Integral field spectroscopy Science with SAMI, Hector and ULTIMATE-IFU

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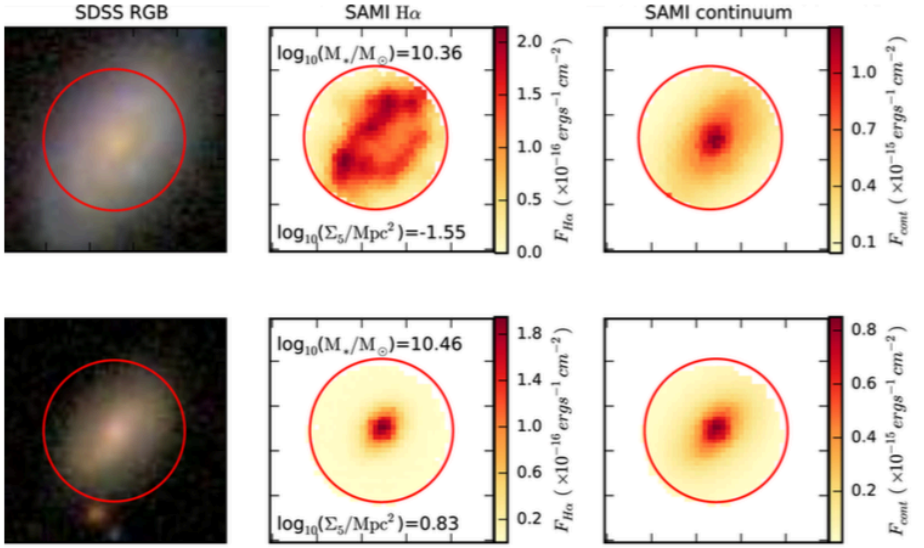
SAMI instrument scientist

Hector project scientist

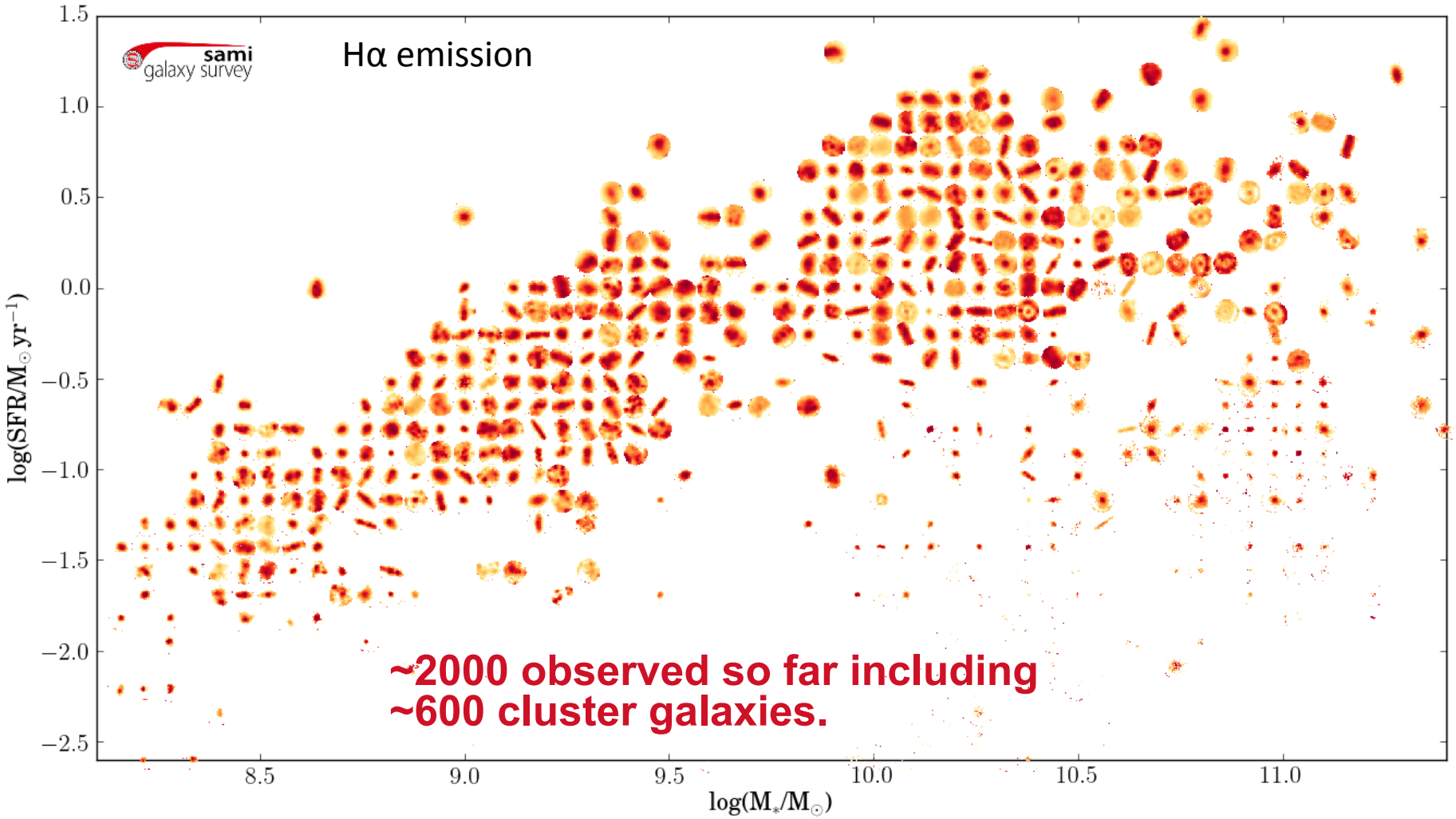
The SAMI Galaxy Survey

- Key science requires a **broad range in environment and stellar mass**:
  - physical processes driving galaxy transformations,
  - build up of mass and angular momentum in galaxies,
  - how does gas get into/out of galaxies (feedback and feeding).
- 2013B-18A. ~40nights /year
- 3600 galaxies = 2800 field/group galaxies + 800 cluster targets

