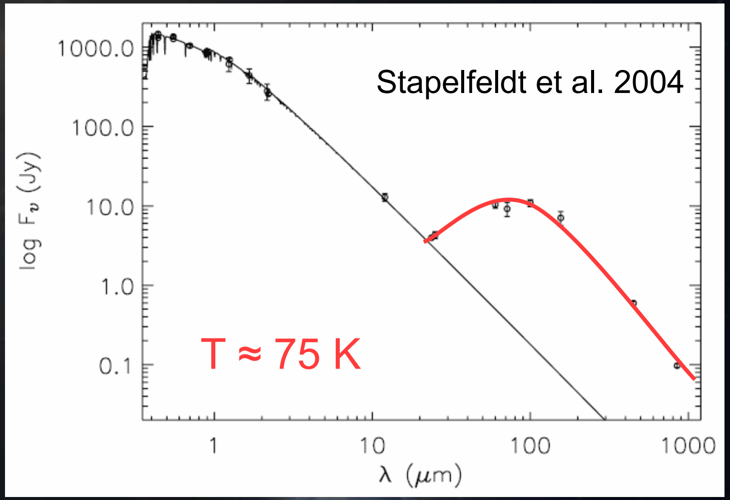
The inner debris disc of Vega as seen by CHARA / FLUOR

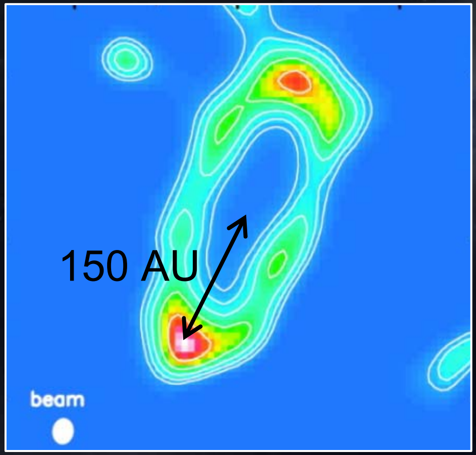
Olivier Absil (Univ. Liège)
E. Di Folco (Obs. Genève)
J.-C. Augereau (LAOG, Grenoble)
A. Mérand (Georgia State University)
V. Coudé du Foresto (LESIA, Paris)

The quest for warm dust

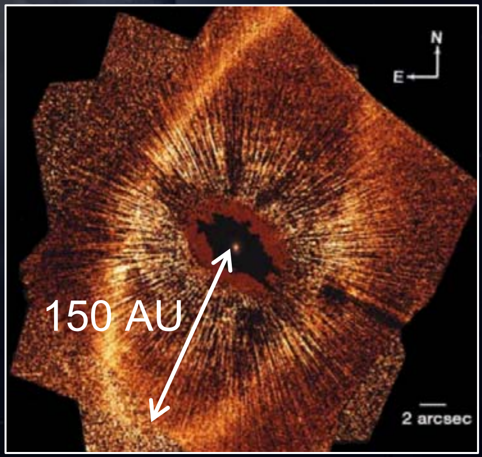
- Until now:
  - Cold and distant (~100 AU)
  - Massive (~10^{-2} $M_\oplus$)
  - Similar to Kuiper belt
  - Evidences for inner holes
- Detected by
  - Far-IR excess flux
  - Sub-mm imaging
  - Visible imaging
- First hints for warm dust with Spitzer
- Final goal: detect debris discs similar to our zodiacal disc
  - Towards Darwin / TPF…



Marsh et al. 2005 (350 μm)



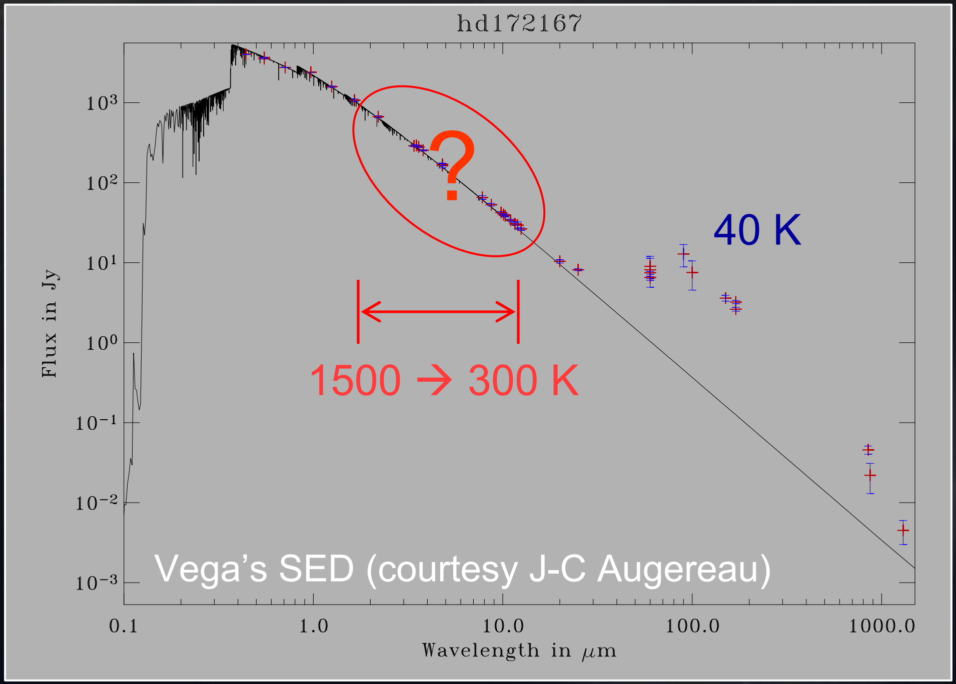
Kalas et al. 2005 (0.8 μm)



