The SAMI Galaxy Survey

International Centre for Radio Astronomy Research

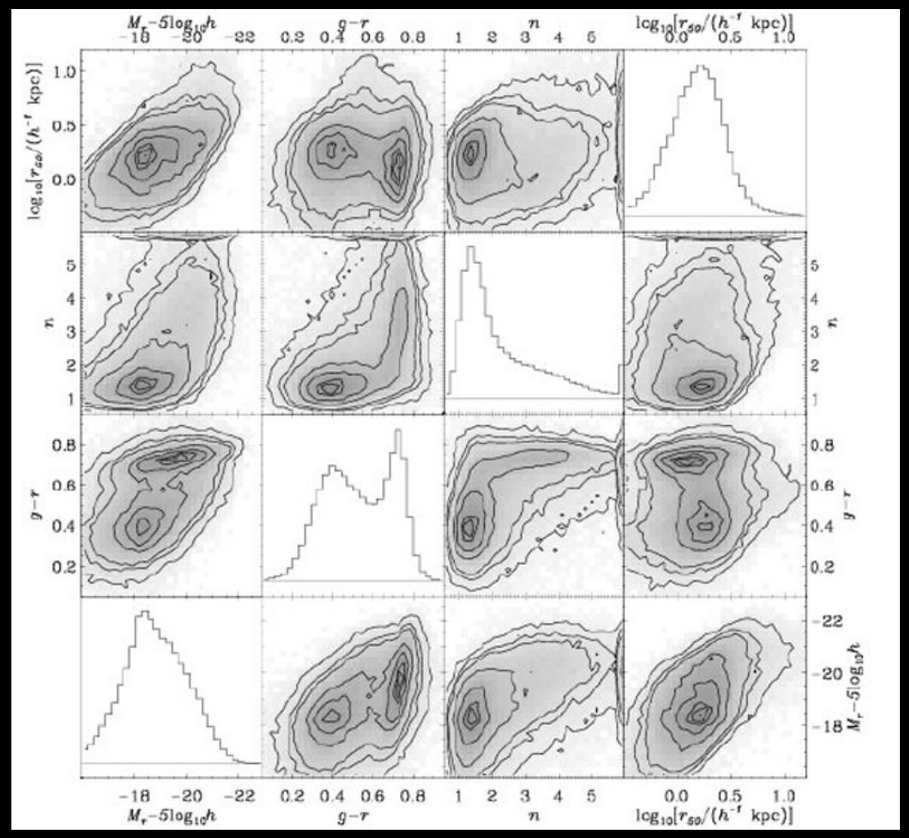
Luca Cortese
on behalf of the SAMI Team

Curtin University

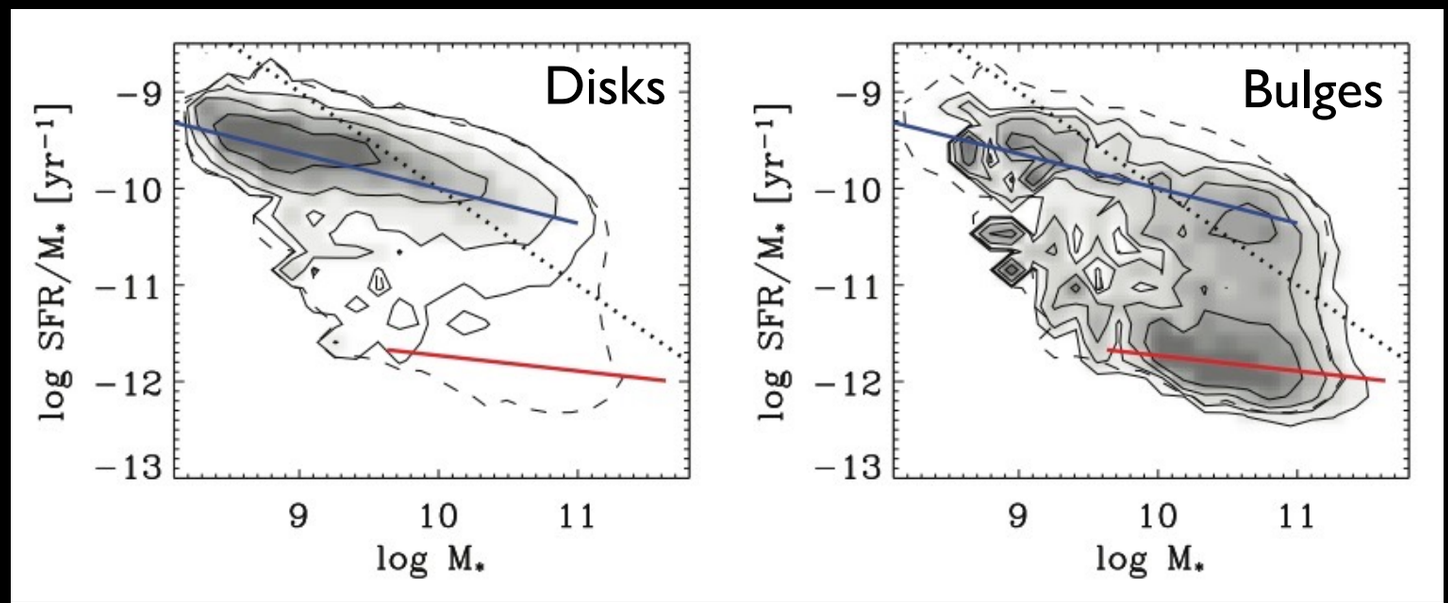
The University of Western Australia

The phenomenology of galaxies at z~0

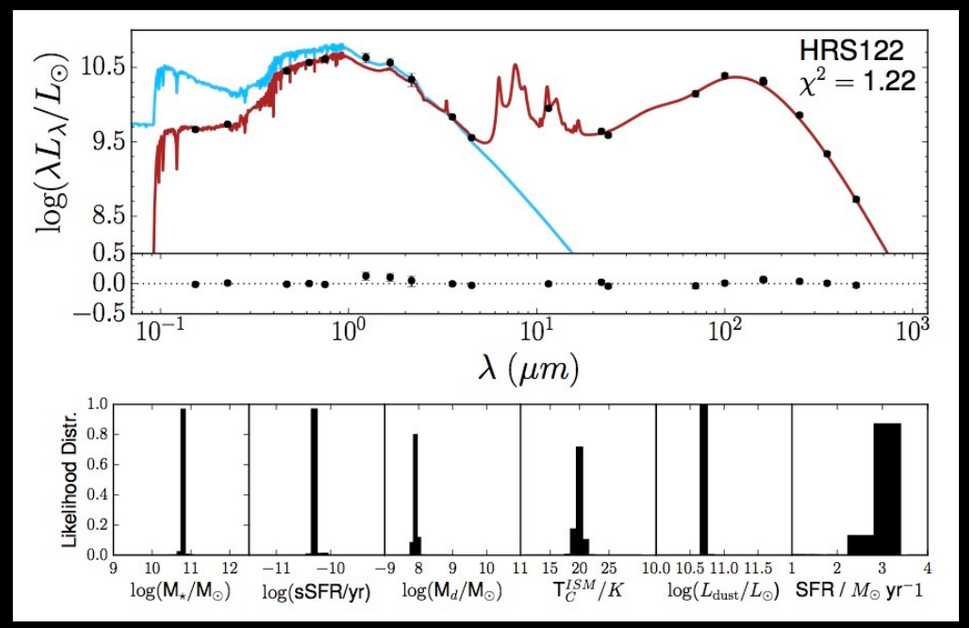
Large area imaging and (fiber) spectroscopic surveys key for progress in the last decade



e.g., Kauffmann+2003; Tremonti et al. 2004; Blanton & Moustakas 2009



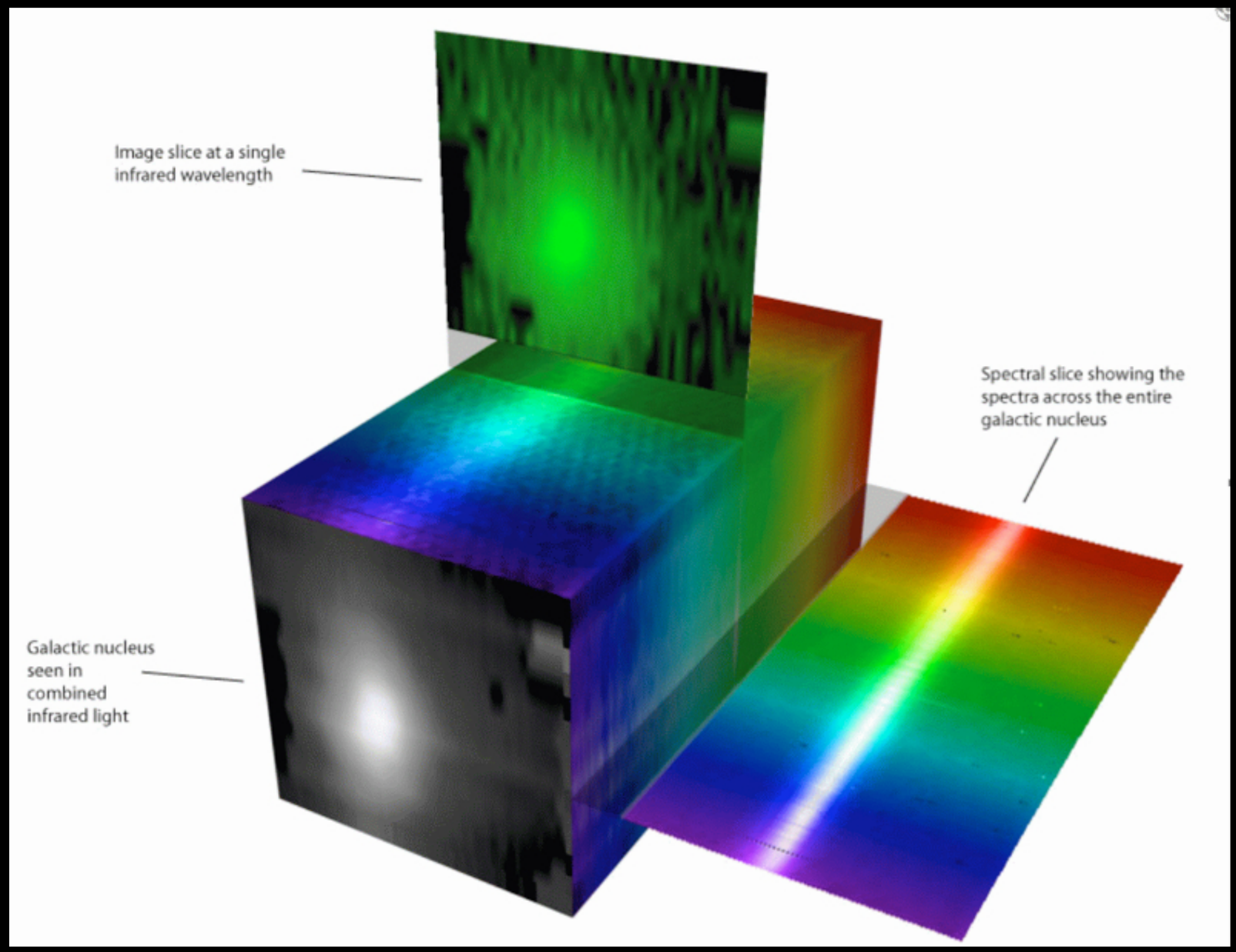
e.g., Schiminovich+ 2007; Renzini & Peng 2015



e.g., da Cunha+2008; Viaene+2015; Pacifici+2016

Getting closer to the astrophysics of galaxies

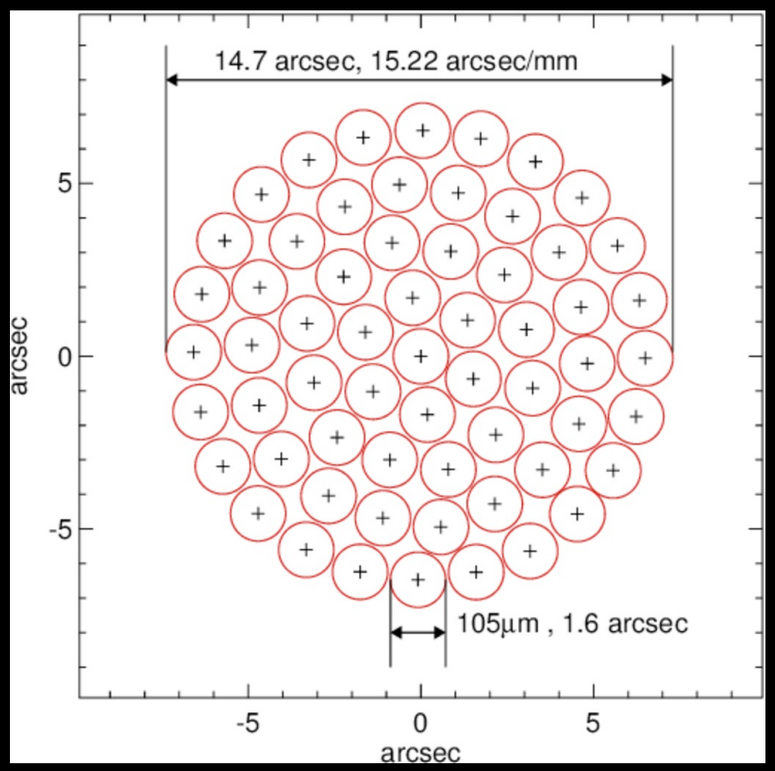
The wonders of integral field spectroscopy

