HECTOR

Next generation multi-object IFU for the Anglo-Australian Telescope

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HECTOR project scientist

Australian Astronomical Observatory

University of Sydney

CAASTRO

SAMI Galaxy Survey

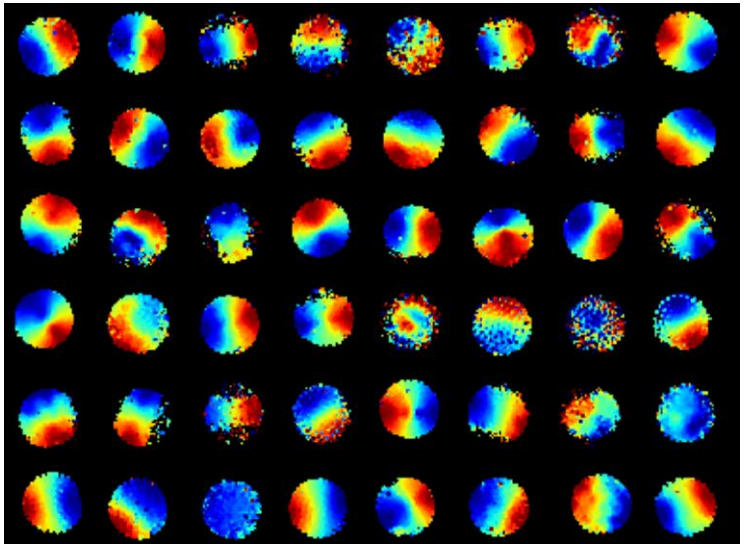
http://sami-survey.org/

- SAMI Galaxy Survey team of ~100 astronomers from Australia and internationally.
- The galaxy survey began March 2013.
- 151-181 nights awarded – from 2013B for ~3years.
- 3400 galaxies =

2800 field/group (from GAMA survey)

+ 600 cluster galaxies

>1000 observed already!



Public data release of 107 galaxies available to you!
http://sami-survey.org/edr

Bryant et al. 2014 Allen et al. 2014 Sharp et al. 2014 Croom et al. 2012

SAMI Galaxy Survey

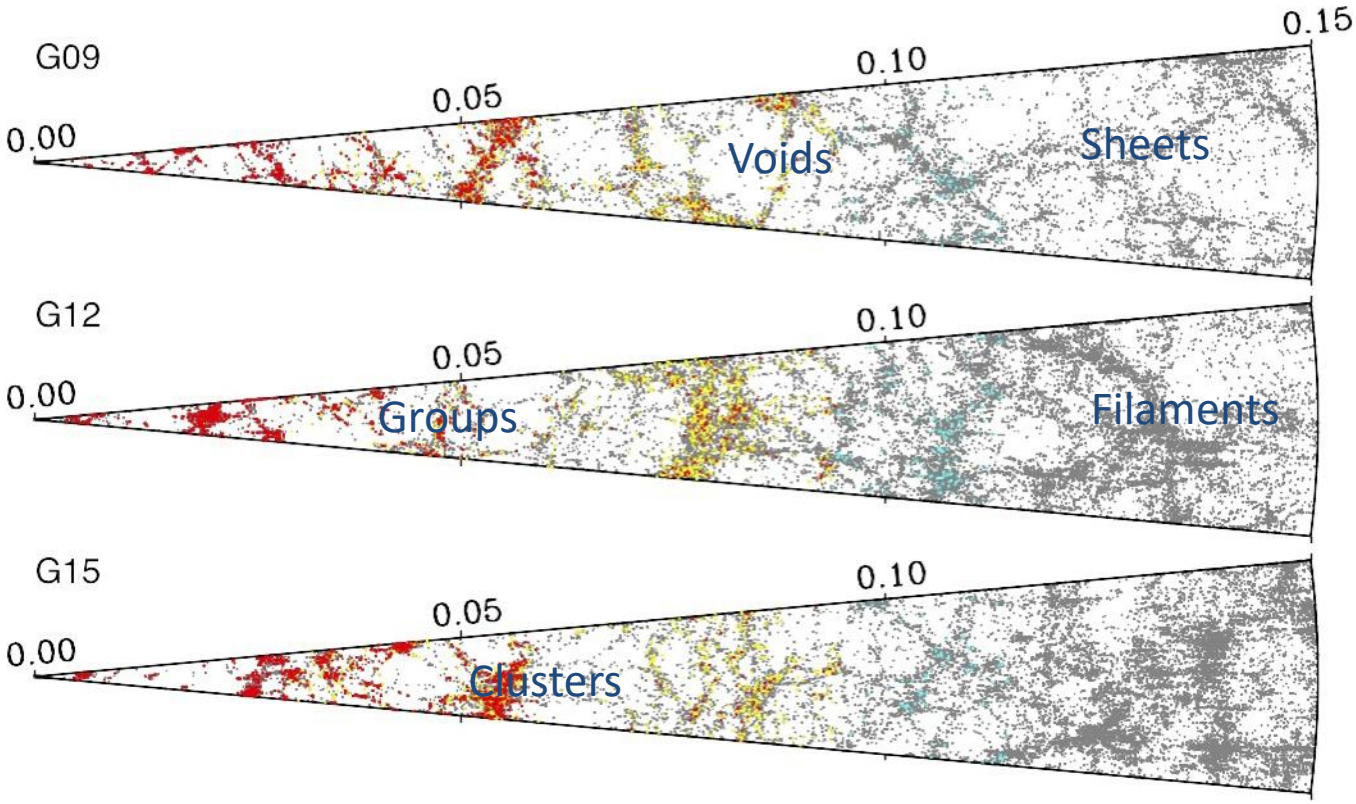
2015MNRAS.446.1567 Allen et al. "The SAMI Galaxy Survey: Early Data Release"
2015MNRAS.447.2857 Bryant et al. "The SAMI Galaxy Survey: instrument specification and target selection"
2015MNRAS.446.1551 Sharp et al. "The SAMI Galaxy Survey: cubism and covariance, putting round pegs into square holes"
2014MNRAS.445.1104 Richards et al. "The SAMI Galaxy Survey: the discovery of a luminous, low-metallicity H II complex in the dwarf galaxy GAMA J141103.98-003242.3
2014MNRAS.444.3894 Ho et al. "The SAMI Galaxy Survey: shocks and outflows in a normal star-forming galaxy"

2014ApJ.795L.37 Cortese et al. "The SAMI Galaxy Survey: Toward a Unified Dynamical Scaling Relation for Galaxies of All Types"
2014MNRAS.443.485 Fogarty et al. "The SAMI Pilot Survey: the kinematic morphology-density relation in Abell 85, Abell 168 and Abell 2399"
2014arXiv1409.7271 Fogarty et al. "The Kinematic Morphology-Density Relation from the SAMI Pilot Survey"
2013ASPC..475..345 Lorente et al. "SAMI Automated Plug Plate Configuration"
2012ApJ...761..169 Fogarty et al. "First Science with SAMI: A Serendipitously Discovered Galactic Wind in ESO 185-G031"

- Galactic winds
- Universal dynamical scaling relation for different galaxy types
- Kinematic morphological-density relation for early-type galaxies
- Enhanced star formation in dwarf galaxies

SAMI is achieving great science, so what's next?

Larger galaxy samples are required



Local density | environment | inclination | stellar mass | morphology | redshift | stochastic variation and precision

➔ 100,000 galaxy survey required.

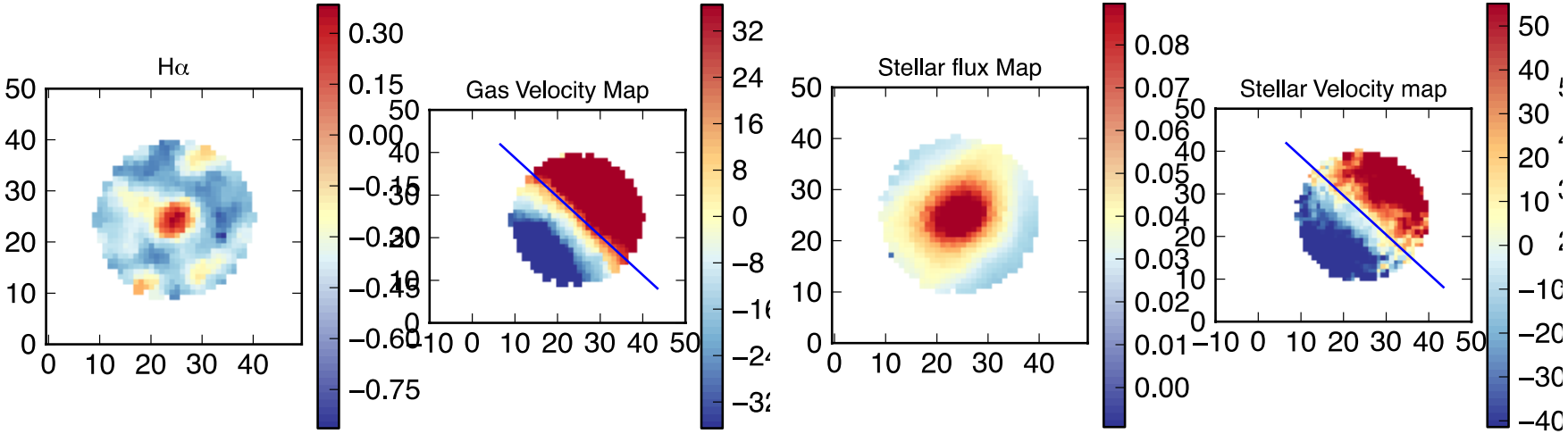
Origin of gas in galaxies

We aim to test the impact of environment, stellar mass and morphology on the origin of gas.

- Total 754 galaxies from SAMI :

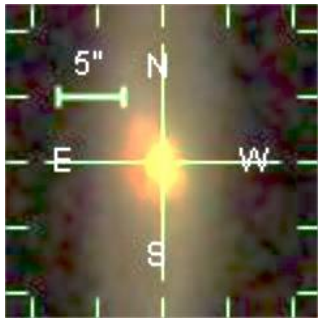
  ~300 in 8 clusters, ~450 in GAMA field/groups.

- Gas and stellar p.a.'s were fitted. ➔ 202 field/group and 123 cluster galaxies had both.

