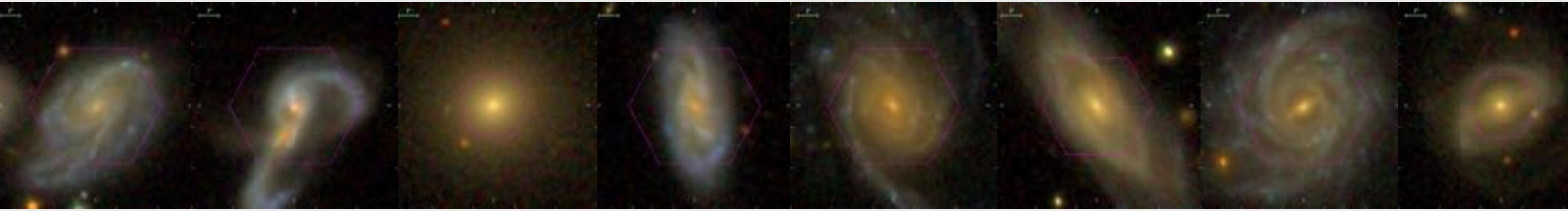
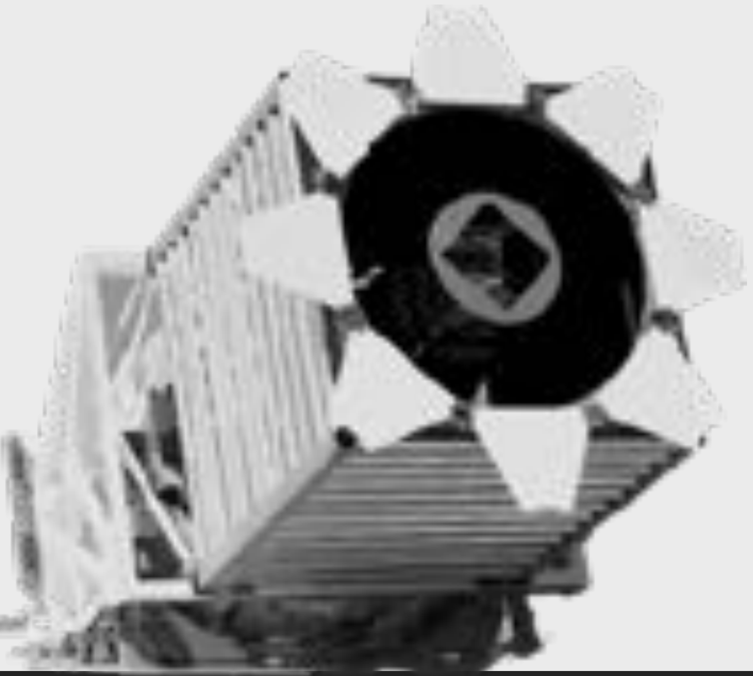
Stellar and Molecular Gas Properties of MaNGA Galaxies



Hsi-An Pan

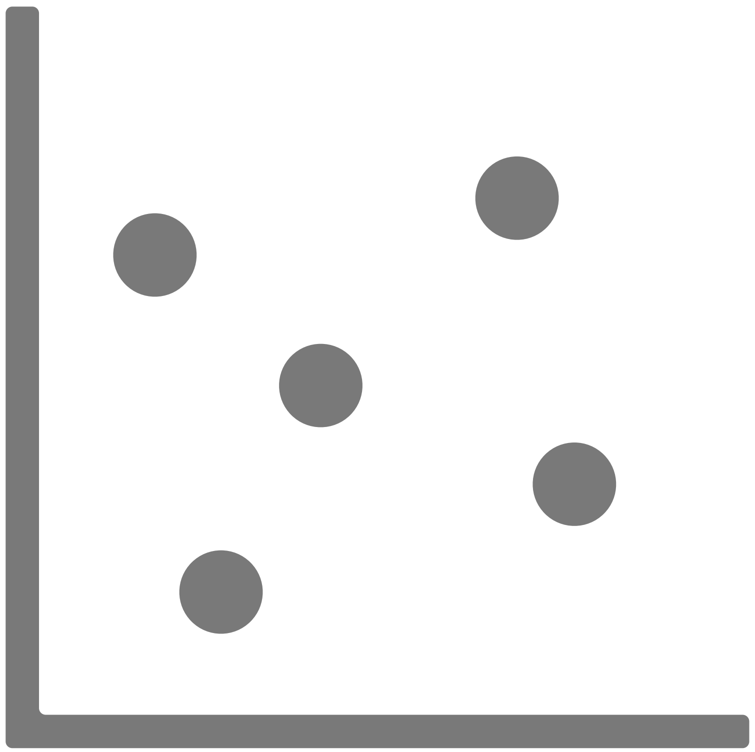
ASIAA

Lihwai Lin, Bau-Ching Hsieh ,Sebastian Sanchez, Hector Ibarra-Medel, Mederic Boquien, Ivan Lacerna, Maria Argudo-Fernandez, Dmitry Bizyaev, Mariana Cano-Dıaz, Niv Drory , Yang Gao, Karen Masters, Kaike Pan, Martha Tabor, Patricia Tissera, and Ting Xiao
and the JINGLE Team



Outline

Outline



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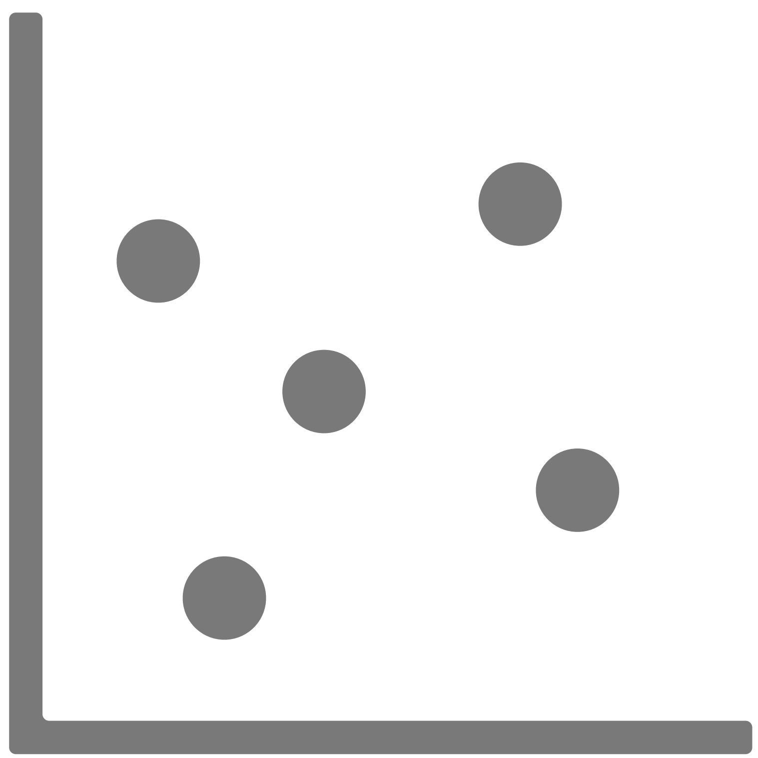
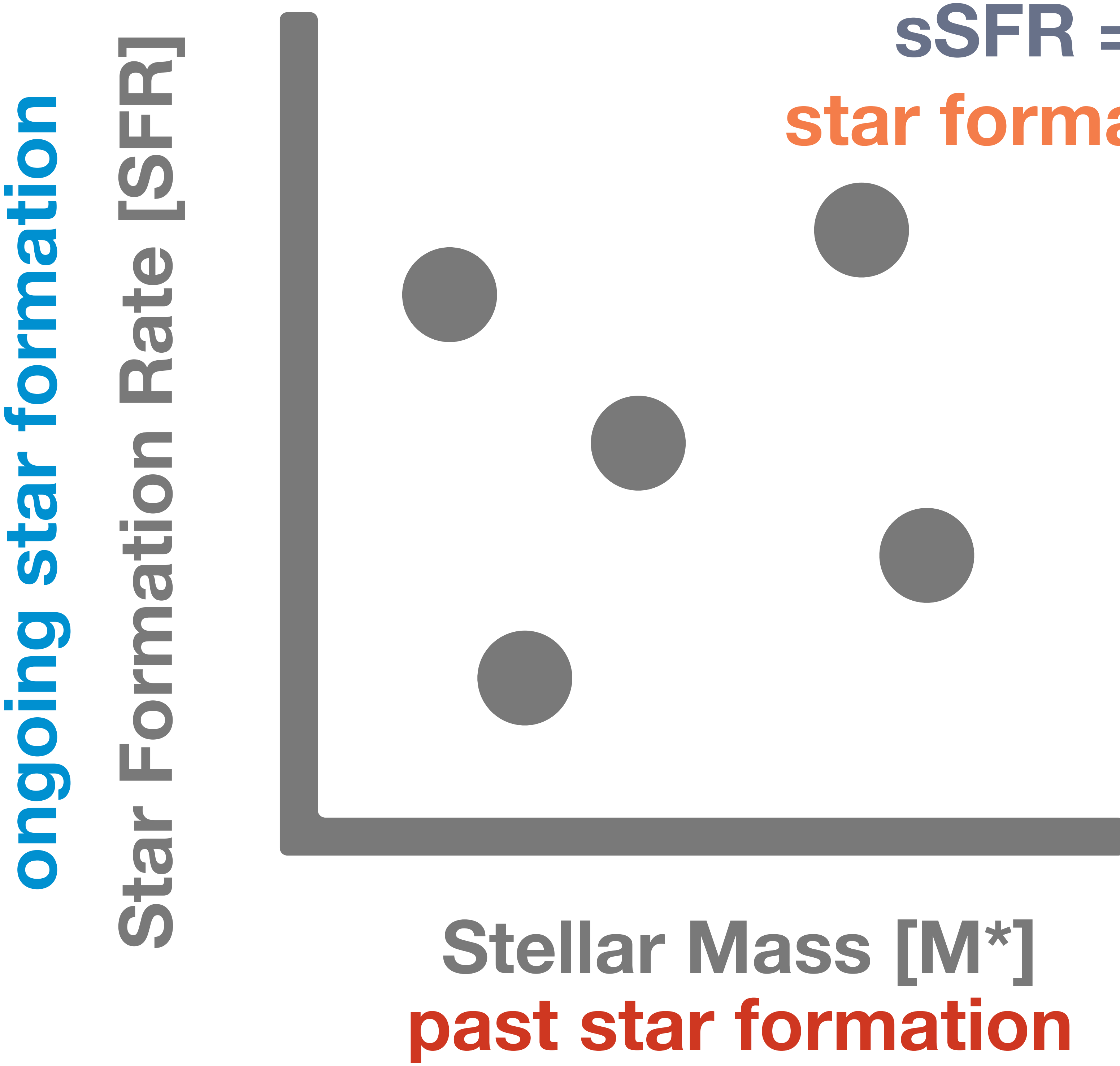


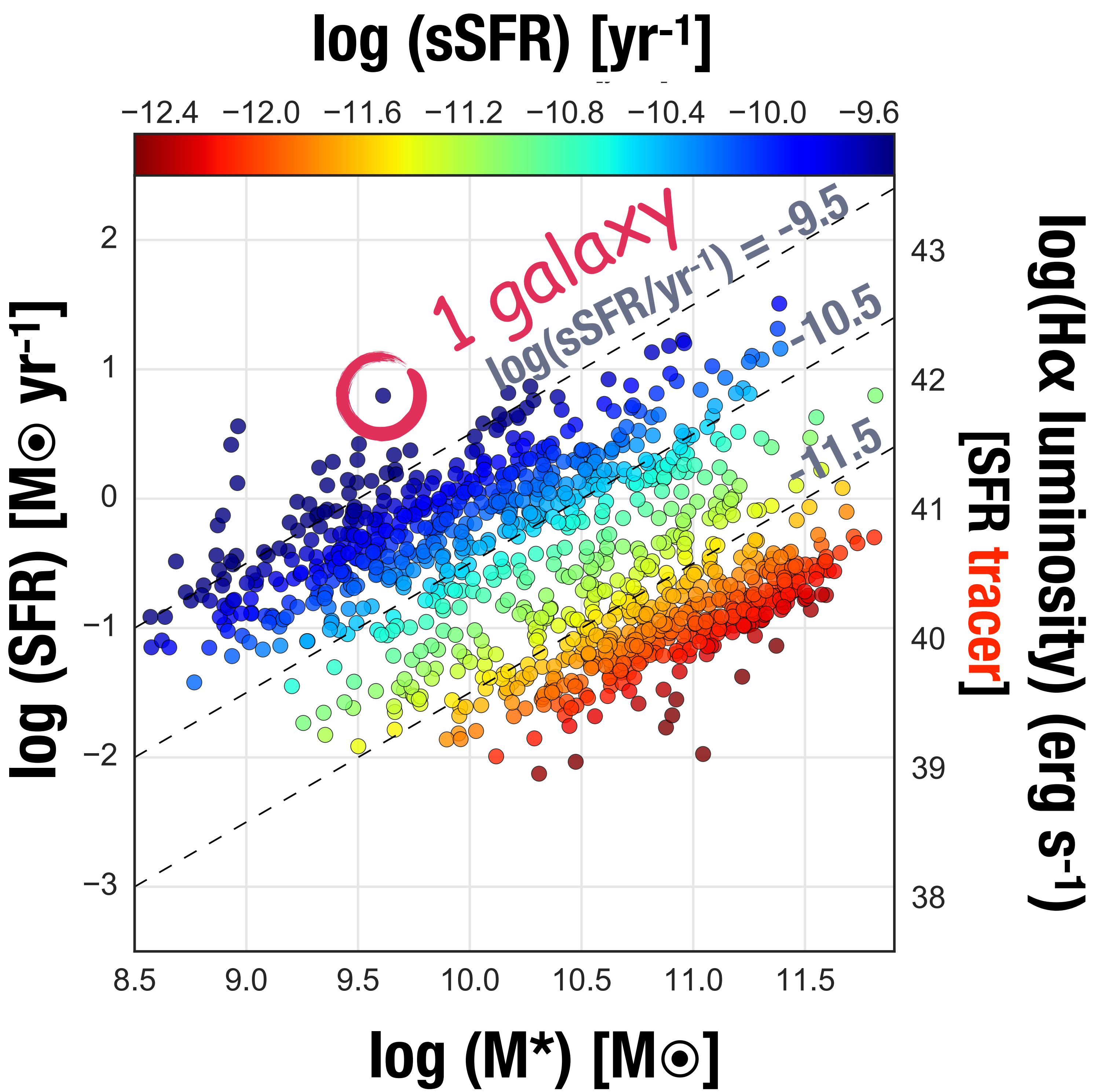
Galaxy SFR-Stellar Mass Relation

sSFR = SFR/M*

star formation history



Integrated SFR-M* Relation of Galaxy



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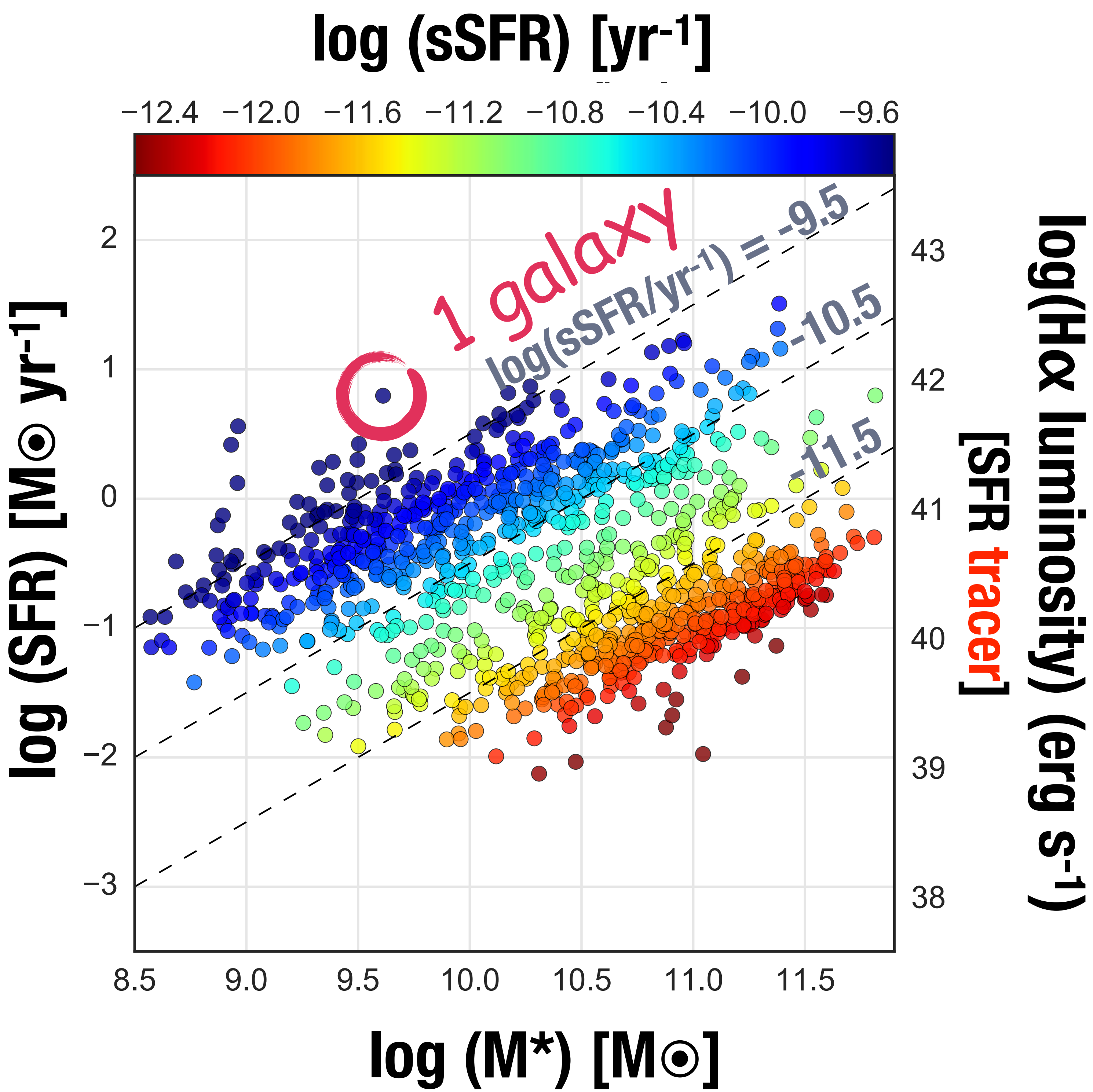
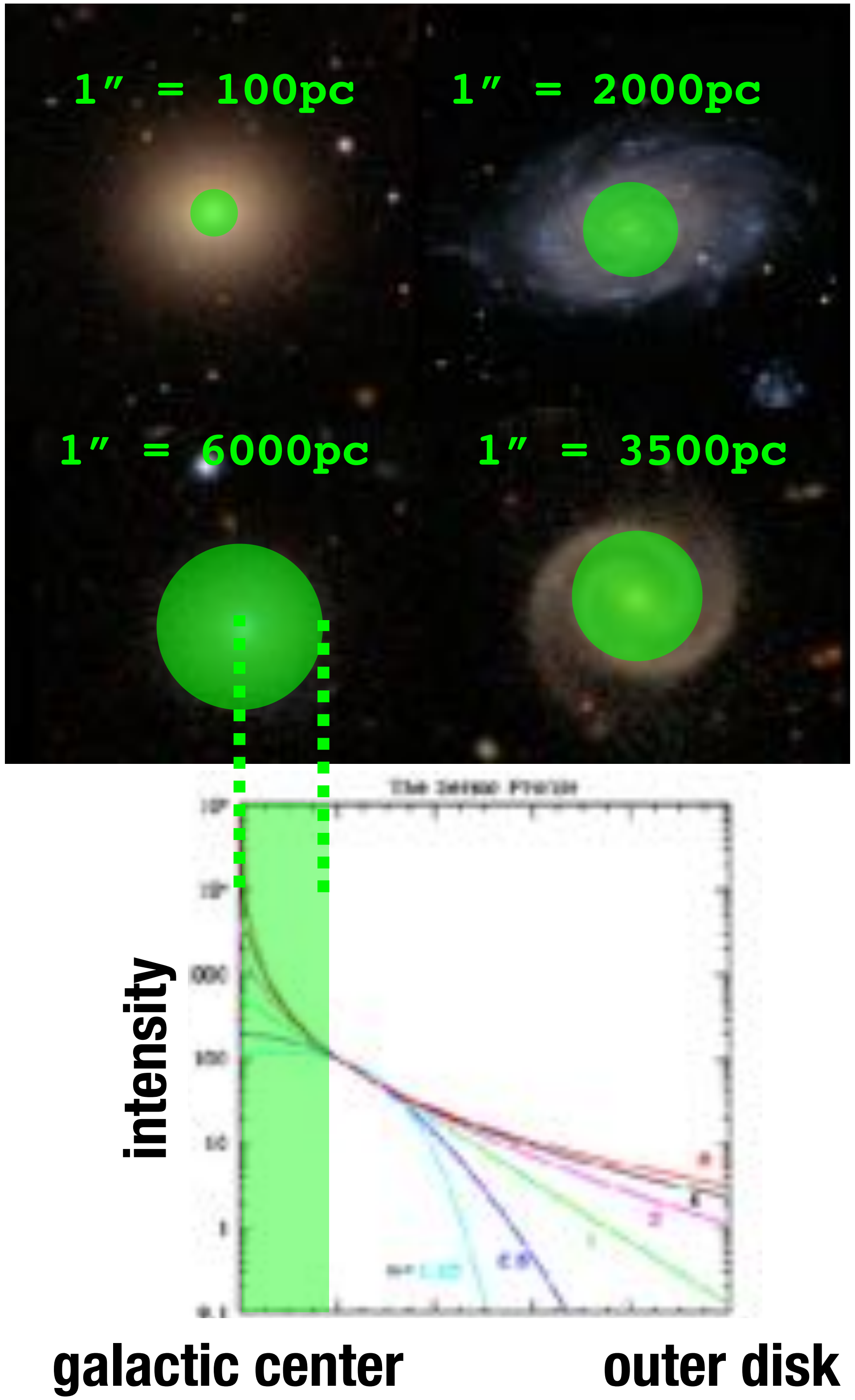


fixed aperture angular size



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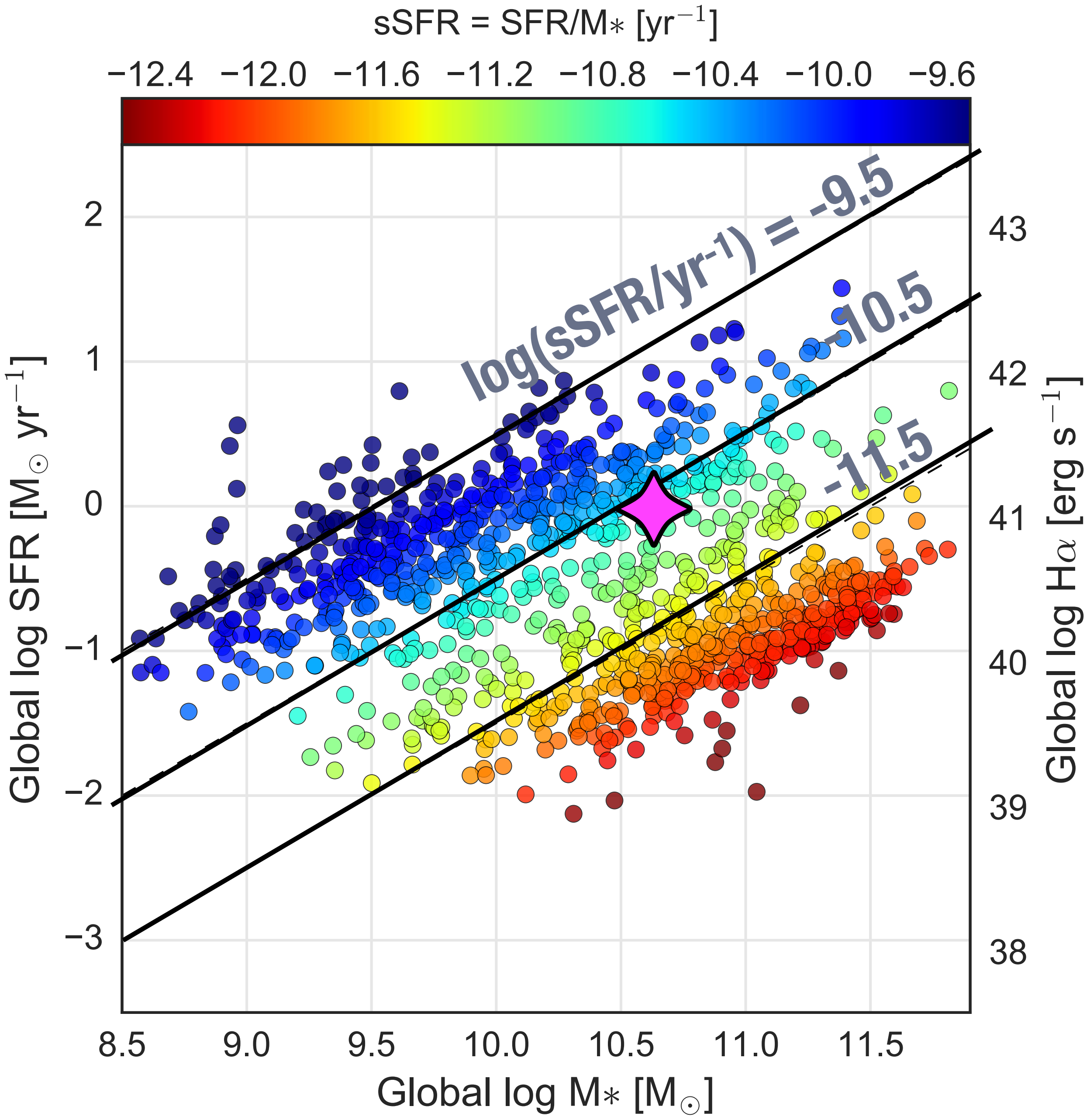

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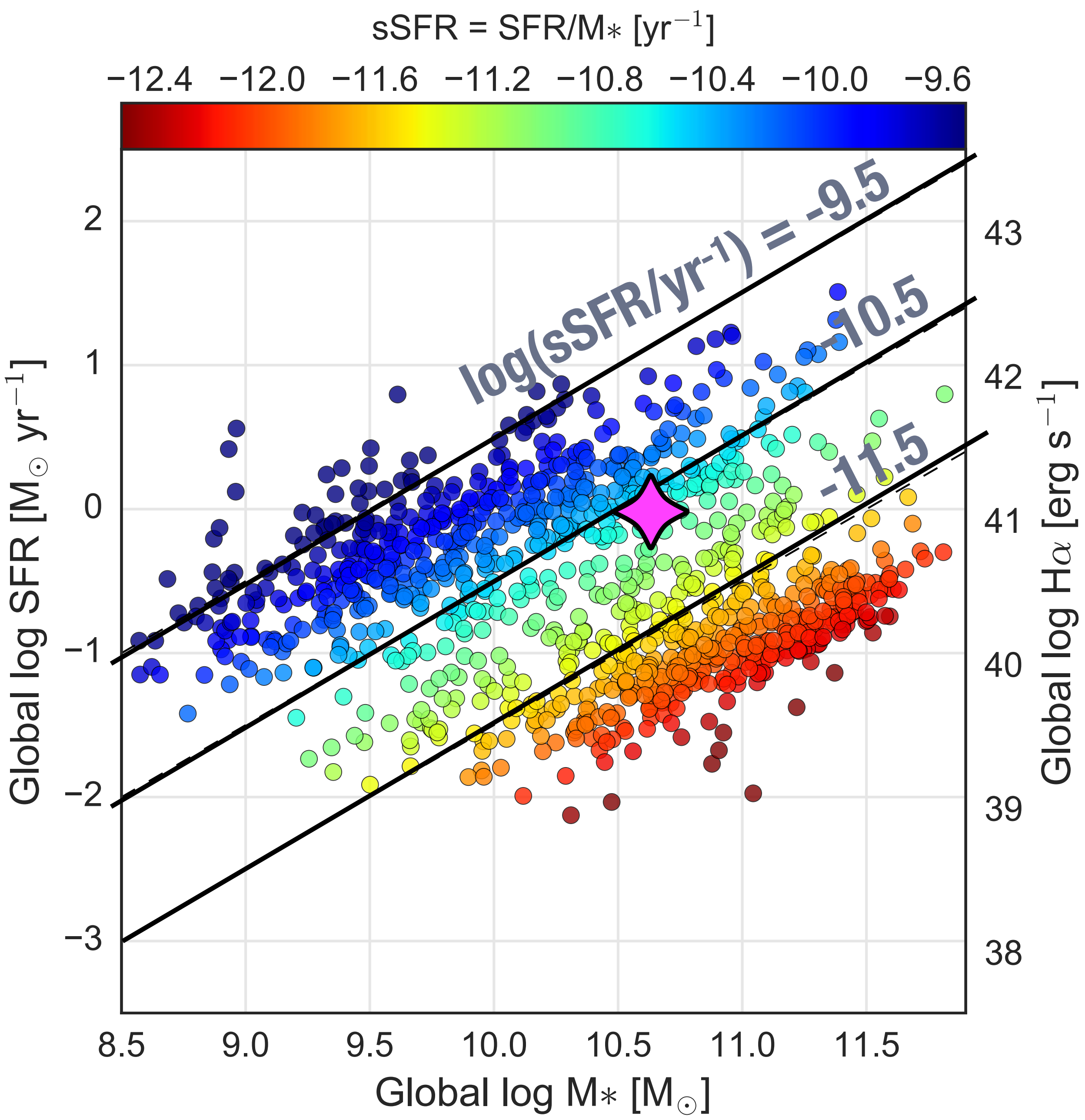
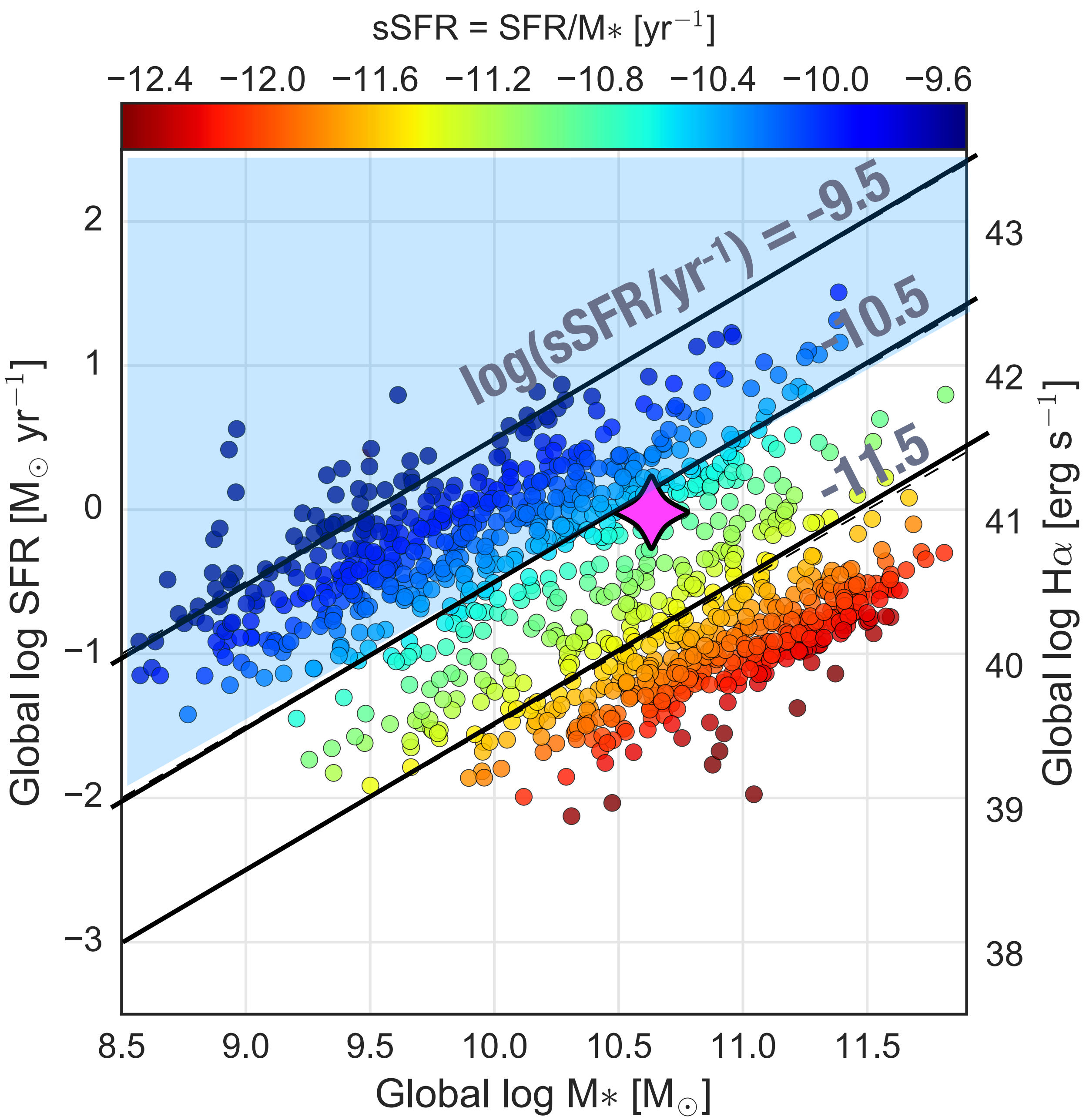


