Exozodiacal discs with infrared interferometry

First results and perspectives

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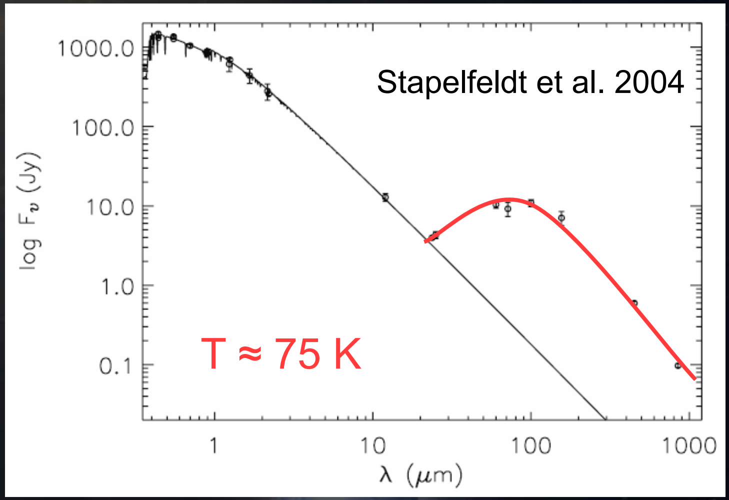
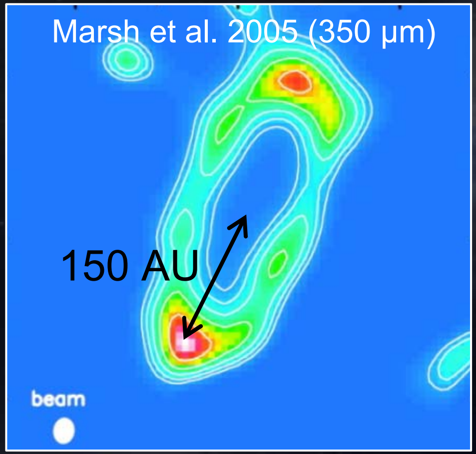
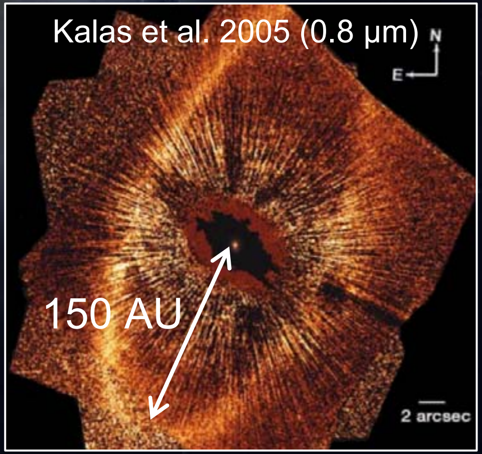
Debris discs: towards warm dust

- Detected debris discs
  - Far-IR, sub-mm, visible
  - Cold and distant (~100 AU)
  - Massive (few 100s × Kuiper belt)
  - Evidences for inner holes
- Zodiacal disc analogues?
  - Inner planetary region
  - Spitzer: first evidence for warm dust (~300 K)
  - Sensitivity ~ 1000 zodi!
- Goal: direct imaging of exozodiacal discs
  - Towards Darwin / TPF…



