The KMOS Deep Survey: Dynamical Measurements of typical star-forming galaxies at z ~ 3.5

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with

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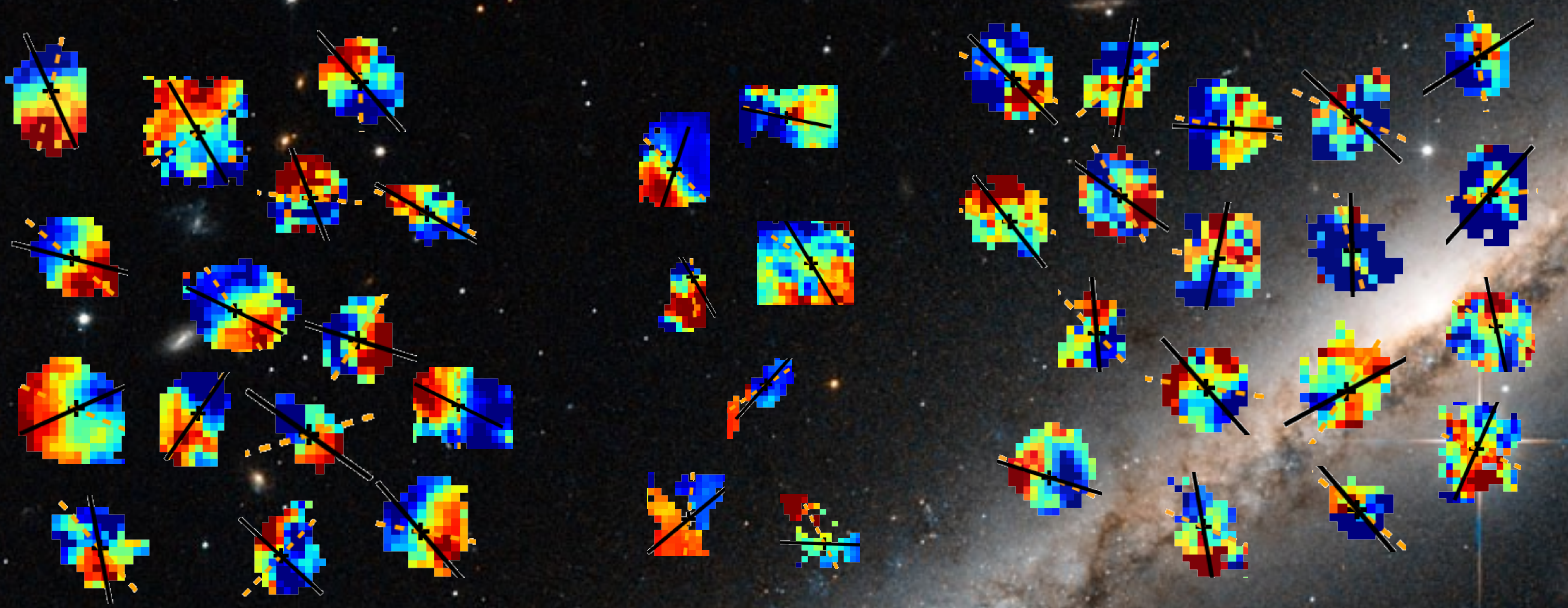

The KMOS Deep Survey: Dynamical Measurements of typical star-forming galaxies at z ~ 3.5

- Gas regulator plot ✓
- Madau & Dickinson plot ✓
- Tully-Fisher relations ✓
- BPT Diagram ✗
- David Sobral as collaborator ✓

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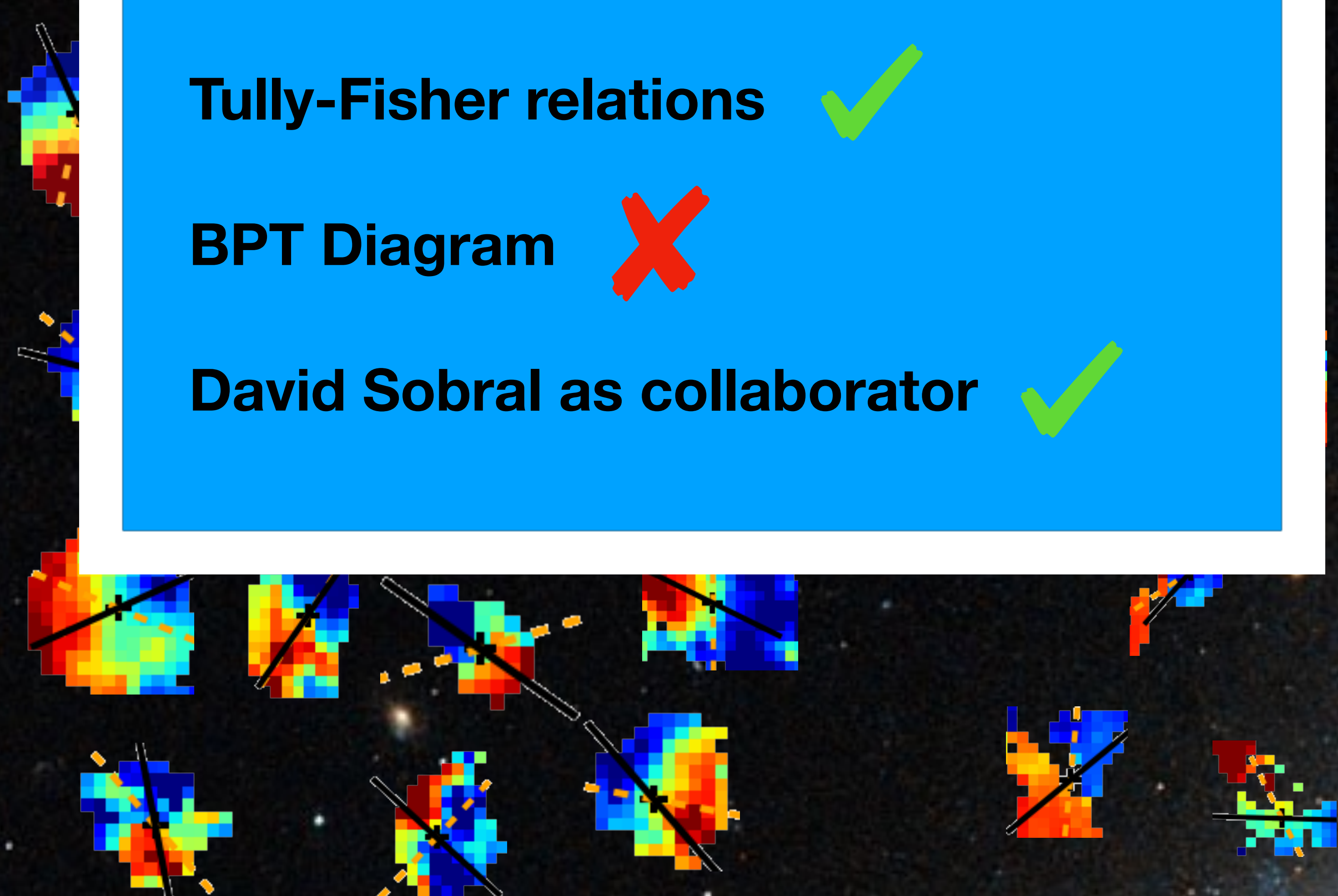

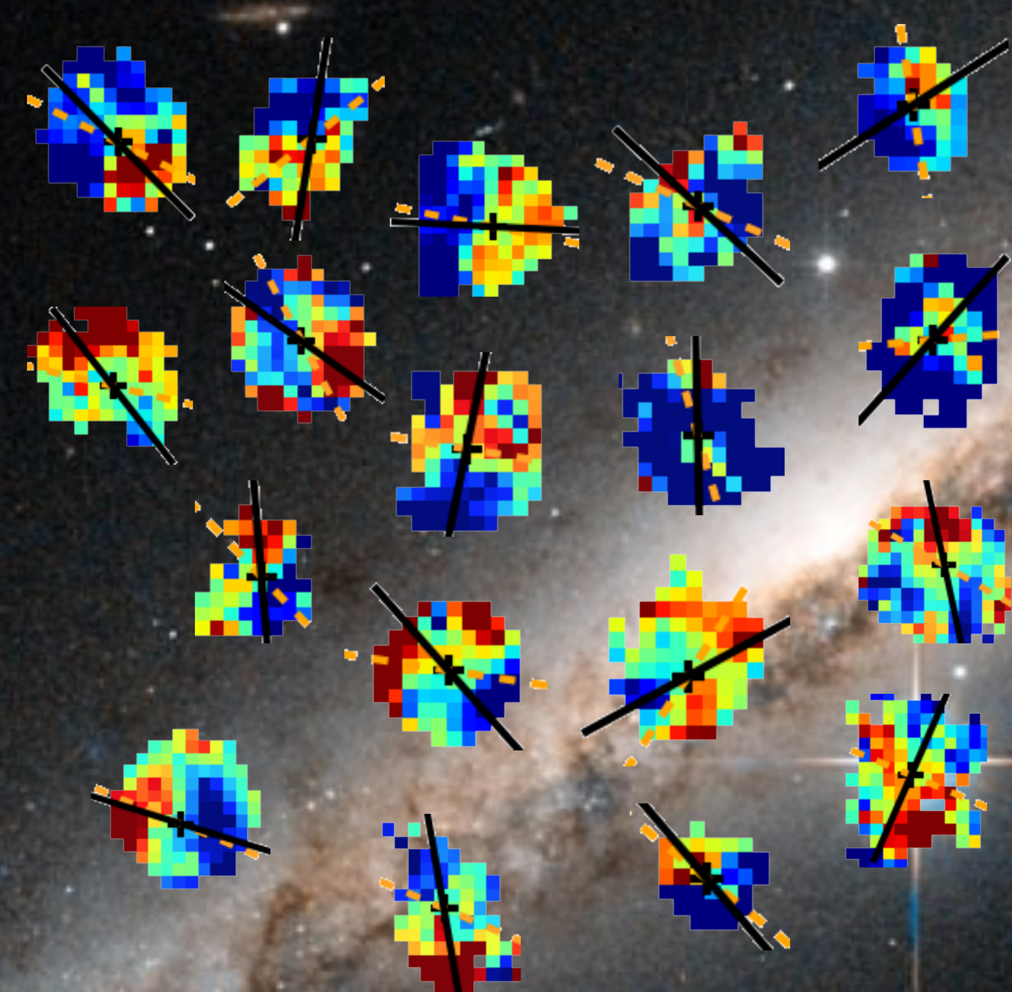

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Outline

1. Motivation/results from other surveys

2. The KMOS Deep Survey
   - rotation velocities and Tully-Fisher evolution between 0 < z < 3.5
   - velocity dispersions and evolution between 0 < z < 3.5
   - the decline of rotation-dominated systems
   - pressure support in the dynamical mass budget

