The connection between star formation and accretion phenomena in local star-forming dwarf galaxies

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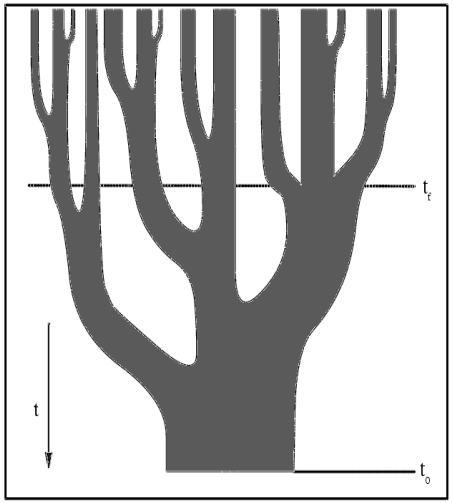
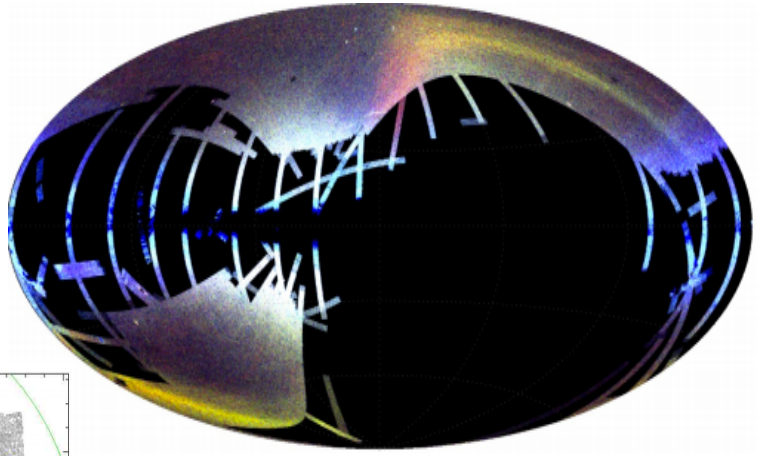
Linking Observations and Theory
Across the Scales of Star Formation in Galaxies
July 12th – Sexten

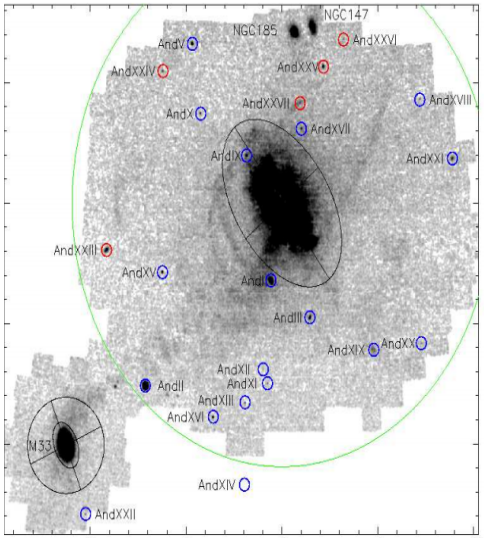
ΛCDM - Hierarchical structure formation

Lacey & Cole (1993)

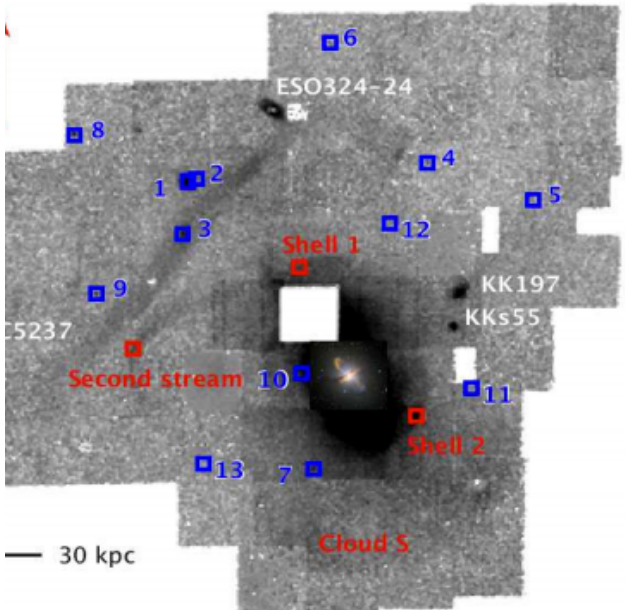


Milky Way
(*Belokurov + 06*)

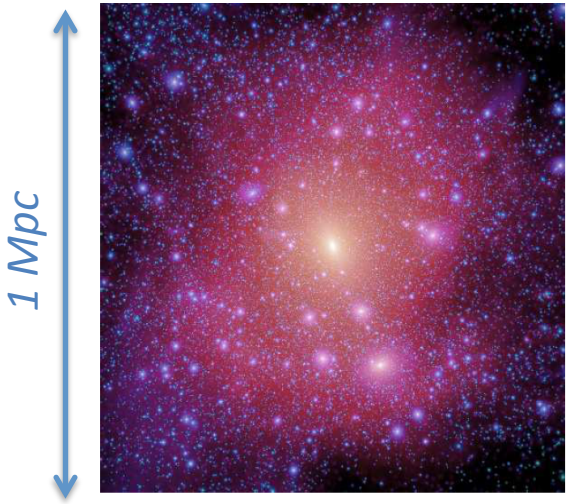




M31 spiral
(*Richardson + 11*)



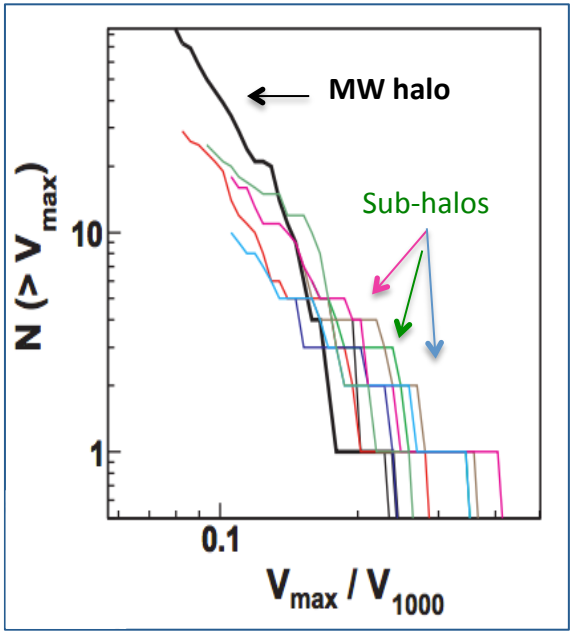
Aquarius simulation



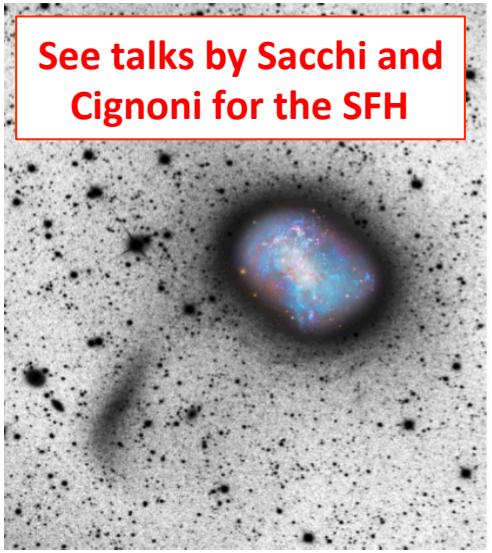
CenA elliptical
(*Crnojevic´ + 16*)

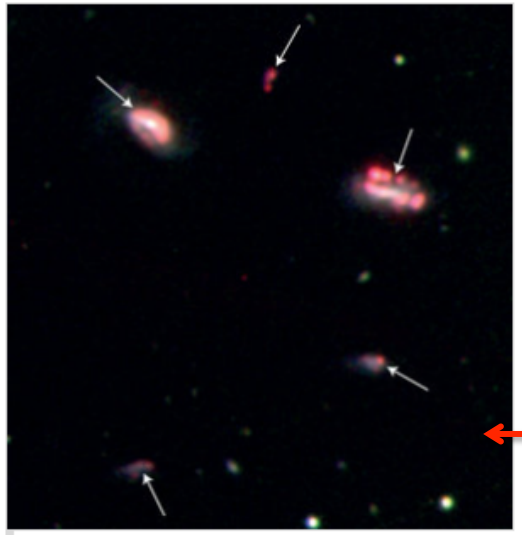
Hierarchical assembly at small galaxy scales

DM halos and sub-halos have the same relative abundance of substructures
(*Diemand + 08, Nature 454, 735*)



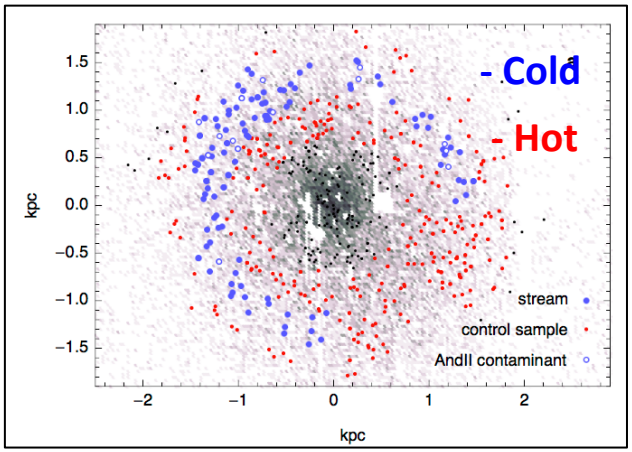
NGC 4449 (*Martinez-Delgado + 12; Rich + 12*)



