The Star Formation History of (some) Local Group dwarf galaxies

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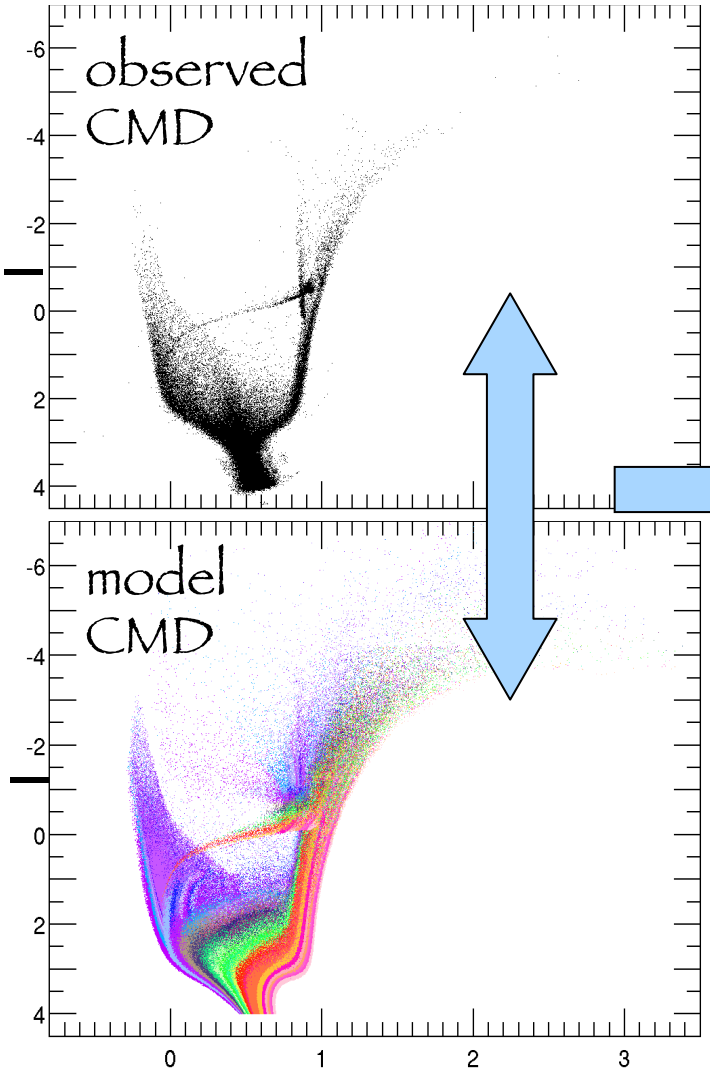
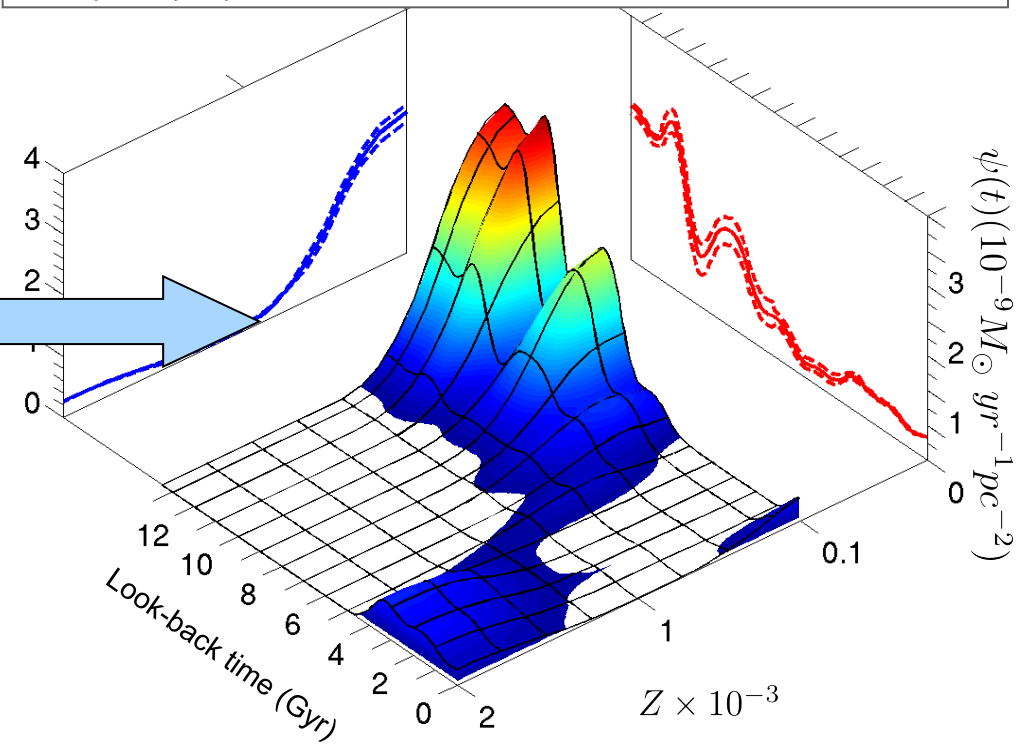
Retrieving Star Formation History of Resolved Systems



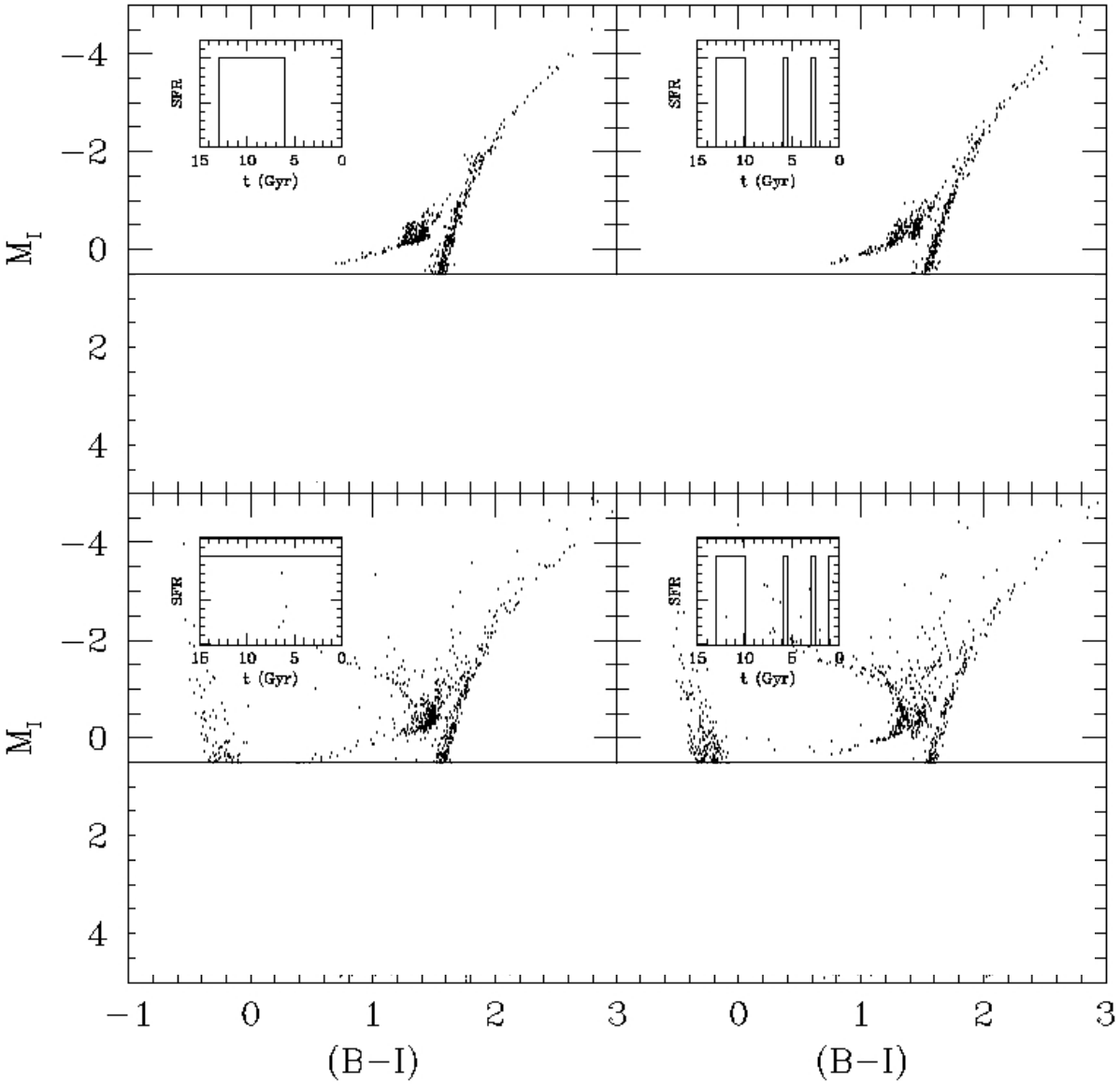
The distribution of stars in the observed CMD is compared with that of a number of *simple populations* in a model CMD.



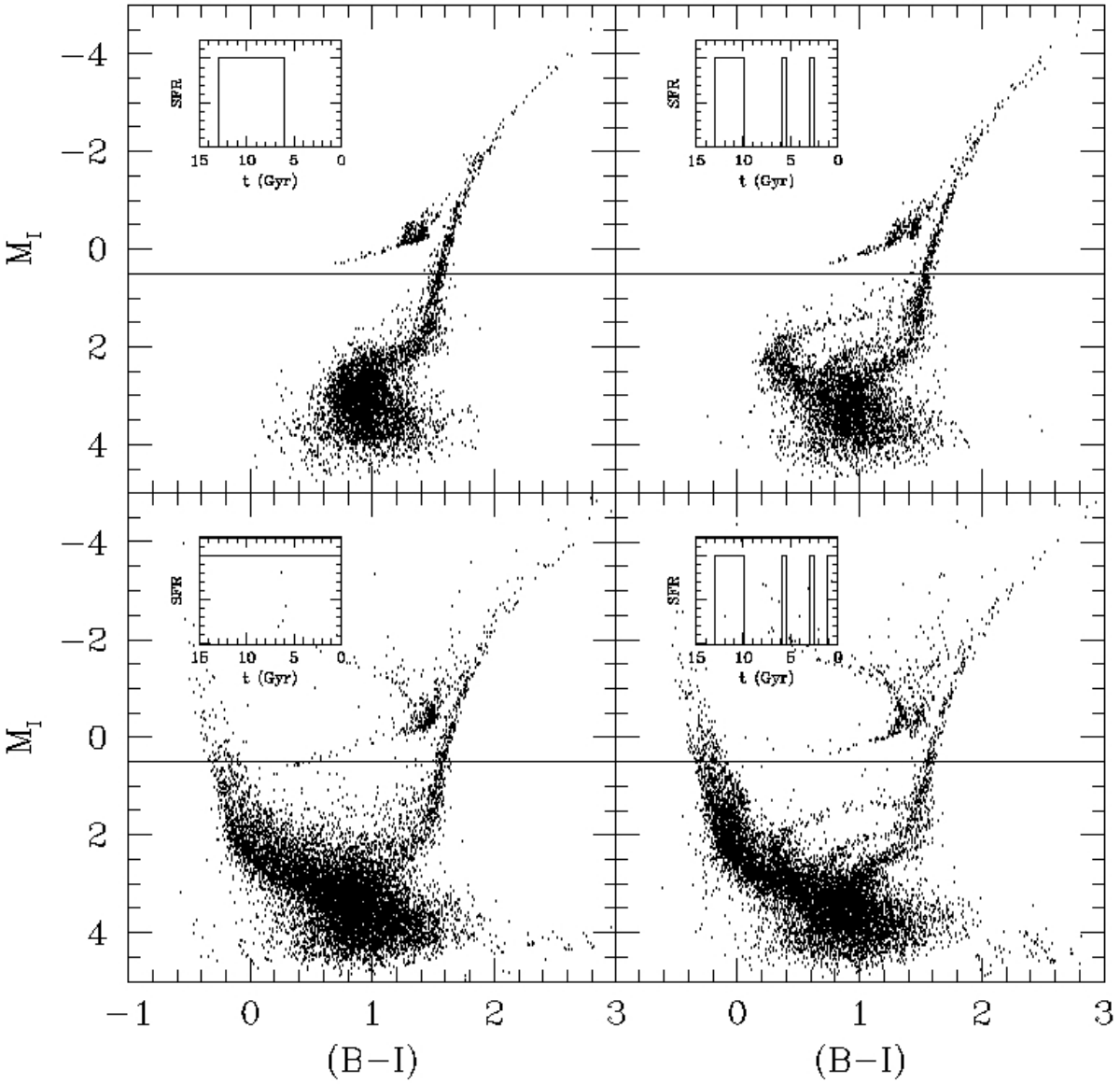
Aparicio & Gallart (2004)
Aparicio & Hidalgo (2009)

By using a merit function, we obtain the combination of simple stellar populations that best reproduces the observed CMD, i.e., the star formation rate and the chemical evolution law, as a function of time.

The importance of accurate photometry of TO stars

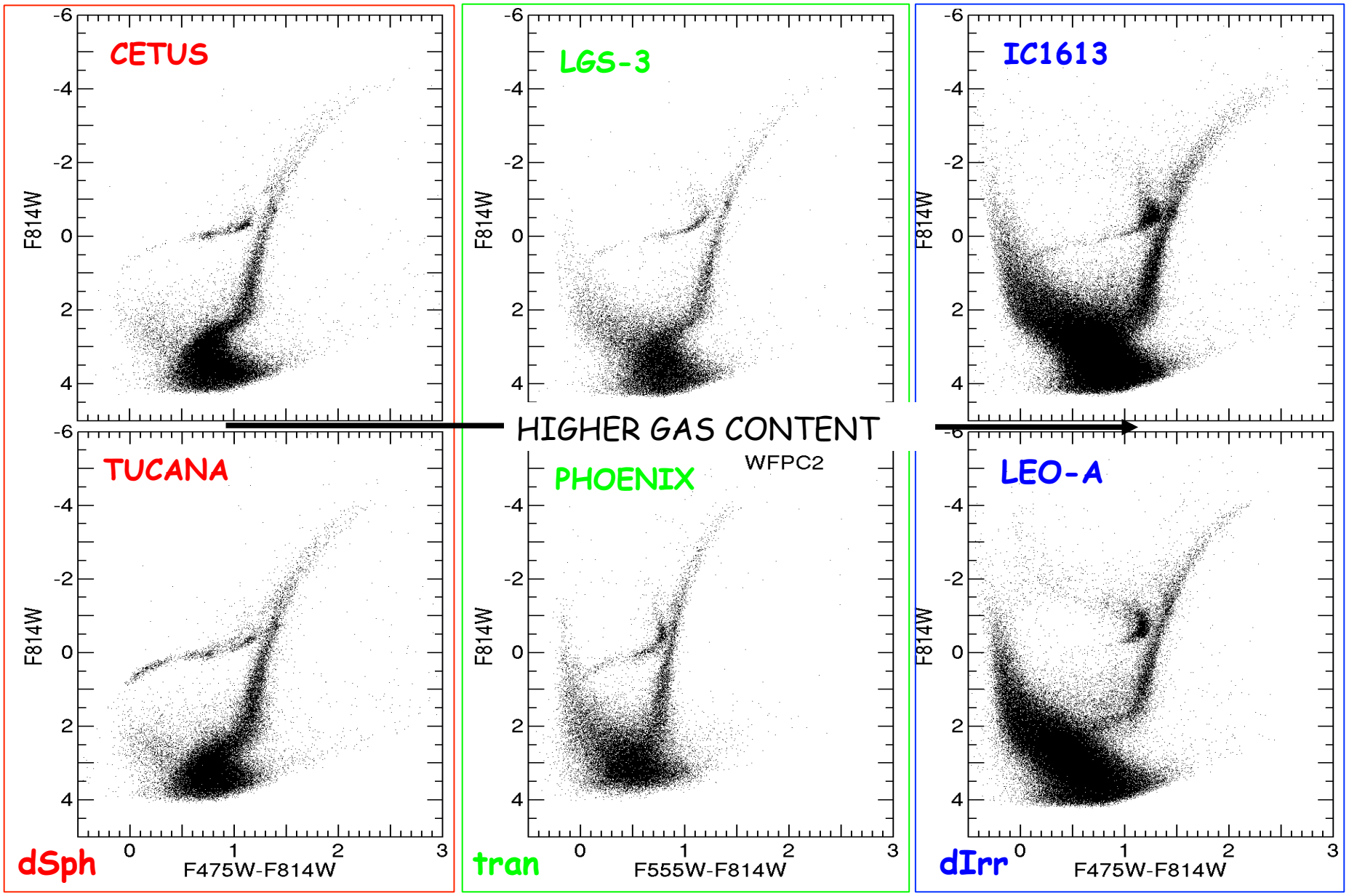


The importance of accurate photometry of TO stars

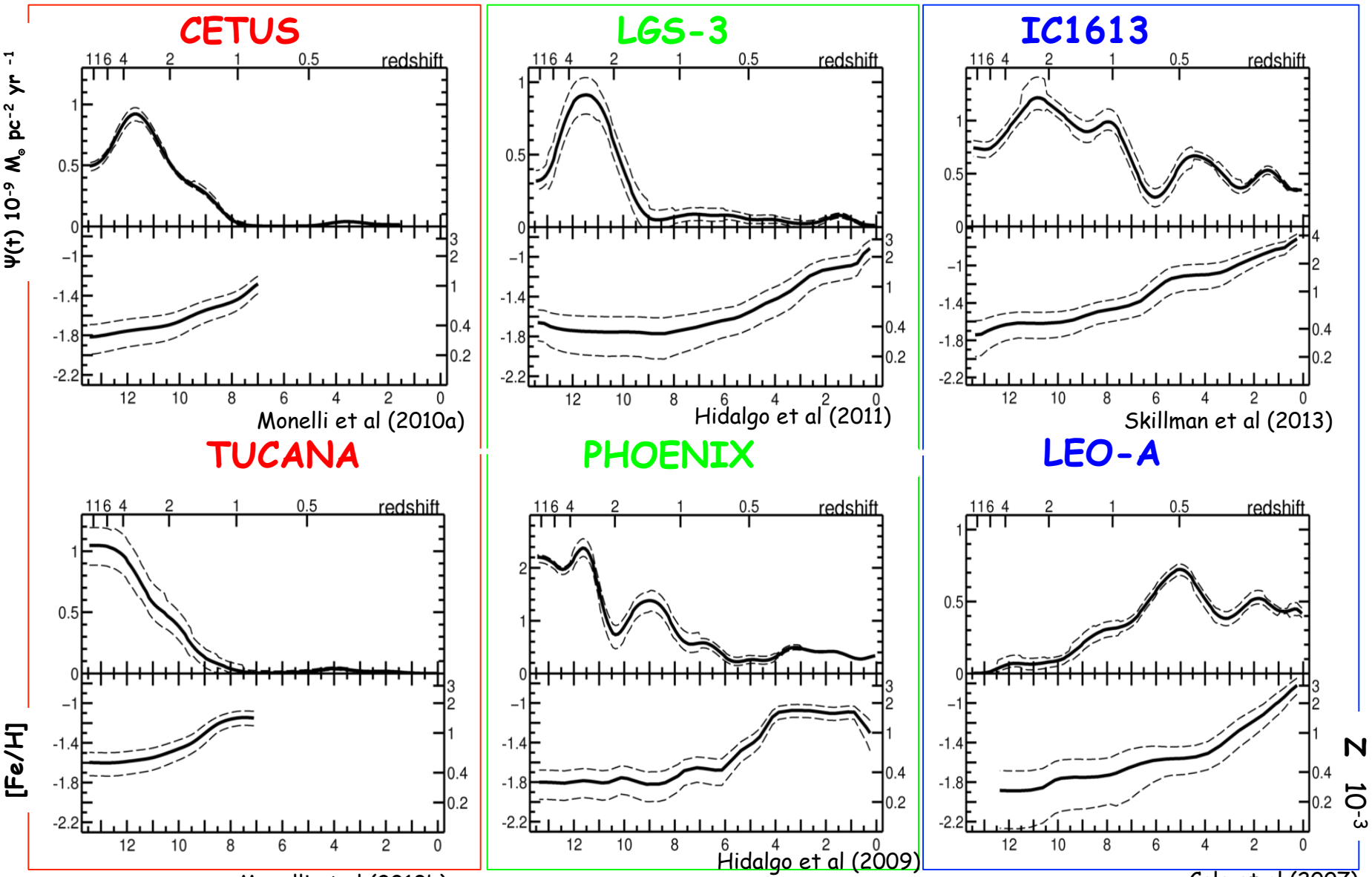


The LCID project

Local Cosmology from Isolated Dwarfs



Global Star Formation Histories: dIrr ≠ dSph



Monelli et al (2010a)

Hidalgo et al (2011)

Skillman et al (2013)

Monelli et al (2010b)

Hidalgo et al (2009)

Cole et al (2007)

What is the origin of morphological differantiation?

Current morphological classification does not reflect the evolutionary pattern of dwarf galaxies.

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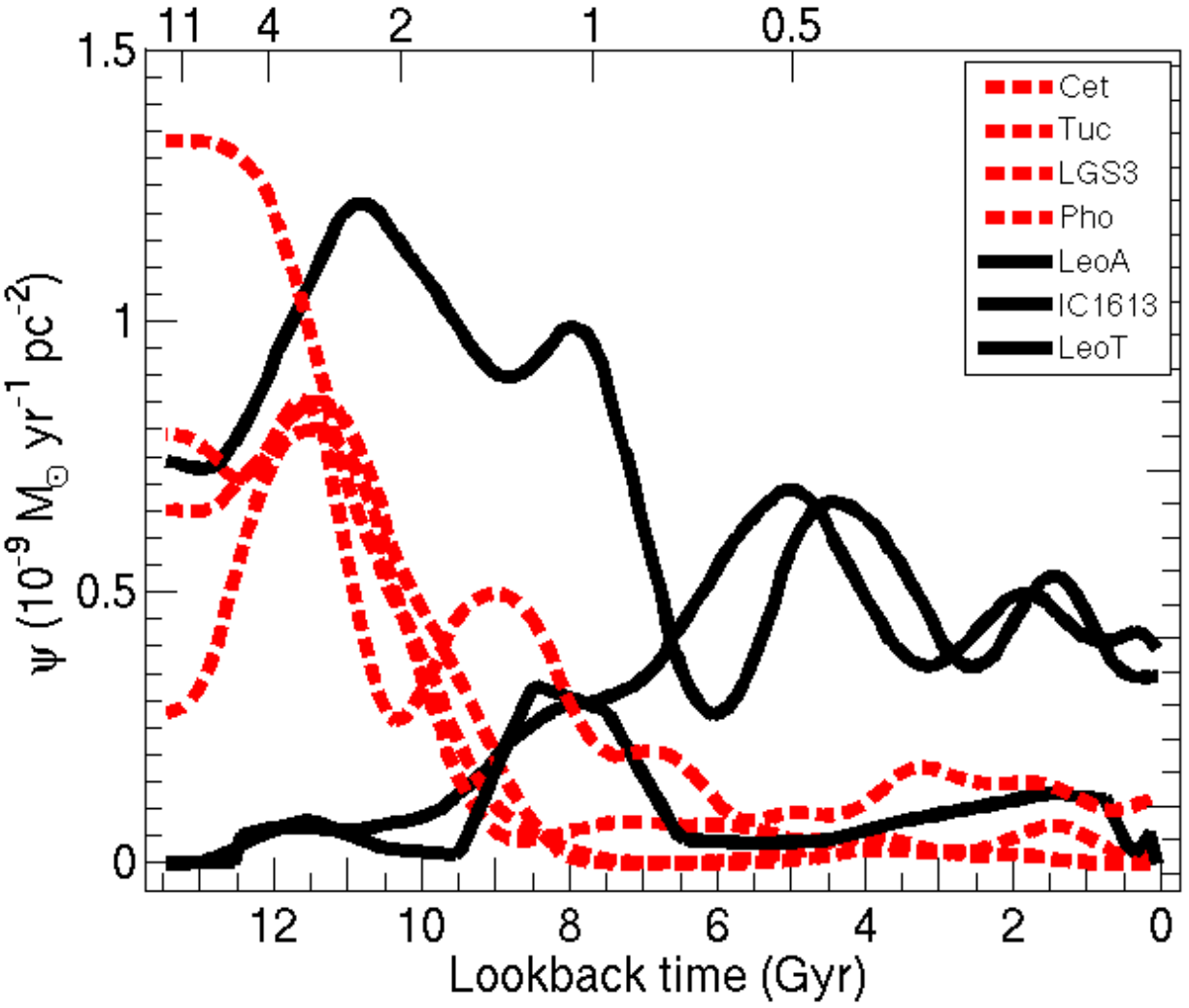


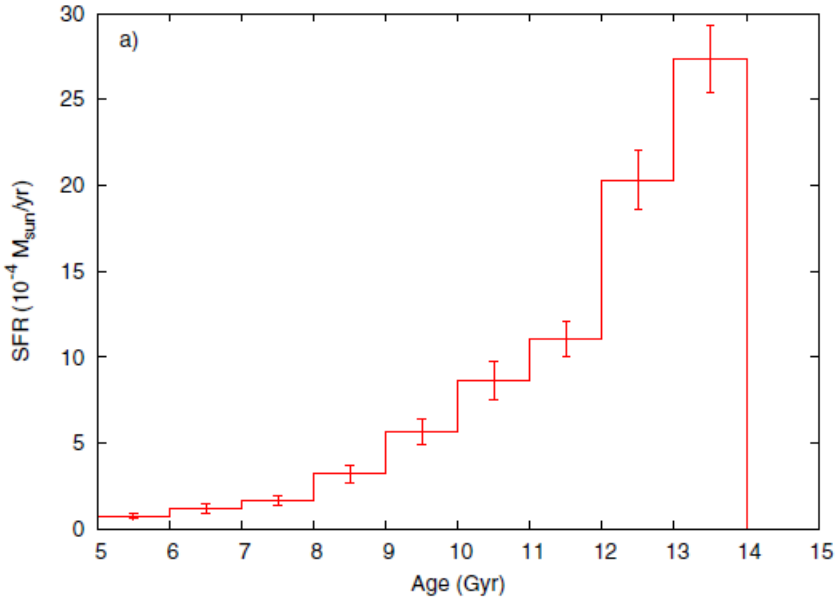
FAST

SLOW

Gallart et al. in prep.

