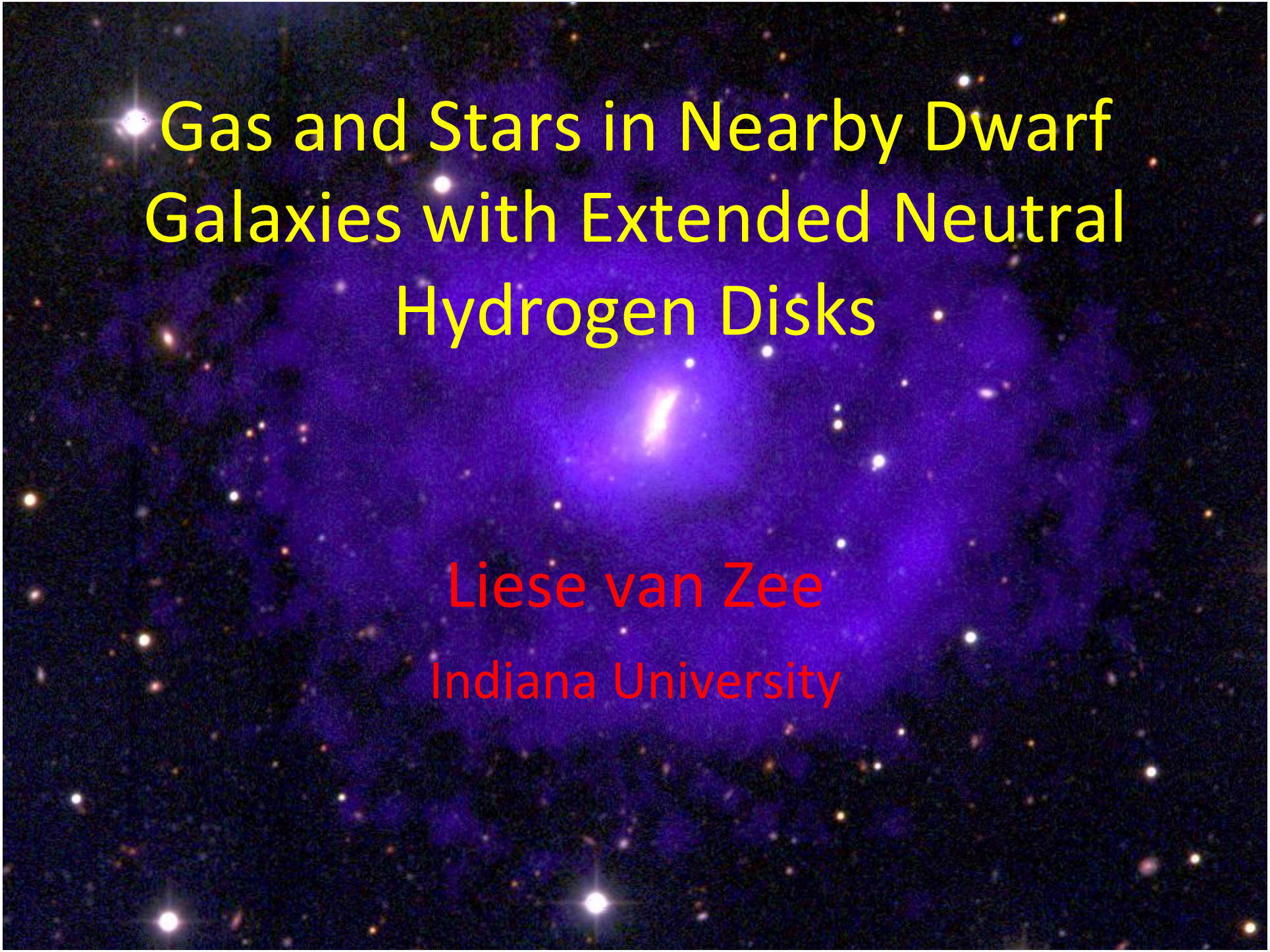


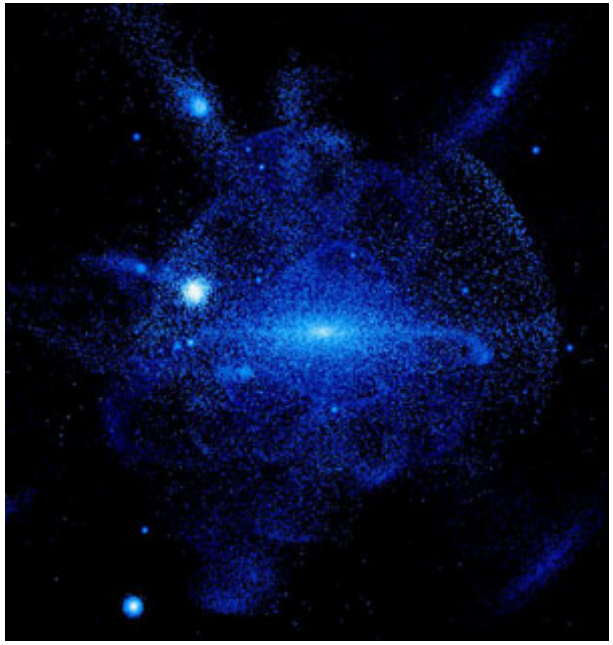
Gas and Stars in Nearby Dwarf Galaxies with Extended Neutral Hydrogen Disks

Liese van Zee

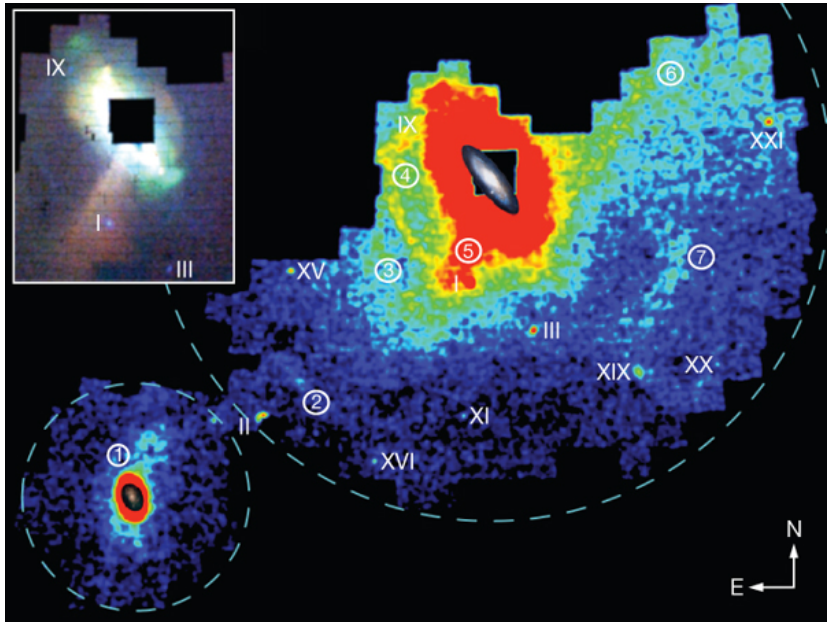
Indiana University

"Existential Crisis" Questions

- What is a galaxy?
- How big is a galaxy?
- Where does one galaxy end and another begin?



