SUB-GALACTIC MUSE VIEW OF Z~1 STRONGLY LENSED GALAXIES

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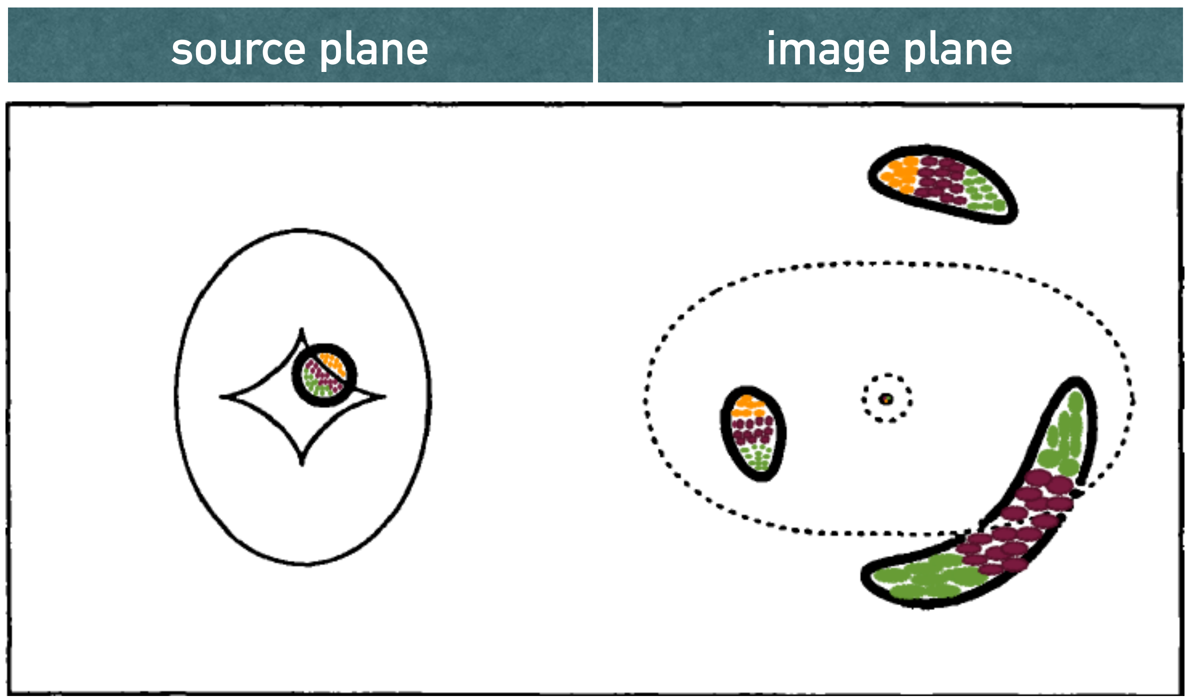
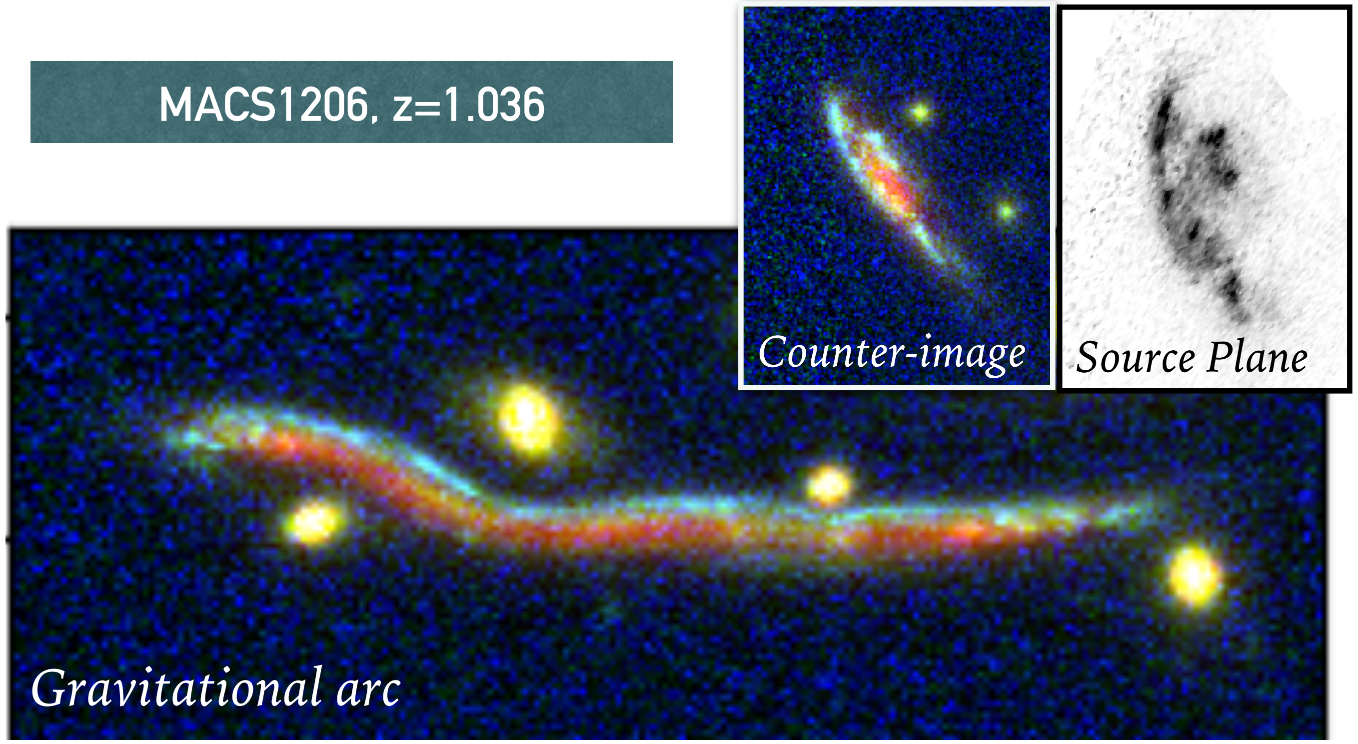
V. PATRICIO

STRONGLY LENSED, EXTENDED OBJECTS

Multiple images: example with a generic elliptical lensing model from Blandford and Narayan, 1992:



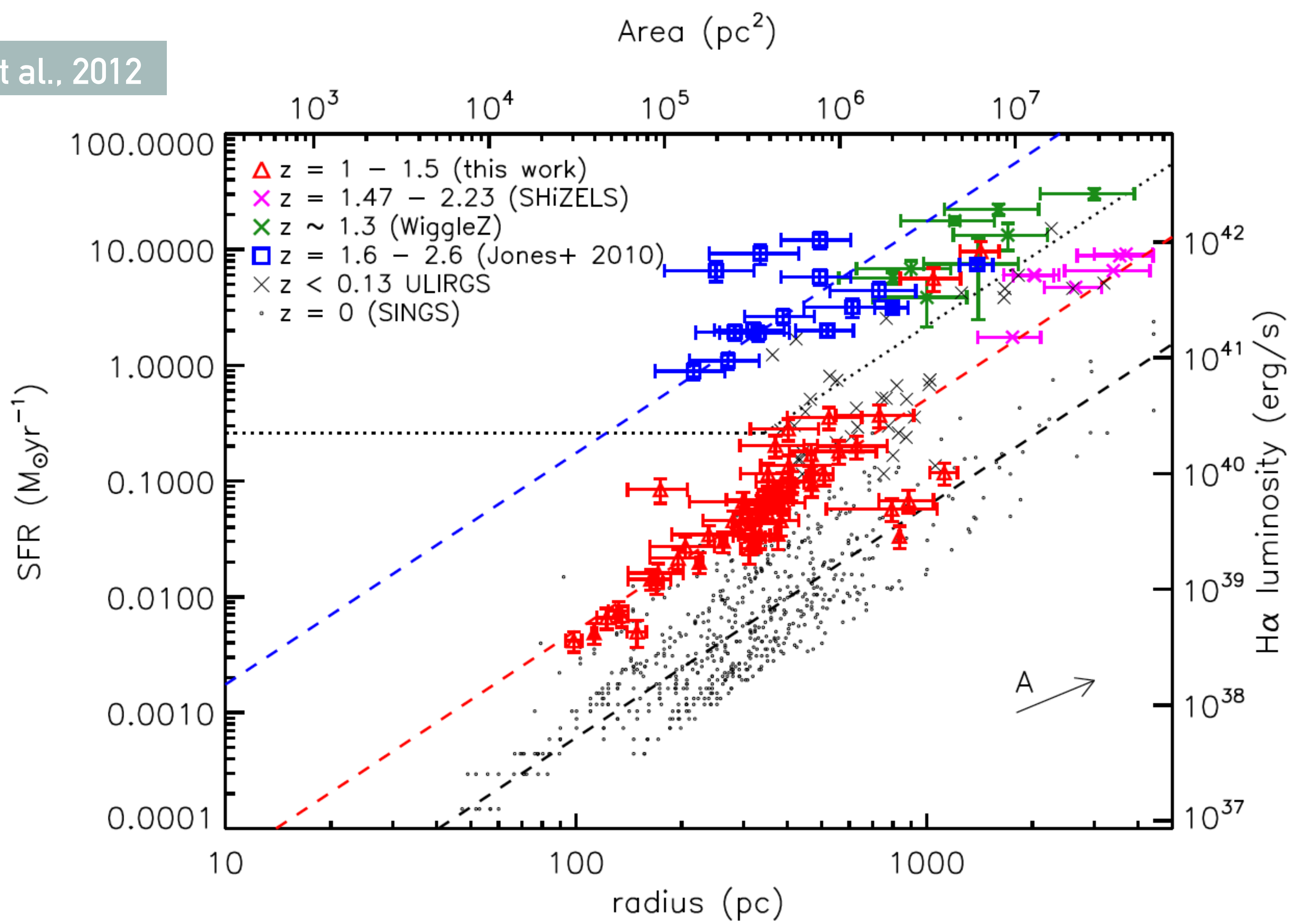


At HST resolution, strongly lensed galaxies can be resolved up to 200~500 pc

CLUMPS: OBSERVATIONAL CHALLENGES

Clump Sizes

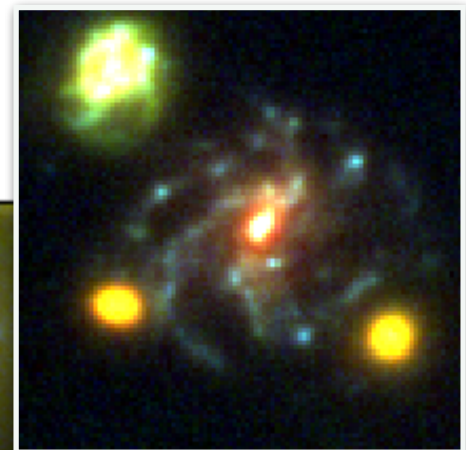
Livermore et al., 2012



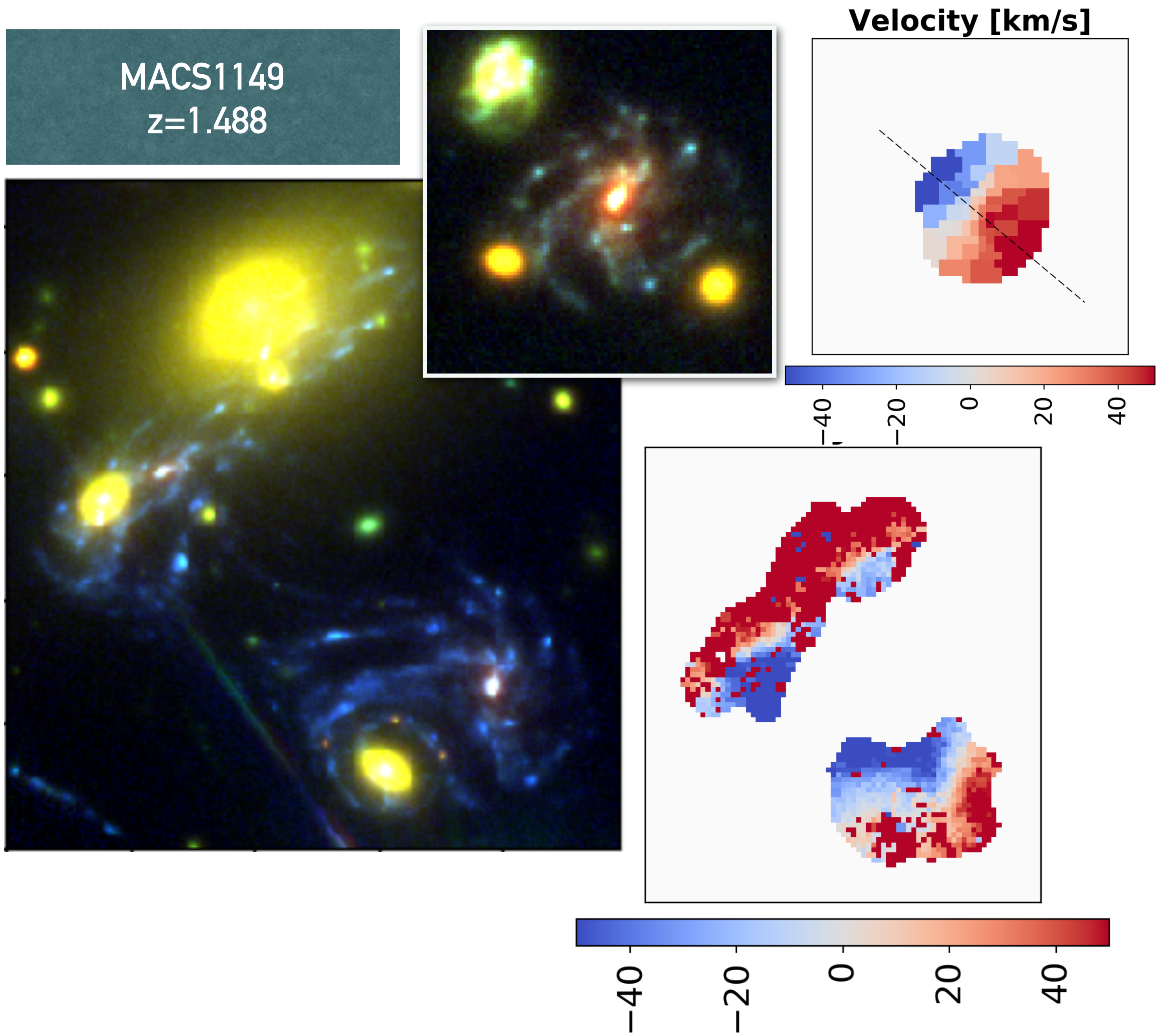
Lensed samples have revealed smaller (<1 kpc) and less massive (<10E8 Msun) clumps at high-z.