Sculptor dSph

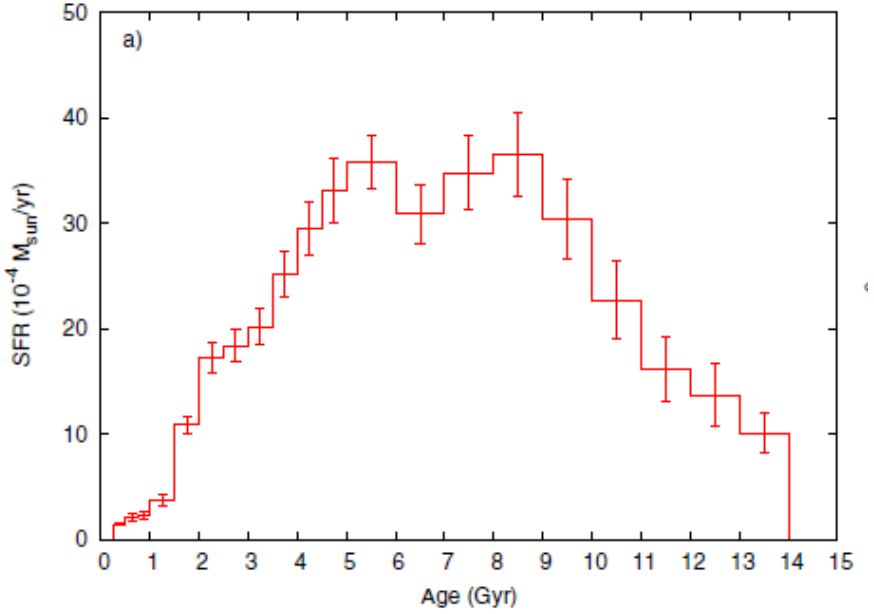
Young Old



De Boer+12a

…and Fornax dSph

Young Old

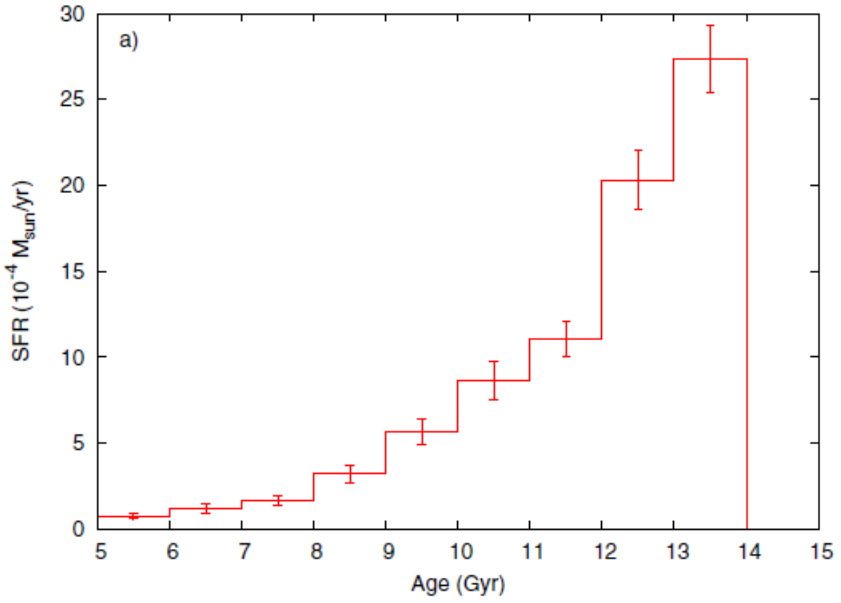


De Boer+12b

(see also Del Pino+13)

Sculptor dSph

Young Old

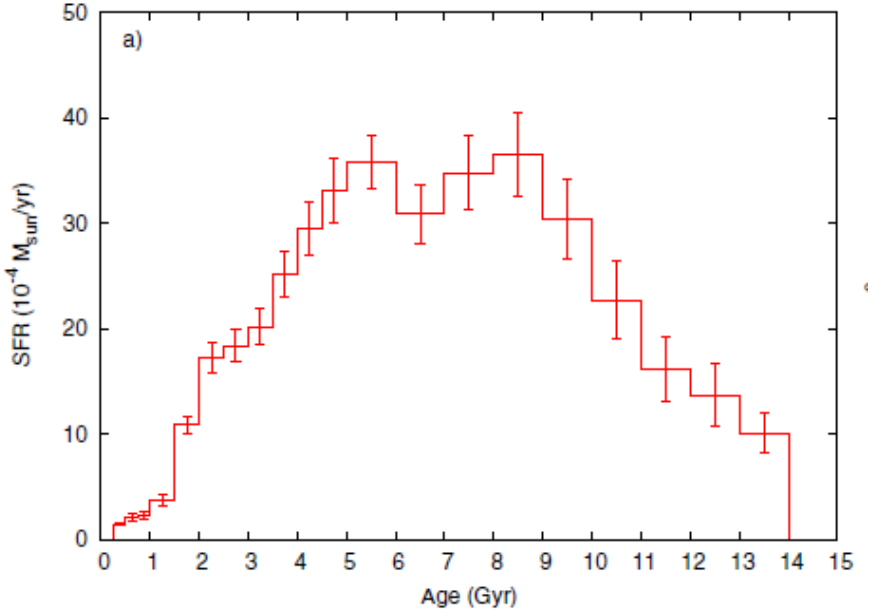


FAST

De Boer+12a

…and Fornax dSph

Young Old



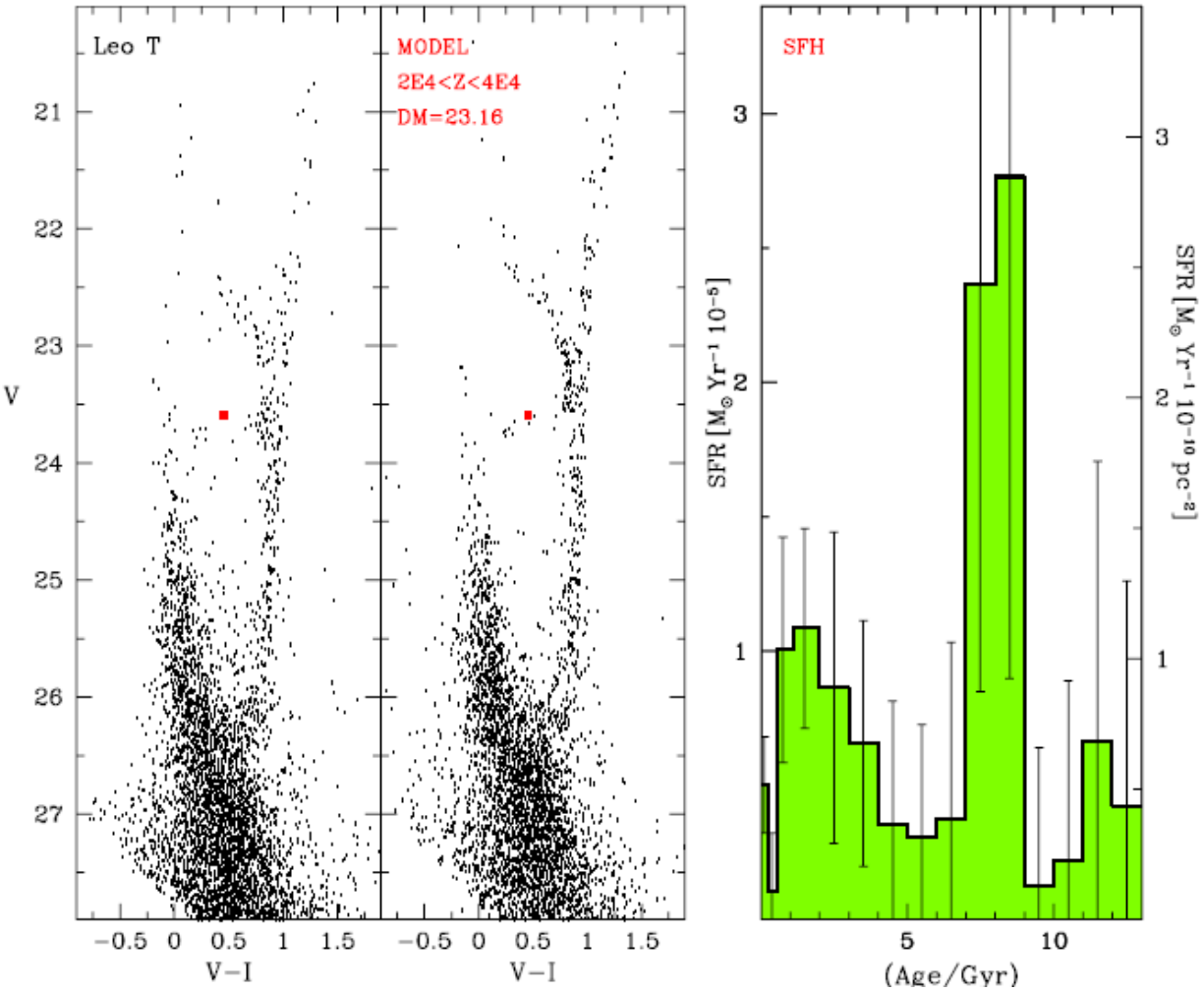
SLOW

De Boer+12b

(see also Del Pino+13)

Leo T

~417 kpc
Bright UFD (?)
with strong
intermediate to old
population



Clementini+12
(see also Weisz+12)

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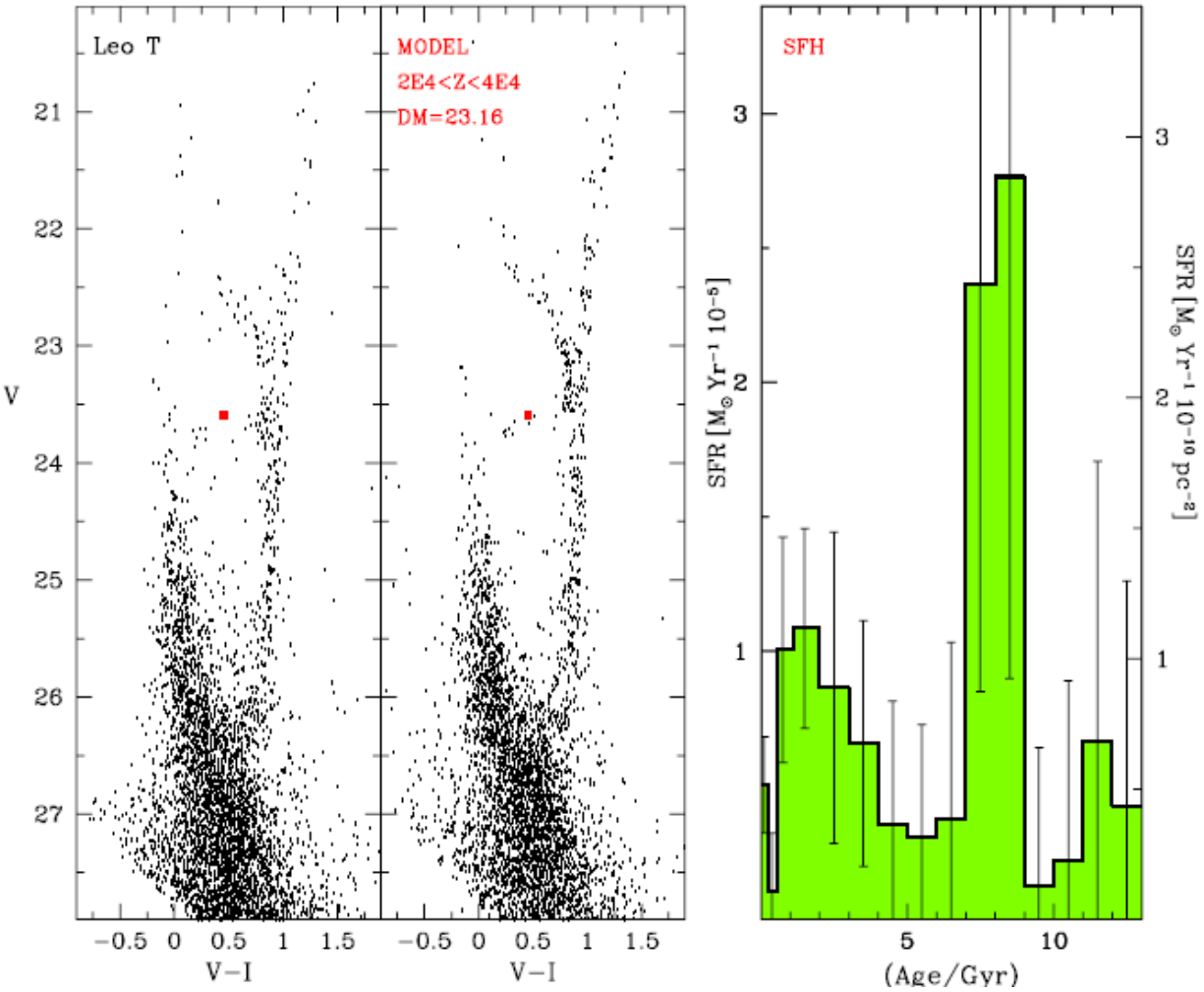
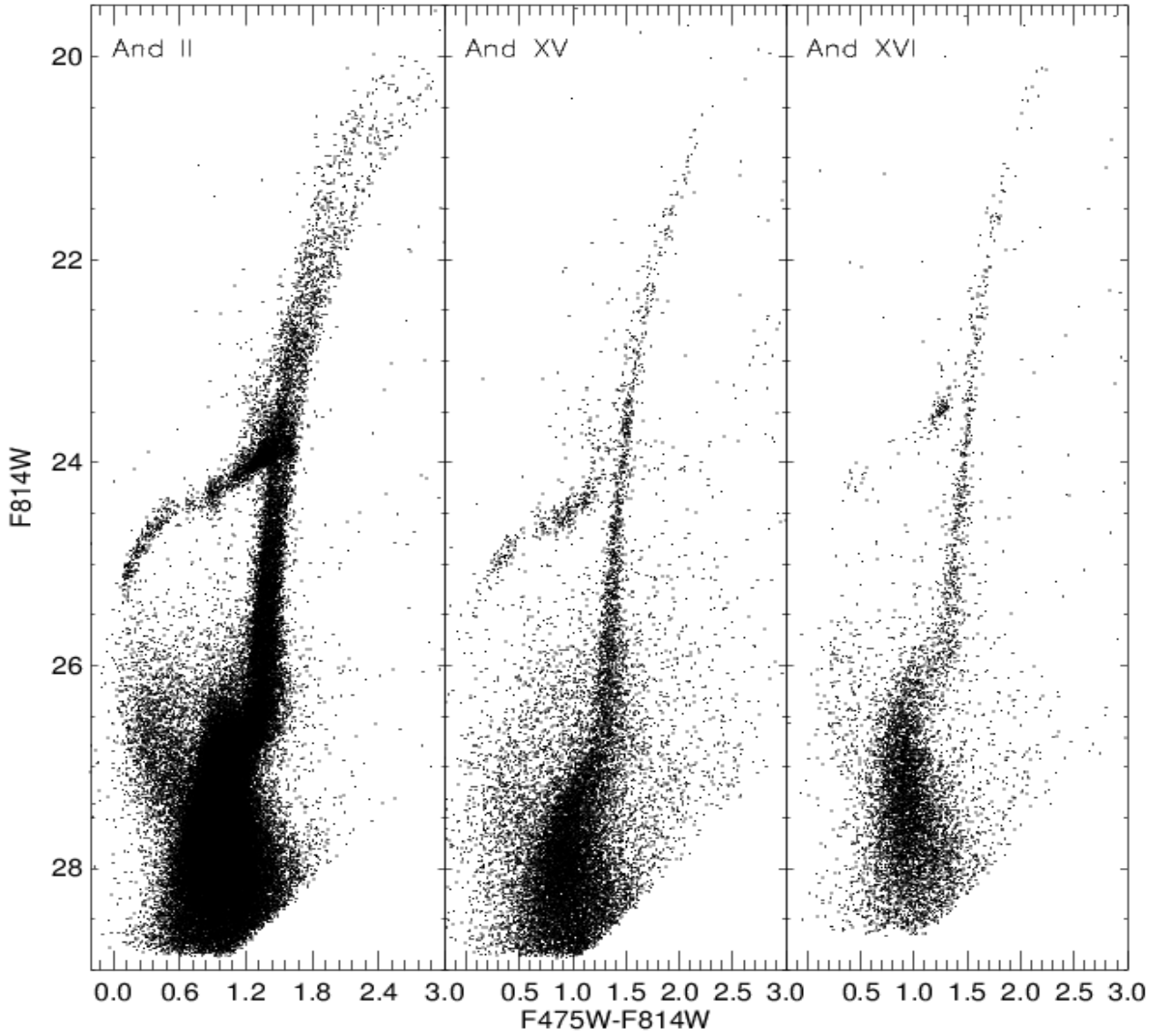


SLOW

Clementini+12
(see also Weisz+12)

