Circumstellar Disks and the Dawn of Planetary Systems

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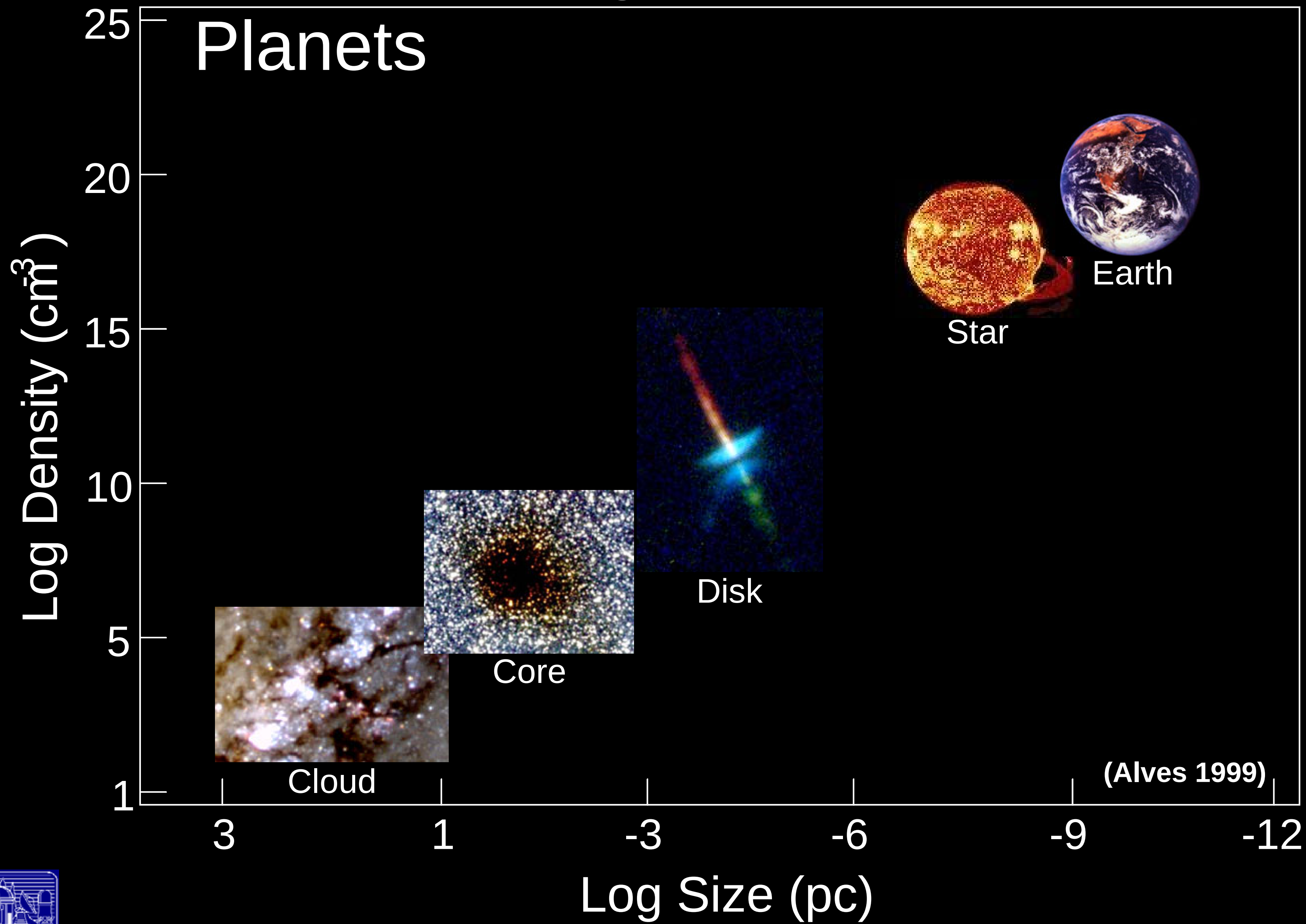
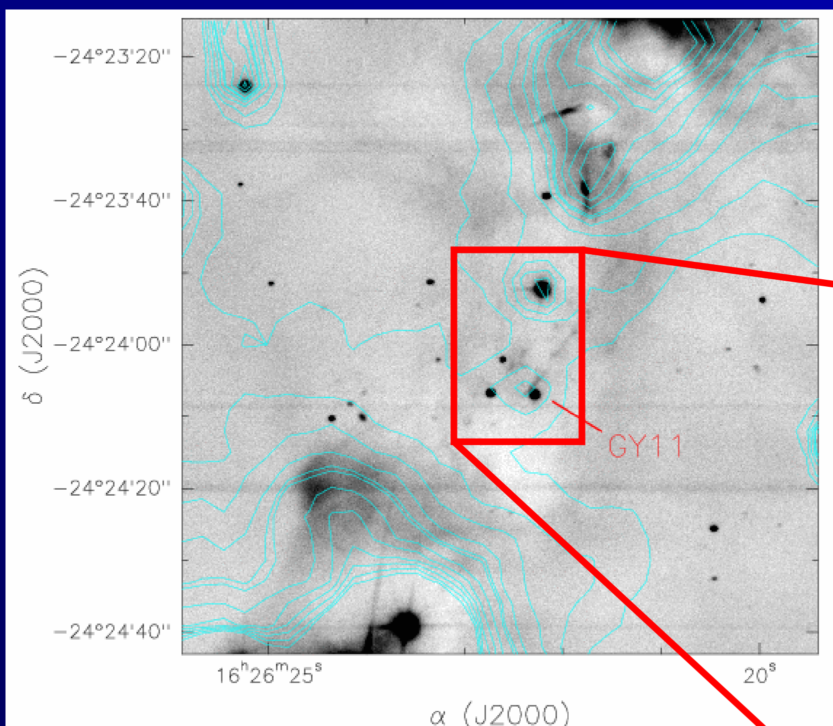
- The Role of Disks in the Formation of Stars and Planets
- Circumstellar Disks across the Stellar Mass Spectrum
- Disks Evolution and the First Steps towards Planetary
- Circumstellar Disks with ALMA

