# Star Formation as a Function of Circular Velocity in Bulgeless Disk Galaxies

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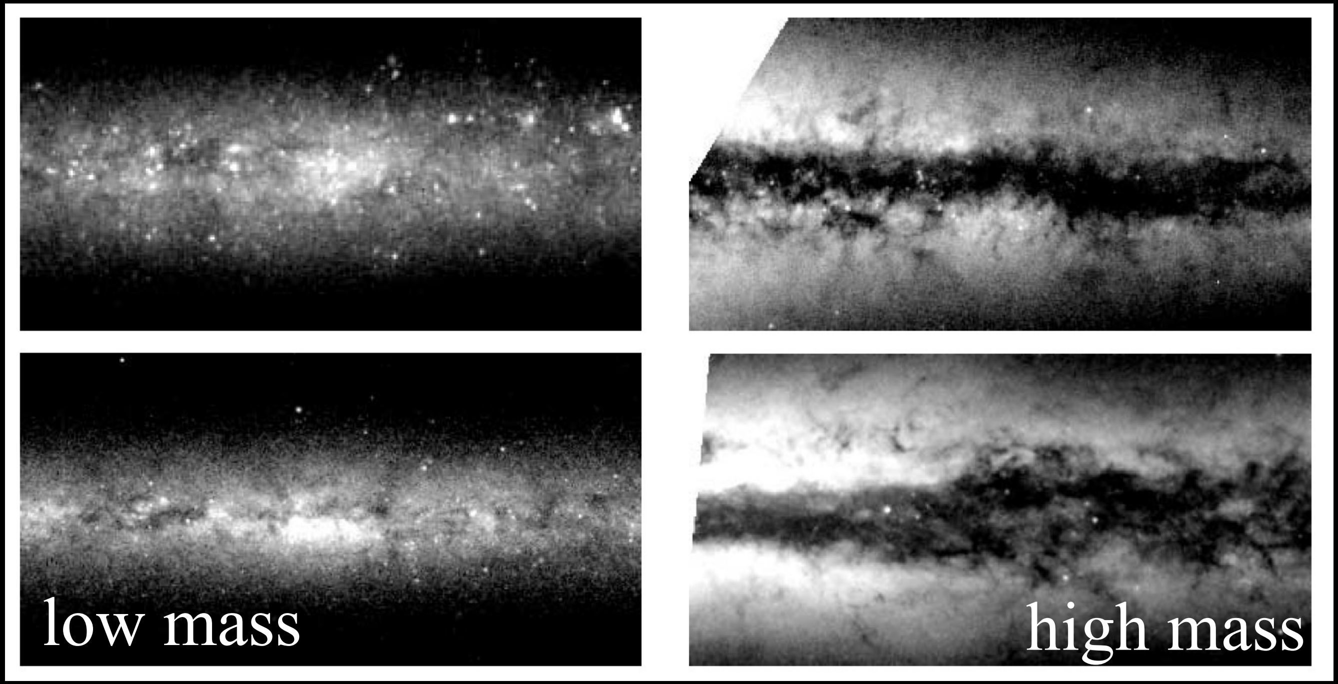
# Background: Dalcanton et al. (2004)

- Study of 49 edge-on, late-type disk galaxies
- Objects with $v_{circ}$ > 120 km/s (high mass) show well-defined dust lanes
- Objects with $v_{circ}$ < 120 km/s (low mass) show no dust lanes




Dalcanton et al. (2004)

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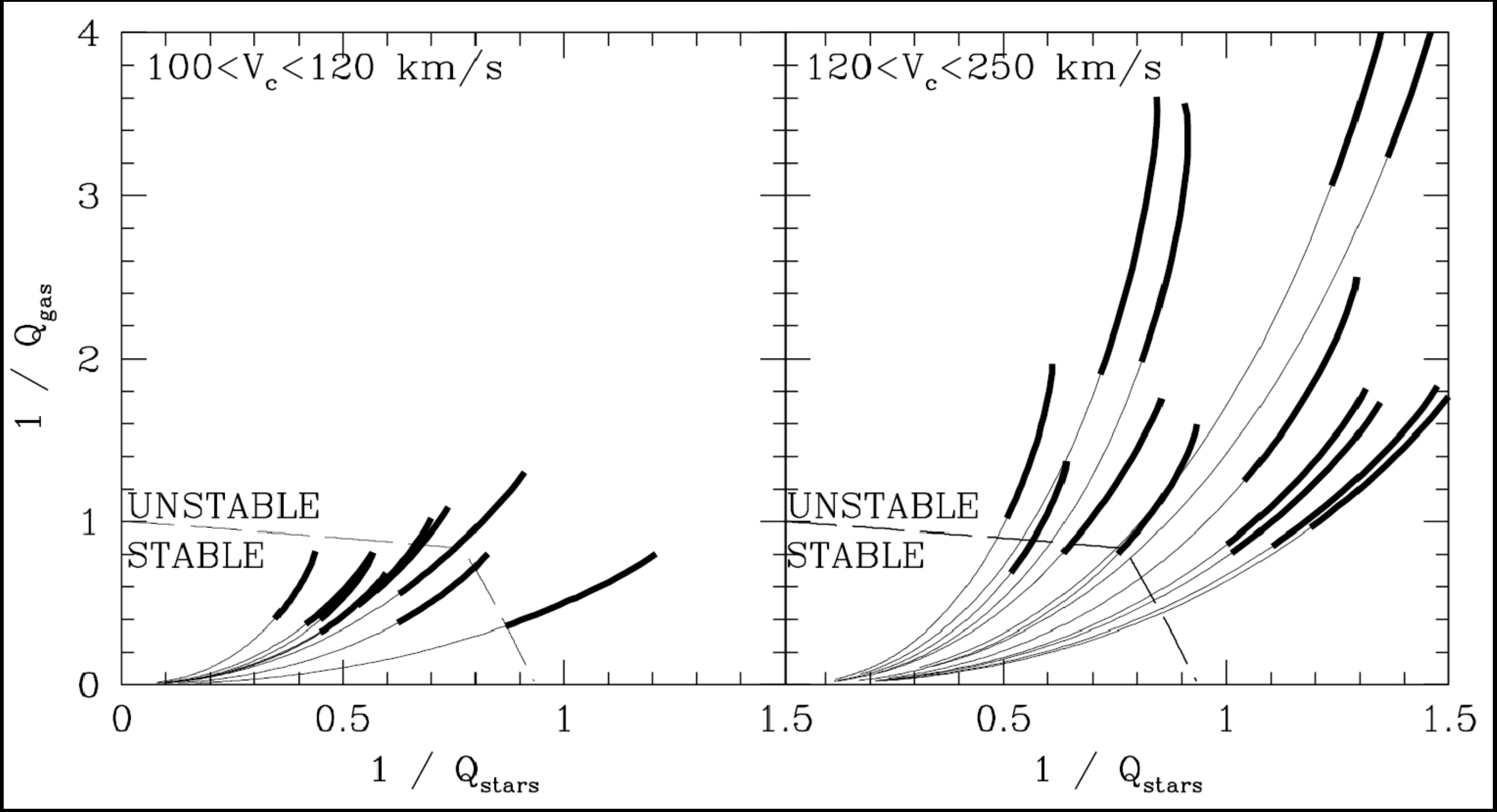



Dalcanton et al. (2004)

$$Q_i = \kappa\sigma_i/\pi G\Sigma_i$$

Q < 1: unstable

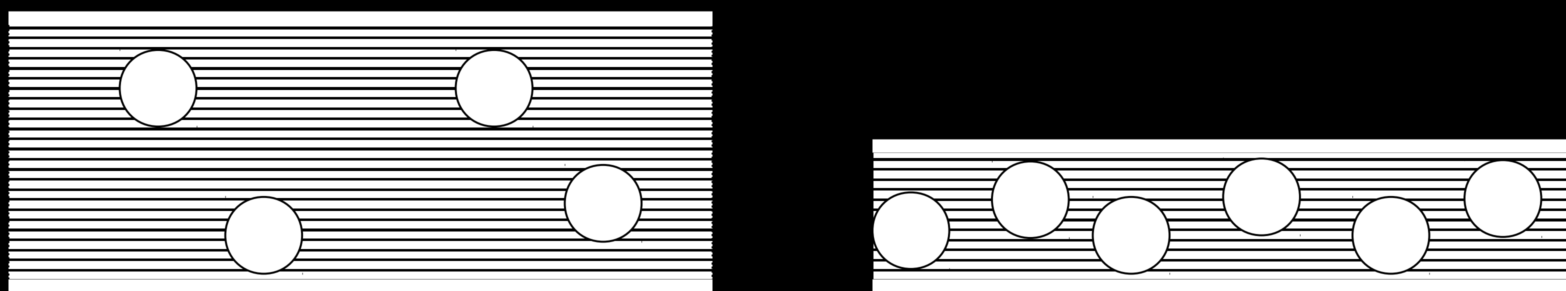
Q > 1: stable

# Motivation

Is there a transition in star formation efficiency at the dust and cold ISM scale height transition of $v_{circ}$ = 120 km/s?

# Motivation – Mid Plane Pressure Model

- Larger scale height → lower gas volume density → lower gas pressure → lower molecular fraction → lower SFR surface density

