Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INAF ISTITUTO NAZIONALE DI ASTROFISICA

# Galactic dynamics at cosmic noon: a new era with ELT

Fabio Rigamonti & Fabio Ditrani

Credits to Ditrani F.

# The classical picture

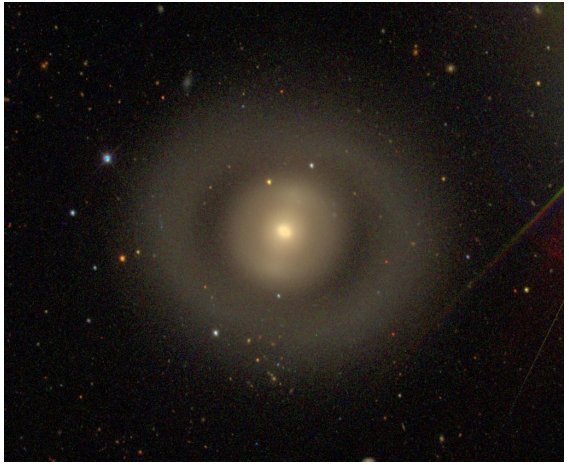
**Disc galaxies:** rotationally-supported disc formed mainly by in-situ star formation +

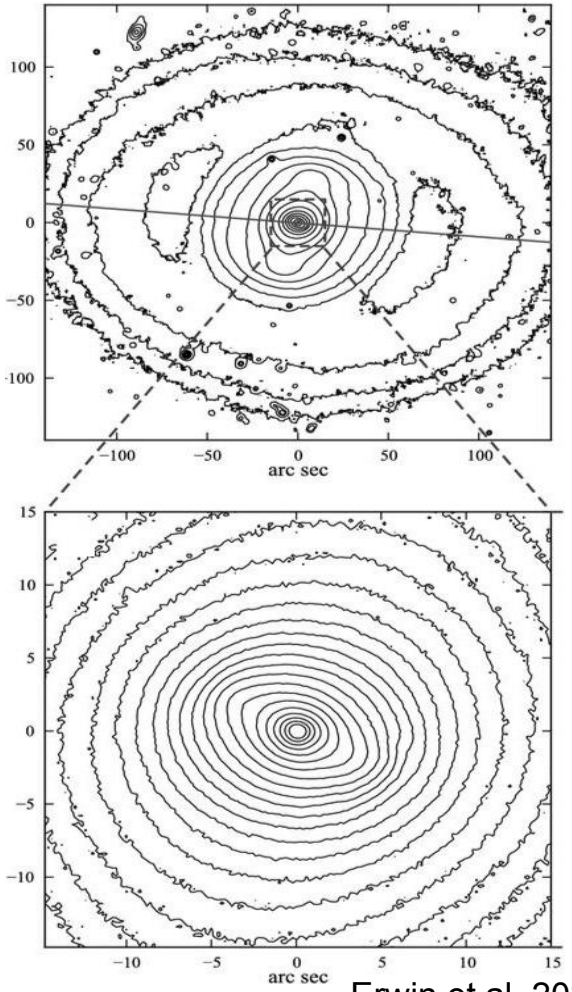
**Bulges:**

- **Photometric:** “the central light component that is in excess of the inward extrapolation of an exponential disc”
- **Classical:** looks like mini-ellipticals, dispersion-supported (can have little rotation), formed through violent events
- **Pseudo:** rotationally-supported, shaped by secular processes

**Spheroids:** often associated to photometric bulges+ellipticals. Ideally, what have been originated by violent processes.