3. Conclusions + Future Work - attempting to study resolved chemical abundances with the KDS

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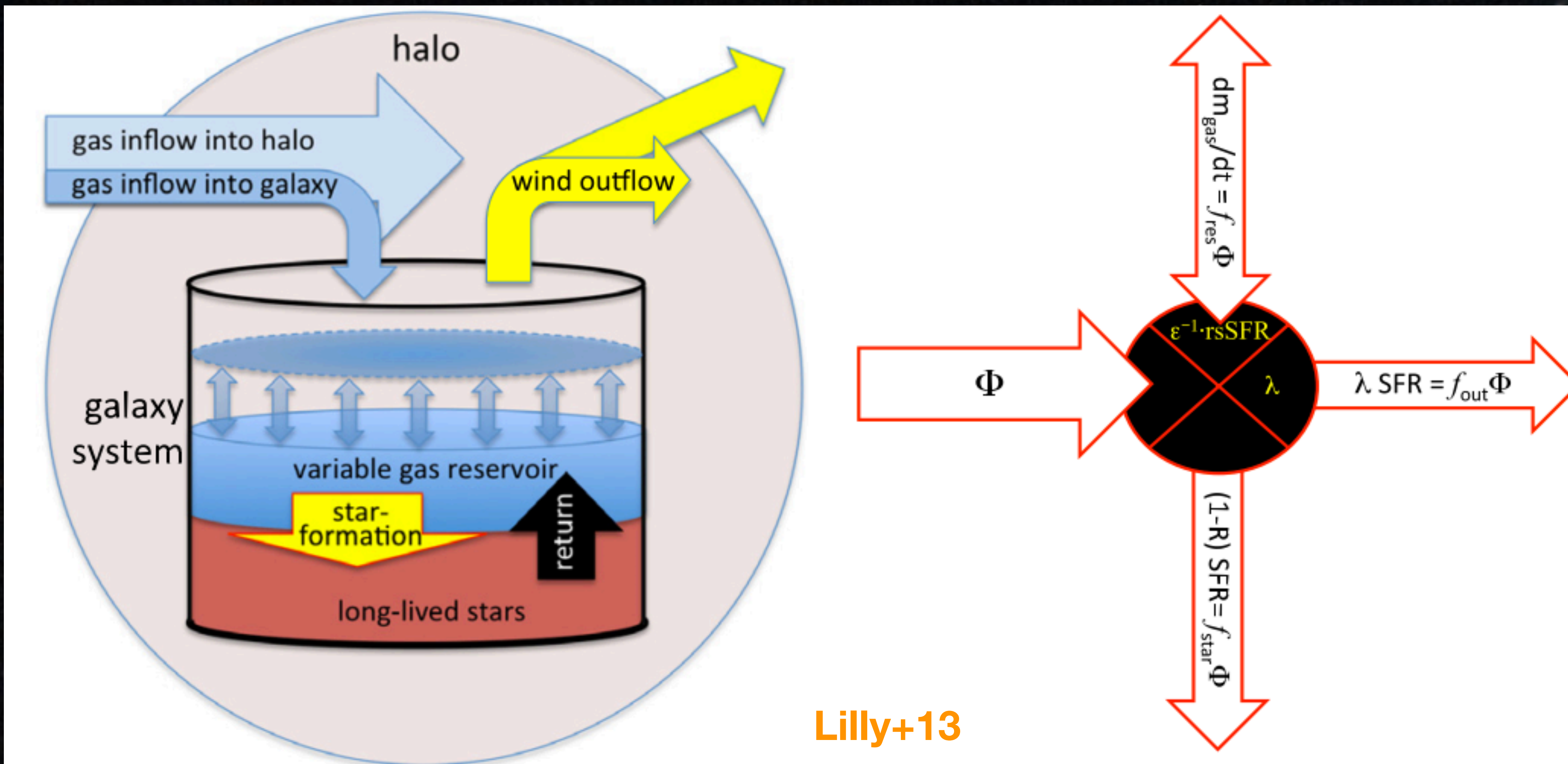
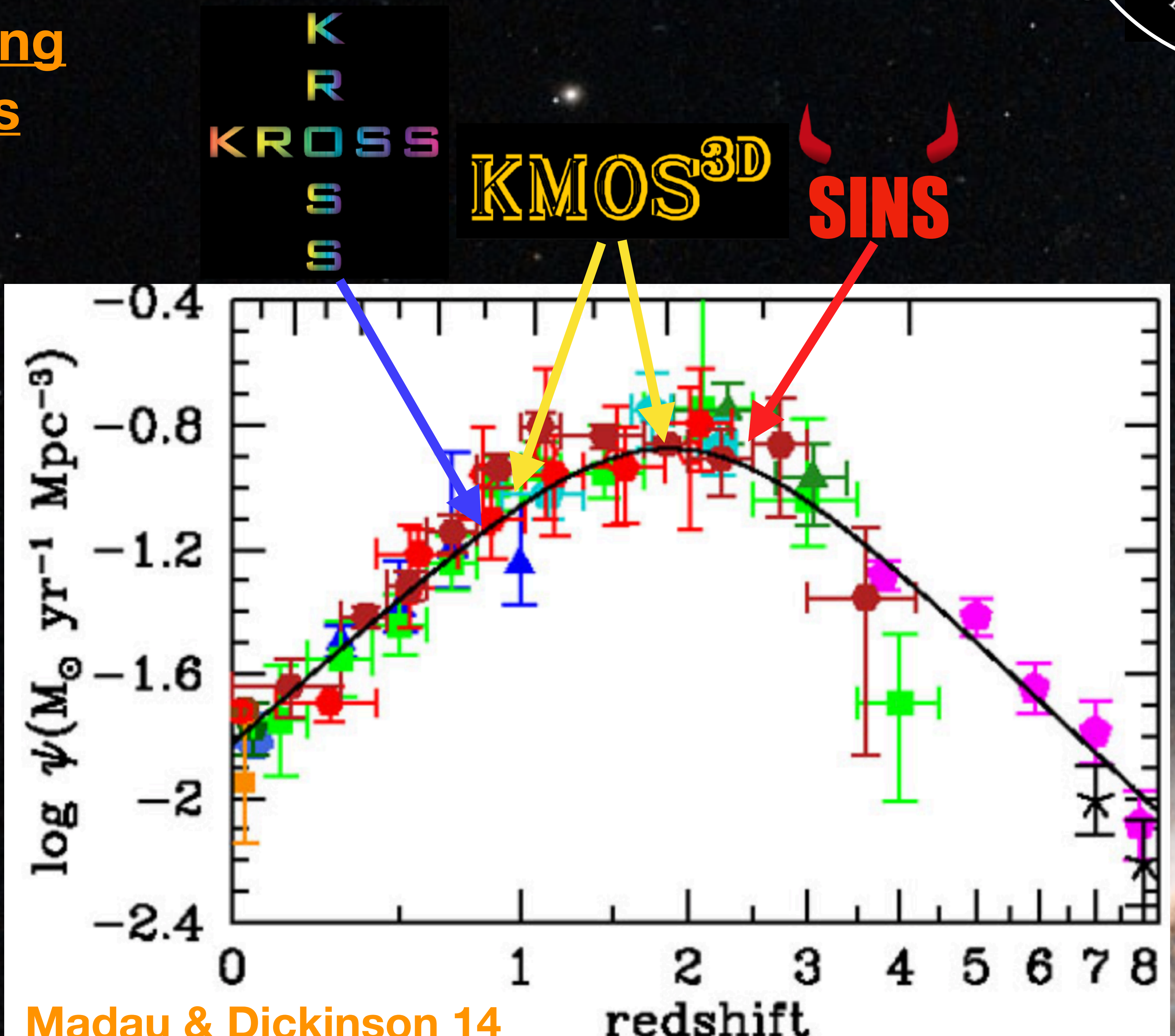
Gas regulator model framework



Lilly+13

IFS studies probing multiple epochs



Madau & Dickinson 14

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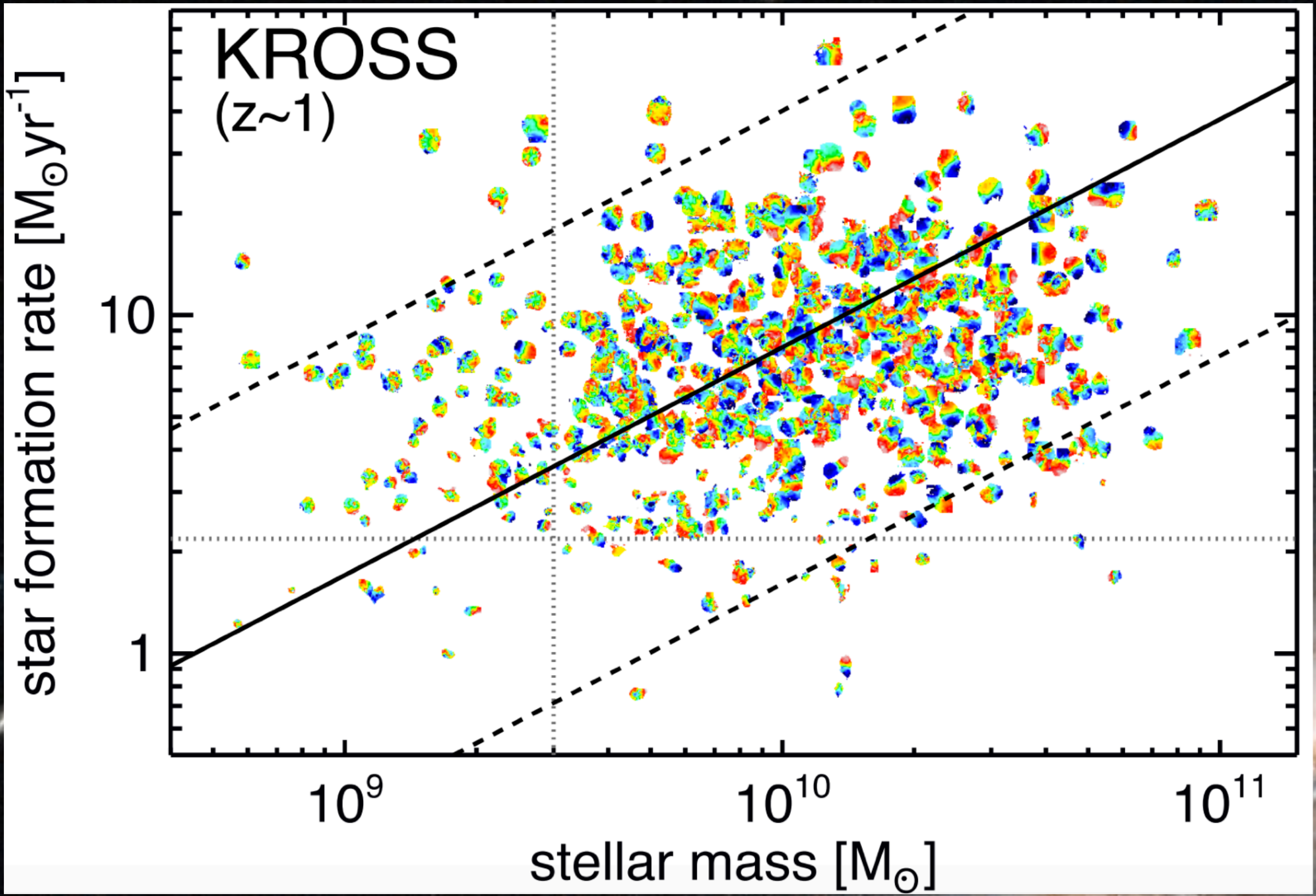
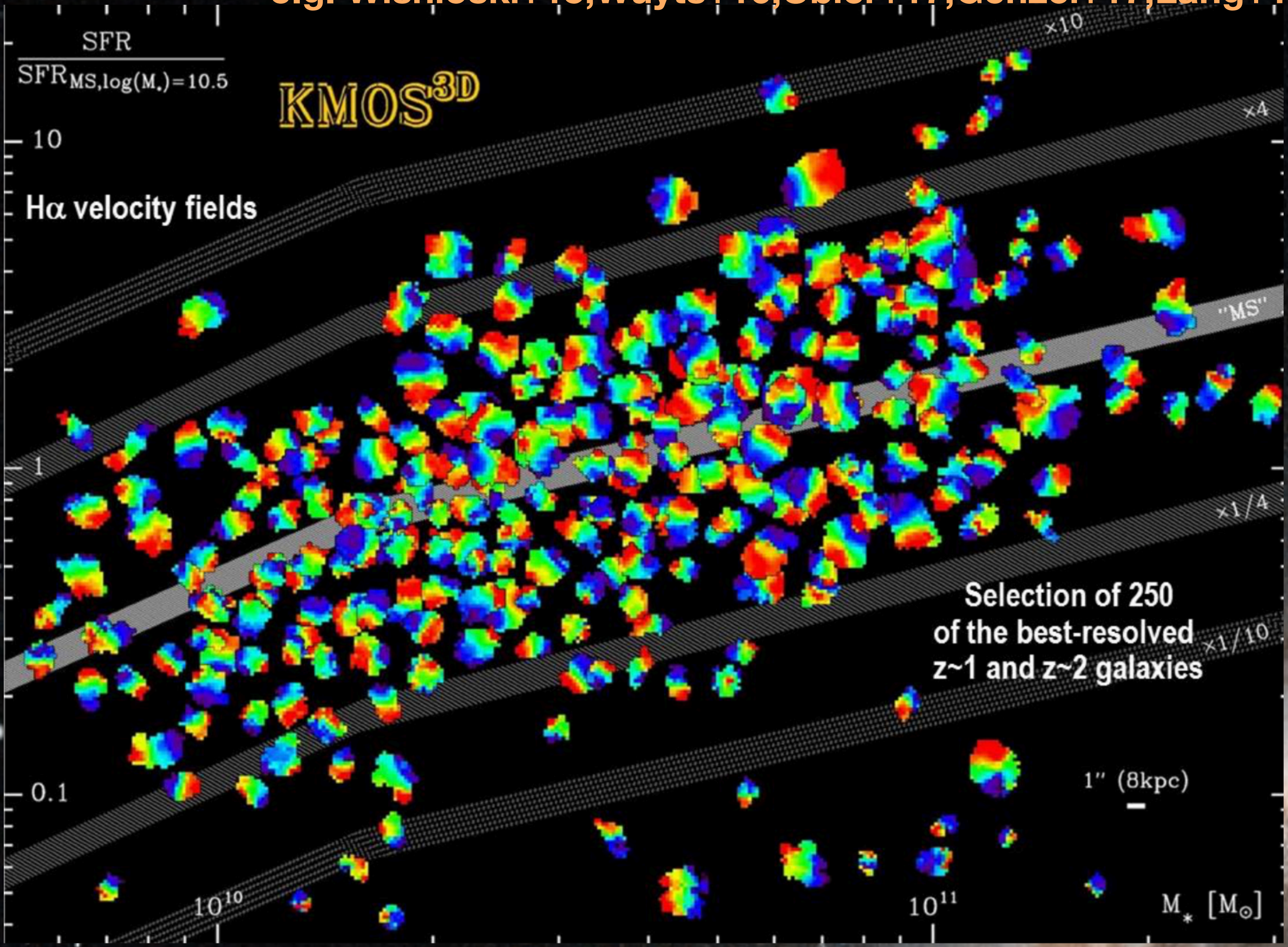
KROSS z ~ 0.9