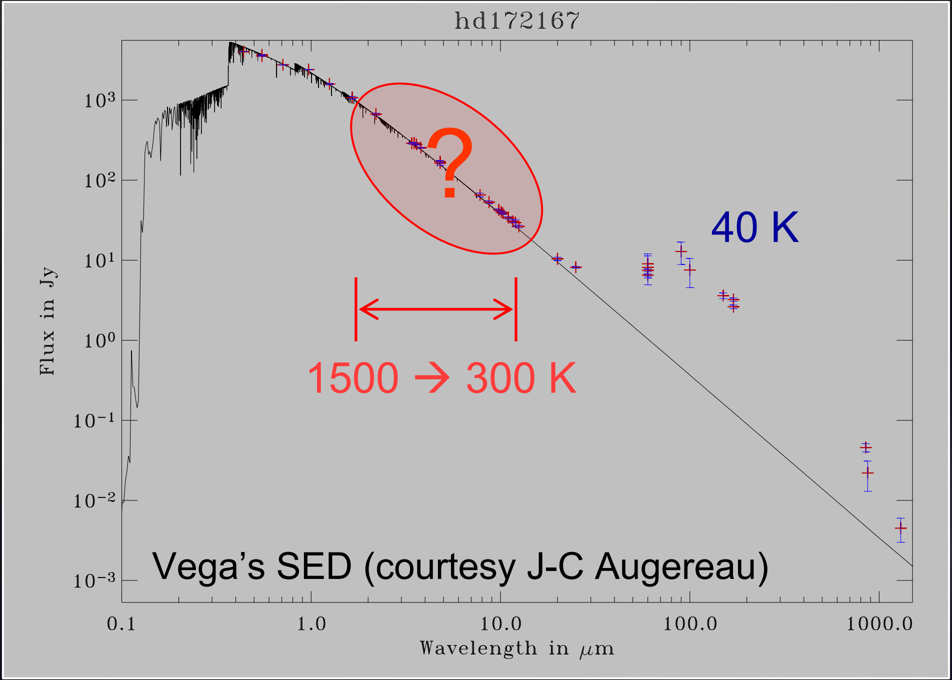


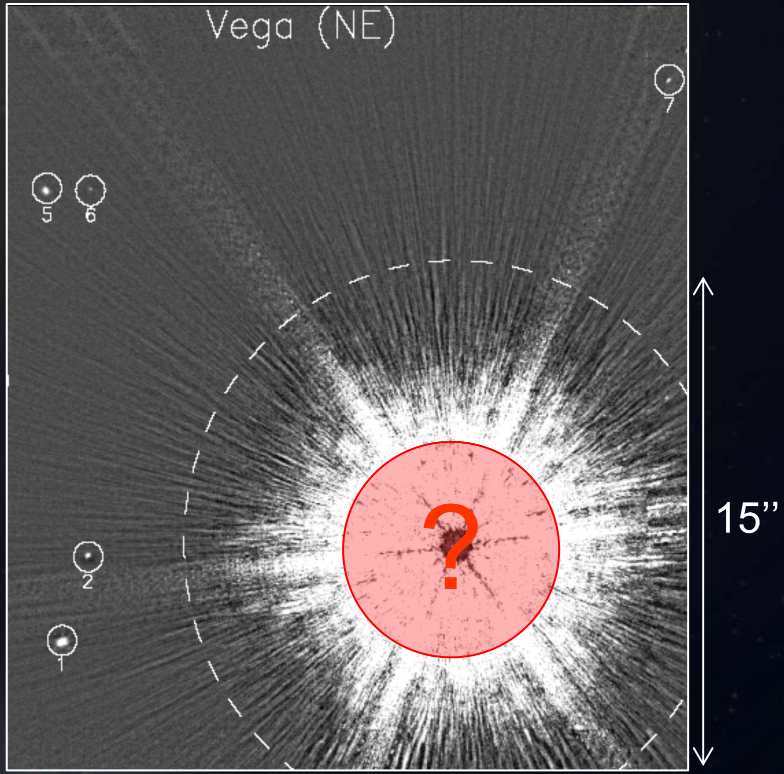


(150 AU ≈ 20'' at 7.7 pc)

The challenges of direct imaging

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

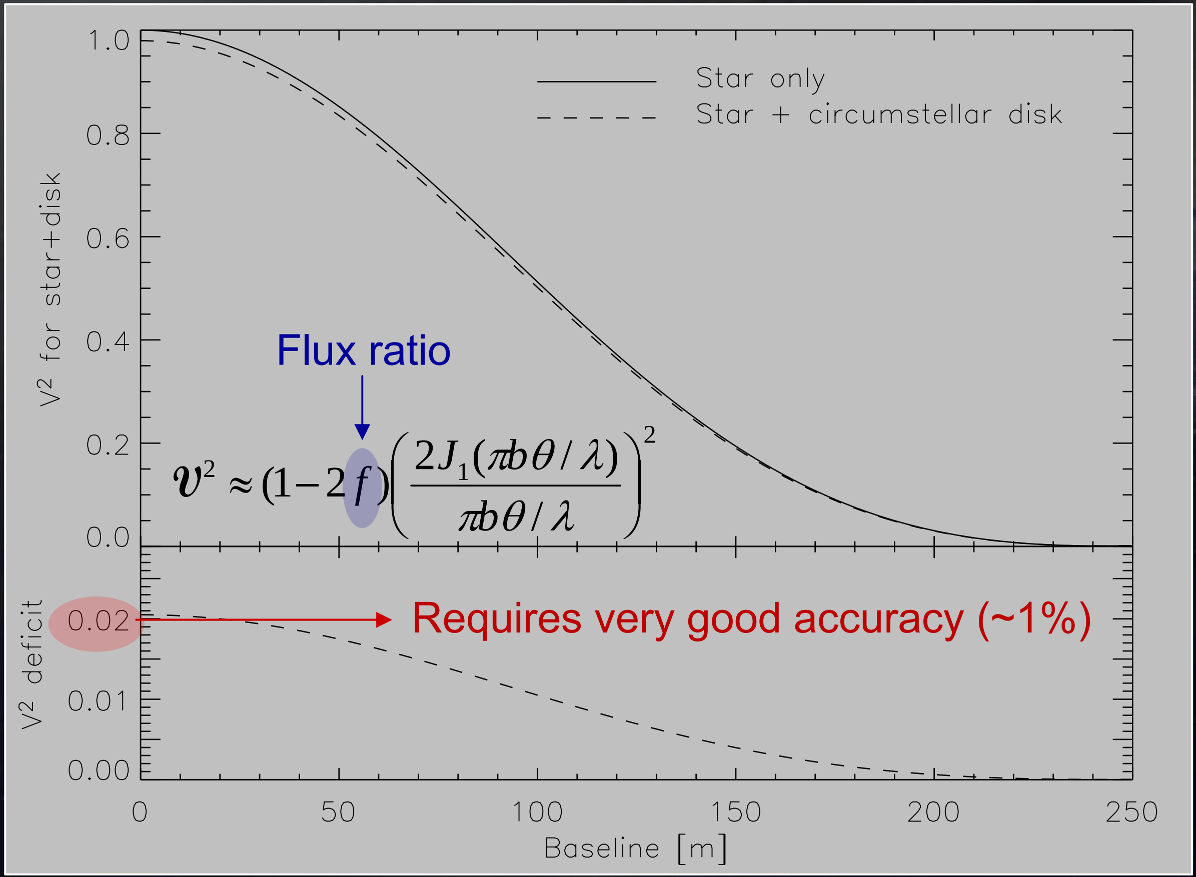




Macintosh et al. 2003 (Keck AO)