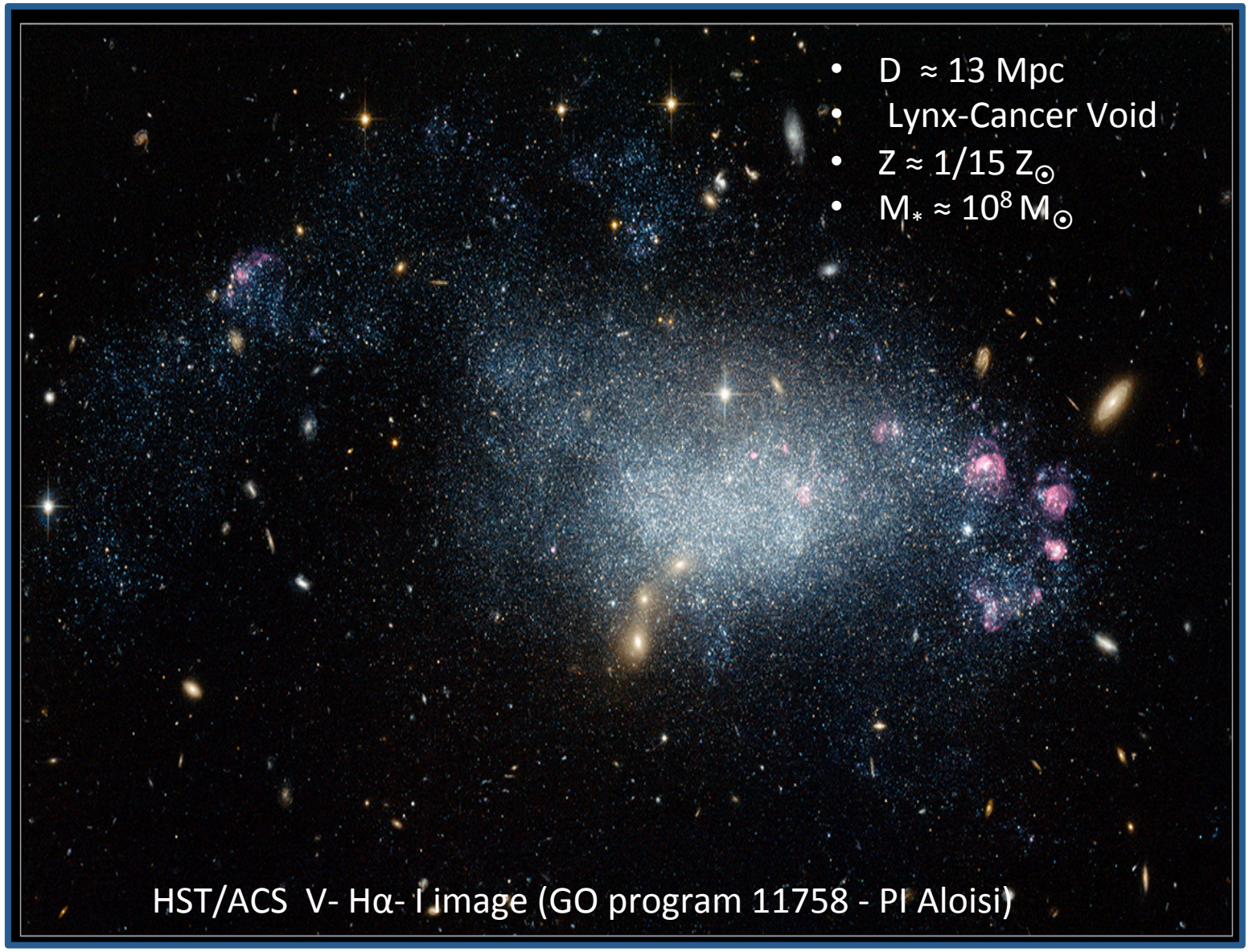


Groups of only dwarfs (Stierwalt + 17)
(see also loose associations of LG dwarfs by Tully+ 06)

"**kinematical stream**" in AndII, with 10^7 $M_\star$ (Amorisco +14)



First evidence of multiple merging at very low galactic scales: **DDO 68**



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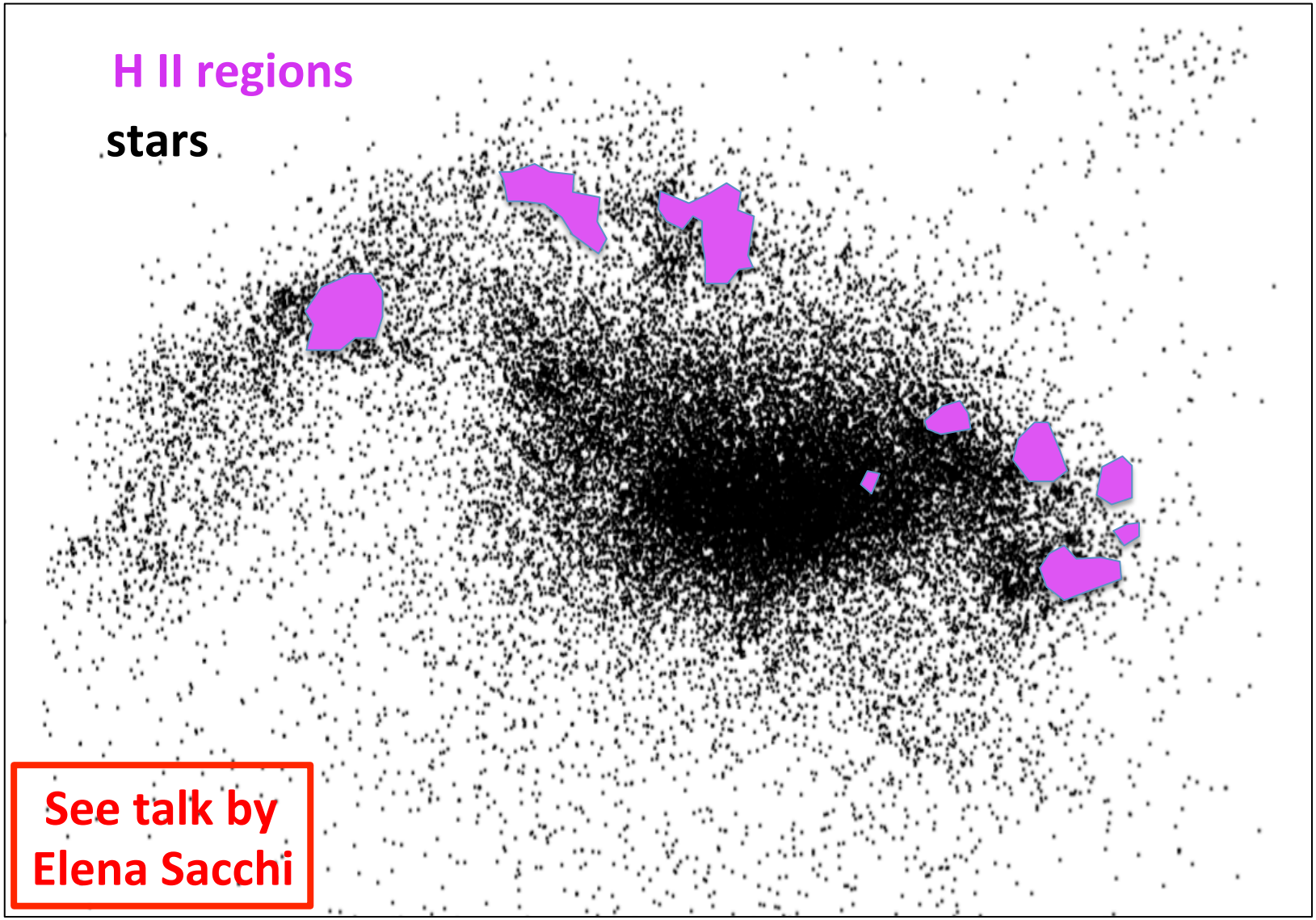
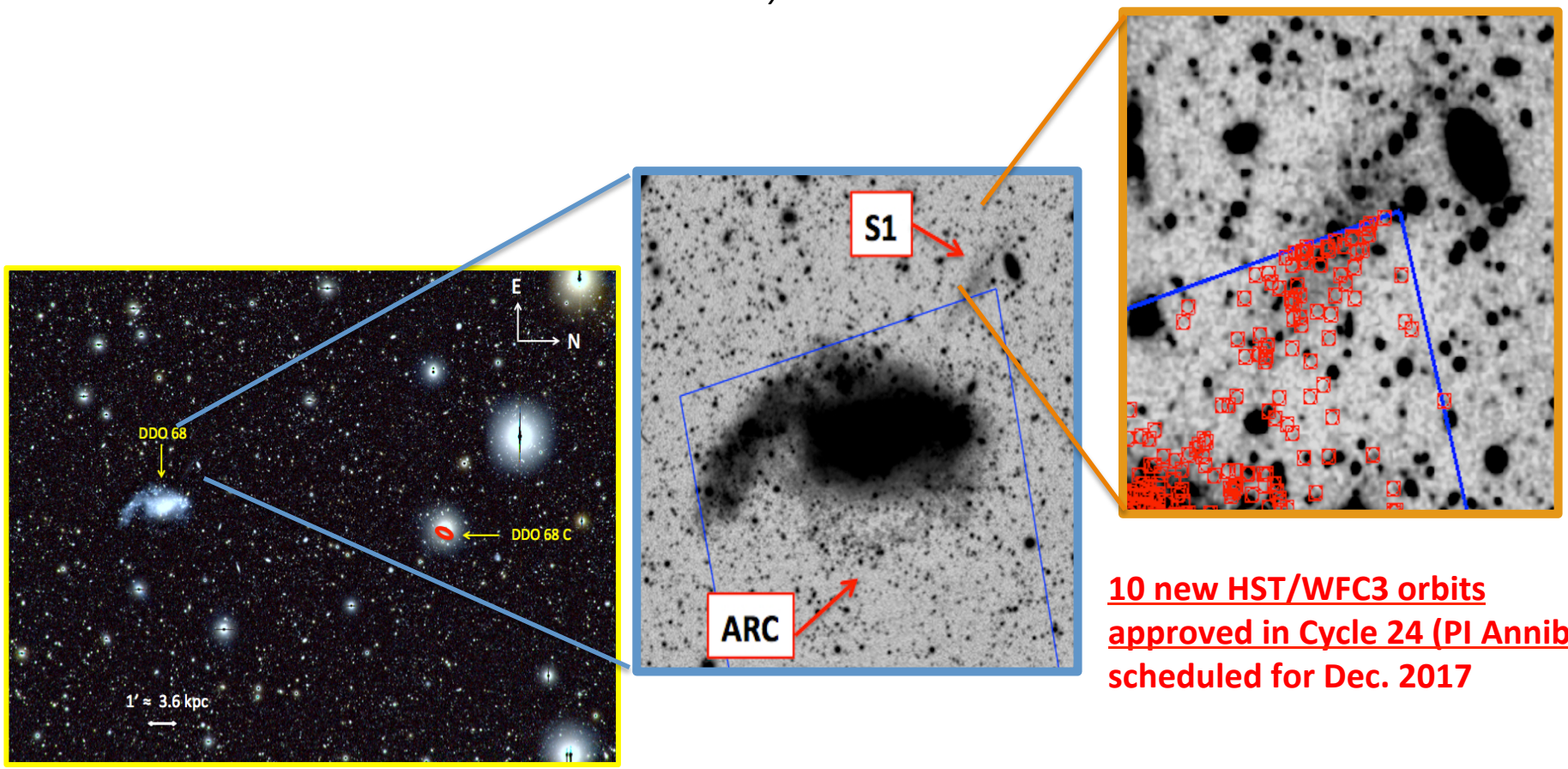


