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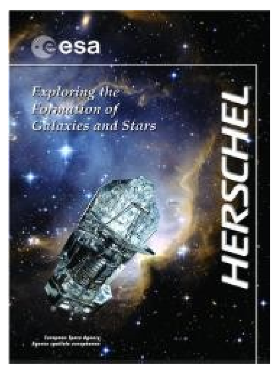
william.langer@jpl.nasa.gov



got c+?

Galactic Observations of Terahertz C+ (GOT C+): Inner Galaxy First Results

William D. Langer, T. Velusamy, J. L. Pineda, P. F. Goldsmith, D. Li, H. Yorke (JPL, Caltech)

GOT C+ Goals

- *Characterize the properties of atomic and molecular diffuse clouds throughout the Interstellar Medium (ISM) by observing the [CII] ($^2P_{3/2}$ -$^2P_{1/2}$) fine structure line in emission and absorption at 1.9 THz (158 μm) throughout the Galactic disk.*
- *Characterize the evolution from atomic to molecular clouds utilizing CII as a probe of the intermediate cloud state with abundant H_2 and little, or no, HI or CO.*
- *Relate the properties of clouds traced by CII as a function of Galactic environment (radiation field, location in the plane, ionization rate, metallicity)*
- *Provide the astronomical community with a data base of CII spectra, to be added to that of HI and CO spectra, as a resource to determine the properties of the Galactic ISM.*

Importance of C+

- *C^+ is a major ISM coolant, and its 158 μm line is an important tracer of the properties of the diffuse atomic and diffuse molecular gas clouds.*
- *CII fine structure line is the strongest far-IR line in the Galaxy as found by COBE.*
- *CII 158 μm line will trace a so-far poorly-studied stage in cloud evolution - the transitional clouds evolving from atomic HI to molecular hydrogen H_2*

GOT C+ Observing Plan

- *Observe high spectral resolution and sensitivity CII spectra over 900 lines of sight.*
- *Produce a uniform volume sample of the Galaxy to provide statistics on CII clouds.*
- *Obtain ancillary HI and CO isotope data for every line of sight.*

