

PISCES II & PEGASUS III: TWIN SISTERS OR ONLY GOOD FRIENDS?

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OUTLINE

DWARF SPHEROIDAL & ULTRA FAINT DWARF GALAXIES
SURROUNDING THE MILKY WAY

PISCES II AND PEGASUS III...

WHY?

PISCES II AND PEGASUS III...

**Our Proposal: LBC@LBT
observations**

goals & methods

Results & Discussion

Future studies

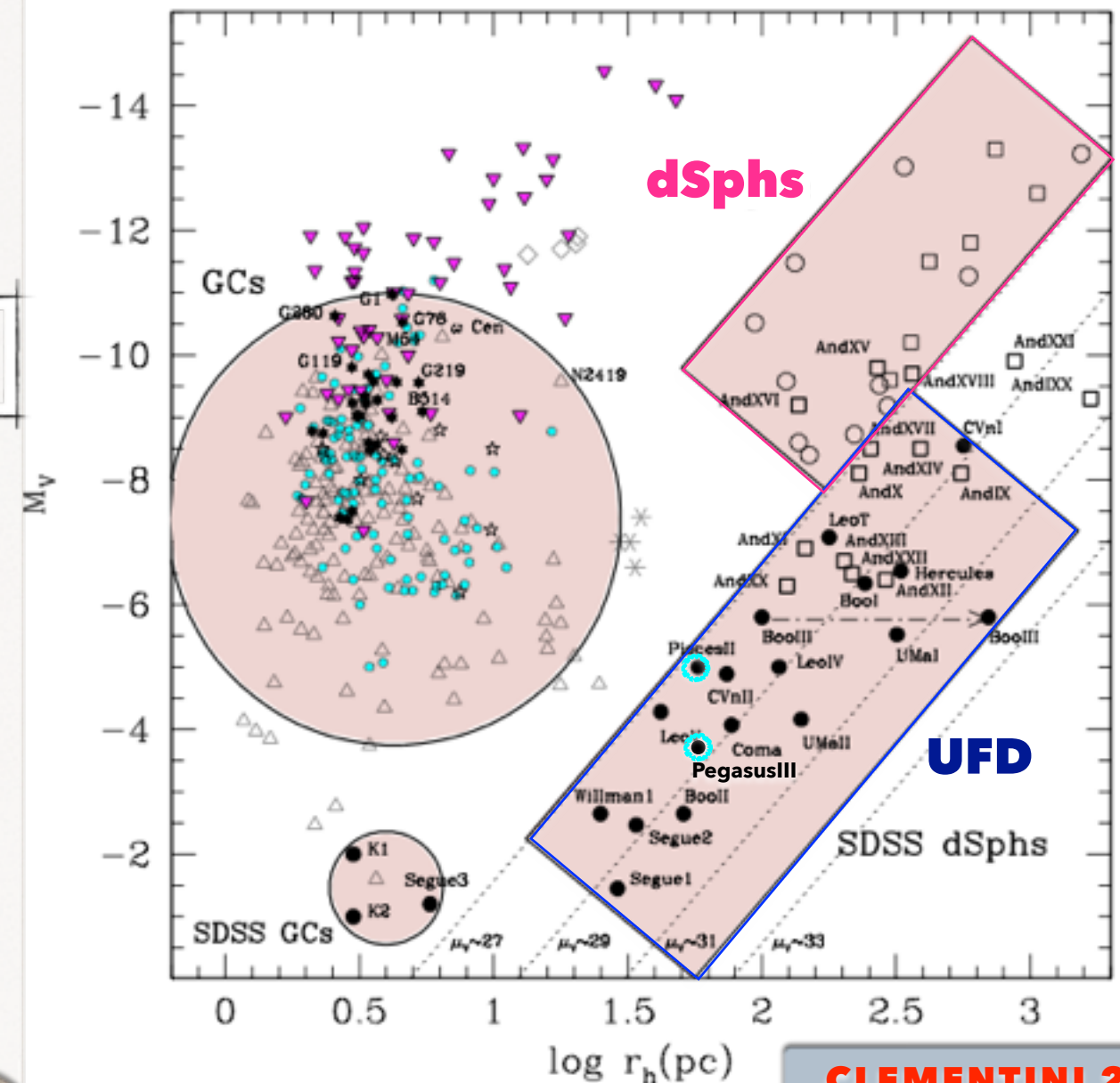
DWARF SPHEROIDAL & ULTRA-FAINT DWARF GALAXIES SURROUNDING THE MILKY WAY

GAS-FREE SYSTEMS

STRONGLY DARK MATTER DOMINATED

NOT ROTATIONALLY SUPPORTED

FOUND NEARBY MASSIVE GALAXIES



CLEMENTINI 2010

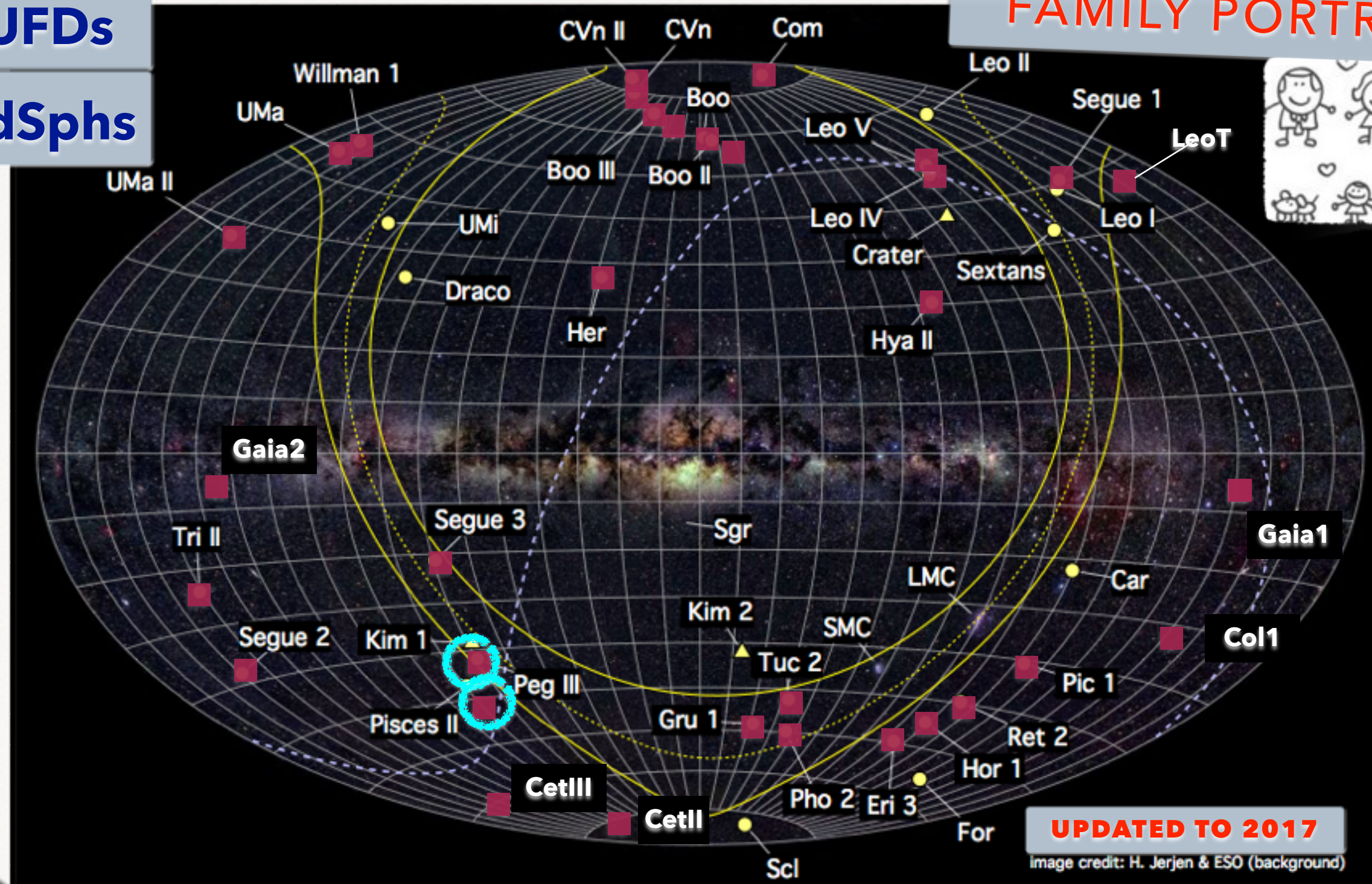
L vs Rh DIAGRAM OF CLASSICAL AND **UFD** dSphs AROUND THE MW AND M31

DWARF SPHEROIDAL & ULTRA-FAINT DWARF GALAXIES SURROUNDING THE MILKY WAY

■ **UFDs**



FAMILY PORTRAIT



UPDATED TO 2017

image credit: H. Jerjen & ESO (background)

DISCOVERED 44 UFDs , 27 (61% , 2013-2017 from DES, Pan-STARRS, VST ATLAS ...)

DWARF SPHEROIDAL & **ULTRA-FAINT DWARF** GALAXIES SURROUNDING **THE MILKY WAY**

- >> LOW SURFACE BRIGHTNESS $\mu_v \geq 28 \text{ mag/arcsec}^2$
- >> HOSTING MOSTLY AN ANCIENT STELLAR POPULATION ($\geq 10 \text{ Gyr}$)
- >> HIGH M/L (≥ 100)  SYSTEMS STRONGLY DARK MATTER DOMINATED
- >> RR LYRAE STARS PULSATIONAL PROPERTIES
- >> METAL-POOR $[\text{Fe}/\text{H}] \geq -2, -3 \text{ dex}$
- >> IRREGULAR/DISTORTED SHAPE  MW TIDAL INTERACTIONS

VARIABLE STARS & UFDs



THE MOST COMMON PULSATING VARIABLE STARS IN dSphs and UFDs
RR LYRAE STARS



MASS FROM 0.6 TO 0.8 M_{SUN}

PERIOD FROM 0.3 TO 1 days; AMPLITUDE V 0.2-1 mag

PRIMARY DISTANCE INDICATORS

OLD STELLAR POPULATION TRACERS ($t > 10$ Gyr)



ACCORDING TO $\langle P_{ab} \rangle$ (Oosterhoff 1939) (GGCs, HALO FIELDS)

Oo-I $\langle P_{ab} \rangle = 0.55\text{d}$ $f_c = 0.17$ \rightarrow $[\text{Fe}/\text{H}] \sim -1.5$ dex

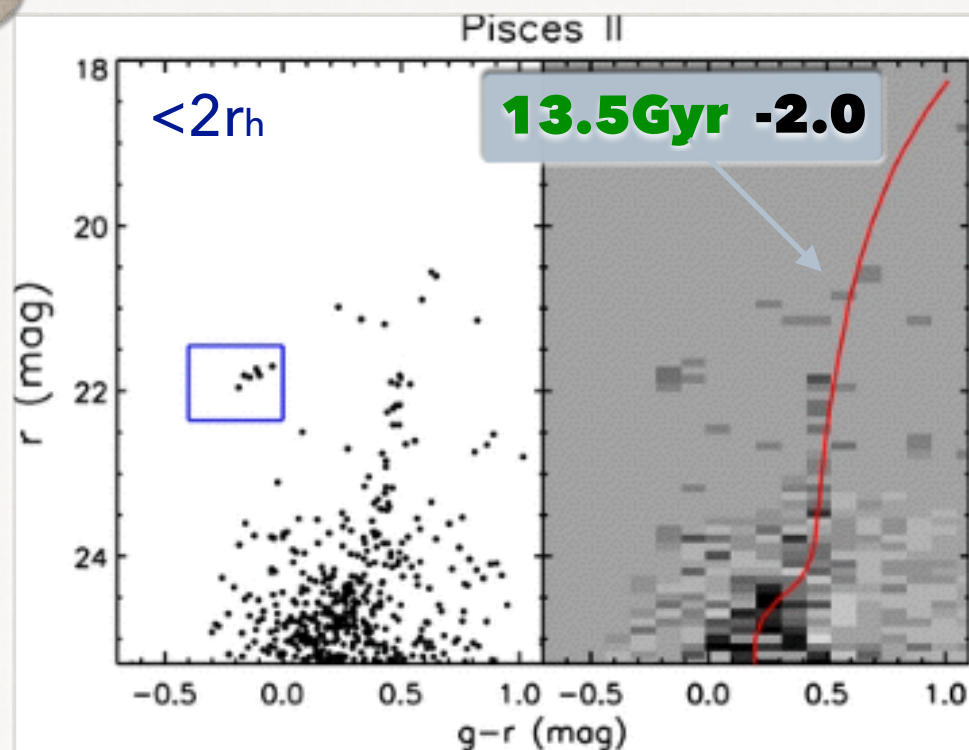
Oo-II $\langle P_{ab} \rangle = 0.64\text{d}$ $f_c = 0.44$ \rightarrow $[\text{Fe}/\text{H}] \sim -2$ dex

PISCES II & PEGASUS III

news from scientific literature



DISCOVERED BY SDSS DR7 (**Belokurov+2010**)



$M_V = -4.1 \pm 0.4$ mag



$rh = 1.09' \pm 0.19'$ (58 ± 10 pc)



$d = 183 \pm 15$ kpc



$\langle [Fe/H] \rangle = -2.45 \pm 0.07$ dex



$\sigma_v = 5.4 \pm 3.6_{-2.4}^{+3.6}$ km/s

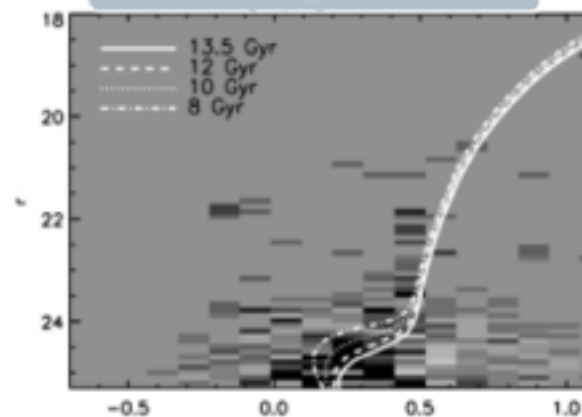
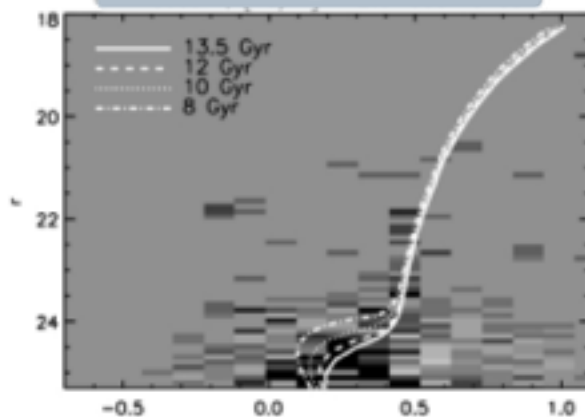
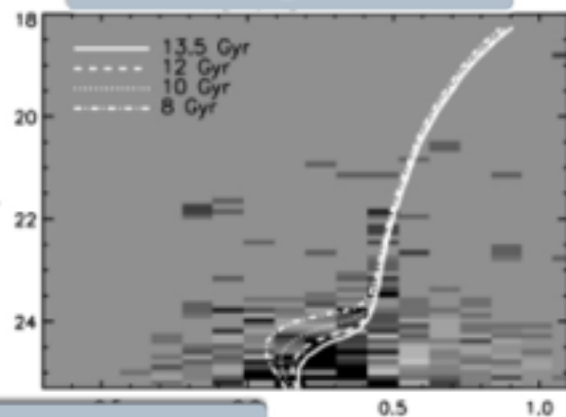


$\langle v_{\odot} \rangle = -226.5 \pm 2.7$ km/s

13.5Gyr -2.3

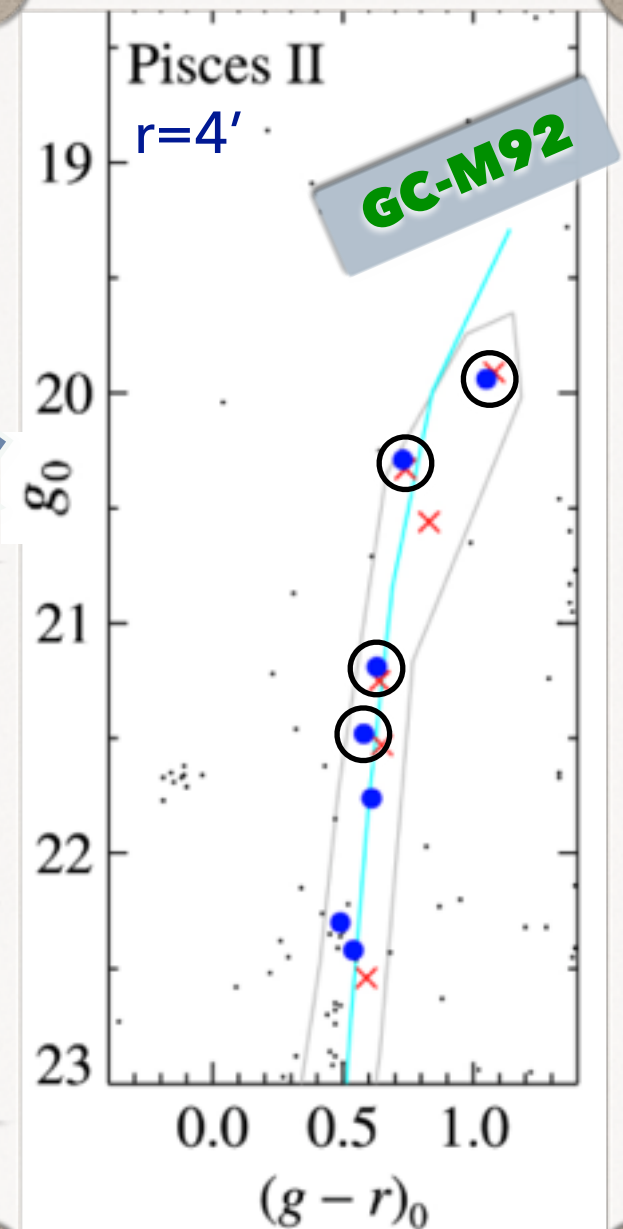
13.5Gyr -2.0

13.5Gyr -1.5



SAND+2012

- MEMBERS (7)
- ✗ NOT-MEMBERS
- $\sigma_{[Fe/H]} < 0.5$ dex (4/7)



KIRBY+2015

PISCES II & PEGASUS III

news from scientific literature



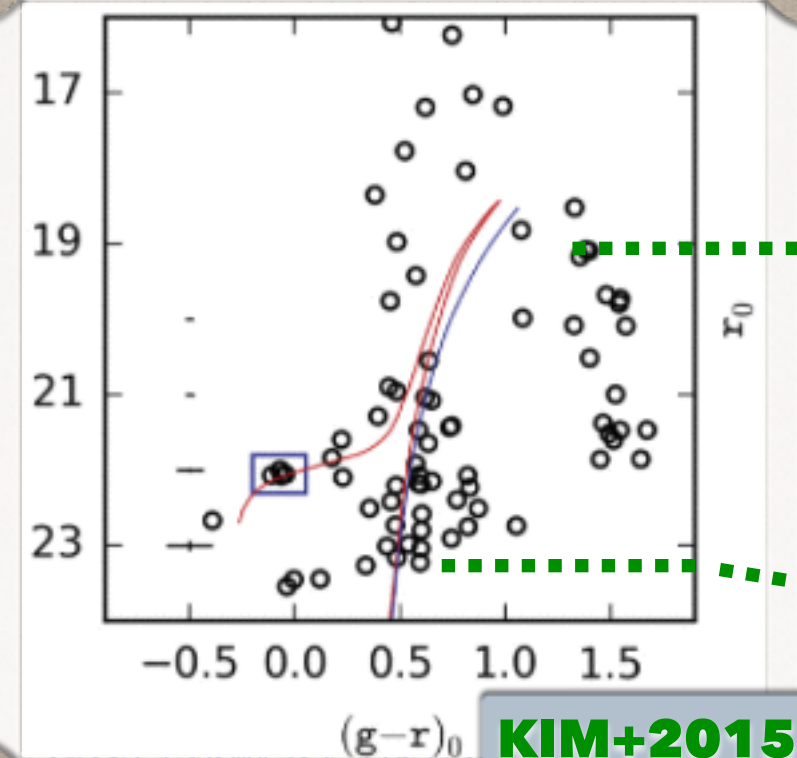
DISCOVERED BY SDSS DR10 - CONFIRMED WITH DECam (**Kim+2015**)



