

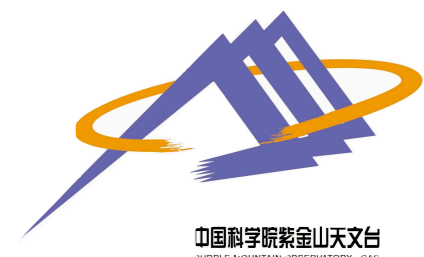
Mapping The Dense Molecular Gas In The Strongest Star-Forming Galaxies

- ▶ PI: Yu Gao, Thomas Greve & Zhiyu Zhang
co-I: Qinghua Tan, Xue-Jian Jiang, Daizhong Liu, Christine Wilson, Aeree Chung, Bumhyun Lee, Satoki Matsushita et al.
- ▶ Resolved dense gas star formation relations
- ▶ Intermediate scales/luminosities
- ▶ Different environments: nuclear vs. disk
- ▶ Radial distribution of dense gas and SF efficiency



XUE-JIAN JIANG (蒋雪健)

PURPLE MOUNTAIN OBSERVATORY



SURVEY STATUS

HCN 4-3 and HCO⁺ 4-3 survey

22 IR-bright galaxies

390 hours

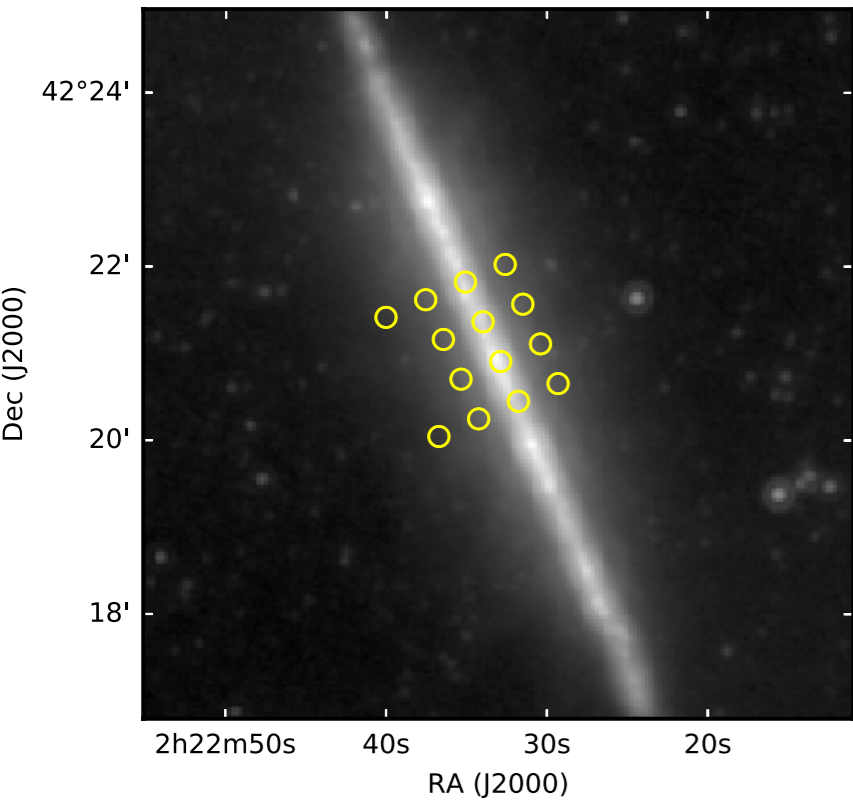
100% complete (Nov. 2015 – Jul. 2017)

- ▶ The survey is completed without any major problem;
- ▶ Sensitivity as expected;
- ▶ but signals are much weaker than predicted.
- ▶ Affected by ozone features NGC 1097 and NGC 1365 were non-detections in neither line.
- ▶ HCN not detected in NGC 2146, NGC 2903 & NGC 3521.

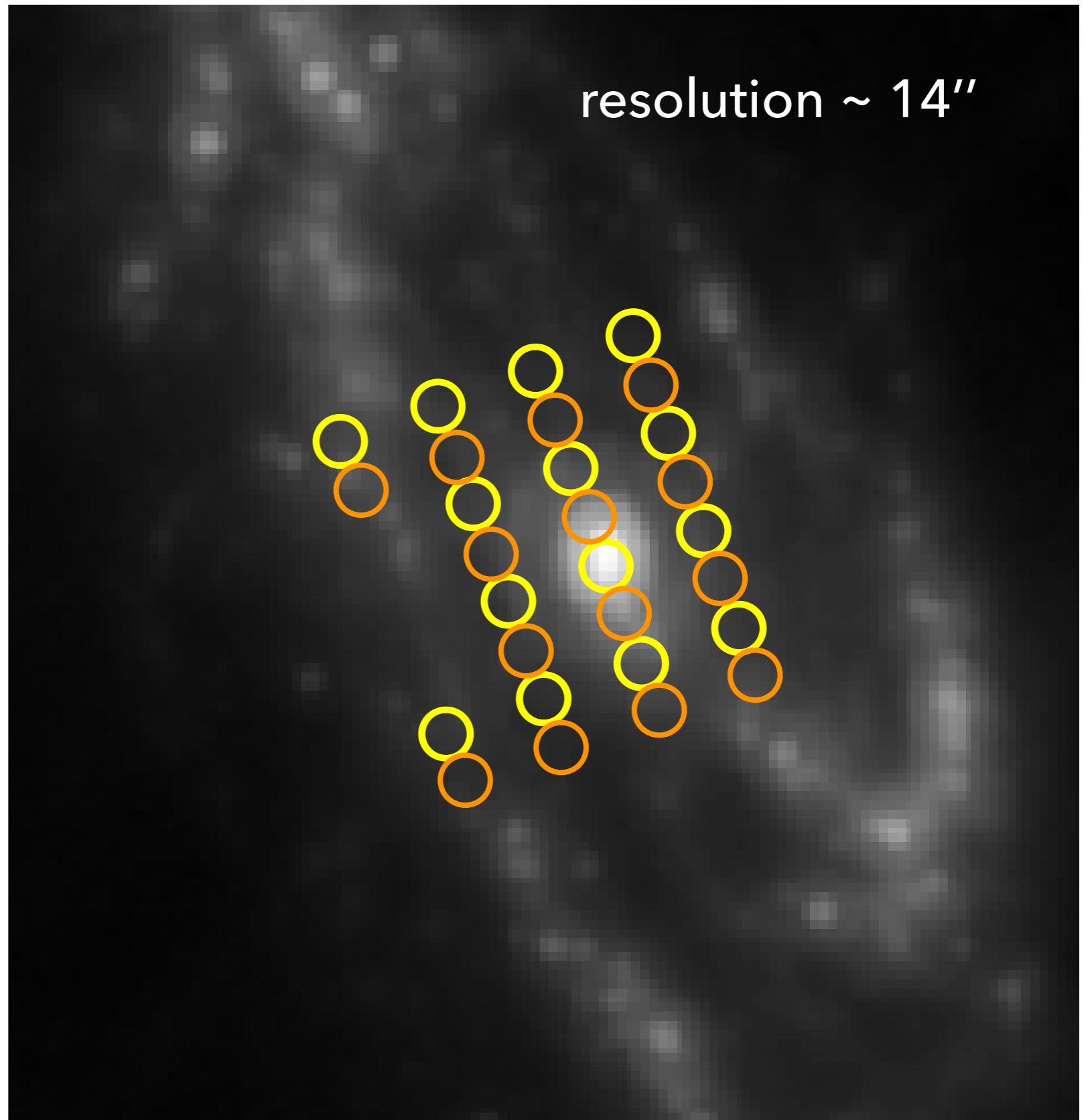
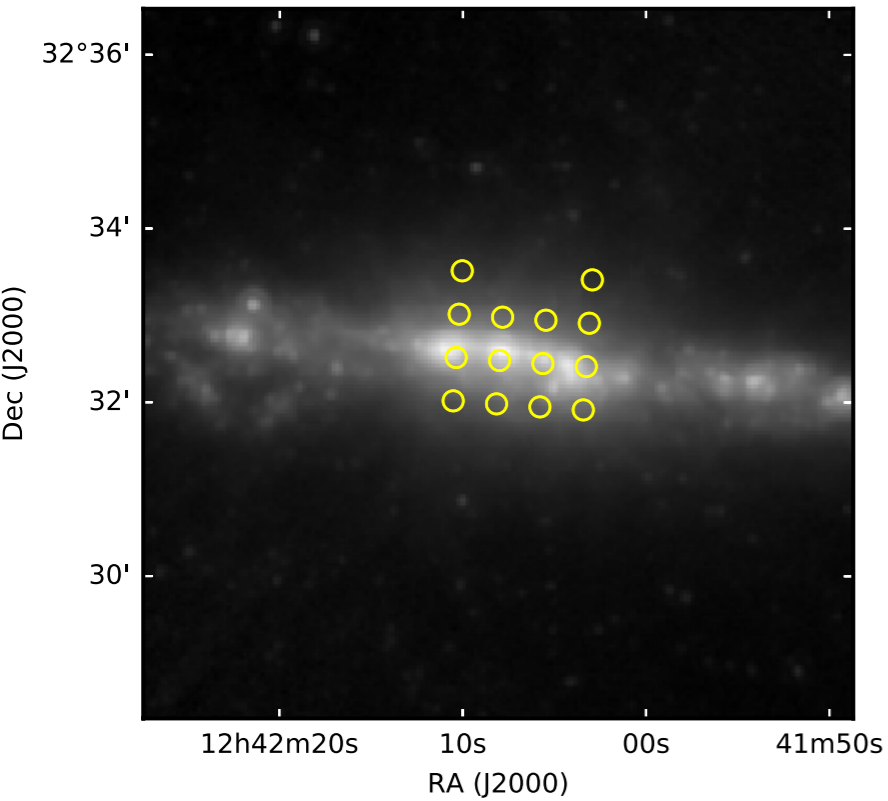
RESULTS

- ▶ six galaxies with jiggle mode (Tan et al. submitted)
 - ▶ Star formation relations
 - ▶ Line ratios (HCN, HCO⁺)
- ▶ NGC 253 (Jiang et al. in prep)
 - ▶ dense gas fraction radial profile
 - ▶ dense gas fraction vs. L_{IR}
 - ▶ Line ratios (HCN, HCO⁺, CO)