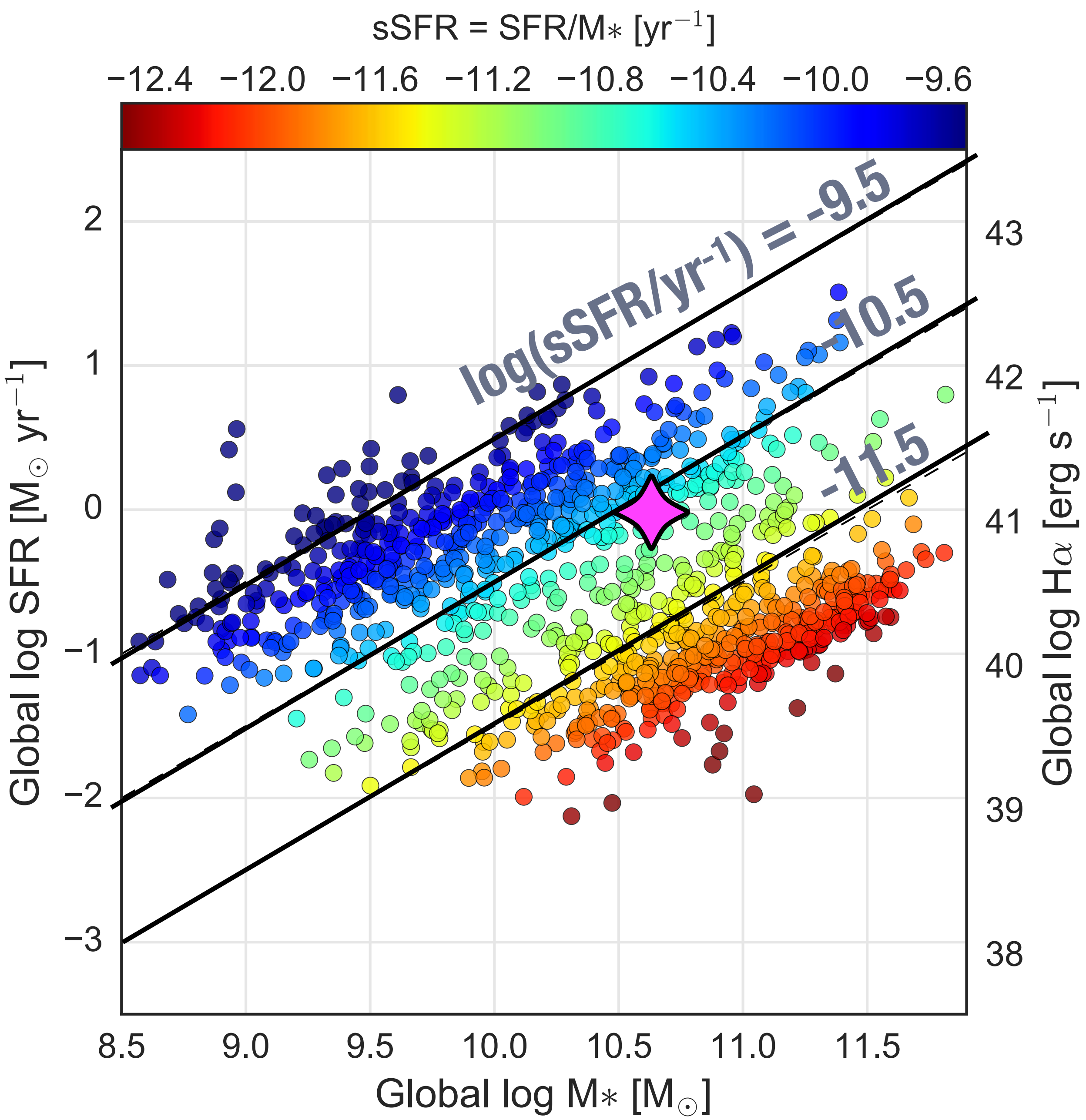
1. **bimodality**

Integrated SFR-M* Relation of Galaxy



1. **bimodality**
   - **star-forming (blue clouds)**

Integrated SFR-M* Relation of Galaxy



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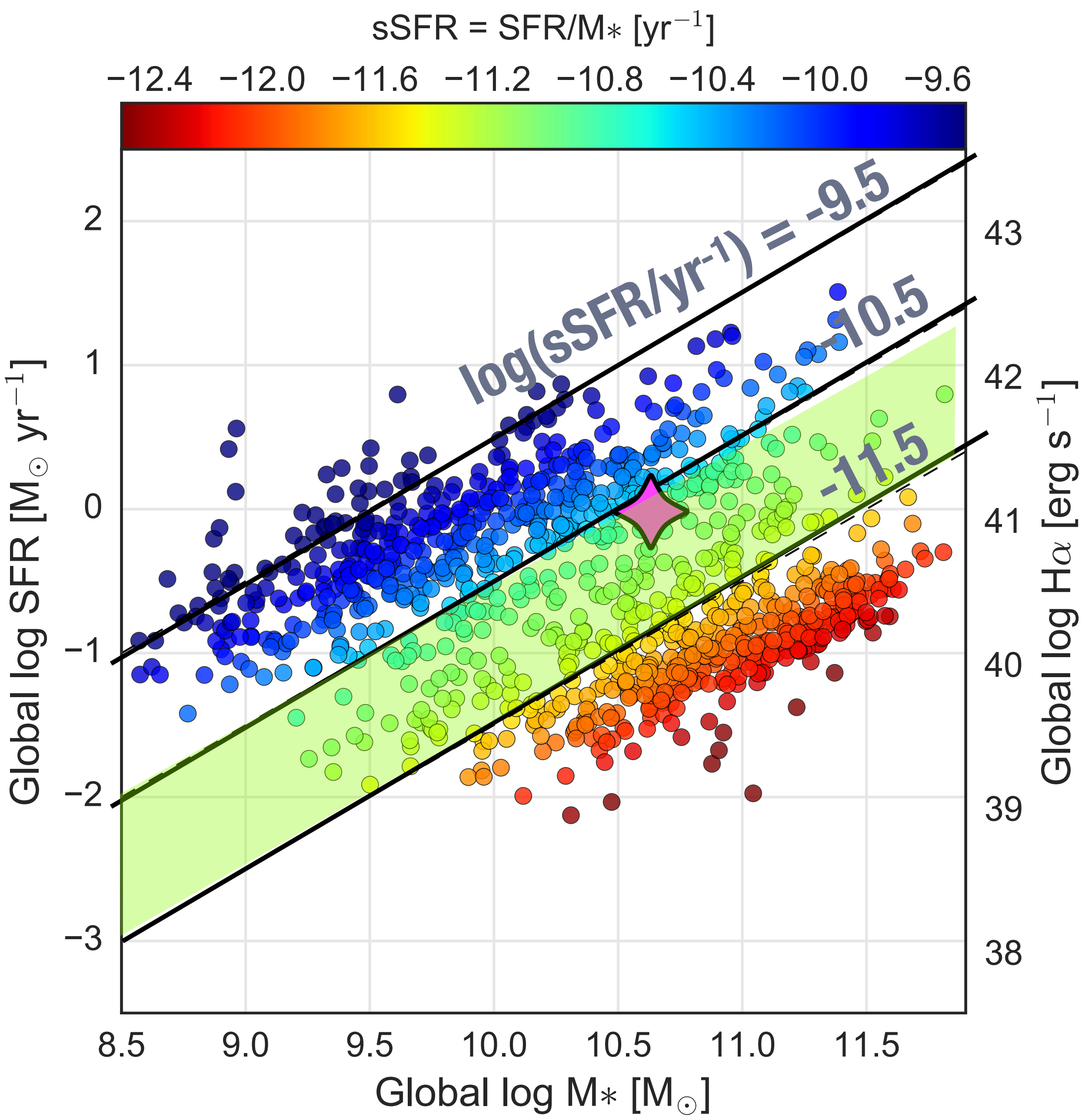
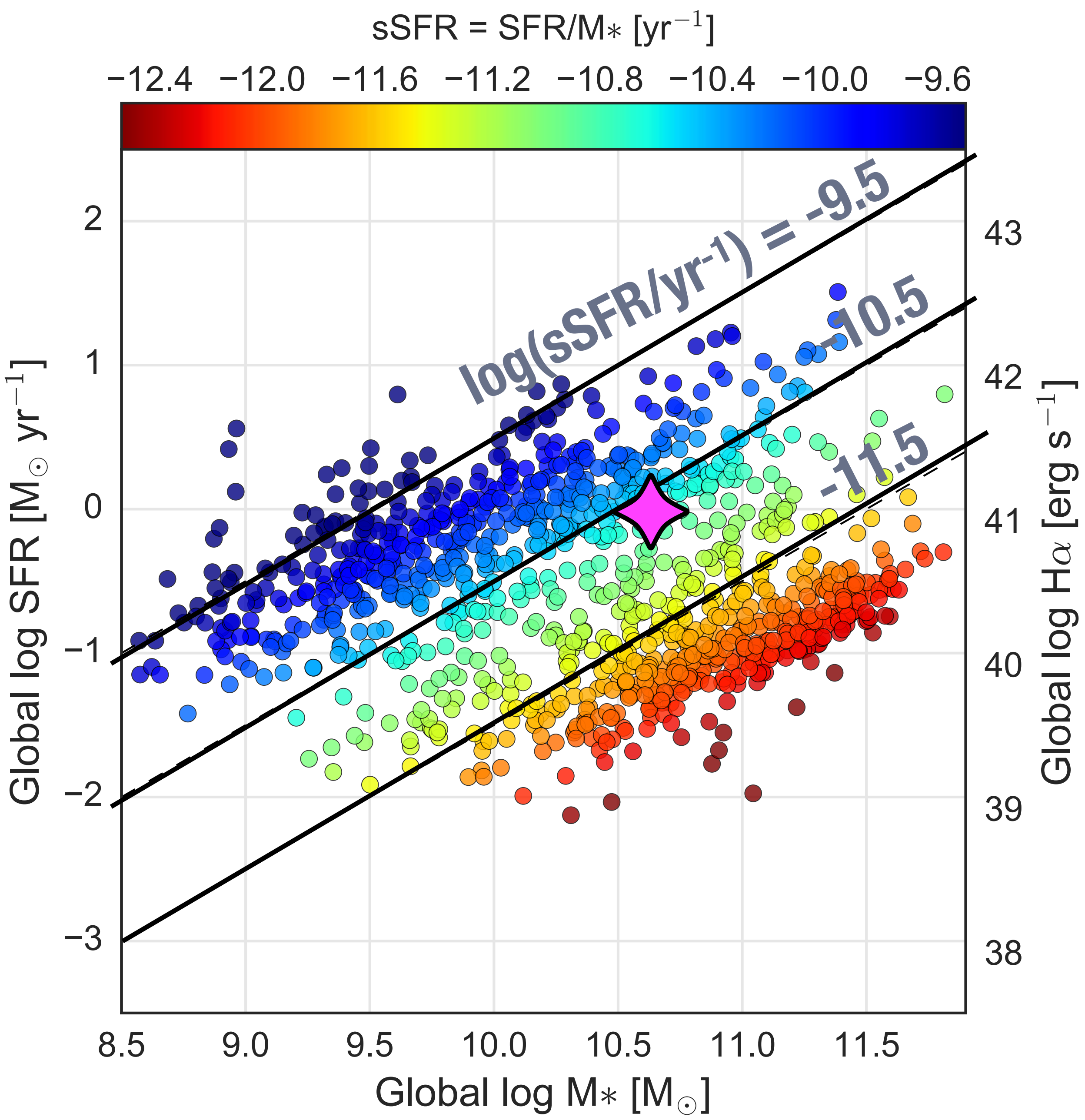


1. **bimodality**
   - **green valley**

Integrated SFR-M* Relation of Galaxy



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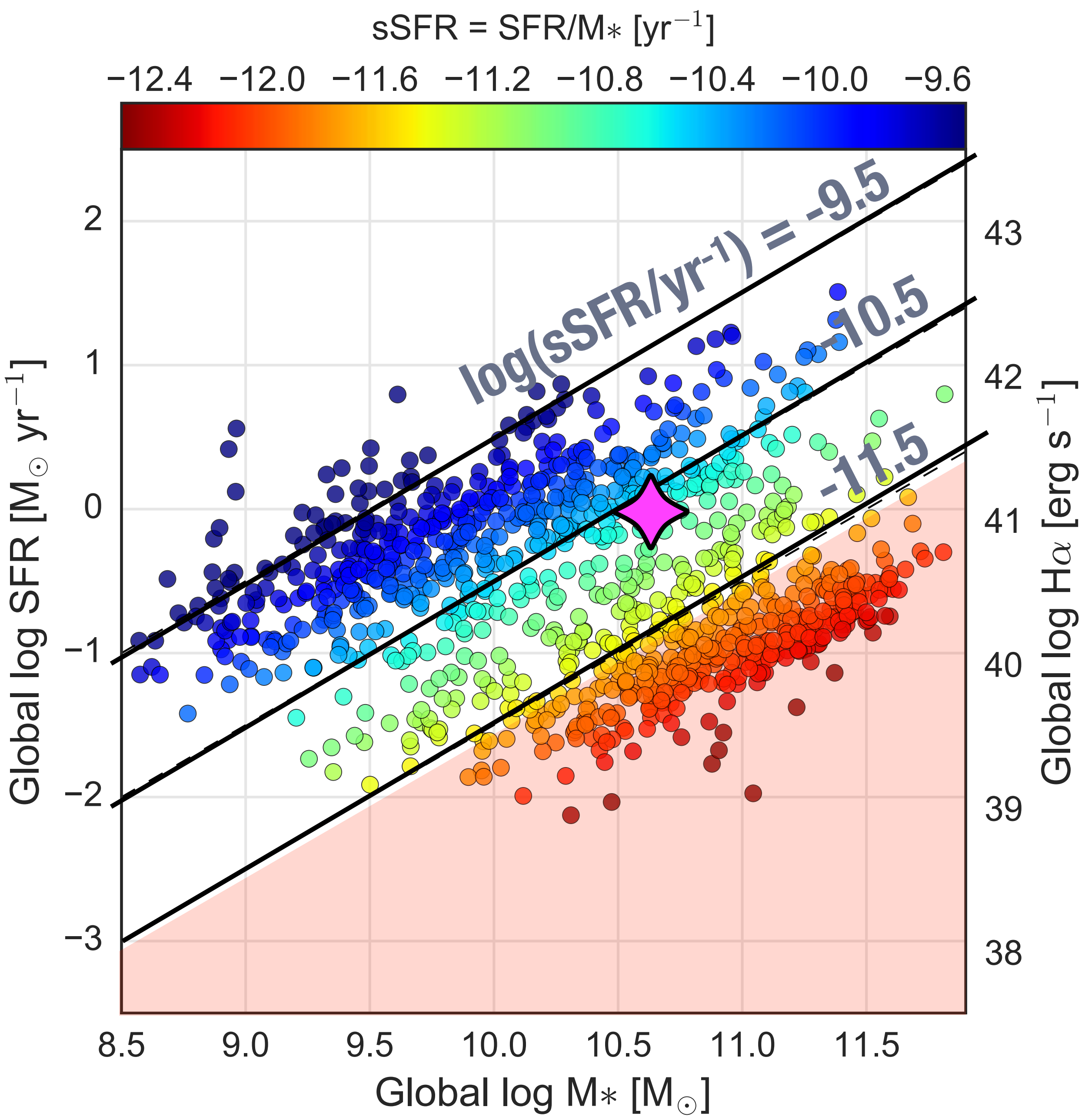
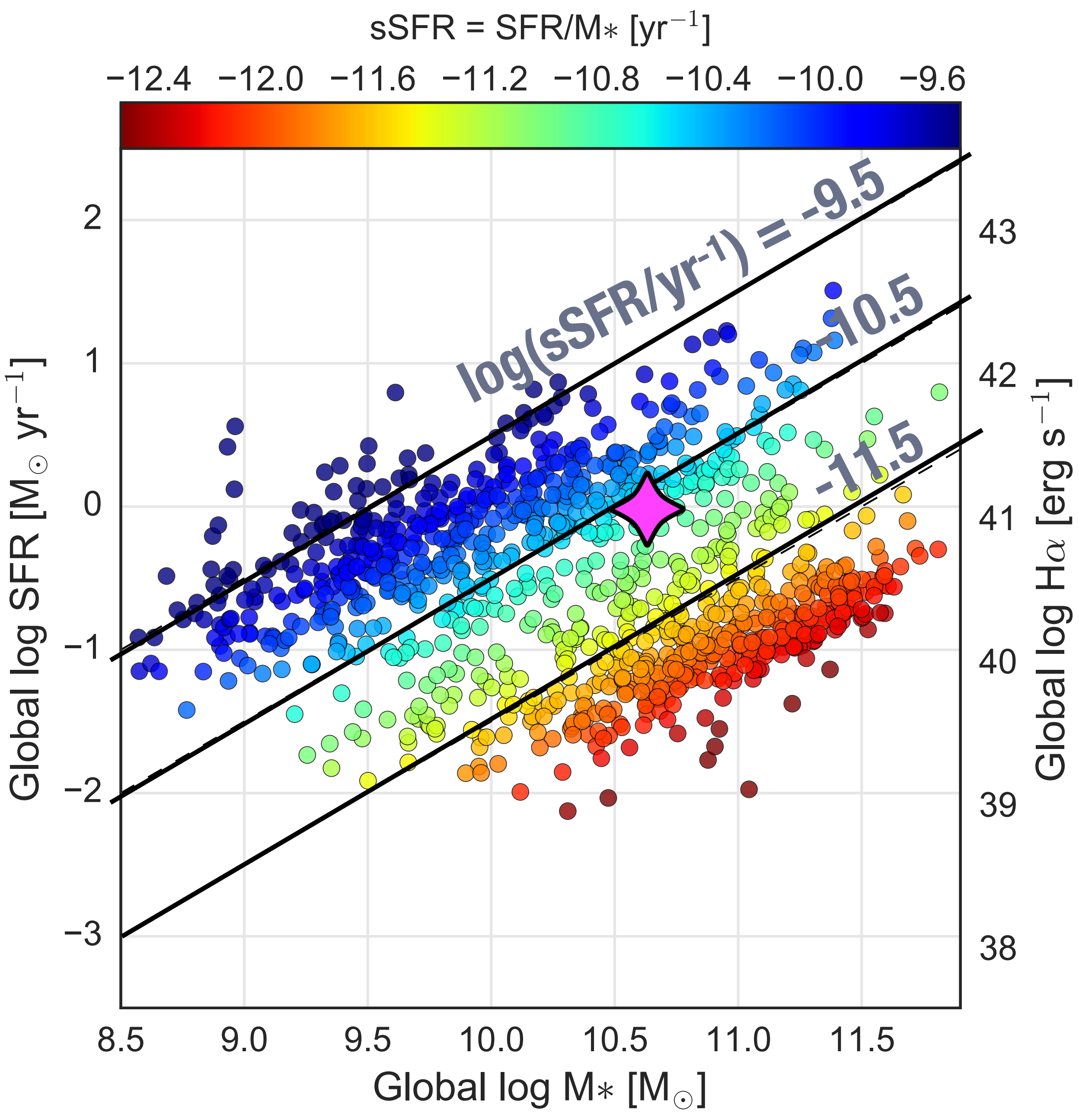


1. **bimodality**
   - **quiescent galaxy**

Integrated SFR-M* Relation of Galaxy



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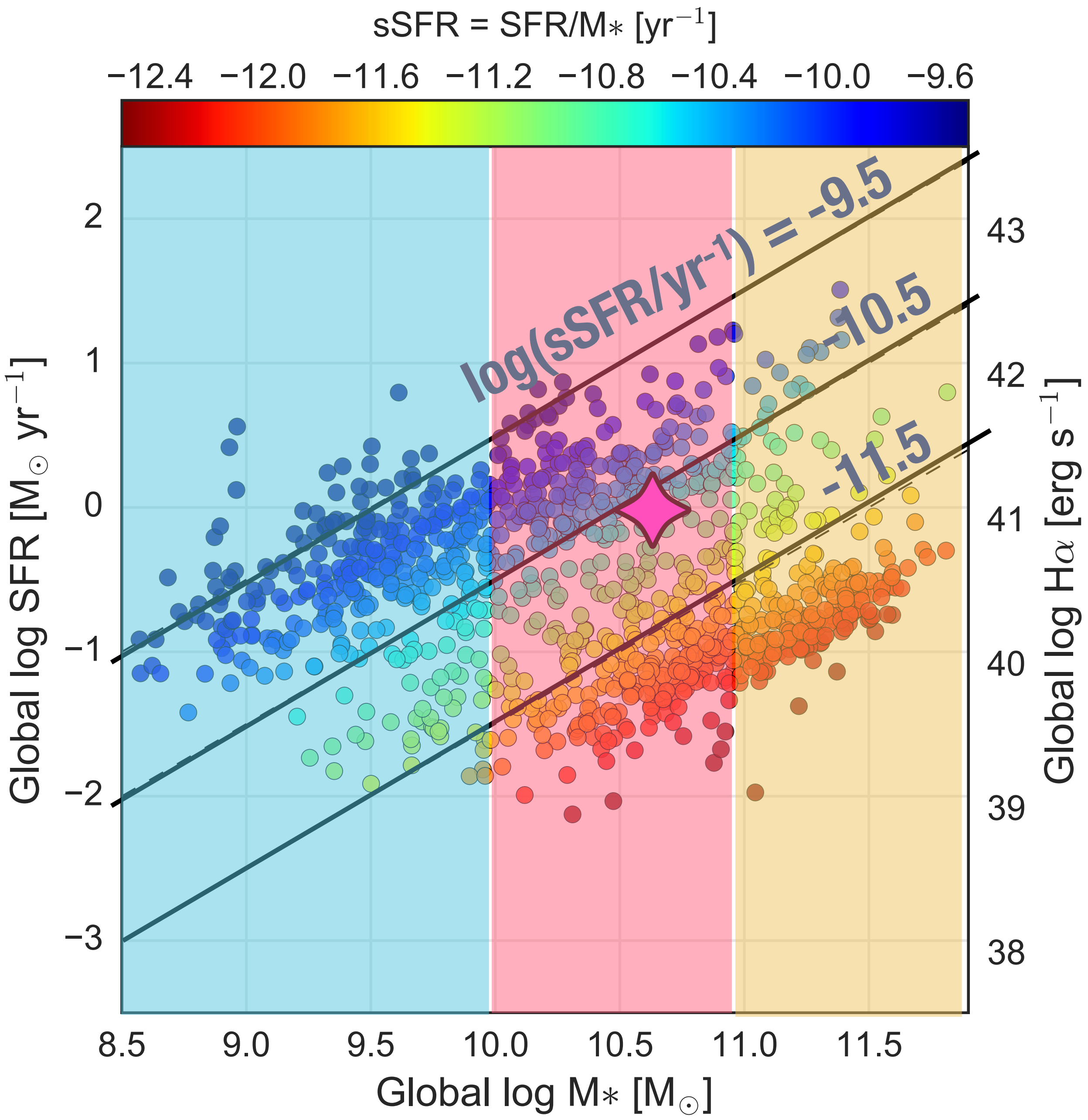
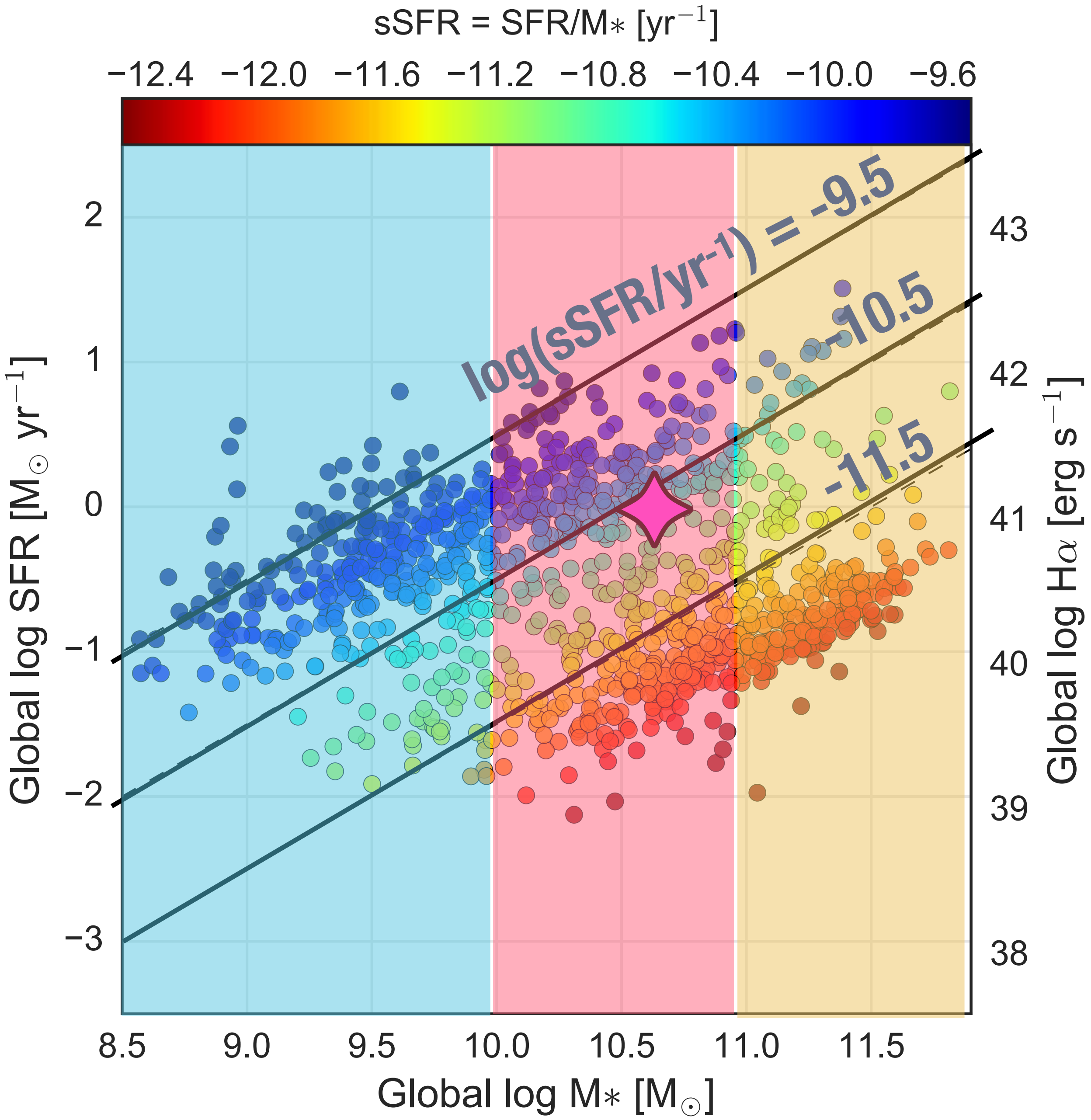


1. **bimodality**

2. **higher the M*, lower the sSFR**

Integrated SFR-M* Relation of Galaxy



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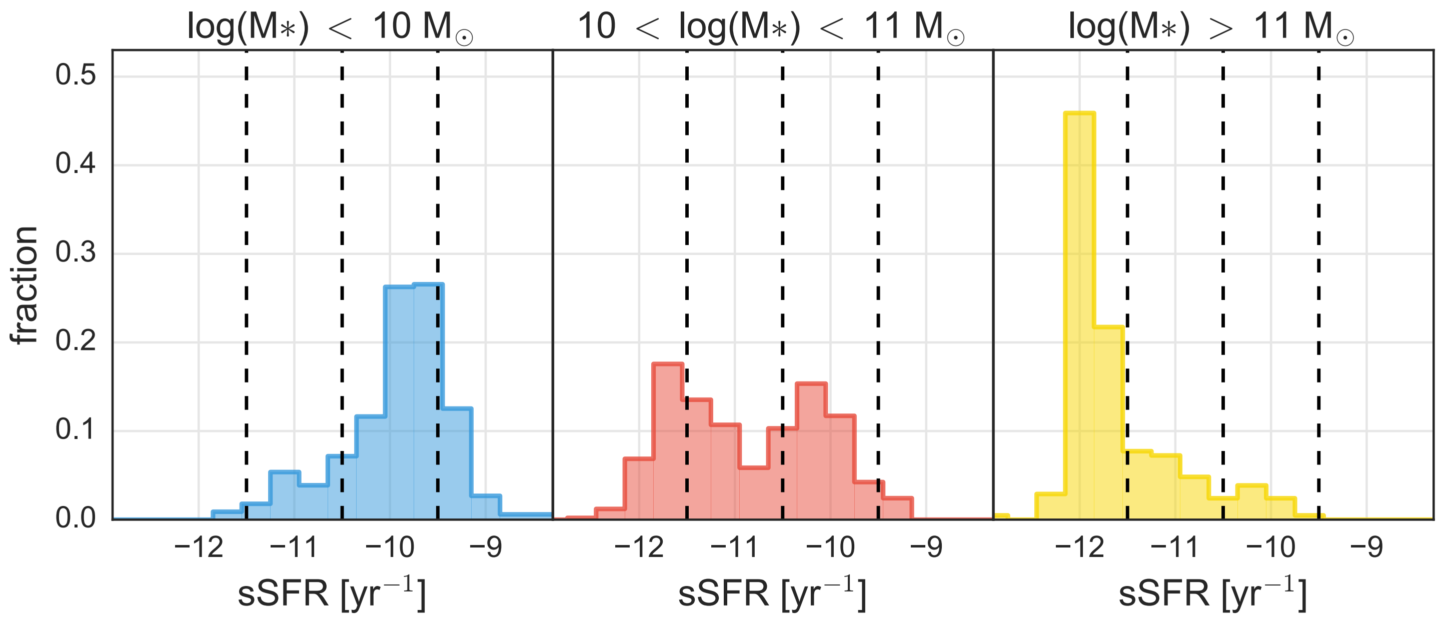
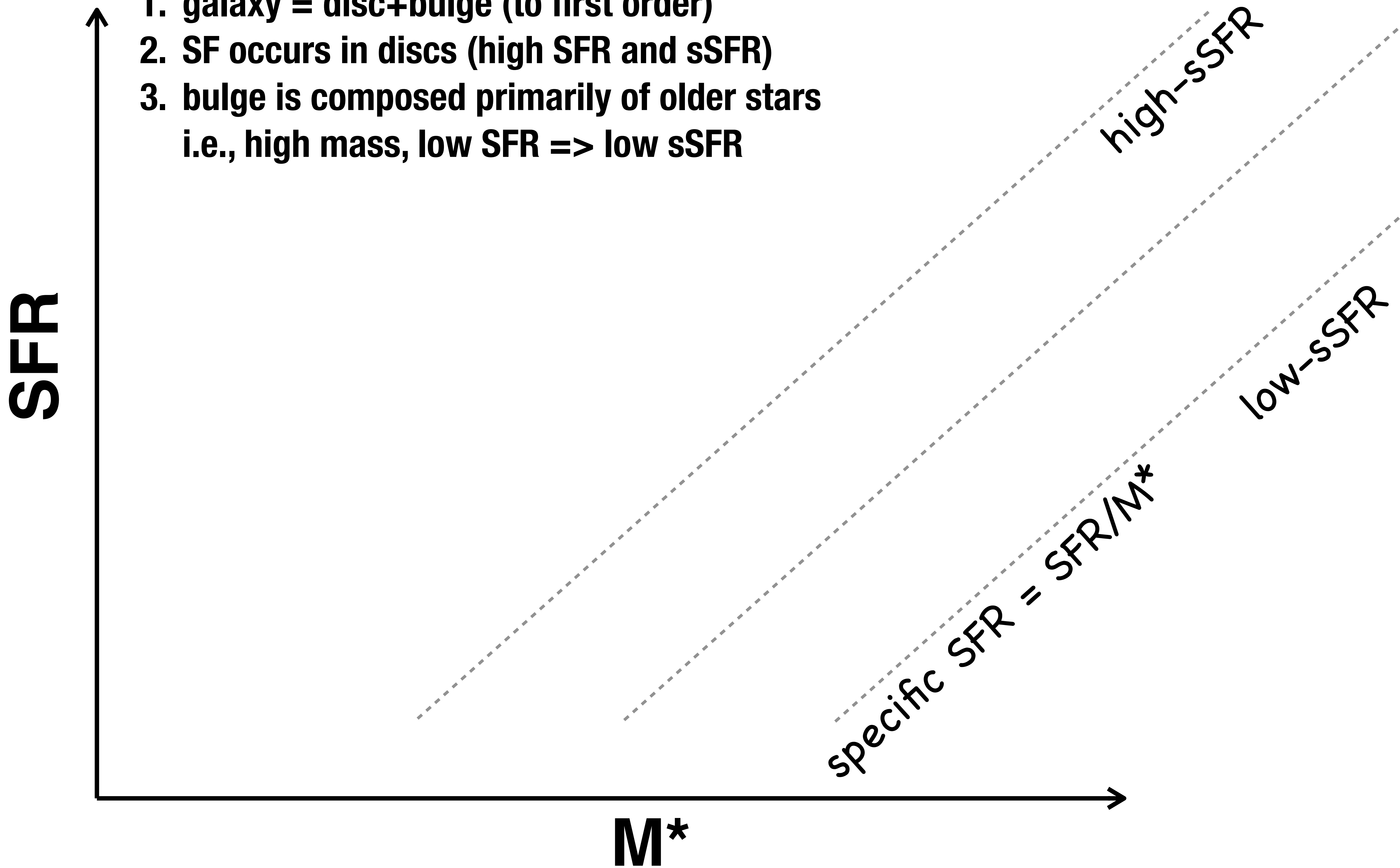


Bulge Growth Scenario

Whitaker+15
Abramson+14

1. galaxy = disc+bulge (to first order)
2. SF occurs in discs (high SFR and sSFR)
3. bulge is composed primarily of older stars
   i.e., high mass, low SFR => low sSFR



