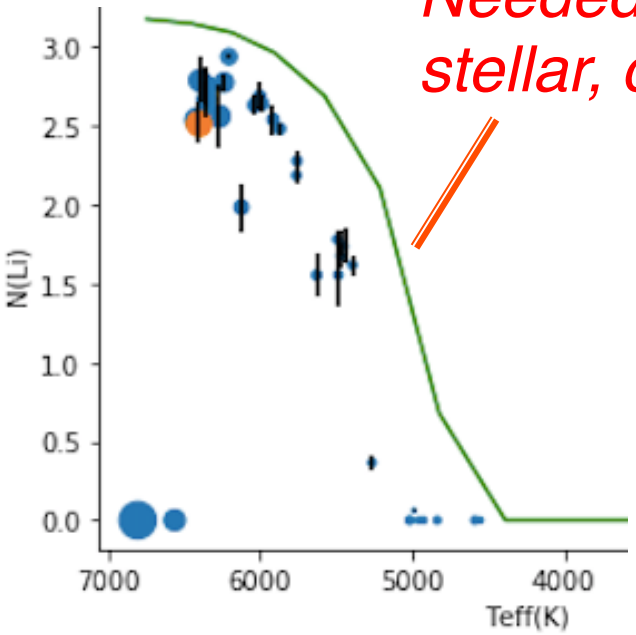
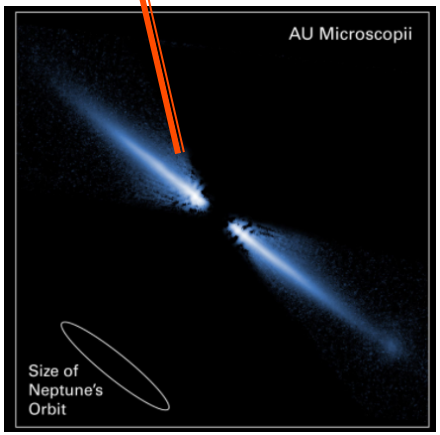
The Ages of Young (and Adolescent Age) Stars

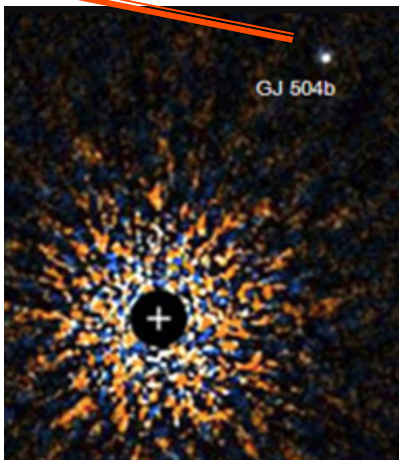
From Pre- to Post-Main Sequence

Russel White (GSU)

Needed for understanding:
stellar, circumstellar, and exoplanet evolution







The Ages of Young (and Adolescent Age) Stars

From Pre- to Post-Main Sequence

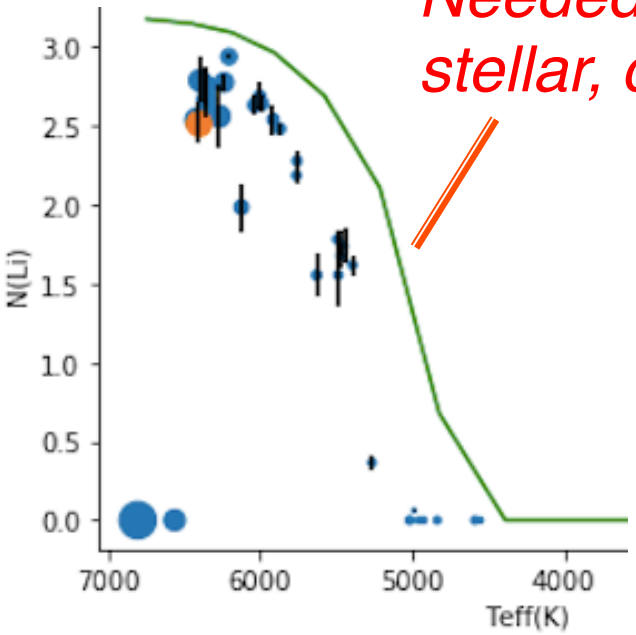
Russel White (GSU)

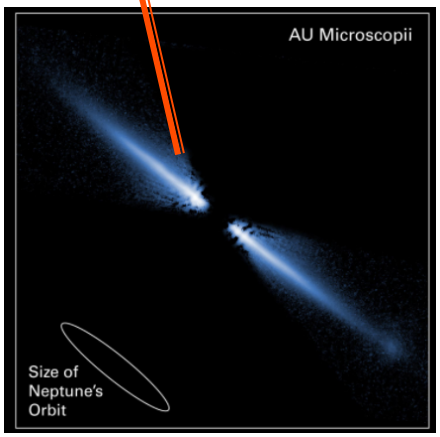
Pre-MS

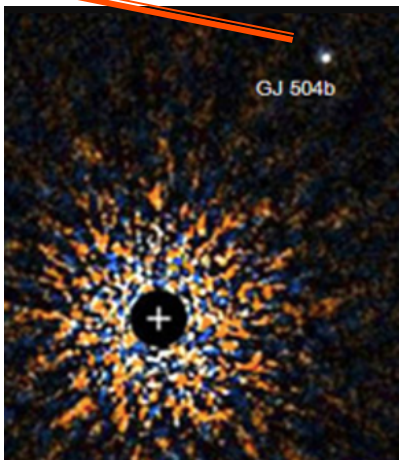
< 1 Gyr

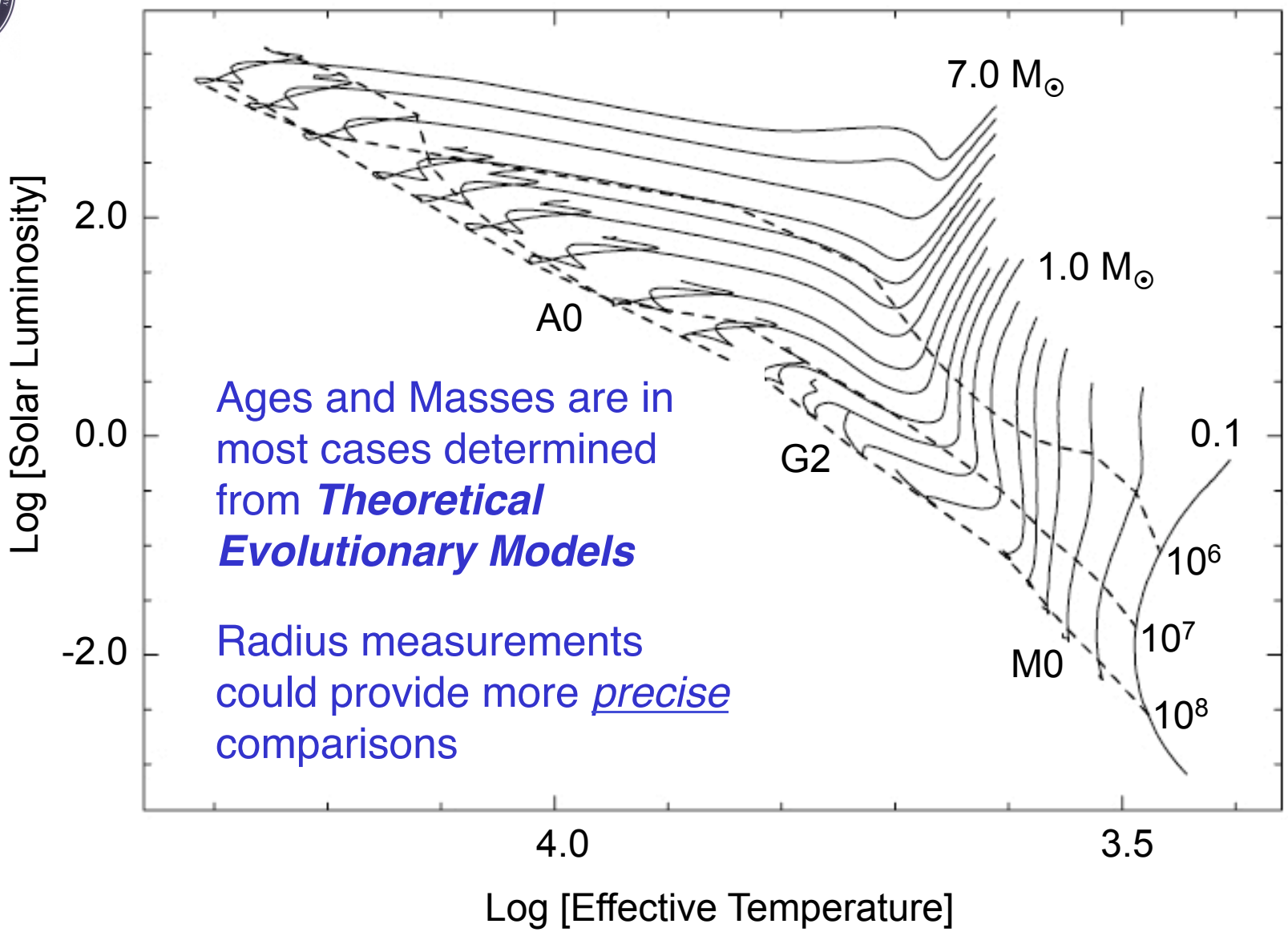
(stars, disks, exoplanets evolve substantially)

