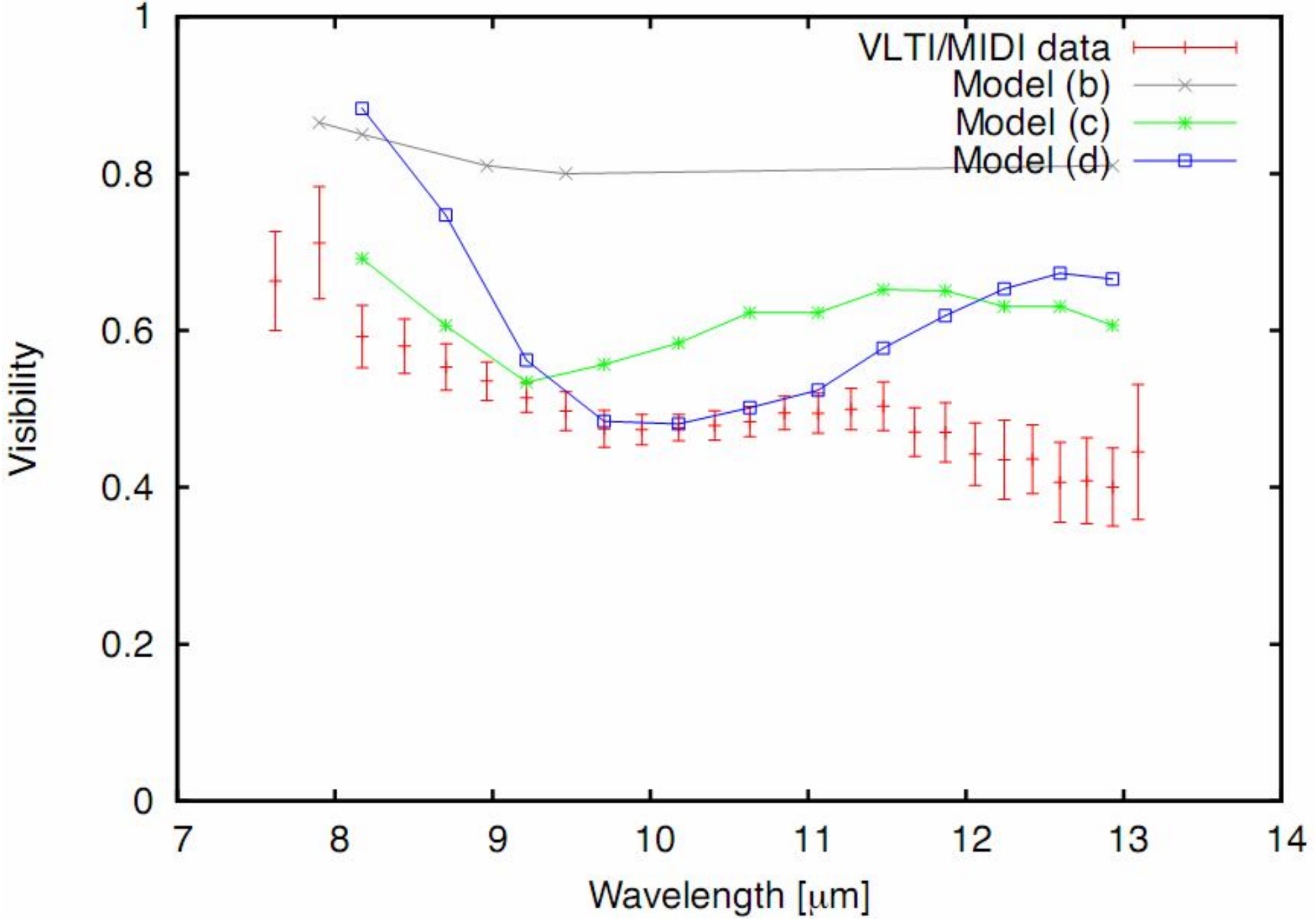
- MIDI GTO

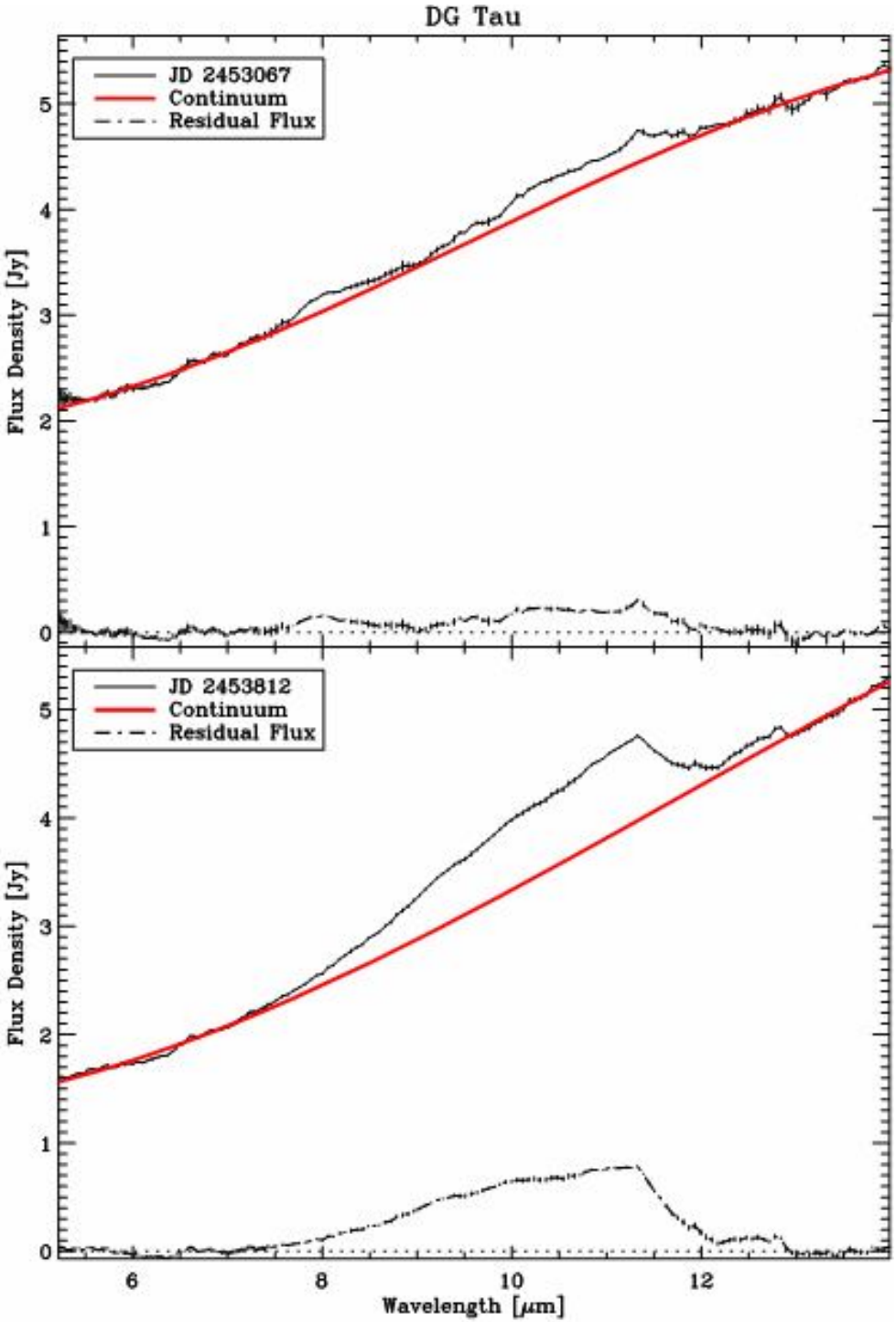
| VLTI baseline | Observing date | Projected baseline Length [m] | P.A. [deg] |
|---|---|---|---|
| U1 – U2 | 2005-05-29 03:09 - 03:38 | 56.4 | 13.6 |
| U1 – U3 | 2005-05-29 06:56 - 07:25 | 91.8 | 45.6 |
| U3 – U4 | 2005-05-30 02:26 - 03:15 | 55.2 | 93.3 |
| U3 – U4 | 2005-05-30 08:38 - 09:18 | 54.6 | 151.5 |

