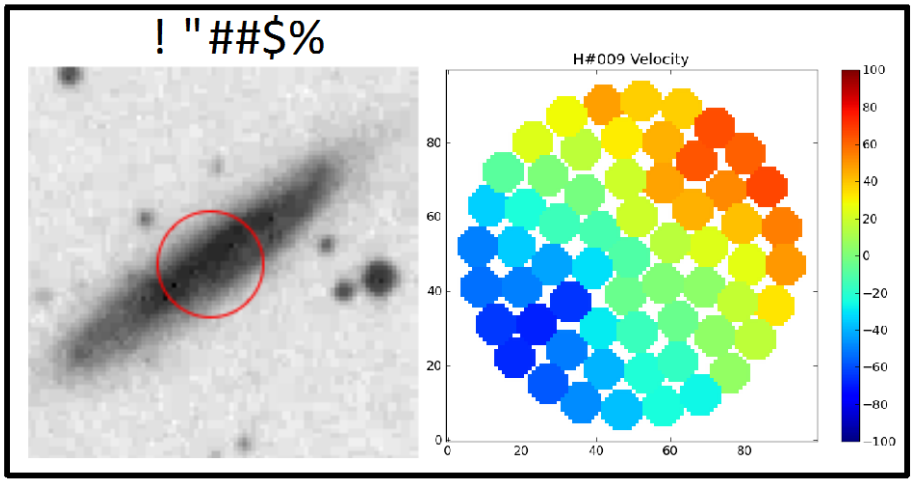
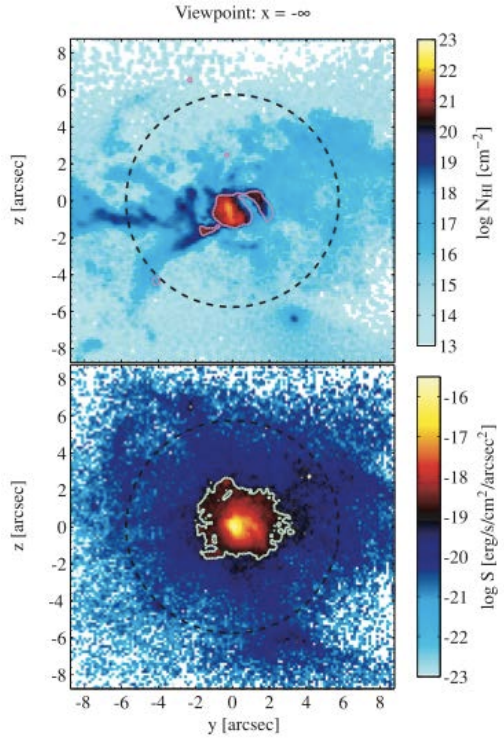
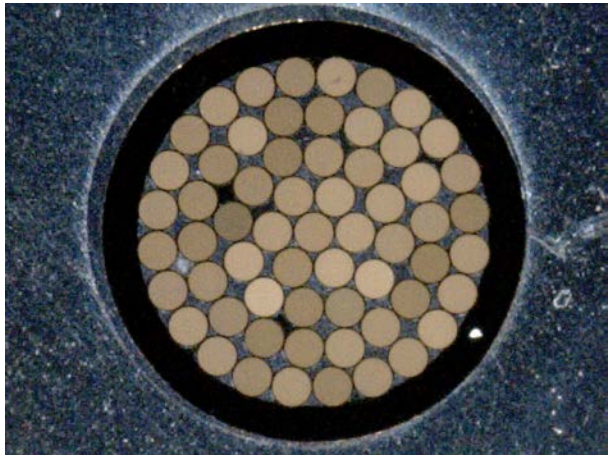
Future Surveys: The view with SAMI







Geraint F. Lewis and the SAMI team

Sydney Institute for Astronomy (SIfA)
University of Sydney

SAMI Survey team

James Allen, University of Sydney
Ivan Baldry, Liverpool JMU
Luke Barnes, University of Sydney
Amanda Bauer, AAO
Kenji Bekki, ICRAR
Mike Birchall, AAO
Joss Bland-Hawthorn, University of Sydney
Alyson Brooks, U Wisconsin, Madison
Sarah Brough, AAO
Julia Bryant, University of Sydney, target selection WG chair
Gerald Cecil, University of North Carolina
Michelle Cluver, Australian Astronomical University
Matthew Colless, AAO
Warrick Couch, Swinburne University
Rob Crain, Leiden Observatory
Scott Croom, University of Sydney, team leader, science WG chair
Darren Croton, Swinburne University of Technology
Roger Davies, University of Oxford
Catherine de Burgh-Day, The University of Melbourne
Francesco Di Mille, University of Sydney/AAO
Michael Drinkwater, University of Queensland
Simon Driver, ICRAR/UWA
Niv Drory, UNAM
Simon Ellis, AAO
Lisa Fogarty, The University of Sydney
Duncan Forbes, Swinburne
Karl Glazebrook, Swinburne University
Michael Goodwin, AAO
Andy Green, AAO webmaster
Andrew Hopkins, AAO
Heath Jones, Monash University
Andreas Kelz, Leibniz-Institut fuer Astrophysik Potsdam (AIP)
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Iraklis Konstantopoulos, AAO, database WG chair
Baerbel Koribalski, CSIRO
Maritza Lara-Lopez, AAO
Jon Lawrence, AAO
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Smriti Mahajan, University of Queensland
Sarah Martell, AAO
Martin Meyer, ICRAR/UWA
Jeremy Mould, Swinburne University
Simon Mutch, Swinburne University of Technology
Peder Norberg, ICC, Department of Physics, University of Durham
Matt Owers, AAO
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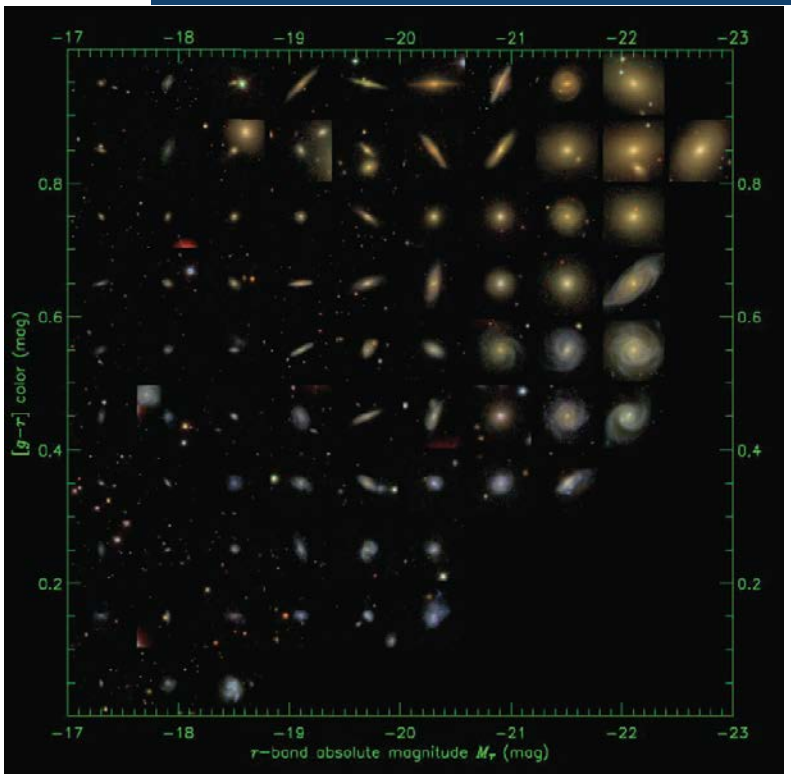
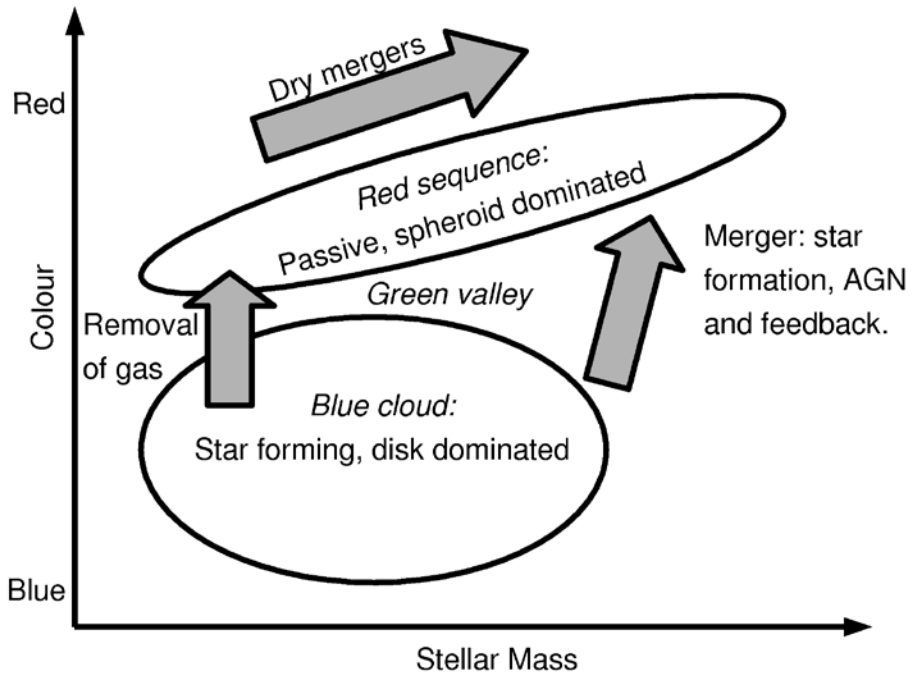
Michael Pracy, Sydney Institute For Astronomy
Justin Read, ETH Zürich & University of Leicester
Samuel Richards, AAO/Usyd
Aaron Robotham, St Andrews
Elaine Sadler, University of Sydney
Sebastian F. Sanchez, Instituto de Astrofisica de Andalucia
Julia Scharwaechter, The Australian National University
Nic Scott, Swinburne
Rob Sharp, The Australian National University, DR WG Chair
Rachel Somerville, Rutgers University
Sarah Sweet, University of Queensland
Edward Taylor, Univ. of Sydney/Univ. of Melbourne
Jakob Walcher, Leibniz-Institut für Astrophysik Potsdam (AIP), quality control WG chair
Lutz Wisotzki Leibniz Institute for Astrophysics Potsdam
Ivy Wong CSIRO

