Australian Government
Department of Industry and Science

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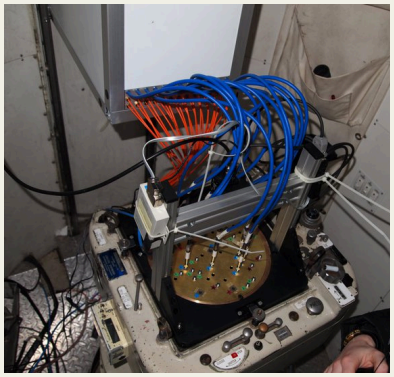
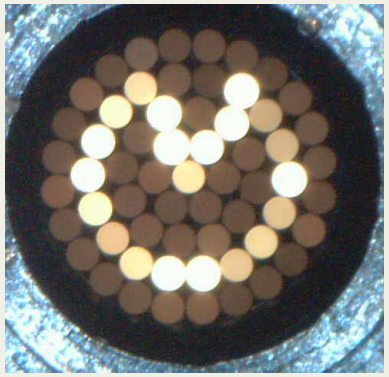
MACQUARIE University

The SAMI Galaxy Survey:

The impact of the cluster environment on the star formation of infalling galaxies



Matt Owers
(Macquarie University and
Australian Astronomical Observatory)
+SAMI Galaxy Survey team



sami galaxy survey

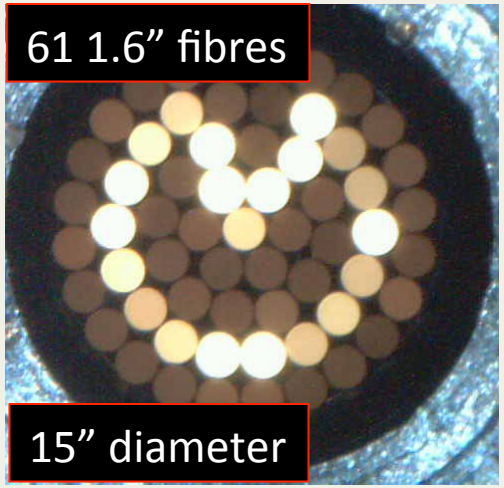
@SAMI_survey

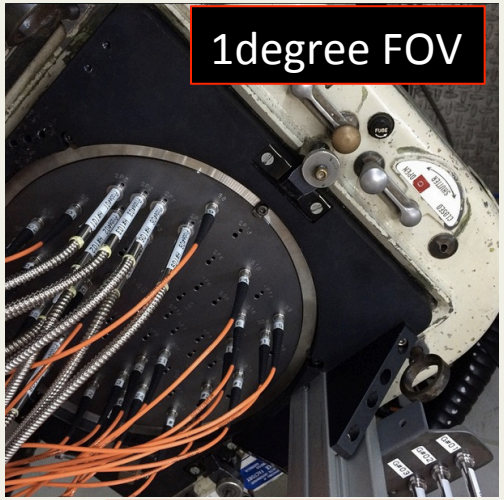
The SAMI Galaxy Survey

SAMI=Sydney-Australian-Astronomical-Observatory Multi-object Integral-Field Spectrograph

Resolved spectroscopy for 3400 galaxies -> 2200 galaxies to date (see Bryant+2015 for survey details)

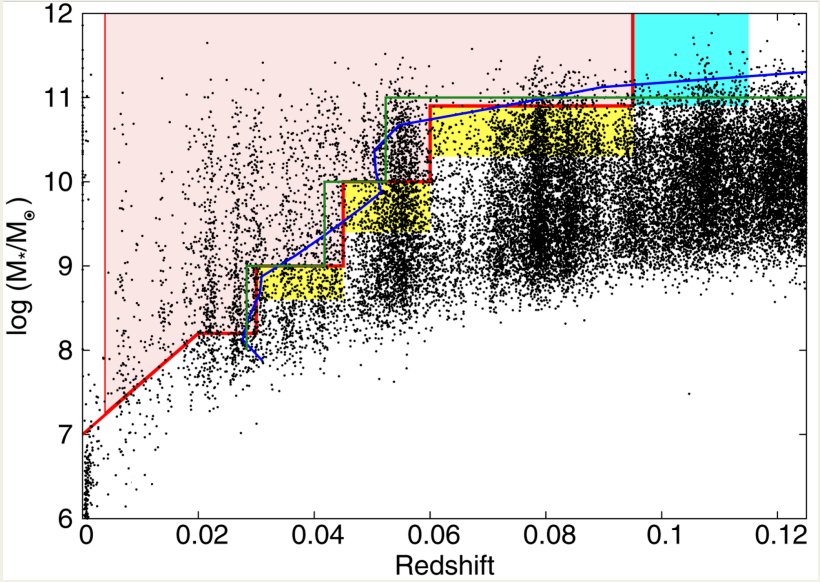
1. Primary fields from GAMA (http://www.gama-survey.org).
   - Three 4x12 deg equatorial regions at 9hr, 12hr & 15hr
   - Deep, complete, spectroscopy to r=19.8
   - Robust group catalogue (Robotham et al. 2011).
   - 21-band photometry: far UV to far IR (Driver+2016).
2. Wavelength coverage/resolution:
   - Blue: 3700-5800A, R~1750, σ=70km/s
   - Red: 6300-7400A, R~4500, σ=30km/s
3. **8 Clusters targeted (~880 gals -> ~700 to date).**

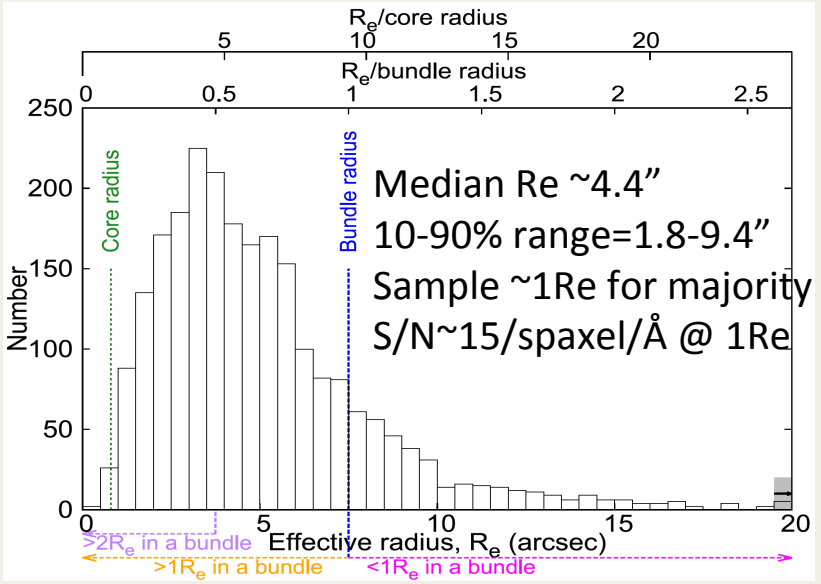


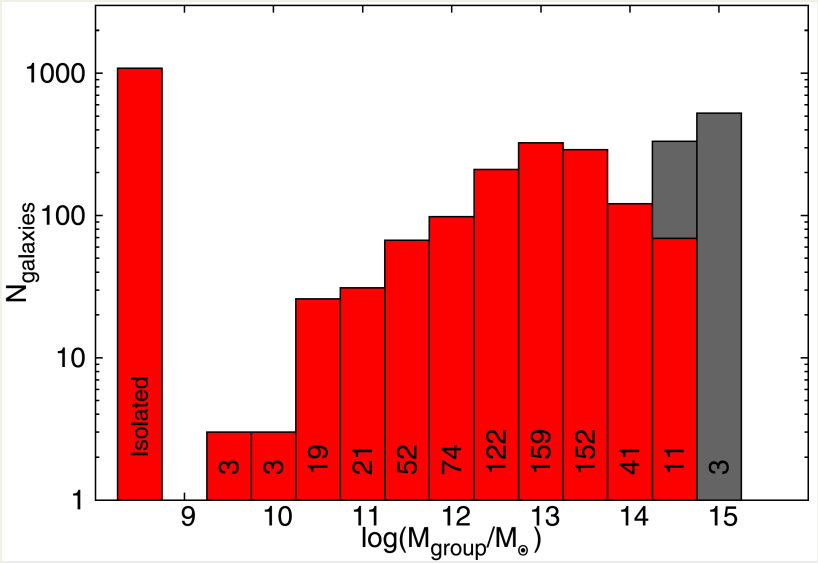


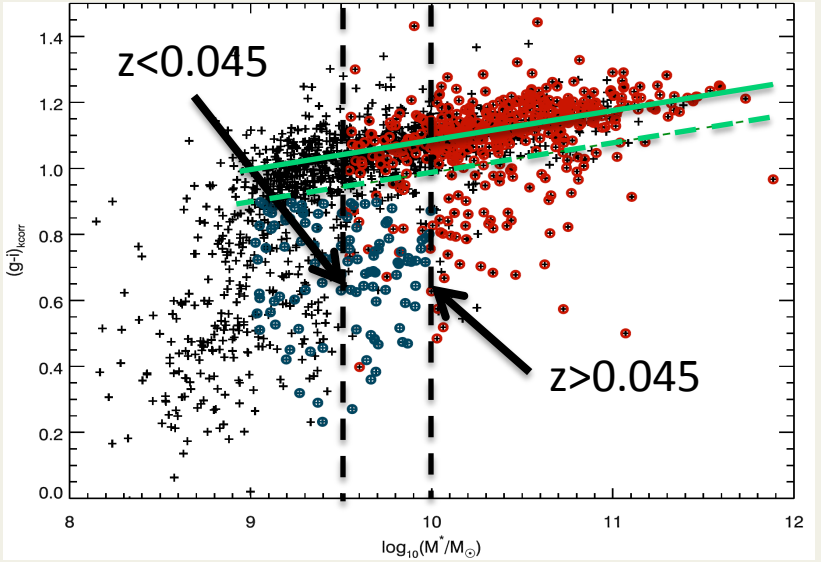
SAMI Galaxy Survey Targets

Bryant+(2015), Owers+(2017)









