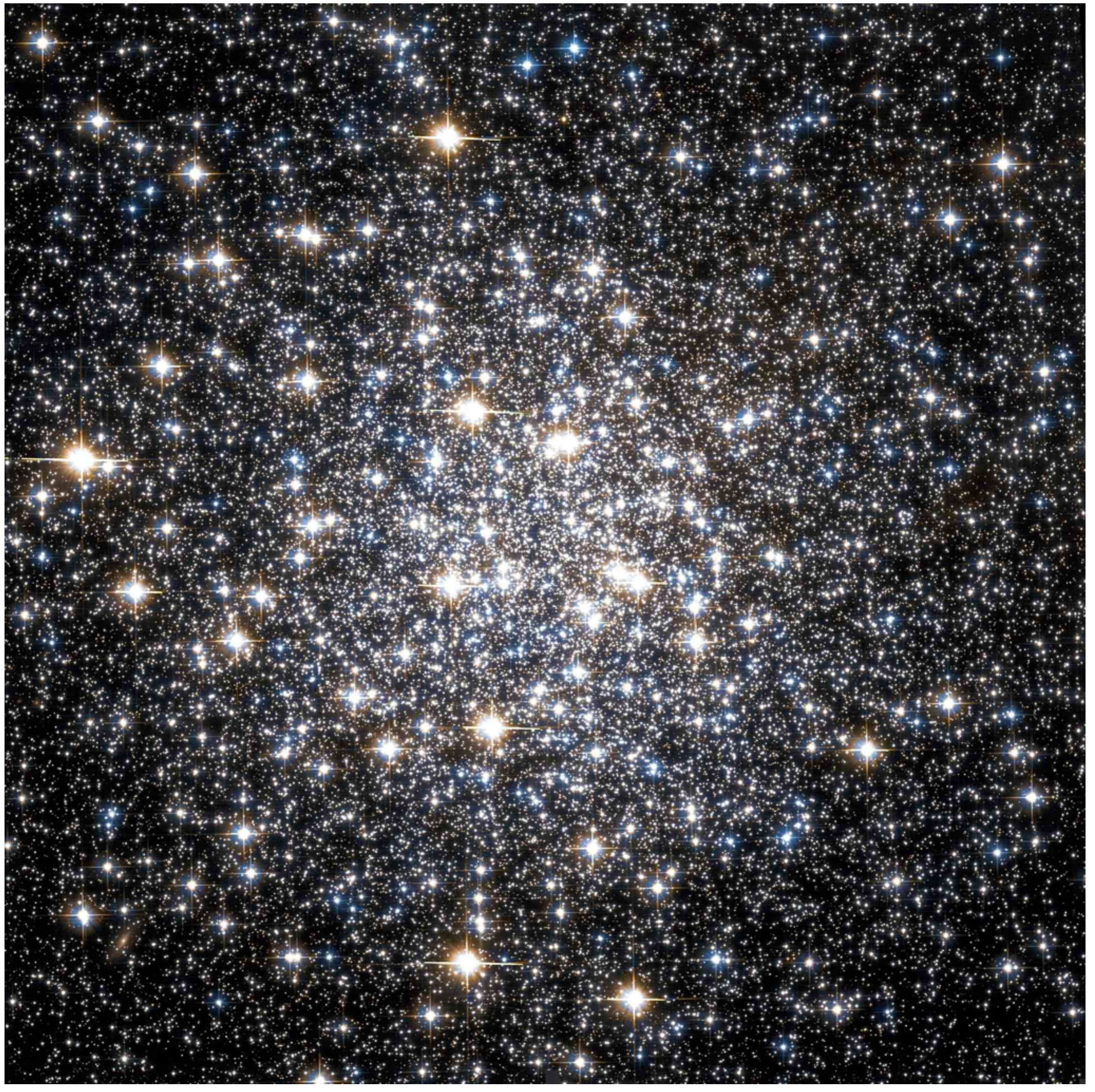
Dwarf galaxies vs. globular clusters: An observer's perspective

Jay Strader (Michigan St)
with Beth Willman (Haverford)

A globular cluster



A galaxy

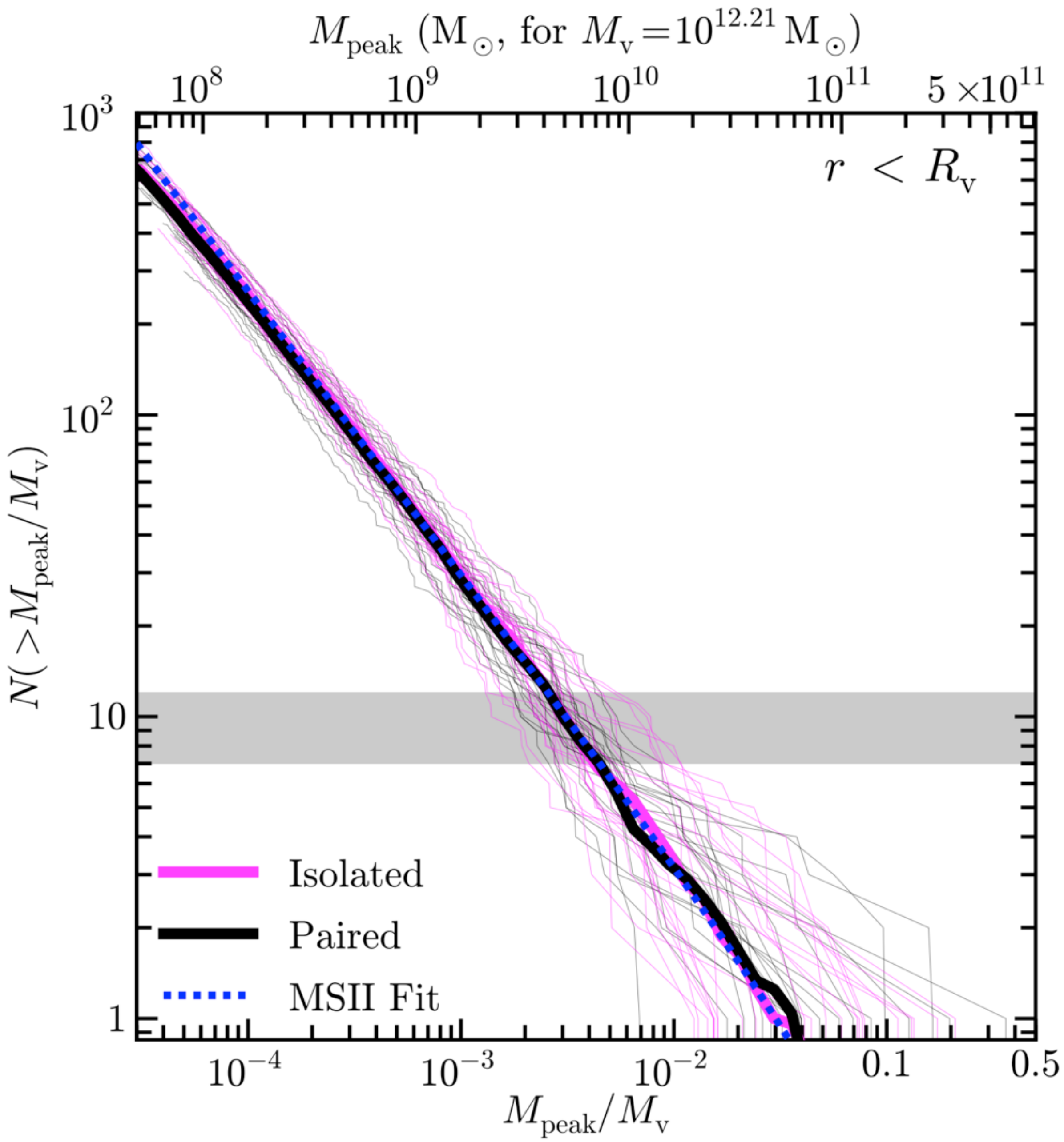
"A galaxy is a gravitationally bound collection of stars whose properties cannot be explained by a combination of baryons and Newton's laws of gravity"

(Willman & Strader 2012)

"A galaxy is a gravitationally bound collection of stars whose properties cannot be explained by a combination of baryons and Newton's laws of gravity"

