

# **The variable star population in the Sextans dwarf spheroidal galaxy**

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**In collaboration with**

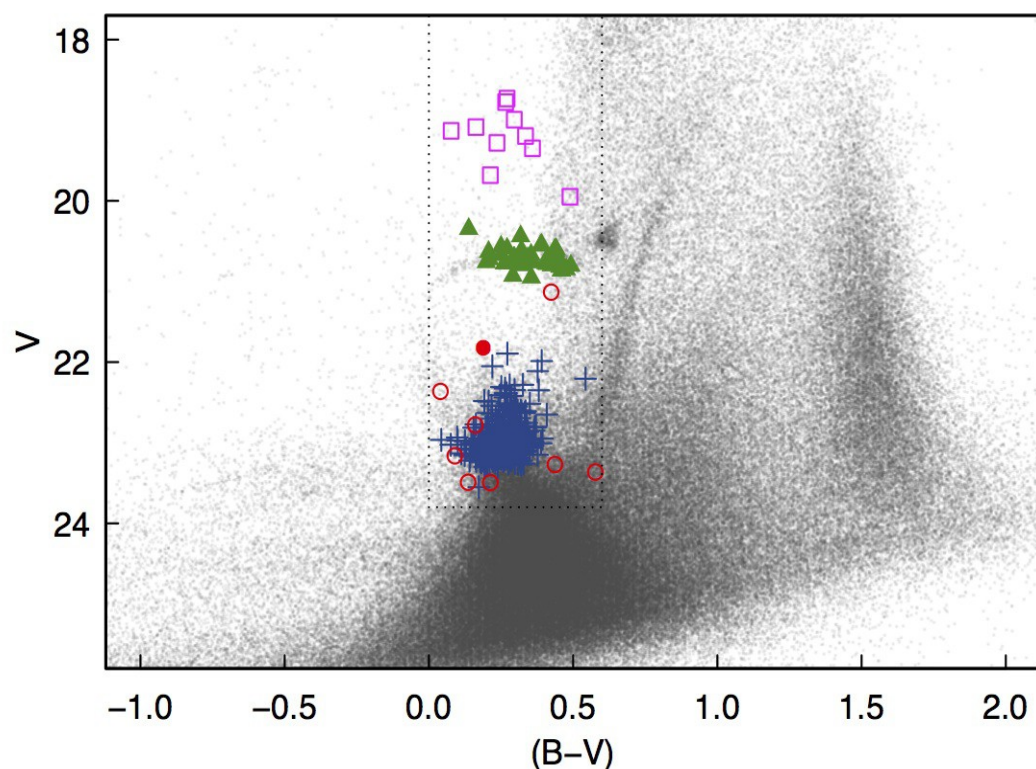
**Javier Alonso-García (*U. of Antofagasta, Chile*)**

**Mario Mateo (*U. of Michigan, USA*)**

**Alistair Walker (*CTIO, Chile*)**

**David Nidever (*NOAO, USA*)**

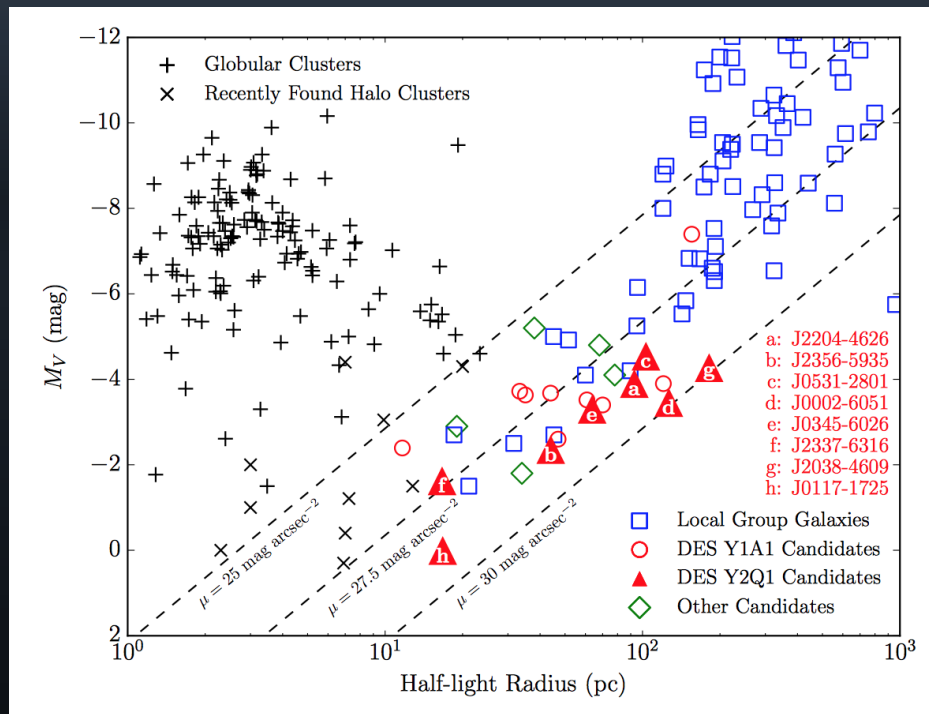
# The Role of Variable Stars



- Tracers of different **stellar populations**
- Standard candles → **Distance Scale**

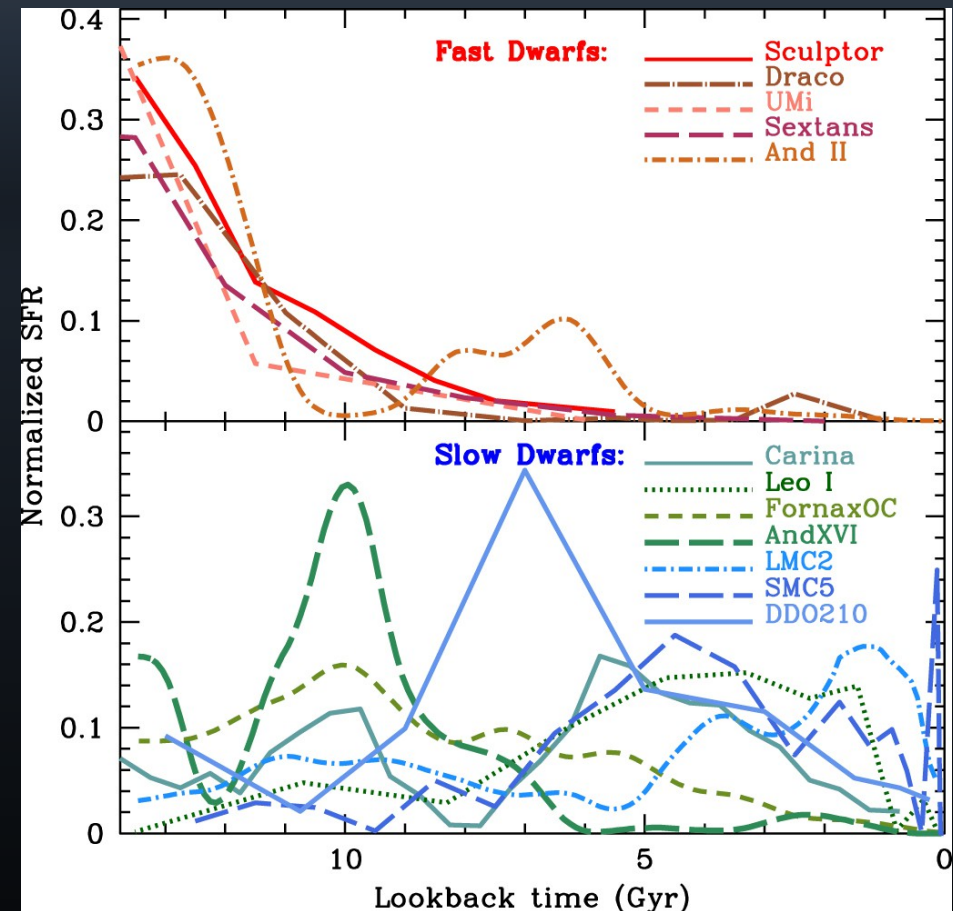
*Variable stars in the Carina dwarf spheroidal galaxy  
(Vivas & Mateo 2013)*

# Properties of the Satellites of the Milky Way



*Drlica-Wagner et al., 2015*

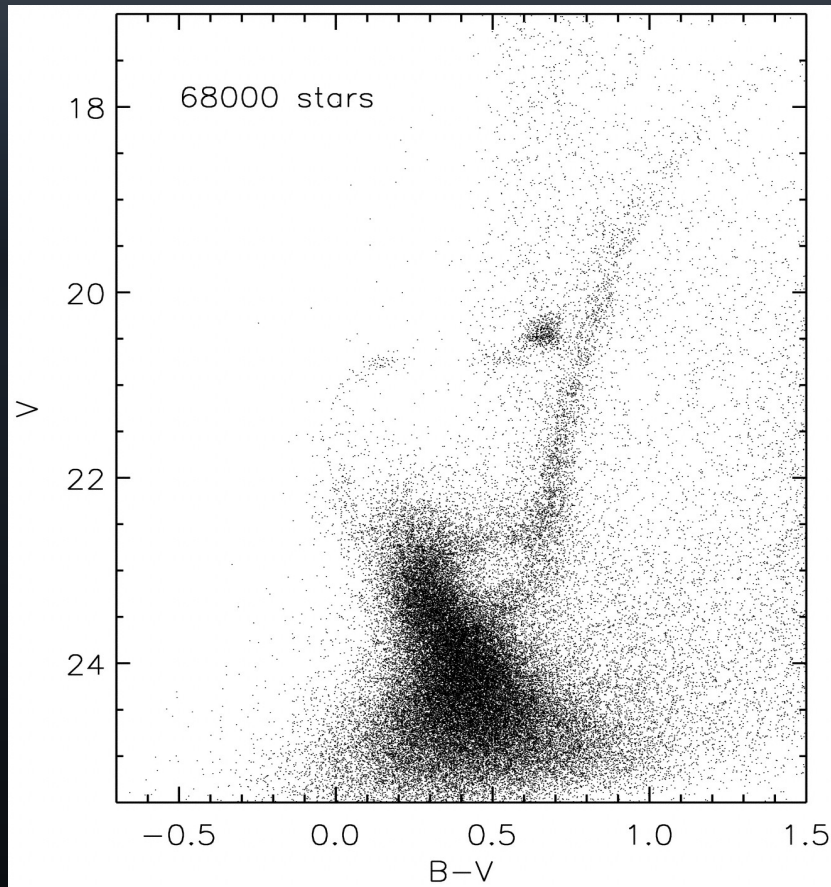
The new discoveries are likely to be ultra-faint dwarf galaxies.



*Gallart et al. 2015*

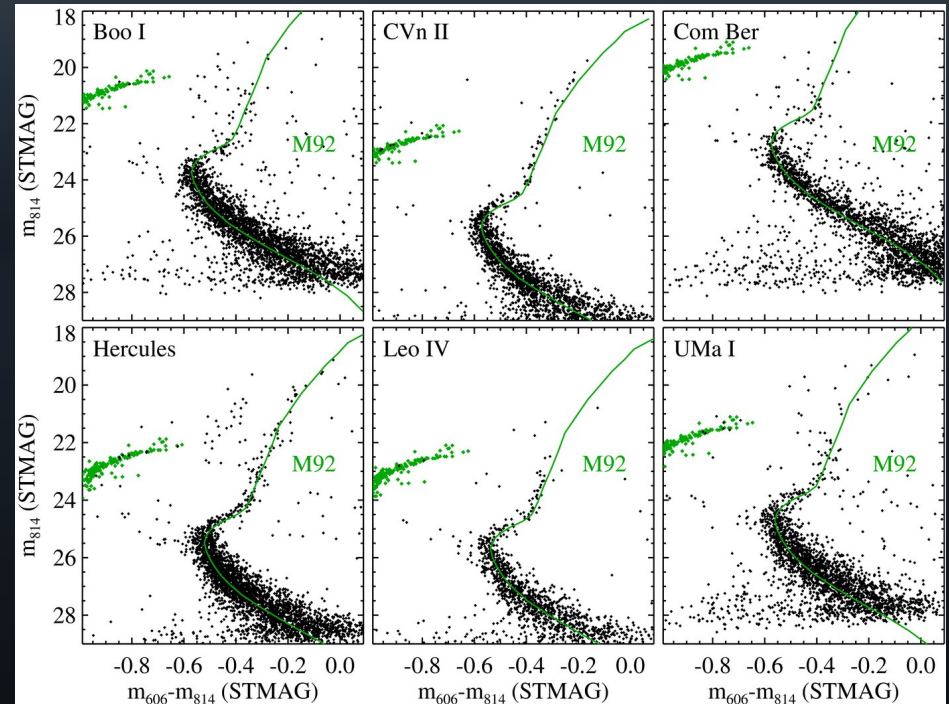
Classical dwarfs display a variety of SFRs

