Gas – Star Formation Scaling Relations (with a Focus on Outer Galaxy Disks)

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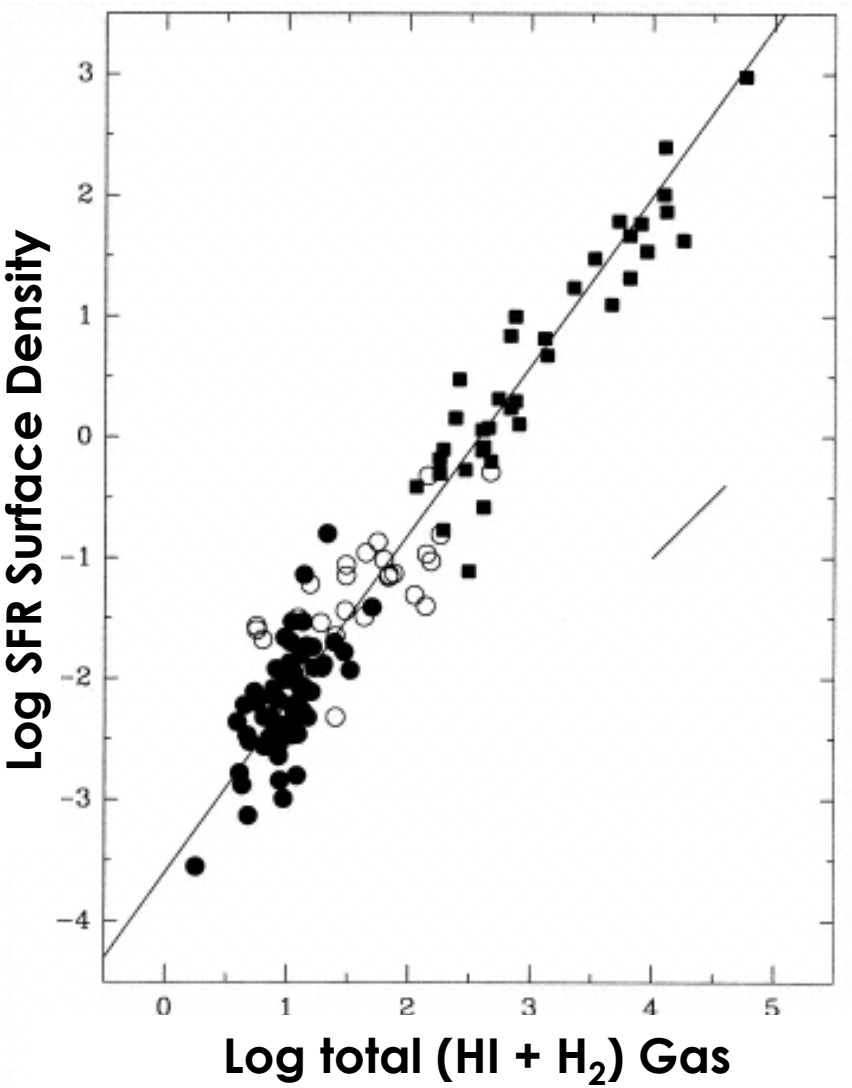
and THINGS & HERACLES teams

Global Scaling Relations



Each Point:
Average over a whole galaxy disk

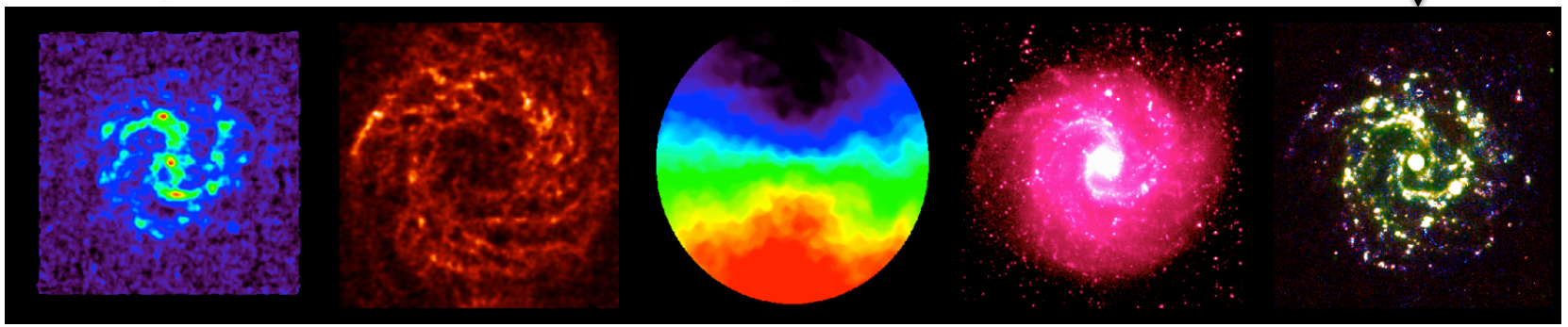
KENNICUTT '98

A Multiwavelength View of Gas and SF in Disks

Molecular Gas
Peak CO intensity
From HERACLES

Kinematics
Here from HI line
Also from CO

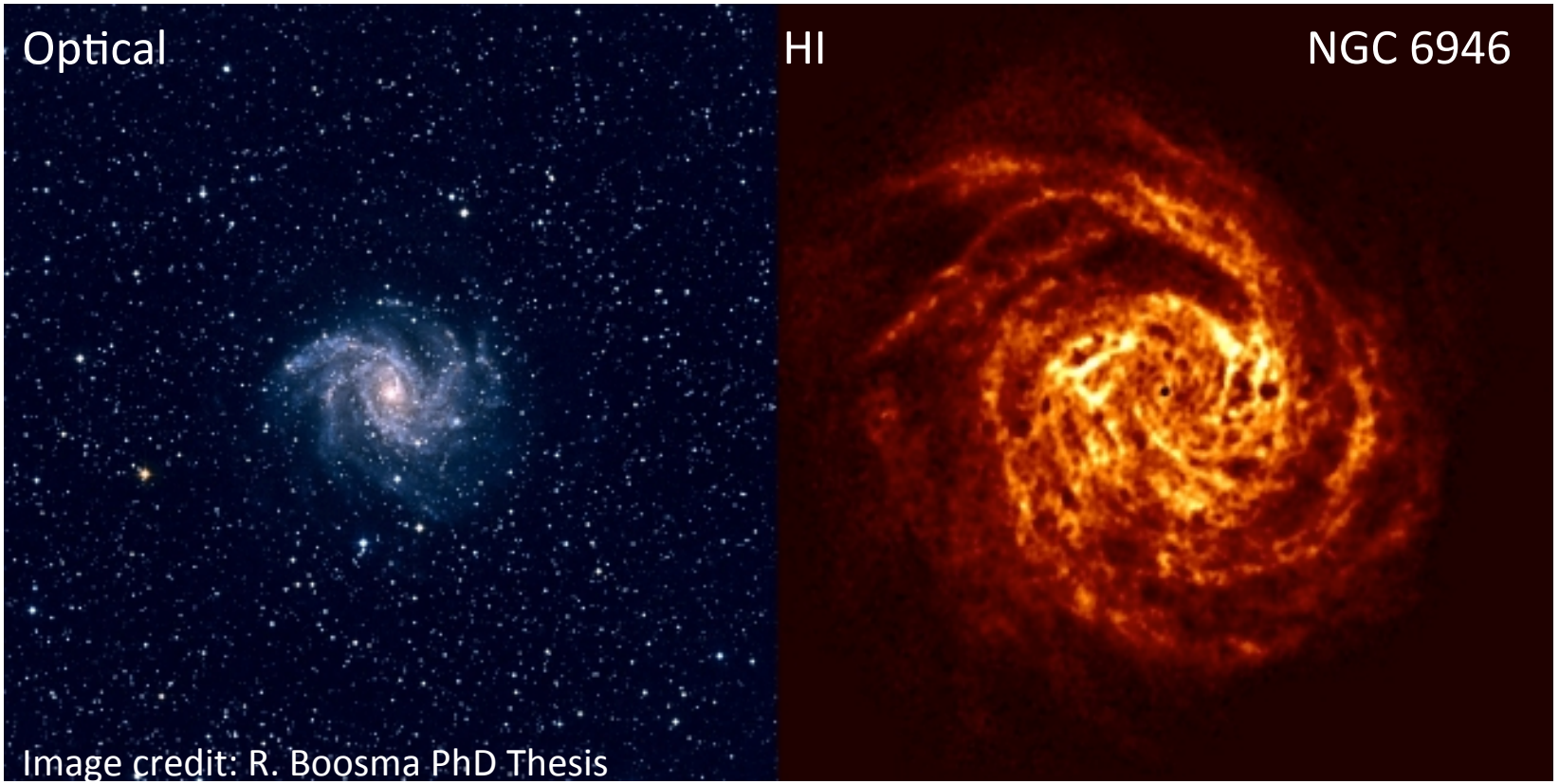
Recent Star Formation
Composite of **FUV** (GALEX),
mid-IR (SINGS/LVL),
and **Hα** (SINGS/LVL)



