

Resolved Stellar Populations: Galaxies



MA2 @ OAS BOLOGNA
17-18 DECEMBER 2018



This is us...



Francesca Annibali
Michele Bellazzini
Francesco Calura
Gisella Clementini
Felice Cusano
Giuliana Fiorentino
Donatella Romano
Monica Tosi



Francesca
Annibali



Michele
Bellazzini



Francesco
Calura



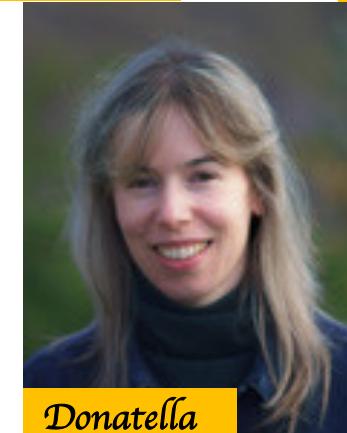
Gisella
Clementini



Felice
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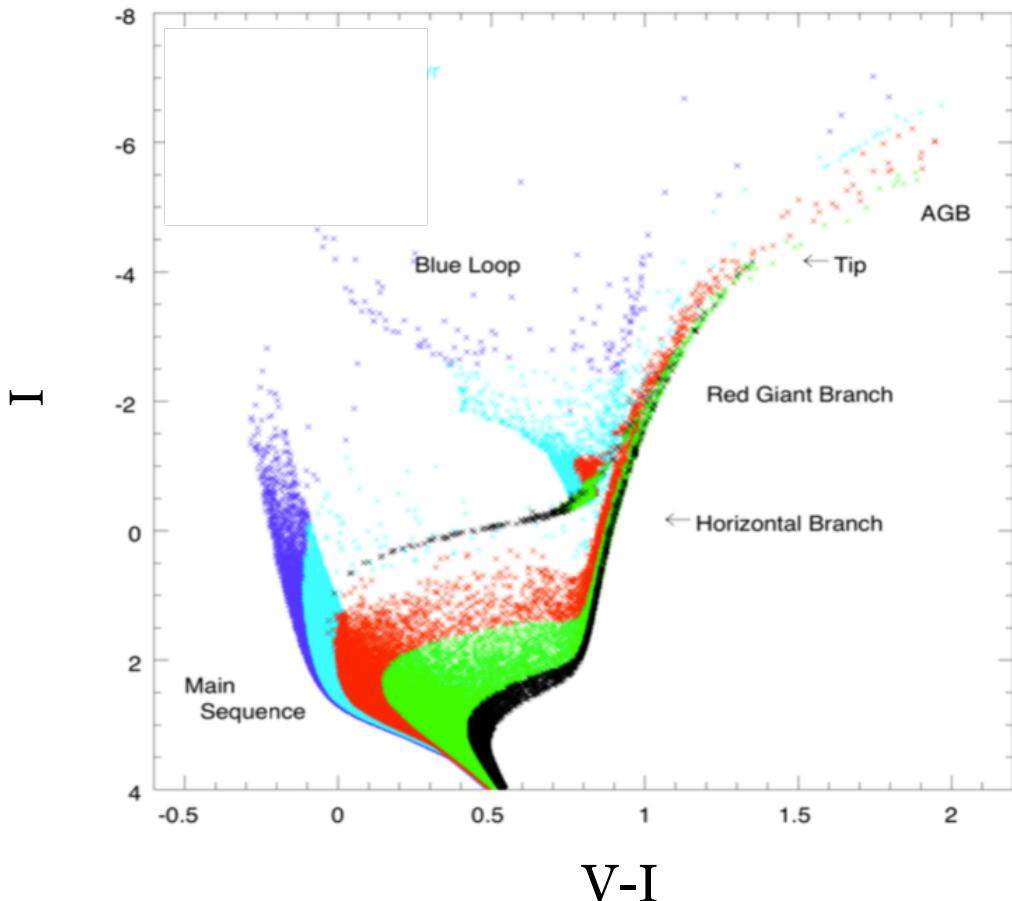


Donatella
Romano



Monica
Tosi

Color-magnitude diagrams of resolved stars tell us the star formation history

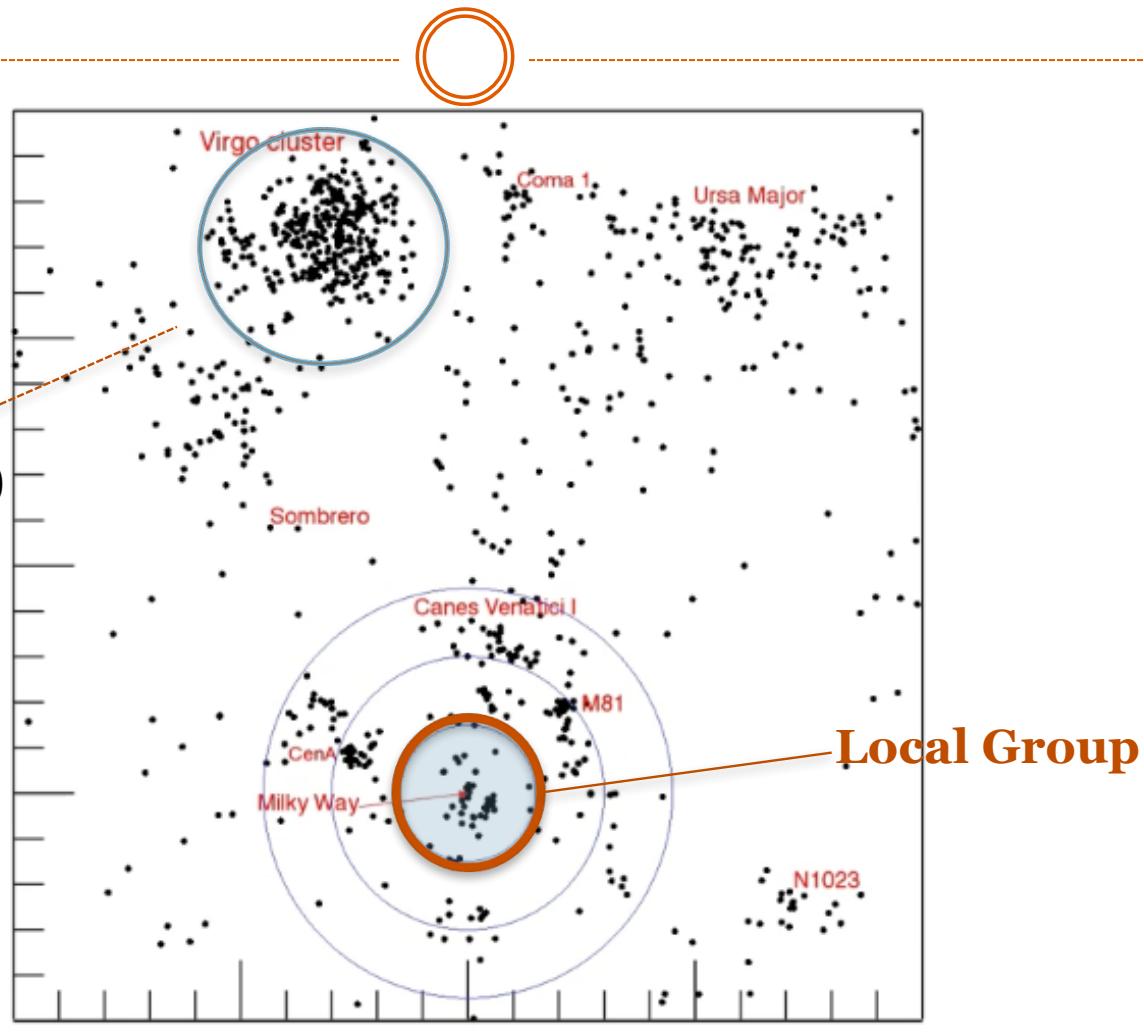


age < 300 Myr
300 Myr < age < 1.1 Gyr
1.1 Gyr < age < 3 Gyr
3 Gyr < age < 8 Gyr
age > 8 Gyr

