The structure of protoplanetary disks

as seen with MIDI

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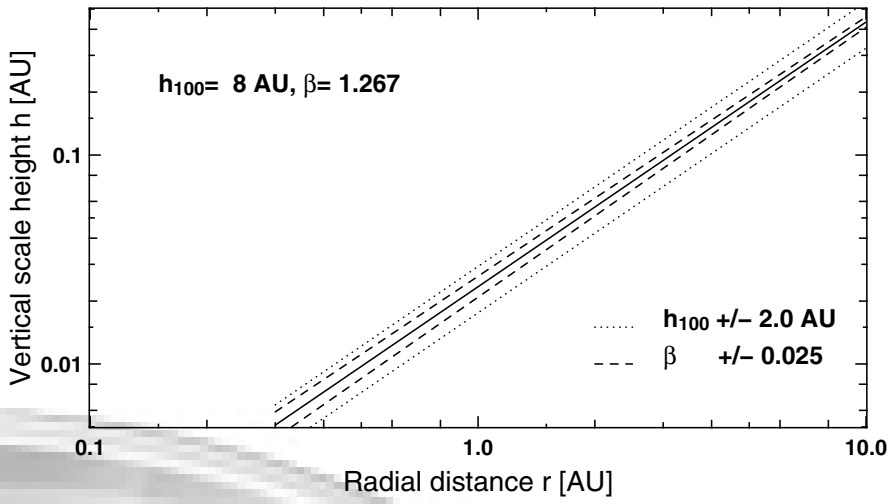
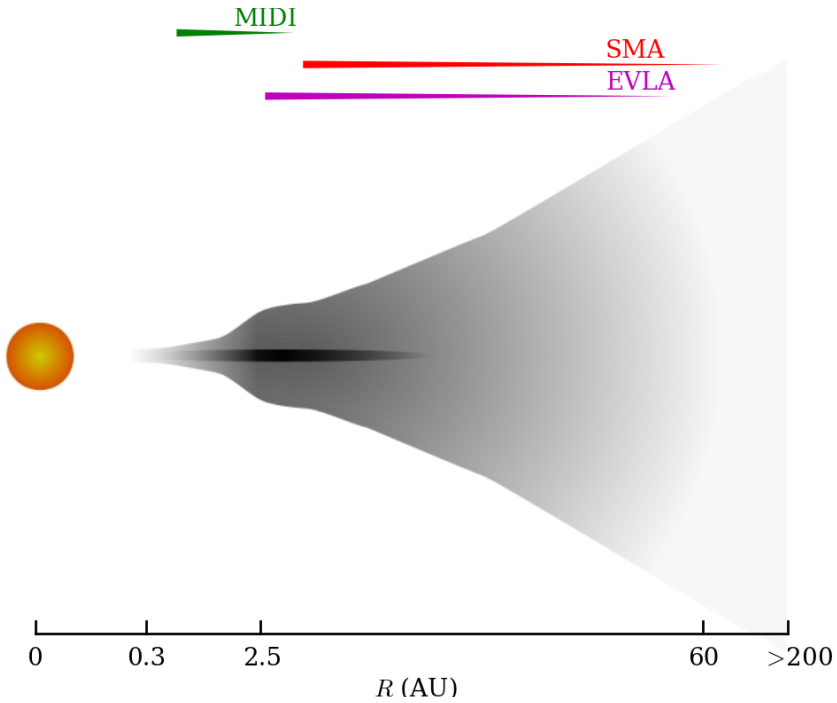
Intro: protoplanetary disks & MIDI

Disk structure



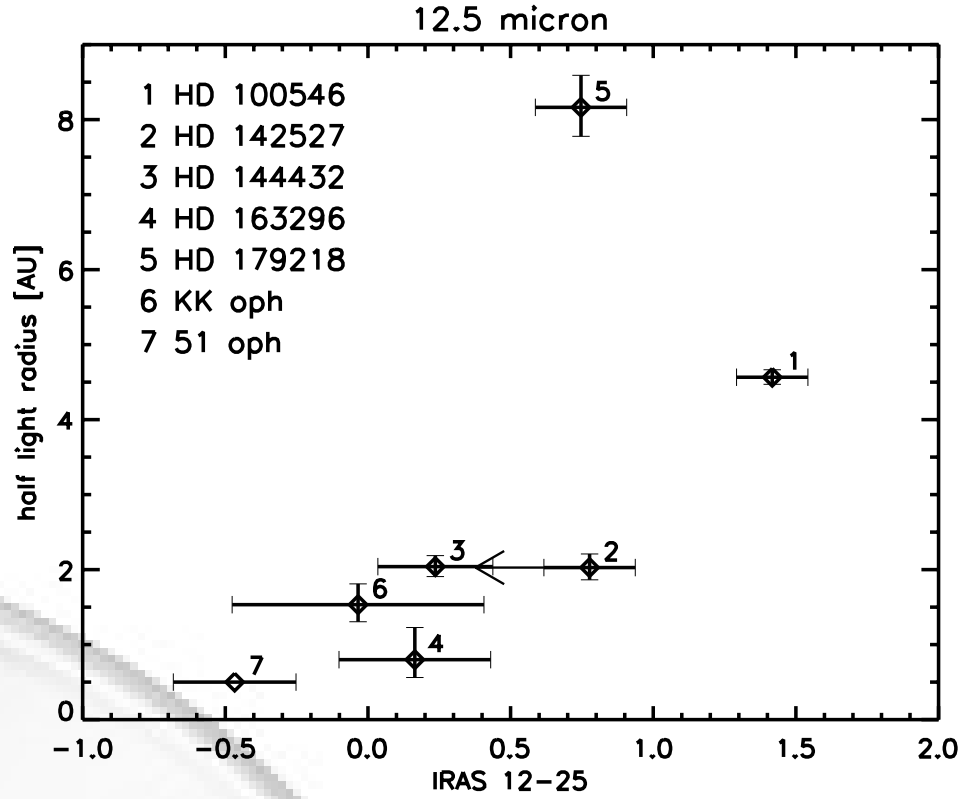
Flaring disk of AB Aur
(di Folco+ 2009)



Rounded rim of TW Hya
(Menu+ 2014)

Intro: protoplanetary disks & MIDI

Disk populations



Sizes of group I and II disks (Leinert+ 2004)

Disk structure & MIDI

+

- well-defined disk structure for several targets
- hints of different disk populations

Disk structure & MIDI

+

- well-defined disk structure for several targets
- hints of different disk populations

−

- lack of statistics: case studies difficult to combine/compare

The MIDI-Herbig project

⟨⟨ *Collective data reduction and analysis of (almost) all MIDI data of intermediate-mass young stars* ⟩⟩

