Masses and Radii of Young Stars

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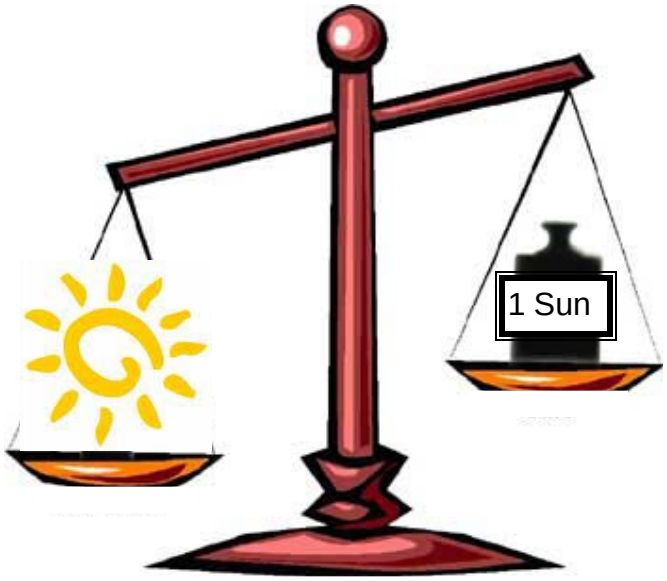
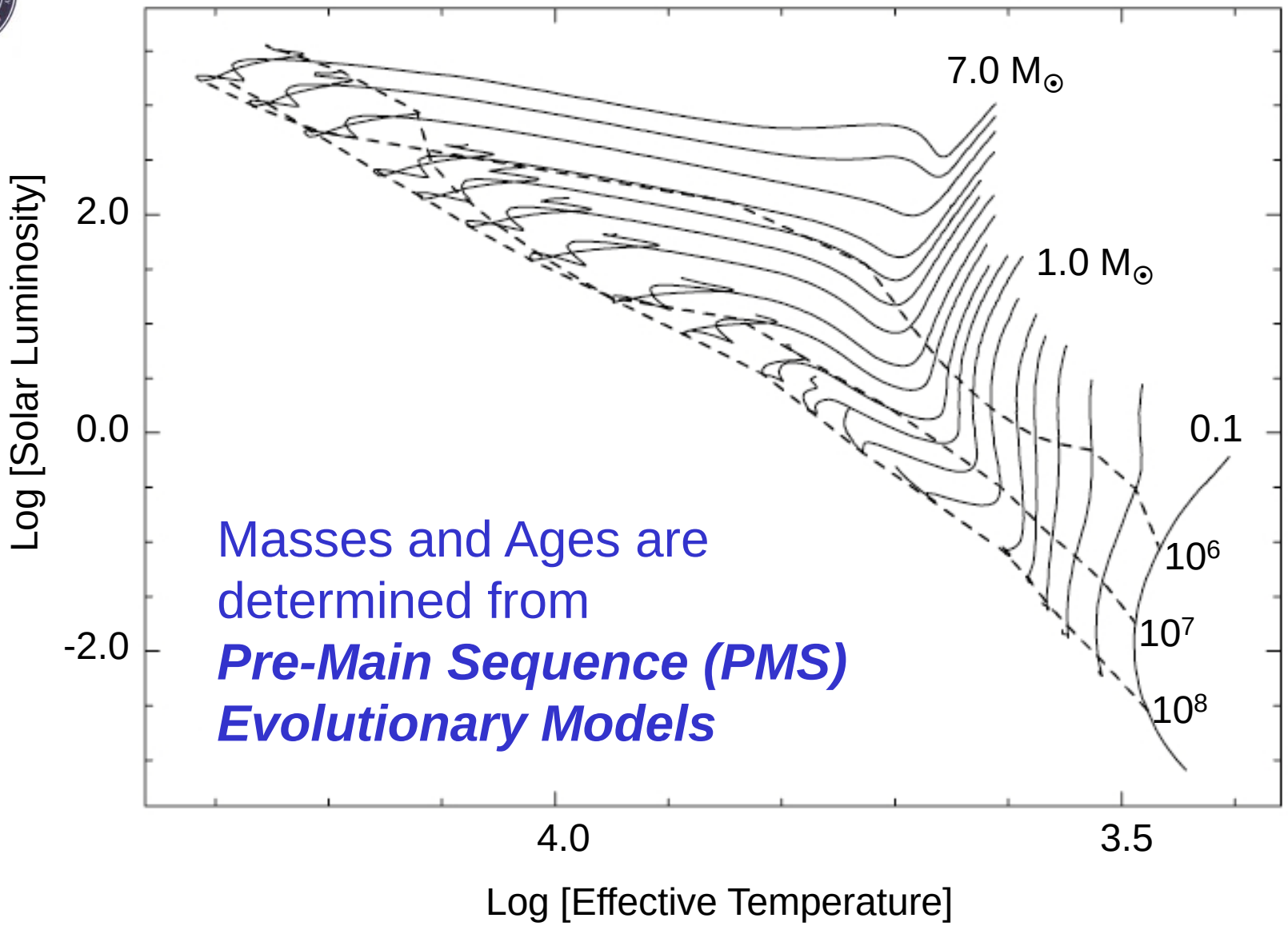
And: Ellyn Baines, Tabetha Boyajian, Theo ten Brummelaar, Leslie Hebb, Ettore Pedretti, Nathalie Thureau

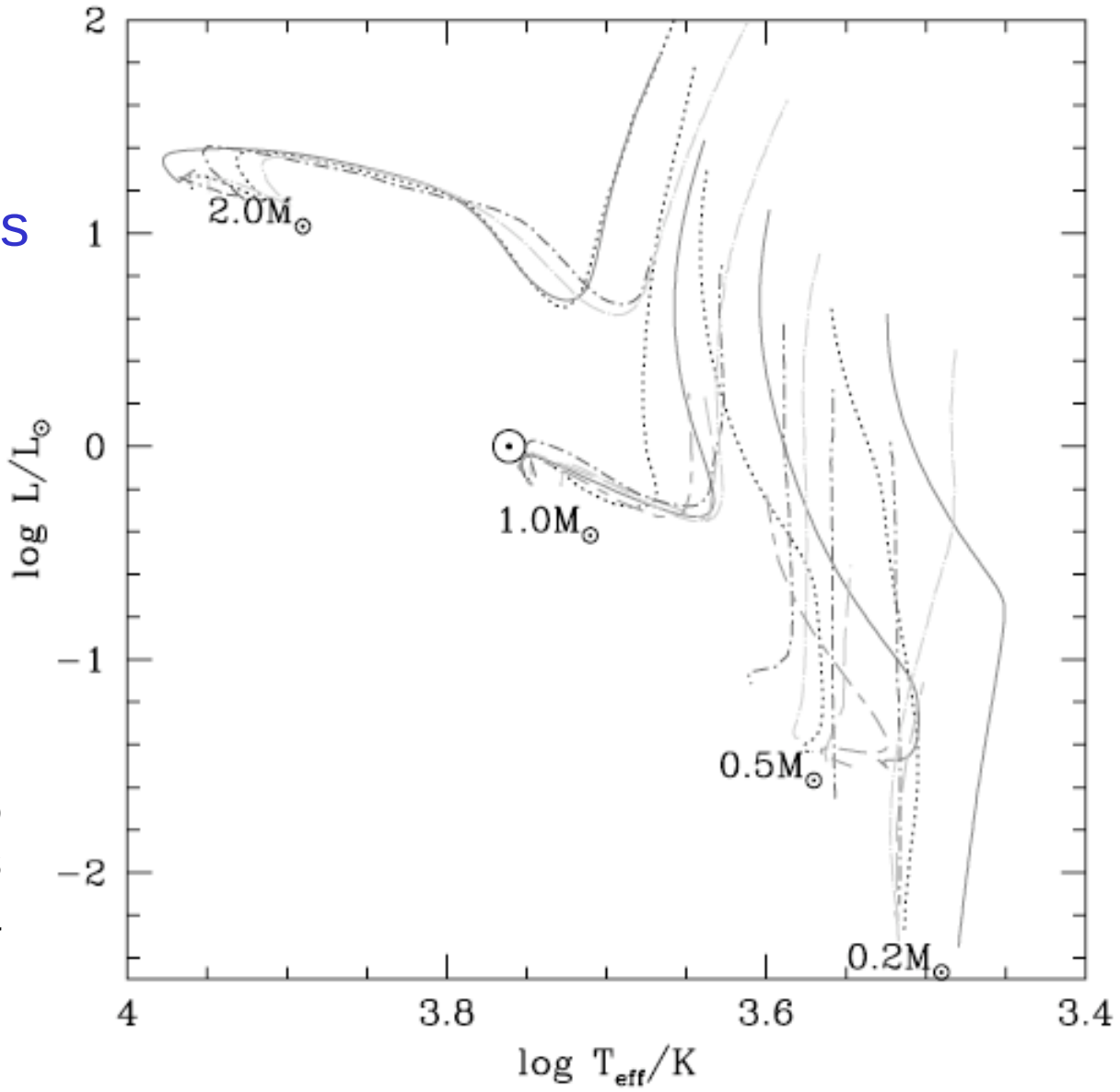
To improve mass & age estimates of young stars





Masses and Ages are determined from ***Pre-Main Sequence (PMS) Evolutionary Models***

… but there are lots of uncertainties in these models.