J. Bullock & K. Johnston 2005



McConnachie et al. 2009, Nature, 461, 66

NGC 247

EDGES: Extended Disk Galaxy Exploration Science Survey

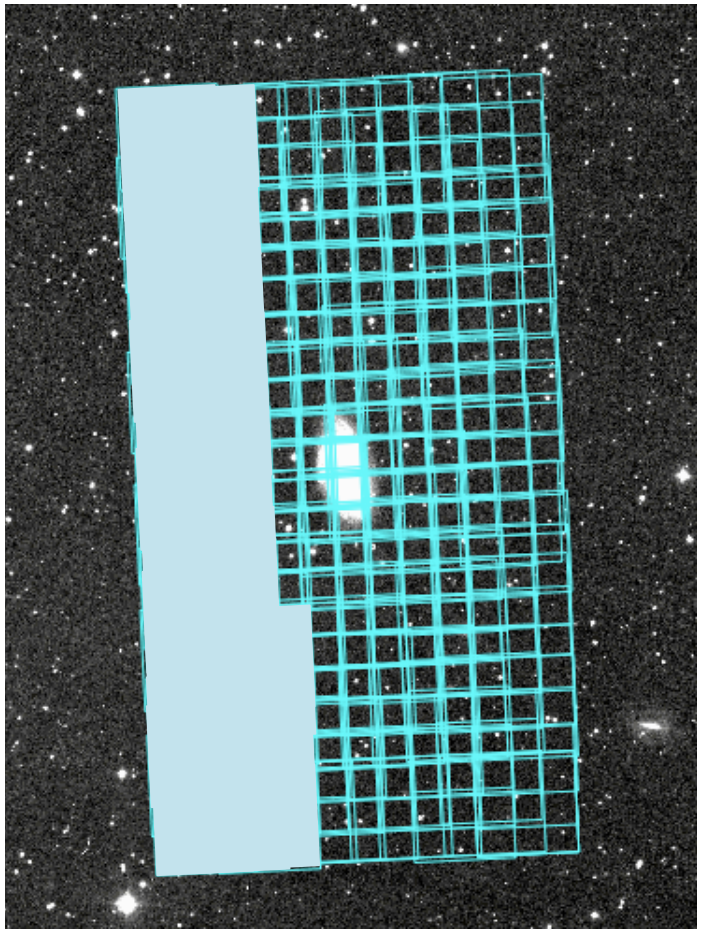
L. van Zee
D. A. Dale
K. L. Barnes
S. Staudaher
D. Calzetti
J. J. Dalcanton
J. S. Bullock
R. Chandar
E. Richards

- *Spitzer* 3.6μm survey of 92 galaxies, spanning a wide range of morphology, luminosity, and environment.
- We are sensitive to stellar mass surface densities of few × 0.01 $M_{\odot}/pc^2$, independent of star formation history.
- Our wide FOV observations allow us to trace substructures out to 5× R_{25}.
- When the analysis is complete, we will create a census with the first quantitative measurements of low surface brightness features identified around nearby galaxies.

Survey Design: EDGES and pre-cursors

- **Deep:** 1800 s/pixel
- **Wide:** at least 5× R_{25}
- **IR:** Relatively insensitive to stellar population and dust extinction

- Concerns: sky background stability and point source masking
- Two precursor studies in Cycle 6:
  - M83
  - **Dwarf Galaxies with Extended HI Distributions**

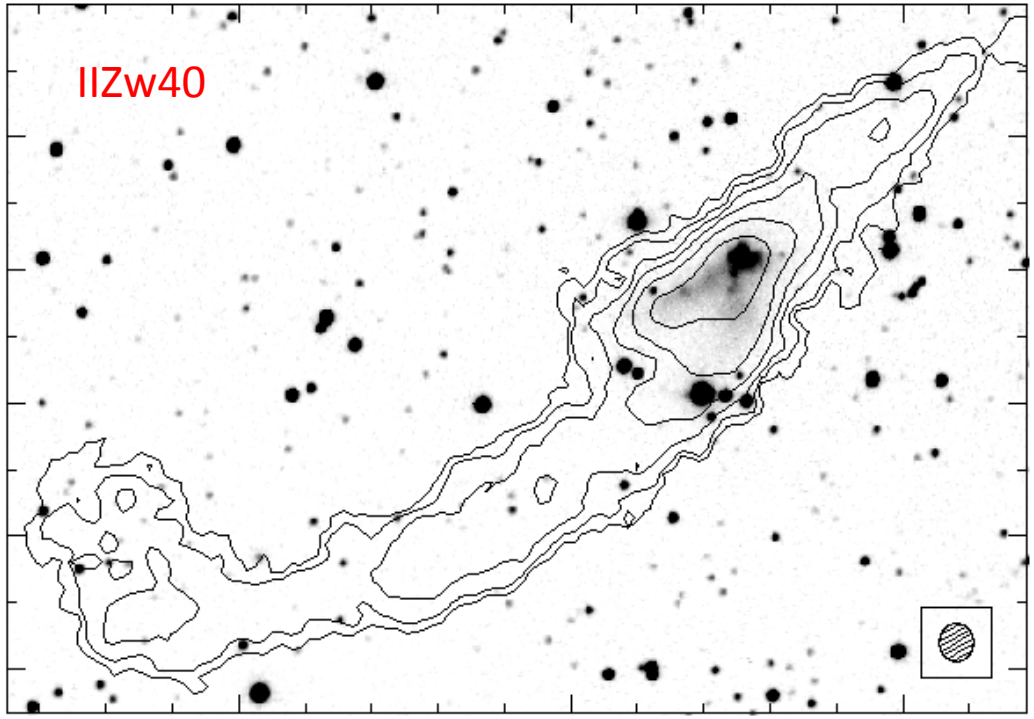


NGC3953: 40’ × 21.7’
a x b : 6.9’ × 3.5’

