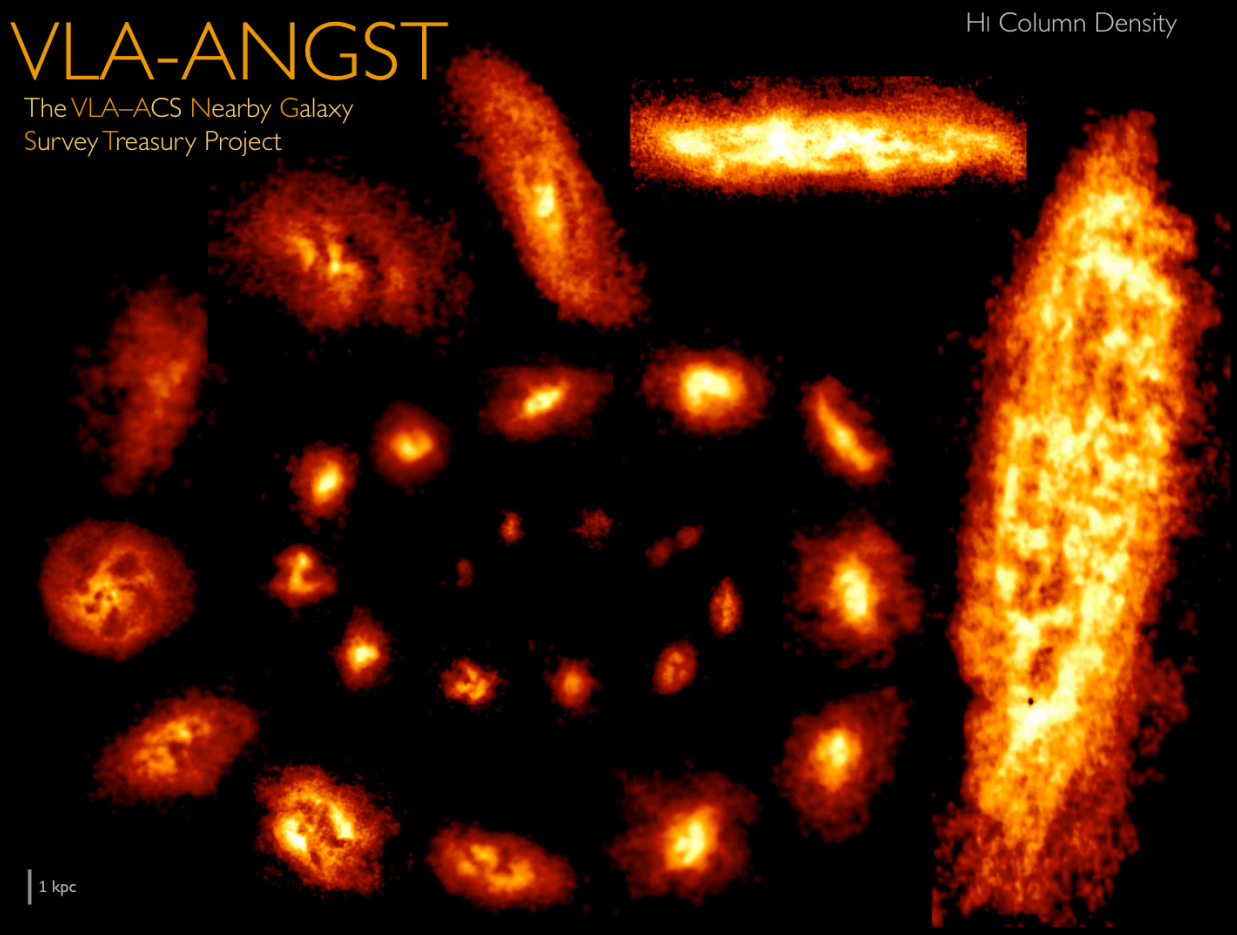
Highlights from the VLA/ANGST Survey



Evan Skillman – U. Minnesota

Gas in Galaxies 2011: From Cosmic Web to Molecular Clouds

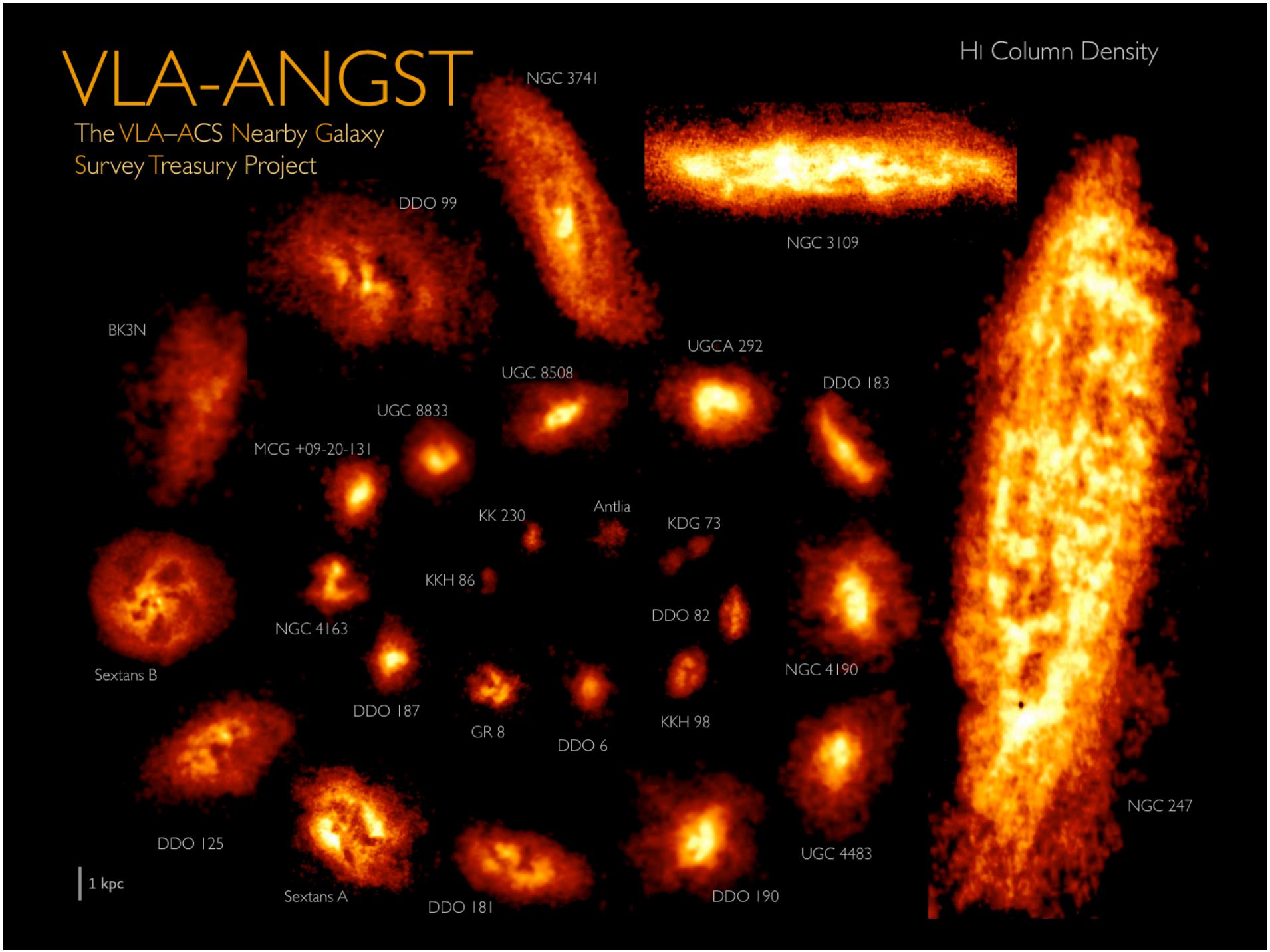
Kloster Seeon, Germany – 16/06/2011

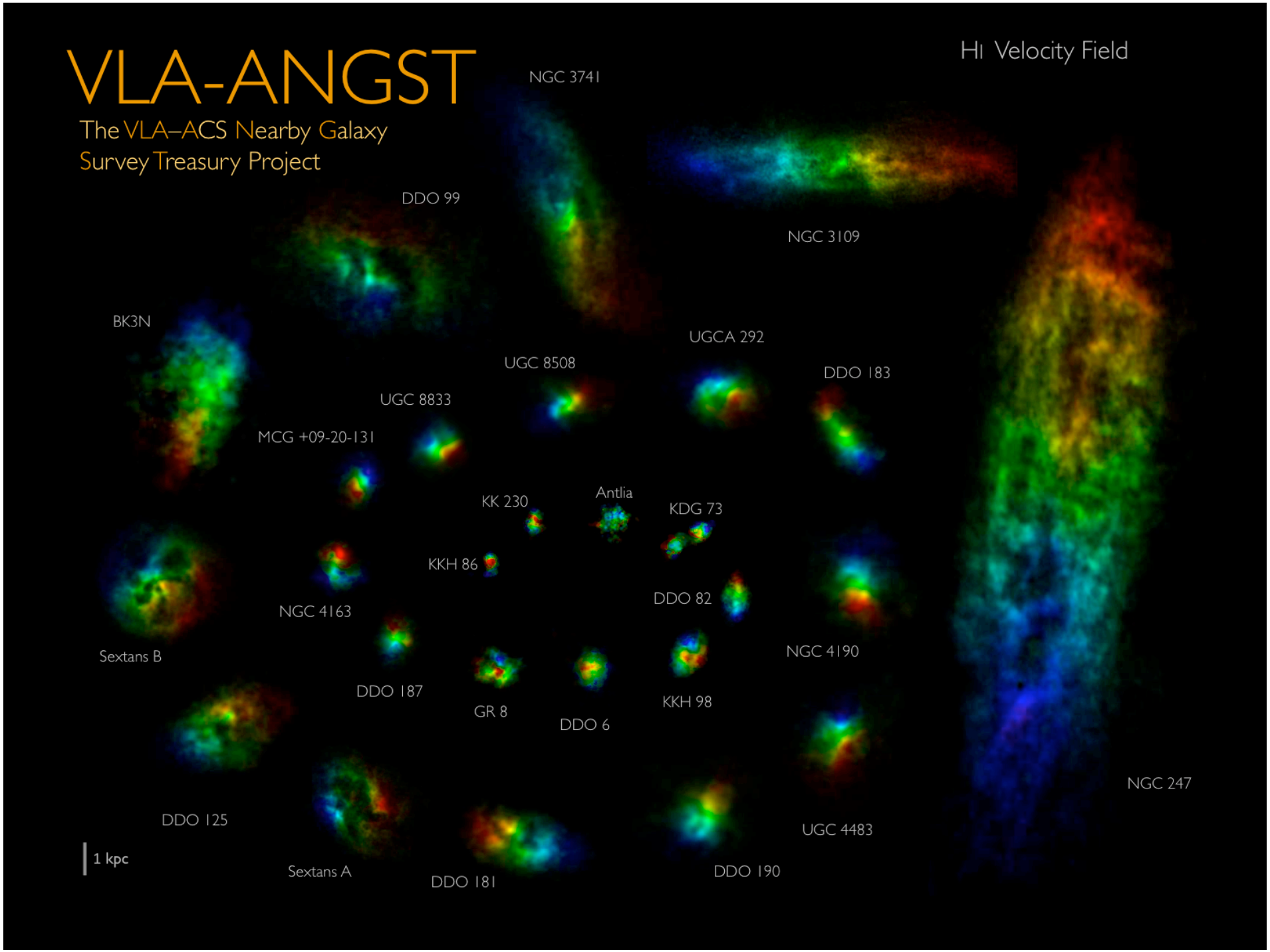
VLA/ANGST

- The ANGST HST Treasury Project allowed a survey of recent SFHs of a large sample of galaxies (~70) within ~4 Mpc. (PI: Dalcanton)
- The NRAO large program VLA/ANGST provides new HI observations for 36 galaxies from the ANGST sample (PI: J. Ott, Team members: A. Stilp, S. Warren, J. Dalcanton, F. Walter, EDS, B. Koribalski, A. West)
- ~500 hours VLA time, 3 configurations, THINGS protocols (sort of), channels of 0.65 or 1.3 km/s

VLA/ANGST

- (important point) The HST observations provide accurate distances and resolved stellar populations.
- ANGST galaxies were part of the Spitzer Local Volume Legacy survey (PI: Kennicutt, Lee), providing Spitzer IR, GALEX UV, and H-alpha imaging (also important).
- We (Steven Warren UMN; Adrienne Stilp UWA) (really important) can compare the ANGST SFHs with the ISM distributions and kinematics to better understand the connections between SF and ISM structures.


