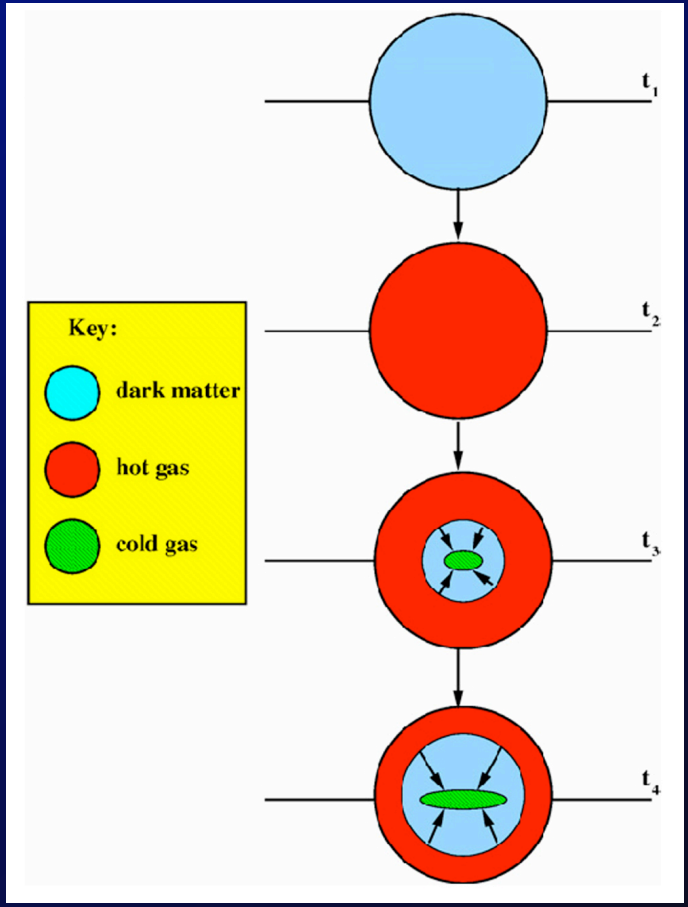
Integral Field Spectroscopy of Local Lyman Break Analogs

Thiago S. Gonçalves (Caltech)
Chris Martin, Ted Wyder (Caltech)
Antara Basu-Zych, David Schiminovich,
Matt O'Dowd (Columbia)
Roderik Overzier (MPA)
Tim Heckman (JHU)
David R. Law, Ryan Mallory, Mike Rich (UCLA)

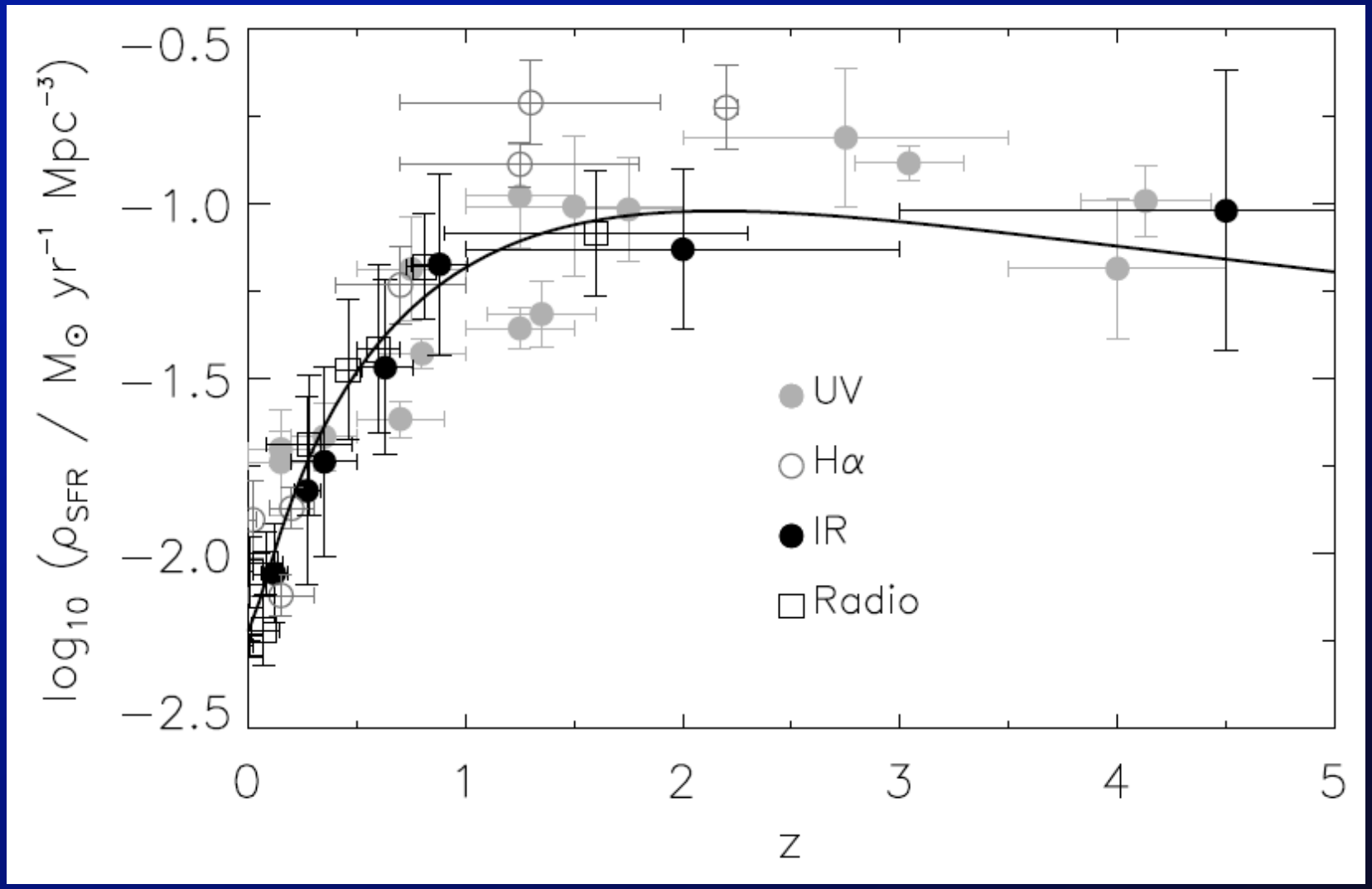
SFR@50 Conference, Sarteano, IT
July 7th 2009

Questions in galaxy formation

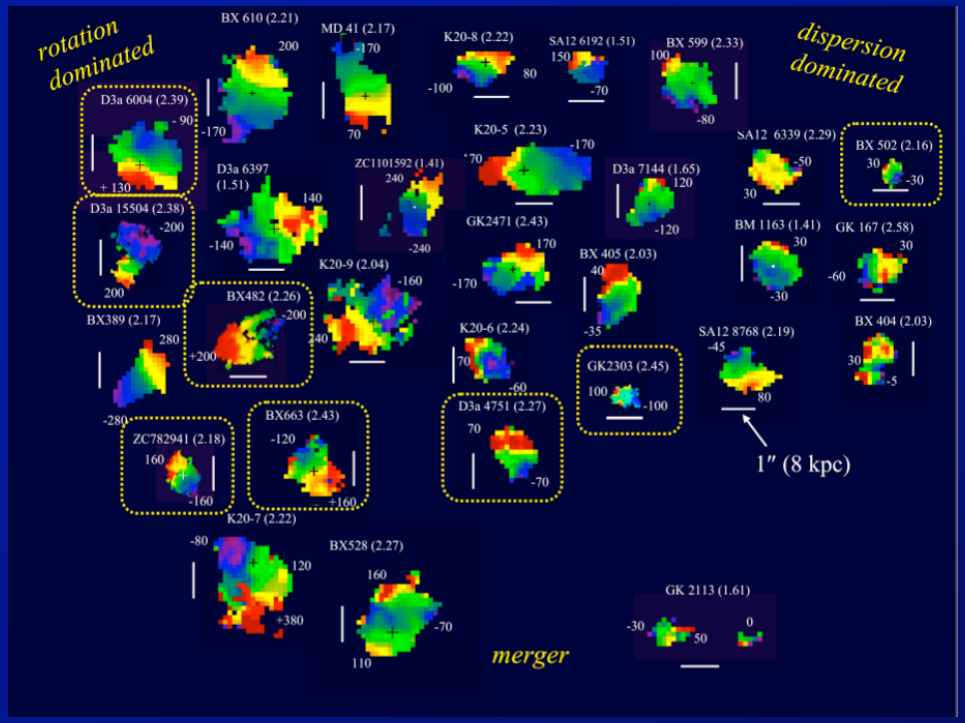
- What triggers SF in galaxies?
- Where does SF occur?
- How do galaxies get their gas?
- What is their typical kinematic structure?