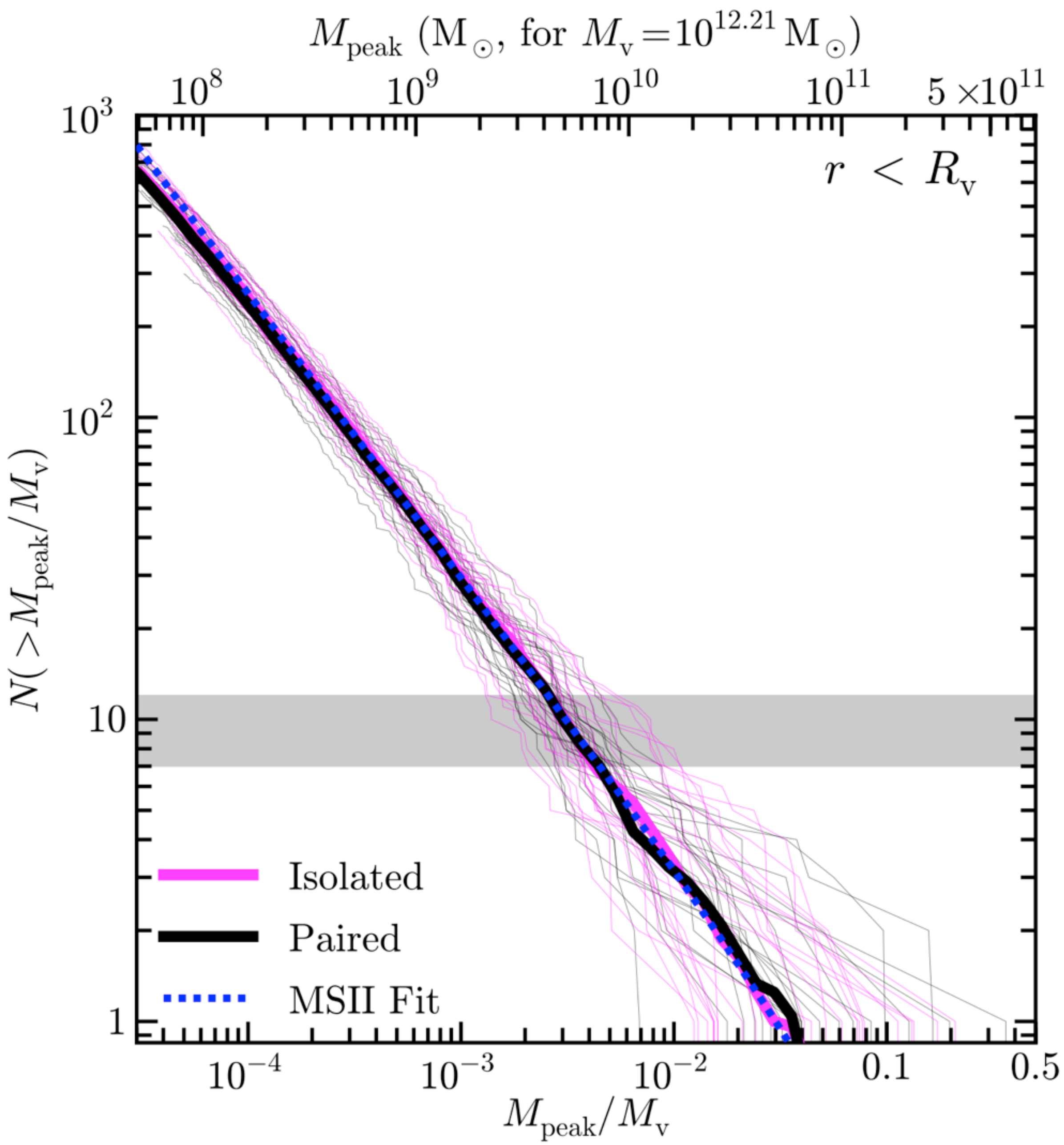
If you think we live in a CDM universe, this is equivalent to saying that galaxies are objects that form in individual dark matter halos

Garrison-Kimmel et al 2014



Depending on physics of galaxy formation, expect hundreds of low-mass dwarfs in next-generation surveys like LSST (and DES already finding many)

Garrison-Kimmel et al 2014



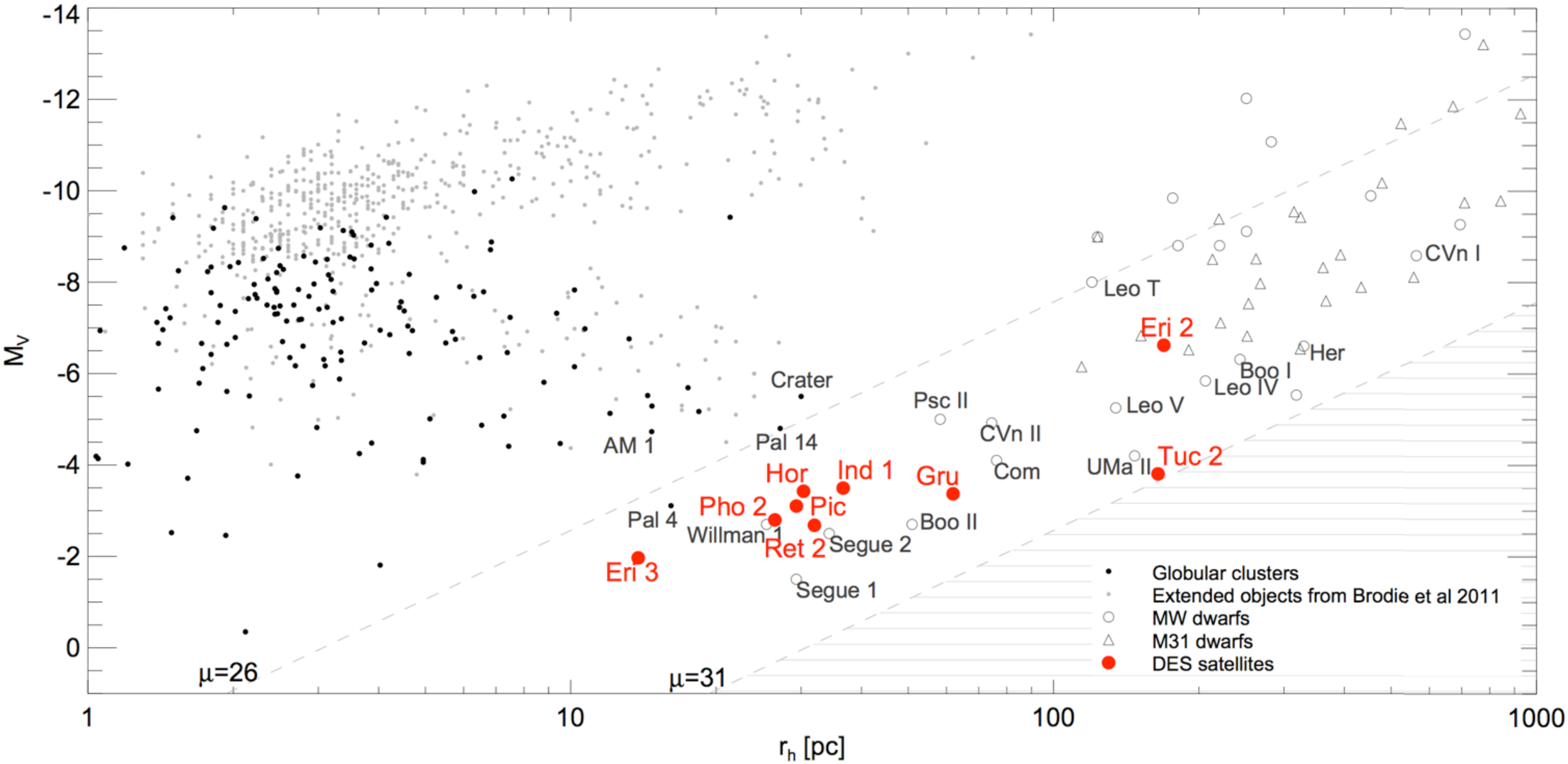
Robust globular cluster formation not imminent in cosmological simulations: burden is on observers to figure out how many dwarfs we see

Definition vs. Diagnostic

The problem is putting this, or any definition, into practice: telling whether a low-mass object is solely made of baryons obeying Newtonian gravity is *hard*

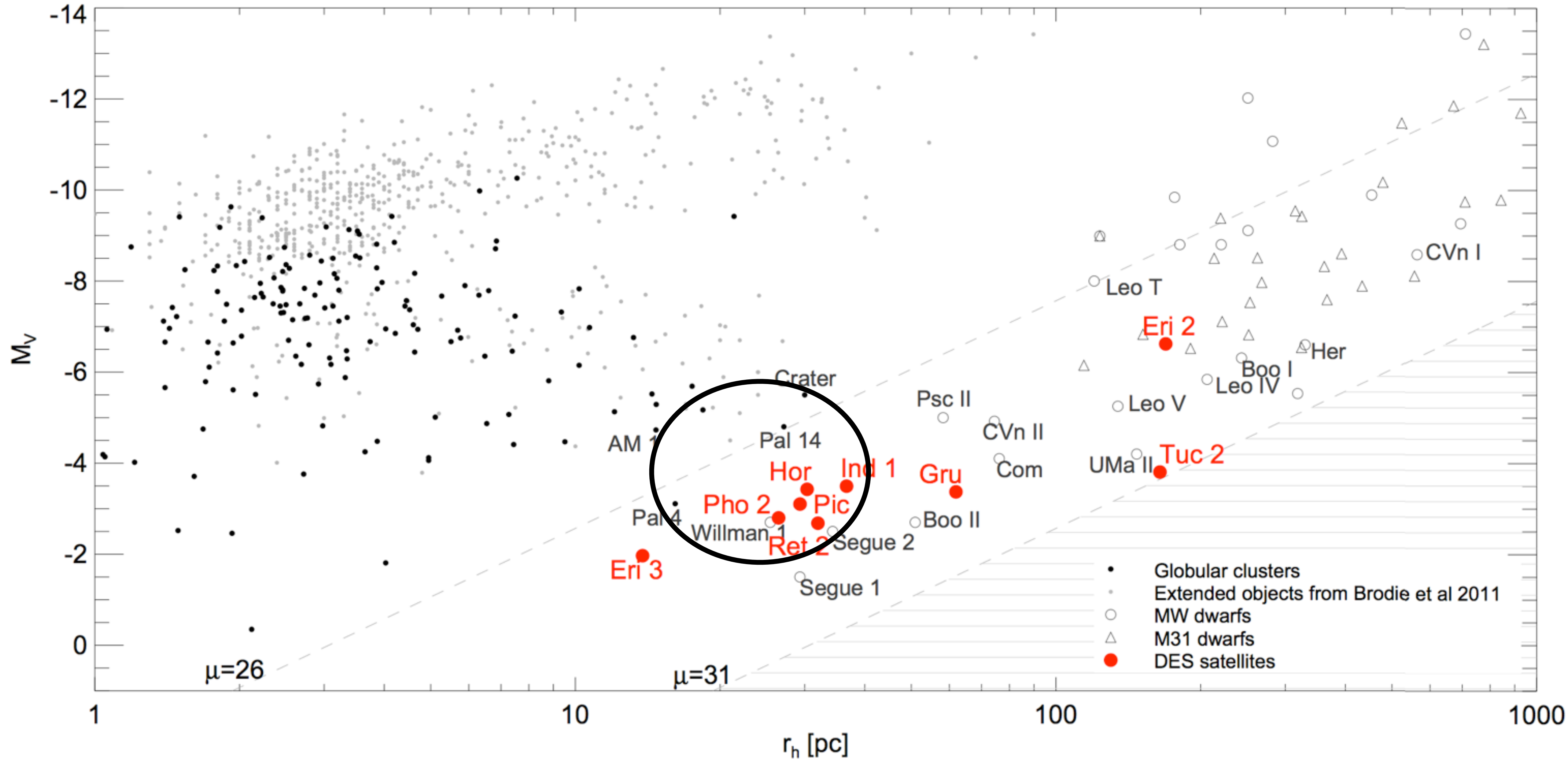
This leads to the use of empirical diagnostics of whether an object is a galaxy: these are *not* definitions