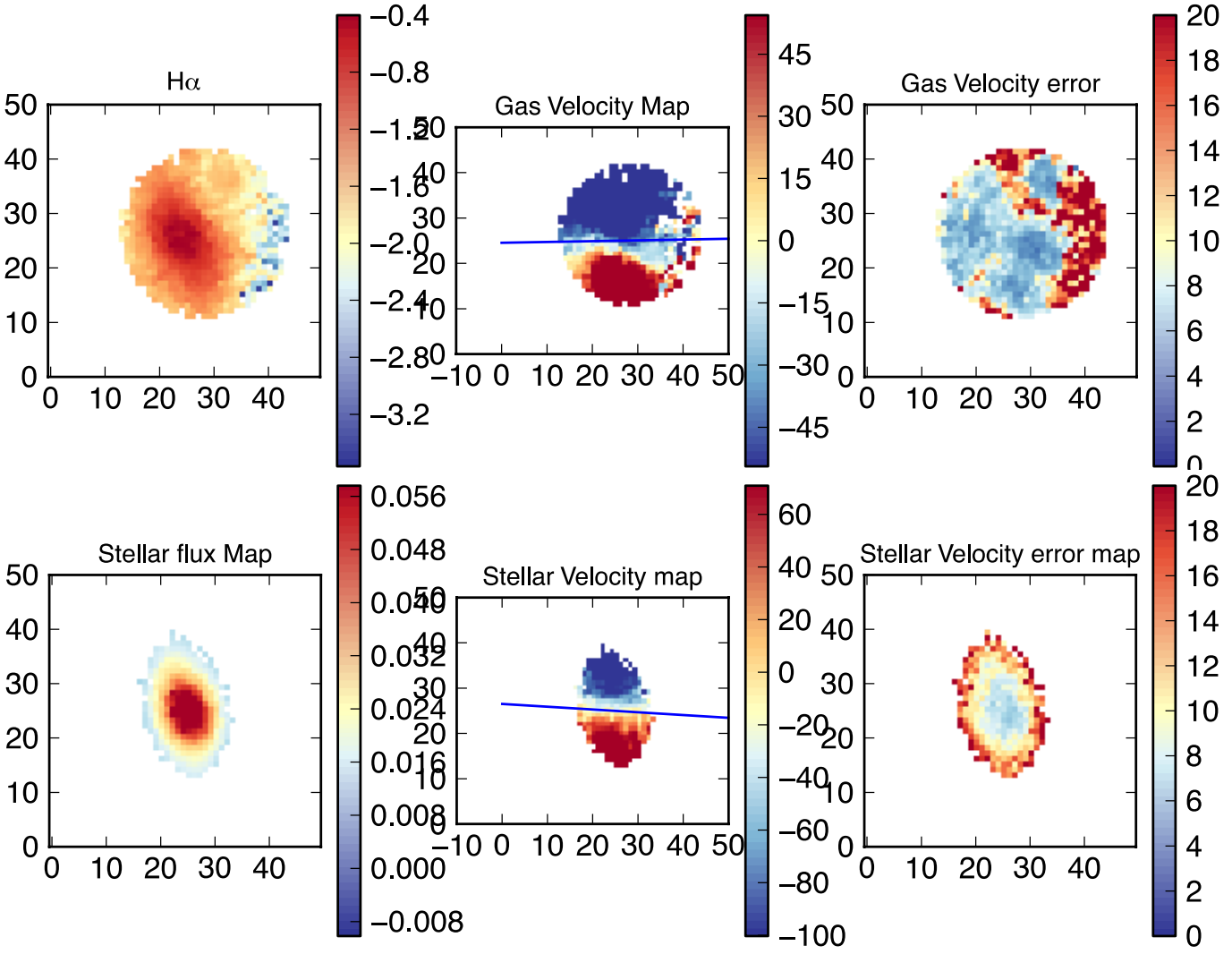


Misalignment fraction

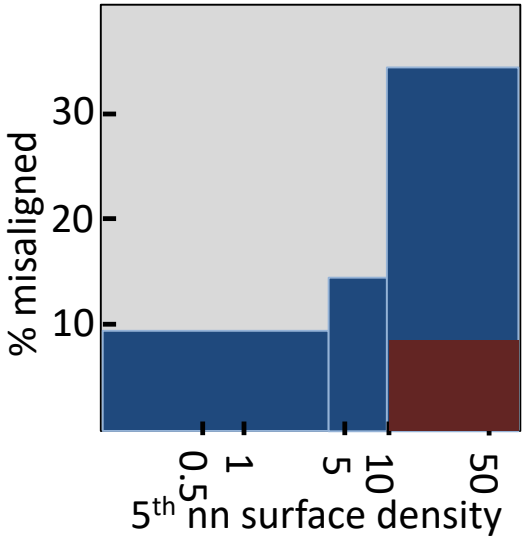
Warped:



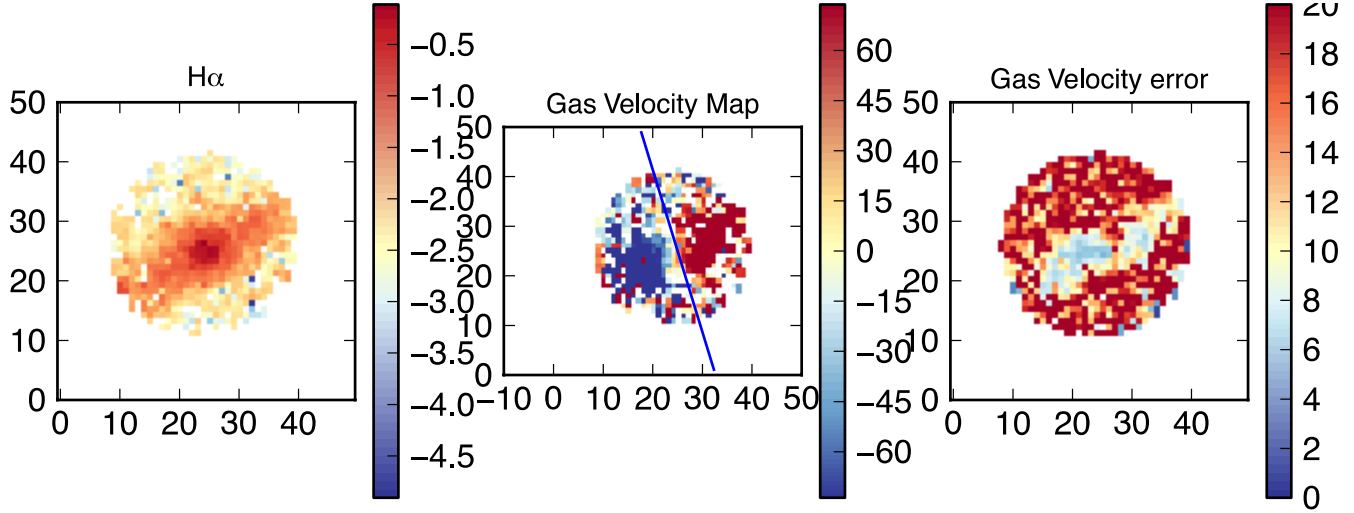
Clusters:
11±3% (14/123)
Field/groups:16
±3% (32/202)

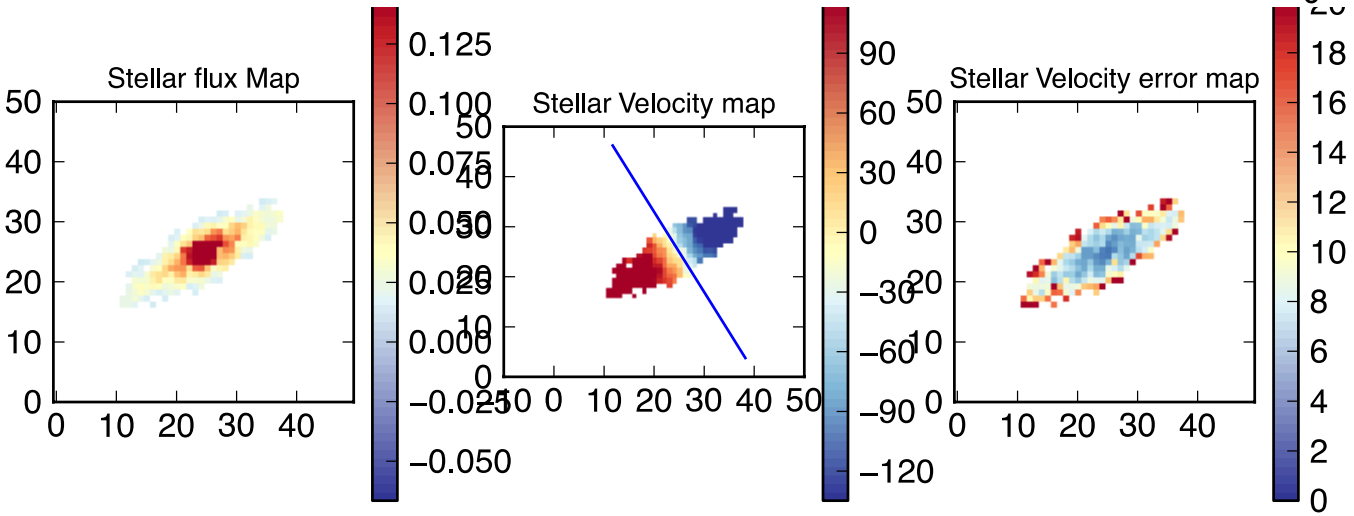


Effect of local surface density



Counter-rotating (in a cluster):





➔Gas is more likely to be misaligned in groups than in clusters even if local density is the same.

