

**The ACS LCID project:  
accurate measurements of the full  
star formation history  
in low metallicity, isolated,  
Local Group dwarf galaxies**

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The ACS **LCID** project:  
Local Cosmology from Isolated dwarfs

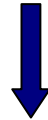
*Accurate SFH over the whole life time of isolated LG galaxies, to answer fundamental questions:*

- Was there any delay in/truncation of the first event of star formation?
  - can we infer the role of the **reionization**?
- Are there big differences with nearby MW satellites due to environmental effects?
- How well did these small galaxies could retain the gas?
  - how important was the SNe feedback?

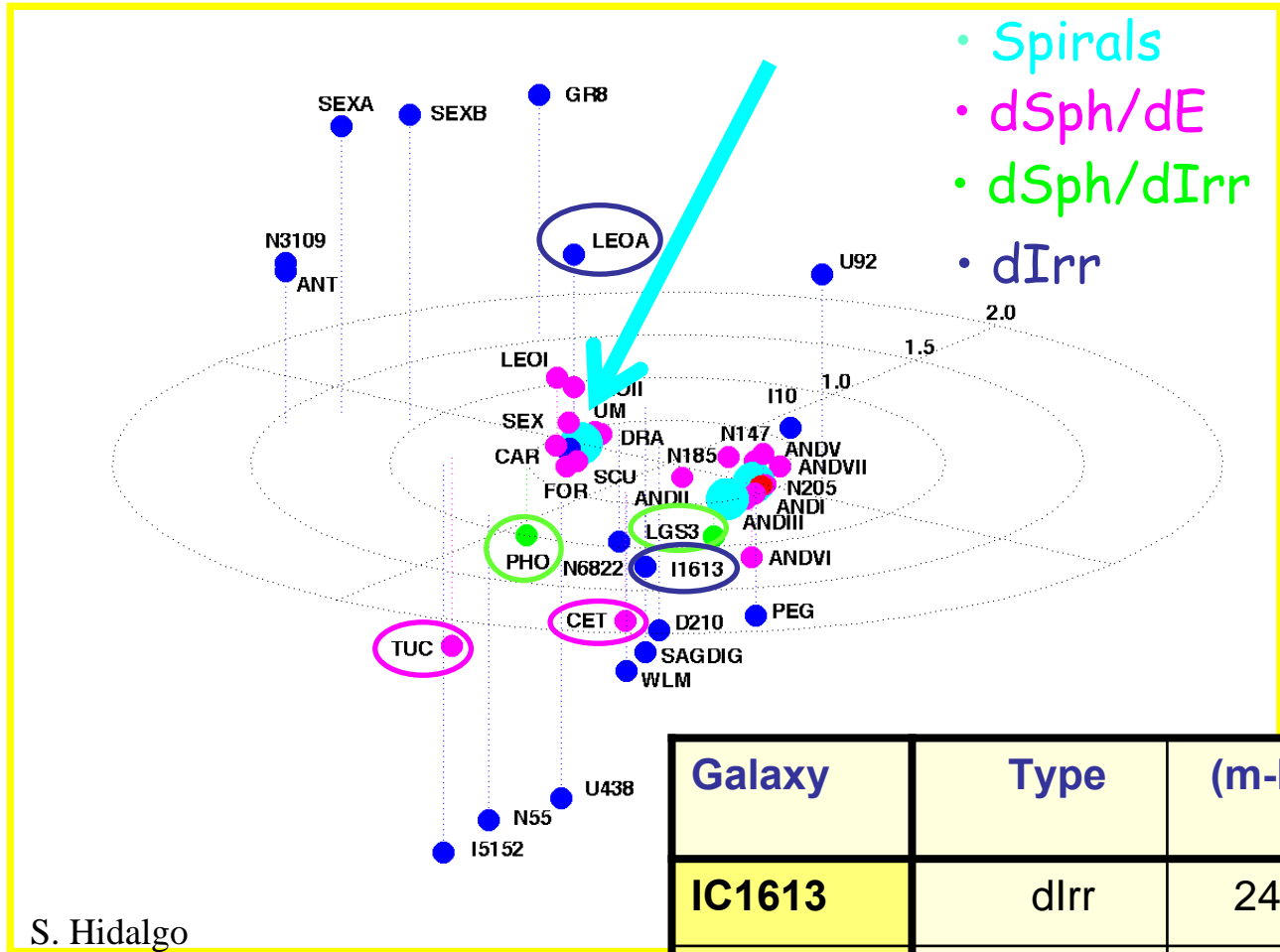
The ACS **LCID** project:  
Local Cosmology from Isolated dwarfs

**I** - Precise photometry of the oldest Turn-Off stars

**II** - Isolated dwarf galaxies:



Evolution free of environmental effects due to the strong interaction with the parent galaxy (Milky Way or M31)



- Spirals
- dSph/dE
- dSph/dIrr
- dIrr

S. Hidalgo

Galaxy	Type	$(m-M)_0$	D(kpc) MW / M31	# Orbits
IC1613	dlrr	24.41	769 / 520	24
Leo A	dlrr	24.50	794 / 1180	16
LGS3	dlrr/dSph	23.98	625 / 270	12
Phoenix	dlrr/dSph	23.30	457 / 610	22 <sub>wfpc2</sub>
Cetus	dSph	24.39	755 / 680	25
Tucana	dSph	24.77	899 / 1340	32

Based on two ACS proposals (C14):

**1) The onset of star formation in the Universe: constraints from nearby isolated dwarf galaxies**  
(Cetus, Tucana, LGS3, IC1613) P.I. C. Gallart, **97 orbits**