Croom et al. 2012,
Bryant et al. 2015,
Owers et al. 2017,
Green et al. 2017



The SAMI Galaxy Survey



Public data release of ~800 galaxies next month: http://sami-survey.org/

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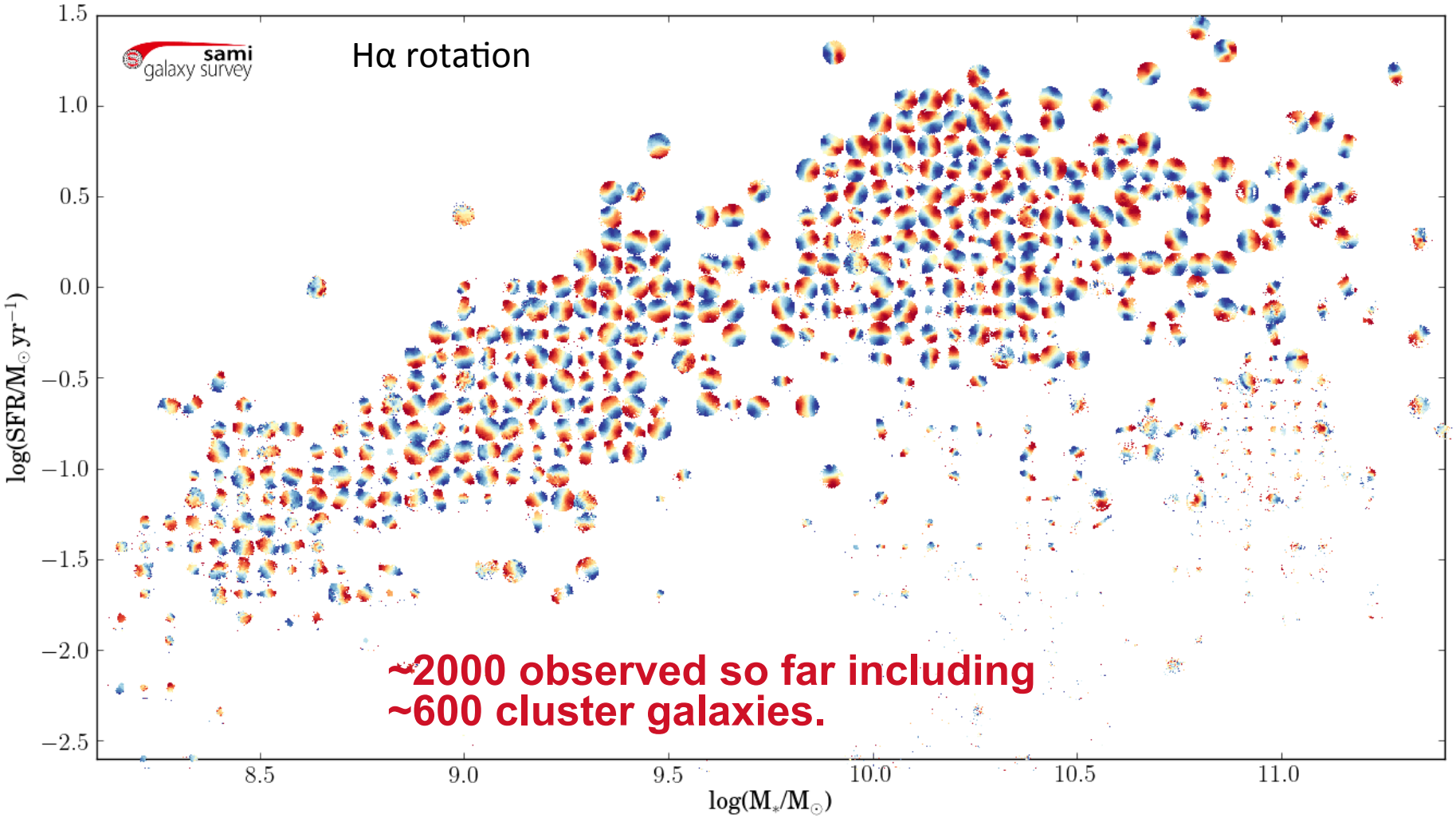
The SAMI Galaxy Survey



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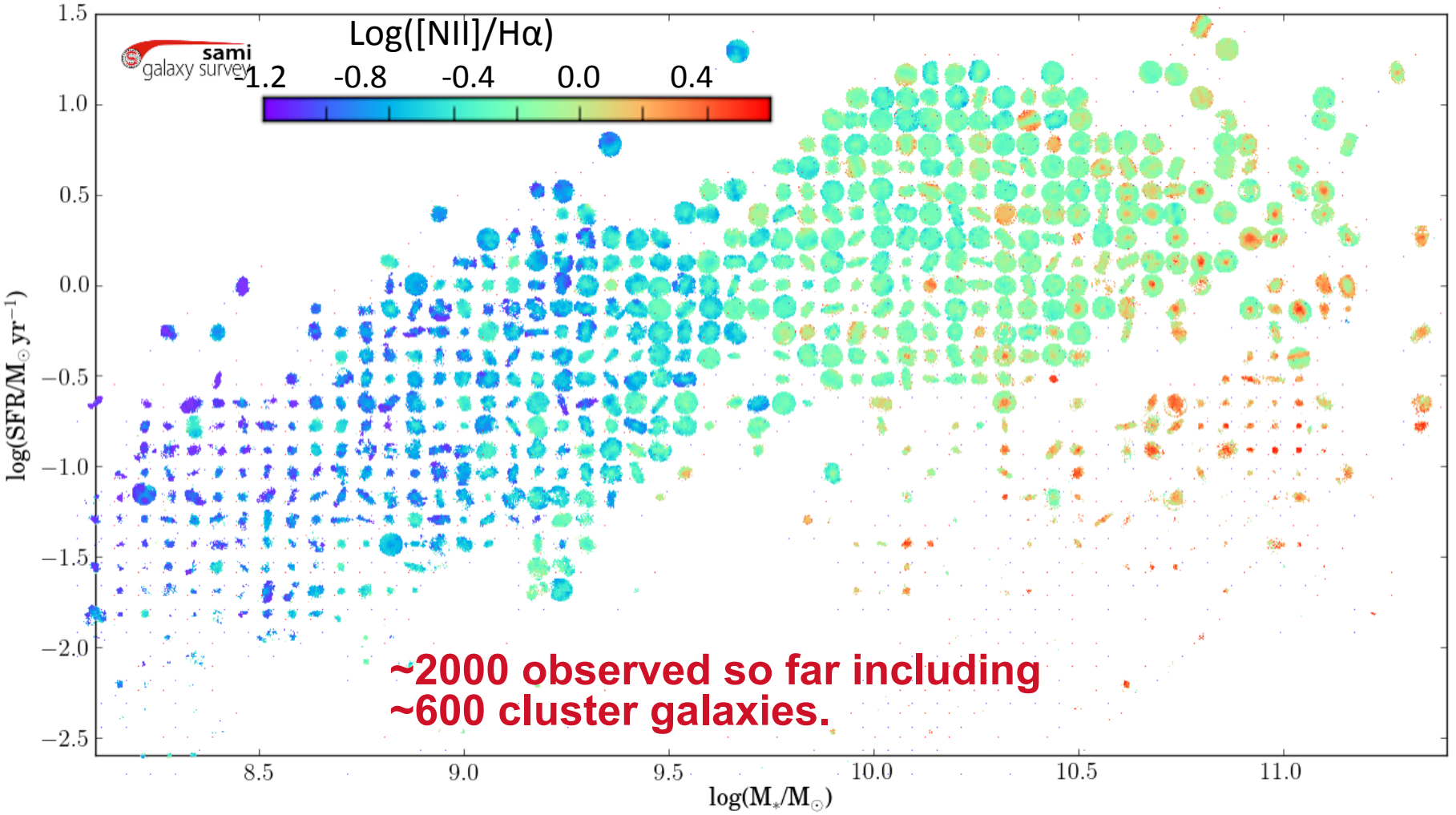

