The Importance of the Spatially-resolved Star Formation in Galaxies

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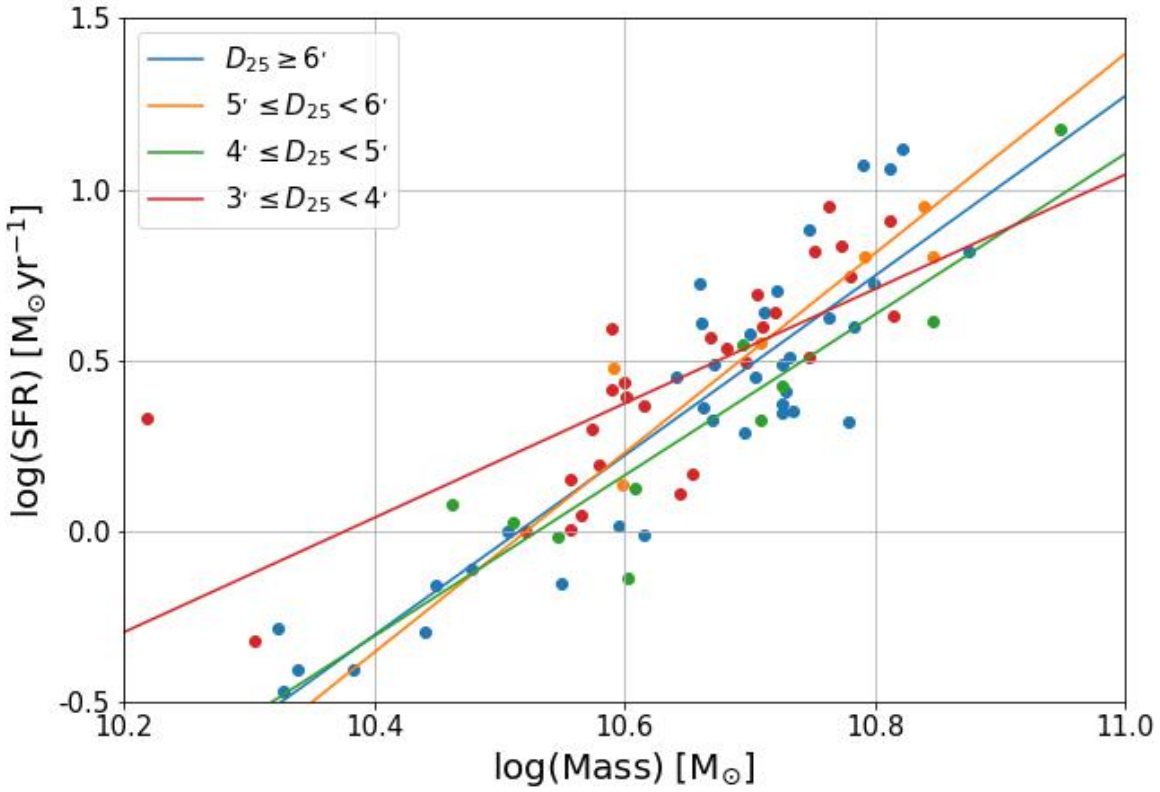
SFMS: star formation main sequence

The majority of star-forming (SF) galaxies follow a relatively tight relation between stellar mass and SFR.

$$\mathrm{SFR} \propto {M_*}^{\alpha}$$

- Integrated SFR-M relation for 36 Dustpedia galaxies (the data will be introduced later)
- Galaxies with different projected size is drawn in different clolors. And a simple linear regression is performed for different groups of galaxies.

