

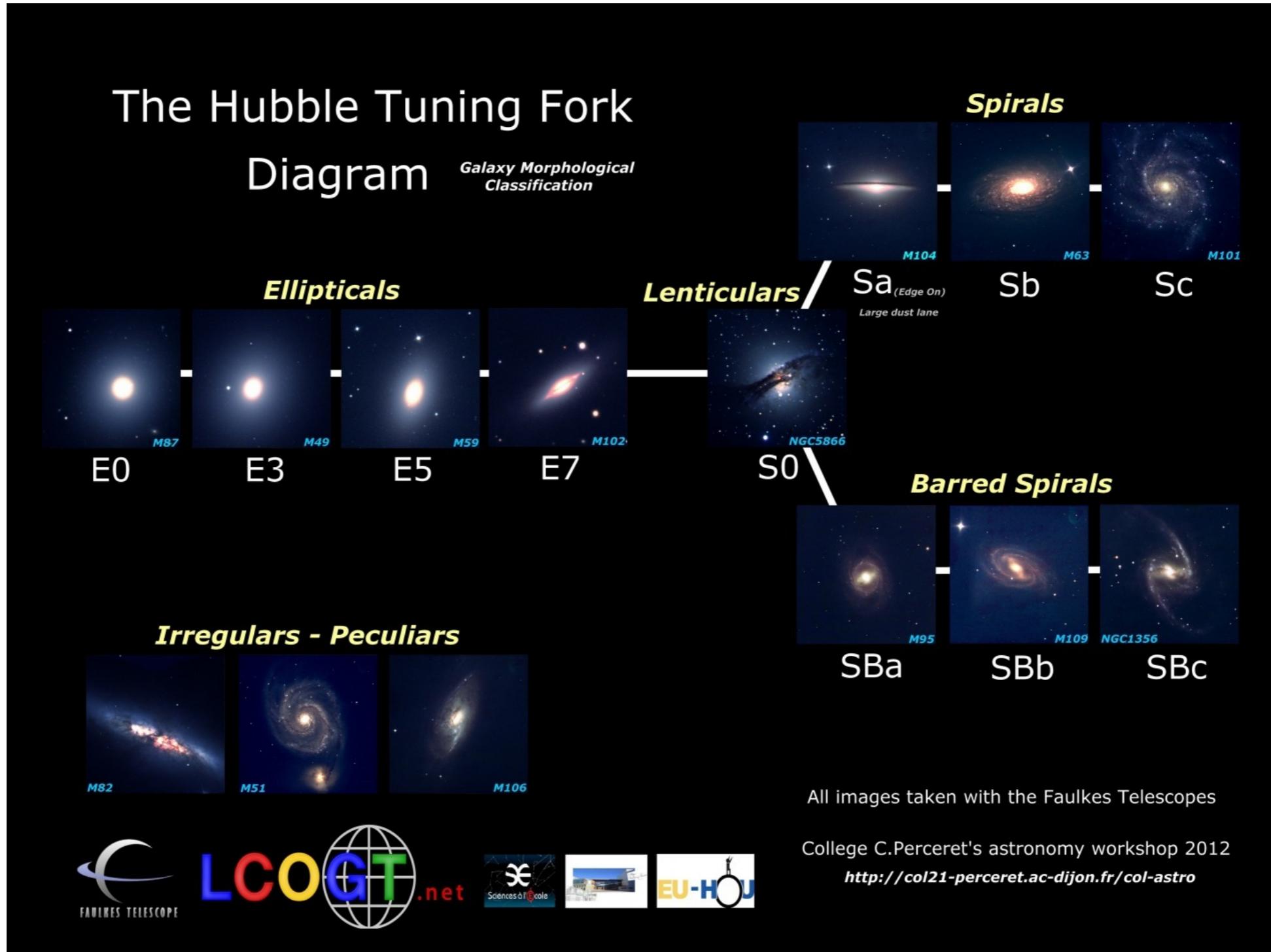
# The relation between stars and gas in distant galaxies

*Jacky Cao*

# Introduction

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

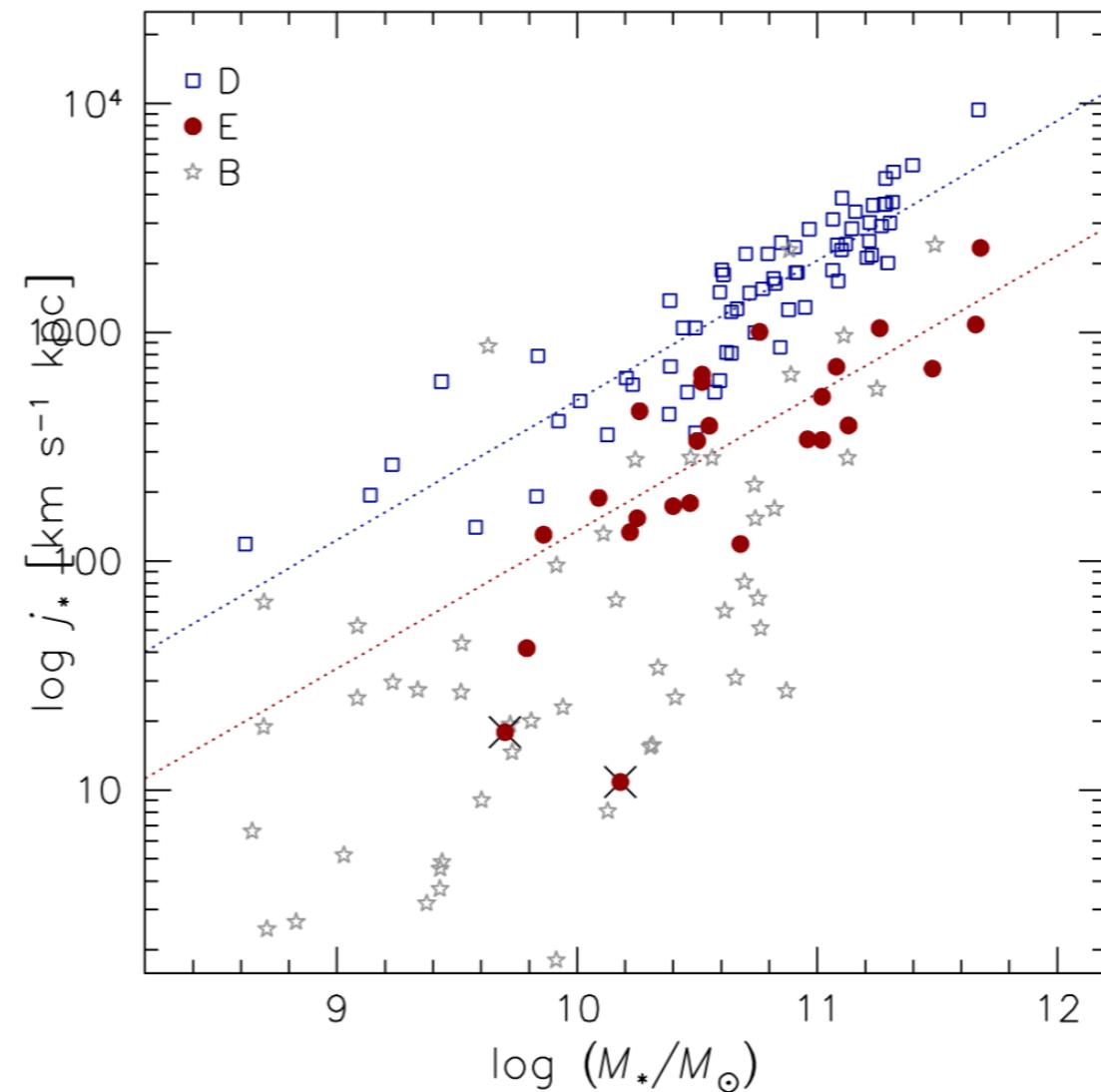
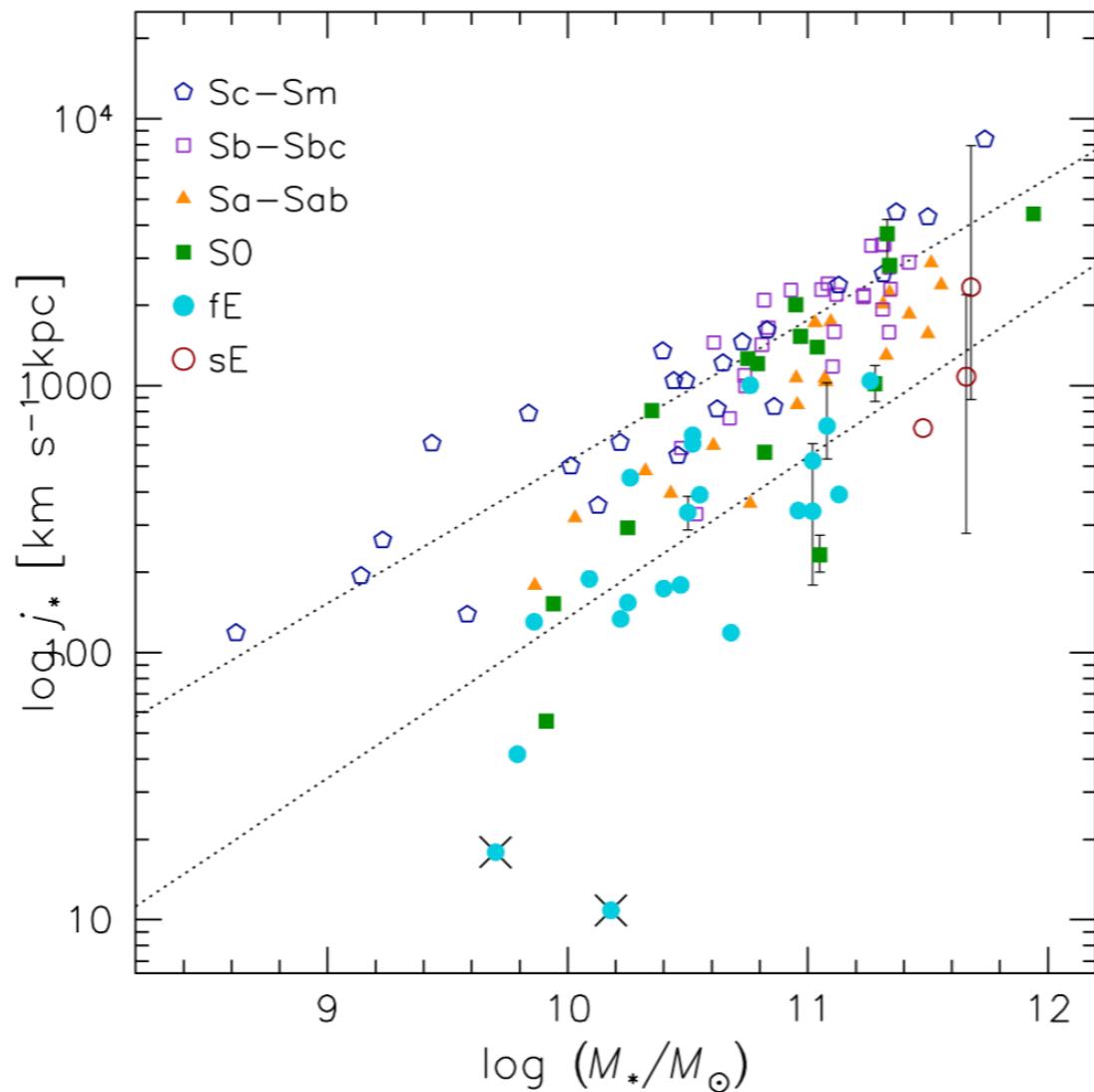
# Classification of galaxies