Debris discs by interferometry

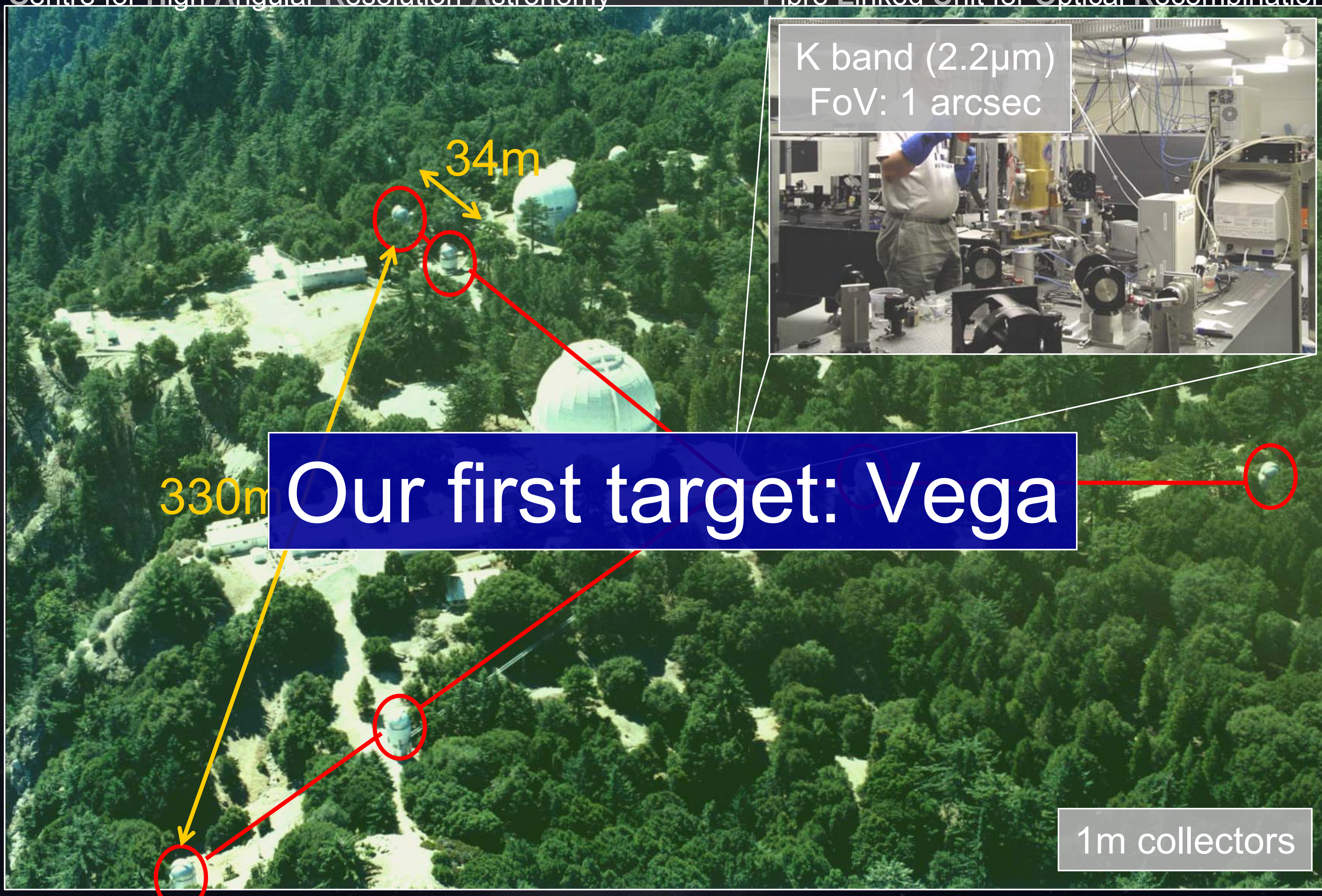
- Disc larger than angular resolution (λ/b) → incoherent flux
- Induces a loss visibility at all baselines
- Best detected at short baselines (~10-30m)