# CMDs of Satellite Dwarfs



*Monelli et al 2003*

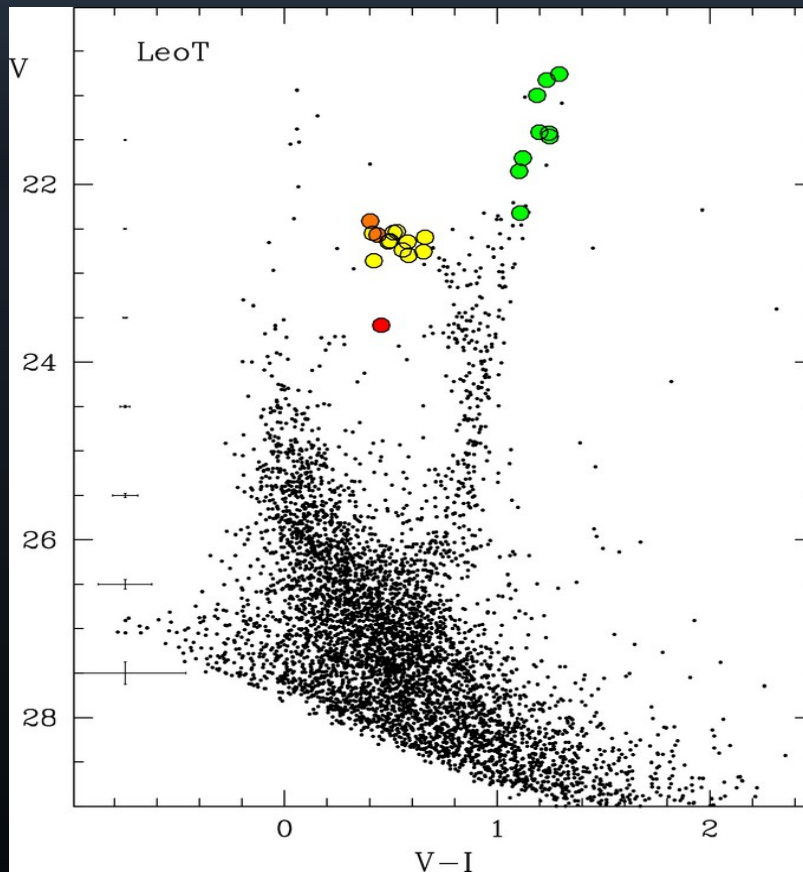
Galaxies like Carina show obvious signs of multiple bursts of star formation



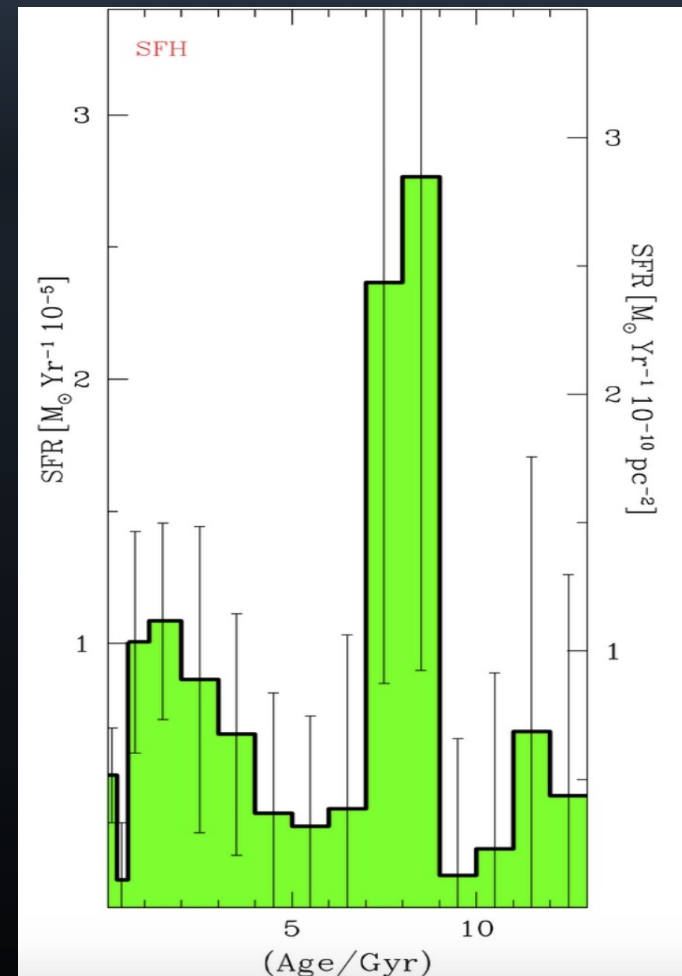
*Brown et al 2014*

On the other hand, ultra-faint dwarfs seem to be consistent with only and old population

# Leo T: a UFD with extended star formation

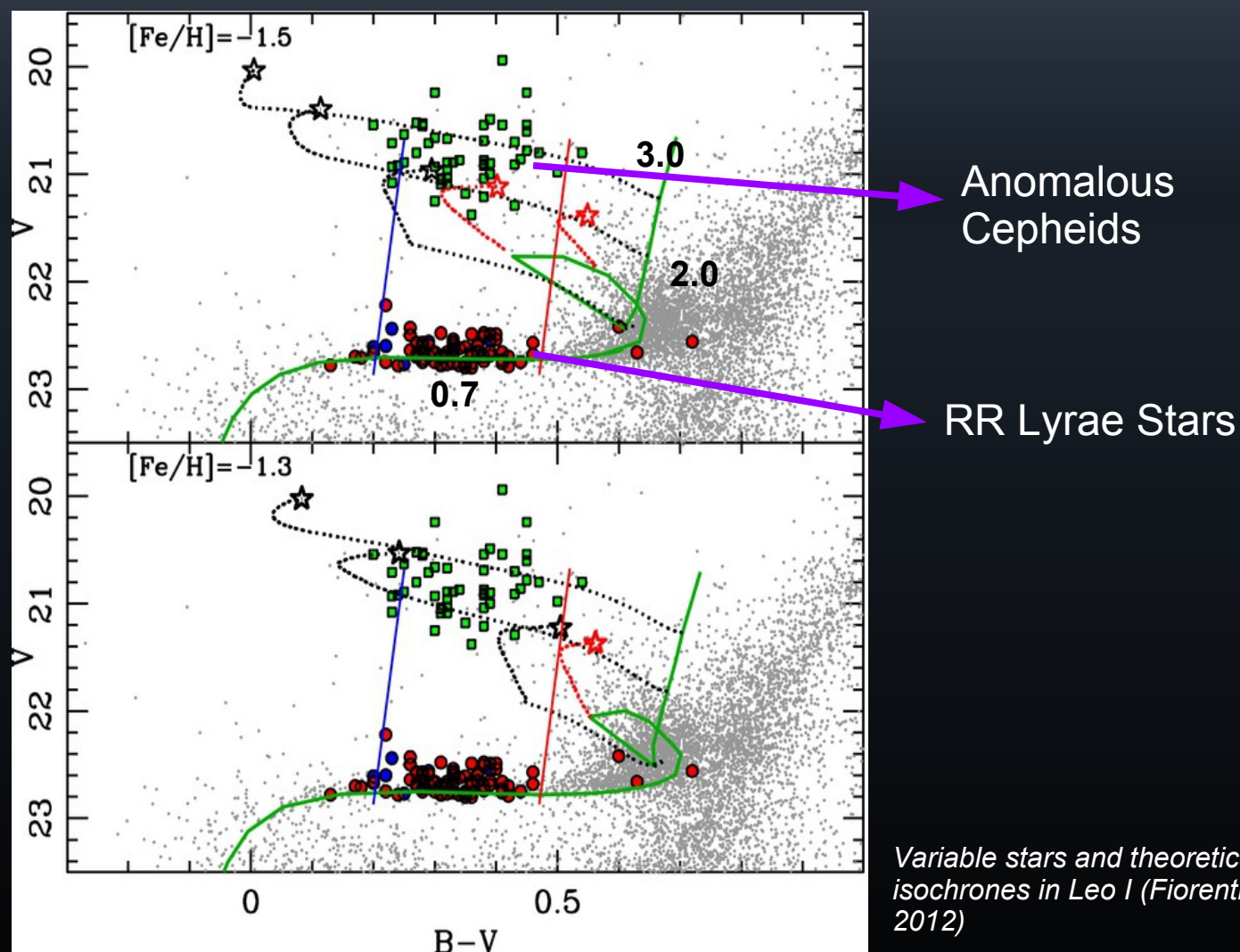


*Clementini et al (2012)*



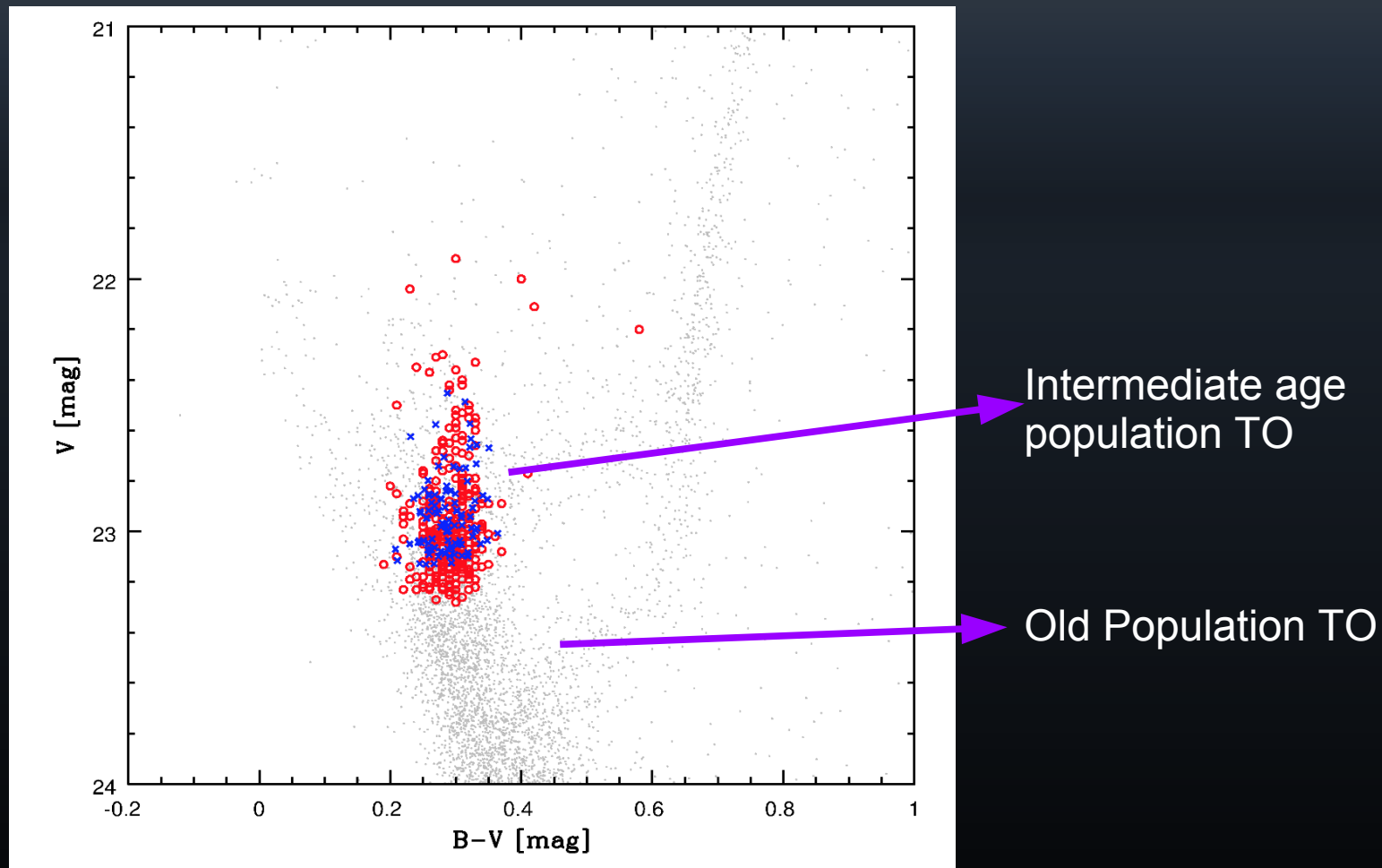


# Helium-Burning Pulsating Stars



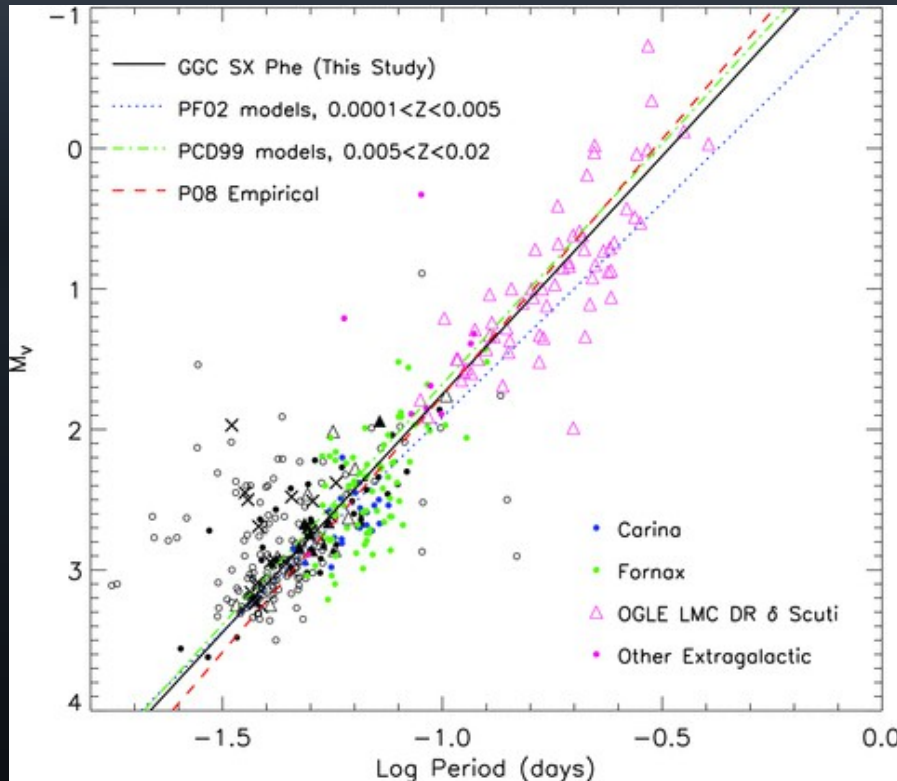
# Dwarf Cepheid Stars

(collective name for  $\delta$  Scuti or SX Phe)



