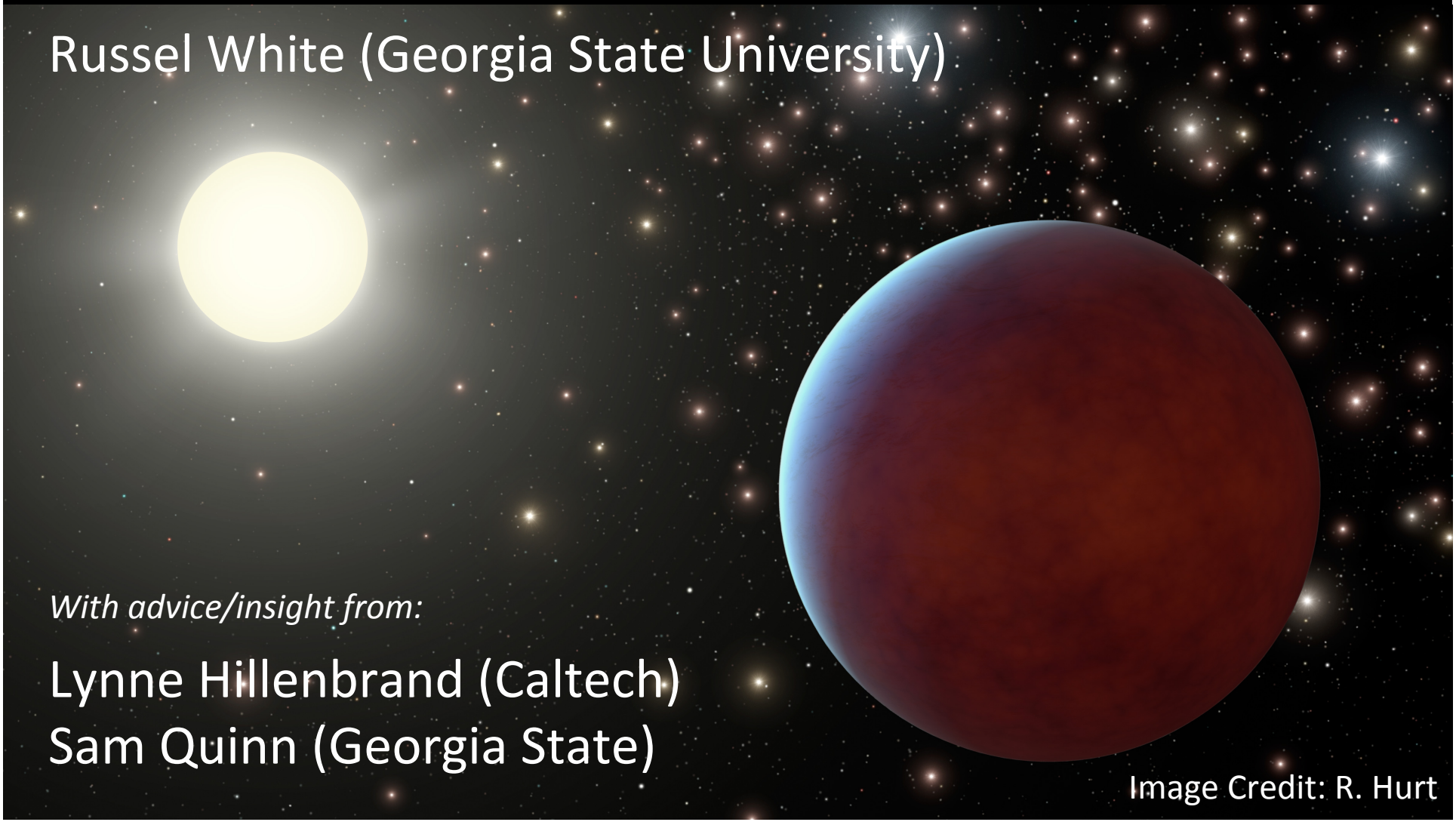
The Thousand Parsec Open Cluster Survey

establishing new benchmarks for star and planet evolution



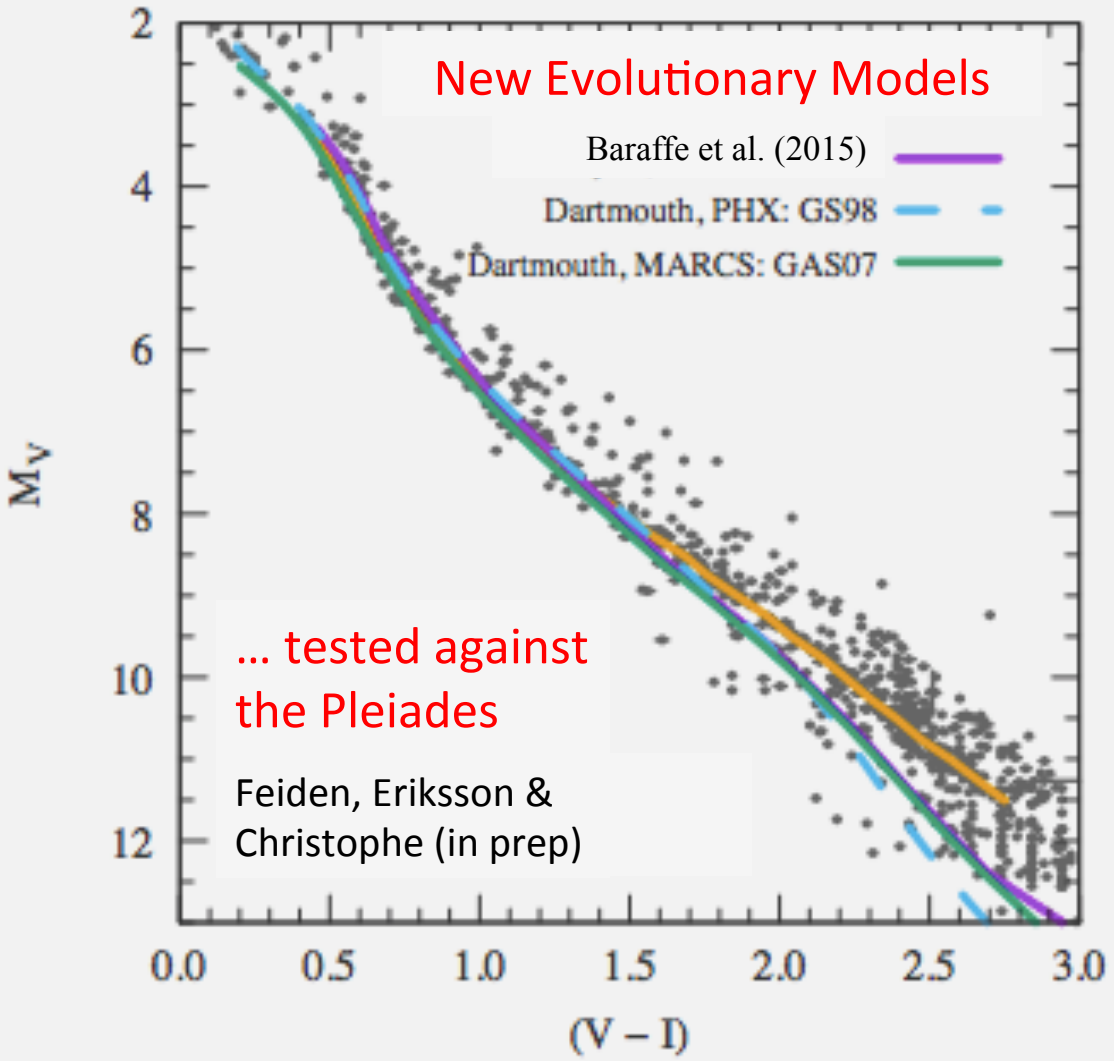
Russel White (Georgia State University)

