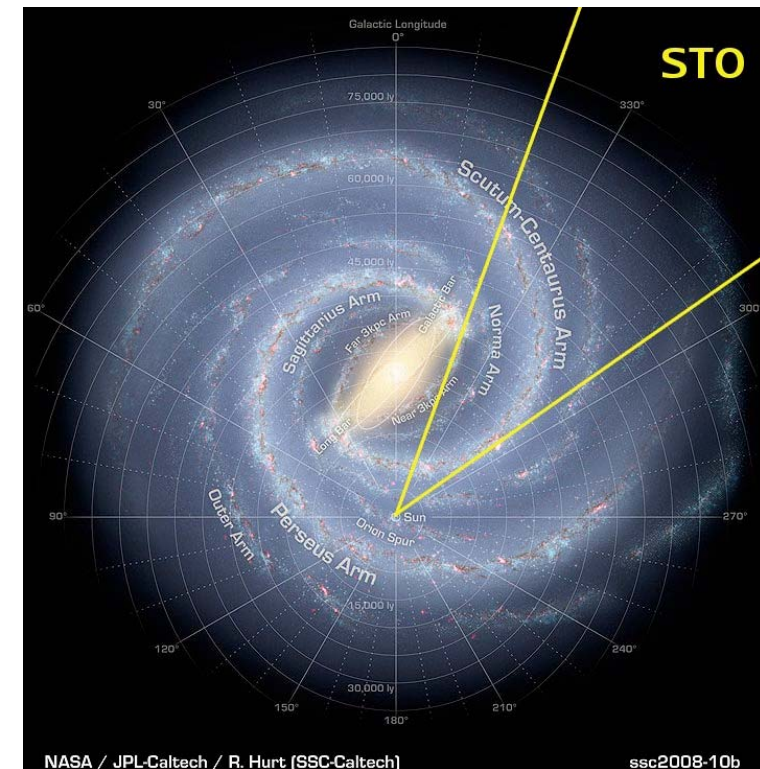
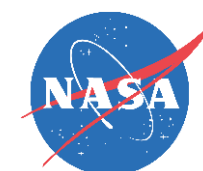


# Stratospheric Terahertz Observatory (STO)

*A Long Duration Balloon survey telescope to explore the life cycle of the interstellar medium*



- 0.8-meter telescope, 1' resolution @158  $\mu\text{m}$
- Heterodyne receiver **arrays** for wide-field [N II] and [C II] spectroscopy, 1 km/s resolution
- Test flight in 2009, LDB Antarctic flight in 2010.
- Complementary to Herschel and SOFIA



# STO: What is it?



80 cm telescope and gondola, rejuvenated from a previous life as a solar observatory: the Flare Genesis Experiment and Solar Bolometric Imager.



Launched from McMurdo Station, Antarctica, long duration balloons fly at 35 km altitude for two weeks before a boomerang return. STO is scheduled to fly in December 2010 after a 1 day North American test flight in September 2009.



After a successful flight, STO can be refurbished with new receivers and flown over and over again. Four such missions are planned.



