Environmental effects on LIRGs and ULIRGs @ z~1

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Outlines:

- Analysis of relation between galaxy star formation rate (SFR) and environmental effects at high redshift through:

  - ✓ SFR – projected local galaxy density relation
  - ✓ Specific SFR (sSFR) - projected local galaxy density relation
  - ✓ sSFR – stellar mass relation

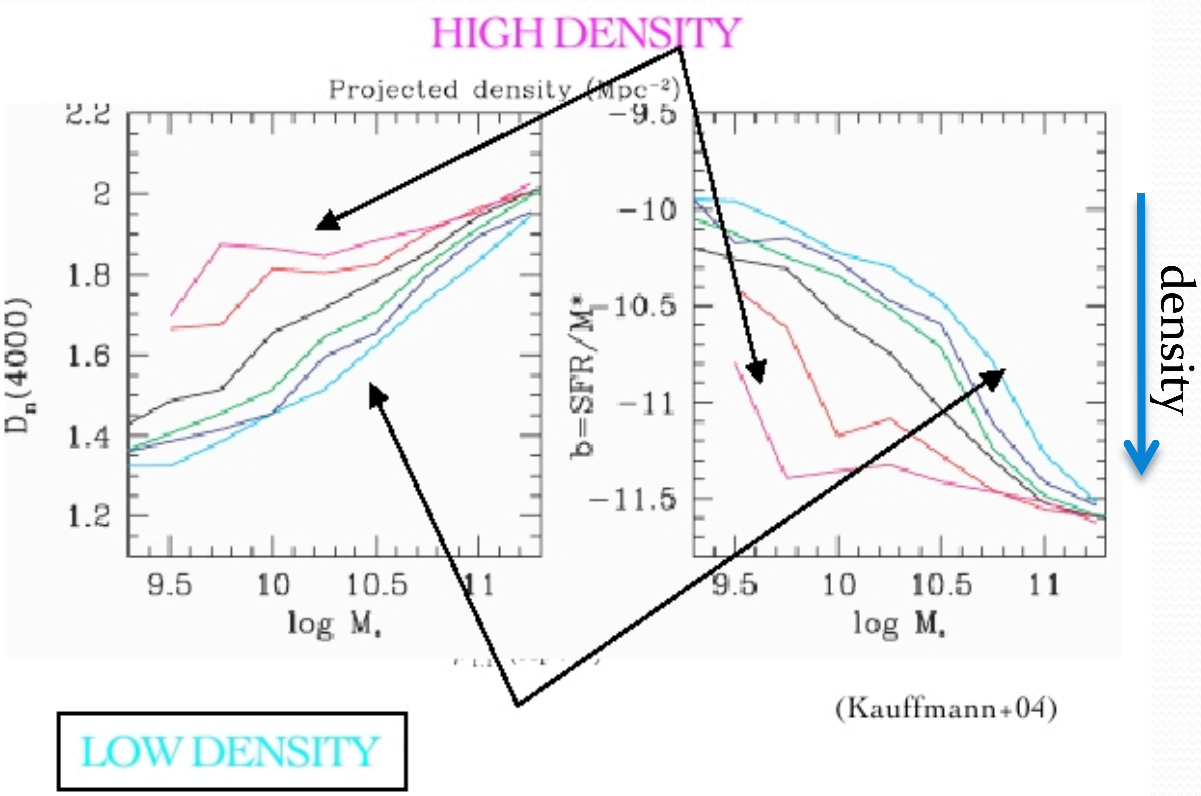
Why and how…

- One of the most fundamental relations observed in the local Universe if the morphology-density relation
- Physical origin of the relation is still matter of debate: does it arise early on during the galaxy formation or by environment-driven evolution?
- An alternative way to tackle this issue is the analysis of the SFR-density relation due to the tight link between SFR and galaxy colors and morphology
- Study the SFr-density relation at high redshift when the galaxy formation process is still ongoing

- GOALS:
  - estimate the effect of the environment on dust-obscured sfr @

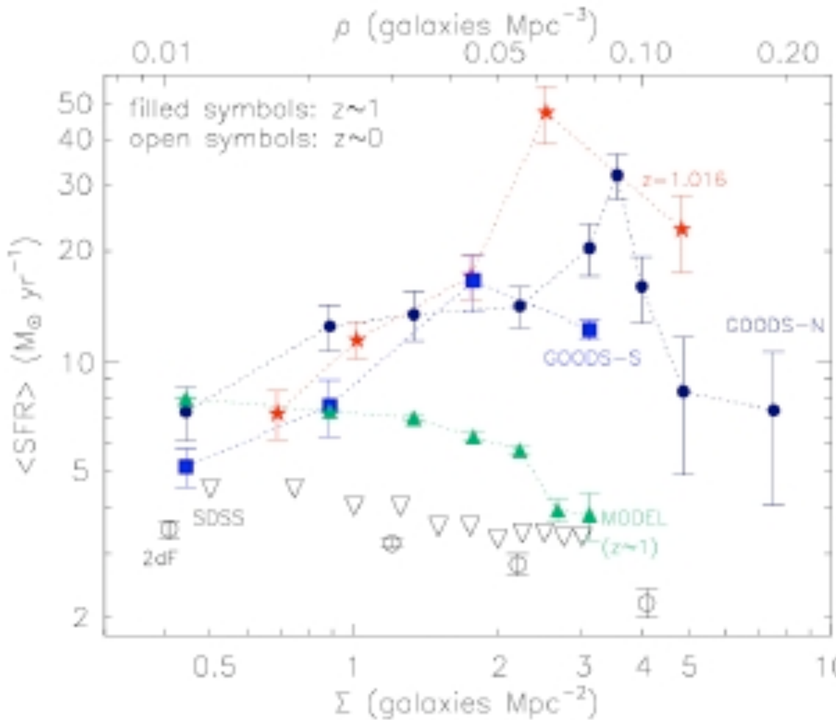
  $0.7 < z < 1.1$ in the GOODS fields observed with PACS @ 100 and 160 μm
  - disentangle mass segregation and environmental effect by studying relations in mass and density bins.

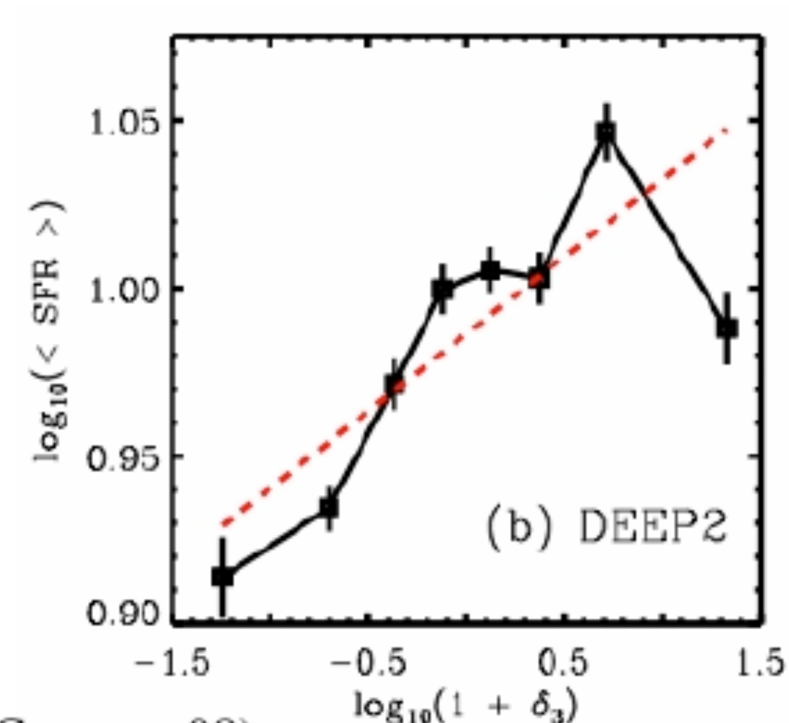
@ low redshift



- @ z=0 local environment and galaxy properties are correlated
- Morphology-density relation
- Fraction of star forming galaxies depends on local density on scale < 1 Mpc

@ redshift ~1





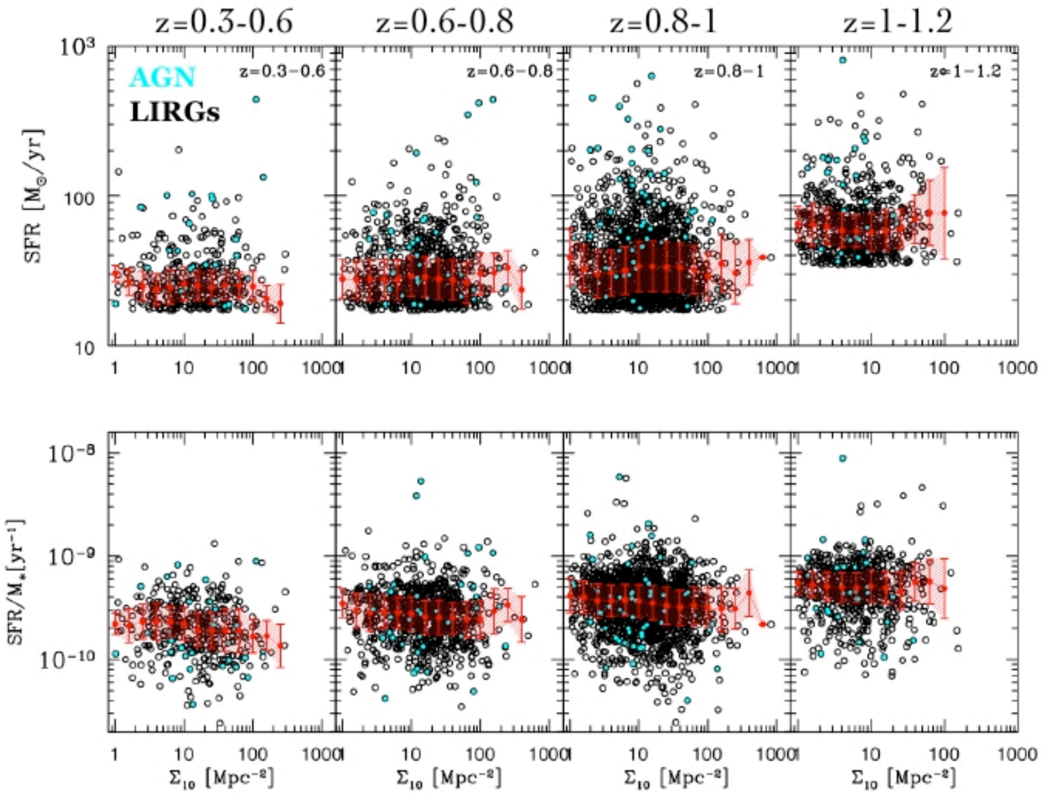
(Elbaz+07,Cooper+08)

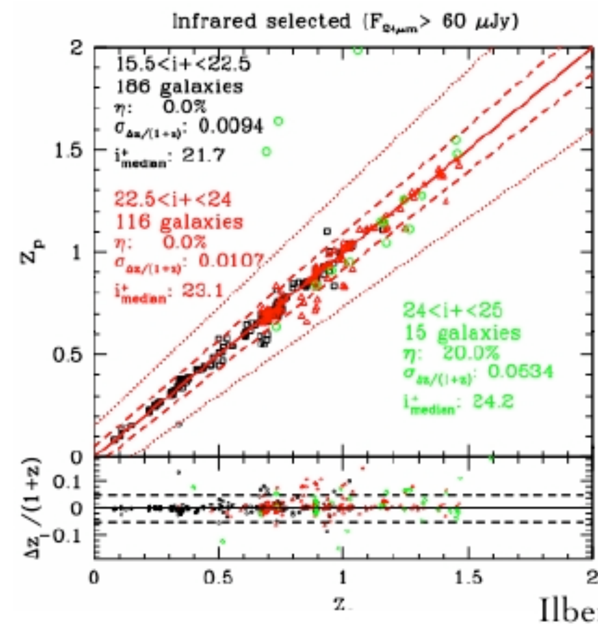
SFR based on MIPS 24 μm

SFR based on [OII] emission

•projected galaxy density based on spectroscopic redshifts

Feruglio et al. (2010)



