T. Goncalves

Integral-Field Observations of Lyman Break Analogs: Lessons for the High-Redshift Universe

Lyman Break Analogs (LBAs), characterized by high far-UV luminosities and surface brightnesses as detected by GALEX, are intensely star-forming galaxies in the low-redshift universe (z~0.2), with star formation rates reaching up to 50 times that of the Milky Way. These objects present metallicities, morphologies and other physical properties similar to higher redshift Lyman-break galaxies (LBGs), motivating the detailed study of LBAs as potential local analogs to this high-redshift galaxy population. Strong hydrogen emission lines and compact sizes make LBAs ideal candidates for integral-field spectrography. We present results for 20 LBAs observed with Keck/OSIRIS with an AO-assisted spatial resolution down to ~200pc. We detect satellite companions, diffuse emission and velocity shear, all with high signal-to-noise ratios. We artificially redshift our data to z=2.2 to allow for a direct comparison with observations of high-z LBGs and find striking similarities between both samples. This suggests that the same physical processes may be responsible for the observed properties of star forming galaxies in the early universe. We also find a strong correlation of observable properties with stellar mass, in which more massive galaxies show greater resemblance to a disk-like structure, not unlike what is observed at high redshifts. Finally, we argue that kinematic studies of the ionized gas in star-forming galaxies is not an appropriate diagnostic to rule out major merger events as the trigger for the observed starburst.

Integral-Field Observations of Lyman Break Analogs: Lessons for the High-Redshift Universe

High-Redshift Universe

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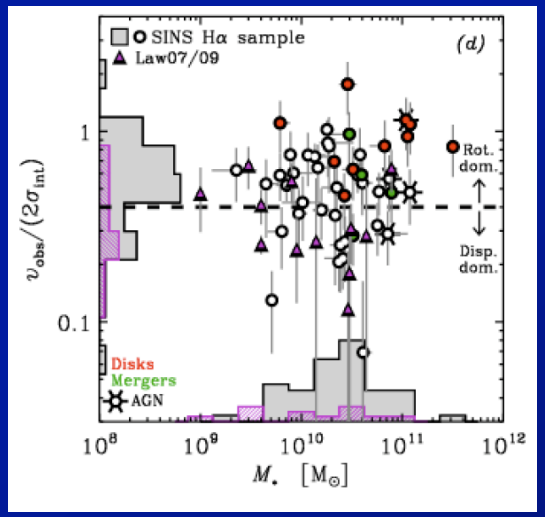
David R. Law

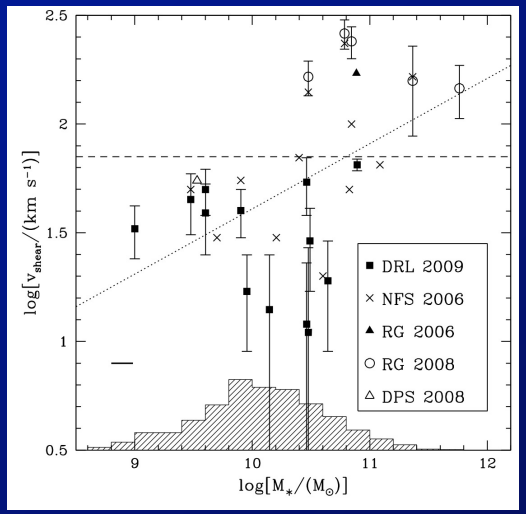
Ryan Mallory

Mike Rich

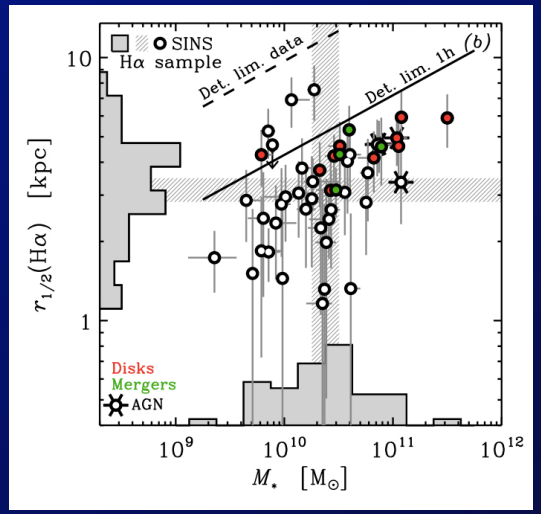
IFU studies at z~2



FS09



Law09



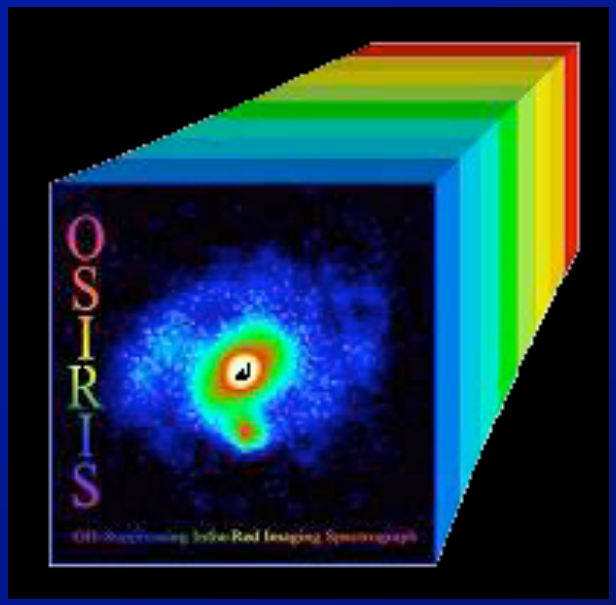
FS09

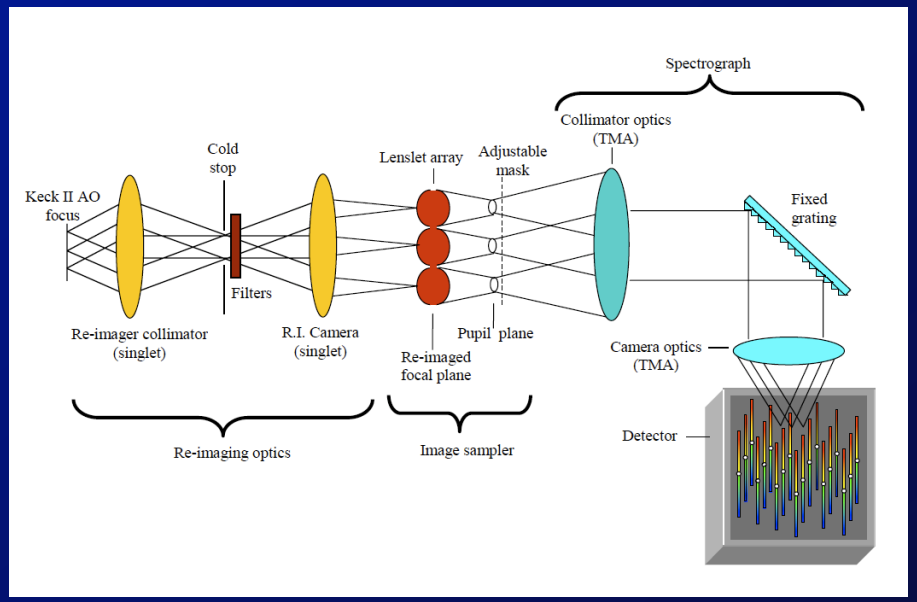
High velocity dispersion

Stellar mass dependence of observables

- Stellar mass of selected sample
- Samples with and without AO
- Issues with observations at high z: Surface Brightness / Resolution