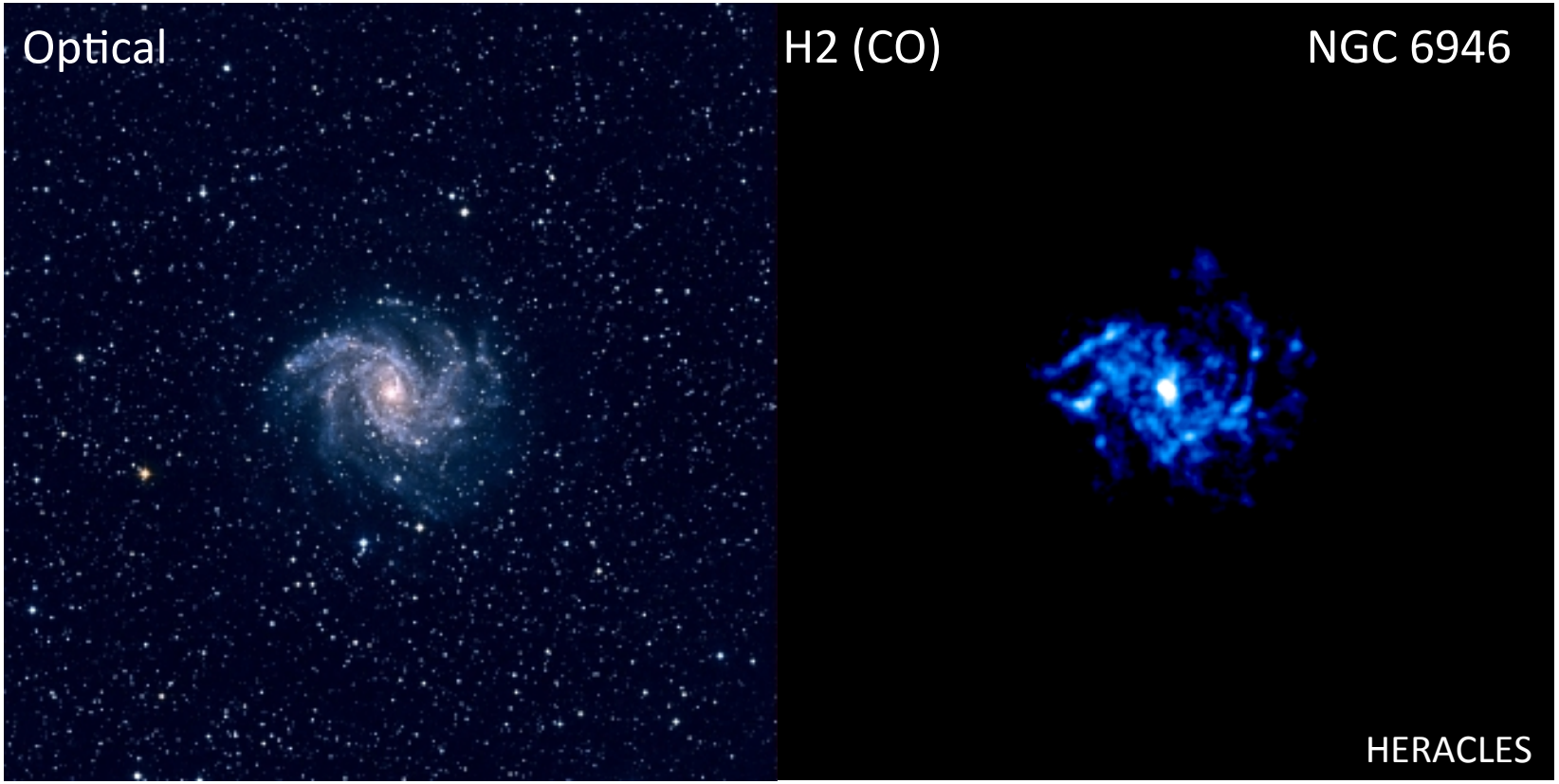
Atomic Gas
VLA 21cm data THINGS +
new & archival

Old Stars
Near infrared intensity
From SINGS and LVL

Stars vs. Atomic Gas

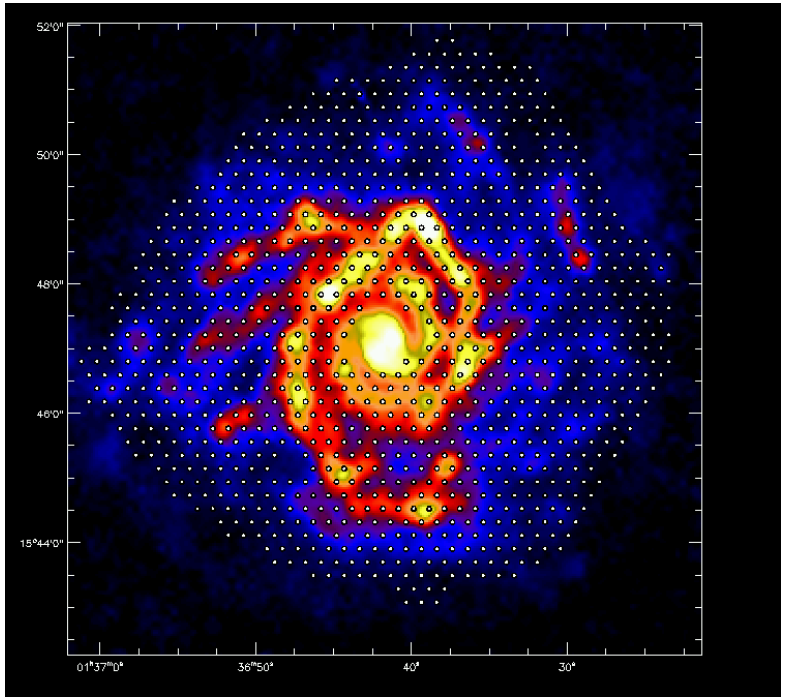


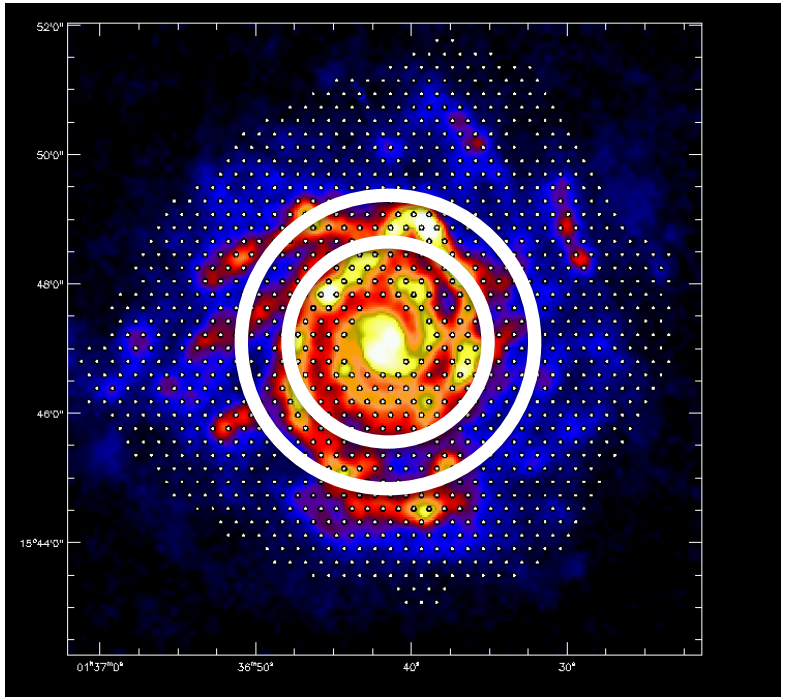
Stars vs. Molecular Gas



What's in a Point?

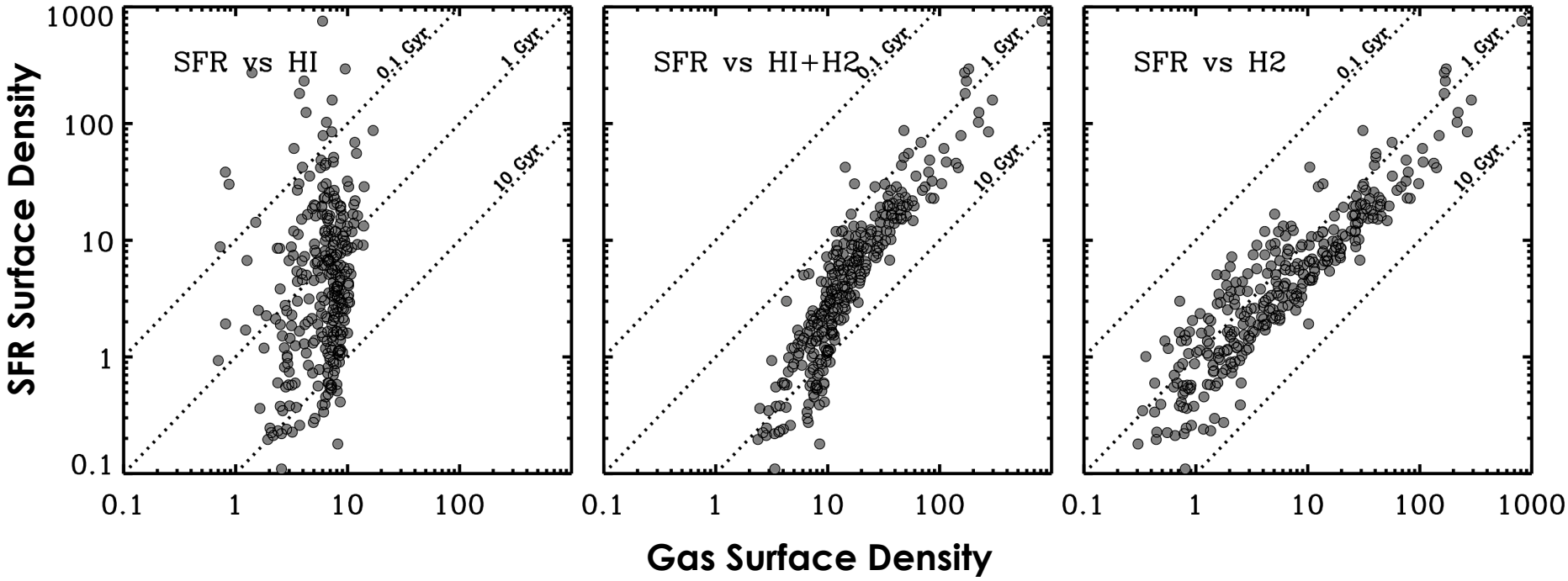
- Convolve all targets to "1 kpc resolution."
- Sample CO, HI, IR, Opt., UV on a 500 pc-spaced hexagonal grid.
- For sensitivity, CO "spectral stacking" to obtain deep profiles (Schruba+ '11).





