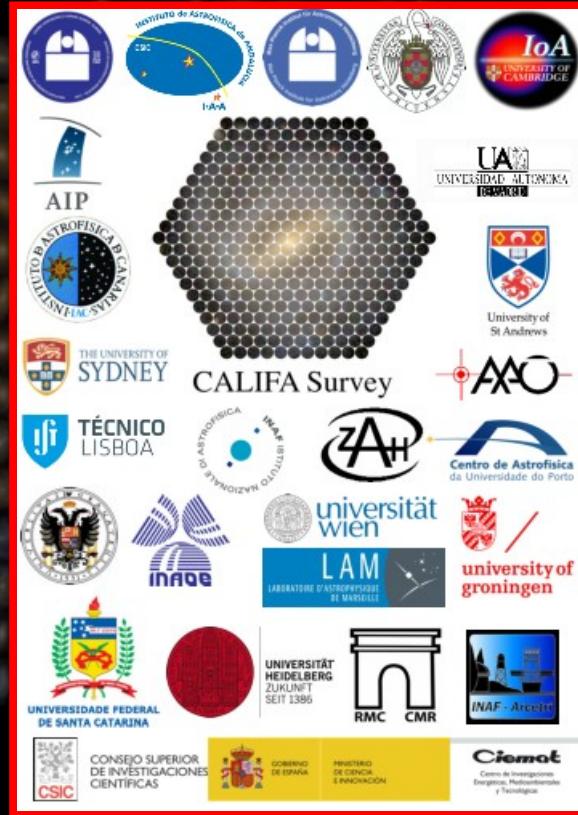


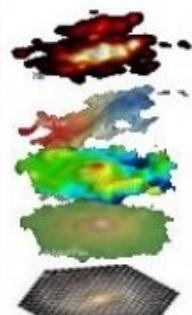
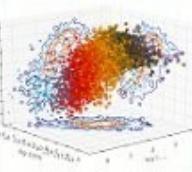
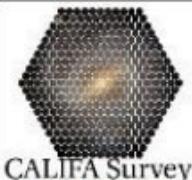
The CALIFA Survey: Radial gradients and local relations

Sebastián F. Sánchez -IA/UNAM



- The Formation and Evolution of Disks in Galaxies -
- Flagstaff, October 2014 -

CALIFA Survey



DR2: 200 galaxies.
1st Oct. 2014.
<http://califa.caha.es/DR2>

Ha velocities

Ha flux

6900 Å 5250 Å 4100 Å

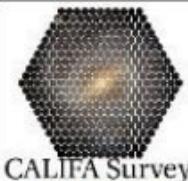
Ha [NII] 6584 Å [OIII] 5007 Å

IFU FoV/2 ~ 2.5 Re
Diameter Selection
All galaxy types.
Good sampling of CM

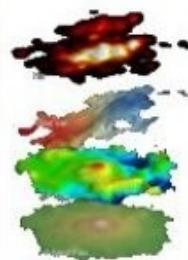
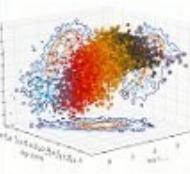
$\log(\mu_* [\mathrm{M}_\odot \mathrm{pc}^{-2}])$

$\log(\mathrm{Age} [\mathrm{yr}])$

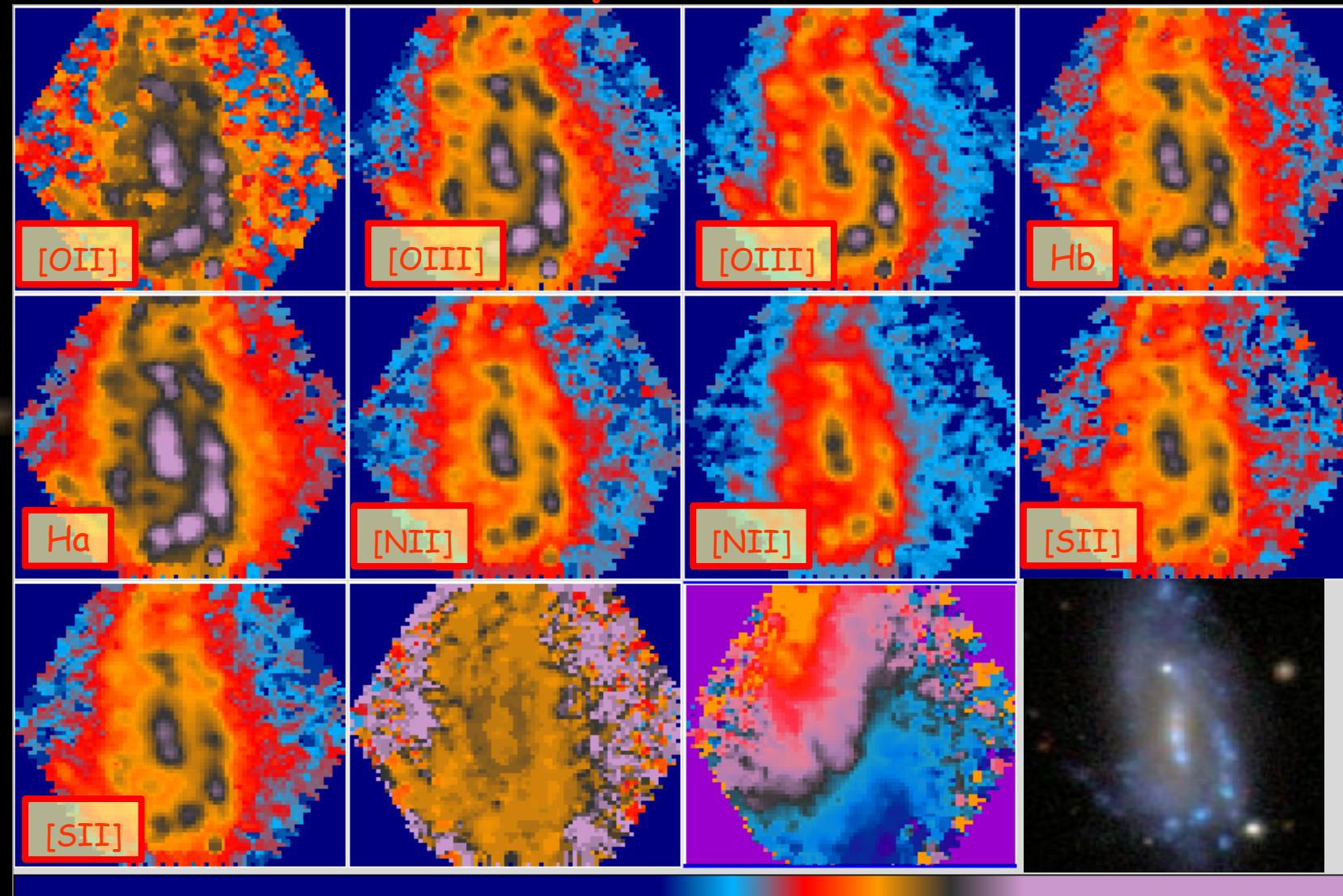
448 cal. obj. obs.
+109 ext. obj. obs.
600 is the final goal



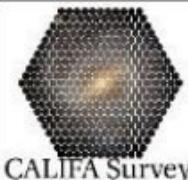
CALIFA Survey



CALIFA: A panoramic view



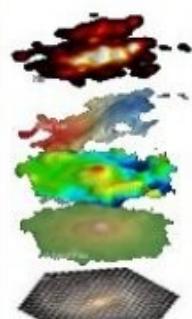
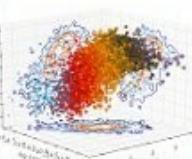
**Ionized Gas: Multiple emission lines intensity maps, velocity
and velocity dispersion.**



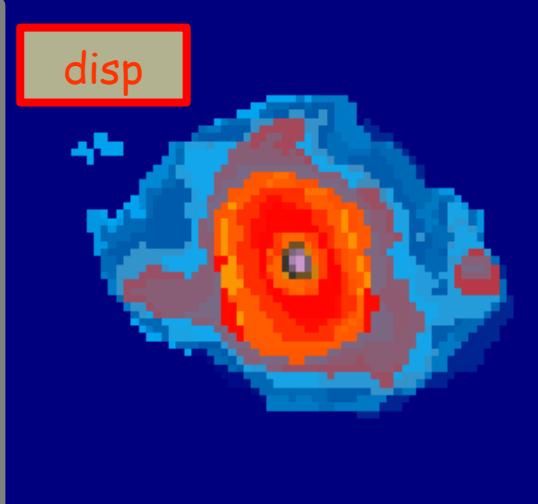
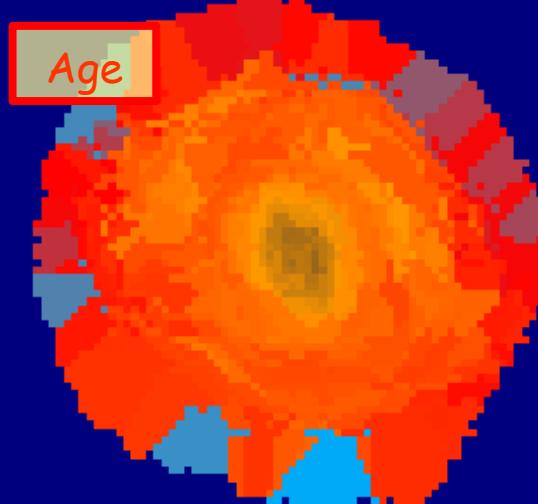
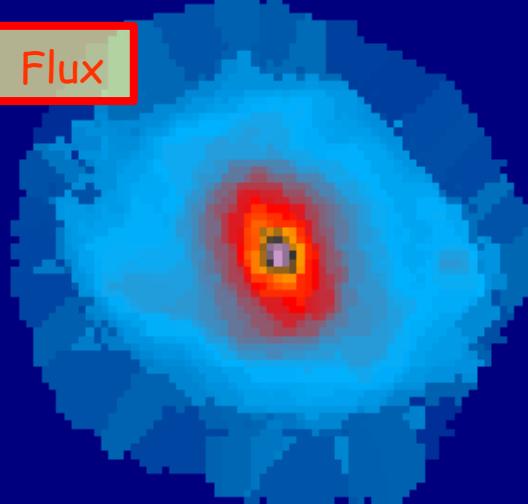
CALIFA Survey



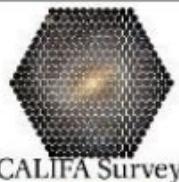
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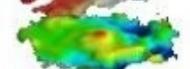
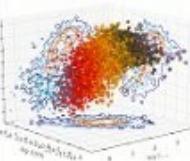
CALIFA: A panoramic view



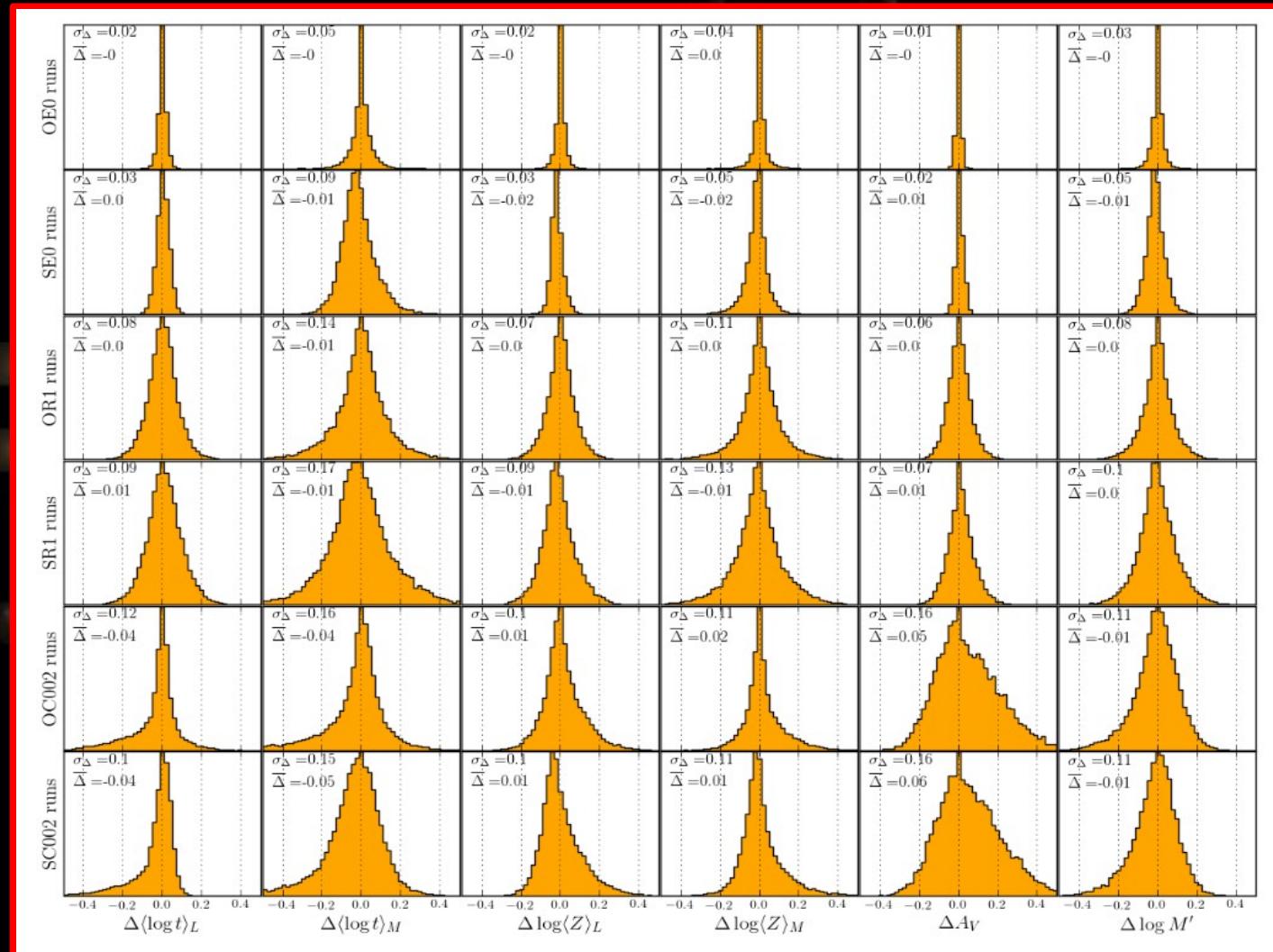
Stellar Populations: Average Properties.

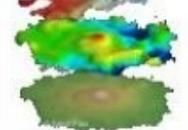
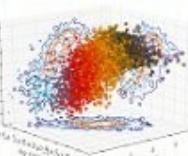
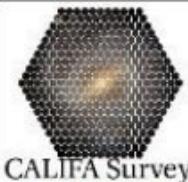


CALIFA Survey

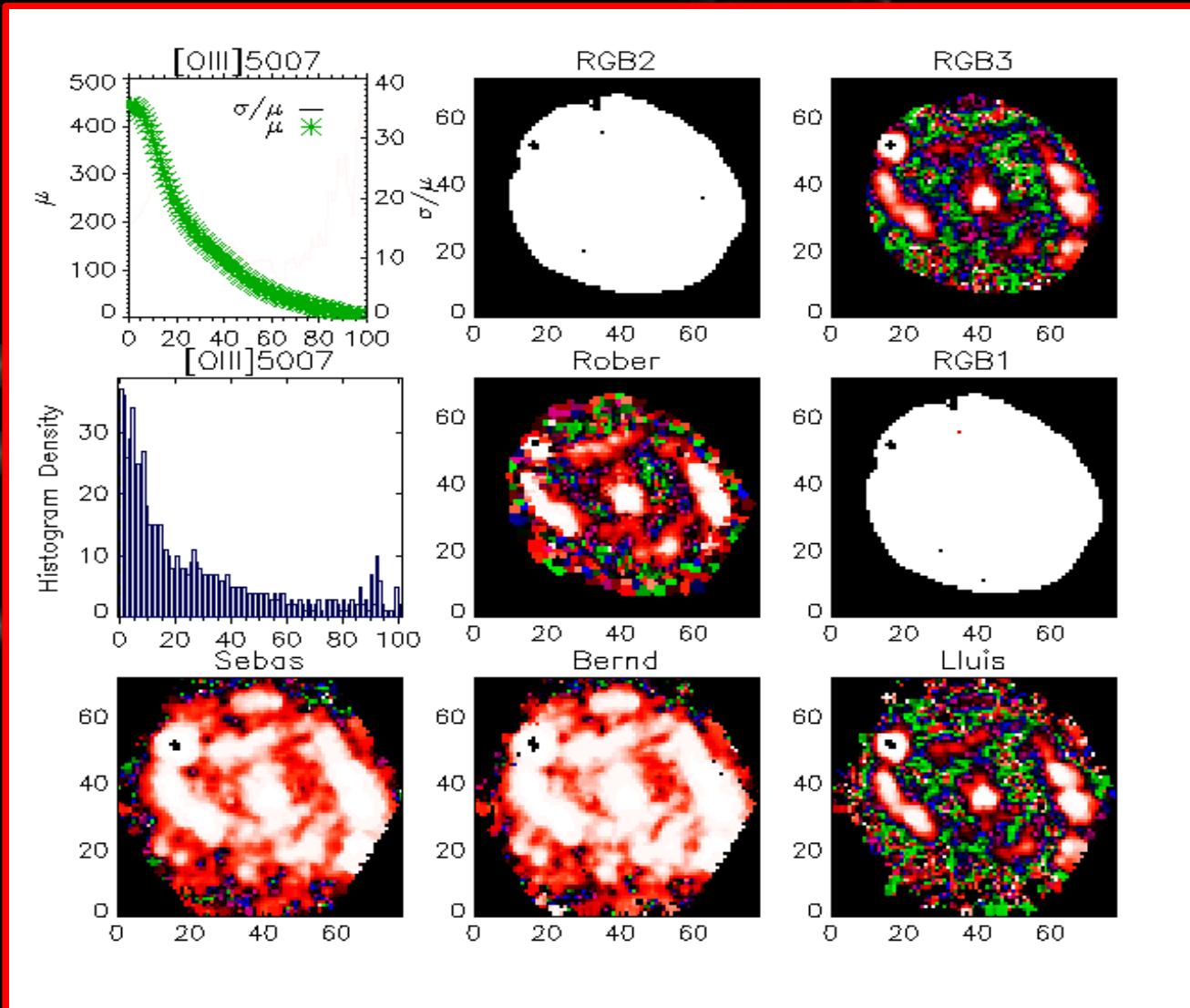


Uncertainties are under control!





Uncertainties are under control!