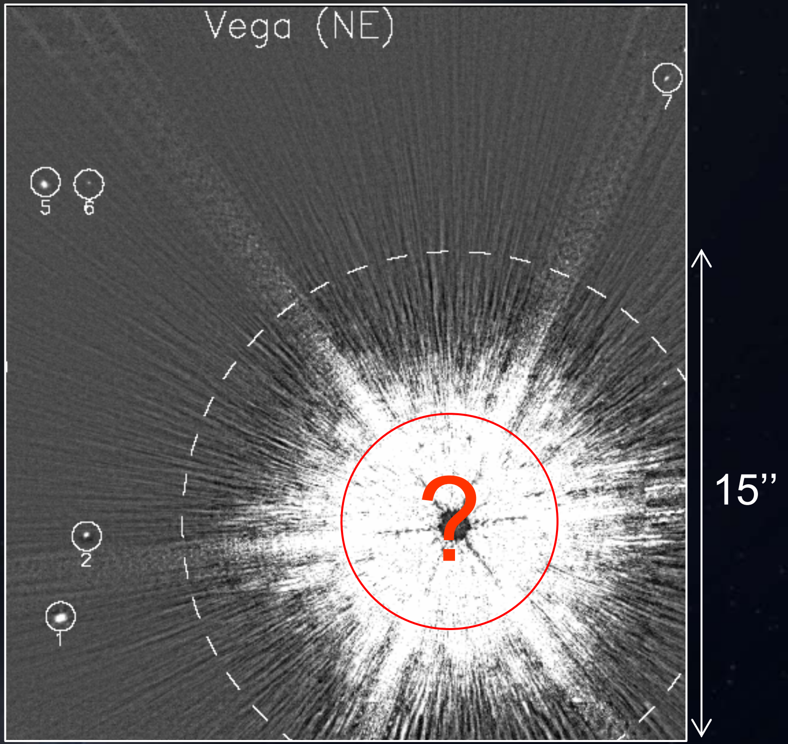
(150 AU ≈ 20'' at 7.7 pc)

Are the inner holes for real?

- Two major difficulties
  - High contrast (>1:100)
  - Small angular separation
    - Inner disc: a few 10 mas
    - Requires IR interferometry

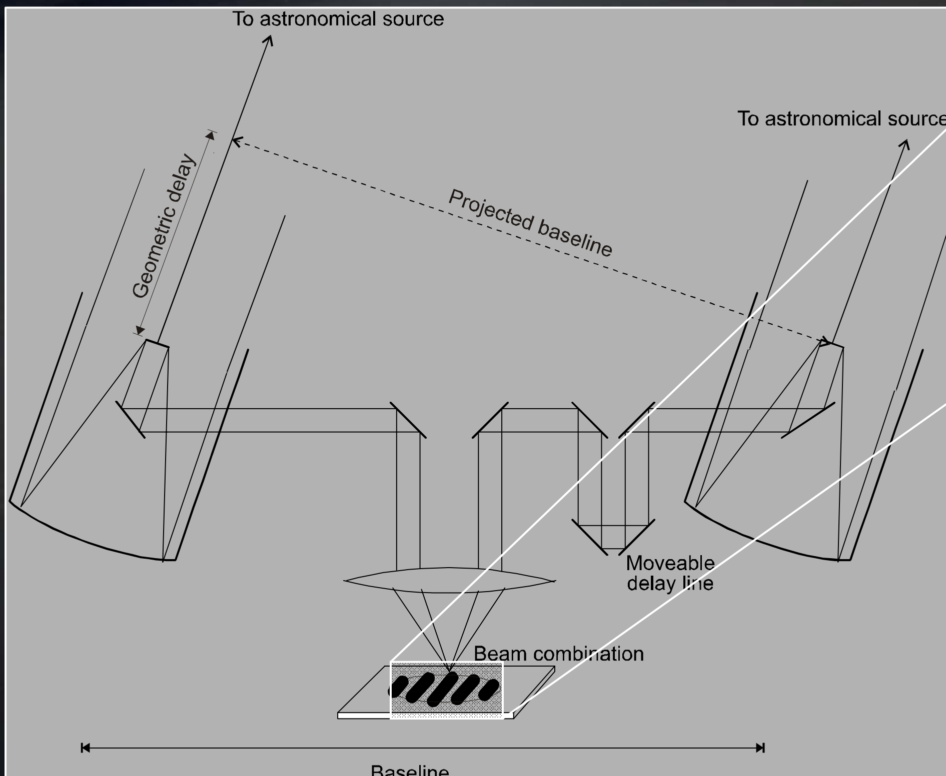


Vega's SED (courtesy J-C Augereau)

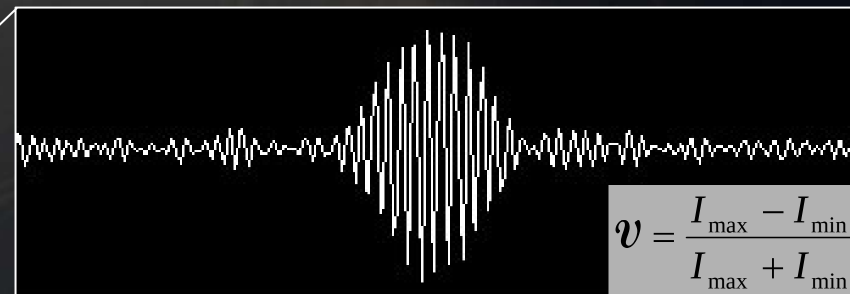


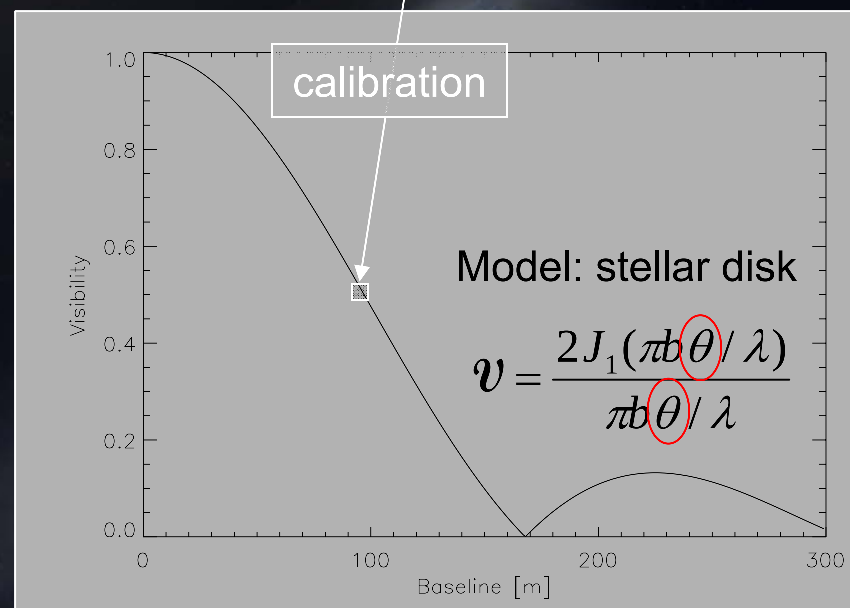
Macintosh et al. 2003 (Keck AO)

