National Aeronautics and
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Status Report on YSO & Main Sequence Circumstellar Dust

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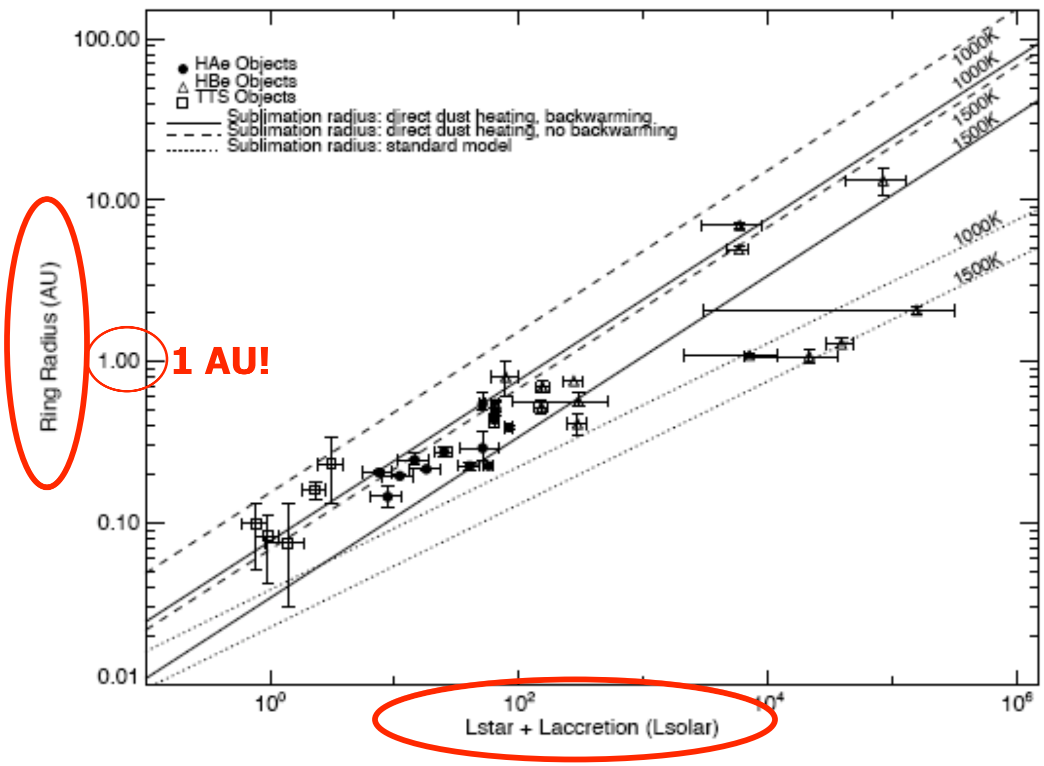
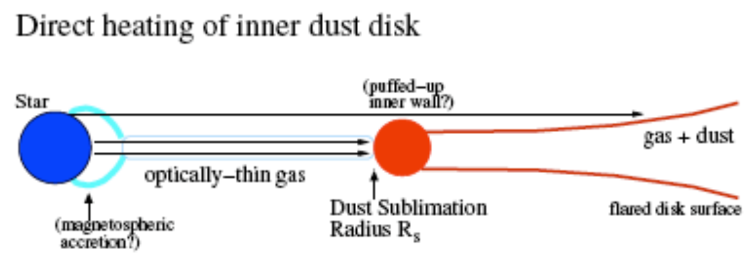
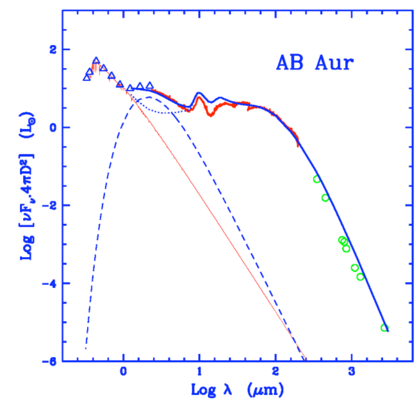
CHARA Meeting - NYC/AMNH - March 14-15 2007