# Introduction



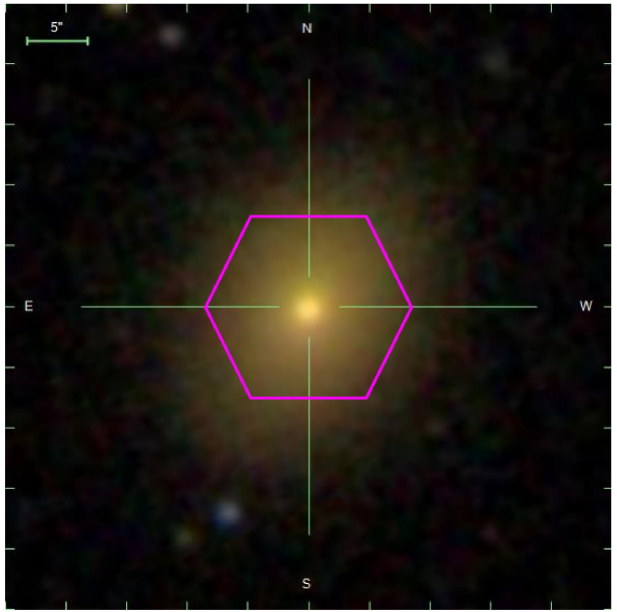


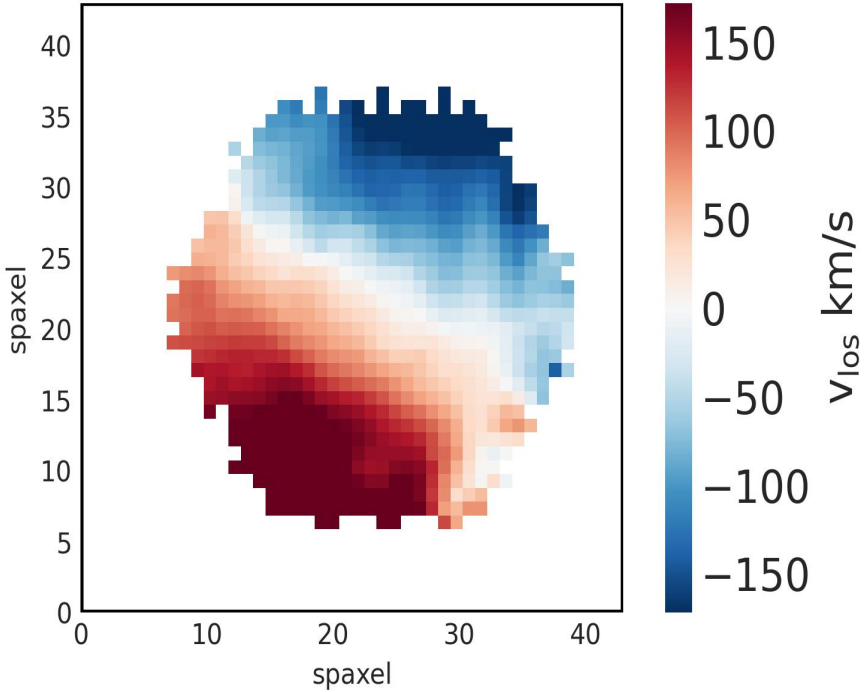

Reality is **far more complex** than a bulge+disc decomposition

Erwin et al. 2021

# Introduction

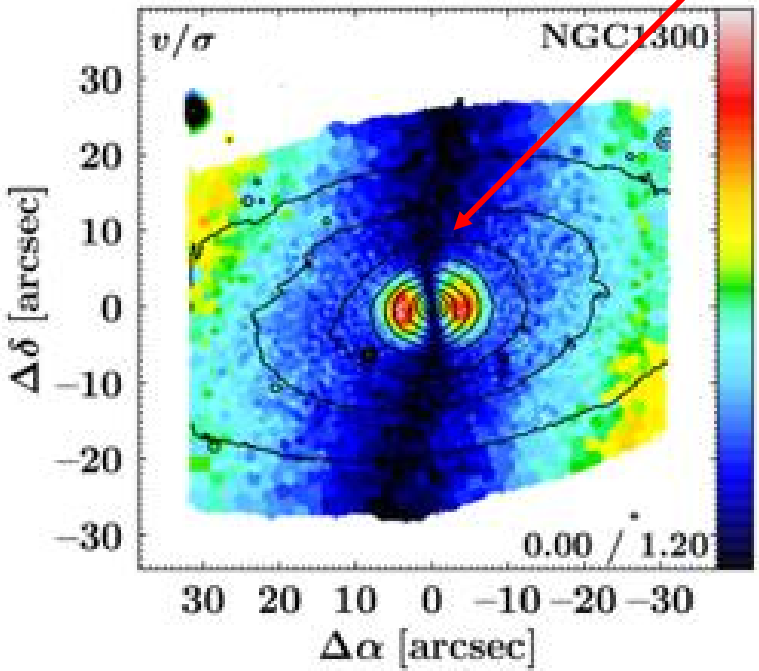
Most of the **elliptical** (beside the most massive) galaxies **rotate**

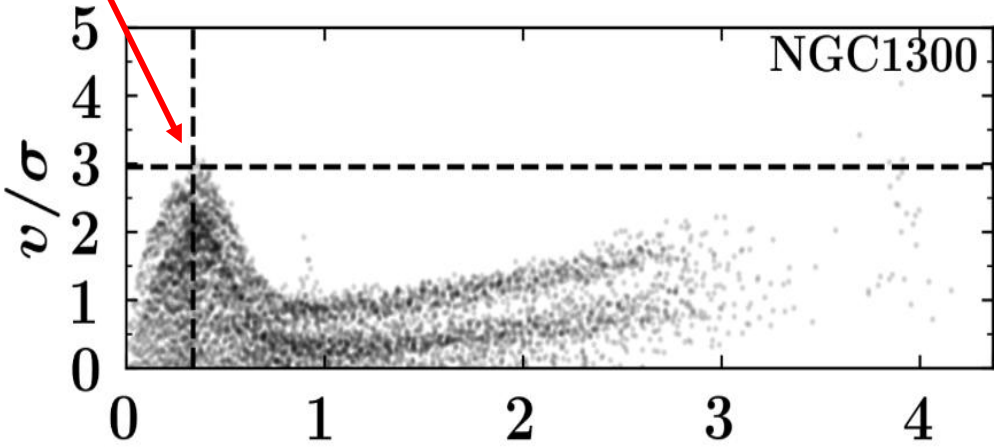


# Introduction

Pseudobulges are **nuclear discs**

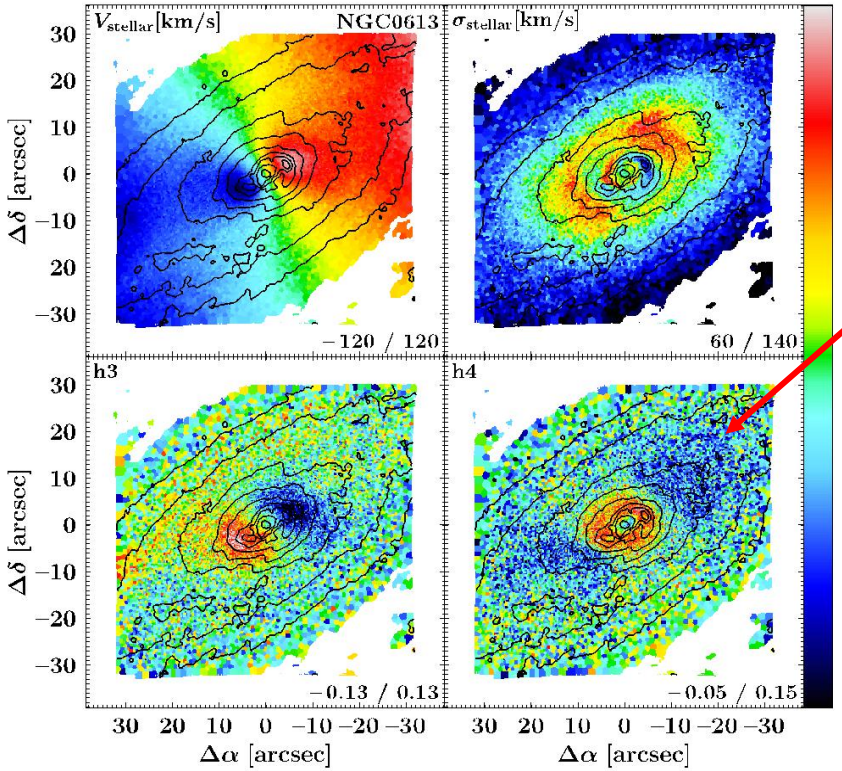



Gadotti+2020

# Introduction

Pseudobulges are **nuclear discs** or **inner part of bars** (boxy-peanut)

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**High resolution photometry** and **kinematics** are keys for unbiased understanding of **galaxy structures**!

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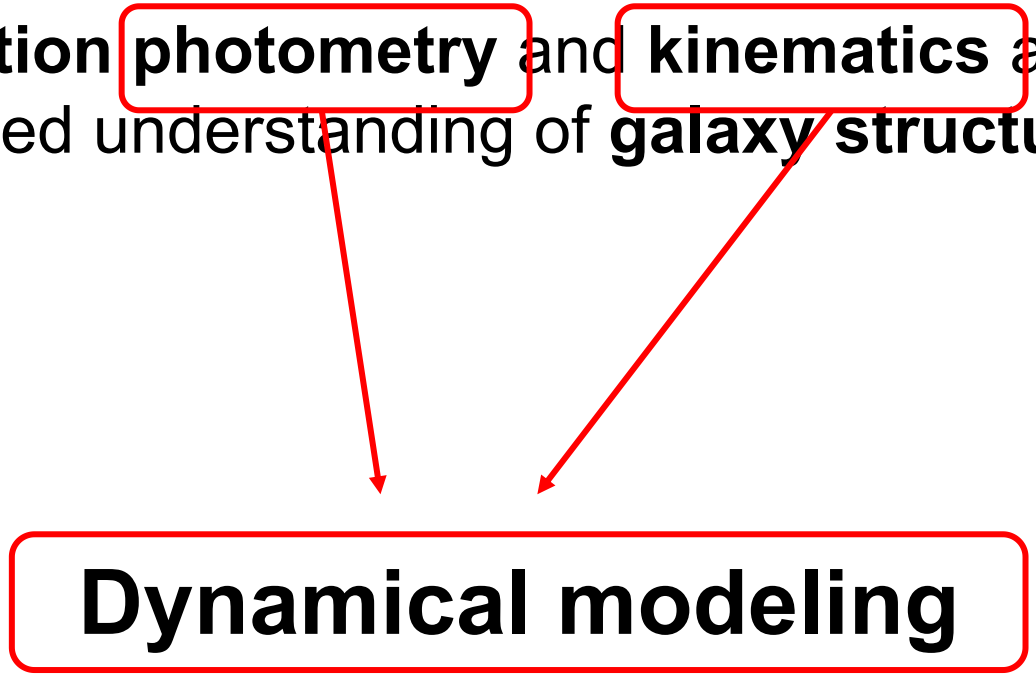