New LBT / LBC imaging of DDO 68 (PI Annibali)

- Annibali *et al.*, ApJ 826, L27, 2016:
  DDO 68: A Flea with Smaller Fleas that on Him Prey

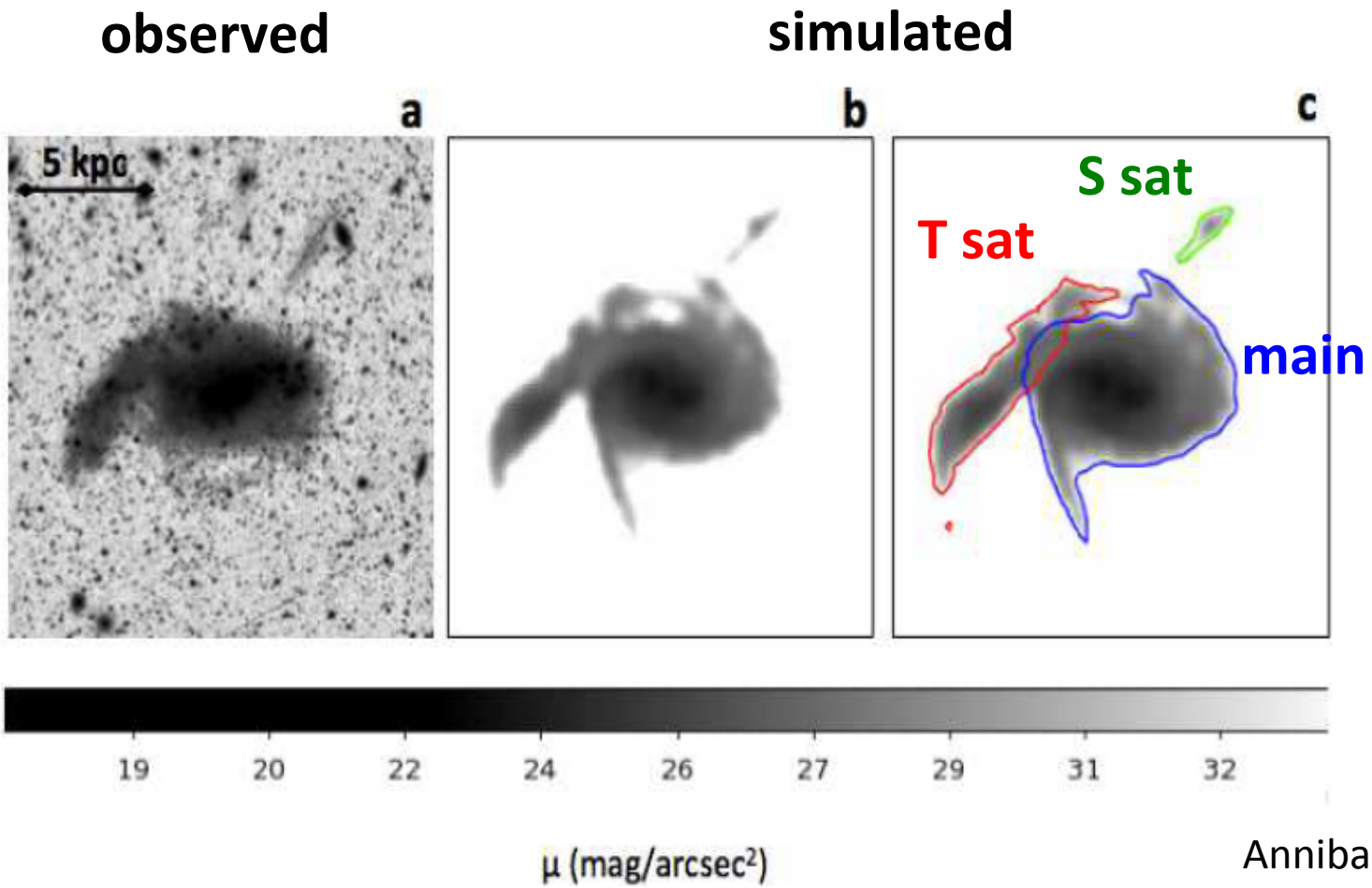


10 new HST/WFC3 orbits approved in Cycle 24 (PI Annibali)- scheduled for Dec. 2017

N-body simulations of DDO 68' s system

- Collisionless N-body code by Nipoti, Londrillo & Ciotti (2003)

$M_{tot} \approx 10^{10} M_{\odot}$ **; T sat: M_{tot}/10; S sat: M_{tot}/150**



Annibali + 16:

SSH: The **S**mallest **S**cale of **H**ierarchy Survey

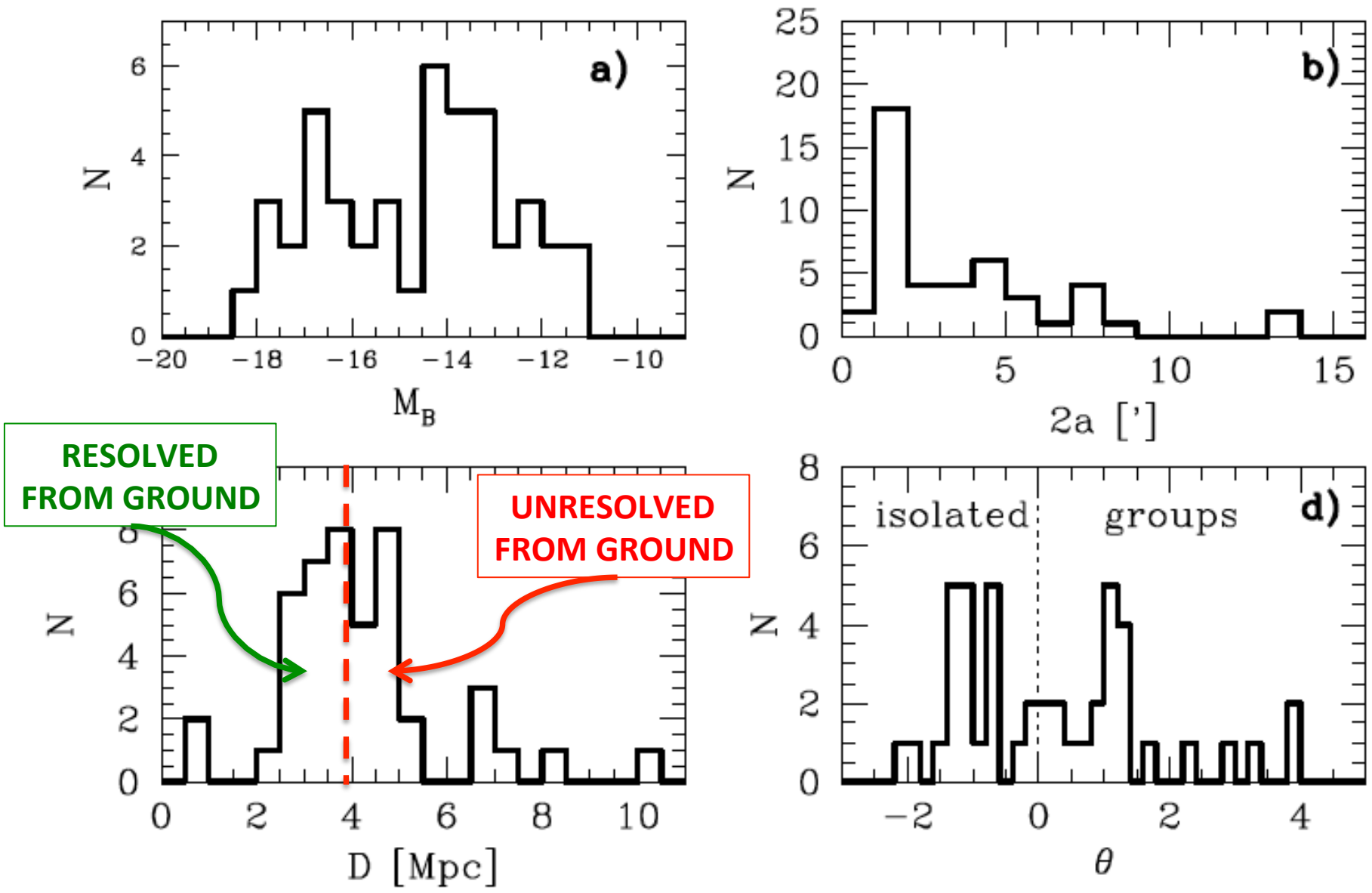
- Two-year **Strategic Program** with LBT/LBC (approved in 2016) to **get deep wide-field** imaging in g and r of ≈ 50 local late-type dwarfs to study the **hierarchical formation at small galaxy scales** and the **connection between SF and accretion events** (PI Annibali).