Stellar interferometry



Spatial frequency: b/λ

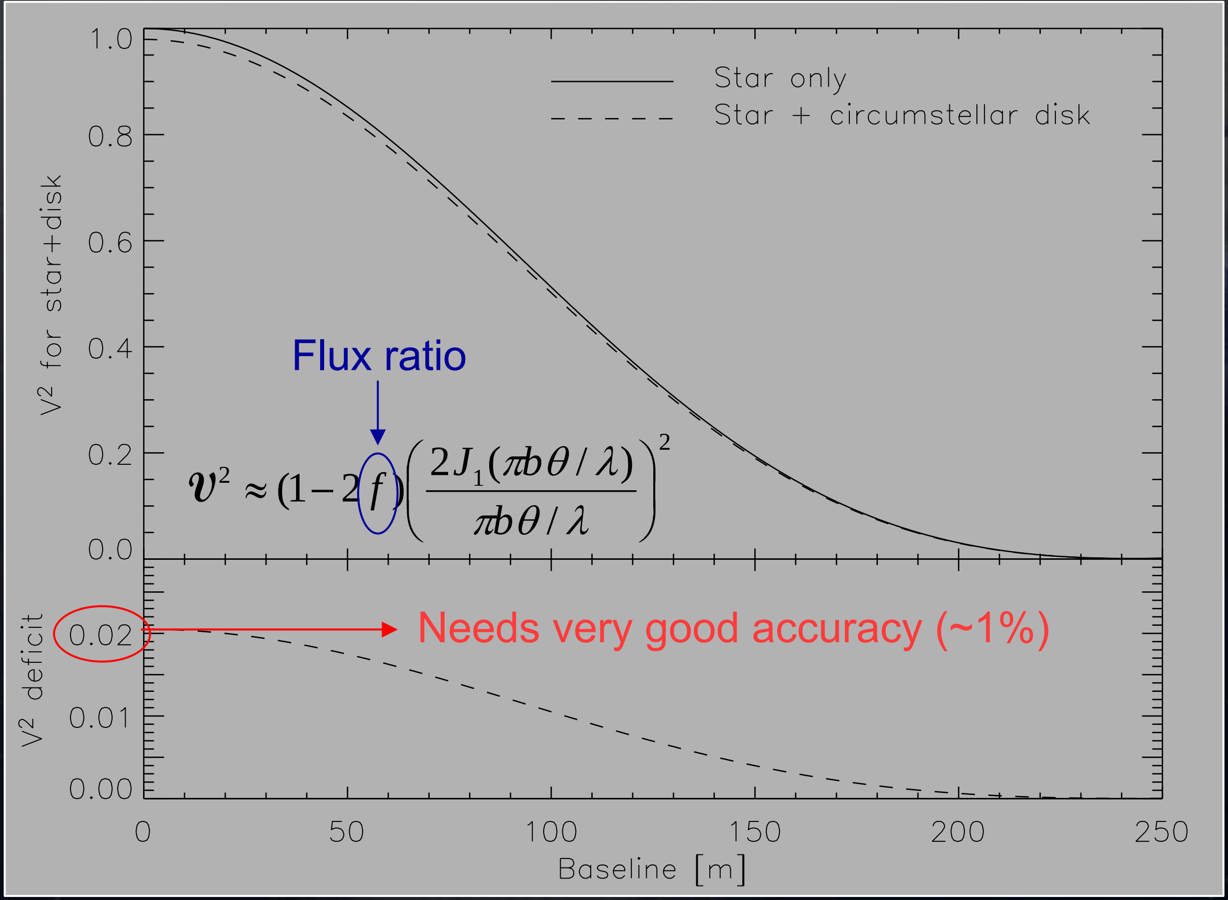




- van Cittert-Zernike theorem: each baseline gives one component of the Fourier transform of the source

Debris discs by interferometry

- Disc larger than angular resolution (λ/b) → incoherent flux
- Induces a visibility deficit at all baselines
- Best detected at short baselines



Previous attempts

Near-IR (K band)

- Ciardi et al. 2001
  - Vega with PTI
  - Baseline too long
  - Suggest possible excess of 3-6%
- Di Folco et al. 2004
  - 5 stars at VLTI
  - Upper limit of a few % on the inner disc emission

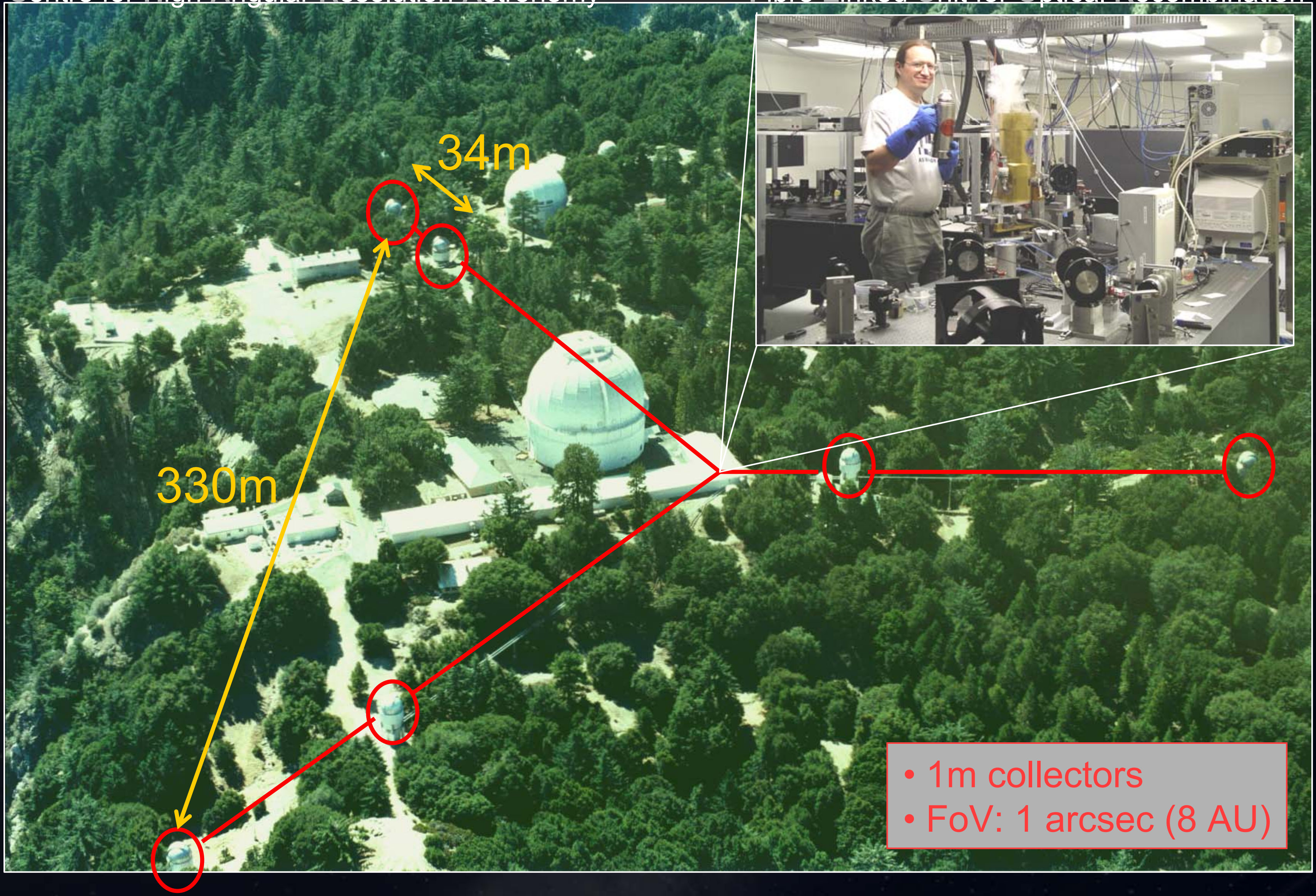
Mid-IR (N band)