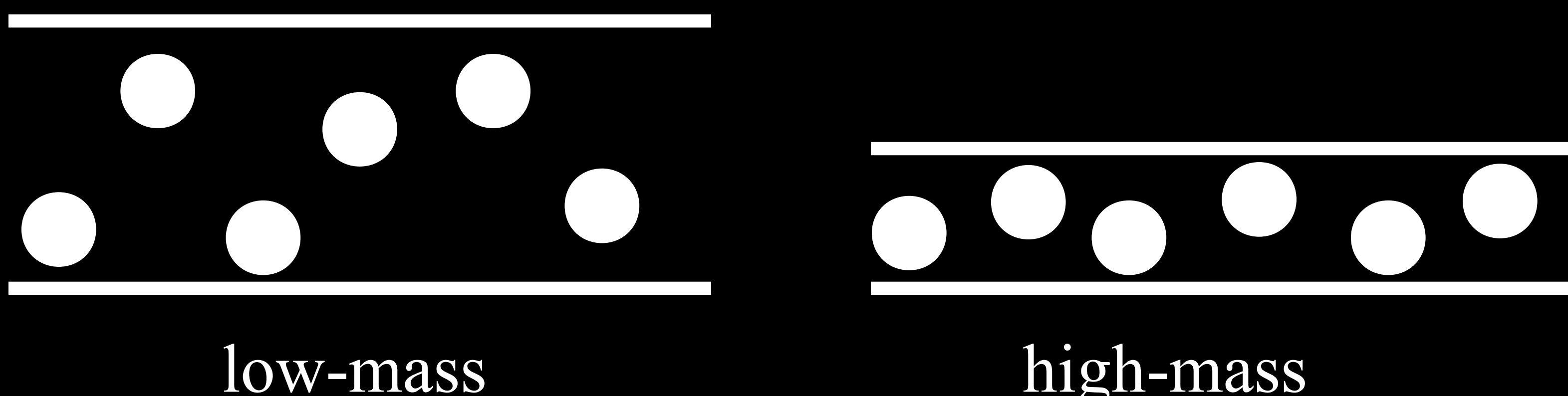


low-mass high-mass

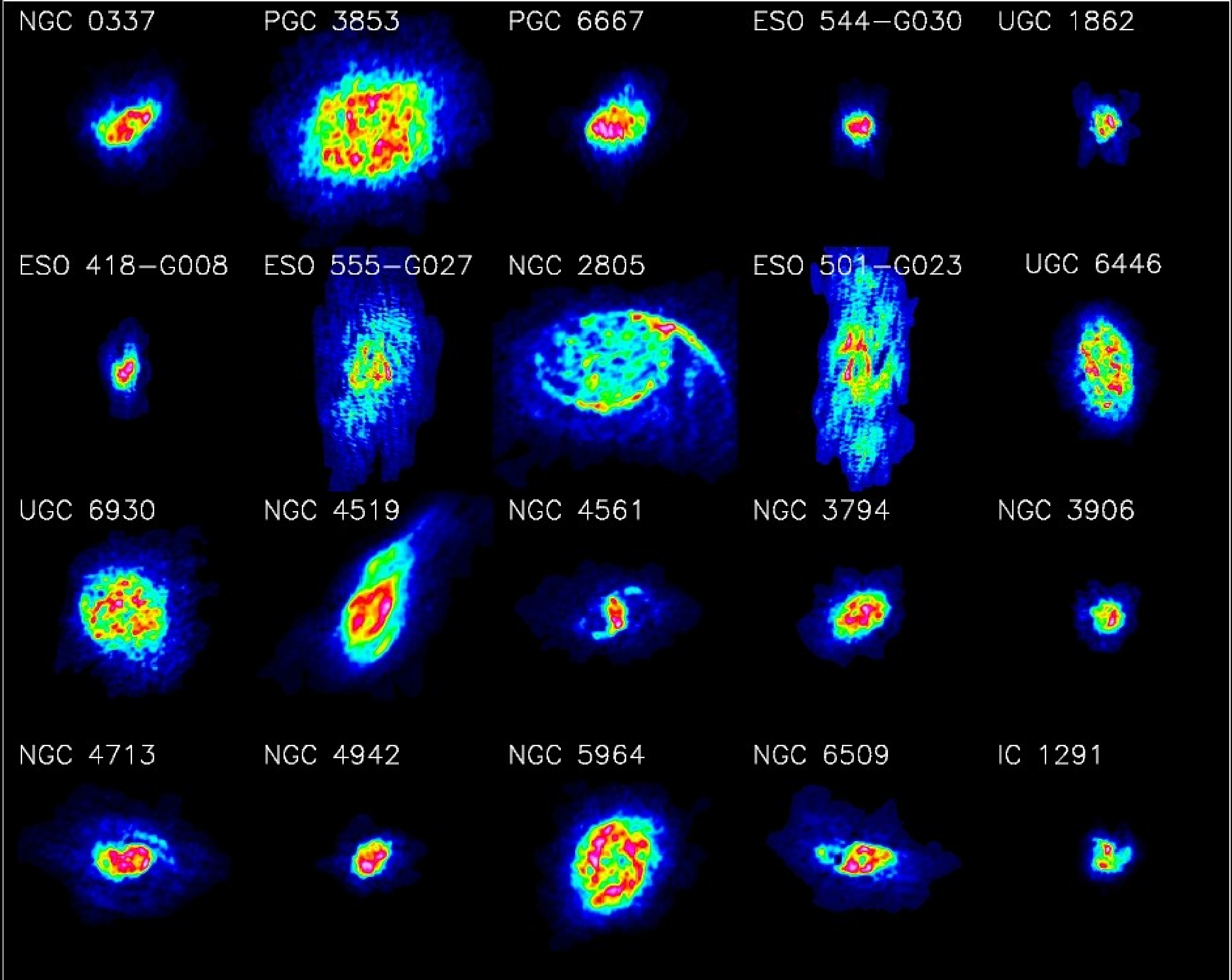
= Molecular cloud with constant molecular SFE

# Motivation – Krumholz et al. (2009) Model

- No obvious scale height dependence




= Atomic-molecular complex with constant molecular SFE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PGC 6667
ESO 544-G030
UGC 1862
ESO 418-G008
ESO 555-G027
NGC 2805
ESO 501-G023
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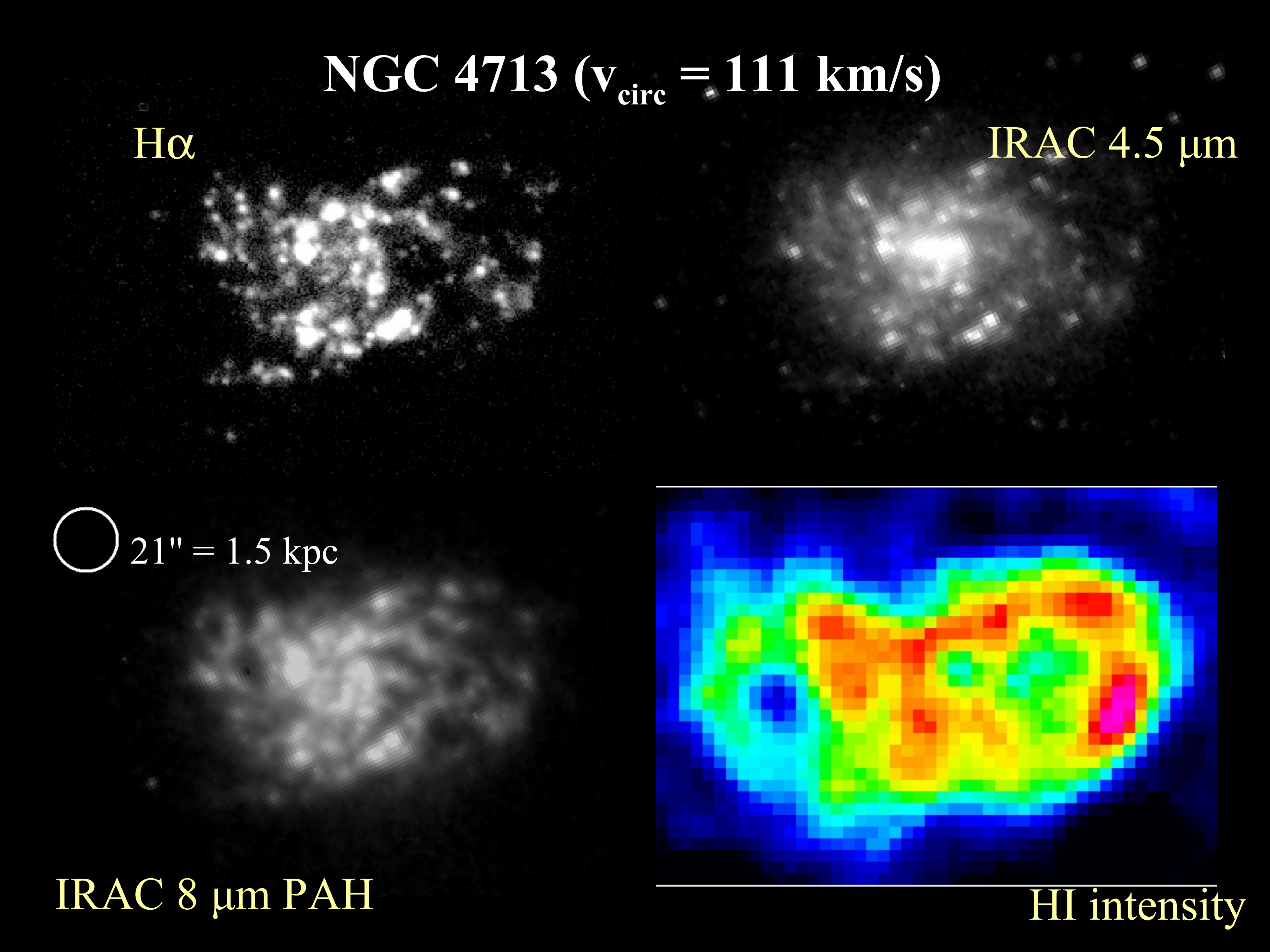
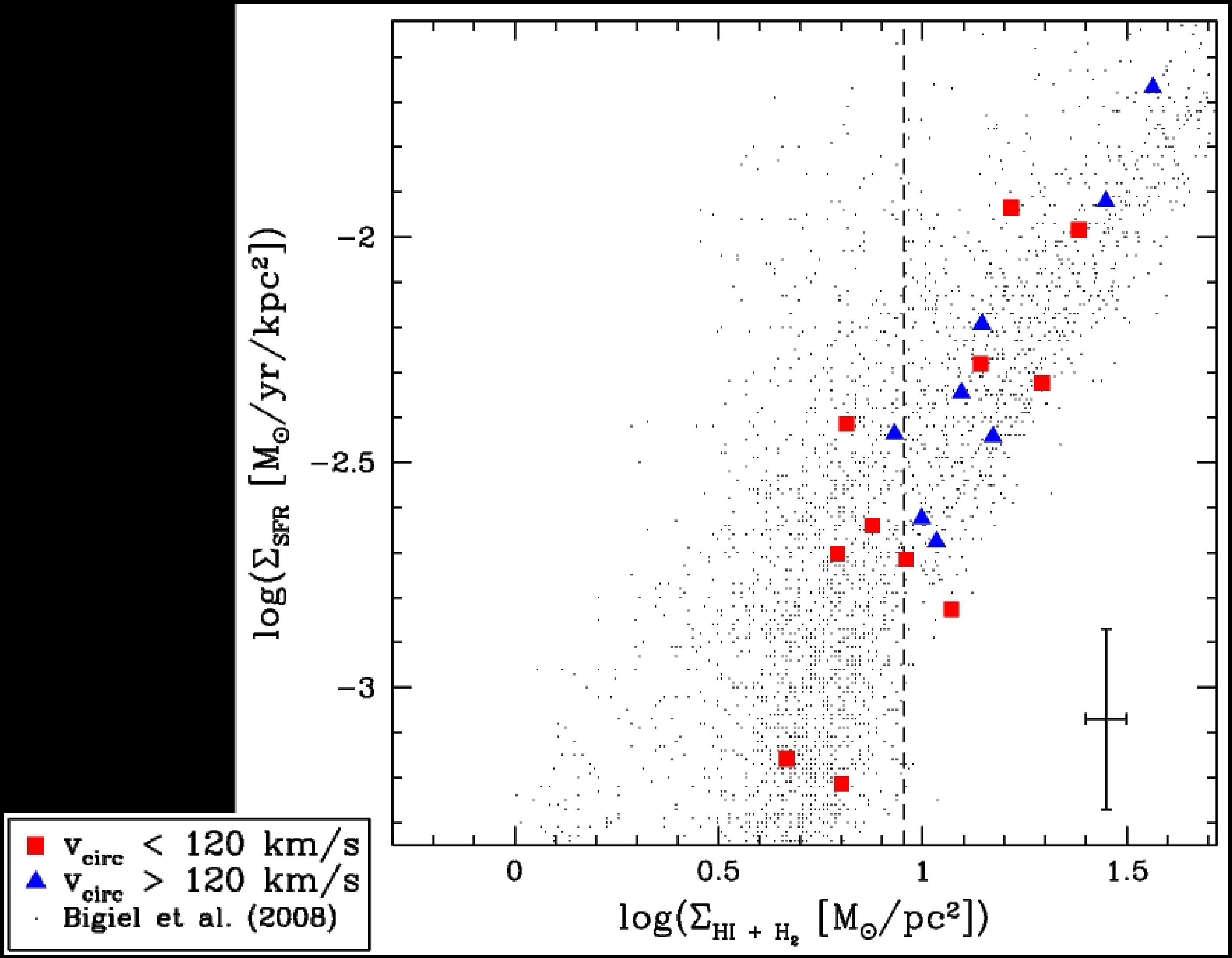
UGC 6930
NGC 4519
NGC 4561
NGC 3794
NGC 3906
NGC 4713
NGC 4942
NGC 5964
NGC 6509
IC 1291

