Bolocam Galactic Plane Survey:
HCO^+ and N_2H^+ Spectroscopy of 1.1mm Sources

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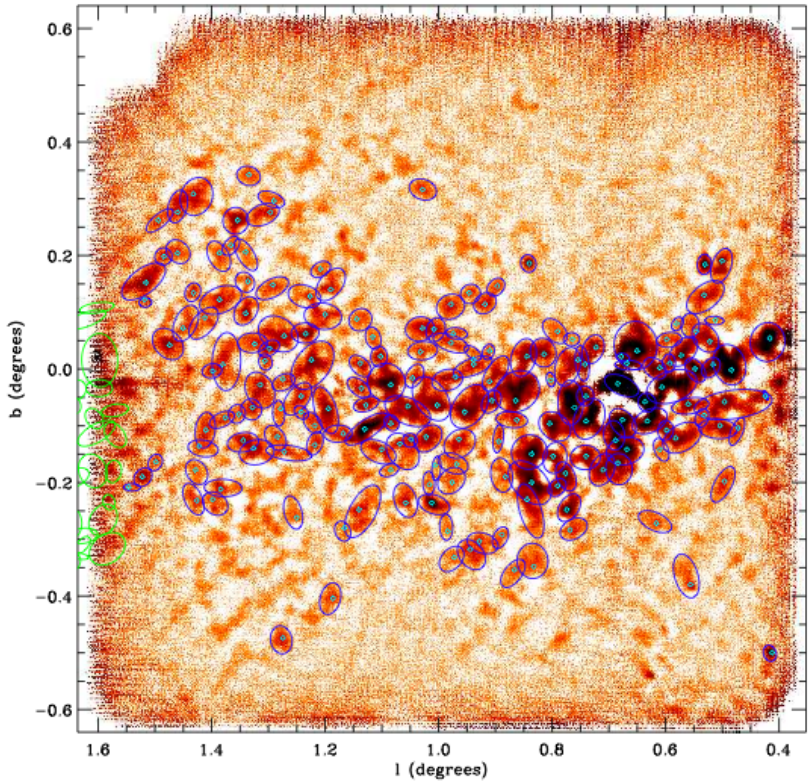
Bolocam Galactic Plane Survey (BGPS)



- Observe the galactic plane using the 10.4m CSO on Mauna Kea
  - Bolocam 115 element bolometer
  - 1.1mm continuum emission
  - 120 contiguous sq degrees from a galactic longitude of -10^{o} to 86^{o}
  - An additional 28 sq degrees in the outer galaxy
  - Depth of ~ 15 mJy rms

Dense Gas Spectroscopy

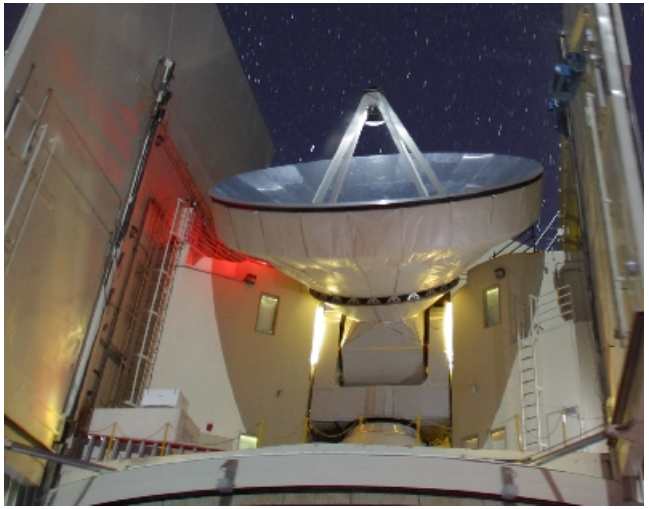
- Heterodyne follow-up
  - Dense gas tracers
    - HCO^+ J = (3 - 2) & N_2H^+ J = (3 - 2)
    - Chemically opposite with respect to CO
    - Similar effective densities to each other and the dust