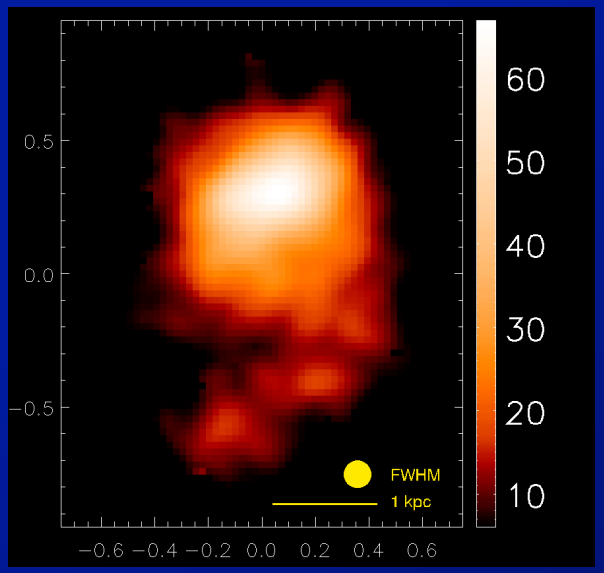
OSIRIS!!!

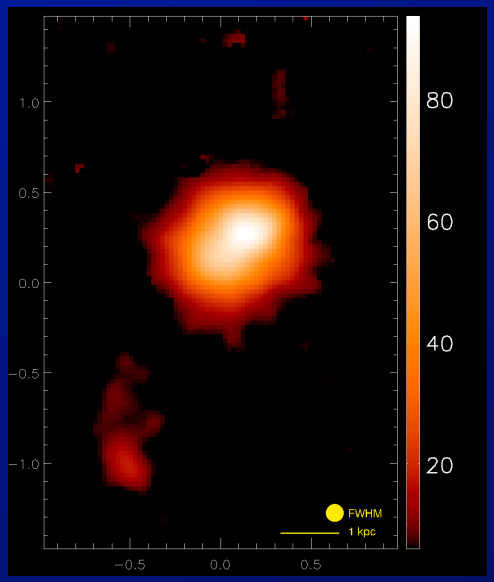


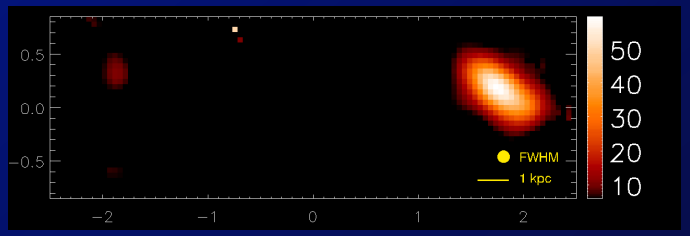


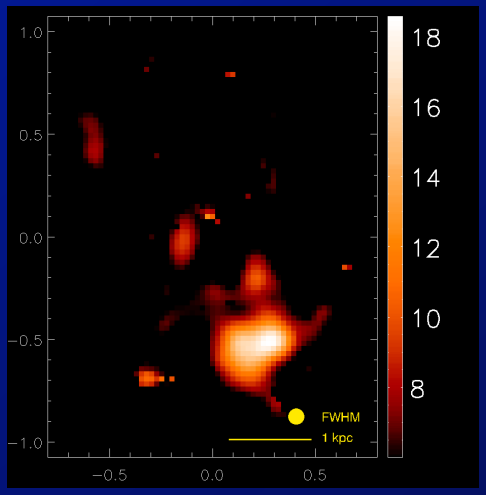
- Compact objects, high SFR, strong line emission – great case!
- Resolution down to 200pc with AO, very close to diffraction limit in a 10m telescope
- Observed line: Pa-α in the K-band