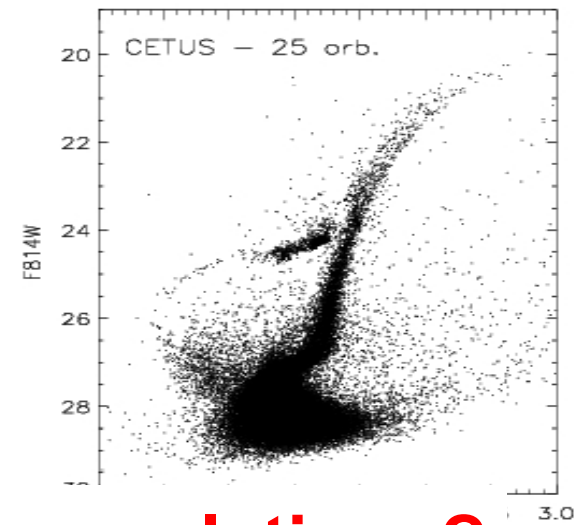
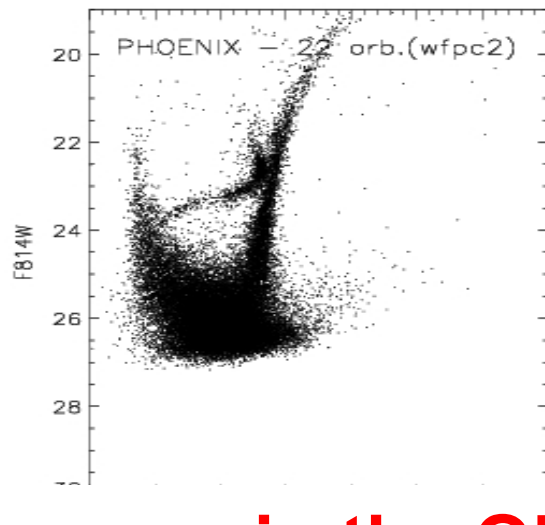
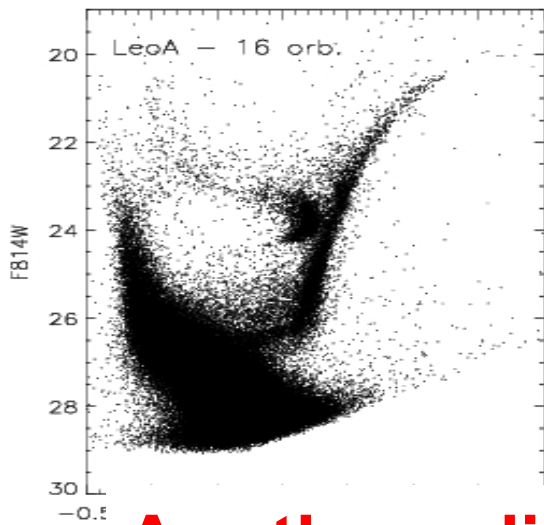
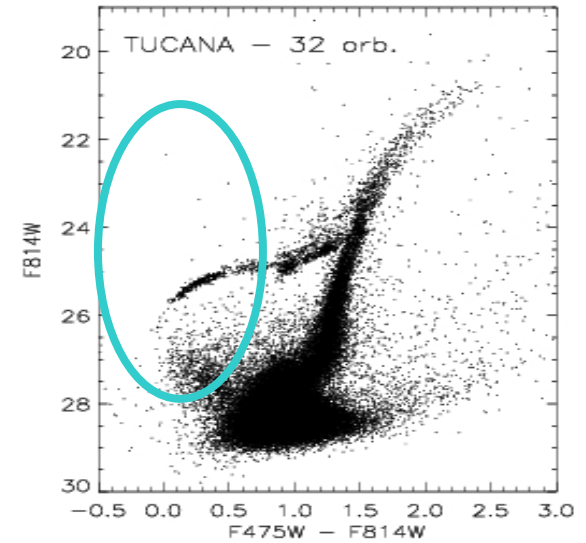
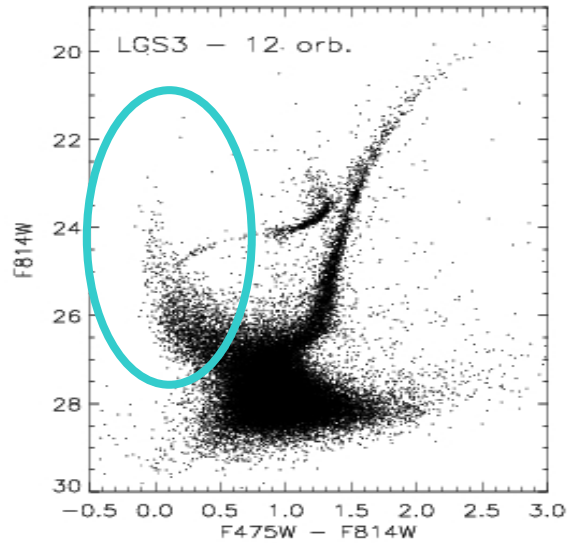
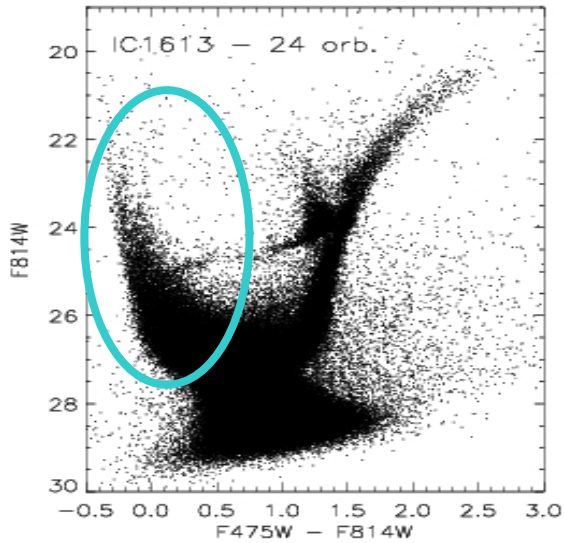
**2) The SFH of an unmerged fragment: Leo A**  
P.I.: A. Cole (U. Minnesota), **16 orbits**

**3) WFPC2 data for Phoenix (C9 Aparicio + C6 archive)**

Co-I:

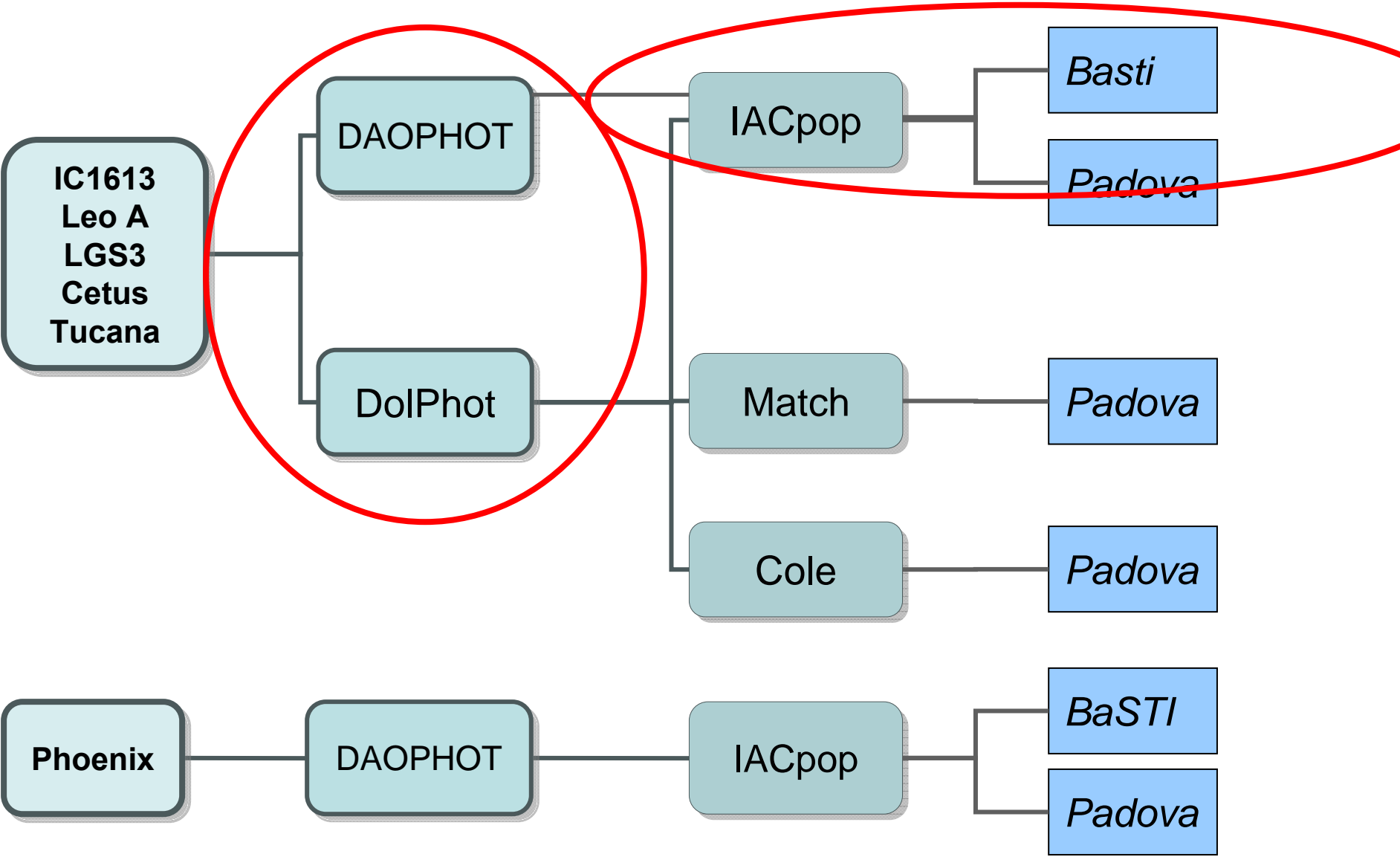
A. Aparicio, I. Drozdovsky, S. Hidalgo, M. Monelli (IAC), E. Bernard (Univ. Edinburgh), G. Bertelli (U. Padova), S. Cassisi (INAF-OA-Teramo), P. Demarque, (U. Yale), H.C. Ferguson (STScI), L. Mayer (U. Zurich), M. Mateo (U. Michigan), J. Navarro (Univ. Victoria), A. Cole (Univ. Tasmania), E. Skillman (U. Minnesota), P.B. Stetson (DAO), E. Tolstoy (Kapteyn), A. Dolphin (Univ. Arizona)

