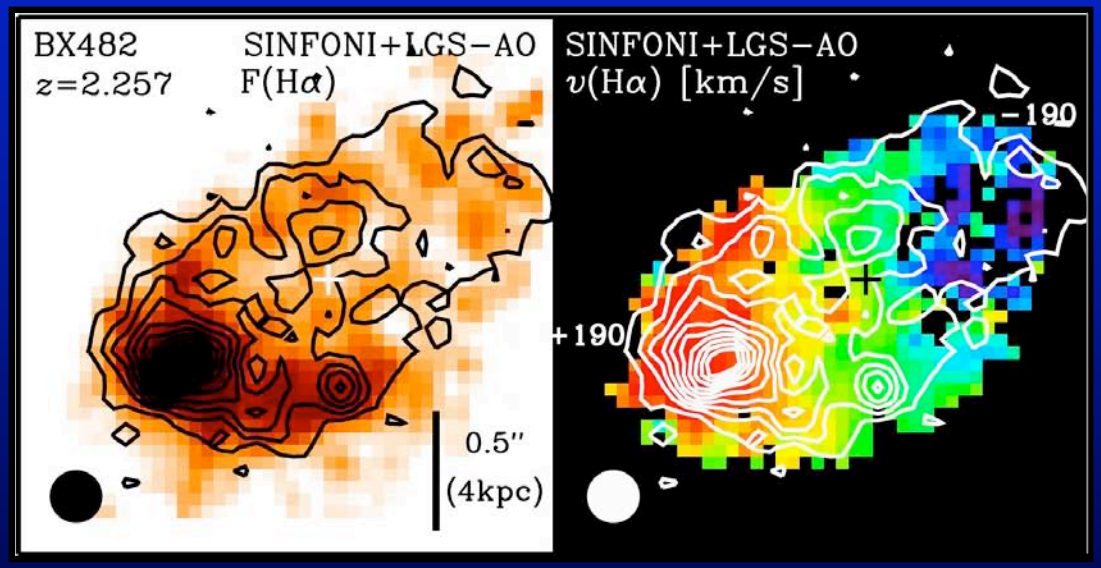
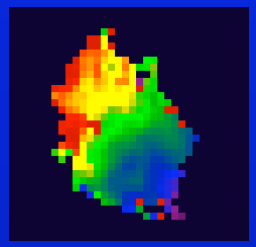
SINFONI Observations of Galaxy Dynamics and Assembly at z~2



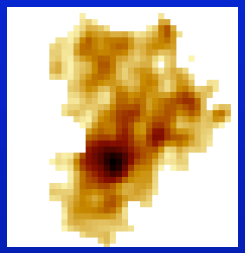
Kristen Shapiro
and the SINS team

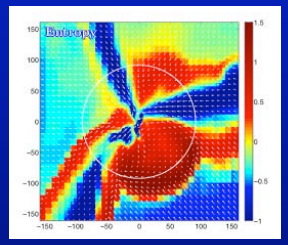
Galaxy Assembly and Evolution at *z*~2



Large, rotating disks are important at high-*z*

They are clumpy, thick, rapidly star-forming





They are assembled by cold flows

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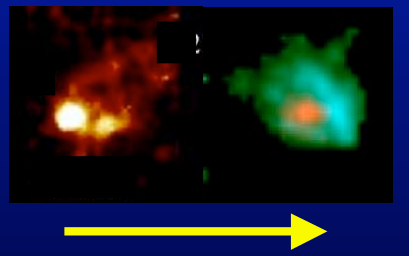
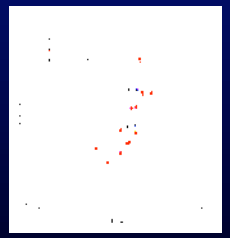
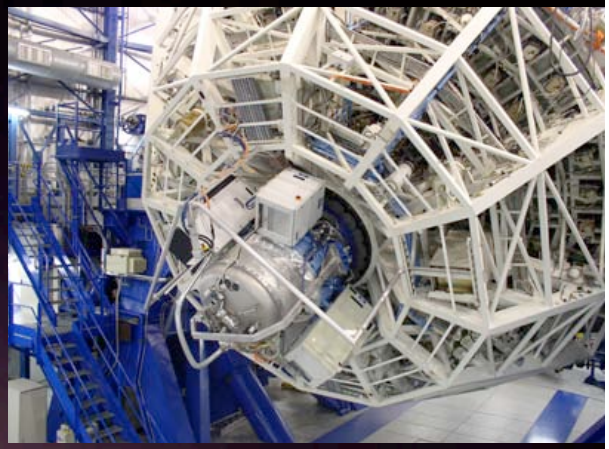




The backbones of local scaling relations are in place

Bouché et al. 2007; Cresci et al. in prep; Förster Schreiber et al. 2006, in prep; Genel et al. 2008; Genzel et al. 2006, 2008; Shapiro et al. 2008, in prep

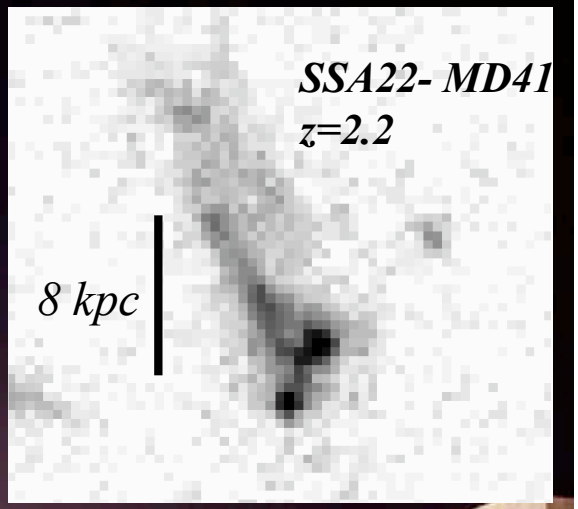
SINFONI

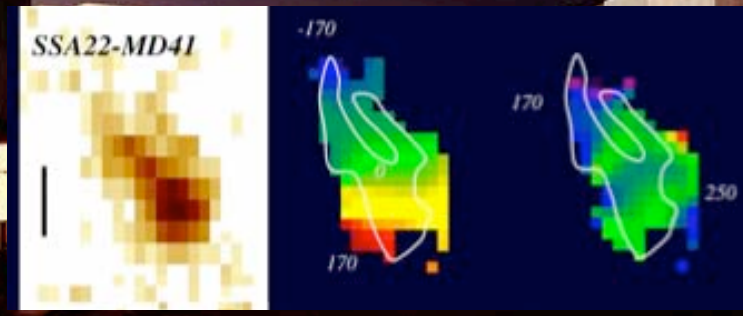


- JHK Integral Field Spectroscopy
- 0.125”/pixel; FOV = 8” x 8”
- R = 2000-4500

PIs: F.Eisenhauer, H.Bonnet

SINFONI at z~2

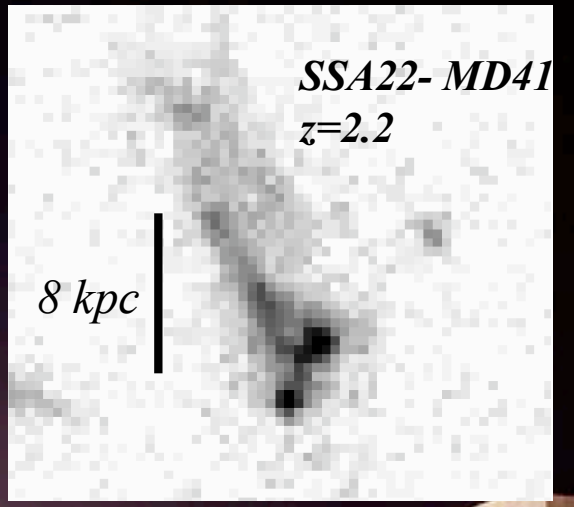


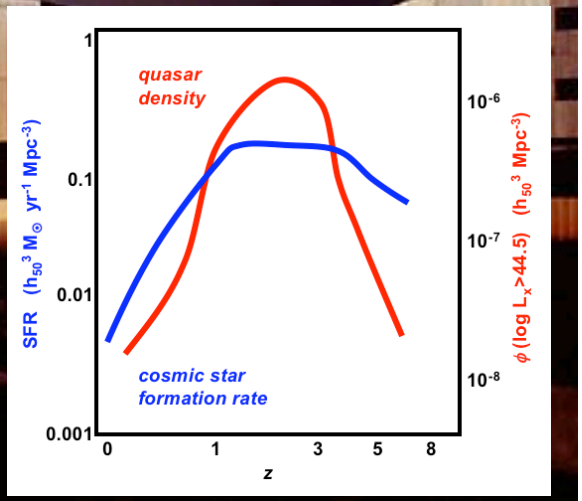


- JHK -> Rest-Frame Optical (Hα Emission)
- 1” ~ 8.2 kpc
- 1-11 hours of integration on 80 objects