VLA-ANGST
The VLA–ACS Nearby Galaxy Survey Treasury Project
HI Column Density
NGC 3741
NGC 3109
DDO 99
BK3N
UGCA 292
UGC 8508
DDO 183
UGC 8833
MCG +09-20-131
KK 230
Antlia
KDG 73
KKH 86
DDO 82
NGC 4163
Sextans B
NGC 4190
DDO 187
GR 8
DDO 6
KKH 98
DDO 125
NGC 247
UGC 4483
1 kpc
Sextans A
DDO 181
DDO 190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The VLA–ACS Nearby Galaxy Survey Treasury Project
HI Velocity Field
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MCG +09-20-131
KK 230
Antlia
KDG 73
KKH 86
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NGC 4163
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GR 8
DDO 6
KKH 98
NGC 247
DDO 125
UGC 4483
1 kpc
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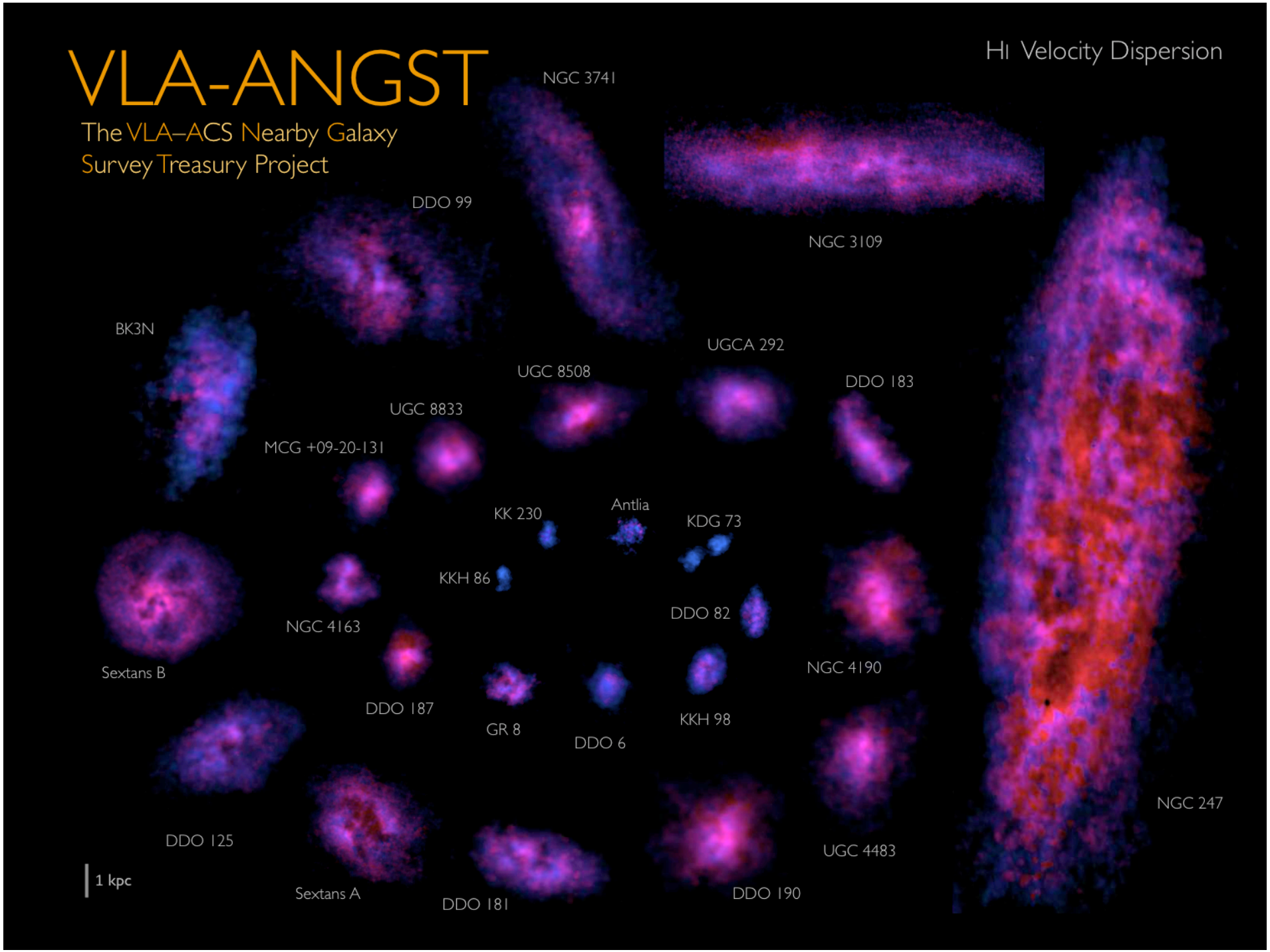
DDO 181
DDO 190


VLA-ANGST
The VLA–ACS Nearby Galaxy Survey Treasury Project
HI Velocity Dispersion
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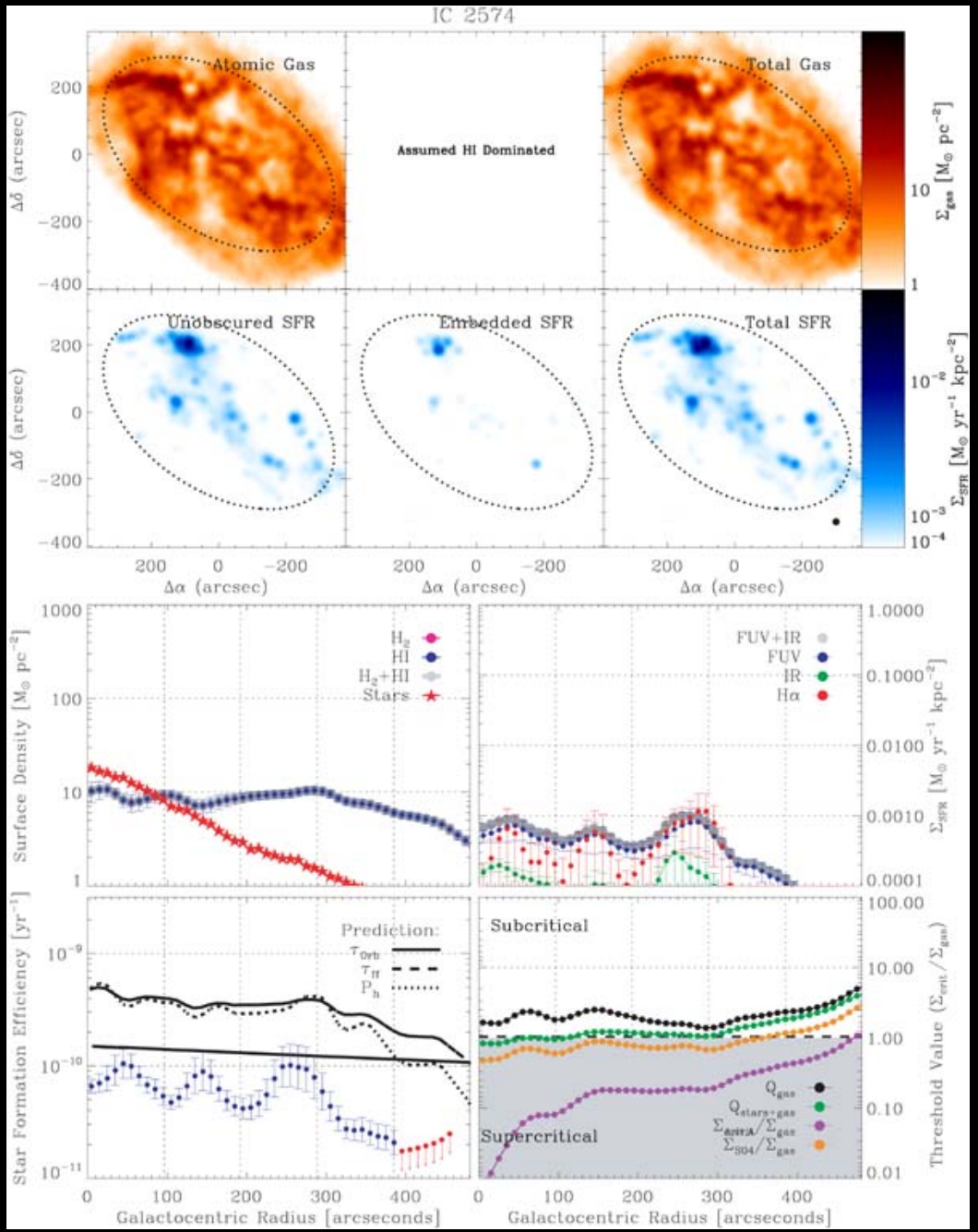
BK3N
UGCA 292
UGC 8508
DDO 183
UGC 8833
MCG +09-20-131
KK 230
Antlia
KDG 73
KKH 86
DDO 82
NGC 4163
Sextans B
NGC 4190
DDO 187
GR 8
DDO 6
KKH 98
DDO 125
NGC 247
UGC 4483
1 kpc
Sextans A
DDO 181
DDO 190

A Challenge:

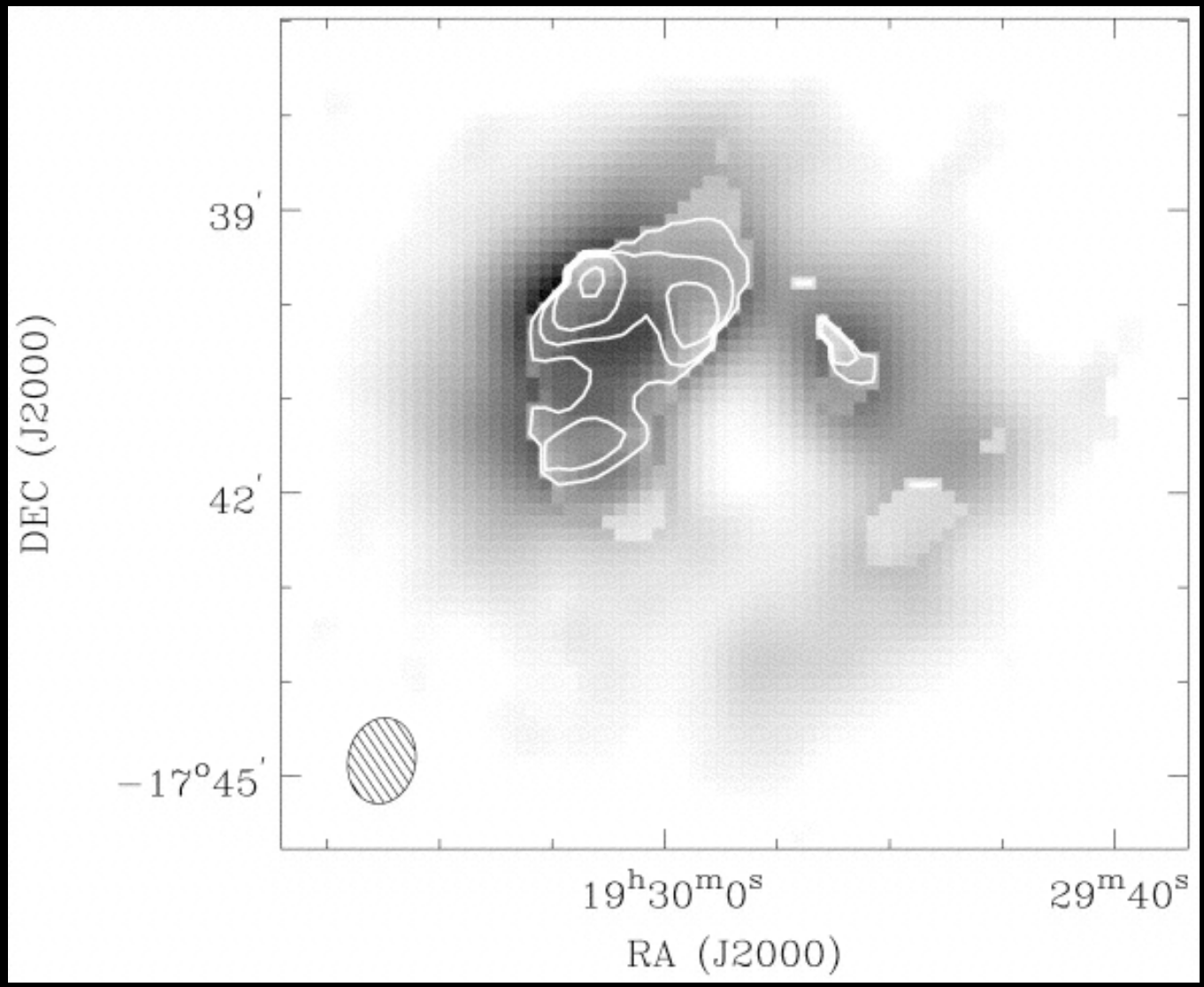
The long standing problem of studying the molecular component in the low metallicity dwarfs continues. Since CO (the favored tracer) disappears at low values of O/H, we need new tracers of the molecular gas in dwarfs.

Example dataset for Leroy et al. (2008) study.



The Low Metallicity ISM:

One potential method for tracing the molecular component is to identify “cold” HI emission a la Young et al. (1997), Begum et al. (2006), de Blok & Walter (2006).



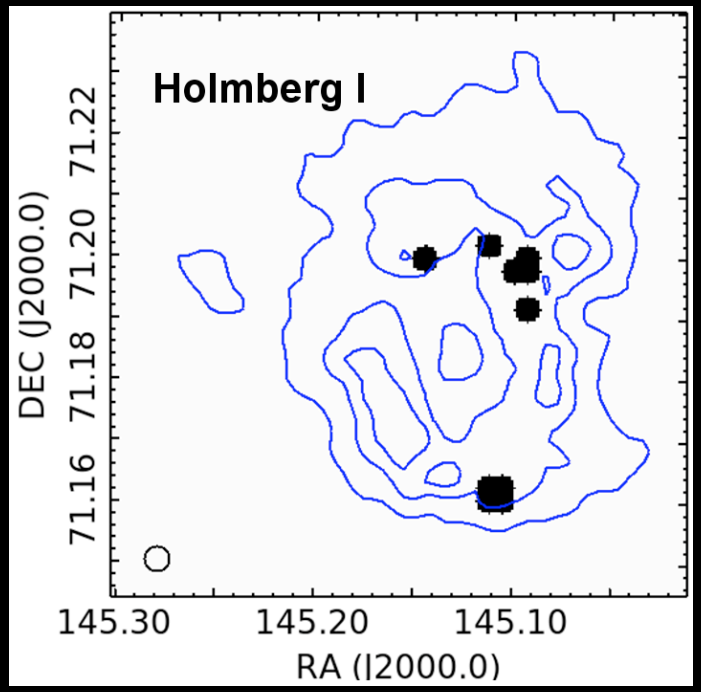
HI in Sag DIG showing both broad and narrow components from Young et al. (1997) study.

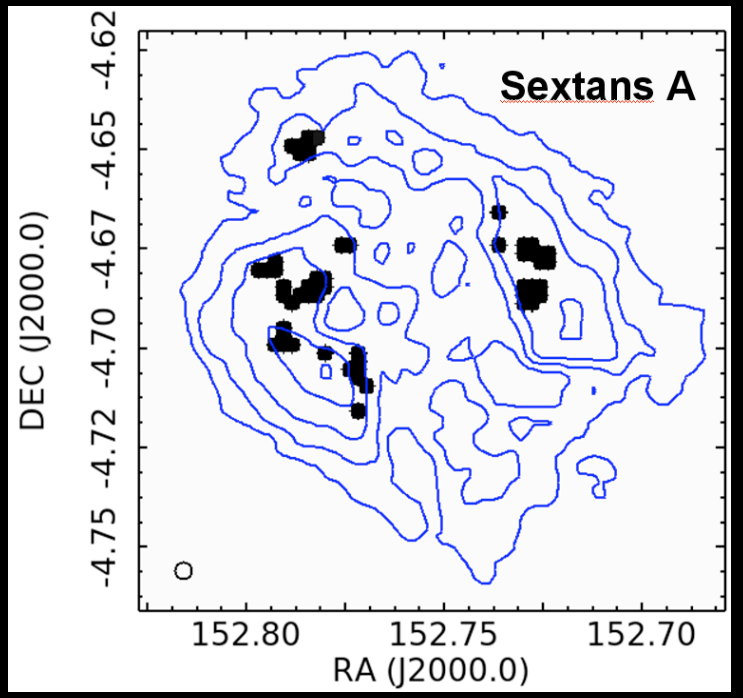
Detecting Cold HI Gas in Low Mass Galaxies