Science drivers



SDSS: Blanton et al. (2006)

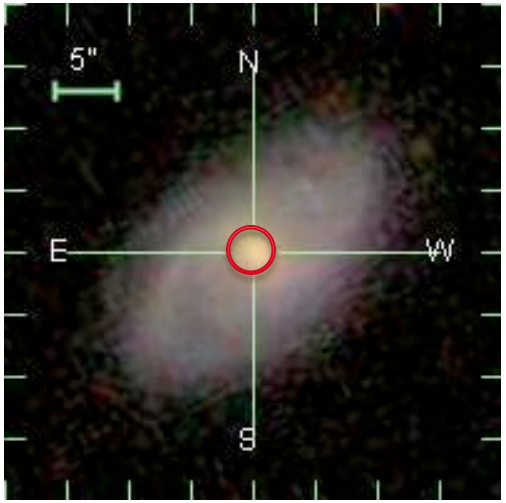


- The physics of galaxy formation.
- Which processes dominate in which regimes?
- ***Moving from properties to processes….***

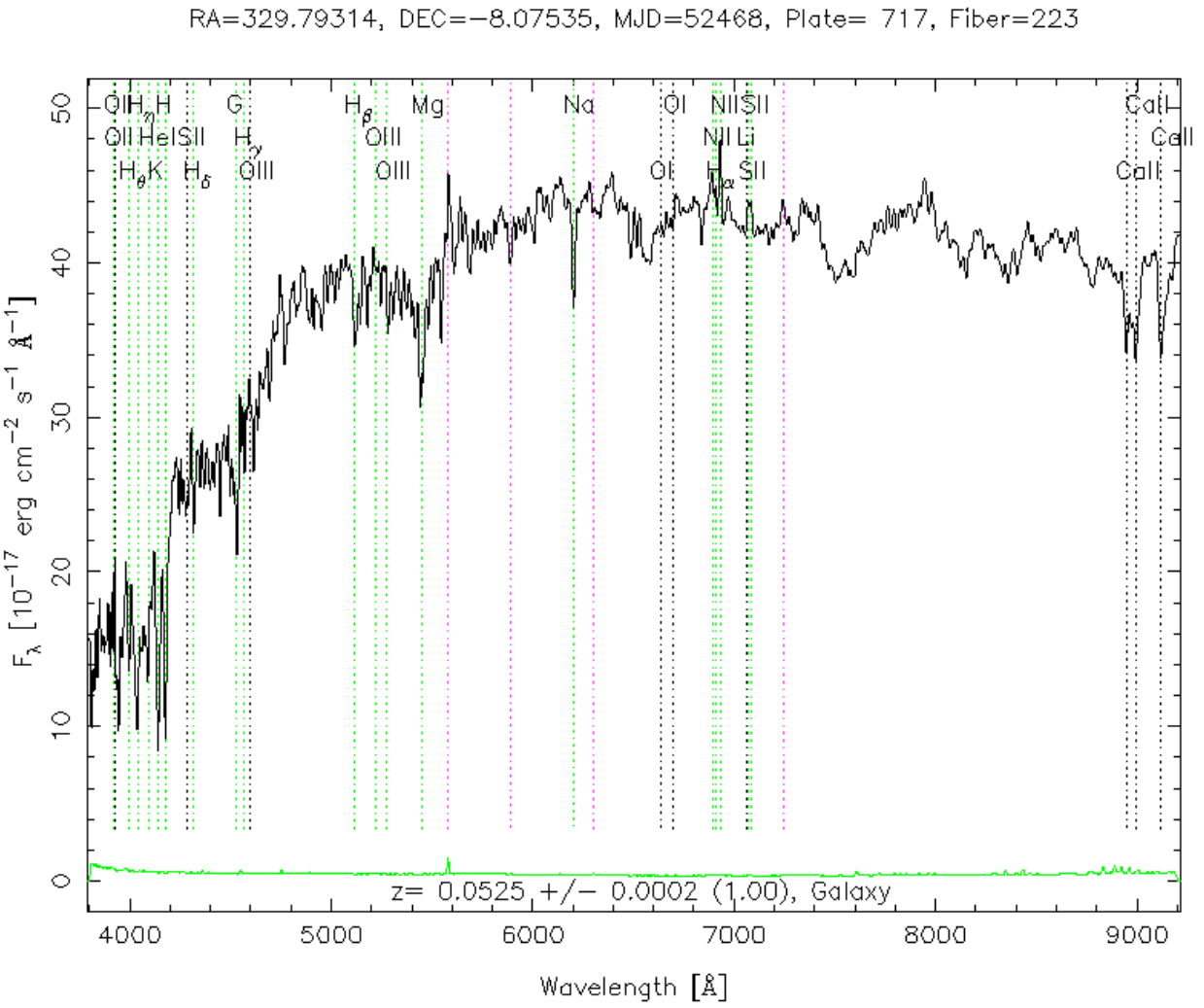
Science drivers

- **What are the physical processes responsible for environmental transformations?**
  - Morphological and kinematic transformations; suppression of star formation; 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; the role of AGN…
  - Important synergies with ASKAP HI surveys.

What do single fibre surveys miss?



SDSS: image and spectrum



SAMI

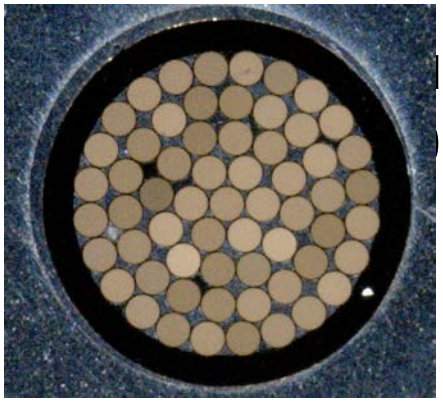
- Sydney-AAO Multi-object Integral field spectrograph.
- 1 degree diameter f-o-v.
- 13 x 61 fibre IFUs using hexabundles (Bryant, Bland-Hawthorn et al.).
- 15” diameter IFUs, 1.6” diameter fibre cores.
-

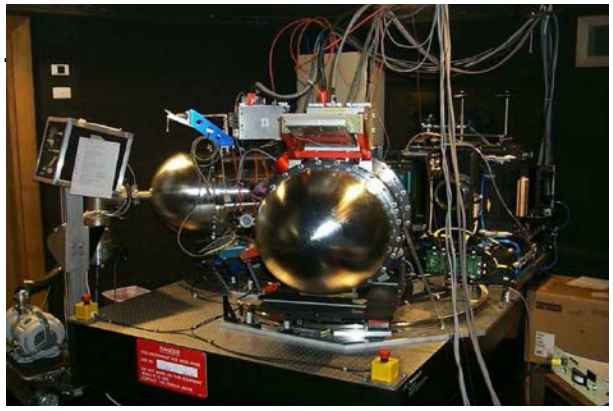
The Sydney-AAO Multi-object Integral-field spectrograph (SAMI)