Koposov et al 2015



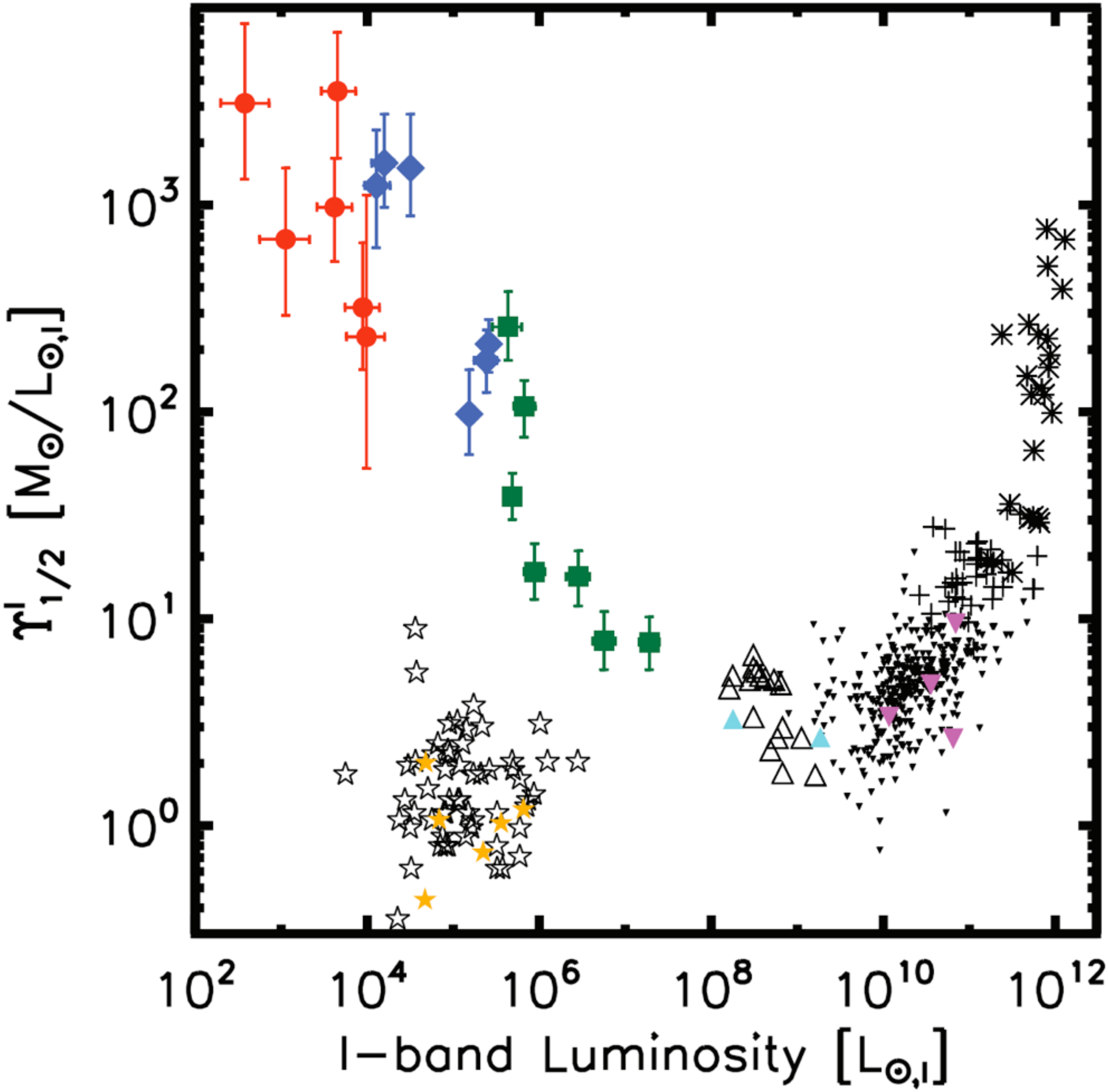
Large, low-mass things are mostly dwarfs, but no size limit is an accurate criterion

