Does Environment Matter? A Lesson from the Coma Supercluster

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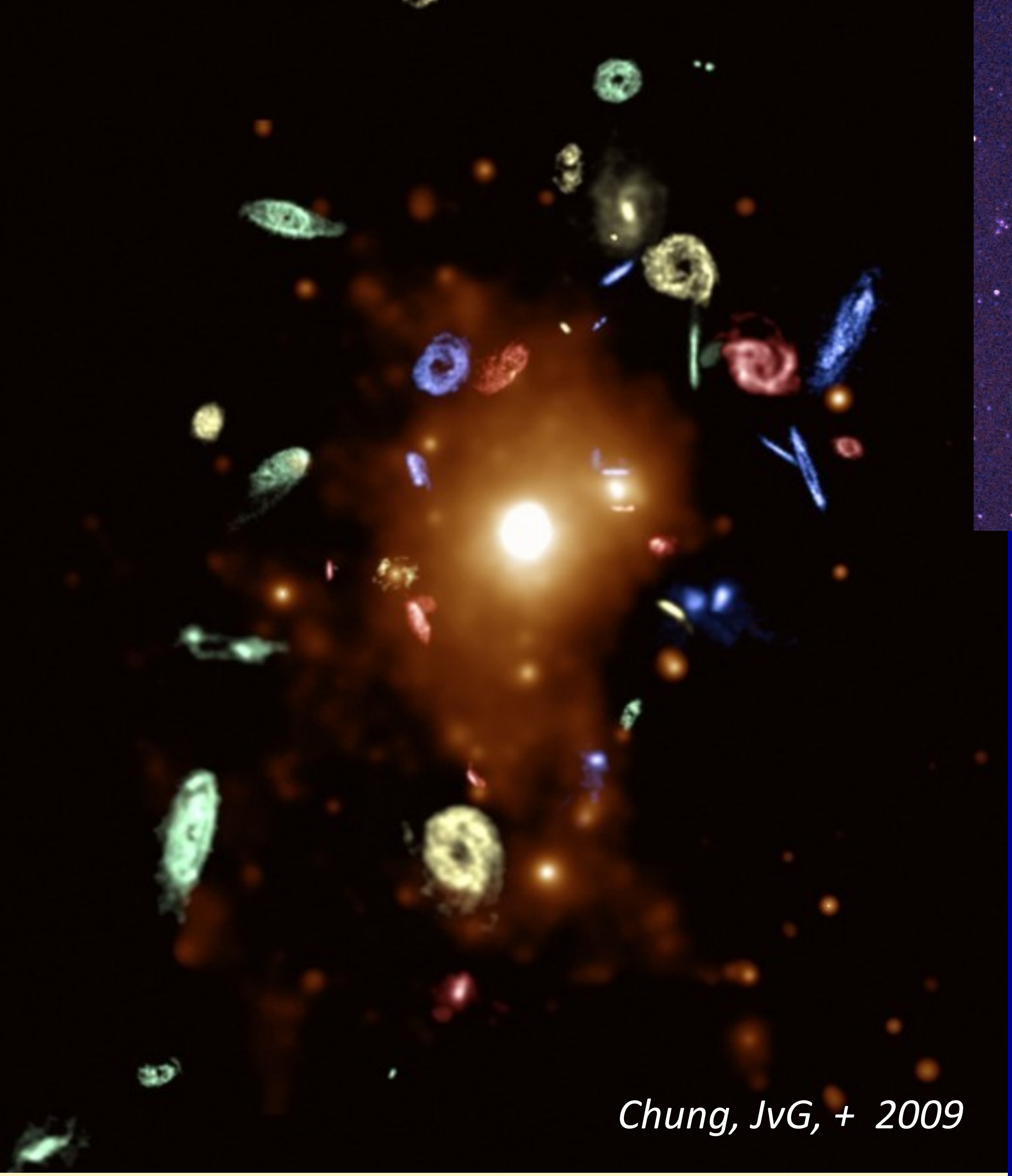