PI: R. Genzel

SINFONI at z~2





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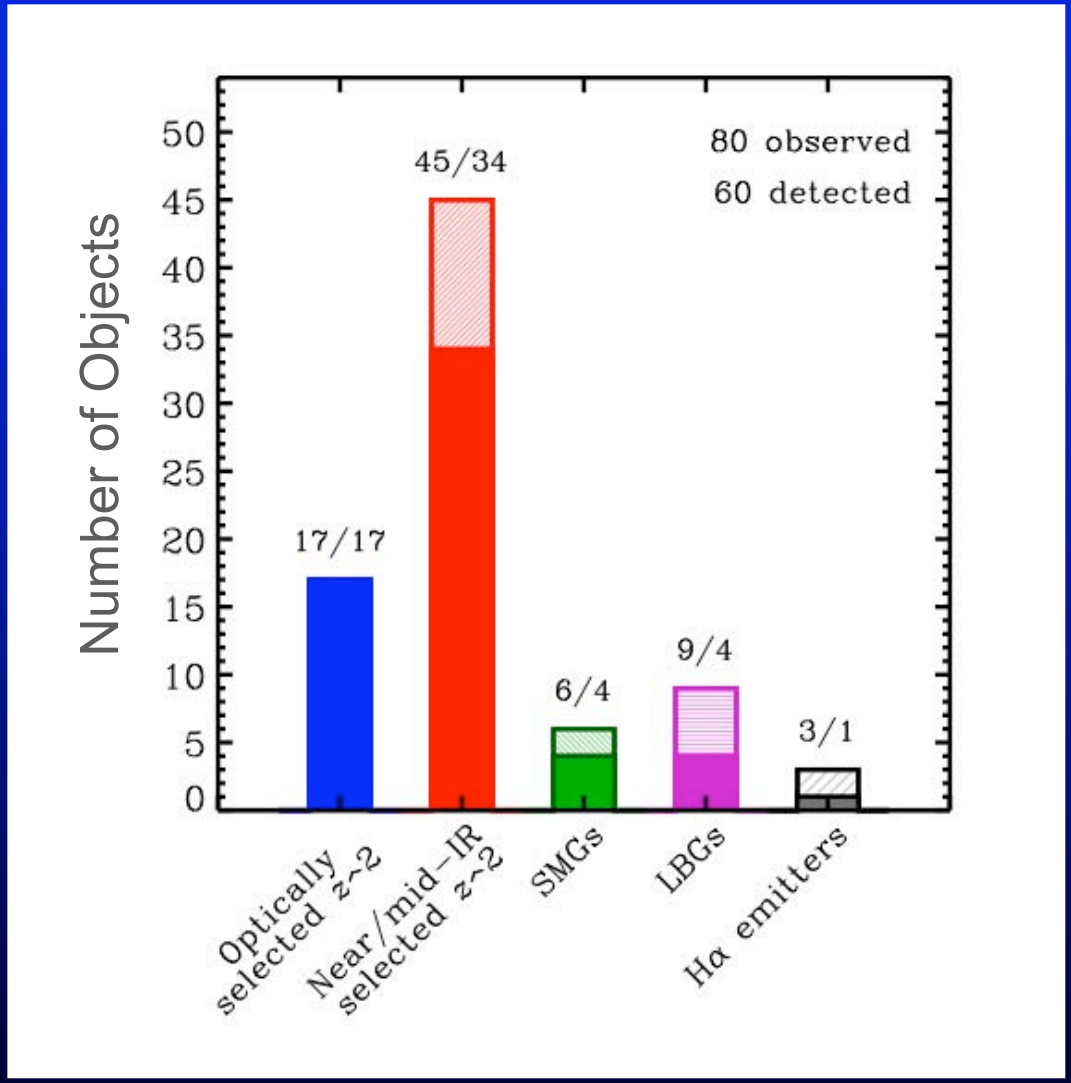
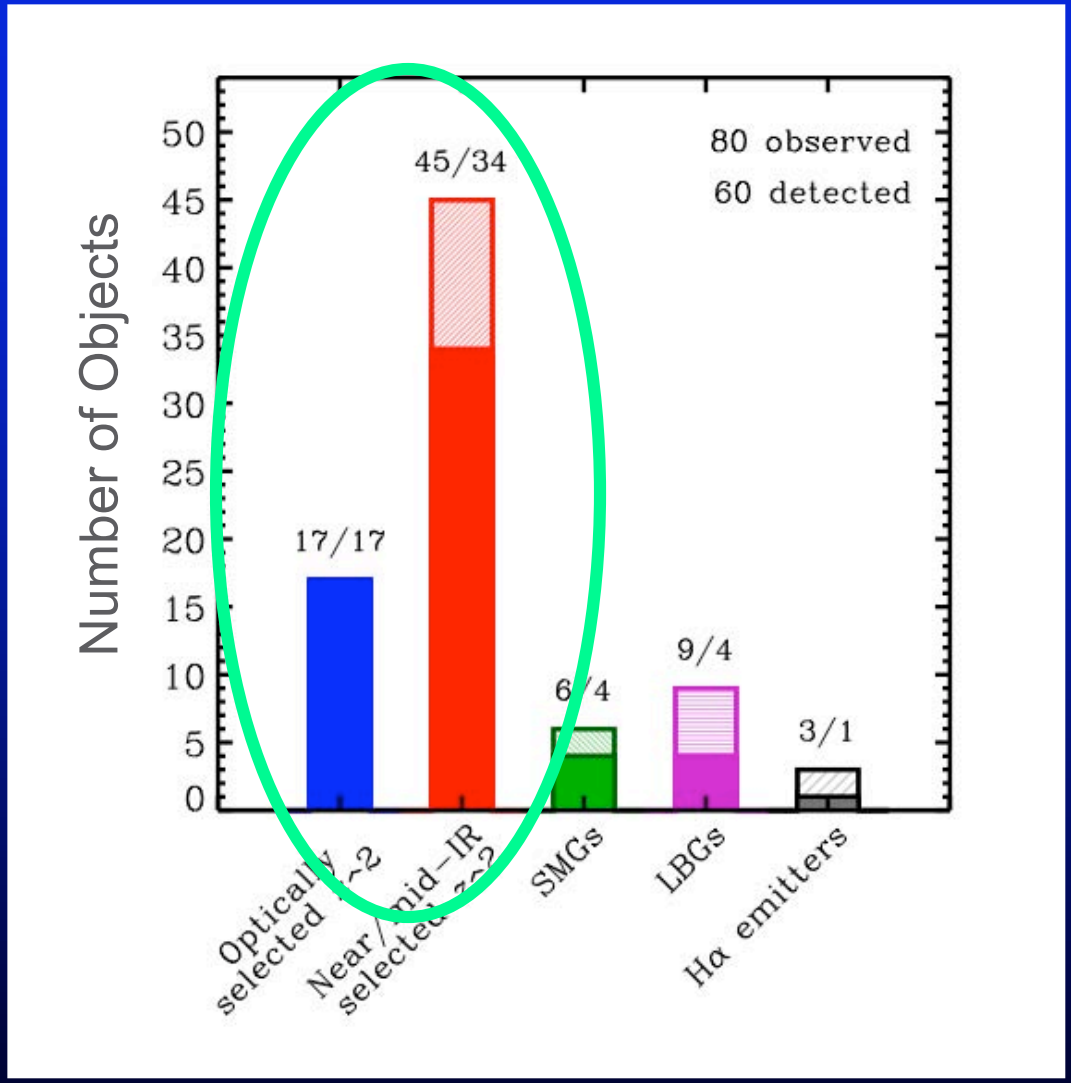
The Survey