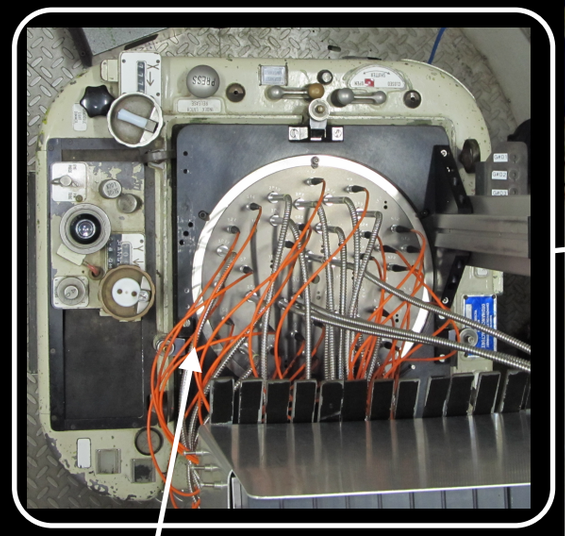


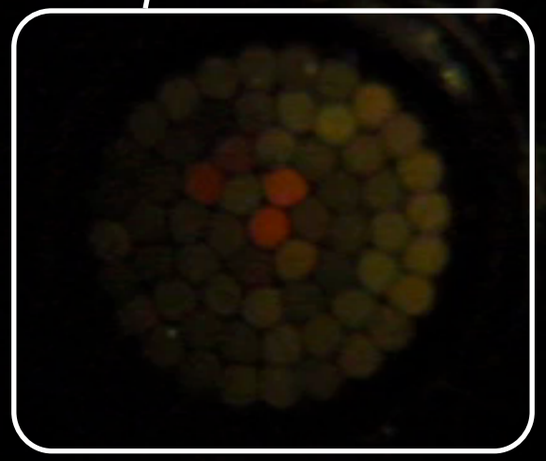
The Sydney-AAO Multi-object IFS (SAMI)

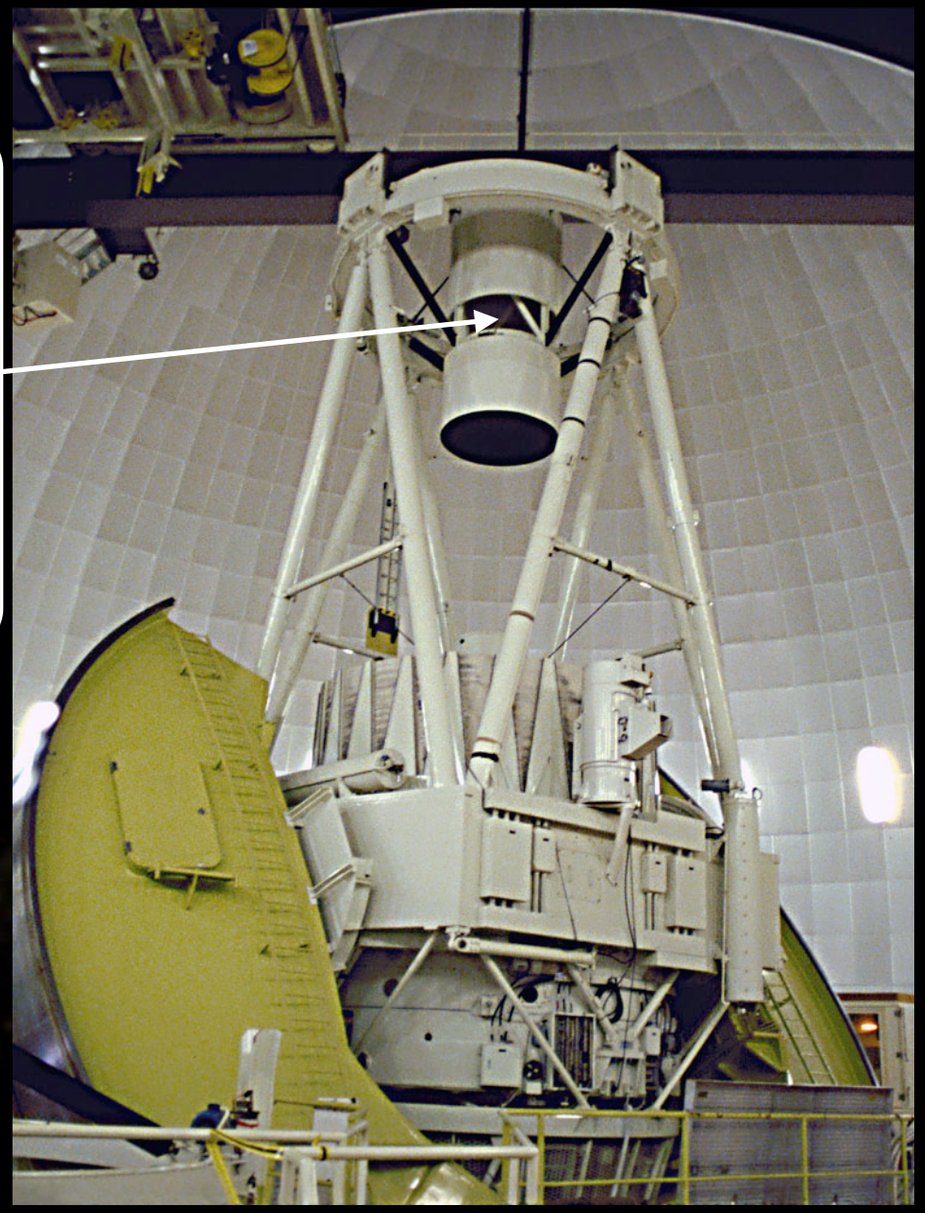


- 13x61 fibre IFUs
- Fused fiber bundles; high fill factor (~75%)
- 15” bundle diameter (each fiber is 1.6”)
- Positioned on 1 degree diameter field-of-view
- Feeds AAT AAOmega spectrograph

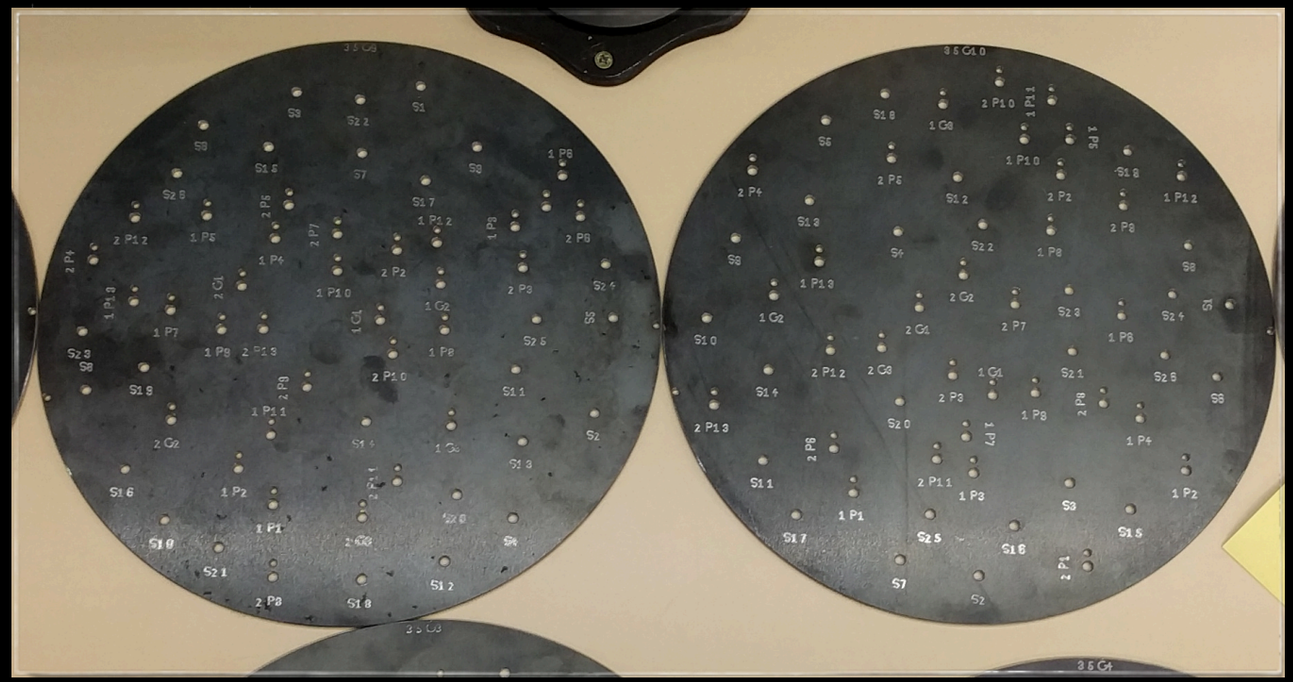








The Sydney-AAO Multi-object IFS (SAMI)

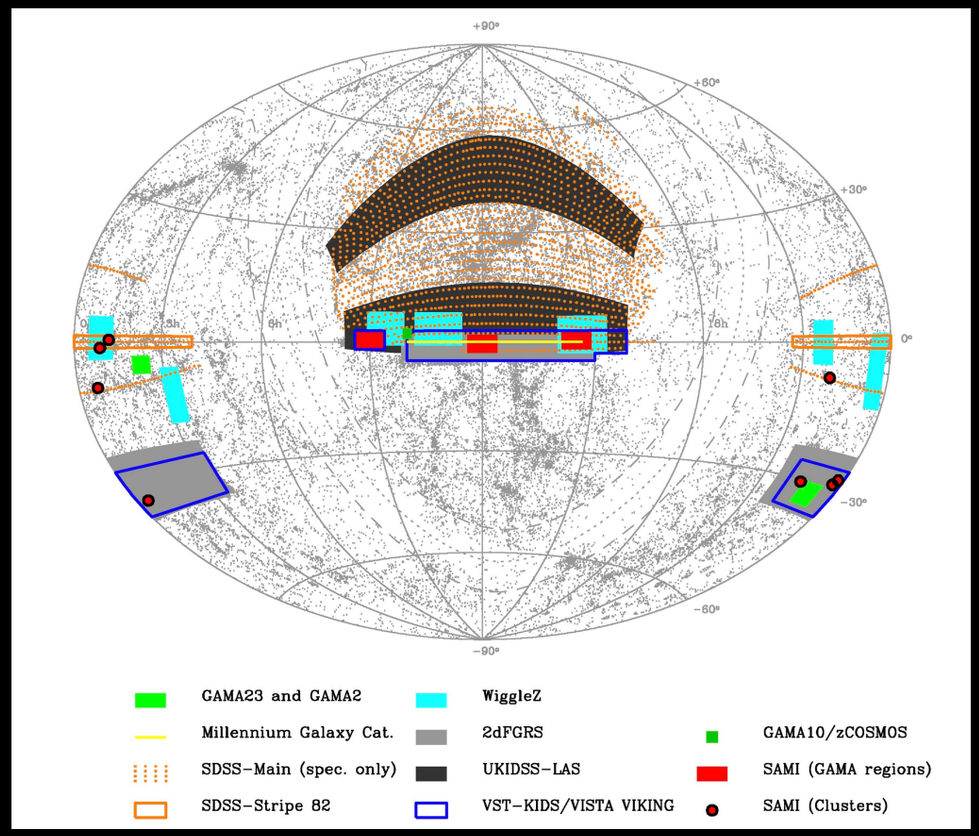


- Plates drilled by the AAT
- 12 objects, 1 calibration star, 3 guide bundles
- One plate can be used for up to 2 fields
- SAMI Galaxy Survey 7 dither pattern (3.5 h)

