The connection between inner and outer debris disks probed by infrared interferometry

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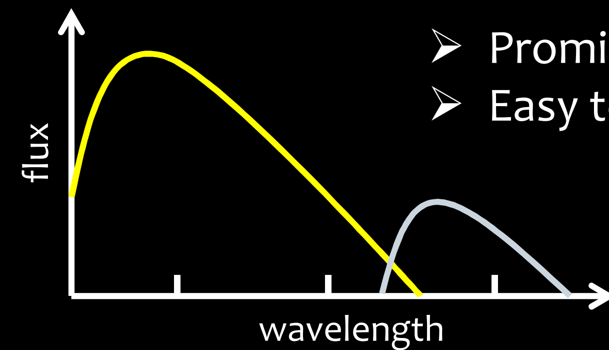
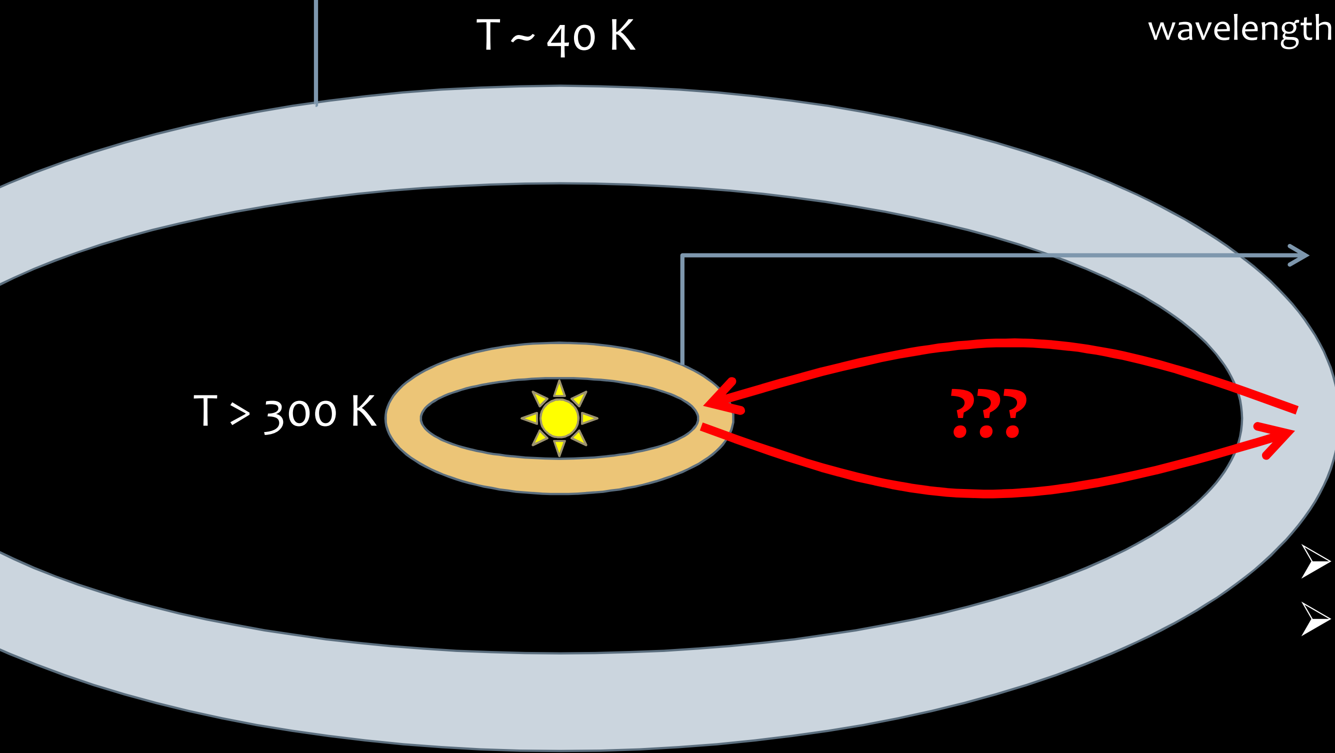
From Atoms to Pebbles – Herschel's view of Star and Planet Formation

Grenoble, 22 March 2012

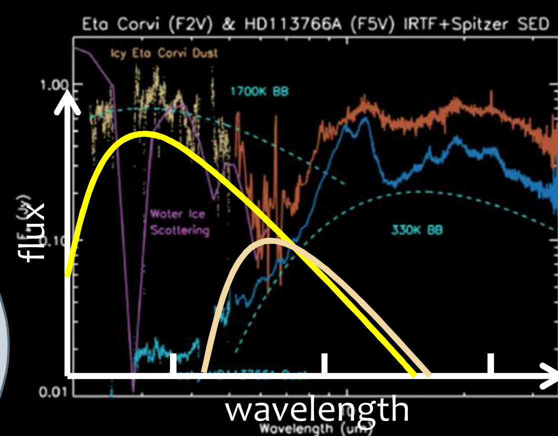
INNER VS. OUTER DEBRIS DISK



- Prominent far-IR excess
- Easy to resolve (>1”)