Needed for understanding:
stellar, circumstellar, and exoplanet evolution





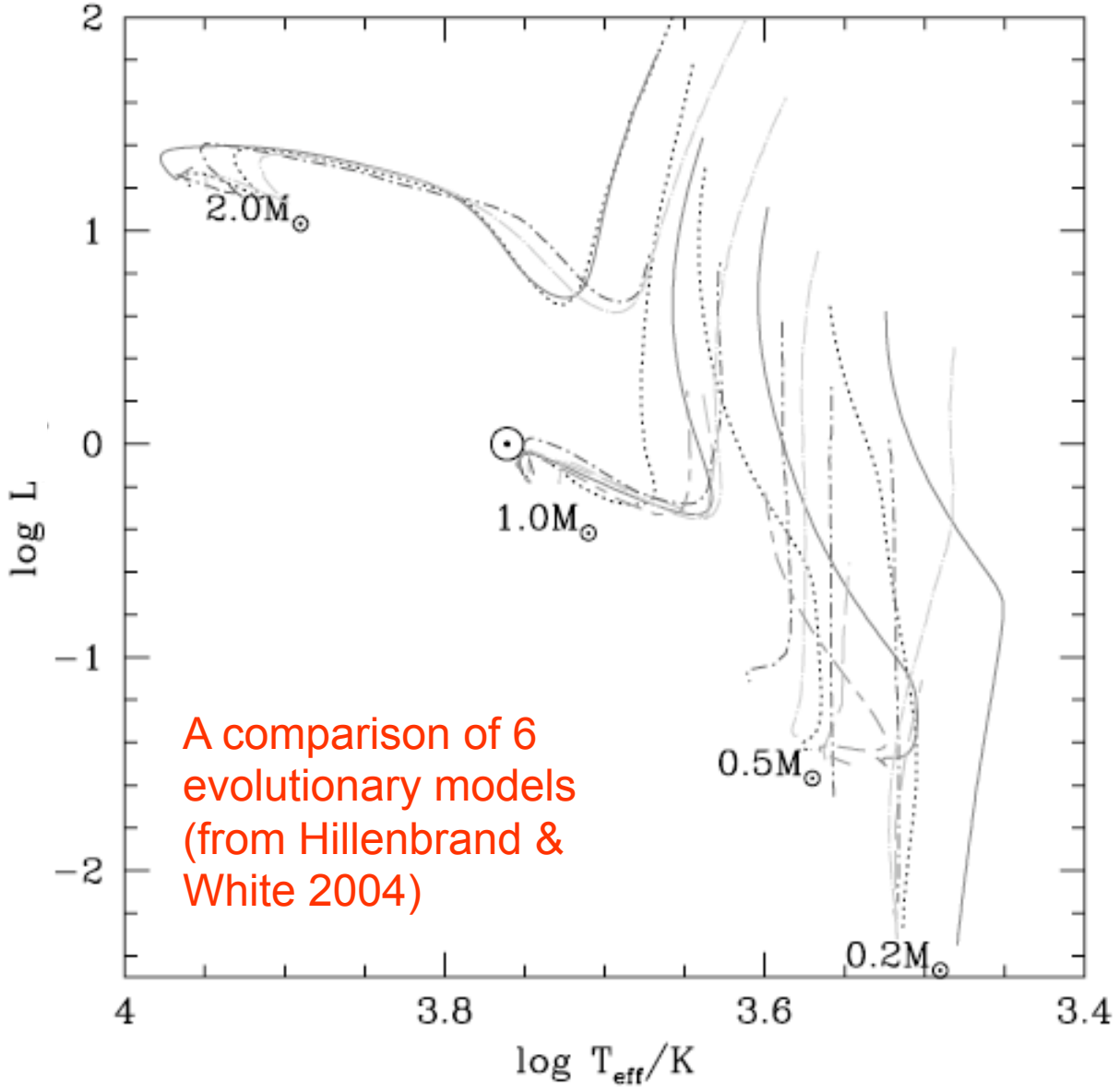




Ages and Masses are in most cases determined from ***Theoretical Evolutionary Models***

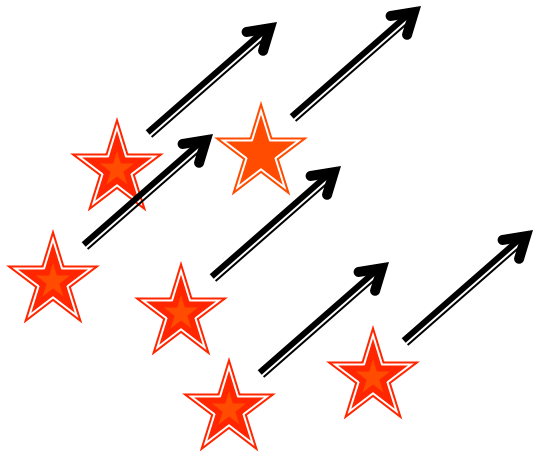
Radius measurements could provide more *precise* comparisons

Improving the *accuracy* will require improving evolutionary models.



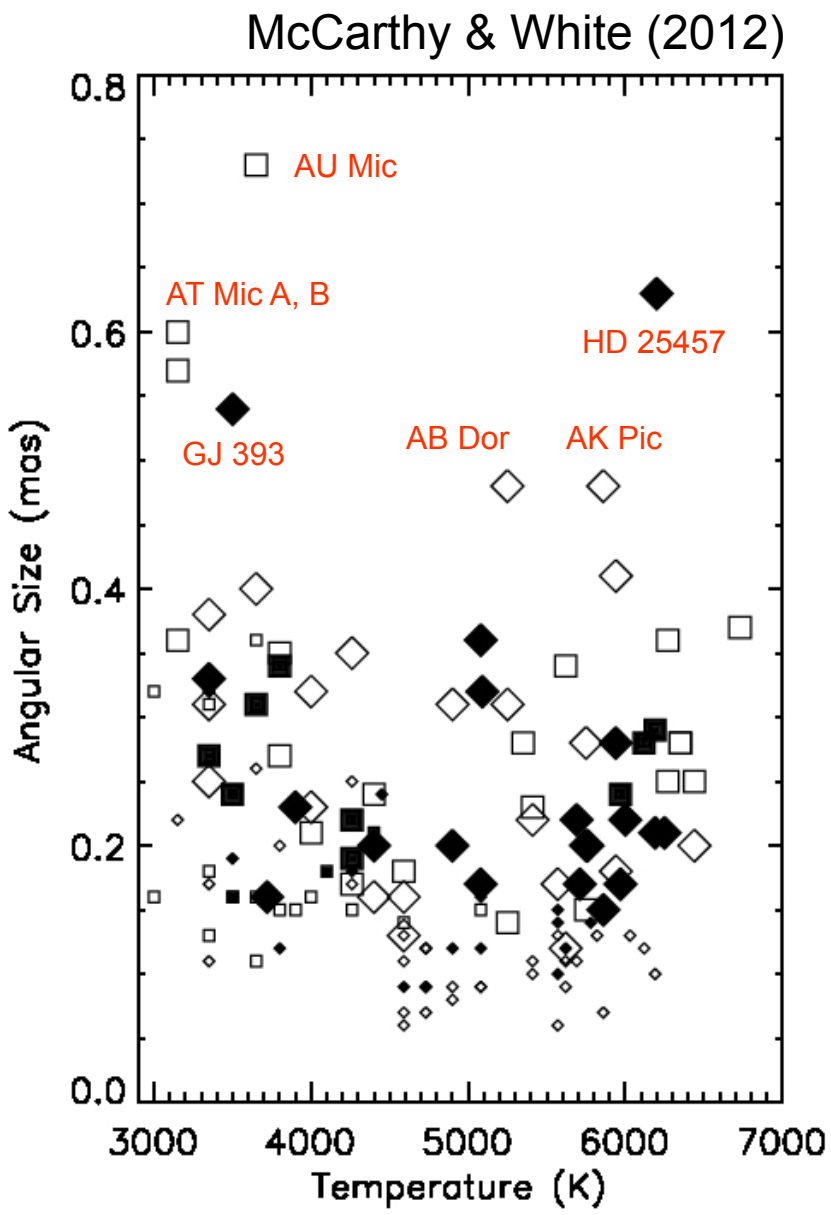
A comparison of 6 evolutionary models (from Hillenbrand & White 2004)