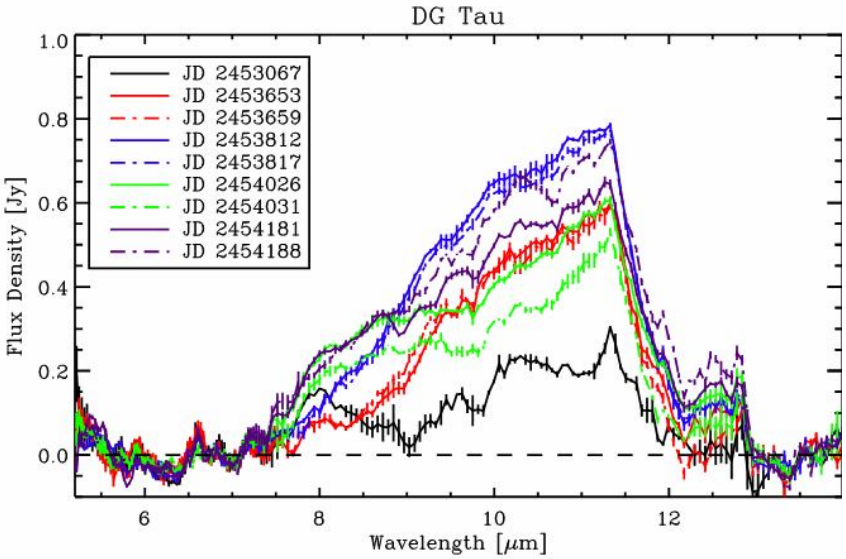
- RT modeling
  (K. Gabányi +
  A. Juhász)