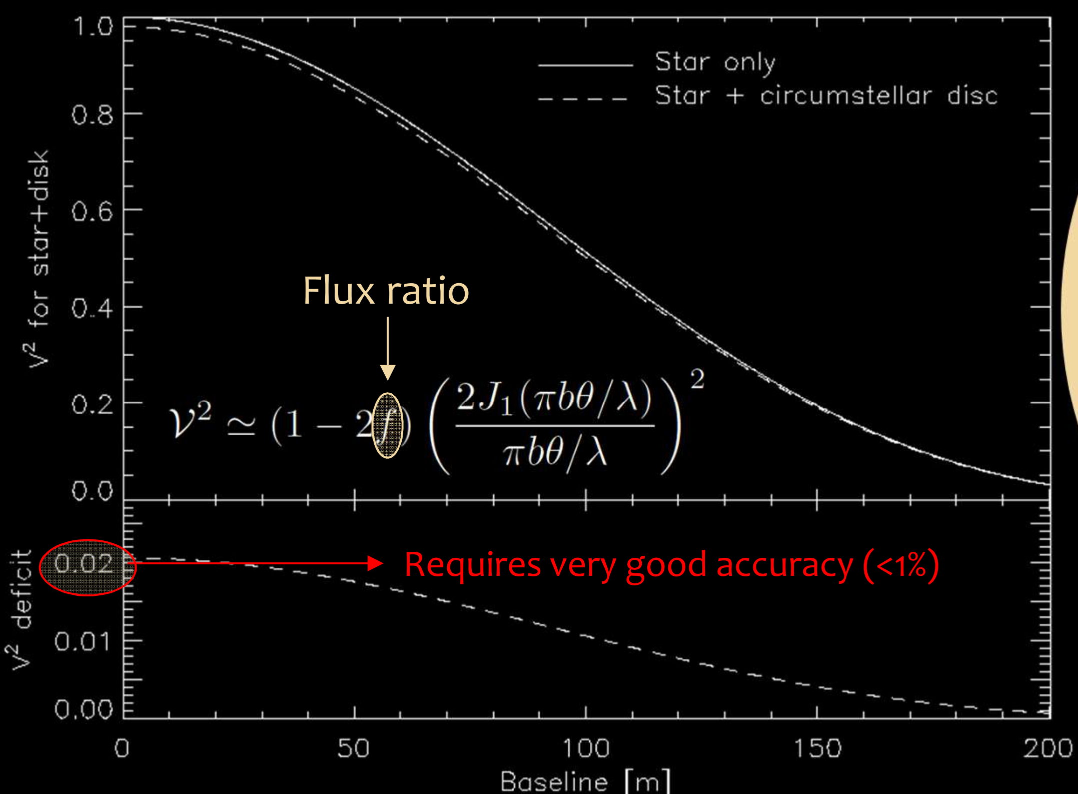
Lisse et al. 2012



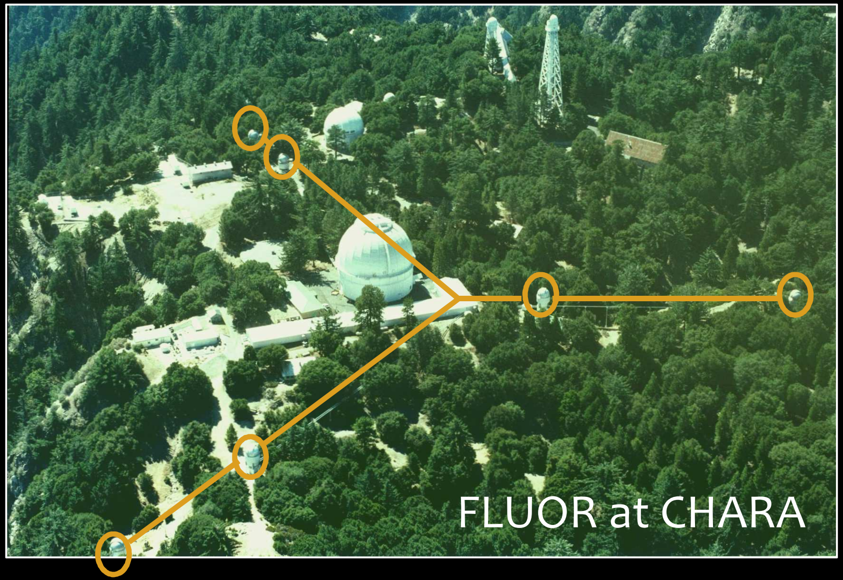
- Small near/mid-IR excess
- Difficult to resolve (< 0.1”)

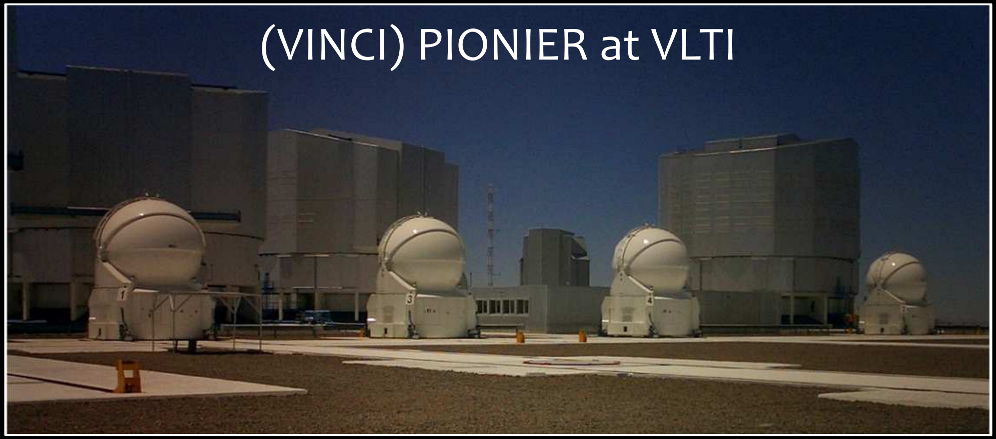
INFRARED INTERFEROMETRY MAY HELP

- Disk larger than angular resolution (λ/B) → incoherent flux
  - Induces a visibility drop at all baselines
- Best detected at short baselines (~10-30m)