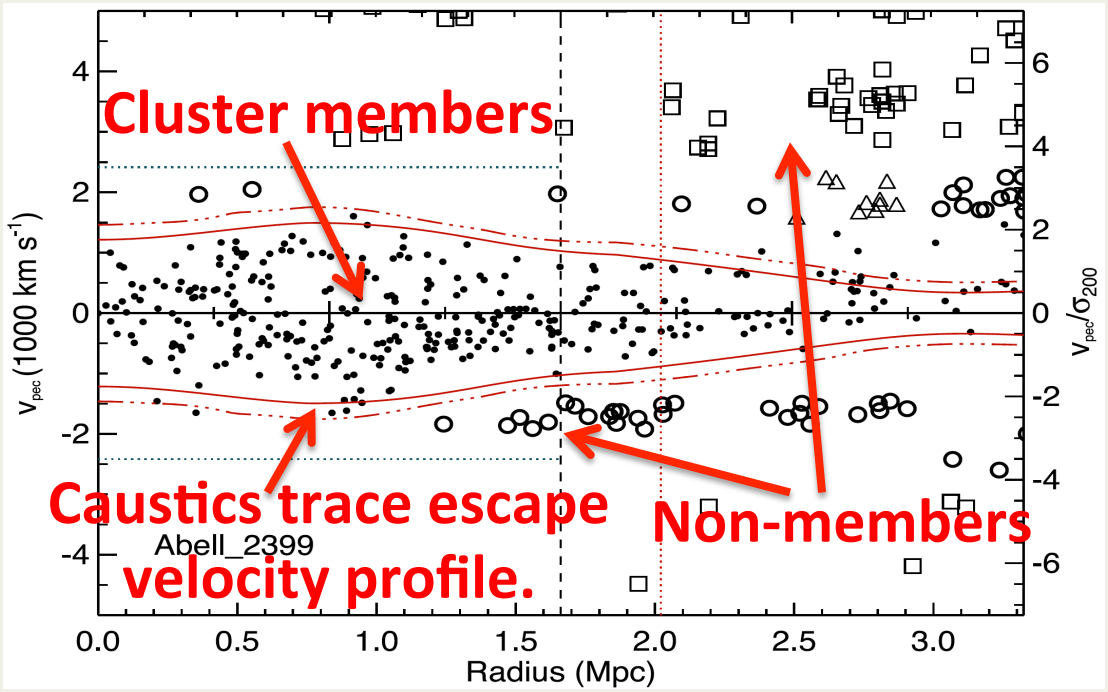
SAMI Galaxy Survey Key Science Goals

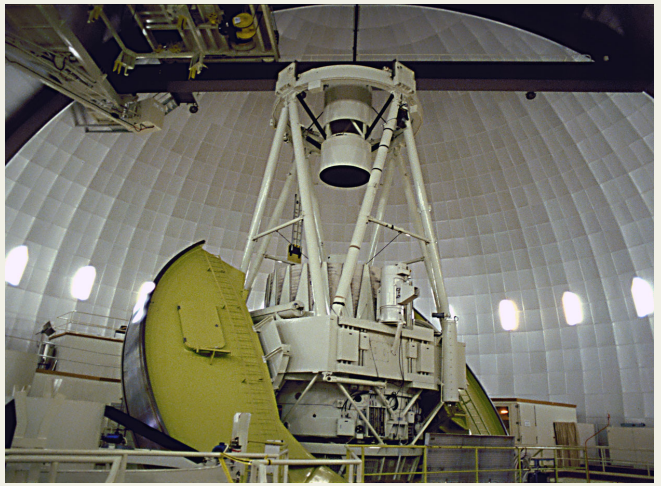
- **What are the physical processes responsible for galaxy transformations?**
  - Morphological and kinematic transformations; suppression of star formation; internal vs. external; secular vs. fast; **ram pressure stripping; harassment, strangulation; galaxy–group/cluster tides**; **galaxy-galaxy mergers; galaxy-galaxy interactions**…
- **How does mass and angular momentum build up?**
  - The galaxy velocity function; stellar mass in dynamically hot and cold systems; galaxy merger rates; halo mass from velocity-field shear; Tully-Fisher relation…
- **Feeding and feedback: how does gas get into galaxies, and how does it leave?**
  - Winds and outflows; feedback vs. mass; triggering and suppression of SF; gas inflow; metallicity gradients; the role of AGN…

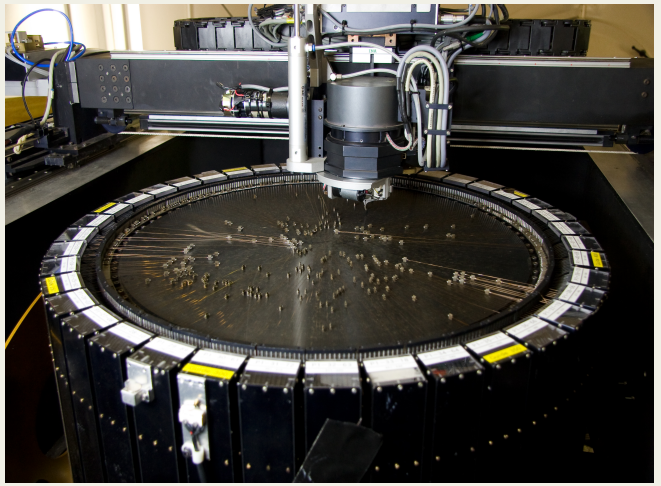
The SAMI Cluster Redshift Survey

(Owers+2017)

- 7 nights using 2dF/AAOmega on the AAT.
- ~21,000 spectra to $r_{petro} < 19.4$, $R < 2\text{-}3R_{200}$.
- Completeness ~95% to $r_{petro} = 19.4$, $R<R_{200}$.
- Around 2850 cluster members ($R<2R_{200}$).



