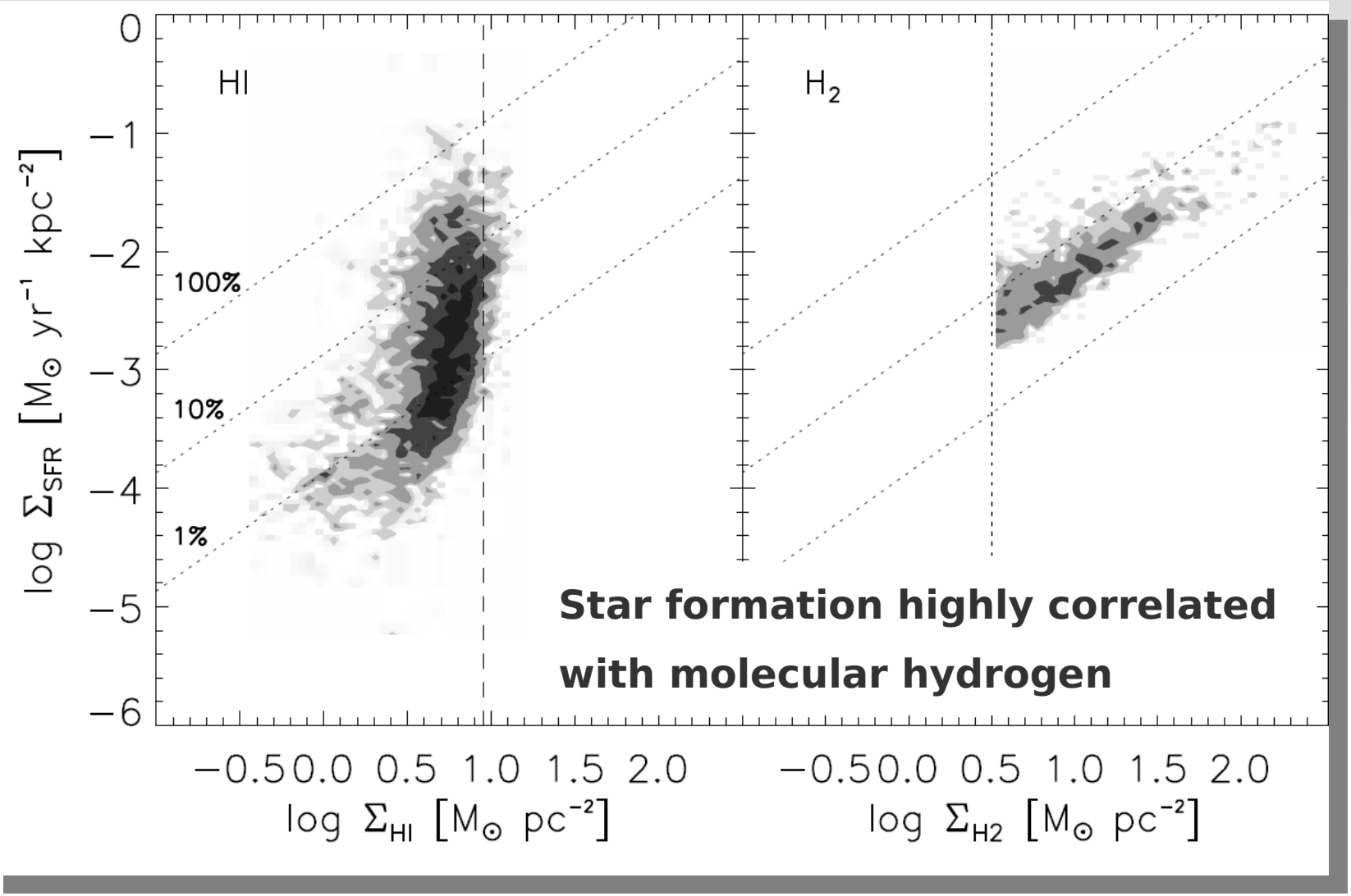
Tracing Cold HI Gas in Nearby, Low-Mass Galaxies

Steven R. Warren, E. Skillman, A. Stilp, J. Dalcanton, J. Ott, F. Walter, E. Petersen, B. Koribalski, A. West.

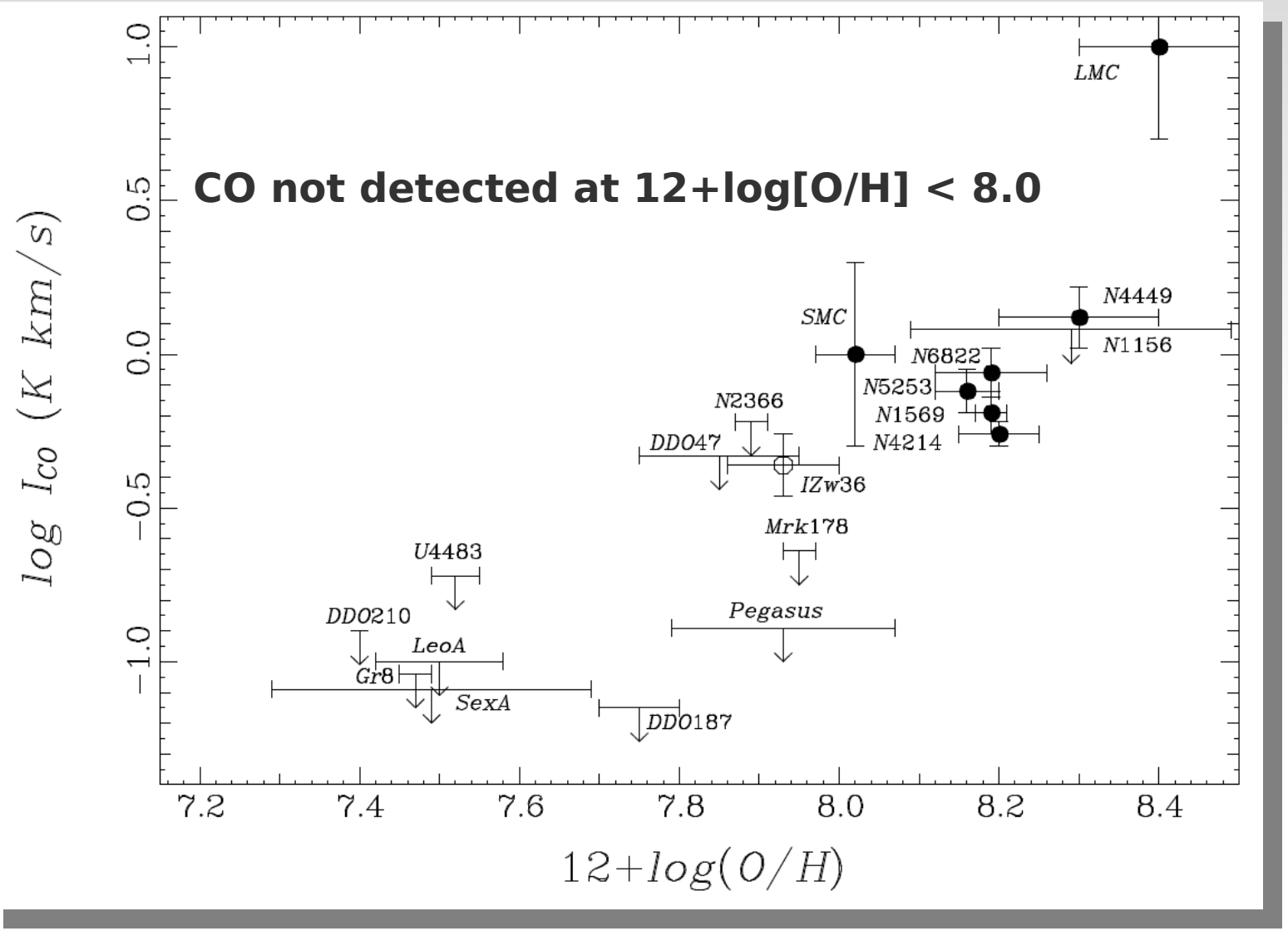
ApJ, *submitted*.