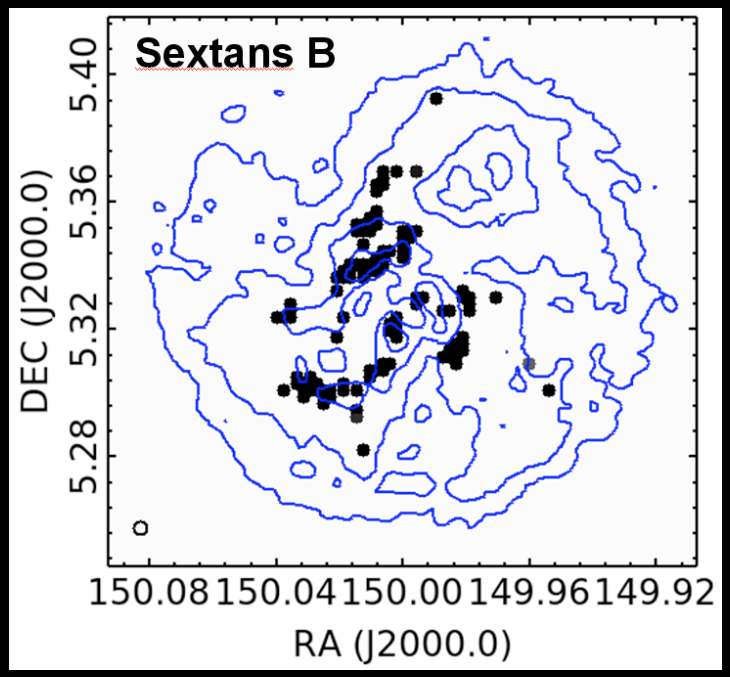
VLA HI line data from the VLA-ANGST and THINGS surveys

- Fit line-of-sight spectra with single and double Gaussians as well as fourth order Gauss-Hermite polynomials.

- Locations where the double Gaussian AND Gauss-Hermite polynomial for the observed spectra fit better than a single Gaussian at the 95% confidence level are identified as containing a broad (warm) and narrow (cold) component.


Holmberg I
DEC (J2000.0)
71.22
71.20
71.18
71.16
145.30
145.20
145.10
RA (J2000.0)


Sextans A
DEC (J2000.0)
-4.62
-4.65
-4.67
-4.70
-4.72
-4.75
152.80
152.75
152.70
RA (J2000.0)


Sextans B
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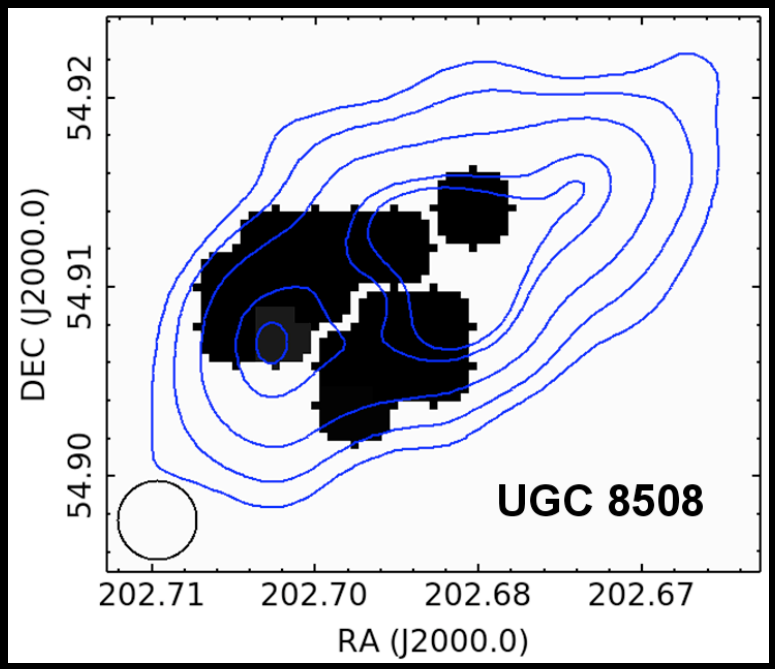
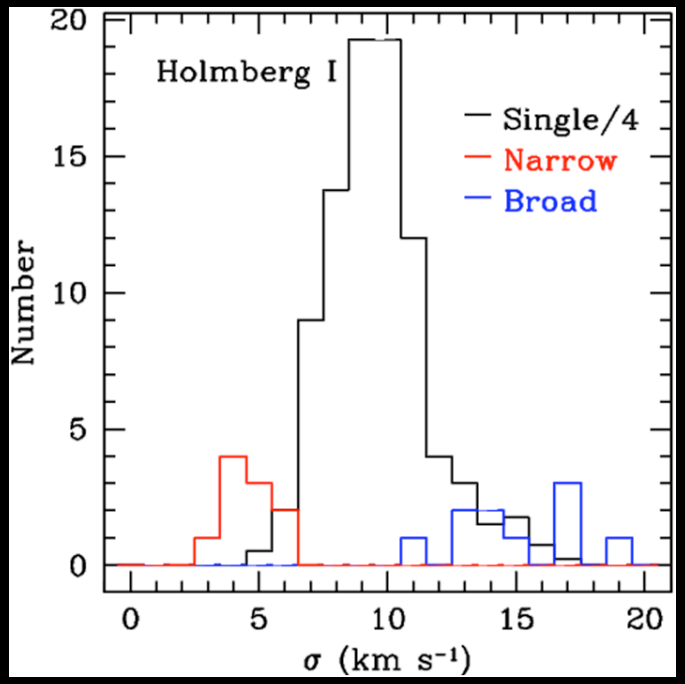
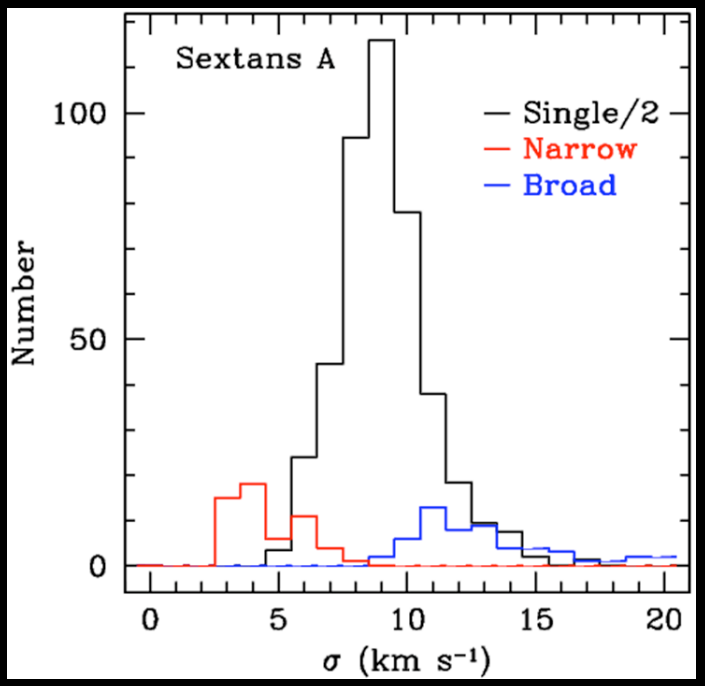
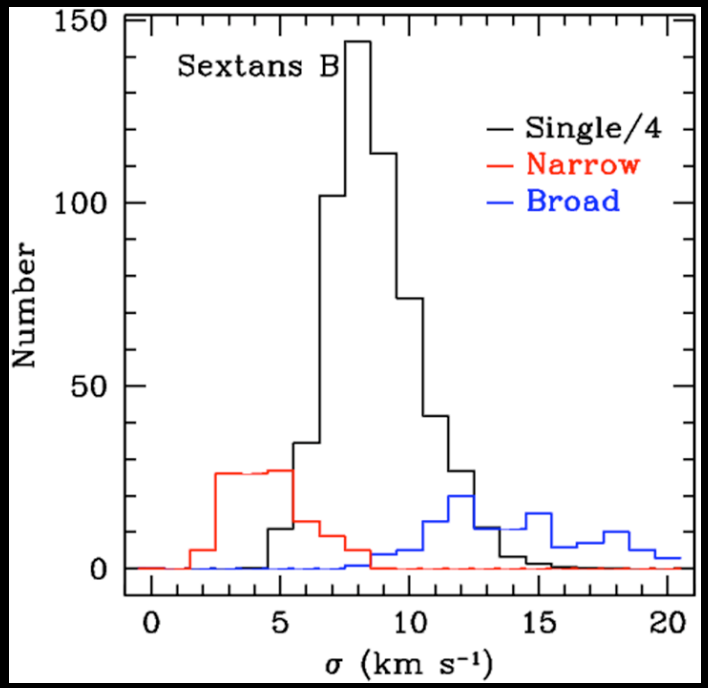
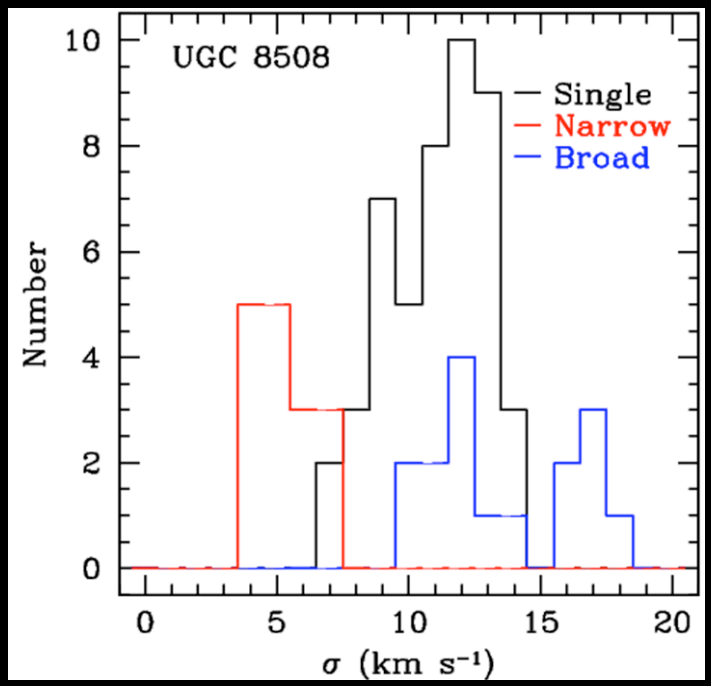
5.36
5.32
5.28
150.08
150.04
150.00
149.96
149.92
RA (J2000.0)


