Molecular Gas Content of HI Monsters

Aeree Chung (NRAO)

Min S. Yun, Stephan Schneider (UMass), Karen O'Neil (NRAO)
Martha Haynes, Riccardo Giovanelli (Cornell)
Redshift Search Receiver Group (UMass)

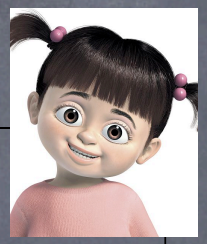
Motivation

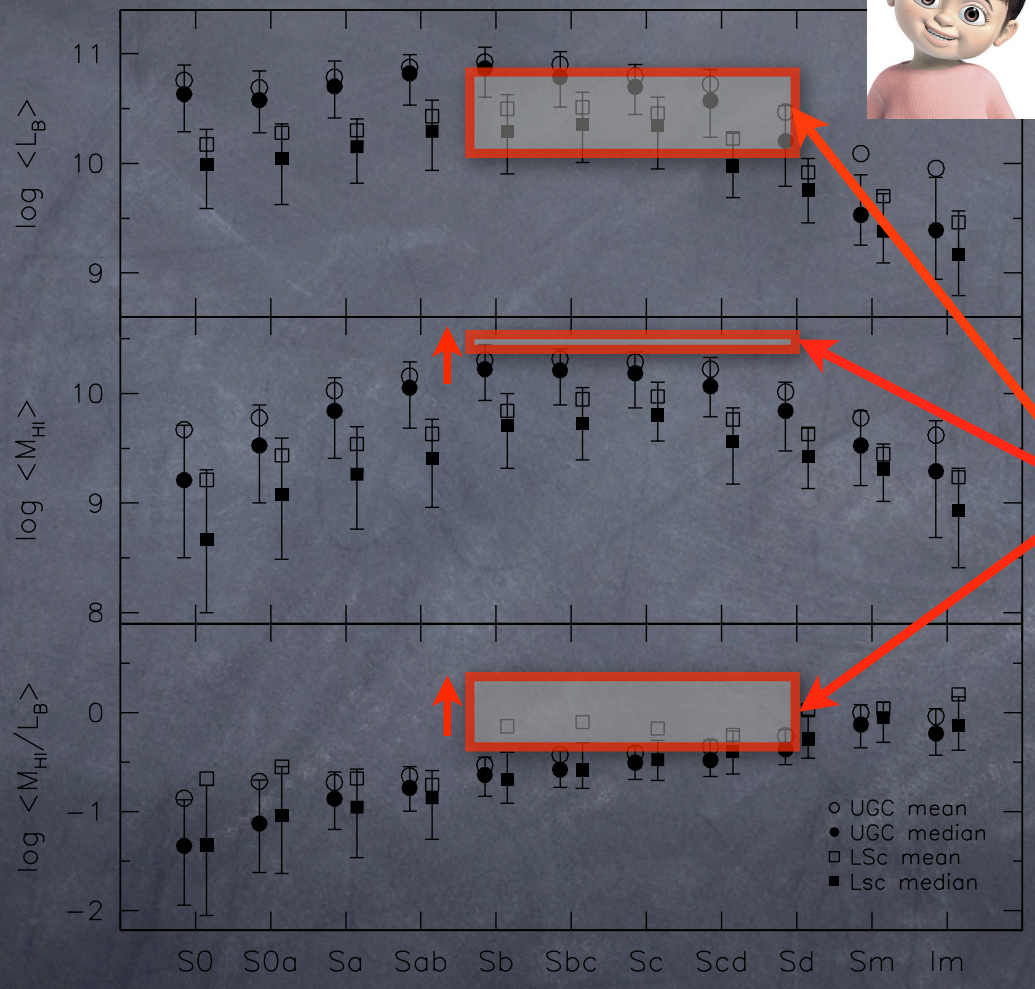
- The gas mass function still evolves: not only finding more of fainter objects in the Local Universe but also finding extremely gas rich galaxies at intermediate (e.g. Cantinella et al. 2008, Verheijen et al. 2007; HI) to high z (e.g. Daddi et al. 2008; CO)
- What is the maximum cold gas content of normal galaxies in the field (atomic or molecular) and what types of galaxies manage to accumulate such a large cold gas reservoir? What is the fraction of the atomic to the molecular gas?
- Determining the frequency of gas-rich normal galaxies can lead to an estimate of the duty cycle for the ultra-luminous infrared galaxy (ULIRG) phenomenon, the most luminous galaxies with the highest star formation rate in the Local Universe which need gas rich progenitors, and an important population to understand cosmic star formation history (Le Floc'h et al. 2005)