$$H_3^+ + CO \rightarrow HCO^+ + H_2$$

$$H_3^+ + N_2 \rightarrow N_2H^+ + H_2$$

$$N_2H^+ + CO \rightarrow N_2 + HCO^+$$

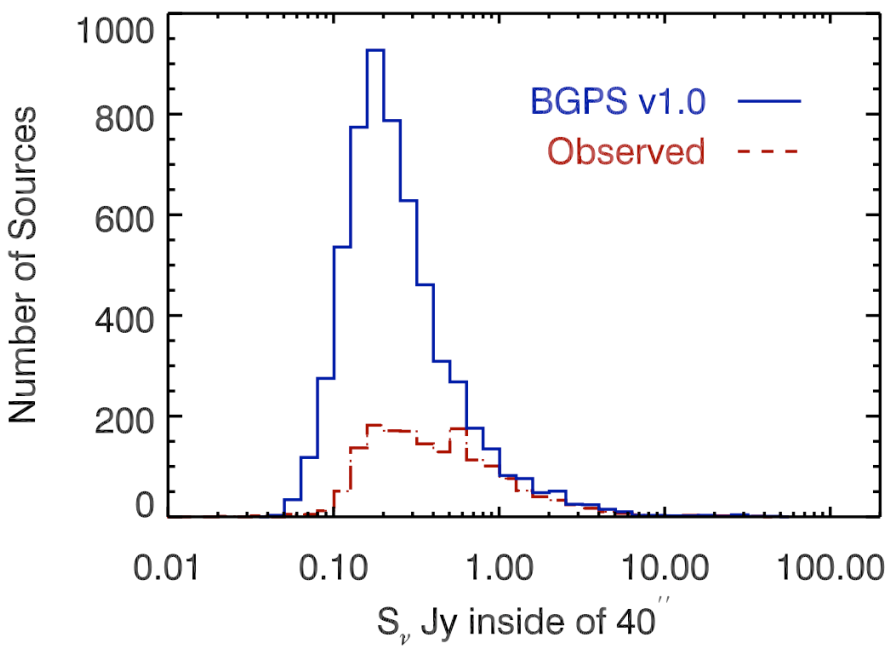
Observations

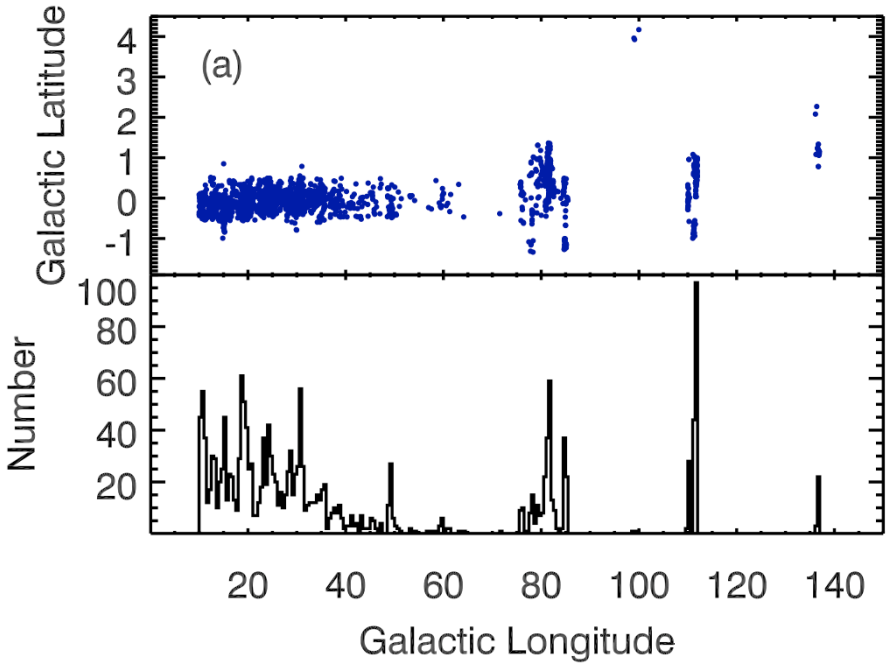


- 1.1 mm ALMA band 6 prototype receiver
  - Baseline r.m.s. < 55 mK
  - 2 minute integrations using ON-OFF position switching.
  - Designated OFF positions for each half degree in galactic longitude
  - 15+ sources per hour
  - Calibration and pointing each hour using available planets

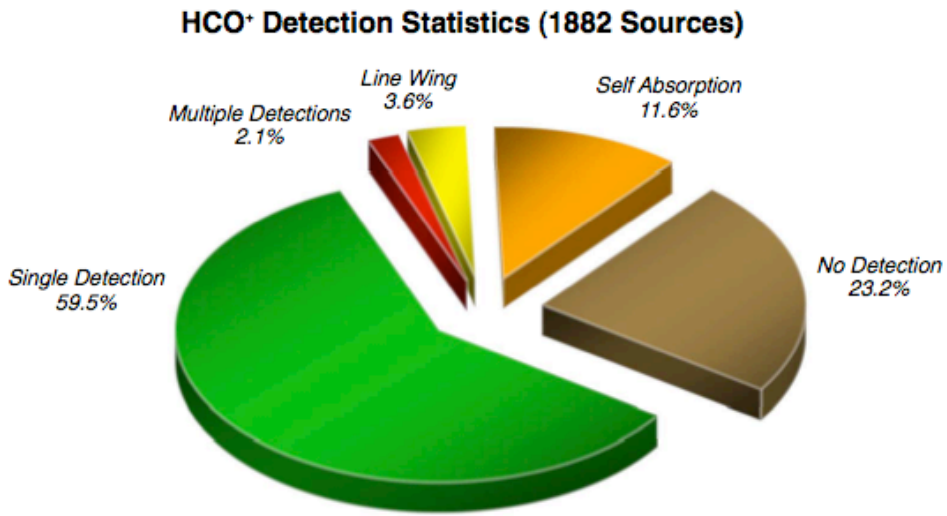
BGPS Source Catalog

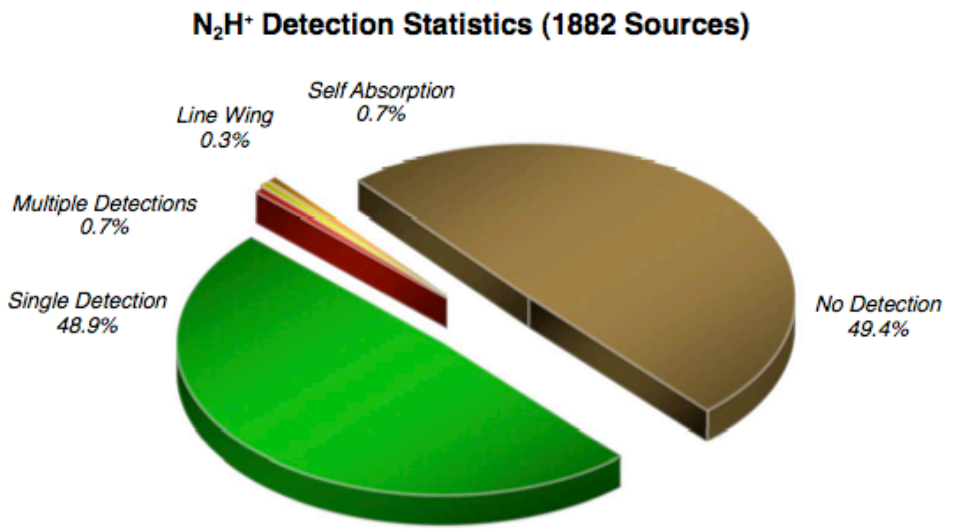
- 1882 sources from the BGPS Catalog
  - 1400 sources selected in a flux limited manner (Q1)
  - 283 sources added to complete coverage at specific galactic longitudes (Q1)
  - 199 sources in quadrant 2

