Interferometric observations of the Darwin Stars

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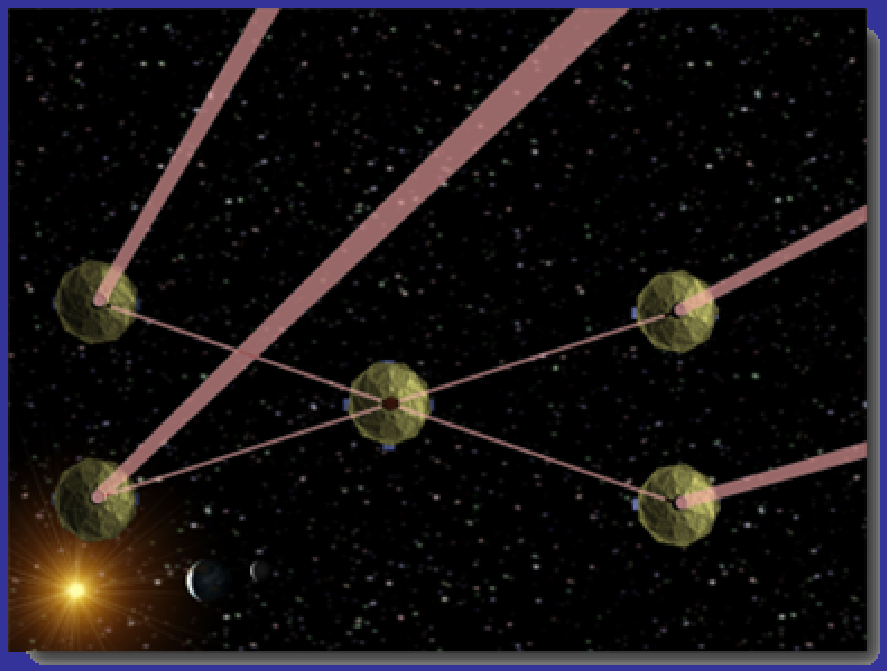
1. Scientific Case

DARWIN stars characterization



X-Array architecture of Darwin

(Courtesy T. Herbst)

DARWIN will search for the presence of extrasolar Earth-like planets around nearby stars.

DARWIN will also characterize their atmospheres, analyze their chemical composition, carry out comparative planetology and look for biosignatures.

Darwin's success depends on an extremely careful selection of the stellar targets.

Observations needed:

Host stars :

Fundamental stellar parameters.

Photometric stellar behaviour and variability.

Chromospheric activity, flares, magnetic fields and stellar winds.

Stellar environments :

Exo-zodiacal disk and Kuiper belts.

Physical membership in stellar associations.

Projected field, angular distance and proper motions.

