Complexity and scatter in kpc-scale star formation scaling relations in ALMaQUEST: (ALMA-MaNGA QUEnching and STar formation survey)

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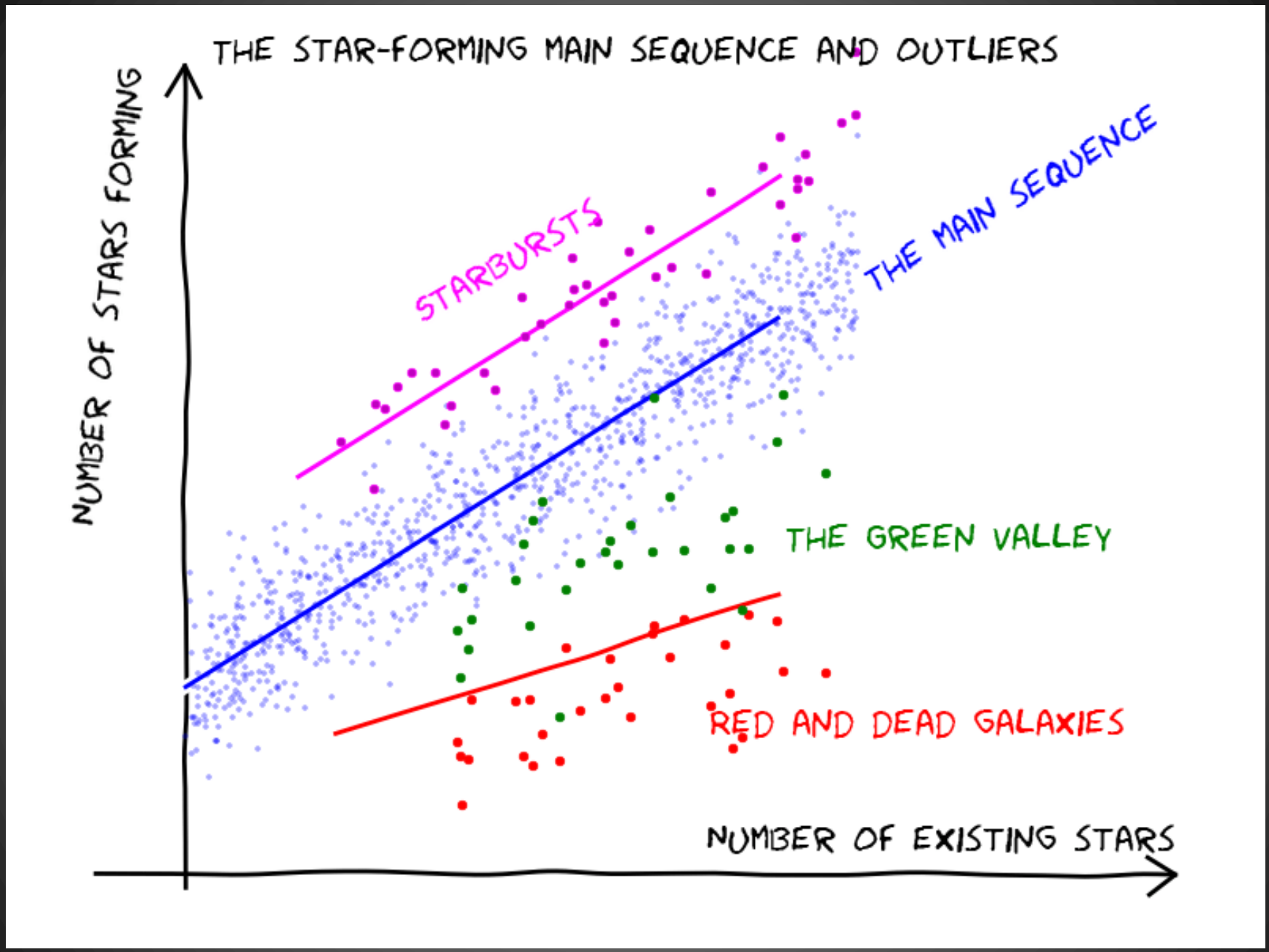
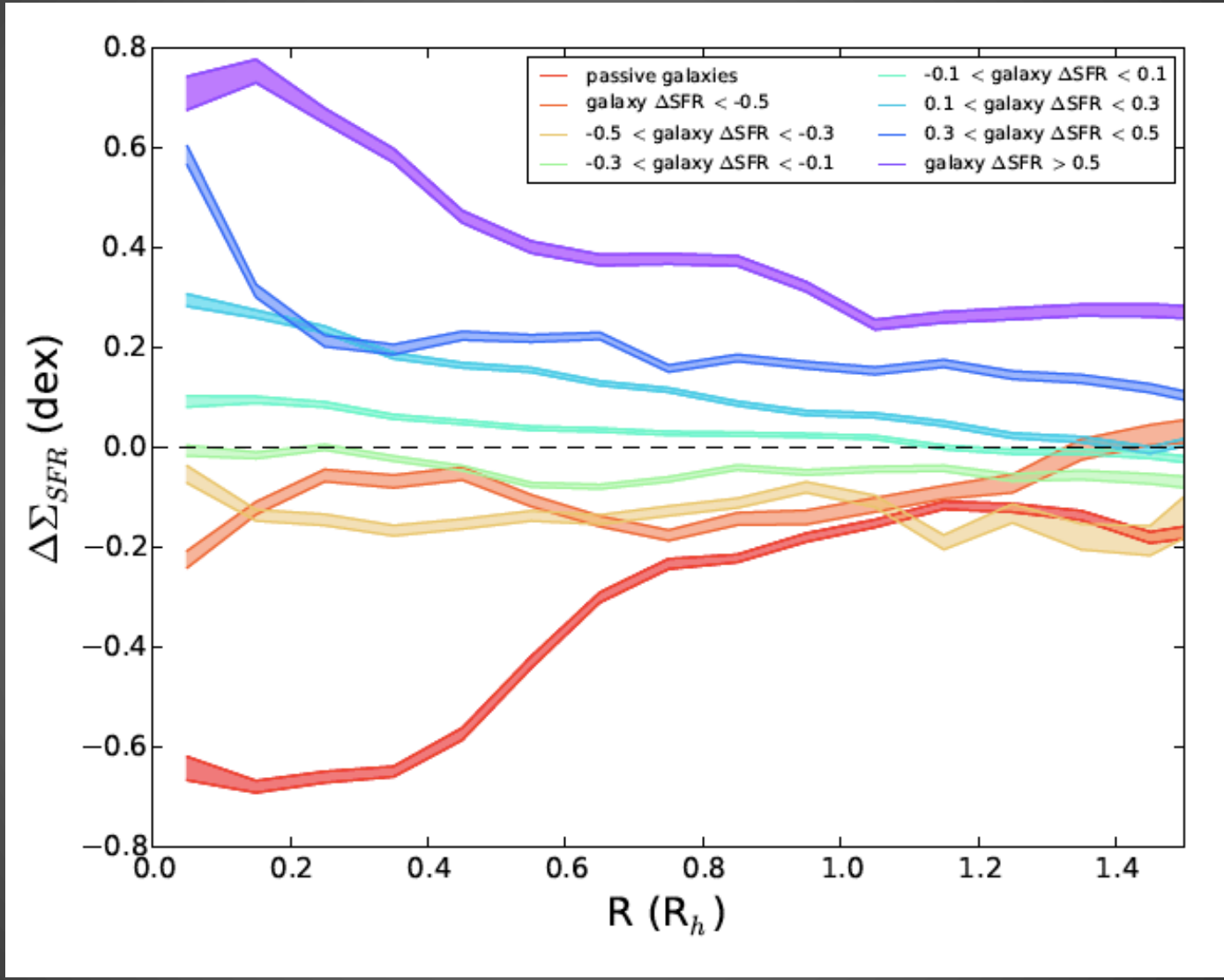
http://arc.phys.uvic.ca/~almaquest/


THE STAR-FORMING MAIN SEQUENCE AND OUTLIERS
NUMBER OF STARS FORMING
STARBURSTS
THE MAIN SEQUENCE
THE GREEN VALLEY
RED AND DEAD GALAXIES
NUMBER OF EXISTING STARS