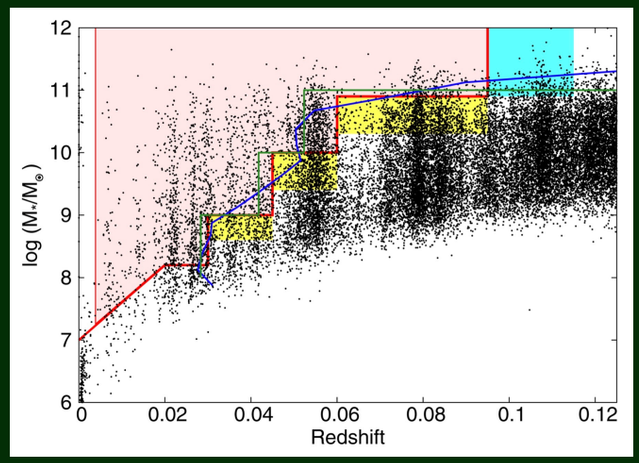
- Plate plug/unplug done manually
- Procedure takes between 30 min and 1hours depending on plugger ability and `crowdness' of the field

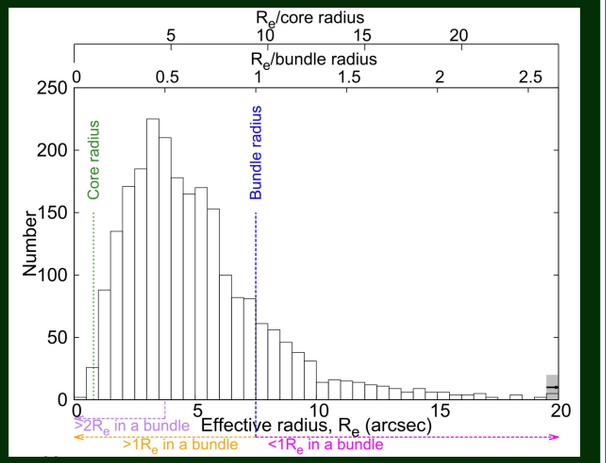
The SAMI Galaxy Survey

IFU survey of ~3000 nearby galaxies with two separate selections



GAMA Equatorial Regions ~2400 galaxies



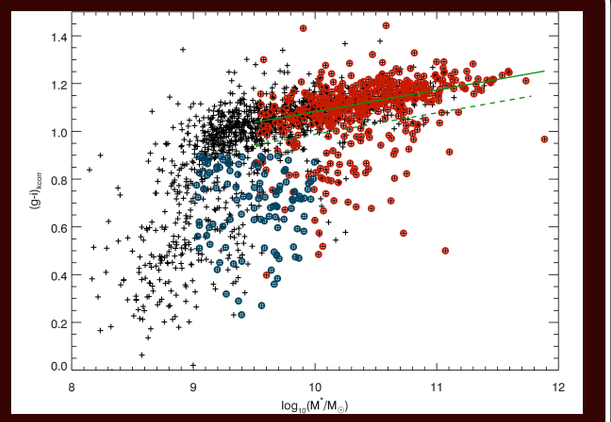


Multiple volume-stellar mass limited samples

Arm	λ_{range} [Å]	$\lambda_{central}$ [Å]	FWHM [Å]	$\Delta\sigma$ [km s^{-1}]
Blue	3750-5750	4800	$2.66^{+0.076}_{-0.070}$	70.4
Red	6300-7400	6850	$1.59^{+0.049}_{-0.040}$	29.6

Cluster survey ~600 galaxies

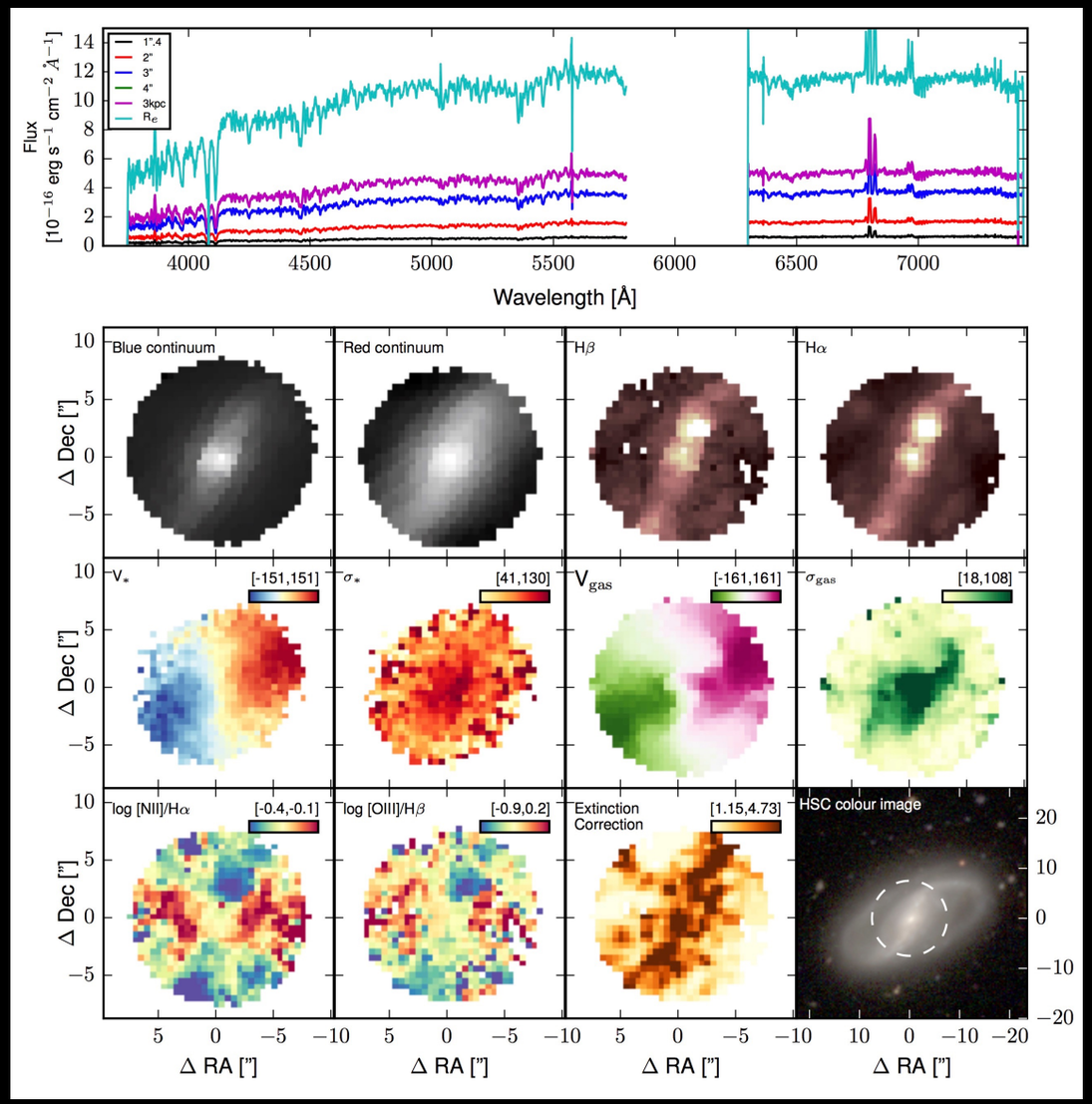
CLUSTER NAME	RA (DEG)	DEC (DEG)	Z	VIRIAL MASS ($10^{14}M_{sun}$)
EDCC0442	6.38068	-33.04657	0.0498	3.6±0.7
Abell0085	10.460211	-9.303184	0.0549	17.0±1.3
Abell0119	14.06715	-1.25537	0.0442	9.5±1.1
Abell0168	18.815777	0.213486	0.0449	2.9±0.4
Abell2399	329.372605	-7.795692	0.0580	6.1±0.8
Abell3880	336.97705	-30.575371	0.0578	4.6±1.1
APMCC0917	355.39788	-29.236351	0.0509	2.1±0.6
Abell4038	356.93781	-28.140661	0.0293	2.9±0.5