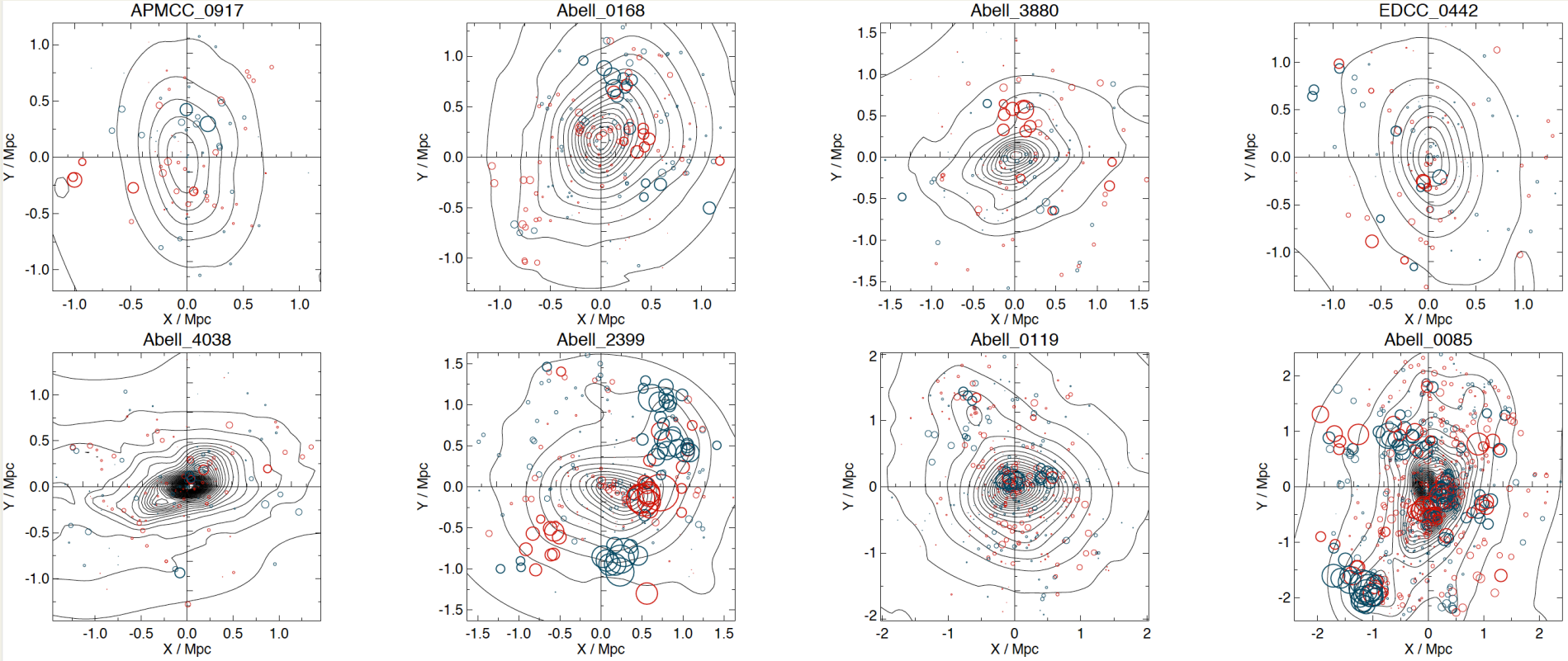




SAMI Cluster Properties

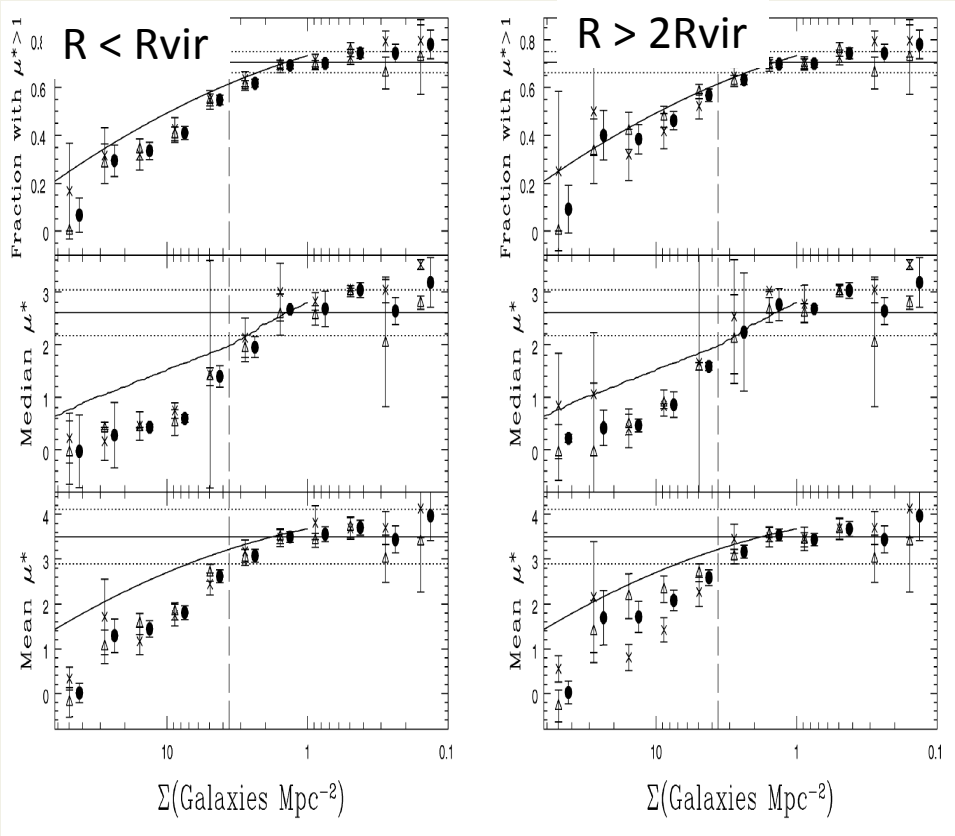
Name	RA (J2000) (deg)	Dec. (J2000) (deg)	z	σ_{200} ($r < R_{200}$) (km s^{-1})	R_{200} (Mpc)	M_{200} (10^{14} M$_\odot$) Caustic	N_{200} (10^{14} M$_\odot$) Virial	$N_{\rm mem}$	$N_{\rm Z}$	Compl. per cent
APMCC 917	355.397 880	−29.236 351	0.0509	492 ± 47	1.19	1.8 ± 0.7	2.1 ± 0.6	86/119	255/654	96/92
Abell 168	18.815 777	0.213 486	0.0449	546 ± 29	1.32	1.9 ± 1.1	3.0 ± 0.4	192/276	505/1382	94/95
Abell 4038	356.937 810	−28.140 661	0.0293	597 ± 29	1.46	2.3 ± 1.4	2.9 ± 0.5	164/263	885/2408	97/91
EDCC 442	6.380 680	−33.046 570	0.0498	583 ± 39	1.41	2.8 ± 1.7	3.6 ± 0.7	123/243	279/927	91/94
Abell 3880	336.977 050	−30.575 371	0.0578	660 ± 46	1.59	4.4 ± 1.3	4.6 ± 1.1	160/307	356/1151	99/99
Abell 2399	329.372 605	−7.795 692	0.0580	690 ± 32	1.66	4.7 ± 1.5	6.1 ± 0.8	254/343	544/1394	99/99
Abell 119	14.067 150	−1.255 370	0.0442	840 ± 36	2.04	8.6 ± 3.1	9.7 ± 1.1	372/578	835/2341	89/85
Abell 85	10.460 211	−9.303 184	0.0549	1002 ± 28	2.42	15.5 ± 3.7	17.0 ± 1.3	590/772	1736/3132	98/94

SAMI Clusters: Diversity in structure

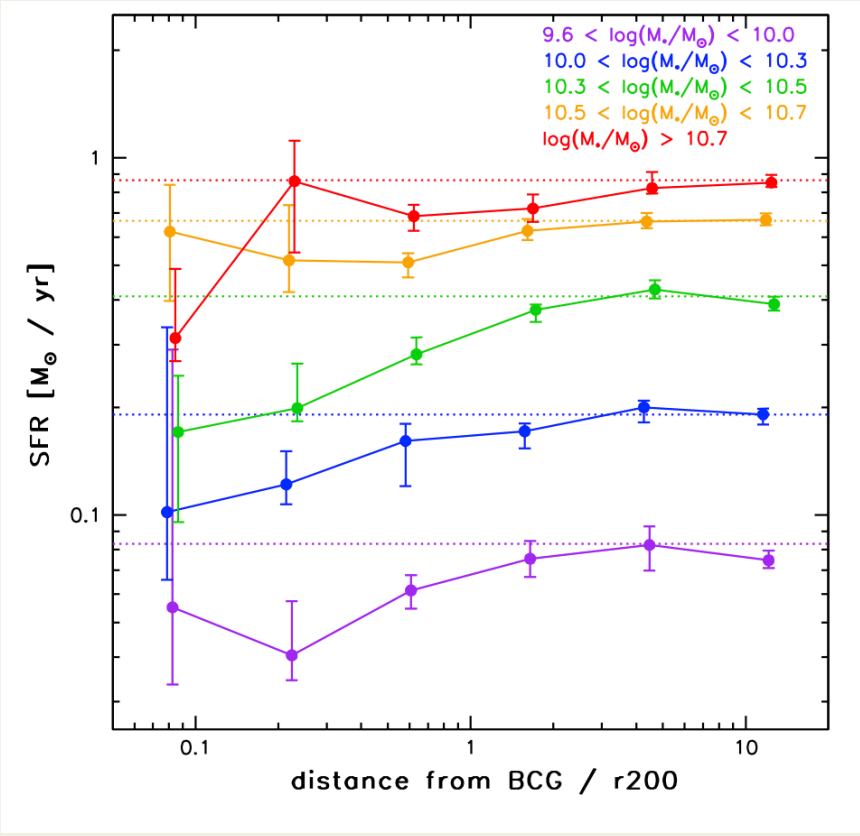


Correlation between galaxy properties and environment.

Fraction of SFR gals lower cf field (Lewis 2002)

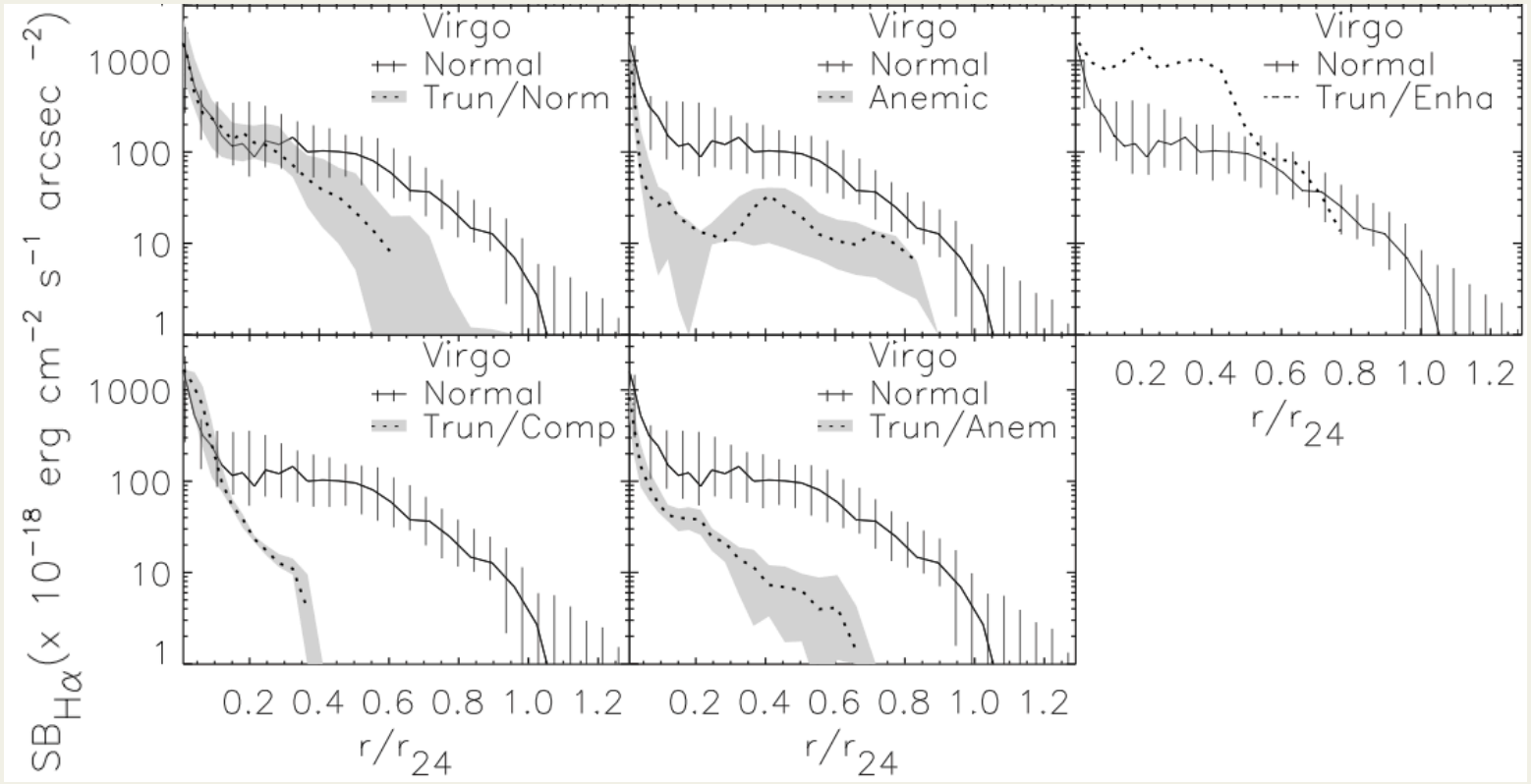


Decline in SFR with radius (von der Linden 2010)