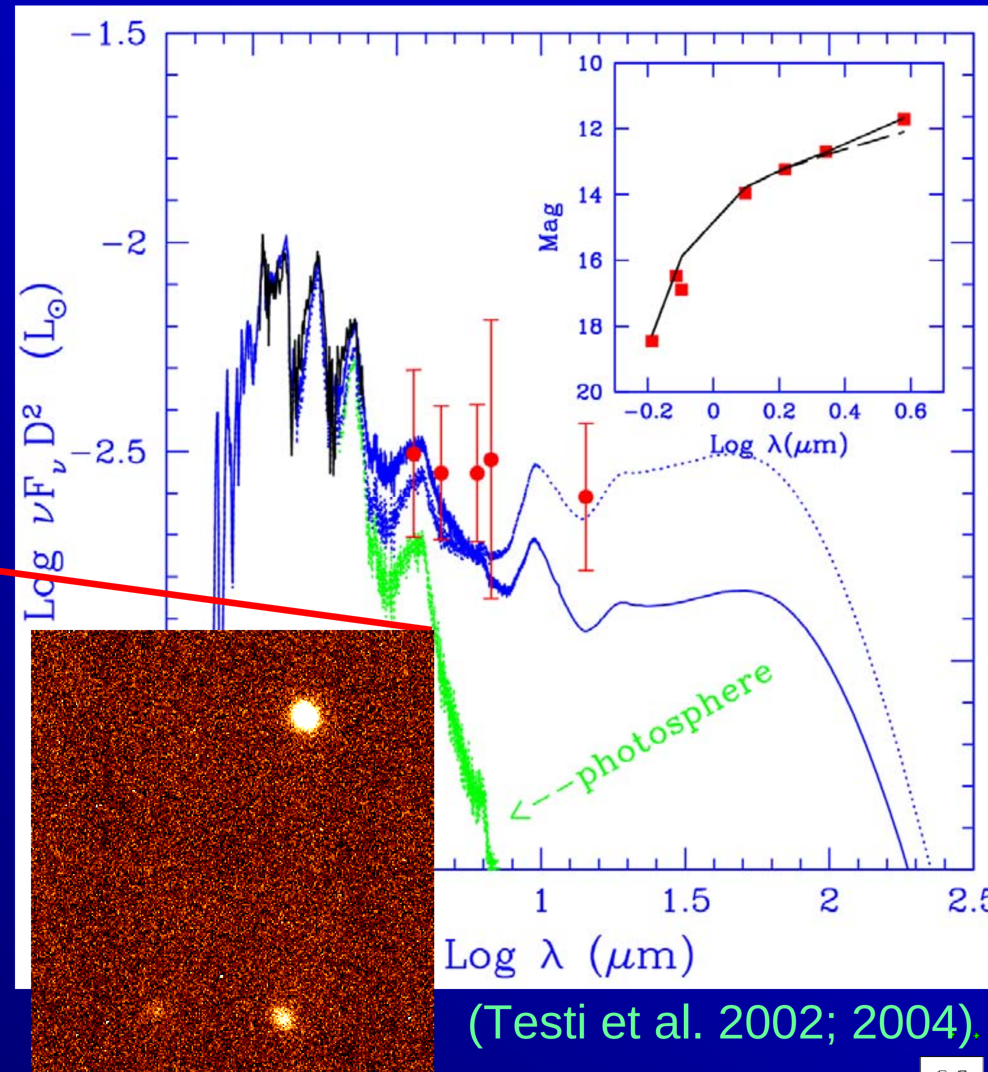
From diffuse gas to Stars and Planets



The Case of GY11/CAM033

- M~8-12 M_J ; age<1Myr
- MIR excess: flared disk with hole
- IR is very sensitive to hot dust, but total disk mass: mm-λ



