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

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

|-------------------|-------------------|-------------------|-------------------|
SAMI is achieving great science, so what’s next?

- 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 Galaxy Survey
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.
Warped:

Clusters: 11±3% (14/123)
Field/groups: 16 ±3% (32/202)
Counter-rotating (in a cluster):

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

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

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

ATLAS-3D was morphologically-selected as ETGs => 42% in the field (Davis et al. 2011) compared to our 11%, and 36% overall.

- Higher local densities have more ETGs.

*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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Effect of stellar mass:

*Need 4 bins in stellar mass*
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Effect of stellar mass:

- Need 4 bins in stellar mass

5 misaligned galaxies/bin in 754 sample

30/bin requires sample of ~4500

x 2 x 3 x 4 = 108,000 galaxies
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 $\geq 15$ arcsec.
- $\lambda$ coverage: 3700 to $\sim 9000$A
- $R=\lambda/d\lambda \sim 4000$ in red ($\lambda > 4800$A) and $\sim 2000$ in blue

Key team members:
Joss Bland-Hawthorn, Scott Croom, Jon Lawrence

Bland-Hawthorn et al. 2015 IAUS, 309, 21; Lawrence et al. 2012 SPIE, 8446, 53
<table>
<thead>
<tr>
<th></th>
<th>SAMI</th>
<th>Hector 2df</th>
<th>Hector 3df</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. hexabundles</td>
<td>13</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>No. fibres</td>
<td>819</td>
<td>&gt;3000</td>
<td>&gt;7000</td>
</tr>
<tr>
<td>Top end</td>
<td>1 deg. field</td>
<td>2 deg. field</td>
<td>3 deg. field</td>
</tr>
<tr>
<td>spectrograph</td>
<td>AAOmega – flexible format</td>
<td>Dedicated fixed-format spectrographs</td>
<td>Dedicated fixed-format spectrographs</td>
</tr>
<tr>
<td>Nights x fields/night x objects/field x weather</td>
<td>181 x 2.1 x 12 x 0.75</td>
<td>~500 x 2.5 x 50 x 0.75</td>
<td>~500 x 2.5 x 100 x 0.75</td>
</tr>
<tr>
<td>Survey objects</td>
<td>3400 in 3 years</td>
<td>50,000 in &lt;5 years</td>
<td>100,000 in &lt;5 years</td>
</tr>
<tr>
<td>Density</td>
<td>15 objects/square degree</td>
<td>16 obj/sq. deg – could increase by 50%</td>
<td>14 obj/sq.deg. – could increase by 50%</td>
</tr>
</tbody>
</table>
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

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) \( \sim 75\% \).
• Low cross-talk < 0.5\%
What can be improved?

- **Fibre configuration**

**Super-sampled hexabundles:**

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

![Image of hexabundles](image_url)
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STARBUGS
Parallel Fiber Positioning Technology
From the Australian Astronomical Observatory

Field plate tilting 90 degrees...

INSIDE
(Plate diameter 400 mm)

OUTSIDE

WIRING AND VACUUM HOSE

61 FIBRE BUNDLE

12 MM STARBUG

LIGHT ENTERS THROUGH GLASS FIELD PLATE
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Key cost saving is in fixed-format, duplicated, non-articulated spectrographs.

~1200 fibres per spectrograph.

Curved VPH grating design by Clemens & O’Donoghue

Reflective Schmidt design with 2 or 4 arms by Will Saunders

Refractive design by Robert Content
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.
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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HECTOR survey selection

Effective radius, \( Re \) (arcsec)

Surface brightness at 1\( Re \) (mag/arcsec^2)

\[ \log(M/M_\odot) \]

Bryant et al. 2015
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Bryant et al. 2015
Design for 2 and 3-degree-field correctors by Peter Gillingham

1-degree-field used by SAMI
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1-degree-field used by SAMI

TRIPLET
60 arcmin
235 mm

element 2 displaced laterally by 13.5 mm for observing at ZD 60°

ADC by lateral offset proportional to Sin(ZD).
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⇒ 100,000 galaxy survey required.