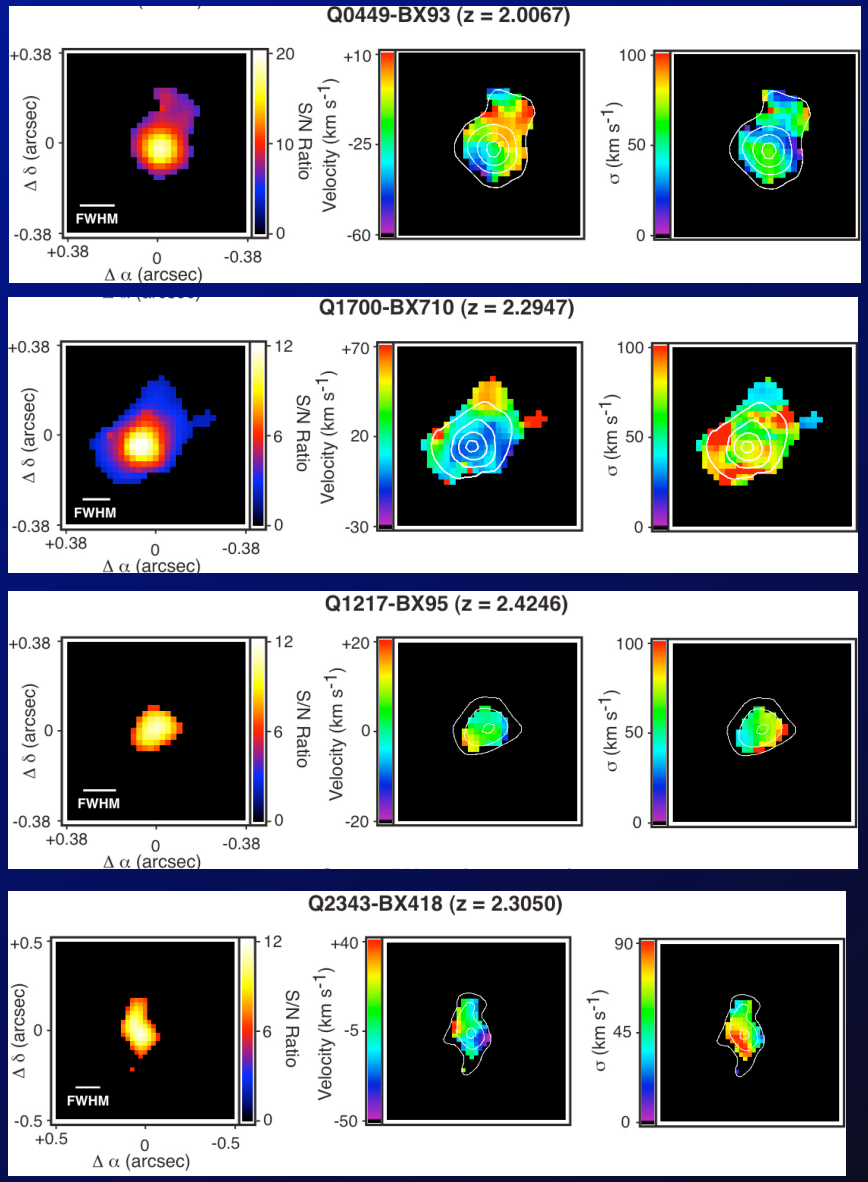
Baugh (2006)



Bell (2004)

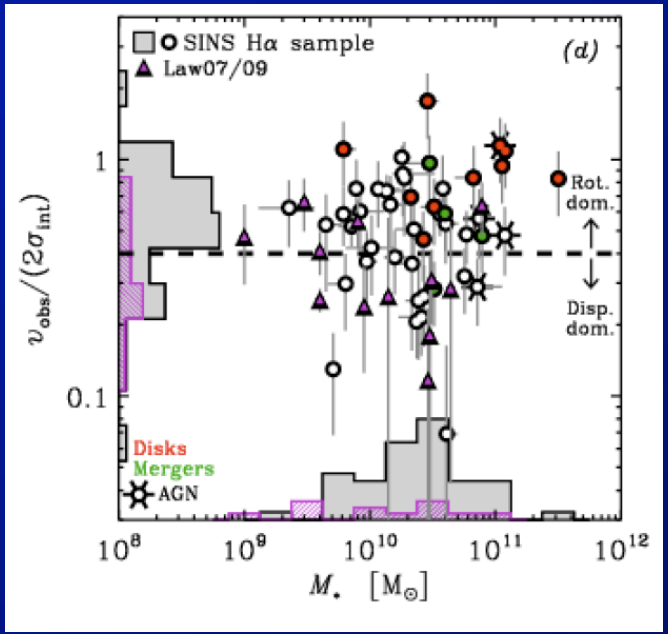


Förster-Schreiber et al. 2009



Law et al. 2009

High velocity dispersion



FS09

- Low v/σ (compared to ~10-20 for local spirals)
- Stellar mass dependence
- OSIRIS is less sensitive
- SINS survey is mostly non-AO and more massive

Lyman Break Analogs: defining a sample

- Heckman et al (2005): first definition of the UVLG sample
- Detected by GALEX in the FUV with

$$L_{FUV} \geq 2 \times 10^{10}\ L_{\odot}$$

- Broad range in sizes, two distinct populations according to surface brightness
    1. Large UVLGs: amongst the most massive late-type objects today
    2. Compact UVLGs: Comparable characteristics of high-redshift LBGs (surface brightness, metallicity, SSFR…)

Table 2. Comparison of Galaxy Properties

LBAs = Lyman Break Analogs

Parameter	Large UVLGs	Compact UVLGs ($I_{1530} > 10^8$ $L_\odot$ kpc^{-2})	Supercompact UVLGs ($I_{1530} > 10^9$ $L_\odot$ kpc^{-2})	LBGs[a]
Number	110	105[b]	35[b]	...
log L_{1530} ($L_\odot$)	10.3 to 11.2	10.3 to 11.0	10.3 to 10.9	10.3 to 11.3
log I_{1530} ($L_\odot$ kpc^{-2})	6.0 to 8.0	8.0 to 10.3	9.0 to 10.3	9 to 10
log $R_{50,u}$ (kpc)	0.9 to 1.6	−0.5 to 0.8	−0.5 to 0.4	0.0 to 0.5
log M_* ($M_\odot$)	10.3 to 11.7	9.2 to 11.0	9.0 to 10.7	9.5 to 11.0
A_{1530}	0 to 5	0 to 2.5	0 to 2	0 to 3
log SFR ($M_\odot$ yr^{-1})	0 to 1.5	0.2 to 2	0.5 to 2	0.5 to 2.5
log SFR/M_* (yr^{-1})	−11 to −9.5	−10.5 to −8	−9.3 to −8	−9 to −8
FUV−r	1.0 to 3.5	0.2 to 2.8	0.2 to 1.7	0.2 to 2.2
12+log(O/H)[c]	8.6 to 9.3	8.5 to 9.2	8.2 to 8.9	7.7 to 8.8
12+log(O/H)[d]	8.4 to 8.9	8.2 to 8.8	8.1 to 8.8	8.2 to 8.6

[a]Properties for LBGs are taken from Shapley et al. (2001), Erb et al. (2006a), Papovich et al. (2001), Giavalisco et al (2002), and Ferguson et al. (2004).

[b]The supercompact UVLGs are a subset of the compact UVLGs, *i.e.*, the compact UVLG sample includes the 35 supercompact UVLGs.