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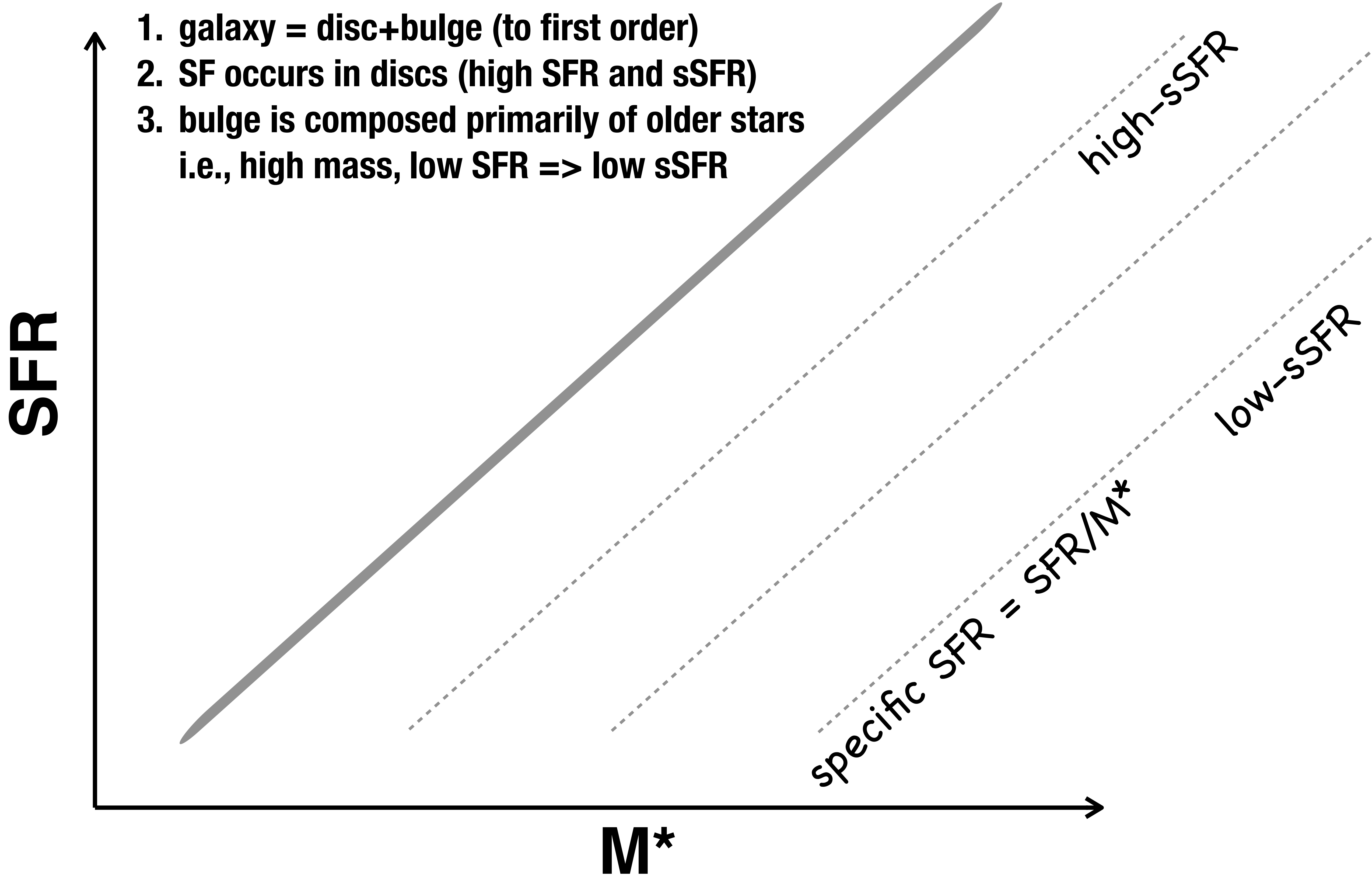

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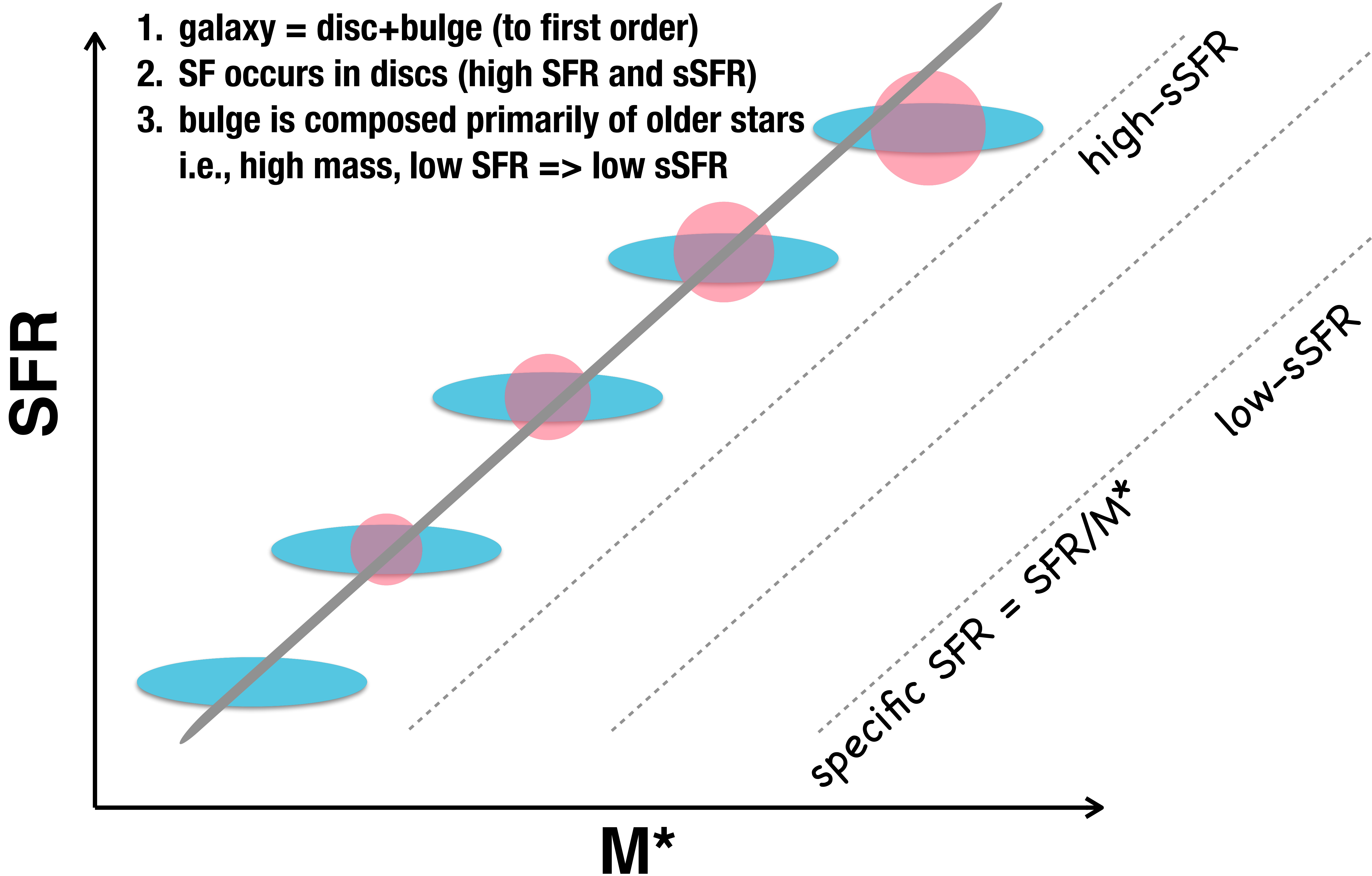

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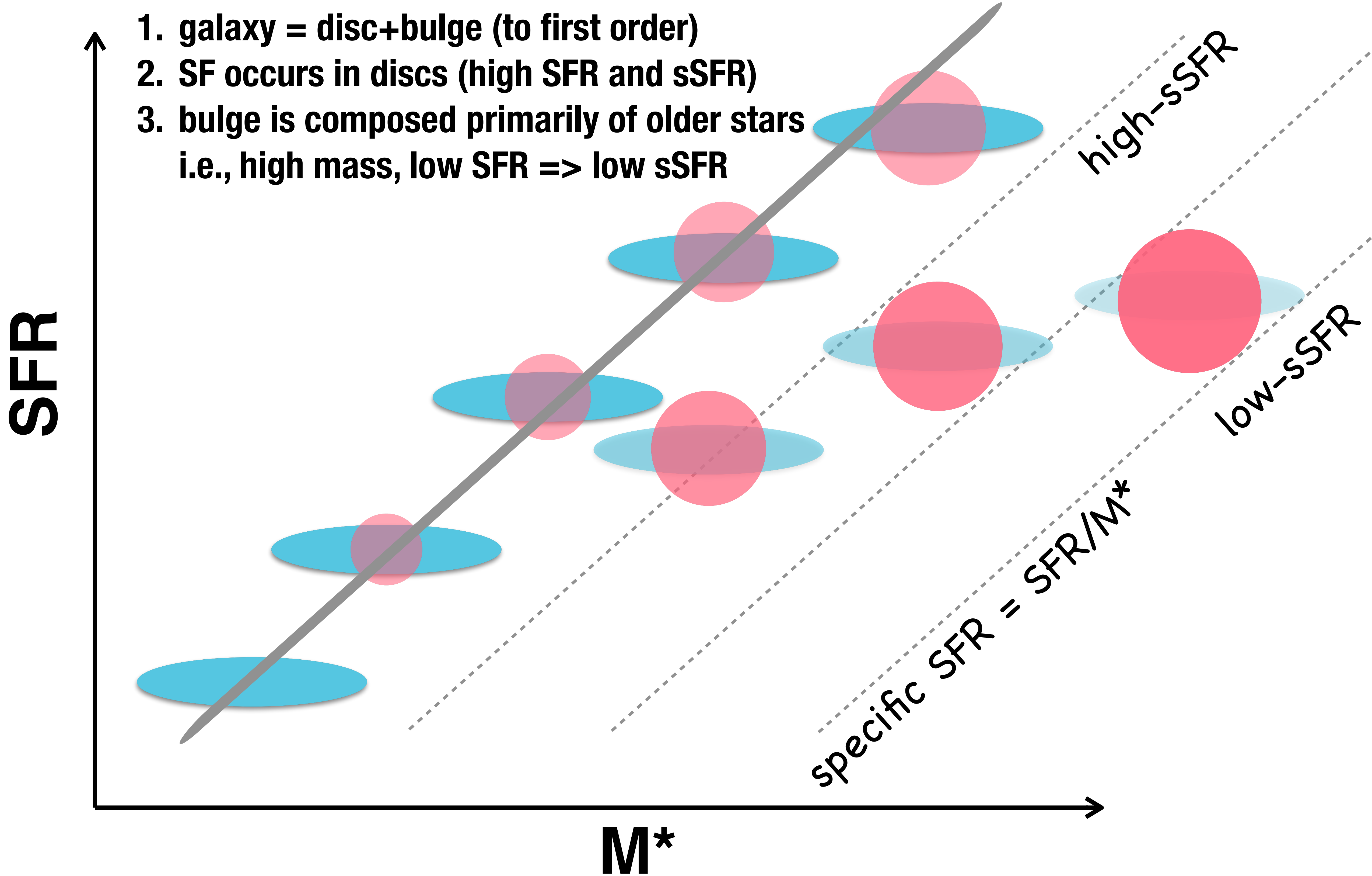

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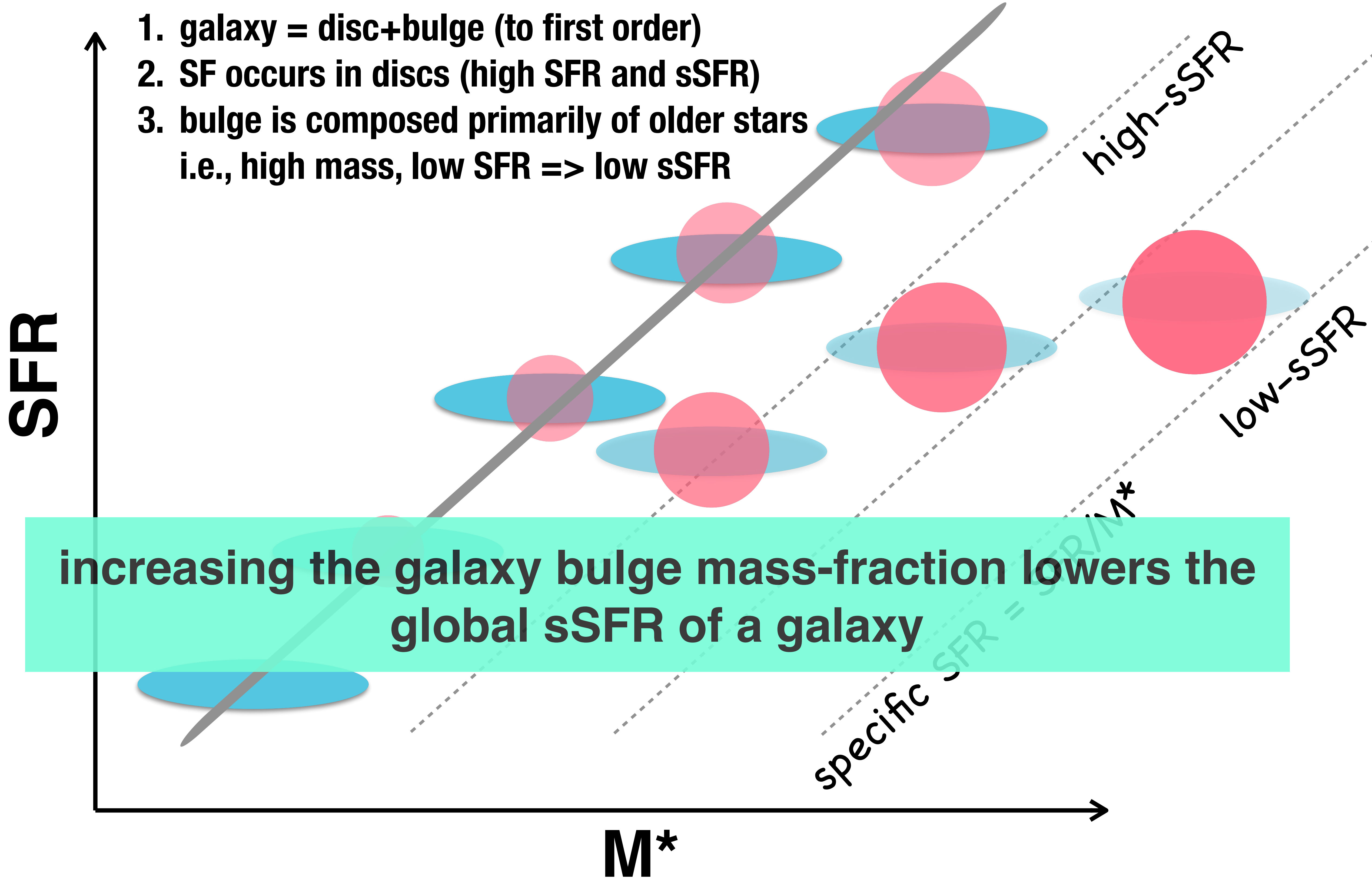

increasing the galaxy bulge mass-fraction lowers the global sSFR of a galaxy

Bulge Growth Scenario

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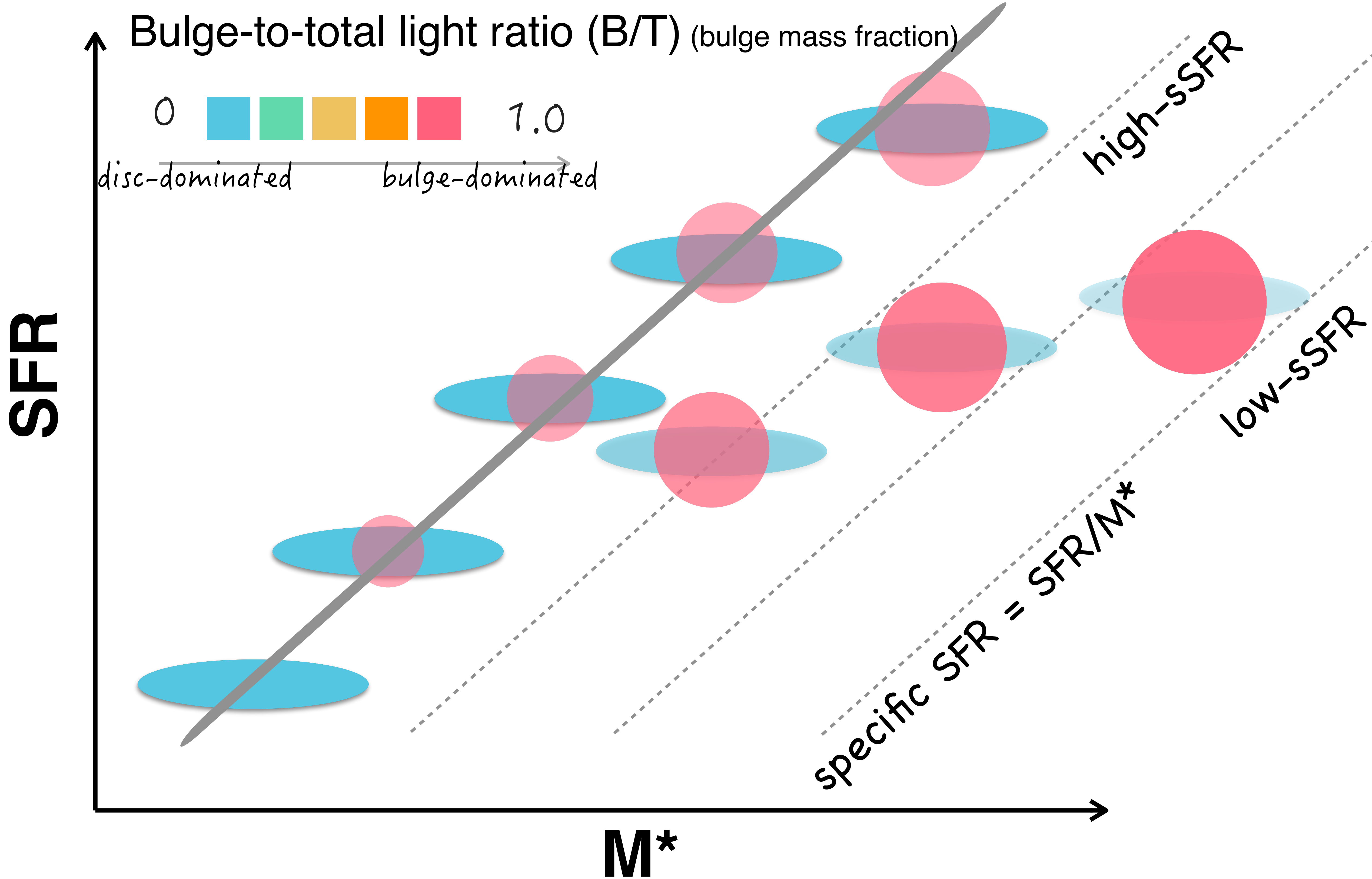
Abramson+14



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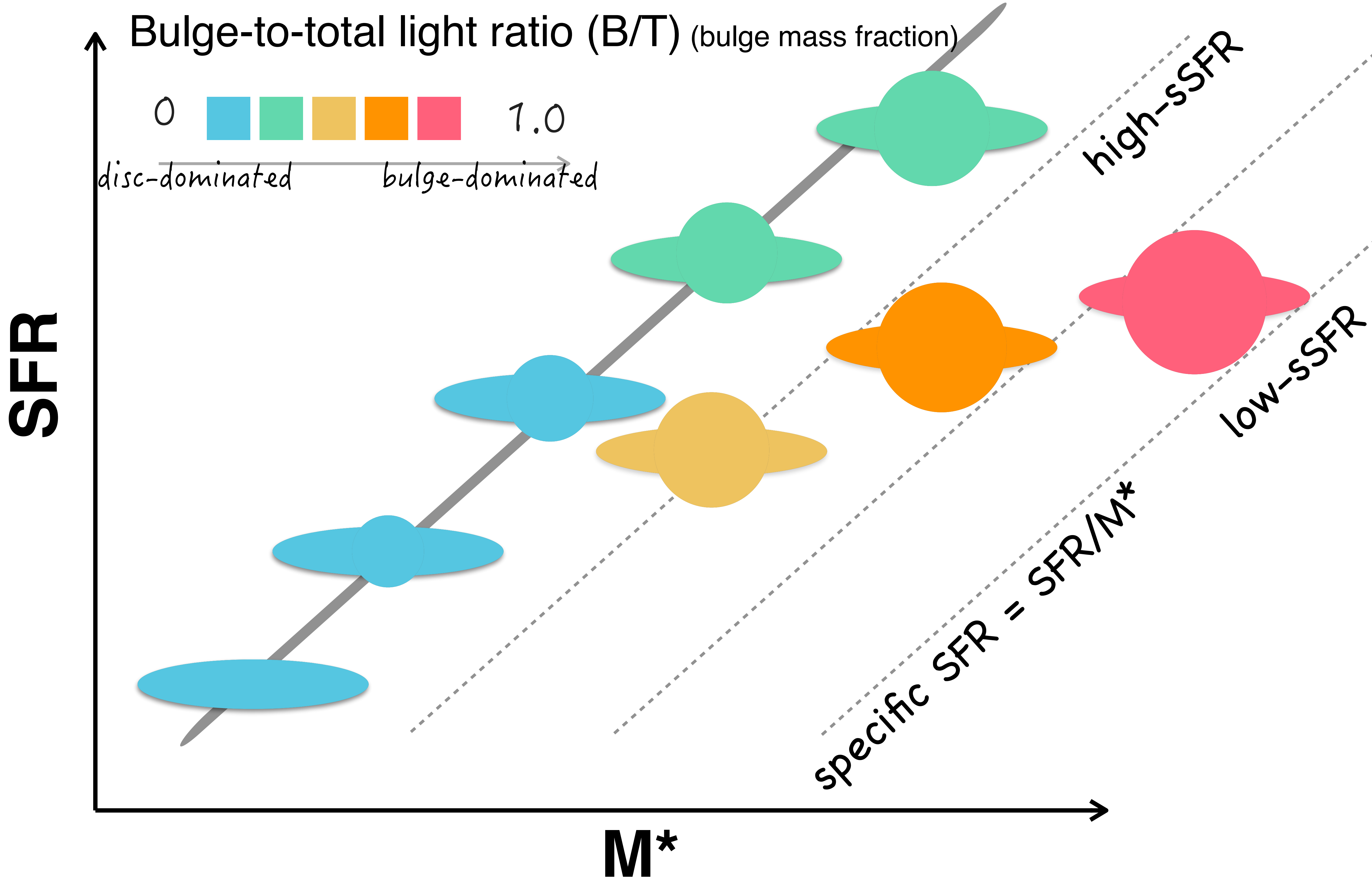


Bulge Growth Scenario

Whitaker+15
Abramson+14

disc-dominated → bulge-dominated

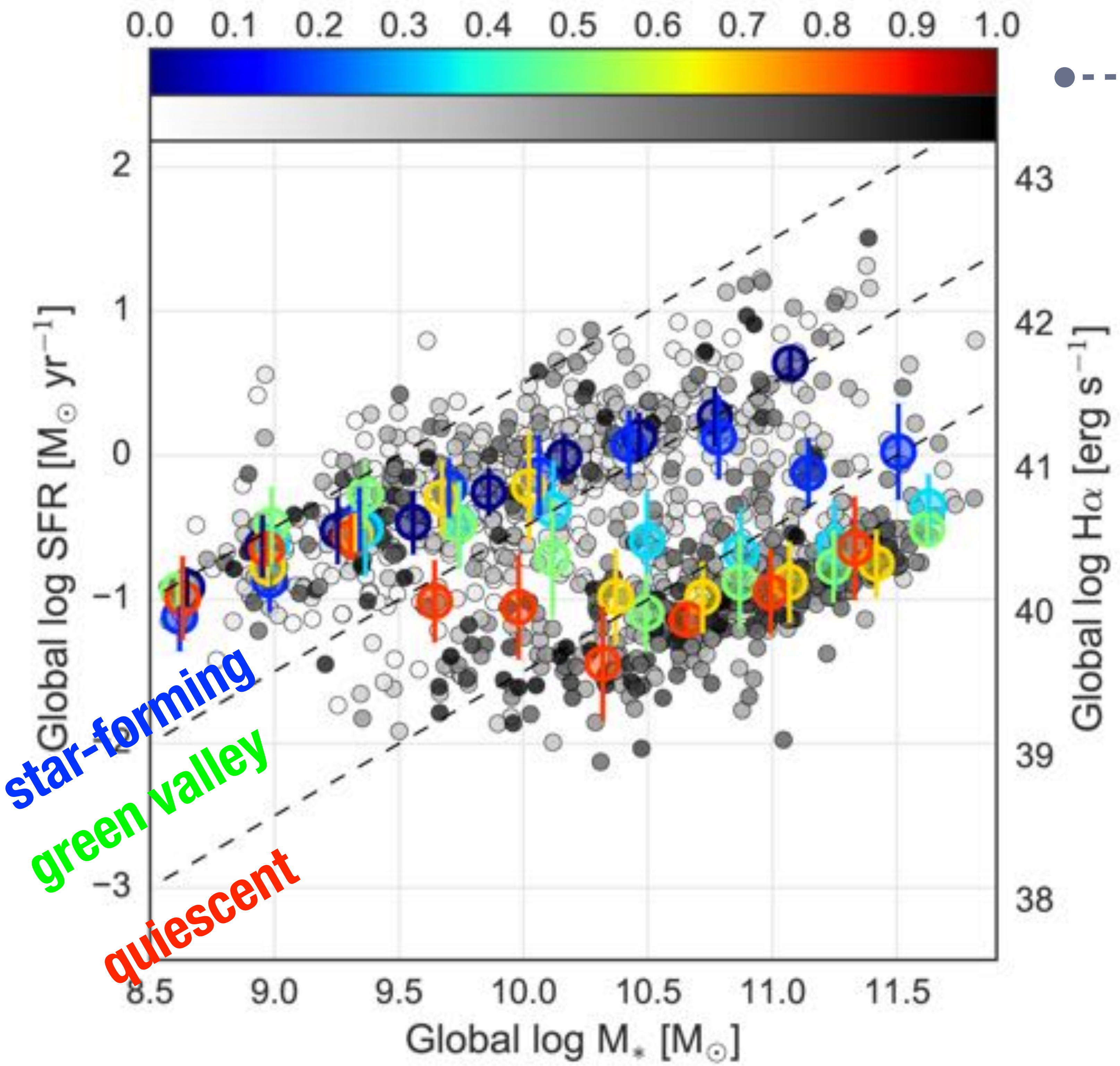
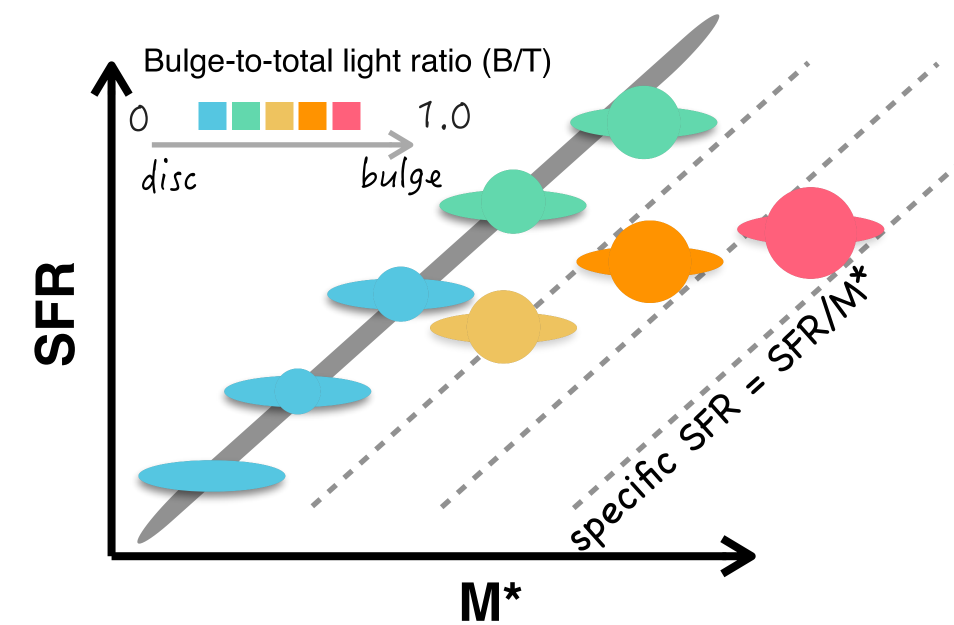


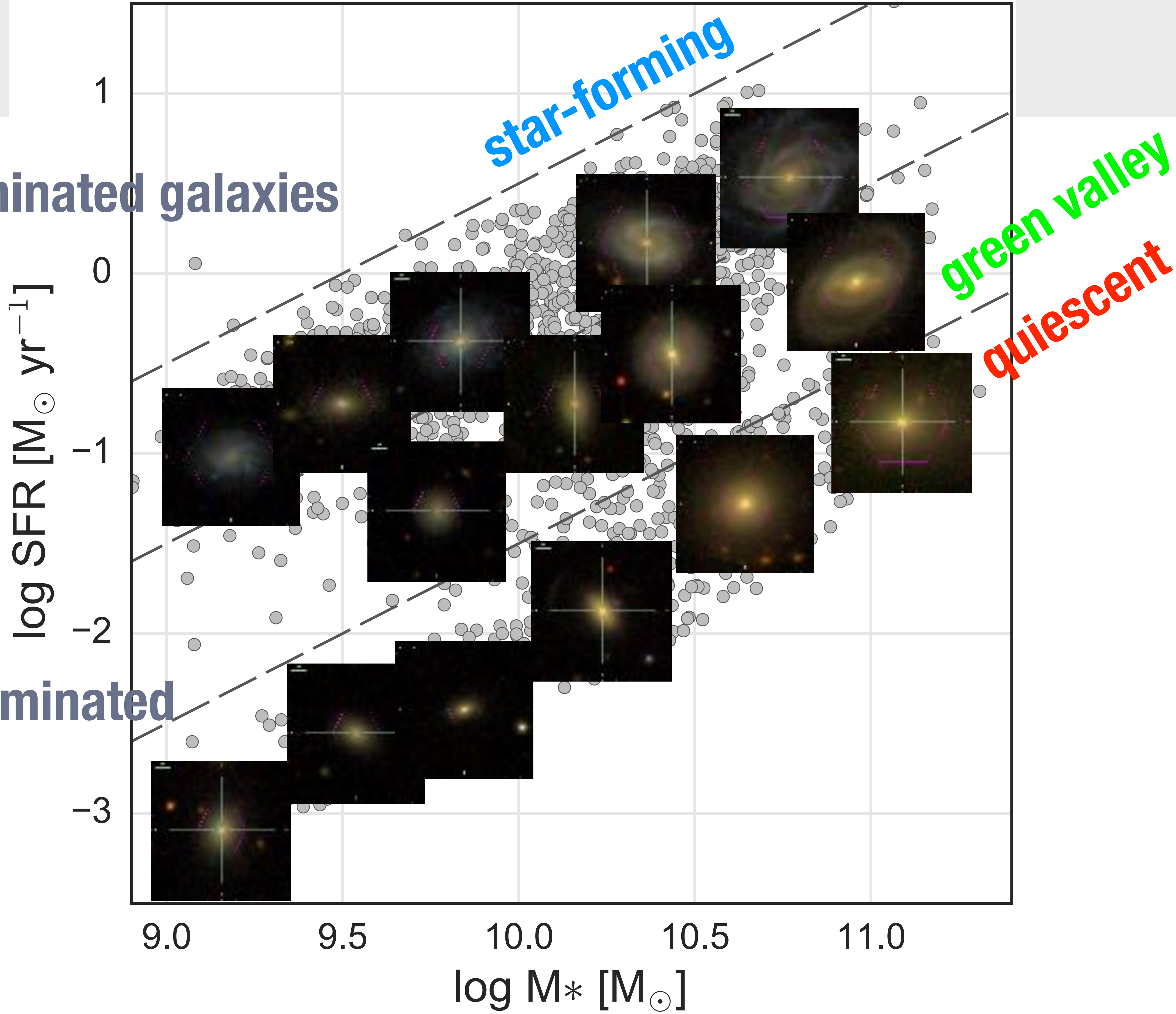
fig: ***integrated (global) star formation rate (SFR) versus stellar mass (M*), colored by B/T (grey scale), and binned by M* (color circles).***

using the color code in Whitaker+15



disk-dominated galaxies

bulge-dominated



From Integrated to Spatially-Resolved Properties

1. SF occurs in discs (high sSFR)
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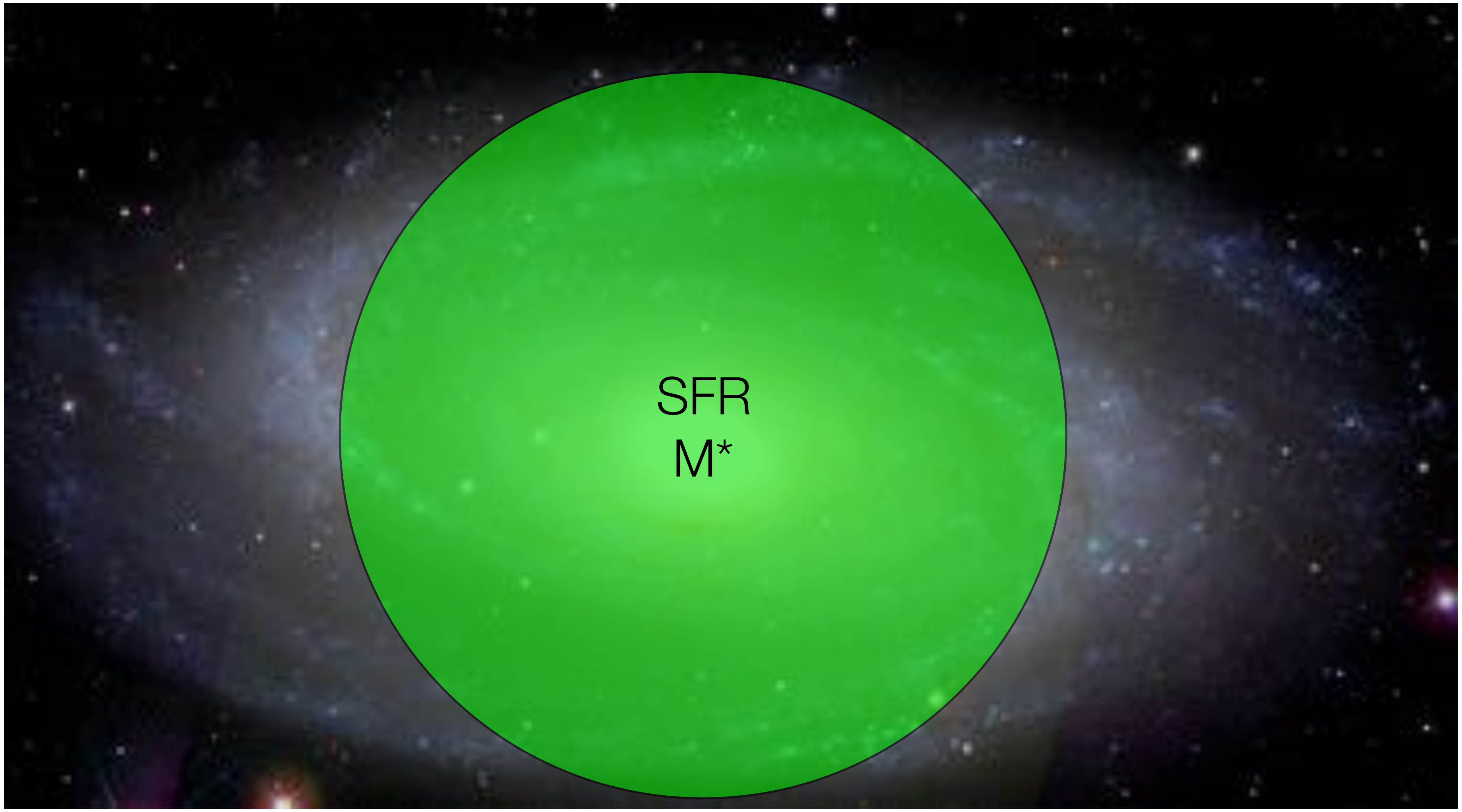

