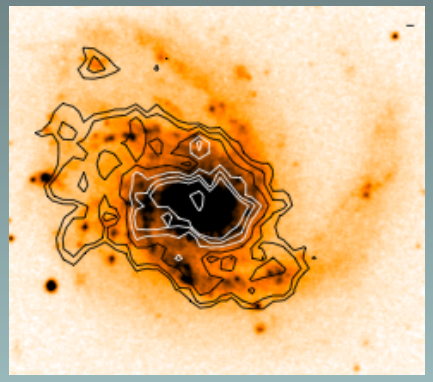
Environmental effects on molecular gas from the JCMT Nearby Galaxies Legacy Survey



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plus ~35 additional collaborators from the UK, Canada, Netherlands, and other countries

Outline

- Introduction and background
- Sample selection and division by environment
- First results
  - Environmentally isolated galaxies are hard to detect in CO
  - Galaxies with CO detections have more luminous and larger stellar disks
- Conclusions

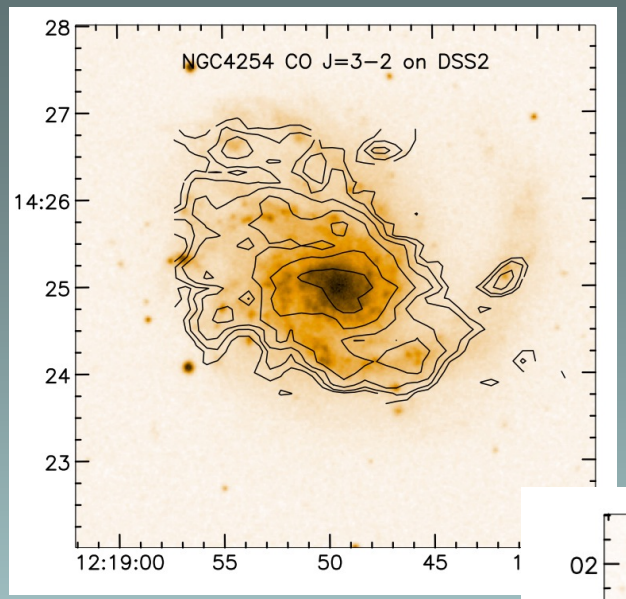
Some previous work on molecular gas and environment

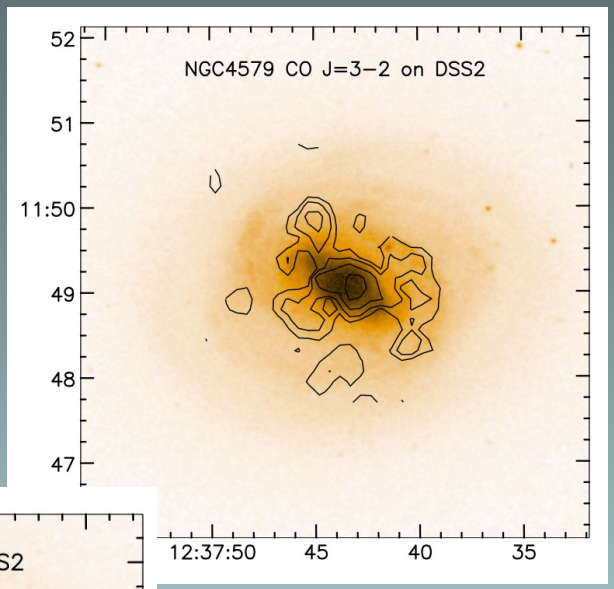
- Kenney & Young (1989, ApJ)
  - Compared CO emission in HI-depleted and normal spirals in Virgo
  - Spatial distributions of CO appear normal in HI deficient galaxies
- Fumagalli & Gavazzi (2008, A&A)
  - Cluster members with moderate HI removal have their H_2 content reduced
- Lisenfeld et al. (2011, A&A)
  - Study a sample of isolated galaxies
  - Have less molecular gas than interacting galaxies

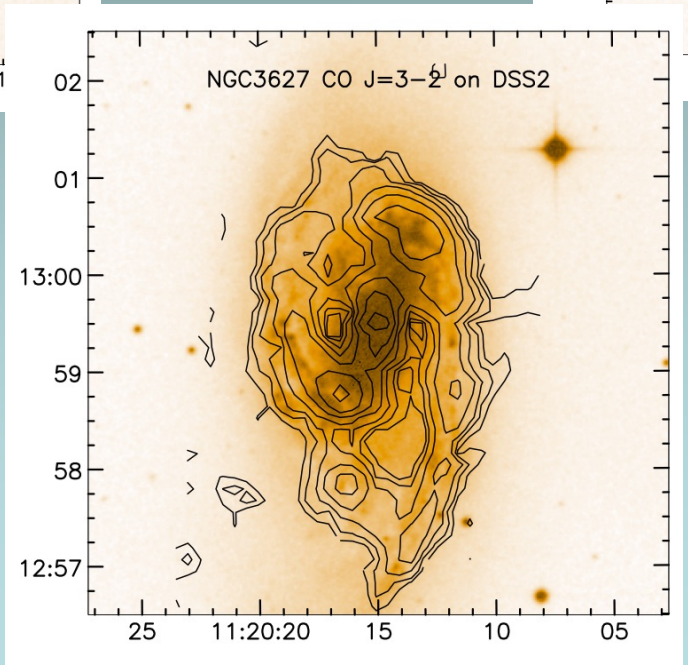
The JCMT Nearby Galaxies Legacy Survey: An HI-selected Sample