# Color-Magnitude Diagrams

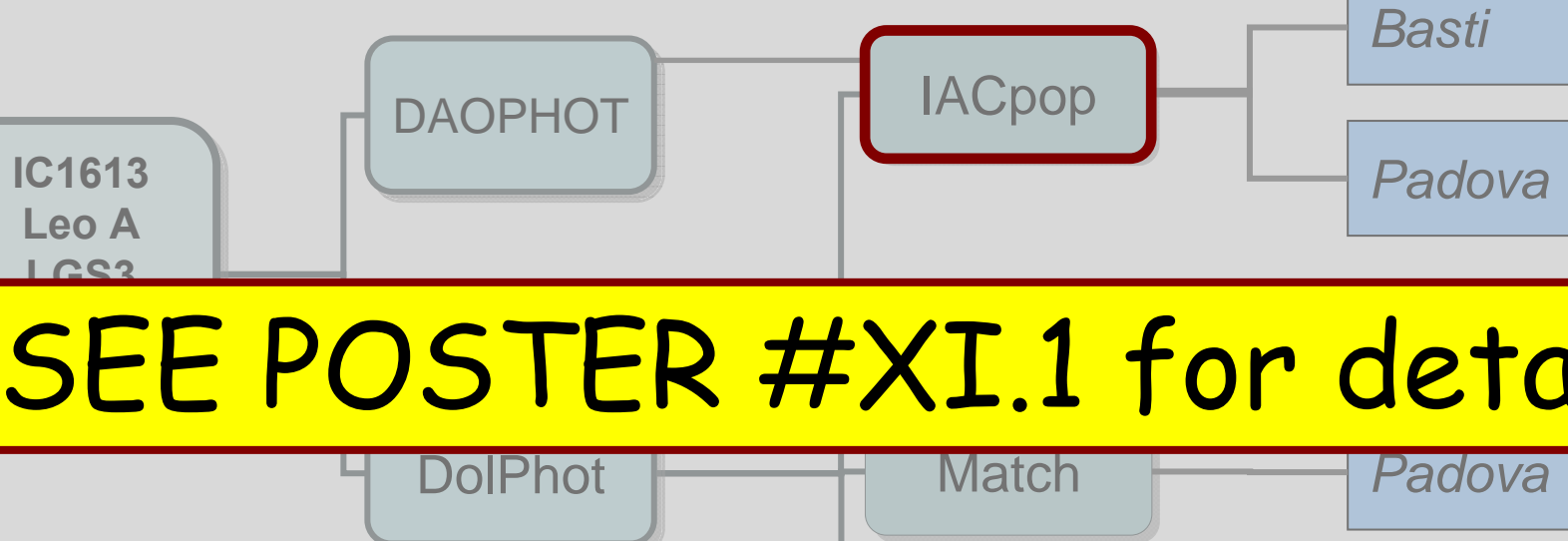


**Are there differences in the OLD populations?  
Can we QUANTIFY these differences?**

**Galaxy :**      **photometry**    +    **SFH code**      +    **Stell. Evol. library**

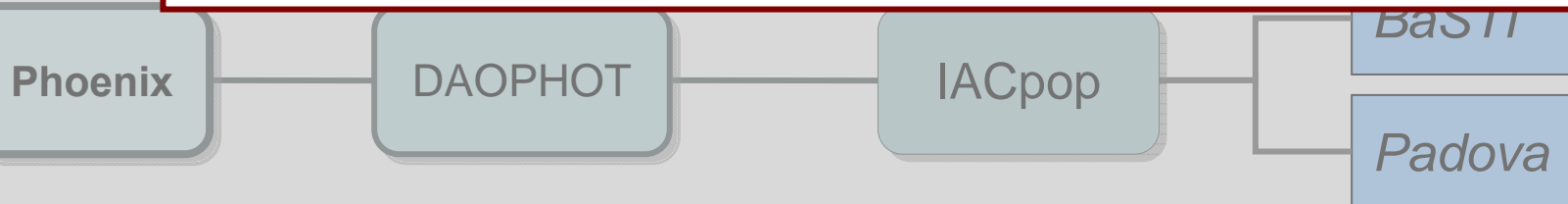


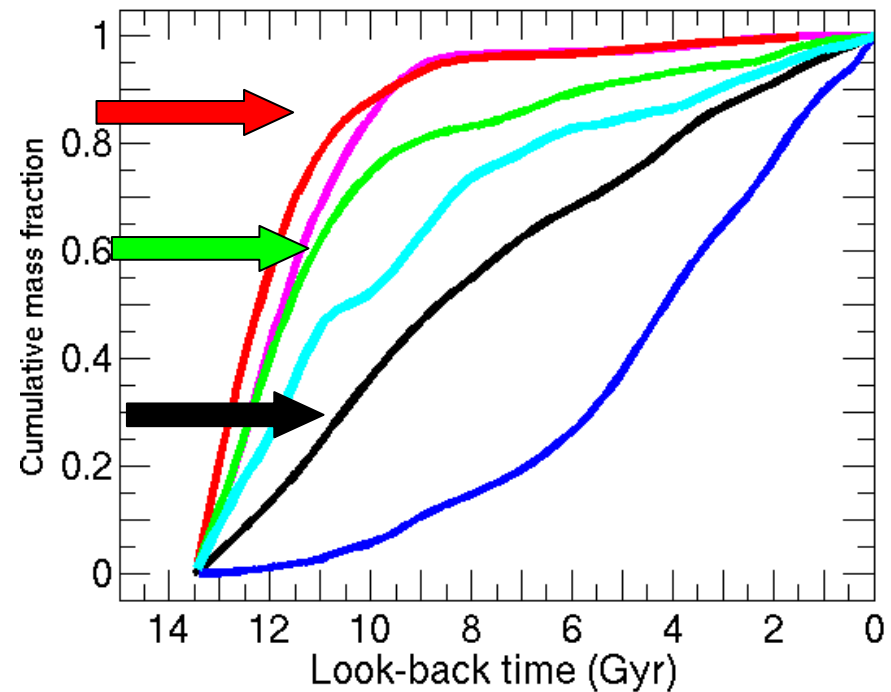