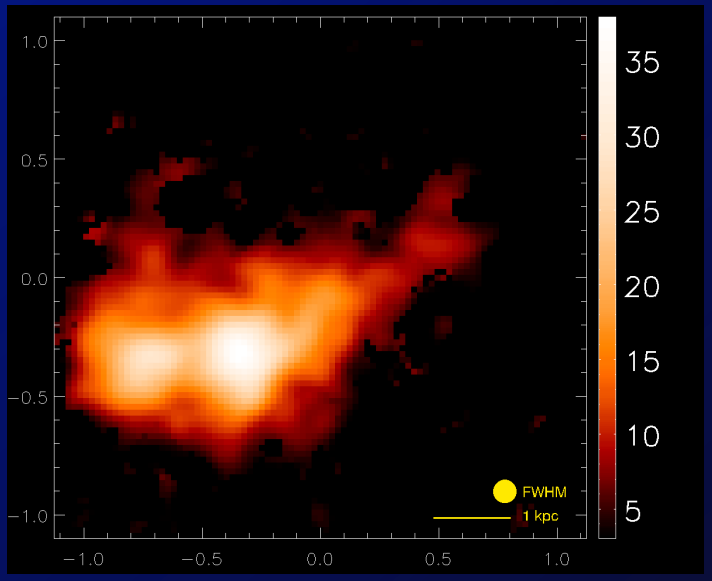
Multiple star forming regions

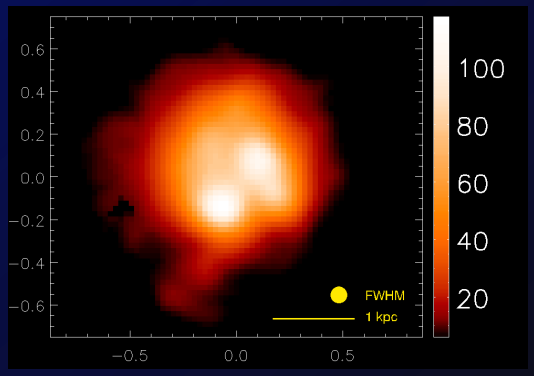




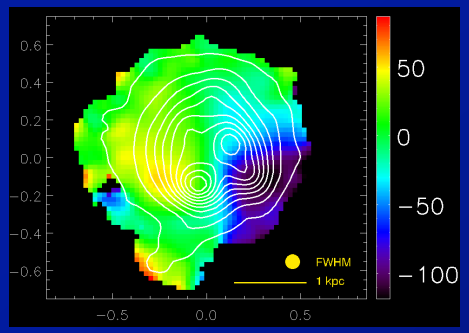


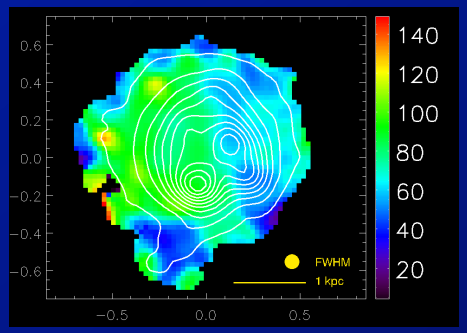


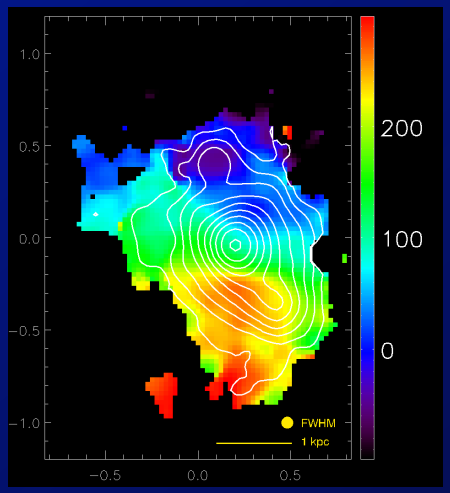


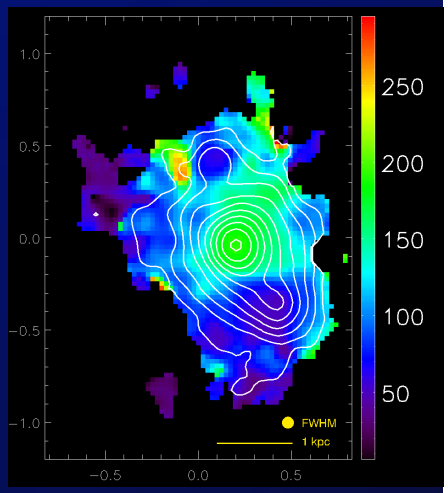


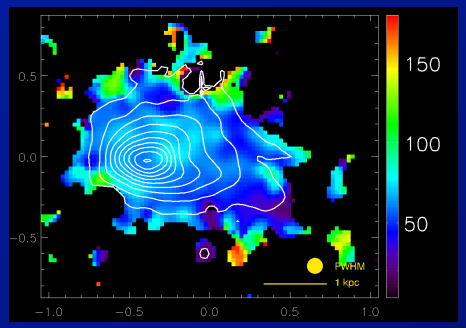
Low v/σ

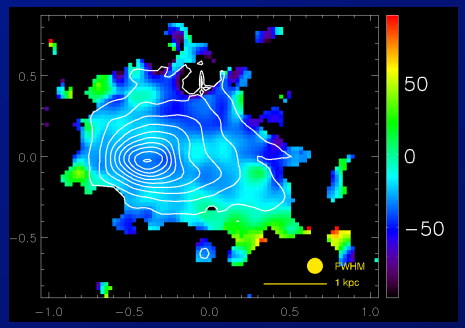

FWHM
1 kpc
50
0
−50
−100

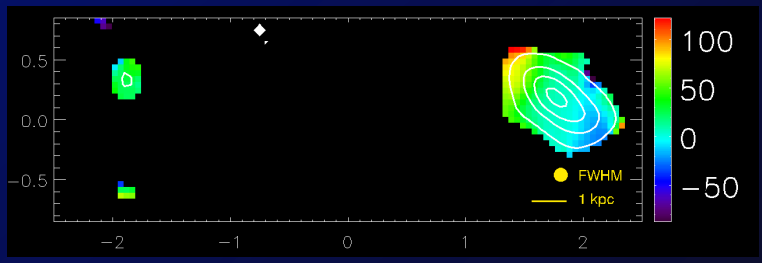

FWHM
1 kpc
140