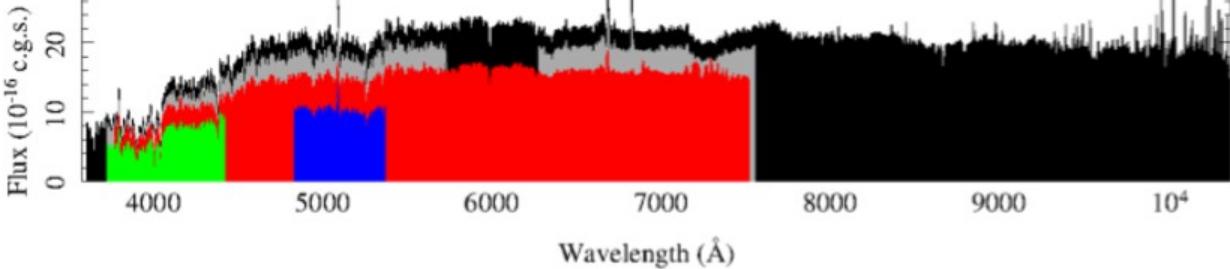
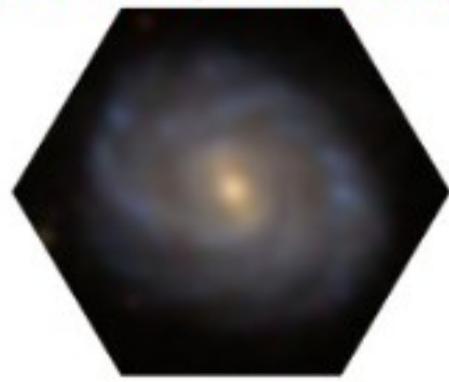


Rosales-Ortega, et al., in prep.

SDSS 90"x90" image



CALIFA (V500/V1200)



Atlas3D



$Z \sim Z$
califa



$Z \sim Z$
Atlas3D

MaNGA largest FoV



FoV $\sim 1.5 R_e$



$\sim 2.5 R_e$

SAMI



$Z \sim Z$
califa



$Z \sim Z$
SAMI

CALIFA

2x3x331 spaxels; 2.7"/spaxel

600 galaxies of any type

$\sim 1.200.000$ spec.; 3700-7500 Å

Atlas3D

1577 spaxels; 0.94"/spaxel

260 ETGs

~ 400.000 spectra; 4810-5350 Å

MaNGA

3x(19-127) spaxels; 2"/spaxel

7000 gal. of any type ($\sim 1.5 R_e$)

2000 gal. of any type ($\sim 2.5 R_e$)

1000 gal. of any type (any R_e)

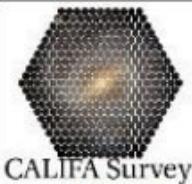
~ 800.000 spec.; 3550-10000 Å

SAMI

9x61 spaxels; 1.6"/spaxel

3400 galaxies of any type

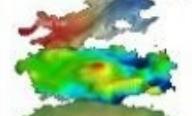
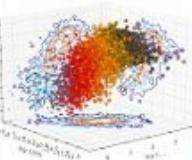
$\sim 1.900.000$ spec.; 3700-9500 Å



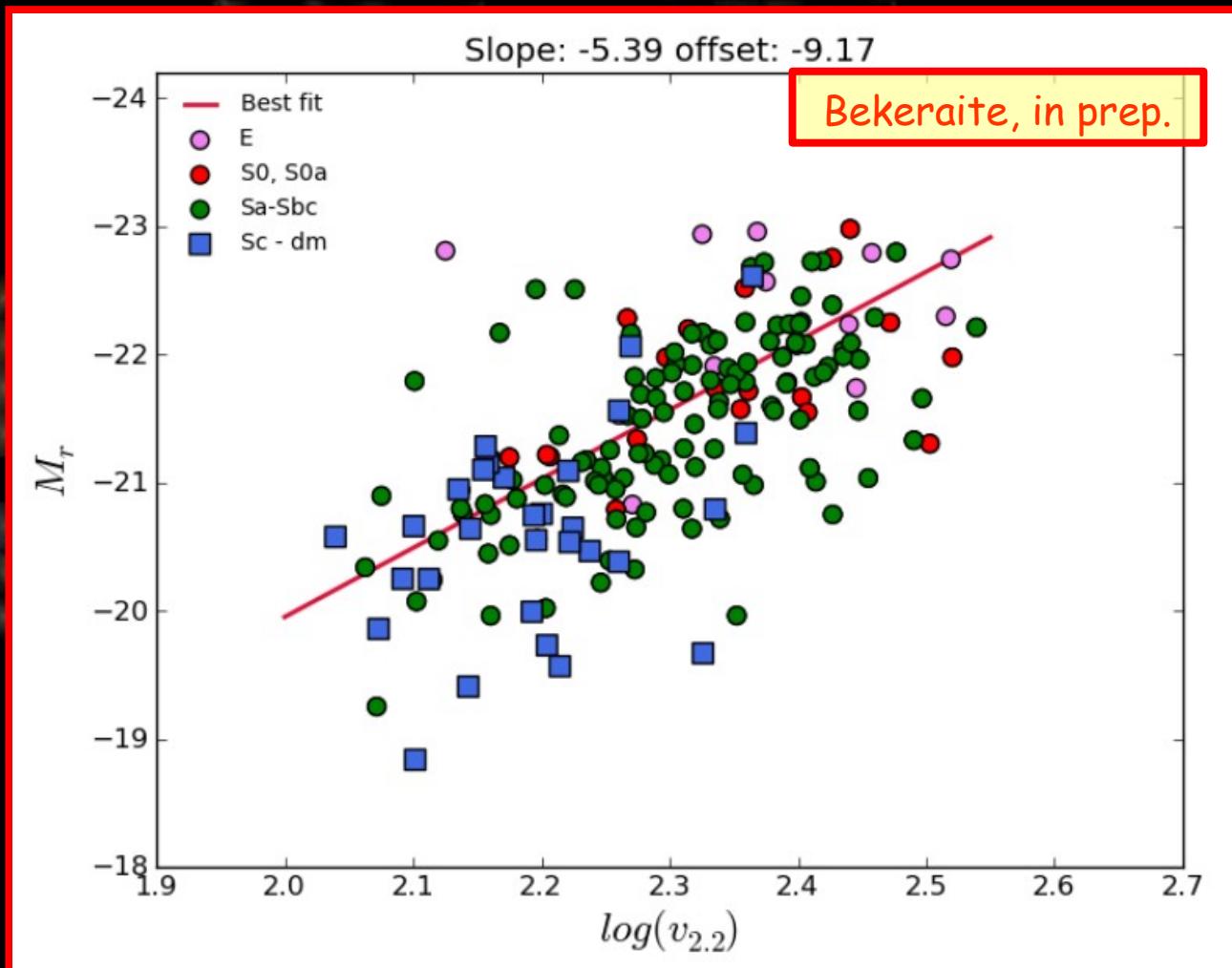
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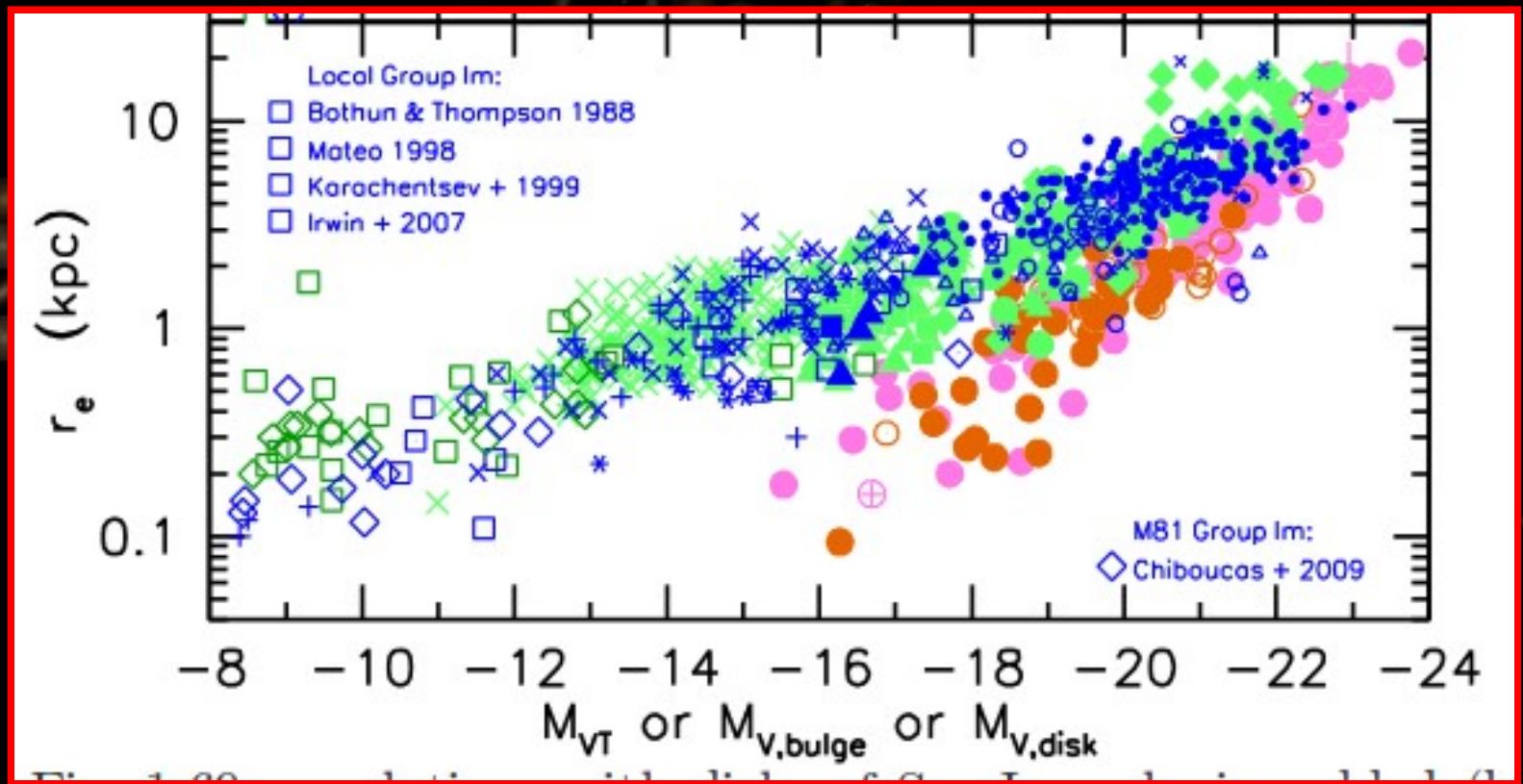
Disk Galaxies: What we know?



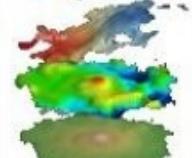
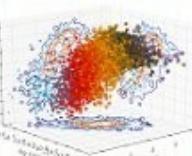
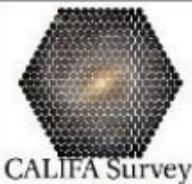
Tully-Fischer relation: Mstar vs. v_rot

Disk Galaxies: What we know?

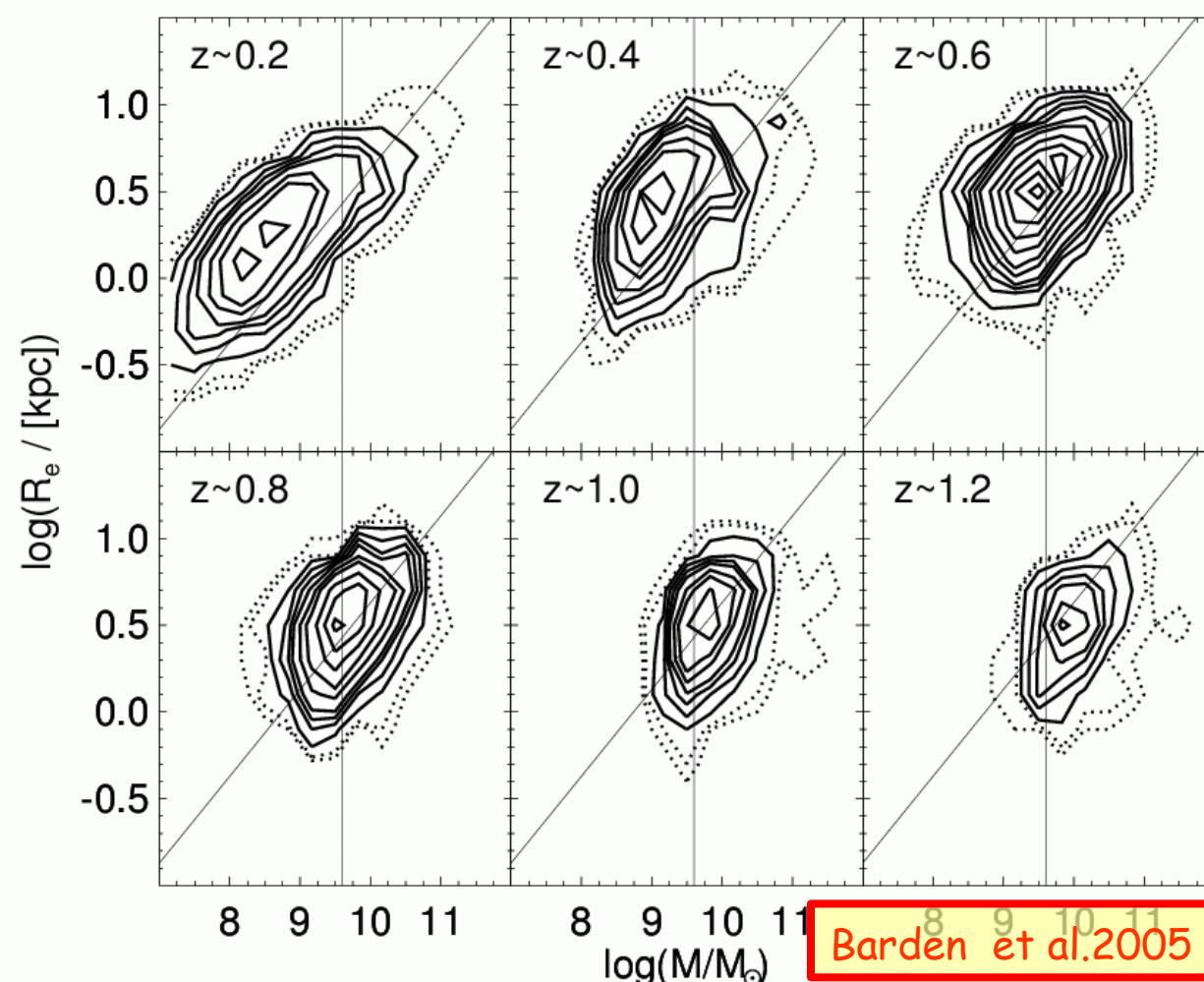
Kormendy 2014



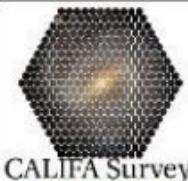
Re vs. Mstar scaling relation



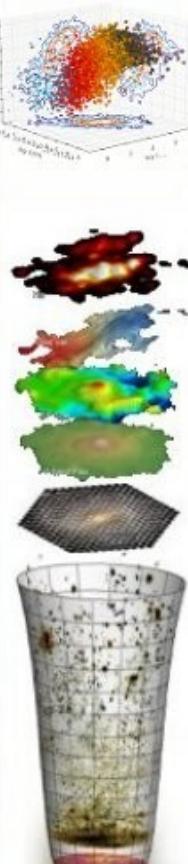
Inside-out growth?



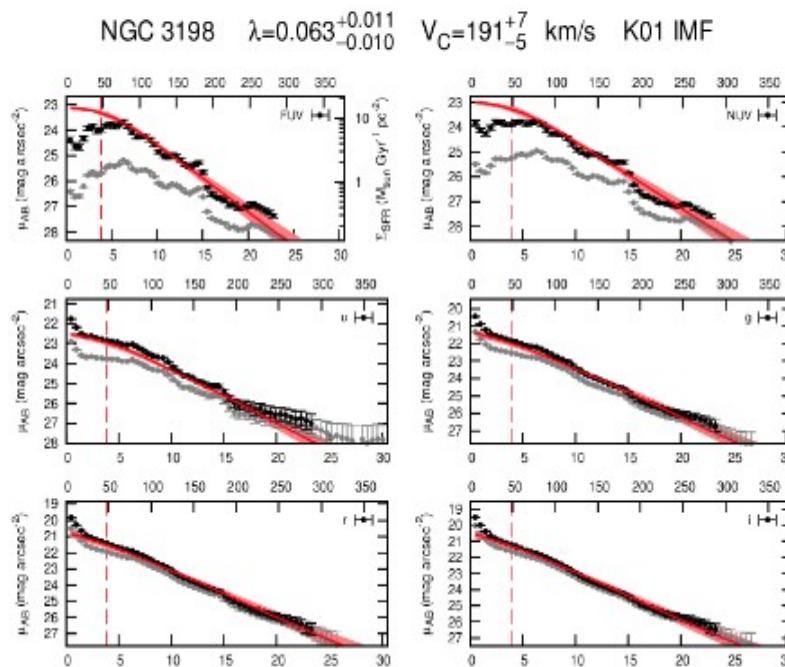
Re vs. Mstar relation: evolution with
redshift



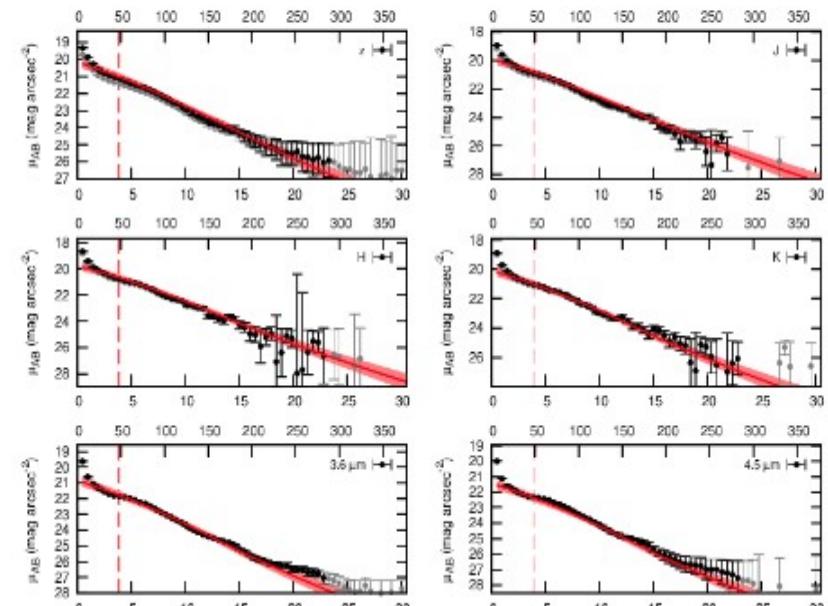
CALIFA Survey



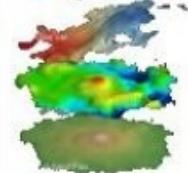
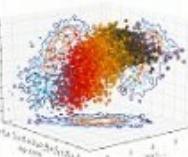
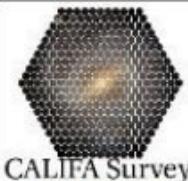
Inside-out growth?