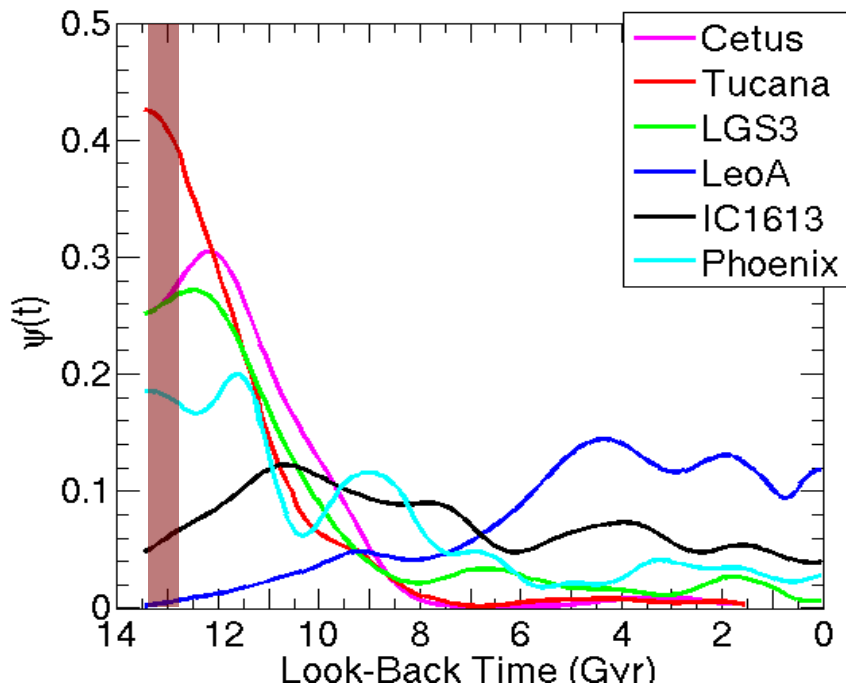
Galaxy : photometry + SFH code + Stell. Evol. library



**SEE POSTER #XI.1 for details!!!**

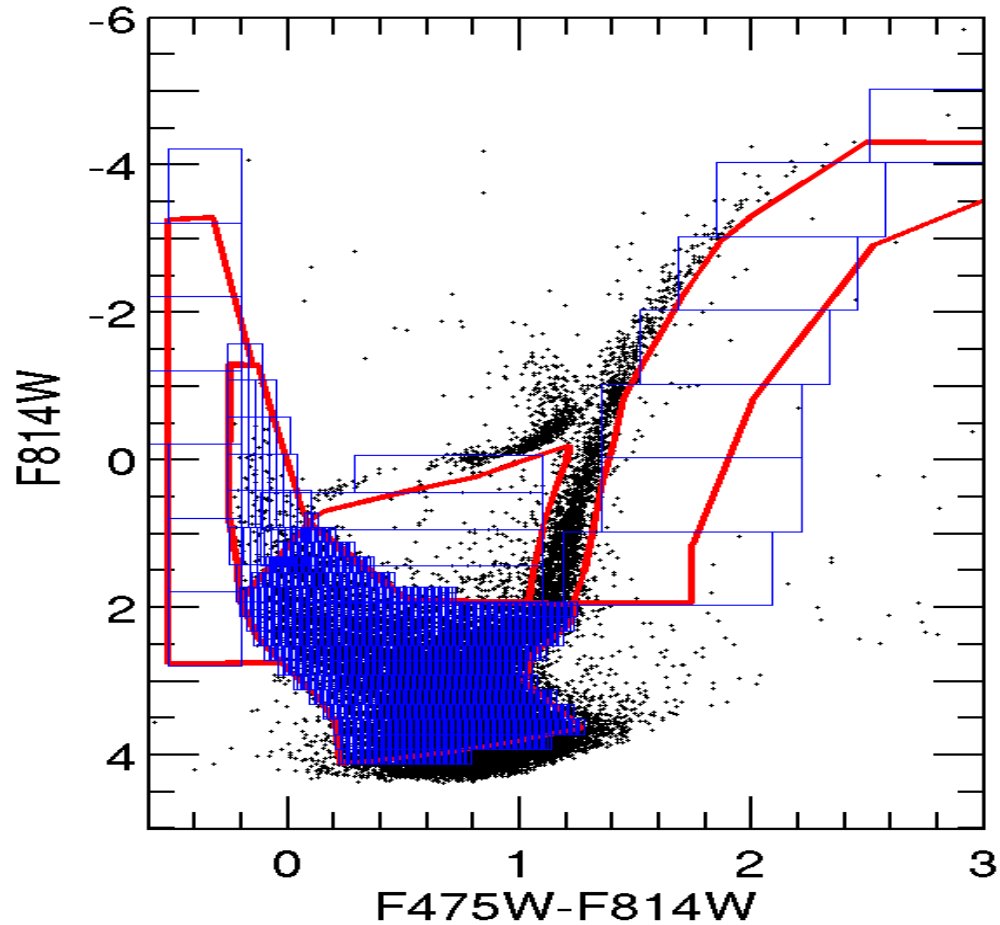
- Homogenous set of data
- Homogenous photometric reduction
- Homogenous SFH analysis
- **Extreme care in the control of systematic effects**