A comparison of 6 evolutionary models (from Hillenbrand & White 2004)

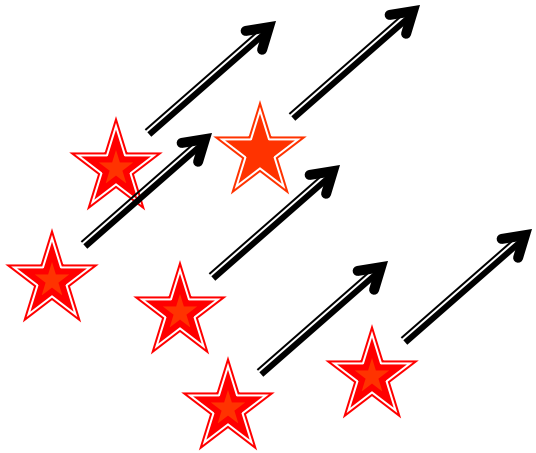
Two Important Advances

CHARA
330-m baseline, $K_{lim} \sim 7$
$\theta_{res} \sim 0.4$ mas

Nearby (< 50 pc)
Young (10-50 Myr)
Moving Groups

Zuckerman & Song (2004);

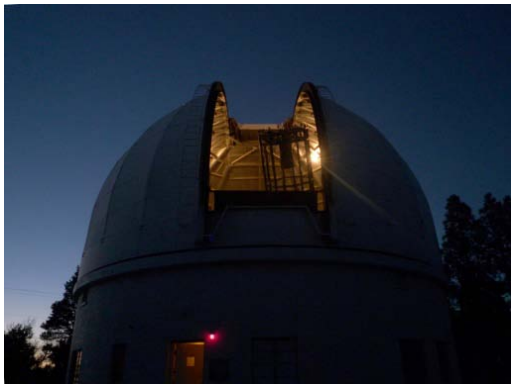
Torres et al. (2008)

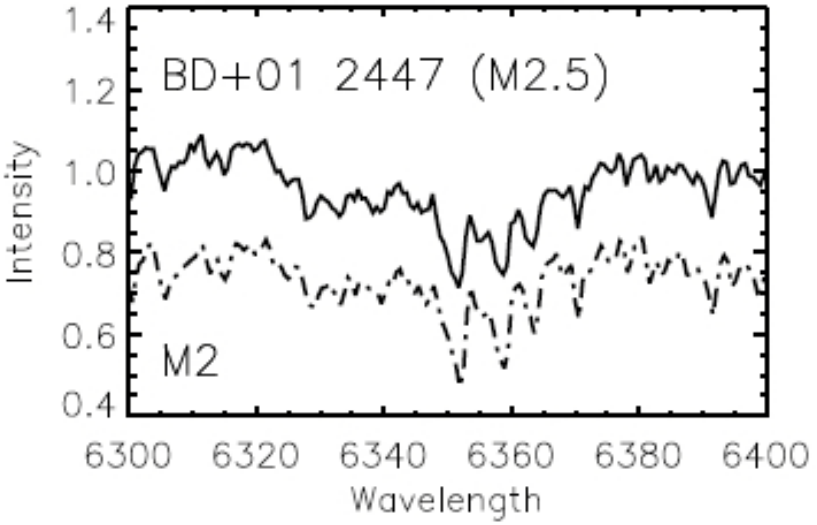


Can Any Be Resolved?

Kyle McCarthy (GSU)

Optical Spectroscopy at Lowell



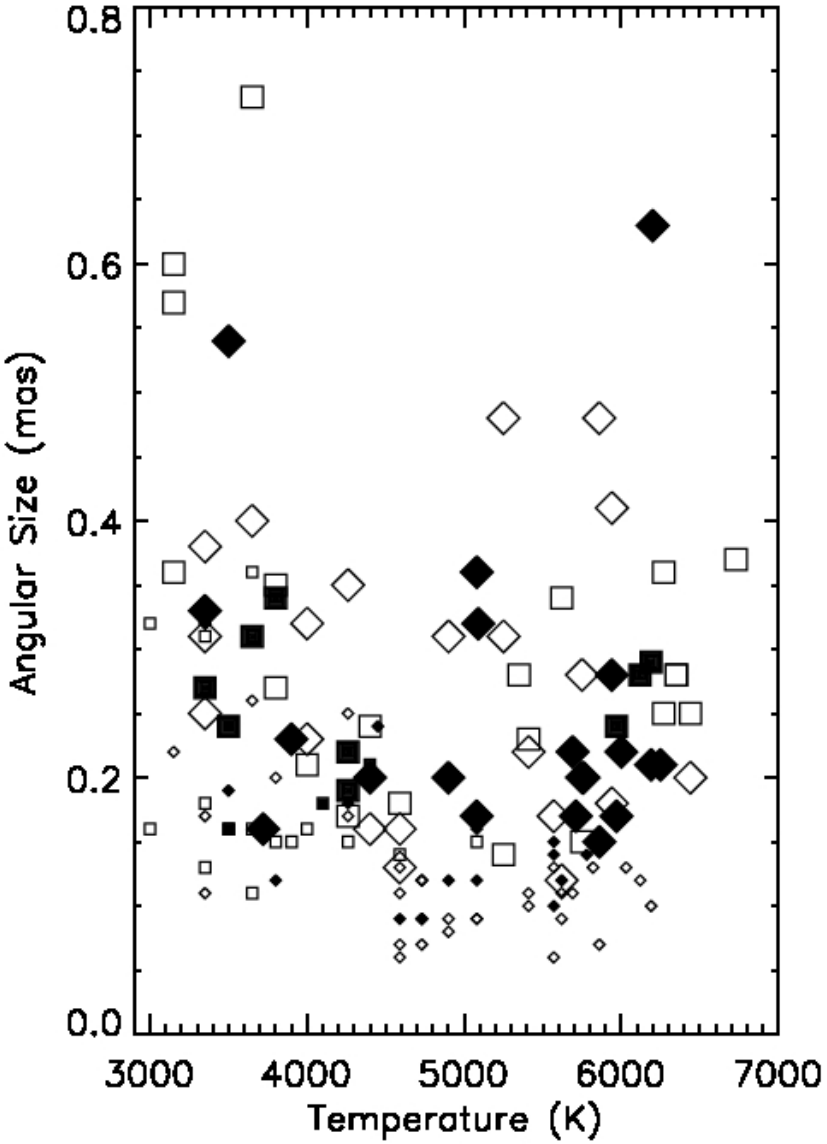


- Improves radius estimates ($L = \pi R^2 \sigma T^4$)

- Helps constrain models

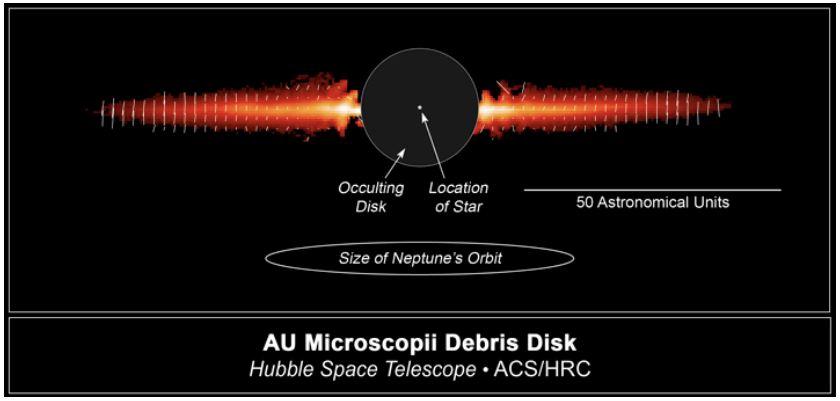
Young Star Sizes

McCarthy & White (2010)