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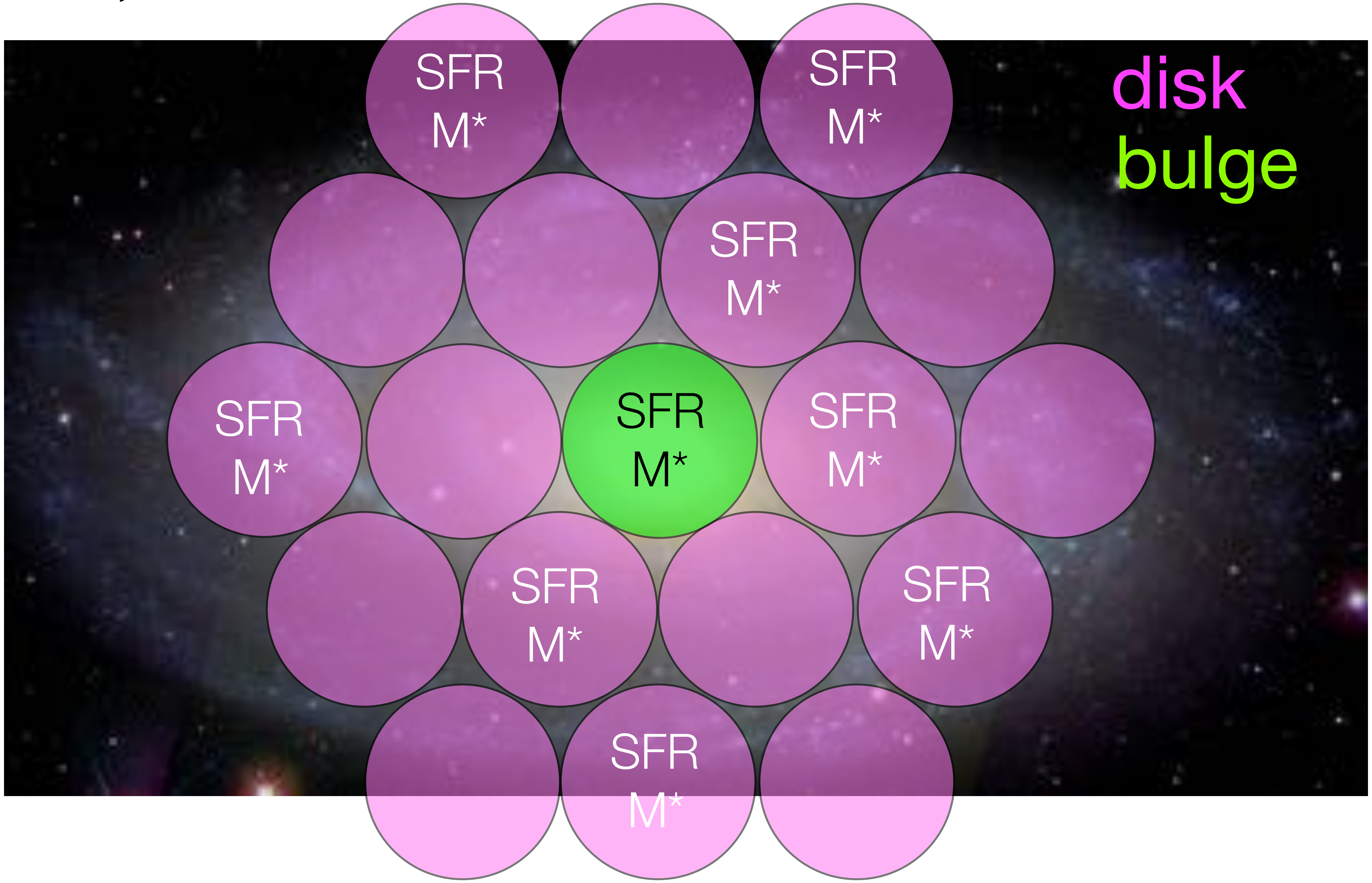
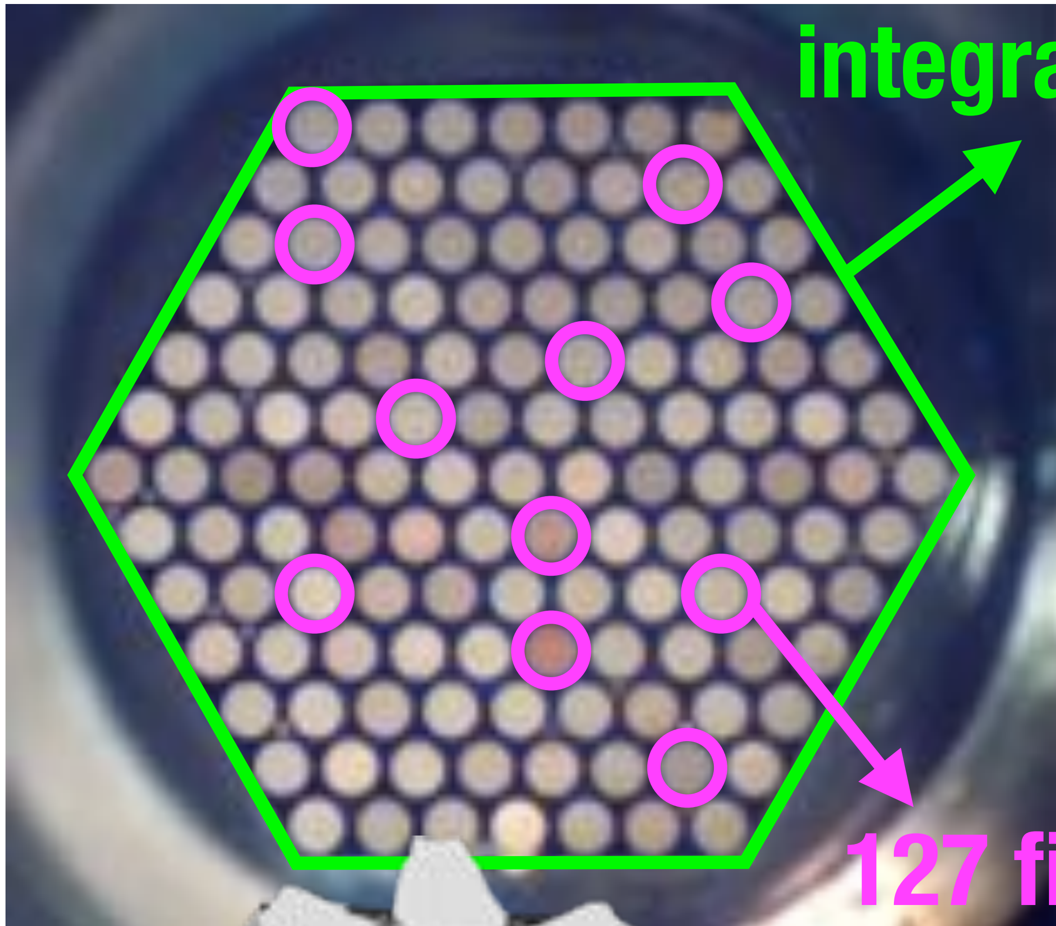
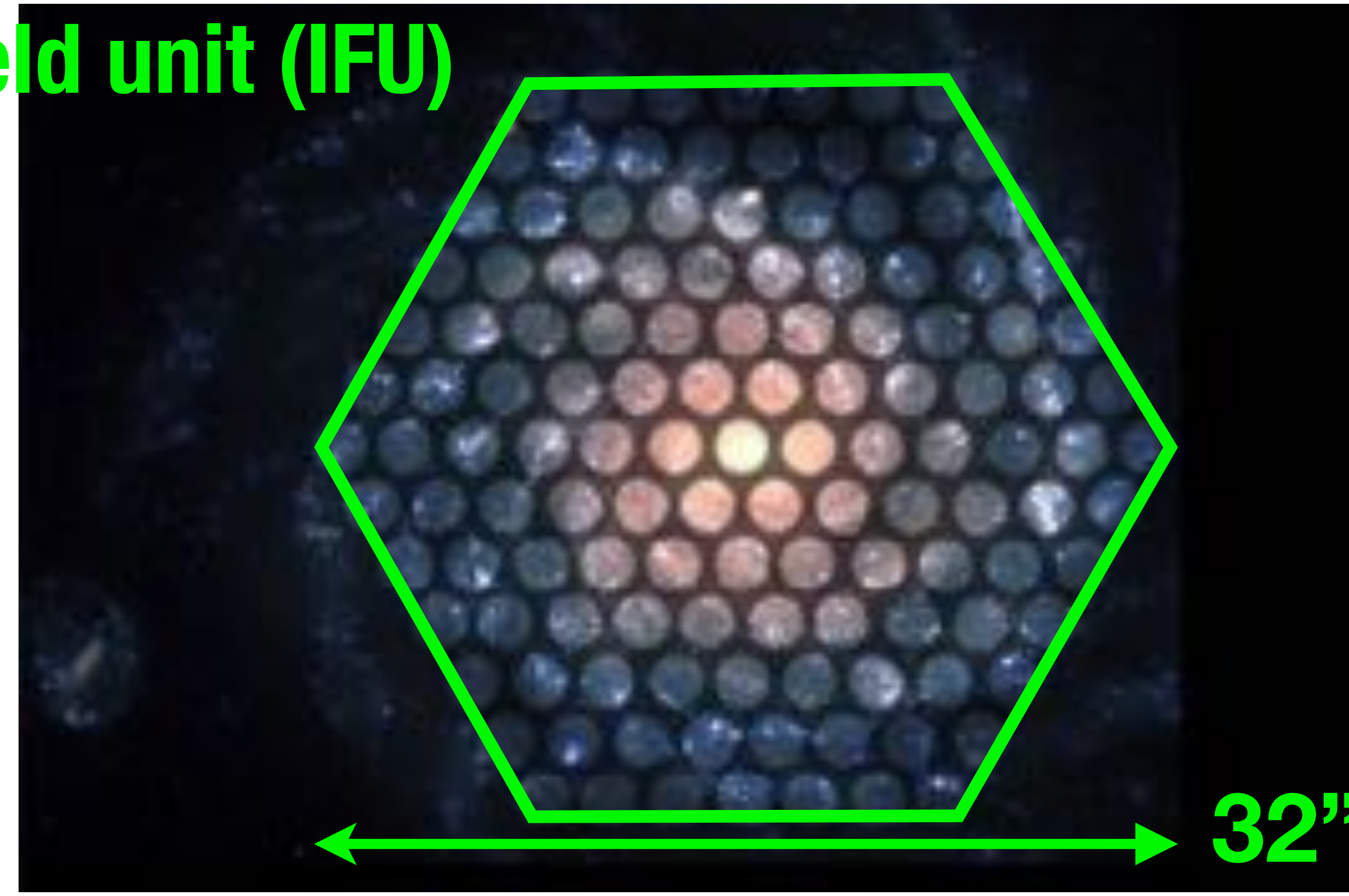


MaNGA: Mapping Nearby Galaxies at APO

Spatially-resolved spectroscopy





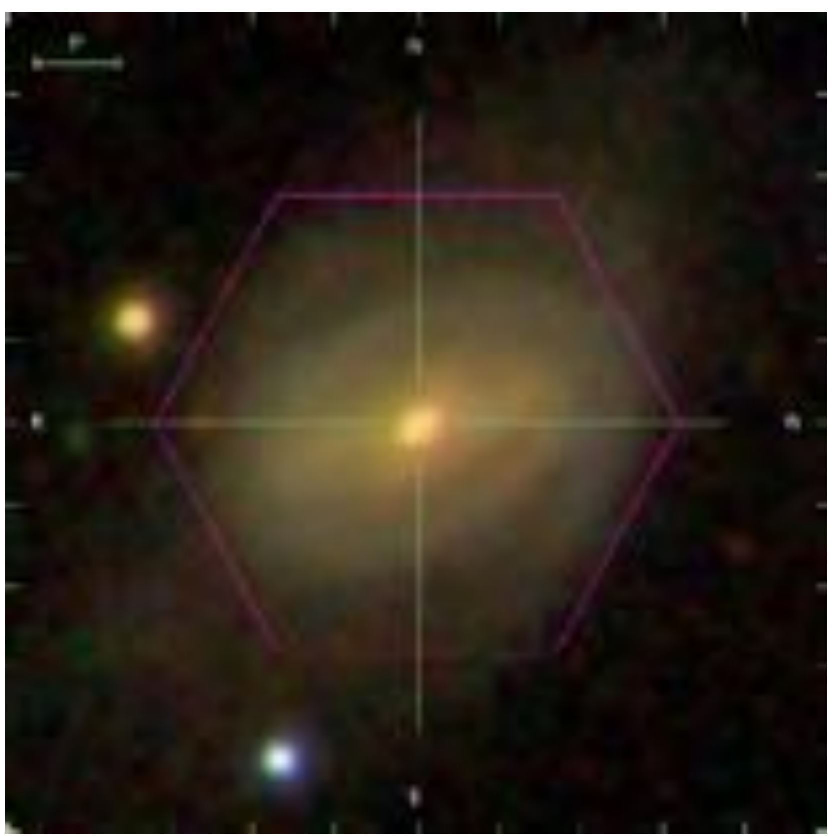
The Sloan 2.5m Telescope

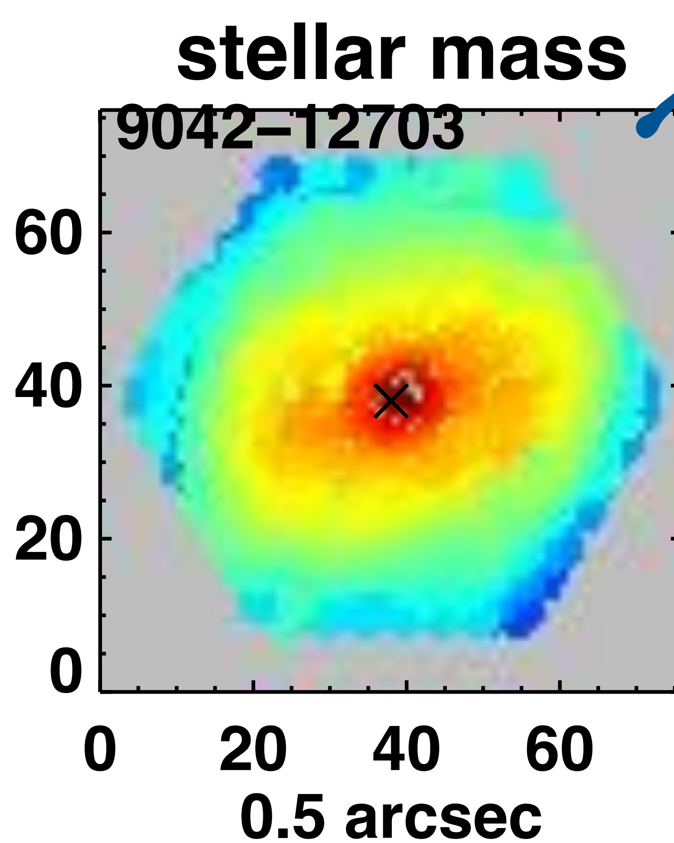
Apache Point Observatory

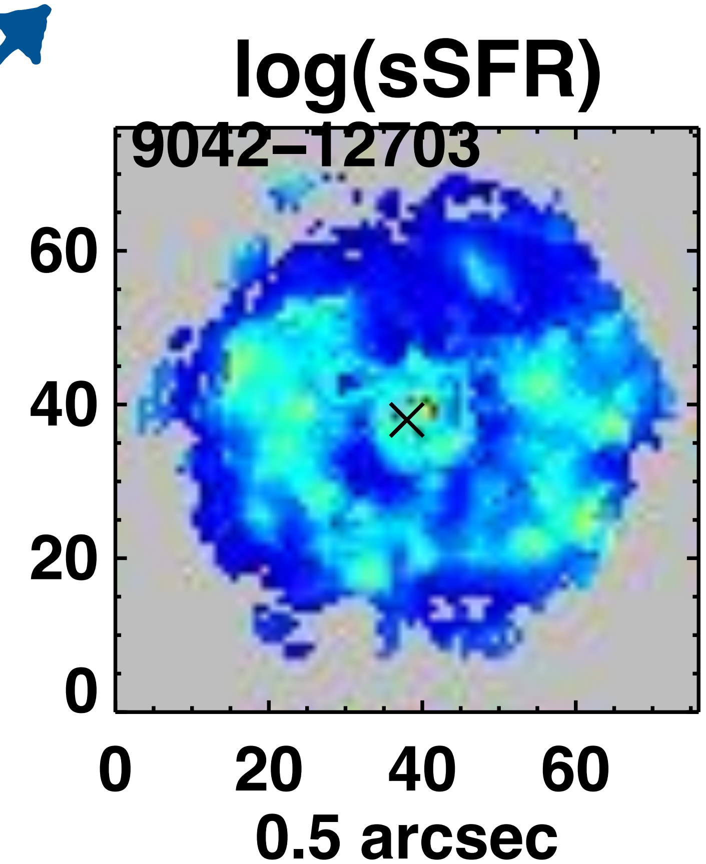
About MaNGA

PI:	Kevin Bundy (UC Santa Cruz)
Project period:	2014~2020
Total number of galaxies:	~ 10500
Number of galaxies released:	~ 4600 (internal) , ~ 2700 (everyone)
spatially resolution:	~ 1 kilo parsec

spectral pixel = spaxel

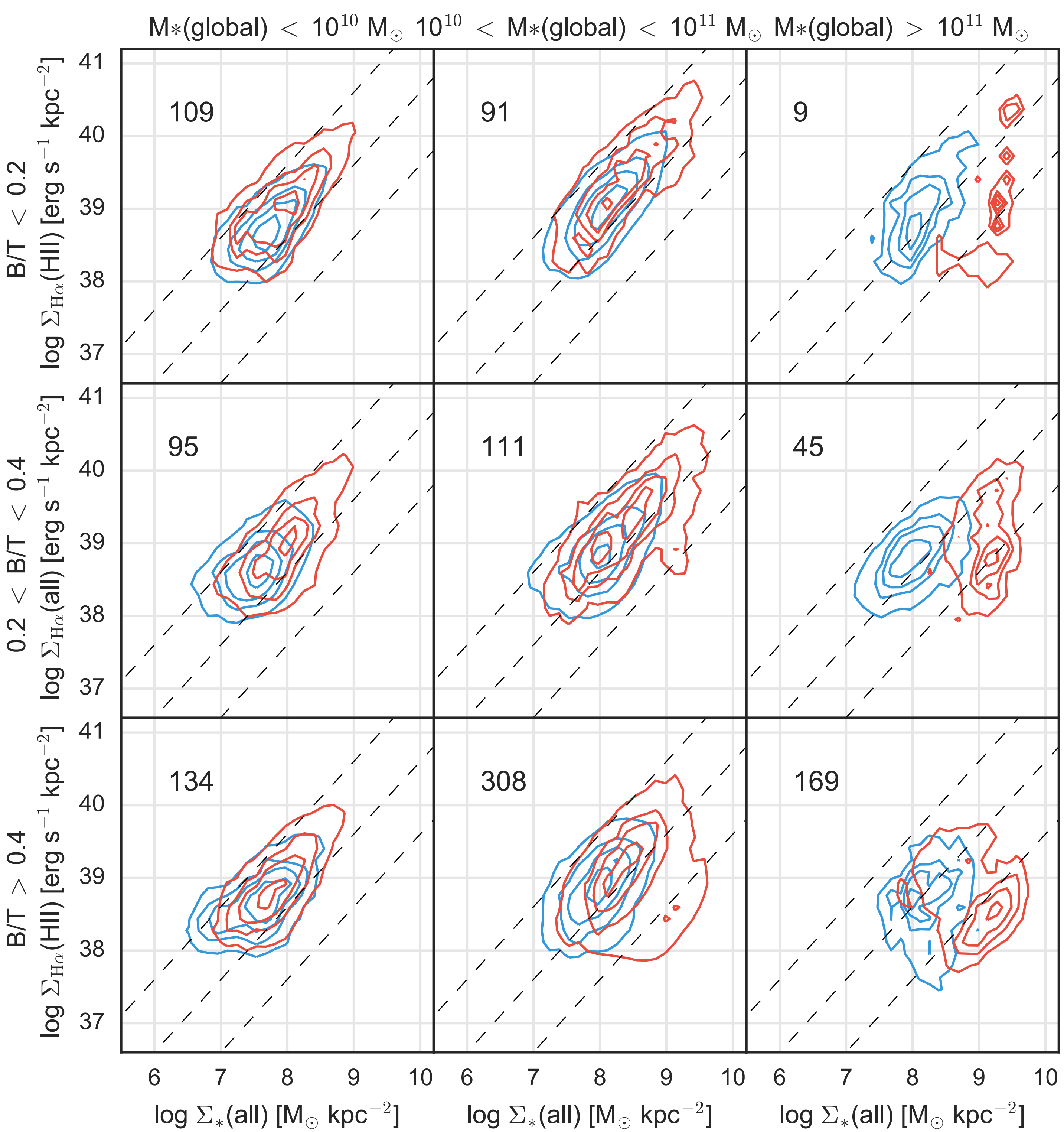


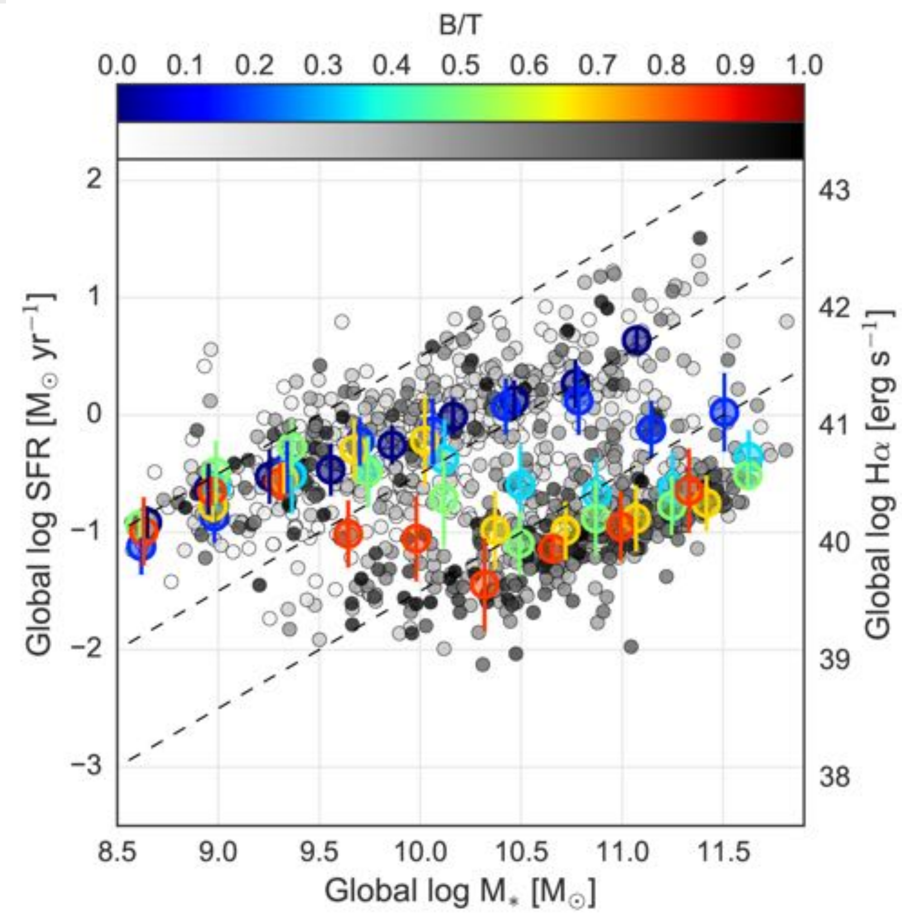




other maps such as average stellar age, metalllcity…

Spatially-Resolved M*-SFR Relationship





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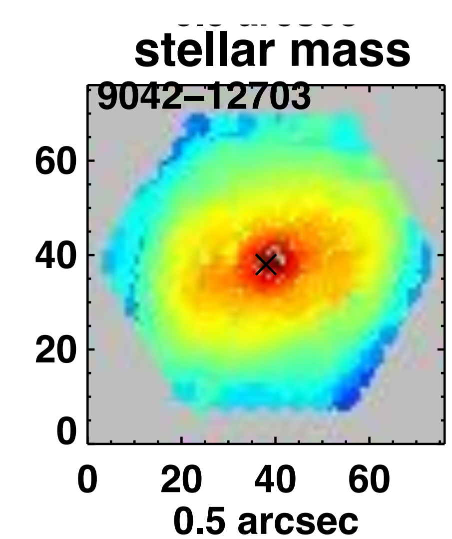
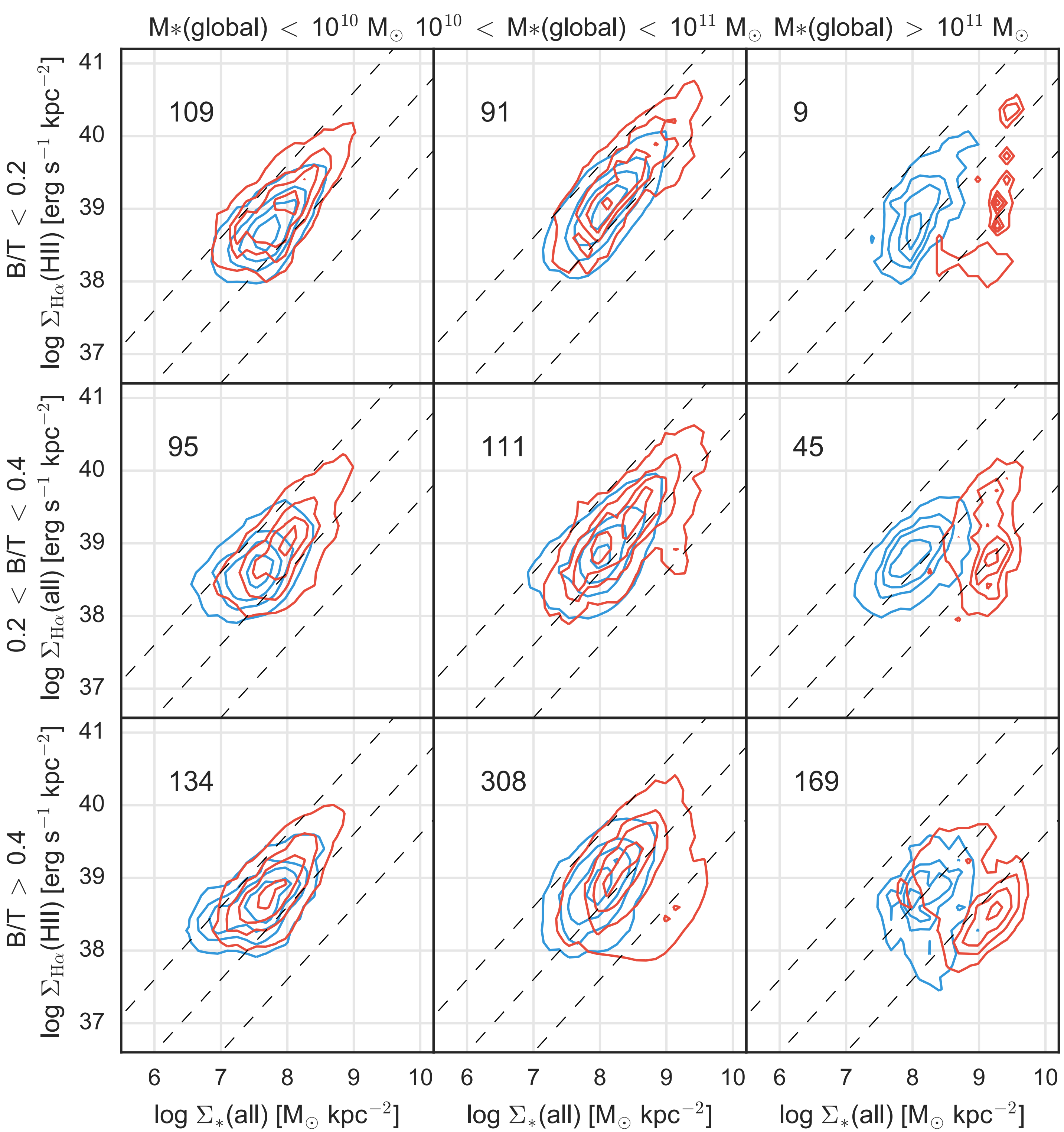


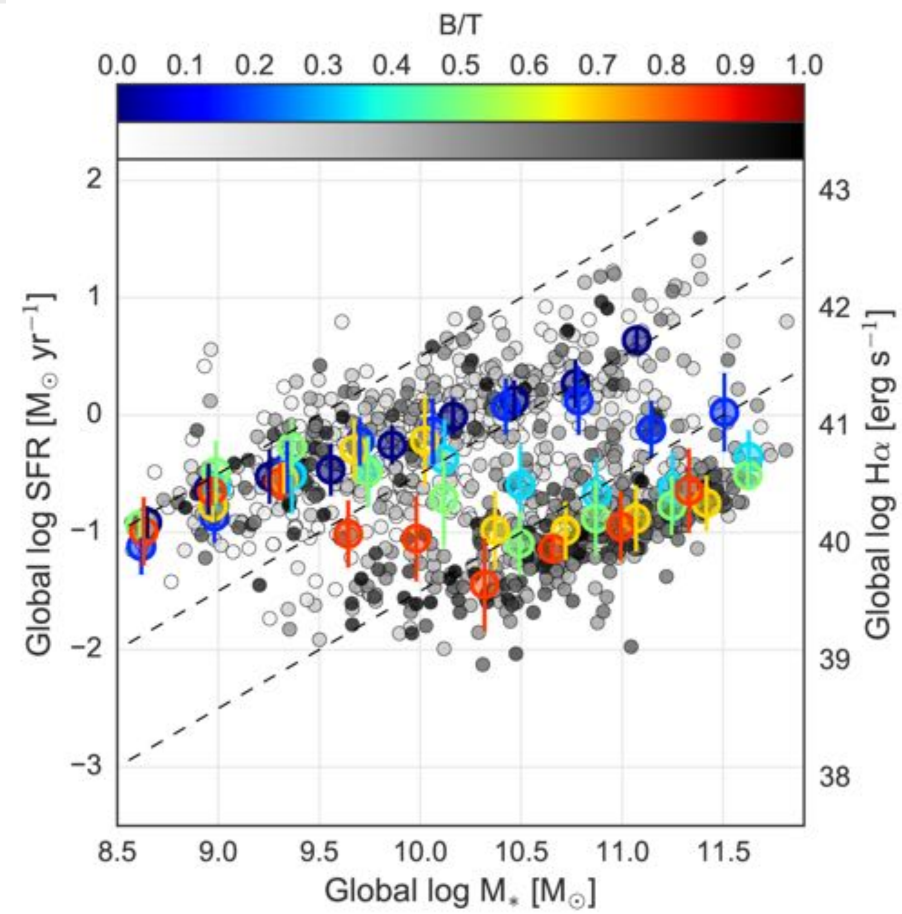
bulge

disc

Spatially-Resolved M*-SFR Relationship

stellar mass





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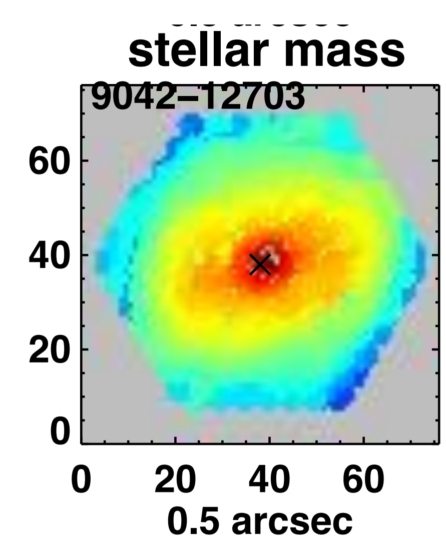