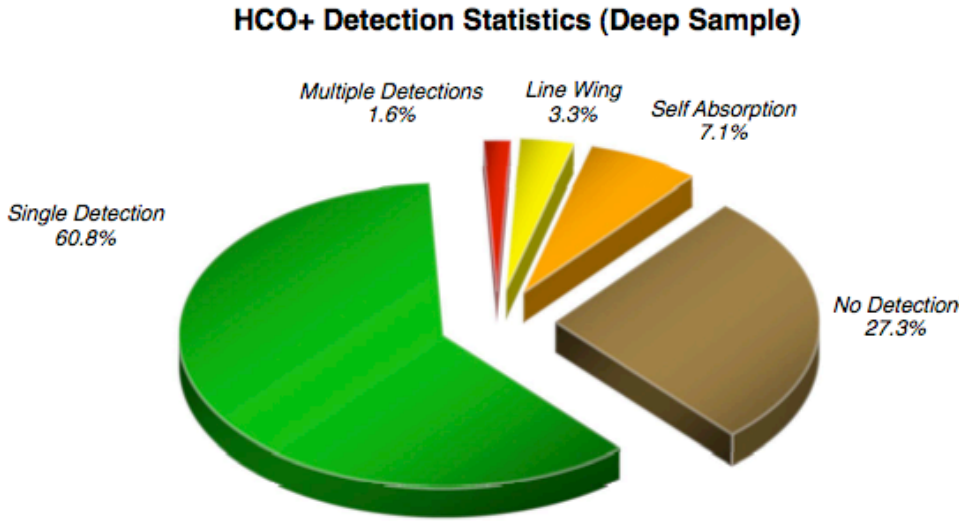


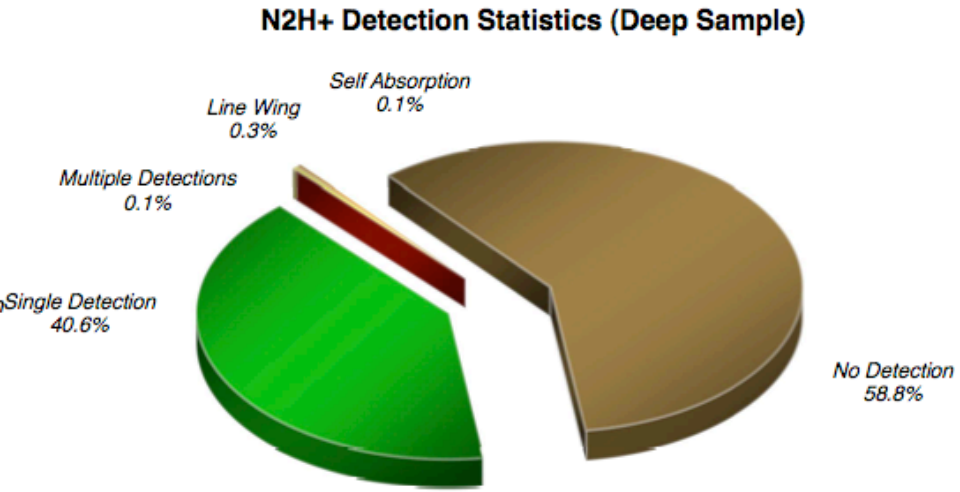


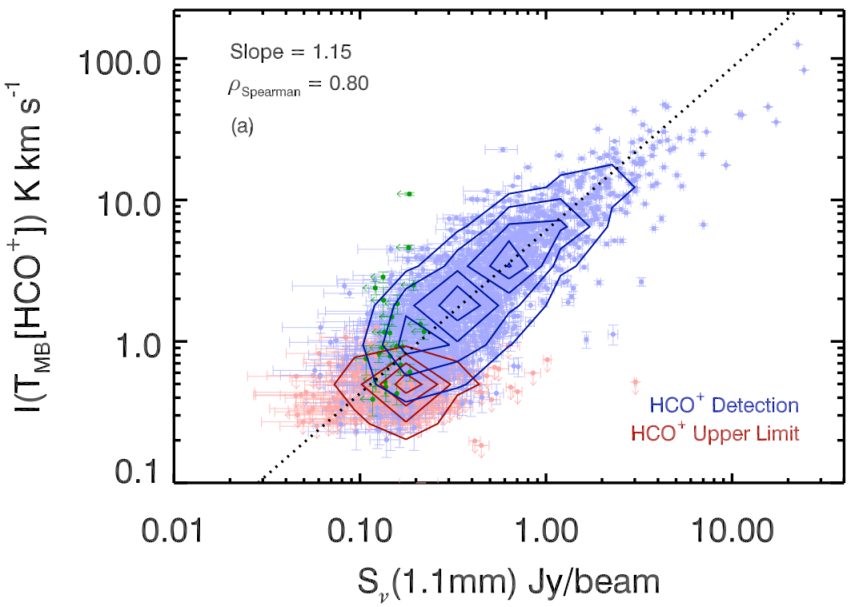
Detection Statistics

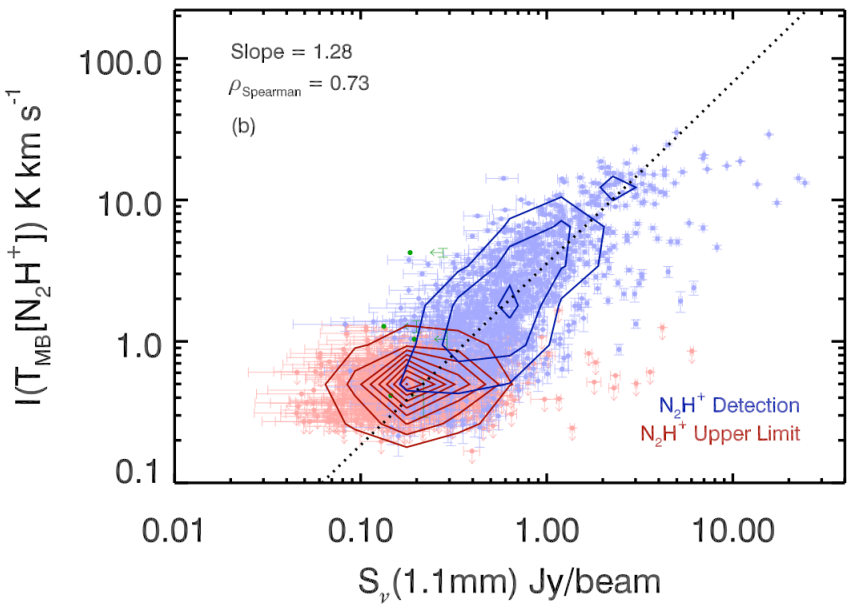


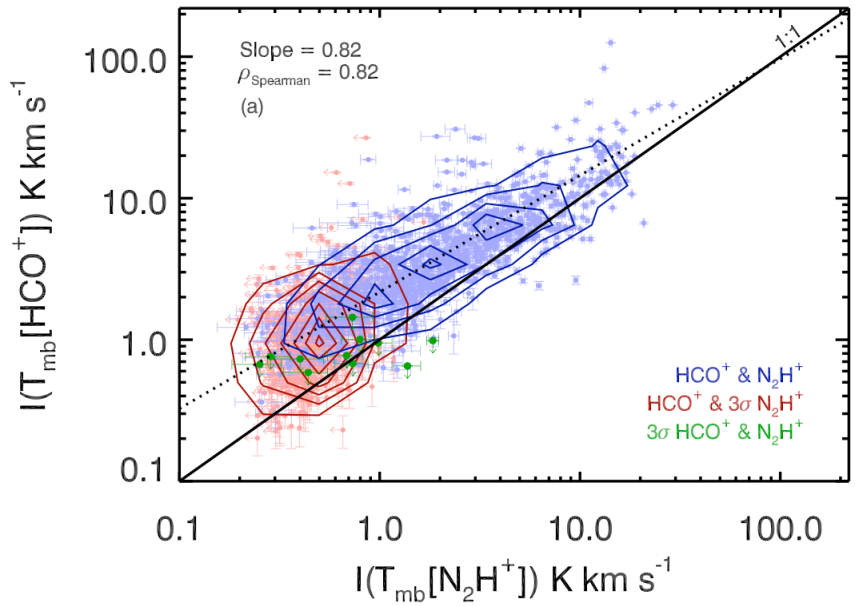