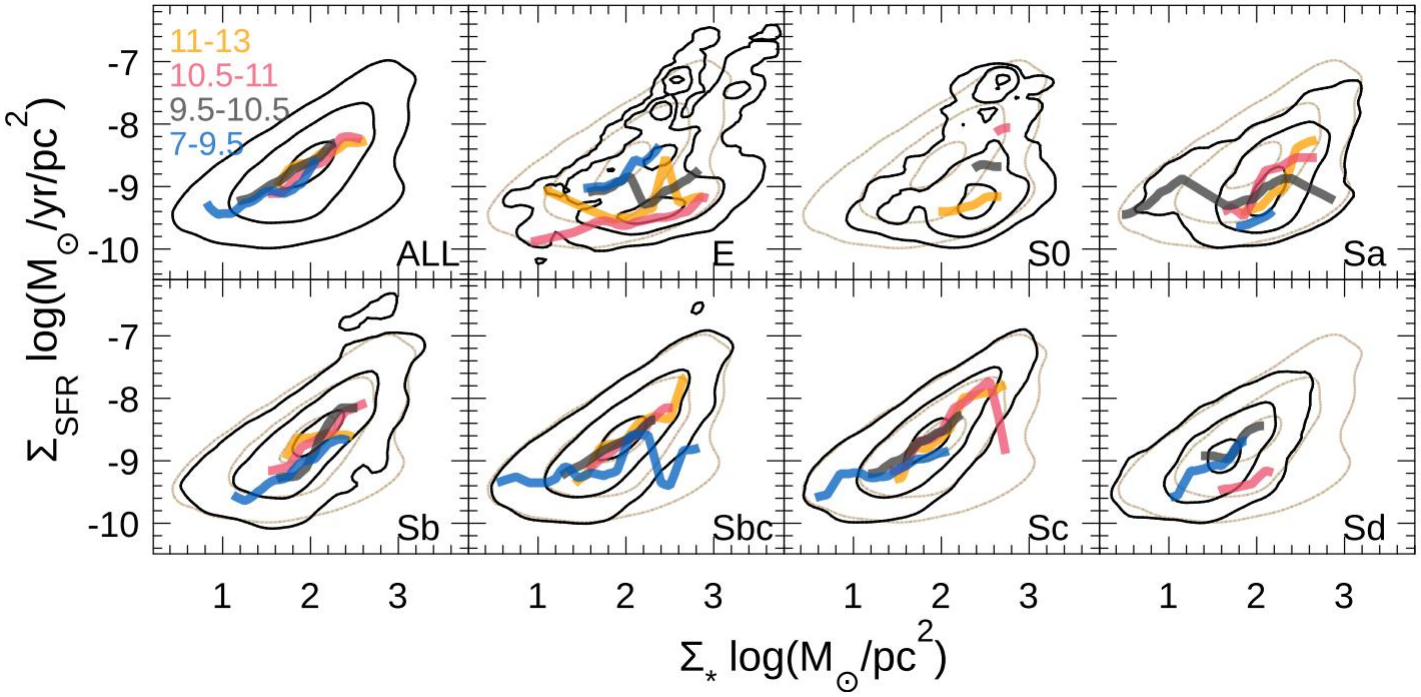


Shi et al. (2021)

Global —> Spatially Resolved

Distribution of the SFR surface densities along the stellar mass surface densities.

- The spatially resolved relation is as tight as the global one. (at least in the nearby universe)
- Bimodality (are you sure TWO groups?): SFAs tracing the described rSFMS relation; RAs located in a cloud well below that relation. (This is clear in more earlier types.)
- The trace of peak densities is shown for different stellar mass bins as color solid-lines, with each color representing a M* bin. (The mass dependence is weaker than the morphological one)



Sebastián F. Sánchez (2020)

Data

DustPedia database: Multiwavelength imagery for **875** nearby galaxies.

(http://dustpedia.astro.noa.gr/Data)

- CAAPR (Clark et al., 2017) is a pipeline that is able to produce consistent photometry and determine robust cross-compatible uncertainties.
- Sample selection: For the purpose of this work, we want large galaxies with a moderate disk inclination. Hubble type T: 1 ~ 8 (Sa ~ Sdm)

Galaxy sample number counts							
	D_{25}<1’	1~2	2~3	3~4	4~5	5~6	>6
I<=72.7	1	122	68	33	15	10	39 ☺
I>72.7	3	65	47	26	15	9	23

Parameters

By combining data in UV and IR band (GALEX, WISE, Spitzer), we can estimate average SFR during the past 10^7 years.

$$\Sigma_{\mathrm{SFR}}[M_\odot \mathrm{yr}^{-1}\mathrm{kpc}^{-2}] = 1.59(3.2\times10^{-3} I_{22} + 8.1\times10^{-2} I_{\mathrm{FUV}})\cos i$$

$$\log_{10}\left(\frac{M_*}{M_\odot}\right) = a + b\,\log_{10}\left(\frac{\nu L_\nu(3.4\mu\mathrm{m})}{L_\odot}\right)$$