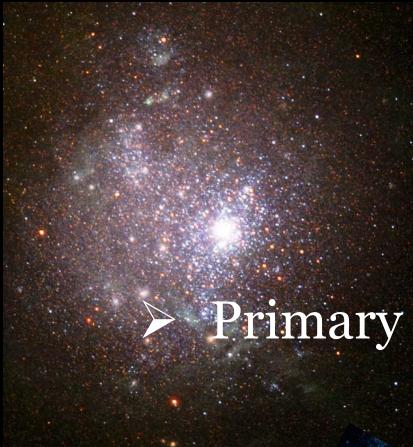
**THE DEEPER,
THE BETTER!**

The Local Group... and beyond

Virgo Cluster
D~17 Mpc
(our limit with HST)



Late-type dwarf galaxies



- In Λ CDM, dwarfs are **first systems** to form



- Primary candidate sources for cosmic **re-ionization**



- Low metallicity, high gas content, active SF: resemble **primeval** galaxies!



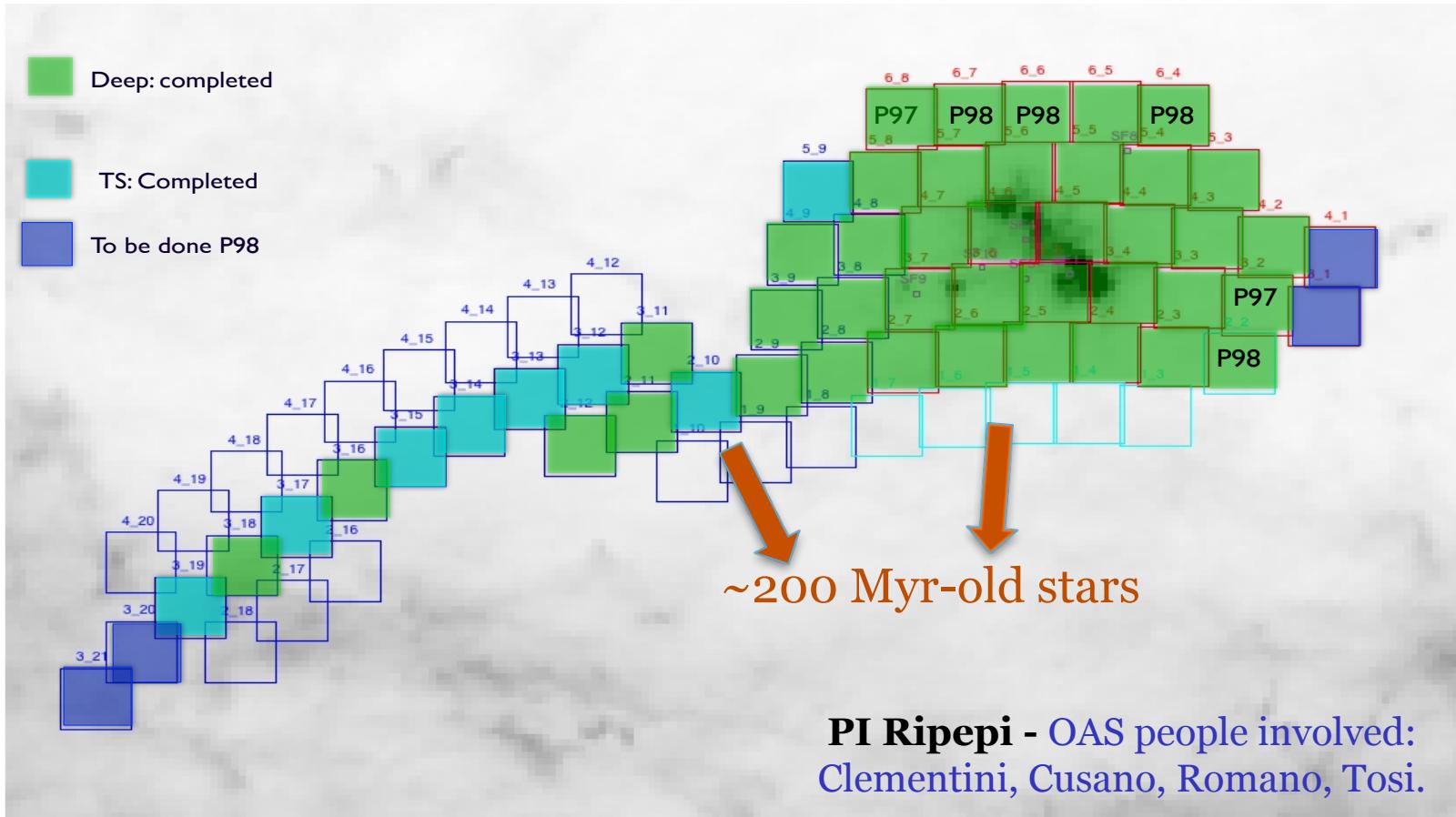
- Best systems to study **feedback** from massive stars, development of galactic winds, enrichment of IGM