DISCS AT Z~1: CLUMPY AND TURBULENT

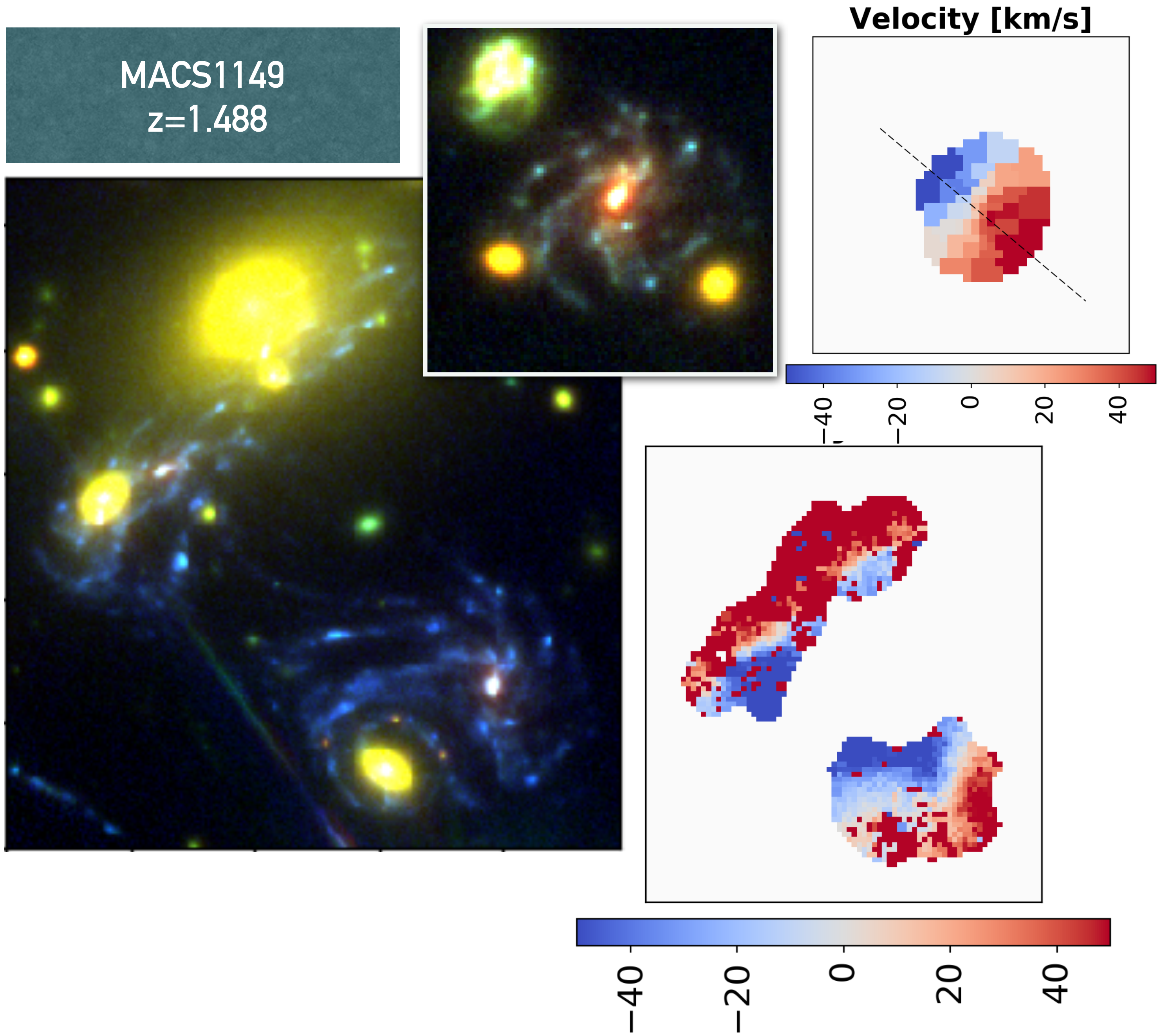
MACS1149
z=1.488



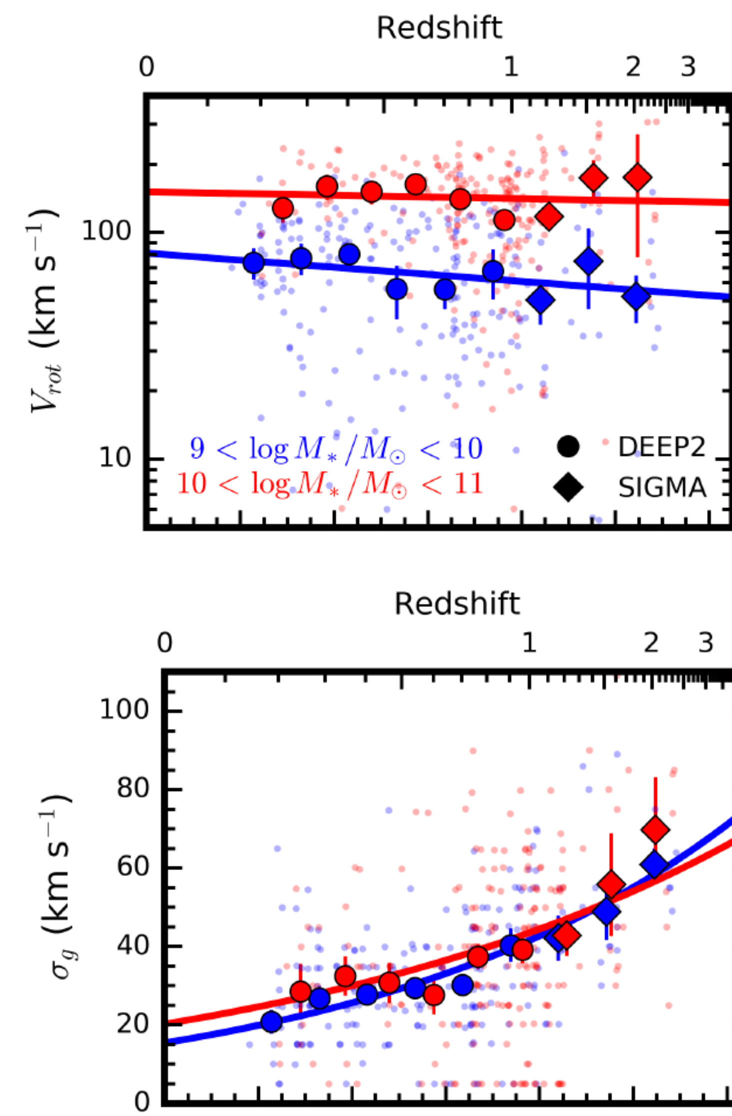
DISCS AT Z~1: CLUMPY AND TURBULENT



DISCS AT Z~1: CLUMPY AND TURBULENT

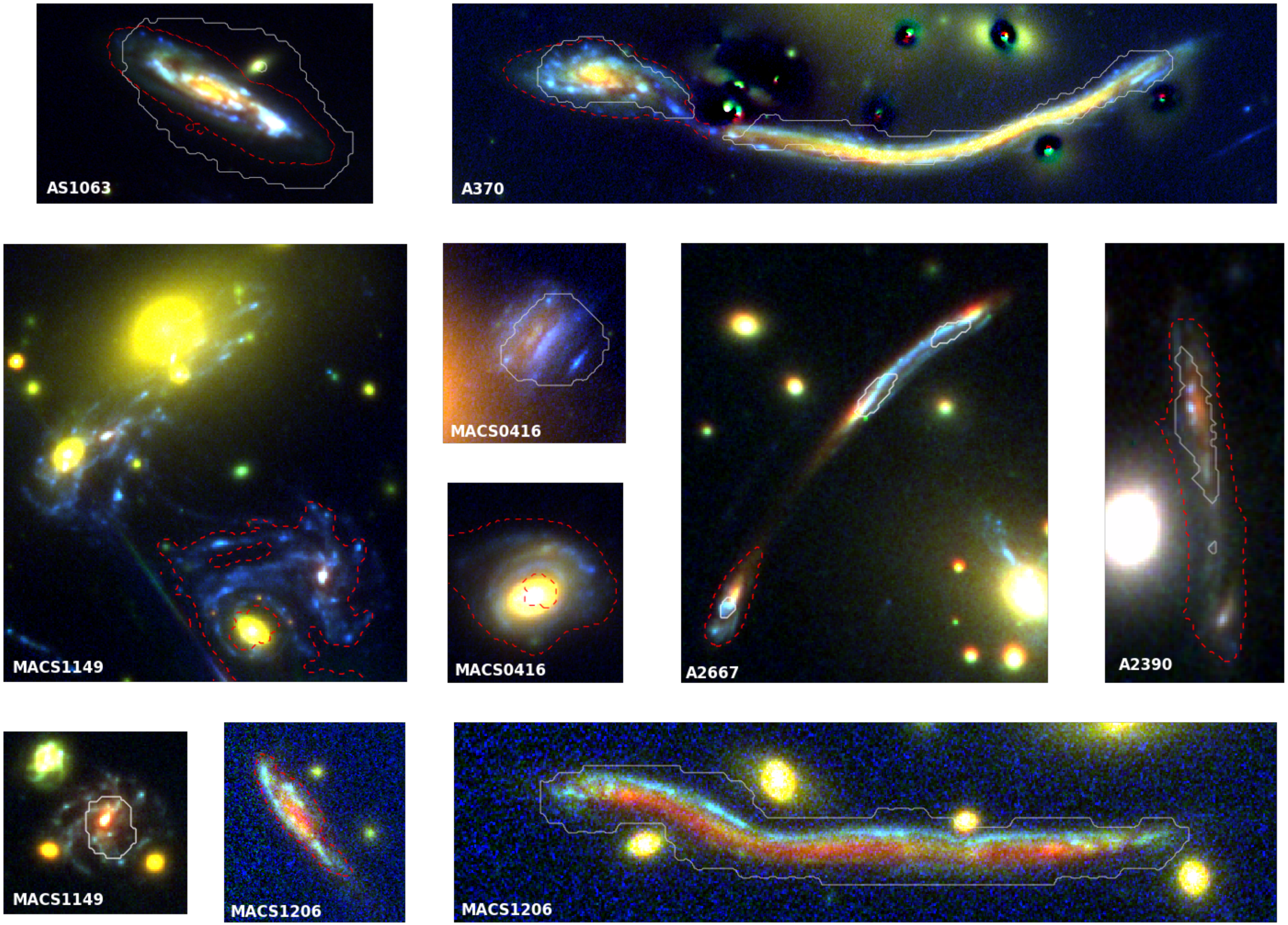


Simons et al., 2017



Discs at z~1 are clumpy and haver higher velocity dispersions.

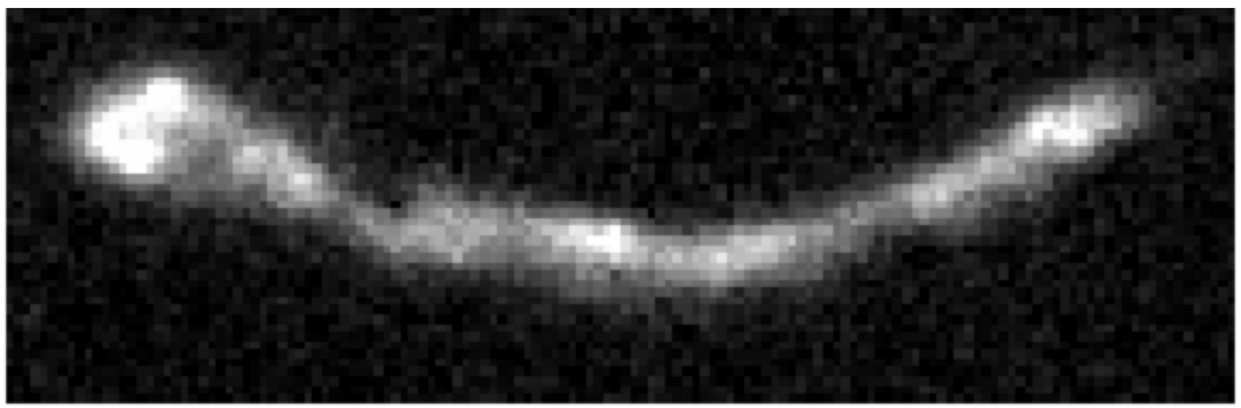
SAMPLE: HST + MUSE DATA



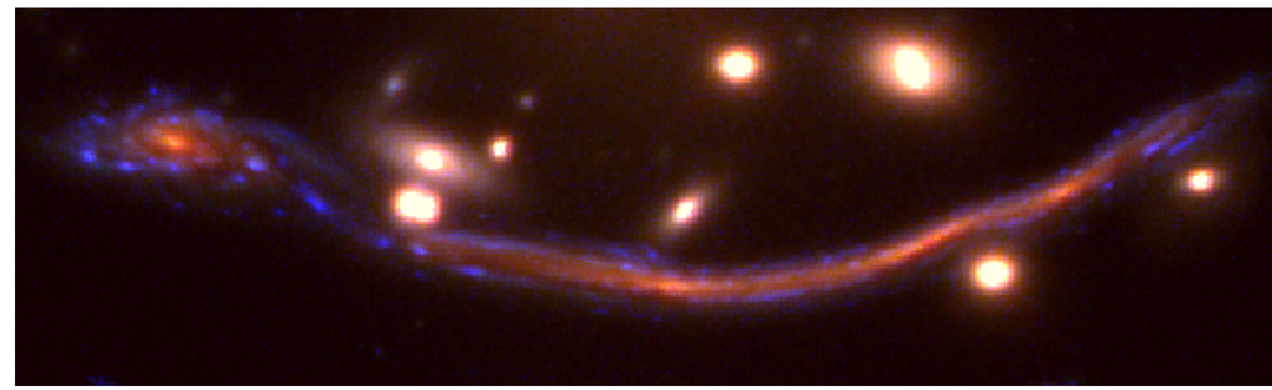
MUSE DATA

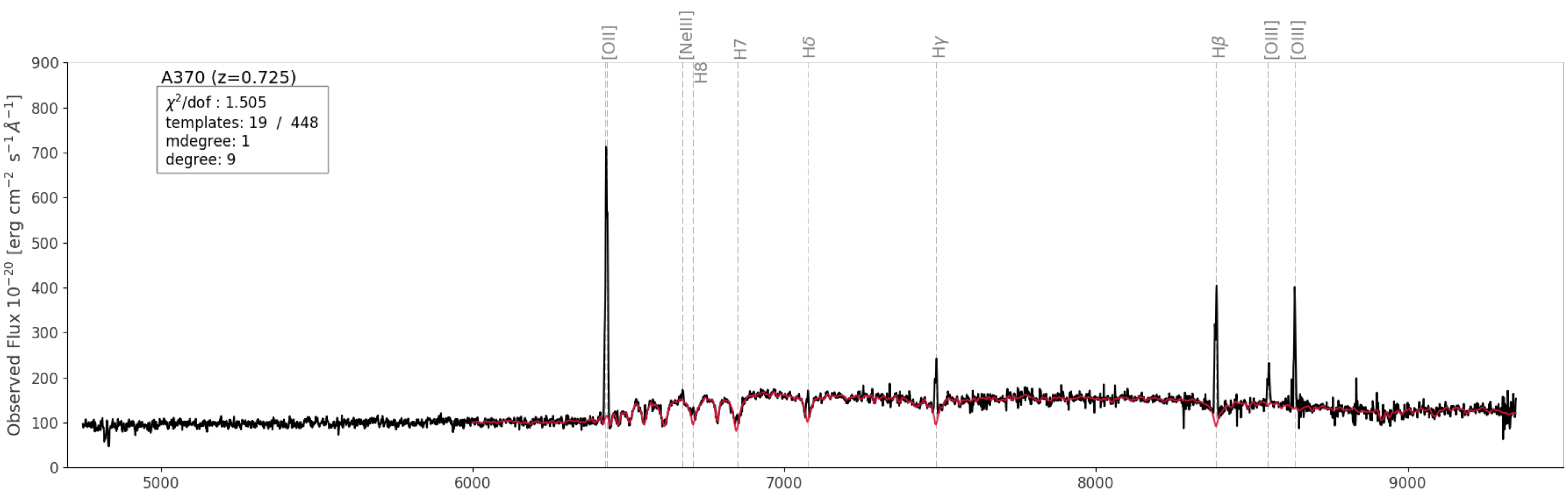
A370 arc (z=0.725) aka 'The Dragon'

MUSE (PSF 0.75")

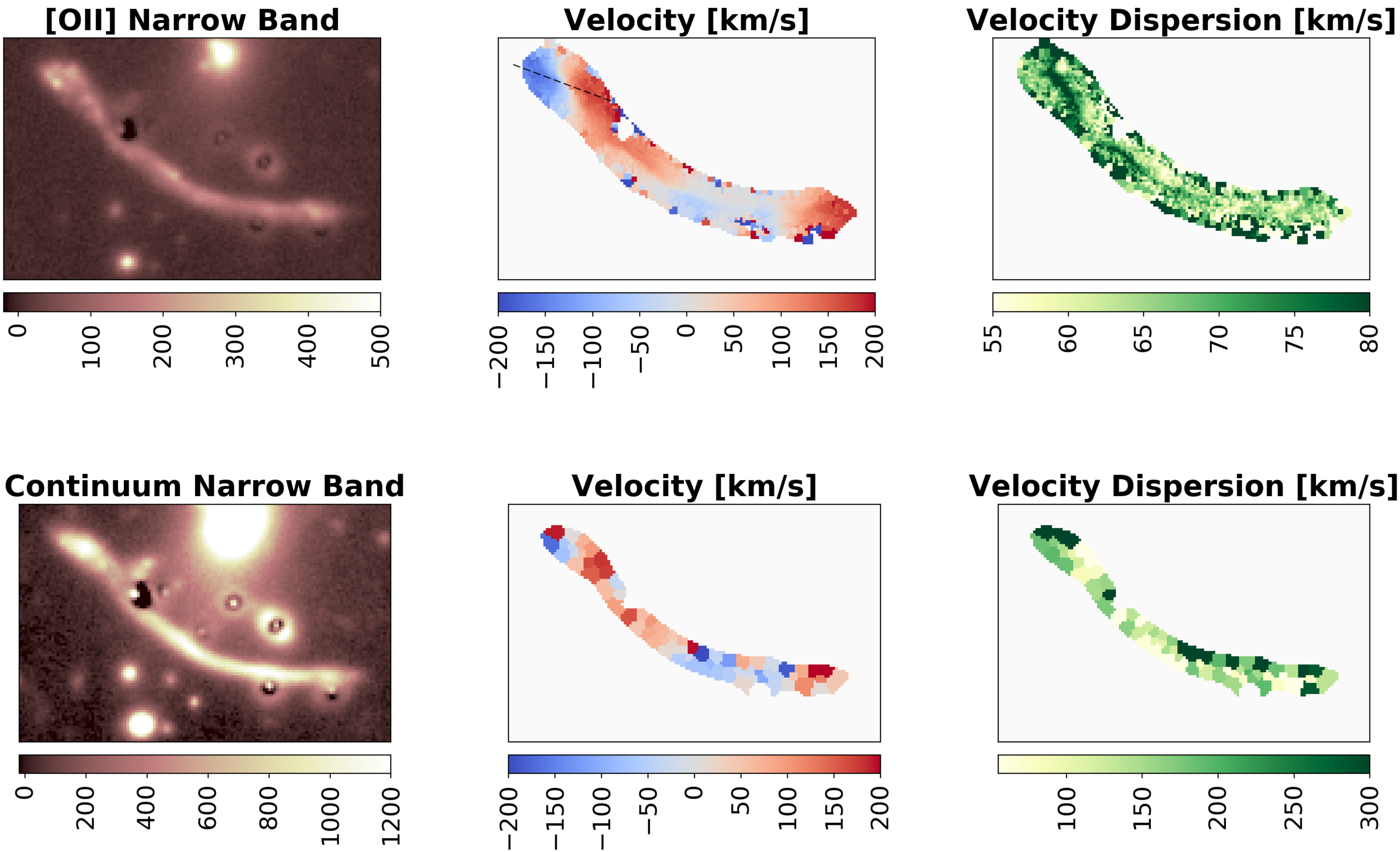


HST (PSF 0.2")