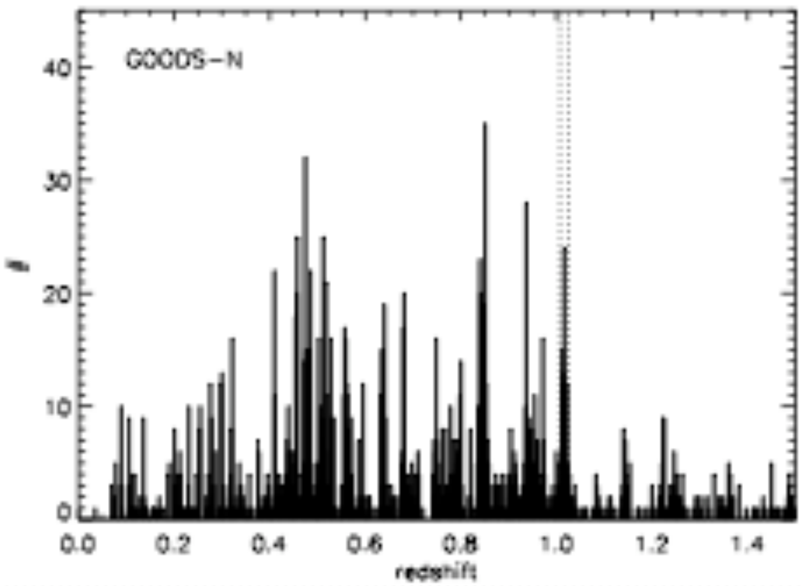


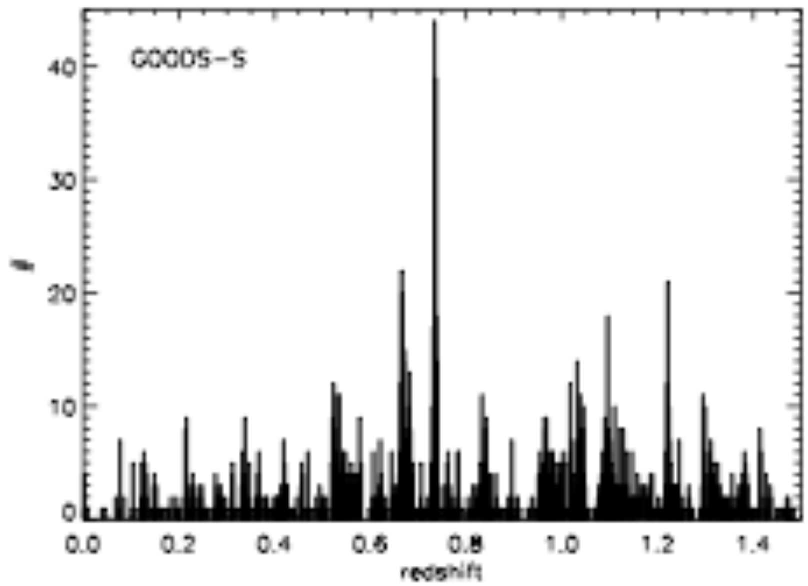
Ilbert+09

SFR based on MIPS 24 µm

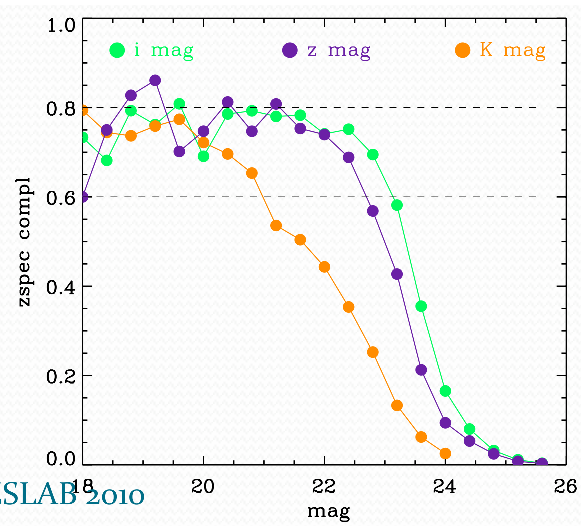
Local density derived from the distance of the 10th nearest Neighbor within 3*σ*(1+z)

GOODS-N and GOODS-S fields

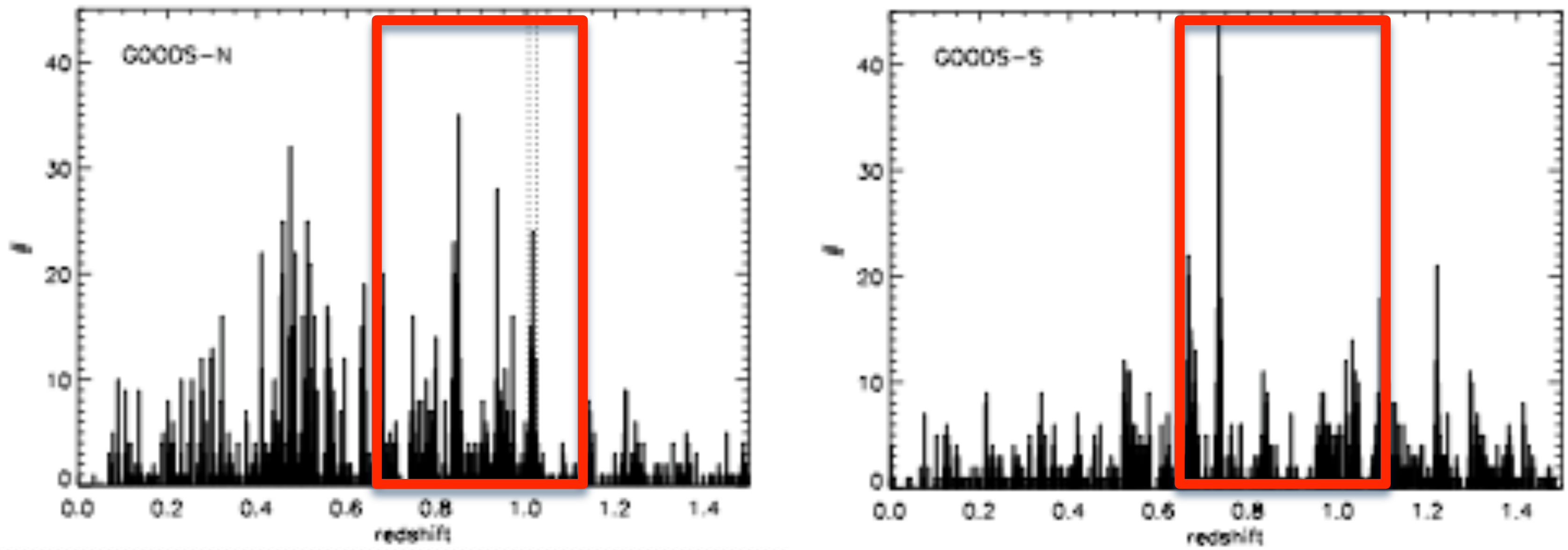




- high spectroscopic completeness
- rich multiwavelength coverage
- deepest PACS PEP observations



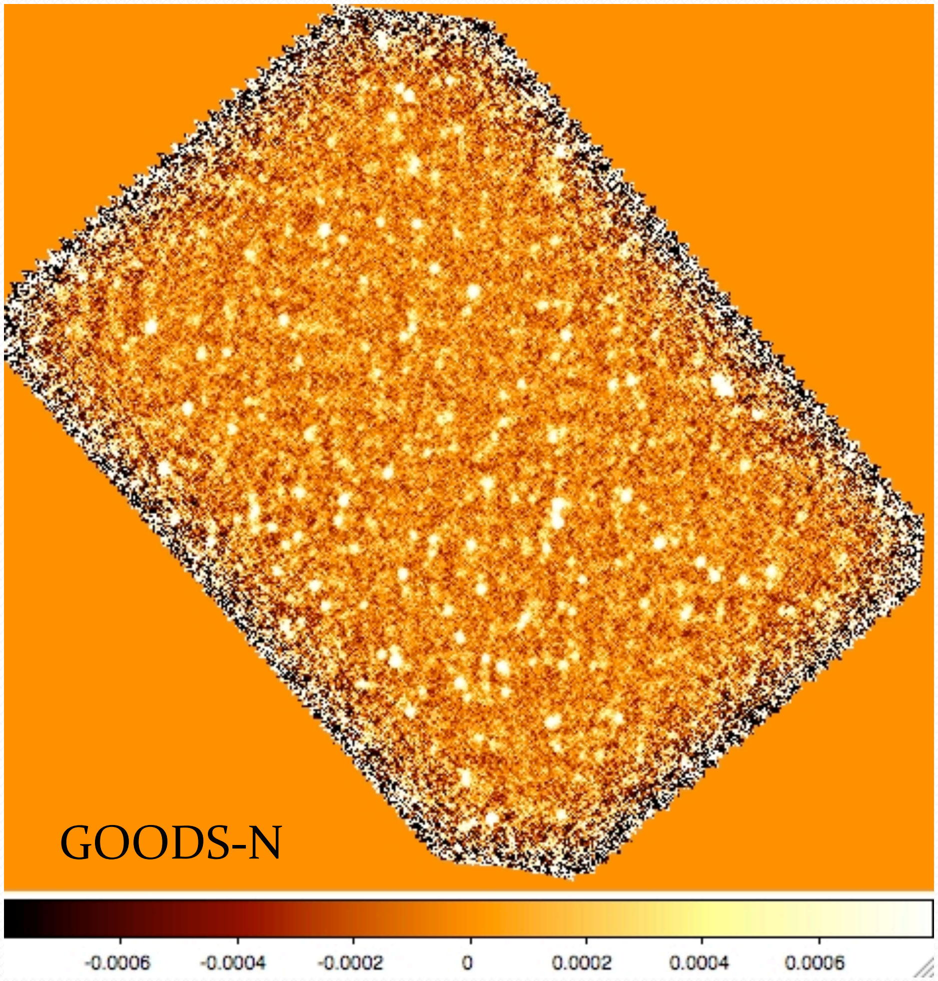
GOODS-N and GOODS-S fields

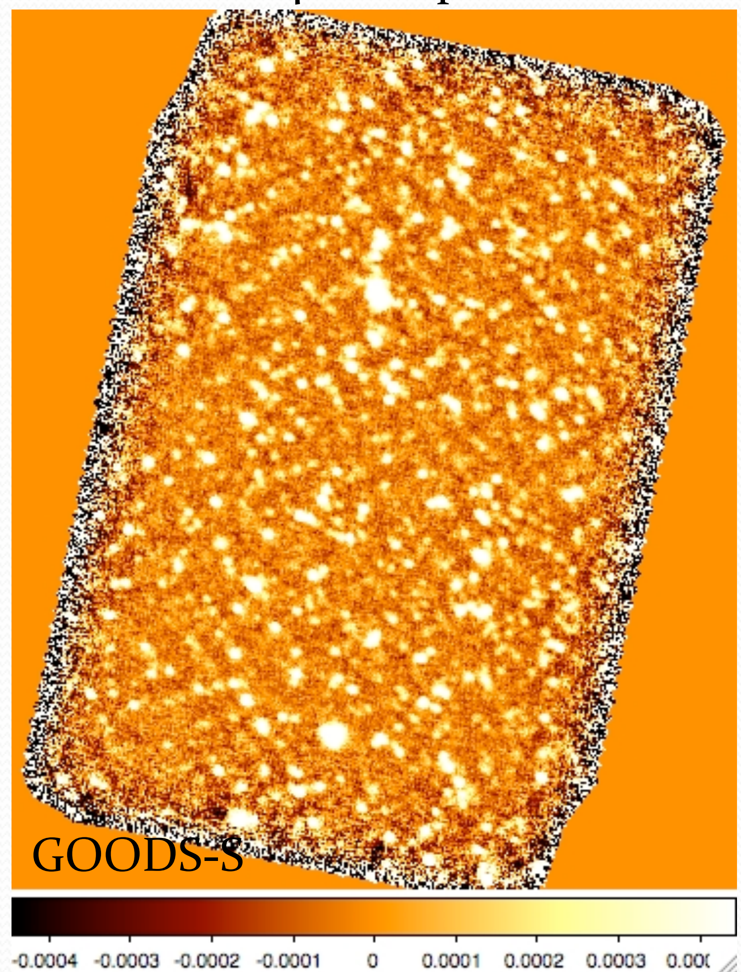


Redshift window $0.7 < z < 1.1$ to sample main large scale structures in the fields:
-X-ray detected group at z=1.016 in GOODS-N
-large sheet like structure at z=0.85 in GOODS-N
-X-ray detected low mass cluster (10^{14} $M_{\odot}$) at z=0.73 in GOODS-S
-X-ray detected groups at z=1.034 in GOODS-S