120
100
80
60
40
20

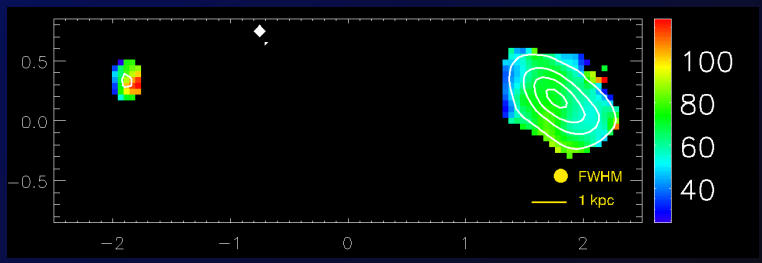

FWHM
1 kpc
200
100
0

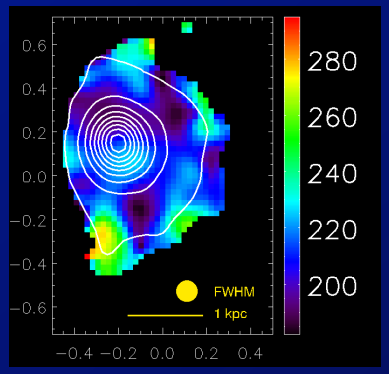

FWHM
1 kpc
250
200
150
100
50

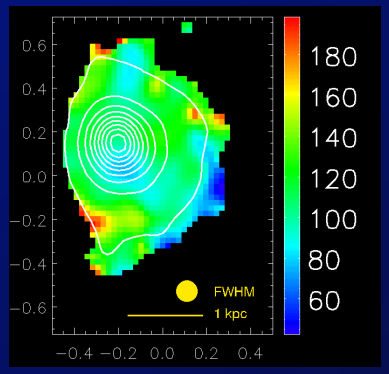

FWHM
1 kpc
150
100
50


FWHM
1 kpc
50
0
−50


FWHM
1 kpc
100
50
0
−50


FWHM
1 kpc
100
80
60
40


FWHM
1 kpc
280
260
240
220
200

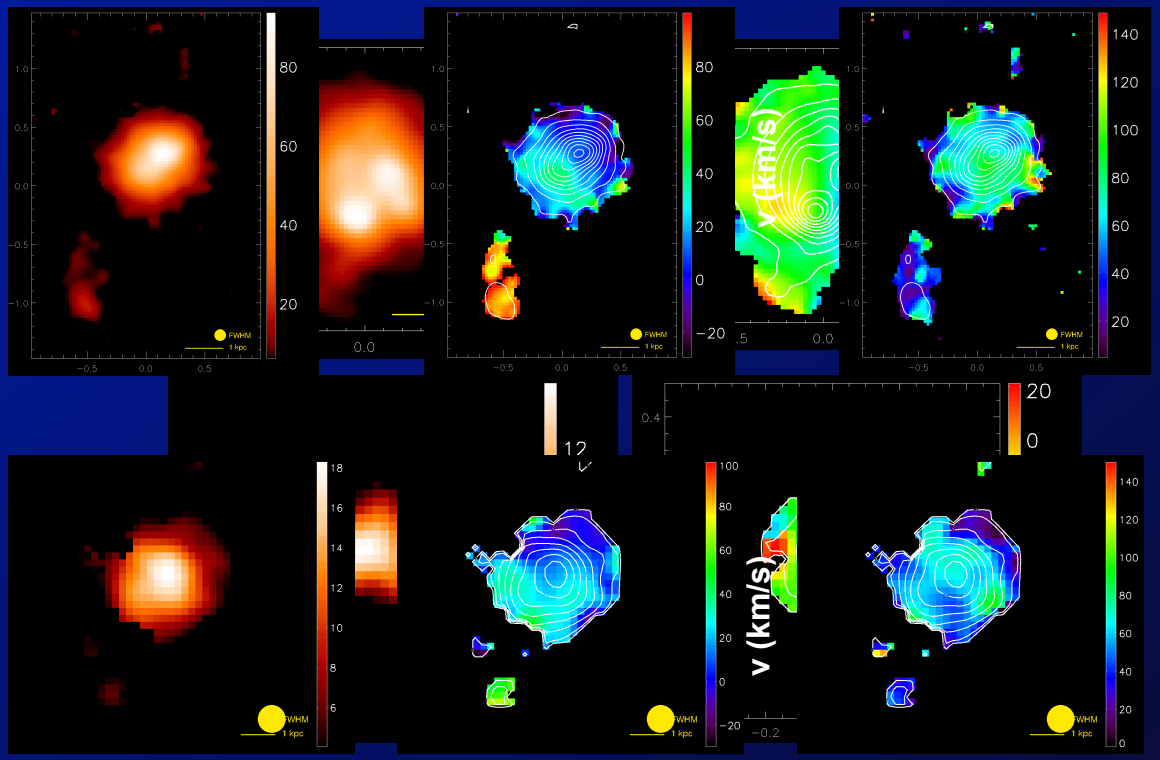

FWHM
1 kpc
180
160
140
120
100
80
60

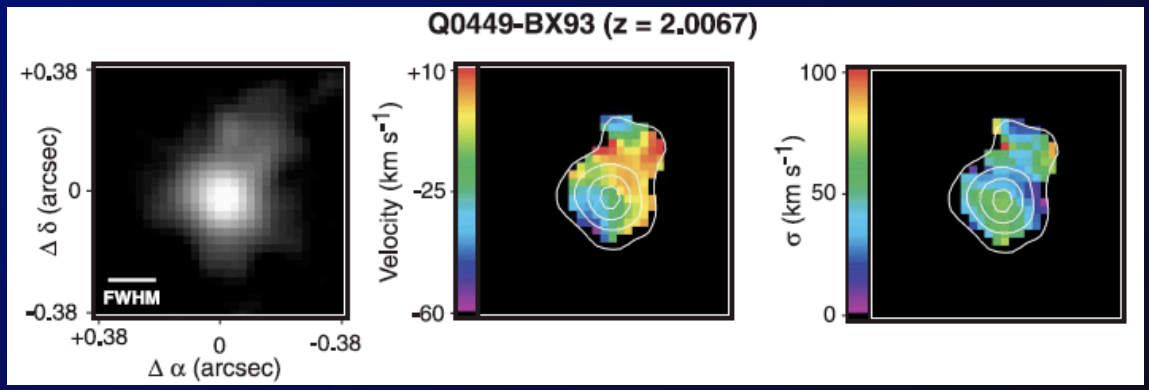
Data at high z?