Multiplicity/binarity of the stars

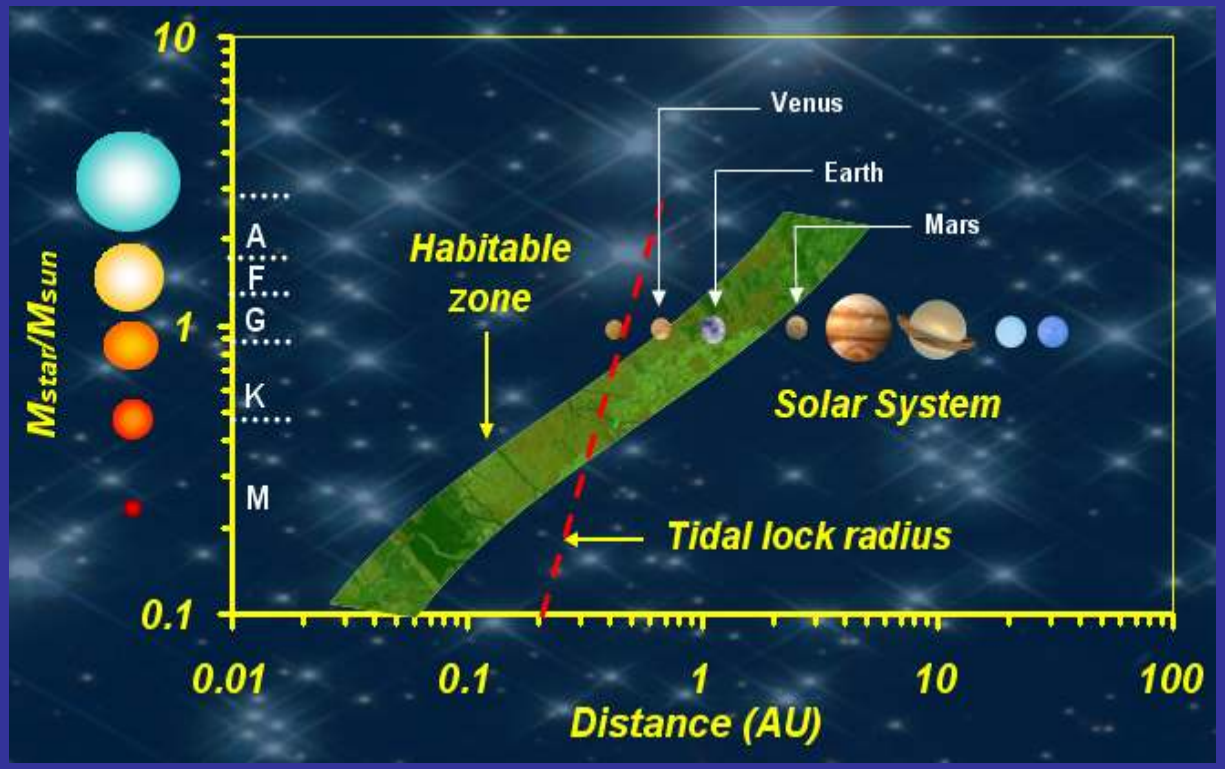
One of the most important observational constraints:

A faint object within the nulling interferometer FOV can prevent us to obtain a clear planetary signal

The existence of a physical companion can influence the proper existence of an Earth-like planet

No systematic studies available.

VLTI can explore the 1-100 mas separation range: the Habitable Zone.



Size of the Habitable Zone around stars as a function of spectral types.

2. Observing proposal

Observing proposal

- Binary detection: Feasibility study
  - Goal: Detection of faint M dwarf companions
- AMBER with ATs Low resolution mode
  - Maximum spatial resolution and FOV
- 2 bright F8V stars at distances 9-25 pc

Star	d (pc)	K	Dit (ms)	Calibrator	Obs Time	Obs Date
HIP 32366	25	4.66	100	HD 48915	1 night	1st Jan
HIP 27072	9	2.42	50	HD 49815	1 night	15th Dec

3. Analysis of the data

Analysis of the data

The observations proposed will

- Resolve binaries in the range 0.7-125 mas (habitable zone for F, G and K stars)
  - 0.06-1.13 AU @ 9pc
  - 0.18-3.13 AU @ 25pc
- Derive positions and flux ratios in 0.7-50 mas
- Derive angular diameters of nearby ~10 pc F stars

Simulations with ASPRO

Problem proposed

- To resolve and characterize a F8V-M2V binary system, with radii inside the habitable zone
- It is representative of the problem, in terms of contrast and distance between binary components