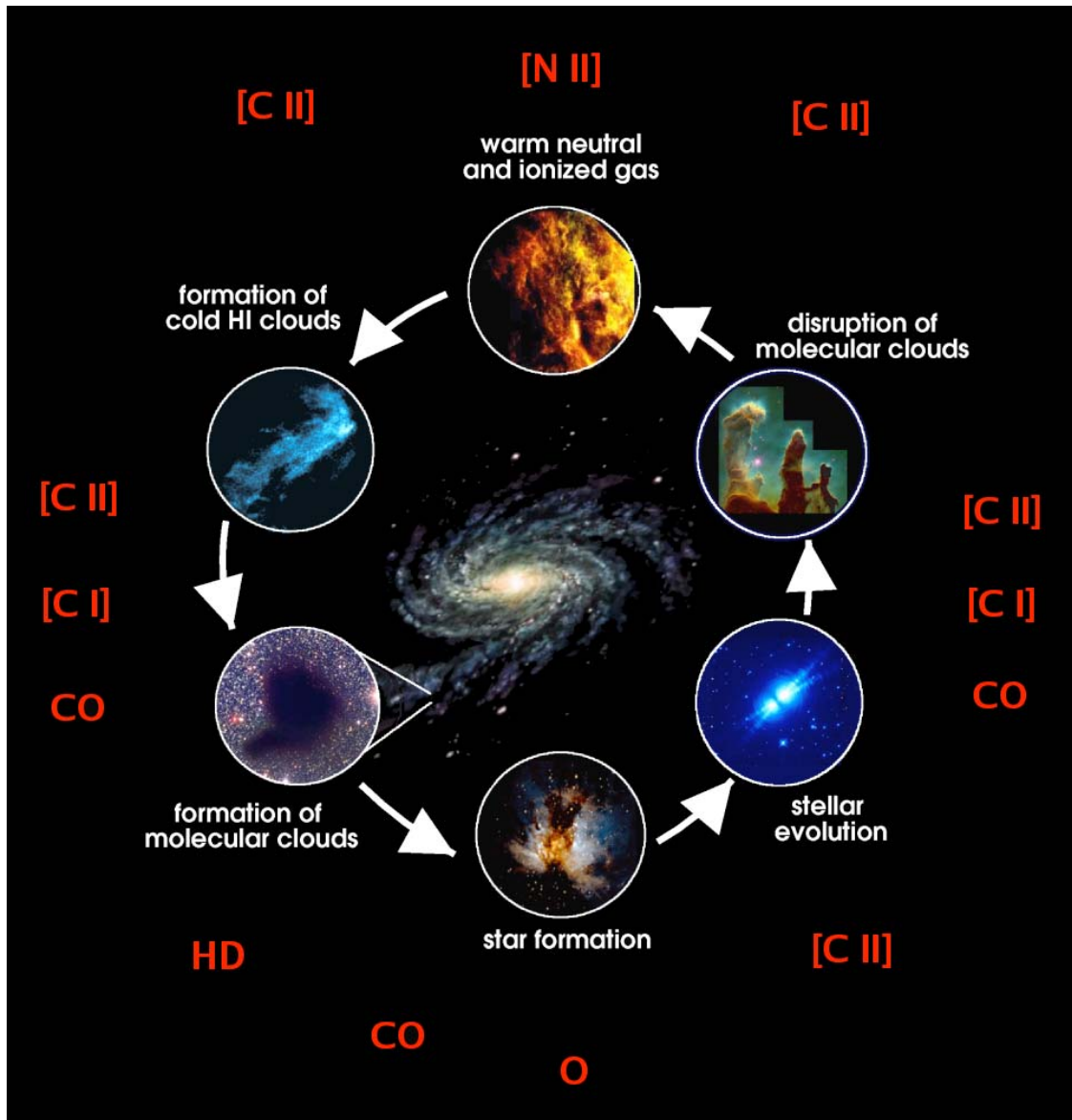
# The need for a Terahertz Observatory

Fundamental aspects of the formation, evolution and dissolution of interstellar clouds are still unobserved!

Enter STO...

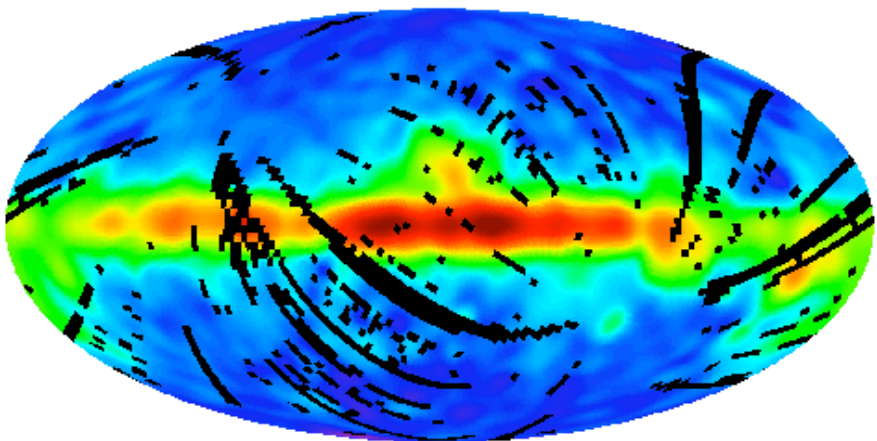
[C II] line emission at  $158 \mu\text{m}$  is the most powerful spectroscopic thread for probing the ionized & neutral components of the ISM and for witnessing cloud formation and destruction.

[N II] observations at  $205 \mu\text{m}$  provide sensitive/detailed maps of star formation rates in the Galaxy, and are used to separate the ionized and neutral components of [C II] emission.