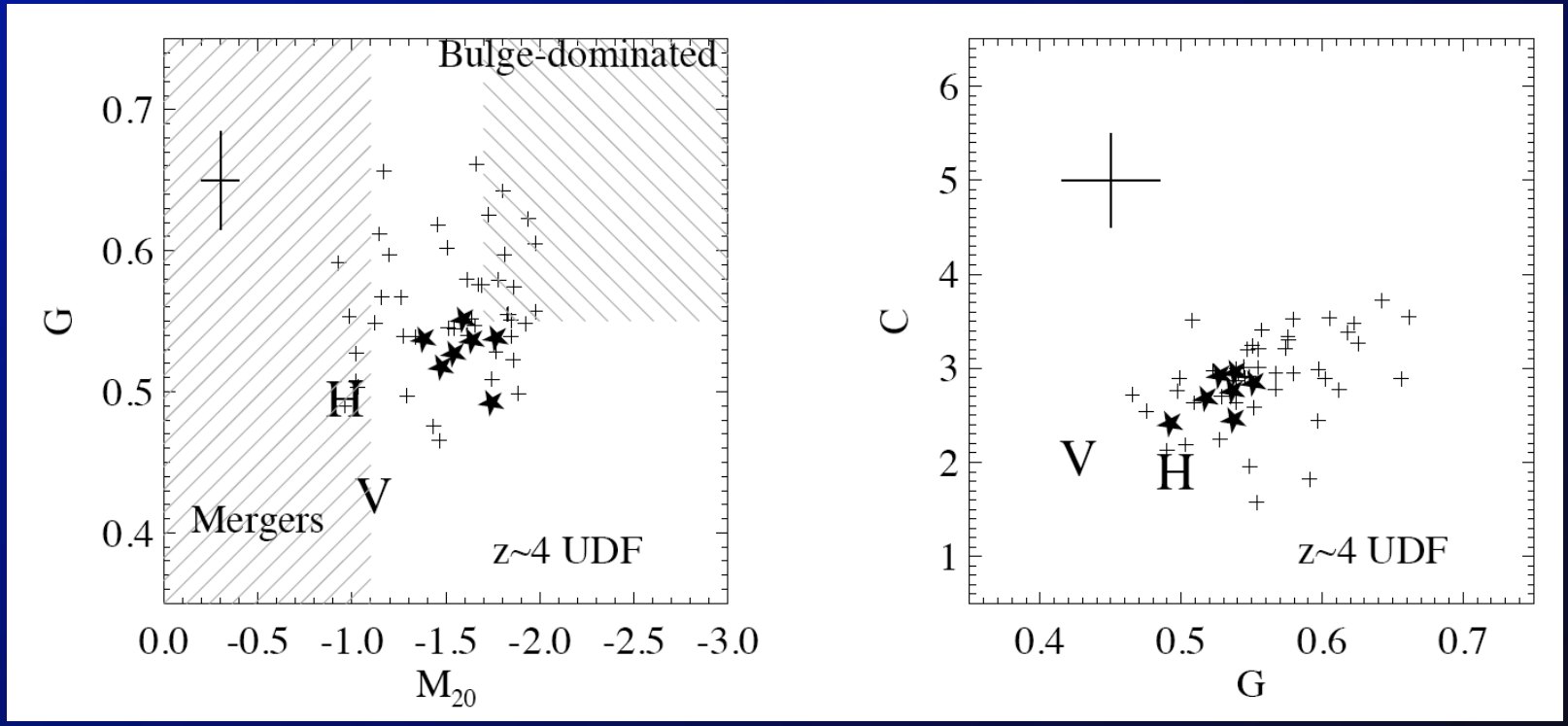
[c]Metallicity determined using the Tremonti et al (2004) technique.

[d]Metallicity determined using the $N2$ technique (see Pettini & Pagel 2004; Erb et al 2006a.)

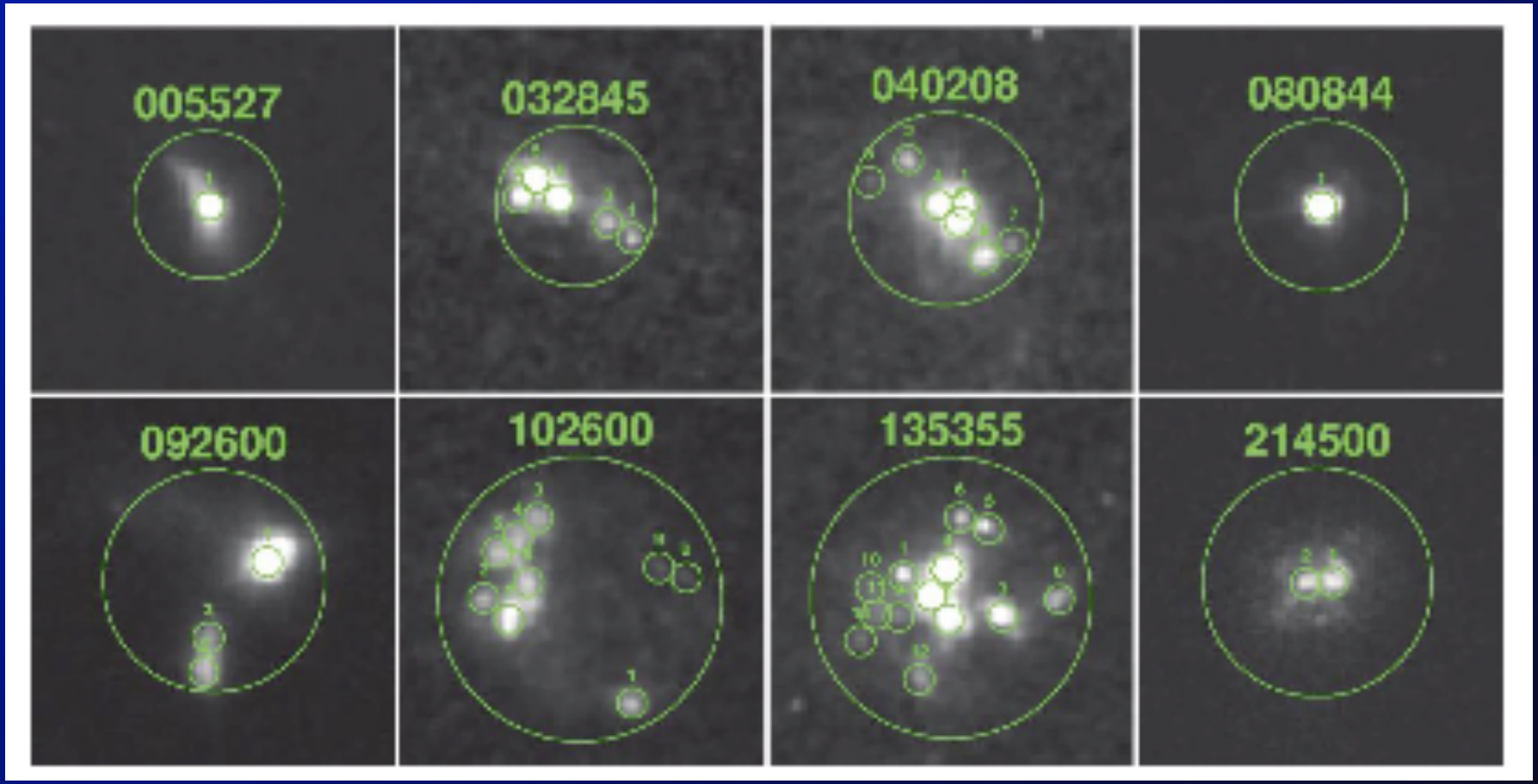
Hoopes et al. (2007)

HST Morphologies

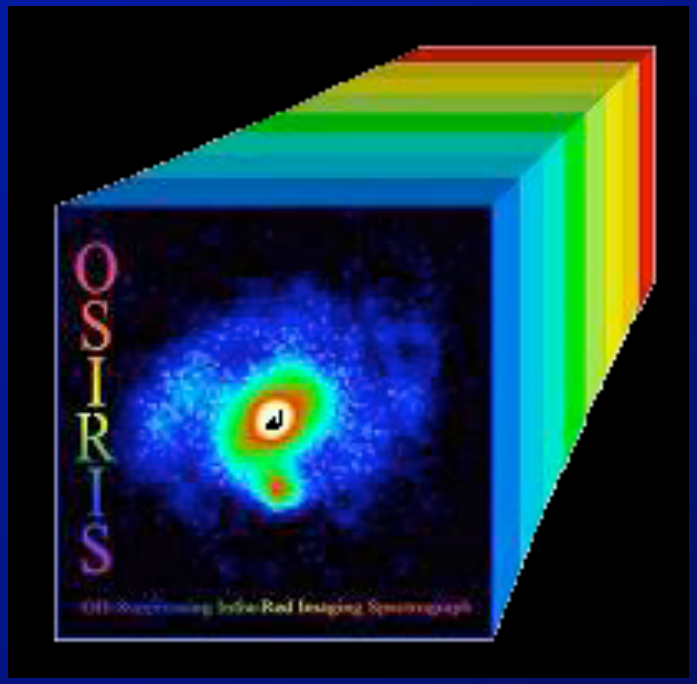
- Overzier et al (2008): HST observations in UV/U-band, 8500Å and Hα
- Similar morphological indices to high-redshift LBGs