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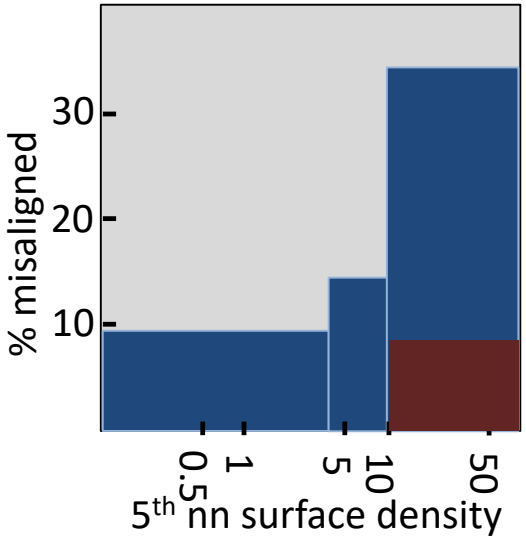

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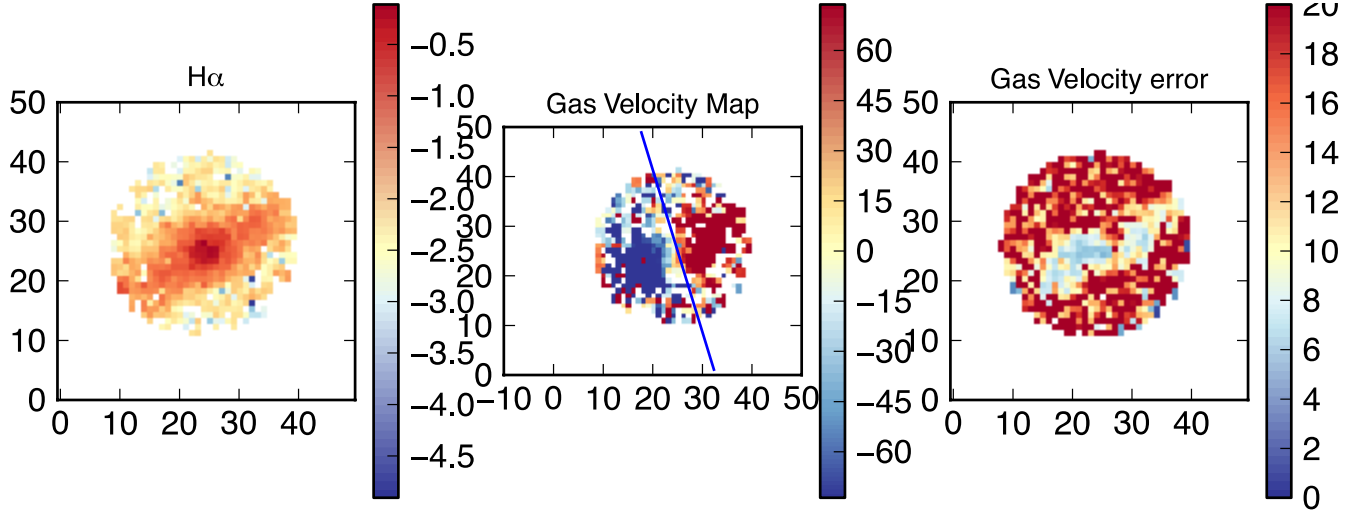

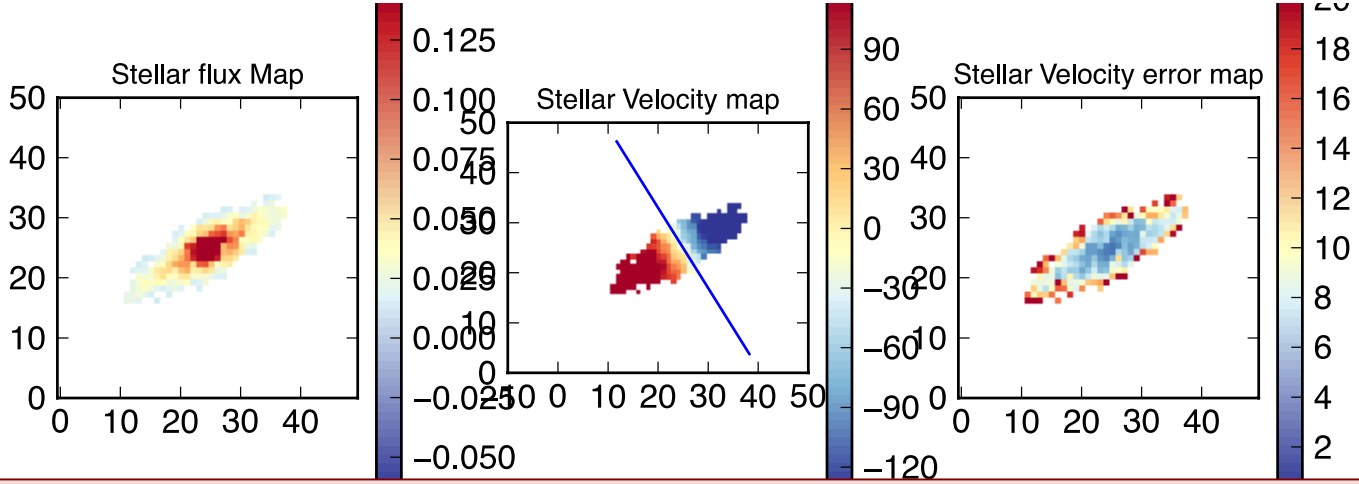

➔Gas is more likely to be misaligned in groups than in clusters even if local density is the same.

3 bins in local surface density => minimum of 5 misaligned galaxies/bin.

Influence of morphological type and preprocessing

Morphological type:

➔ Early-type galaxies have 3x misalignments of late-types.

ATLAS-3D was morphologically-selected as ETGs => 36% misaligned (Davis et al. 2011) compared to our 11%.

➔ Higher local densities have more ETGs.

Need at least 2 bins in morphological type

Influence of morphological type and preprocessing

Morphological type:

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Need at least 2 bins in morphological type

The morphological-density relation:

➔ galaxies in the outskirts of clusters should then have fewer misalignments than in the centre.

Need 3 bins in cluster radius

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Need 4 bins in stellar mass

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5 misaligned galaxies/bin in 754 sample

30/bin requires sample of ~4500

x 2 x 3 x 4

= 108,000 galaxies

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THE UNIVERSITY OF SYDNEY

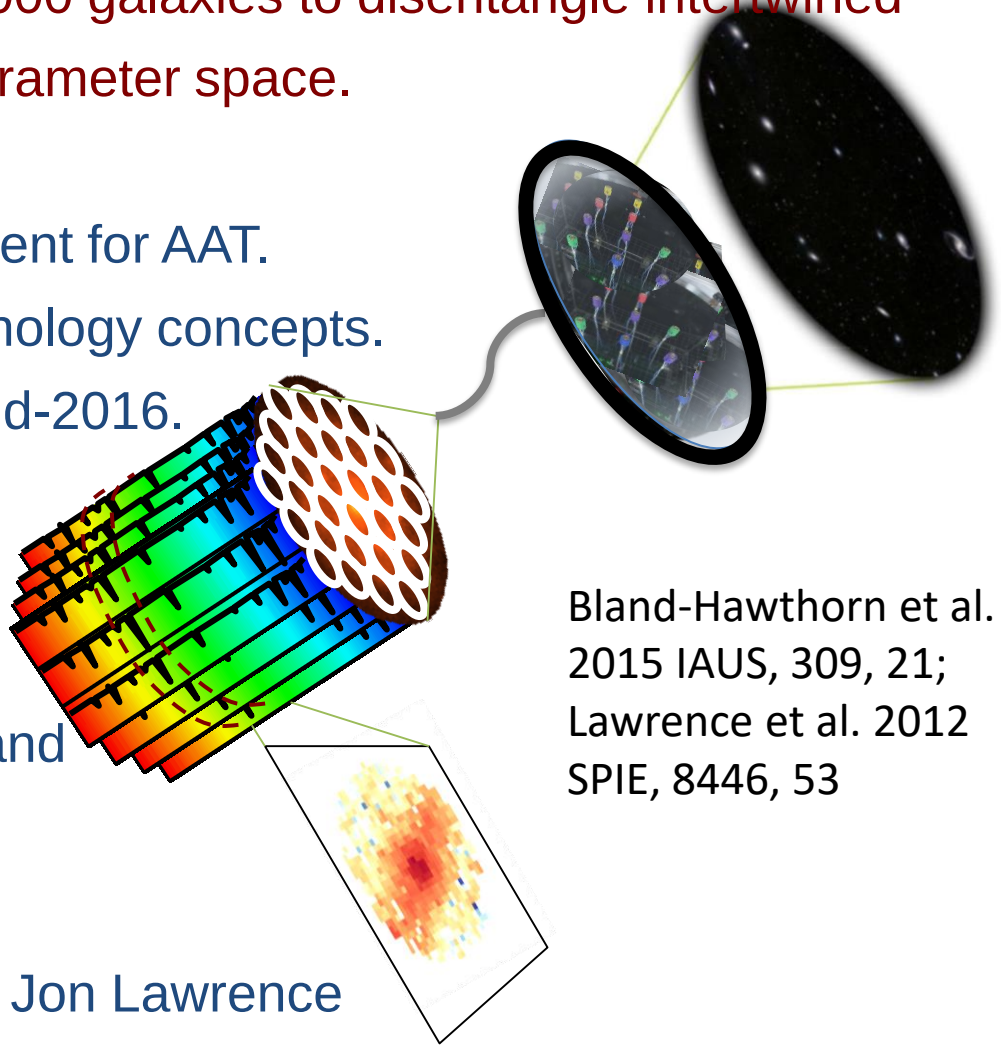
AAO

HECTOR

A new massive MOS IFU instrument for the AAT.

Aim: Volume-limited survey of 100,000 galaxies to disentangle intertwined processes in a multi-dimensional parameter space.