Why is cold HI important?



Bigiel, F., Leroy, A., & Walter, F. 2011, Computational Star Formation, 270, 327

Why is cold HI important?

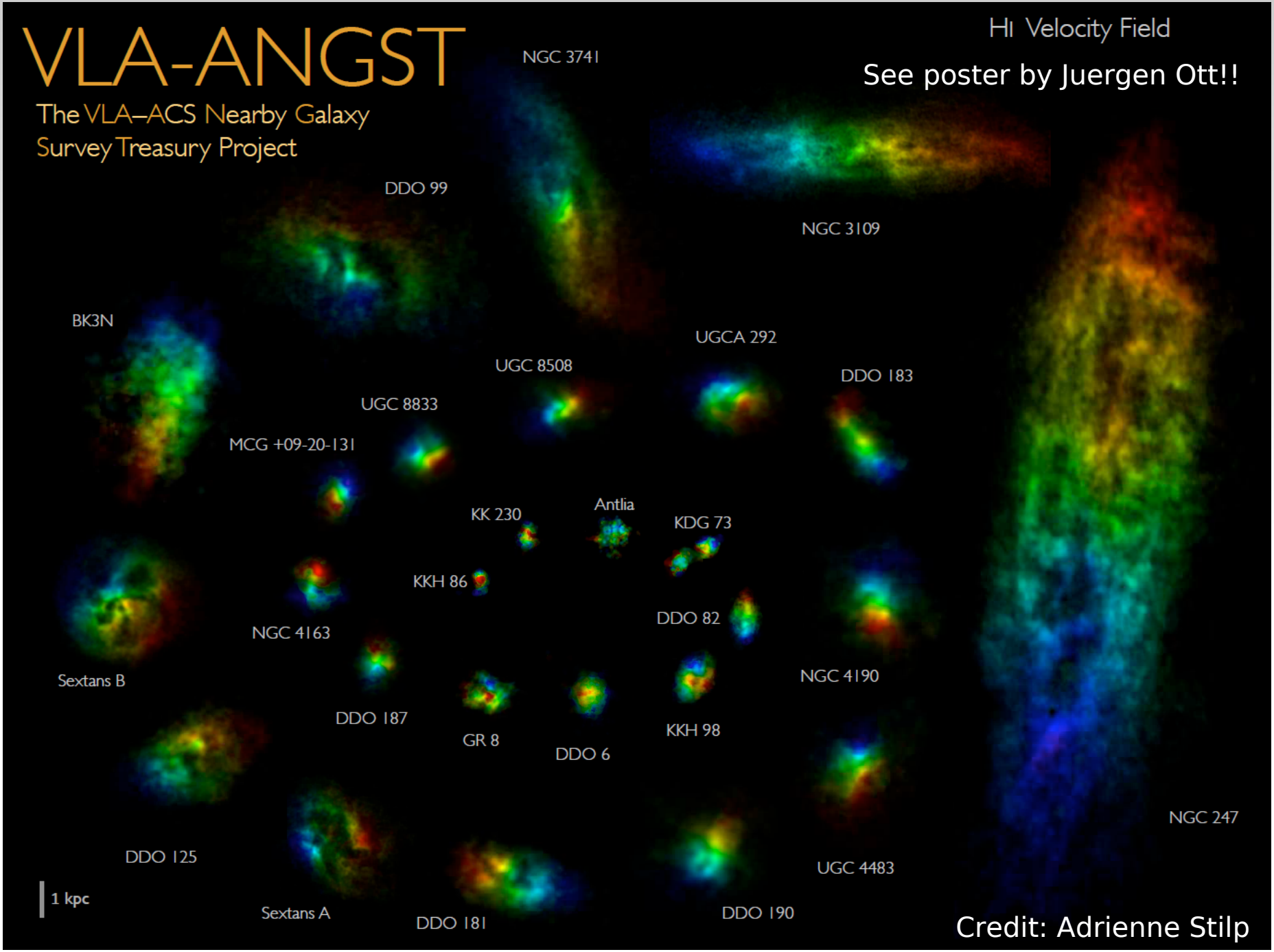


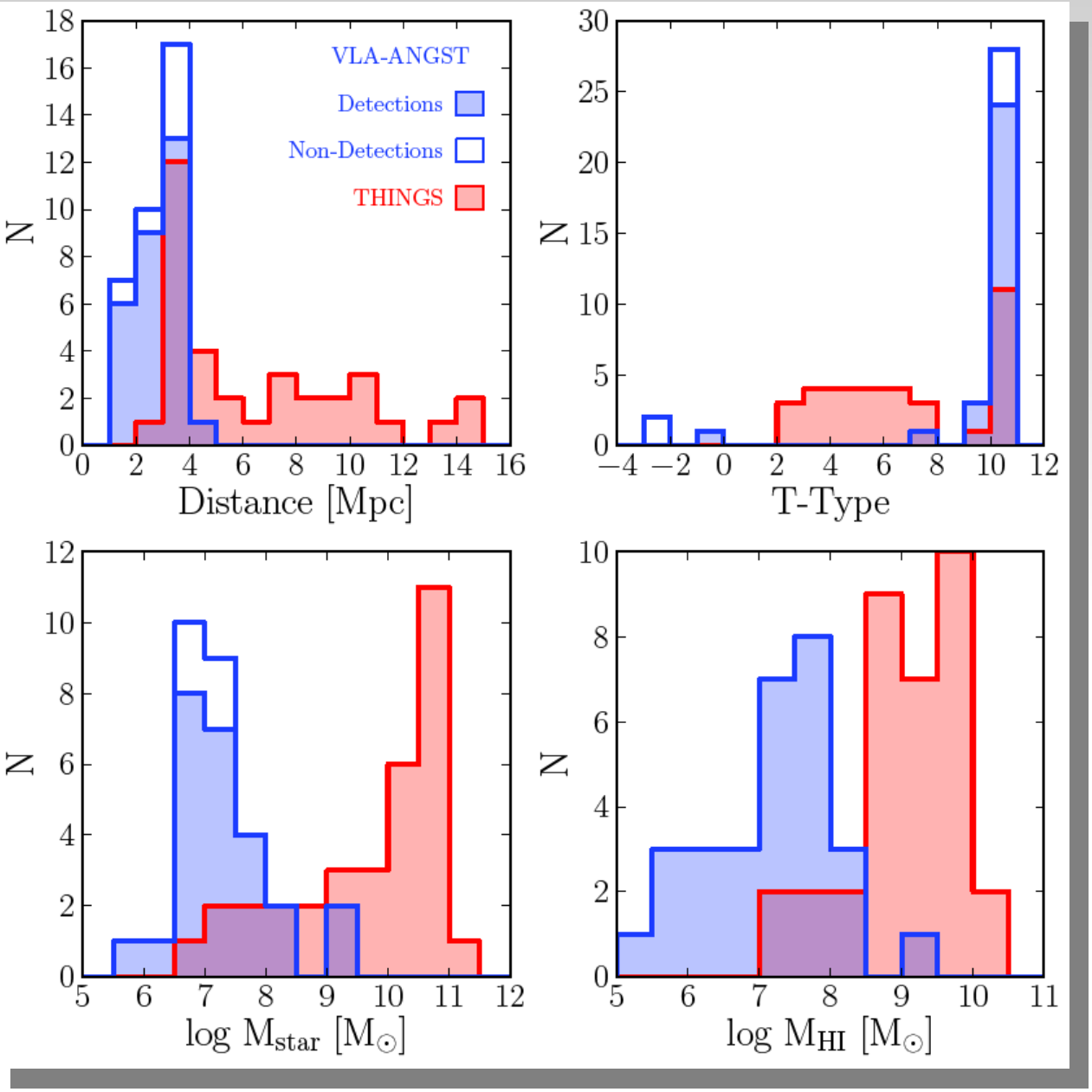
Taylor, C. L., Kobulnicky, H. A., & Skillman, E. D. 1998, AJ, 116, 2746