Star in Moving Groups

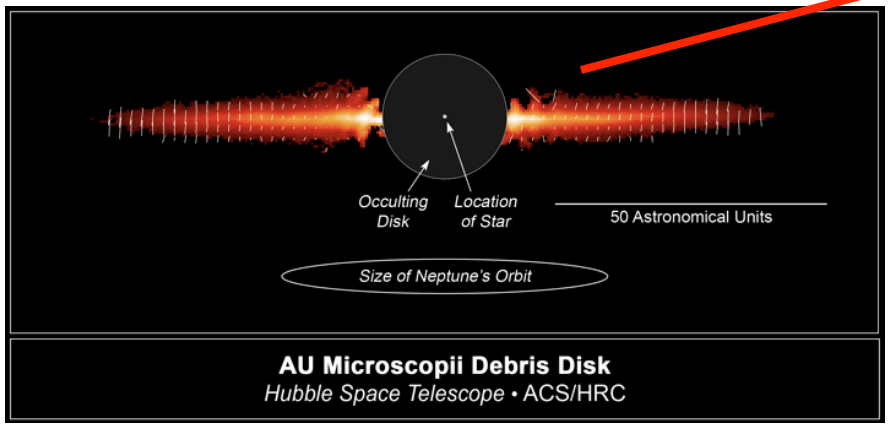


… that can be spatially resolved

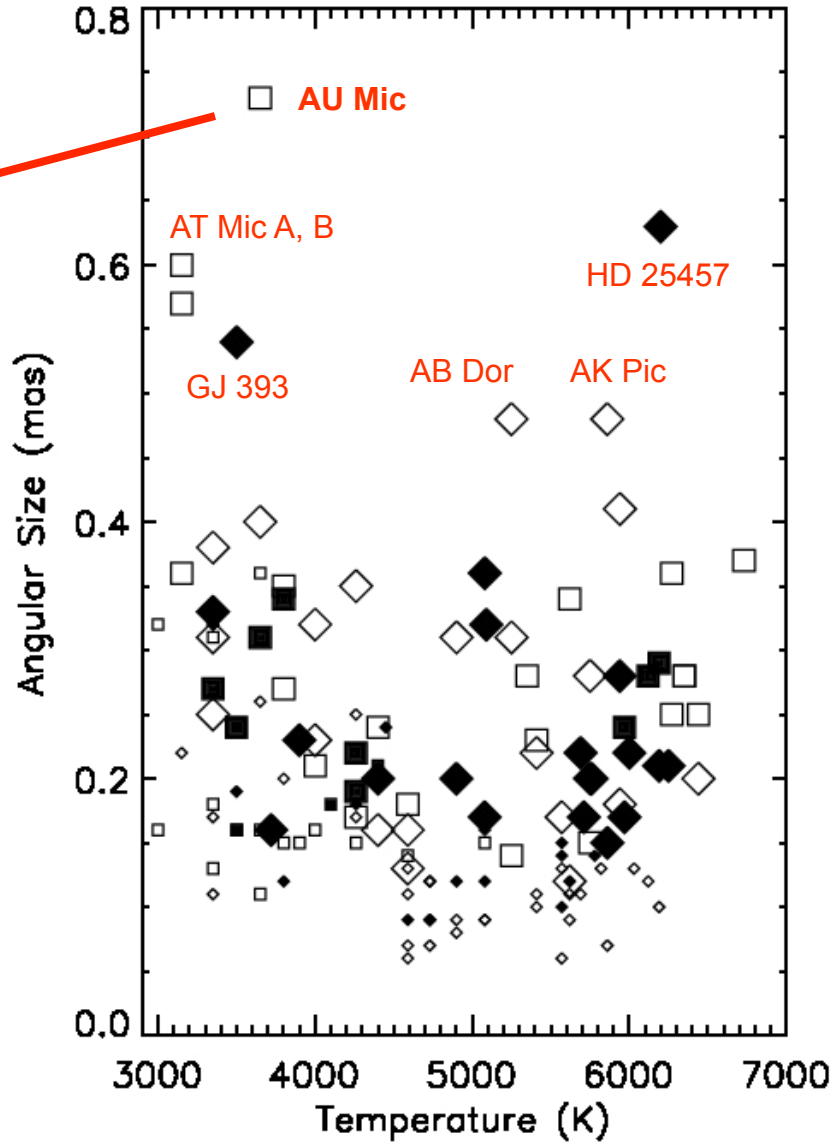
Large: K < 7; *Filled:* DEC > -10



The nearest M dwarf debris disk



McCarthy & White (2012)

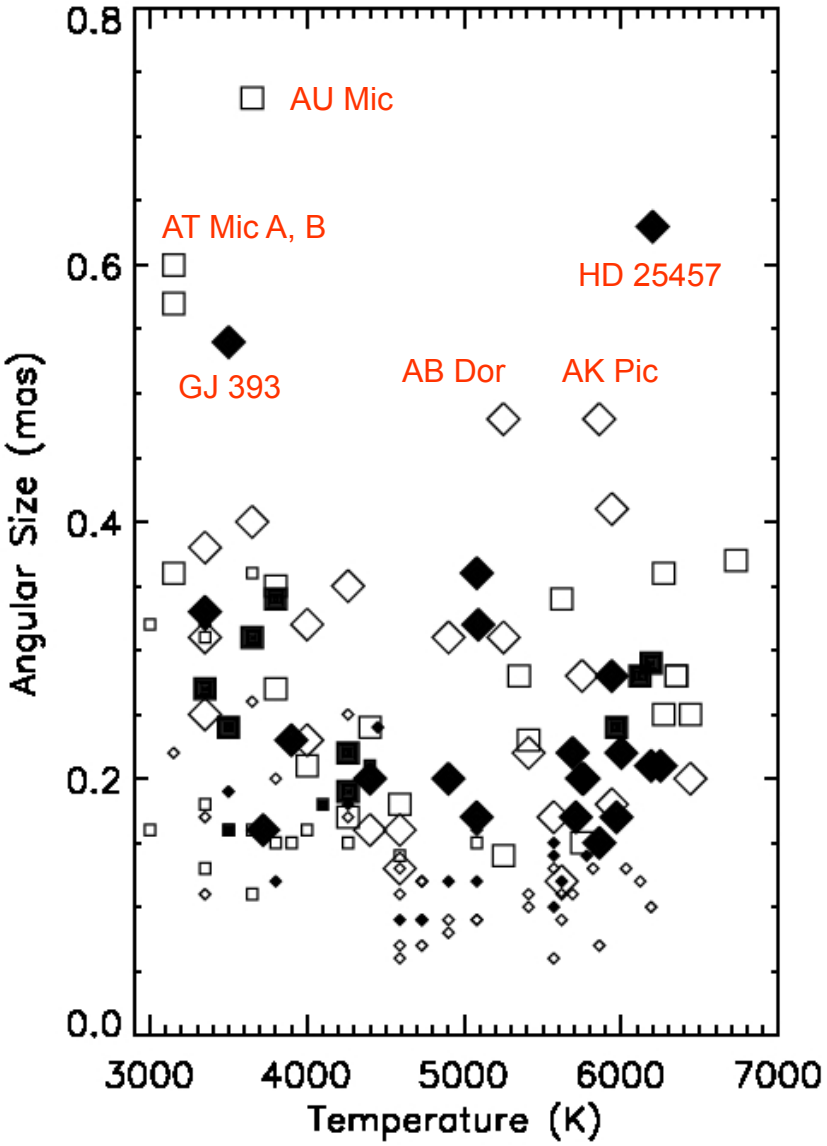


Large: K < 7; *Filled:* DEC > -10

Is challenging to observe at DEC -31!

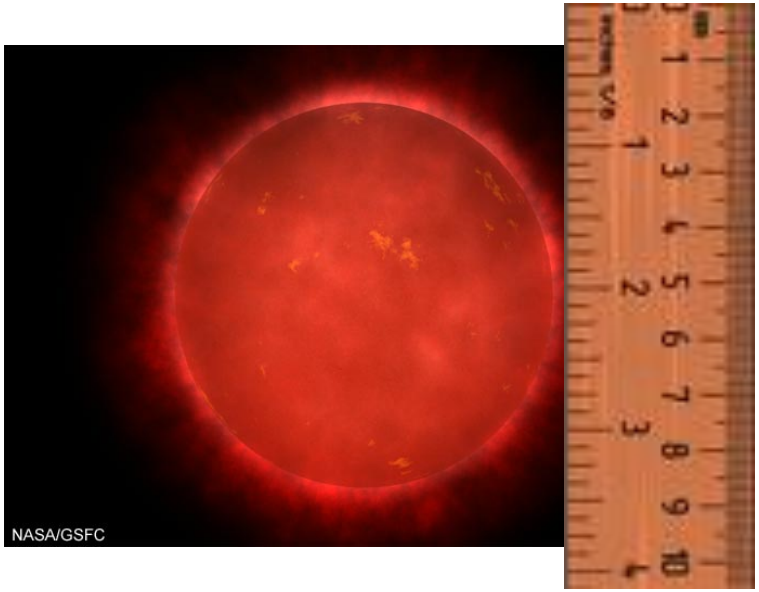
Large: K < 7; *Filled:* DEC > -10

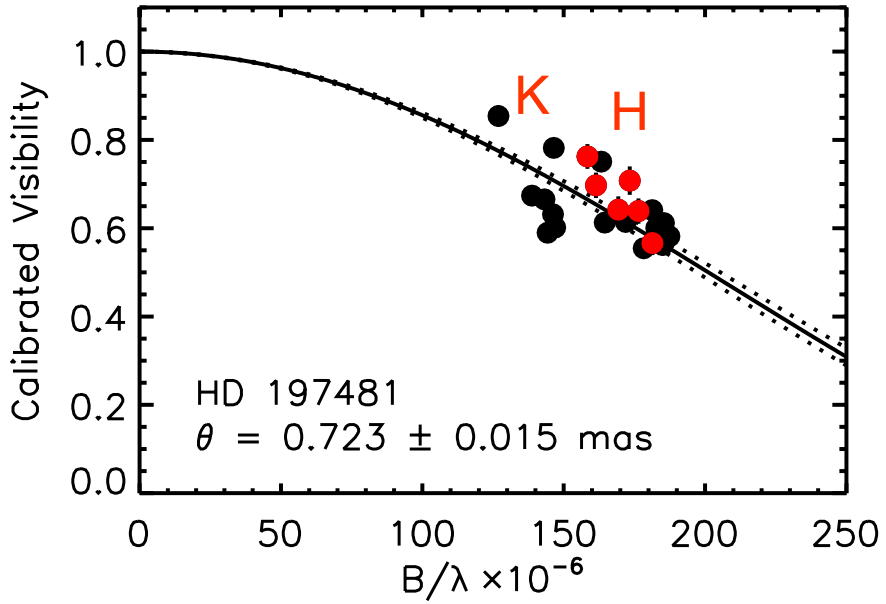
McCarthy & White (2012)