$M_v = -3.4 \pm 0.4$ mag



$rh = 0.85' \pm 0.22'$ (53 ± 14 pc)



KIM+2015



$d = 215 \pm 12$ kpc



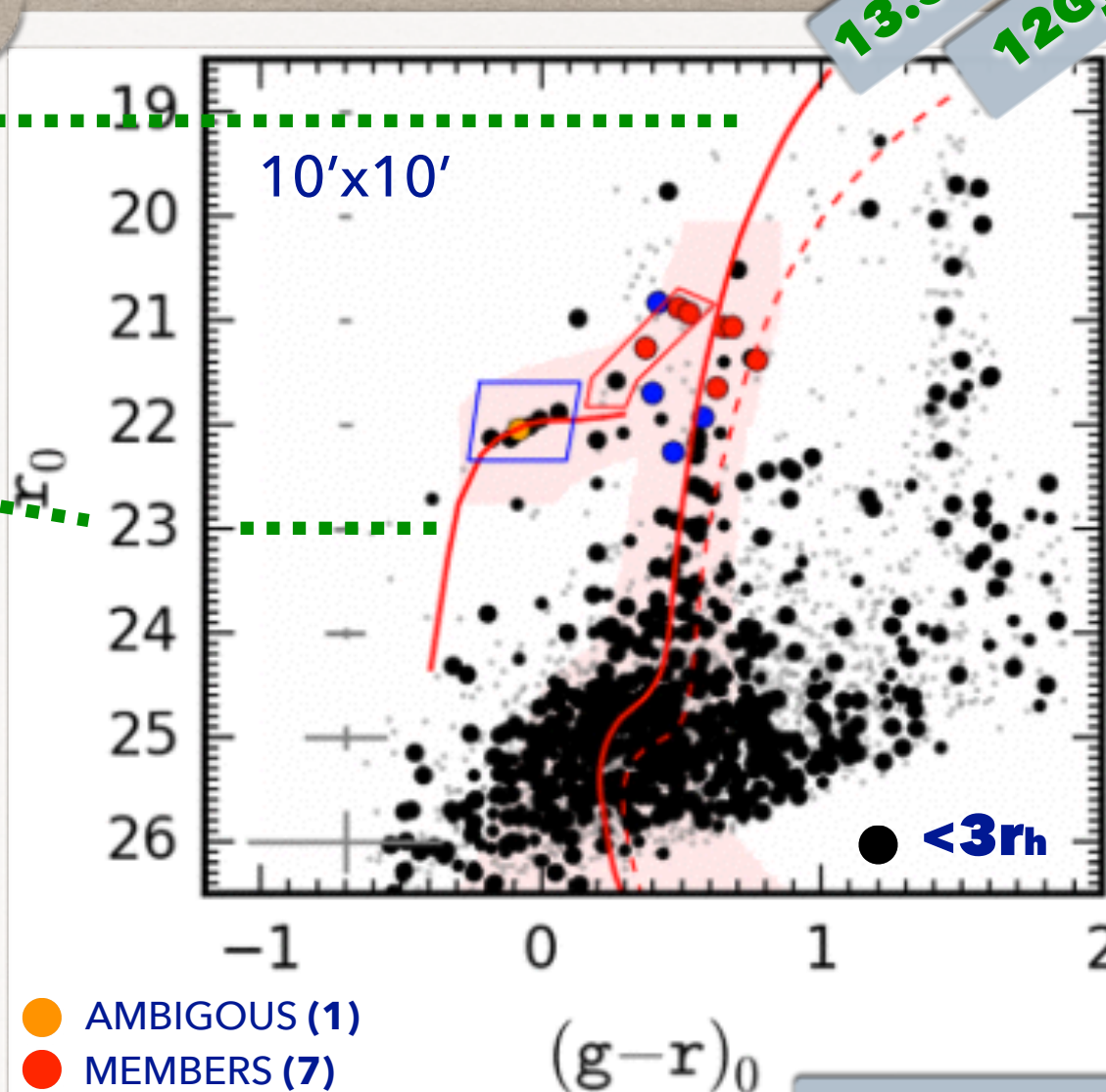
$\langle [Fe/H] \rangle = -2.55 \pm 0.15$ dex



$\sigma_v = 5.4 \pm_{2.5}^{3.0}$ km/s



$\langle v_o \rangle = -222.9 \pm 2.6$ km/s



● AMBIGUOUS (1)

● MEMBERS (7)

● NOT-MEMBERS (4)

KIM+2016

13.5Gyr -2.5

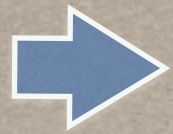
12Gyr -1.1

PISCES II & PEGASUS III

Our proposal

G.CLEMENTINI

★ PEG III and PSC II SHARE SIMILAR PROPERTIES



ASK TO OBTAIN B and V time-series TO:

PEG III + PSC II + 10 fields

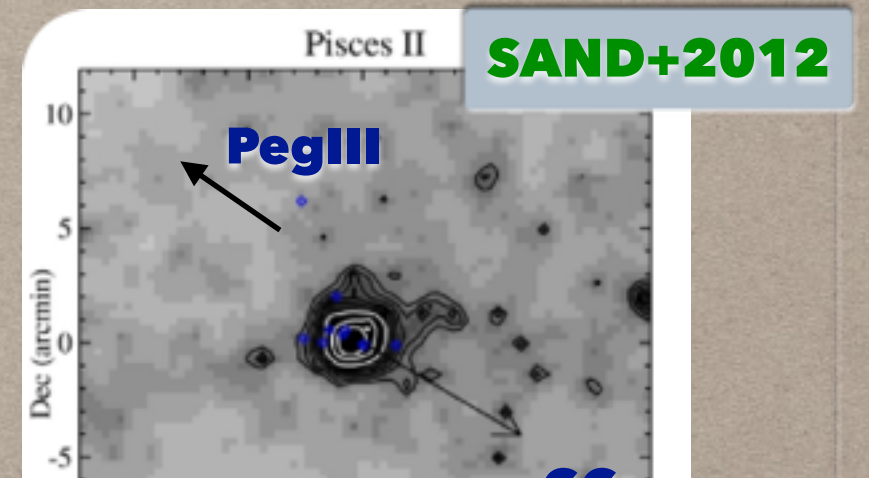
a.DERIVE PROPERTIES (AGES METALLICITIES, DISTANCE MODULI, Oo-TYPE, SPATIAL DISTRIBUTION)

OBSERVABLES

★ PULSATING VARIABLES FOUND IN THE UFDs

★ COLOR-MAGNITUDE DIAGRAM (CMD) OF THE RESOLVED STELLAR POPULATIONS

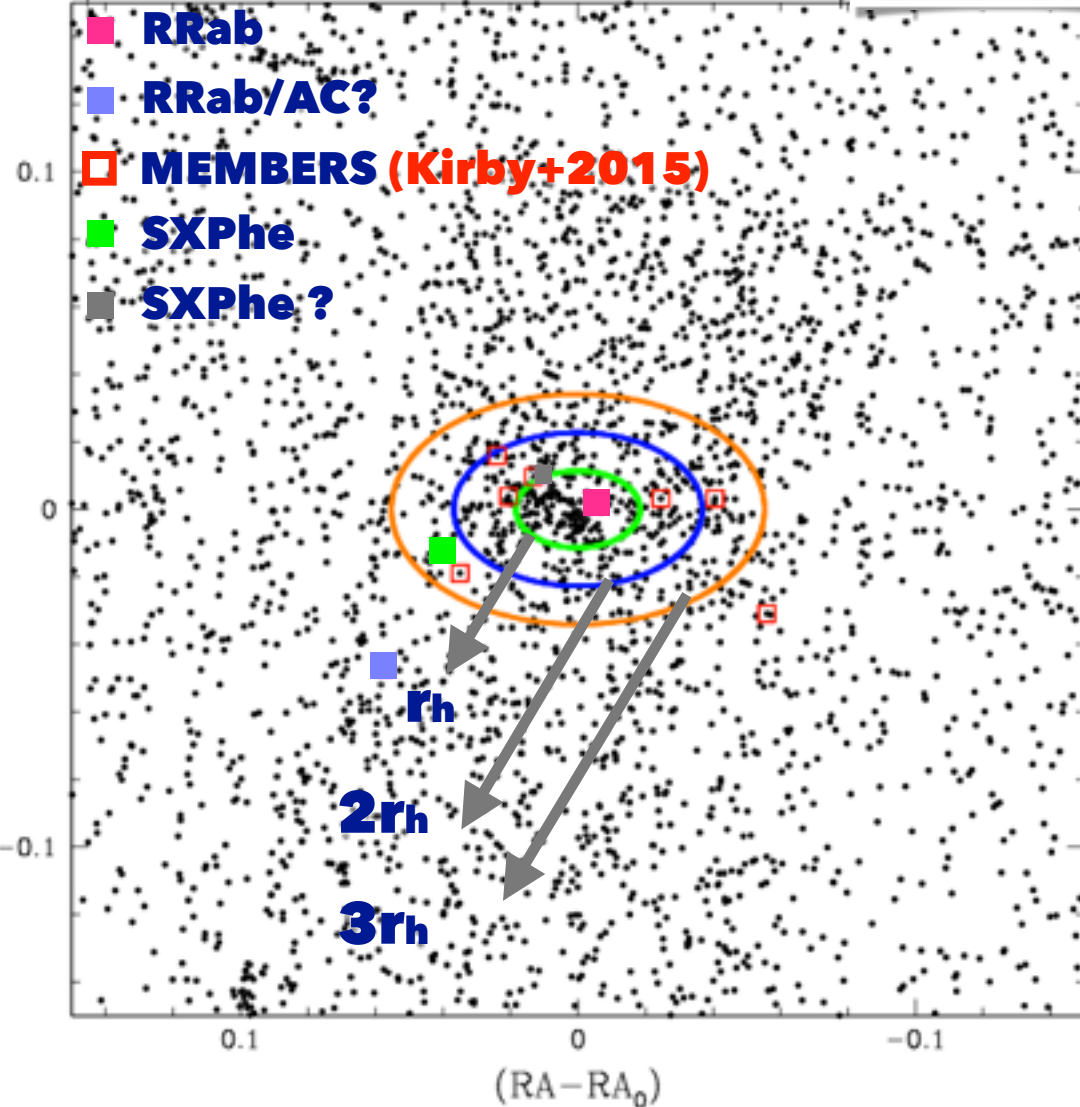
b.INVESTIGATE SIGNATURES OF A PHYSICAL CONNECTION
PEG III and PSC II (SIMILAR DISTANCE FROM US , 8° APART IN



PISCES II



$rh = 1.09' \pm 0.19'$ (58 ± 10 pc)



DATES

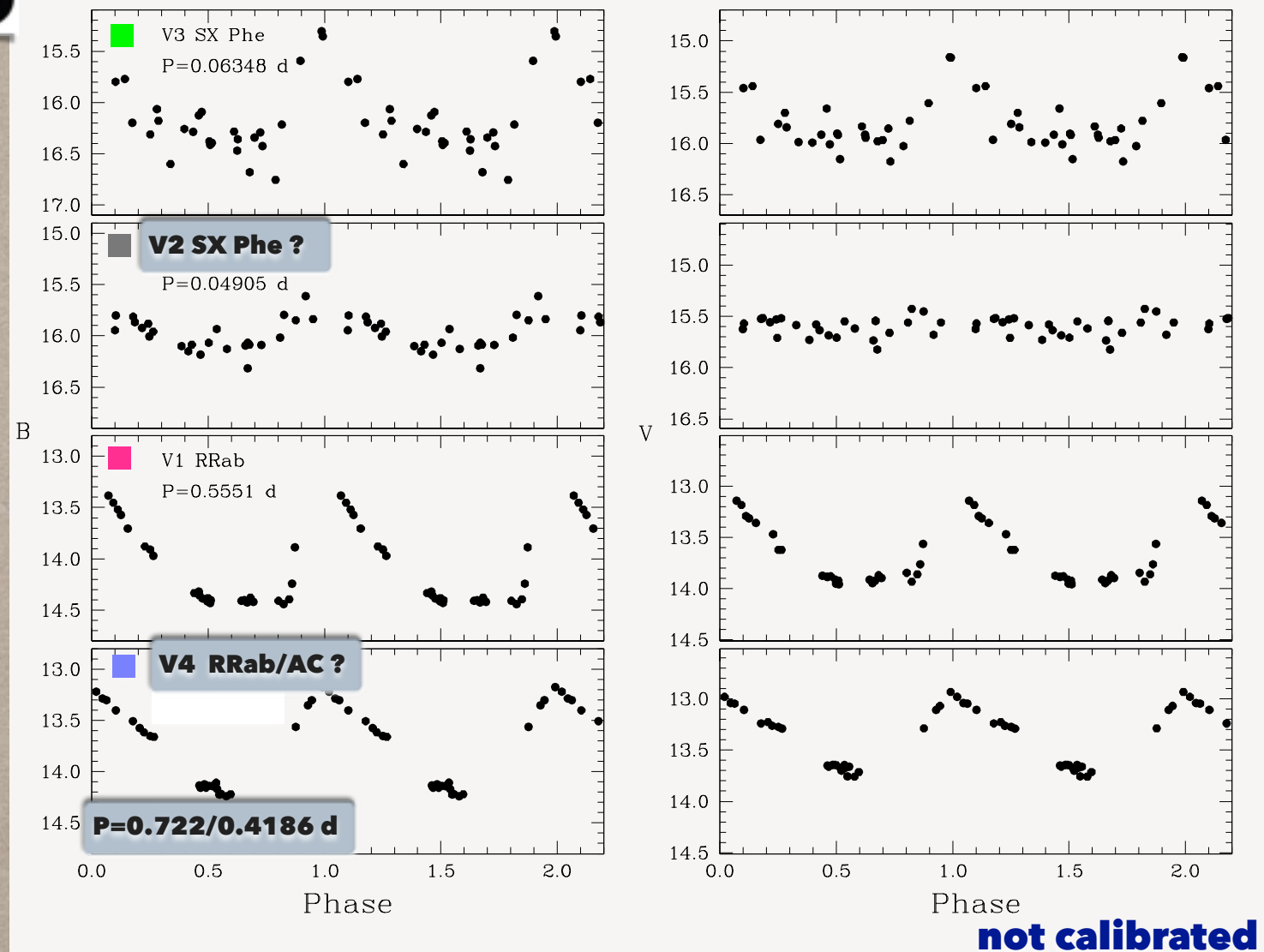
OCTOBER-DECEMBER 2015

N FILTER

26 B - 26 V

T_{EXP} SEEING

180s 0.8-2.2"