- The **sample** was selected from the *Updated Nearby Galaxy Catalog* of Karachentsev + 13 (D<11 Mpc) according to the following criteria:

    - galaxies in the northern hemisphere;
    - with distance from Tip of the RGB;
    - with HST – **WFPC2/ACS/WFC3** data;
    - with low foreground extinction (A_V<0.5);
    - with morphological type T≥ 6 (late spirals and irregulars);
    - with magnitudes -11 < M_B < -19
    - with apparent major axis (2a) in the range 1-15 arcmin.

- **Surface brightness limit:**
    - Where stars resolved down to 1 ≈ mag below TRGB → **μ_r≈32 mag arcsec^{-2}**
    - Otherwise → **μ_r≈29 mag arcsec^{-2}**

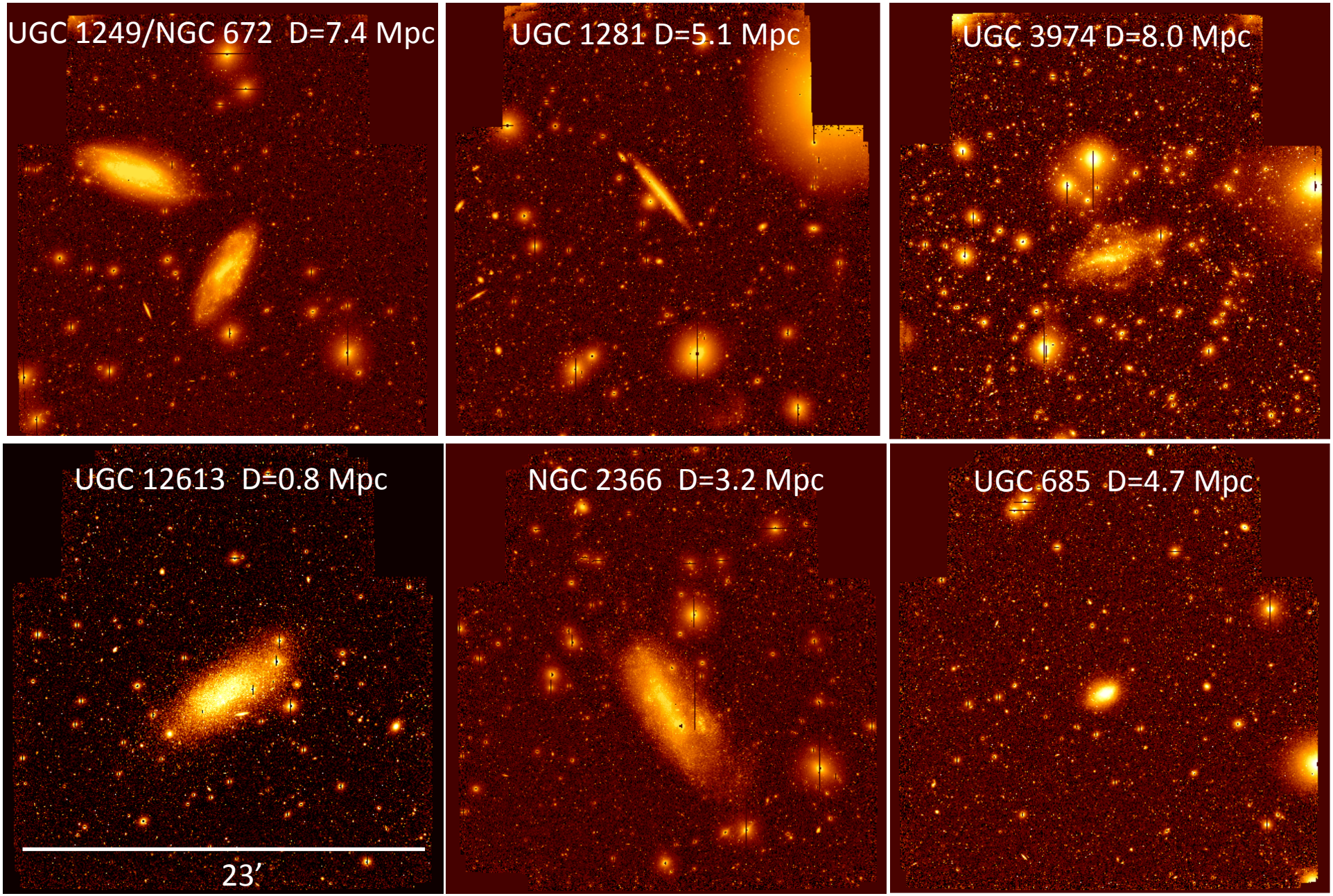
SSH: The **S**mallest **S**cale of **H**ierarchy Survey



SSH Survey

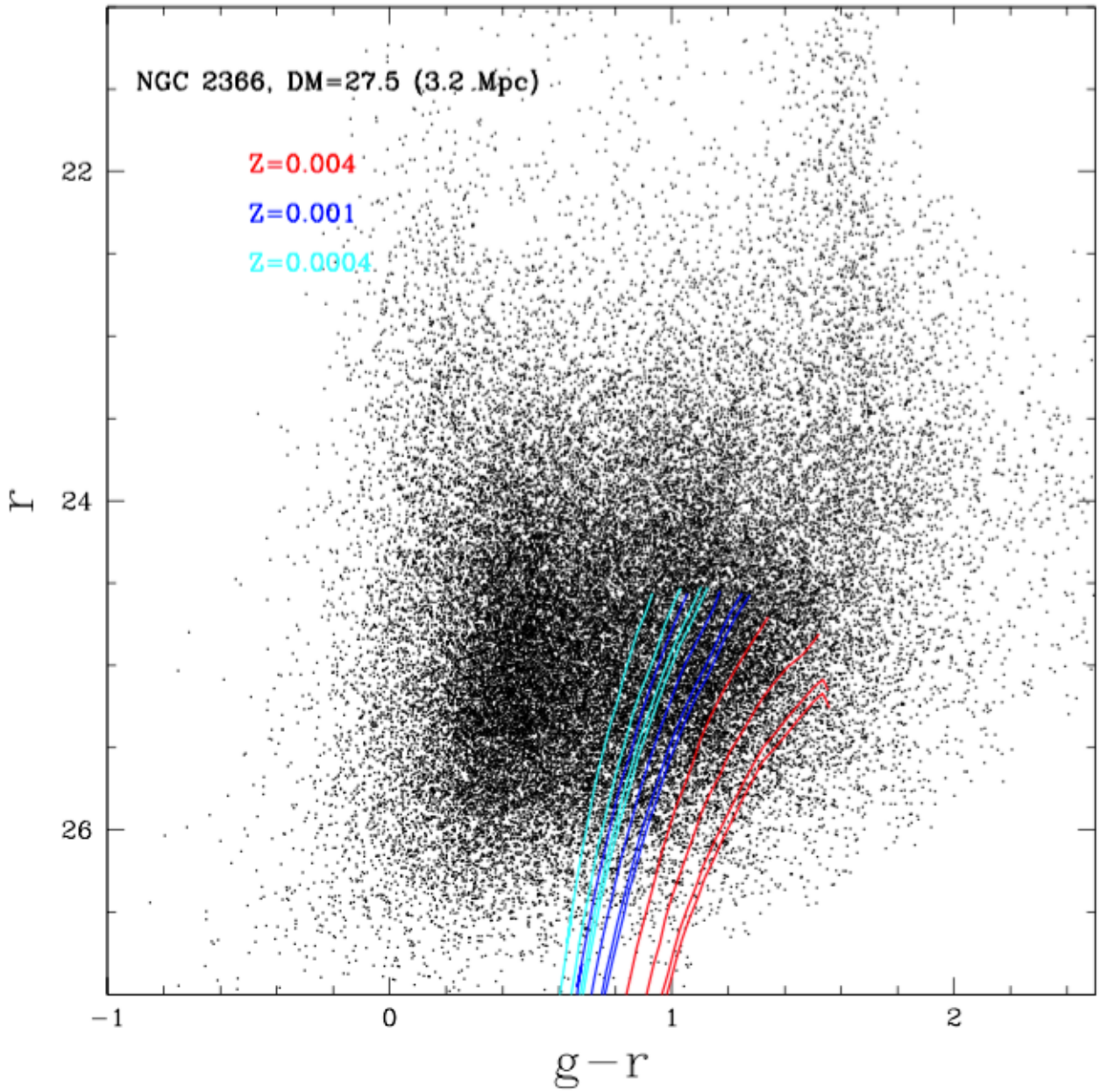
RUN	NAME	RA	DEC	D Mpc	MB	LEGUS	STATUS	RUN	NAME	RA	DEC	D Mpc	MB	LEGUS	STATUS
R1	UGC 685	01 07 22.4	16 41 02	4.7	-14.3	YES	COMPL	**R24**	NGC 3741	11 36 06.2	45 17 01	3.2	-13.1		
R2	UGC 1249	01 47 29.9	27 20 00	7.4	-18.1	YES	COMPL	**R25**	UGC 6817	11 50 53.0	38 52 49	2.6	-13.6		
R3	UGC 1281	01 49 32.0	32 35 23	5.1	-16.7		2/3	**R26**	NGC 4163	12 12 09.1	36 10 09	3.0	-13.7		
R4	KK 16	01 55 20.6	27 57 15	4.7	-12.1			**R27**	UGCA 276	12 14 57.9	36 13 08	3.2	-11.8		
R5	KK 17	02 00 09.9	28 49 57	4.7	-11.2			**R28**	NGC 4214	12 15 38.9	36 19 40	2.9	-17.1		
R6	NGC 784	02 01 17.0	28 50 15	4.9	-16.1			**R29**	UGC 7408	12 21 15.0	45 48 41	7.0	-16.0	YES	
R7	KKH 37	06 47 45.8	80 07 26	3.4	-11.6			**R30**	NGC 4395	12 25 48.9	33 32 48	4.6	-17.7	YES	
R8	UGC 3755	07 13 51.6	10 31 19	6.7	-15.9		COMPL	**R31**	UGC 7577	12 27 40.9	43 29 44	2.7	-14.4		
R9	NGC 2366	07 28 54.6	69 12 57	3.2	-16.2		COMPL*	**R32**	UGC 7605	12 28 38.7	35 43 03	4.4	-13.5		
R10	UGC 3974	07 41 55.4	16 48 09	8.0	-16.0		COMPL	**R33**	UGC 7866	12 42 15.1	38 30 12	4.6	-14.6		
R11	UGC 4305	08 19 04.0	70 43 09	3.4	-16.7	YES		**R34**	UGC 8320	13 14 27.9	45 55 09	4.3	-15.1		
R12	UGC 4426	08 28 28.4	41 51 24	10.3	-15.2			**R35**	NGC 5204	13 29 36.2	58 25 06	4.6	-16.6		
R13	UGC 4459	08 34 07.2	66 10 54	3.6	-13.1	YES		**R36**	NGC 5238	13 34 42.5	51 36 49	4.2	-14.3	YES	
R14	UGC 5139	09 40 32.3	71 10 56	3.8	-13.9	YES		**R37**	UGC 8638	13 39 19.4	24 46 32	4.3	-13.1		
R15	NGC 2976	09 47 15.3	67 55 00	3.6	-16.7			**R38**	UGC 8651	13 39 53.8	40 44 21	3.0	-13.0		
R16	KDG 61	09 57 03.1	68 35 31	3.6	-12.8			**R39**	UGC 8760	13 50 50.6	38 01 09	3.2	-13.1		
R17	UGC 5364	09 59 26.4	30 44 47	0.7	-11.3			**R40**	NGC 5477	14 05 33.3	54 27 40	6.8	-15.0	YES	
R18	NGC 3077	10 03 20.6	68 44 04	3.8	-17.5			**R41**	UGC 9128	14 15 56.5	23 03 19	2.2	-12.3		
R19	UGC 5456	10 07 19.6	10 21 46	3.8	-14.3			**R42**	UGC 9240	14 24 43.4	44 31 33	2.8	-14.0		
R20	UGC 5666	10 28 21.2	68 24 43	4.0	-17.3			**R43**	NGC 6503	17 49 27.1	70 08 40	5.3	-17.8	YES	
R21	UGC 5692	10 30 35.0	70 37 07	4.0	-14.4			**R44**	NGC 6789	19 16 42.1	63 58 17	3.0	-14.3		
R22	UGC 6541	11 33 28.9	49 14 14	3.9	-13.6			**R45**	UGC12613	23 28 36.2	14 44 35	0.8	-12.1		2/3
R23	NGC 3738	11 35 48.8	54 31 26	4.9	-16.5	YES									