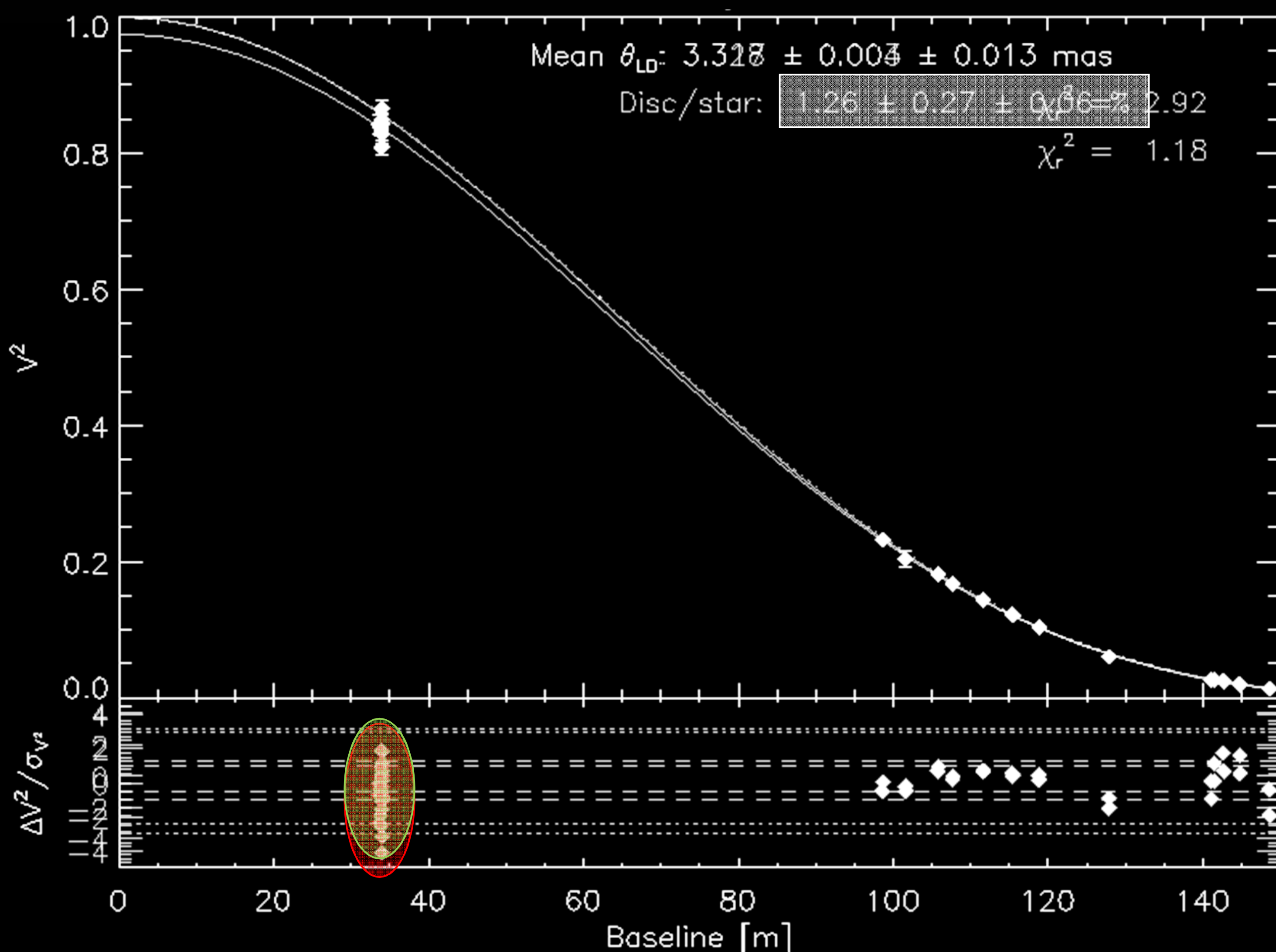
HIGH PRECISION INTERFEROMETERS





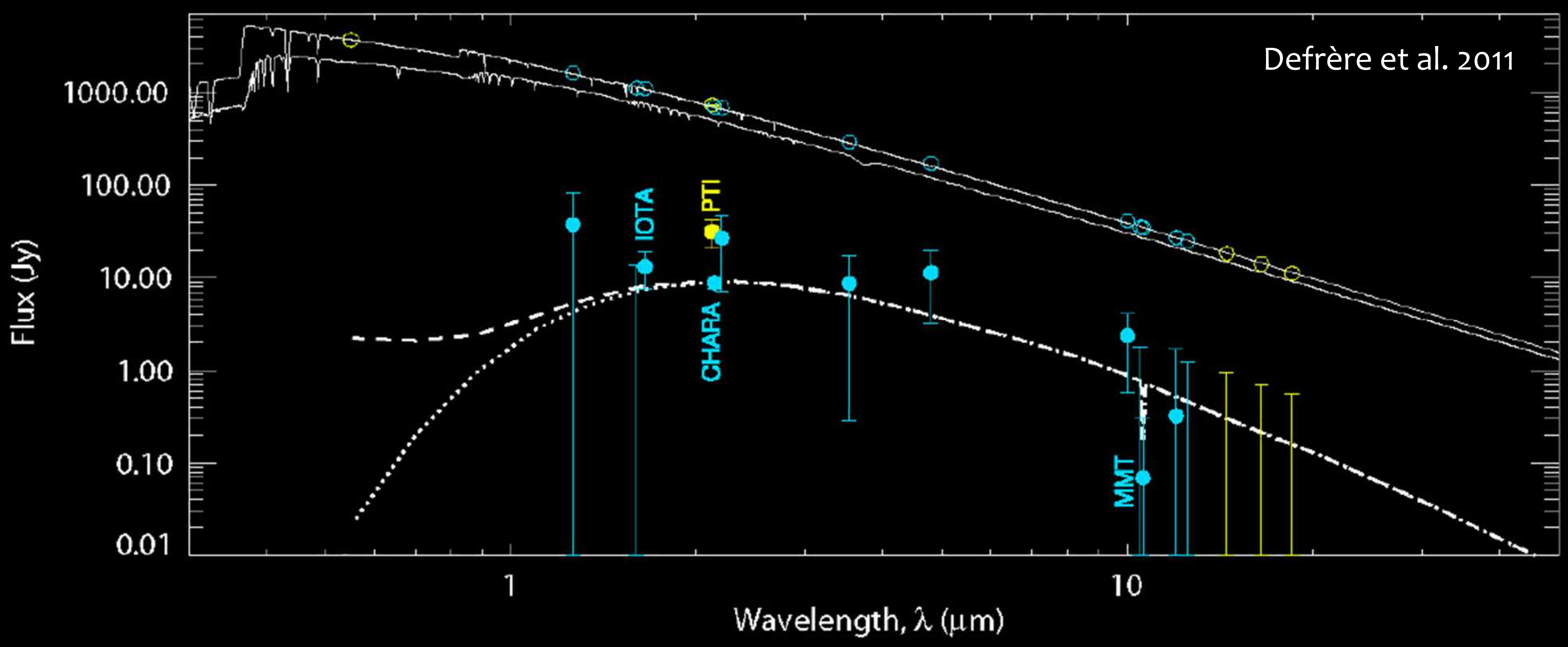
VEGA VIEWED BY CHARA/FLUOR

Absil et al. 2006



RADIATIVE TRANSFER MODELING

- H- and K-band interferometry (CHARA/FLUOR, IOTA/IONIC)
- N-band nulling interferometry (MMT/BLINC)
- Archival near- to mid-IR spectro-photometry