Sample

- 31 Galaxies
  - VLA-ANGST
  - THINGS
- $5x10^5 – 1x10^9$ M_{sun}
  - (median $3x10^7$ M_{sun})
- 1.3 - 5.3 Mpc
  - (average 2.9 Mpc)
- Velocity resolution 0.65 - 2.6 km/s

DDO 53	M81 Dwarf A
DDO 82	M81 Dwarf B
DDO 99	MCG09-20-131
DDO 125	NGC 247
DDO 181	NGC 2366
DDO 183	NGC 3109
DDO 187	NGC 3741
DDO 190	NGC 4163
GR8	NGC 4190
Holmberg I	NGC 4214
Holmberg II	Sextans A
IC 2574	Sextans B
KDG 73	UGCA 292
KK 230	UGC 4483
KKH 98	UGC 8508
	UGC 8833


VLA-ANGST
The VLA–ACS Nearby Galaxy Survey Treasury Project
HI Velocity Field
See poster by Juergen Ott!!
NGC 3741
DDO 99
NGC 3109
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
NGC 247
DDO 125
UGC 4483
1 kpc
Sextans A
DDO 181
DDO 190
Credit: Adrienne Stilp



VLA-ANGST Team:

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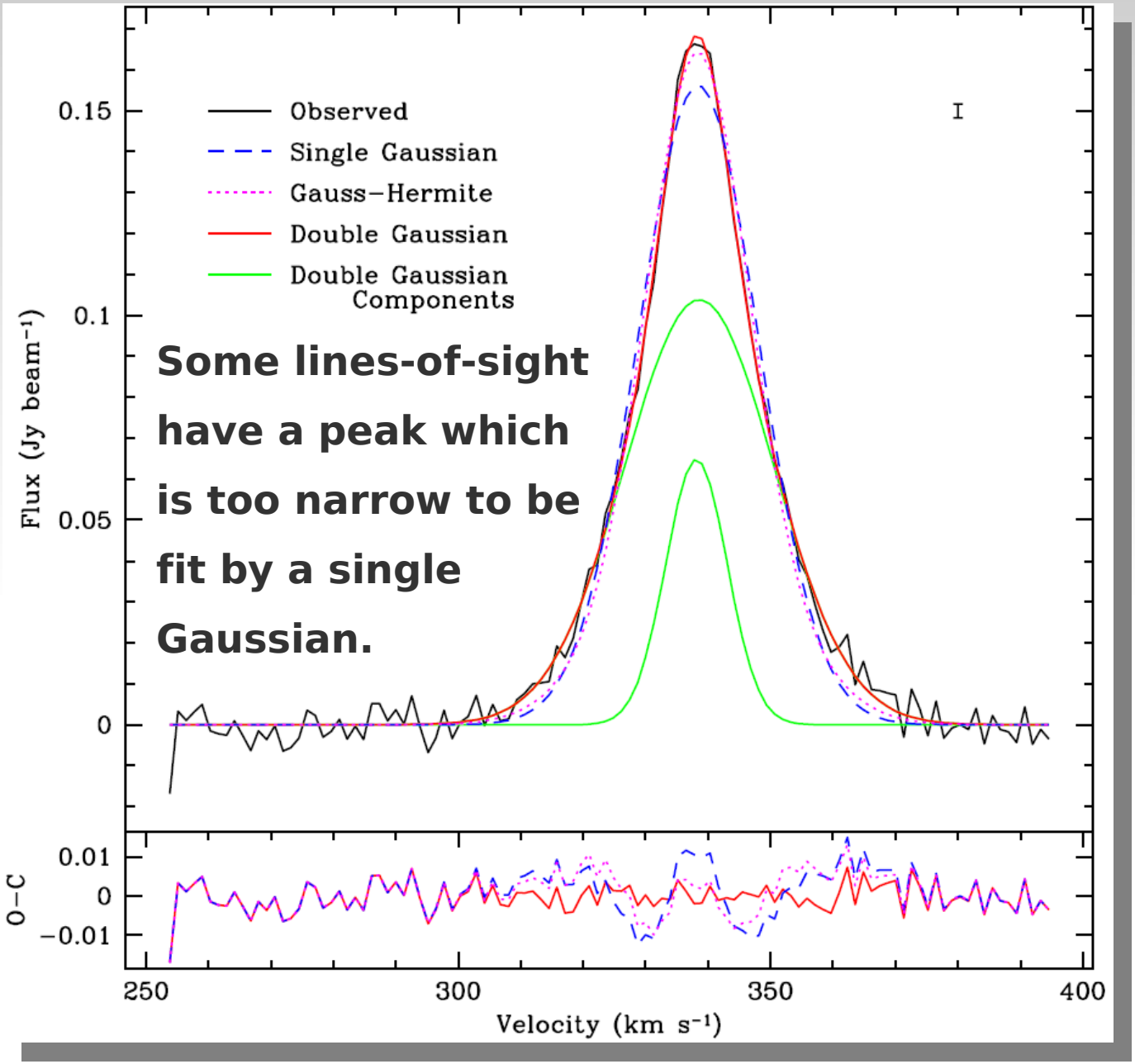
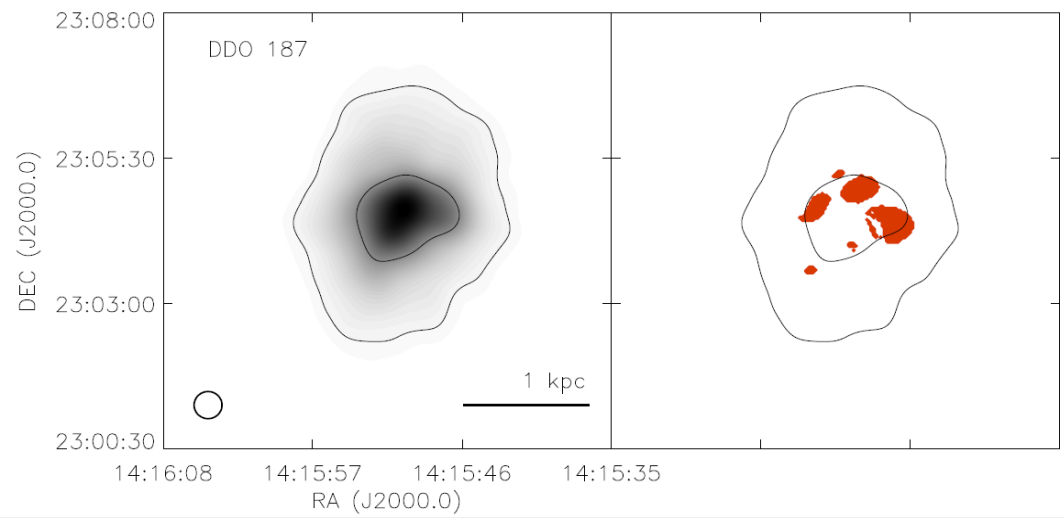
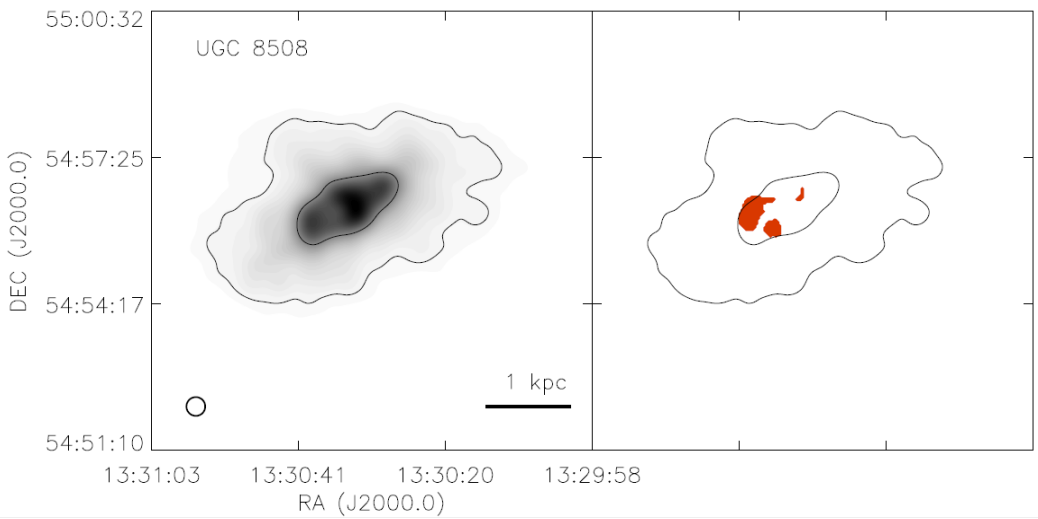
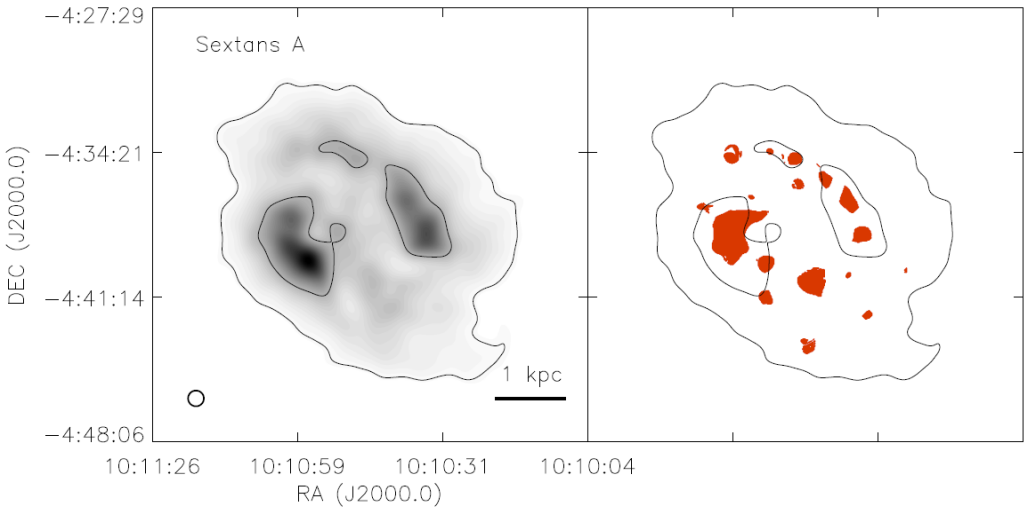
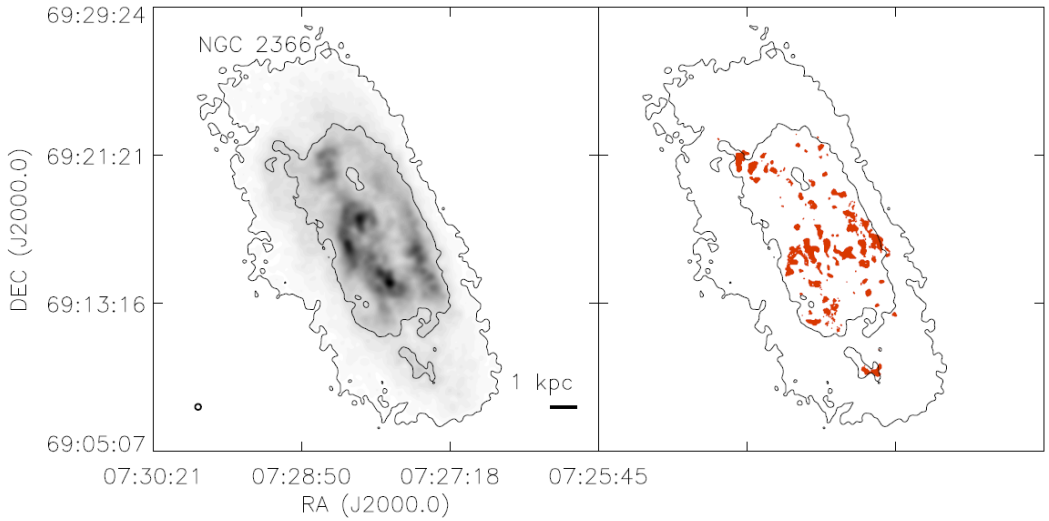

Observed
Single Gaussian
Gauss−Hermite
Double Gaussian
Double Gaussian Components
I
Some lines-of-sight have a peak which is too narrow to be fit by a single Gaussian.
Flux (Jy beam⁻¹)
0.15
0.1
0.05
0
O−C
0.01
0
−0.01
250
300
350
400
Velocity (km s⁻¹)