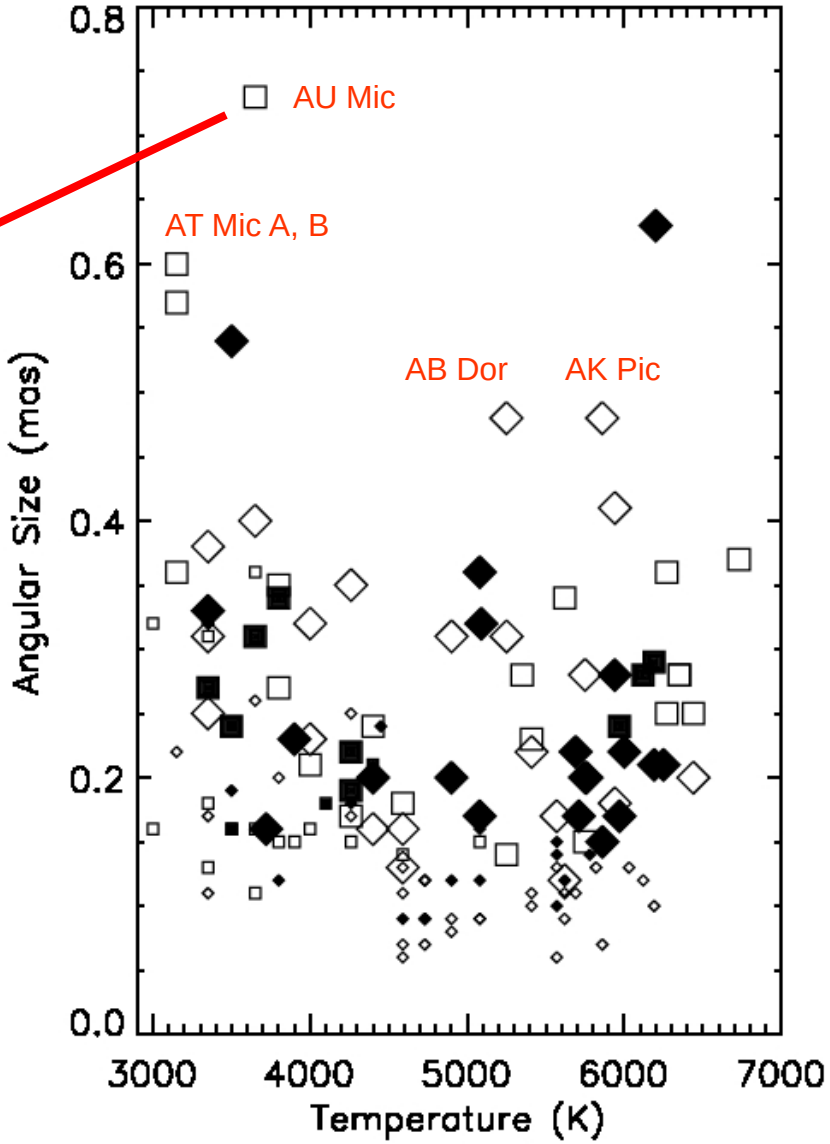


Large: K < 7; *Filled:* DEC > -10

Young Star Sizes



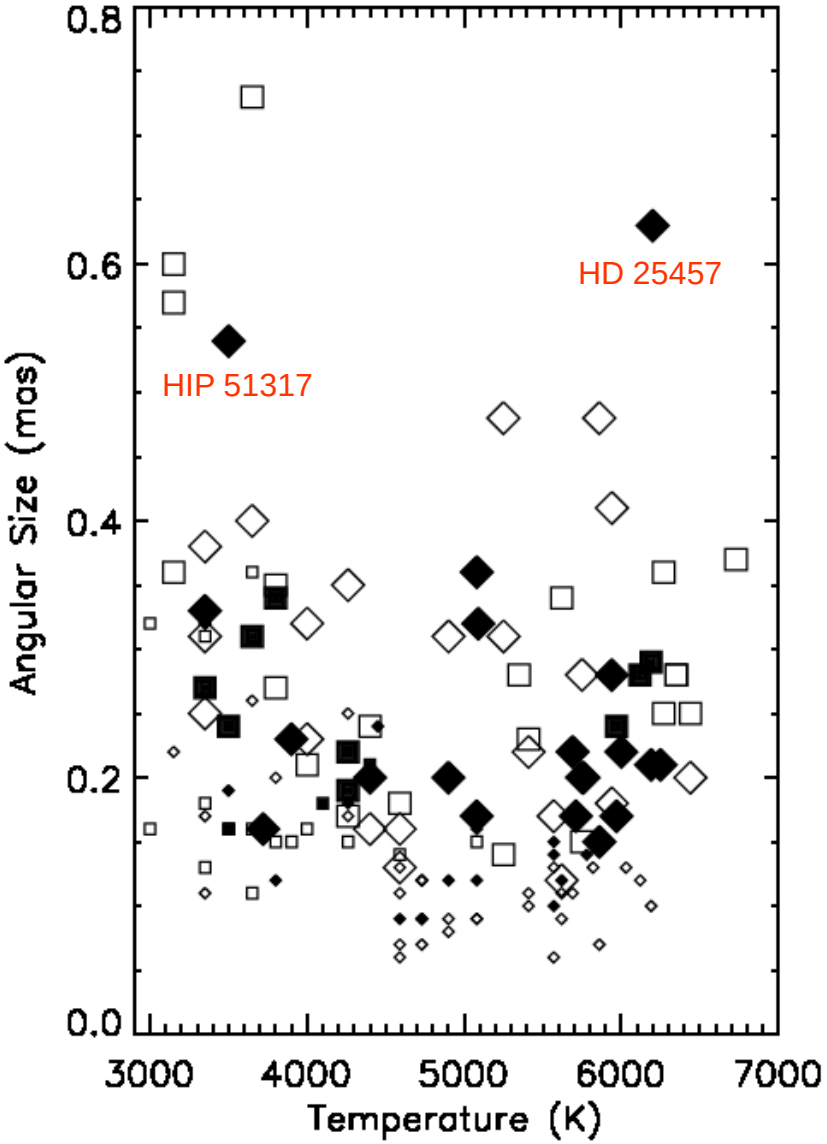
McCarthy & White (2010)



Large: K < 7; *Filled:* DEC > -10

Young Star Sizes

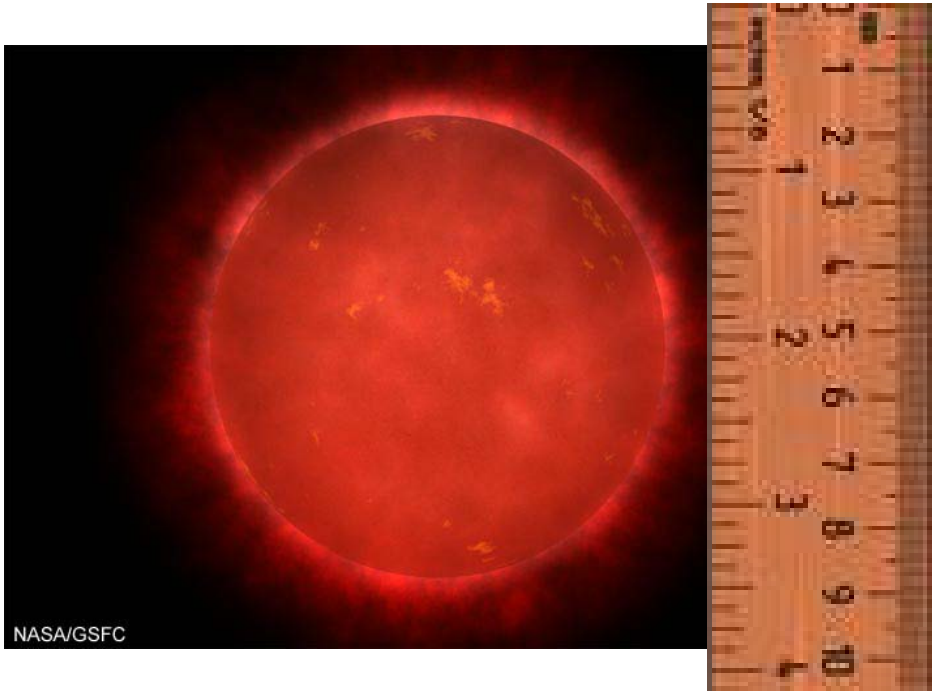
McCarthy & White (2010)



Large: K < 7; *Filled:* DEC > -10

A CHARA/Classic Survey

Beta Pic Members (10 - 30 Myr)
AB Dor Members (30 - 100 Myr)
with K < 7 and Dec > -5



Will yield…

(1) Radii of closest

(2) Frequency of close binaries

(3) dynamical masses of binaries

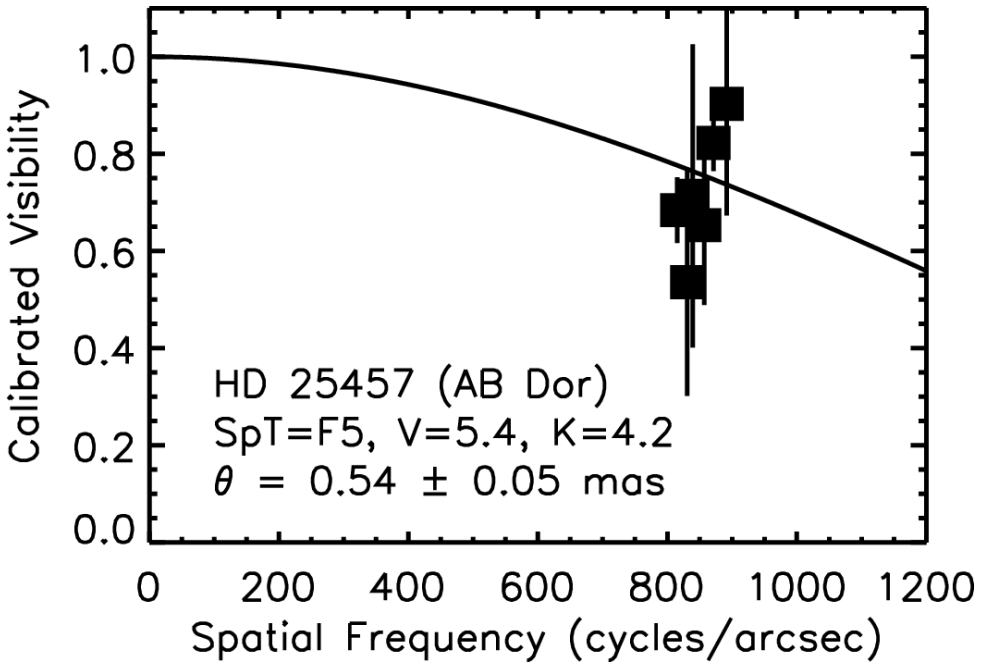
Some Initial 2008 Results

HD25457 (F5V)