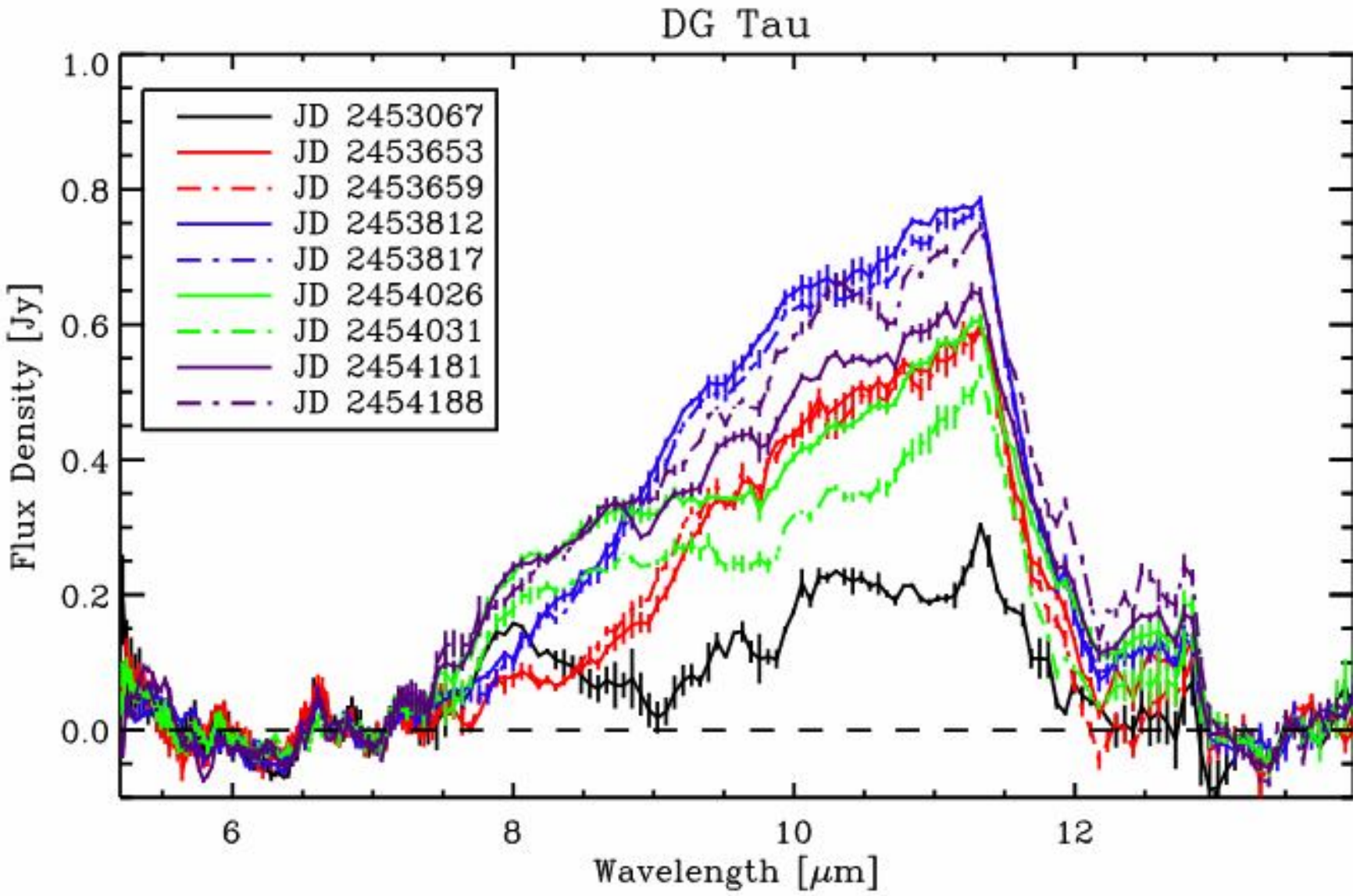



Observed SED
Model (c)
Model (d)
1e-06
1e-08
1e-10
1e-12
1e-14
1e-16
1e-18
1e-20
νF_ν [erg/s/cm^2]
0.1
1
10
100
1000
10000
Wavelength [μm]