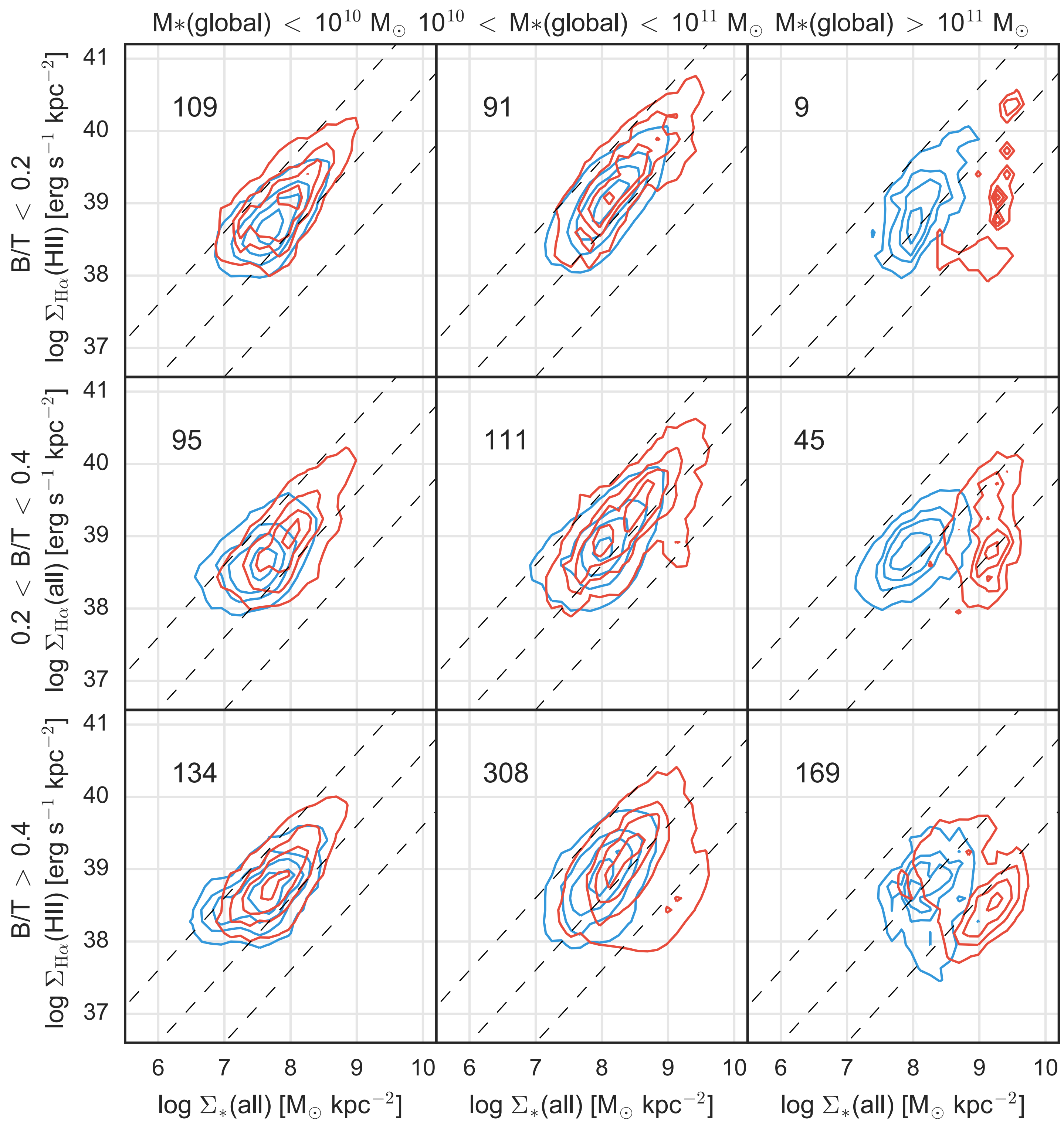
bulge

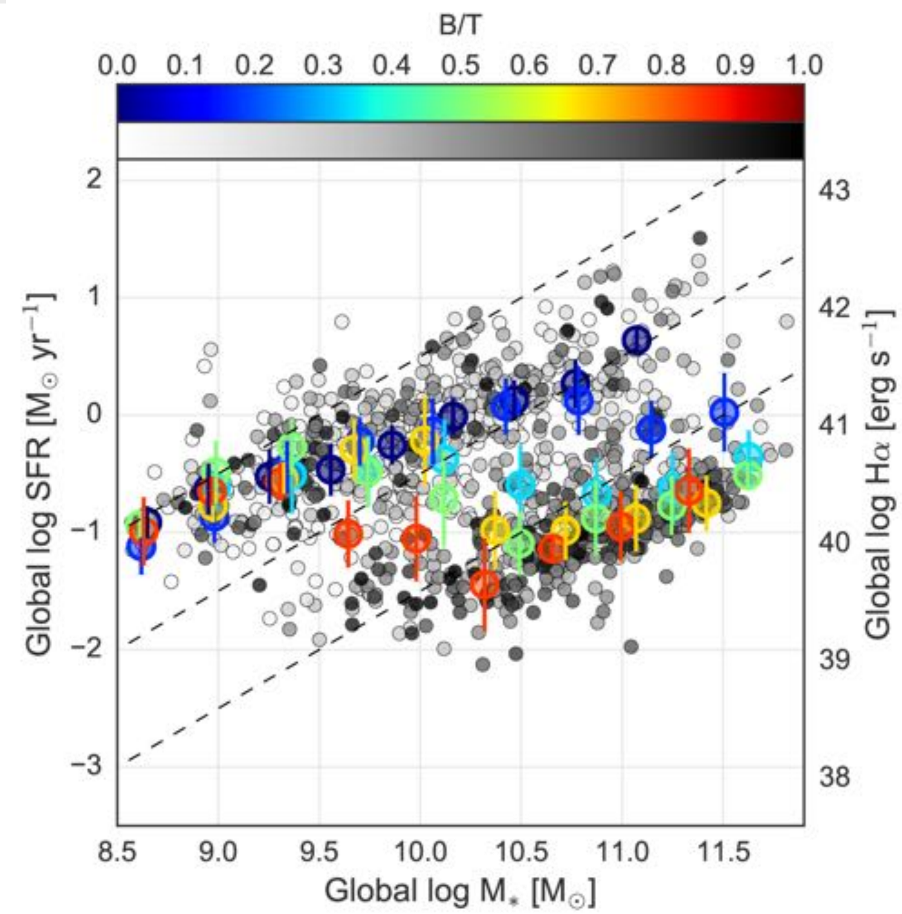
disc

Spatially-Resolved M*-SFR Relationship

stellar mass

bulge dominance





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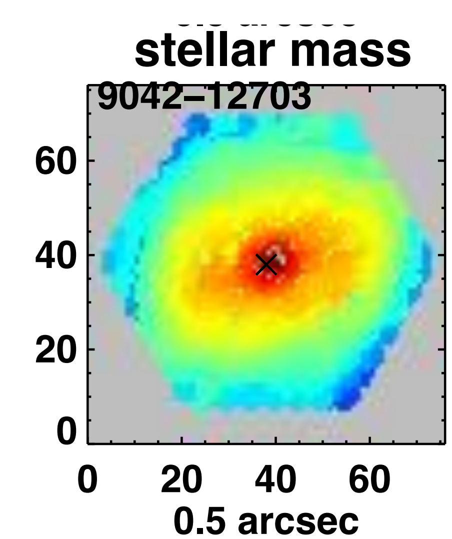


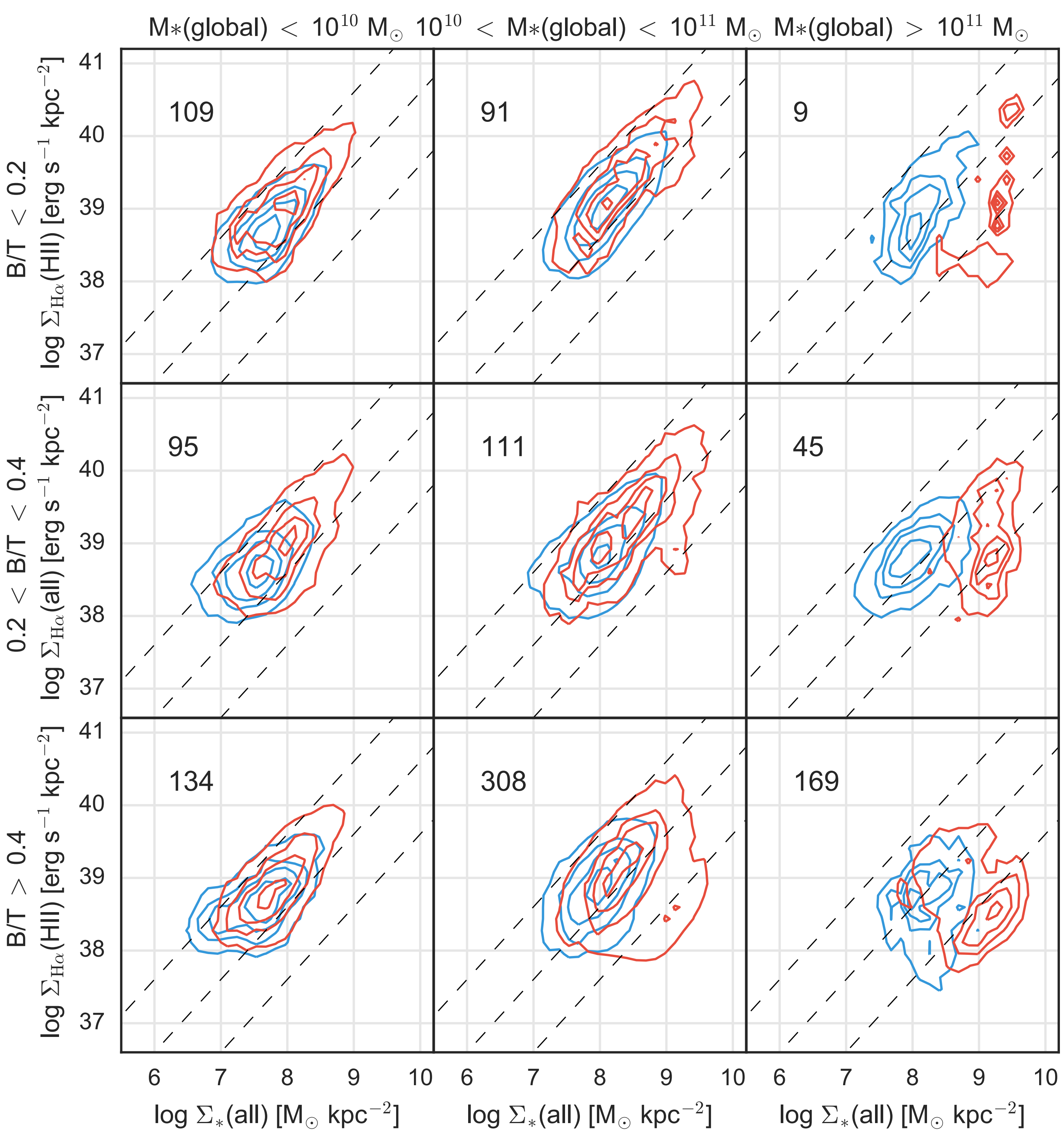
bulge

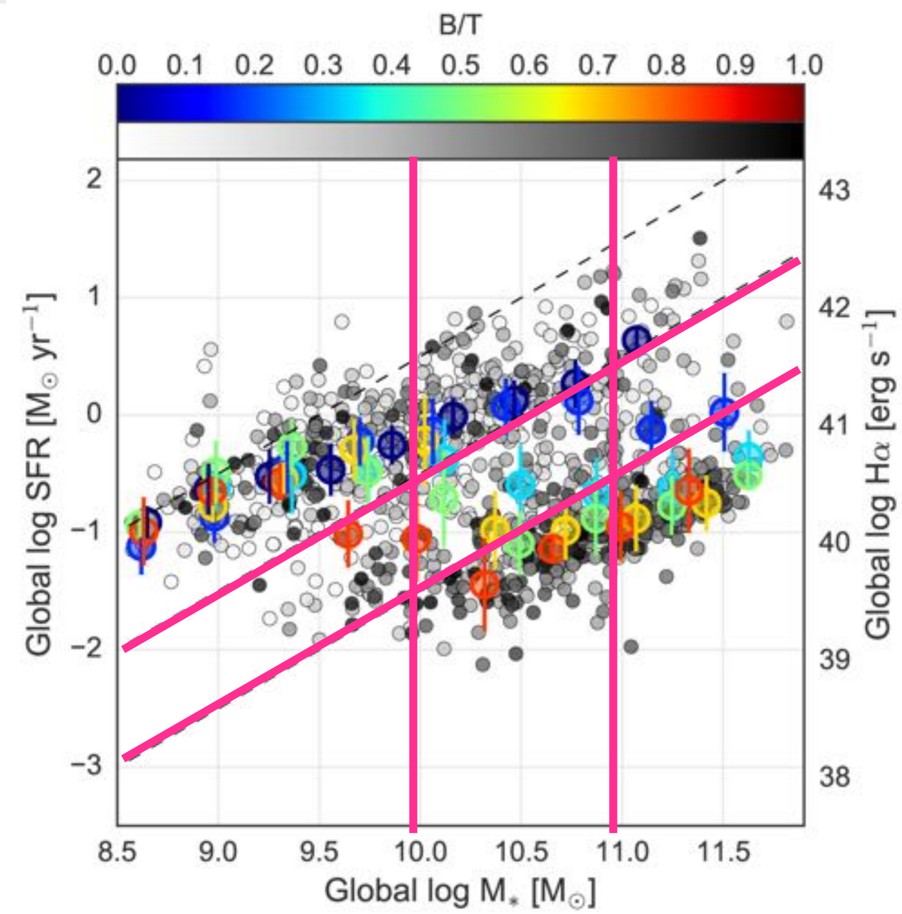
disc

Spatially-Resolved M*-SFR Relationship

stellar mass

bulge dominance





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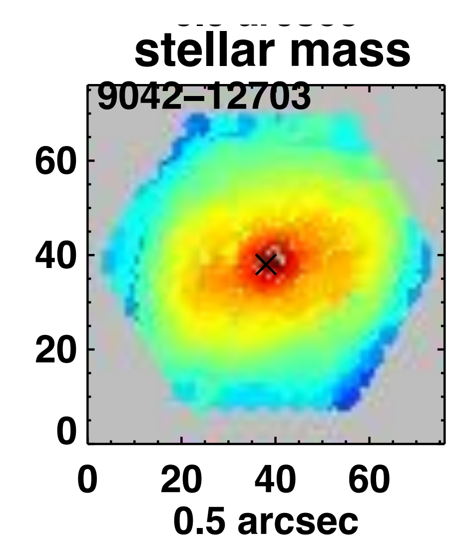
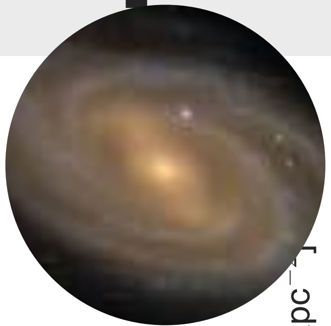
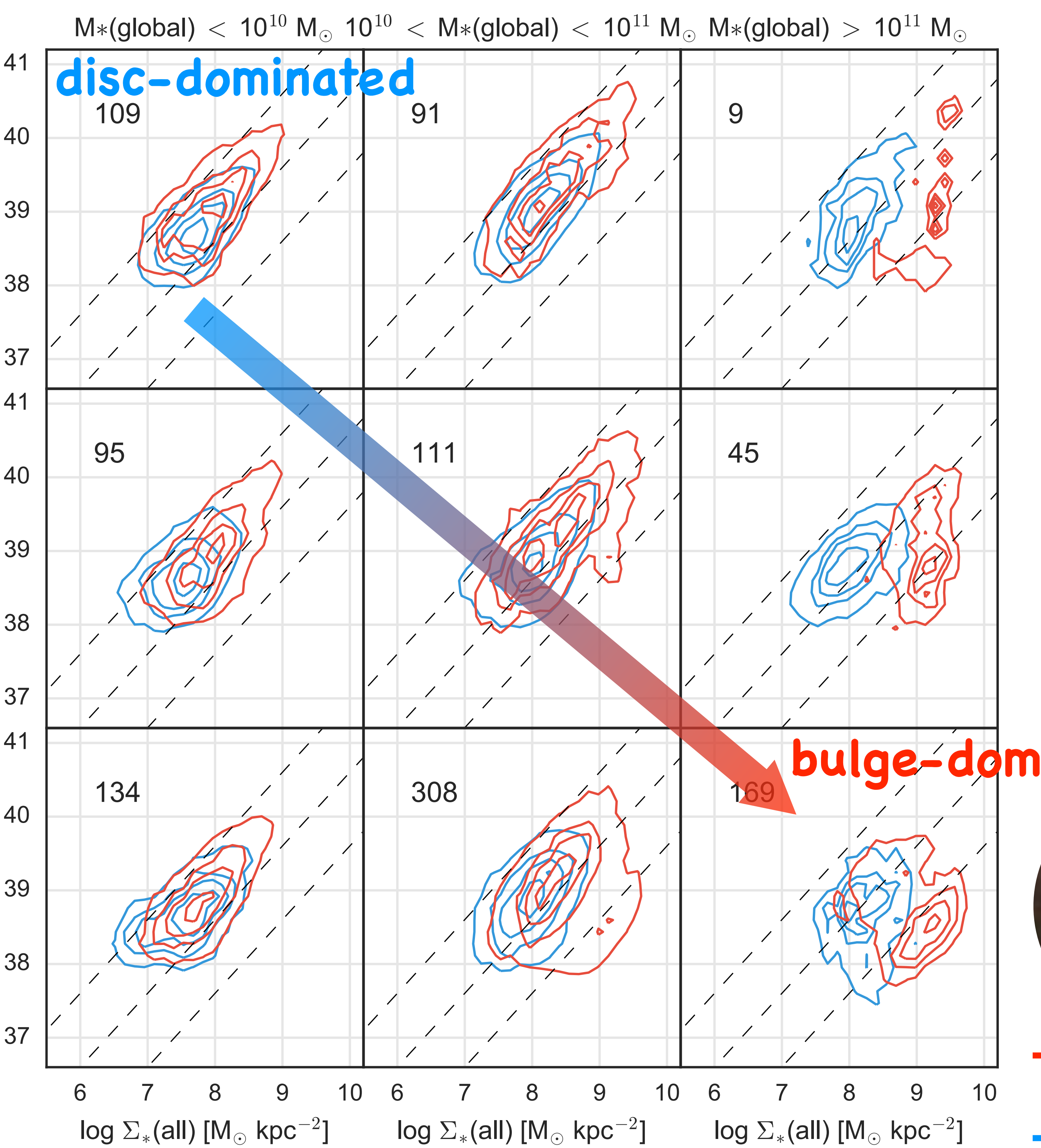


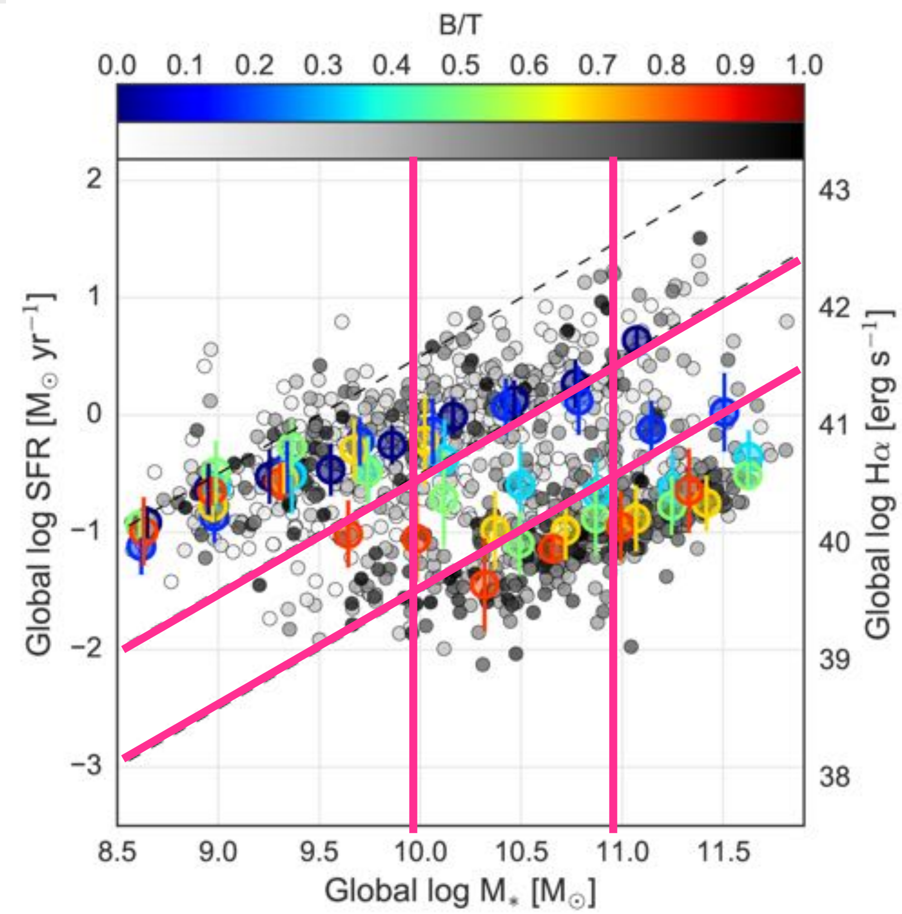
bulge

disc

Spatially-Resolved M*-SFR Relationship







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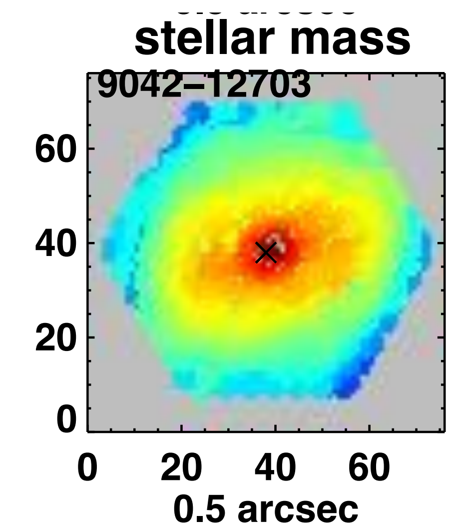

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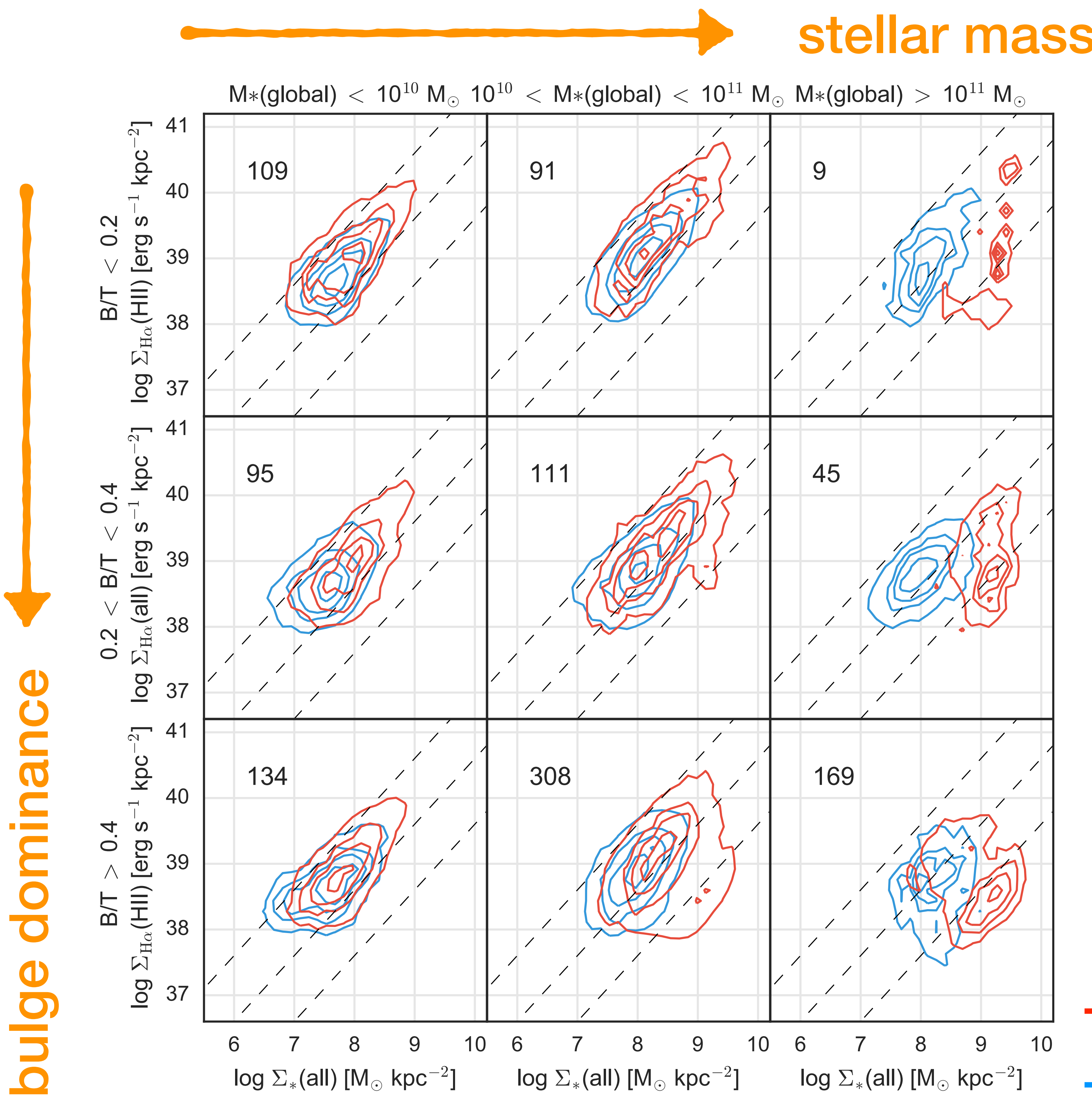

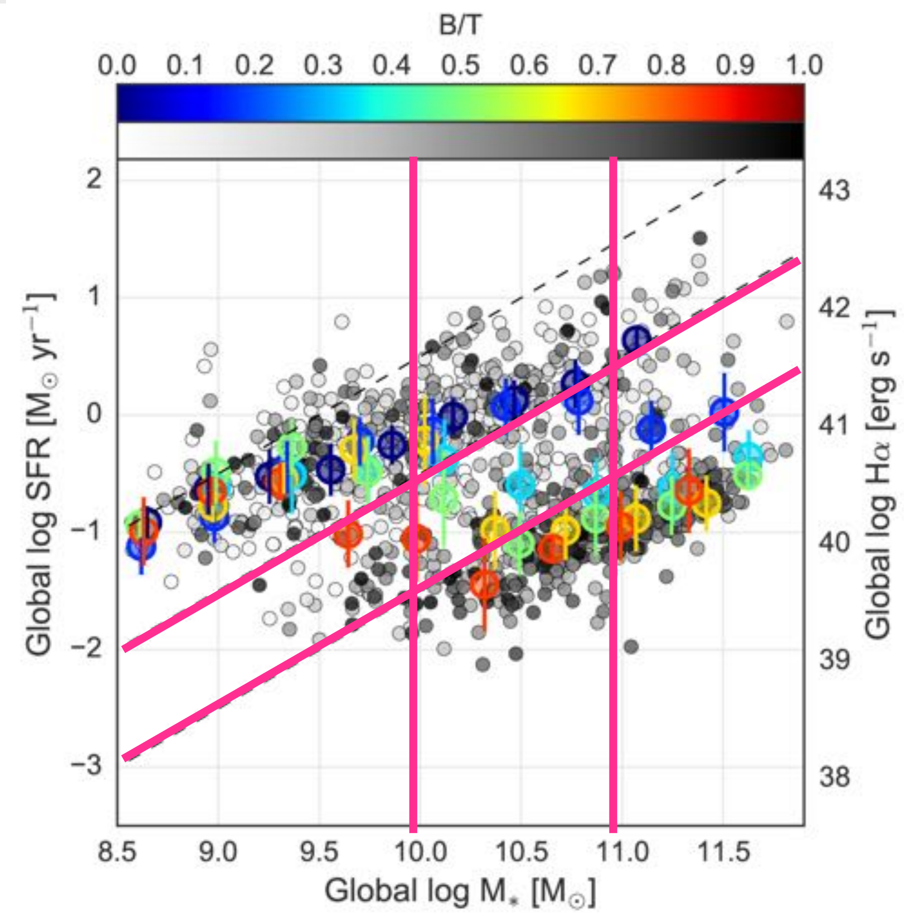

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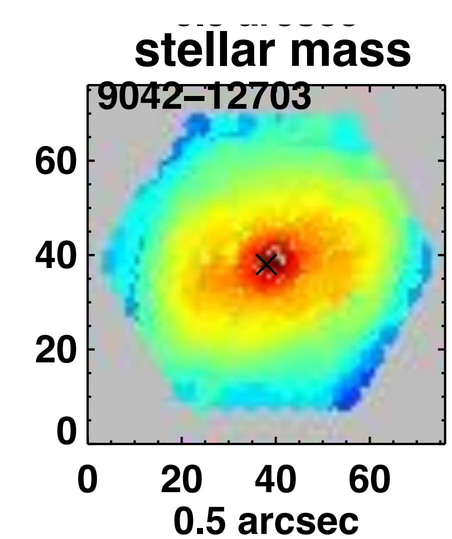