Real data

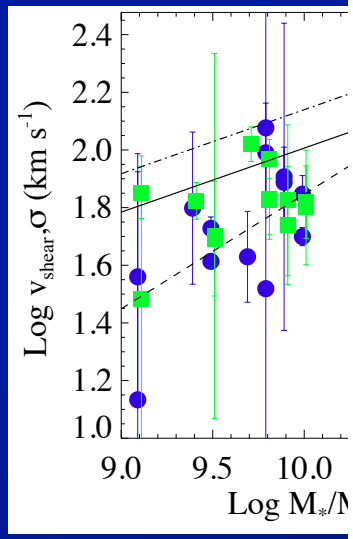
Artificially redshifted to z=2.2

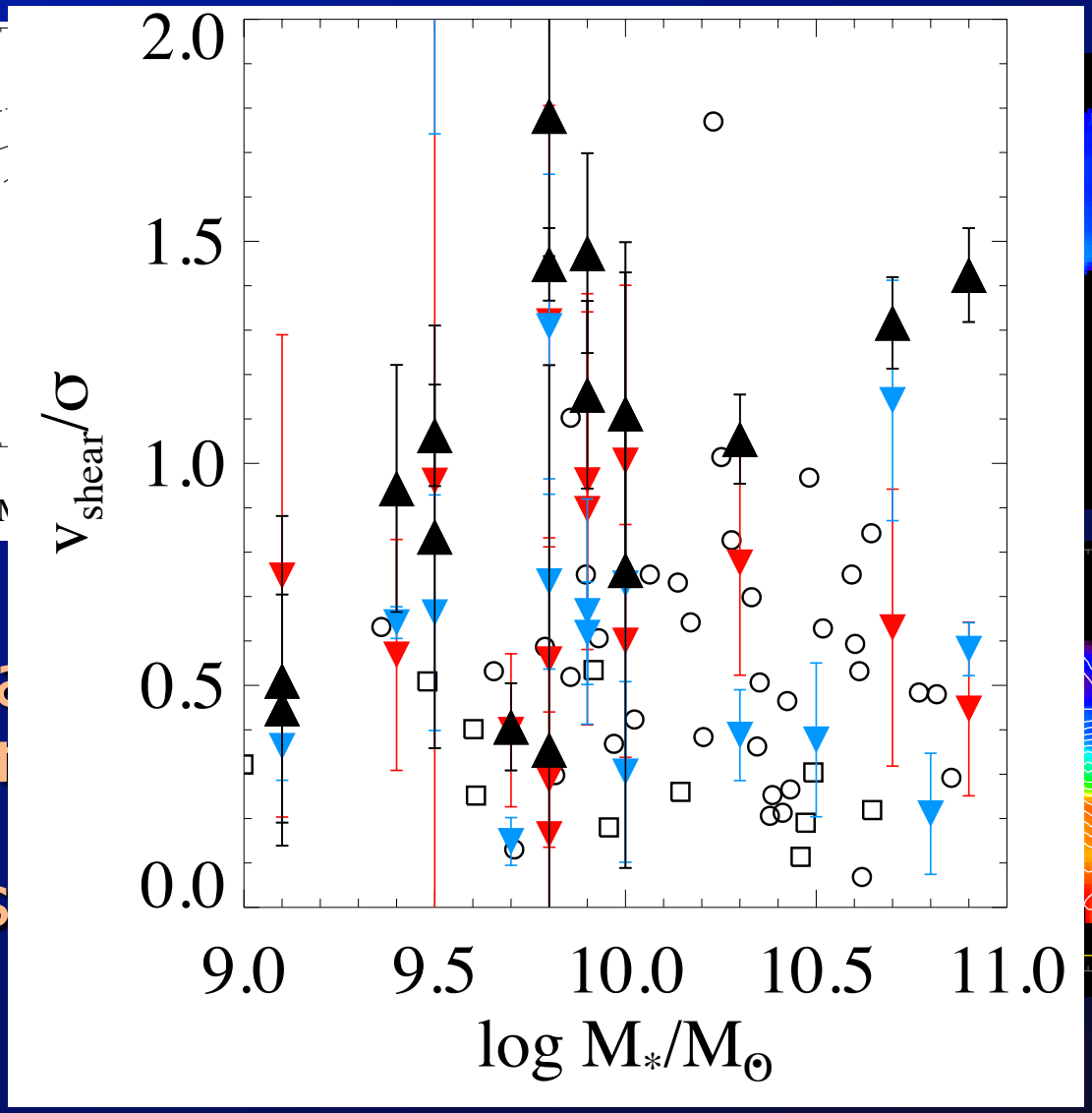
Law et al. 2007

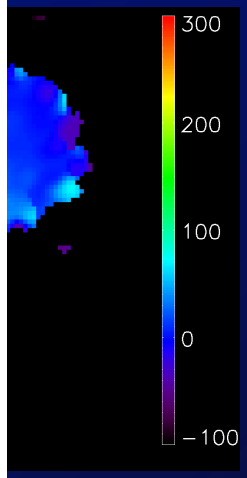


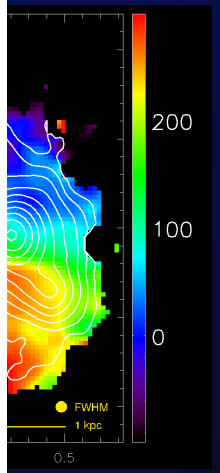


Stellar mass dependence





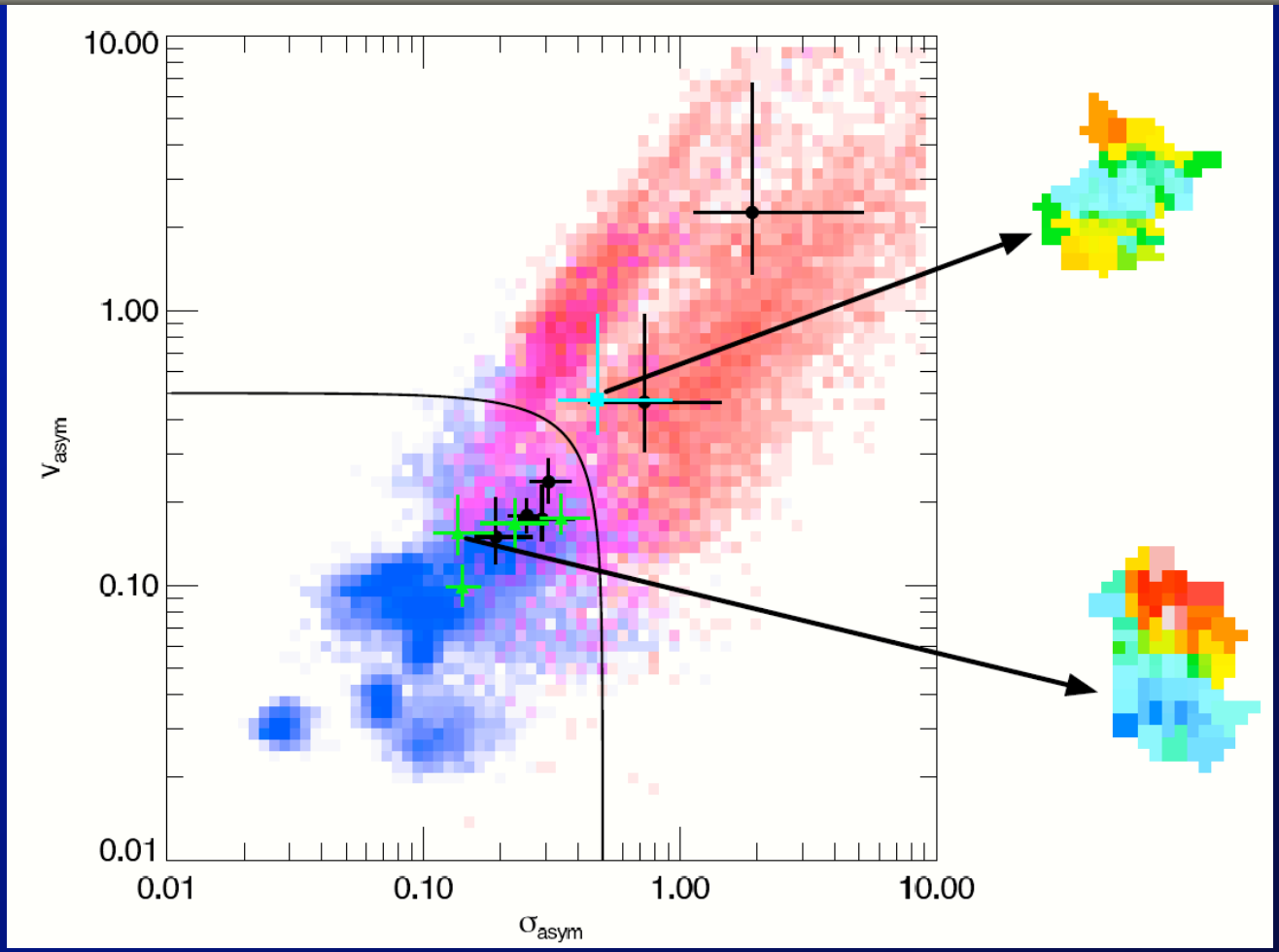