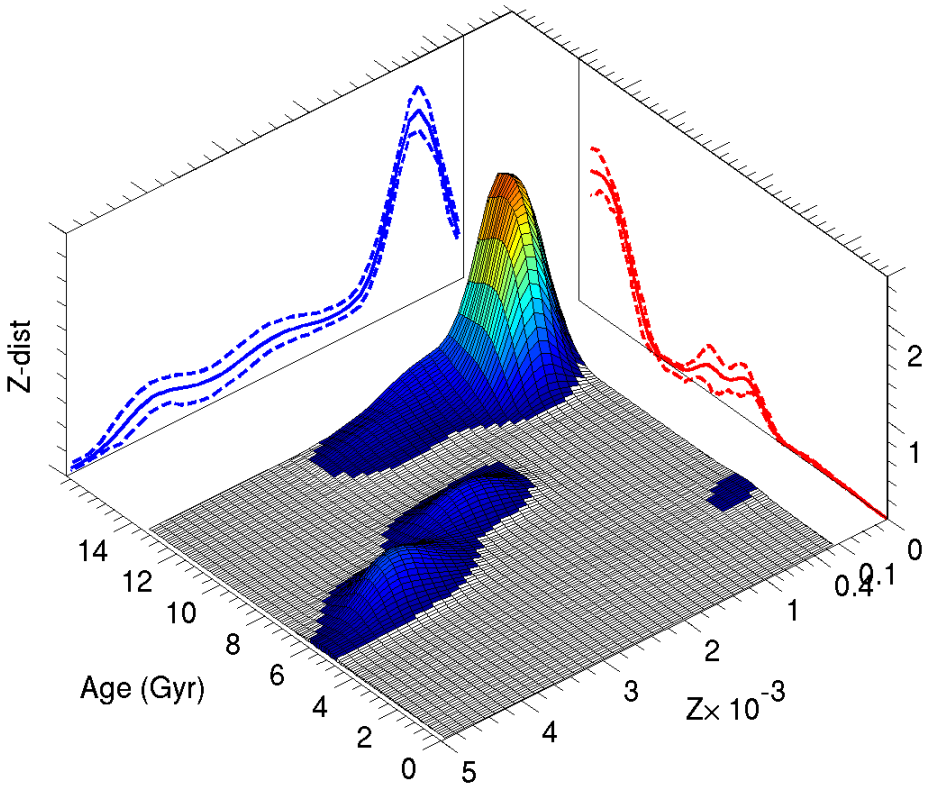
M31 Satellites

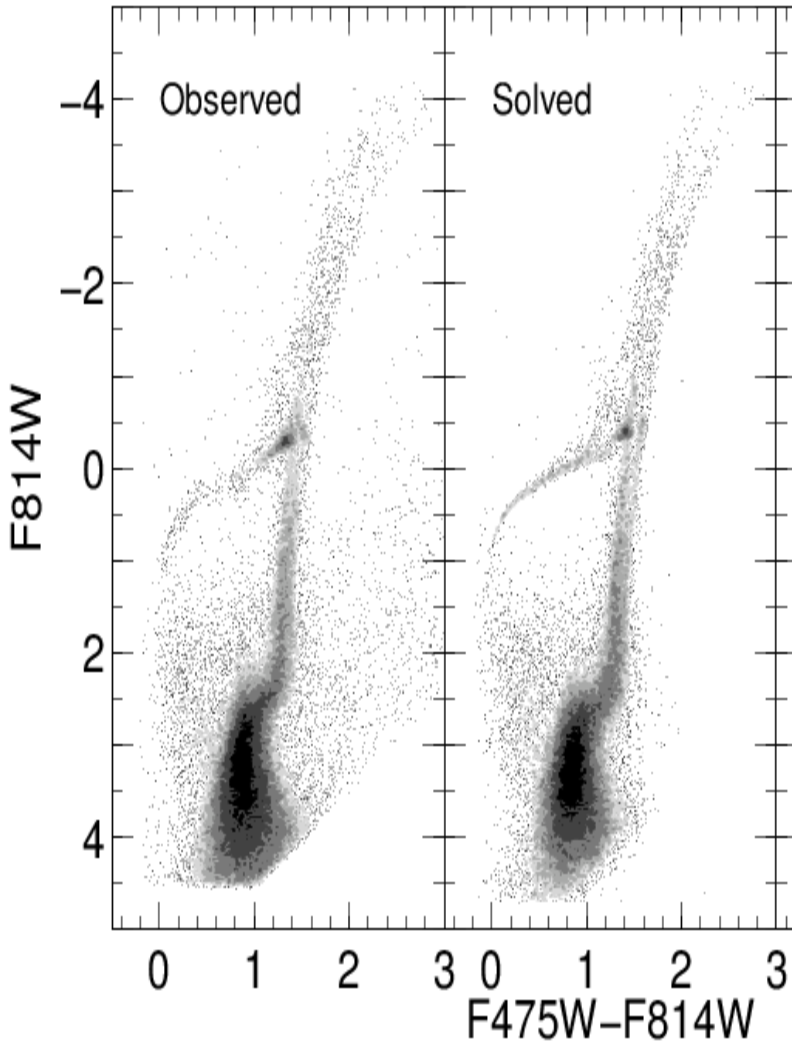


Two HST programs
111 Orbits
PI E. Skillman

M31 Satellites: And II

And II

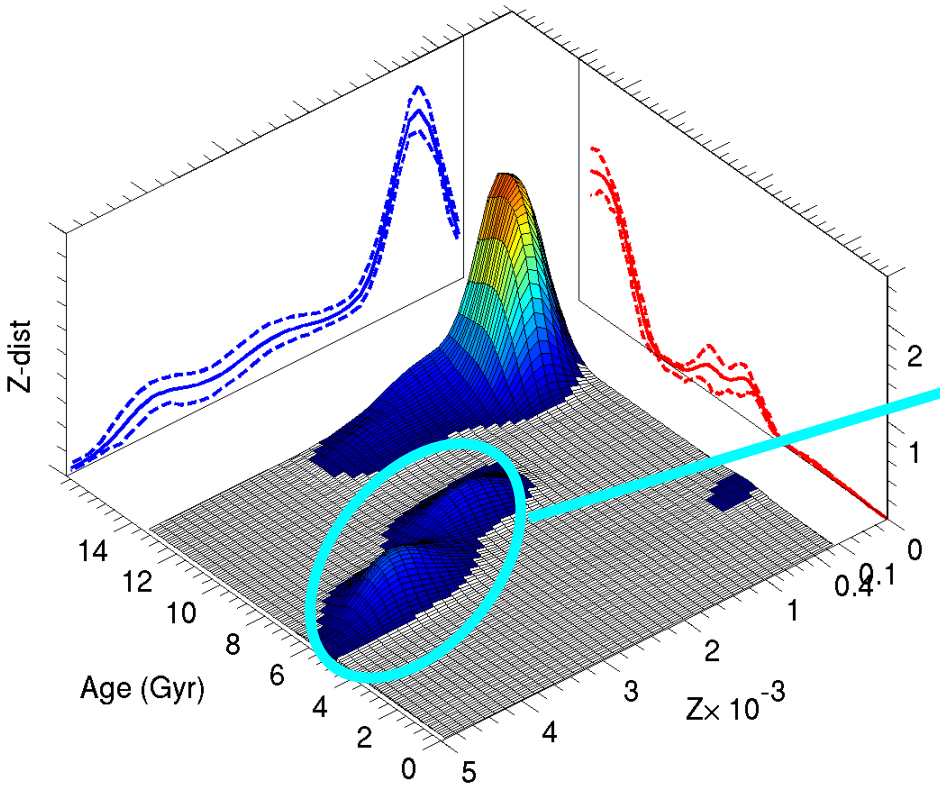


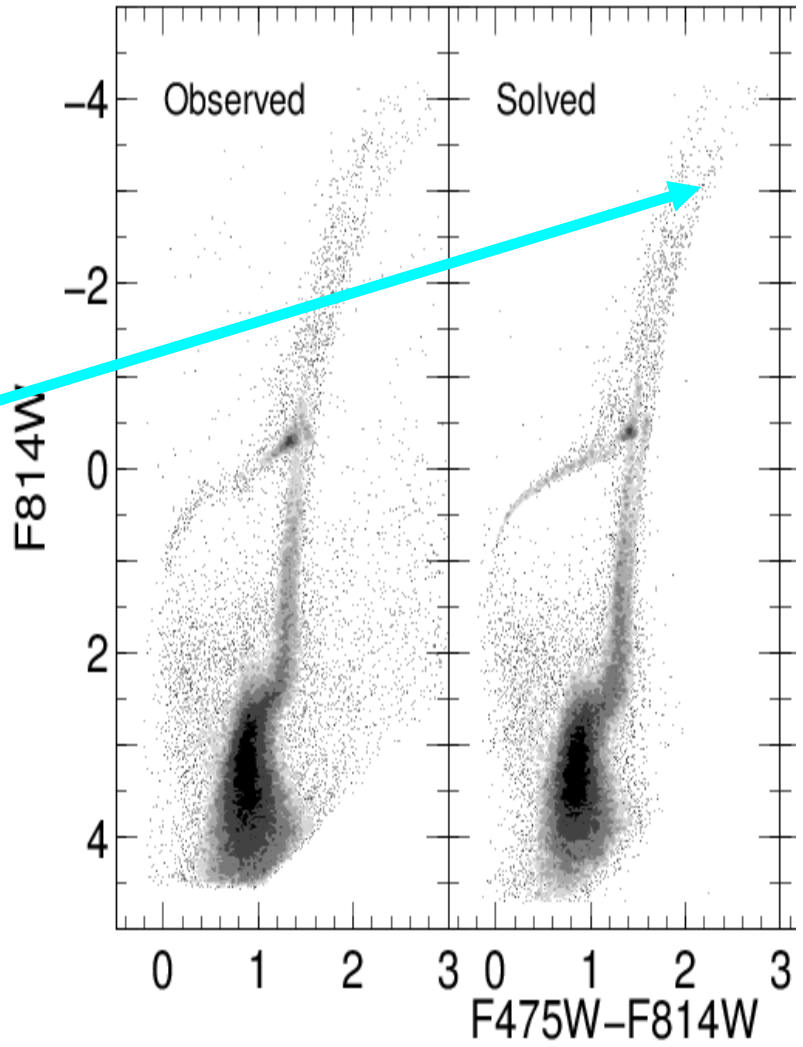


Hidalgo et al. in prep

M31 Satellites: And II

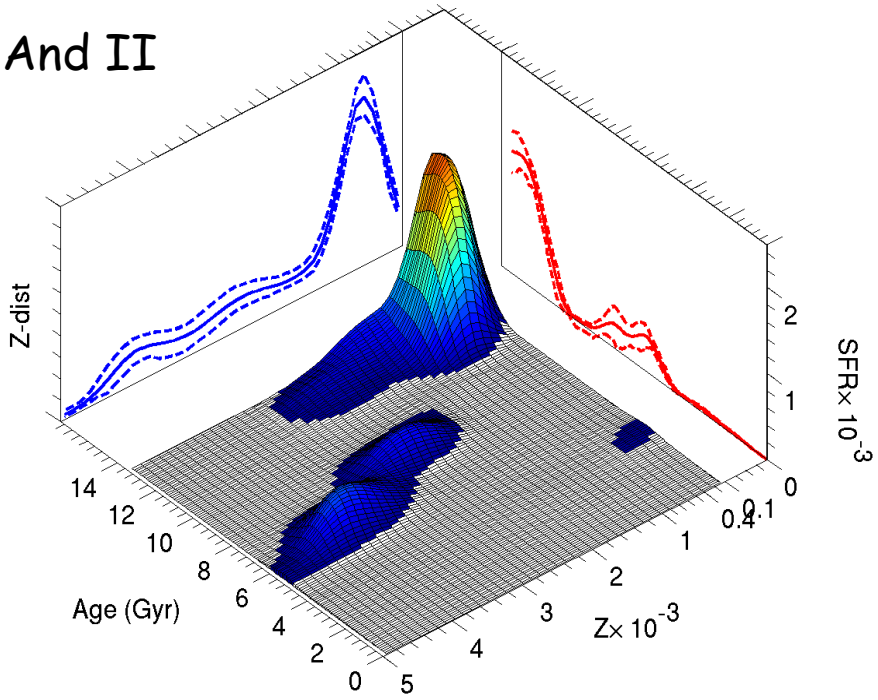
And II



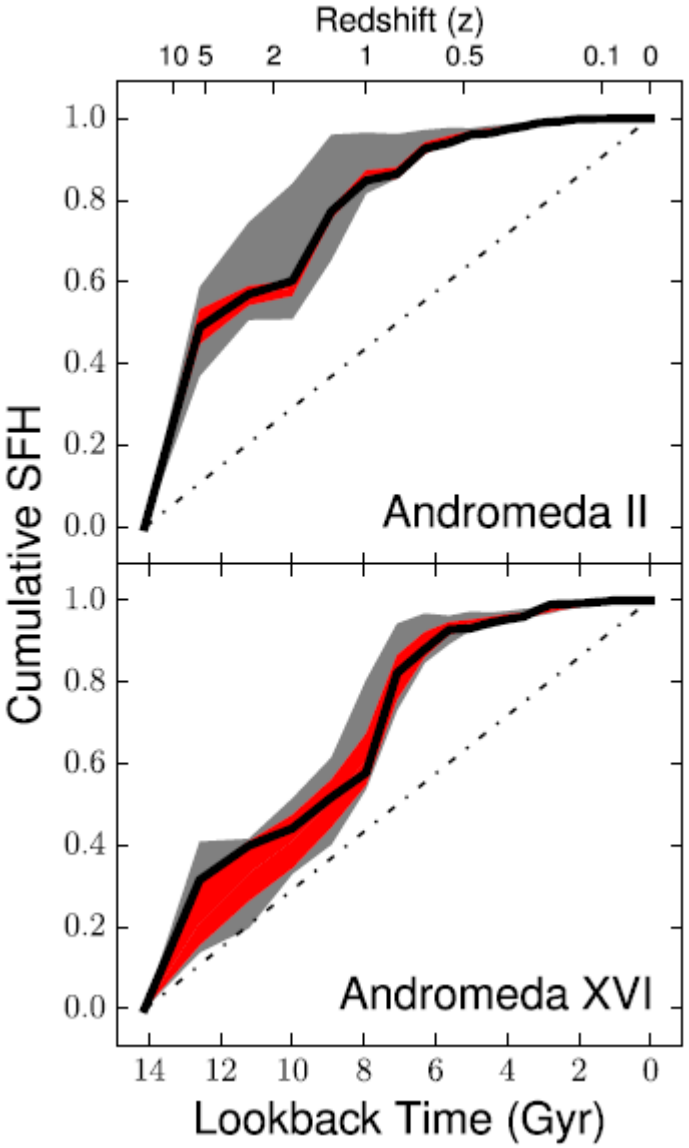


Hidalgo et al. in prep

M31 Satellites: And II & And XVI



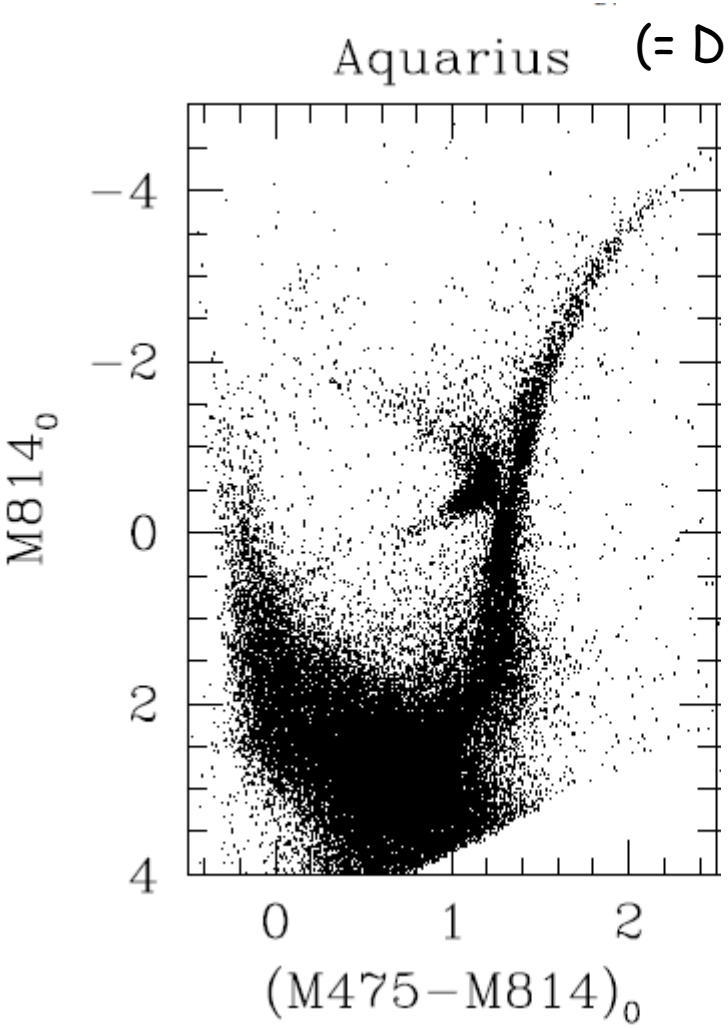
Weisz+14



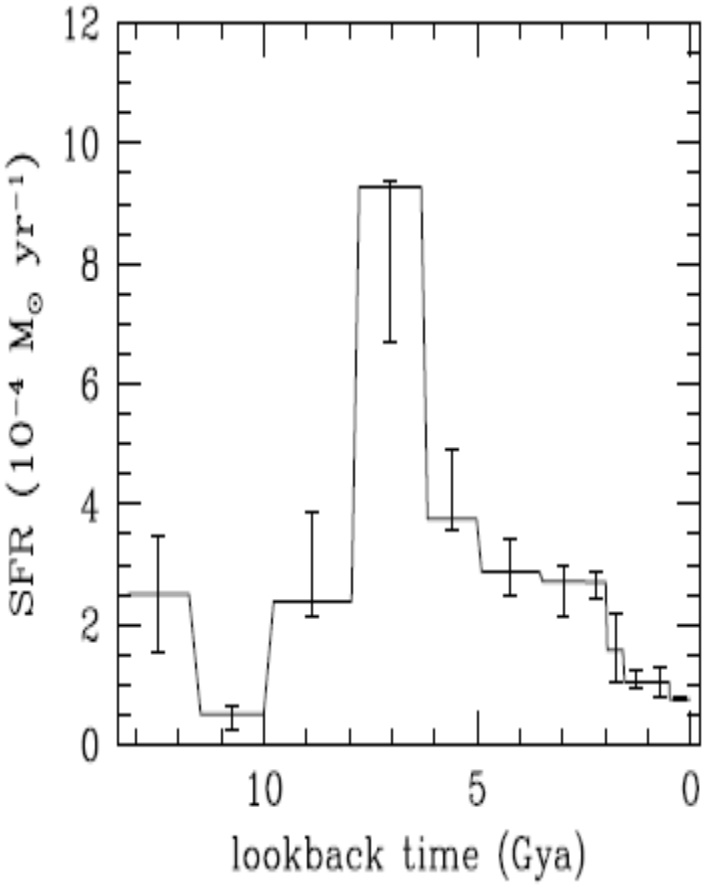
FAST ?? But…

Systematic difference between the MW and M31 satellites systems?
Environmental effect?

(Other) Isolated dwarfs



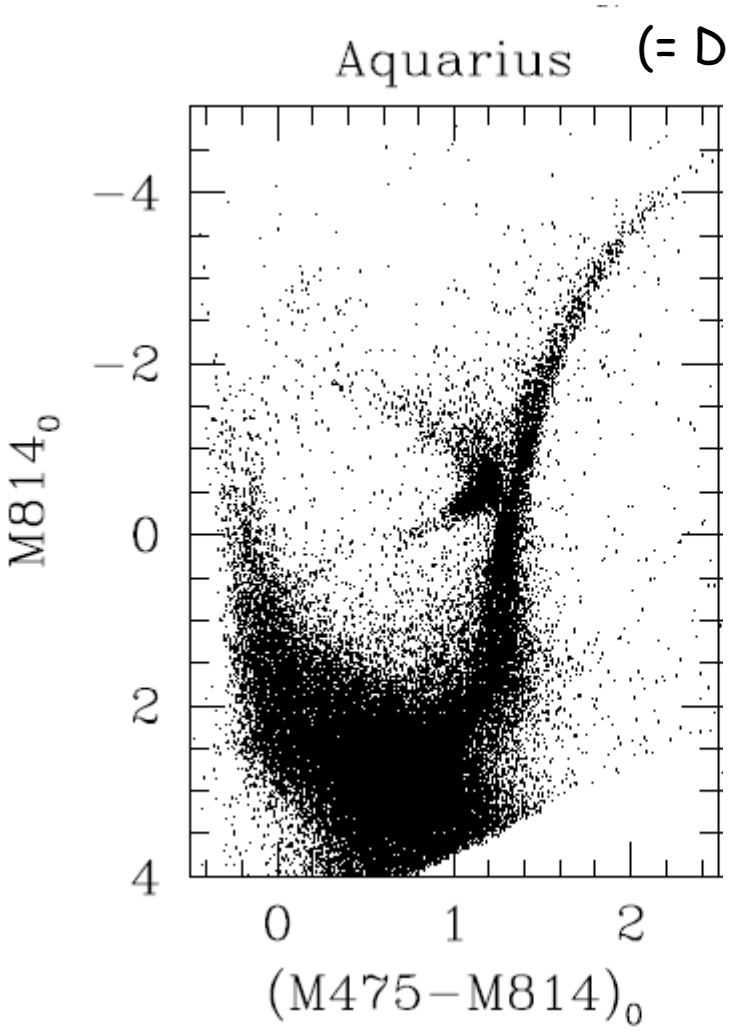
(= DDO210)



~1060 kpc
Truly isolated

Cole+14

(Other) Isolated dwarfs



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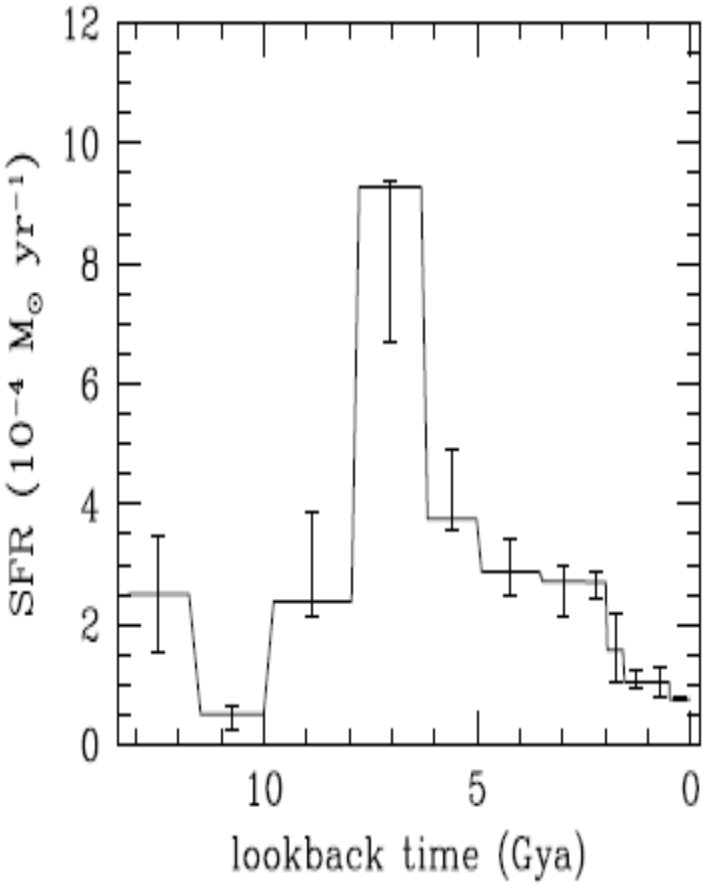

~1060 kpc
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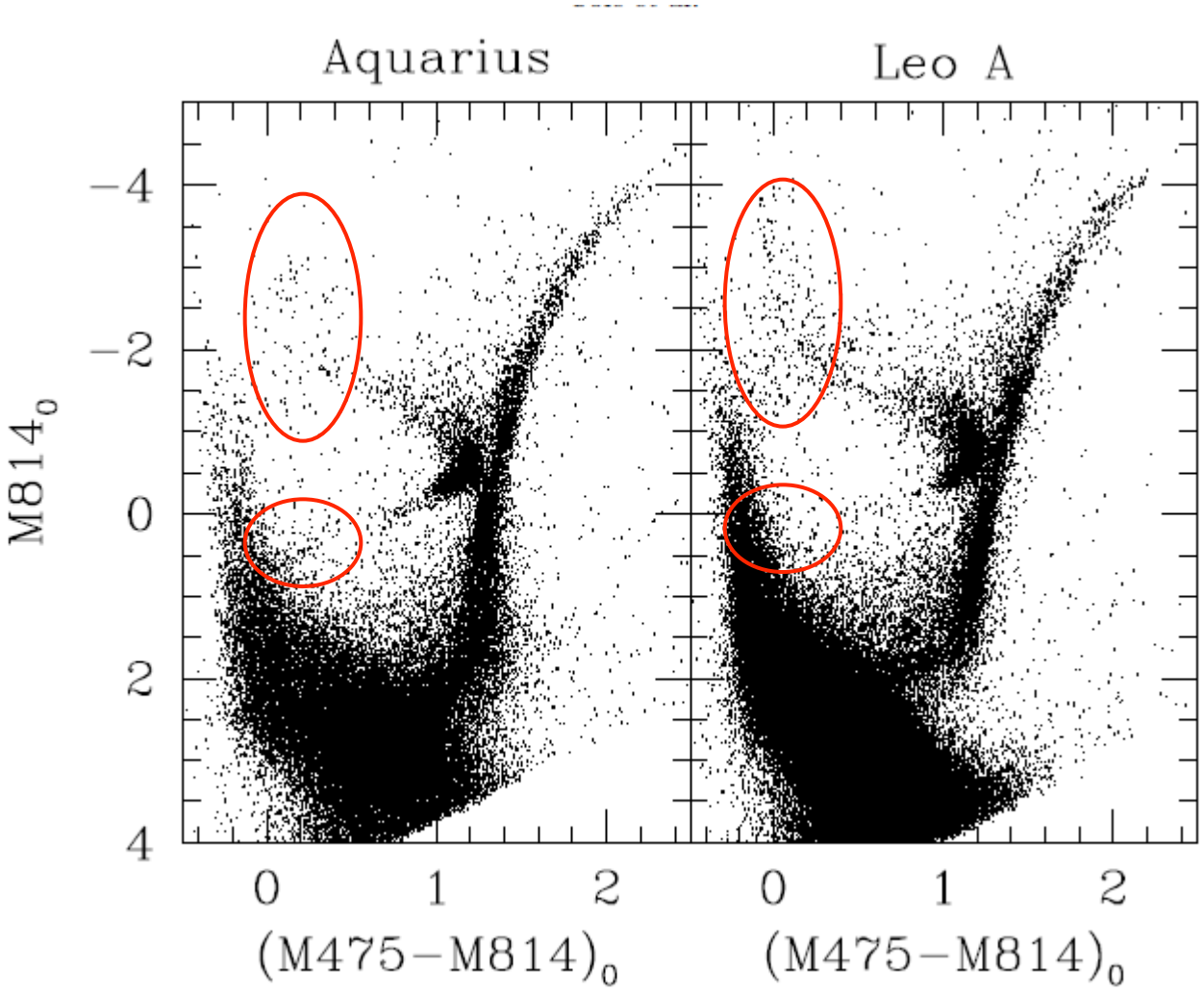
Cole+14

SLOW

(Other) Isolated dwarfs

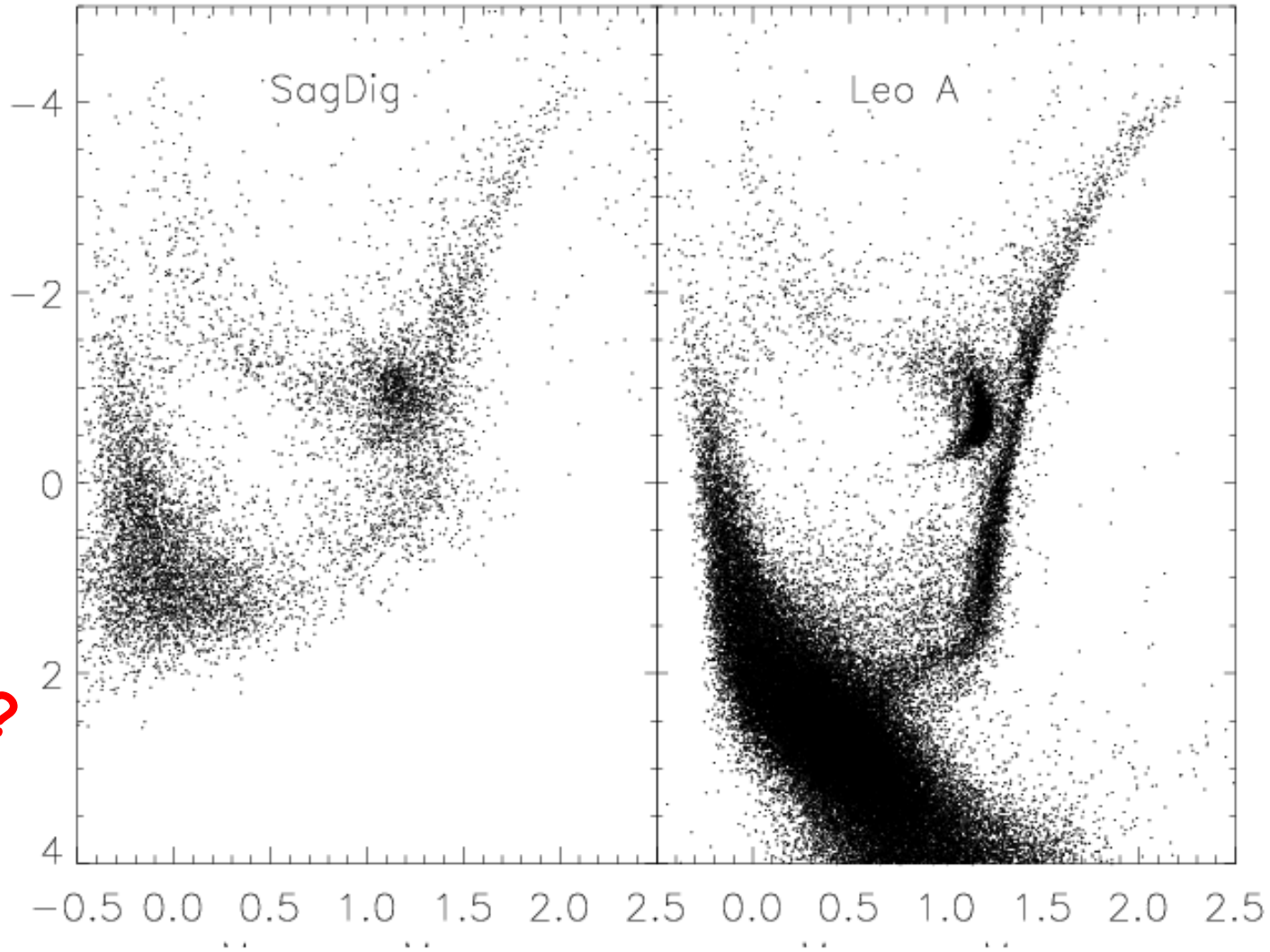


DDO210 is not as exteme as Leo A

Cole+14

(Other) Isolated dwarfs

SagDig



SLOW ??