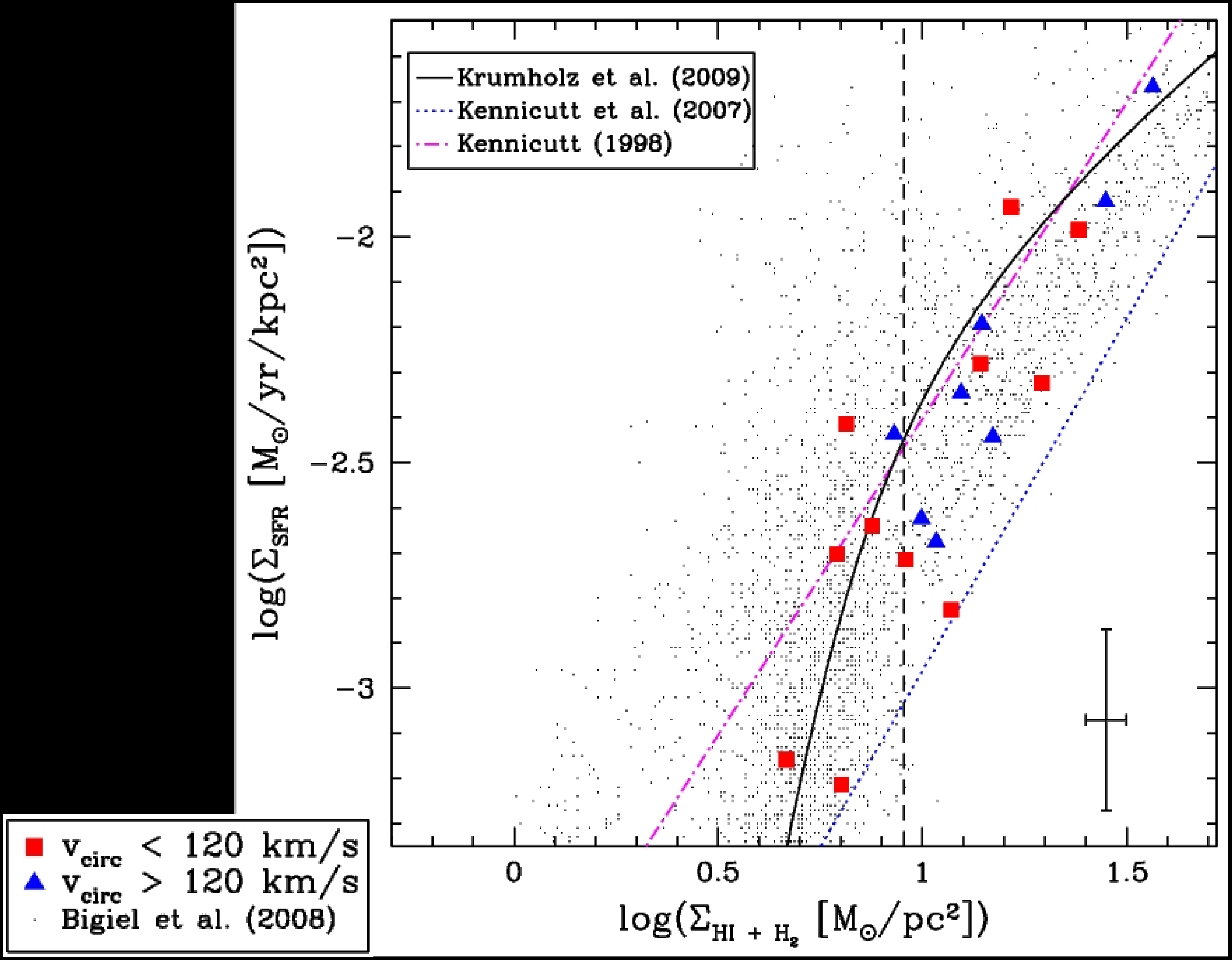

NGC 4713 ($v_{circ}$ = 111 km/s)
Hα
IRAC 4.5 μm
21" = 1.5 kpc
IRAC 8 μm PAH
HI intensity

# Star Formation Relation – Total Gas



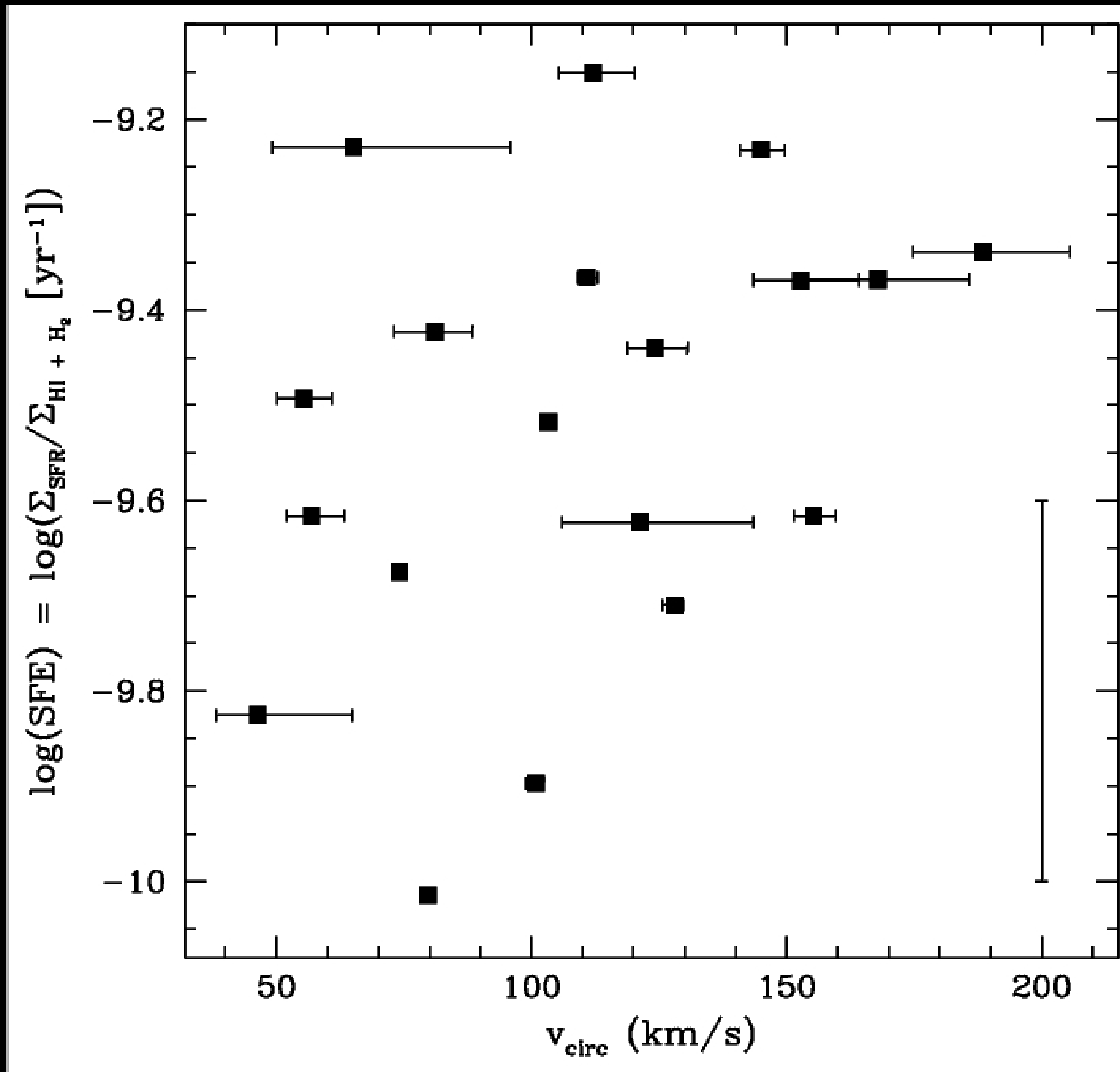

Watson et al. (2012)

# Star Formation Relation – Total Gas




Watson et al. (2012)

# No Star Formation Transition at Any Circular Velocity

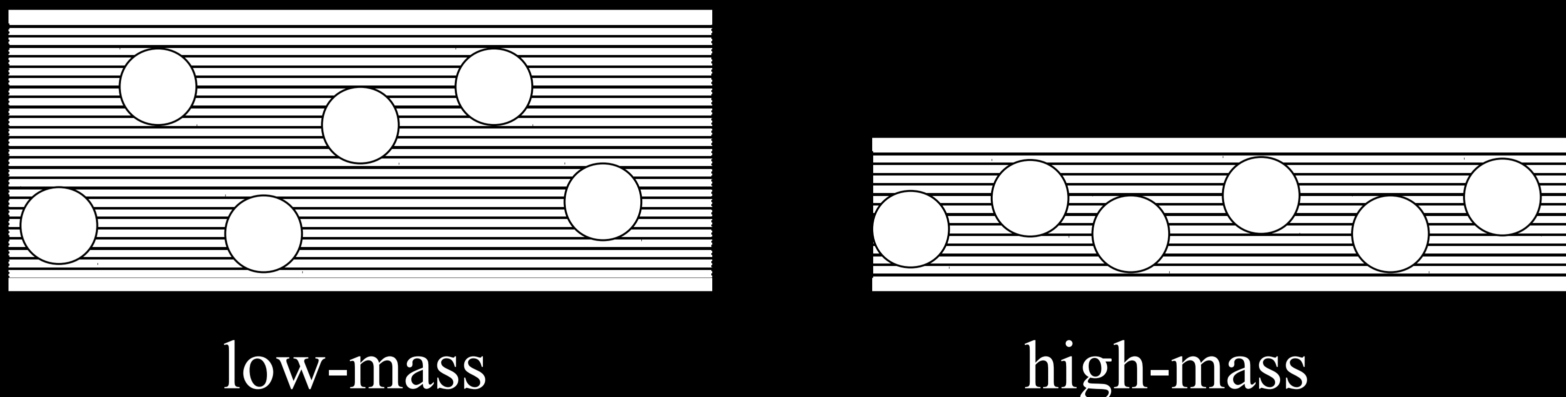


# Consequences of Star Formation Relation Results

- We find no transition in star formation efficiency at $v_{circ}$ = 120 km/s, or at any circular velocity probed by our sample