e.g. Stott+16,Tiley+16,Harrison+17,Johnson+17



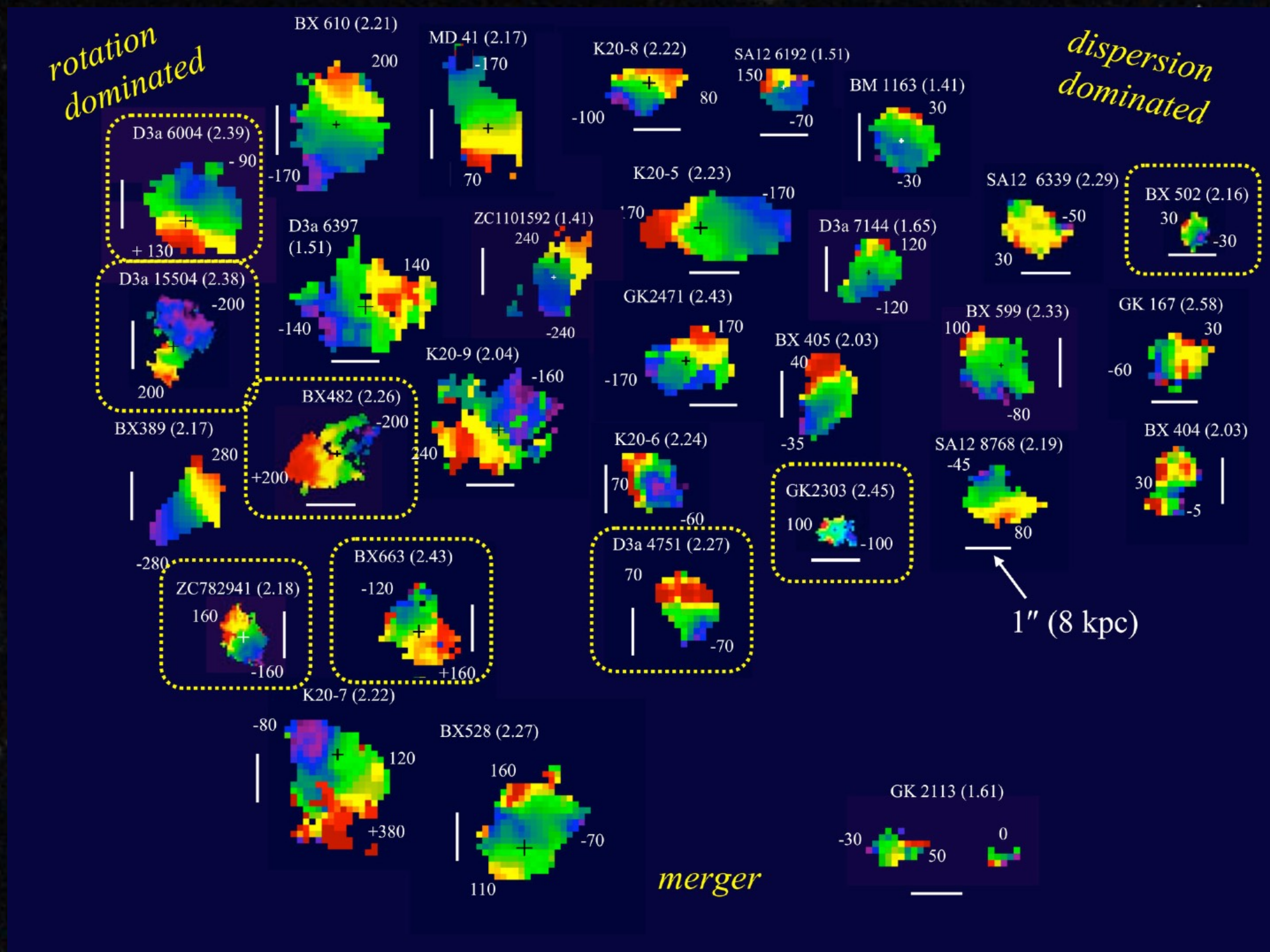
KMOS^{3D} z ~ 0.9 & 2.3

e.g. Wisnioski+15,Wuyts+16,Übler+17,Genzel+17,Lang+17

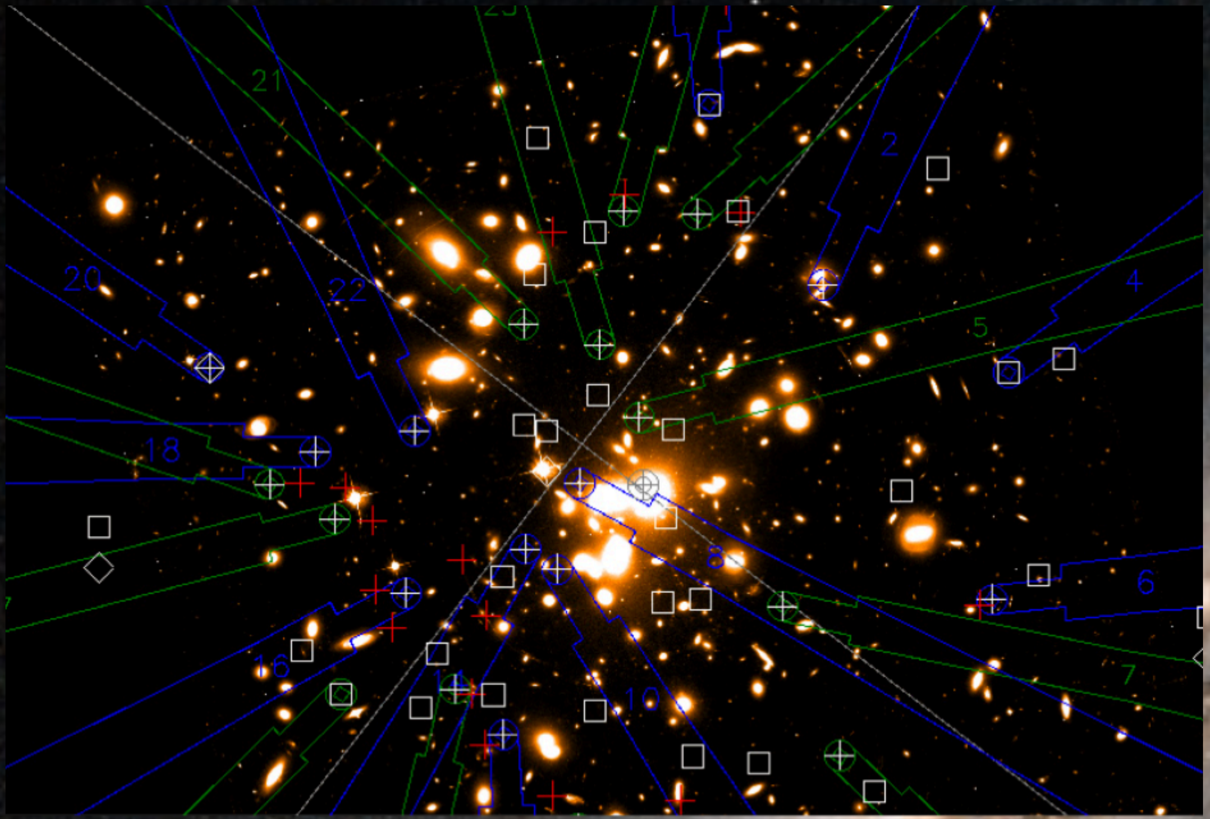


SINS z ~ 2.0

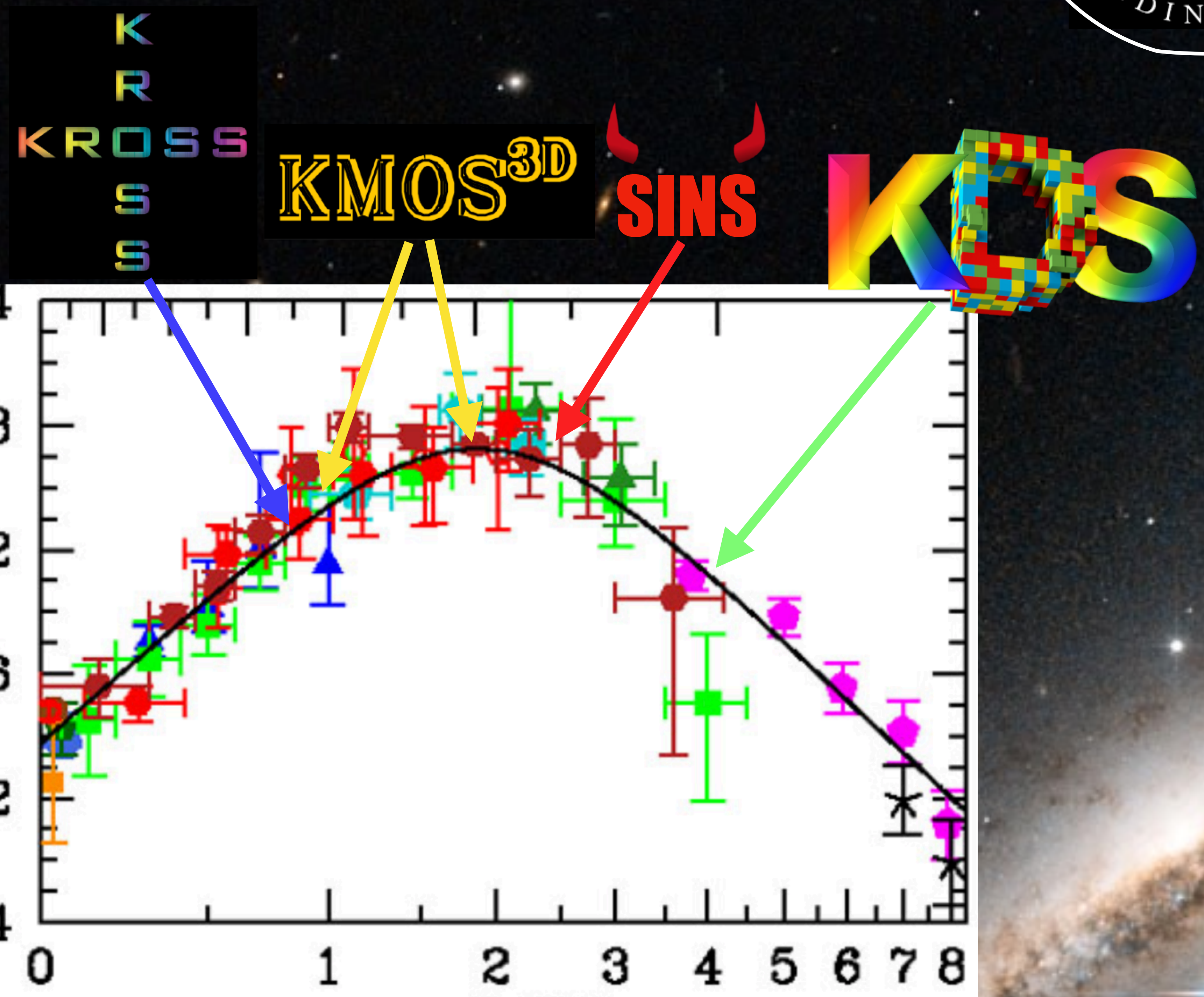
e.g. Förster Schreiber+06,09,11,Genzel+08,Newman+13