Koposov et al 2015

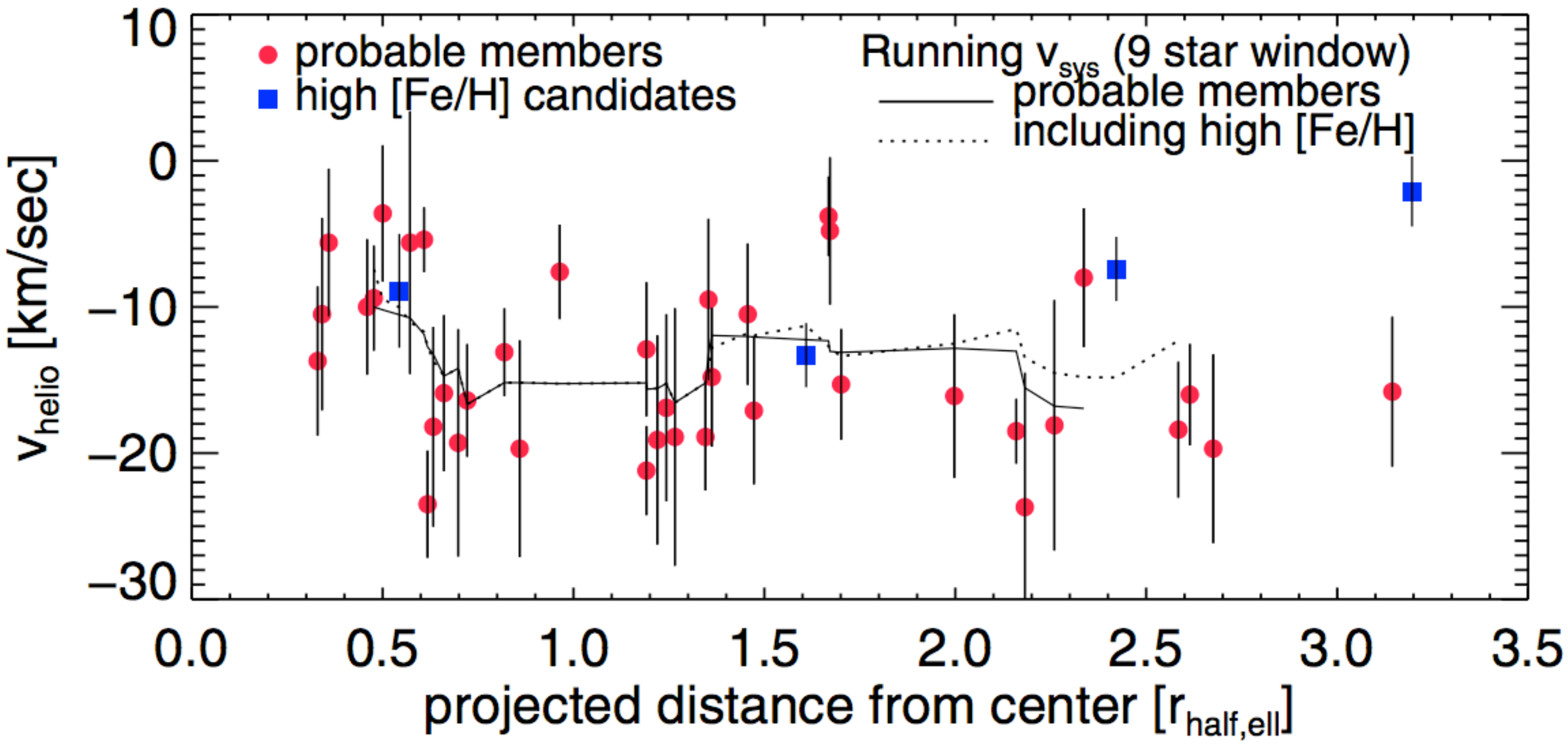


I guarantee you that GCs live here, they are just hard to find

Wolf et al 2010

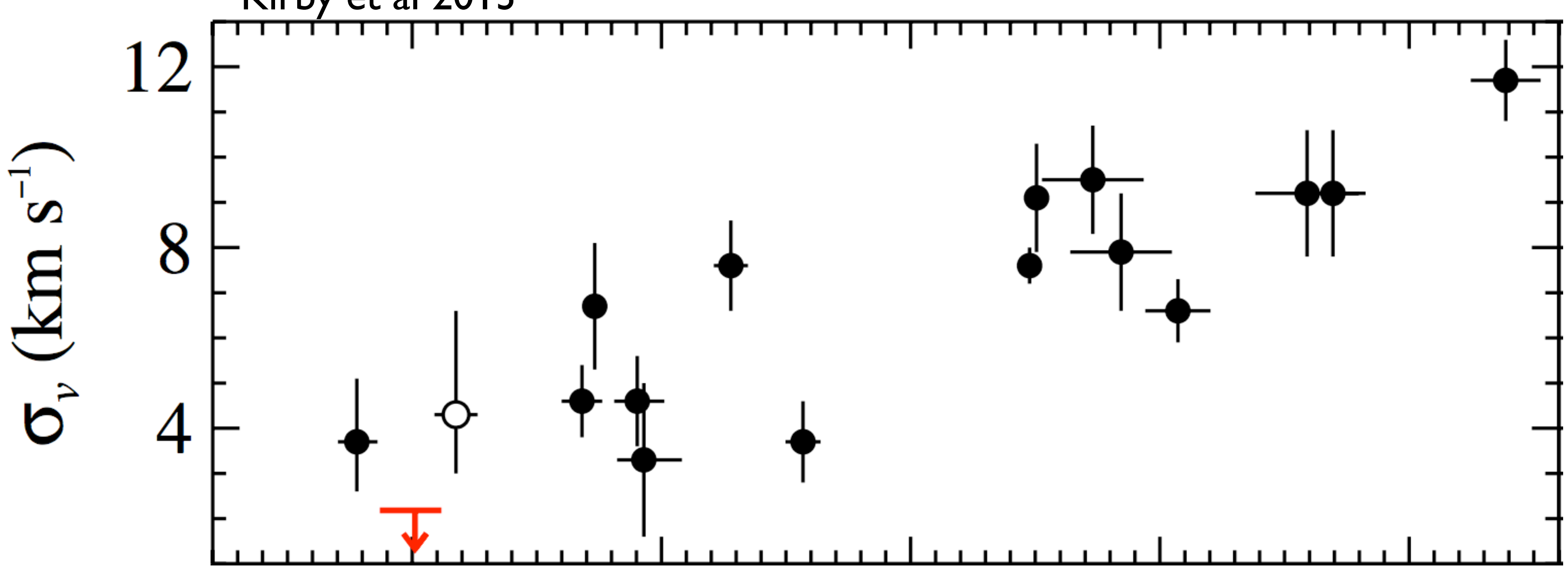


Willman et al 2011



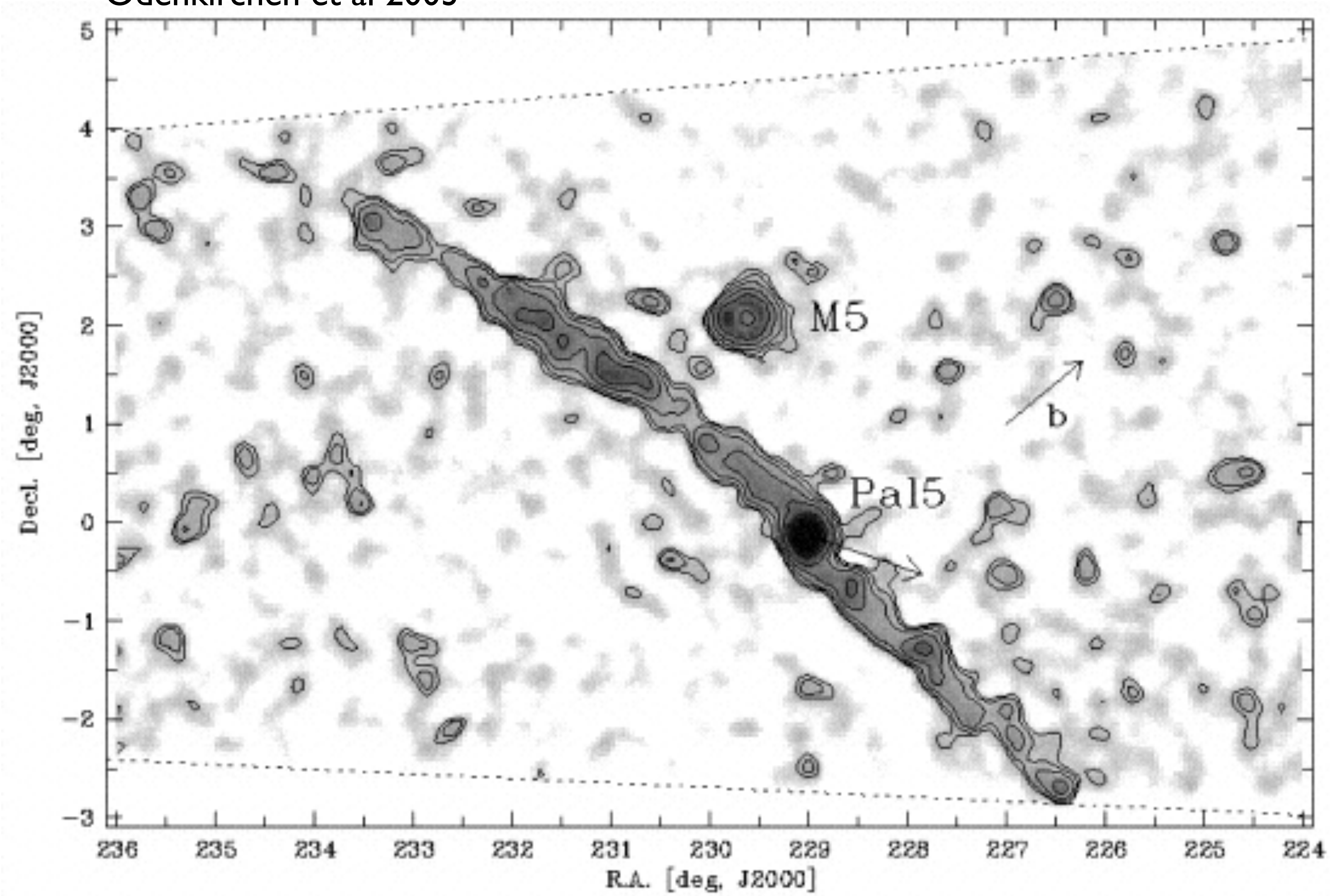
Some objects not in dynamical equilibrium