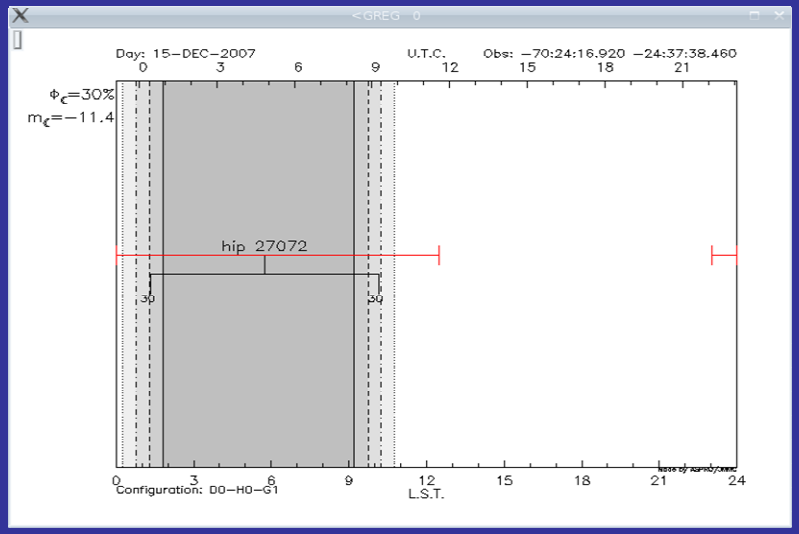
Model used

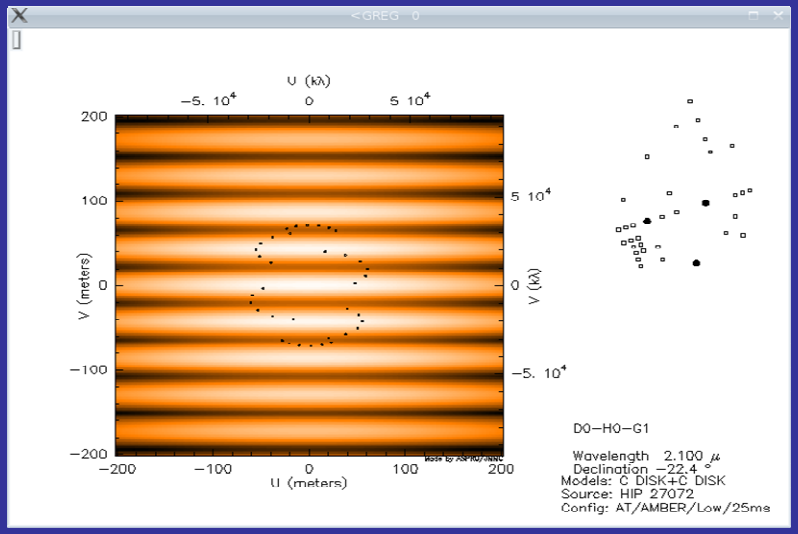
- Flux ratio: 0.70/0.30, based on Kurucz flux models for 2.1 μm
- Stellar radii: 1.29/0.50 R_{Sun}, based on Straizys empirical calibrations