A gallery of SSH images . . .



NGC 2366 – D=3.2 Mpc, $M_B \approx -16$

NGC 2366: Color–Magnitude Diagram



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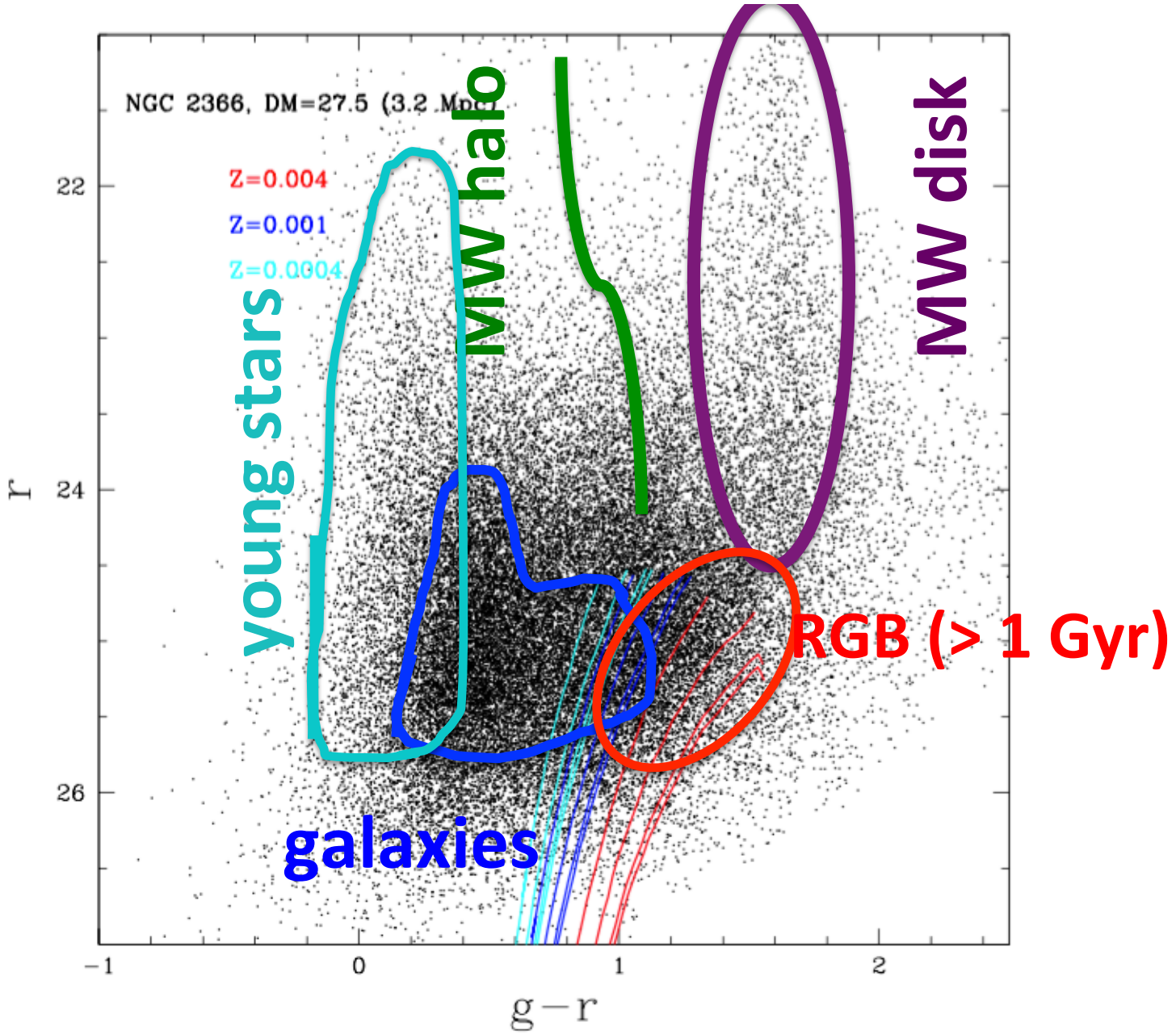
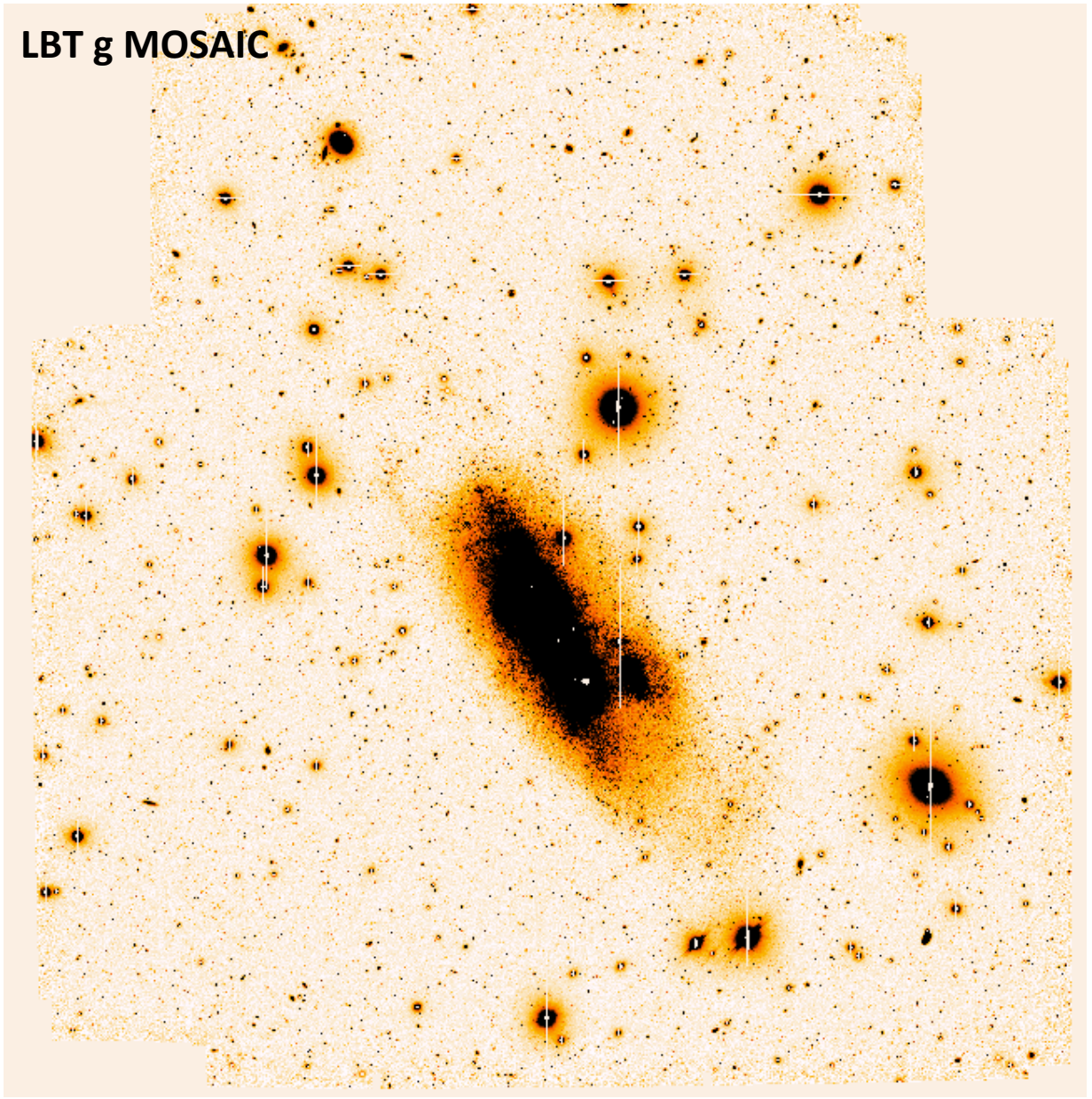
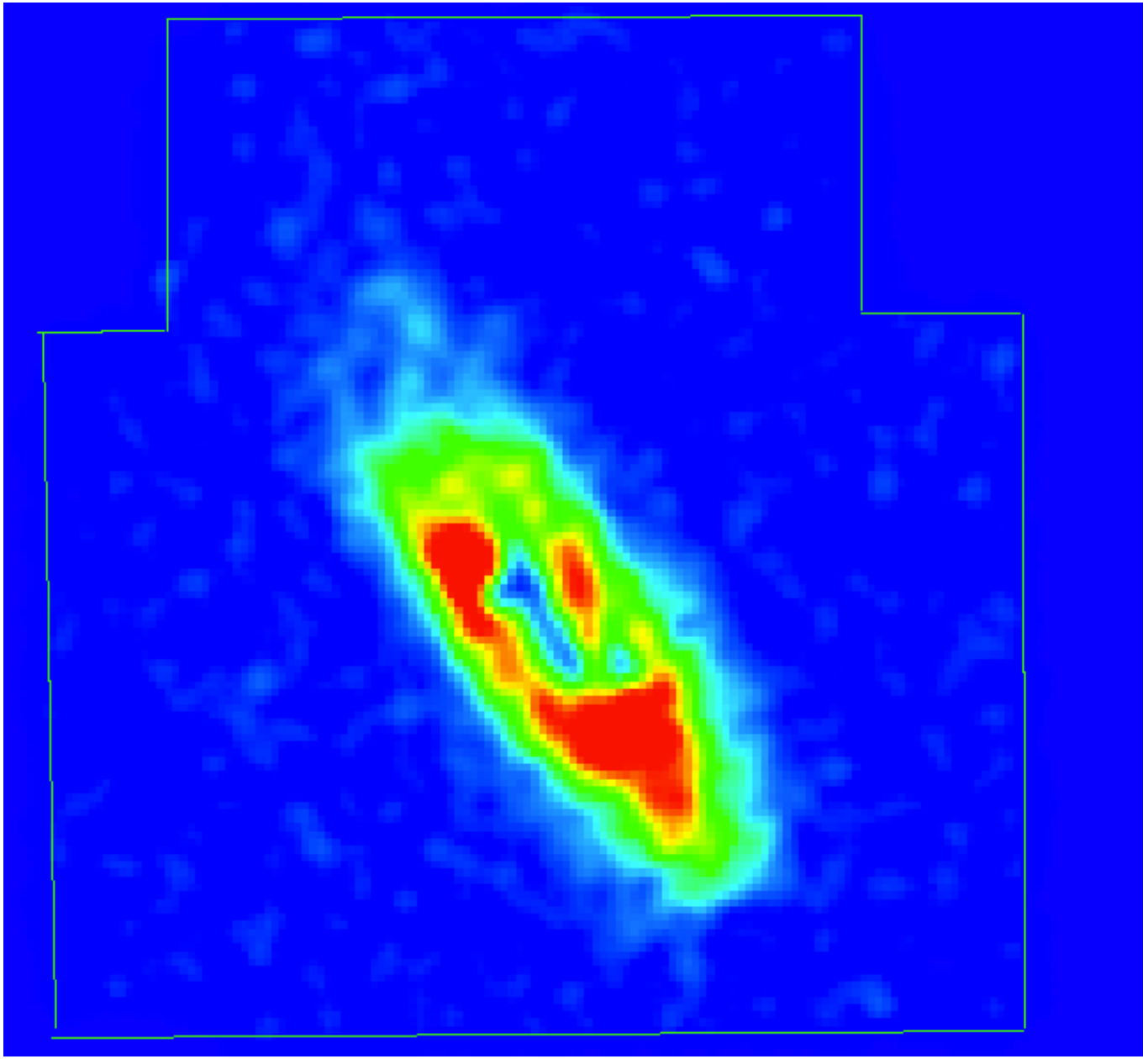


