Patricia Sanchez-Blazquez (UAM)

Stellar Population gradients in disk galaxies

Why to study chemical abundance gradients

- Chemical abundance gradients are affected by the combined action of *inflows*, *outflows*, *secular evolution*, *mergers and interactions*, *gas stripping*.

- In the current cosmological paradigm these proccesses take place as galaxies are *assembled in a non-linear way*
-
- As a consequence: the imprint chemical patterns in the stellar population and the ISM store valuable information for galaxy formation studies.

Chemical abundance gradients

→ numerical simulations still describe the baryonic physics mostly by subgrid modelling which *need the adjustment of free parameters*

→ chemical abundance gradients are powerful tools to confront those models and obtain information of the galaxy assembly in a cosmologica context (Tissera et al. 2012; Gibson et al. 2013; Aumer et al. 2013; Tissera et al. 2016ab)

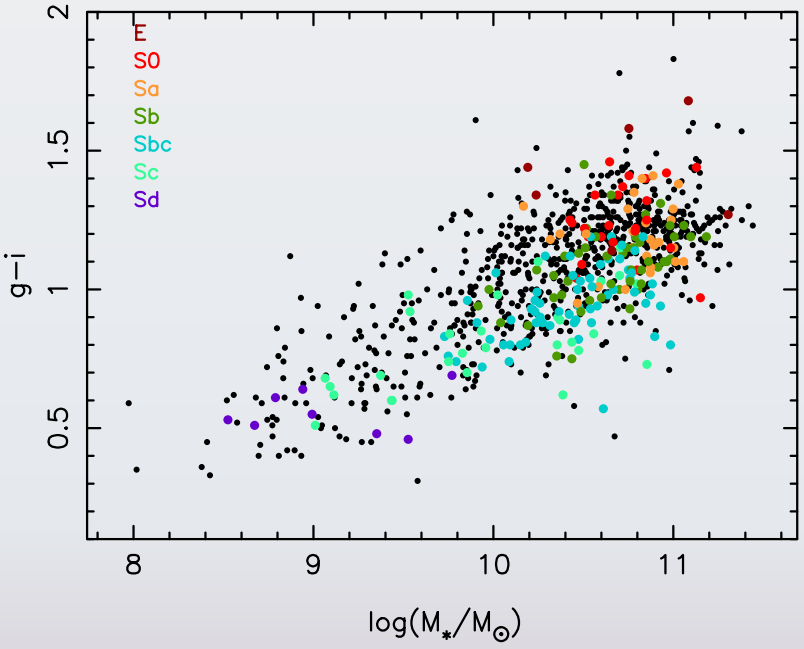
Abundance gradients in disk galaxies

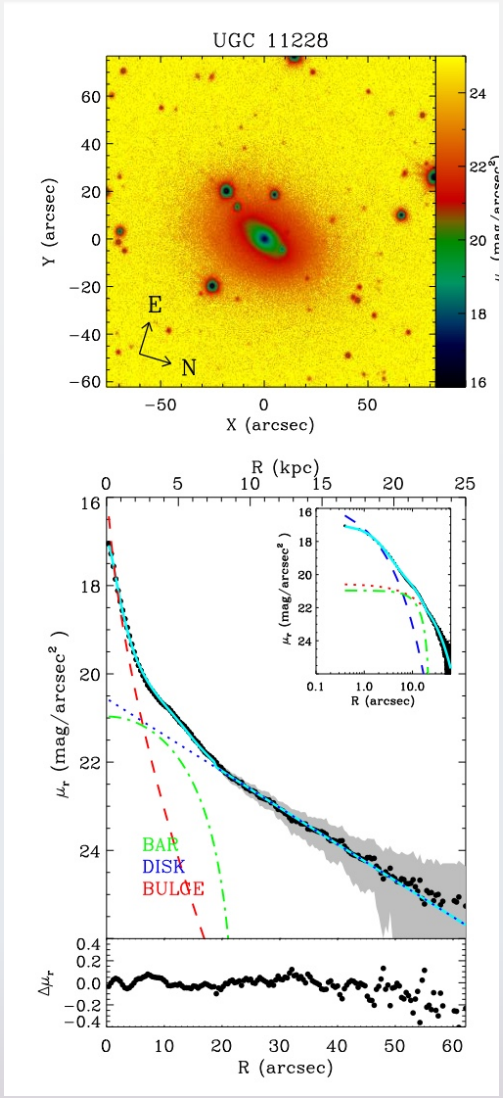
- Most observational studies are devoted to the gas-phase abundances in discs traced by HII regions
- However, an important fraction of the synthesized chemical elements is locked into stellar populations as the gas is transformed into stars
- Hence the chemical abundances of the SPs provide complementary information to understand the chemical loop between the gas-phase medium and the SPs within a context of galaxy formation

The sample

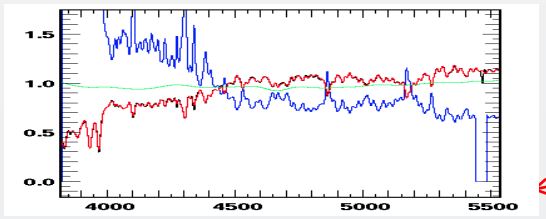
- 201 disk galaxies galaxies from the CALIFA survey with inc < 60
- In the photometric decomposition (Mendez-Abreu+ 2018) they have a disk

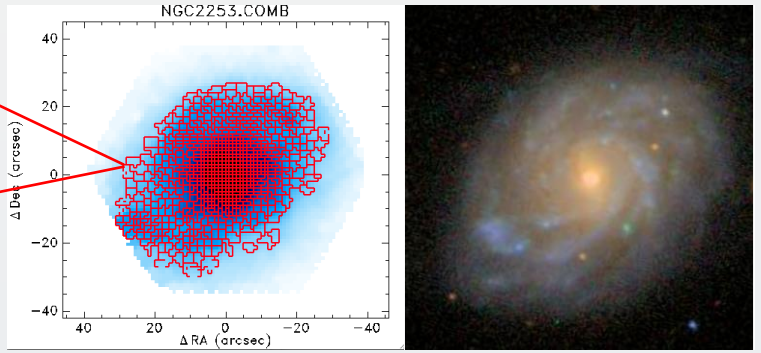
Mendez-Abreu et al. (2017)



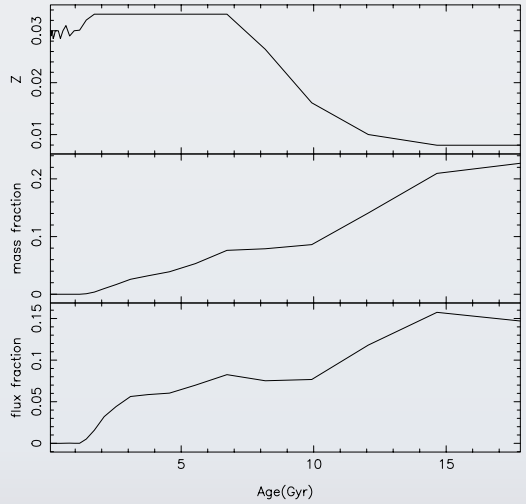


S/N~40 per Å (@ 5800Å)