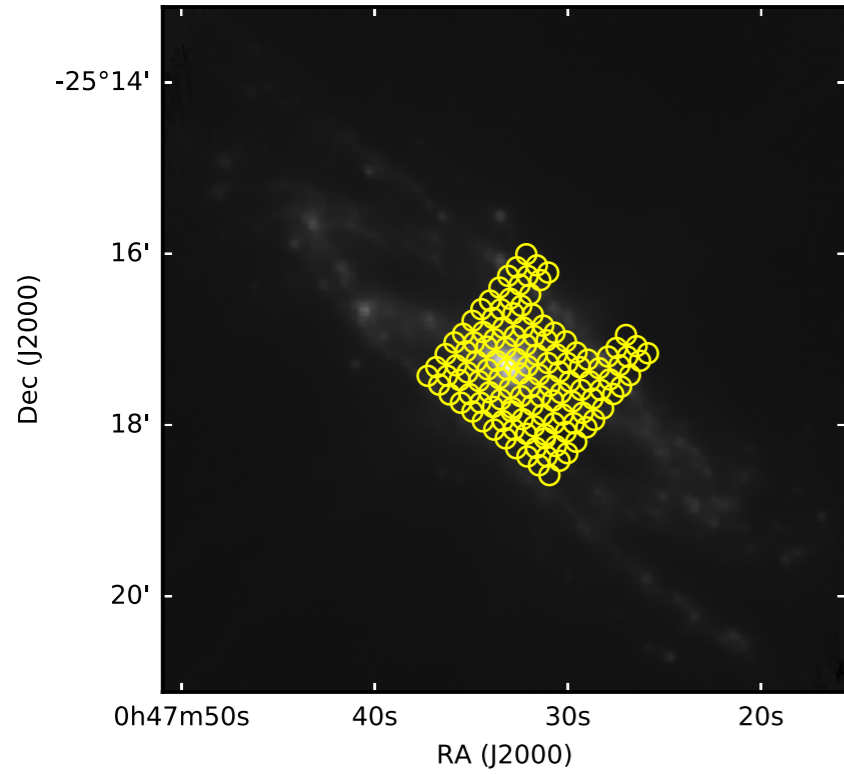
NGC891



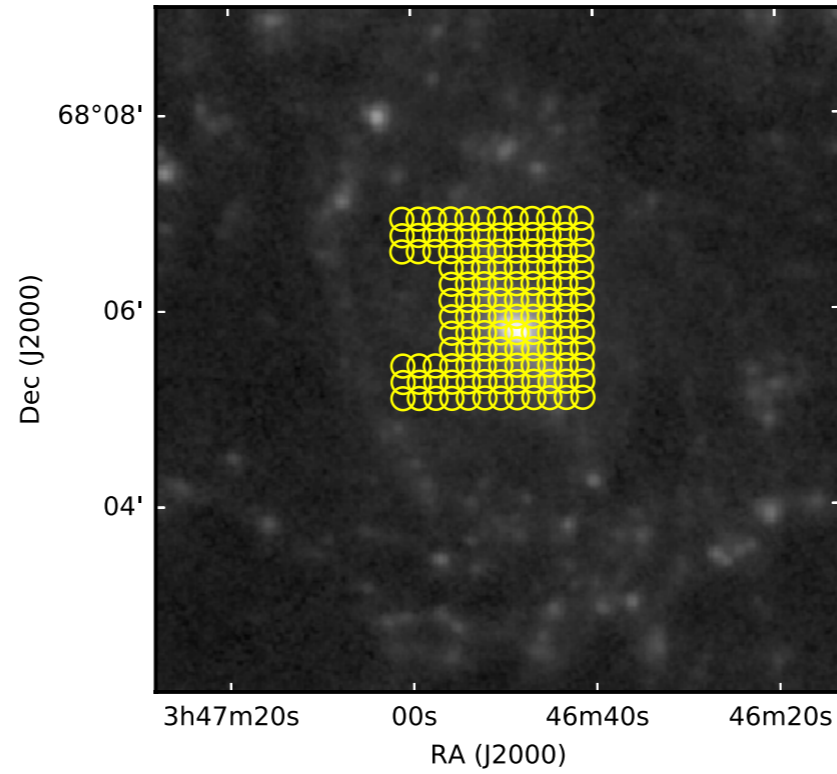
NGC4631



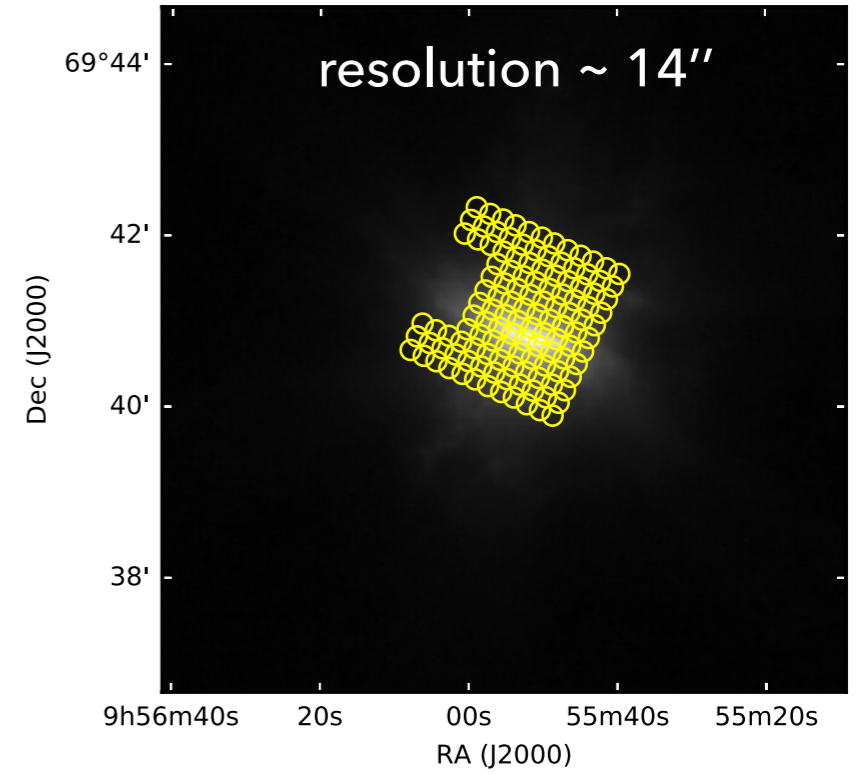
NGC253



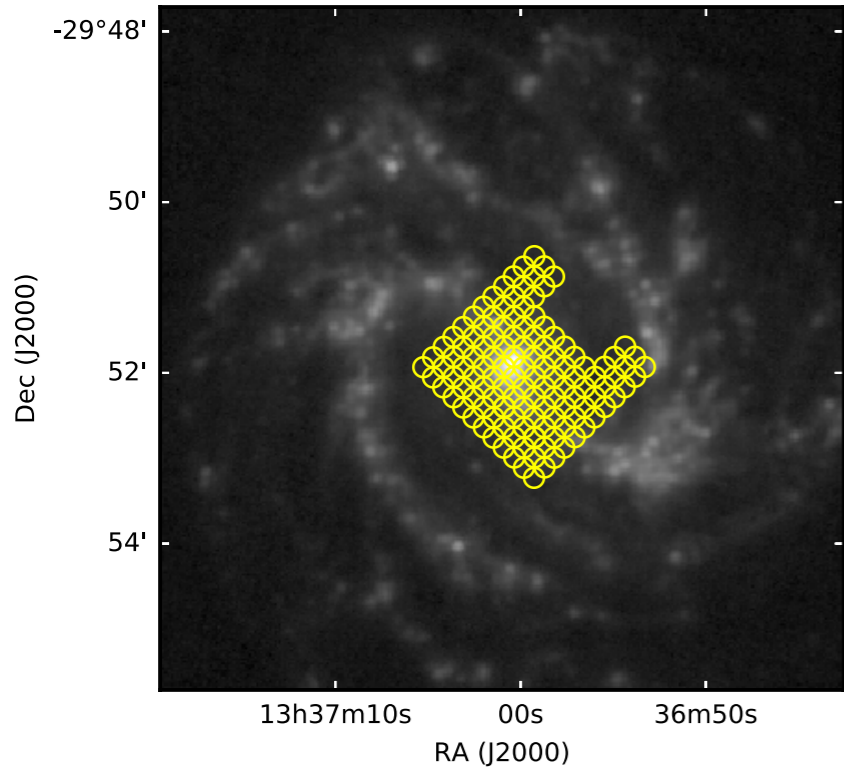
IC342



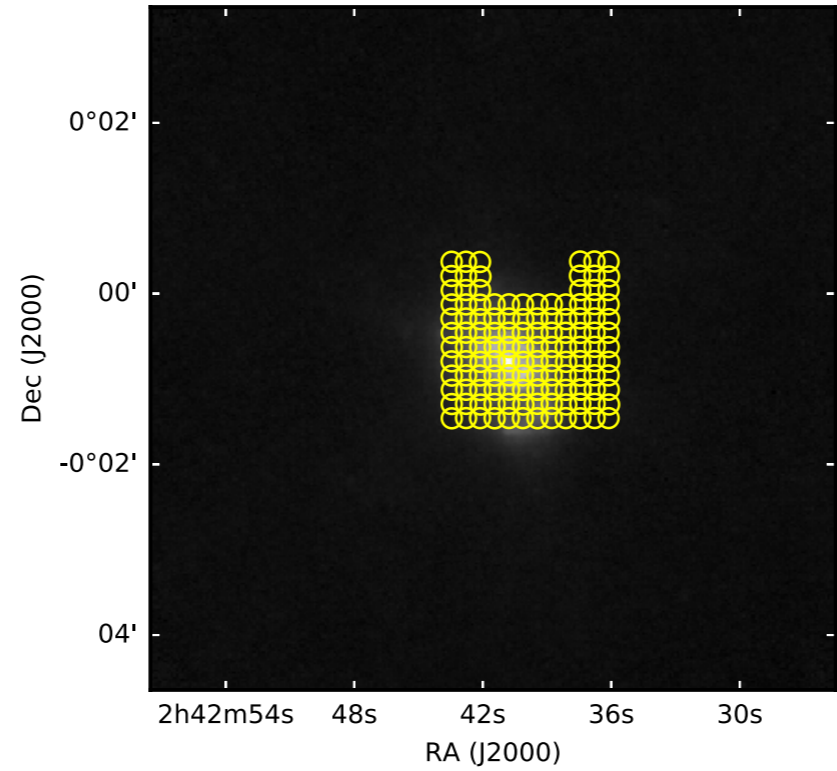
M82



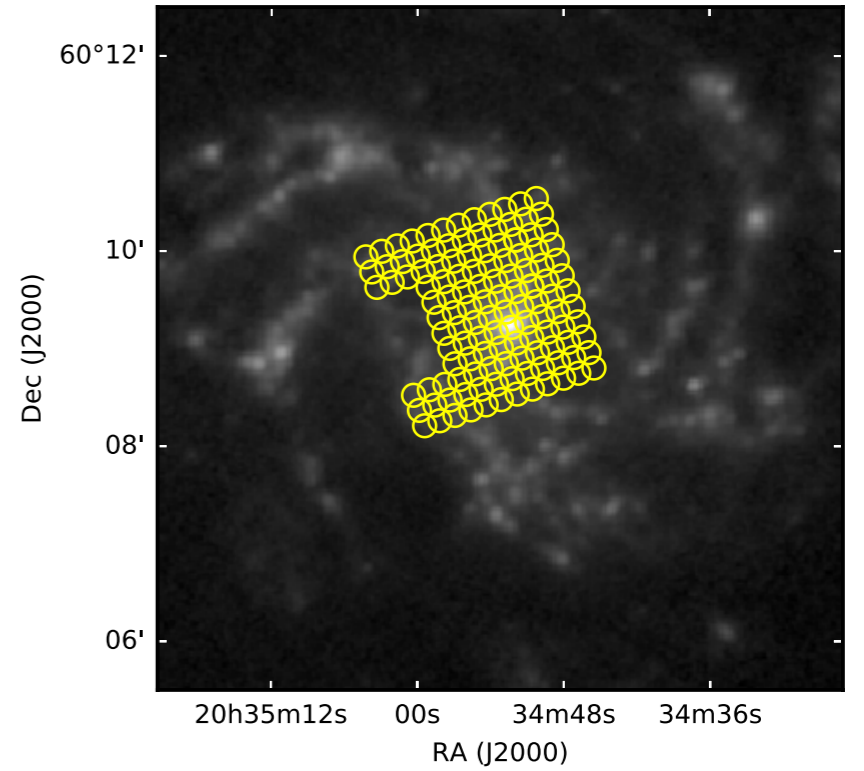
M83



NGC1068



NGC6946



sample in [Tan et al. \(submitted\)](#)