Coppola et al 2015, Vivas & Mateo 2013

# Dwarf Cepheids as distance indicators



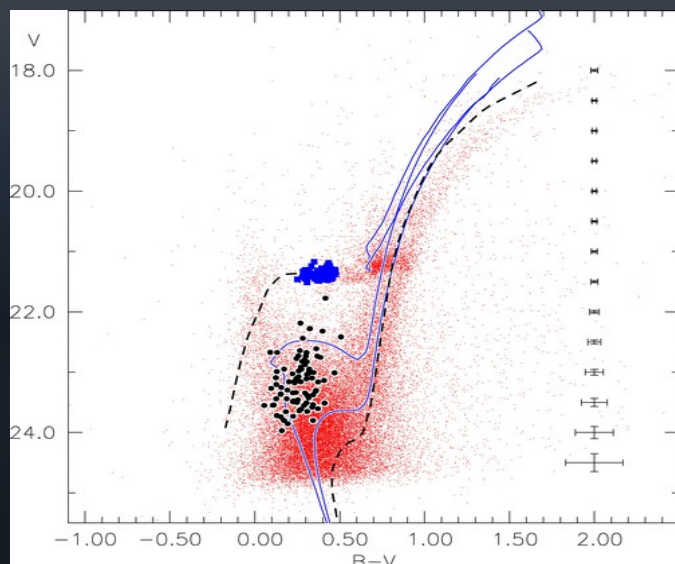
**Need to study more systems!**

*Cohen et al (2012)*

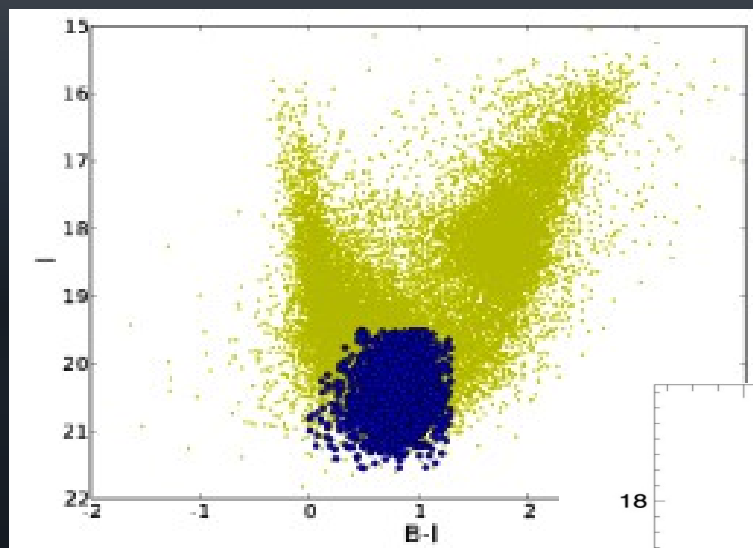
P-L relationship (independent of metallicity) → standard candles



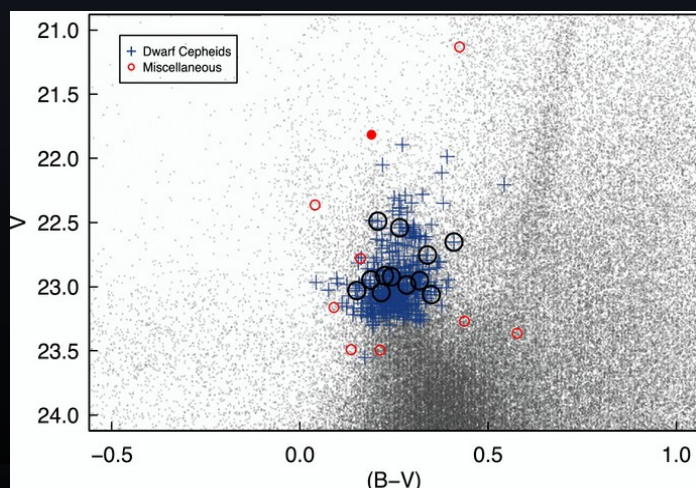
# Dwarf Cepheids in other galaxies



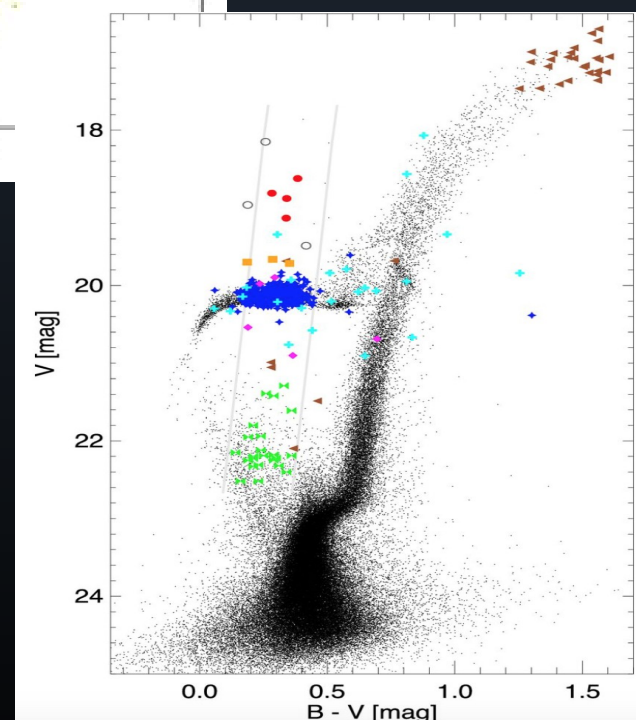
85 dwarf cepheids in Fornax  
(Poretti et al. 2008)



A few thousand in  
the LMC (Garg et  
al. 2010, Poleski  
et al 2010)



340 in Carina  
(Vivas & Mateo  
2013), but there are  
~100 more reported  
in Coppola et al.  
2015.



23 in Sculptor (Martinez-  
Vazquez et al 2016)

# The challenge of observing dwarf cepheid stars

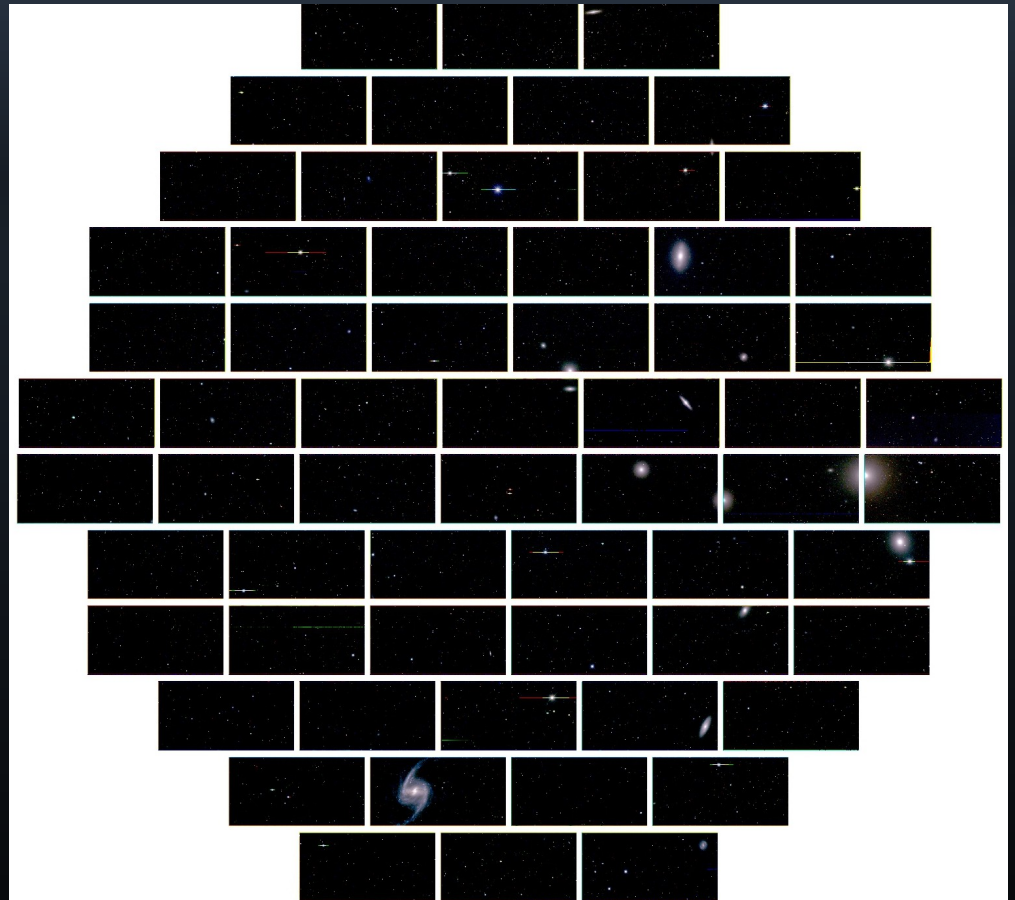
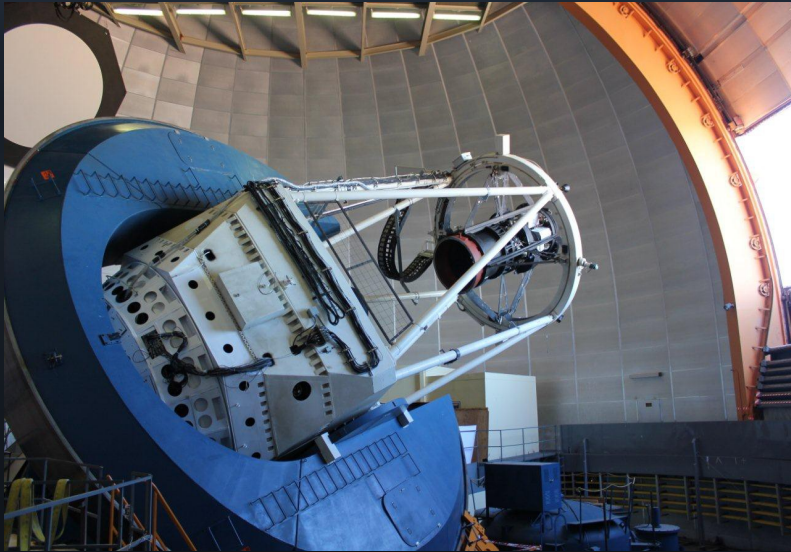
- Faint (2-3 mags below HB)
- Periods are short (1-2 hours) → exposure times cannot be long
- Some galaxies are quite extended