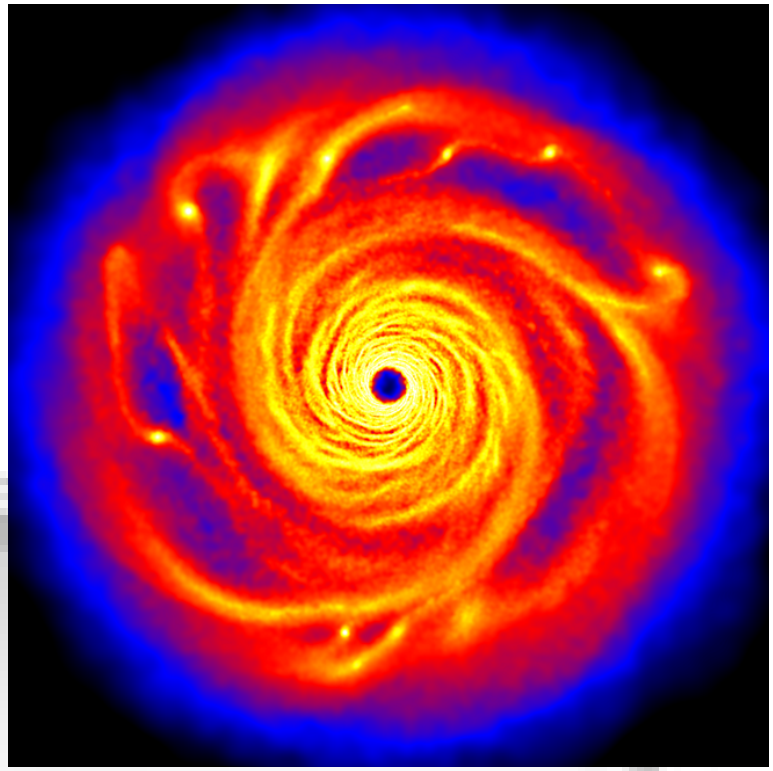
Data: 238 nights of archival MIDI observations, 80 targets

First results:

1. size-luminosity relation
2. towards a family picture

First results: 1. Size-luminosity relation

Principle: complex disk → simple disk



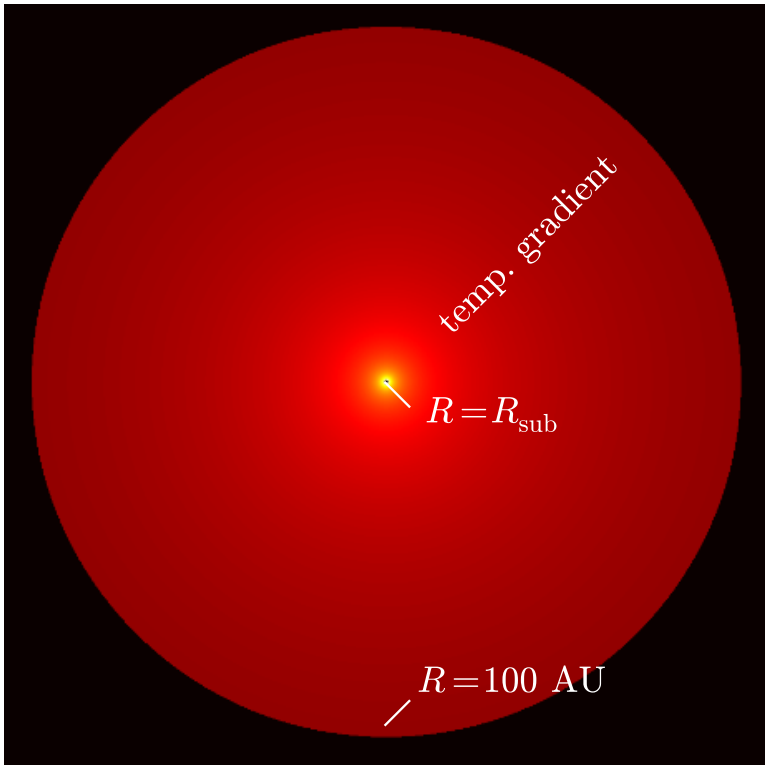


Fig *left*: Rice+ (2003); *right*: temperature-gradient disk

First results: 1. Size-luminosity relation

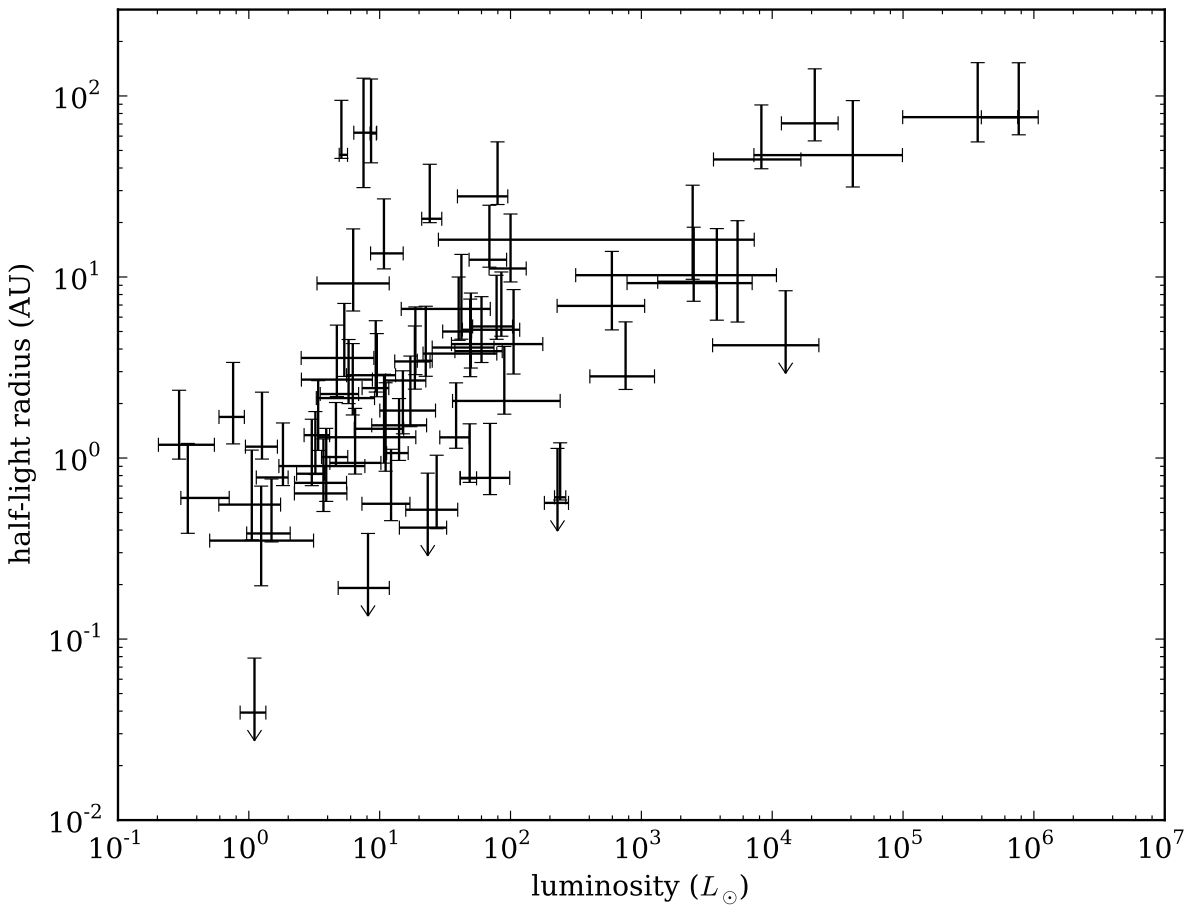


Fig Mid-infrared (10-μm) size-luminosity relation

First results: 1. Size-luminosity relation

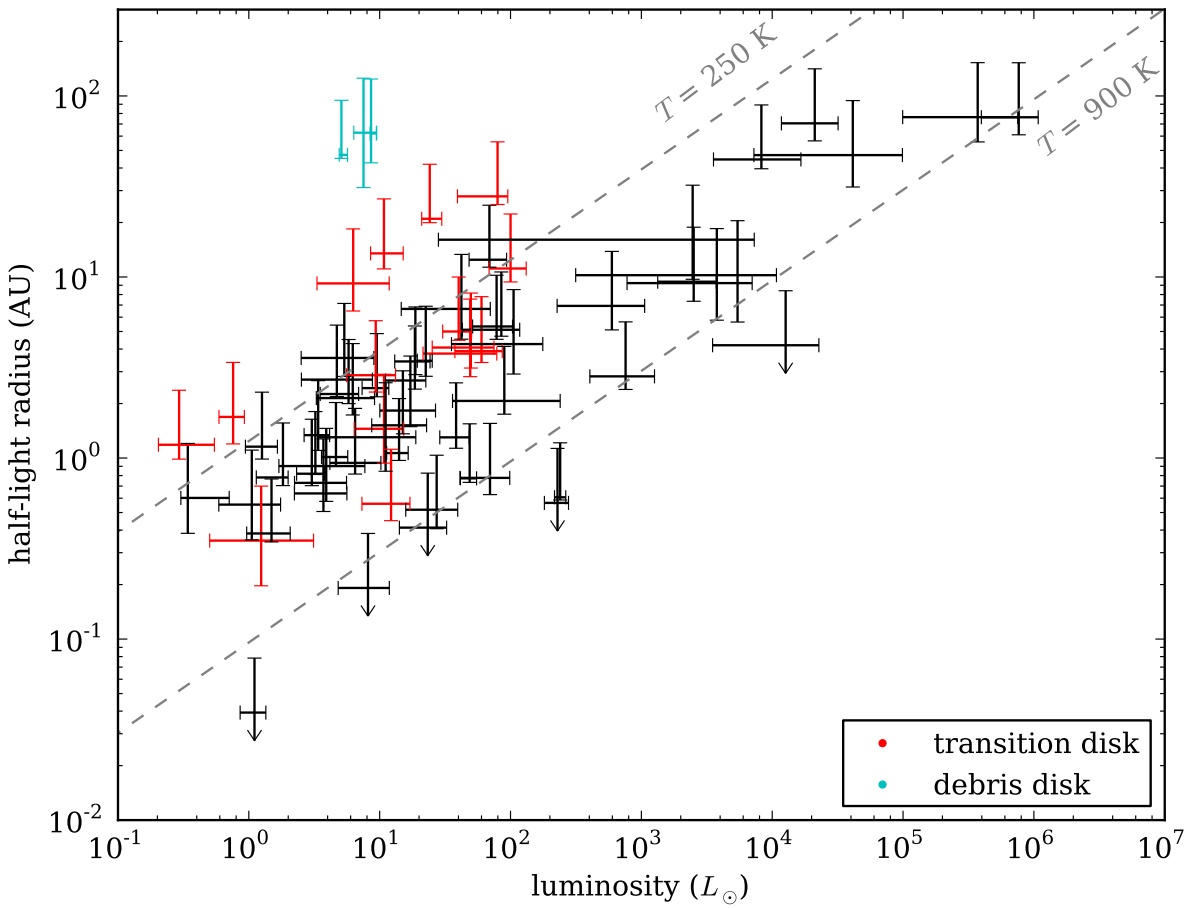
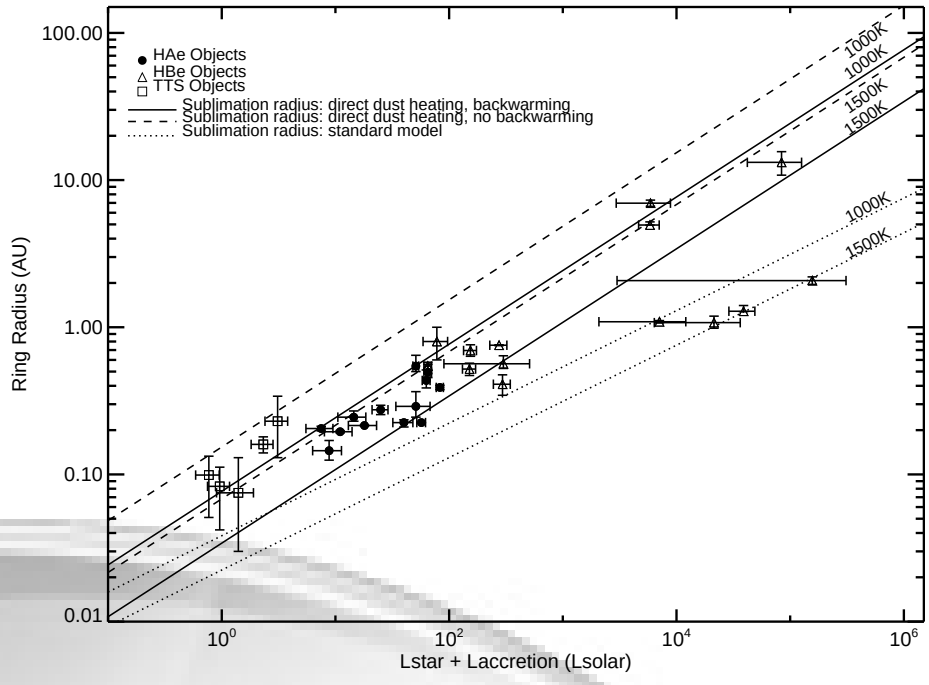