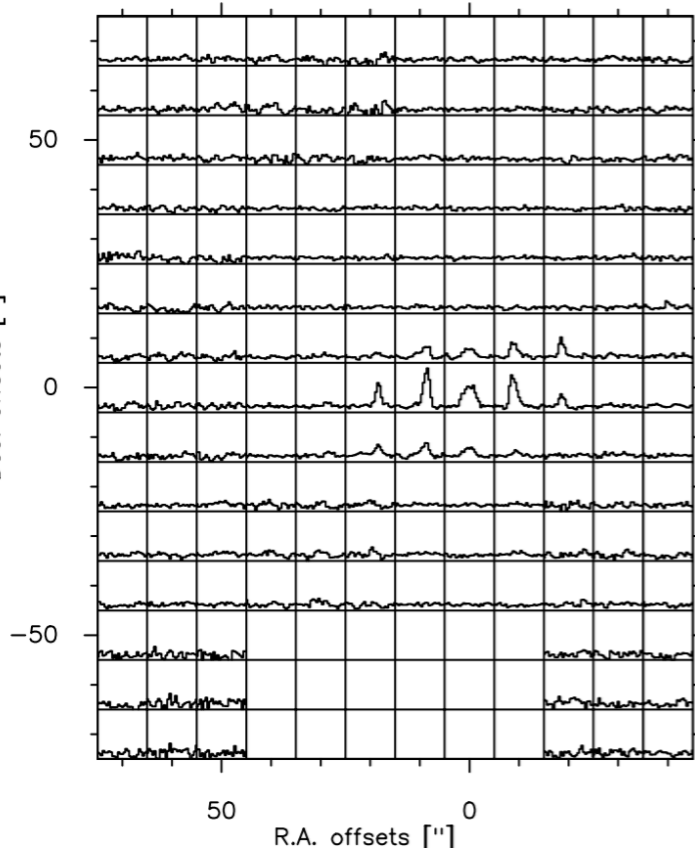
RESULTS

Tan et al. (submitted)

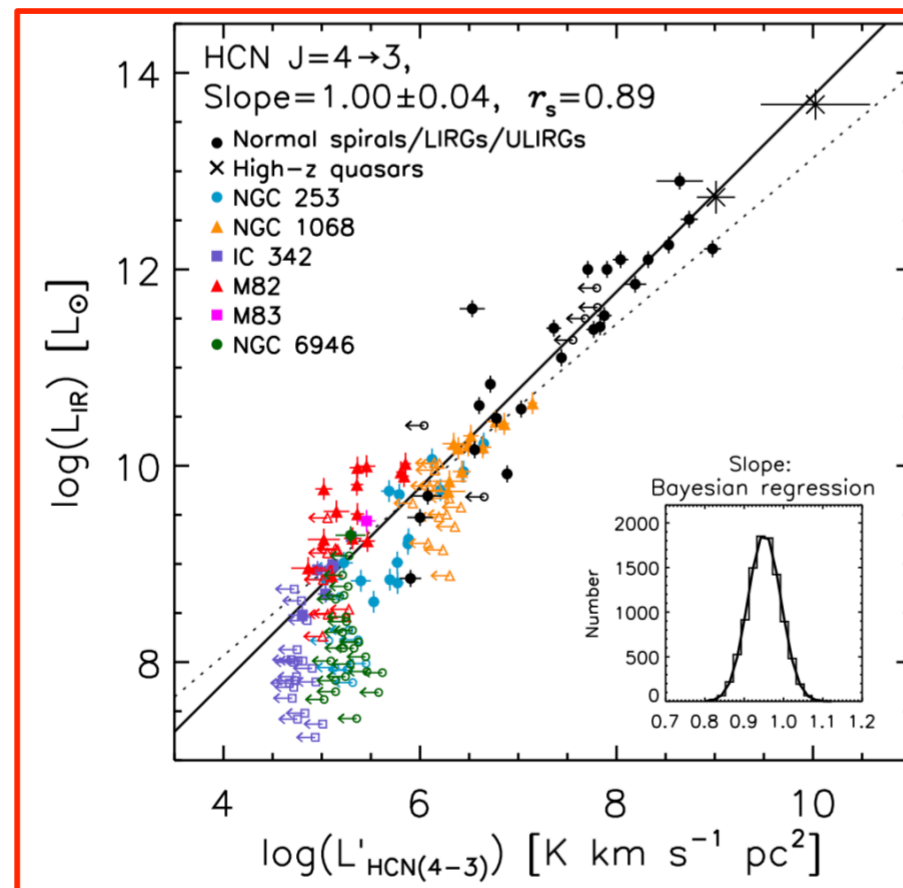
Jiggle-mapping:

2×2 arcmin² central region

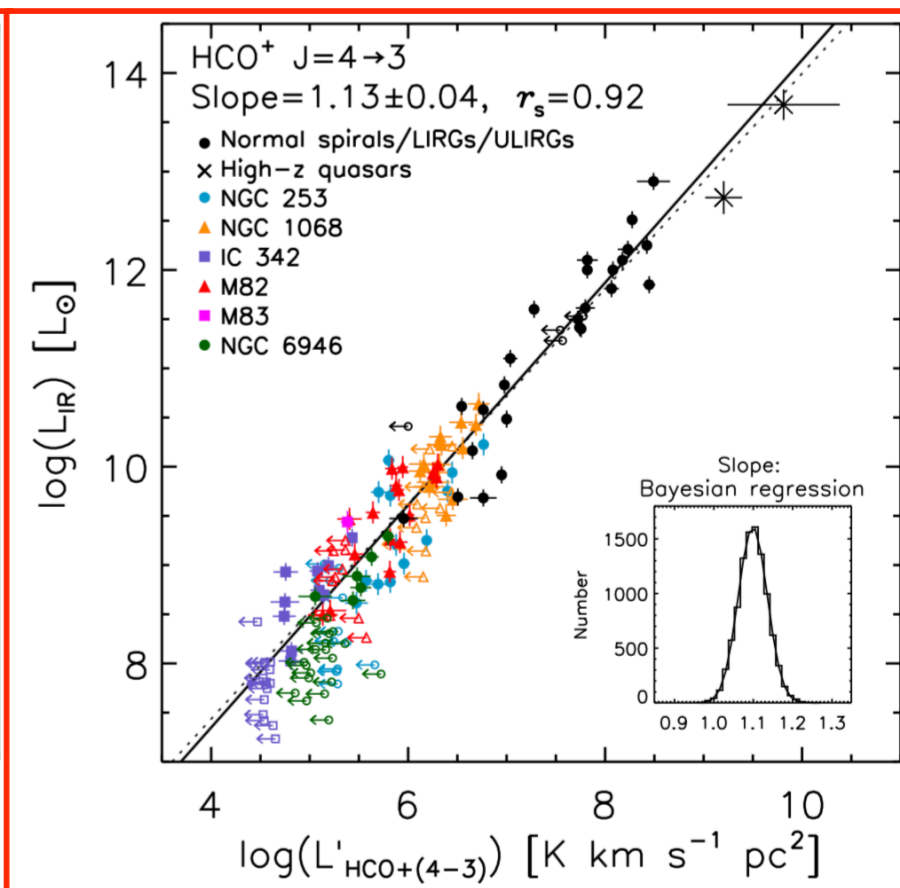
M82: HCO⁺(4-3)



L_{IR} vs. $L'_{\text{HCN}(4-3)}$



L_{IR} vs. $L'_{\text{HCO}^+(4-3)}$



The dense gas as traced by HCN(4-3) and HCO⁺(4-3) is linearly correlated with the IR emission on sub-kpc scales.

