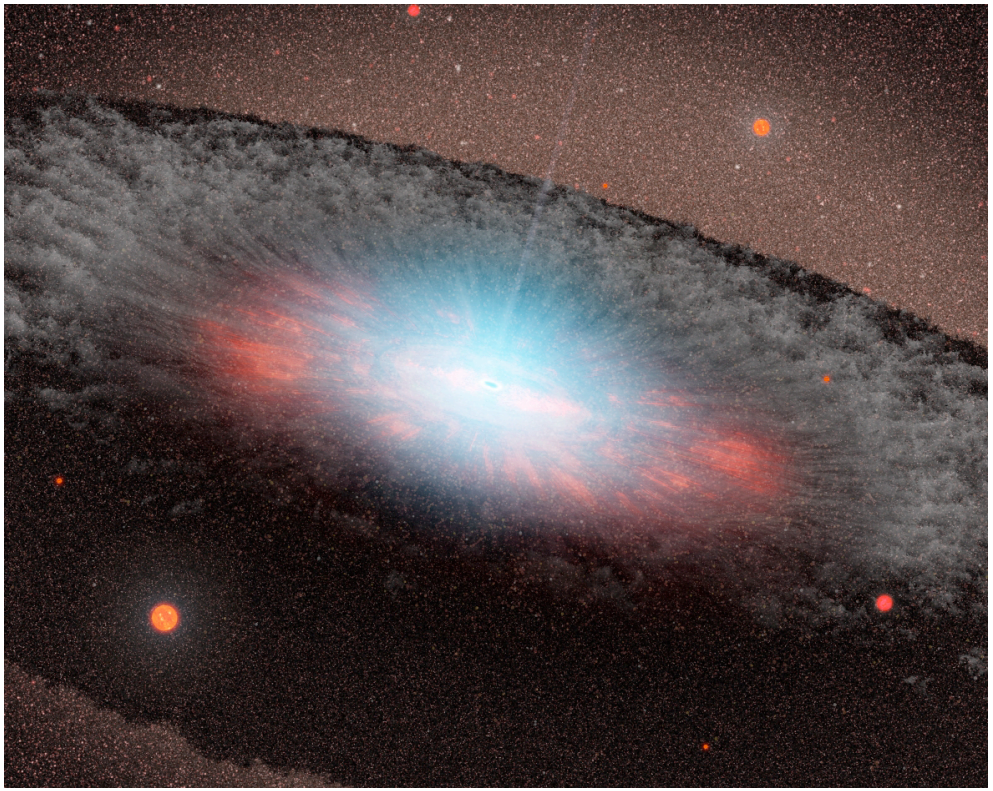
Observing AGN Feedback in Action in Early-type Galaxies

Kevin Schawinski
Department of Physics, University of Oxford, UK



ESO Workshop Obscured AGN Across Cosmic Time
Seeon, Bavaria, Germany, 5-8 June 2007

People that have Contributed to this Research

Yonsei

Sukyoung Yi

Seok-Joo Joo

Oxford

Sugata Kaviraj

Marc Sarzi

Joe Silk

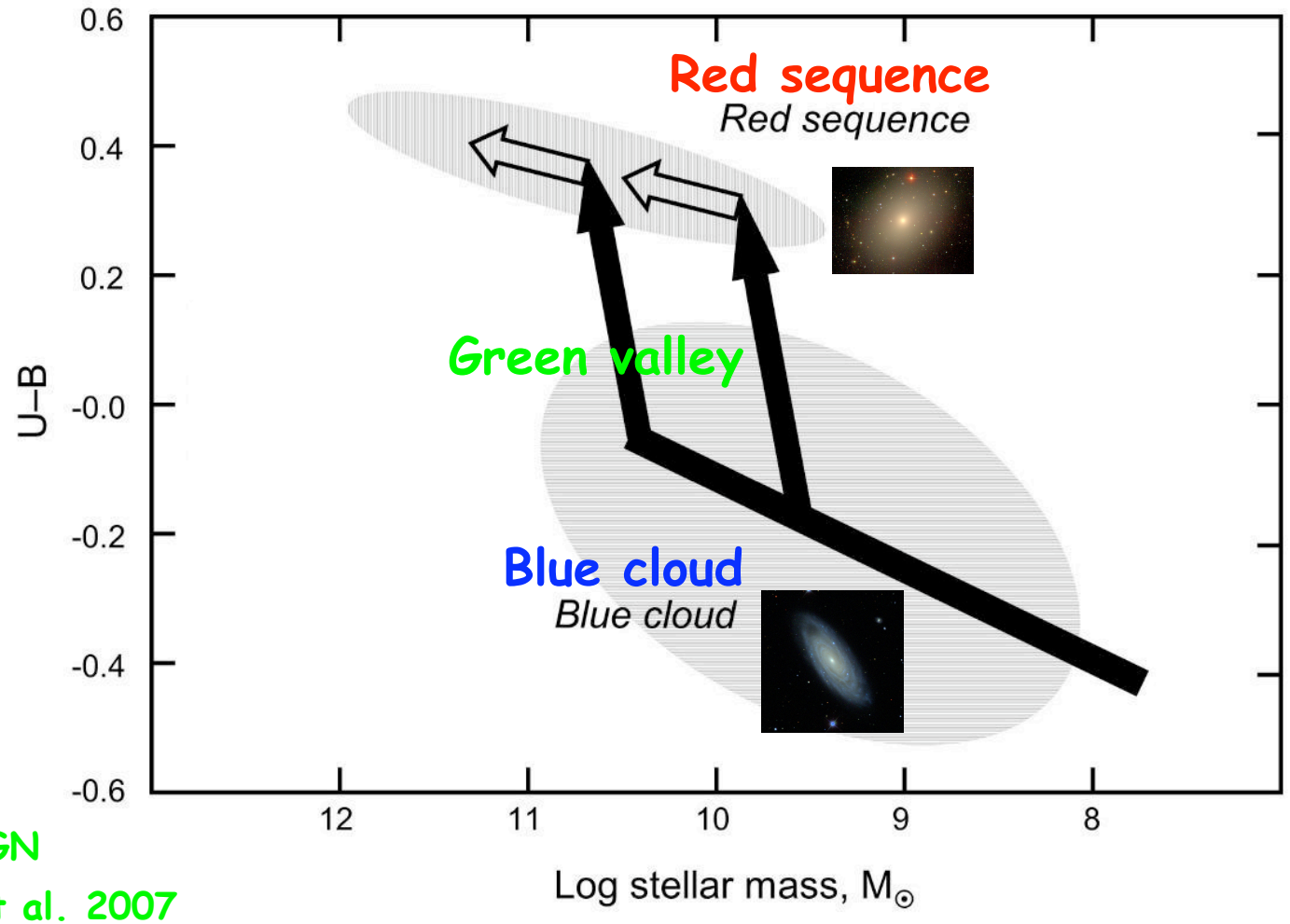
Chris Lintott

ICG Portsmouth

Daniel Thomas

Claudia Maraston

The Migration from the Blue Cloud to the Red Sequence



Faber et al. (2006)

Implicating AGN

e.g. Martin et al. 2007

Nandra et al. 2007

Salim et al. 2007

Observing AGN Feedback in Action: What do we need?

Step 1: Select appropriate sample

- Capture early-types in the process of formation
- Selection of early-types not biased against SF/AGN
- Large sample along process to draw statistical conclusions

Step 2: Develop analysis tools

- 2a: Classify types of activity – emission lines
- 2b: Quantify recent star-formation history

Step 3: Analyse!

What are galaxies like during the transformation process?

The MOSES Sample:

The Morphologically Selected Early-type Galaxies from SDSS

Selection Criteria: SDSS DR4

Redshift **0.05 < z < 0.10**

Apparent magnitude **r < 16.8**

Number of galaxies ~ 50 000

Analysis of Spectra:

The SDSS spectra are re-analysed with **GANDALF** (a.k.a. **ppxf** from the **SAURON** project; Cappellari & Emsellem 2004, Sarzi et al. in prep), fitting stellar continuum and emission lines simultaneously. Measure: emission line fluxes and gas kinematics, stellar absorption lines (Lick indices) and velocity dispersion.