$\theta_{Obs} = 0.54 \pm 0.05$ mas

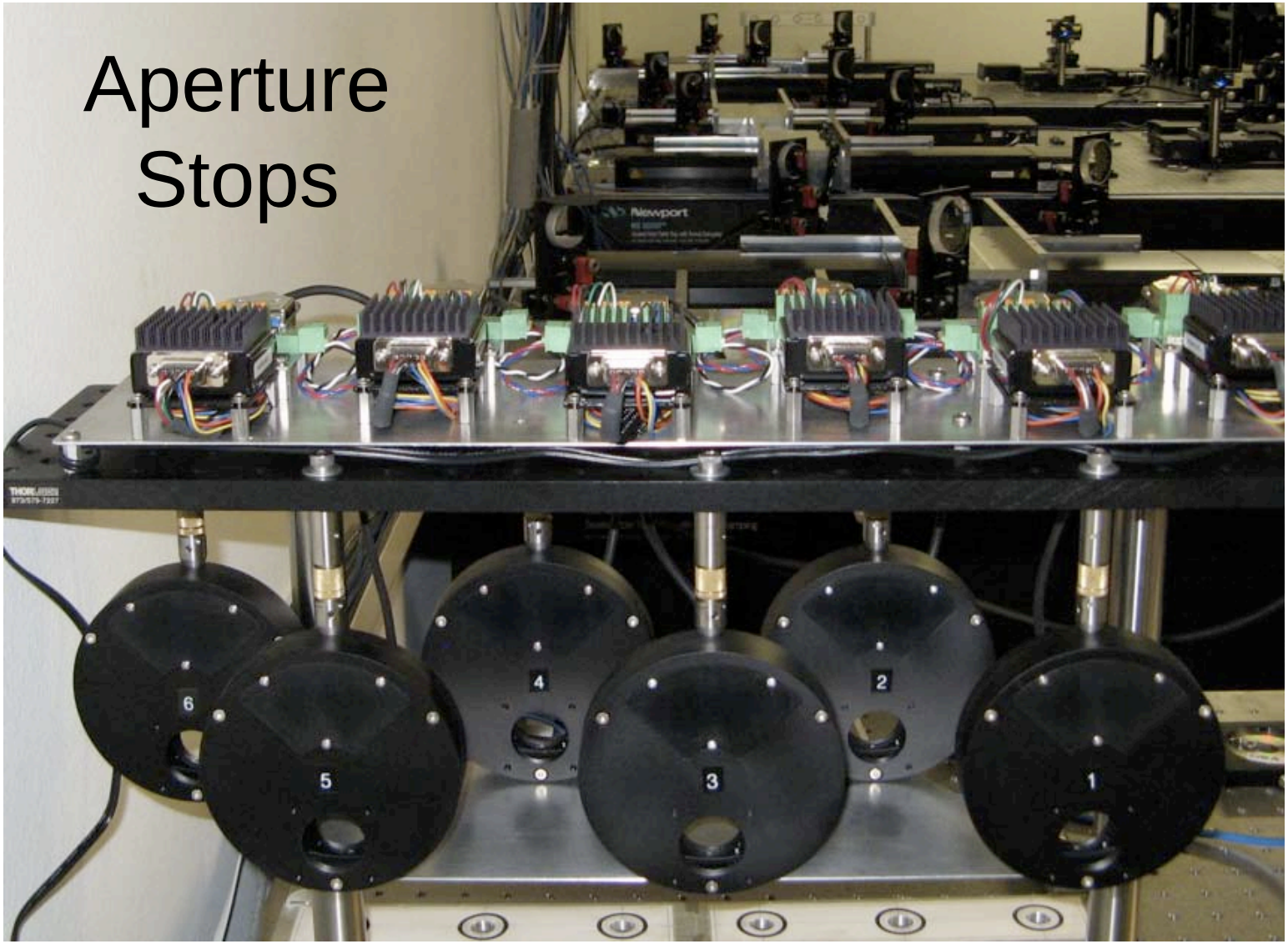
($\theta_{Predicted} = 0.57$)

Errors too large to be useful!



Large scatter due to destructive (noisy) readout.

Aperture Stops

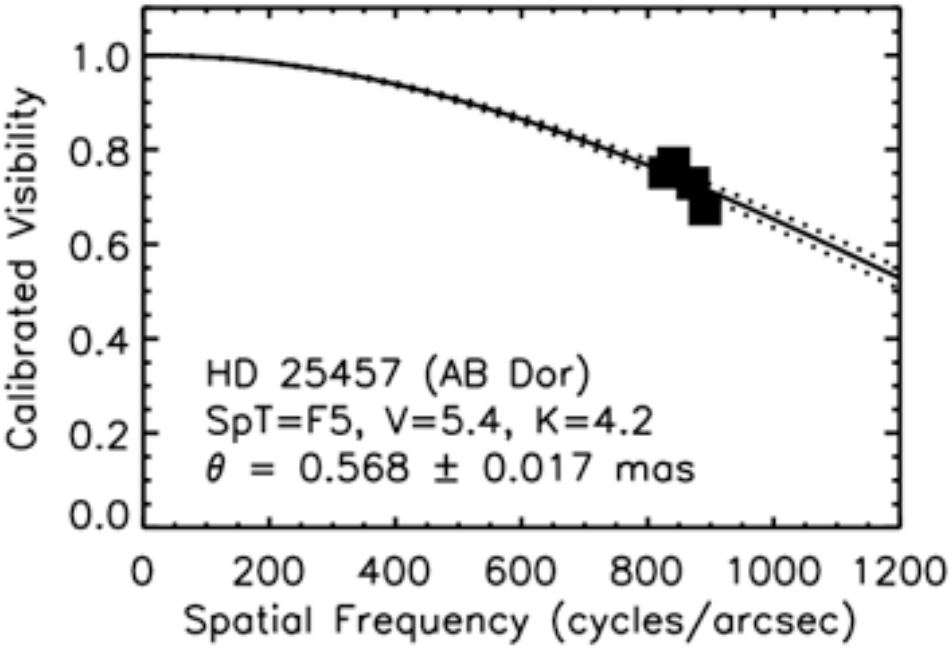


2009 Results

HD25457 (F5)

θ_{Obs} = 0.568 ± 0.017 mas

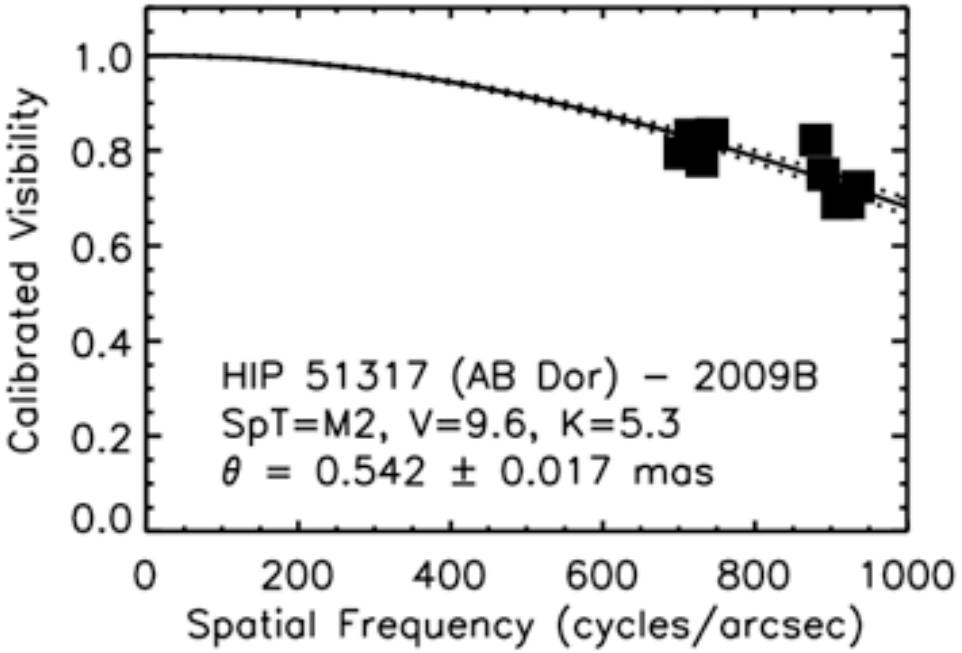
Single set error of only 3%!