# The challenge of observing dwarf cepheid stars

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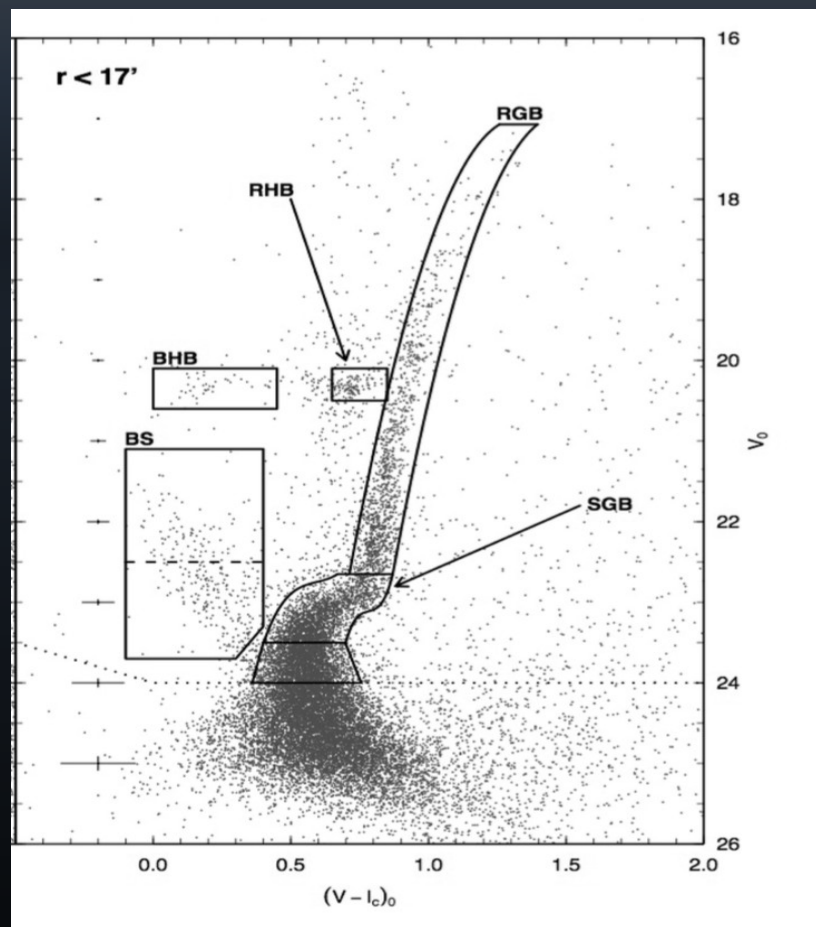
# DECam

# The Dark Energy Camera (DECam) at the CTIO 4m Blanco Telescope



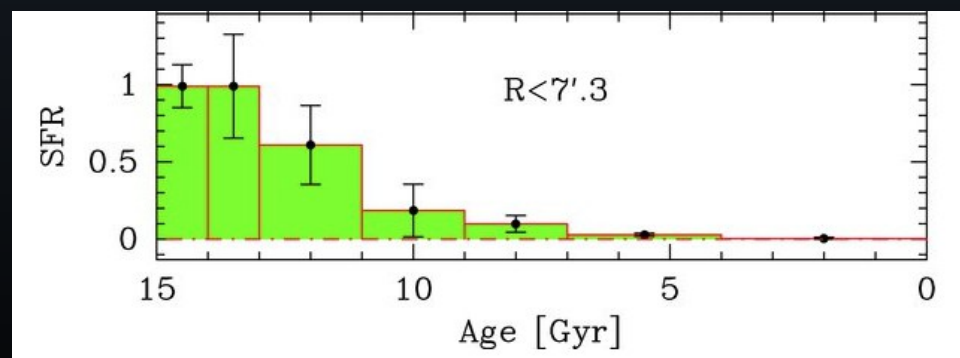
**2.2 deg**

# Sextans Dwarf Spheroidal Galaxy



*Okamoto et al (2017)*

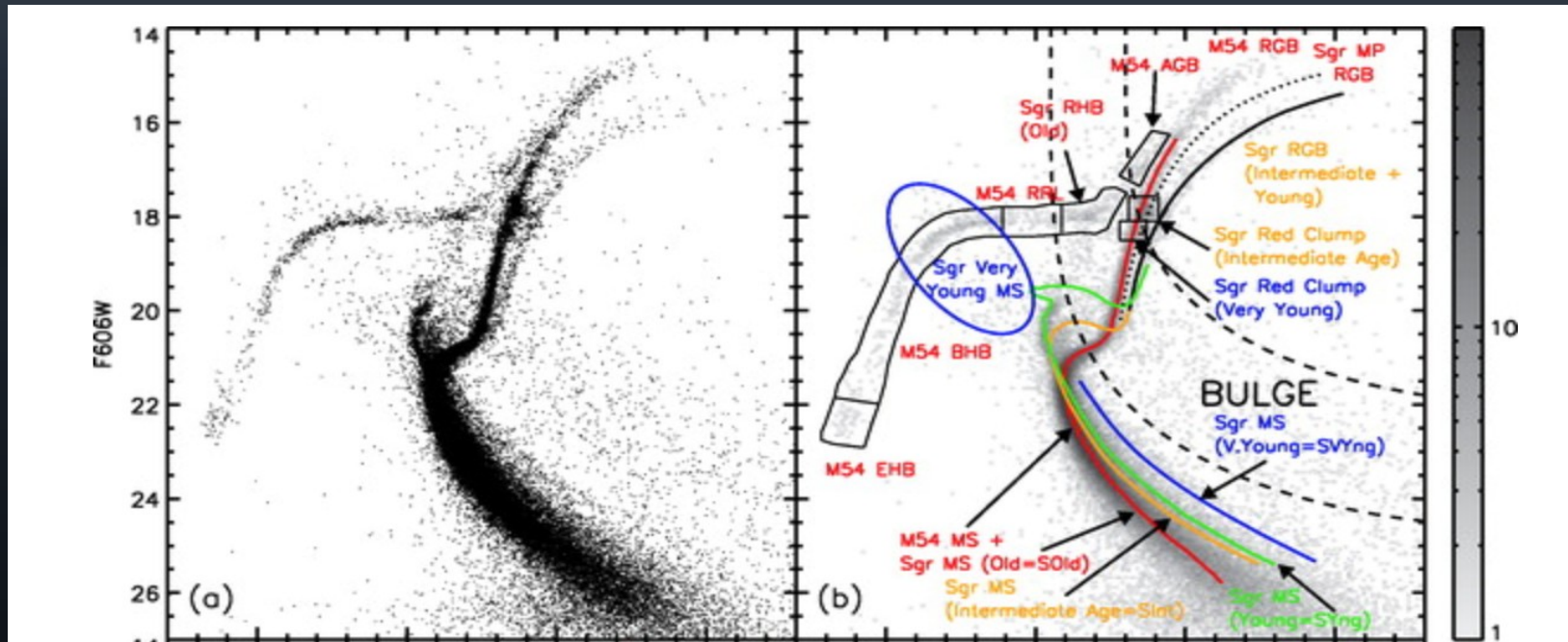
- Mostly old-population, but hints of intermediate age stars
- Blue stragglers
- Large metallicity spread
- Distance  $\sim 90$  kpc



*Lee et al. (2009)*



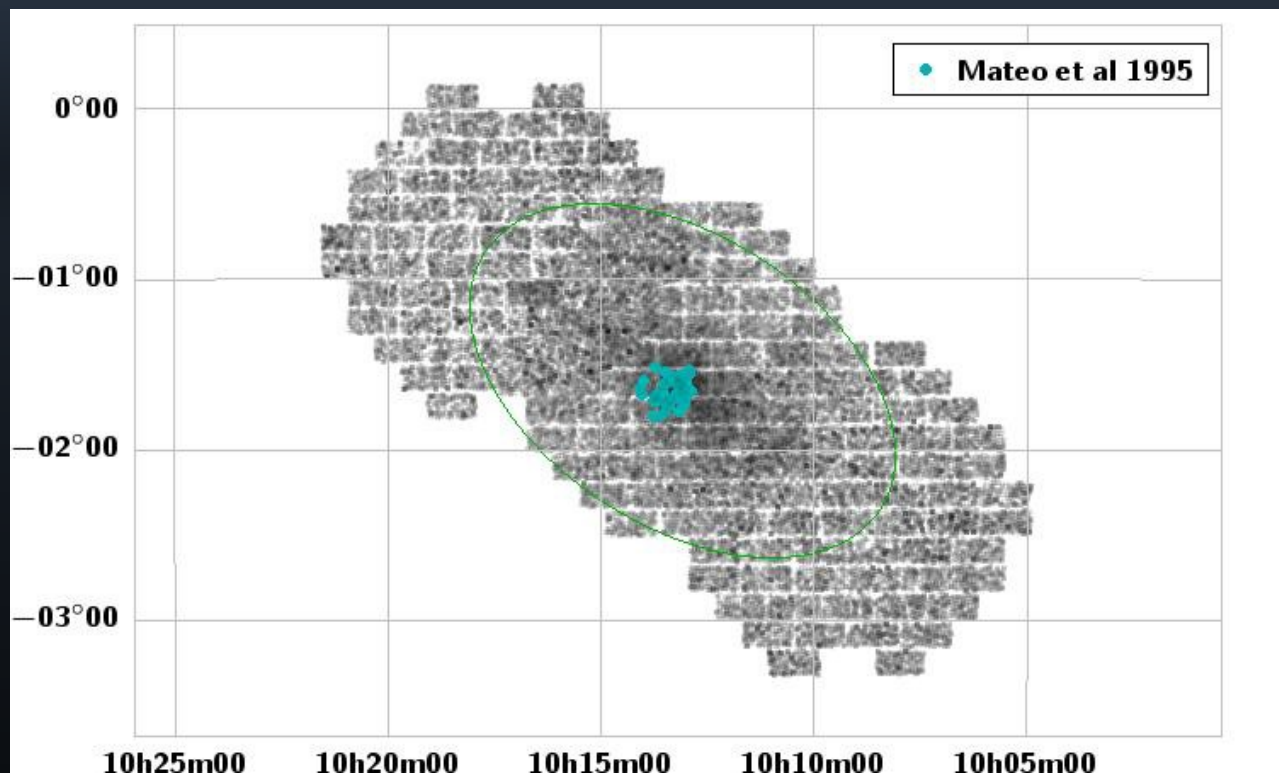
# Sagittarius Dwarf Spheroidal Galaxy



*Siegel et al (2007)*

- Multiple stellar populations, including prominent intermediate-age pop
- Distance ~24 kpc

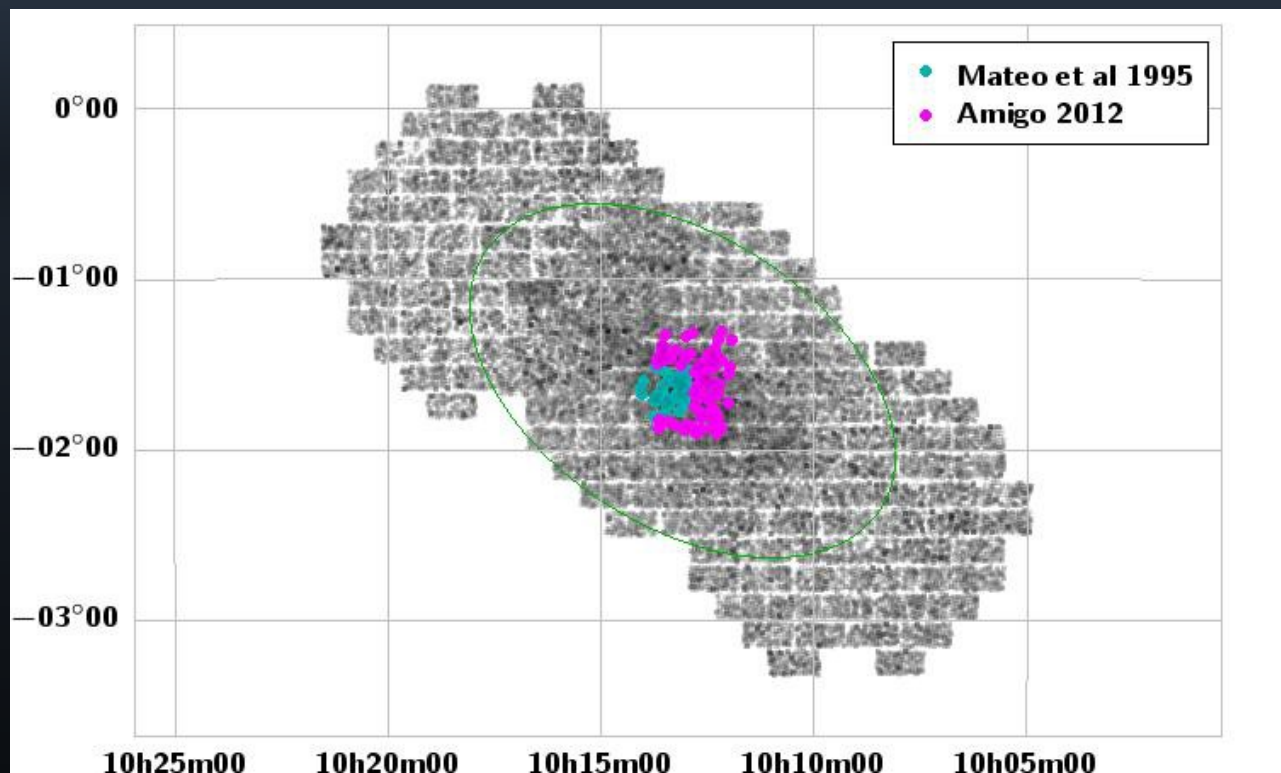
# Observations



*Tidal radius = 83.2  
arcmin (Roderick  
et al 2017)*

Time series in g and r (~30 epochs/band, with a cadence of ~10 minutes). Central field has multi-epoch data only in g