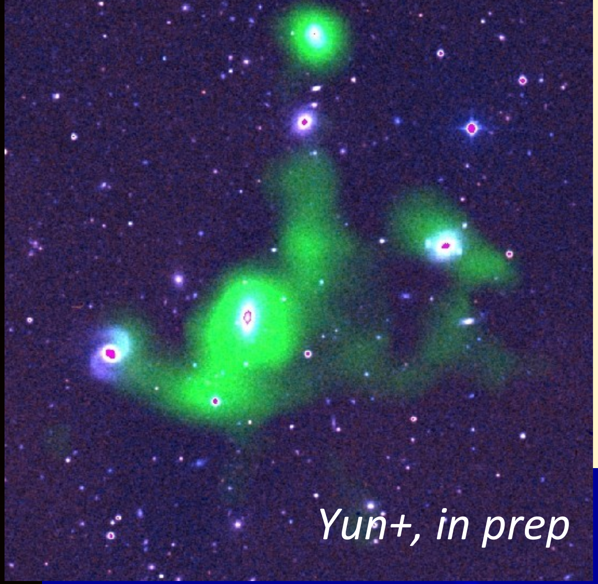
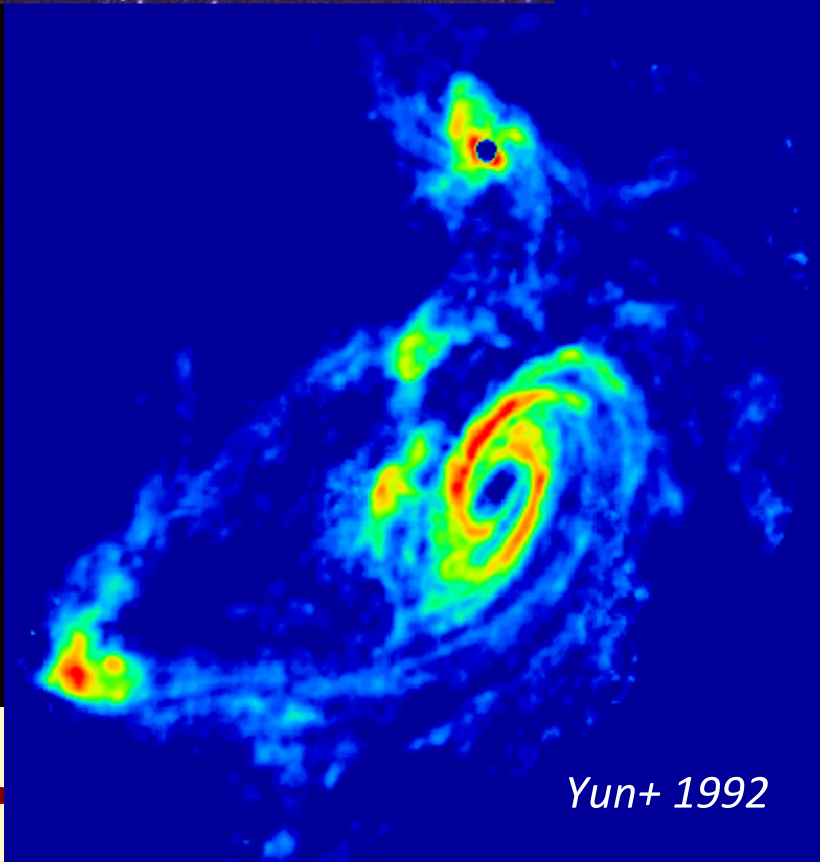
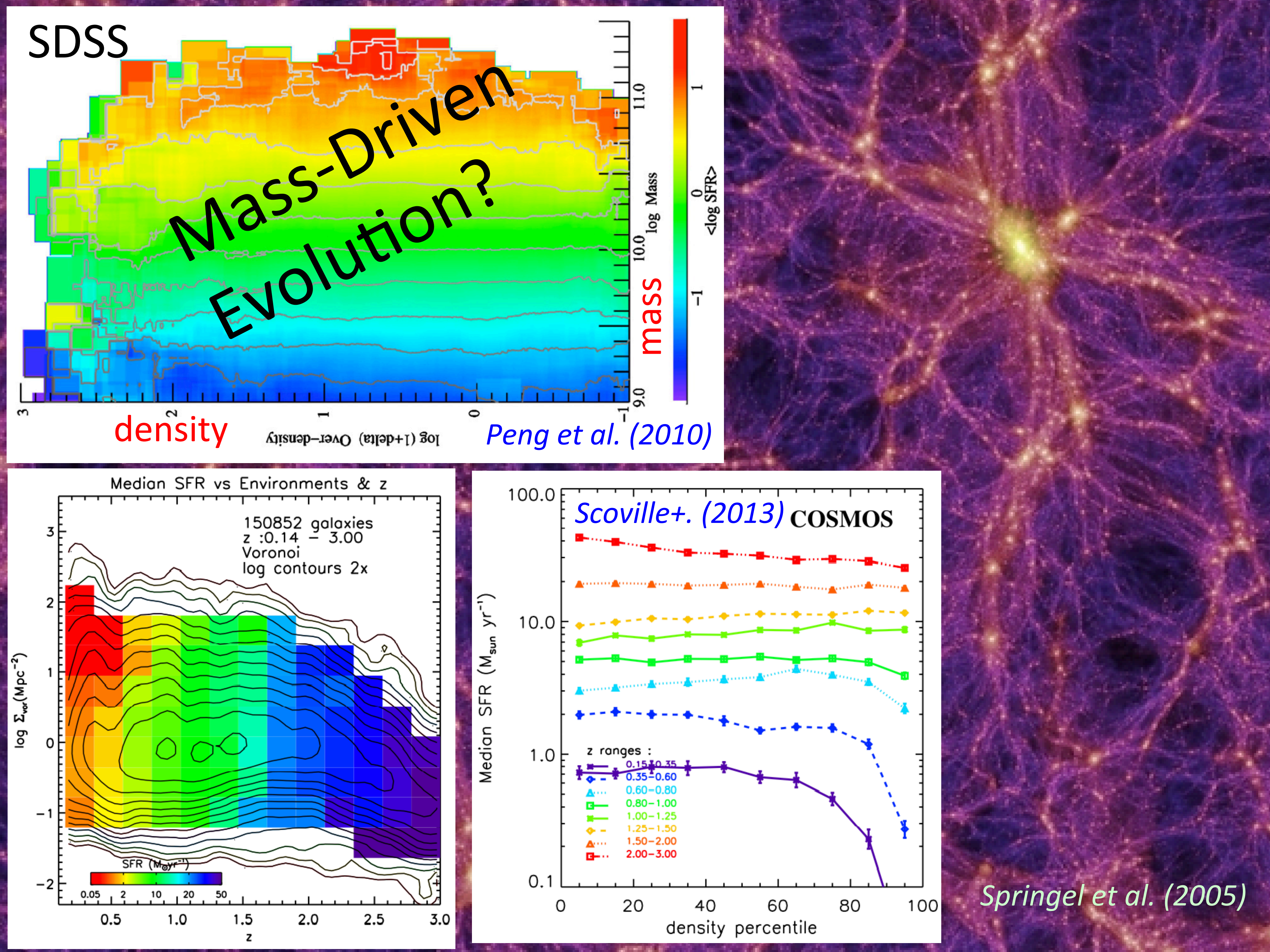