2D VELOCITY FIELDS

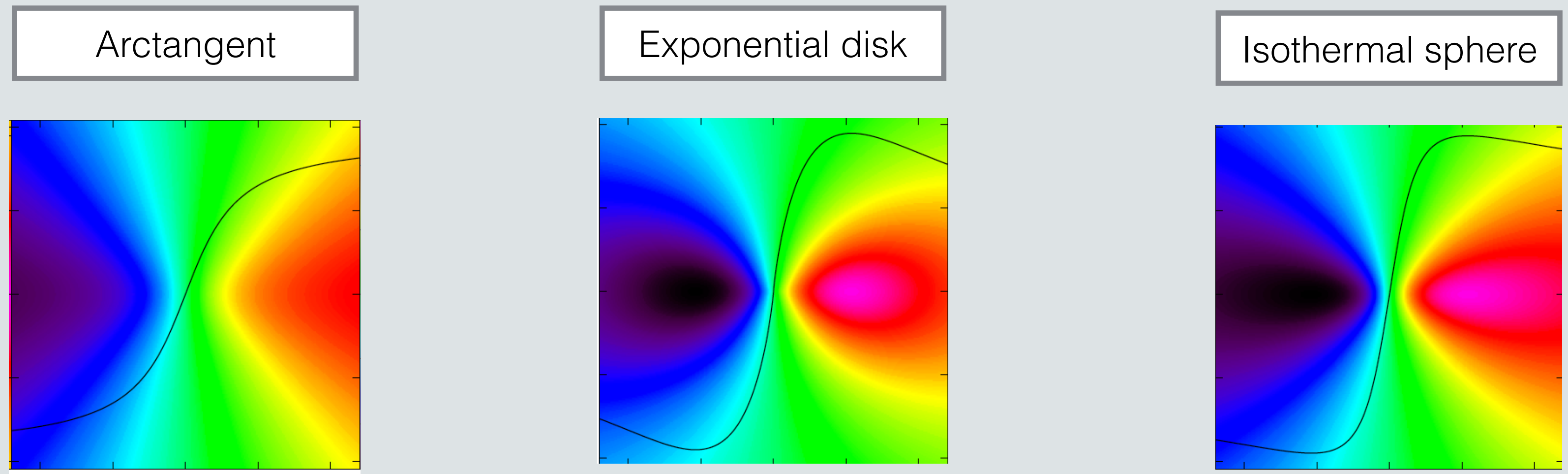


2D VELOCITY FIT

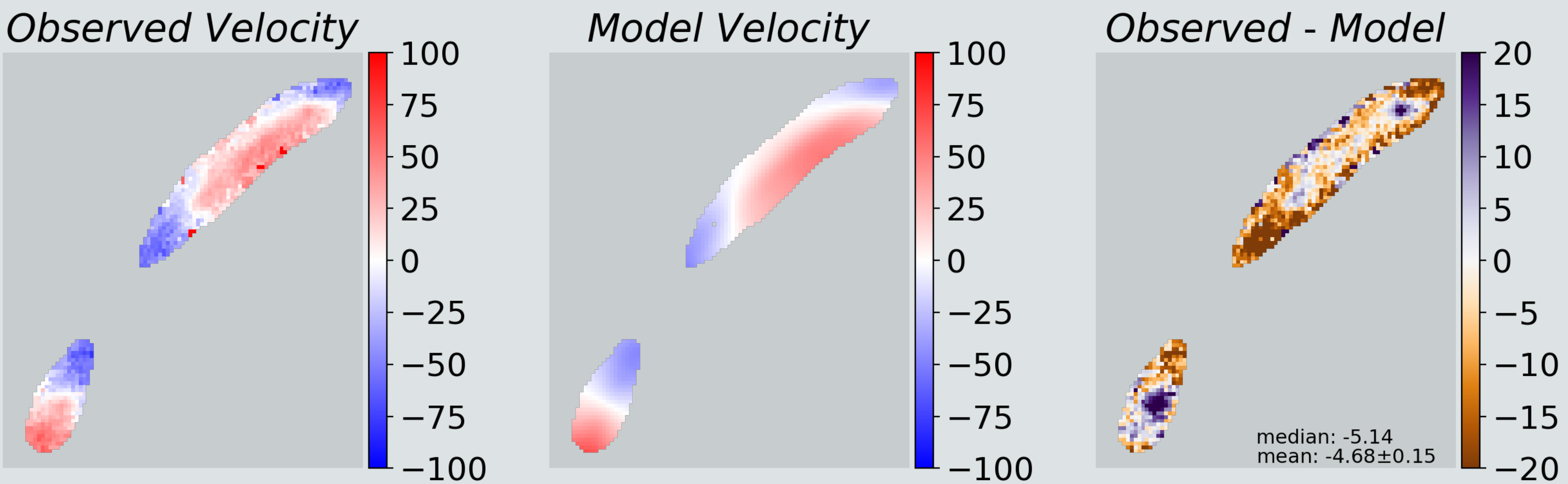
1) A 2D kinematic model is created in Source Plane.

Parameters:

- Centre position (x,y)
- Inclination
- Position angle
- Truncation velocity
- Truncation radius



2) The model is lensed to image plane and the velocity field compared with the data



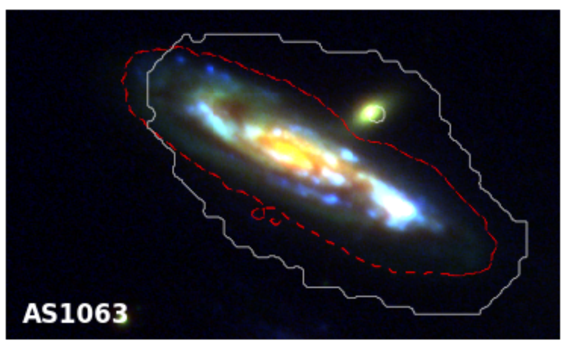
3) MCMC for a n number of steps (using the emcee python package Foreman-Mackey).

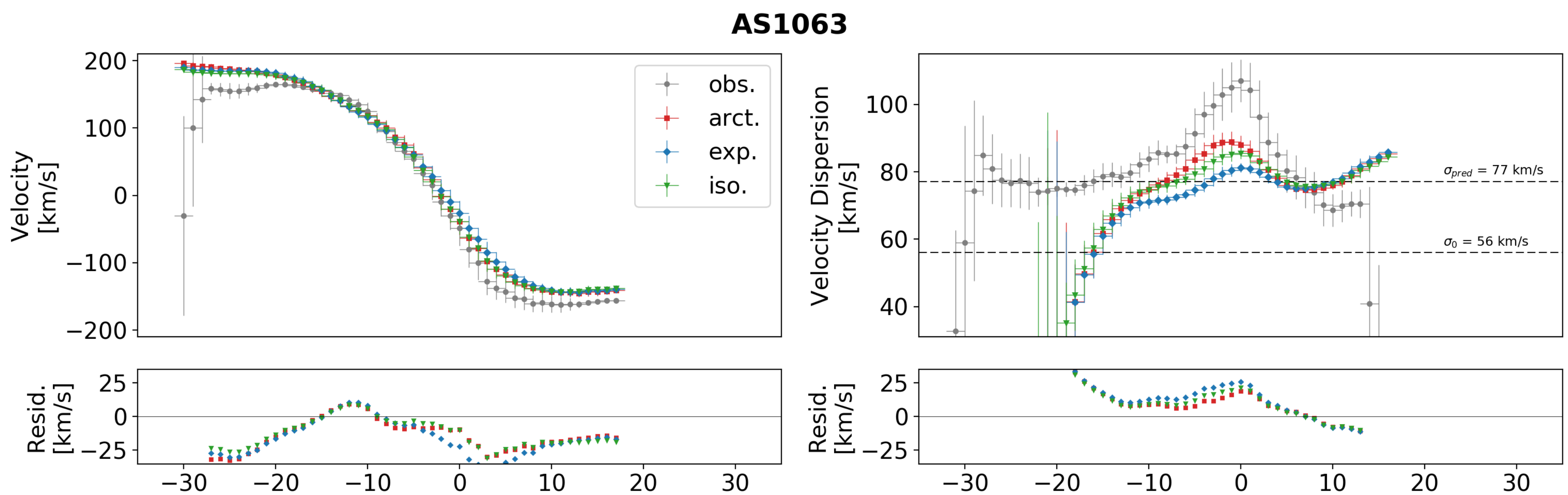
KINEMATIC FIT RESULTS

Best model?