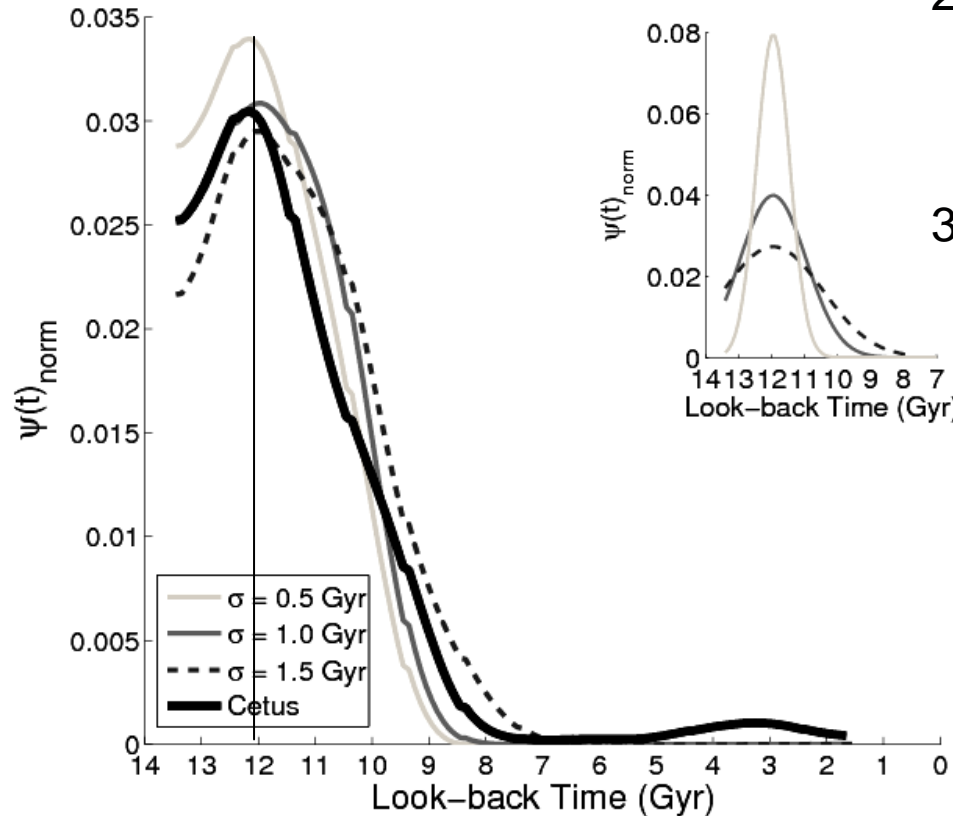


- ❑ the dSph Cetus and Tucana are old and similar
- ❑ dlrr experienced continuous and different SFH
- ❑ LeoA is anomalous
- ❑ Transition type galaxies are more similar to dSph than to dlrr
- ❑ limited/not obvious effect of reionization (Tucana?)

We **only** use the Main Sequence and SGB to derive the SFH!  
We did not include the evolved stages: NO RGB and NO HB!



# On the age resolution

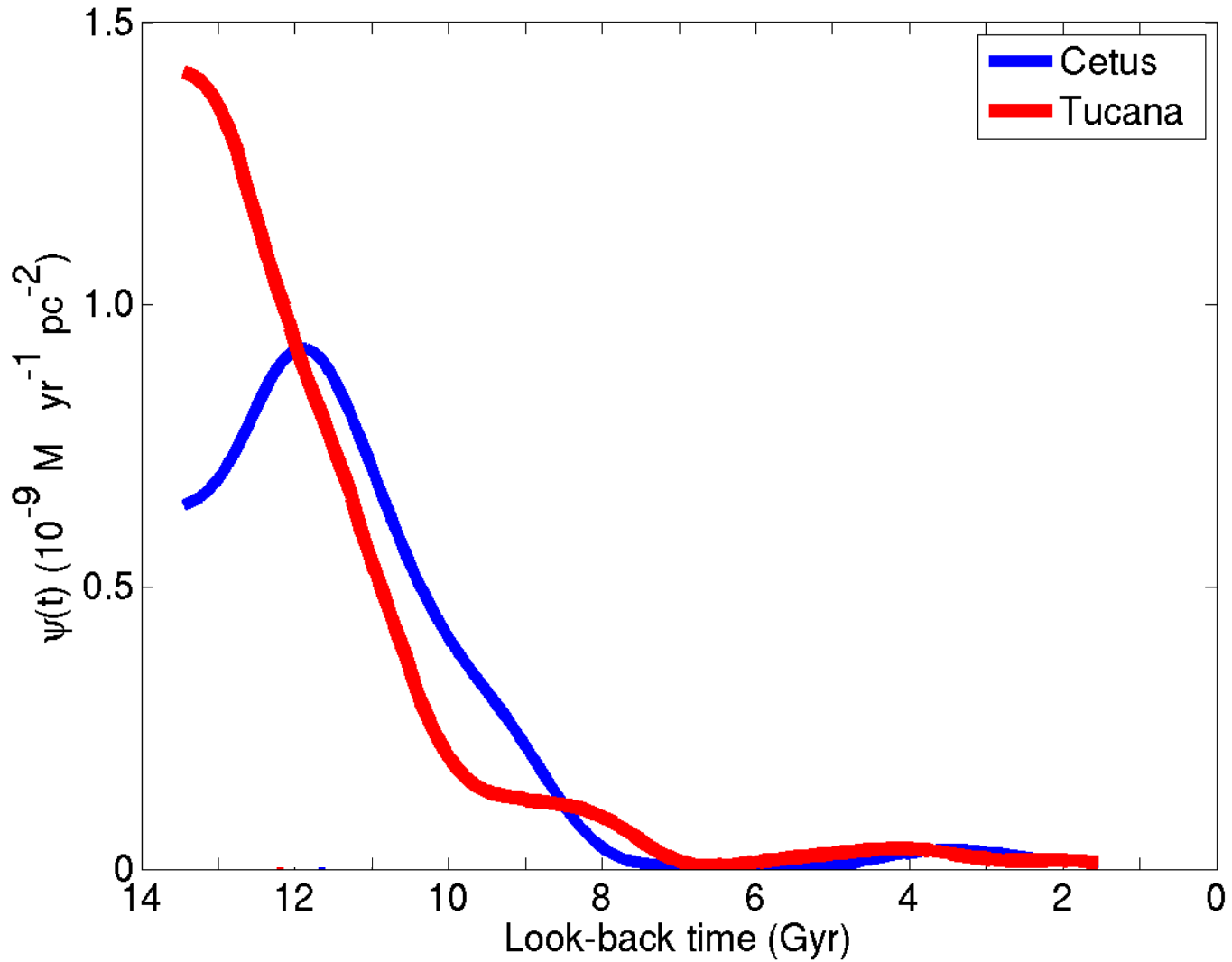


Tests with mock populations:

- 1) Excellent agreement in the age of the peak ( $< 0.3$  Gyr)
- 2) The duration if the recovered SF is significantly longer than the input one, due to *observational errors*
- 3) We can estimate the duration of the main episode