PSF PHOTOMETRY
DAOPHOT-ALLSTAR-ALLFRAME



LIGHT CURVE
CLASSIFICATION AND STUDY
GRATIS

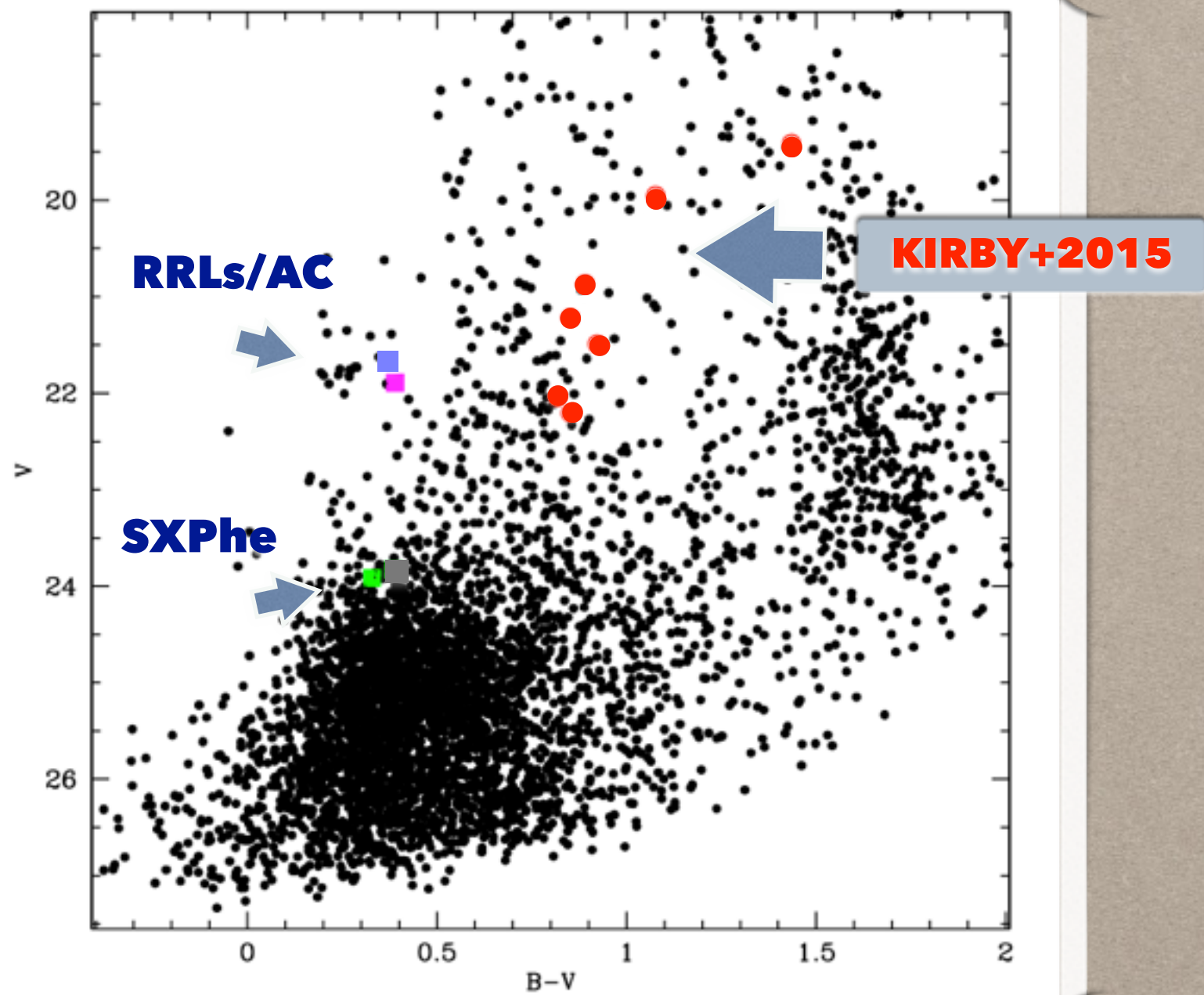


1RRAB 1SXPH? → **<rh**
1SXPH → **<3rh**
1RRAB/AC? → **>3rh**

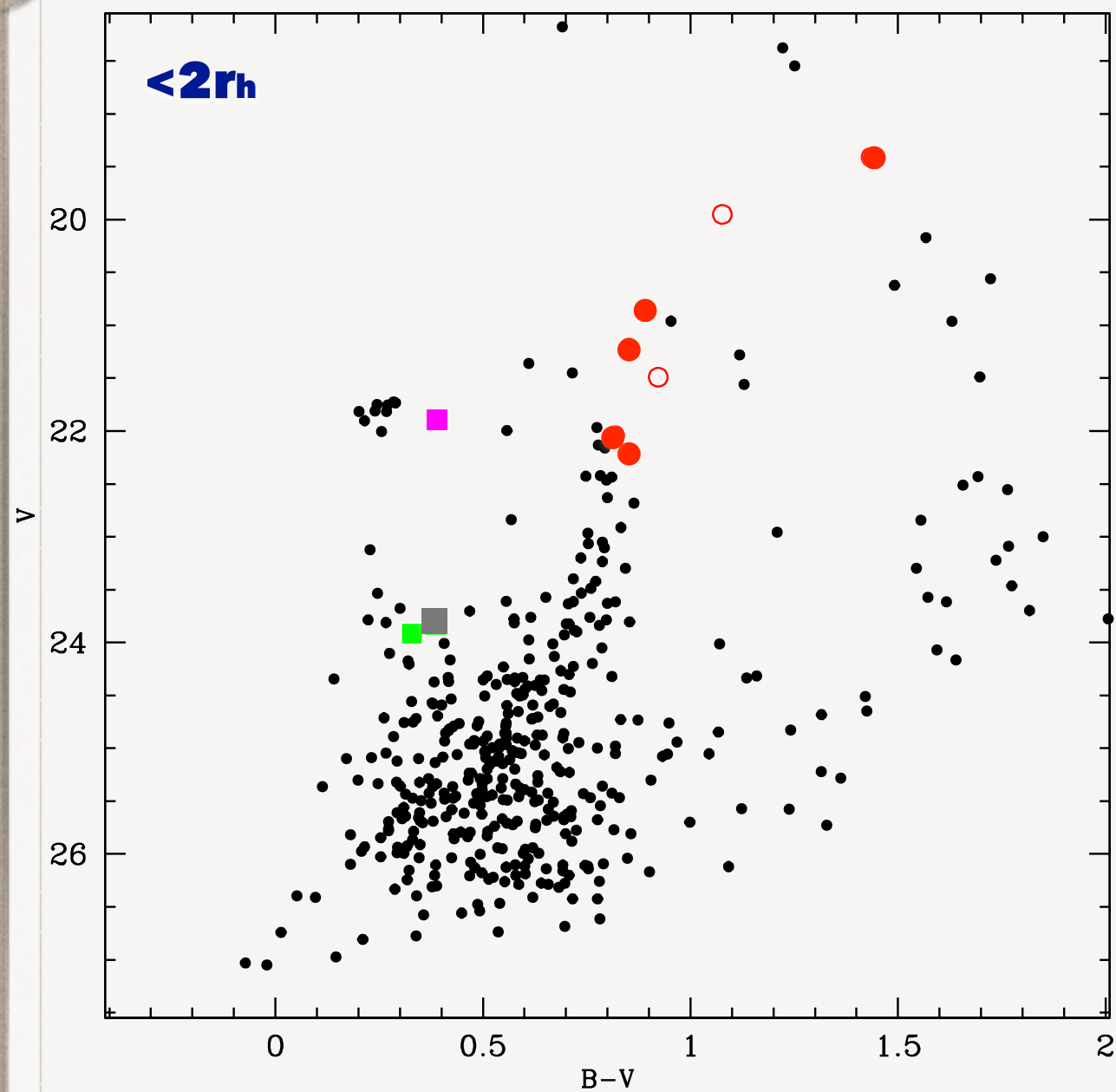


V4 IS 0.25 mag BRIGHTER THAN V1

PISCES II



PISCES II



$$(m-M)_0 = 21.22 \pm 0.14 \text{ mag}$$



$$\mathbf{d = 175 \pm 11 \text{ kpc}}$$

$$d = 183 \pm 15 \text{ kpc}$$



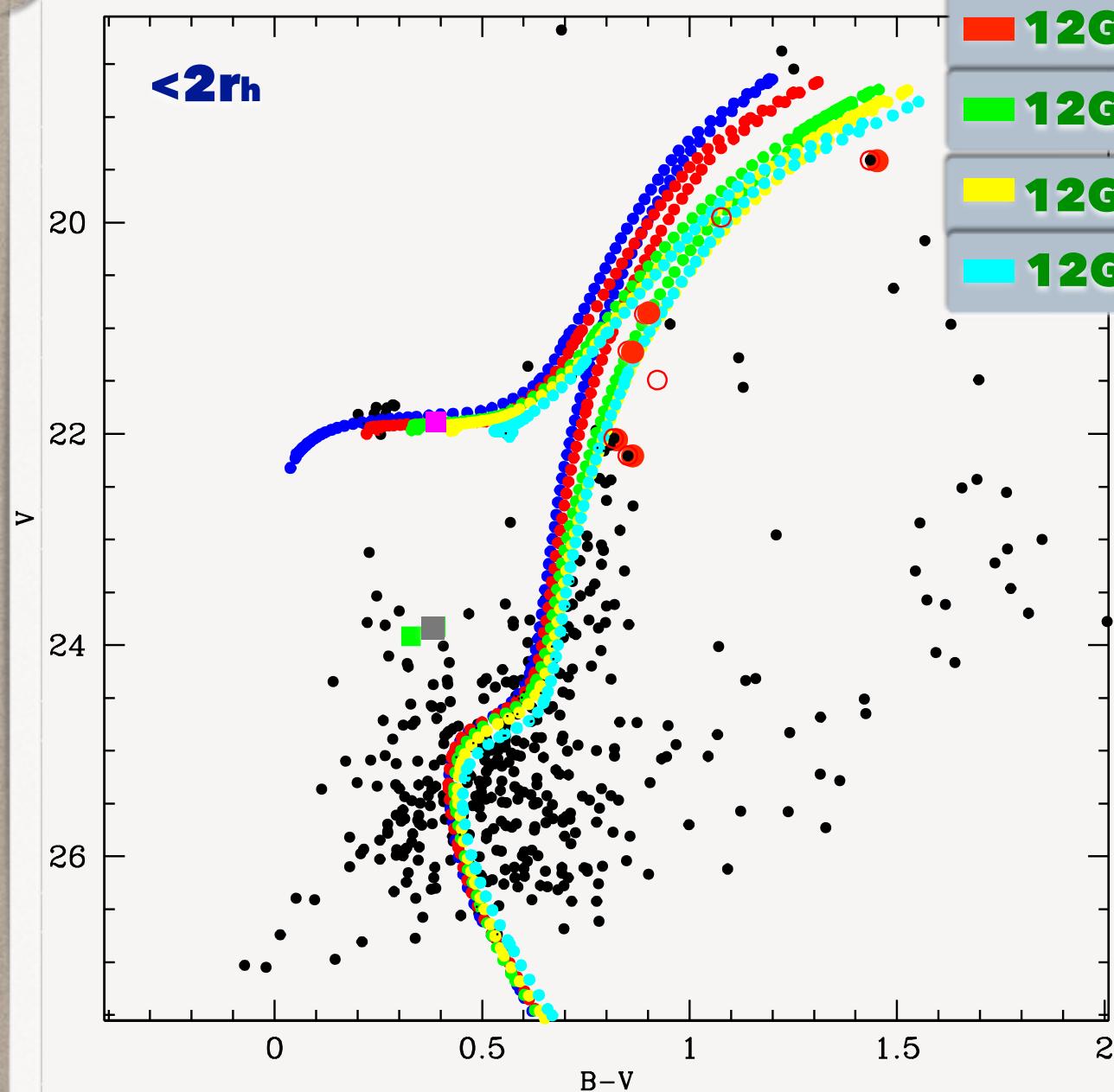
$$E(B-V) = 0.056 \pm 0.052 \text{ mag}$$



$$E(B-V)_{\text{RR}} = 0.052 \pm 0.023 \text{ mag}$$

(Piersimoni+02)

PISCES II



$$(m-M)_0 = 21.22 \pm 0.14 \text{ mag}$$



$$d = 175 \pm 11 \text{ kpc}$$

$$d = 183 \pm 15 \text{ kpc}$$



$$E(B-V) = 0.056 \pm 0.052 \text{ mag}$$



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(Piersimoni+02)

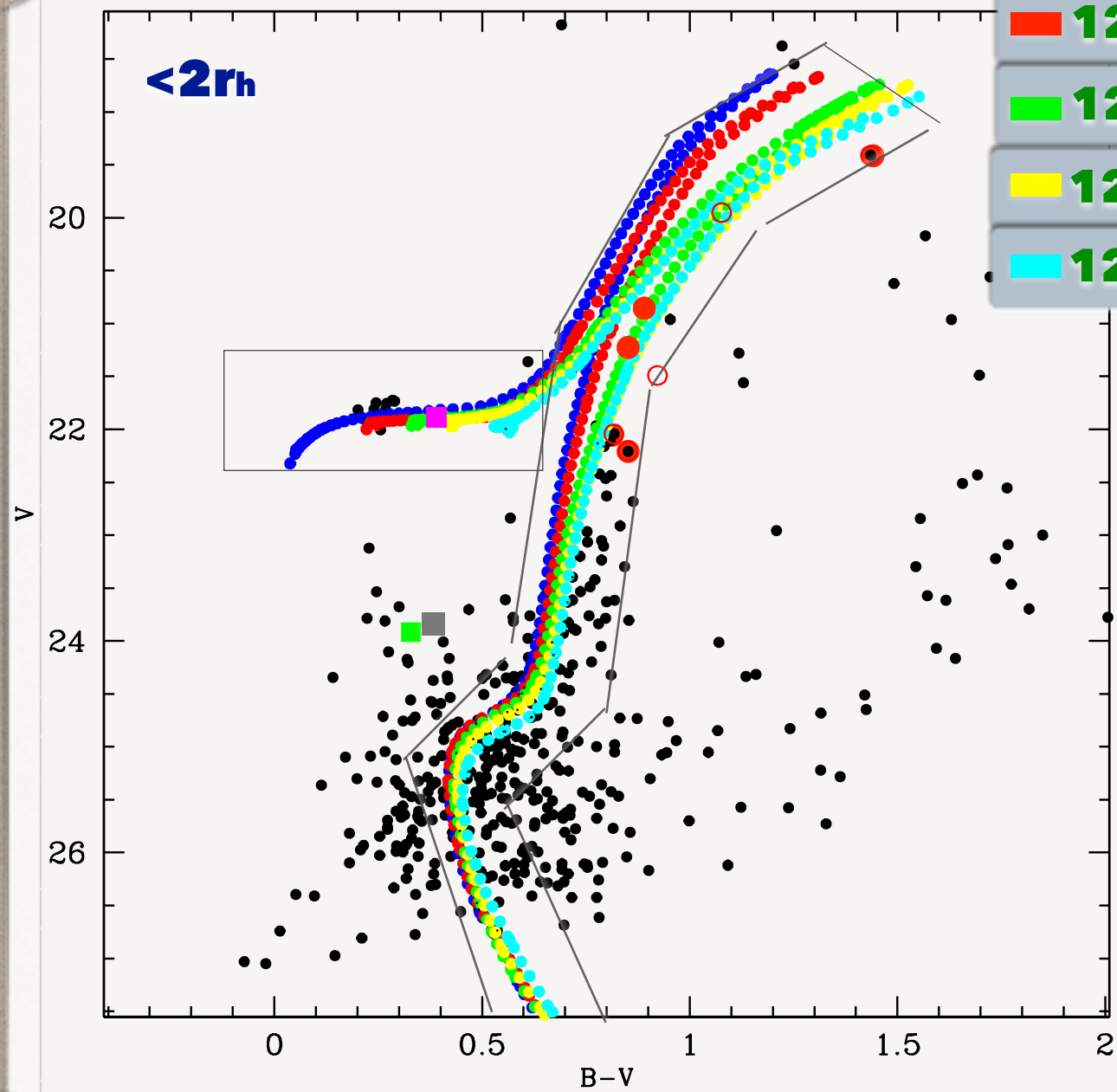


HB + RGB stars best matched:
stellar population **12 Gyr** old
with $[Fe/H] = -1.8 / -1.7$ dex

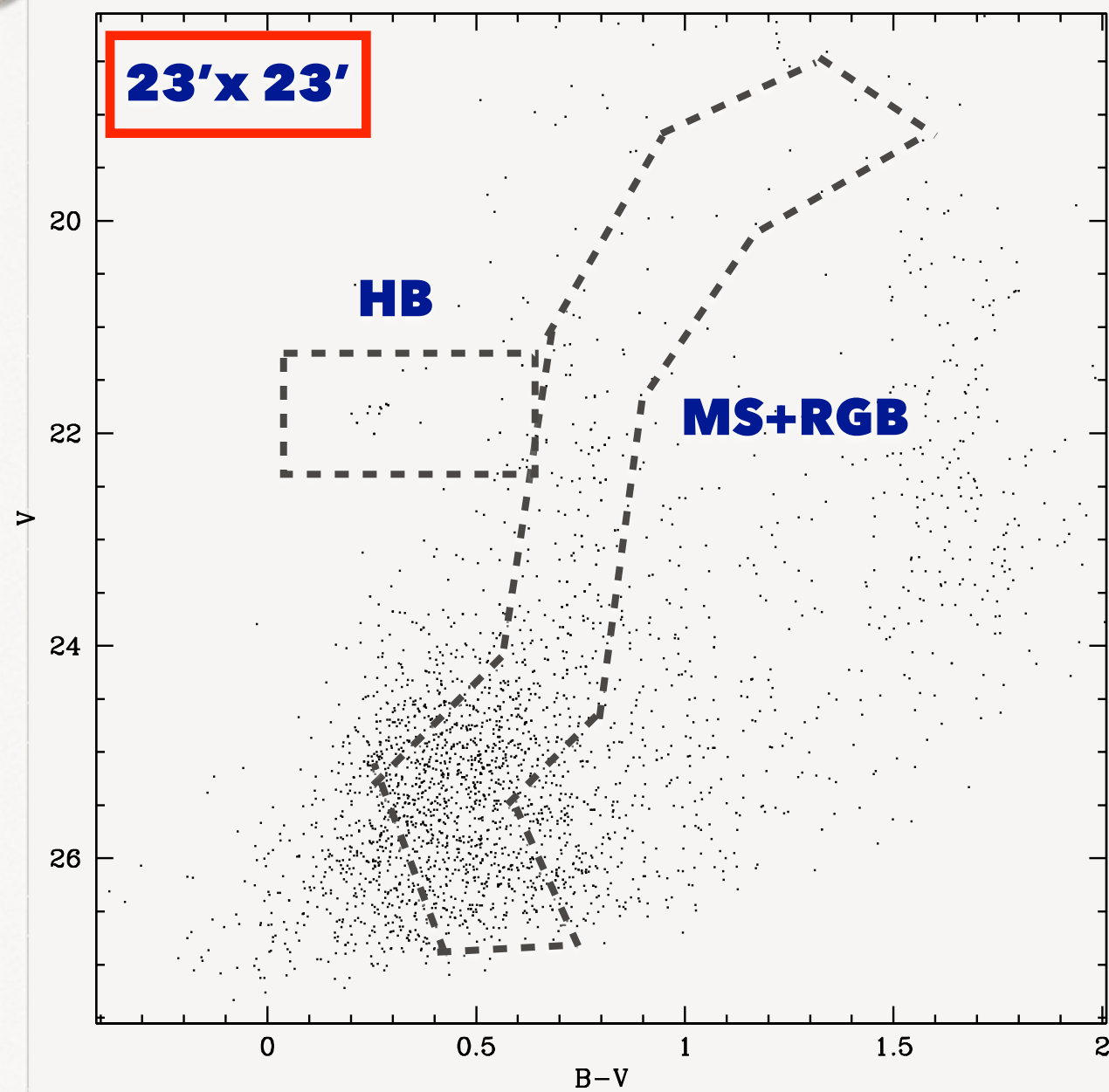


RIDGE LINES FROM CMD 2.7 **(Bressan+12)**

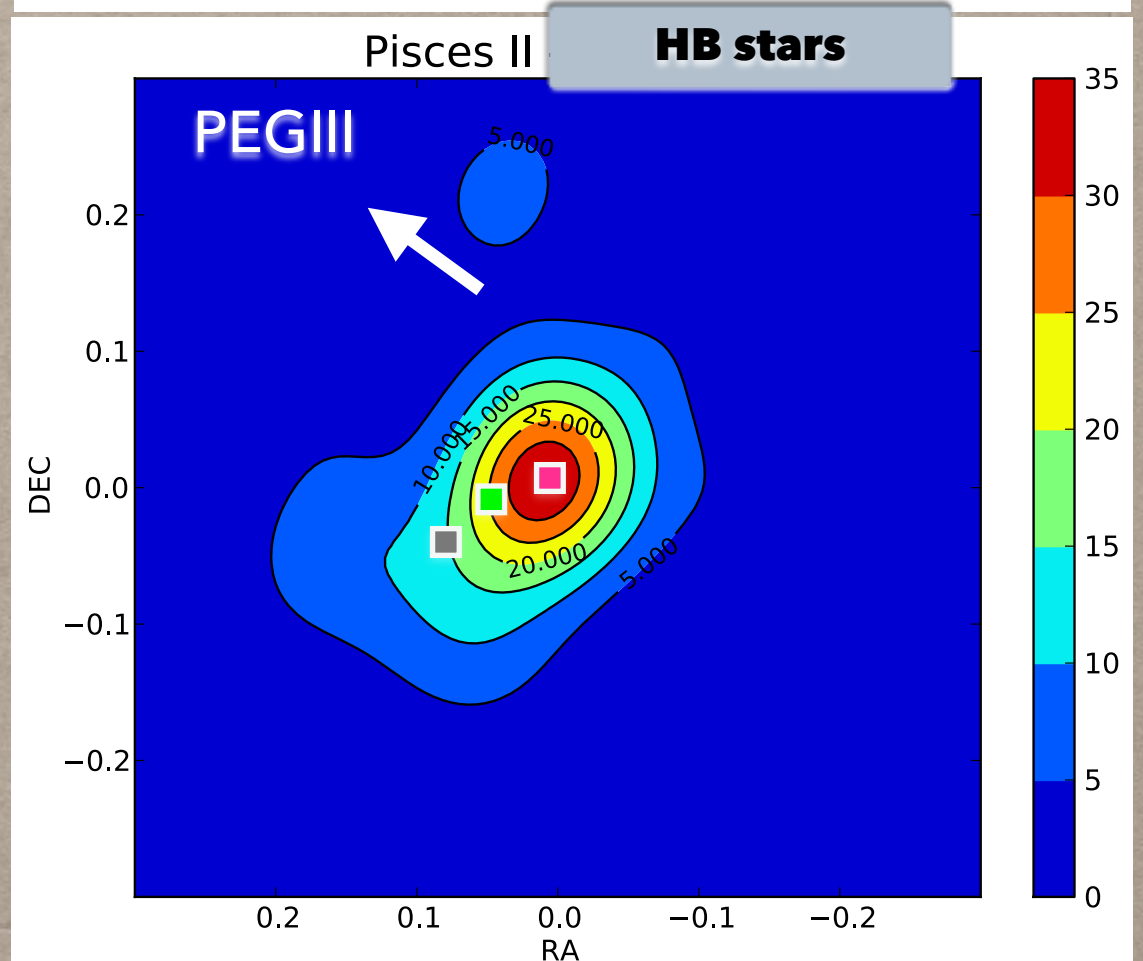
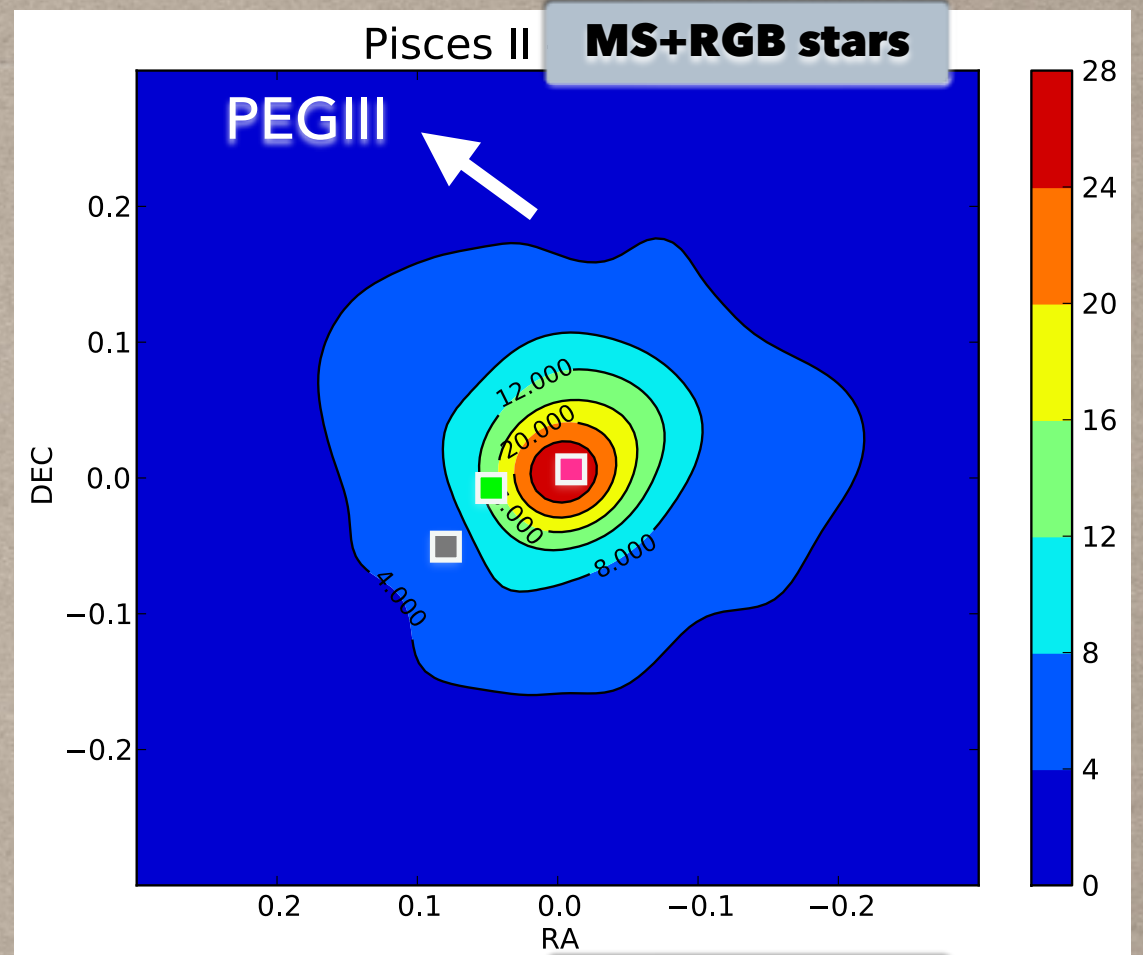
PISCES II