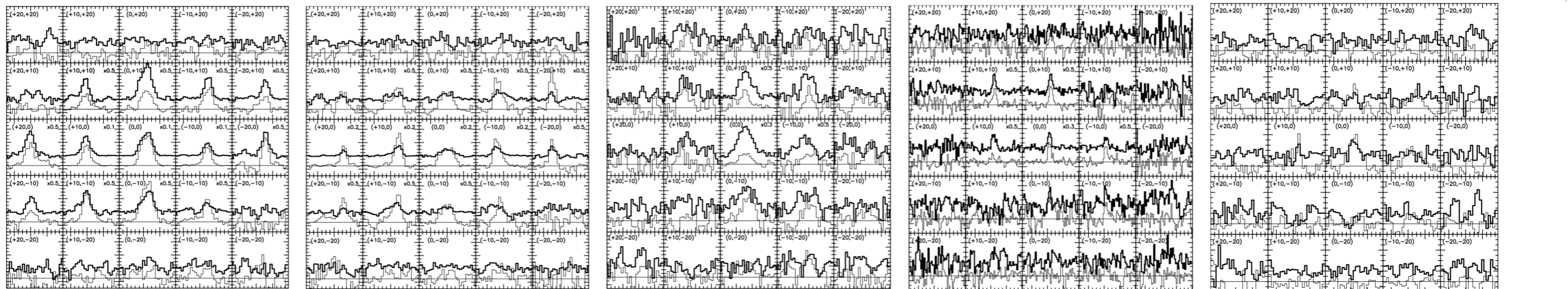
NGC 253

M82

NGC 1068

IC 342

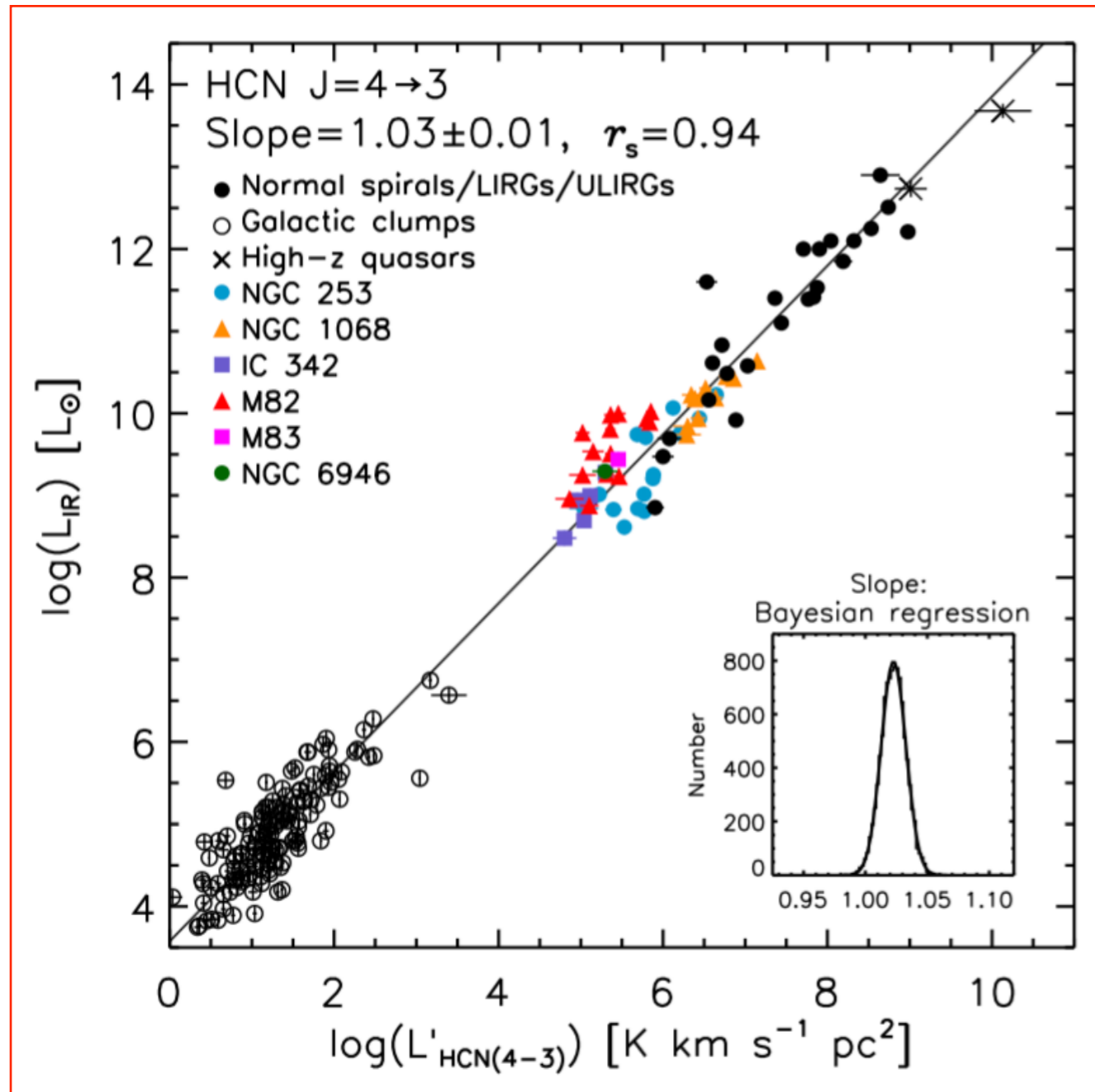
NGC 6946



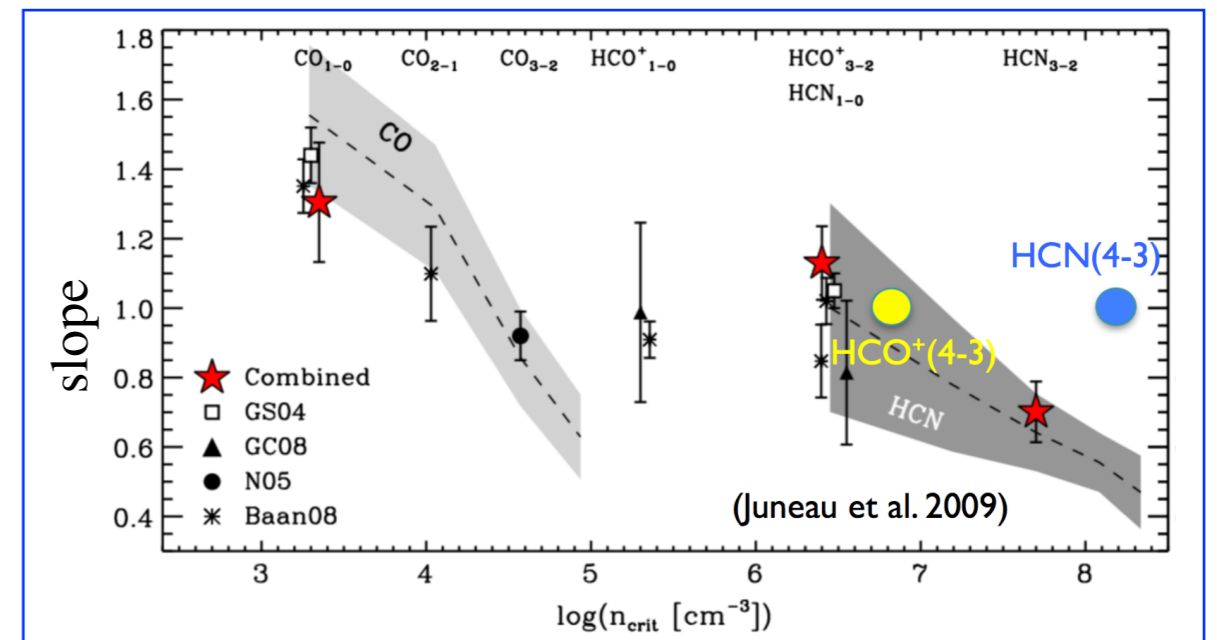
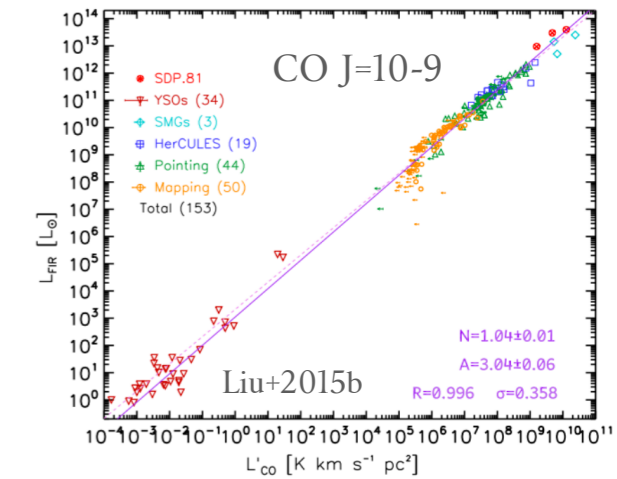
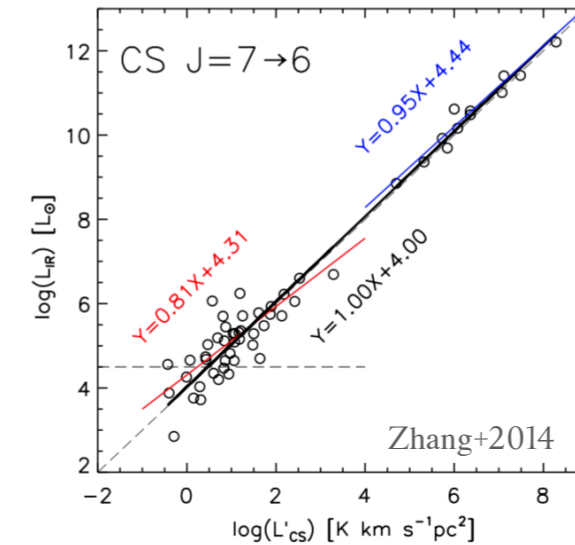
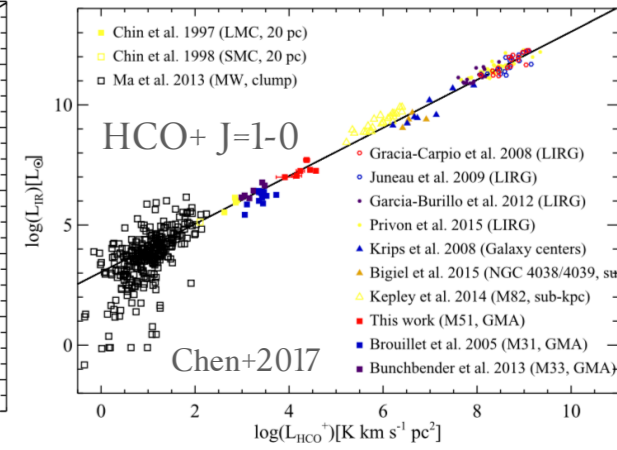
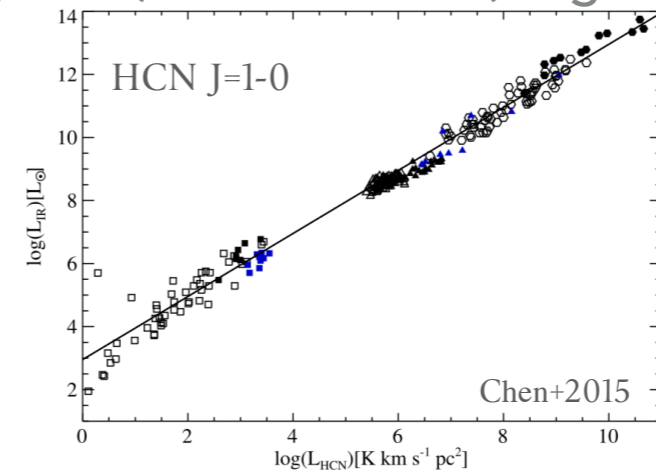
RESULTS

Tan et al. (submitted)