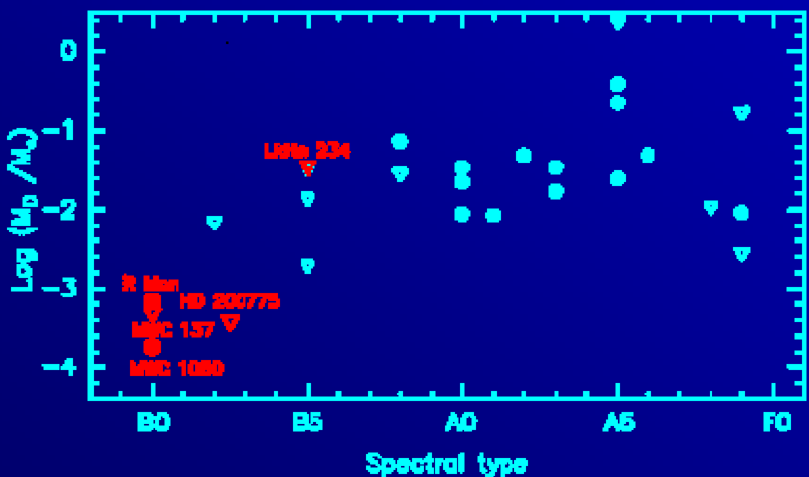


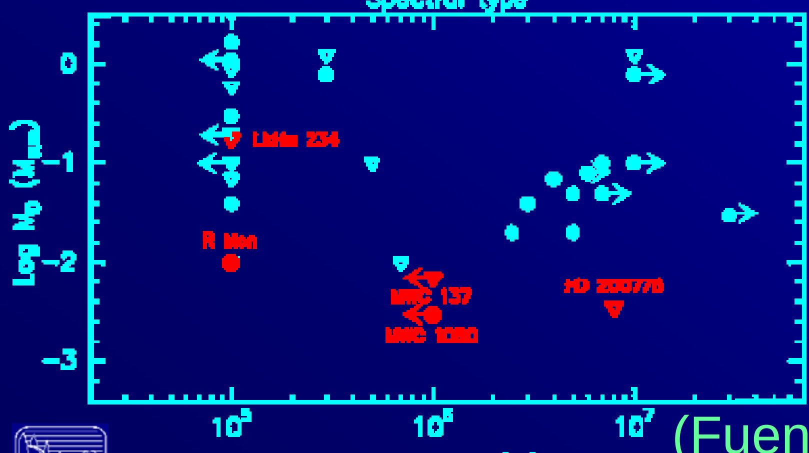
(VLT/ISAAC 3.5 μm)

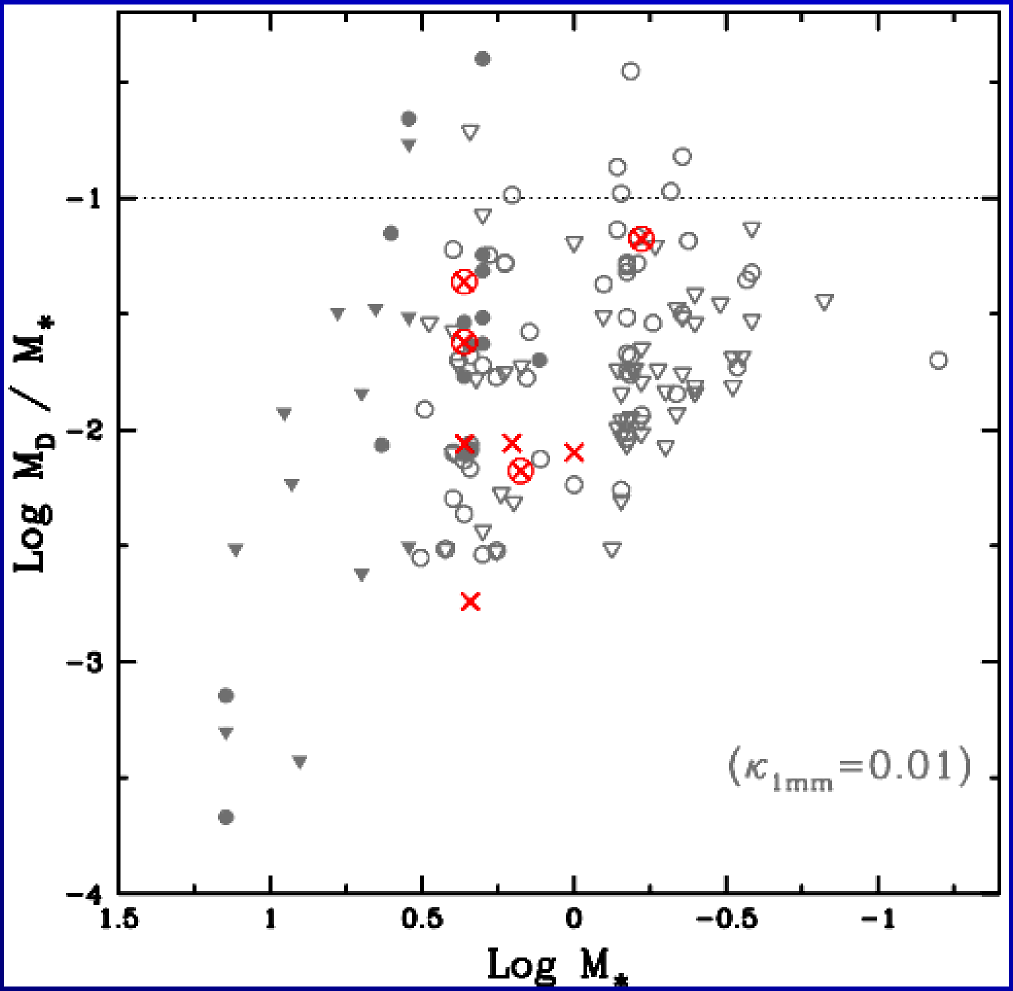
(Testi et al. 2002; 2004)