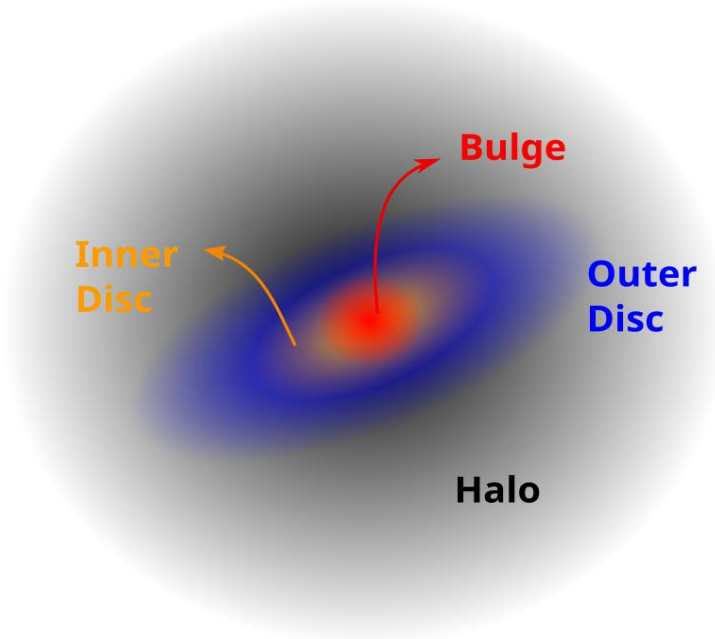
# The Model

https://pypi.org/project/BANGal/

**Rigamonti** et al., 2022

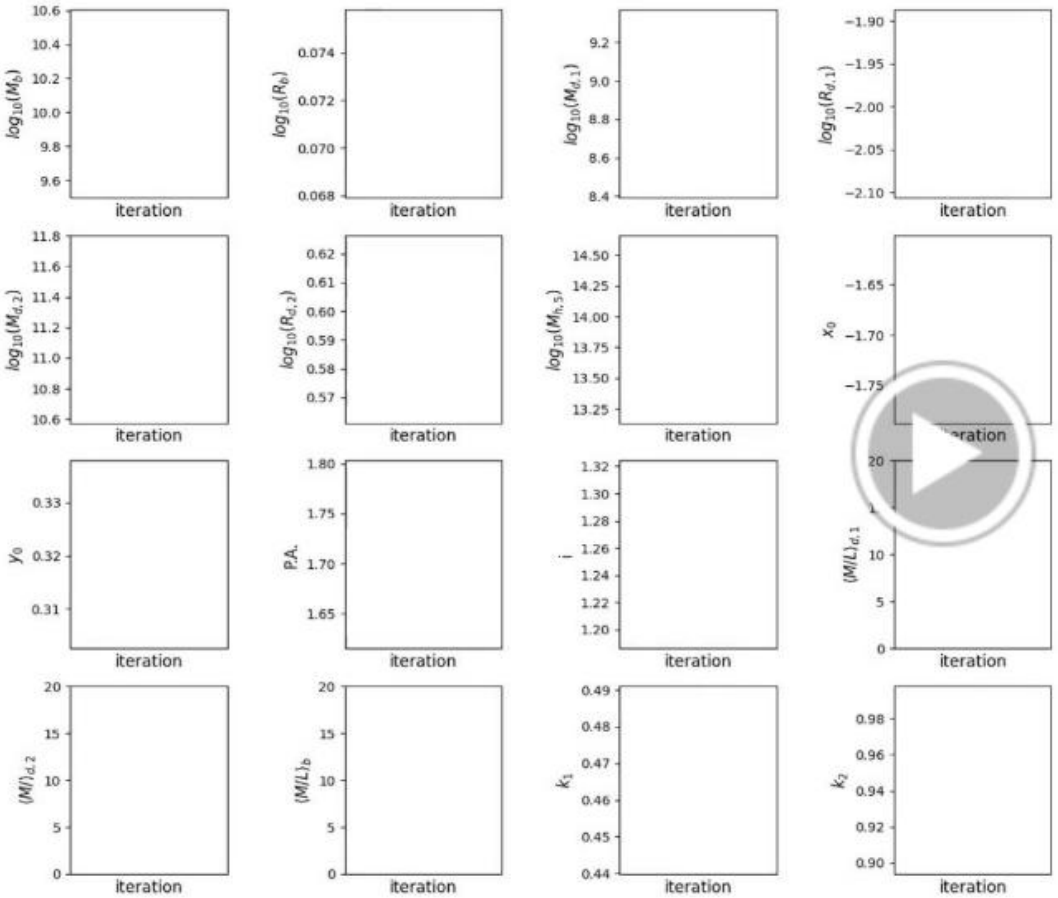
We propose a new methodology (**BANG**) to morpho-kinematically decompose galaxies:

- **Simultaneous modelling** of photometry and kinematics
- Robust **Bayesian parameter estimation** (Nested sampling)
- High computational efficiency (**GPUs parallelization, x200 speed up**)