SF and Gas Across the Optical Disk

- Inside galaxies: Strong correlation between SFR and H_2
- No correlation between SFR and HI
- SFR and total gas driven by molecular gas fraction

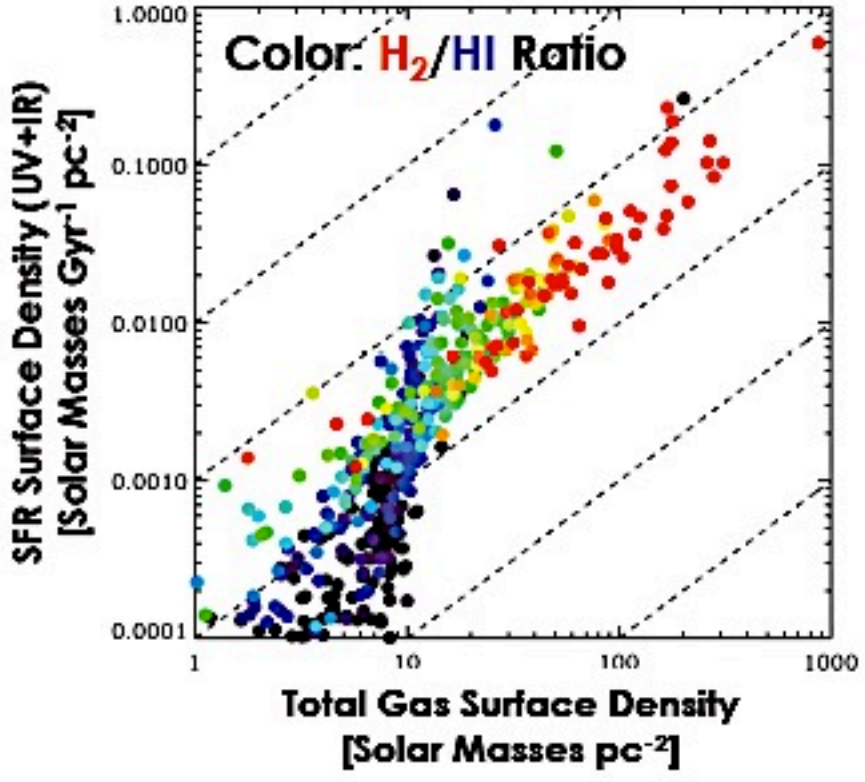


Each Point:
Azimuthal average (ring) in one galaxy

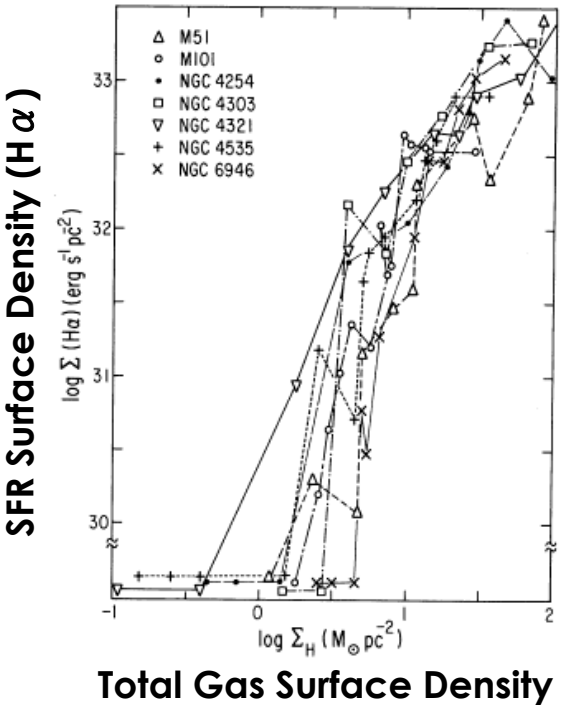
WONG & BLITZ '02, KENNICUTT+ '07, BIGIEL+ '08, 11, **SCHRUBA+ '11**