More ma
stronger

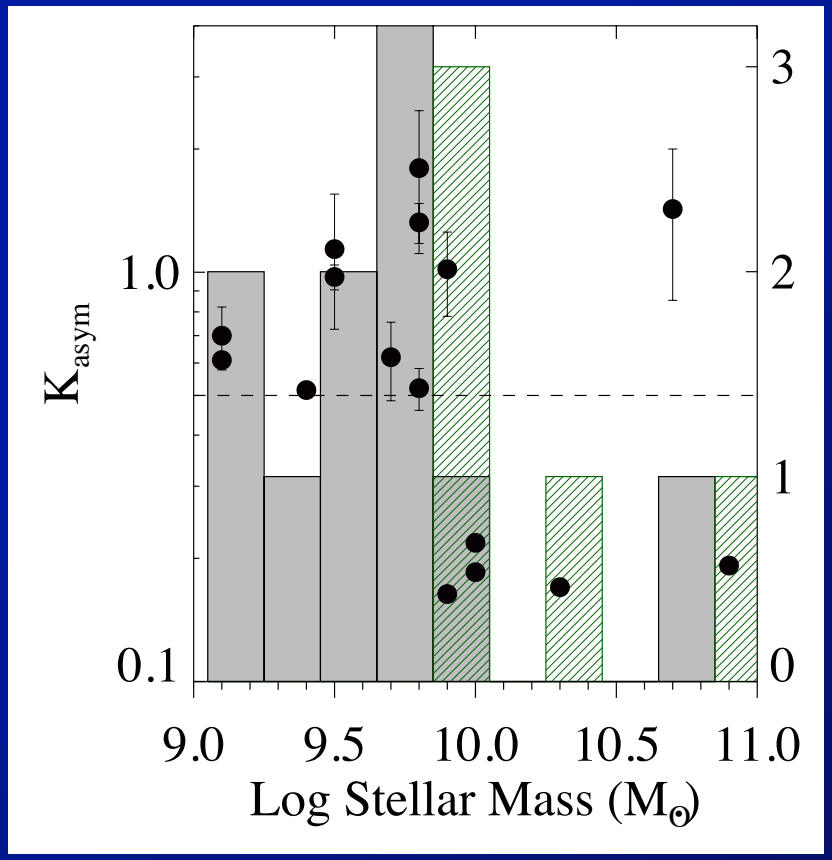
… with s
high-z

Kinemetry

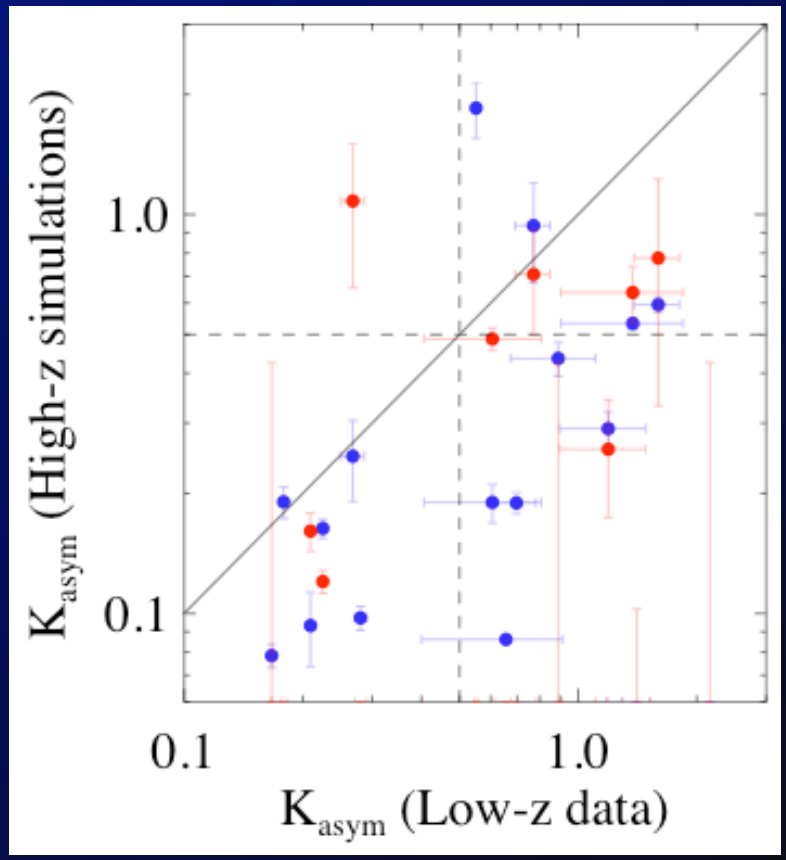


Krajnović et al. 2006
Shapiro et al. 2008

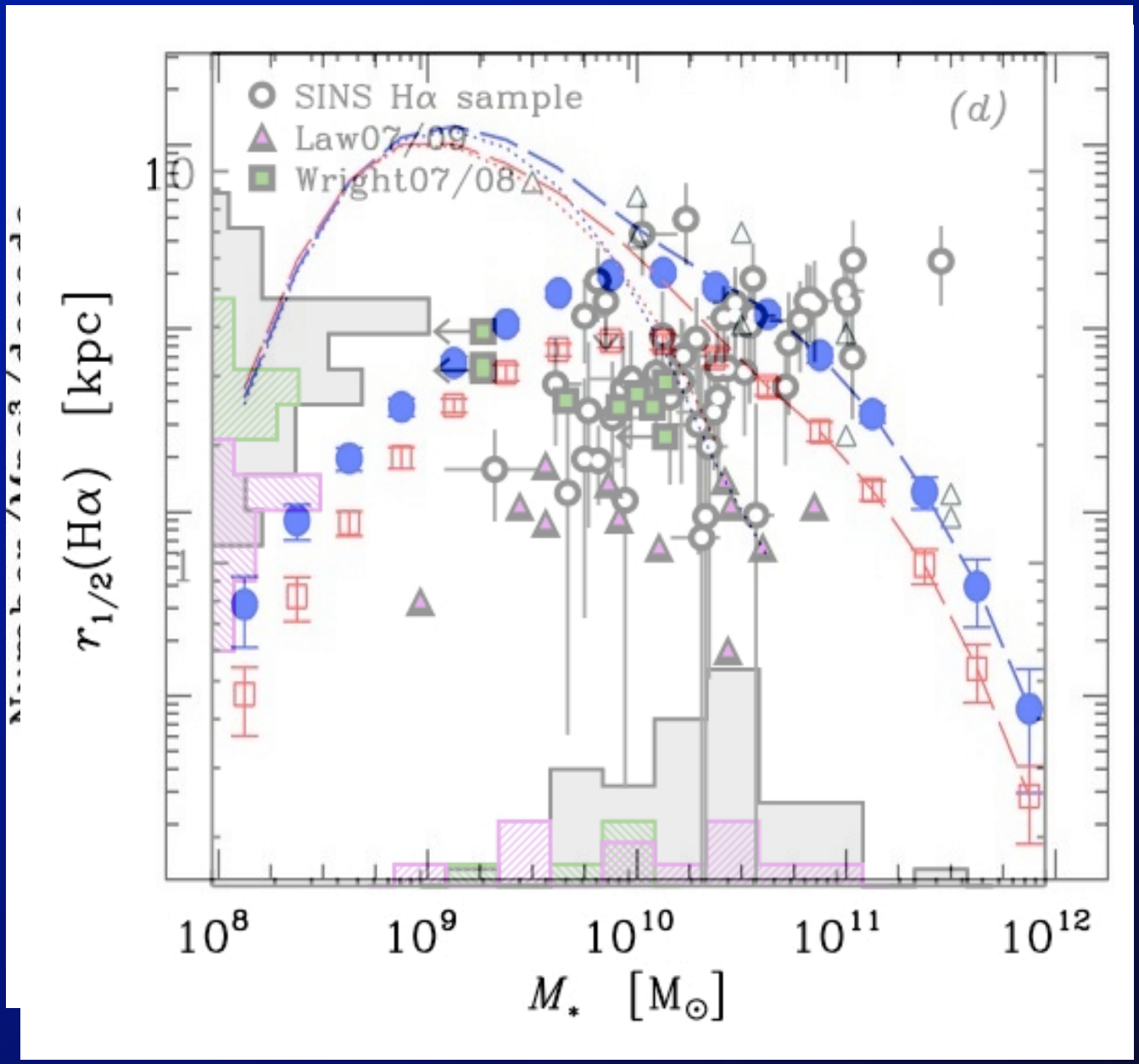
- Asymmetry measurement
- Distinction between mergers and rotating disks