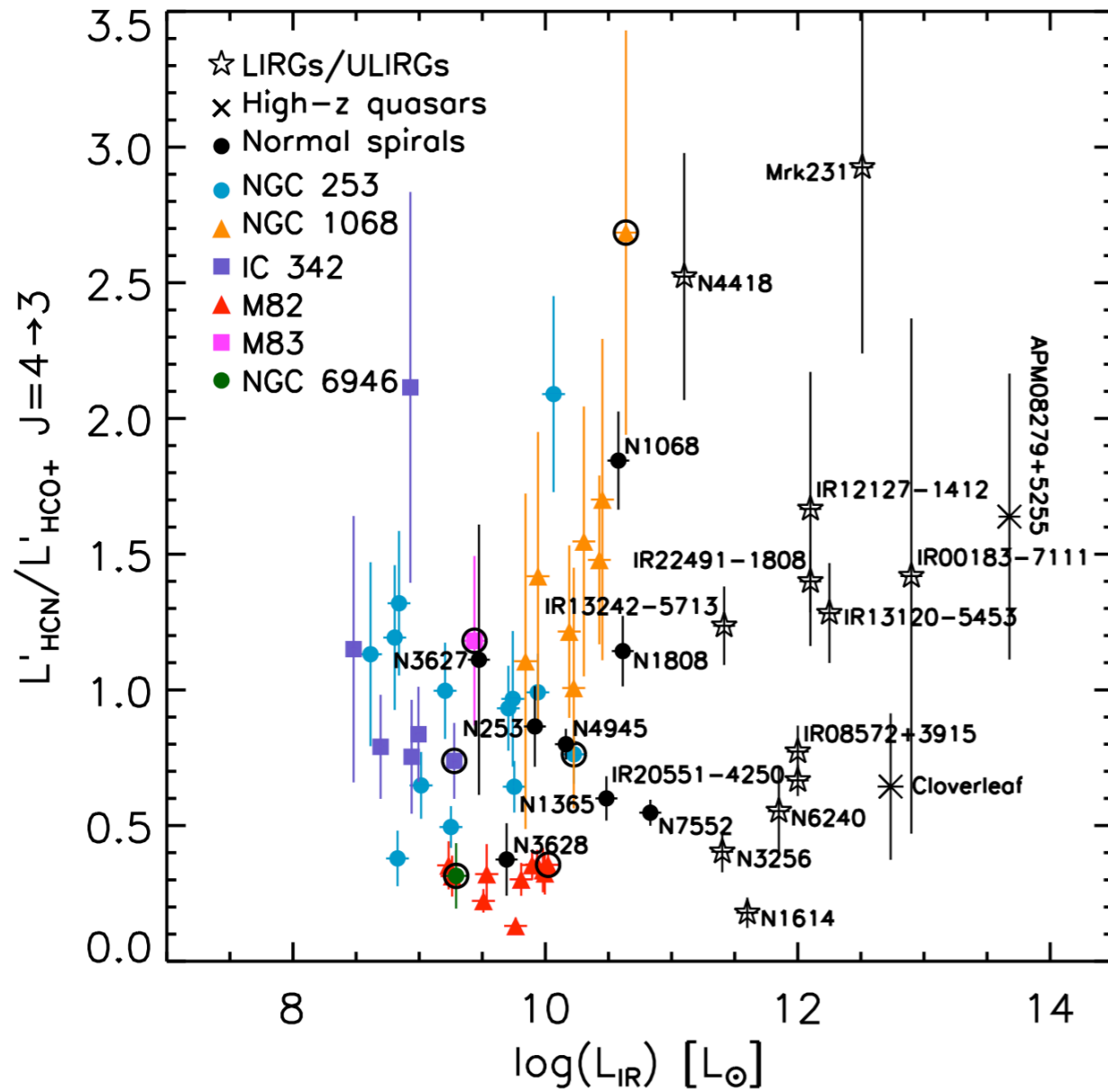
- ▶ Bridge the gap between extragalactic (galaxy-integrated) and Galactic (single clouds) observations
- ▶ linear correlations hold for all densities $>10^4 \text{ cm}^{-3}$!



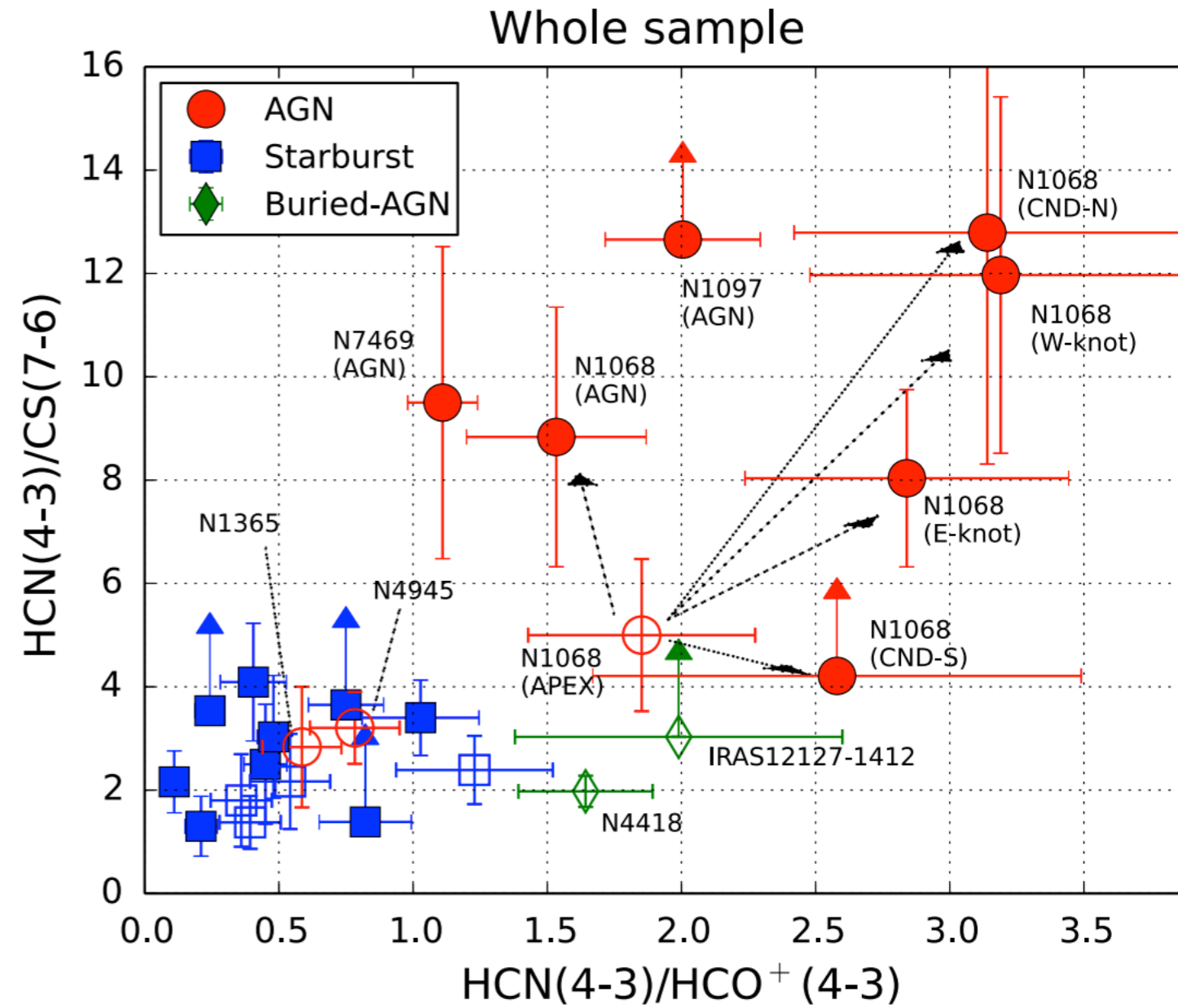
Tan et al. (submitted)



HCN/HCO⁺ RATIO VS. ENVIRONMENT



Tan et al. (submitted)