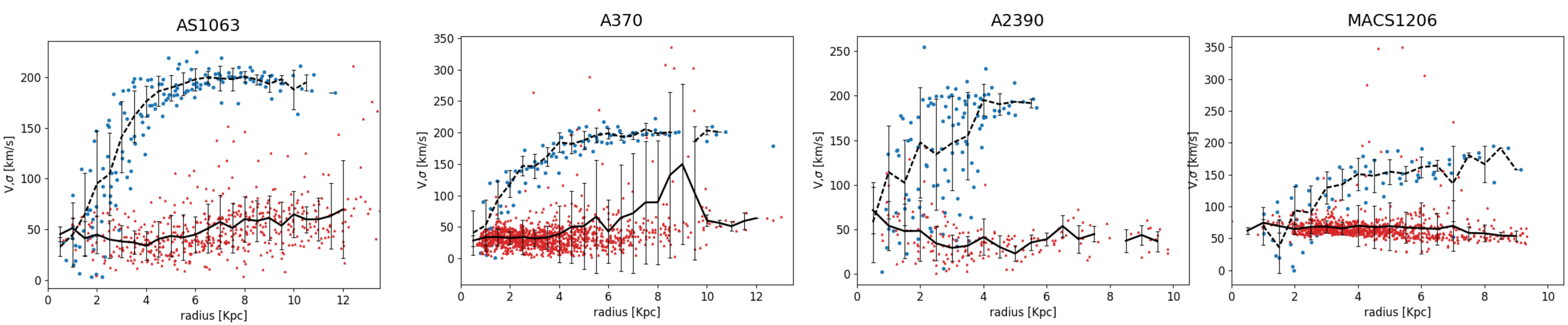
Arctangent: 4; Exponential Disc: 3; Isothermal Sphere: 0. ***Differences are very small.***

Image Plane



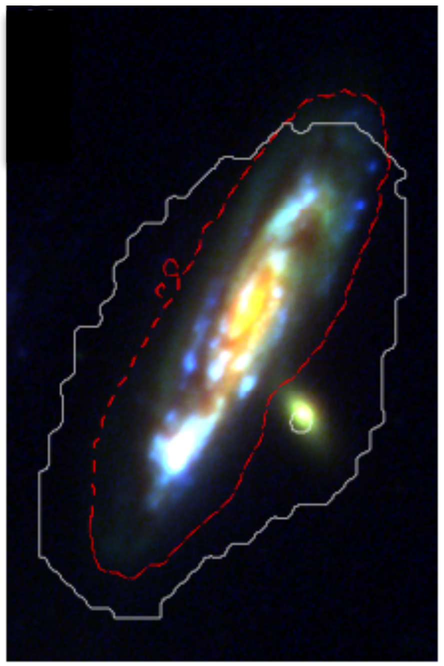


Source Plane

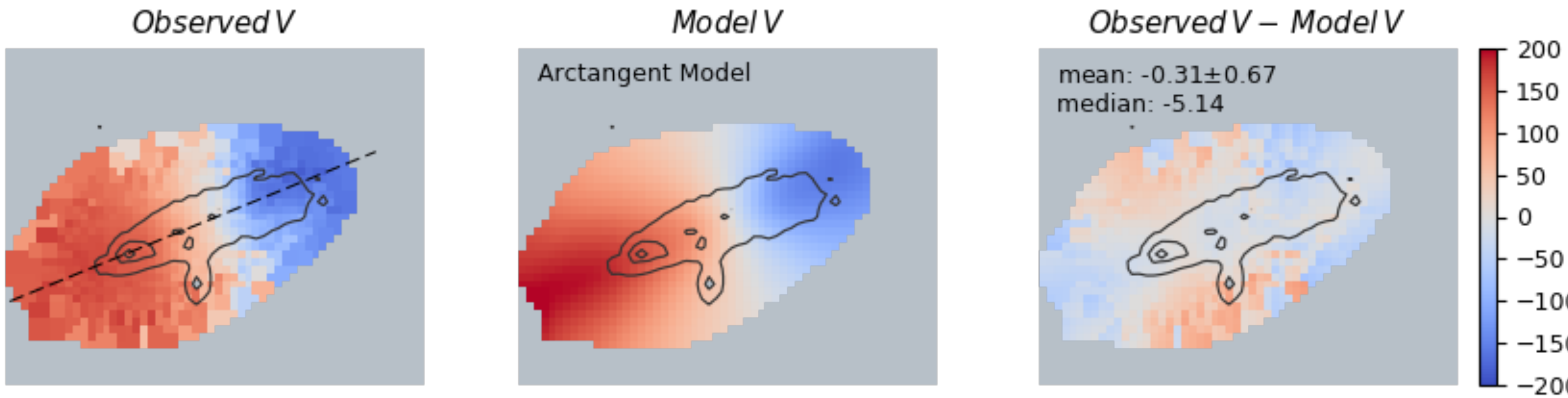


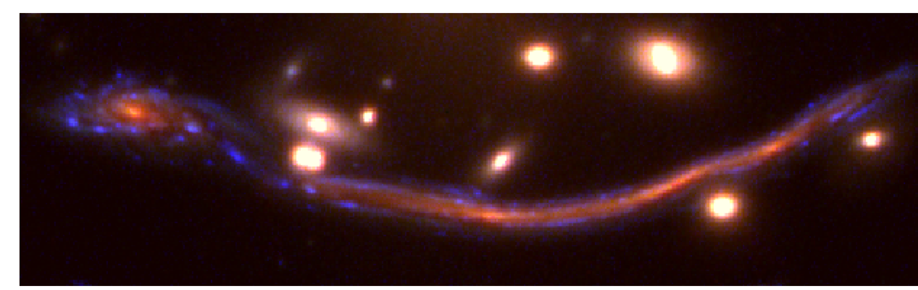
2D VELOCITY FIELDS

AS1063



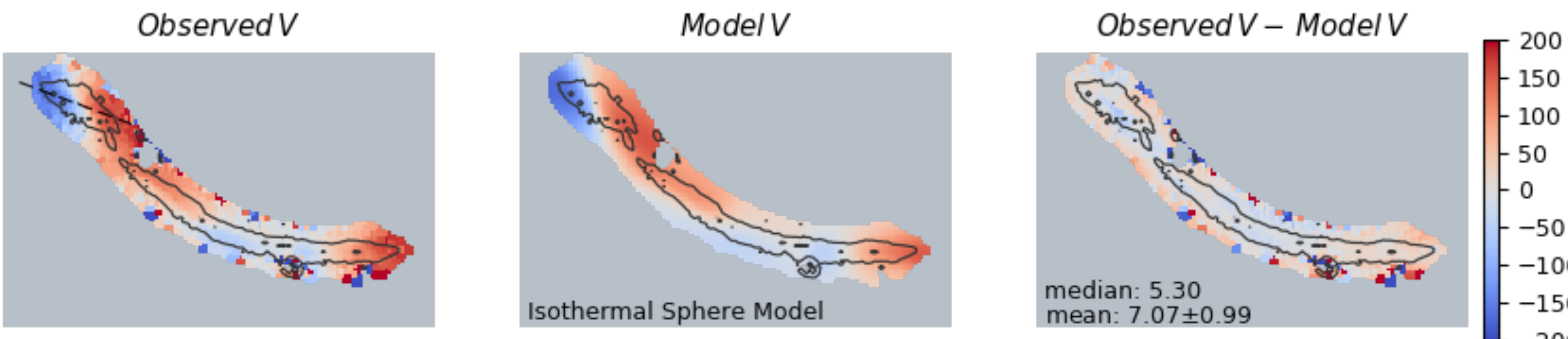
z=0.611 8.74x10E10 M⊙ 8.81 (12+log(O/H))





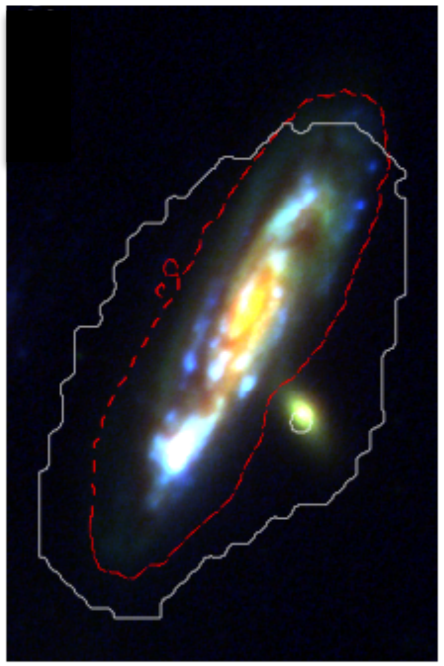
A370

z=0.752 2.49x10E10 M⊙ 8.88 (12+log(O/H))



2D VELOCITY DISPERSION

AS1063



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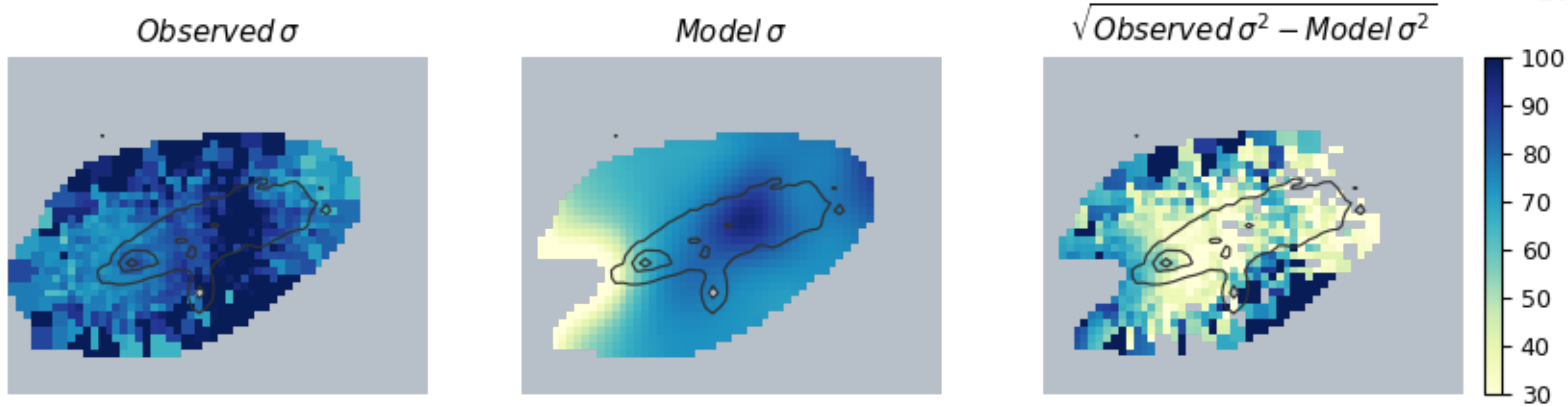