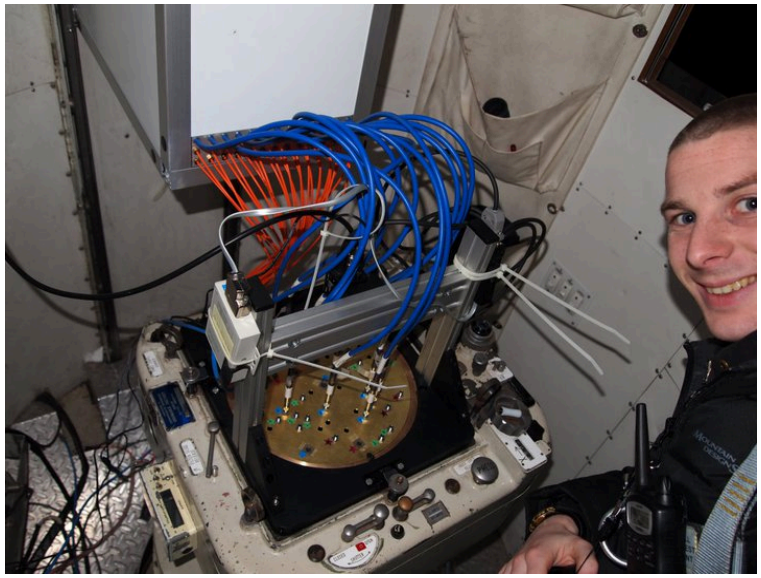
Scott M. Croom[1,2⋆], Jon S. Lawrence[3,4], Joss Bland-Hawthorn[1], Julia J. Bryant[1], Lisa Fogarty[1], Samuel Richards[1], Michael Goodwin[3], Tony Farrell[3], Stan Miziarski[3], Ron Heald[3], D. Heath Jones[5], Steve Lee[3], Matthew Colless[3,2], Sarah Brough[3], Andrew M. Hopkins[3,2], Amanda E. Bauer[3], Michael N. Birchall[3], Simon Ellis[3], Anthony Horton[3], Sergio Leon-Saval[1], Geraint Lewis[1], Á. R. López-Sánchez[3,4], Seong-Sik Min[1], Christopher Trinh[1], Holly Trowland[1]

[1] *Sydney Institute for Astronomy (SIfA), School of Physics, University of Sydney, NSW 2006, Australia*
[2] *ARC Centre of Excellence for All-sky Astrophysics (CAASTRO)*
[3] *Australian Astronomical Observatory, PO Box 296, Epping, NSW 1710, Australia*
[4] *Department of Physics and Astronomy, Macquarie University, NSW 2109, Australia*
[5] *School of Physics, Monash University, Clayton, VIC 3800, Australia*

Croom et al. 2012





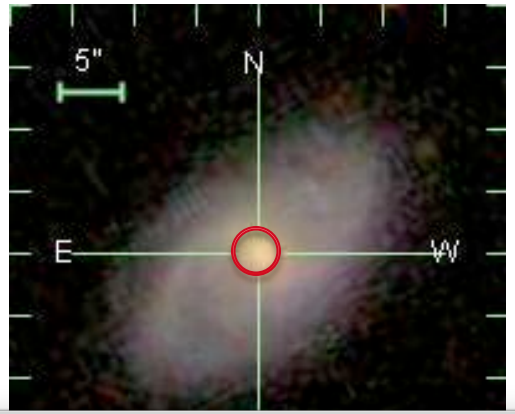


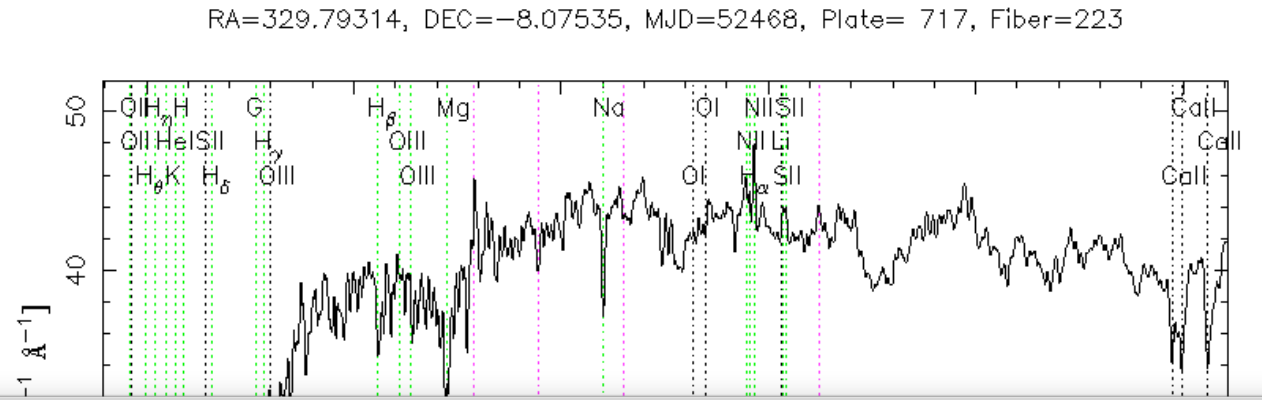
Observations so far

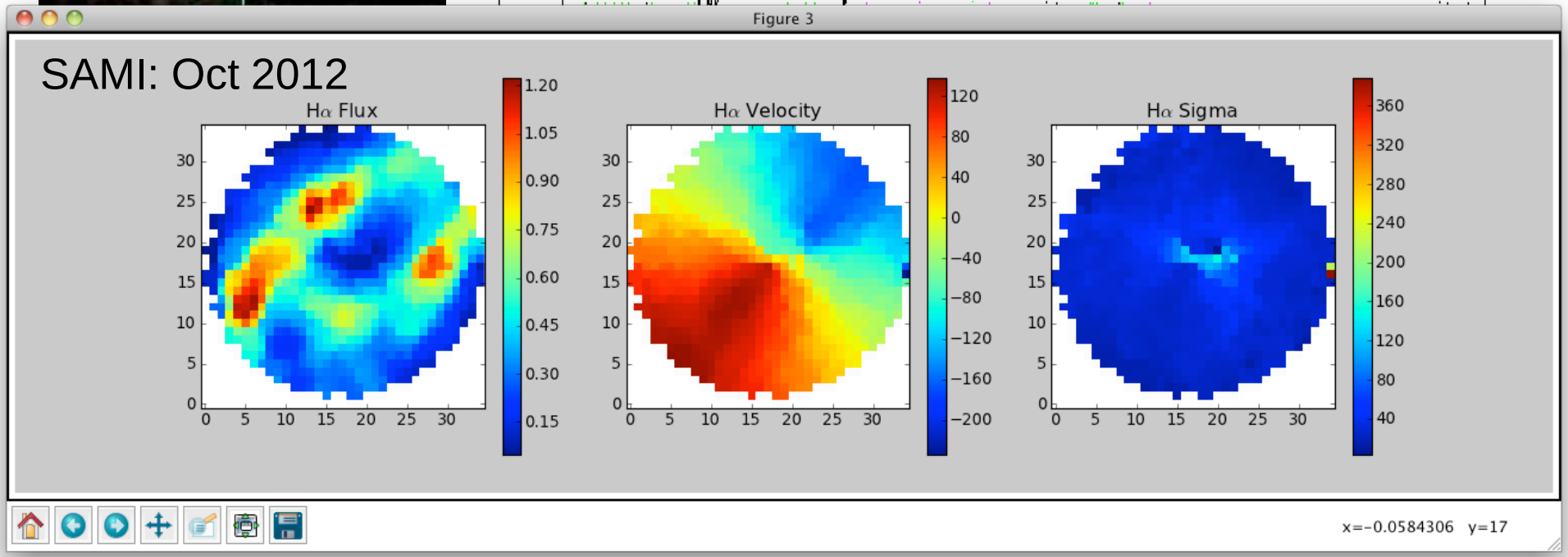
- Commissioning data from July 2011 (10 6dFGS galaxies)
  - Relatively large and bright galaxies (disks and early types).
  - Serendipitous wind galaxy discovery (Fogarty et al. 2012 in press)

- 10 nights on AAT for pilot observations in Sept/Oct 2012, completed:
  - Targeting galaxy clusters at z~0.05.
  - Studying the environmental dependence of fast and slow rotators.
  - First look at spatially resolved star formation vs. environment.
  - Sample of 133 galaxies (including a few targets from commissioning in May 2012).

What do single fibre surveys miss?