Inversion algorithm

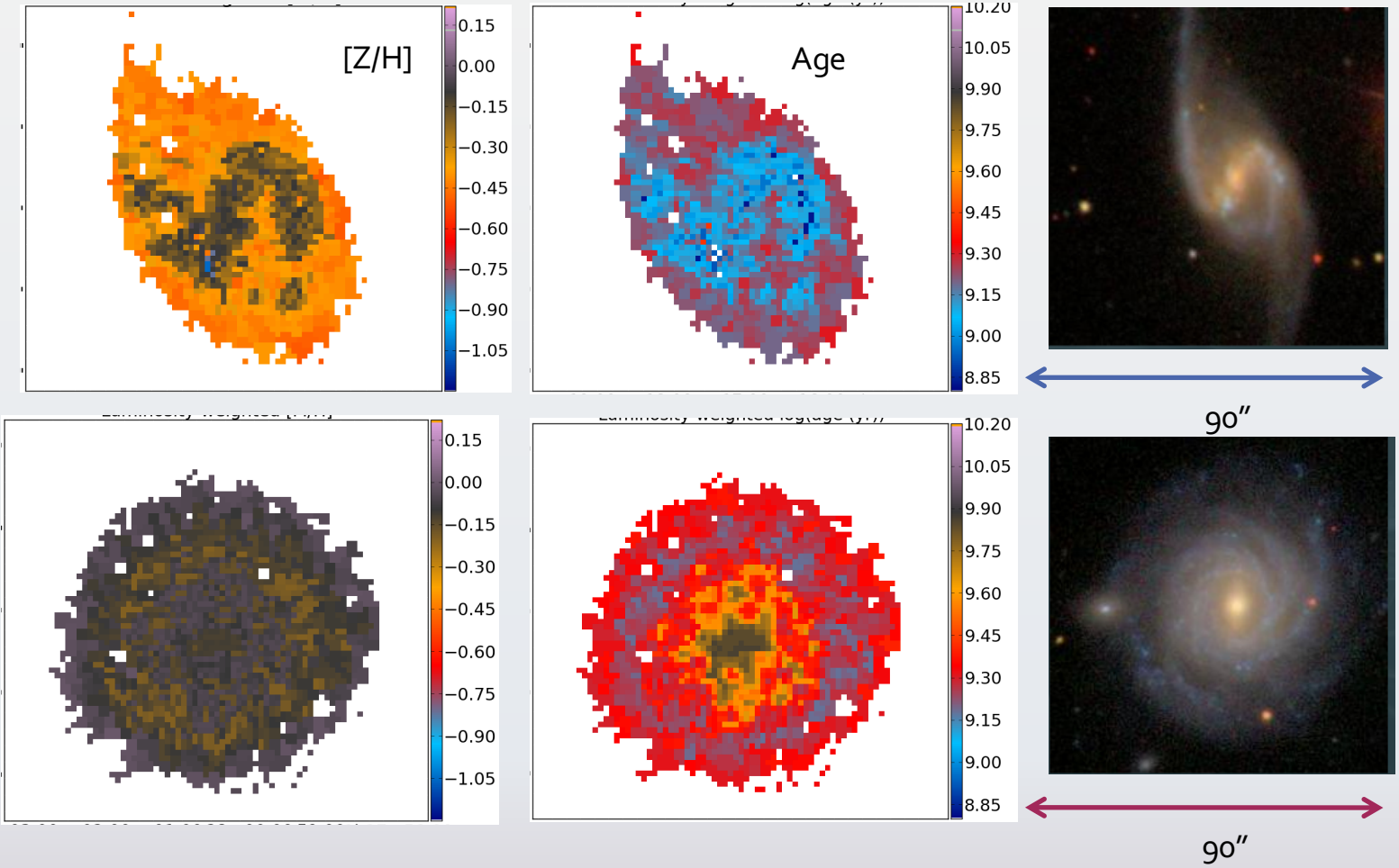


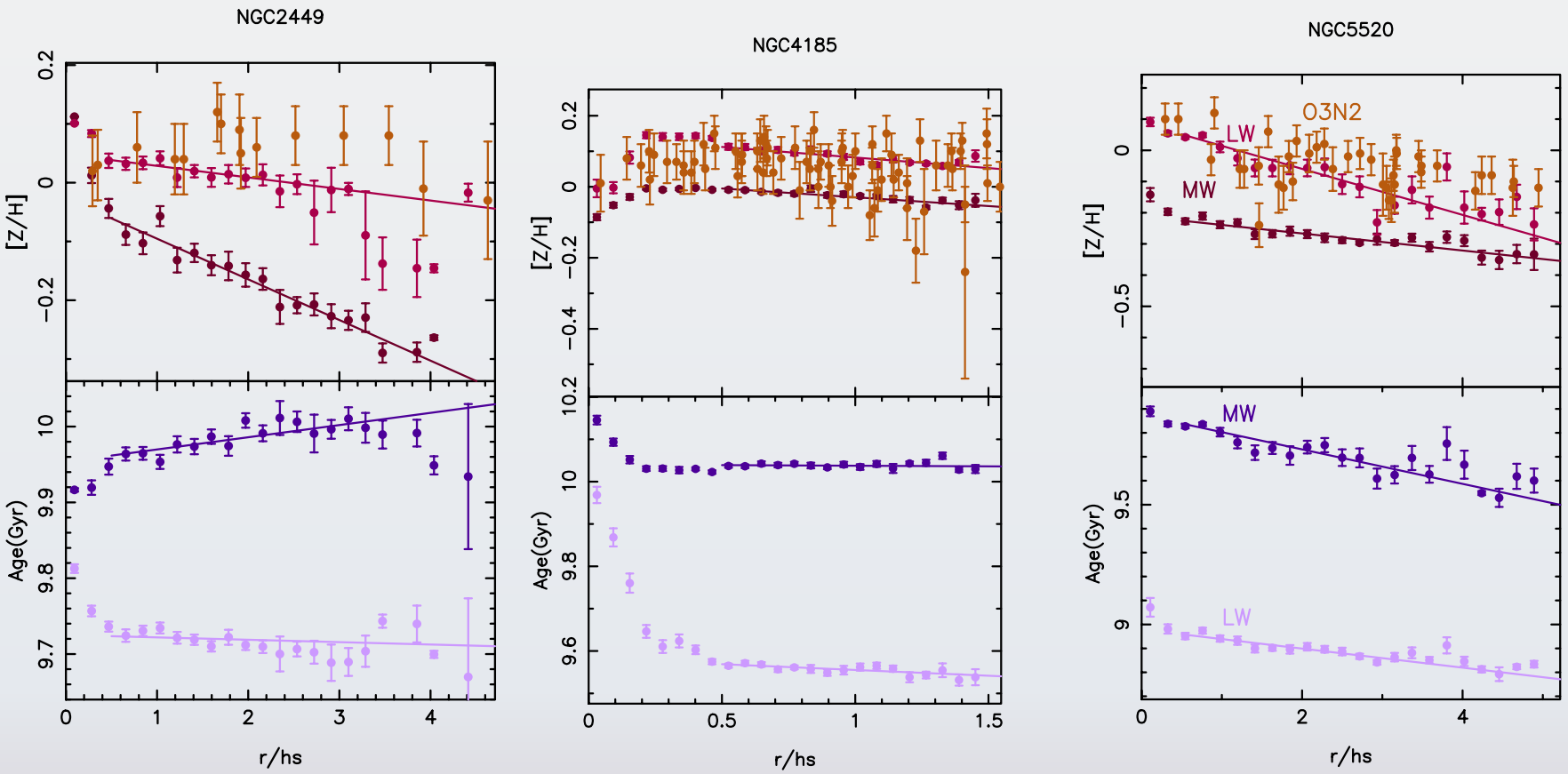
Mean values

$$< \log age >_{MW} = \frac{\sum_i mass(i) \log age_i}{\sum_i mass(i)}$$

$$< \log age >_{LW} = \frac{\sum_i flux(i) \log age_i}{\sum_i flux(i)}$$

PSB et al. (2014)