- 155 galaxies between 2 and 25 Mpc
- HI flux > 6 Jy km/s
- Dec > -25^{o} and |latitude| > 25^{o}
- CO J=3-2 observations complete for entire sample (15” resolution)
  - Sensitivity <19 mK (T_A*) at 20 km/s resolution
  - Cover area out to $D_{25}/2$
- SCUBA-2 observations began Feb 2012

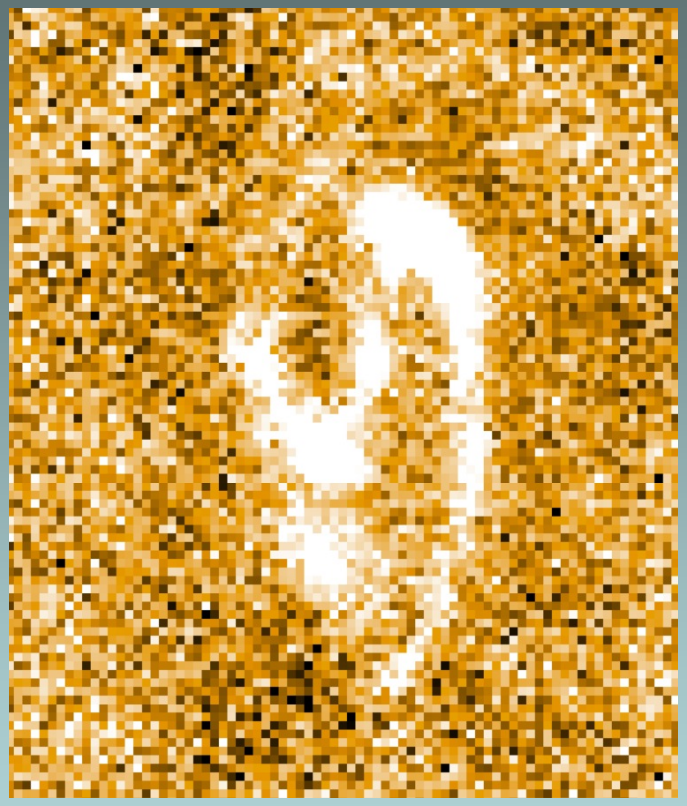
Example CO maps for SINGS galaxies (Wilson et al. 2012, MNRAS)



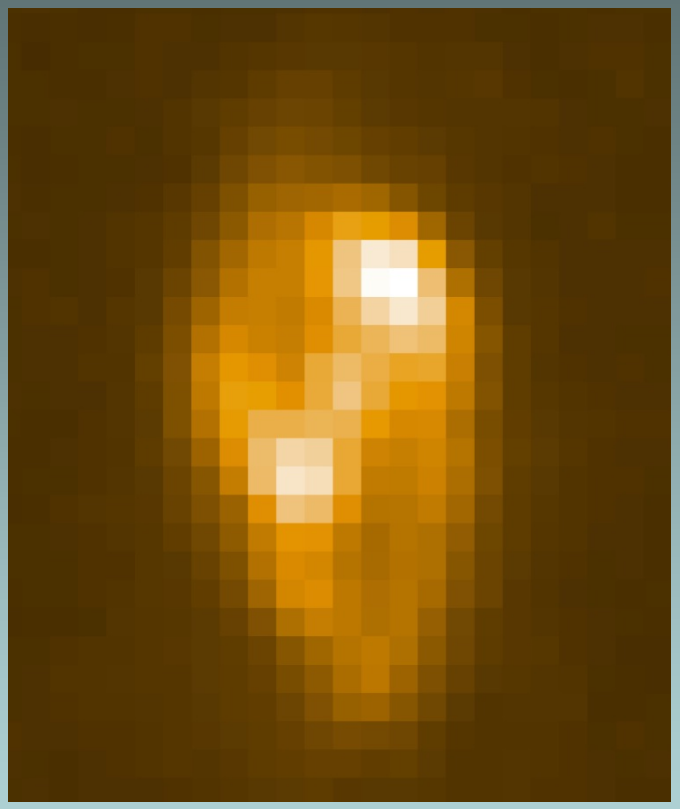




SCUBA-2 sneak preview!