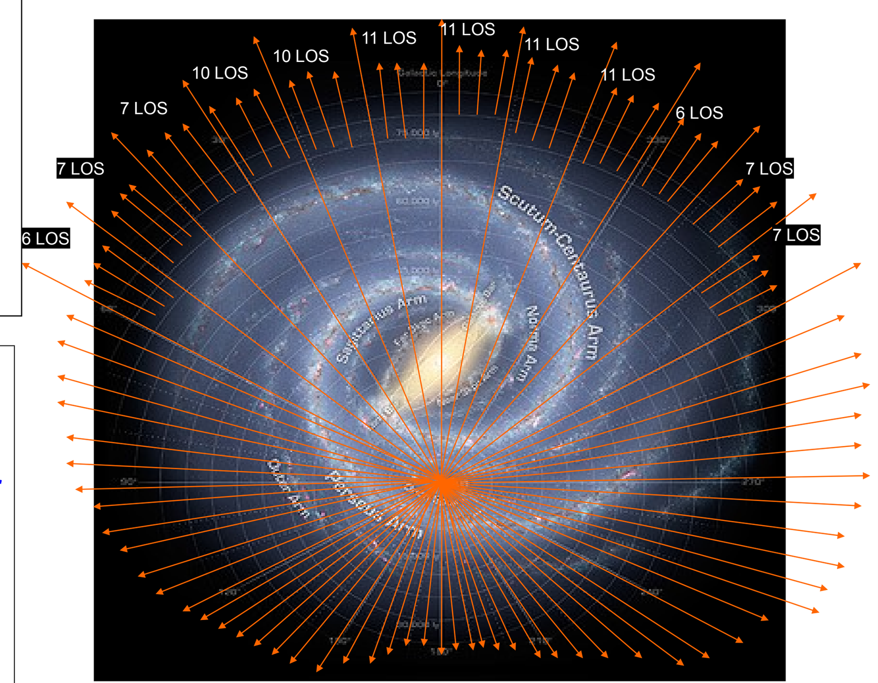


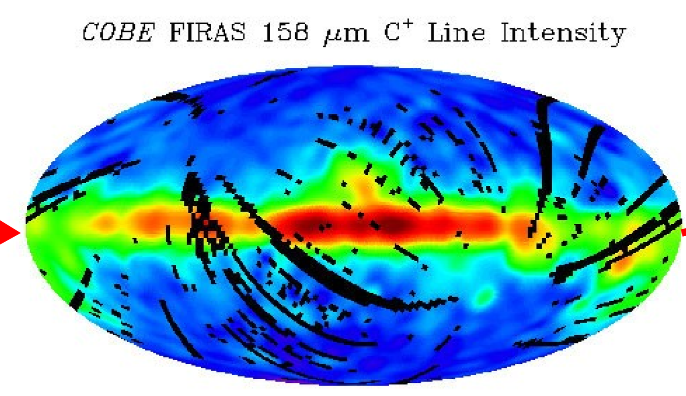
Fig 1. *A* top view of LOS sampling of a face-on disk, the origin of the lines is the solar location.

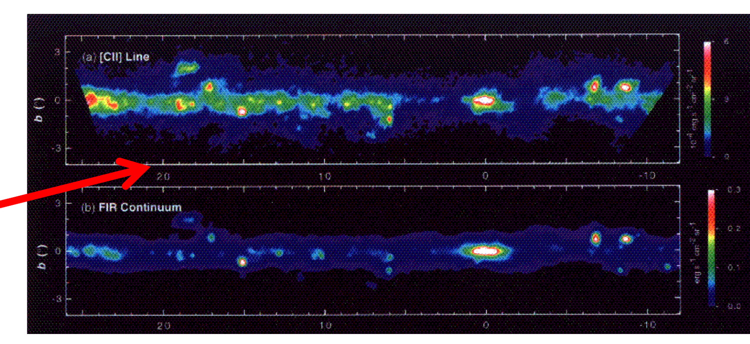
- **Galactic Plane Survey** - Uniform volume sample of the galaxy
  - –About 500 lines of sight (LOSs) in and out of the galactic plane
    - Concentration of lines of sight is larger towards inner Galaxy
    - 166 longitudes: $b = 0^o$, 0.5^o and 1^o alternating with 0^o, -0.5^o and -1^o
- **High latitude HI Absorption Clouds**: 5 LOS through Heiles & Troland (2003) high column density HI absorption clouds towards extragalactic objects in $l = 1159°$ *to* $187°$ & $b = -7°$ *to* $-33°$ to model high-latitude clouds combining CII with other tracers.
- **Central 300 pc of Galaxy**: region of strongest CII emission
  - –Observe about 360 LOS in strip maps with finer (arcmin) sampling
  - –The warm and extended nature of the CII emission will allow detection of cold foreground clouds in CII absorption
- **Outer Galactic Warp**: 30 LOS $l \sim 250°$ *to* $265°$ & $b \sim +1°$ *to* $-5°$

GOT C+ First Results: CII Detections & ISM Cloud Sample

From COBE and BICE to Herschel HIFI

COBE established the widespread distribution of CII in the Galactic plane, and BICE delineated the distribution towards the inner Galaxy, but Herschel HIFI provides the spectral (0.2 km/s) and spatial resolution (12") to detect and study individual clouds.