PISCES II



ISODENSITY CONTOURS REVEAL A
SIMMETRICAL AND REGULAR SHAPE



PEGASUS III



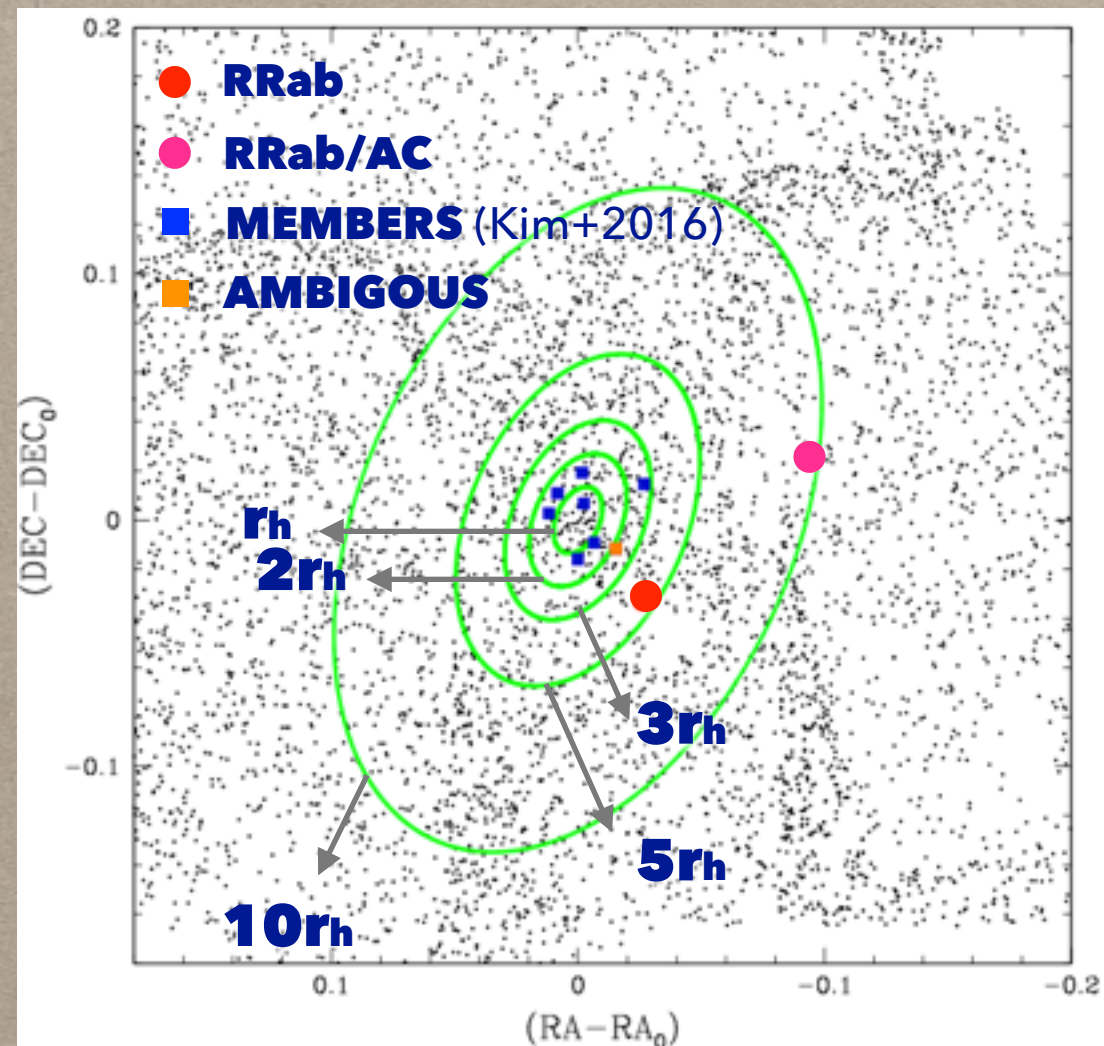
1RRAB → **<5_{rh}**
1RRAB/AC? **10_{rh}**



4 AUXILIARY PHASE-POINTS
FROM SDSS DATA



V2 IS 0.20 mag BRIGHTER THAN V1
(as V4 in PSC II)



DATES

OCTOBER-DECEMBER 2015

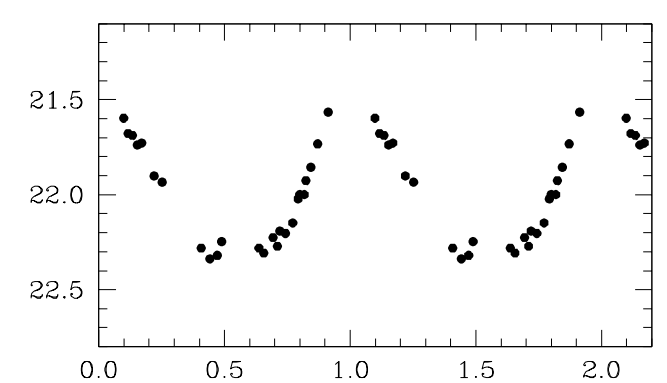
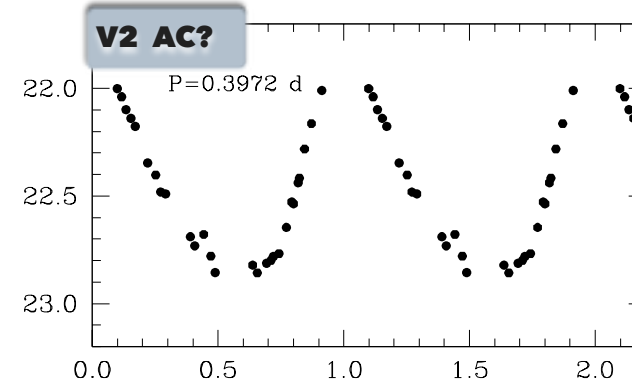
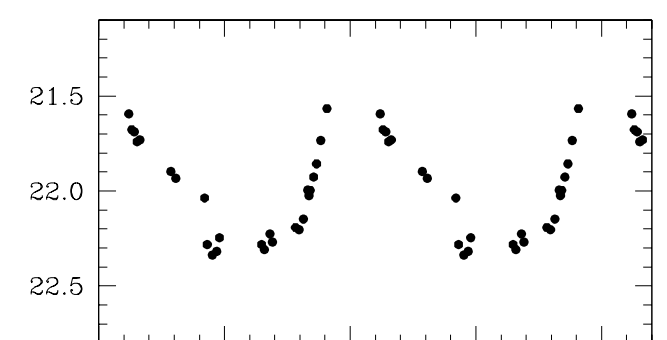
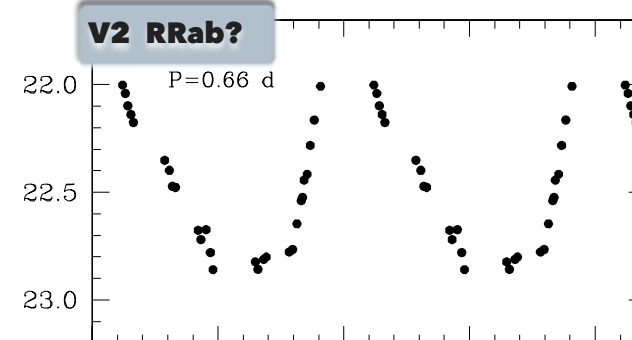
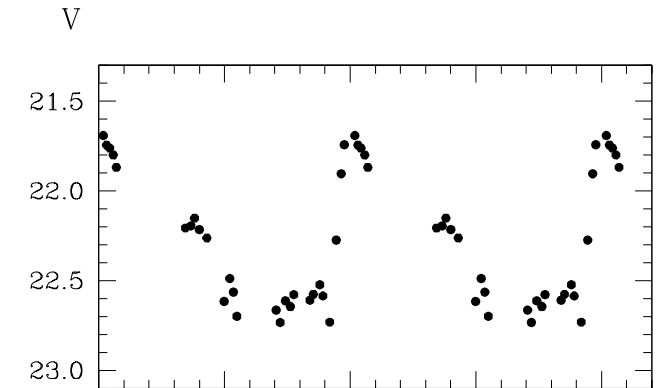
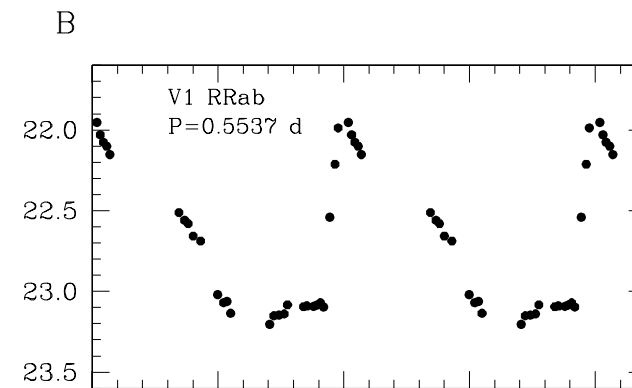
N FILTER

28 B - 28 V

T_{EXP}

180s 0.8-2.2"

SEEING



$rh = 0.85' \pm 0.22'$ (53 ± 14 pc)



DURING PEG III OBSERVATIONS...

PEGASUS III

DATES

N FILTER

T_{EXP}

SEEING

OCTOBER-DECEMBER 2015

28 B - 28 V

180s 0.8-2.2"



1RRAB



<5 r_h

1RRAB/AC?

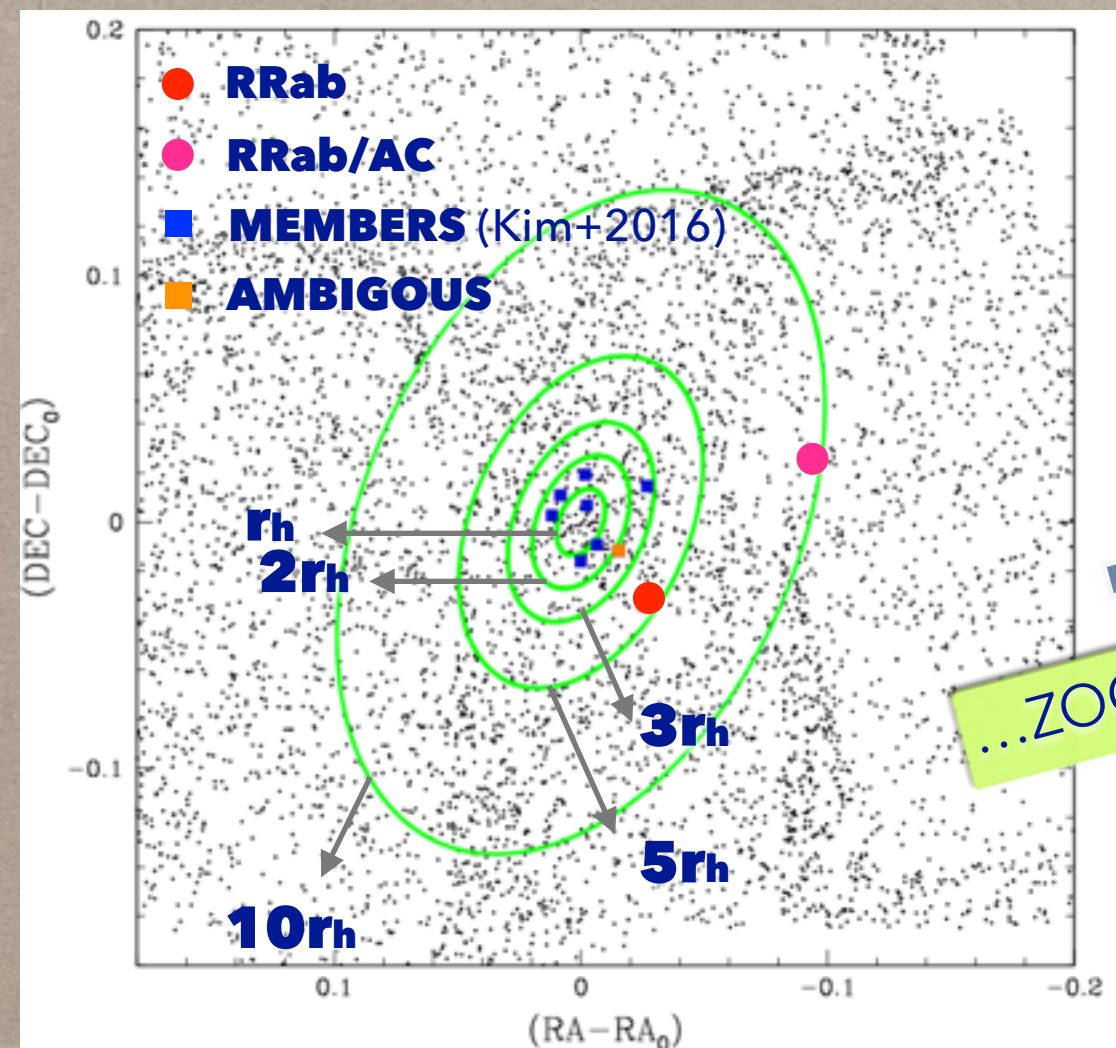
10 r_h



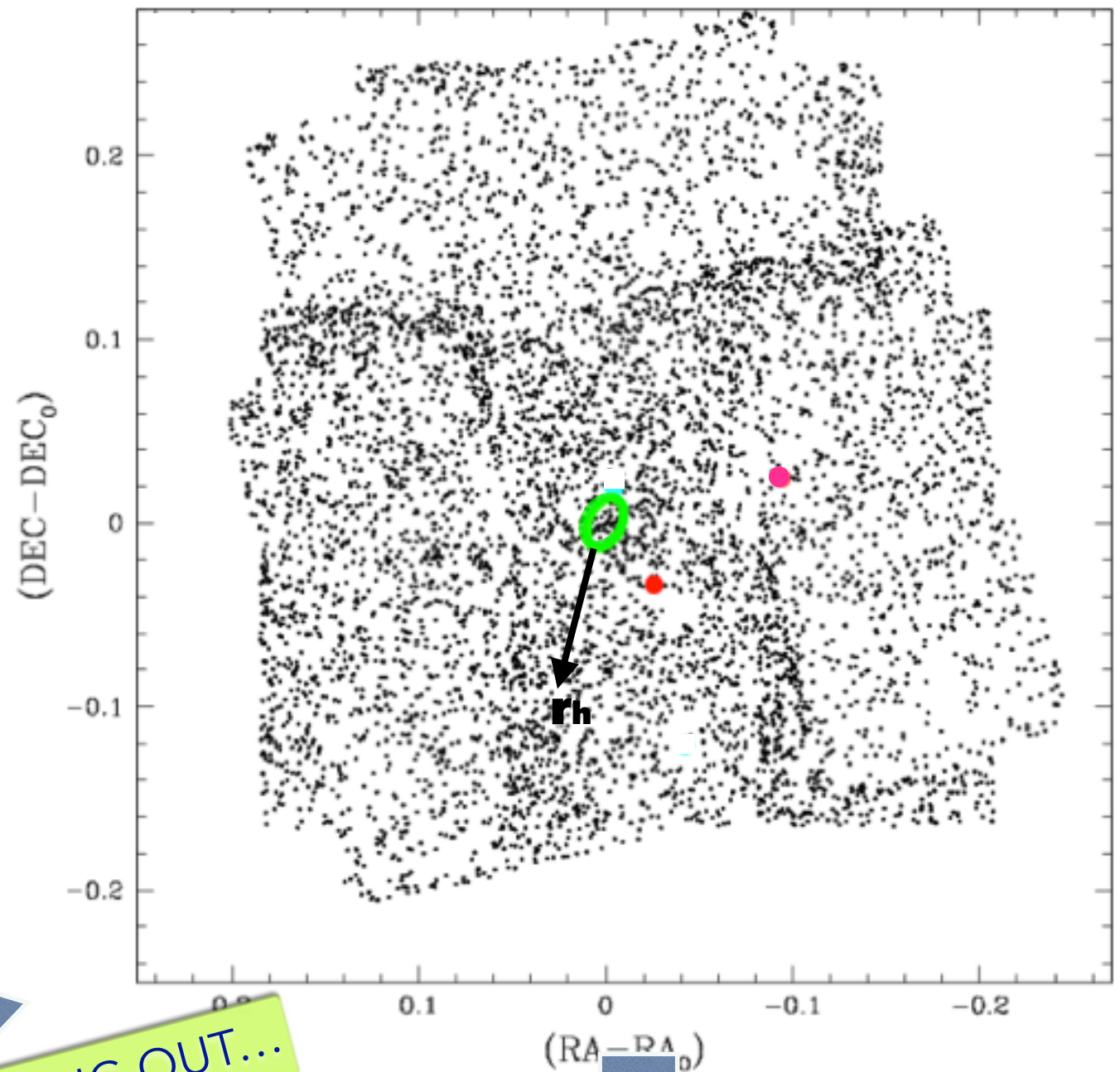
4 AUXILIARY PHASE-POINTS
FROM SDSS DATA



V2 IS 0.20 mag BRIGHTER THAN V1
(as V4 in PSC II)

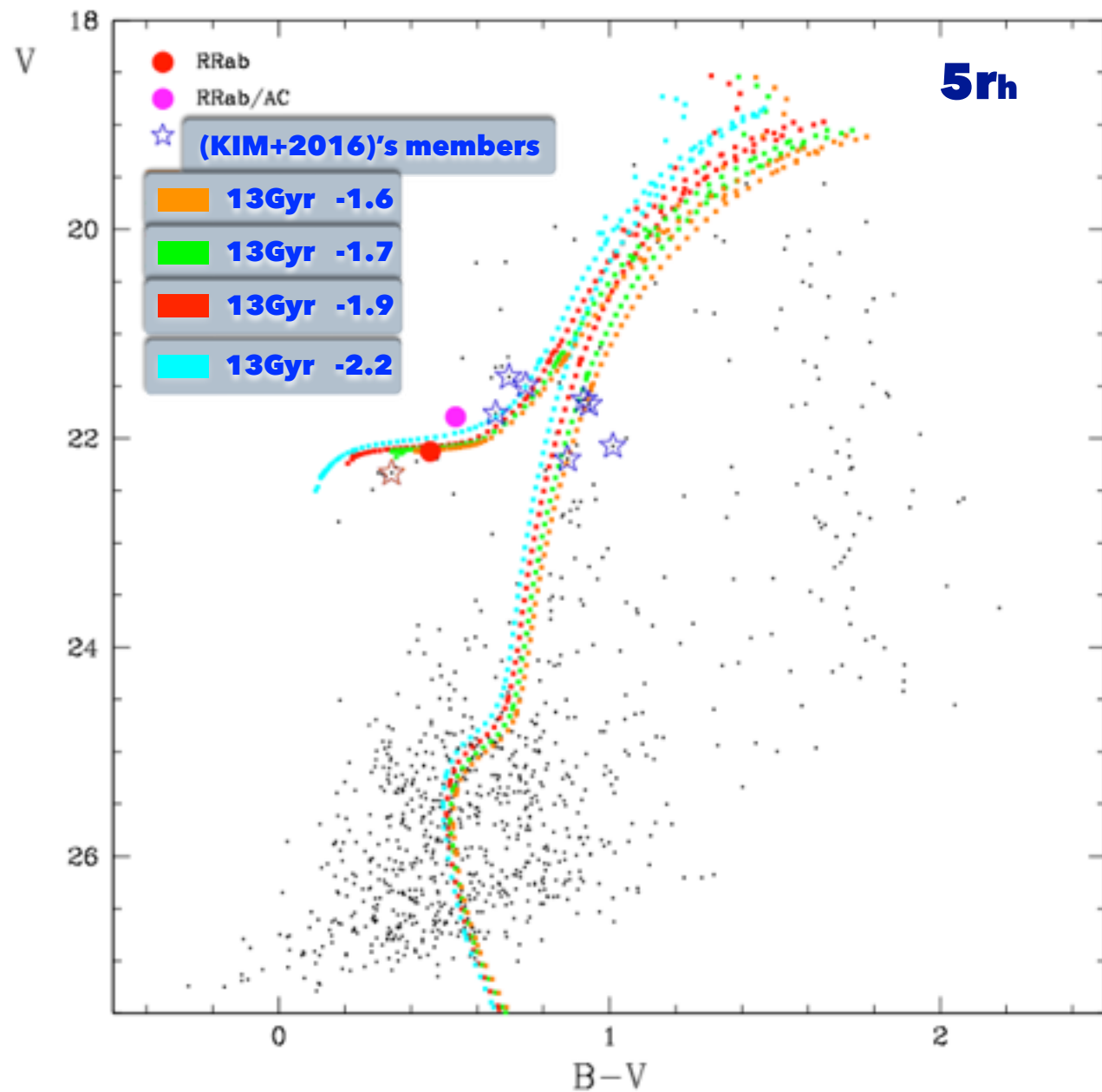


...ZOOMING OUT...