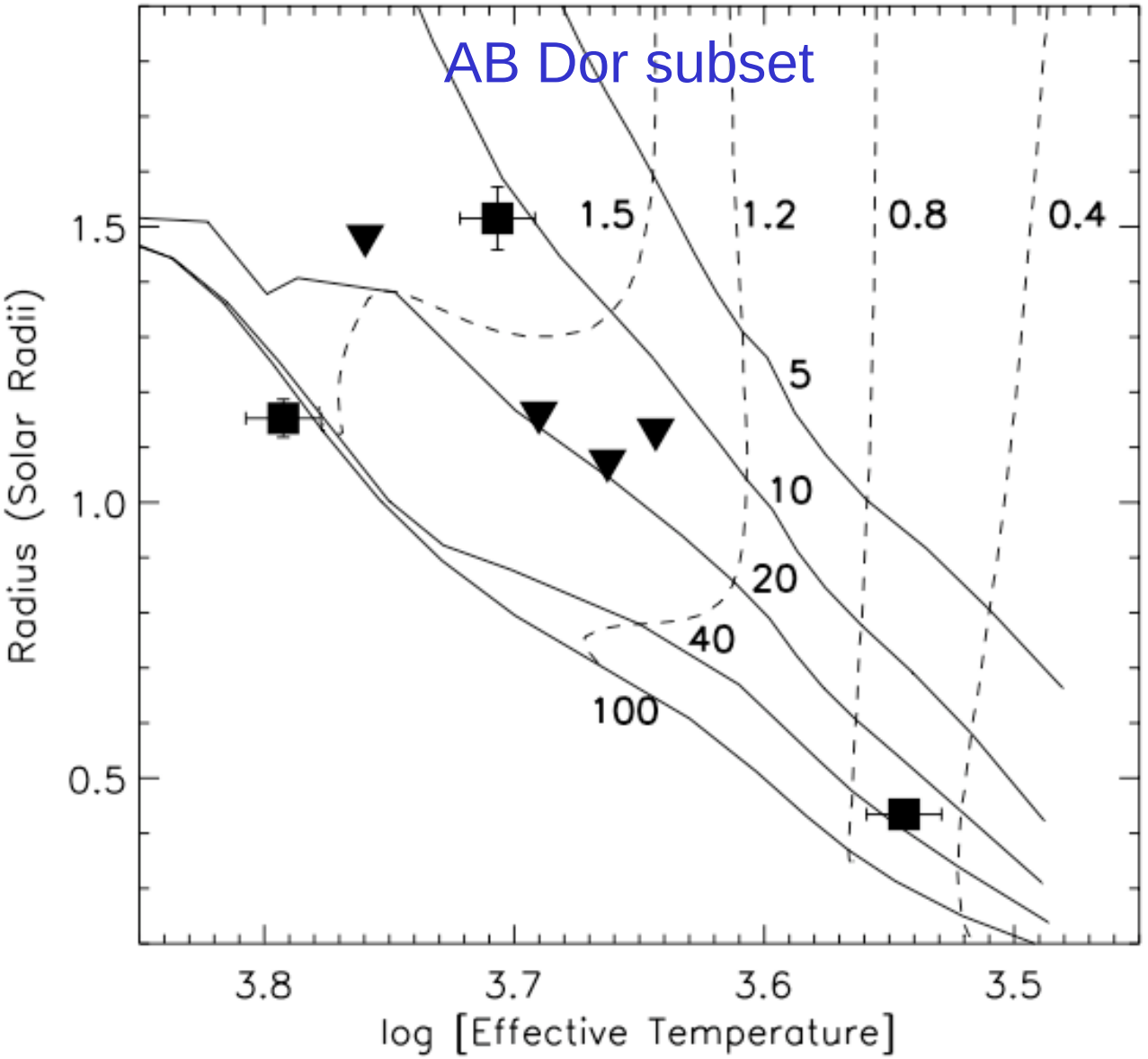


2009 Results

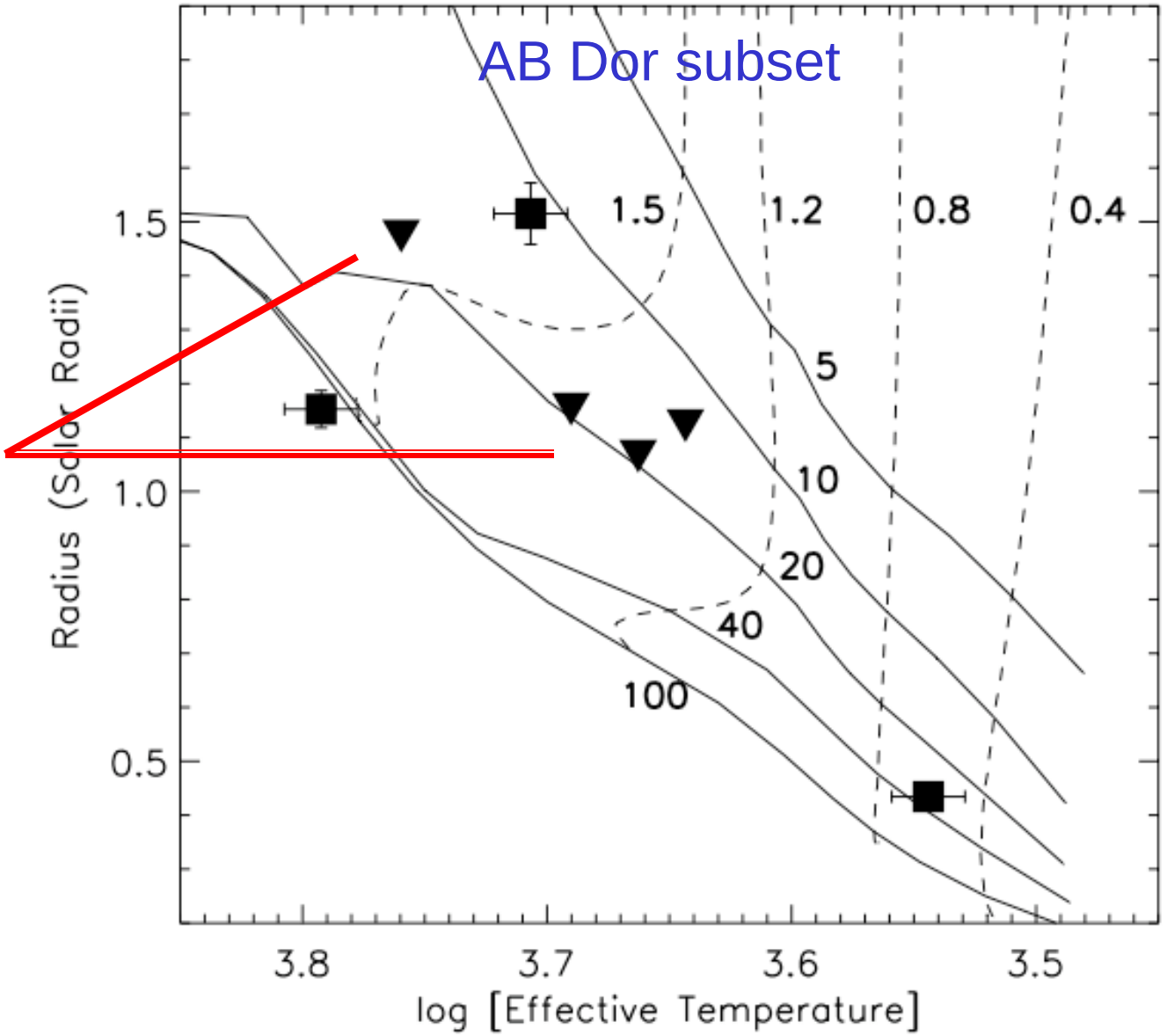
HIP 51317 (M2)

θ_{Obs} = 0.542 ± 0.017 mas



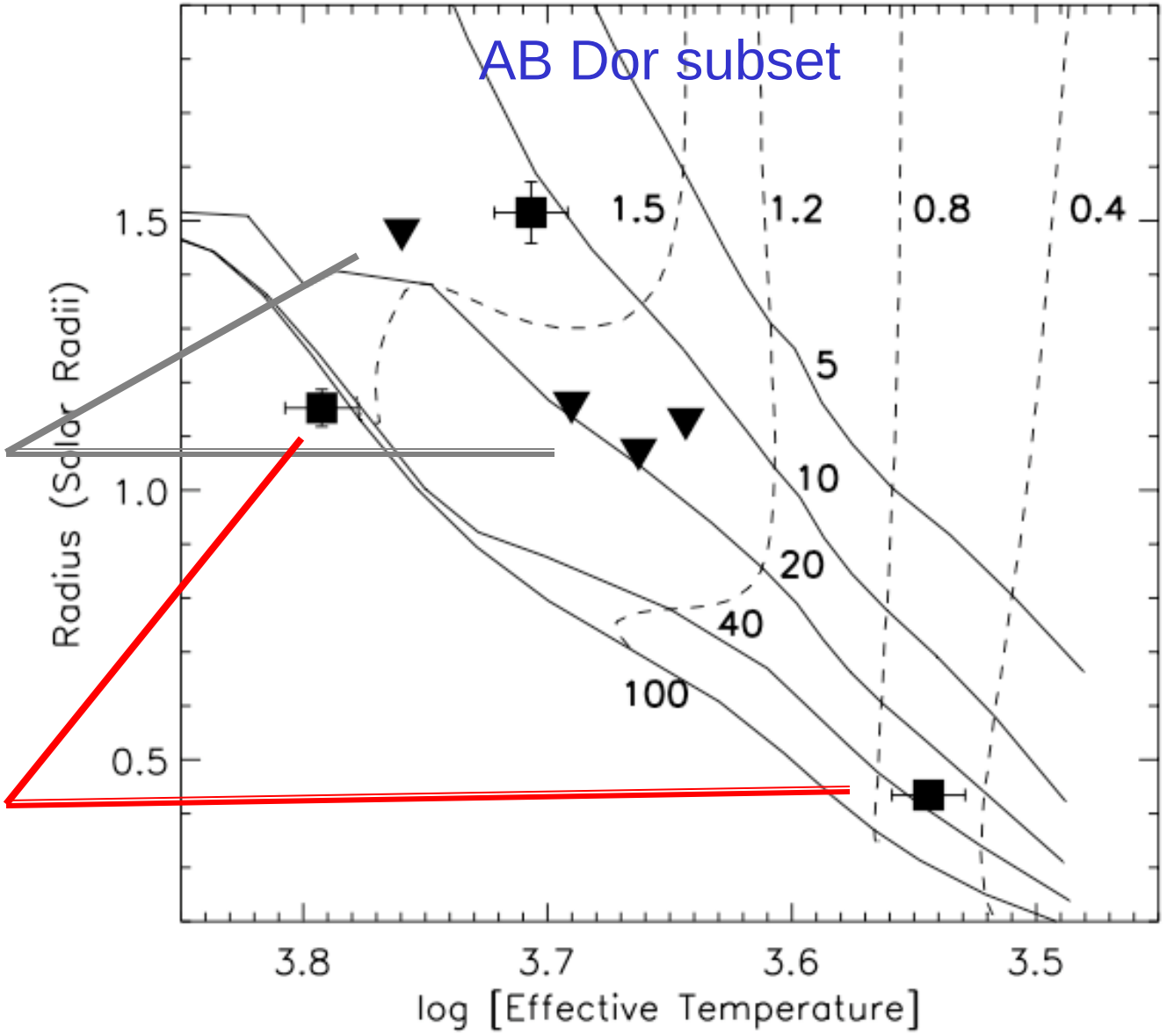

AB Dor subset
1.5
1.2
0.8
0.4
5
10
20
40
100
Radius (Solar Radii)
1.5
1.0
0.5
3.8
3.7
3.6
3.5
log [Effective Temperature]