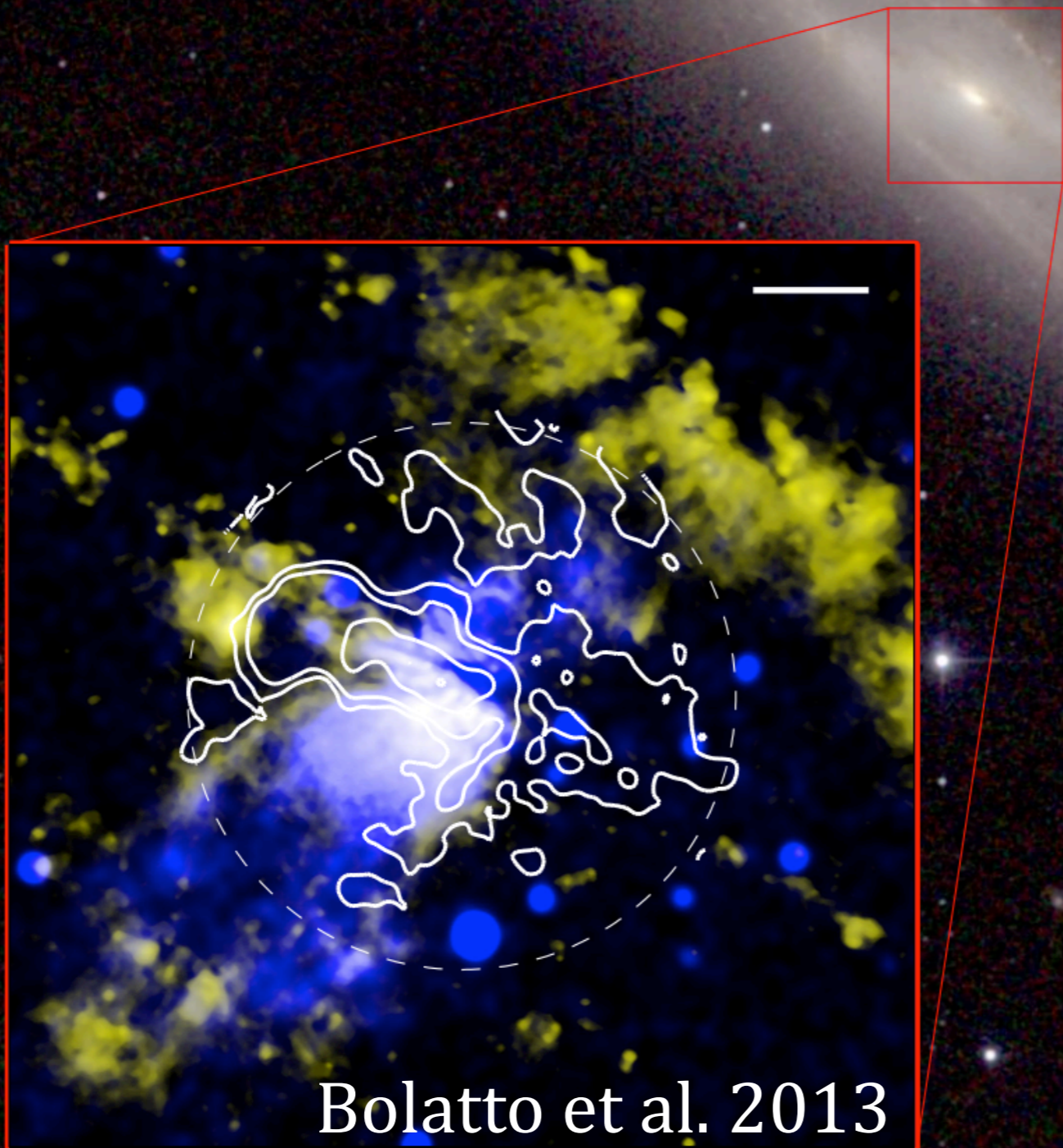


Izumi+ 2016

RESULTS

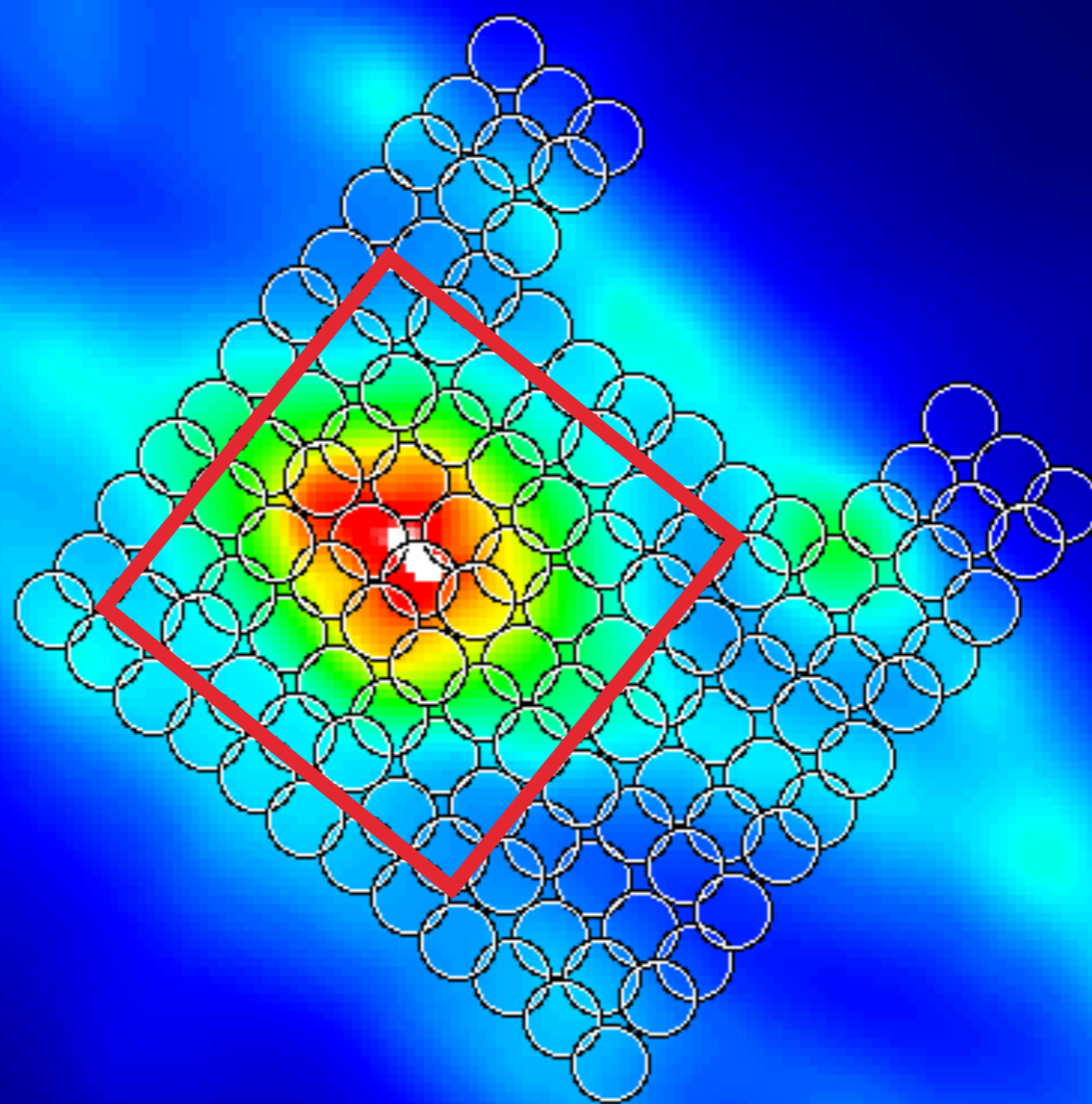
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NGC 253 the nearest nuclear starburst



Bolatto et al. 2013

MALATANG COVERAGE OF NGC253

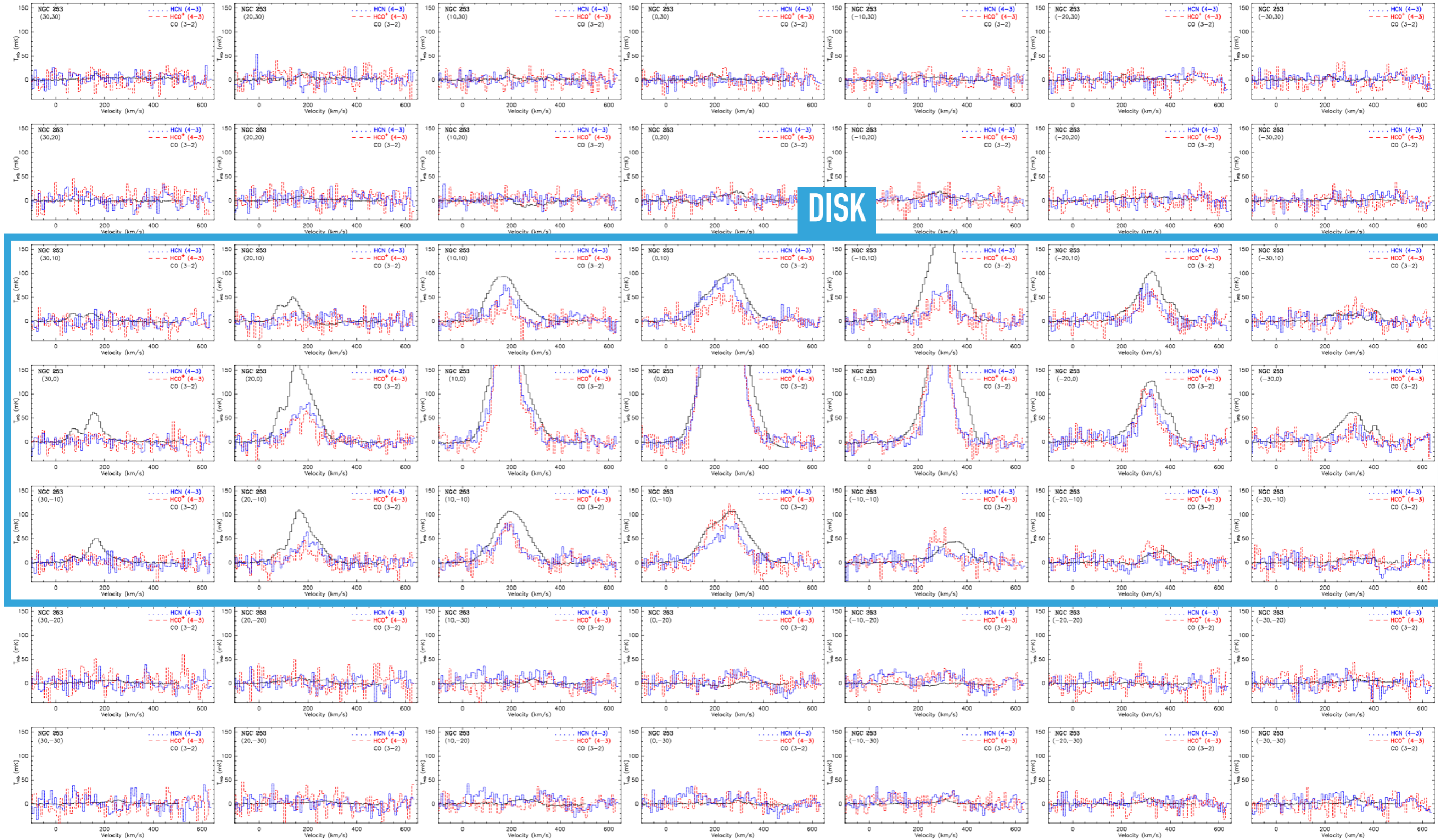


NGC253 SPECTRA

HCN (4-3)

HCO+ (4-3)

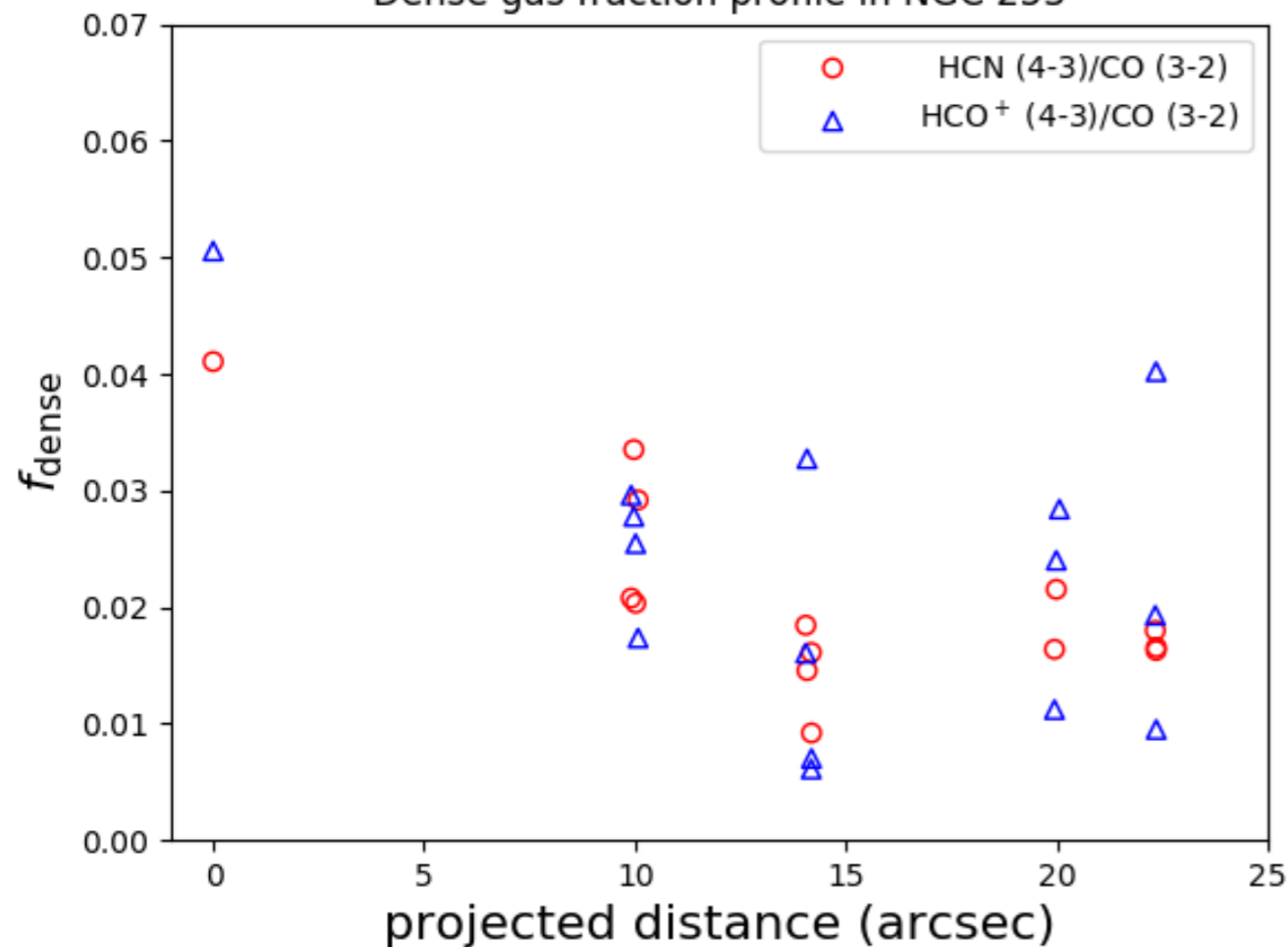
CO (3-2) /20
(JCMT archive)