GOODS-N and GOODS-S fields

160 μm maps



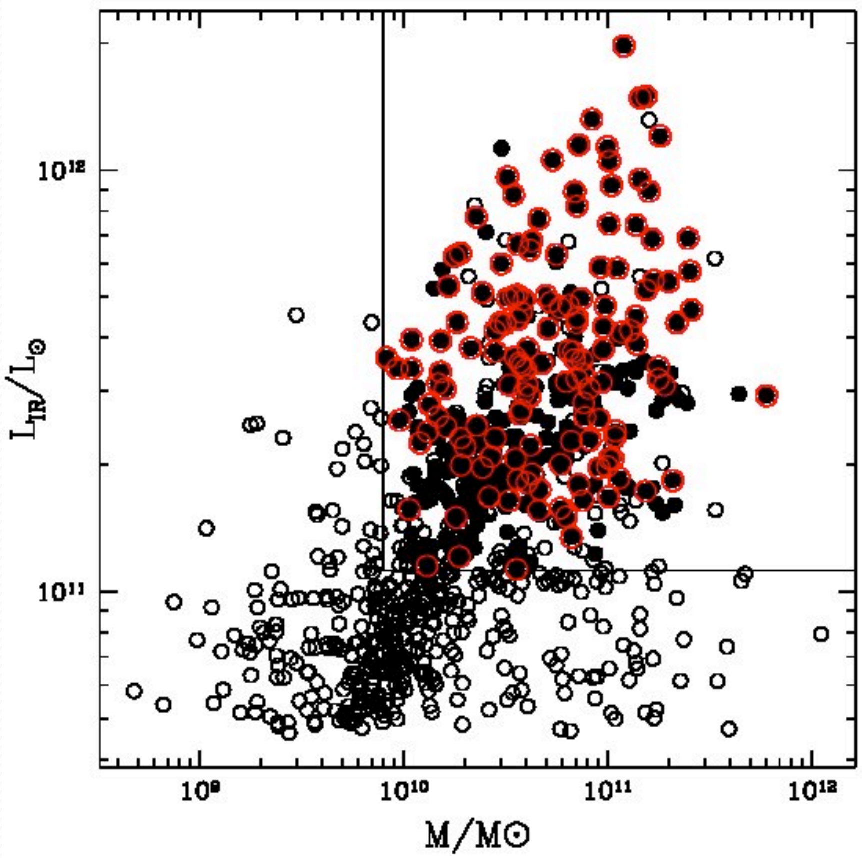


The GOOD(S) sample

- GOODS-N and GOODS-S have different depth
  - @ 160 μm the 3σ level is reached at 5.7 mJy in the north and at 3.5 mJy in the south
  - different photometric completeness

- In order to cope with incompleteness without losing in depth we combine MIPS 24 μm and PACS catalogs

The GOOD(S) sample

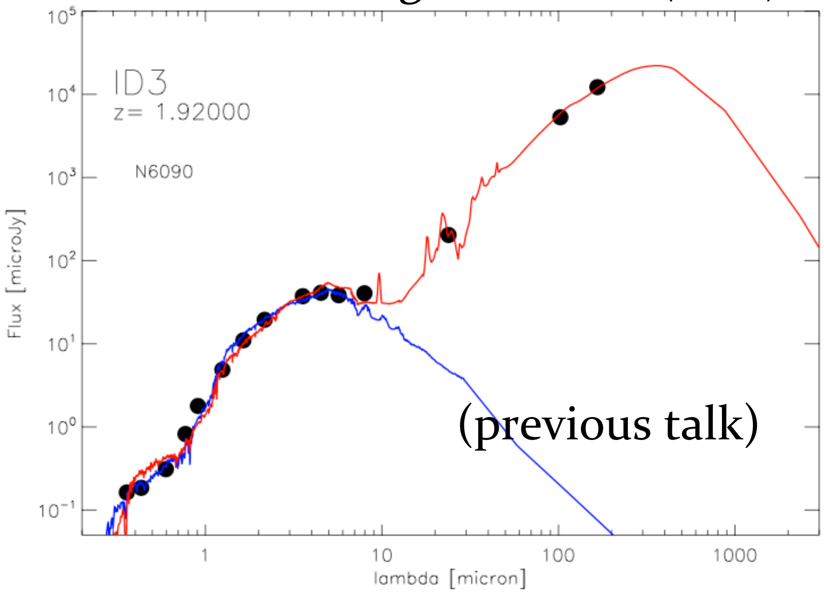


- 24 µm fluxes > 80 mJy
- IRAC 4.5 µm > 23 mag (Mancini et al. 2009)
  - $L_{IR} > 10^{11}\ L_{\odot}$
  - $M > 8 \times 10^{9}\ M_{\odot}$
  - z_{spec} available
- Sample comprises 55 X-ray detected AGNs
  - 3 BL AGNs excluded
  - 52 obscured AGNs keept in the sample, reliable estimate of the mass (Merloni et al. 2009) and SFR from PACS (Lutz et al. 2010)

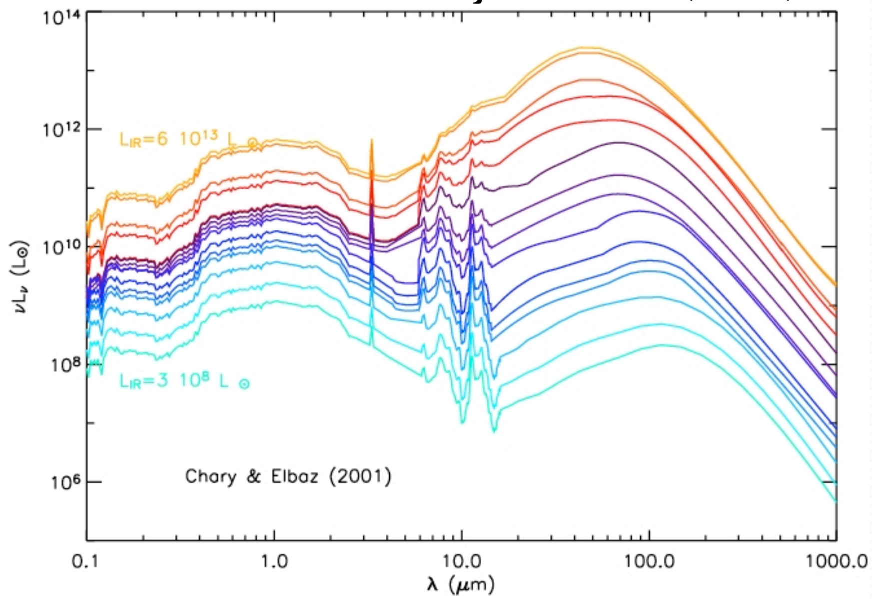
326 galaxies, 185 PACS detection, 52 obscured AGNs

L_{IR} and stellar Masses estimates

Rodighiero et al. (2010)

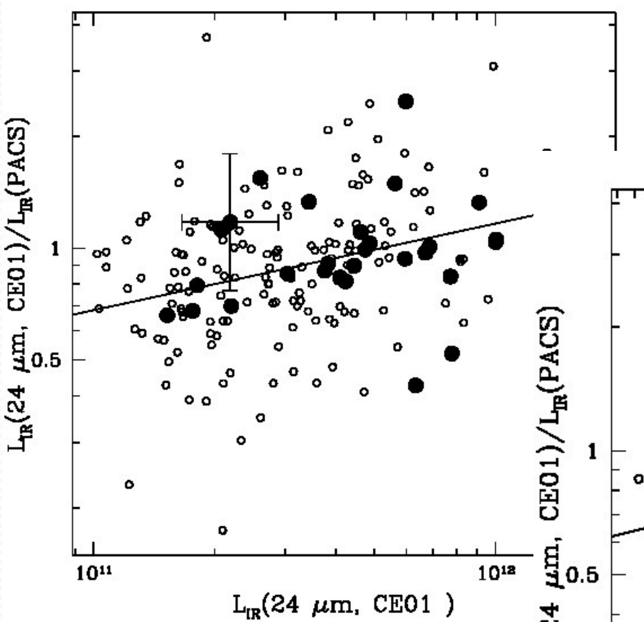


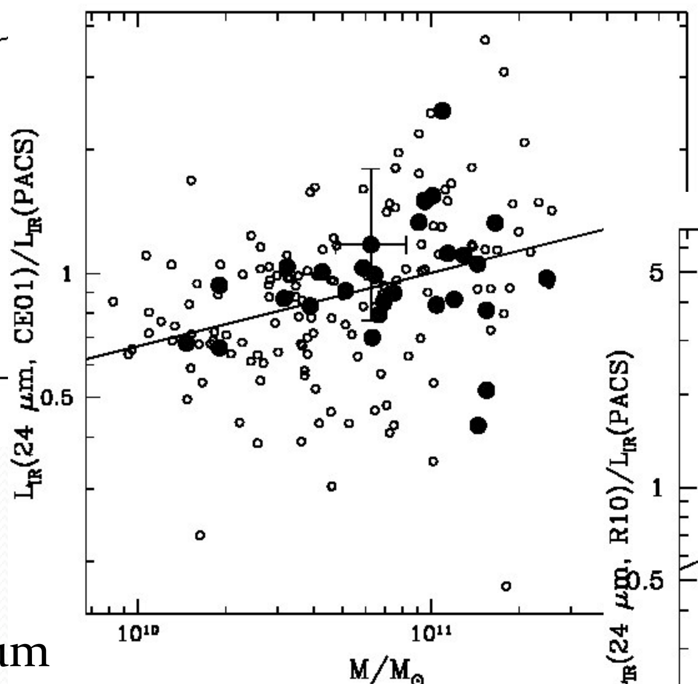
Chary & Elbaz (2001)

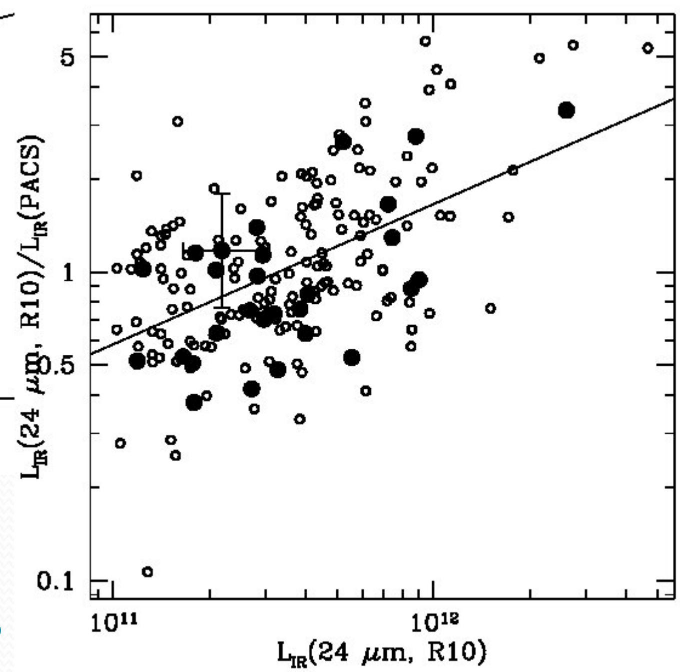


L_{IR} based on PACS data (Rodighiero et al. 2010)
For 24 μm only detected sources L_{IR} extrapolated via Chary & Elbaz (2001) method
Mass estimated via SED fitting with Salpeter IMF, Calzetti's extinction law