$$(a = -0.040 \pm 0.001; b = 1.120 \pm 0.001)$$

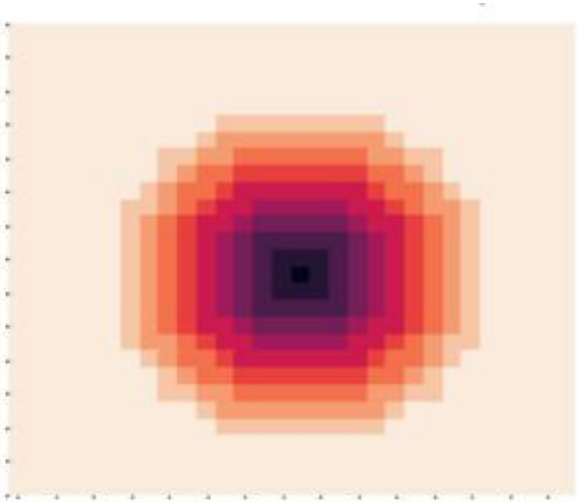
$$\log(\mathrm{M/L}) = -0.339(\pm 0.057)(\mathrm{I}_{[3.6]}\text{-}\mathrm{I}_{[4.5]})\text{-}0.336(\pm 0.002)$$

Casasola et al., 2017; Bigiel et al. (2008); Wen et al., 2013; Querejeta et al. (2015)

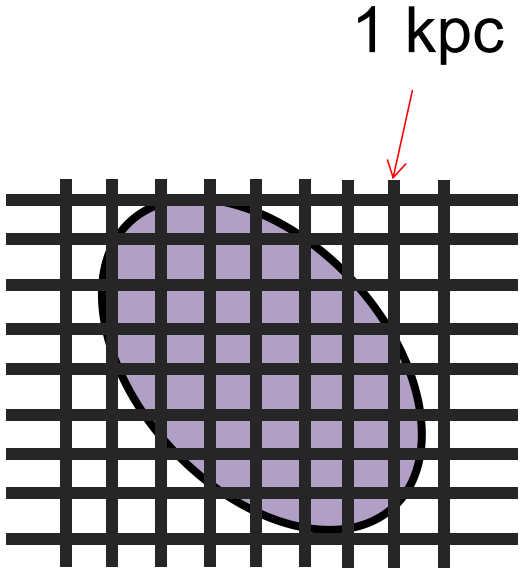
Data

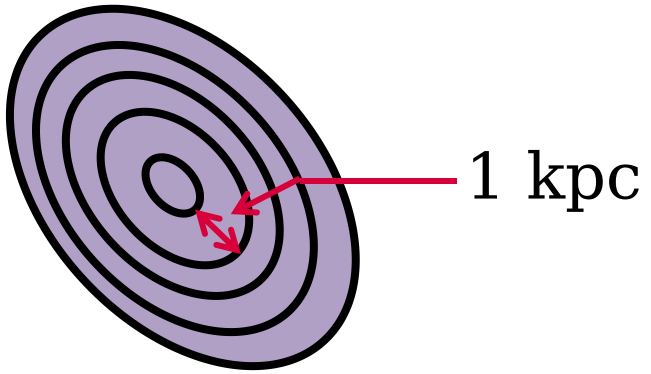
CAAPR → obtain the center, long/short axis, and inclination of the galaxy

1. Galaxies are divided in pixels with $1\ \mathrm{kpc}$ side length
2. Calculate the galactocentric radius of each pixel
3. Make “Concentric ellipses”, with 1 kpc intervals



Shi et al. (2021)