KMOS

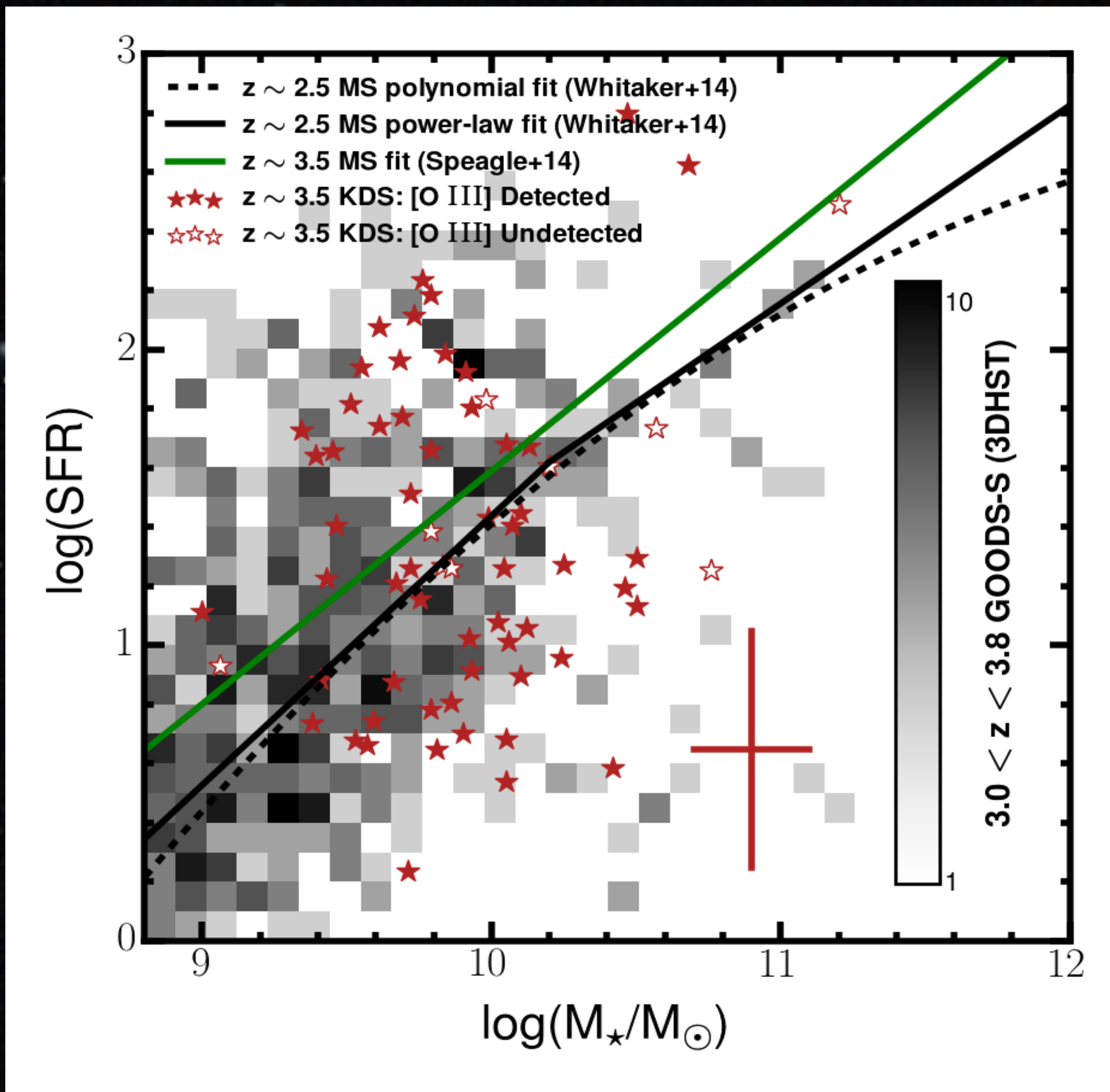


The KDS



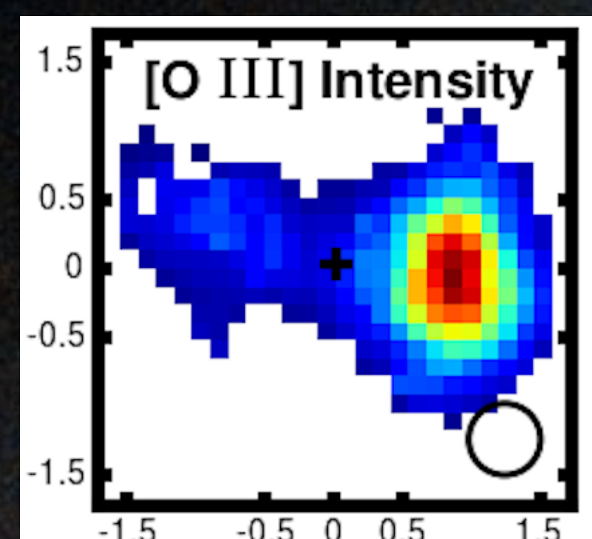
Madau & Dickinson 14

Survey Description



~ 80 star-forming galaxies observed with KMOS K-band in search of [OIII]5007 & Hβ, reduced using our custom pipeline

63 with detected line emission, for which we produce 2D maps of the flux and dynamics



48 spatially resolved

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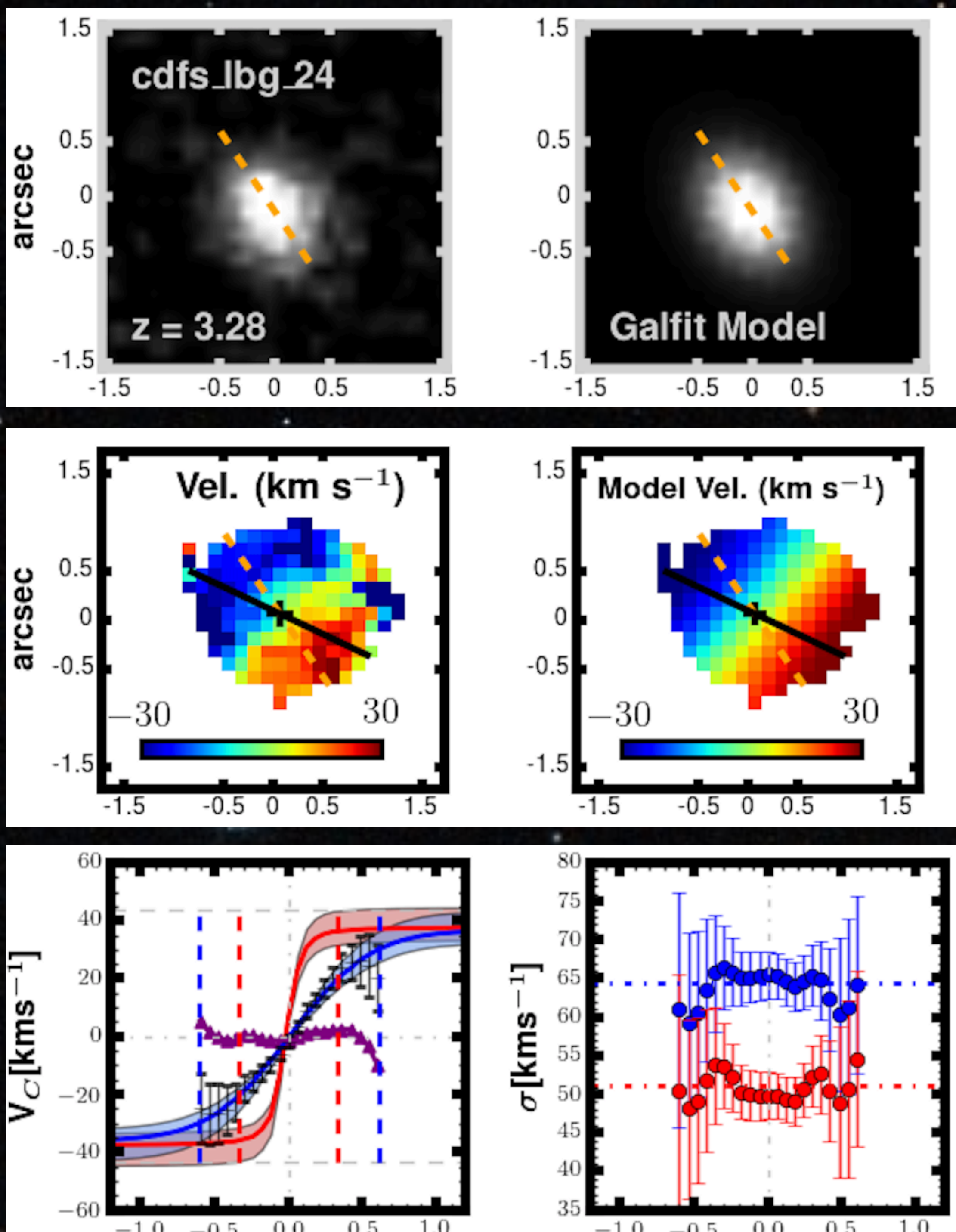
Analysis

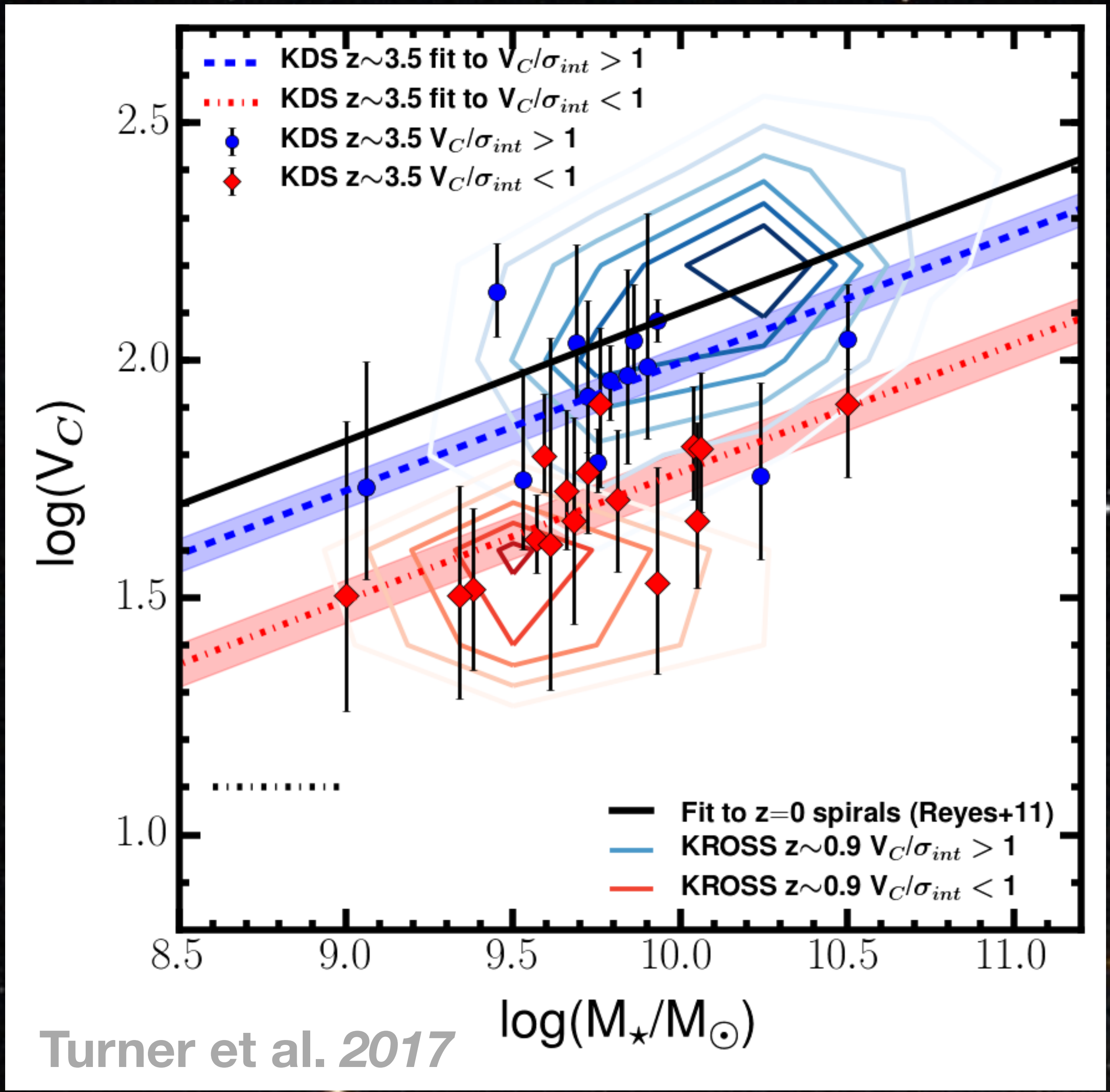


- GALFITTING & visually inspecting HST H-band images
- Using morpho-kinematic information we define an 'isolated field sample' of 33 galaxies