L_{IR} and stellar Masses estimates

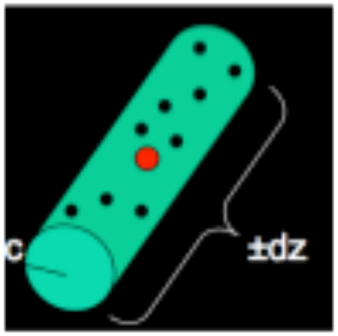




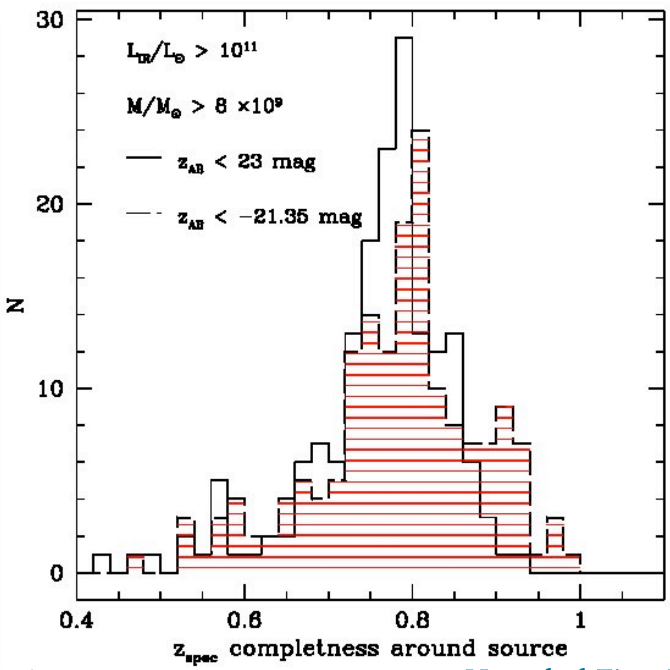


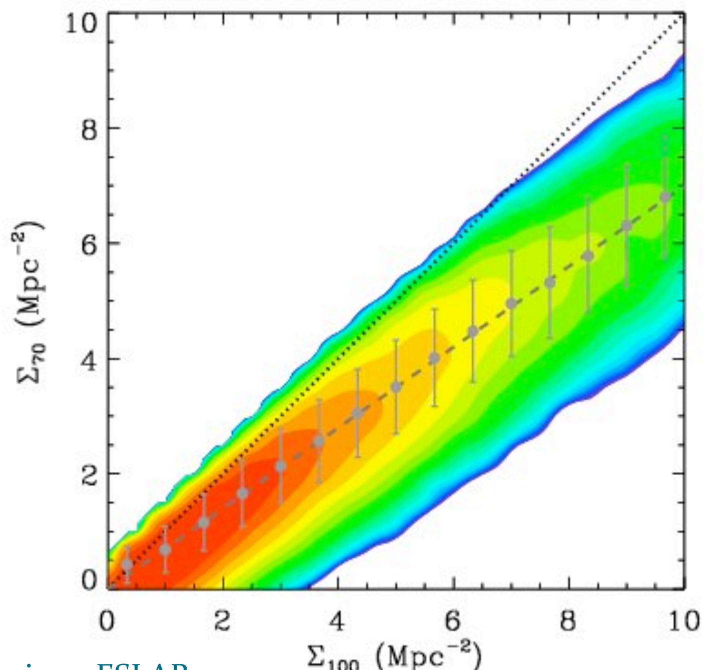
L_{IR} extrapolated from 24 µm
Based on CE01 method after correction

The projected local galaxy density

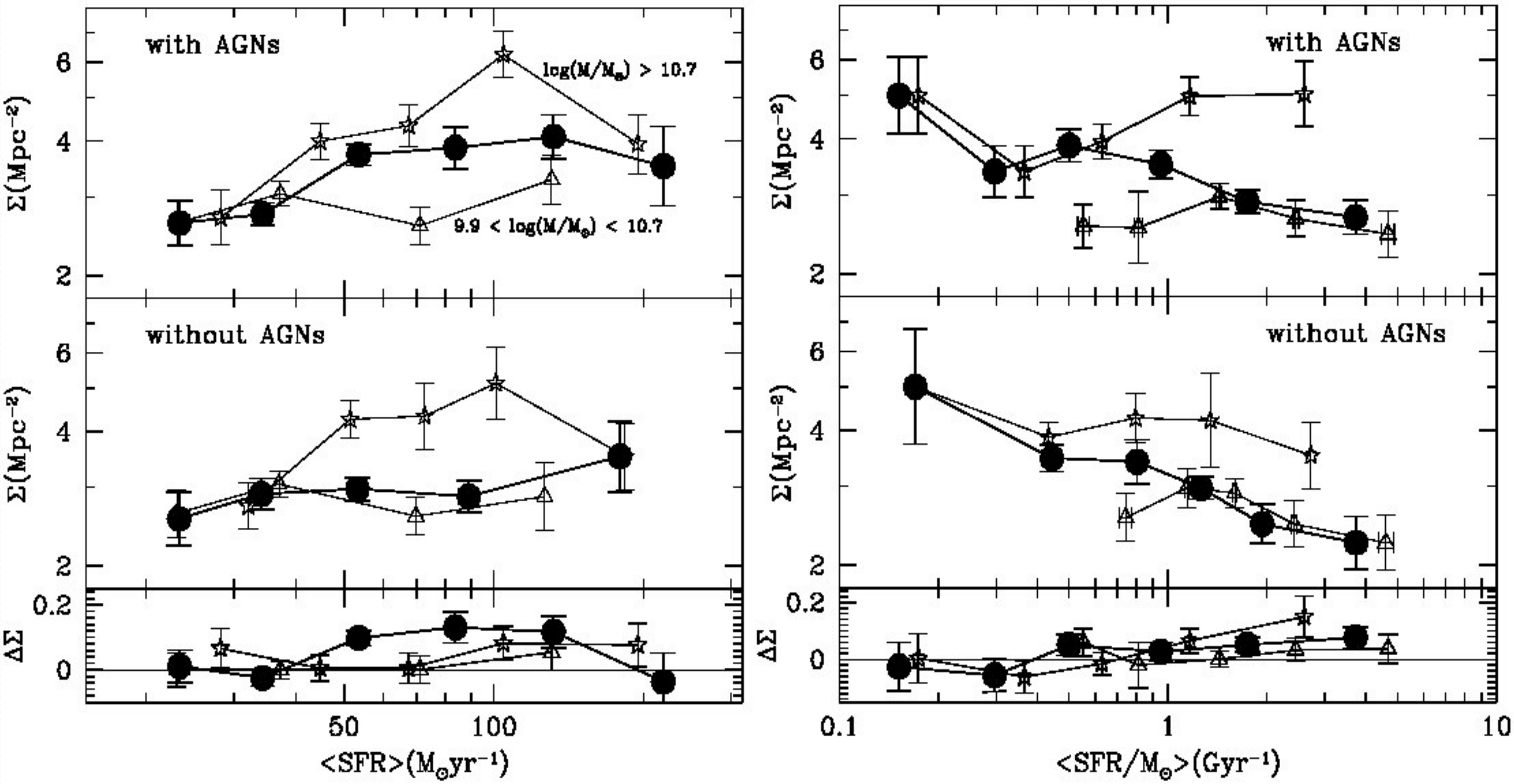


- Ξ= number of galaxies within 0.75 Mpc and within 3000 km/s @ z_{AB} < -21.35 mag
- Ξ completeness = number of galaxies with z_{spec} over all galaxies in the cylinder @ z_{AB} < mag limit
- 79% ±0.05 completeness level@ z_{AB} < -21.35





SFR and sSFR vs density



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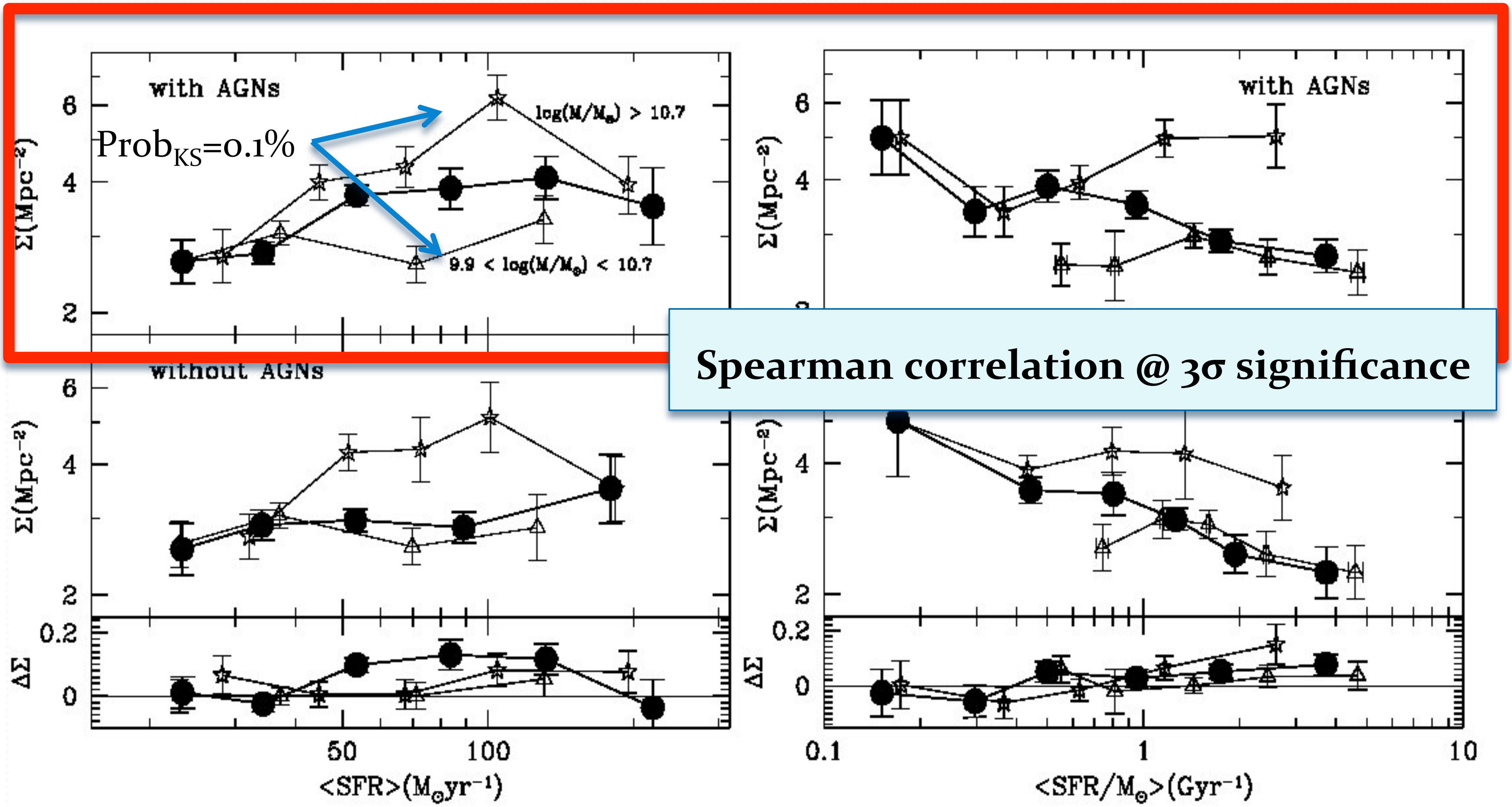