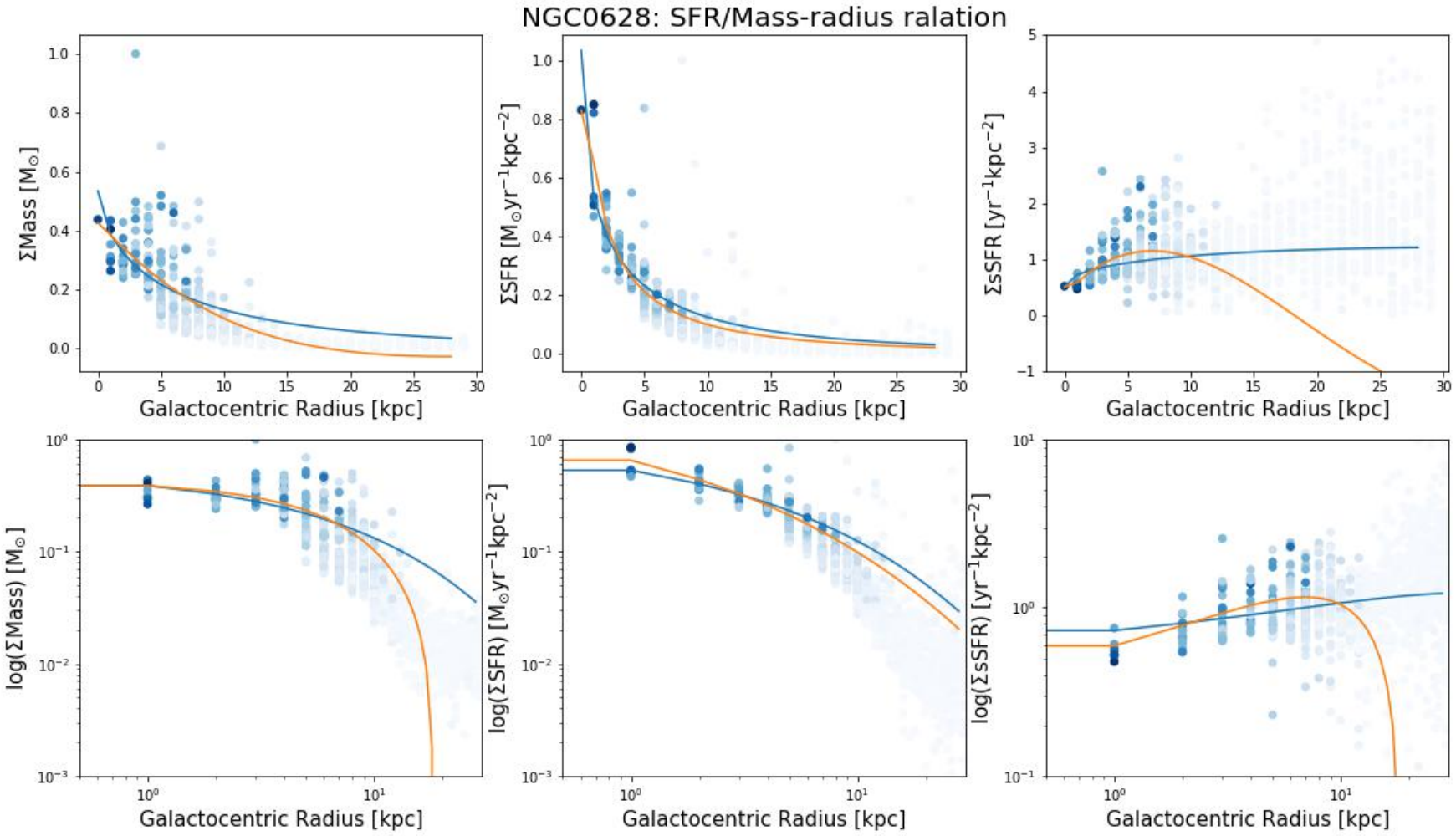




Heat plot showing the Galactocentric radius (up to 1.5 D_{25}, a pure mathematical property) of a random galaxy (IC3267)