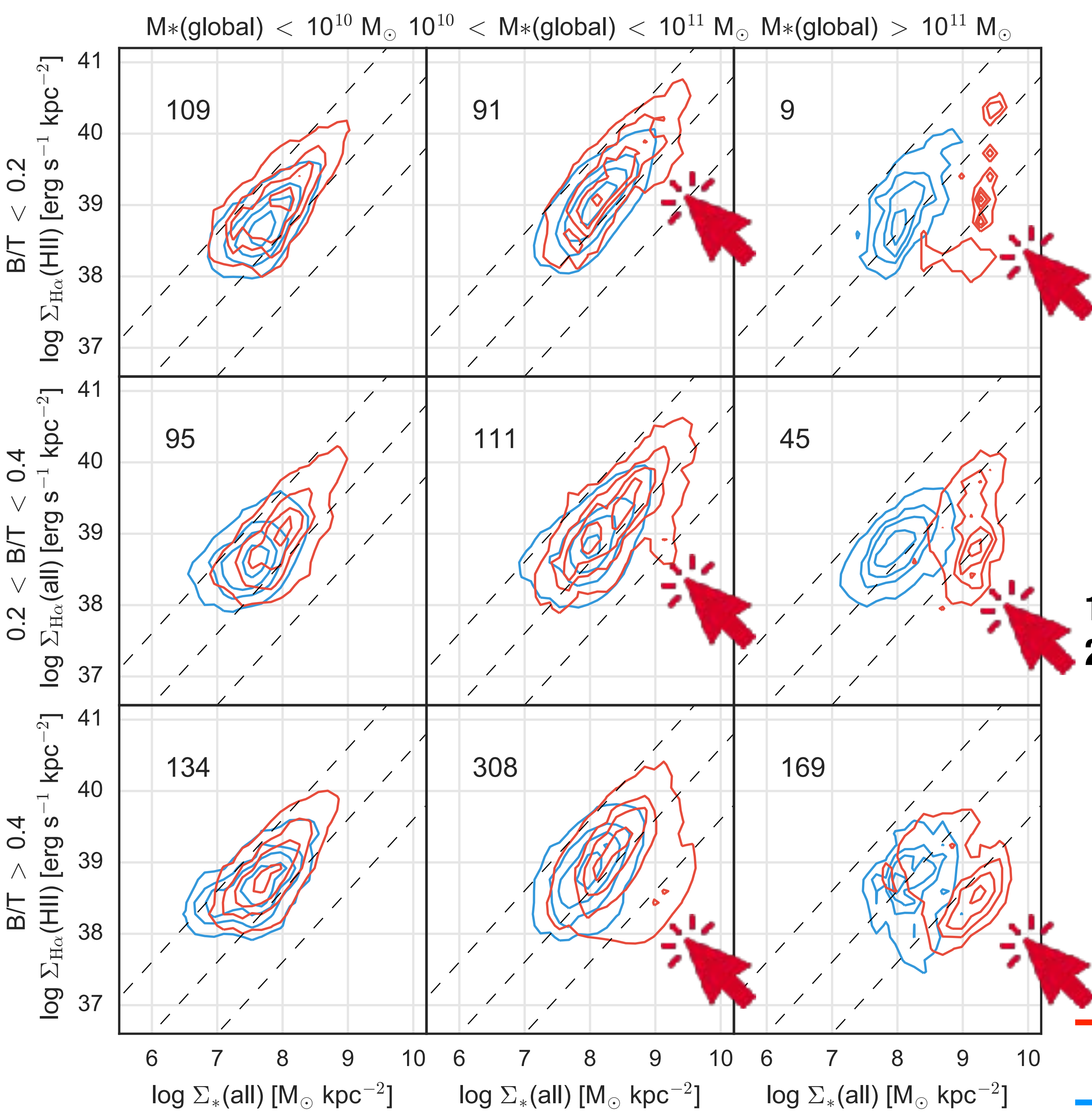
bulge

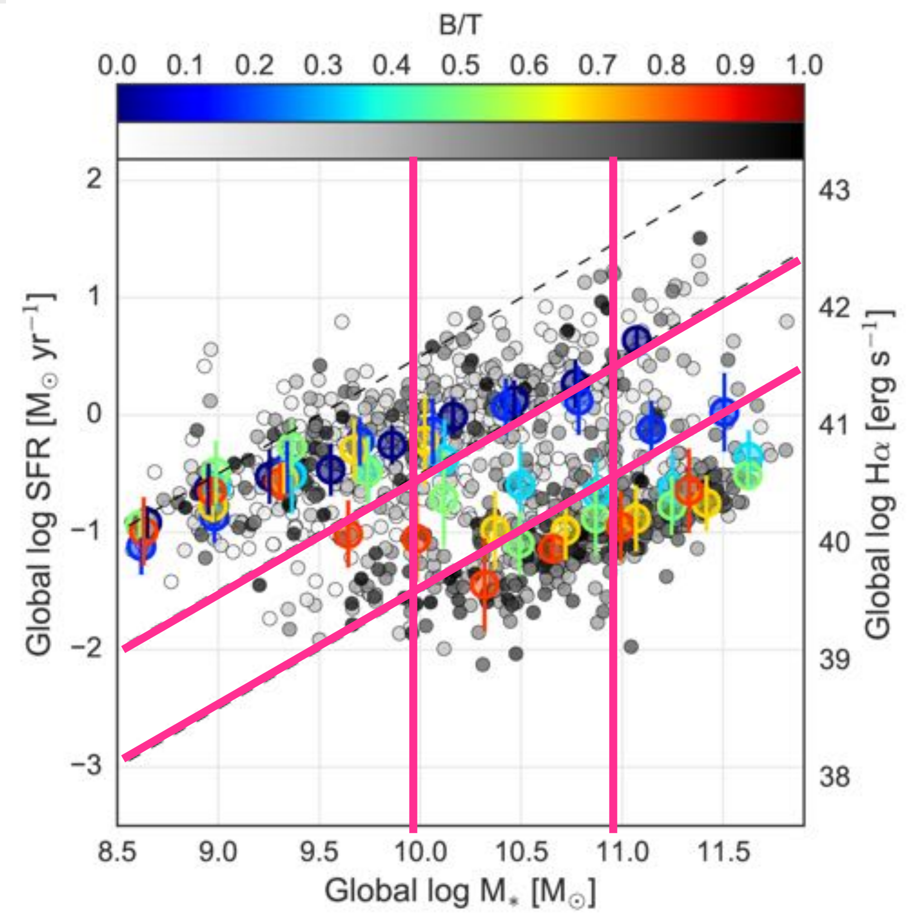
disc

Spatially-Resolved M*-SFR Relationship

stellar mass

bulge dominance





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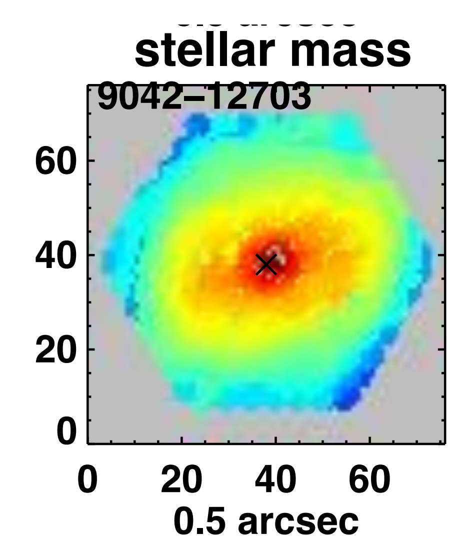

bulge

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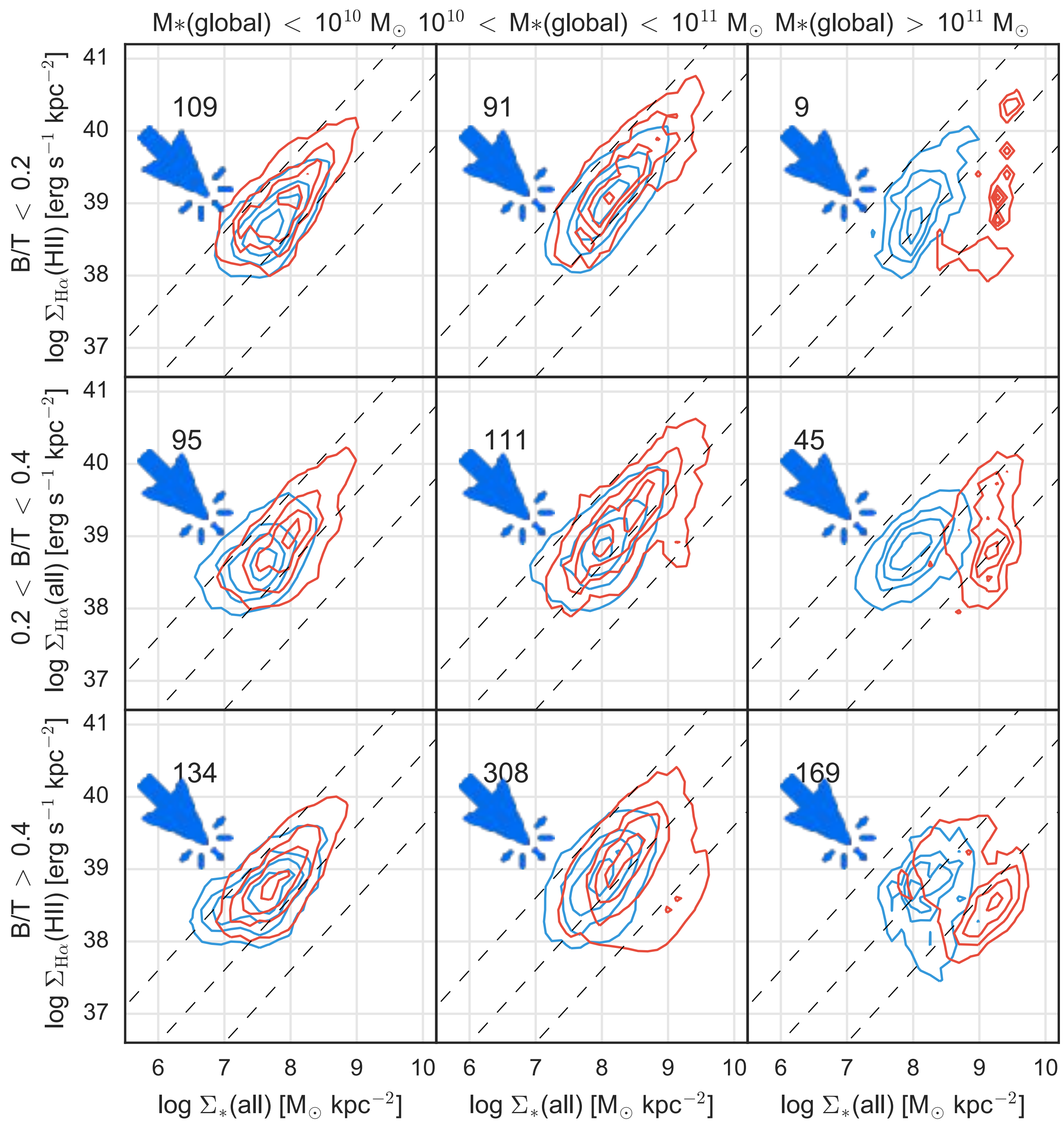

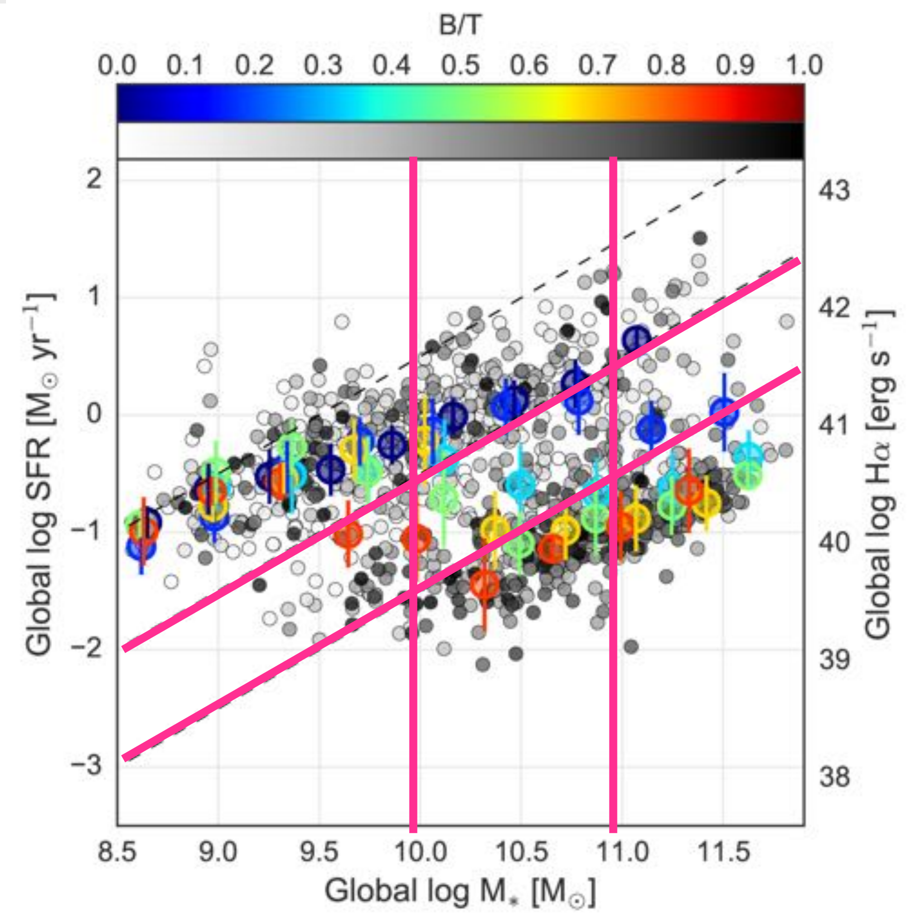

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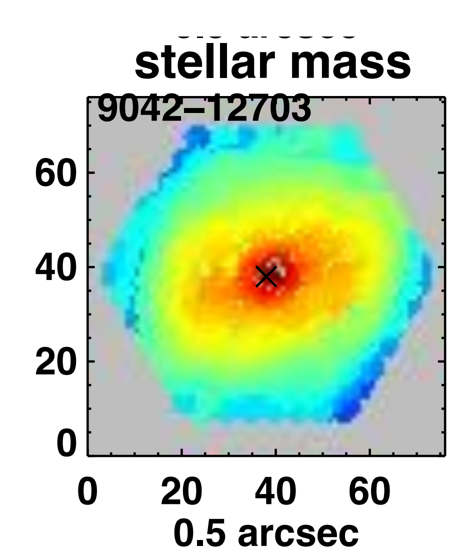
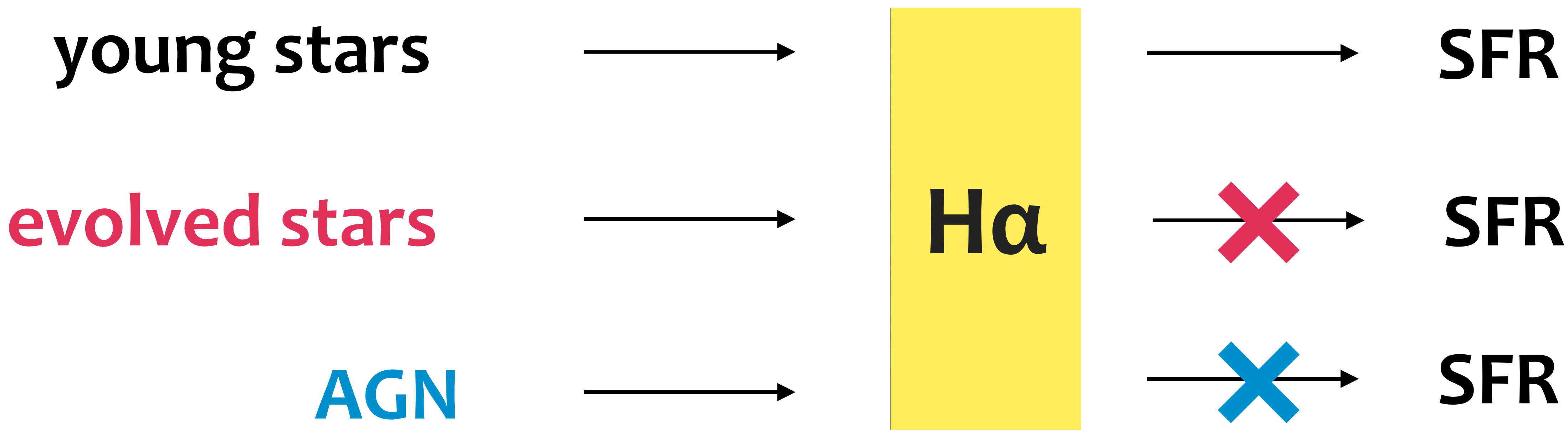


bulge

disc

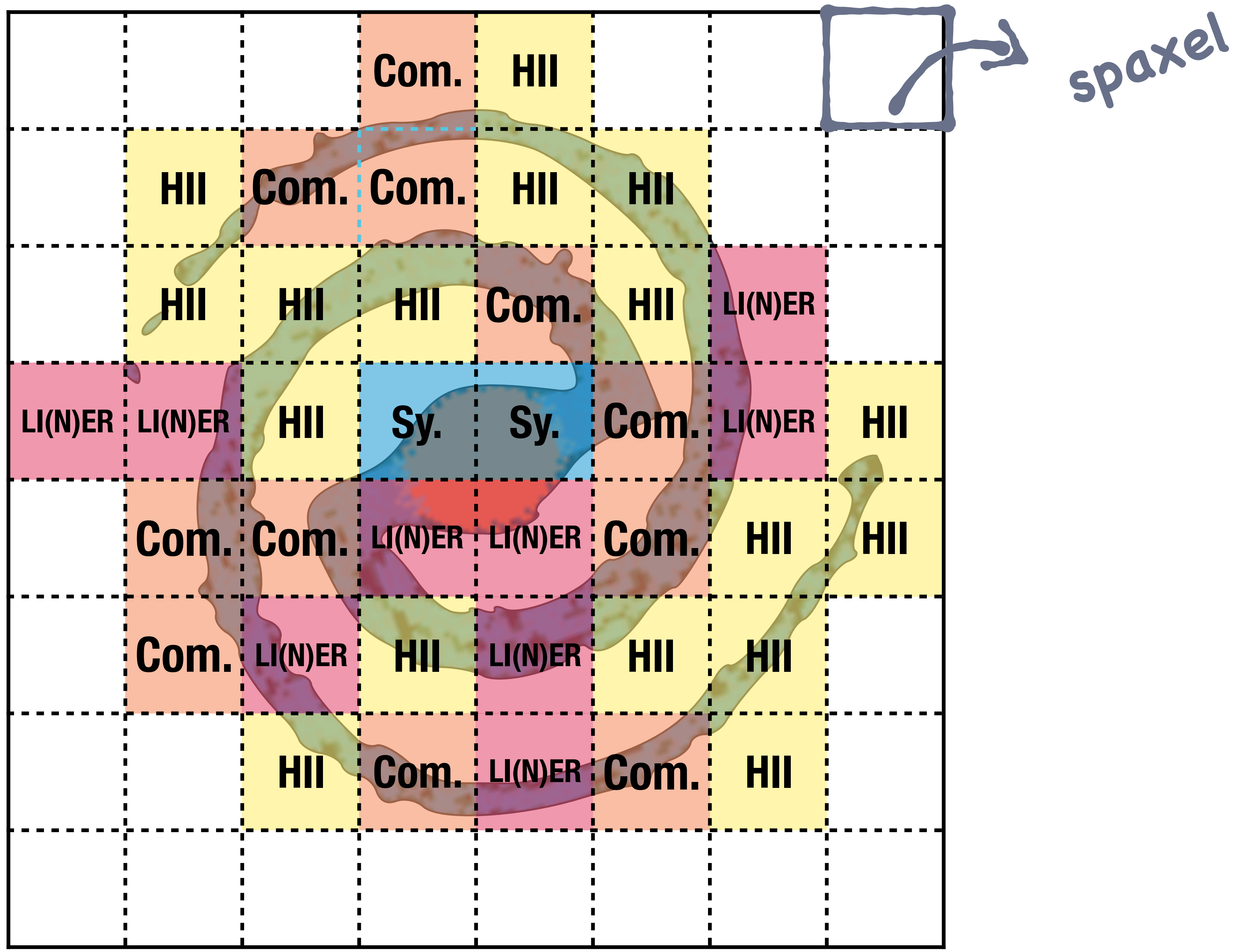
Problem: SFR Tracer



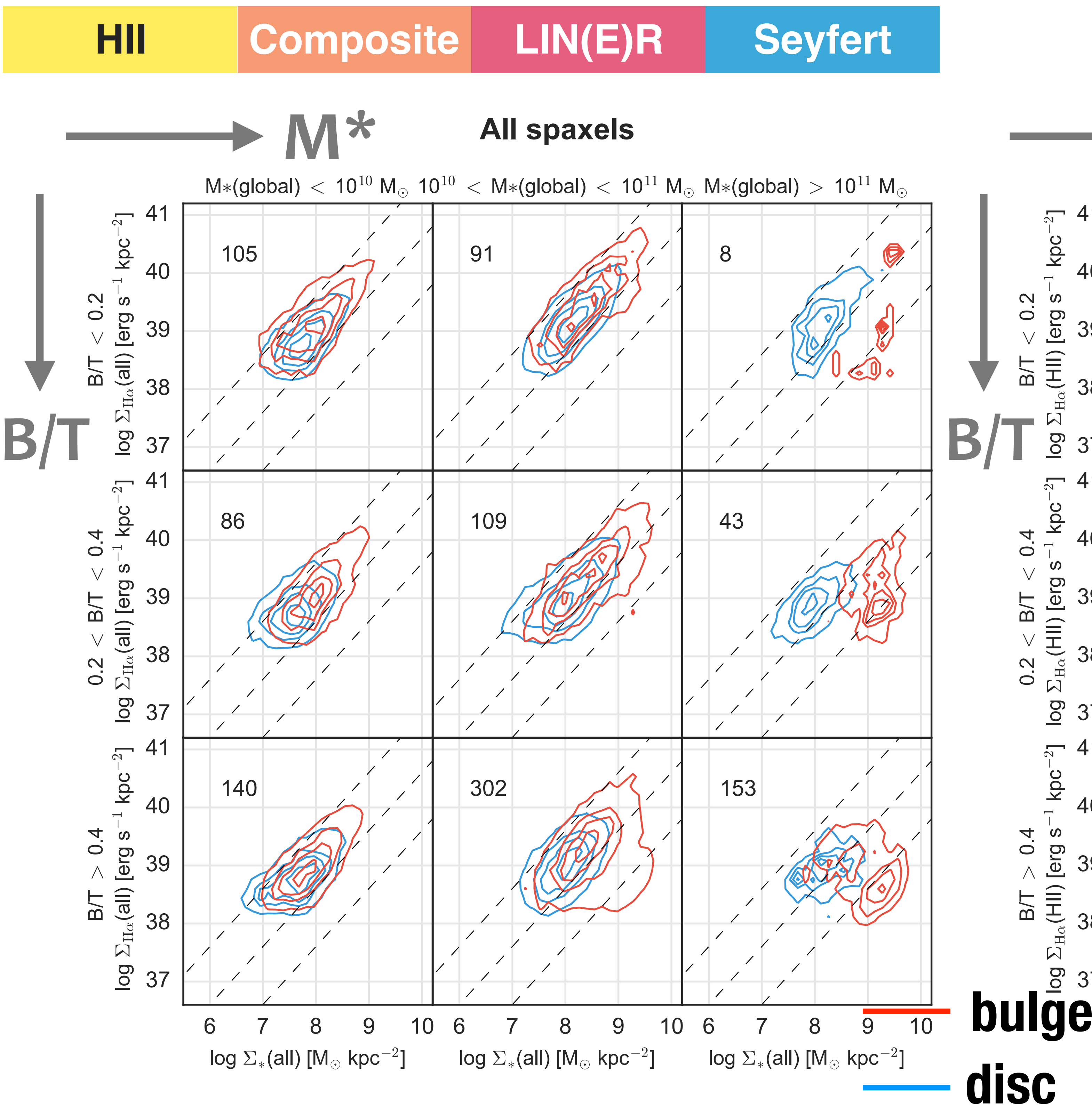
Ionizing Sources of SFR Tracer

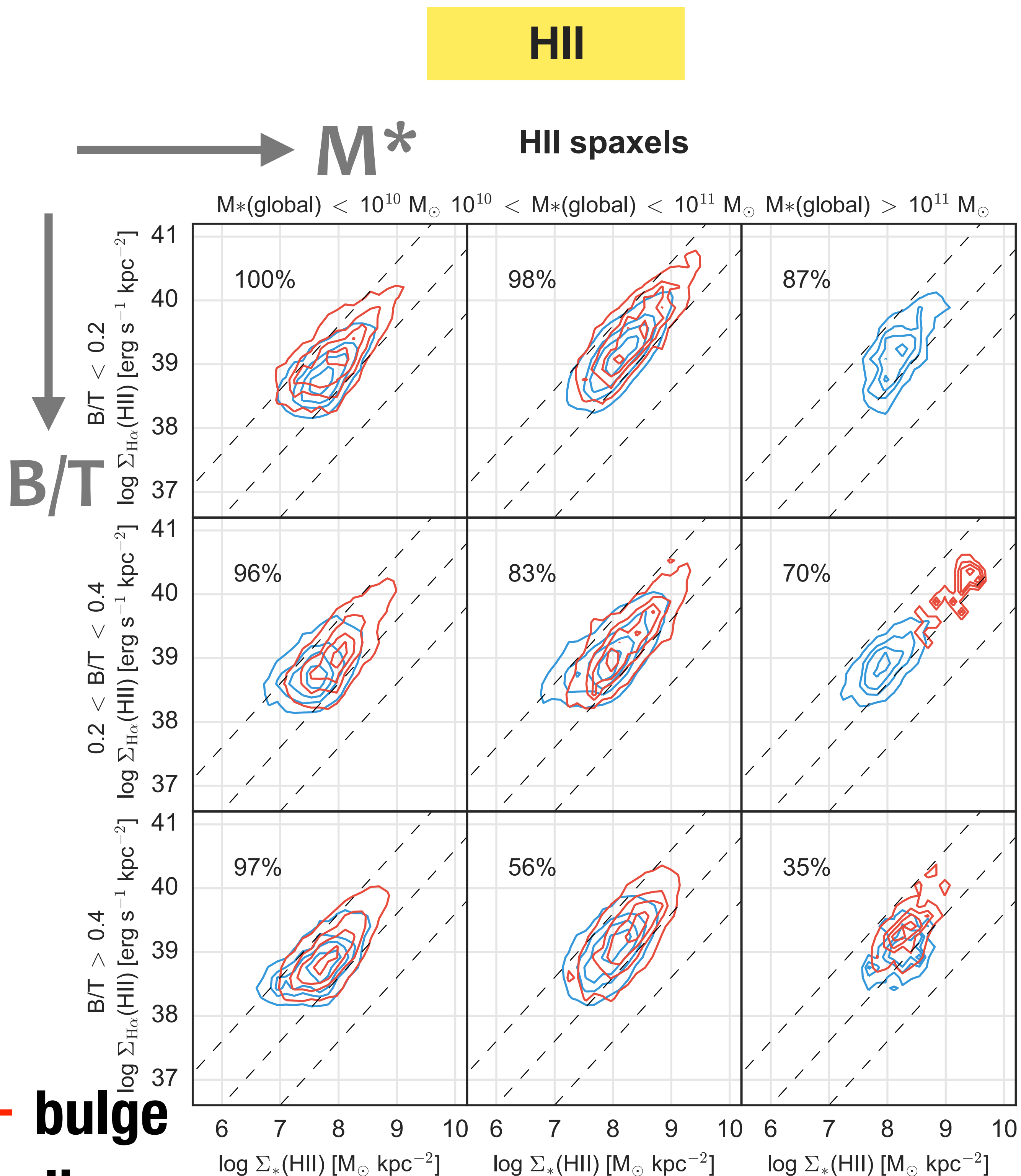
Spatially-resolved ionizing-source map for each galaxy

HII | Composite | LI(N)ER | Seyfert



Revisit the Spatially-Resolved SFR-M* Relation





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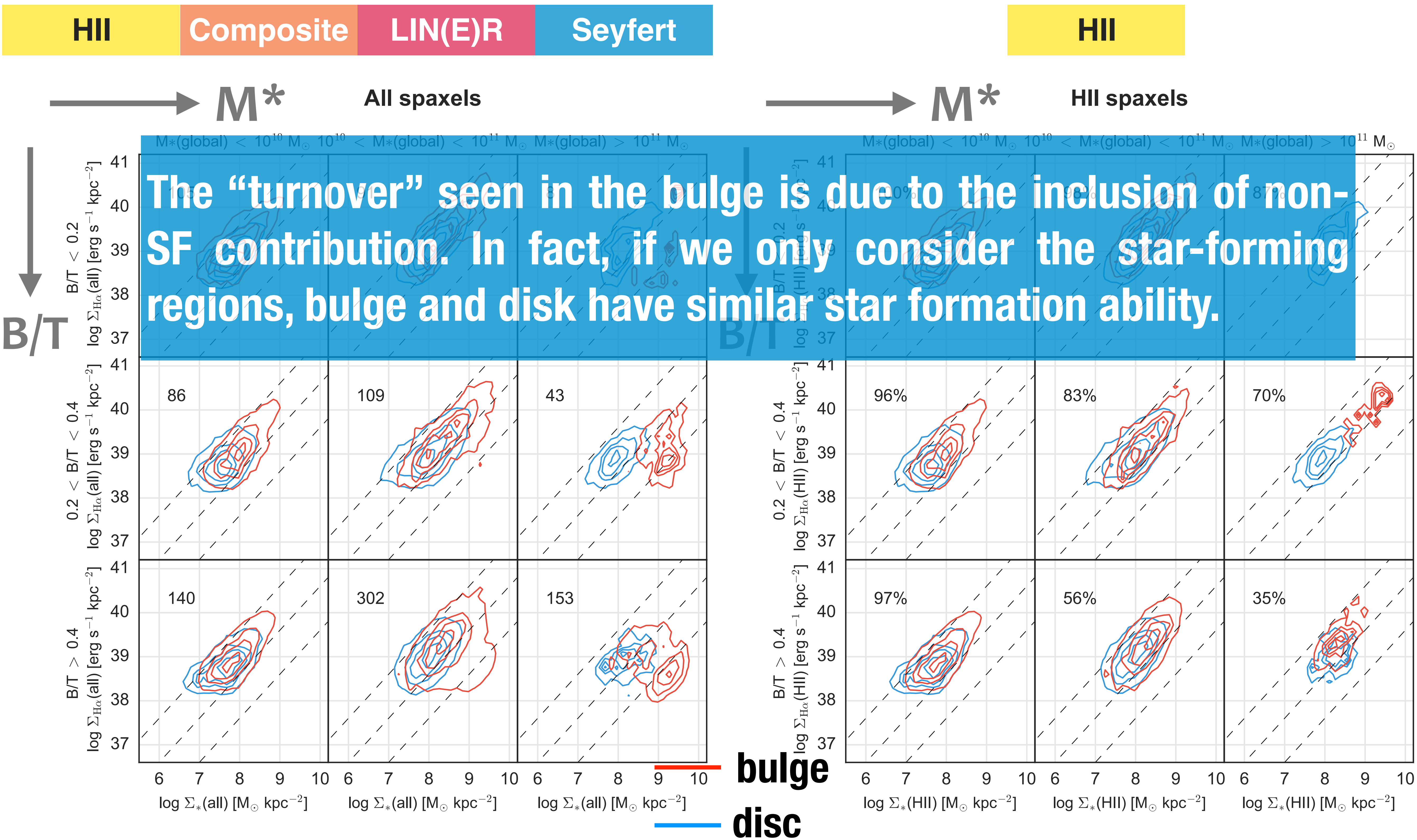
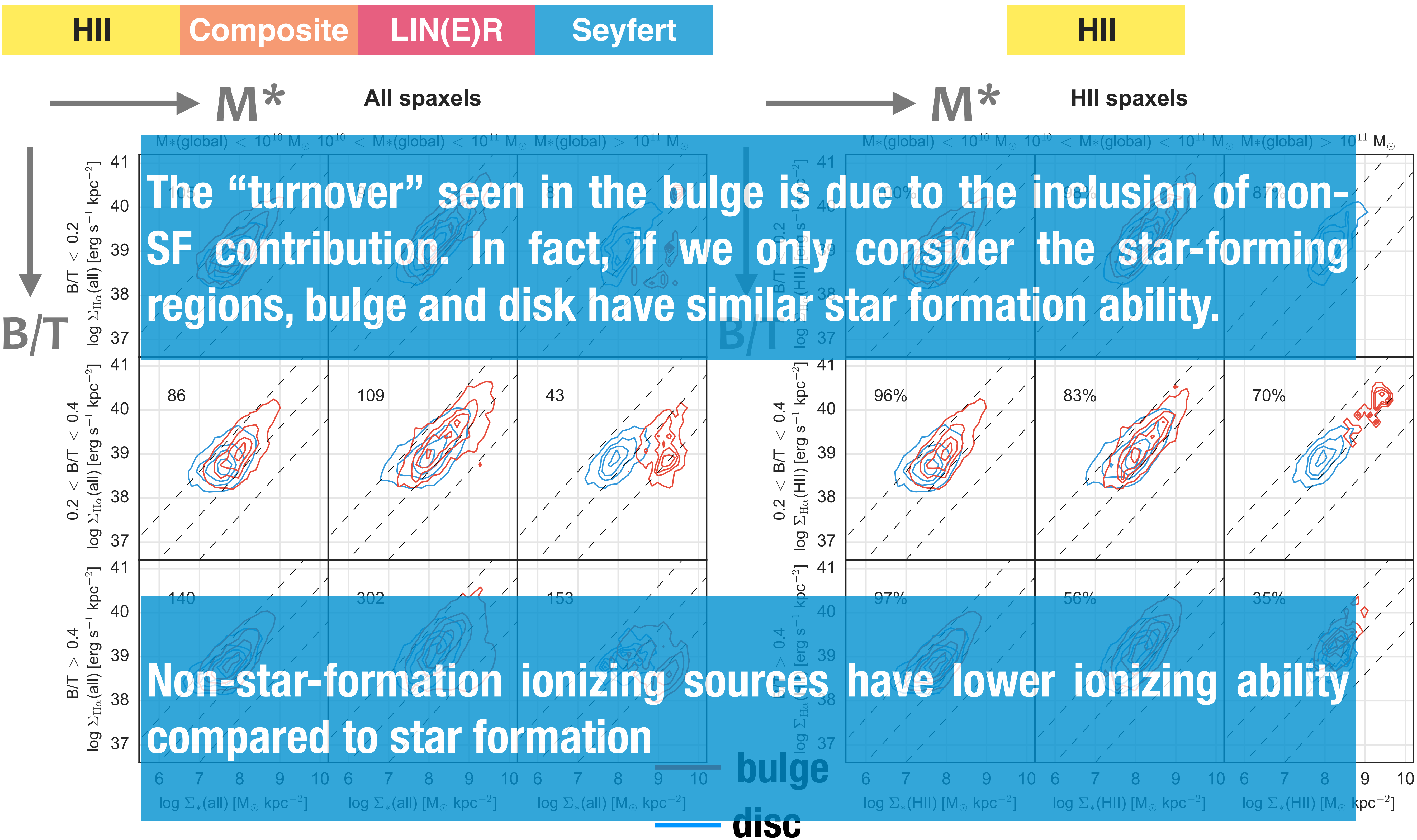


The "turnover" seen in the bulge is due to the inclusion of non-SF contribution. In fact, if we only consider the star-forming regions, bulge and disk have similar star formation ability.