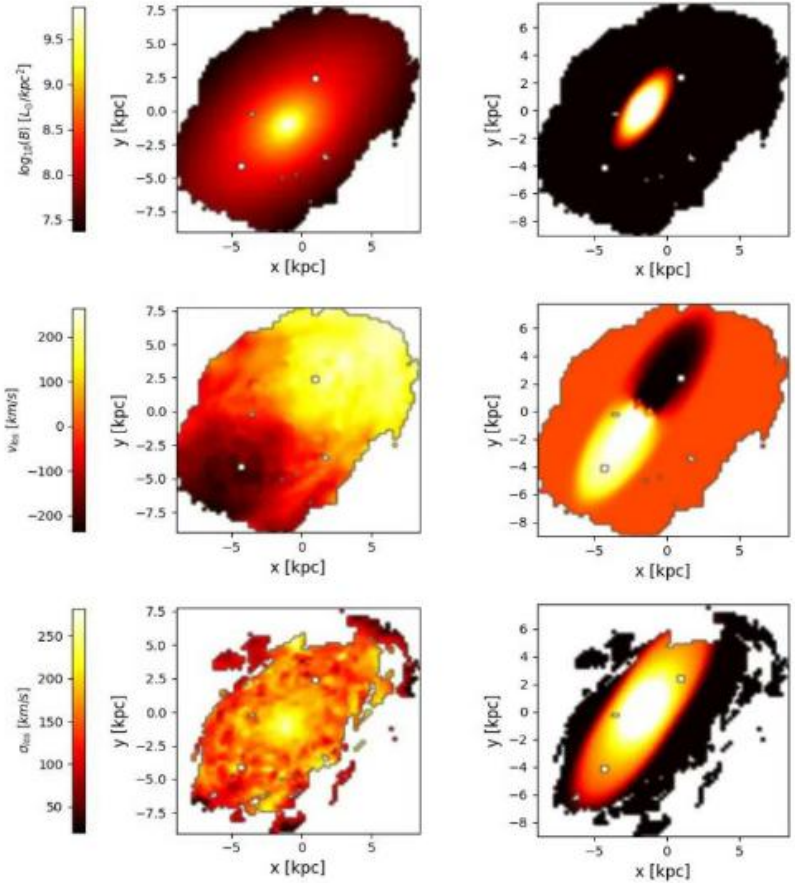
# Application to NGC 7683

**Rigamonti** et al., 2022




Data

Model



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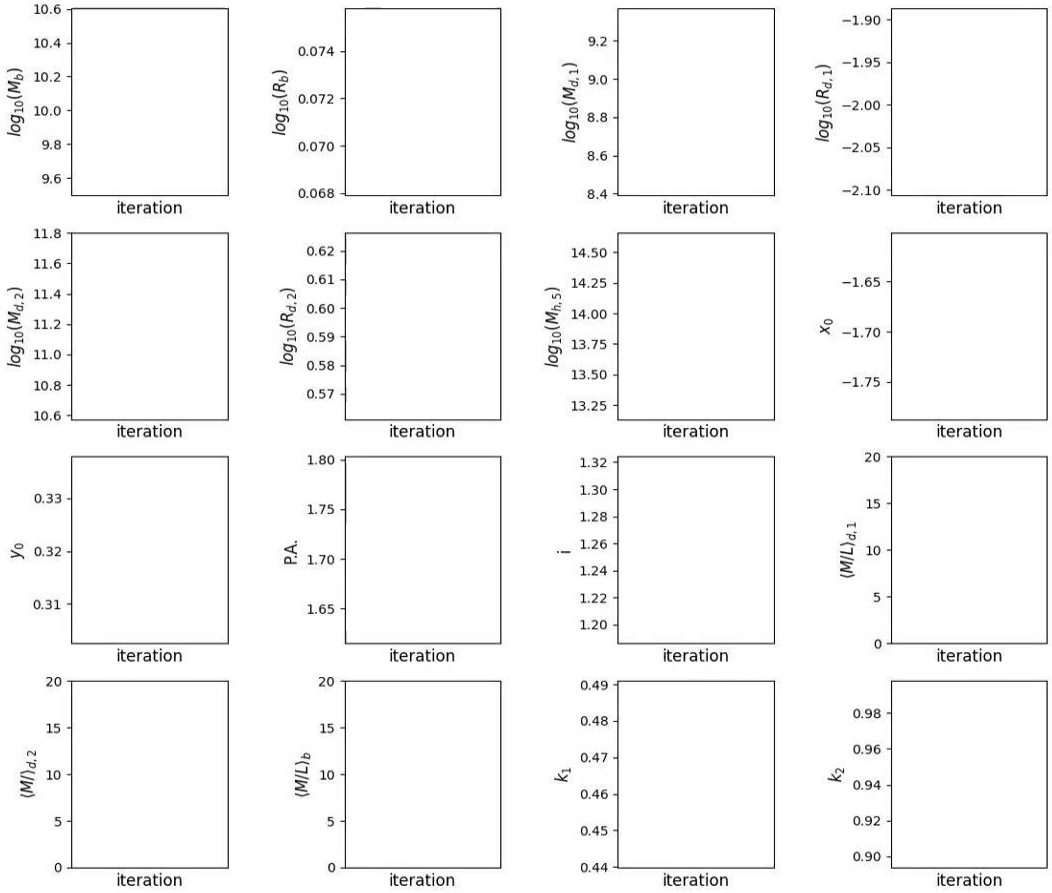


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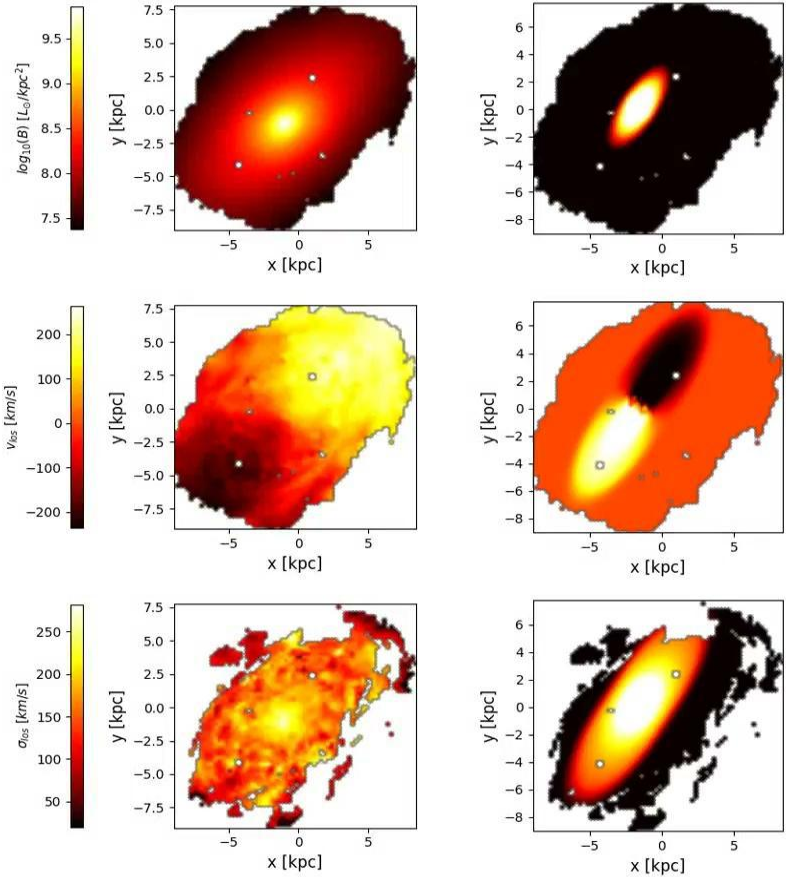
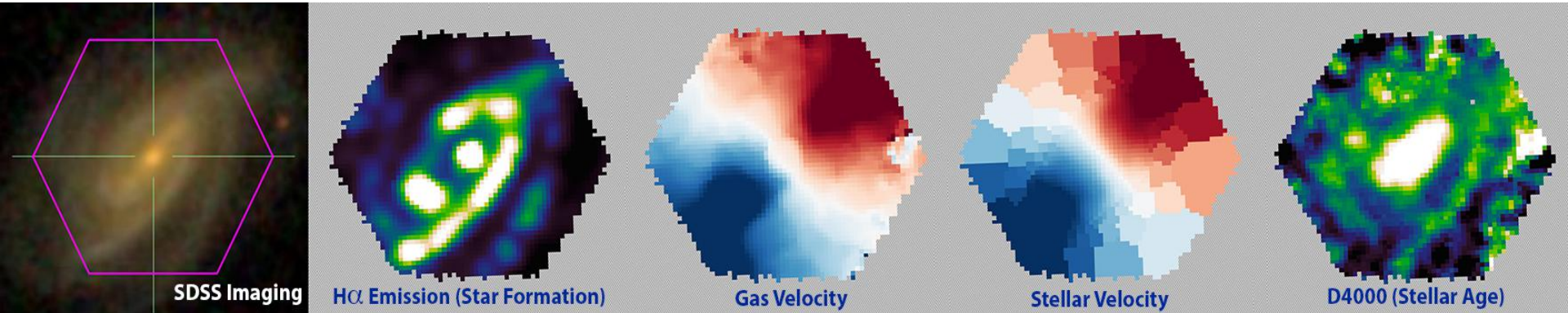