Muñoz-Mateos 2010

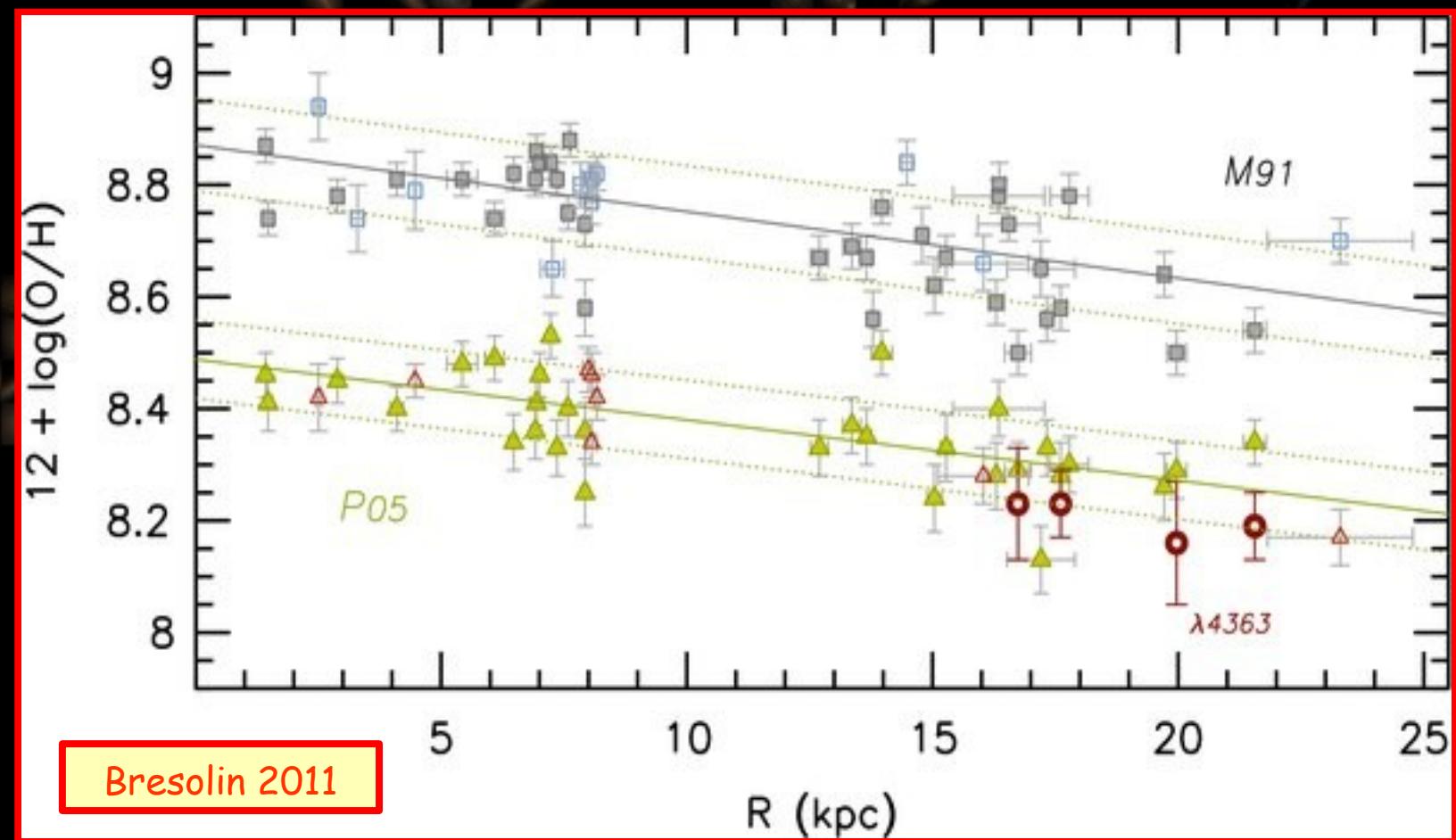
Multi- λ fitting of SINGS disks by
Muñoz-Mateos et al. (2010)
Data: FUV+NUV,ugriz,JHK,IRAC,MIPS
Models: Boissier & Prantzos (2000)



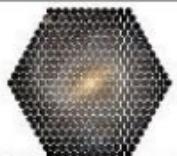
Multi-band surface brightness
distribution.



Inside-out growth?



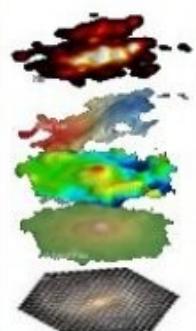
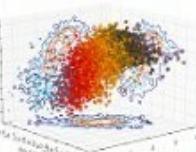
Oxygen abundance gradients: Universal?



CALIFA Survey

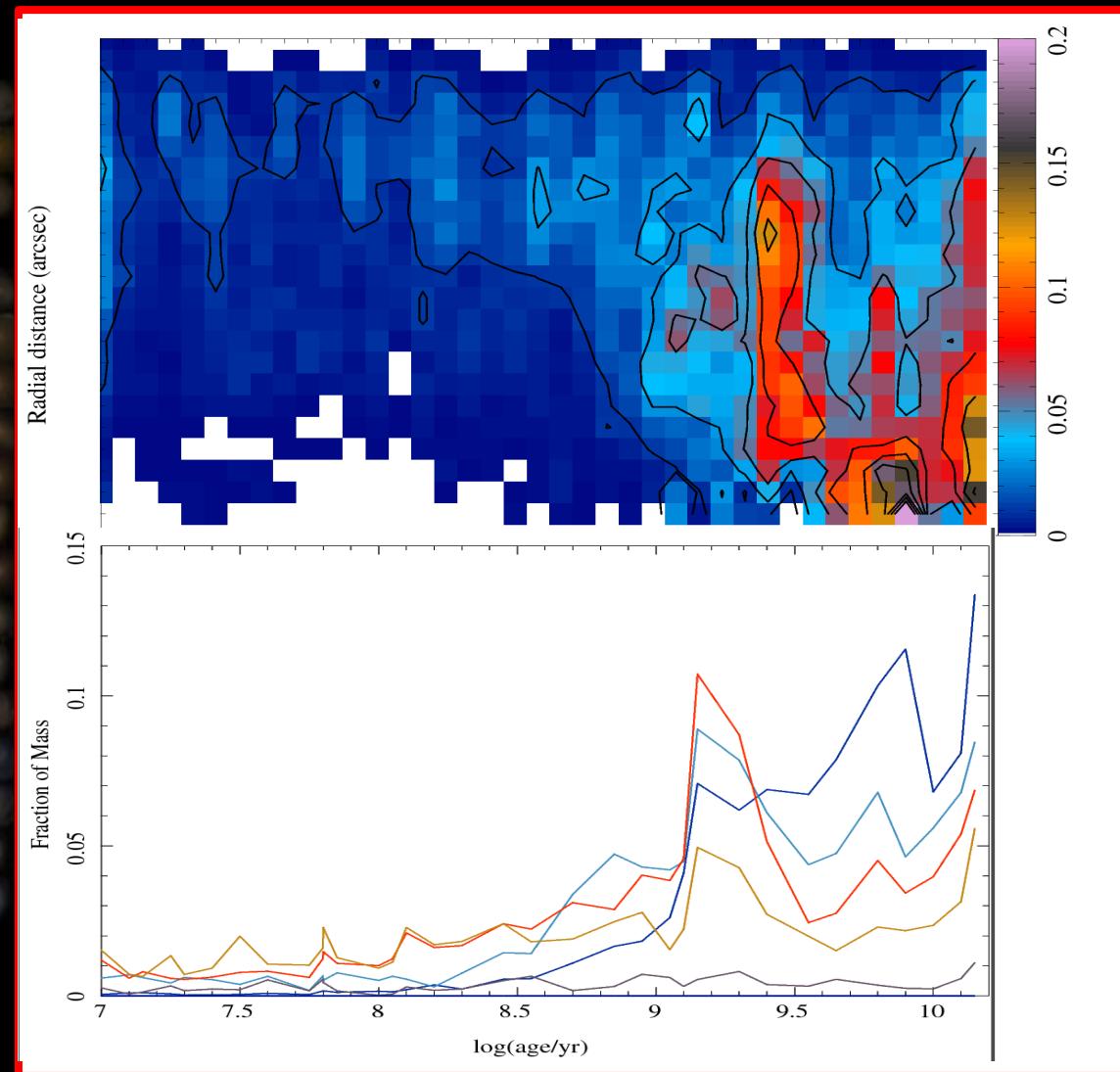
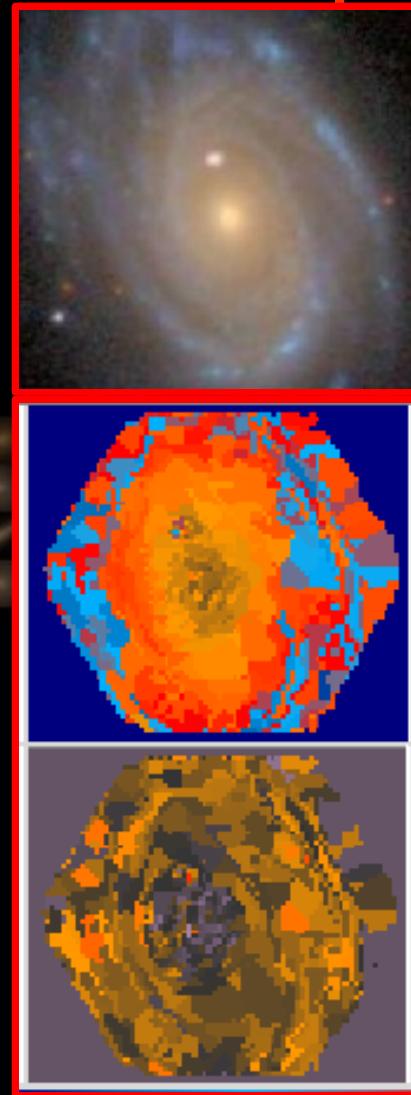
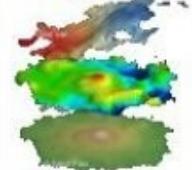
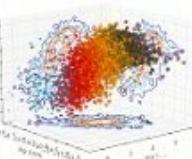
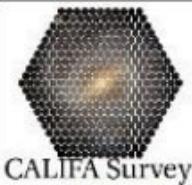


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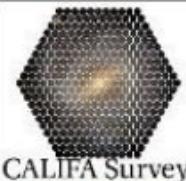
What we have
found
with
CALIFA?

Spatial Resolved SFH

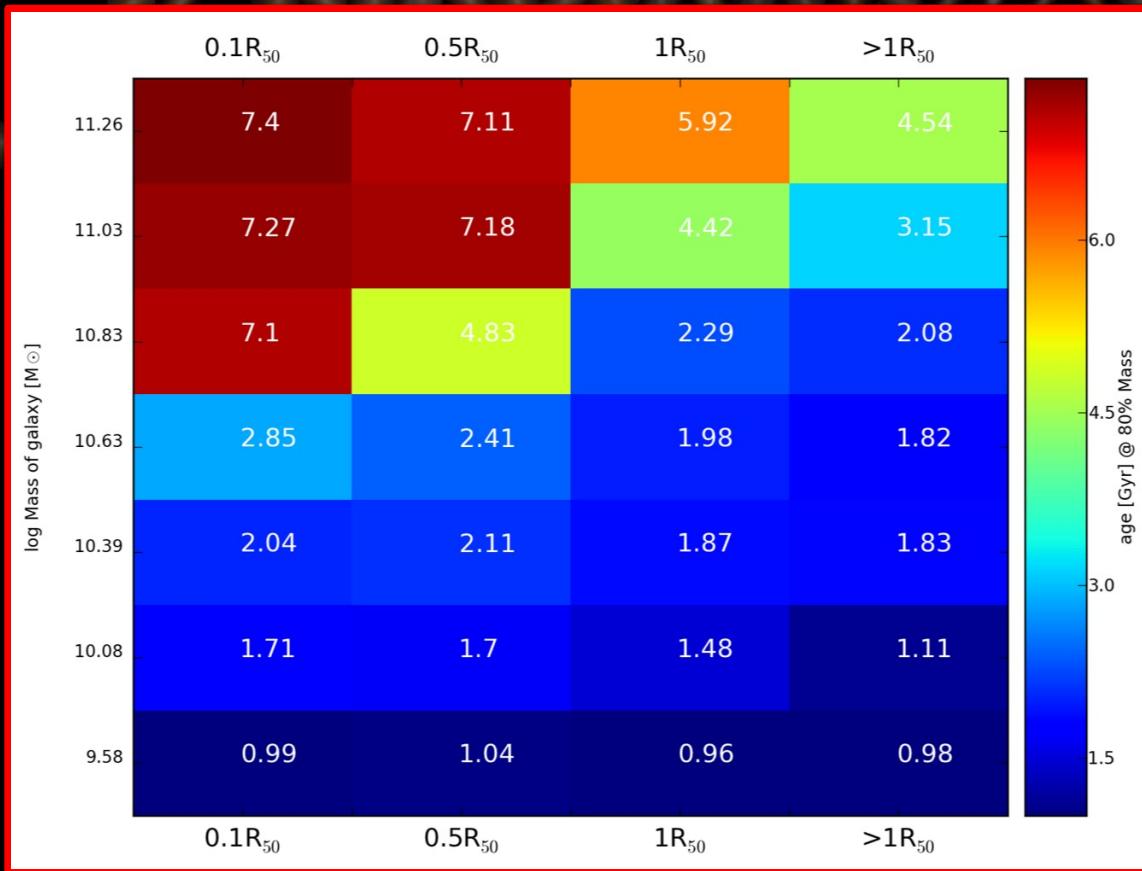
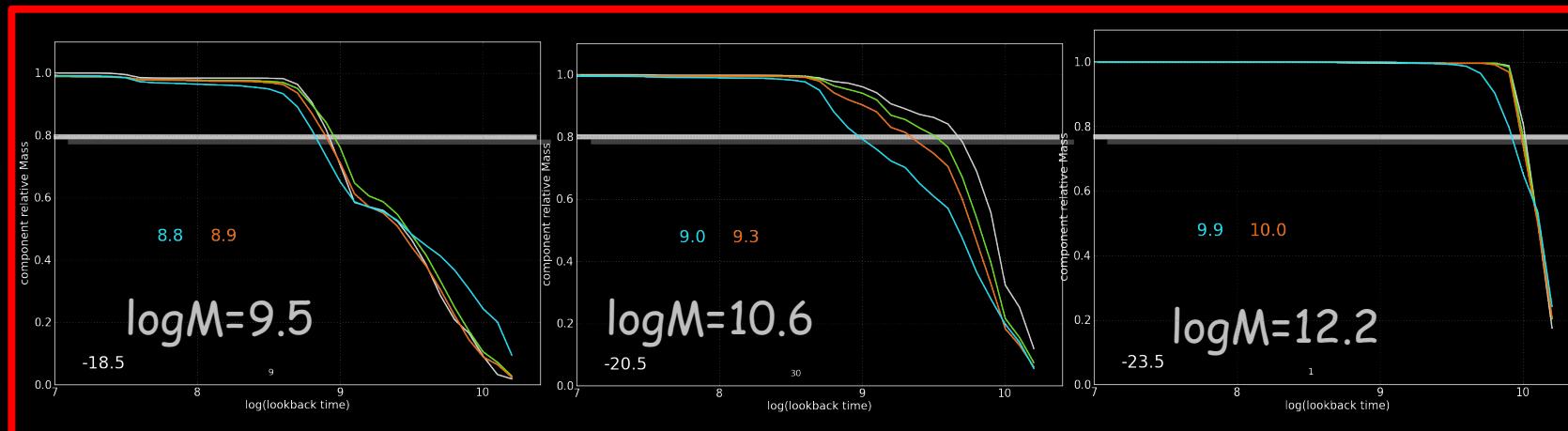
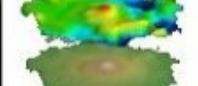
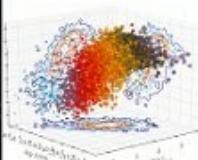


Mass grows inside-out.