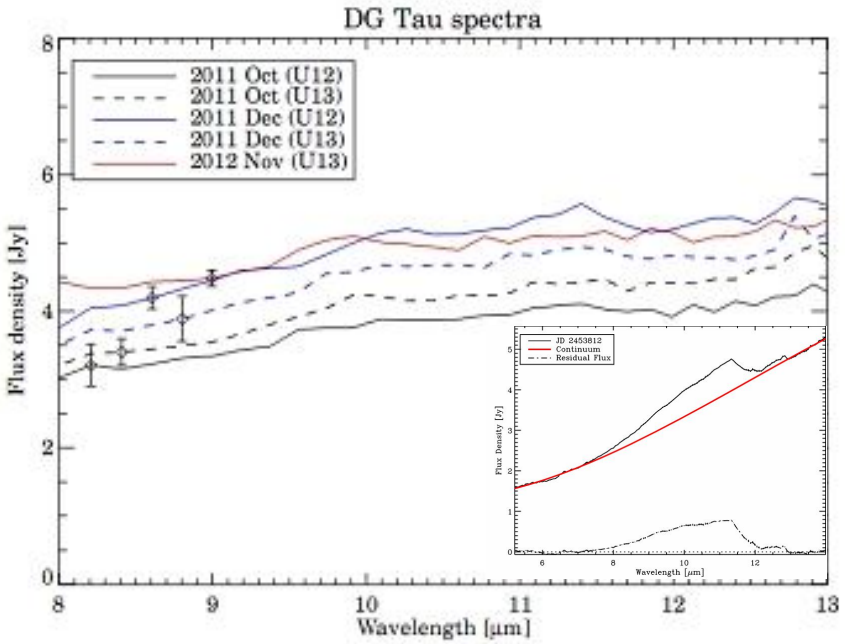

VLTI/MIDI data
Model (b)
Model (c)
Model (d)
Visibility
Wavelength [μm]
0
0.2
0.4
0.6
0.8
1
7
8
9
10
11
12
13
14

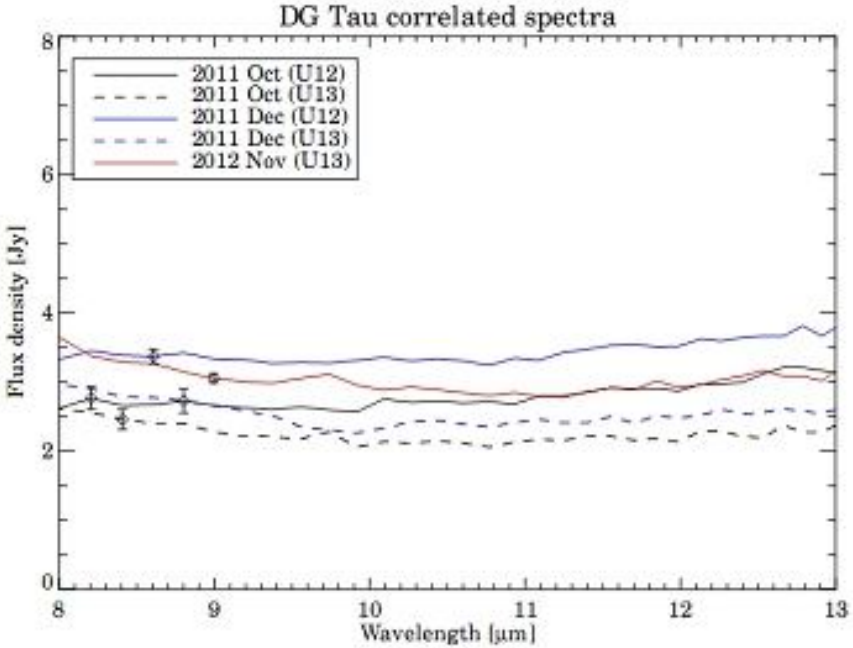

DG Tau
JD 2453067
Continuum
Residual Flux
JD 2453812
Continuum
Residual Flux
Flux Density [Jy]
Wavelength [μm]