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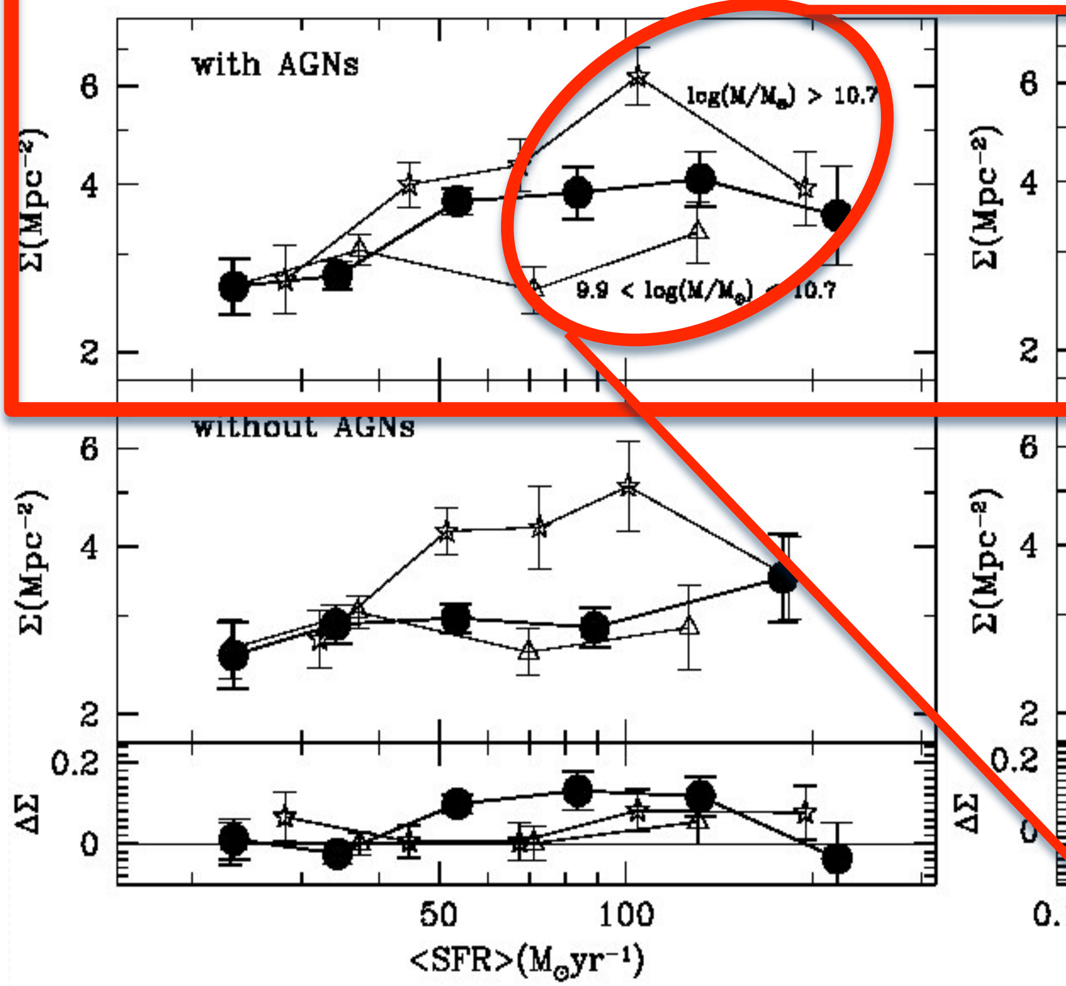
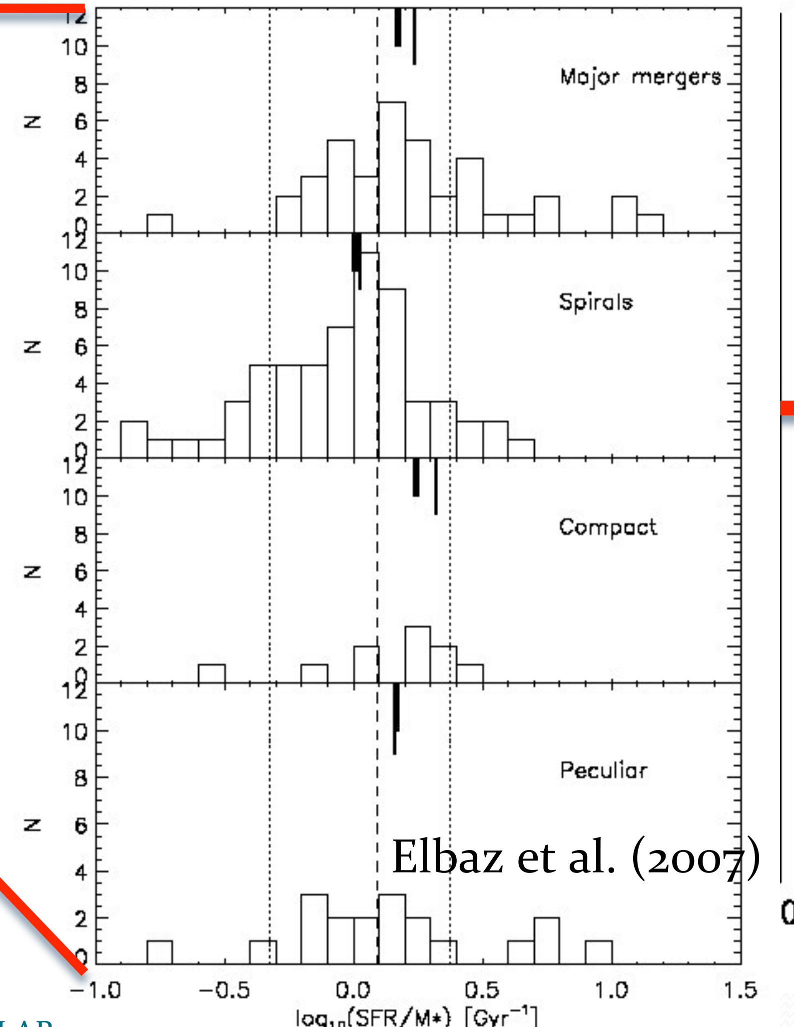
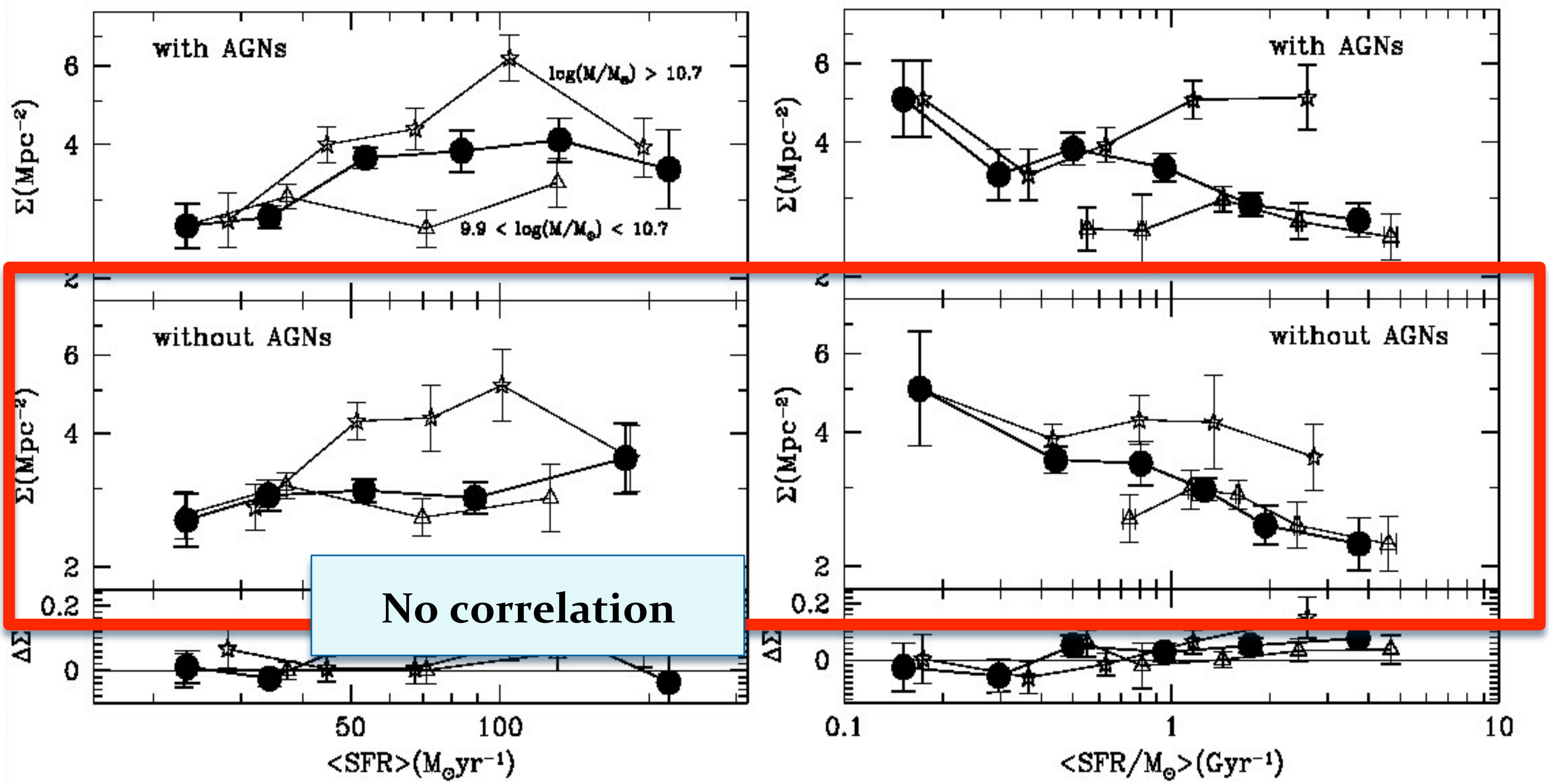


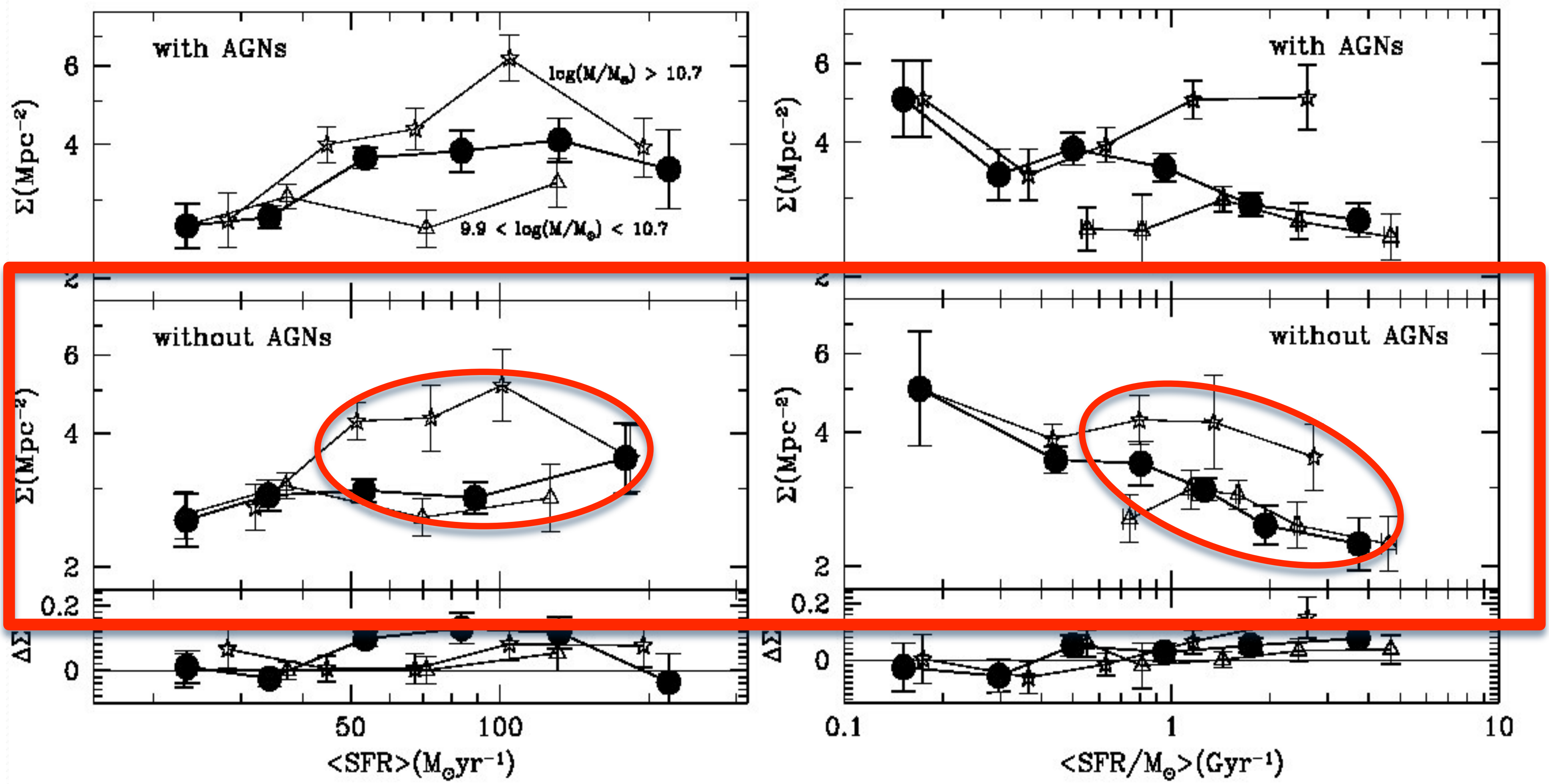


Elbaz et al. (2007)

