ThrUMMS: large-scale maps of the molecular Milky Way

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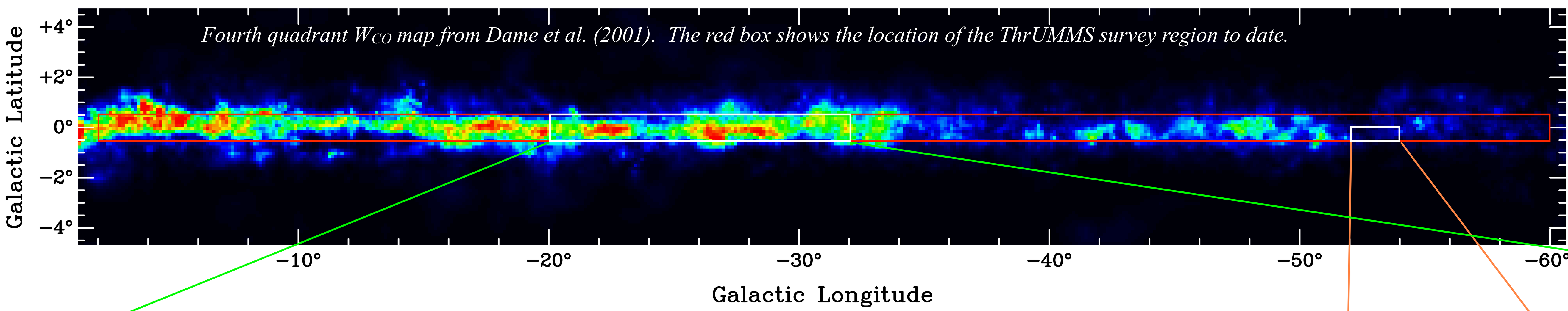
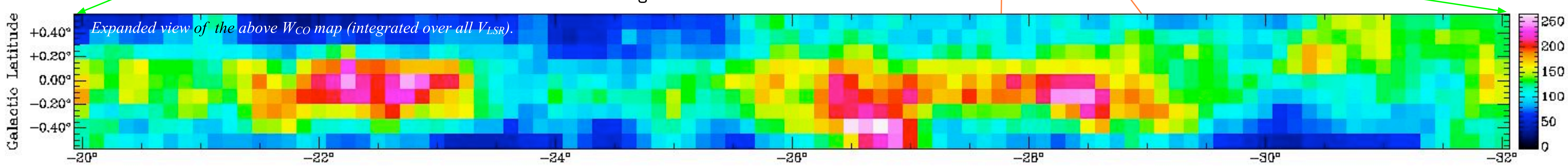
The Three-mm Ultimate Mopra Milky way Survey