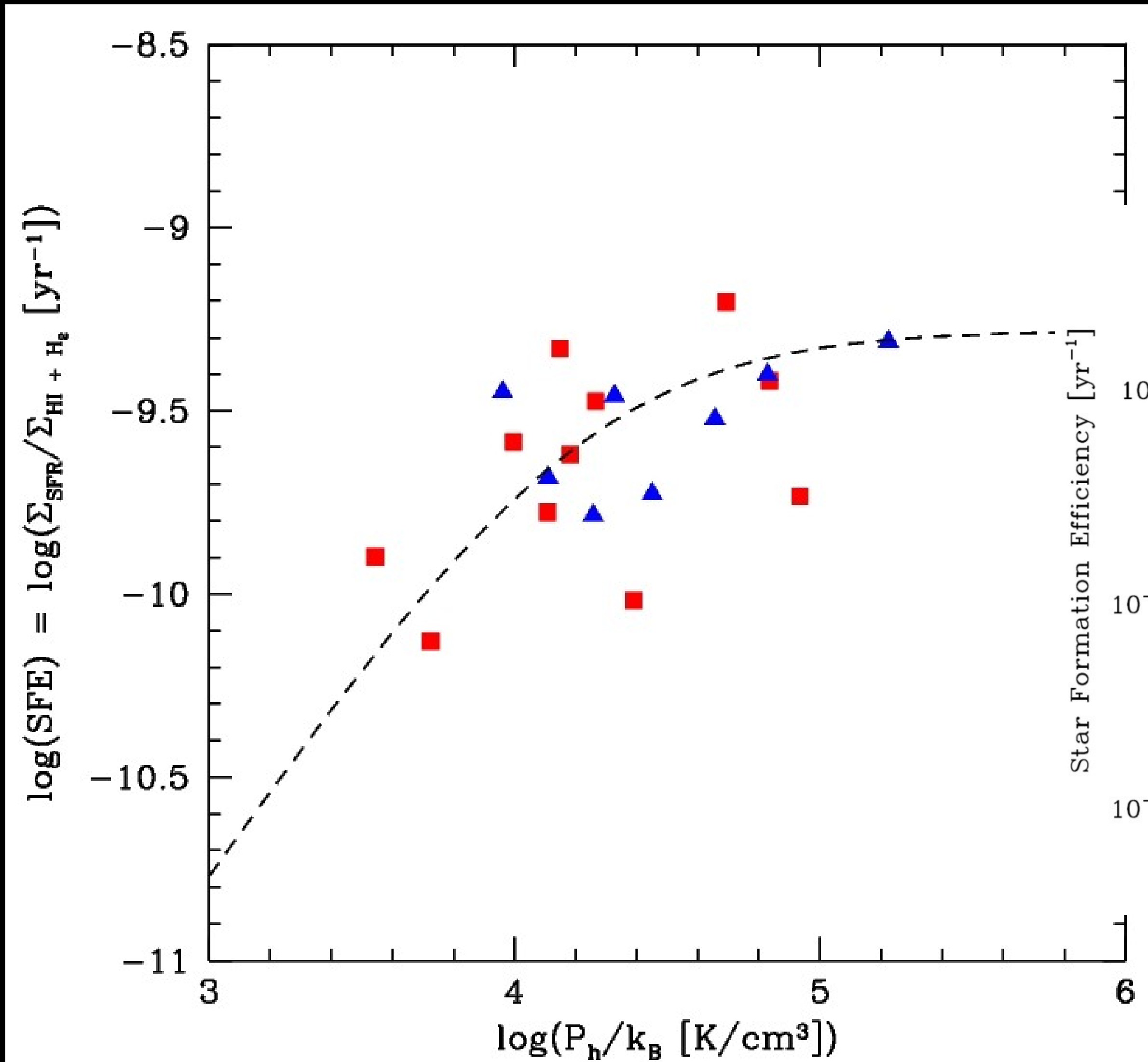
- Differences in the scale height of the dust and cold gas at the level found by Dalcanton et al. (~factor of 2 level) do not affect the molecular fraction or star formation efficiency

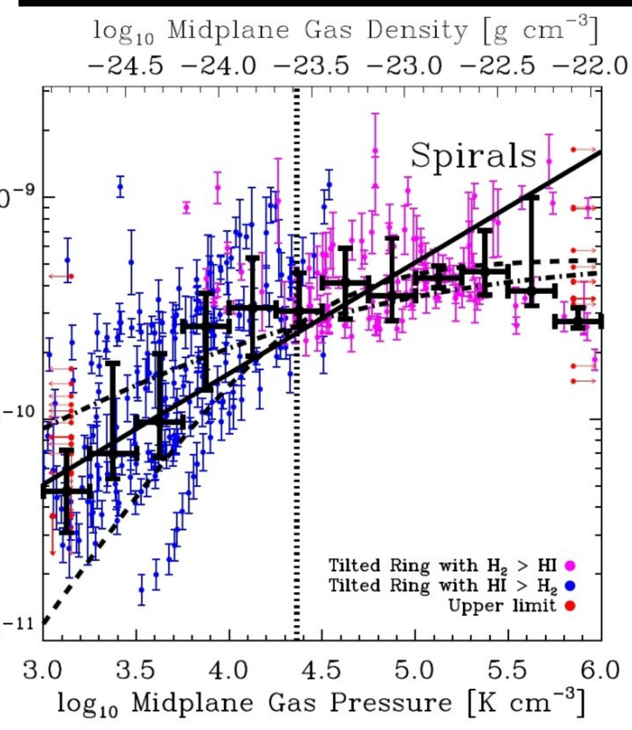
- Our results suggest that star formation is affected by physical processes that act on smaller scales than the tens of parsecs probed by dust scale heights




○ = Molecular cloud with constant molecular SFE

# Comparison to Mid-Plane Pressure Model



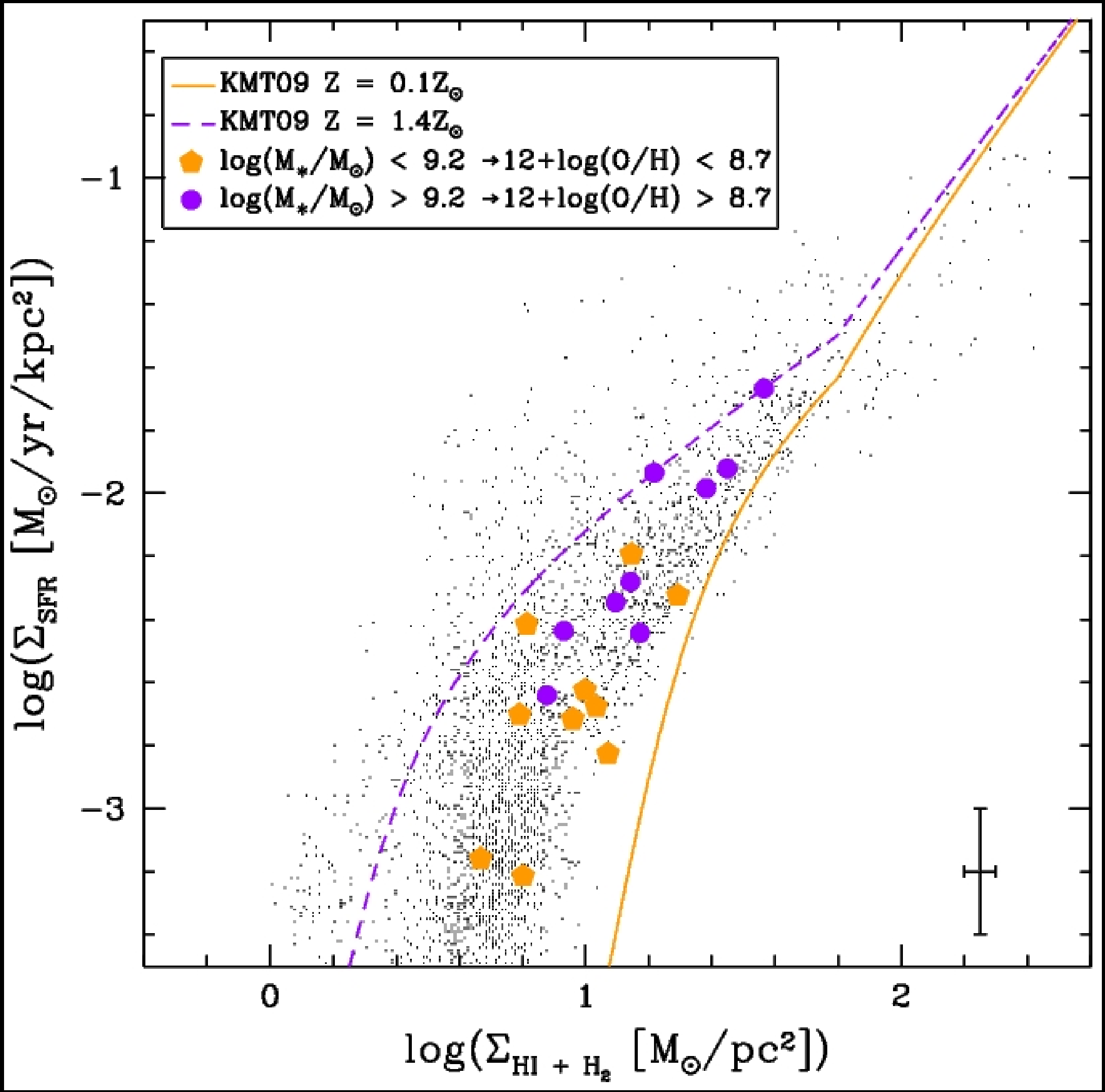




Leroy et al. (2008)

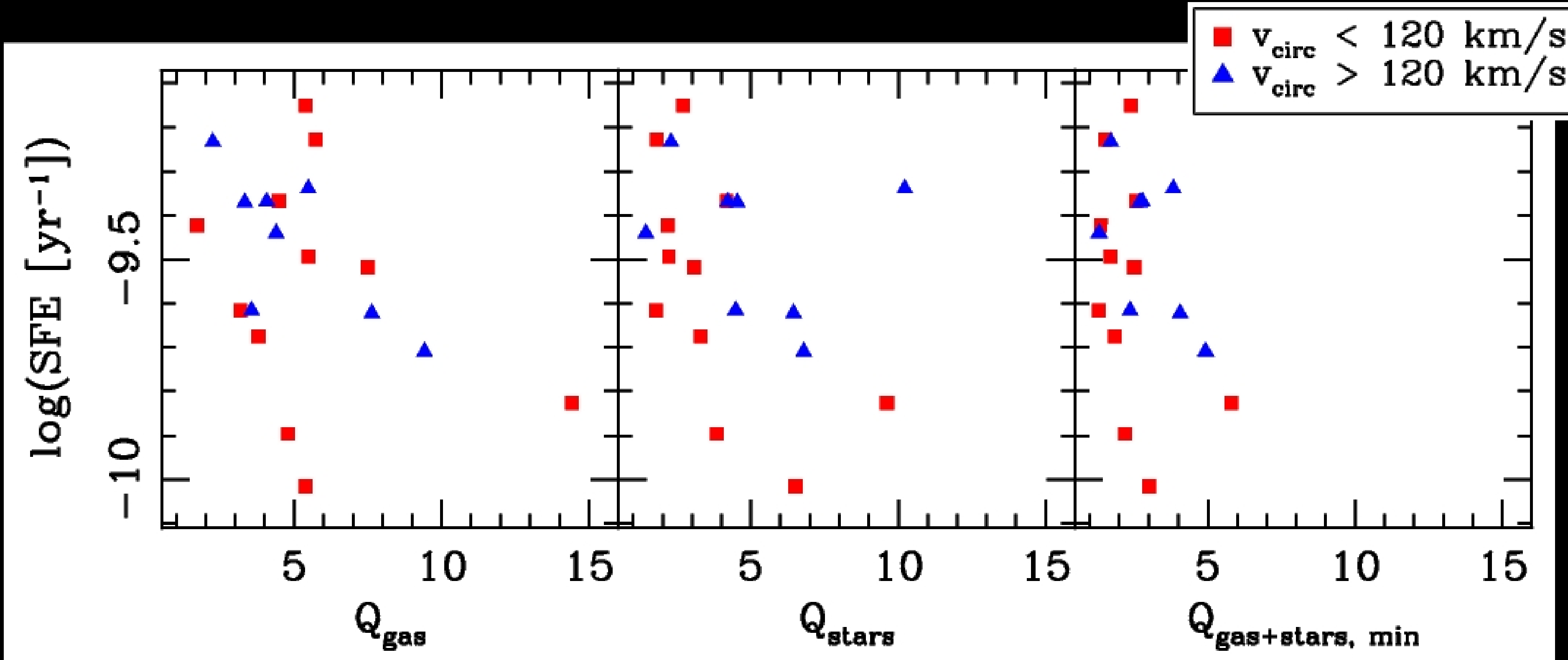
$$P_{\rm h} \approx \frac{\pi}{2} G\, \Sigma_{\rm gas}\left(\Sigma_{\rm gas} + \frac{\sigma_{\rm gas}}{\sigma_{*,z}}\,\Sigma_*\right)$$