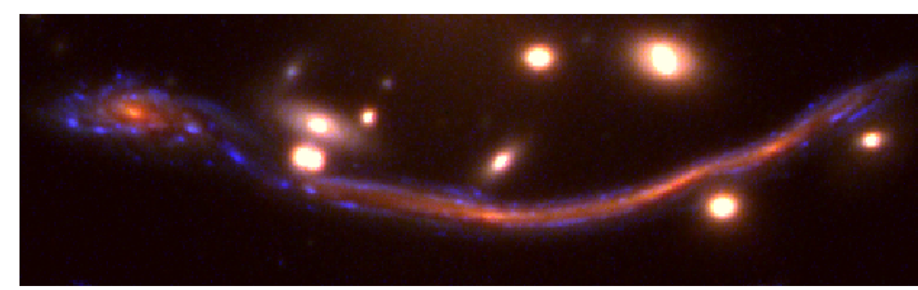

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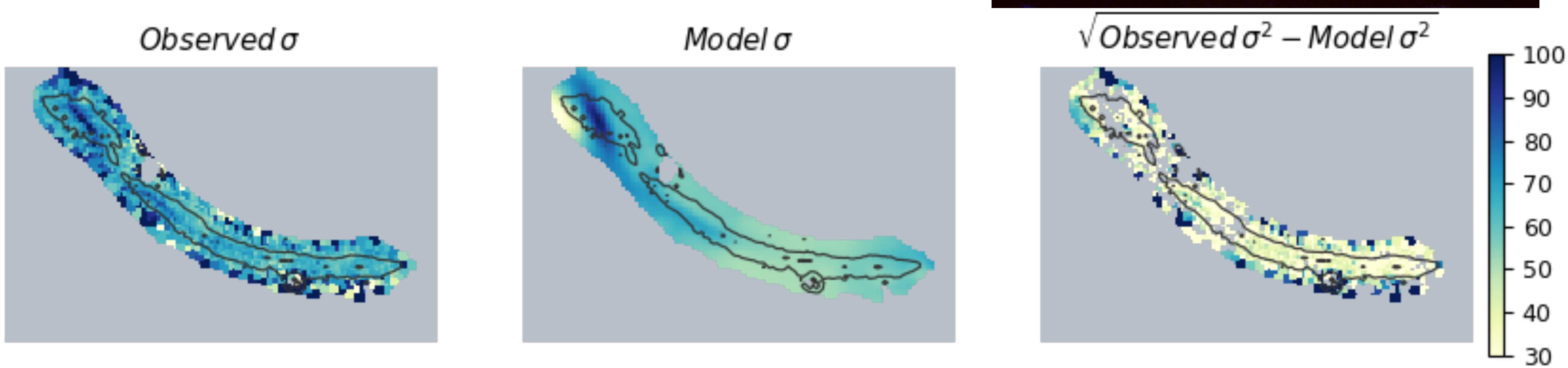
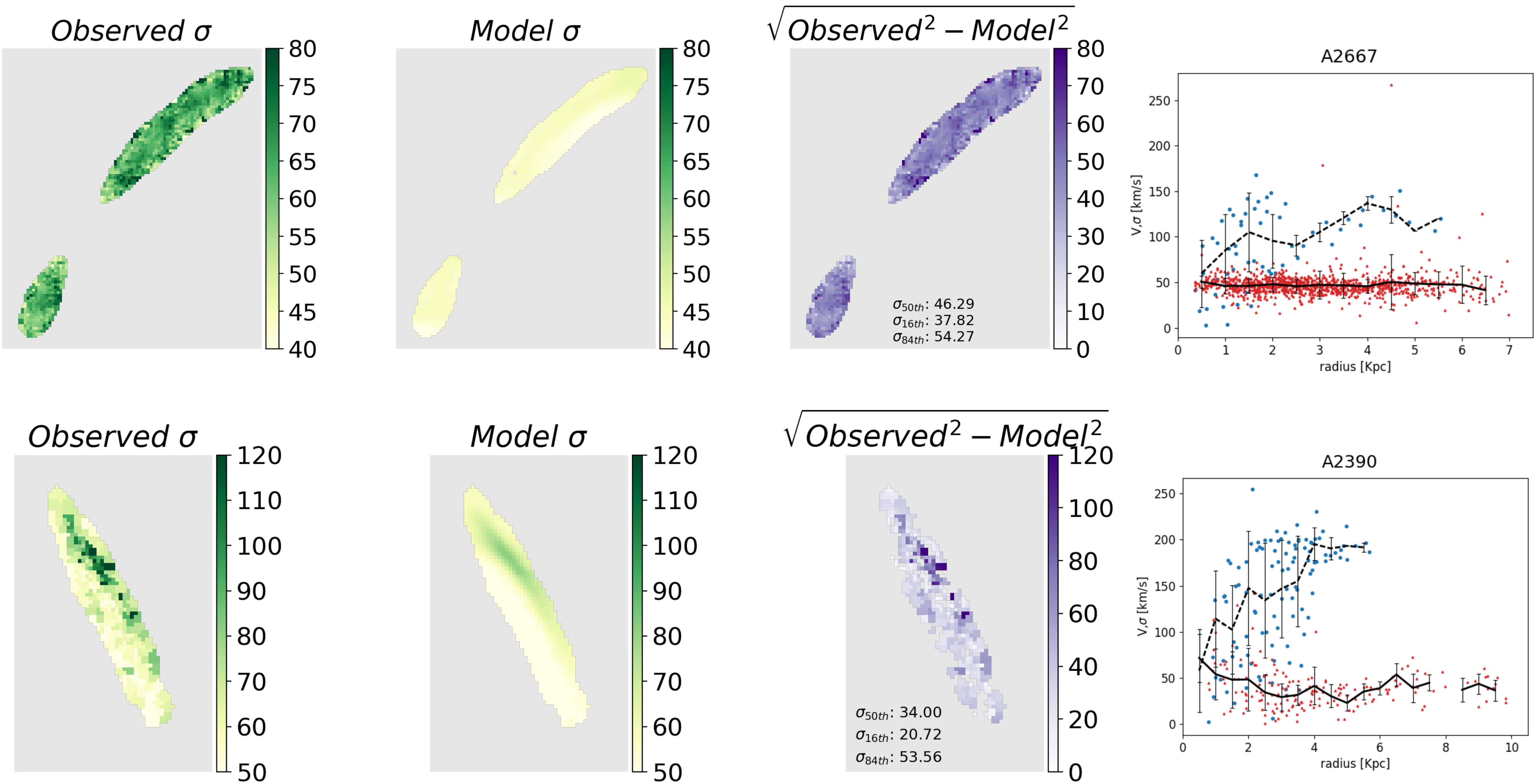
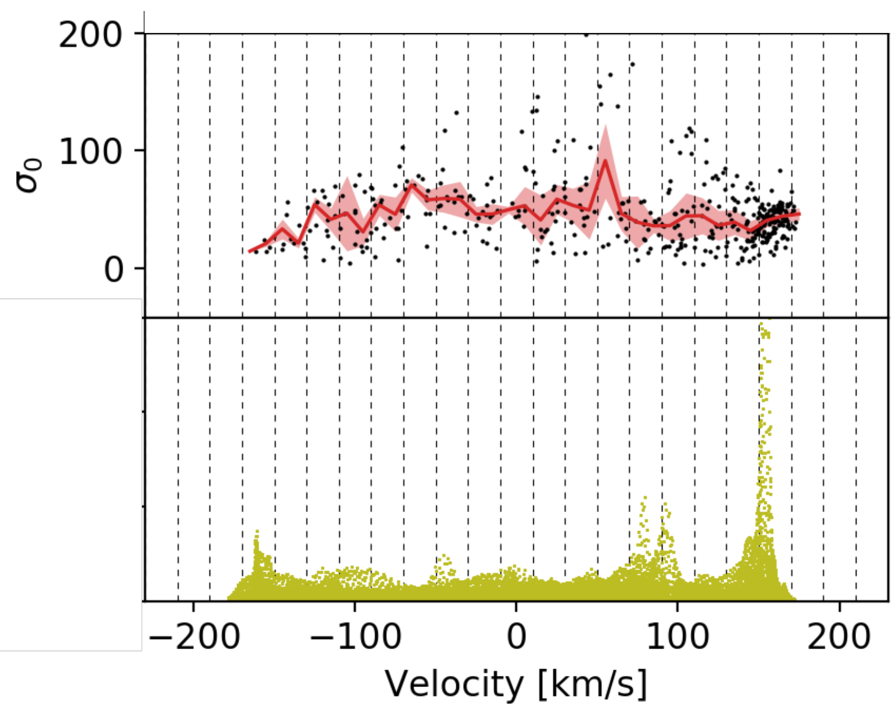


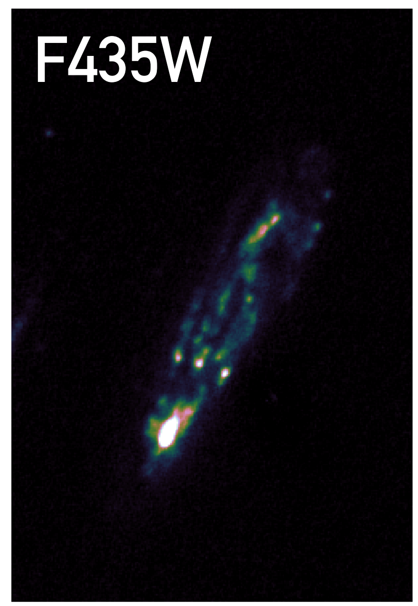
VELOCITY DISPERSION

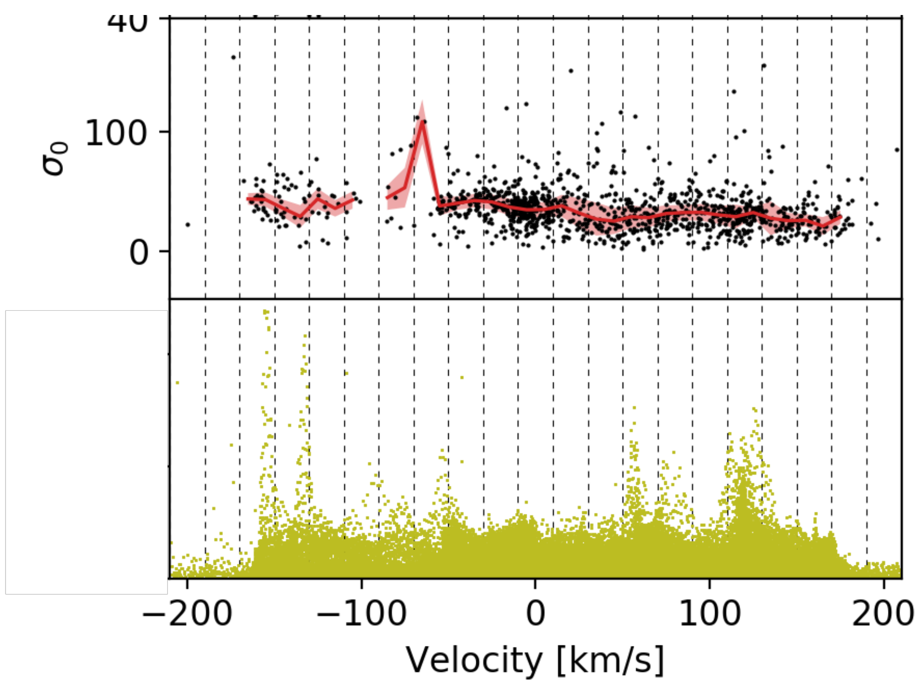
Velocity dispersion maps are ***global flat, as seen at local/low-z discs****, although with higher velocity dispersions.*