- Liu et al. 2004
  - Vega by nulling interferometry (MMT)
  - Very short baseline (4m)
  - Observation restricted to radius > 1 AU
  - Upper limit of 2.1% on mid-IR excess

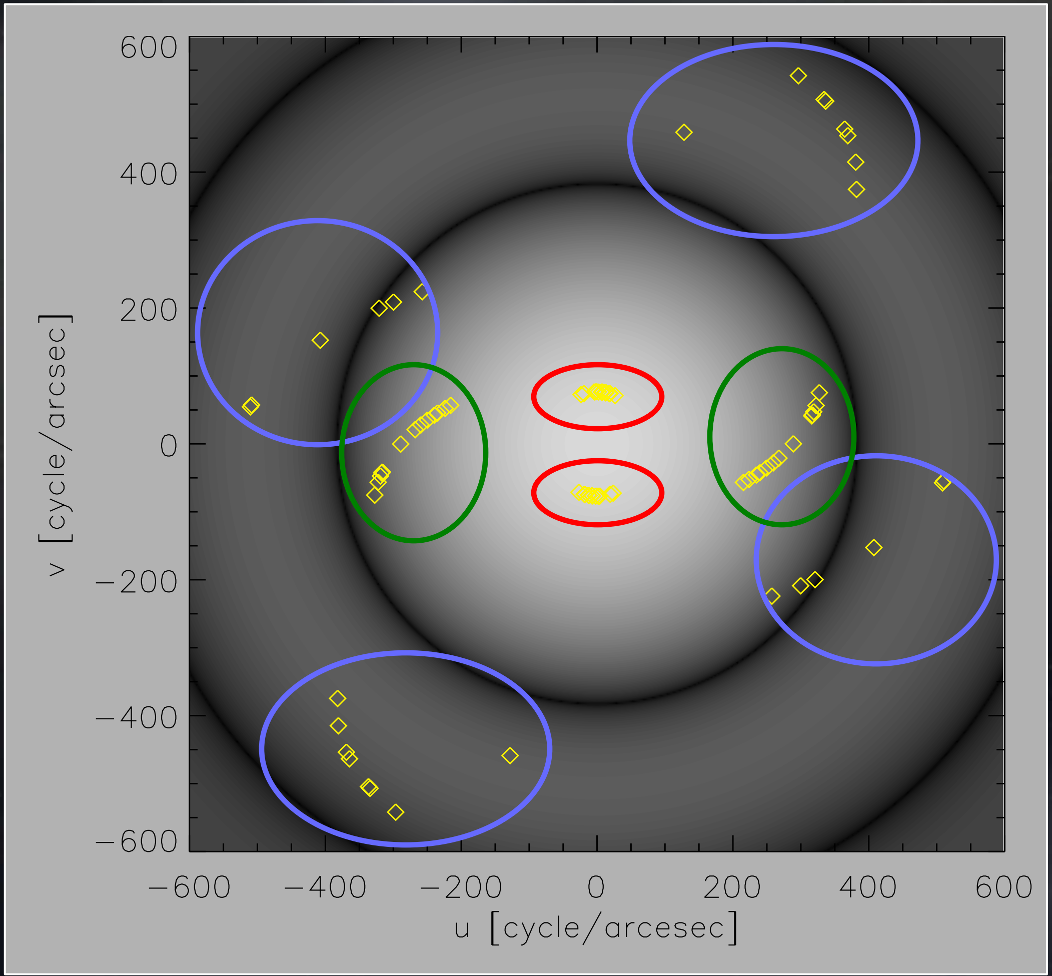
CHARA - FLUOR

Centre for High Angular Resolution Astronomy