UNREQUESTED ROTATION OF **LBT** !!!

PEGASUS III



$$(m-M)_0 = 21.21 \pm 0.26 \text{ mag}$$



$$\mathbf{d = 174 \pm 21 \text{ kpc}}$$

$$d = 215 \pm 12 \text{ kpc}$$



$$E(B-V) = 0.13 \pm 0.04 \text{ mag}$$



$$E(B-V)_{\text{RR}} = 0.16 \pm 0.05 \text{ mag}$$

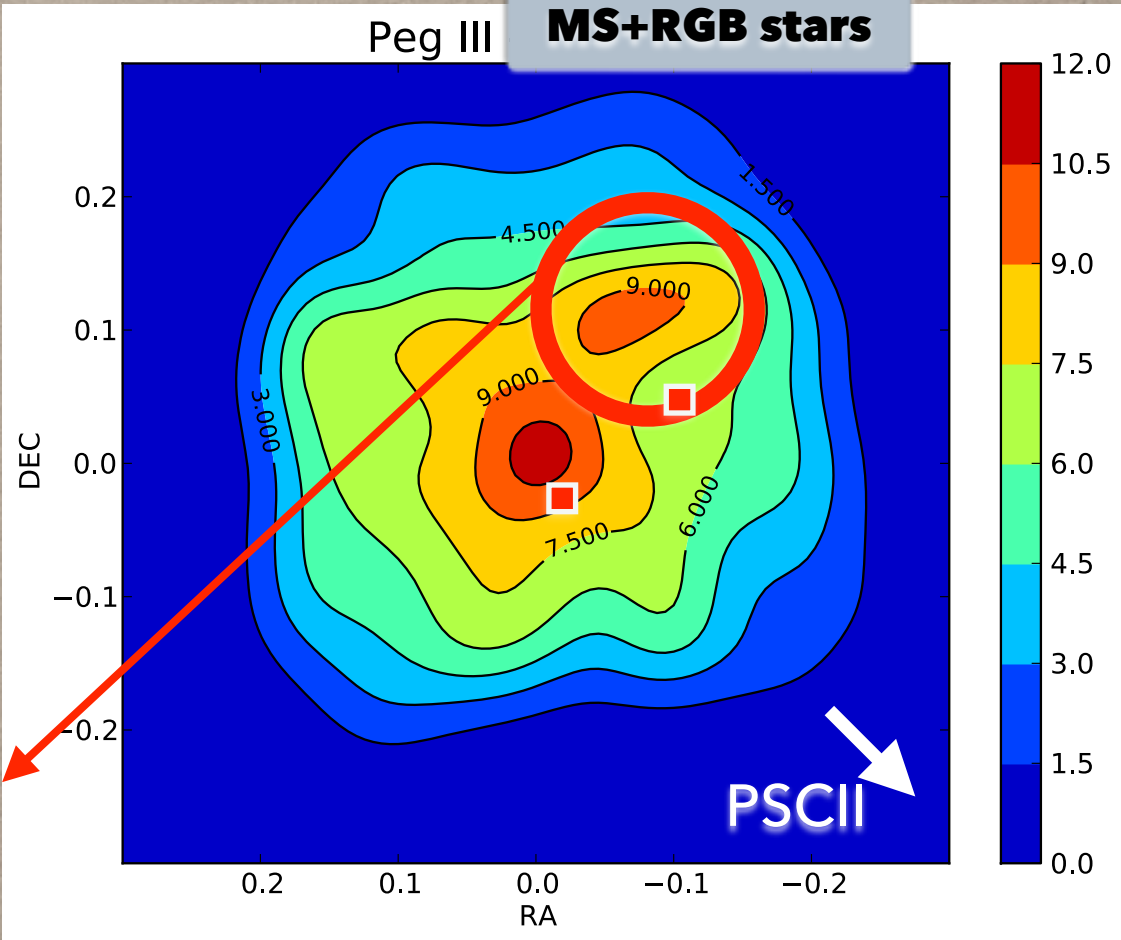
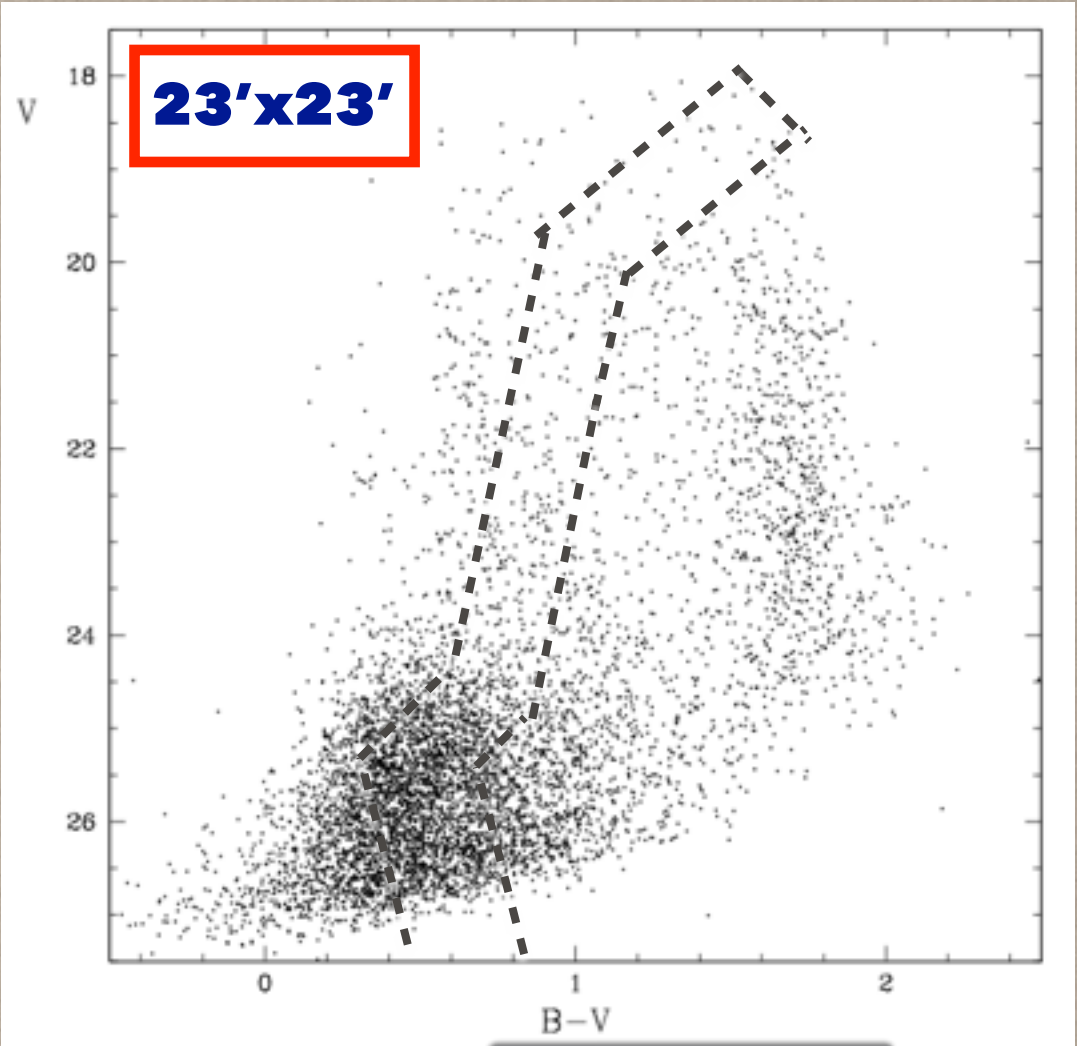
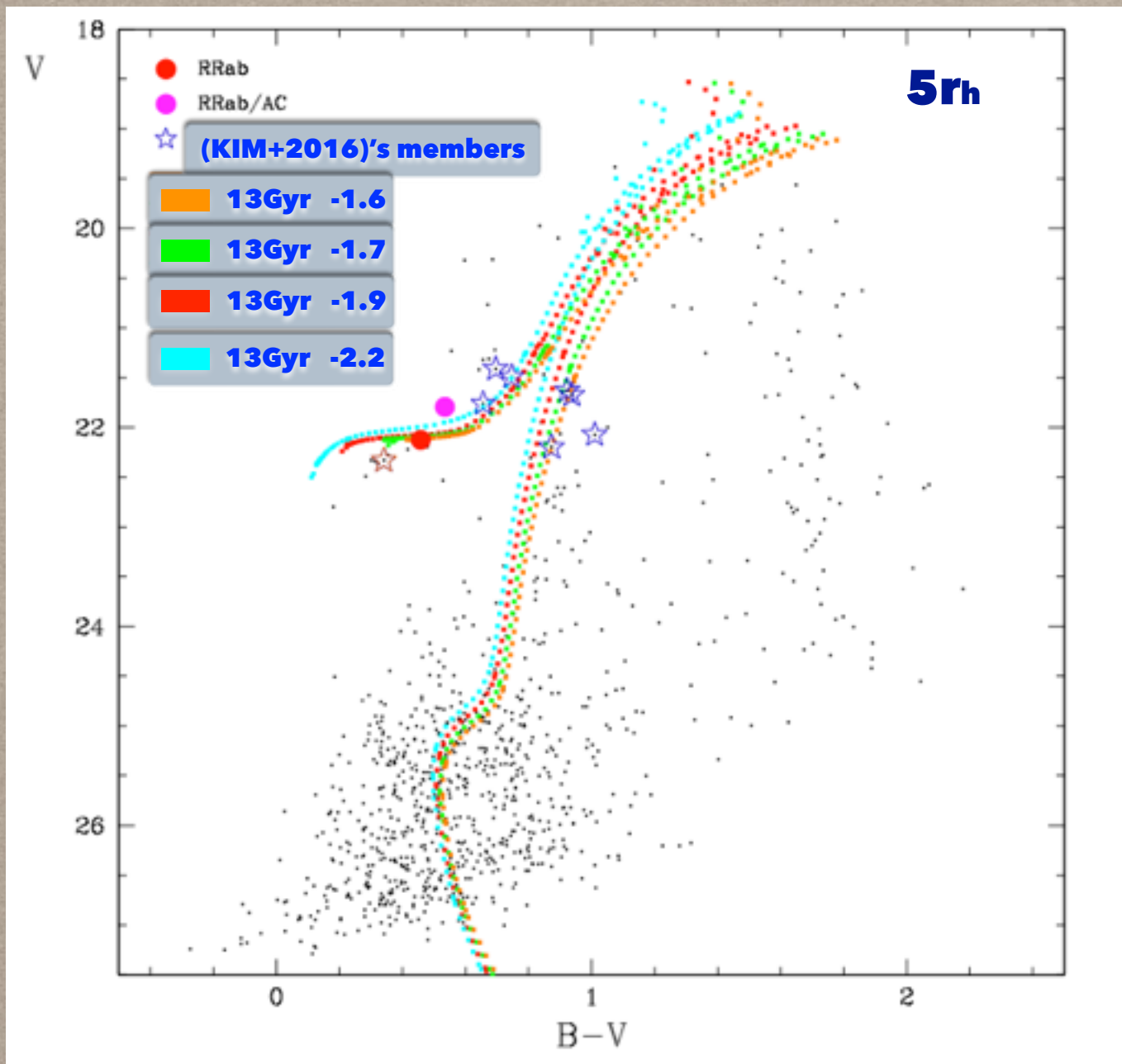


HB + RGB stars best matched:
stellar population 13 Gyr old
with $[\text{Fe}/\text{H}] = -1.7/-1.6$ dex



RIDGE LINES FROM CMD 2.9

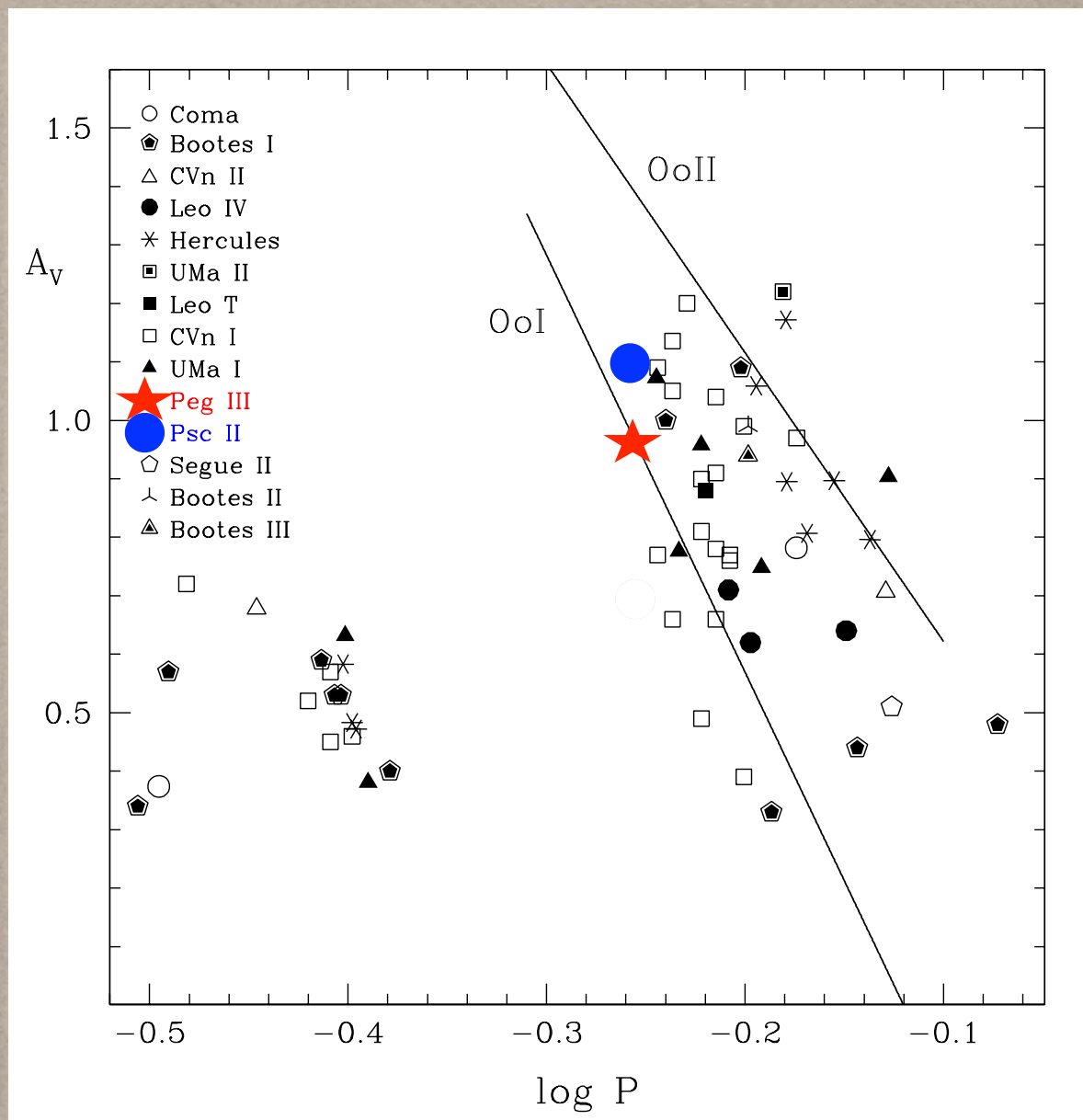
PEGASUS III



RIDGE LINES FROM CMD 2.9

FAKE DUE TO LBT ROTATION

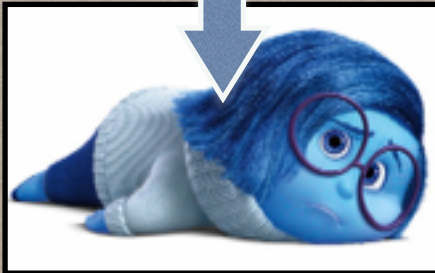
PISCES II & PEGASUS III



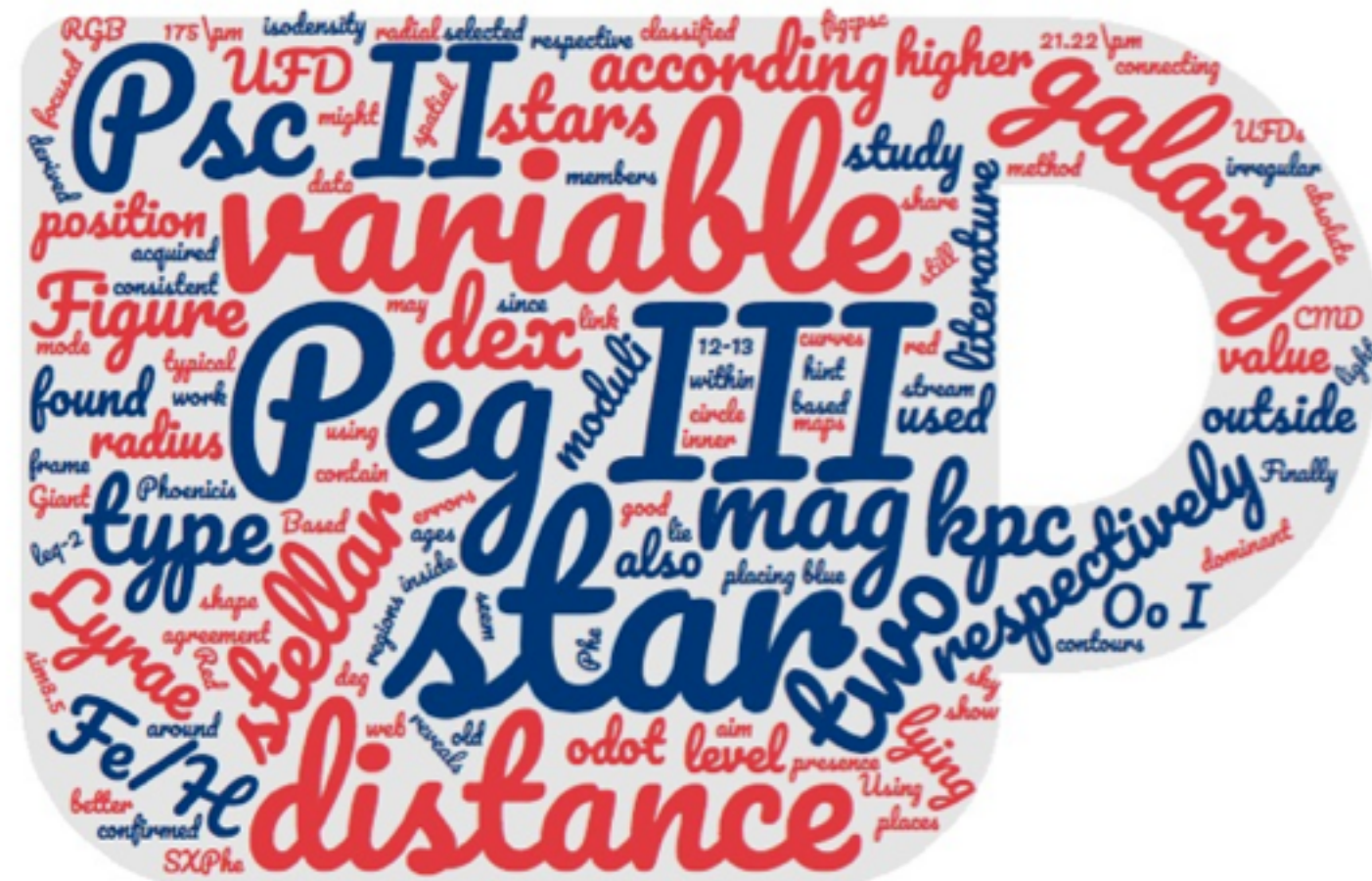
UFDs	# RRL	$\langle P_{ab} \rangle$	Oo-Type
Pisces II	1	0.55	Oo-I
Pegasus III	1	0.55	Oo-I