Context: NIR Sizes and the Inner Dust Disk







Natta 2001

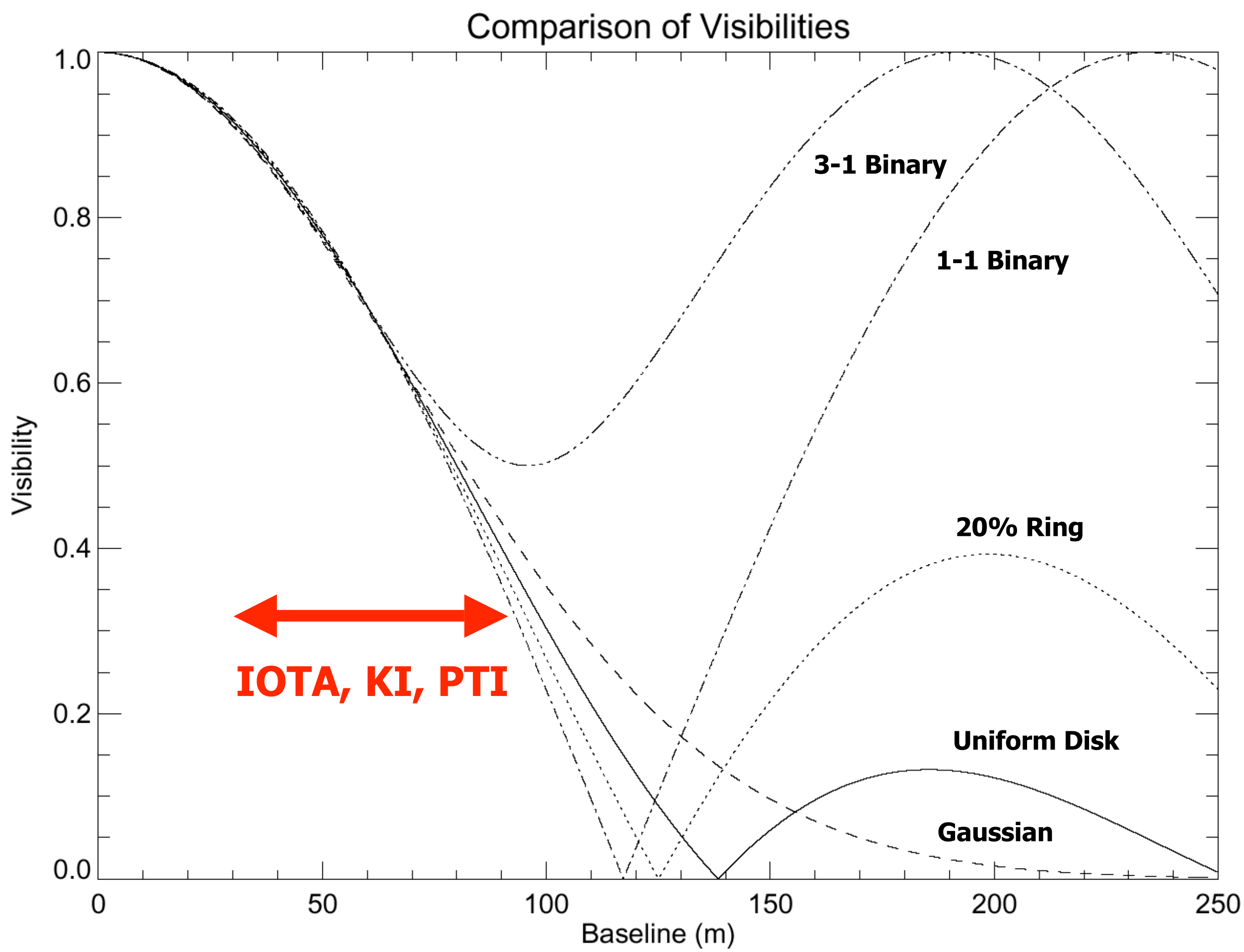
Characteristic near-infrared sizes of many YSOs measured by IOTA, PTI, and KI played an crucial role in establishing the new inner-disk paradigm: the "puffed-up" inner rim (Natta et al. 2001, Dullemond et al. 2001).