Fig Mid-infrared (10-μm) size-luminosity relation

Size-luminosity: near-IR vs. mid-IR

Near-IR (Millan-Gabet+ 2007)

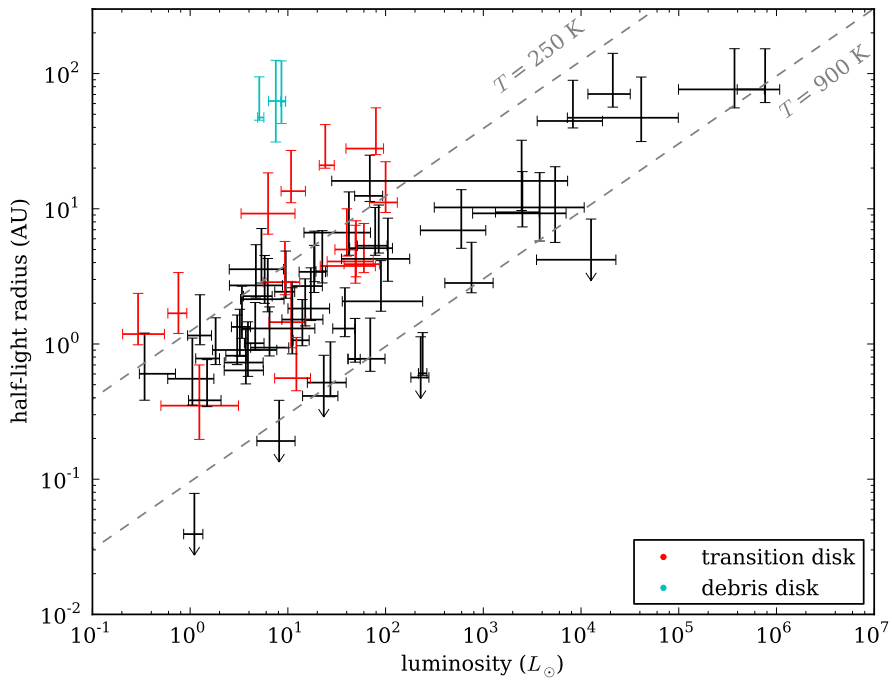


tight relation

Physics: dust sublimation

$\leftrightarrow$

Mid-IR (our MIDI sample)



loose relation

Physics: **flaring + gaps?**

Flaring

Flaring disk intercepts more stellar flux

Mechanism:
#(small grains) $\uparrow \implies$ flaring $\uparrow$

Observational appearance of disk:

1. larger
2. redder

$\Rightarrow$ small, large

Fig Flaring vs. flat disk

Color: the MIDI sample

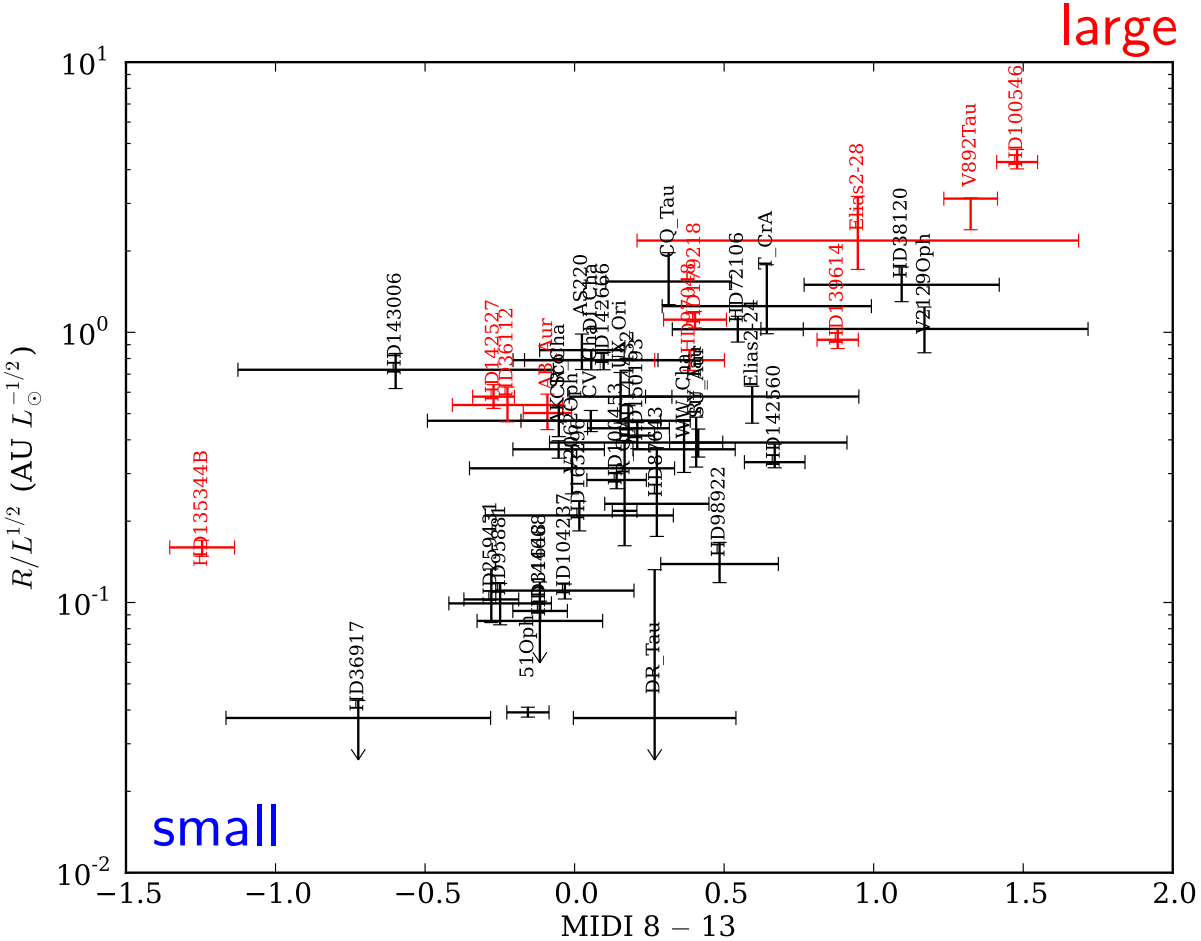


Fig Correlation between **normalized size** and **color**: larger disks are redder

Distinguishing flaring from gaps?