D = ~1060 Kpc
(Momany et al. 2005)

Conclusions: open questions

Current morphological classification does not reflect the evolutionary pattern of dwarf galaxies.

FAST → initial strong SF, no or negligible after the main event

SLOW → intermediate/young dominated, regardless of the initial SF

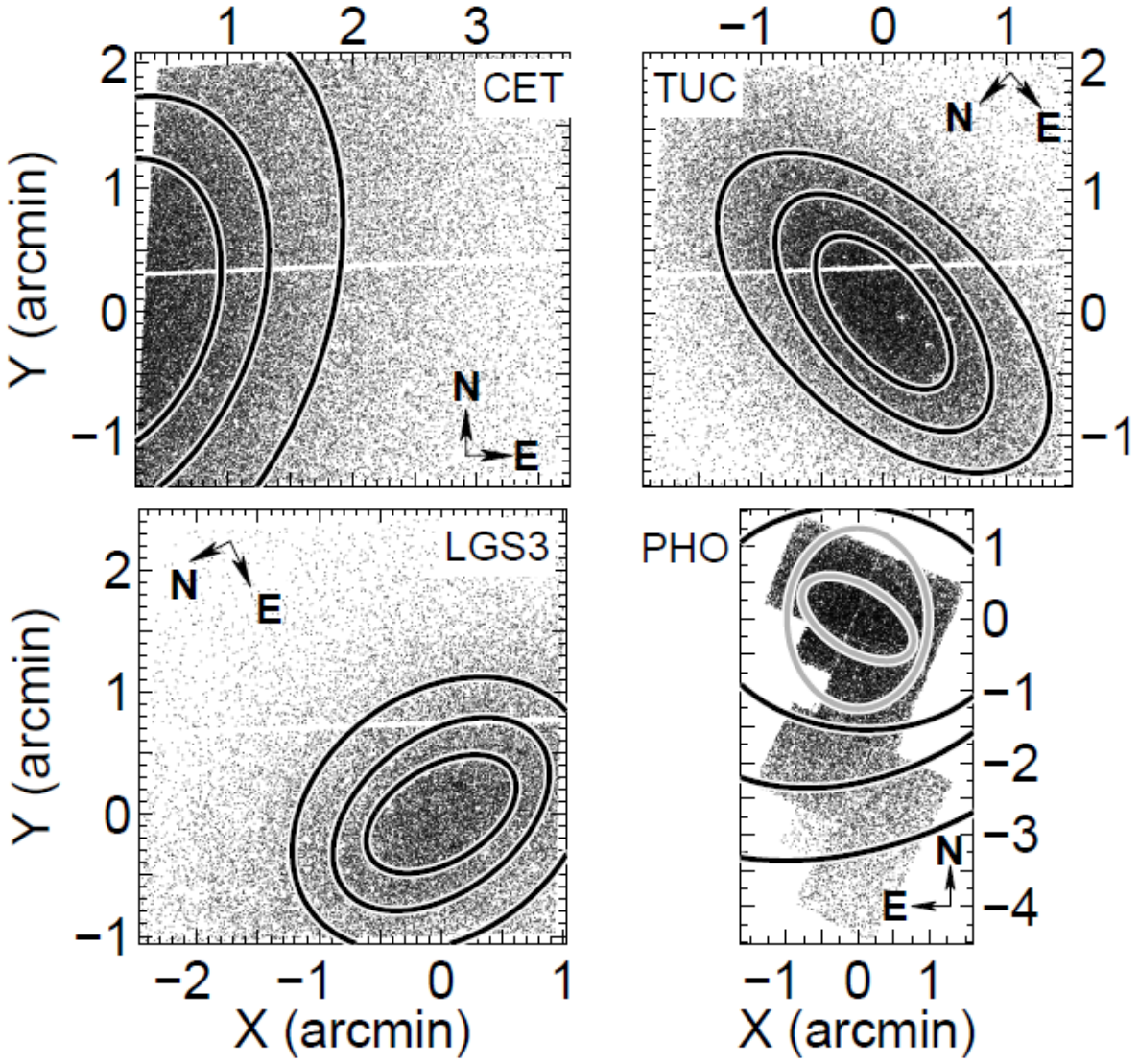
<u>All dIrr (so far) are slow, but not all dSph are fast</u>

What else?
- Leo I, Leo T, IC1613 have all negative velocities
- Recent accretion of the Magellanic Clouds
- DDO210, LeoA, SagDig evolved in isolation

→ are SLOW evolvers born in low-density environment ?
  → different mass assembling history ?
  → effect of reionization in the lowest mass ones ?
→ are all dIrrs SLOW?

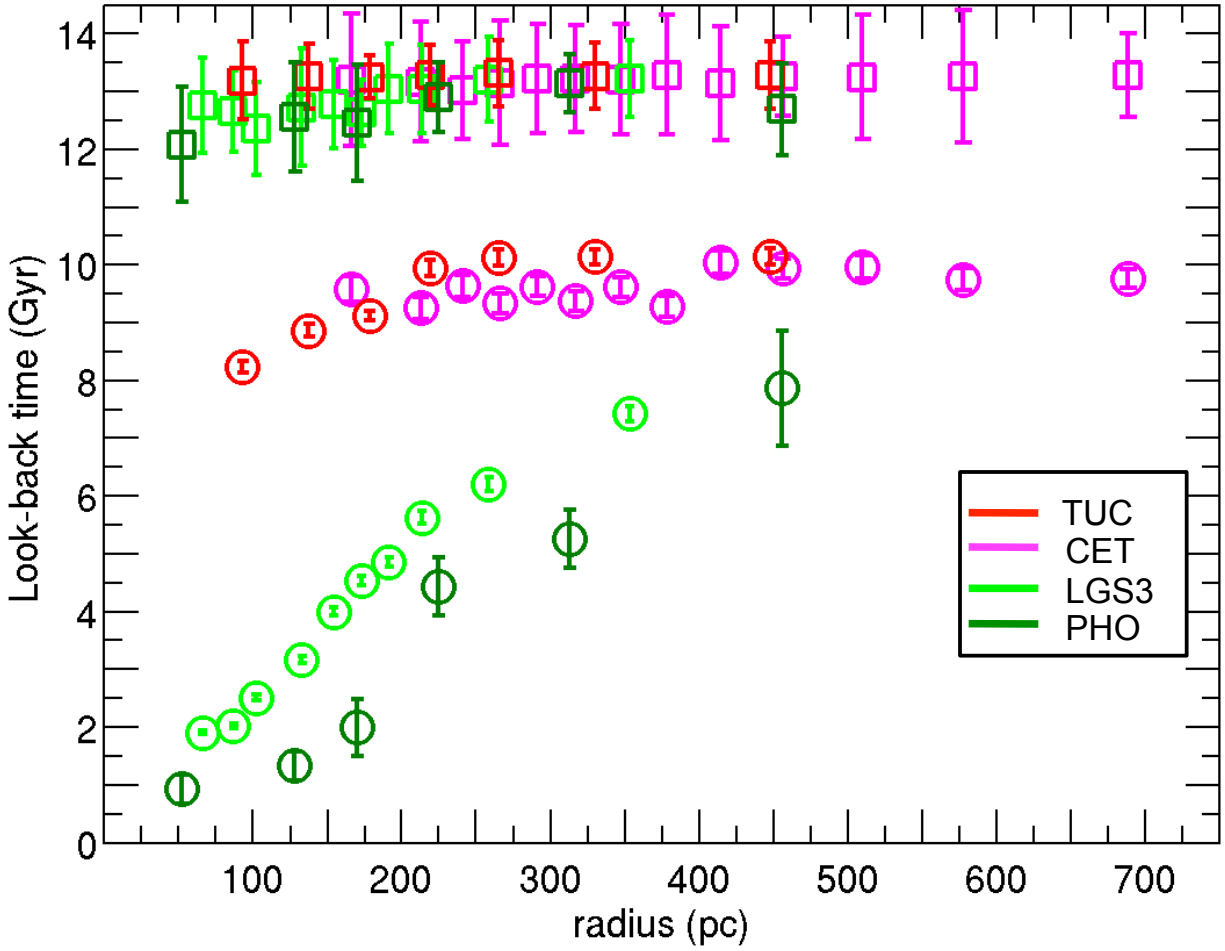
Stellar populations gradients: SFH vs radius

Stellar populations gradients: LCID



Hidalgo et al. 2013

Stellar populations gradients: LCID



□ 10-percentile of $\int\psi(t,r)$

(Age of the first star formation event)

○ 95-percentile of $\int\psi(t,r)$

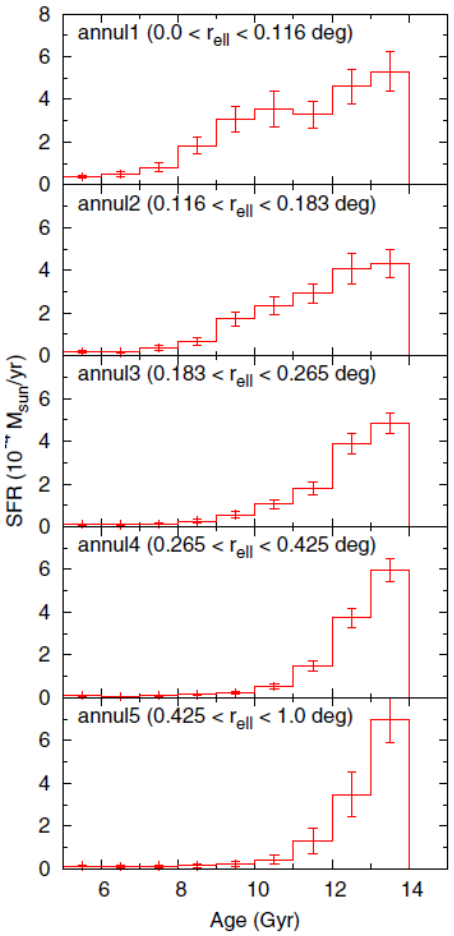
(Age of the end of star formation)

These galaxies started forming stars at the same epoch everywhere

In case of prolonged star formation, the SF shrinks with time to the innermost regions

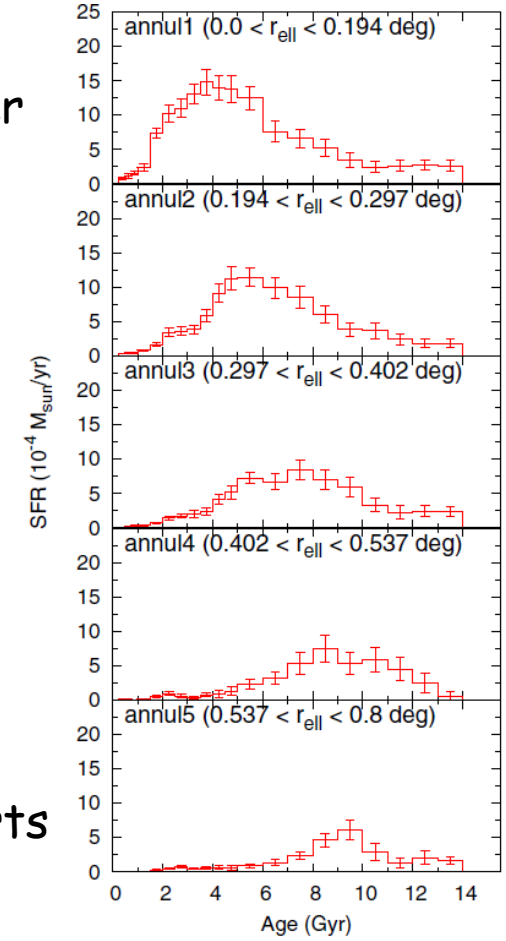
Stellar populations gradients: MW satellites

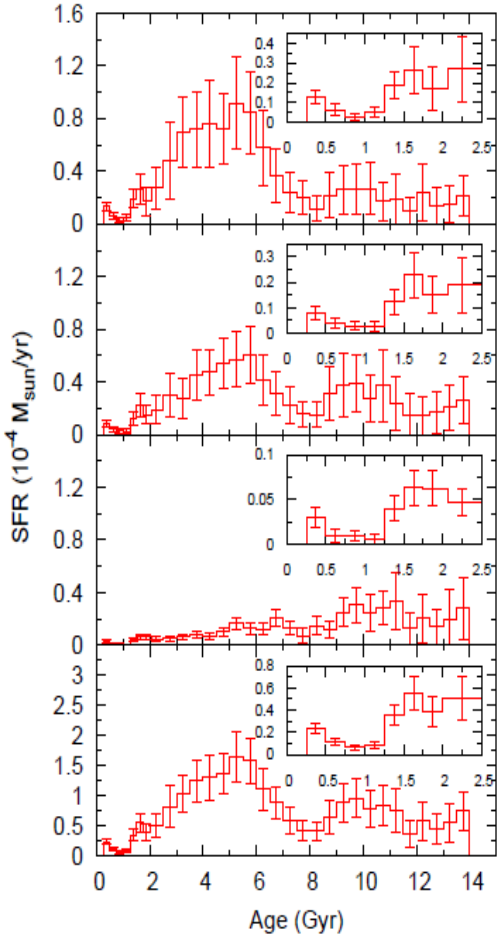
Young Old



center

outskirts



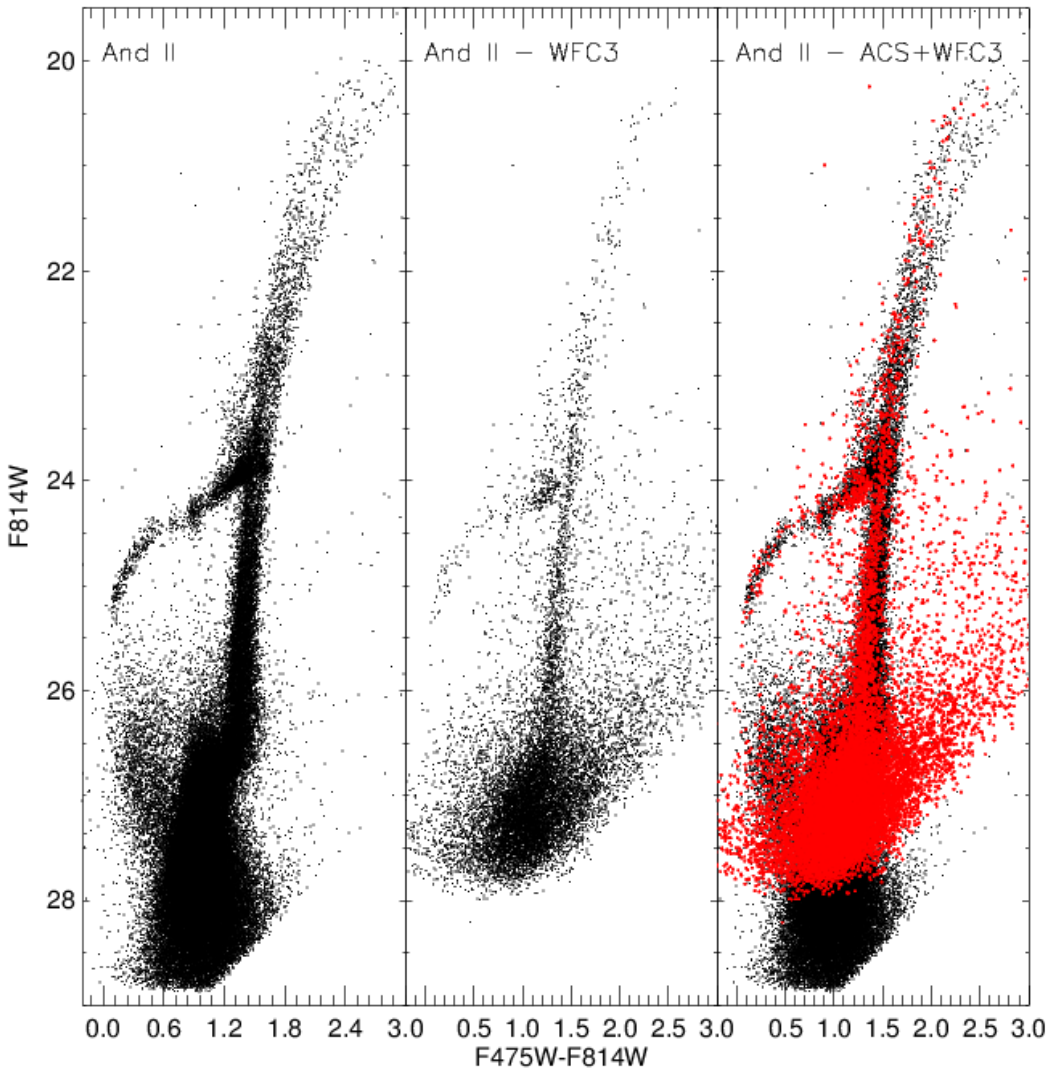


De Boer+12a
Sculptor

De Boer+12b
Fornax

De Boer+14
Carina

Stellar populations gradients: And II



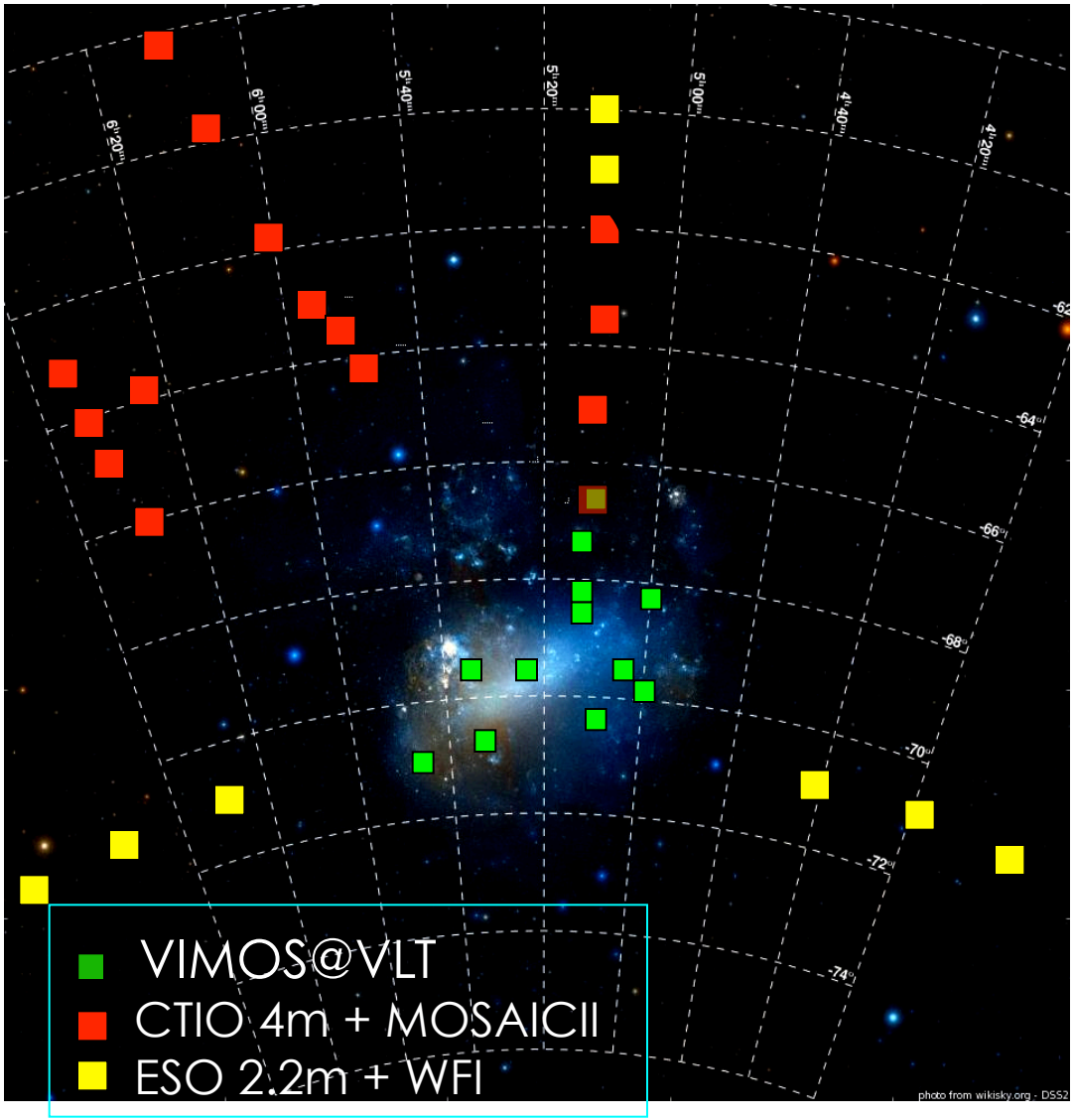
Stellar populations gradients: the LMC

CMDs reaching the oldest main sequence turnoffs in
4 fields CTIO+MOSA (35'x35')
8 fields 2.2 ESO+WFI (35'x35')
12 fields VLT+VIMOS
9 WFPC2 fields

+

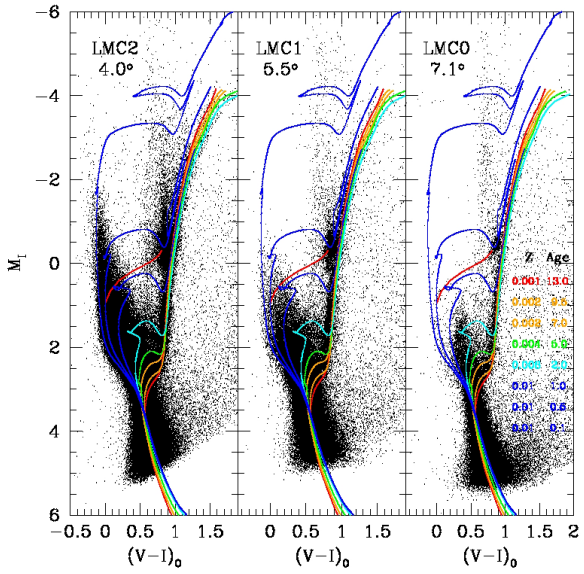
Spectra
- medium resolution CaT for ≈900 member stars in 4 fields
- FLAMES high resolution spectra for ≈300 stars