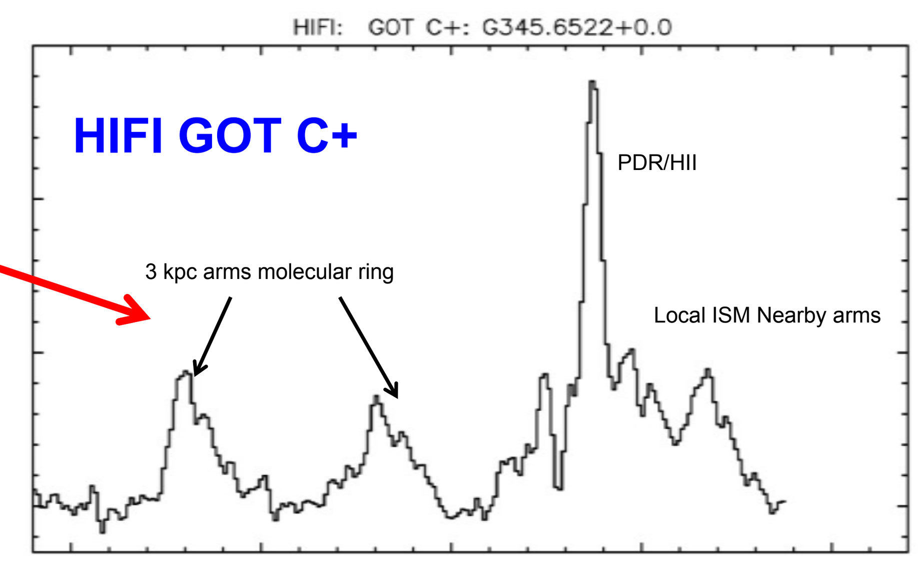
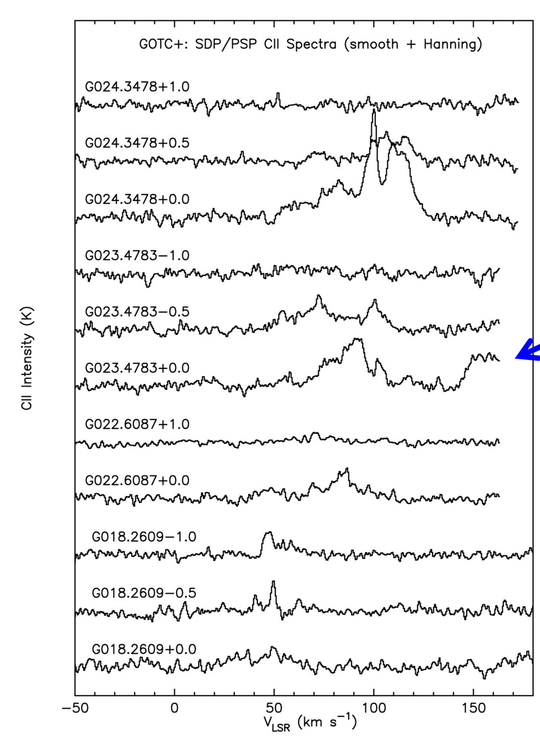
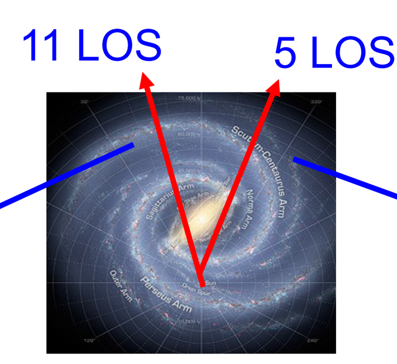


Fig 2. (left) COBE CII intensity (Bennett et al. 1994) with 7° beam & no significant spectra resolution (ΔV ~ 1000 km/s). BICE CII intensity (center) 15' beam & ΔV=175 km/s spectral resolution (Nakagawa et al. 1998). HIFI GOT C+ CII spectra (right) towards inner Galaxy. . HIFI has the spectral resolution (0.22 km/s) to isolate the CII emission from thousands of diffuse interstellar clouds in the Galaxy & reveal their physical and dynamical state.

- *Over 20 spectrally complex CII emission features have been detected along16 LOSs observed to date towards the inner Galaxy – see panels to the right.*
- *Identified over 110 individual CII clouds from multiple Gaussian fits to these features. – see panel to far right*
  - *HI (Stil et al 2006 & McClure-Griffiths et al. 2005) and CO (Mopra – GOT C+) spectra obtained for every LOS for comparison to CII diffuse gas.*
- *Identified dense molecular clouds associated with CII from ^{13}CO.*
- *Identified diffuse clouds by from CII without a ^{13}CO counterpart.*