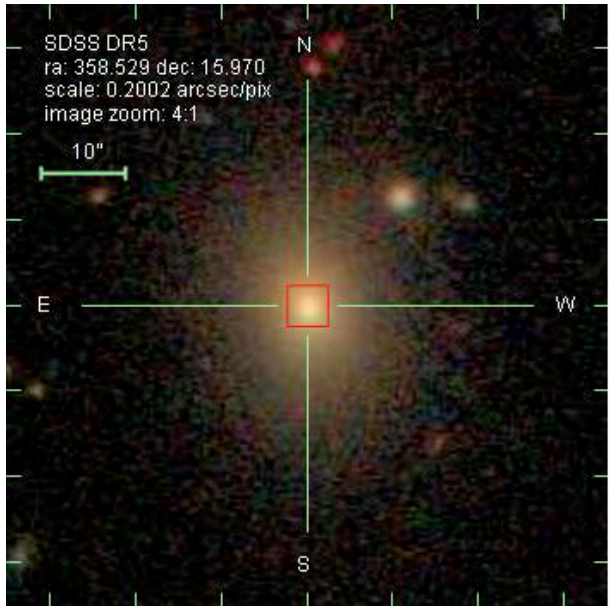
Visual Classification of Morphology:

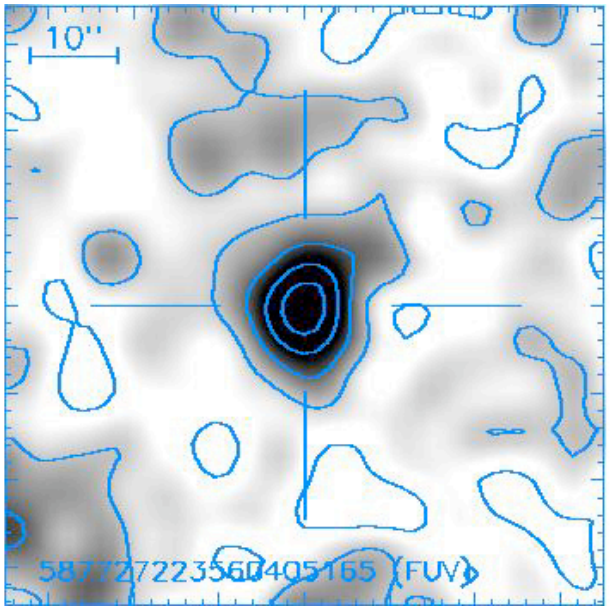
All 50 000 galaxies have been visually classified into early- and late-type morphology to find non-quiescent early-types.