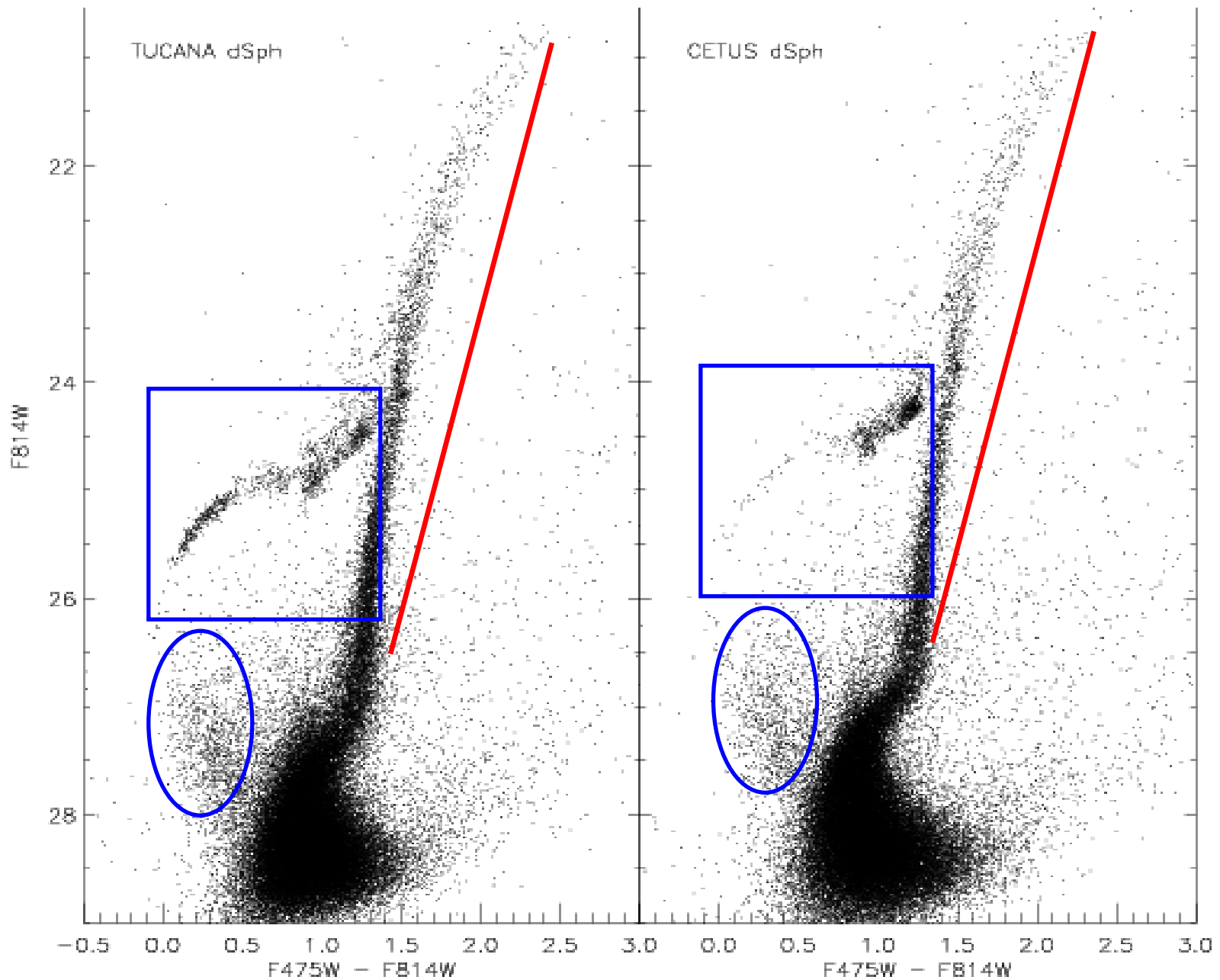
$\sigma_{in}$	$\sigma_{out}$
<b>0.5</b>	<b>1.44</b>
<b>1.0</b>	<b>1.61</b>
<b>1.5</b>	<b>1.95</b>
<b>Cetus</b>	<b>1.53</b>

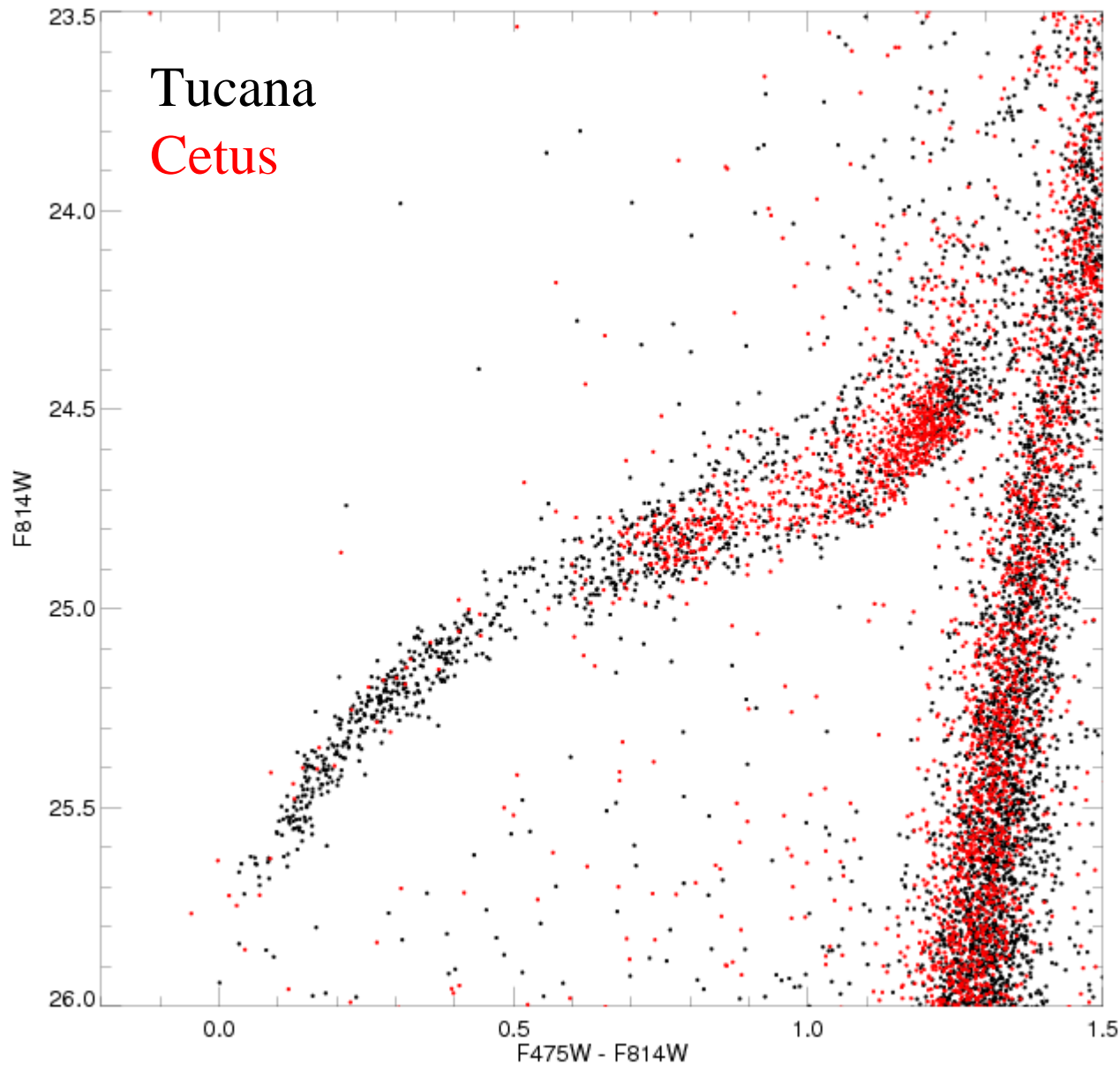
- 1) The age of the peak at ages  $> 10$  Gyr is known with 0.5 Gyr precision
- 2) Cetus' main episode of star formation is compatible to a gaussian with  $\sigma \sim 0.8$  Gyr



Where can find more evidence of this difference?