Sample

- The top 20 galaxies in HI mass from the ALFALFA survey catalog (March 2008) with $M_{HI} > 3 \times 10^{10}\ M_{\odot}$ at $0.04<z<0.06$
- Eight additional systems with high HI mass ($1.2 \times 10^{10}\ M_{\odot} < M_{HI} < 6.3 \times 10^{10}\ M_{\odot}$) with relatively low surface brightness (Schneider & O'Neil) at $0.04<z<0.083$
- Optically, normal spirals (Sb - Sd) with no sign of interactions

SAMPLE





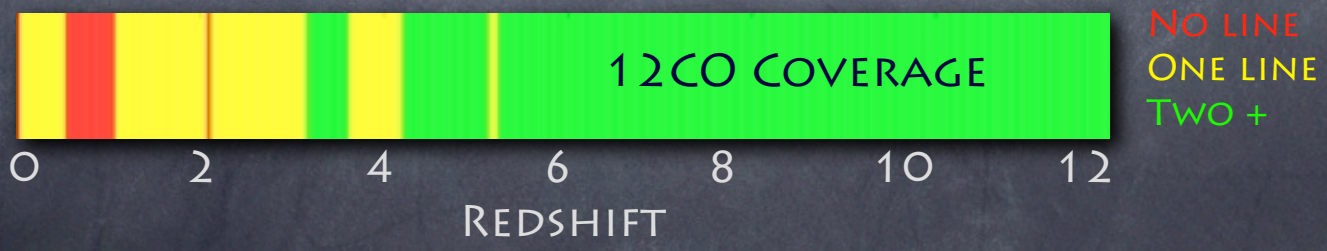
HI rich galaxy sample

HI MONSTER

- Roberts & Haynes 1994, ARA&A, 32, 115
  (7930 RC3-UGC & 2864 RC3-LSc sample)

Observations

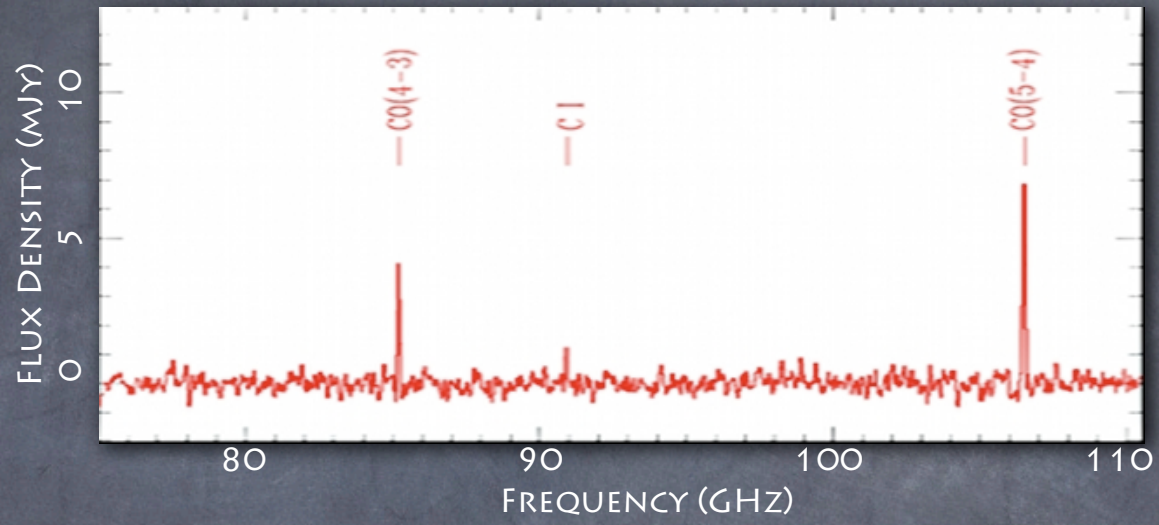
- The FCRAO 14 meter, May 2008
- The Redshift Search Receiver (RSR)
- ✓ Ultra-wide band spectrometer (74-111 GHz simultaneously) with medium spectral resolution (31 MHz)
- ✓ Principal goal is to detect more than two CO lines at the same time to uniquely determine the redshift of dusty star-forming galaxies in high redshift universe