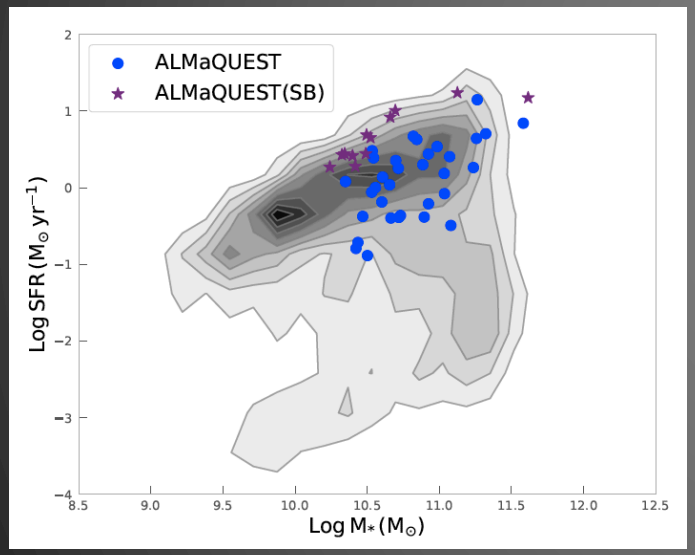
Radial profiles of relative SFR:
Star formation is boosted and quenched from the inside out.

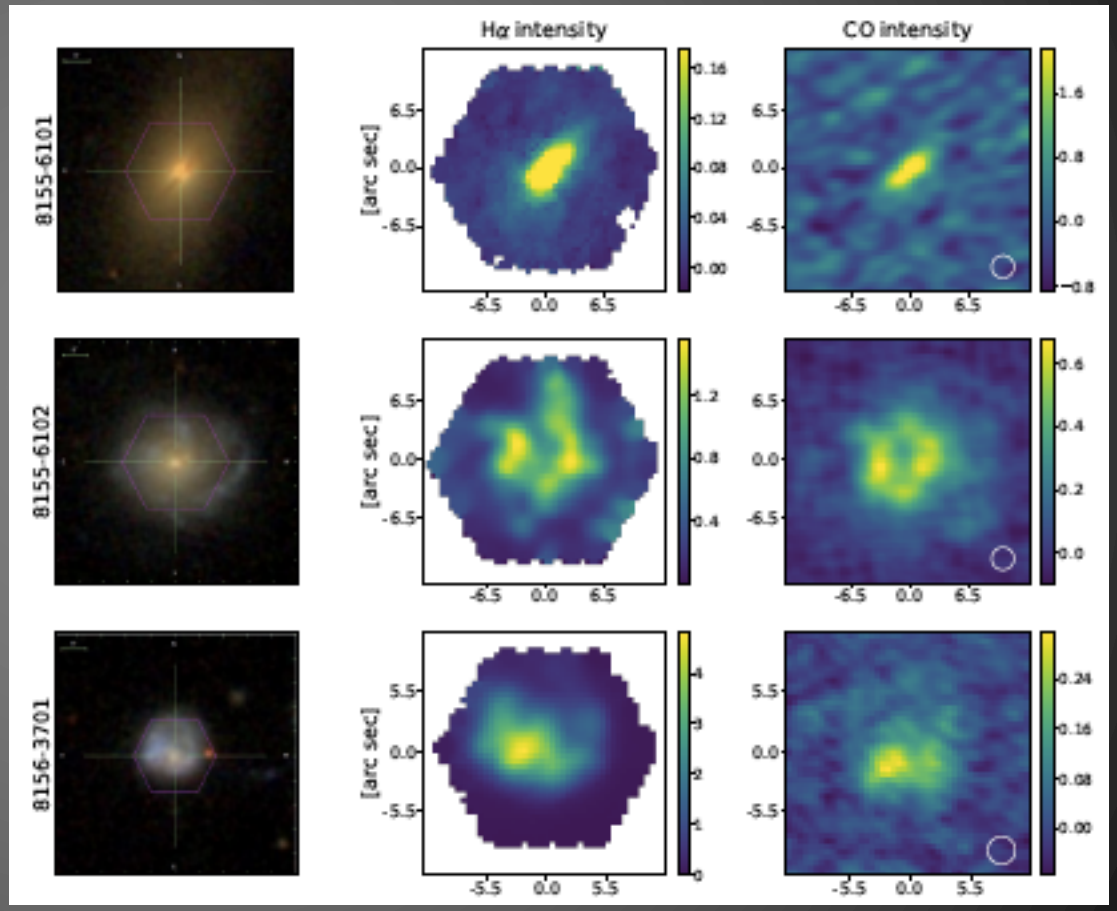


Ellison et al. (2018)

The ALMaQUEST Survey:
46 MaNGA selected galaxies observed in CO(1-0) with ALMA.

Resolution (~kpc) matched molecular gas maps ($\sum_{H2}$) complement the MaNGA data products, such as $\sum_{*}$ and $\sum_{SFR}$.





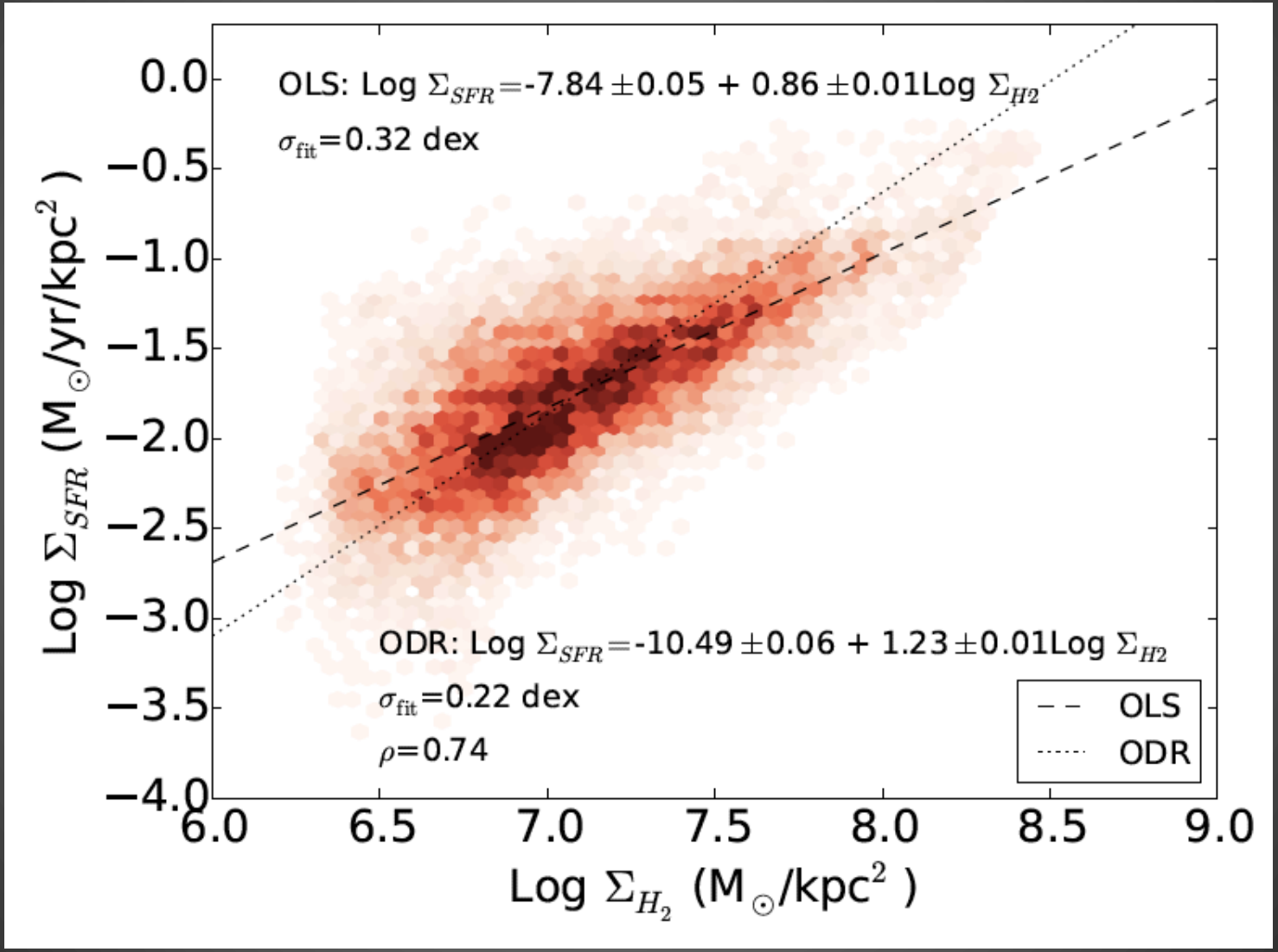
Sample includes galaxies on the SFMS, in the green valley and those with central starbursts.