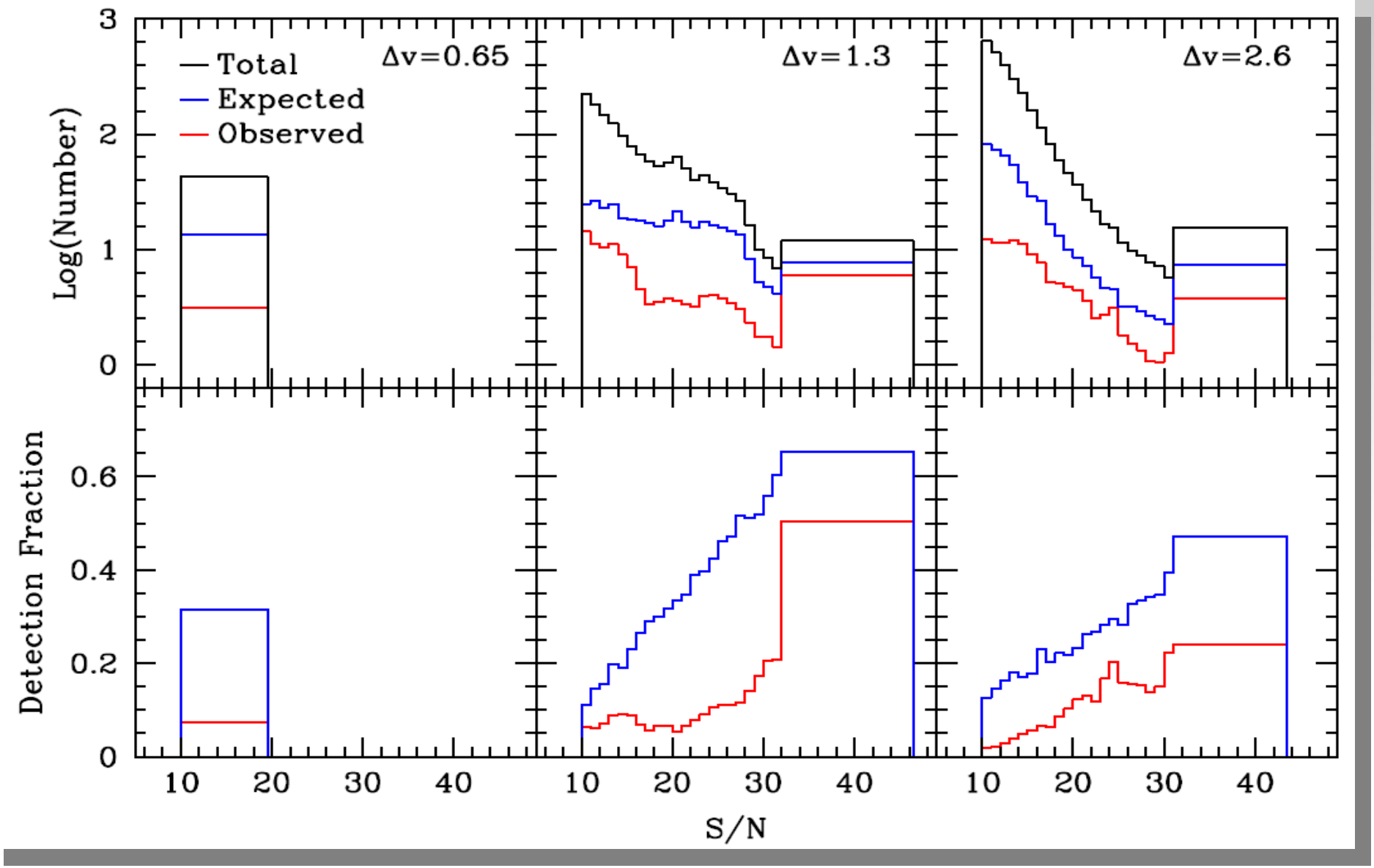




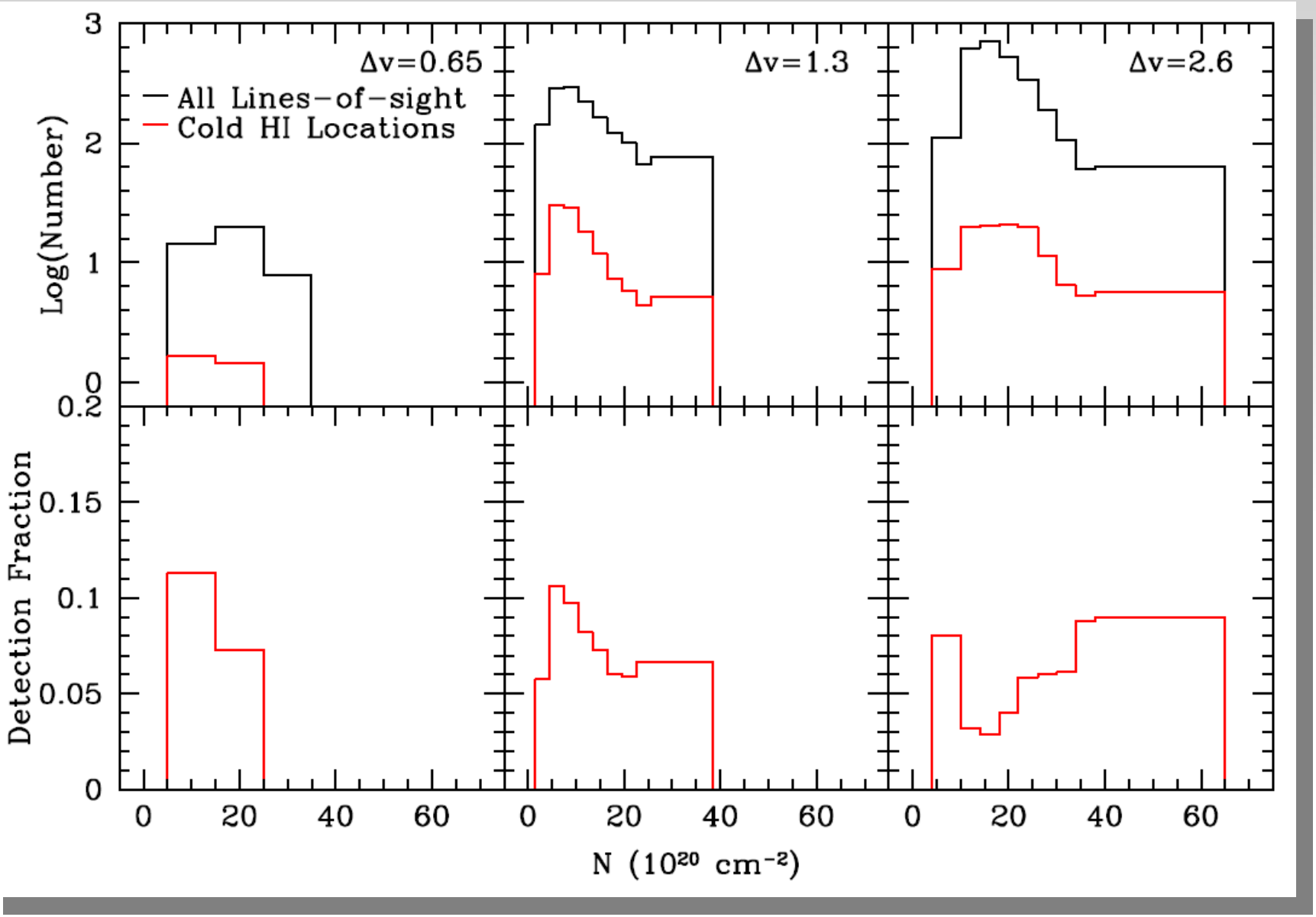
The cold HI is typically found in column densities above 10^{21} cm^{-2} but usually not coincident with the very highest peaks in the total HI distribution.