The next steps: determine the detailed physical properties of the inner disk (precise geometry and location, dust properties, inner gas component …).

Important: for understanding the initial conditions for terrestrial planet formation.

Reviewed in Millan-Gabet et al. PPV

What CHARA/Classic can Contribute



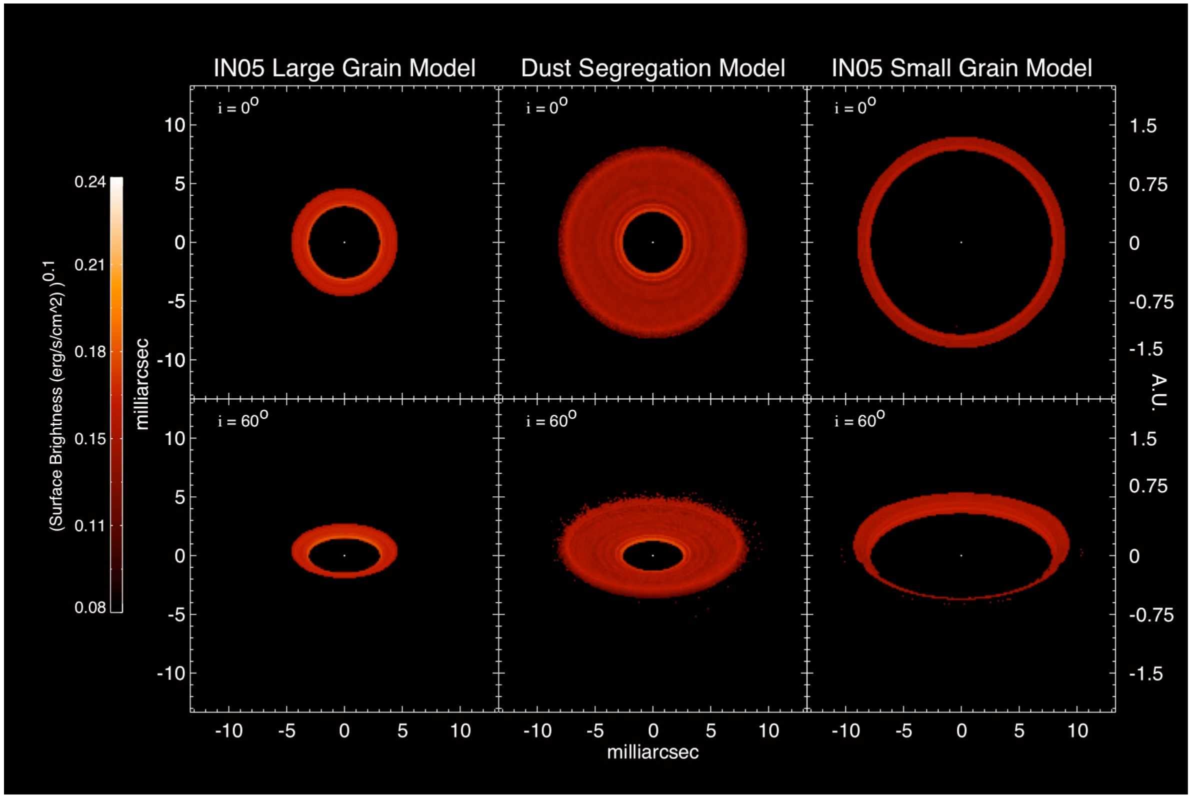
Long Baselines: 330m => resolution ~1mas or 0.15AU @ 150pc

Isolate the stellar component

Measure high sp. freqs. to probe detailed structure of putative inner rim

CHARA can test the new paradigm and discriminate between detailed models of the inner dust rim

- Curved inner dust rims expected physically
  - Tsublimation dependence on gas density (Isella & Natta 05)
  - Grain settling to and growth in midplane (Tannirkulam et al. 07)
- Also favored by IOTA closure phases (Monnier et al 2006)
- Predict less visibility “ringing” at long baselines