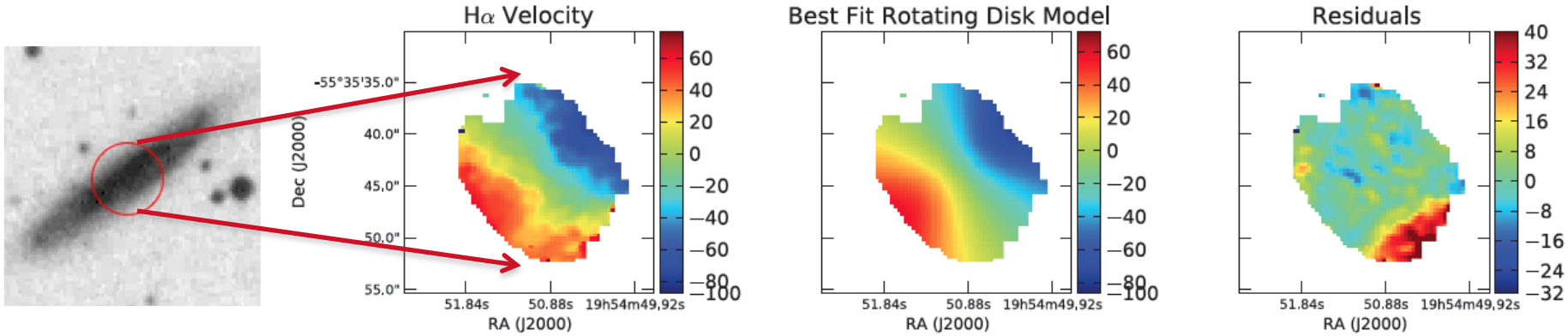




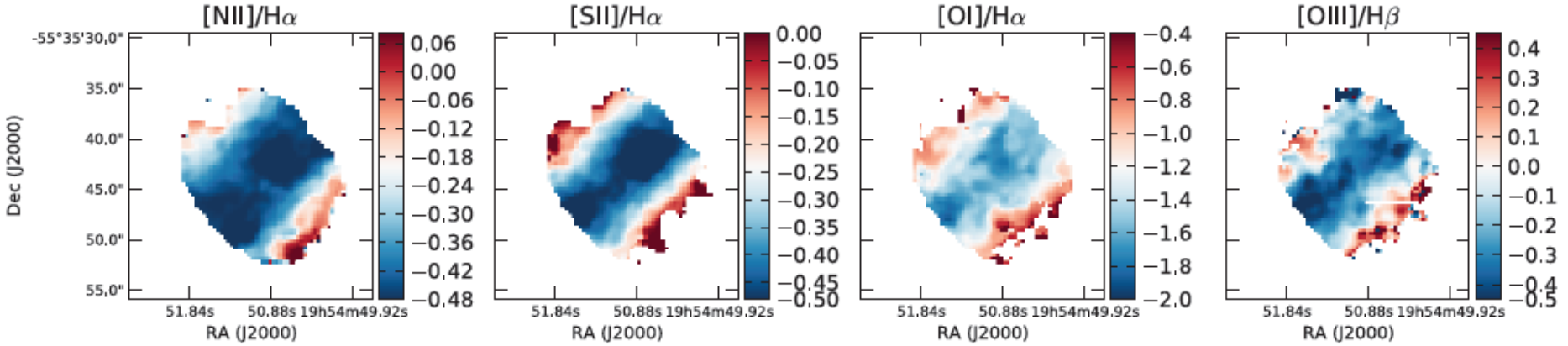


Science: serendipitous wind discovery

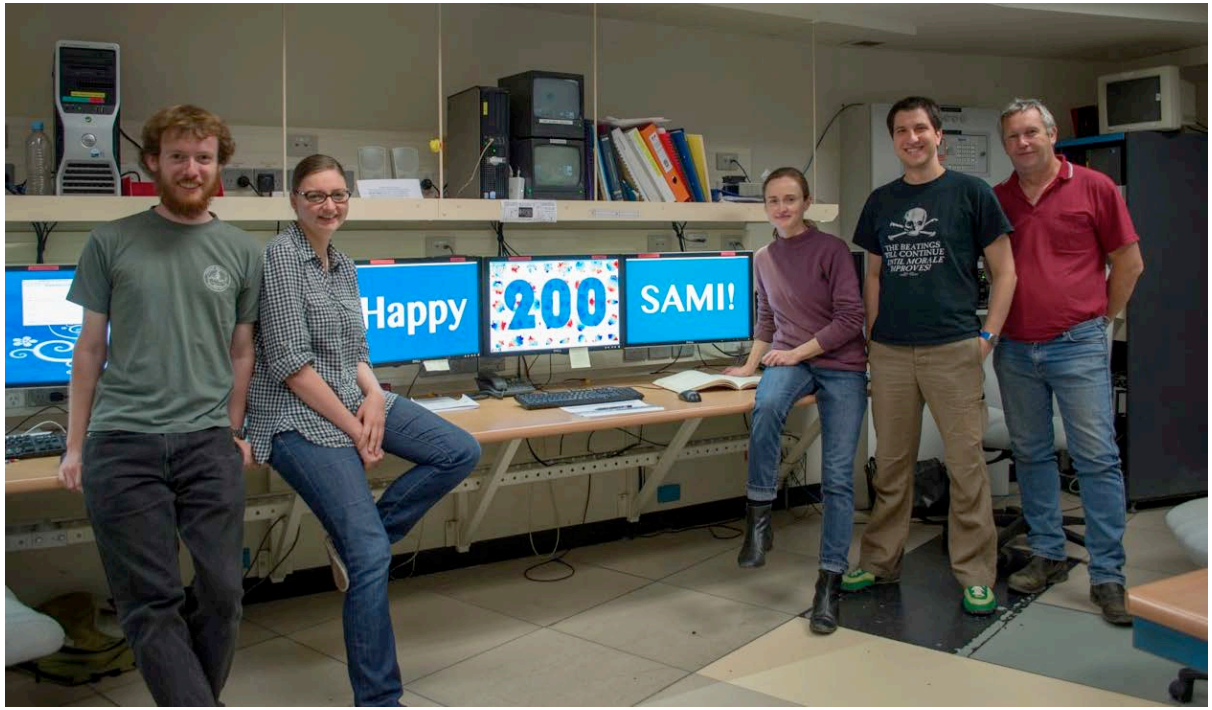
Lisa Fogarty et al. (2012), ApJ,



(a) The Hα velocity field with the best fitting rotating disk model and residuals.



SAMI Galaxy Survey: 250++ galaxies



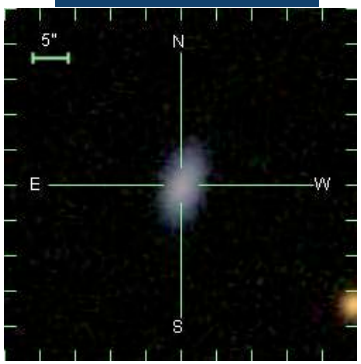
Upgrade of instrument: new hexabundles and fibre cable for improved blue throughput, completed Jan 2013.

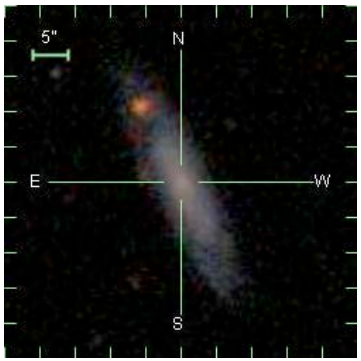
›Hot off Press: 21 nights in 13A, with a specific focus on the galaxy velocity function. 252 galaxies in 13 nights.