- The next major dark time instrument for AAT.
- Based on new or expanded technology concepts.
- Prototype beginning operation mid-2016.
- Full science operations by 2020.
- IFUs covering >=15 arcsec.
- λ coverage: 3700 to ~9000A
- R=λ/dλ ~4000 in red (λ>4800A) and ~2000 in blue



Bland-Hawthorn et al. 2015 IAUS, 309, 21; Lawrence et al. 2012 SPIE, 8446, 53

Key team members:

Joss Bland-Hawthorn, Scott Croom, Jon Lawrence

HECTOR

A massively multiplexed hexabundle instrument

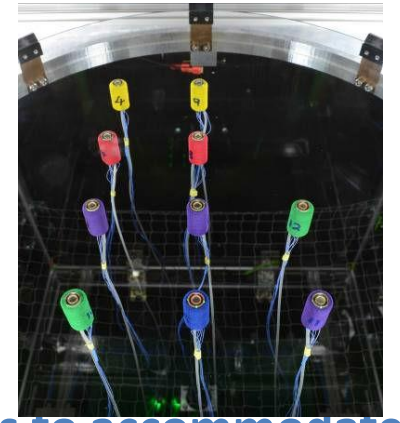
	SAMI	Hector 2df	Hector 3df
No. hexabundles	13	50	100
No. fibres	819	>3000	>7000
Top end	1 deg. field	2 deg. field	3 deg. field
spectrograph	AAOmega – flexible format	Dedicated fixed-format sectrographs	Dedicated fixed-format sectrographs
Nights x fields/night x objects/field x weather	181 x 2.1 x 12 x 0.75	~500 x 2.5 x 50 x 0.75	~500 x 2.5 x 100 x 0.75
Survey objects	3400 in 3 years	50,000 in <5 years	100,000 in <5 years
Density	15 objects/square degree	16 obj/sq. deg – could increase by 50%	14 obj/sq.deg. – could increase by 50%

HECTOR instrument design

3 main components:

1. New fibre IFUs

- New fibre geometries
- New configurations and sizes



2. New positioning technology

- Starbugs

SPIE 2014 papers:
Kuehn 9147-35
Piersiak 9147-357
Goodwin 9152-26

3. New fixed-format spectrographs to accommodate up to ~8000 fibres

- Curved VPH grating design

Clemens, O'Donoghue et al. SPIE 9151-54, 2014

- Reflective Schmidt

Wil Saunders - AAO

- Refractive

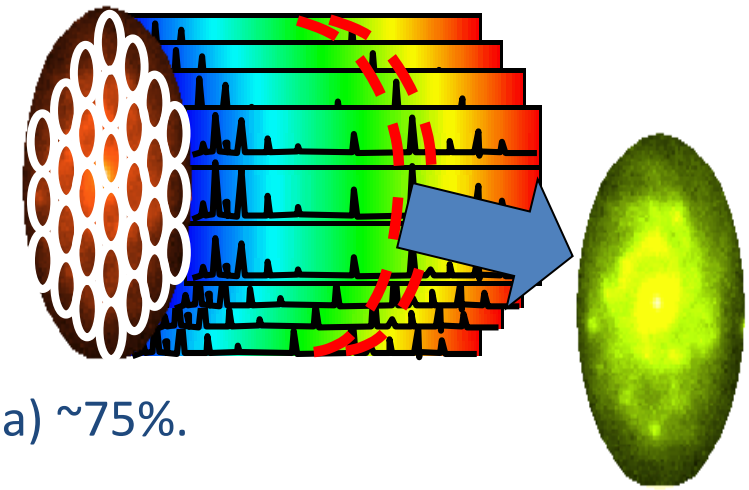
Robert Content- AAO

All require careful integration based on science goals.

Hexabundles – optical fibre IFUs

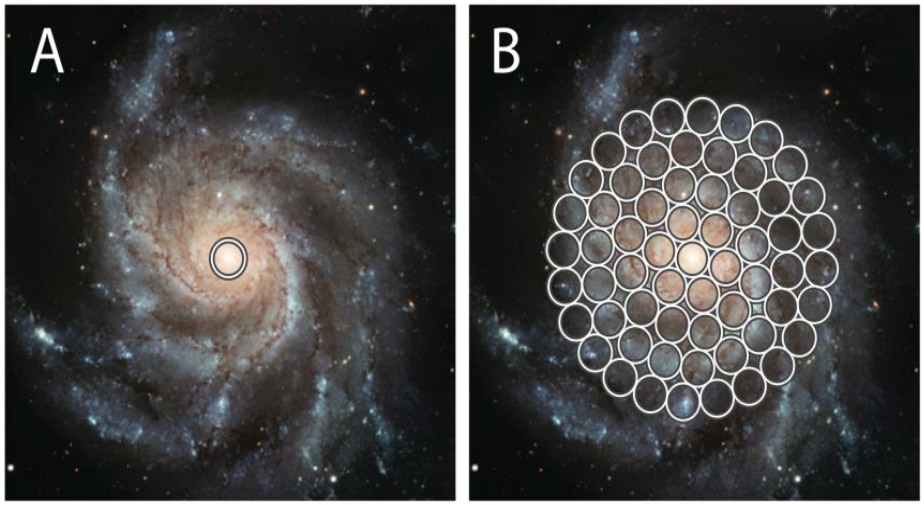
Hexabundles

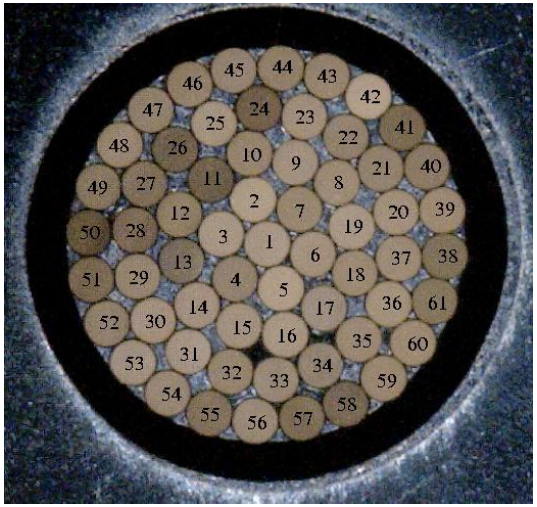
61 optical fibres fused together using our glass fibre processing unit in the SAIL astrophotonics labs at Sydney University.



Advantages of this design:

- Fill fraction (Area of fibre cores/total bundle area) ~75%.
- Low cross-talk < 0.5%





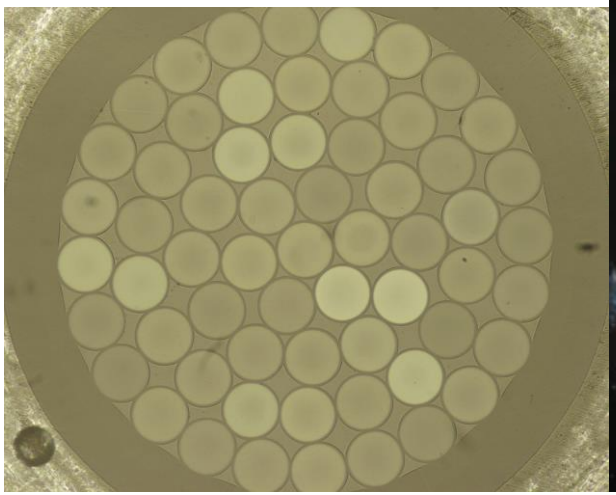
New developments in hexabundles

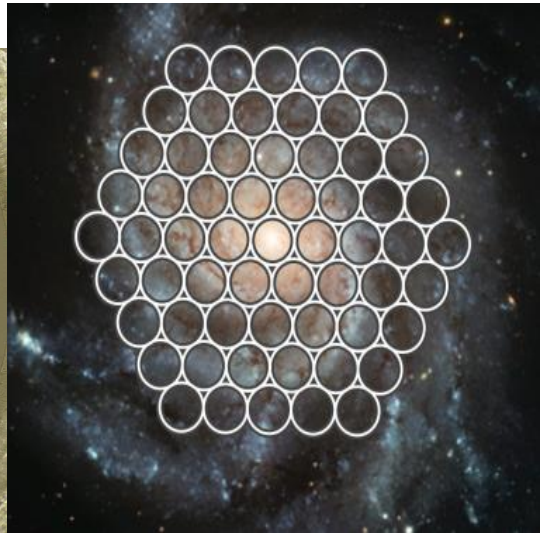
What can be improved?

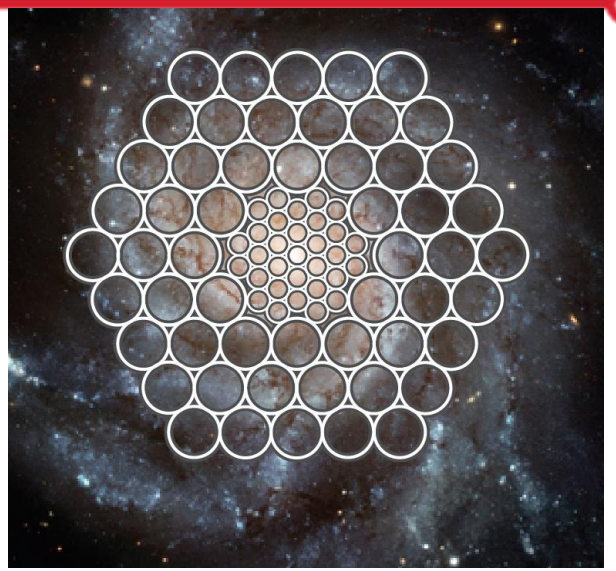
- **Fibre configuration**

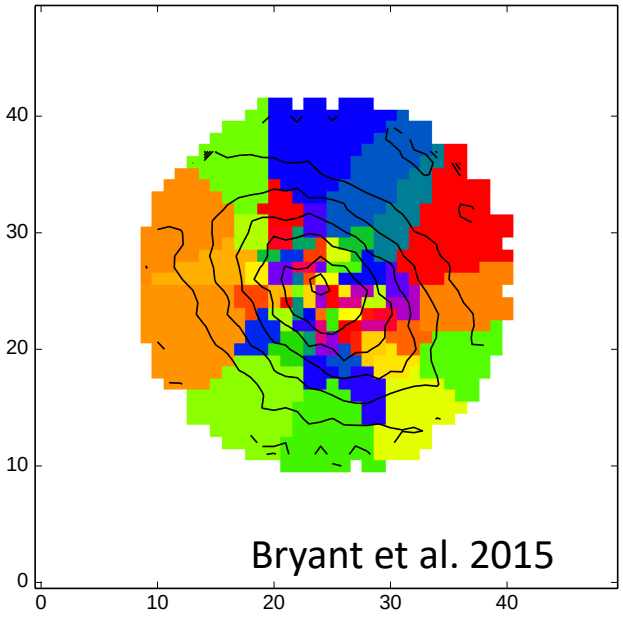
Super-sampled hexabundles:

- Uniform S/N
- Half-sized cores sample the same physical size at double the redshift.