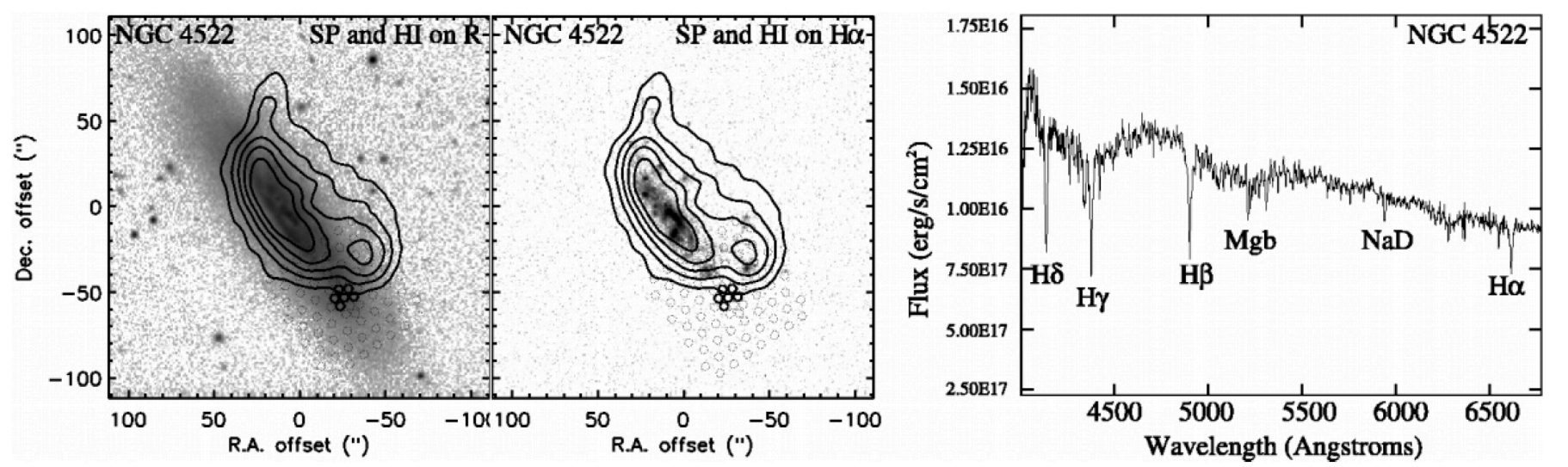
Correlation to Causation: Identifying environment-driven transformation.

- Koopmann & Kenney (2004) show 50% of spiral galaxies in Virgo cluster have truncated Hα distribution.



Moving from Correlation to Causation.

- Crowl & Kenney (2006, 2008): IFU spectra show stellar pop. ages outside truncation radius <500Myr -> rapid shutdown of star formation.

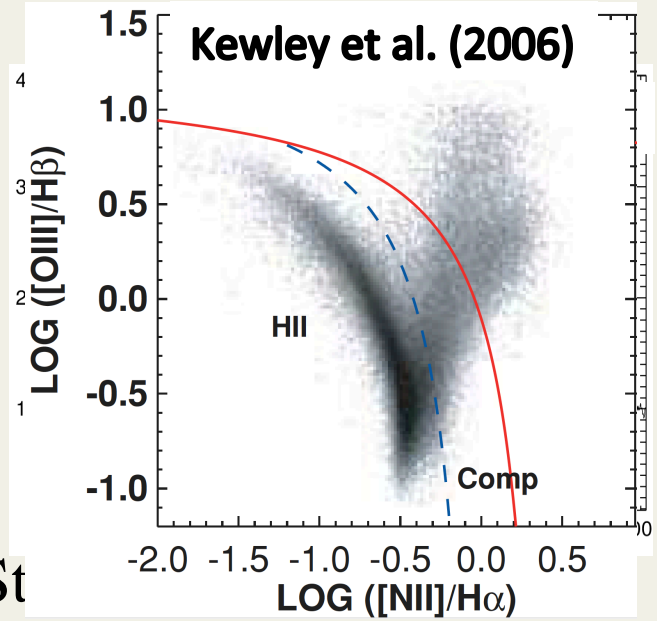


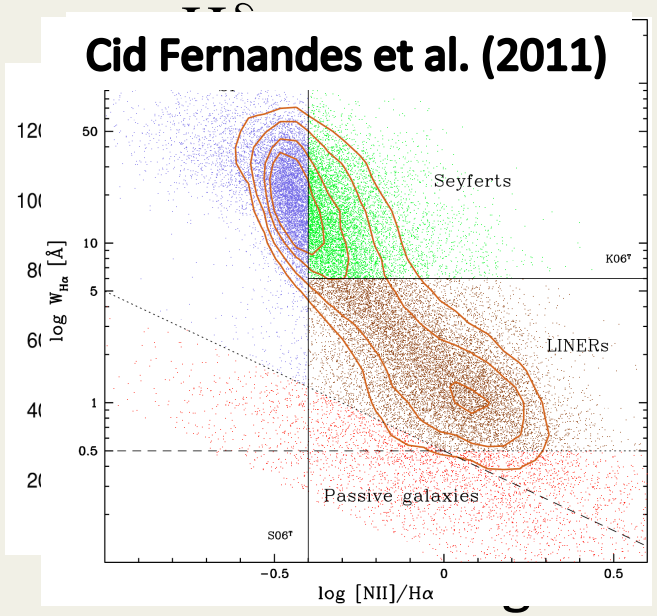
10 galaxies in Virgo cluster – representative?

Answer with IFU data for large sample across range of clusters.

