

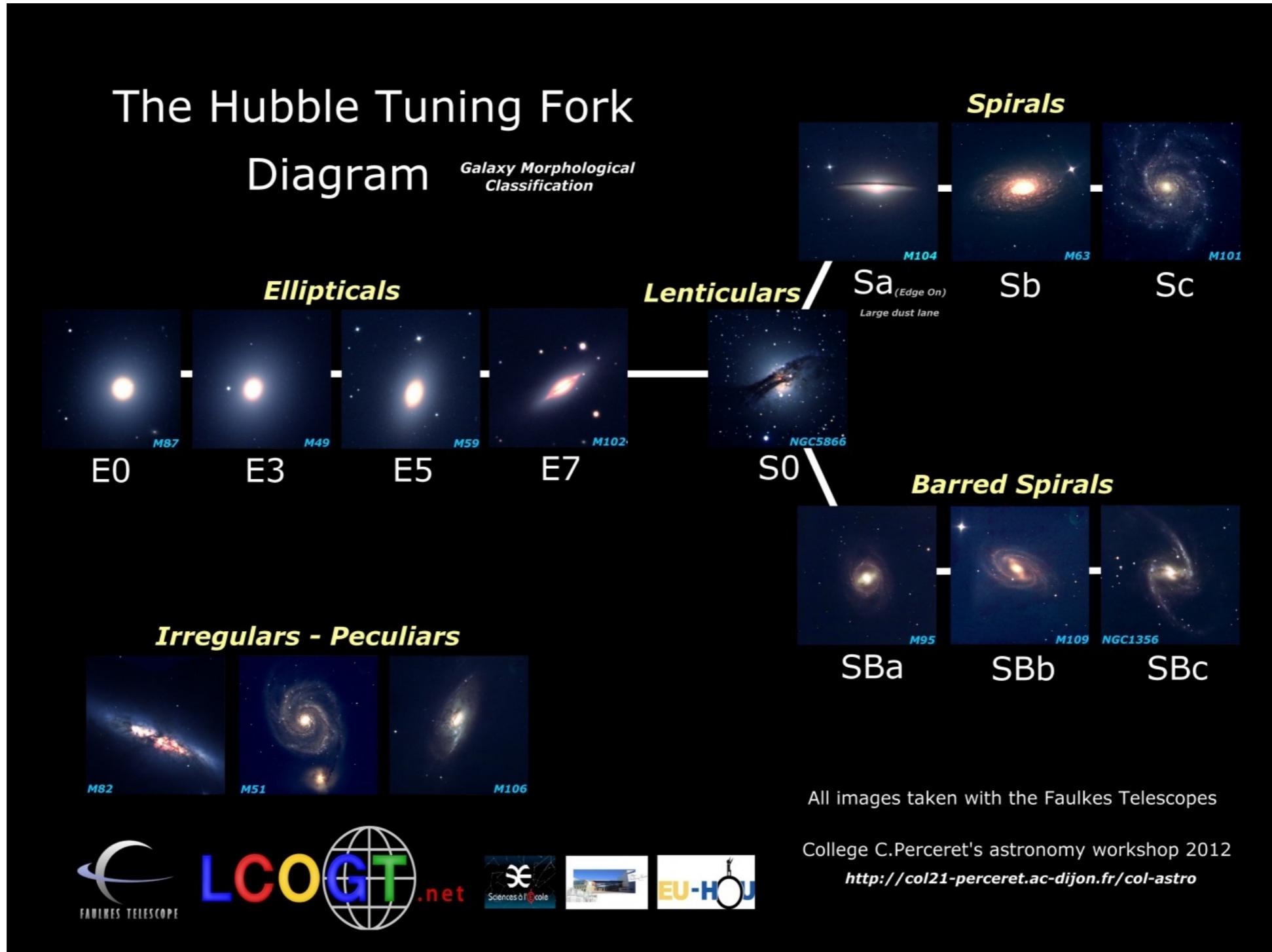
# The relation between stars and gas in distant galaxies

*Jacky Cao*

# Introduction

- Classification of galaxies through different methods
- Scaling relations defined by local galaxies and their applicability to the extended universe
- Quantifying the parameters of a distant galaxy to test locally derived scaling relations