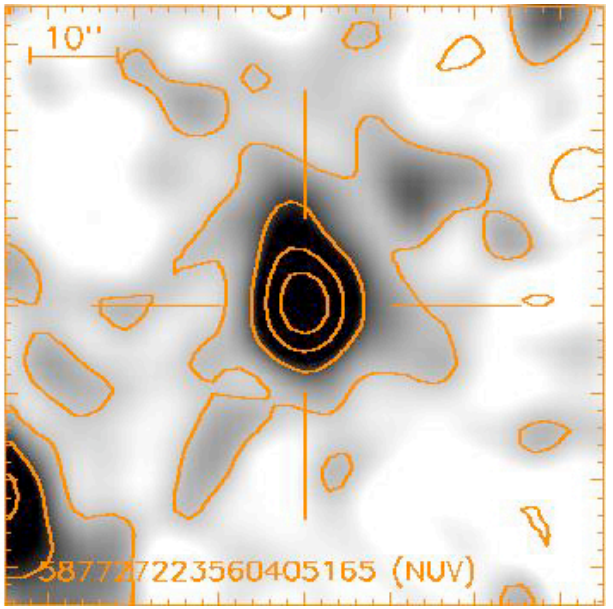
SDSS gri

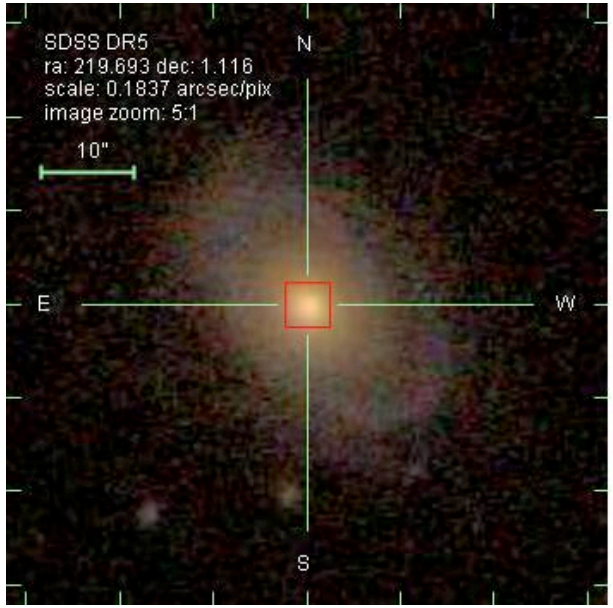
GALEX Far-UV

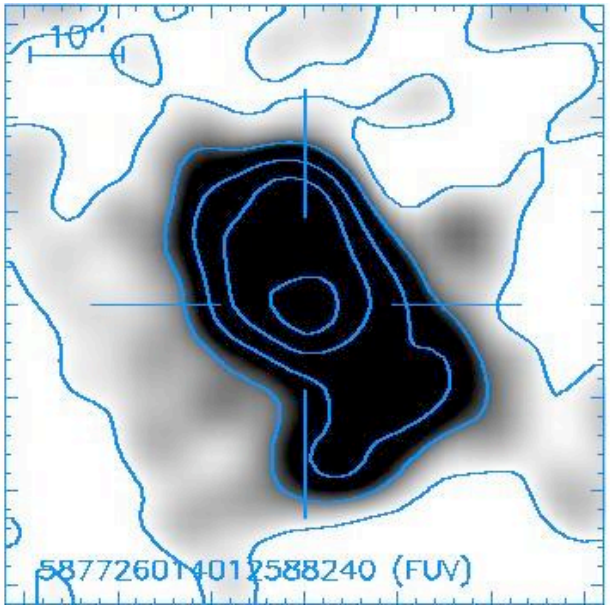
GALEX Near-UV

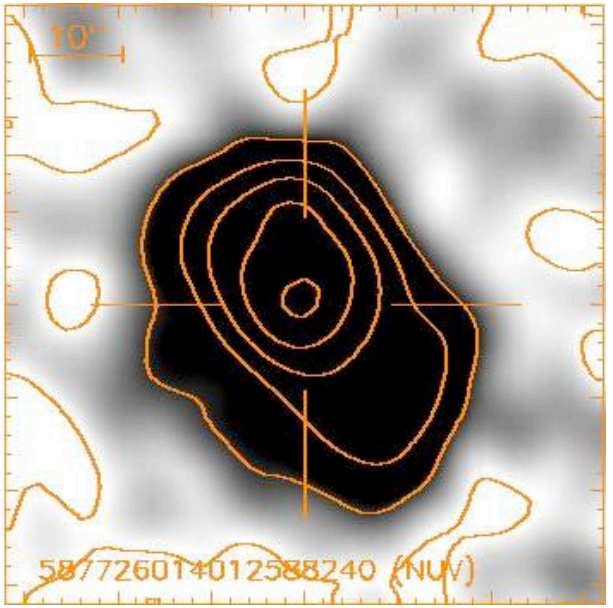










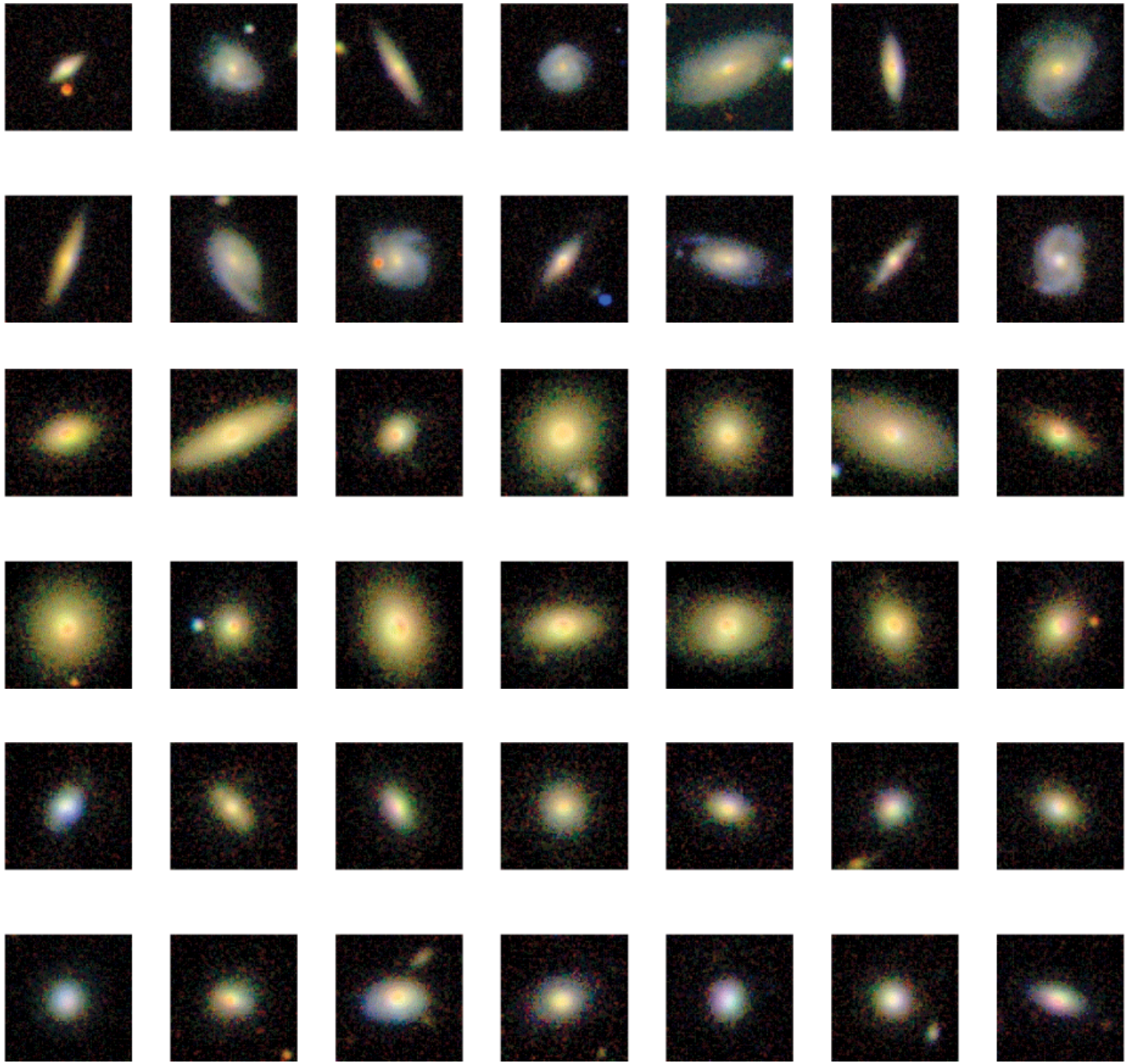


See also Yi et al. (2005), Kaviraj et al. (2006), Schawinski et al. (2006a,b), Ree et al. (2007)