■ $v_{circ}$ < 120 km/s
▲ $v_{circ}$ > 120 km/s

# Comparison to Krumholz et al. (2009) Model



# No Stability Transition at $v_{circ}$ = 120 km/s




$$Q_{\rm gas} = \frac{\kappa \sigma_{\rm gas}}{\pi G \Sigma_{\rm gas}}$$

$$Q_{\rm stars} = \frac{\kappa \sigma_{*,\rm r}}{\pi G \Sigma_{*}}$$

Q < 1: unstable

Q > 1: stable

# Summary

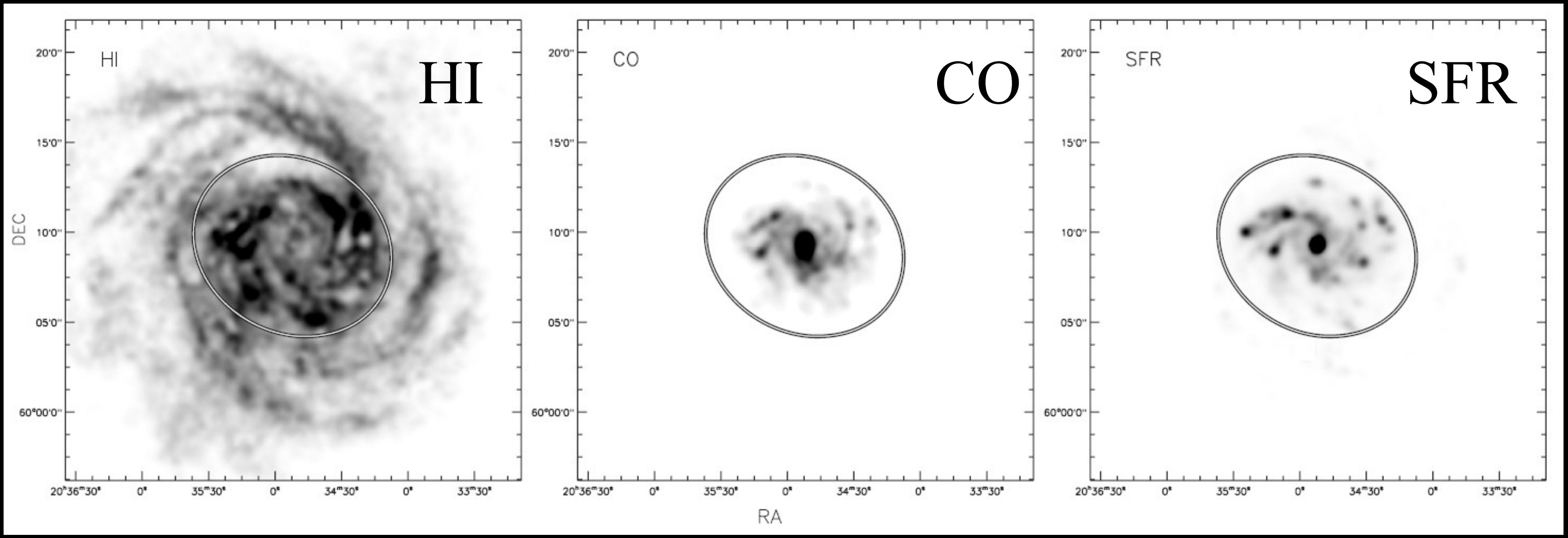
- We find no transition in star formation efficiency or stability at $v_{circ}$ = 120 km/s, or at any circular velocity probed by our sample

- Differences in the scale height of the dust and cold gas at the level found by Dalcanton et al. do not affect the molecular fraction or star formation efficiency

- Our results may indicate that star formation is affected by physical processes that act on smaller scales than the tens of parsecs probed by dust scale heights

- Our results are somewhat more consistent with the Krumholz et al. (2009) star formation model than the mid-plane pressure model

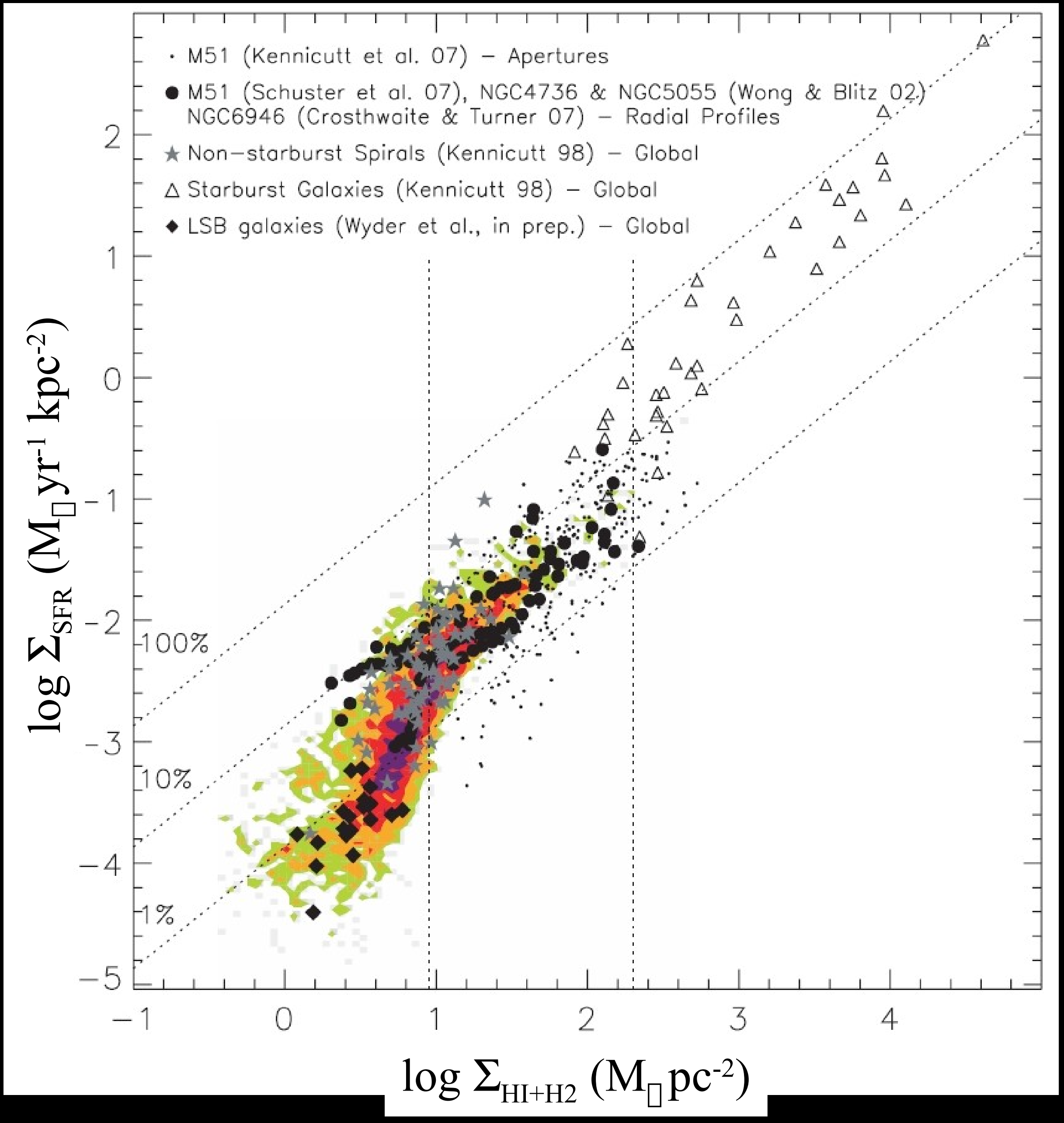
# The Important Players in Star Formation




Bigiel et al. (2008)

- What physical processes are important for determining the star formation rate (SFR) in galaxies?