Of Course, It Matters….


SDSS
Mass-Driven Evolution?
mass
density
log (1+delta) Over-density
log Mass
<log SFR>
Peng et al. (2010)
Median SFR vs Environments & z
150852 galaxies
z :0.14 – 3.00
Voronoi
log contours 2x
log Σvor(Mpc^-2)
SFR (M⊙yr^-1)
z
Scoville+. (2013)
COSMOS
Median SFR (Msun yr^-1)
density percentile
z ranges :
0.15–0.35
0.35–0.60
0.60–0.80
0.80–1.00
1.00–1.25
1.25–1.50
1.50–2.00
2.00–3.00
Springel et al. (2005)

Motivation

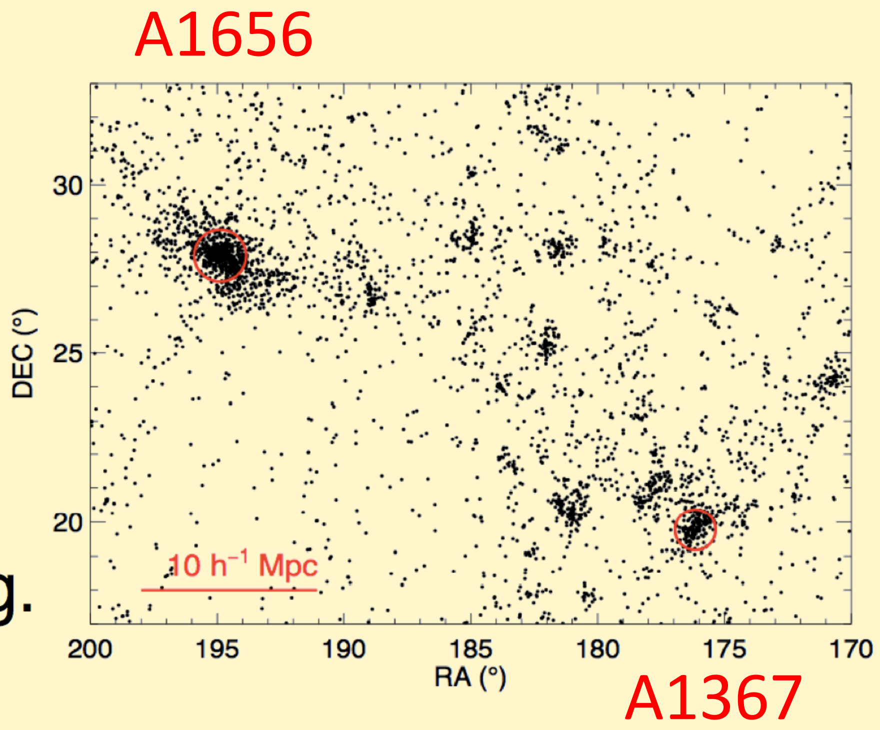
- Test environ. mapping technique (with Voronoi Tessellation & Minimal Spanning Tree) on Coma Supercluster (z=0.023), **identifying cluster, group, filament, and void populations**

- Use WISE all-sky survey [22] to get dust-obscured SFRs in Coma, combined with GALEX for **total SFR**

- **Quantify the degree to which pre-processing affects galaxies at z~0** by measuring fraction of SF and blue galaxies as a function of environment

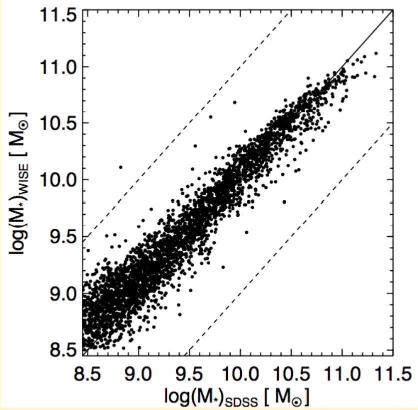
Coma Supercluster

- z=0.023 [+/- 2000 km/s]
- 2 massive clusters
- Dozens of groups
- Large dynamic range of densities over 500 sq. deg.
- SDSS spect. complete to r≤17.77 mag



Sample

- 3505 galaxies with: 8.5 $M_\odot$<log M*<11.5 $M_\odot$
  - r ≤ 17.77 mag
  - SDSS spec-z (SPECPRIMARY=1 & ZWARNING=0)
  - Detections in WISE [3.4] & [4.6] (for M_*)



- SFR_{UV} from *GALEX*, and SFR_{IR} from WISE [22]

0.02 $M_\odot$/yr < SFR < 5 $M_\odot$/yr

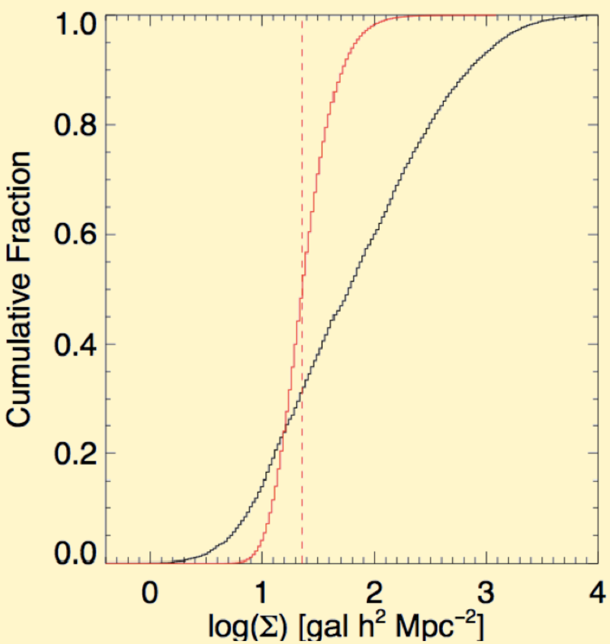
Star Formation Rate (SFR)