Kirby et al 2013



In others the sigma is too low to measure

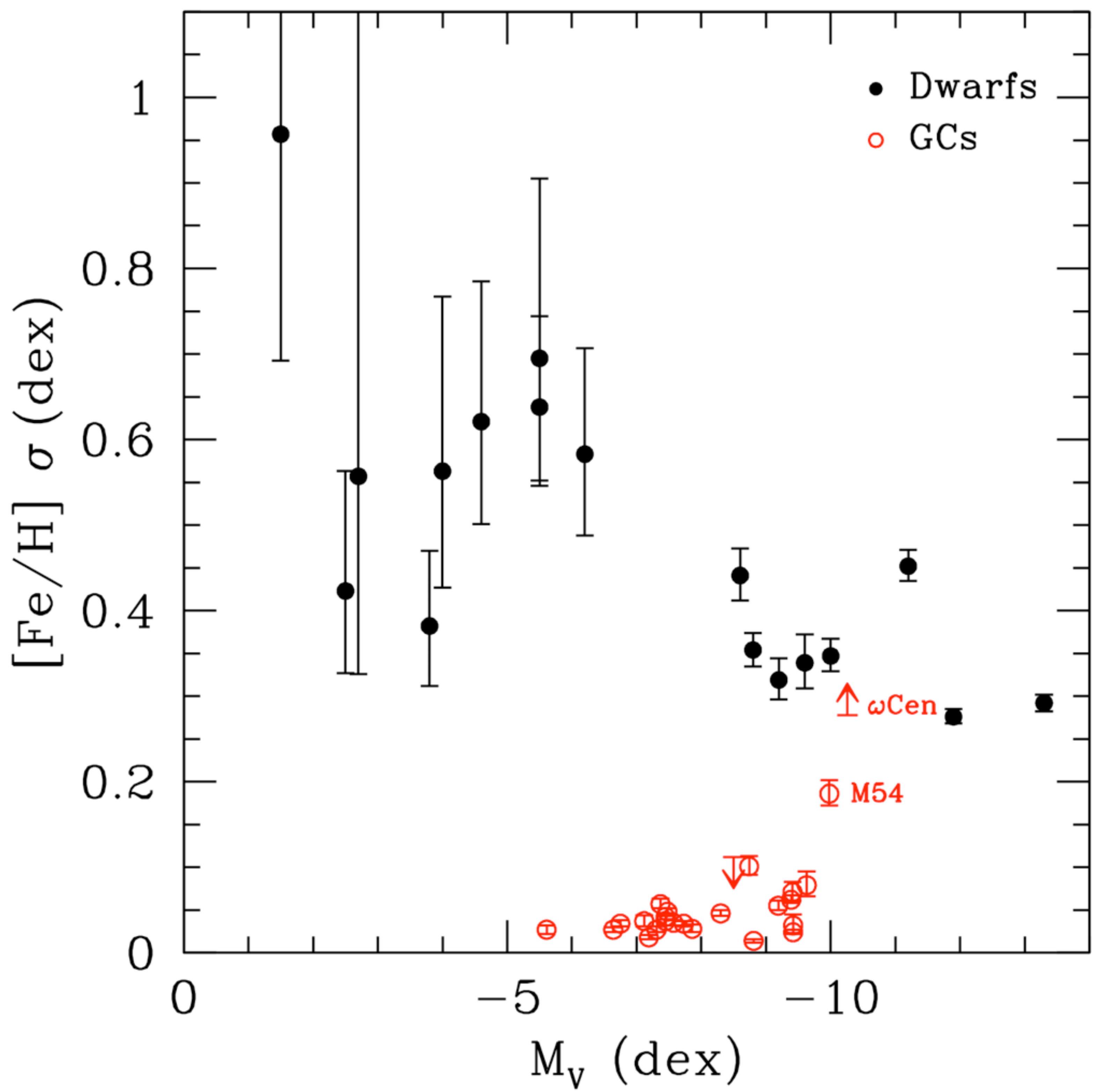
Odenkirchen et al 2003



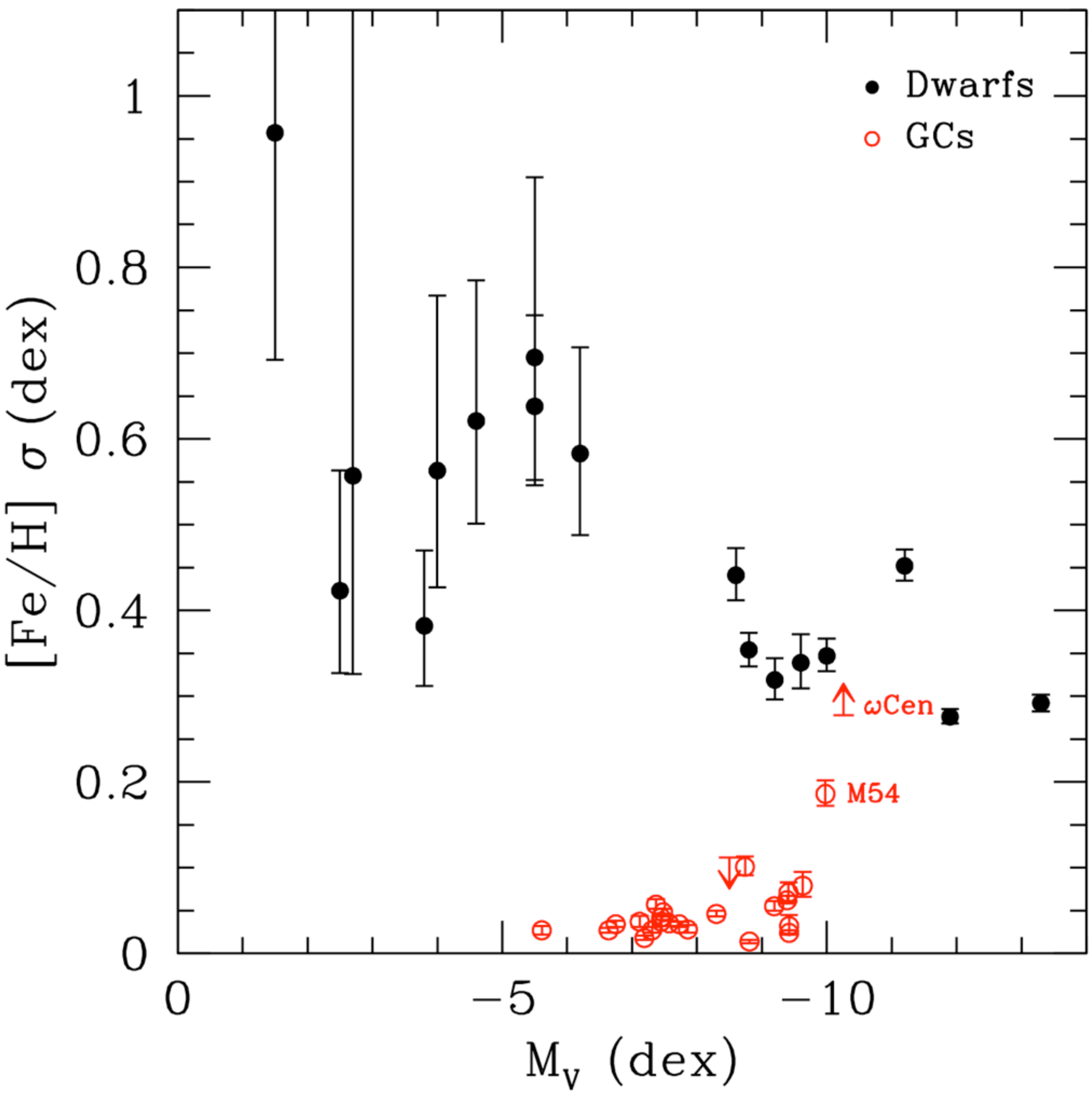
A stream seen projected along the LOS will have an inflated, non-equilibrium sigma