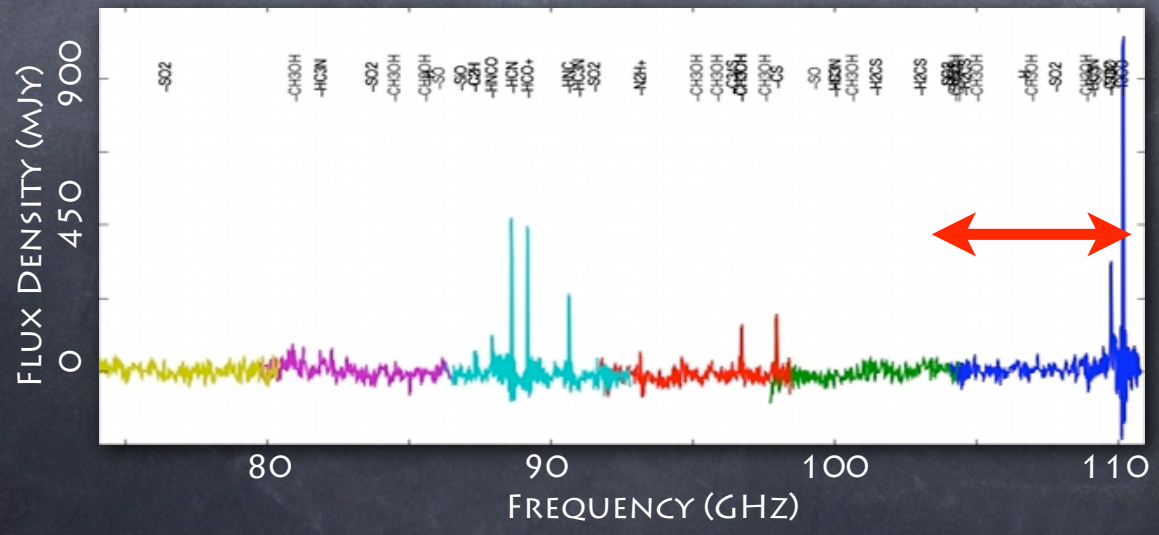
- ✓ Besides 12CO, other molecular lines will be also detect