Cid Fernandes, et al.,
A&A 2013, 2014

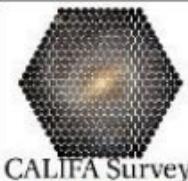


CALIFA Survey

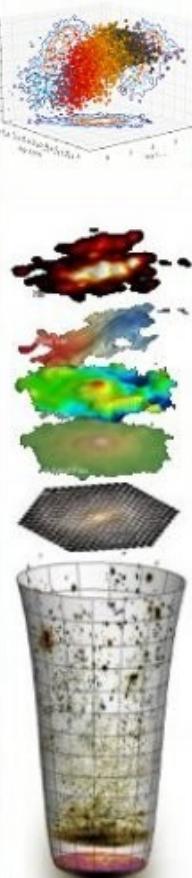


Mass
Growth

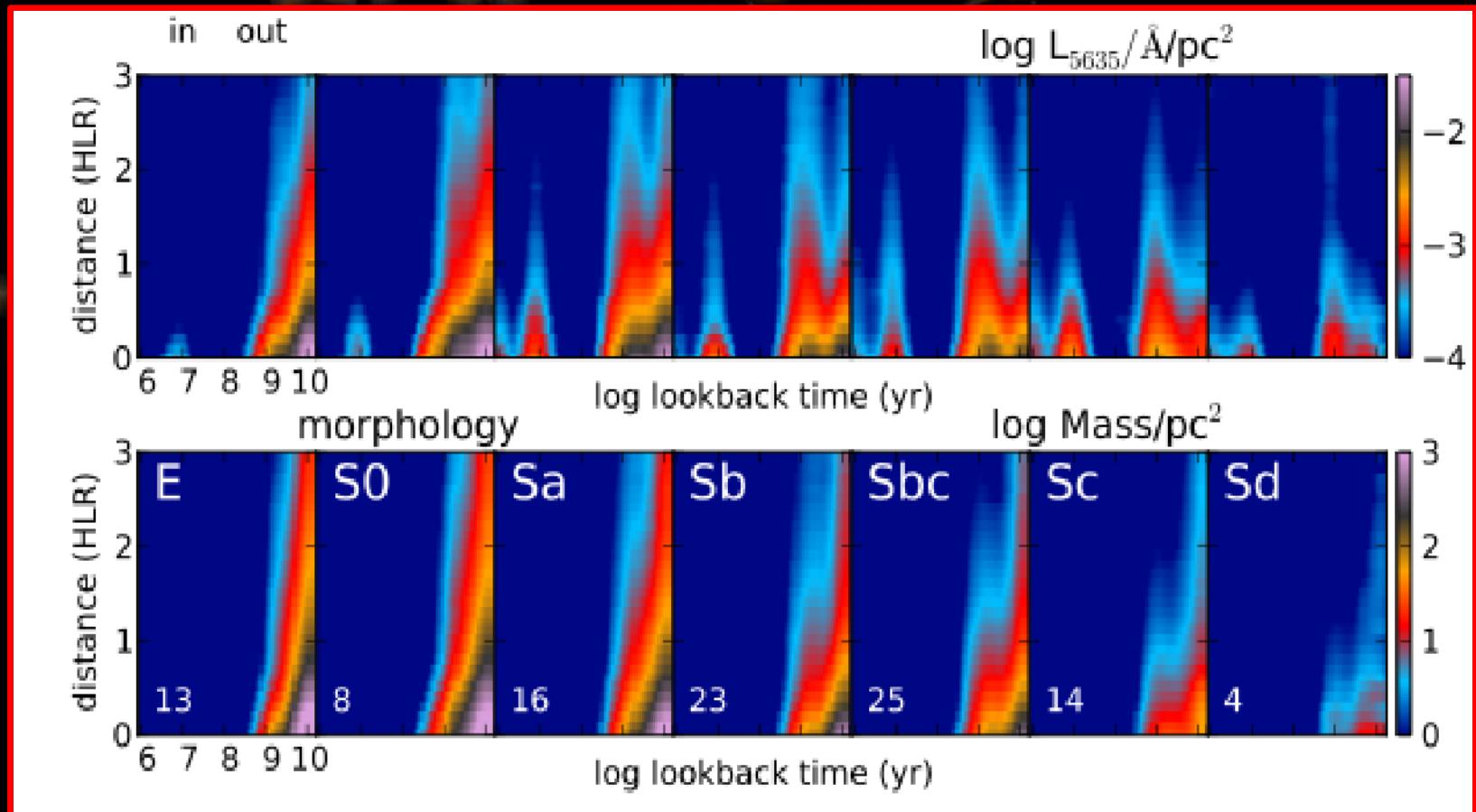
Perez et al.,
ApJL, 2013



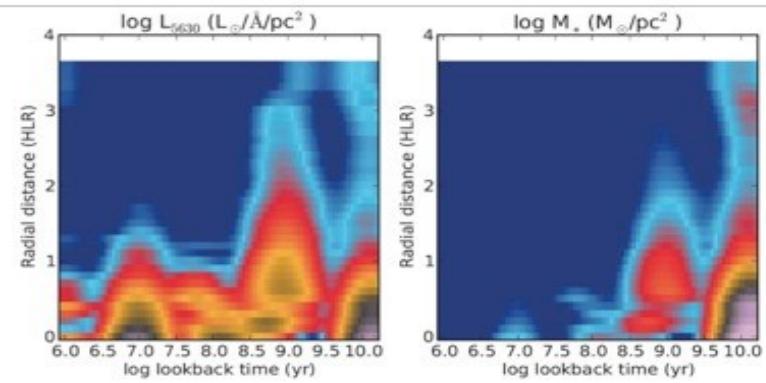
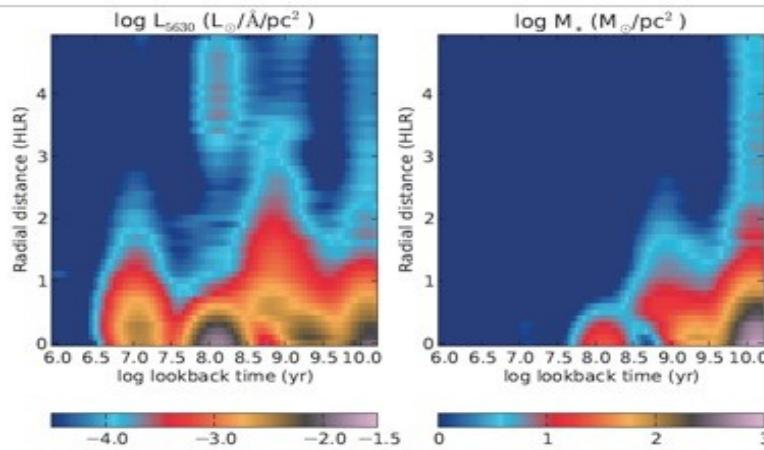
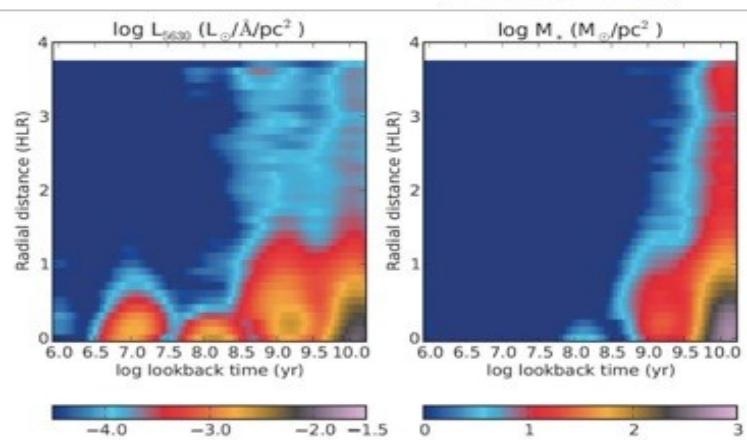
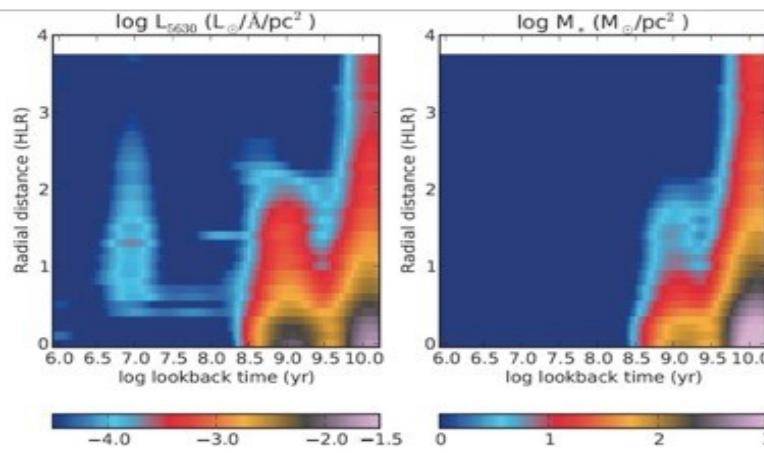
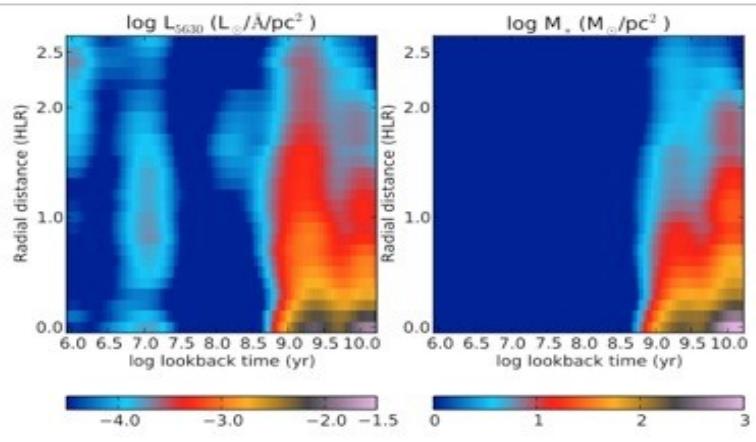
CALIFA Survey



Spatial Resolved SFH Differences by morphology

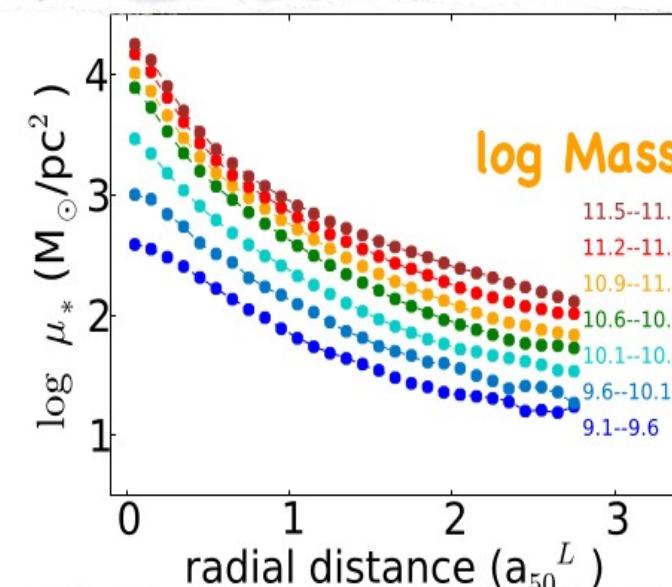
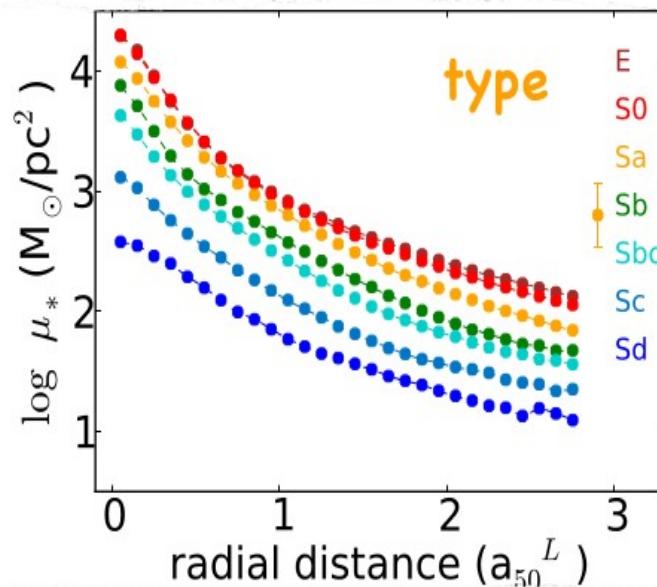
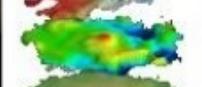
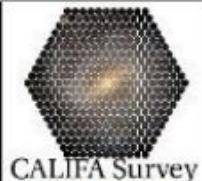


Gonzalez Delgado, et al., IAU Symp. 295, , 2012
(arXiv:1301.1685)



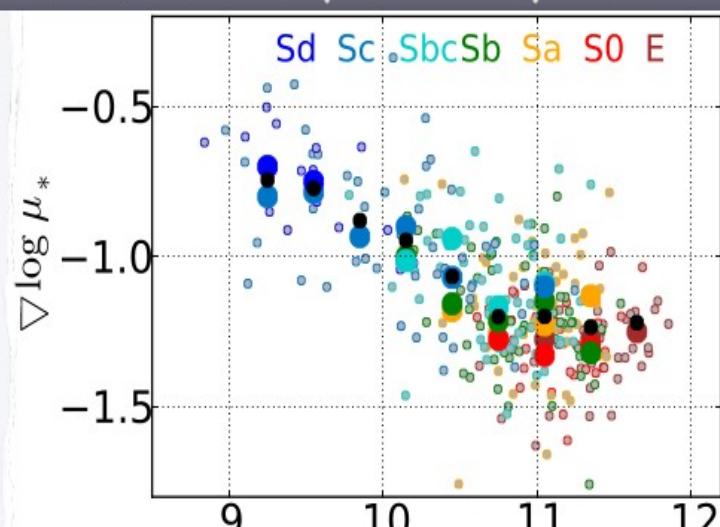
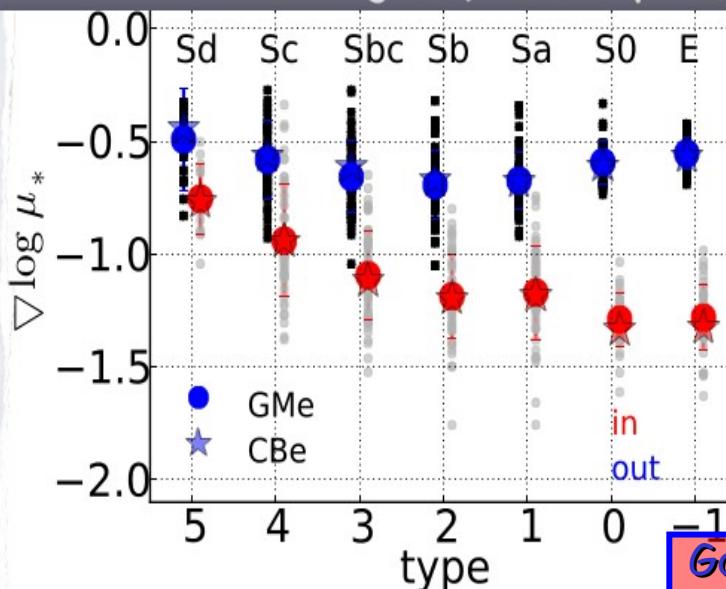
Gonzalez Delgado, et al., AIP, 2013

Radial structure of the stellar mass surface density (μ_*)

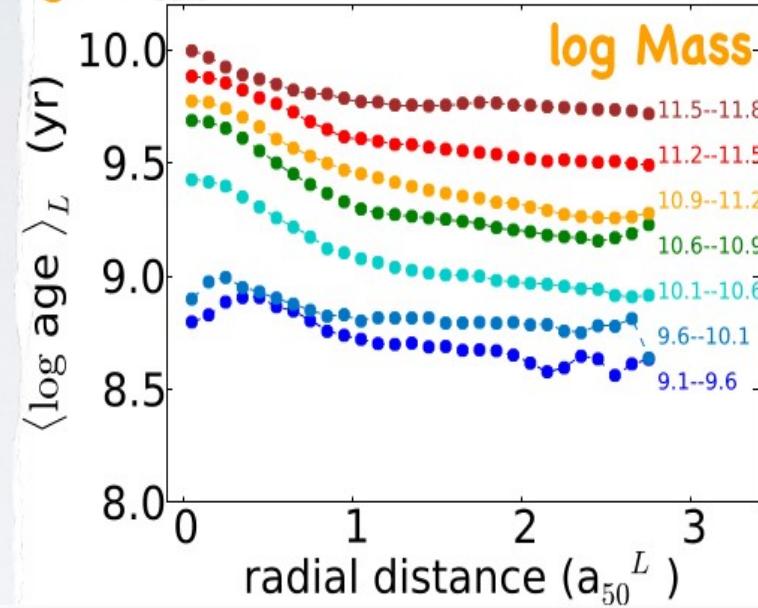
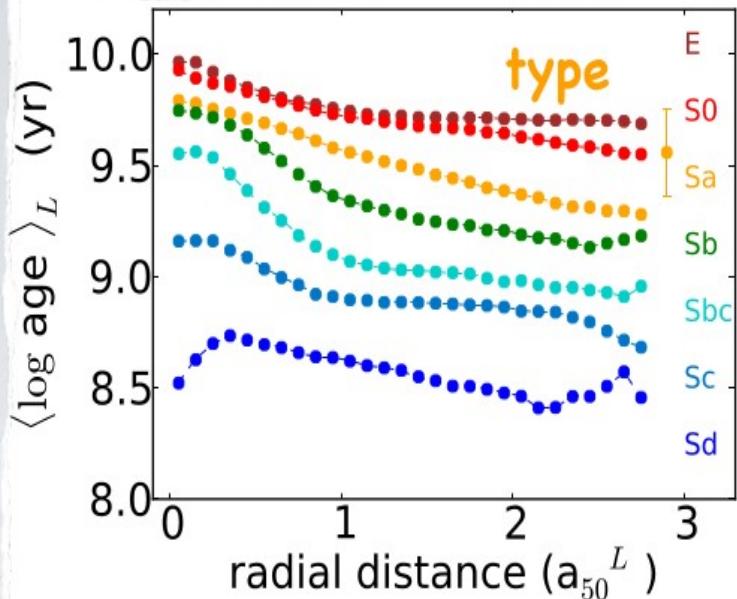


negative gradients: increasing from late (Sd) to early type (SO, E)

at constant galaxy Mass: spheroidals (E, S0) more compact than spirals

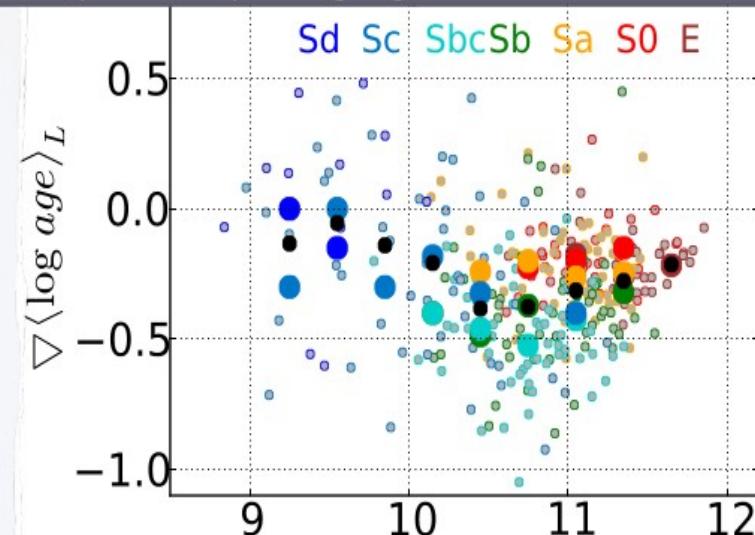
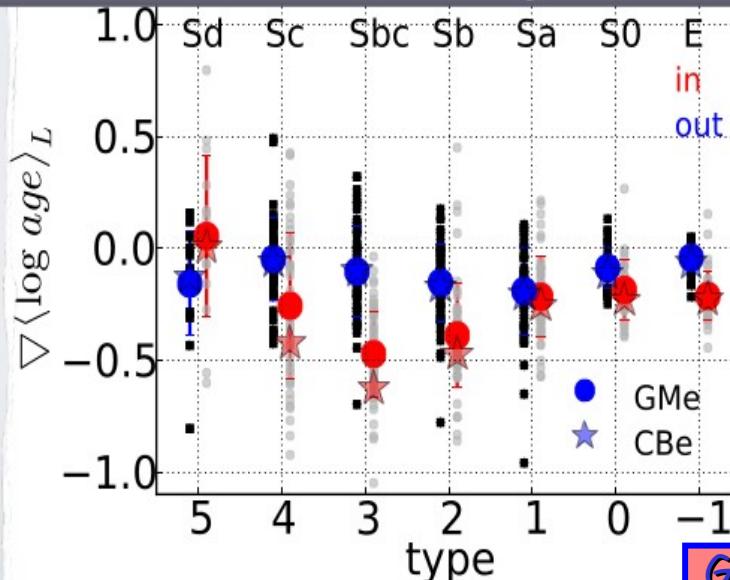