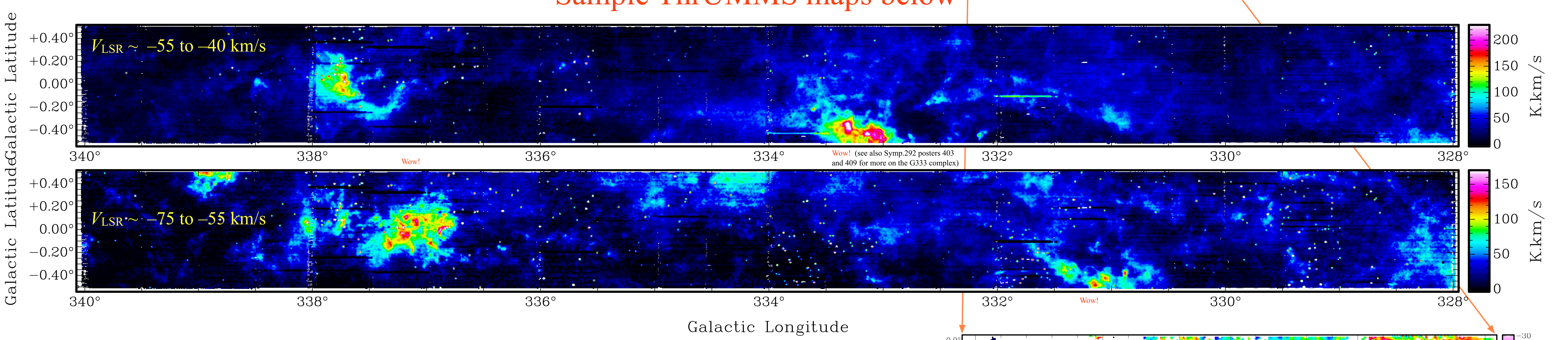
Starting point: As a testament to the importance of a homogenous and wide-field understanding of the large-scale molecular cloud distribution in our Galaxy, the Columbia-CfA CO survey (Dame et al 2001) is one of the most highly-cited studies in astronomy. Yet its angular resolution of just 8′ limits critical new comparisons with recent broad-spectrum Milky Way surveys, such as GLIMPSE (Benjamin et al 2003), the BGPS (Aguirre et al 2011), and Hi-GAL (Molinari et al 2010). Moreover, these continuum surveys also lack the kinematic dimension, necessary for a full three-dimensional understanding of the Milky Way's structure and dynamics. While the GRS (Jackson et al 2006) mapped ^{13}CO in part of the first quadrant, at this higher (~1′) resolution, the southern Milky Way is largely unexplored. In addition, modern receiver technology can now map multiple molecular species simultaneously. Therefore, a significant update to wide-field maps of the Milky Way is now both feasible and urgently needed.

With the 22m Mopra dish (part of ATNF), we have developed a very fast OTF mapping technique (which could be practically extensible to many existing facilities; Barnes & Dame 2009), and have used this to perform a **complete, high-resolution** (1.′2 and 0.1 km/s) **mapping survey** of a 58°×1° area in the Milky Way's fourth quadrant, simultaneously in four J=1–0 lines (^{12}CO, ^{13}CO, C^{18}O, and CN).



