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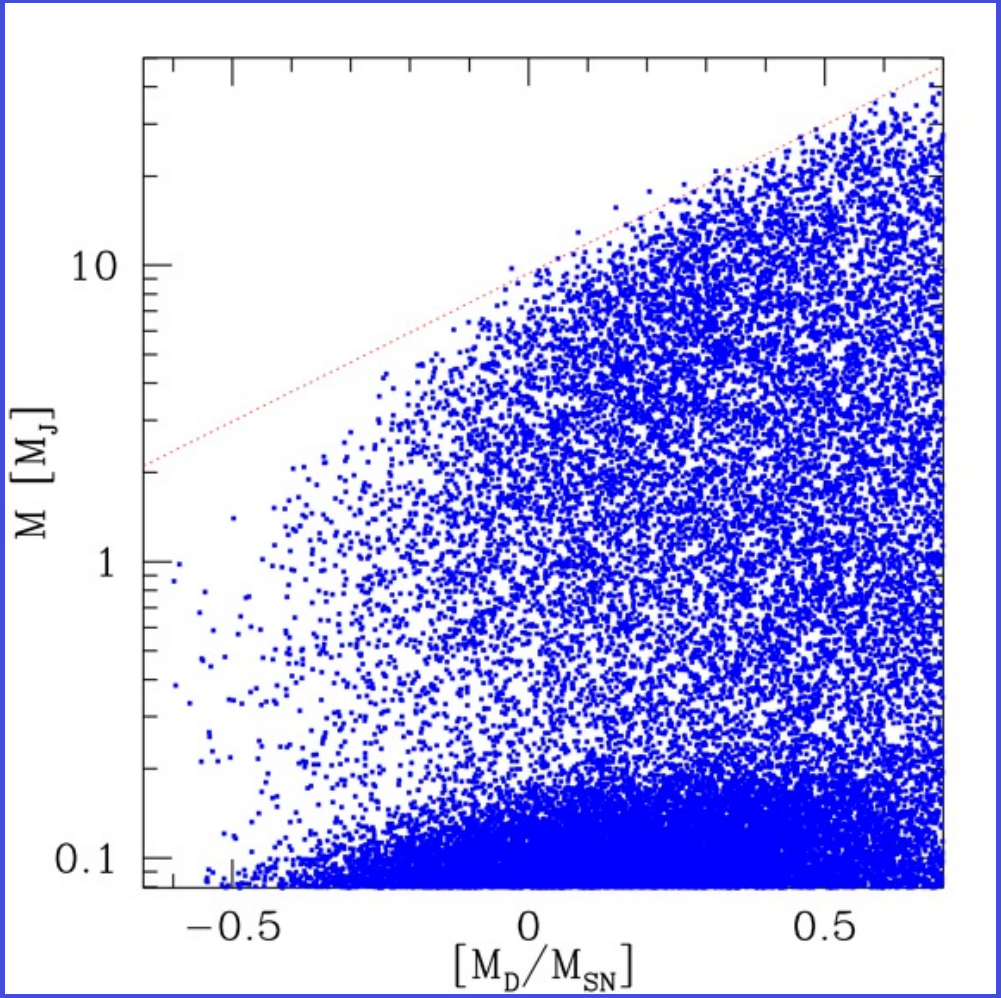
A Herschel Search for Cold Dust in BD Disks

From Atoms to Pebbles, Herschel Meeting, Grenoble, March 2012

Motivation

- Disk masses and structure as a function of stellar mass
- Planetary system architectures around BDs/low-mass stars



Mordasini ea. 12

Background

- Detection of disks around BD dwarfs from IR to submm wavelengths

  (e.g. Klein ea. 03, Apai ea. 04, Bouy ea. 08, Luhmann ea. 10)

- Many sensitive Spitzer/WISE studies [Lifetime]

  (e.g. Allers ea. 06, Hernandez ea. 07, Guieu ea. 07, Luhman ea. 10, Riaz ea. 12)