- Bright clumps of star formation

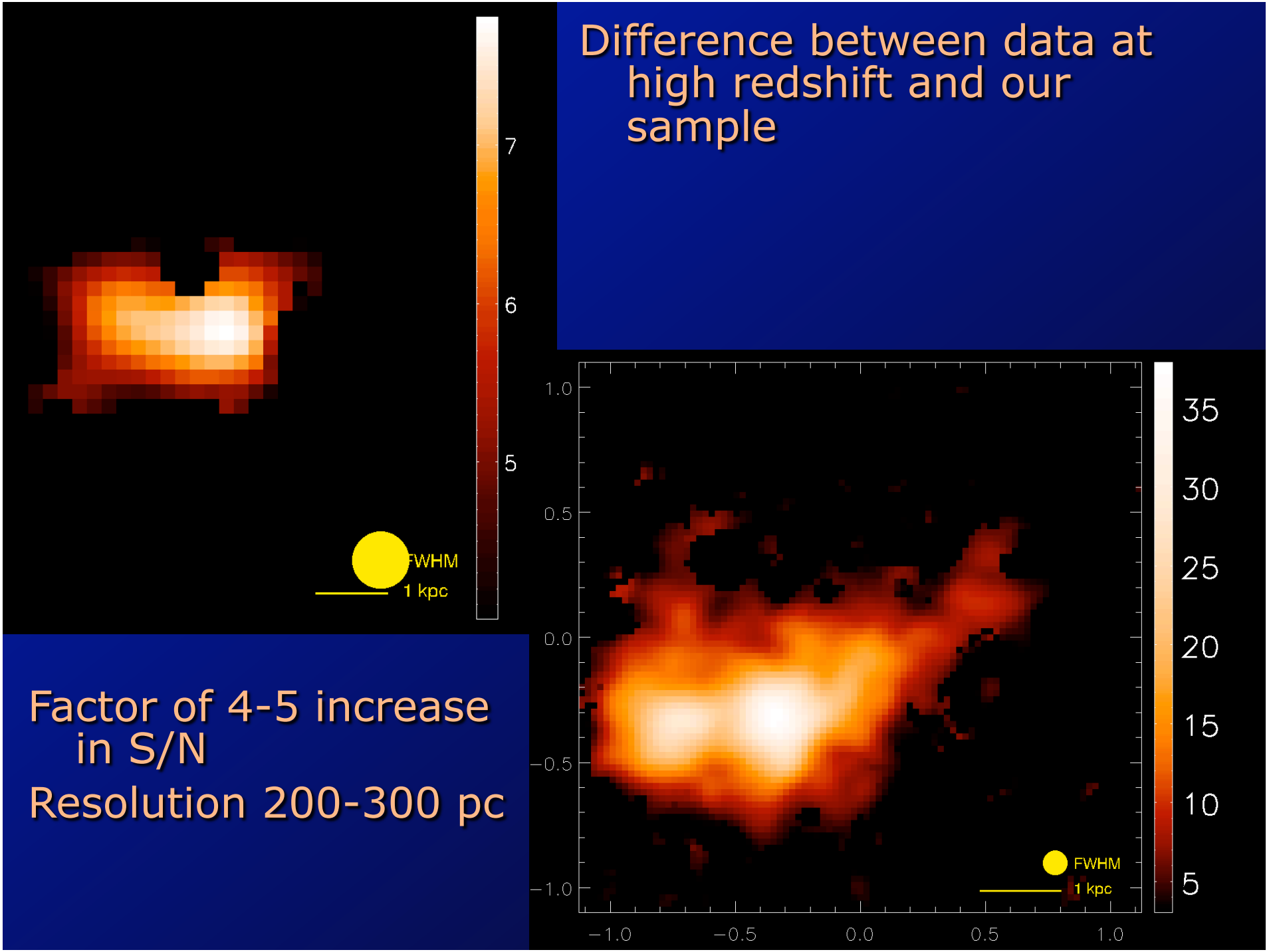


OSIRIS!!!



- Compact objects, high SFR, strong line emission – great case!
- Observed in Pa-α for 2+1 hours on February and October
- 50/100 mas lenslet scale, K-band

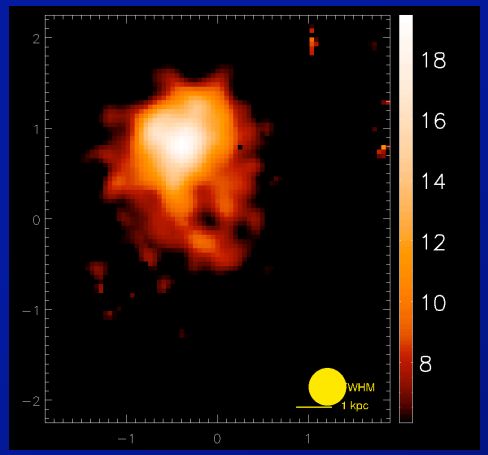
Difference between data at high redshift and our sample