HECTOR

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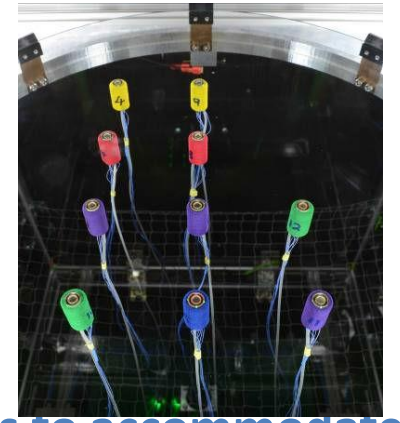

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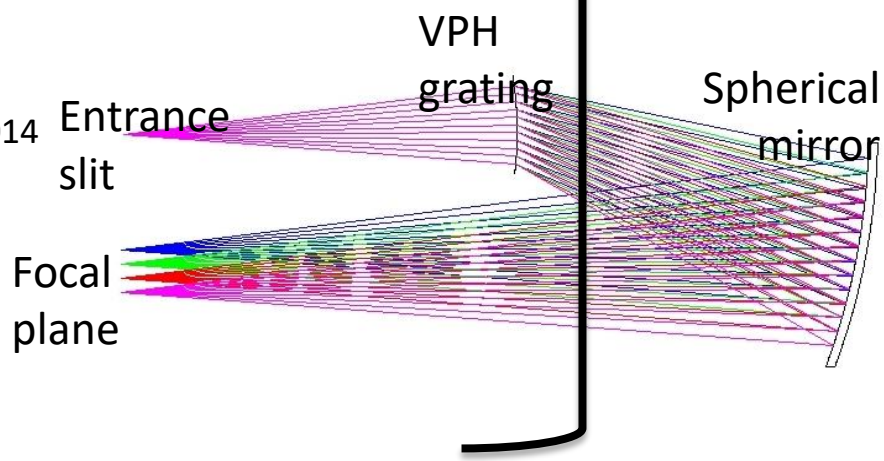

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AAO

Starbugs

STARBUGS

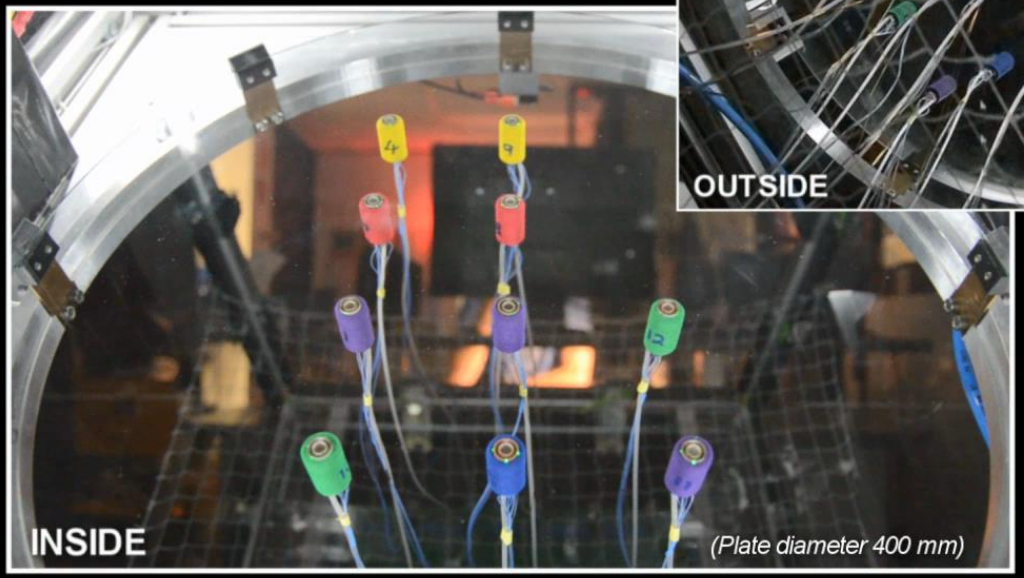
Parallel Fiber Positioning Technology

From the Australian Astronomical Observatory

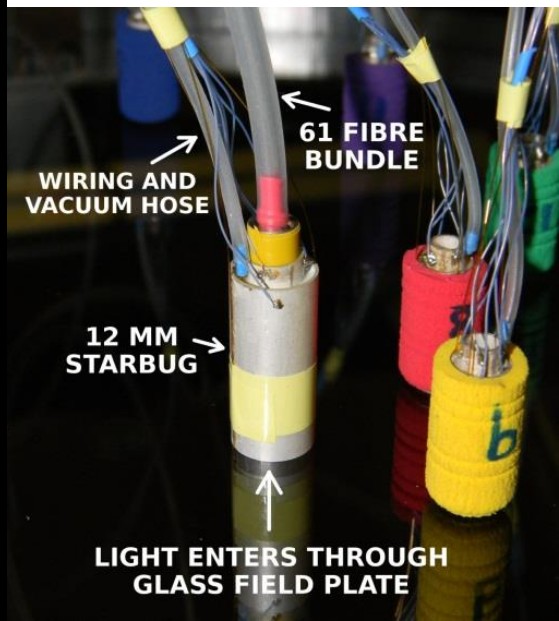
Australian Government
Department of Industry Innovation, Science, Research and Tertiary Education

AAO

Field plate tilting 90 degrees...



AAO



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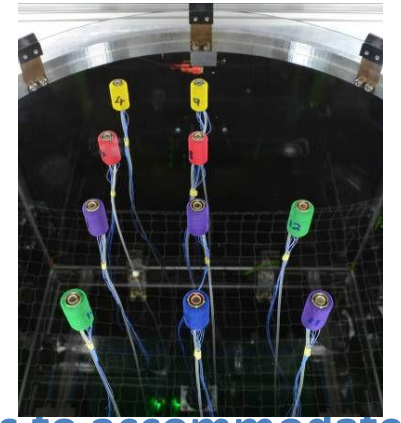

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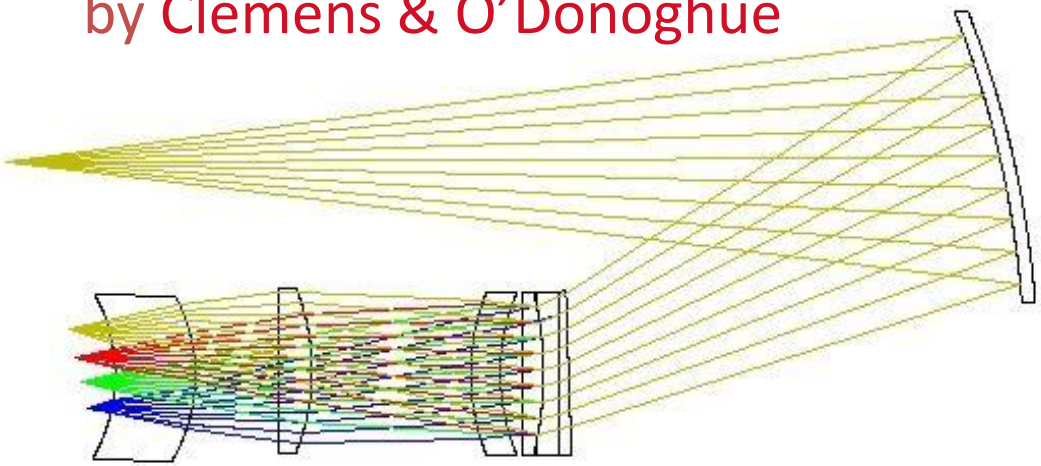
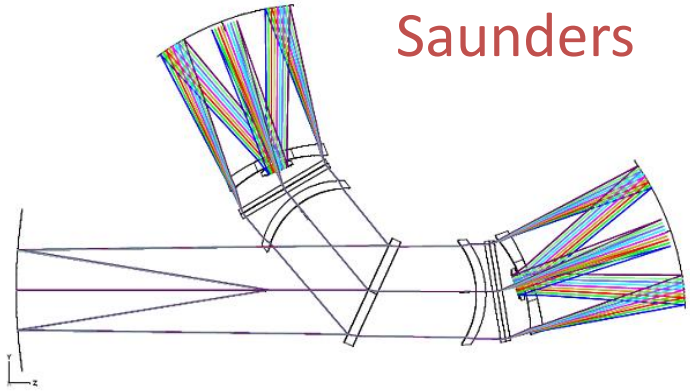
HECTOR spectrographs

Curved VPH grating design by Clemens & O'Donoghue

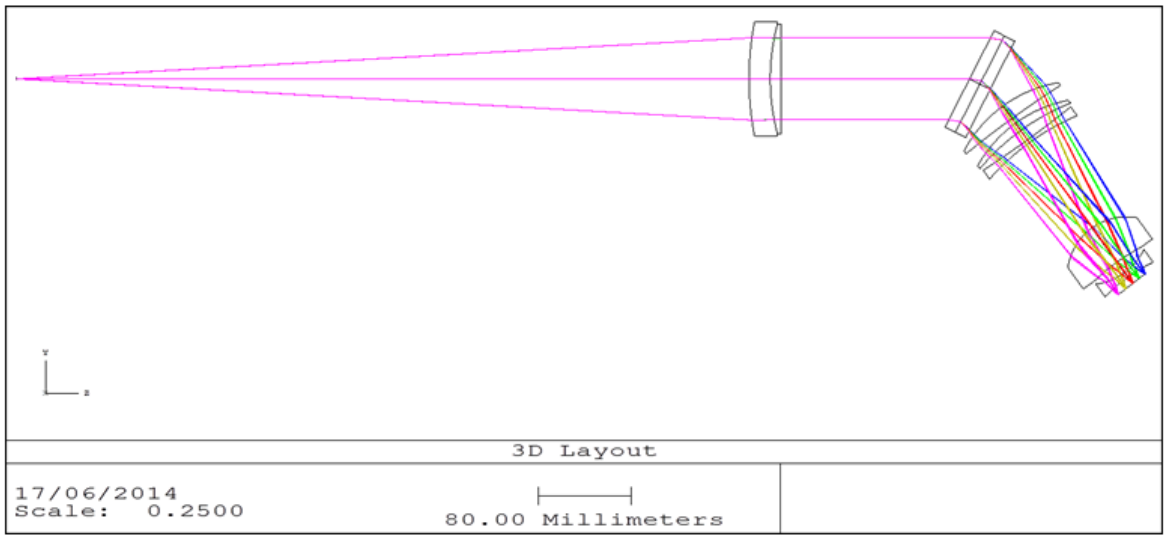


- Key cost saving is in fixed-format, duplicated, non-articulated spectrographs.
- ~1200 fibres per spectrograph.

Reflective Schmidt design with 2 or 4 arms by Will Saunders



Refractive design by Robert Content



HECTOR survey selection

Potential selection catalogue: 4MOST/WAVES

- deep spectroscopy complemented by photometric surveys (VST KIDS; VISTA VIKING)
- overlaps Euclid & SKA cores surveys, giving HI.
- Existing GALEX, and WISE, HERSHEL imaging in these fields.
- Simon Driver will talk further about WAVES at 11:30.

Conclusion

The SAMI instrument and galaxy survey:

- **Hexabundles** are now a proven and successful technology. .
- The SAMI Galaxy Survey has >1000 galaxies observed and 107 in a public data release.
- Science papers are now coming out (Fogarty+, Ho+, Sharp+ , Allen+, Bryant+, Richards+, Cortese+.....)