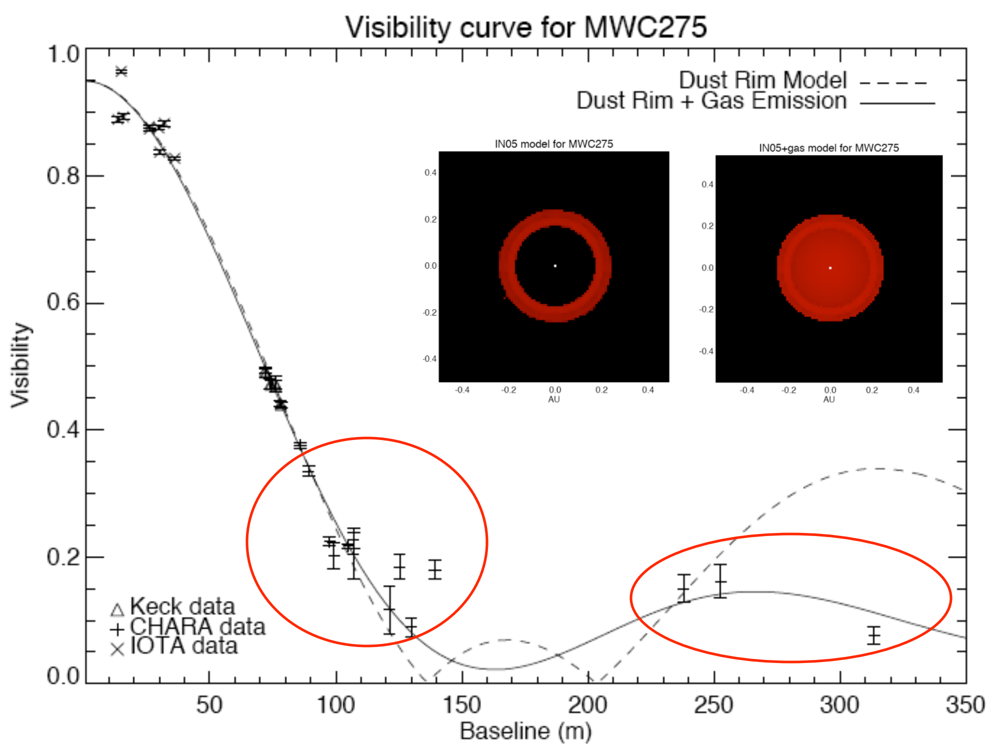


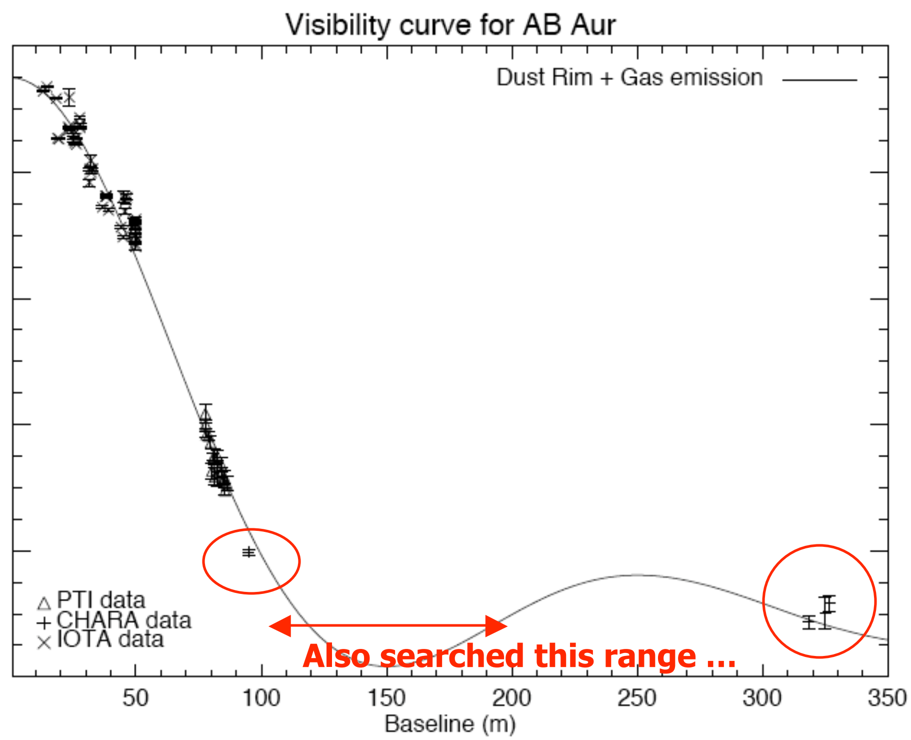
Finding Tiny Fringes on "Faint" Targets is Challenging ...