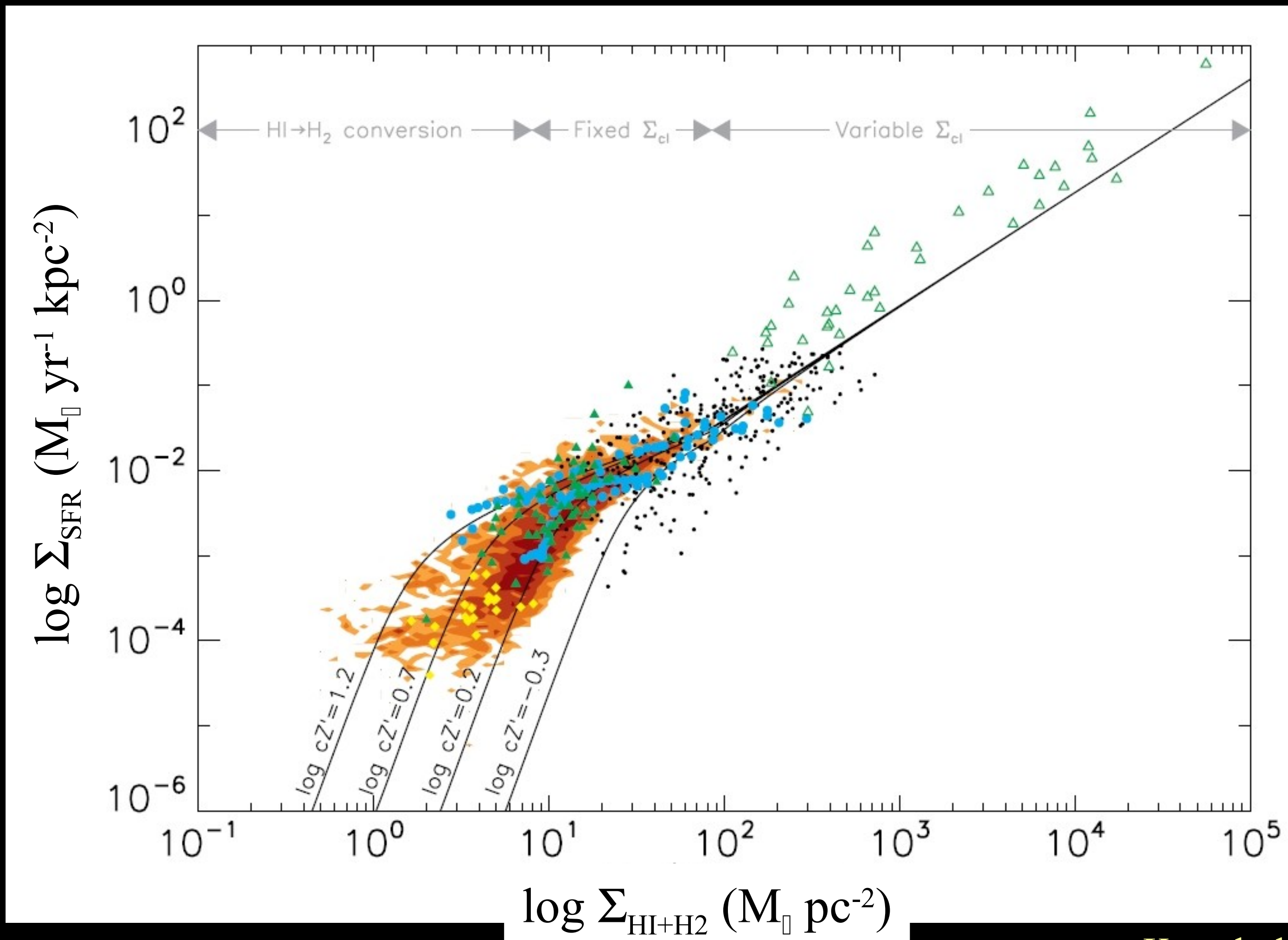
# The Kennicutt-Schmidt Relation




Bigiel et al. (2008)

# Star Formation Models

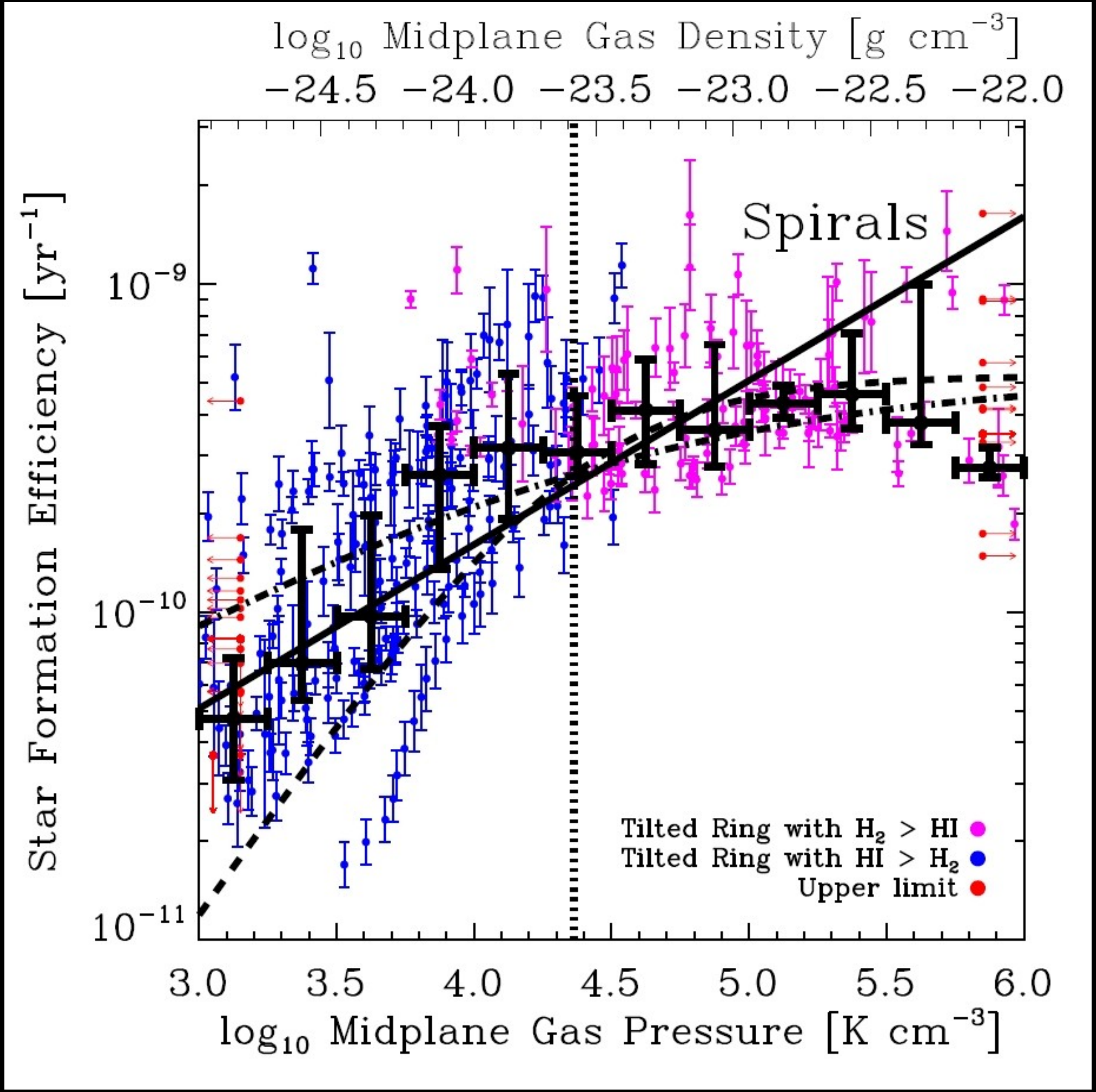
Balance between the creation and destruction of molecular hydrogen:




Krumholz et al. (2009)

# Star Formation Models

Mid-plane gas pressure sets the molecular fraction:




Leroy et al. (2008)

# The Data

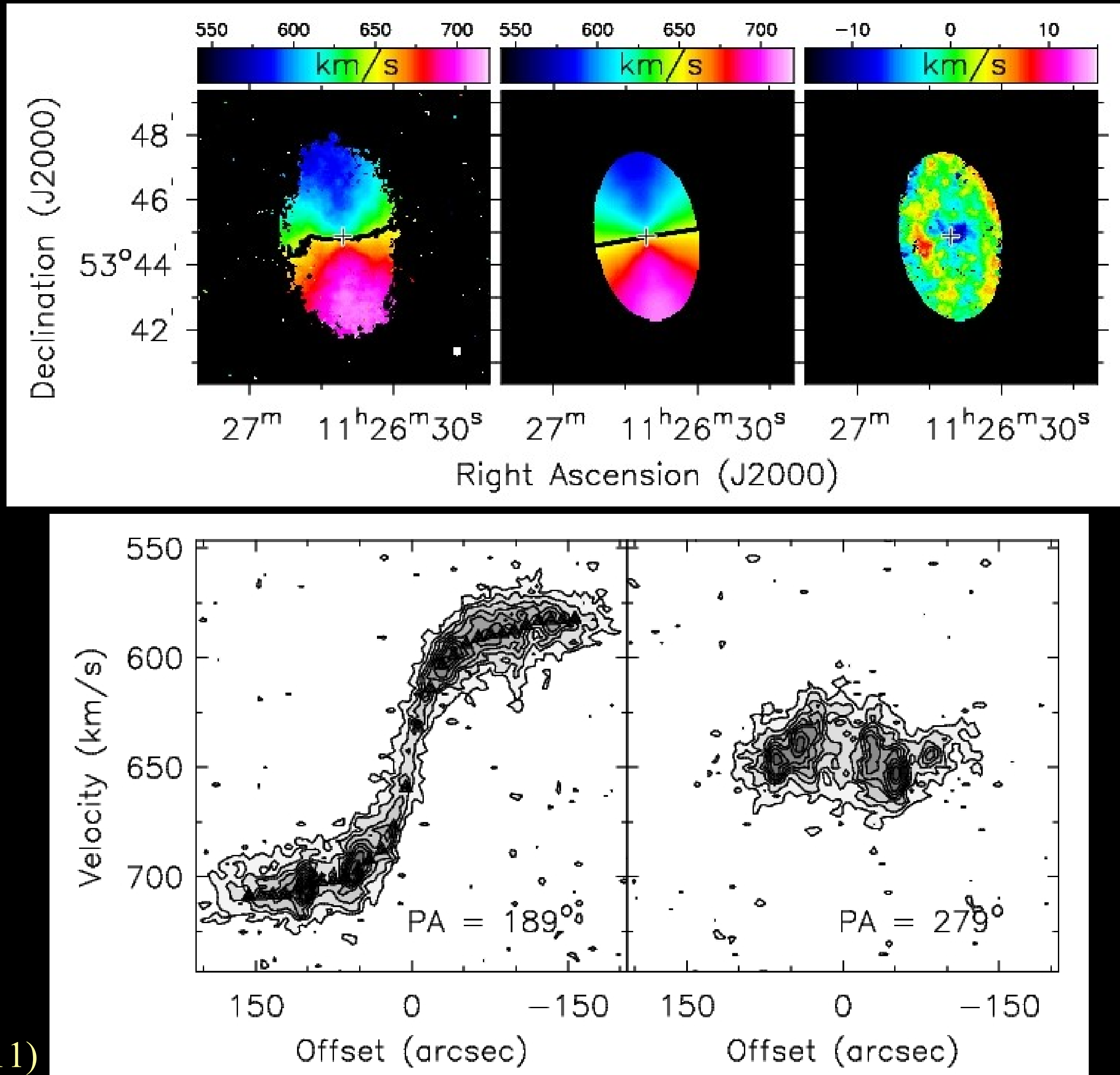
- Sample: 20 nearby, moderately inclined, bulgeless disk galaxies

- Gas surface density ($\Sigma_{gas}$):
  - $\Sigma_{HI}$ from VLA 21 cm data
  - $\Sigma_{H_2}$ from IRAM 30m CO J=1-0 2.6 mm data

- Star formation rate surface density ($\Sigma_{SFR}$):
  - MDM 2.4m H$\alpha$ data
  - Spitzer IRAC PAH (8 μm) data