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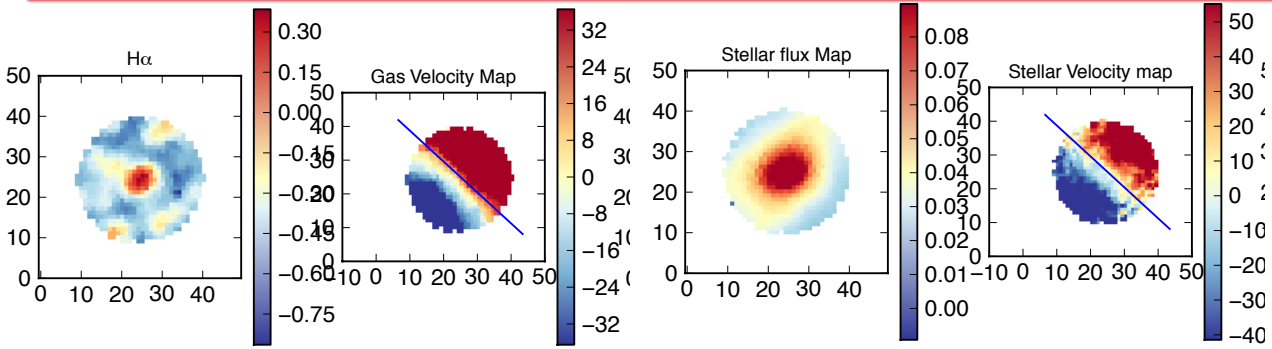
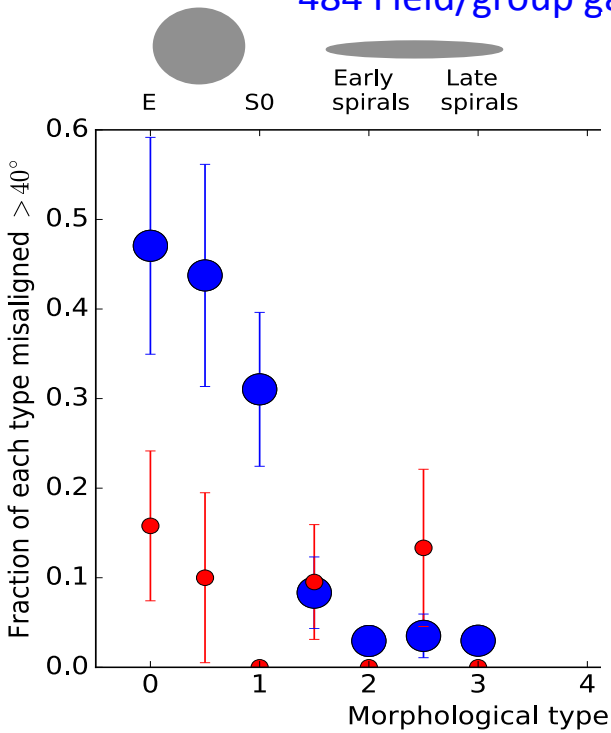
Origin of gas in galaxies