Galaxies classified as rotating disks are more massive



High-redshift data underestimates the asymmetry levels



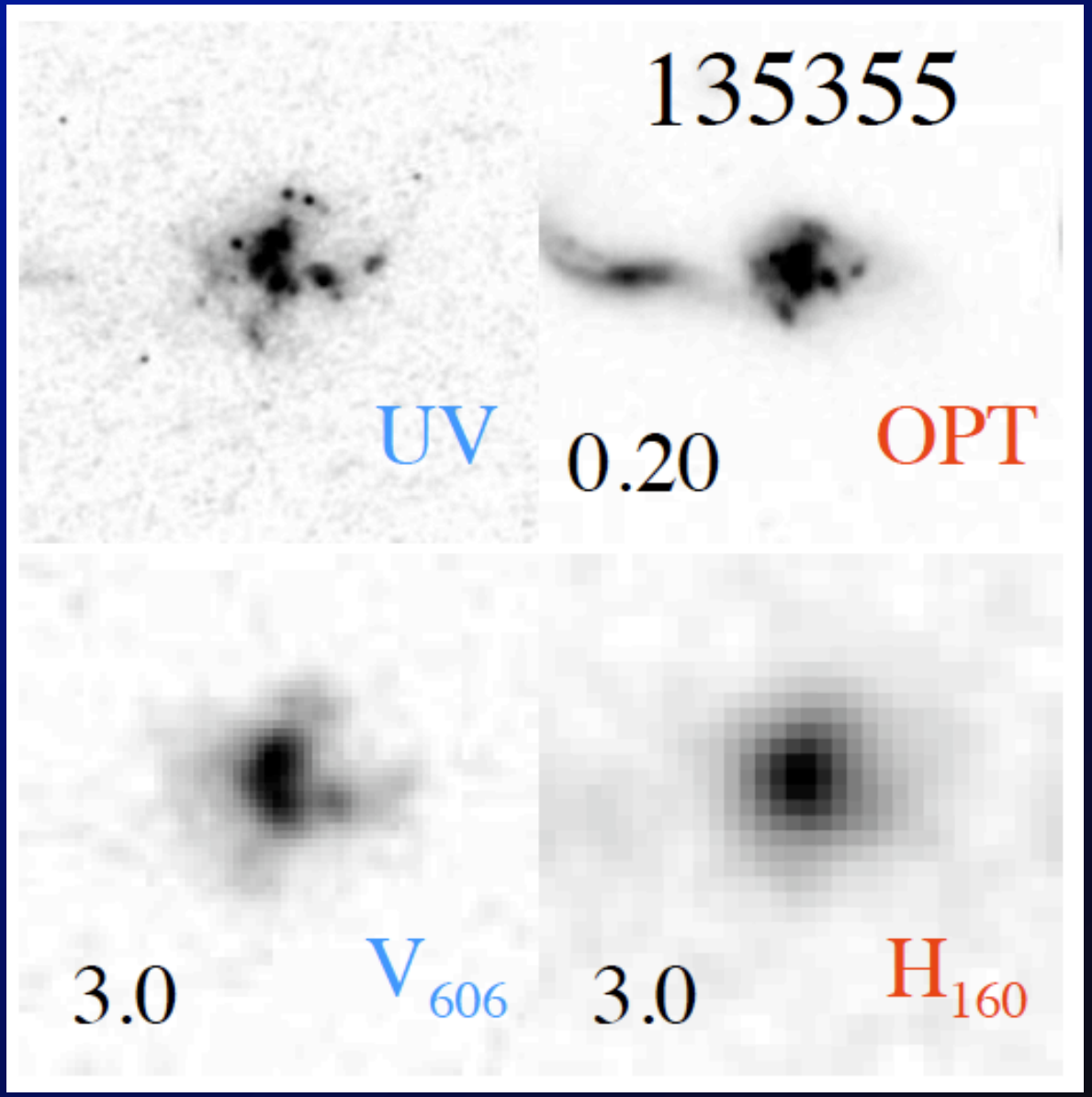
Reddy & Steidel, 2009

Detectability of mergers

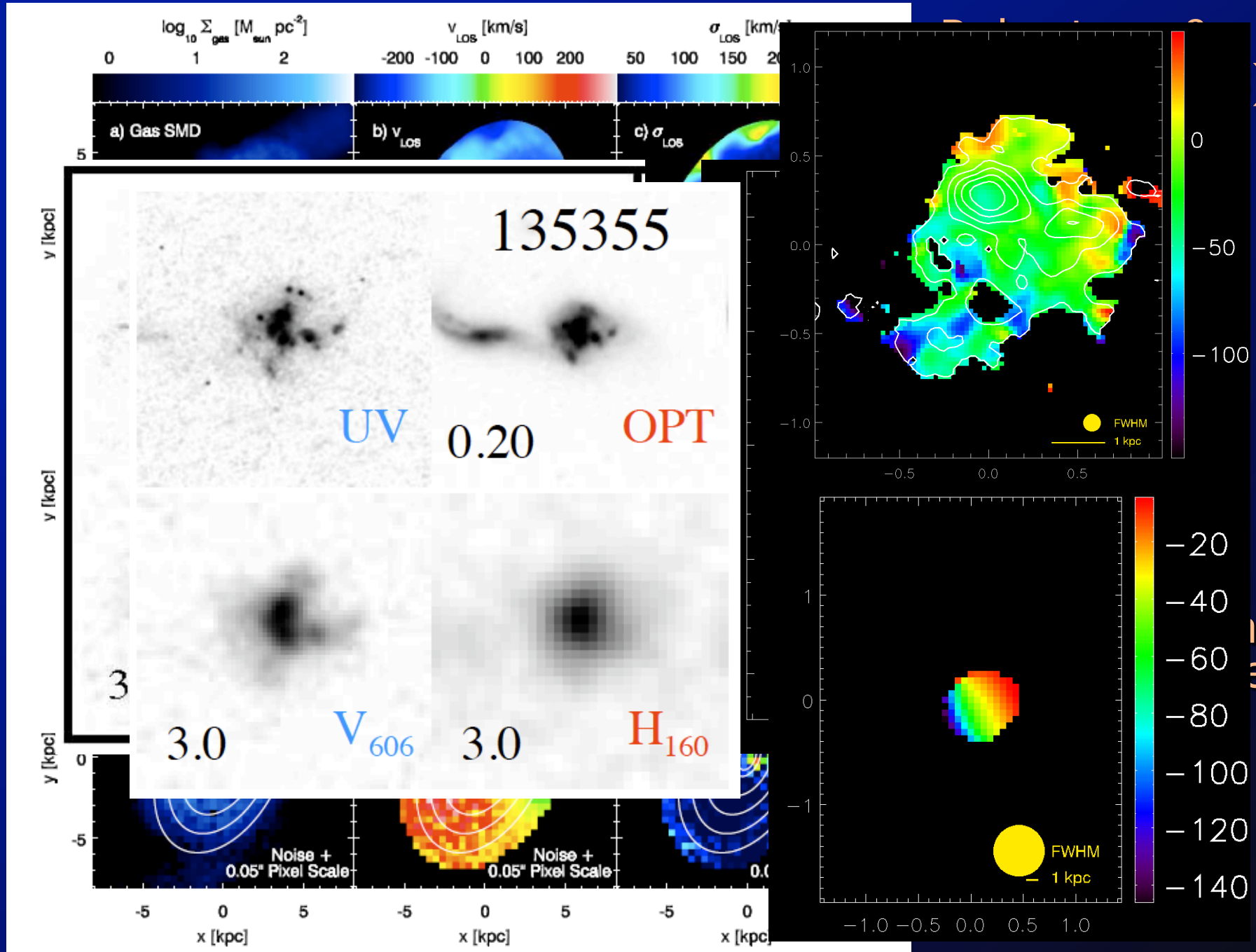
Mergers? Could we see that at high z?