Team
Gallart, Monelli, Monteagudo, Stetson, Carrera

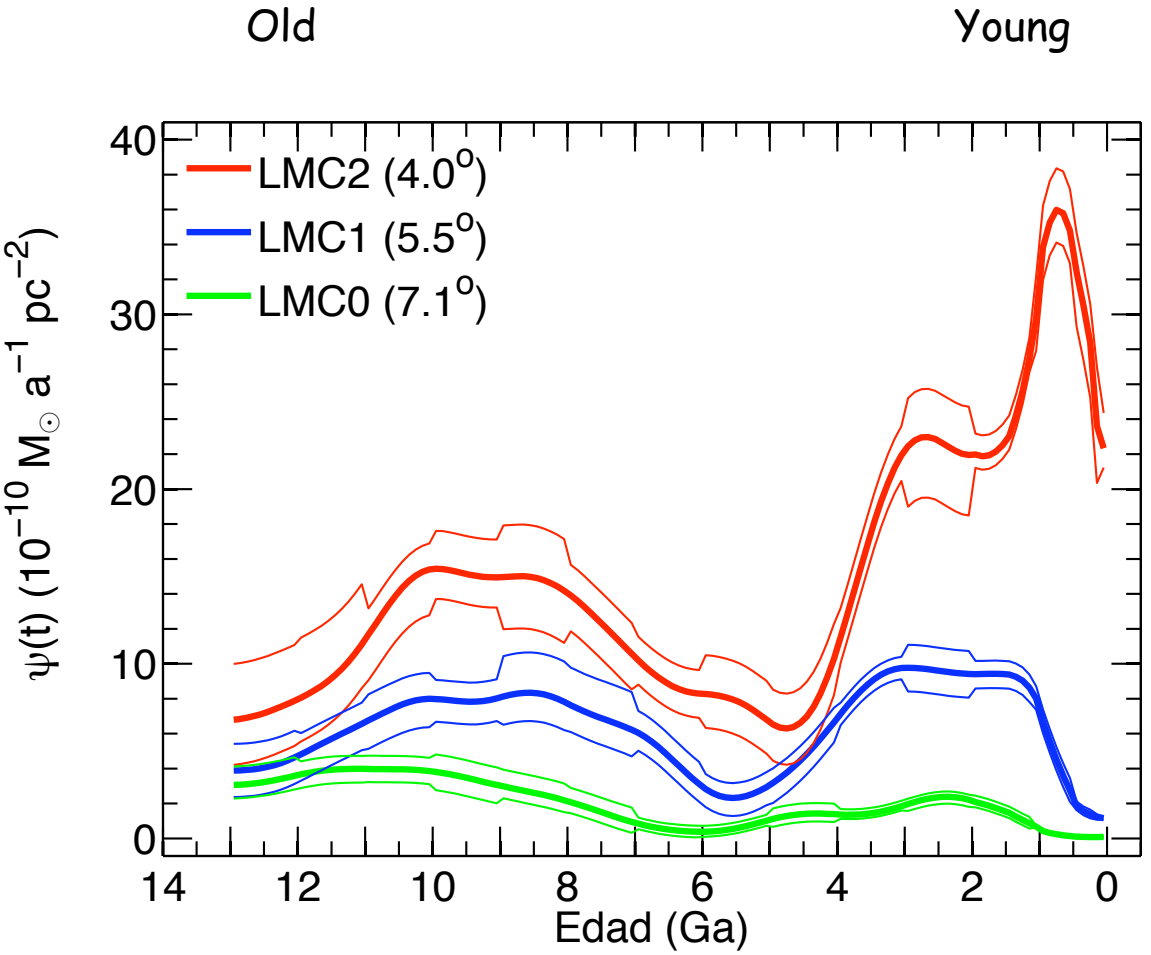


Gallart et al. 2004, 2008, AJ
Carrera, et al. 2008a ,b, 2011
Meschin,et al. 2014, MNRAS
Monelli, et al. 2014 a,b,c in prep

Stellar populations gradients: the LMC



Meschin et al. 2013

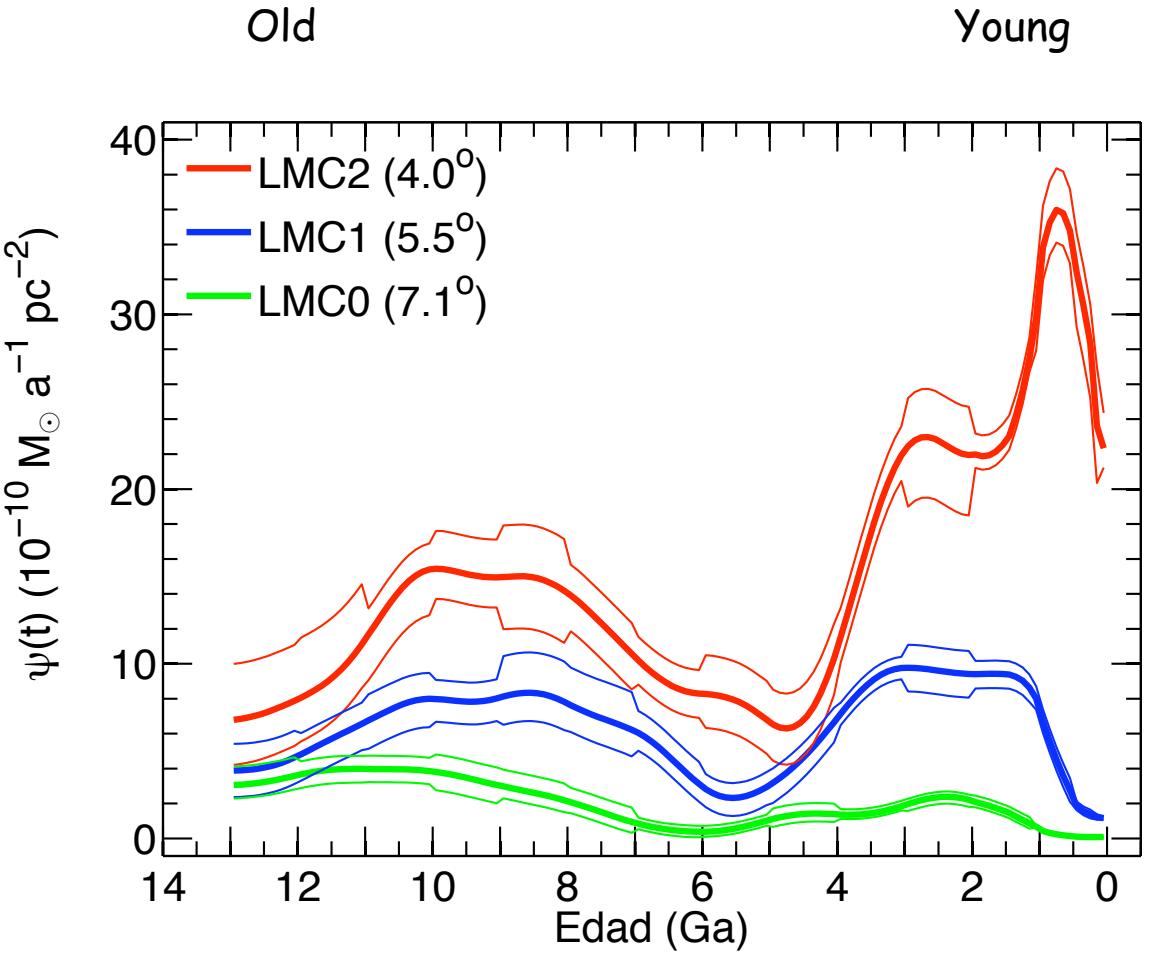


Y_{SFE}/O_{SFE}=(1.1 : 0.8 : 0.4) for (LMC2 : LMC1 : LMC0)

Stellar populations gradients: the LMC

SLOW

(as the SMC,
e.g. Nöel+09, Cignoni+12)



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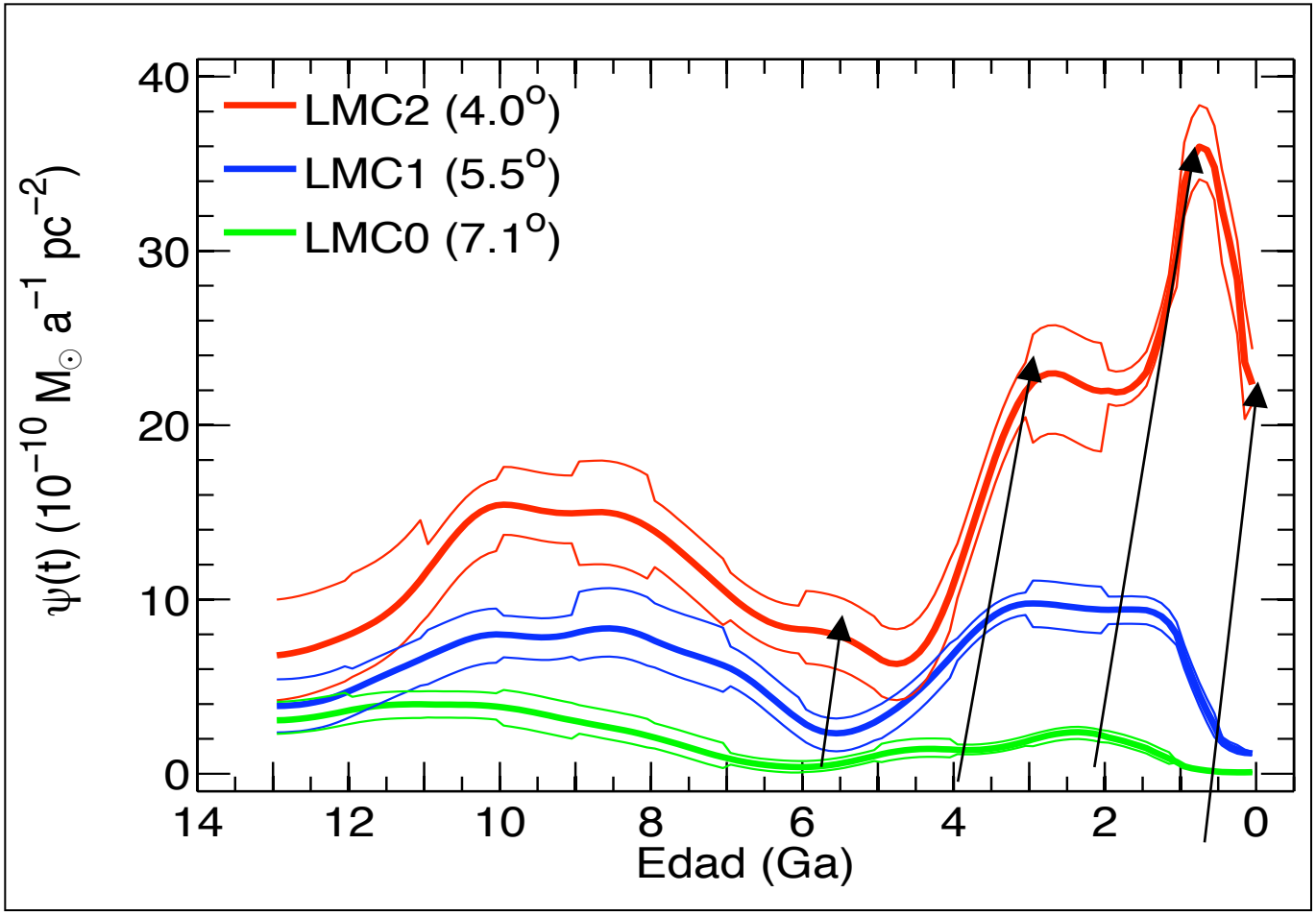
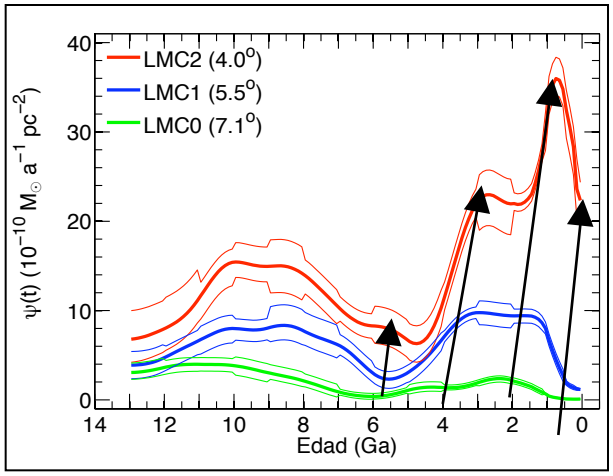
Stellar populations gradients: the LMC

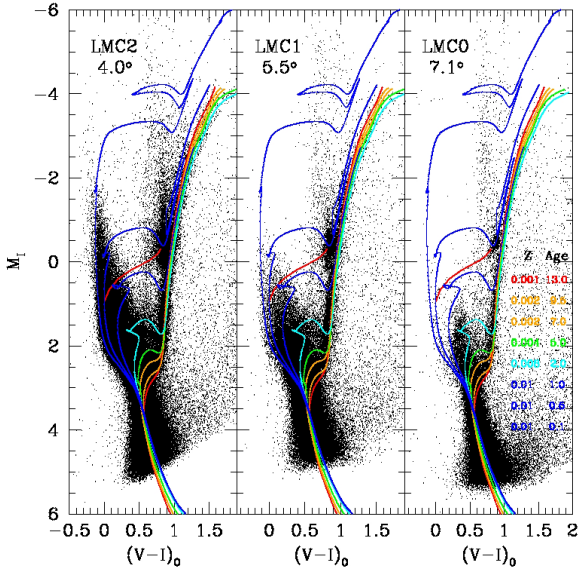


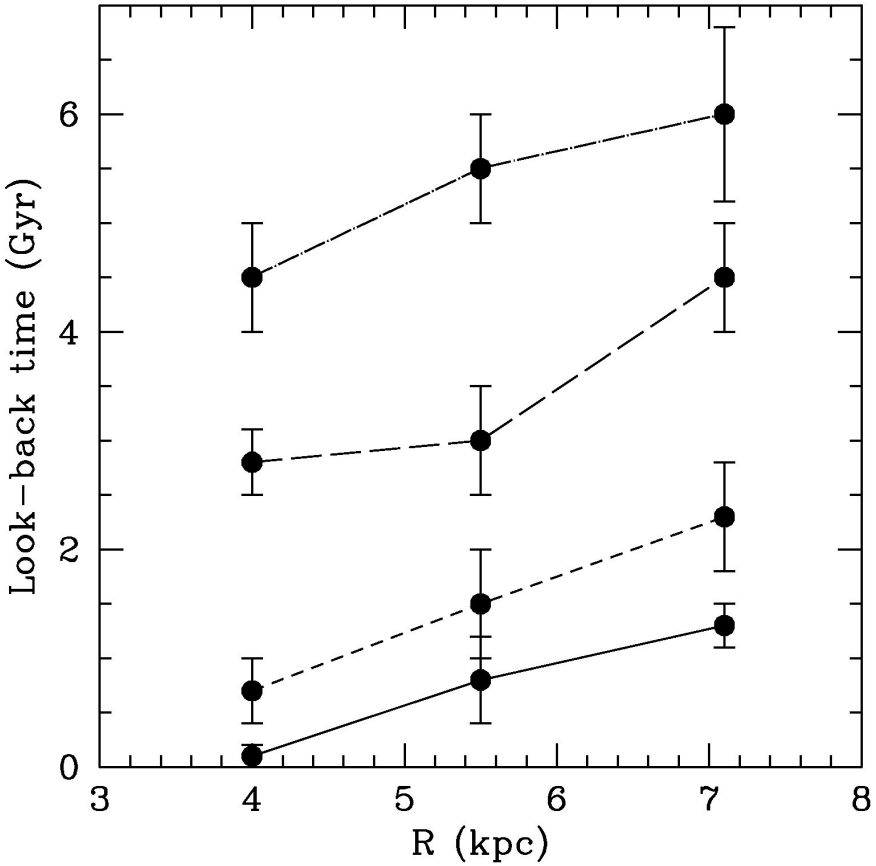
Feature migration with radius?