# Application to MaNGA

**Rigamonti** et al., 2023
**Rigamonti** et al., 2024

Mapping Nearby Galaxies at APO (MaNGA):

- IFS survey (+10,000 galaxies ) of the SDSS
- mean z~0.03
- log flat stellar mass distribution in the range $\left[10^9\ \mathrm{M}_\odot;\ 10^{11}\ \mathrm{M}_\odot\right]$



# Application to MaNGA

- Reproduction of well-know kinematic scaling relation also as validation of our methodology
- Characterization of the inner and outer discs through their kinematics
- Mass-budget and kinematics: implications for photometric decomposition
- Light- and mass- weighted kinematics depending on star-formation: the role of disc fading

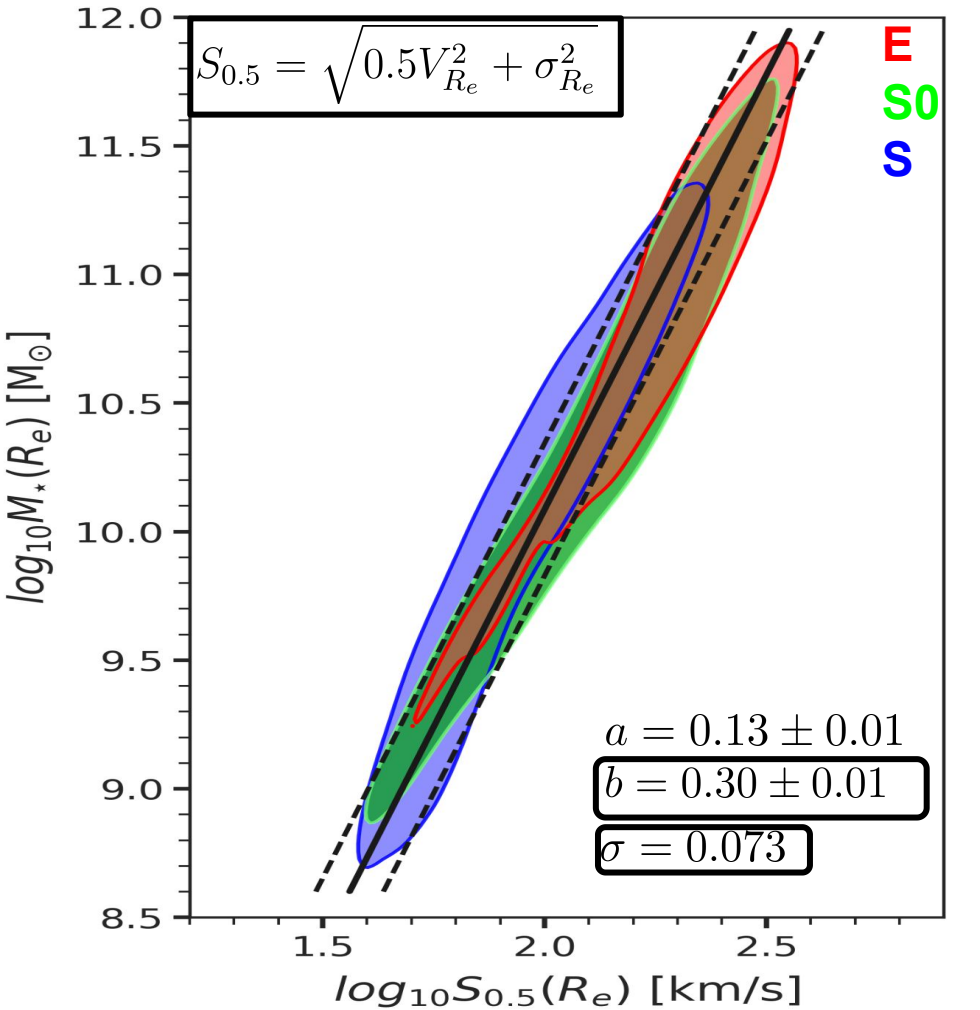
**Rigamonti** et al., 2023
**Rigamonti** et al., 2024

# Application to MaNGA

The slope is consistent with *Aquino-Ortìz et al., 2020* (b=0.31)

The scatter is **reduced by 30%** even without applying any quality-cut on the sample

**Rigamonti** et al., 2023



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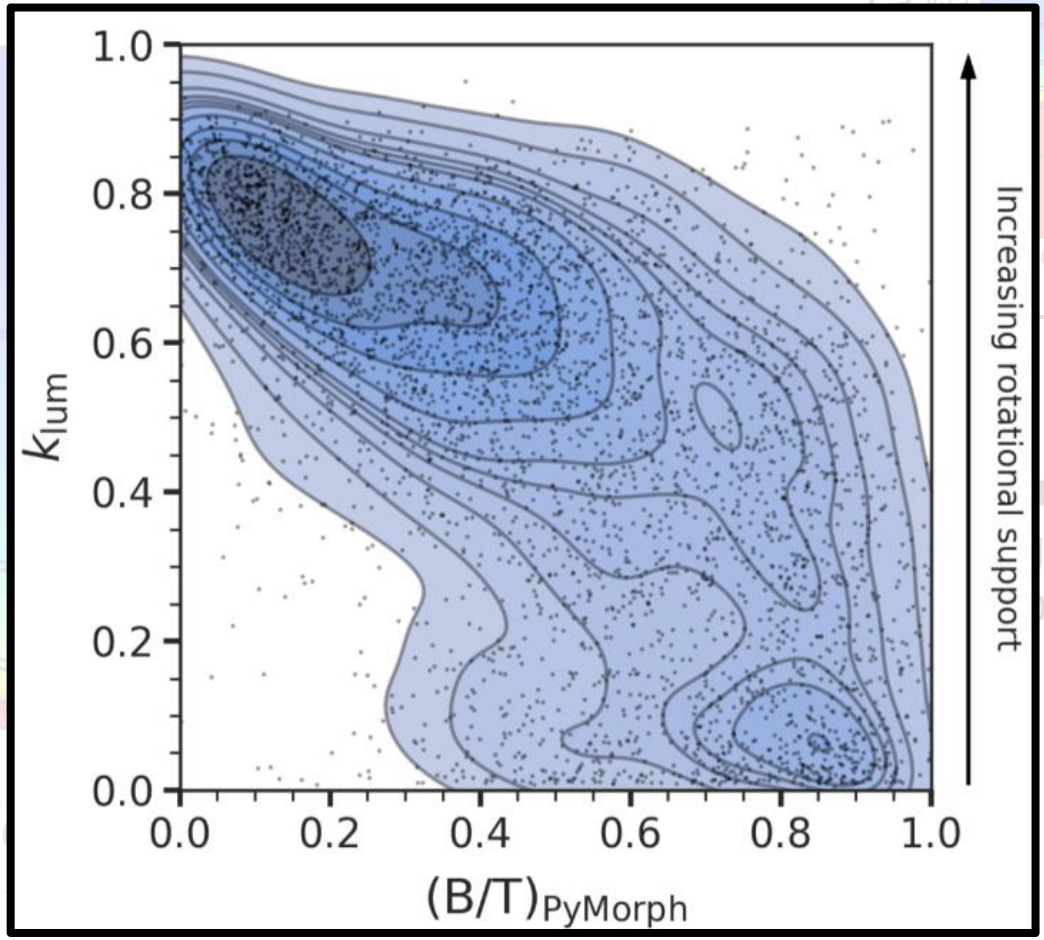