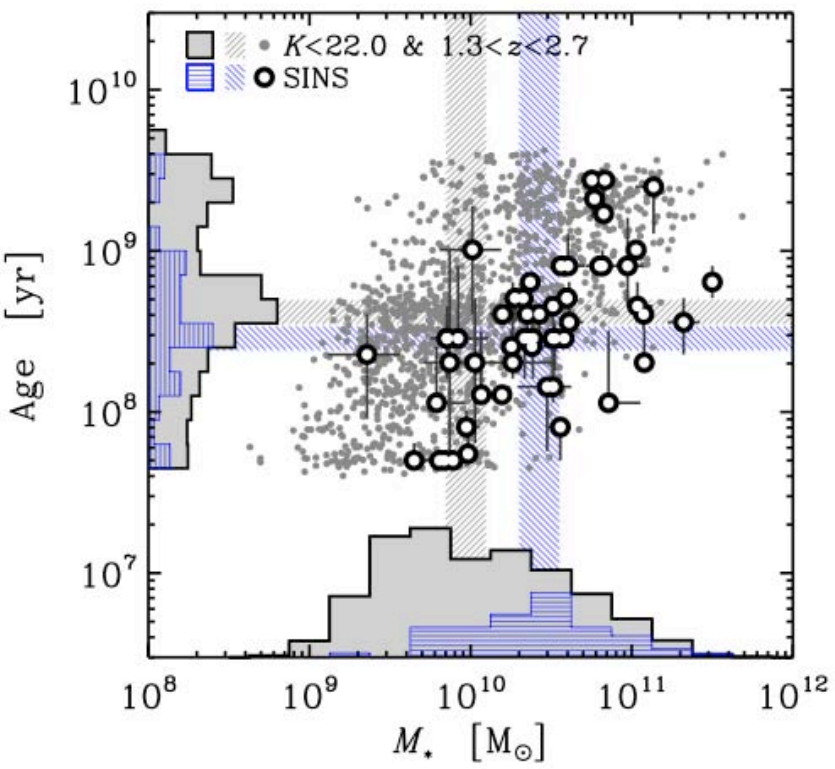
Förster Schreiber et al. in prep

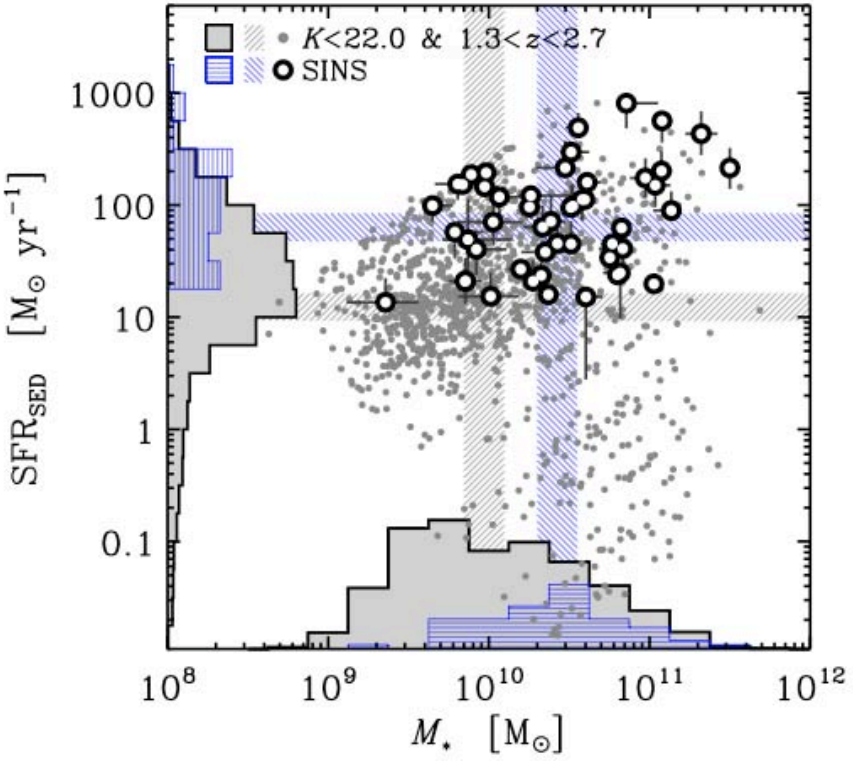
The Survey



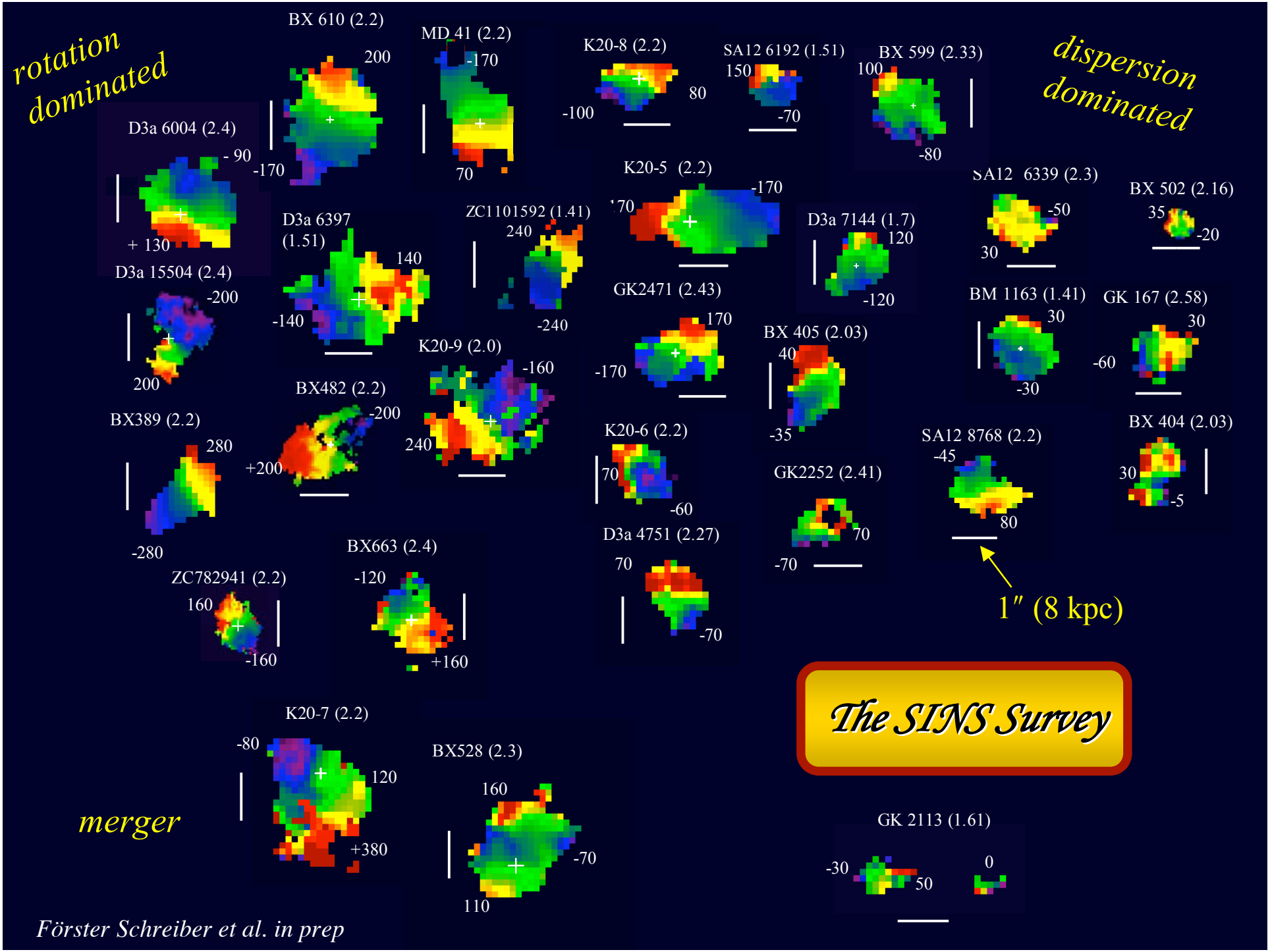
Förster Schreiber et al. in prep

The Survey

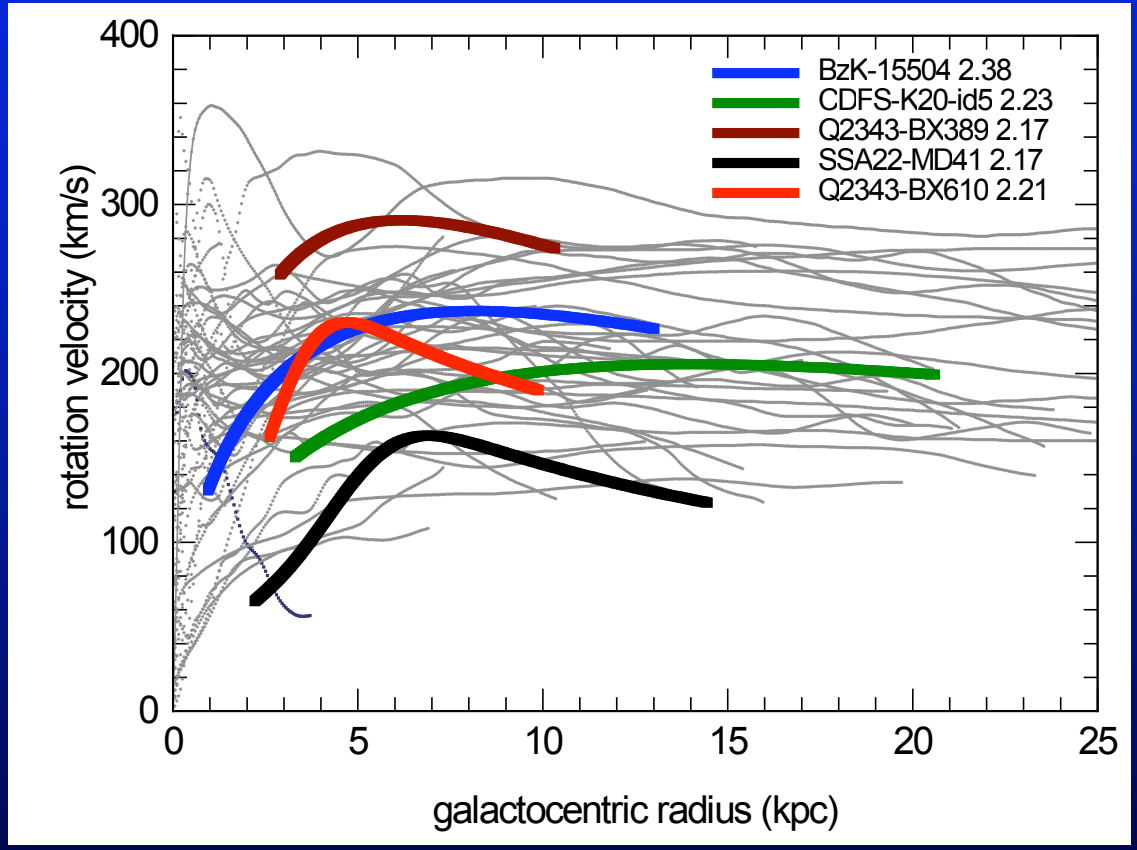




Förster Schreiber et al. in prep

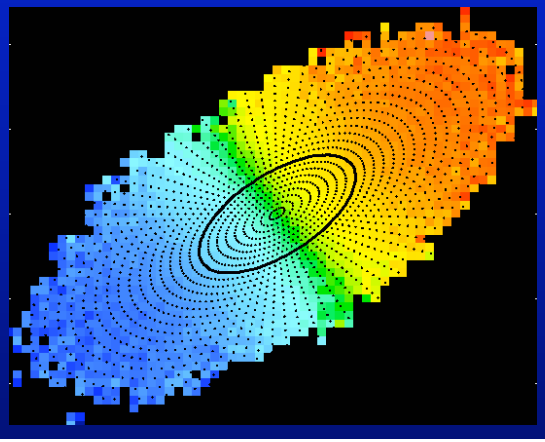

rotation dominated
dispersion dominated
BX 610 (2.2)
200
-170
MD 41 (2.2)
-170
70
K20-8 (2.2)
-100
80
SA12 6192 (1.51)
150
-70
BX 599 (2.33)
100
-80
D3a 6004 (2.4)
- 90
+ 130
K20-5 (2.2)
-170
170
SA12 6339 (2.3)
-50
30
BX 502 (2.16)
35
-20
D3a 6397 (1.51)
140
-140
ZC1101592 (1.41)
240
-240
D3a 7144 (1.7)
120
-120
D3a 15504 (2.4)
-200
200
GK2471 (2.43)
170
-170
BM 1163 (1.41)
30
-30
GK 167 (2.58)
30
-60