Result

SFR/Mass - Galactocentric radius relation within D_{eff}

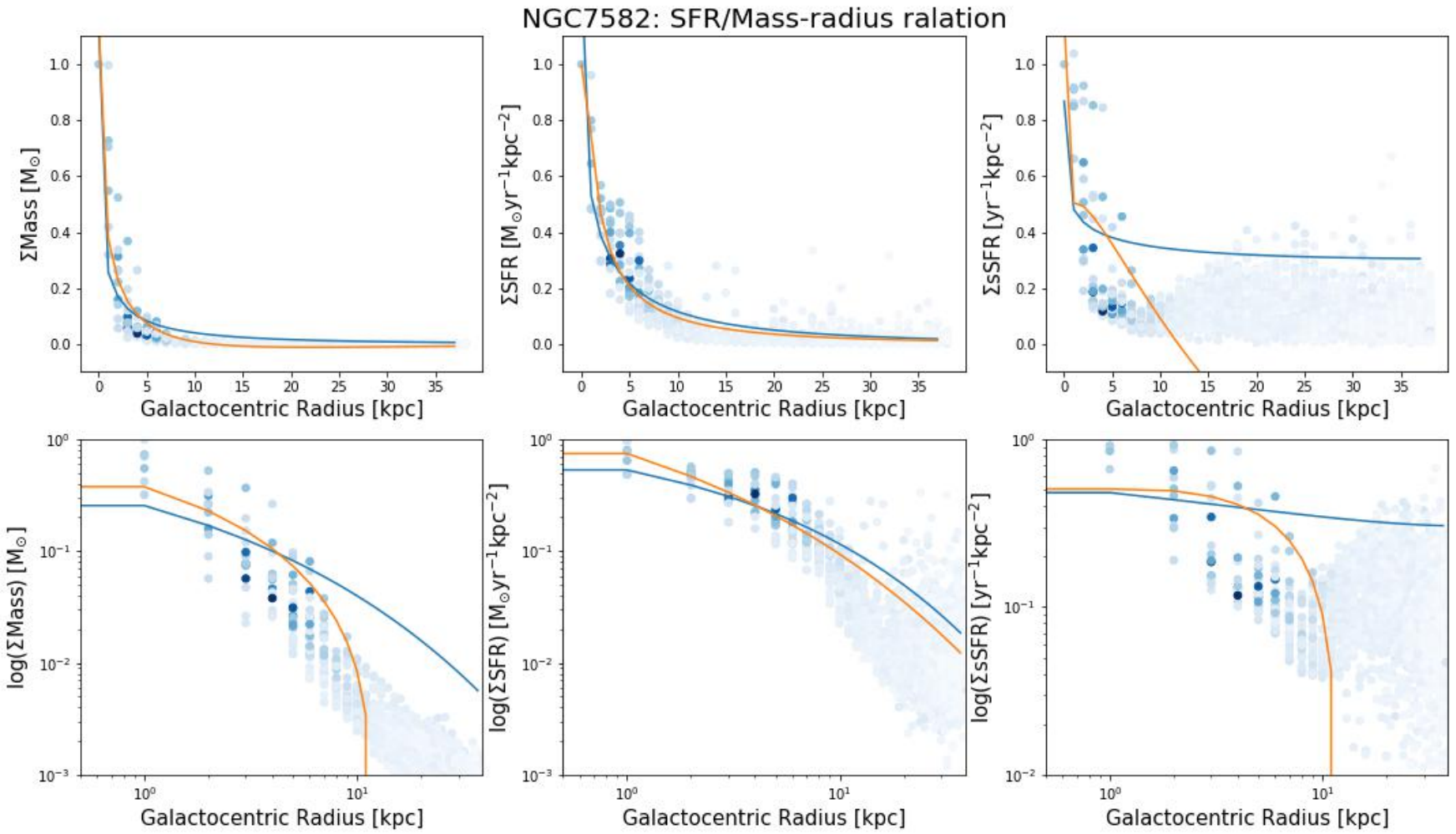


- The Mass and SFR is normalized.
- Fitting: 1 (blue) and 2 (yellow) sersic formula; sSFR is the quotient of SFR/Mass
- The transparency of every spaxel is related to its S/N ratio

Shi et al. (2021)

Result

SFR/Mass - Galactocentric radius relation within D_{eff}



- sSFR = SFR/Mass
- Inside-out quenching process
- The blue and yellow lines in the third column is not a fitting, but directly, the division between SFR fitting and Mass fitting.