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**Rigamonti** et al., 2023
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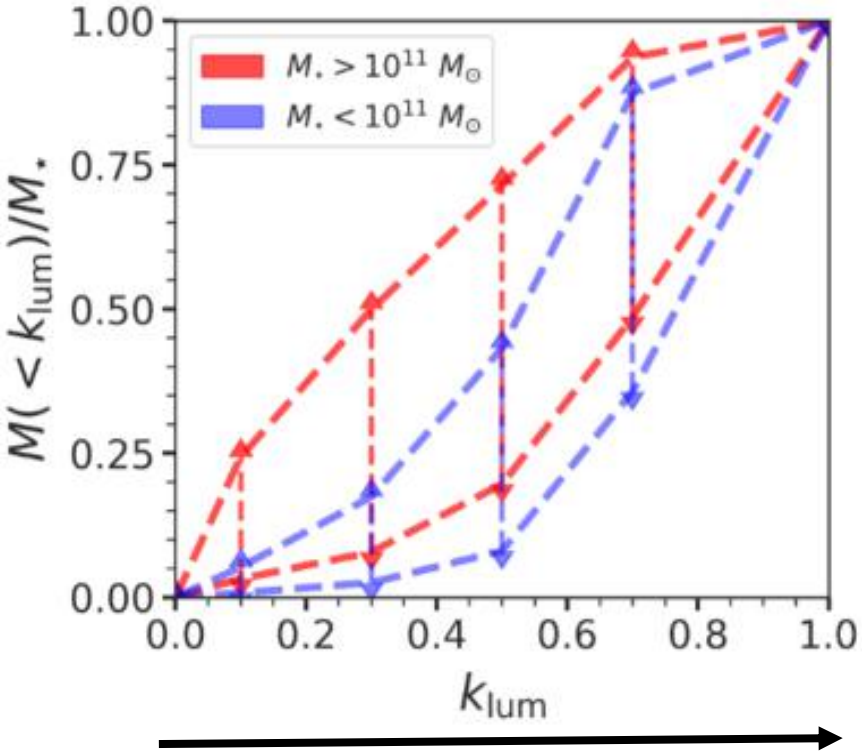
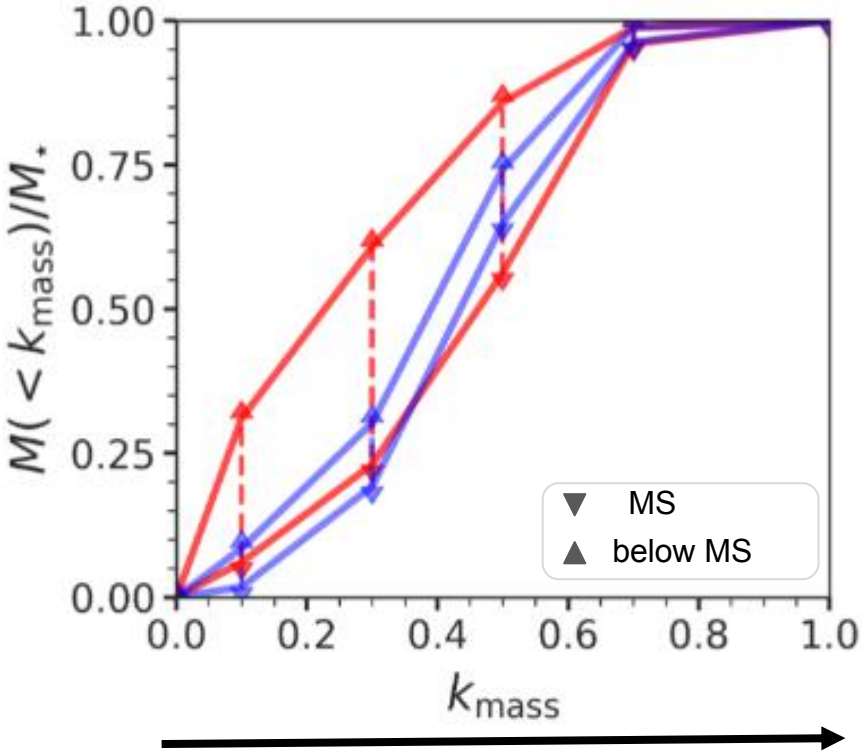
# MaNGA: star-formation & kinematics

**Rigamonti** et al., 2024




Increasing rotation (**luminosity-weighted**)