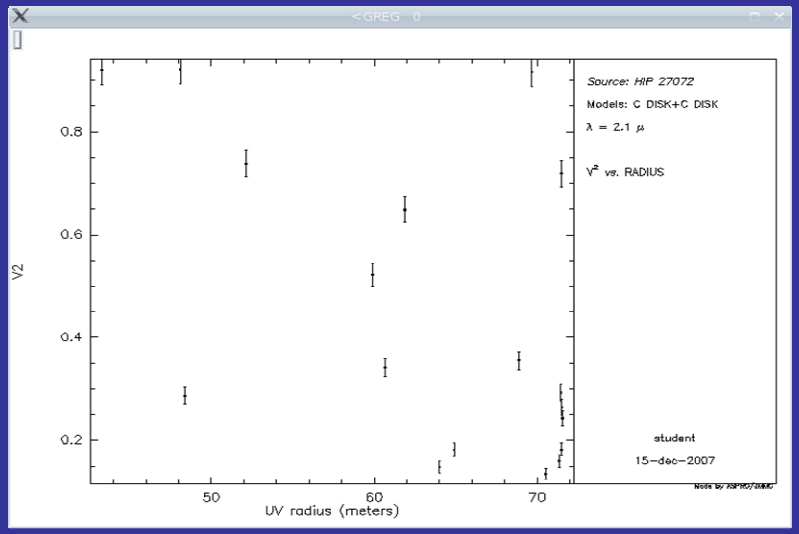
HIP 27072. ASPRO model

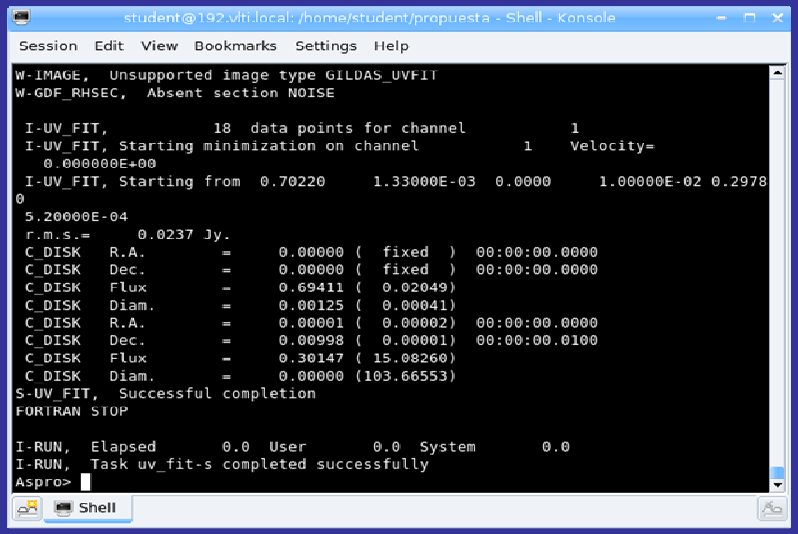
- Distance: 9 pc
- Stellar disks: homogeneous C_DISK
- Primary: F8V, R = 1.33 mas, Flux = 0.70
- Secondary: M2V, R = 0.52 mas, Flux = 0.30
- Separation: 0.7-125 mas in DEC (ATs full FOV)
- Baselines: D0-H0-G1 (widest allowed)

HIP 27072 (10mas)