450 micron
JCMT+SCUBA2
NGLS(Wilson et al.)



500 micron
Herschel+SPIRE
KINGFISH (Kennicutt et al. 2011, PASP)

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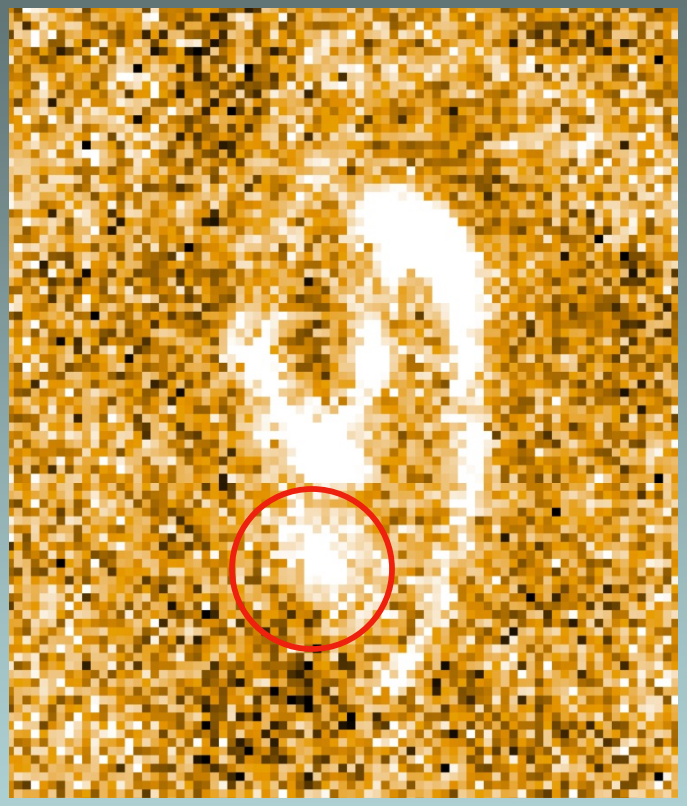

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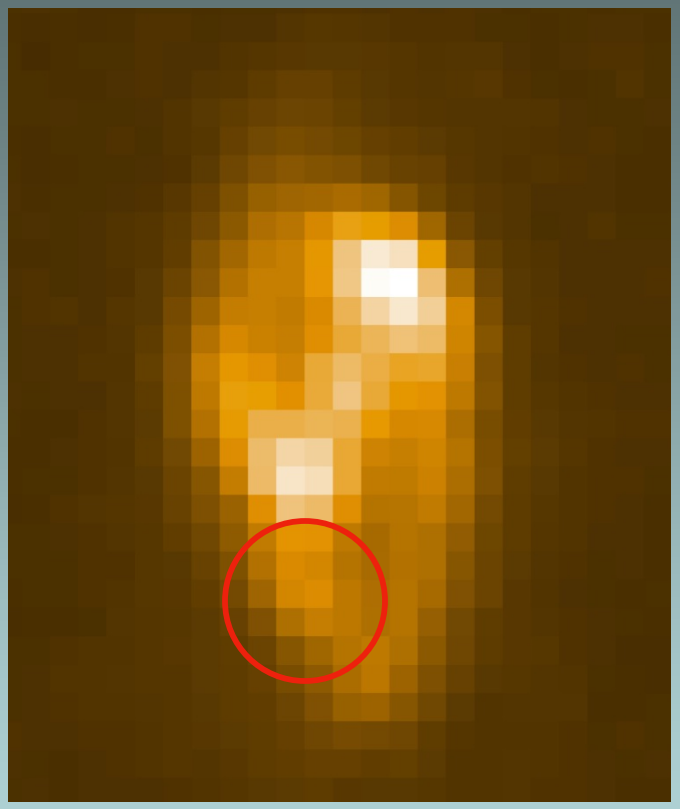


500 micron
Herschel+SPIRE
KINGFISH (Kennicutt et al. 2011, PASP)