Disk Masses

- Disk masses derived from mm continuum observations



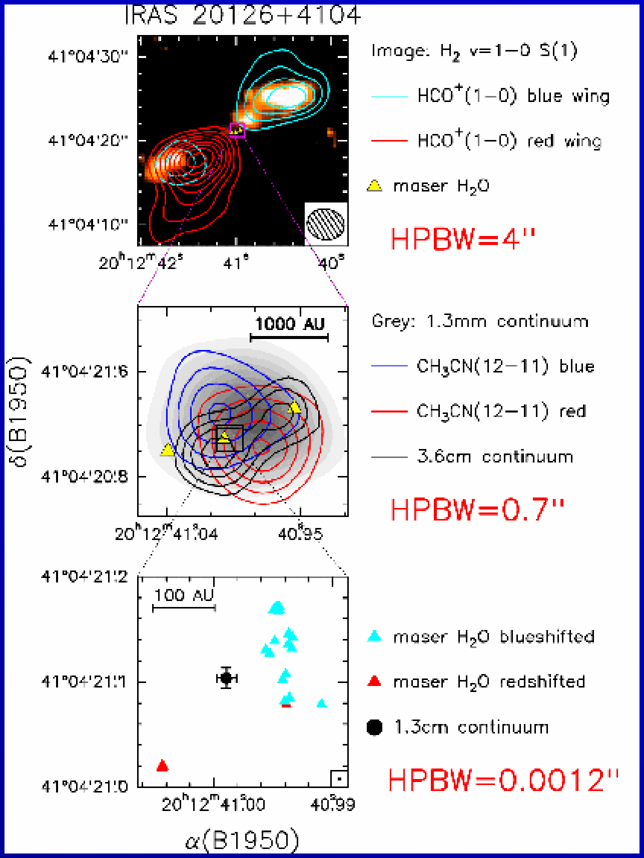




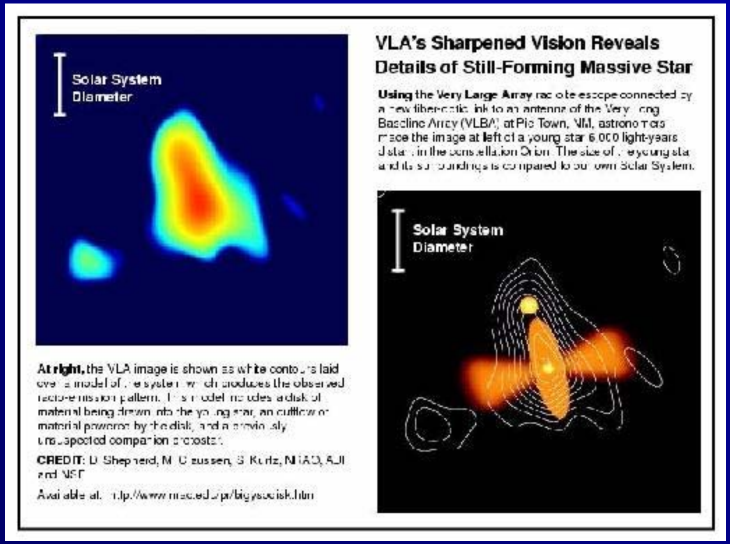
(Fuente et al. 2003)

Disks and High-Mass

- There is evidence that also high-mass surrounded by massive (accretion?) disks
- Best examples:
  - **G192** (Shepherd et al. 2001)
  - **IRAS 20126+4104** (Cesaroni et al.



G192: 7mm cont
40 mas resol
VLA+PT



VLA's Sharpened Vision Reveals Details of Still-Forming Massive Star

Using the Very Large Array radio telescope connected by a new fiber-optic link to an antenna of the Very Long Baseline Array (VLBA) at Pie Town, NM, astronomers made the image at **left** of a young star 6,000 light-years distant in the constellation Orion. The size of the young star and its surroundings is compared to our own Solar System.

At right, the VLA image is shown as white contours laid over a model of the system which produces the observed radio-emission pattern. This model includes a disk of material being drawn into the young star, an outflow of material powered by the disk, and a previously unsuspected companion protostar.

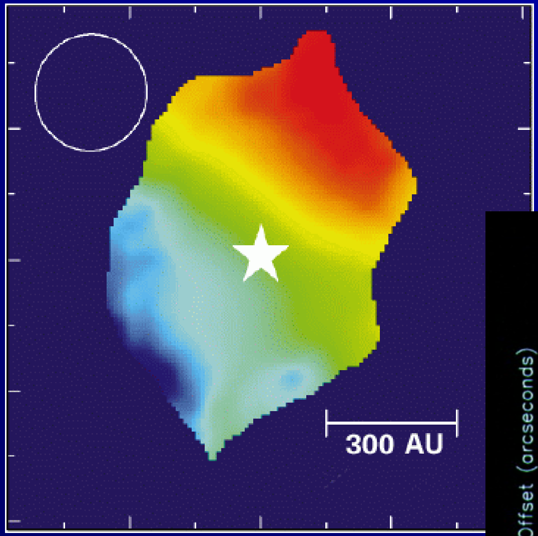
CREDIT: D. Shepherd, M. Claussen, S. Kurtz, NRAO, AUI and NSF