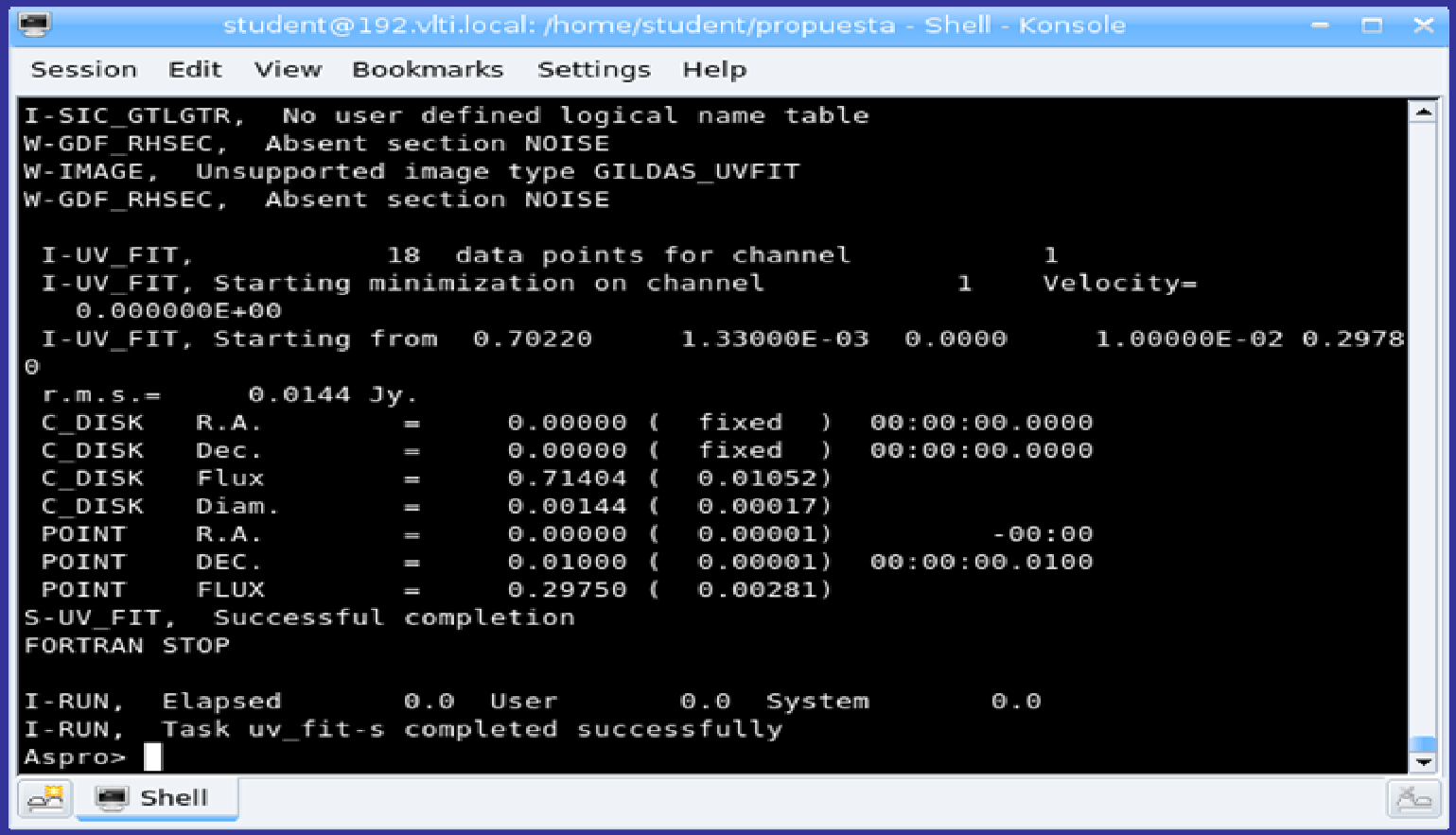






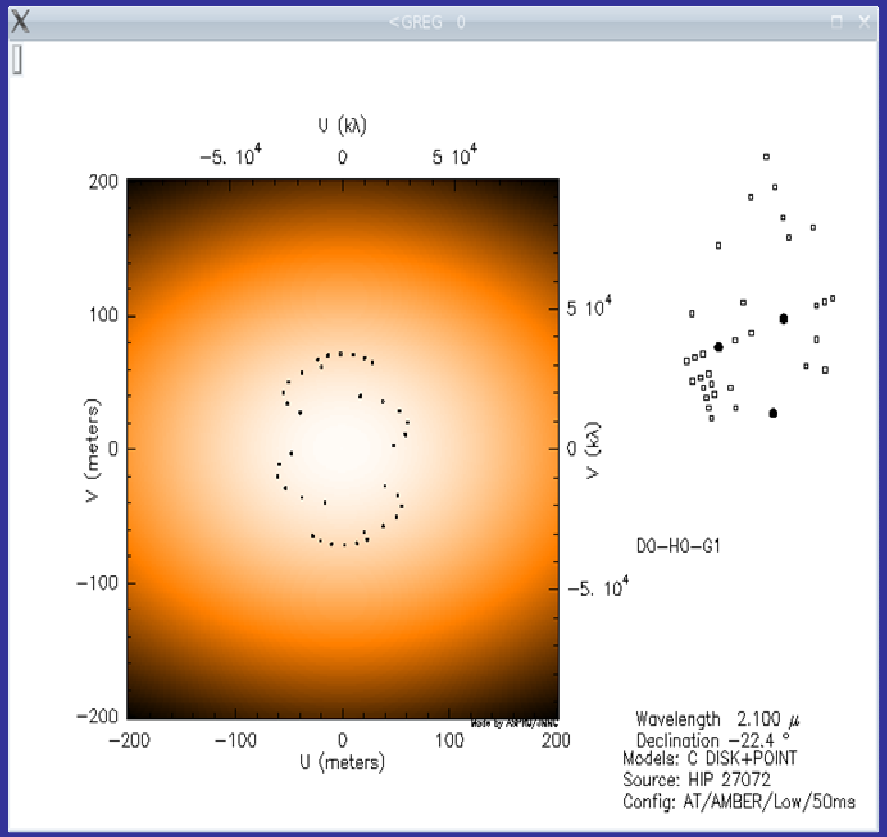
HIP 27072: improved fit (10mas)