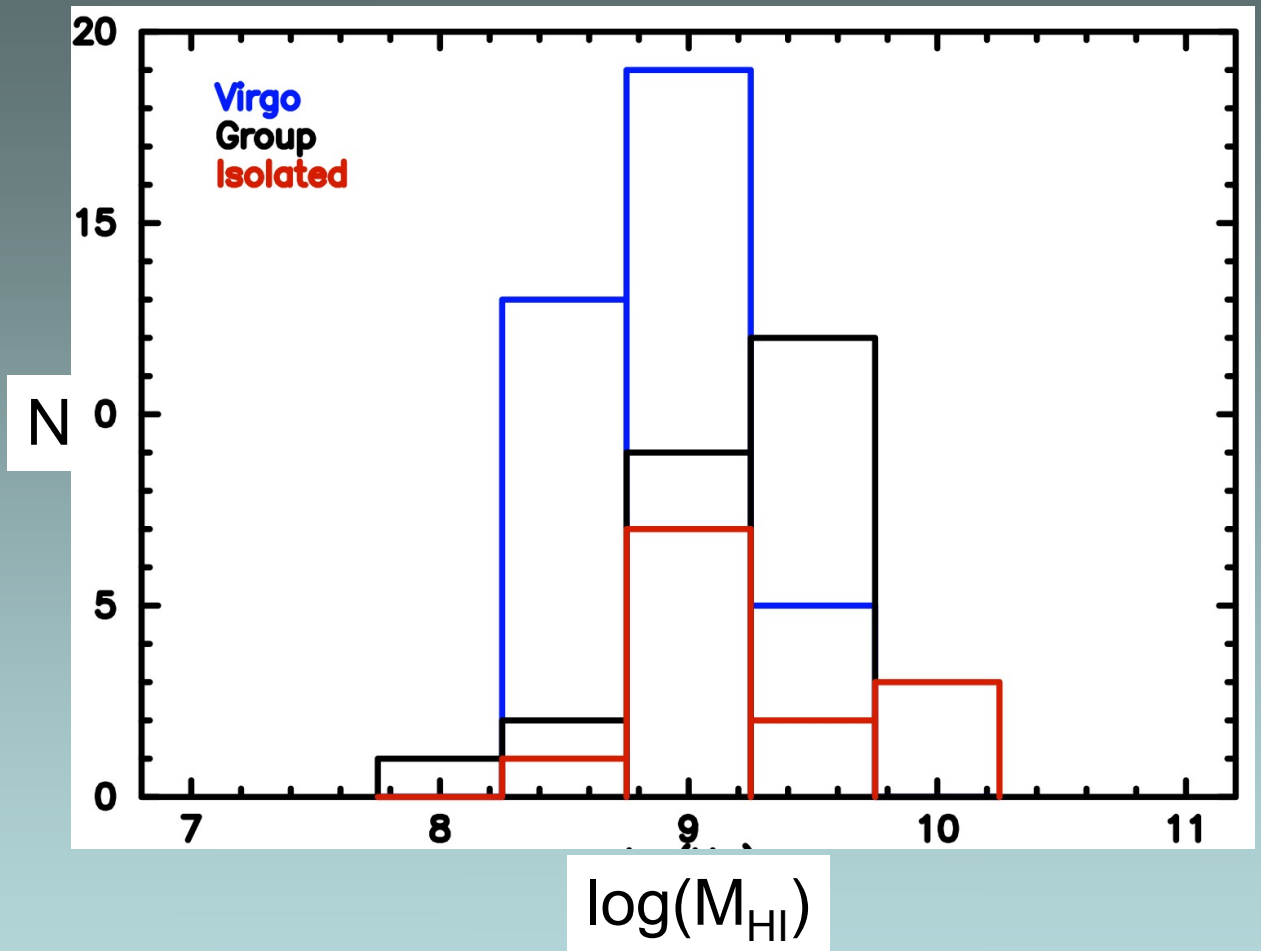
The JCMT Nearby Galaxies Legacy Survey: Three components

- 47 **SINGS galaxies** (Kennicutt et al. 2003)
- **Virgo Cluster** sub-sample (D_{25} < 5')
  - Ellipse 8^ox16^o centered on M87 with 500 < v < 2500 km/s
  - 18 HI brightest Irr and E galaxies (HI flux > 3 Jy km/s)
  - 18 randomly selected spirals
- **Field galaxies sub-sample** (D_{25} < 5')
  - Randomly select 18 galaxies in each of 4 morphology bins (E, early S, late S, Irr)
  - 72 galaxies total