SF and Gas Across the Optical Disk

- Classical "Thresholds" can be understood as change in molecular gas fraction



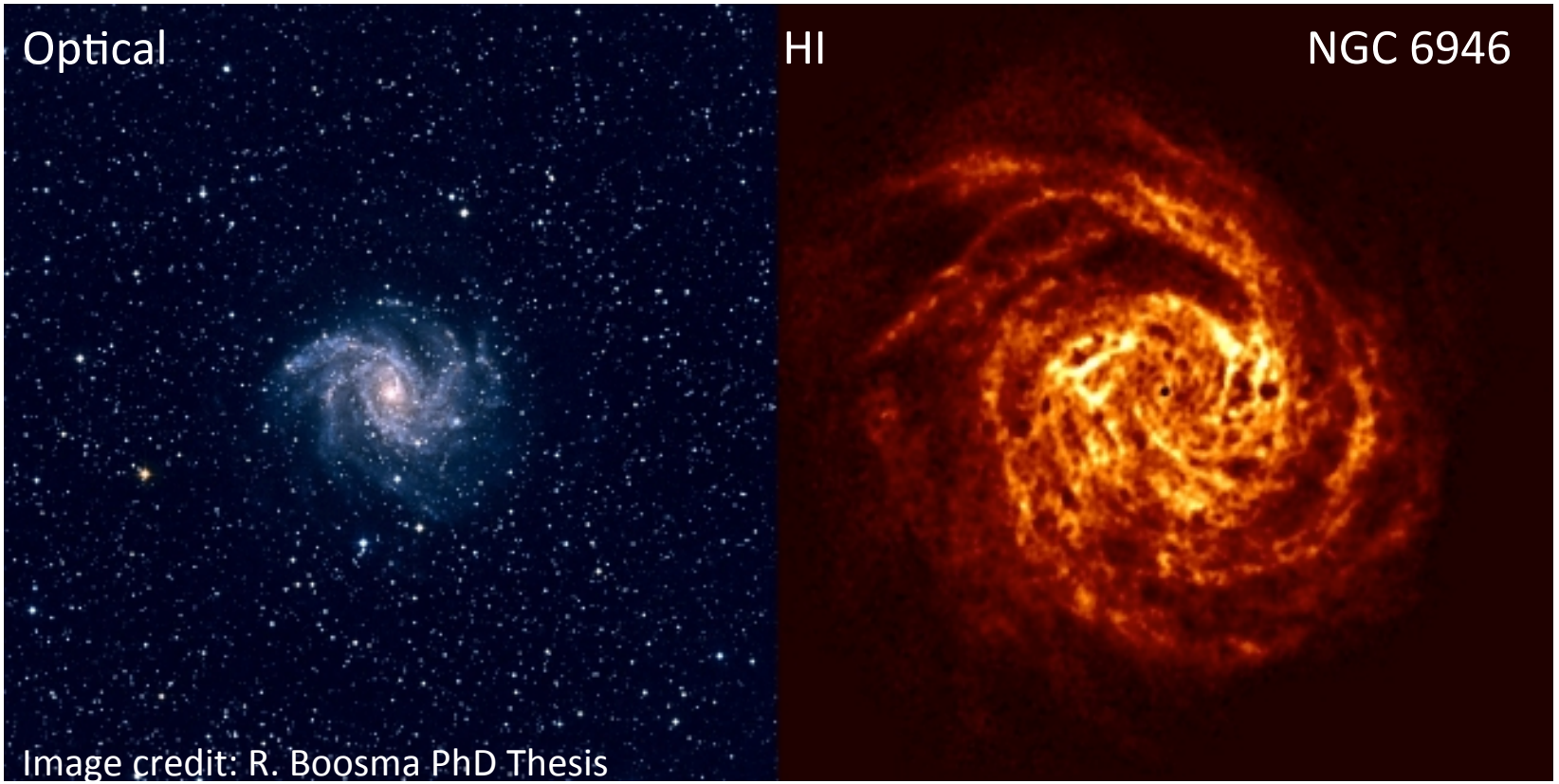
KENNICUTT '89



Each Point:
Azimuthal average (ring) in one galaxy

SCHRUBA+ '11

SF and Gas at Large Radii