Stellar populations gradients: the LMC

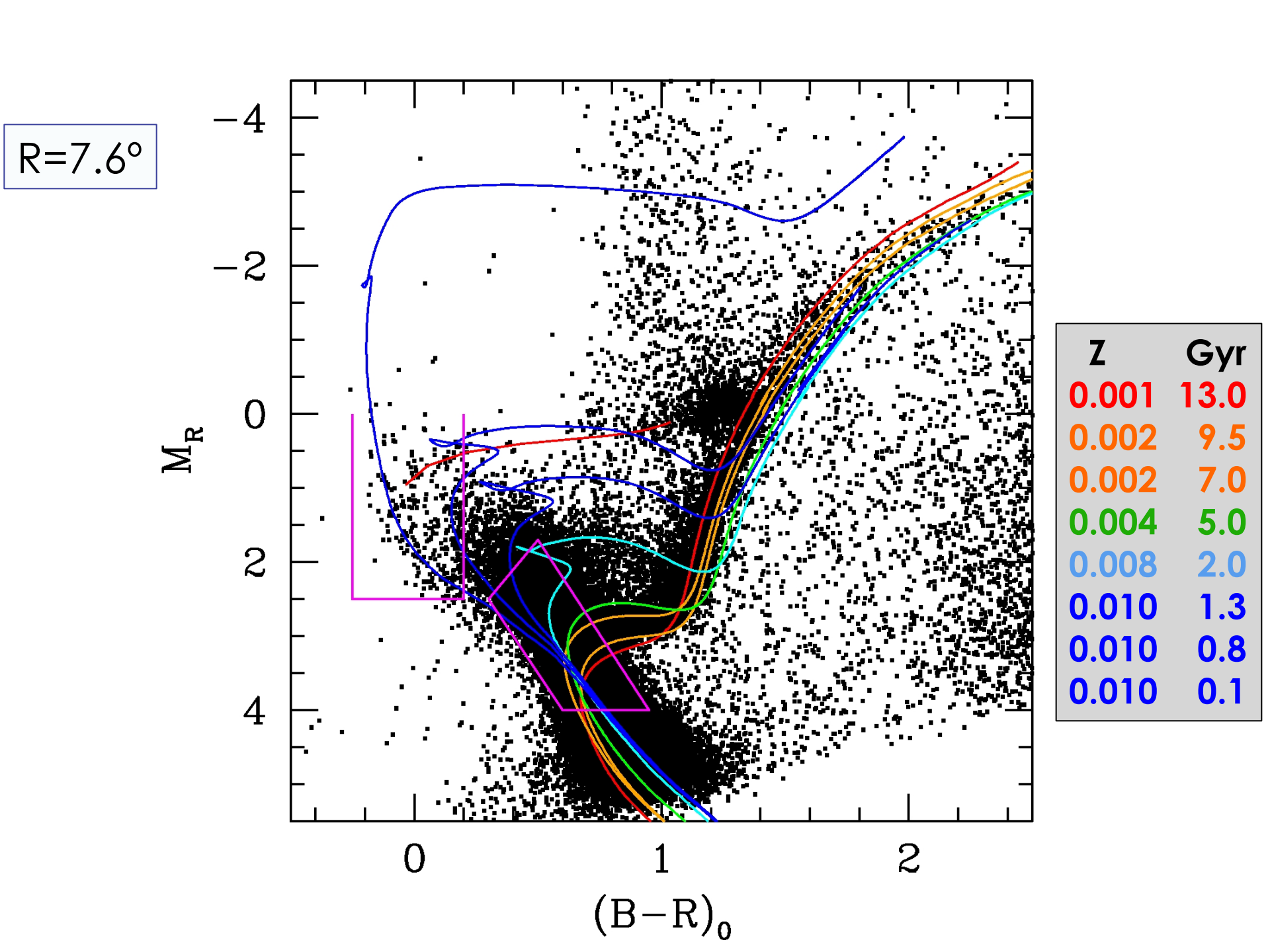


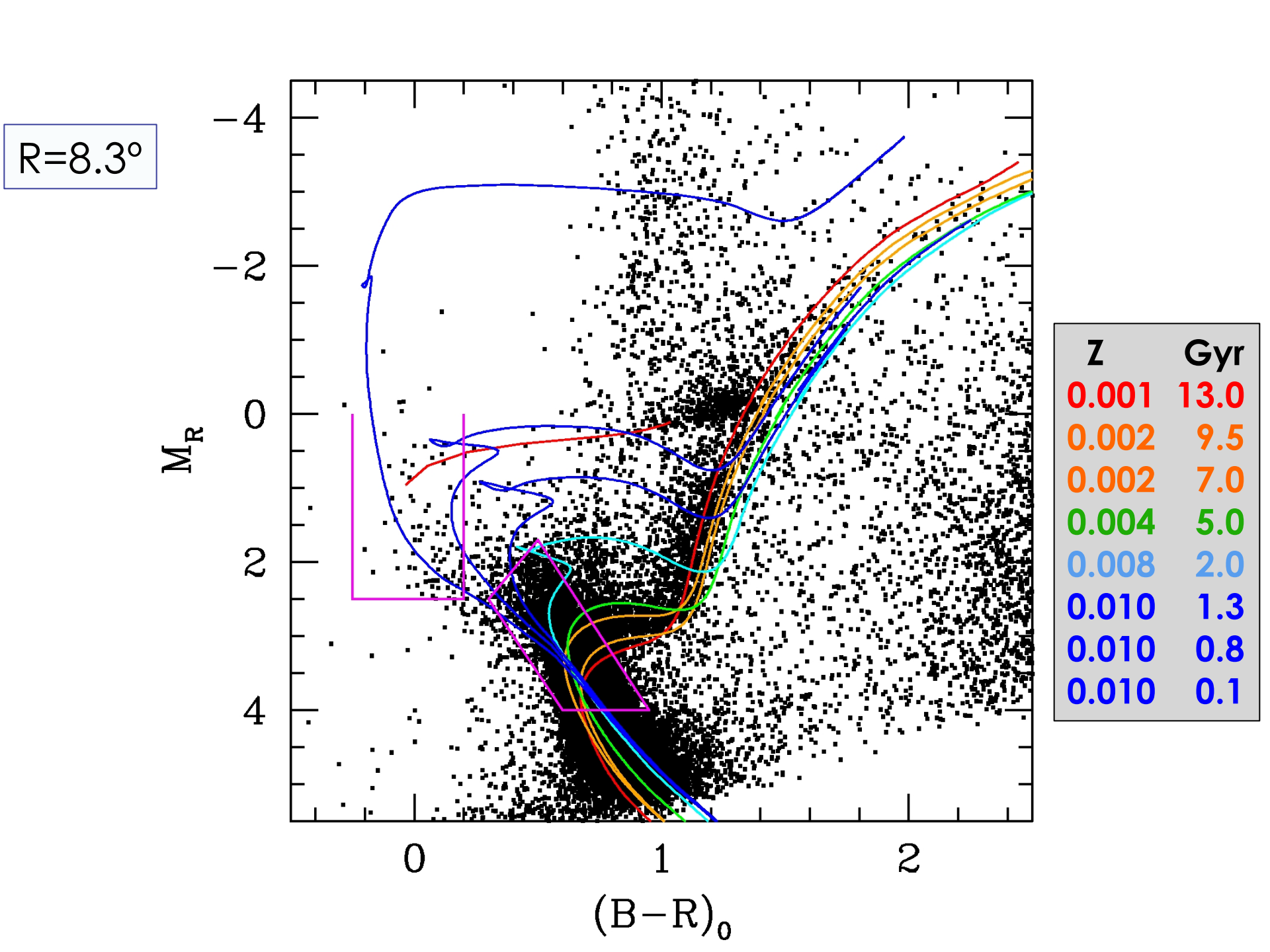
Meschin et al. 2013

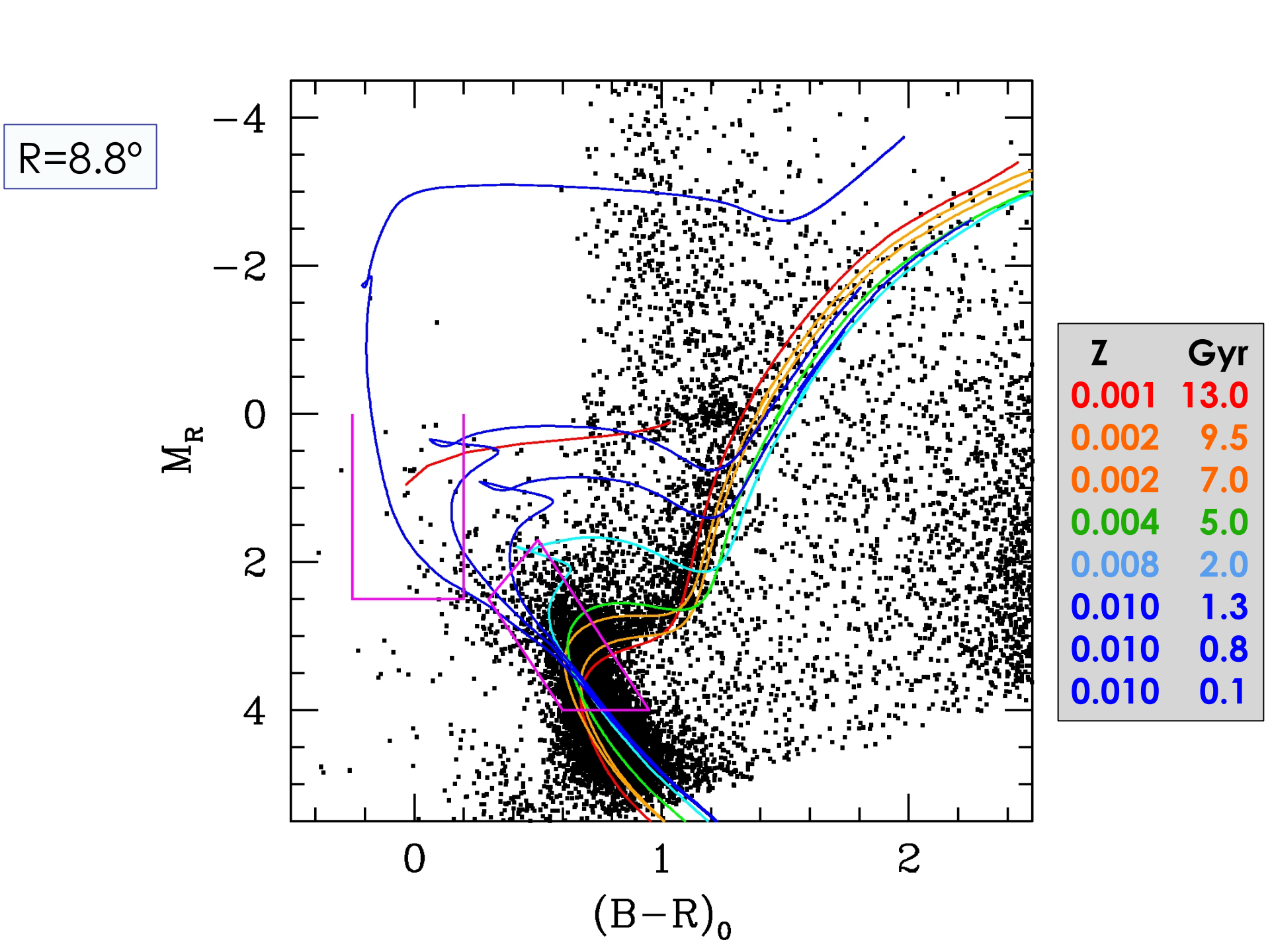


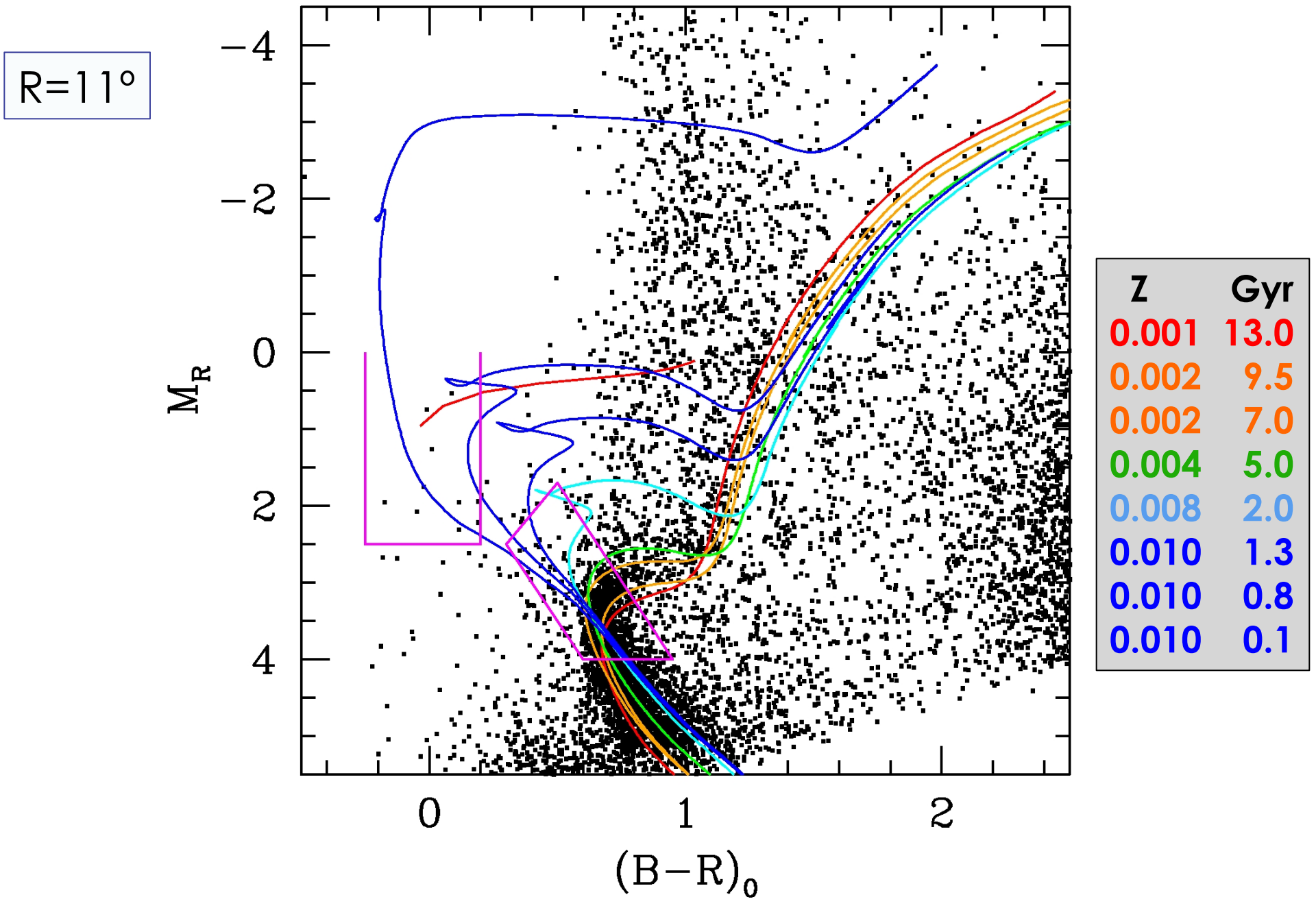


Various features in the SFR(t) 'migrate' as a function of radius at a rate of ≈ 0.4 Gyr/Kpc

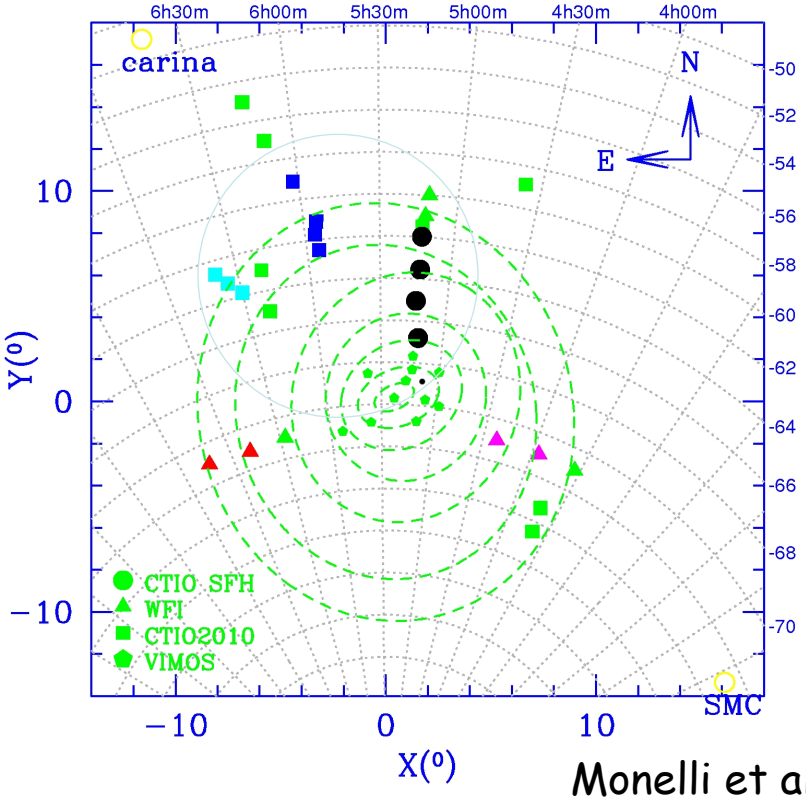

R=7.6°
−4
−2
0
2
4
M_R
0
1
2
$(B-R)_0$
Z
Gyr
0.001
13.0
0.002
9.5
0.002
7.0
0.004
5.0
0.008
2.0
0.010
1.3
0.010
0.8
0.010
0.1

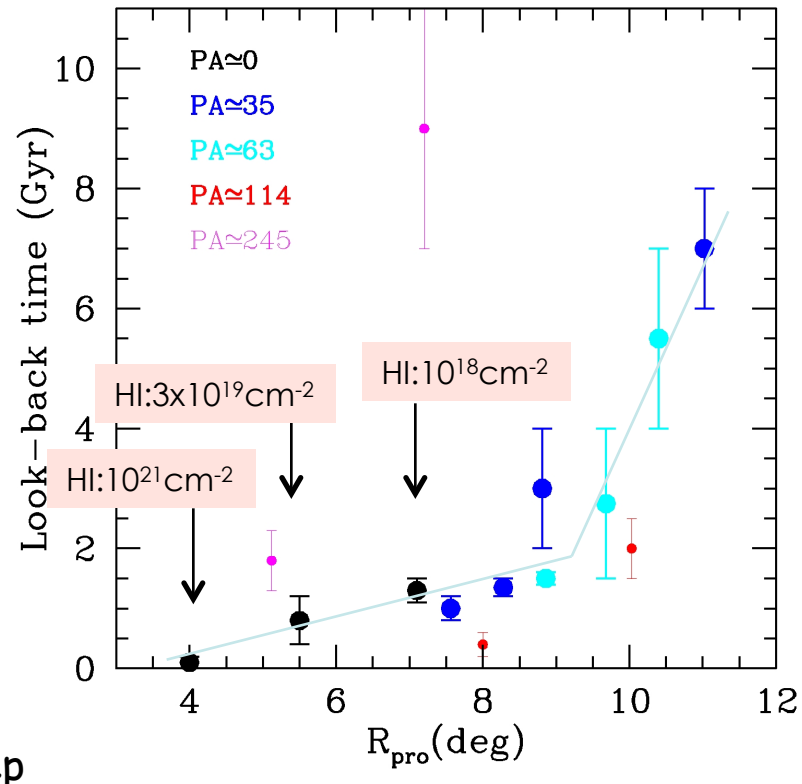

R=8.3°
−4
−2
0
2
4
M_R
0
1
2
$(B-R)_0$
Z
Gyr
0.001
13.0
0.002
9.5
0.002
7.0
0.004
5.0
0.008
2.0
0.010
1.3
0.010
0.8
0.010
0.1


R=8.8°
−4
−2
0
2
4
M_R
0
1
2
$(B-R)_0$
Z
Gyr
0.001
13.0
0.002
9.5
0.002
7.0
0.004
5.0
0.008
2.0
0.010
1.3
0.010
0.8
0.010
0.1


R=11°
−4
−2
0
2
4
M_R
0
1
2
$(B-R)_0$
Z
Gyr
0.001
13.0
0.002
9.5
0.002
7.0
0.004
5.0
0.008
2.0
0.010
1.3
0.010
0.8
0.010
0.1

Stellar populations gradients: the LMC





Monelli et al. in prep

Same migration rate of ≈ 0.4 Gyr/Kpc for the age of the end of the star formation out to ≈9 Kpc

Survey of the MAgellanic Stellar History: SMASH

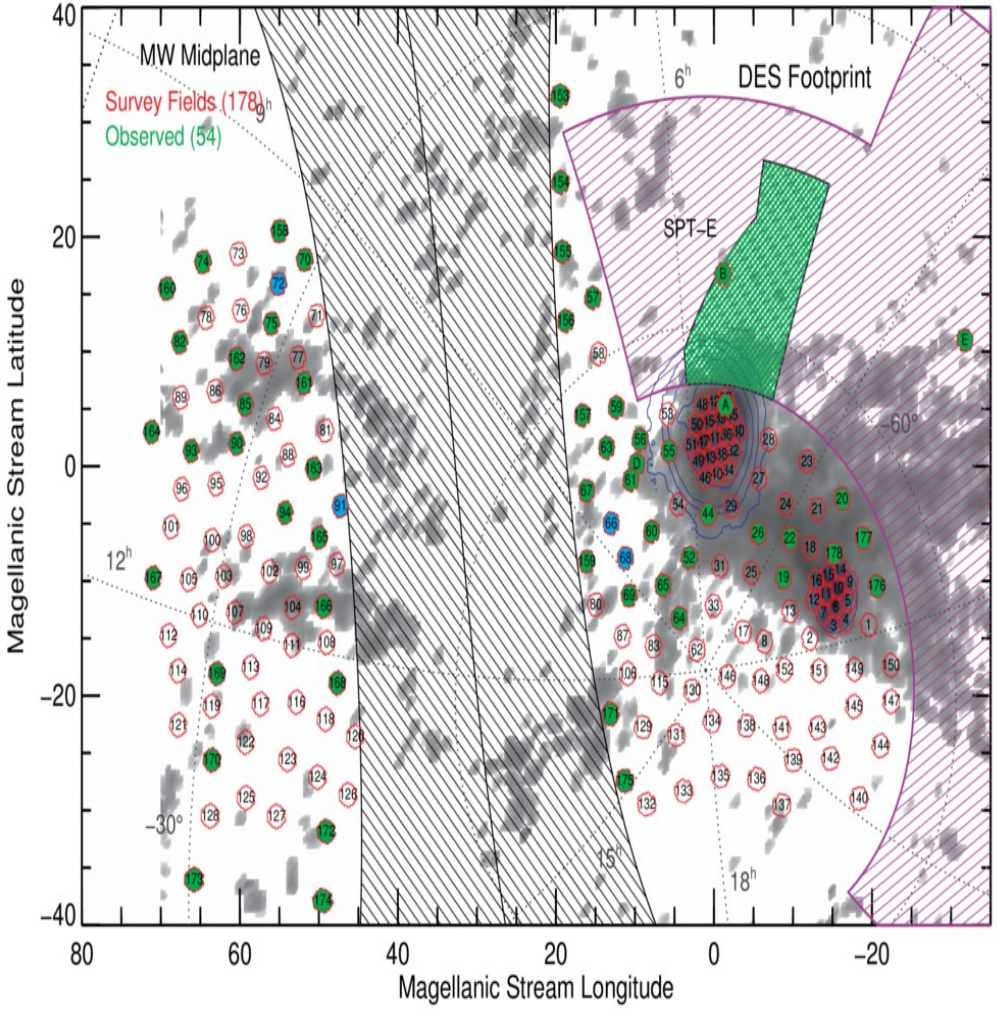
- 40 nights with CTIO/DECam
- 480 deg^2 distributed over 2500 deg^2 complementary to DES footprint
- ugriz filters, to 24th mag
- 30 researchers, P.I. D. Nidever

GOALS:

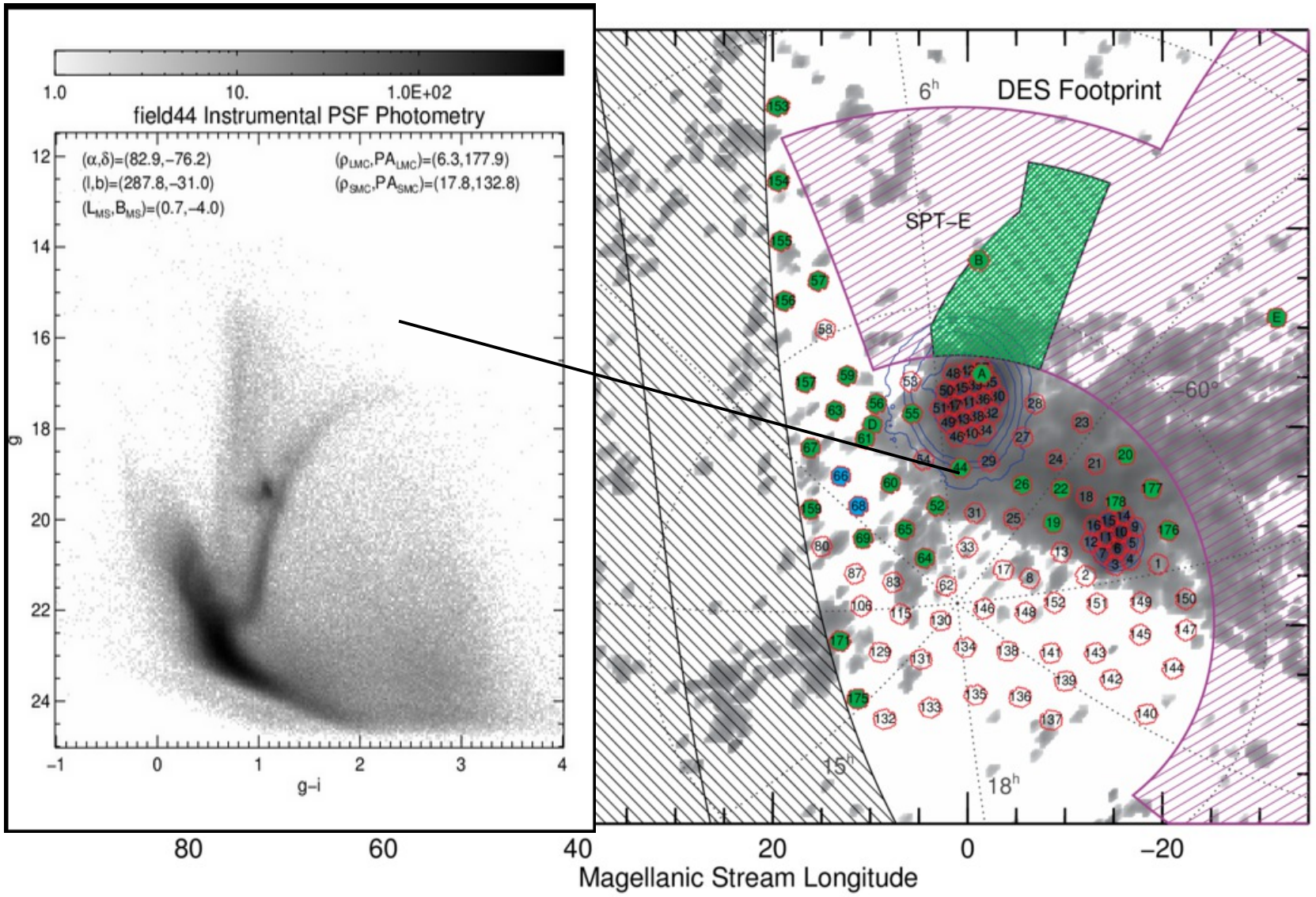
-Map the Magellanic stellar periphery with old main-sequence turnoff stars revealing relics of their formation and past interactions

- Search for the stellar component of the Magellanic Stream and Leading Arm

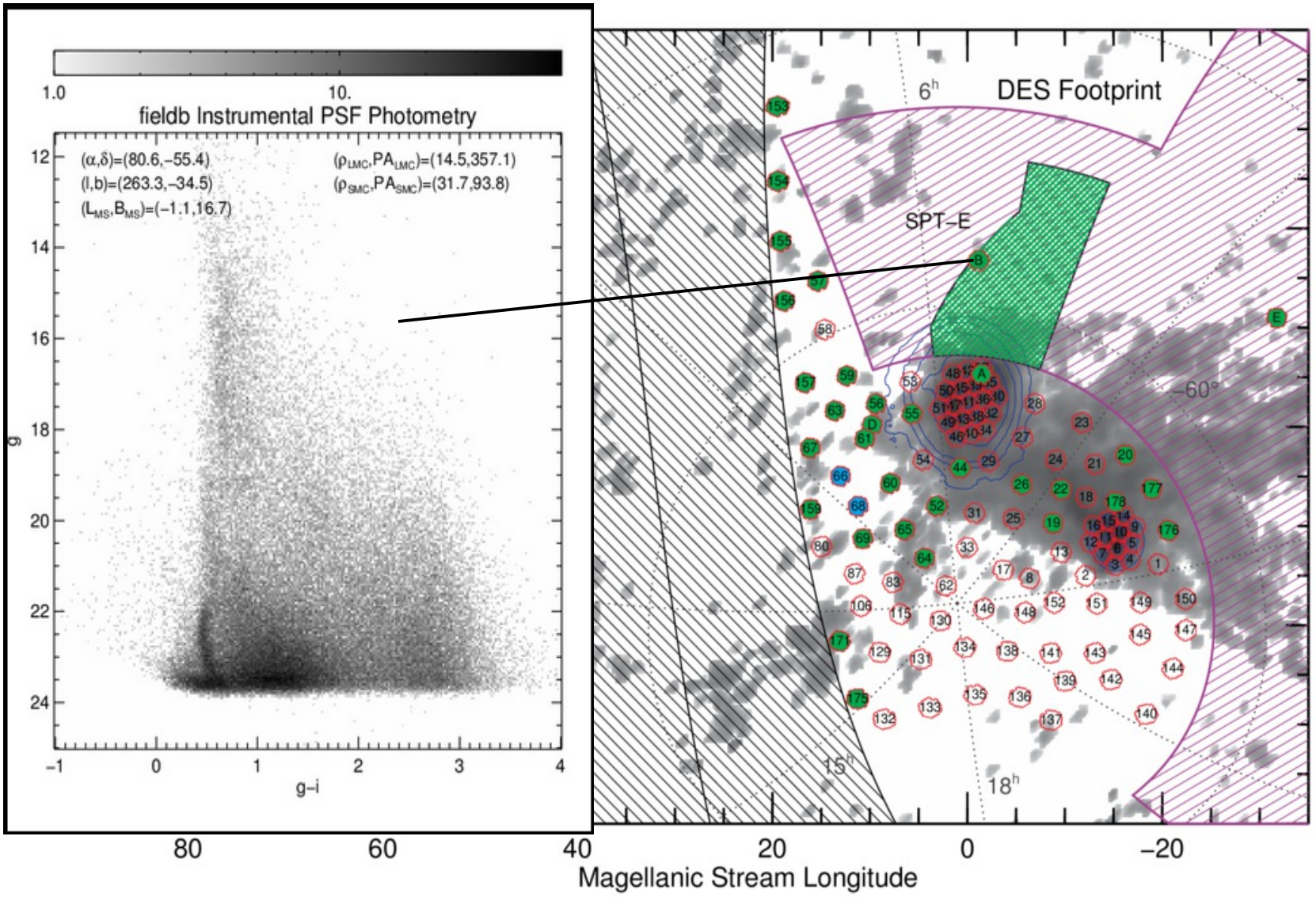
- Derive spatially-resolved star formation histories covering all ages out to large radii