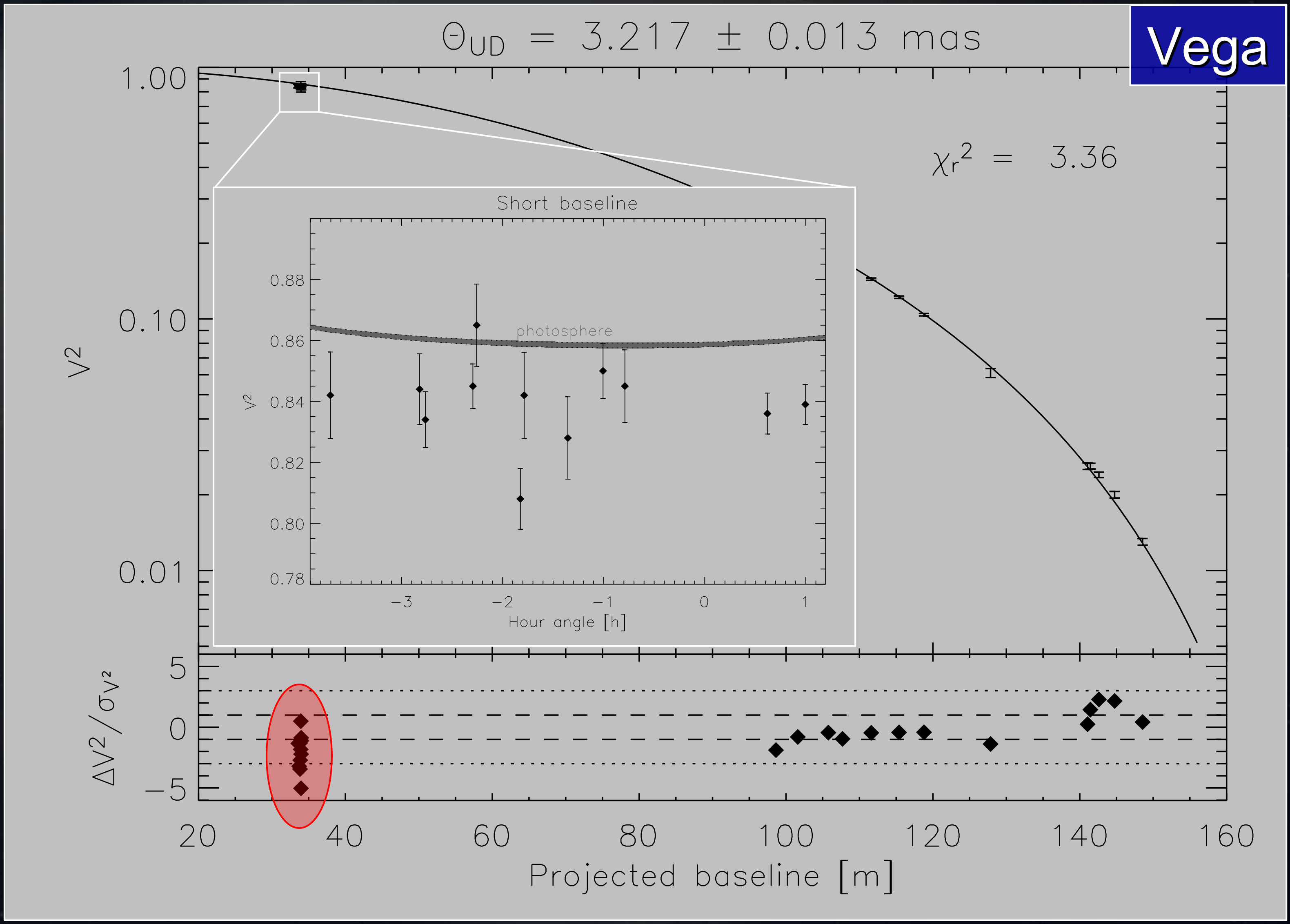
CHARA – FLUOR

Centre for High Angular Resolution Astronomy

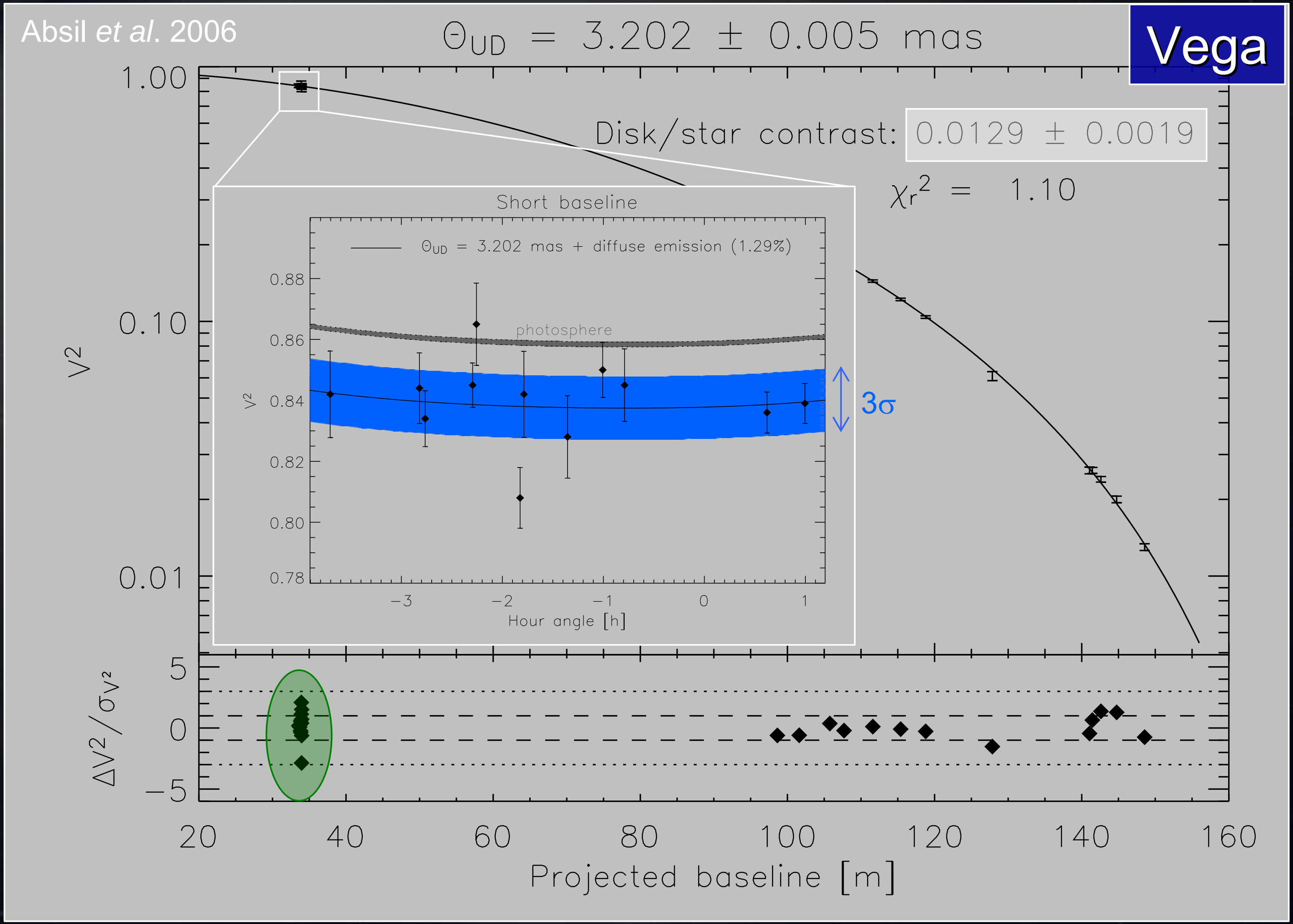
Fibre Linked Unit for Optical Recombination