The [Fe/H] spread–magnitude

Willman & Strader 2012

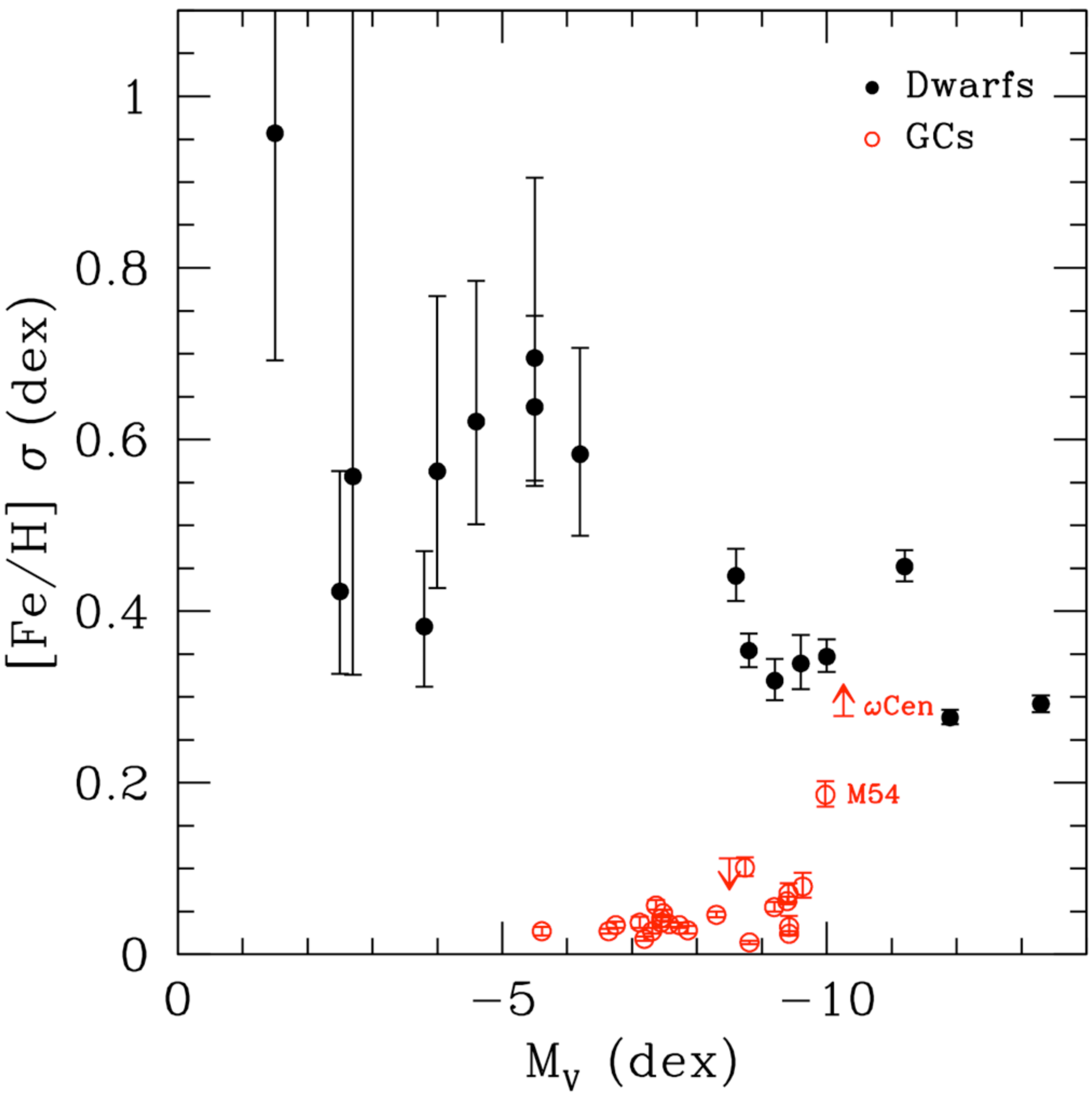


Willman & Strader 2012



works well where things are hard: the lowest mass objects

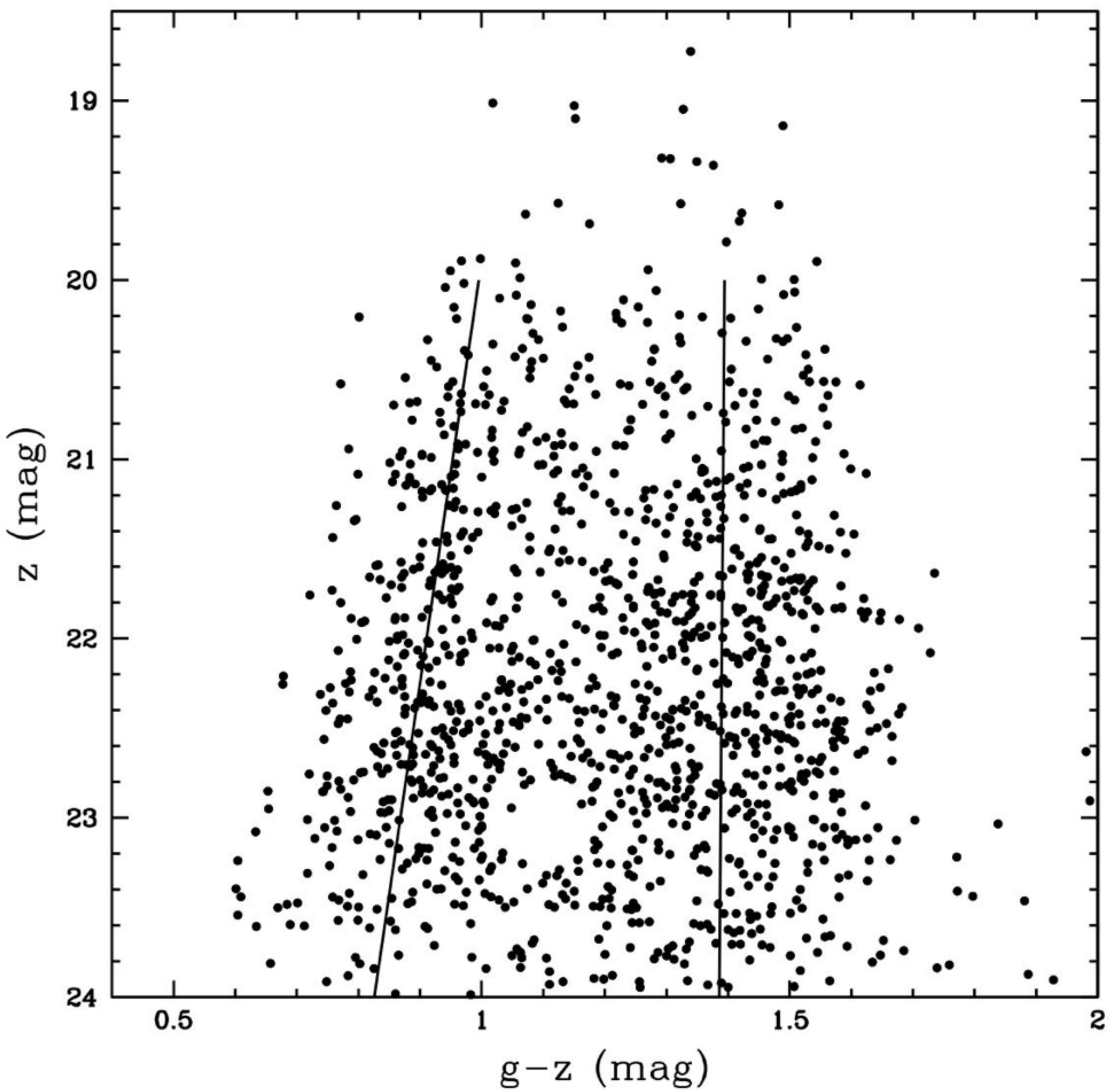
Willman & Strader 2012



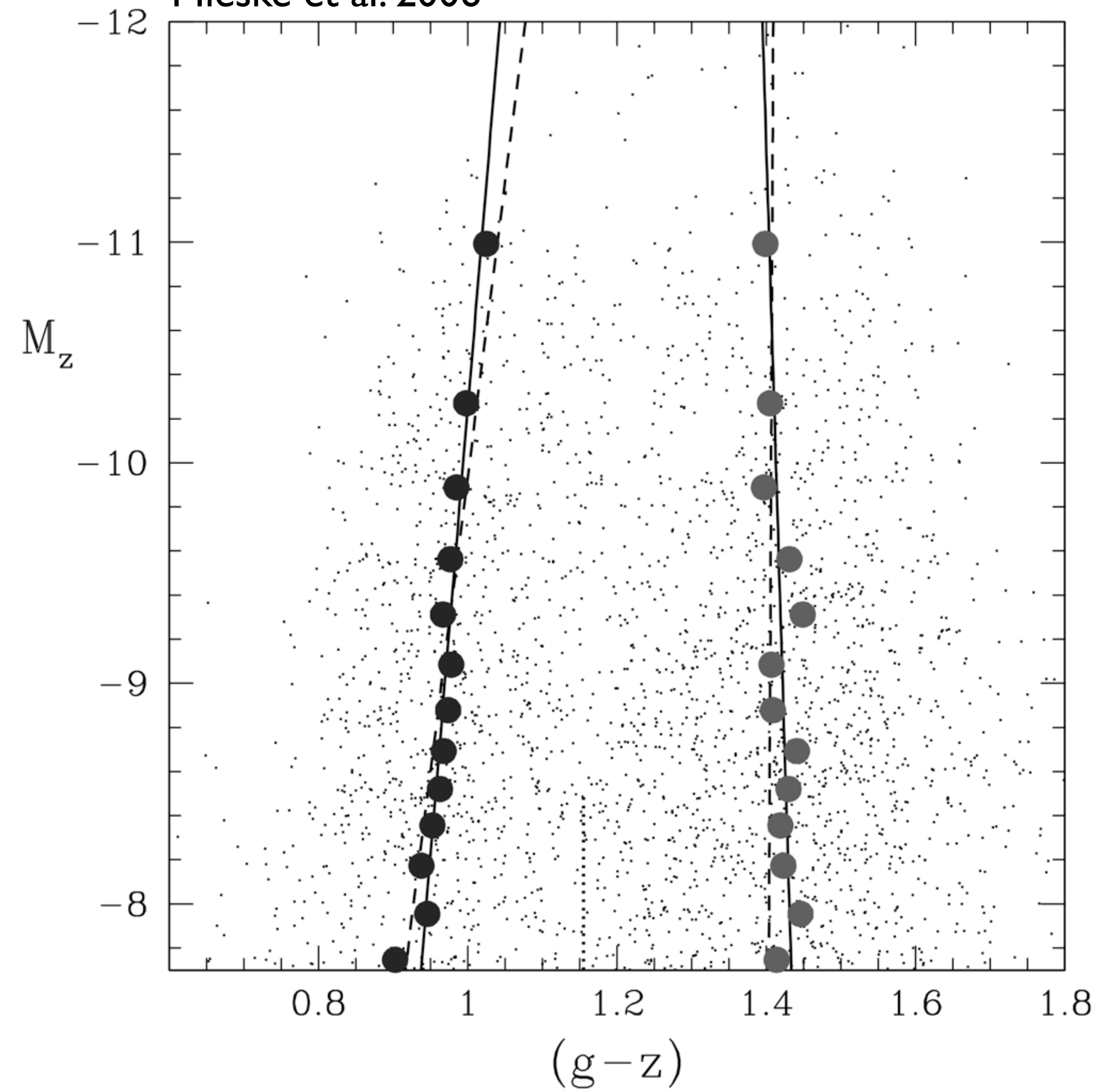
not magical---
does not work
perfectly at all
masses

It appears that
most stellar
systems above a
million solar
masses want to
self-enrich in Fe