Survey of the MAgellanic Stellar History: SMASH

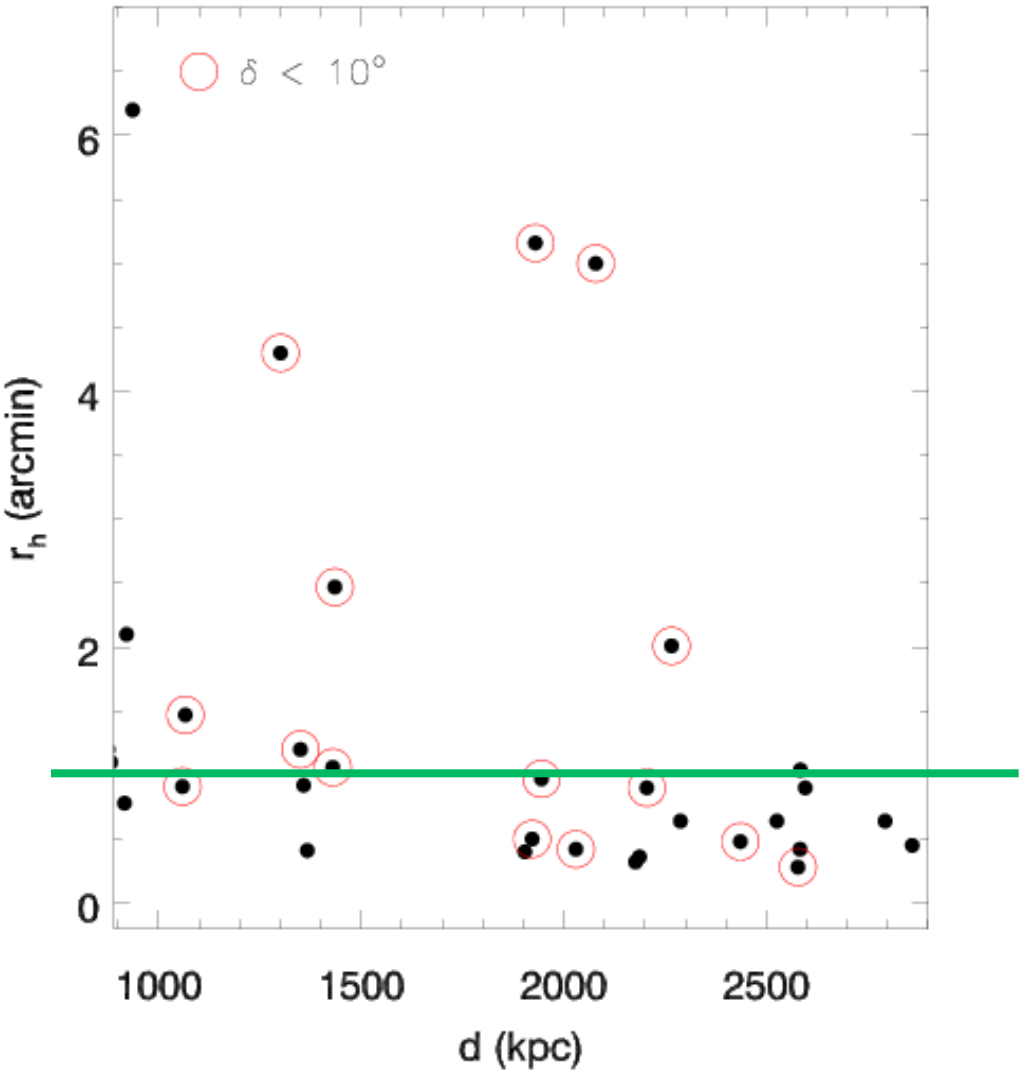


Survey of the MAgellanic Stellar History: SMASH



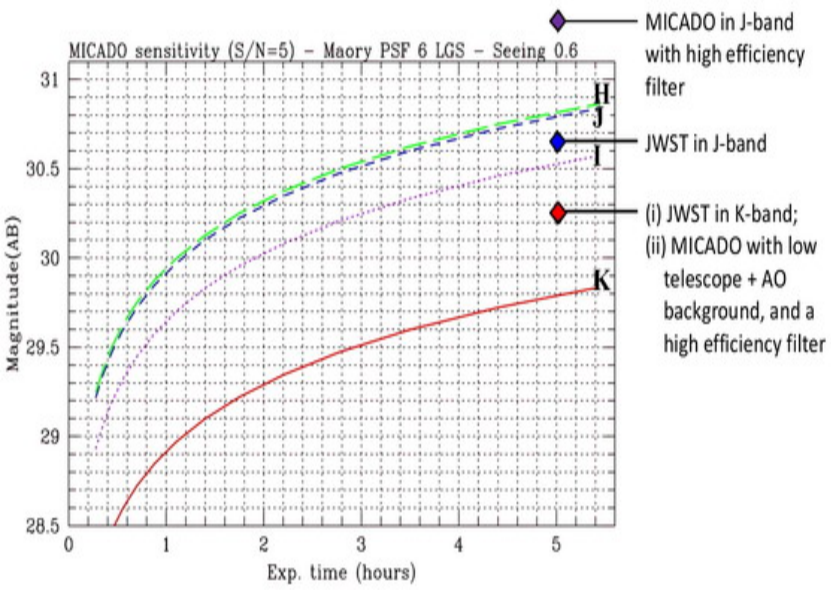
The impact of the E-ELT

The impact of the E-ELT

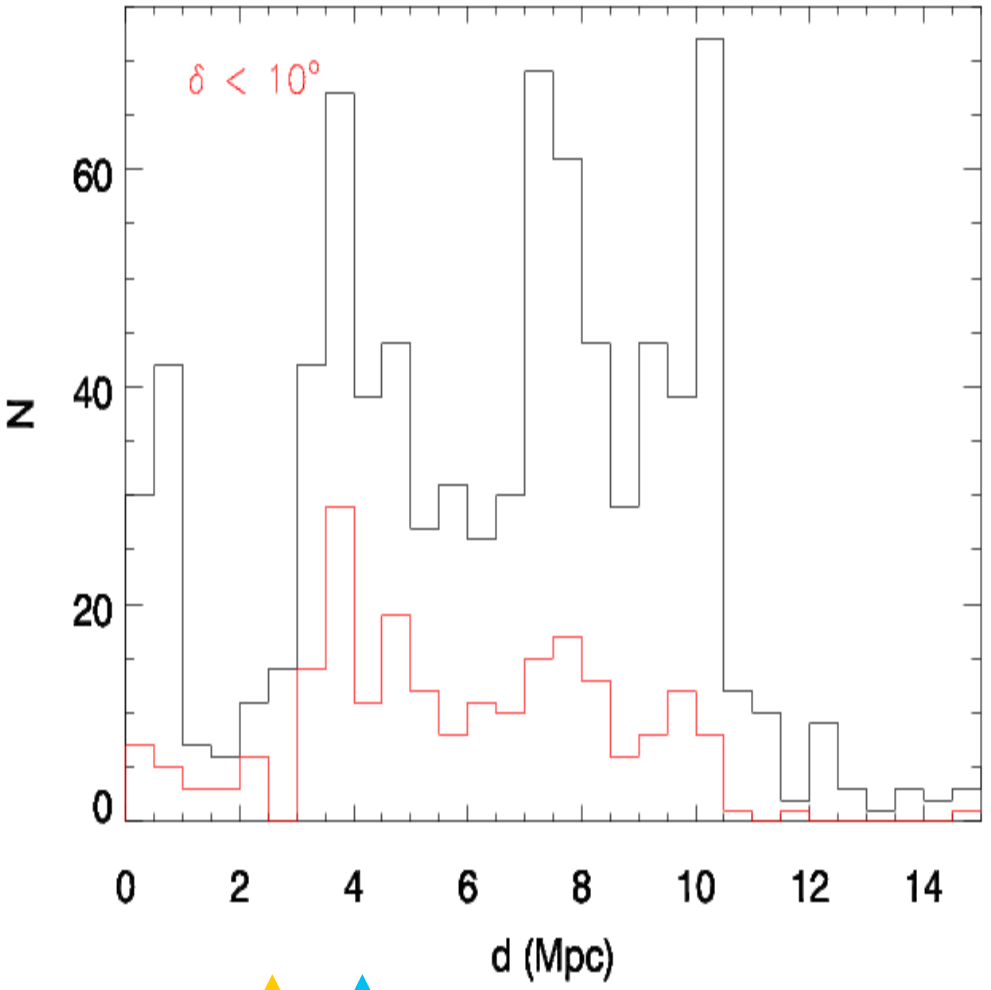


Data from McConnachie 2012

The impact of the E-ELT



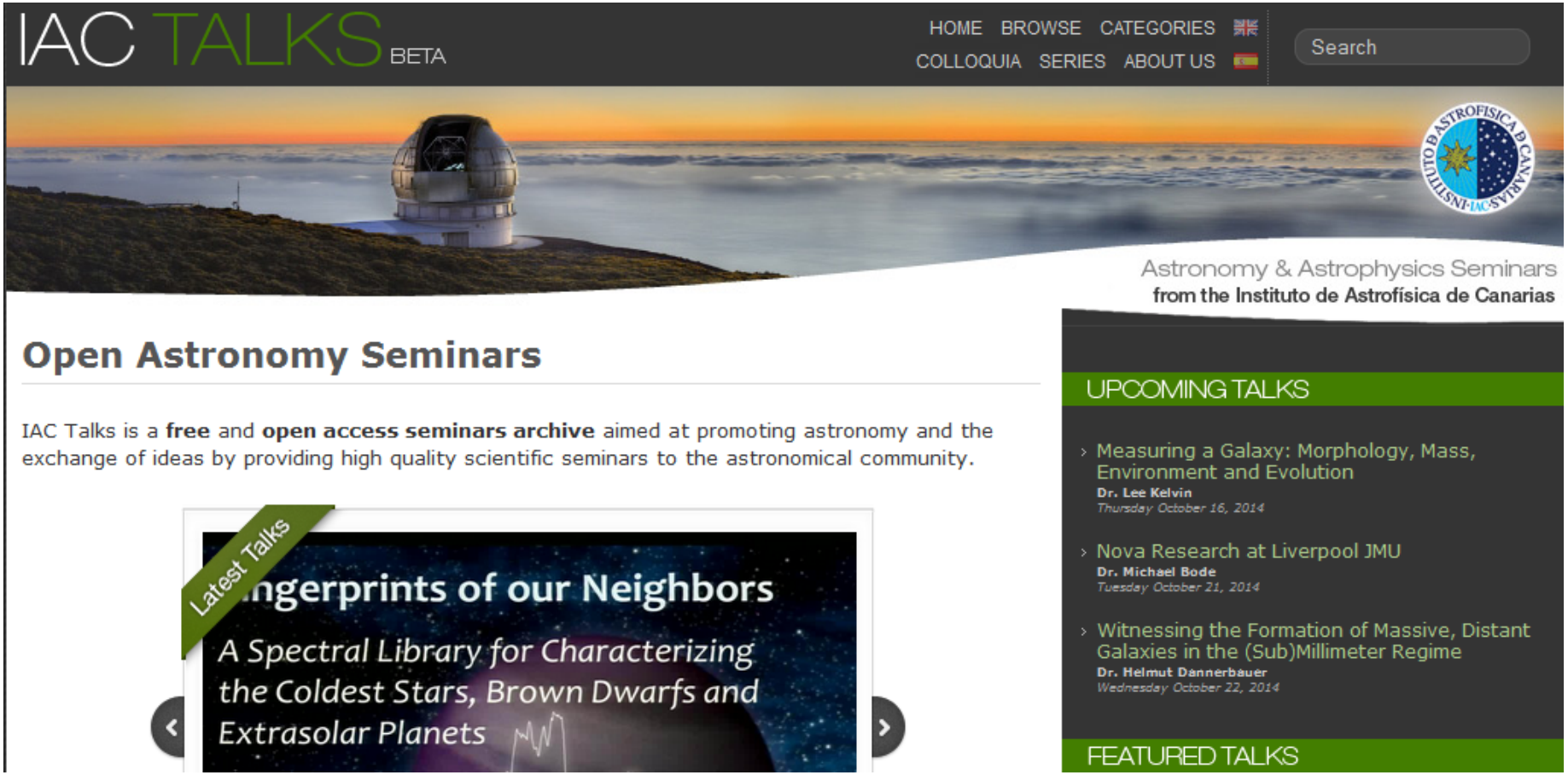
Micado expected limit magnitude



TO (S/N=10)

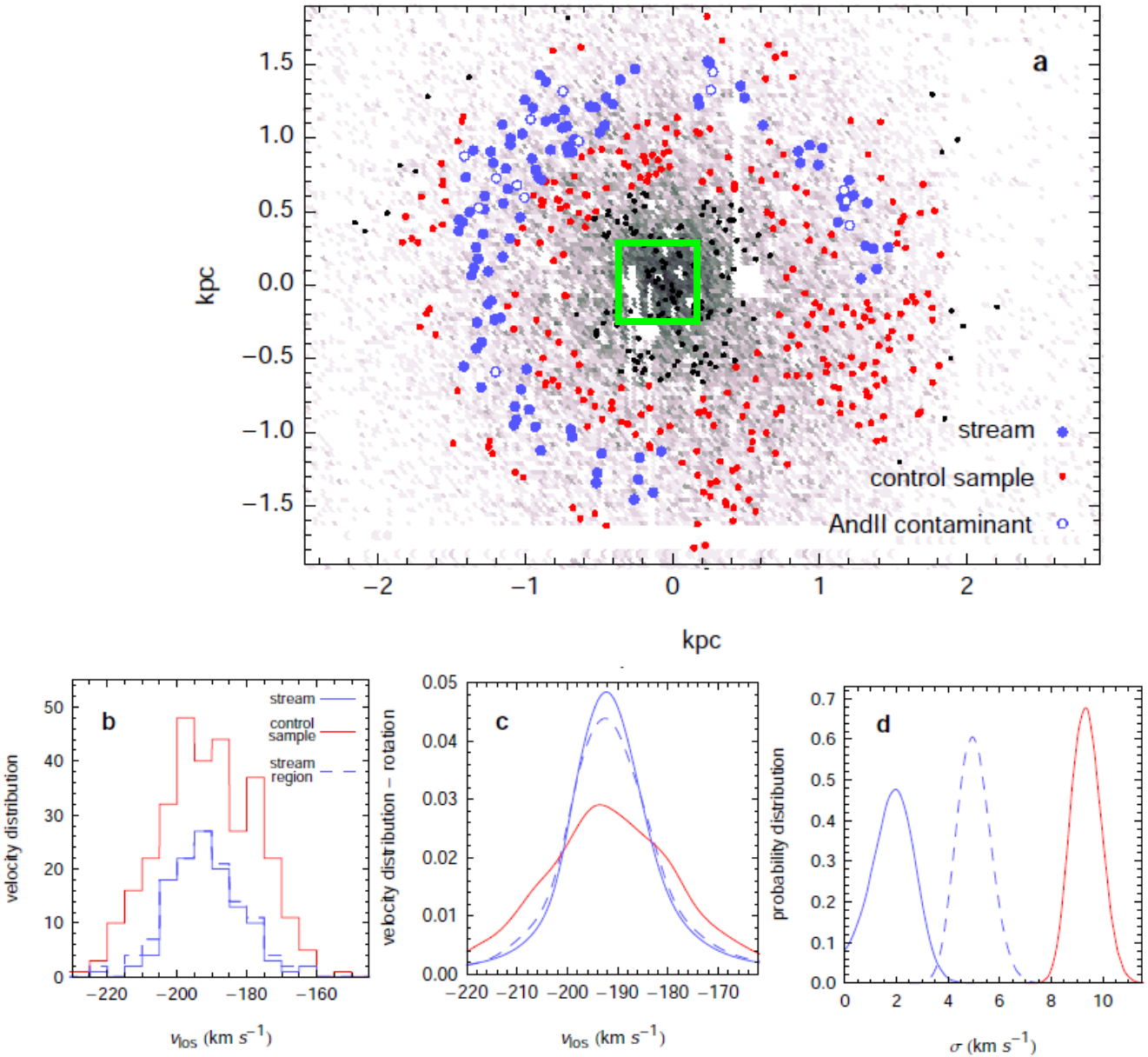
Time series for RR Lyrae

Data from Karachentsev et al. 2013



http://iactalks.iac.es

M31 Satellites: And II



Amorisco+14

Outline

(1) Global Star Formation History of LG dwarfs:

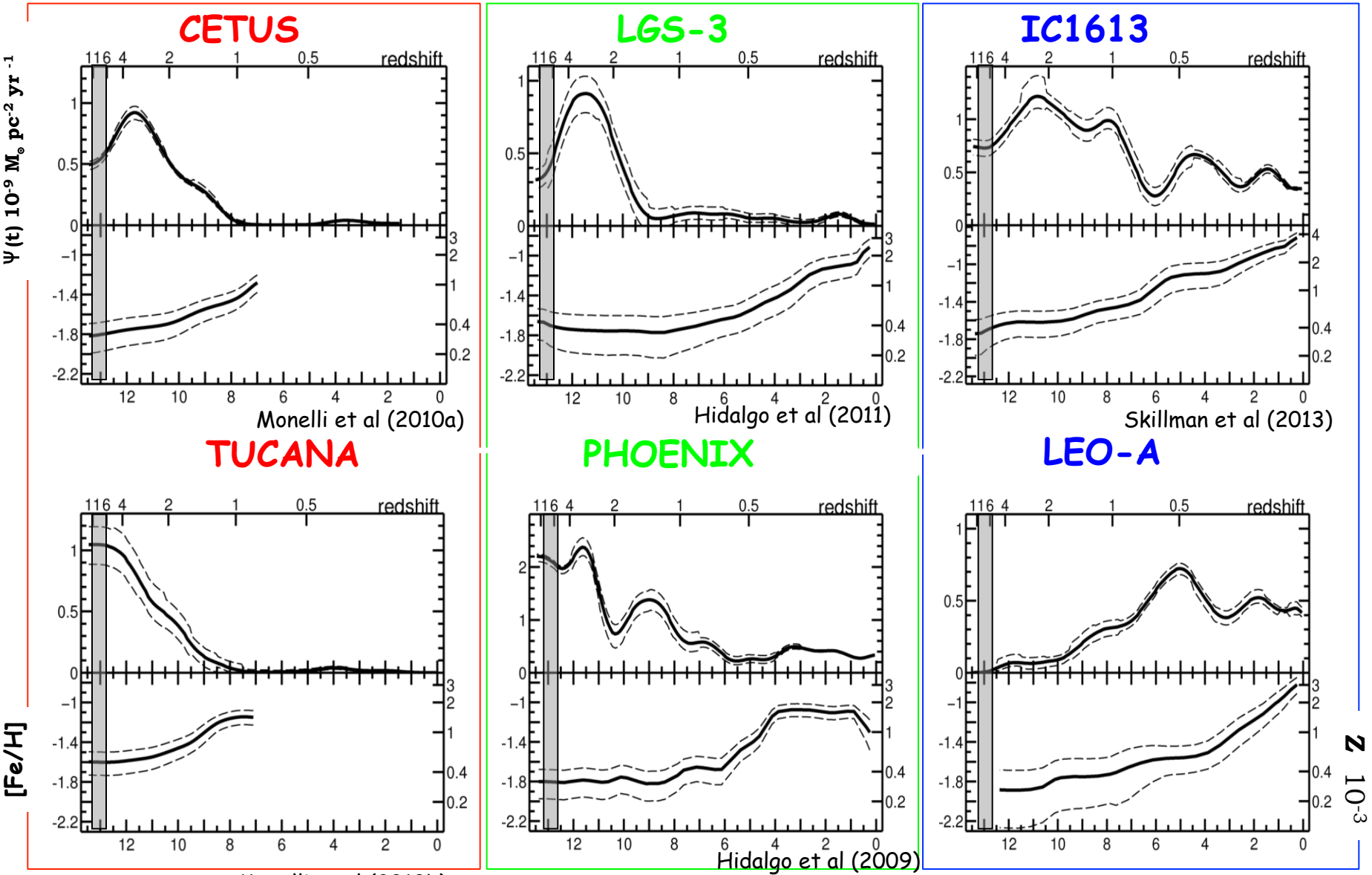
- Isolated – the LCID project (a bit more detailed)
- MW satellites (selected)
- M31 satellites

(2) Spatial gradients

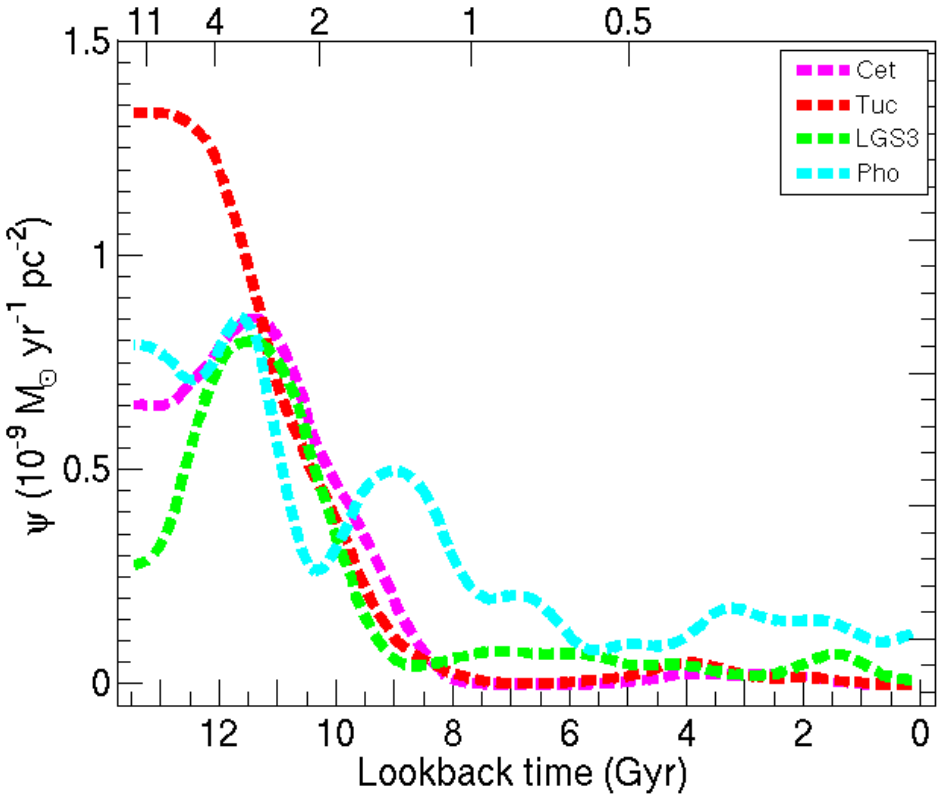
- LMC (special guest)

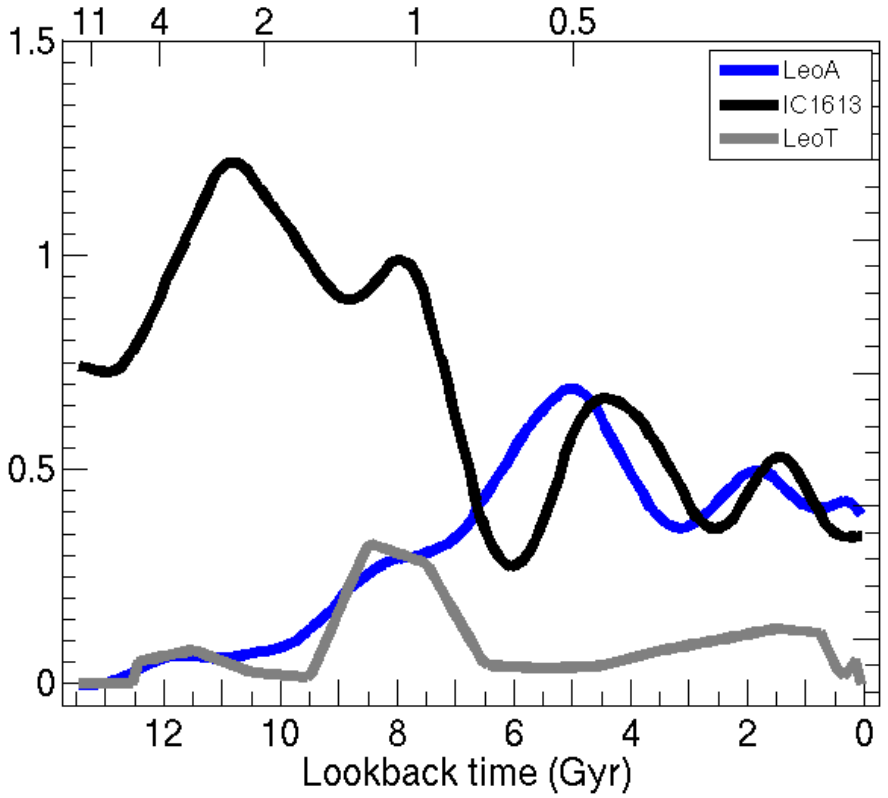
(3) The impact of the E-ELT

Global Star Formation Histories: Reionization



Morphological classification: a different scheme?





FAST

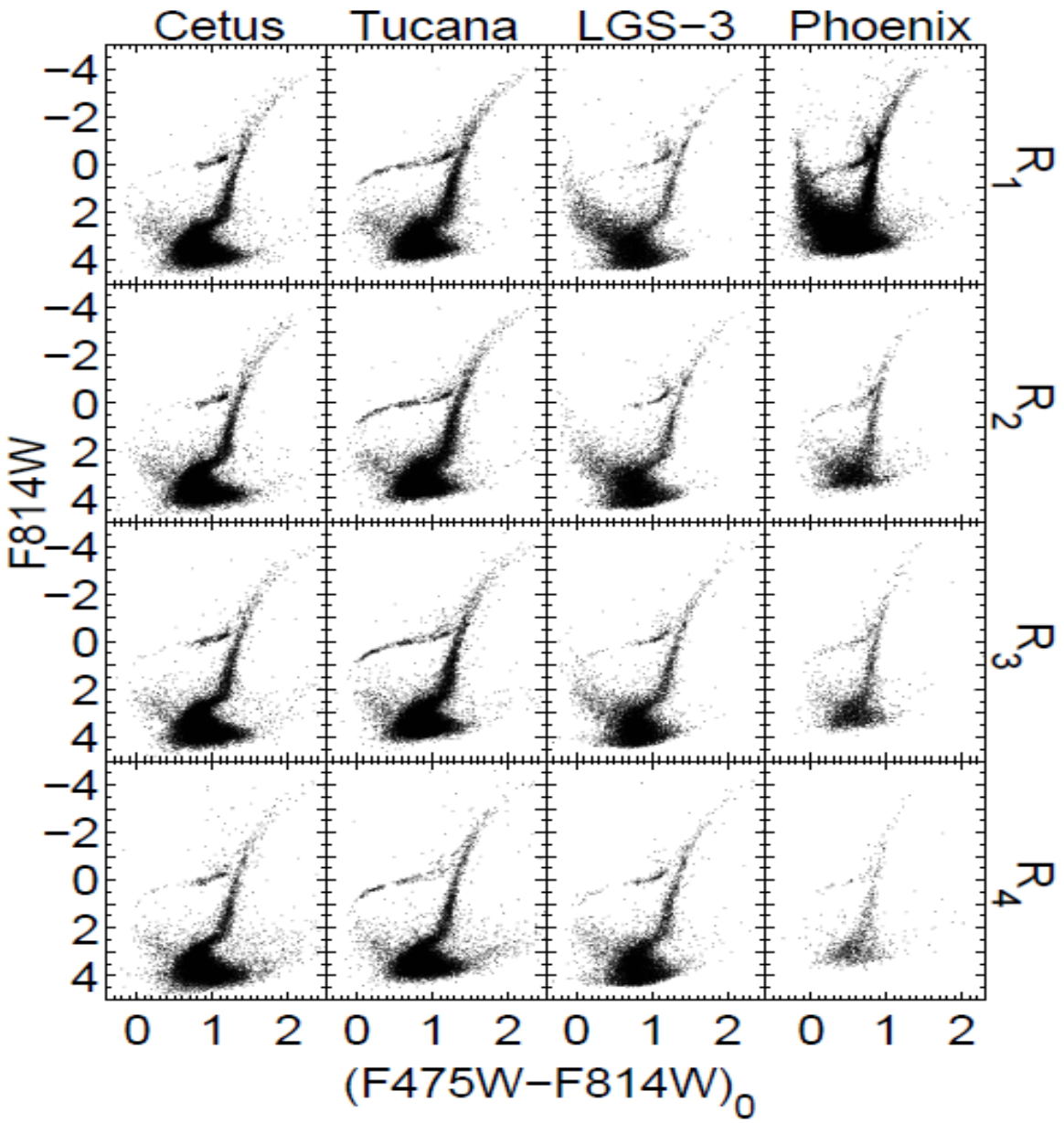
SLOW

Gallart et al. in prep.