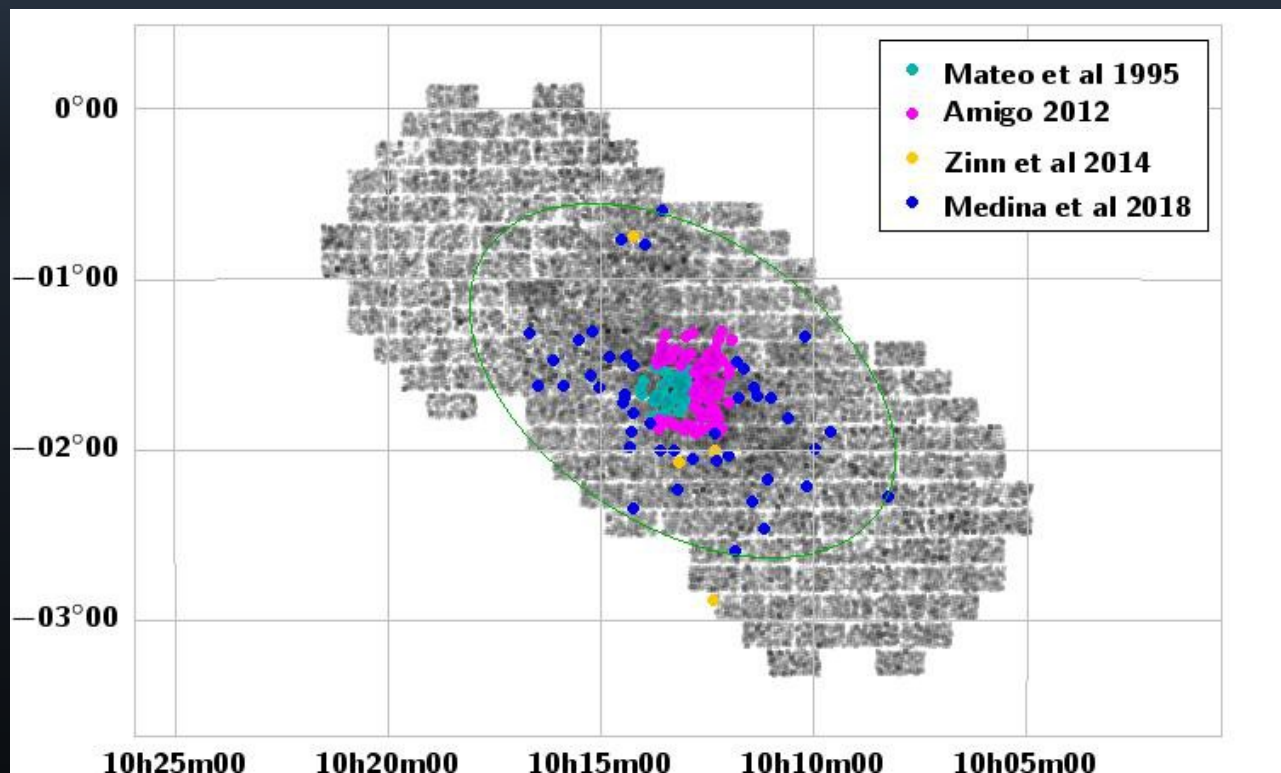
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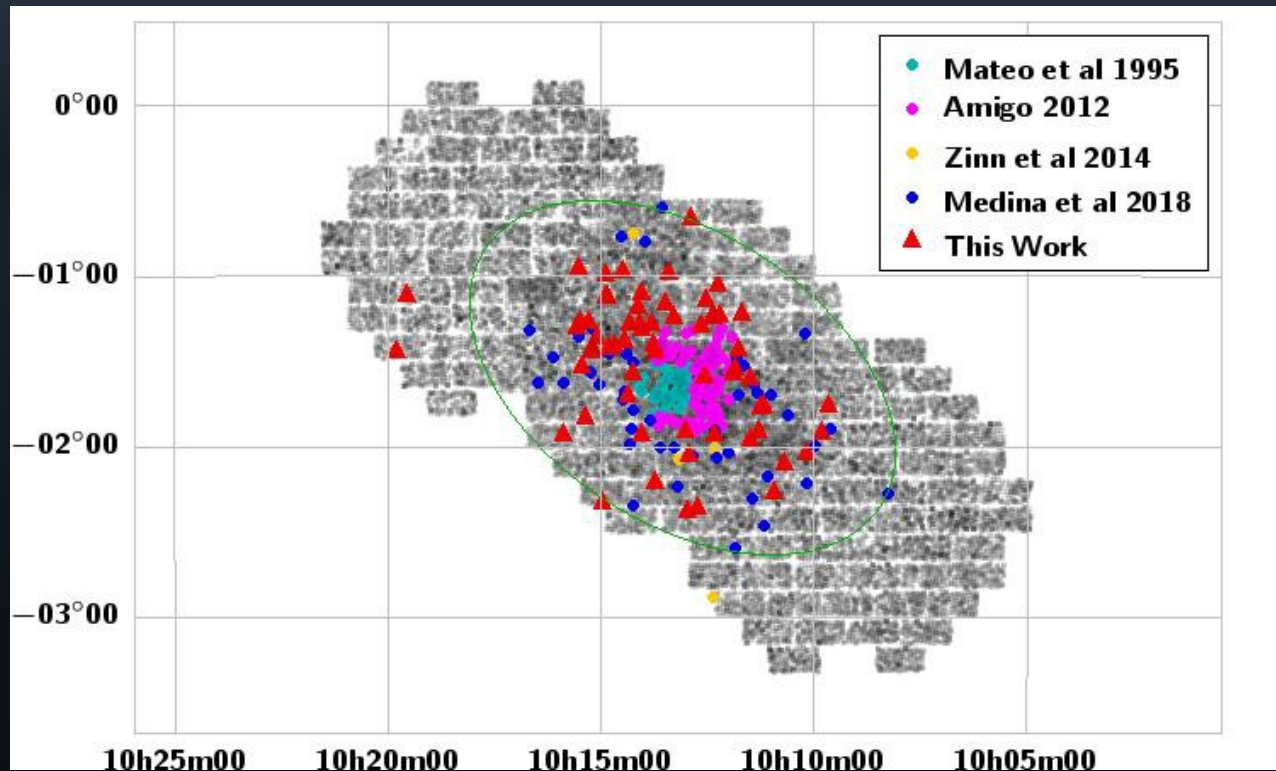
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Time series in g and r (~30 epochs/band, with a cadence of ~10 minutes). Central field has multi-epoch data only in g

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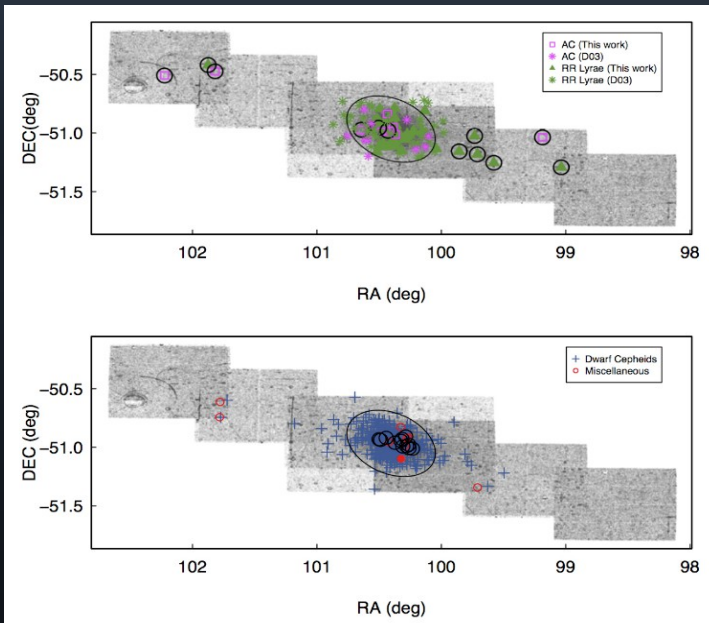


*Tidal radius = 83.2 arcmin (Roderick et al 2017)*

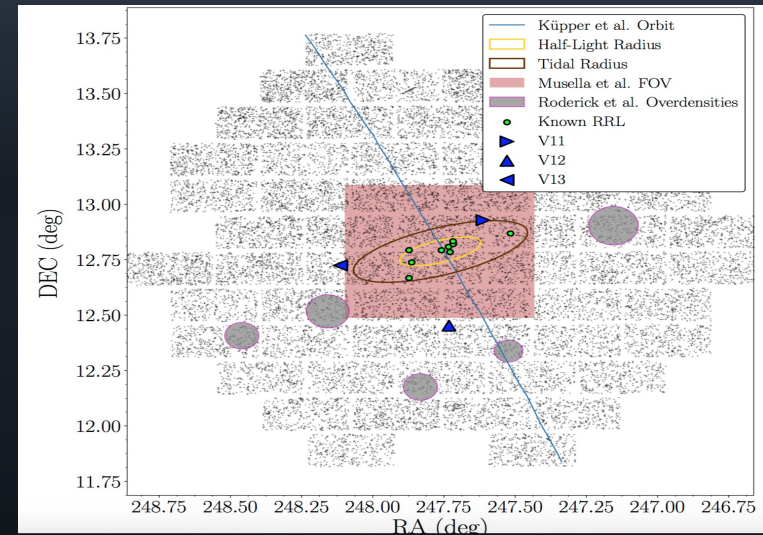
Time series in g and r (~30 epochs/band, with a cadence of ~10 minutes). Central field has multi-epoch data only in g



# Large FoV surveys of variables as tracers of extra-tidal material

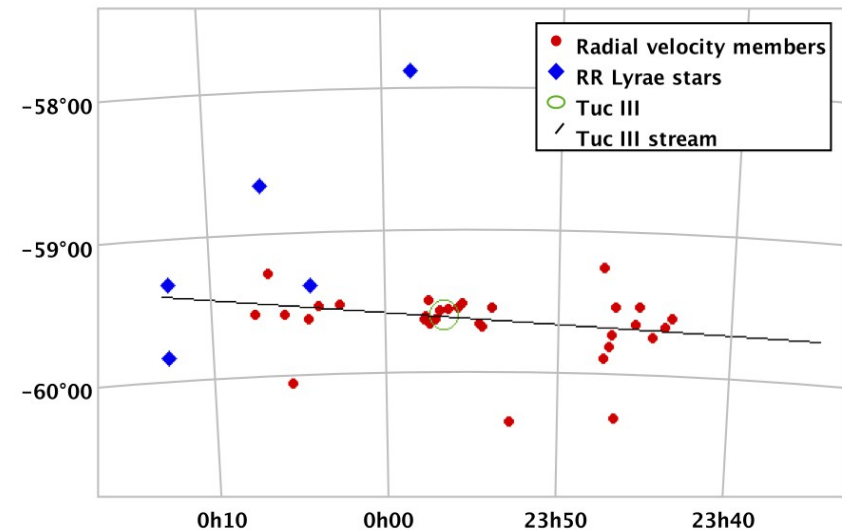


Hercules  
(Garling et al 2018)



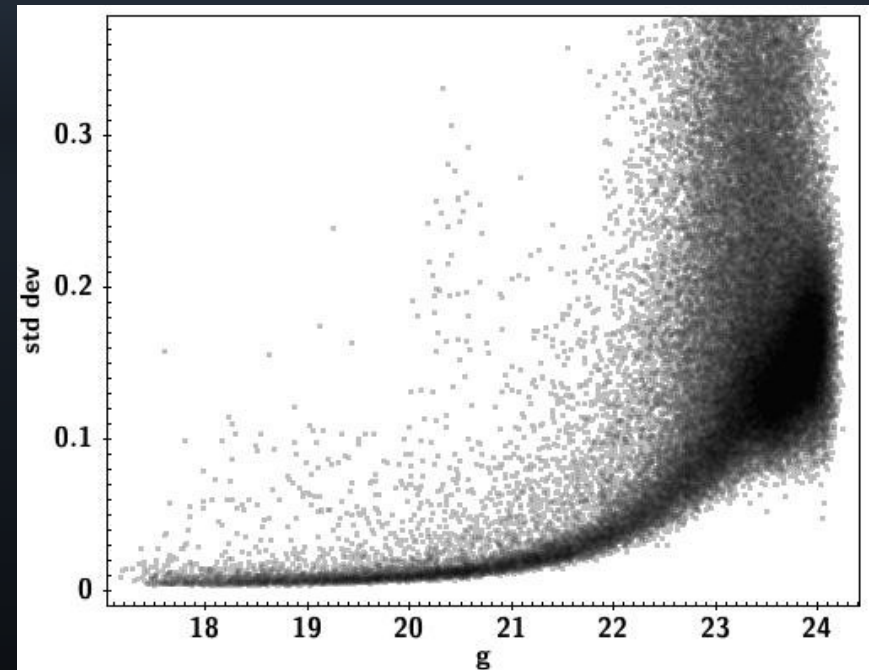
Carina (Vivas & Mateo 2013)