SUMMARY & RESULTS



- ★ WE IDENTIFIED IN PSC II AND PEG III 3 AND 2 VARIABLE STARS RESPECTIVELY. WE RE-DEFINED THEIR DISTANCES
- ★ THE COMPARISON OF THE CMDS WITH STELLAR ISOCHRONES REVEALS THE PRESENCE OF AN OLD STELLAR POPULATION (12-13 Gyr), WITH $[Fe/H] > -1.8$ dex IN BOTH GALAXIES
➡ higher than the spectroscopic estimates, higher than the typical UFDs metallicity
- ★ WE CLASSIFIED PSC II AND PEG III AS AN OO-I SYSTEMS BASED ON THE PERIOD OF ONLY THE INNER RR LYRAE STAR... THE FIRST UFDs OO-I SYSTEMS
- ★ ISODENSITY CONTOURS DO NOT SEEM TO SHOW EVIDENCE FOR AN IRREGULAR SHAPE WHICH MIGHT HINT TO THE EXISTENCE OF A LINK/STREAM CONNECTING GALAXIES
- ☁ TO BETTER CONSTRAIN UNCERTAIN PERIODS (V4, V2) WE ARE COLLECTING ABOUT NEW 10 PHASE POINTS (**JUNE 2017**) ➡ IMPROVING LIGHT CURVES SAMPLING
A blue cartoon character with long dark hair, wearing red-rimmed glasses and a white shirt, lying on their side with their head down. A blue arrow points from the text "JUNE 2017" to the character.
SEPTEMBER ?
- ★ **THIS IS THE INSTRUMENT, THIS IS THE TIME!**

THANK YOU !



ACs...

▶ M_{ACs} → from 1.8 to 2.2 M_{SUN}

▶ $[Fe/H]_{ACs}$ → > -1.8 dex



Fixed M_{ACs} and $[Fe/H]_{ACs}$

Fixed PISCES II / PEGASUS III distance

a) Adopting EVOLUTIVE TRACKS FROM **BASTI (Pietrinferni+2004)**



NO AC belonging to PISCES II / PEGASUS III → AC field (background)?

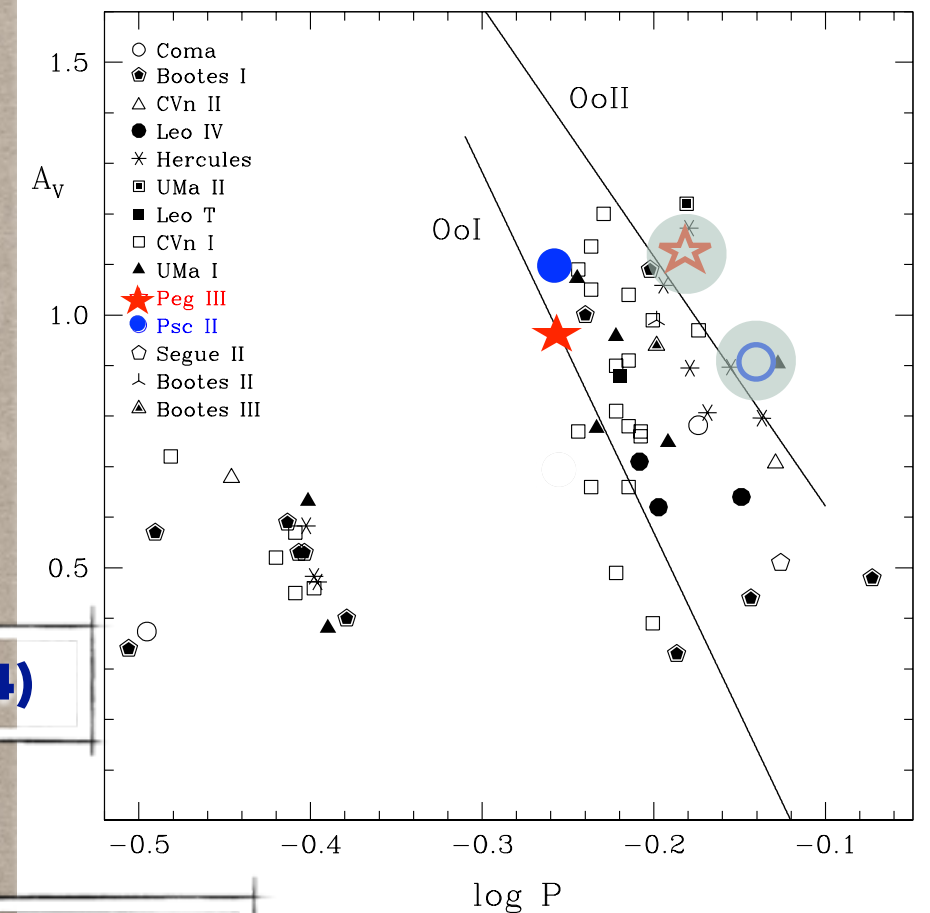
b) Adopting PERIOD-WESENHEIT RELATION for ACs



YES, AC belonging to PISCES II / PEGASUS III

TOTALLY IN DISAGREEMENT

... OR RRLs?