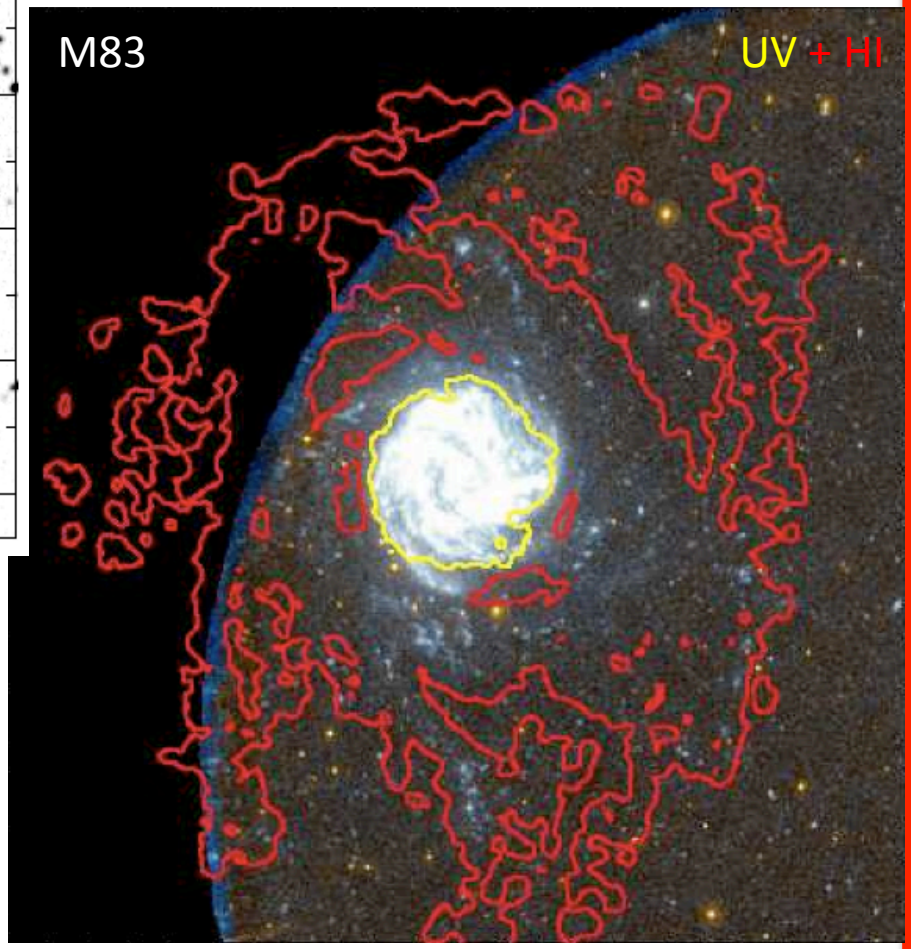
Gas Distributions in Normal Galaxies

- Typical HI-to-optical diameters are approximately 1.2 (Broeils & Rhee 1997).
- Spectacular examples of extended gas distributions from tidal interactions (see HI Rogues Gallery, compiled by John Hibbard)
- There are a handful of galaxies with unusually extended HI distributions that do not appear to be associated with tidal interactions such as M63, M83, NGC 628, all of which have an underlying faint stellar/star forming component when deep optical/UV observations are obtained.

Extended Gas: tidal or stable?



van Zee et al. 1998, AJ, 116, 1186



Thilker et al. 2005, ApJ, 619, L79

Searching for Stars in Extended Gaseous Disks

- Observed 9 dwarf irregular galaxies with *Spitzer*
  - 5 galaxies with extended HI
  - 4 galaxies with normal HI distributions
- Precursor to the EDGES Survey; with same observing design, but FOV ~ $10 \times R_{25}$

Why Near-Infrared Observations?

M/L is Less Sensitive to Stellar Population

T=30,000 K

T=10,000 K

T=5,000 K

T=3,000 K

Intensity (arbitrary units)

10^{14} 10^{13} 10^{12} 10^{11} 10^{10} 10^{9} 10^{8} 10^{7} 10^{6} 10^{5} 10^{4}