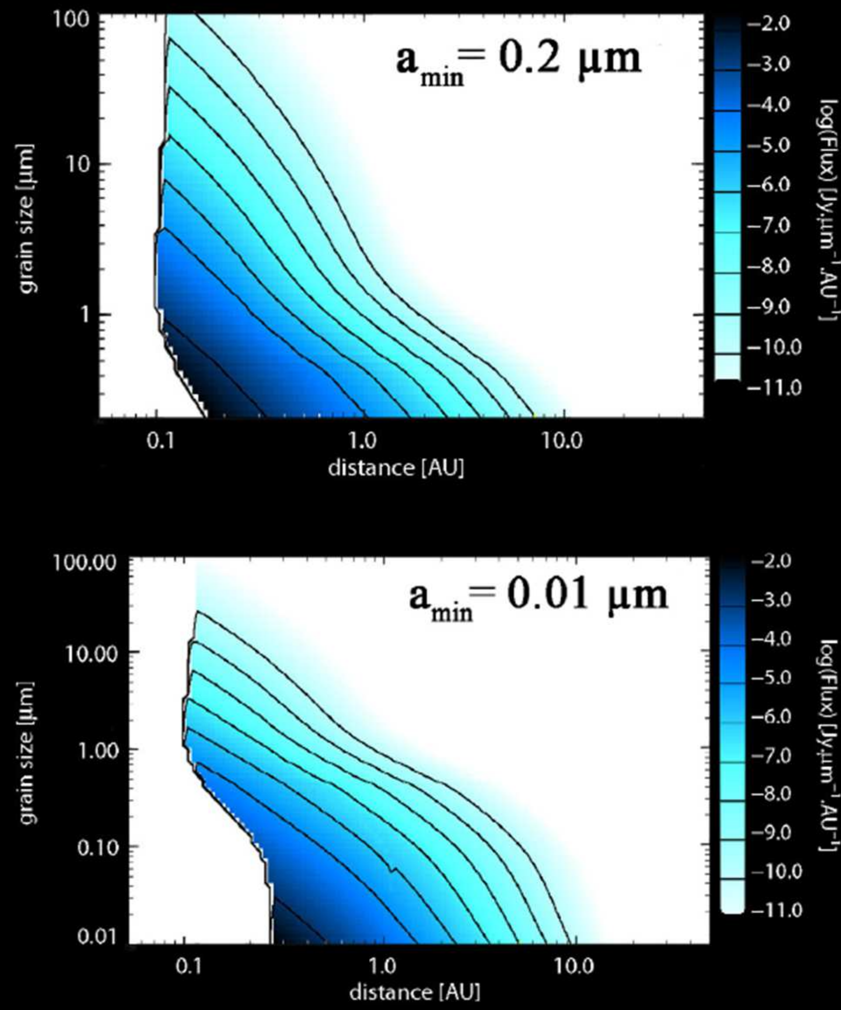


Most probable dust properties

- Bayesian χ^2 analysis of large parameter space
  - Grains < blowout size
  - Hot grains (> 1000 K)
  - Presence of carbons ≥ 10%
  - Distance: ~ 0.1 – 0.5 AU
  - Steep density power law: $\alpha < -3$ → ring?
- Mass: $\sim 2\times10^{-9}\ M_{Earth}$
- Luminosity: $\sim 5\times10^{-4}\ L_{star}$

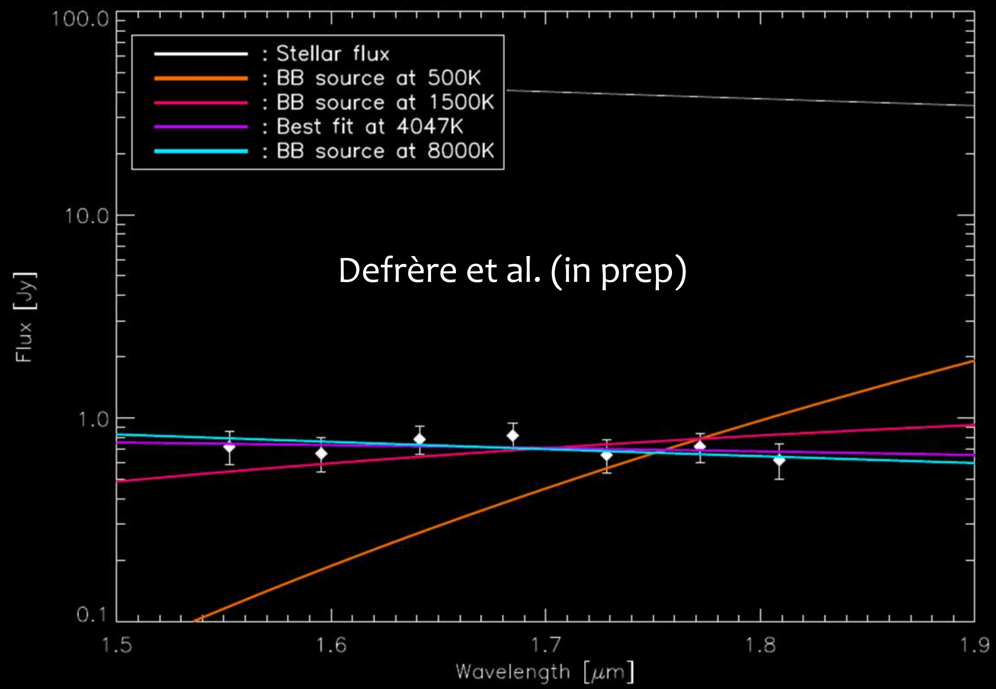
(same approach as in Lebreton et al. 44)