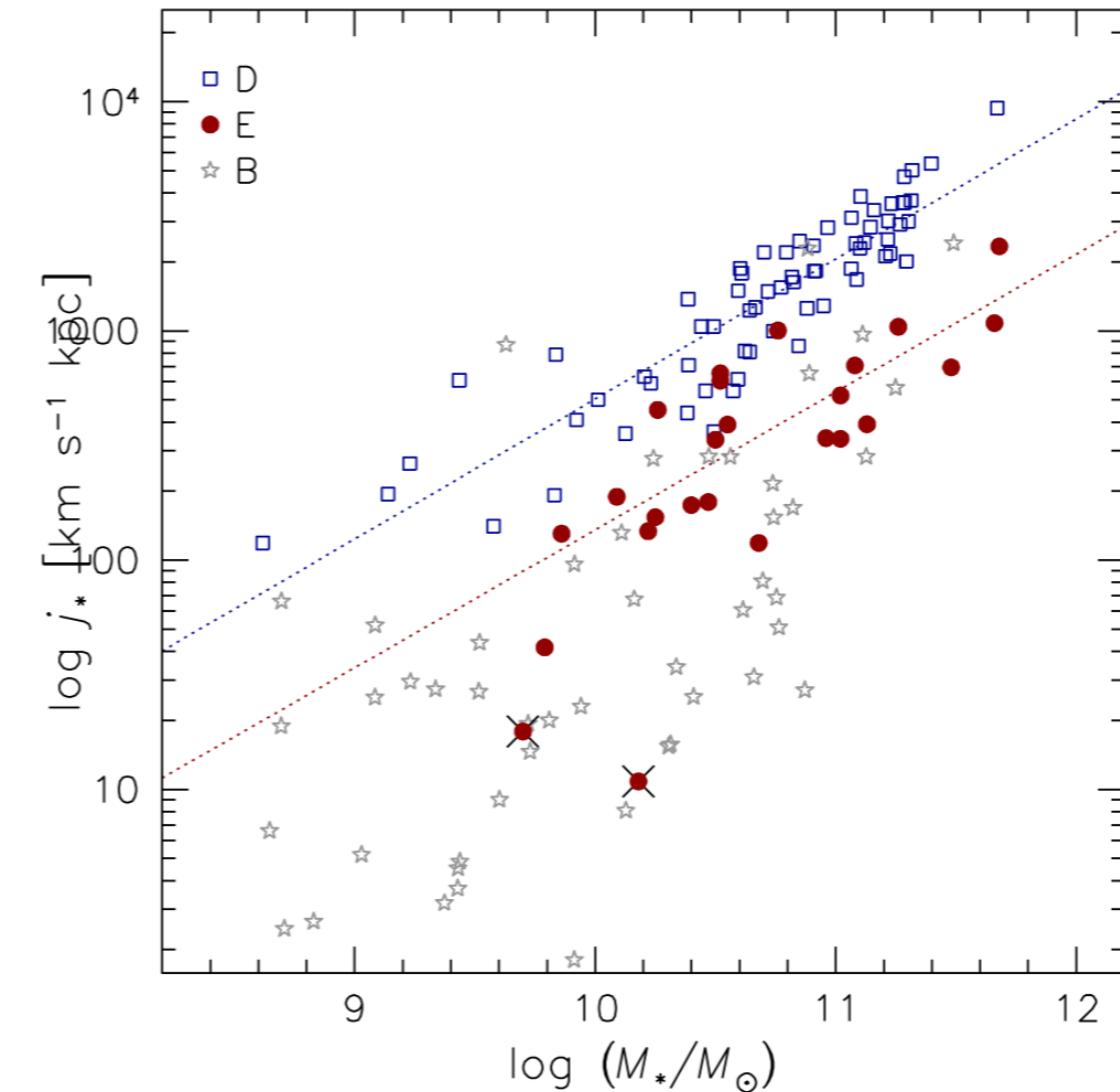
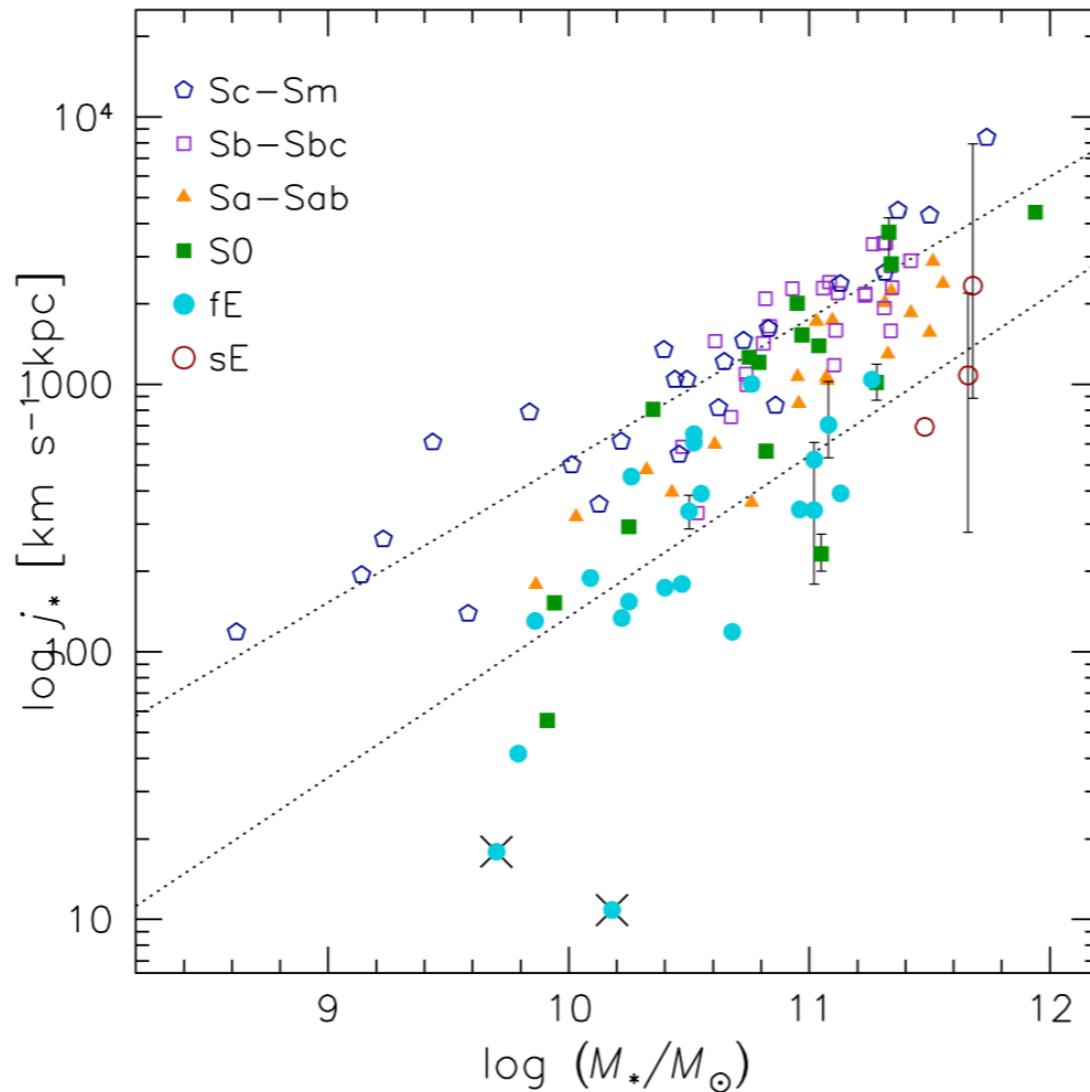
# Classification of galaxies



Astronomie au collège PERCERET (2012), 'HUBBLE TUNING FORK DIAGRAM', <http://col21-perceret.ac-dijon.fr/col-astro/spip.php?article9>

# Fundamental galactic dynamics

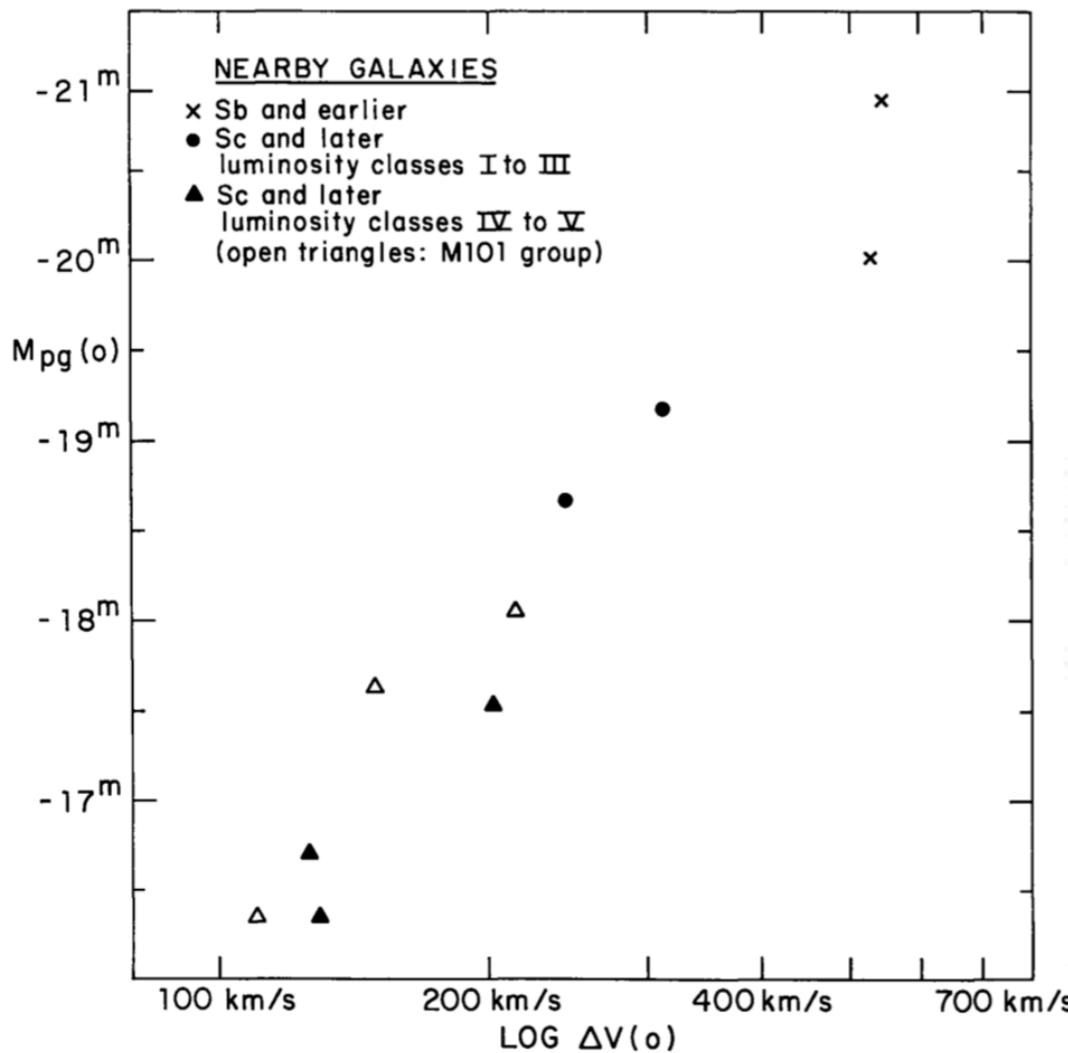
- Quantifying galaxies by the fundamental values of energy, mass, and angular momentum