- Stellar mass and estimated oxygen abundance:
  - Spitzer IRAC 4.5 μm data

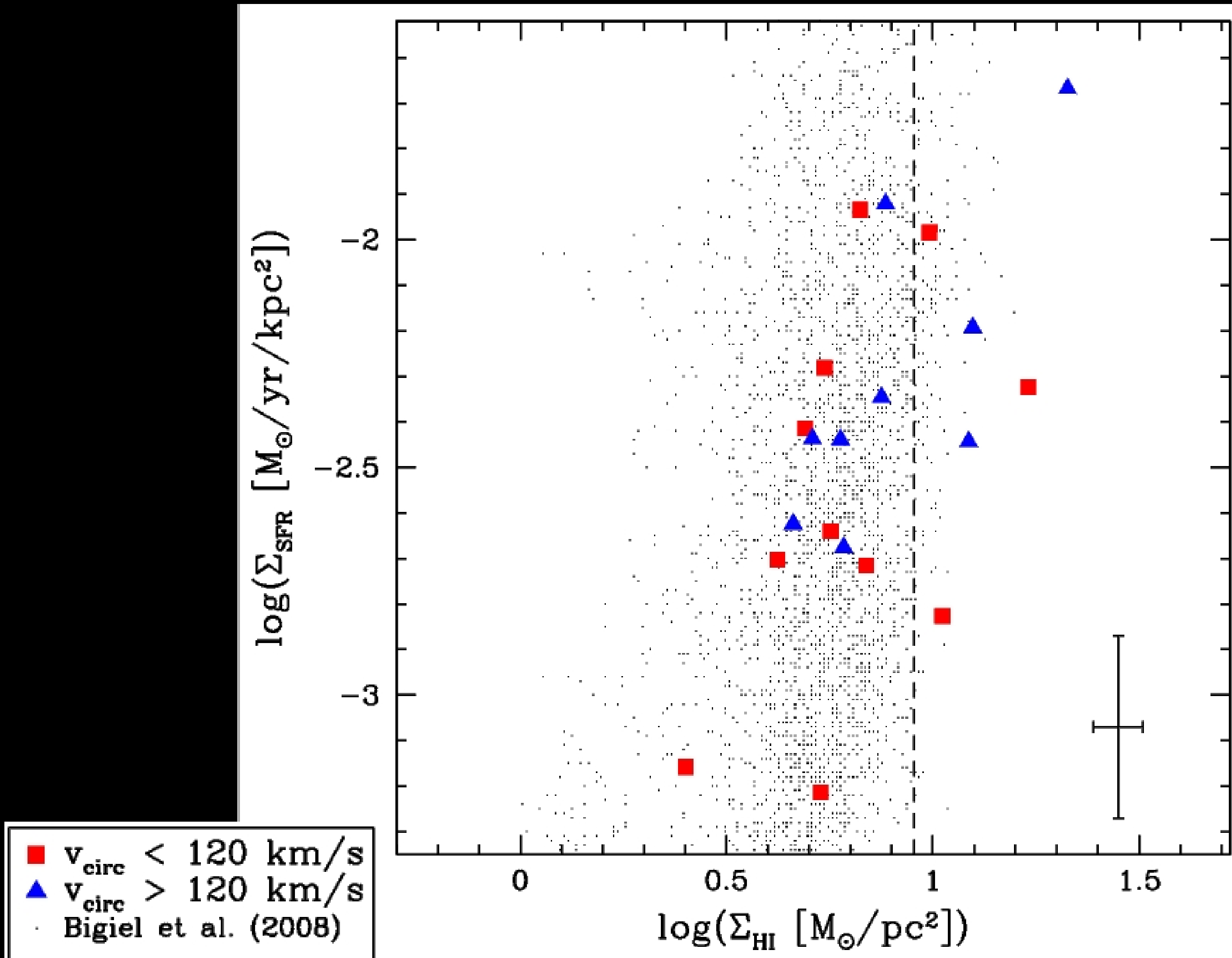
# Deriving Circular Velocities



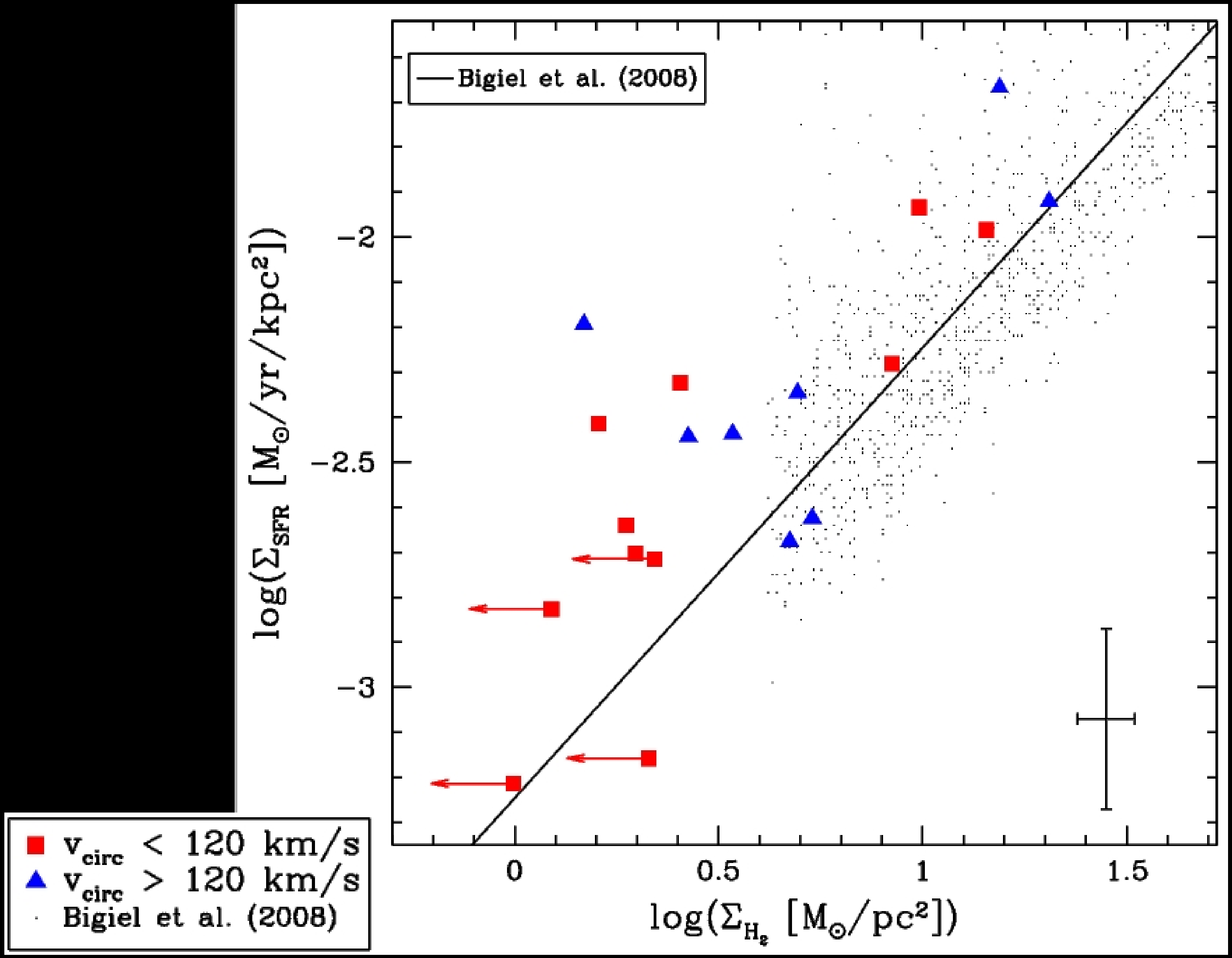

Watson et al. (2011)