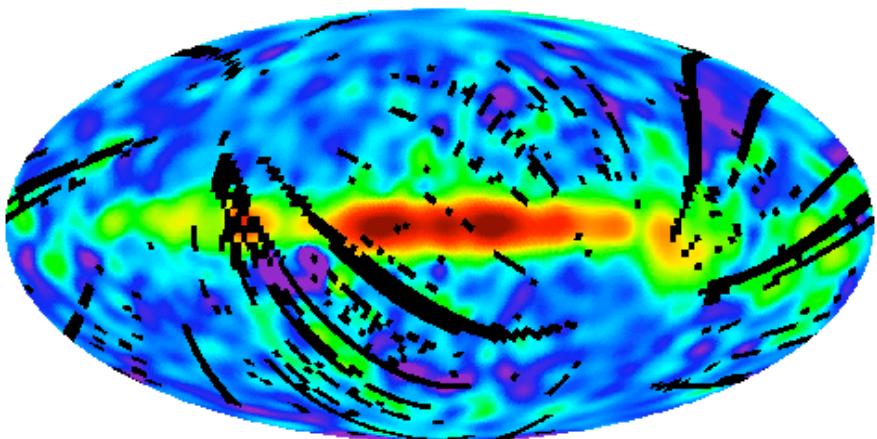


*The Life Cycle of the Interstellar Medium*

COBE FIRAS 158  $\mu\text{m}$  C<sup>+</sup> Line Intensity



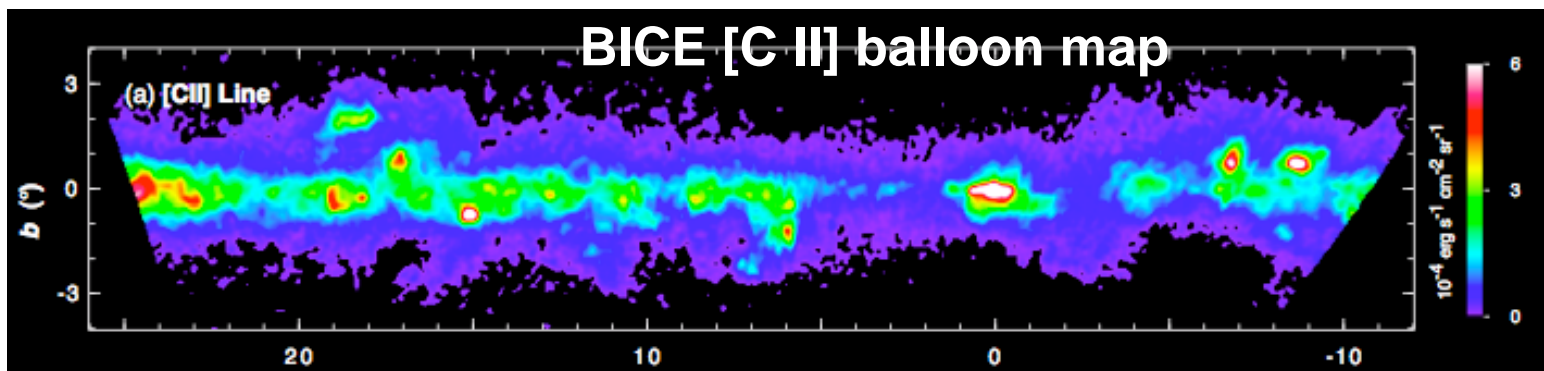
COBE FIRAS 205  $\mu\text{m}$  N<sup>+</sup> Line Intensity



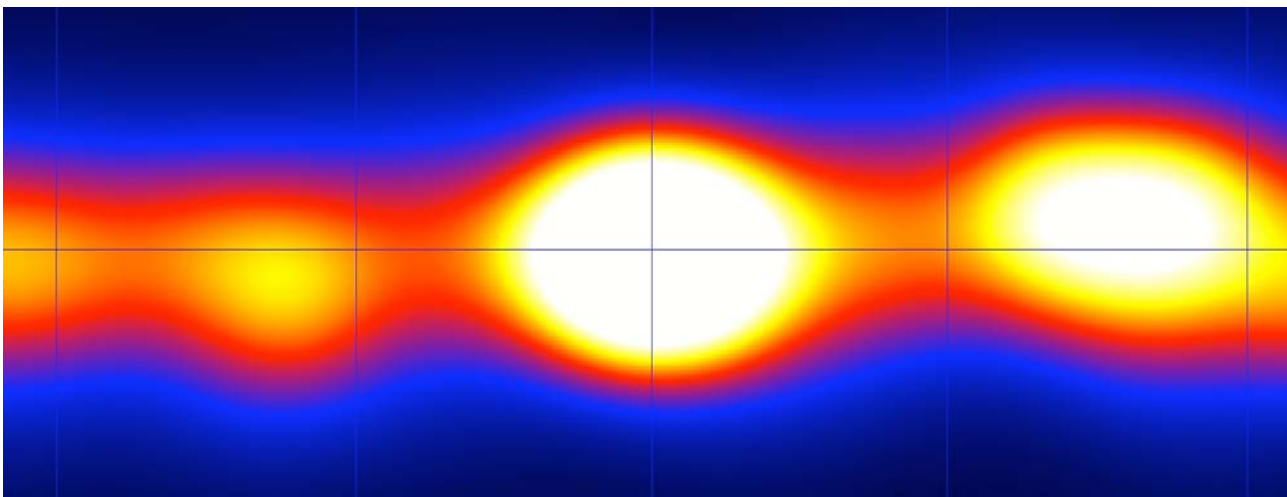
The only large scale Galactic Plane survey in both lines was performed by FIRAS on COBE with 7 degree spatial resolution and R=100 resolving power.