Cover the entire range of halo masses
Nearly complete above $10^{10}M_{sun}$

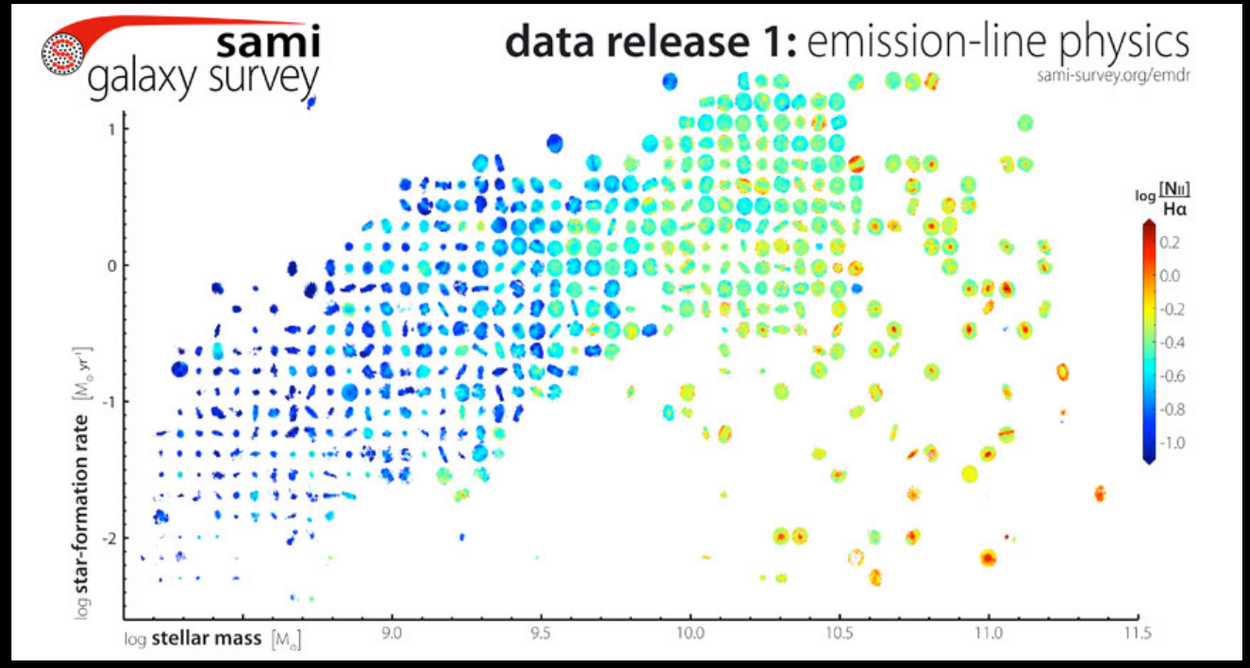
The SAMI Galaxy Survey DR2

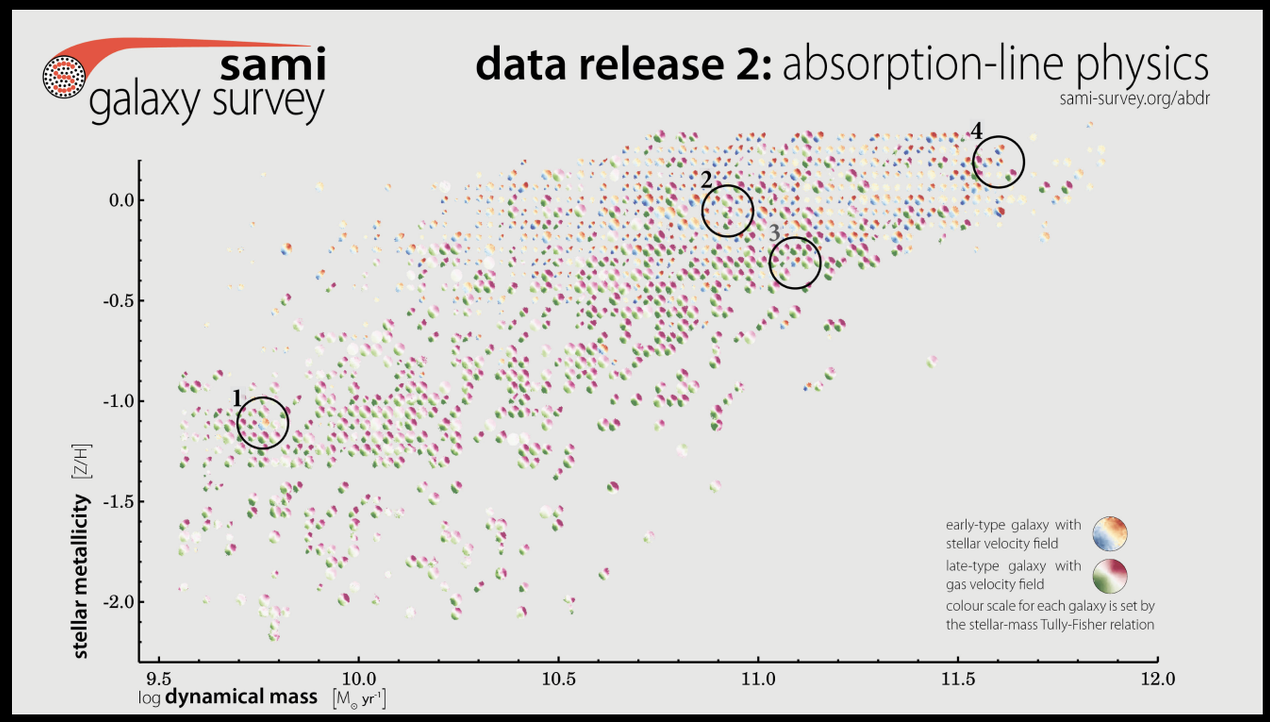
Cubes and value-added products publicly available for ~1600 galaxies



https://sami-survey.org/abdr

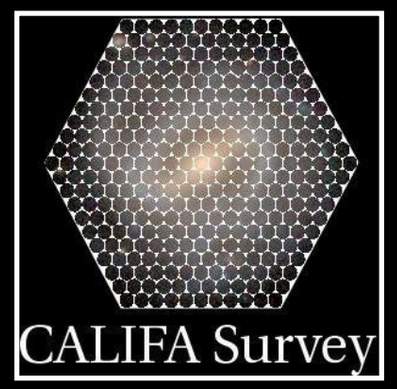
Scott et al. 2018





Why SAMI?

The 3 major IFS surveys in a nutshell



Specification	MaNGA	SAMI	CALIFA
Sample Size	10,000	3,400	600
Selection	$M > 10^9 M_\odot$	$M > 10^{8.2} M_\odot$	$45" < D_{25} < 80"$
Radial coverage	$1.5r_e$ (2/3), $2.5r_e$ (1/3)	$1\text{-}2r_e$	$>2.5r_e$
S/N at $1r_e$	15-30	10-30	$\sim$30
Wavelength range(Å)	3600-10300	3700-7350	3700-7500
Instrumental resolution	50-80 km/s	75/28 km/s	85/150 km/s
Input Spaxel Size	2.0″	1.6‴	2.7″

Sanchez 2015

Highly complementary to other IFS surveys

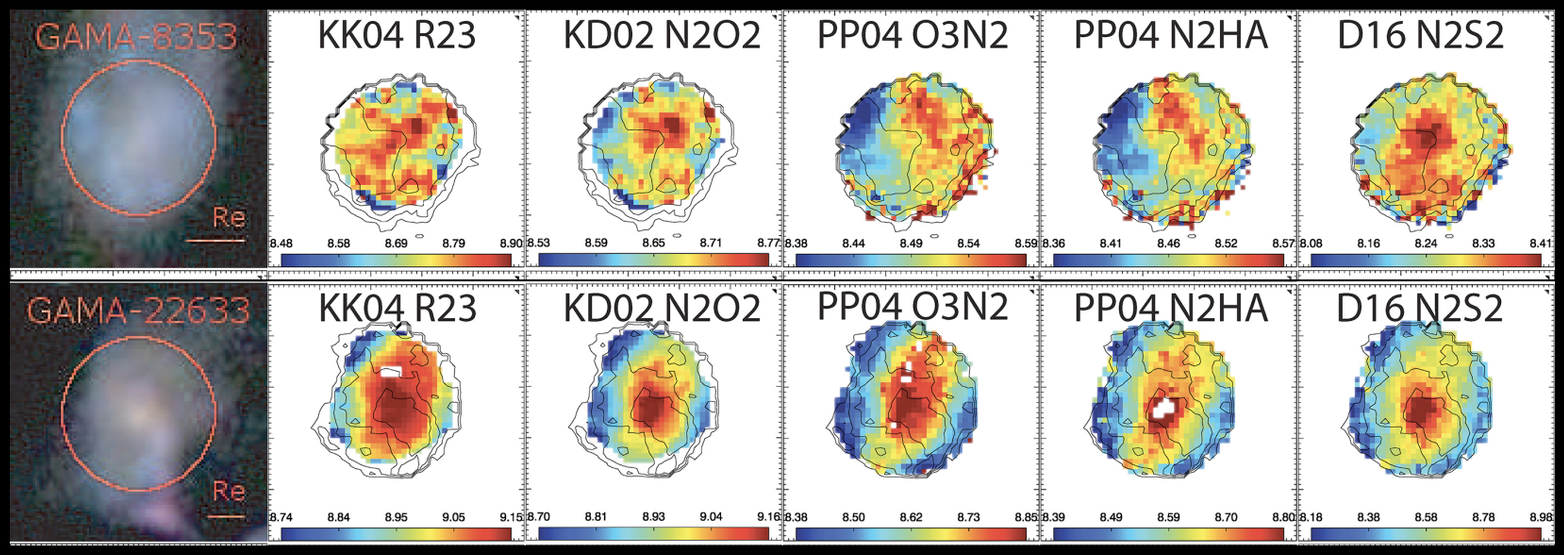
SAMI unique in terms of:

- higher gas velocity resolution
- wider stellar mass range
- wider environmental coverage (cluster regime)
- homogenous quality of ancillary data [FUV to FIR] and legacy potential

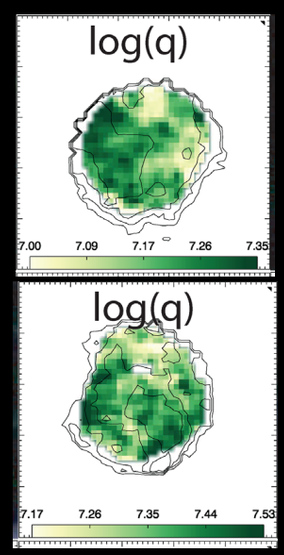
Gas physics

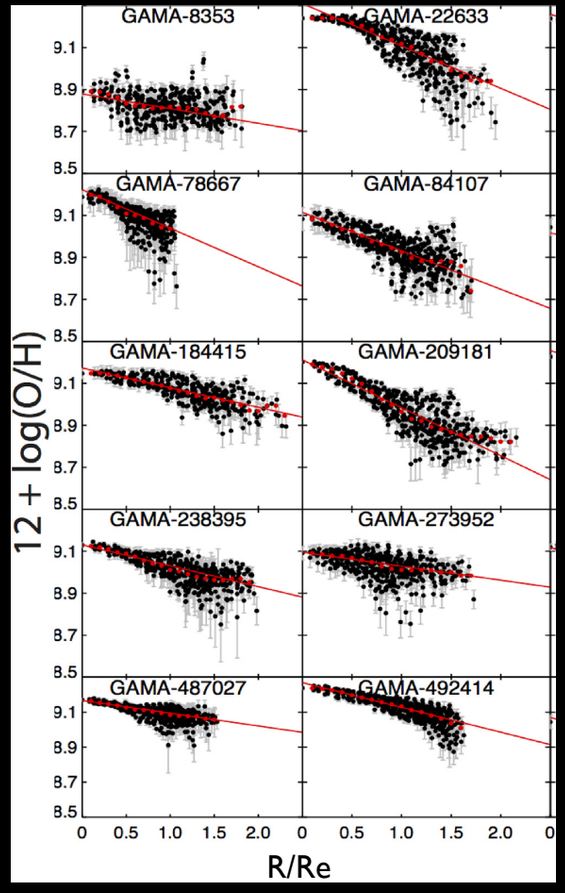
Ionisation and gas-phase metallicities

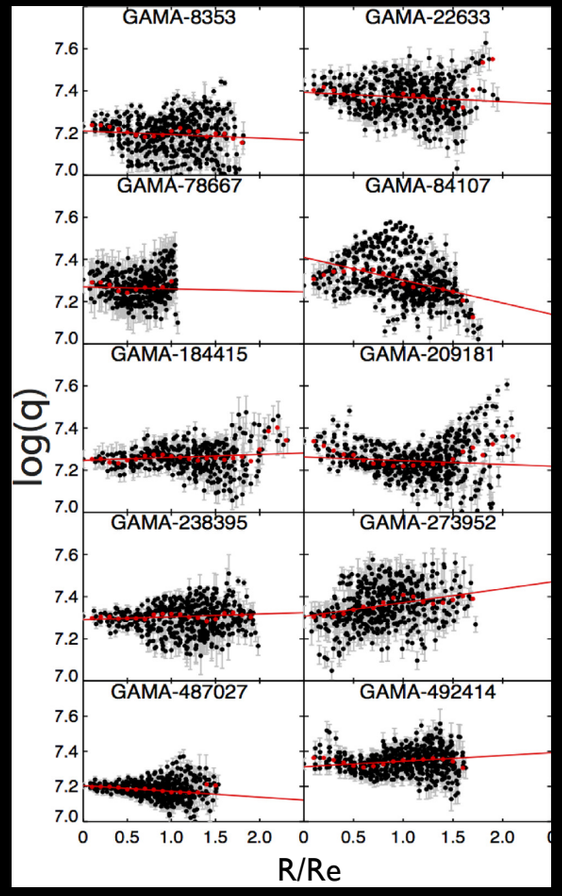
O/H maps



Ionisation parameter maps (q)