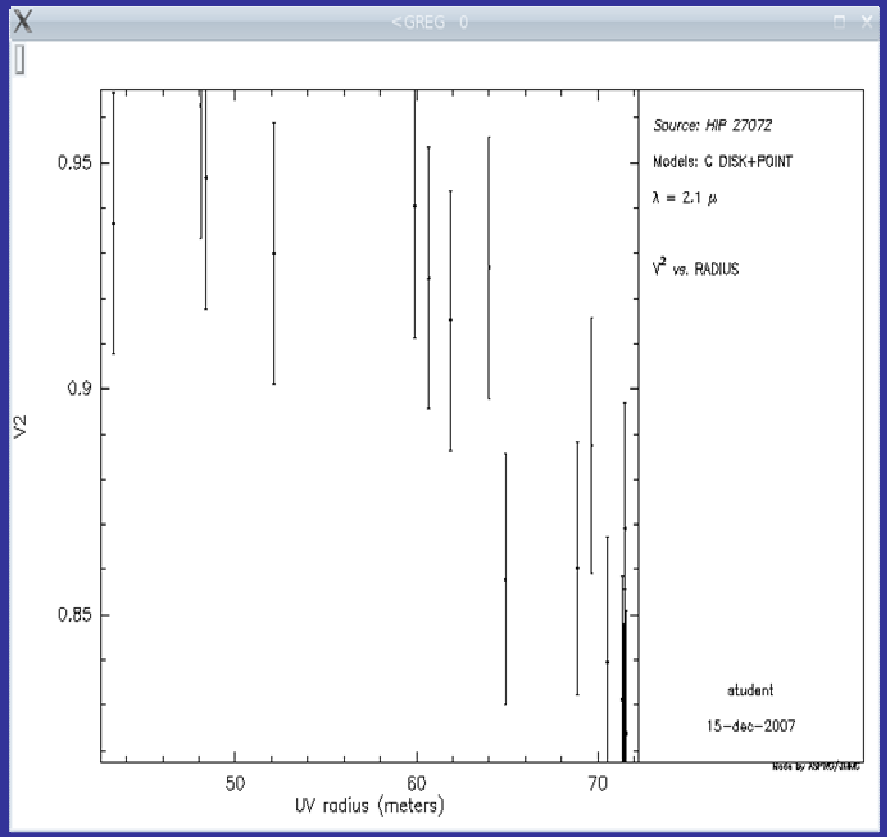
- Secondary stellar disk is not resolved => point source => fit improved



HIP 27072 (0.7mas)