Observations

- Simulated RSR-LMT Spectrum of QSO at z=4.4

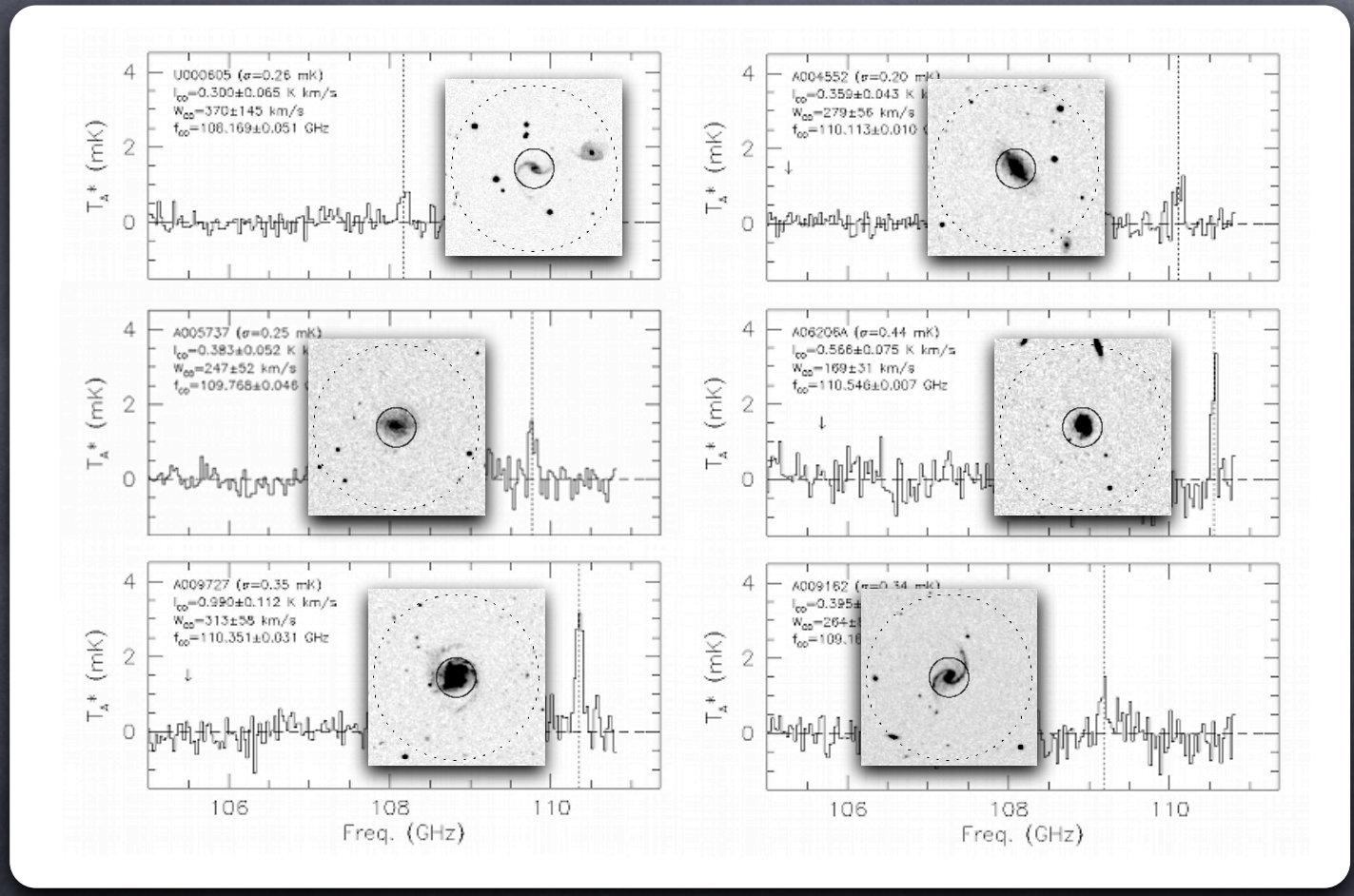


- RSR-14M Spectrum of IC 342, A Nearby Starbursting System



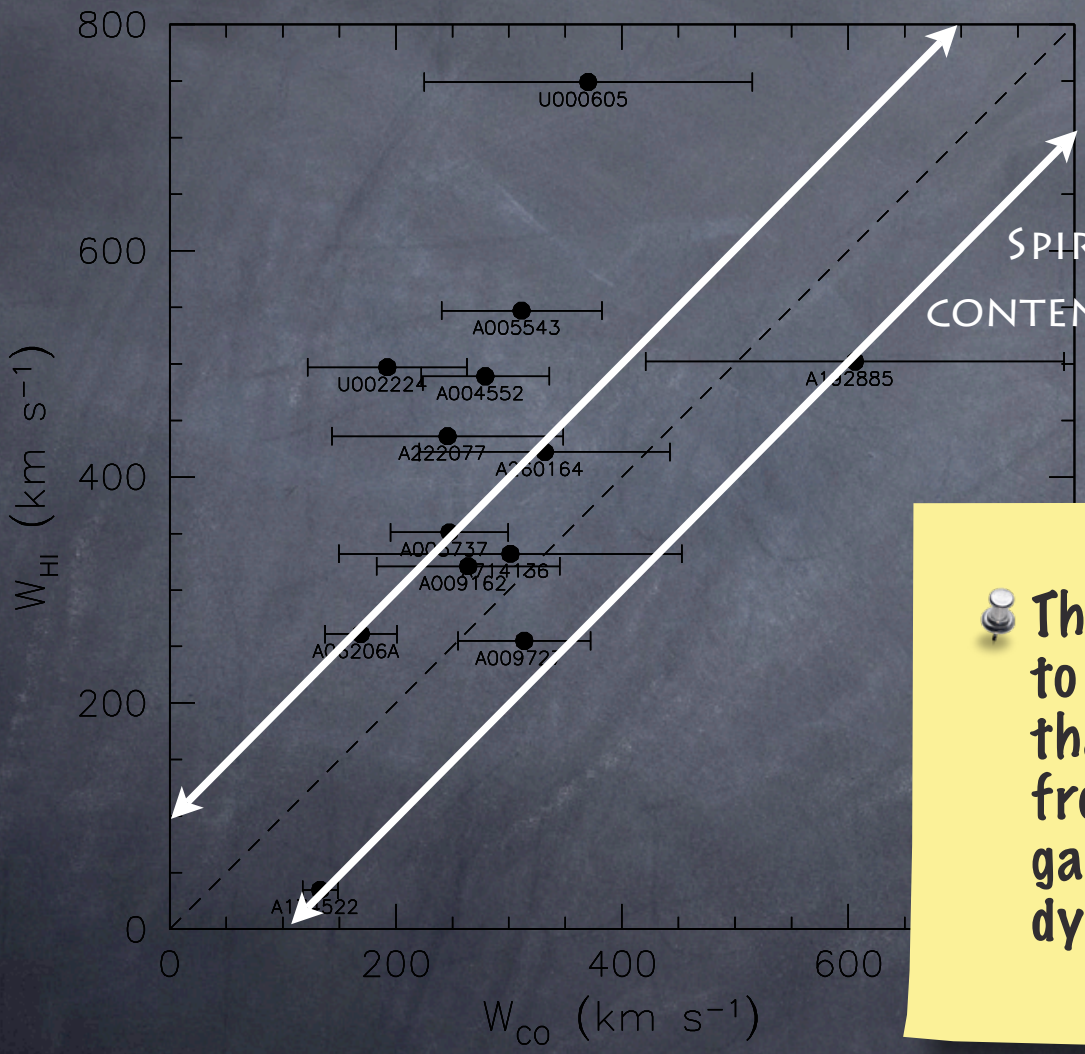
CO (1-0) of our HI monsters

Result



- 13 out of 28 HI rich galaxies detected in CO (11 of the top 20 in HI mass from the recent ALFALFA catalog + 2 of the 8 LSBs): $M_{H_2} \sim 9.5 \times 10^9\ M_\odot$ adopting $M(H_2) \sim 4.6 L'_{CO}$