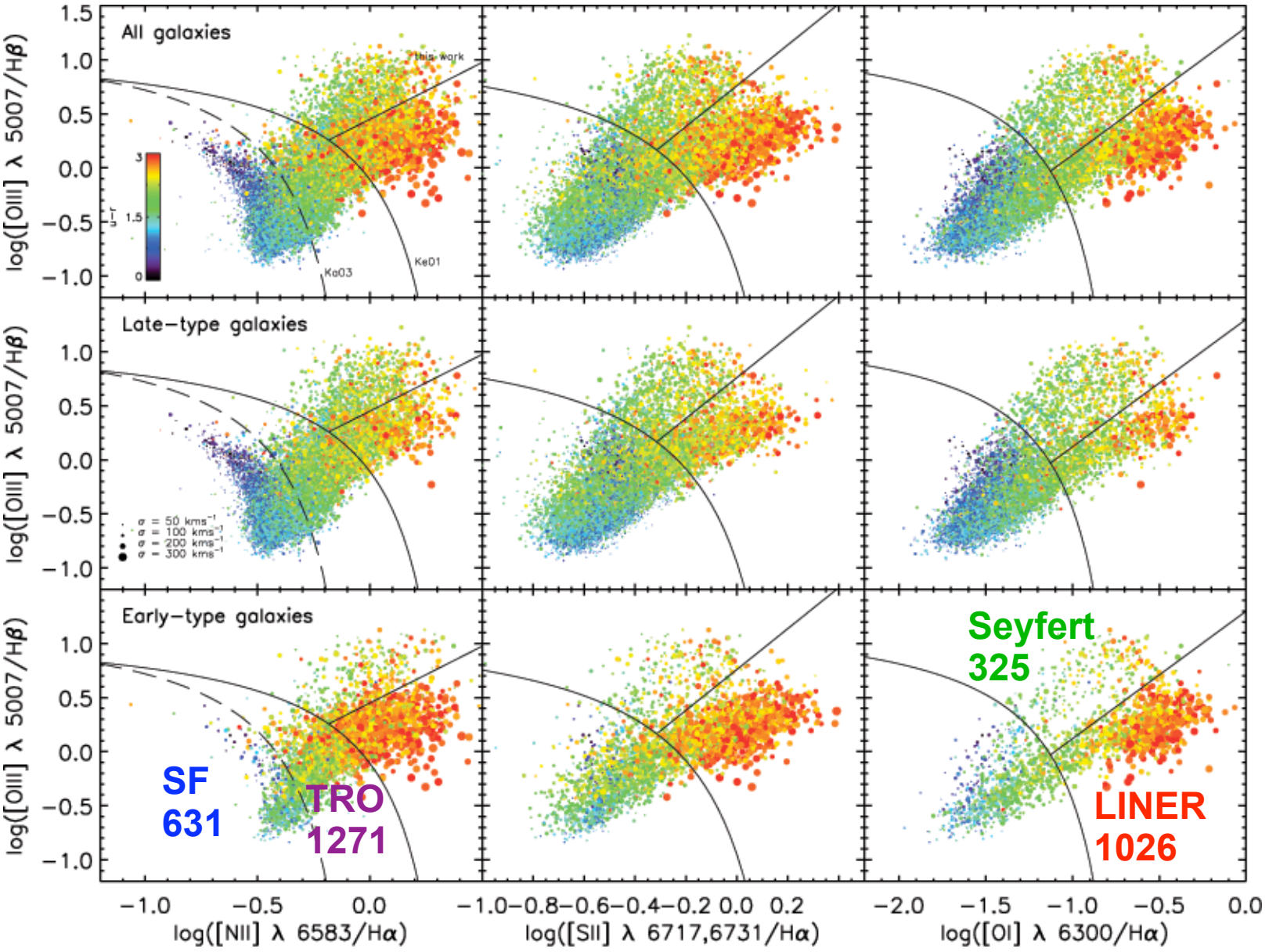
Late-type Galaxies

Early-type Galaxies

Unusual Early-type Galaxies



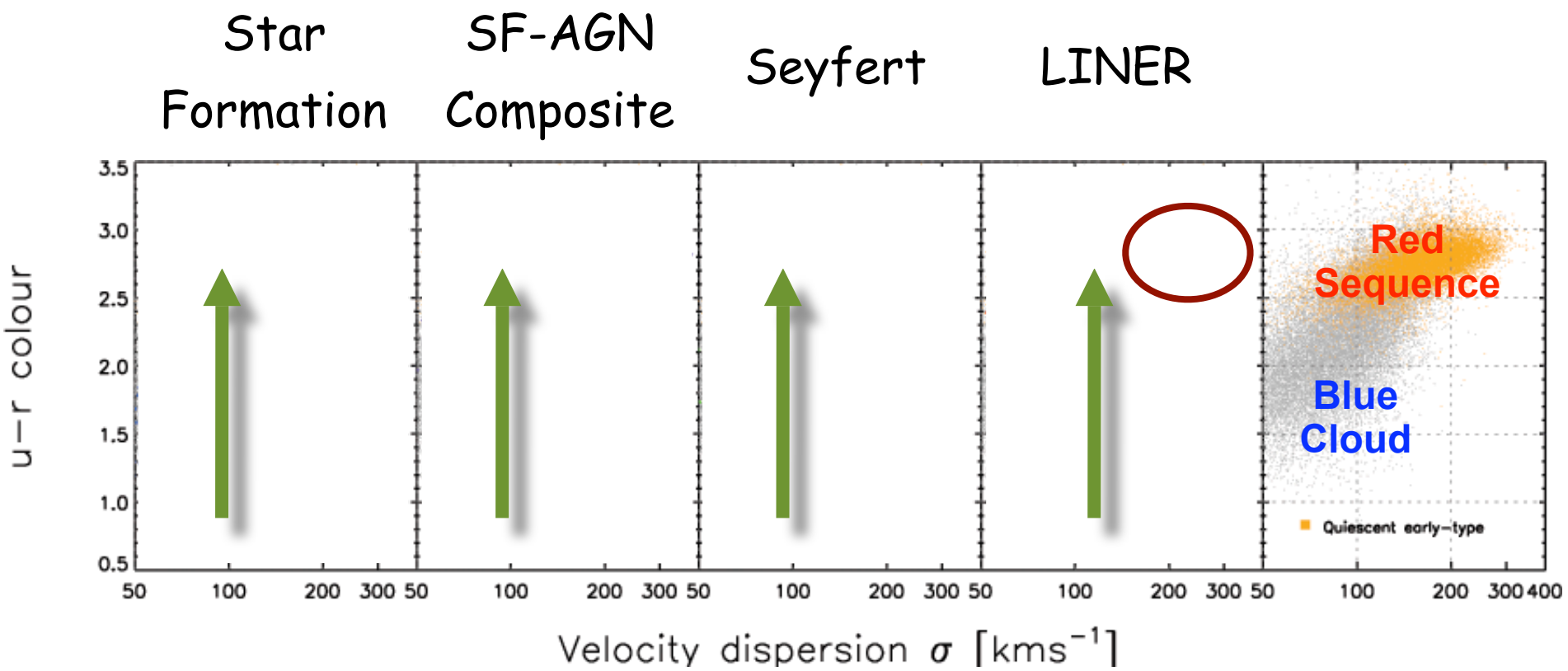
Step 2a: Emission Line Diagnostics



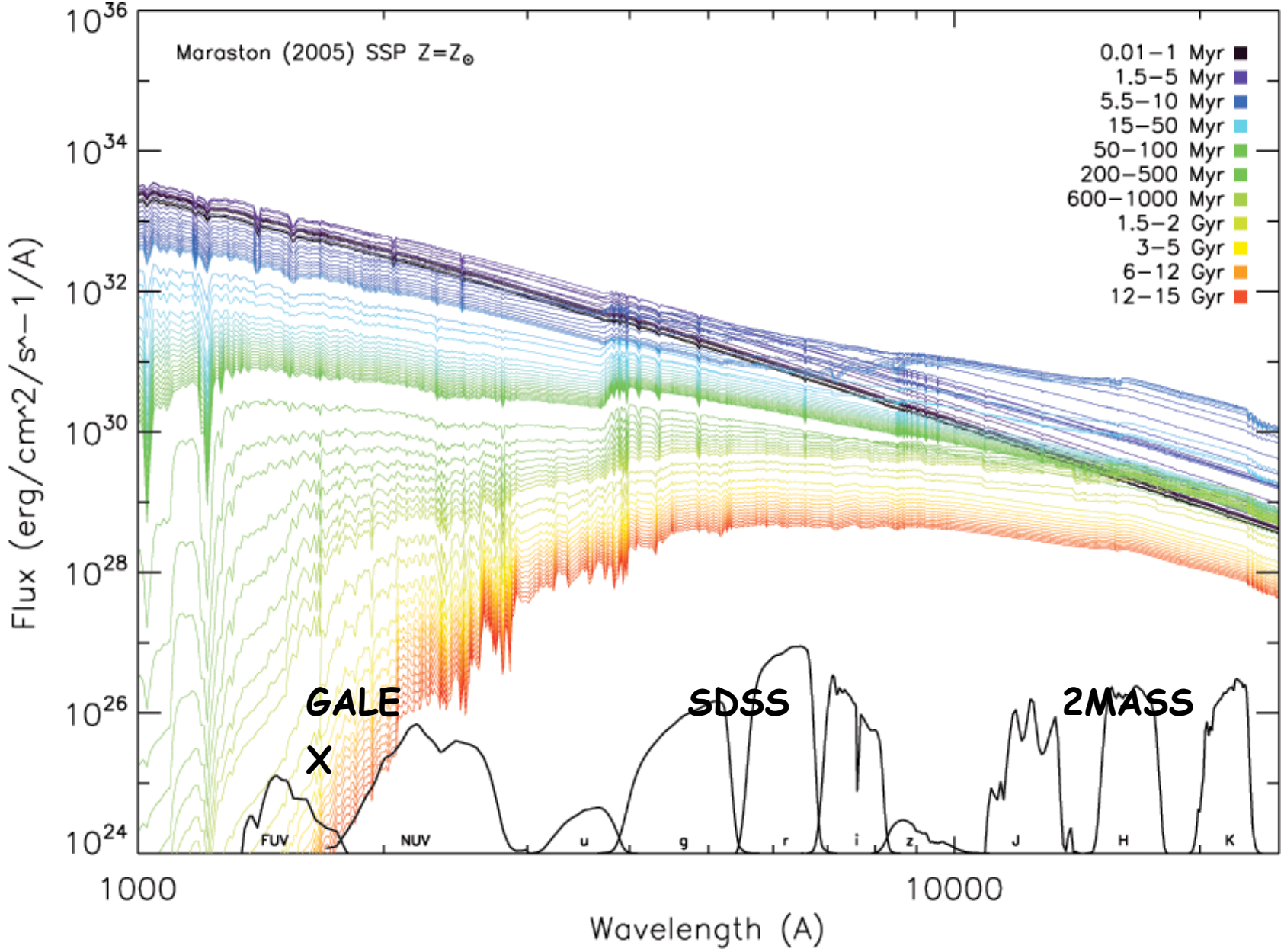
Quiescent
16187 out of 19440

Baldwin, Philips & Terlevich 1987, Kewley et al. 2001, 2006, Kauffmann et al. 2003

An Evolutionary Time Sequence?