SAMI data: Resolved Spectroscopic Classification

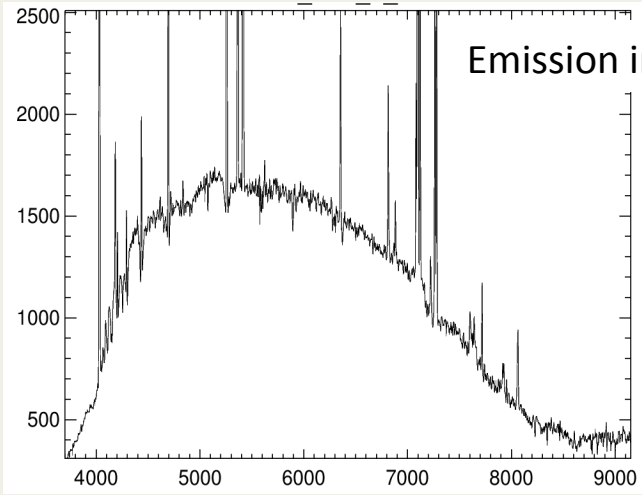
Absorption line





Emission line

Emission in at least Hα + 1 other



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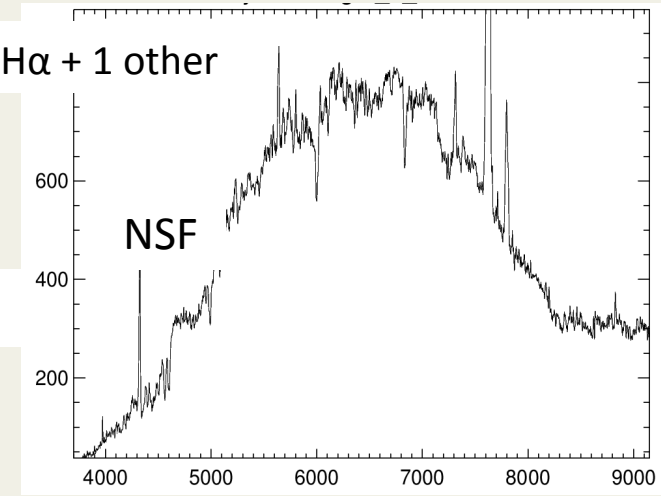
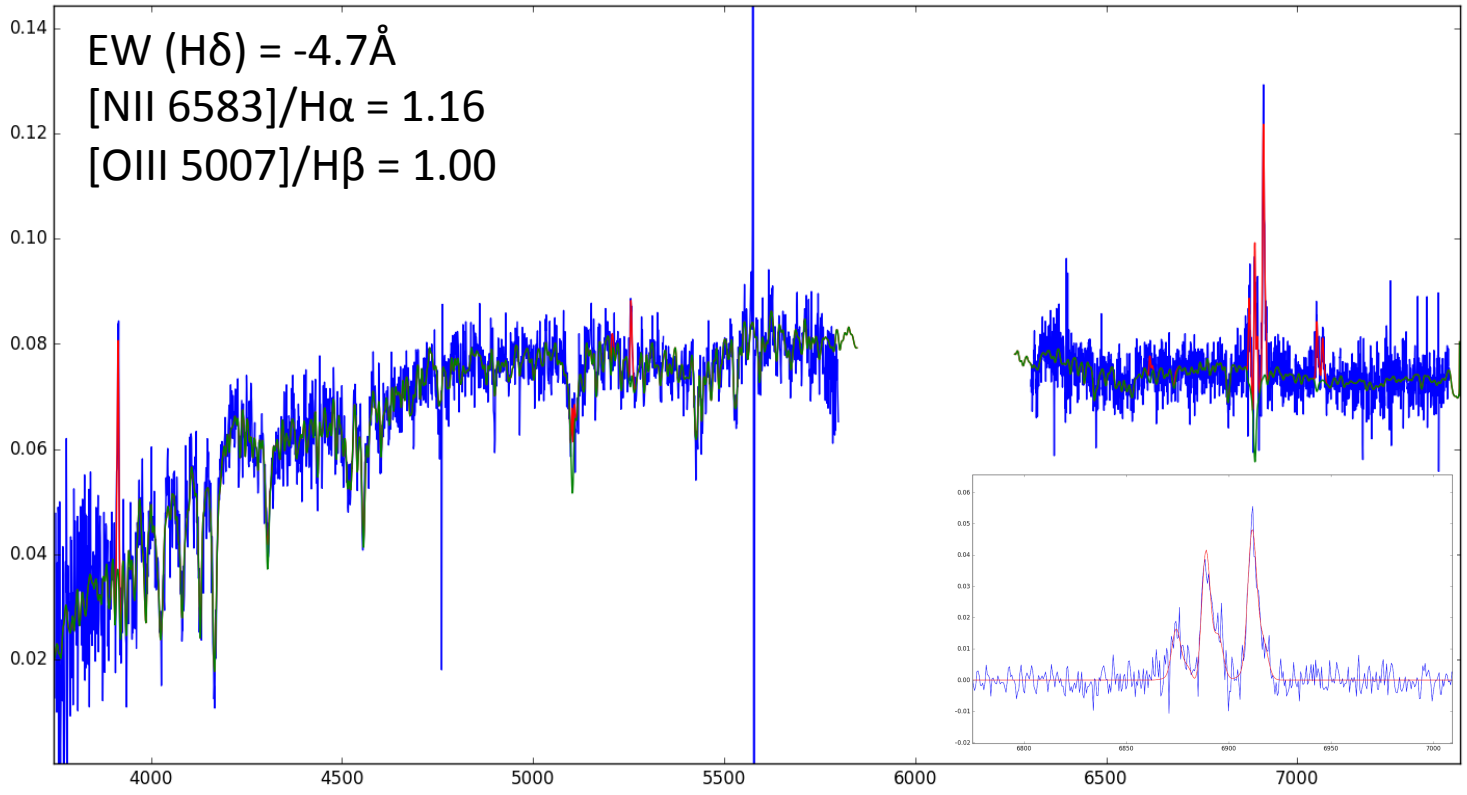


Line ratio -> SF ionising src

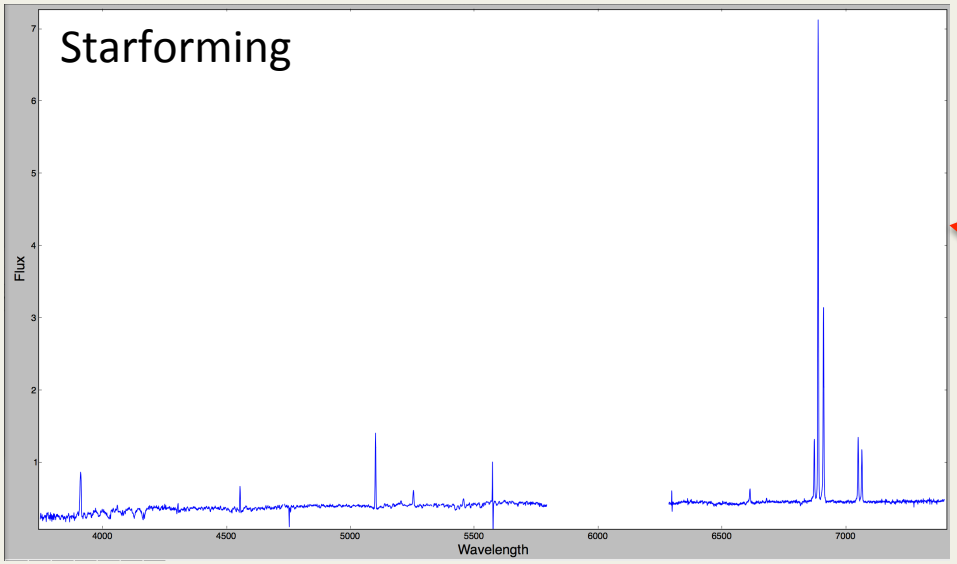
Line ratio -> nonSF ionising src

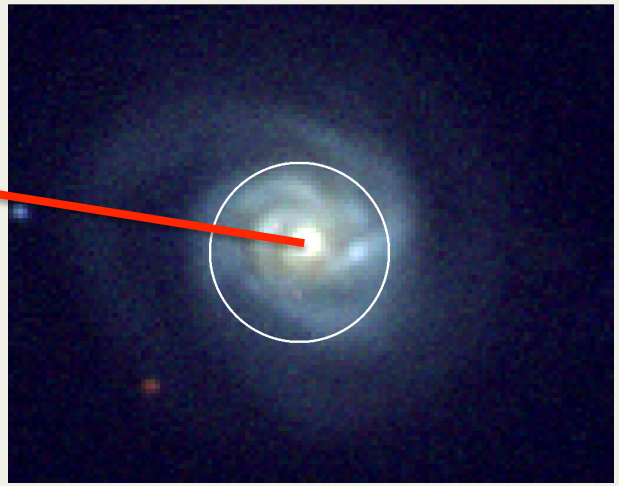
Also, Non-SF HDS

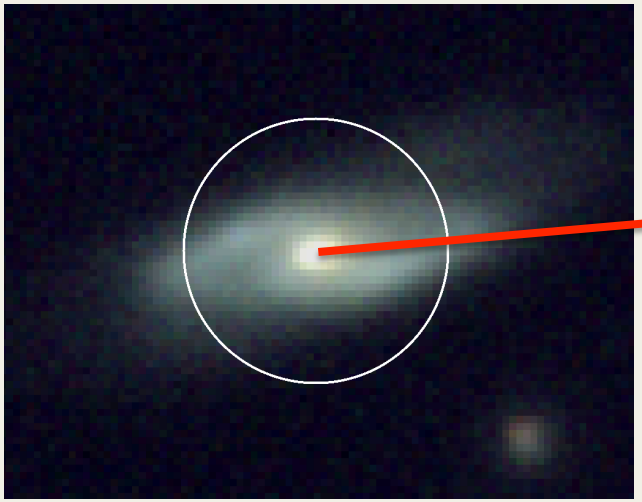
- Strong Balmer with non-SF emission lines:

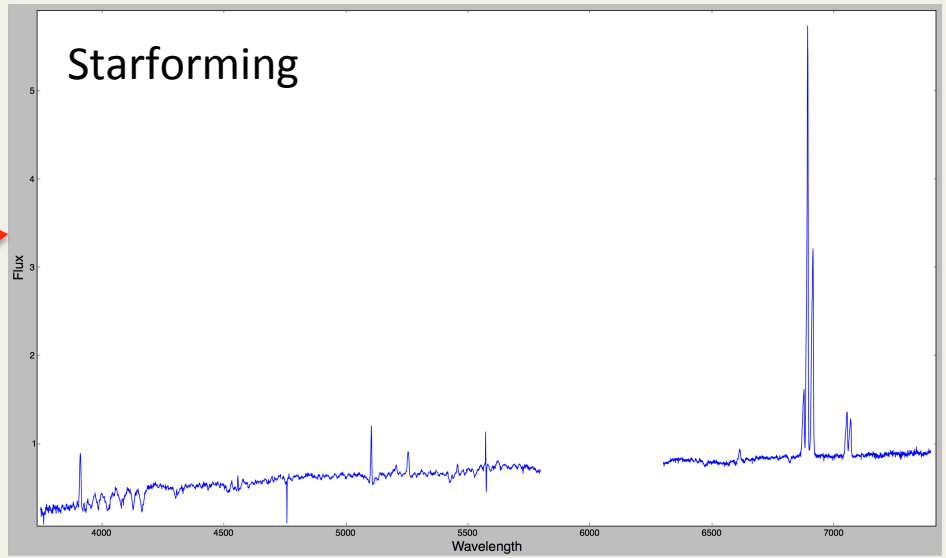


Disk galaxies in A119.