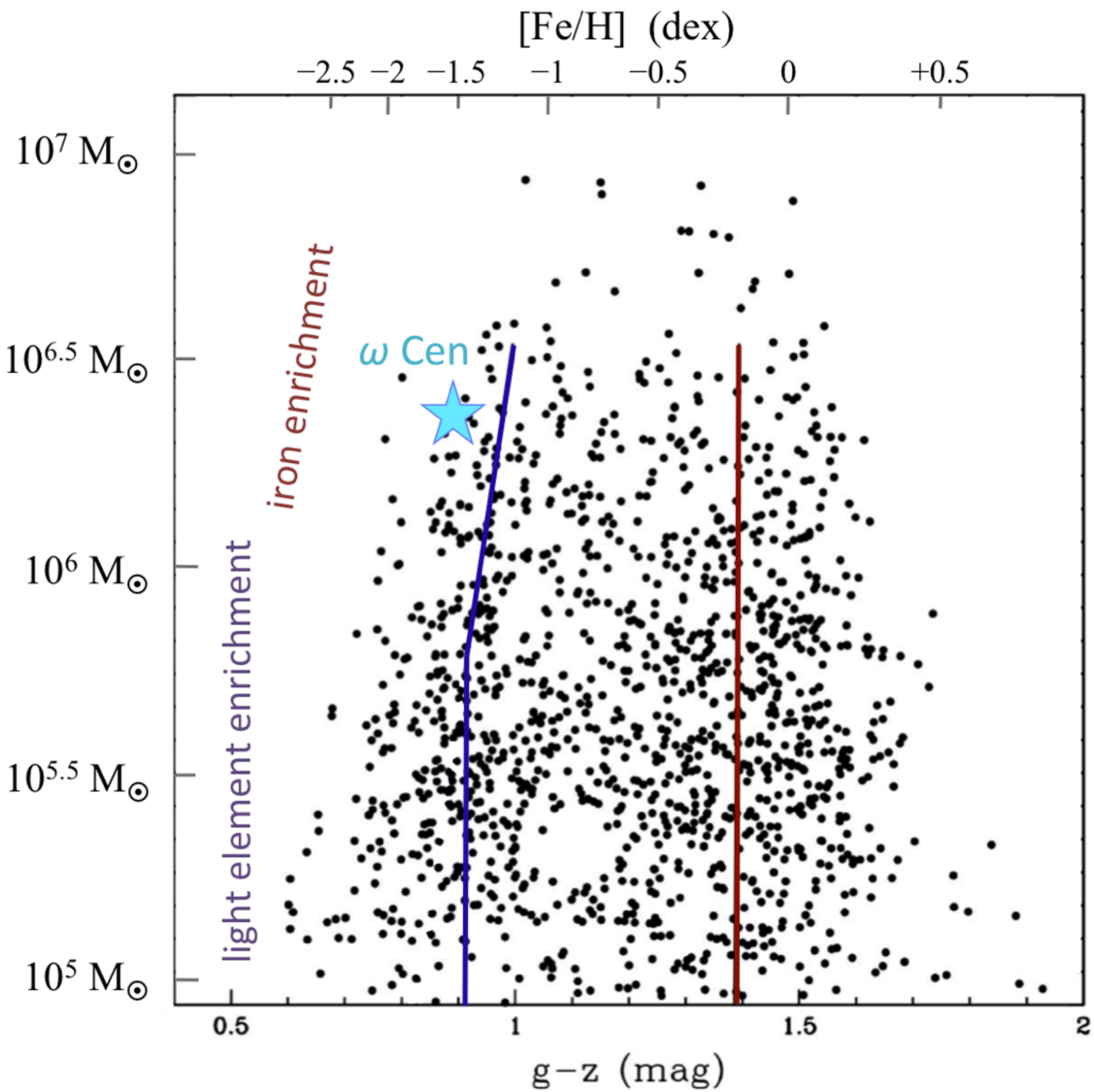
Strader et al. 2006



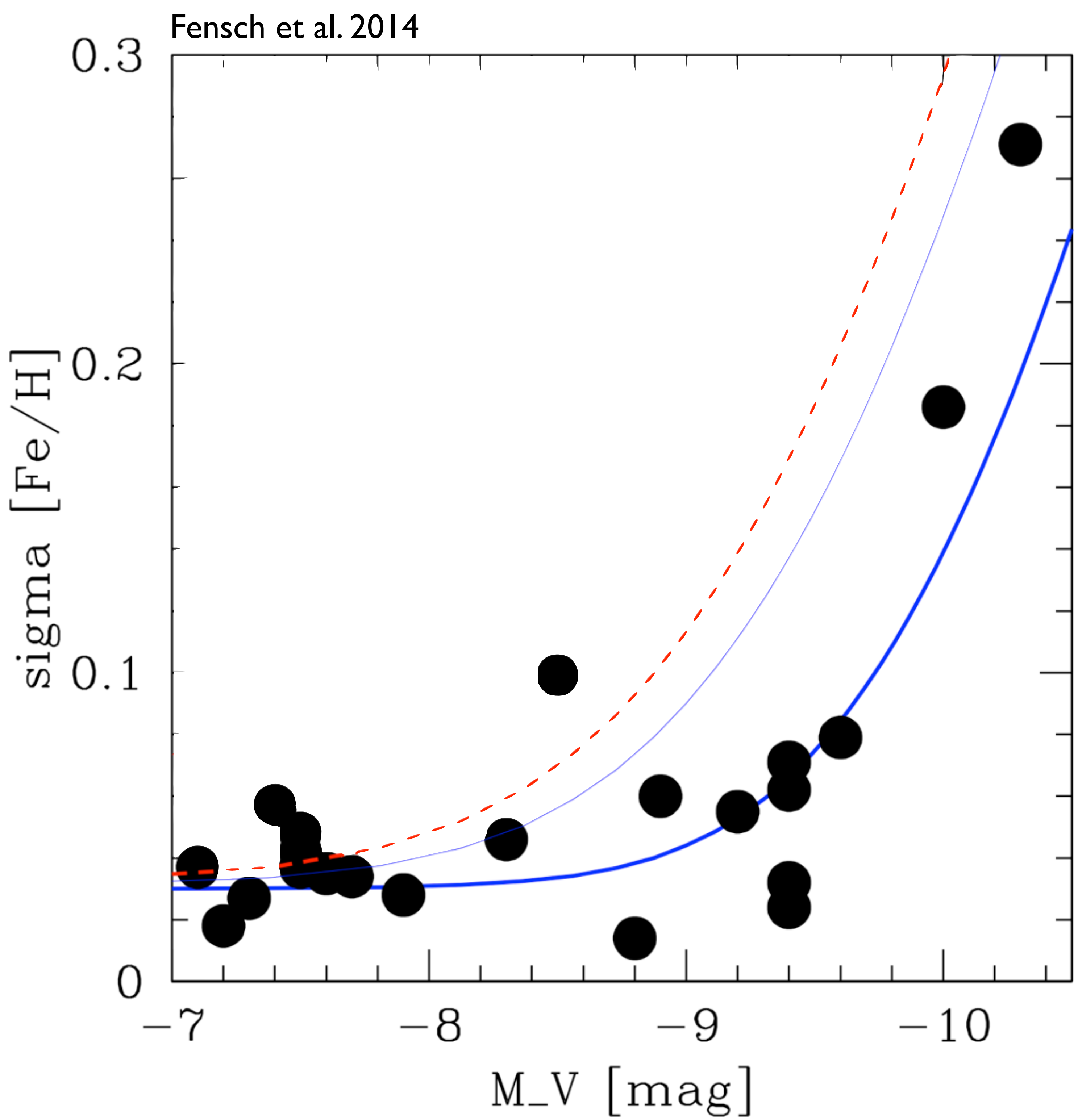
Mieske et al. 2006



“Blue tilt”: mean color of massive metal-poor GCs correlates with mass



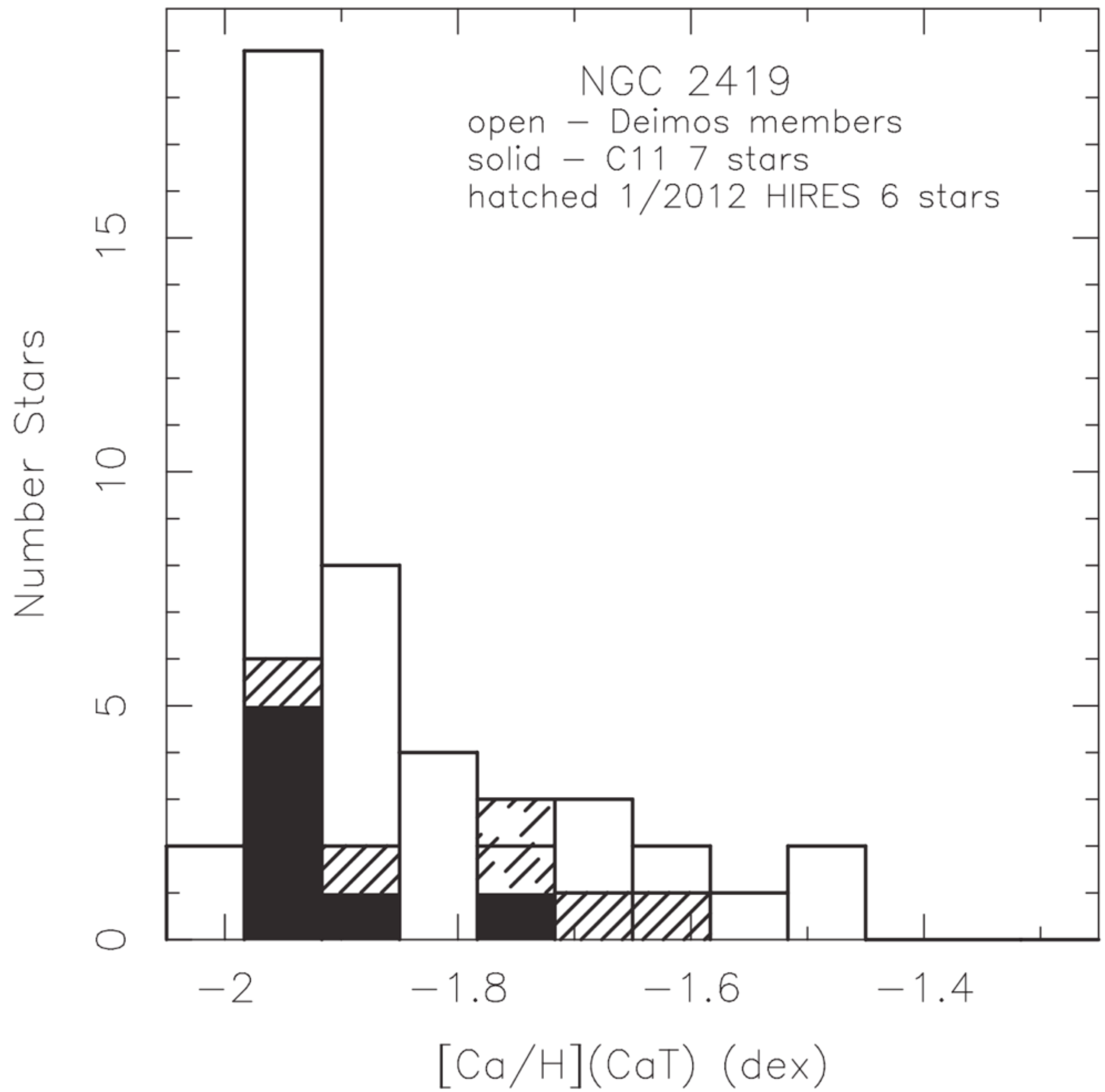
[Fe/H] (dex)
−2.5 −2 −1.5 −1 −0.5 0 +0.5
10^7 M⊙
10^6.5 M⊙
10^6 M⊙
10^5.5 M⊙
10^5 M⊙
iron enrichment
light element enrichment
ω Cen
0.5 1 1.5 2
g−z (mag)