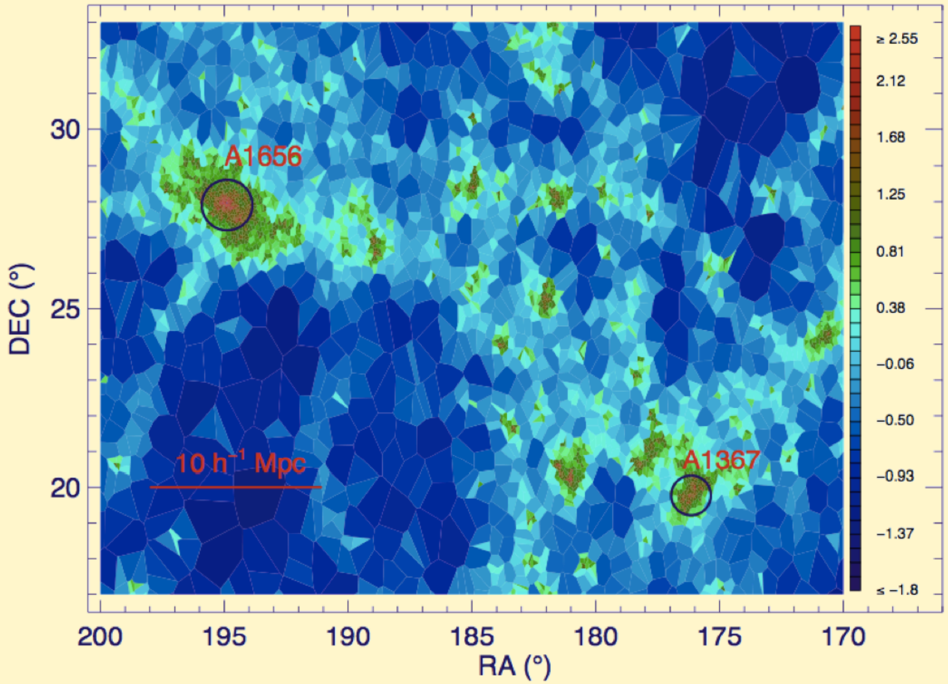
- SFR(IR)
  - From WISE 22 mm (>4.7 mJy)
  - L(IR) > 2 x 10^8 $L_{\odot}$ or SFR(IR) > 0.2 $M_{\odot}$ /yr
  - 1039/3505 galaxies detected
- SFR(UV)
  - GALEX NUV (60-30,000 secs)
  - L(NUV) → SFR(UV), SFR(UV) > 0.02 $M_{\odot}$ /yr
- Adopted the calibration by Murphy et al. (2011)

Mapping the Supercluster Environment

Voronoi Tessellation (VT)

- Local den. ∝ (cell area)$^{-1}$



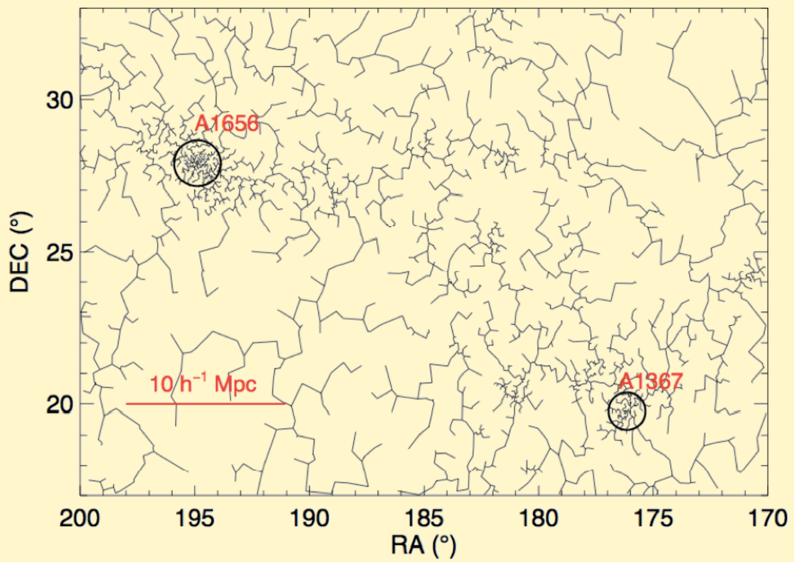


Mapping the Supercluster Environment

Minimal Spanning Tree (MST)

- Define continuous structures by "pruning" sections of branches connected entirely by branches of length ≤ L_{crit}

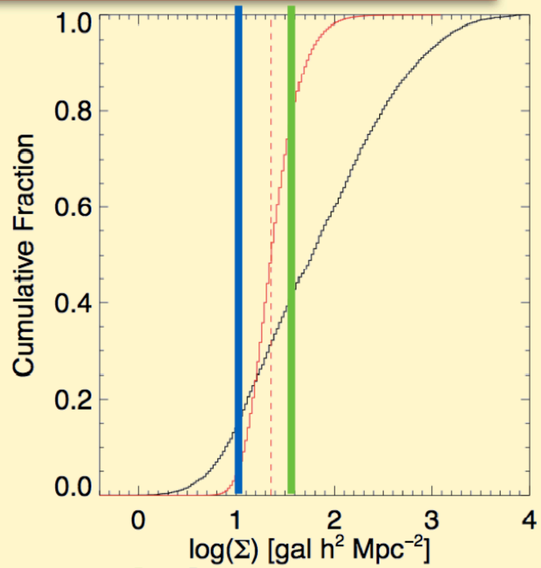
- Selecting cluster, group, and filament structures entails more than one L_{crit} value

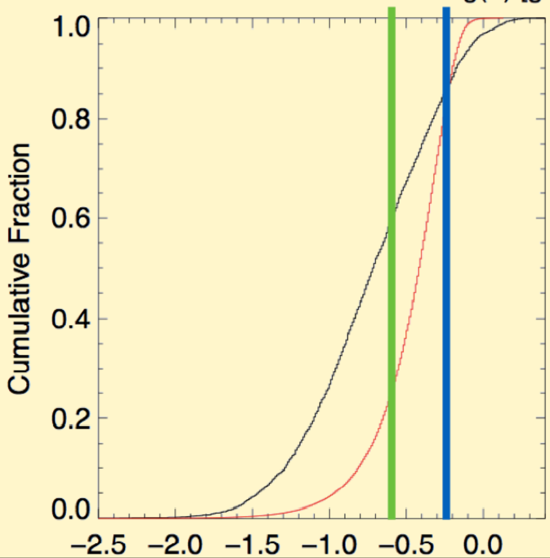


Choosing L_{crit}

- **L_{crit1}**: separate cluster/group from filament
- **L_{crit2}**: separate filament from void
- Use VT dens. thresholds to define these boundaries, exploiting the similarity of VT cell and MST branch length distributions
  - For L_{crit1}: 40 gal. h^2 Mpc^{-2}
  - For L_{crit2}: 10 gal. h^2 Mpc^{-2}