LMC and SMC

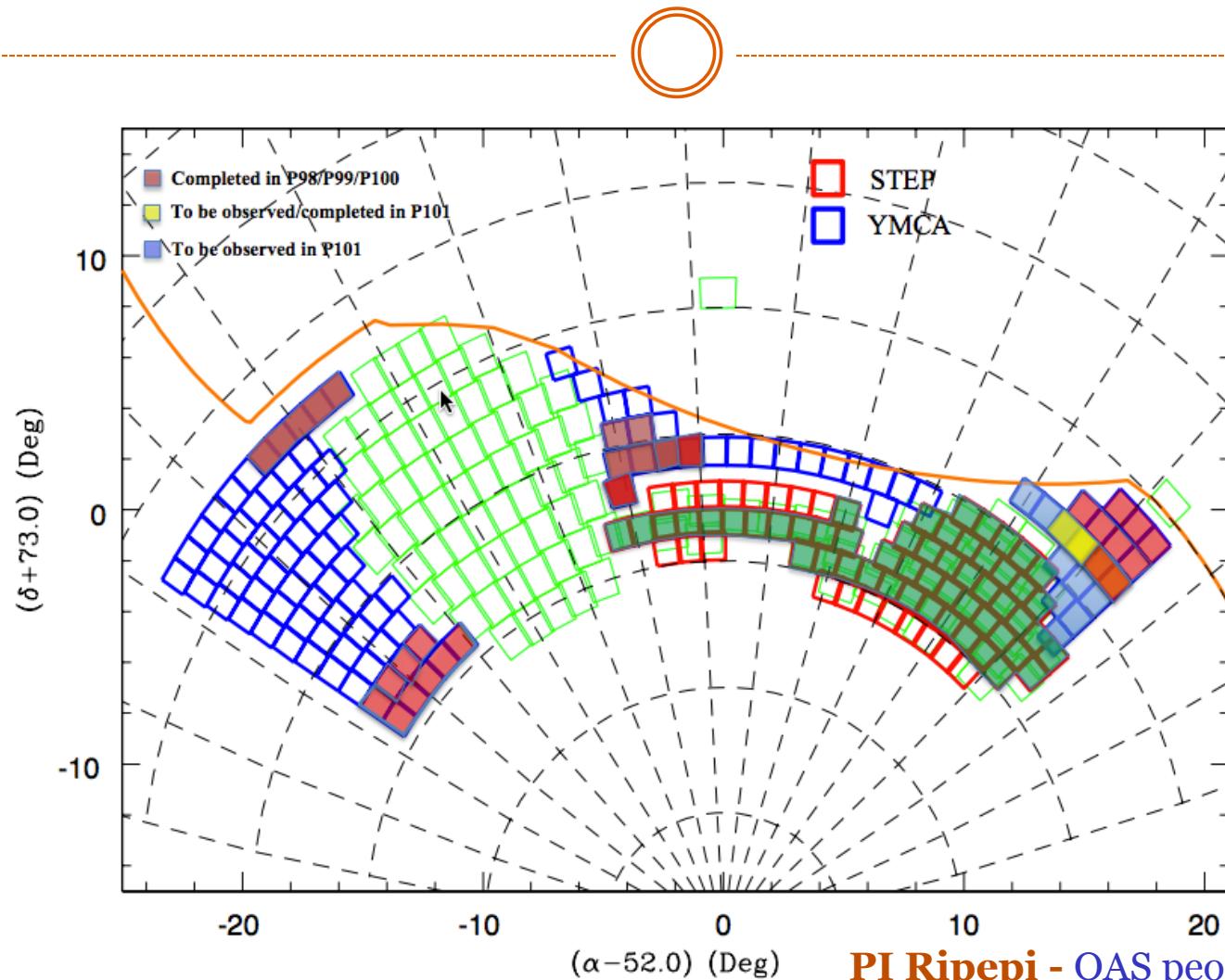


Credits: Belokurov & Erkal;
based on GAIA data

STEP: the VST survey of the SMC and bridge



YMCA: Yes, Magellanic Clouds Again



**PI Ripepi - OAS people involved:
Bellazzini, Clementini, Cusano, Tosi.**

Late-type dwarf galaxies outside the Local Group

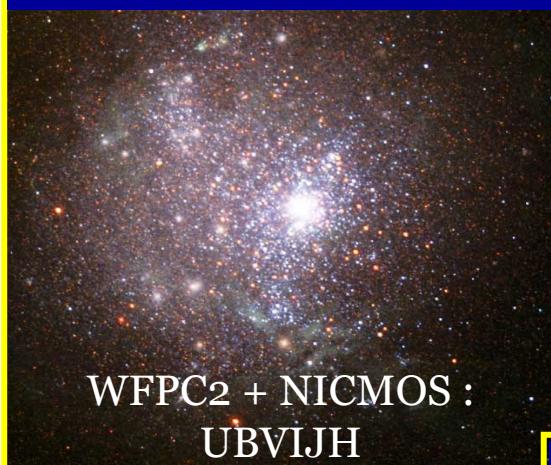


NGC 1569 – 3 Mpc



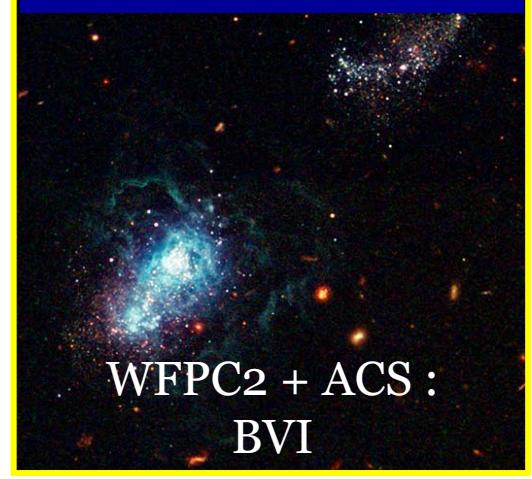
WFPC2 + NICMOS + ACS :
BVIJH H_α

NGC 1705 – 5 Mpc



WFPC2 + NICMOS :
UBVIJH

IZw18 – 18 Mpc



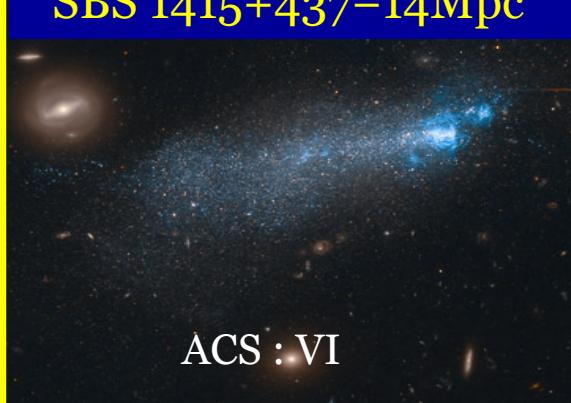
WFPC2 + ACS :
BVI

NGC 4449 – 4 Mpc



ACS : BVIH_α

SBS 1415+437–14Mpc



ACS : VI

DDO 68 – 12 Mpc



ACS : VIH_α

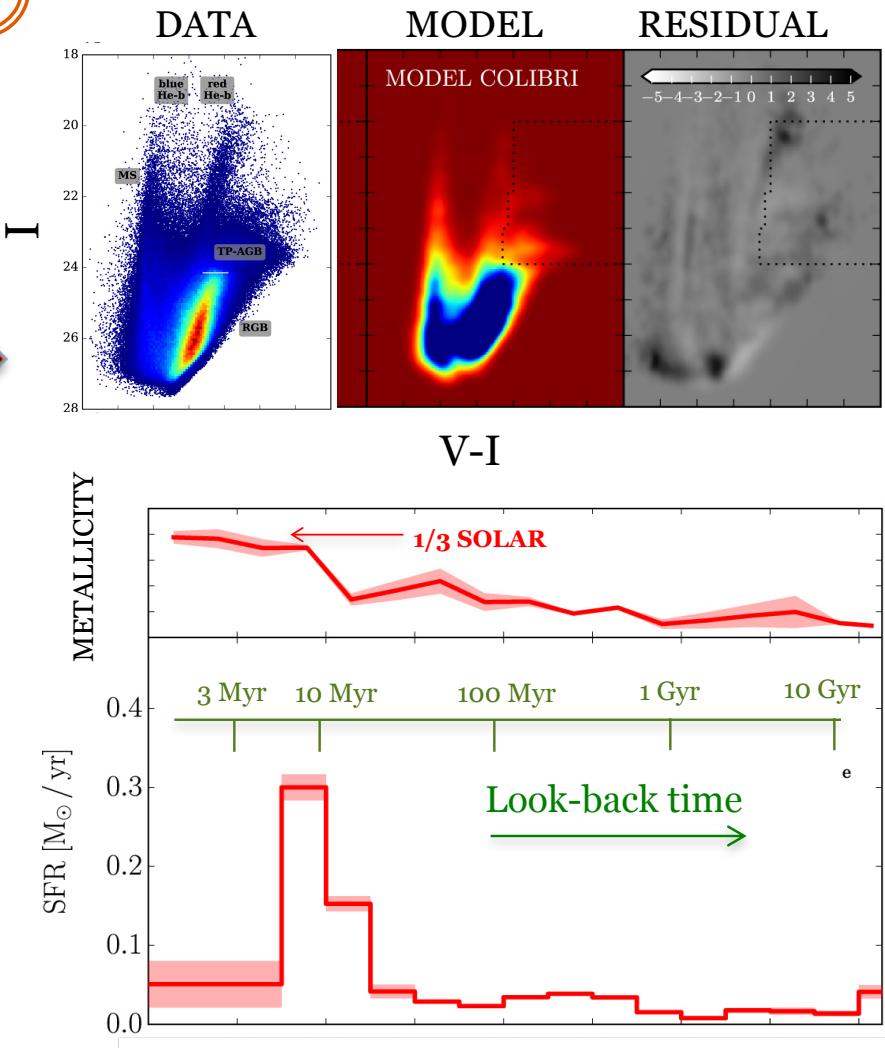
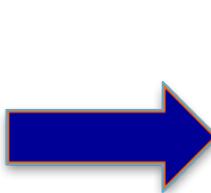
Star-forming dwarfs: star formation histories

NGC 4449 - 4 Mpc



STARBURST DWARF !