NGC 2366 – D=3.2 Mpc, $M_B \approx -16$



NGC 2366 – MAP of the resolved RGB STARS



SSH: Concluding Remarks and Perspectives

- About **10 targets** observed during the first year of the survey. . . **HOPE TO BE MORE LUCKY DURING NEXT YEAR!!!**

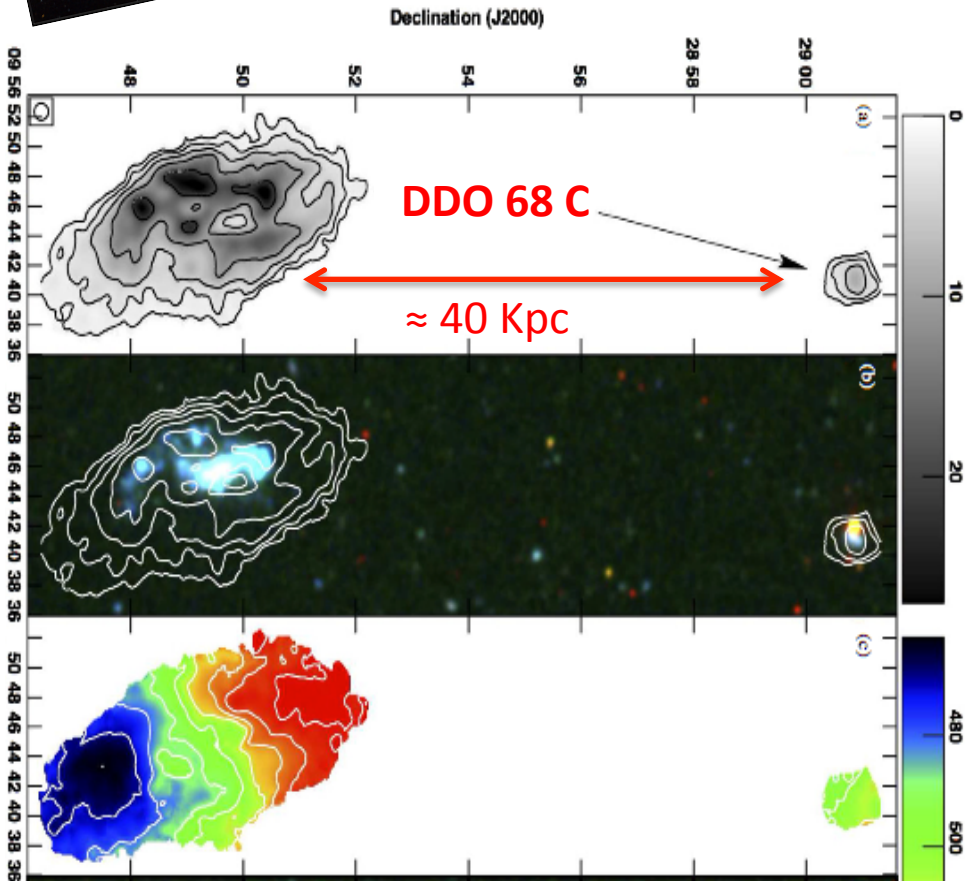
- At completion, SSH will provide:
  - statistics on **number and mass of satellites/streams** around dwarf galaxies
  - dependence with **environment**

- **N-body simulations** to infer properties and timescales of the interaction events

- Galaxy **Star Formation History** from HST/LBT color-magnitude diagram → CONNECTION BETWEEN SF AND INTERACTION

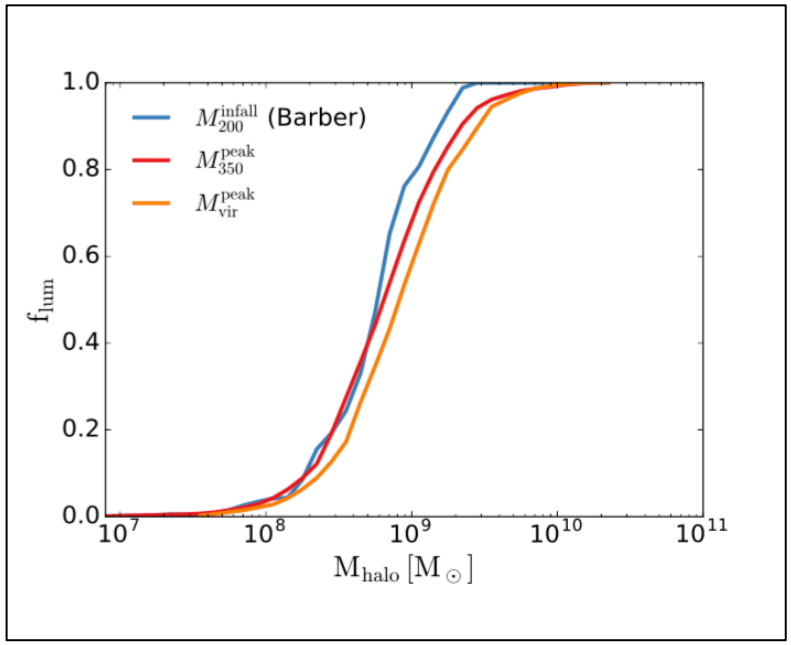
First evidence of multiple merging at very low galaxy scales: **DDO 68**