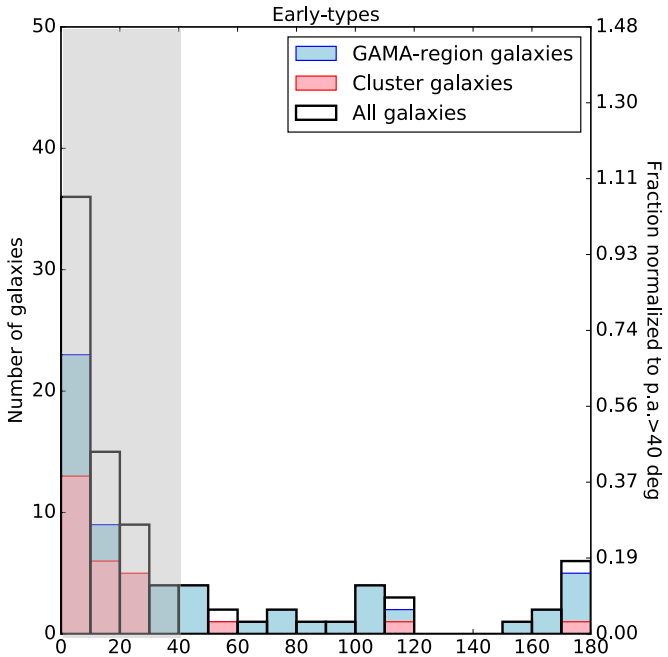


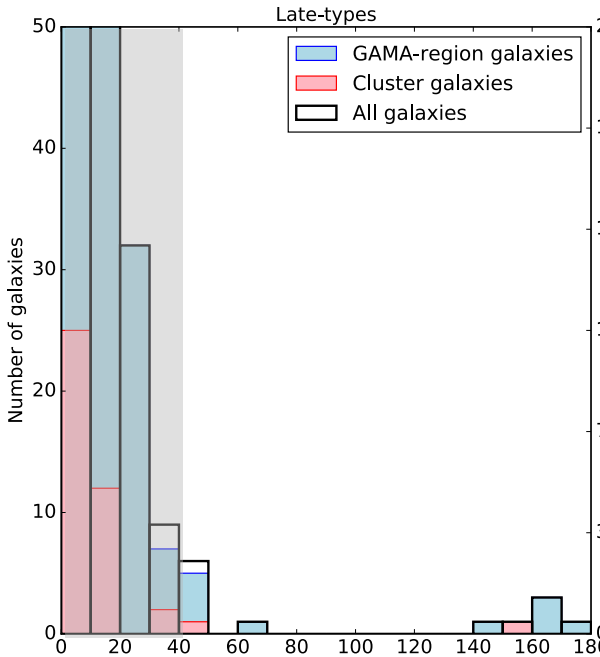
Bryant et al. (in prep)

$T_{torque} \approx t_{dyn} / \varepsilon$
(Lake & Norman 1983)?

136 Cluster galaxies
484 Field/group galaxies

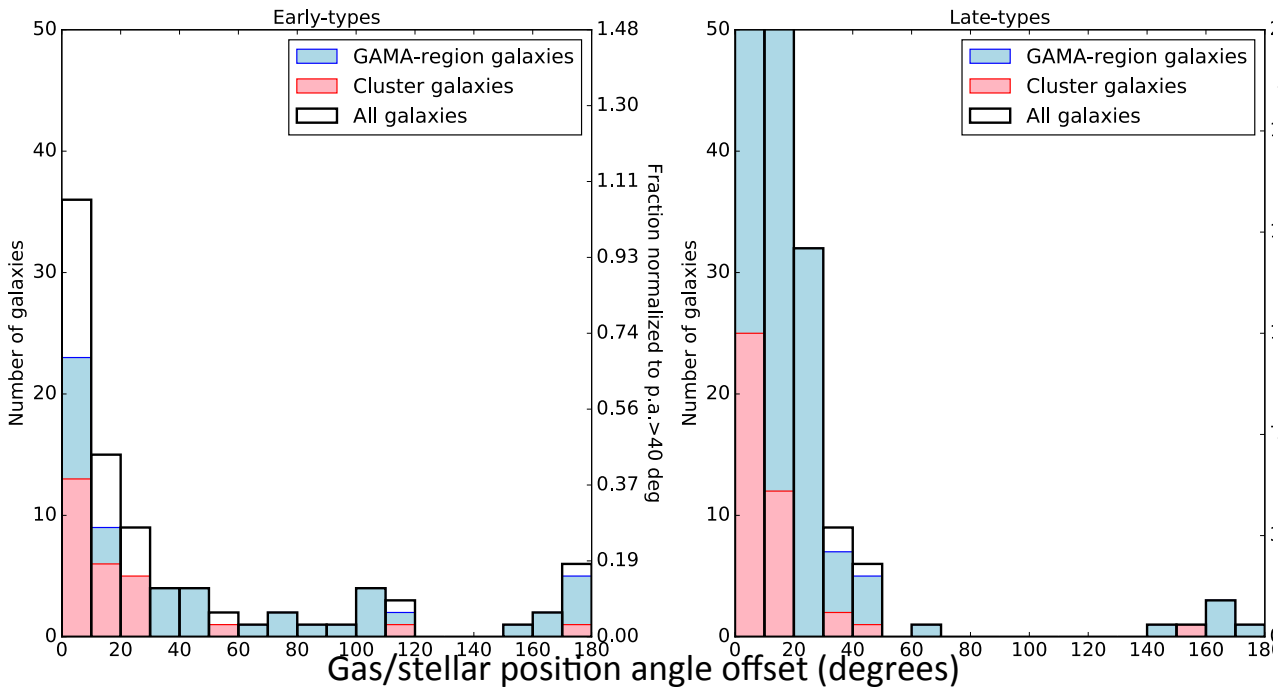


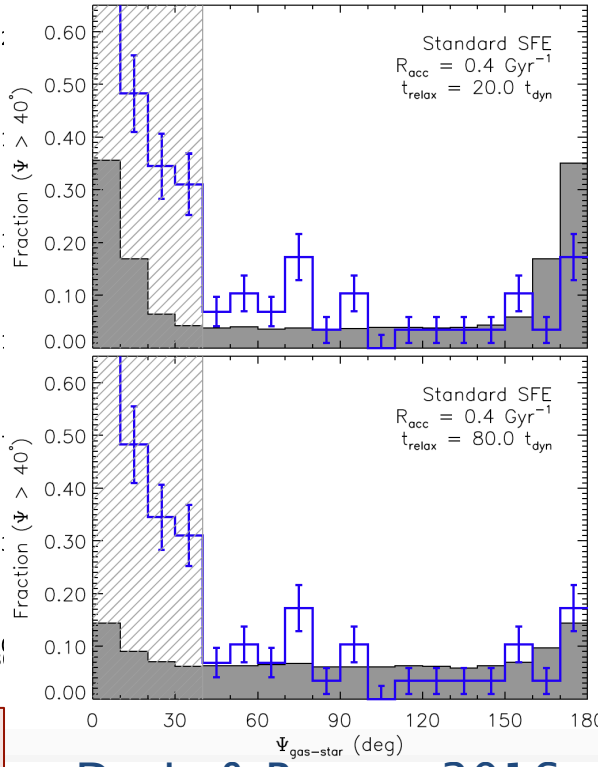




Gas/stellar position angle offset (degrees)