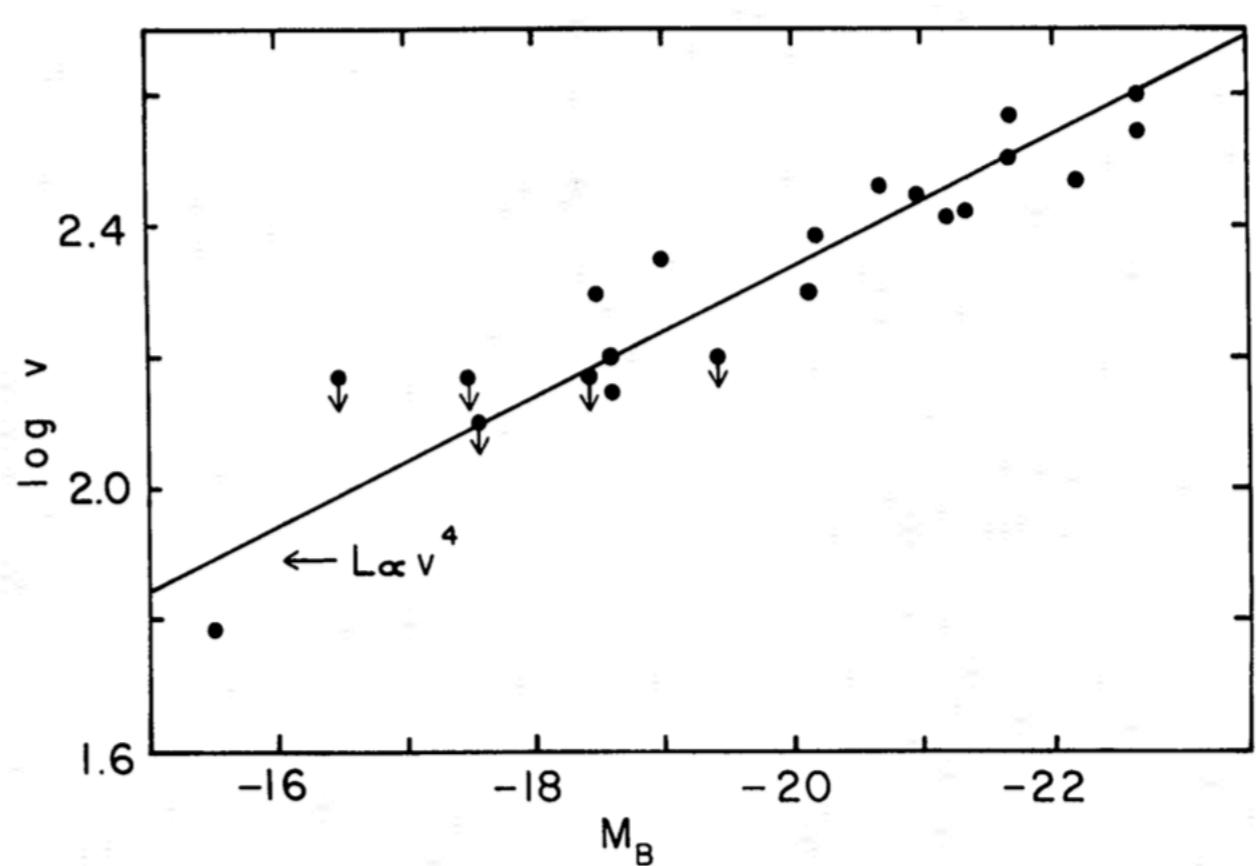
Romanowsky, A. J. and Fall, S. M. (2012), 'Angular Momentum and Galaxy Formation Revisited', *The Astrophysical Journal Supplement Series* 203, 17.