Available at: http://www.nrao.edu/pr/bigyso/disk.htm

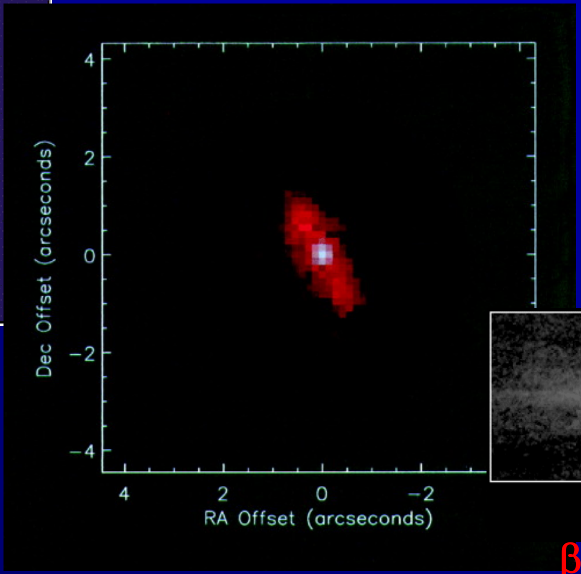
I20126: CH_3CN
PdBI

Disk Evolution

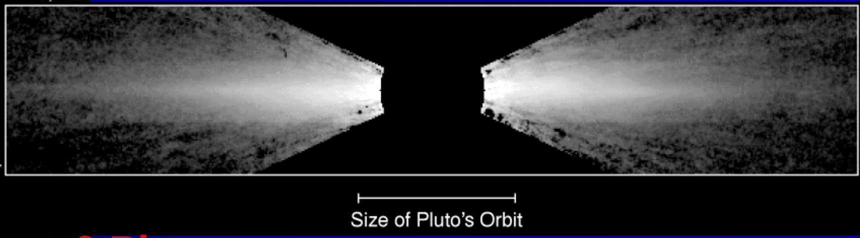
- There is evidence that disk evolution and planet formation on timescales of a few million years



MWC 480
Young gaseous disk – 6 Myrs
CO(2-1): Mannings et al 1997



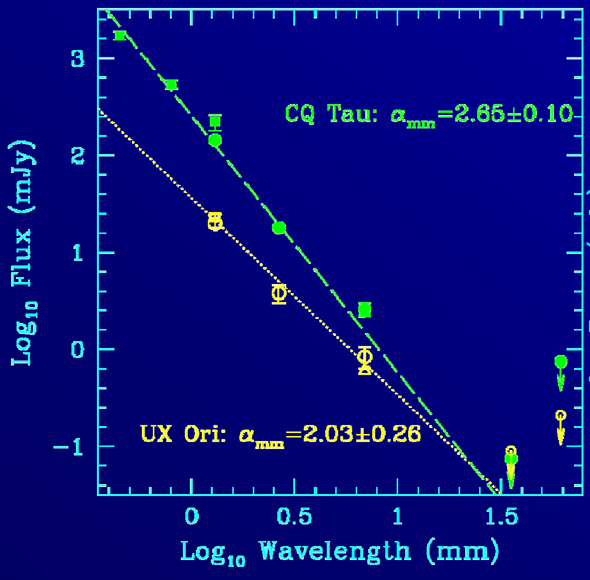
HR 4796 A
Evacuated inner disk – 15Myr
MID-IR: Koerner et al. 1998

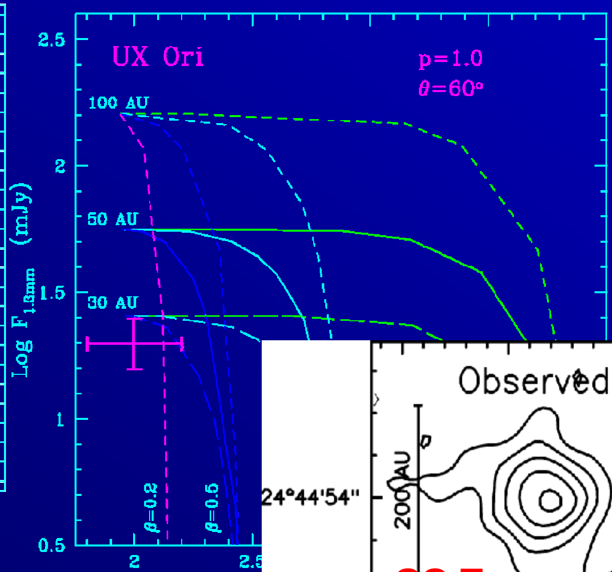


β Pic
Debris disk – 100 Myrs
Scattered light: Burrows et al. 1995

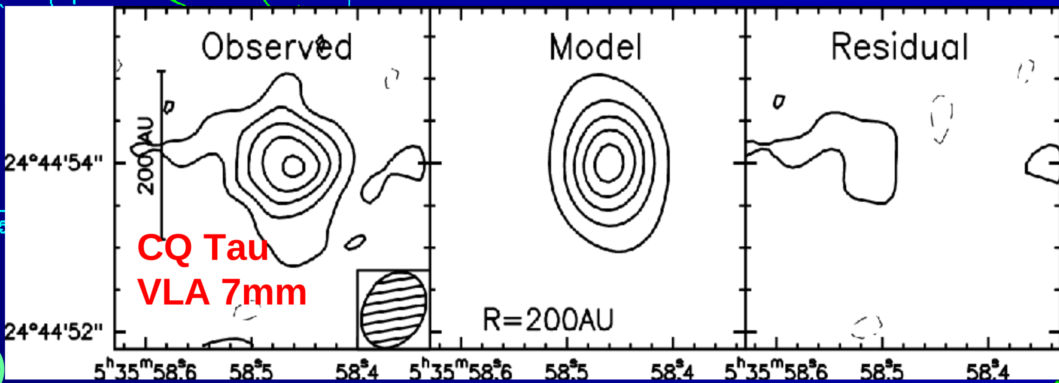
Evolved dust in HAe disks

- Search for the presence of large (cm-size) grains
- The basic idea is to search for mm spectra that approach the spectrum ⇒ this limiting case is reached only if the disk is dust opacity is grey (size>>λ). **[$F_\nu \sim \nu^\alpha; \alpha=2+\beta; \kappa_\nu \sim \nu^\beta$]**