- Requires flux optimization and best seeing
- 3 objects so far observed in this program:
  - MWC275, V=6.8, K=4.7, A1, HAe object
  - AB Aur, V=7.1, K=4.4, A0, HAe object
  - MWC361, V=7.4, K=4.7, B2, HBe binary

Results to Date: Unexpected, Again! …

- Favors smooth brightness
  - Models with sharp features are ruled out
  - Even curved rims (smooth ring morphologies) do not work for these 2 systems …
  - MWC275 does not show sign of asymmetry (outer disk i=60deg)
  - **Preliminary models**: large grains in inner rim **+** central gas, or remnant halo





Next

- Detailed modeling of new CHARA data + existing vis. + SED data to test/constrain the new physical models being proposed.

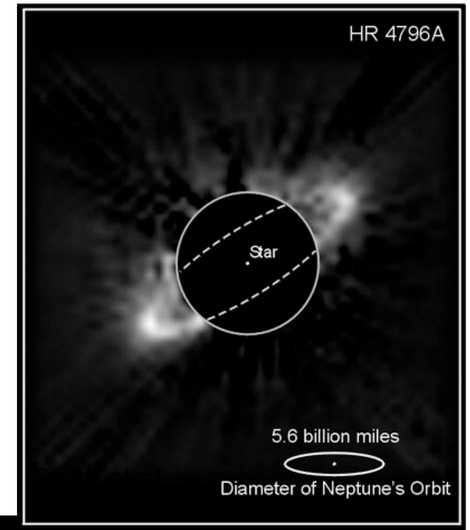
- More objects:
  CHARA limits (first proposals): V<9, K<6 (point source), could do:

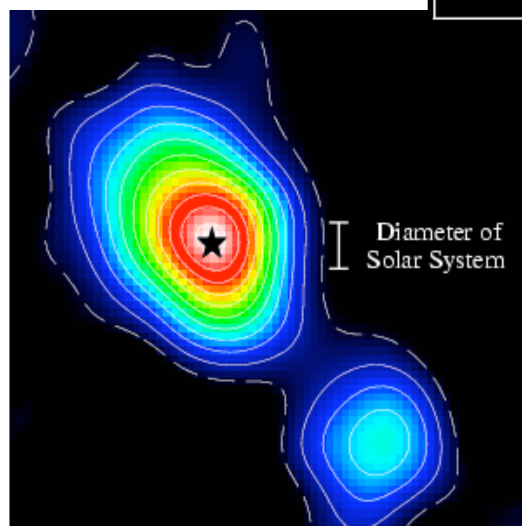
  - 10 HAeBe objects. But only 4 have K<5, closer to real limit for small fringes
  - 1 T Tauri object
  - 1 FU Ori object

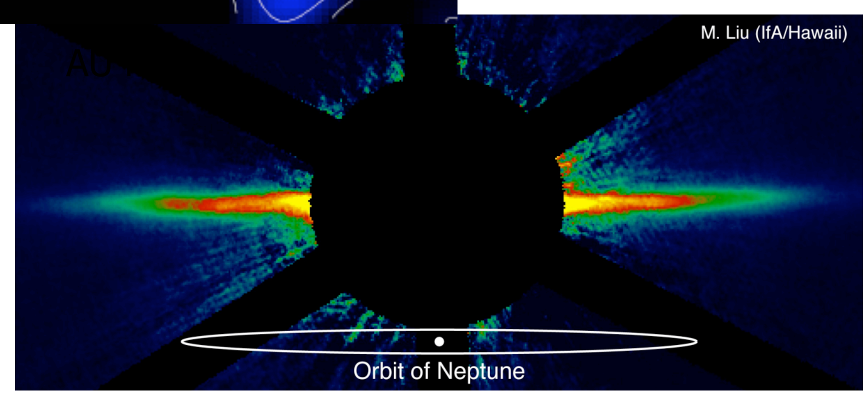
  - If Vlimit=12, Klimit=8 (e.g. scaling from IOTA), then could do:
  - 13 T Tauri objects, 4 FU Ori objects