# Scaling relations

Tully-Fisher for spirals



Faber-Jackson for ellipticals

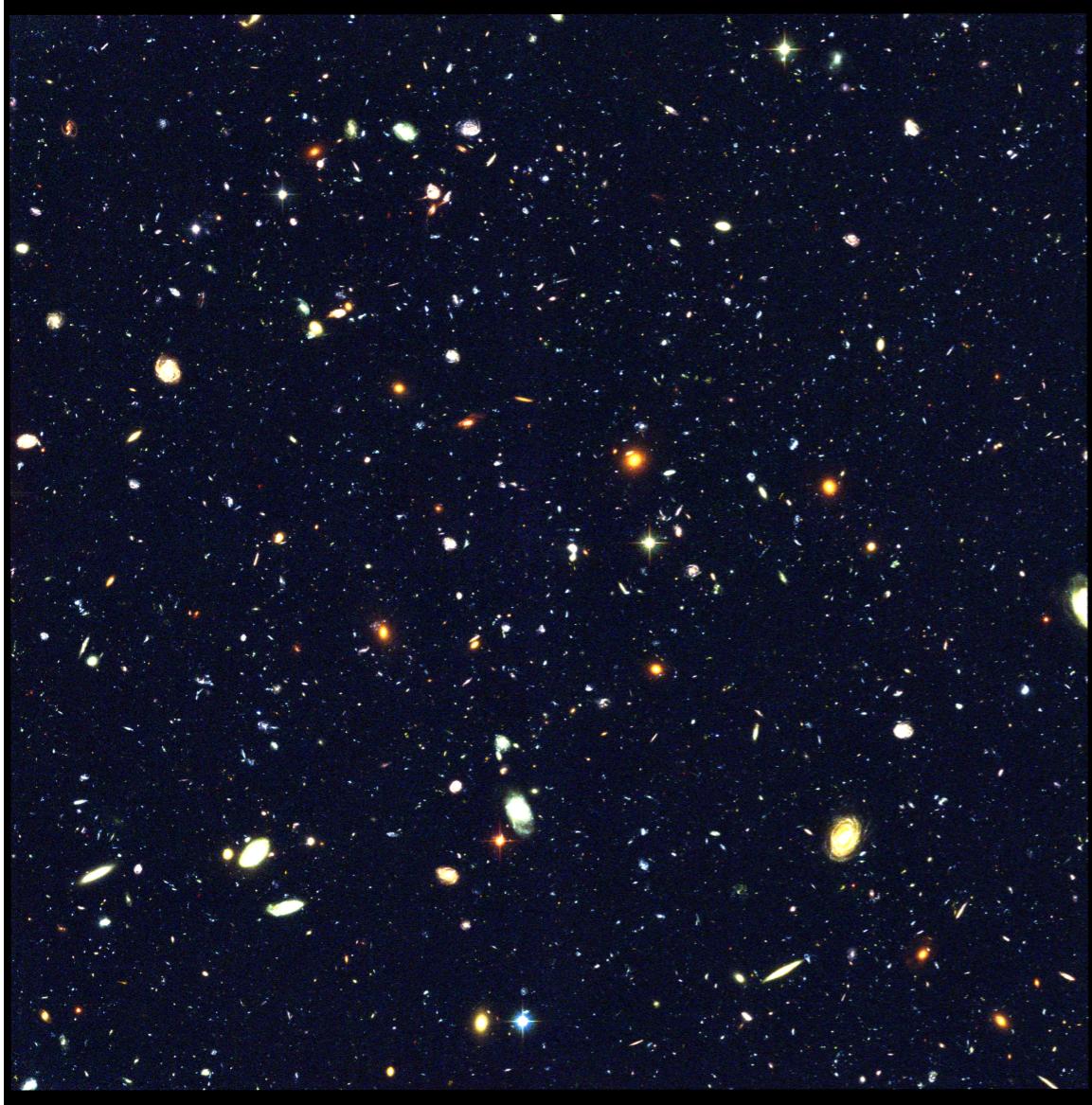


Tully, R. B., & Fisher, J. R. (1977). A new method of determining distances to galaxies. *Astronomy and Astrophysics*, 54, 661-673.

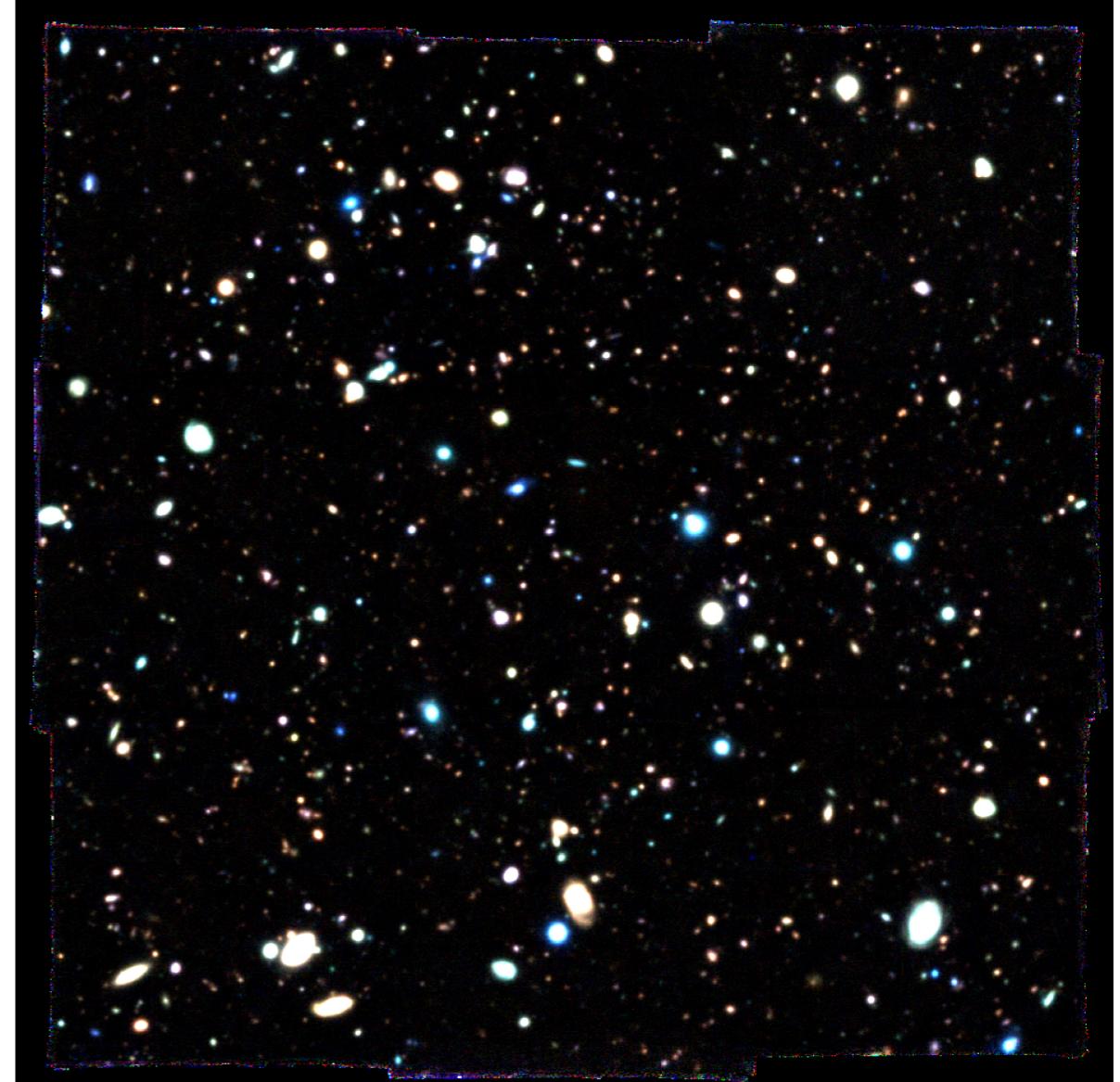
Faber, S. M., & Jackson, R. E. (1976). Velocity dispersions and mass-to-light ratios for elliptical galaxies. *The Astrophysical Journal*, 204, 668-683.

Are locally calibrated scaling relations valid and applicable for the high-redshift universe?