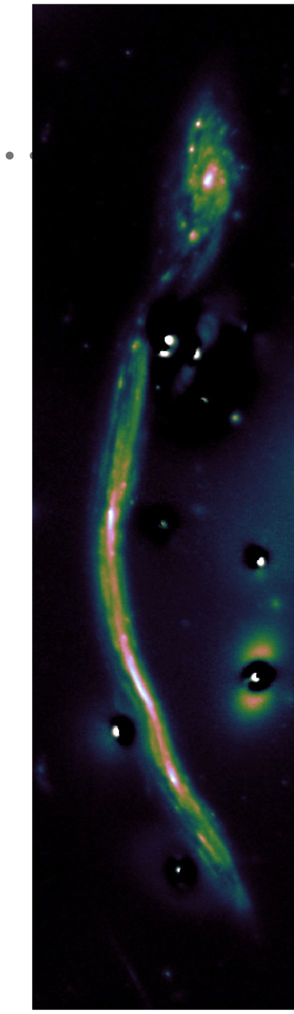


CLUMPS AND VELOCITY DISPERSION



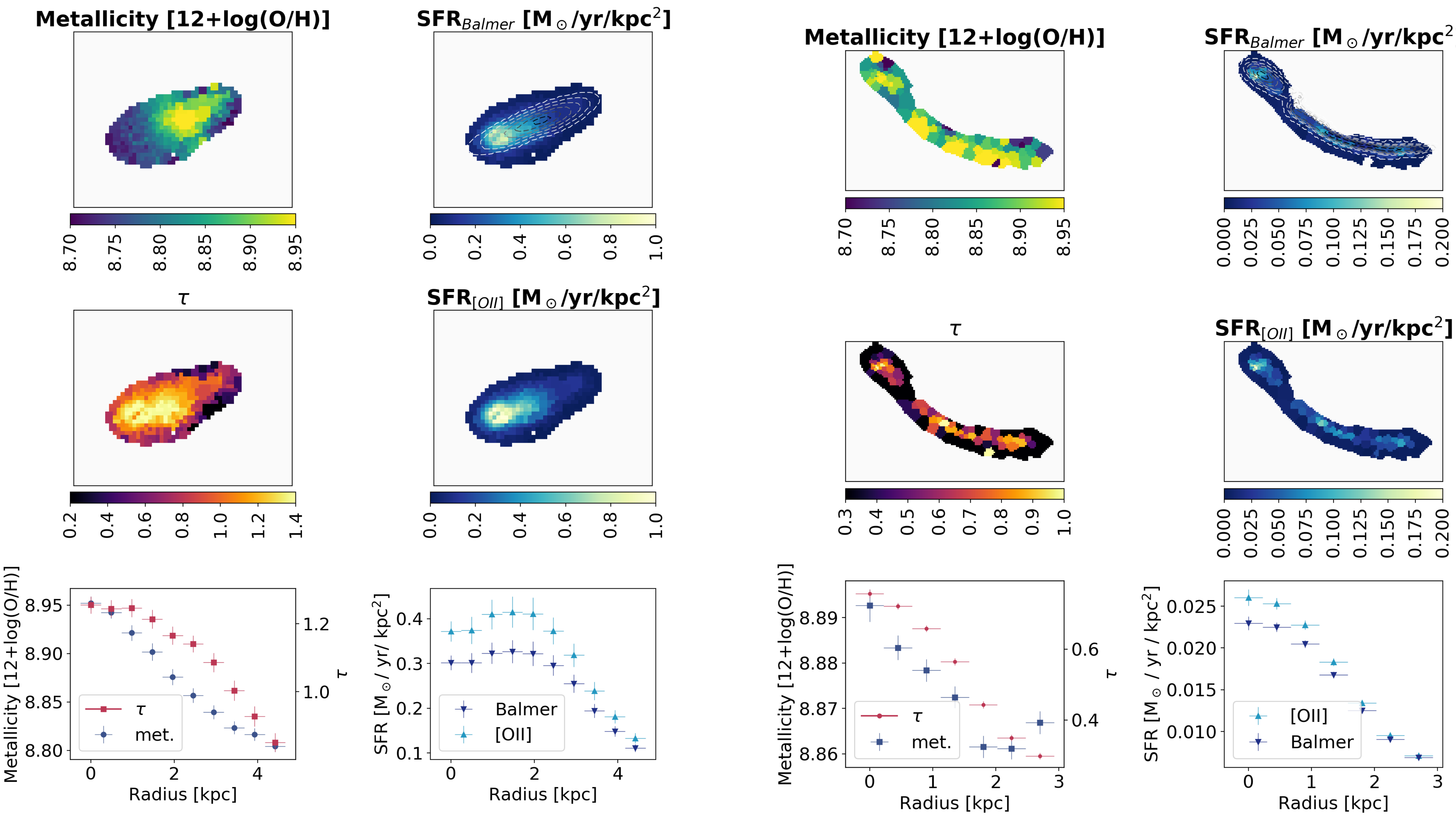






Nothing particular at the location of the star-forming clumps.

METALLICITY, ATTENUATION AND SFR DENSITIES



Using Maiolino et al., 2008 metallicity calibrations; Charlot & Fall, 2000 dust model; Kennicut 1998 and Kewley et al, 2008 SFR calibrations.

VELOCITY DISPERSION AND SFR DENSITY

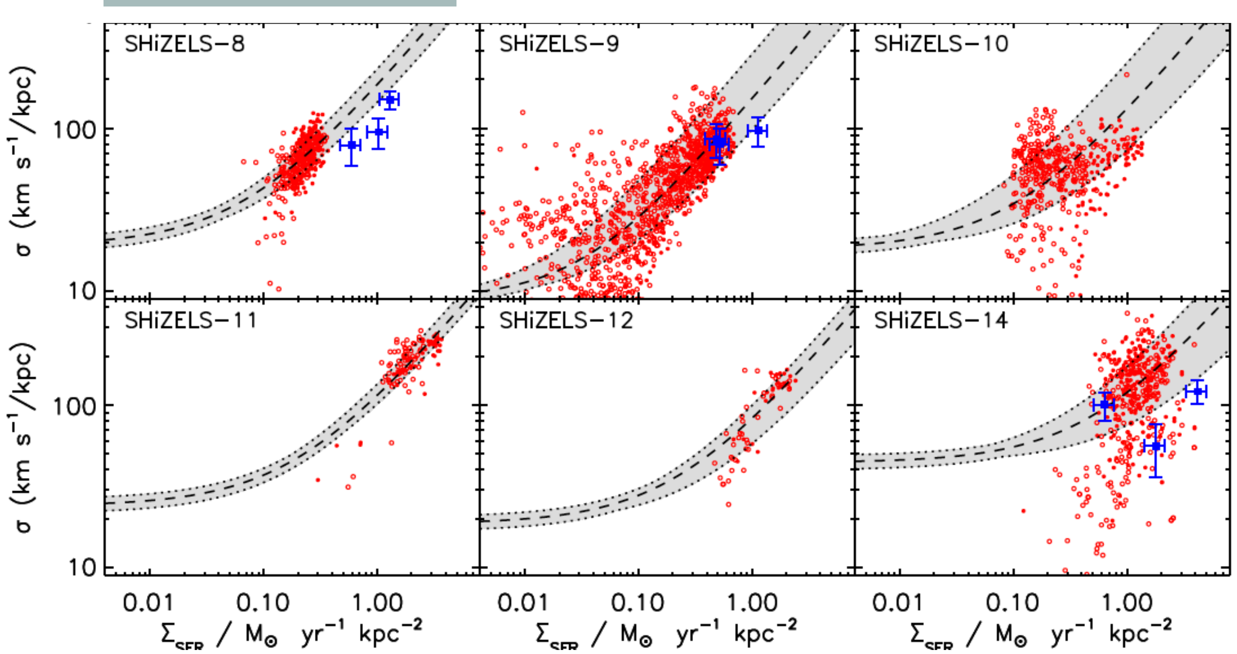
Is local feedback driving the higher velocity dispersion values at high-z?

From the Kennicutt-Schmidt relation and the Toomre parameter:

$$\Sigma_{SFR} \sim A\ \Sigma_{gas}{}^{n} \qquad Q= \sigma\,\kappa\,/\Sigma_{gas} G\pi \qquad \longrightarrow \qquad \Sigma_{SFR} \sim A\ \sigma^{\,1/n}$$

Correlation?

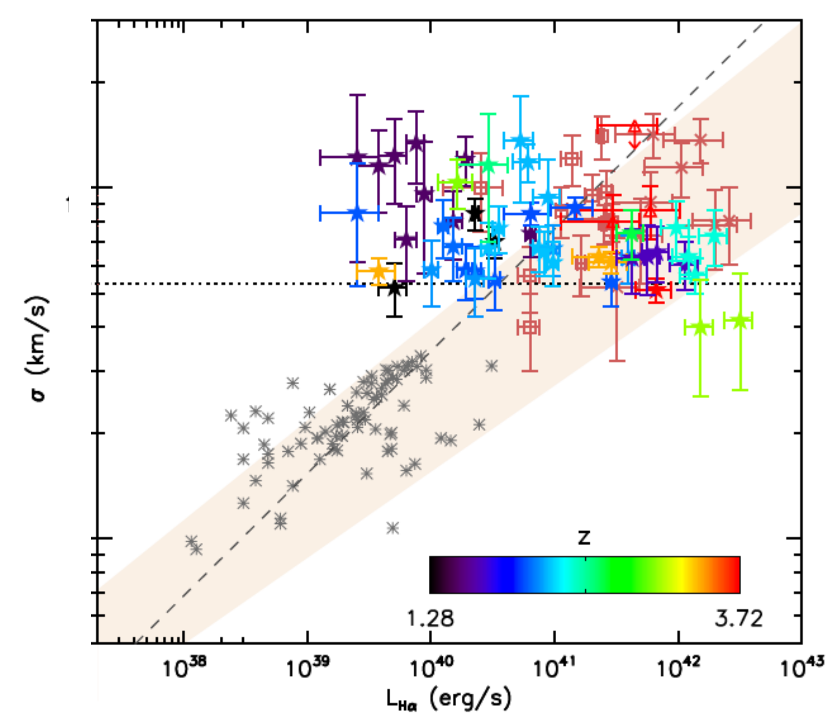
Swinbank et al., 2012



also Lehnert et al., 2009

No correlation?

Livermore et al., 2015



also Genzel et al., 2011

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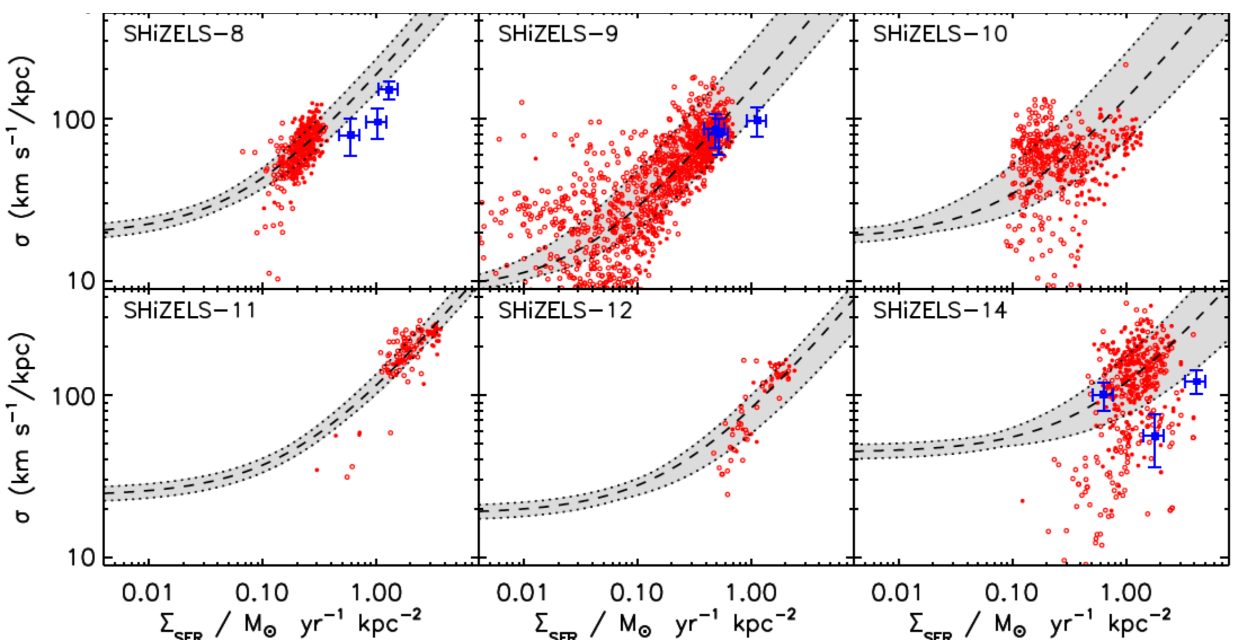