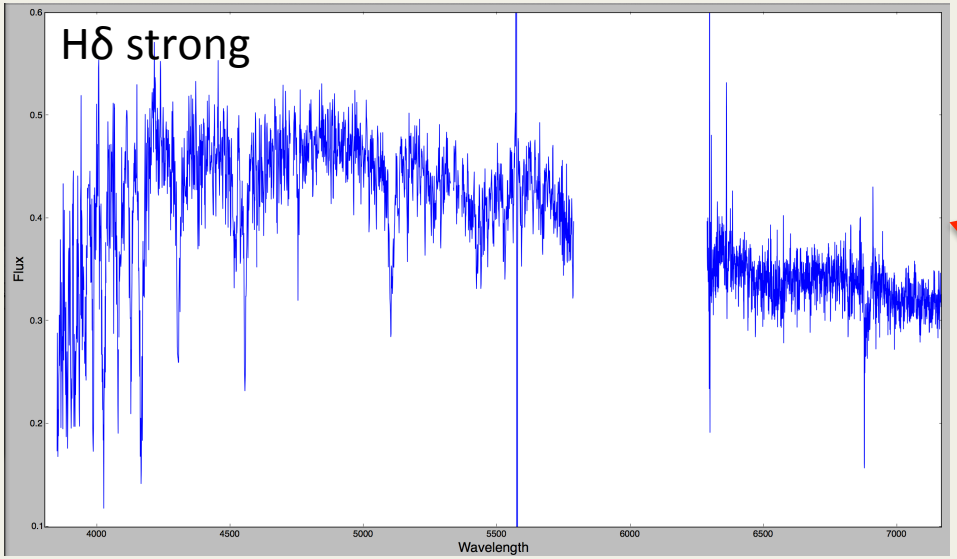


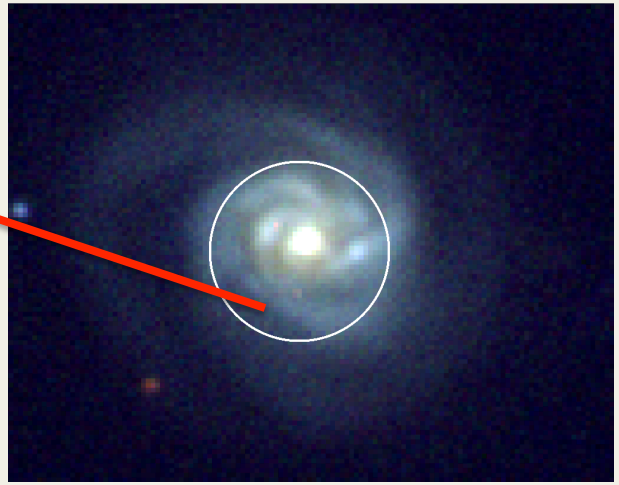


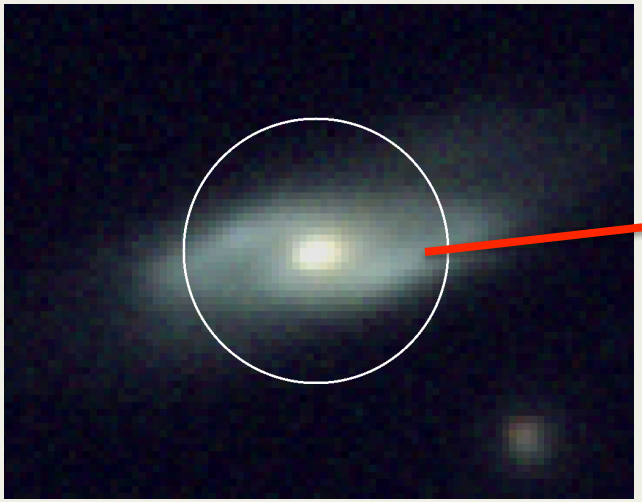


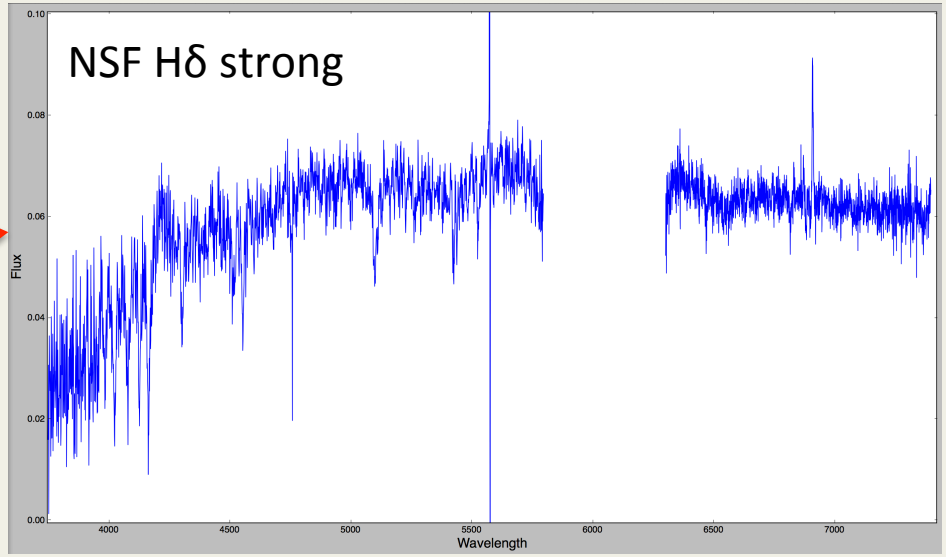


Disk galaxies in A119.