# The Hubble Ultra Deep Field

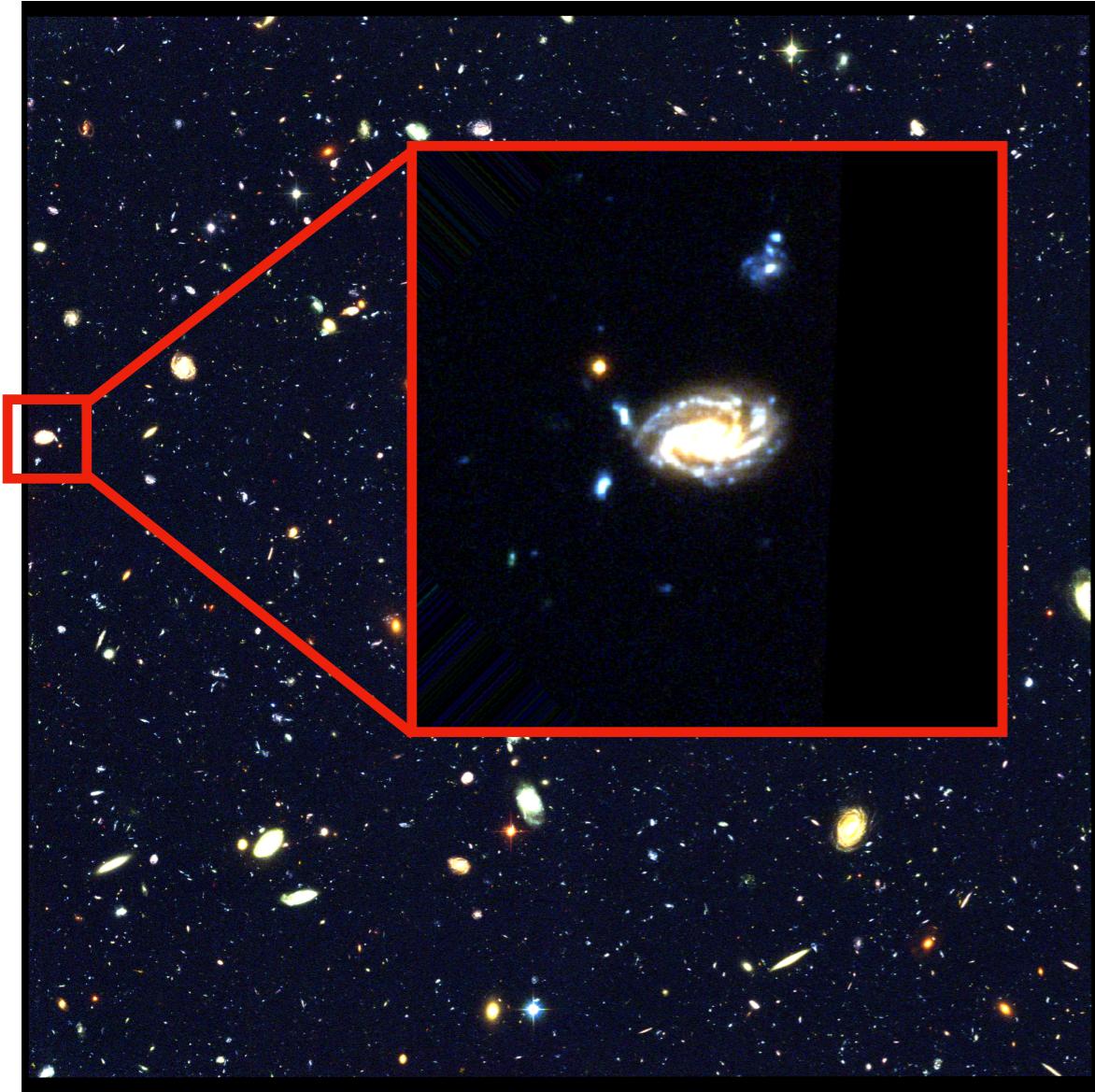


HST

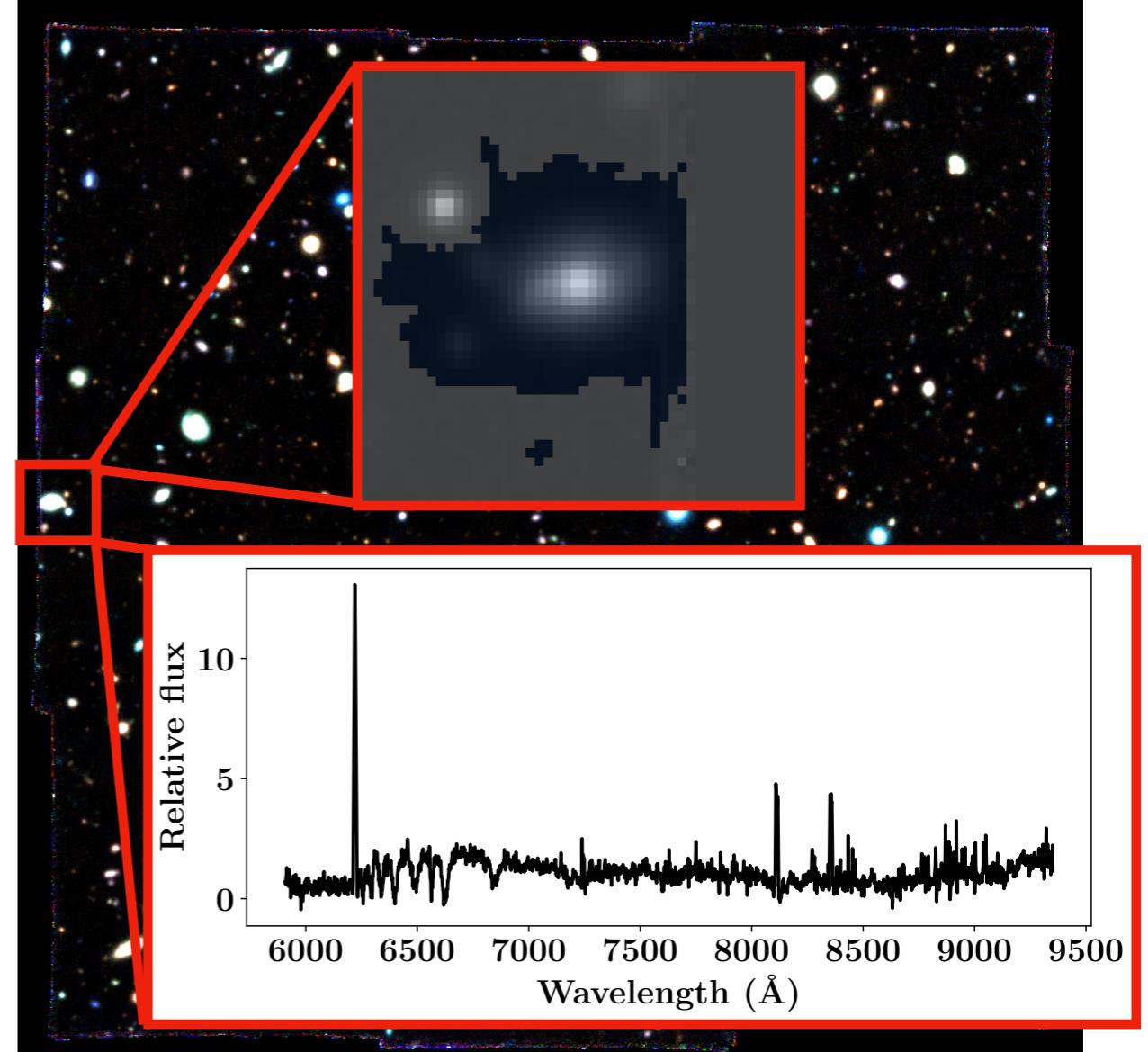


MUSE

# Galaxy extraction

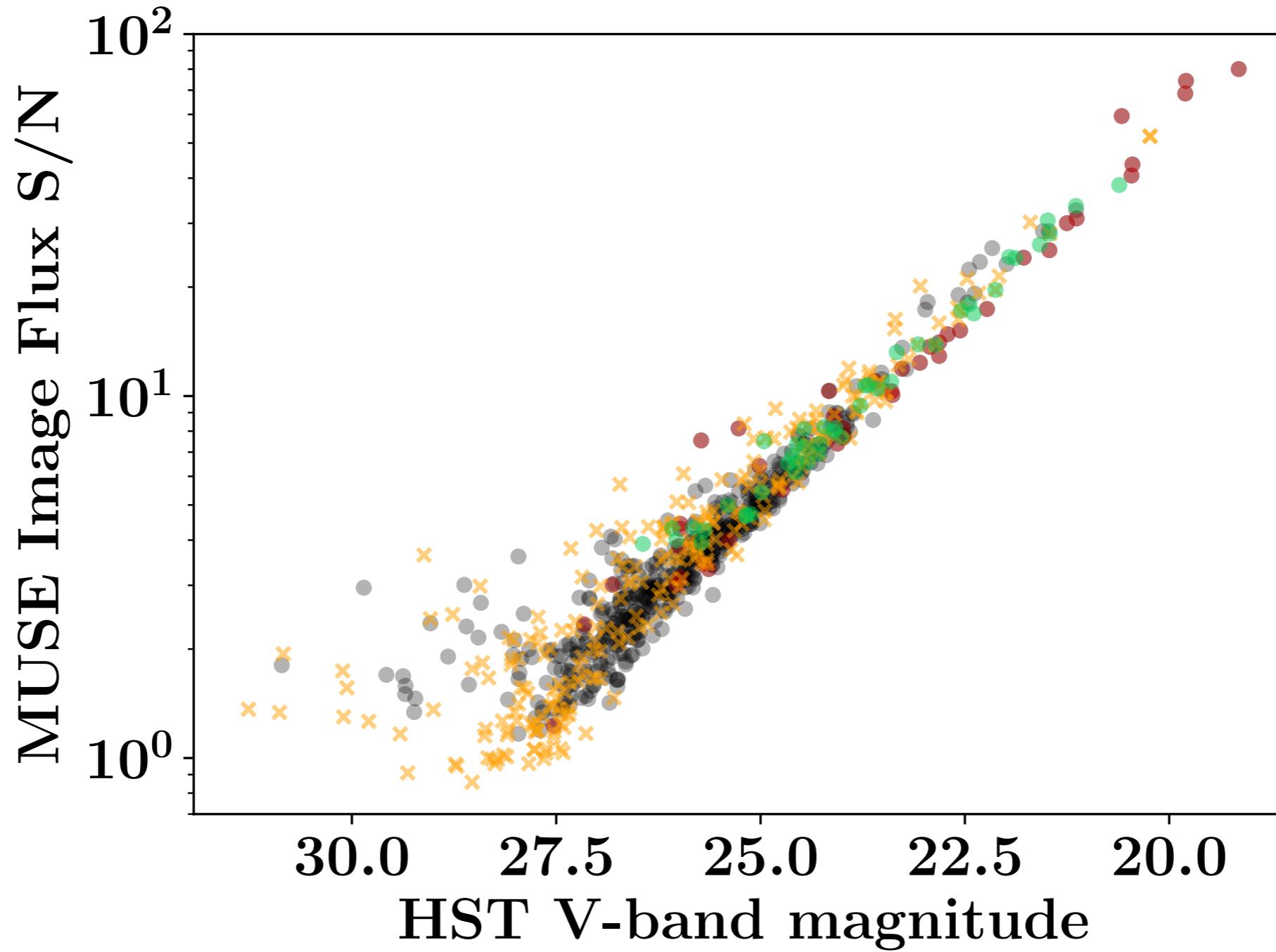


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# Sample of galaxies



# Gas dynamics

- Applying segmentation map to data to create a single spectra