Fibre Linked Unit for Optical Recombination

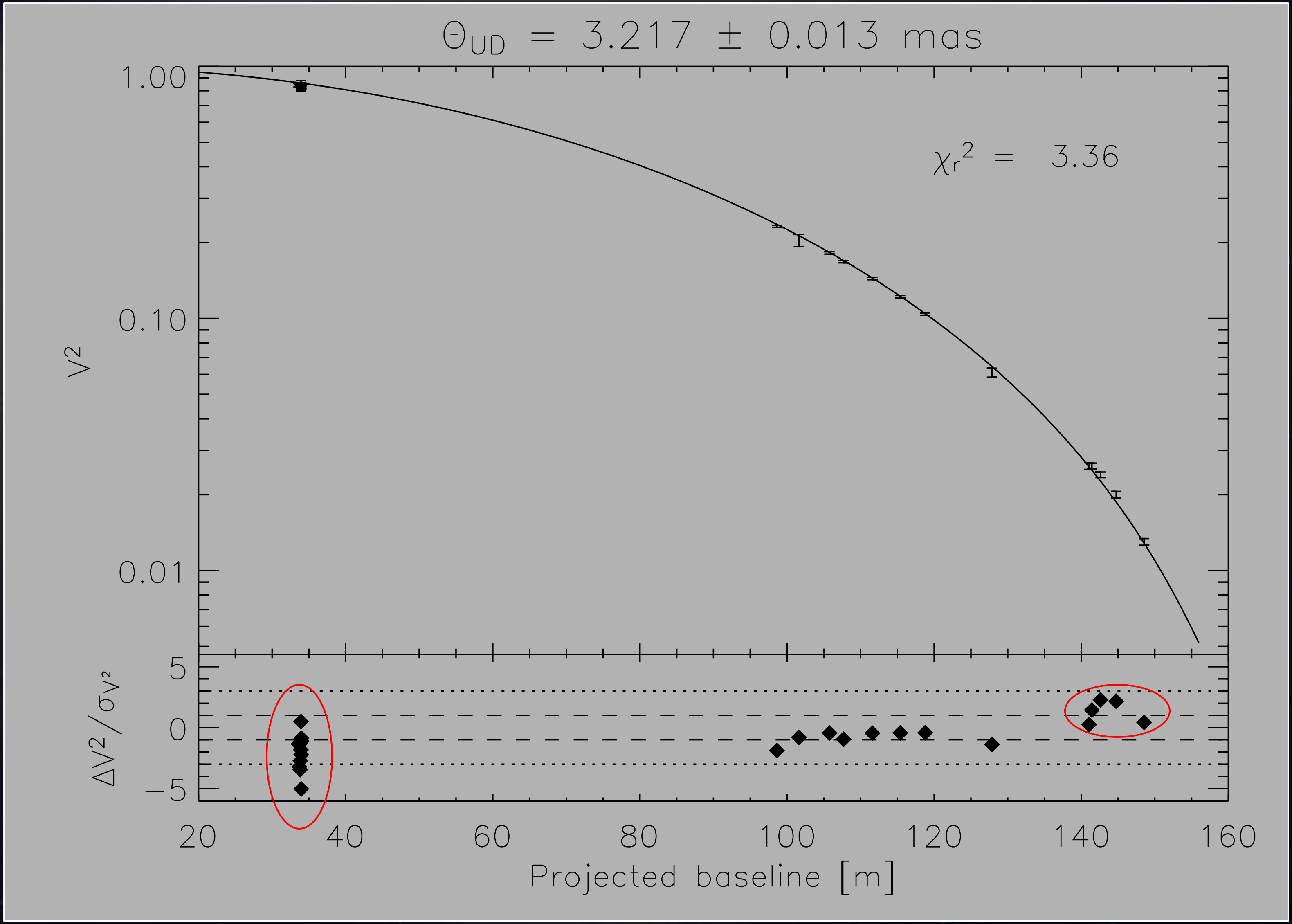


The Fourier Vega



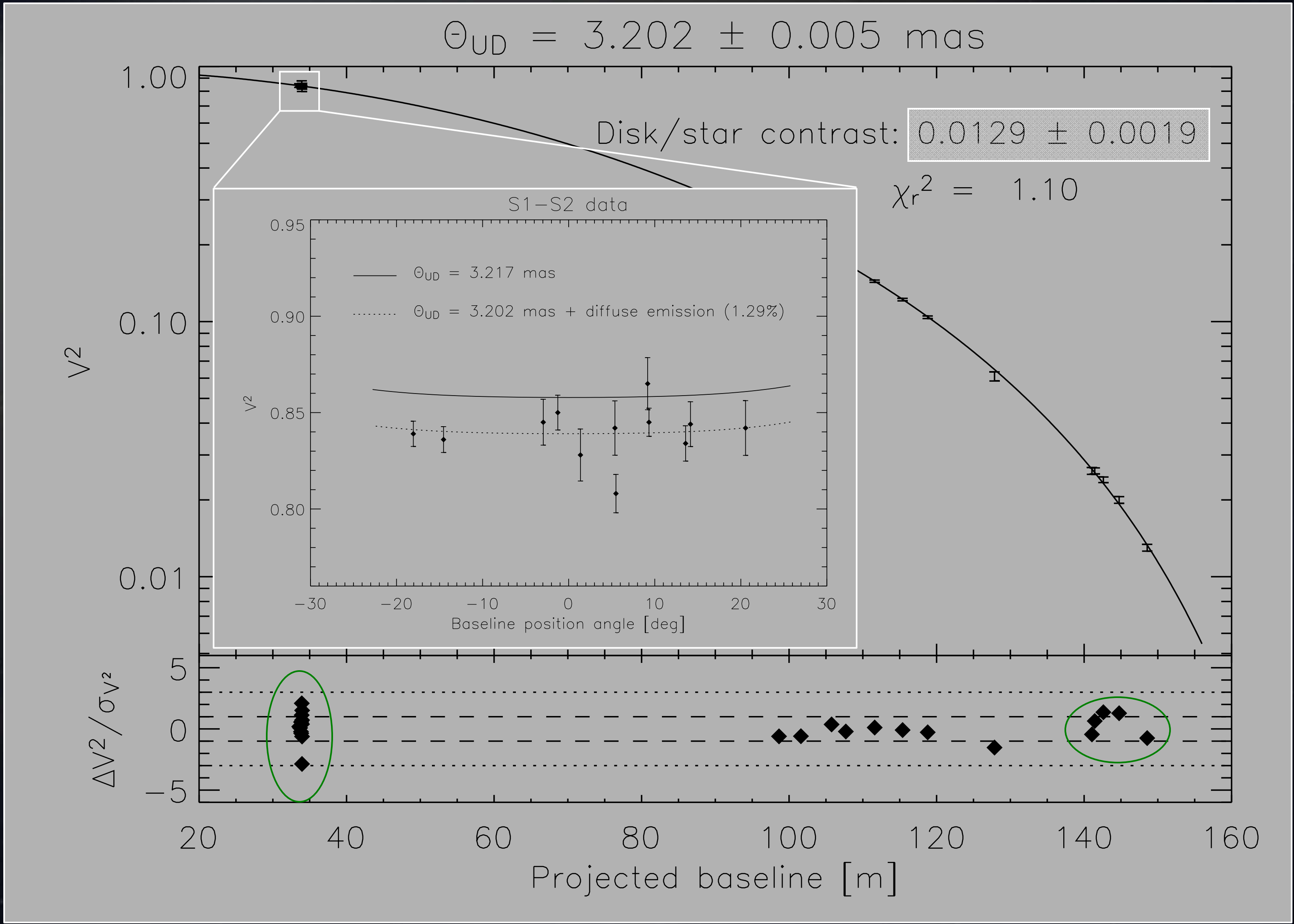
- Pole-on → no azimuthal dependence
- Stellar diameter (150 m)
- Limb darkening (>200 m)
- Circumstellar dust (30 m)