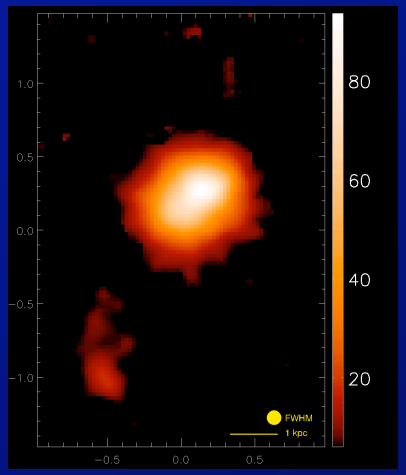


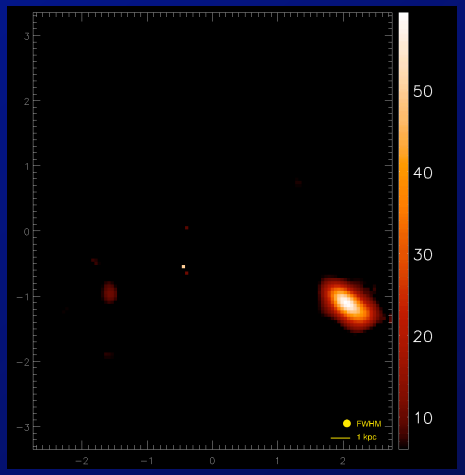
Factor of 4-5 increase in S/N

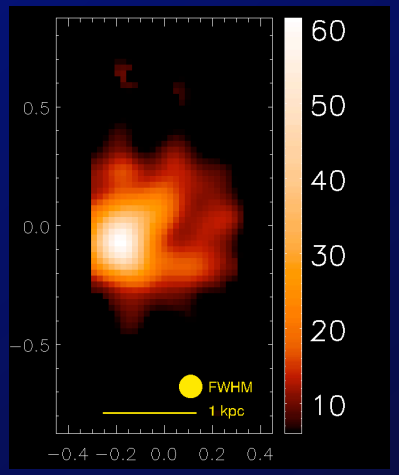
Resolution 200-300 pc

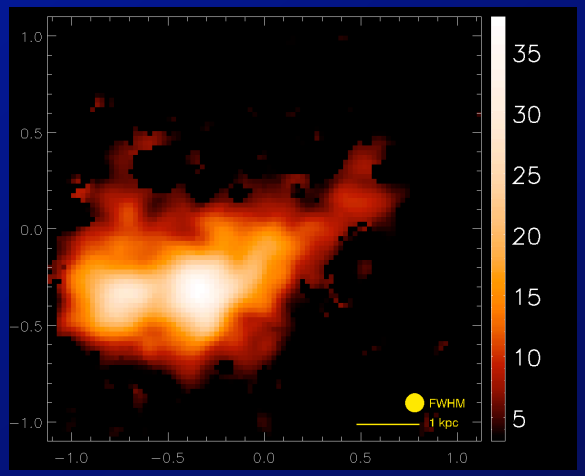
Multiple star forming regions

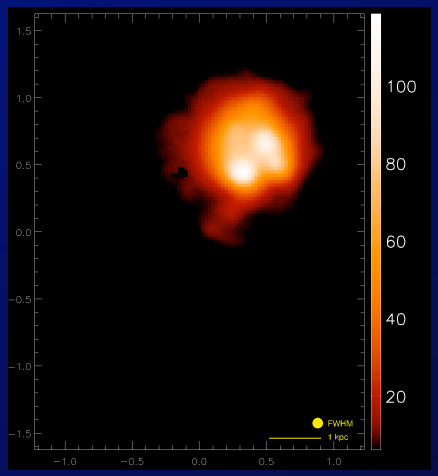






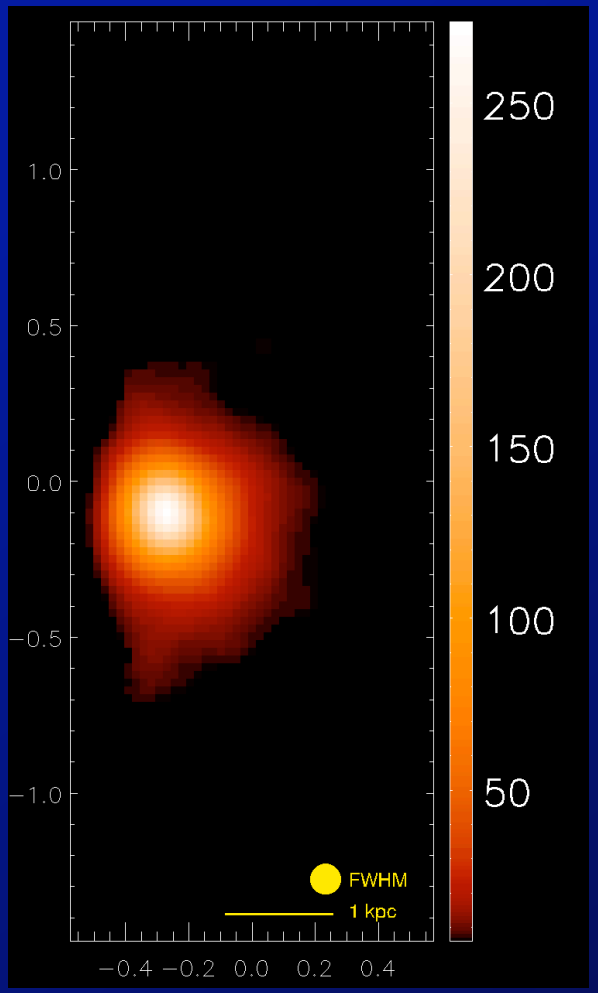


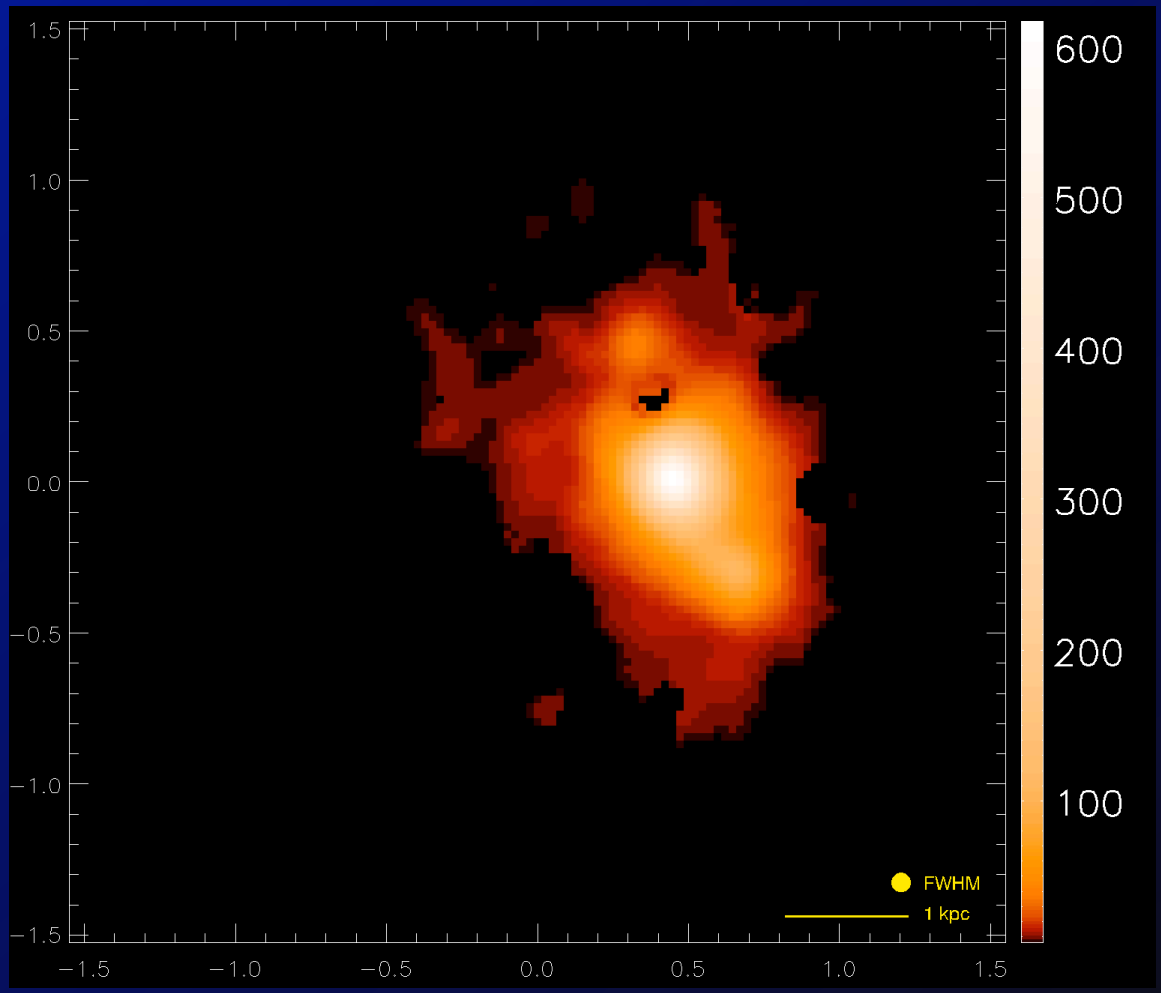




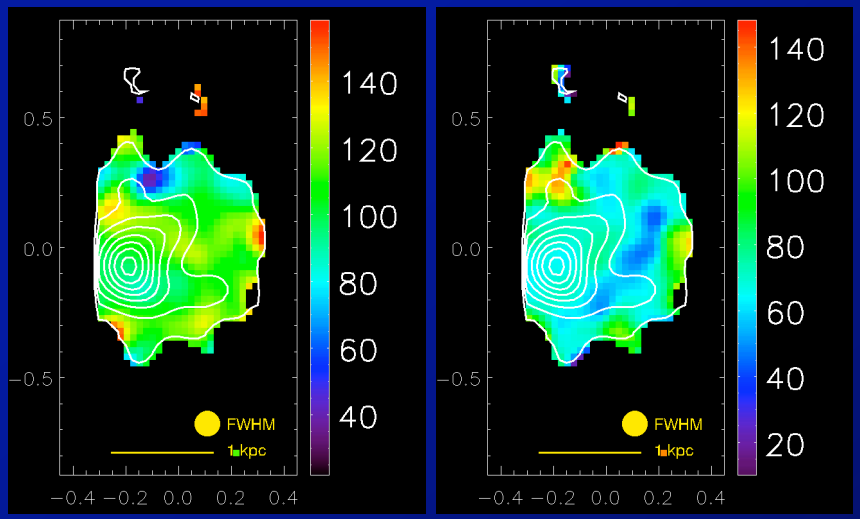
What looks like a giant clump at high redshift might be a collection of smaller clumps of sub-kpc scale