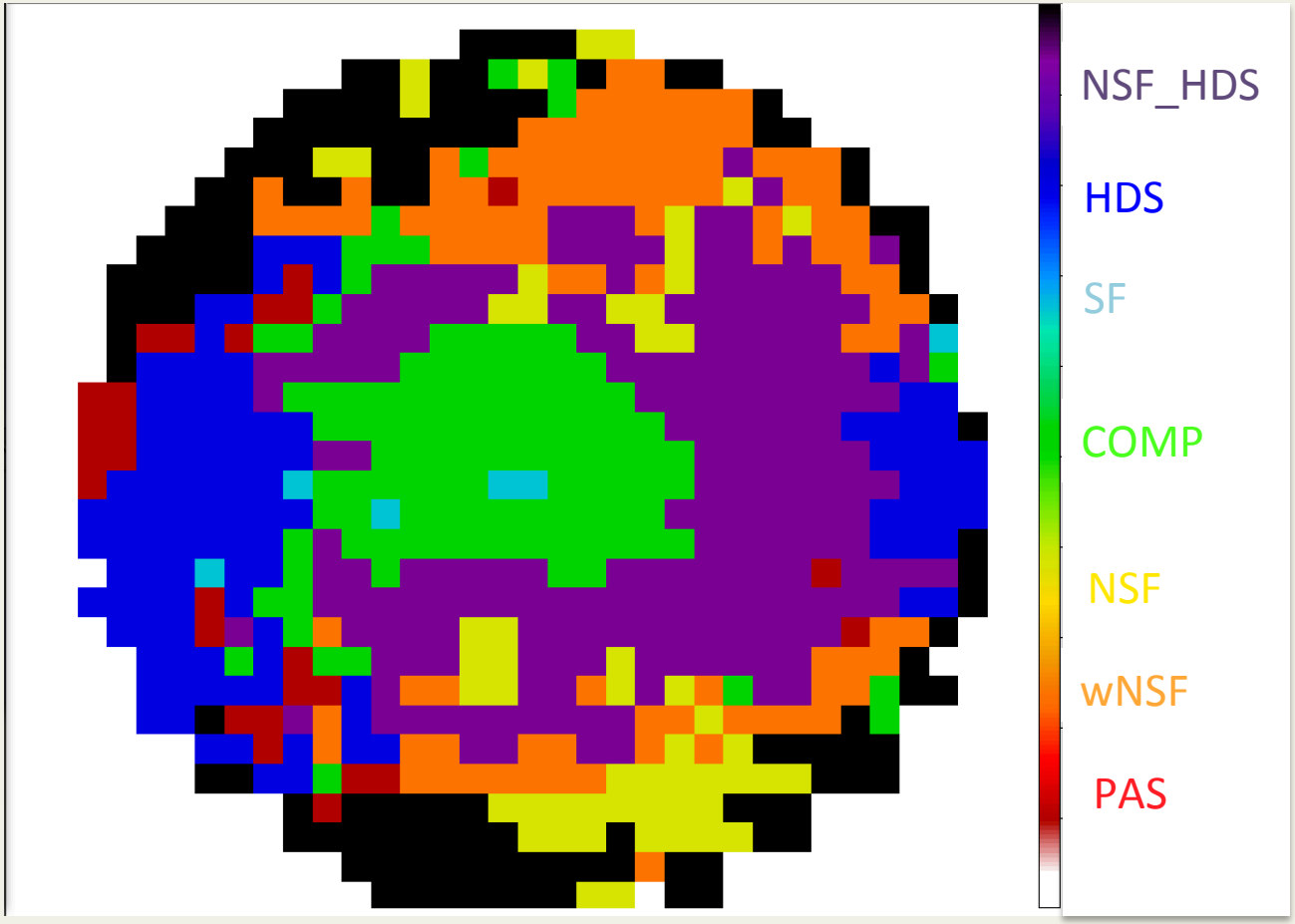






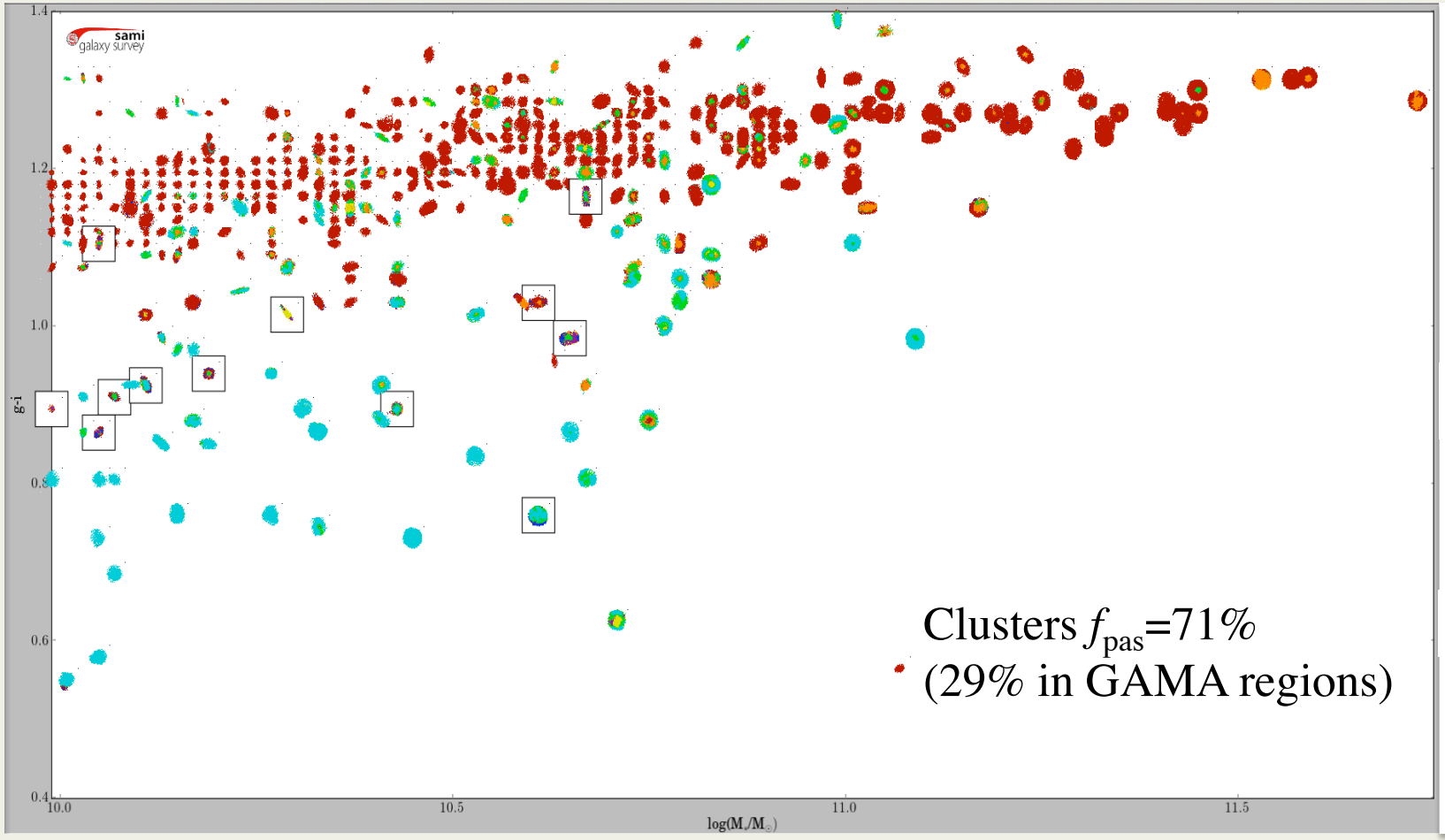


Classification maps: more complicated in 2D!

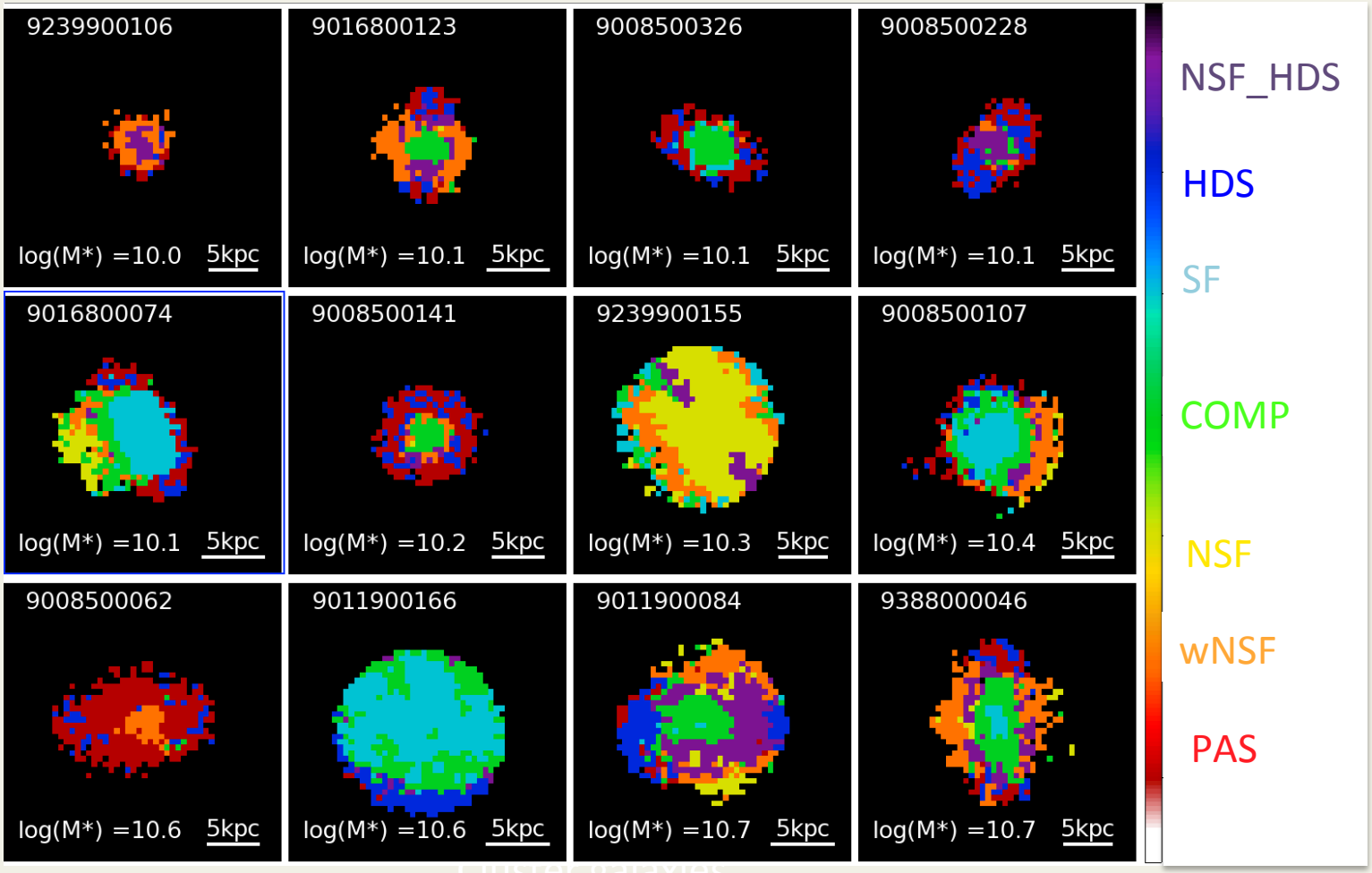


Red-sequence is dominated by spectroscopically passive galaxies.

Passive galaxies: >90% spaxels have passive spectral type

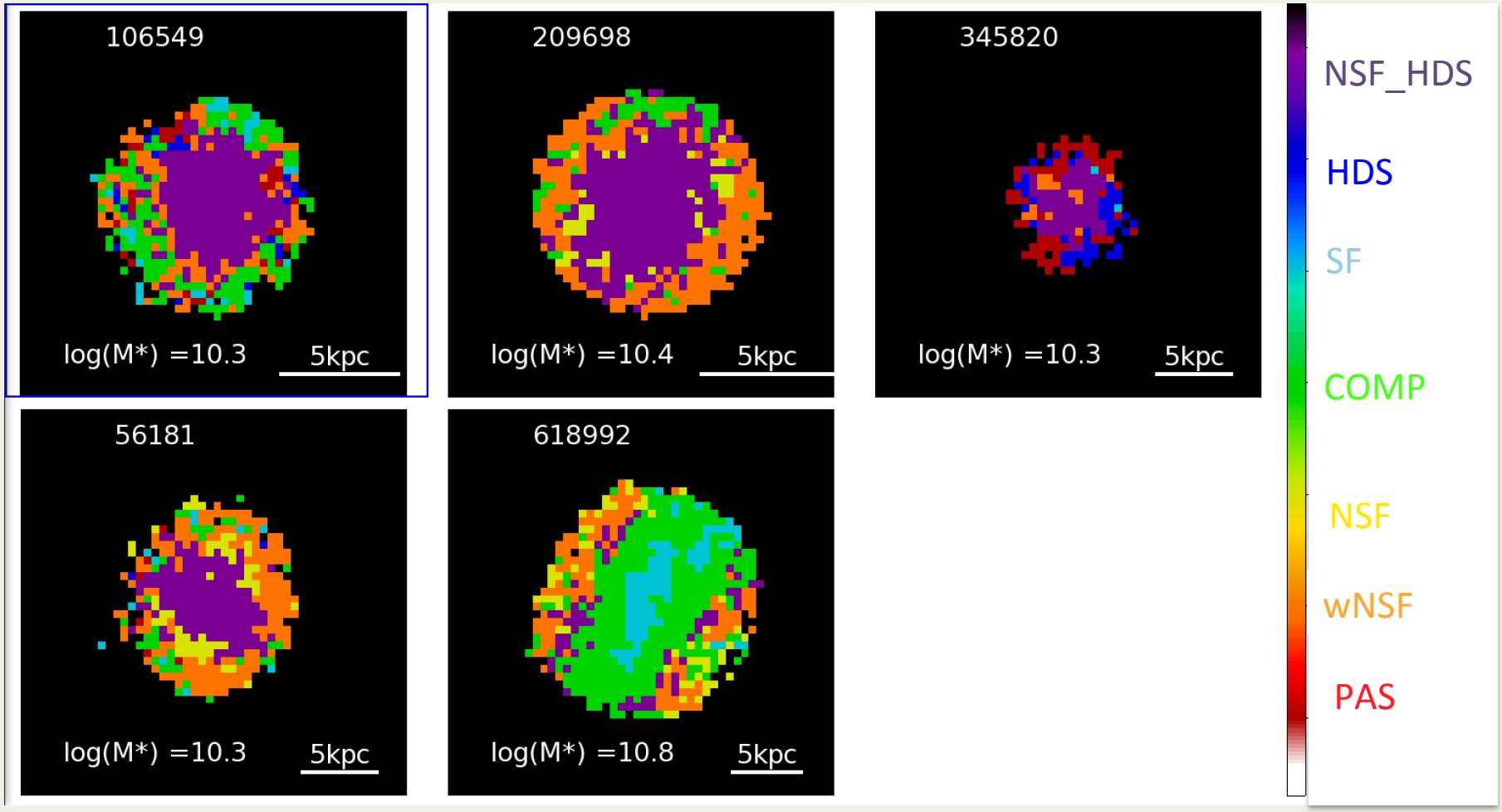


Clusters: 11% of non-passive galaxies have >10% HDS classified spaxels.