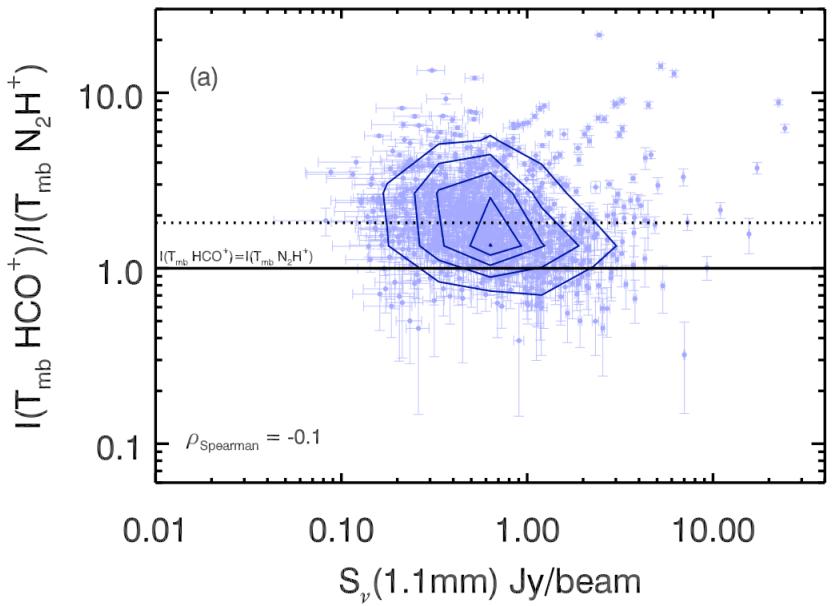




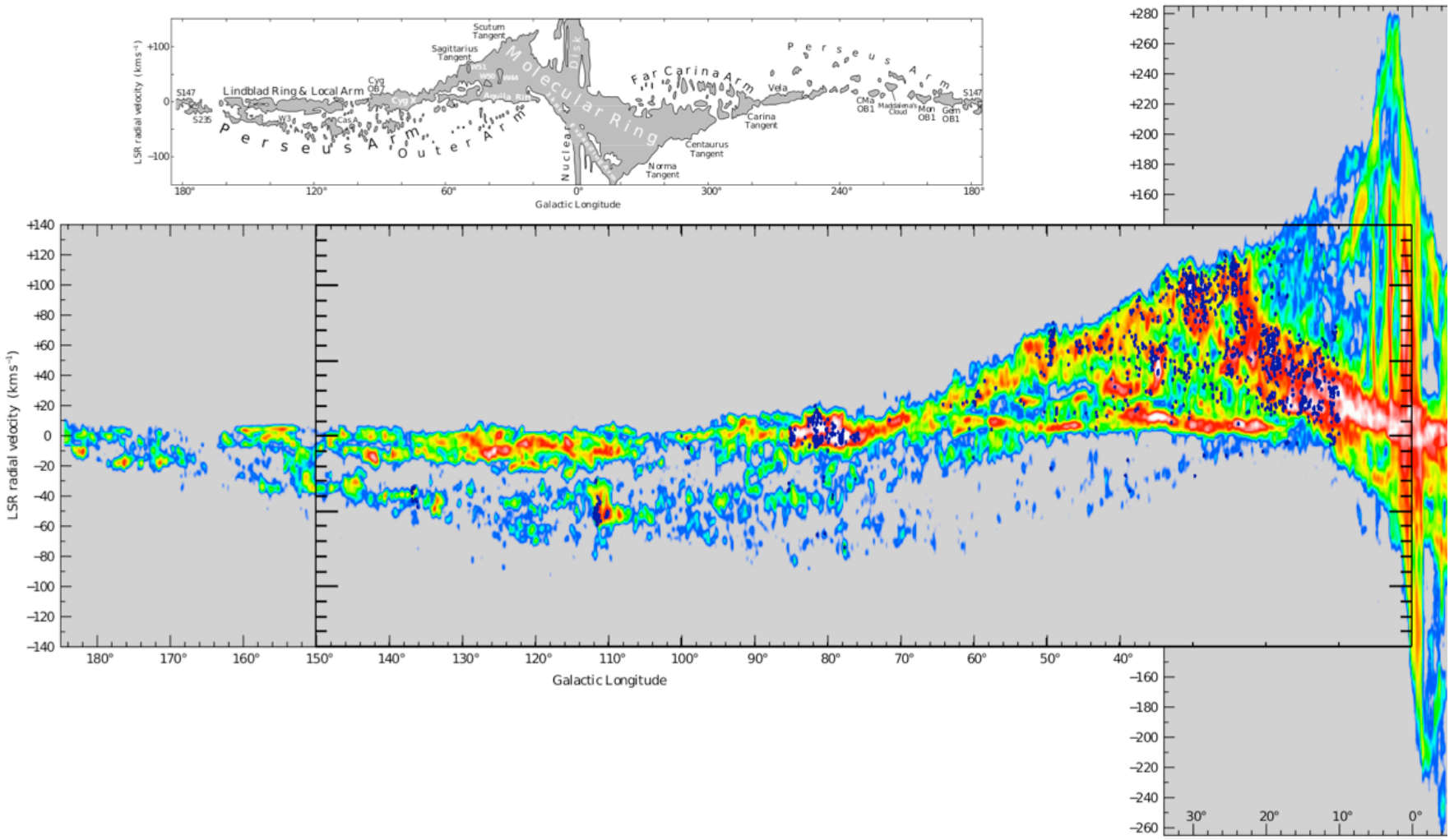

Slope = 1.15
$\rho_{Spearman}$ = 0.80
(a)
HCO$^+$ Detection
HCO$^+$ Upper Limit
I(T$_{MB}$[HCO$^+$]) K km s^{-1}
S$_\nu$(1.1mm) Jy/beam