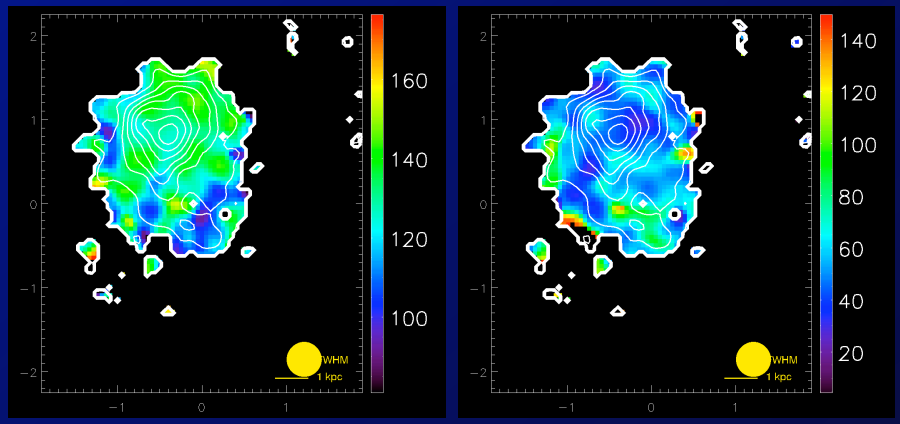
Bright cores

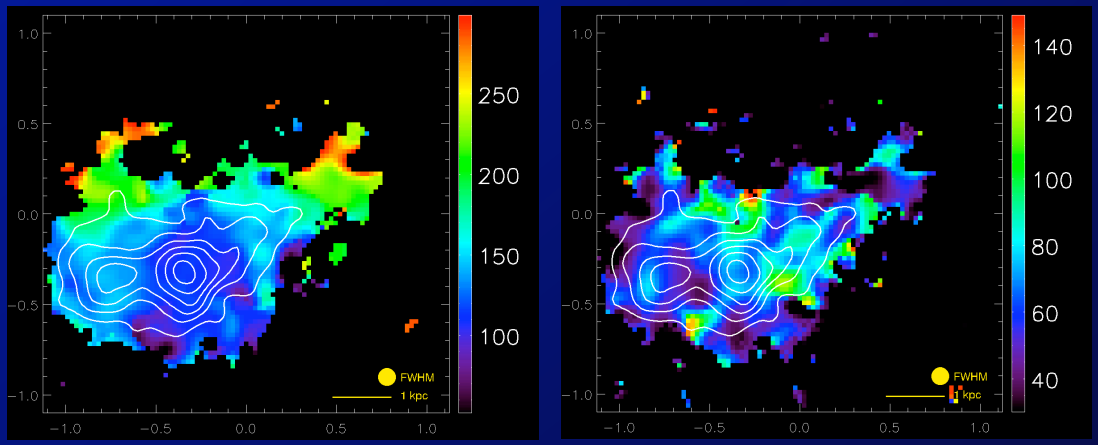


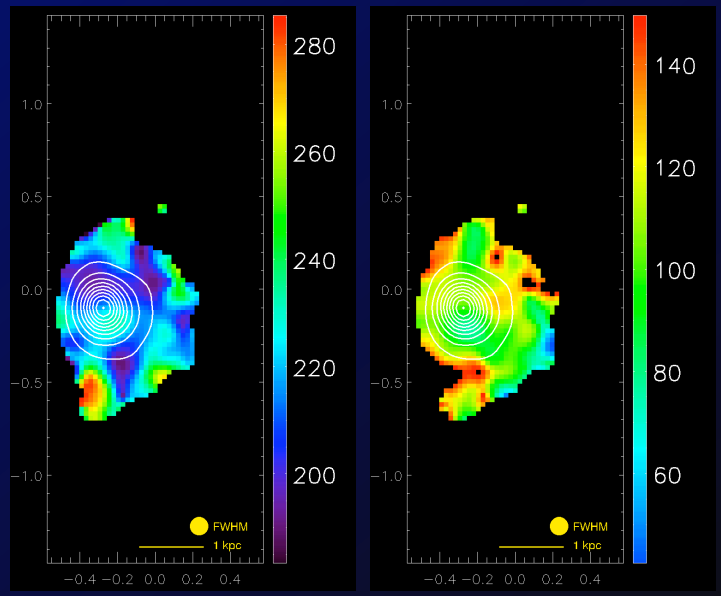


Low v/σ



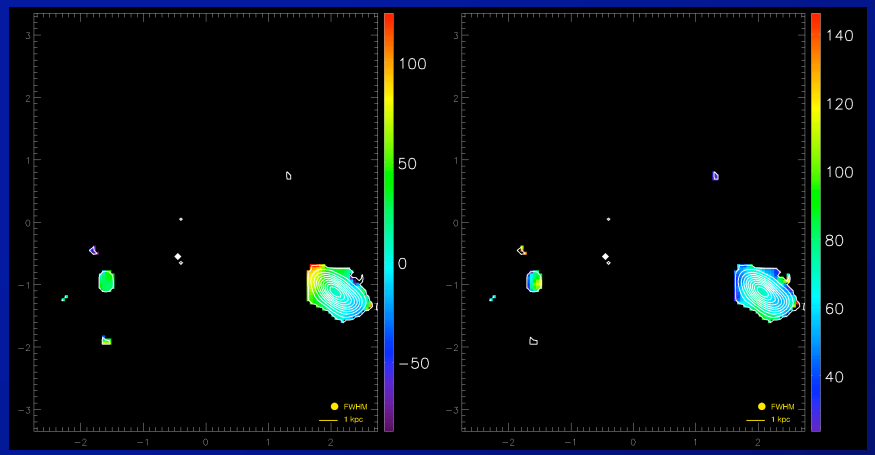




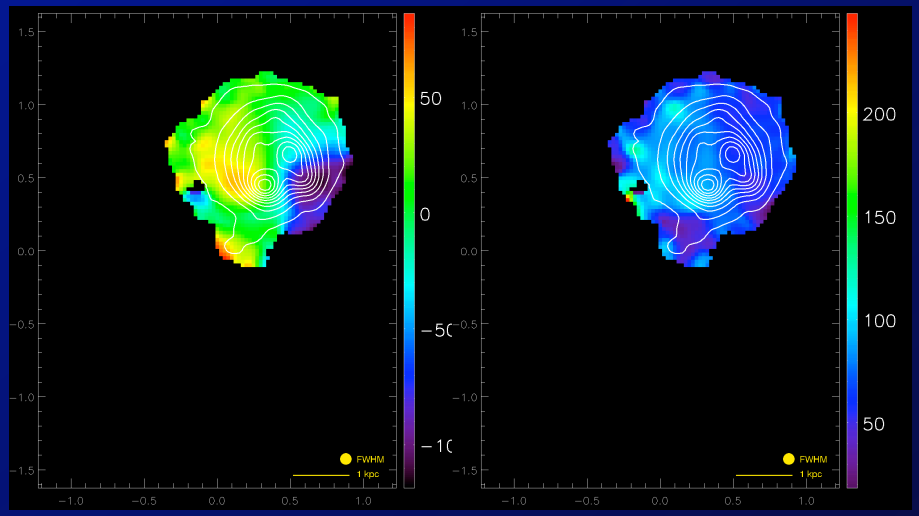


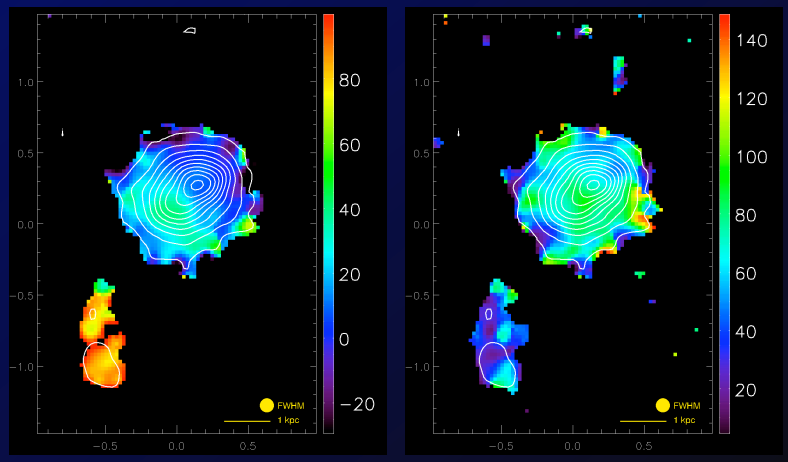
Left: velocity map
Right: σ map

Some velocity shear, but...