K20-9 (2.0)
-160
240
BX 405 (2.03)
40
-35
BX482 (2.2)
-200
+200
BX389 (2.2)
280
-280
K20-6 (2.2)
70
-60
SA12 8768 (2.2)
-45
80
BX 404 (2.03)
30
-5
GK2252 (2.41)
70
-70
D3a 4751 (2.27)
70
-70
BX663 (2.4)
-120
+160
ZC782941 (2.2)
160
-160
1″ (8 kpc)
The SINS Survey
K20-7 (2.2)
-80
120
+380
BX528 (2.3)
160
-70
110
GK 2113 (1.61)
-30
50
0
merger
Förster Schreiber et al. in prep

There are large disks at z~2



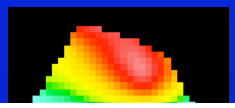
There are large disks at z~2

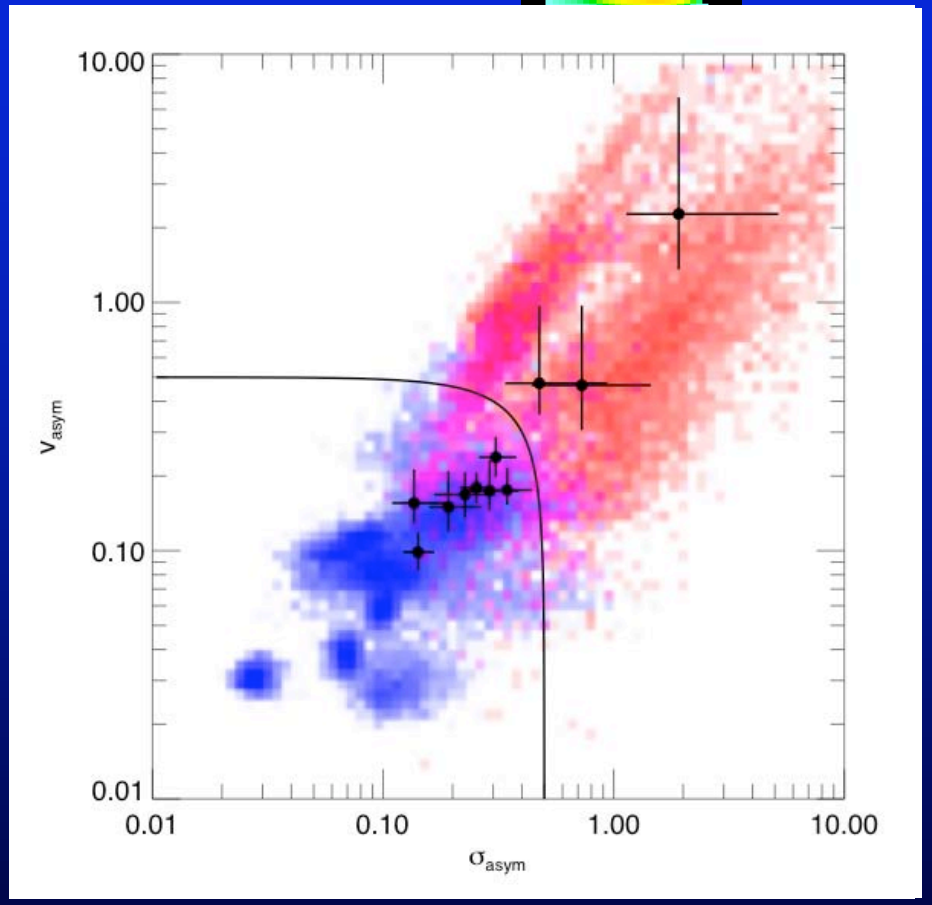
Kinemetry analysis of first and second velocity moment for highest quality SINS data



$$K(\psi) = A_0 + A_1 \sin(\psi) + B_1 \cos(\psi) + A_2 \sin(2\psi) + B_2 \cos(2\psi) + A_3 \sin(3\psi) + B_3 \cos(3\psi) \ldots$$