Fitting a uniform-disc photosphere



Fitting photosphere + debris disc

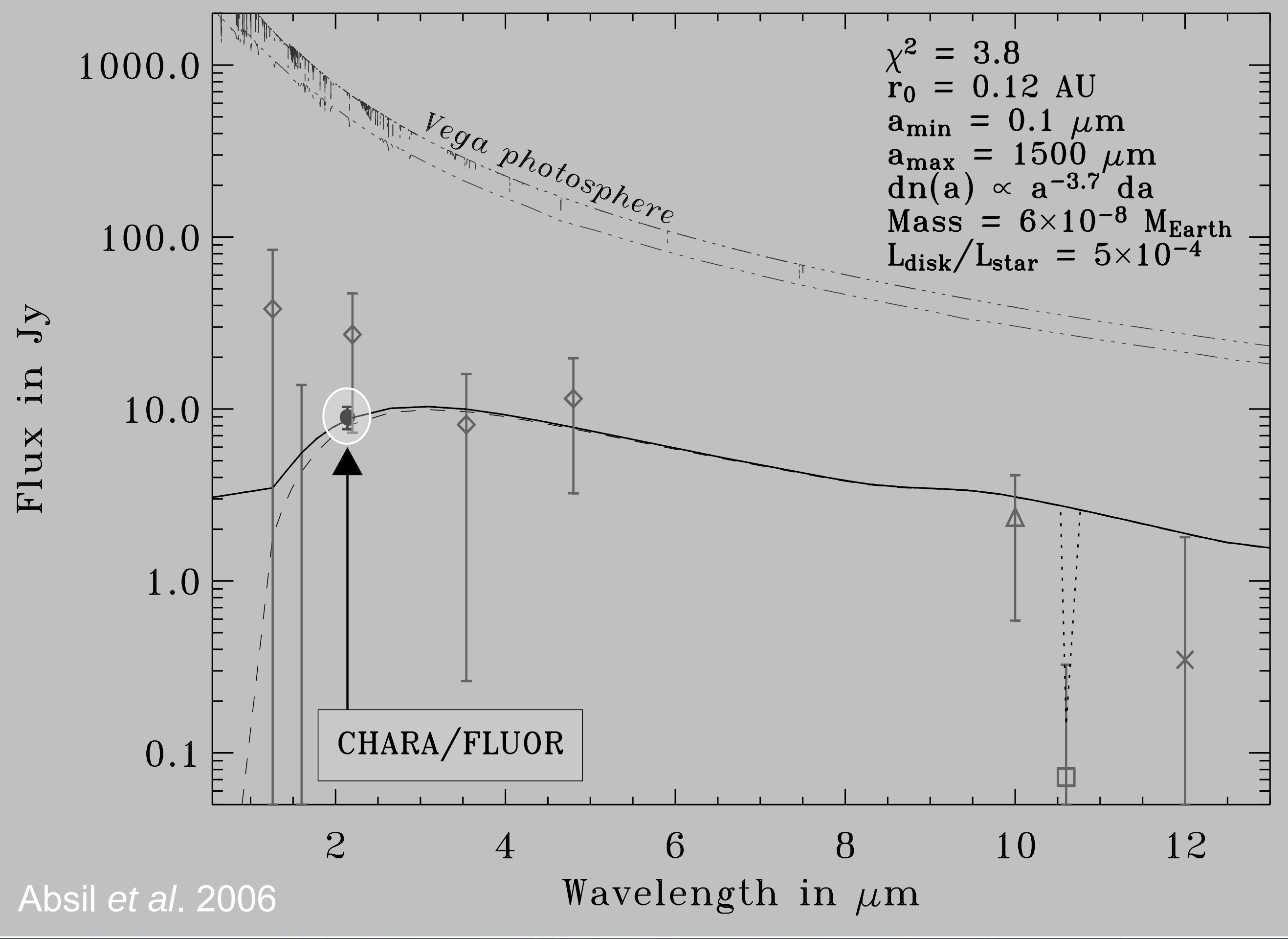


Possible sources of near-IR excess

- Point-like source?
  - RV and astrometry stable → no companion
  - Very low probability for background star
- Stellar wind?
  - A stars: very weak winds ($\sim 10^{-12..14}\ M_{\odot}$/yr)
- Circumstellar dust?
  - Thermal emission & reflected flux
    - Most probable explanation
  - Need to check compatibility with literature

Reproducing the global Vega SED

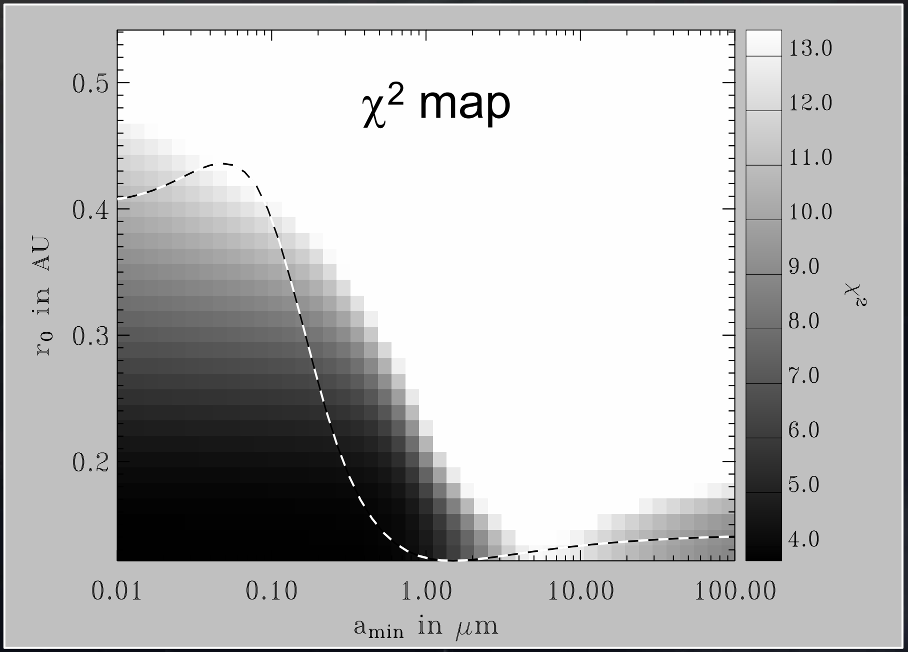
- Using the debris disc models of Augereau et al. (1999)