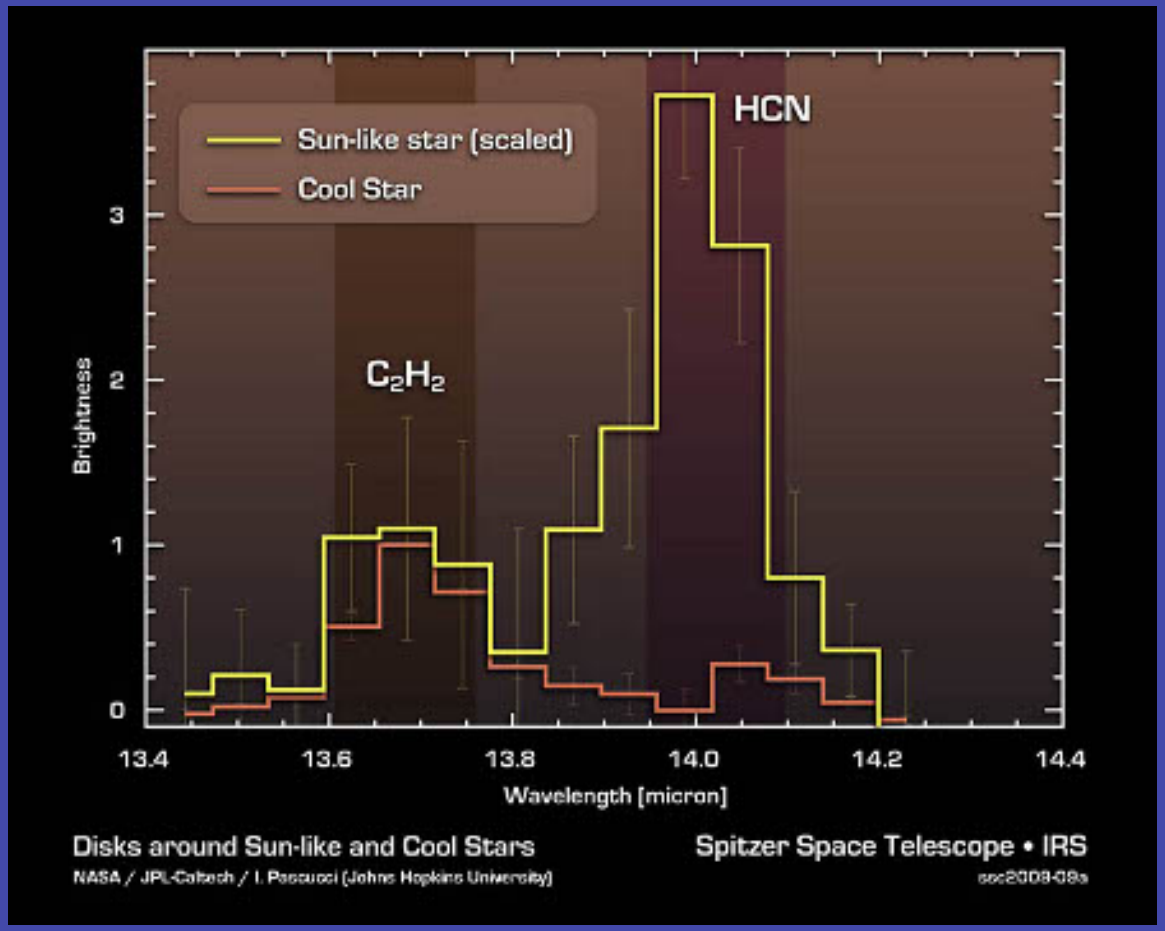
- Very few objects detected at submm wavelengths:
  Disks masses are up to few Jupiter masses (10^{-5}-10^{-3} M_{sun})
  Relative masses in the 1-5% range

  (Klein ea. 03, Scholz ea. 09, Boy ea. 08, Riaz ea. 12)

- Spitzer spectroscopy indicates flatter disks and more evolved dust than in disks around T Tauri stars

  (Apai ea. 05, Pascucci ea. 09, Sicilia-Aguilar ea. 09; see also Szücs ea. 10)