Cignoni et al. 2018;
Sacchi et al. 2018;
Annibali et al. 2011



Star-forming dwarfs: star formation histories

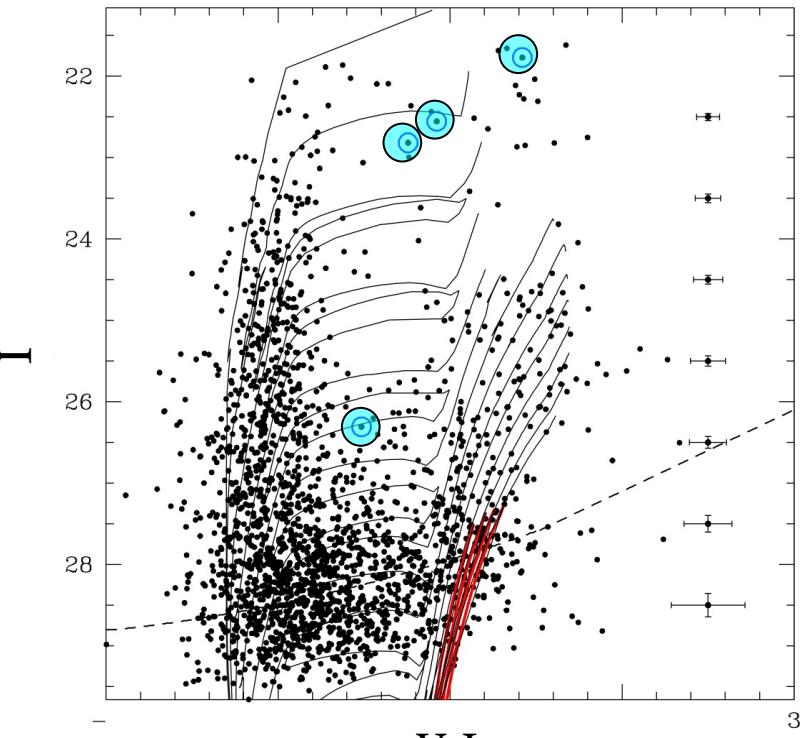


IZW18 – 18 Mpc



**ONE OF THE MOST
METAL POOR DWARFS KNOWN !**

CMD AND CEPHEIDS
(see Gisella's talk)



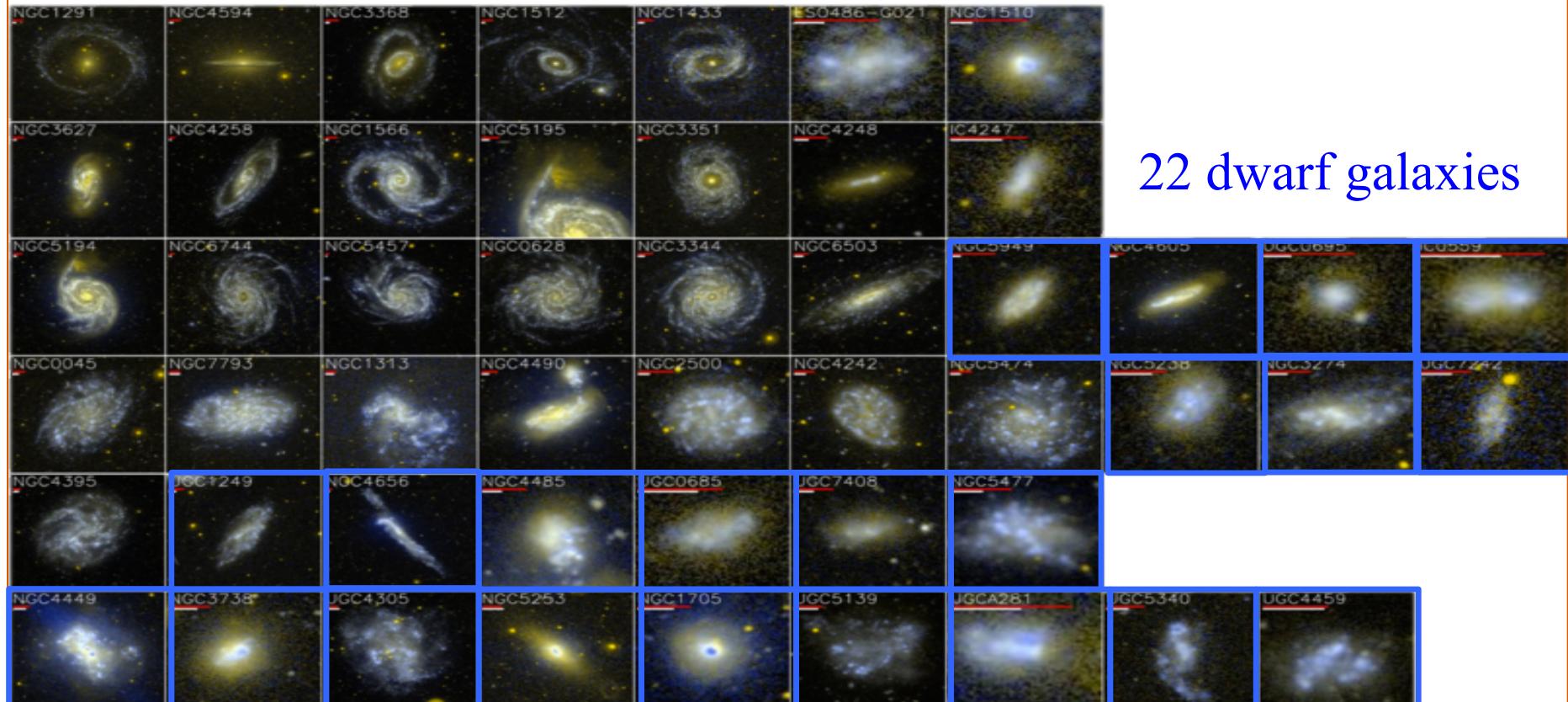
V-I
Aloisi et al. 2007;
Fiorentino et al. 2010;
Annibali et al 2013.