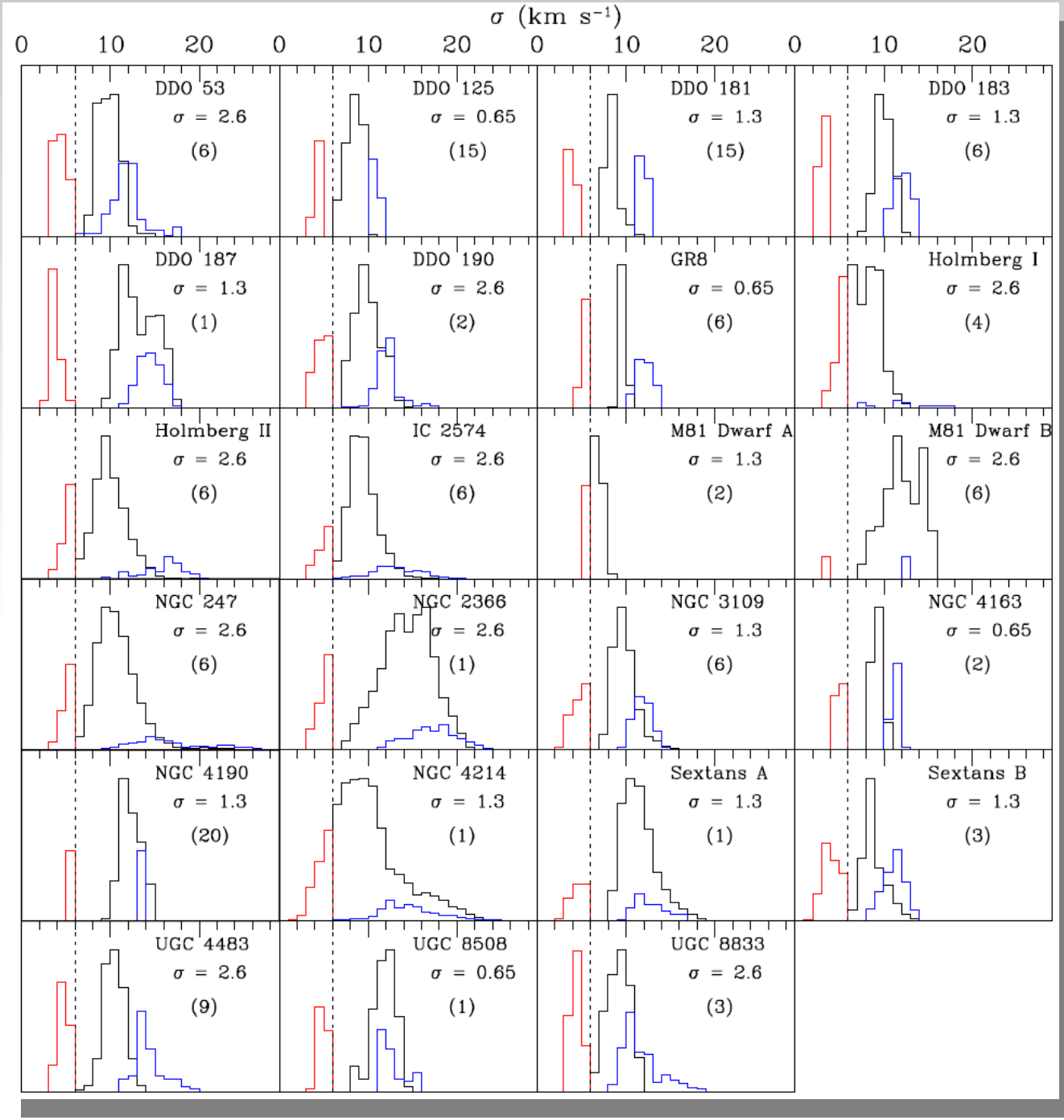
Results

Velocity Resolution (km/s)	Number of Galaxies with a Cold HI Detection	Average Areal Filling Fraction (%)	Average Cold-to-Total HI Mass Fraction (%)	Average Narrow Gaussian Velocity Dispersion (km/s)
0.65	4/5	11.8	3.5	4.9
1.3	9/12	9.7	3.6	4.5
2.6	10/10	6.1	2.2	4.8



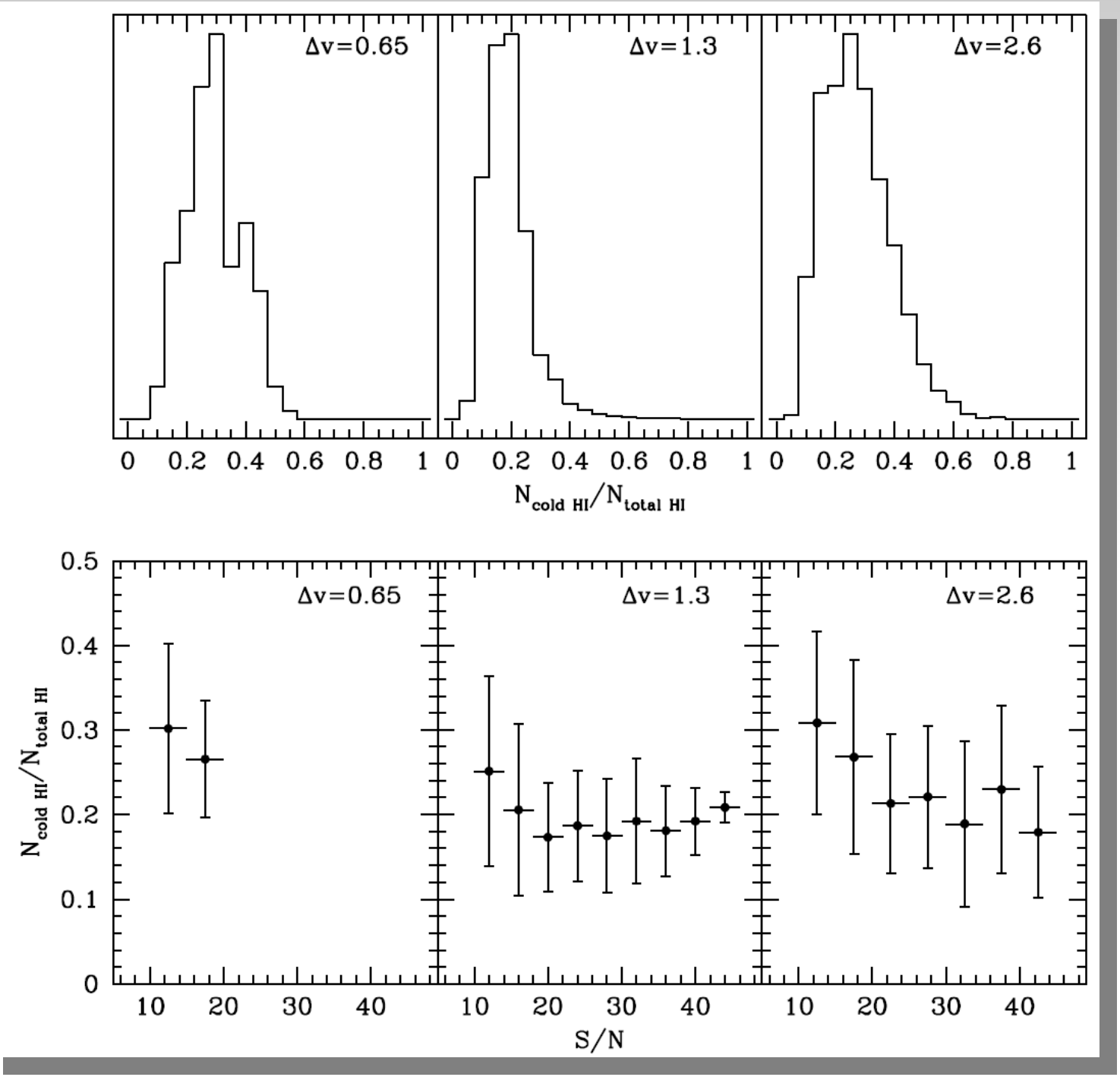
The observed distribution is very different from the expected (which assumes there exists two Gaussians all every line-of-sight). This suggests the cold HI is not ubiquitous.