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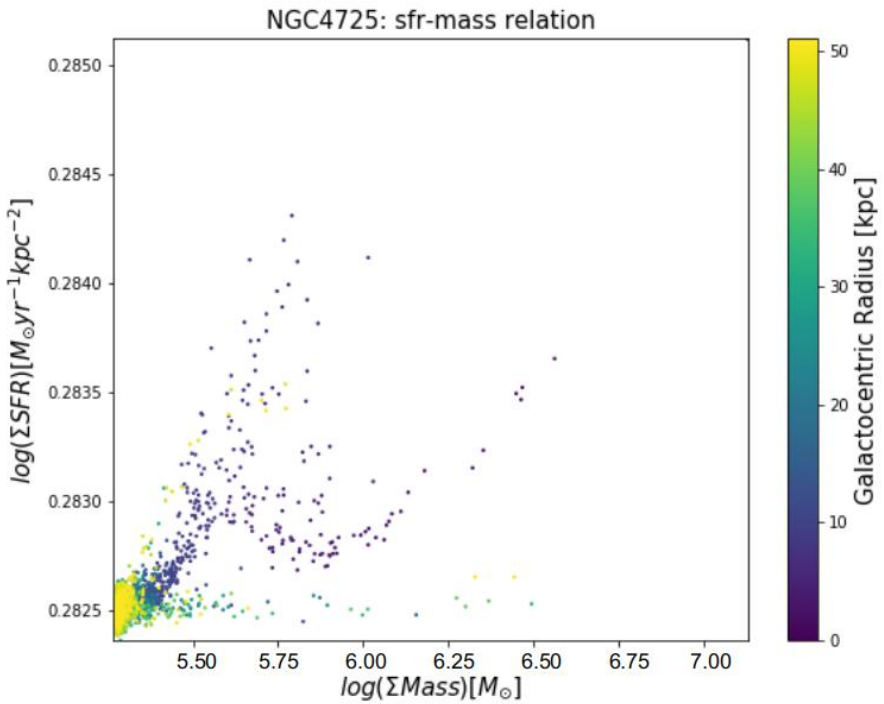
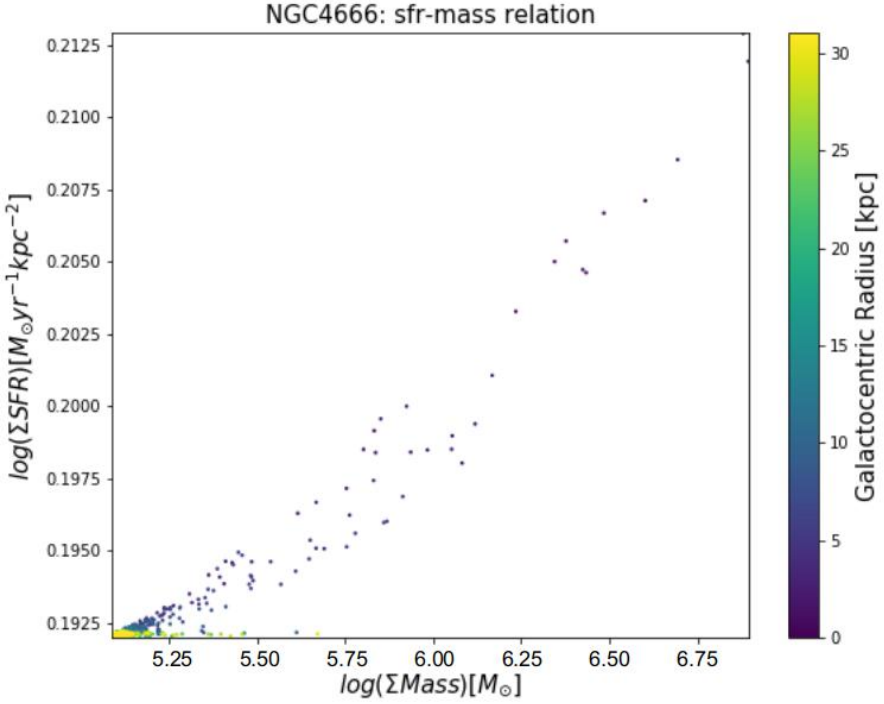
Result





Shi et al. (2021)