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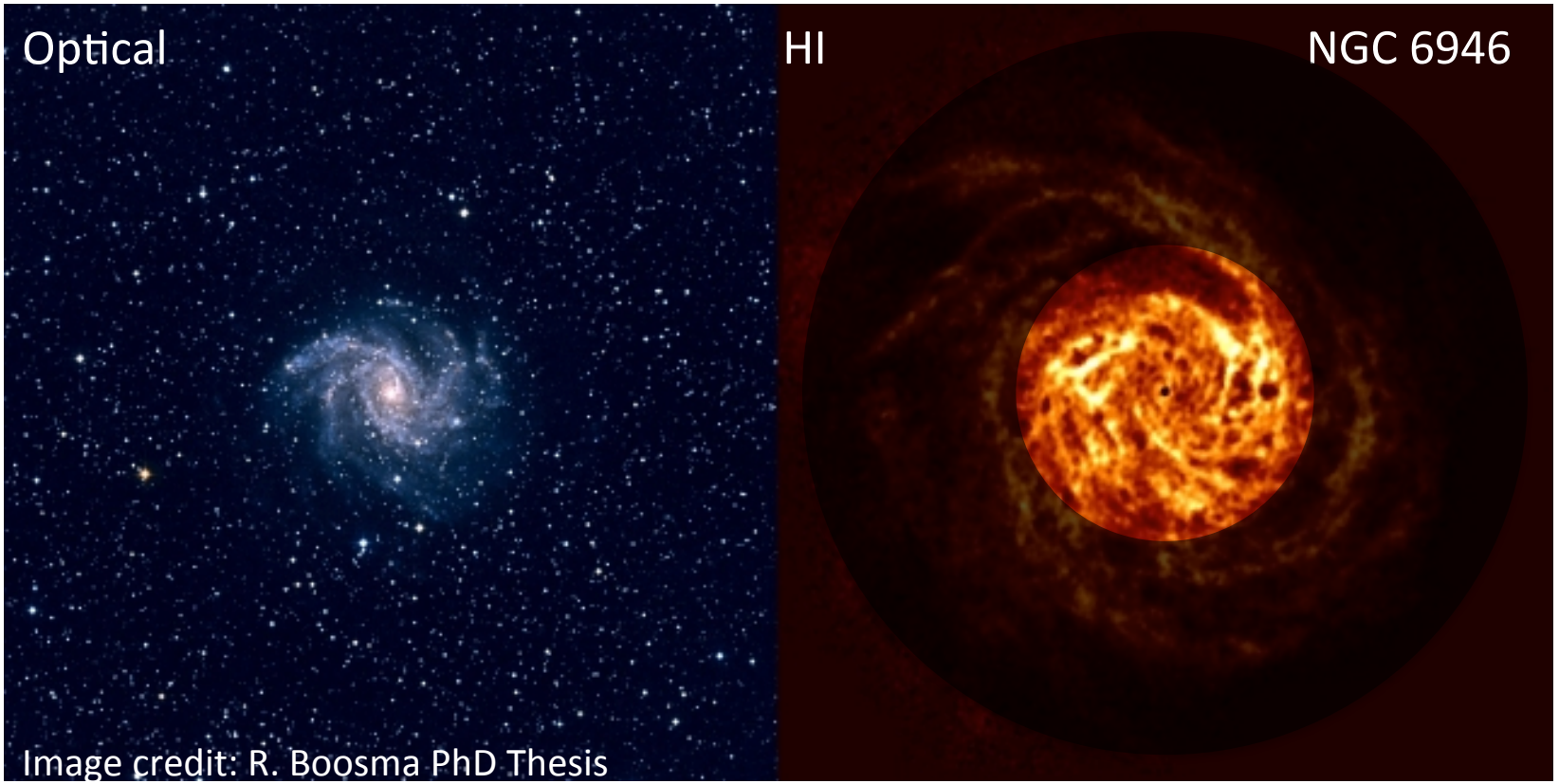

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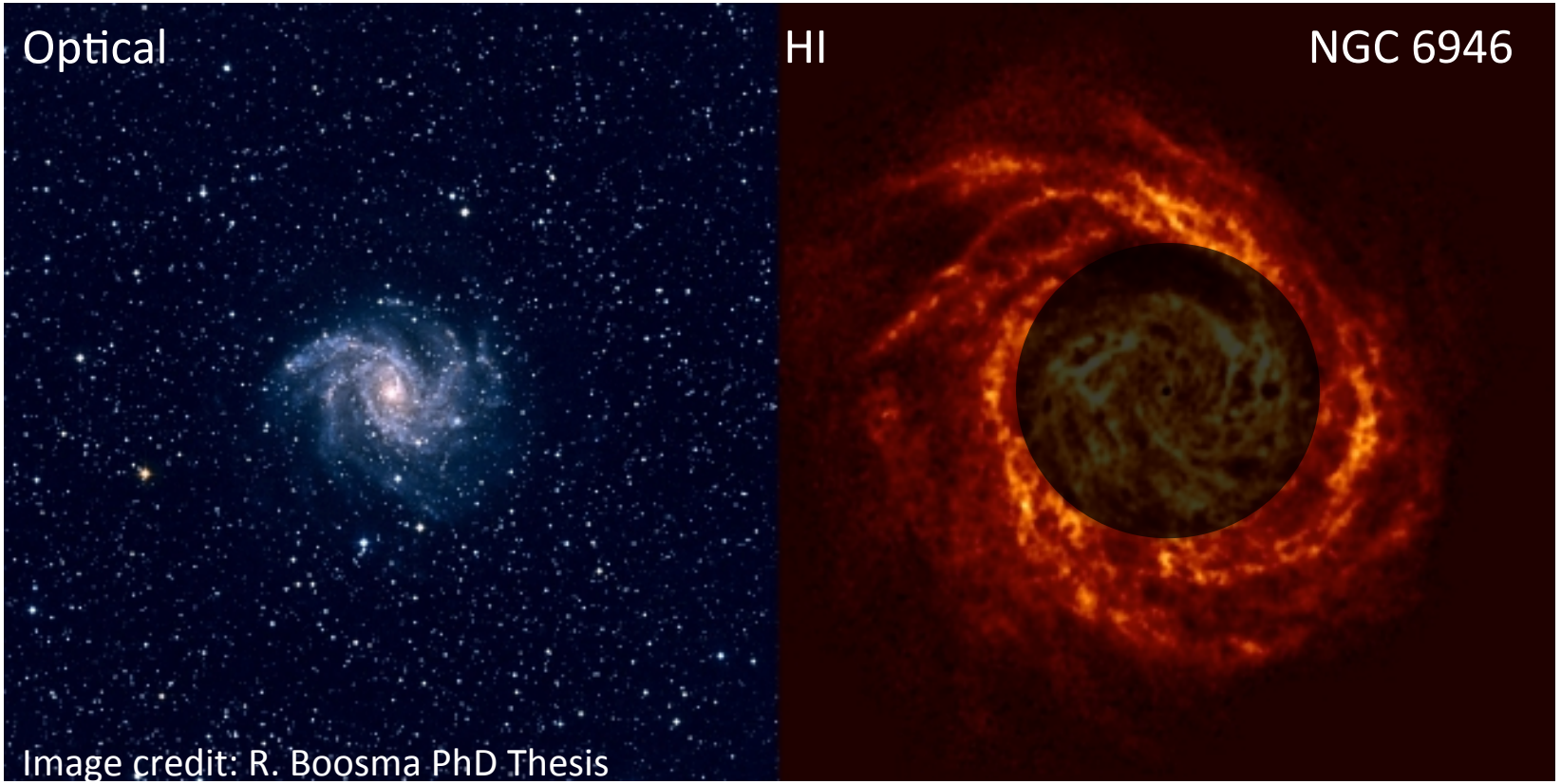
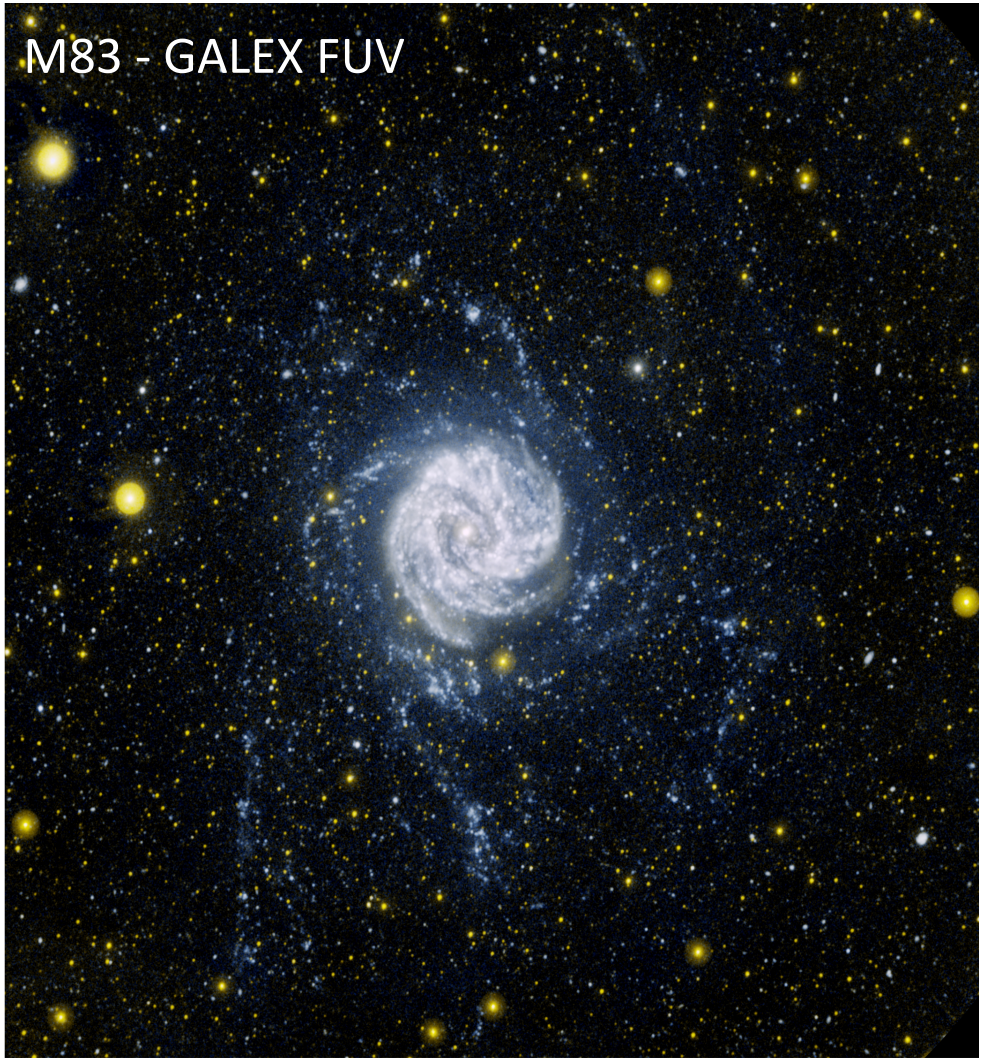
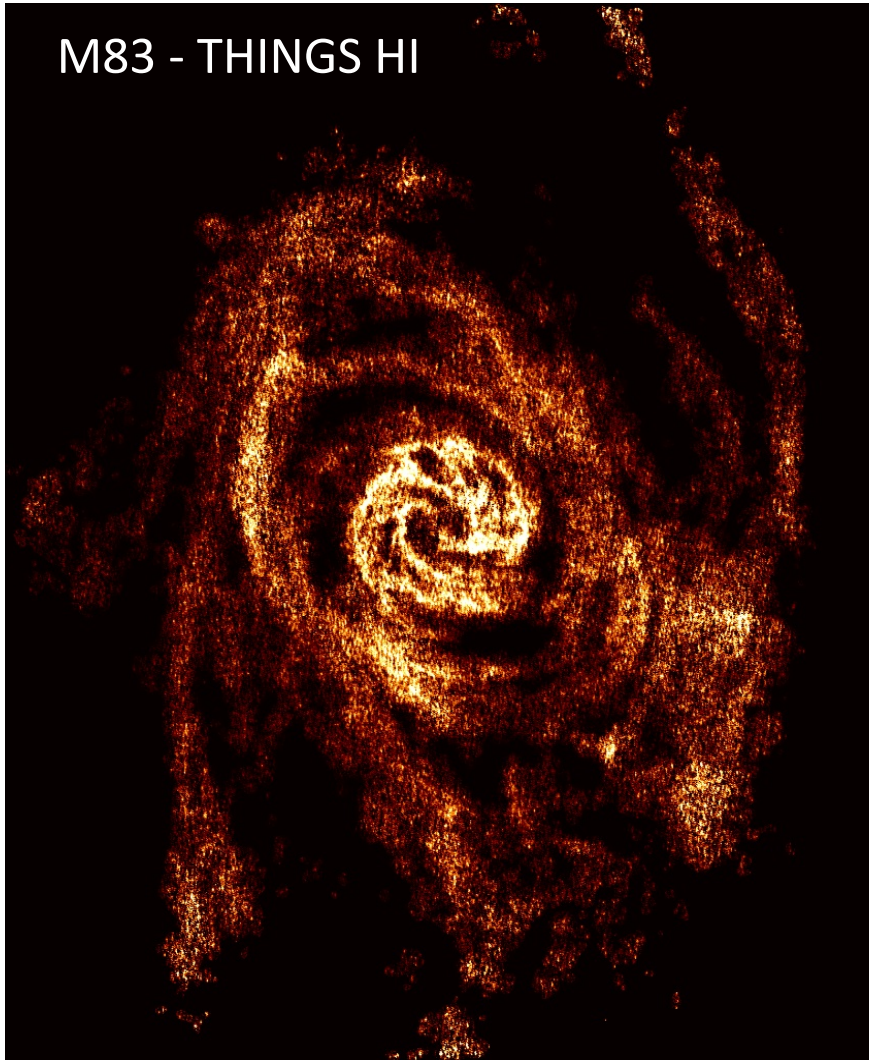