SFR and sSFR vs density

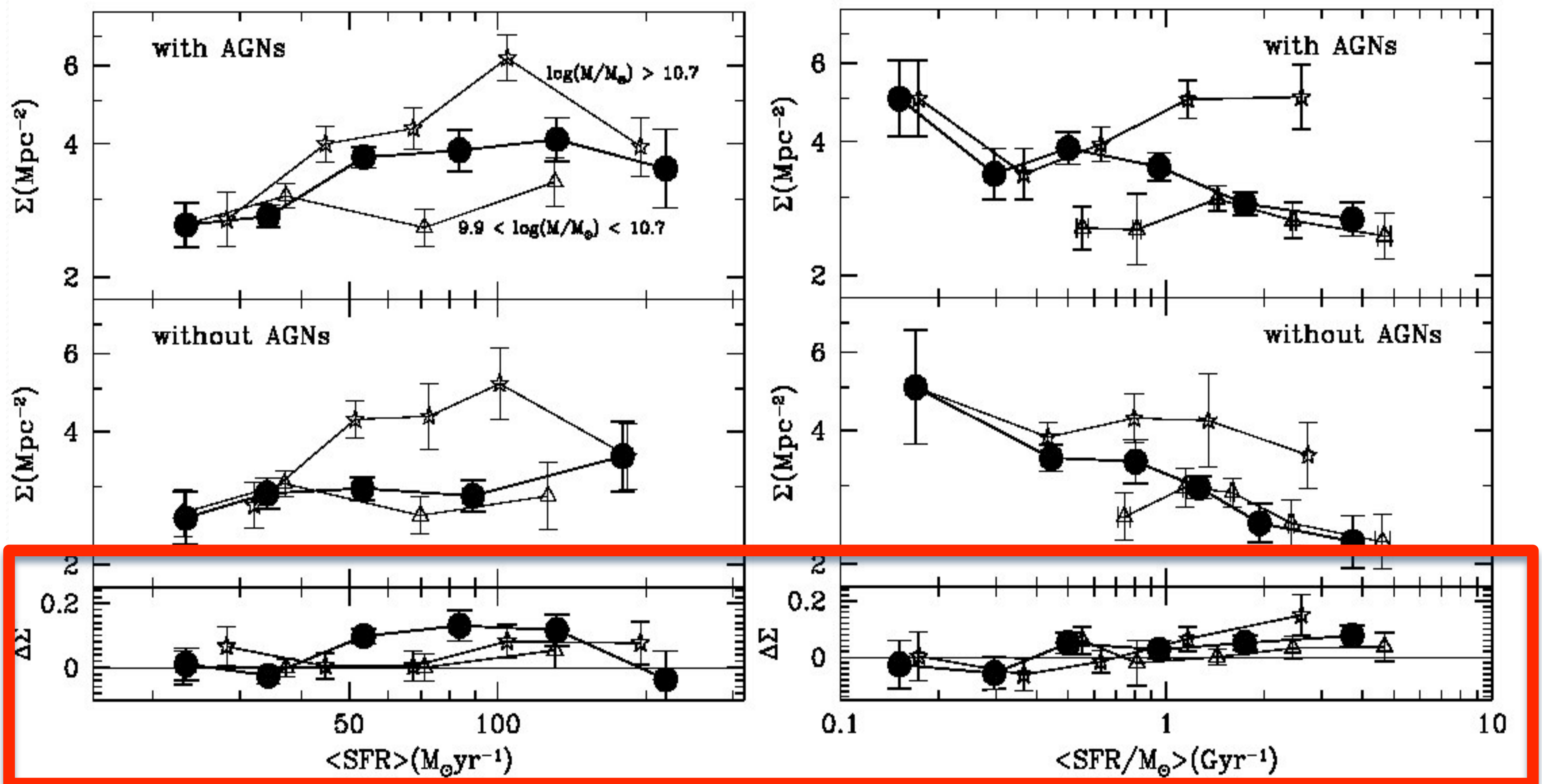


The AGN root



with AGNs
log(M/M☉) > 10.7
9.9 < log(M/M☉) < 10.7
without AGNs
Σ(Mpc⁻²)
ΔΣ
<SFR>(M☉yr⁻¹)
<SFR/M☉>(Gyr⁻¹)

The AGN root



with AGNs
log(M/M⊙) > 10.7
9.9 < log(M/M⊙) < 10.7
without AGNs
Σ(Mpc⁻²)
ΔΣ
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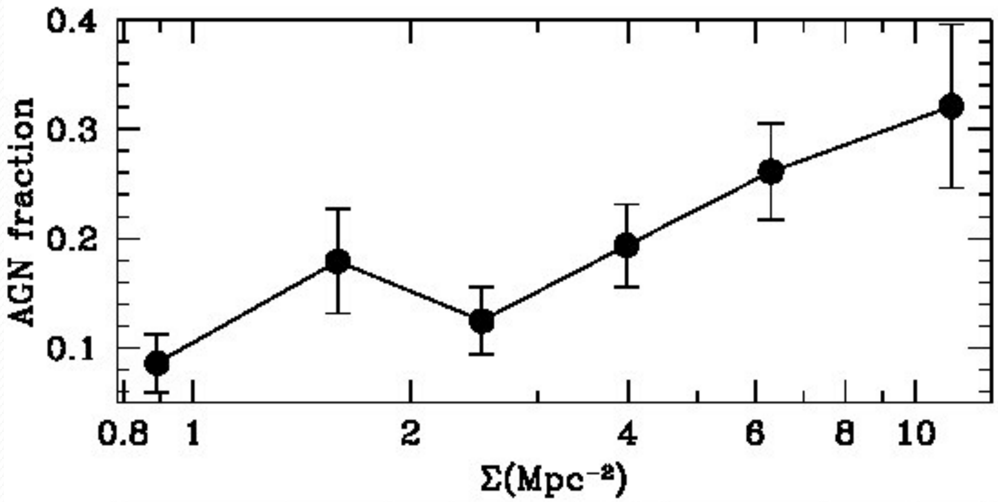
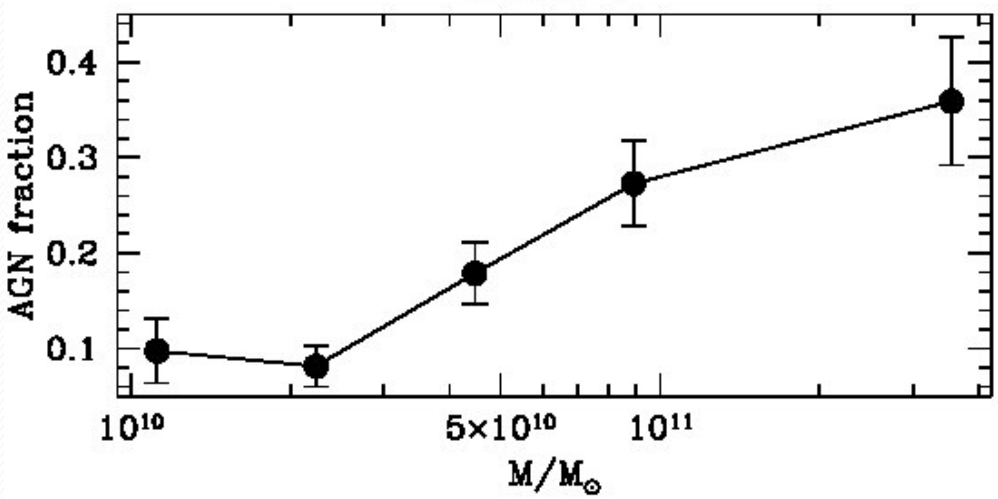
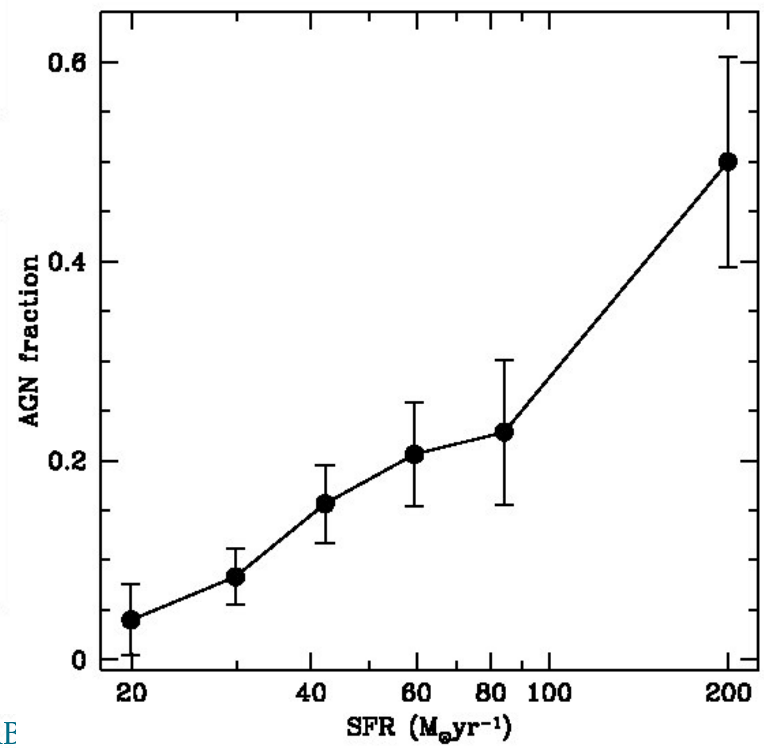
AGNs or just massive galaxies?