IRAC
Ch1

Dust, T=100 K

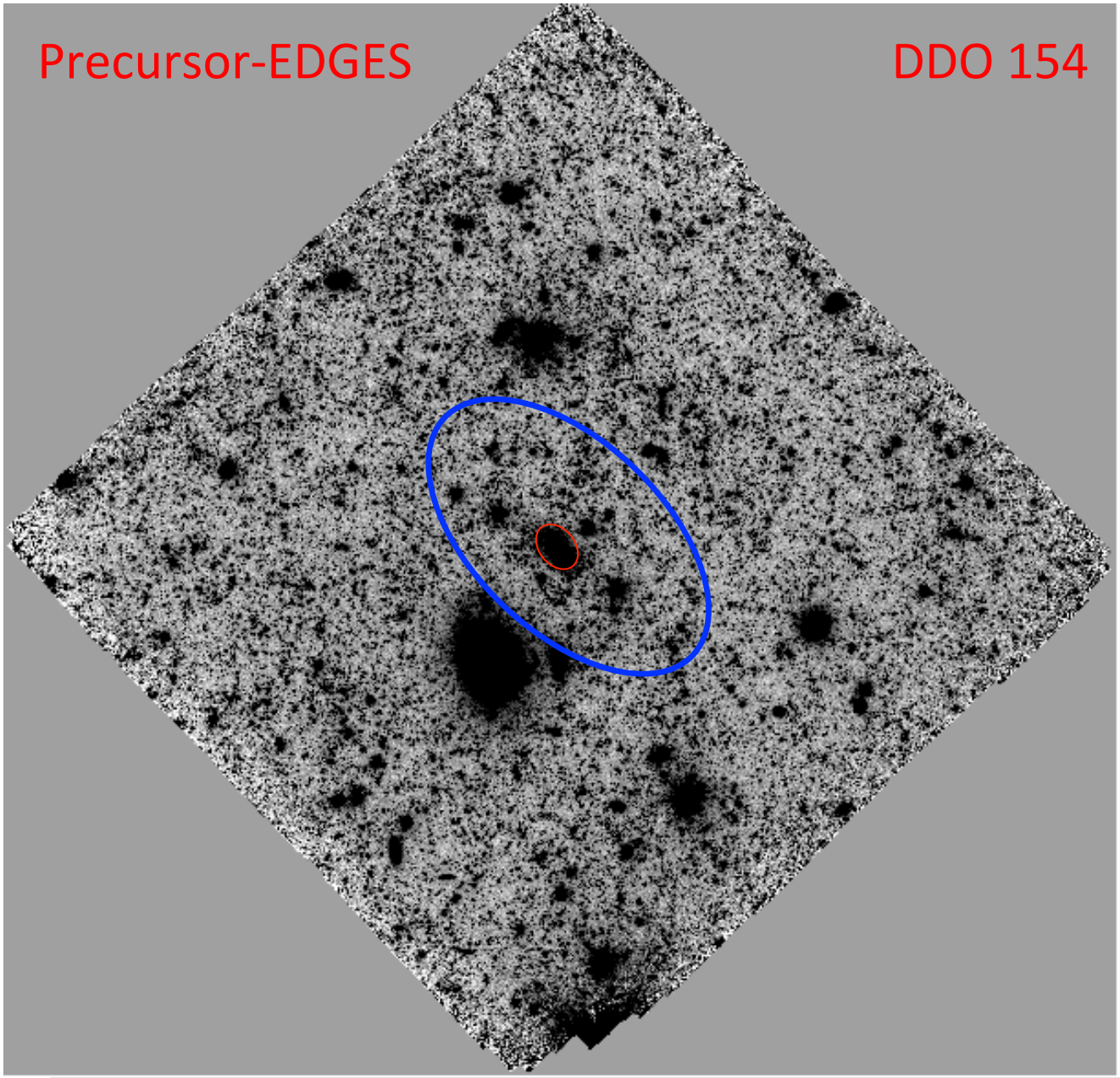
0.1 1 10 100

Wavelength (μm)

Comparison to Other *Spitzer* Surveys

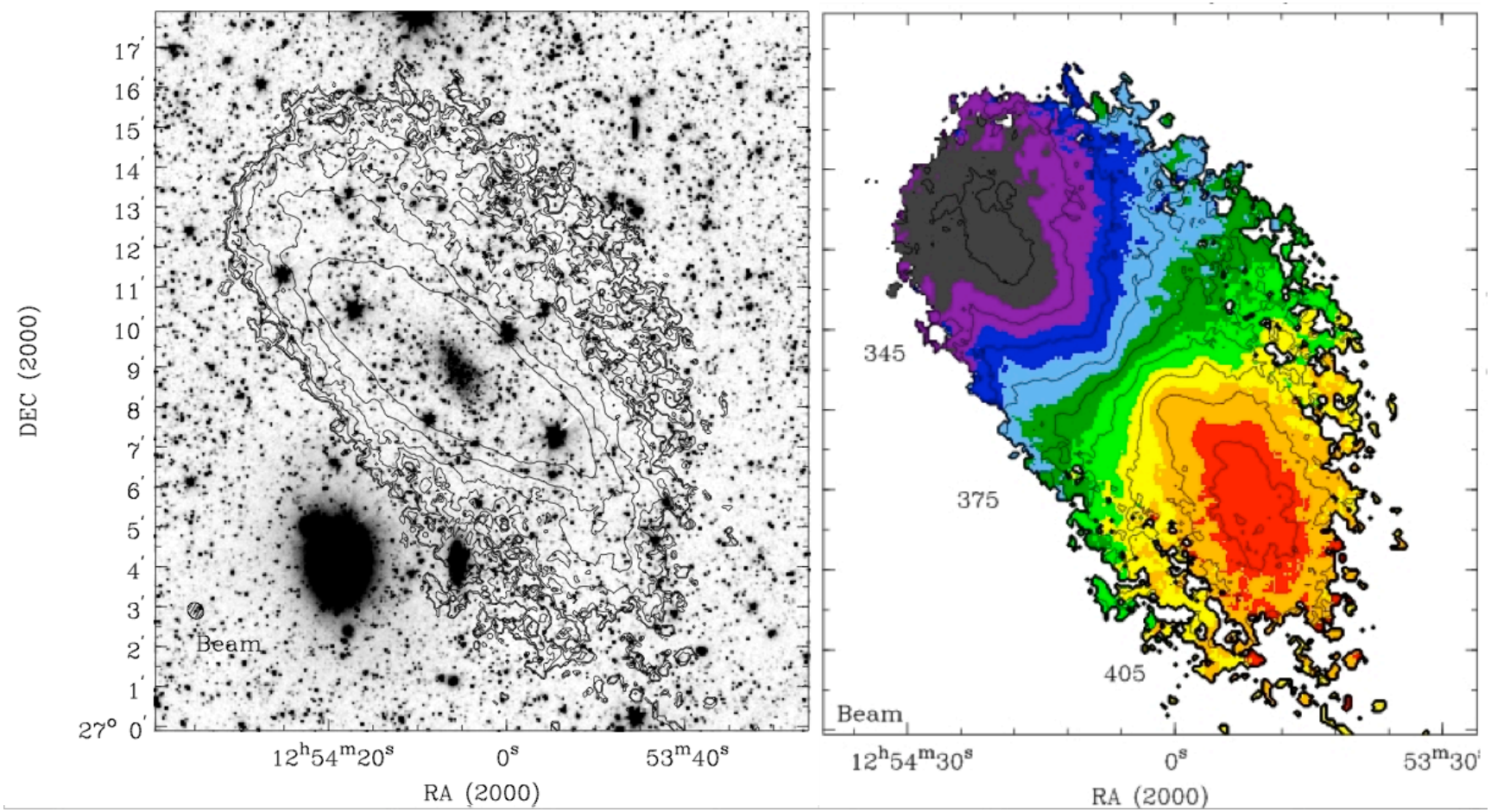
- For example: SINGS, LVL, S^{4}G:
  - Shallow: 240 s/pixel
  - Small: at least 1× R_{25} (usually)
  - IR: Relatively insensitive to stellar population and dust extinction
- Consider DDO 154, observed by Kennicutt et al. as part of SINGS and reprocessed by S^{4}G