Slope = 1.28
$\rho_{Spearman}$ = 0.73
(b)
N$_2$H$^+$ Detection
N$_2$H$^+$ Upper Limit
I(T$_{MB}$[N$_2$H$^+$]) K km s^{-1}
S$_\nu$(1.1mm) Jy/beam


Slope = 0.82
$\rho_{Spearman}$ = 0.82
(a)
1:1
HCO$^+$ & N$_2$H$^+$
HCO$^+$ & 3σ N$_2$H$^+$
3σ HCO$^+$ & N$_2$H$^+$
I(T$_{mb}$[HCO$^+$]) K km s^{-1}
I(T$_{mb}$[N$_2$H$^+$]) K km s^{-1}

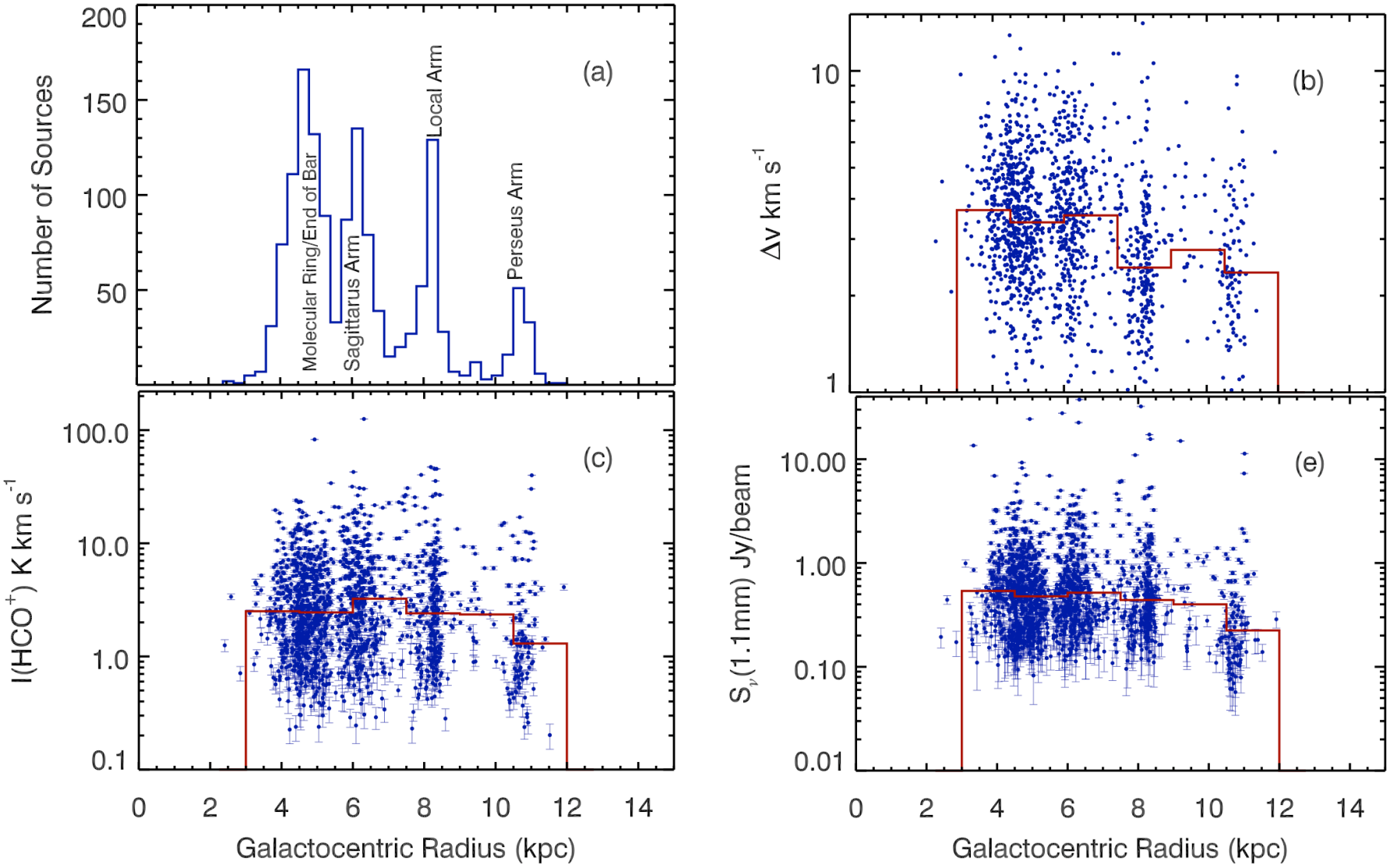

(a)
I(T$_{mb}$ HCO$^+$)=I(T$_{mb}$ N$_2$H$^+$)
$\rho_{Spearman}$ = -0.1
I(T$_{mb}$ HCO$^+$)/I(T$_{mb}$ N$_2$H$^+$)
S$_\nu$(1.1mm) Jy/beam