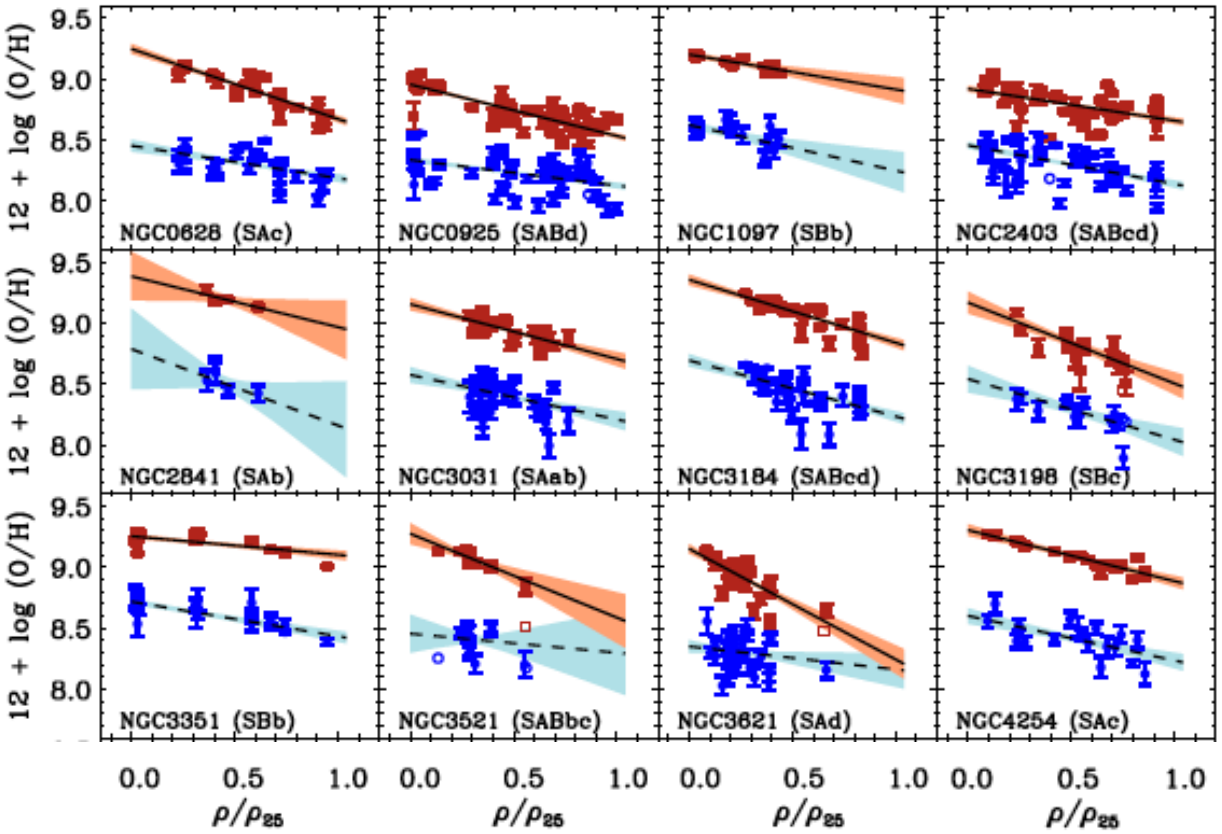
SF and Gas at Large Radii





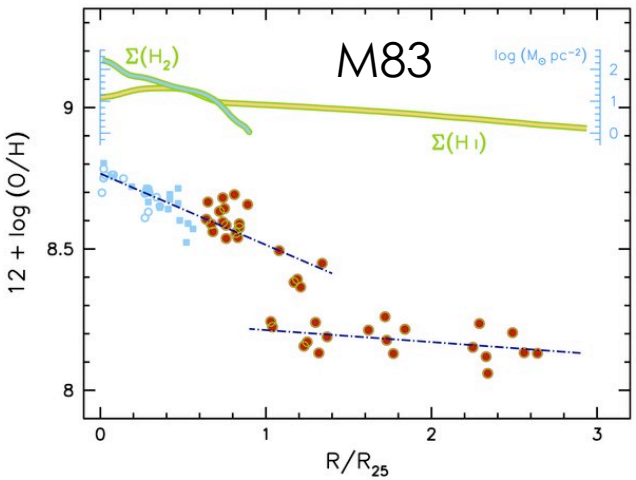
BIGIEL+ ‘10

Metallicities at Large Radii



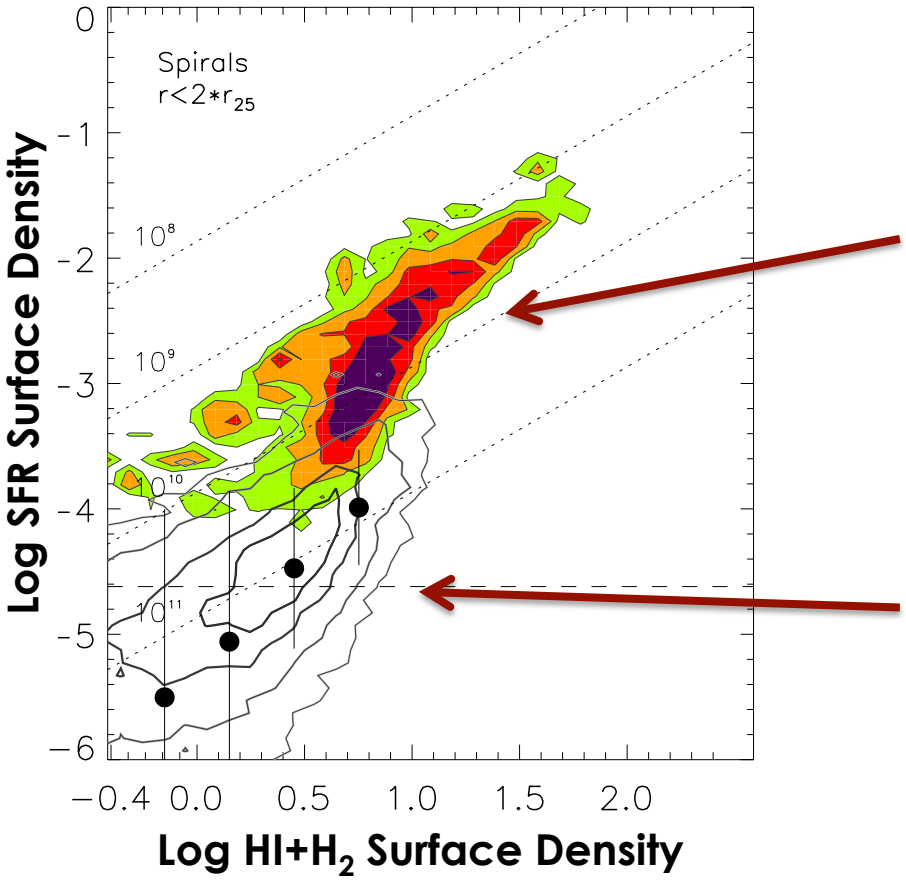
MOUSTAKAS+ '10

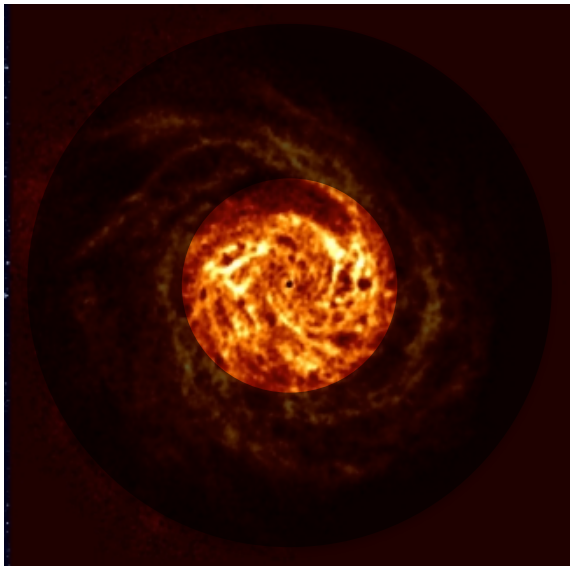
BRESOLIN+ '09

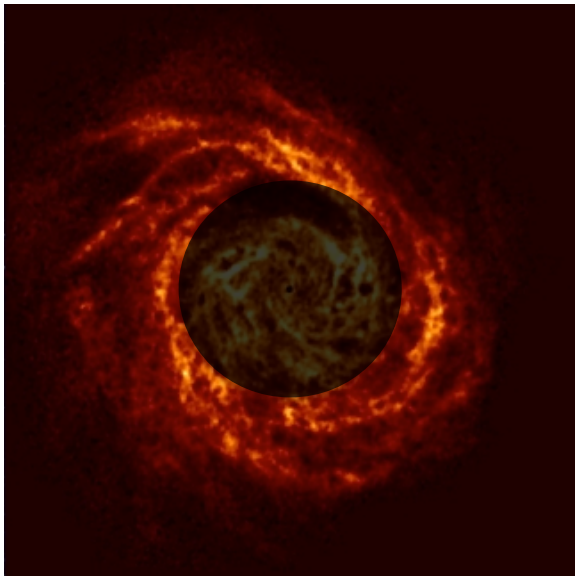


SF and Gas at Large Radii

BIGIEL+ '10

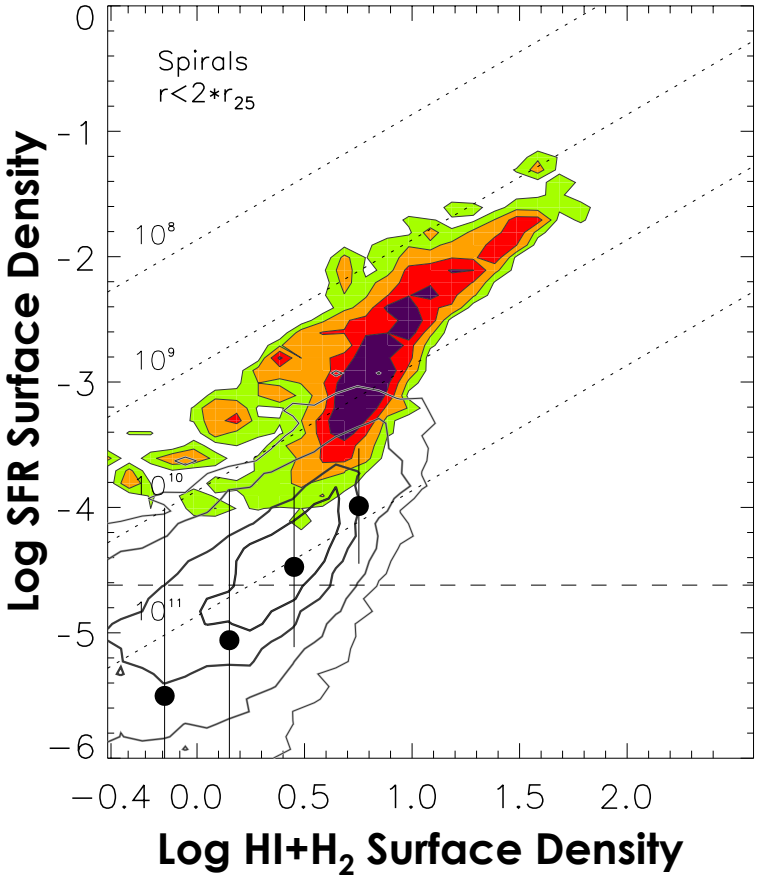


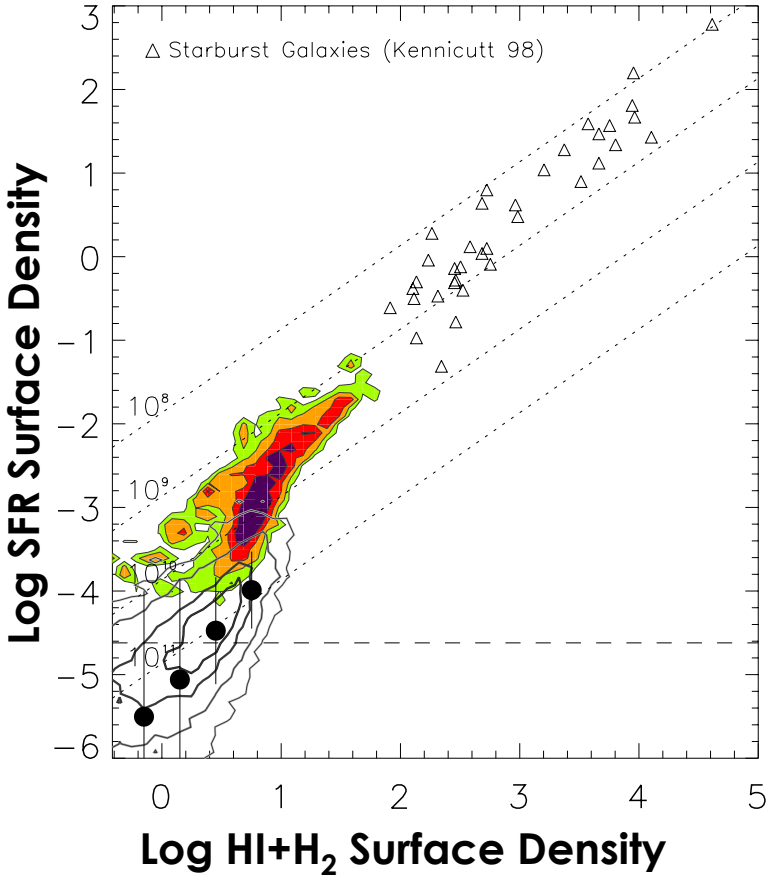




Contours:
Data point density; 1 kpc resolution

SF and Gas at High Densities