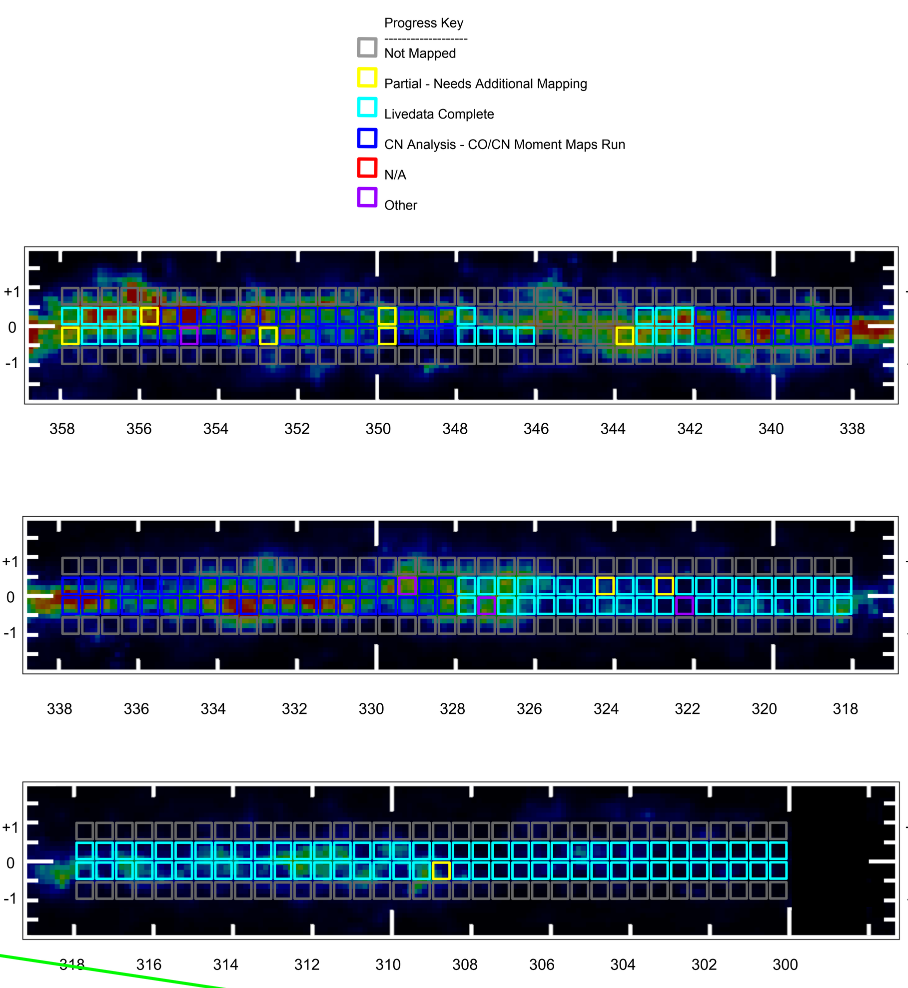


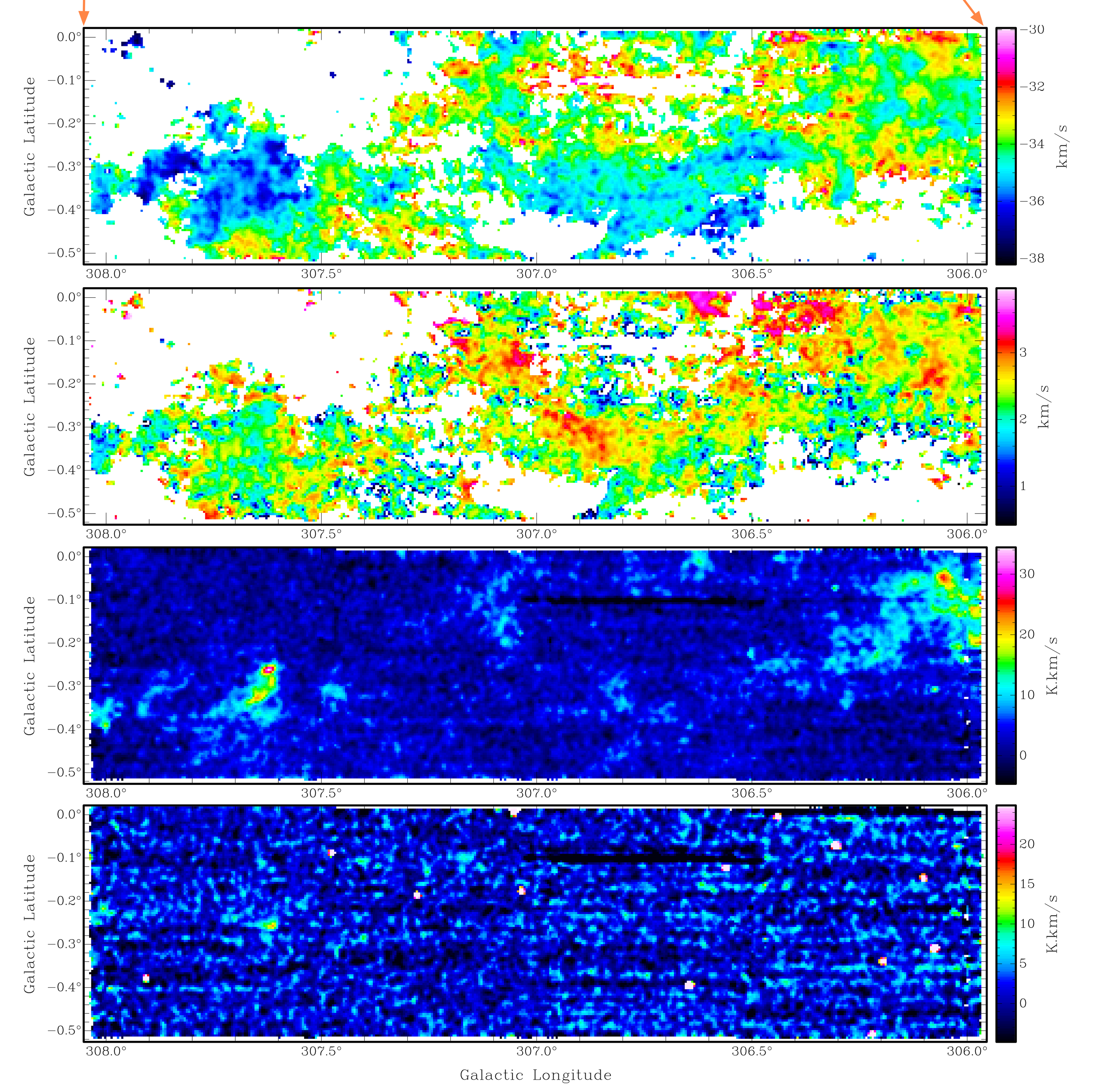
Sample ThrUMMS maps below



Sample 1: Here we show a 12.°0×1.°0 section of the ^{12}CO data cube from 2011–12 observations, comprising **~20% of our spatial coverage** to date. The top panel is an expanded view of the Dame et al (2001) W_{CO} map for comparison with the next 2 panels. The middle panel is our ThrUMMS map of the integrated intensity over a velocity range of around –55 to –40 km/s, while the bottom panel is integrated from around –75 to –55 km/s. The data cubes actually cover all relevant Galactic velocities from around –250 to +150 km/s at a velocity resolution of ~0.09 km/s, so the above panels comprise only **~10% of our velocity coverage**. These images are from our DR2 maps, which have not yet been treated for various artifacts; weather-related "stripes" and single-pixel errors will be removed in the DR3 data. In these maps the rms noise level is ~3 K km/s.

Progress to Date





Sample 2: Shown above are 2.°0×0.°5 maps from 2010 pilot observations as labelled (note faintness of this area in the Dame et al 2001 map), obtained simultaneously in just 5 hr clock time at Mopra. The upper two panels are higher-moment maps of the ^{12}CO line, while the lower panels show the ^{13}CO and CN integrated intensities.

Data Release