- Fitting model velocity fields to provide beam-smearing corrected measurements

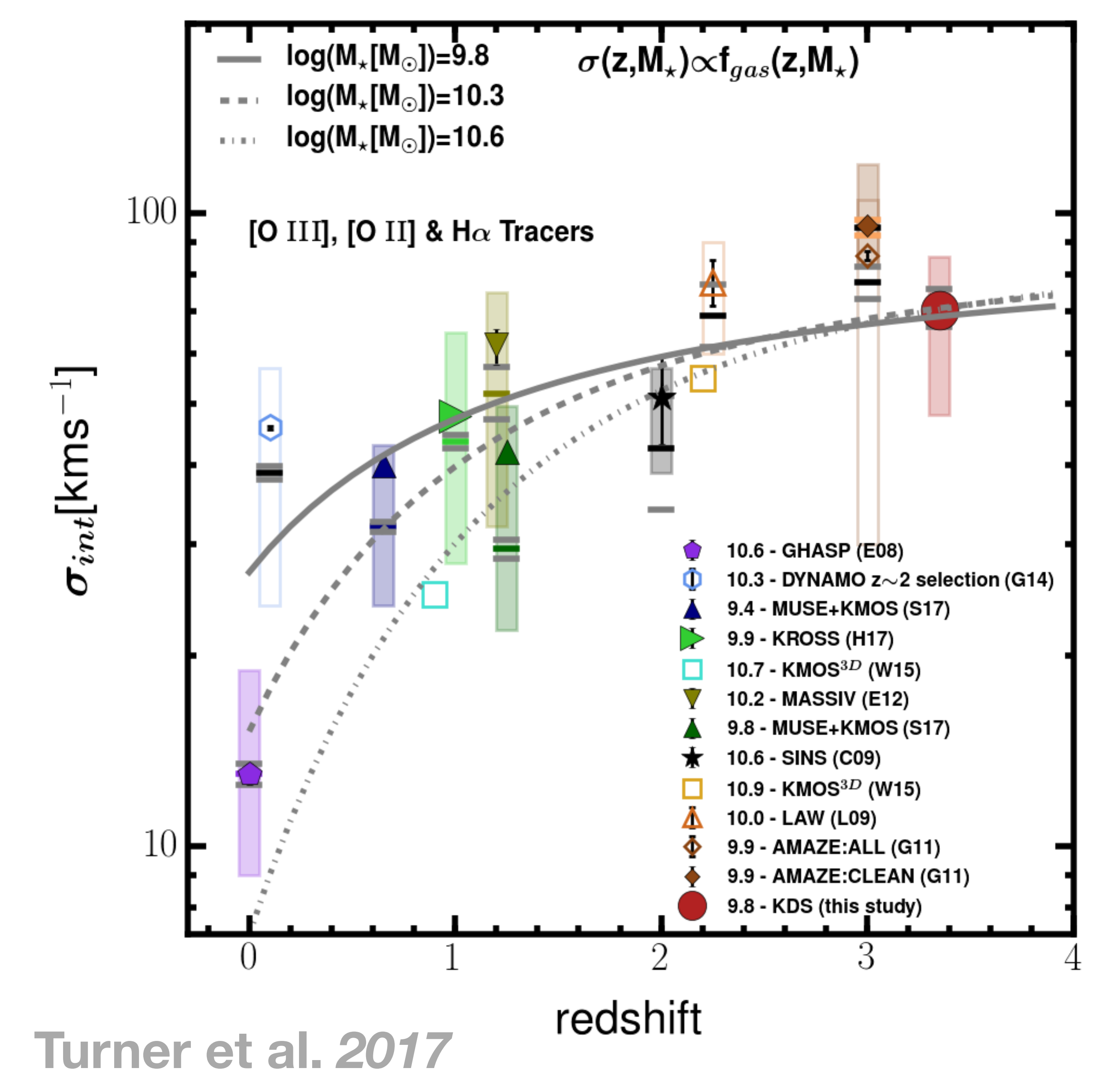
- A single number for the velocity and velocity dispersion is extracted
- The isolated field sample galaxies are classified as rotation or dispersion-dominated on the basis of $V/\sigma > 1$

Results - velocity vs. mass



- **Lower rotation velocities at fixed stellar mass than in the local Universe**

Results - velocity dispersions

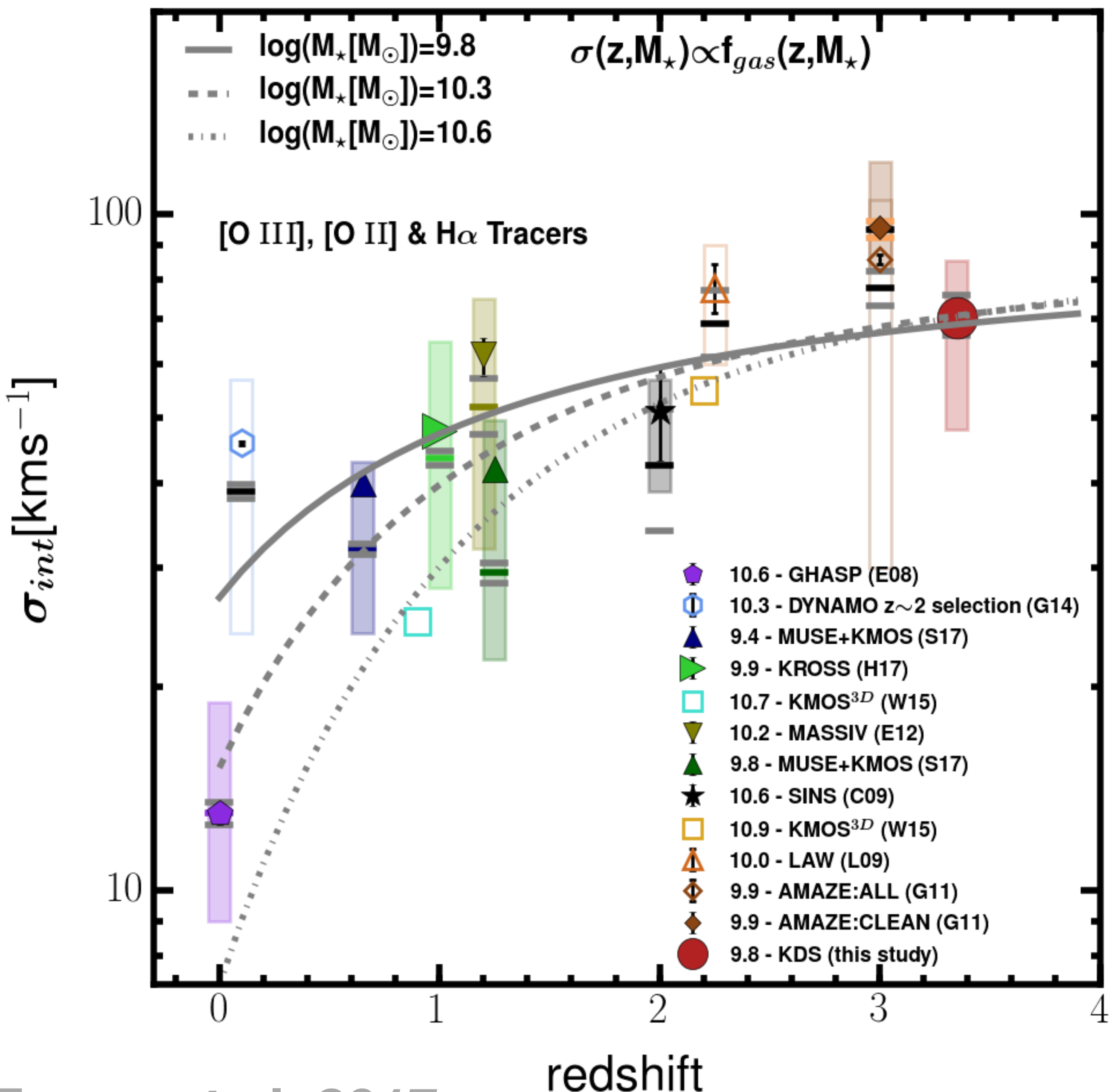


Turner et al. *2017*

- We find a steady increase in the mean velocity dispersion of star-forming galaxies with redshift using comparison samples with range of sample selection criteria

- Turbulence driven by gravitational instabilities and/or feedback from star-formation can also increase observed velocity dispersions at high redshift e.g. Krumholz+16,17