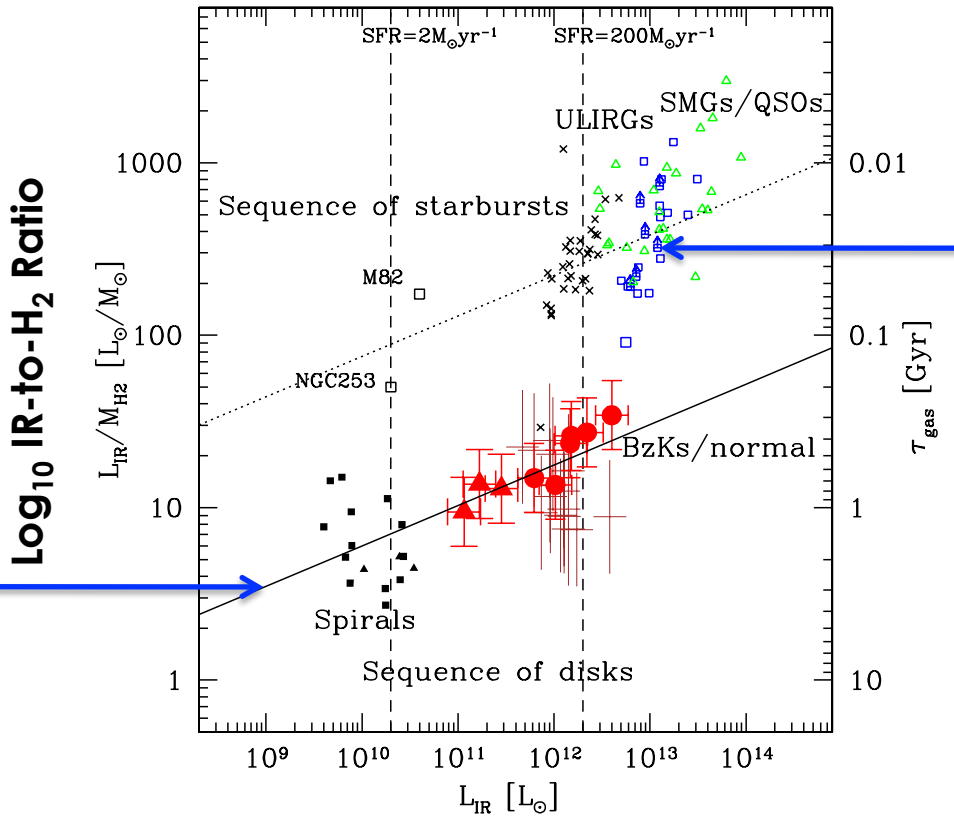




Contours:
Data point density; 1 kpc resolution

BIGIEL+ '10

SF and Gas at High Densities



Log$_{10}$ IR-to-H$_2$ Ratio

IR Luminosity

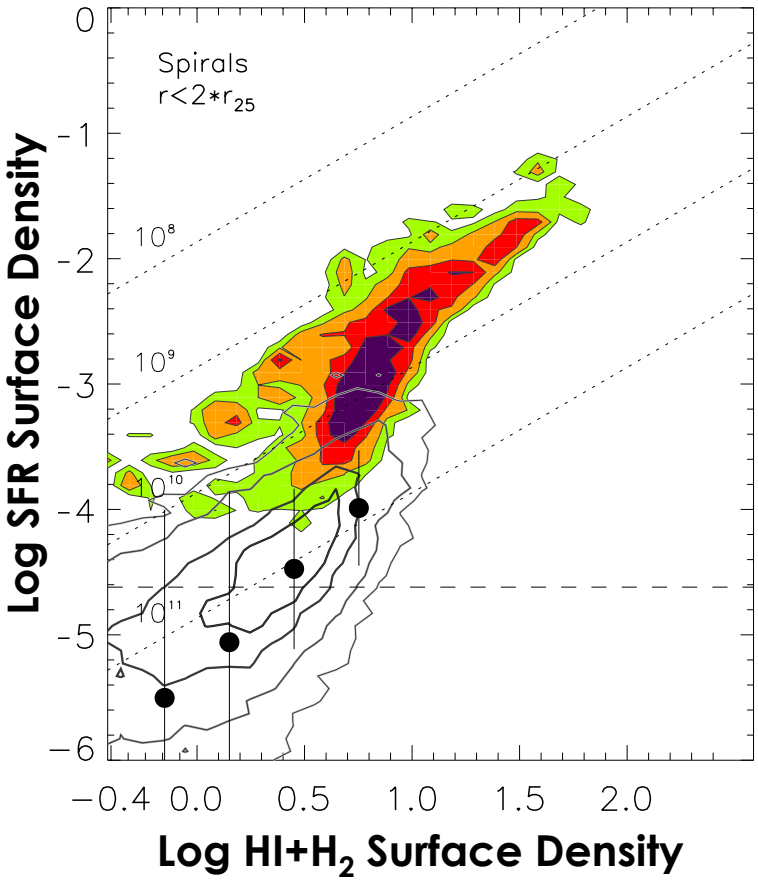
ULIRGs (merger-induced starbursts)

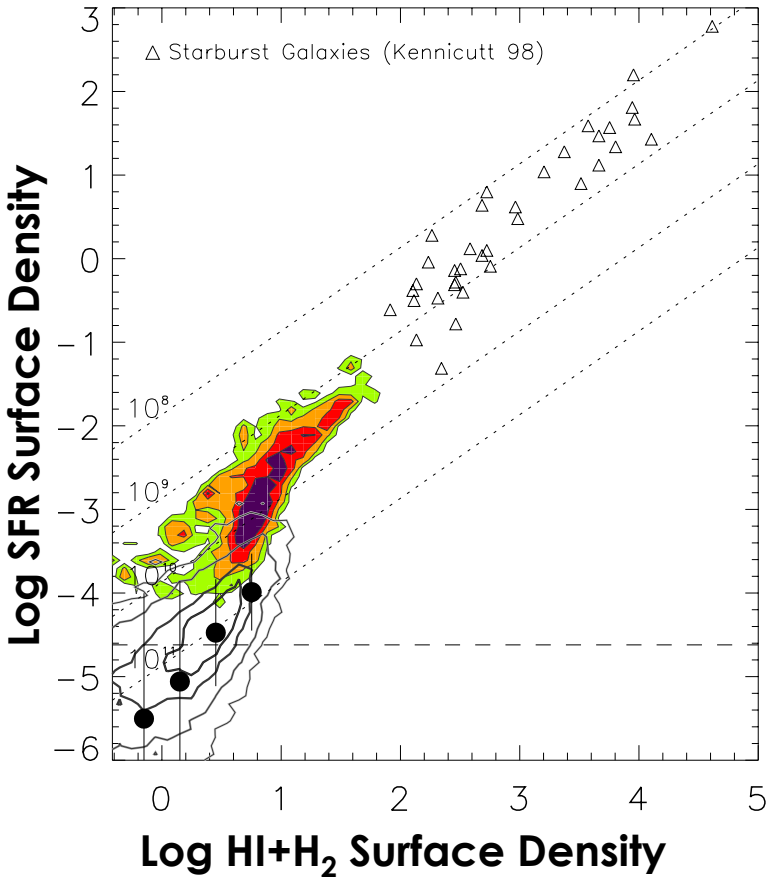
Normal Spirals

Each Point: Whole-galaxy average

DADDI+ '10

SF and Gas at High Densities





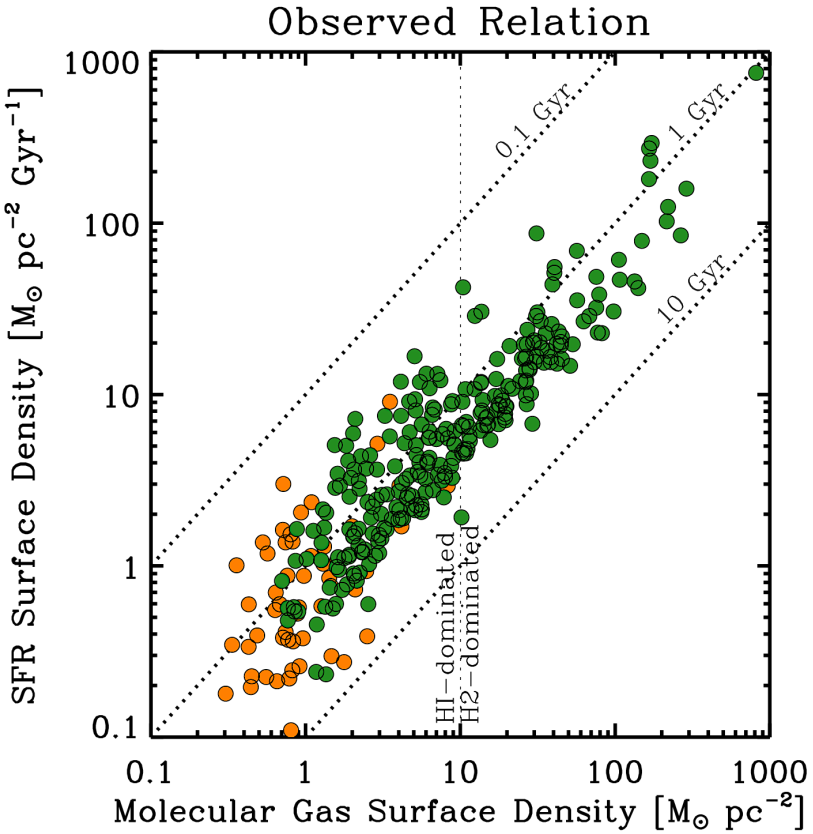
- When galaxy disks are resolved, the relationship between total gas and SFR is complex and depends on environment