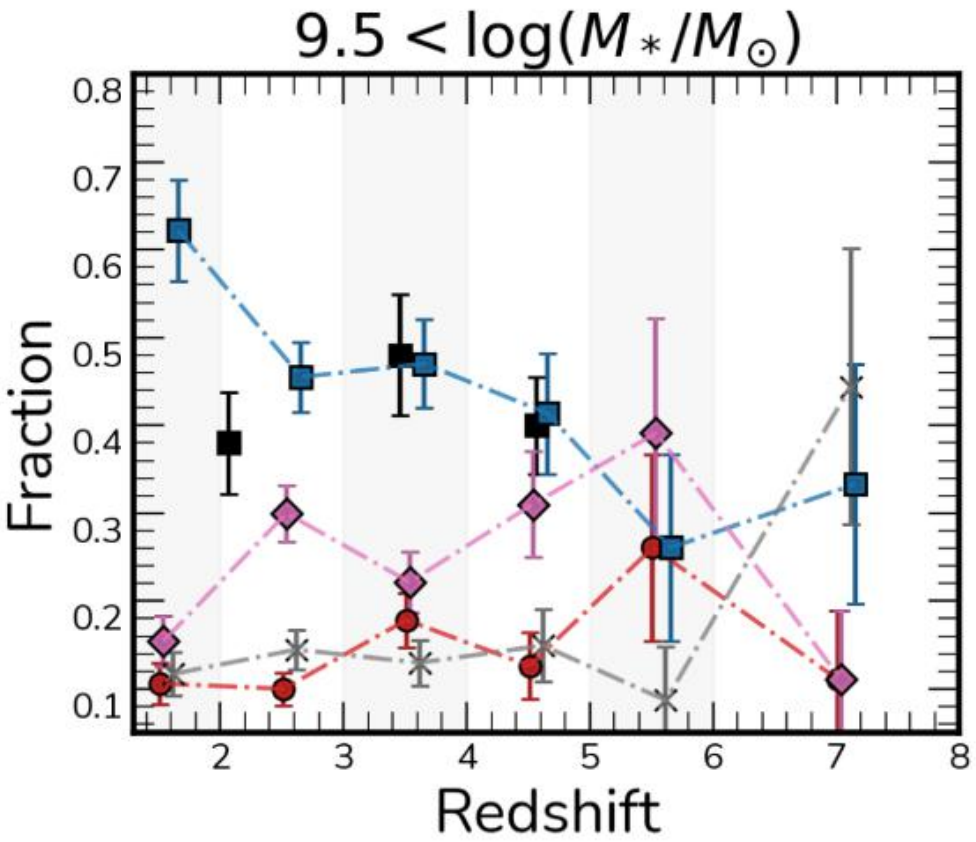

Increasing rotation (**mass-weighted**)

# High-redshift dynamics

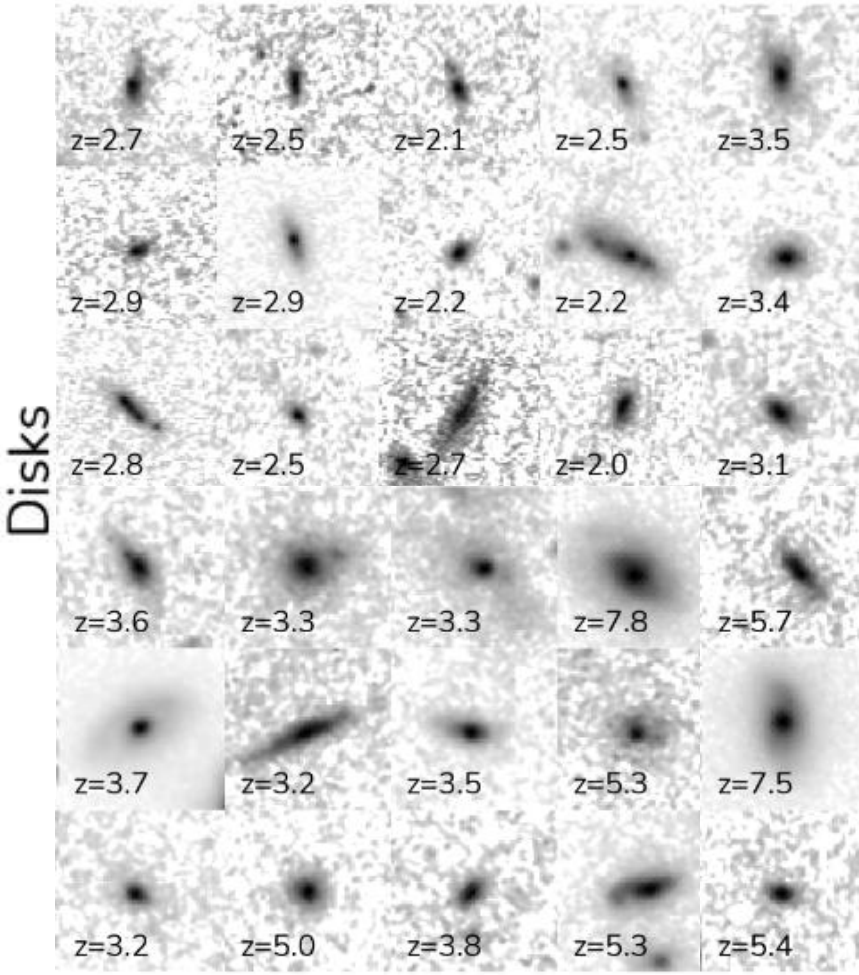
High resolution and kinematics combined with dynamical modelling.

Does it make sense to apply a **dynamical modelling** based approach at **high-redshift**?