Statistical sample for analysis of effect of environment

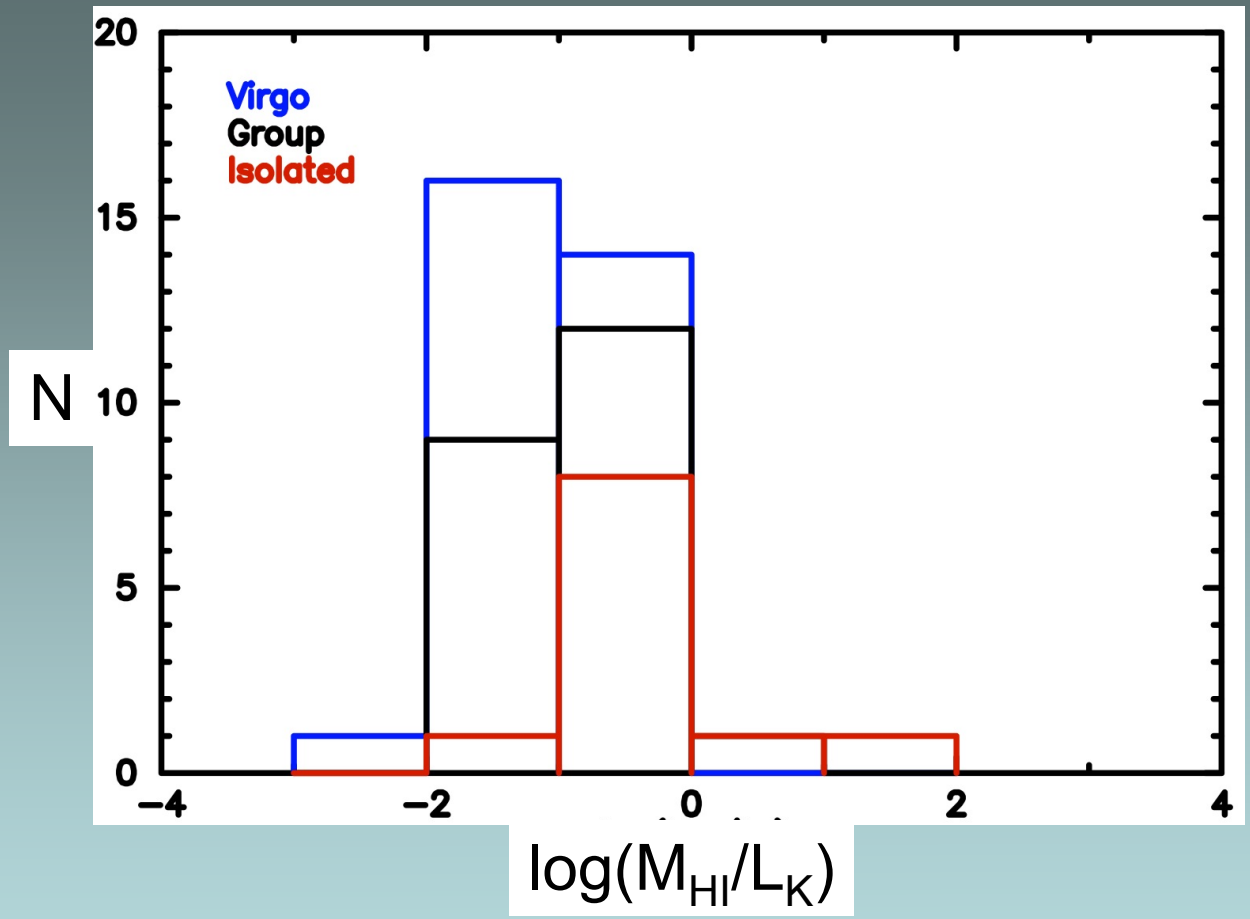
- Observed 27 additional spiral galaxies in Virgo
  - Combined with NGLS, forms a complete HI-flux limited sample of Virgo spiral galaxies
- Field sample divided into group and isolated galaxies using group identifications from Garcia et al. (1998ab, journal)
- For statistical comparisons of spirals as a function of environment, impose an additional cutoff $D_{25} < 7.4'$ on the Virgo sub-sample

HI mass versus environment



- As expected, Virgo cluster has lower HI content (mean 2x below groups, 3x below isolated)
- K-S test: statistically significant difference

M_{HI}/L_K versus environment



- Isolated galaxies have significantly higher M_{HI}/L_K: rich in atomic gas compared to stars
- K-S test: statistically significant difference