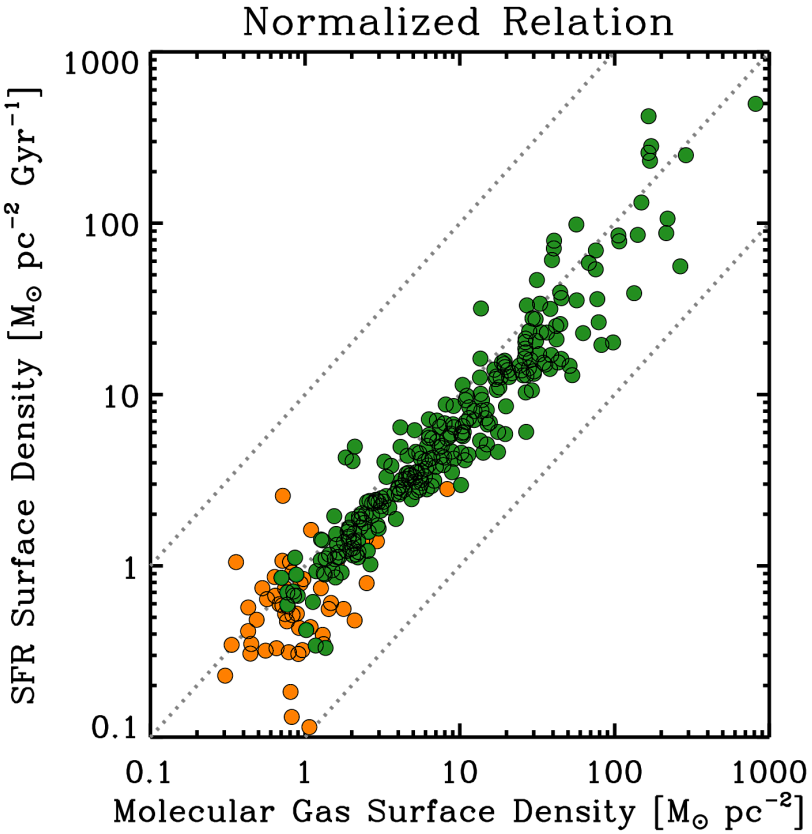
Contours:
Data point density; 1 kpc resolution

BIGIEL+ '10

Scatter in the SF-H_2 Relation

- Galaxy-to-galaxy scatter from CO-SFR relation:



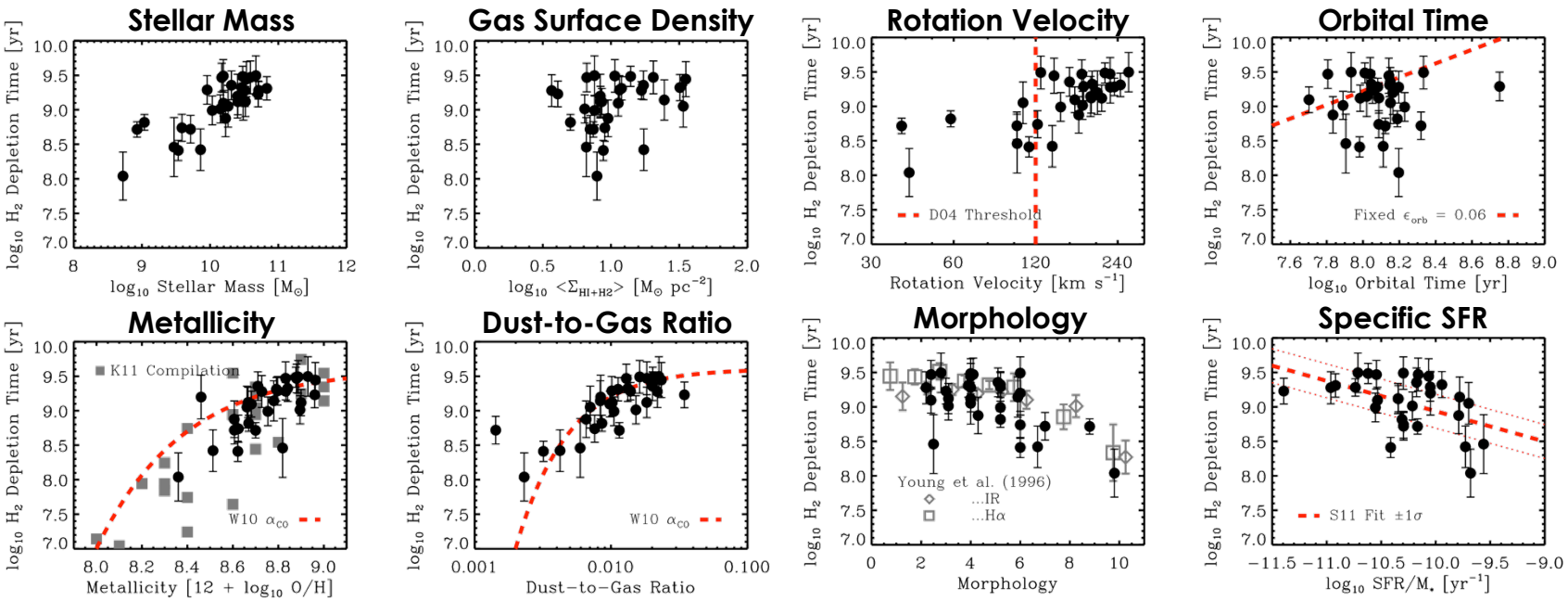


Each Point:
Azimuthal average (ring) in one galaxy

SCHRUBA+ '11

SFR/CO Varies With Mass and Metallicity

CO Divided by SFR - Each Point 1 Galaxy

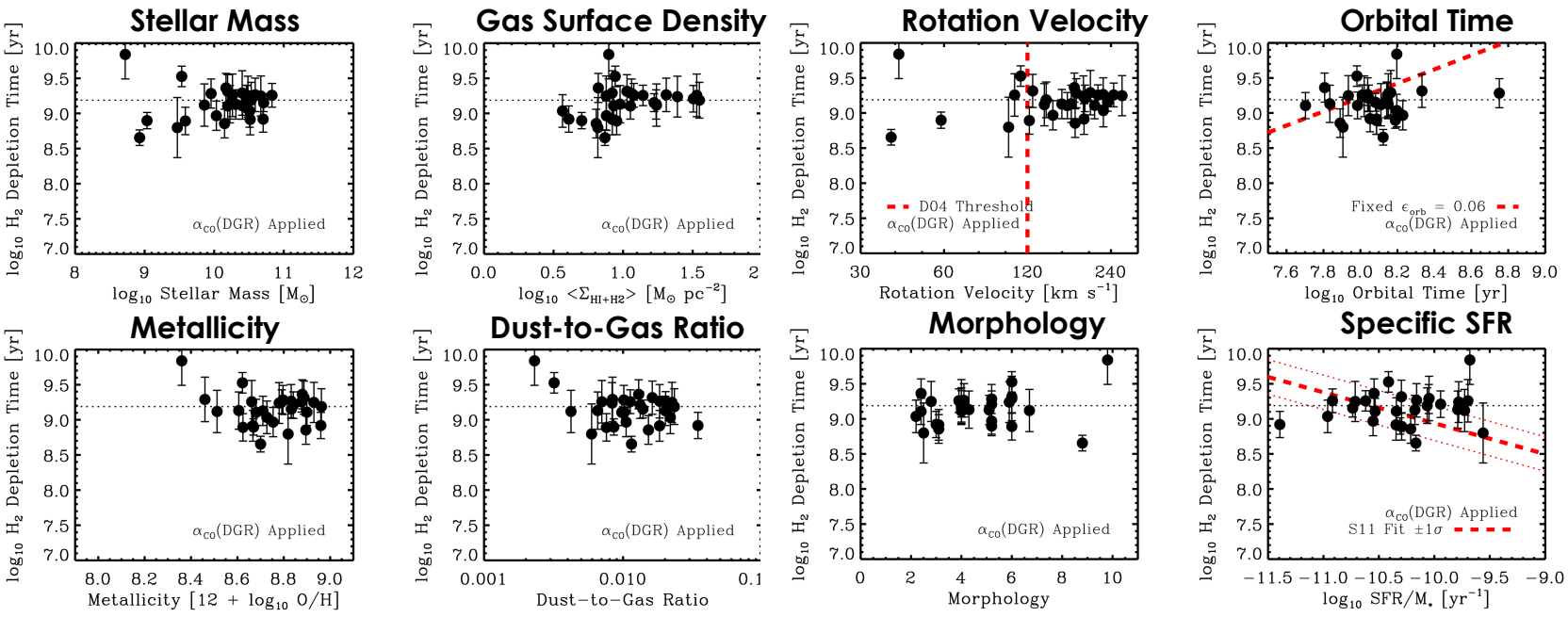


Each Point:
Whole-galaxy average

LEROY+ SUBMITTED

Conversion Factor Variations?

CO Divided by SFR - Each Point 1 Galaxy



Each Point:
Whole-galaxy average

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Gas – Star Formation Scaling Relations In Disk Galaxies

- Stars form where the gas is molecular.
  SFR TRACERS CORRELATE ~LINEARLY WITH CO EVEN WHERE MOST GAS IS HI.
- SFR-gas scalings depend on environment (ISM conditions) and gas phase.
- To first order, SFR/H_2 is fixed in big, normal disks.
  - Low mass, low metallicity galaxies show depressed CO.
    MOST SENSIBLE EXPLANATION ARE X_{CO} VARIATIONS.
  - Star formation in starbursts/ULIRGS appears more efficient.
    MOST SENSIBLE EXPLANATION IS ENHANCED GAS DENSITY.
  - Low star formation efficiencies in outer galaxy disks.