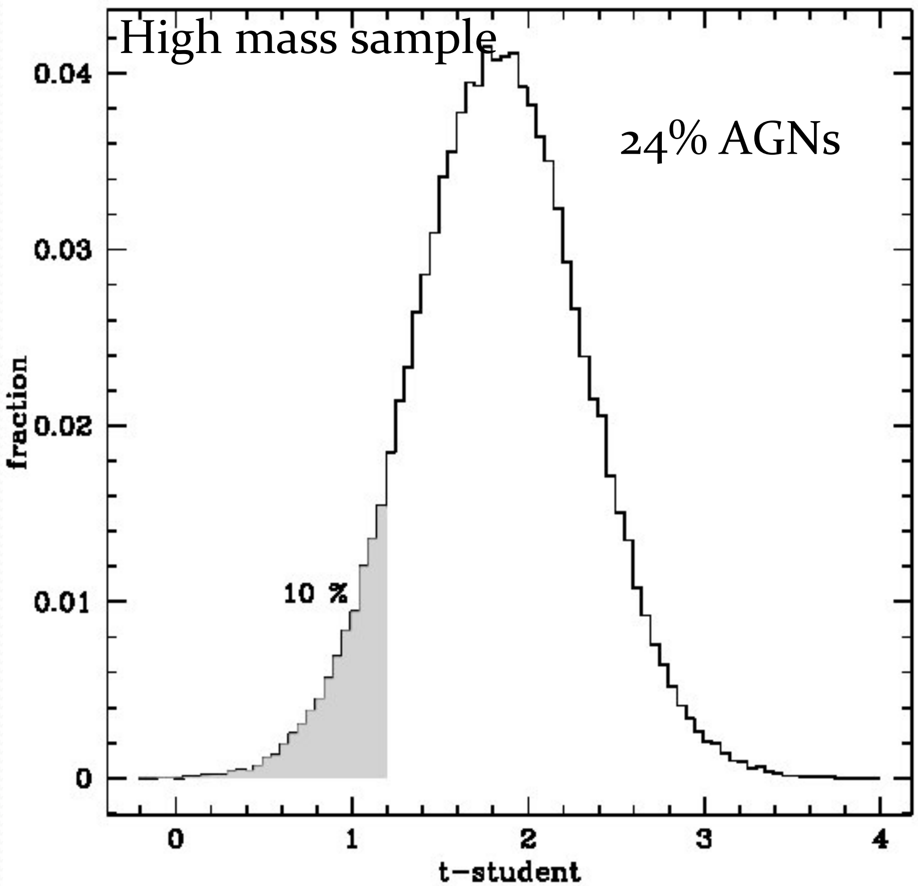


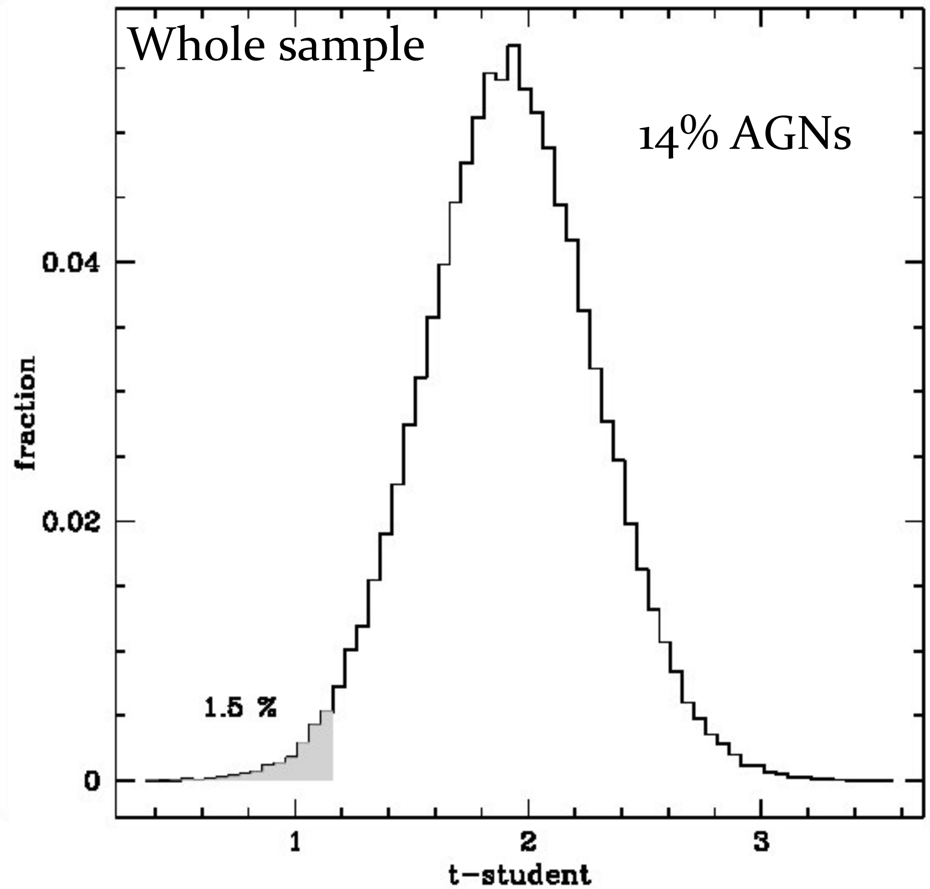
Consistent z ~0
(Kauffmann et al. 2003)
and z~0.5 AGN fraction
(Silverman et al. 2009)



AGNs or just massive galaxies?

- 100000 simulation with removal of $N=N_{AGN}$ randomly chosen galaxies
- Spearman test applied to remaining sample





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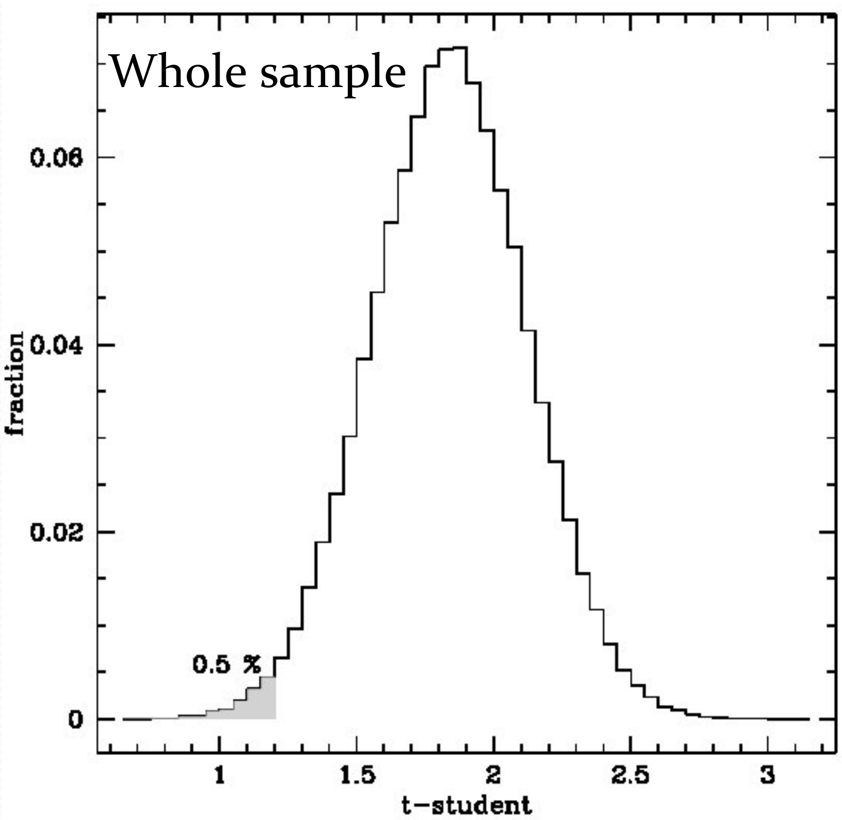
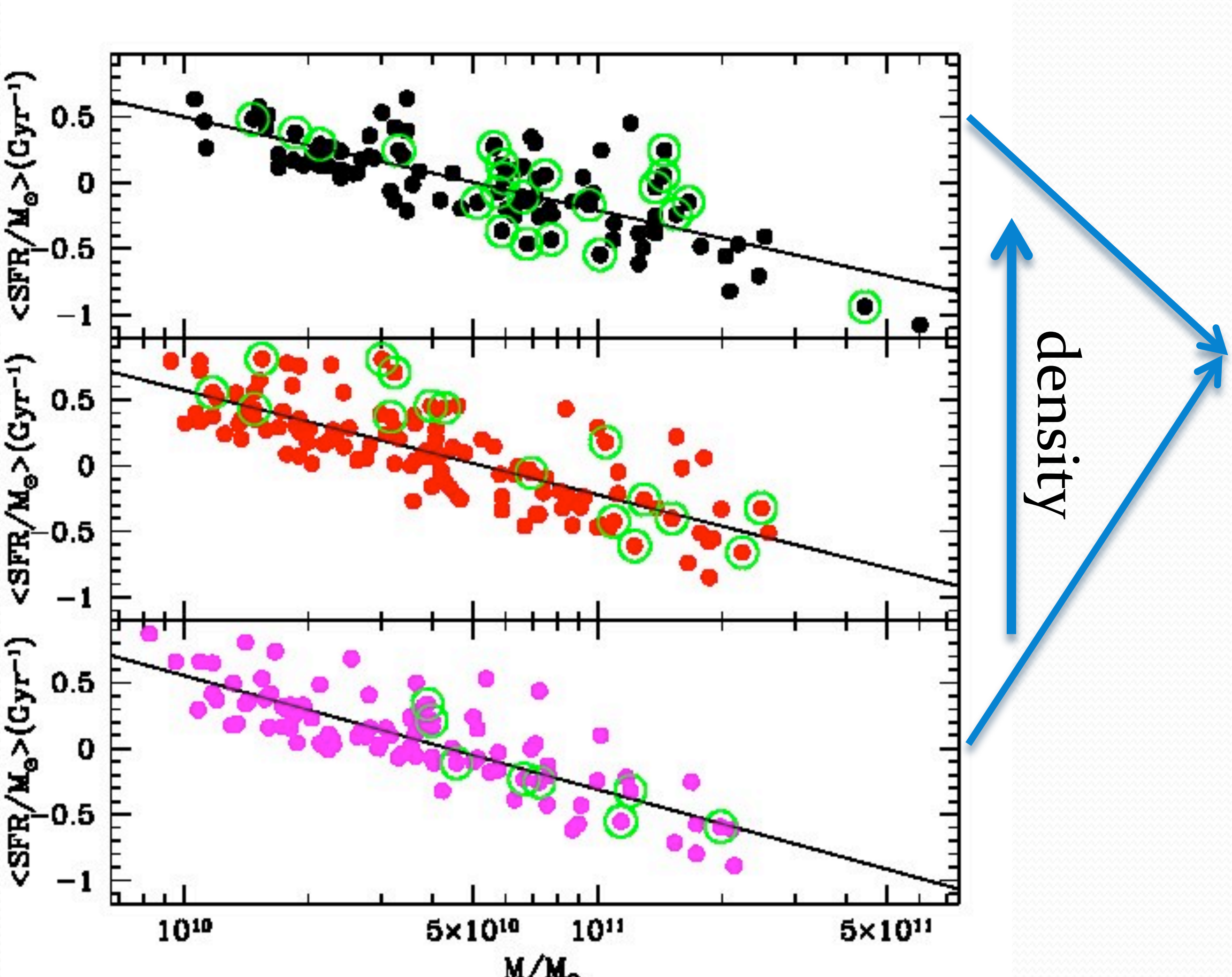


- The removal of only massive galaxies leads to a 0.5% probability of deteriorating the correlation