Stellar ages

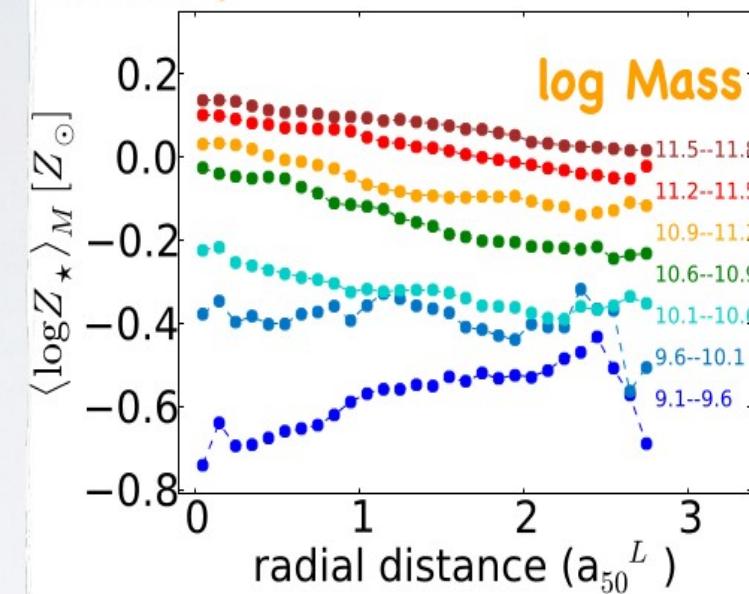
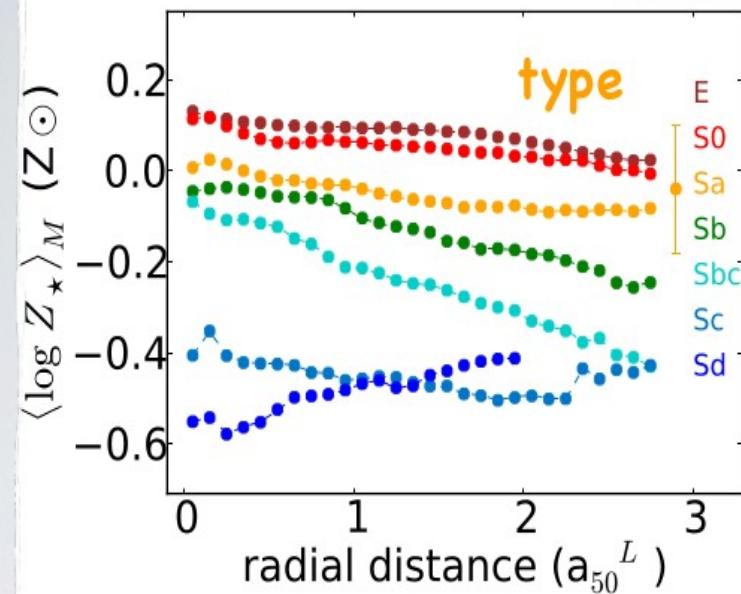
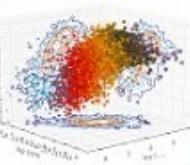
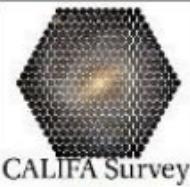


negative gradients (quenching outwards): largest in MW type galaxies (Sbc)

at constant galaxy Mass: late types steeper age gradient

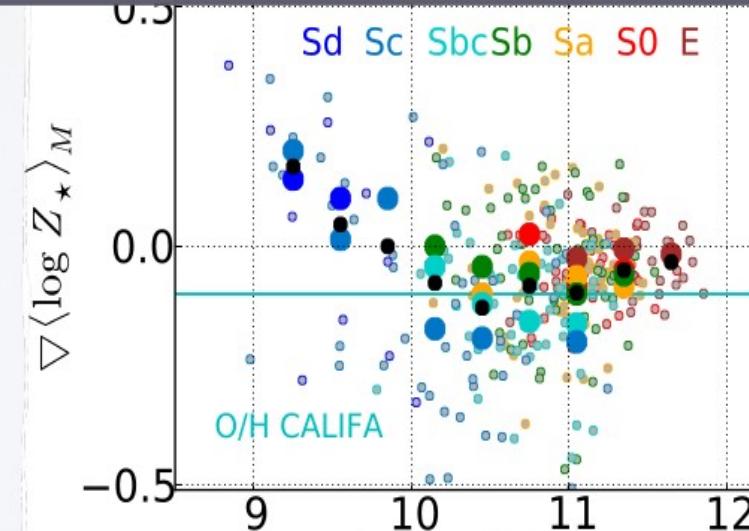
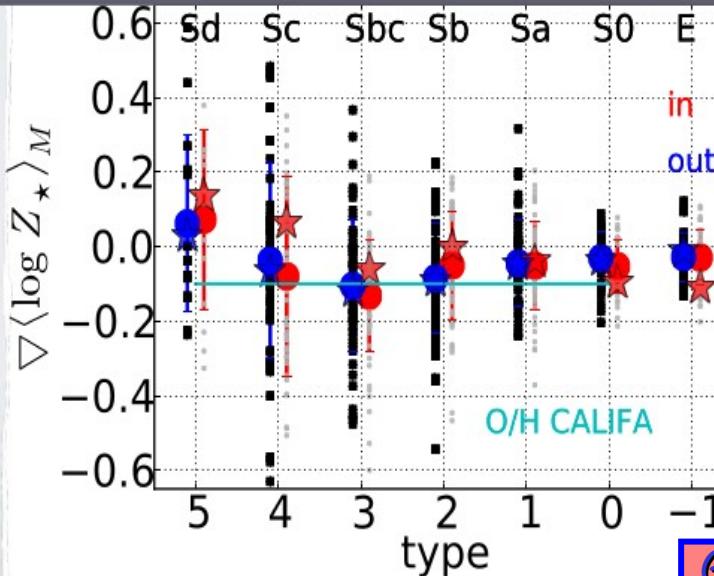


Stellar metallicity

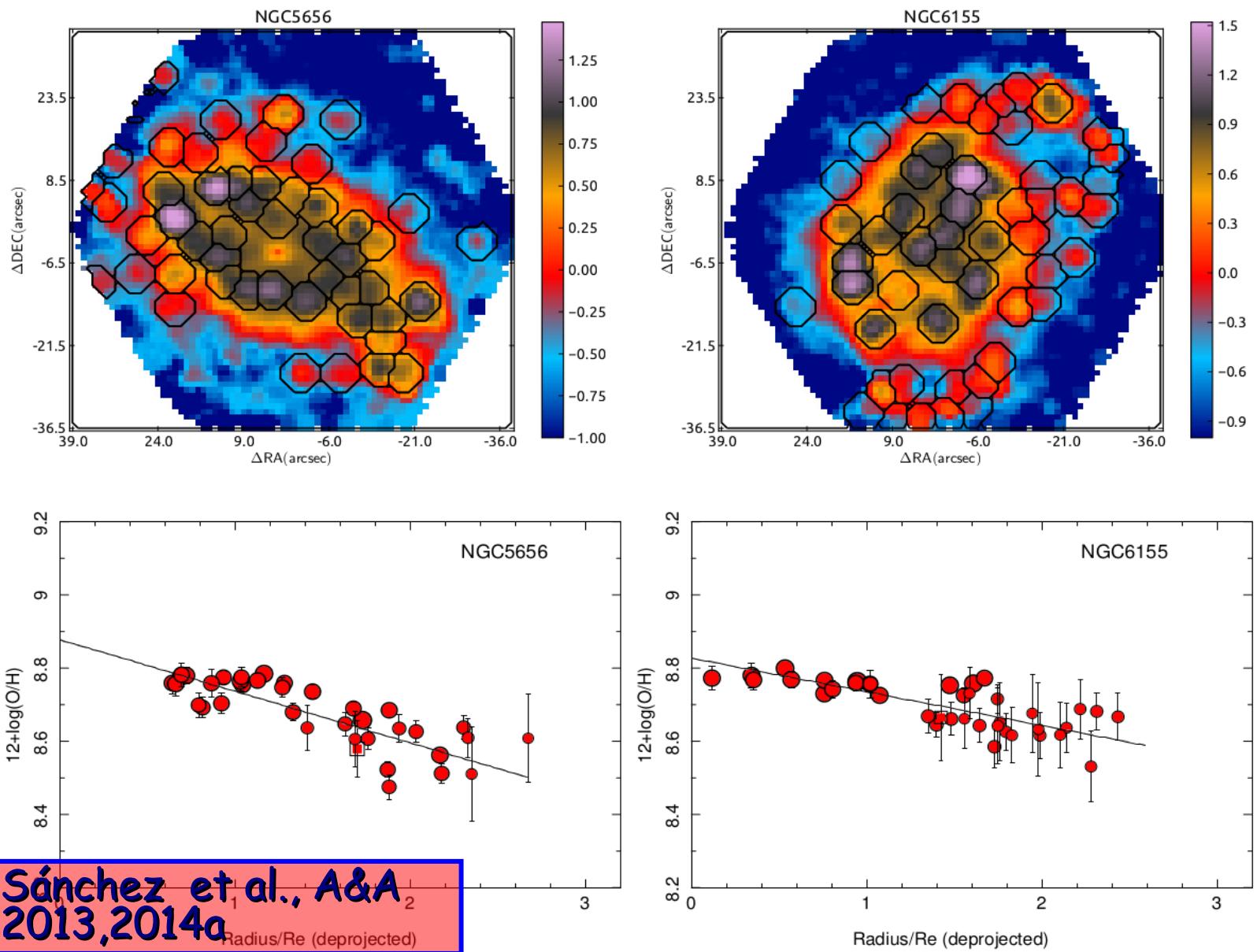
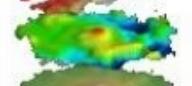
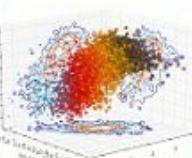
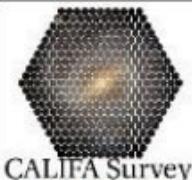


negative gradients (except in late spirals): largest in MW type galaxies (Sbc)

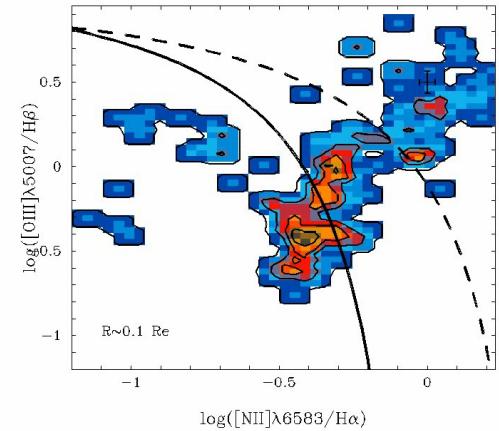
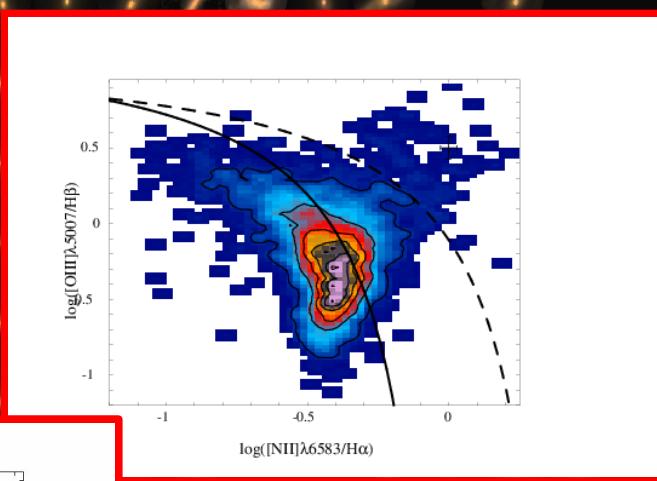
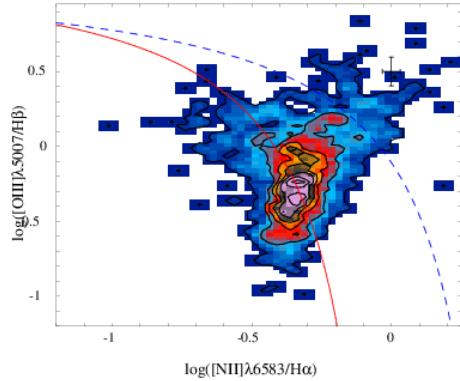
gradient = -0.1 dex/HLR (similar to nebular O/H gradients)



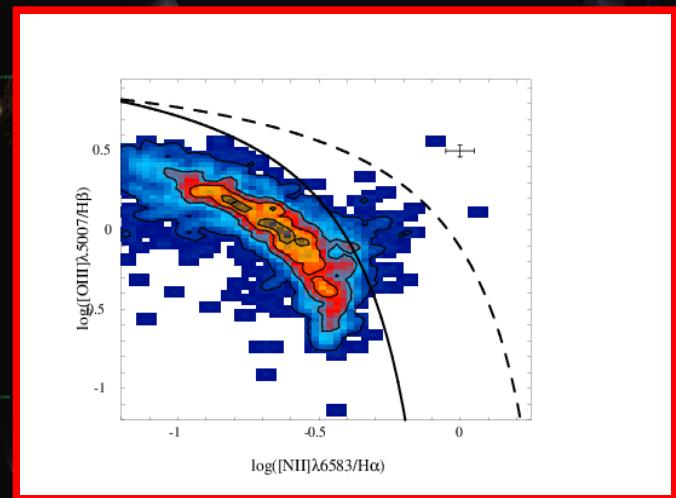
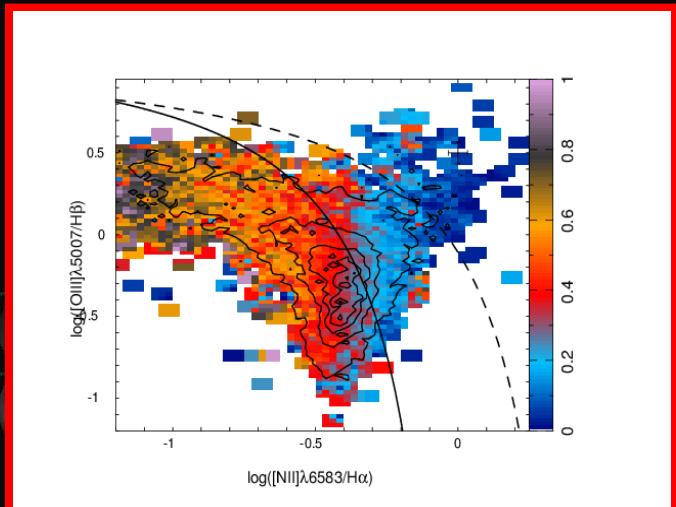
~9000 Hii regions, with CALIFA



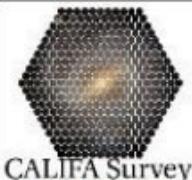
Ionized Gas: Global vs. Local?



Sánchez et al.
(arXiv:1409.8293)



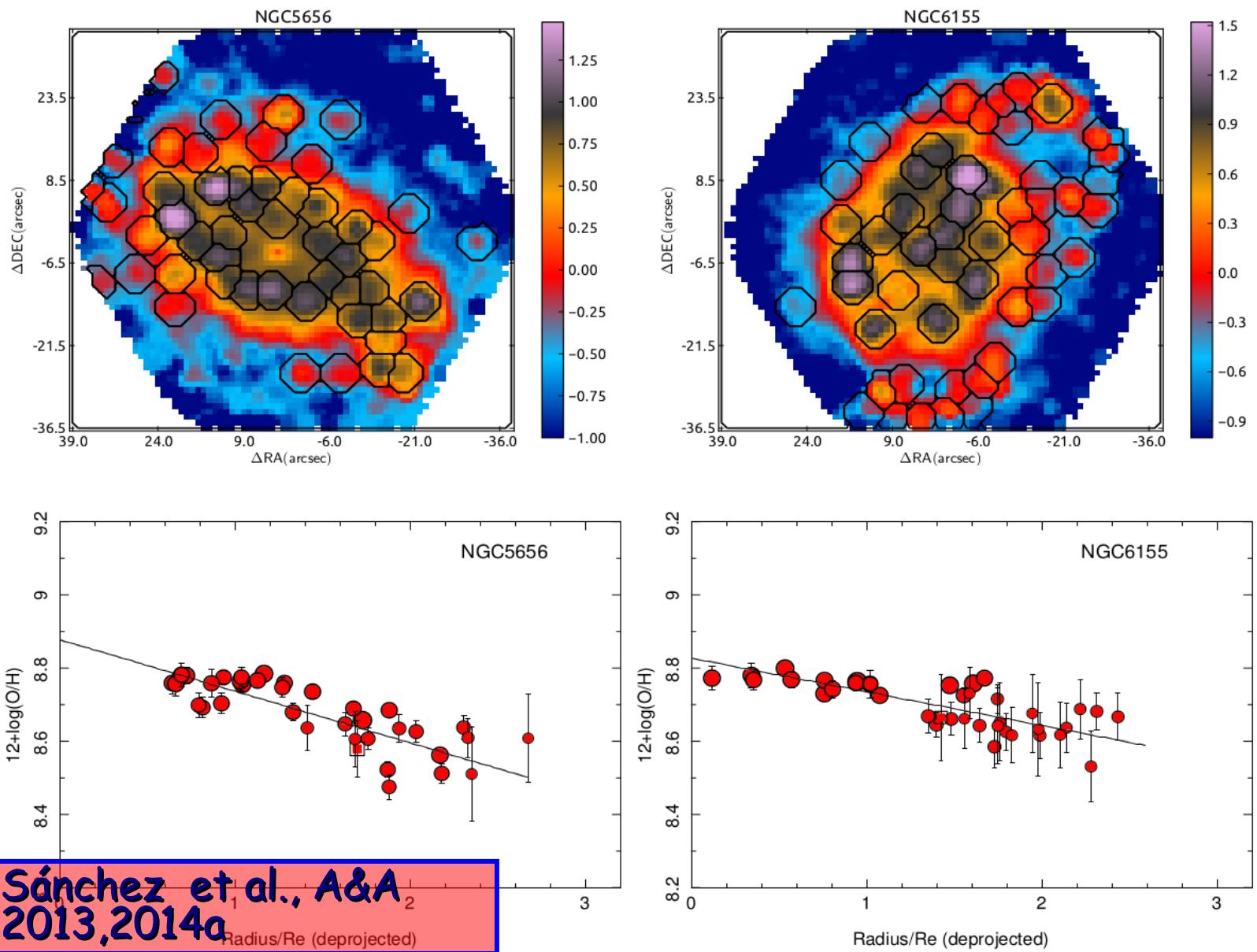
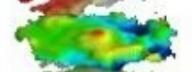
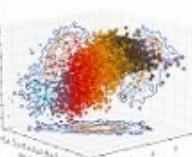
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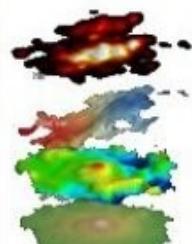
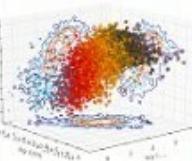
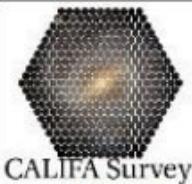