Comparison to Other *Spitzer* Surveys



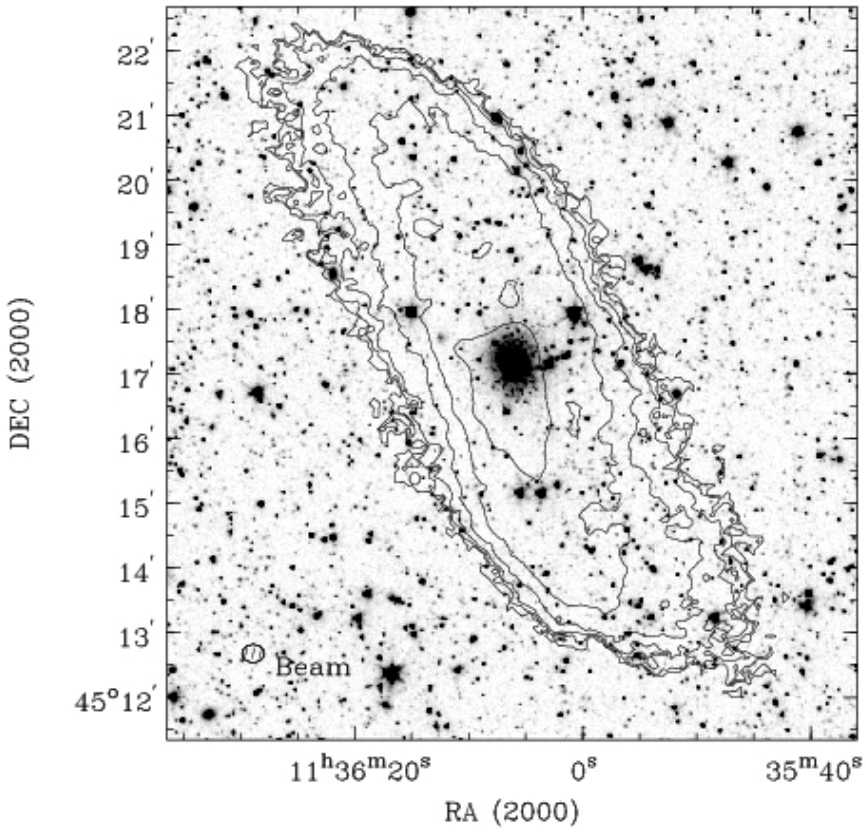
DDO 154

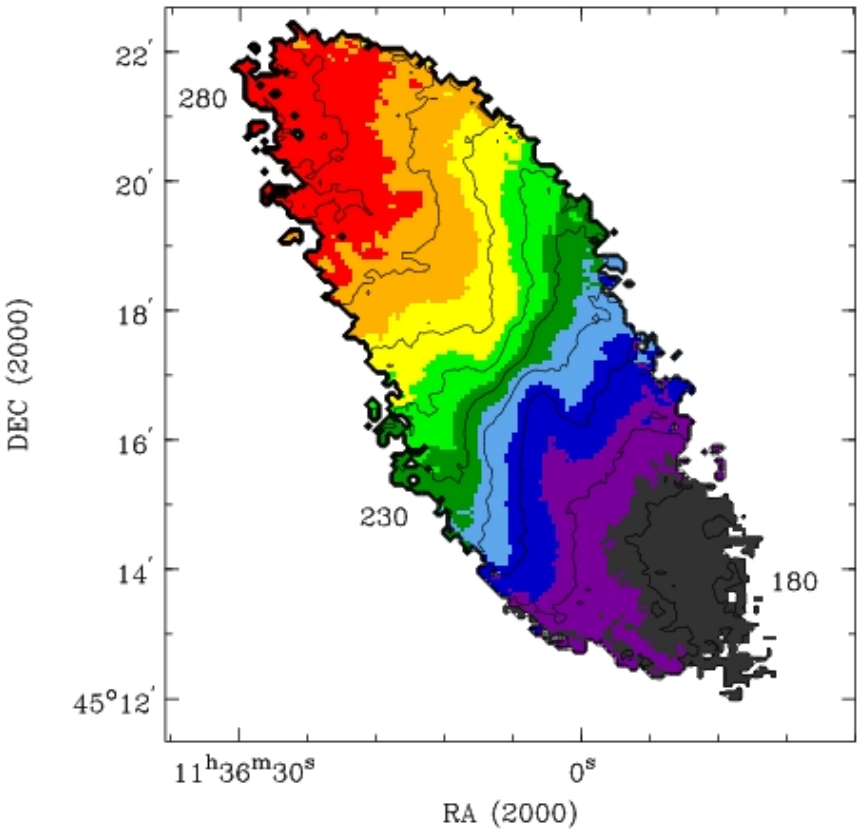
- An extended gaseous disk was discovered by Krumm & Burstein (1984): $D_{HI}/D_{25} \sim 6$