http://arc.phys.uvic.ca/~almaquest/

Lin et al. (2020, submitted)

Resolved (kpc) scaling relations in star forming galaxies

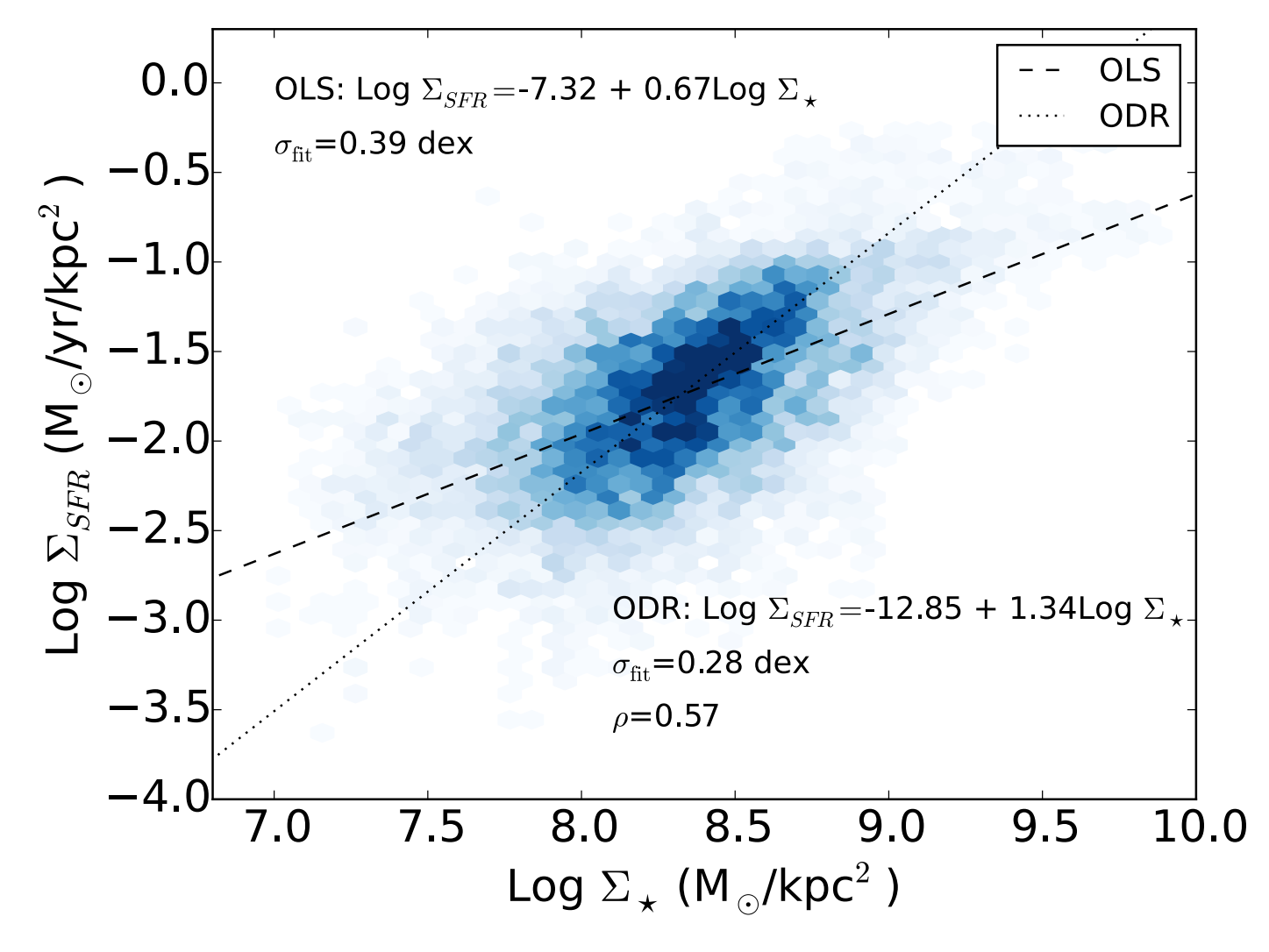
The resolved Schmidt-Kennicutt relation (rSK)



Ellison et al. (submitted); See also Lin et al. (2019)

Resolved (kpc) scaling relations in star forming galaxies

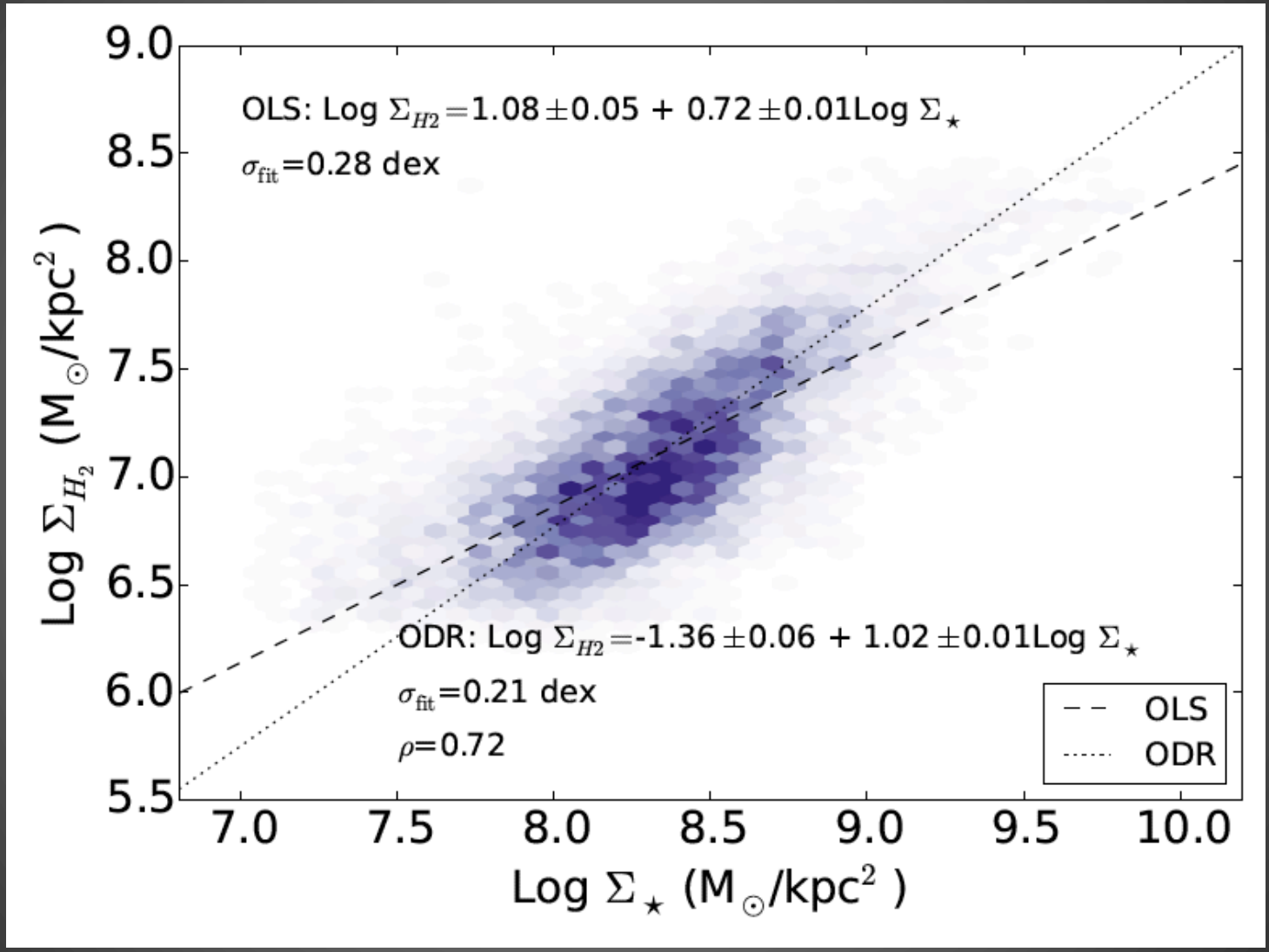
The resolved star forming main sequence (rSFMS)