Results - velocity dispersions



Turner et al. *2017*

A model

- We fi... ...he mea... star-forming galaxies with redshift

$$\sigma(z, M_\star) = \frac{V_C Q_{crit}}{a} f_{gas}(z, M_\star)$$

-

$$f_{gas} = \frac{1}{1 + \left(t_{dep} sSFR\right)^{-1}}$$

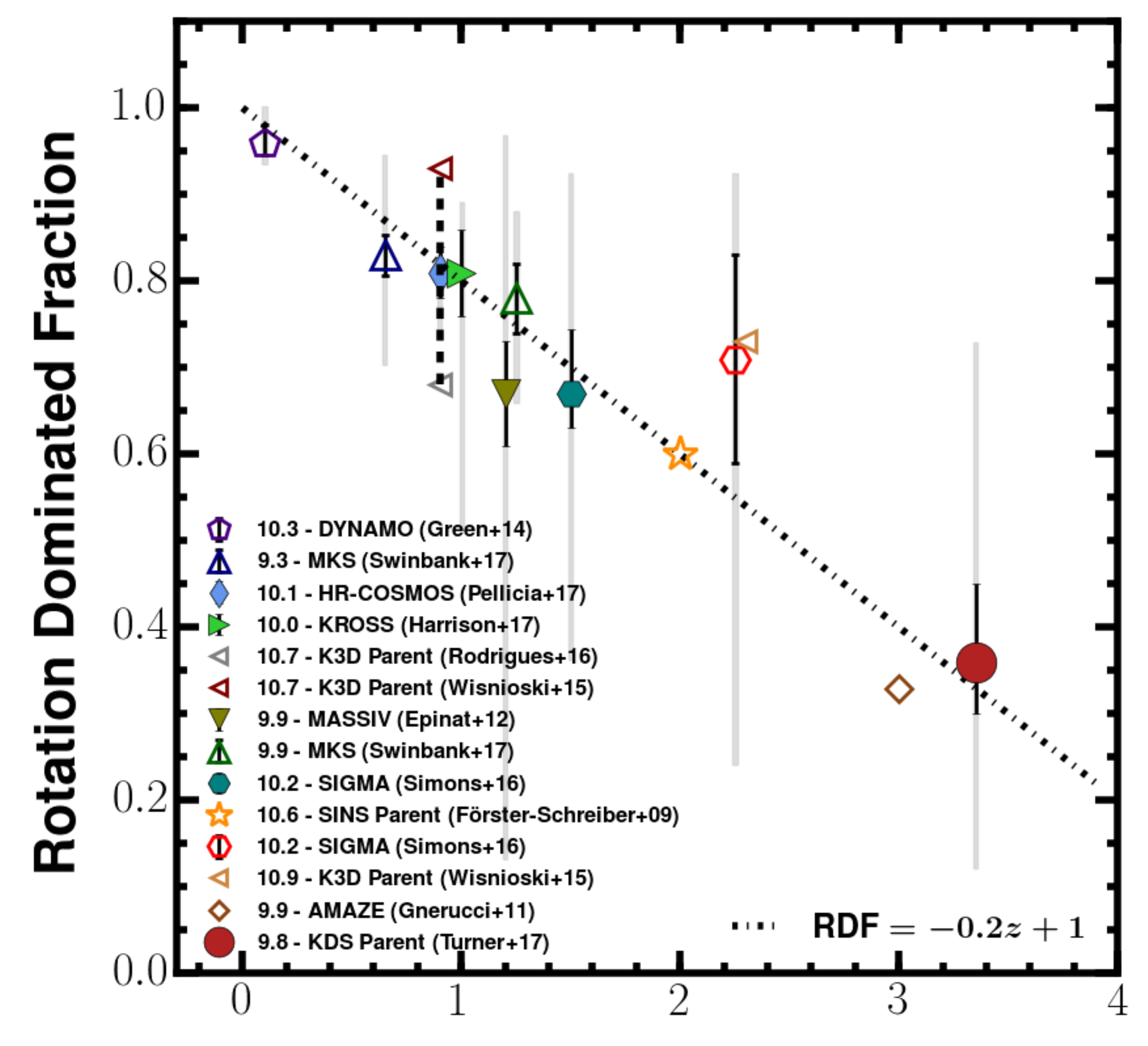
$$= \frac{1}{1 + \left(1.5 \times 10^{a(M_\star)}(1+z)^{b(M_\star)+\alpha}\right)^{-1}}$$

$$a(M_\star) = -10.73 + \frac{1.26}{1 + e^{(10.49 - \log(M_\star/M_\odot))/(-0.25)}}$$

$$b(M_\star) = 1.85 + \frac{1.57}{1 + e^{(10.35 - \log(M_\star/M_\odot))/(0.19)}}$$

Wisnioski+15

Results - declining RDF



Turner et al. *2017*

- The fraction of galaxies dominated by ordered rotation is declining with increasing redshift, dropping to ~ 1/3 at z = 3.5 (direct result of increasing dispersions)
- At high redshift it appears that many typical star-forming galaxies are dominated by random motions. Important to understand the partitioning between pressure support and ordered rotation at this epoch

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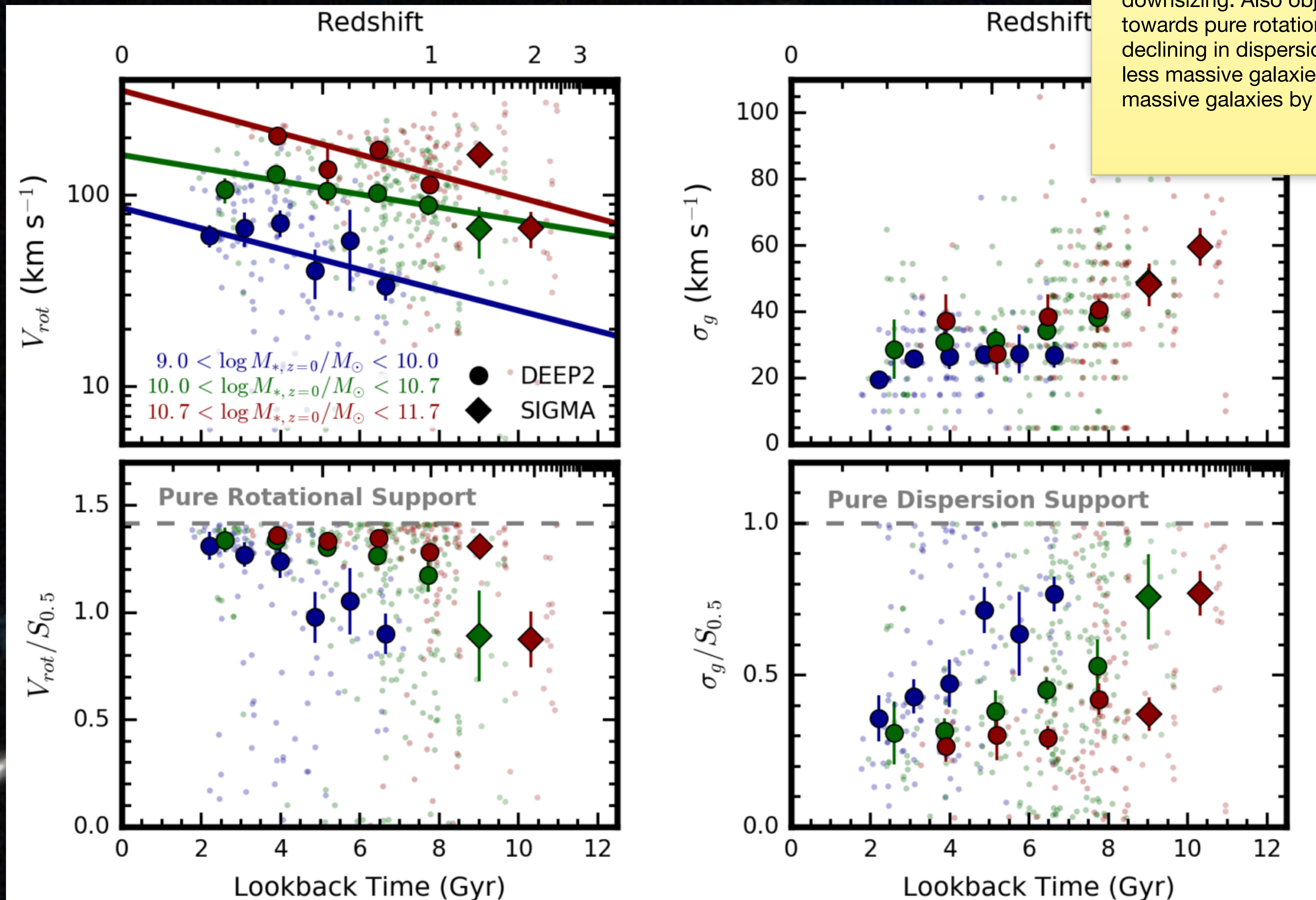
Results - declining RDF

Simons+17



Galaxies appear to spin up as they assemble their stellar mass

Strong mass dependence of kinematic state known as kinematic downsizing. Also objects transitioning towards pure rotational support and declining in dispersion support - lag of less massive galaxies behind most massive galaxies by several Gyrs.

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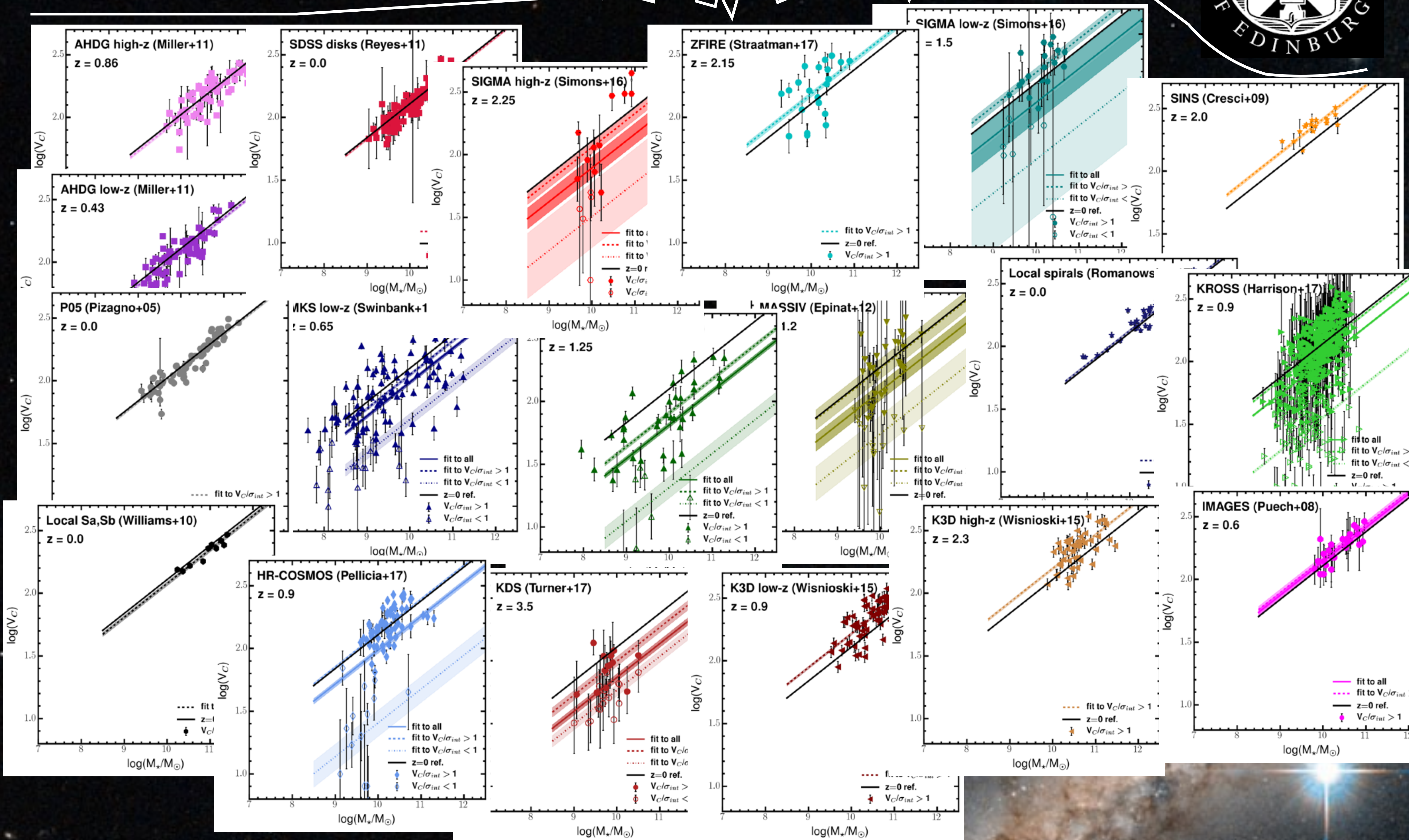
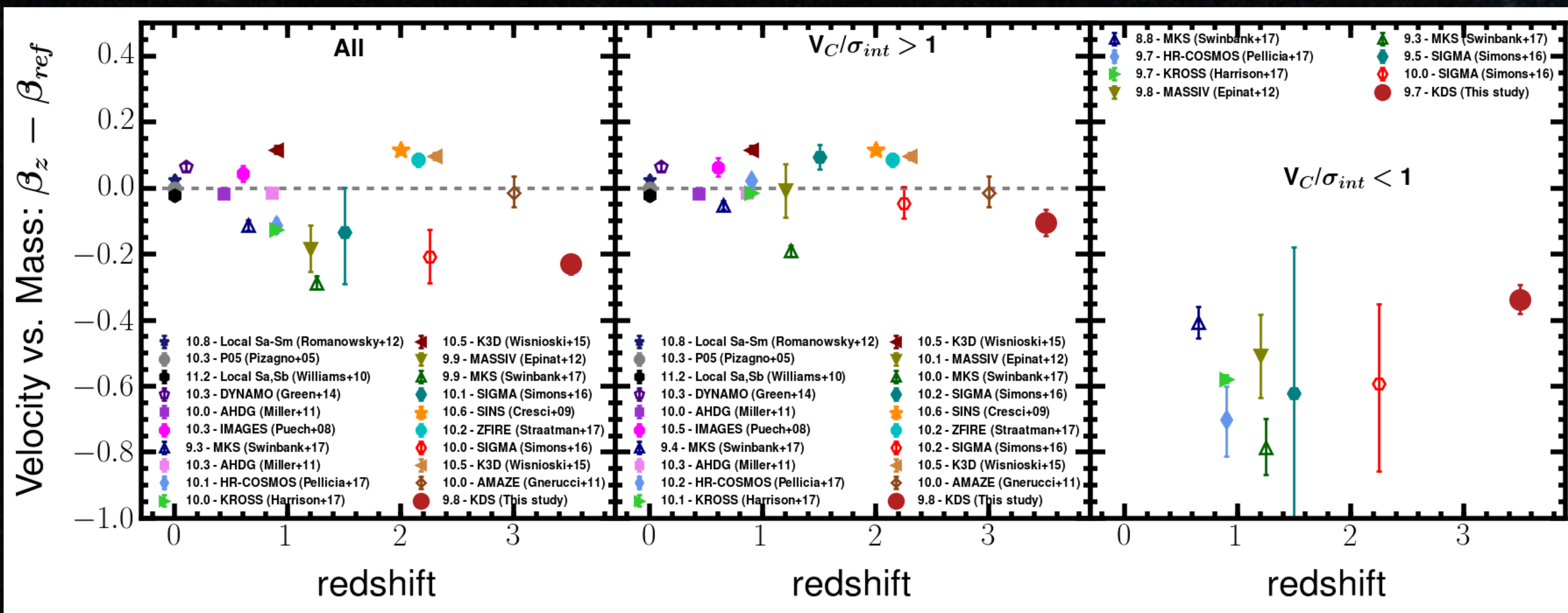