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

# Fundamental galactic dynamics

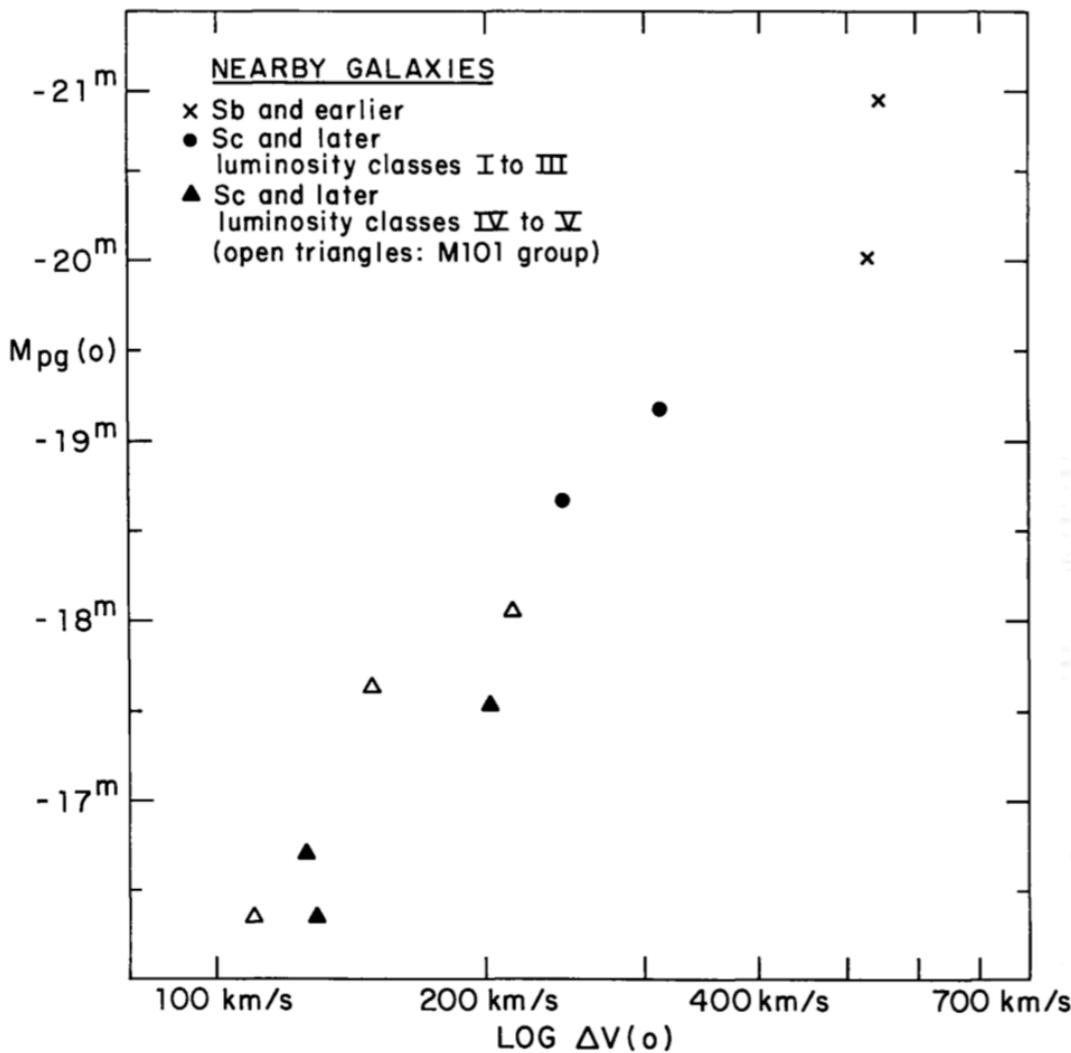
- Quantifying galaxies by the fundamental values of energy, mass, and angular momentum



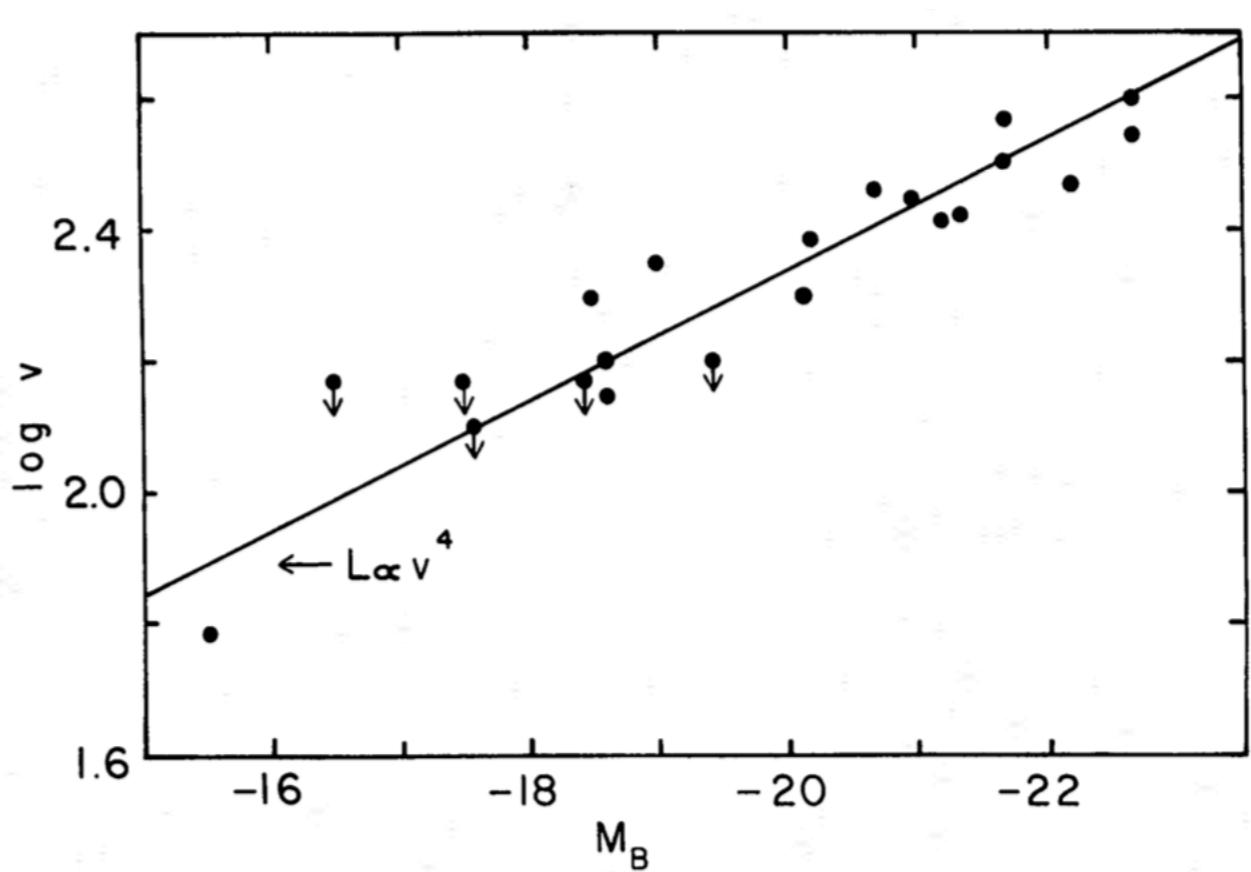
Romanowsky, A. J. and Fall, S. M. (2012), 'Angular Momentum and Galaxy Formation Revisited', *The Astrophysical Journal Supplement Series* 203, 17.