Origin of gas in galaxies





Davis & Bureau 2016

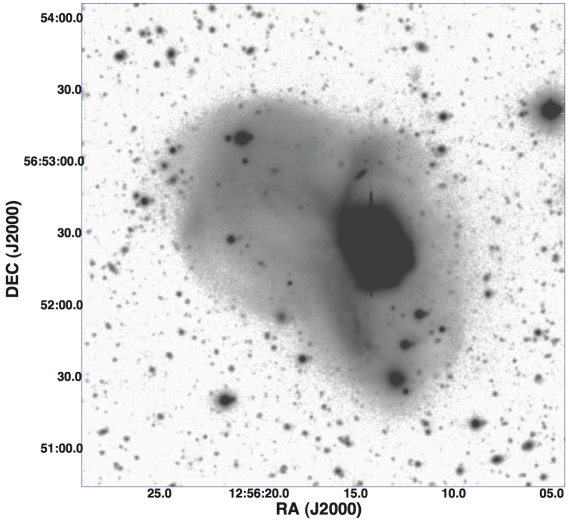
Is the misaligned gas accreted sporadically from mergers or fed continuously from outer halos?

- Smooth accretion from halo required in ETGs to give >40% misalignment (Lagos et al. 2015).
- ETGs in this sample all have disks => Simulations predict product of merging gas-rich galaxies (e.g. Naab, Jesseit & Burkert 2006)

➔ need **deep imaging** to identify tell-tale remnants of mergers such as tidal tails.

SUBARU deep imaging of SAMI galaxies

MRK231 SuprimeCam R_c
Koda et al. 2009



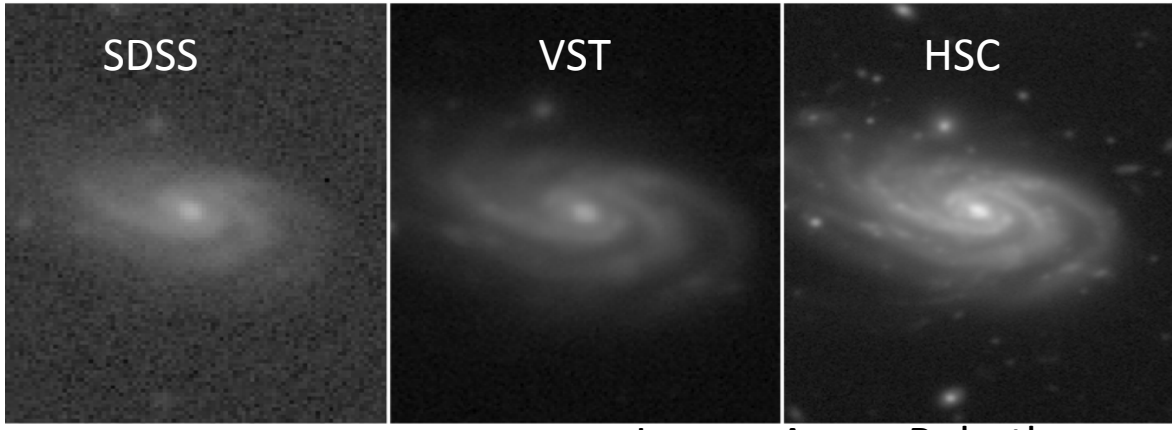
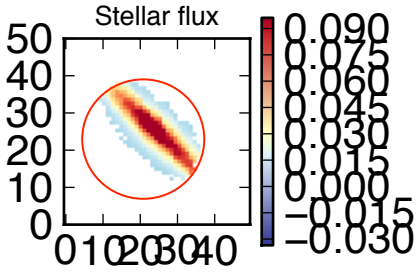


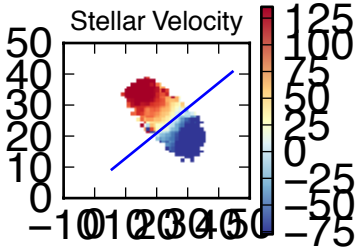
Image: Aaron Robotham

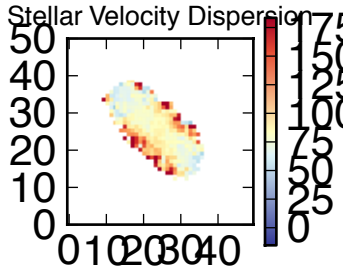
- HSC would give g,r,i,z imaging deep enough to image tidal features for a direct identification of mergers, plus bulge/disk decomposition, intra-cluster light.
- GAMA (field and groups) regions will have HSC & VST/KiDs imaging,
- Clusters only have SDSS and VST/KiDS imaging. HSC imaging of SAMI clusters would allow direct comparison of environments.