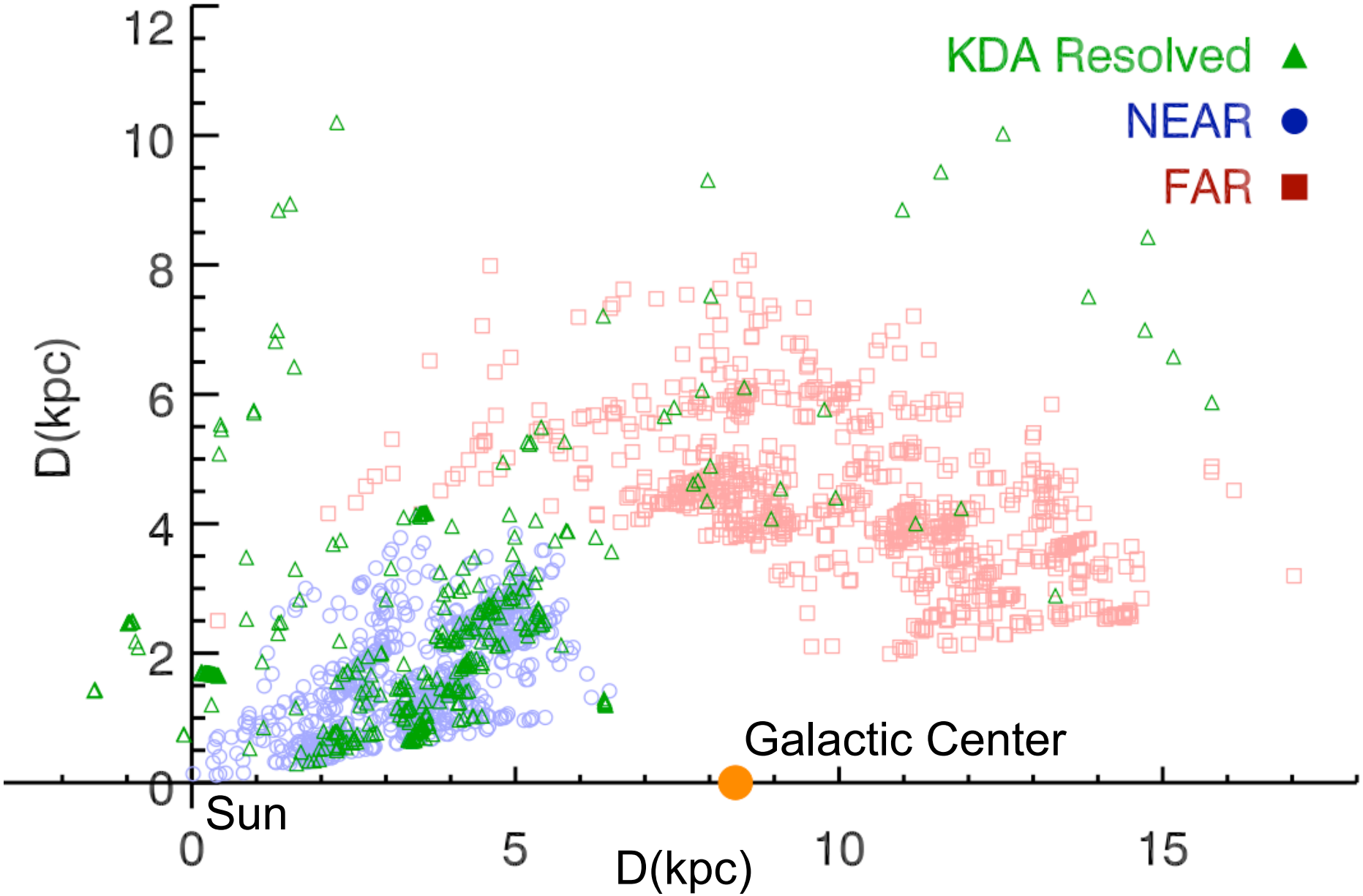
V_{LSR} vs. Galactic Longitude



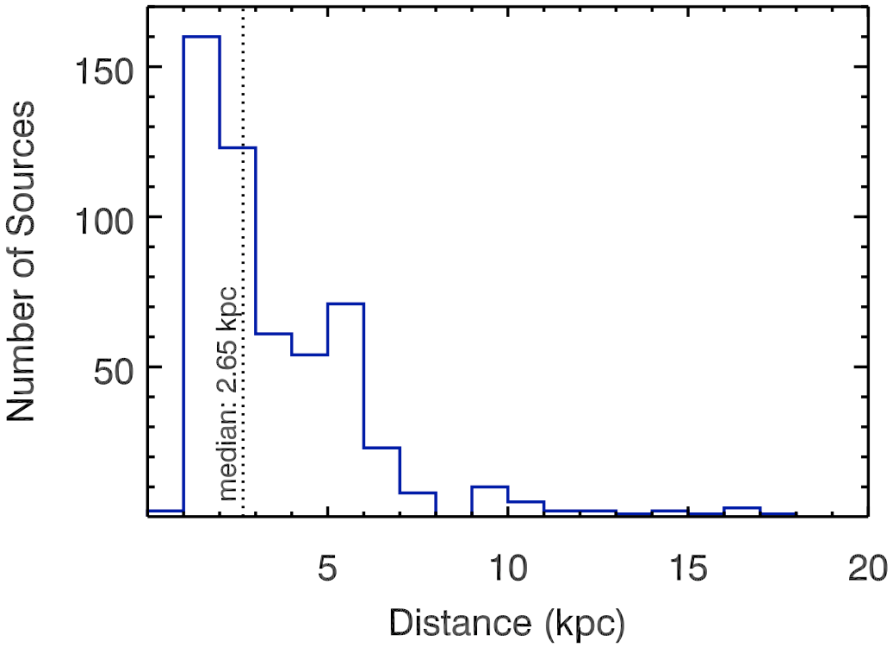
Dame et al. 2001

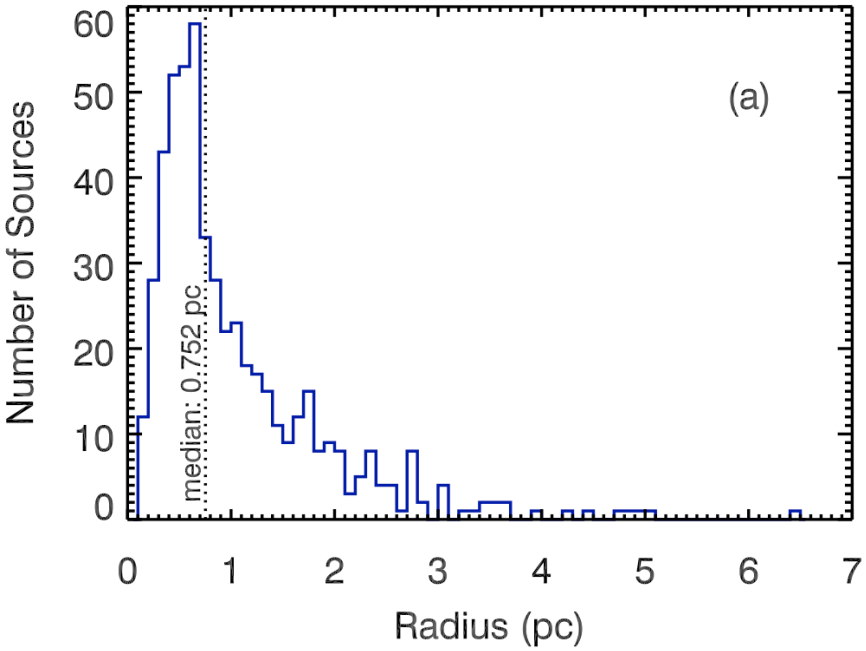