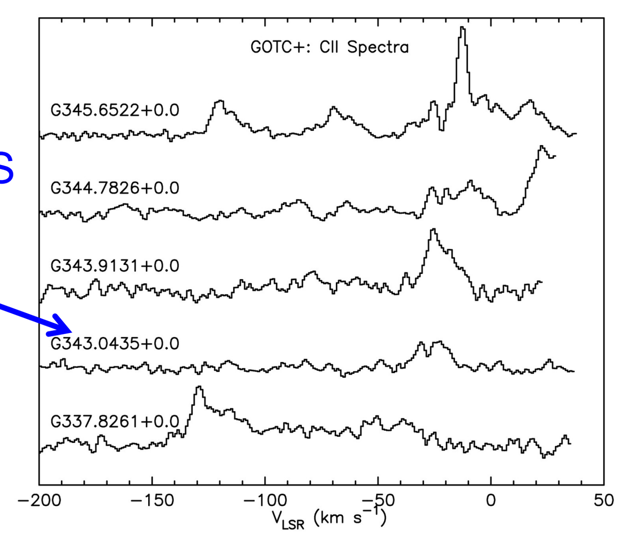


Fig. 3. Panels showing CII from all 16 LOS. The red arrows indicate the general direction of two sets of observations on either side of the inner Galaxy.

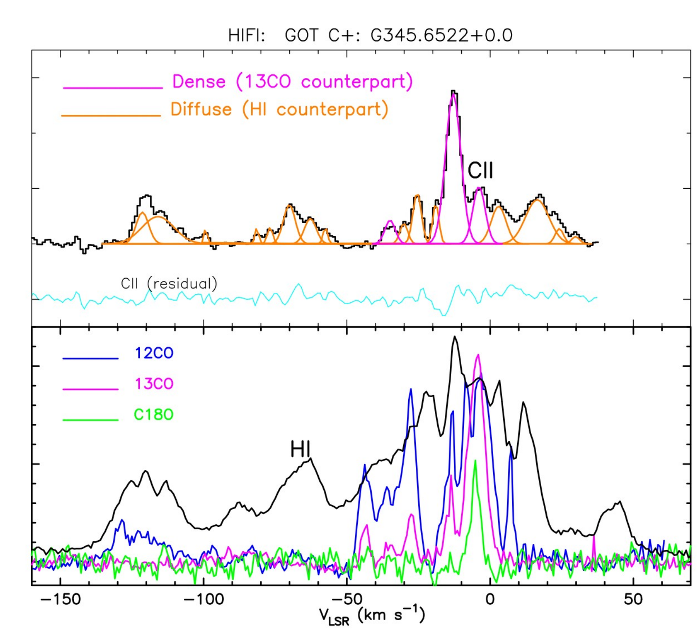


Fig. 4. Examples of profile fitting of CII, HI, and CO for identification of dense and diffuse CII clouds.