- Significance correlates with AGN fraction

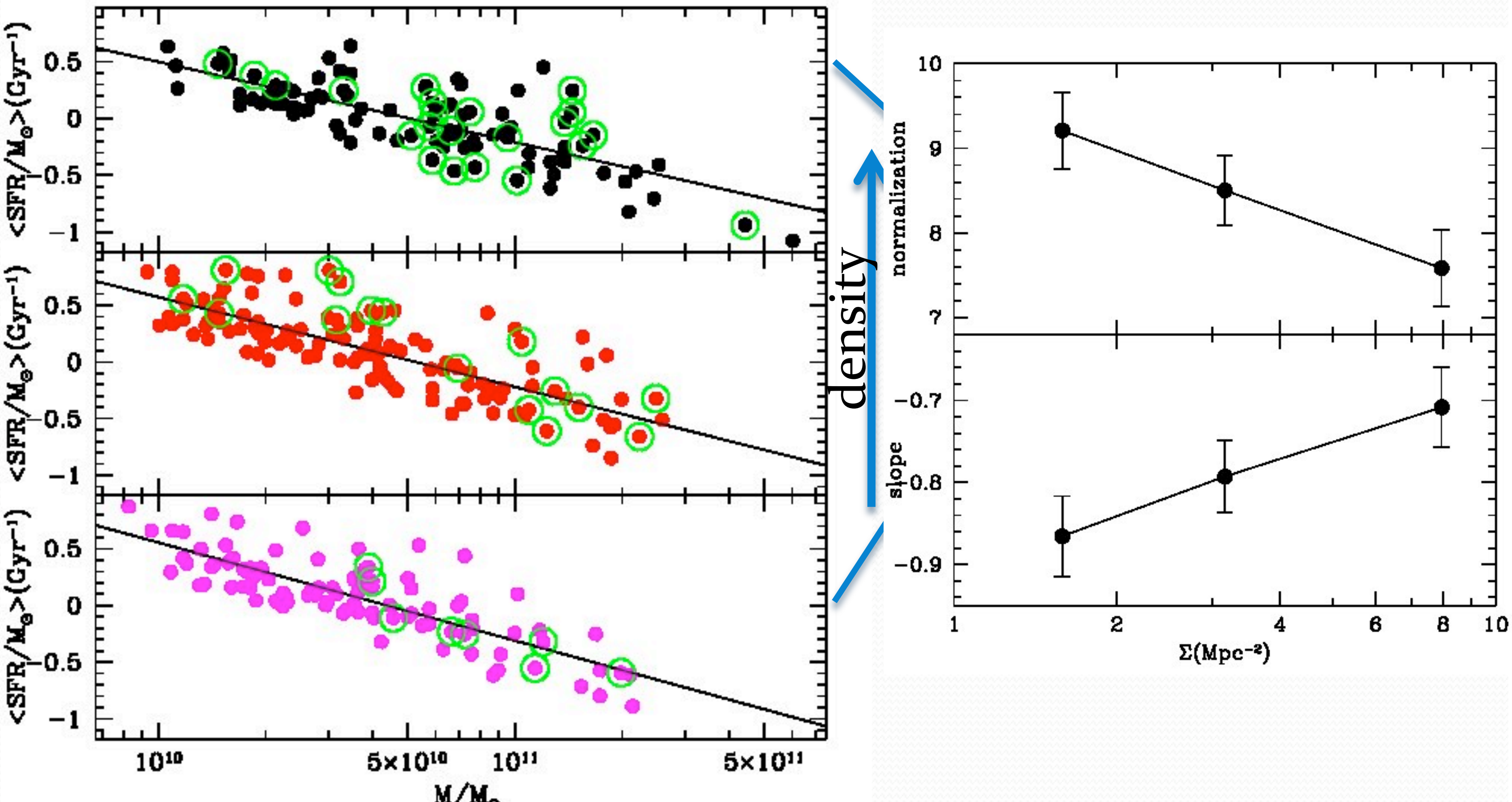
- "...If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck."
- duck=AGN

sSFR-stellar mass vs. density



2D KS test shows that high and low density distributions are not drawn from same parent distribution: $\mathrm{Prob}_{KS} = 6\times10^{-3}$

sSFR-stellar mass vs. density



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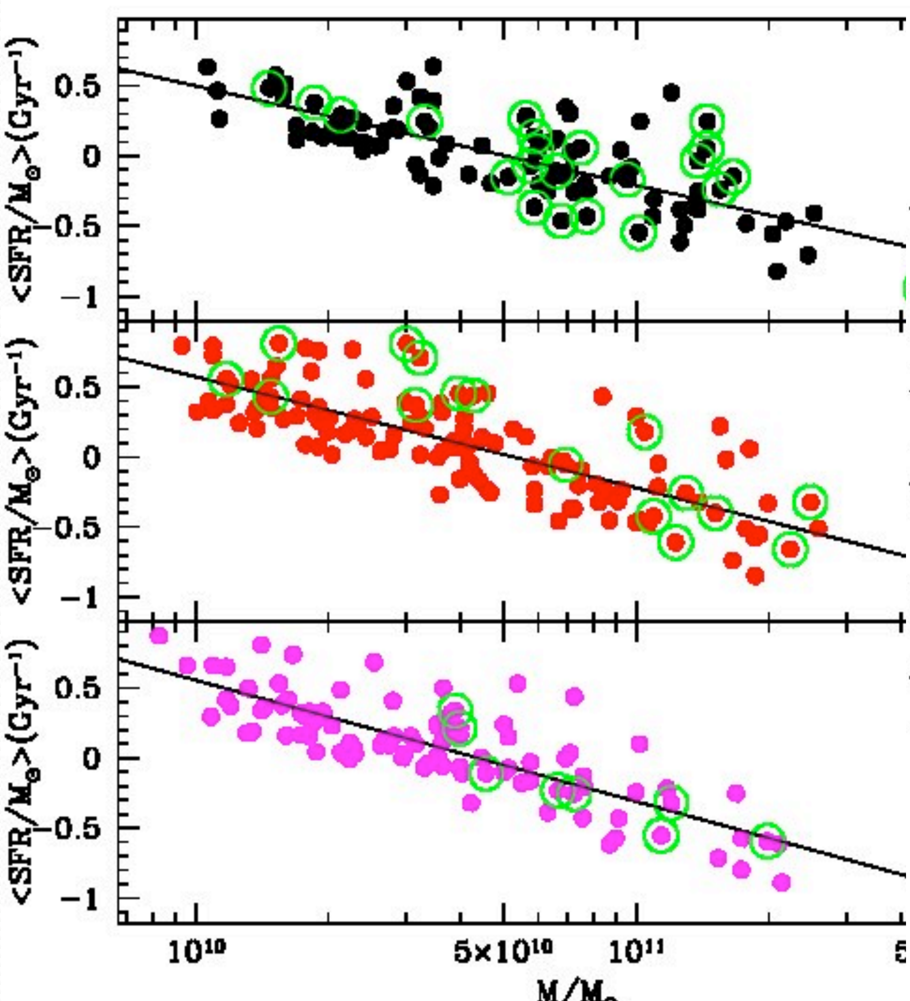

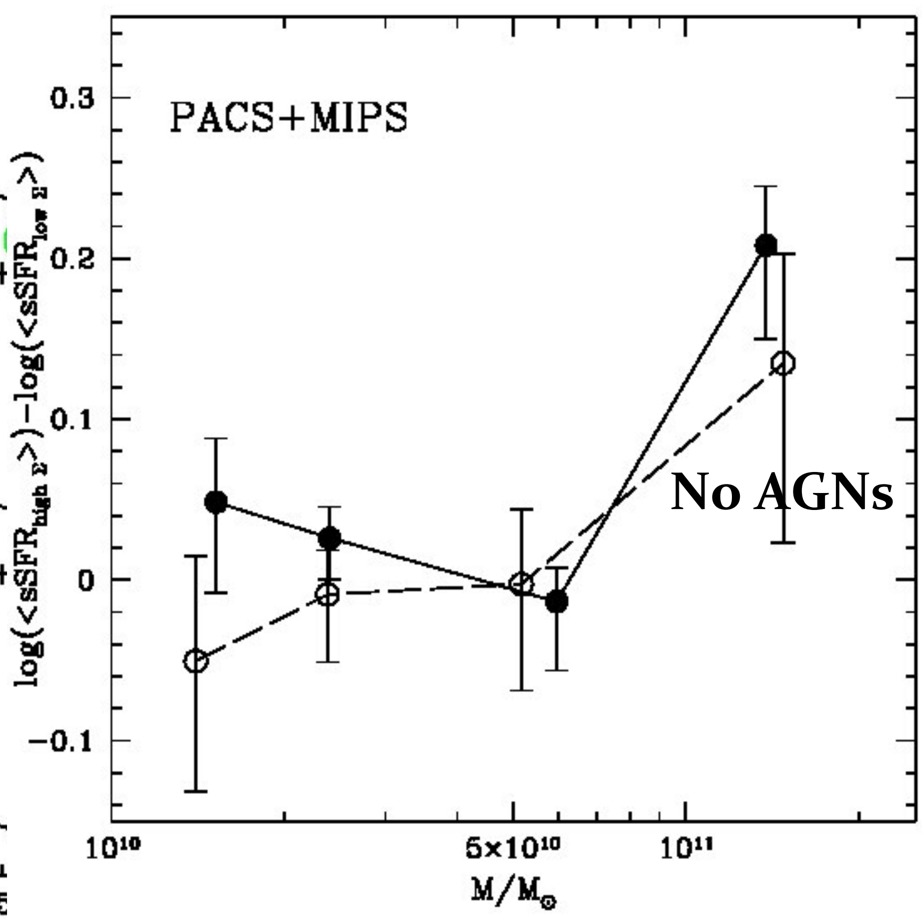

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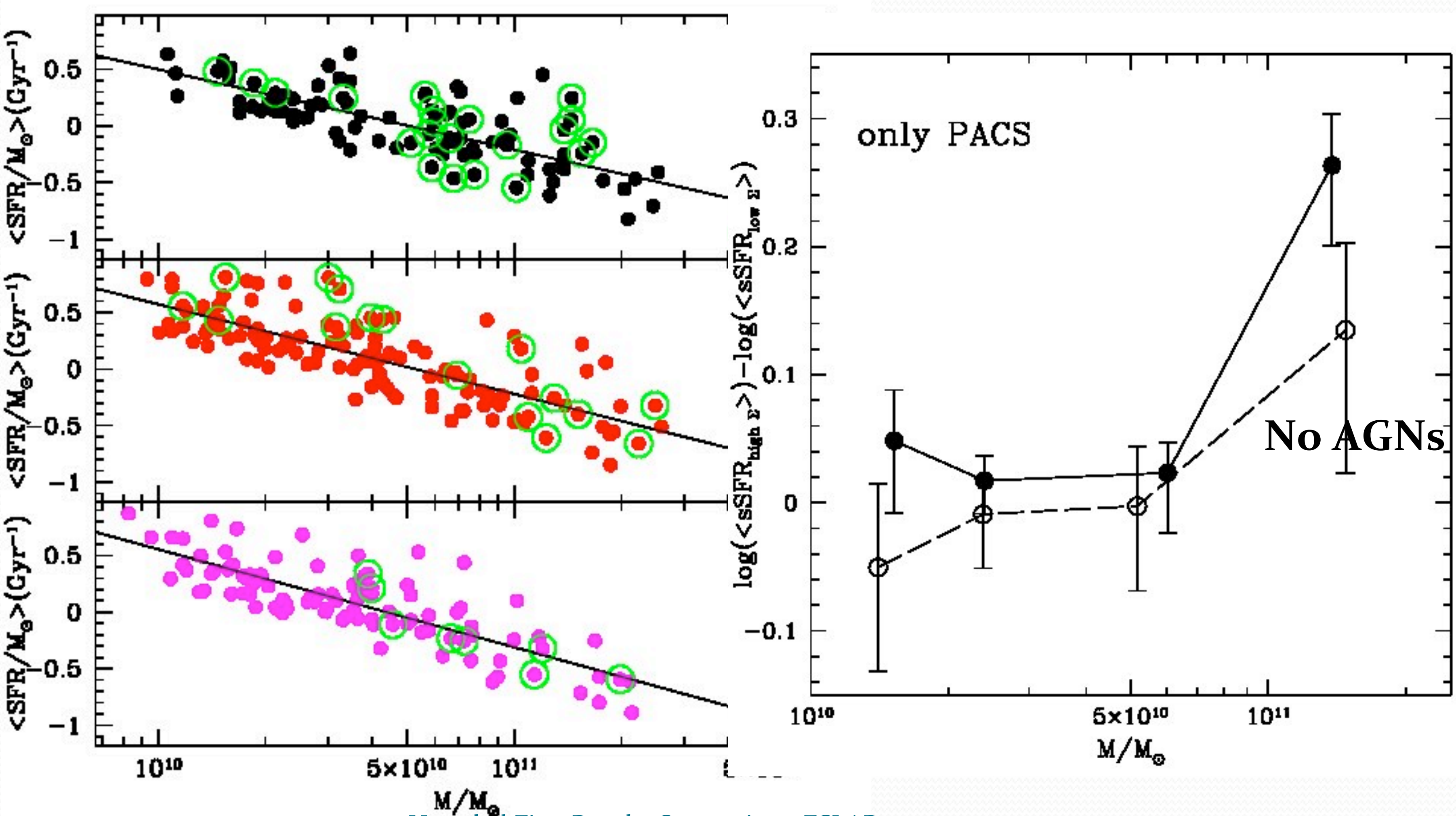

Conclusions

- We observe a reversal of the SFR-density relation @ z~1 not due to mass segregation
  - ✓ different relation in different mass bins
- we observe a sSFR-density anti-correlation due to different contribution of low and high mass galaxies respectively
- we explain the environmental effect via the AGN root
  - ✓ higher fraction of AGNs in high density regimes
- we see a clear environmental effect in the sSFR-mass relation
  - ✓ hint for AGN root but need of larger statistical sample (soon available!)