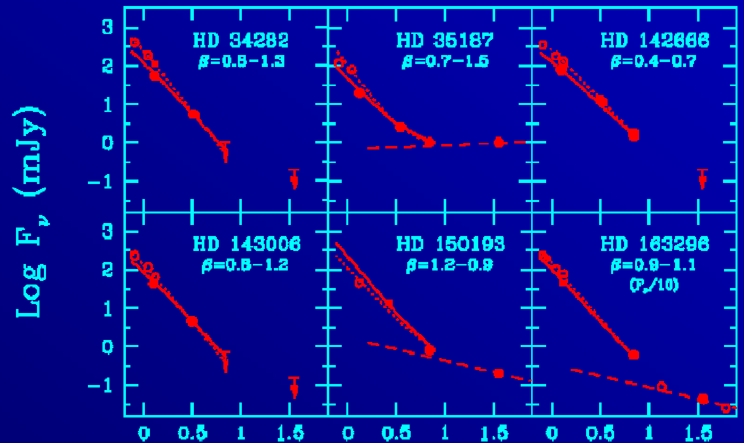
1. **Very small, optically ISM grains disk**
2. **Large disk with very (few cm size) grains**

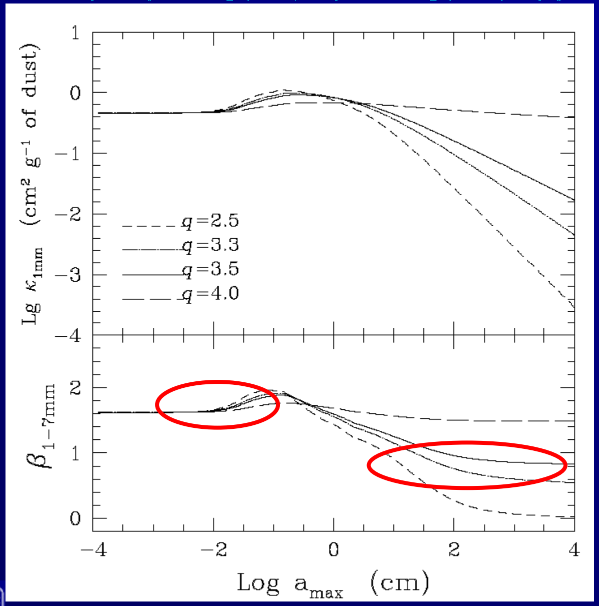


VLA 7mm and 3.6cm

a ≥ 10cm (Testi et al. 2001; 2003)

A small survey using mm and VLA)

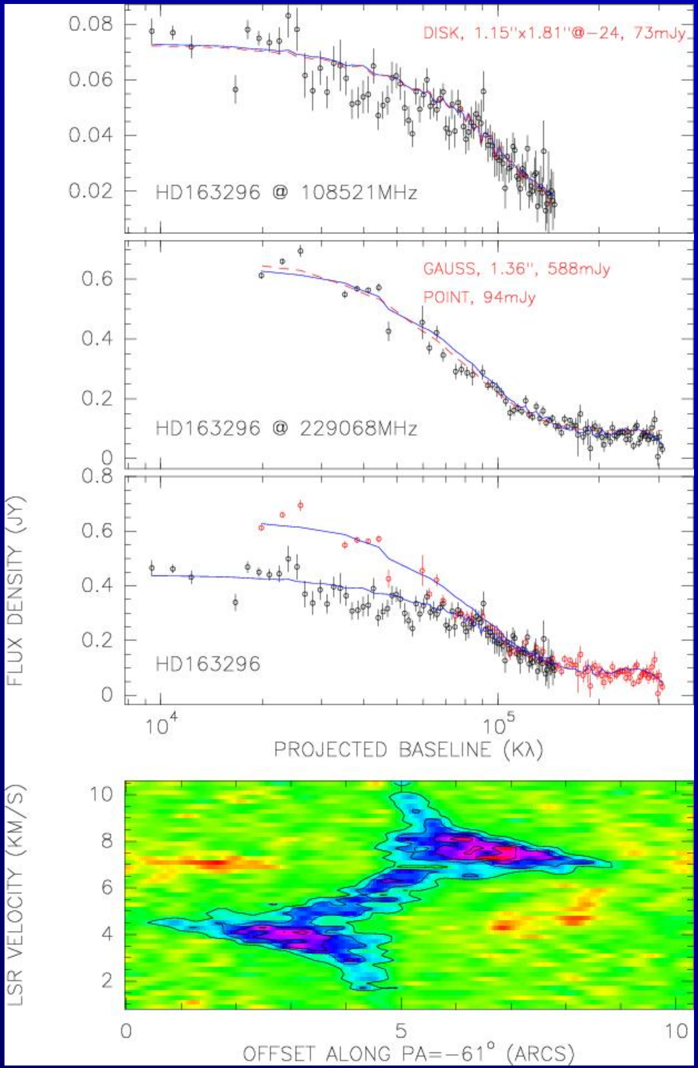




(Natta et al. 2004)