Δv=0.65
Δv=1.3
Δv=2.6
All Lines−of−sight
Cold HI Locations
Log(Number)
Detection Fraction
N (10²⁰ cm⁻²)
0
1
2
3
0.2
0.15
0.1
0.05
0
20
40
60



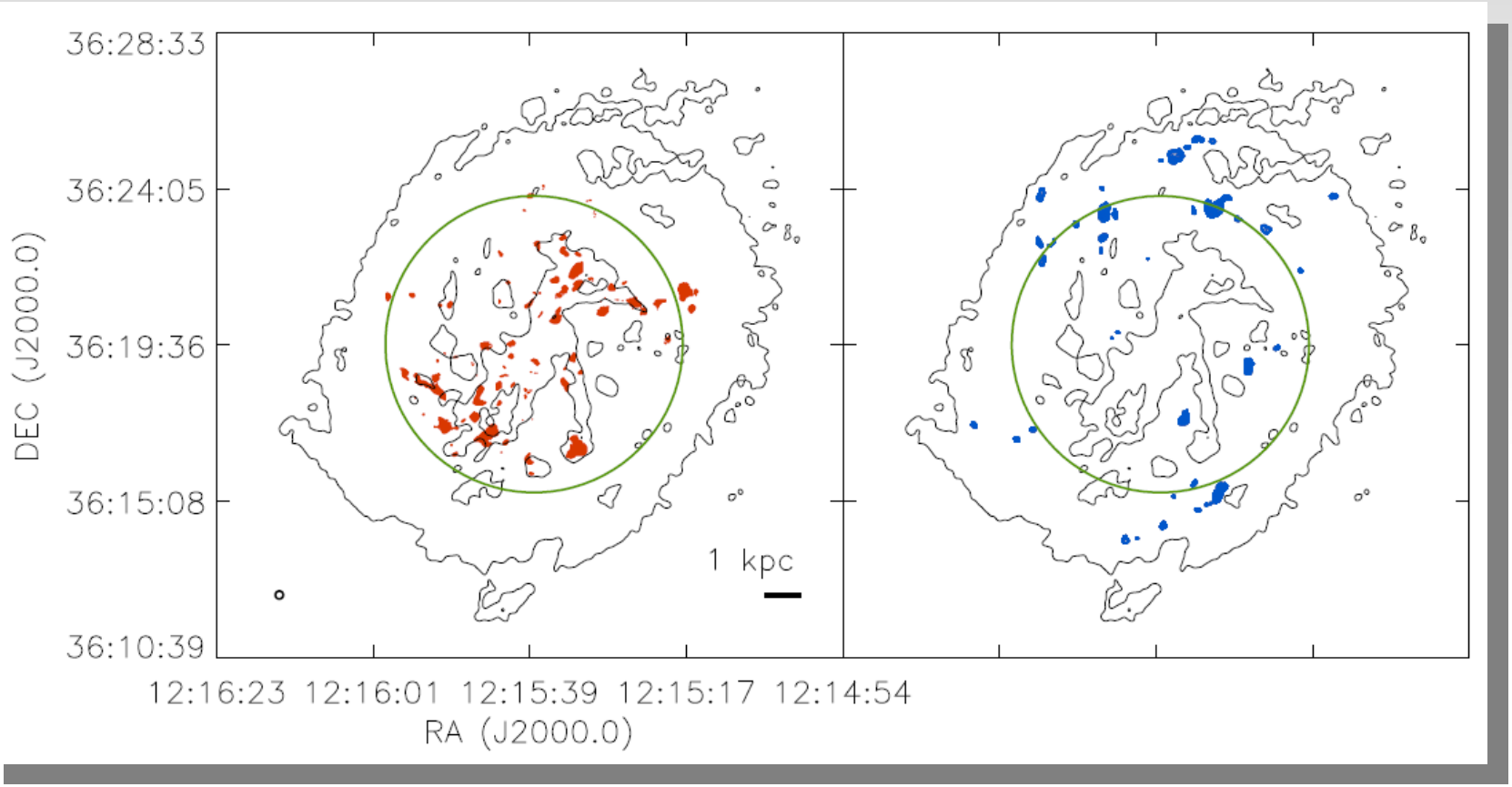
The broad component (blue) occupies a similar region as the typical HI (black) in each galaxy.

This suggests the broad component is in the same gas phase as the ubiquitous warm HI.