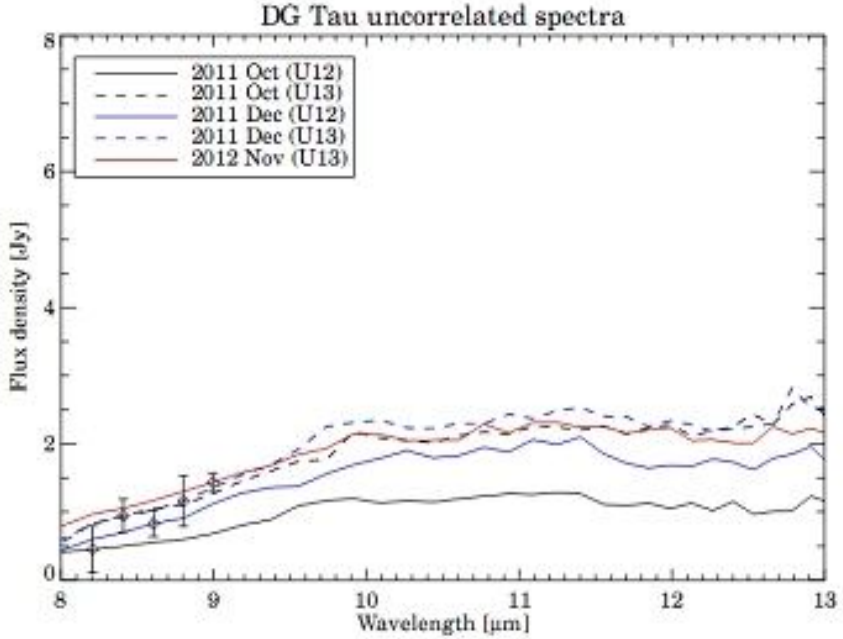

DG Tau
JD 2453067
JD 2453653
JD 2453659
JD 2453812
JD 2453817
JD 2454026
JD 2454031
JD 2454181
JD 2454188
Flux Density [Jy]
Wavelength [μm]

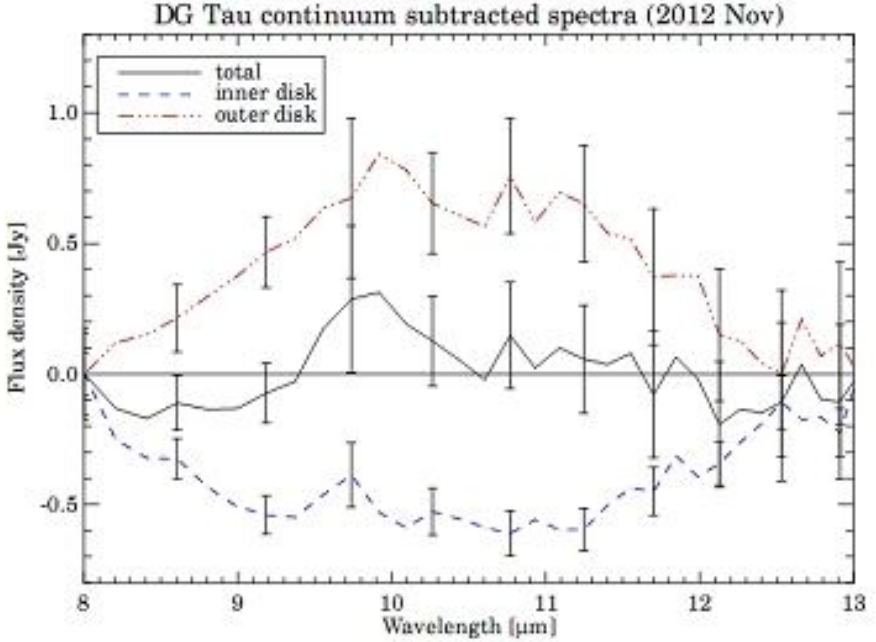



check variations of silicate on UT1-UT2 and UT1-UT3
– finally seven epochs (2012 Oct – 2014 Jan), one with ATs


DG Tau spectra
2011 Oct (U12)
2011 Oct (U13)
2011 Dec (U12)
2011 Dec (U13)
2012 Nov (U13)
JD 2453812
Continuum
Residual Flux
Flux Density [Jy]
Wavelength [μm]
Flux density [Jy]
Wavelength [μm]


DG Tau correlated spectra
2011 Oct (U12)
2011 Oct (U13)
2011 Dec (U12)
2011 Dec (U13)
2012 Nov (U13)
Flux density [Jy]
Wavelength [μm]


DG Tau uncorrelated spectra
2011 Oct (U12)
2011 Oct (U13)
2011 Dec (U12)
2011 Dec (U13)
2012 Nov (U13)
Flux density [Jy]
Wavelength [μm]


DG Tau continuum subtracted spectra (2012 Nov)
total
inner disk
outer disk
Flux density [Jy]
Wavelength [μm]

# Other (GTO) objects

- a few observations per object (10+)
- no capacity for RT modeling
- survey paper as Boley et al., or Menu et al.?
  - what kind of modeling?
  - include some Hae stars? open time targets?