Galactocentric Distance



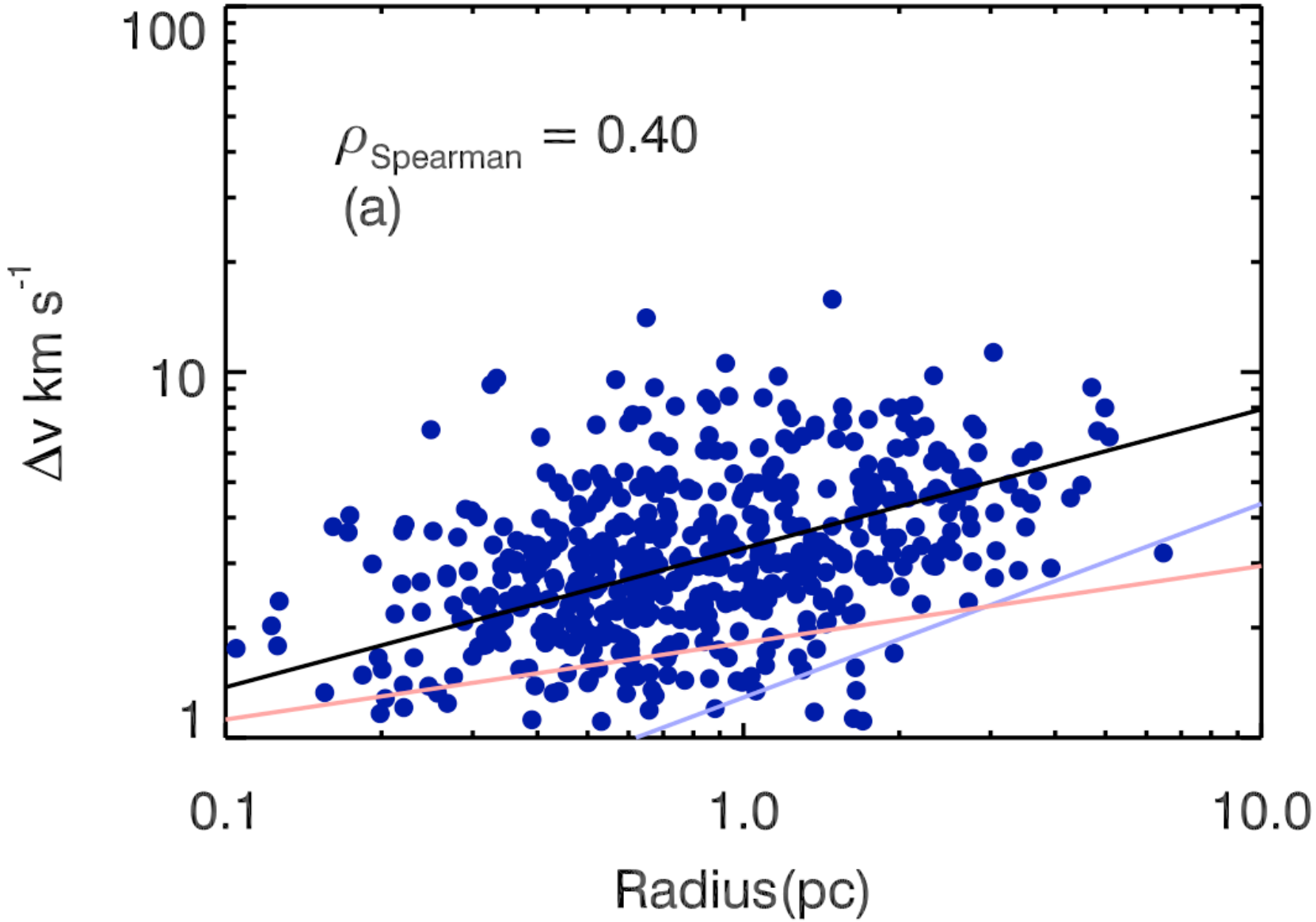

KDA Resolved
NEAR
FAR
D(kpc)
12
10
8
6
4
2
0
Sun
Galactic Center
0
5
10
15
D(kpc)