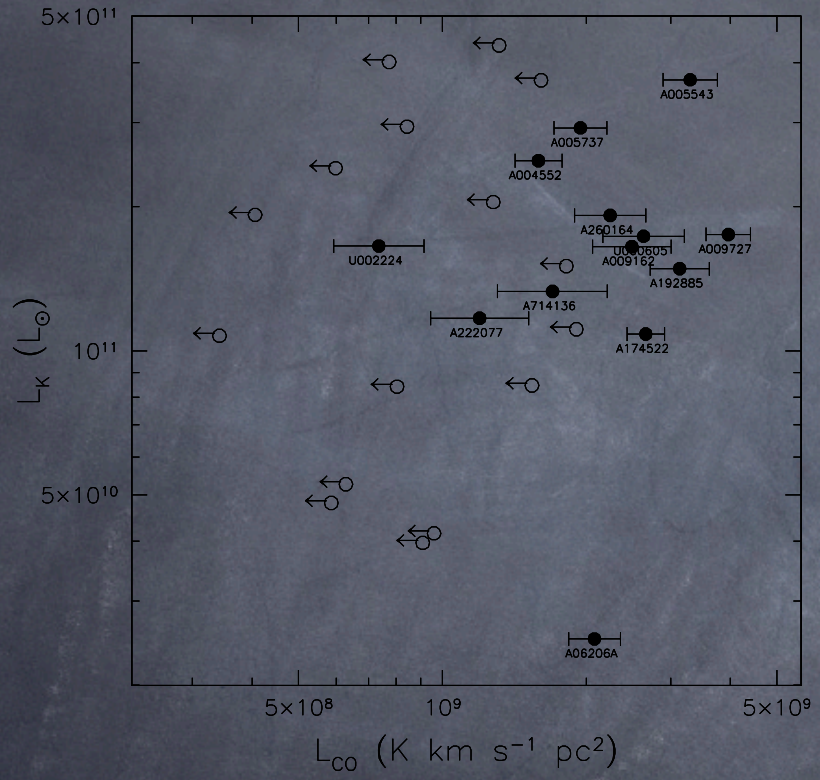
HI vs. CO Linewidth

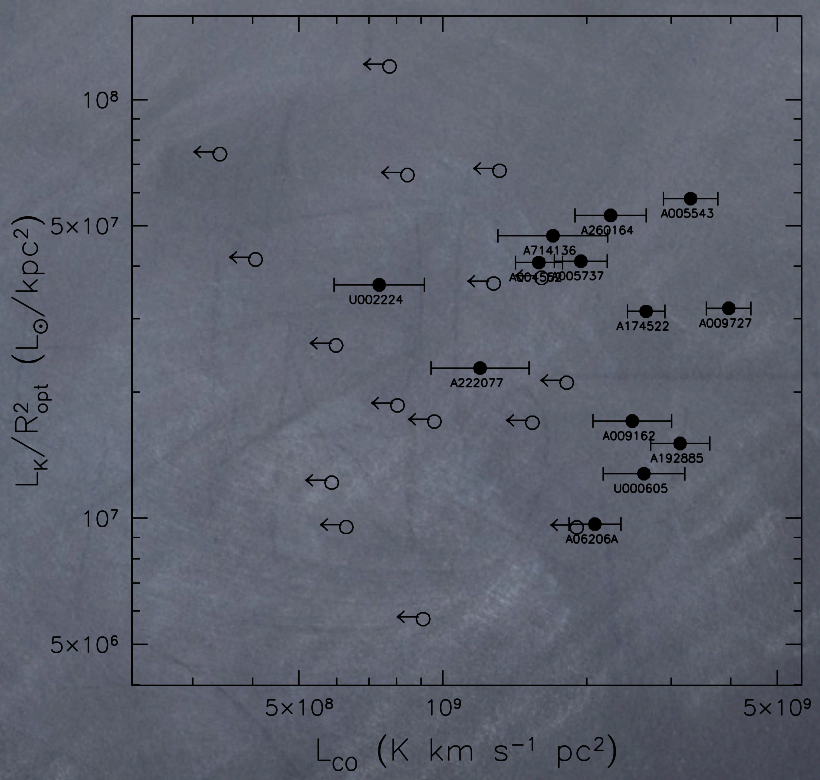


Spirals with normal gas content (e.g. Ursa Major Spirals)

- The HI linewidth appears to be systemically larger than that of CO (different from spirals with normal gas content): in different dynamical states?