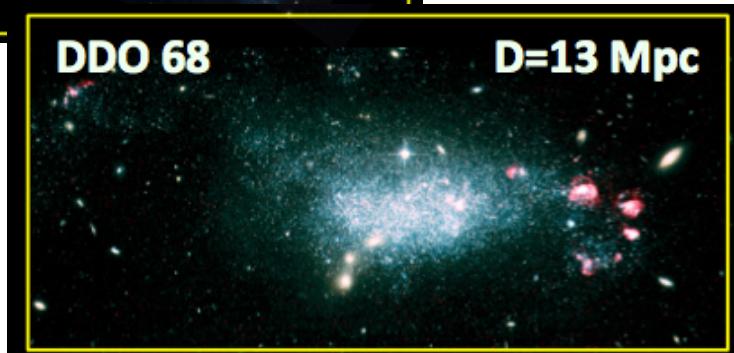
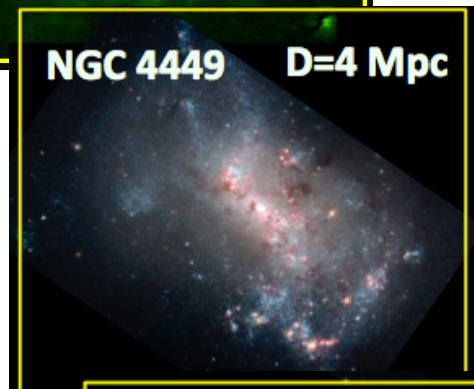
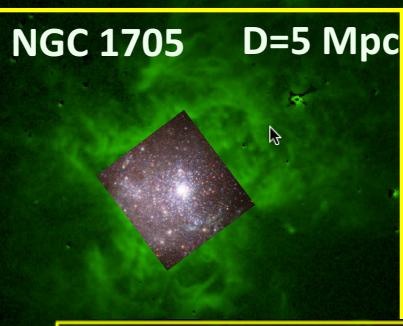
Cycle 21 HST Treasury (PI Calzetti)

WCF3+ACS **NUV,U,B,V,I**

50 galaxies in the range 3.5-12 Mpc



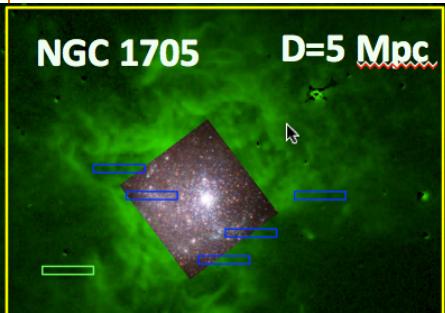
Star-forming dwarfs: chemical properties



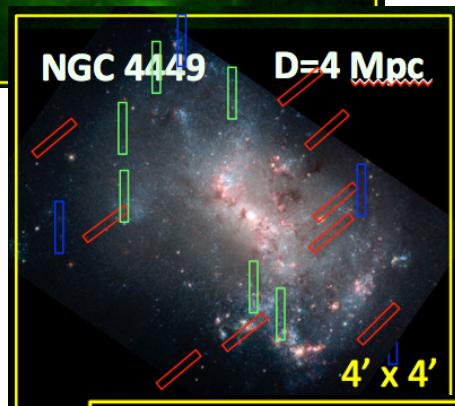
~~At these distances,
spectroscopy of individual stars is not possible~~

- Possible chemical tracers are:
 - ✓ H II regions (≤ 10 Myr)
 - ✓ Planetary nebulae (>100 Myr)
 - ✓ Un-resolved star clusters (all ages)

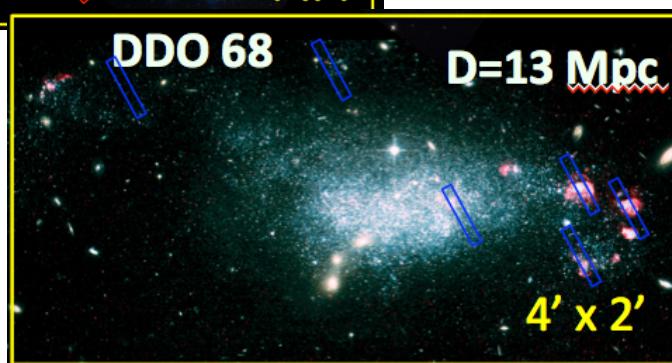
Star-forming dwarfs: chemical properties



FORS2 @ VLT, 10 h (PI Tosi)
H II regions and PNe

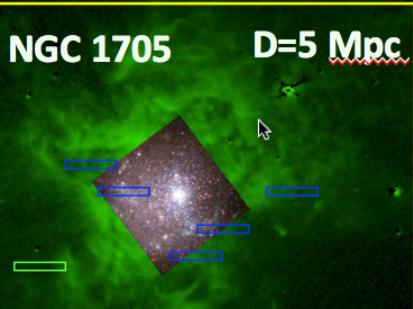


MODS @ LBT, 10 h + 4h (PI Annibali)
H II regions and PNe
Globular clusters

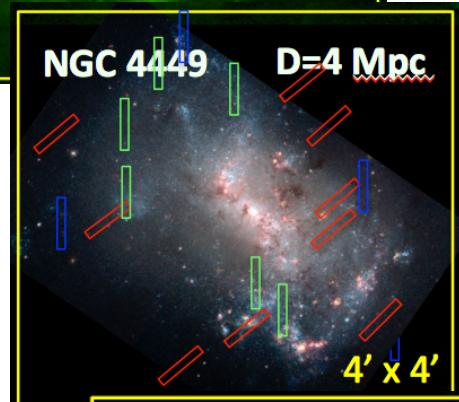


MODS @ LBT, 4h (PI Annibali)
H II regions

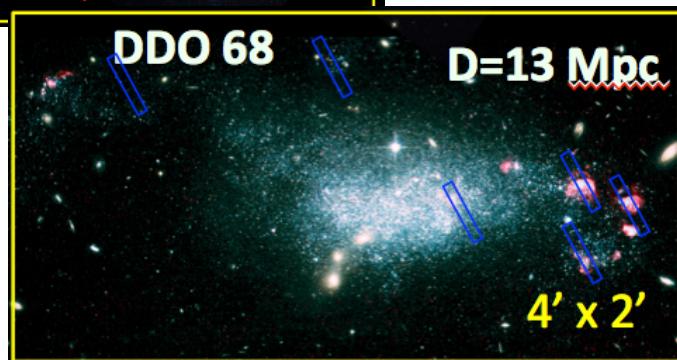
Star-forming dwarfs: chemical properties



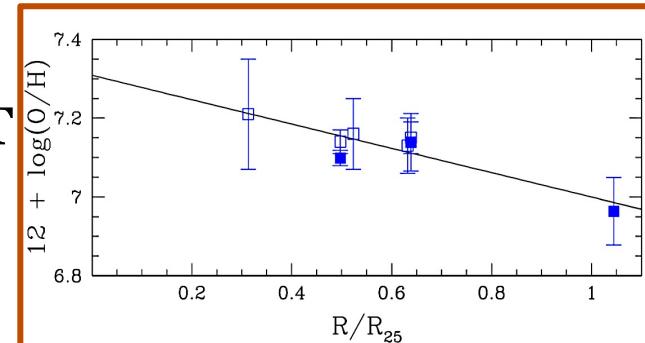
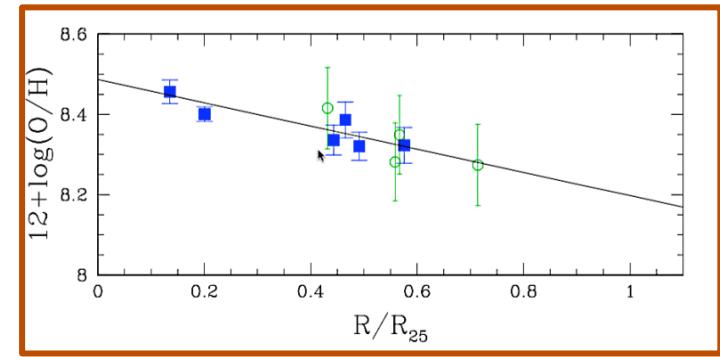
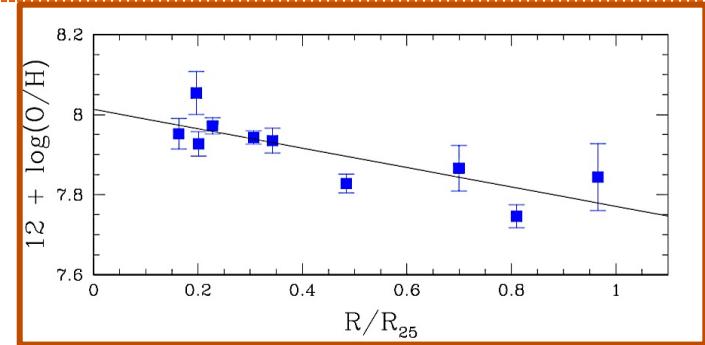
FORS2 @ VLT
H II regions and PNe