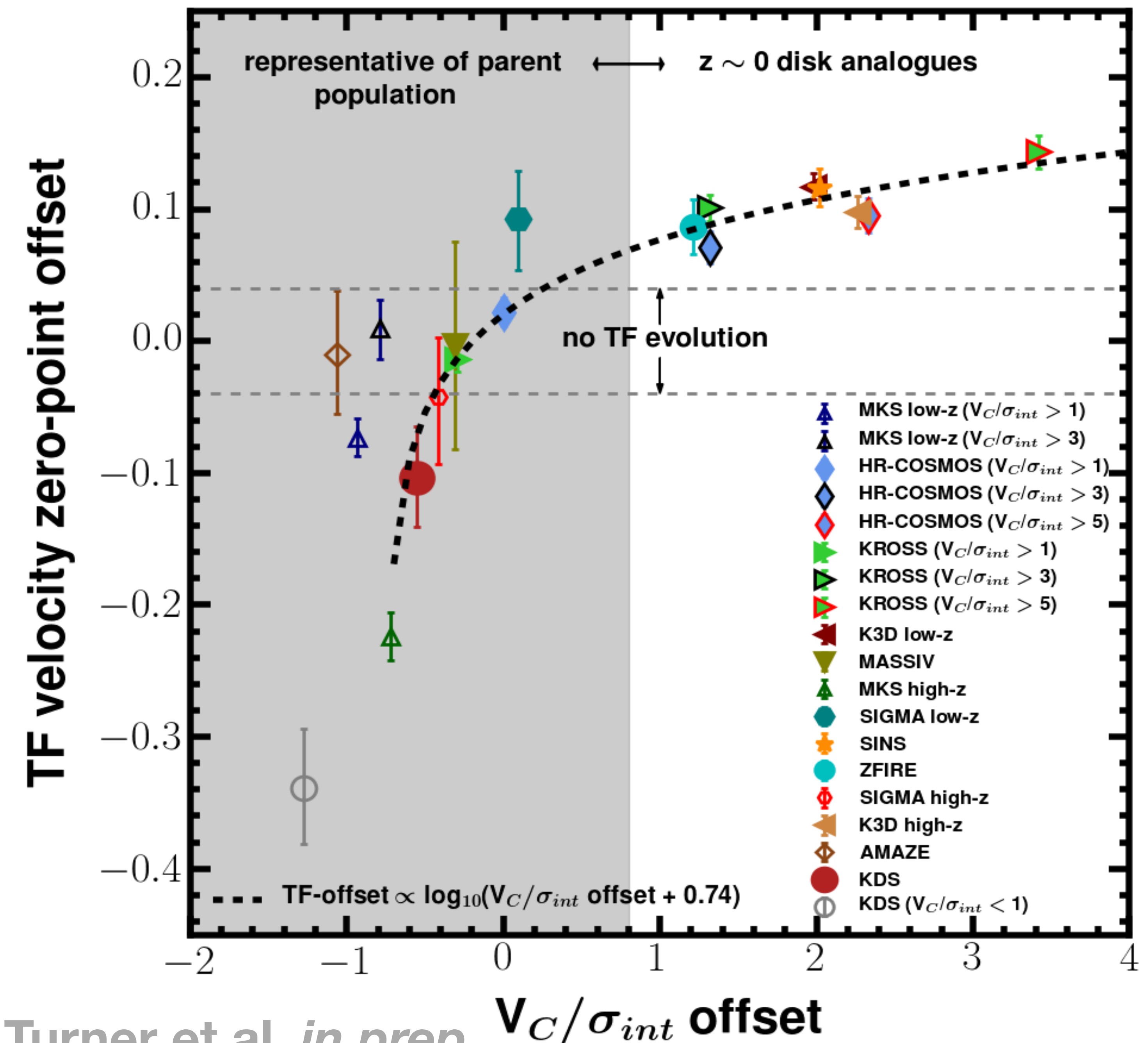
Results - velocity vs. mass (stellar mass Tully-Fisher) evolution



Turner et al. *in prep*

Unclear whether the relationship evolves or not (in this view)

Results - Explaining Tully-Fisher literature discrepancies



Turner et al. *in prep*

Sample selection can be understood in terms of the median ratio of velocity to velocity dispersion for the star-forming galaxy samples. Those characterised by higher V/σ show positive stellar mass TF evolution.

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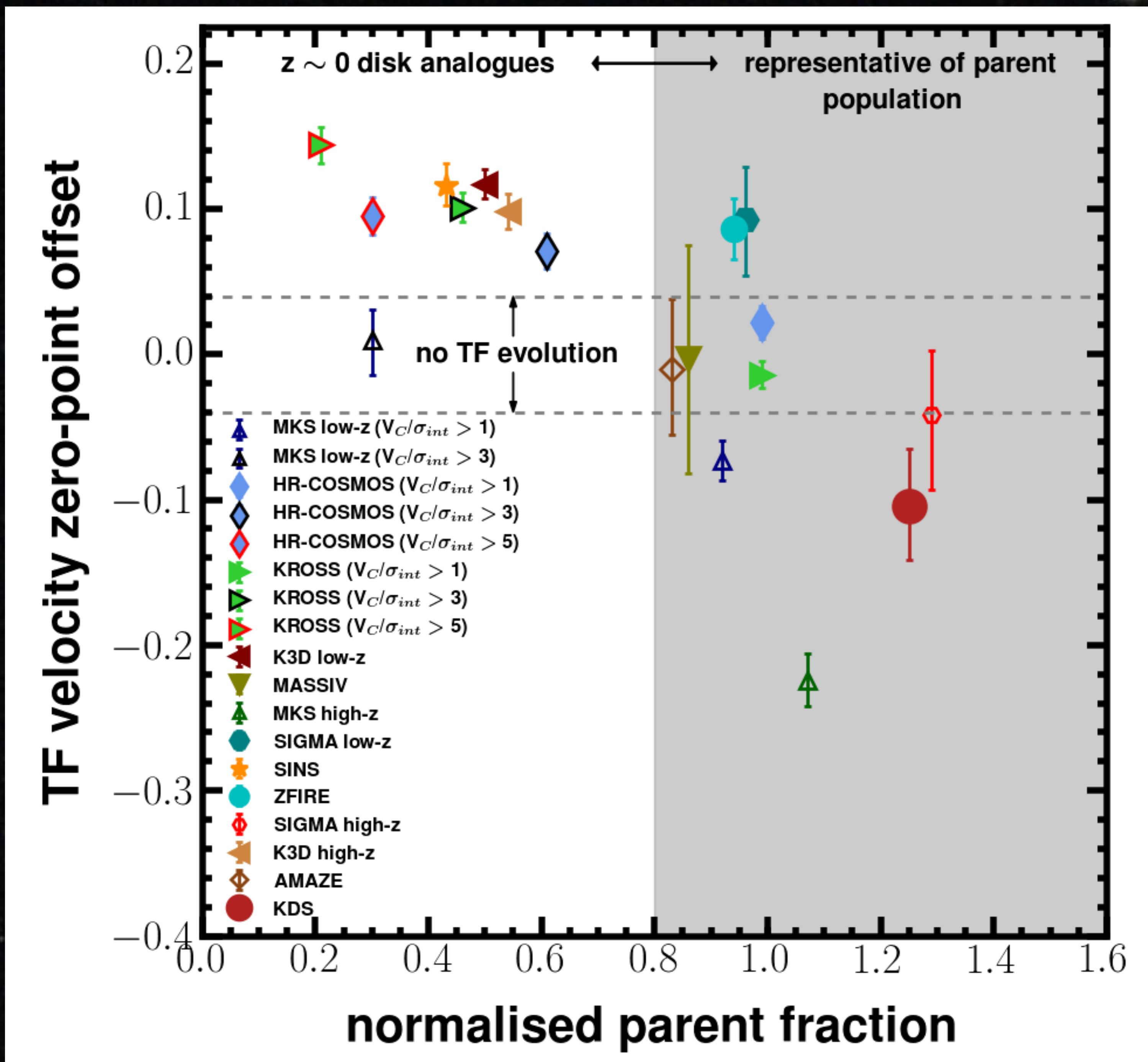
Results - Explaining Tully-Fisher literature discrepancies



These z=0 disk analogues are a small fraction of the parent population at each redshift (and not representative of the star-forming population at that redshift)

<u>The take home</u> - the degree of evolution observed is a consequence of sample selection. When evolution is seen it reflects the build-up of stellar mass within galaxies.