Step 2b: Quantifying The Star Formation Histories of Galaxies

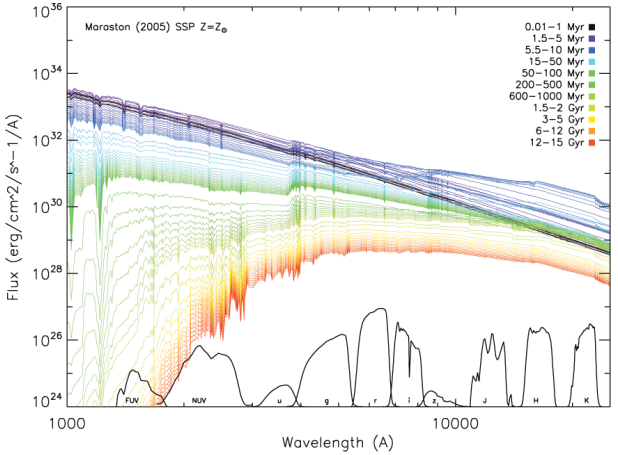


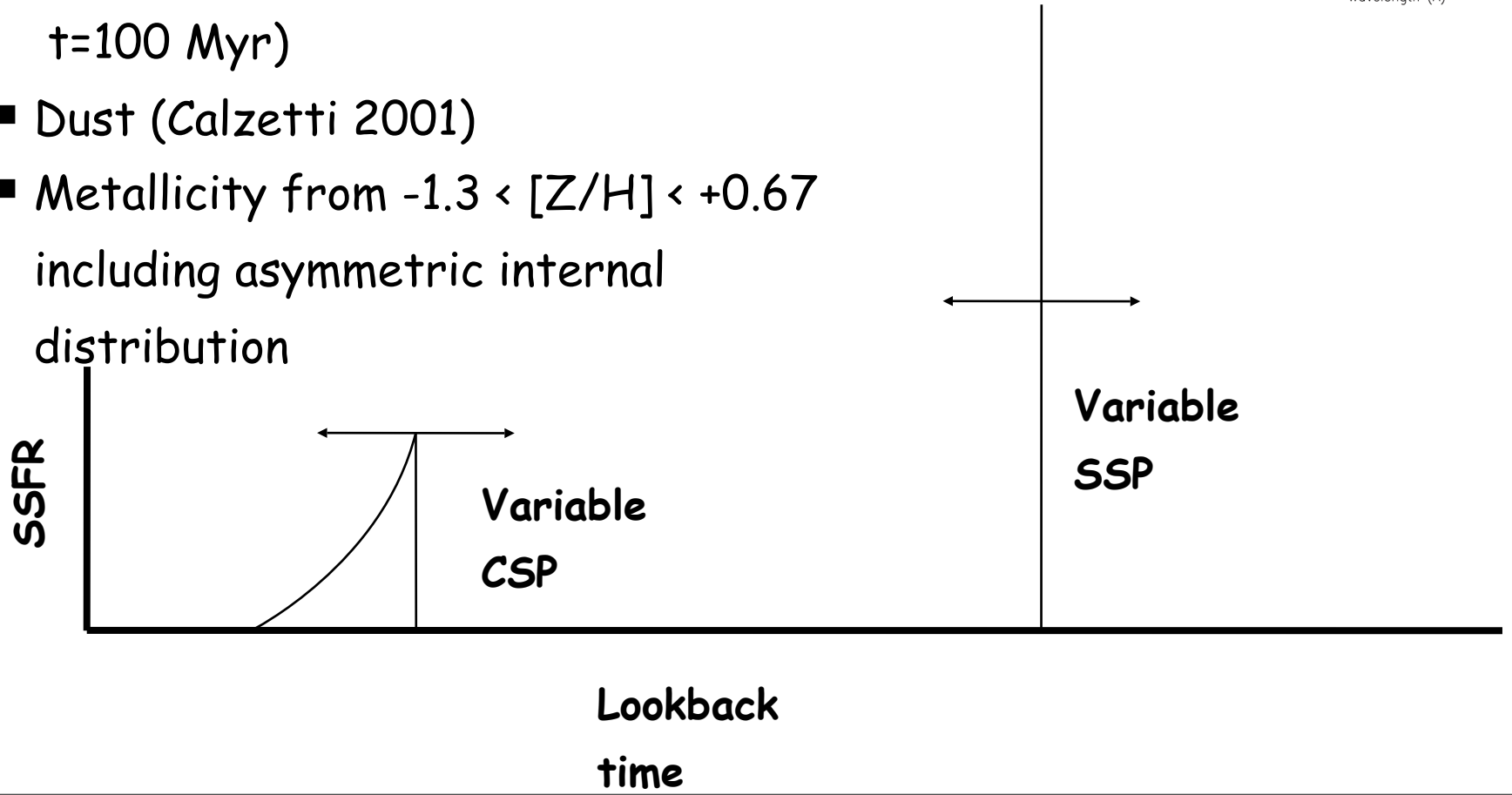
Step 2b: Parameter Estimation

1. Parameterisation

Describe the SFH as a two-component model (see Kaviraj et al. 2006).

- Old component – SSP (Maraston 2005)
- Young Component – CSP (exponential, t=100 Myr)
- Dust (Calzetti 2001)
- Metallicity from -1.3 < [Z/H] < +0.67 including asymmetric internal distribution





Step 2b: Parameter Estimation

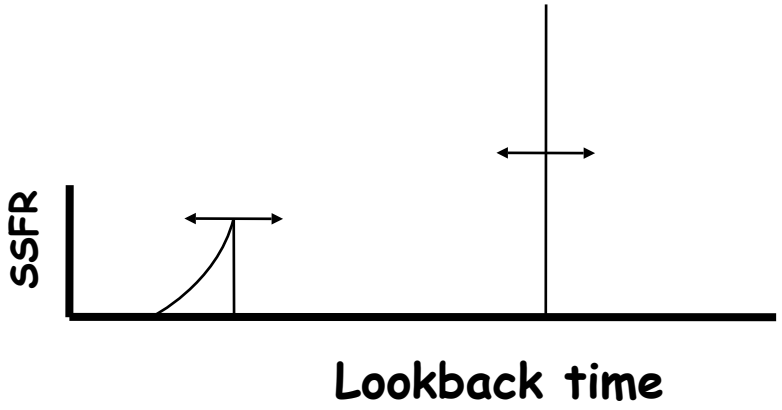
2. Fitting SED

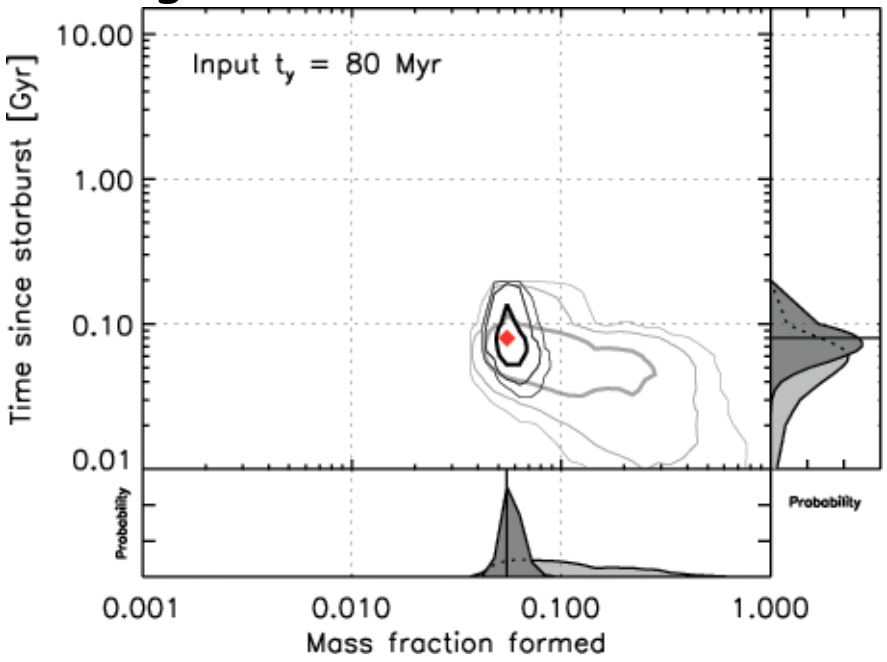
Fit the photometry: FUV, NUV, u, g, r, i, z, J, H, K

Compute χ^2 for 5-d array. Total of ~5 million SFHs.

Time to fit 1 galaxy ~ 20-45 minutes.

An immense computational task for ~20 000 galaxies!