SAMI Galaxy Survey: 250++ galaxies

252 SAMI galaxies > 34 THINGS galaxies

Examples…


5"
N
E
W
S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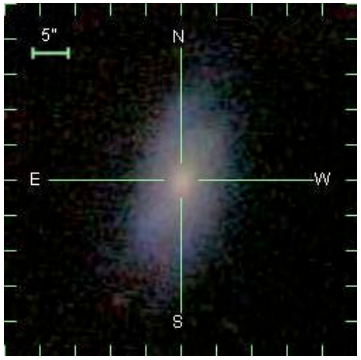
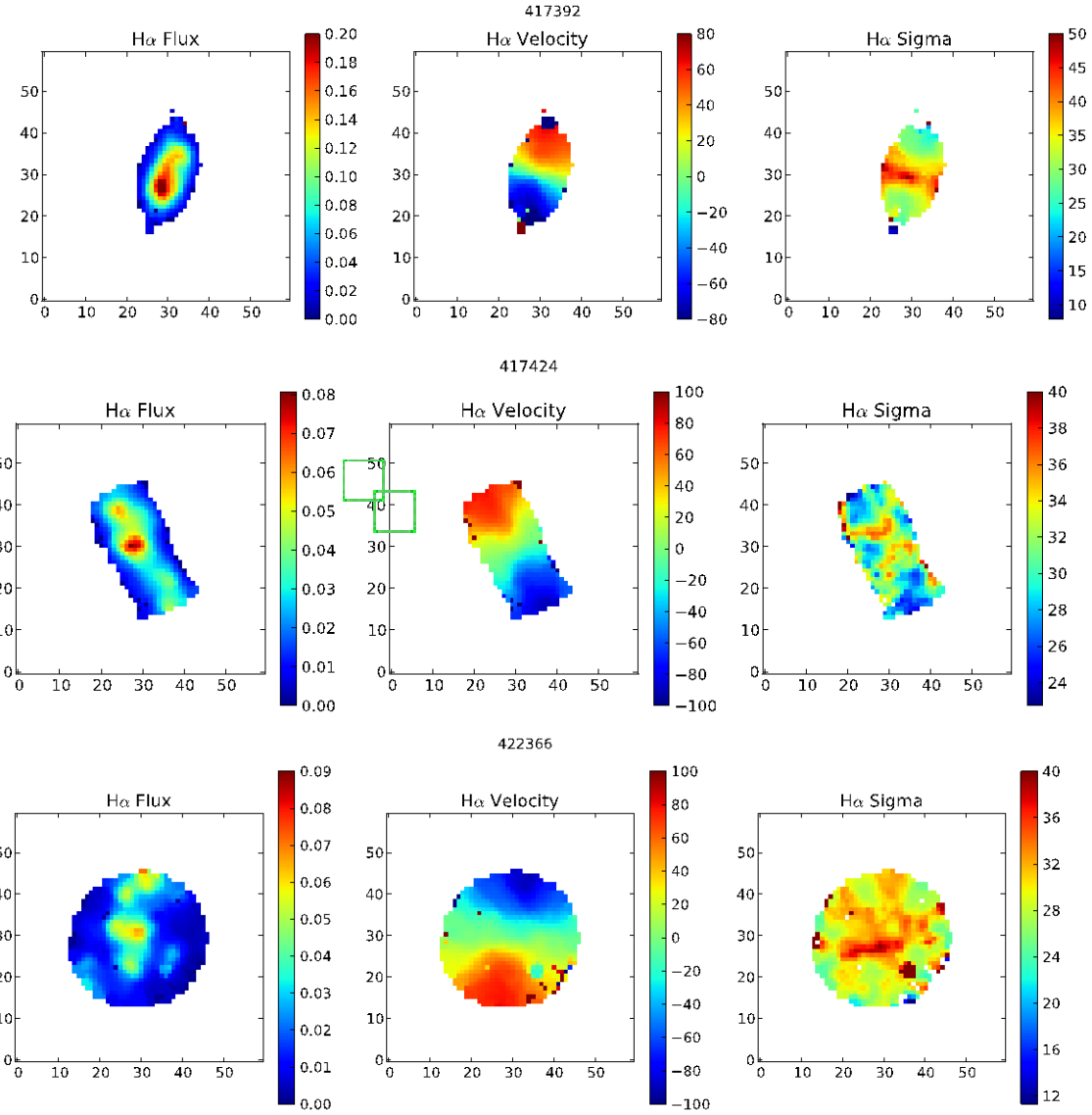

5"
N
E
W
S

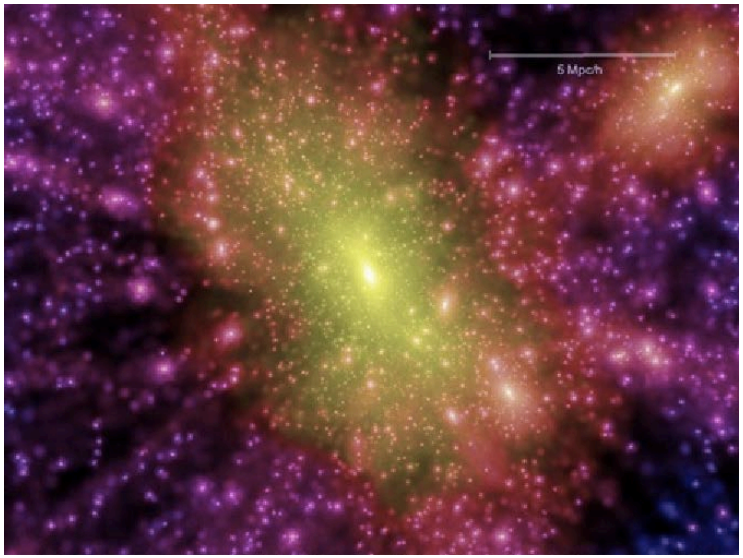

417392
Hα Flux
Hα Velocity
Hα Sigma
417424
Hα Flux
Hα Velocity
Hα Sigma
422366
Hα Flux
Hα Velocity
Hα Sigma

Where next?

- SAMI Galaxy Survey of 3000 galaxies:
  - 2500 in the Galaxy And Mass Assembly (GAMA; Driver et al. 2010) regions.
  - 500 galaxies in local (z~0.05) massive clusters.
  - Large enough to study galaxy formation as a function of both environment and mass.
  - 3 year program.
  - Semi-analytic and hydro simulation program (Chris Power, Geraint Lewis et al.)

Proposal Submitted Last Week!

Simulations: Observational Signatures



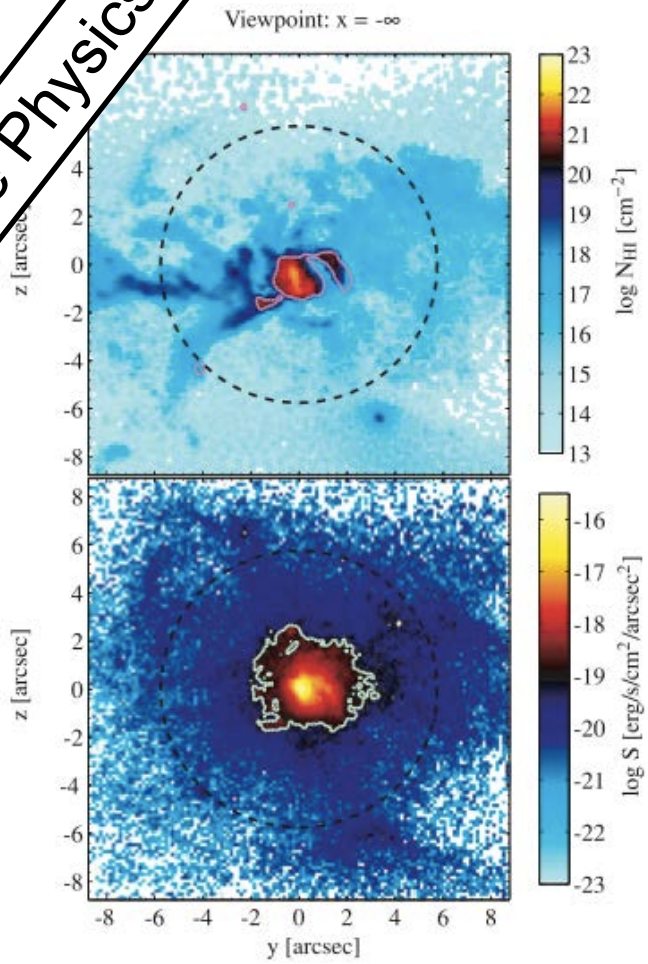
?

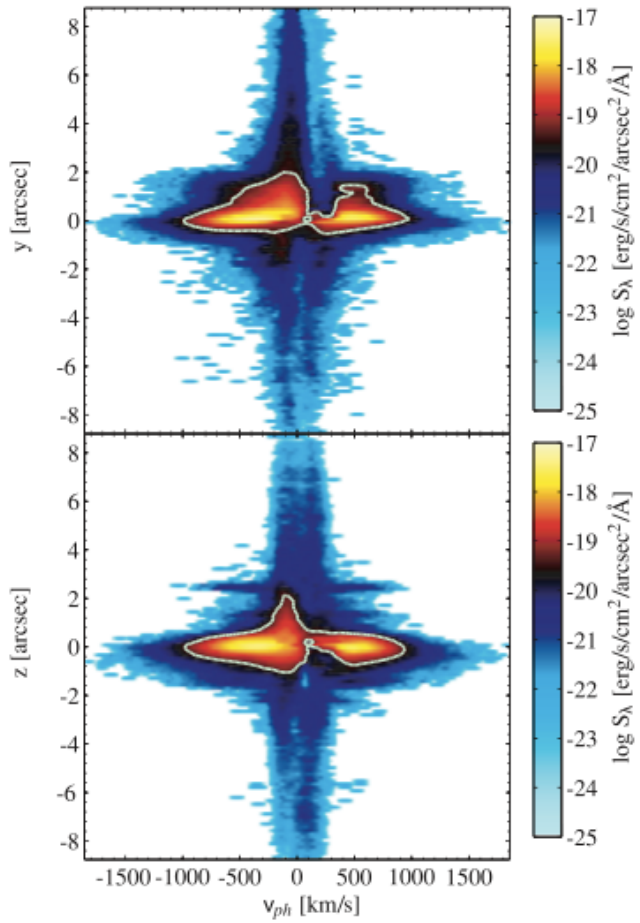
We are faced with the age-old problem:

How do we compare simulations with observations?

Simulations: Observational Signatures

Add More Physics!!