UGC 8508
DEC (J2000.0)
54.92
54.91
54.90
202.71
202.70
202.68
202.67
RA (J2000.0)

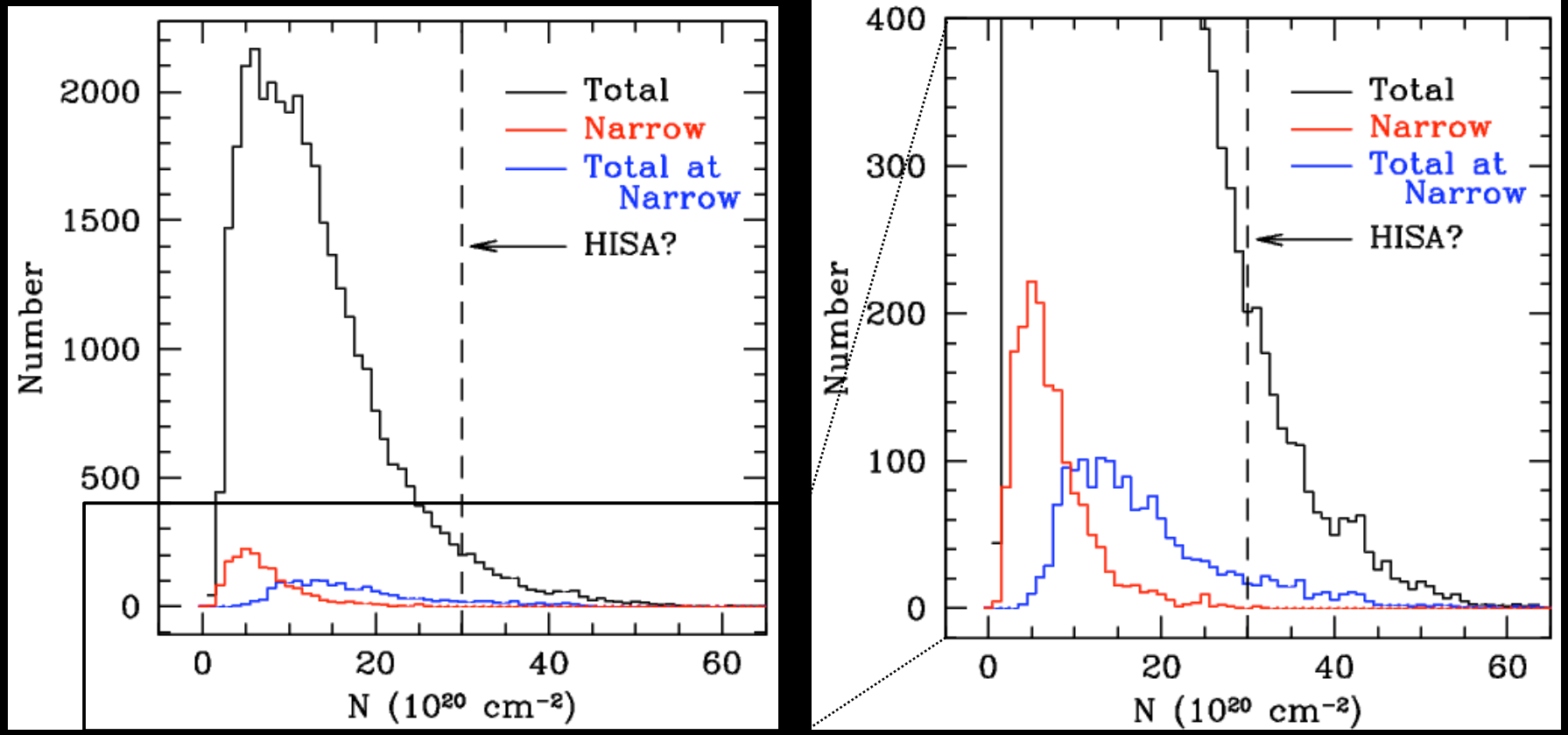

Holmberg I
Single/4
Narrow
Broad
Number
σ (km s⁻¹)
0
5
10
15
20


Sextans A
Single/2
Narrow
Broad
Number
σ (km s⁻¹)
0
50
100
0
5
10
15
20


Sextans B
Single/4
Narrow
Broad
Number
σ (km s⁻¹)
0
50
100
150
0
5
10
15
20


UGC 8508
Single
Narrow
Broad
Number
σ (km s⁻¹)
0
2
4
6
8
10
0
5
10
15
20

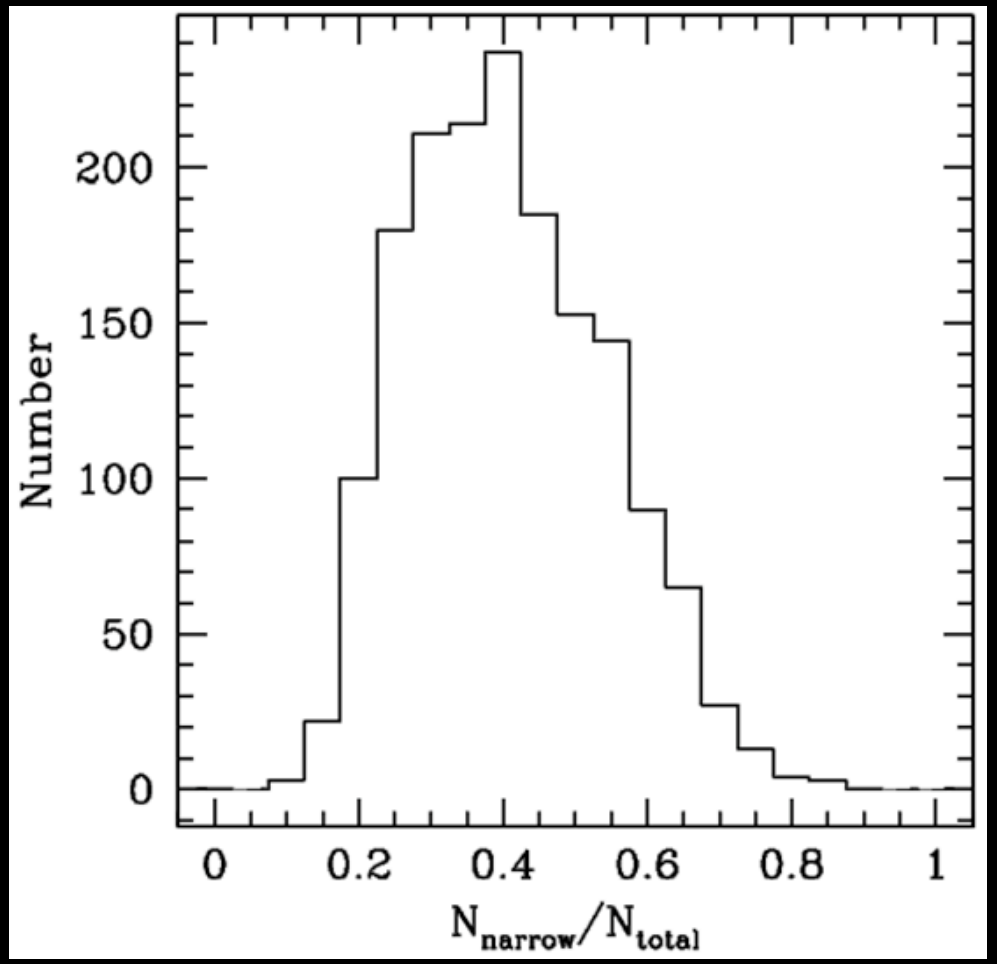
Column Density Comparison