HECTOR:

- Massively multiplexed IFU facility instrument for the AAT
- Incorporates new hexabundle, spectrograph and Starbugs positioning technologies.
- Prototypes will be on-sky mid-2016.
- A 100,000 galaxy survey will break new ground in fundamental low redshift galaxy science.

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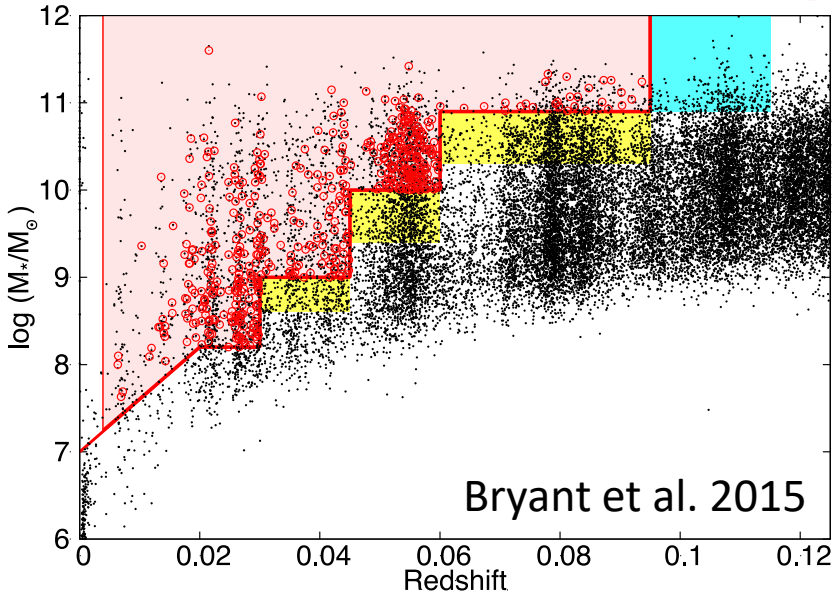

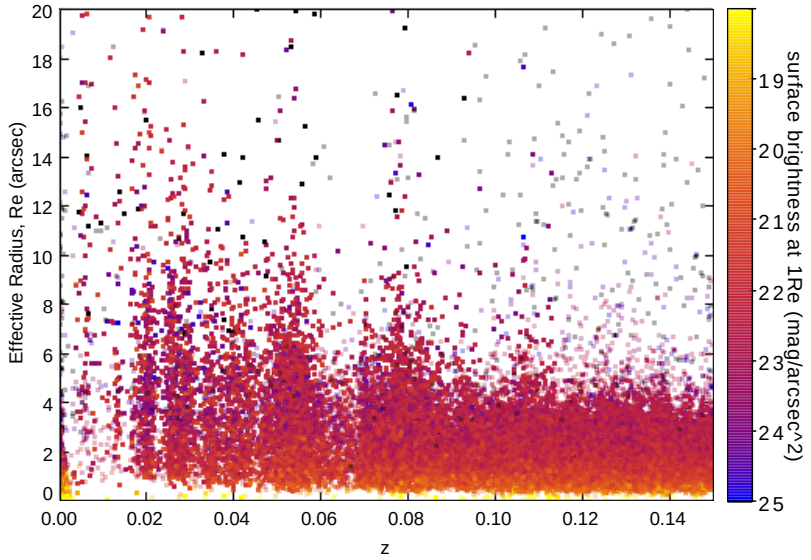

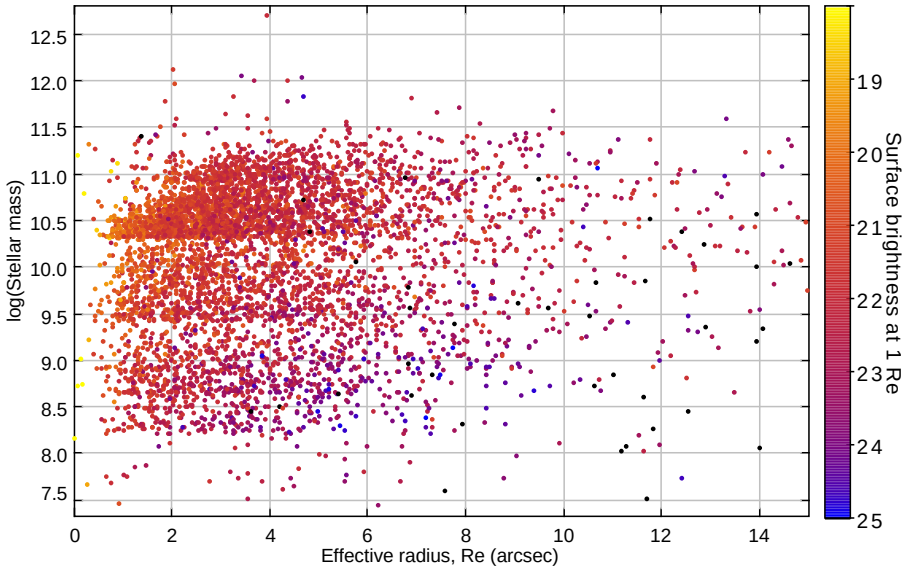

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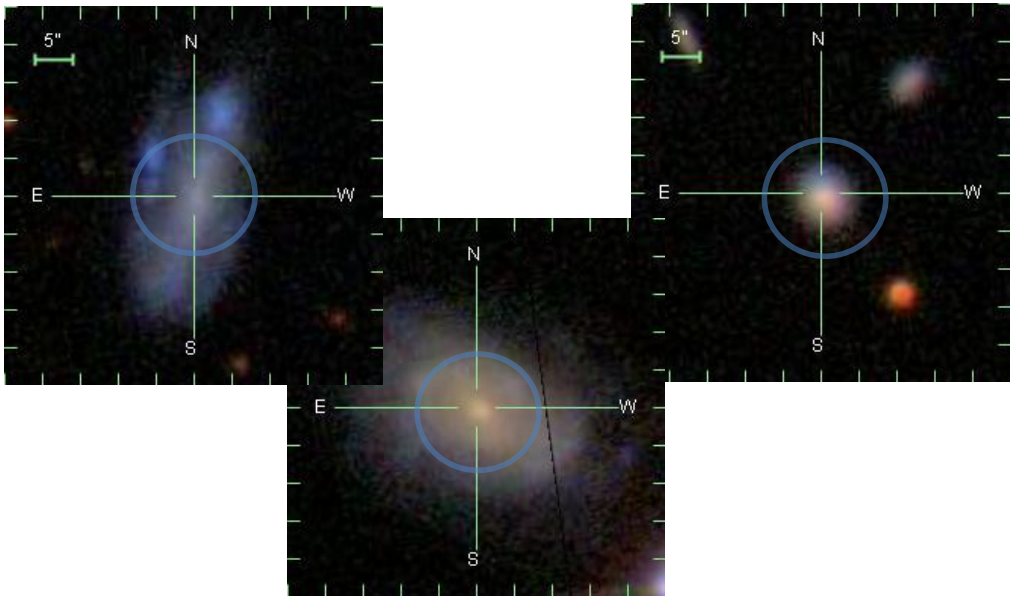