Difference in Gas Content



Pascucci ea.09

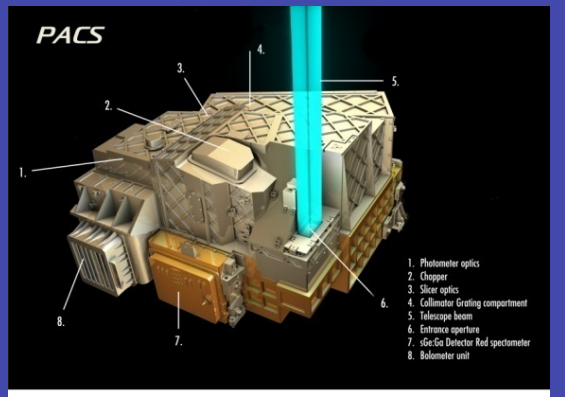
N atoms from photodissociation of N_2

The Herschel Program

Structure and Evolution of Discs around BDs and VLM Stars

P.M. Harvey, Th. Henning, Yao Liu, F. Ménard, C. Pinte, S. Wolf, L.A. Cieza, N.J. Evans, I. Pascucci

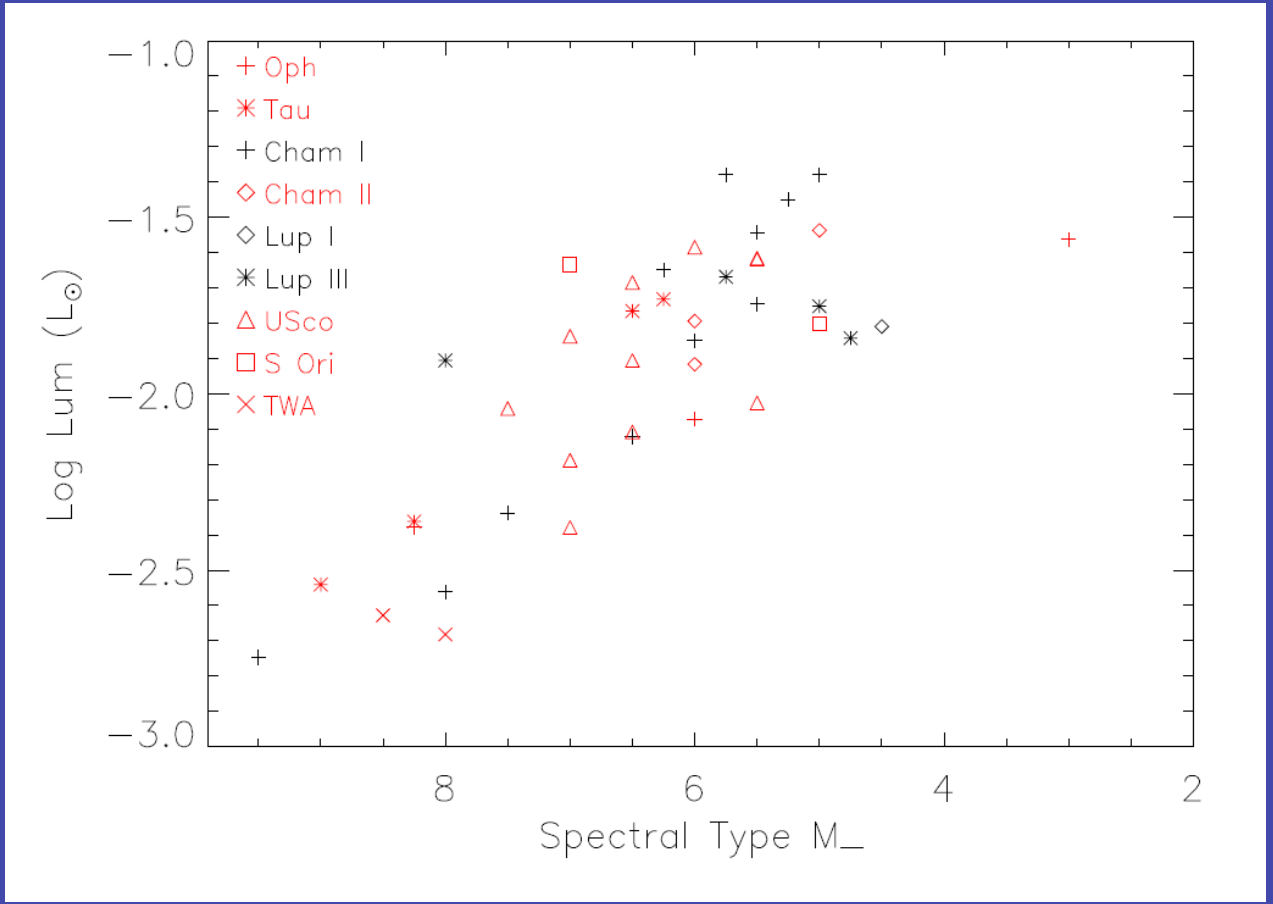
Deep PACS Photometry of 49 young BDs in SF regions with different ages and spectral types at 70 and 160 microns