Revisit the Spatially-Resolved SFR-M* Relation



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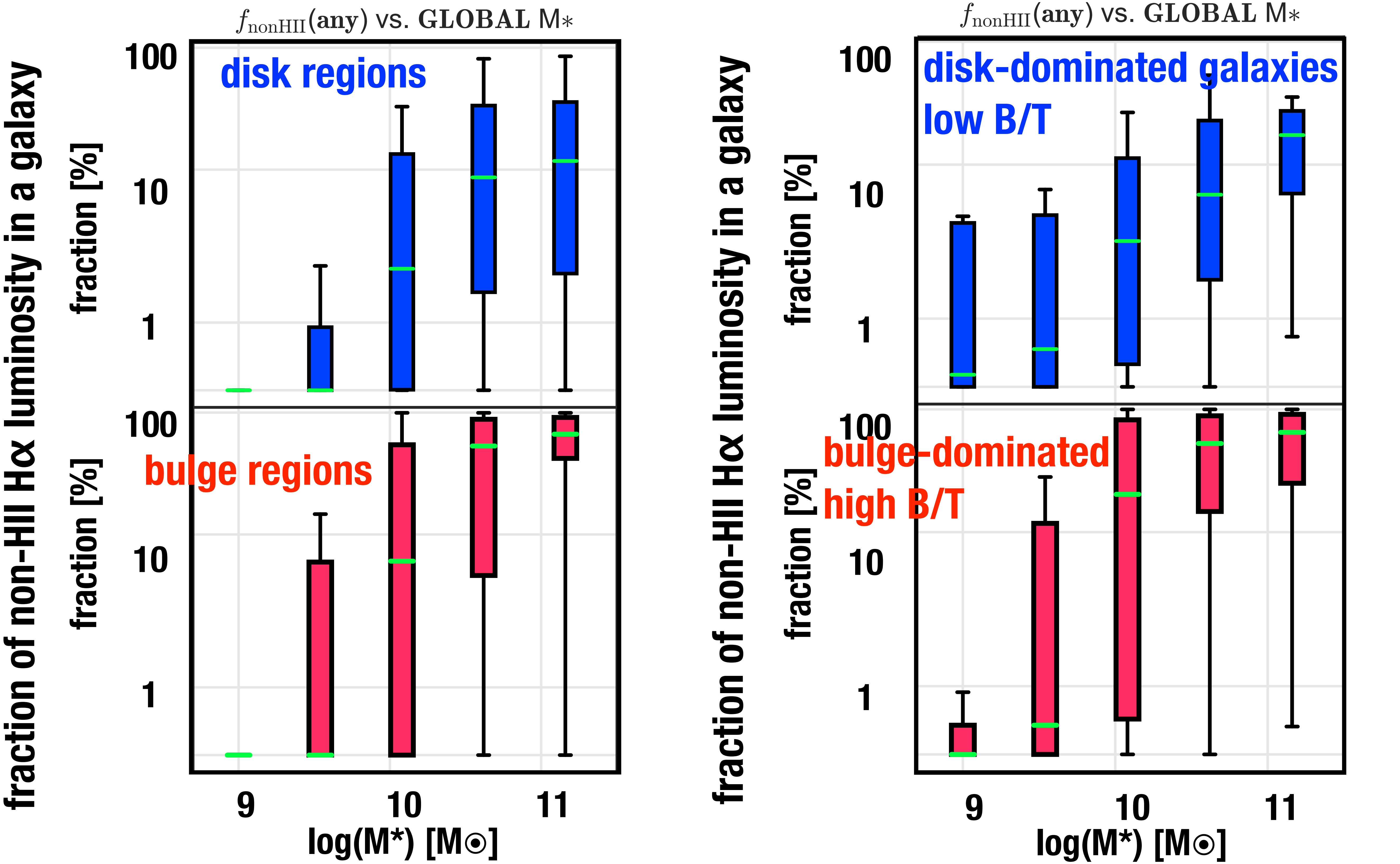
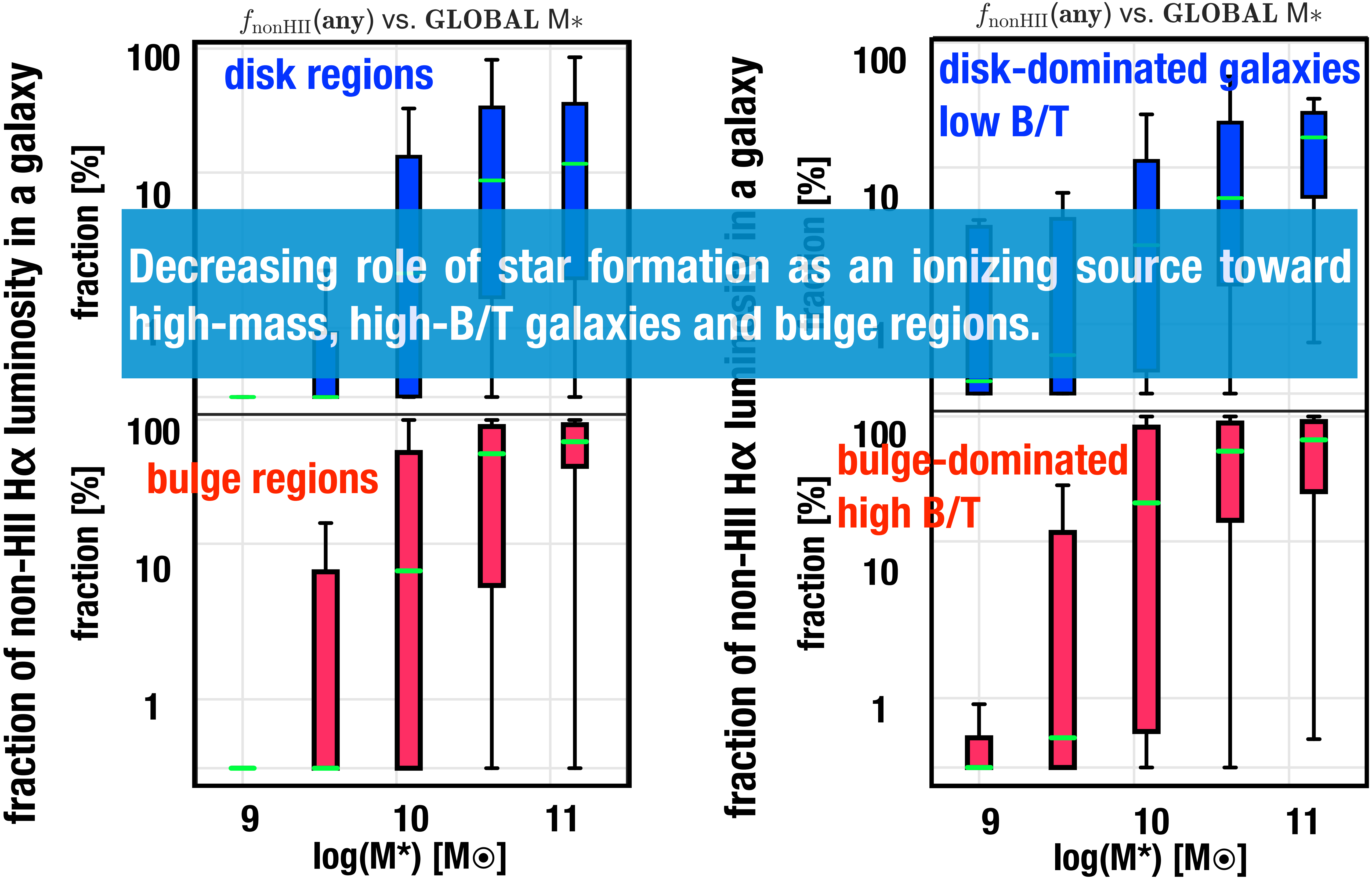
Non-star-formation ionizing sources have lower ionizing ability compared to star formation

Contribution of Non-SF sources in Galaxies

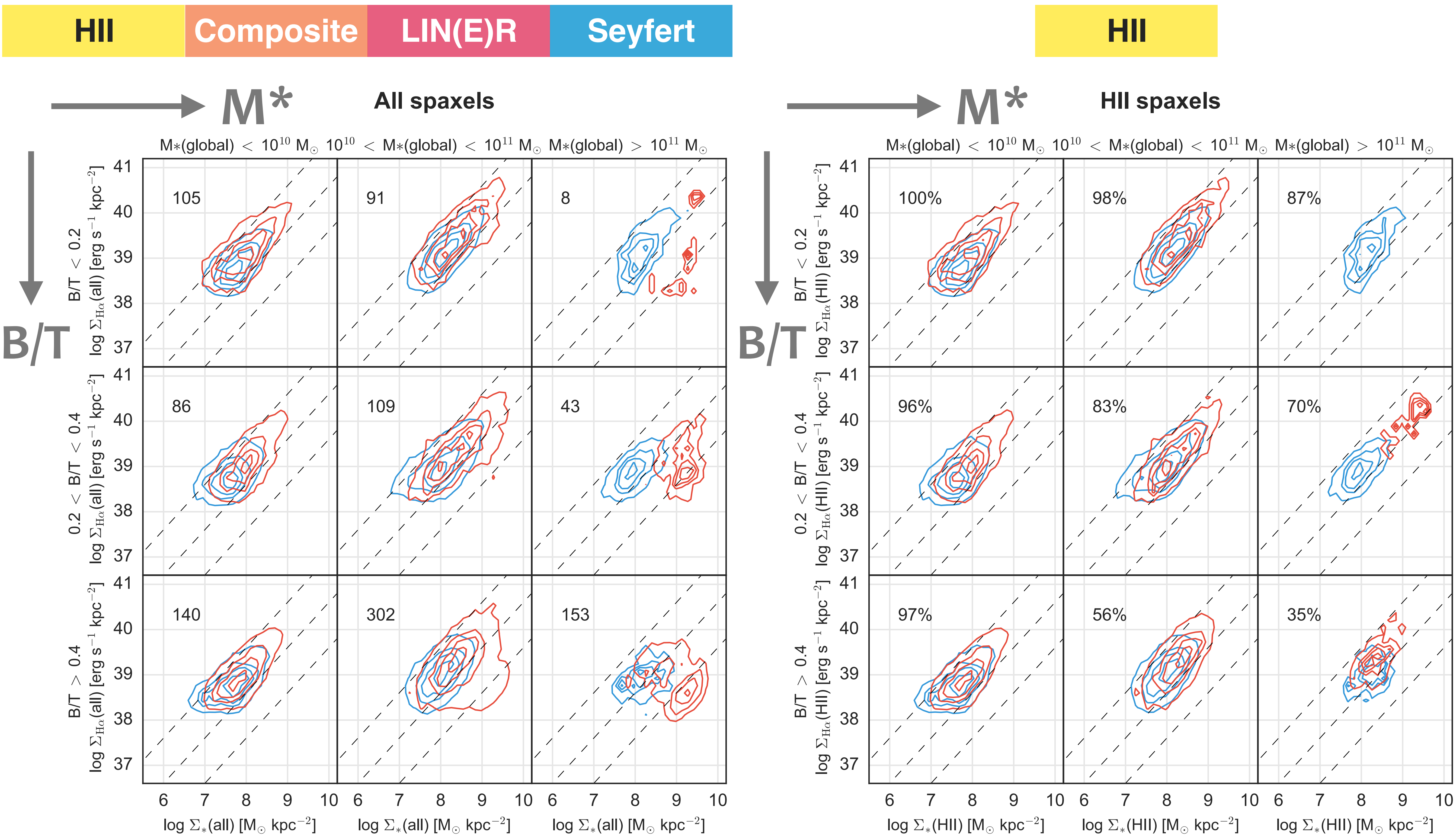


Contribution of Non-SF sources in Galaxies



Decreasing role of star formation as an ionizing source toward high-mass, high-B/T galaxies and bulge regions.

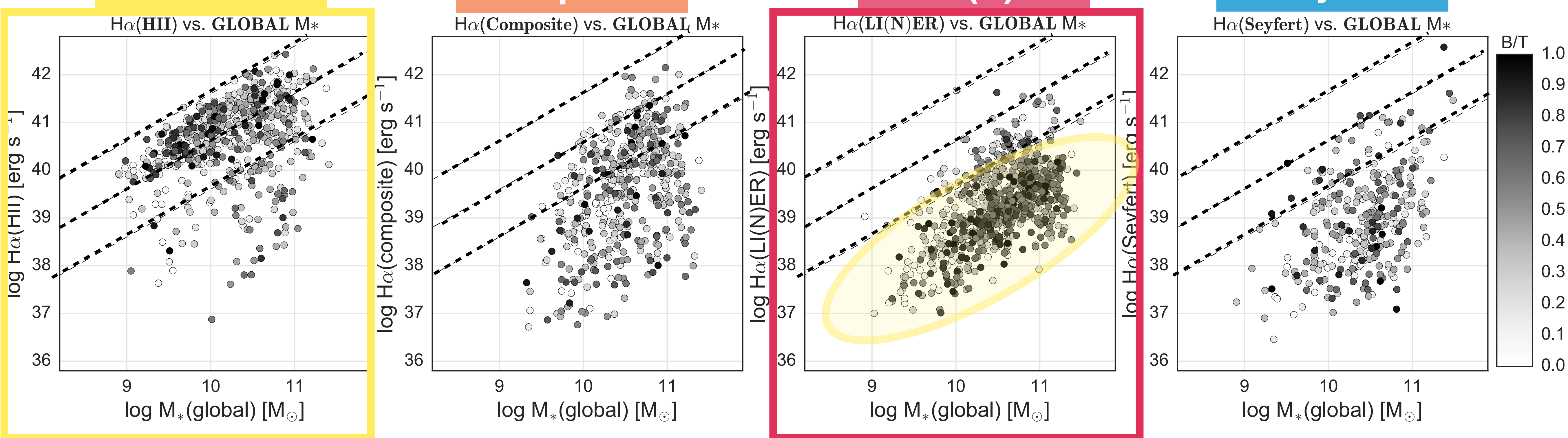
Revisit the Spatially-Resolved SFR-M* Relation

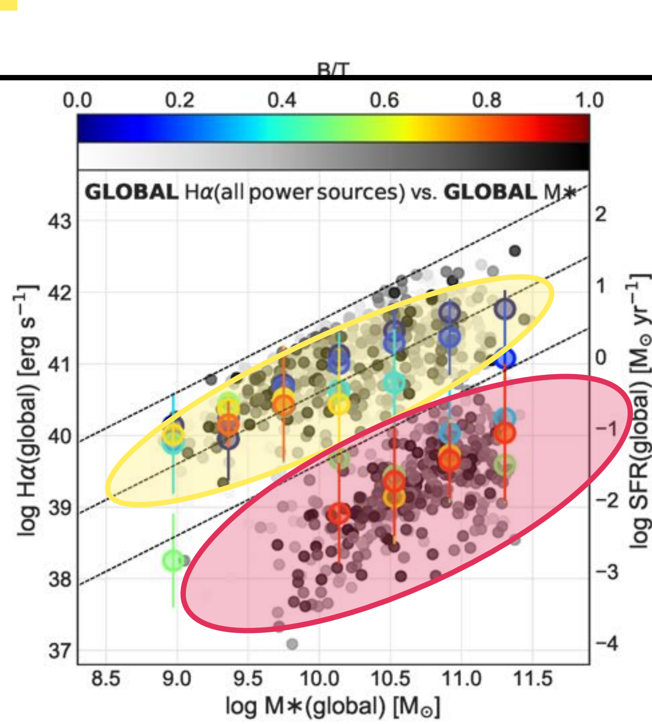


Revisit the Integrated SFR-M* Relation

What drive the two sequences in the integrated relation with all ionizing sources?

HII | Composite | LIN(E)R | Seyfert





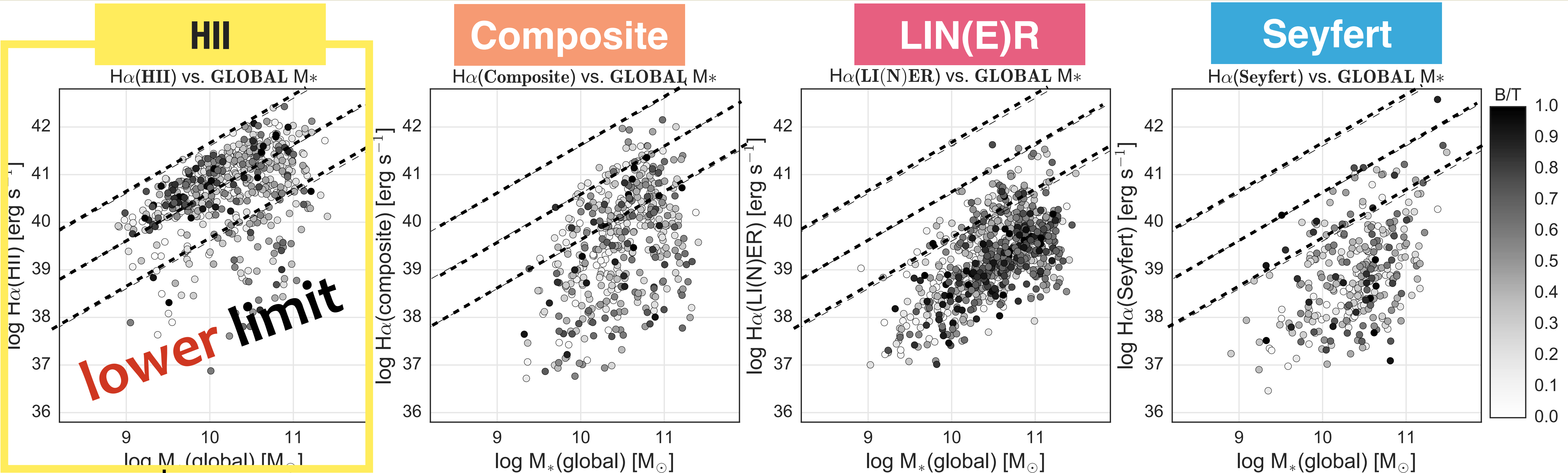
young stars powered

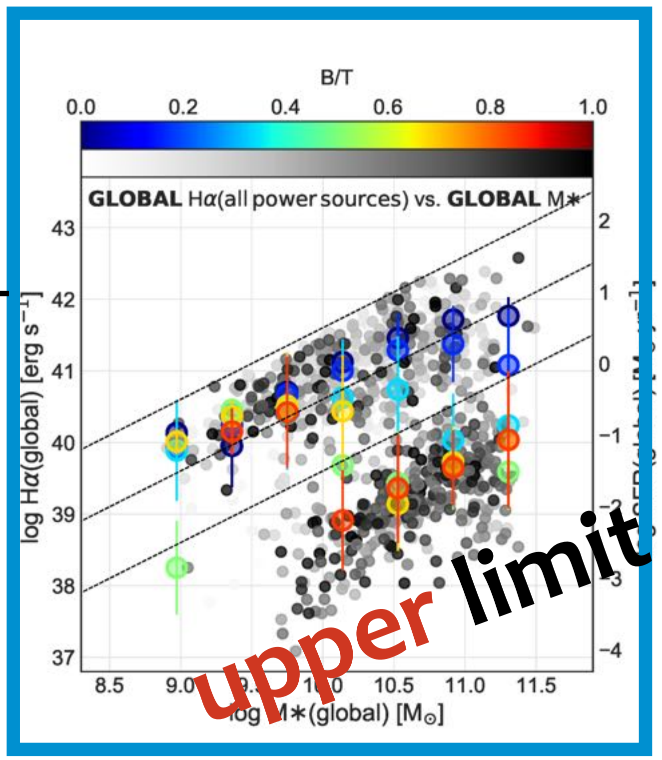
evolved stars powered

B.-C. Hsieh+2017 ApJL

Revisit the Integrated SFR-M* Relation

How does the true Hα-M* relation look like?

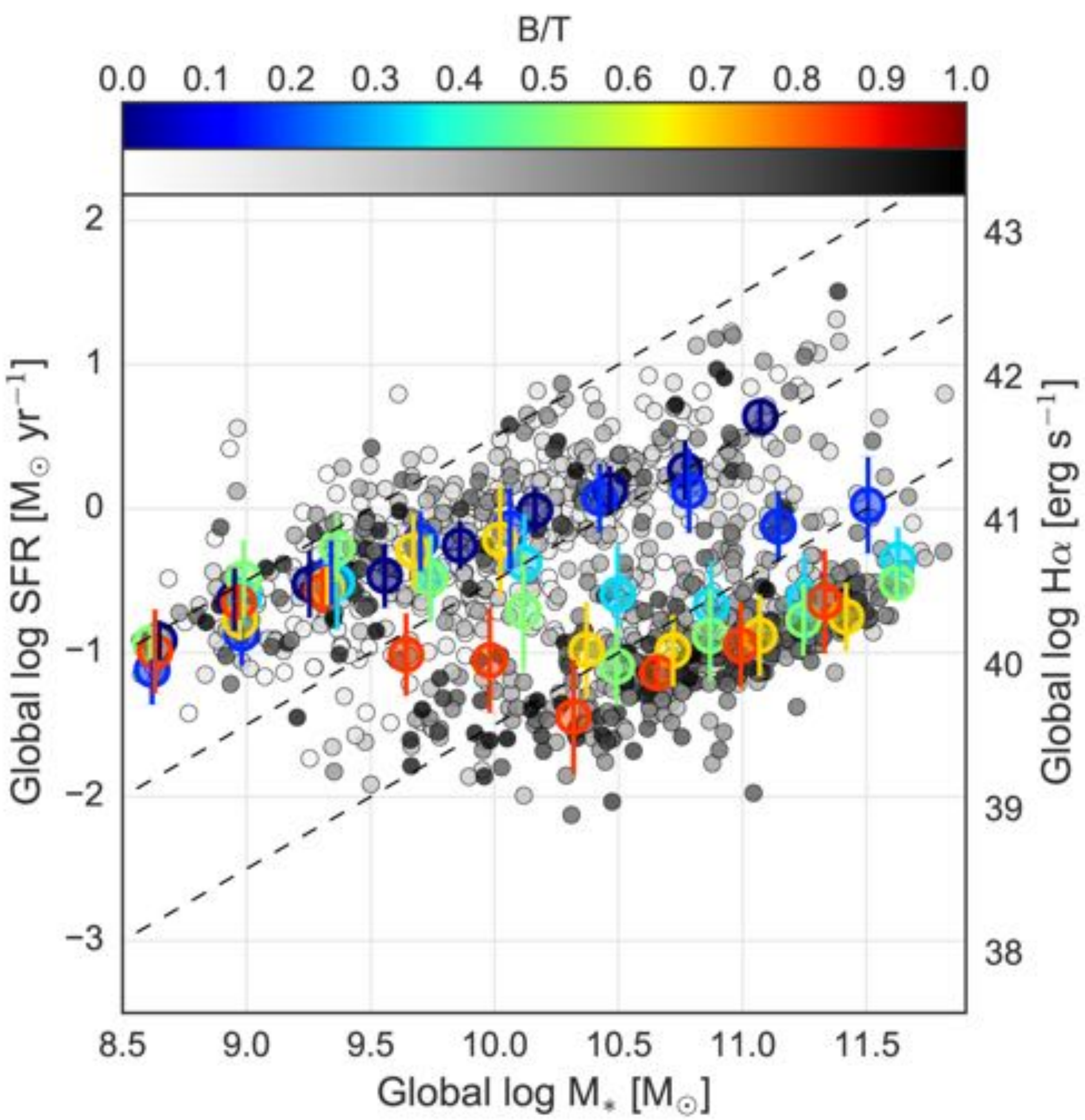




The non-HII spaxels are not necessarily devoid of star formation, but simply being dominated by mechanisms other than star formation…

bracketing scenarios

Revisit the Spatially-Resolved SFR-M* Relation



Summary for this part:

past explanation:

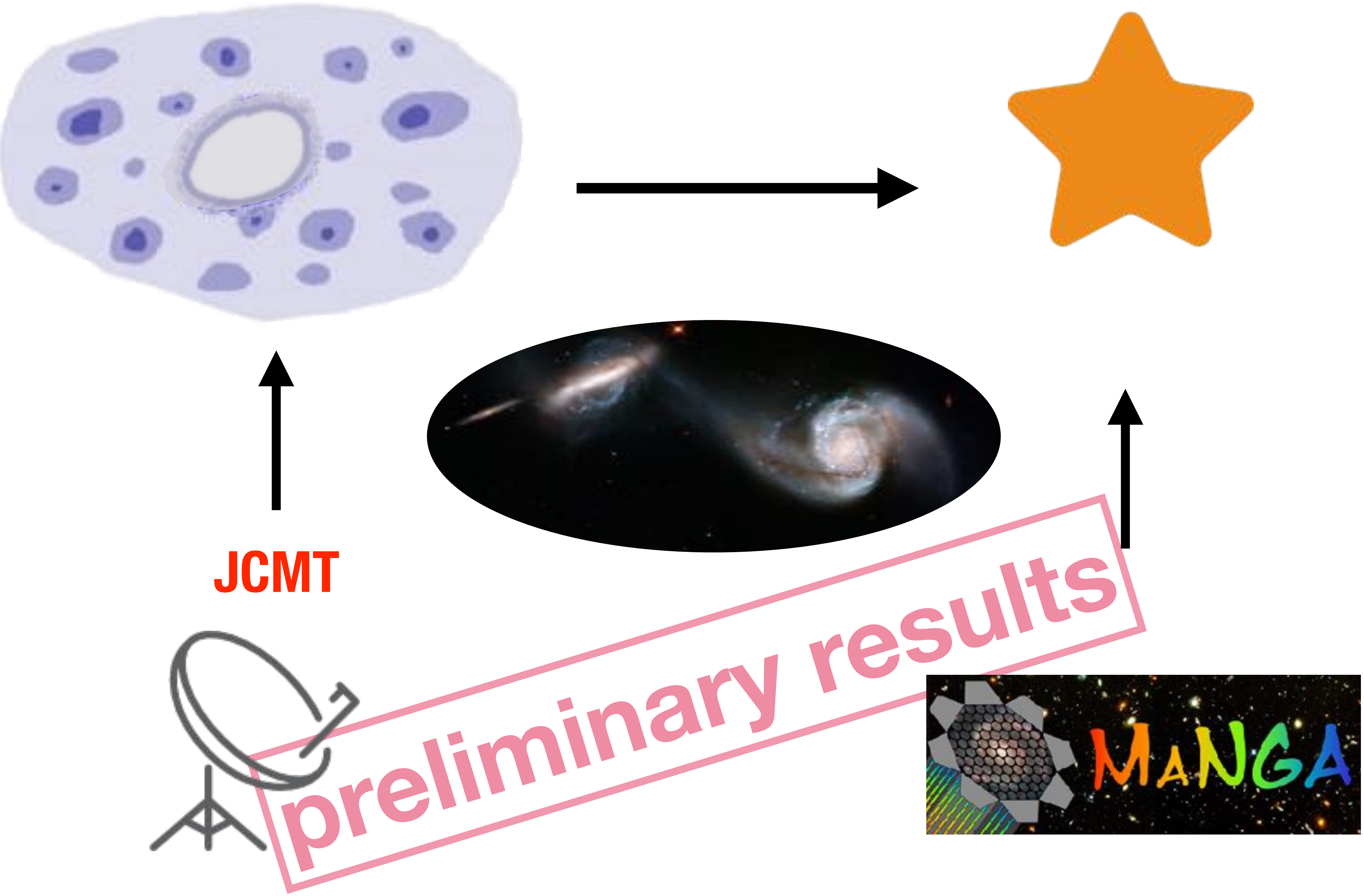
bulge (and therefore bulge-dominated galaxies) has lower sSFR. (Abramson+14, Whitaker+2015)

our explanation:

star-forming regions in bulge has same sSFR with that in disk, but bulge has higher fraction of Ha contributed by those non-SF mechanisms with low ionizing ability.

(submitted to the The Astrophysical Journal)

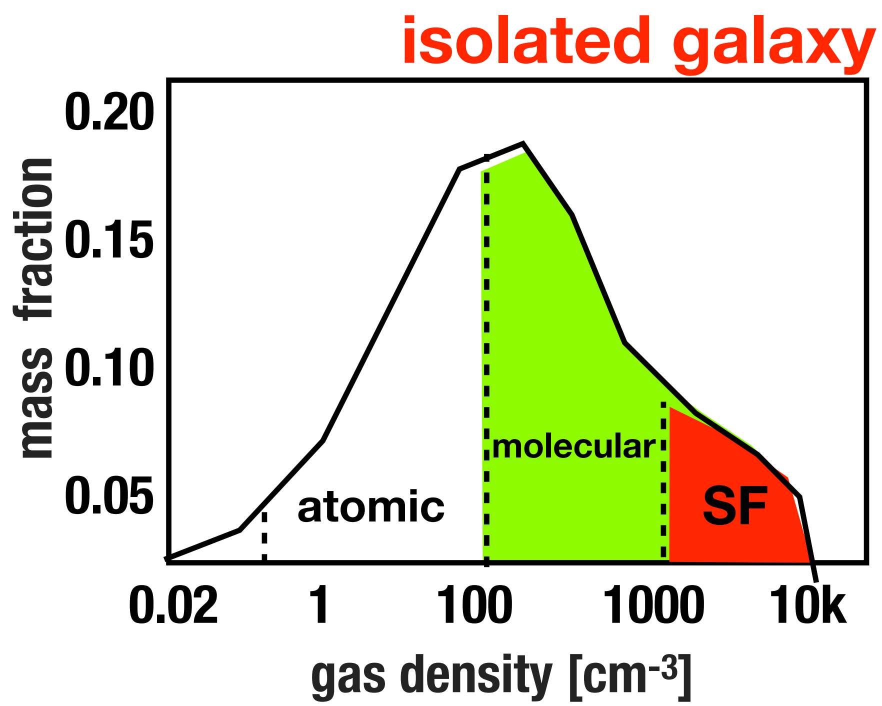
Gas and Star Formation in Interacting Galaxies

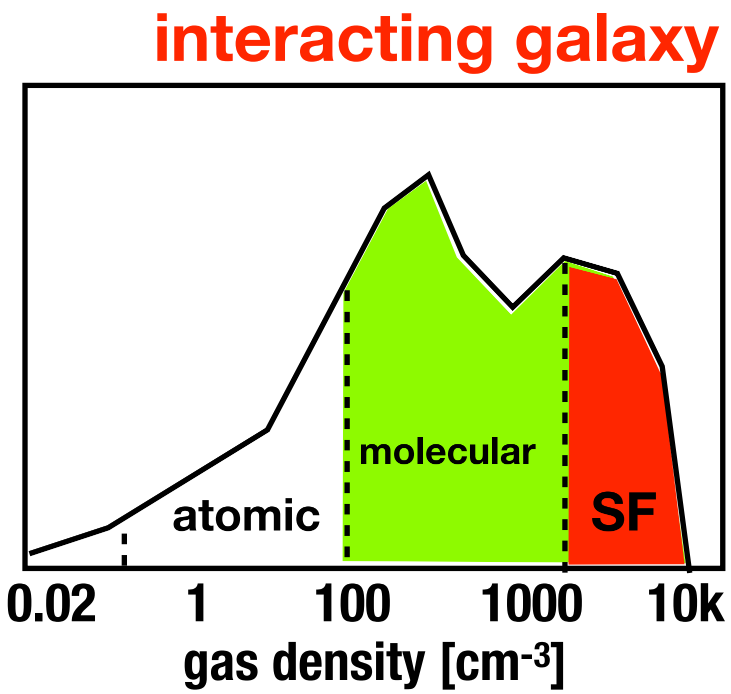


Star Formation in Interacting Galaxies

conflict between theory and observation 1 (level of enhancement)