With advice/insight from:

Lynne Hillenbrand (Caltech)
Sam Quinn (Georgia State)

Image Credit: R. Hurt

Open Clusters Serve as Benchmarks for Stellar Evolution



But detailed comparisons are only possible for nearest clusters (< 200 pc) with precision spectroscopy - membership, T_{eff}, A_v, rotation, multiplicity, metallicity (lithium), etc.

e.g. morning talks by Robberto, Hasan, etc.

... And Soon, Benchmarks for Planetary Structural/Dynamical Evolution

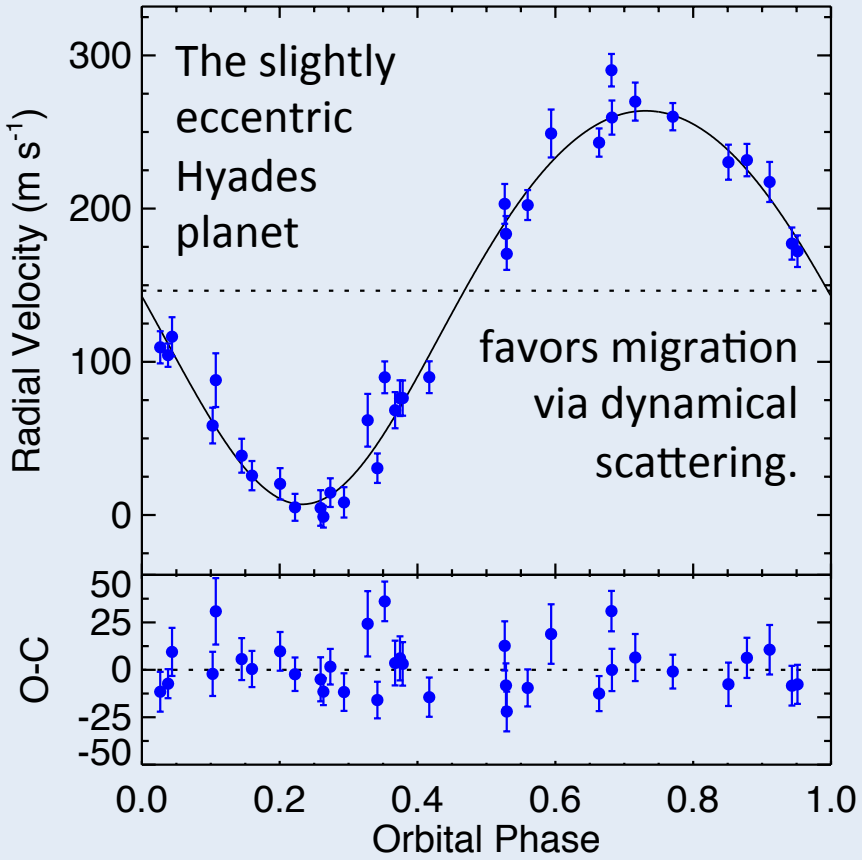
Gas giant planets exist around Sun-like stars in open clusters

(Praesepe: 2; Hyades: 1; Coma Ber: 1; NGC 6811: 2 M67: 2)