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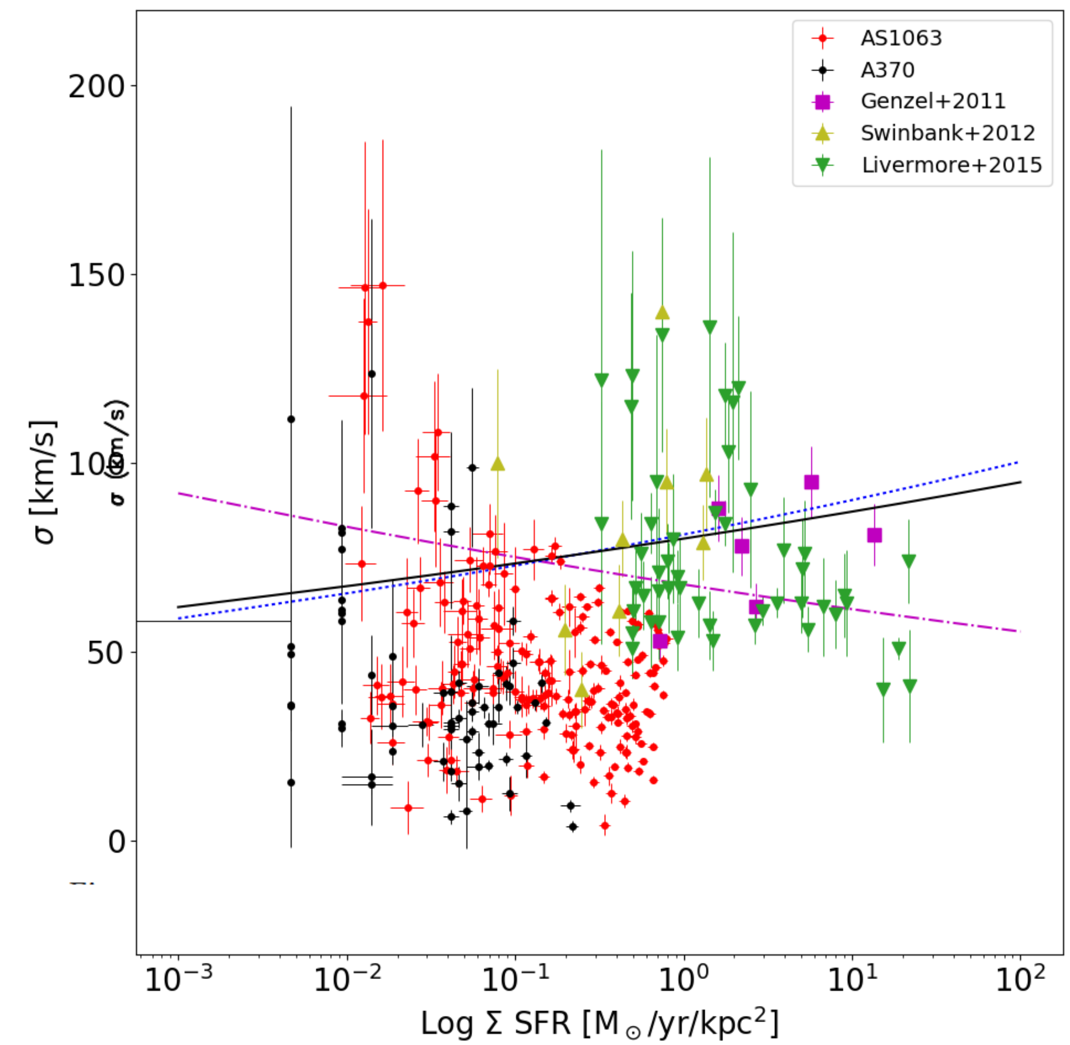


CONCLUSIONS

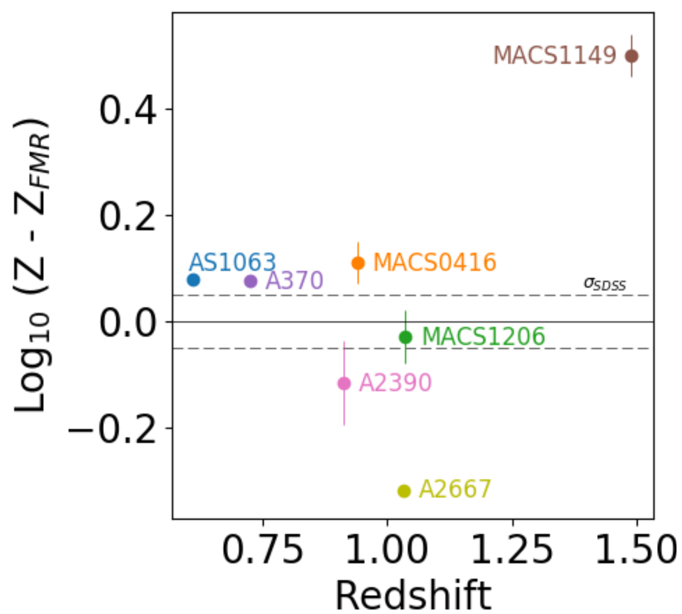
- *Our **data does not allow to clearly distinguish between kinematic models**.*
- *After beam-smearing correction, these typical z∼1 disc galaxies display smooth 2D velocity maps, compatible with a **constant intrinsic velocity dispersion** with velocities **between 40 and 60 \kms**.*
- *There is no strong evidence of increased (or decreased) velocity dispersion at the clumps positions.*
- *We also do **not find a correlation between the local SFR density and the velocity dispersion**.*

GLOBAL PROPERTIES OF THE GRAVITATIONAL ARCS

Sample is in good agreement with other z~1 samples and local analogues.

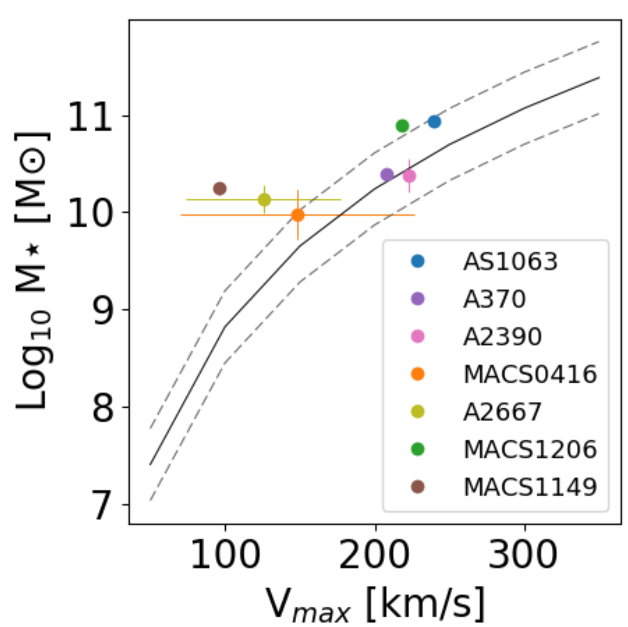
MZR

Mannucci et al, 2011

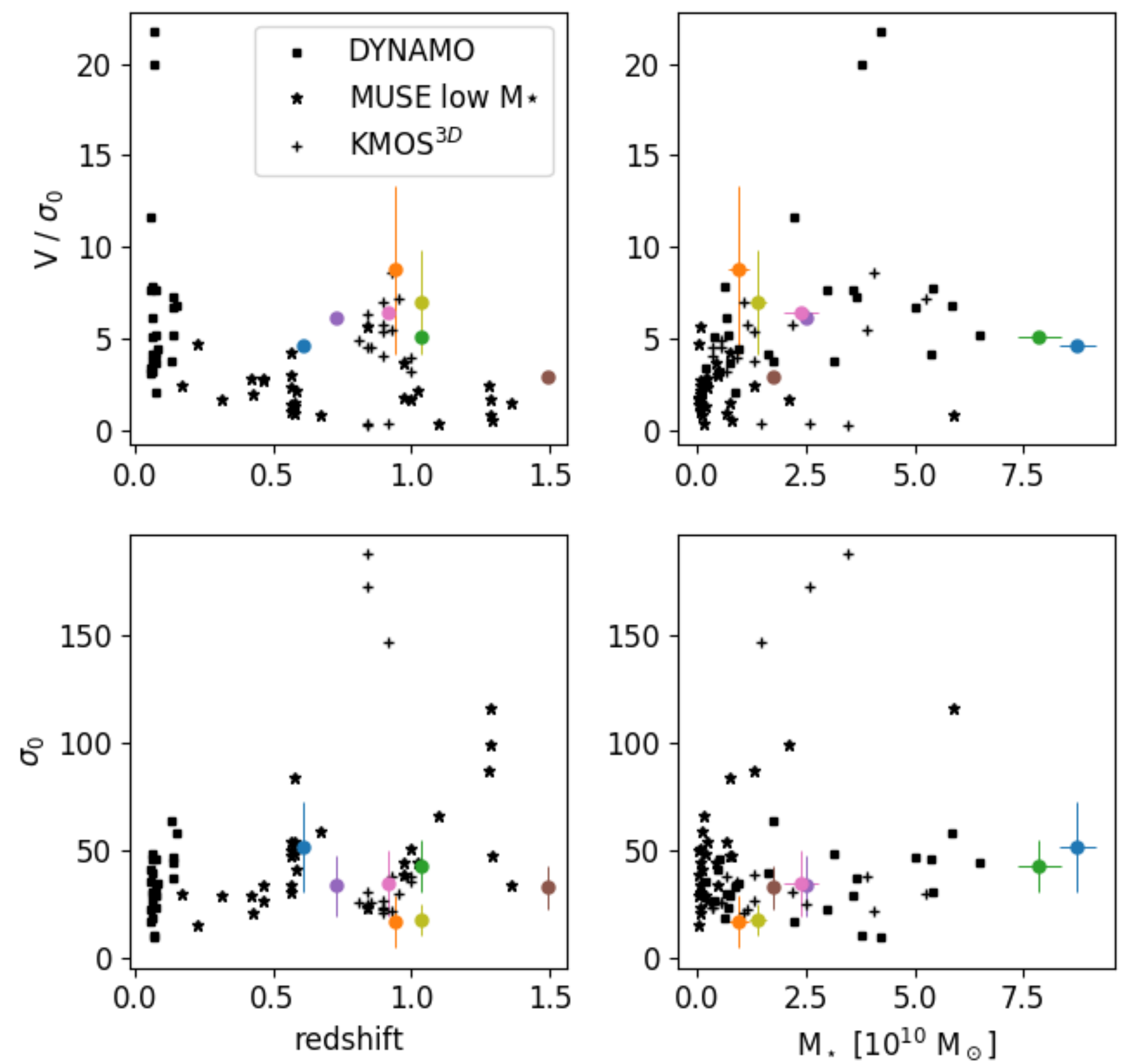


TULLY-FISHER

Tiley et al, 2016



KINEMATIC PROPERTIES



DYNAMO: Green et al., 2014; MUSE low Mass: Contini et al., 2016; KMOS^{3D} : DiTeodoro et al., 2016, Wisnioski et al., 2015

TOOMRE PARAMETER