Fitting a uniform stellar model



Fitting star + debris disc

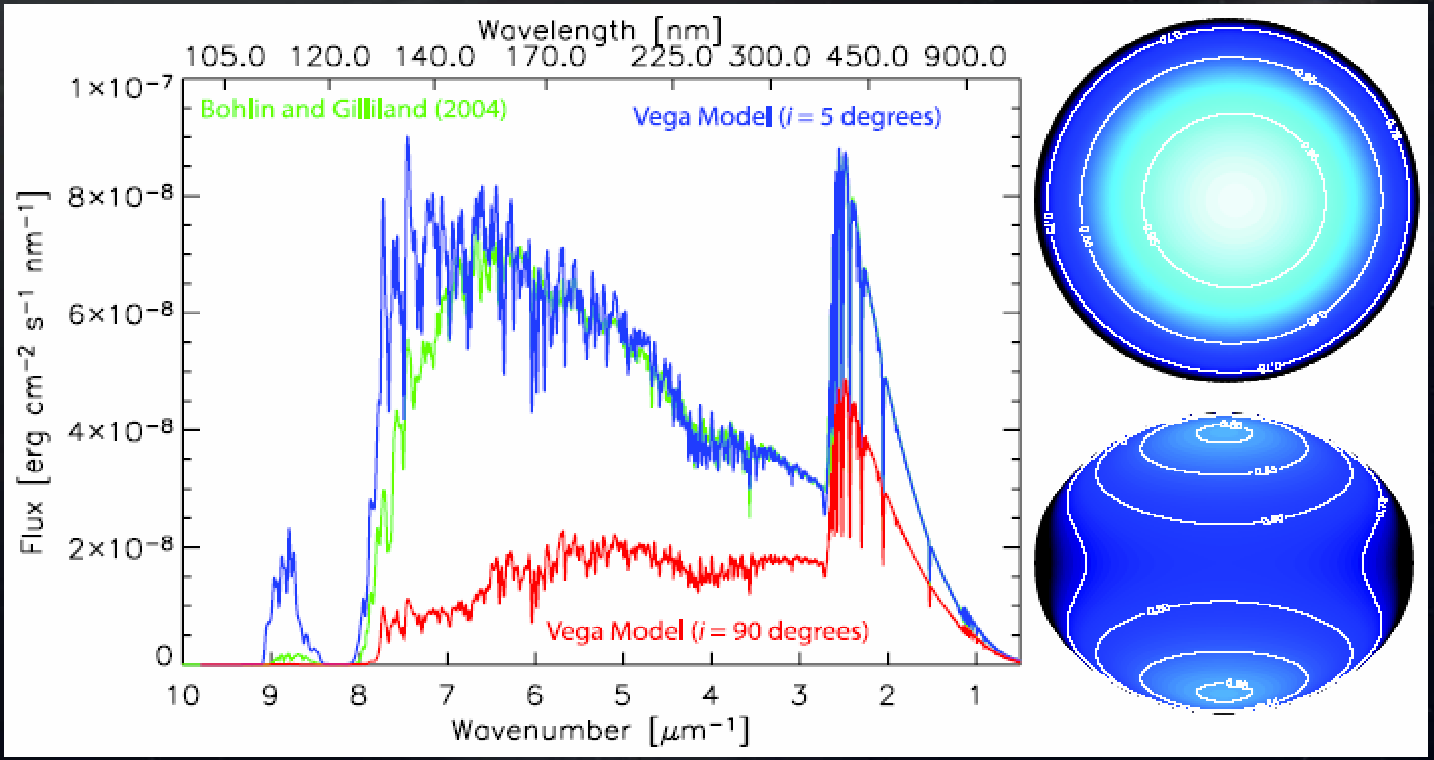
Absil et al. 2006, A&A 452



Modelling the inner disc

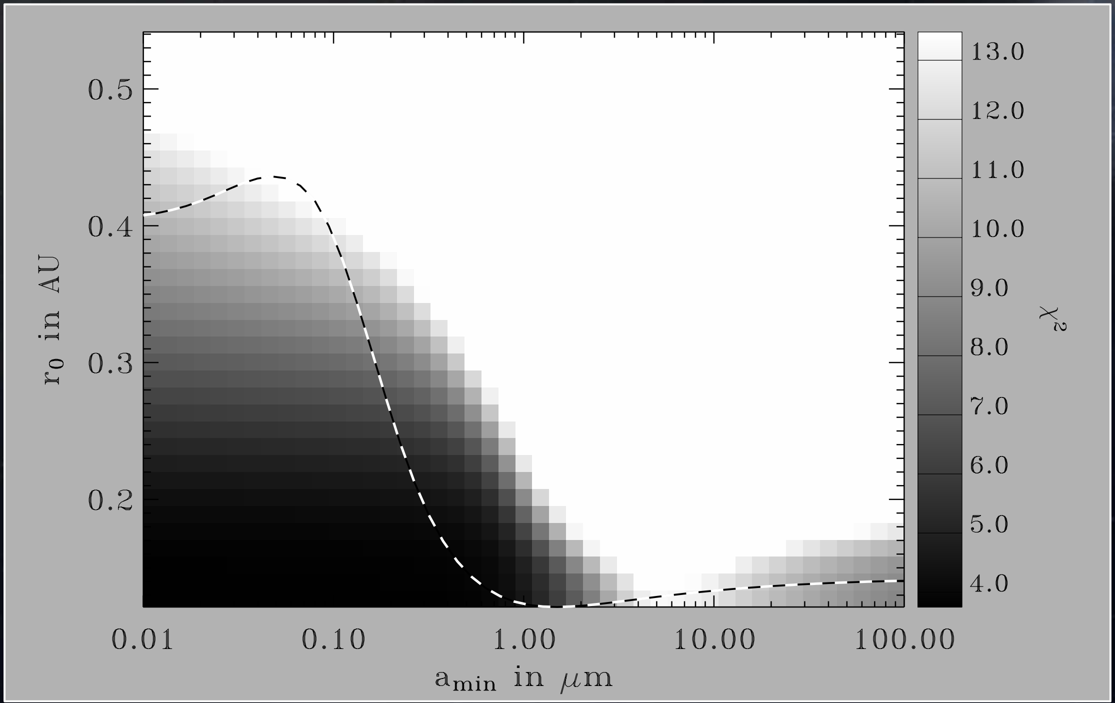
- Spectral Energy Distribution constrained by
  - Photometric data, from 1 to 12 µm
  - Interferometric data, at 2.2 and 10.6 µm
- Caveat: Vega is a rapid rotator!