Defrère et al. 2011



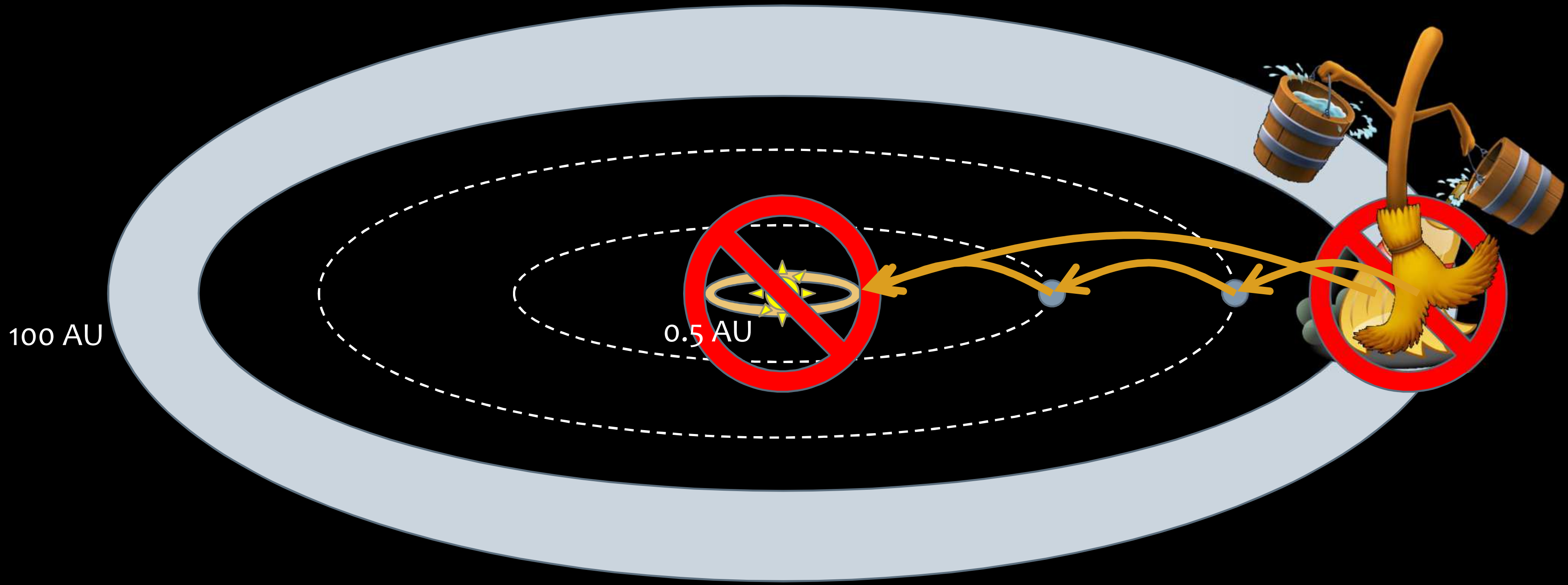
Next step: low-resolution spectra

- Dispersed fringes with PIONIER (soon FLUOR)
  - Flux ratio measurements across H and/or K band
  - Direct constraint on dust temperature



Origin of hot dust: steady state?

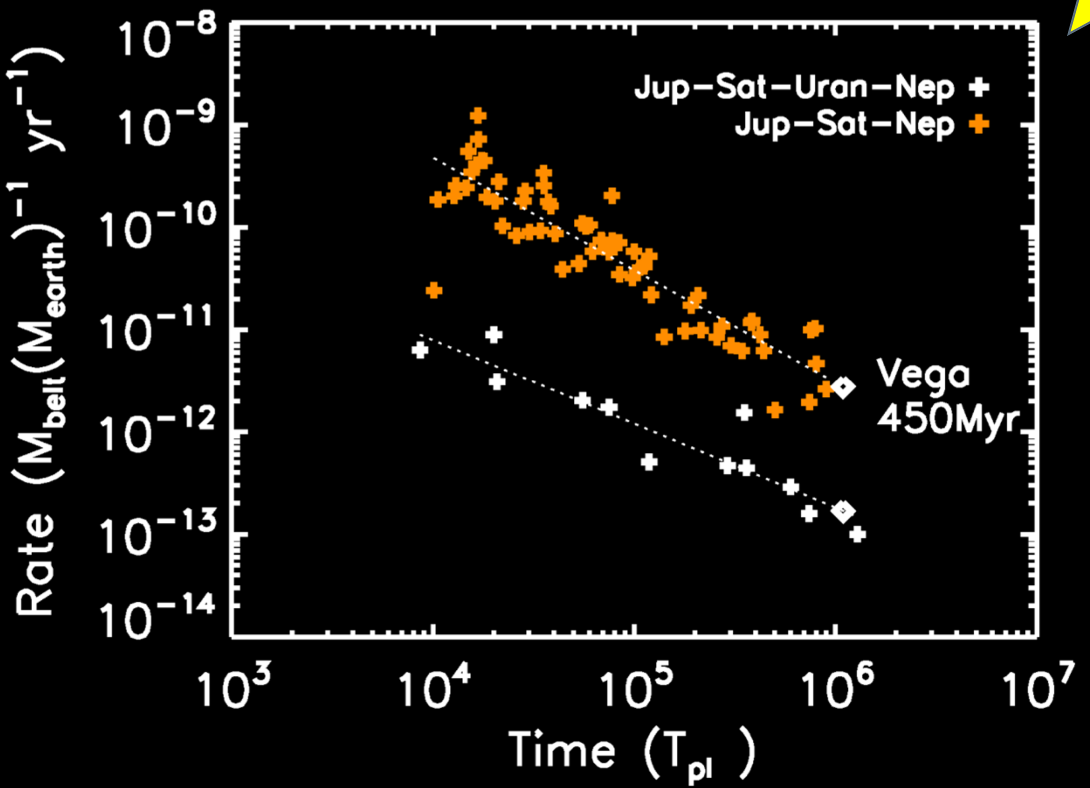
- Local production?
- Connection to outer disk?
  - Poynting-Robertson drag?
  - Multiple scattering of comets?



Steady state multiple scattering

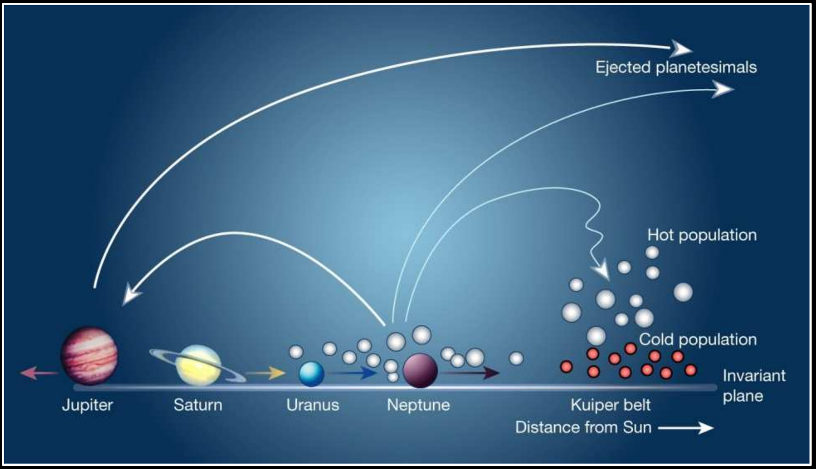
- Requires 3+ planets and 10^3 M_E in cold reservoir