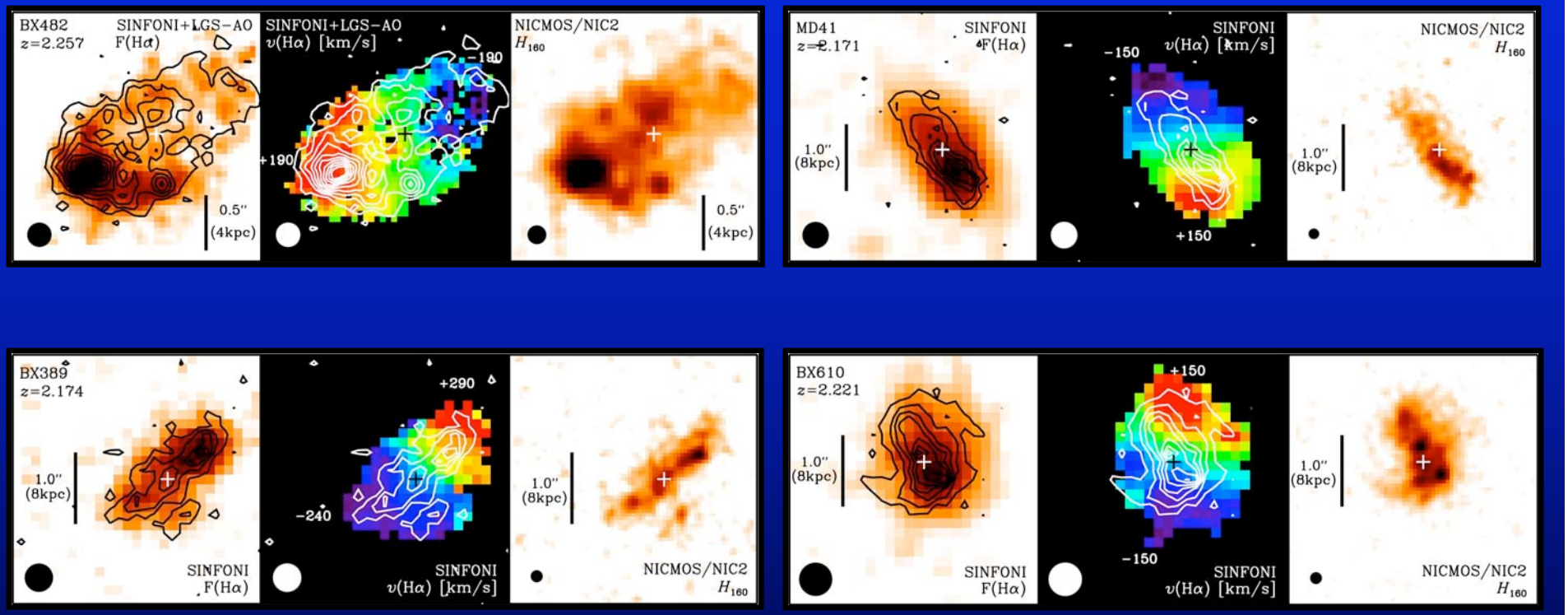
Krajnović et al. 2006





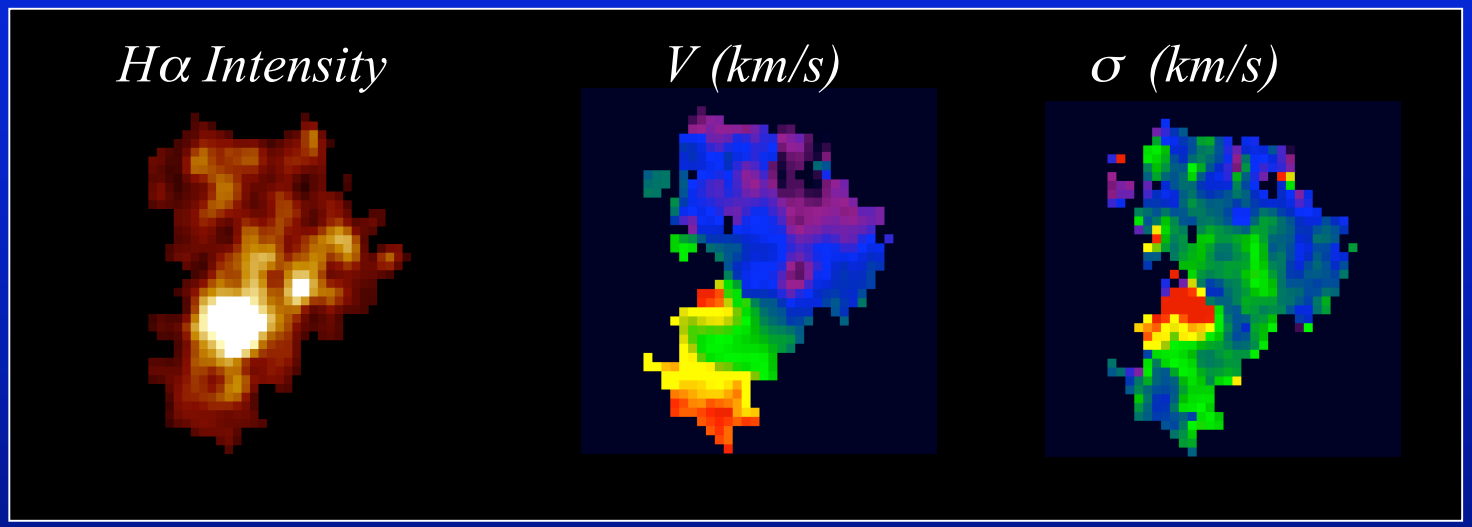
Shapiro et al. 2008

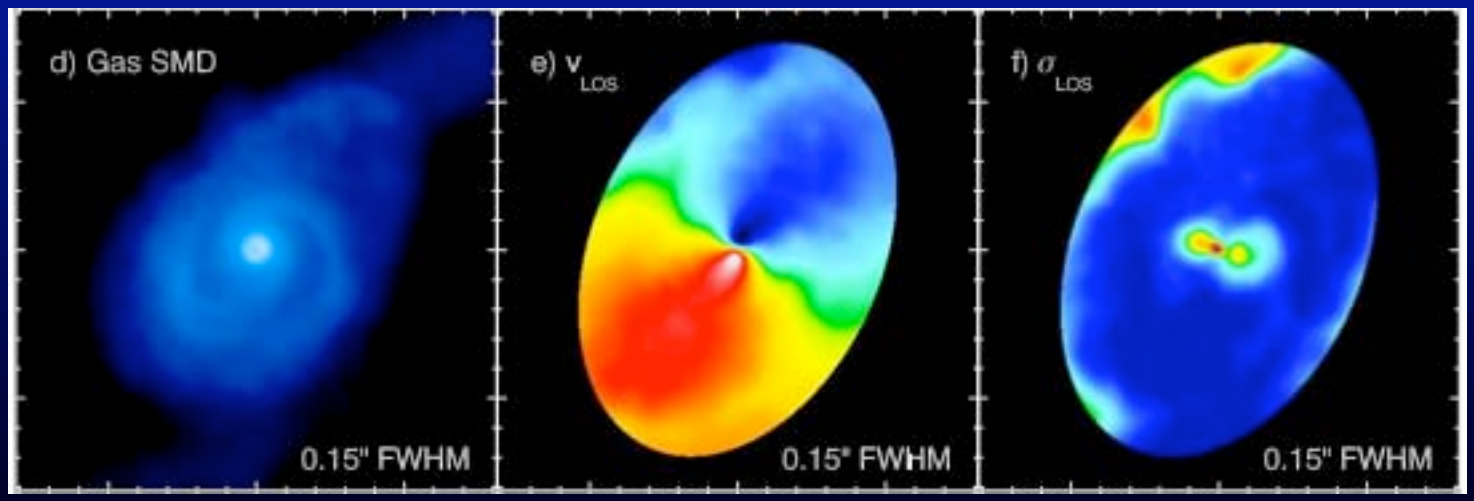
High-z disks are clumpy



Förster Schreiber, Shapley et al. in prep, see also e.g. Elmegreen & Elmegreen 2007

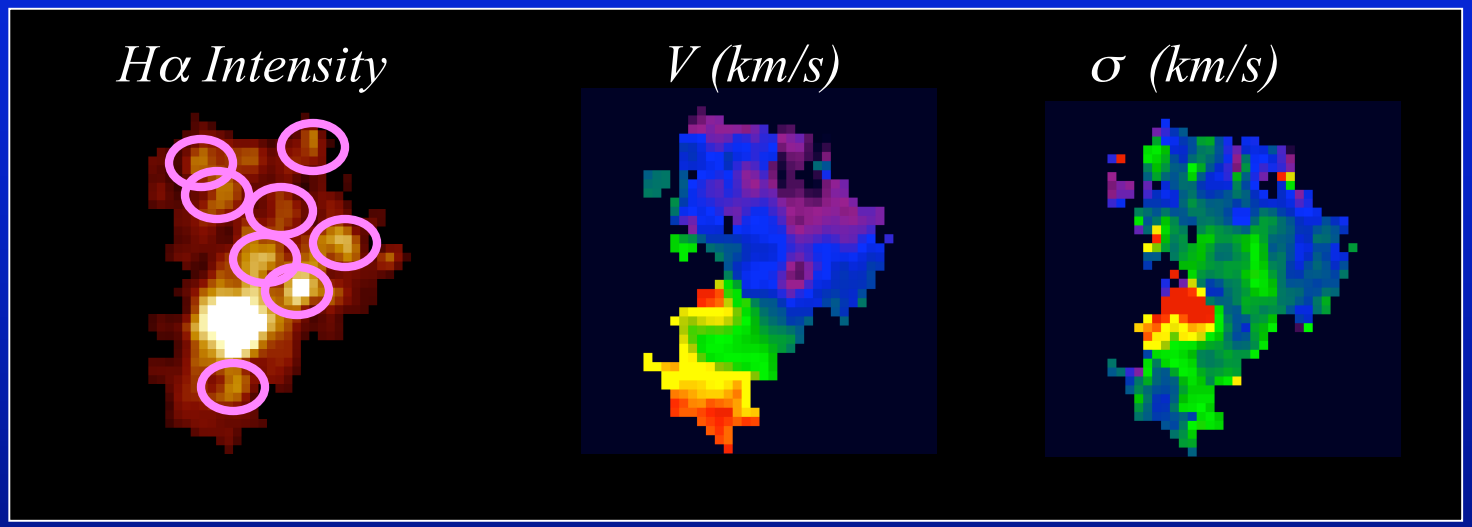
High-z disks are clumpy, unlike merger remnants