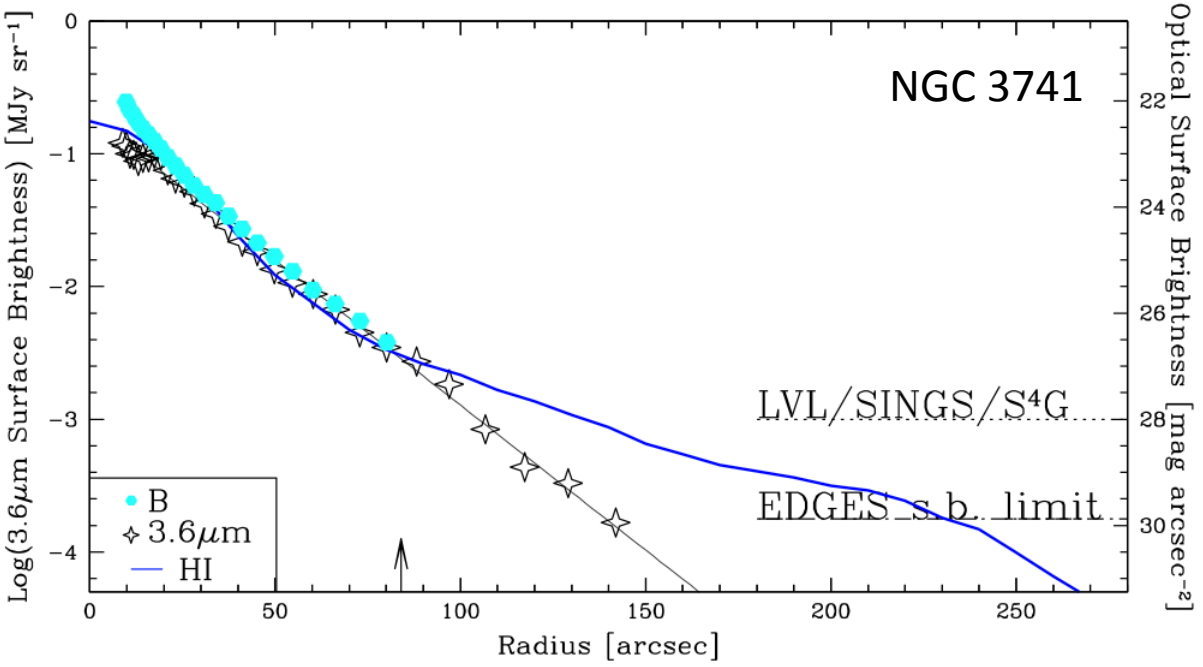


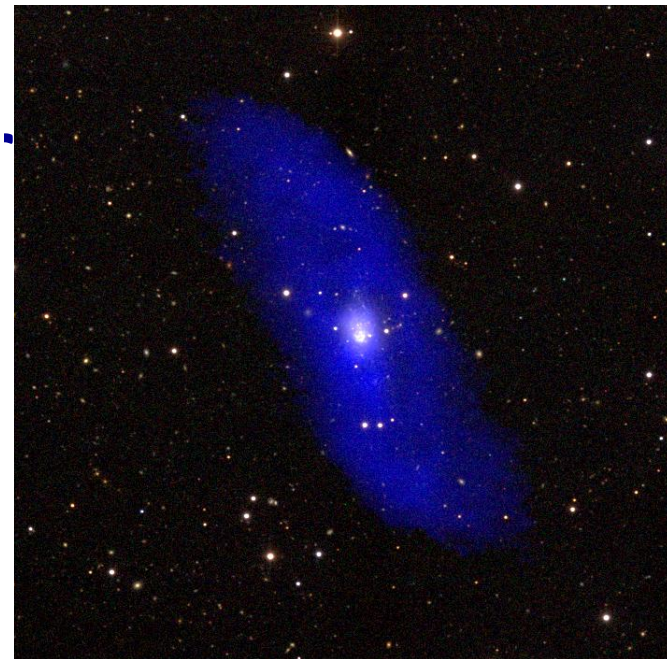
NGC 3741

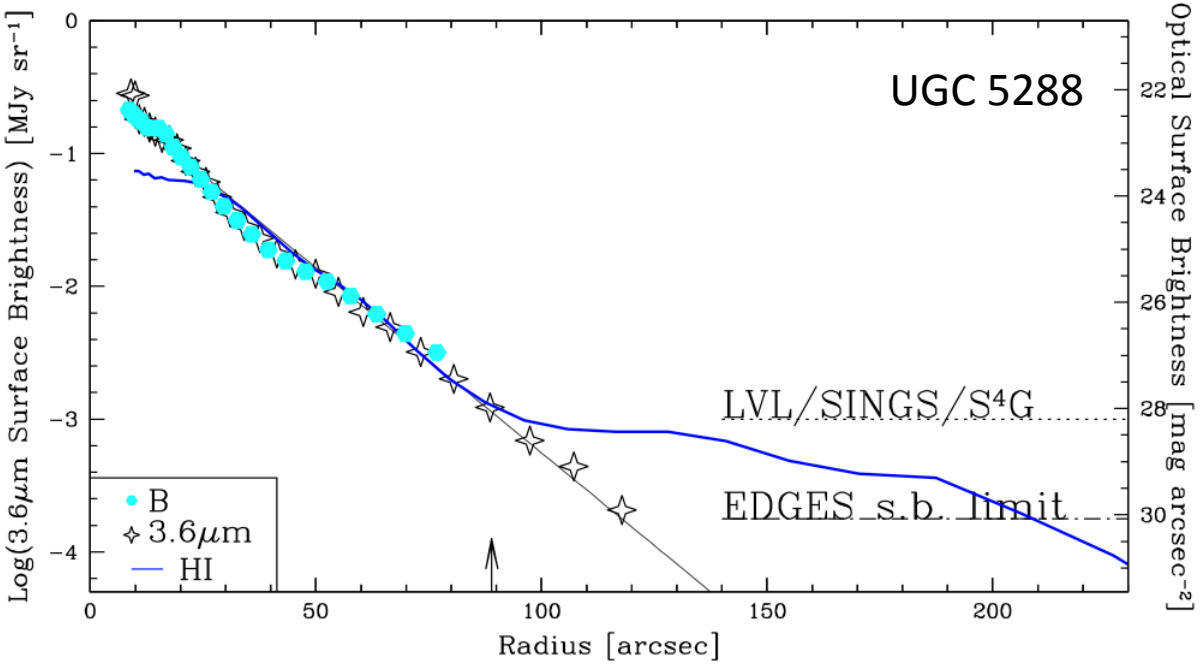
- An extended gaseous disk was discovered by Begum et al. (2008): D_{HI}/D_{25} ~ 11