theoretical perspective

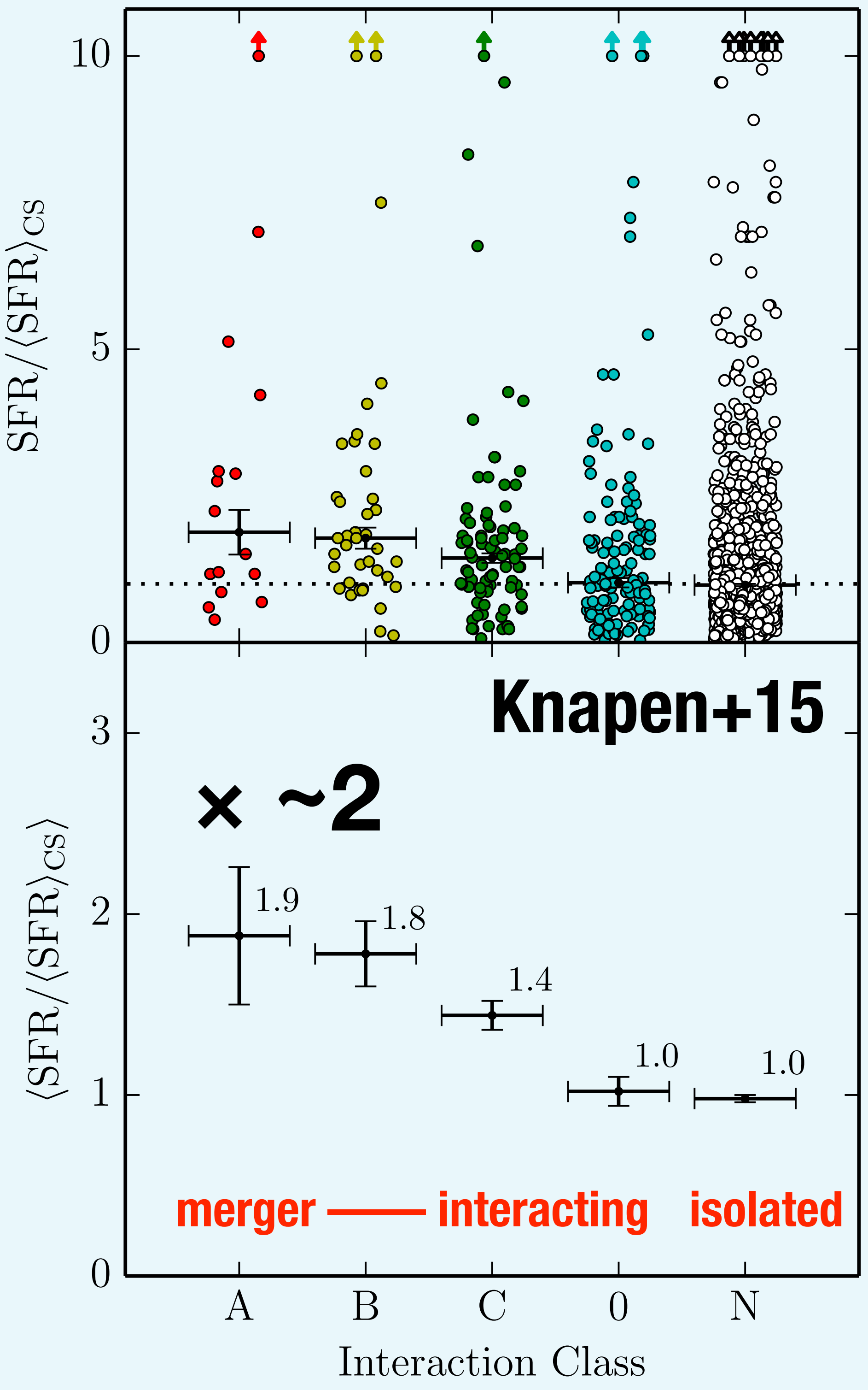




Bournaud+11

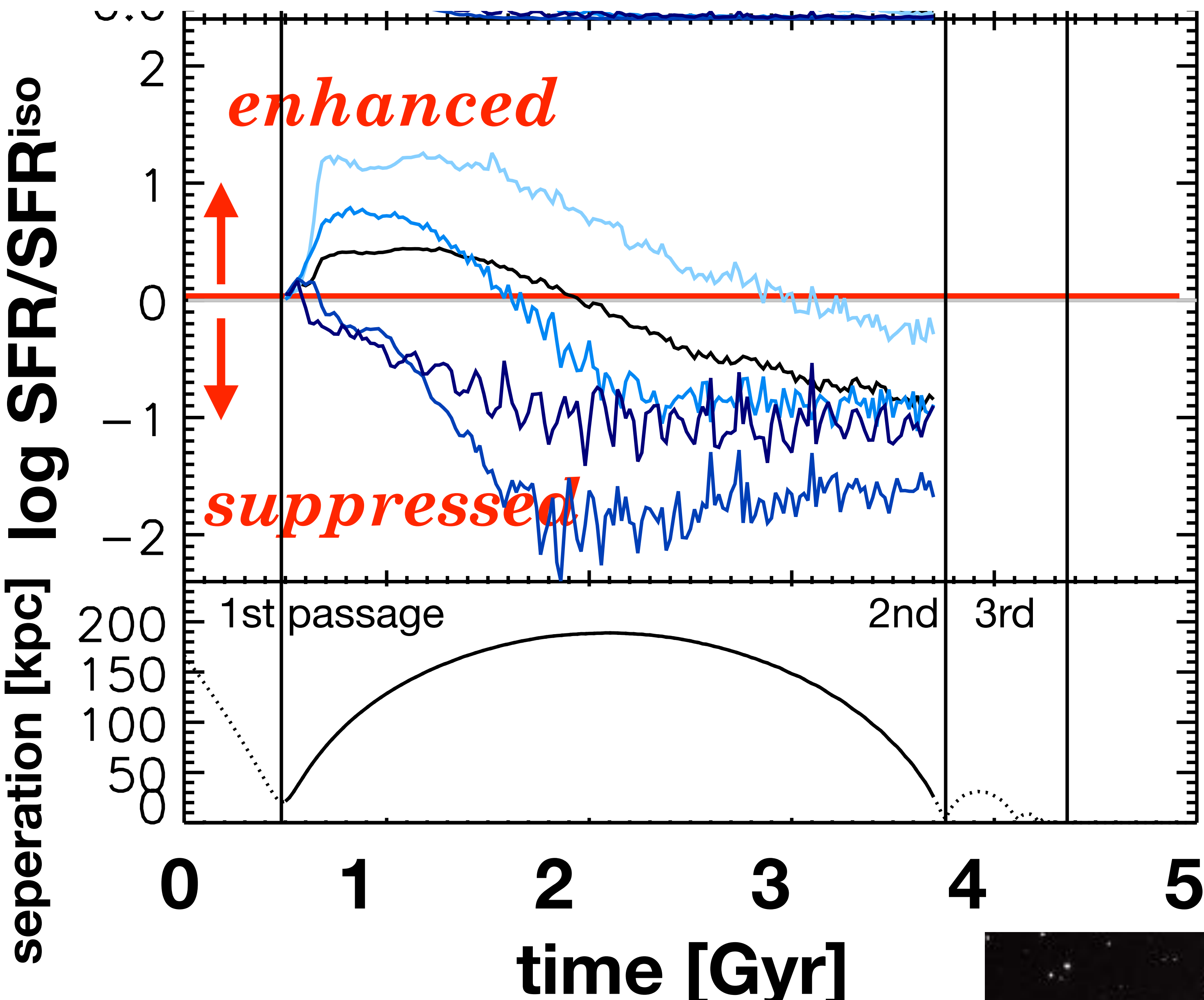
3 — 10 times enhanced in SFR

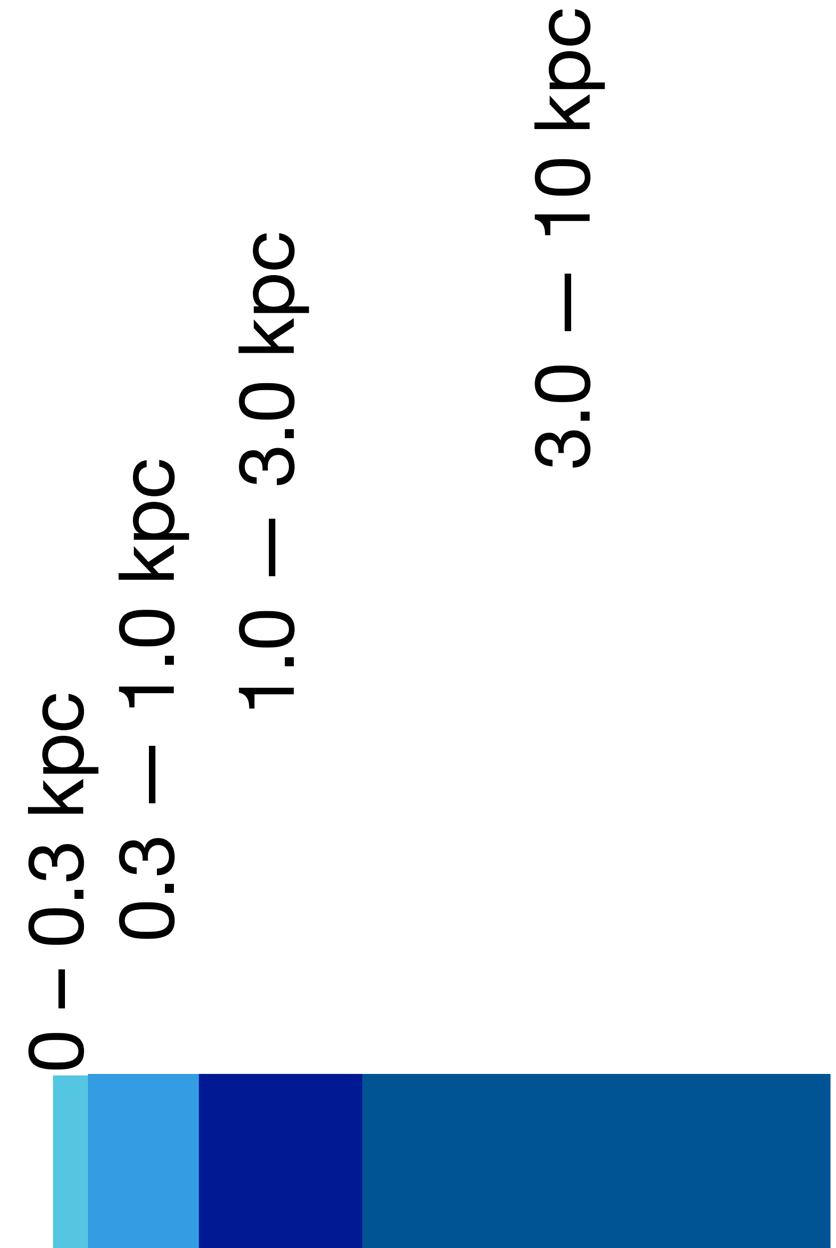
observation



Star Formation in Interacting Galaxies

conflict between theory and observation 2 (spatial distribution)



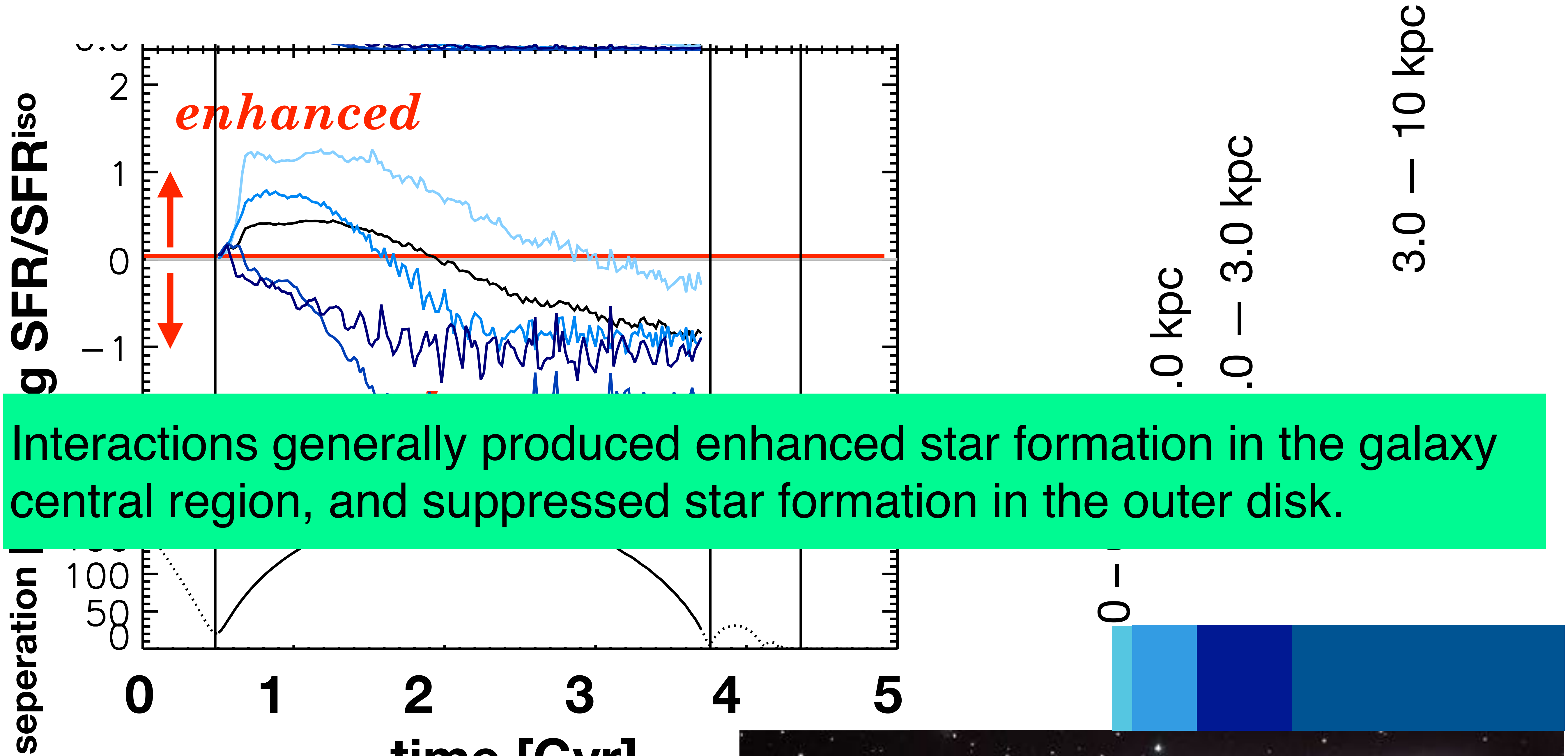


Moreno+15

theoretical prediction

Star Formation in Interacting Galaxies

conflict between theory and observation 2 (spatial distribution)



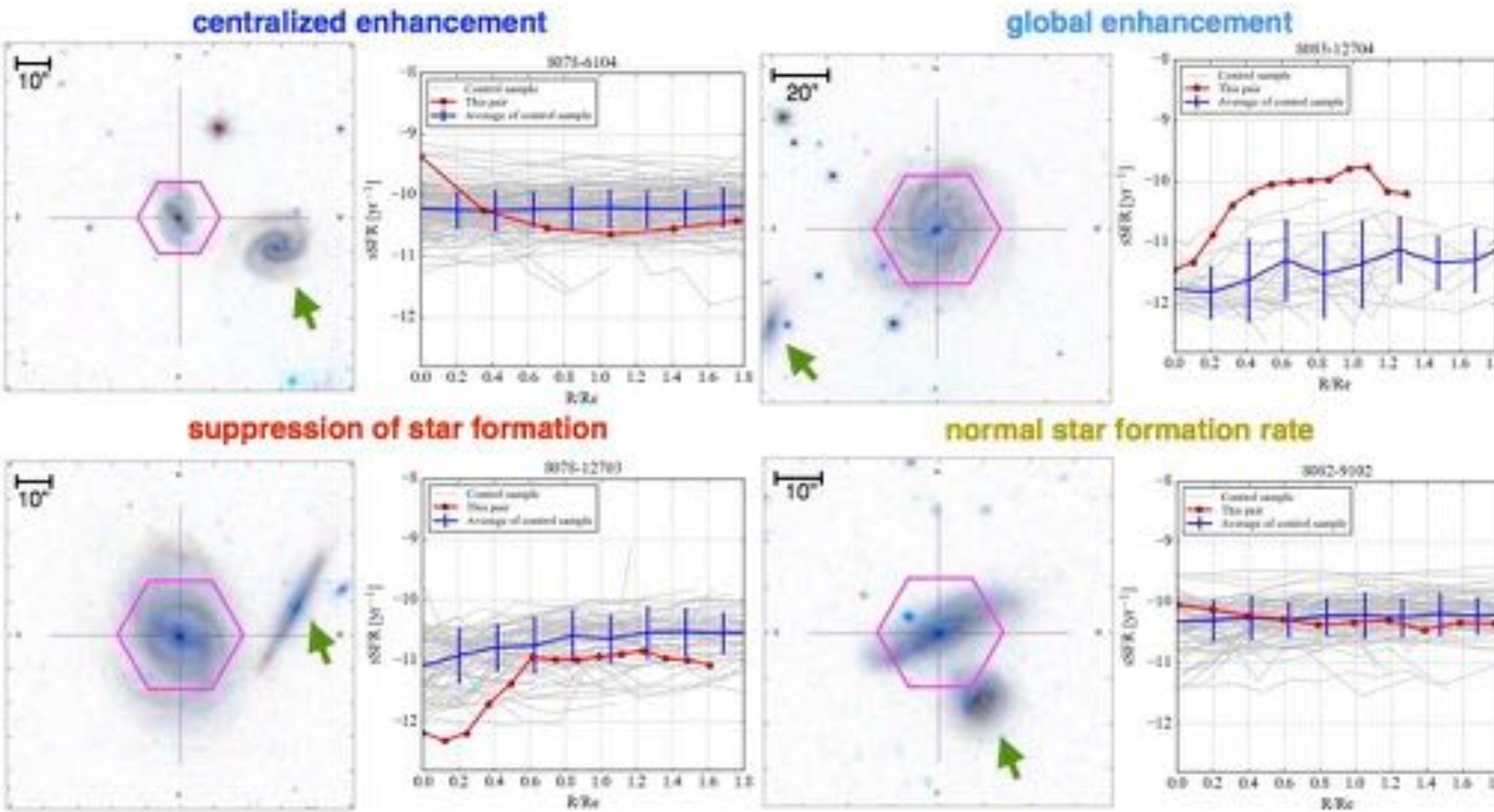
Interactions generally produced enhanced star formation in the galaxy central region, and suppressed star formation in the outer disk.

Moreno+15

theoretical prediction

Star Formation in Interacting Galaxies

observation



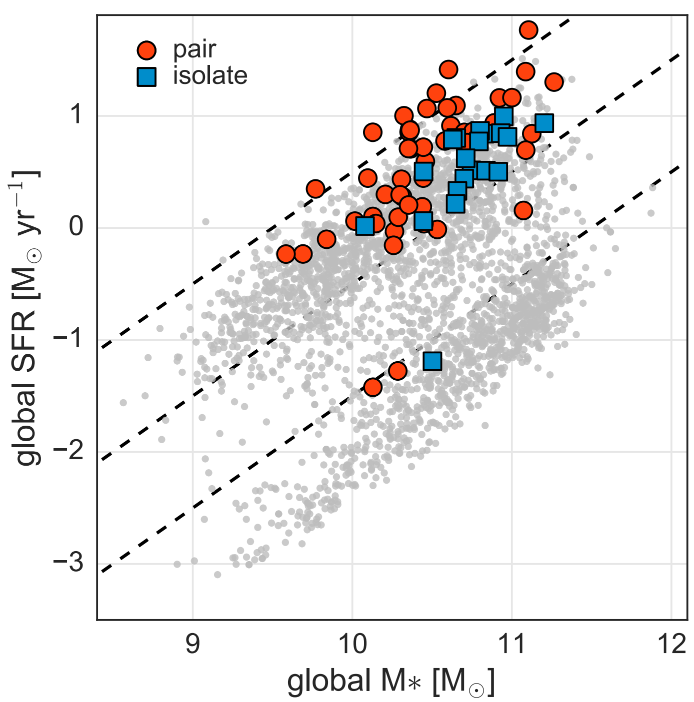
Molecular Gas Observations by JCMT

*The JCMT dust and gas In Nearby Galaxies Legacy Exploration

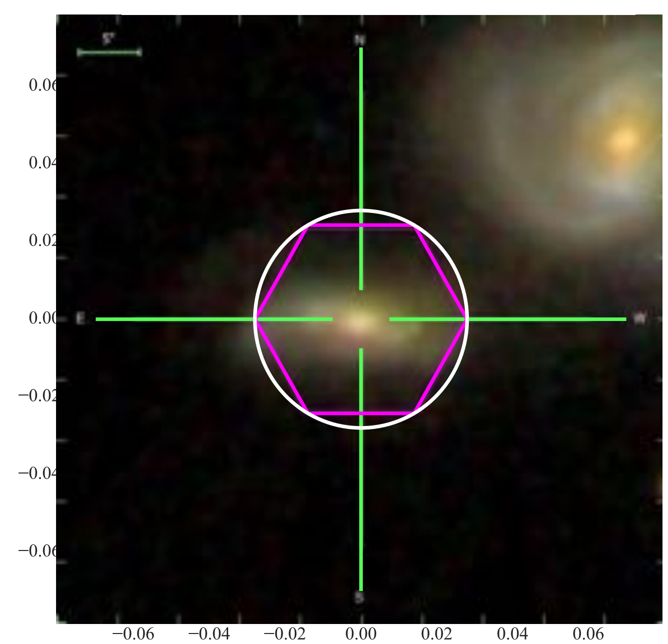
Project	JINGLE*	JINGLE Pilot	Close Pairs
PI	A. Saintogne	T. Xiao L. Lin	H.-A. Pan
telescope	JCMT	JCMT/PMO/CSO	JCMT
status	ongoing	completed	ongoing
transition	dust continuum $^{12}CO(2\text{-}1)$	$^{12}CO(1\text{-}0)$ $^{12}CO(2\text{-}1)$	$^{12}CO(2\text{-}1)$
number of galaxies used	4	30	40

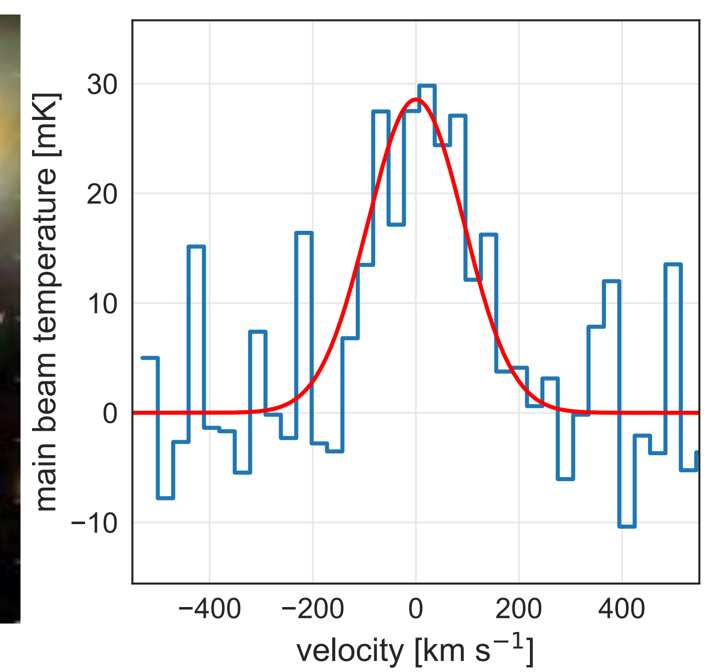
74

Sample on SFR-M* plane

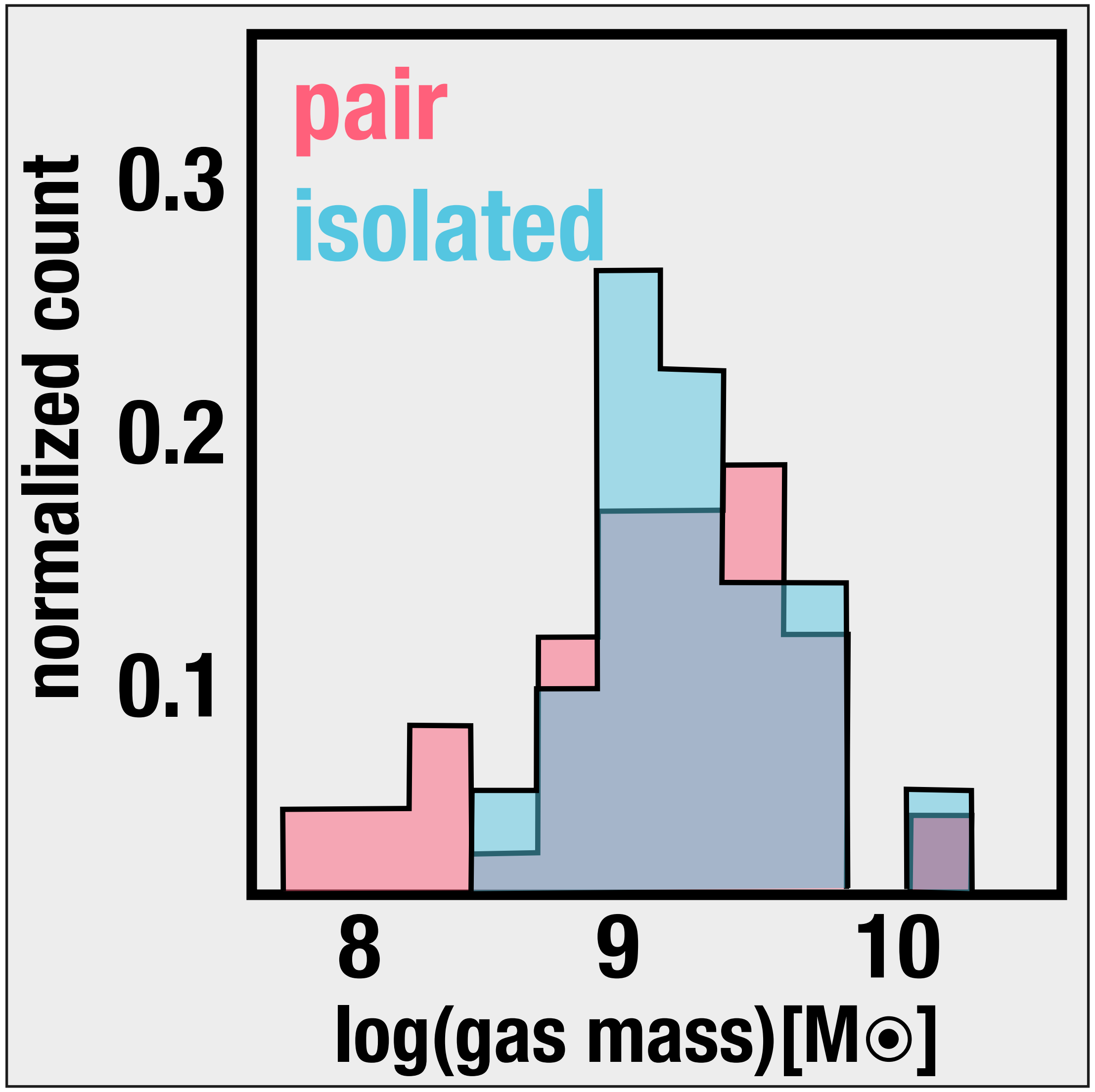


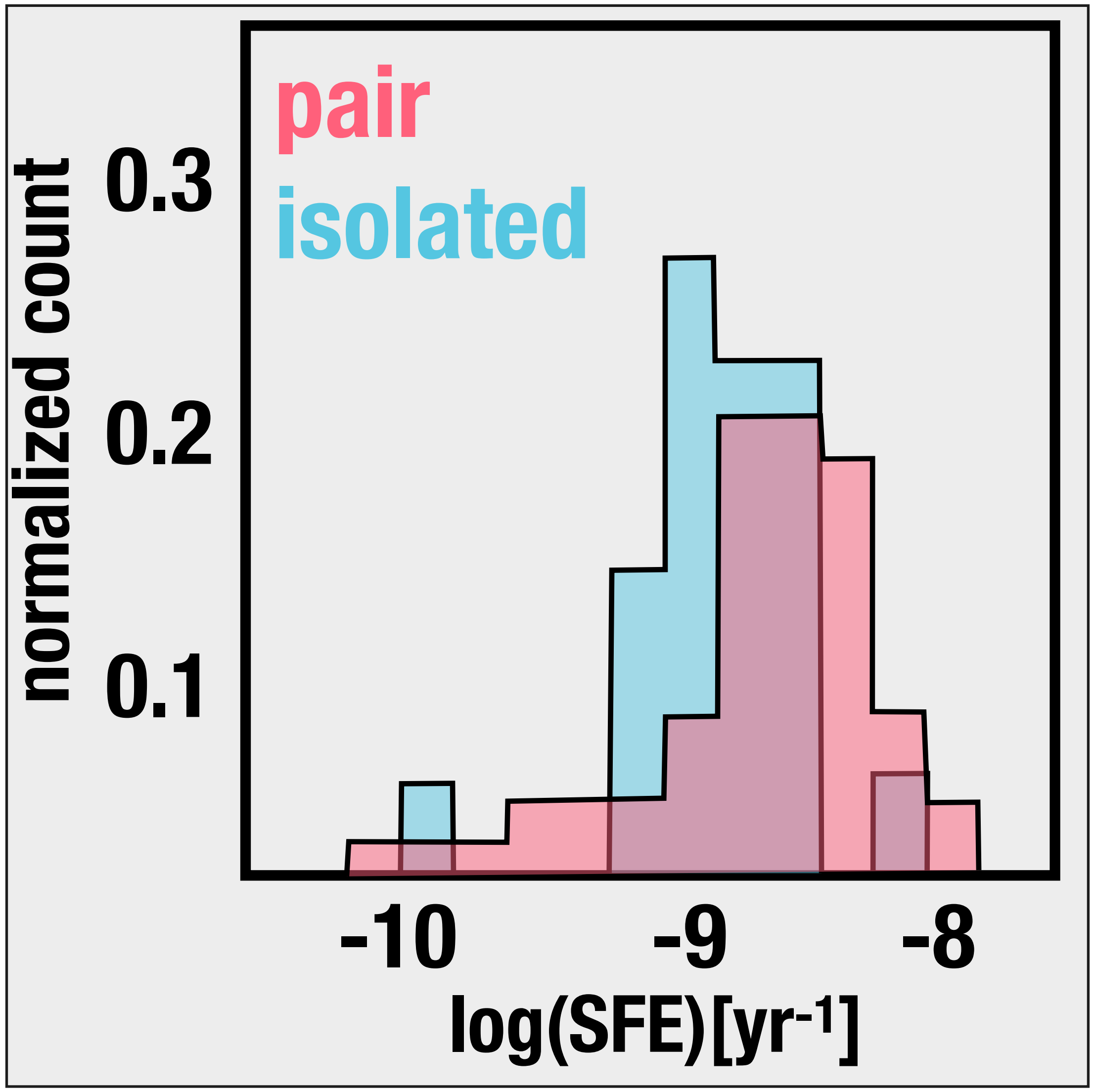
JCMT Spectra





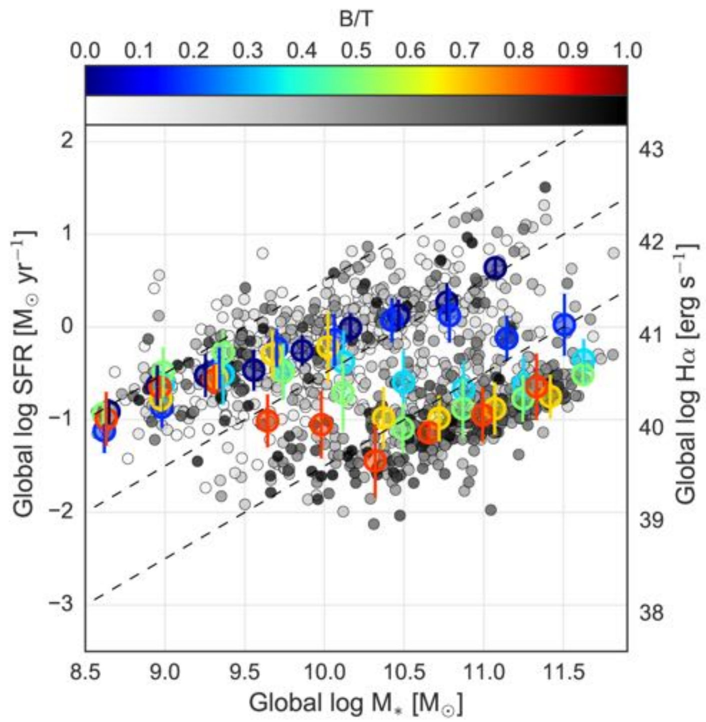
Molecular Gas in Close Pairs





- Gas mass and SFE spread a wider range in galaxy pairs compared to isolated galaxies, leading to the various level and appearance of star formation in close pairs.
- Interacting stage, mass ratio, …

Summary



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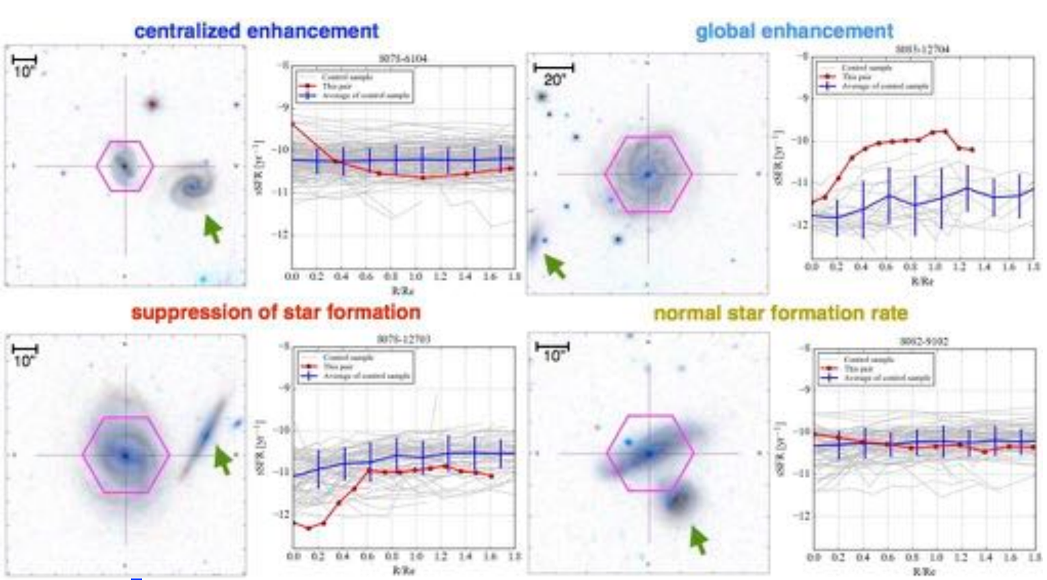

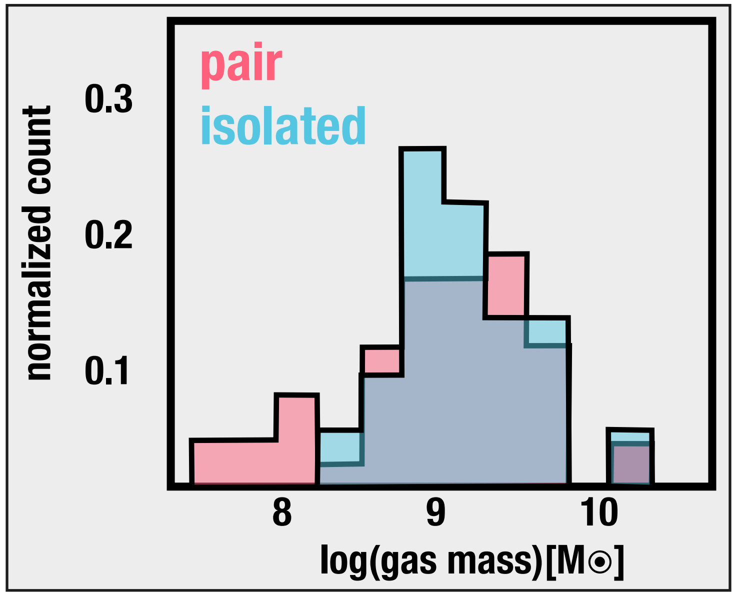

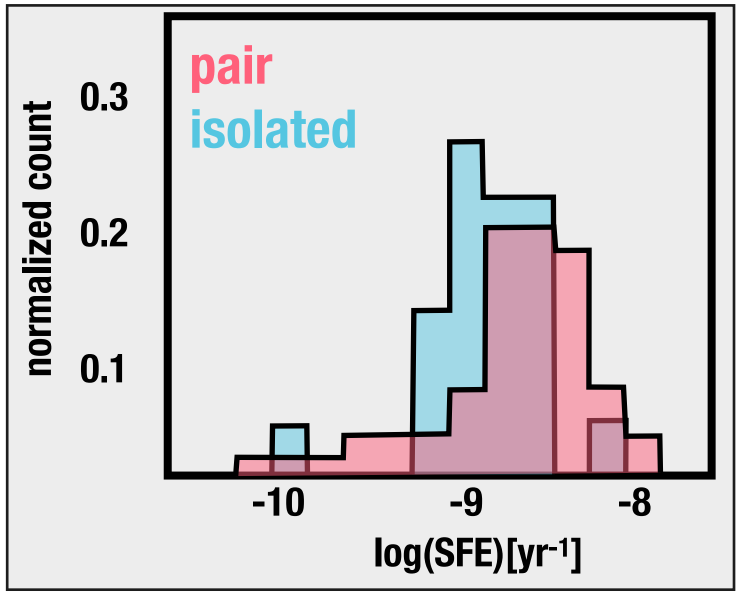

past:

galaxy interaction generates enhances SFR at the galactic center

our finding:

galaxy interaction generates various types of star formation appearance and gas properties