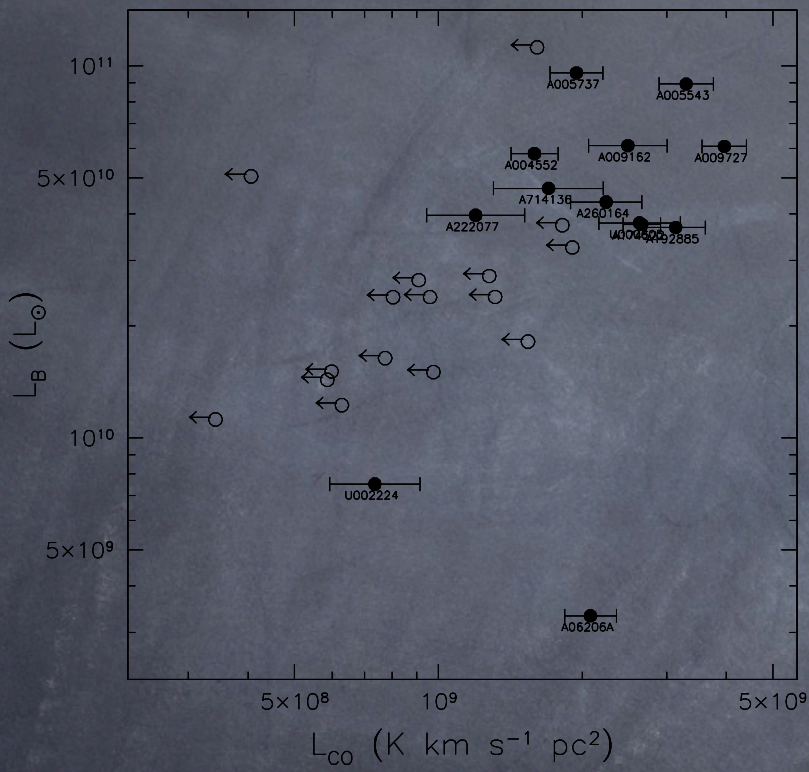
K Luminosity & Σ_K vs. CO

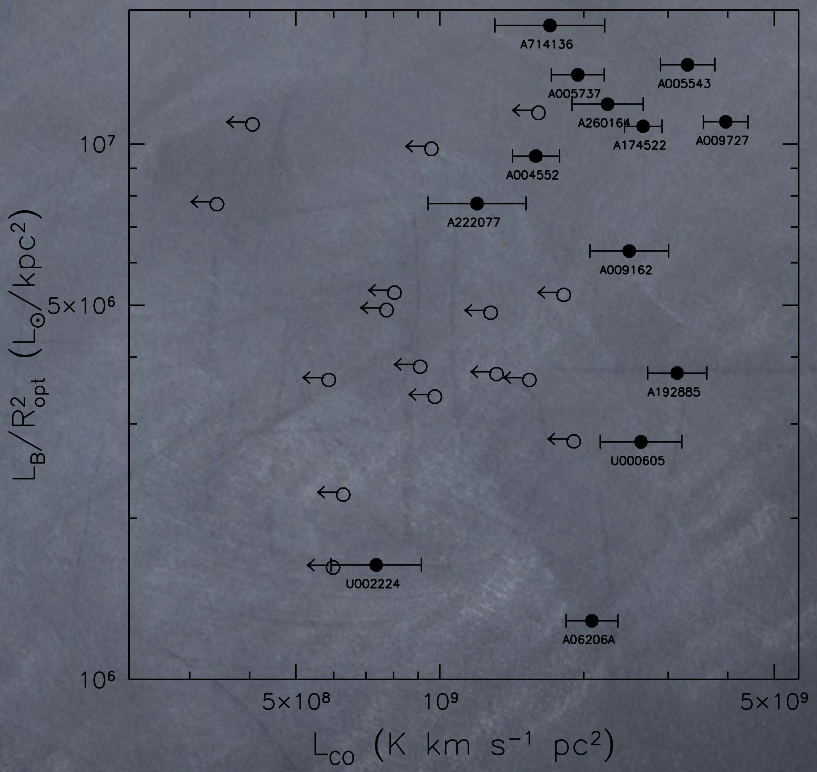




- Almost uniform detection rate: The molecular gas content does not seem to care about the stellar mass or the old stellar disk density