Model population

Grid of radiative transfer models for (gapless) disks

(varying dust mass $M_{\rm dust}$, surf. dens. p, settling parameter α, halo mass $M_{\rm halo}$, particle size distr. q)

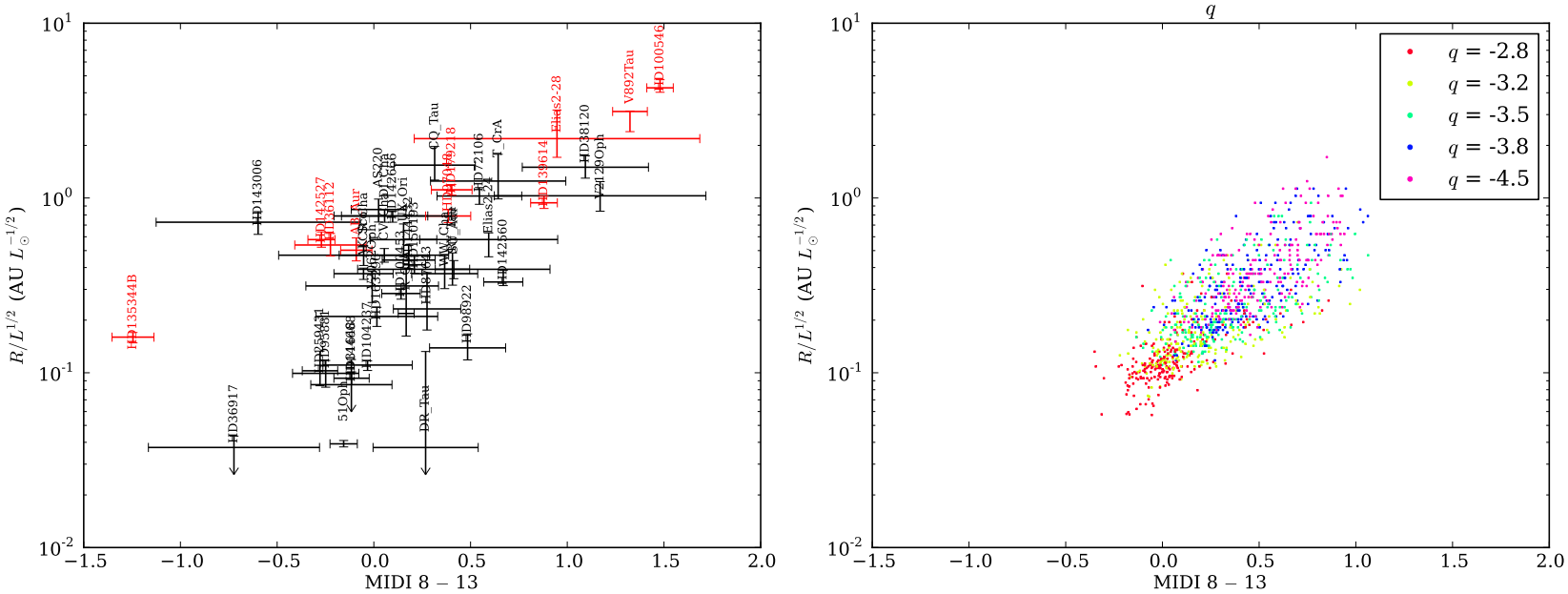
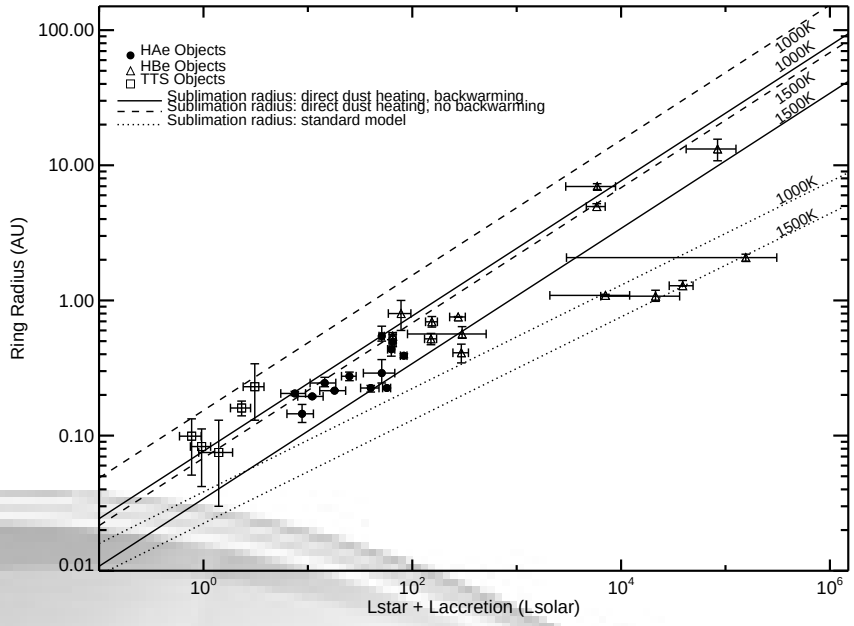


Fig Gapless disks explained by flaring (i.e., amount of small grains)

Size-luminosity: near-IR vs. mid-IR **revisited**

Near-IR (Millan-Gabet+ 2007)

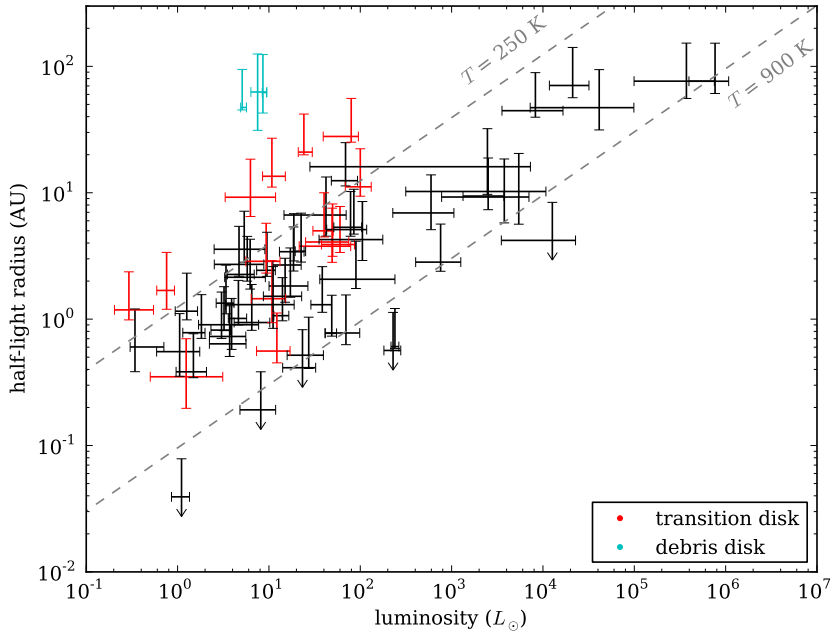


tight relation

Physics: dust sublimation

↔

Mid-IR (our MIDI sample)



loose relation

Physics: **flaring + gaps**

Flaring: correlation with spectra?