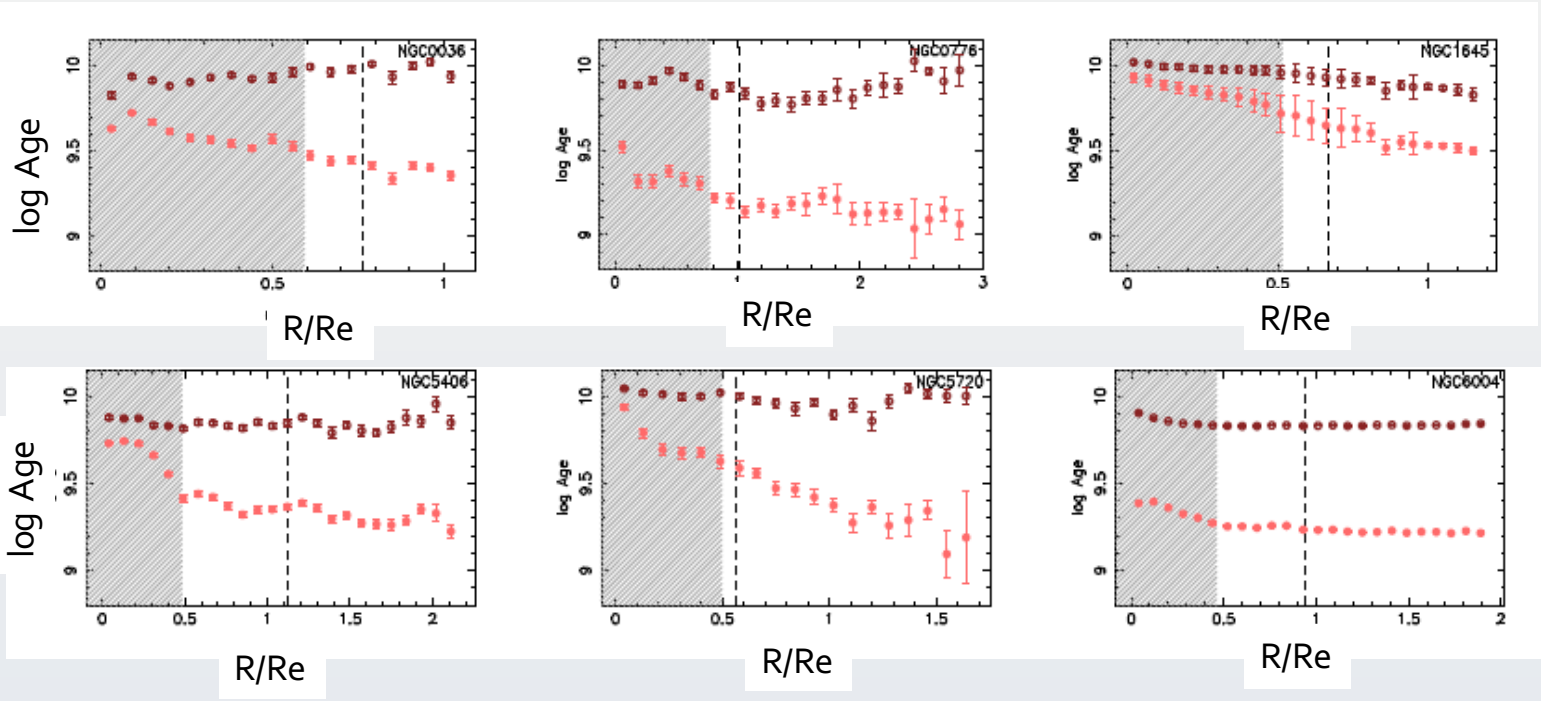

[Z/H]
0.15
0.00
−0.15
−0.30
−0.45
−0.60
−0.75
−0.90
−1.05
Age
10.20
10.05
9.90
9.75
9.60
9.45
9.30
9.15
9.00
8.85
90″
90″


NGC2449
NGC4185
NGC5520
[Z/H]
Age(Gyr)
r/hs
O3N2
LW
MW

Age gradients

Luminosity weighted values
Mass weighted values

reff = 1.67835rd



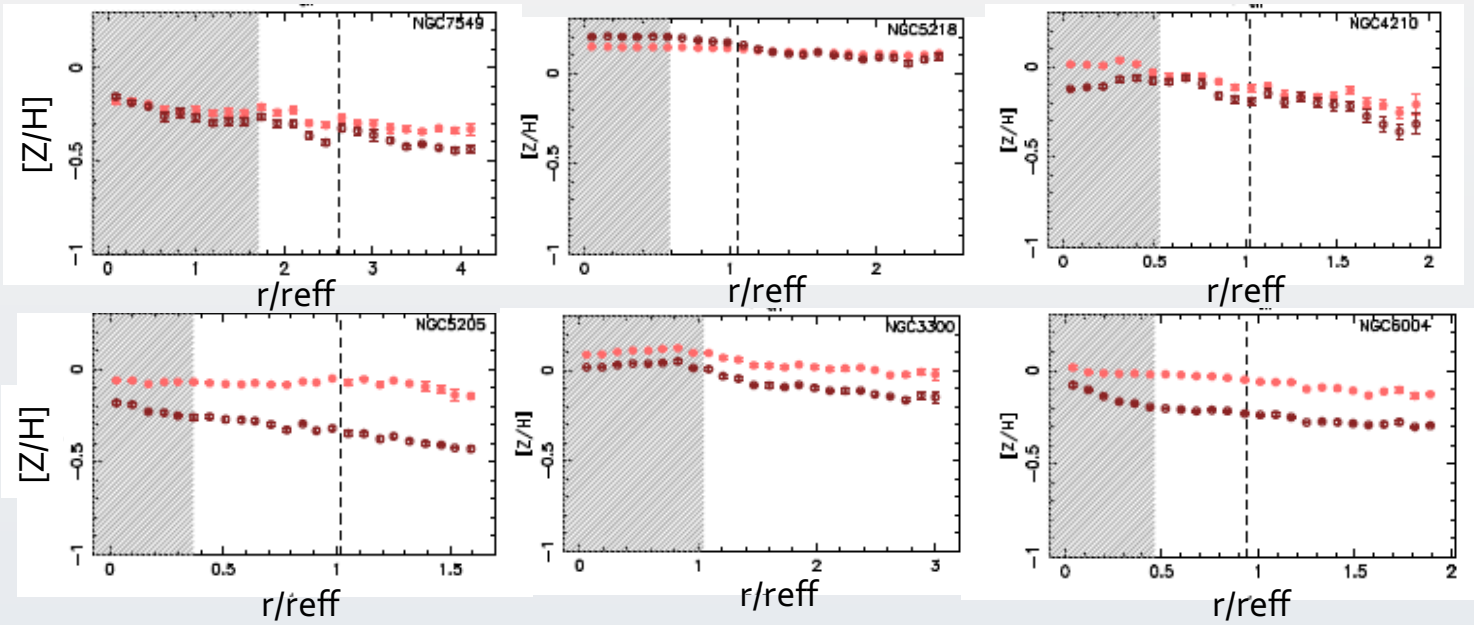
- Results:
- Mass-weighted age gradient reflect **old stellar populations** at all sampled radii
- Lum-weighted age gradient is always negative in the disk region (although very mild)

Sanchez-Blazquez et al. (2014)

CALIFA Survey

Luminosity weighted values
Mass weighted values

Metallicity gradients

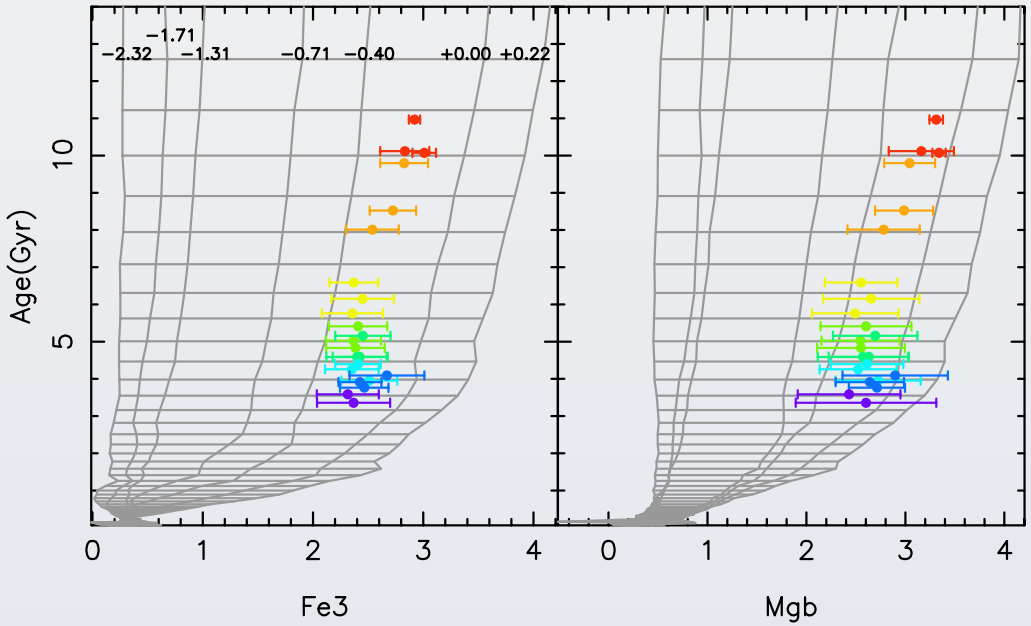


Results:
- The LW metallicity is always larger than the MW
- In general, metallicities are very high in the disk region
- The slopes of the MW and LW metallicities are very similar