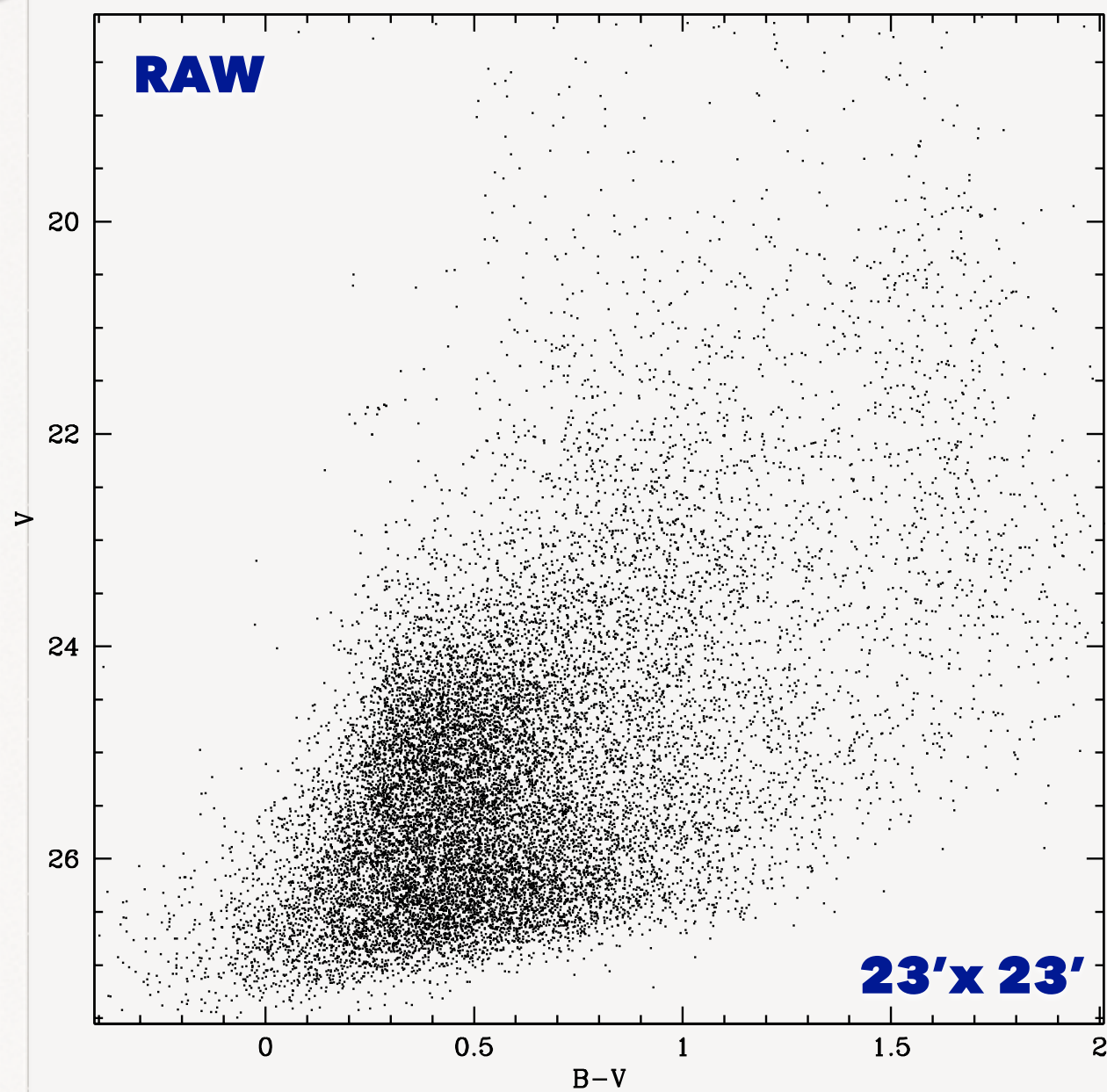


V2 AND V4 are about 0.2 mag
BRIGHTER THAN inner RRLs



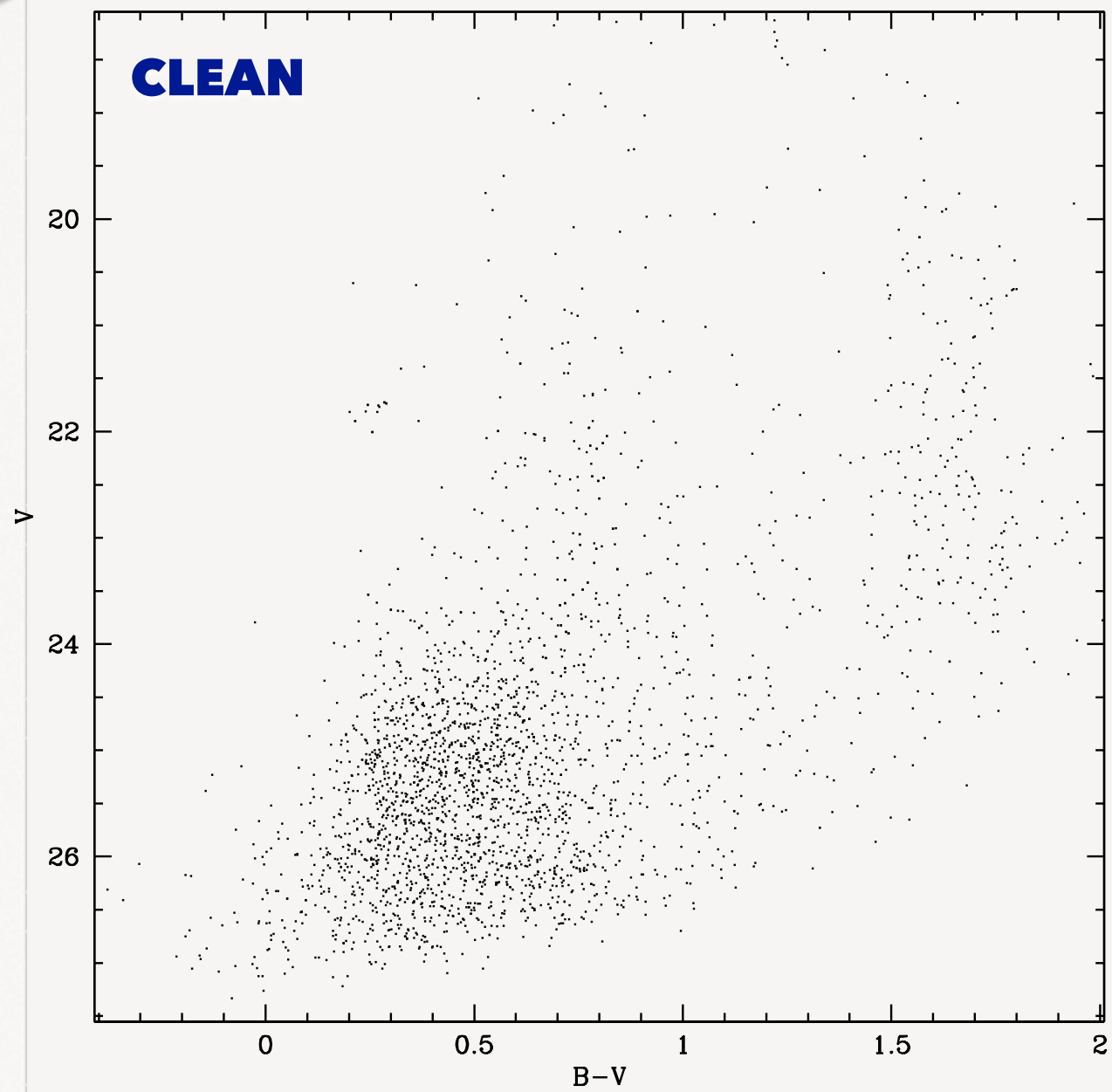
RRL field (foreground)? → Oo-II

PISCES II

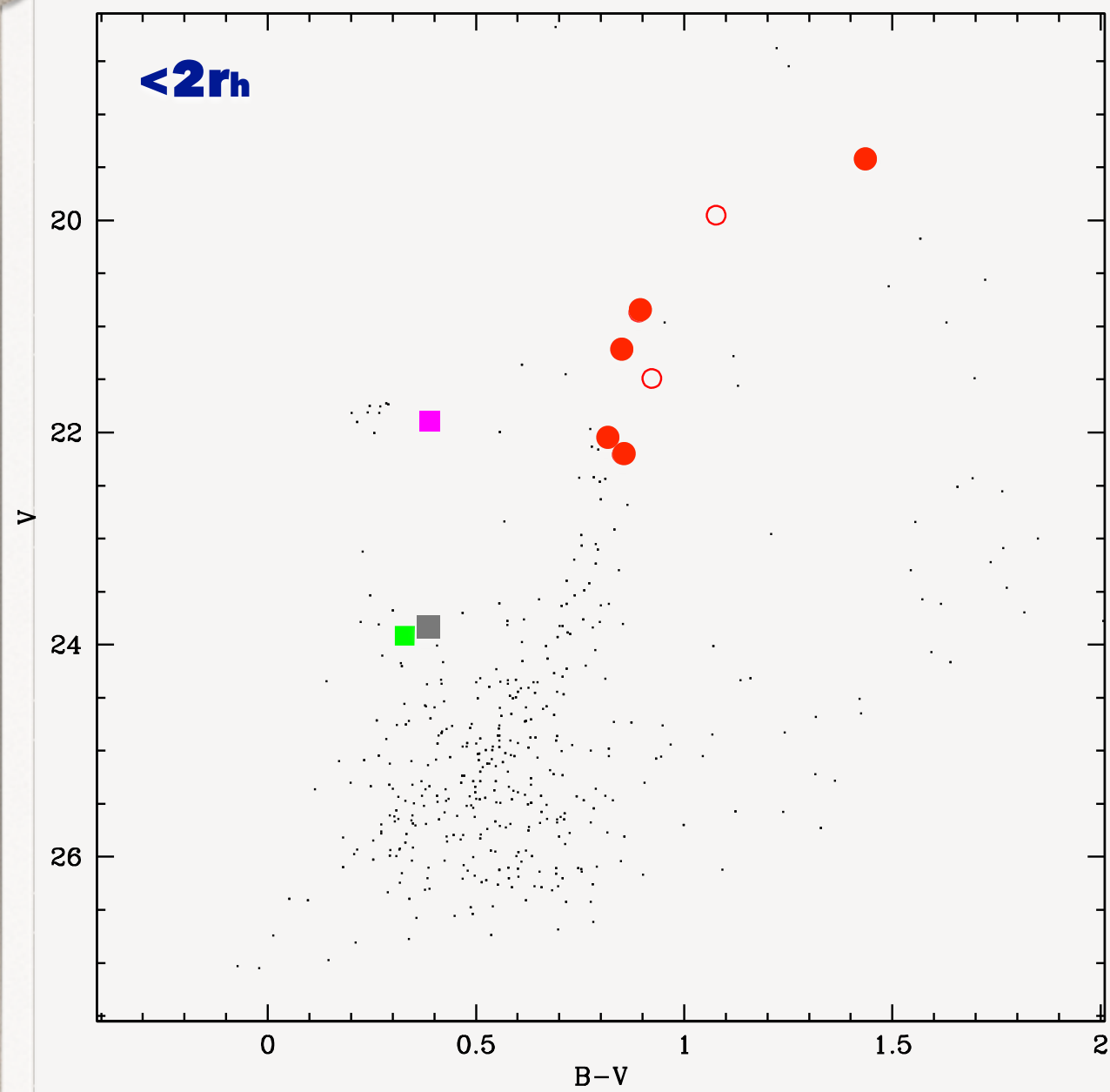


CORRECTION FOR **DAOPHOT** QUALITY IMAGE PARAMETERS

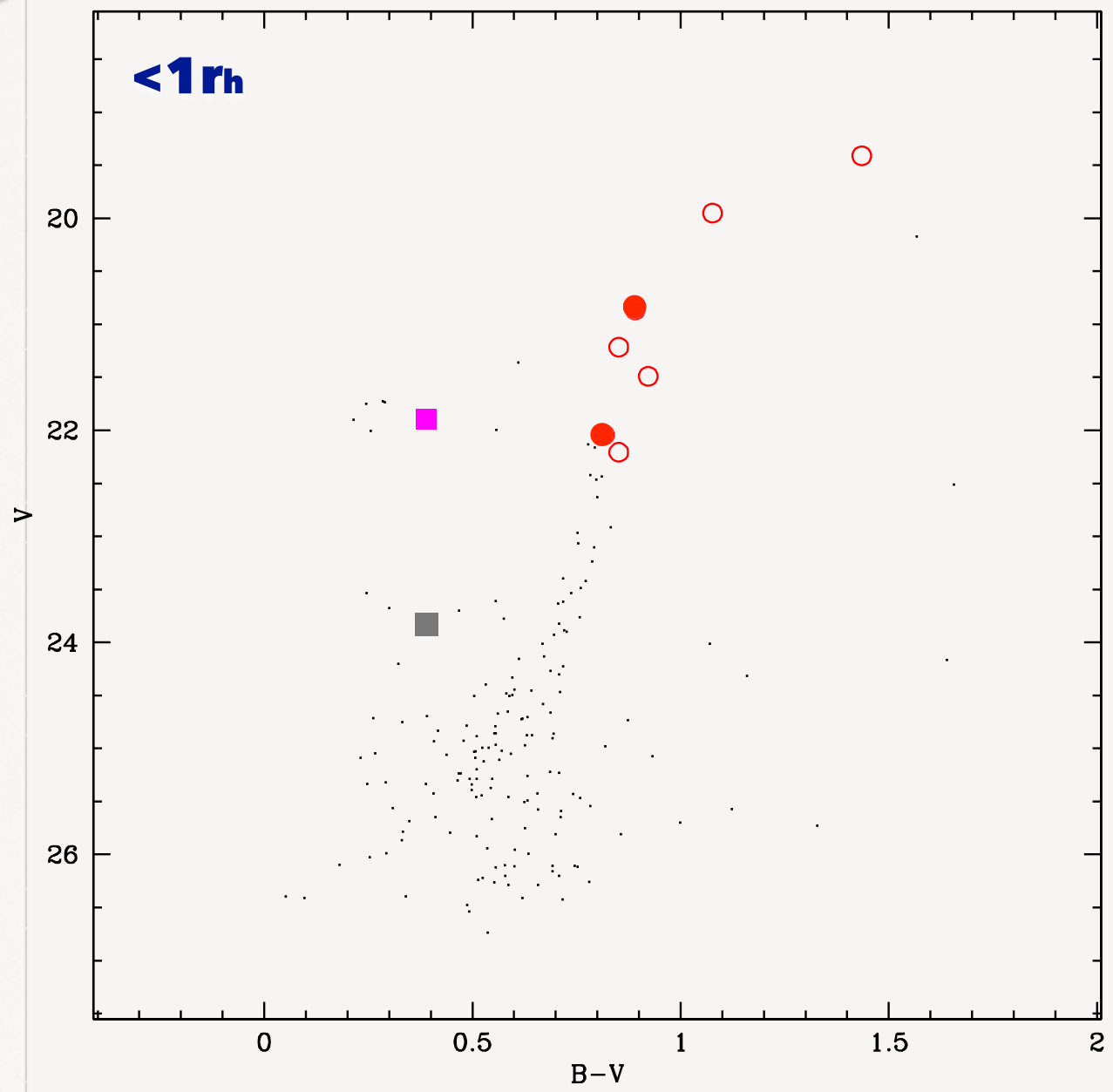
PISCES II



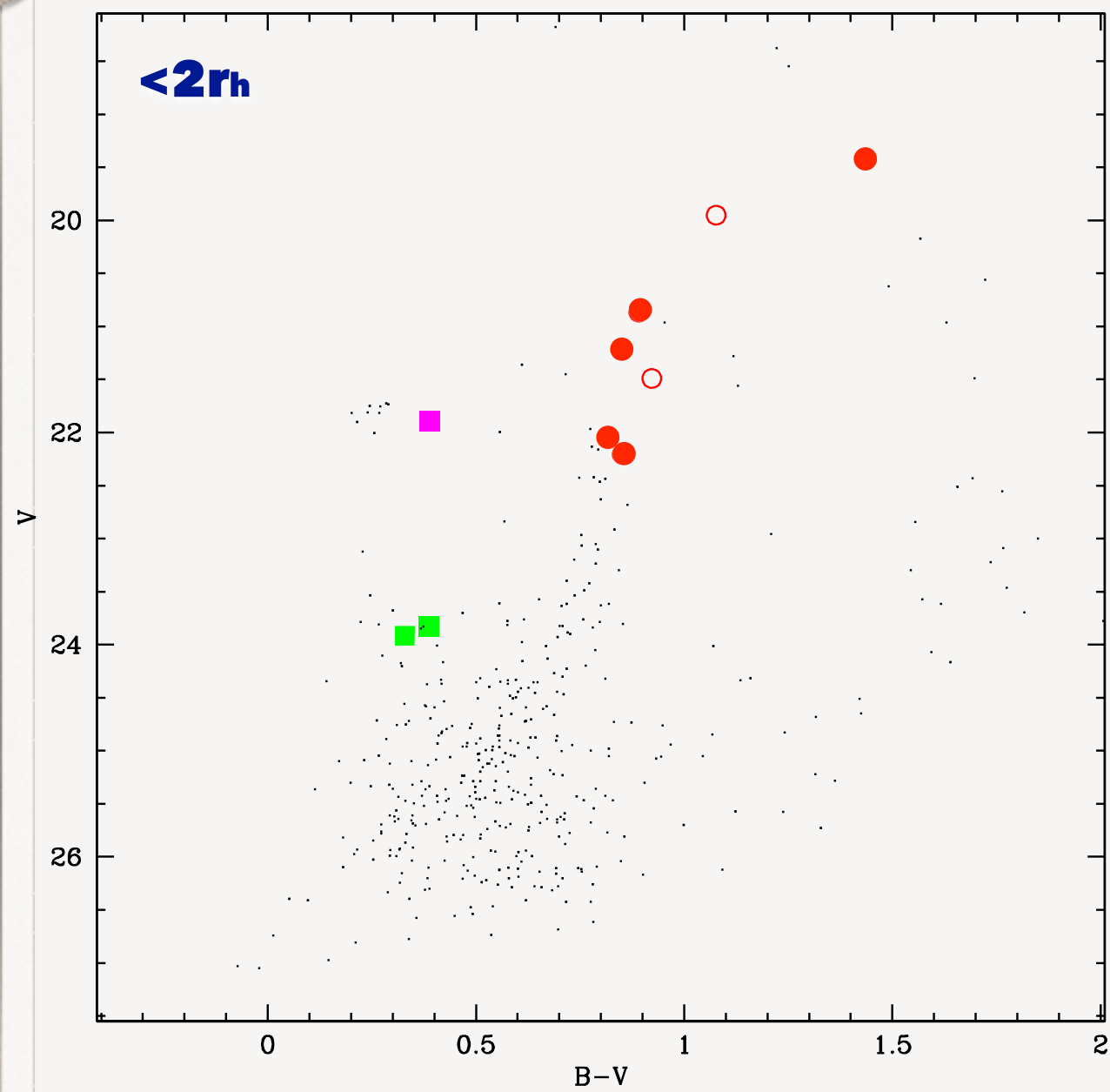
PISCES II



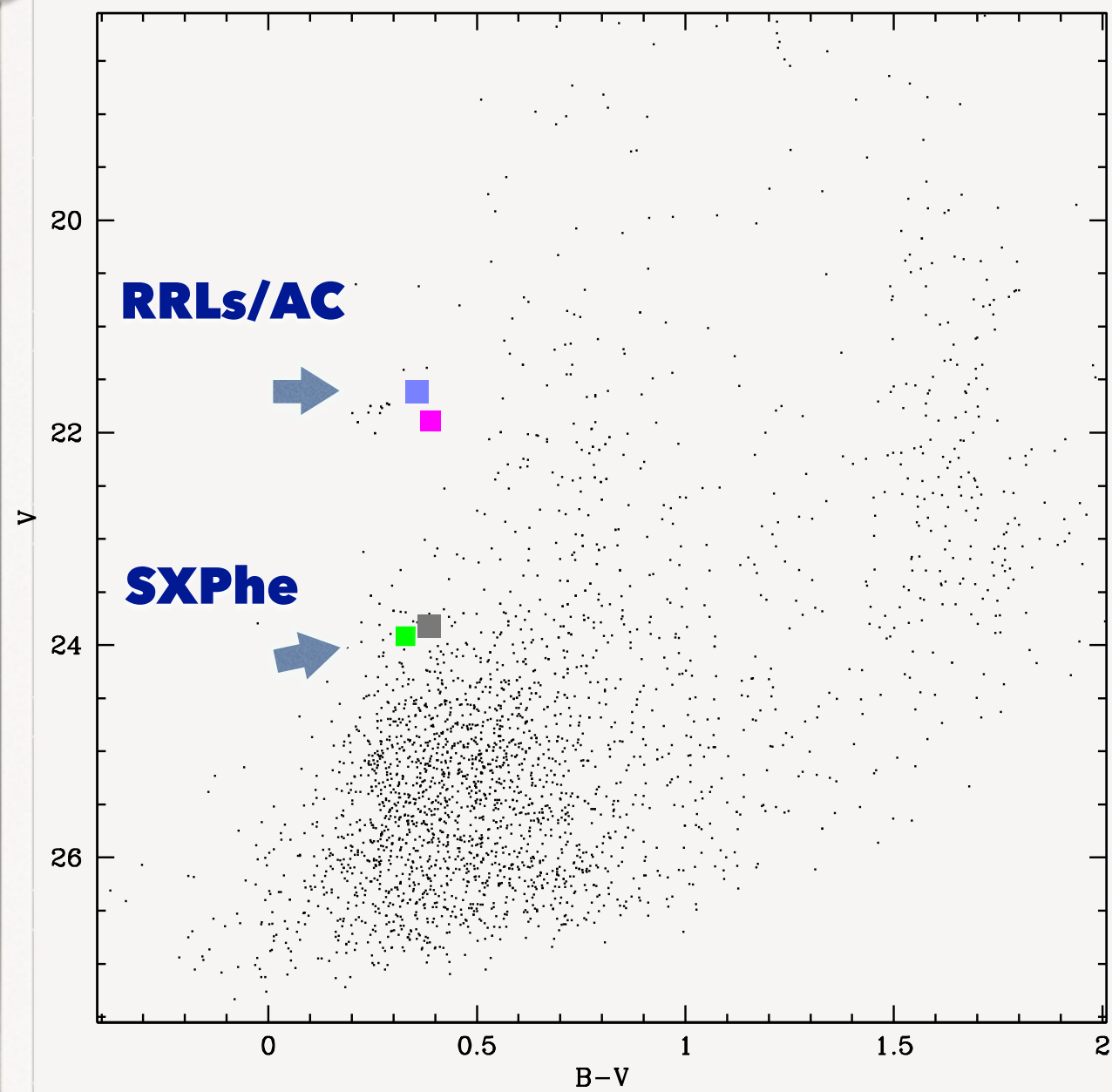
PISCES II



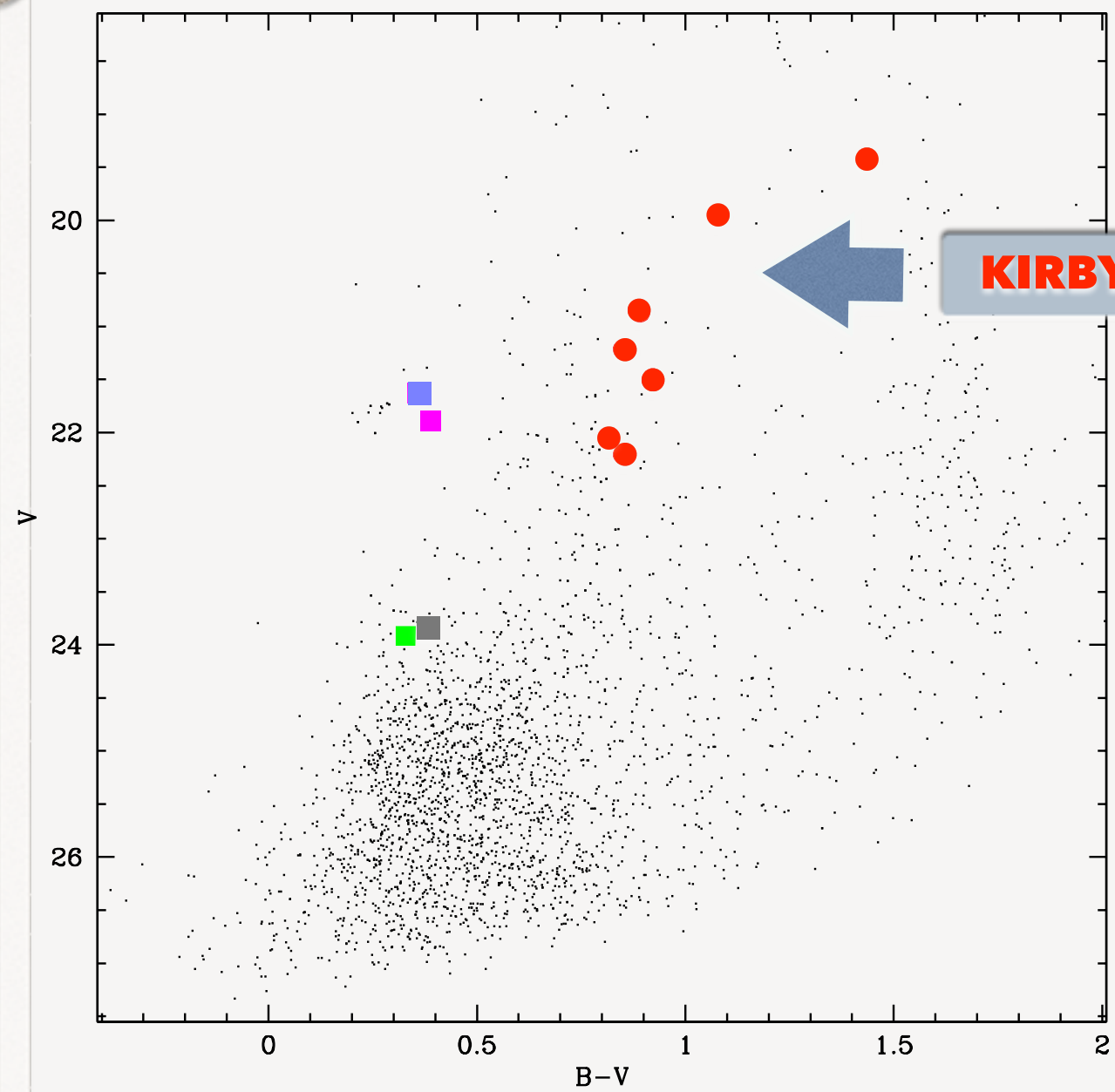
PISCES II

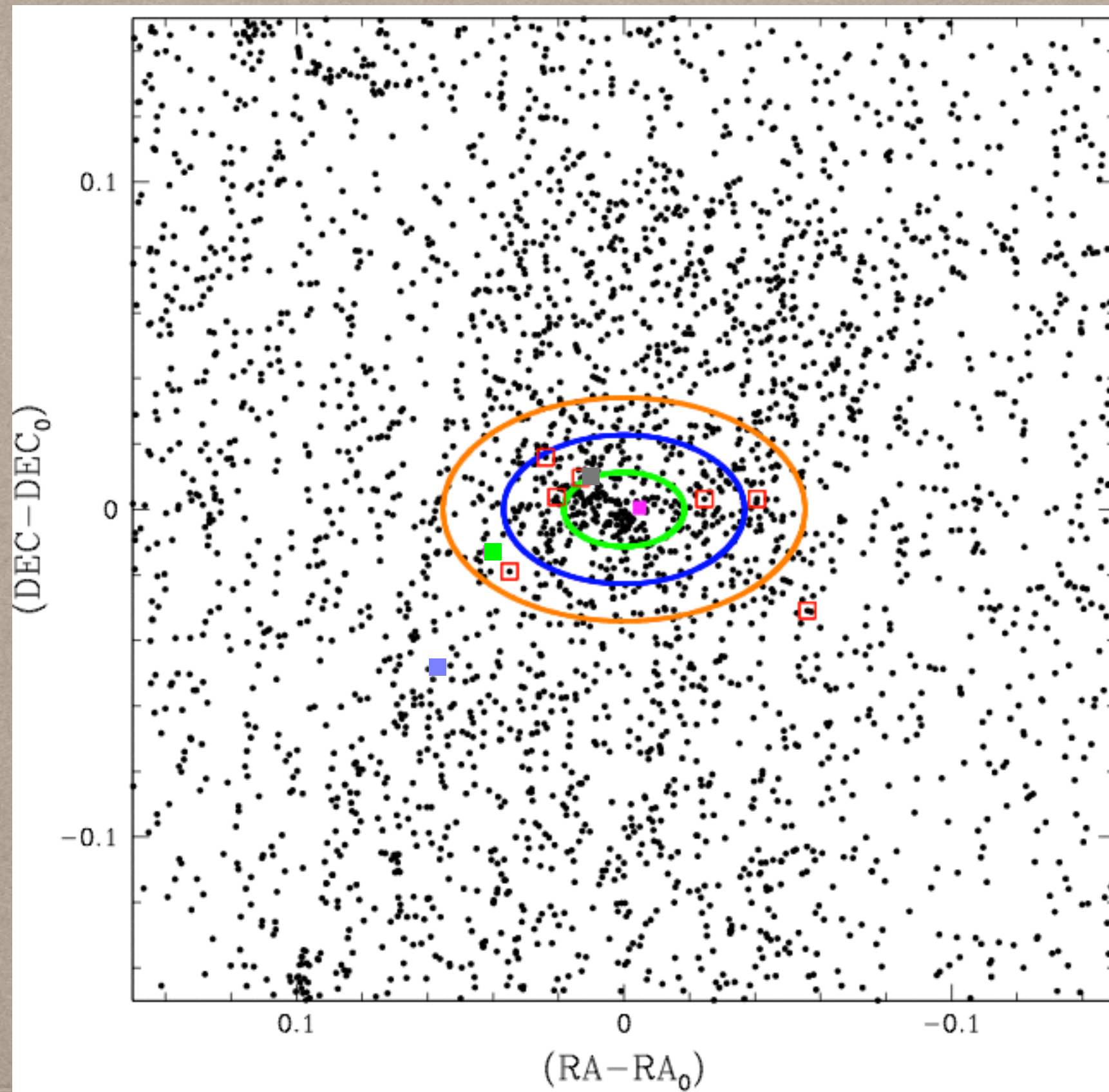


PISCES II

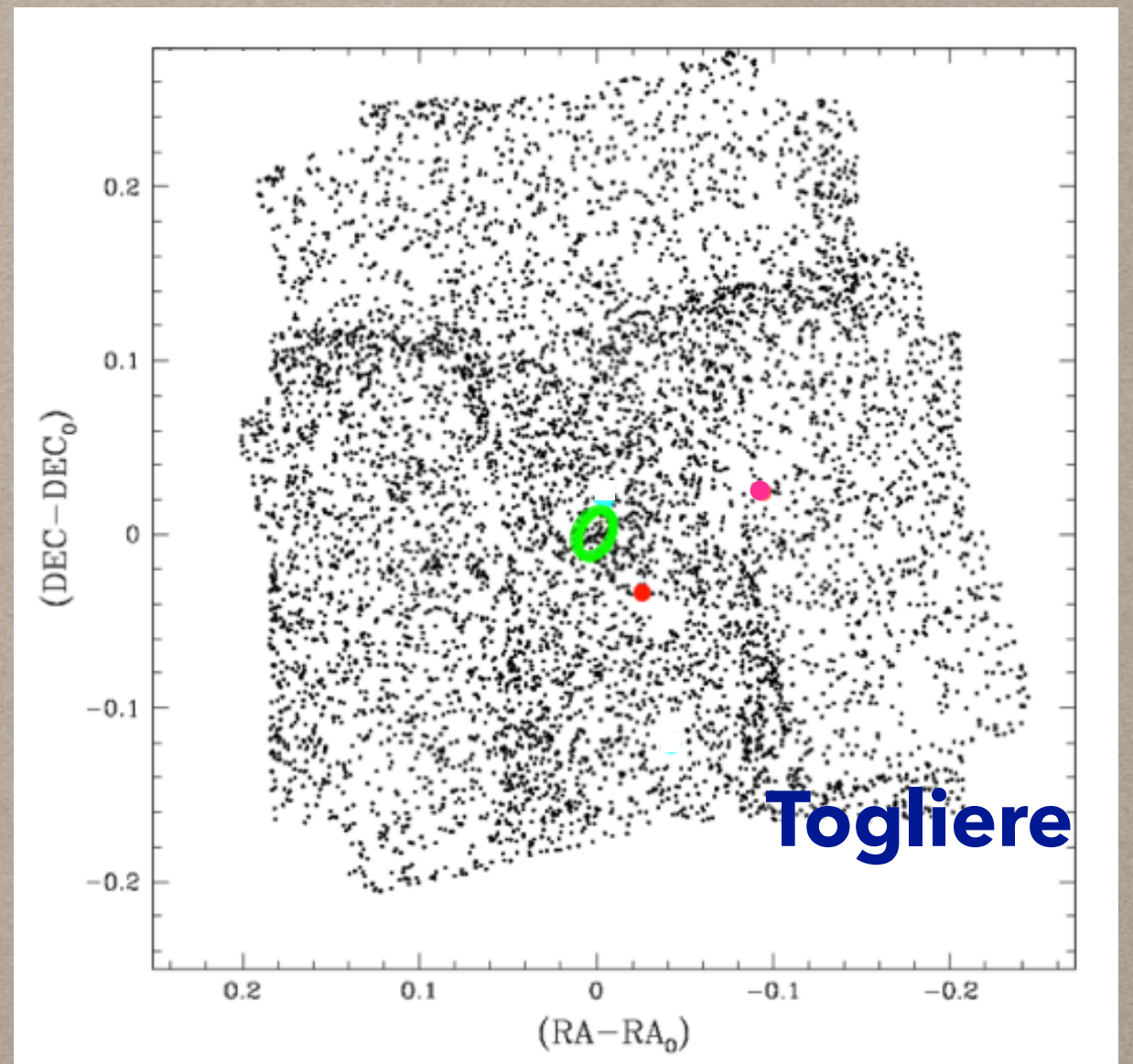
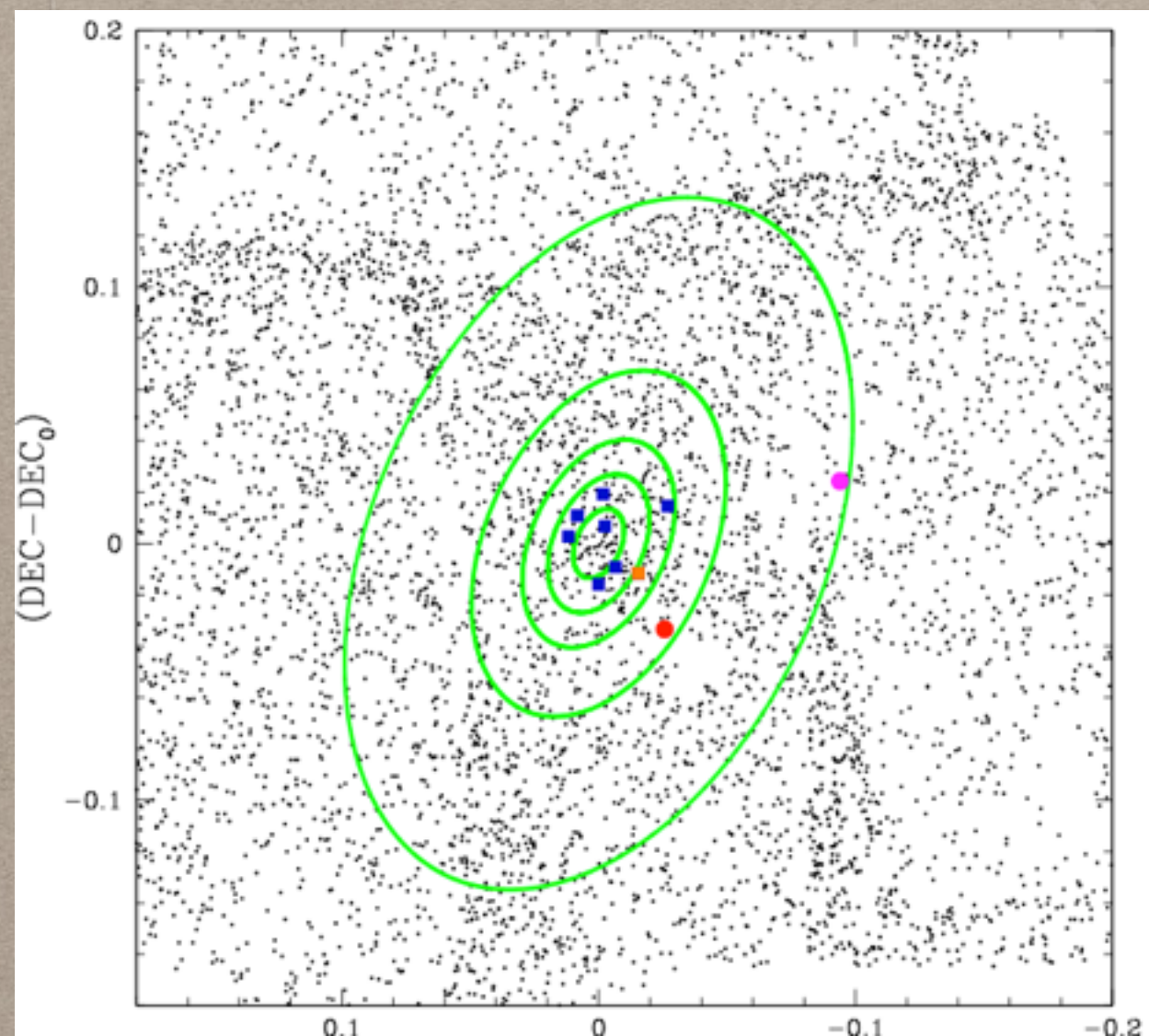