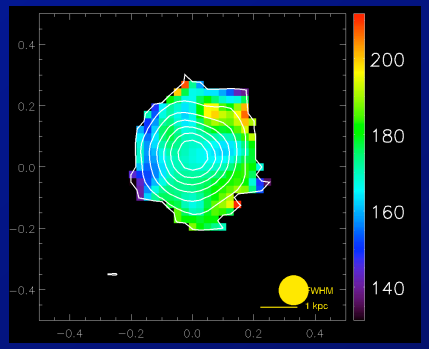
Presence of companions and substructure not detectable at high redshift

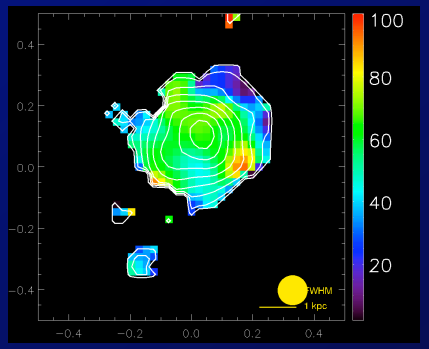


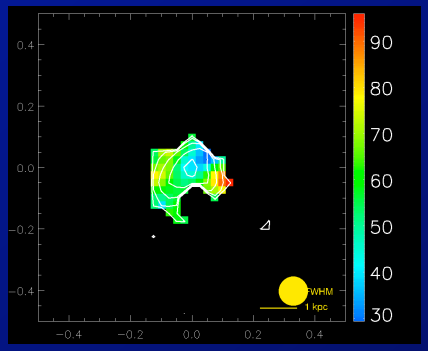


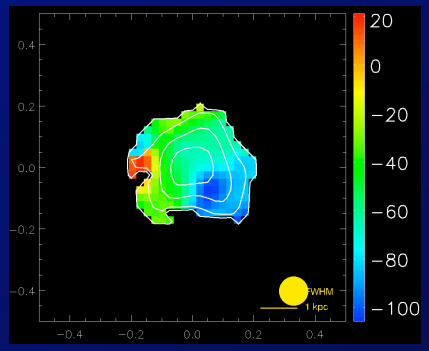
Data artificially redshifted

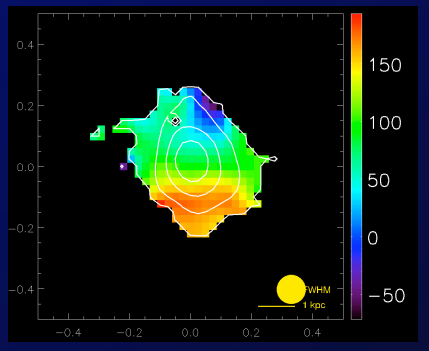
Qualitatively similar to real high-z data