densities above 10^21 – the supposed star formation / molecular cloud formation limit

Column Density Comparison

Narrow component, when detected, is typically 30 to 50% of the total column density for that sightline.

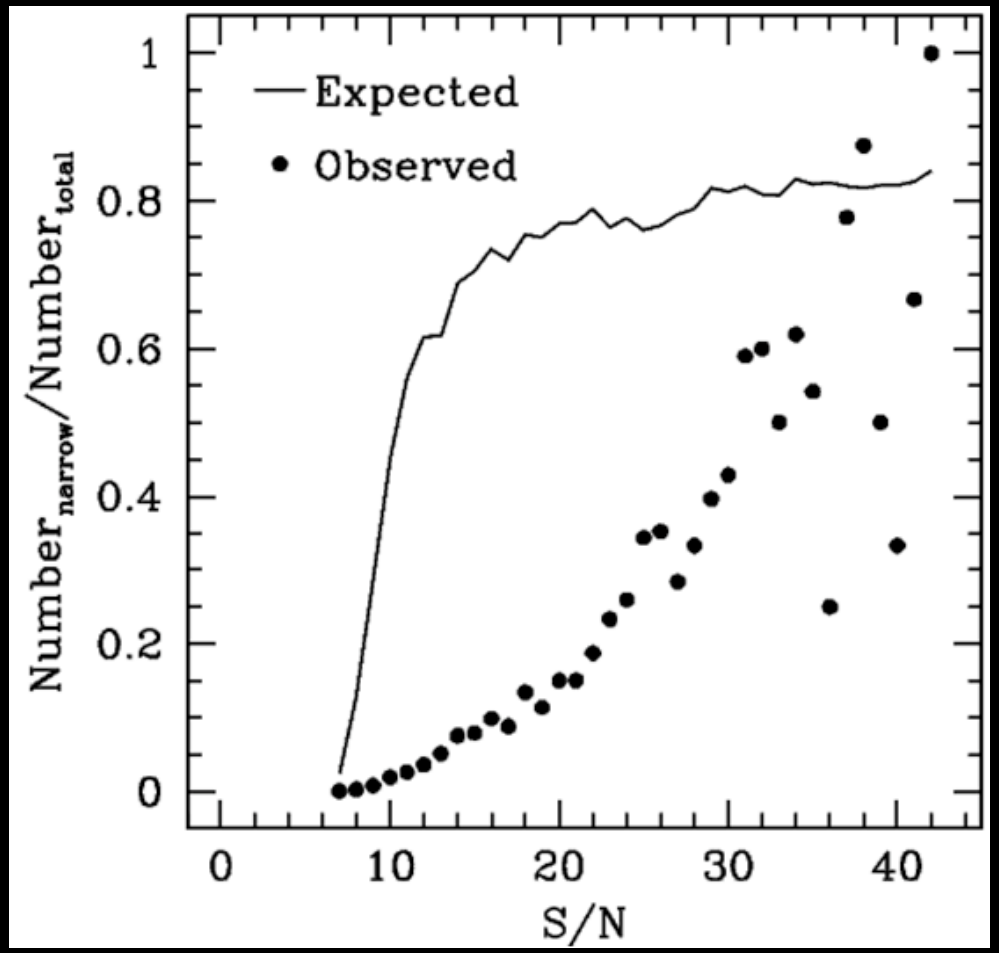


Testing for Bias

If every line of sight has two components, what is our ability to recover each component for a given S/N?

- Create ~75,000 synthetic spectra
  - random S/N, amplitude, and velocity dispersion for each component

Most lines of sight do not contain two components.