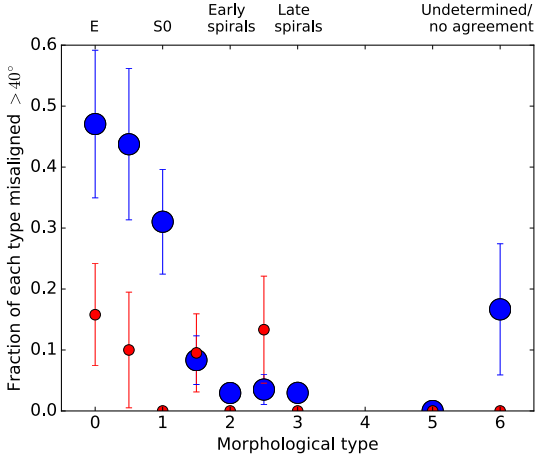
Misalignment in clusters

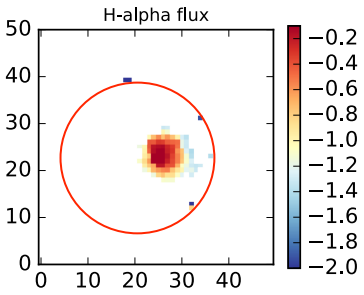
Ram-pressure stripped spiral

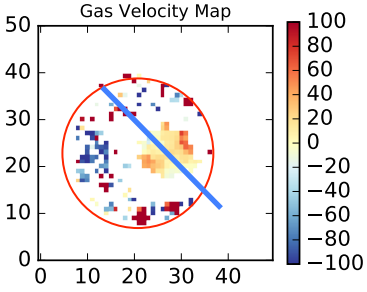


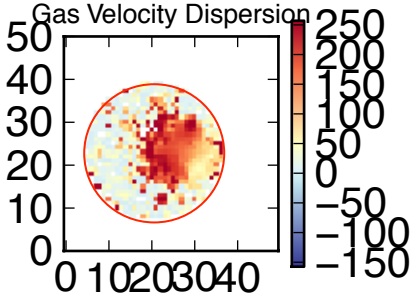


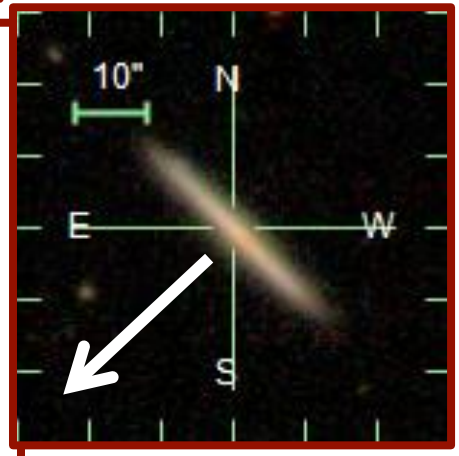






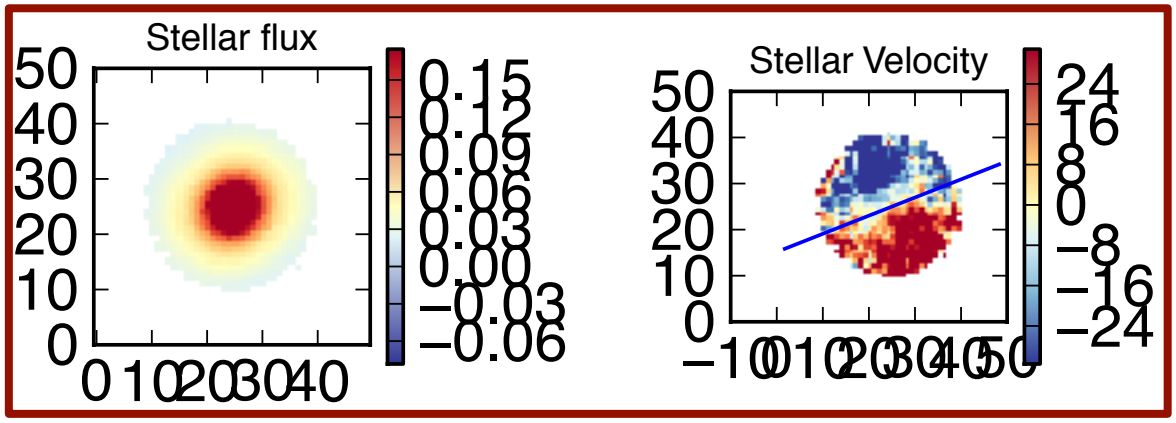


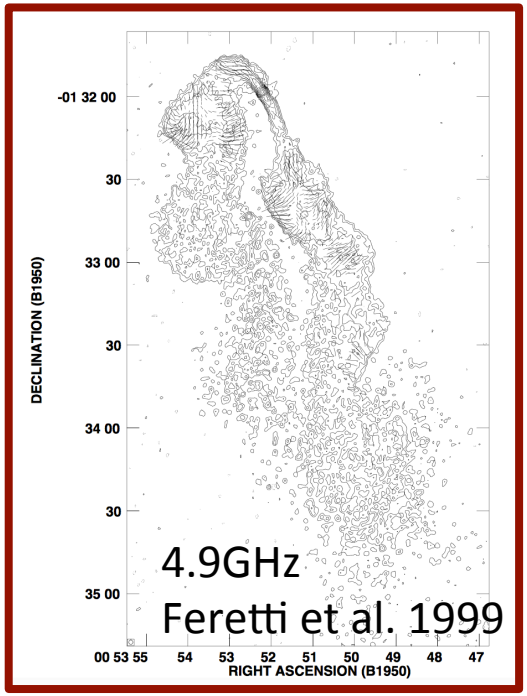




Misalignment in clusters

Ram-pressure stripped early-type galaxy





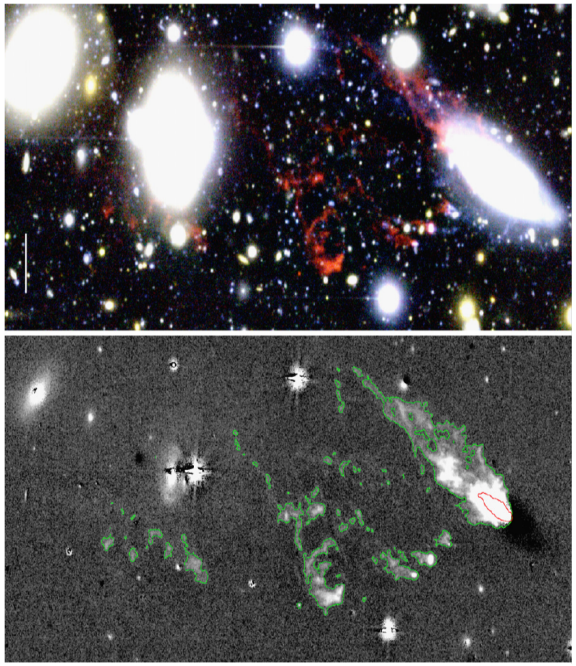
Outside-in truncation of star formation

SUBARU narrow-band imaging of SAMI clusters

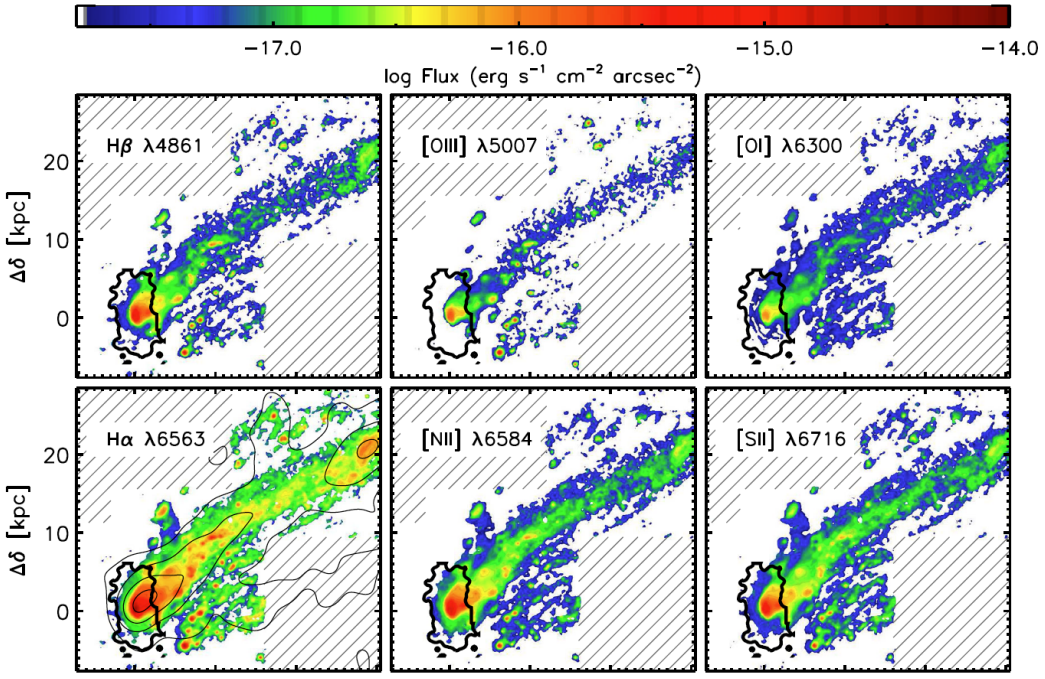
Deep NB515/NB527 narrow-band imaging covers [OIII]5007 for SAMI/Hector clusters:

- Ionised gas tails due to ram pressure stripping.
- Outflows: Gas recycling – is newly accreted gas pristine or re-accreted after a previous outflow event.