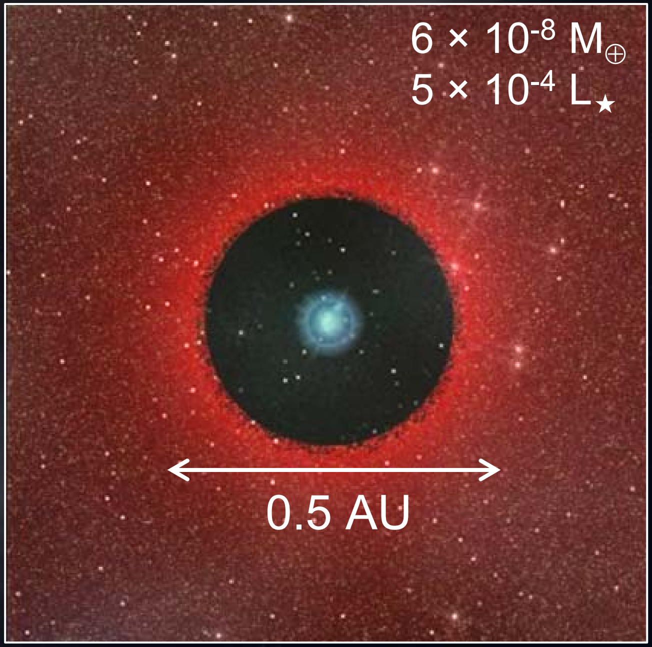


Absil *et al*. 2006

Best-fit disc properties

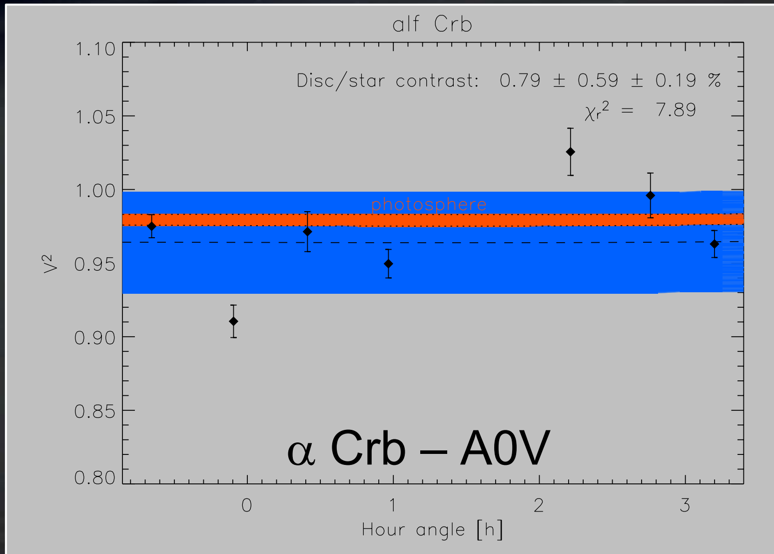
- χ^2 maps for various disc models
  - 2 fit parameters: minimum grain size (a_{min}) and inner radius (r_0)
- Small grains (mostly < 1 µm) at distances ~ 0.1 – 0.5 AU
- Highly refractive grains, no silicate feature → carbons ≥ 50%
- Steep density power law: $\Sigma(r) \sim r^{-4}$ (Solar System: $r^{-0.3}$)