Physics of flaring: #(small grains) $\uparrow$ $\Longrightarrow$ flaring $\uparrow$

Expected: correlation between disk size and spectra
(= probe for small grains)

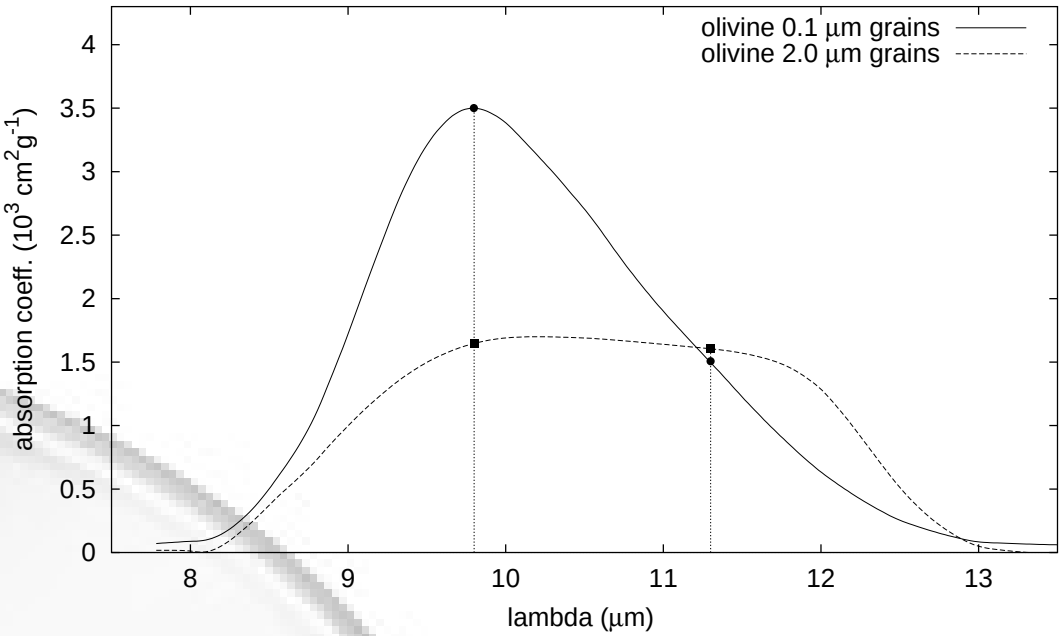


Fig Emission of sub-micron and micron-sized silicates (Przygodda+ 2003)

Flaring vs. gaps?

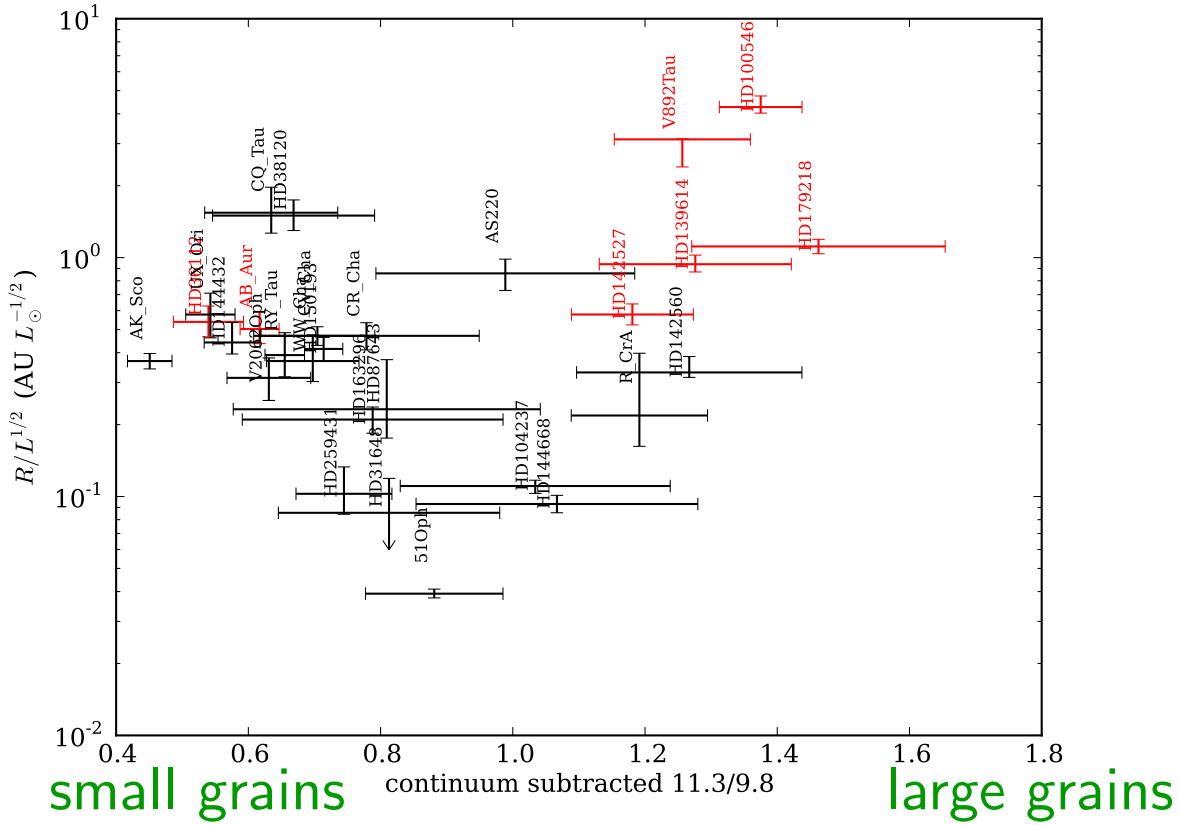
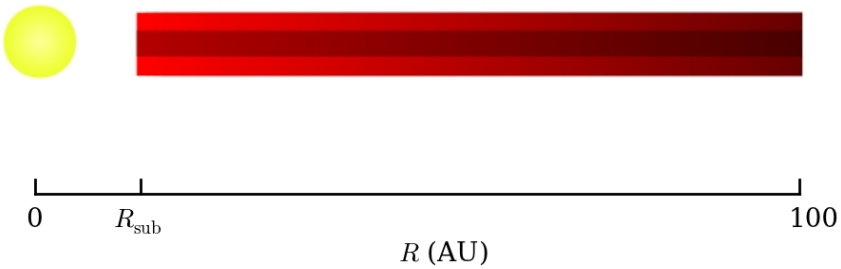


Fig Correlation between **normalized size** and **grain processing**? (*silicate-feature sources only*)