See also Owers et al. (in prep.)



Yagi+2010 Subaru Hα image



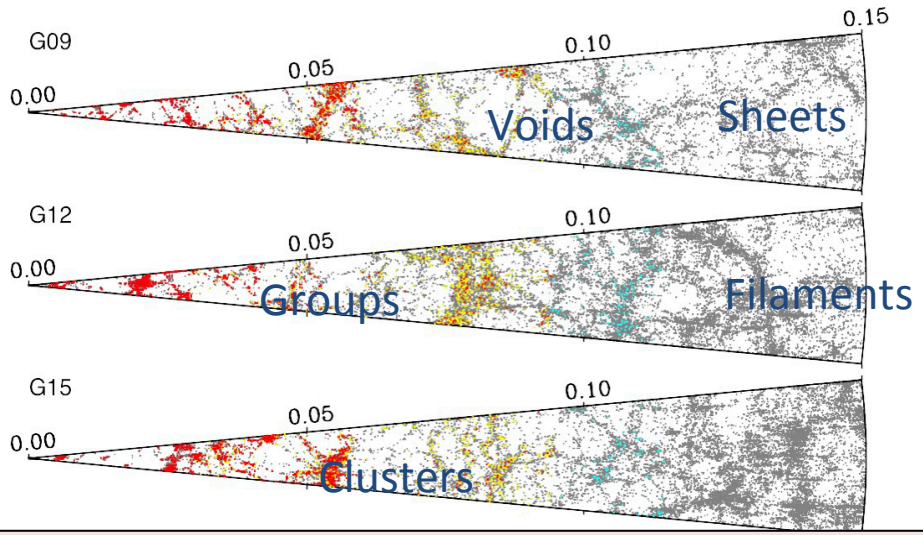
Fossati+2016 MUSE

The next step for IFS in Australia: Hector

Mass and local environment

Accretion and merger history ➔ morphology and star formation history.

Large-scale environment ➔ modulate galaxy growth through tidal torques and gas accretion.



>50,000 z<0.15 galaxies

The only IFS survey large enough to link IFS to large scale structure for the first time.

Measurables:

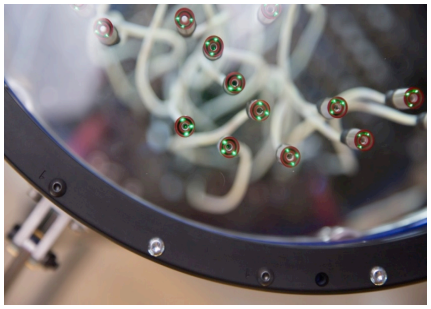
- Spin parameters, specific stellar angular momentum => merger histories
- Higher-order kinematics of the line-of-sight velocity distribution => formation paths
- Measure current kinematic disturbance as a probe of ongoing dynamical interactions
- Gas/stellar misalignment, metallicity gradients => external gas accretion