# Scaling relations

Tully-Fisher for spirals



Faber-Jackson for ellipticals



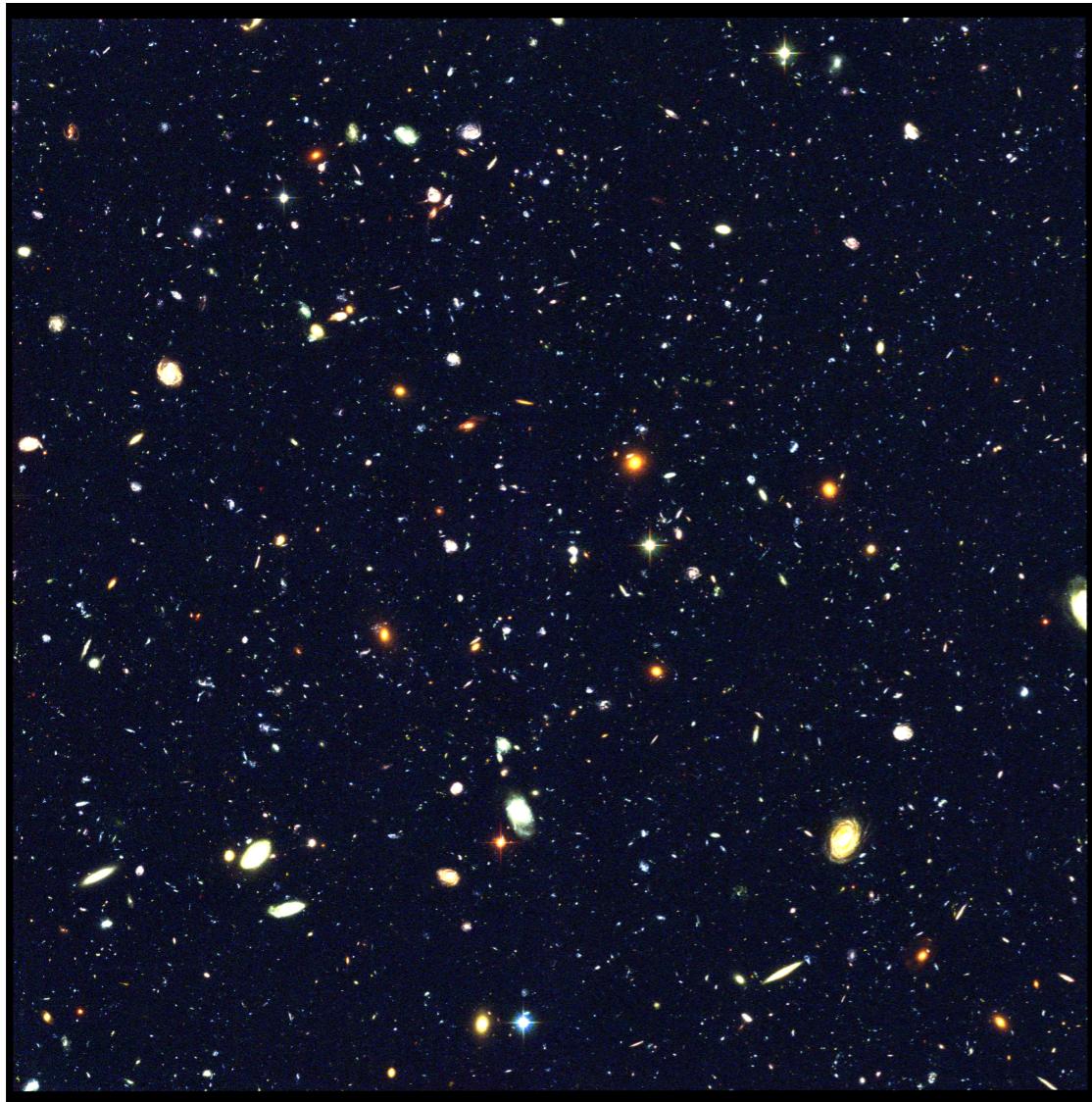
Tully, R. B., & Fisher, J. R. (1977). A new method of determining distances to galaxies. *Astronomy and Astrophysics*, 54, 661-673.

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 ( $z>0.3$ ) universe?

# The Hubble Ultra Deep Field

HST



HUDF (2006)