Massive MW GCs consistent with self-enrichment in Fe

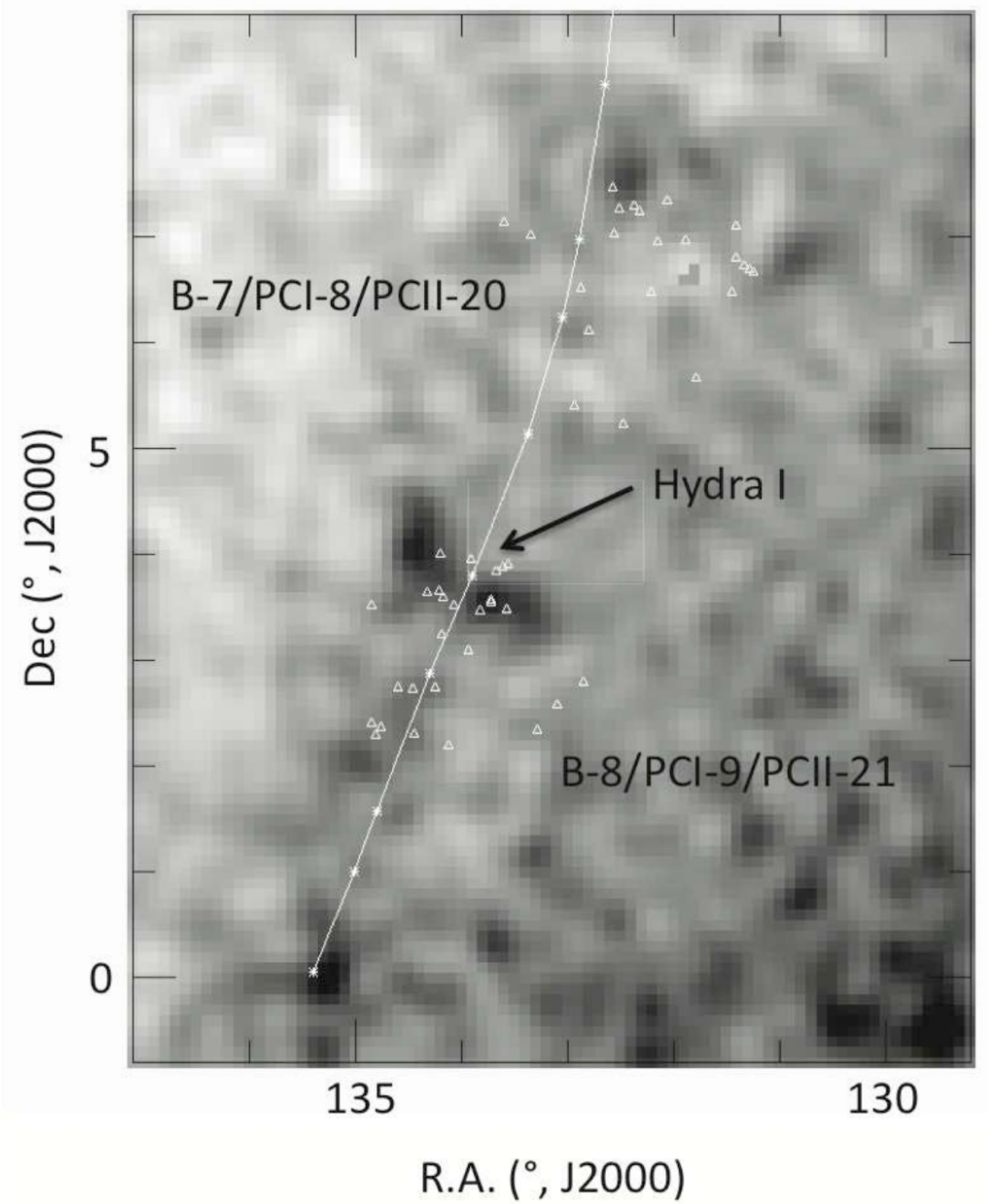
Some might well be nuclei, but an [Fe/H] spread alone does not represent compelling evidence for a nuclear origin

Cohen & Kirby 2012



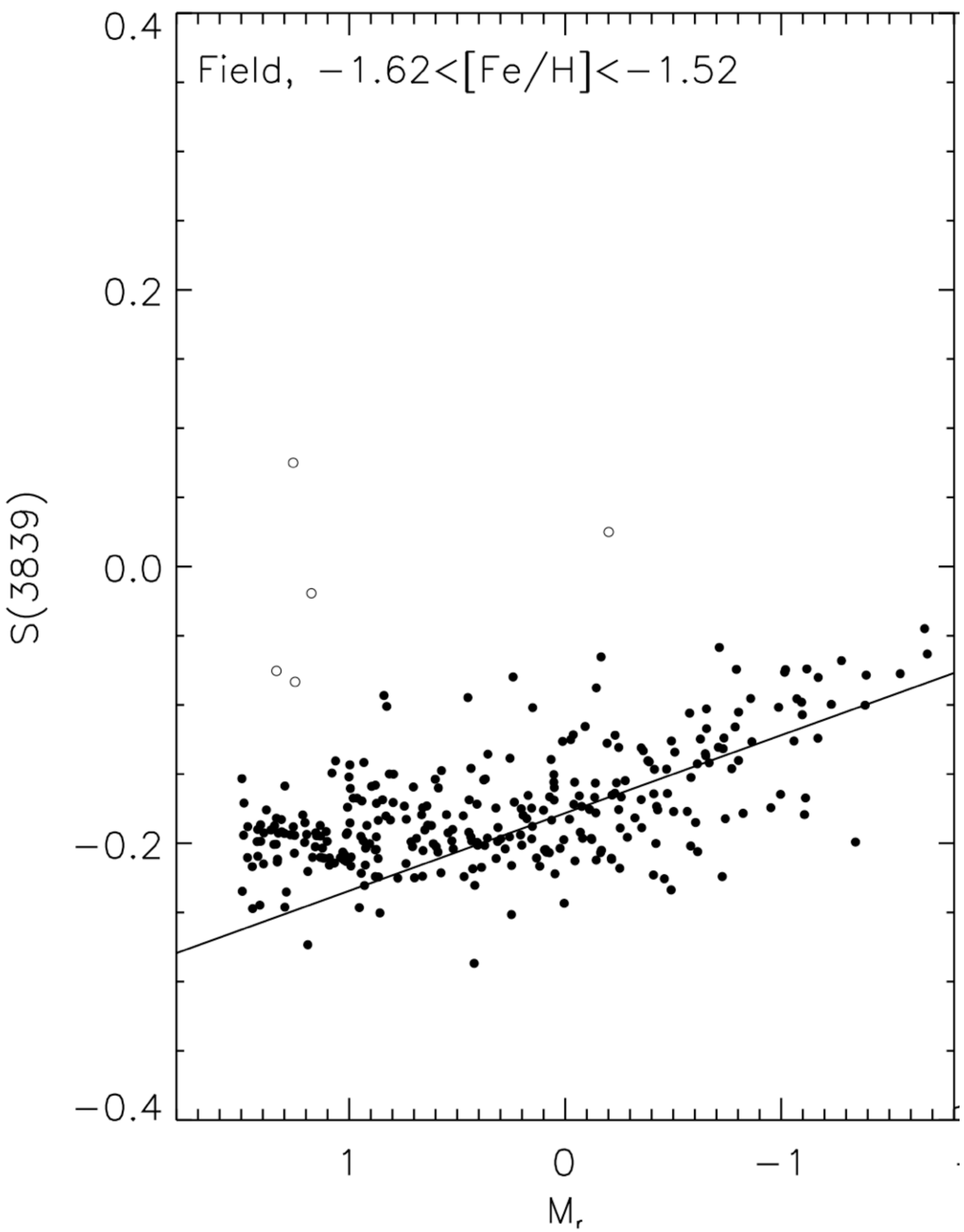
NGC 2419 has a spread in Ca, but not Fe

Grillmair 2011



Many streams/clumps may be hard to separate from field stars via kinematics or [Fe/H]

Martell & Grebel 2010



Can "cheaply" look for CN-strong stars common in GCs

Have to be careful due to stellar evolution effects: looking for stars with strong Na and Al is safer, but takes medium to high-res spectra

No one has yet demonstrated the ability to accurately measure metallicity spreads at the lowest [Fe/H] values for very faint main sequence stars (V>24) from photometry

It would be extremely helpful to either do this, or prove that it can't efficiently be done

LG dwarfs have traditionally been named after constellations

Globular clusters have been named after everything (constellations, catalogs, surveys, people...)

This naming scheme is terrible, but as a field we haven't agreed on anything better

LG dwarfs have traditionally been named after constellations

Globular clusters have been named after everything (constellations, catalogs, surveys, people...)

If you are not 99% sure that your object is a LG dwarf, please don't name it after a constellation

At present, determining an [Fe/H] spread---which can be done with as few as ~3 stars---appears to be the most robust way to classify the faintest MW satellites

An [Fe/H] spread for a dense stellar cluster does not imply it is a stripped nucleus

Let’s see how things improve with new dwarfs and spectroscopic data!