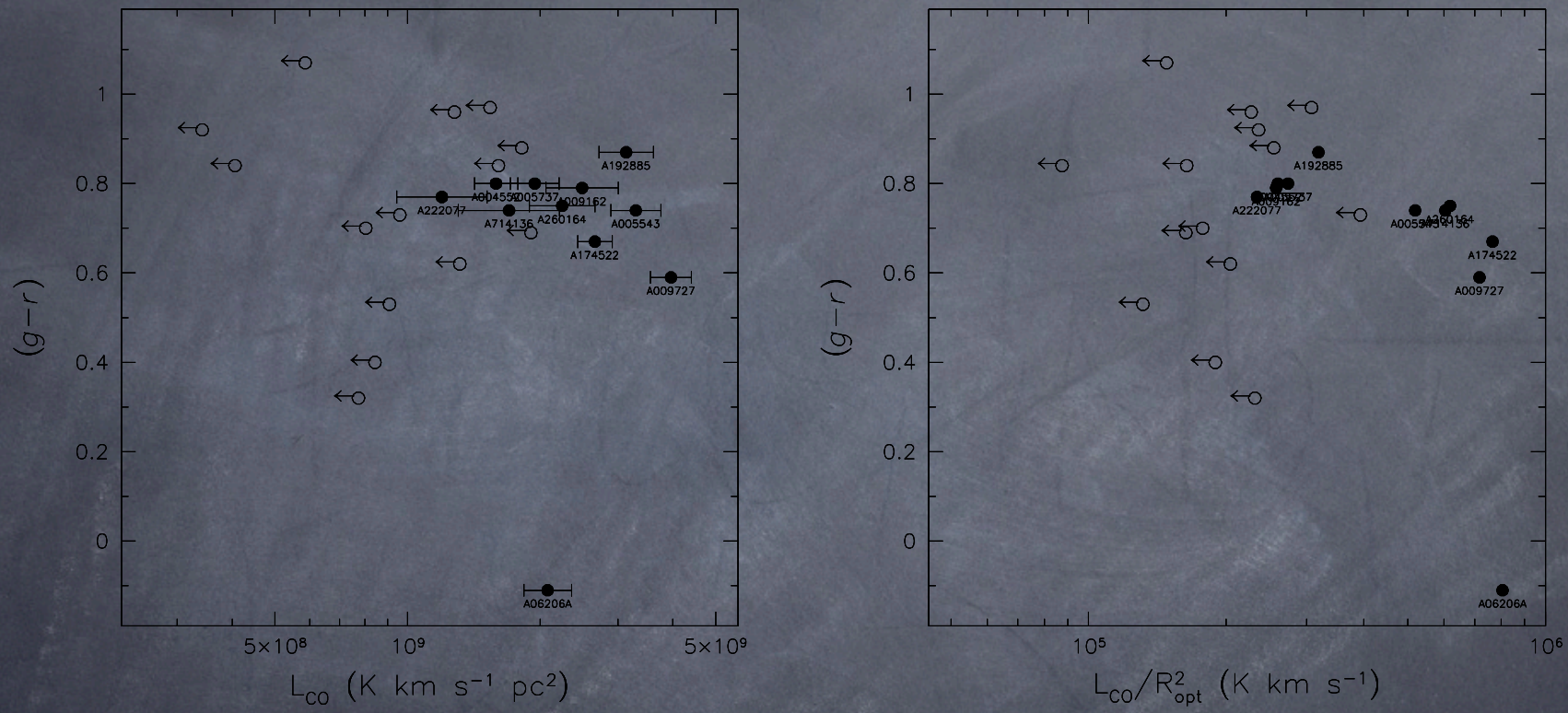
B Luminosity & Σ_B vs. CO





With a few exceptions, molecular gas rich galaxies tend to be brighter with higher density in B-band (more tightly correlated with younger stellar pop)

COLOR (g-r) VS. CO



- CO detected galaxies are not always bluer BUT among the detections galaxies with more CO tend to be bluer (stronger trend with surface density)

Summary & Future Work

- So far, the significant linewidth difference (atomic gas and molecular gas are in different potential well in a single system?), a higher detection rate in bluer galaxies (not all of them then what makes the distinction?) are intriguing
- Work in progress - more gas properties (the total gas mass, the atomic or molecular gas mass fraction, the mean surface density vs. star formation properties, morphology, etc.)
- In the future, we plan to expand our sample and keep exploring the molecular and total cold gas properties at the high end of the HI mass function.