LINE RATIOS VS. DISTANCE TO NUCLEI

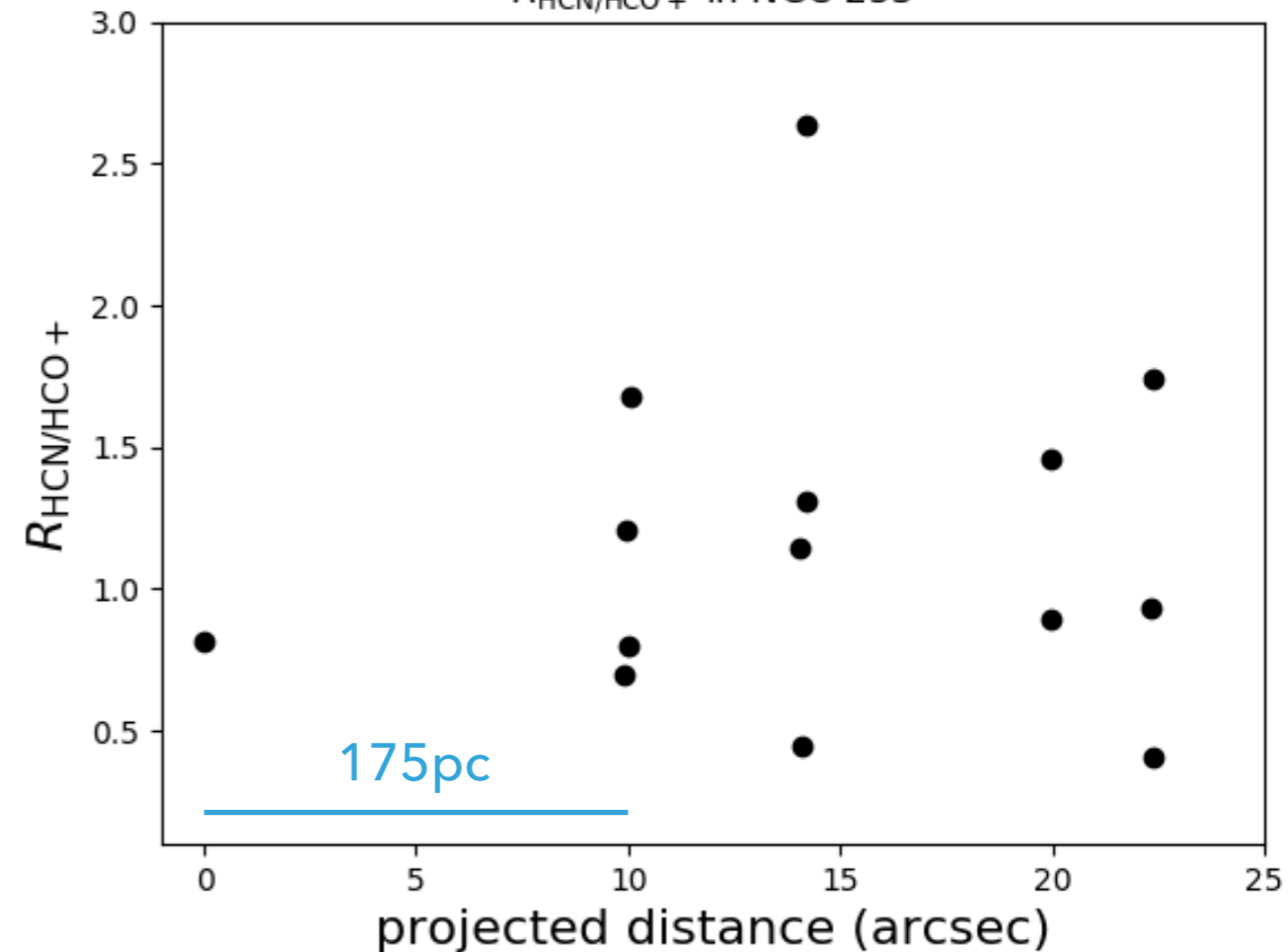
- ▶ Dense gas fraction:
HCN/CO or **HCO⁺/CO**