Bonsor et al. 50



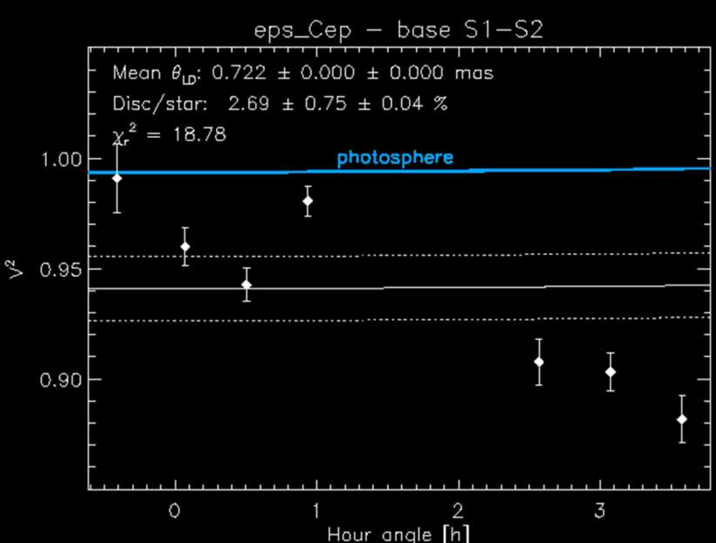
Origin of hot dust: transient?

- Isolated event?
  - Large collision (e.g. Earth-Moon)
  - Break-up of giant comet
- Dynamical perturbations?
  - Falling Evaporating Bodies
    - Asteroid belt disturbed by MMR with massive planet
  - Late Heavy Bombardment
    - Global rearrangement
- Statistical study may help

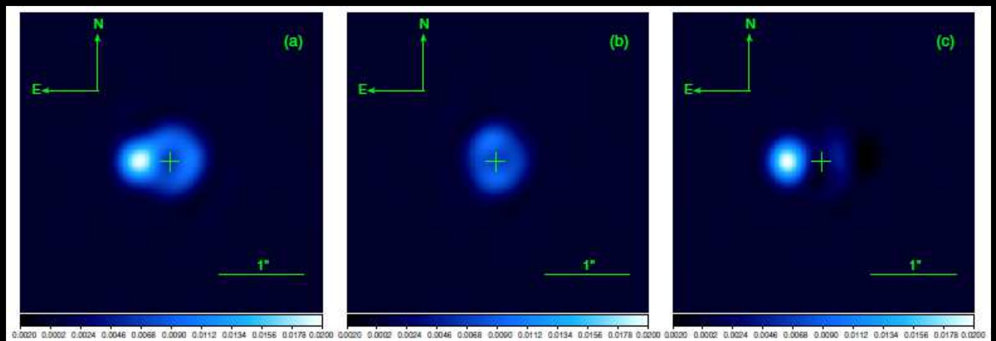


DEBRIS DISK SURVEY AT CHARA/FLUOR

- Magnitude-limited sample (K < 4)
  - 25 cold disk host stars (dec > - 15°)
  - "Unbiased" control sample: 25 stars w/o cold dust
- Observed most stars, ~42 of sufficient quality
- One surprise: companion to epsilon Cephei