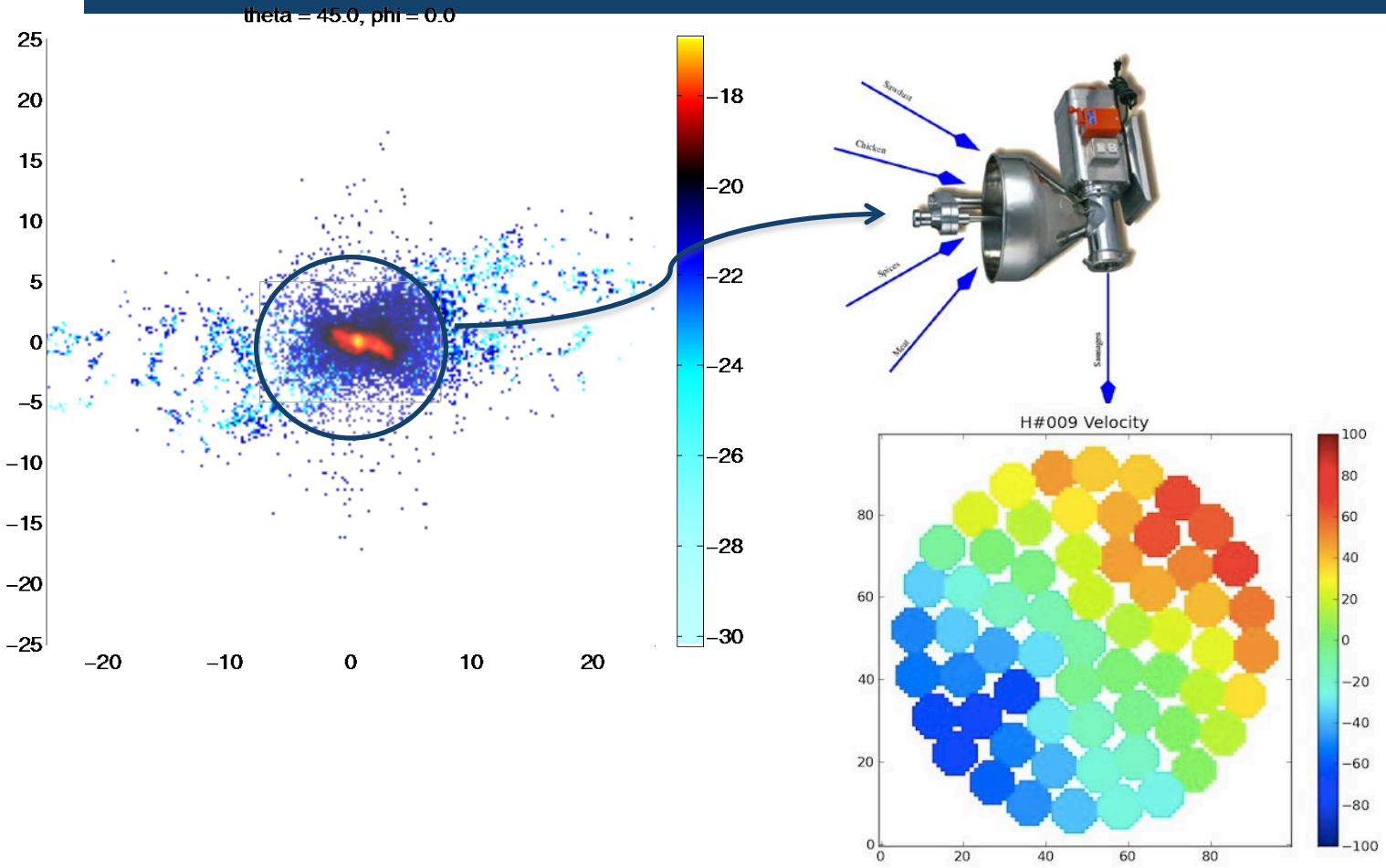




Lya-emitters (Luke Barnes)

Gas dynamics, cooling, AGN, star formation, metals, radiative transfer, photo ionization, feedback, and even magnetic fields! = “Realistic Galaxy”

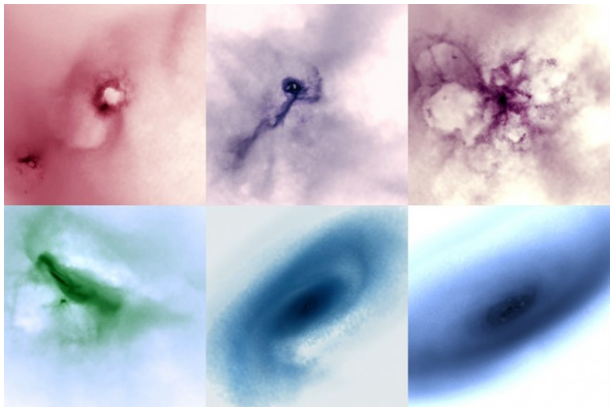
Simulations: Observational Signatures

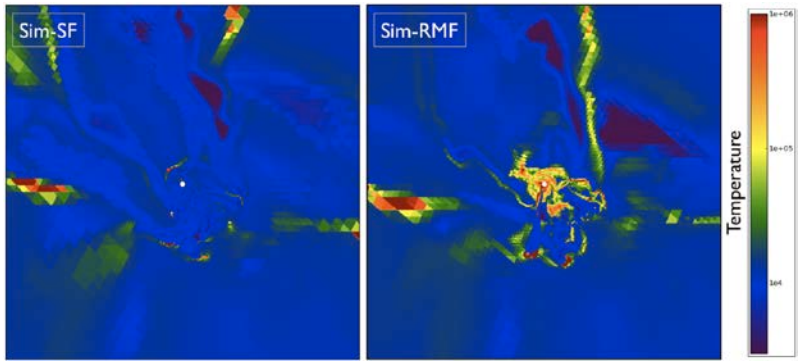


Need to include the “SAMI” observational signature, and compare in the observational plane!

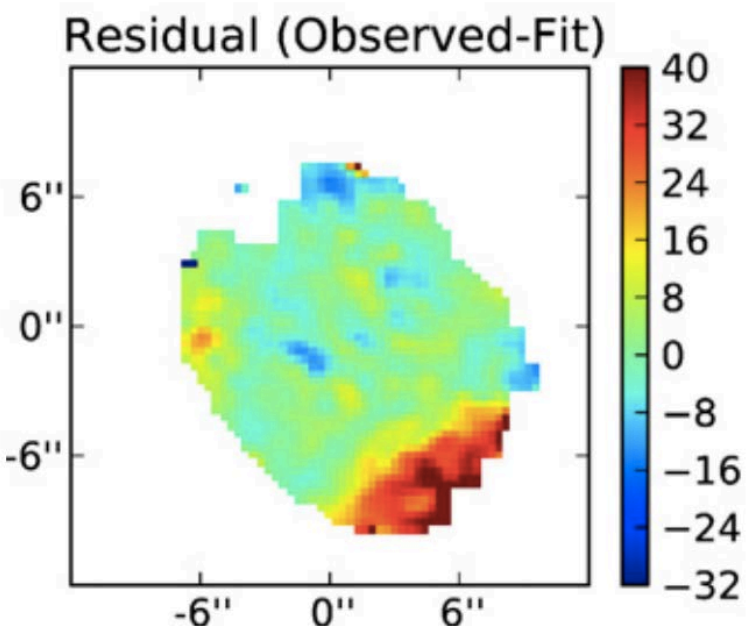
Simulations: Observational Signatures

Governato et al.



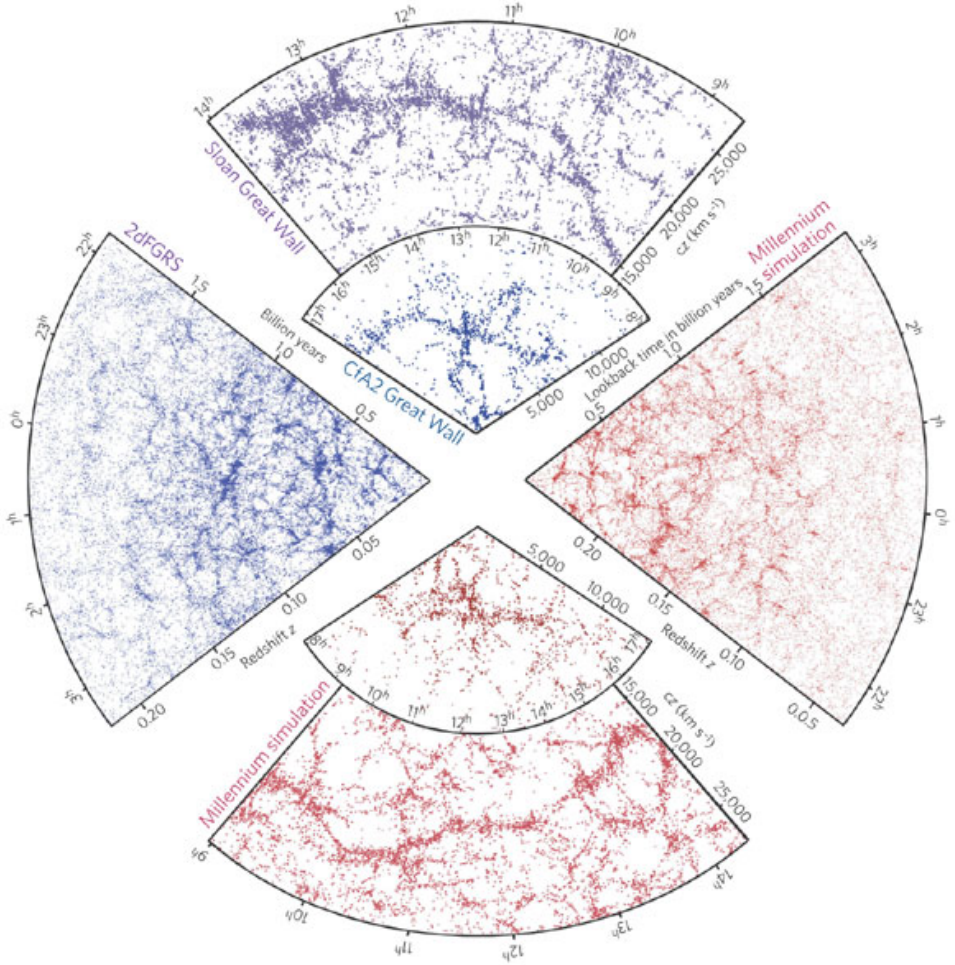


Kim et al.