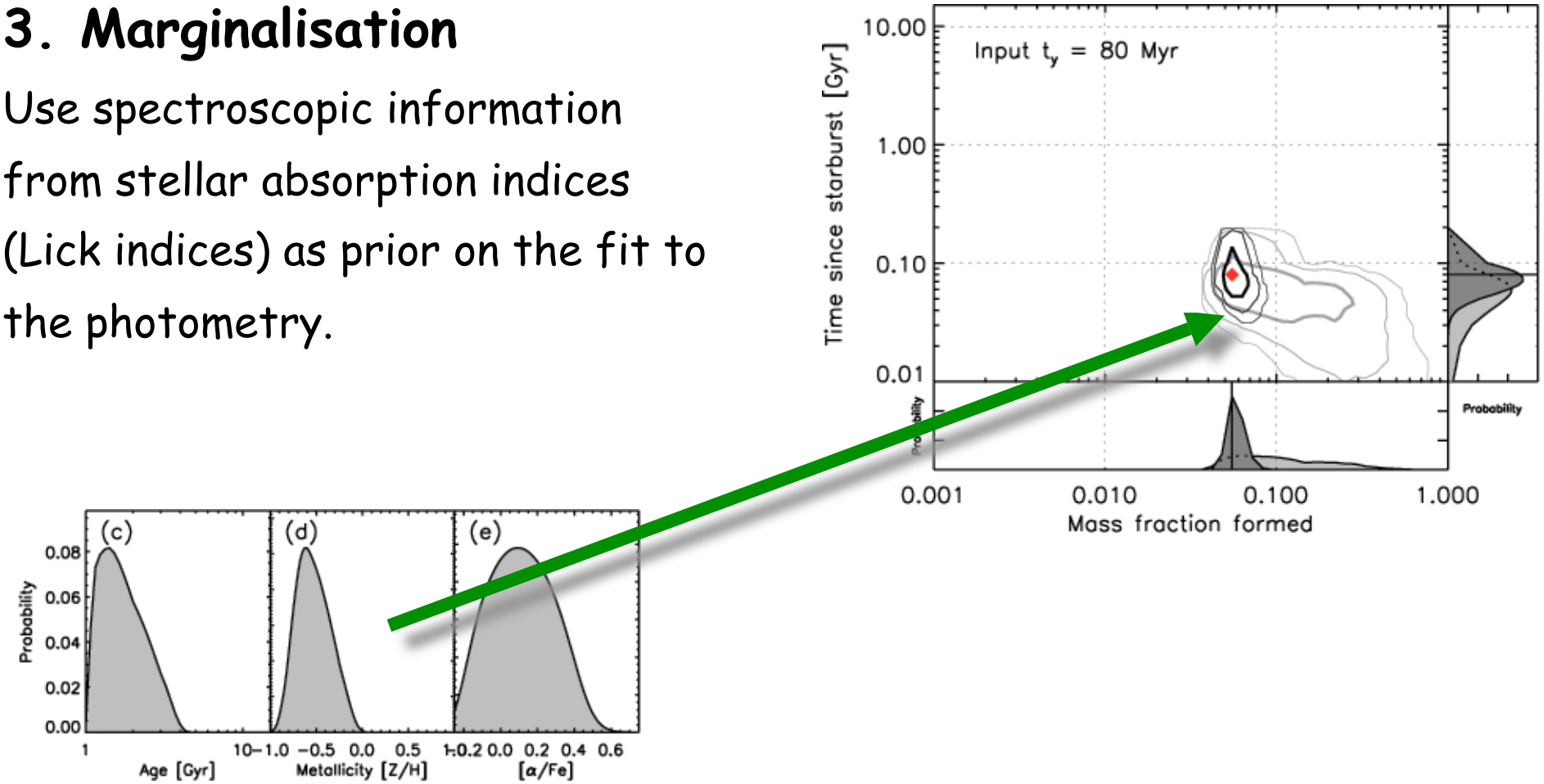




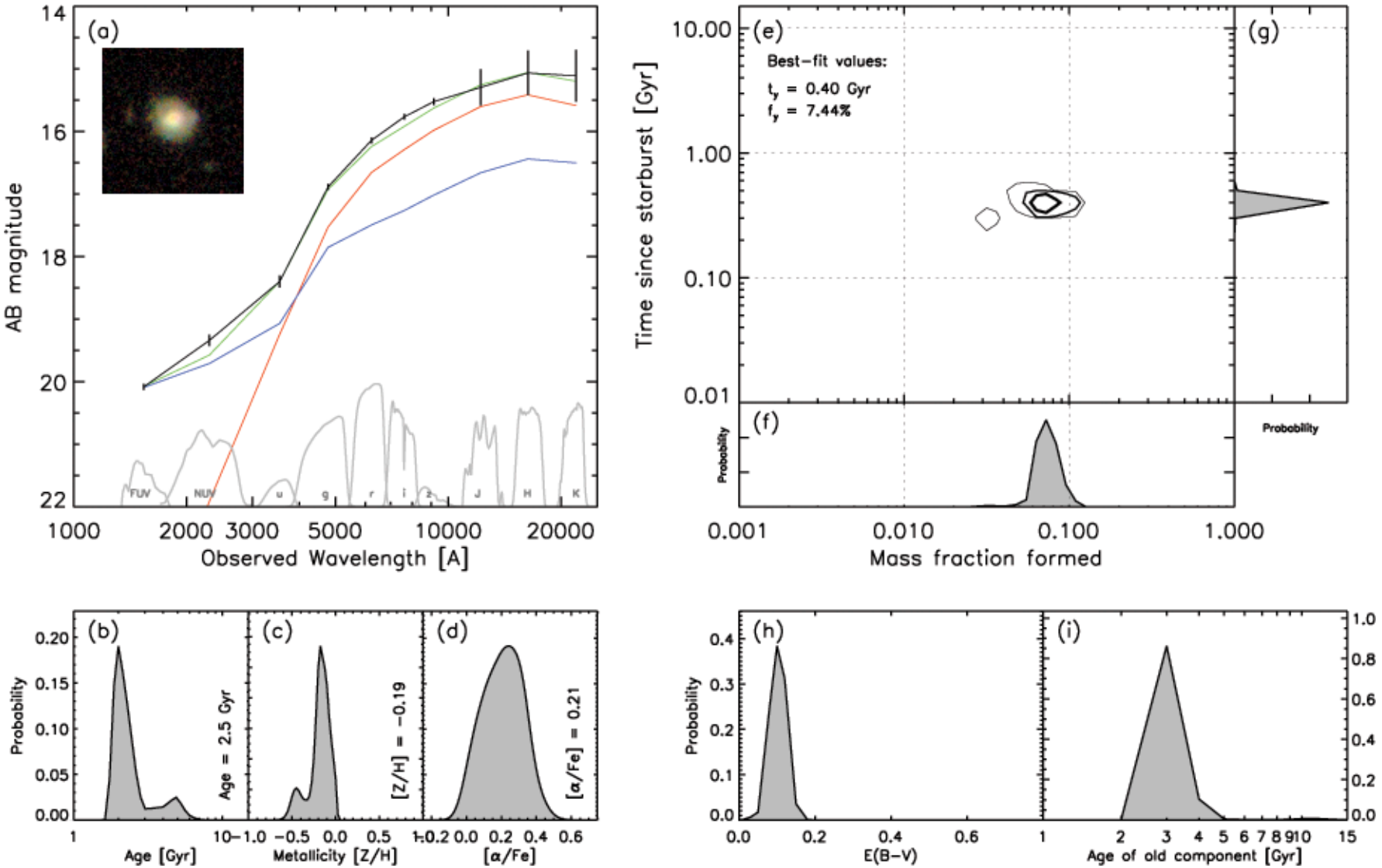
Step 2b: Parameter Estimation

3. Marginalisation

Use spectroscopic information from stellar absorption indices (Lick indices) as prior on the fit to the photometry.



Step 2b: Example Fits: How well can we do?