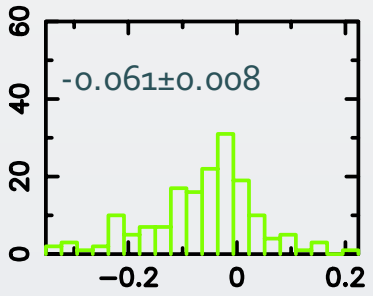
Sanchez-Blazquez et al. (2014)

[Mg/Fe]

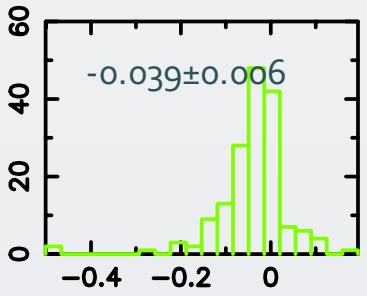
We derive a proxy for [Mg/Fe] by comparing the metallicity obtained using a Fe and a Mg sensitive index with the method described in *La Barbera et al. (2013)*



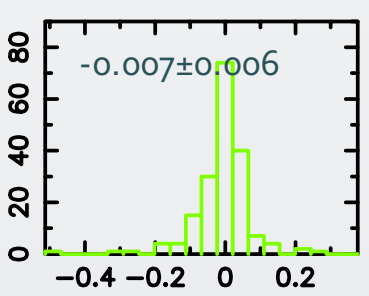
Mean gradients



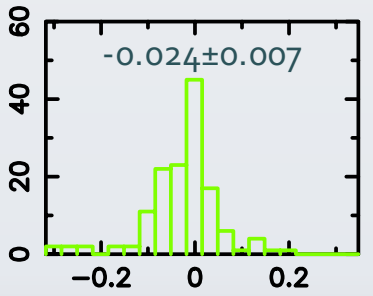
∇_{Age} (dex/hs) [LW]



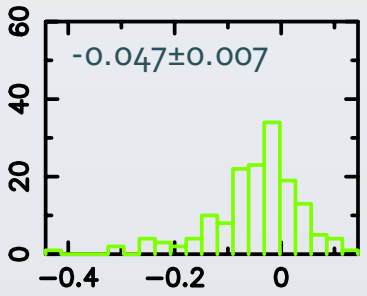
∇_{Z} (dex/hs) [LW]



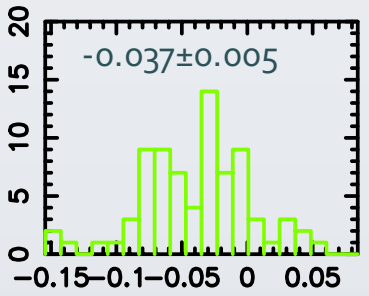
$\nabla_{[Mg/Fe]}$ (dex/hs)



∇_{Age} (dex/hs) [MW]



∇_{Z} (dex/hs)[MW]

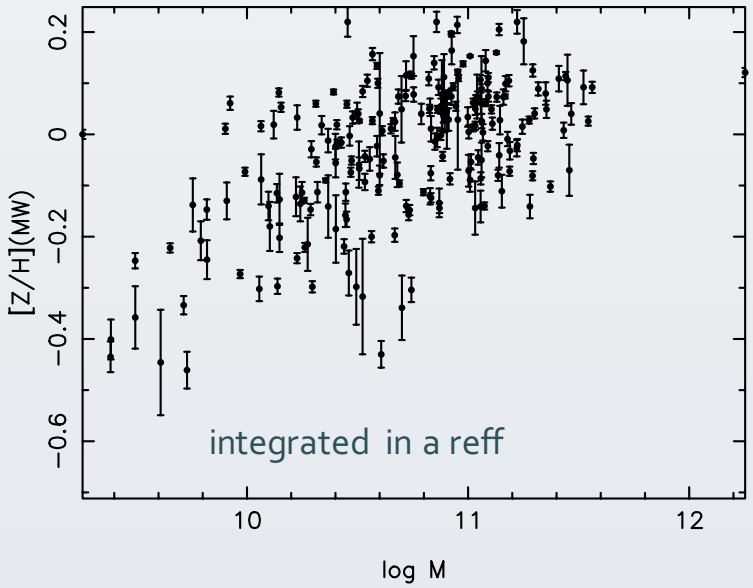


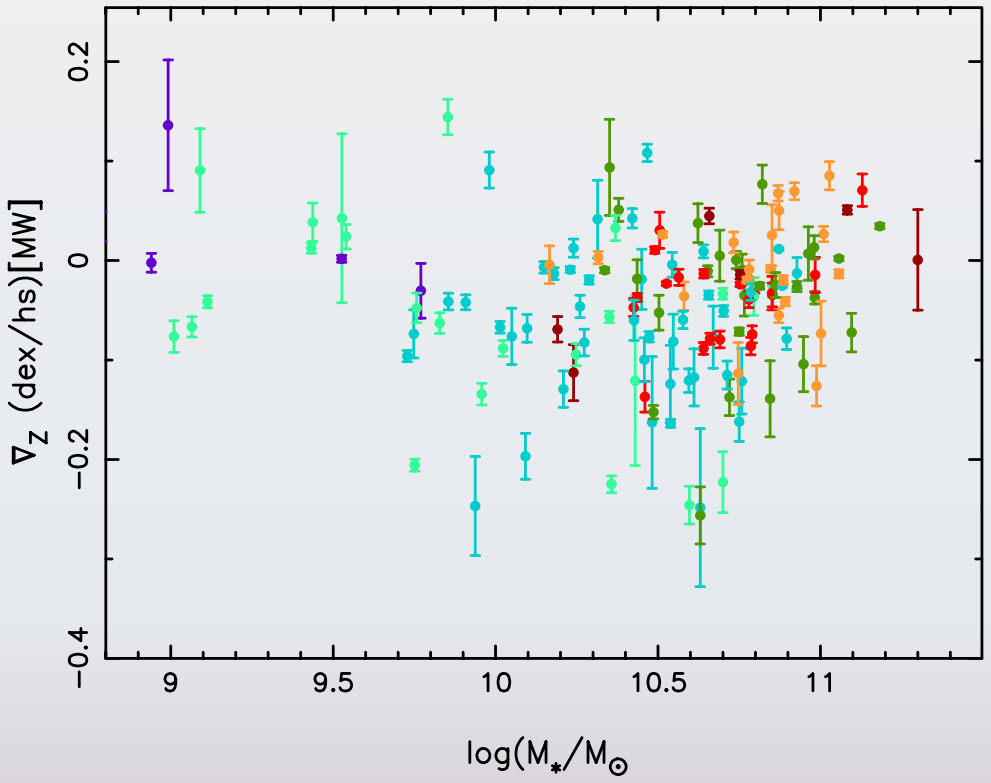
$\nabla_{(O/H)_{O3N2}}$ (dex/hs)

Stellar population gradients in disks

- Results:
- Mass-weighted age gradient reflect **old stellar populations** at all sampled radii
- **Lum-weighted age gradient** is always **negativ**e in the disk region (although very mild)
- Negative metallicity gradients (both LW and MW) → LW always more metal rich
- Values compatible with those measured in the MW
- [Mg/Fe] gradients very flat
- The gas abundance granditns are slightly flatter than those of the stellar component and the dispersion is also smaller