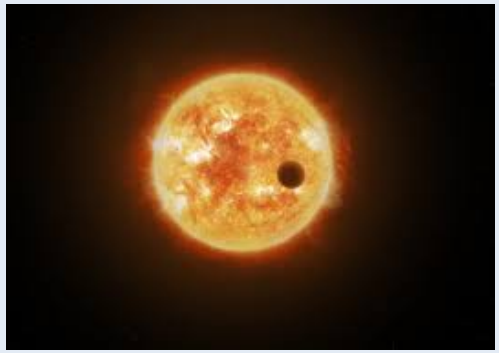
Quinn et al. 2012, 2014, in prep

Brucalassi et al. 2014

Meibom et al. 2013

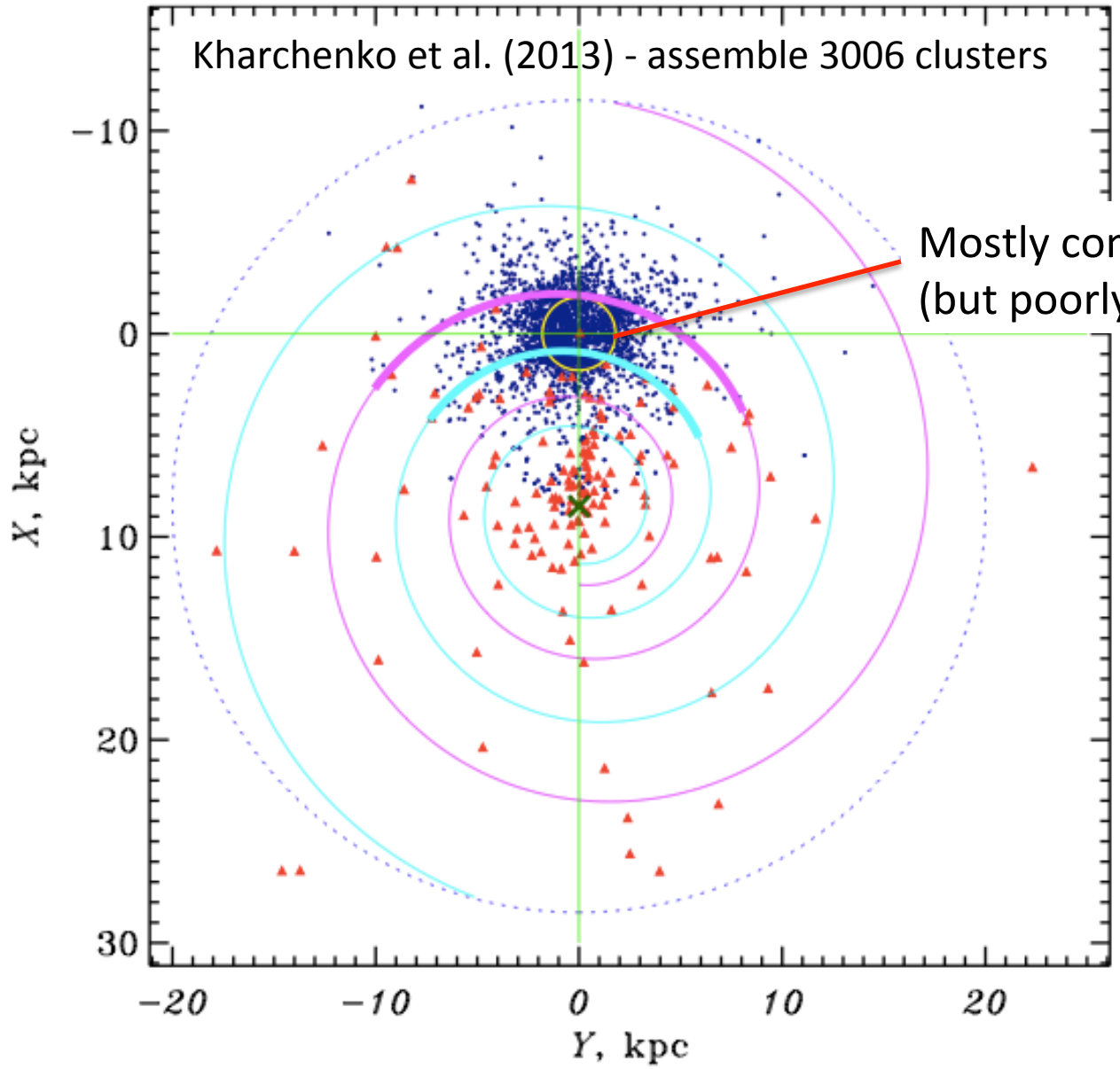


If an RV planet transits we get mass, radius AND age.



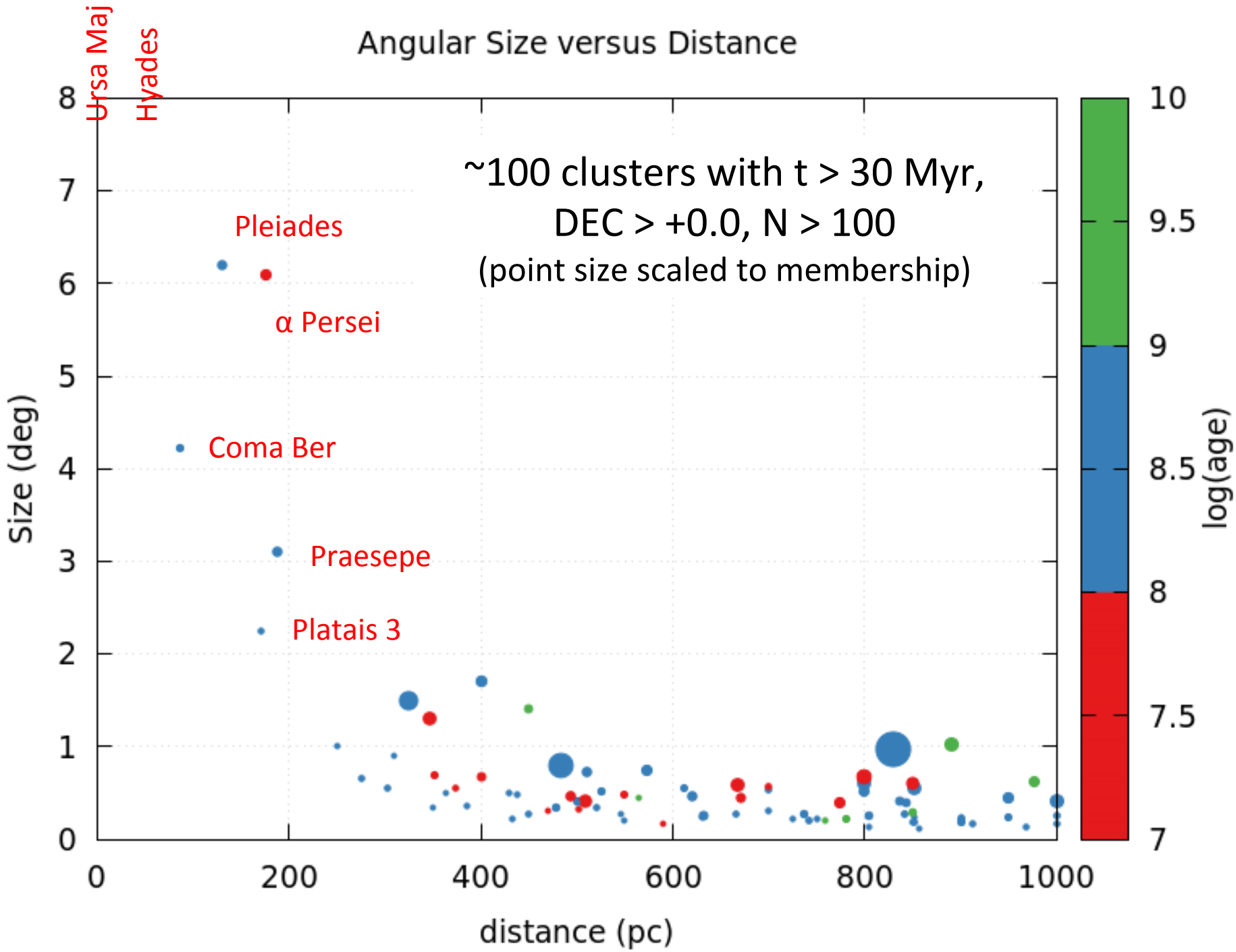
Need to survey more clusters (e.g. K2, Gaia ESO with VLT, TMT)