HST

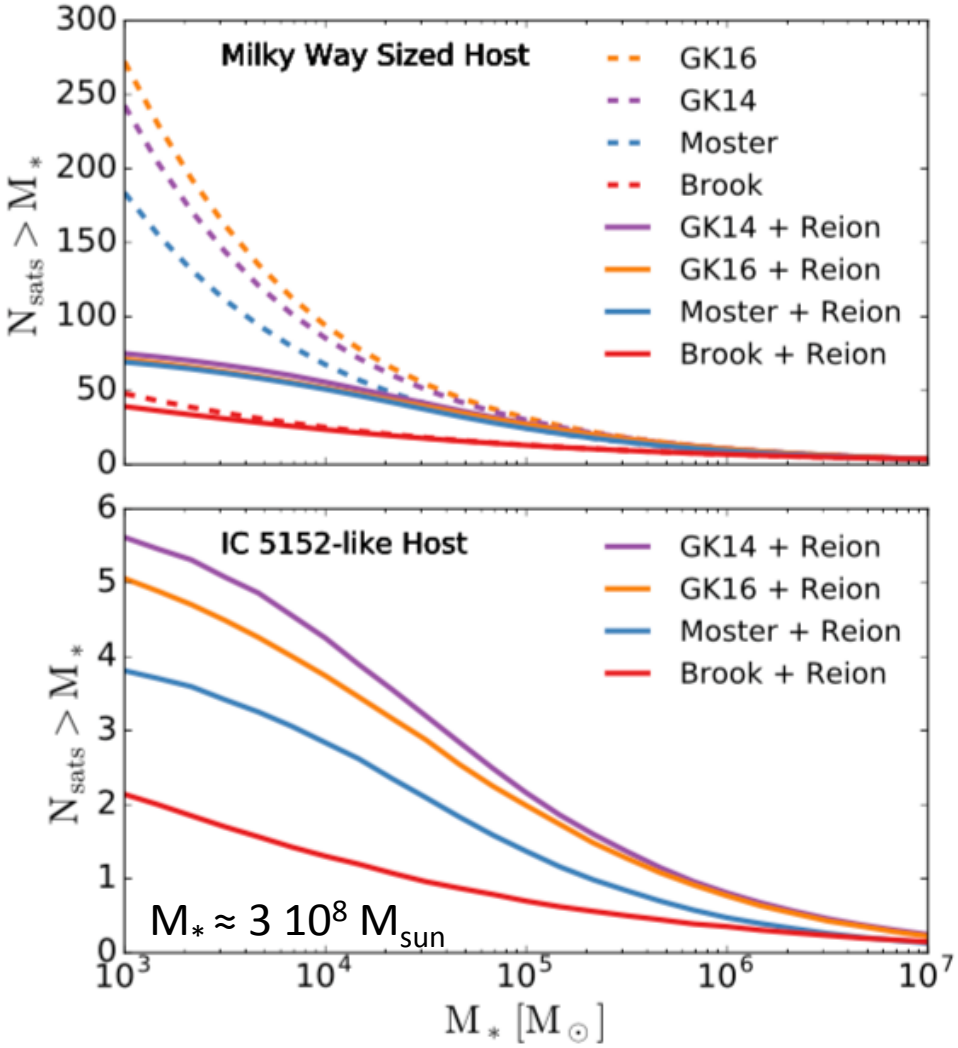


Predictions for satellite abundance

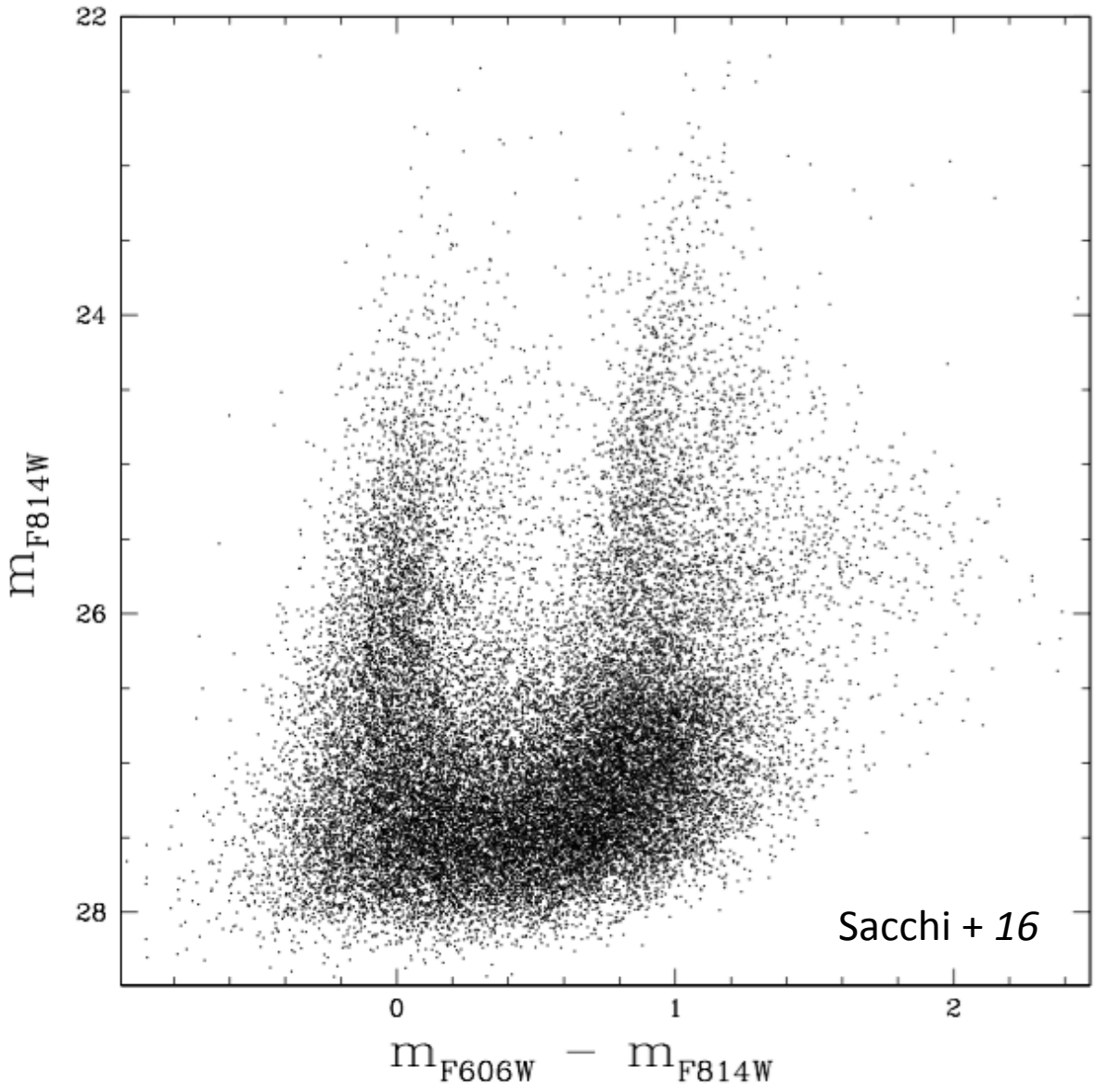
Dooley et al. 2016



Fraction of dark matter halos that host luminous satellites at z=0



DDO 68: CMD of stars resolved with HST/ACS



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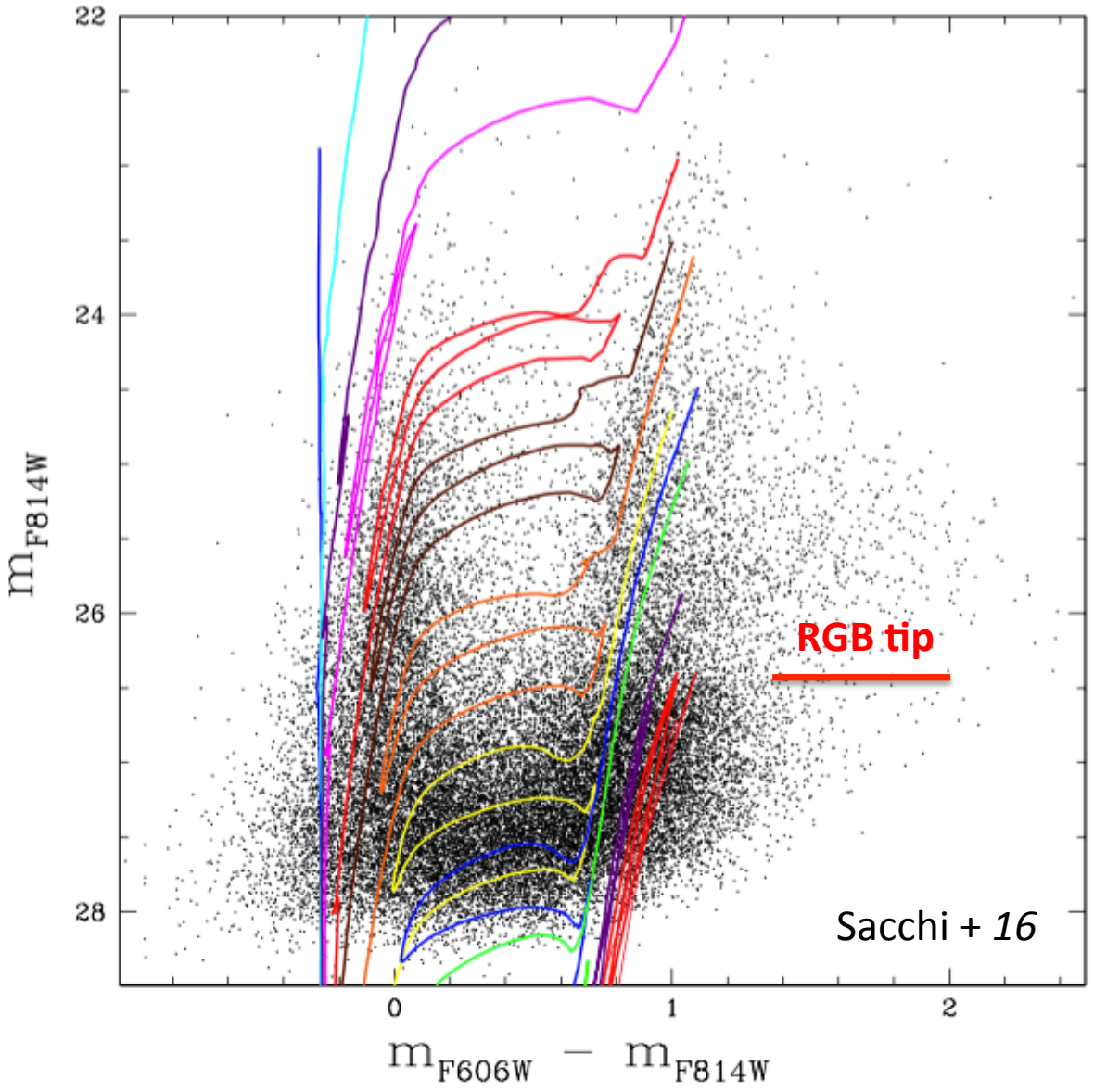
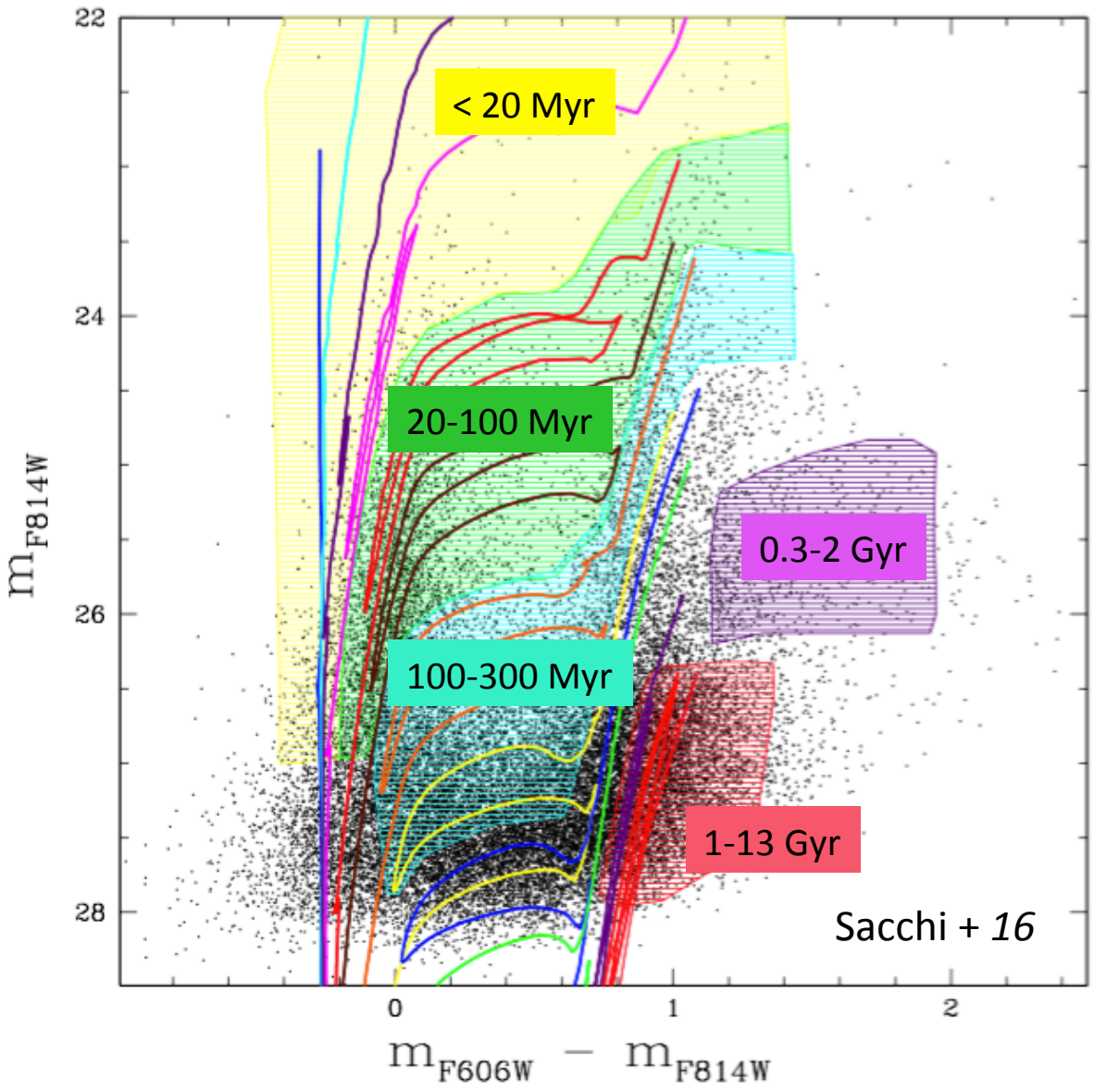


PARSEC iso - Z=0.0004
(Bressan+12)

1 MYR