CHARA/Classic Observations

with Gail Schaefer





Initially uncertain,

… but improving

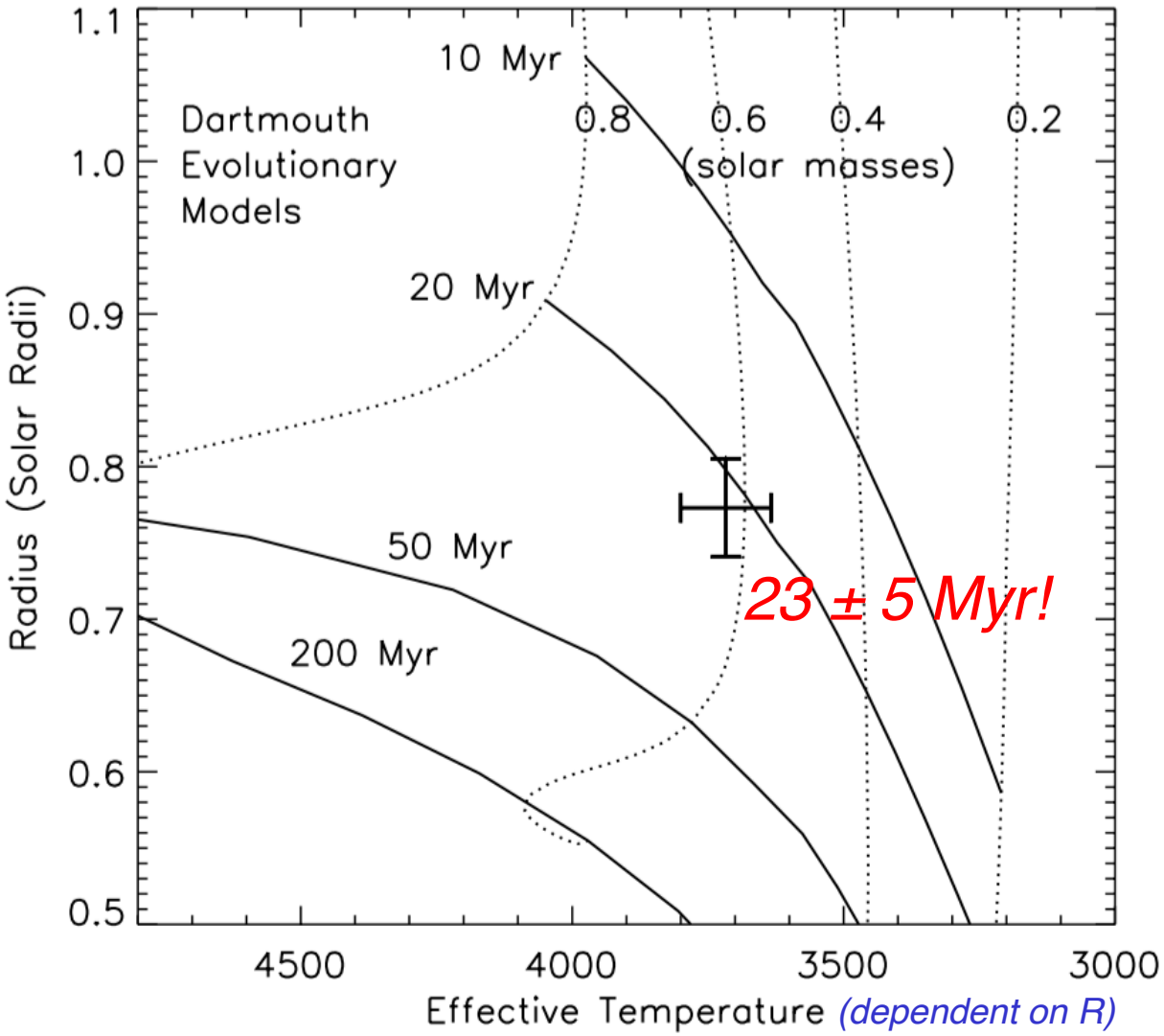
And now with Tabetha Boyajian, Kaspar von Braun

Adopting:
θ = 0.72 ± 0.03 mas

$R = 0.77 \pm 0.03\ R_{Sun}$

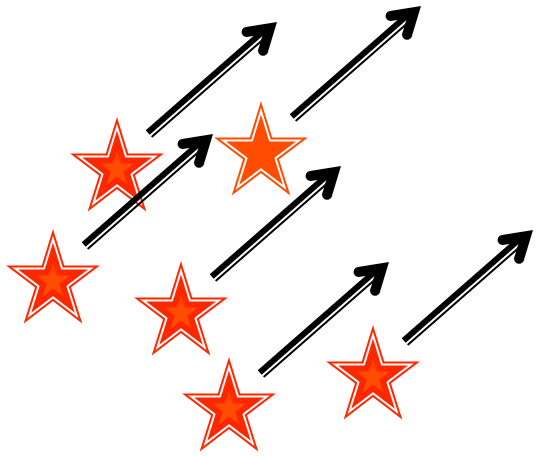
and with F_{bol} to 3%

$T = 3713 \pm 83$ K



First size estimate of a single, fully convective PMS star?

Star in Moving Groups



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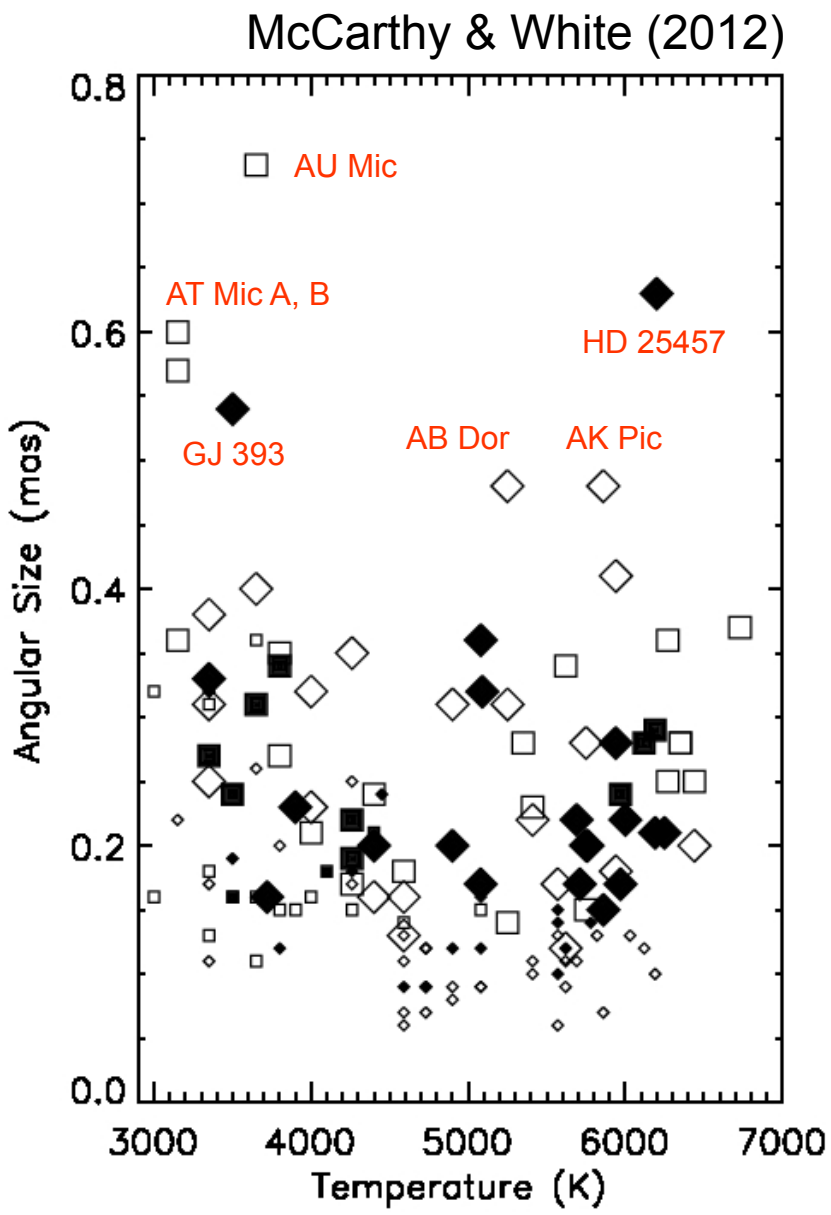
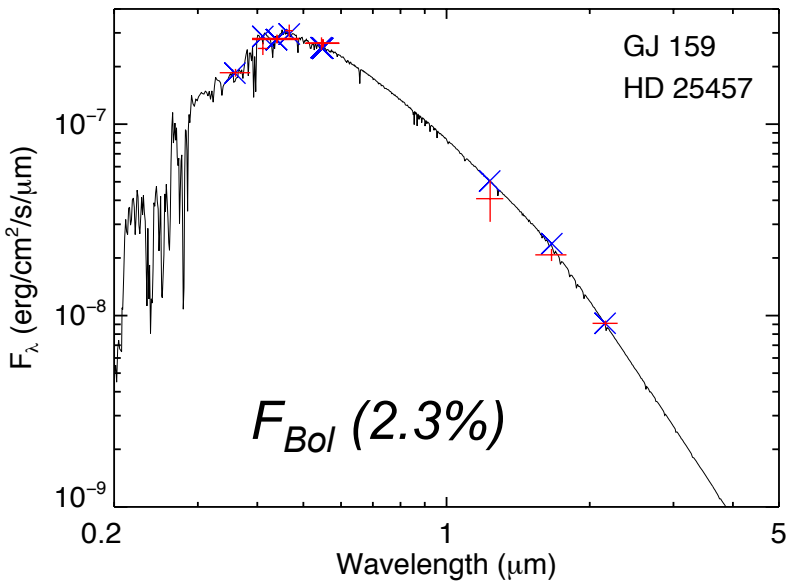
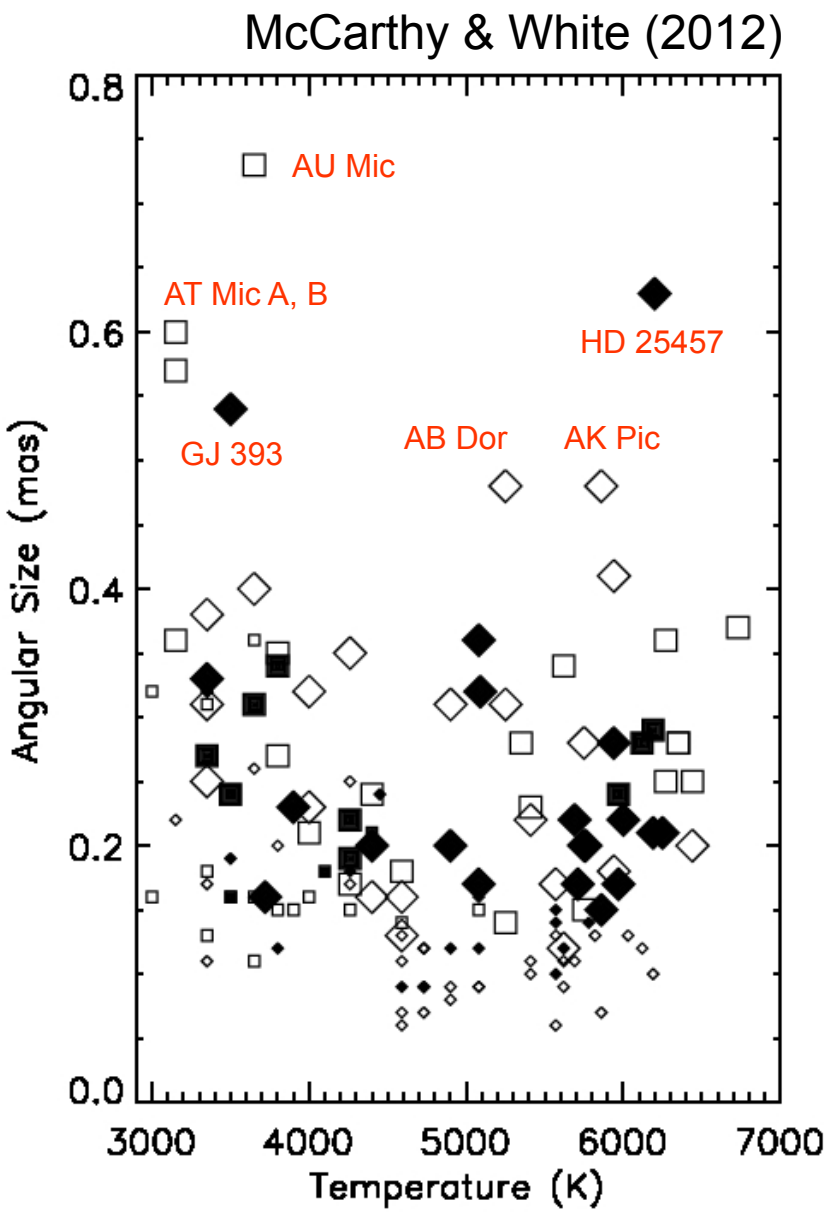