PACS mini-scan-map mode + psf fitting tool c2dphot

(Only 2 reported Spitzer detections at 70 microns: Guieu et al. 2007, Riaz & Gizis 2008)

Sample

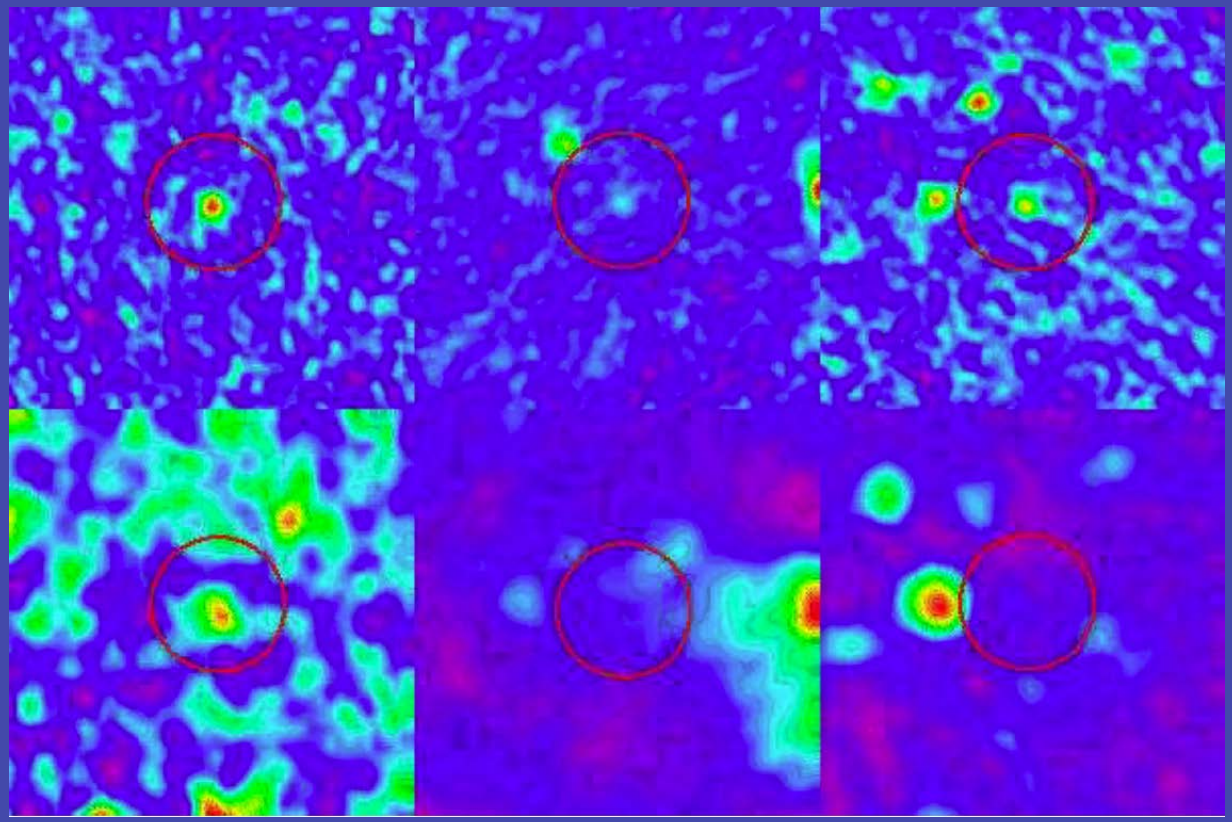


- Most objects have spectral types later than M 5
- Ages from 1-2 Myrs (Tau, Oph, …) to 10-12 Myrs (TWA, U Sco)
- Evidence for disks from Spitzer observations
- Regions of low structured diffuse emission based on Spitzer images