Cluster galaxies

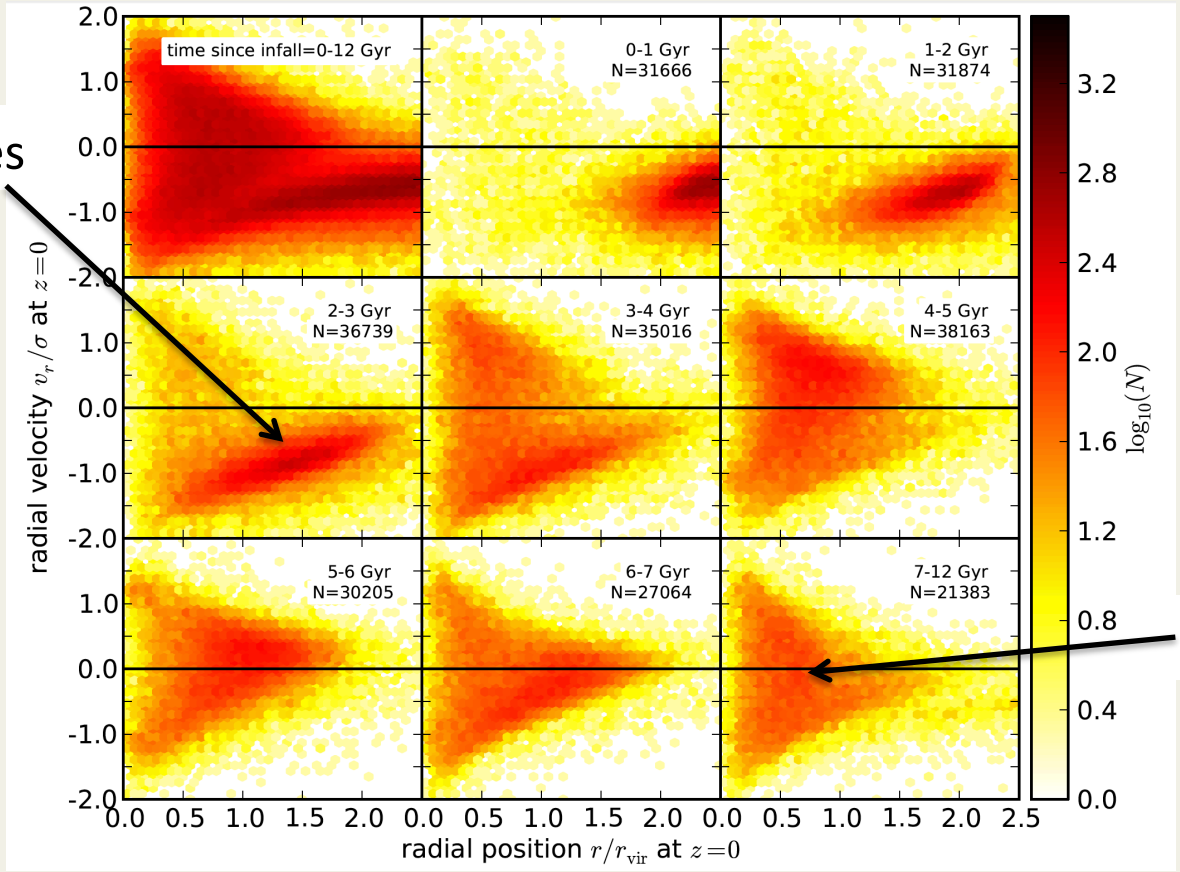
GAMA: Only 2% non-passive galaxies have >10% HDS classified spaxels.



Projected-Phase-Space: a metric for environment.

Oman+13 simulations: infallers inhabit distinct regions of phase space (also Mahajan+11, Noble+13, Jaffe+15, Muzzin+14, Haines+15, Oman+16).

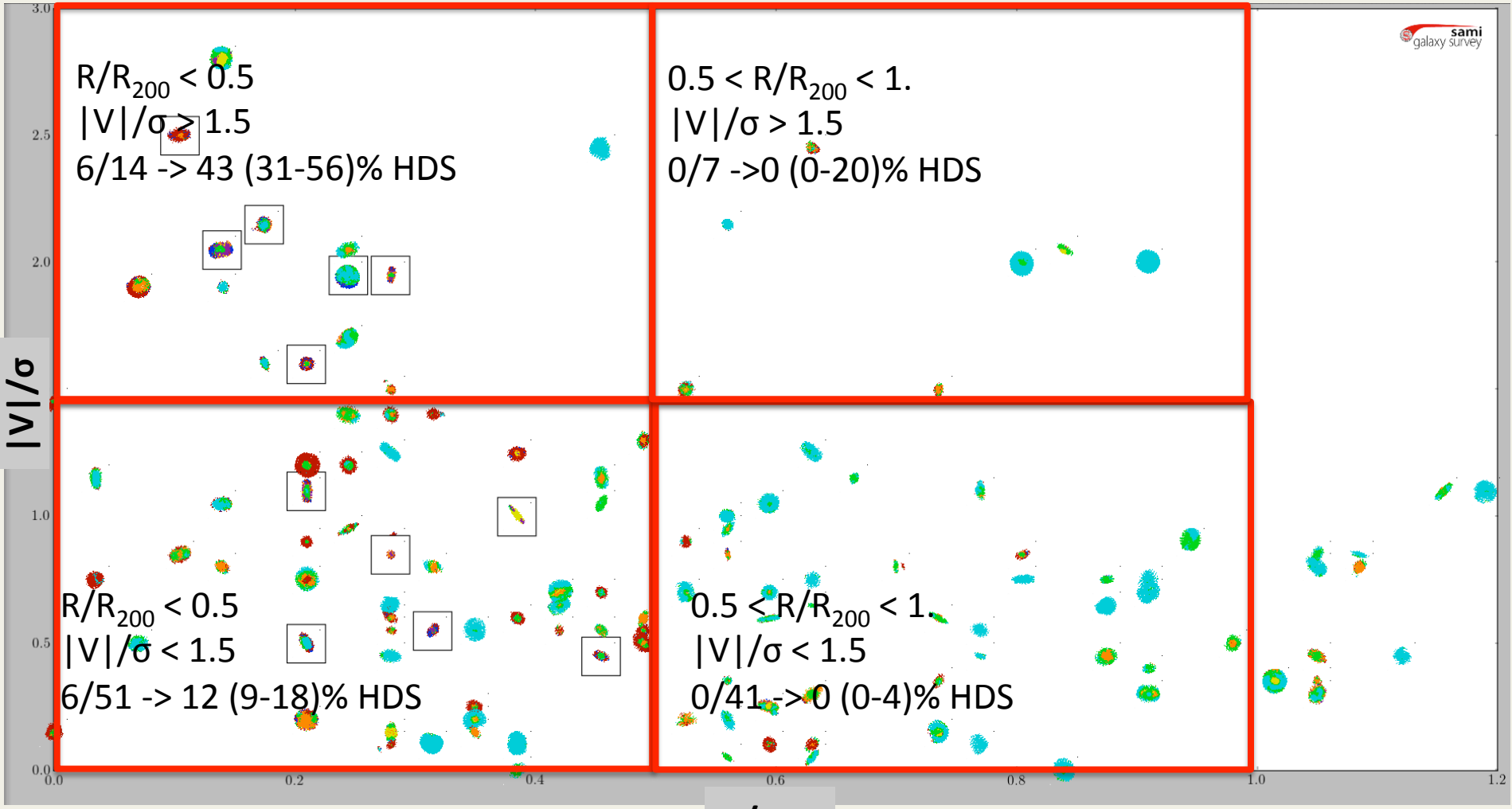
Infalling galaxies



T_0 at $2.5R_{vir}$
T_{cross}~3.5Gyr

Virialised region

PPS for non-passive cluster galaxies



Summary.

- SAMI Galaxy Survey: resolved spectroscopy for ~3400 galaxies finishing 2018A.
- 11% of non-passive cluster galaxies have evidence for young stellar populations with no ongoing star formation in >10% of their spaxels.
- This population is rare (~2-3%) in the non-cluster SAMI galaxies in the GAMA regions.
- The HDS galaxies are only found within $0.5R_{200}$ (~19%) with an increased fraction for high velocity galaxies (~43%) cf. lower velocity galaxies (12%).
- Consistent with ram-pressure stripping of gas leading to outside-in truncation of star formation as the galaxy traverses the cluster.
- Stayed tuned for full sample!

Extra slides