5 MYR
10 MYR
15 MYR
30 MYR
50 MYR
100 MYR
200 MYR
300 MYR
500 MYR
> 1 GYR

DDO 68: CMD of stars resolved with HST/ACS

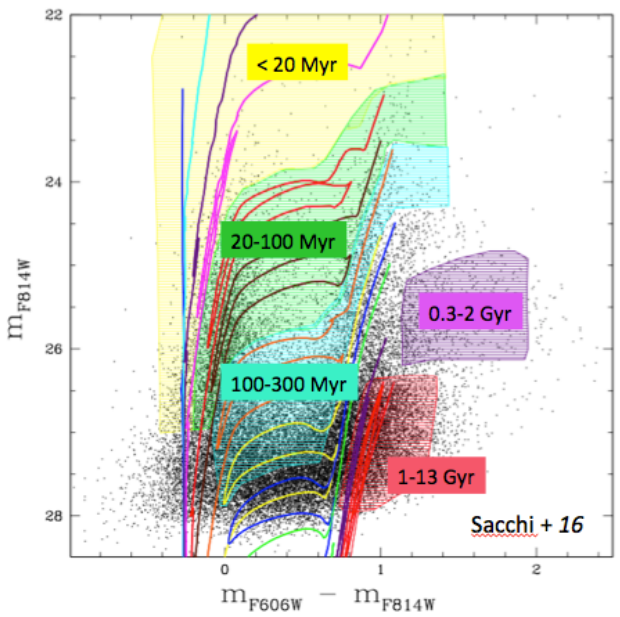


PARSEC iso - Z=0.0004
(Bressan+12)

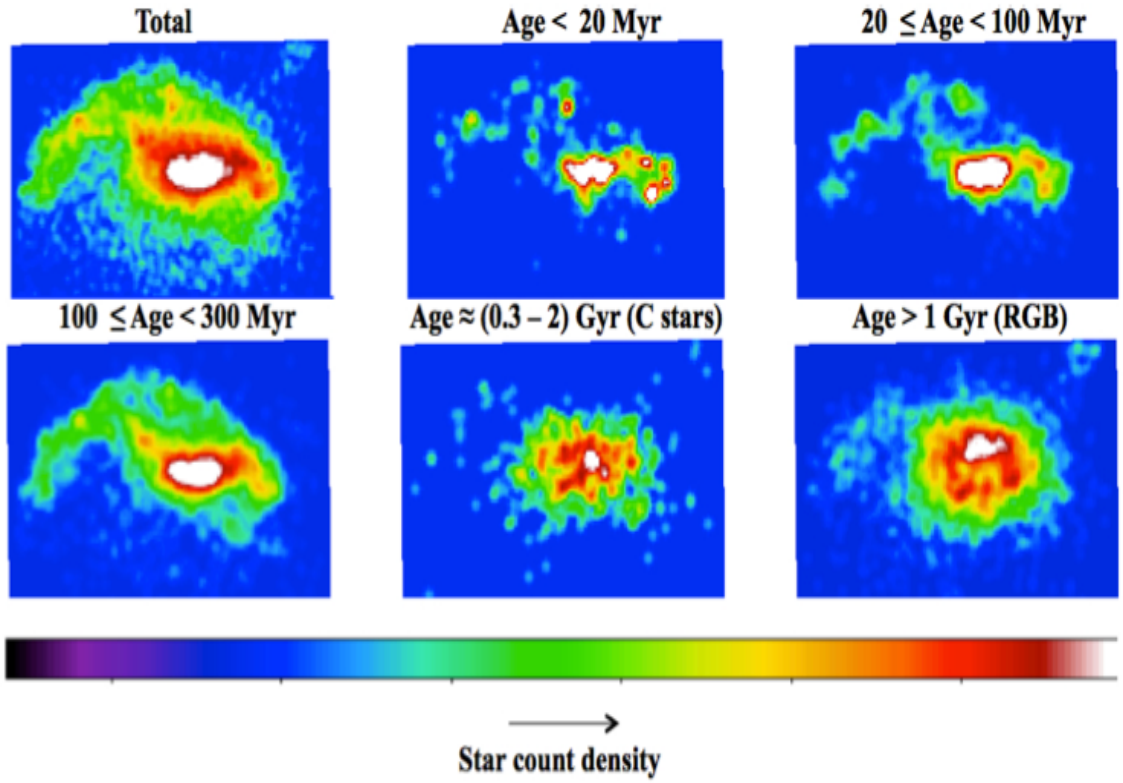
1 MYR
5 MYR
10 MYR
15 MYR
30 MYR
50 MYR
100 MYR
200 MYR
300 MYR
500 MYR
> 1 GYR

DDO 68: Stellar populations from HST/ACS

CMD of stars resolved with HST



Density maps for different age bins



Sacchi + 16