MODS @ LBT
H II regions and PNe
Globular clusters



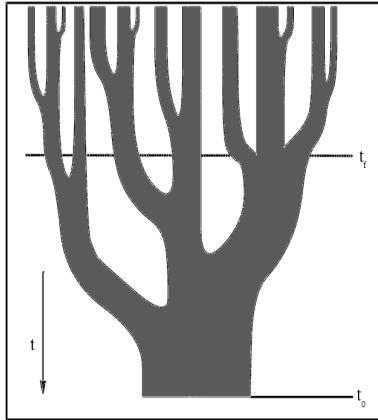
MODS @ LBT
H II regions



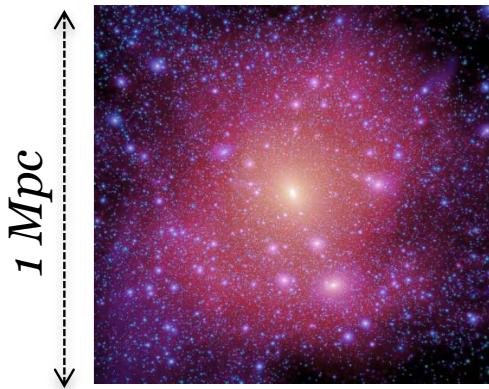
Λ CDM and the hierarchical galaxy formation

Theory

Lacey & Cole (1993)

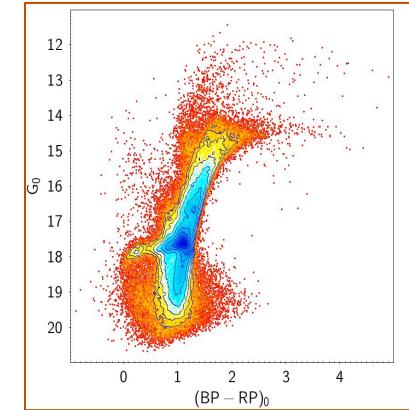
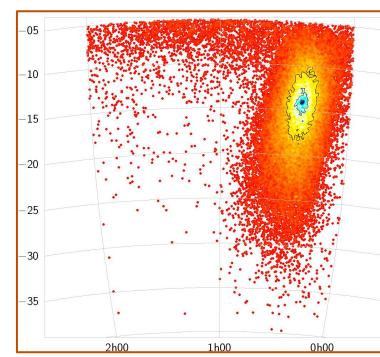


Aquarius simulation

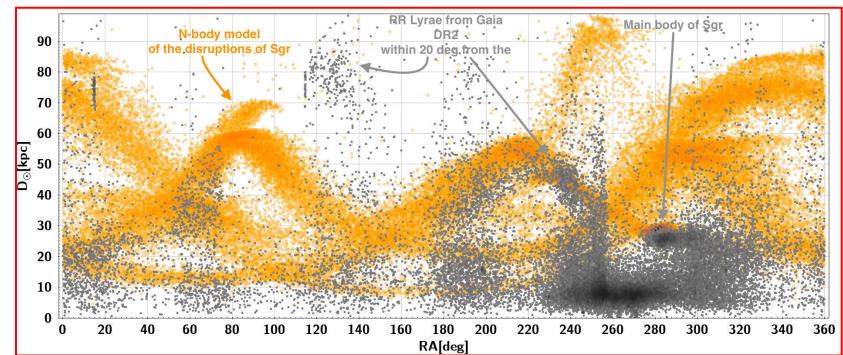


Observations:

Sgr dSph, the main relic of the hierarchical merging of the Milky Way (**M. Bellazzini**)



Satellites accreting onto giant galaxies

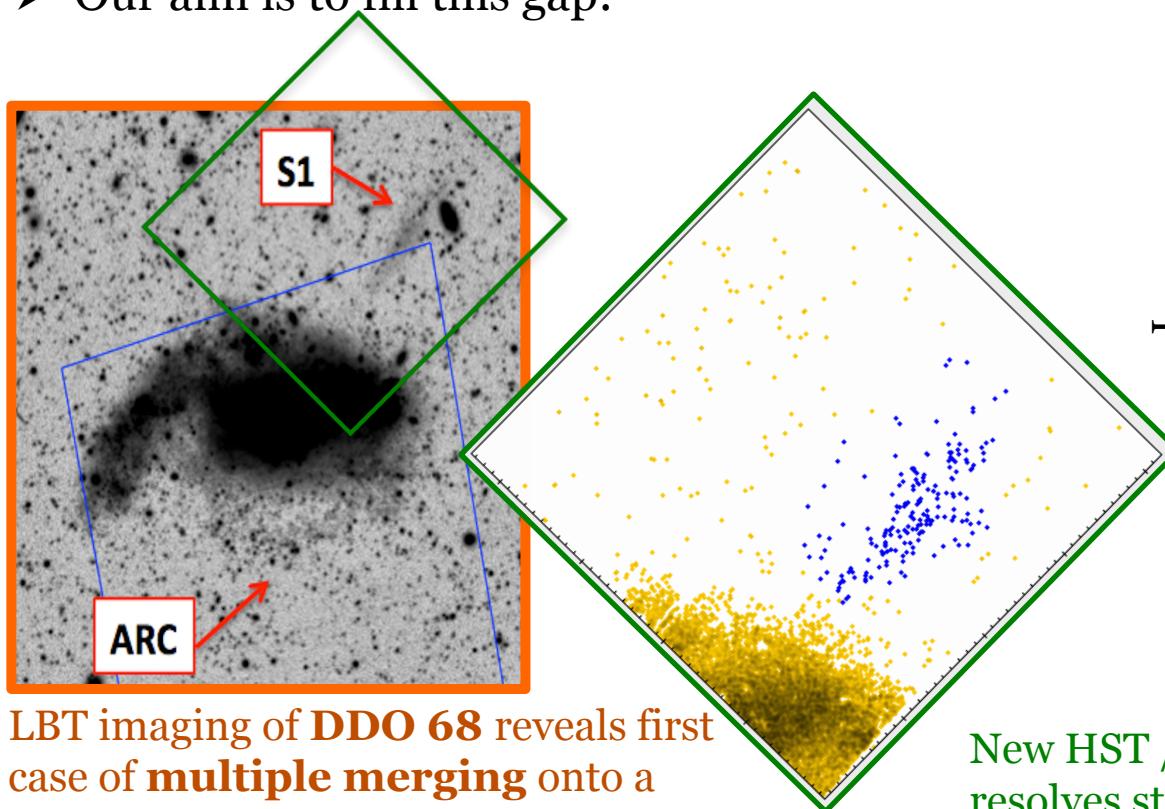


... plus many more examples !!!