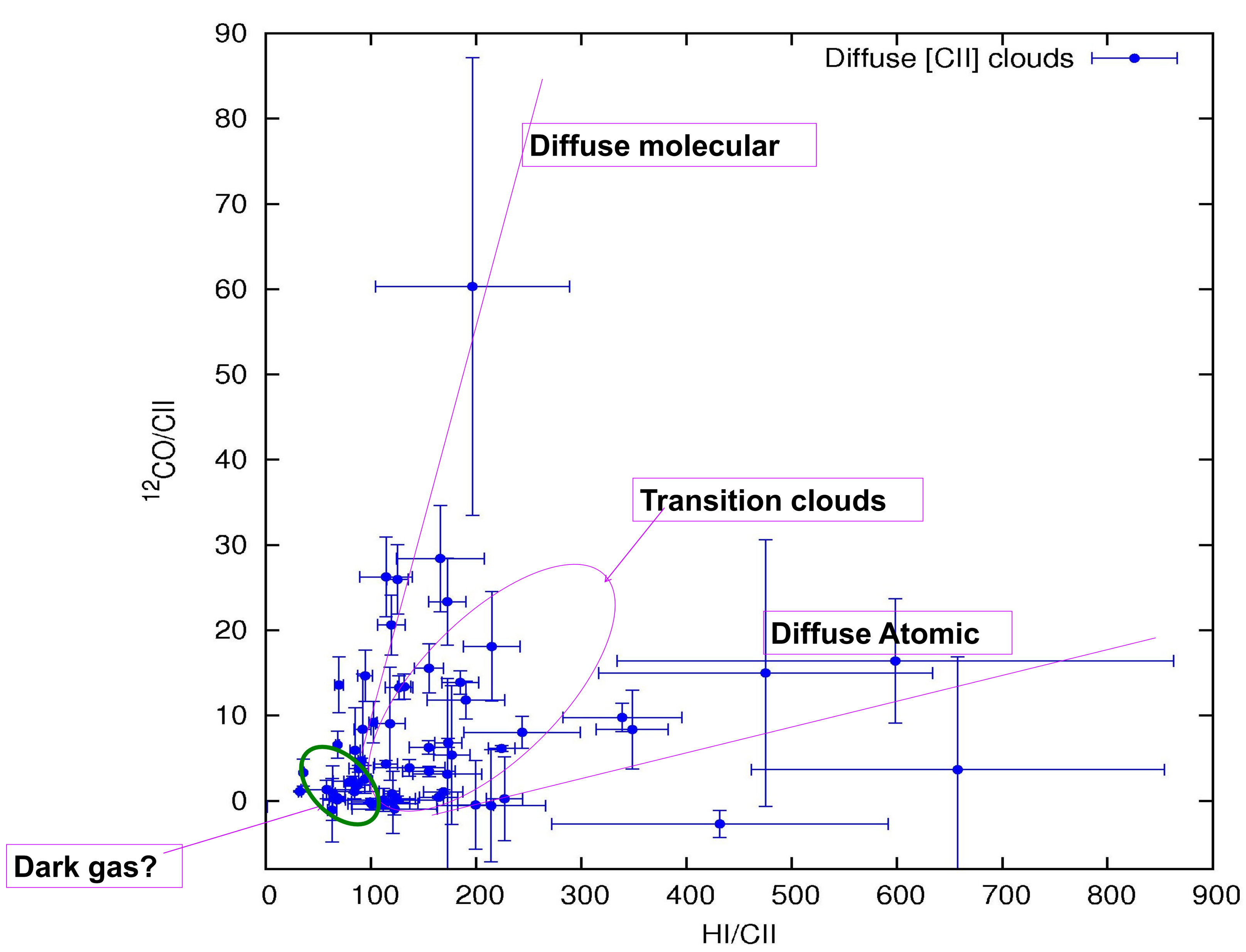


Fig. 5. ^{12}CO/CII versus HI/CII intensity ratios for all 64 diffuse sources. As summarized in the Key Results box on the right these sources separate into four main cloud types.

References

Bennett , C. L. et al. 1994, Ap J 434, 587.
Heiles, C., & Troland, T. H. 2003, ApJ, 586, 1067
McClure-Griffiths et. al. 2005, ApJS 158, 178
Nakagawa, T. et al. 1998, Ap. J. Suppl. 115, 259.
Stil et. al. 2006, AJ, 132, 1158S.

Key GOT C+ Results

- Along 16 LOS detected 110 CII clouds
- *64 Diffuse ISM clouds*
- *46 Dense molecular clouds with ^{13}CO counterparts*
- In Figure 5 (left) we plot ^{12}CO/CII versus HI/CII integrated intensities for all 64 diffuse clouds.
- Based on these ratios we identified four ISM cloud regimes (see Velusamy et al. – Poster Session 2 for more details)
  - – Diffuse Atomic Clouds (low ^{12}CO/CII and HI α CII)
  - – Diffuse Molecular Clouds (high ^{12}CO/CII and low HI/CII)
  - – Transition Clouds, on their way from CII to CO, contain a mix of HI, CII, and CO
  - – Dark Gas tentatively detected by the signature of their CII intensity (not shown) and both low CO/CII and HI/CII intensity ratios.
- For 46 sources with ^{13}CO, we compared the CII and CO intensities with PDR models and identify two UV environments: the vast majority (~95%) are weak to modest UV fields and a small fraction (5%) are strong UV fields likely associated with massive star formation. – See Pineda et al. –Session 2 – for more details.

Future Prospects from GOT C+

With less than 2% of our unbiased survey complete, the data strongly suggests that the GOT C+ survey of CII will provide a very rich data base of ISM features, likely to exceed 5000 clouds and PDRs. There are likely to be many new surprises and information about the ISM.

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