Tucana III (Martinez-Vazquez, Vivas et al, in preparation)

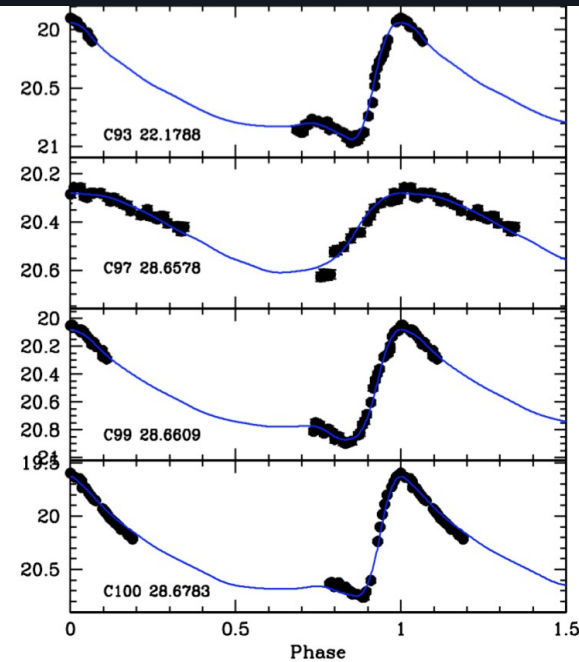
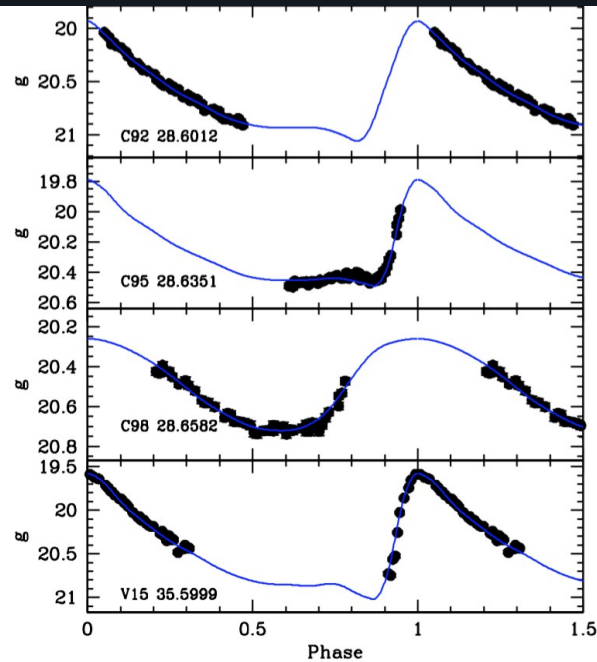
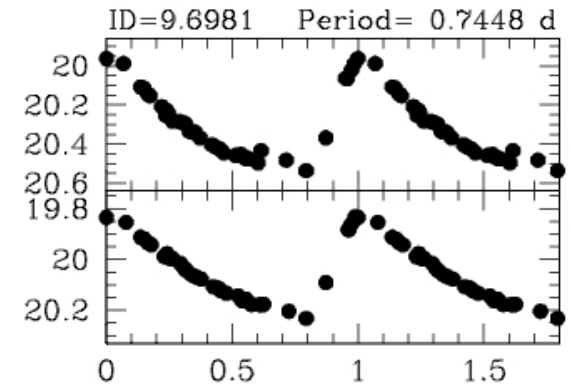
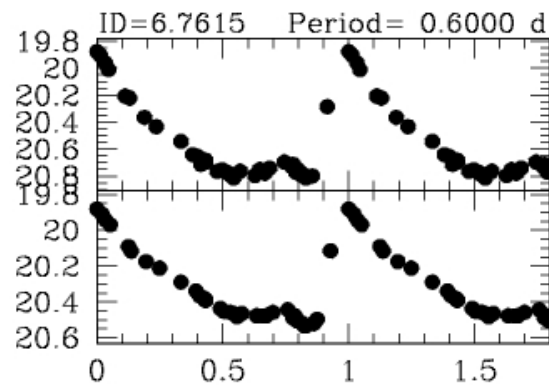
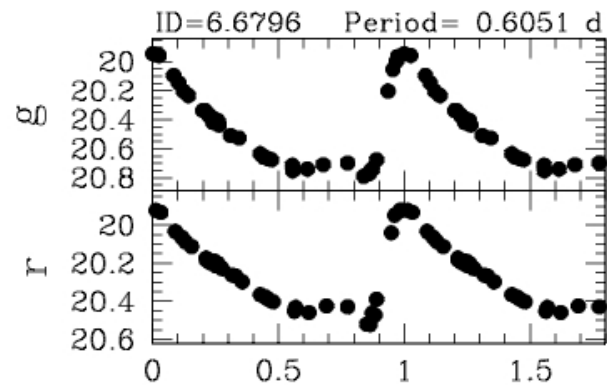


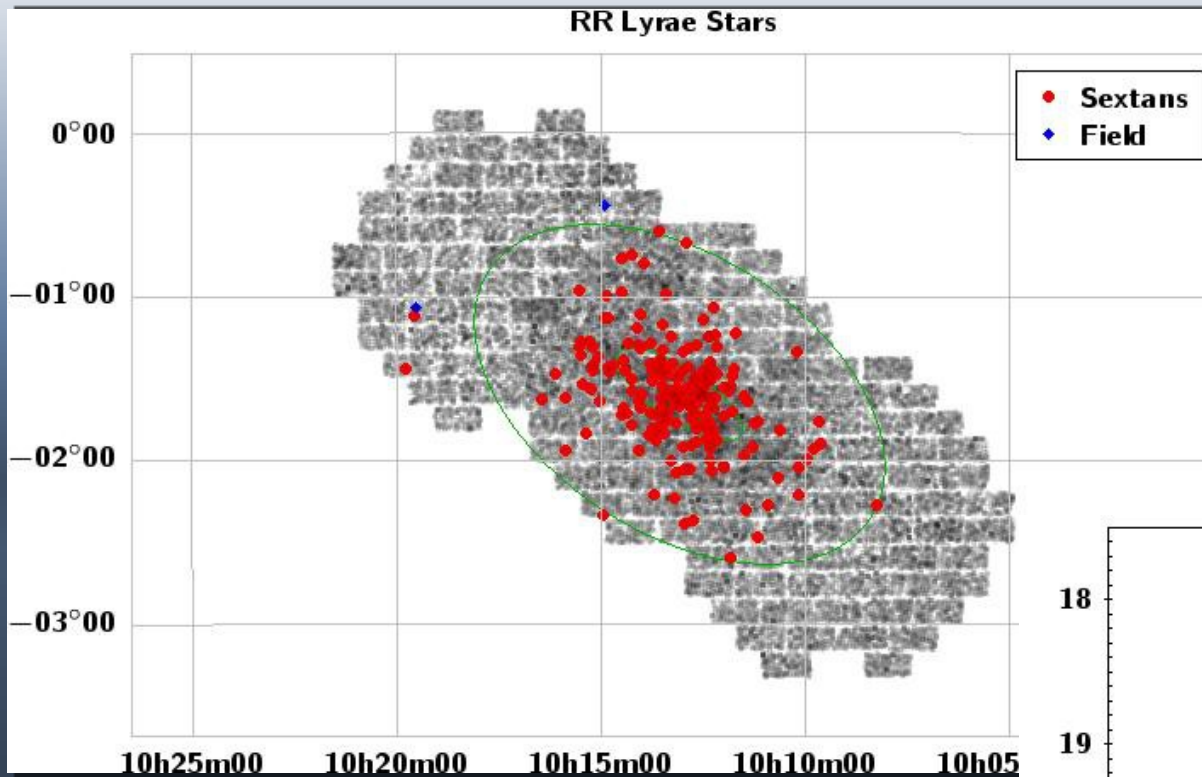
# Procedure

- Community Pipeline
- DoPhot photometry on individual images
- Calibration (with PS1)
- **Variables**

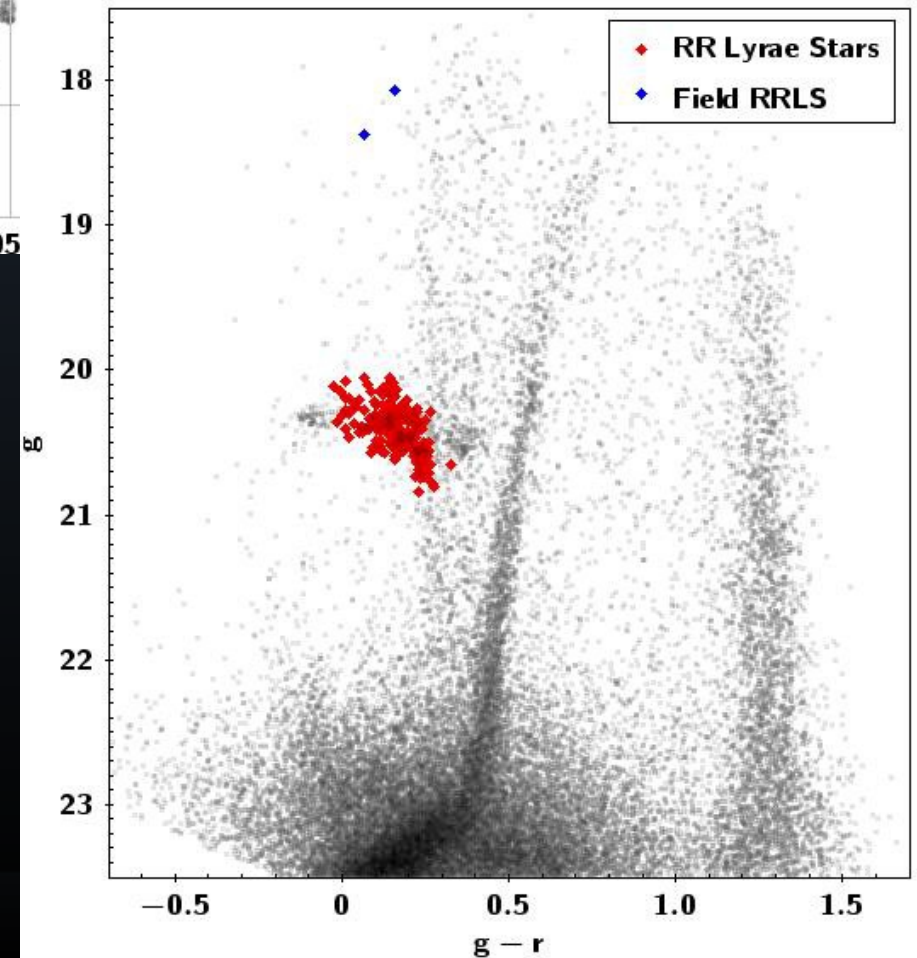


# RR Lyrae stars





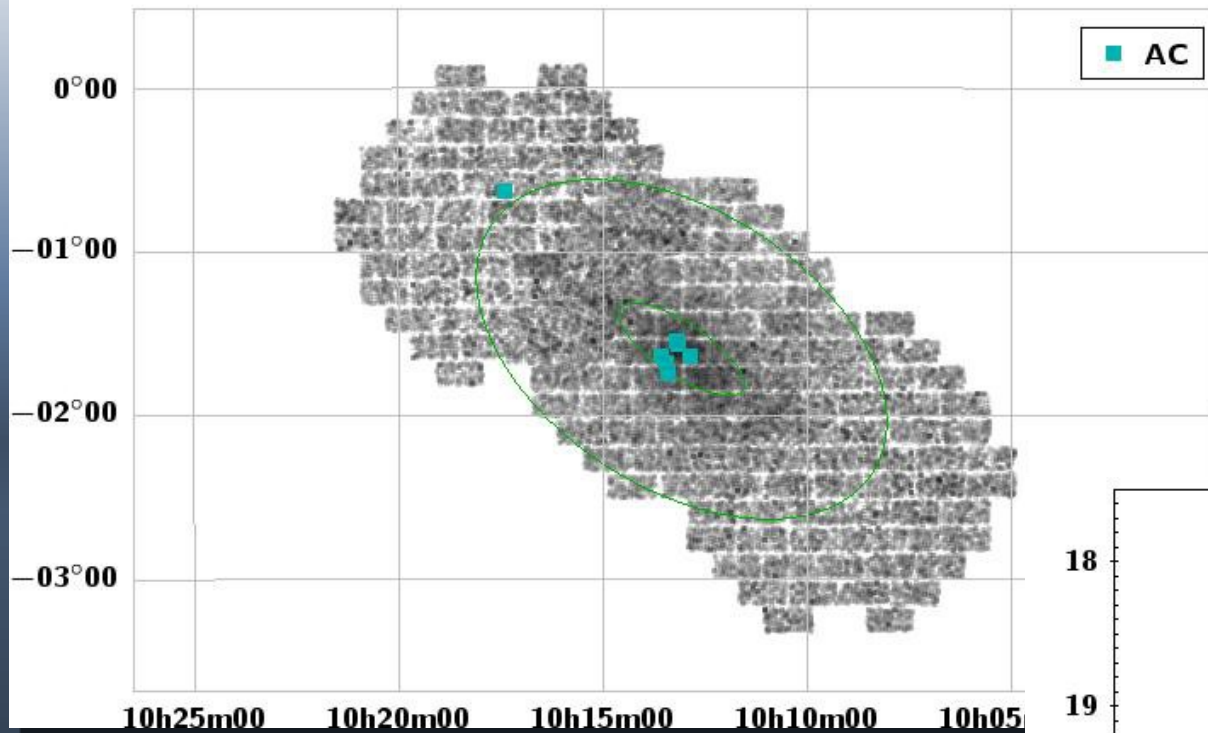
# RR Lyrae Stars



- 200 RR Lyrae Stars (65 new; Total in Sextans = 230)
- A few extra-tidal RR Lyrae stars