Debris Disks

- Circumstellar material around main sequence stars
  - First observed by IRAS, now imaging from optical to sub-millimeter
  - Dust grain survival time scales can be used to argue that material is not primordial, but must be generated from collisions of larger bodies
  - Spitzer observations are greatly expanding the number of known sources, but can not directly measure spatial distribution
  - Structures in images debris disks have been used to infer planetary sized bodies

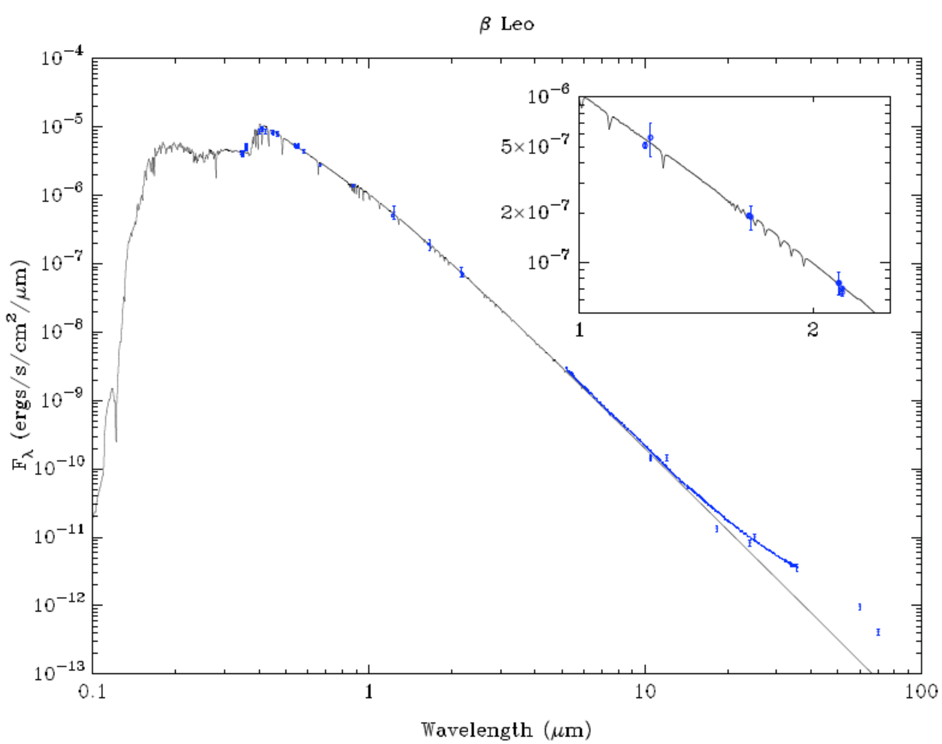


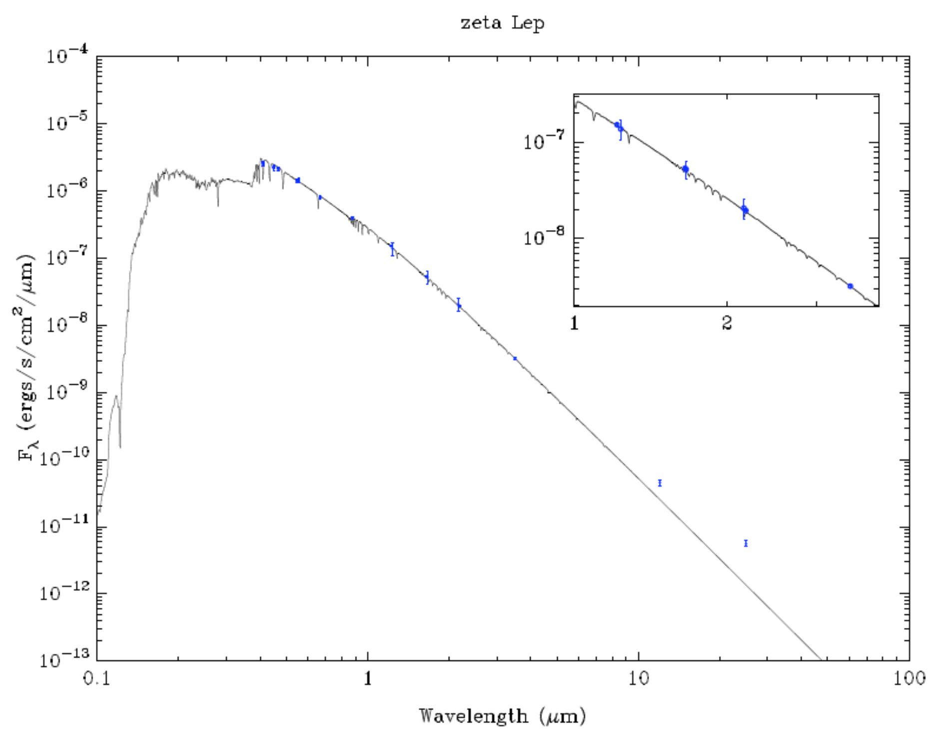




What CHARA can do

- Interferometry can determine the spatial distribution of the material close to the star **[first results on Vega, Ciardi et al 2001 - PTI; Absil et al 2006 - CHARA]**