Figures from Genzel et al. 2006, Robertson & Bullock 2008

Super SF clumps are massive

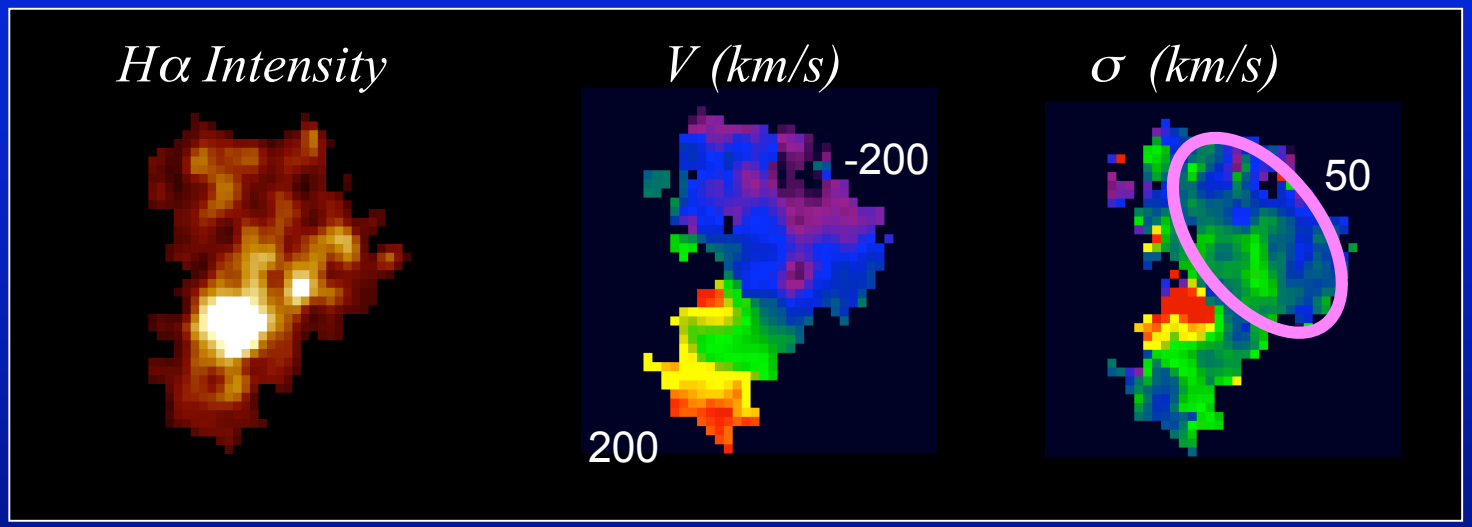


$M_{SF\ Region} \sim 10^8\ M_\odot$

~ 8-10 clumps / galaxy

e.g. Genzel et al. 2006, Elmegreen & Elmegreen 2006

High-z disks are thick

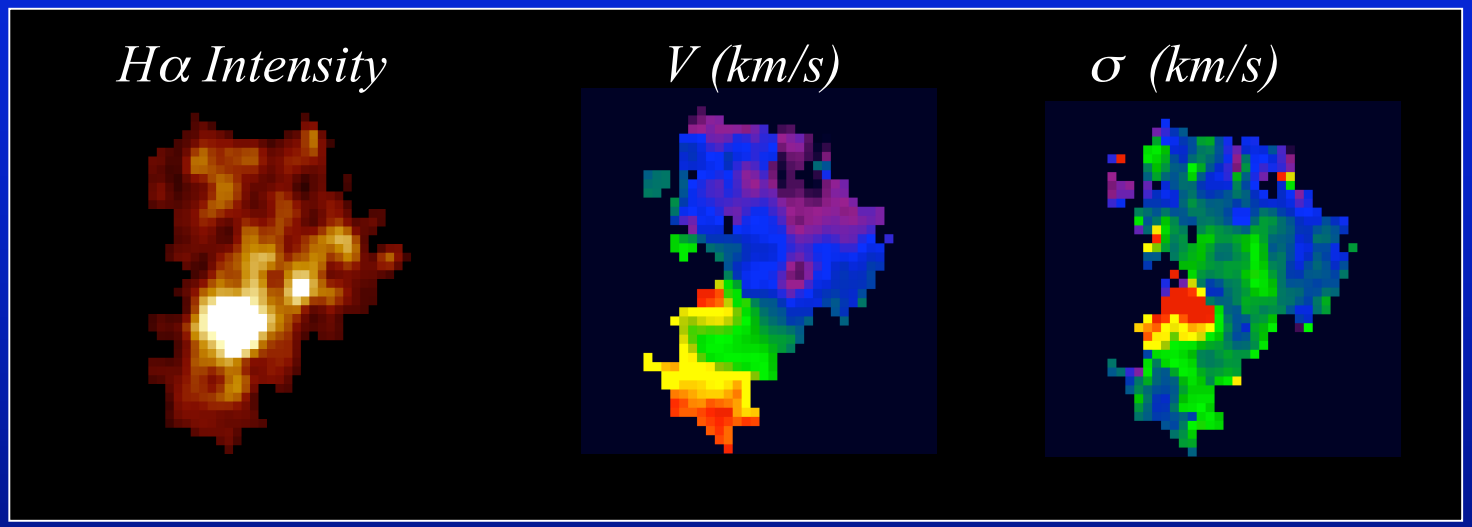


$V/\sigma \sim$ 1-7

(from detailed dynamical modeling of 19 systems)

Genzel et al. 2008, Cresci et al. in prep

High-z disks form stars continuously



SFR ~ 30-200 $M_{\odot}$/yr

Förster Schreiber et al. 2006, in prep, Genzel et al. 2006,2008

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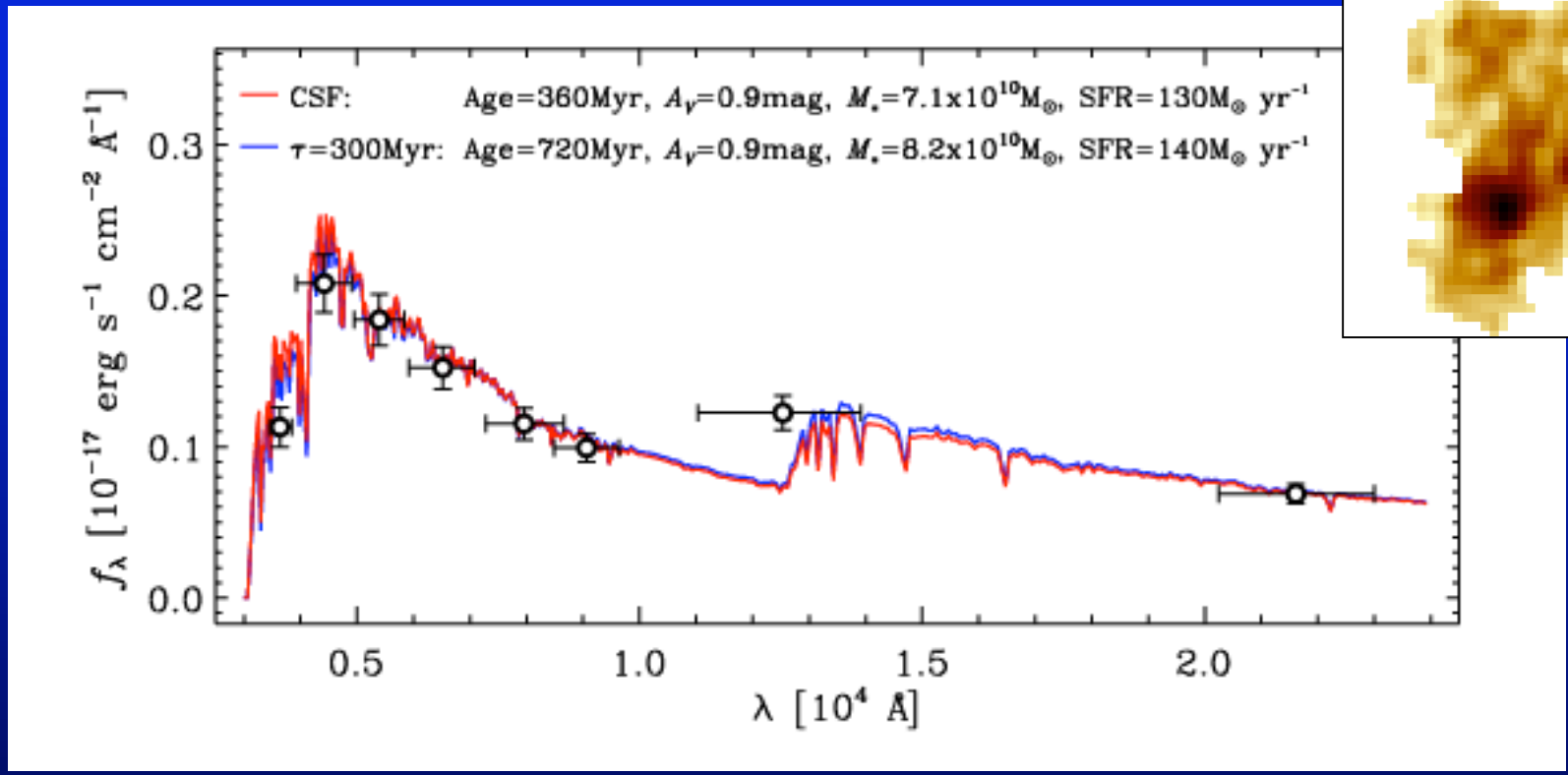
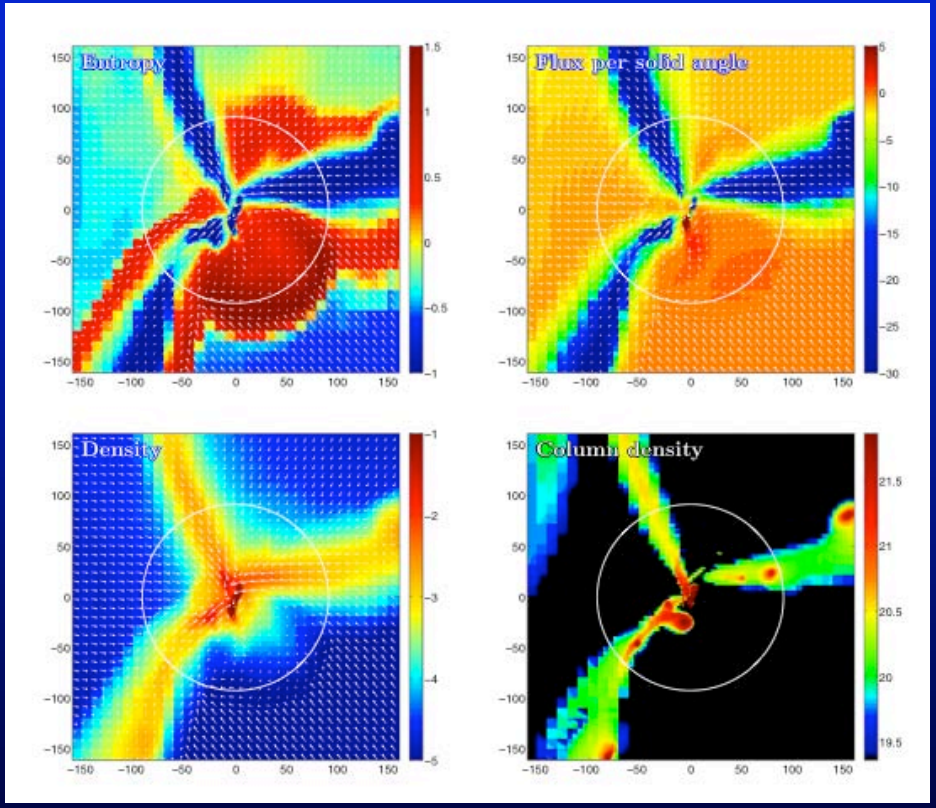


$M_* \sim 8 \times 10^{10}\ M_\odot$
$SFR \sim 100\text{-}200\ M_\odot/yr$ → Age ~ 500 Myr

Förster Schreiber et al. 2006, in prep, Genzel et al. 2006,2008, see also Daddi et al. 2007