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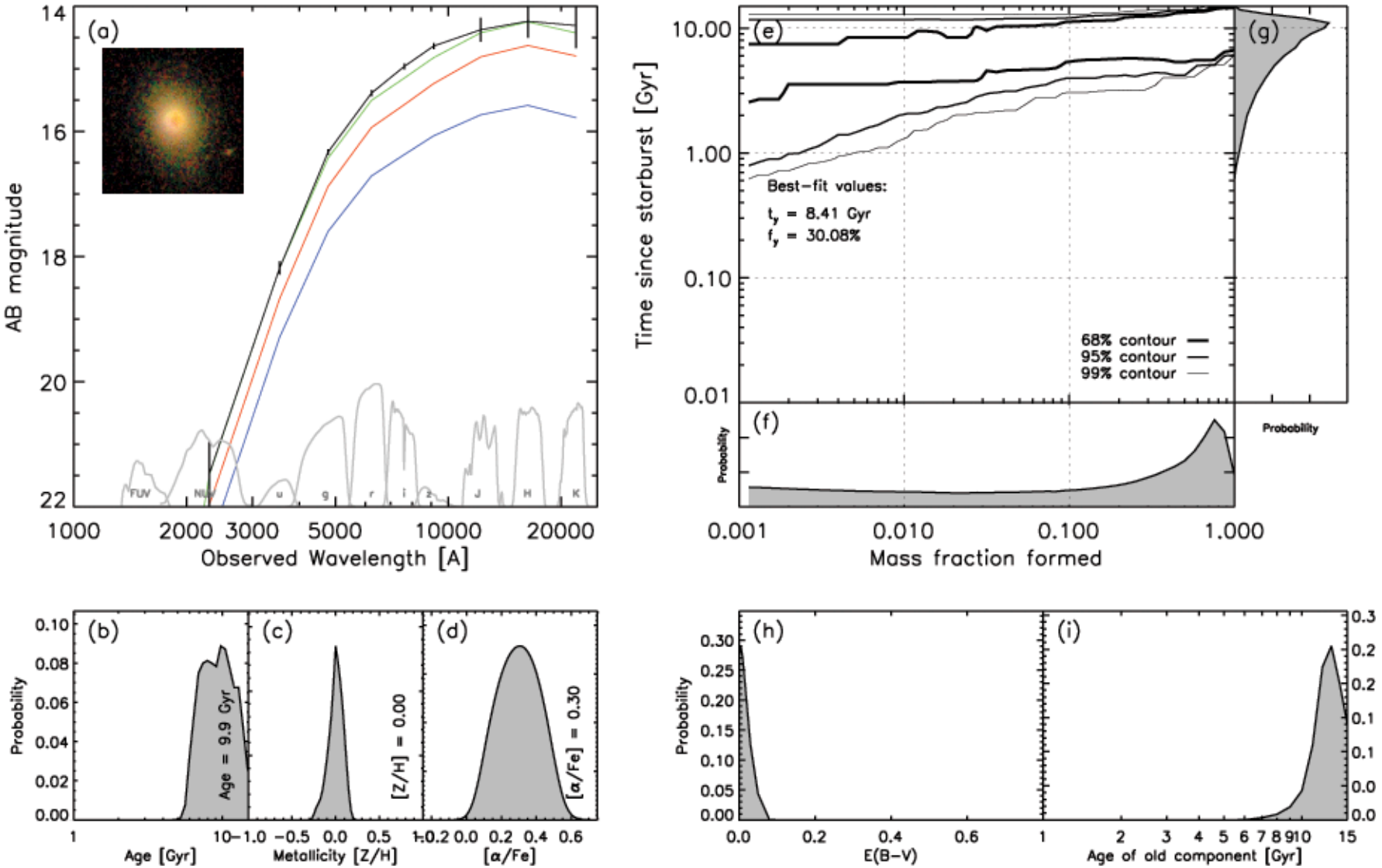
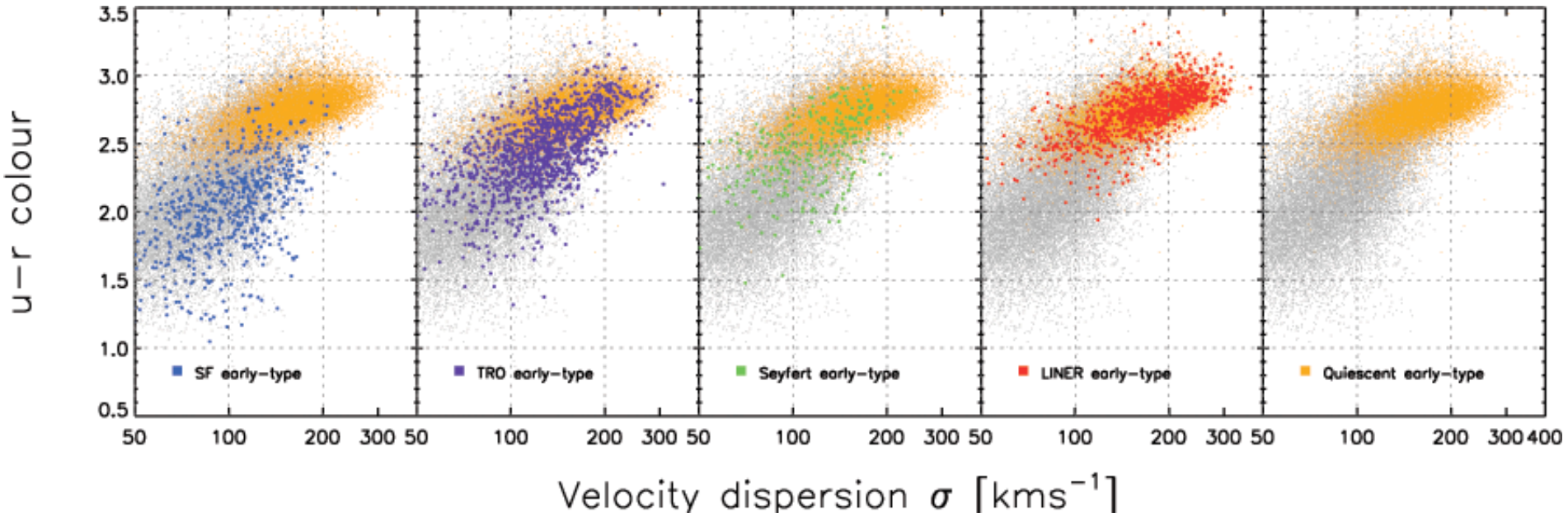


Step 3: Putting it All Together



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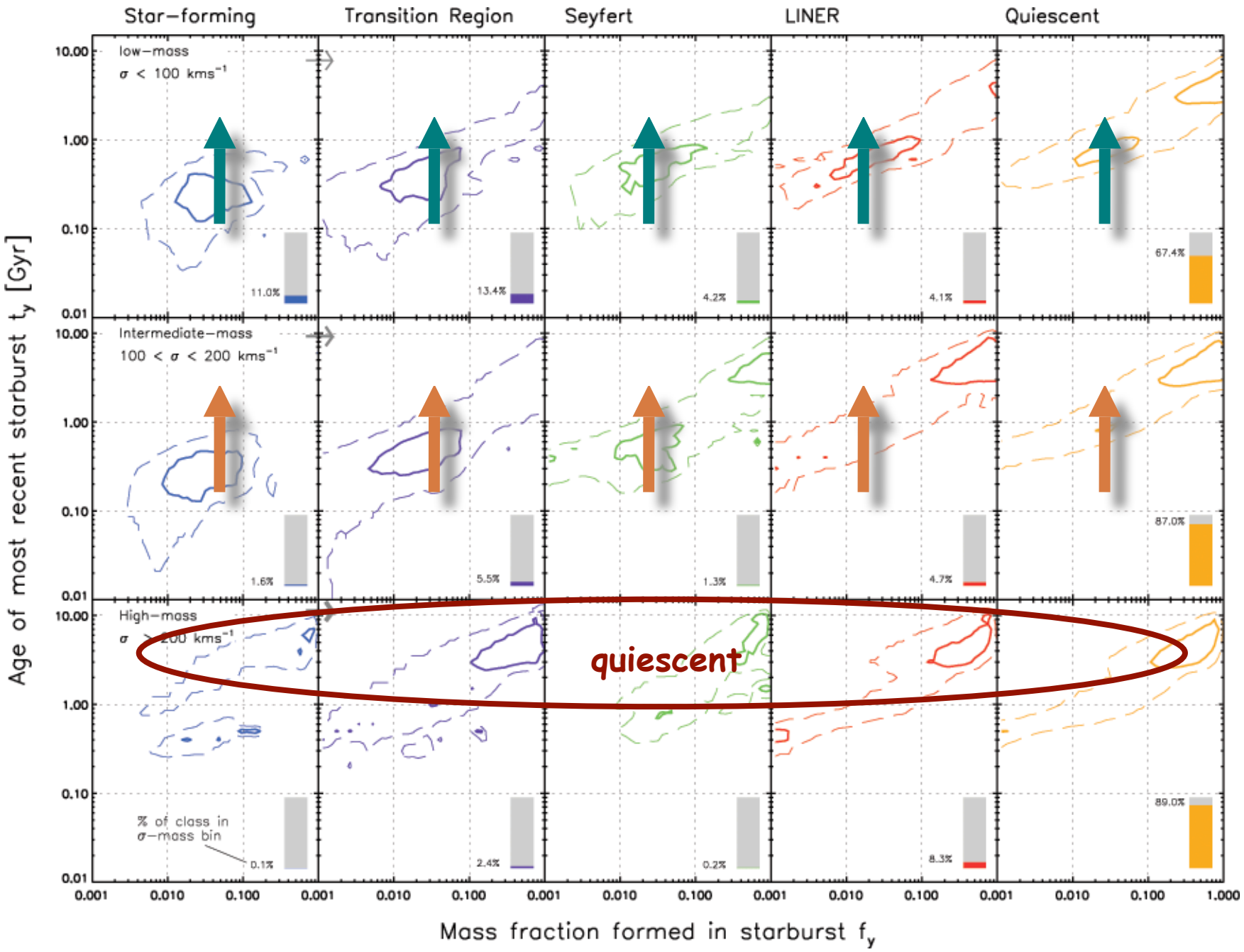
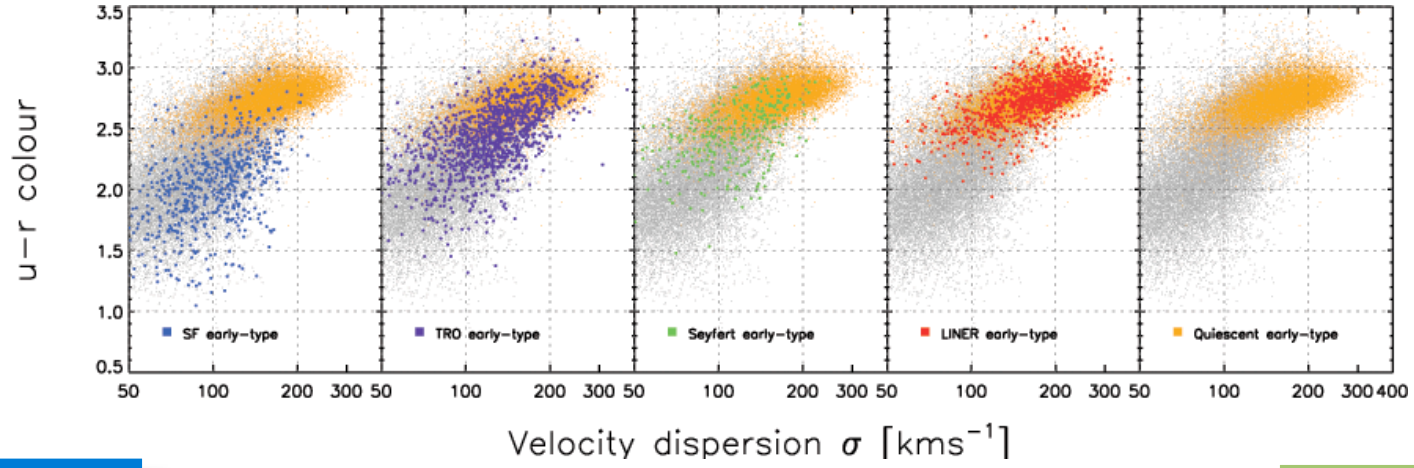