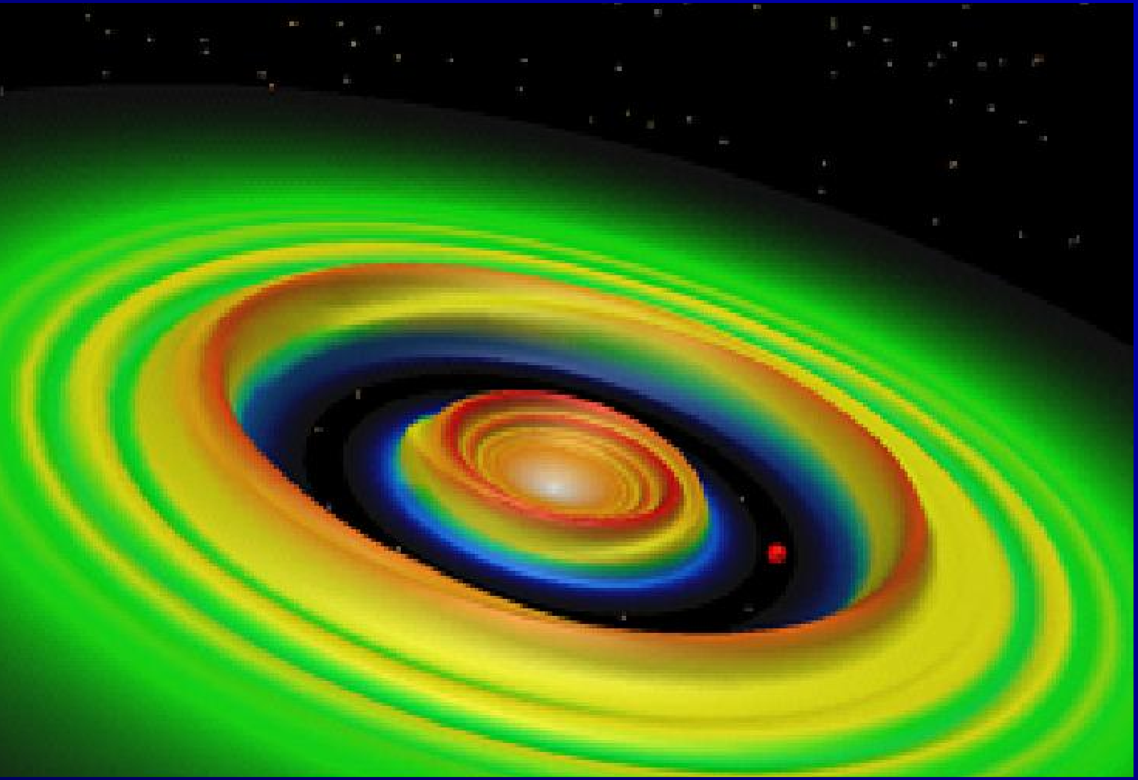
- Lo values of β imply a certain level processing but it is not trivial to maximum particle sizes and how these "pebbles" are around
- Predicted values of β as a function maximum grain size depend on the size distribution, physical and properties
- The dust opacity coefficient [and disk mass estimate] also depend on parameters

The Case of HD163296



- HST (Grady et al.), VLA 7mm
  PdBI 1/3mm observations
  the disk around HD163296
  a gap, possibly due to the
  a planetary object in the disk

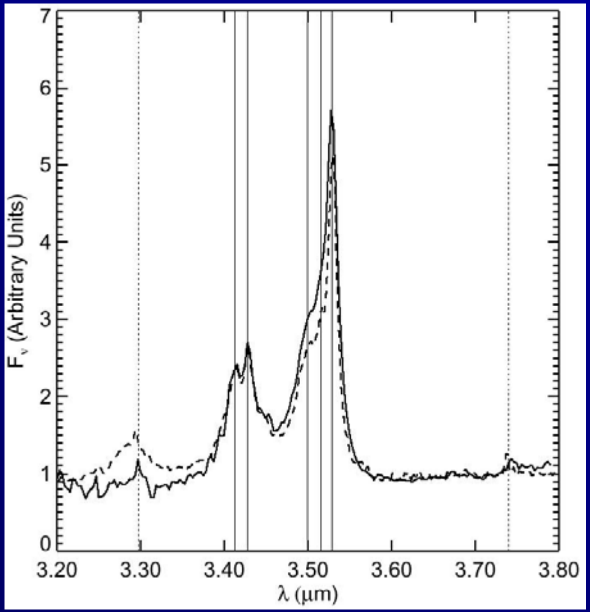
A Bright Future for Disks and Studies in Europe