CALIFA Survey

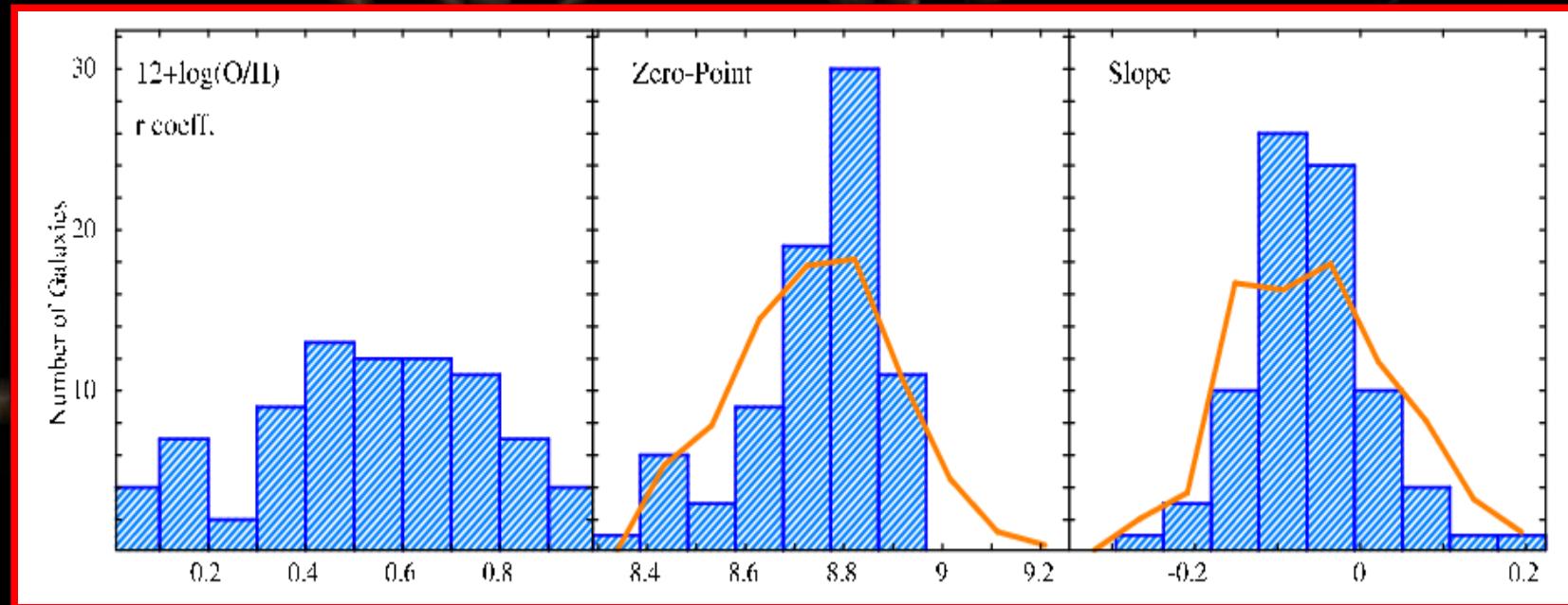


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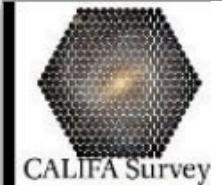




O/H Abundance gradients With CALIFA galaxies



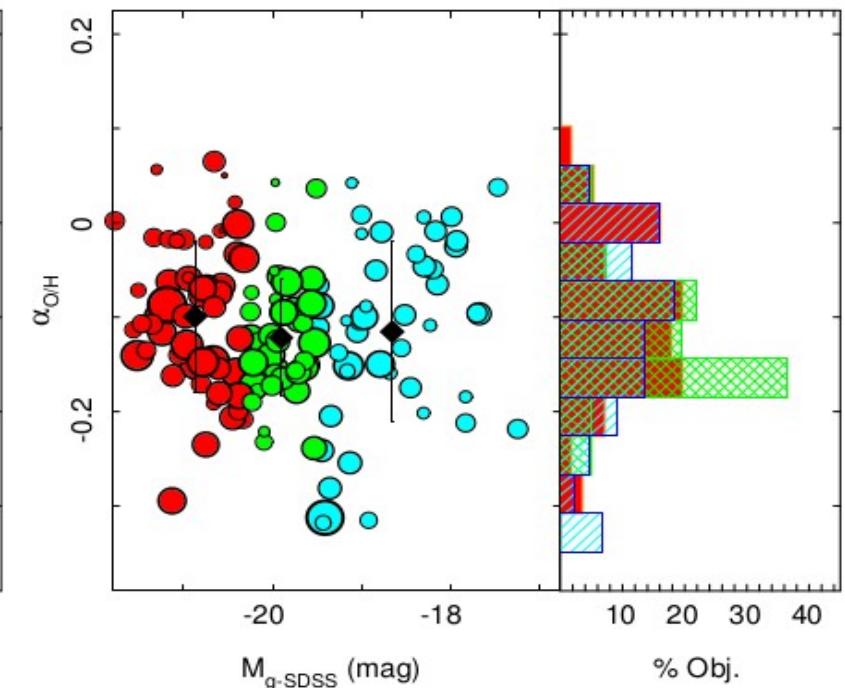
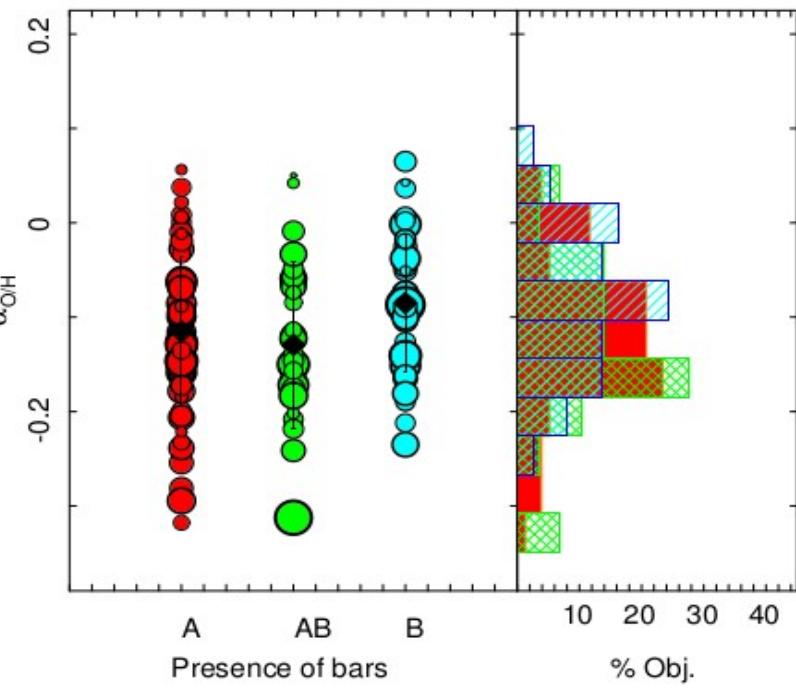
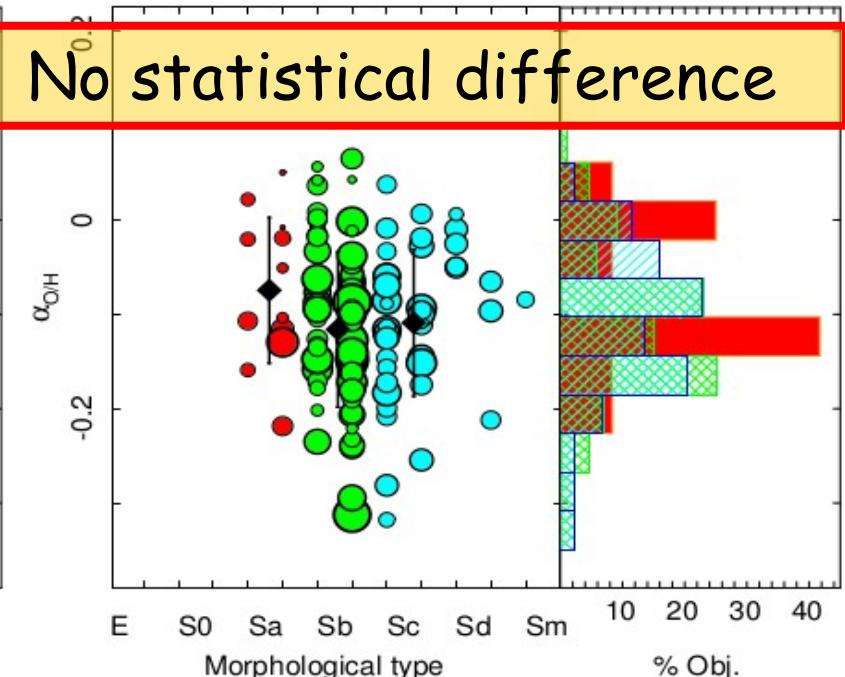
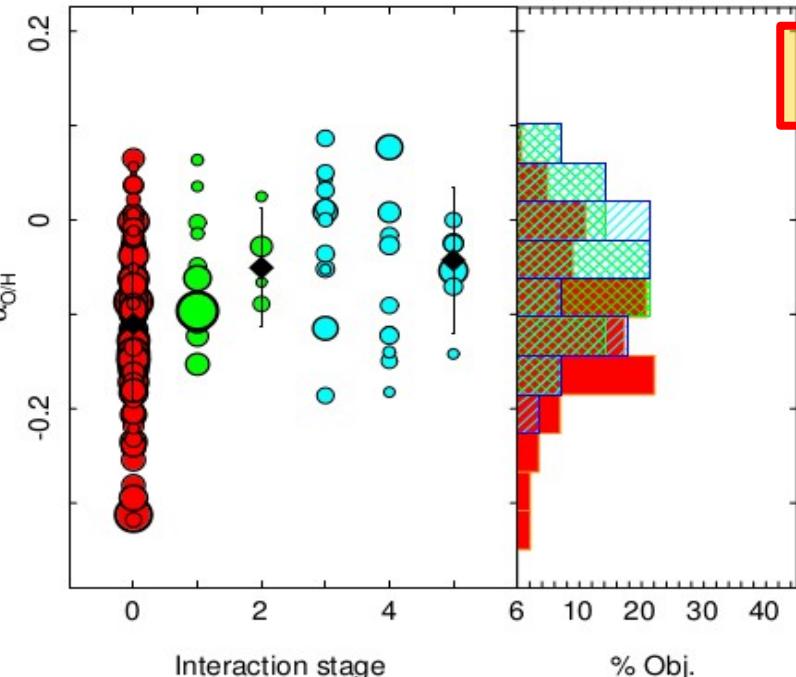
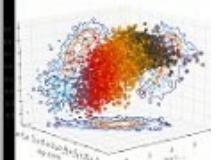
- Gradients determined at $0.3 < R/\text{Re} < 2.1$.
- 207 galaxias, ~ 6500 regions $\rightarrow 9000$ reg!!!
- Gradients distribution compatibles with of single Gaussians.
- Slope $\sim -0.11 \pm 0.08$ dex/Reff.



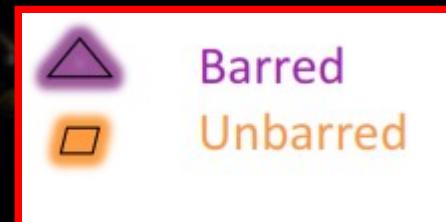
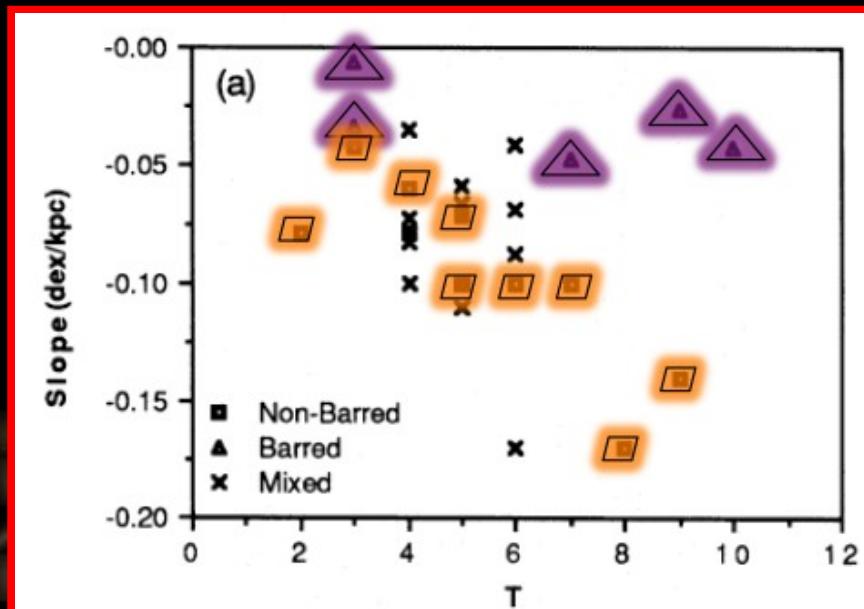
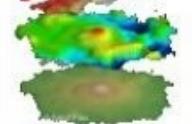
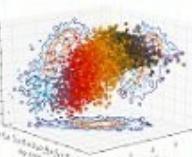
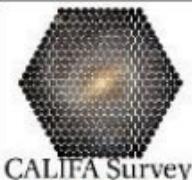
CALIFA Survey



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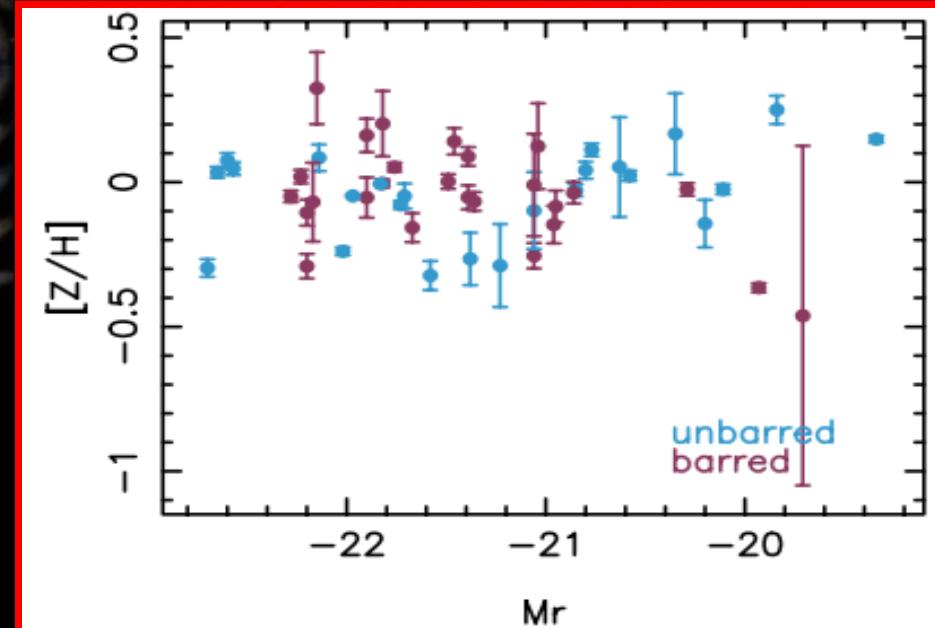


Effects of Bars

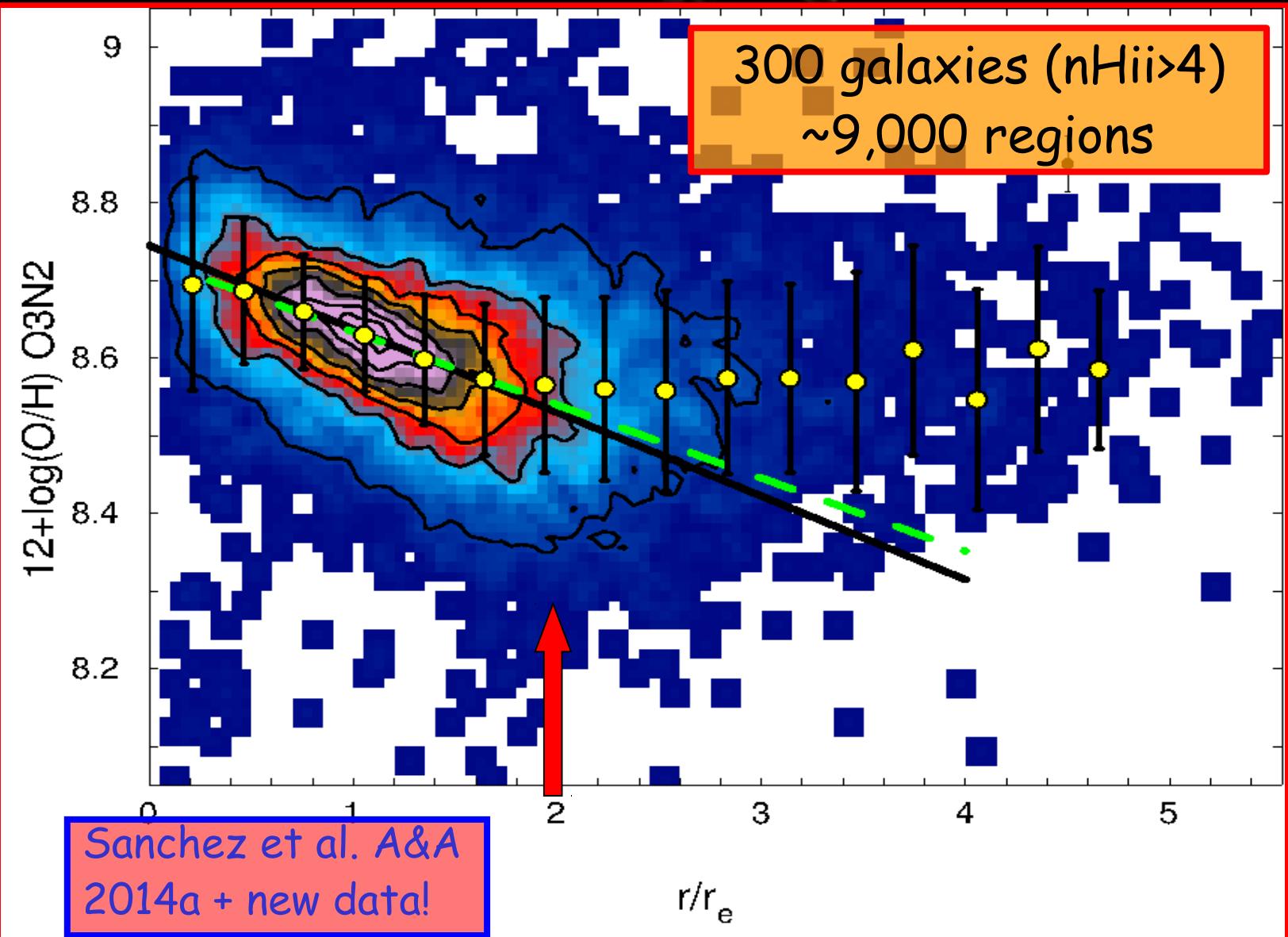
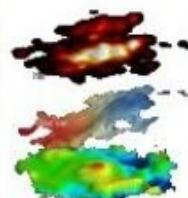
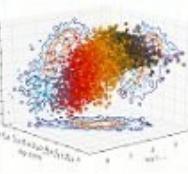
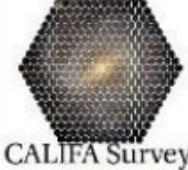