Radius upper limits



Radius upper limits

The AB Dor Isochrone

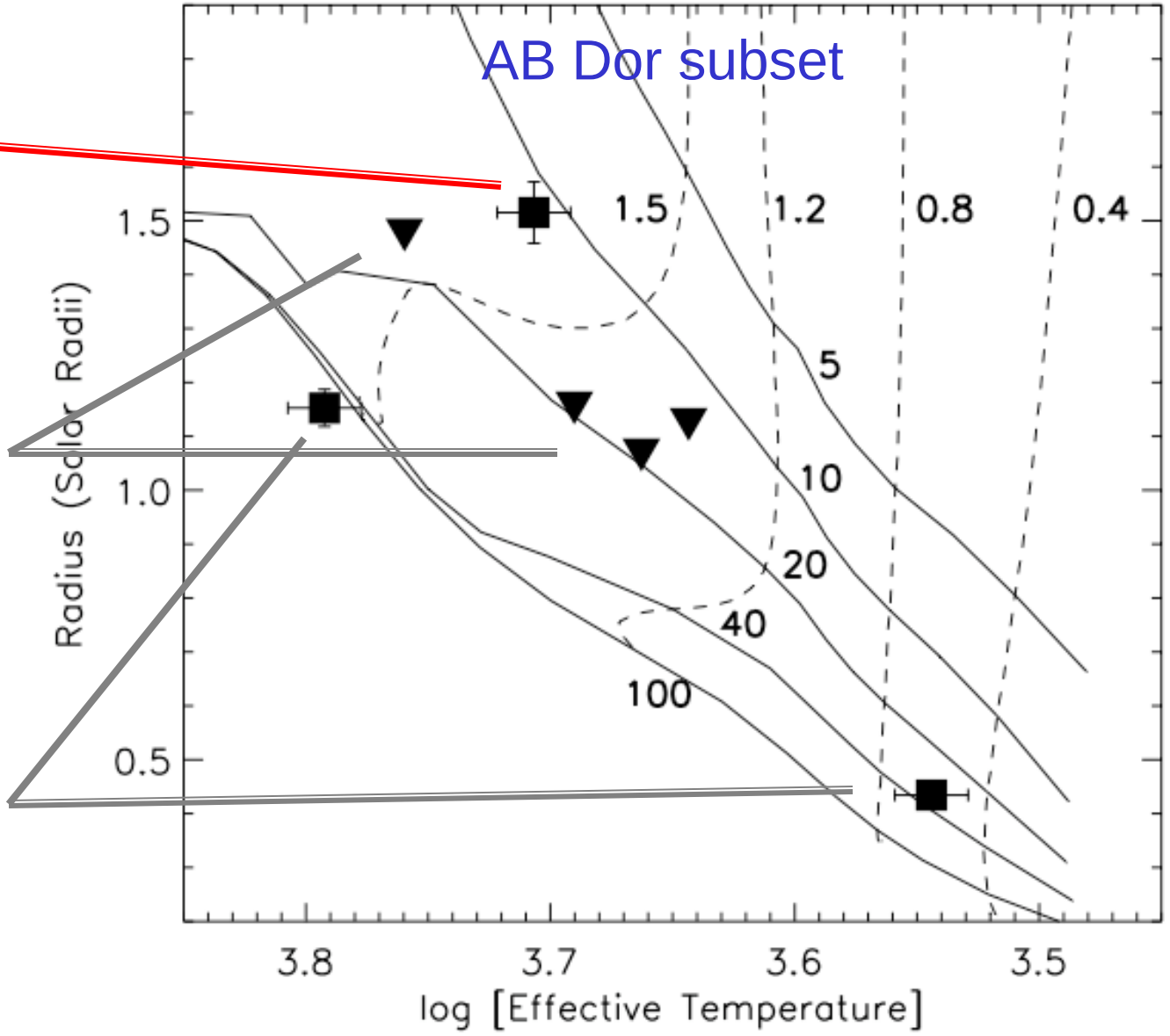


AB Dor subset

A Binary?