Aufdenberg et al. 2006

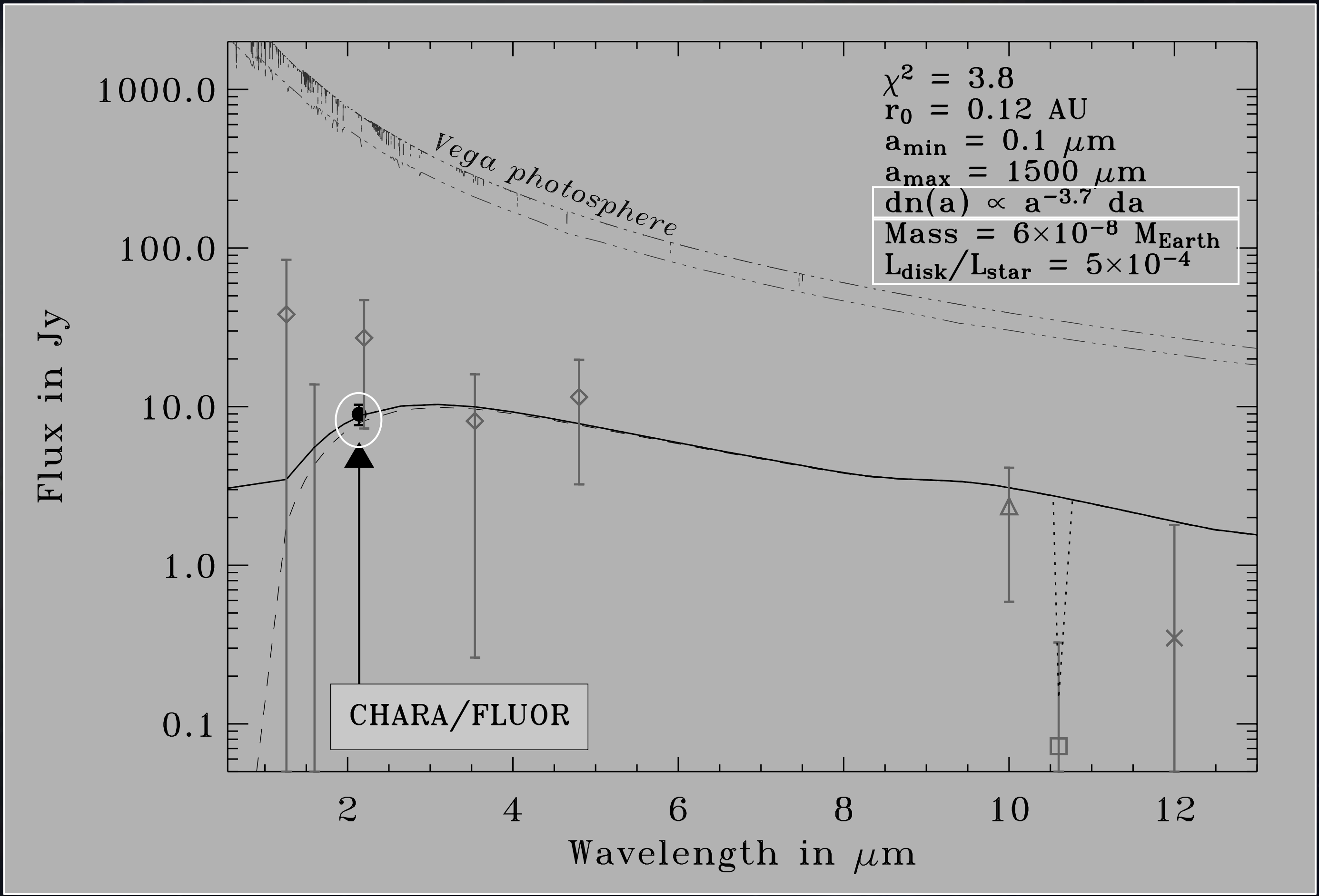


SED fitting procedure

- SED fitted with model of Augereau et al. (1999)
  - Various density power laws, size distributions & compositions
  - 2 fit parameters: minimum grain size (a_{min}) and inner radius (r_0)