Is the wind we see SN driven, AGN driven, a mixture of both or something else?

Simulations: Velocity & Angular Momentum

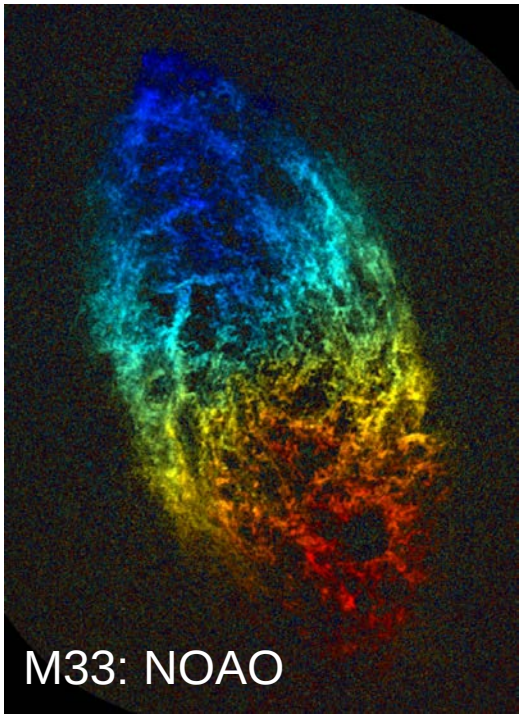


We have learnt a lot from galaxy surveys, using them as tracers of the underlying mass distribution.

To compare to simulated cosmologies, we have had to “bias” the mass distribution to identify galaxies.

The comparison is pretty good. But we will have more information.

Simulations: Velocity Function

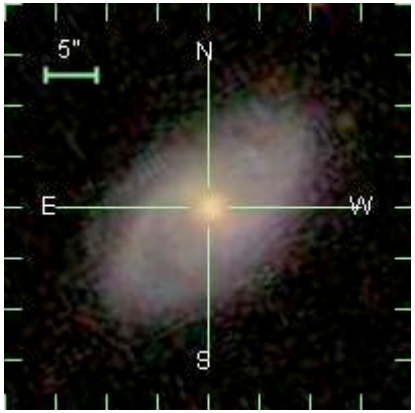


The velocity is a proxy for mass, and we can define a velocity function similar to the luminosity function.

$$\Phi(L)dL = \Phi_* \left(\frac{L}{L_*}\right)^{\alpha} \exp\left(-\frac{L}{L_*}\right)\frac{dL}{L_*},$$

Dynamical Relations

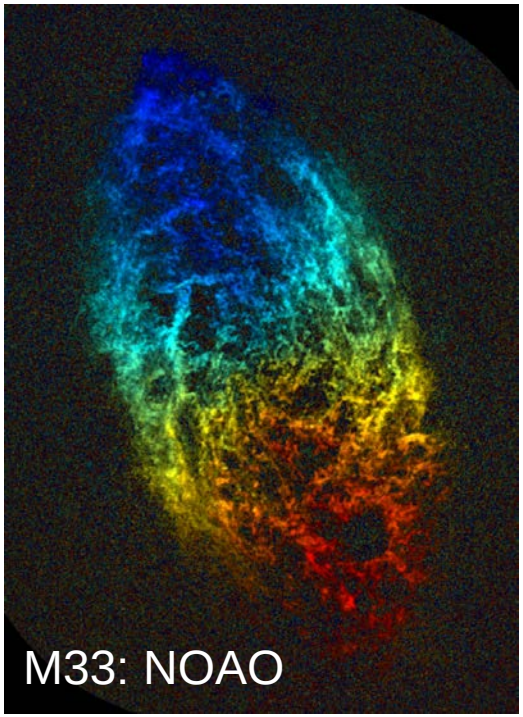
$$\tilde{\Psi}(v)dv = \tilde{\Psi}_* \left(\frac{v}{v_*}\right)^{\beta} \exp\left[-\left(\frac{v}{v_*}\right)^{n}\right]\frac{dv}{v_*},$$



With single fibre spectra we measure velocity dispersion and relate to circular velocity;

$$v_c = \sqrt{2}\sigma$$

Simulations: Velocity Function

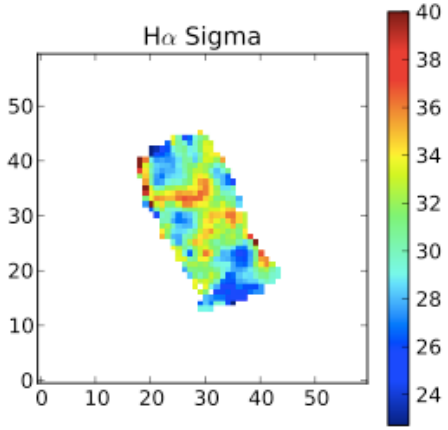


The velocity is a proxy for mass, and if we can define a velocity function similar to the luminosity function.

$$\Phi(L)dL = \Phi_* \left(\frac{L}{L_*}\right)^{\alpha} \exp\left(-\frac{L}{L_*}\right)\frac{dL}{L_*},$$

Dynamical Relations

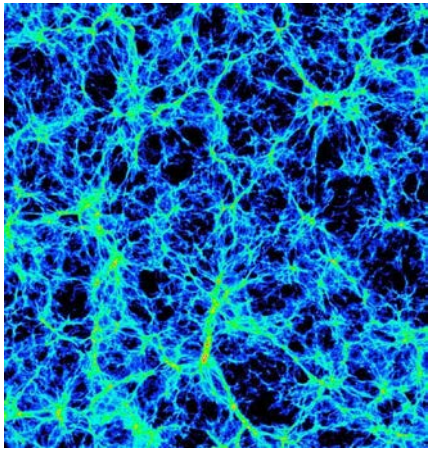
$$\tilde{\Psi}(v)dv = \tilde{\Psi}_* \left(\frac{v}{v_*}\right)^{\beta} \exp\left[-\left(\frac{v}{v_*}\right)^{n}\right]\frac{dv}{v_*},$$



With single fibre spectra we measure velocity dispersion and relate to circular velocity;

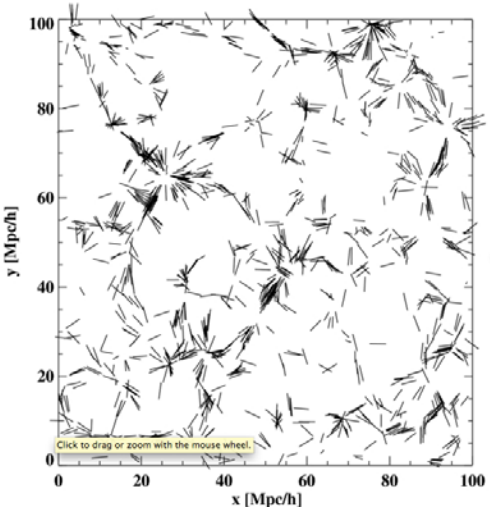
$$v_c = \sqrt{2}\sigma \quad ?$$

Simulations: Angular Momentum Evolution

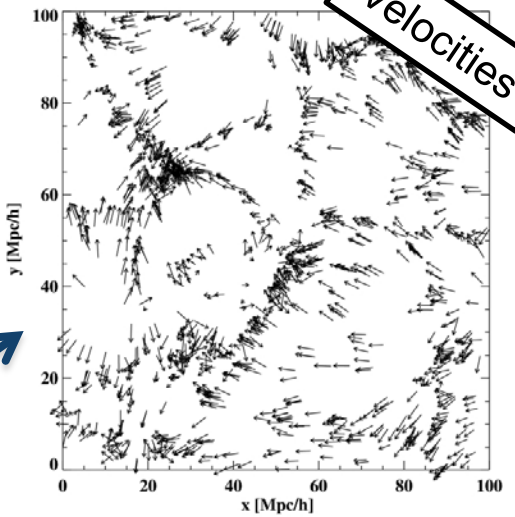


Finkbeiner et al.