Stellar populations gradients: LCID

CENTER

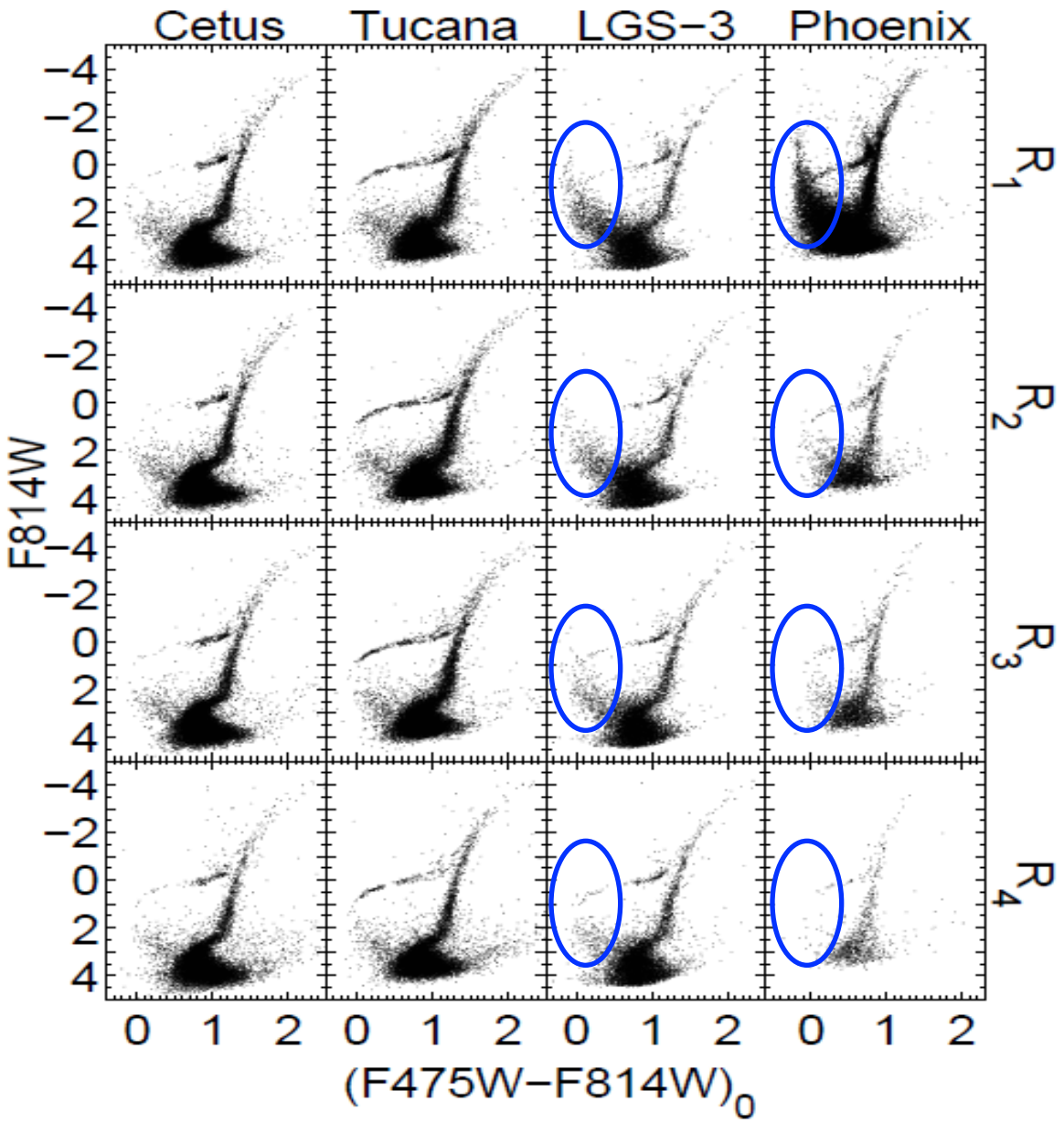
OUTSKIRTS



Stellar populations gradients: LCID

CENTER

OUTSKIRTS



Stellar populations gradients: LCID

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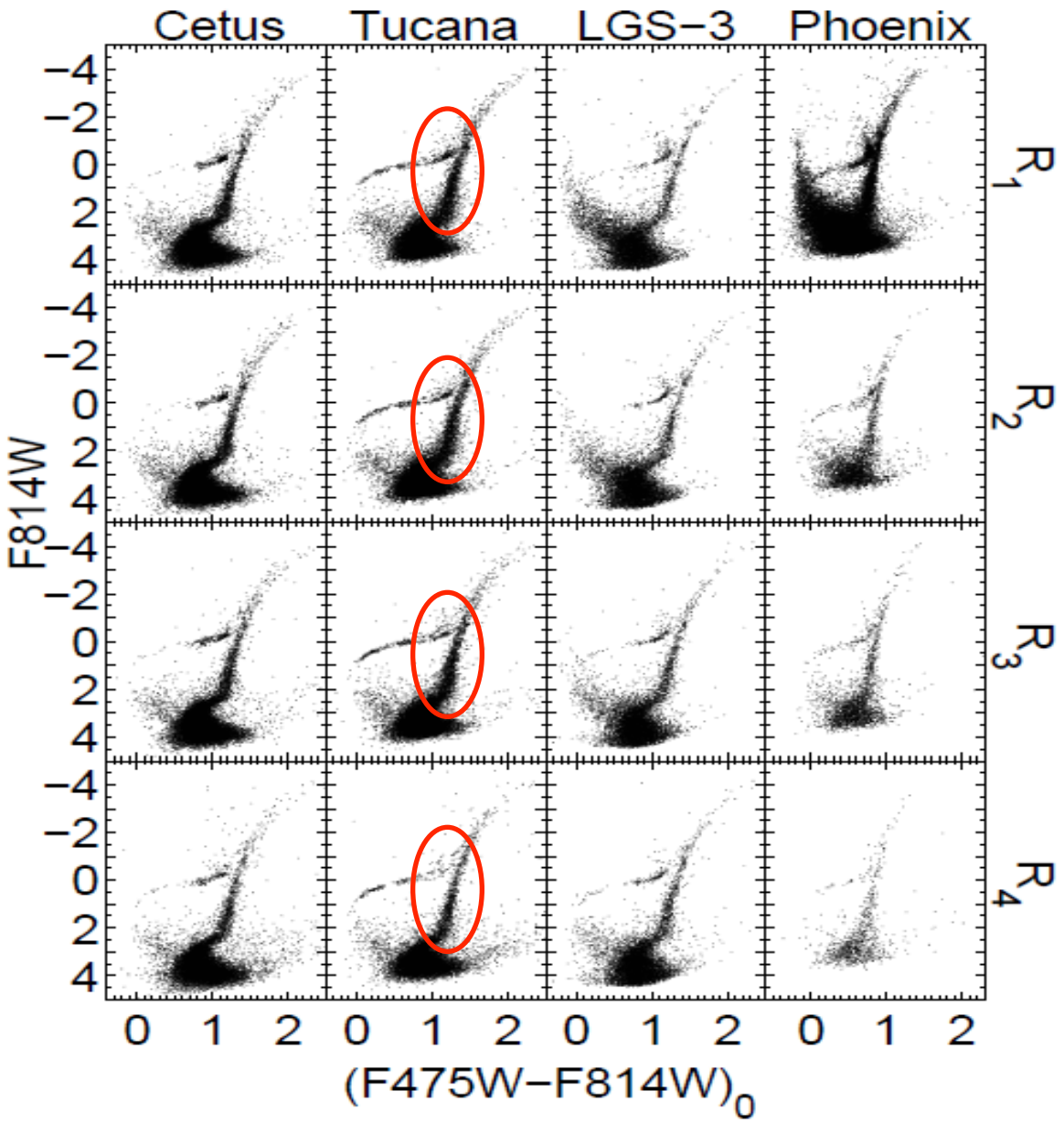
OUTSKIRTS



Stellar populations gradients: LCID

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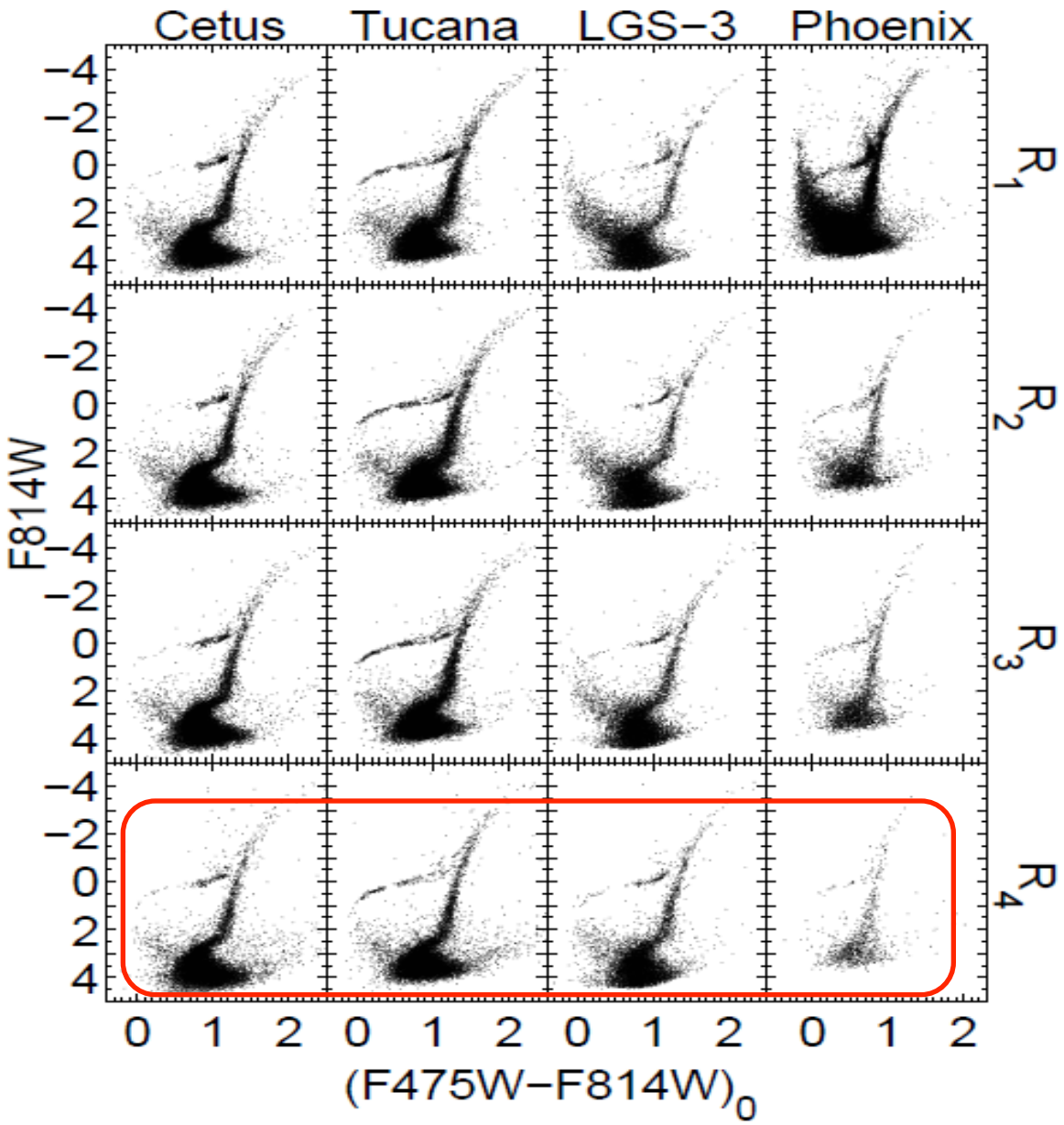
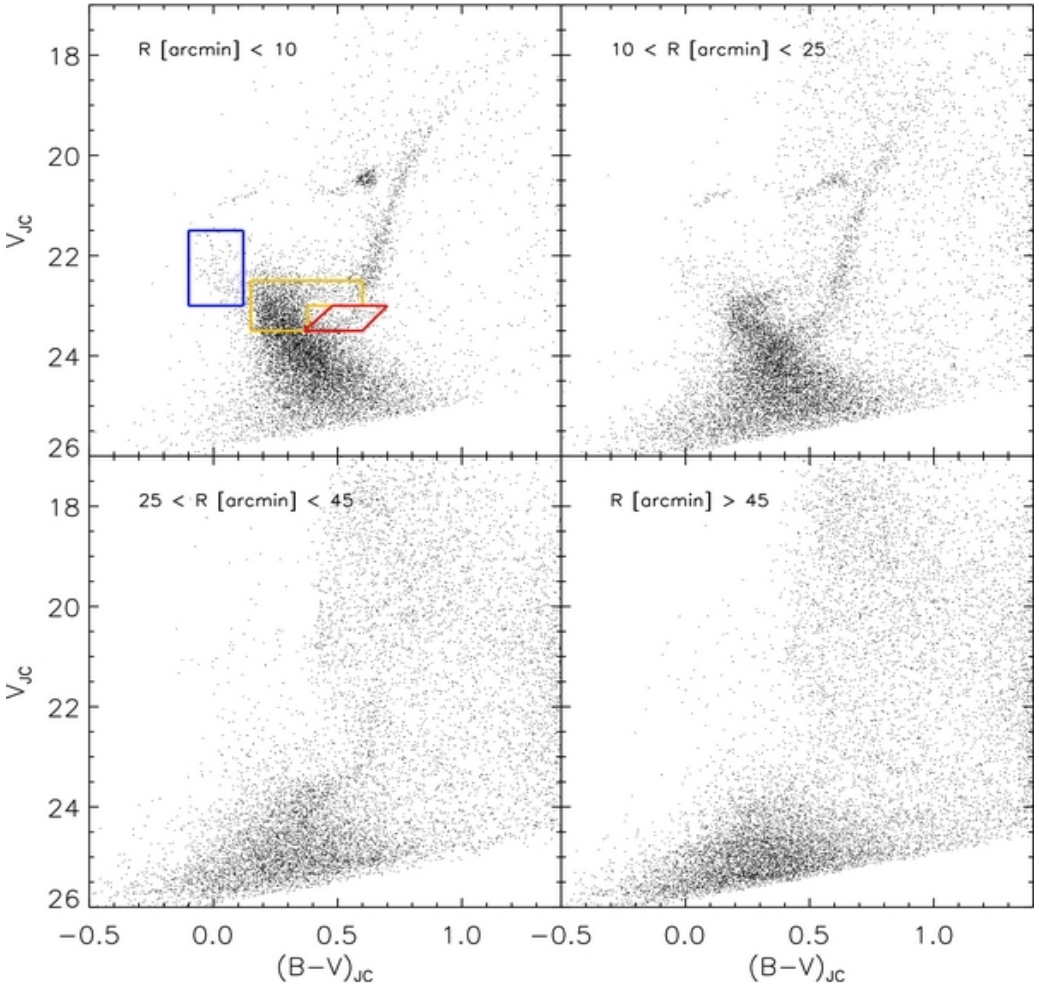
OUTSKIRTS



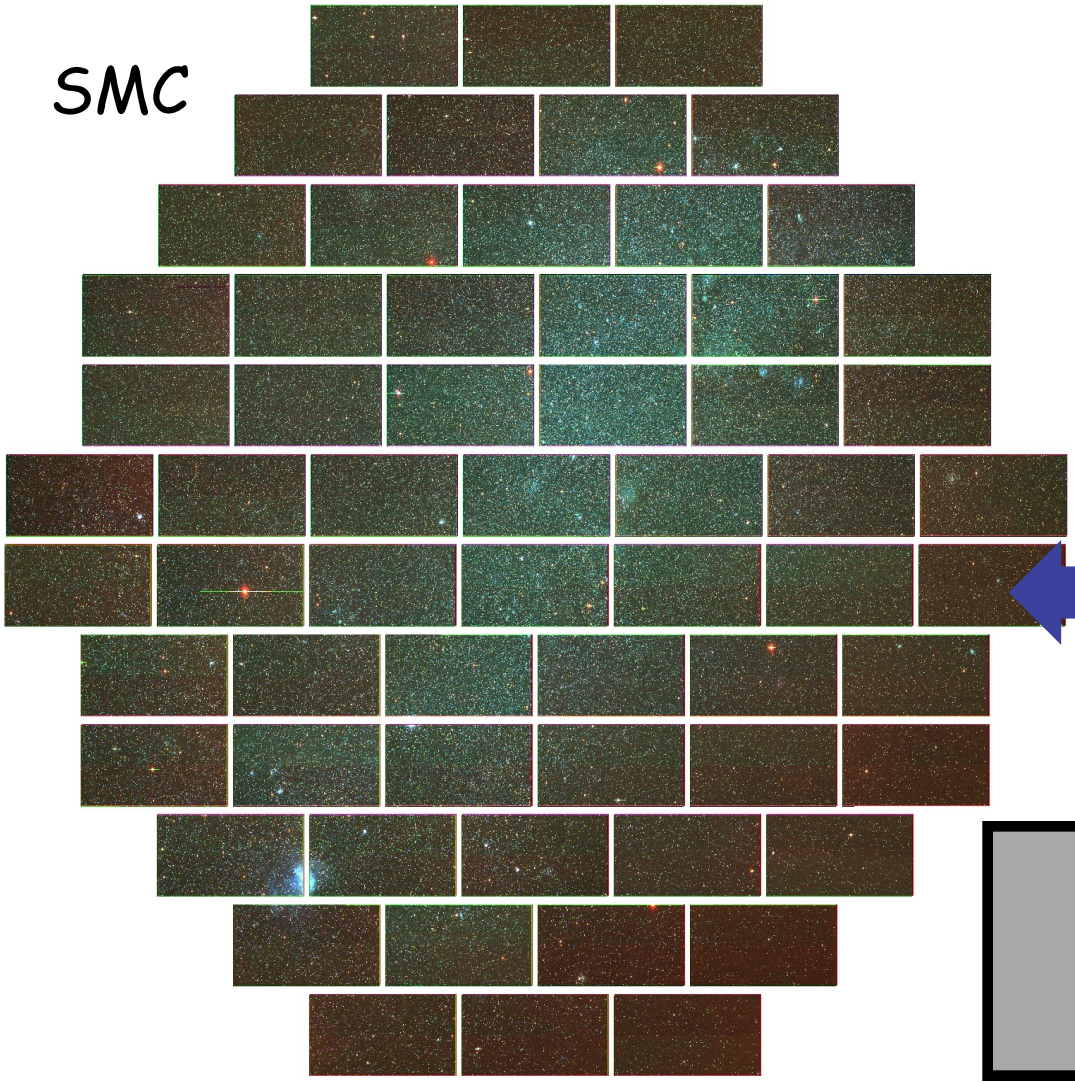
dSph and dT look the same at large radius

Stellar populations gradients: Carina dSph



Battaglia+12

Survey of the MAgellanic Stellar History: SMASH



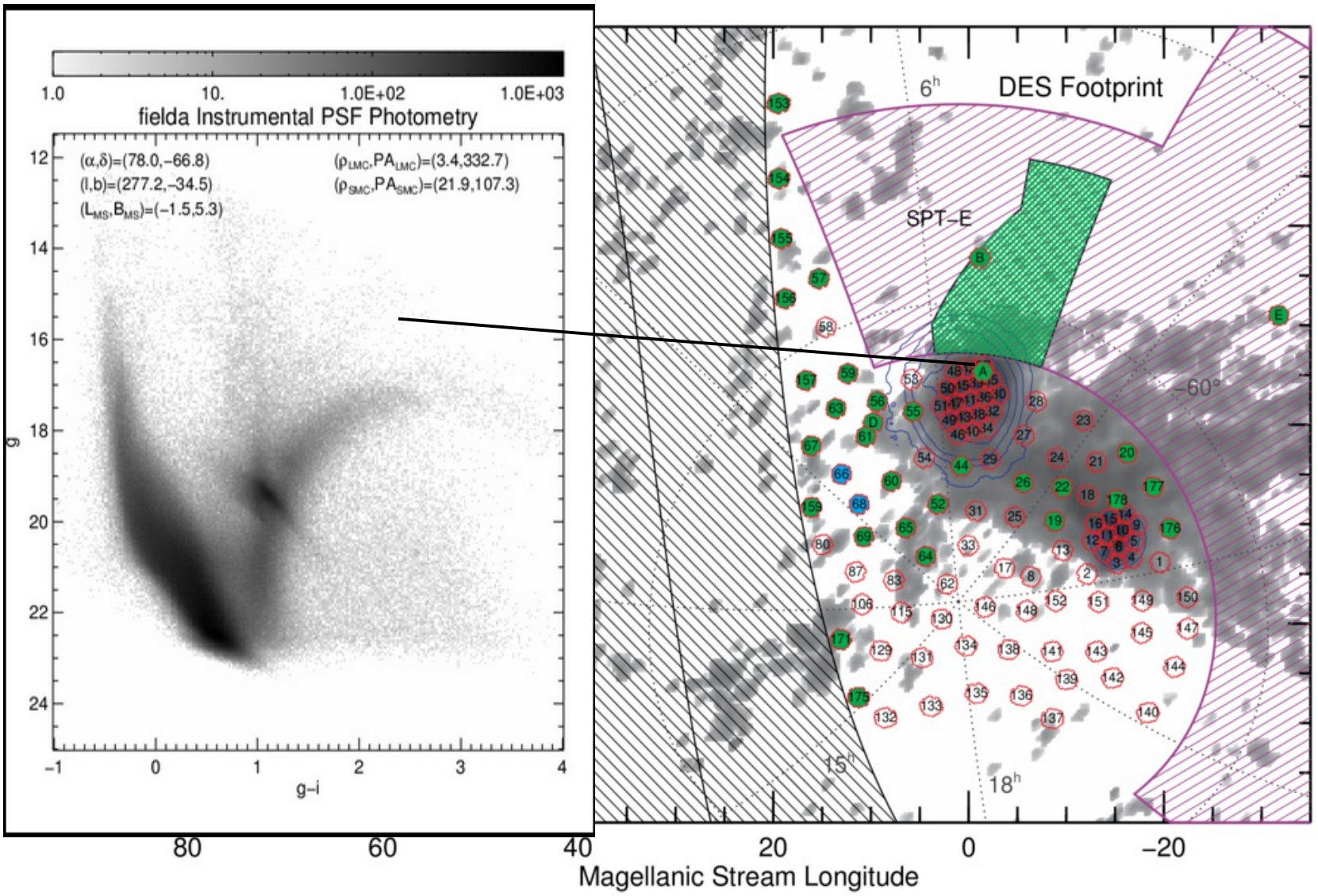
Challenges:
- 62 CCDs
- 1 image = 2 Gb
- 1 field > 50 Gb
  and milions of sources
-artificial stars tests!!!!
-field contamination

DECam@4mCTIO

Former 35' x35' detectors

2 degrees

Survey of the MAgellanic Stellar History: SMASH



Survey of the MAgellanic Stellar History: SMASH