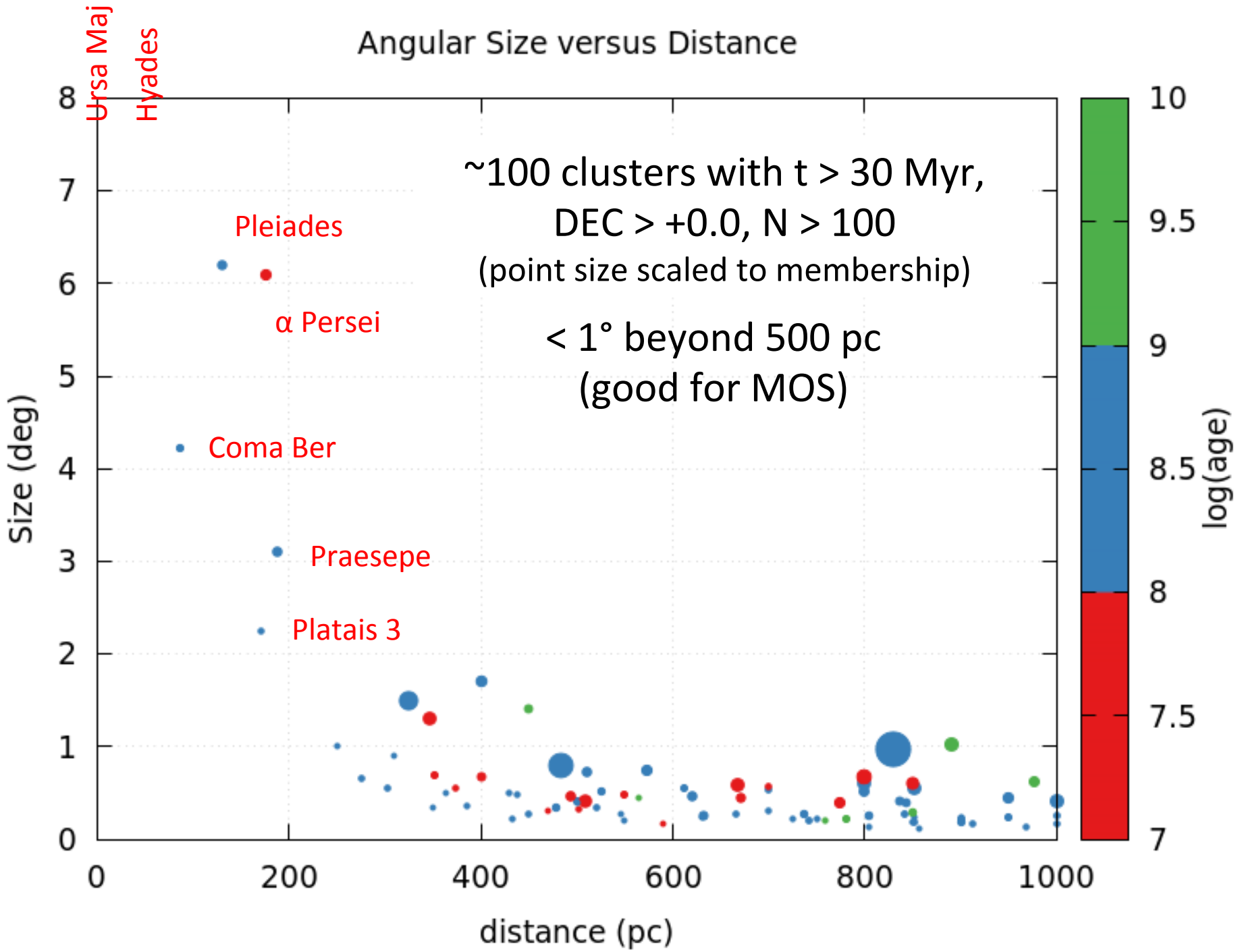
Milky Way Open Clusters

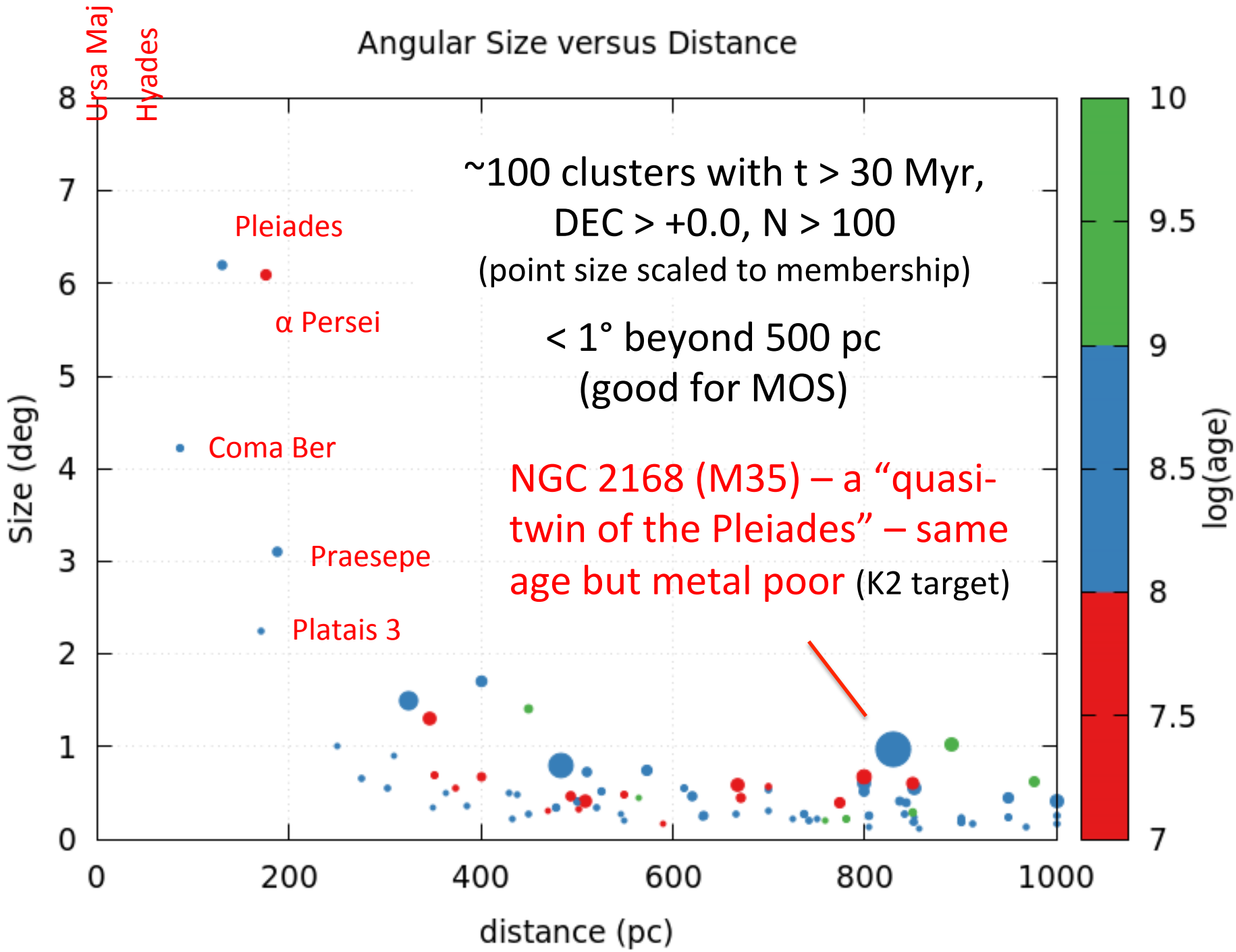


Mostly complete to 1.8 kpc
(but poorly defined)