Relative importance of merging events at low and high redshift

Distinction between major and minor mergers

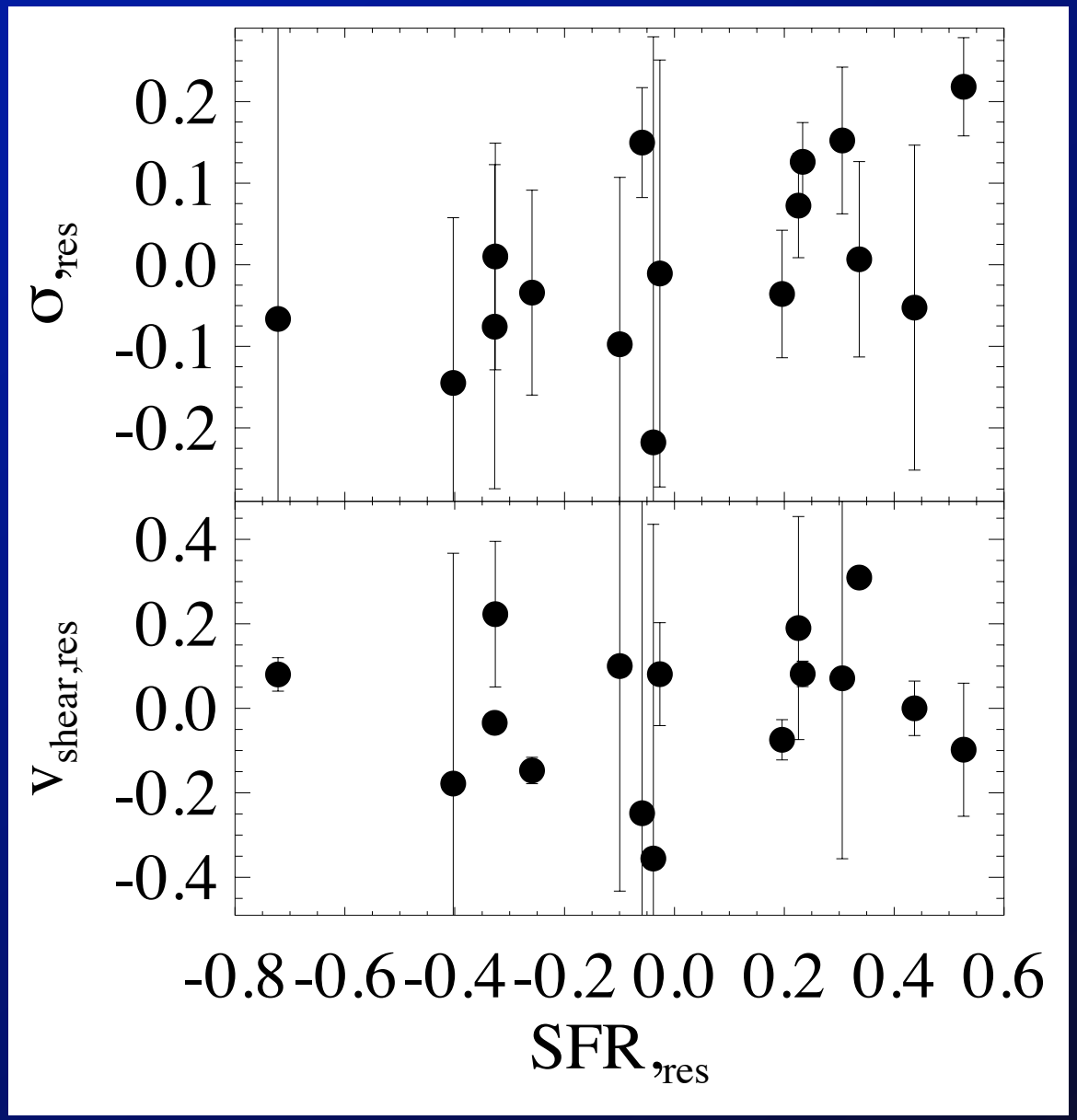


Overzier et al. 2010


log10 Σgas [Msun pc-2]
vLOS [km/s]
σLOS [km/s]
a) Gas SMD
b) vLOS
c) σLOS
135355
UV
0.20
OPT
3.0
V606
3.0
H160
Noise + 0.05" Pixel Scale
Noise + 0.05" Pixel Scale
x [kpc]
y [kpc]
FWHM
1 kpc

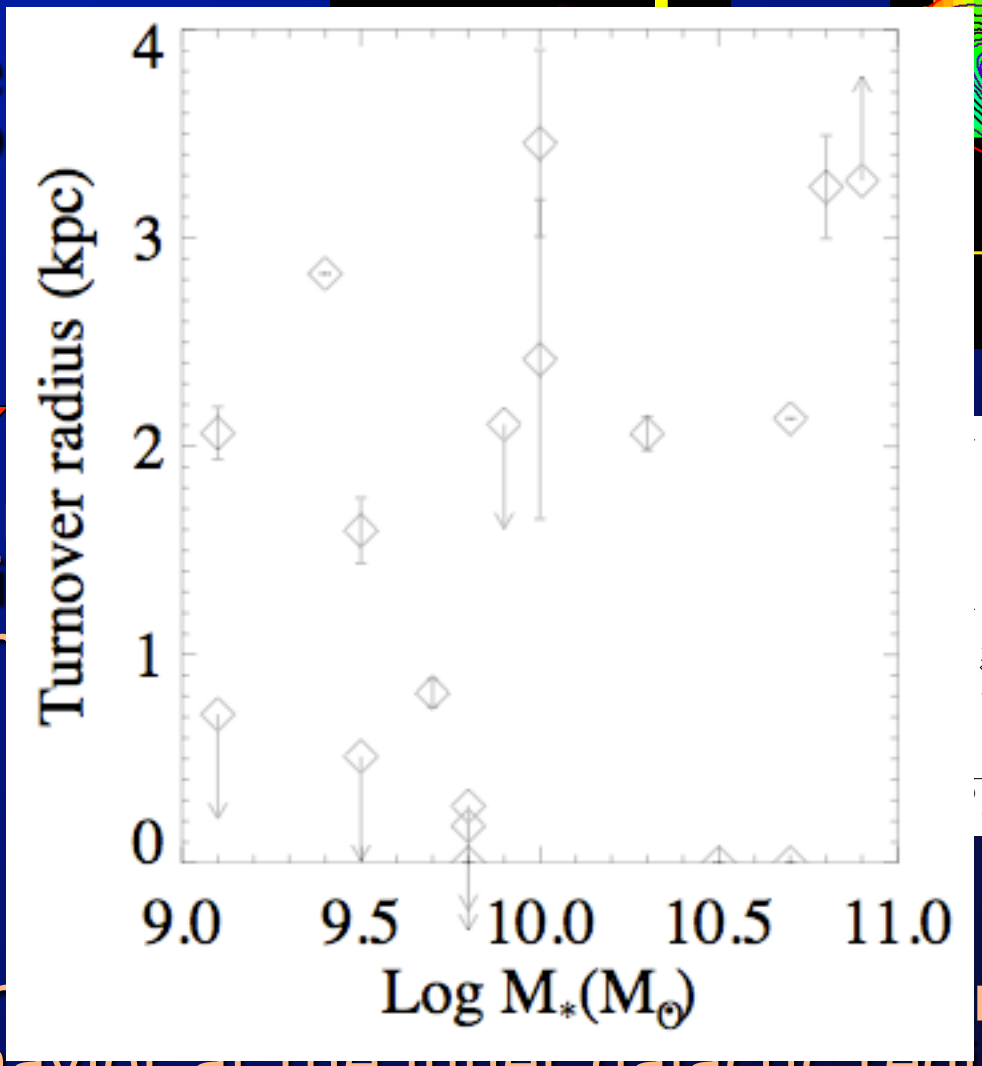
Summary

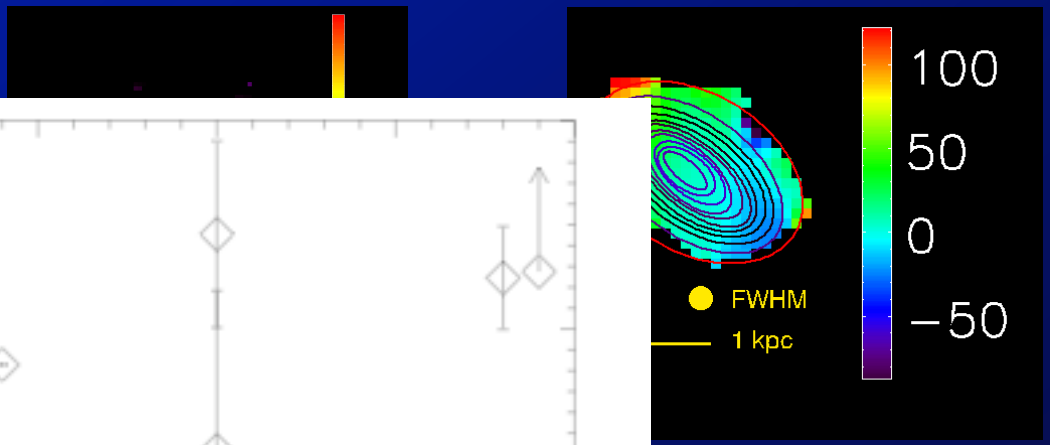
- ScUVLGs make an excellent case for local analogs to star forming galaxies at z~2-3
- Some detail might be lost due to SB brightness effects + loss of spatial resolution
- There is a clear trend of observed properties as a function of stellar mass
- Symmetry of gas kinematics is not a good diagnostic to rule out mergers as origin for the starburst

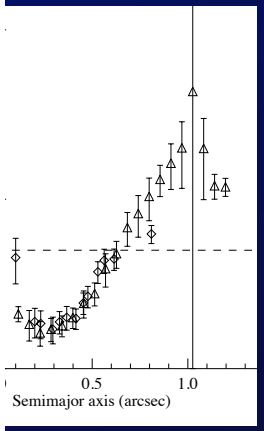

0.2
0.1
0.0
-0.1
-0.2
σ,res
0.4
0.2
0.0
-0.2
-0.4
V shear,res
-0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6
SFR,res

Increase
resolutio

Spatially
kinemetri
measuren







Mar ric
behavior at the inner galactic regions