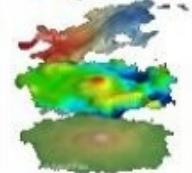
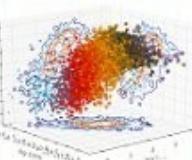
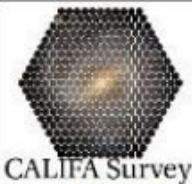
Zaritsky, Kennicutt & Huchra 1994

P. Sánchez-Blazquez et al., (arXiv:1407.0002)

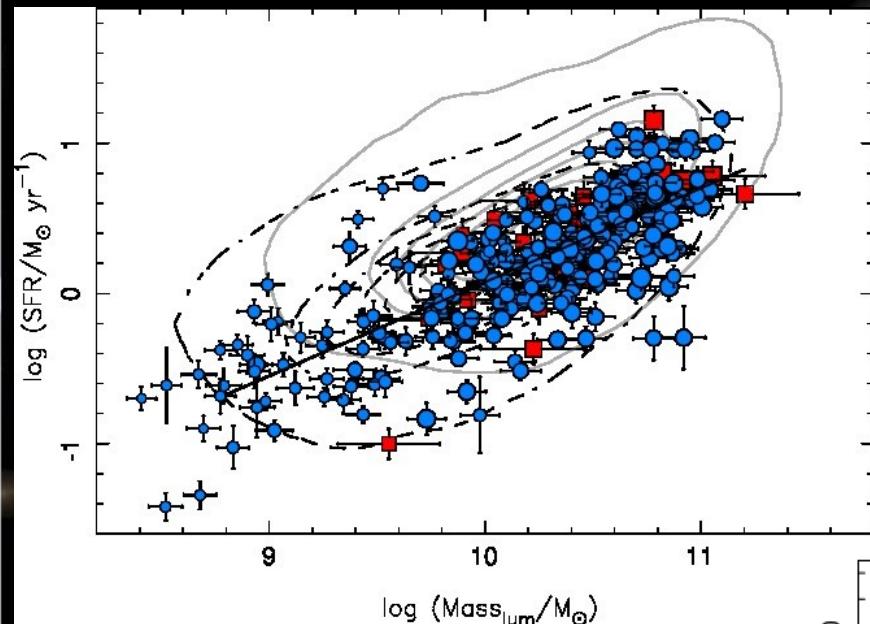


O/H Abundance gradients





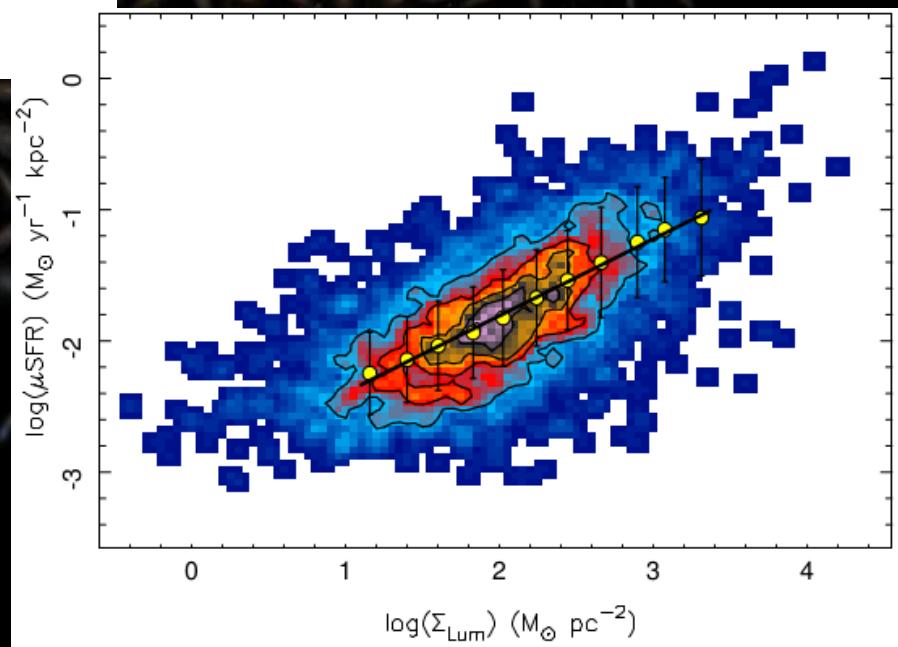
Local vs. Global Relations

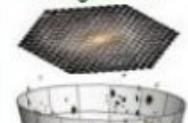
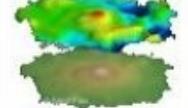
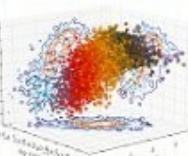
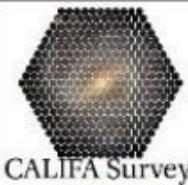


Main Sequence of
Star-forming galaxies

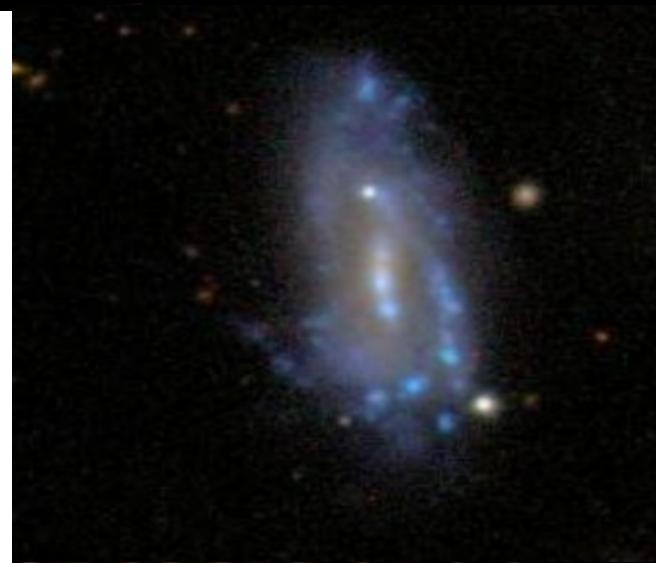
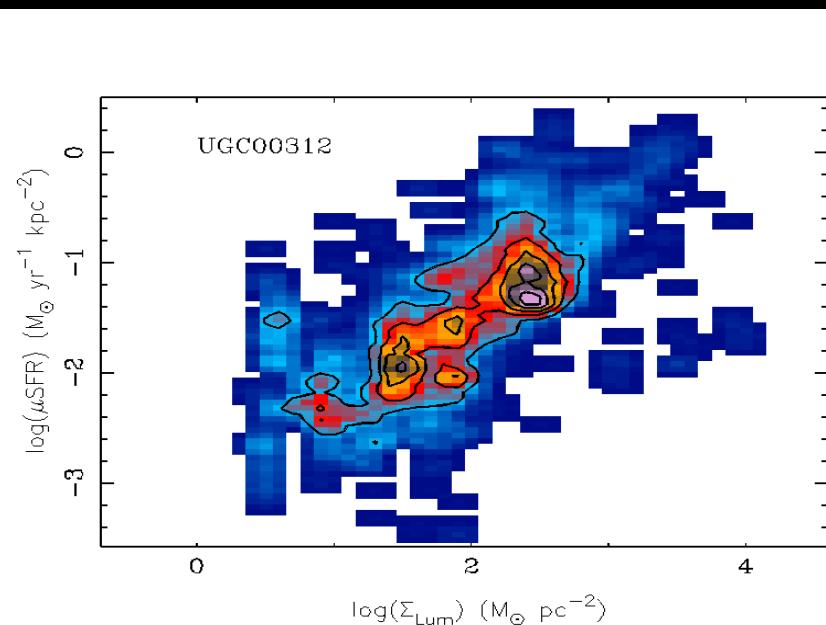
Main Sequence of
Star-forming regions?

Sánchez et al. A&A 2013



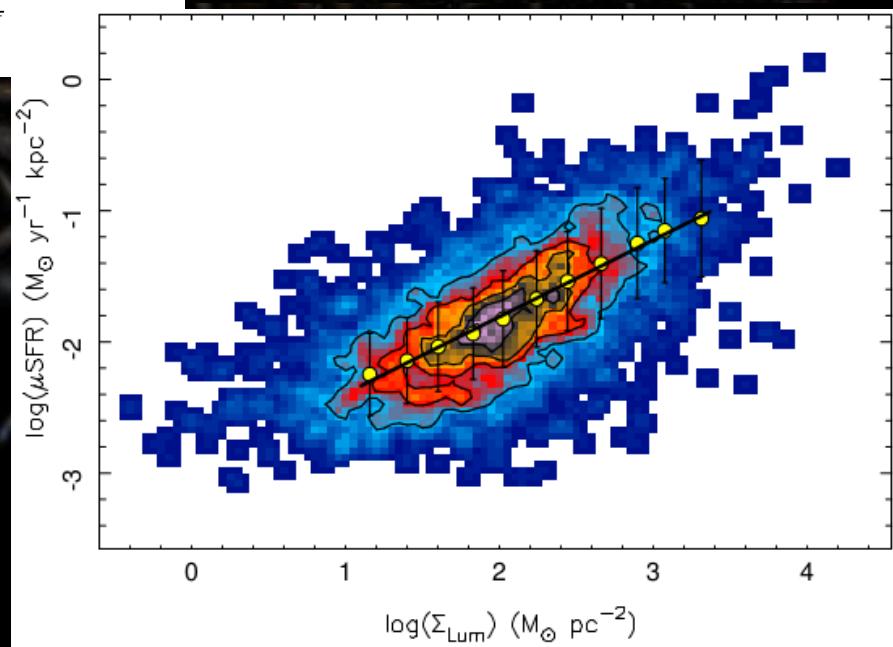


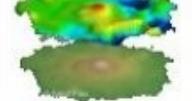
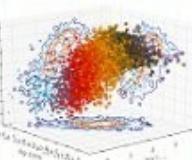
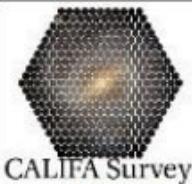
Local vs. Global Relations



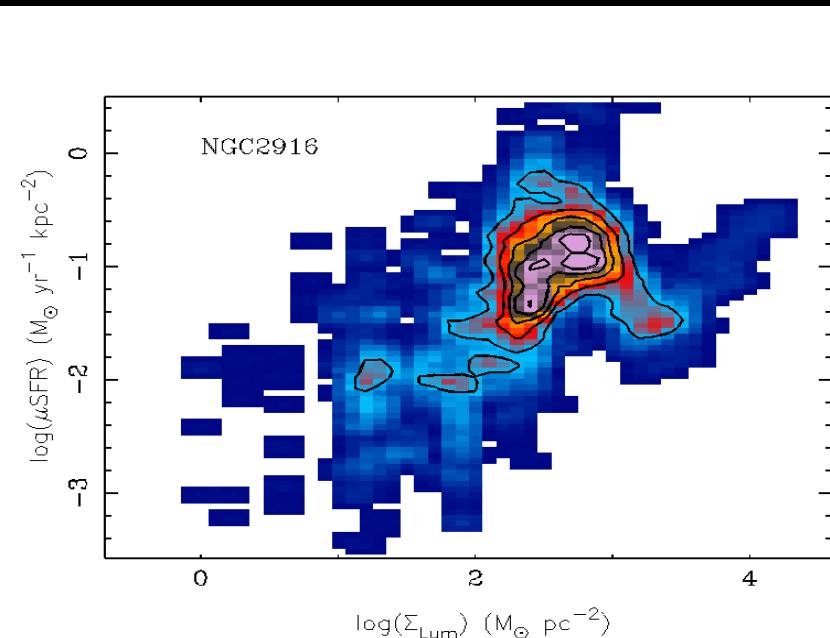
Main Sequence of
Star-forming regions?

Cano et al., in prep.



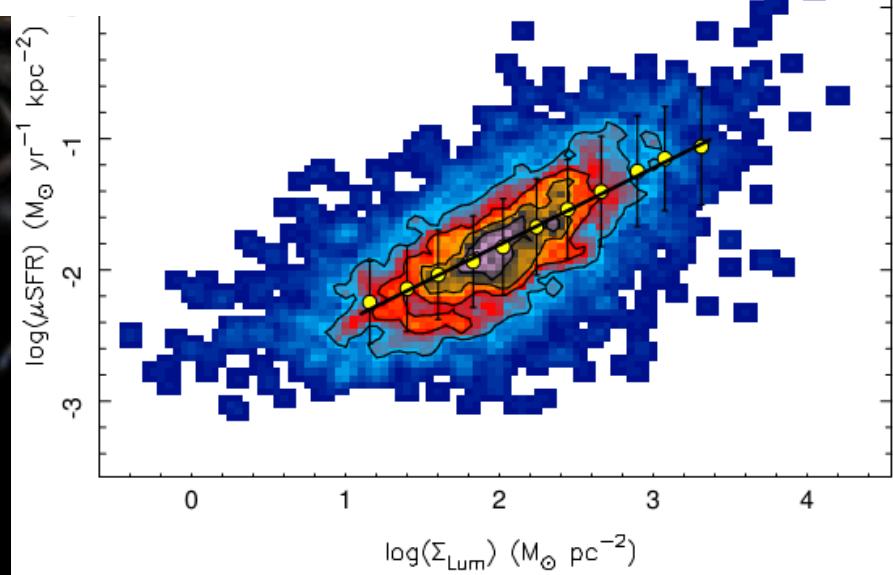


Local vs. Global Relations

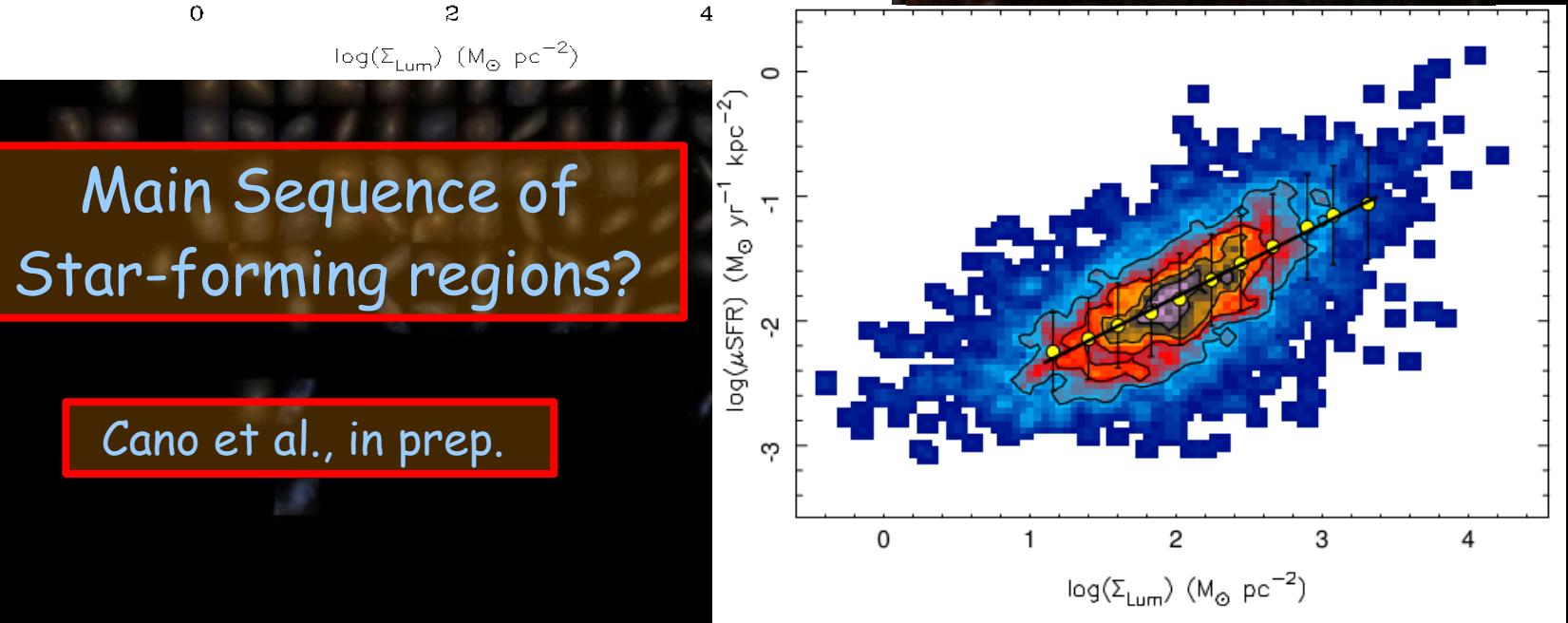
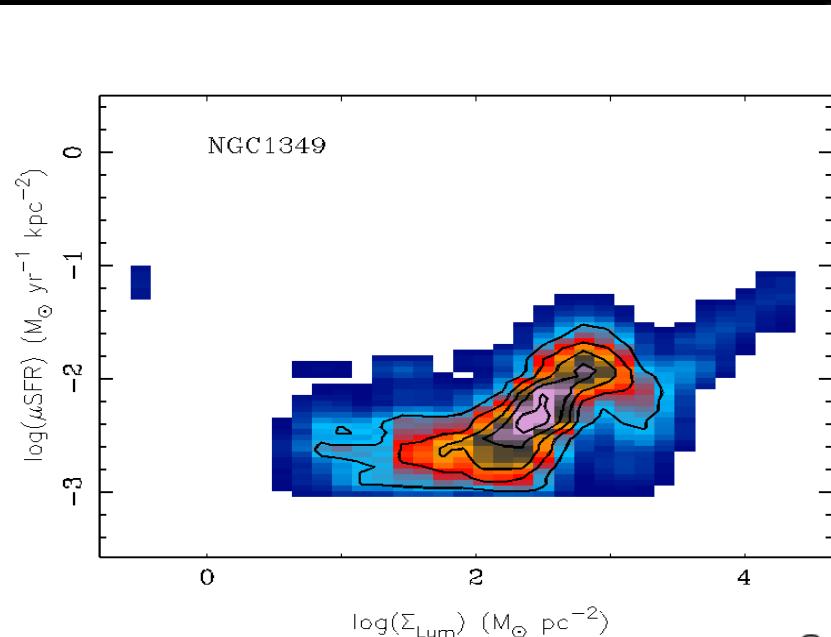
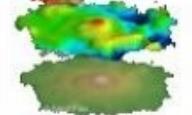
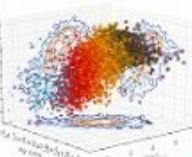
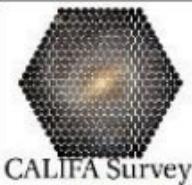


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Cano et al., in prep.