First results

70 μm

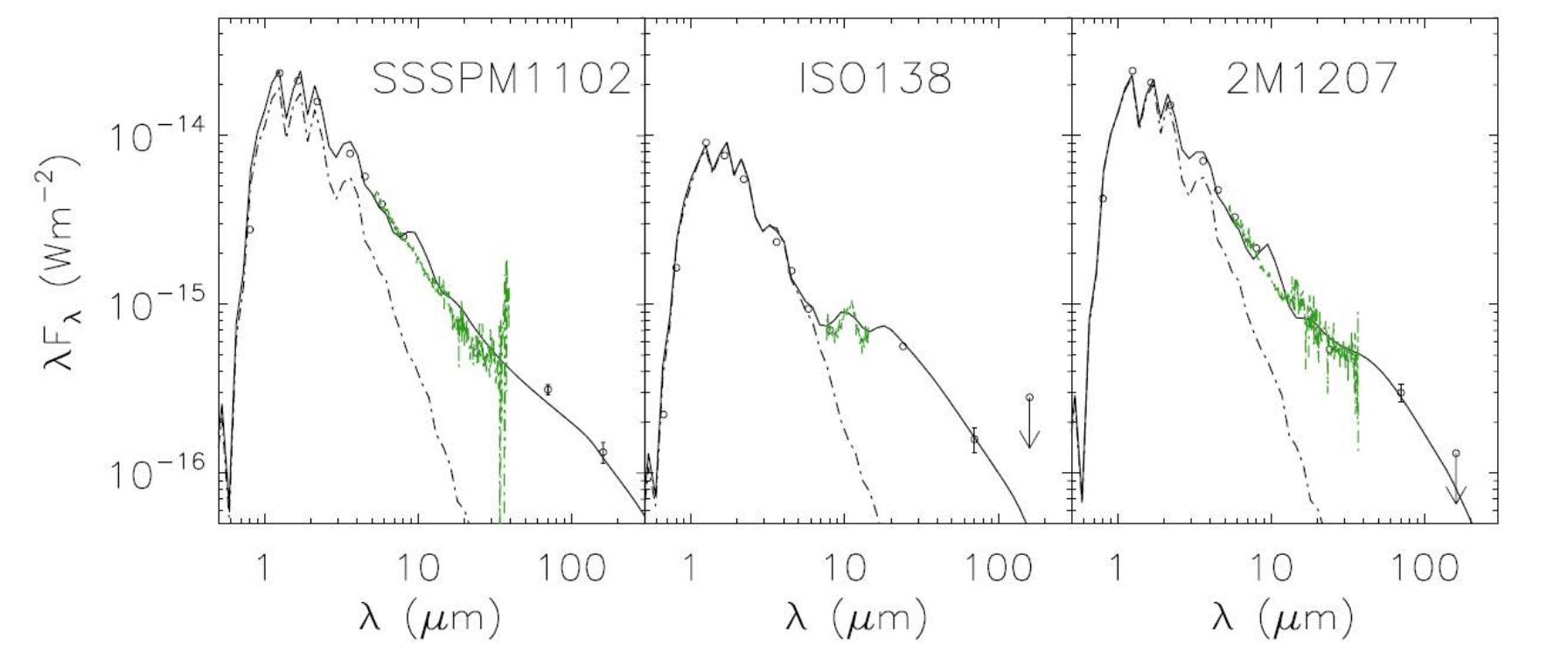
160 μm



SSSPM1102 ISO 138 2 MASS 1207

M8.5 in TWA M6.5 in ChaI M8 BD in TWA

First results



$5x10^{-5}$ M_{sun} few x 10^{-6} M_{sun} few x 10^{-5} M_{sun}

Harvey, Henning, Ménard et al. (2012)

Analysis Tools

MC3D (Wolf, Henning, Stecklum 1999)