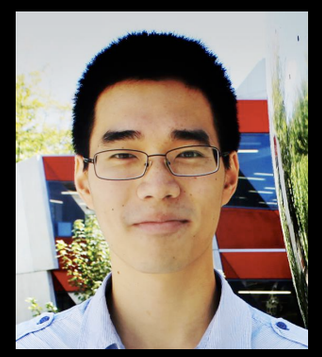




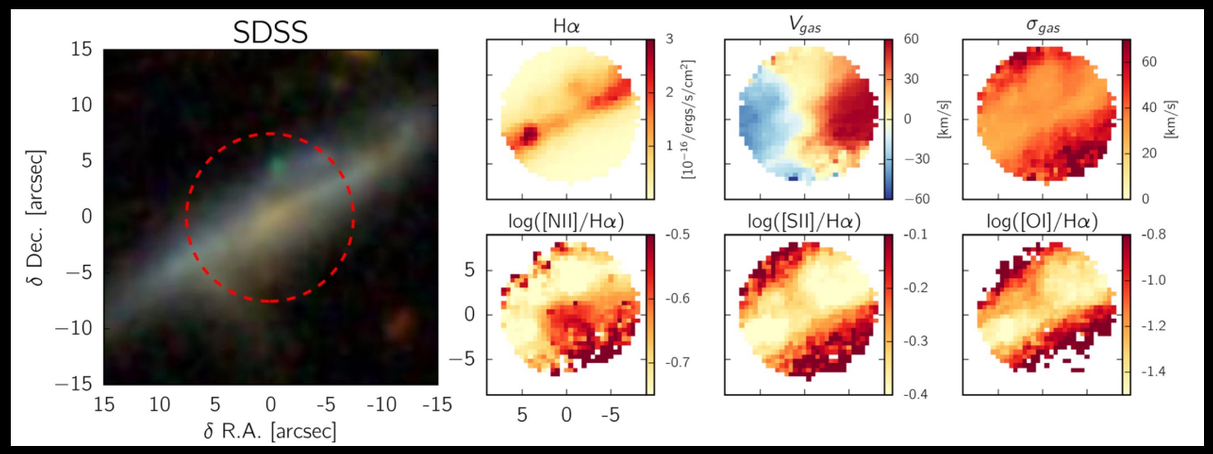


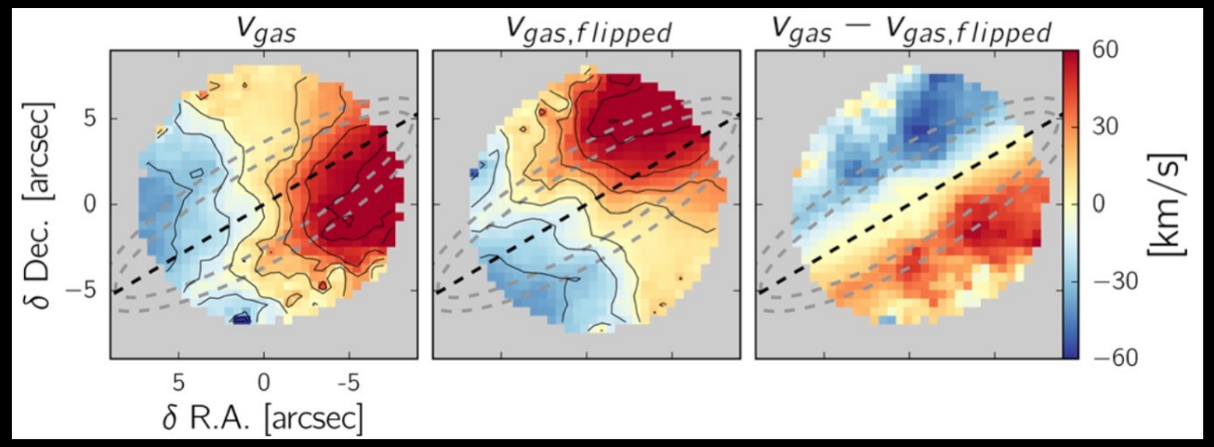
- Resolved distributions of O/H and q
- Radial gradients in O/H but not in q
- Variations in q are important for O/H estimates
- Methods no allowing for varying q may introduce bias in metallicity estimates
- Getting closer to more reliable O/H?

Poetrodjojo et al. 2018

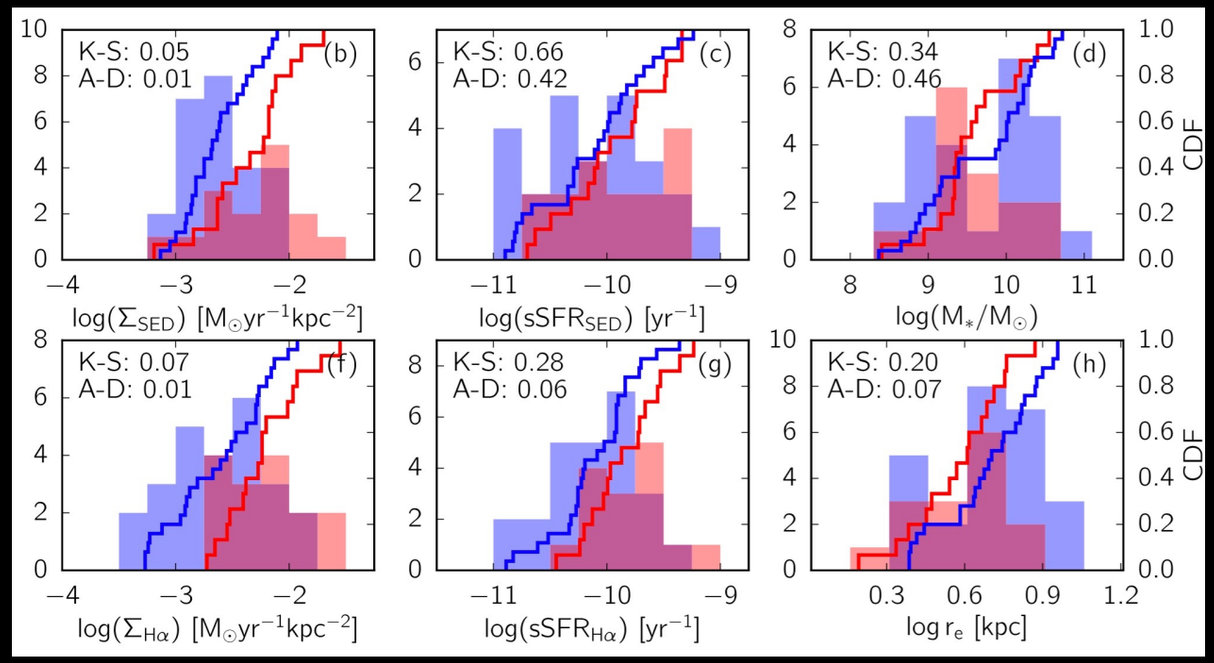


Ionised gas outflows in nearby galaxies

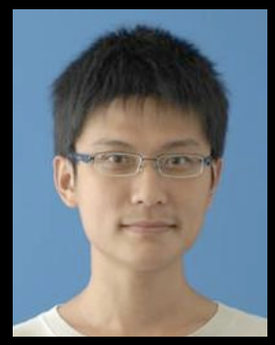




- Ability to isolate kinematic and ionisation signatures of outflows
- Disturbance in velocity field (i.e., multiple velocity components)
- Ionisation/velocity dispersion extraplanar gradients
- Hint that SFR surface density key parameter driving likelihood of ionised gas outflow
- Full survey will provide best local sample



Ho I-T. et al. 2014, 2016



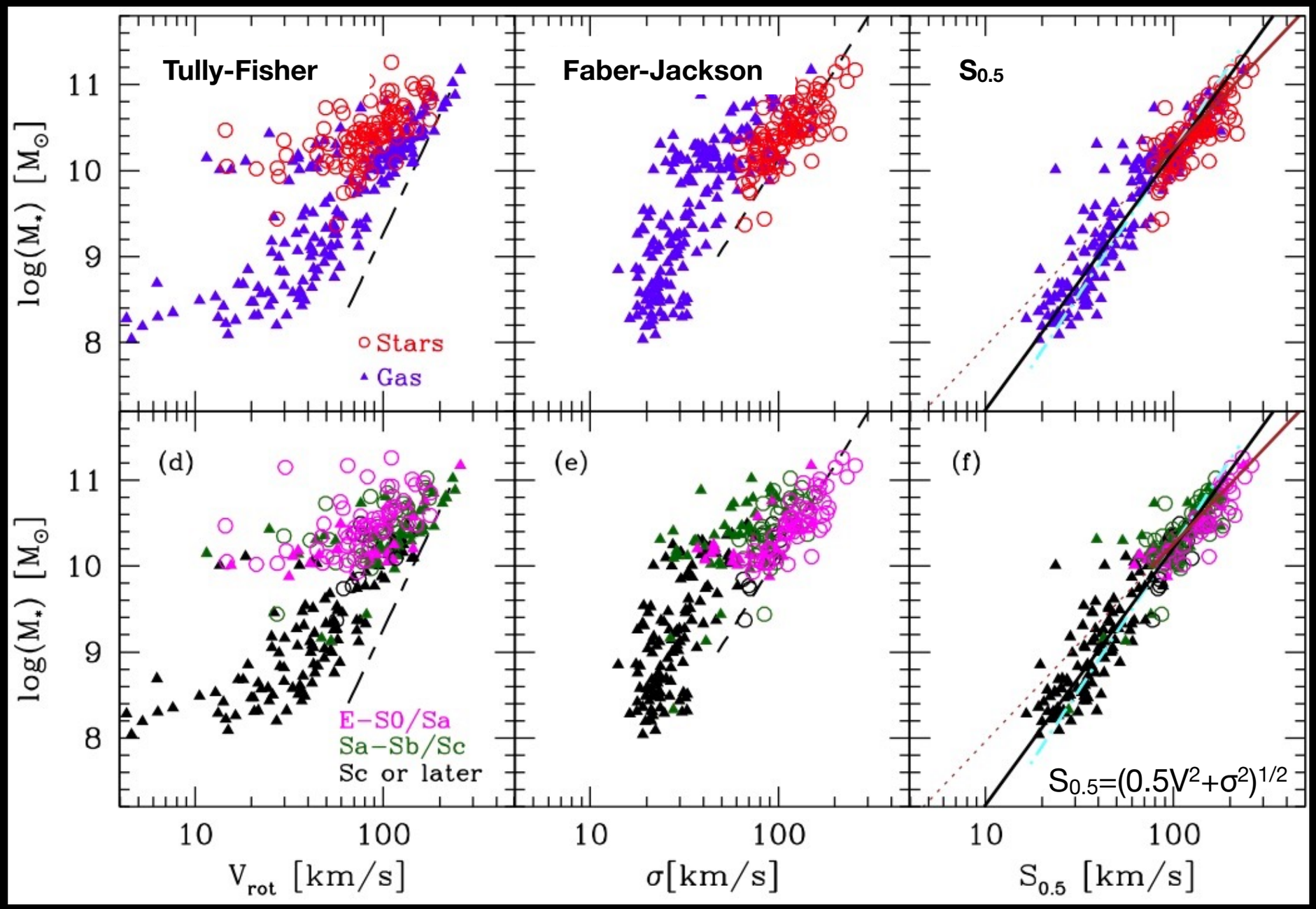
Kinematic scaling relations

The power of resolved kinematics for both gas and stars

Rotation and dispersion within one effective radius

Gas vs. Stars

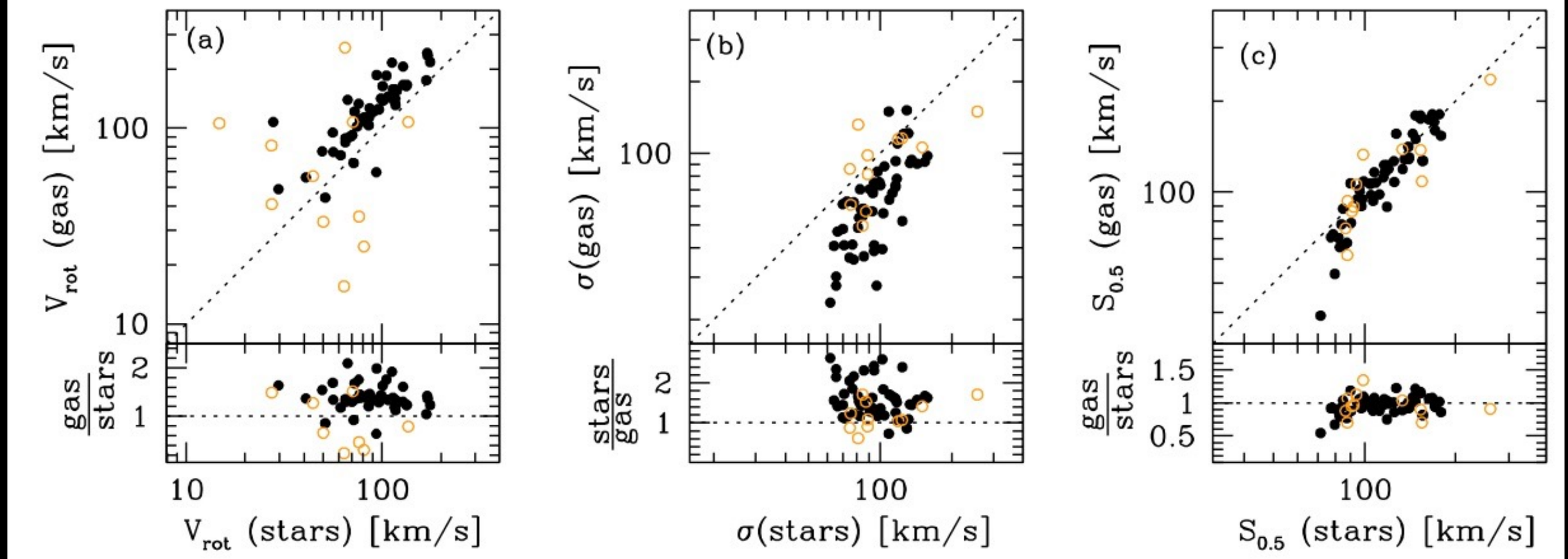
Morphology



Unified dynamical scaling relation for galaxies of all types
Scatter (0.1dex) similar to pruned TF and FJ relations