  - Much more sensitive to small amounts of emission than SED modeling
    - NIR SED cannot constrain excess at the few% level
    - IRAS, Spitzer excess traces dust further from star [10s AU]
  - Use the interferometer to compare emission on short and long baselines
    - Short baselines = large spatial scales (star + disk)
    - Long baselines = small spatial scales (star only)





The Sample so far

(see also the work of Absil & Di Folco)

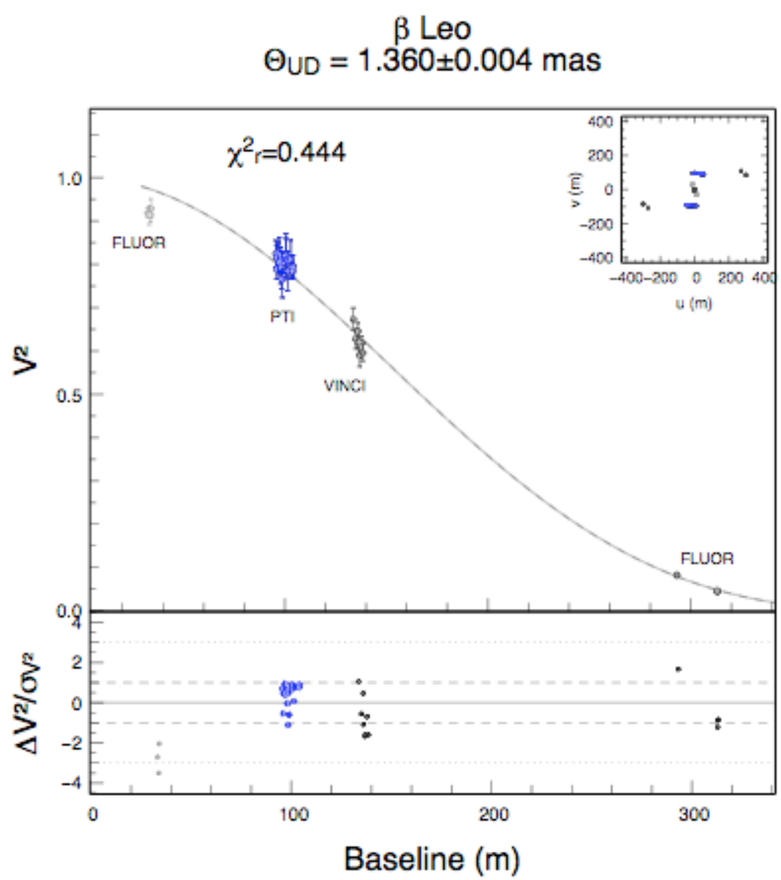
- “Young” MS stars, 100-300 Myr.
- By analogy with our own Solar System, good candidates for planet searches (e.g TPF sample).