The philosophy of ThrUMMS is provide open-source data free of proprietary restrictions, for the benefit of the scientific community. More background information and all maps & data are freely available at the ThrUMMS website, www.astro.ufl.edu/thrumms, ahead of publication. Preparation of all DR2 cubes and moment maps of the 58°×1° area illustrated above are currently underway. Collaborations on any science applications are welcome.

Pending Applications

We anticipate that ThrUMMS' legacy value will be enormous, and will generate a large number of follow-up studies. Among those we are now pursuing are:

- Spatially-resolved gas temperature maps of GMCs, & comparison with Herschel-based SED fits/dust temperatures
- Detailed structural & kinematic comparisons with Herschel data and the GASKAP HI survey, studies of molecular cloud formation
- Kinematic distances of all major ISM structures from a ThrUMMS+GASKAP comparison
- Detailed dynamics of Galactic-scale features
- Studies of Galactic structure, arm-interarm comparisons, radio-FIR correlation
- Spatial dependence of cloud turbulence, origin of turbulence
- Unbiased catalogue of all CN-bright clouds, suitable for Zeeman measurements with ALMA
- Dependence of astrochemistry, cloud structure, and kinematics on Galactocentric distance and other environmental factors

Future Work

In principle, ThrUMMS could easily be expanded to cover much more of the Galactic Plane where CO emission is easily detectable, e.g. a total area of 200°×4° covering l = 40°–0°–200° and $|b|$ < 2°, although portions of this have already been well mapped by other projects, such as CHaMP (300° > l > 280°; Barnes et al 2011).

References

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