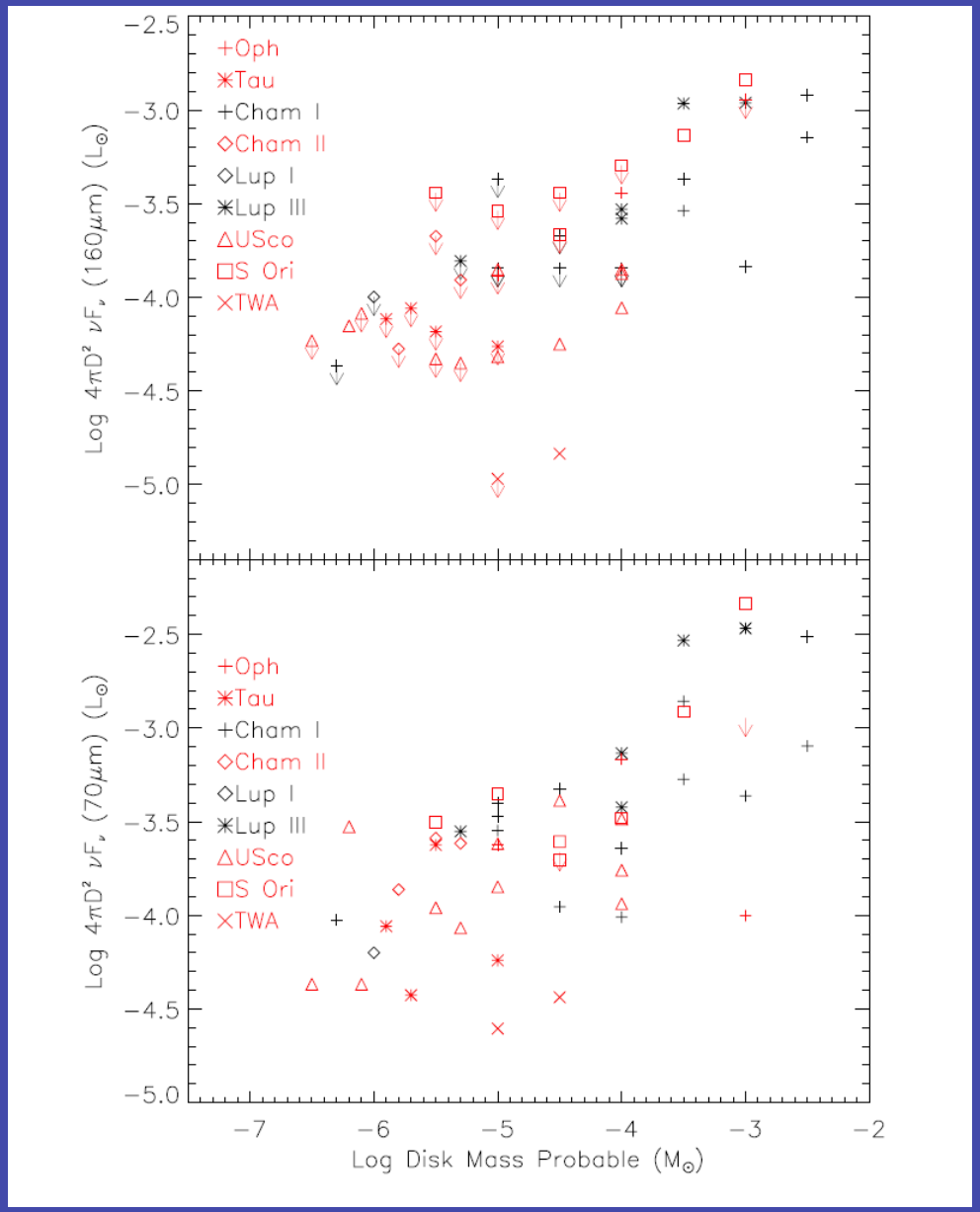
MCFOST (Pinte et al. 2006, 2009)

3D Monte Carlo radiative transfer models with NextGen stellar atmosphere parameters

Disk model with power law surface density and prescribed disk scale height $h(r)=h_o\ (r/r_o)^{\gamma}$

Supplementary 2MASS, DENIS, WISE, Spitzer IRAC/MIPS and IRS (36 objects) data: Very complete SEDs for all sources