Known Distance Sample N=650

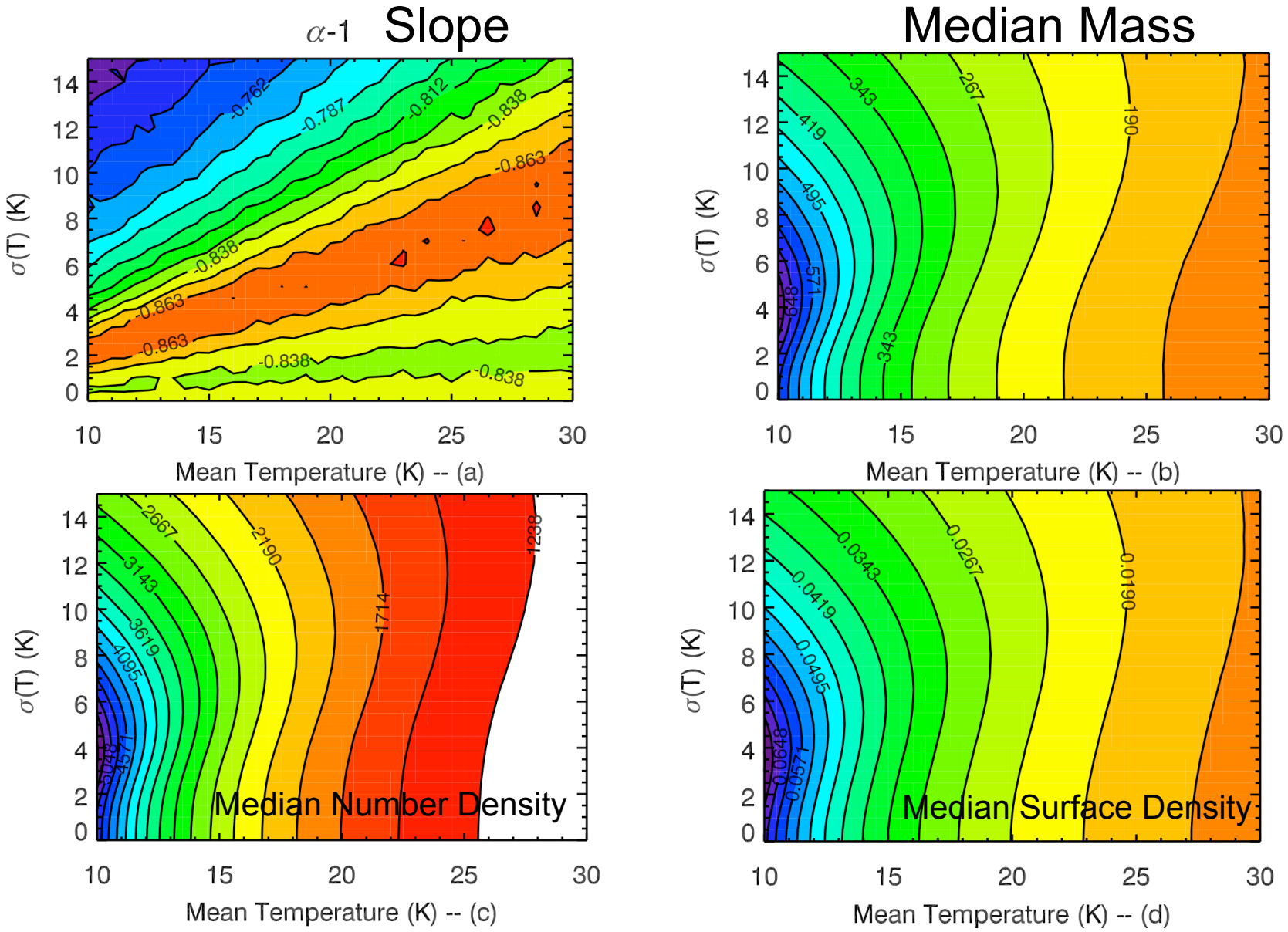


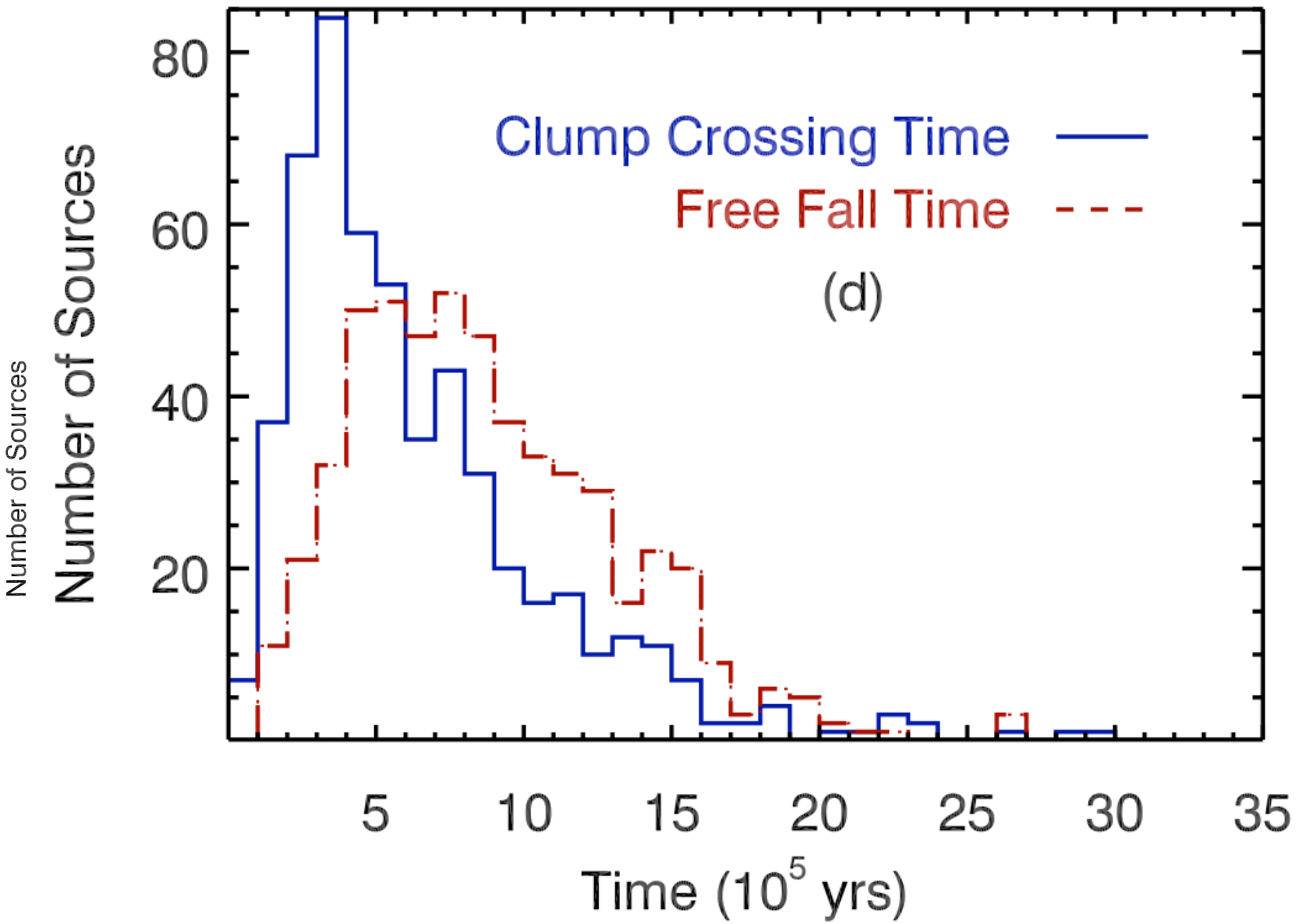


Size Line-width Relation



Monte Carlo Simulations




Number of Sources
Number of Sources
80
60
40
20
Clump Crossing Time
Free Fall Time
(d)
5
10
15
20
25
30
35
Time (10^5 yrs)

Whats next?

- Finish observing BGPS (~6500 sources)
- Evolutionary Sequence (EVLA, ALMA)
  - Masers, chemistry, temperature, etc.
- Mapping clumps with ALMA
  - Clumps will decompose into cores
  - Temperature of cores
  - Resolve the chemistry
  - Mass function

Conclusions

- 1882 sources from the Bolocam Galactic Plane Survey
  - Detect 77% of sources in HCO^+ and 50% in N_2H^+
  - Multiple velocity components are rare, unlike CO
  - Strong correlations between integrated intensity and peak temperatures
  - Strong correlations between dense gas properties and dust emission
- Observed V_{LSR} follows the same distribution as Dame et al. in CO
- Obtain kinematic distances for 648 of our detections (almost half)
- Median sizes of 0.0752pc at a median distance of 2.65 pc
- Weak evidence for a size-linewidth relation
- Median mass of 300 Msun (Tdust = 20K)
- We find an intermediate slope of 0.9, between that of diffuse CO (0.6) clumps and Salpeter (1.35)

Stay Tuned!!!