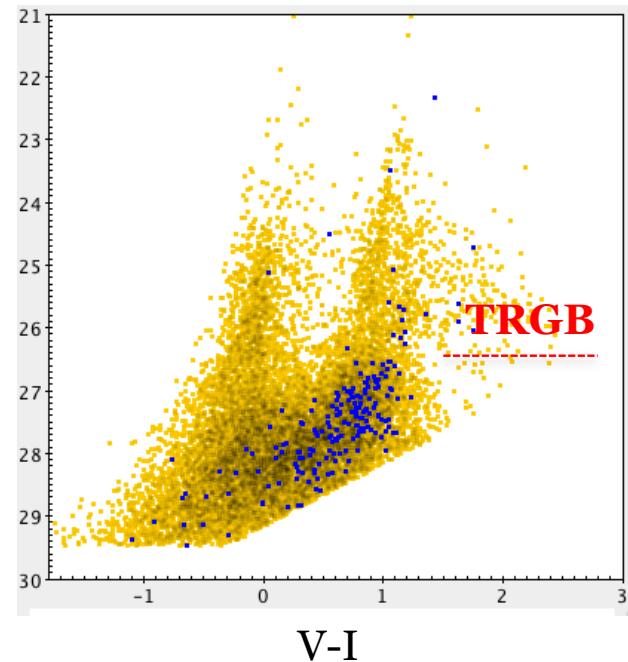
Λ CDM and the hierarchical galaxy formation... at the smallest scales!



- Observational evidence for **hierarchical merging** onto **dwarf galaxies** very poor so far
- Our aim is to fill this gap!



LBT imaging of **DDO 68** reveals first case of **multiple merging** onto a dwarf galaxy (Annibali et al. 2016)

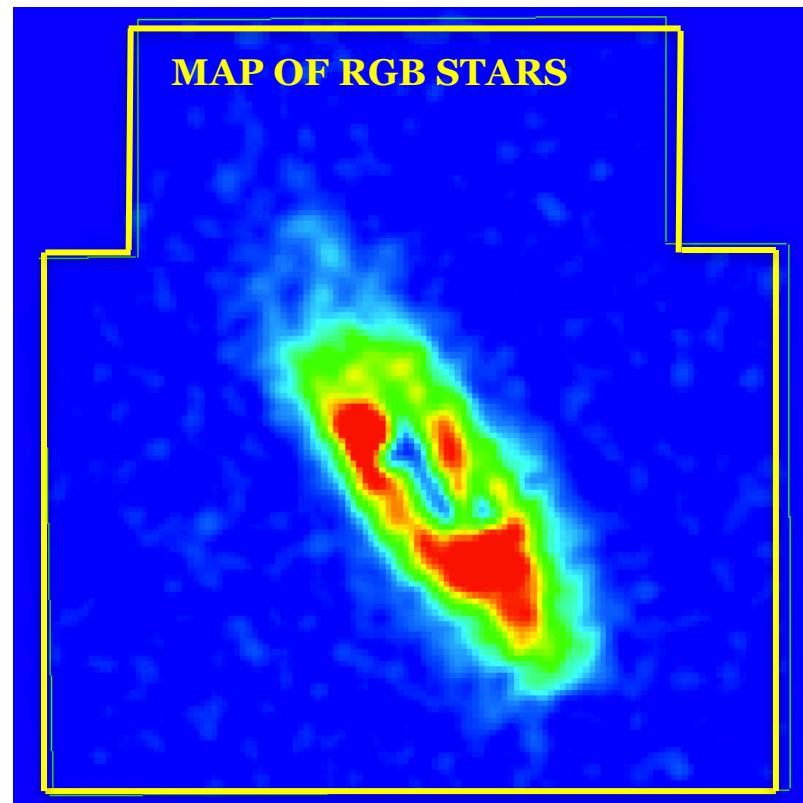
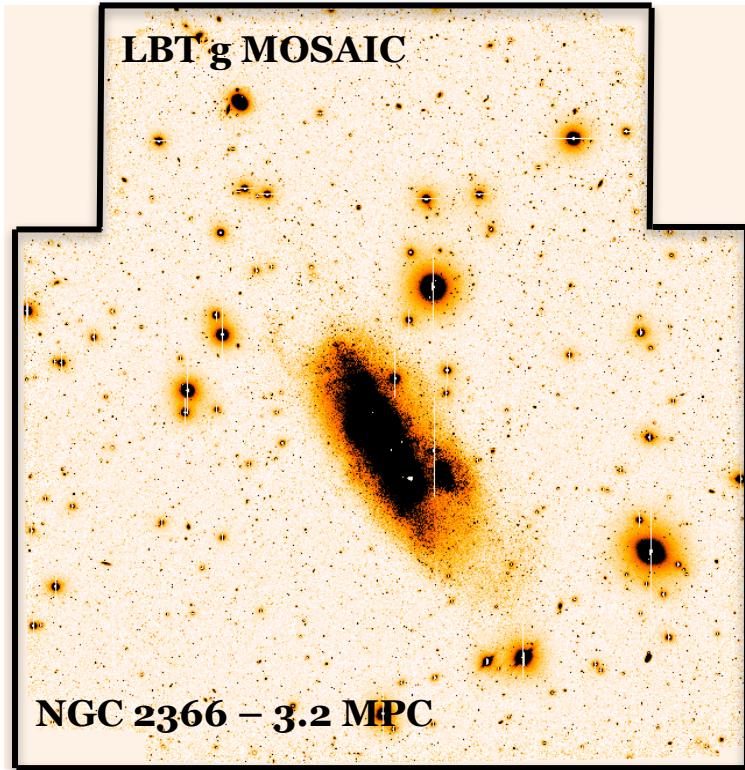


New HST /WFC3 imaging (PI Annibali)
resolves stars of the stream S1

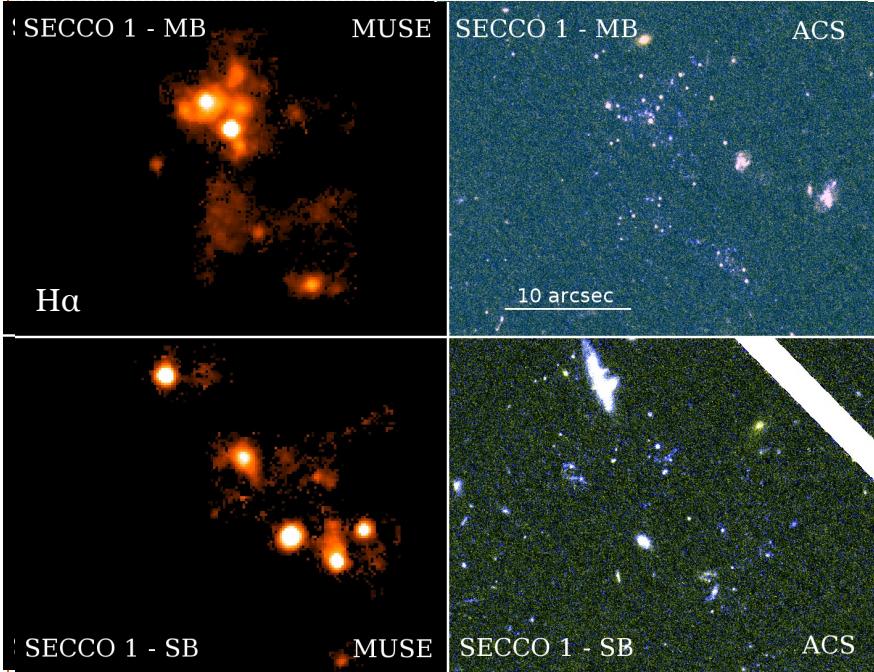
The LBT Smallest Scale of Hierarchy Survey (SSH)



- LBT/LBC **Strategic Program** to get deep wide-field ($23' \times 23'$) imaging in g and r of ≈ 50 late-type dwarfs within 10 Mpc to detect streams /satellites (PI Annibali).