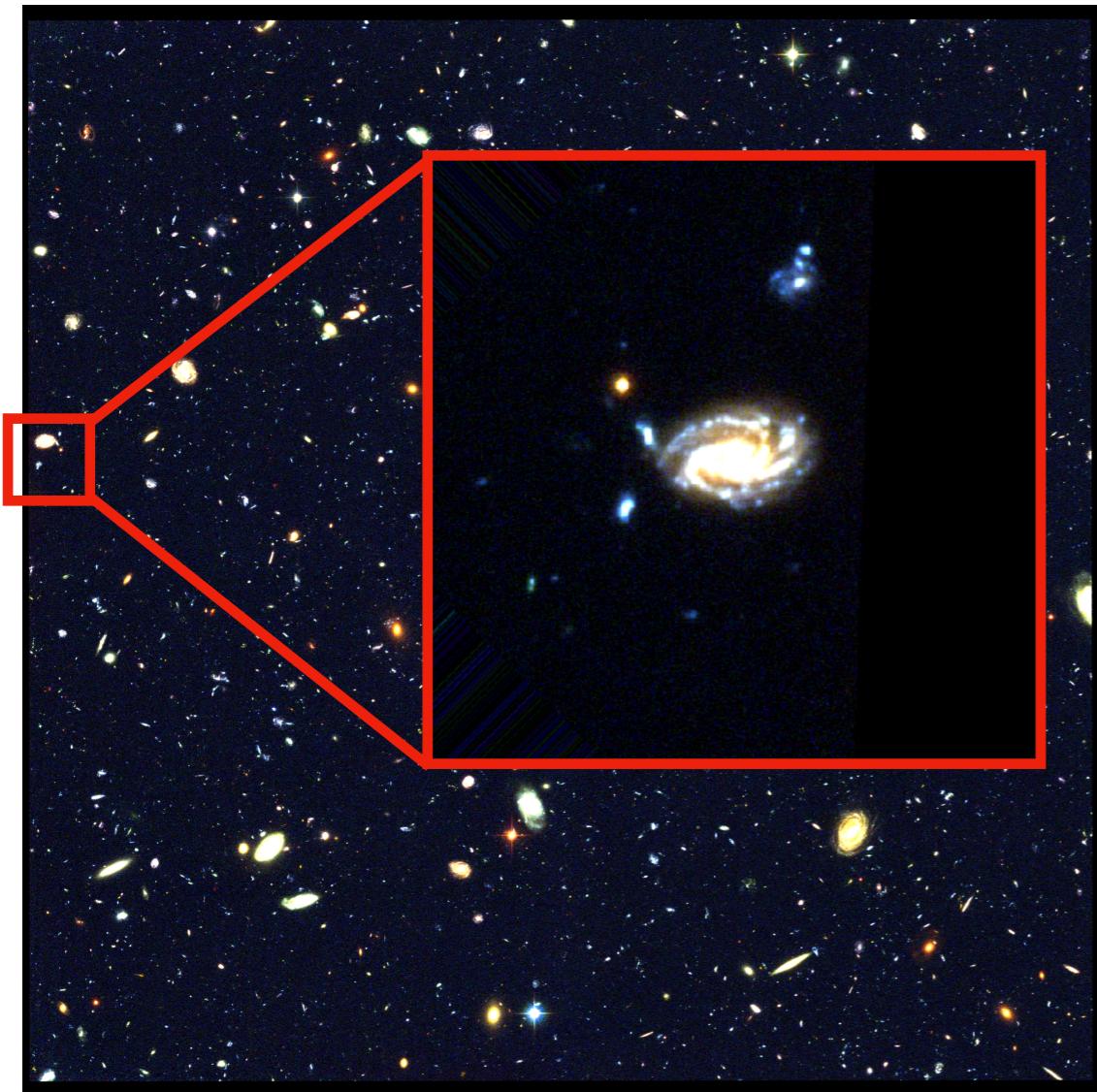
MUSE



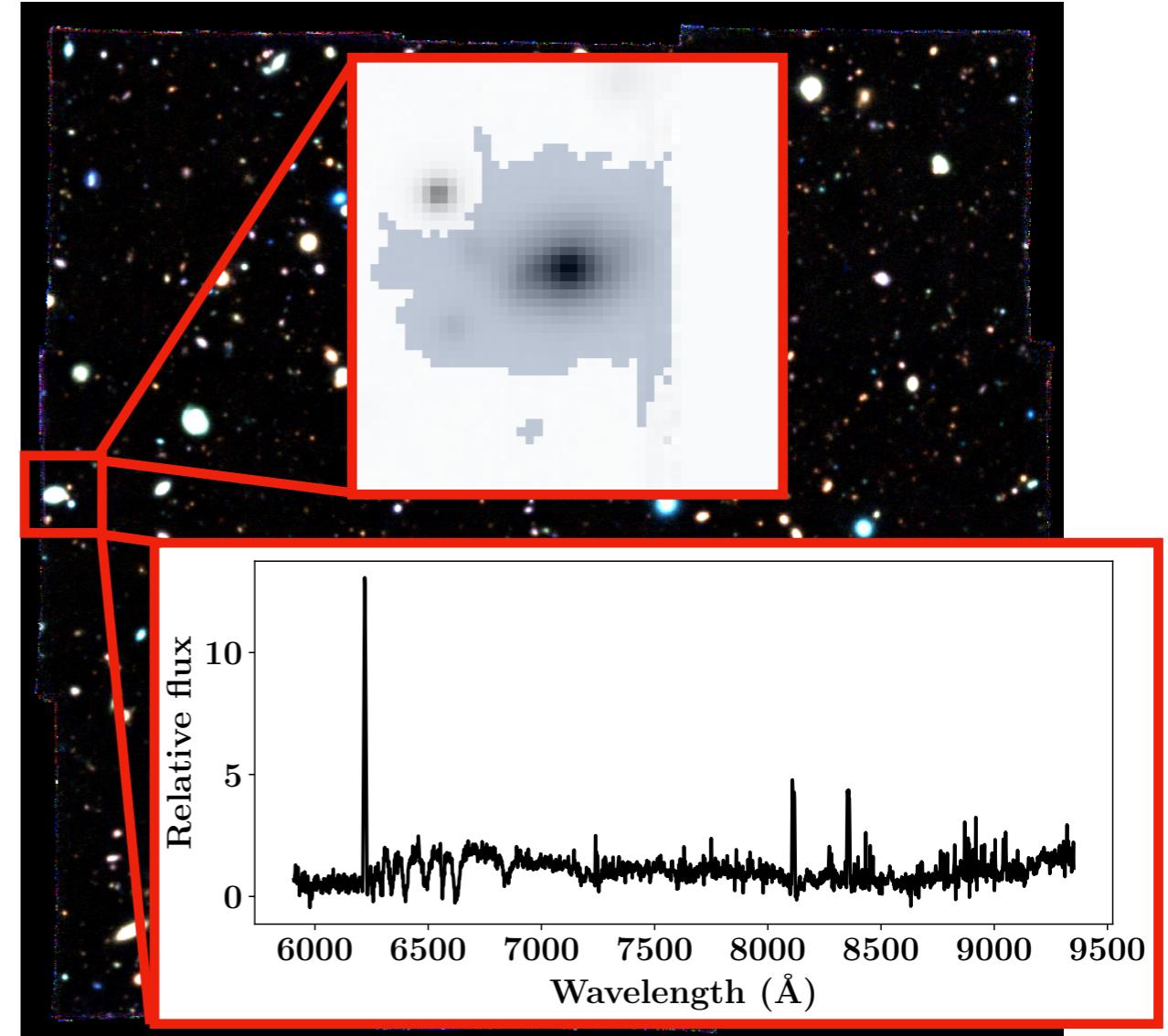
MUSE (2013-2017)