Ellison et al. (submitted); See also Lin et al. (2019)

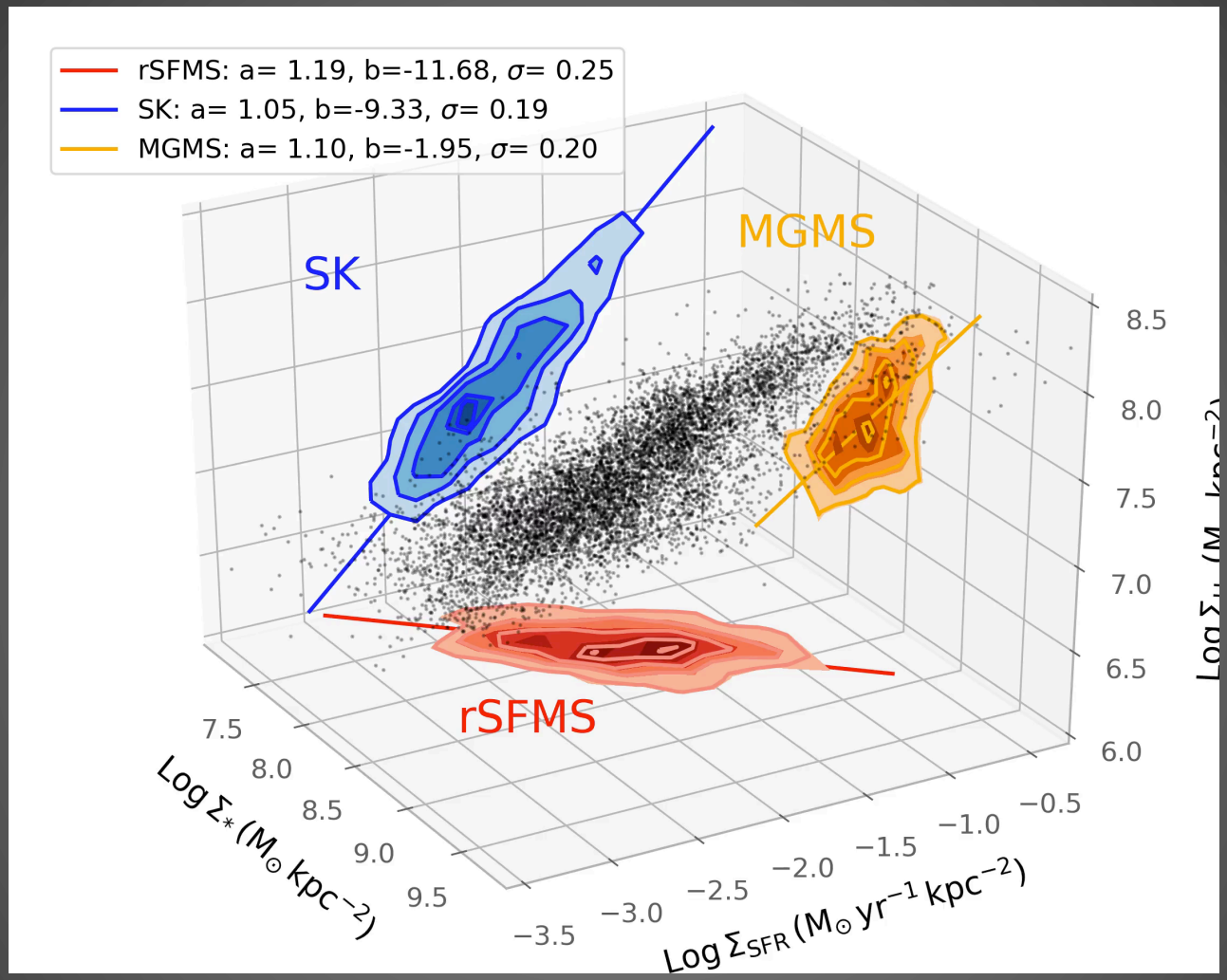
Resolved (kpc) scaling relations in star forming galaxies

The resolved molecular gas main sequence (rMGMS)



Ellison et al. (submitted); See also Lin et al. (2019)

Resolved (kpc) scaling relations in star forming galaxies

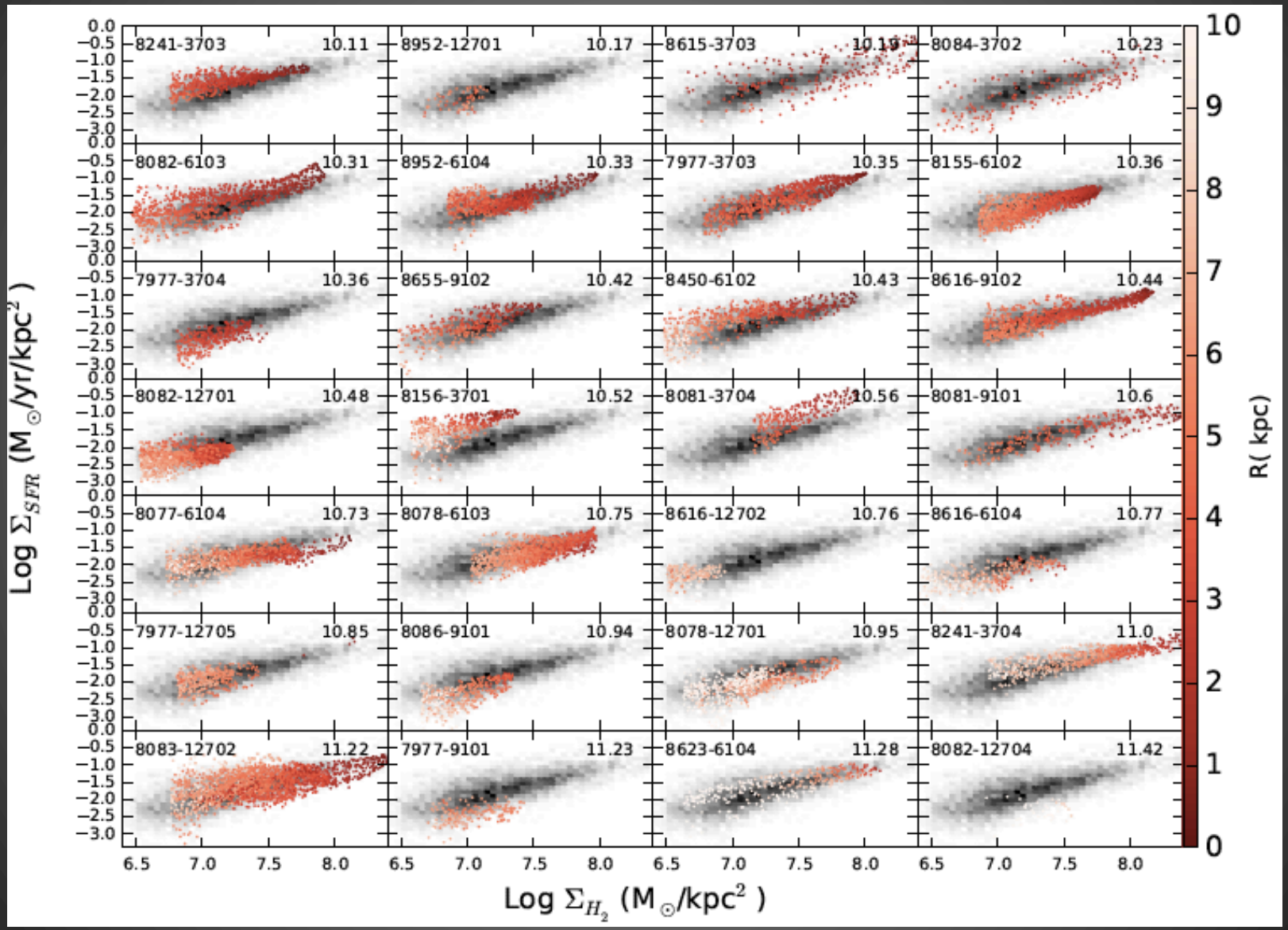


Three star forming scaling relations: rSK, rMGMS and rSFMS. The rSFMS arises as a result of the rSK and rMGMS and is not fundamental.