Dependence of the stellar population gradients on the Stellar mass

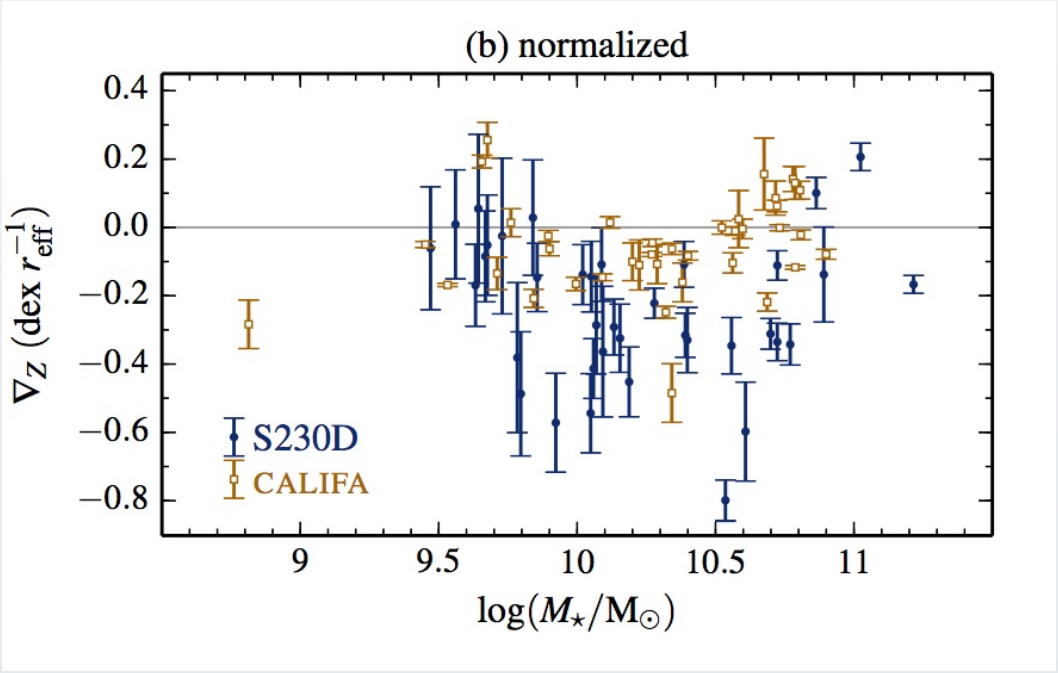




Dependence of the stellar population gradients on the Stellar mass

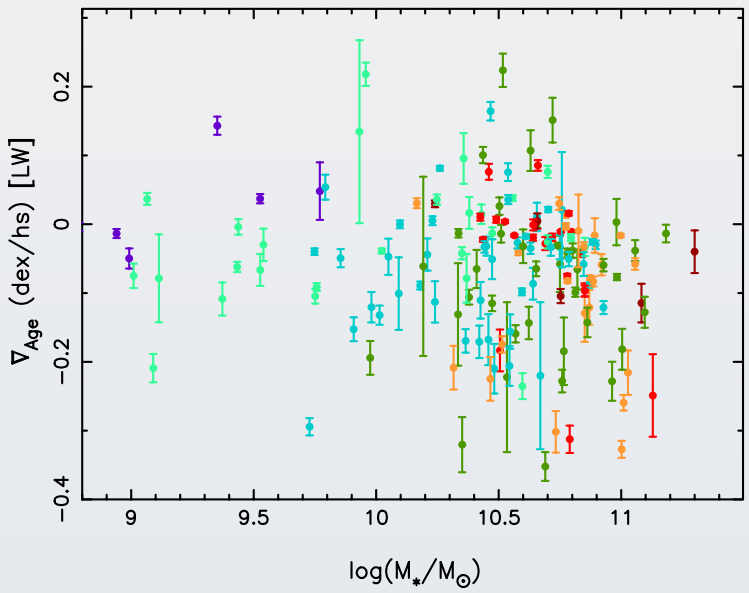
The effects of the SN feedback around this stellar mass change due to combined effects of the SN strength and the potential well of the systems that affect t (de Rossi+2013):

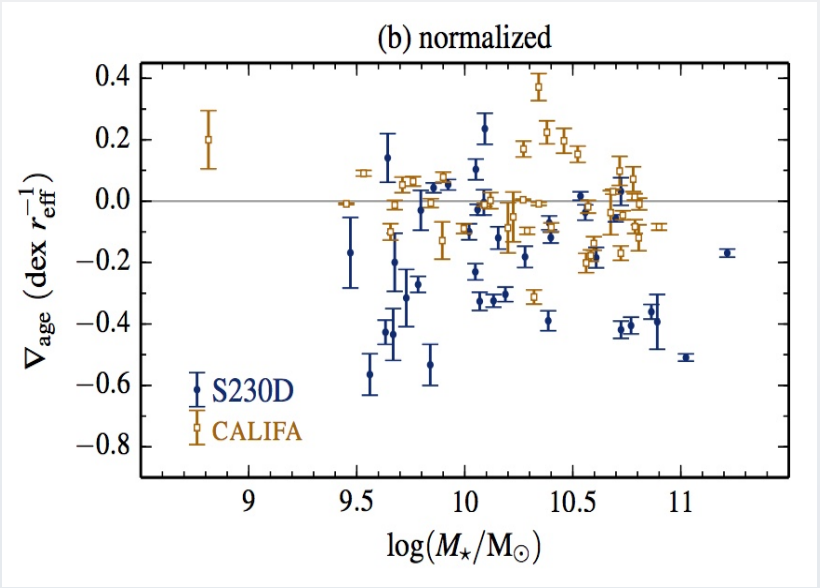
1. The gas cooling time
2. The star formation activity
3. The amount of metals ejected in galactic winds



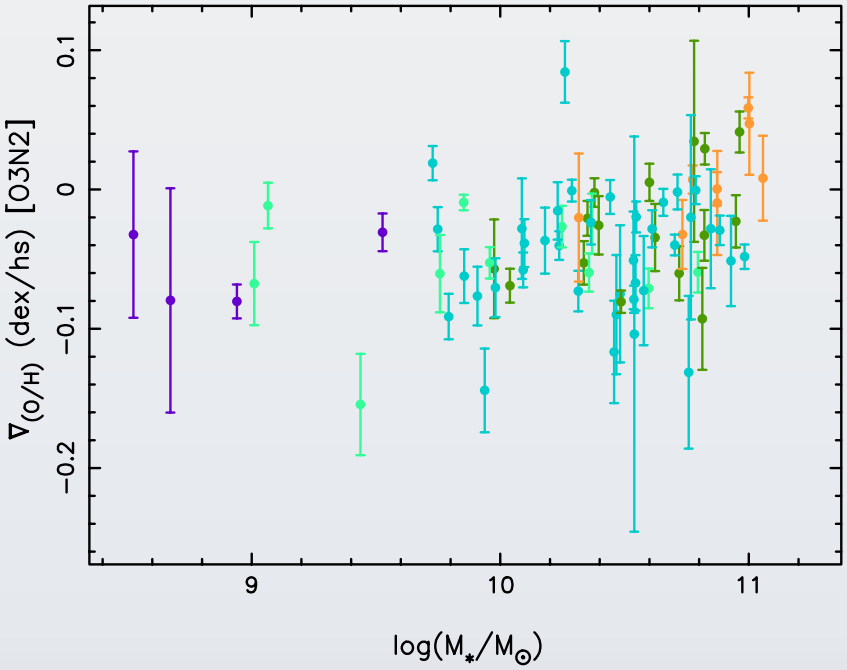
Tissera et al. (2016)
(see also Molla & Diaz (2005)

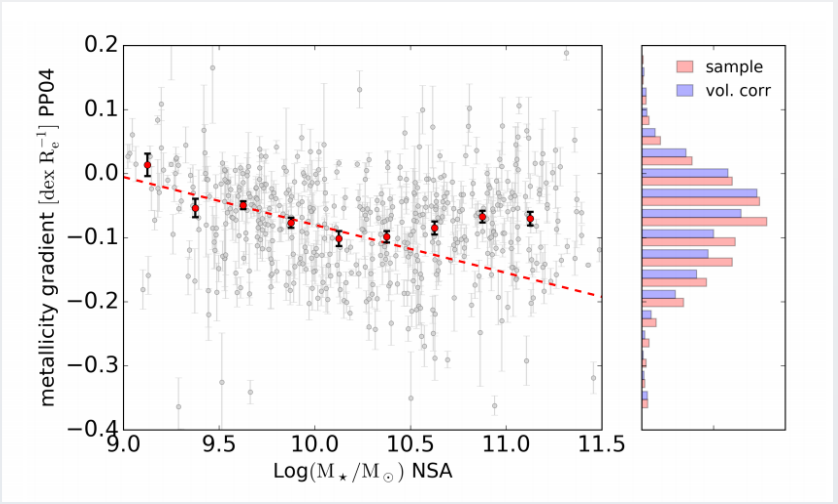
Dependence of the stellar population gradients on the Stellar mass