LC et al. 2014

Taking advantage of gas and stars simultaneously

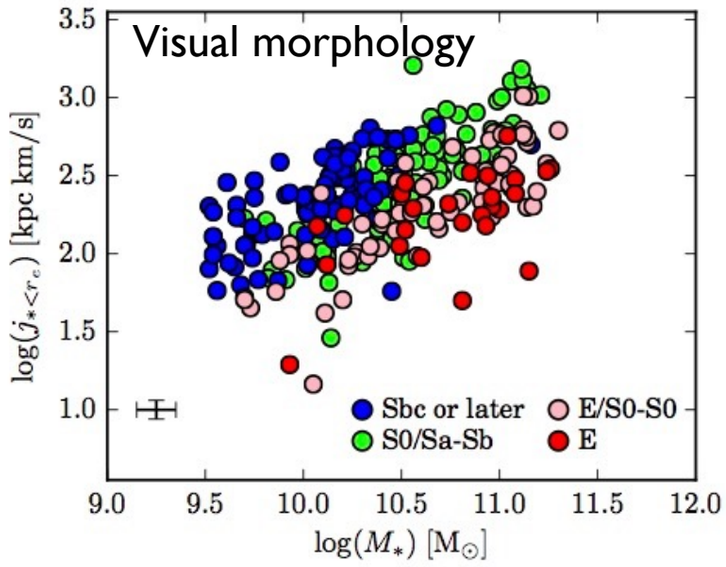


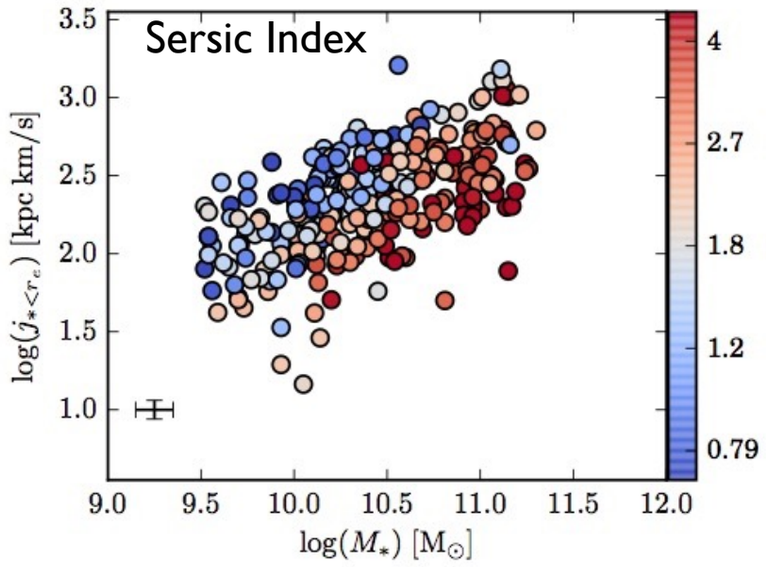
Ability to trace both gas and stars simultaneously provides great sanity check

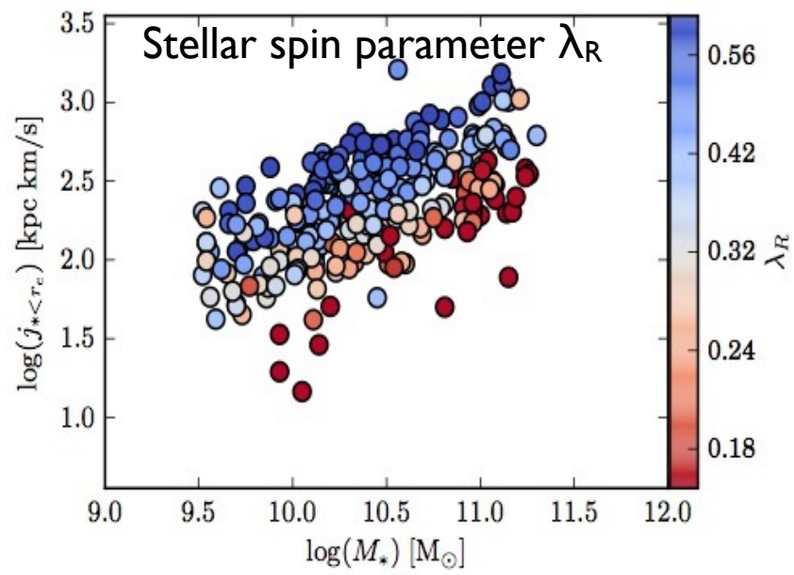
Combining rotation and dispersion balance effect of asymmetric drift

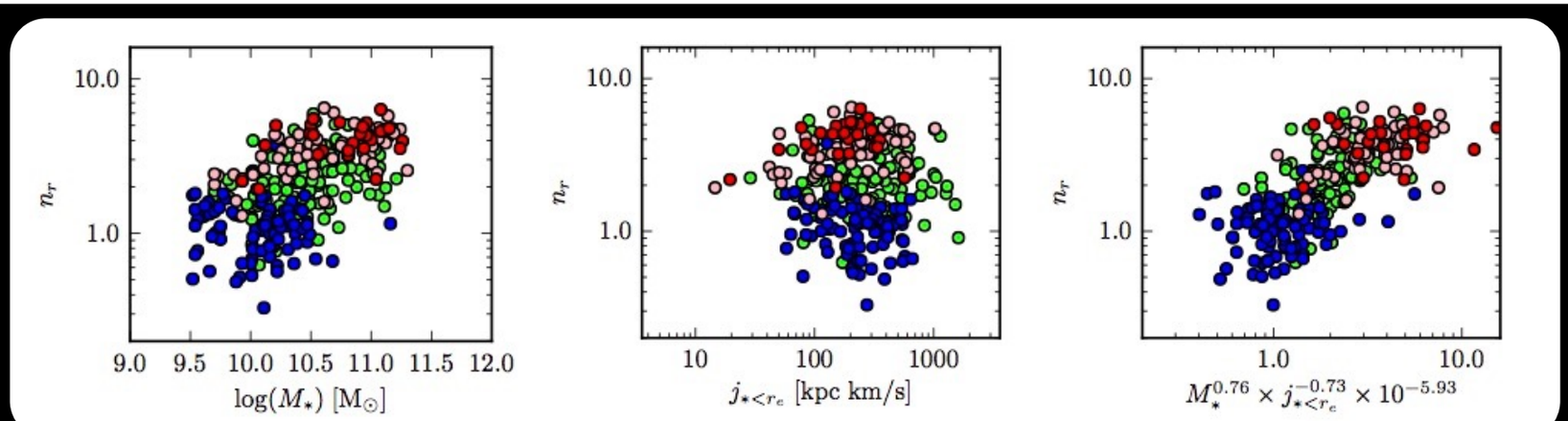
Angular momentum and optical morphology

Specific angular momentum







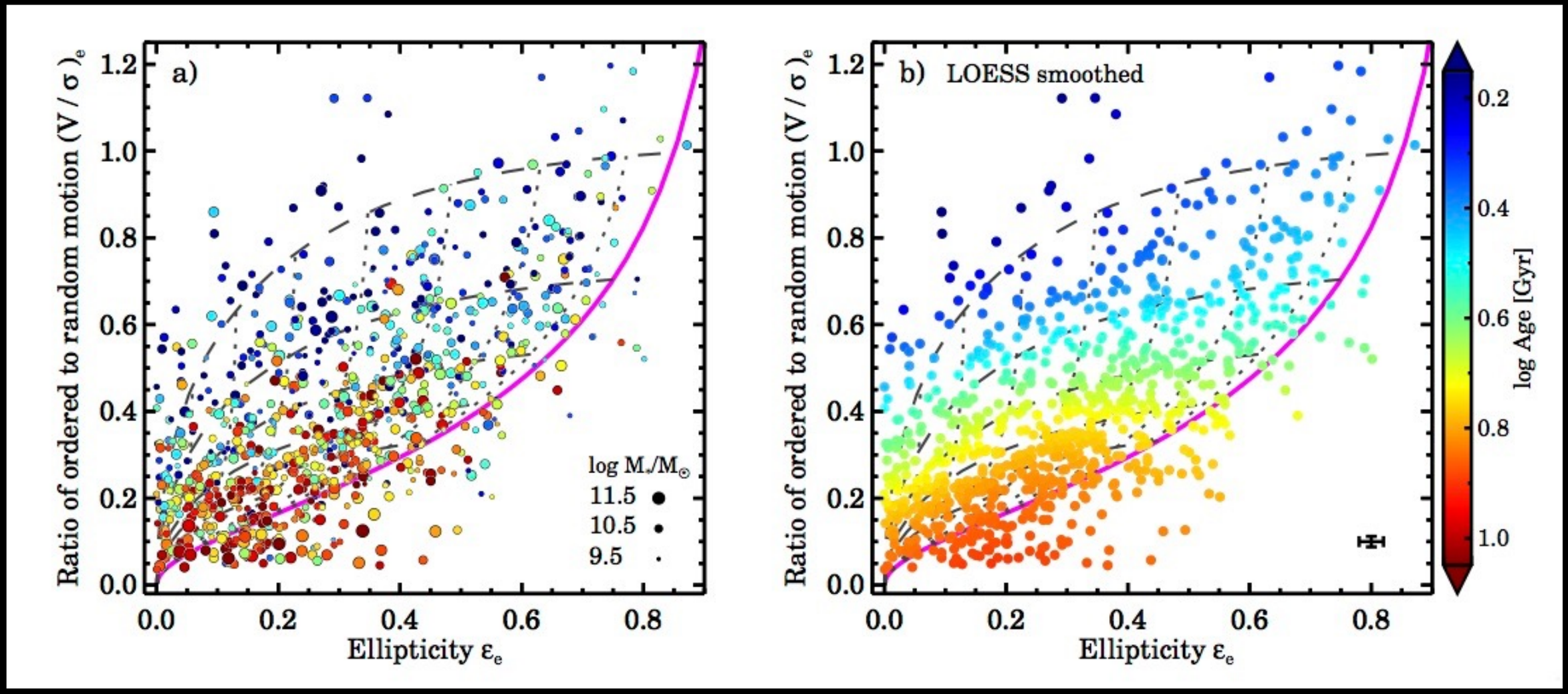


LC et al. 2016

The scatter of M*-j* relation correlates with stellar distribution
Galaxies sit on a `plane': "morphology" set by mass and j.

Note: this is just within 1r_e!