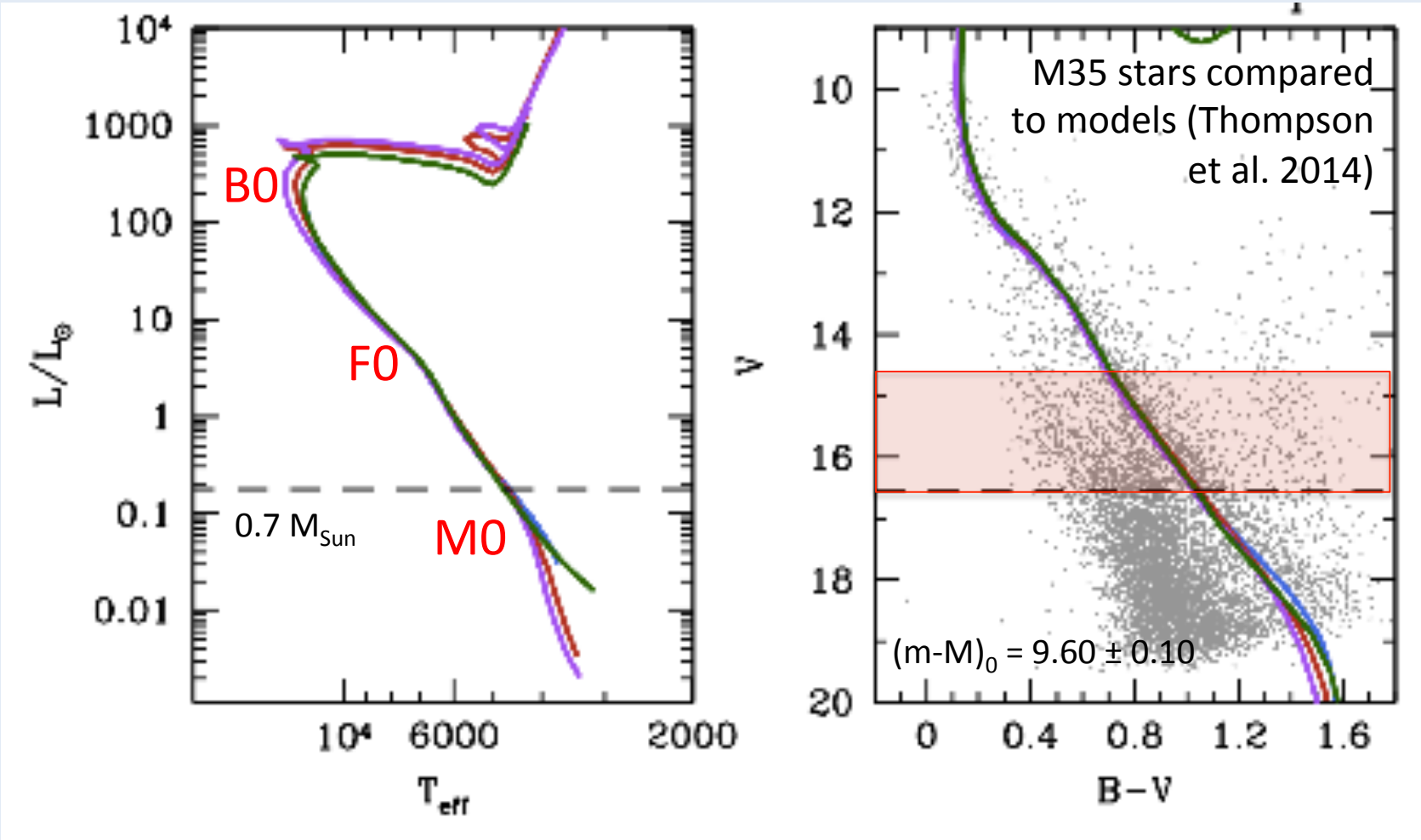
Gaia will improve membership lists considerably
(1% distances at 1 kpc)


Angular Size versus Distance
Ursa Maj
Hyades
~100 clusters with t > 30 Myr,
DEC > +0.0, N > 100
(point size scaled to membership)
Pleiades
α Persei
Coma Ber
Praesepe
Platais 3
Size (deg)
distance (pc)
log(age)
0
1
2
3
4
5
6
7
8
0
200
400
600
800
1000
7
7.5
8
8.5
9
9.5
10


Angular Size versus Distance
Ursa Maj
Hyades
Pleiades
α Persei
Coma Ber
Praesepe
Platais 3
~100 clusters with t > 30 Myr,
DEC > +0.0, N > 100
(point size scaled to membership)
< 1° beyond 500 pc
(good for MOS)
Size (deg)
distance (pc)
log(age)
0
1
2
3
4
5
6
7
8
0
200
400
600
800
1000
7
7.5
8
8.5
9
9.5
10


Angular Size versus Distance
Ursa Maj
Hyades
Pleiades
α Persei
Coma Ber
Praesepe
Platais 3
~100 clusters with t > 30 Myr,
DEC > +0.0, N > 100
(point size scaled to membership)
< 1° beyond 500 pc
(good for MOS)
NGC 2168 (M35) – a "quasi-twin of the Pleiades" – same age but metal poor (K2 target)
Size (deg)
distance (pc)
log(age)
0
1
2
3
4
5
6
7
8
0
200
400
600
800
1000
7
7.5
8
8.5
9
9.5
10

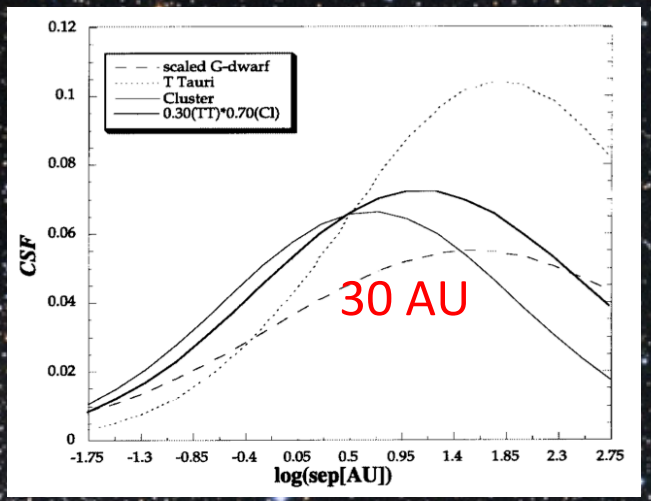
The Need for Large Telescopes



Sun-like stars (F5-K5) are V = 14.5 – 16.5, but bottom of the MS extends to well below V=20 mag