Molecular gas properties as a function of environment

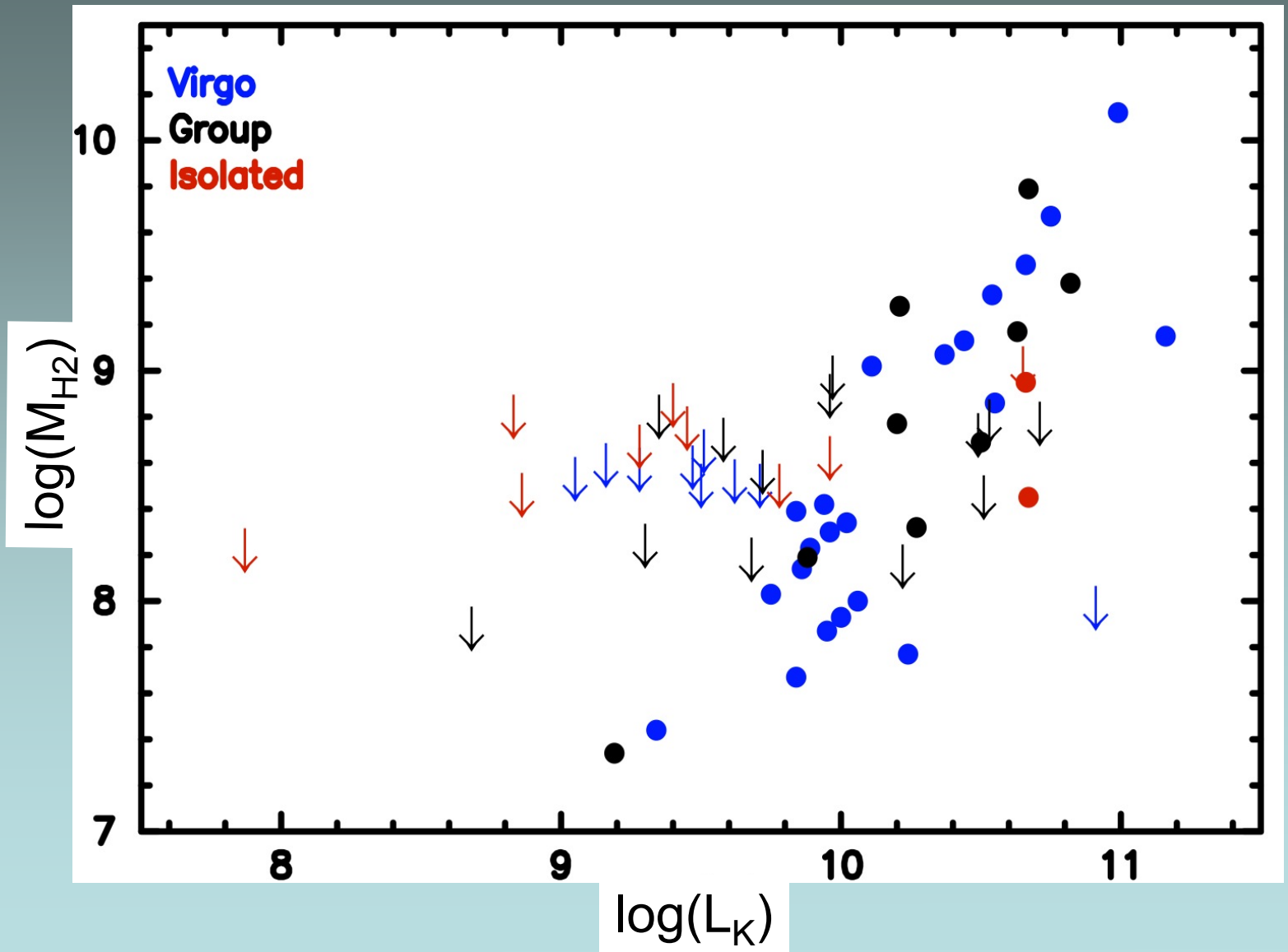
	Number	$\overline{D_{25}}$ (kpc)	$\overline{D}$ (Mpc)	CO detection rate (%)	$\overline{\log M_{H_2}}$ ($M_\odot$)
Virgo	39	13.2 ± 1.2	16.7	62 ± 13	8.56 ± 0.15
Group	24	13.5 ± 1.4	18.2 ± 1.4	38 ± 13	8.77 ± 0.25
Isolated	13	14.8 ± 2.7	21.4 ± 1.2	15^{+15}_{-5}	8.70 ± 0.25

- Significantly lower CO detection rate in isolated galaxies
- Galaxies that *are* detected have similar H_2 masses

Result #1: Little molecular gas in isolated galaxies

- Group and isolated galaxies have very similar HI mass and distance distributions
- If isolated galaxies had lower metallicity, could affect ability to detect them in CO
- B luminosity can be a crude proxy for metallicity
- no statistically significant differences in L_B between Virgo, group, and isolated subsamples …

M_{H2} versus L_K

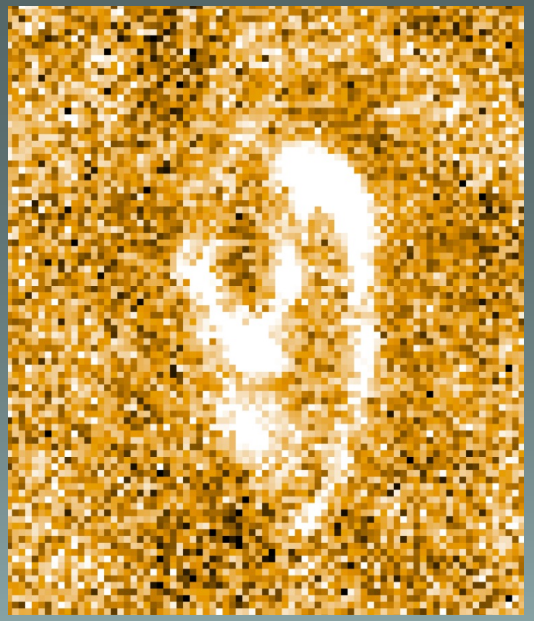


Results #2: Properties of CO detections versus CO non-detections

- Compared to non-detections, CO detections have
  - higher L_K, L_B, and larger diameters
  - lower M_{HI}/L_K
  - More likely to be found in groups or cluster
- Detections and non-detections have similar distance and M_{HI} distributions