Lin et al. (2019)

Galaxy-by-galaxy (kpc) scaling relations

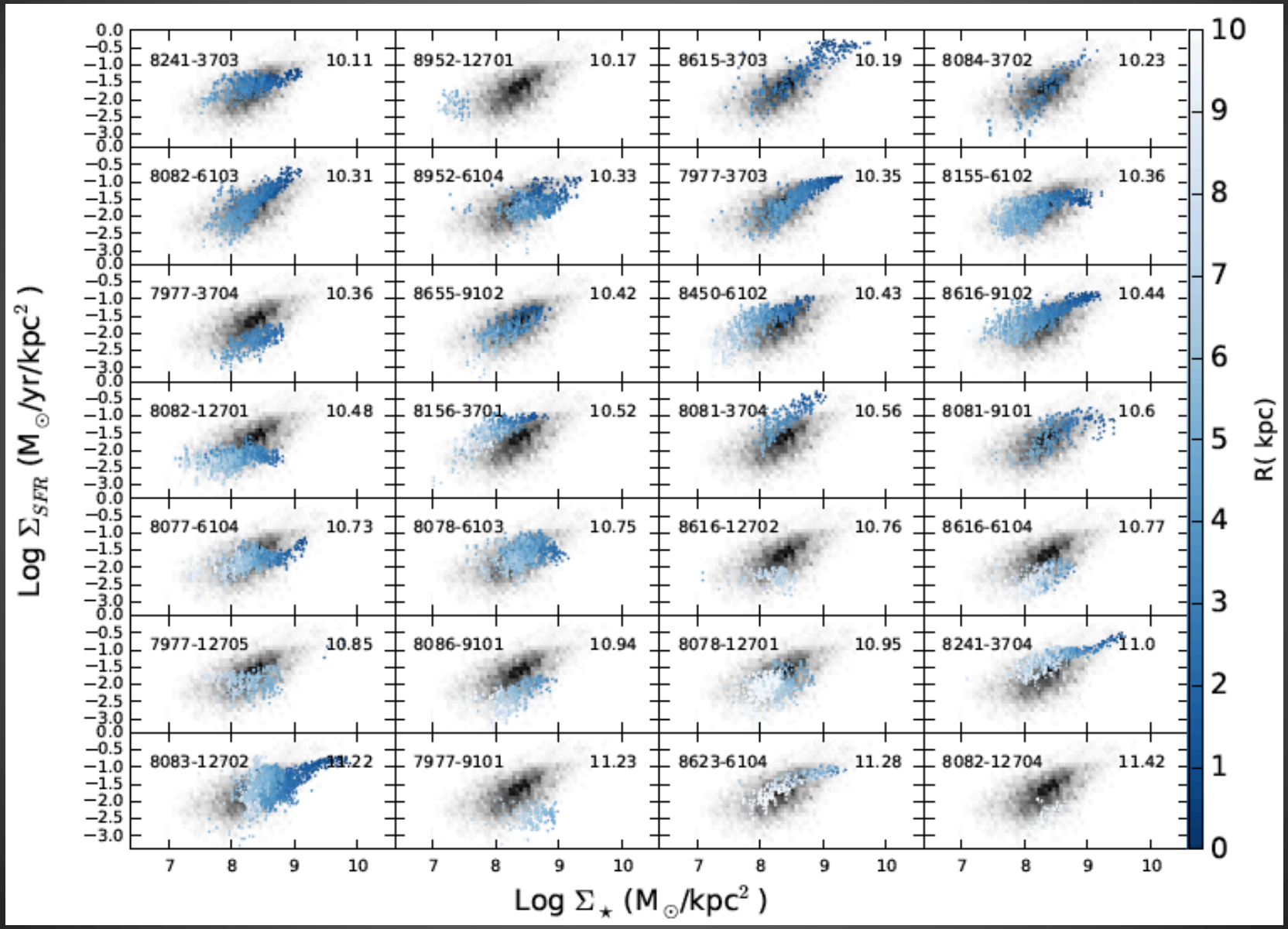
The resolved Schmidt-Kennicutt relation (rSK)



Ellison et al. (submitted)

Galaxy-by-galaxy (kpc) scaling relations

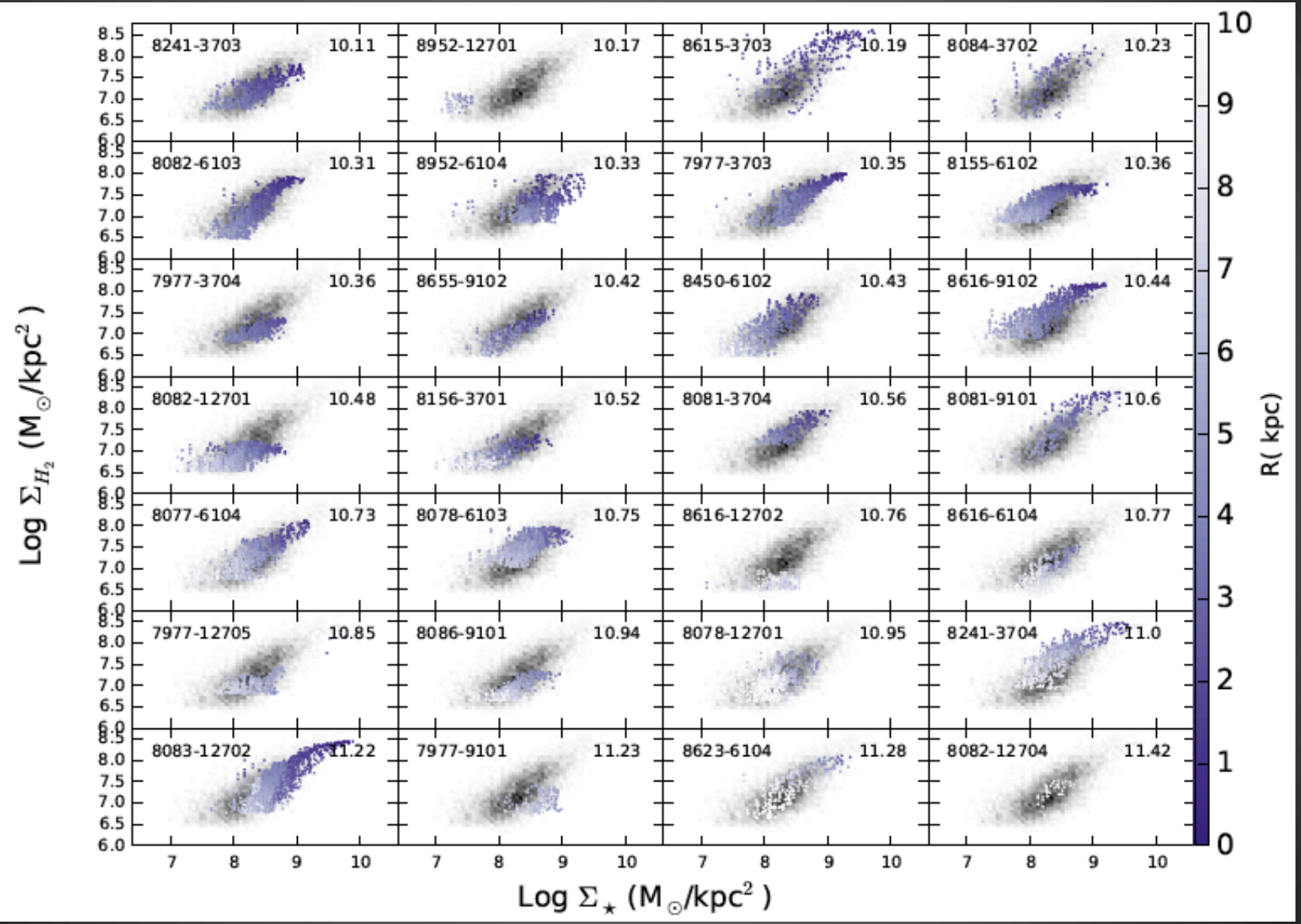
The resolved star forming main sequence (rSFMS)