The Time Sequence of Galaxy Transformation

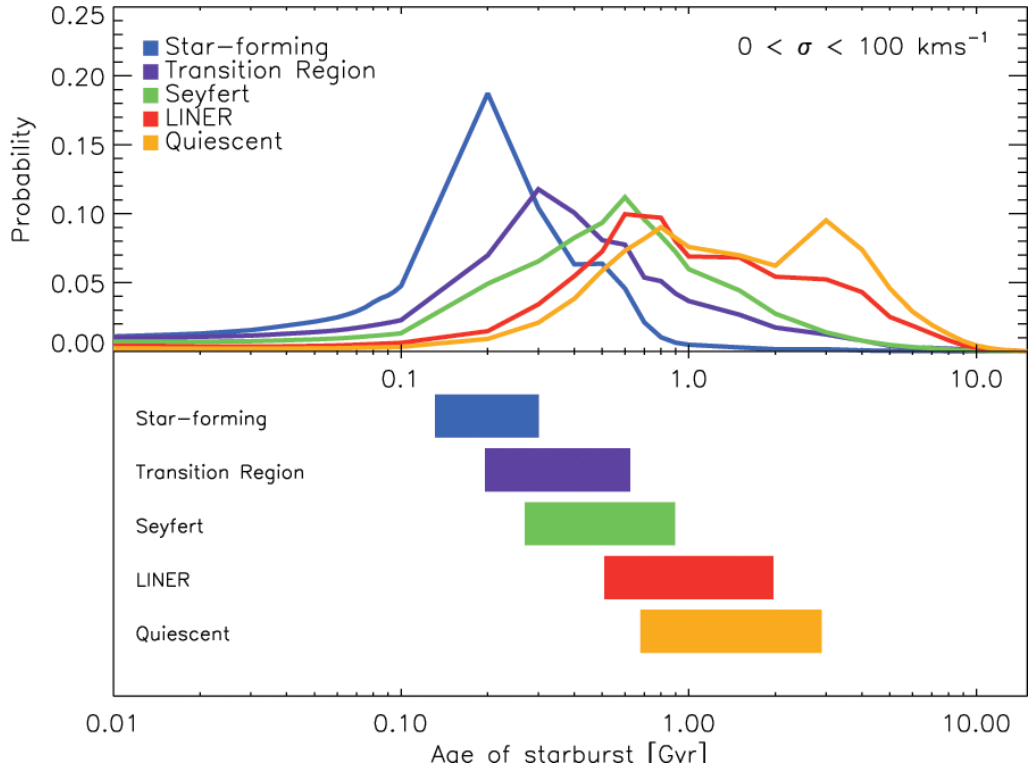


Star Formation

Time: 100-300 Myr
Past U/LIRGs?
1E9-1E10 M* formed
Obscured AGN?
Triggered by Mergers?

Transition Region

Time: 200-600 Myr
AGN-SF composite
Induced SF?



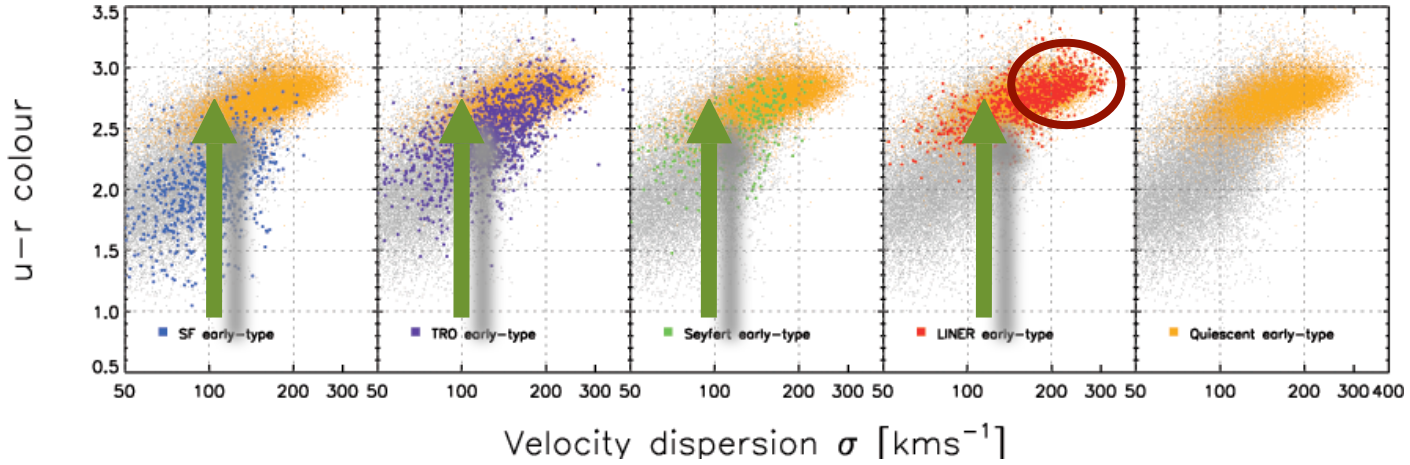
Seyfert AGN

Time: 250-800 Myr
High L[OIII]
and Eddington Ratio
Rarer than TR

LINER

Time: 500-2000 Myr
Lower L[OIII]
and Eddington Ratio
Gas running out?
Extended emission?

Summar



Our sample tracks the migration of early-type galaxies from the blue cloud to the red sequence via an AGN phase.

Are we seeing AGN feedback in action? It's possible, but we need further observations for proof that the AGN does the suppression.

The MOSES sample is the ideal laboratory to find out!