# Galaxy extraction

HST



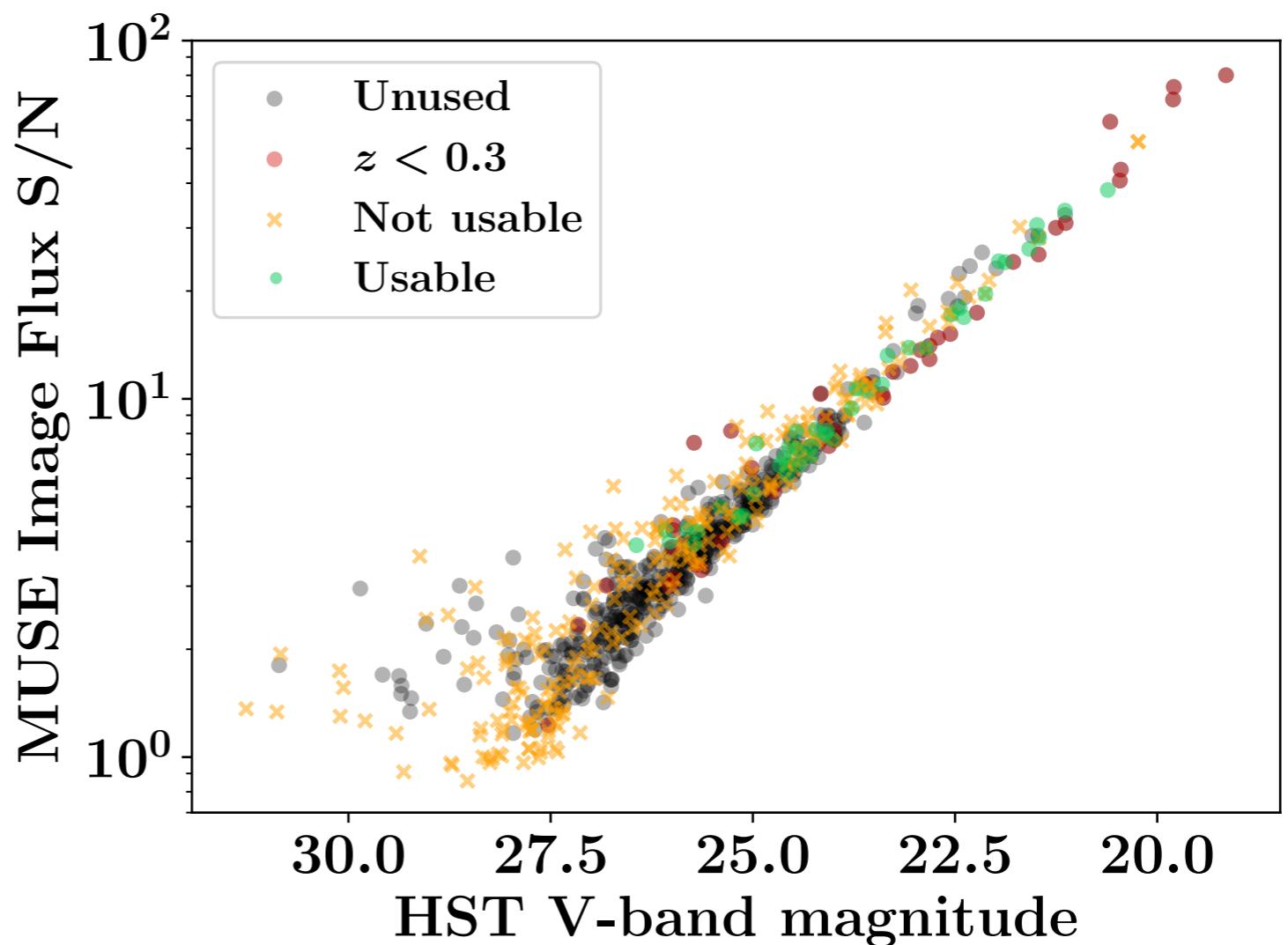
MUSE



- MUSE sample ~10,000 objects from the 25GB HUDF cube

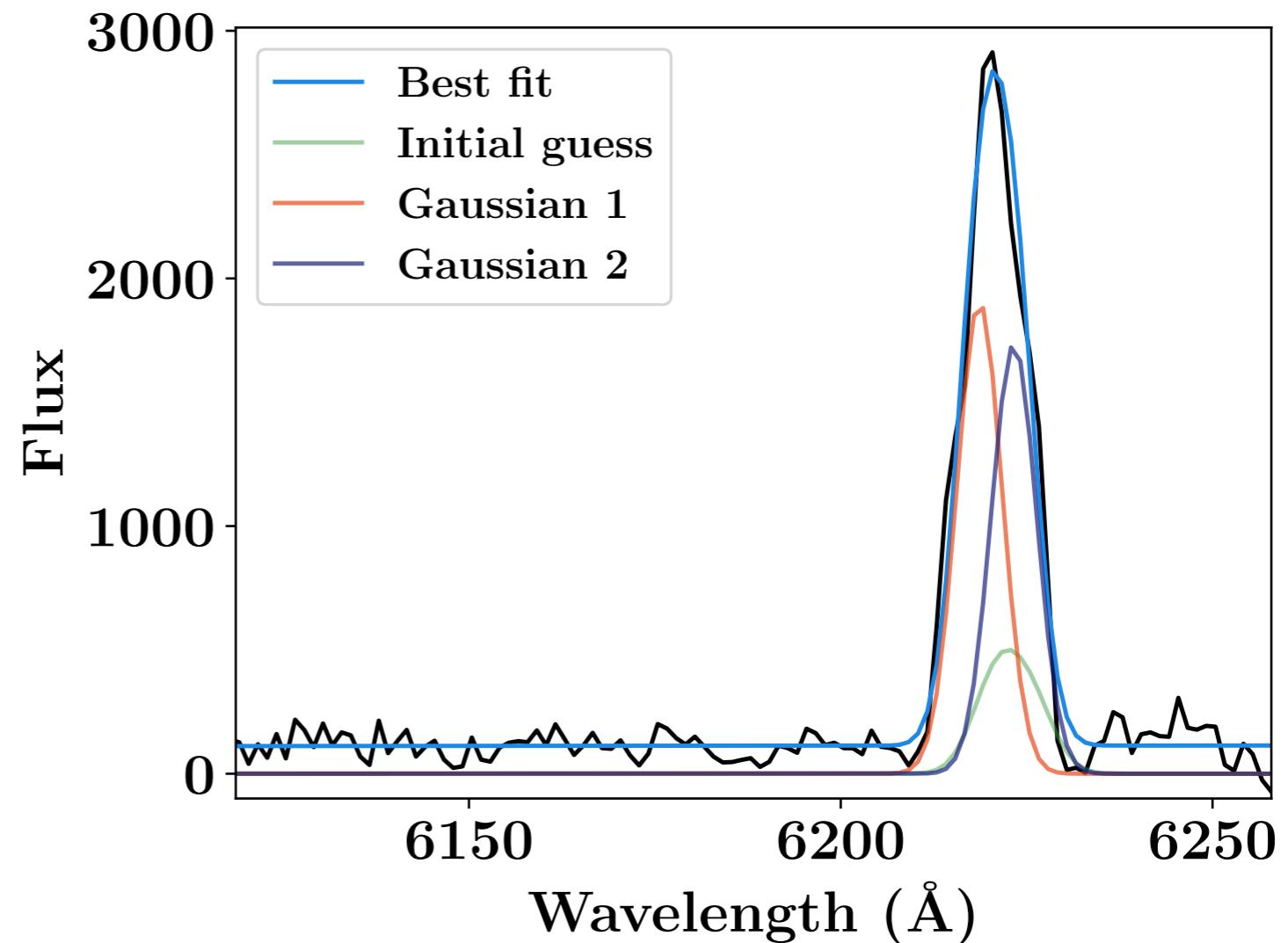
# Sample of galaxies

- Sample reduction using: redshifts, magnitudes, and probabilities of being a star
- Final sample contains  $\sim 40$  usable objects



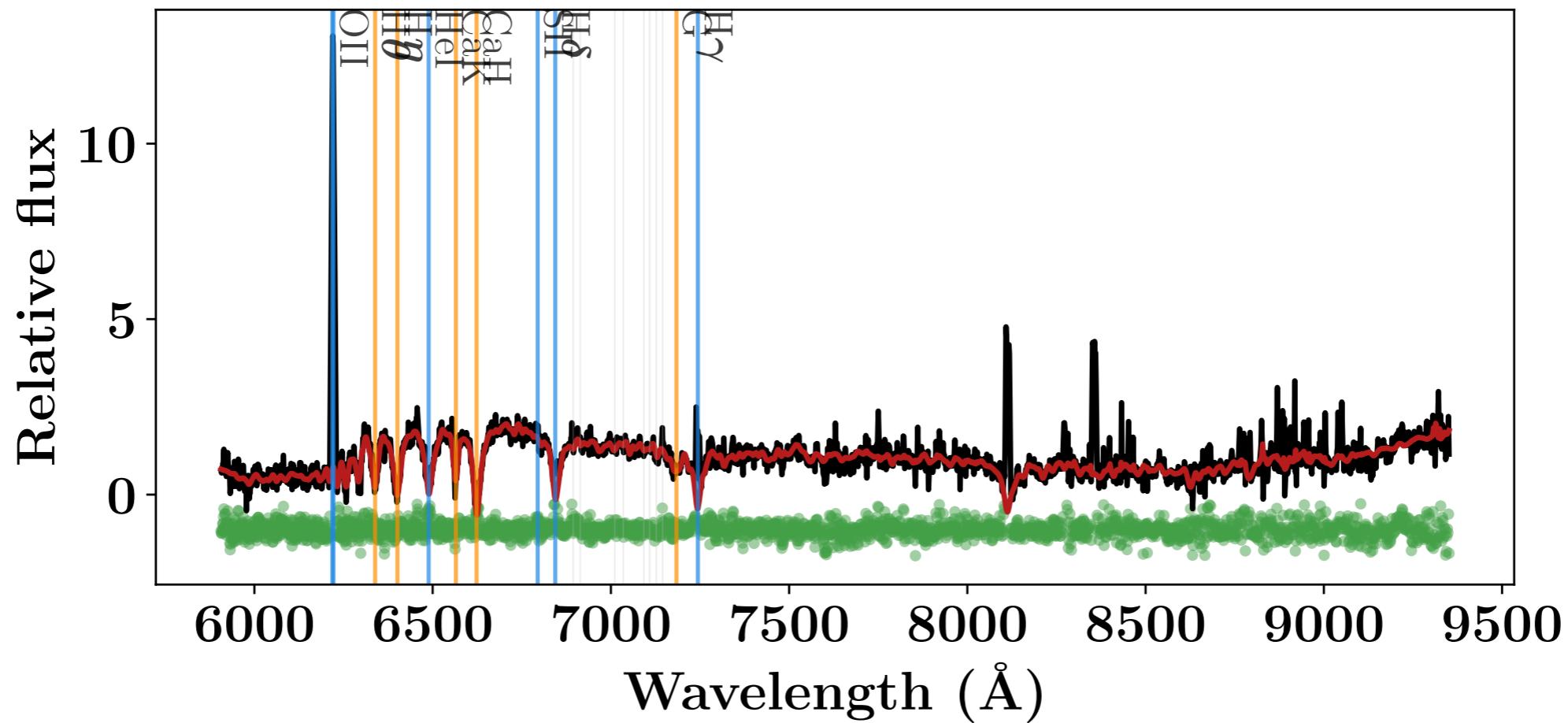
# Gas dynamics

- [OII] emission line used as a stellar-formation rate indicator for high-z galaxies
- Emission line width (velocity dispersion) represents the kinematics of the gas

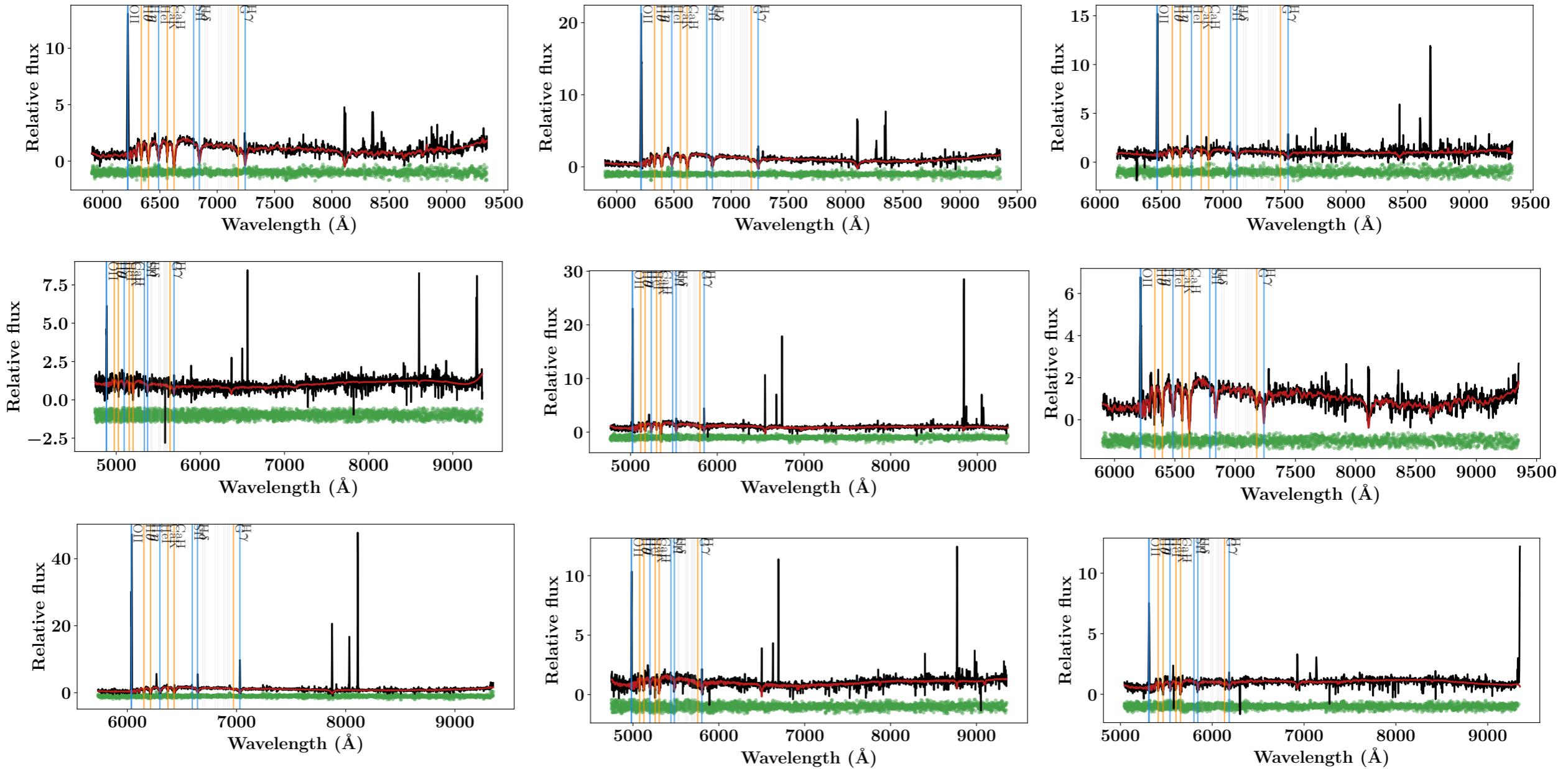


# Stellar dynamics

- Spectra absorption features fitted with combinations of multiple stellar templates
- Absorption line velocity dispersions quantify the stellar dynamics