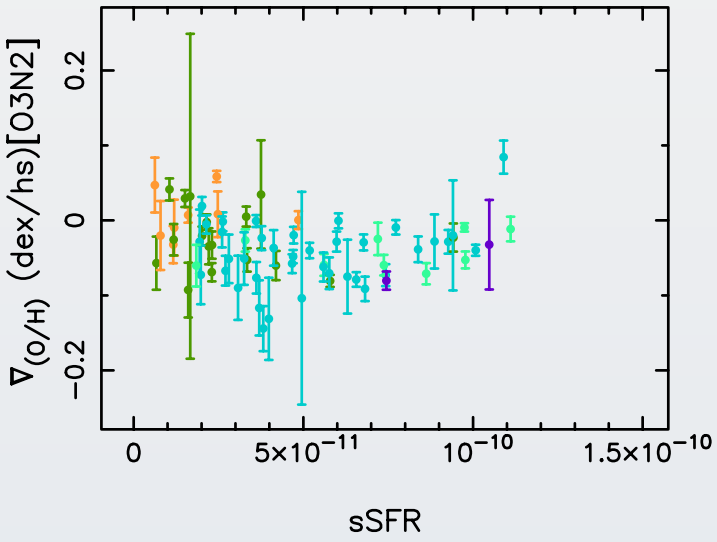
Gas phase metallicity



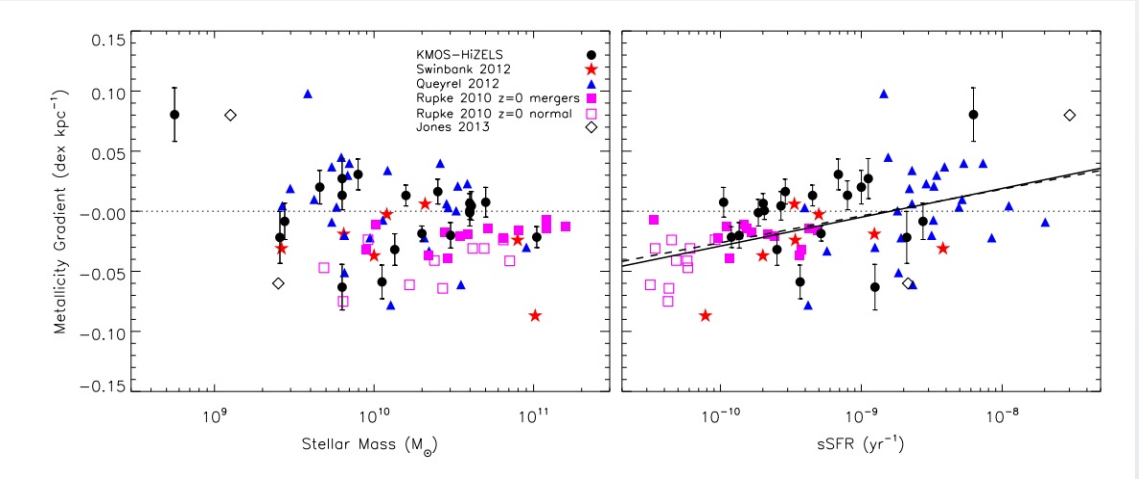


Bilefiori et al. (2013)

(O/H) gradient and sSFR



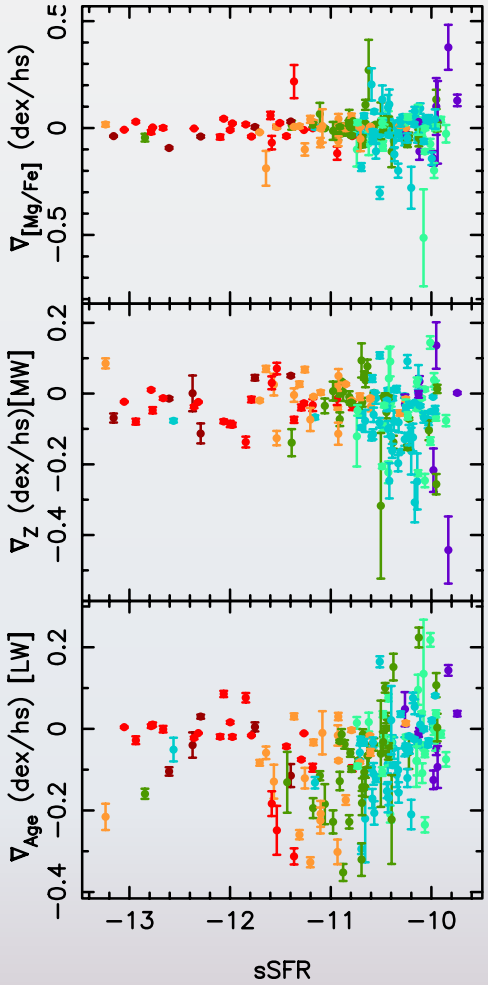
Stott et al 2014



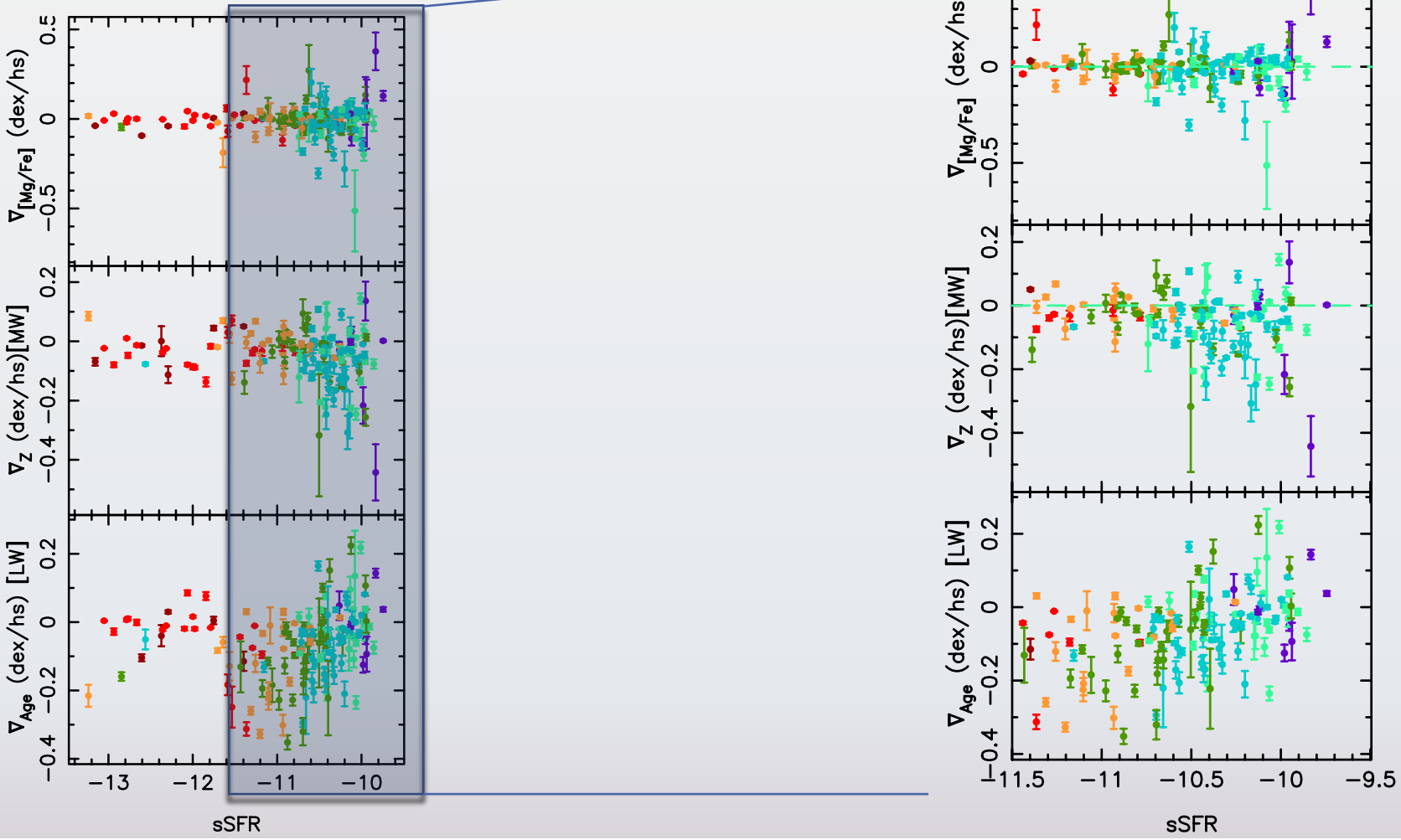
Triggering of low-metallicity gas inflows to the center:

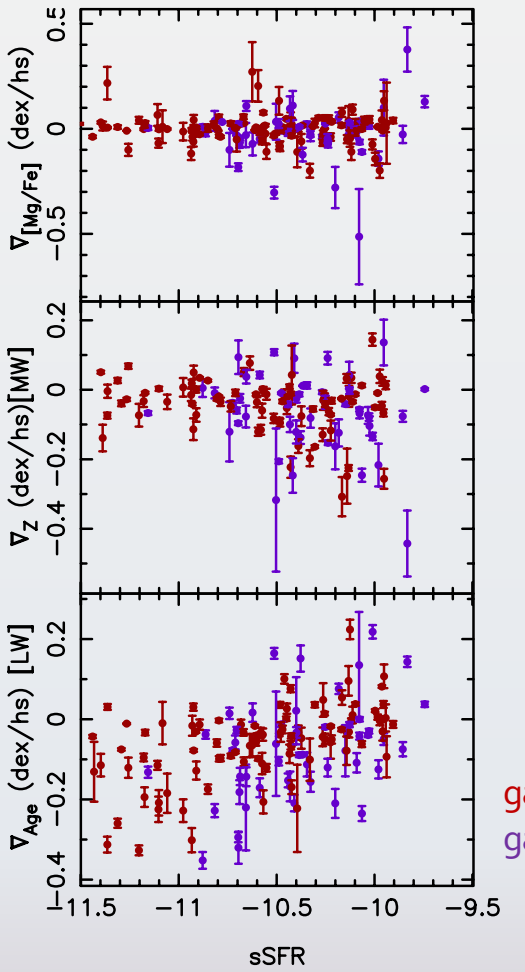
- Mergers or Interactions
- Efficient gas accretion into the central regions

SP gradients vs. sSFR



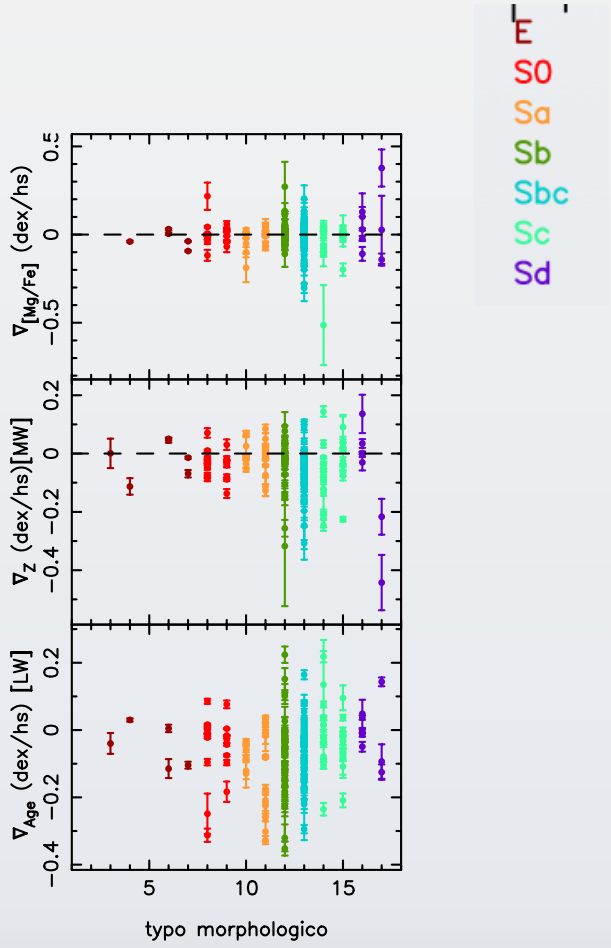
SP gradients vs. sSFR





gas frac < 0.4

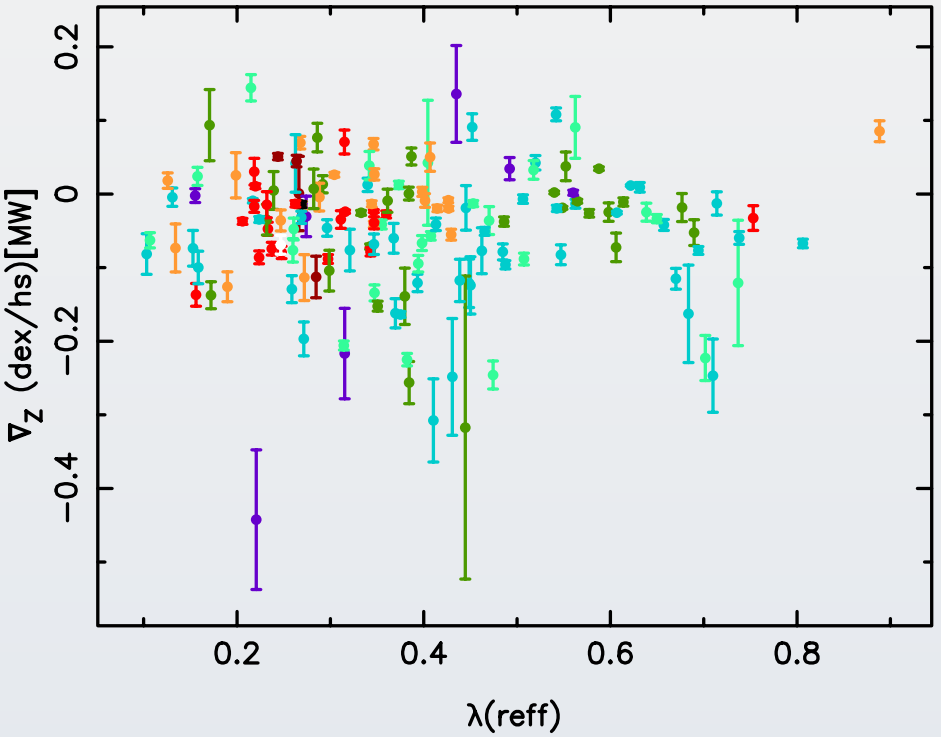
gas frac > 0.4

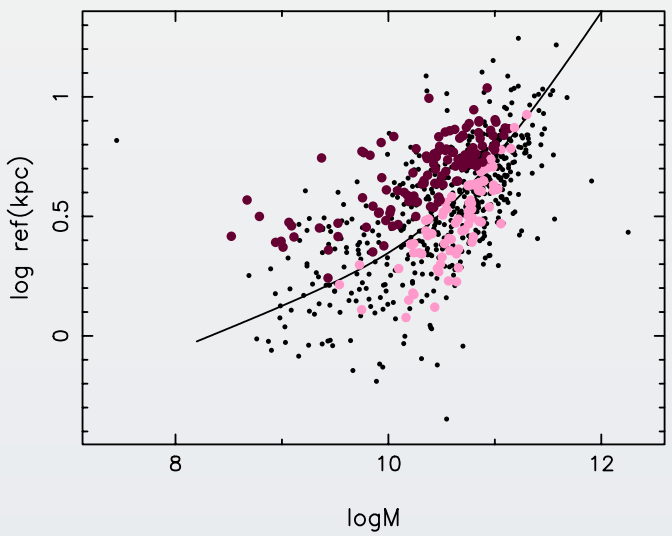

E
S0
Sa
Sb
Sbc
Sc
Sd
$\nabla_{[Mg/Fe]}$ (dex/hs)
∇_Z (dex/hs)[MW]
∇_{Age} (dex/hs) [LW]
typo morphologico