Ellison et al. (submitted)

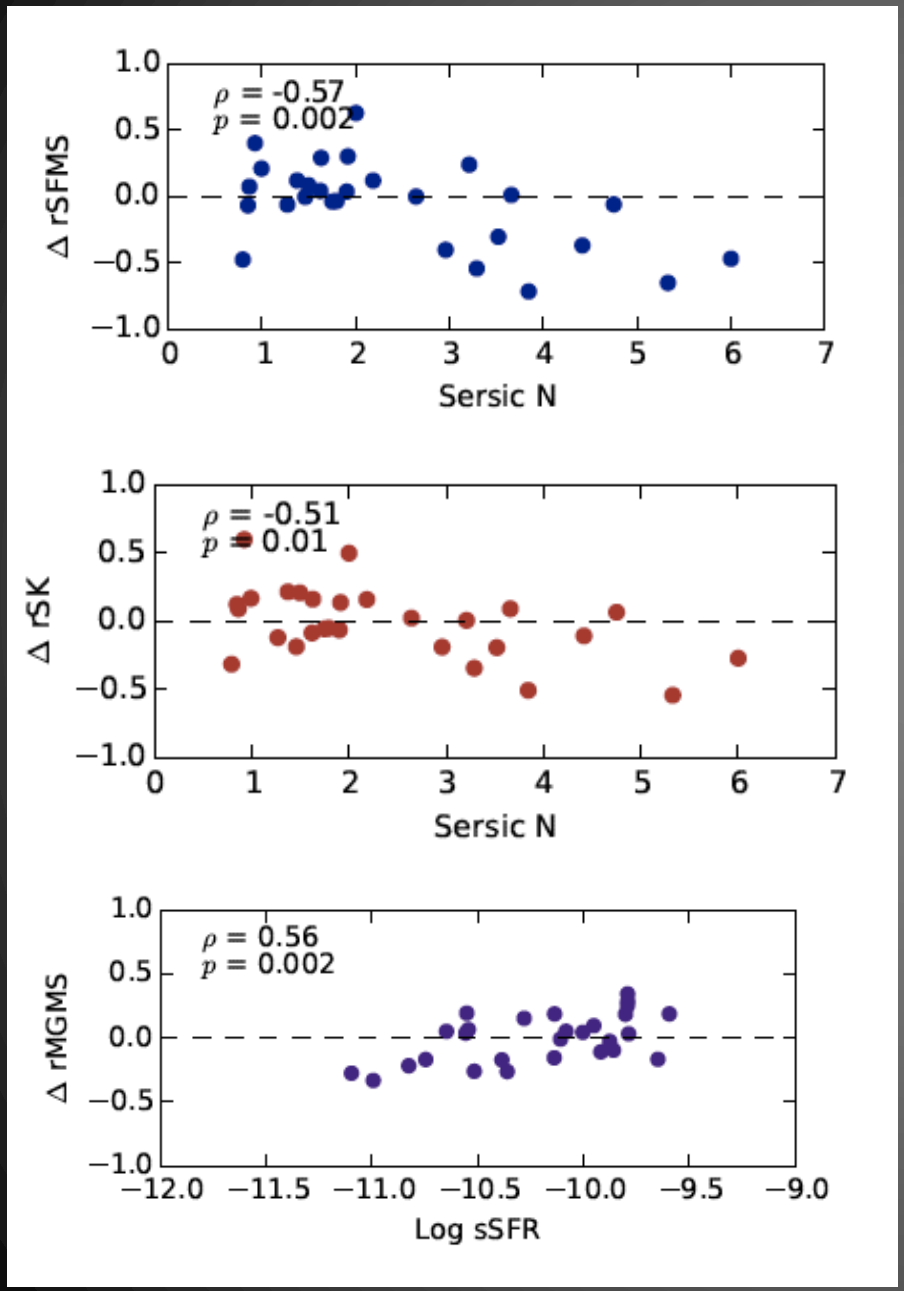
Galaxy-by-galaxy (kpc) scaling relations

The resolved molecular gas main sequence (rMGMS)



Ellison et al. (submitted)

Galaxies show considerable variation in the scaling relations

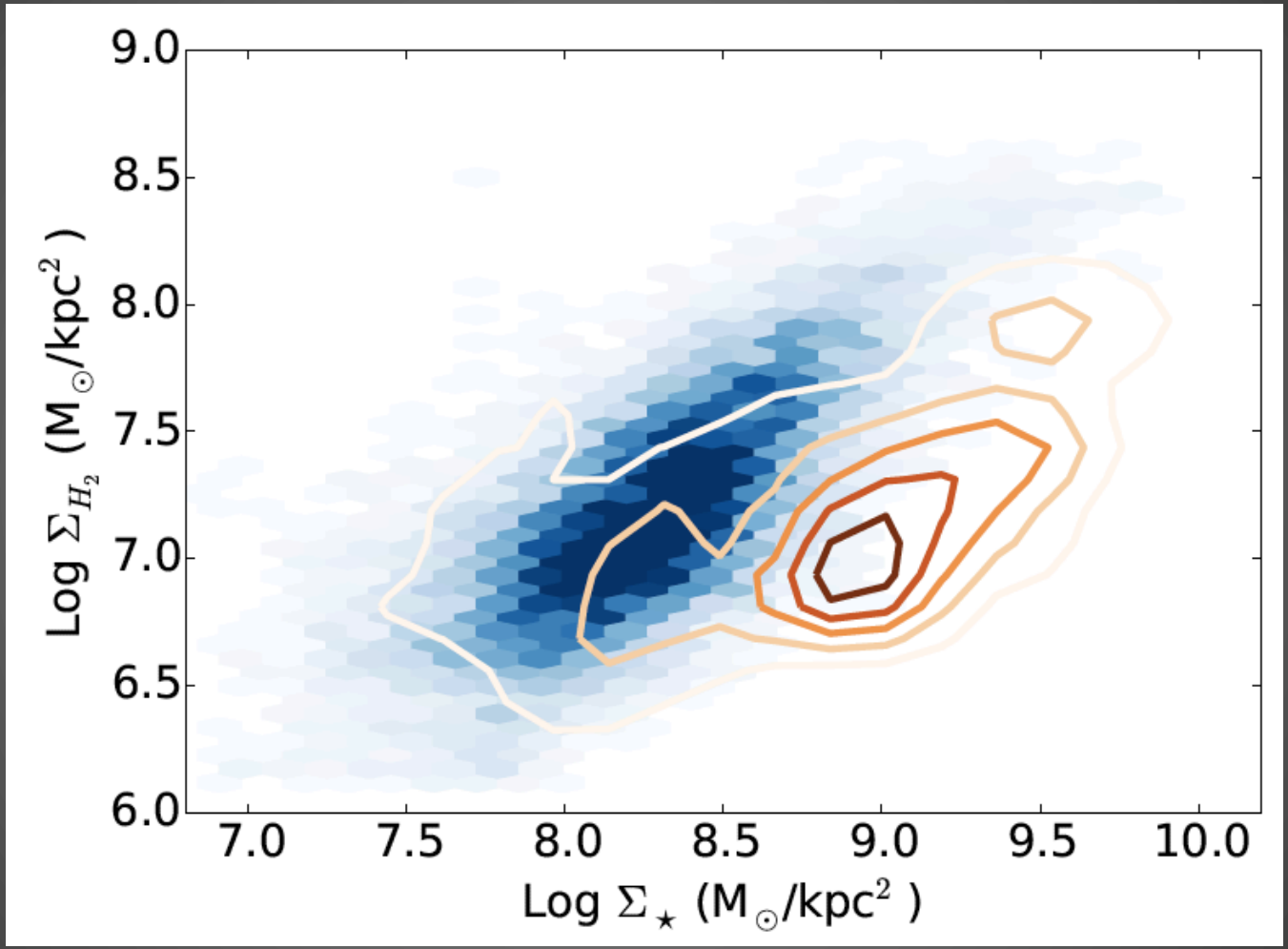


The offset of a given galaxy from the average relation correlates with global properties, such as morphology.