Narrow HI Summary

- Narrow line gas is found in every galaxy in our sample where the S/N is adequate.
- Narrow line gas is near, but not necessarily coincident with the highest column density gas.
- Narrow line gas is a small fraction of the total HI (typically 1 – 3 %).
- Future work will compare locations of narrow line detection to known tracers of star formation and molecular cloud formation.

The Low Metallicity ISM:

HERSCHEL represents a great addition.

The SPIRE instrument allows us to trace the very cold dust component, which should correlate well with the molecular gas (cf. Leroy et al. 2011).

The PACS instrument allows spectroscopy of [CII] at 158 microns. Madden et al. (1997) showed that this traces the photo-dissociated CO, which traces the molecular gas.

The Low Metallicity ISM:

ALMA allows a different approach.

At high resolution and sensitivity, it may be possible that the small CO cores are detectable.

At higher sensitivities, it may be that other molecular species are detectable.

Note the connection between understanding the low metallicity environment and high redshift galaxies.

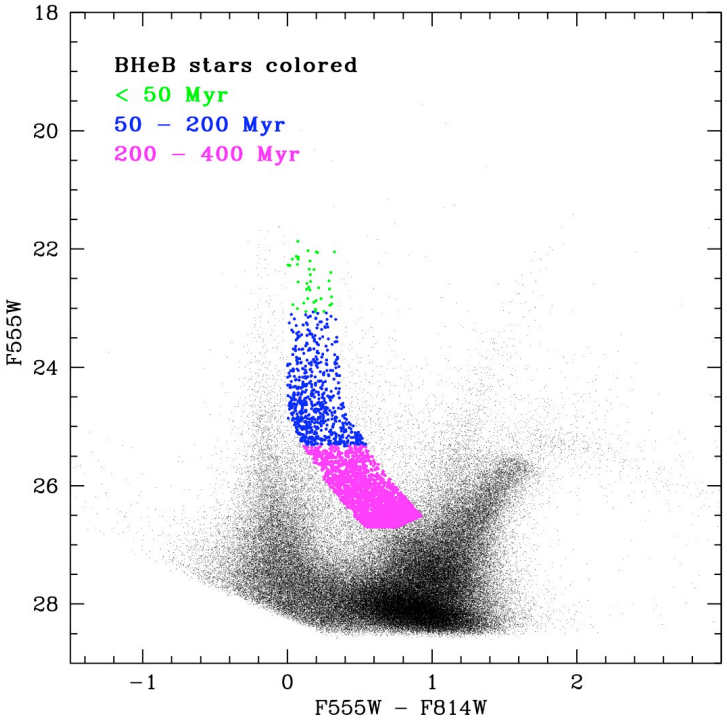
Studying Feedback

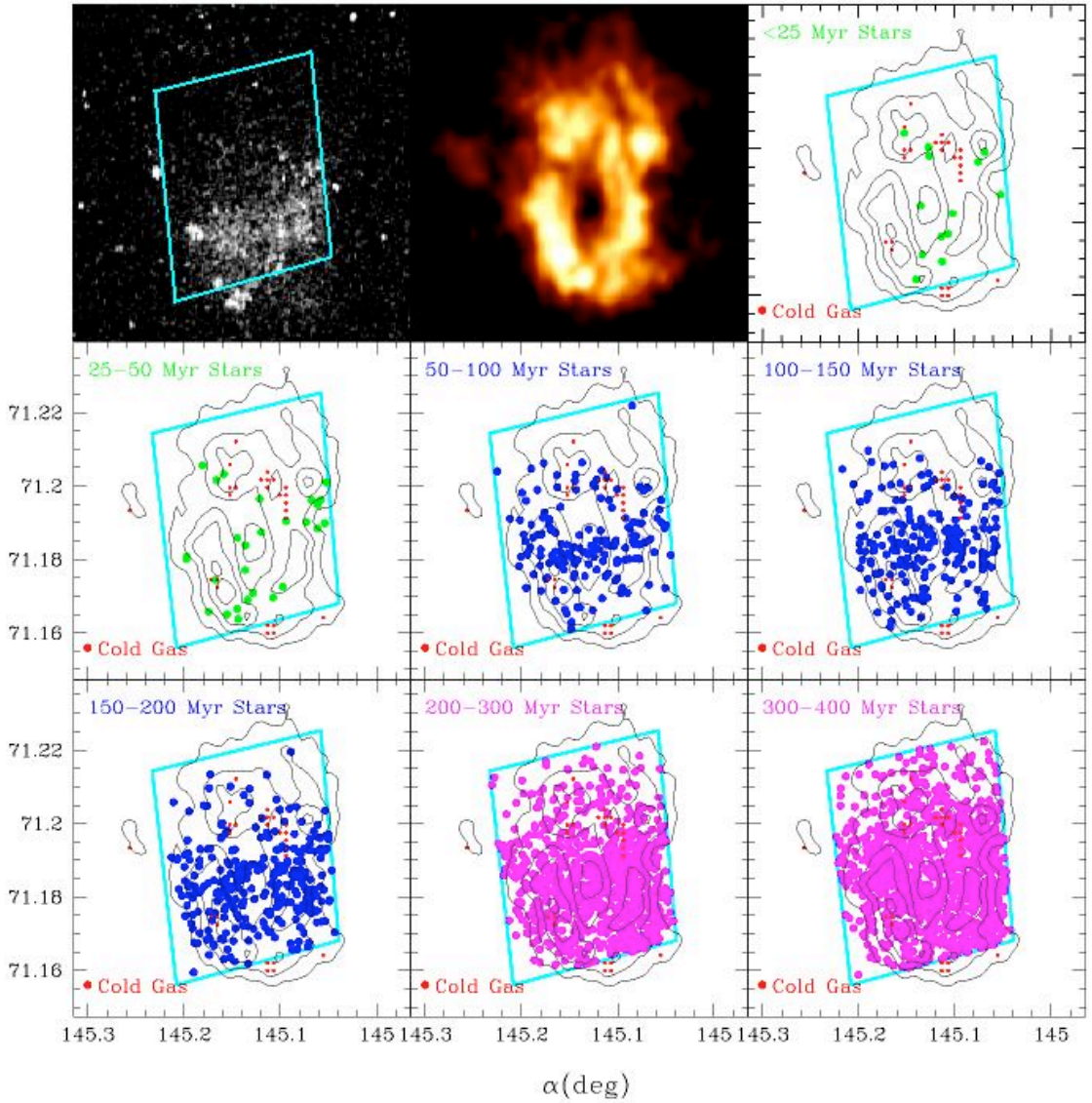
We have compared the spatially resolved recent star formation histories derived from HST with the ISM distributions from the VLA and studied the connections between star formation and ISM structures (following Weisz et al. 2008, 2009) and determined that large, central holes have sufficient recent star formation to create the holes from “distributed” star formation (Warren et al. 2011).

Ultimate Goal

We can compare the spatially resolved recent star formation histories derived from HST with the ISM distributions from the VLA and study the star formation process (Does star formation induce more star formation or quench star formation?, Does star formation propagate or is it stochastic?).

Example: The Narrow HI Emission in Holmberg I





Refractory Period ~ 100 Myr (c.f., Stinson et al. 2007)

Summary:

VLA/ANGST has allowed us to characterize the narrow line HI gas in a large sample of dwarf galaxies. Comparison with other observations (e.g., cold dust) will allow us to determine if the cold HI traces the molecular gas. Comparison with the spatially resolved star formation histories allow us to see temporal connections between star formation and the ISM.