Diffraction limited imaging with TMT/IRIS

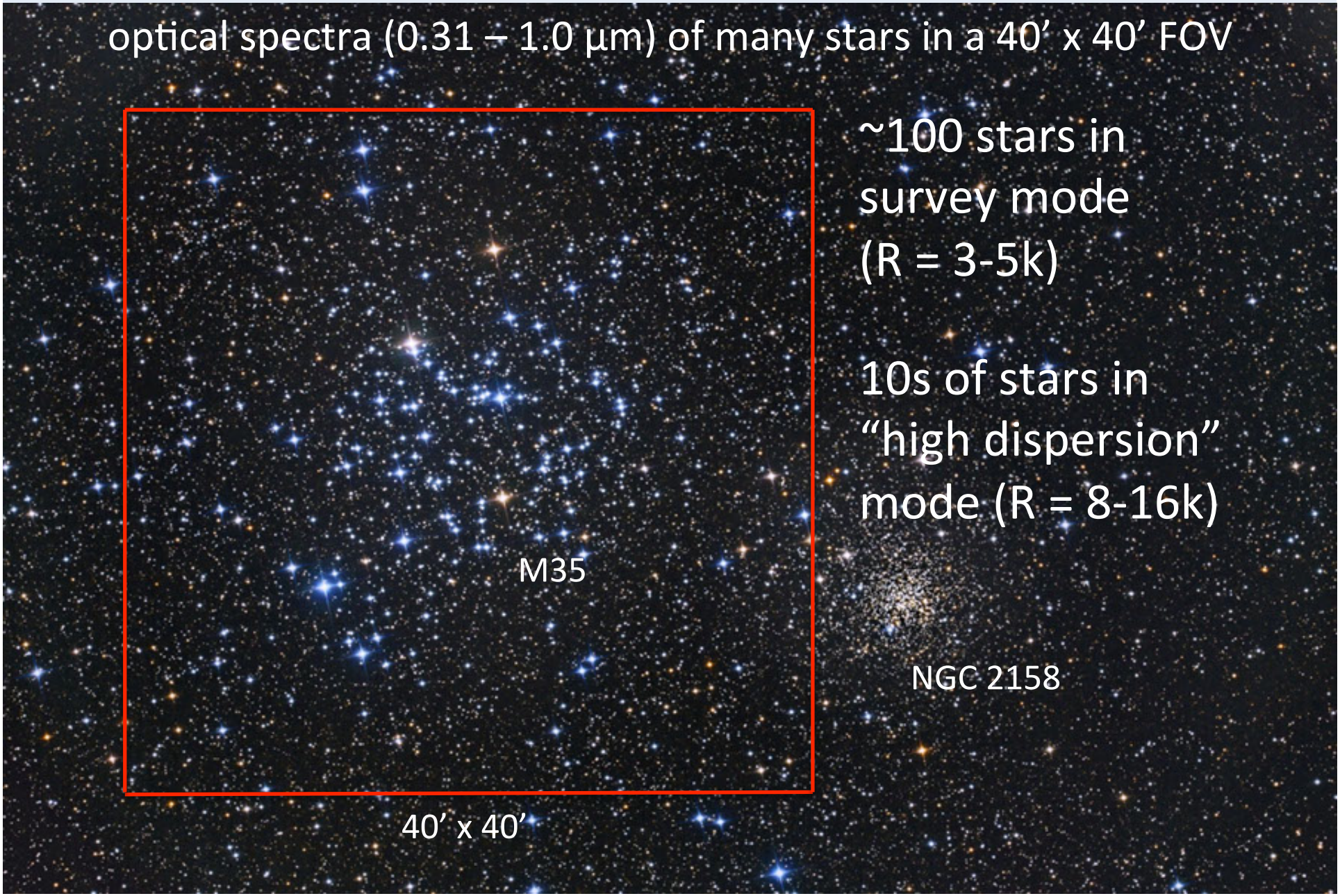
~0.01” resolution would resolve the majority of stellar companions



M35

NGC 2158

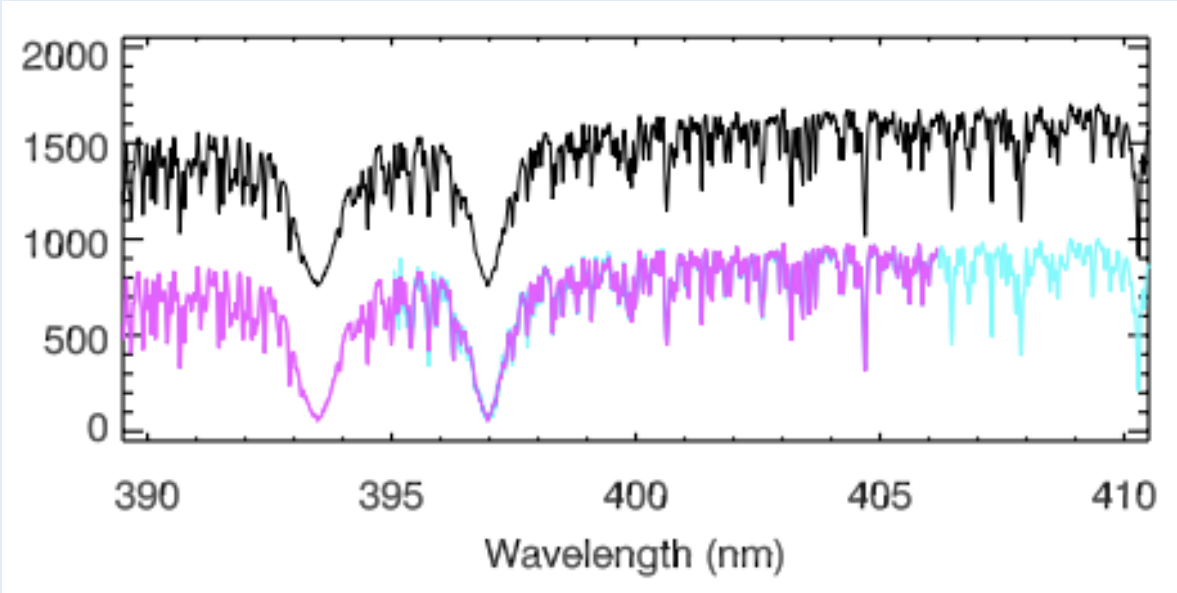
Spectroscopic Survey with TMT/WFOS



In High Dispersion Mode (R~10k)

dλ = 0.6 Å at 6000 Å

T_{eff}, log g,
Ca II H & K, Hα,
Lithium, Fe/H,
etc.