Star formation scaling relations are not universal. There is considerable galaxy-to-galaxy variation in the three resolved star formation scaling laws and correlations with global galaxy quantities.

Ellison et al. (submitted)

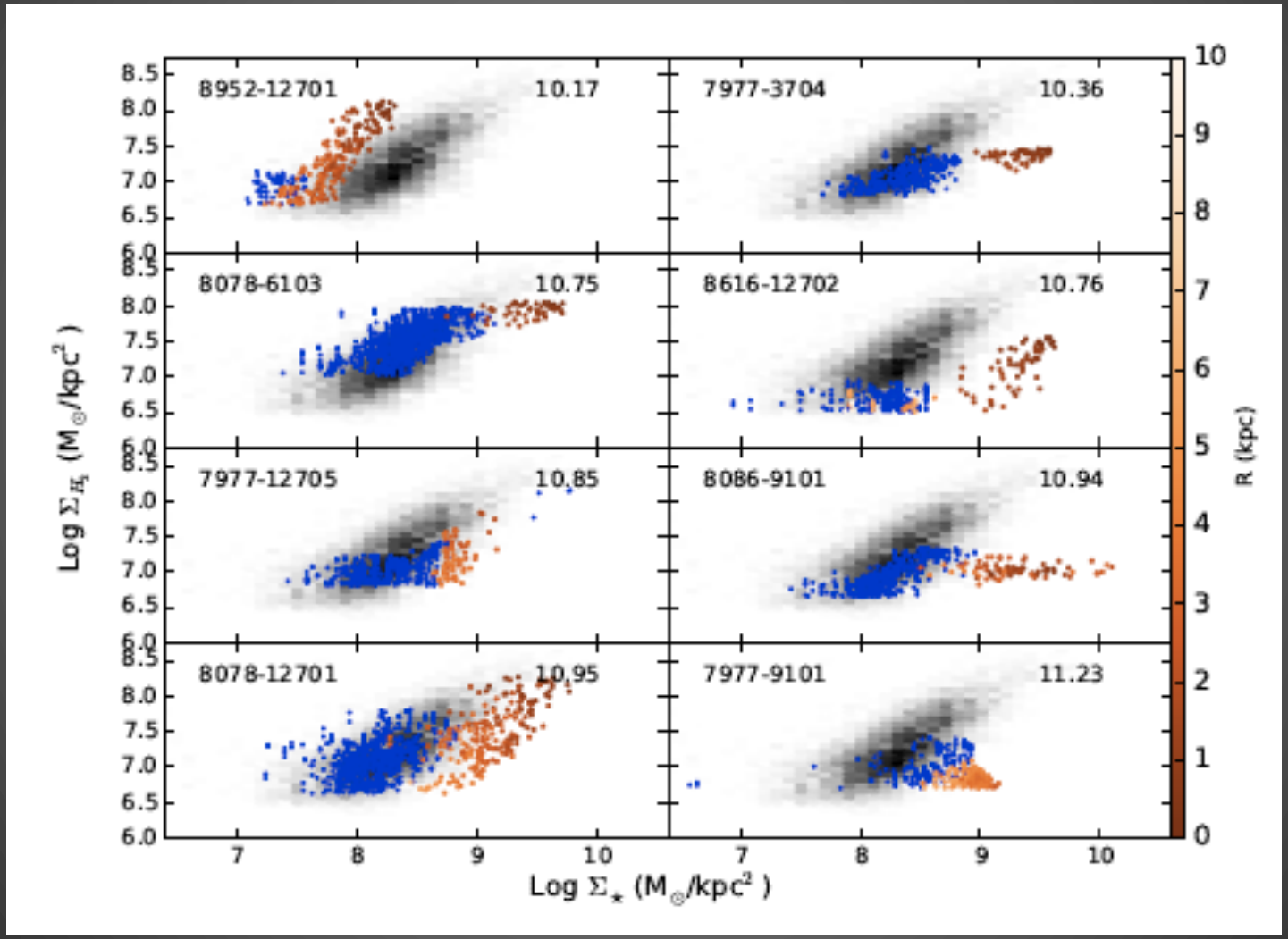
What about non-star-forming spaxels?
The resolved molecular gas main sequence in `retired' spaxels.



Retired spaxels have lower gas fractions than star-forming spaxels

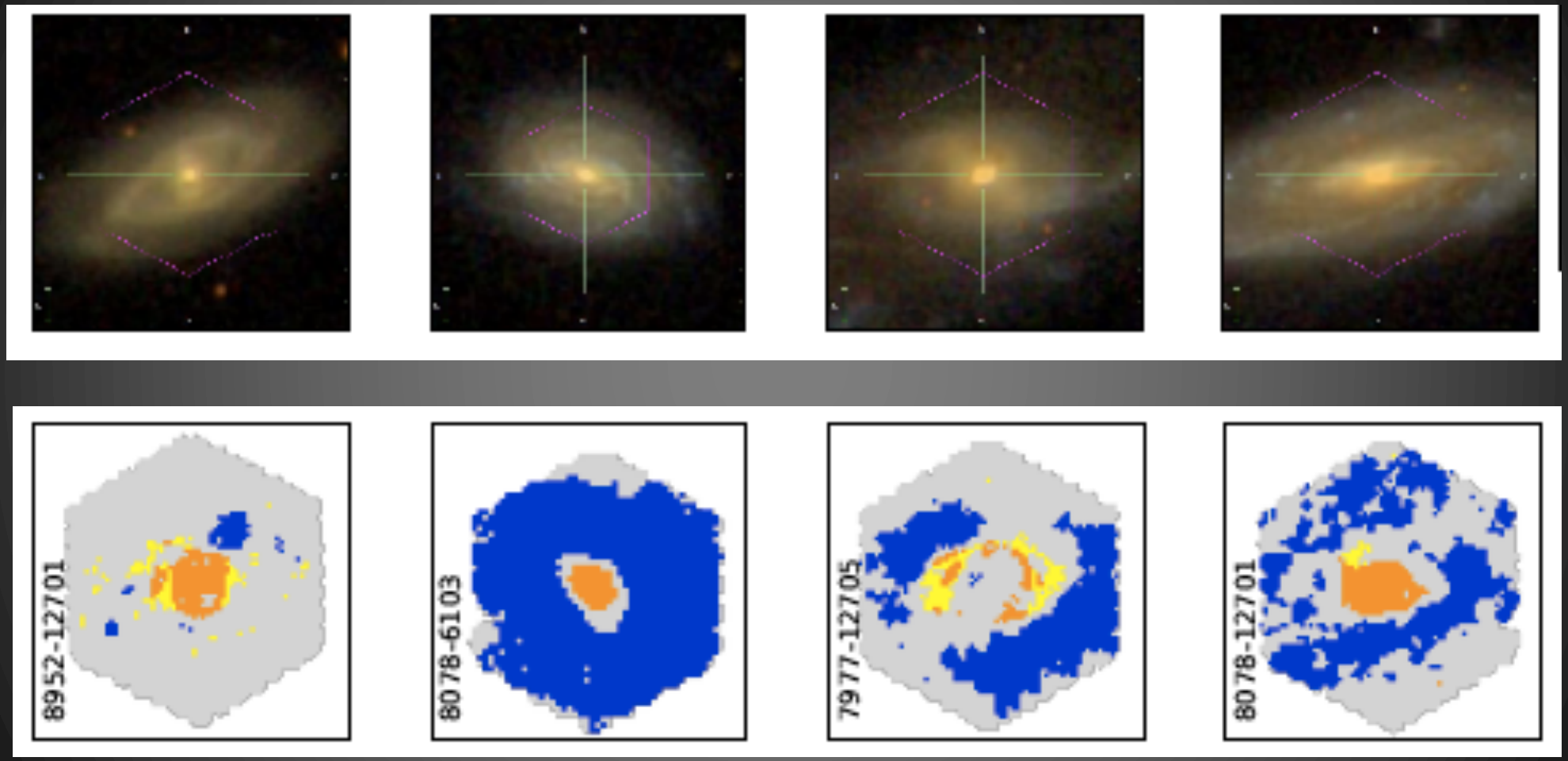
Ellison et al. (in prep)

Even within a given galaxy, retired regions have lower average gas fractions than their star-forming regions. Decline (but not absence) of gas is a plausible reason for the onset of quenching.