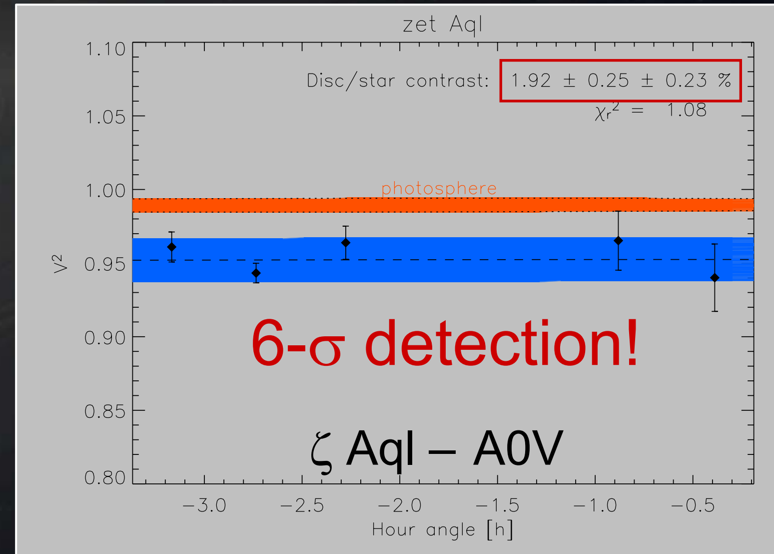


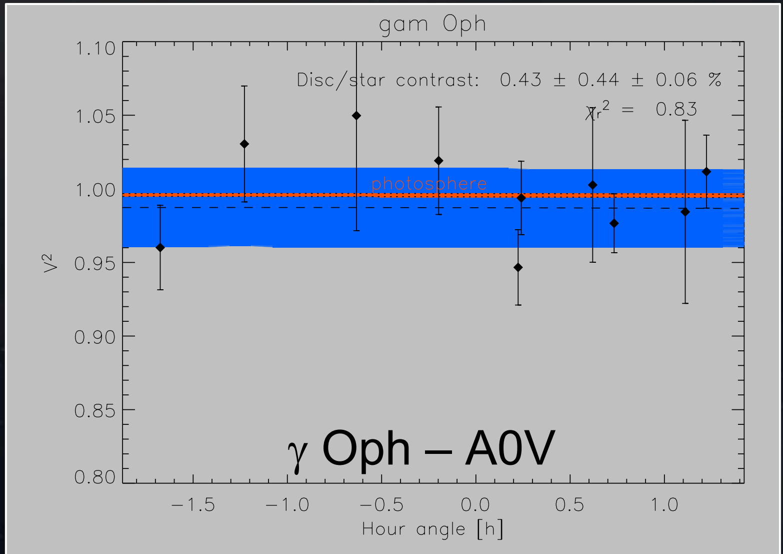


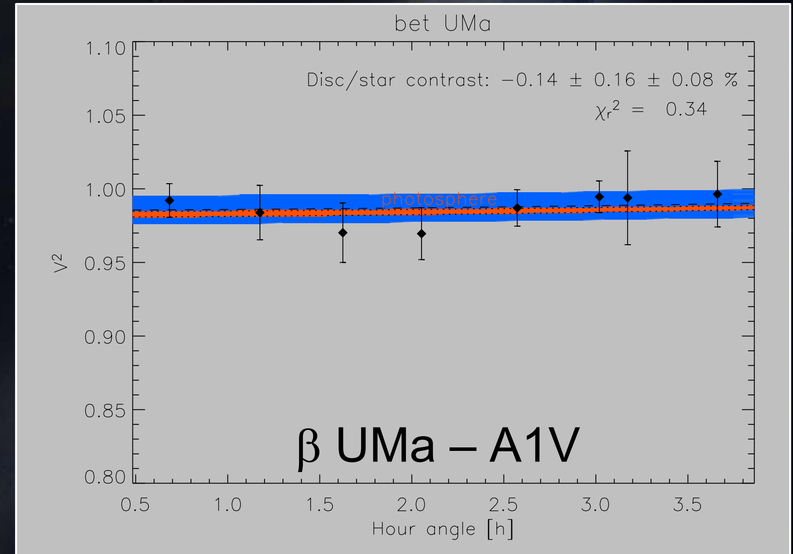
Survey: early-type stars

Absil *et al*, in prep









Survey: early-type stars

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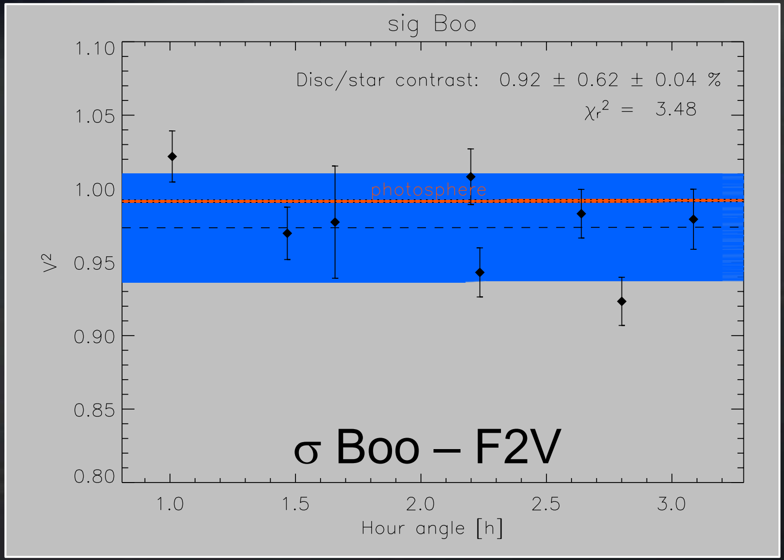
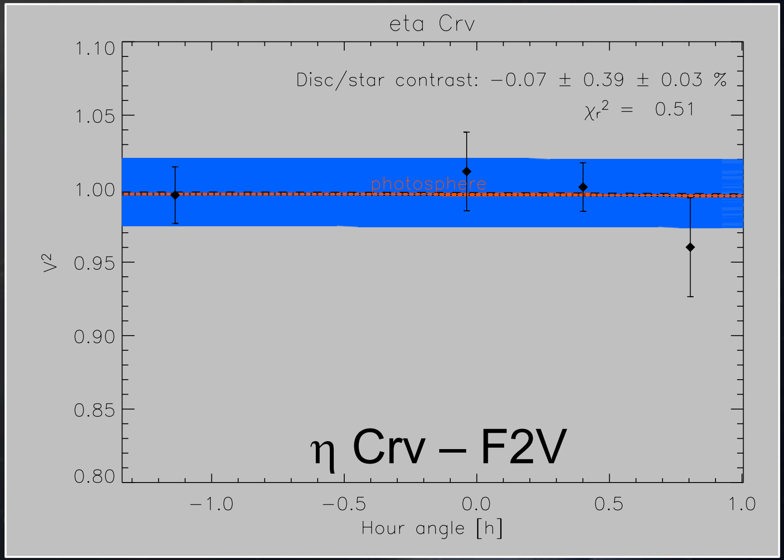
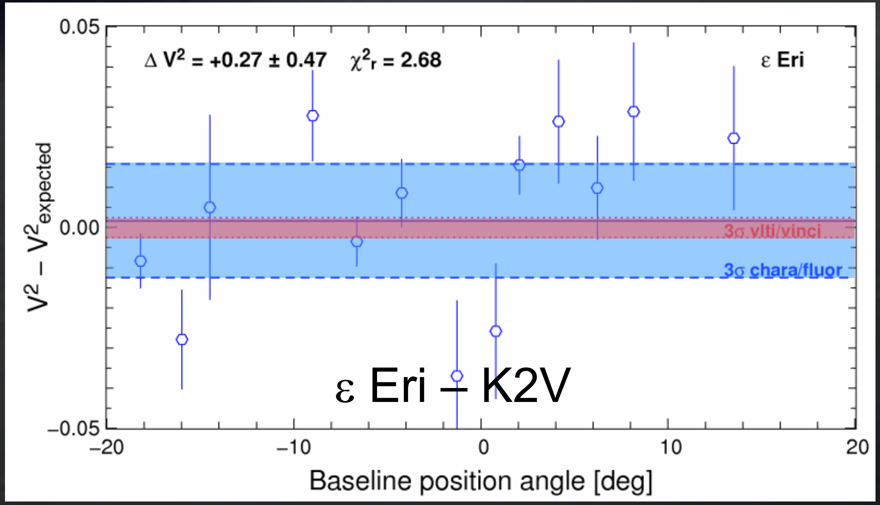


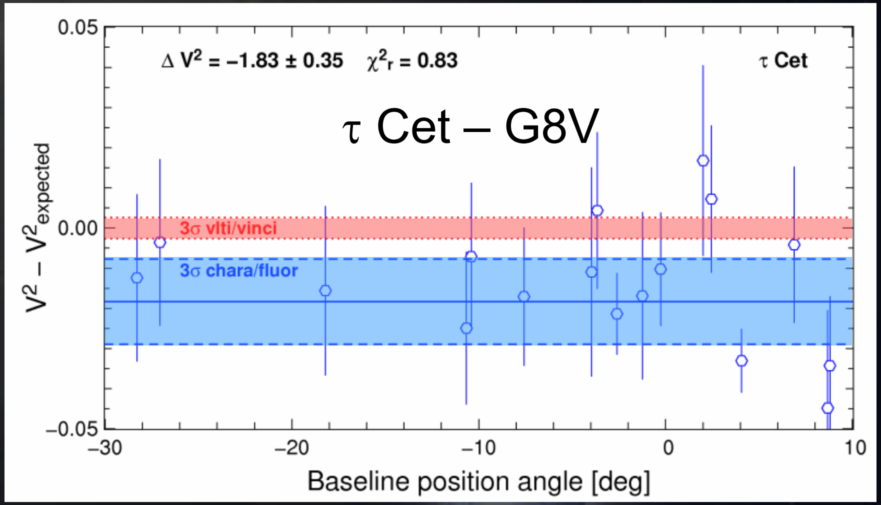


- Vega is not an isolated case!
  - Akeson *et al*: excess also around β Leo (A2V)
- Non-detections have a “healthy” behaviour
  - Detection is not an instrumental effect!