First results: 2. Towards a family picture

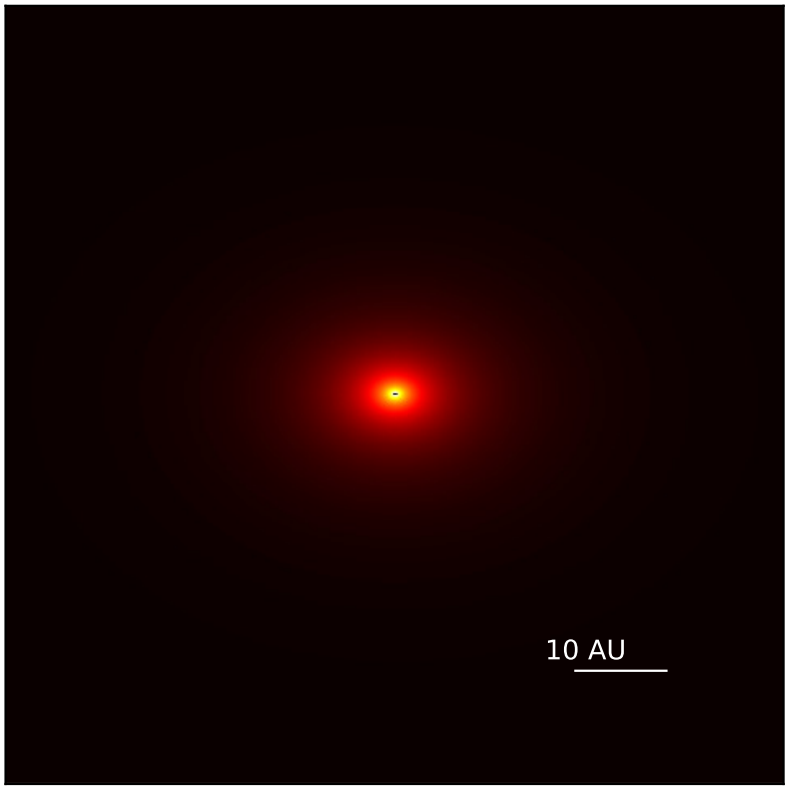
Two-layer model, homogeneous disk

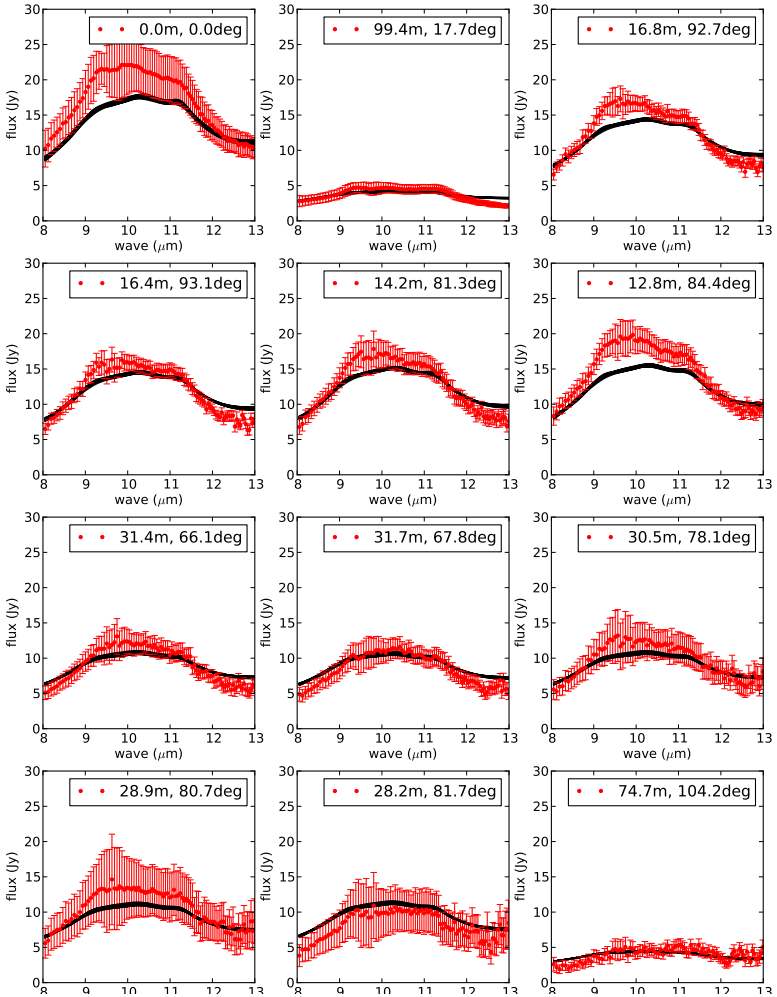


Physics:

1. inclination **i**, position angle **PA**
2. $T(R) \propto R^{-\mathbf{q}}$, with $R_{\rm in} = R_{\rm sub}$ and $R_{\rm out} = 100\,{\rm AU}$
3. silicate dust species + carbonaceous grains: $\boldsymbol{\kappa_{\rm i}}$