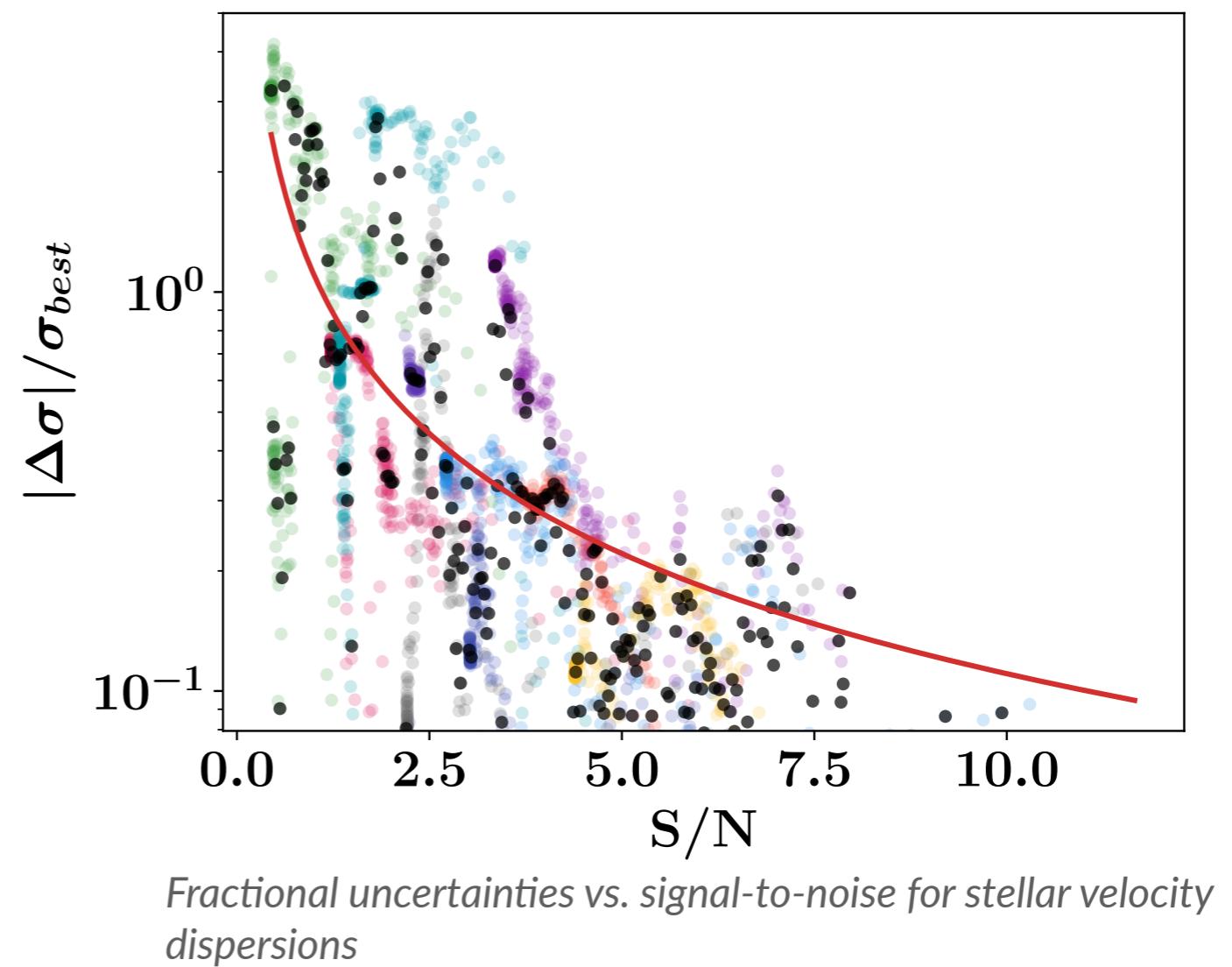


# Parsing the sample

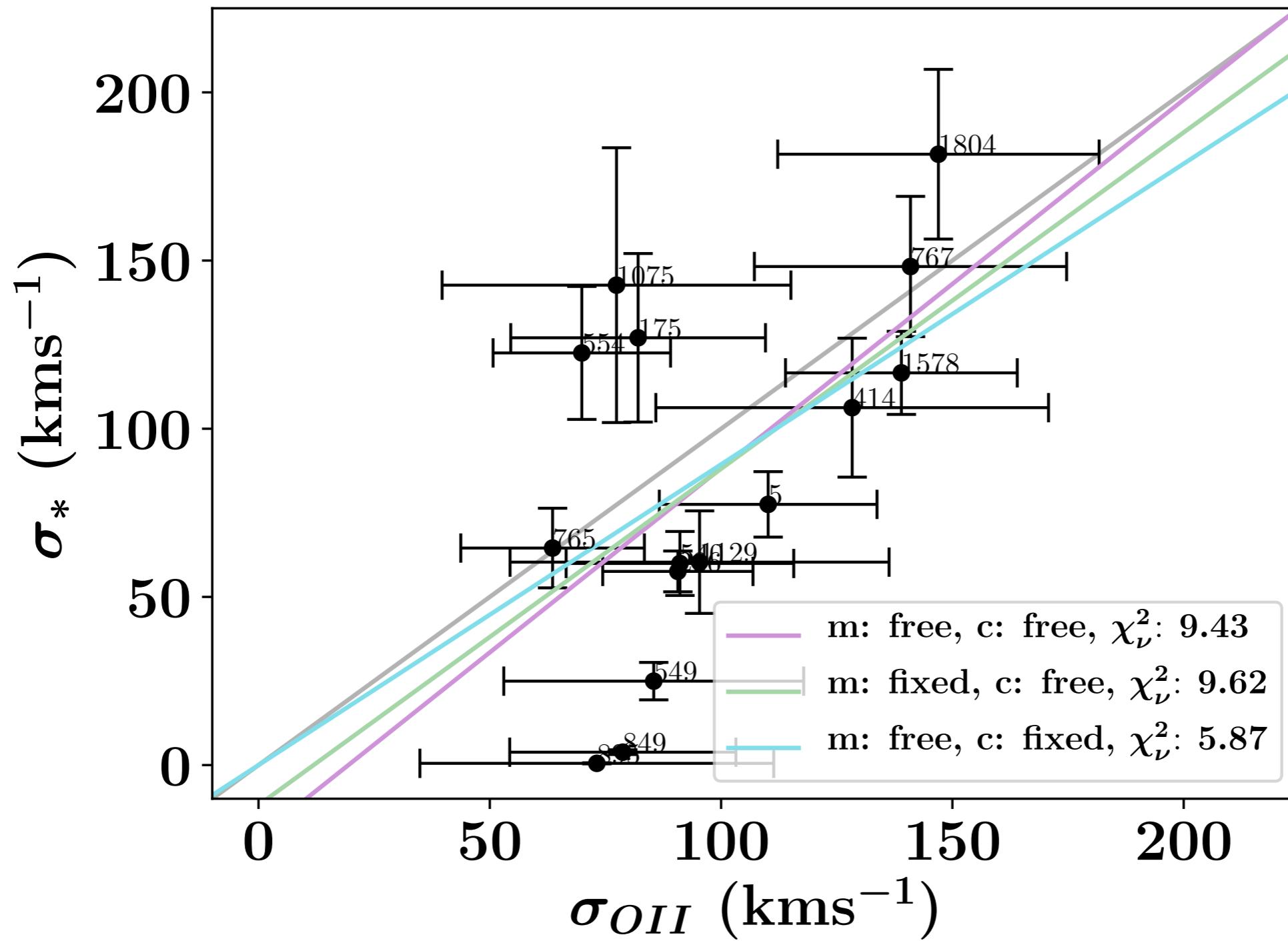


# Validity of fitting routines

- Stellar spectra fitting can utilise different spectral template sets
- Obtaining fractional uncertainties through perturbing a single spectra with noise and passing to fitter