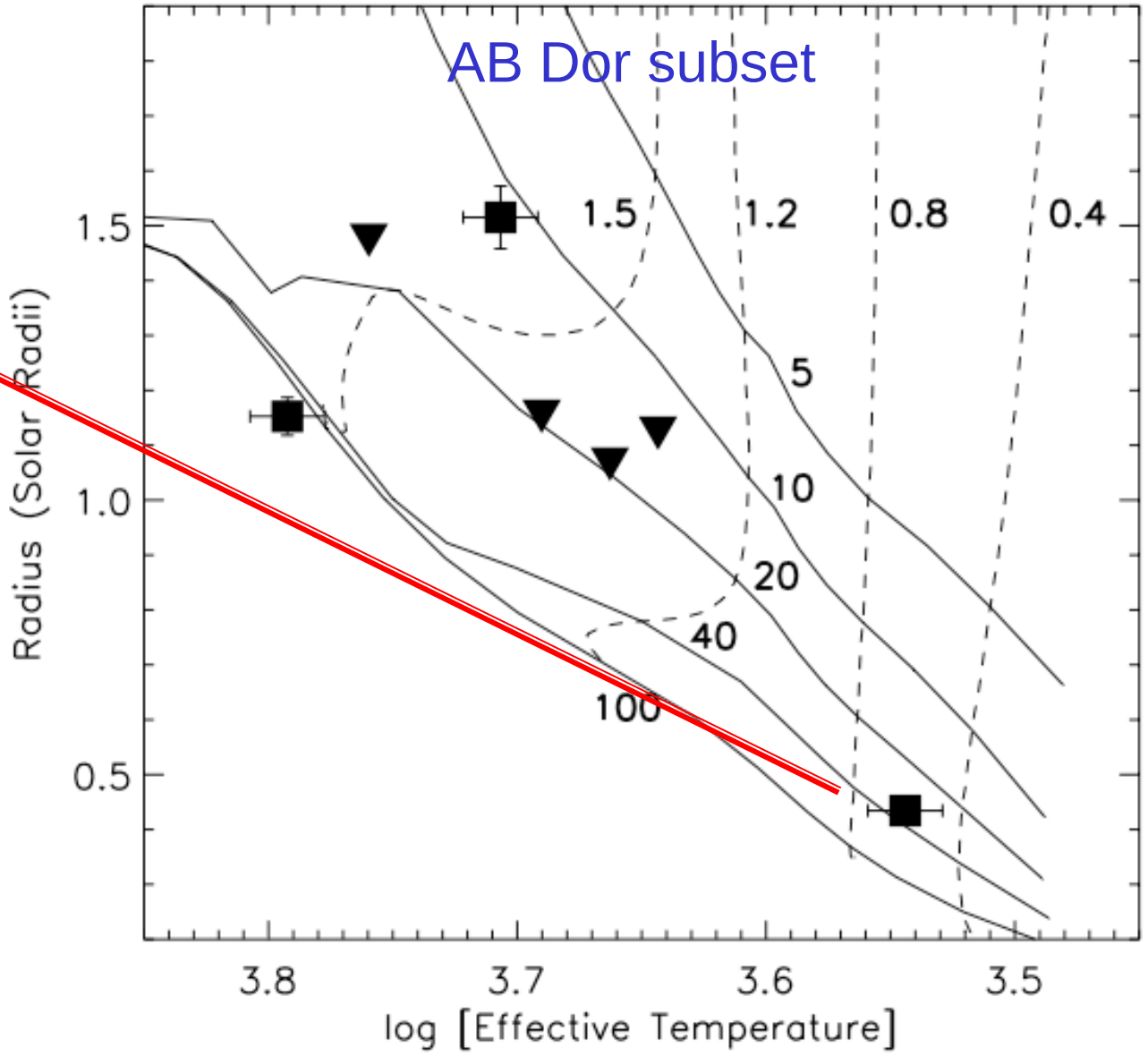
Radius upper limits

The AB Dor Isochrone

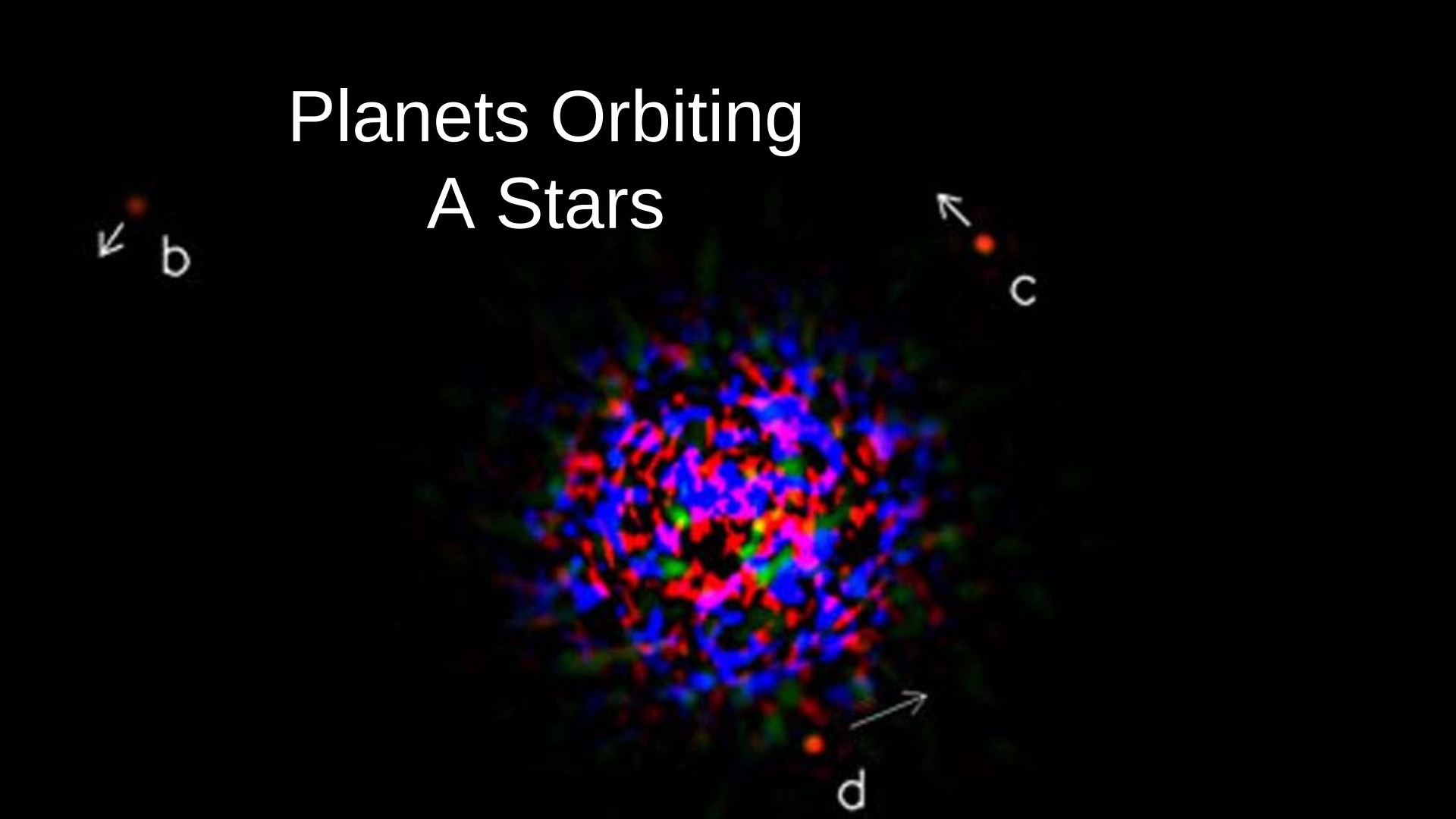


The first-ever spatially resolved fully-convective PMS star?!

… implies an AB Dor age of 35±10 Myr

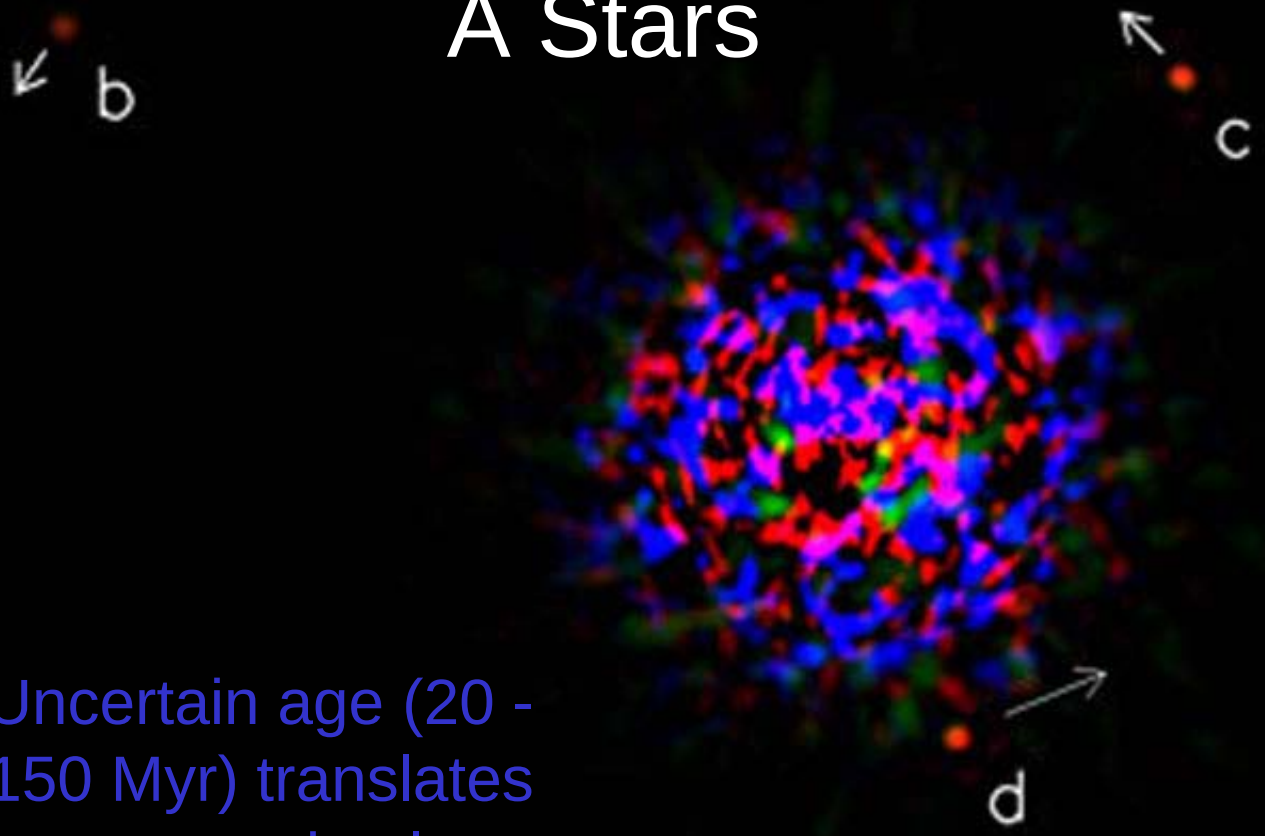


Planets Orbiting A Stars



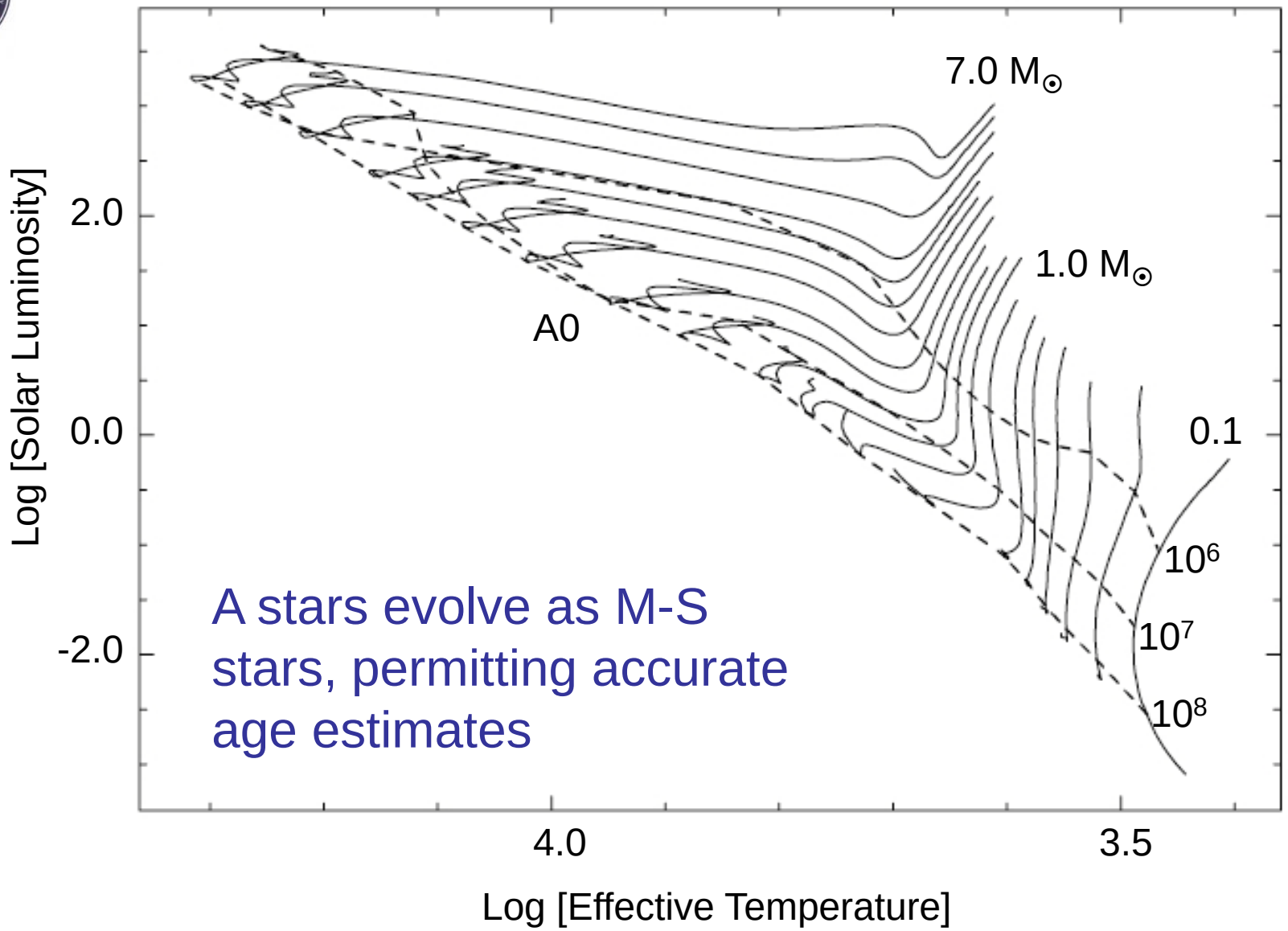
HR 8799 from Marois et al. (2008)

Planets Orbiting A Stars



Uncertain age (20 - 150 Myr) translates into uncertain planet masses (5 - 13 M_{Jup})