Galaxy Shapes and Stellar Ages



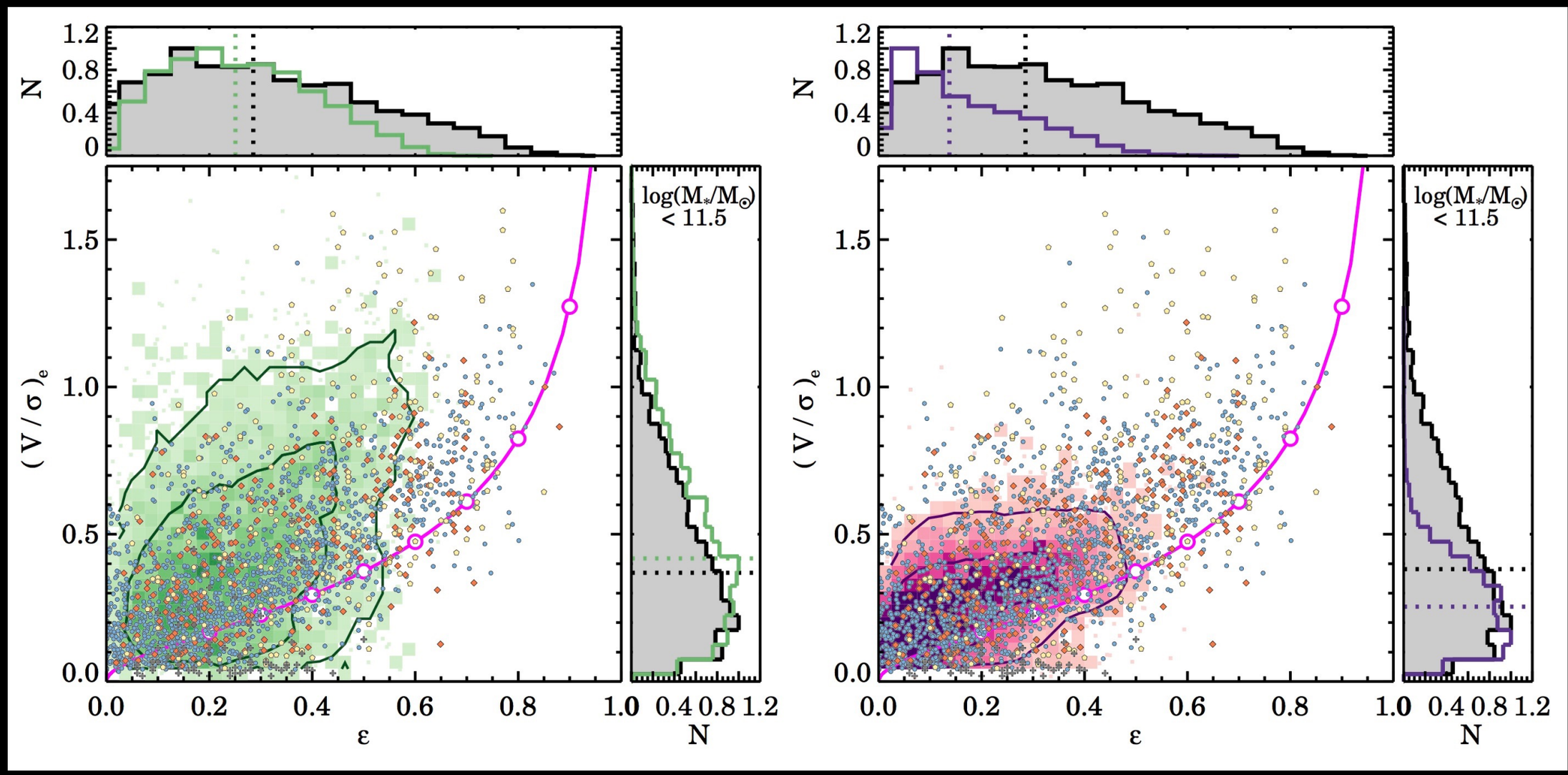
van de Sande et al. 2018

Intrinsic shape of galaxies linked to stellar ages

Constraining cosmological simulations of galaxy formation

SAMI vs. EAGLE

SAMI vs. Horizon AGN

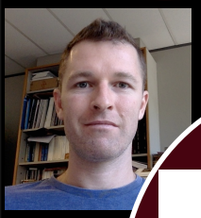


van de Sande et al. in prep.

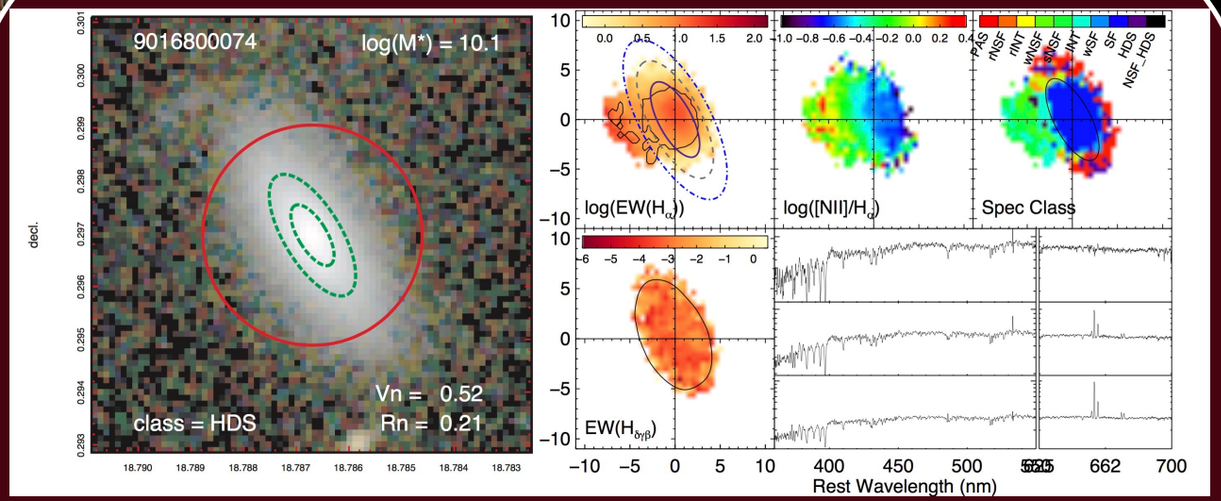
Cosmological simulations not able to produce thin/fast-rotating disks

Role of environment

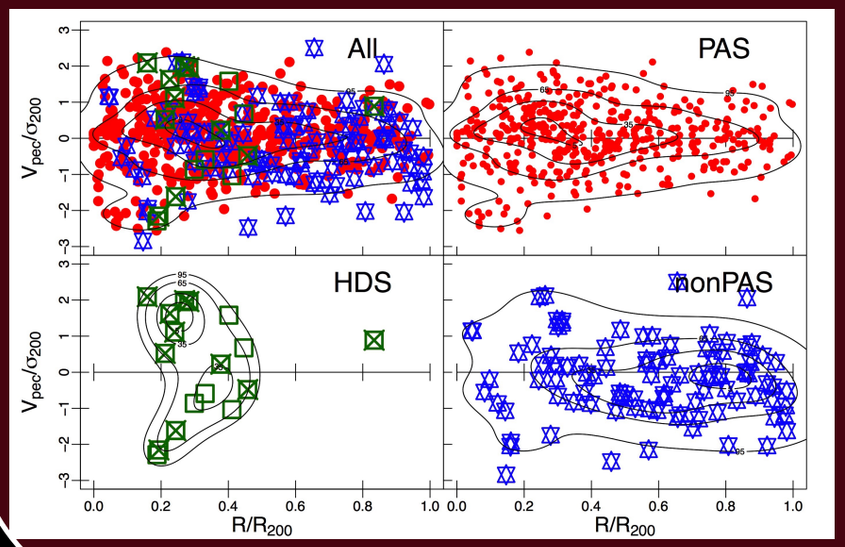
How are galaxies really transformed?



Cluster environment

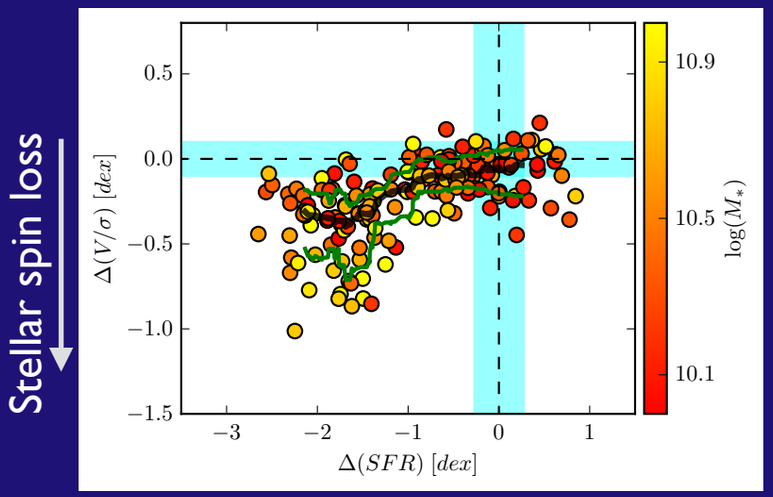


First unbiased IFS census of cluster galaxies
Representative sample of perturbed/jelly-fish systems
Rapid truncation features (Hδ-strong) only for infalling population.



Owers et al. in prep

Group environment

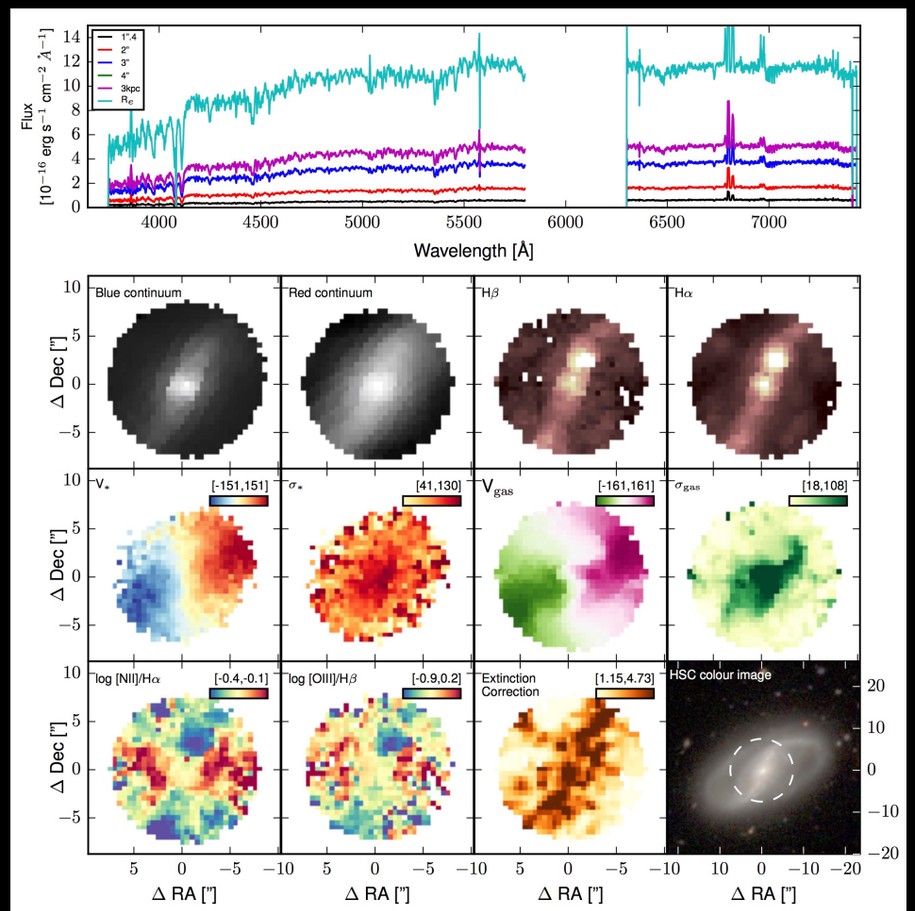


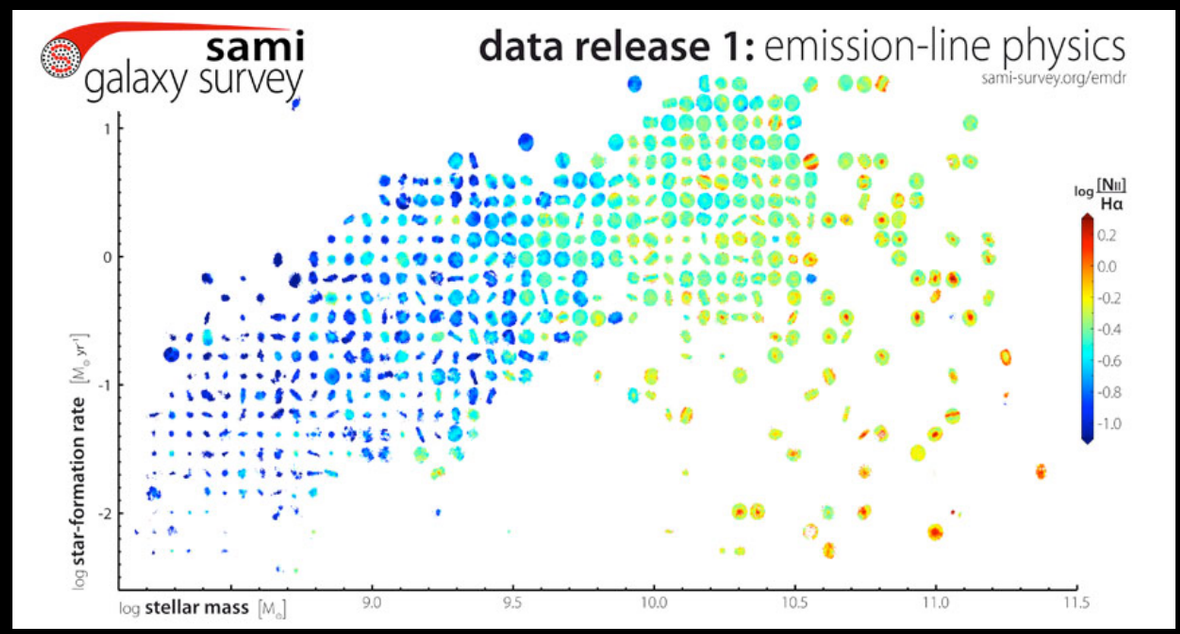
Ability to reveal how satellites are transformed in groups
Disentangle between quenching and structural changes