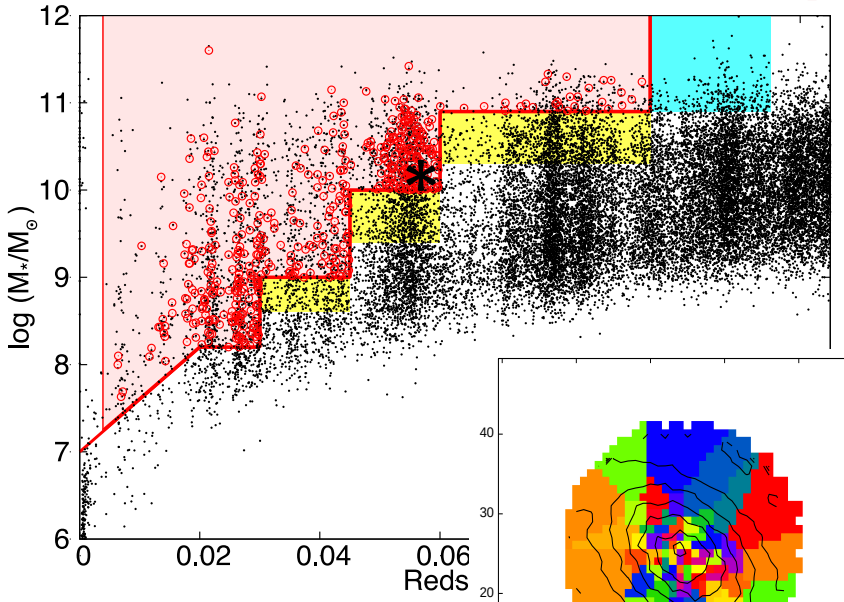

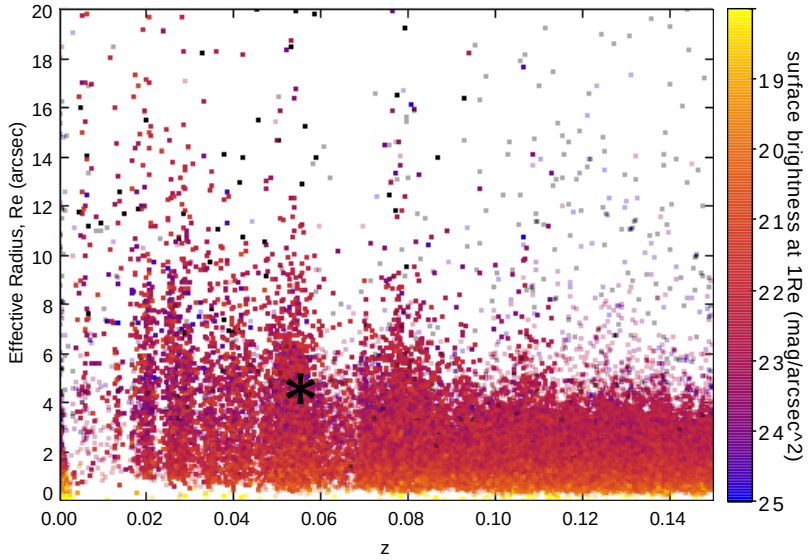

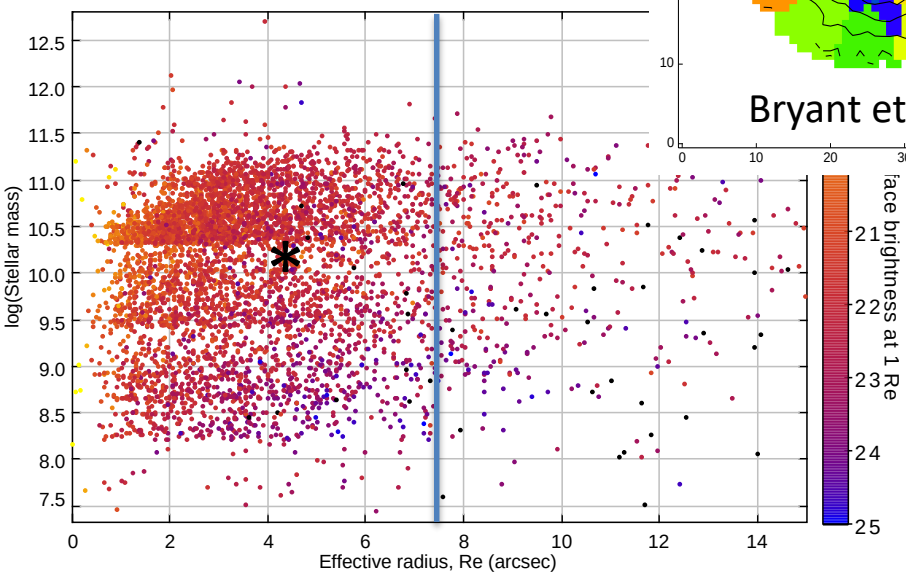

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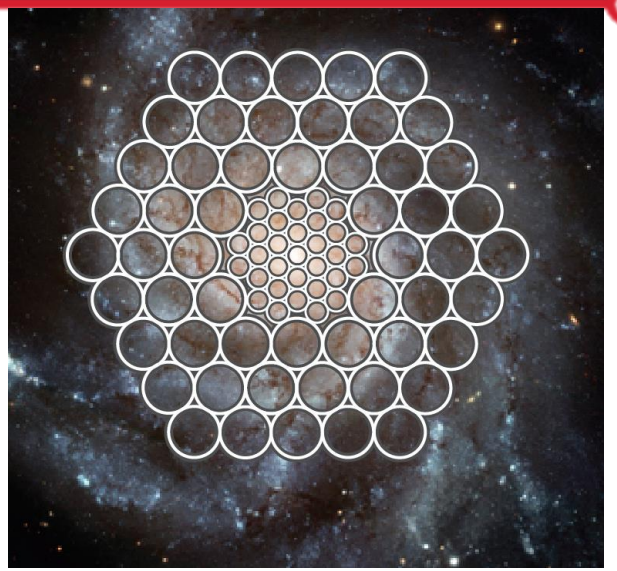
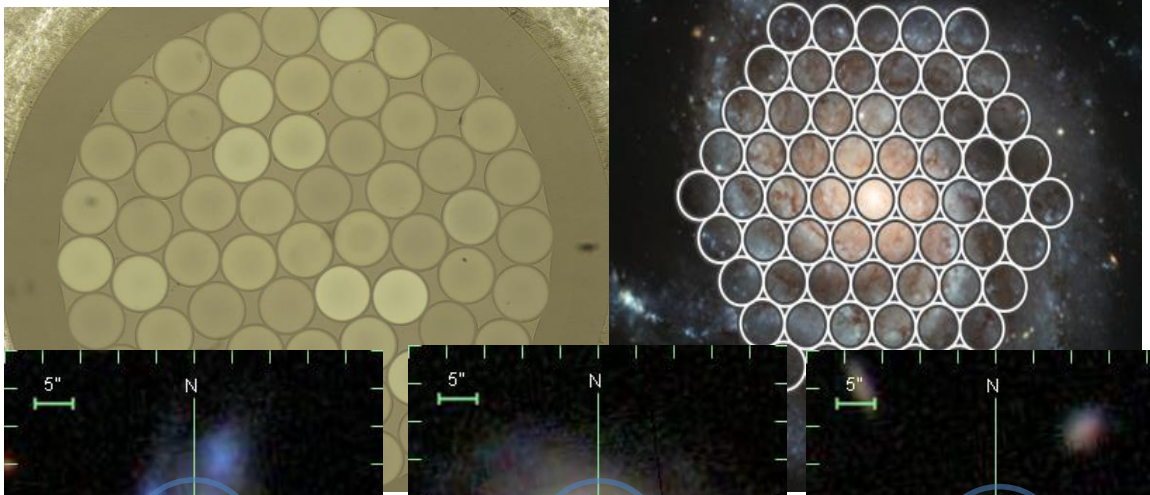
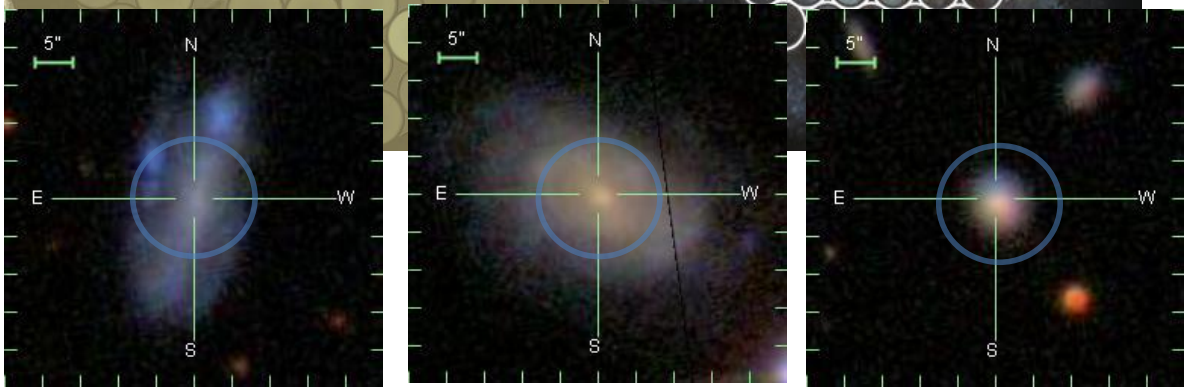
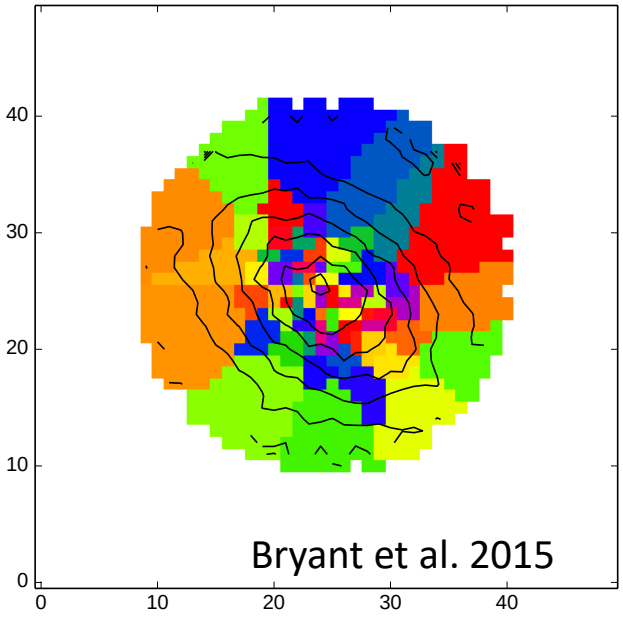