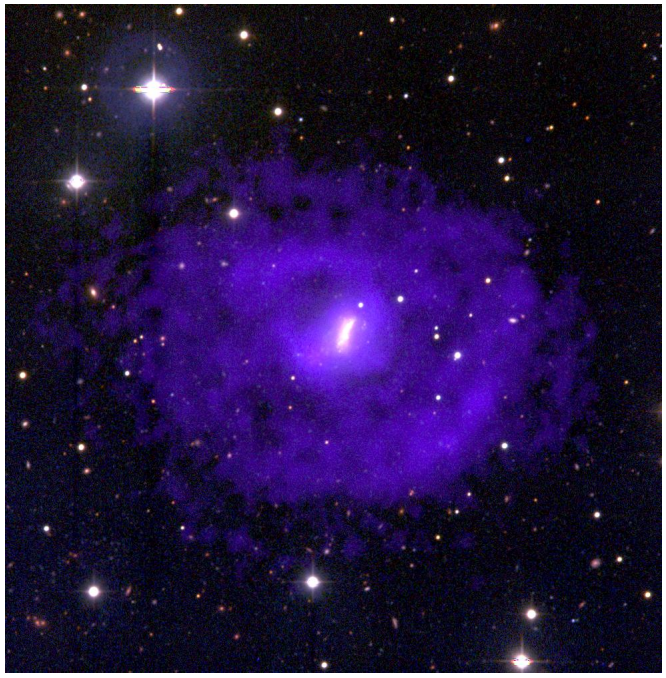




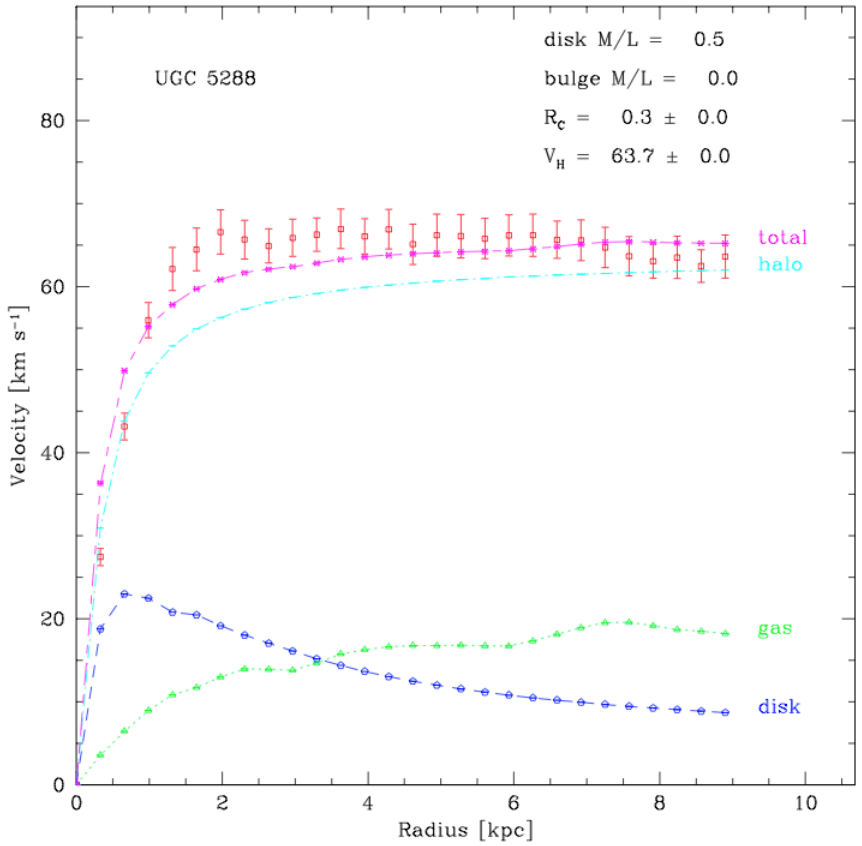

NGC 3741
LVL/SINGS/S4G
EDGES s.b. limit
B
3.6μm
HI
Log(3.6μm Surface Brightness) [MJy sr⁻¹]
Optical Surface Brightness [mag arcsec⁻²]
Radius [arcsec]

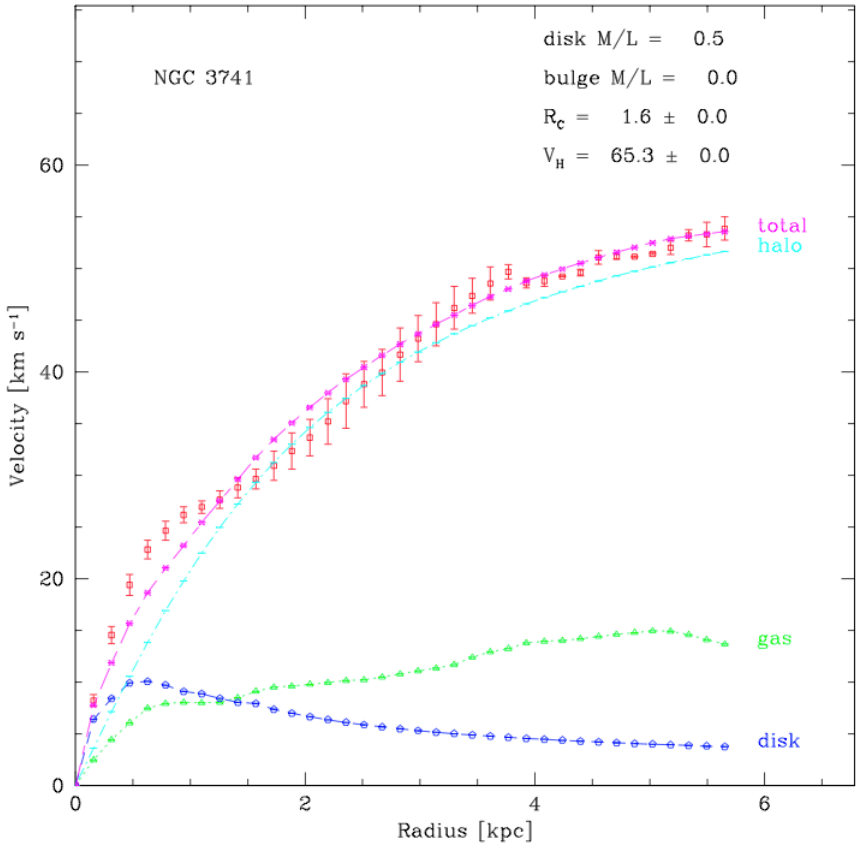



UGC 5288
LVL/SINGS/S4G
EDGES s.b. limit
B
3.6μm
HI
Log(3.6μm Surface Brightness) [MJy sr⁻¹]
Optical Surface Brightness [mag arcsec⁻²]
Radius [arcsec]