CO Category (# of galaxies)	$\overline{\log M_{HI}}$ ($M_\odot$)	$\overline{\log L_K}^a$ ($L_\odot$)	$\overline{D_{25}}$ ($L_\odot$)	$\overline{\log M_{HI}/L_K}$ (kpc)	$\overline{\log M_{H_2}}$ ($M_\odot$)
Detections (35)	9.09 ± 0.07	10.27 ± 0.08	16.2 ± 1.3	-1.16 ± 0.08	8.68 ± 0.12
Non-detections (41)	9.08 ± 0.06	9.64 ± 0.12	11.3 ± 1.1	-0.51 ± 0.12	$< 8.52 \pm 0.05$

Summary

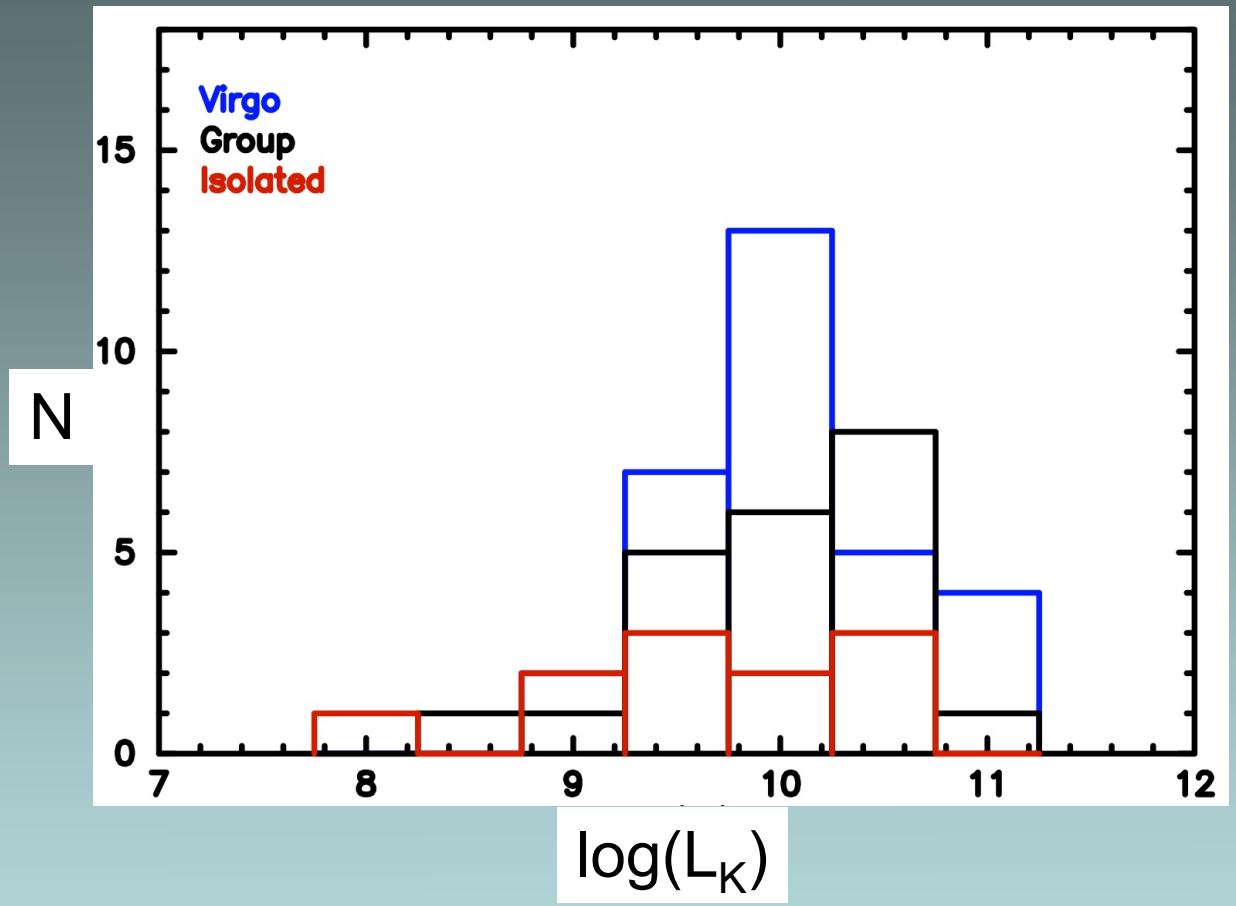


- NGLS is an HI-flux limited sample of galaxies within 25 Mpc
- Low rate of CO detection in isolated spiral galaxies
- Galaxies that are detected in CO tend to have higher optical luminosities and larger disk sizes
- Links to continuing growth of galaxy disks? e.g. Moran et al. 2012, ApJ: galaxies with outer metallicity gradients are still growing their stellar disks
- How important are neighbors for forming stars/building galaxies? e.g. Kreckel et al. 2012, AJ: void galaxies are gas rich, blue, low luminosity

Analysis is continuing and new SCUBA-2 data are coming: stay tuned!