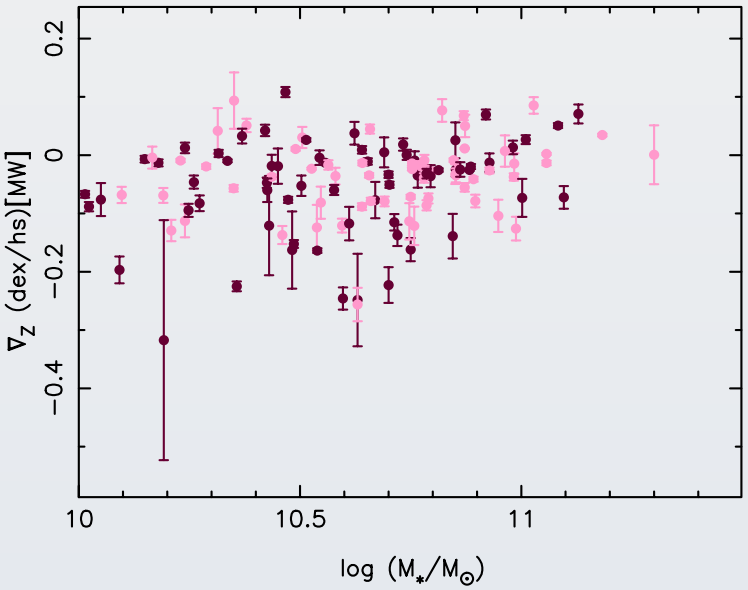
Some authors claim that the spin parameter is the most fundamental quantity in spiral galaxies.

They dictate the density normalization and the radius of the final system →

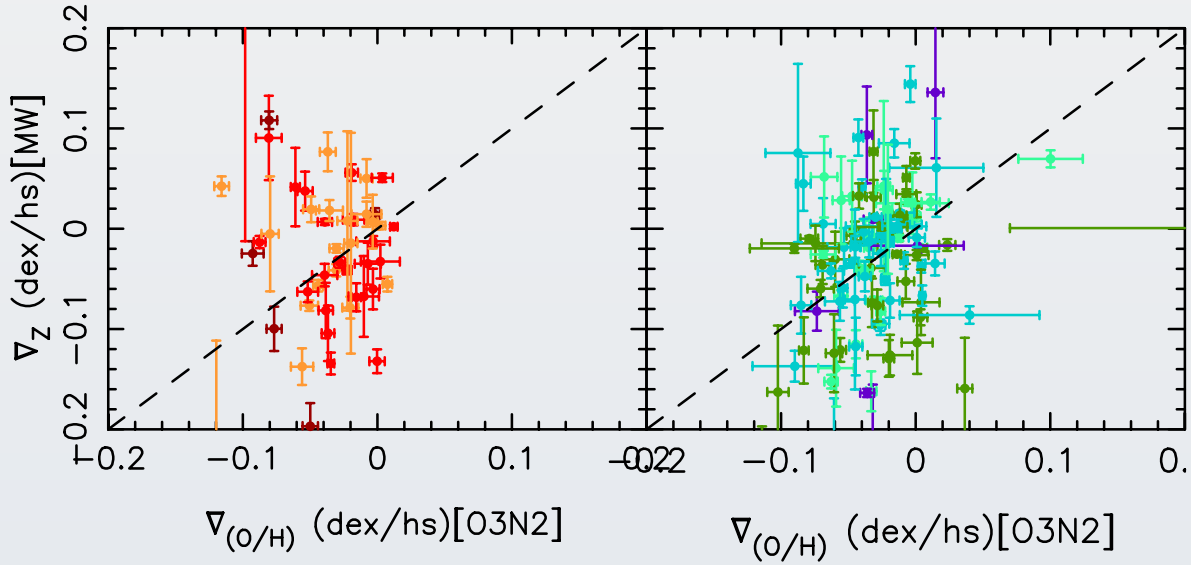
$$\frac{J}{M} = \frac{\sum_{k=1}^{n} M_k R_k |V_k|}{\sum_{k=1}^{n} M_k}$$

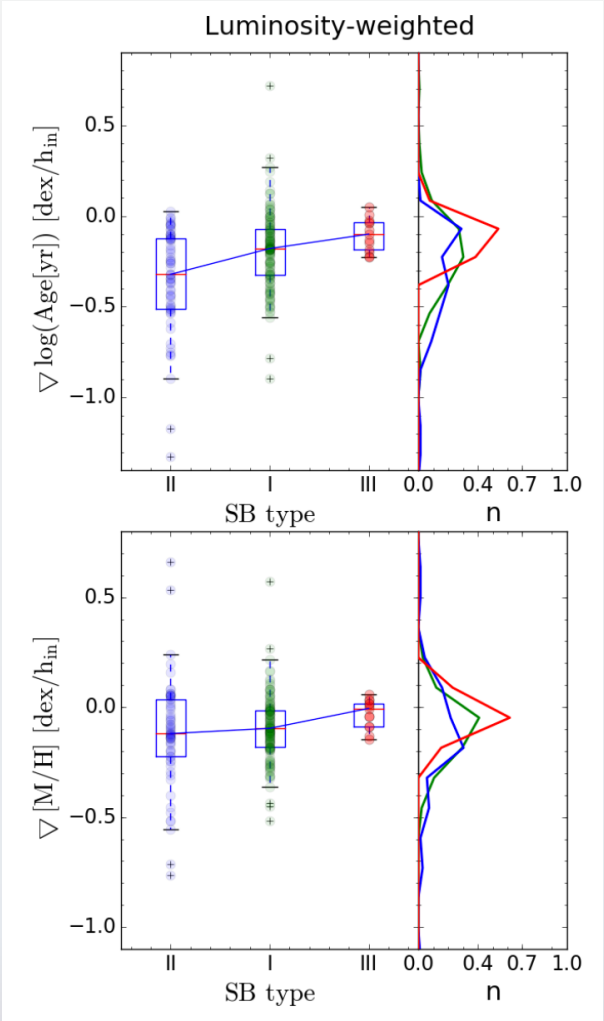


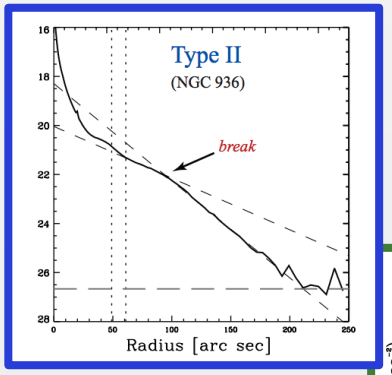

log ref(kpc)
0
0.5
1
8
10
12
logM

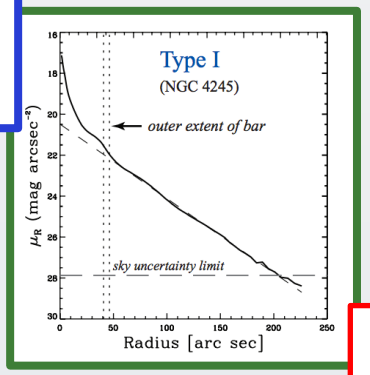

∇_Z (dex/hs)[MW]
0.2
0
−0.2
−0.4
10
10.5
11
log ($M_*/M_\odot$)

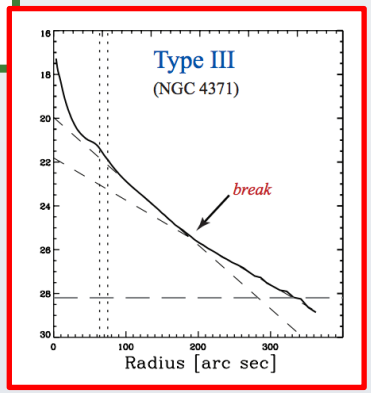
Comparison gas and stars











Relation between SP gradients and surface brightness profile

Ruiz-Lara et al. (2017)

Summary

- Old stellar populations dominate the mass budget in disks; small negative (younger outside) LW age gradient; No dependence of the slopes with mass, B/T or the presence of bars.
- Shallow, negative metallicity gradients (both, ionized gas and stellar)

Different correlations for log M above and below ~10.3. For log M >~10.3 :

gas-phase metallicity gradient gets flatter with higher sSFR

gas-phase metallicity gradient gets steeper with mass

stellar-phase metallicity gradient spreads with higher sSFR (steepest but also positive)

stellar-phase metallicity gradient gets flatter with mass

no clear dependence with morphology, presence of bars,