- [OII] emission doublet isolated and a Gaussian function applied

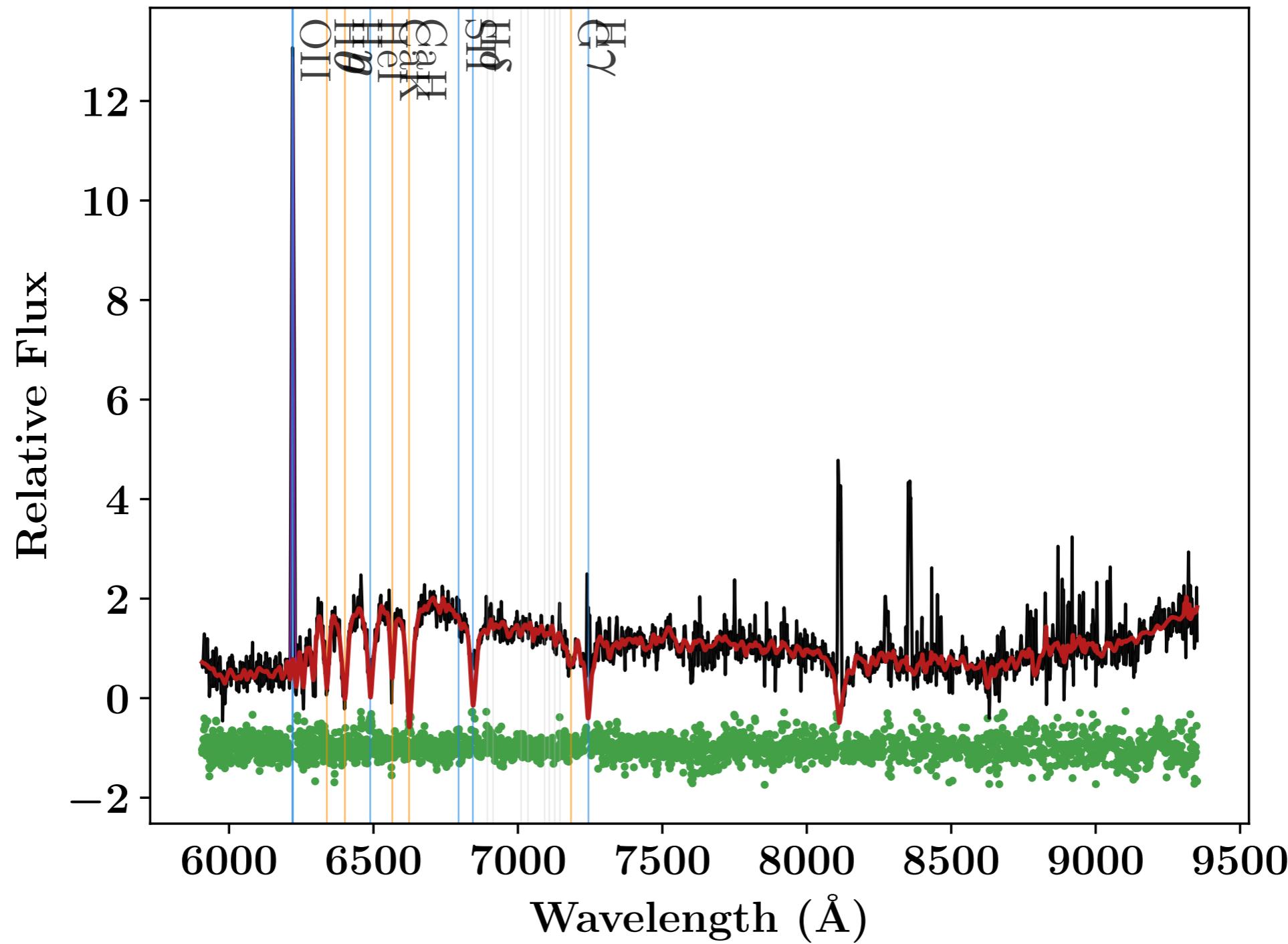
$$f_{OII} = cx + \frac{I_1}{\sqrt{2\pi}\sigma} \exp \frac{-(x - \lambda_1)^2}{2\sigma^2} + \frac{I_2}{\sqrt{2\pi}\sigma} \exp \frac{-(x - \lambda_2)^2}{2\sigma^2} \quad \text{with} \quad \sigma = \sqrt{\sigma_{gal}^2 + \sigma_{inst}^2}$$