Star in Moving Groups





Stars in AB Dor

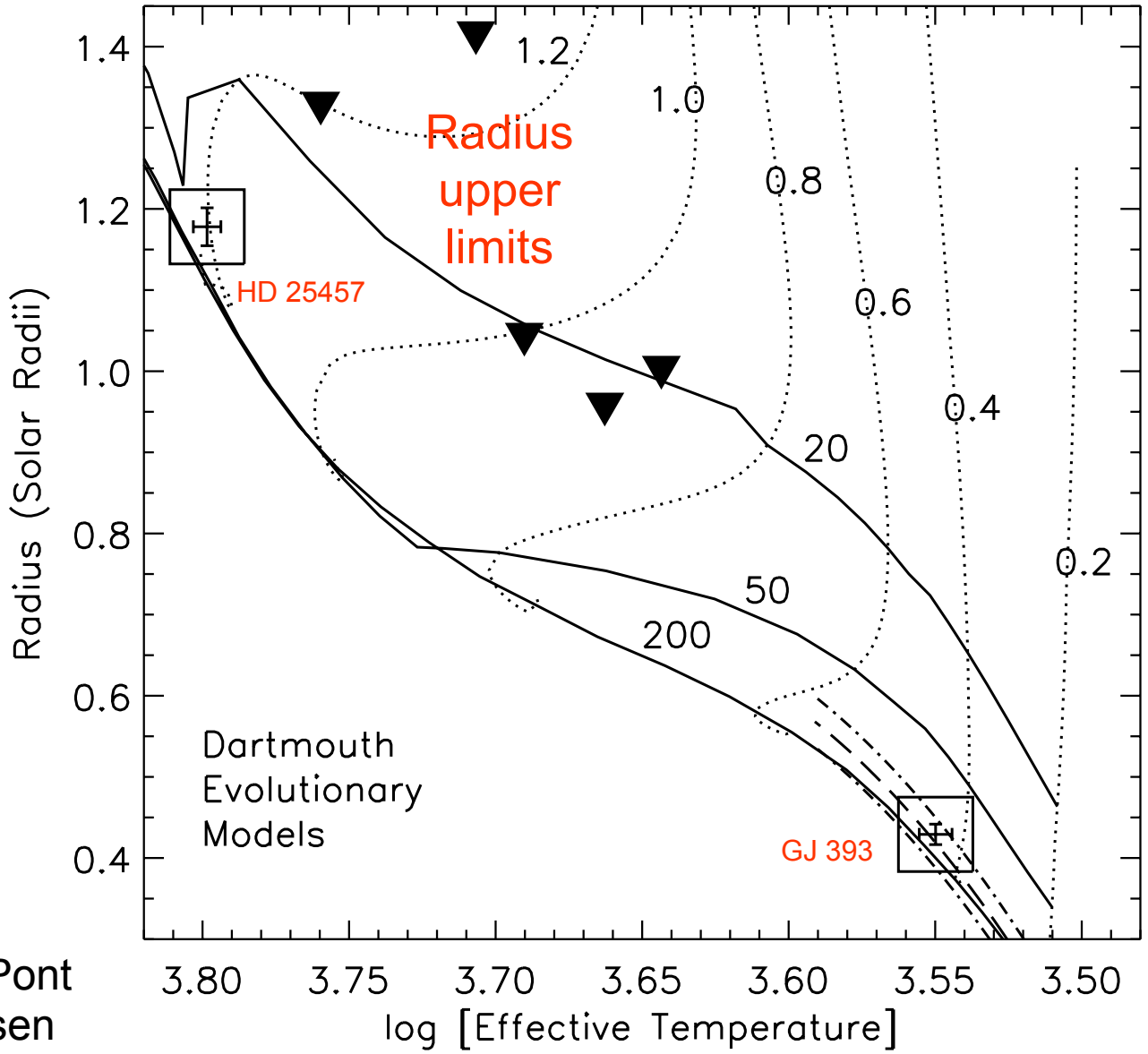
with Gail Schaefer, Ellyn Baines

HD 25457:

Contracting or Expanding?