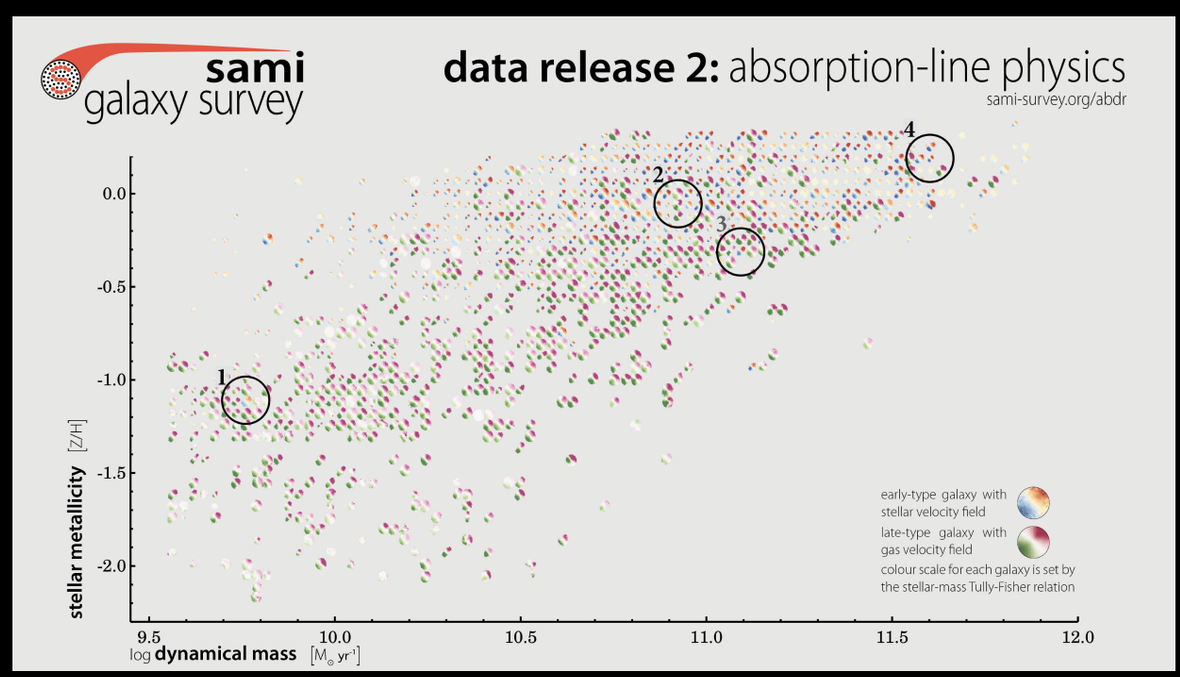
Any structural changes take place after quenching

LC et al. in prep

The SAMI Galaxy Survey







Extremely rich dataset
Scratched only the tip of the iceberg
Full dataset key for statistical studies

HECTOR

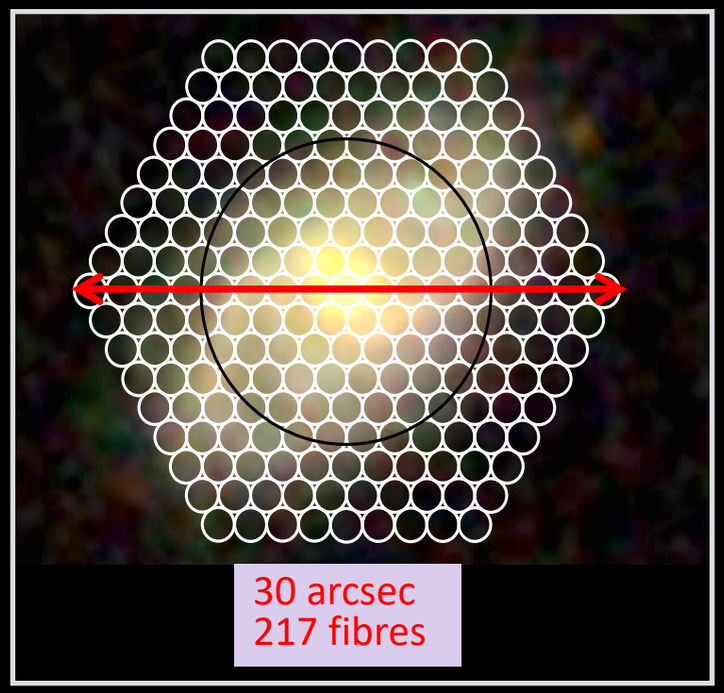
The next-generation Australian IFS instrument

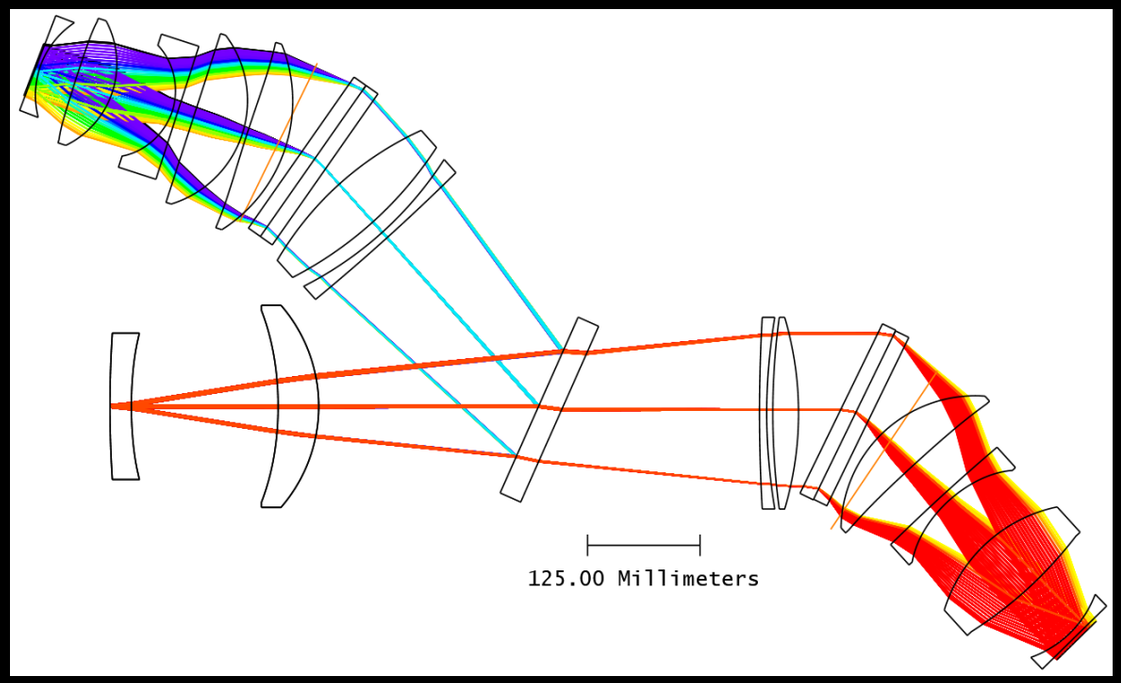
HECTOR-I: 21 hexabundles across a 2 degree field

13 SAMI-like+ 8 bigger (up to 30") bundles

New spectrograph: Continuous coverage from 3726 to 7761A R=1.3A

Major improvement in stellar kinematic studies





Commissioning to start in mid 2019

Credit: Julia Bryant

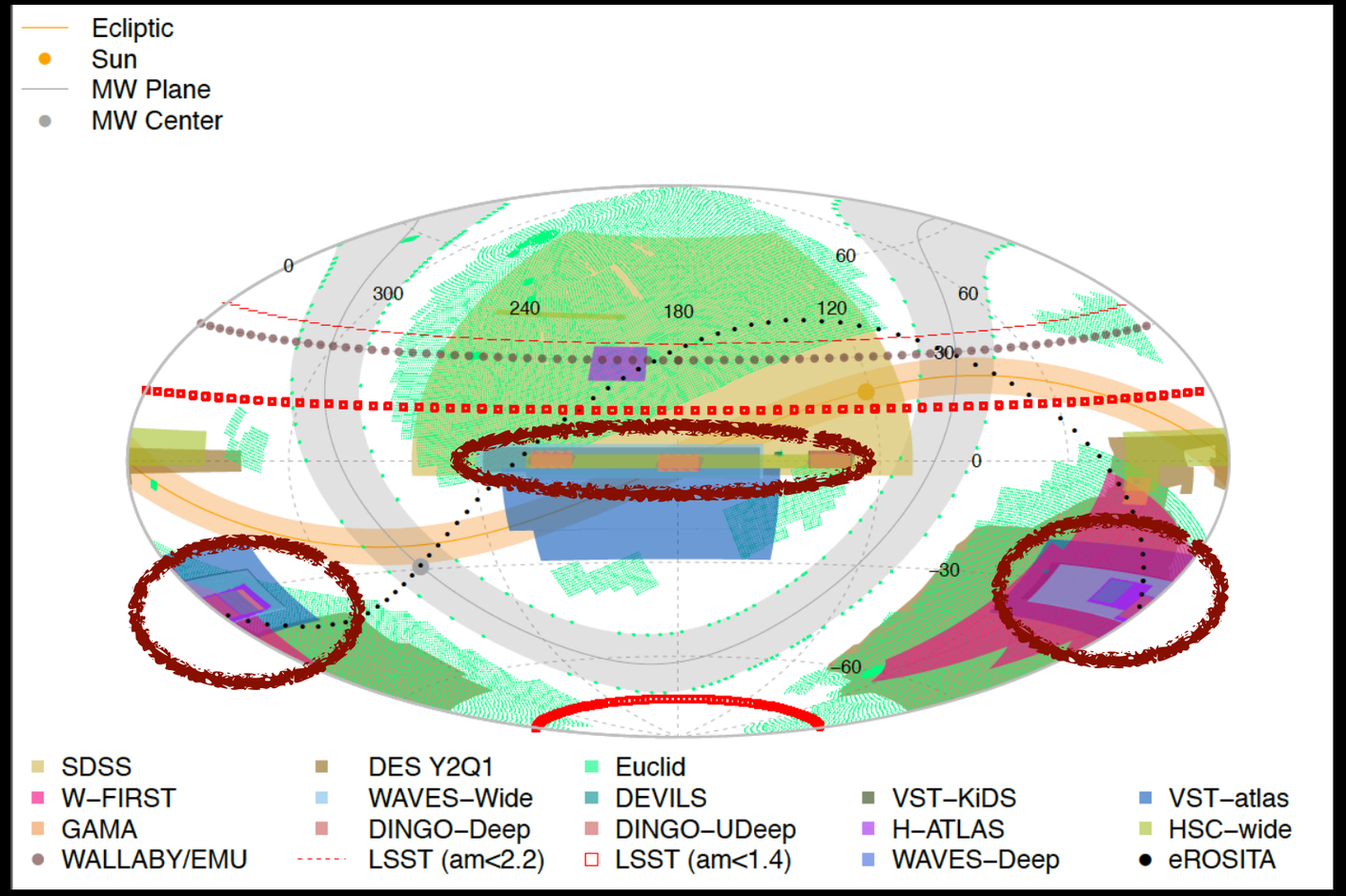
The HECTOR Galaxy Survey

The next-generation Australian IFS survey

Primary scientific drivers: Extend stellar kinematic studies below 10^{10} M_{sun}
Link galaxy evolution to LSS (role of filaments in build-up of AM)
Maximise synergy with blind ASKAP HI survey

Targeted regions: Primarily 4MOST WAVES-wide/-deep footprint

Detailed target selection under way: aiming for 10-20k galaxy survey [starting in ~2020]



The case for a CAHA IFS survey of nearby galaxies

Highly complementary to SAMI/HECTOR and MANGA: smaller samples but better spatial resolution

Going for higher spectral resolution would increase discovery potential: at least 20-30 km/s in Hα

Main competitor SDSSV: Local Volume Mapper program
MW, LMC,SMC, M31, M33 plus galaxies with D<5 Mpc (R~4000)

Focus on the 5<D<20 Mpc (including Virgo!) - Huge legacy value (in particular if same spec. resolution)