Cold flows are the dominant accretion mechanism



e.g. Dekel et al. 2008

$V / \sigma \sim$ 1-7

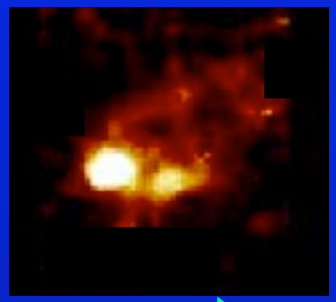
$\downarrow$

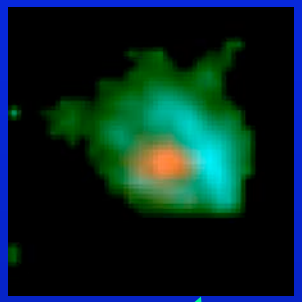
$t_{accretion} \sim$ 200-800 Myr

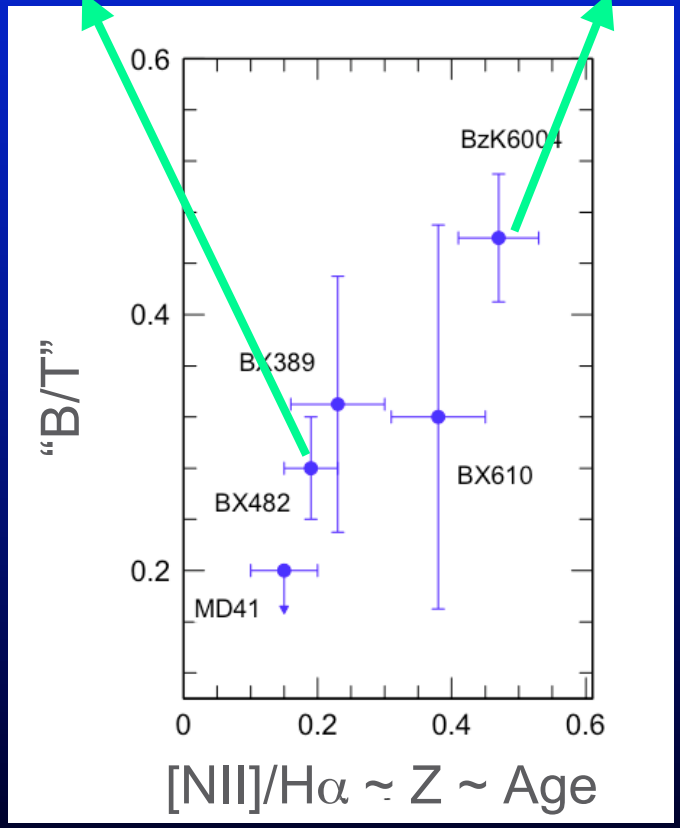
SFR ~ 30-200 $M_{\odot}$/yr
and is continuous