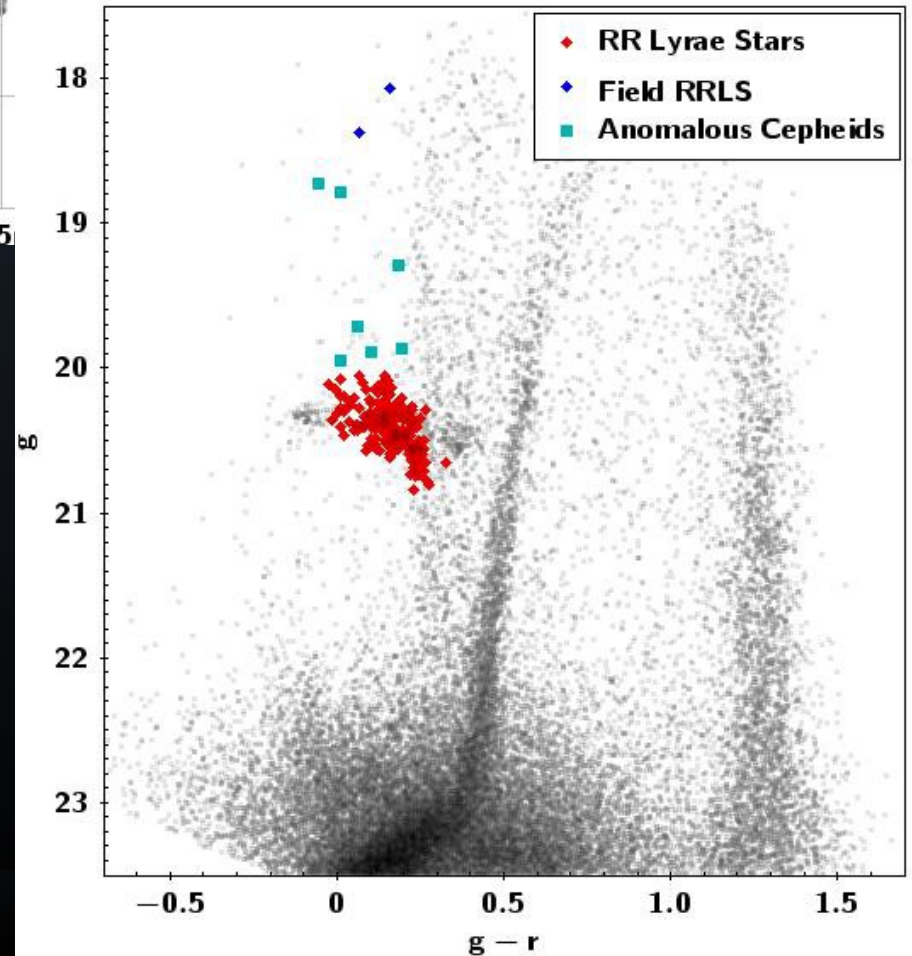


Anomalous Cepheids

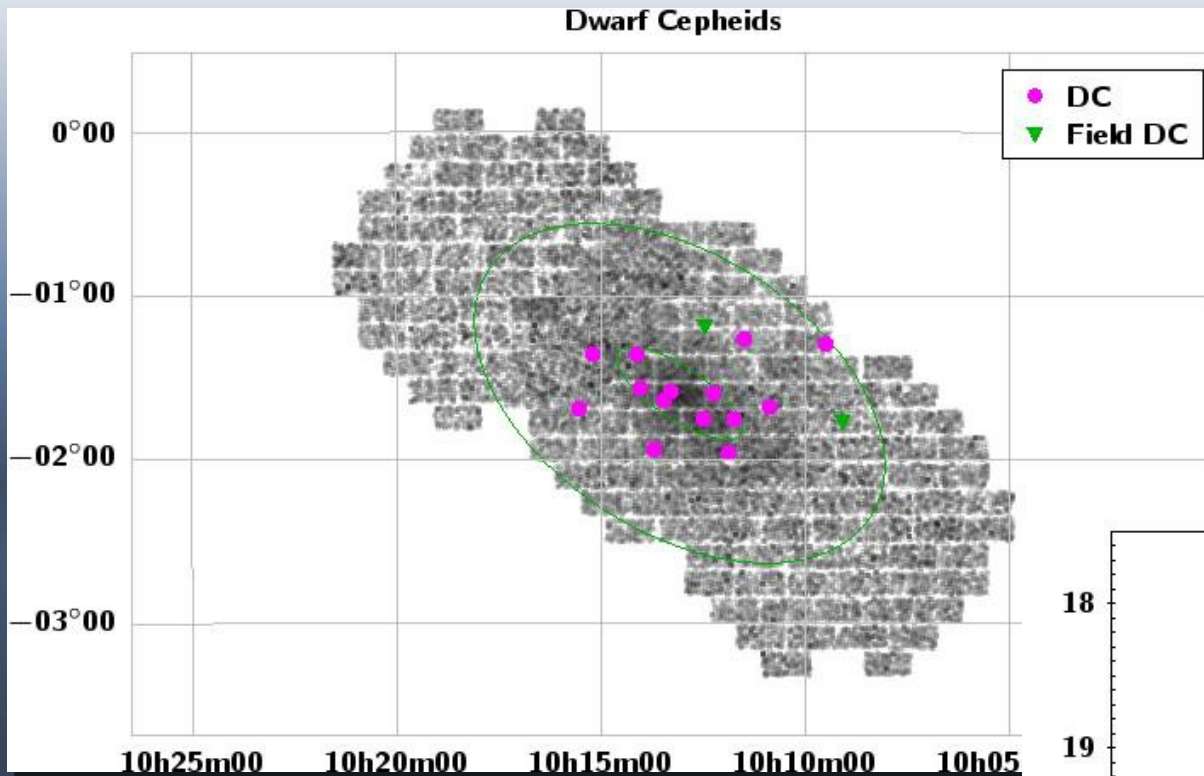


# Anomalous Cepheids

- 7 Anomalous Cepheids (1 new)