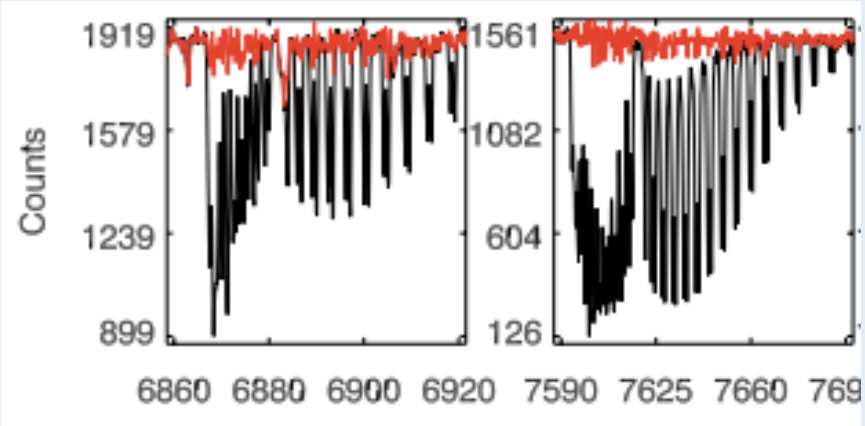


VLT/X-shooter spectra at R~10k (Chen et al. 2014)