Ellison et al. (in prep)

The central location of the retired spaxels indicates that retirement happens from the inside-out



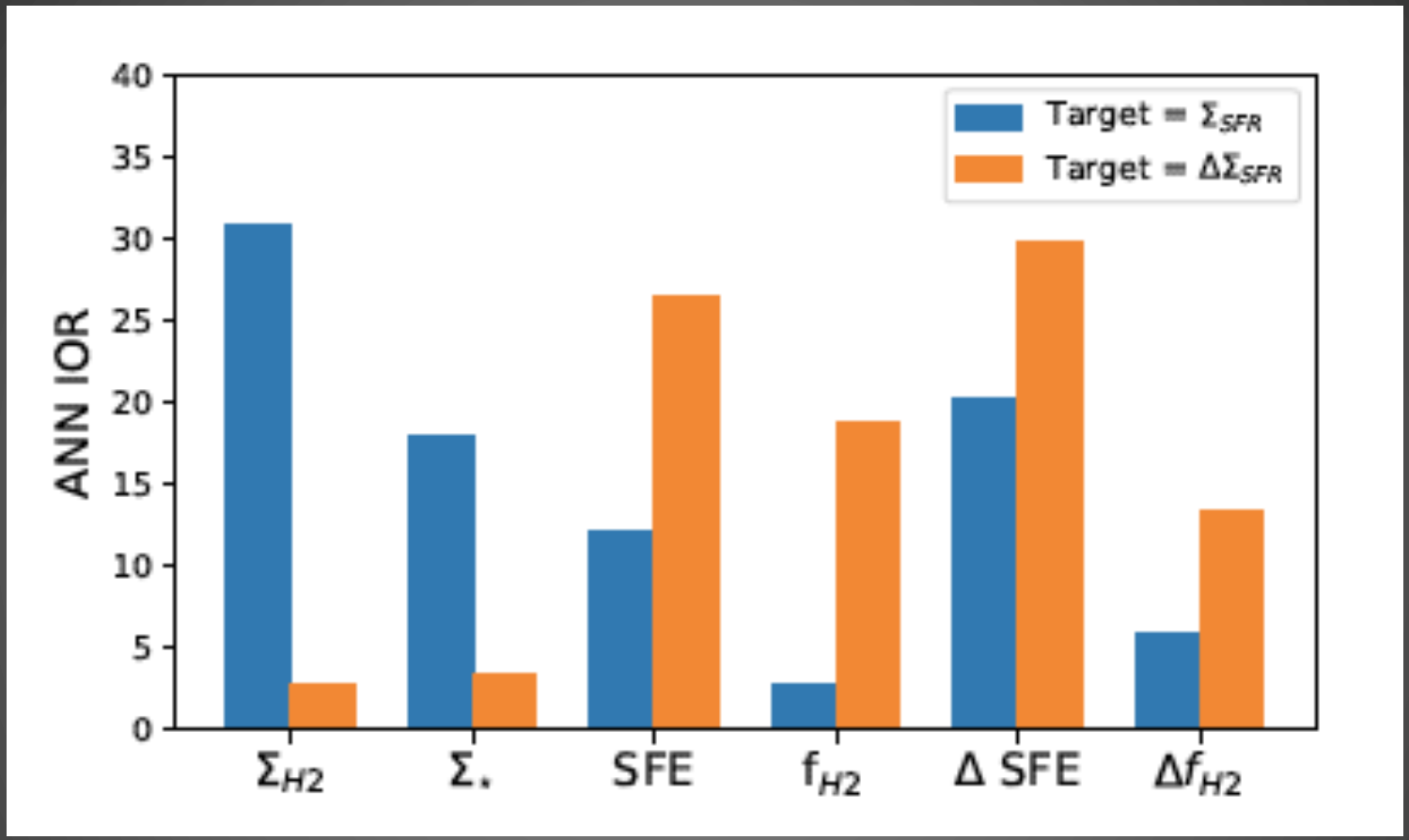
BPT map colour-coding: Retired spaxels

BPT map colour-coding: Star-forming spaxels

Ellison et al. (in prep)

What regulates star formation?

Gas fraction? Star formation efficiency? Both?



An artificial neural network analysis of ~11,500 spaxels.

Whilst $\sum_{H2}$ is the most important for predicting $\sum_{SFR}$, SFE (and variations therein) drive scatter around the rSFMS (i.e. $\Delta\sum_{SFR}$).

Ellison et al. (2020a, b)

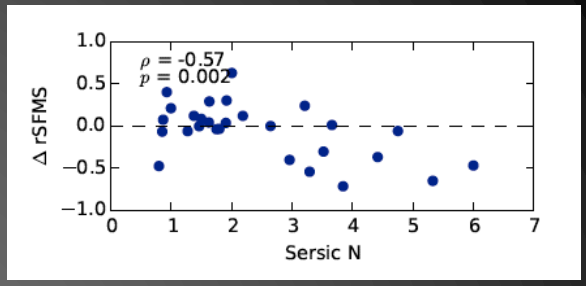
Summary

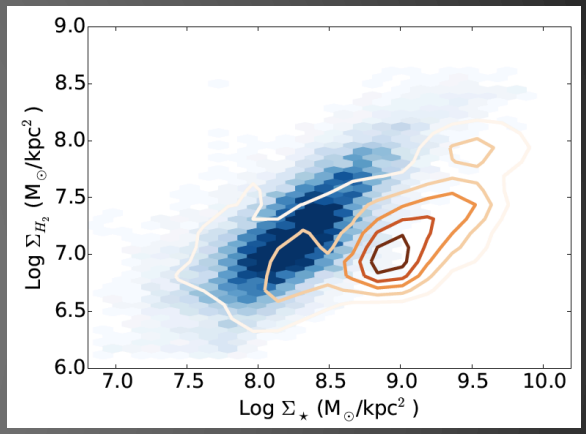
- The ALMaQUEST survey consists of 46 galaxies with MaNGA+ALMA CO(1-0) observations at ~kpc scale resolution: Lin et al. (2020, submitted).

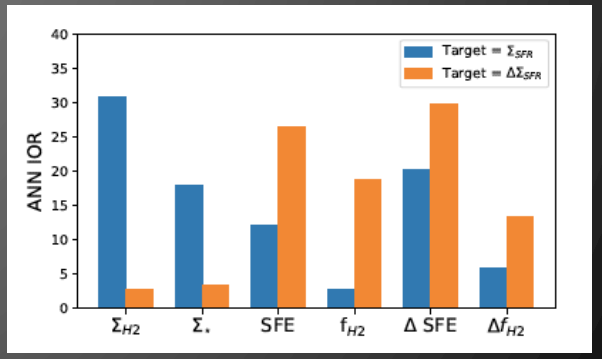
- There is significant galaxy-to-galaxy variation in all 3 scaling relations, which drives the shape and scatter of the ensemble relations. The individual galaxy scaling relations correlate with global galaxy parameters, e.g. Sersic N: Ellison et al. (submitted).

- The rMGMS of retired spaxels is offset to lower gas fractions compared with star forming spaxels, even with the same galaxy. Depleted gas reservoirs play a role in quenching, which happens from the inside out: Ellison et al. (in prep).

- Whilst $\sum_{H2}$ is the most important for predicting $\sum_{SFR}$, SFE (and variations therein) drive scatter in the rSFMS (i.e. $\Delta\sum_{SFR}$), with gas fraction in a secondary role: Ellison et al. (2020a,b).







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