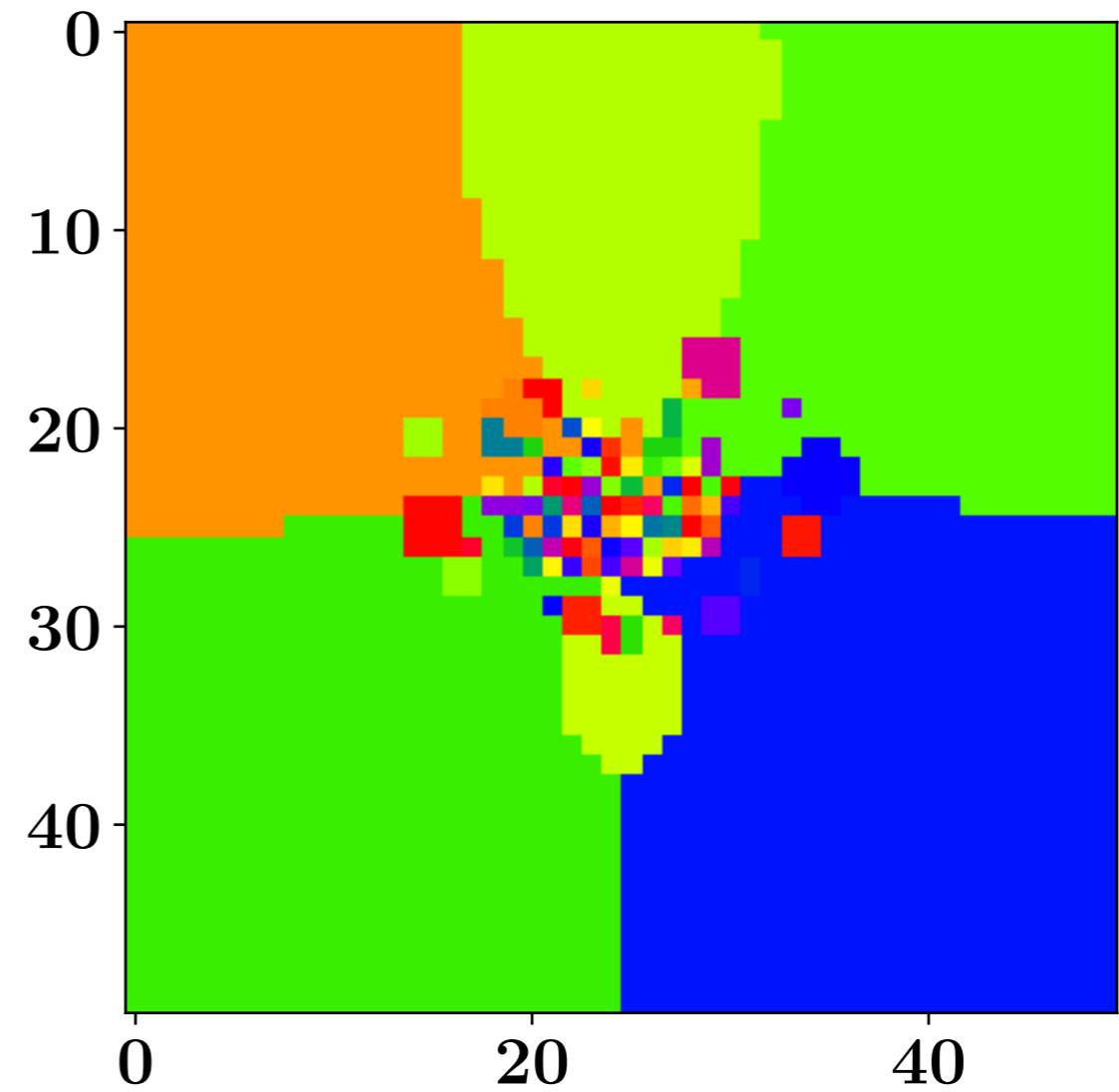
# Comparison of dynamics



# Voronoi tessellation (1)

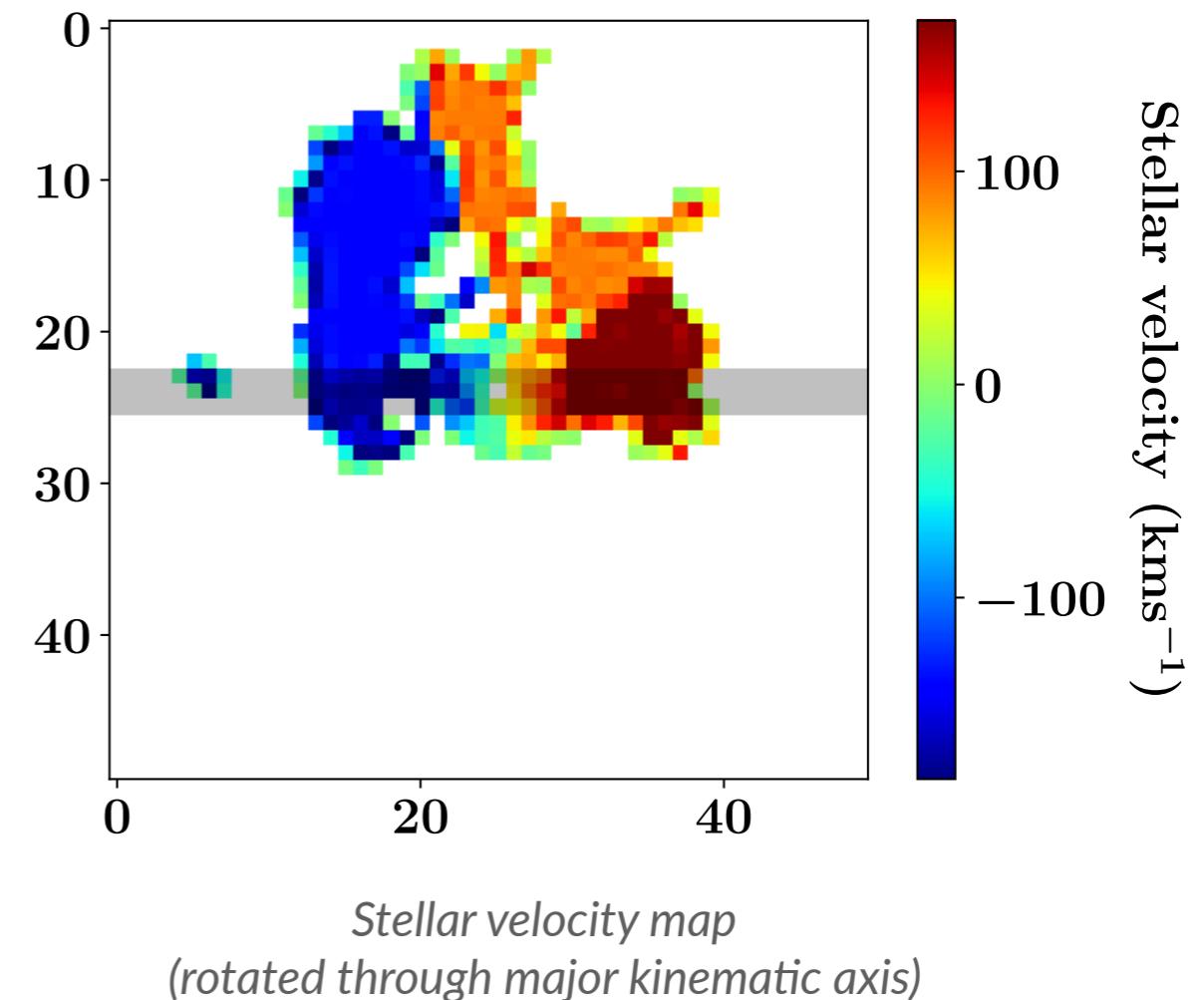
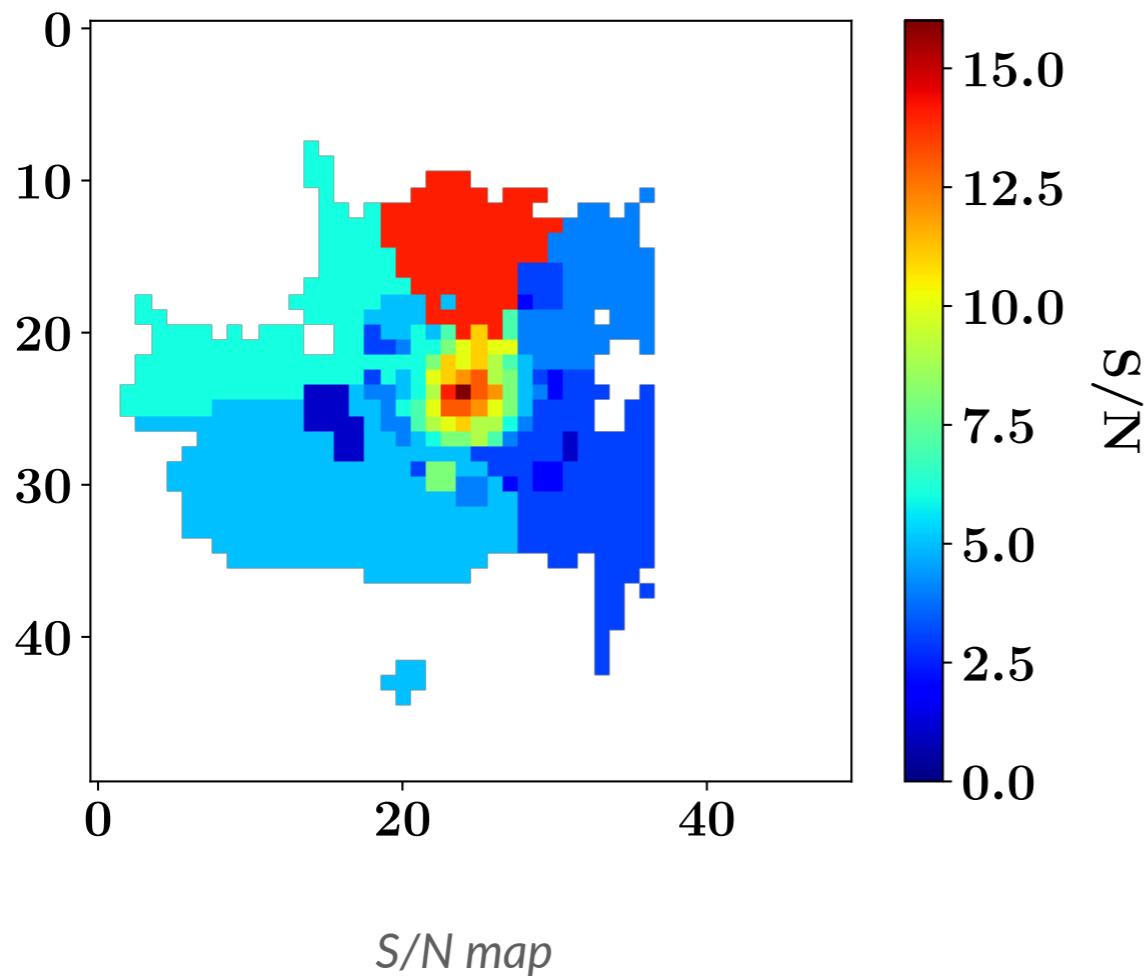