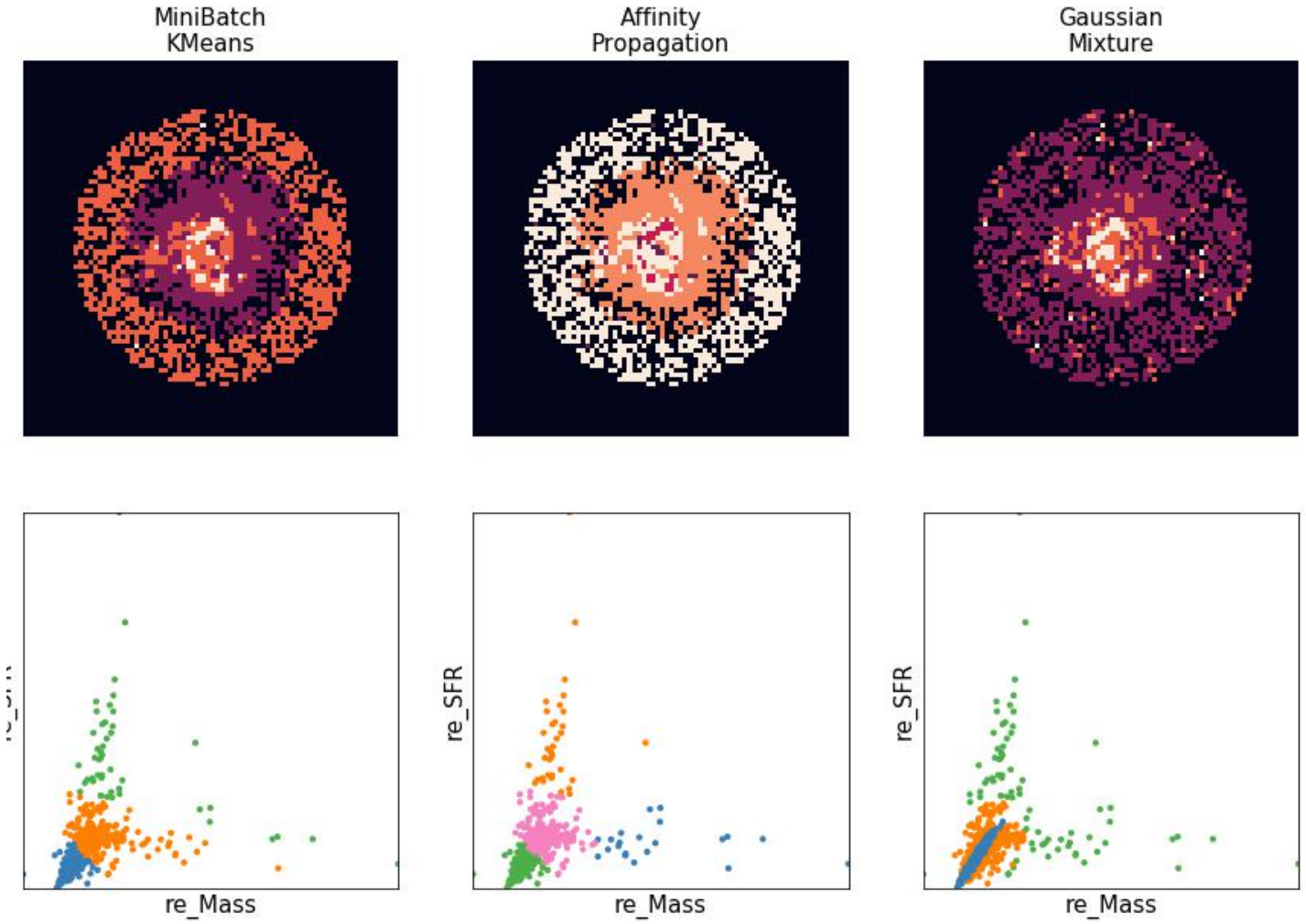
Spatially resolved SFR-M relation for individual galaixies

- Colors are given to the dots according to their Galactocentric radius.
- But we need some method to describe (clustering?) them if we want to study the relation!

Result

Can we identify the active and passive regions (structures) in galaxies?

- 3 clusering methods
- residuals: the difference between SFR/Mass and fitting prediction
- The first row shows identified regions within D_{eff} (the colors doesn't matter)
- The second row is the corresponding re SFR-Mass space for the spaxels.