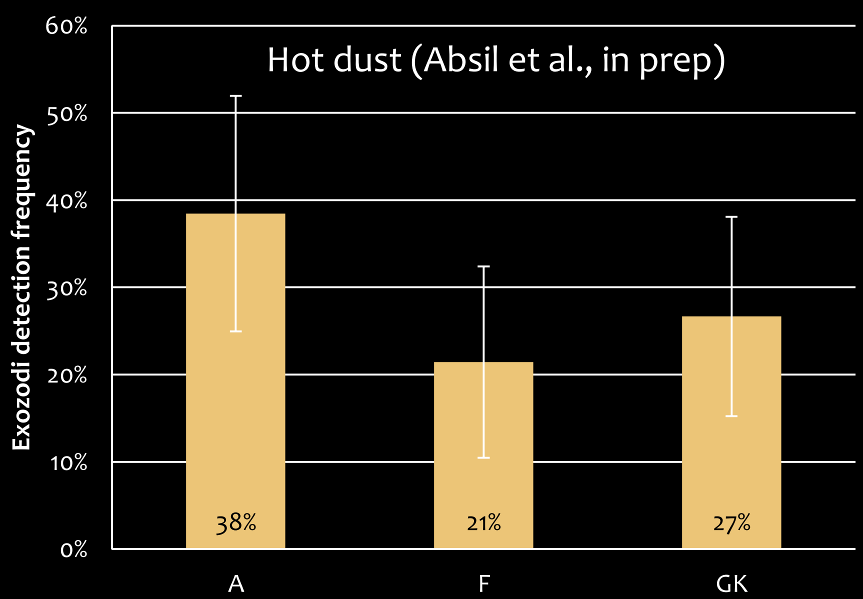
Mawet et al. 2011

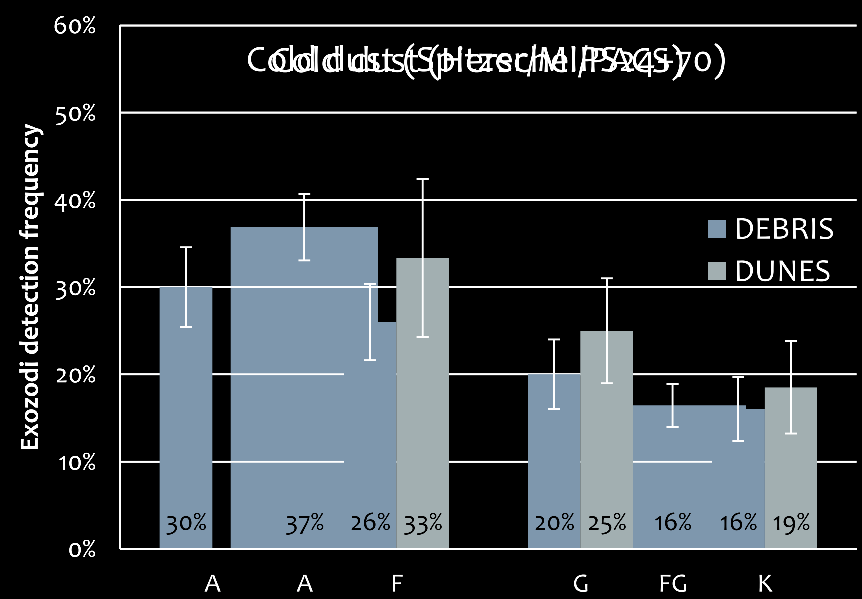


330 mas separation, 2% flux ratio

Preliminary statistics vs. spectral type

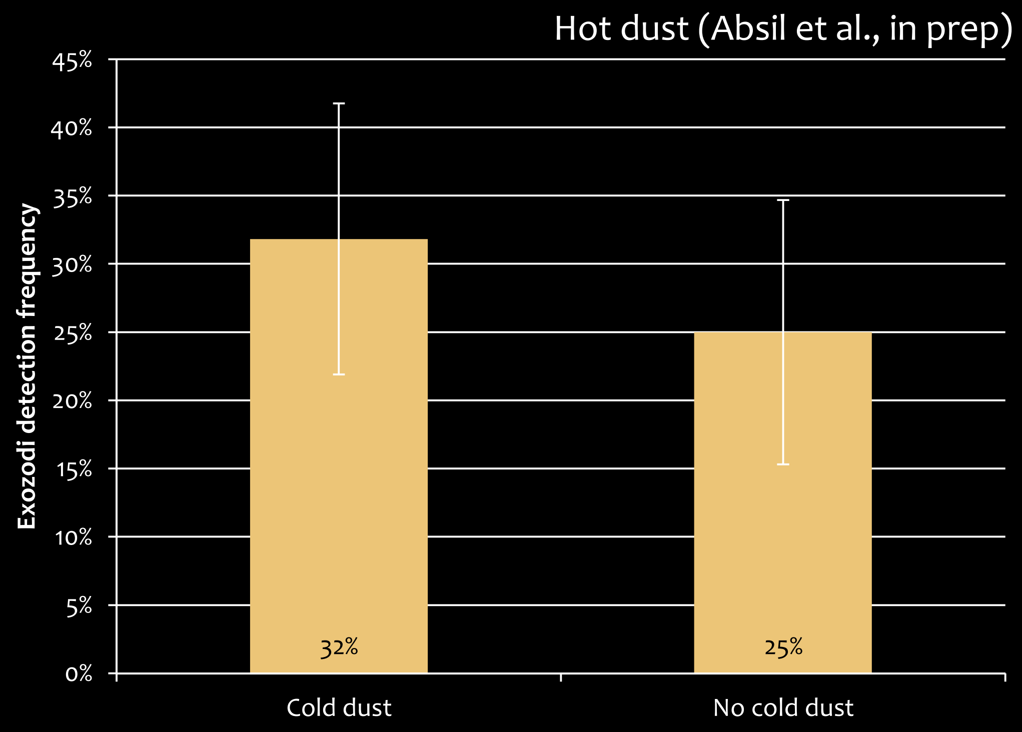
- Many more K-band excesses than anticipated!
  - Still need confirmation that this is (only) dust
- A-type stars more prone to hot dust
  - Same trend as in cold disks, frequency compatible
  - Suggests that they could be related (scattering?)





PRELIMINARY STATISTICS VS. COLD DUST

- No correlation with cold dust reservoirs
  - Suggests transient event rather than steady state



PERSPECTIVES

- EXOZODI project (French ANR, 2011-2015)
- Extend survey to confirm statistics (goal: 200 stars)
  - North: refurbished FLUOR at CHARA
  - South: PIONIER at VLTI (Le Bouquin et al. 59)
- Investigate age dependence
- Follow up detections
  - Discriminate with potential binaries
  - Multi-color information for SED modeling
- Search for variability
- Improve models (RT, dynamics, collisions)

EXOZODI team

- Augereau (PI)
- Thébault (Co-PI)
- Absil
- Beust
- Bonsor
- Coudé du Foresto
- Defrère
- Ertel
- Kral
- Lebreton
- Le Bouquin
- Marbeuf
- …