# High-redshift dynamics

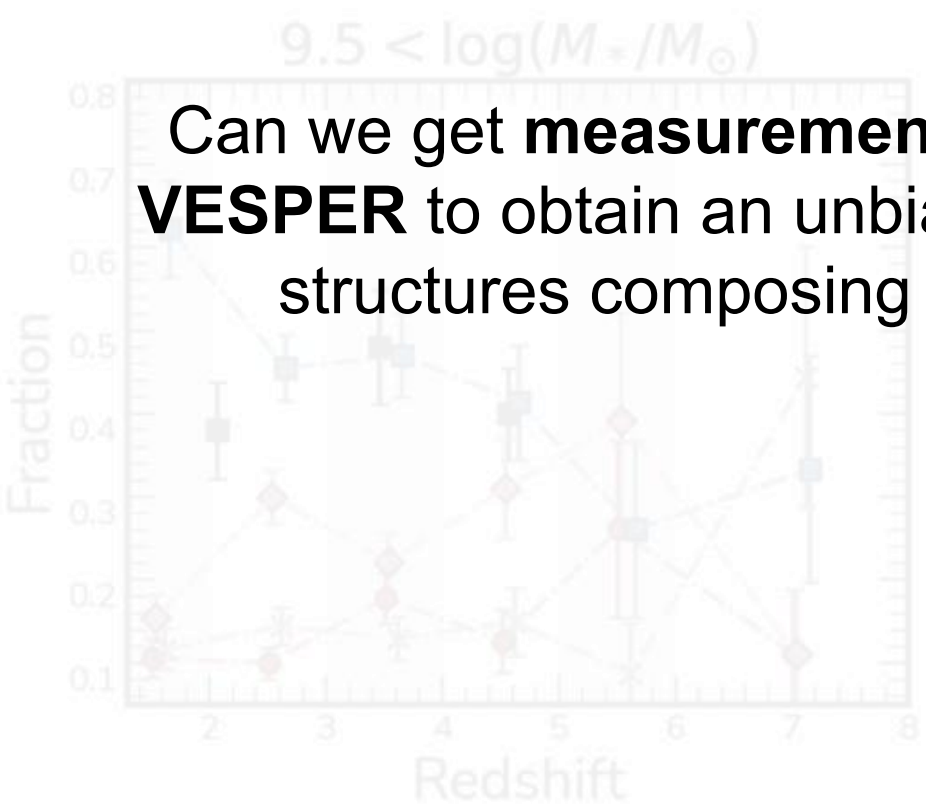


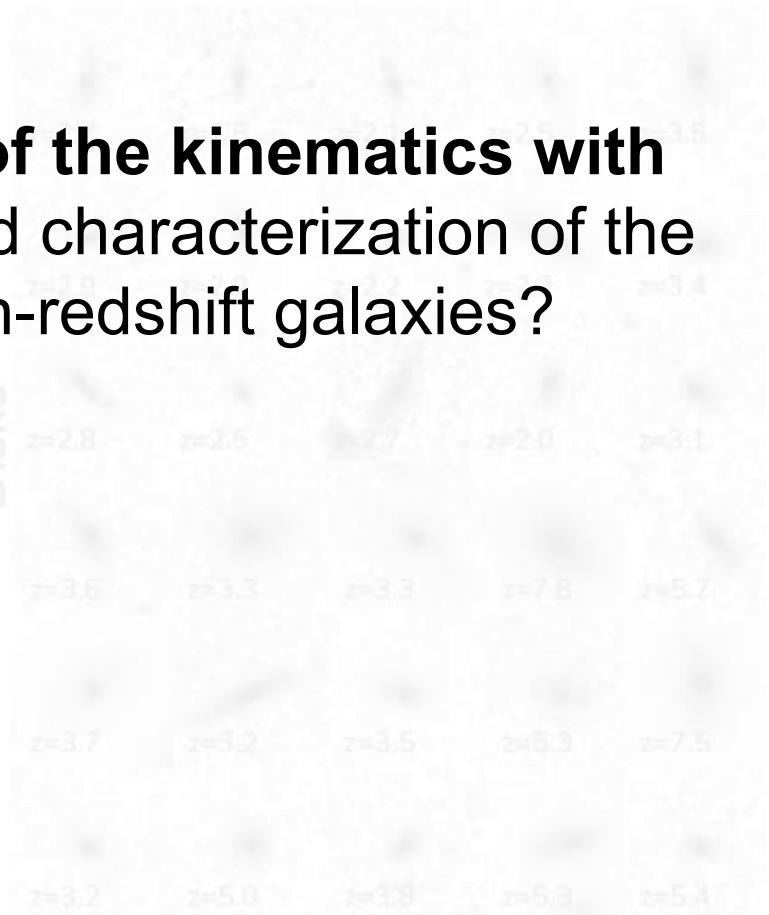

Ferreira et al. 2023



# High redshift dynamics with VESPER

Can we get **measurements of the kinematics with VESPER** to obtain an unbiased characterization of the structures composing high-redshift galaxies?



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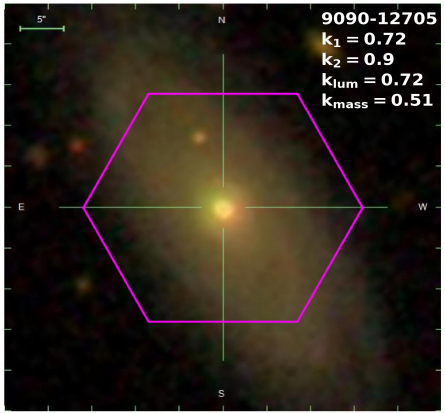
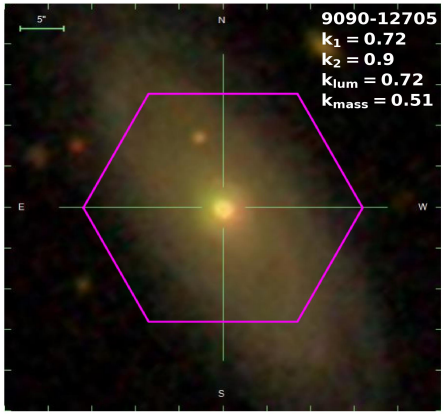



**MaNGA**

- z ~ 0.05, Re~8 kpc
- FoV 15 kpc (~ 20 x 20 kpc)
- Spatial Resolution ~0.5 kpc/spaxel
- Wavelength 360-1000 nm, resolution R~2000

# High-redshift dynamics with VESPER

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**Vesper**

- z ~ 2, Re~2-4 kpc
- FoV (1 IFU)  (~ 12 kpc x 14 kpc)
- Spatial Resolution ~0.25 kpc/spaxel
- Wavelength 1200-2400 nm, resolution R~3000

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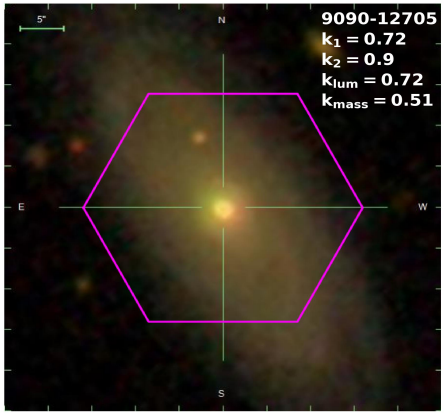


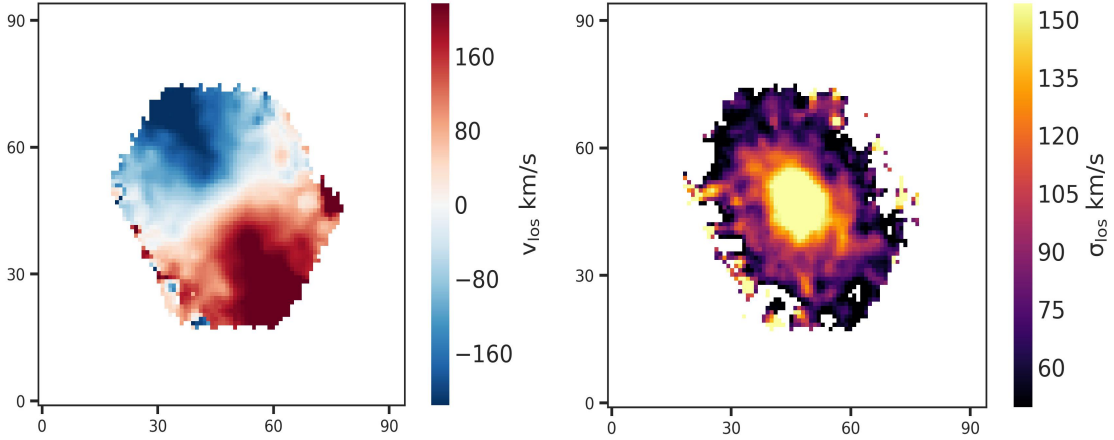


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Spatially resolved stellar kinematic and population

↓

20 hrs exposure for S/N high enough for stellar kinematics

# Conclusion

Dynamical modelling of high-redshift galaxies:

- **Unbiased view on 3D galaxies structures to probe their growth with cosmic-time**:
  - How stellar kinematic changes with cosmic time? Does it coevolve with the stellar population properties?
  - Where are classical bulges? How do they evolve? What are their shapes?
  - Do high-z bars have nuclear discs? When do they form?
  - What is the relation between mass, kinematics and quenching?

- **Independent measurements of mass (dark and luminous) profiles:**
  - Do dark-matter fractions evolve with redshift?
  - Are there evidences for IMF variations?