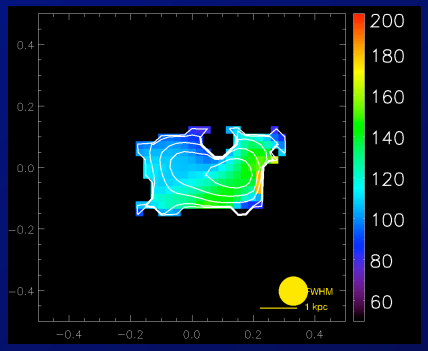


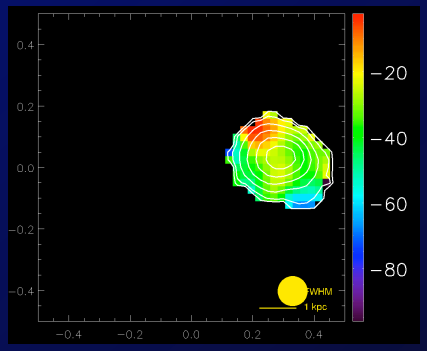


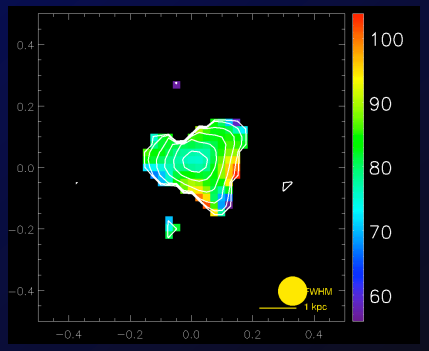


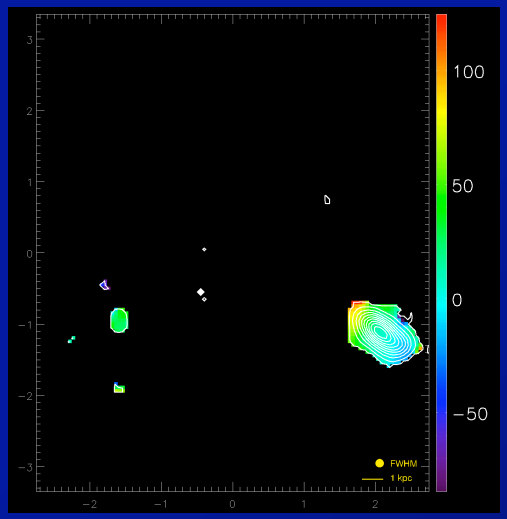


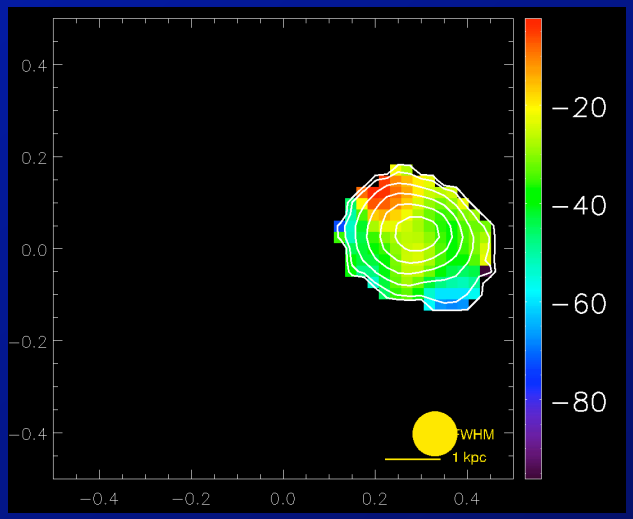






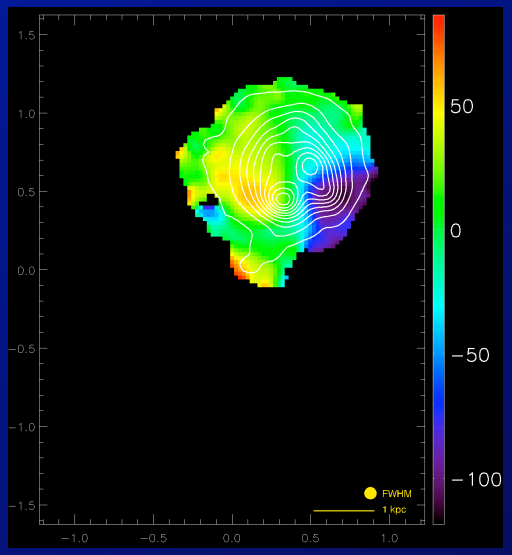


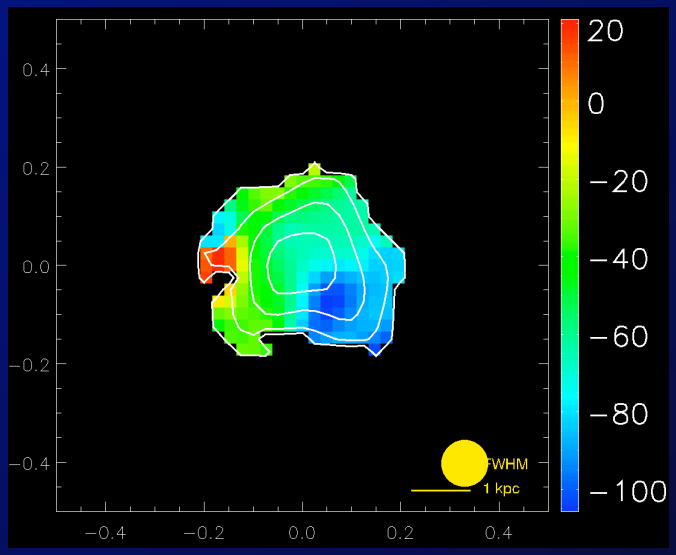




z = 0.2

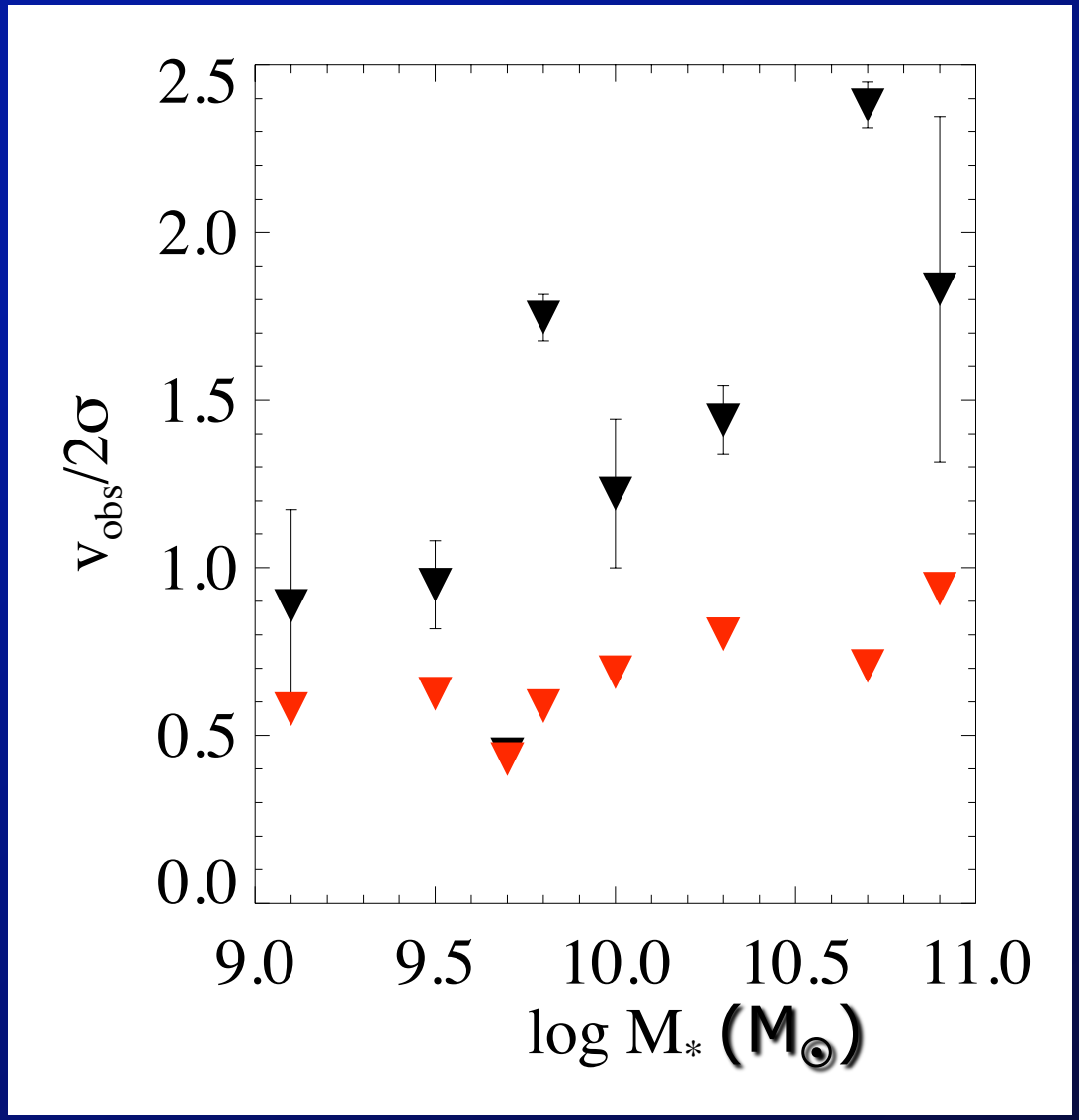
z = 2.2



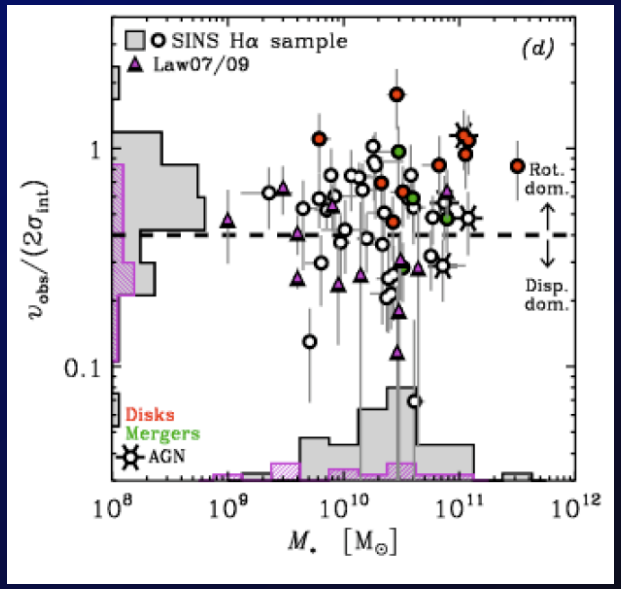


Loss of spatial resolution, even when observing with AO, make objects with complex gas dynamics with subcomponents and companions resemble rotating disks

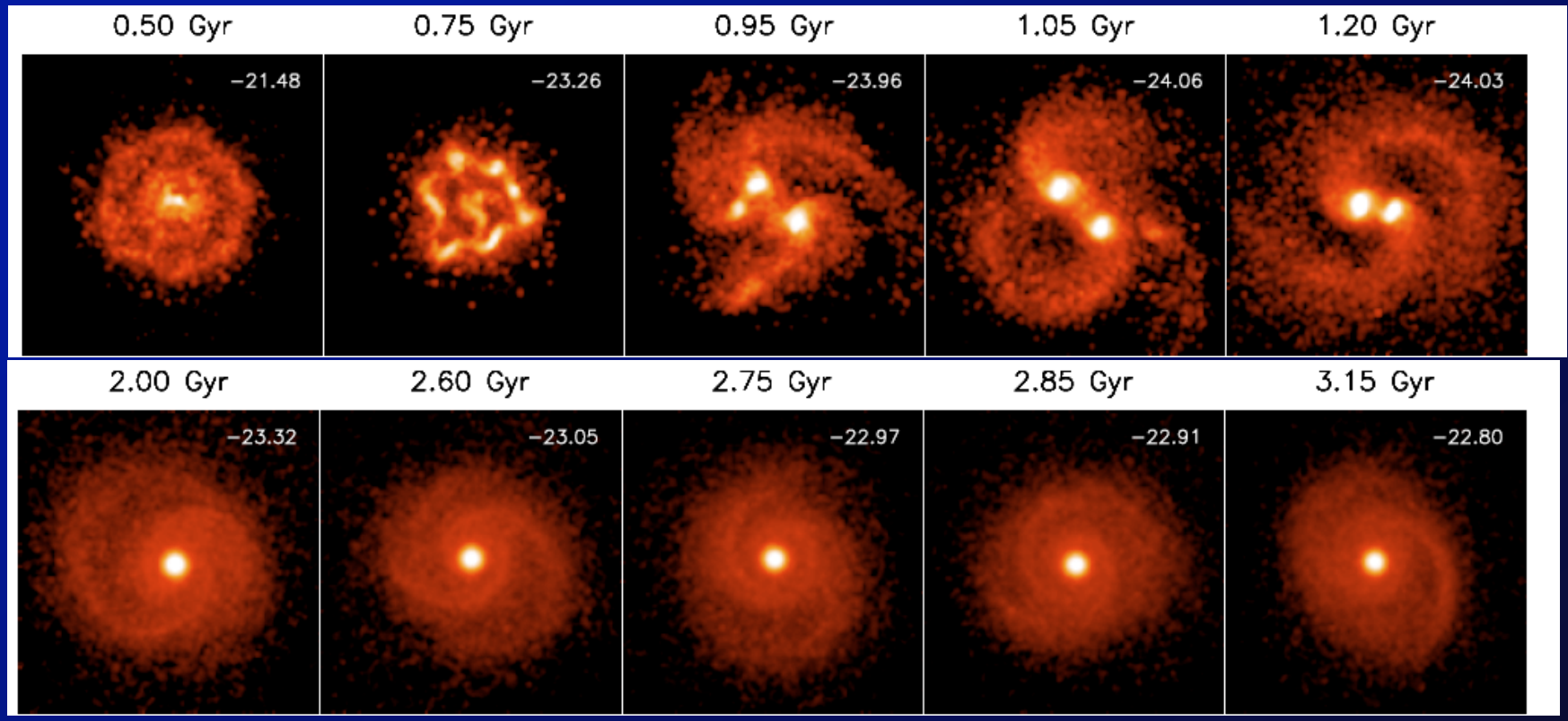
Stellar mass dependence



Strong correlation!



Fragmented disks?



Immeli et al. 2004

Talks by Debra Elmegreen, Bruce Elmegreen, Avishai Dekel

Also suggested by HST data; see Overzier et al. in prep.

Summary

- ScUVLGs make an excellent case for local analogs to star forming galaxies at z~2-3

- These objects are not regularly rotating disks, similarly to what is observed at high z at high resolution, but unlike what is concluded from non-AO studies

- Detail seems to be lost due to SB brightness effects + loss of spatial resolution