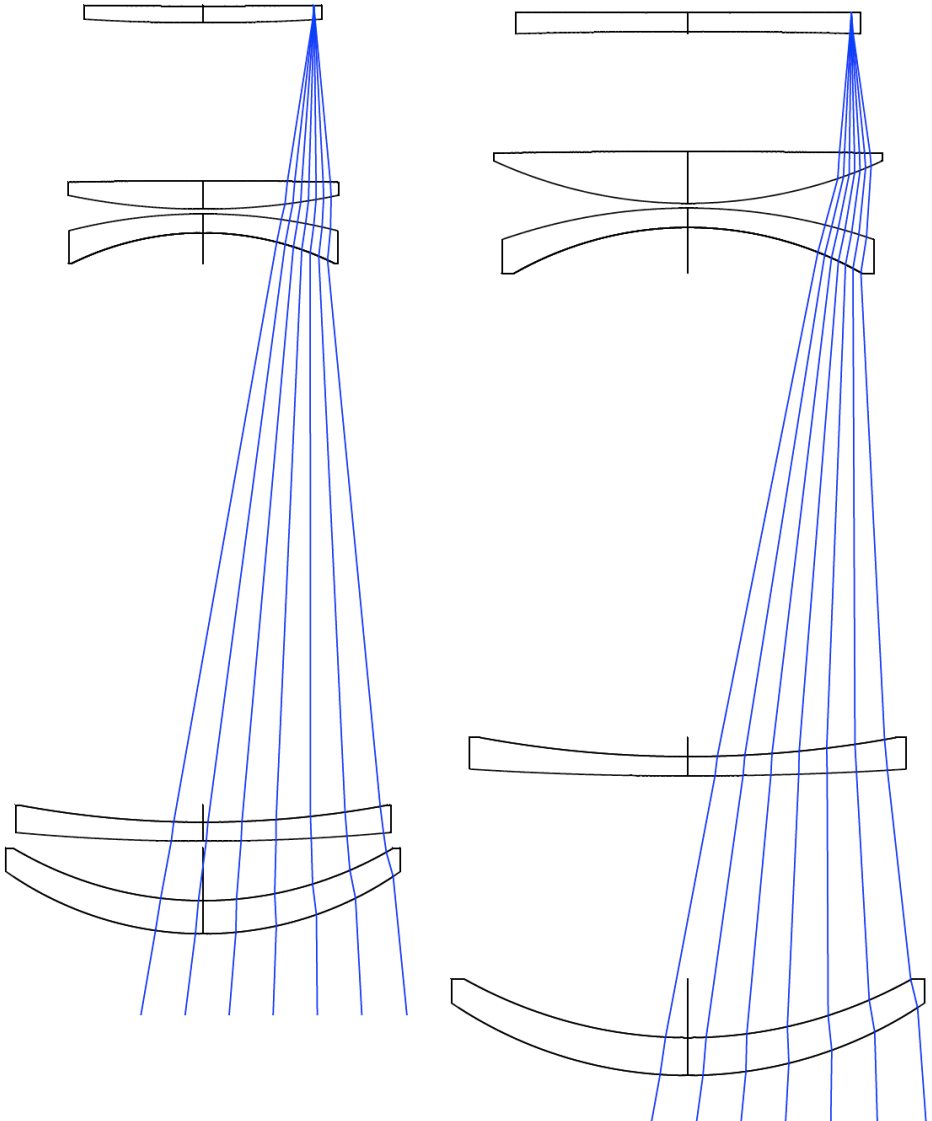




OUTHECTOR corrector

Design for 2 and 3-degree-field correctors by Peter Gillingham

1-degree-field used by SAMI



OUTHECTOR corrector

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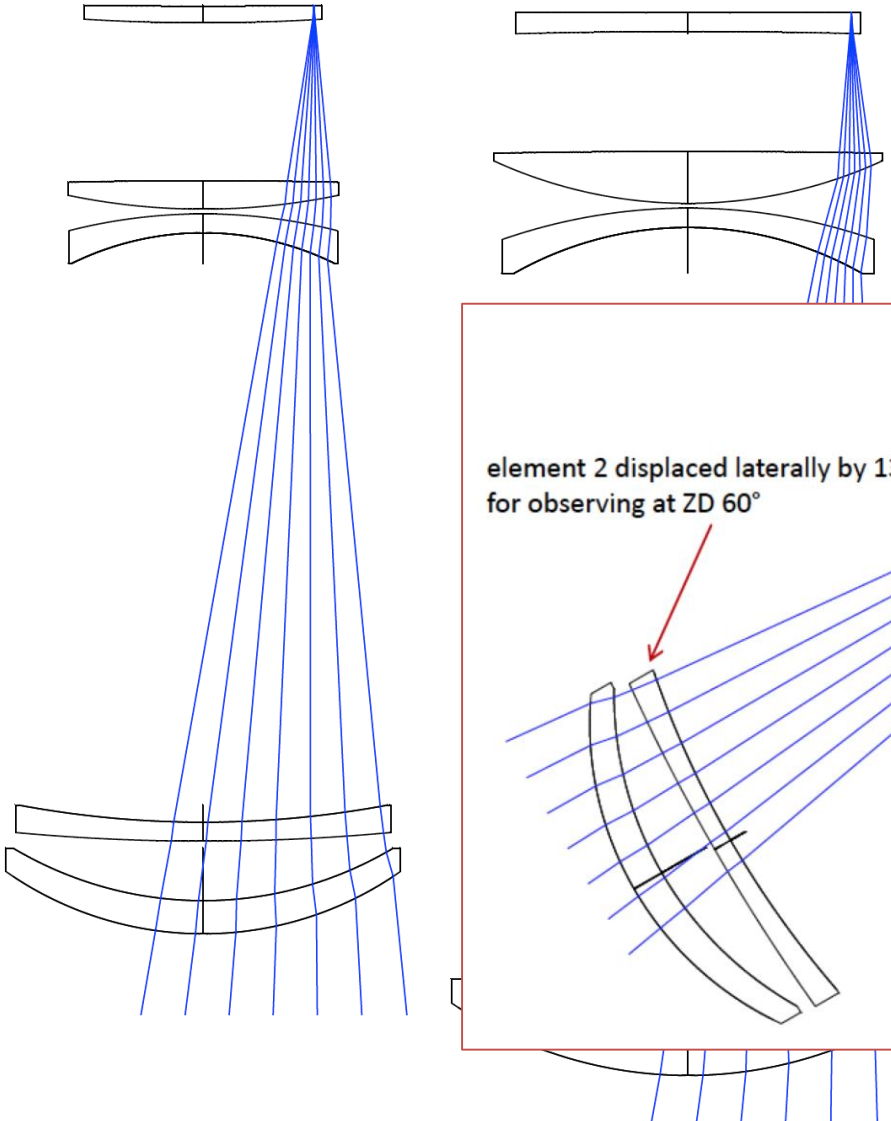
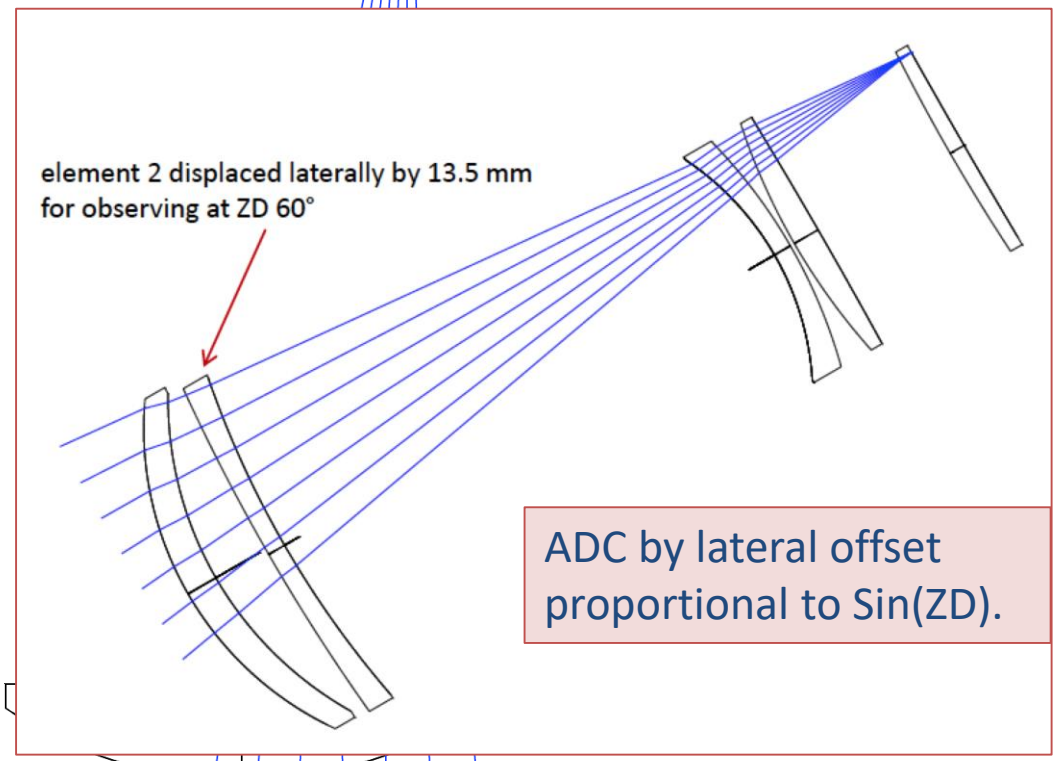
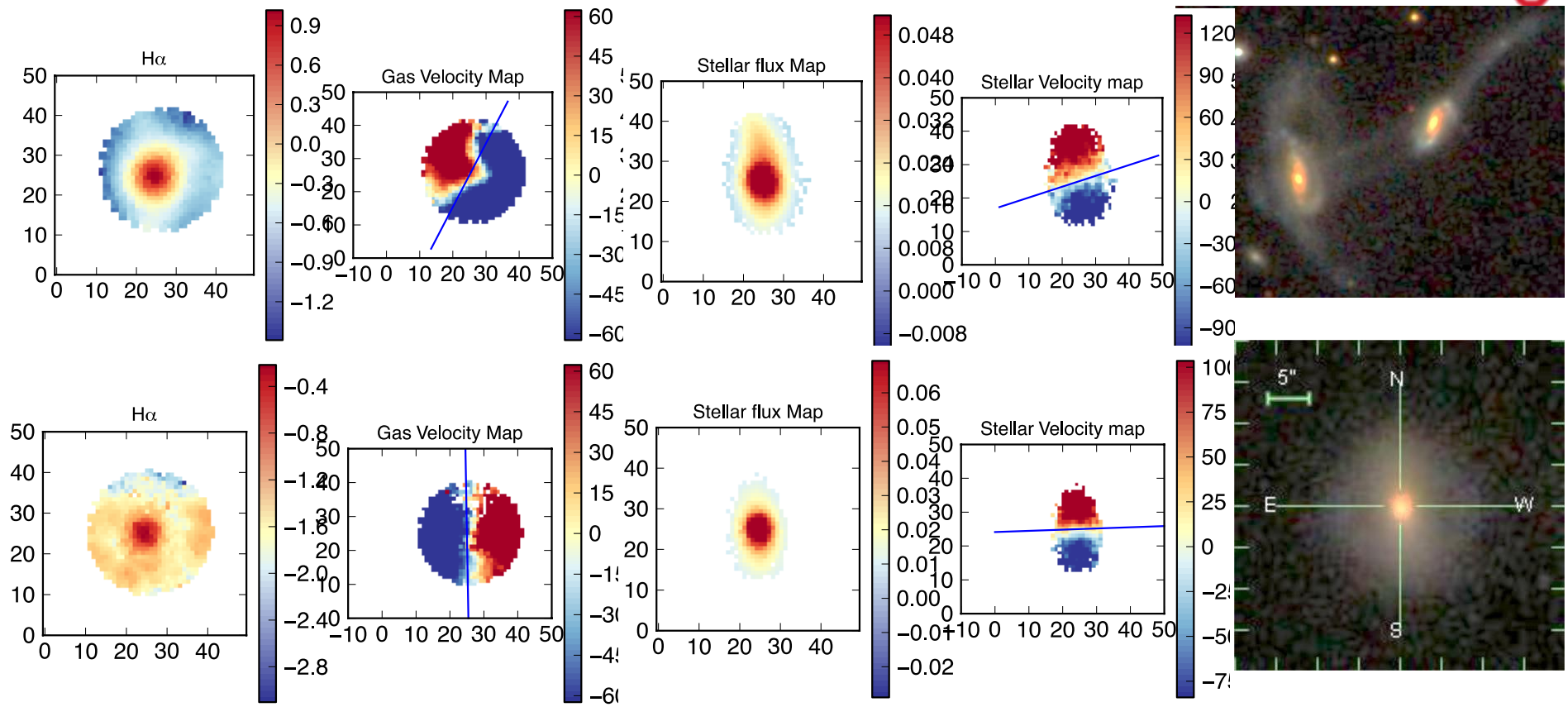
1-degree-field used by SAMI





ADC by lateral offset proportional to Sin(ZD).

OUTLarger galaxy samples are required.



Local density | environment | inclination | stellar mass | morphology | redshift | stochastic variation and precision

➔ 100,000 galaxy survey required.