Dense gas fraction profile in NGC 253



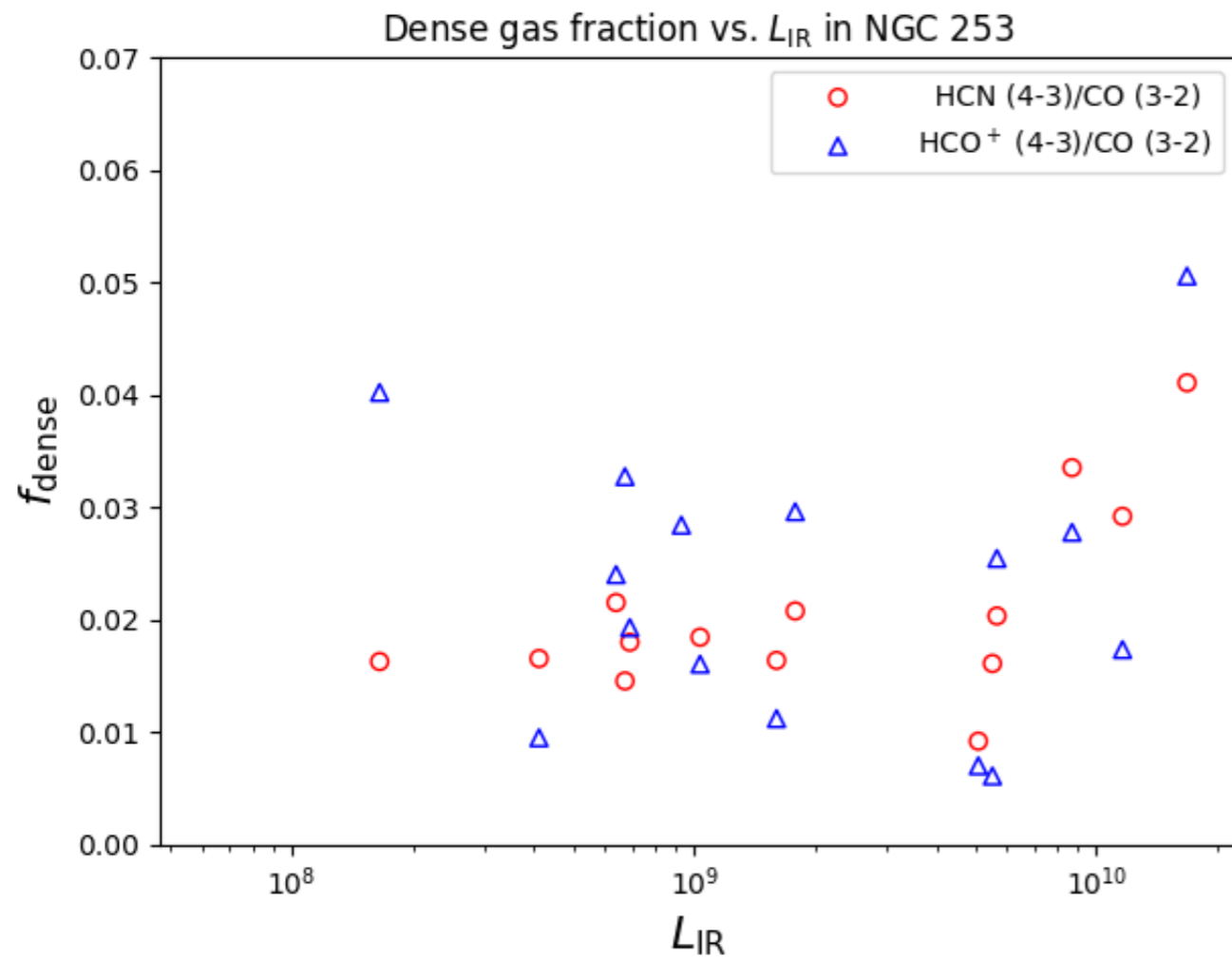
- ▶ HCN/HCO⁺ ratio

$R_{\text{HCN/HCO}^+}$ in NGC 253

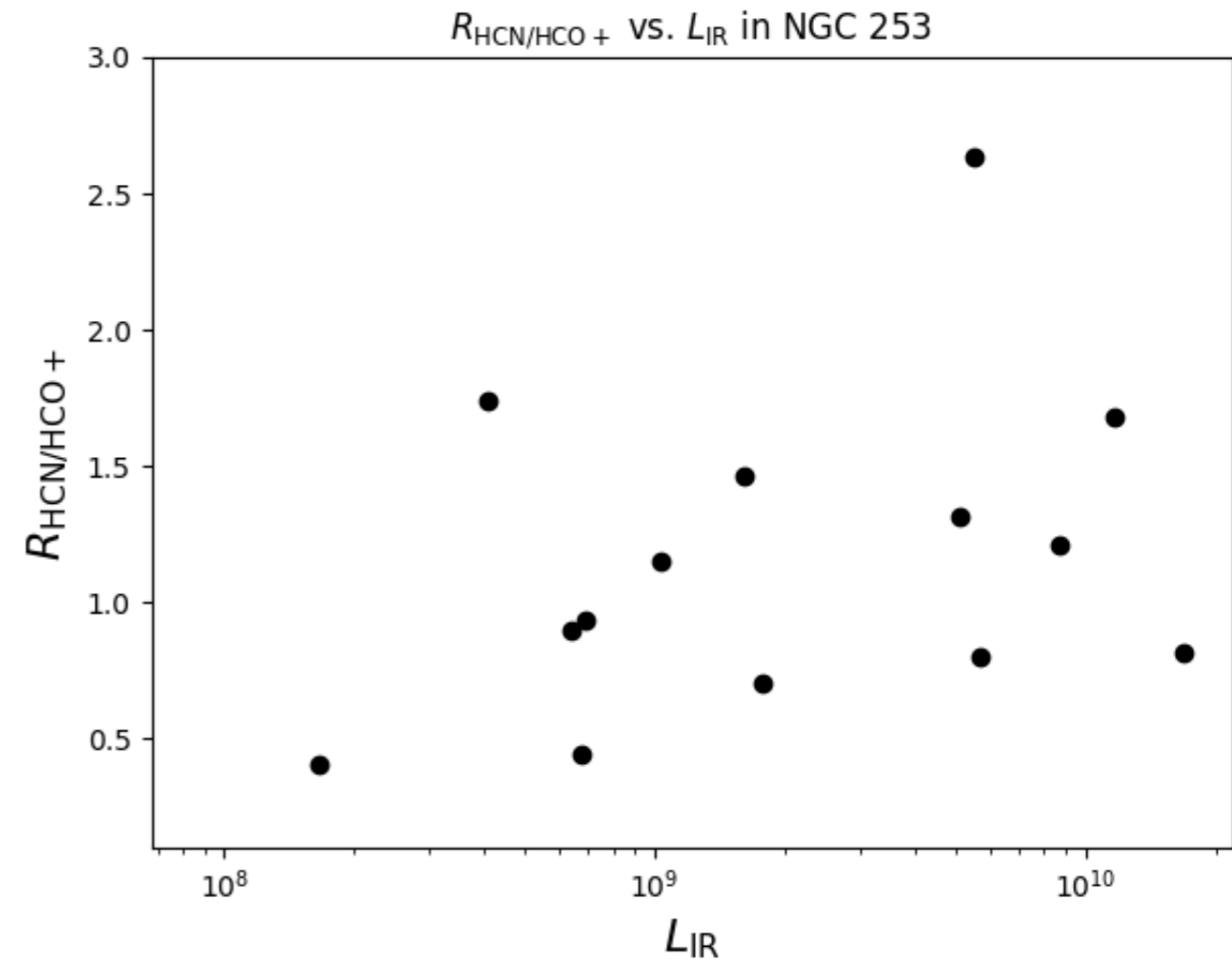


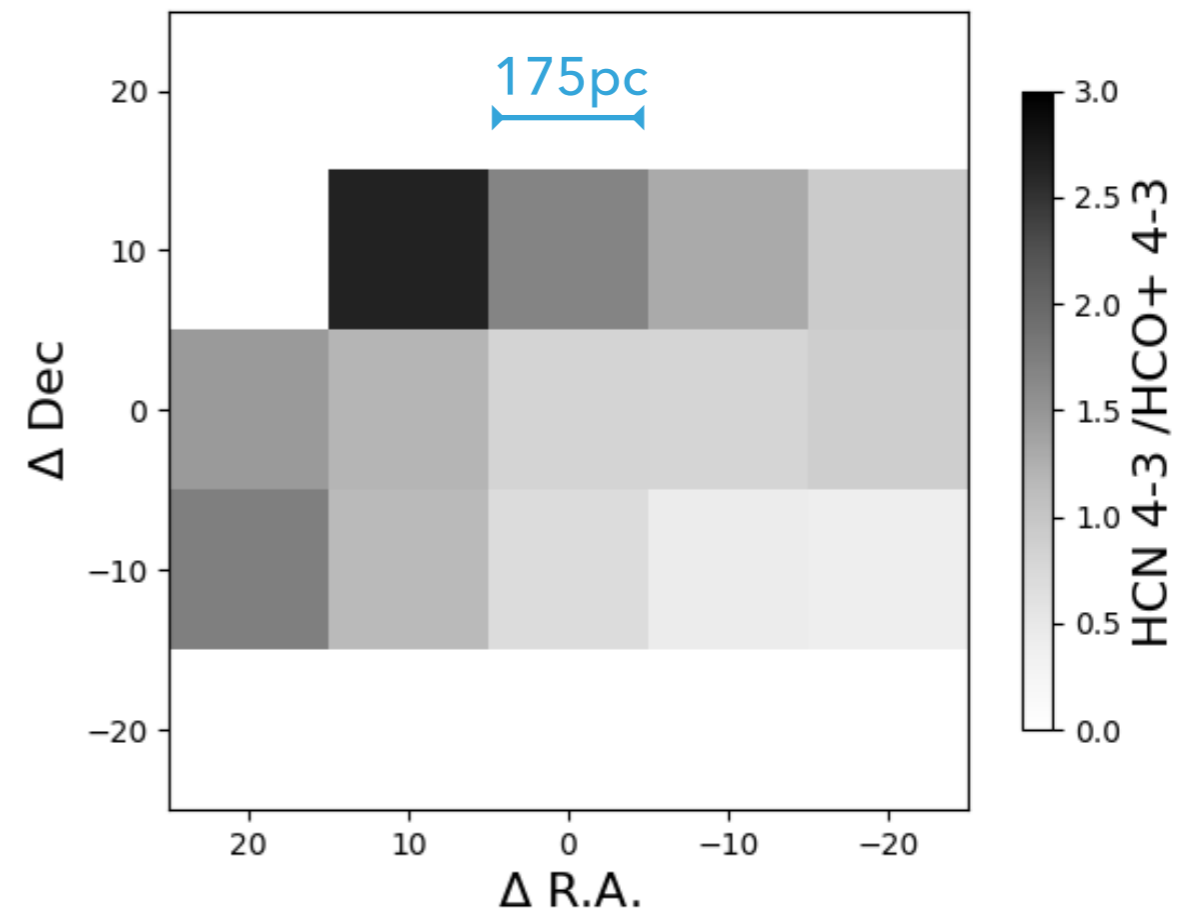
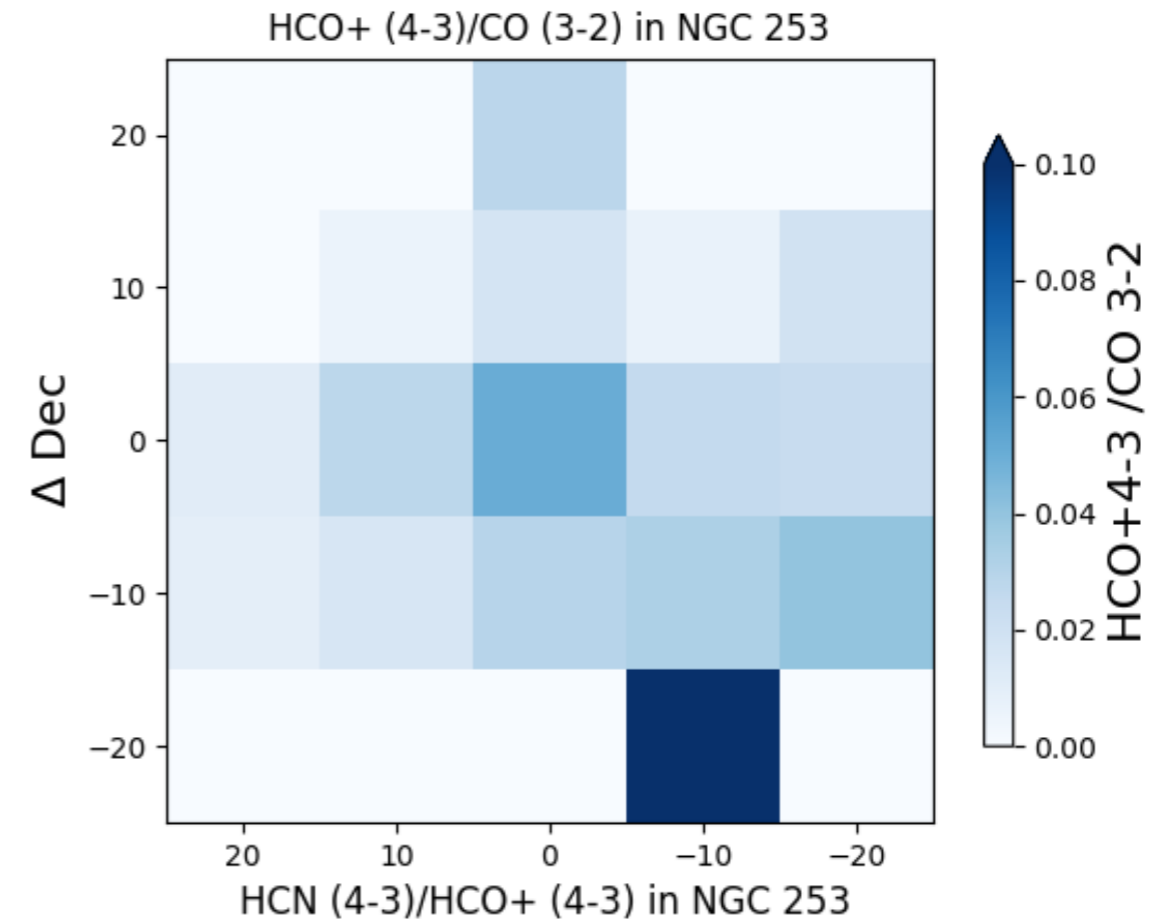
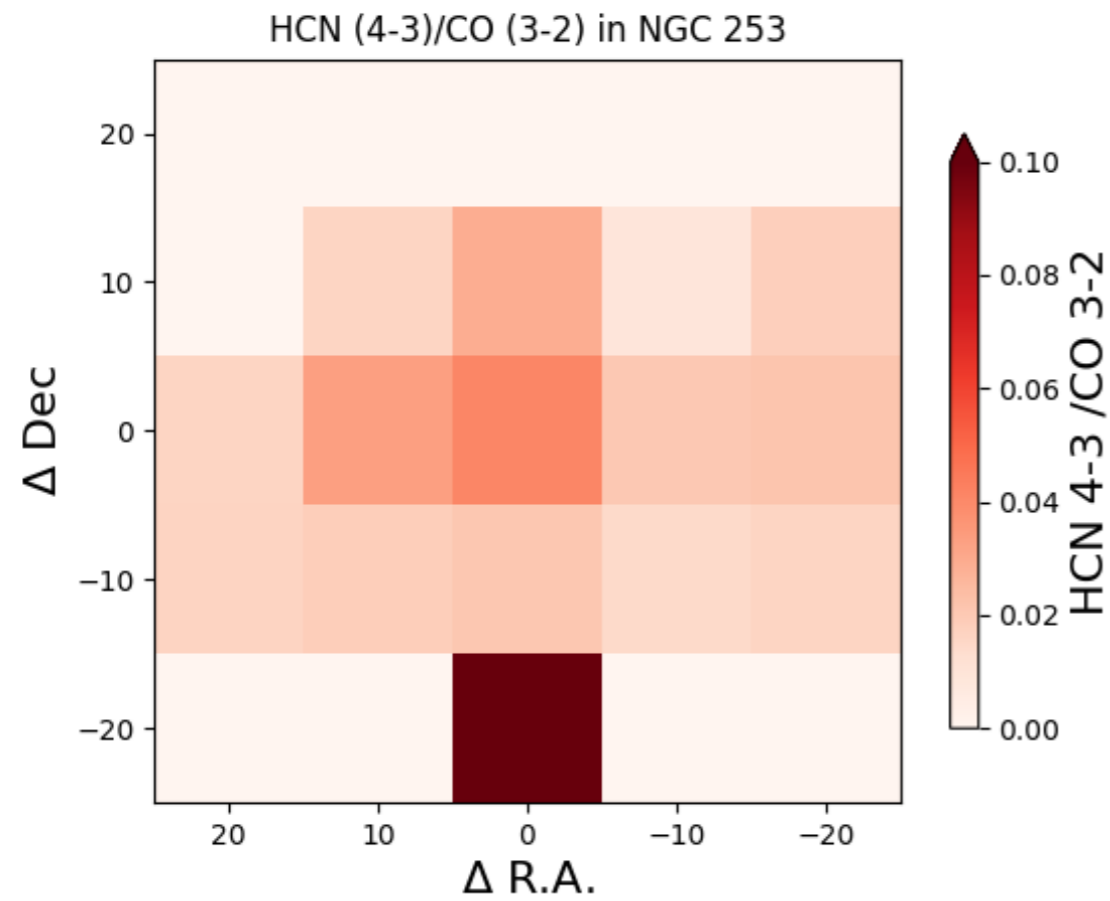
LINE RATIOS VS. L_{IR}

- ▶ Dense gas fraction:
HCN/CO or **HCO⁺/CO**



- ▶ HCN/HCO⁺ ratio





- ▶ HCN/HCO+
~ 0.5 to 2 in the
central ~kpc

SUMMARY — MALATANG RESULTS

- ▶ linear star formation relation ($L_{\text{IR}} \propto L_{\text{dense}}$)
- ▶ HCN/HCO+ ratio show large variation
- ▶ f_{dense} decreasing in outer nuclear region;
 f_{dense} higher in stronger L_{IR} (NGC253)

XUE-JIAN JIANG (蒋雪健)

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