- Obtained velocity dispersion  $\sigma$  represents the galactic gas dynamics

# Stellar dynamics

- Considering absorption features of the spectrum
- Applying template fitting routine, pPXF
  - Combines multiple different spectral templates
  - Ability to return the velocity and velocity dispersion of the galaxy

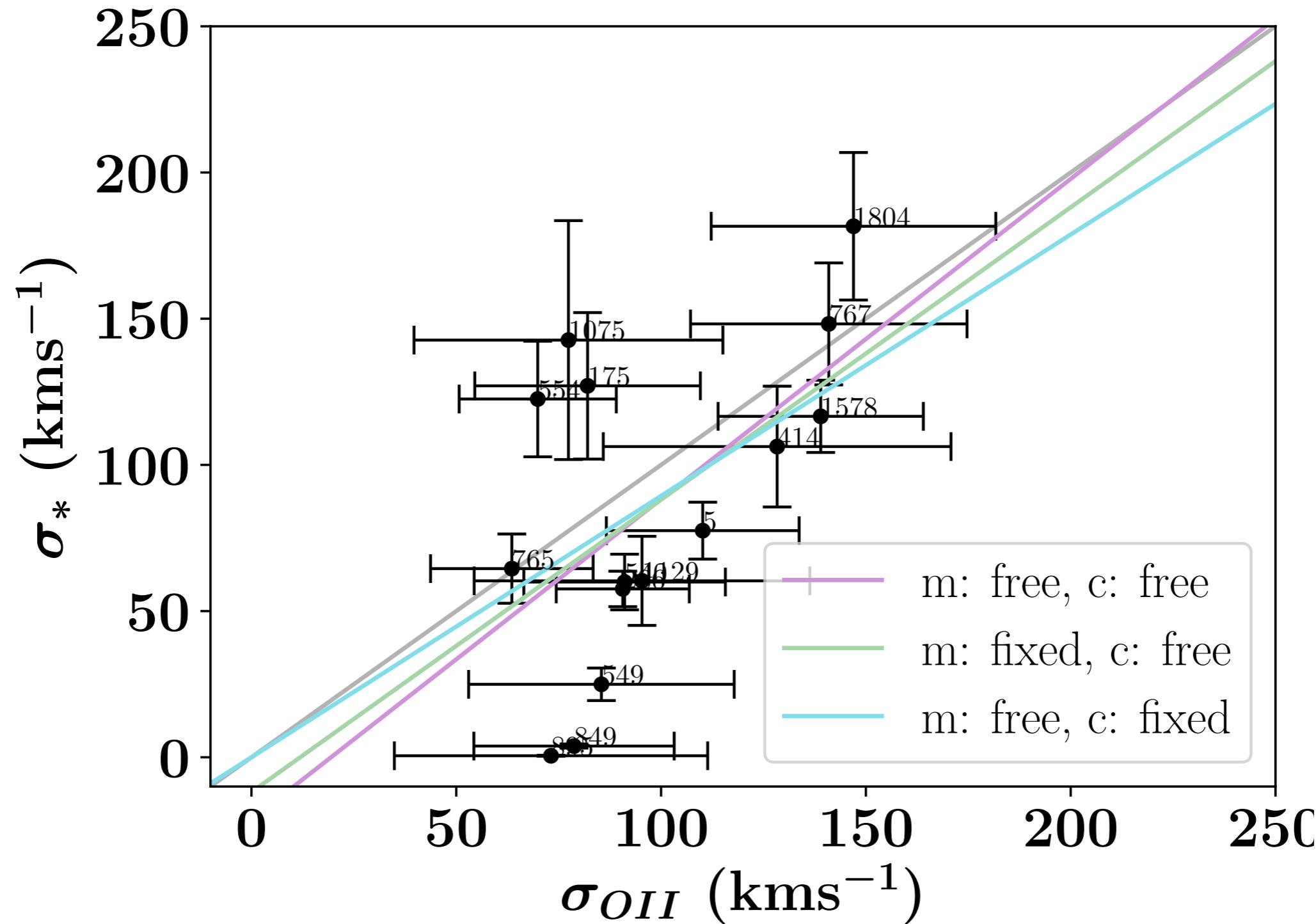
# Galaxy spectra



# Validity of fitting routines

- Stellar spectra fitting can utilise different spectral template sets
- Comparing [OIII] velocity dispersions from doublet fitting with values provided by a pPXF gas fitting
- Obtaining fractional uncertainties vs. S/N through perturbing a single spectra with normal noise