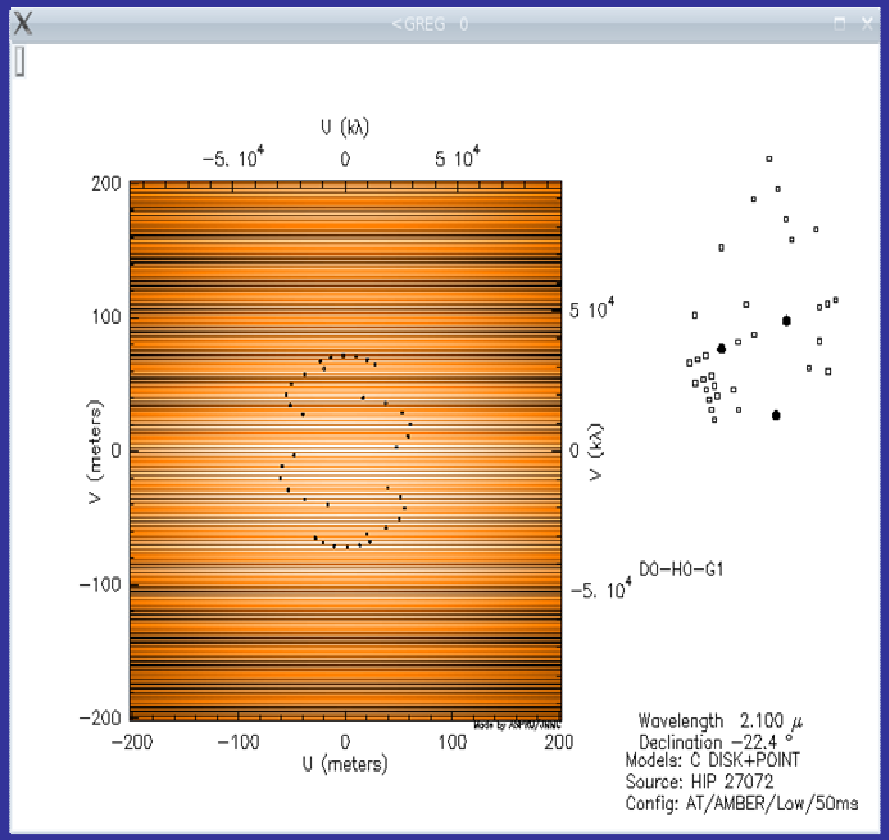
Resolution limit for AMBER in K band

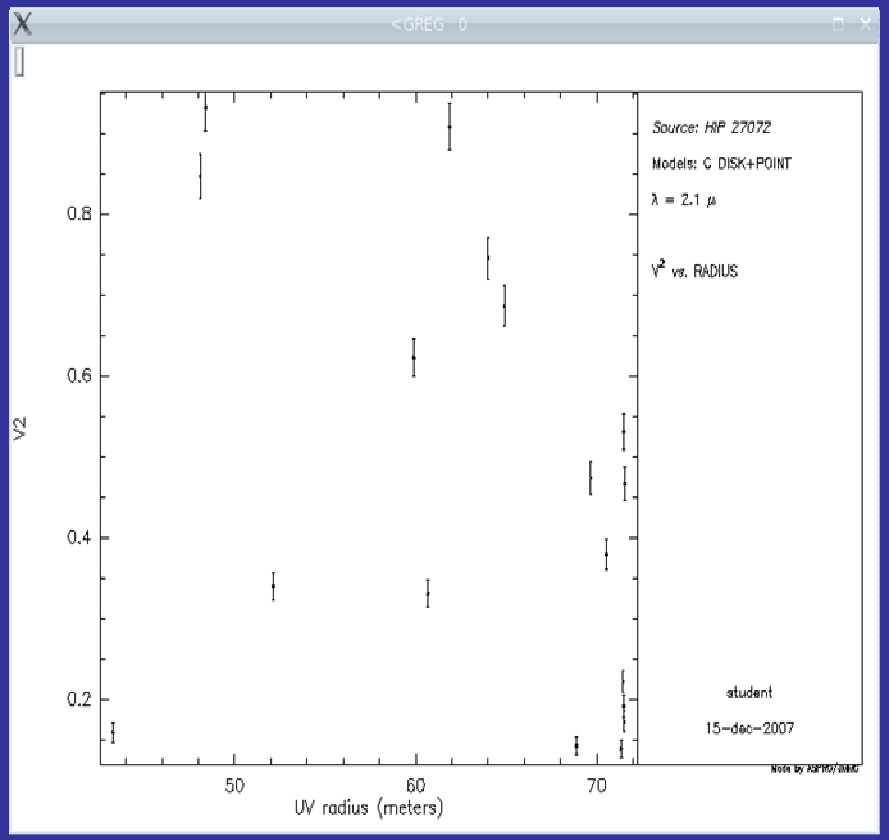




HIP 27072 (125mas)

Binary over resolved: characterization difficult but main objective (resolution) achieved





HIP 32366

- Distance: 25 pc
- Stellar disks: homogeneous C_DISK
- Primary: F8V, R = 0.50 mas, Flux = 0.70
- Secondary: M2V, R = 0.19 mas, Flux = 0.30
- Separation: 0.7-125 mas in DEC (ATs full FOV)
- Baselines: A0-K0-H1 (widest for ATs)
- Primary stellar disk is not resolved
- Similar results in binary characterization

The future

- The "crazy people" of Darwin are working in the characterization of the target stars
  - More than 250 high resolution echelle spectra (Maldonado et al, 2007, in prep.)
  - Several proposals in the mid IR
  - DAMA (Darwin Madrid Archive) under construction (Solano et al, 2007, in prep.)
- Interferometric observations and improvements
  - Combination with lucky imaging and adaptive optics to explore parameter space and optimize the observations
  - Wait for improvements in AMBER sensitivity to observe G and K stars
  - Optimize the observing strategy to allow the observation of multiple objects during the same night