*Galaxy and segmentation map*

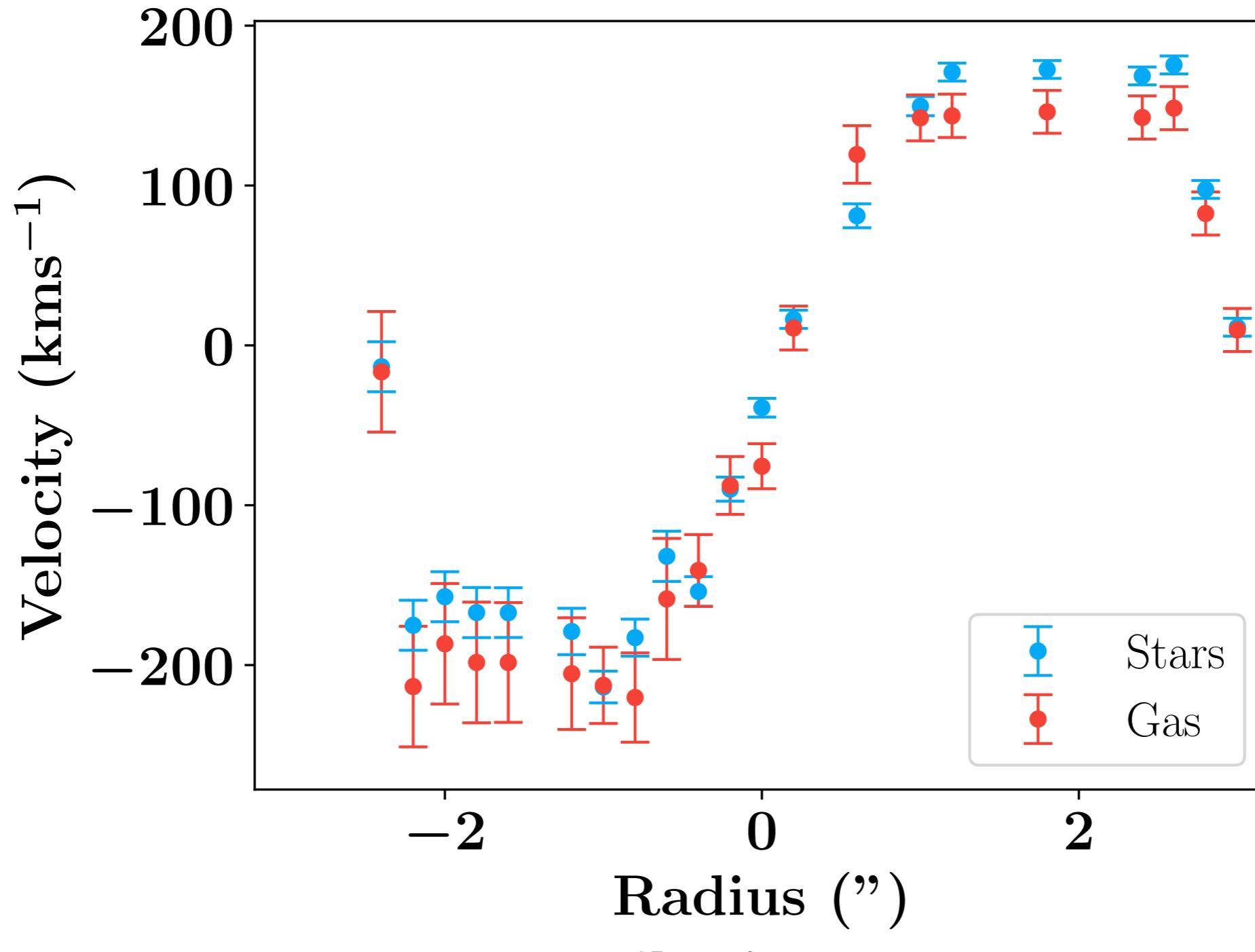


*Voronoi tessellated galaxy*

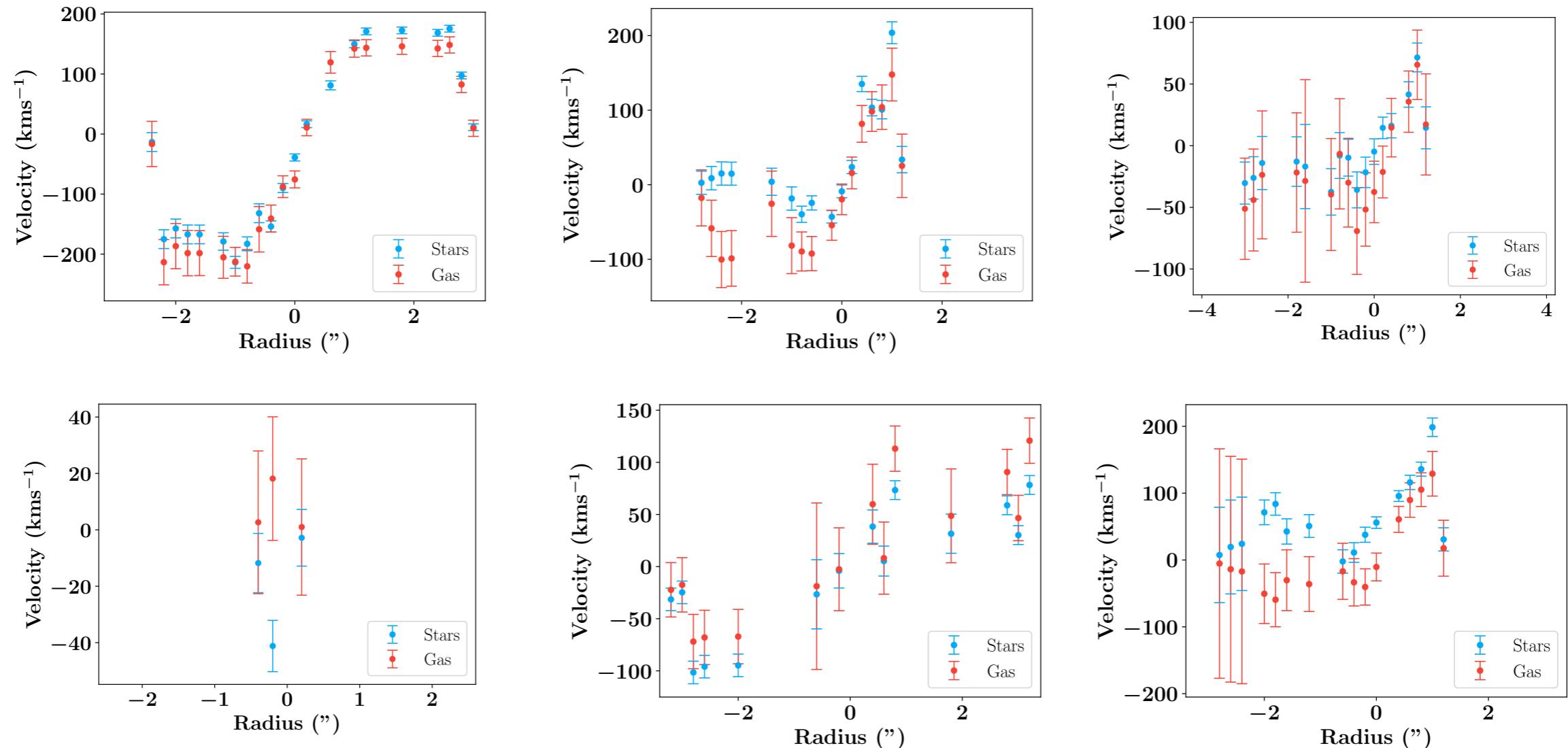
# Voronoi tessellation (2)



# Rotation curves



# Parsing the sample



- S/N for some objects limits the potential extractable data
- Requires 2D collapsing of the galaxy to include more data points

# 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 high-redshift 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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