Complete Sample

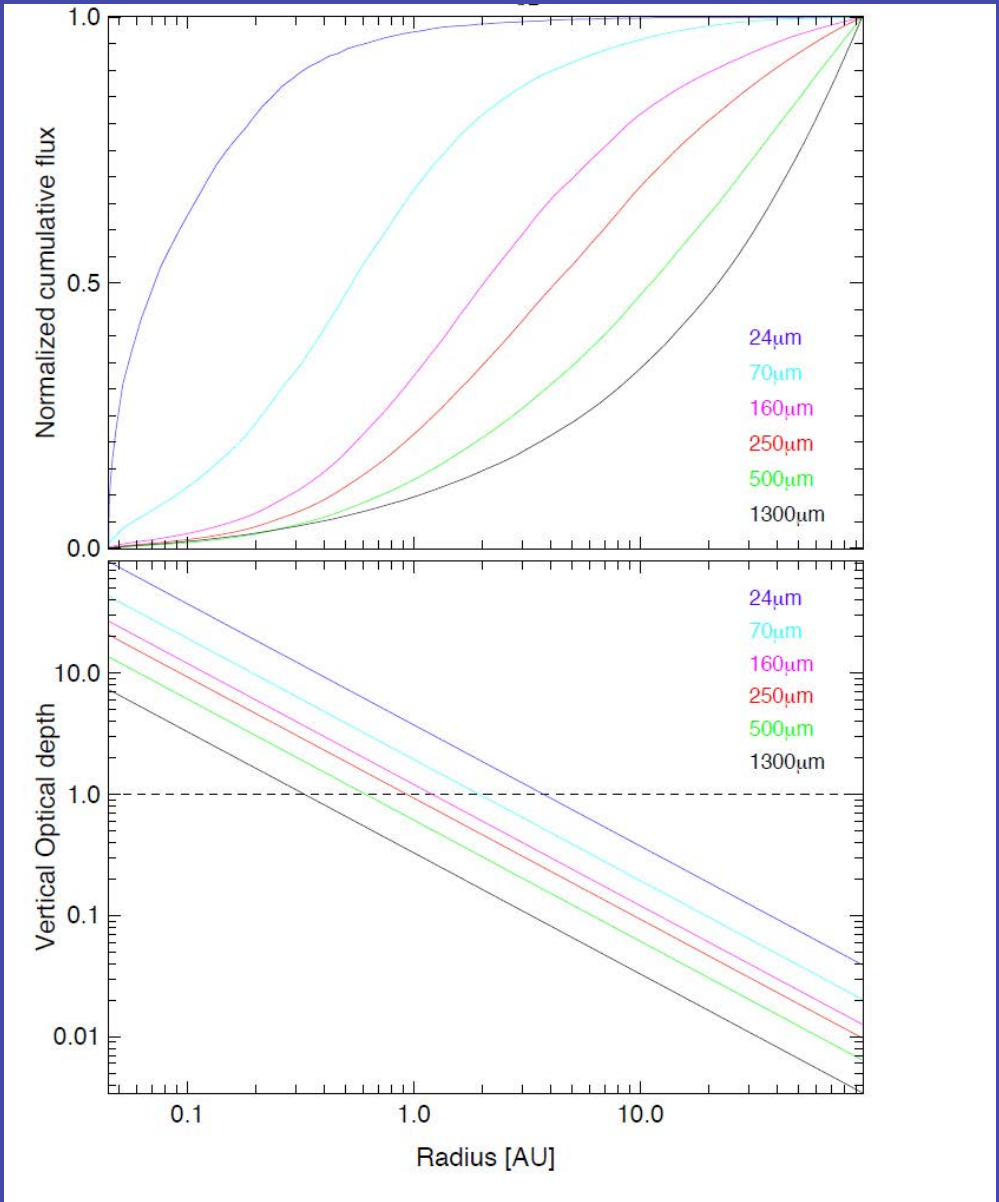


- 38 detections at 70 μm
  16 detections at 160 μm
- Disk masses between 10^{-6} up to 10^{-3} M_{sun};
  Median value of $3x10^{-5}$ M_{sun}
  (0.03 M_{jup})

T Tauri stars: 10^{-3}-10^{-1} M_{sun}
(Andrews & Williams 05, 07)