VT



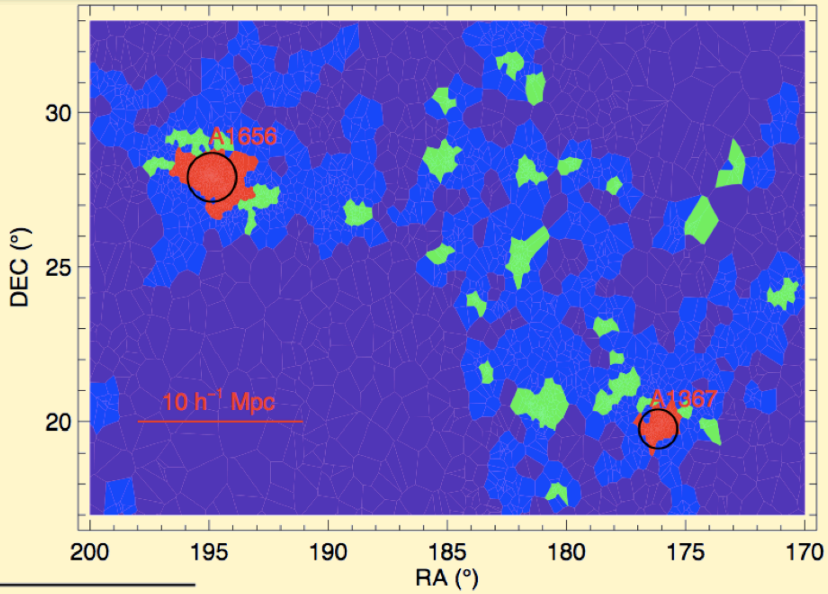


MST

Mapping the Supercluster Environment

MST-defined environments

- cluster, group, filament, void

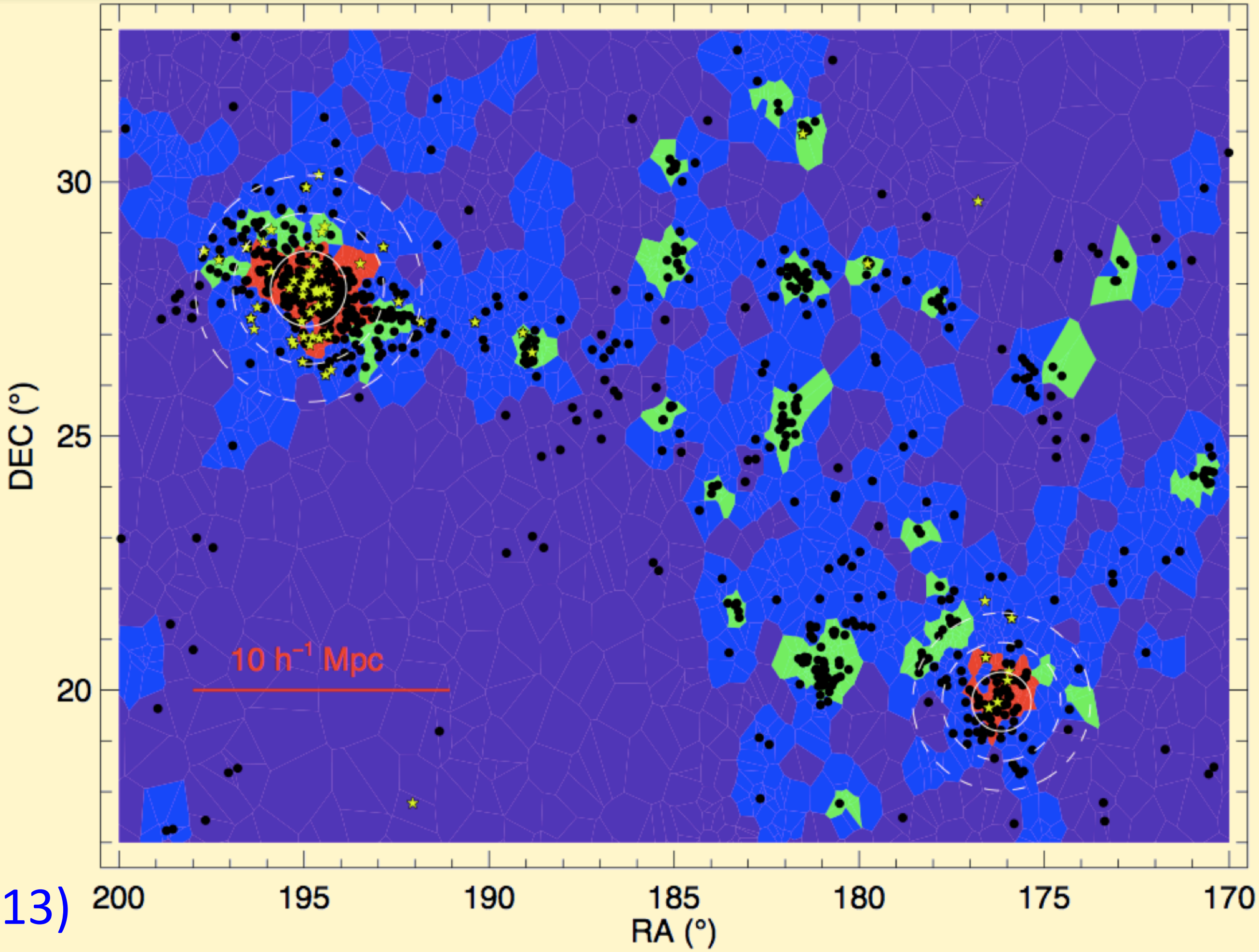


Environ.	N_{gal}	Area (h^{-2} Mpc^2)	<Σ> (h^2 Mpc^{-2})	log(<SSFR>) [yr^{-1}]
Cluster	741	19.5	108.5	-11.27
Group	716	57.5	38.7	-11.06
Filament	1292	423.6	6.3	-10.60
Void	756	891.0	1.7	-10.40

Distribution of Quiescent Galaxies

- Black dots: quiescent galaxies
- Yellow stars: k+A (post-starburst) galaxies (62 total)
- Obvious abundance of quiescent galaxies in (most) groups
- Significant quiescent pop. extends to 2-3R_{vir} of A1656.