The next step for IFS at SUBARU: ULTIMATE-IFU

A SAMI-like emission-line-focused IFS survey at : z~0.6, 0.9, 1.4

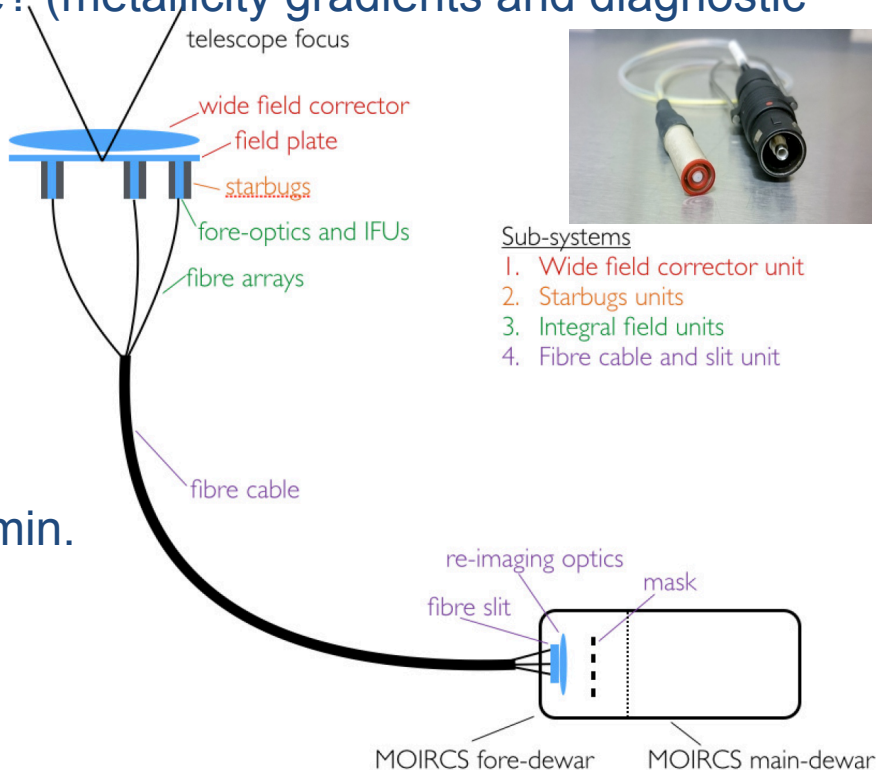
Science focus:

- How does feeding and feedback change with cosmic time? (AGN and stellar-driven outflows)
- What causes star formation quenching in dense environments? (SFR gradients)
- How does gas accretion change with time? (metallicity gradients and diagnostic emission-line ratios)
- What drives galaxy transformations? (internal kinematics)



Instrument:

- 8-13 IFUs
- 61 microlens arrays
- Starbug robotic positioner over 14 x 8 arcmin.
- Feed nuMOIRCS in near-IR and/or PFS visible/near-IR spectrographs.



Ellis et al. 2016 SPIE, 9908, 19

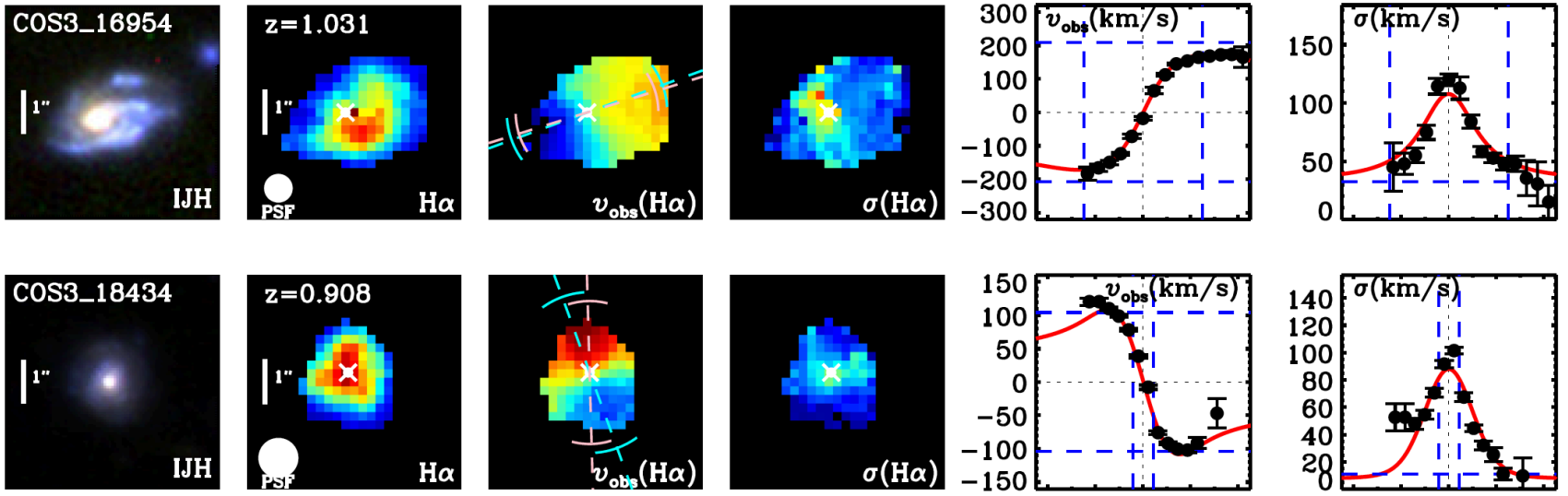
ULTIMATE-IFU complements SAMI and Hector

	SAMI	ULTIMATE
Spaxel	1.6”	0.15”
Number of spaxels	61	61
FoV	15”	1.2”
Number of IFUs	13	7 – 13
Patrol field	1 degree diameter	14’×8’
Spectral resolving power	1700 (blue), 4500 (red)	3000 – 5000
1.6” at $z = 0.05$	1.56 kpc	–
0.15” at $z = 0.5$	–	0.92 kpc
0.15” at $z = 1$	–	1.20 kpc
0.15” at $z = 1.5$	–	1.27 kpc
15” FoV at $z = 0.05$	14.7 kpc	–
1.35” FoV at $z = 0.5$	–	8.2 kpc
1.35” FoV at $z = 0.1$	–	10.8 kpc
1.35” FoV at $z = 0.15$	–	11.4 kpc

Ellis et al. 2016 SPIE, 9908, 19

ULTIMATE-IFU complements SAMI and Hector

- Direct analogs to SAMI at higher redshift –
  e.g. KMOS^{3D} Survey (Wisnioski et al. 2014)
- ULTIMATE-IFU unique higher spatial resolution.



Conclusion

- SAMI Galaxy Survey has demonstrated the power of integral field spectroscopy for tracing the origin of gas feeding star formation in galaxies of different morphologies from field to groups to clusters.
- Deep imaging of SAMI clusters with HSC would separate mergers from halo feeding and environmental gas stripping processes impacting gas accretion.

Want to be involved in this? Let me know.

- Hector will be the only instrument in the world that can achieve a large enough galaxy sample at sufficient spectral resolution to disentangle LSS and environmental effects in driving the individuality of galaxy formation.
- ULTIMATE-IFU would be a powerful instrument to extend the 3D view of galaxy evolution to higher redshift with uniquely high spatial resolution.

Are you interested in the Hector – ULTIMATE-IFU connection? Let me know.

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