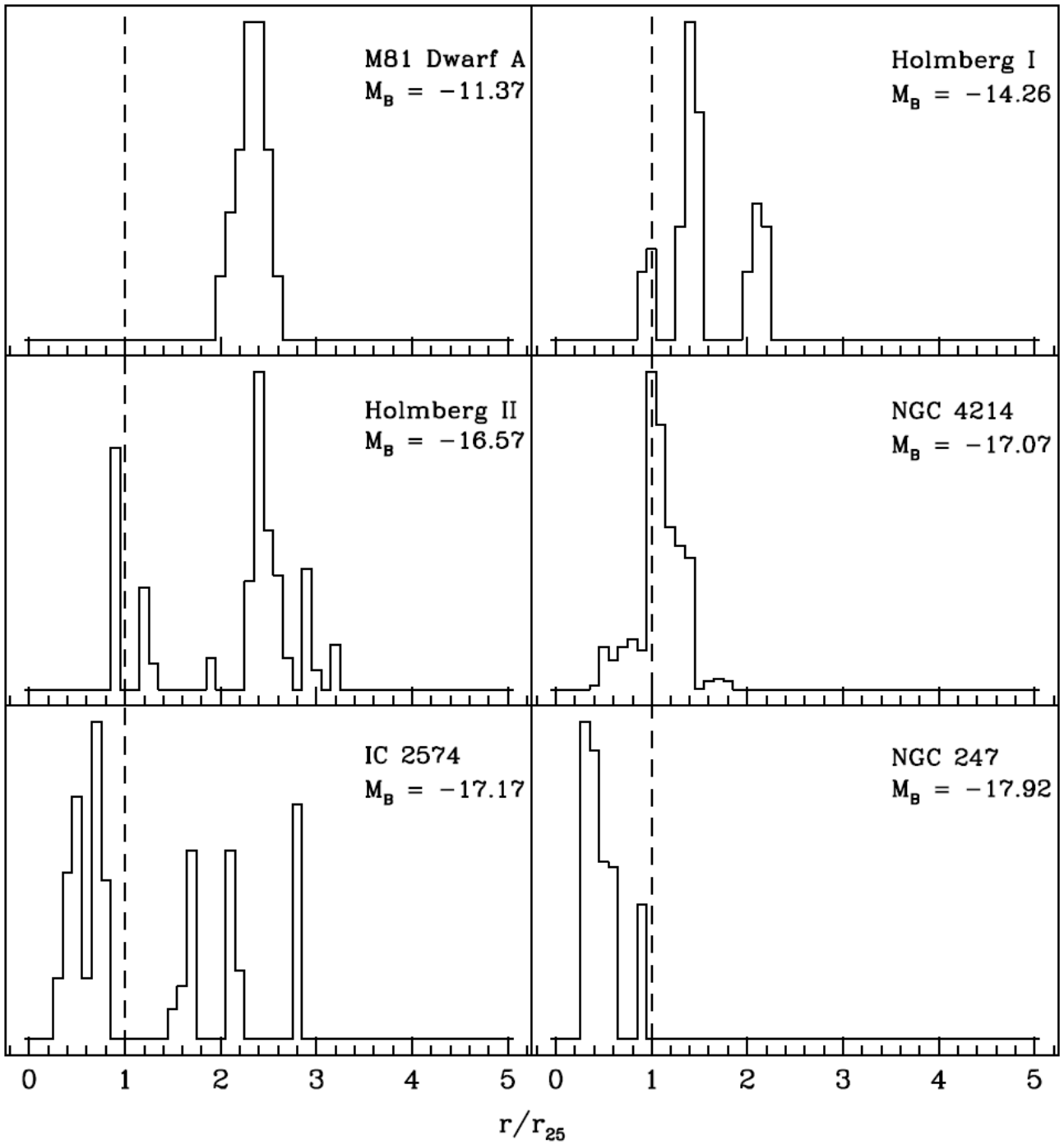


The cold HI contributes ~20% of the flux along the lines of sight which contain a cold and warm HI component.

NGC 4214



Spectra best fit by a single Gaussian with σ<6 km/s located beyond r_{25}

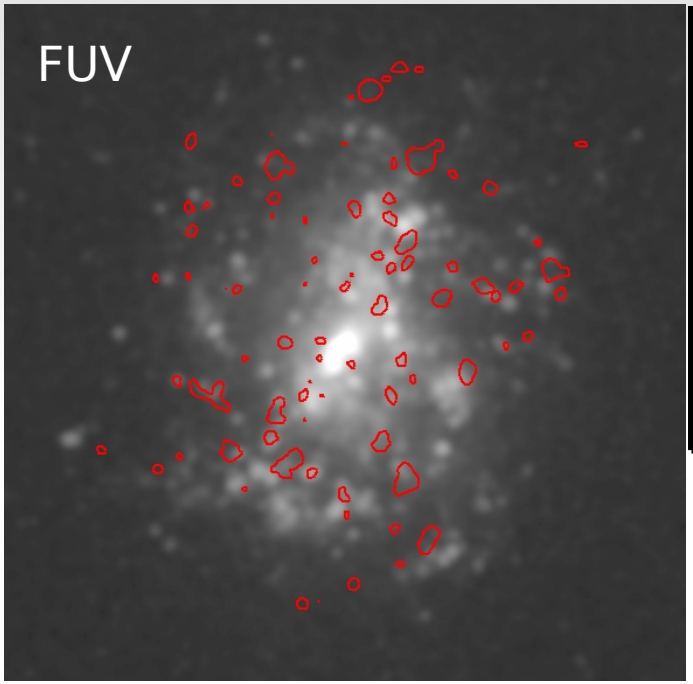


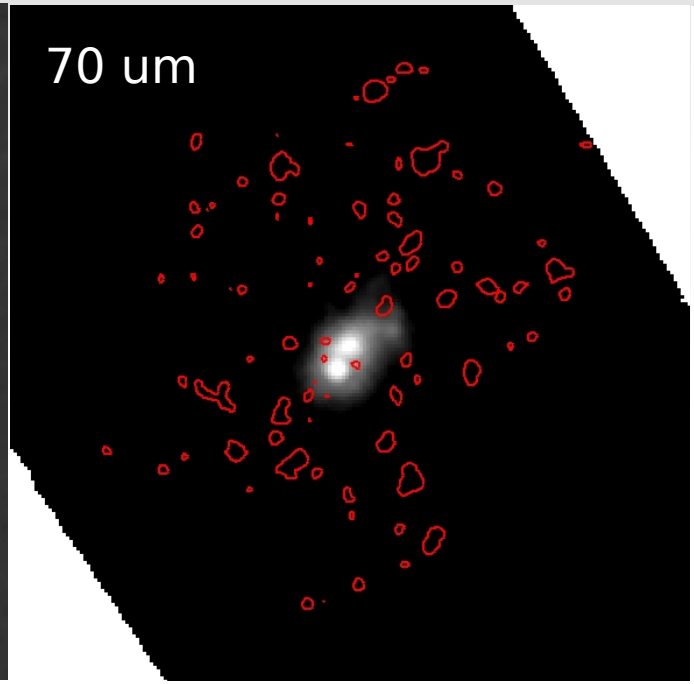
Ordered by absolute B-band magnitude (low to high)

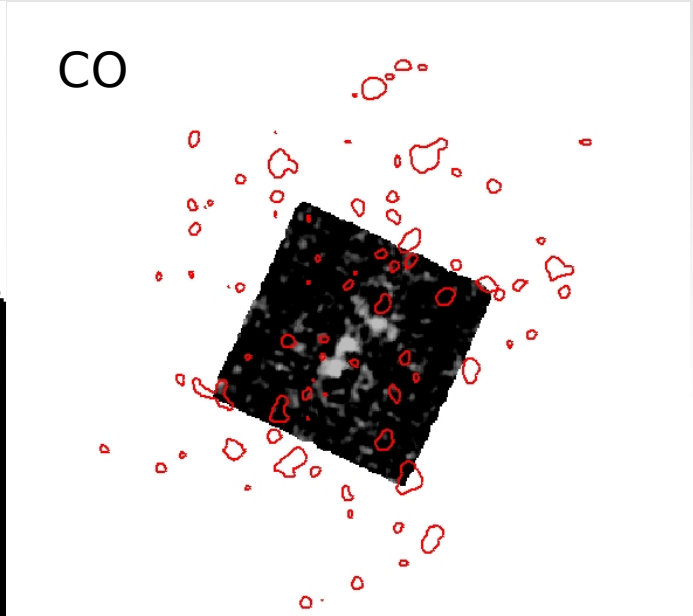
Large fraction of single Gaussians with σ<6 km/s located beyond r_{25}

Correlated with Star Formation?

NGC 4214







McQuinn priv. comm.

SINGS – Dale et al. (2009)

Heracles – Leroy et al. (2009)

Cold HI does not seem to be correlated with recent tracers of star forming regions... ???

Conclusions

- Cold HI is found in 23 of 27 galaxies in our final sample
- Minimum Areal filling factors of ~9 %
- Minimum Cold-to-Total HI mass fractions of ~3%
- Cold HI ~20% of the total flux when cold *and* warm HI are found
- Cold HI (without warm HI) typically found beyond r_{25}
- Cold HI does not appear to trace recent star forming regions