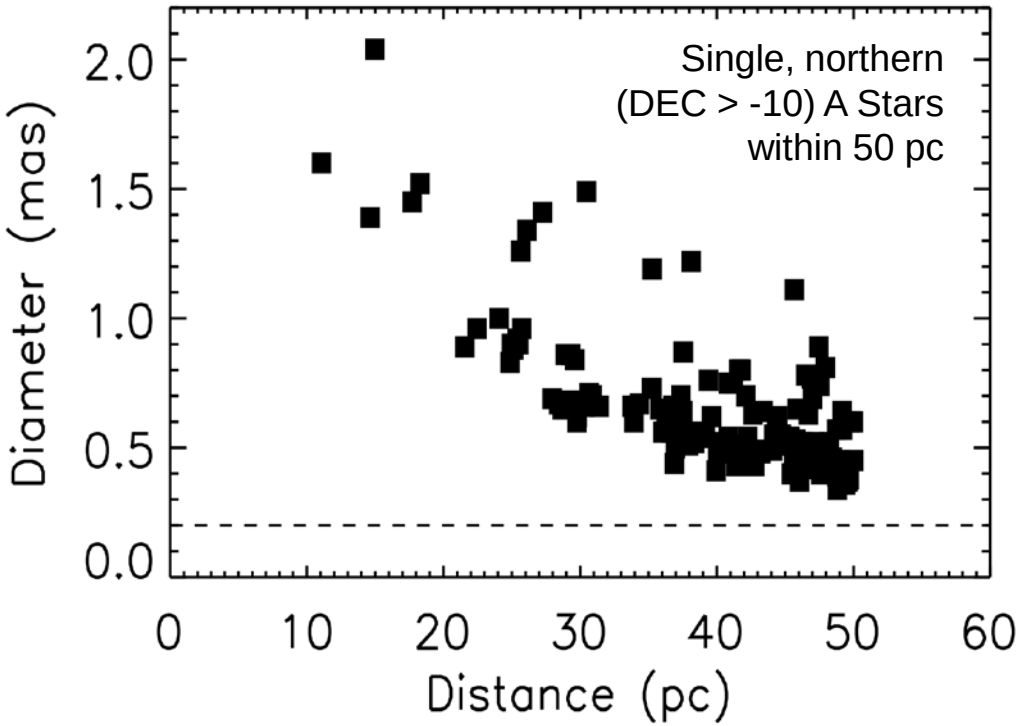
HR 8799 from Marois et al. (2008)



A stars evolve as M-S stars, permitting accurate age estimates

A Star Ages Project (ASAP)

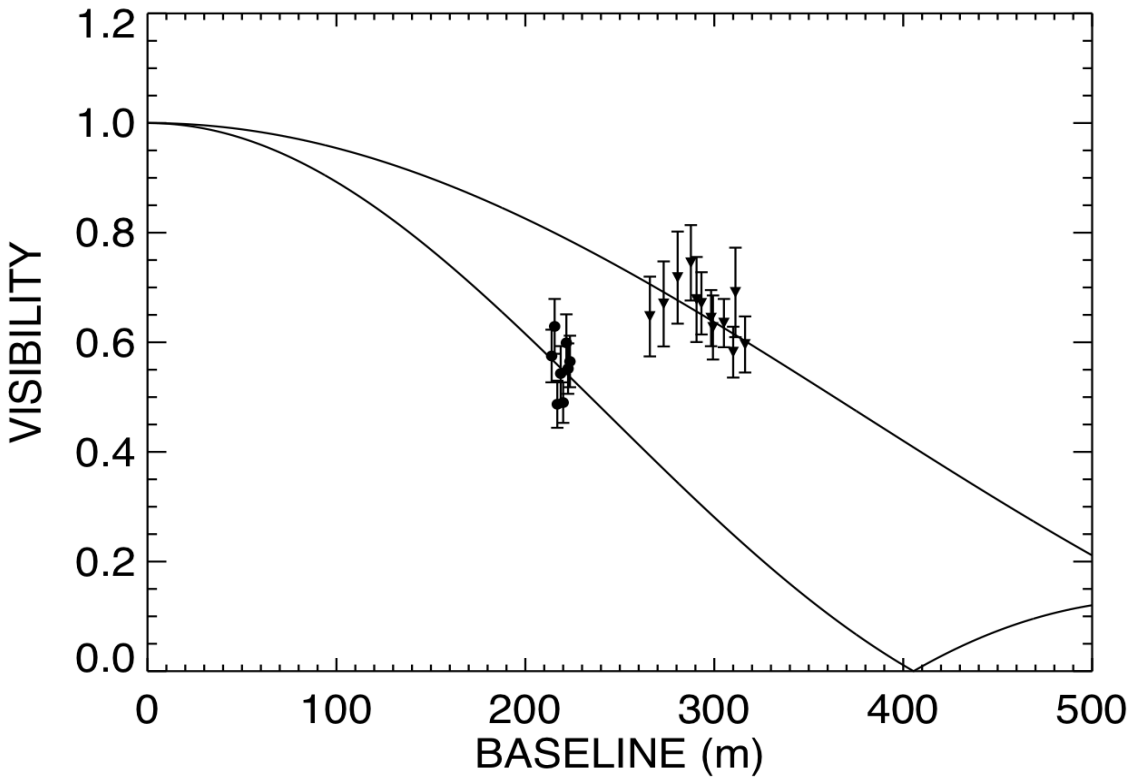
Using CHARA + Classic/CLIMB & PAVO



with …
Ellyn Baines (USNL)
Tabetha Boyajian (GSU)
Mike Ireland (Sydney)
Jenny Patience (Exeter)
Gail Schaefer (CHARA)
Ming Zhao (JPL)

NSF funding pending …

11 of 67 Already Observed



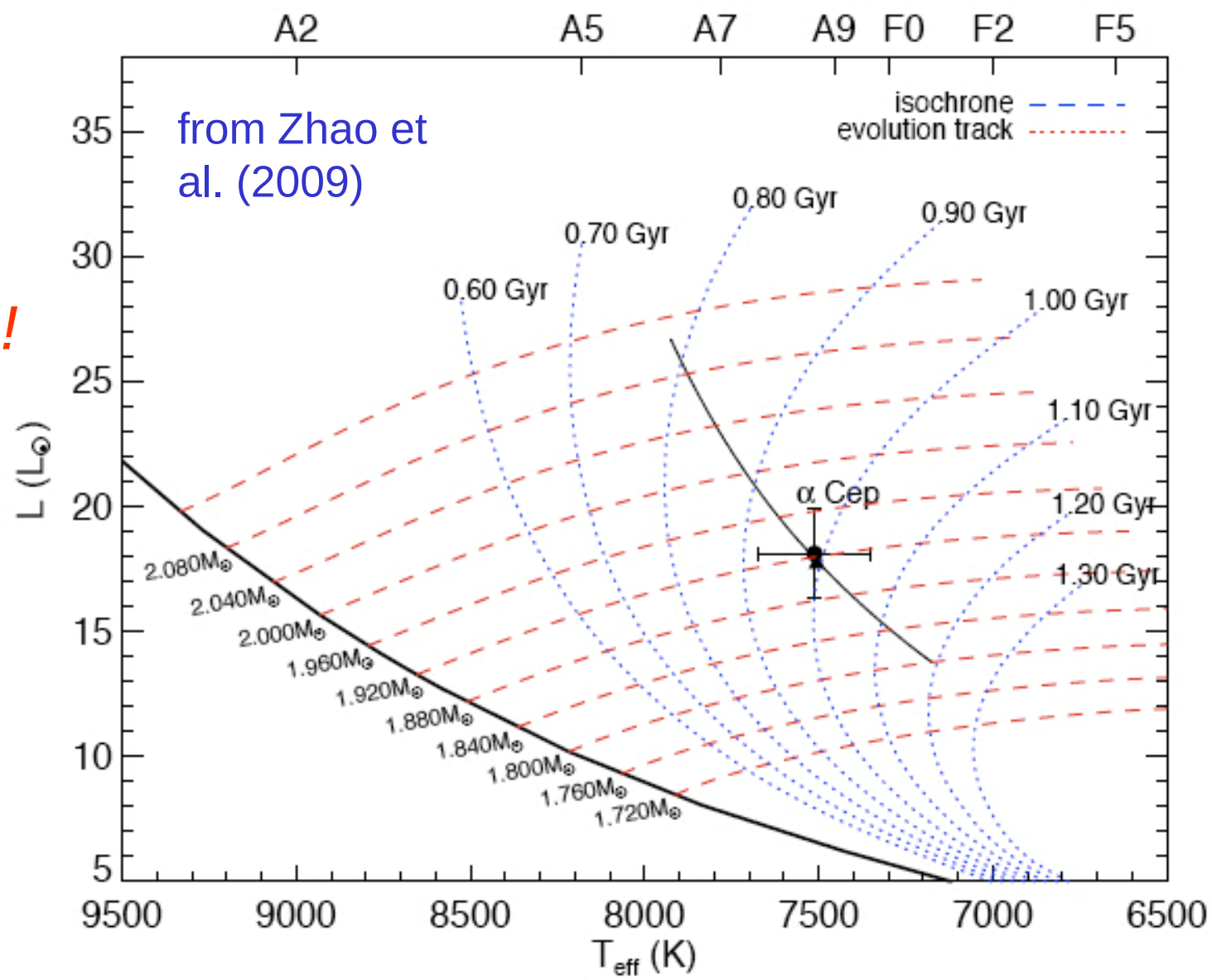
CHARA Classic (K)

HD81937 (F0IV)
1.334 ± 0.028 mas

HD118090 (A3V)
2.012 ± 0.036 mas

From Boyajian et al. (2010)

Ages accurate to 5-20%!



Summary

- First Spatially Resolved Convective PMS Star
  - Suggest AB Dor age of ~35 Myr
  - additional stars from Mike Simon (NOAO)
- New close binaries for dynamical masses
- A Star Ages Project (ASAP; ±20% ages)
  - Important for planet and debris disk science