(cf., Bahé et al. 2013)

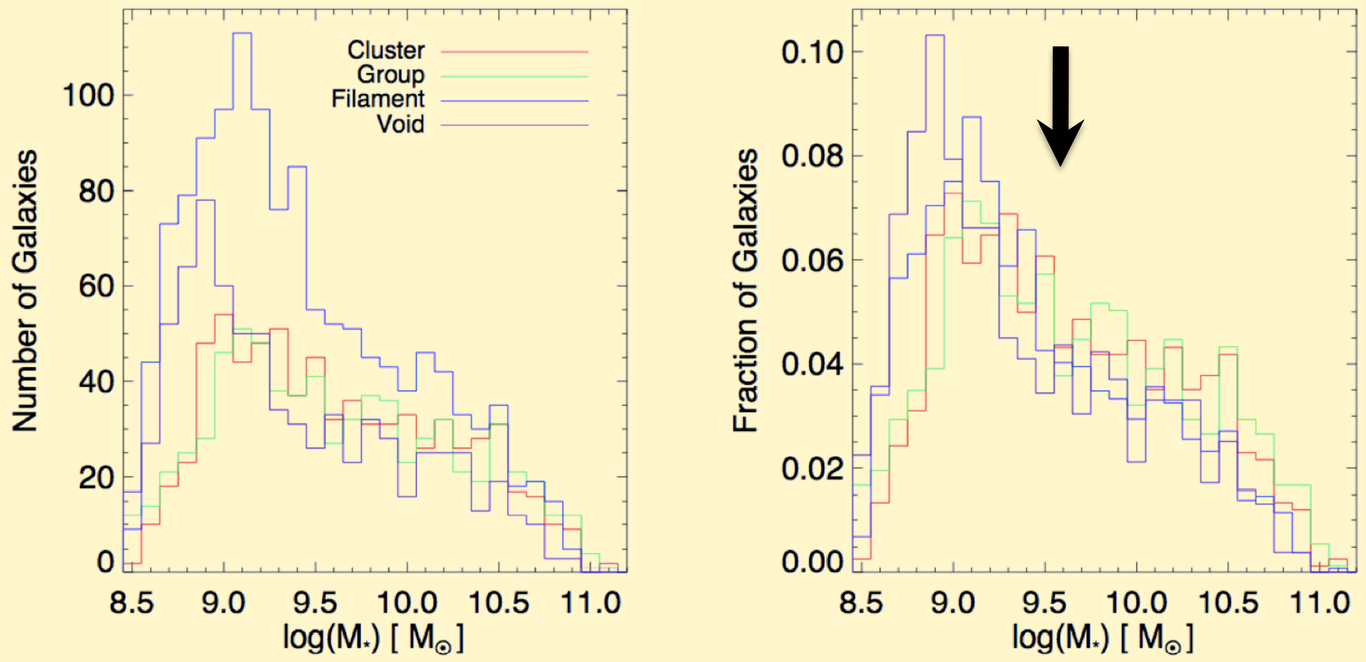


Mapping the Supercluster Environment

Stellar mass distributions of galaxies in each environment

"dwarf": 8.5 $M_\odot$<log M*<9.5 $M_\odot$

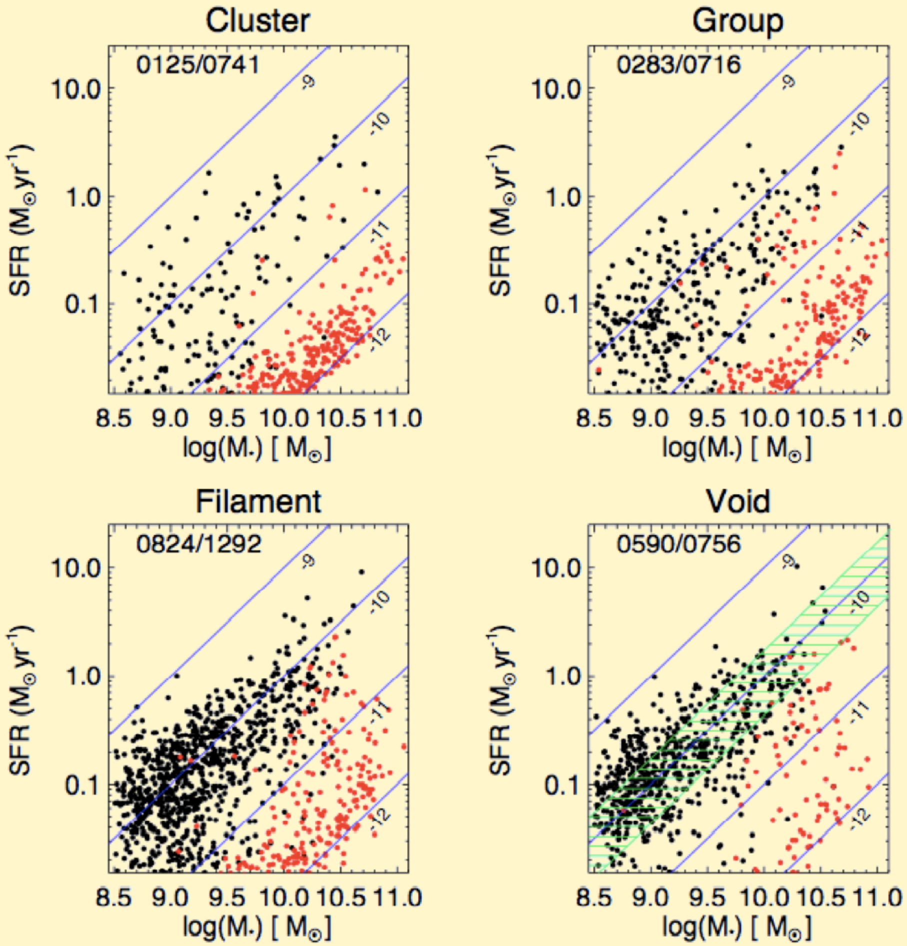
"massive": log M* > 9.5 $M_\odot$



SFR vs Environment

star-forming (SF) galaxy:

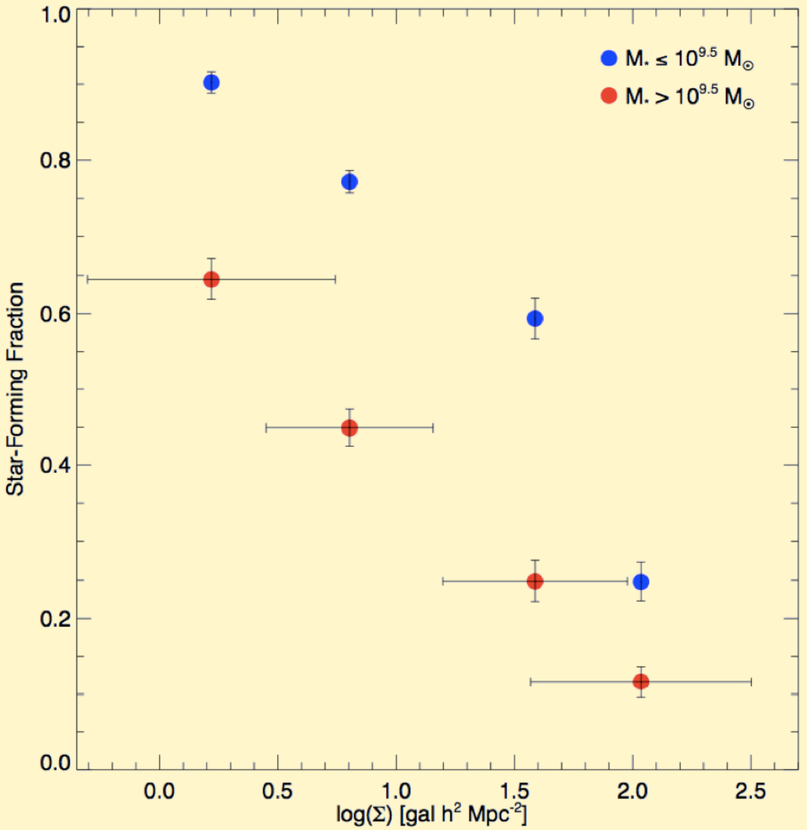
- log(SSFR) > -11 [yr^{-1}]
- $D_n4000 < 1.6$



SFR vs Environment

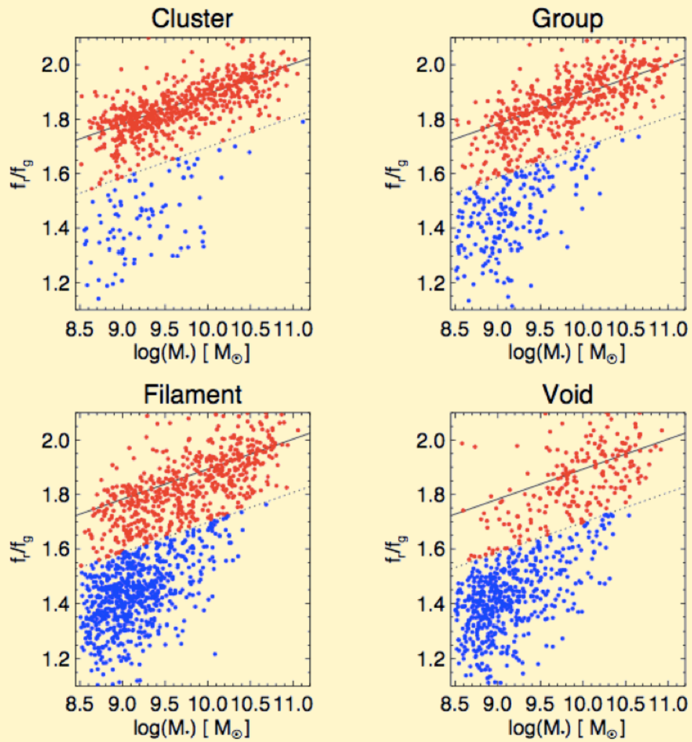
- Fraction of SF galaxies in each environment, separated by dwarf and massive galaxies

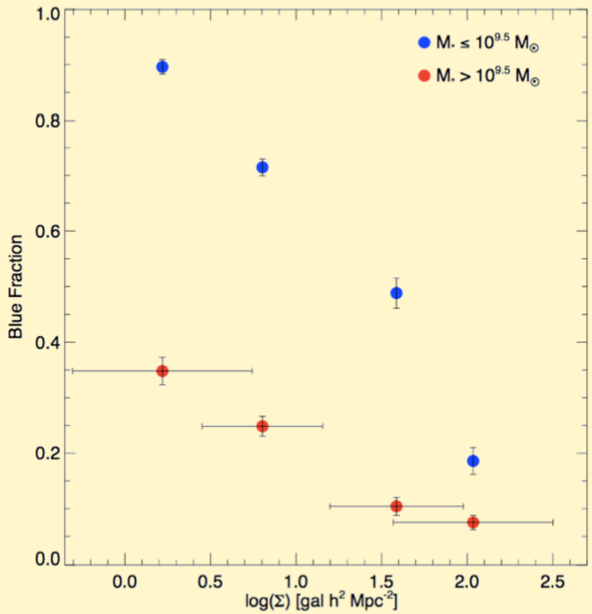
- f_{SF} declines steadily with increasing density, for both mass bins