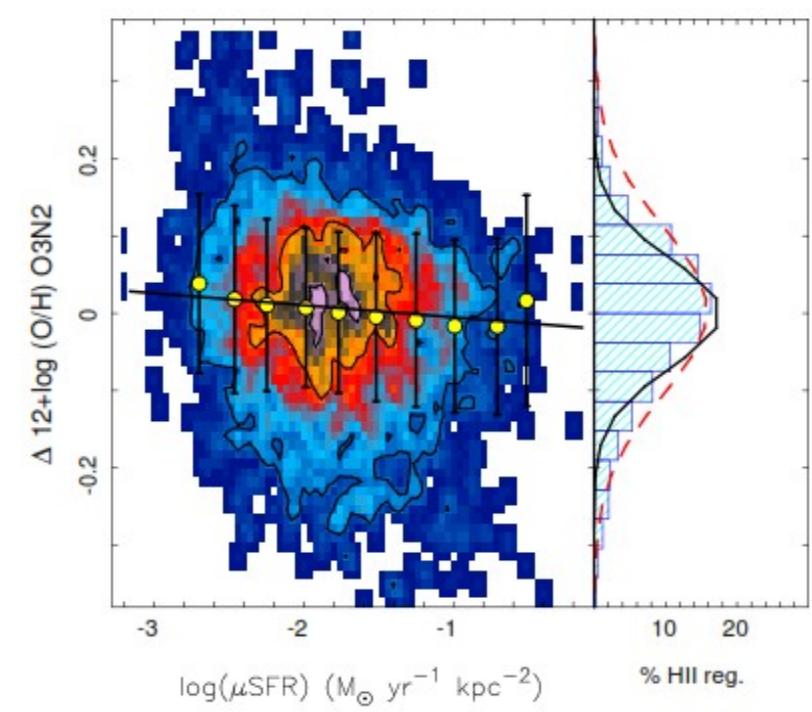
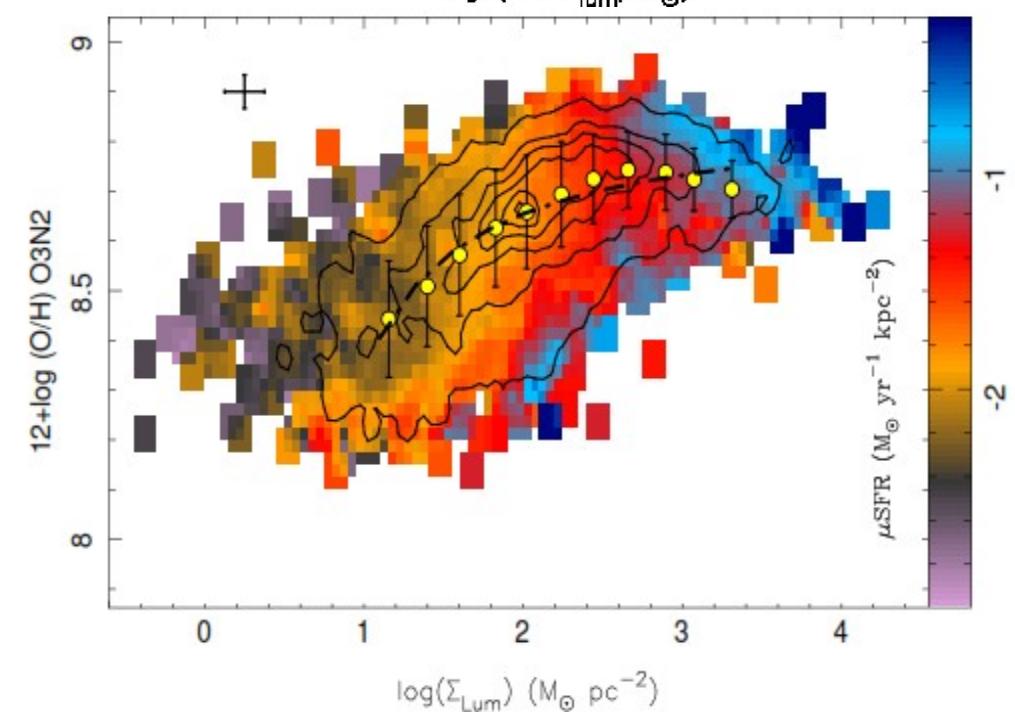
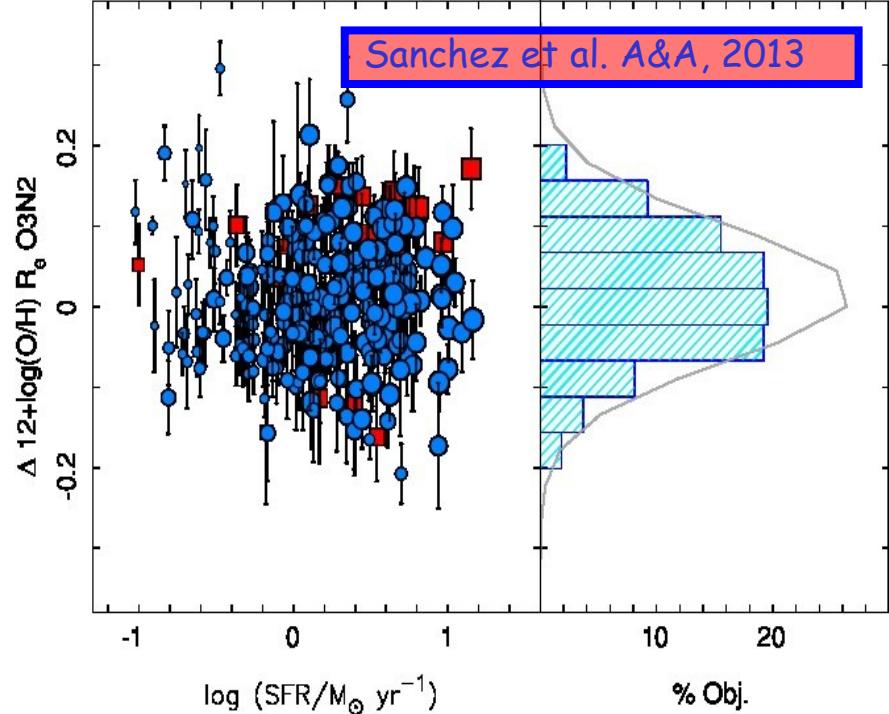
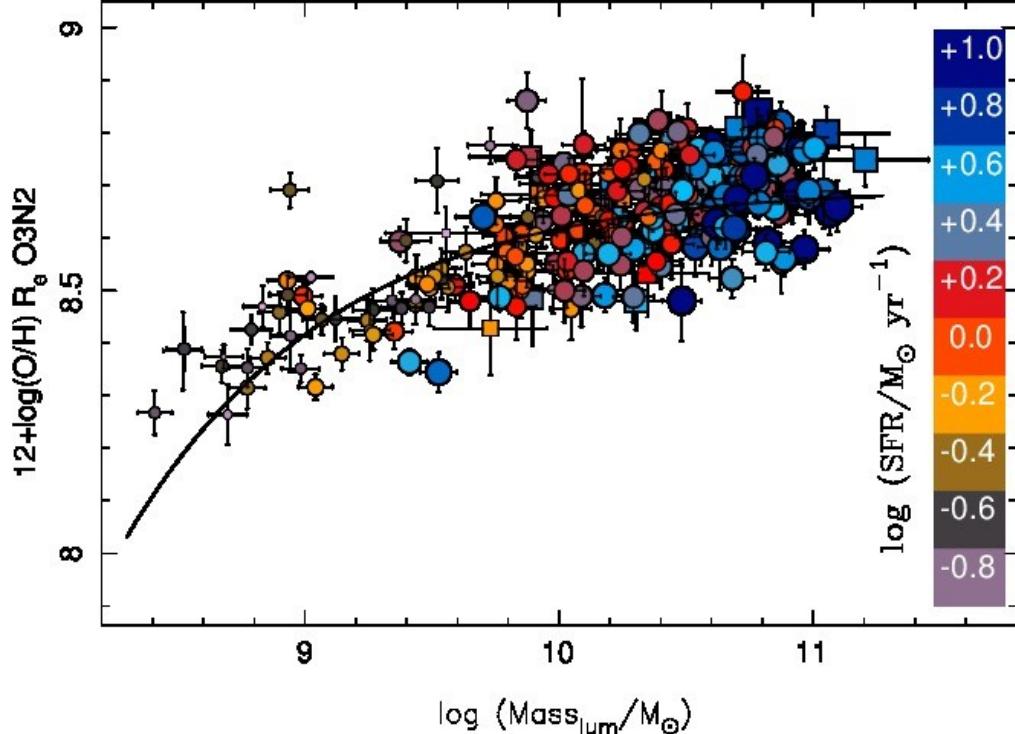


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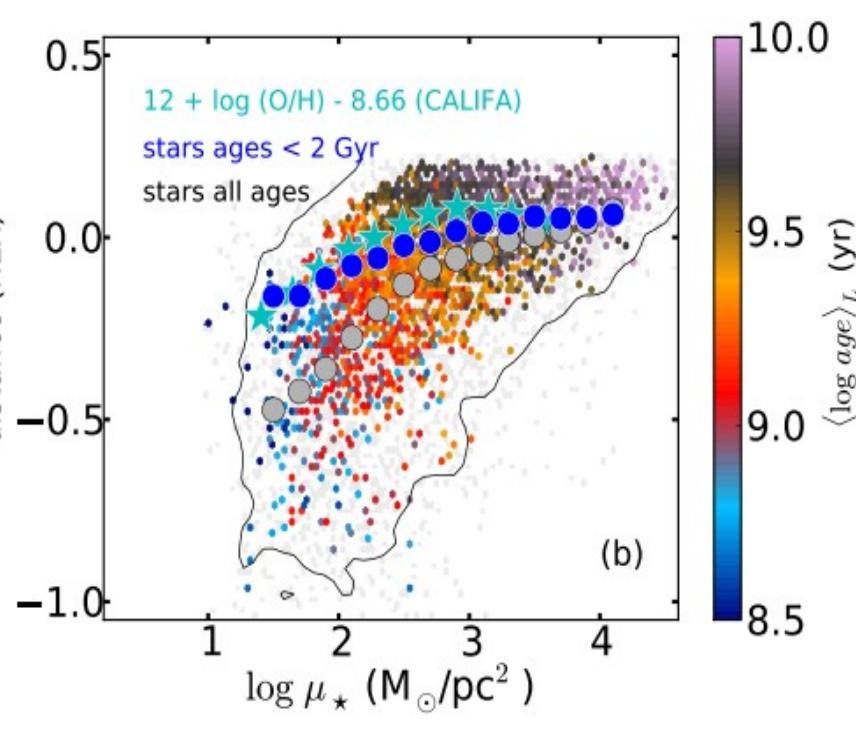
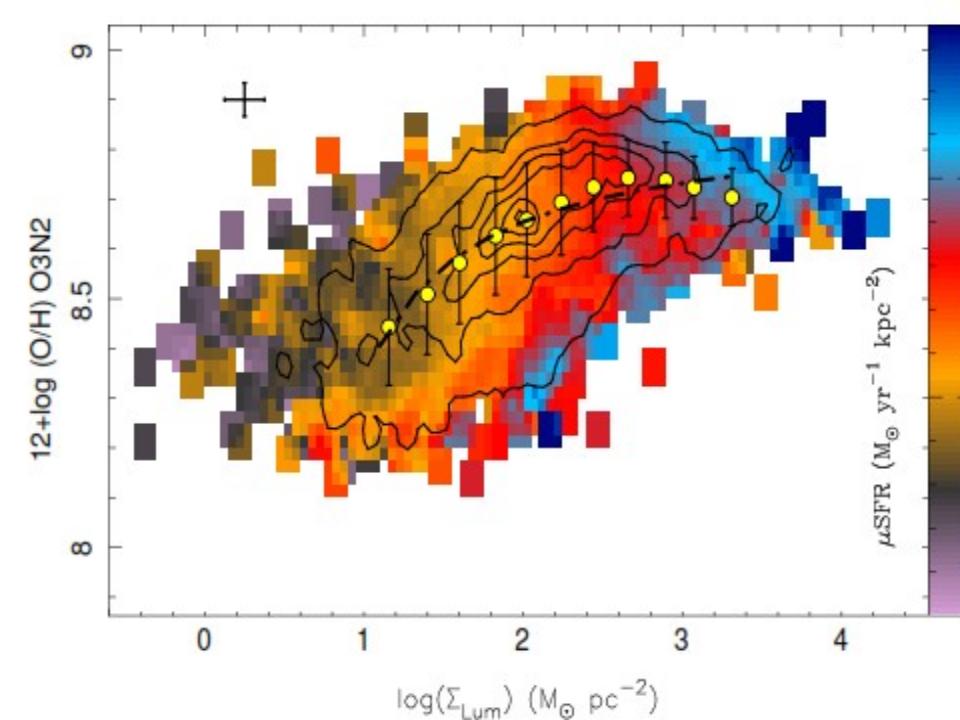
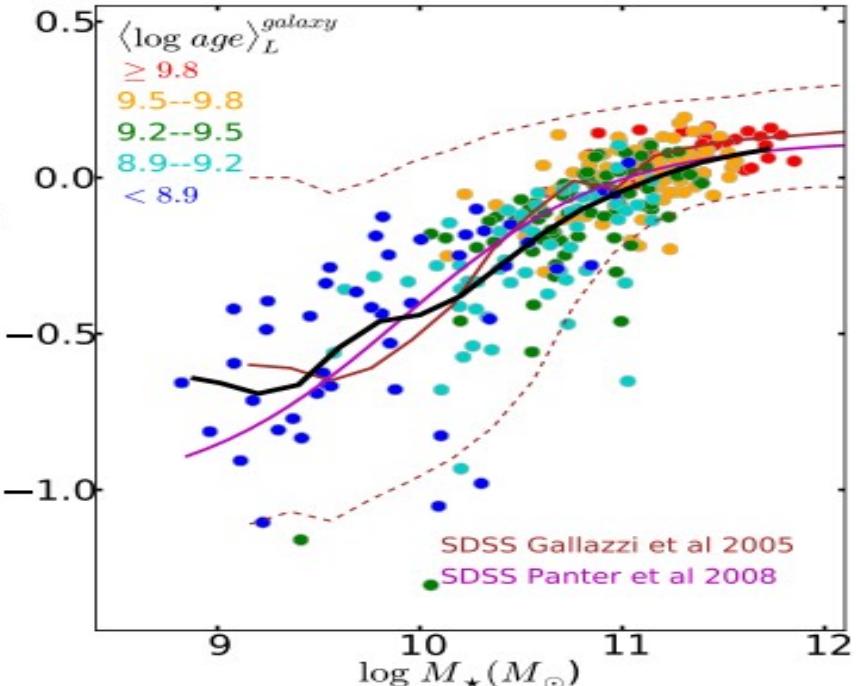
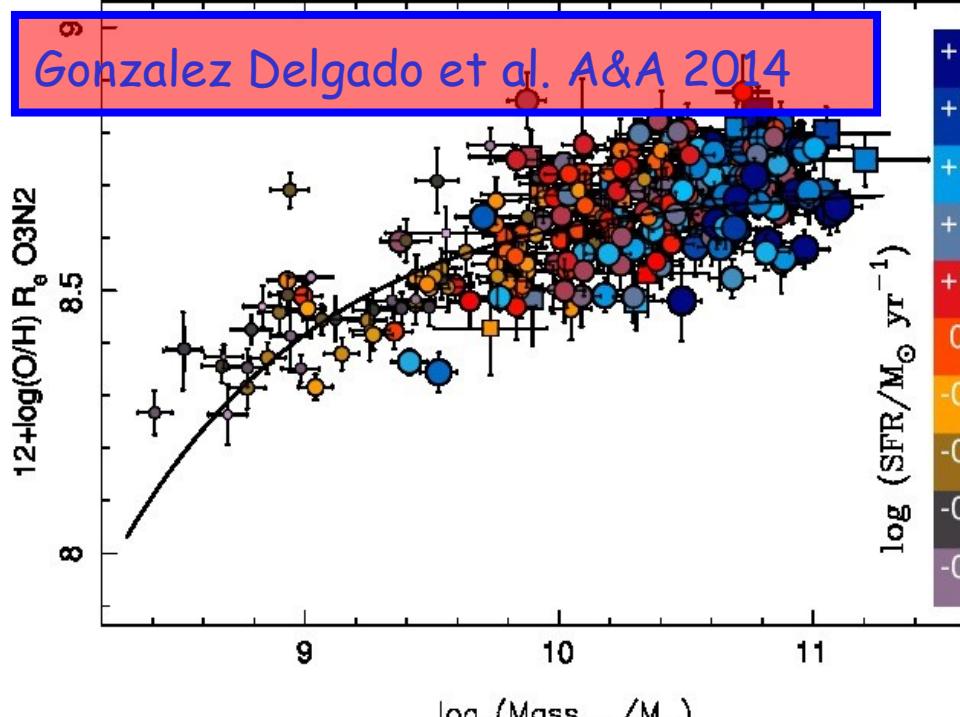


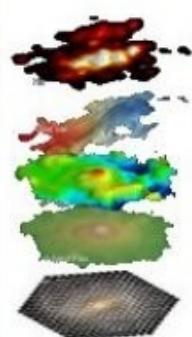
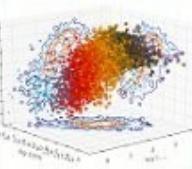
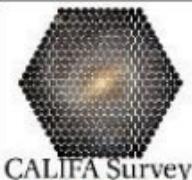
Main Sequence of
Star-forming regions?

Cano et al., in prep.



Gonzalez Delgado et al. A&A 2014





Summary

- IFUs surveys provide with unique datasets to understand the properties and evolution of (disk) galaxies.
- All the results indicate that:
 - Disk galaxies grow inside-out for $M^* > 10^{9.5}$ and Type earlier than Sd.
 - Their evolution is dominated by the local mass density.
 - Star formation is a local process!
 - Chemical enrichment is dominated by local processes with strong constraints to the effect of radial mixing.
 - The effects of bars seems to be less important than anticipated.