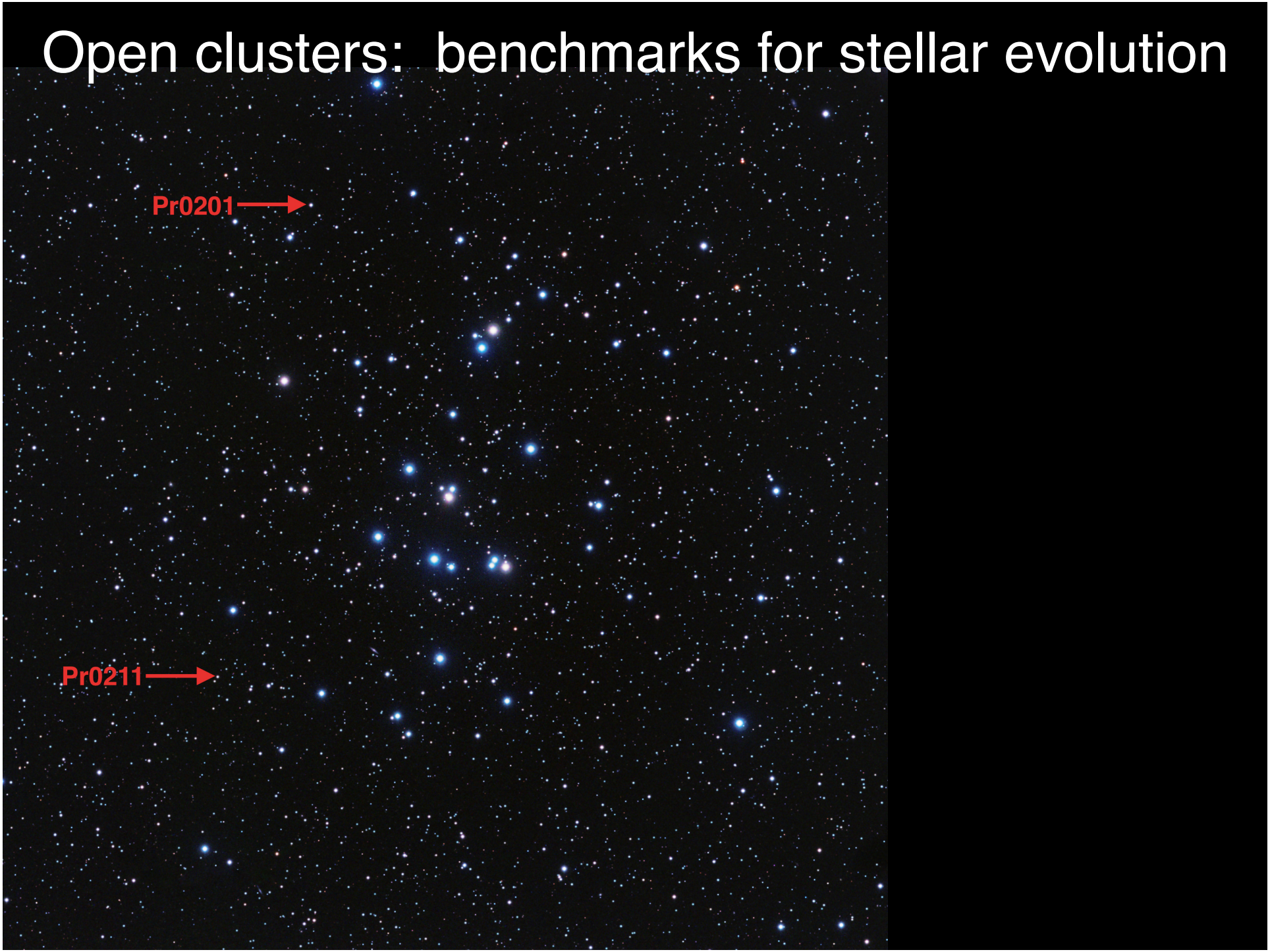
23 Myr vs 1.7 Gyr

Requires 'likelihood' analysis

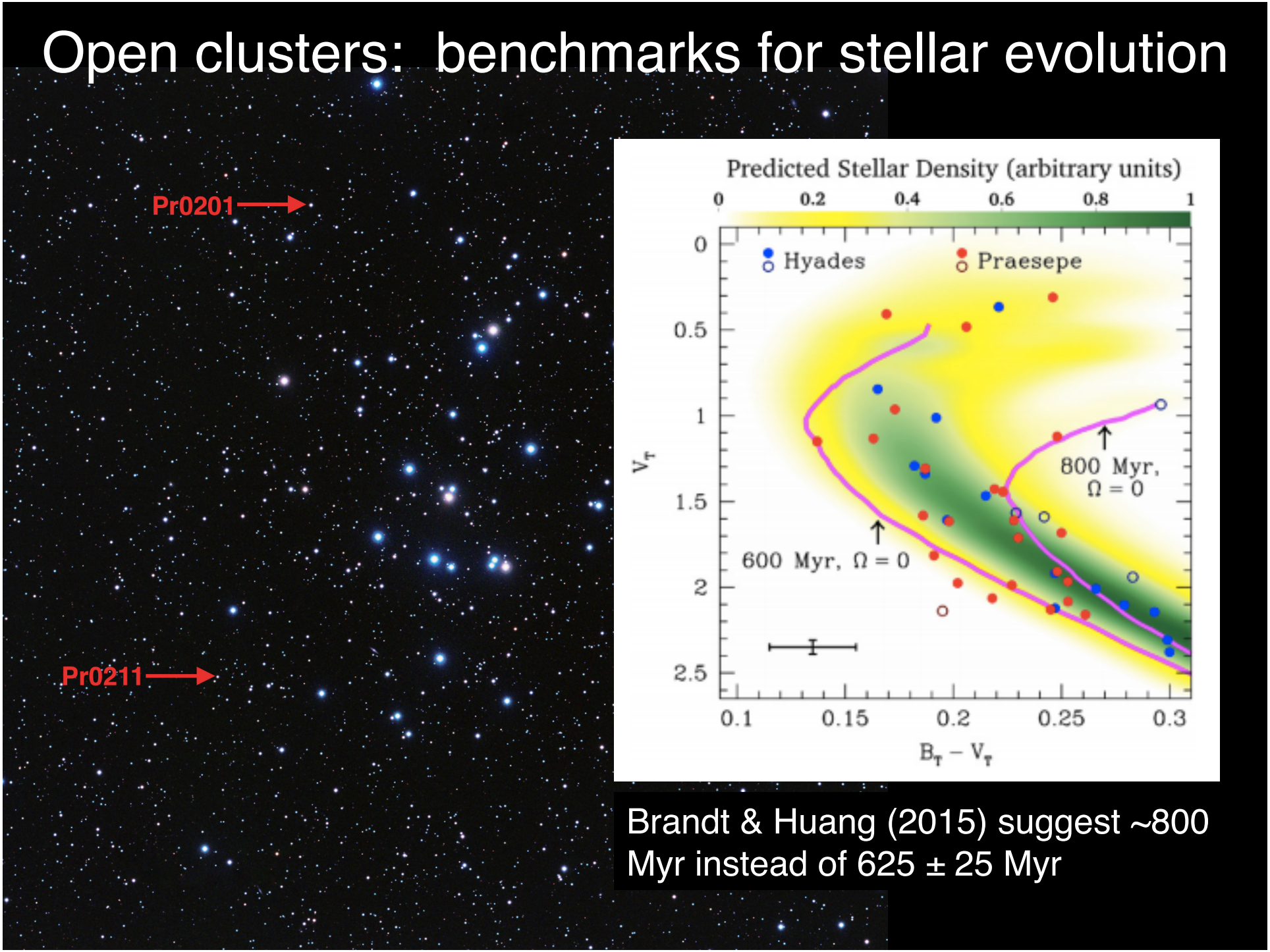


See Ligi et al. (2016), Pont & Eyer (2004), Jørgensen & Lindegren (2005).

Open clusters: benchmarks for stellar evolution

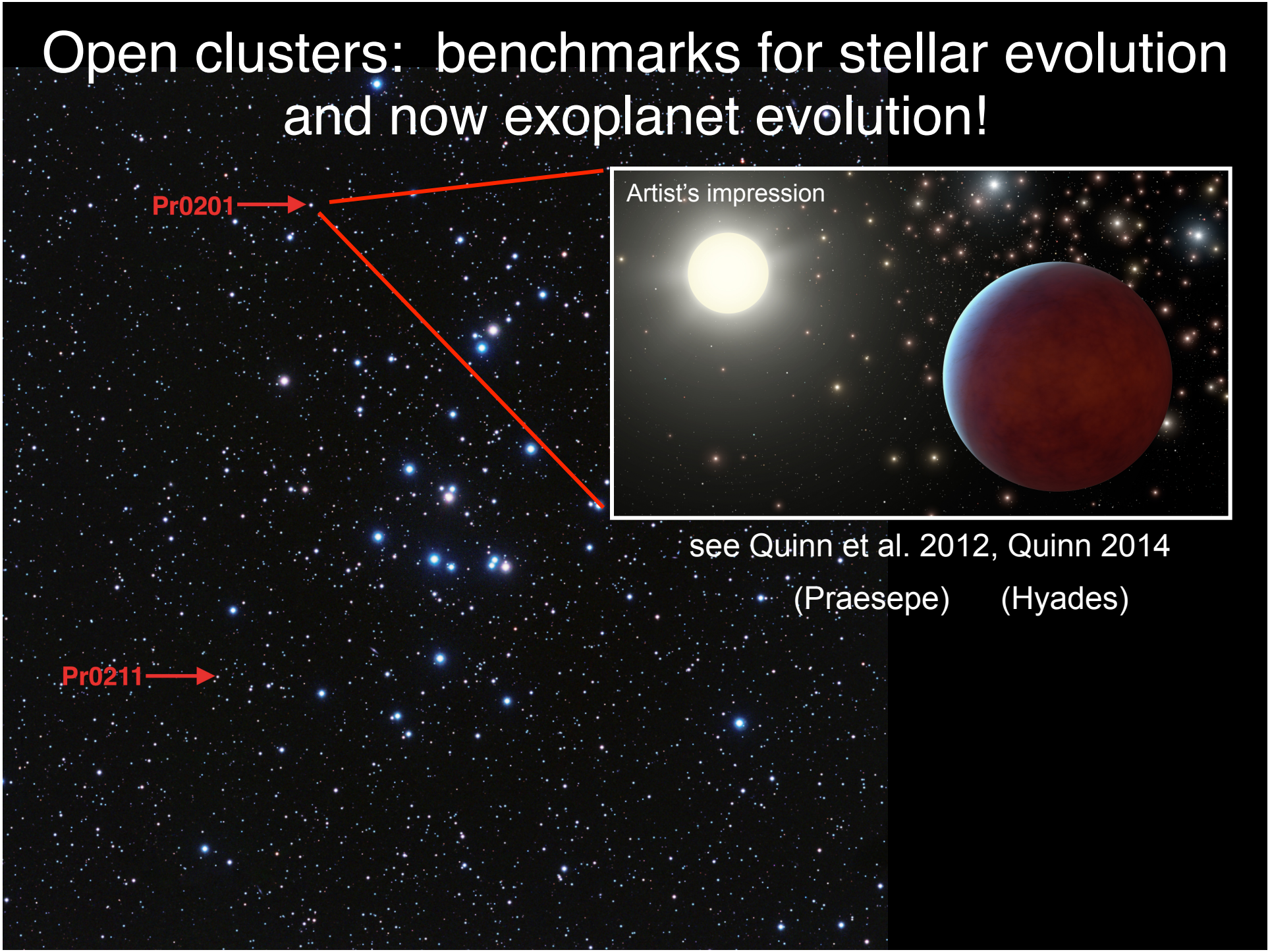


Open clusters: benchmarks for stellar evolution



Brandt & Huang (2015) suggest ~800 Myr instead of 625 ± 25 Myr

Open clusters: benchmarks for stellar evolution and now exoplanet evolution!

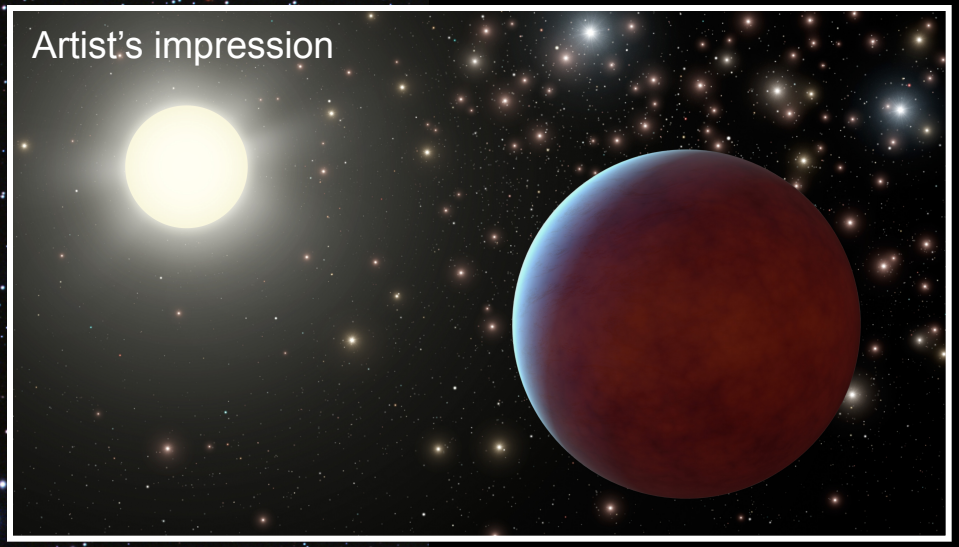


see Quinn et al. 2012, Quinn 2014

(Praesepe) (Hyades)

Open clusters: benchmarks for stellar evolution and now exoplanet evolution!