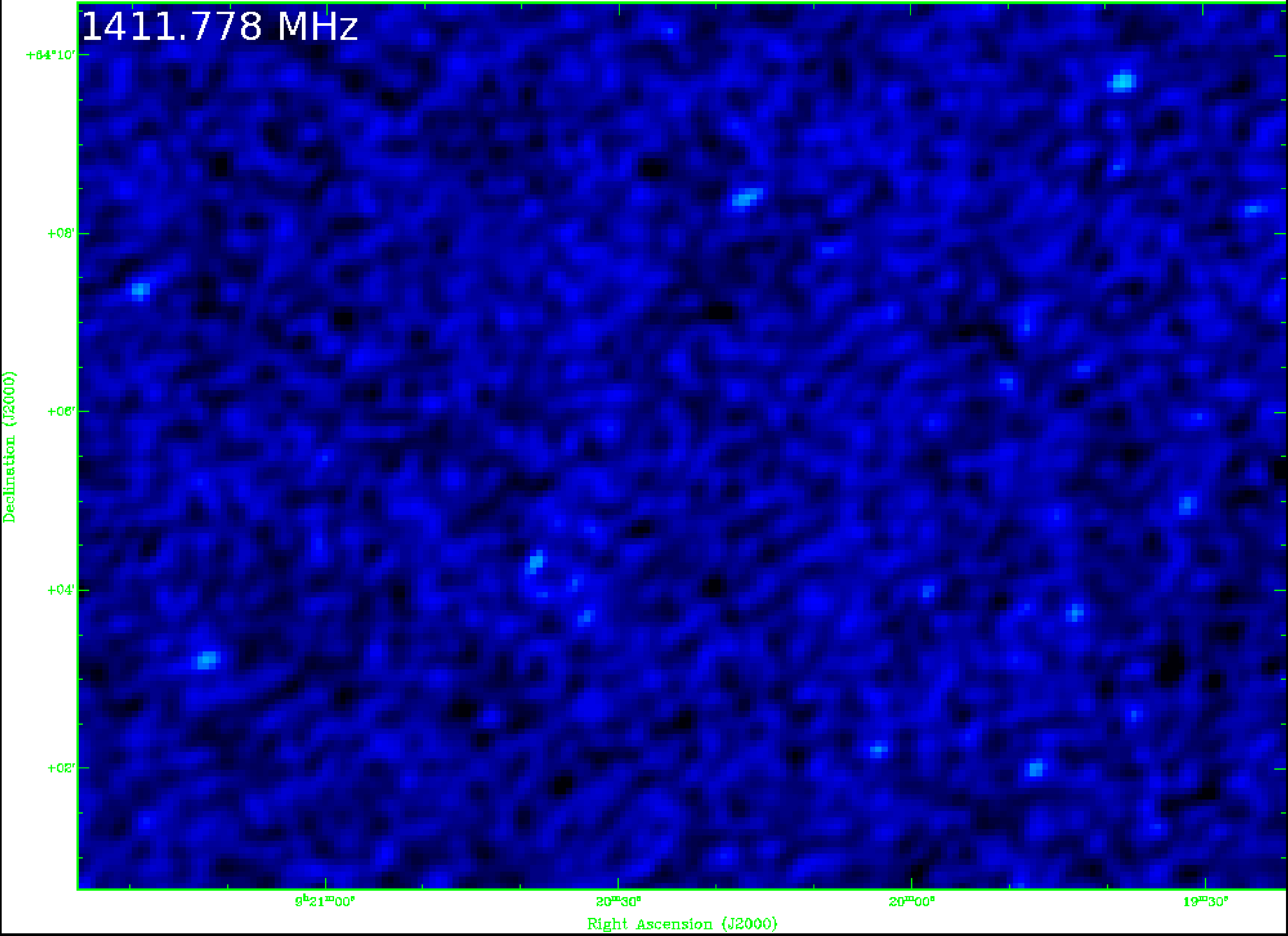
UGC 6446

# Star Formation Relation – Atomic Gas



# Star Formation Relation – Molecular Gas

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+08'
+06'
+04'
+02'
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20m30s
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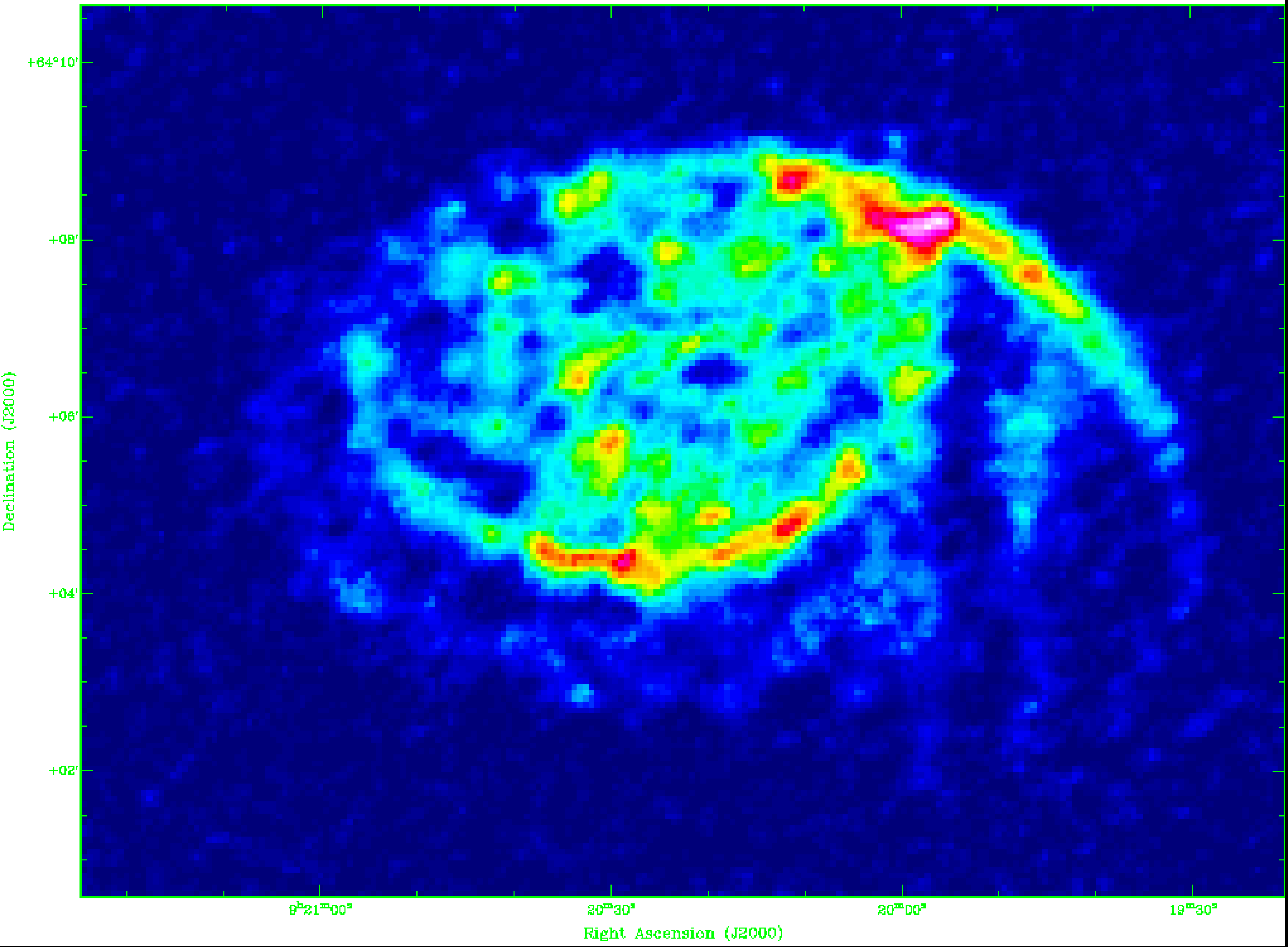
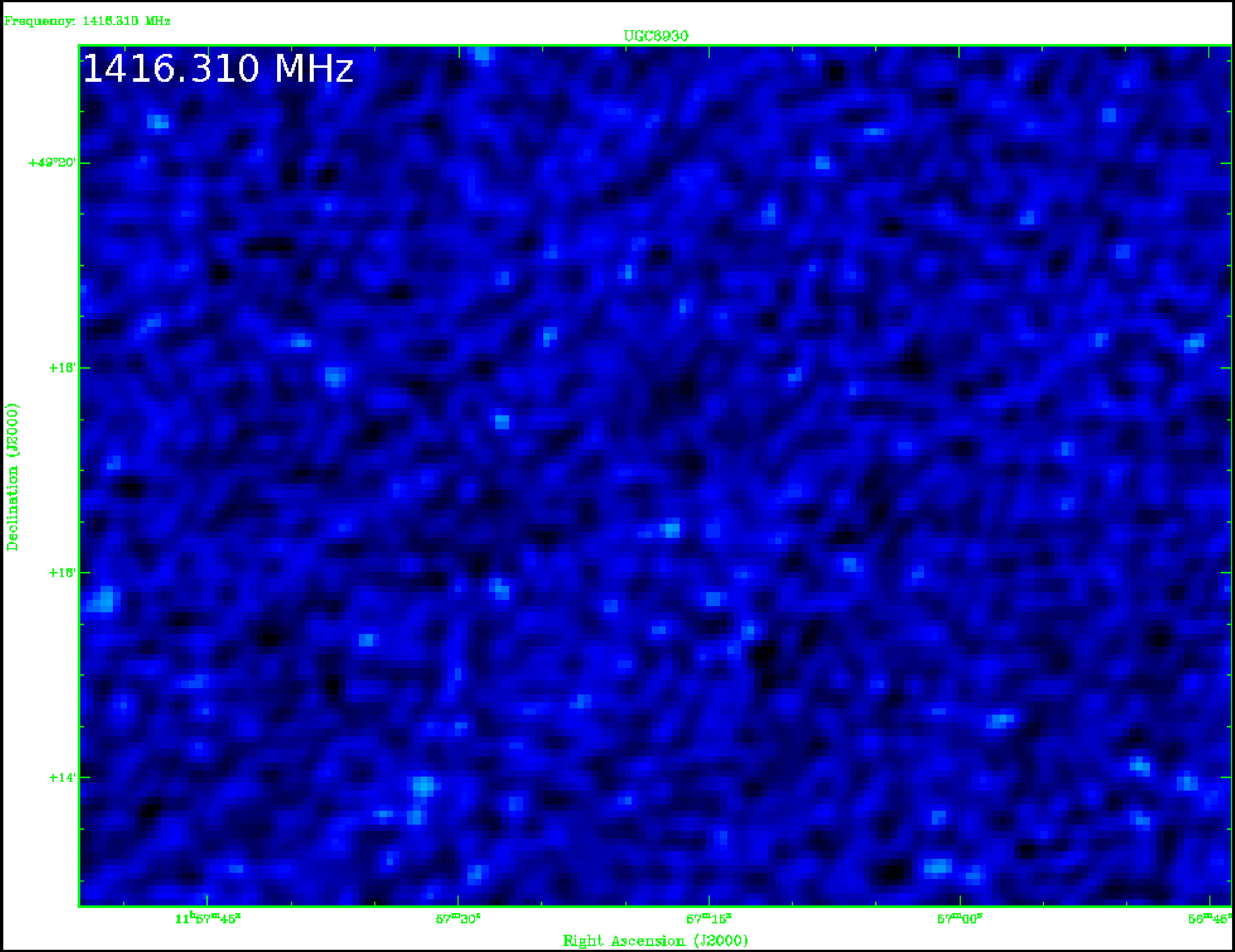
19m30s
Right Ascension (J2000)



+64°10'
+08'
+06'
+04'
+02'
Declination (J2000)
9h21m00s
20m30s
20m00s
19m30s
Right Ascension (J2000)



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UGC6930
1416.310 MHz
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+18'
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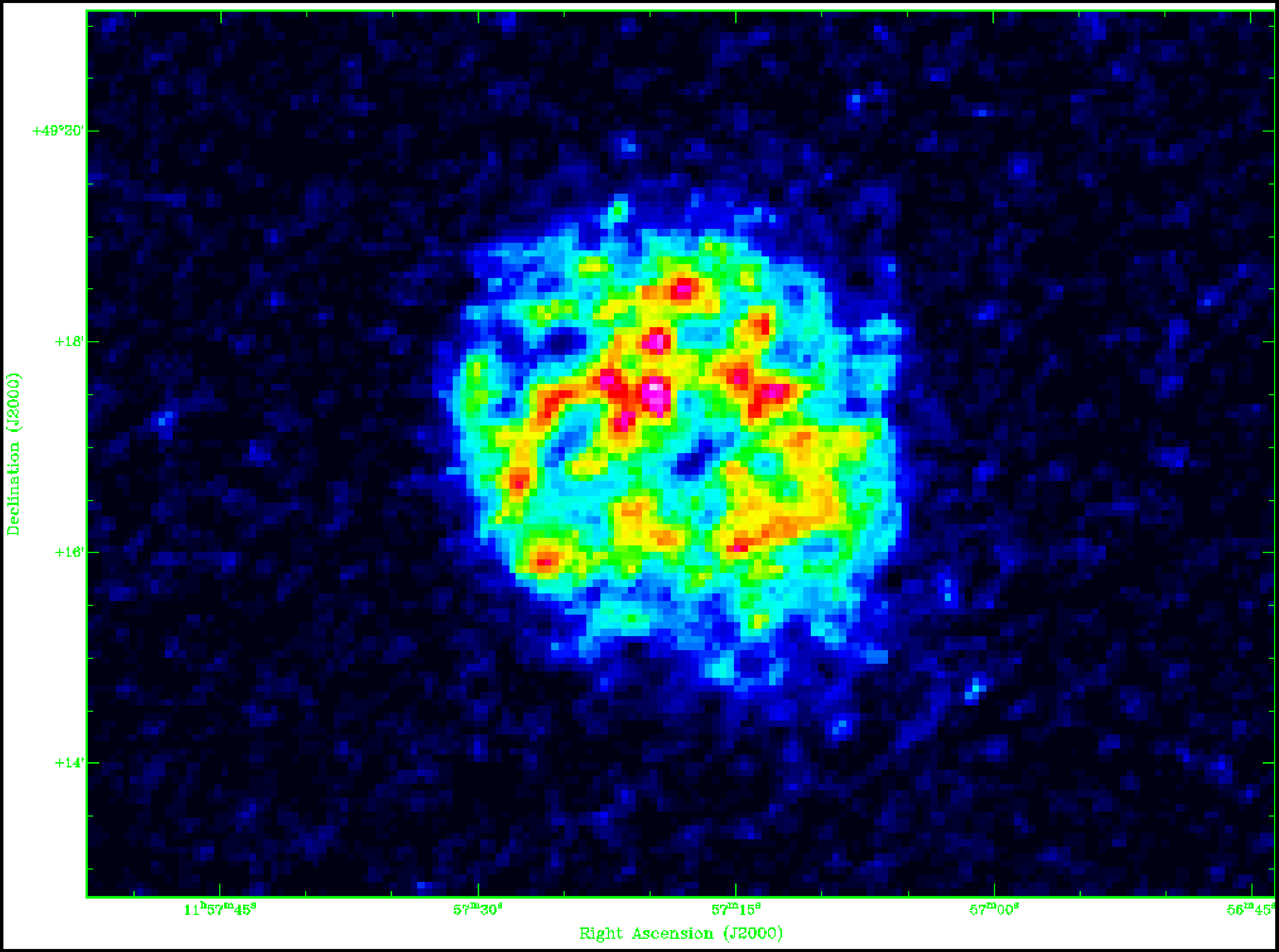
56m45s
Right Ascension (J2000)



+48°20'
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