# Tucana and Cetus look very similar, but also present subtle differences....





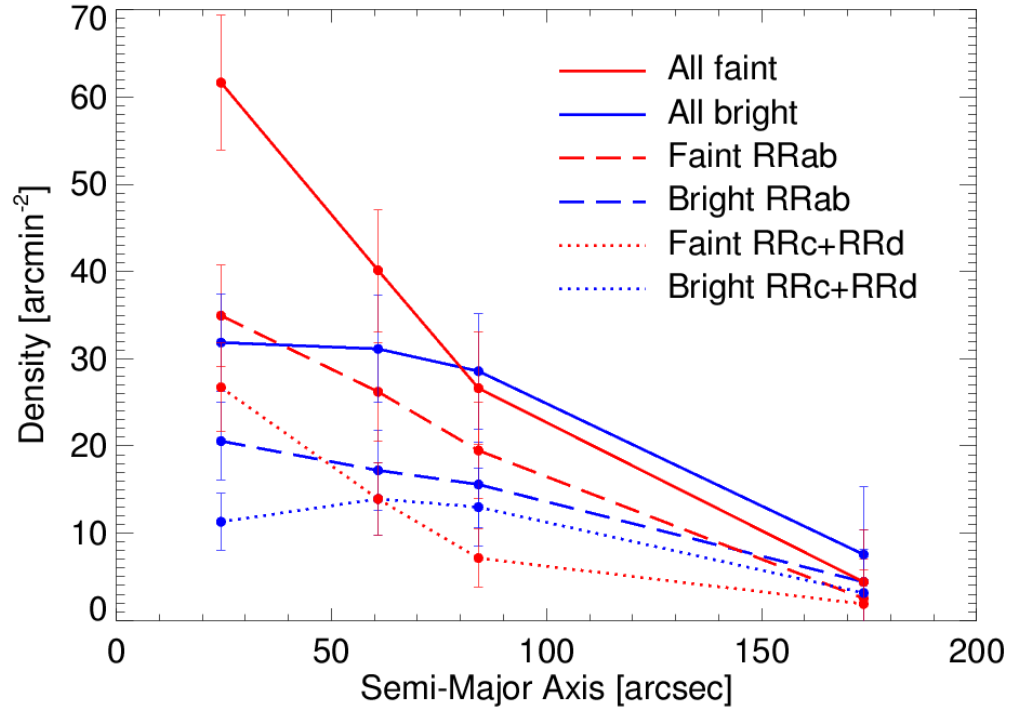
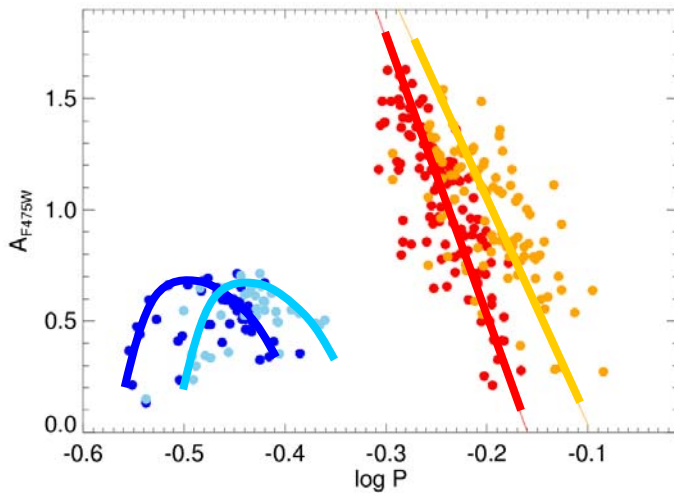
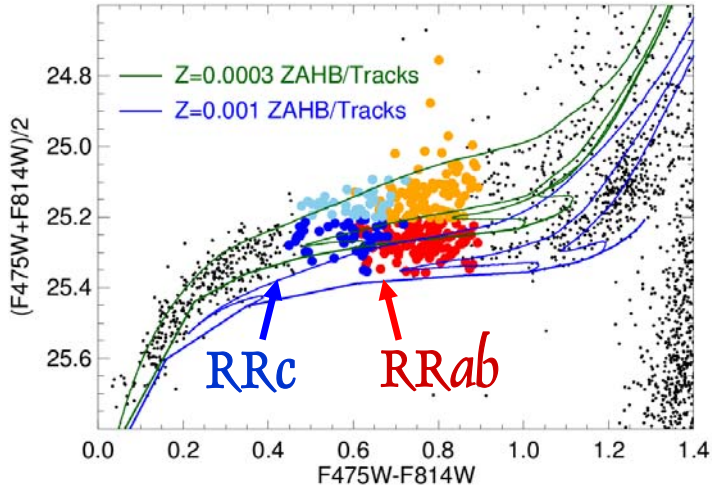
Different HB morphology:

Similar extension to the blue side, but the blue HB in Tucana is significantly more populated  
→ Strong initial SF

In addition, the ratio  $RR_c/RR_{ab}$  is higher in Tucana (0.40) than in Cetus (0.05), based on the 298+155 RR Lyrae we detected (*Bernard et al. 2009*)

# Moreover in Tucana....

Bernard et al. 2008



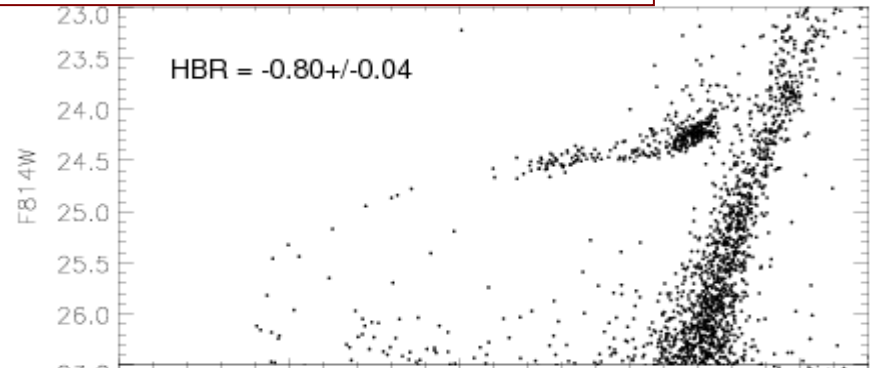
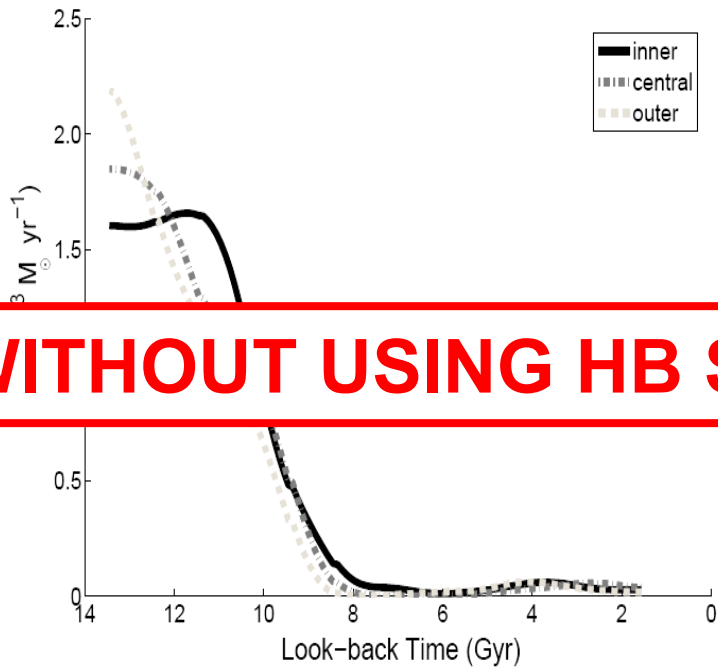
Suggesting:

- Radial gradients
- Fast chemical enrichment
- Strong initial star formation

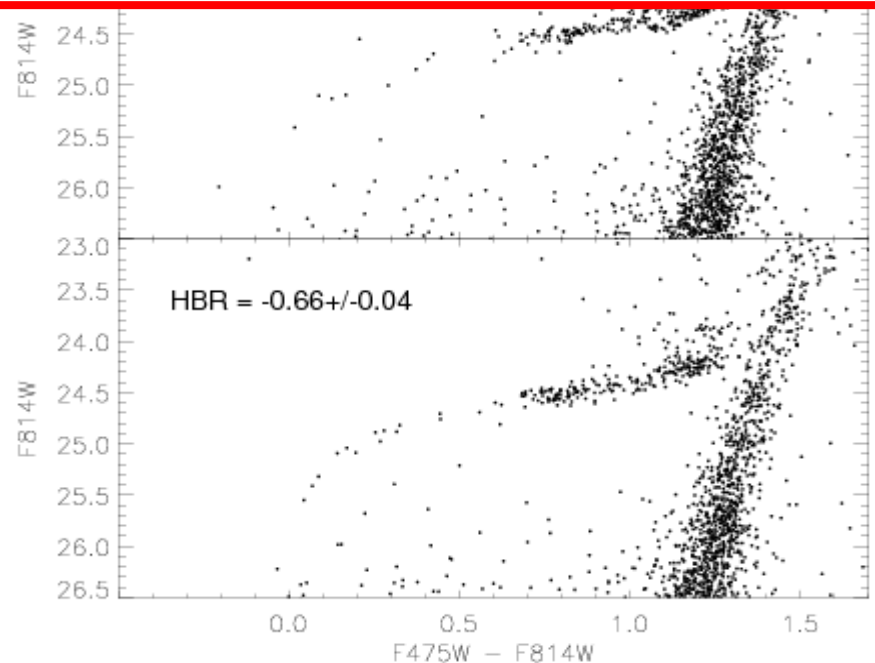
## Is Cetus YOUNGER than Tucana?

Did cetus formed the majority of its mass after Tucana: **YES**

Did Cetus started forming stars after Tucana: **NO**



**WITHOUT USING HB STARS TO DERIVE THE SFH!**



Radial gradients:

Star formation started at the same time at all distances, in particular at the same time than in Tucana

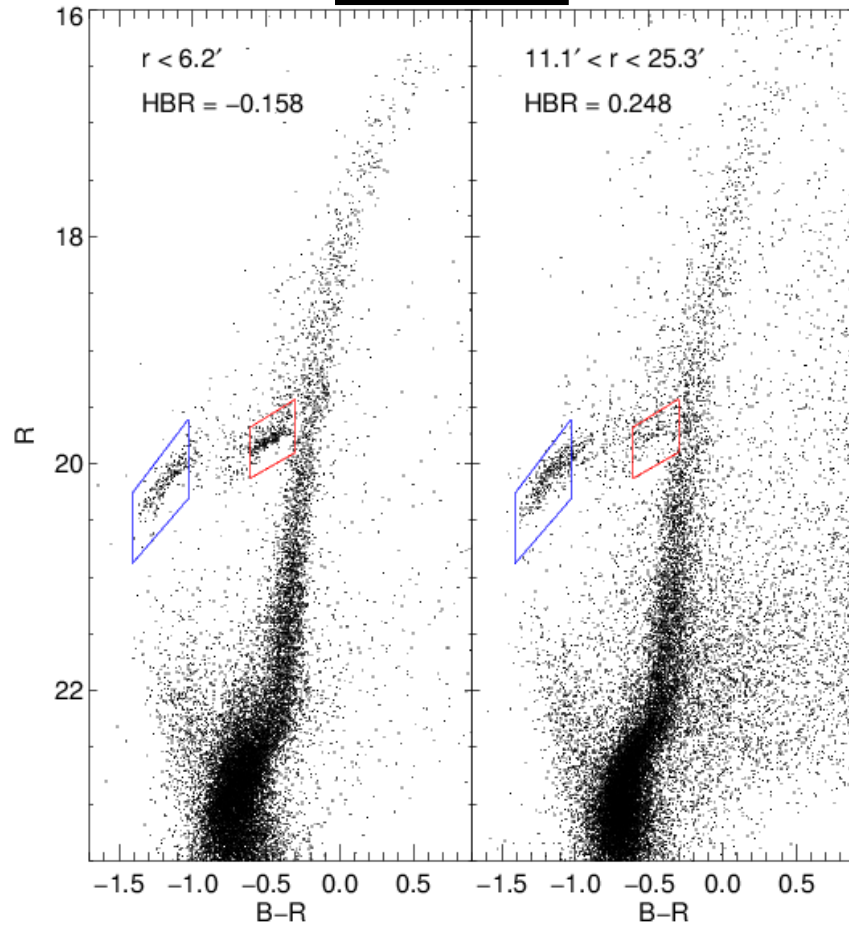
Only in central regions it increased to reach a peak  $\sim 1.5$  Gyr later.

# Conclusions

- I. We presented a homogenous and precise analysis of the full life star formation history of six isolated dwarf galaxies in the Local Group
- II. We are able to reliably and precisely determine age difference of the order of 1 Gyr at epochs  $> 10$  Gyr
- III. Reionization had a limited and no obvious effect on the SFH of the galaxies in our sample
- IV. Tucana present the oldest peak of star formation in our sample, in particular the peak is 1 Gyr older than in the case of Cetus
- V. LeoA is the only galaxy presenting a delay of few Gyr in the age of the peak of star formation
- VI. Transition dlrr/dSph galaxies are more similar to dSph than to dlrr galaxies

# Future prospects: Sculptor dwarf

Sculptor



Tucana