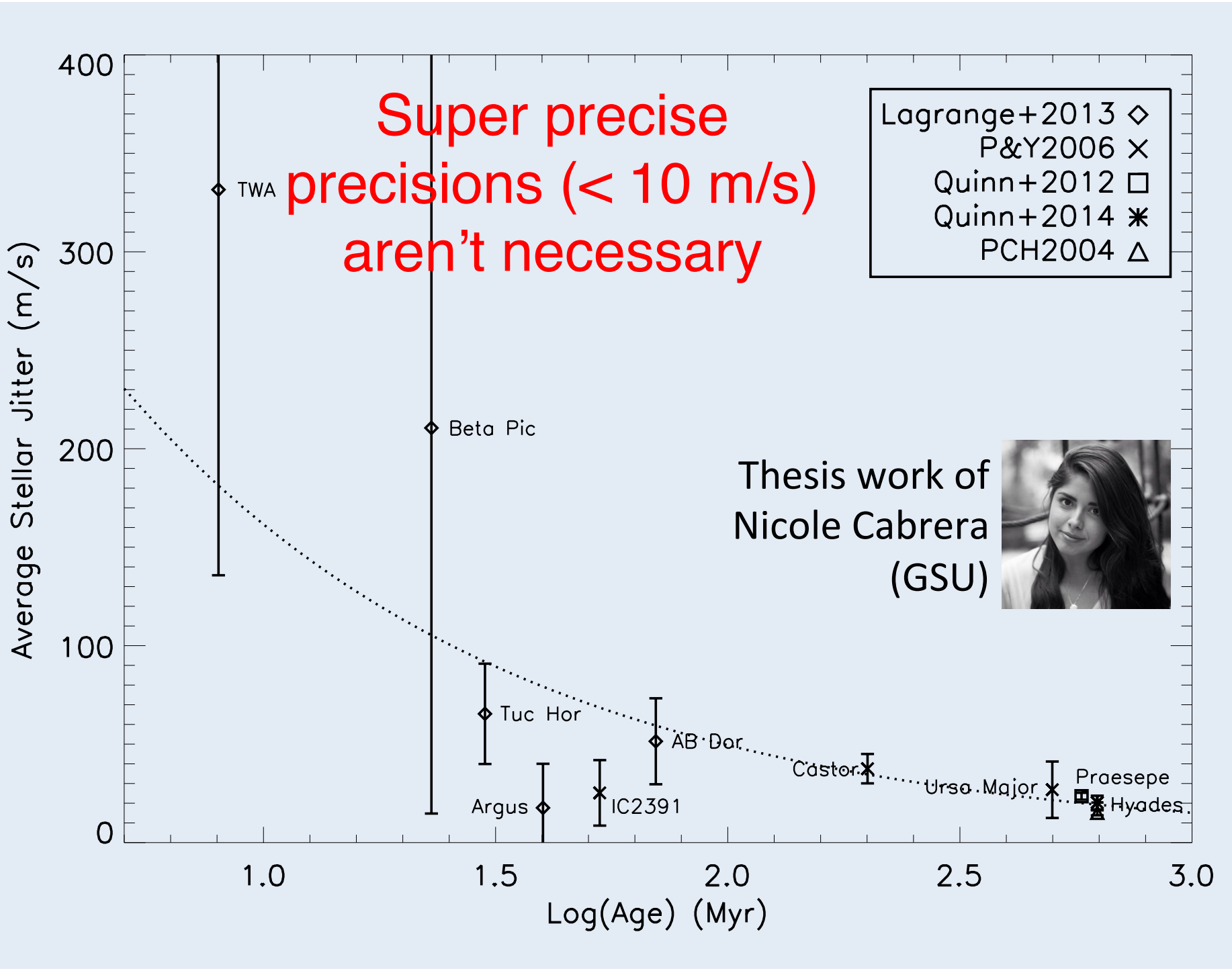
dv = 30 km/s

vsini, RV

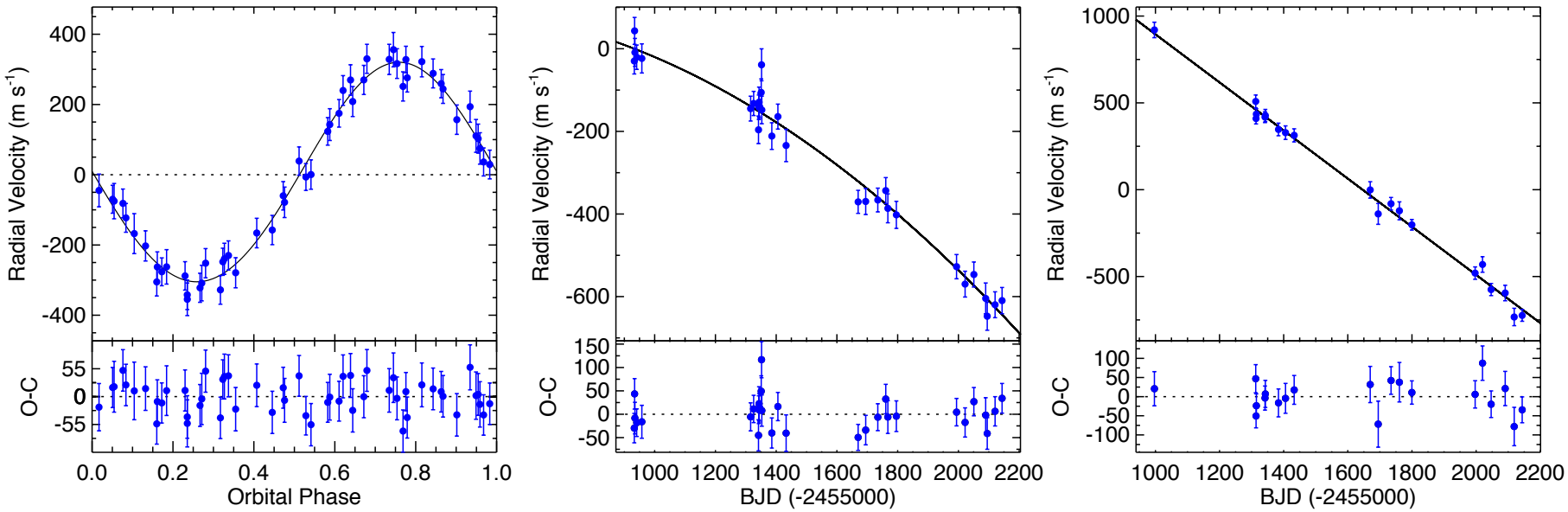
If line centers can be measured to 1 part in 300, could get RVs of 100 m/s



Telluric absorption in the A and B bands


Super precise precisions (< 10 m/s) aren't necessary
Lagrange+2013
P&Y2006
Quinn+2012
Quinn+2014
PCH2004
Thesis work of Nicole Cabrera (GSU)
TWA
Beta Pic
Tuc Hor
AB Dor
Argus
IC2391
Castor
Ursa Major
Praesepe
Hyades
Average Stellar Jitter (m/s)
Log(Age) (Myr)
400
300
200
100
0
1.0
1.5
2.0
2.5
3.0

Companions Detectable at 0.1 km/s



Hot Jupiters

A Praesepe planet, with K = 300 m/s, P = 2.1 d, msini = 1.8 M_{Jup}

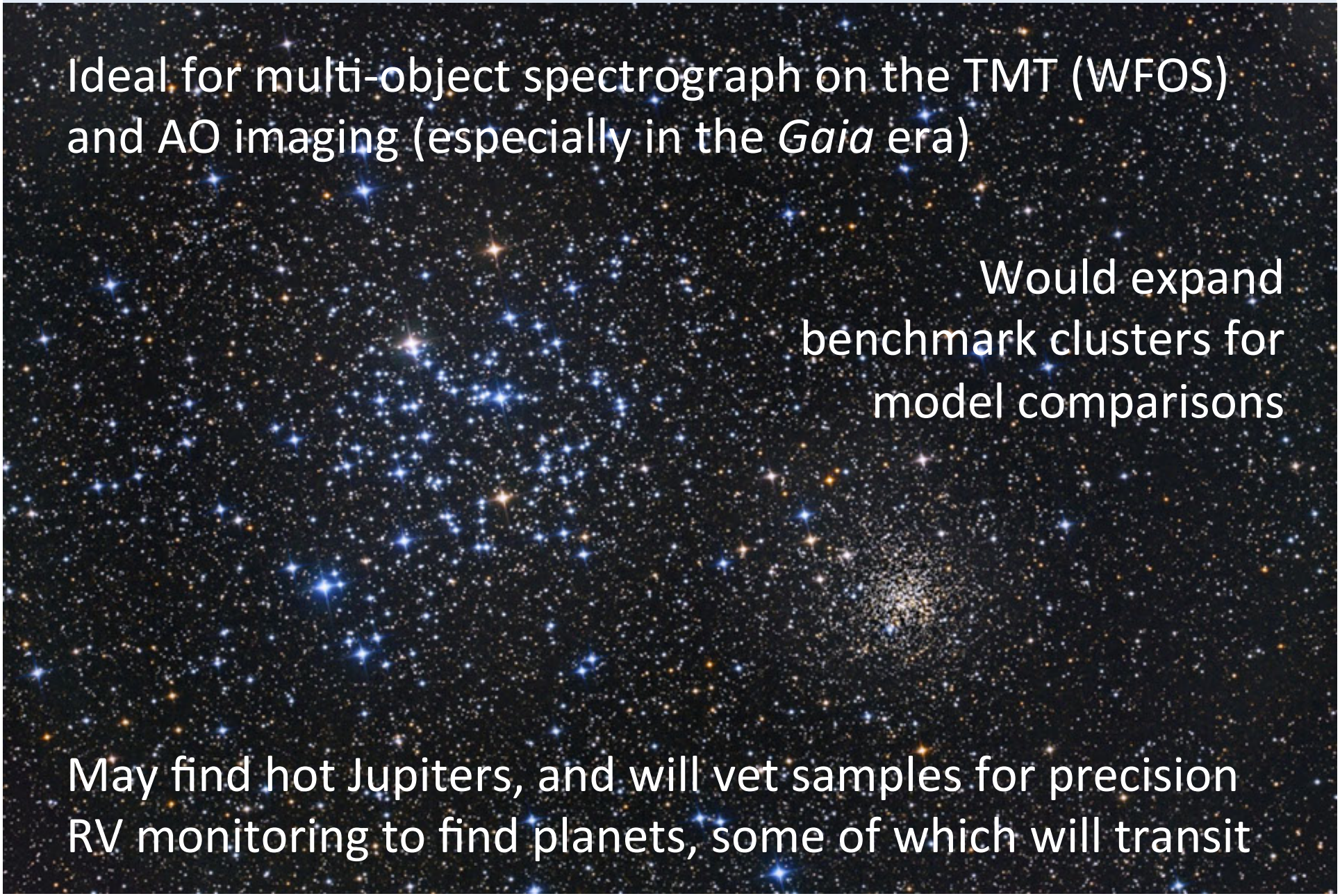
Low amplitude SBs

Trends show that these stars are not single

Precision would also complement *Gaia* μ (15 μas/yr = 70 m/s at 1 kpc): cluster membership, dispersal τ

Thesis work of Sam Quinn (GSU)

Open Clusters Out to 1 kpc



Ideal for multi-object spectrograph on the TMT (WFOS) and AO imaging (especially in the *Gaia* era)

Would expand benchmark clusters for model comparisons

May find hot Jupiters, and will vet samples for precision RV monitoring to find planets, some of which will transit