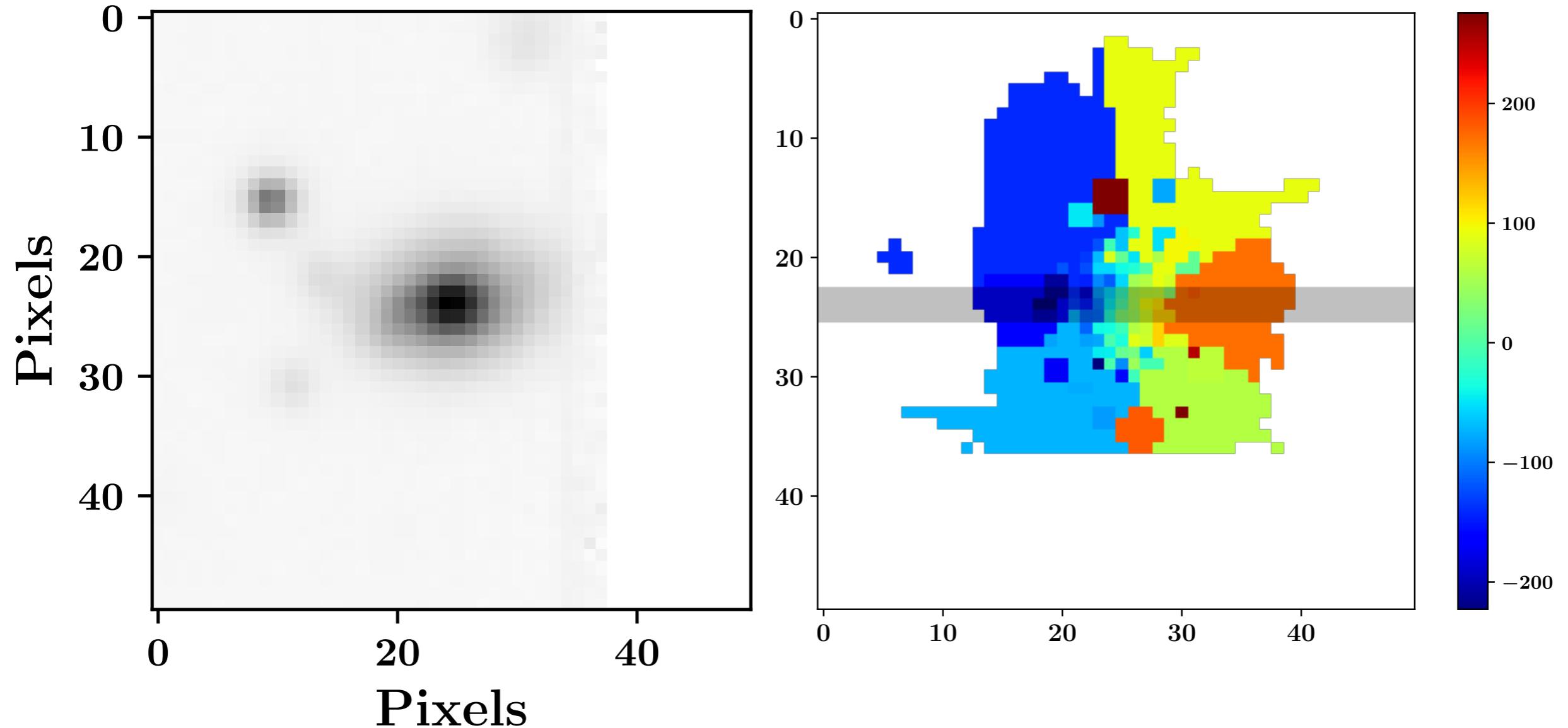
# Comparison of dynamics



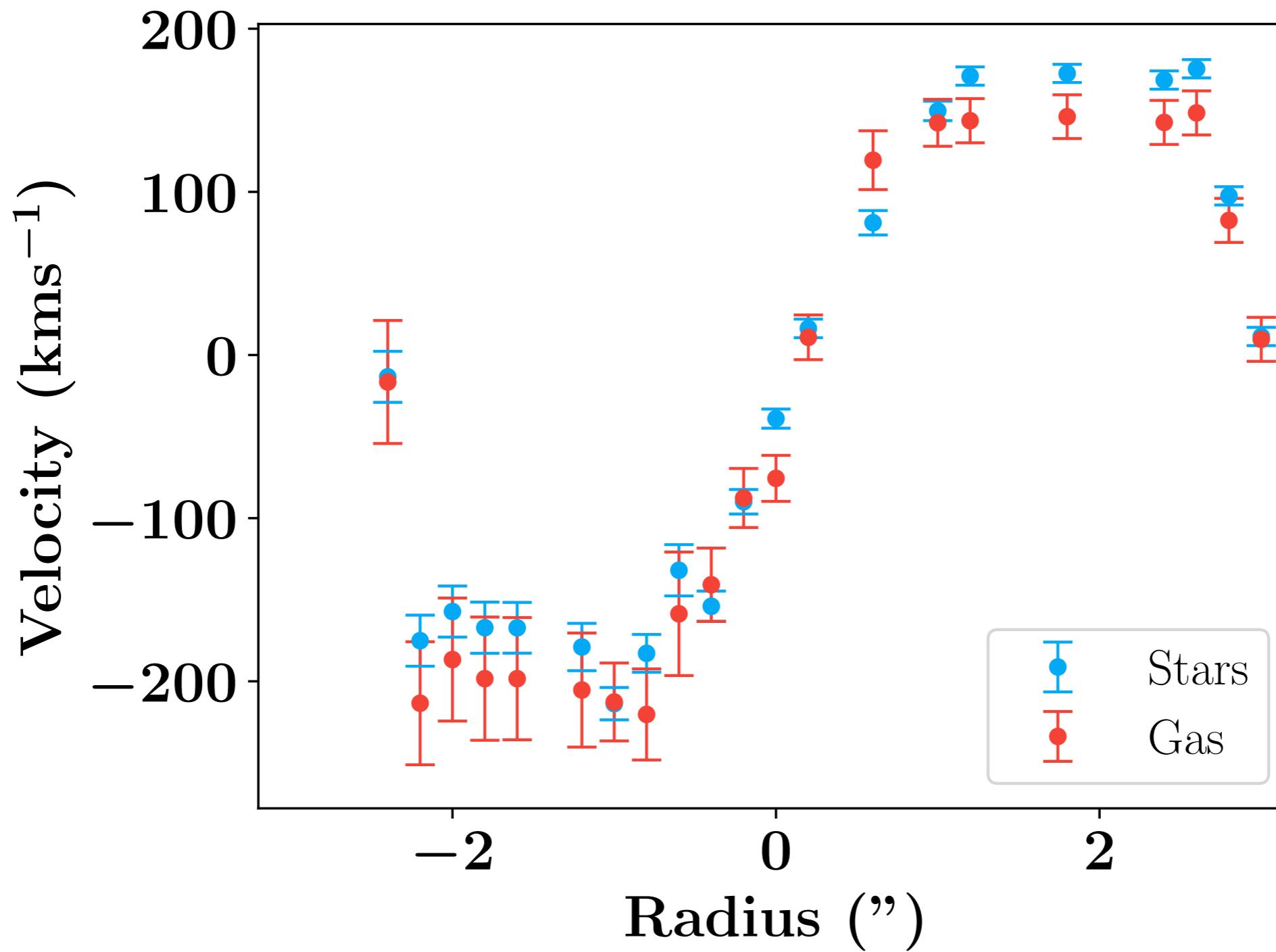
# Voronoi tessellation

- Splitting a galaxy up into specific areas which are based on achieving a certain S/N
- Fitting for the stellar and gas dynamics in each individual area to produce a map of the velocities and velocity dispersions
- Production of rotation curves for a galaxy to demonstrate the galactic dynamics

# Tessellated maps



# Rotation curves



# Summary

- Galaxies can be classified by fundamental parameters and not just by their morphologies
- Scaling relations between galaxy parameters are calibrated in the local universe
- Testing scaling relations for the extended universe requires deeper optical and spectroscopic data
- Fitting for spectroscopic features quantifies the current dynamics in a galaxy so comparisons can be made

# Any questions?

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