Survey: solar-type stars

Di Folco *et al*, in prep



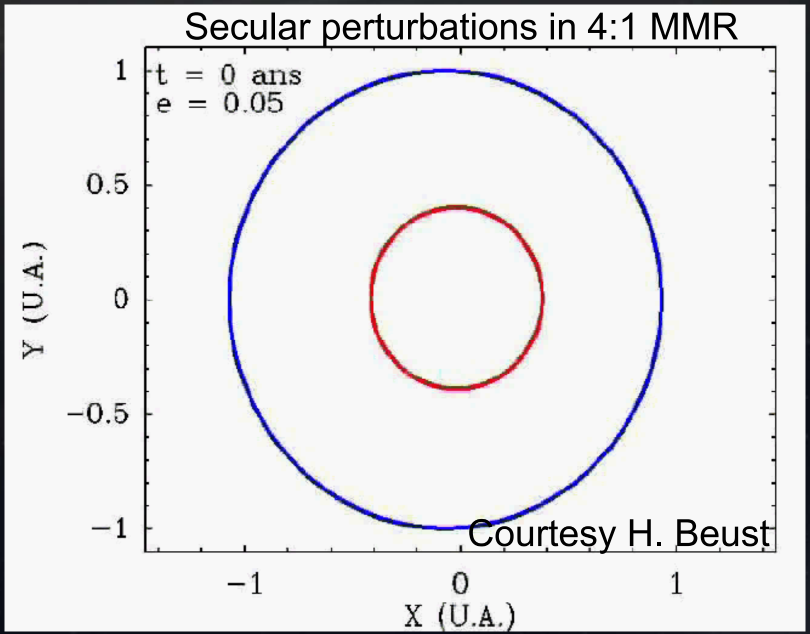


- τ Cet (~10Gyr, G8V): also small C-rich grains!
- Where does all this dust come from?
  - Small → very short lifetime (radiation pressure)
  - Need high replenishment rate
  - Solar F-corona and zodiacal cloud are much weaker

→ Augereau *et al*, in prep

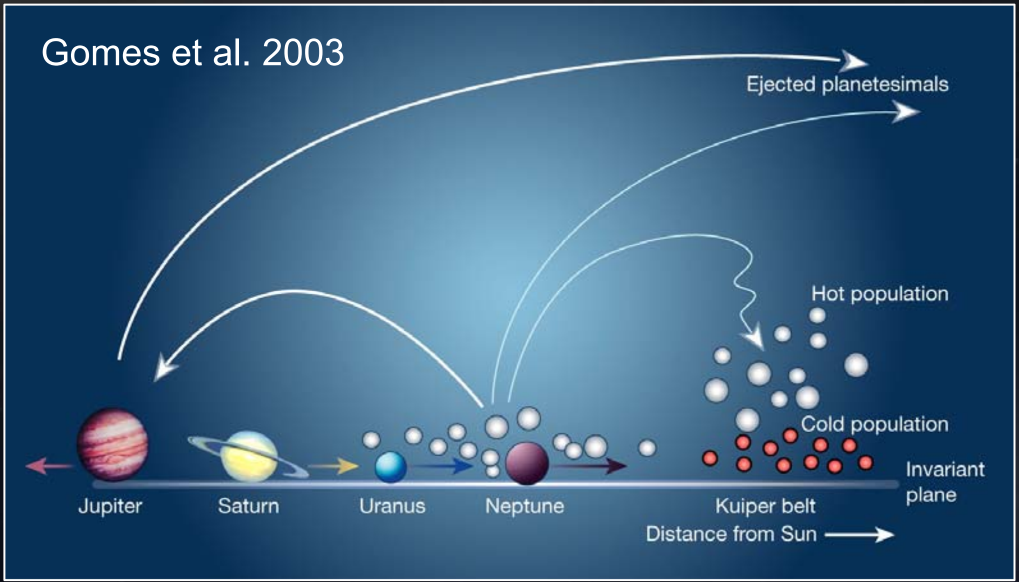
Origin of the dust

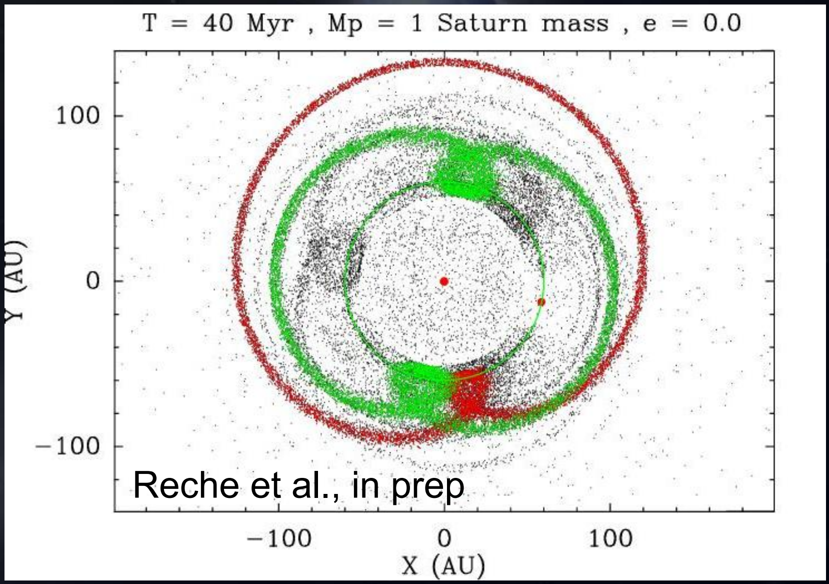
- 1^{st} scenario: Falling Evaporating Bodies
  - Proposed for β Pic (Beust & Morbidelli 2000)
  - Local disc perturbation by a planet
  - Production of star-grazing comets
  - Needs replenishment (migration?)



Origin of the dust

- 2nd scenario: Late Heavy Bombardment
  - Dynamical re-arrangement of planets
  - Global disc perturbation
  - Injection of bodies from asteroid and Kuiper belts
  - Collisions and evaporation





What's next: VLTI

- AMBER
  - (J), H and K band
  - Good accuracy (FINITO) + closure phases
- MIDI
  - N band → silicates?
  - Limited accuracy → bright discs only
- 2nd generation instruments
  - VSI (near-IR) & MATISSE (mid-IR)
  - More baselines → increased efficiency
  - Larger surveys are considered

Perspectives: nulling interferometry

- Cancel starlight by destructive interference
- VLTI-GENIE
  - End-to-end simulation → sensitivity: 50 – 100 zodi
  - Instrument now discarded by ESA/ESO
- Dome C: ALADDIN
  - Sensitivity: ~ 20 zodi (Absil et al., in prep)