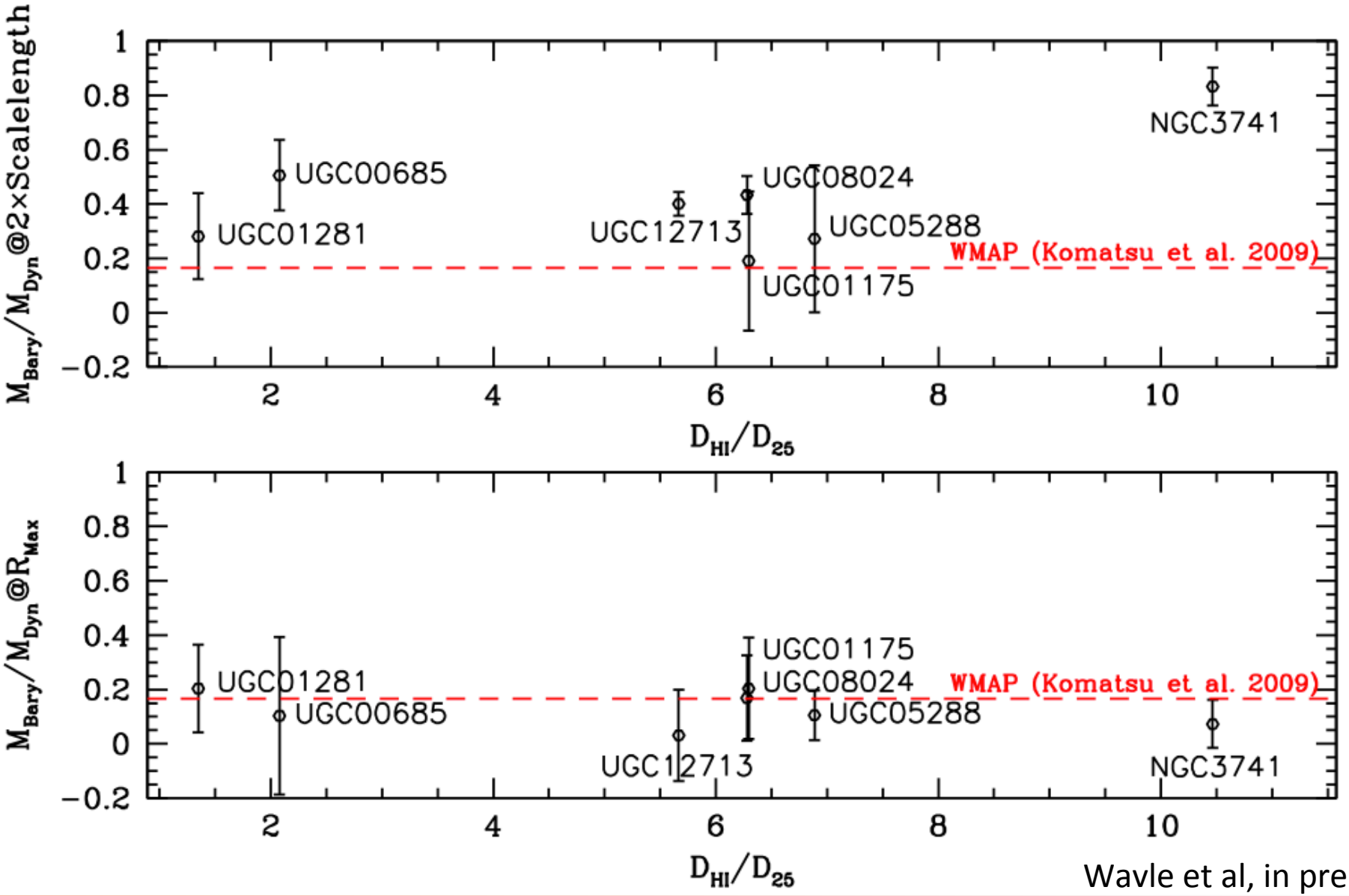
Rotation Curve Decomposition





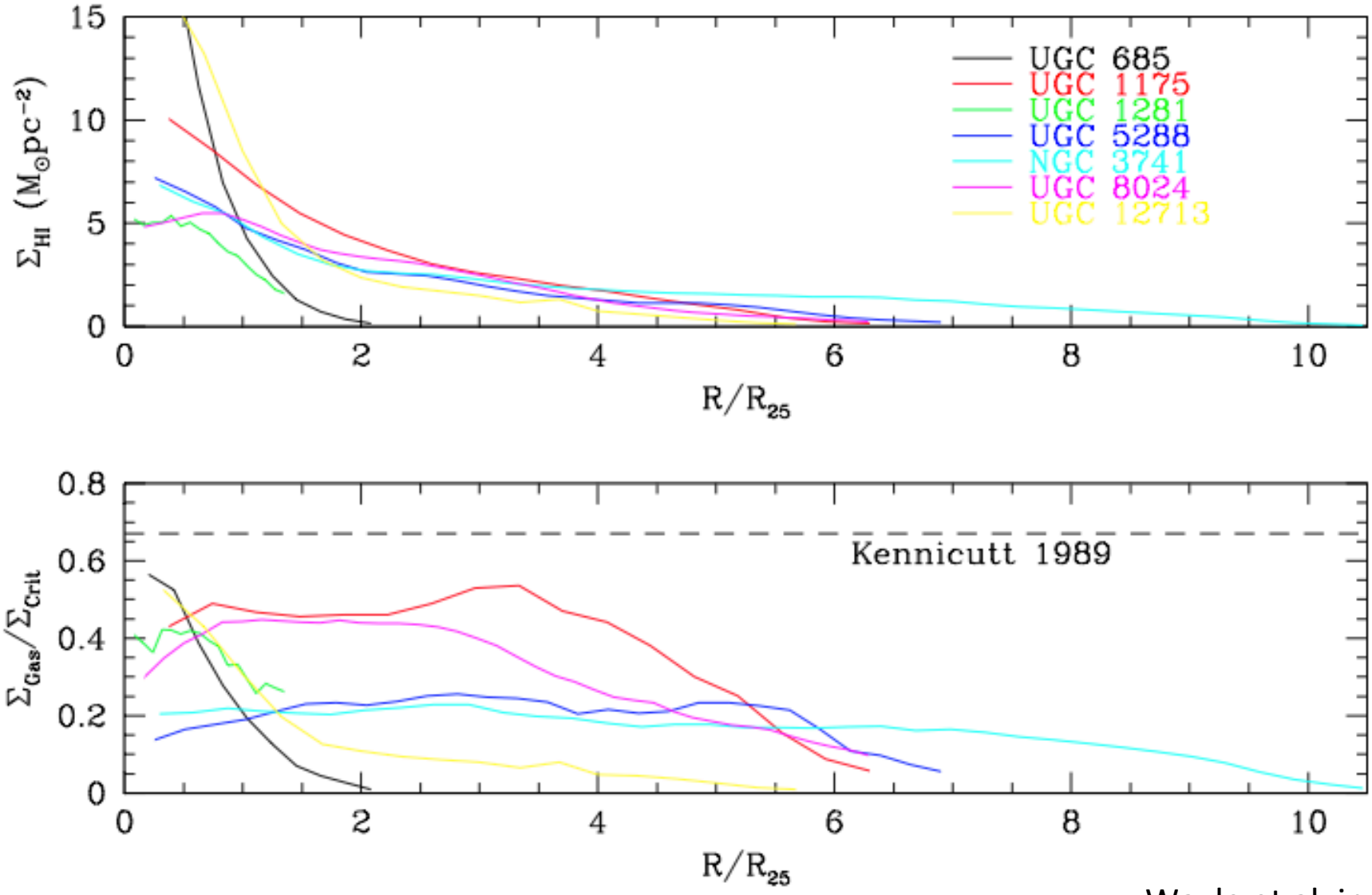
Wavle et al, in prep

Baryon Fraction: Dark Matter Dominated



Wavle et al, in prep

Gas Surface Density and Stability



Wavle et al, in prep

Conclusions

- Deep *Spitzer* 3.6μm images can trace stellar disks to large radii, but the stellar distributions for these particular galaxies fall off more rapidly than their gaseous disks.
- As is typical of dwarf galaxies, atomic gas surface densities fall well below the Toomre criterion throughout their gaseous disks, indicating that these galaxies are relatively stable against cloud collapse and subsequent star formation activity.
- Despite their "extended gaseous disks," these galaxies trace the same fraction of the dark matter potential as other dwarf galaxies, suggesting that it is not the gas that is extended, but rather that the stars are too compact, or under performing.