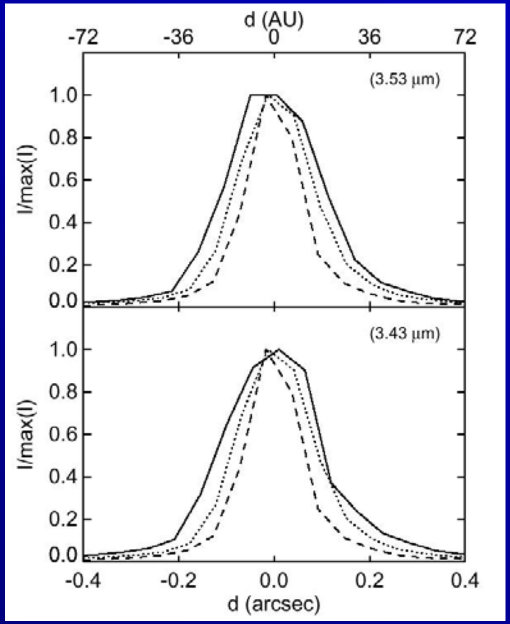


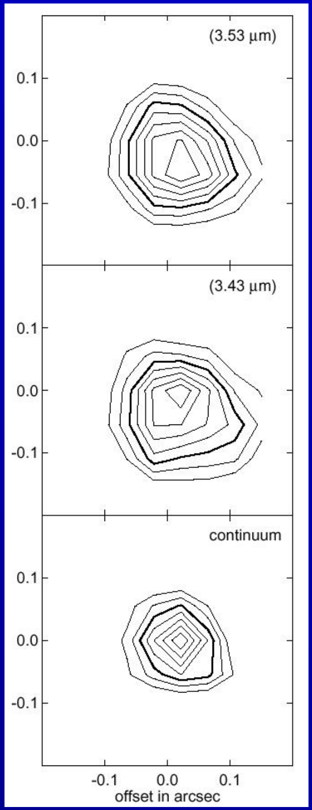
- VLT/AdaptiveOptics
  - Disk surface structure and composition
  - Direct imaging of planes
- VLTI
  - Inner disks structure
  - Disk accretion
  - Disk/Jet interaction
- ALMA
  - Disks structure and composition below 10AU
  - Gaps and density

Diamonds in the HD97048 Disk

- VLT/NACO 0.08 arcsec 3.3μm spectroscopy
- Resolve the spatial location of different dust components







Large Grains: r <=10AU
(nano) Diamonds: r <=15 AU
PAHs: r > 20 AU

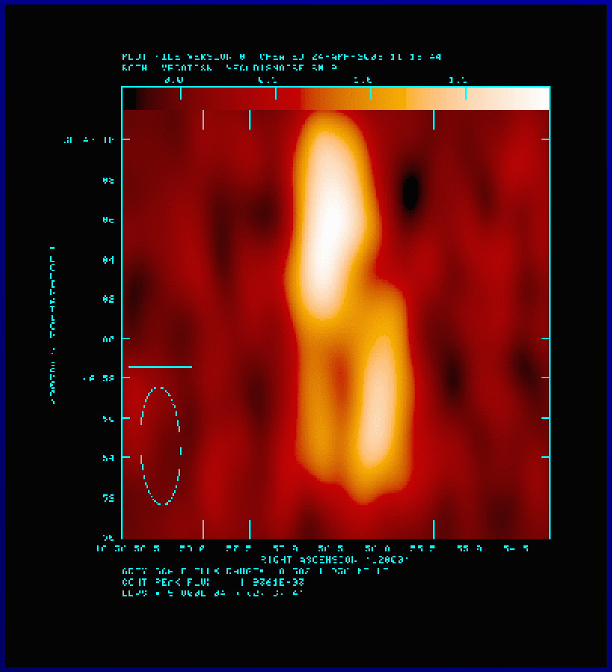
(Habart et al. 2004)

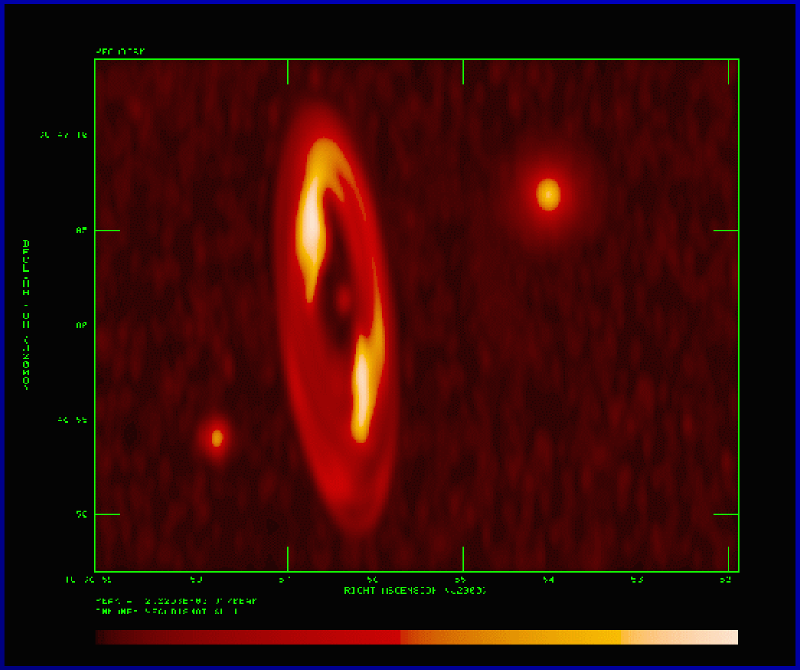
Circumstellar Disks and ALMA

- Obtaining precise (high-fidelity), high angular resolution disks is one of the top science goals of ALMA
  - Long Baselines
  - Large Collective Area
  - Wide Frequency Coverage
- Gas chemical processes and phisical conditions
- Disk structure and evolution (formation of gaps)
- Dust properties and evolution (grain growth processes,

Circumstellar Disks and ALMA

- Simulations of the observations of a disk similar to that as observed with PdB and with ALMA





Summary

- Circumstellar Disks are very common around young stars objects. This is a necessary result of the formation
- Dissipation of disks around massive stars is a fast process 1Myr), while lower mass stars retain massive circumstellar periods (> 10Myr).
- Dust evolution occurs within circumstellar disks on a few Myr ~10Myr disks are found to contain dust particles which have significant grain growth, with the most massive “pebbles” in to 100 cm. These large grains carry a minority of the disk stage.