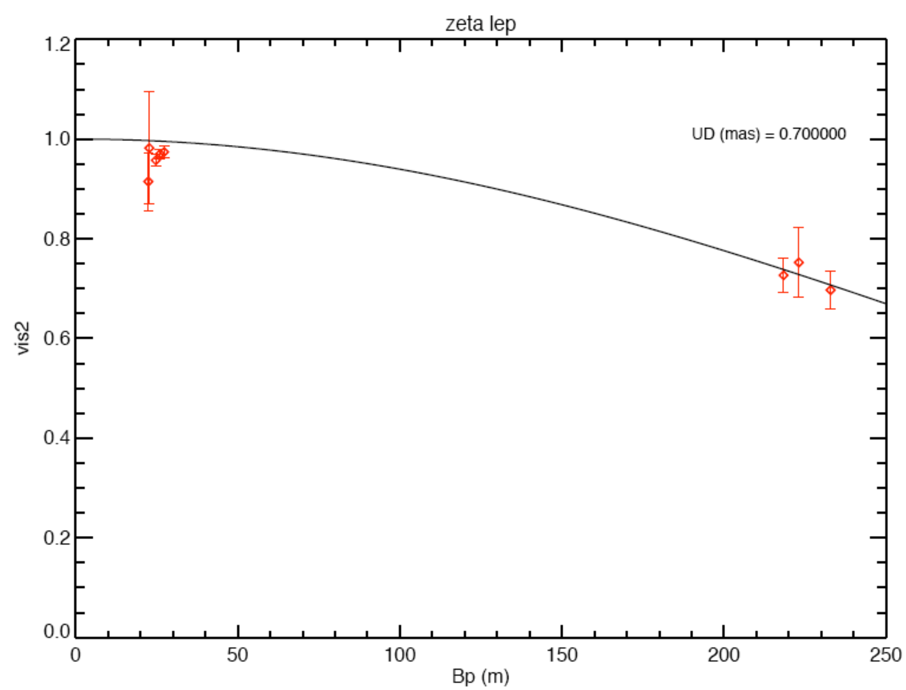
- beta Leo = Denebola
- A3V star, V=2.1, K=1.9
- d = 11 pc

- zeta Lep
- A2V star, V=3.5, K=3.3
- d = 22 pc

Preliminary Results

- Detected visibilities on short baselines lower than expected from the star → presence of additional large scale material.
- bet Leo: $\Delta(V\hat{}2) = 0.056$, 5.7σ, ~4% incoherent K-flux
- zet Lep: $\Delta(V\hat{}2) = 0.028$, 4.7σ, ~2% incoherent K-flux





Detecting %-level Visibility Changes is Challenging …

- It is crucial to understand/believe the calibration.
- We have used check stars for which we expect no vis deficits.
  - Delta Leo: short baseline vis low by 1σ, some of it due to rotation
  - 11 Eri: no deficit
- We have compared the results of the FLUOR and IOTA/FLUOR pipelines.
  - Results are consistent w.i. their error bars, but have in some cases differences that would impact the interpretation.
- Ability to draw definite conclusions limited by small data set, especially on short baselines, and for the check stars.
- Estimated FLUOR errors are consistent with rms of visibilities.
- Estimated FLUOR visibilities for same object are consistent night-to-night.
- We would all probably benefit from a definitive test of the calibration & estimated errors (in relevant SNR,V2 regime) - is there a good test case at the %level? (binary?).

Next

- Constrain near-infrared emission geometry and origin
  - Simple dust disk model from Rsublimation to FOV (~5AU)
  - Scattered light models
  - Joint SED and visibility fitting
- How is the material measured at K band and by Spitzer related
  - Single blackbody fit to Spitzer data suggests origin at a small range of radii
  - Is the disk continuous or are there gaps?
- Is near-infrared emission common from these disks?
  - More observations planned