Color vs Environment

- g-r colors
- decline in blue fraction with increasing density
- optical extinction artificially lowers f_{blue}, especially for massive galaxies





SFR vs Environment

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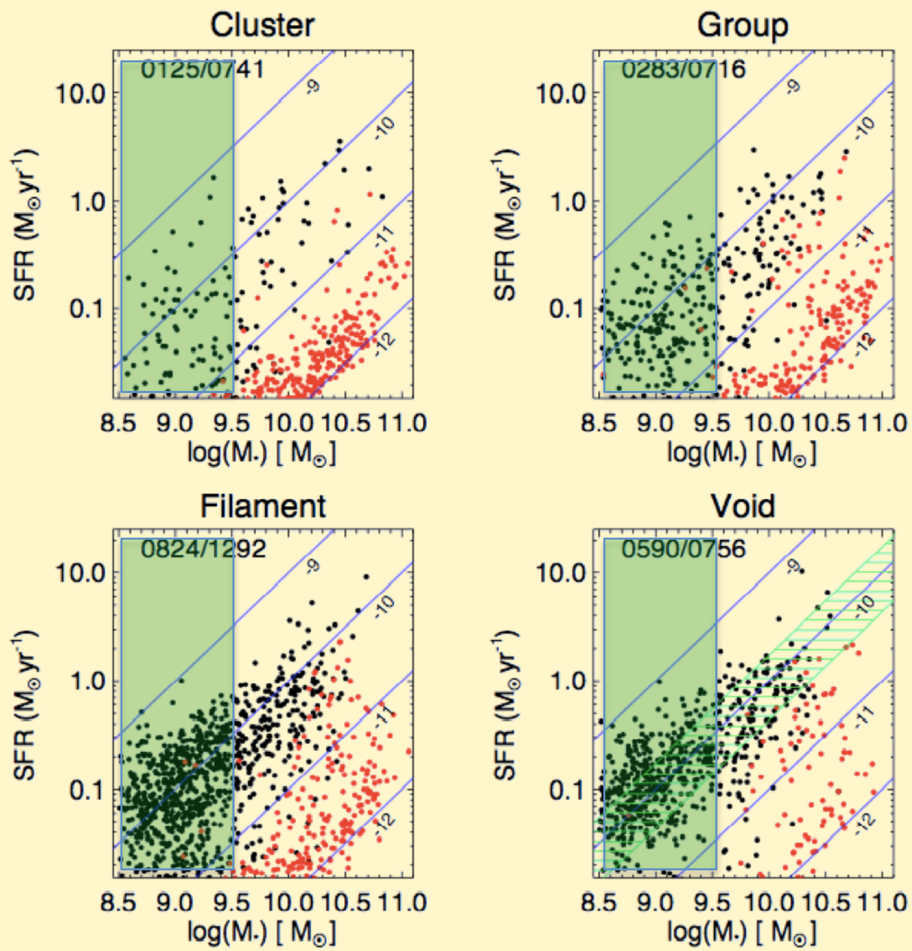
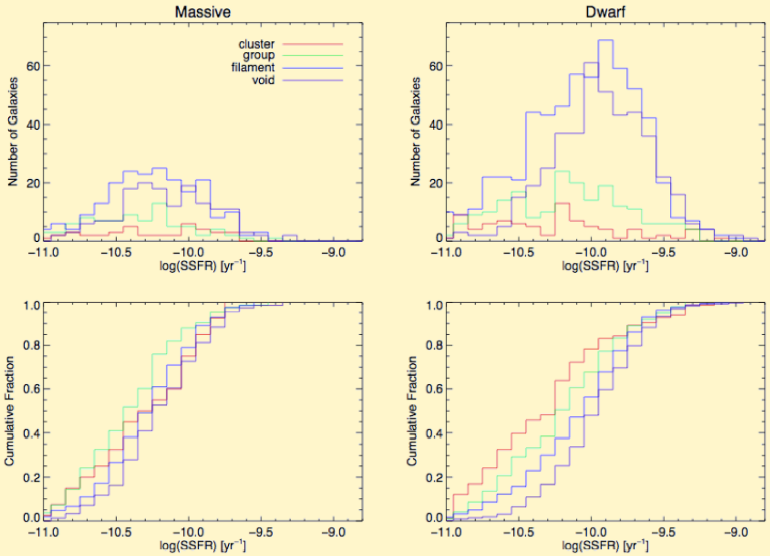
Mass Selection



SFR Distribution vs Environment

- Mann-Whitney U test comparing distrib. of SSFRs & SFRs for SF galaxies in each environ.

Environments	$P_{U_{SSFR}}$	$P_{U_{SFR}}$	$P_{U_{SFRd}}$	$P_{U_{SFRm}}$
Cluster-Group	**0.12**	**0.34**	**0.018**	**0.064**
Cluster-Filament	<0.0014	**0.030**	<0.0014	**0.20**
Cluster-Void	<0.0014	<0.0014	<0.0014	**0.39**
Group-Filament	<0.0014	**0.0068**	<0.0014	**0.086**
Group-Void	<0.0014	<0.0014	<0.0014	**0.0031**
Filament-Void	<0.0014	**0.0040**	**0.0036**	**0.020**



SFR distributions vary for most environ. for dwarf galaxies, but for massive galaxies they all are consistent with being drawn from the same distrib.

Conclusions

- Statistically significant decline in fraction of SF and blue galaxies in progressively denser environments, for both massive and dwarf galaxies! (not a threshold effect)
- Distinct distribution of dwarf SF galaxies for most environment, but not for massive galaxies – an important caution at high-z.
- Pre-processing plays an extremely important role at low-z, as group galaxies are significantly more likely (~50%) to be quiescent than isolated void galaxies

Check the astro-ph for the paper next week!