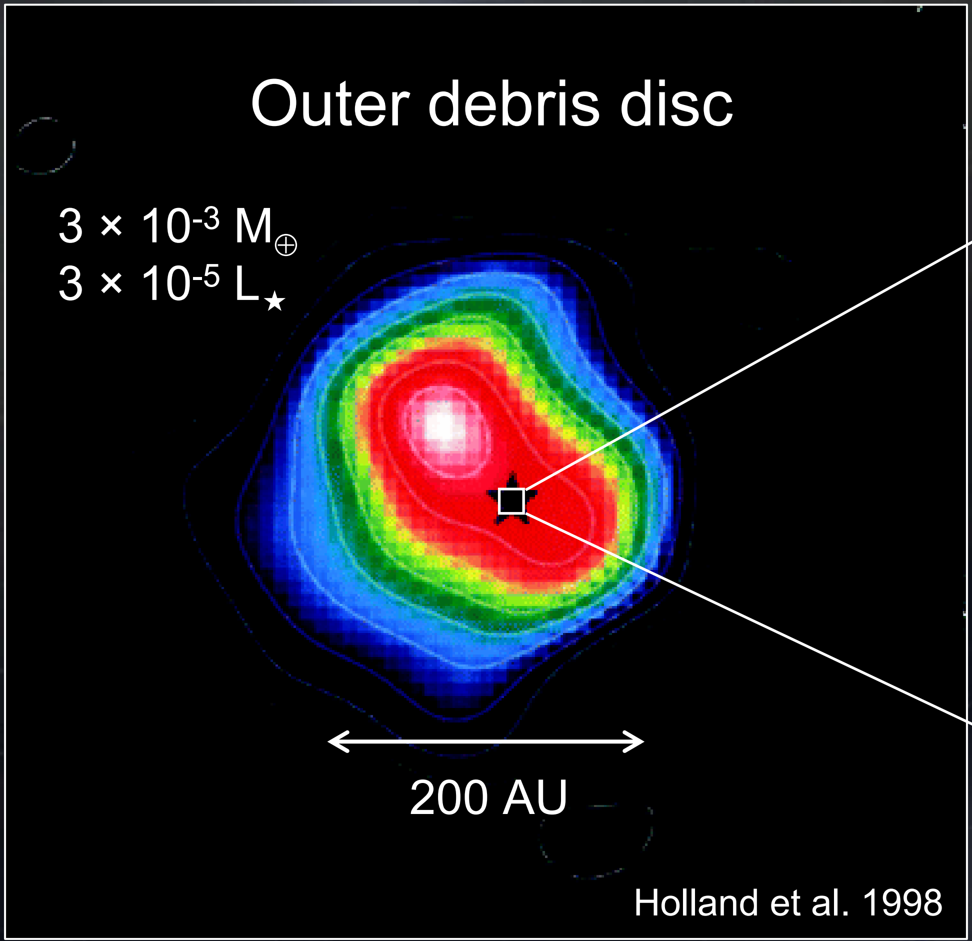


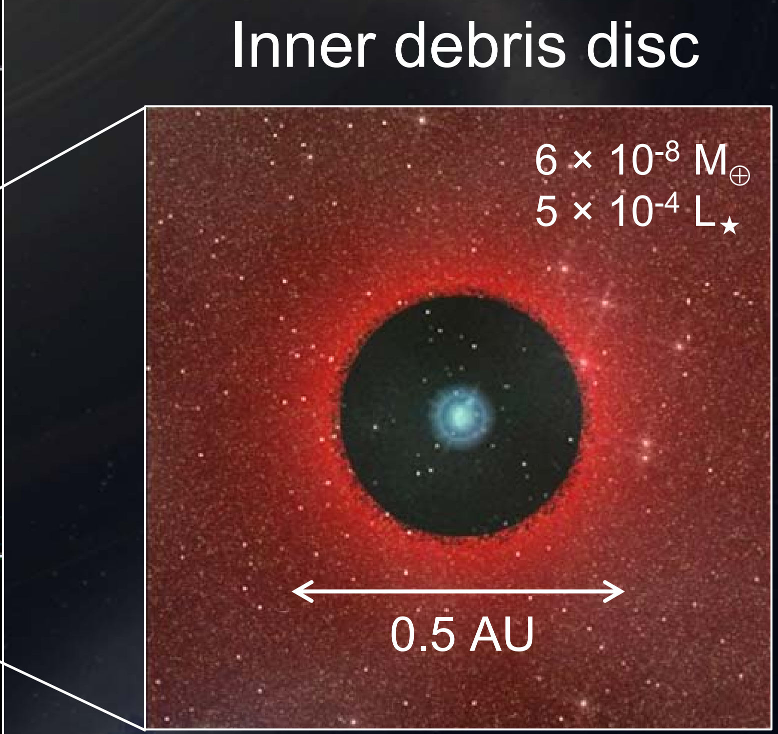
Properties of the inner disc



- Small grains (mostly < 1 µm) at distances ~ 0.1 – 0.5 AU
- Highly refractive grains, no silicate feature → carbons > 50%
- Steep density power law: $\Sigma(r) \sim r^{-4}$ (or steeper)

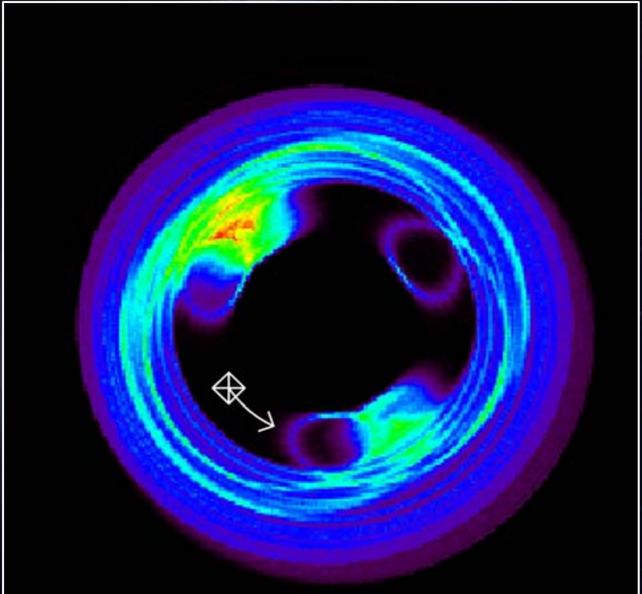
Our new view of Vega





Origin of the dust

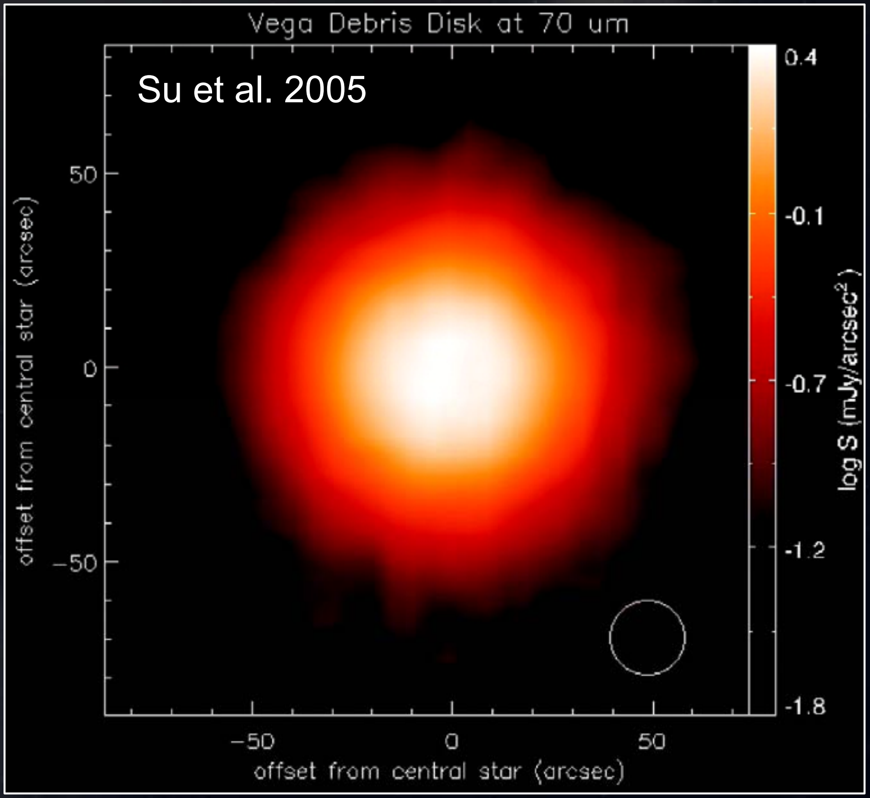
- Radiation pressure → grains blown out in ~10 yr
  - High replenishment rate needed (~10^{-8} $M_\oplus$/yr)
- Cometary origin is favoured
  - Grain size distribution ($dn \propto a^{-3.7}\,da$)
  - Steep density distribution
  - ~10 Hale-Bopp per day!
- Dynamical perturbations
  - Migrating Neptune suggested by Wyatt (2003)
  - See also poster 44 by Rèche



Wyatt 2003

Towards a global scenario?

- Late Heavy Bombardment scenario
  - Triggered by late migration of giant planets
  - Compatible with age of Vega (~350 Myr)
- Could explain at the same time
  - Asymmetry of outer disc
  - Small grains in outer disc
  - Dust in inner disc



What's next?

- Further observations of Vega
  - Confirm the excess in H/K with IOTA/IONIC
  - VISIR: mid-IR spectroscopy
- Interferometric survey of bright Vega-type stars (K<5)
  - 6 more targets at CHARA in 2006
    - Preliminary result: 3 of them seem resolved
  - First observations with VLTI (MIDI + AMBER)
- Multi-wavelength approach
- More short baselines for morphology