PISCES II





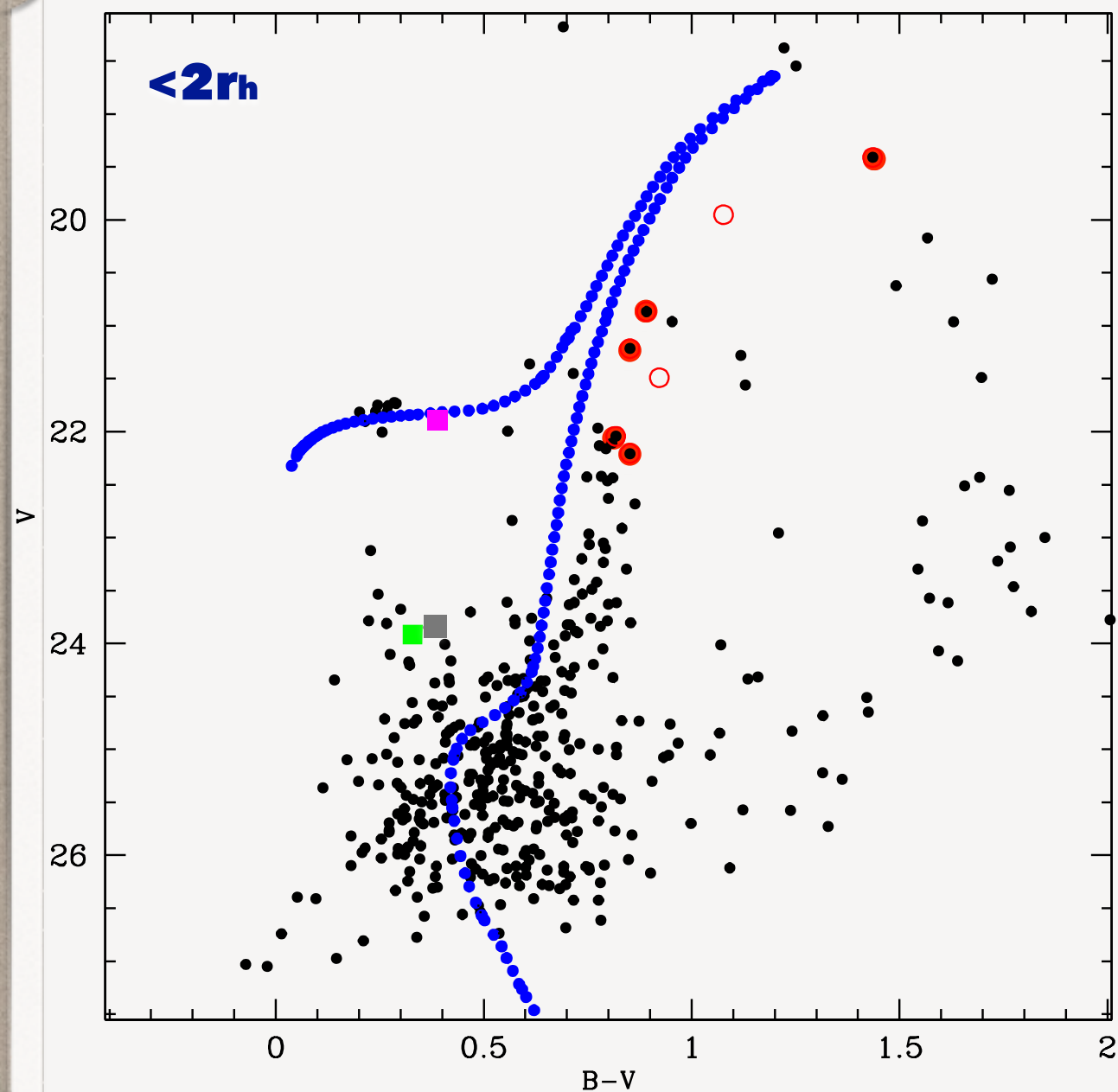
Togliere



Togliere

PISCES II

13Gyr -2.3



$$(m-M)_0 = 21.22 \pm 0.14 \text{ mag}$$



$$d = 175 \pm 11 \text{ kpc}$$



$$E(B-V) = 0.056 \pm 0.052 \text{ mag}$$



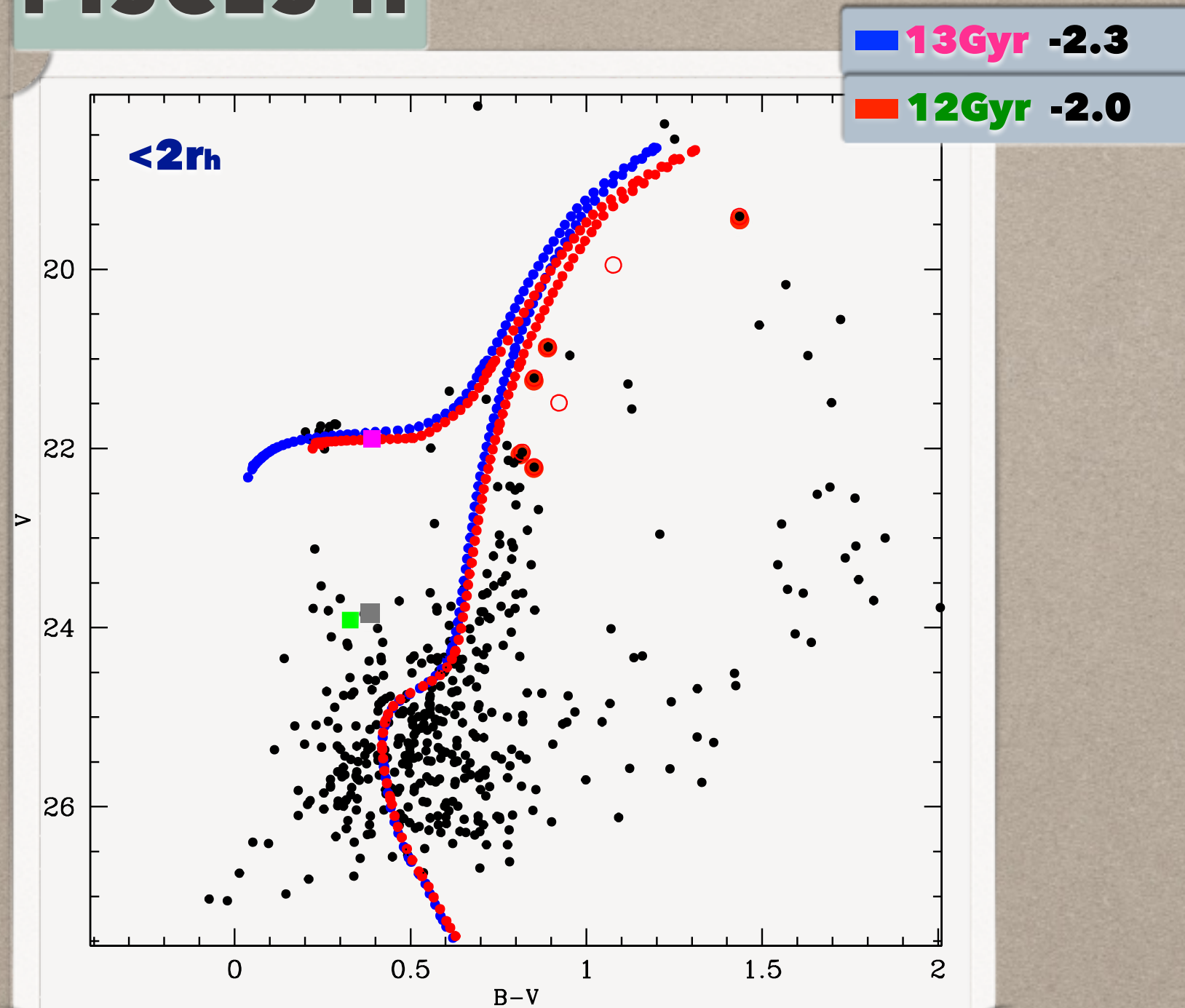
$$E(B-V)_{\text{RR}} = 0.052 \pm 0.023 \text{ mag}$$

(Piersimoni+02)



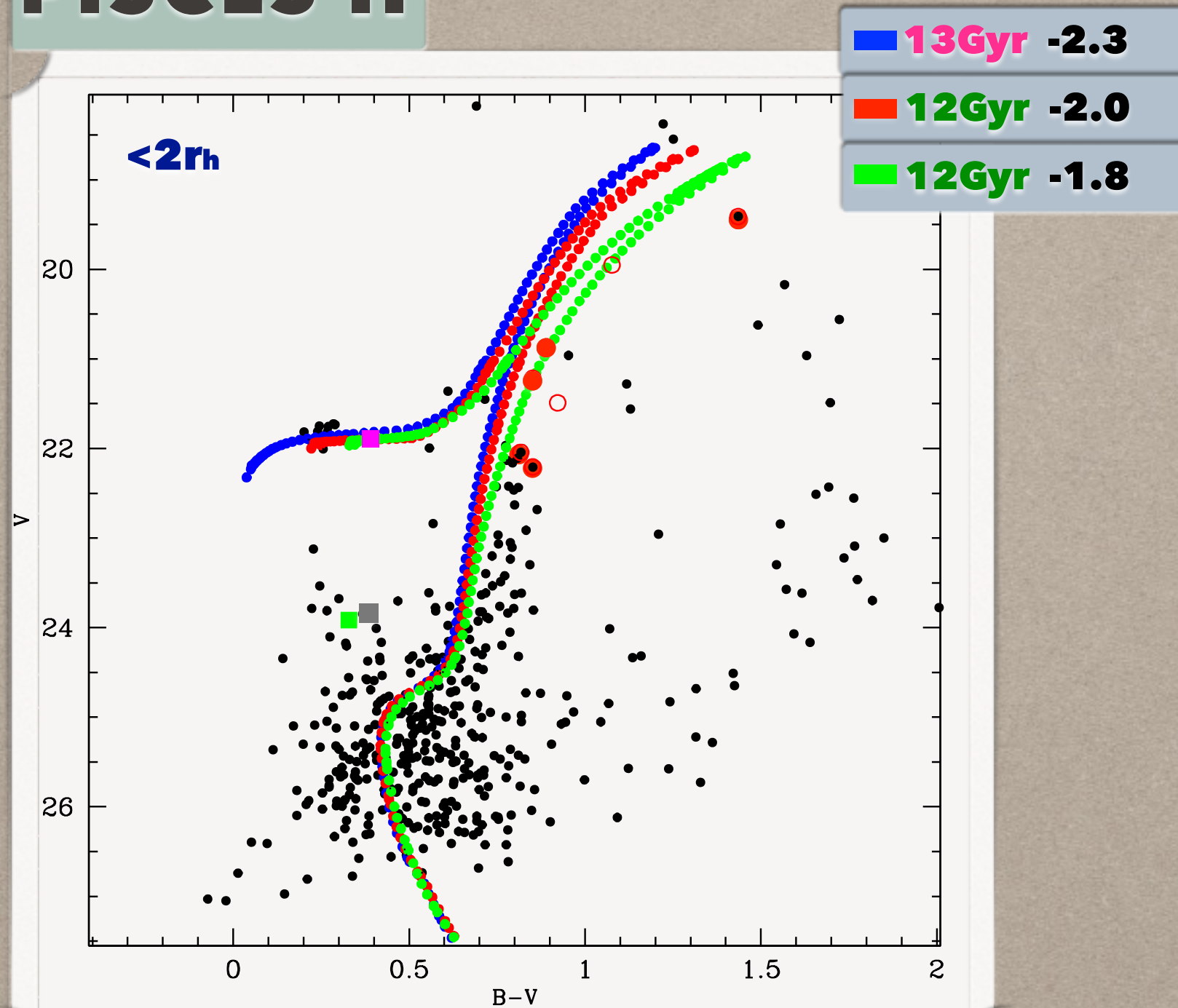
RIDGE LINES FROM CMD 2.7 **(Bressan+12)**

PISCES II



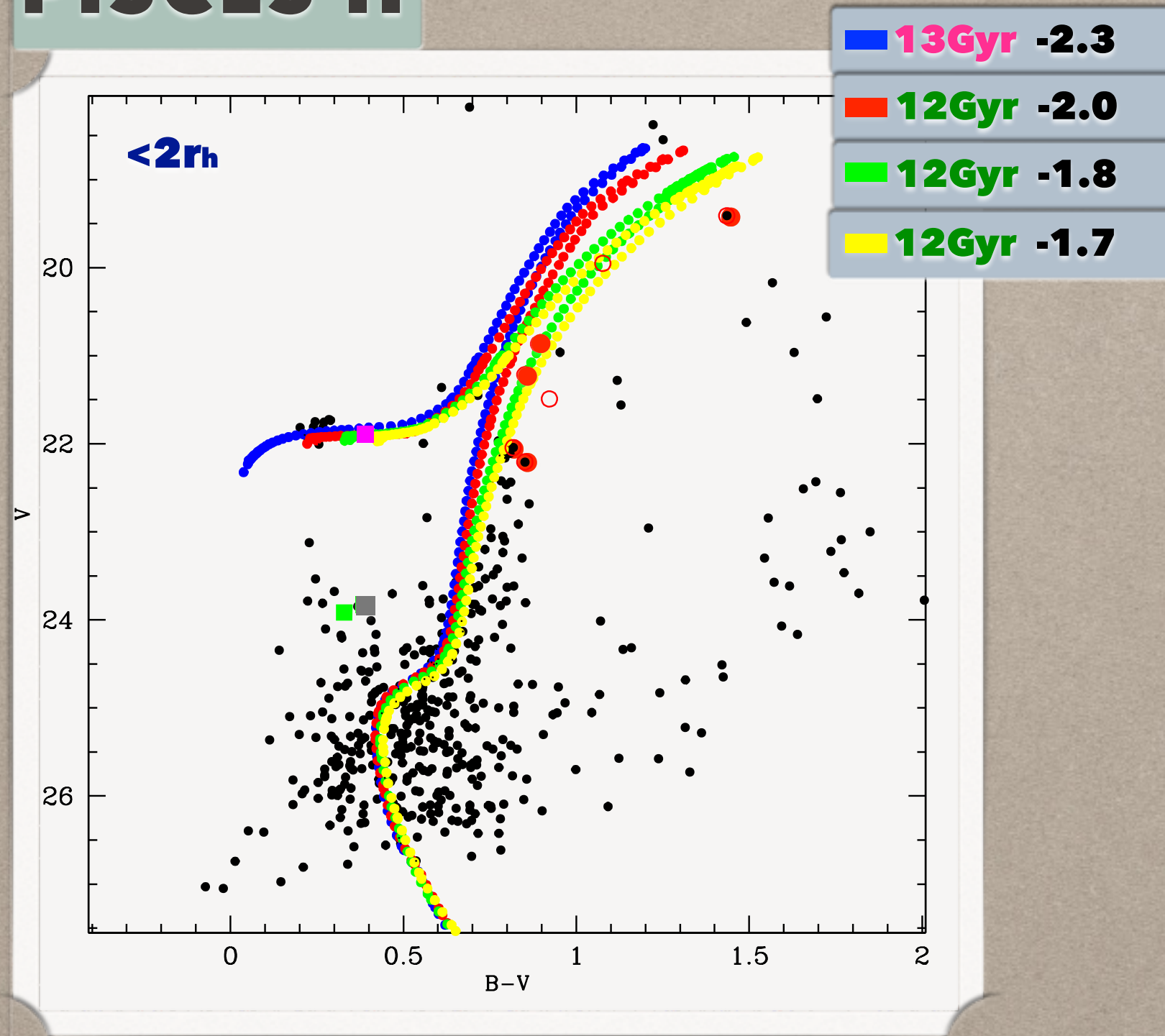
RIDGE LINES FROM CMD 2.7 (**Bressan+12**)

PISCES II



RIDGE LINES FROM CMD 2.7 (**Bressan+12**)

PISCES II



RIDGE LINES FROM CMD 2.7 (**Bressan+12**)