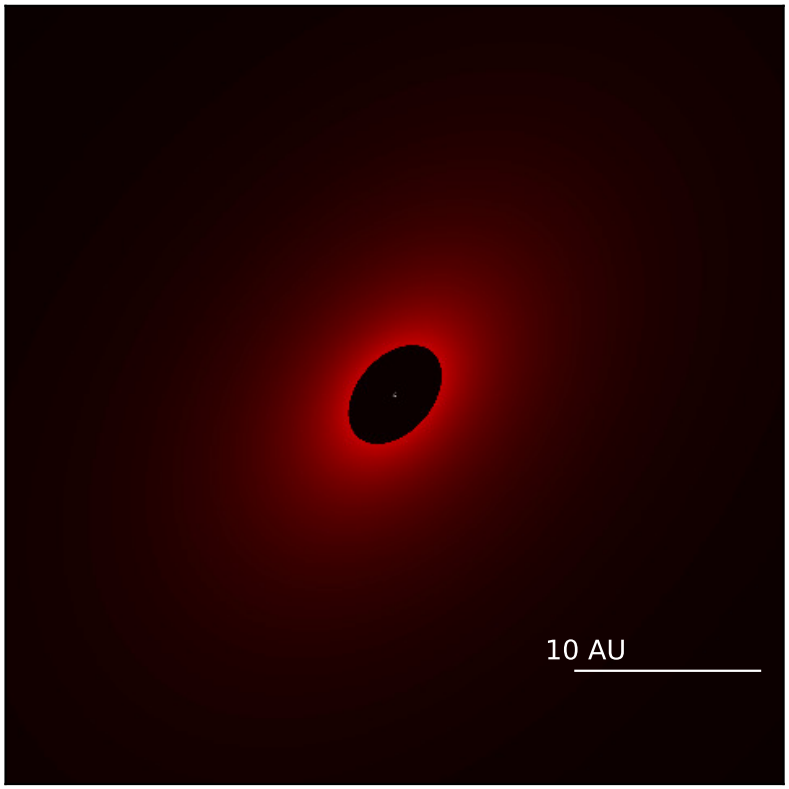
HD 163296

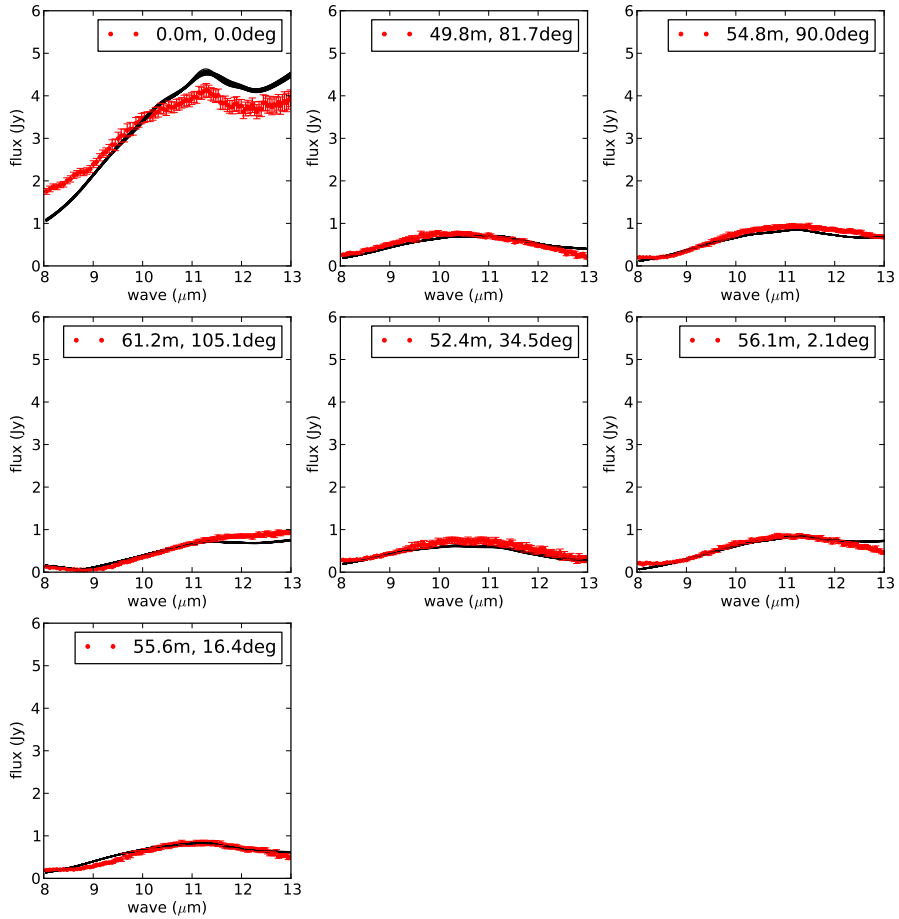




HD 163296: model image (*left*), fit to correlated fluxes (*right*)

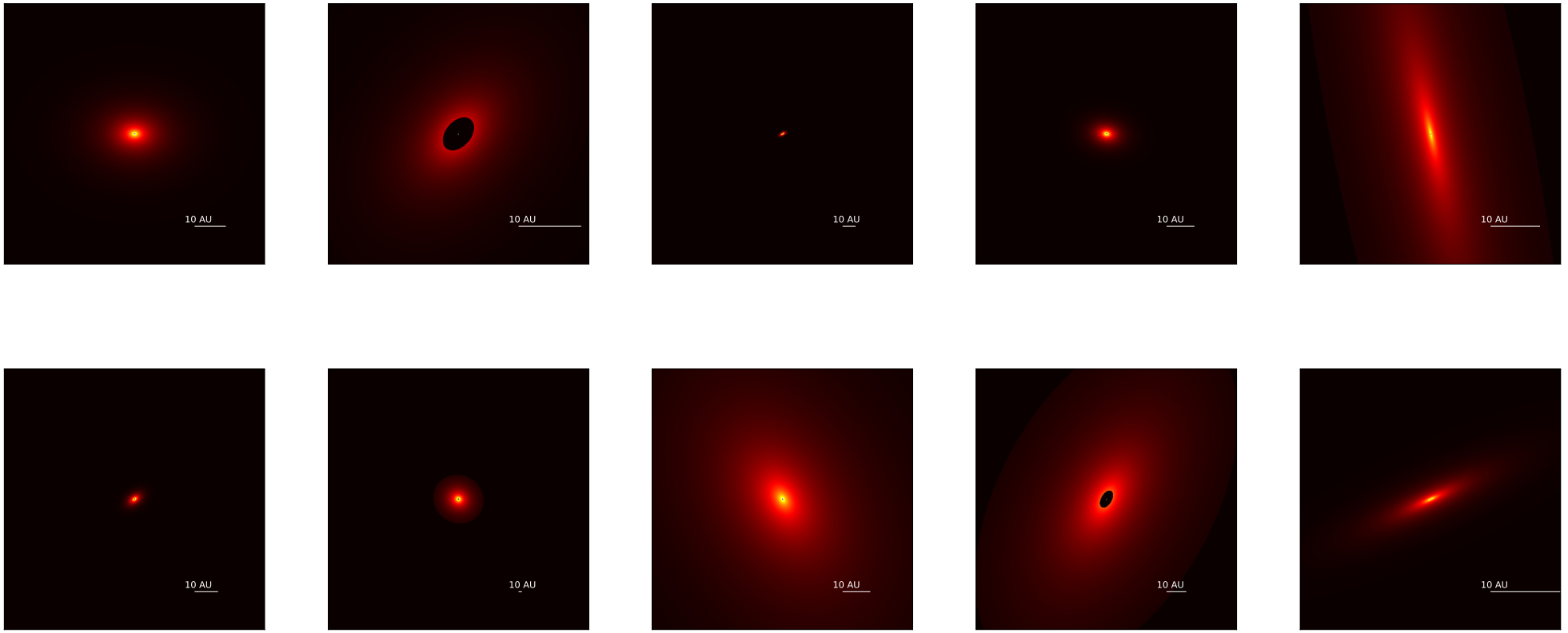
HD 139614





HD 139614: model image (*left*), fit to correlated fluxes (*right*) (*cf. Matter+ 2014*)

A family picture?



Preliminary "images": HD 163296, HD 139614, 51 Oph, HD 104237, RY Tau, HD 144668, HD 98922, HD 36112, HD 179218, HD 142560

Conclusions

MIDI: structure (and composition) of protoplanetary disks

The MIDI-Herbig project: statistics!

Preliminary results:

1. size-luminosity diagram for full sample of objects: flaring vs. gaps?
2. first model images

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