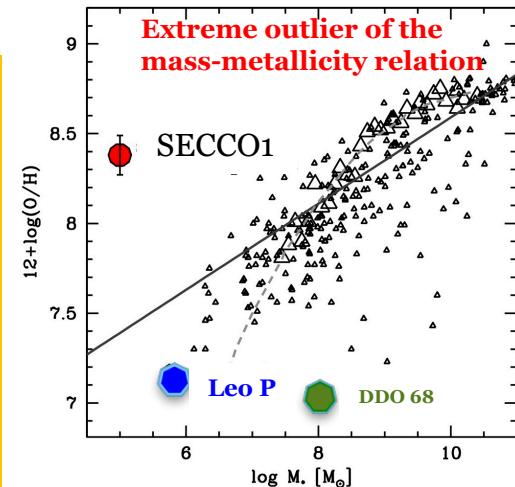


A new class of stellar systems? Stripped gas clouds in galaxy clusters, confined by the pressure of the ICM



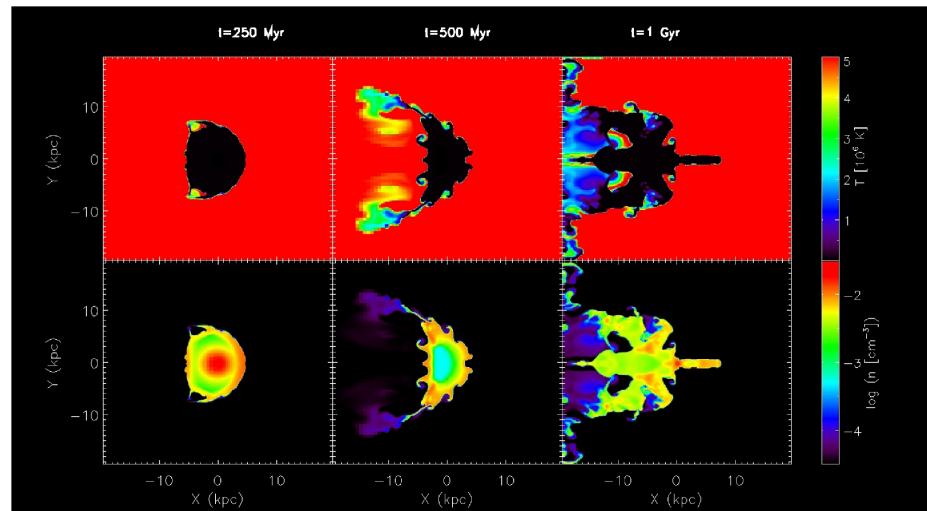
Secco 1, the prototype
of the class
discovered at OAS
**(Bellazzini et al.
2105, 2018).**

Five additional
candidates being
followed up with HST
and MUSE

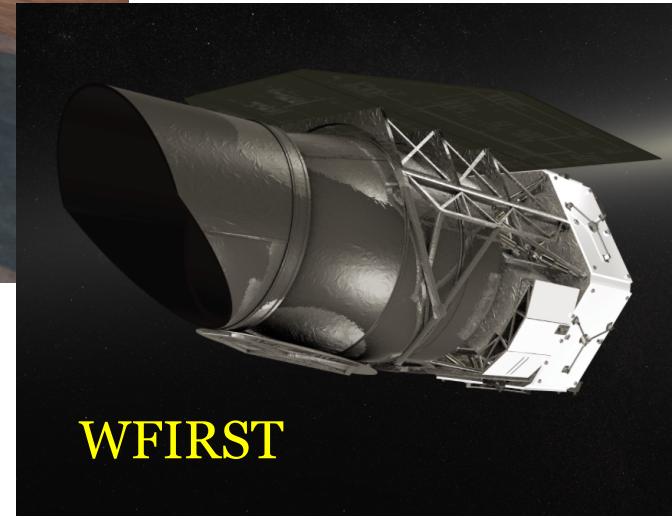
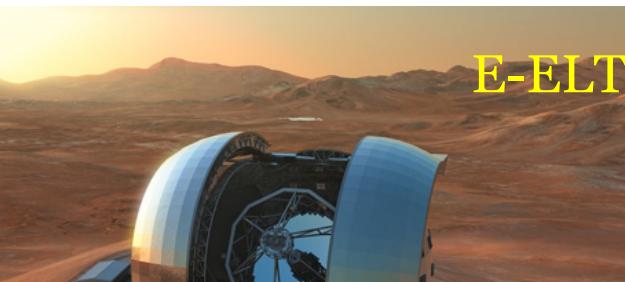


A HI cloud with $M_{\text{HI}}=10^7 M_\odot$ with $10^5 M_\odot$ of stars
in extreme isolation (>250 kpc in projection from
the nearest candidate progenitor).

Hydrodynamic simulations (by F. Calura)
suggests that it can be long-lived, lasting > 1.0 Gyr
while traveling
in the outskirts of the Virgo cluster.
Kept together by external pressure.



Looking forward





Searching for IMBH in star clusters with MAORY + MICADO@ELT



ASTROMETRIC accuracy

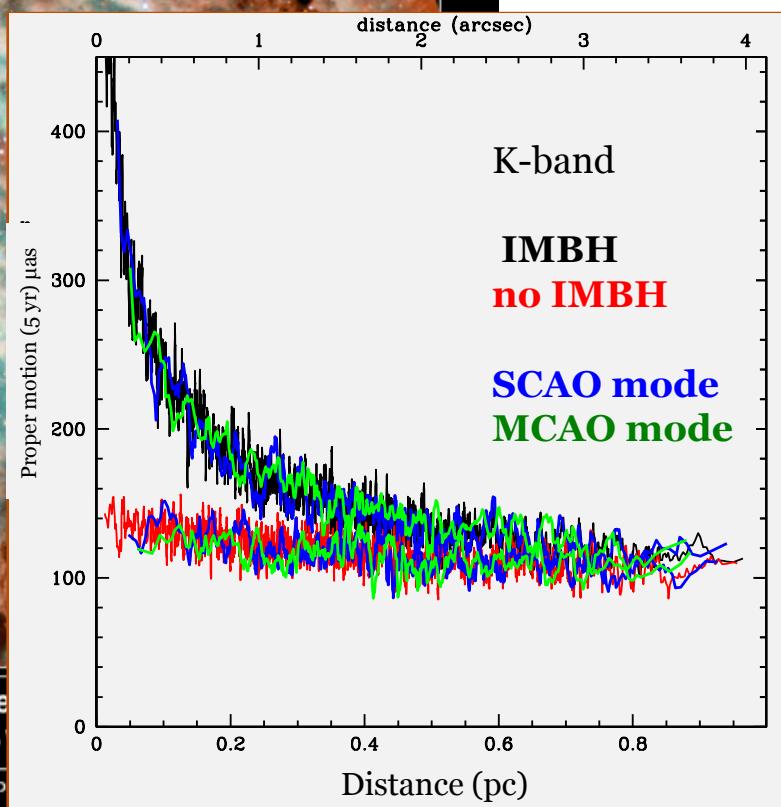
K range	σ_K (μas)	n stars K
$K < 16$	12	45
$16 < K < 18$	10	101
$18 < K < 19$	30	145
$19 < K < 20$	79	453
$20 < K < 21$	163	429
$21 < K < 22$	243	1221
$22 < K < 23$	696	62



30 Doradus in the Large Magellanic Cloud
Hubble Space Telescope •

© 2018, J. Maiz-Apellániz (STScI), and R. Barbá (La Plata Observatory)

G. Fiorentino
& MAORY
science team



Thanks for your attention!



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Monica Tosi