Pr0201



see Quinn et al. 2012, Quinn 2014

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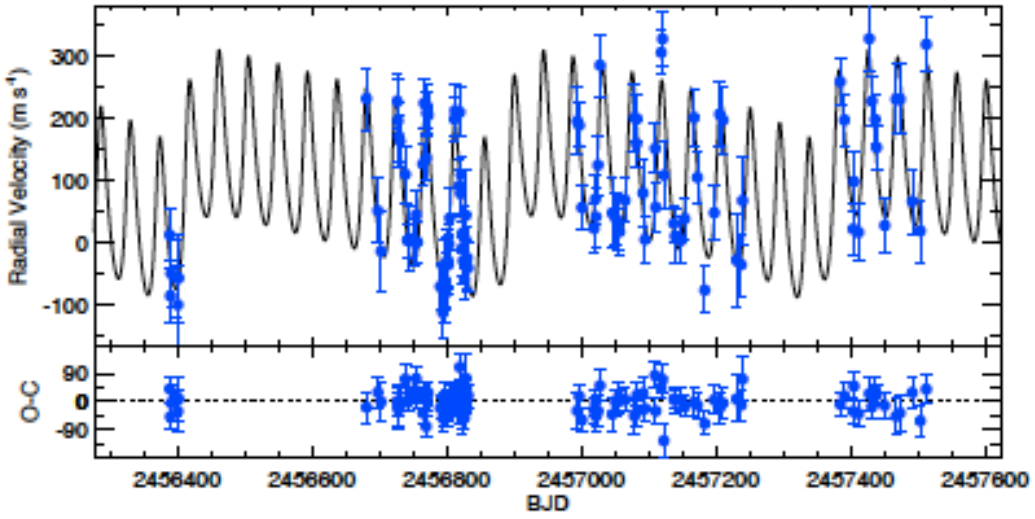

A new double-planet system in Coma Berenices!

Quinn et al. in prep

Open Cluster Ages from Giant Star Sizes

(Hyades, Praesepe, Coma Berenices, Ursa Major)

with Sam Quinn, Jeremy Jones

Open Cluster Ages from Giant Star Sizes

(Hyades, Praesepe, Coma Berenices, Ursa Major)

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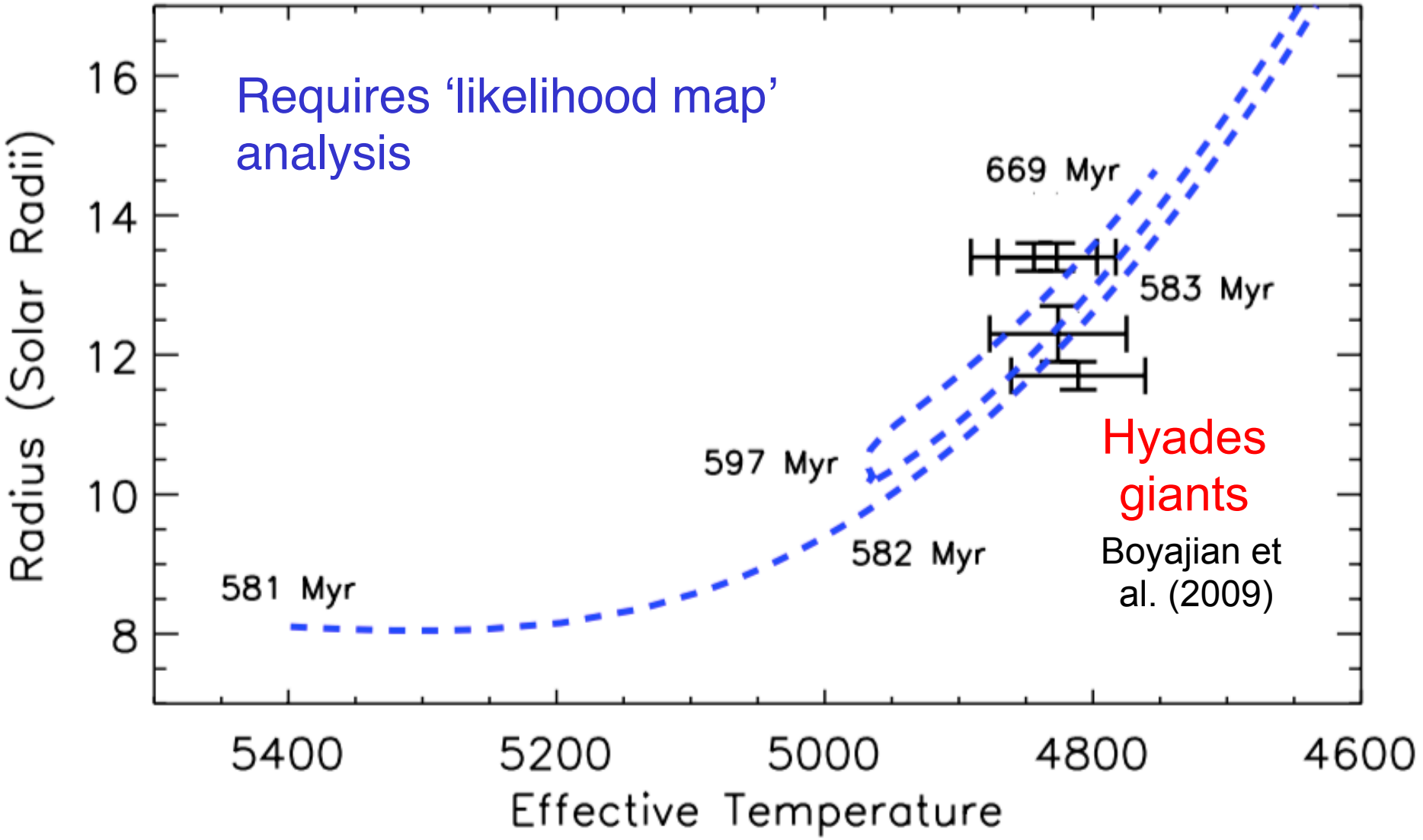
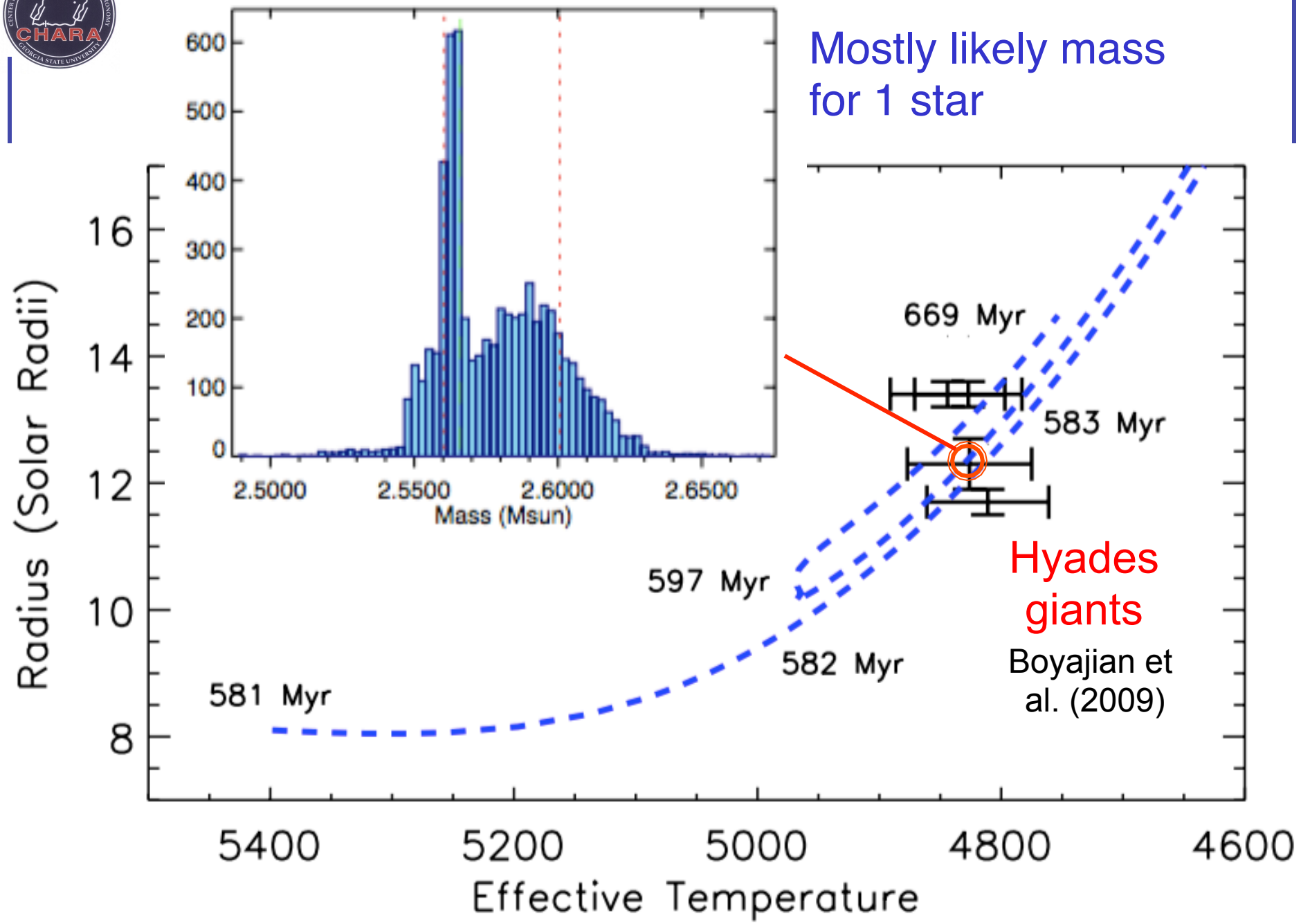
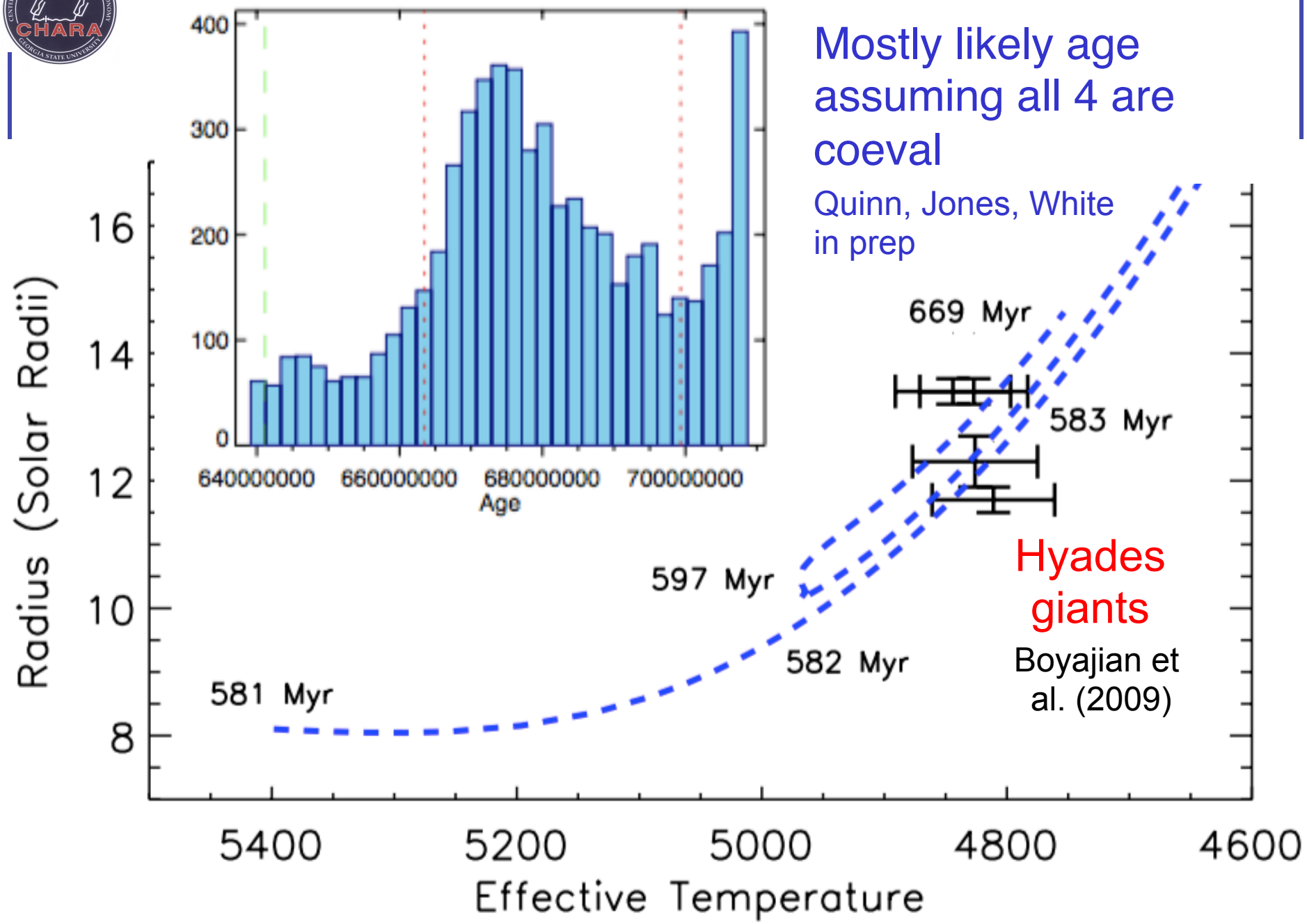