Genzel et al. 2006, Shapiro et al. 2008

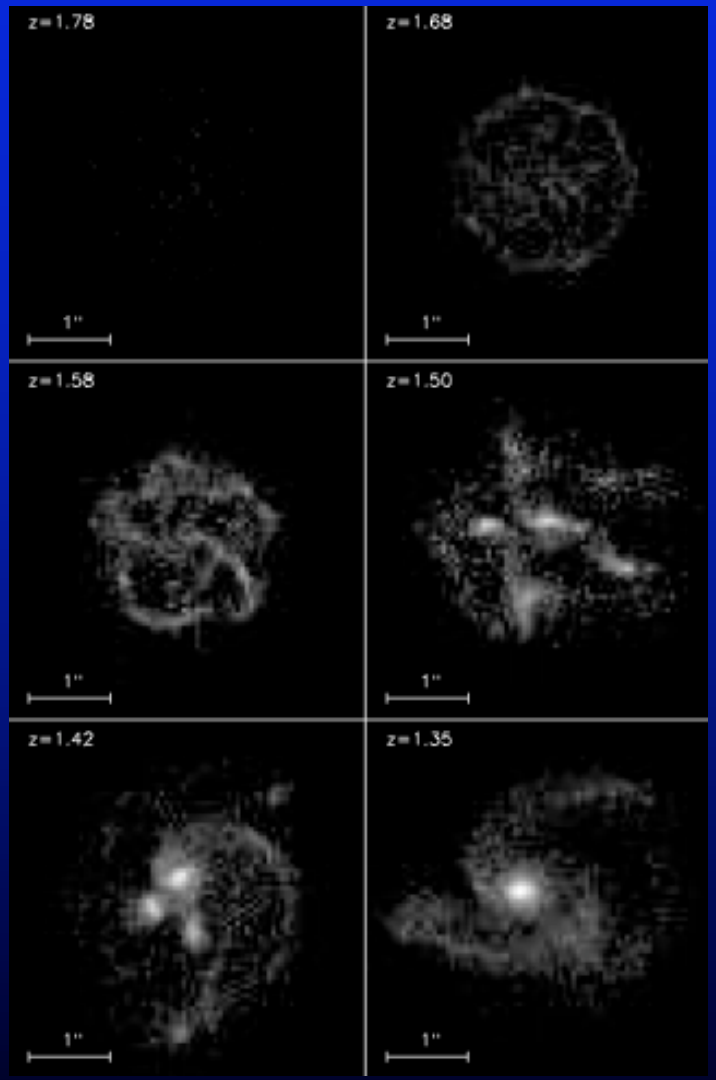
Central concentrations are forming





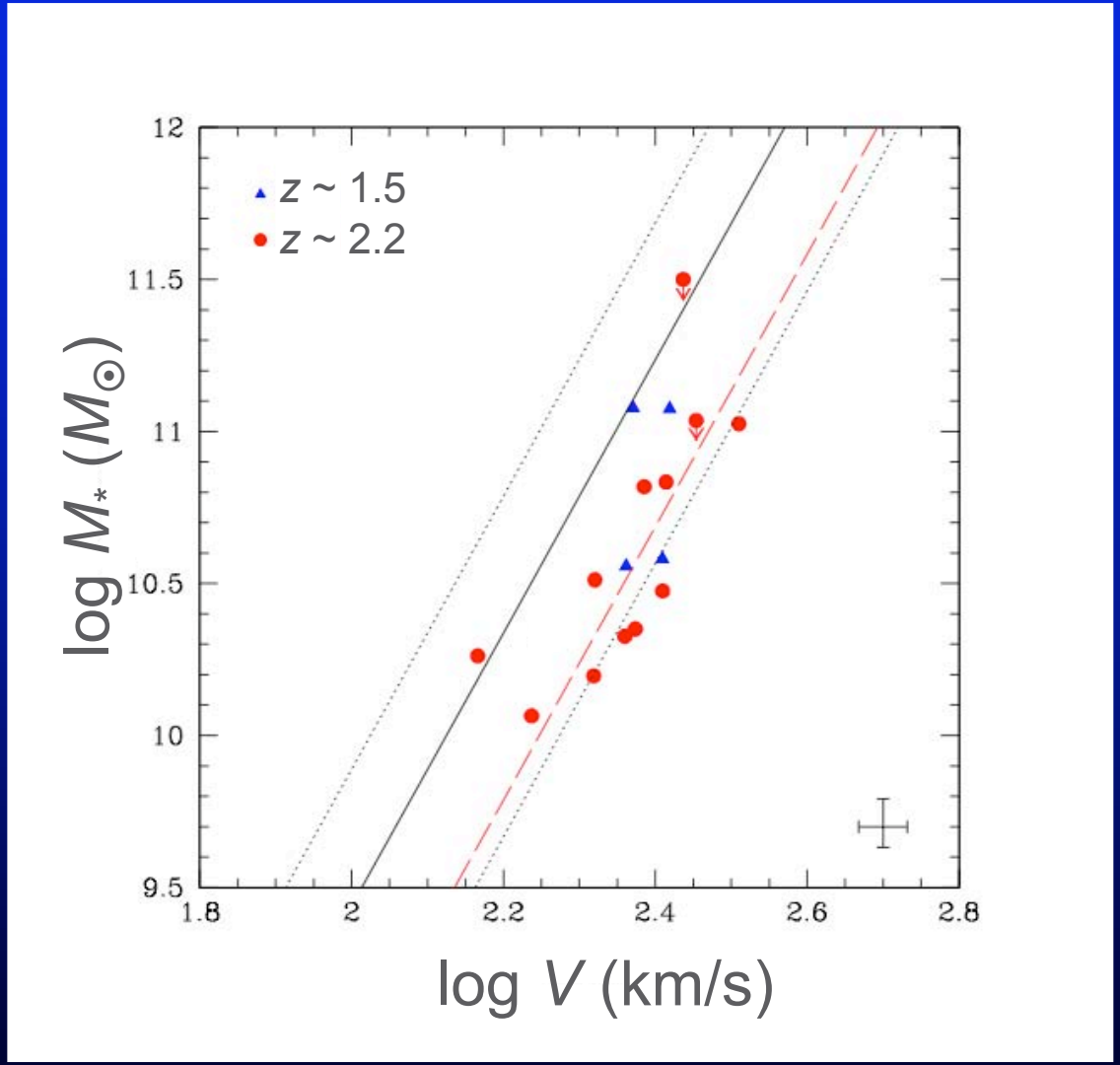


Genzel et al. 2008



Noguchi 1999, Immeli et al. 2004, Bournaud et al. 2007

Local scaling relations are appearing



Cresci et al. in prep

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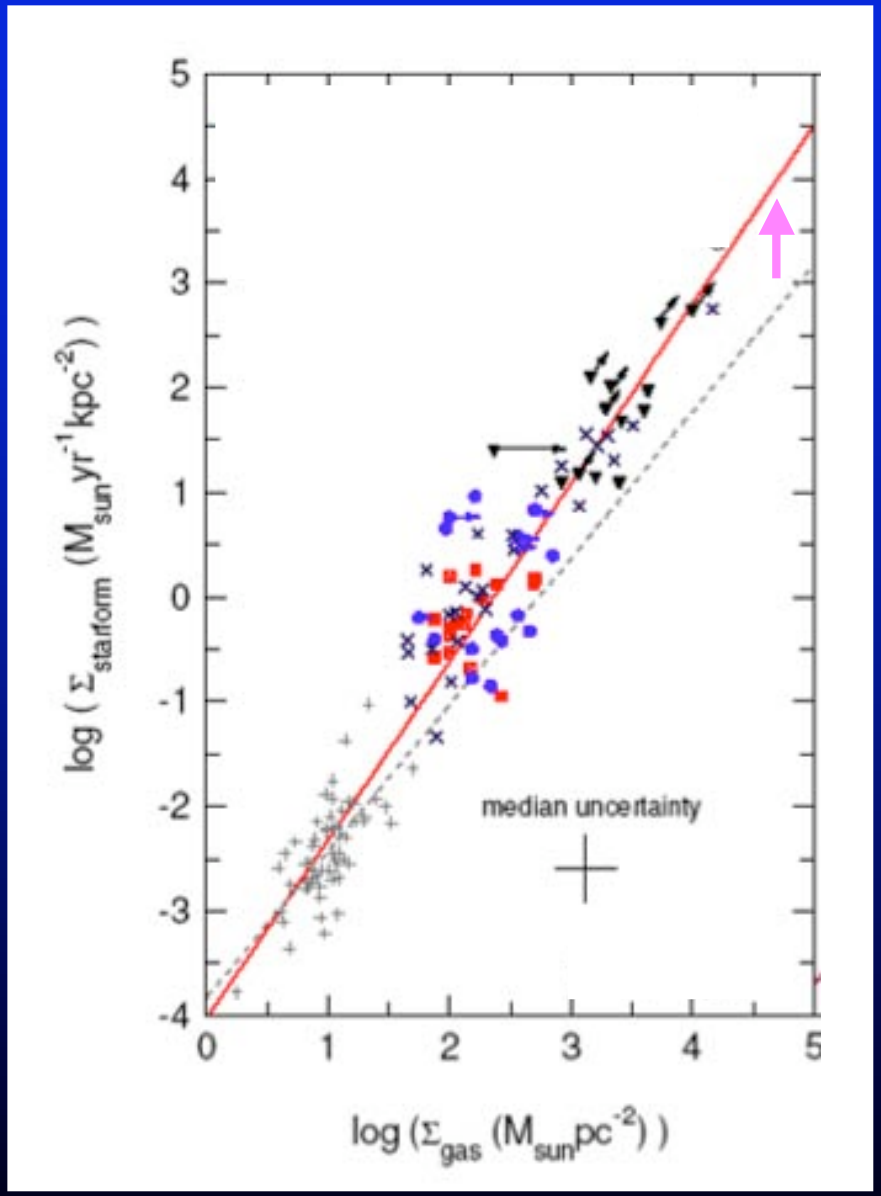
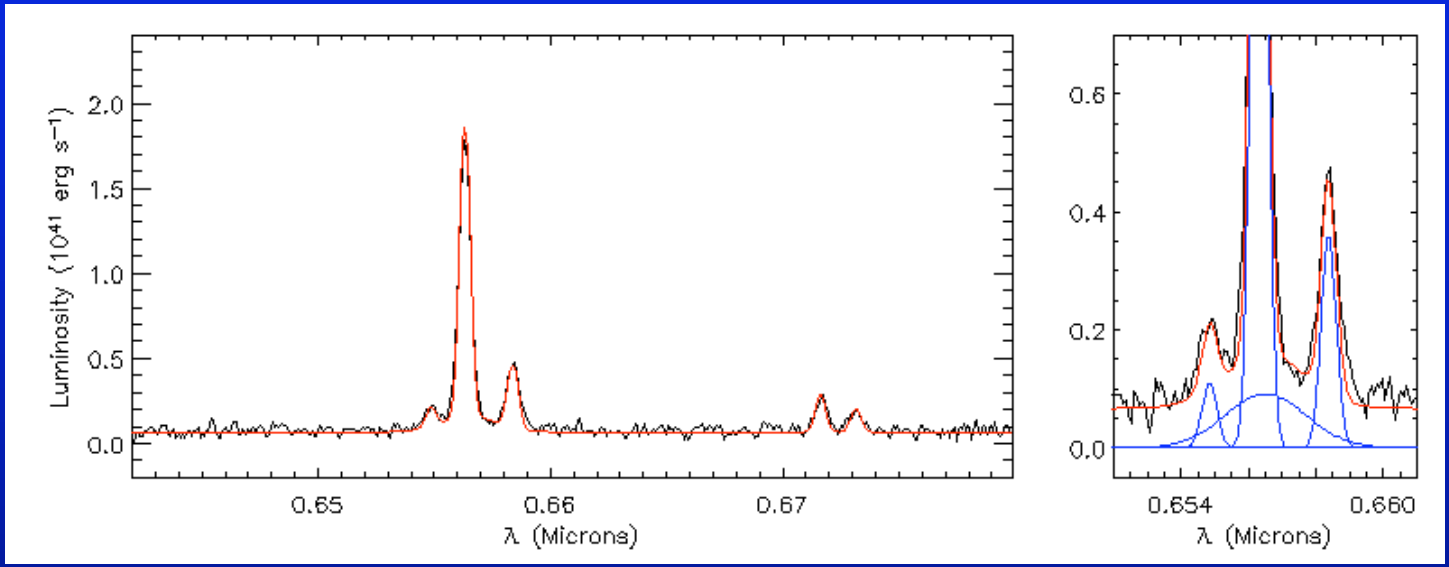
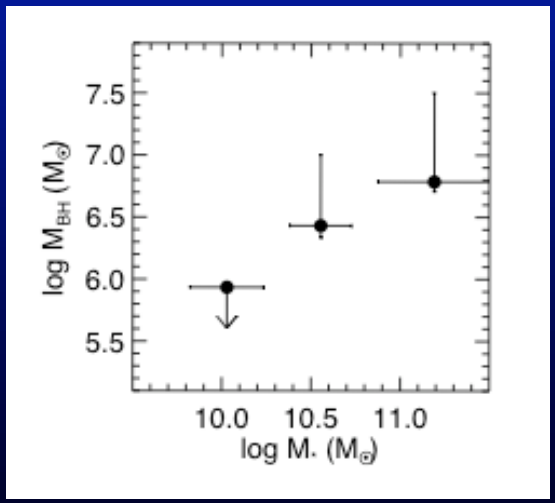


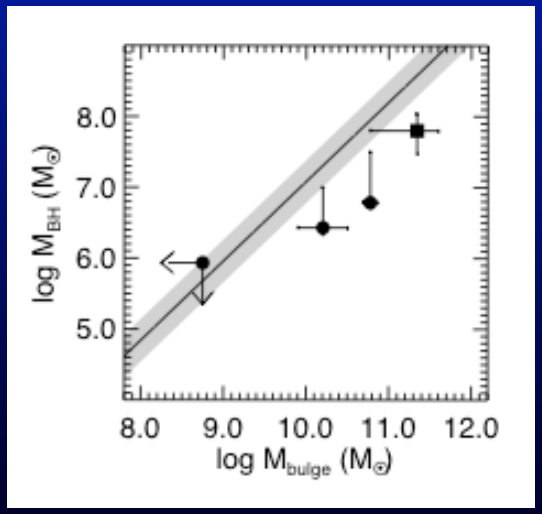
Bouché et al. 2007

… maybe even BH scaling relations



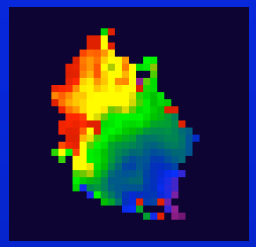


+ Genzel et al. 2008 dynamical modeling of bulge masses



Shapiro et al. in prep

Galaxy Assembly and Evolution at *z*~2



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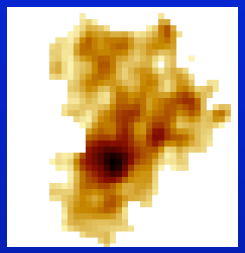

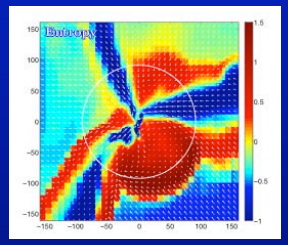

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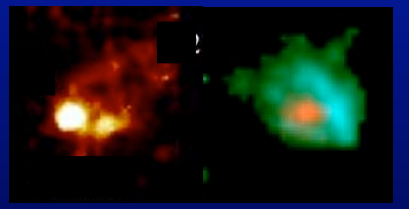

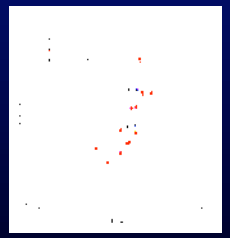

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