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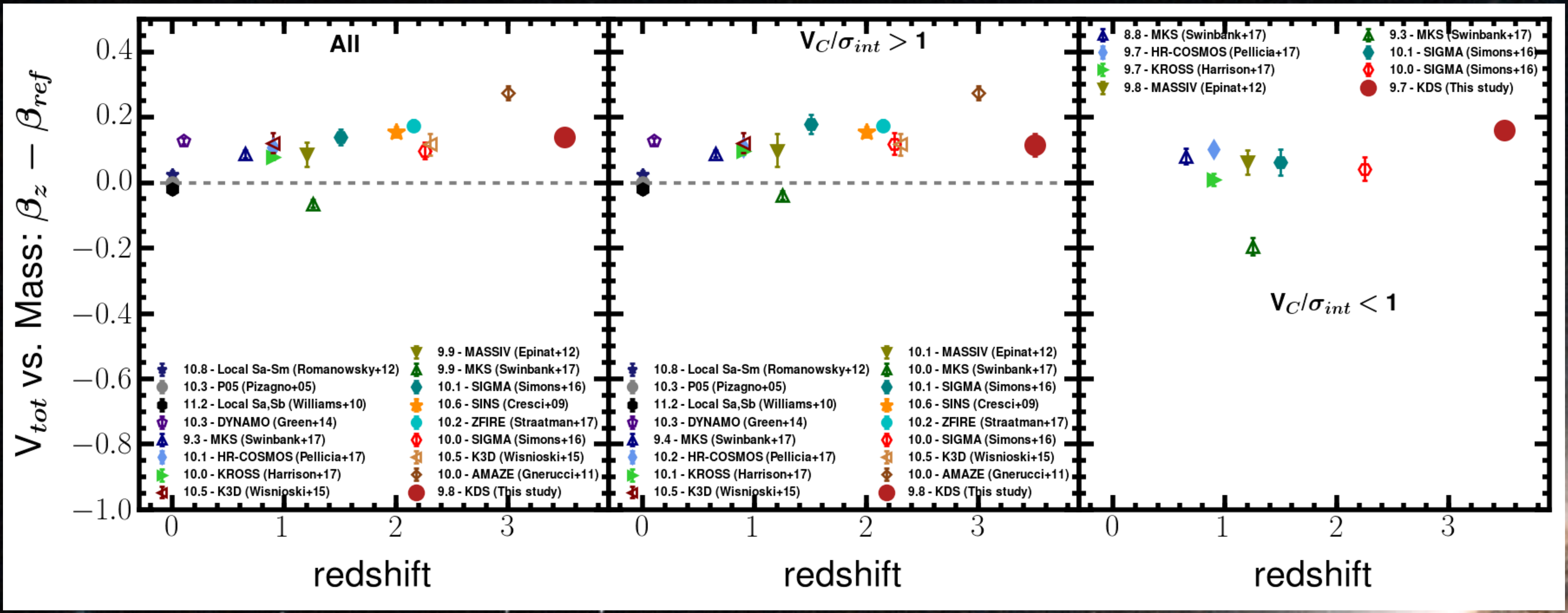
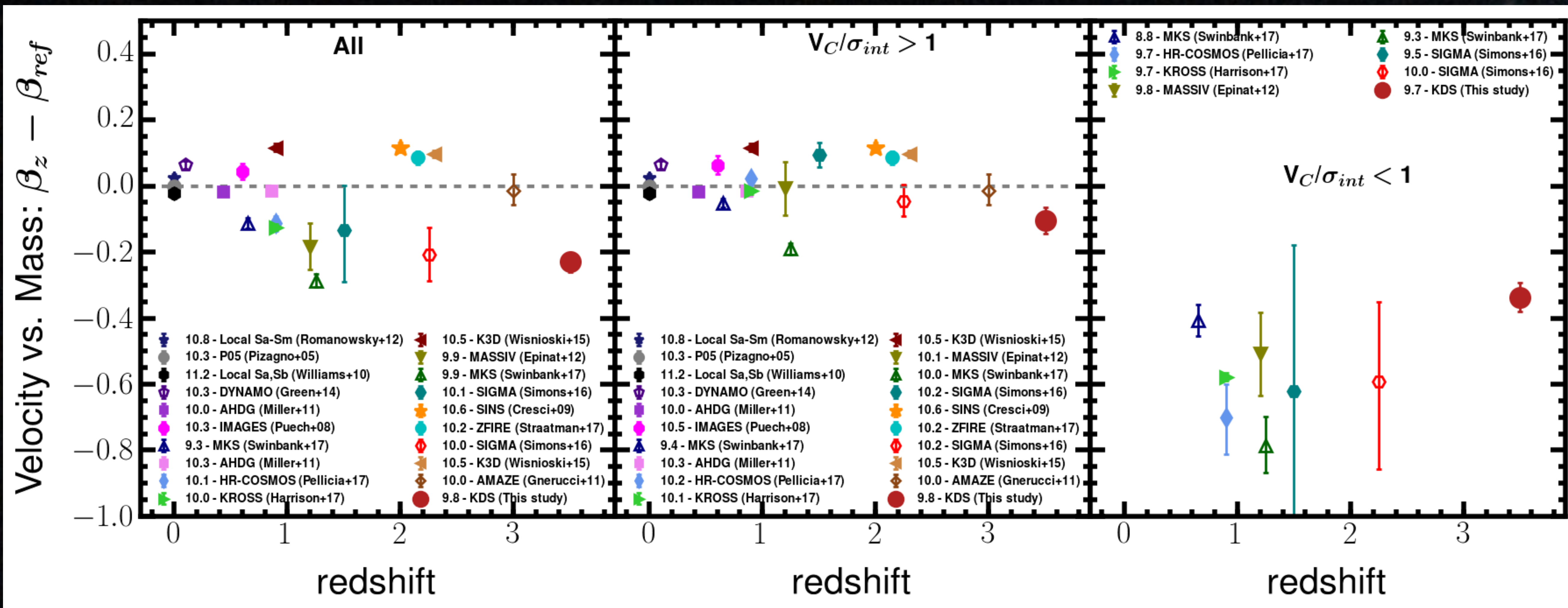
Results - pressure corrected velocity vs. mass evolution



Turner et al. *in prep*

Vtot offset from local Universe indicates paucity of stellar mass in relation to dynamical mass at intermediate and high redshift



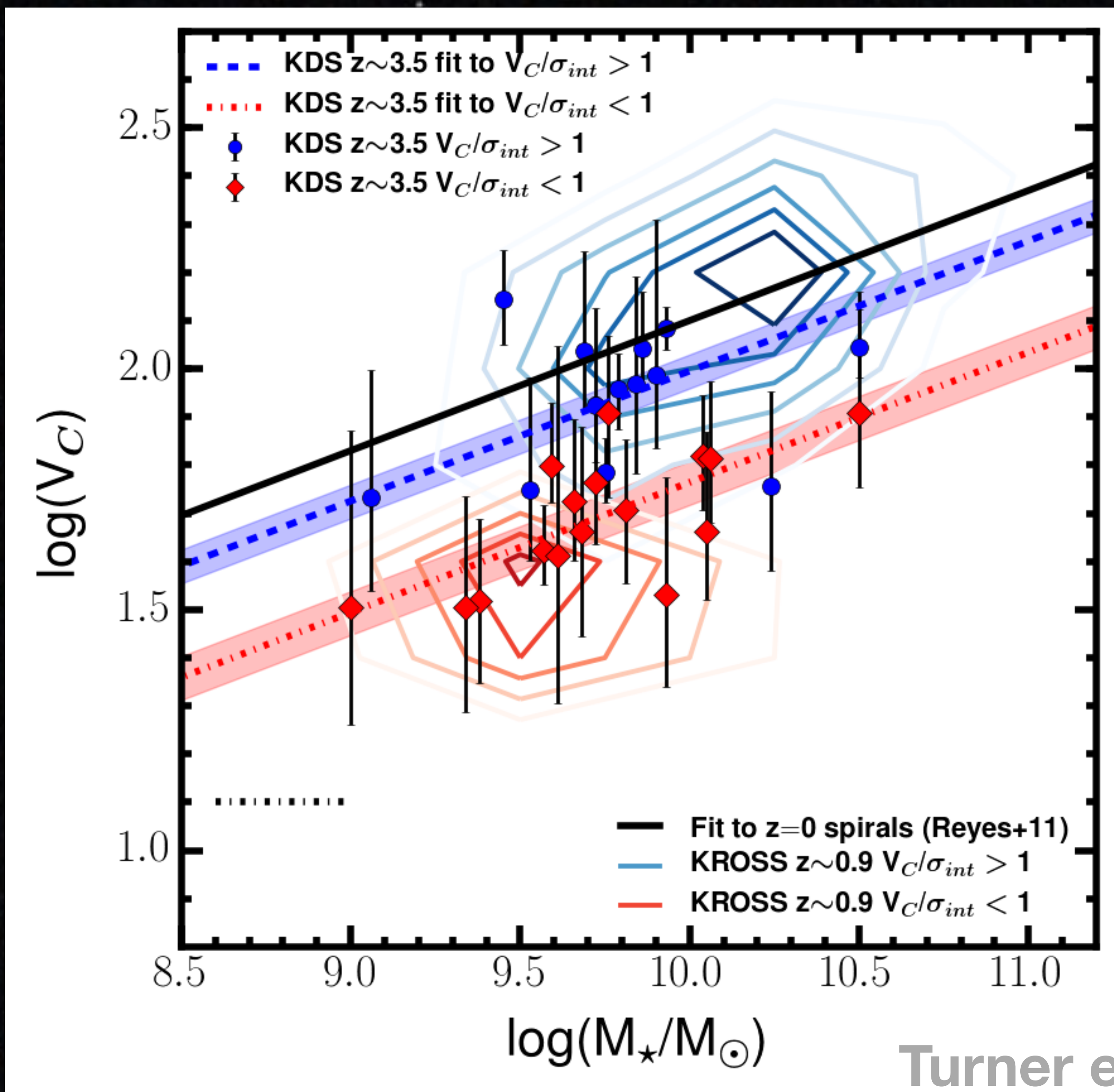
Turner et al. *in prep*

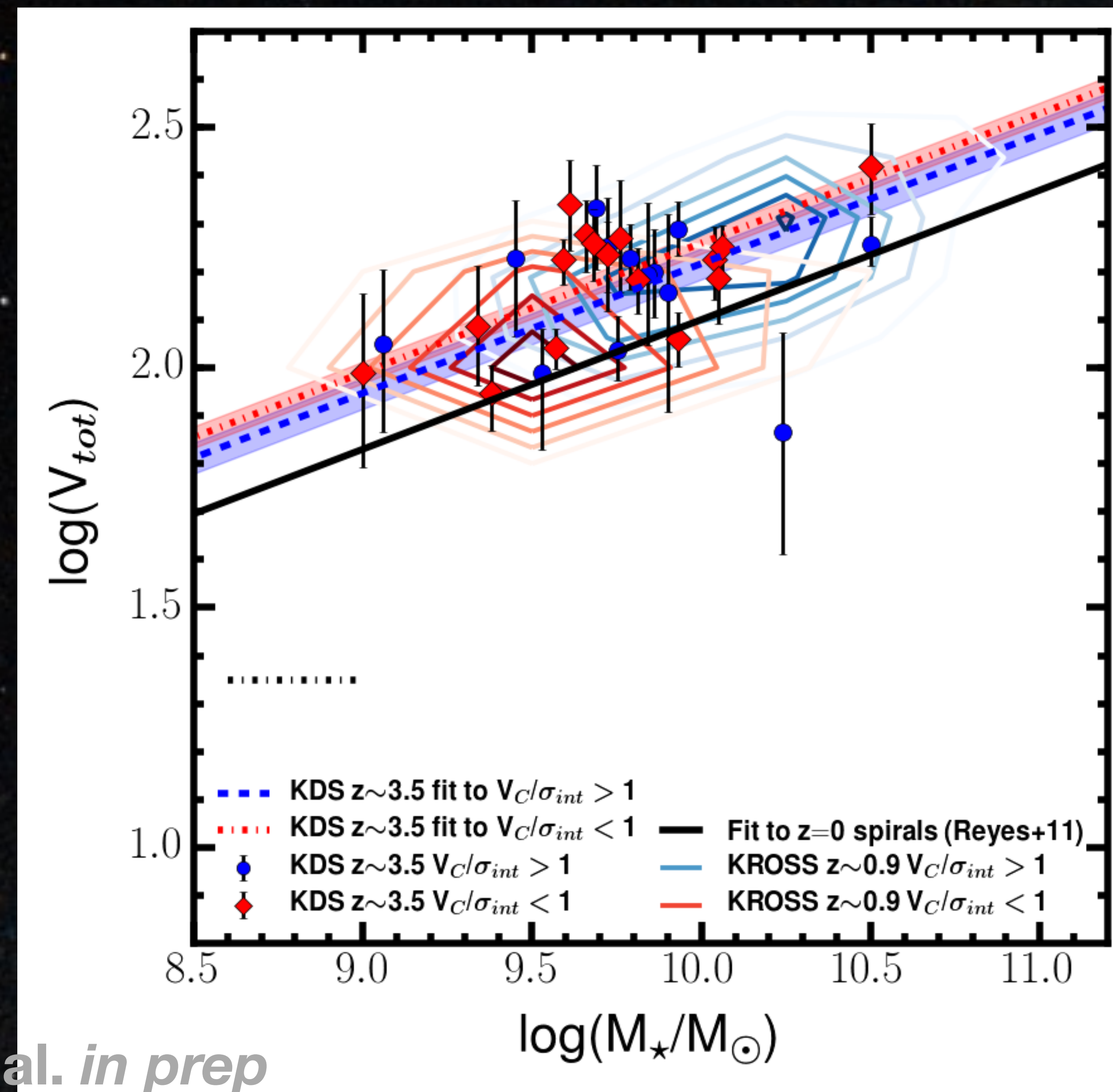
Conclusions - from KDS and other surveys spanning 0 < z < 3

- Sample of main-sequence galaxies observed with IFS at z ~ 3.5
- Strong dynamical evolution of typical star-forming galaxies. Random motions begin to dominate over rotation at z > 3 and form a significant part of the dynamical mass budget
- Evolution of scaling relations like the stellar mass Tully-Fisher relation dictated by sample selection criteria. Taking this into account can resolve literature discrepancies
- These observations are consistent with a hot, turbulent formation picture, after which star-forming galaxy disks gradually build and settle into entities supported by ordered rotation

Results - pressure corrected velocity

$$V_{tot} = \sqrt{V_C^2 + 4.0\sigma_{int}^2}$$





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cf. Kassin+07,12 $S_{0.5}$ parameter