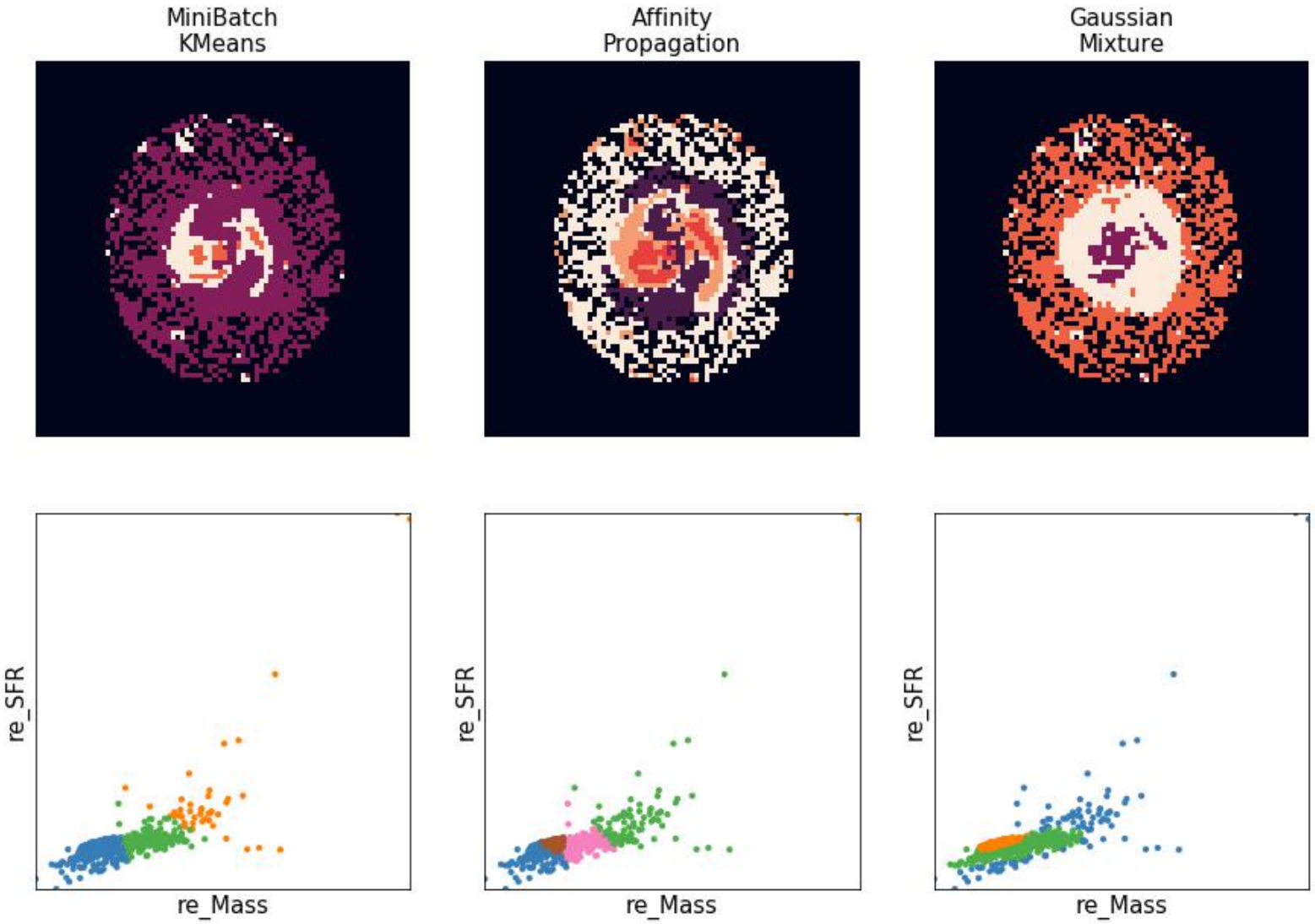


Shi et al. (2021)

Result

Can we identify the active and passive regions (structures) in galaxies?

- Some structures can be identified with this method.



Shi et al. (2021)

Conclusion and future

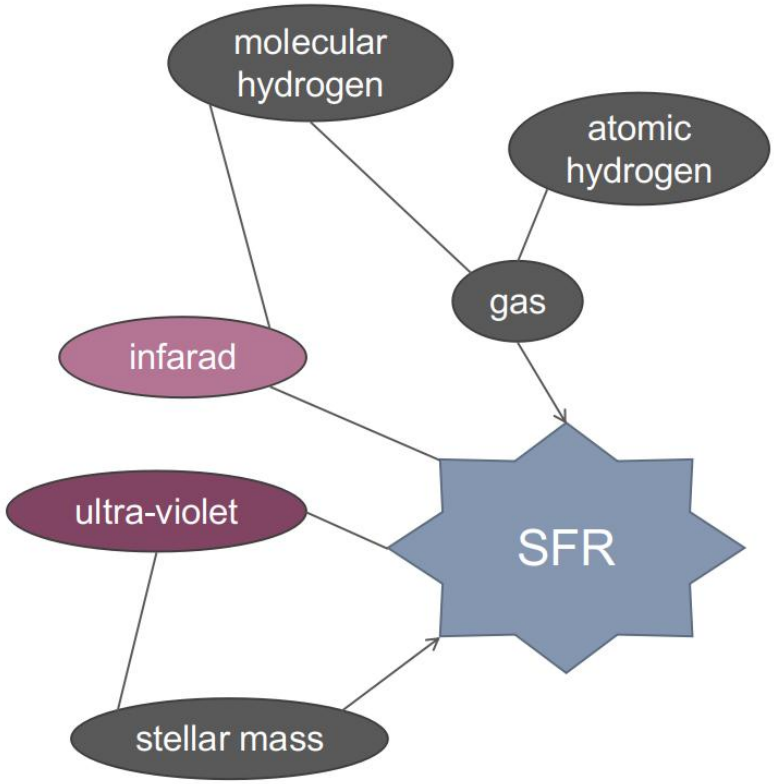
We studied spatially resolved SFR and SFMS for hundreds of nearby galaxies.

When divided with concentric ellipse rings, the star formation rate along the radius shows different patterns of SFR/Mass & sSFR.

Seek for more sophisticated algorithms to deal with them.

Comparision of different SFR & mass estimation methods

Sample size & significance test & improved fitting method & more indicators……



Thank You!