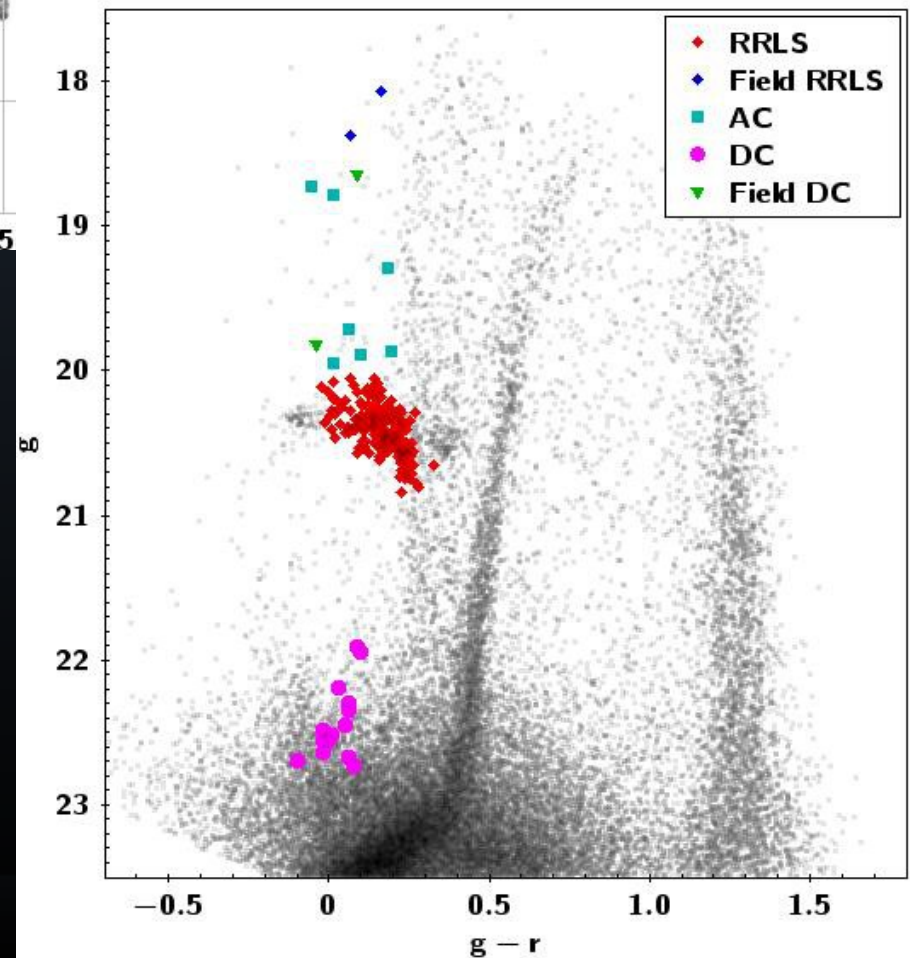




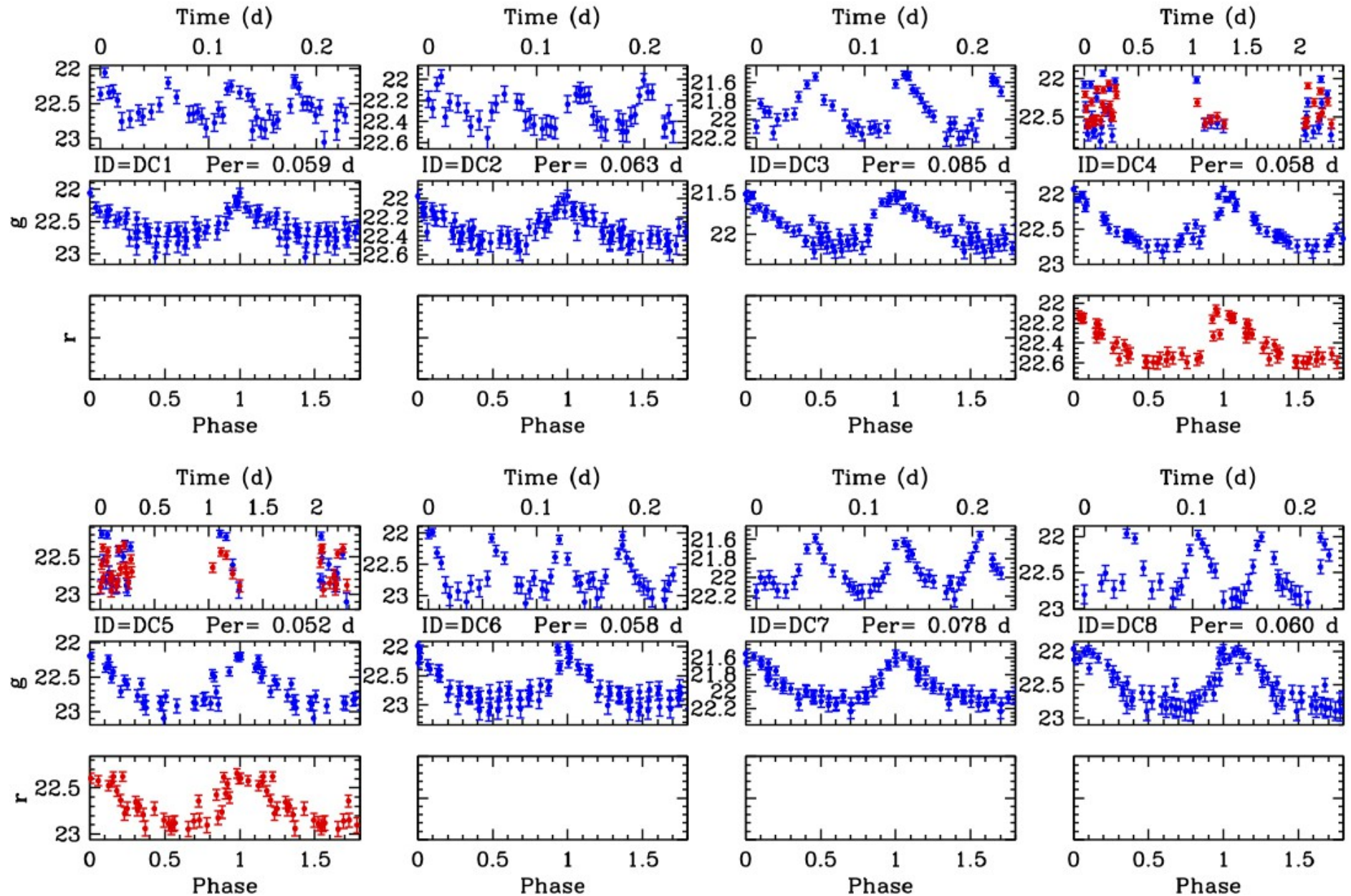


# Dwarf Cepheids

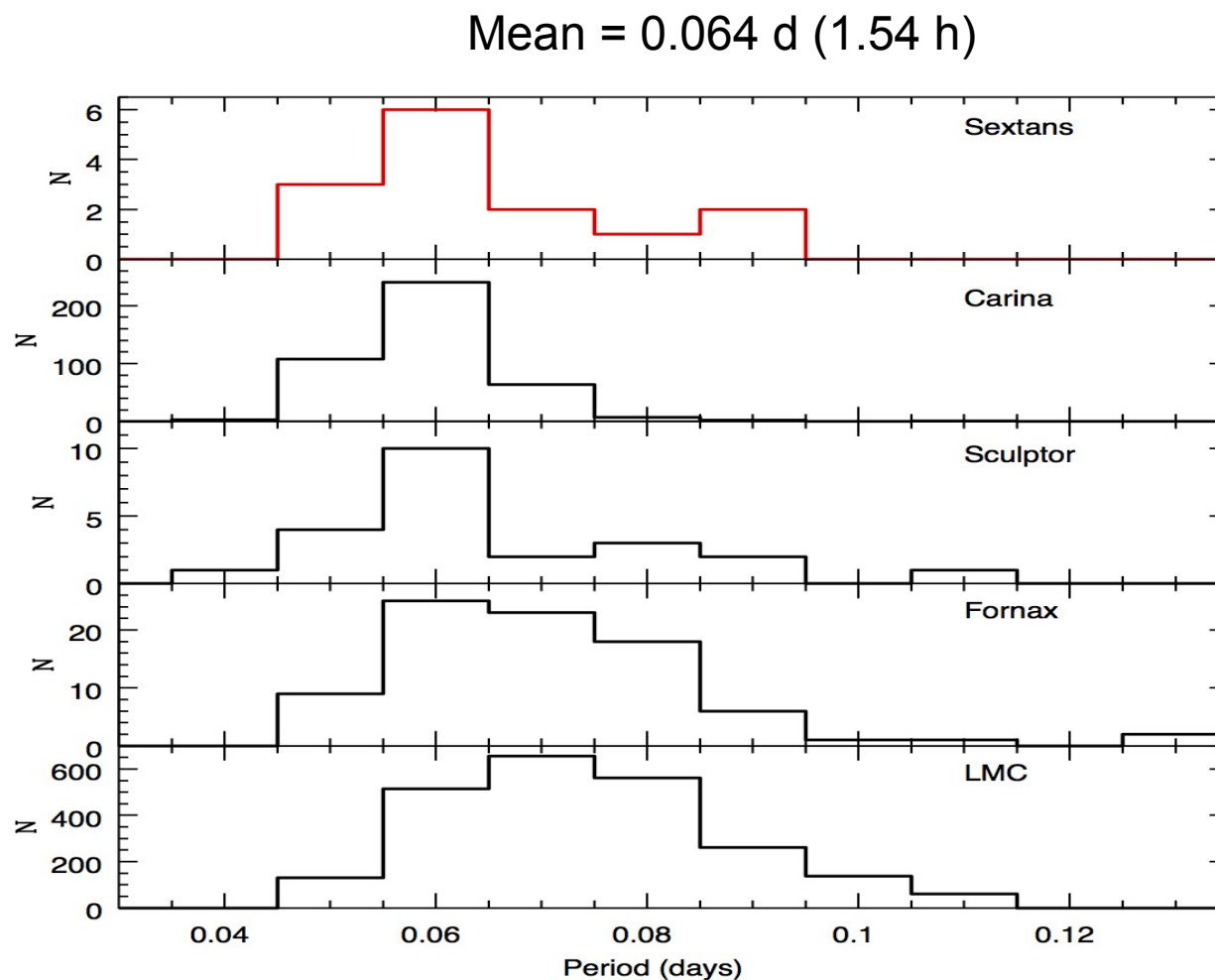
- 14 Dwarf Cepheids (all new discoveries)
- More centrally concentrated than RRLS



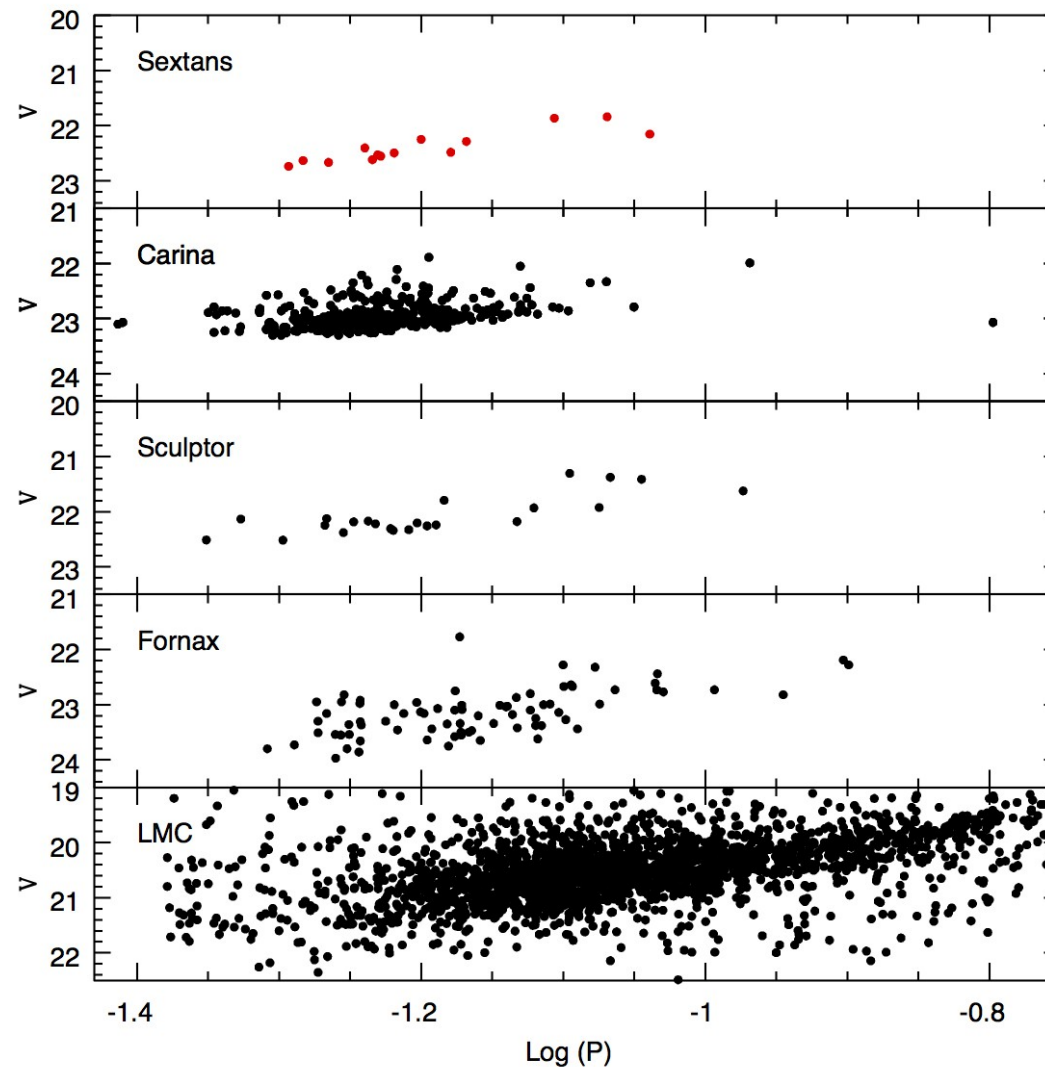
# Dwarf Cepheids



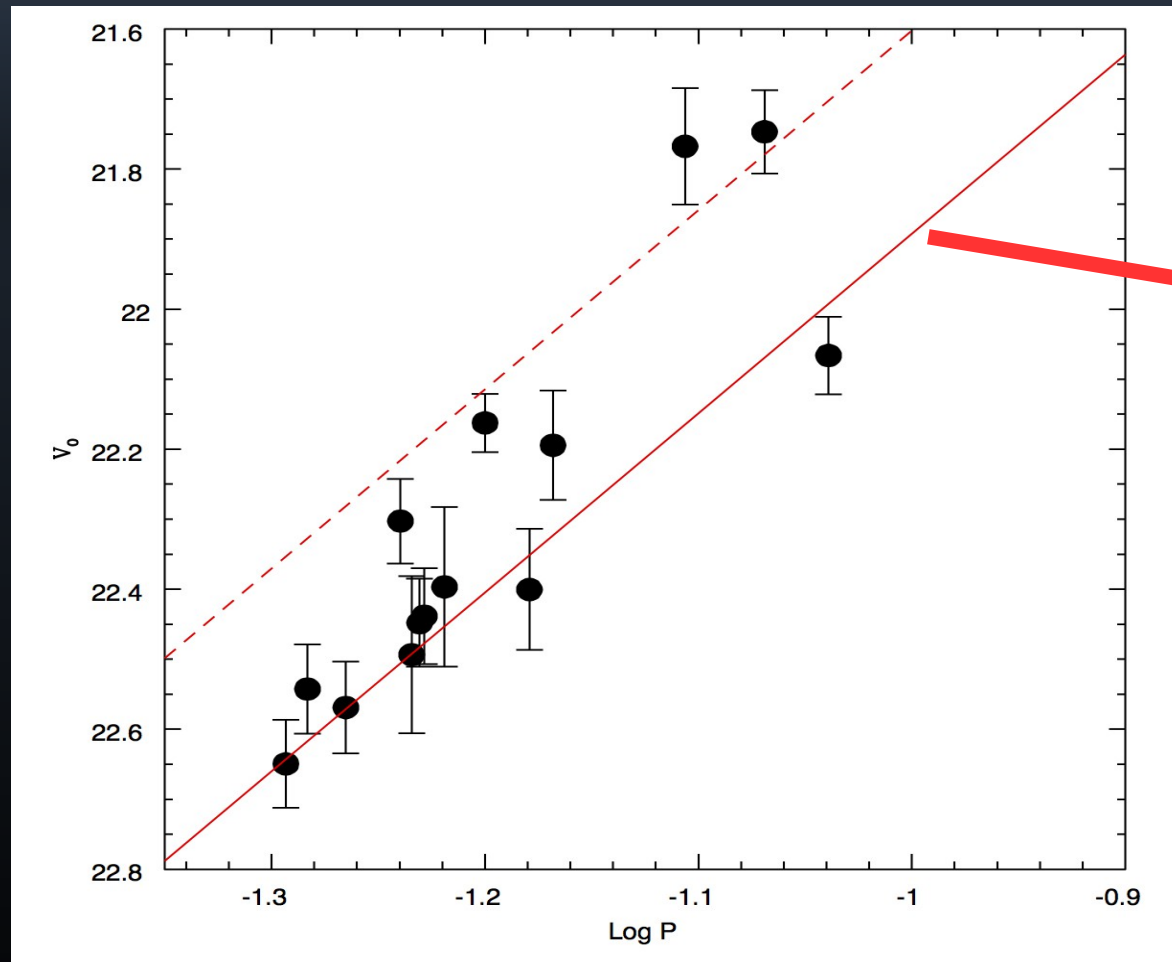
# Dwarf Cepheids – Period distribution



# Dwarf Cepheids – PL relationship



# Dwarf Cepheids – PL relationship



Lines are PL relationships by Nemec et al (1994) for fundamental and first overtone pulsators shifted to  $\mu_0 = 19.6$



# Summary and Future Work

- Sextans is rich in pulsating stars but it has few dwarf cepheid stars.
- Number and period distribution of dwarf cepheids in Sextans are similar to Sculptor
- A P-L relationship for dwarf cepheids may become more relevant in the LSST era.
- Sagittarius is expected to have a larger number of dwarf cepheids since it has an important intermediate age population.