Mostly likely mass for 1 star
600
500
400
300
200
100
0
2.5000
2.5500
2.6000
2.6500
Mass (Msun)
Radius (Solar Radii)
16
14
12
10
8
669 Myr
583 Myr
597 Myr
582 Myr
581 Myr
Hyades giants
Boyajian et al. (2009)
5400
5200
5000
4800
4600
Effective Temperature


Mostly likely age assuming all 4 are coeval
Quinn, Jones, White in prep
669 Myr
583 Myr
597 Myr
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Hyades giants
Boyajian et al. (2009)
Radius (Solar Radii)
Effective Temperature
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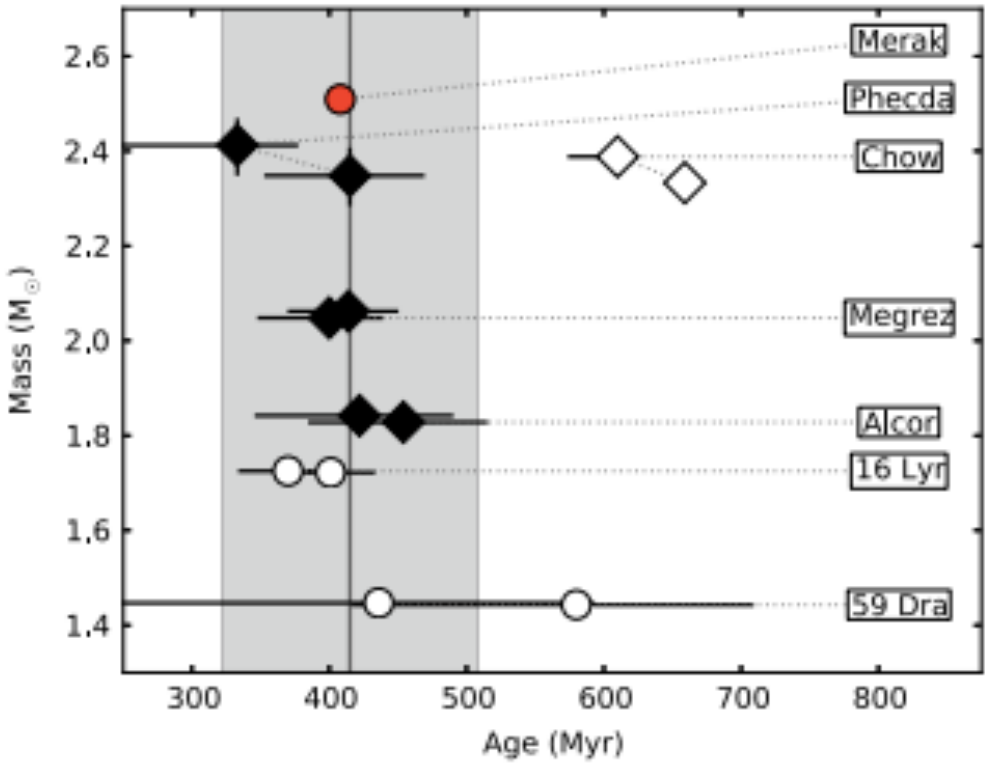
16
14
12
10
8
5400
5200
5000
4800
4600
400
300
200
100
0
640000000
660000000
680000000
700000000

Cluster and Moving Group Ages from A Star Shapes (Ursa Major, Hyades)

Jeremy Jones et al. (2015)



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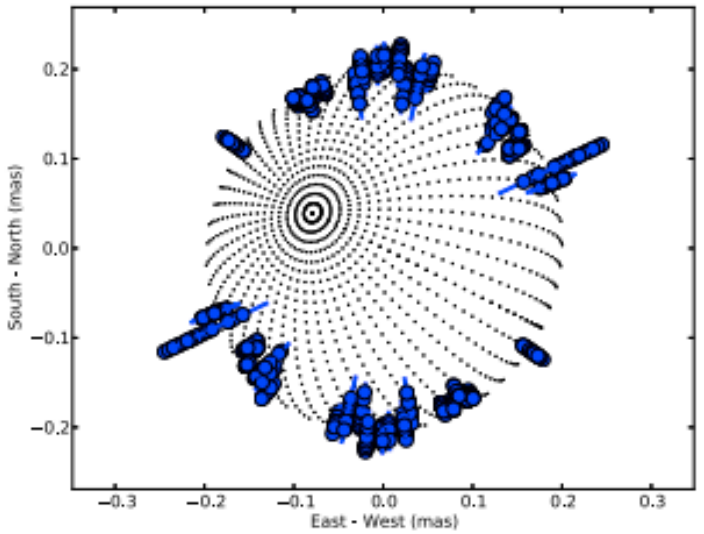

Kappa Andromeda:
Age = 47 $^{+27}_{-40}$ Myr

Ursa Major Moving Group:
Age = 414 ± 23 Myr

Hyades in progress …
See Jeremy's talk tomorrow

Summary

- New Sizes of Young Pre-Main Sequence Stars
  - AU Mic is 23 ± 5 Myr, (consistent with Bell et al. 2015)
  - AB Dor star are ZAMS
- Ages of Clusters from Giant Star Sizes
  - Need better photometry (F_{Bol}) and weather!
  - With *K2* asteroseismology? (see Mosser et al. 2014)
- Ages of the Hyades and Ursa Major from A Stars