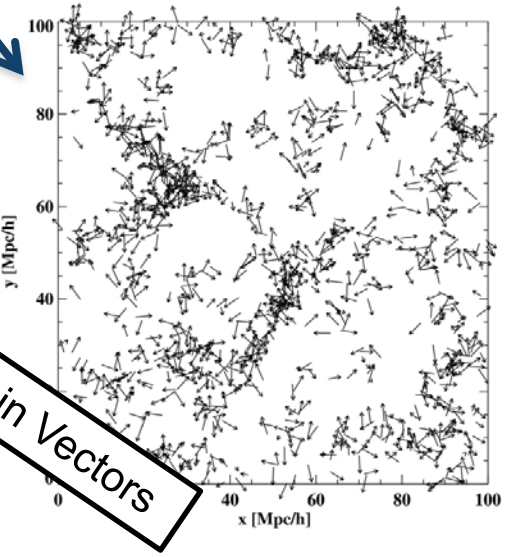
Filament Axis



Velocities



Spin Vectors

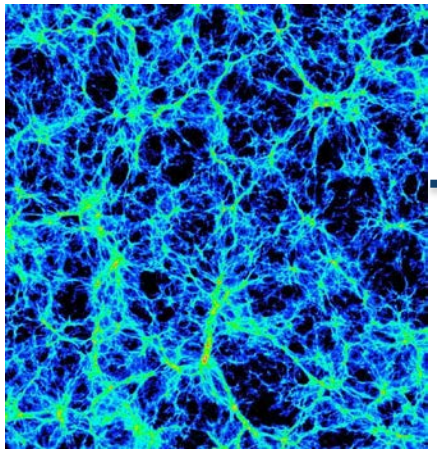


Trowland et al.

Tidal torques get things spinning, then spin evolves through interactions and merging. Result, spin is correlated with structure.

Simulations: Angular Momentum Evolution

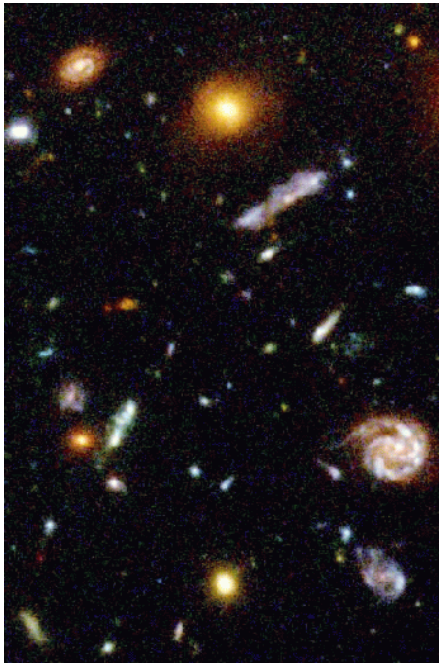
Finkbeiner et al.



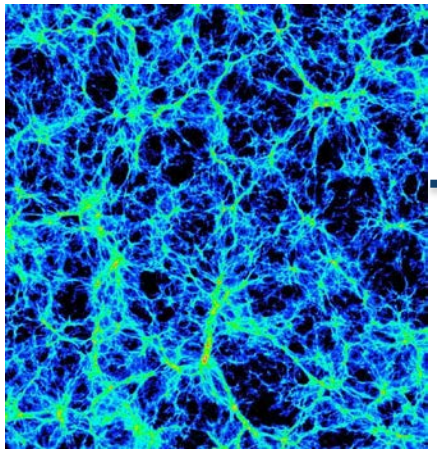
Theoretical Astrophysical Observatory

Centre for Astrophysics and Supercomputing – Swinburne University of Technology

We need “realistic” synthetic universes.



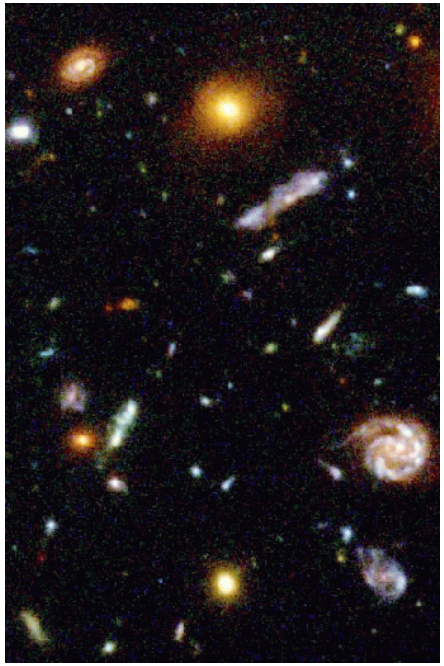
Simulations: Angular Momentum Evolution



Finkbeiner et al.

Theoretical Astrophysical Observatory

Centre for Astrophysics and Supercomputing – Swinburne University of Technology



We need “realistic” synthetic universes.

Alternative Cosmological Models

Evolving equation of state, dark energy decay
interacting dark sector, f(R) and many more…

Carlesi, Knebe, Power, Lewis

Simulations: Join us!

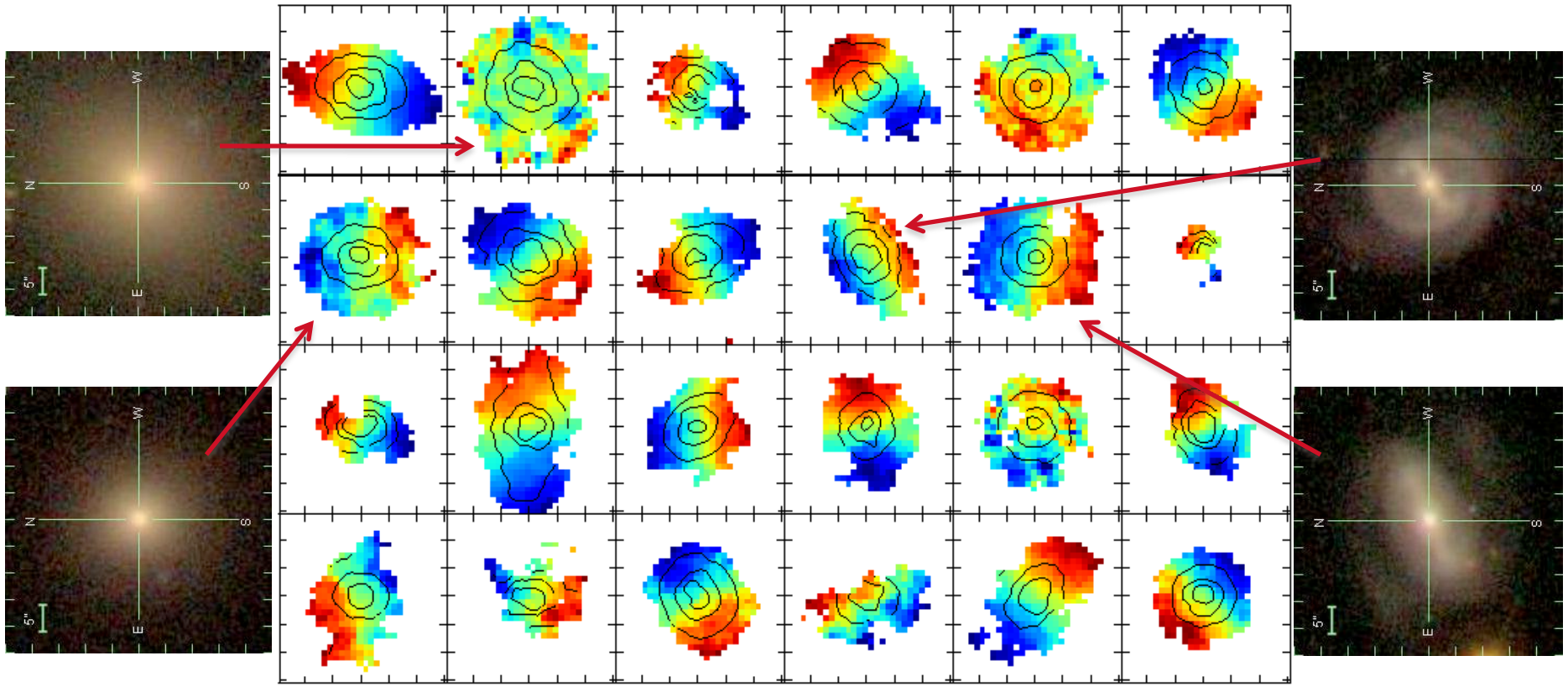
Survey Simulations PipeLine (SSimPL)

Growing effort of bring computational cosmology under one umbrella, including the SAMI simulation.

If you’re interested, talk to Chris Power, Greg Poole or me.

Pilot: cluster galaxies

Stellar velocity fields of Abell 168 galaxies
(Lisa Fogarty, Nic Scott++):



25% of full pilot sample…