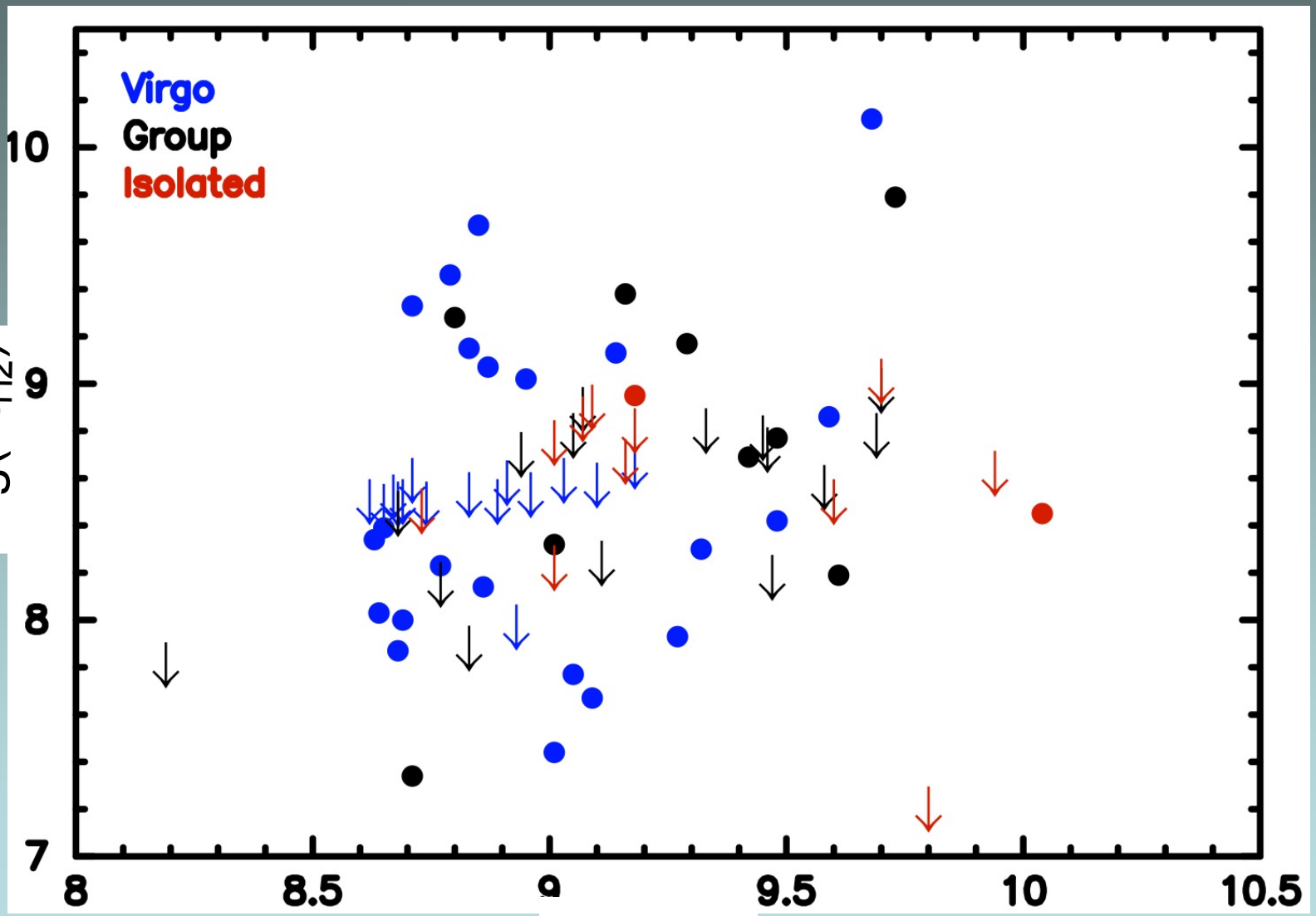
END

L_K versus environment



- Mean L_K and L_K distribution are very similar across the three environments
- K-S test: distributions are not statistically different

M_{H2} versus M_{HI}



CO mass calculations

- Assume J=3-2/J=1-0 ratio of 0.18 (Wilson et al. 2012, MNRAS, in press)
- Assume X(CO) = 2×10^{20} cm^{-2} $(K\ km/s)^{-1}$ (Strong et al. 1988 A&A)

- $M_{H2} = 17.8\ L_{CO(3-2)}$

Science Goals for NGLS: Physical Processes in the Interstellar Medium

- Relative mass and physical properties of different dust components (Galliano et al. 2003)
- Molecular gas and the gas-to-dust ratio (Neininger et al. 1996)
- **Effect of dense cluster environments (Kenney & Young 1989)**
- Gas and dust in unusual environments (near AGN, starbursts, low metallicity, etc.)