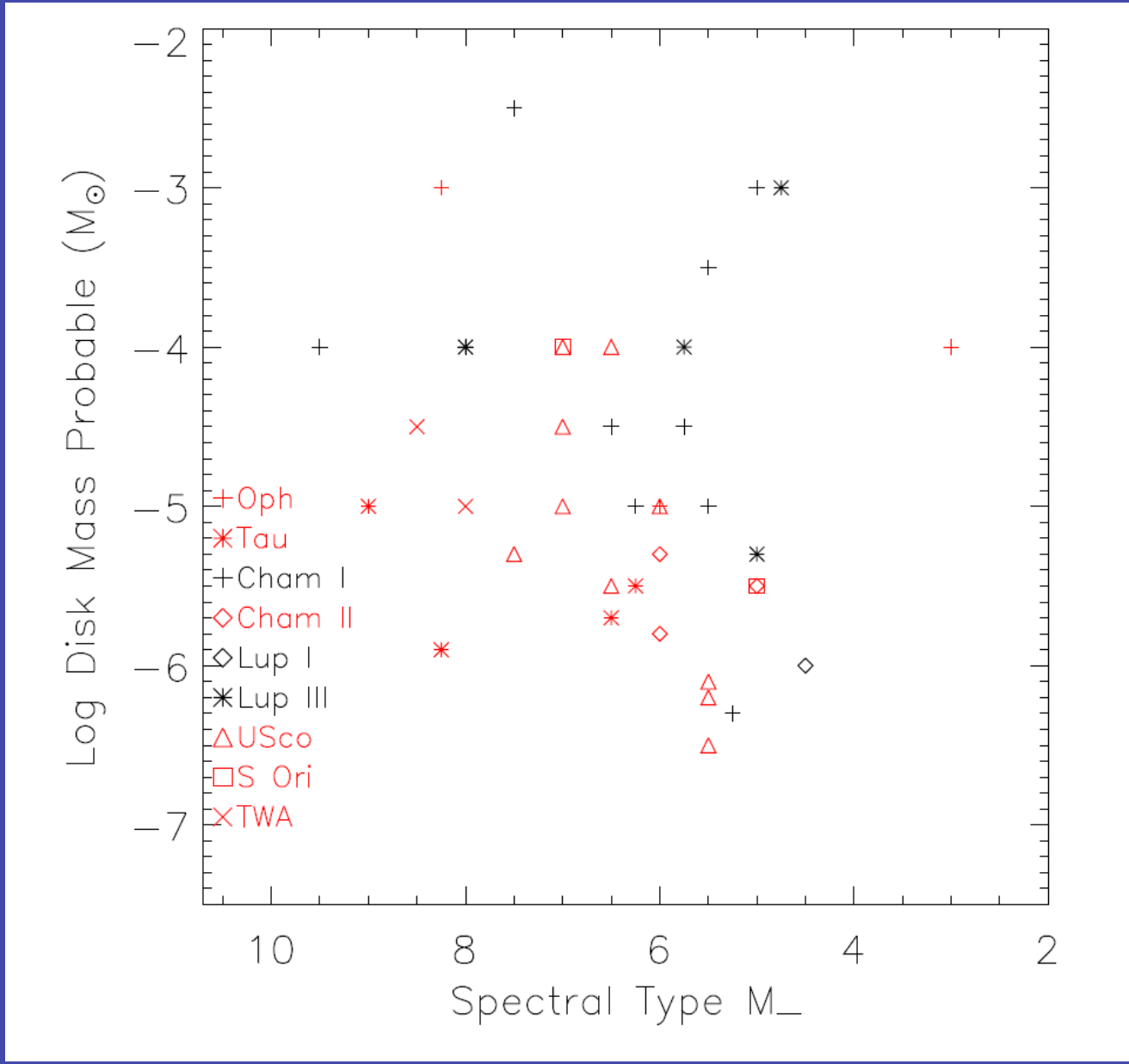
- Relative good correlation between disk mass and 160 μm flux
- Scale height of 5-20 AU at 100 AU (dust sedimentation)

BD disks mostly optically thin at 160 μm …



$M_{dust} = 2\ 10^{-6}\ M_{sun}$
H= 10 AU at 100 AU
p = -1.0
T_{eff} = 3000 K
i = 30 degrees

BD disk masses and spectral types



Conclusions and Perspective

- Herschel is providing a legacy for BD disk studies (disk masses, flaring, surface density profile, …)

- Excellent sample for ALMA observations