The balloon-borne BICE experiment measured [C II] over 200 square degrees with 15' resolution and a resolving power of R=1500.

In its first long flight, STO will measure 40 square degrees of the 4<sup>th</sup> Galactic quadrant with 1' resolution and a resolving power of 10<sup>6</sup>! STO will **resolve spatially and spectrally** all interstellar components of [C II] and [N II] emission.

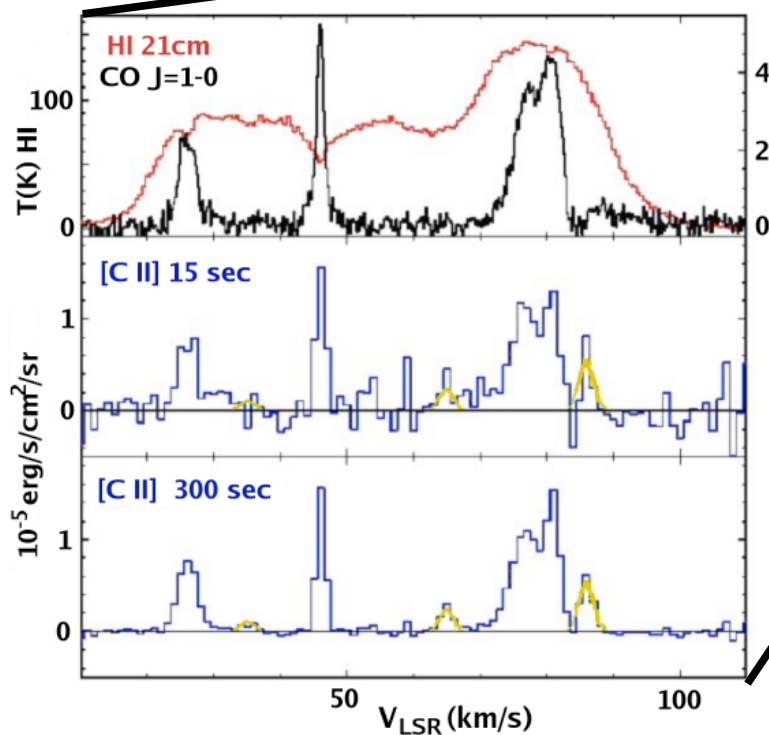
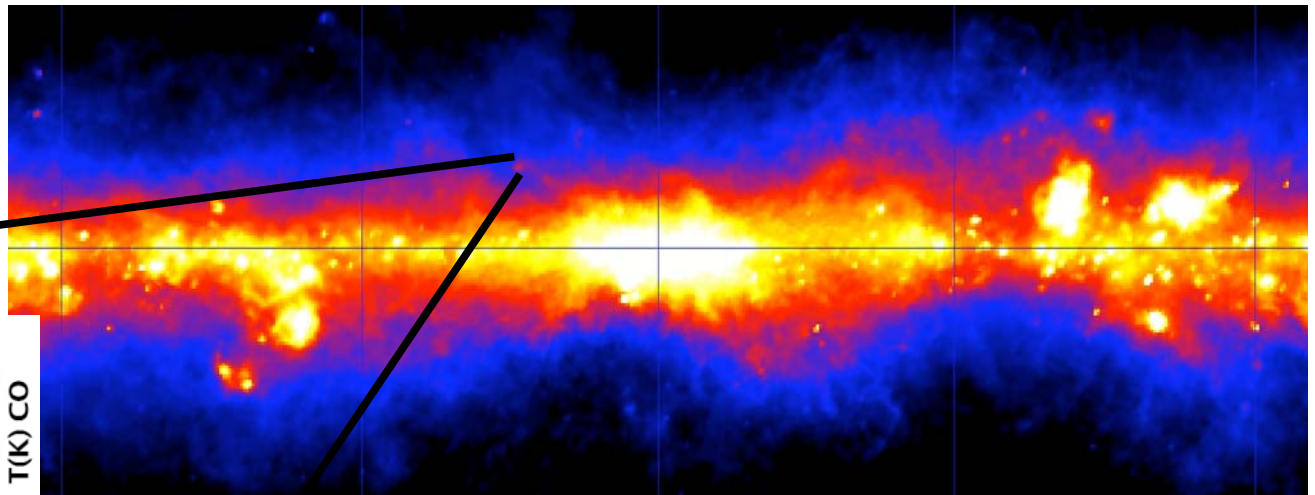


**We'll go from this...**



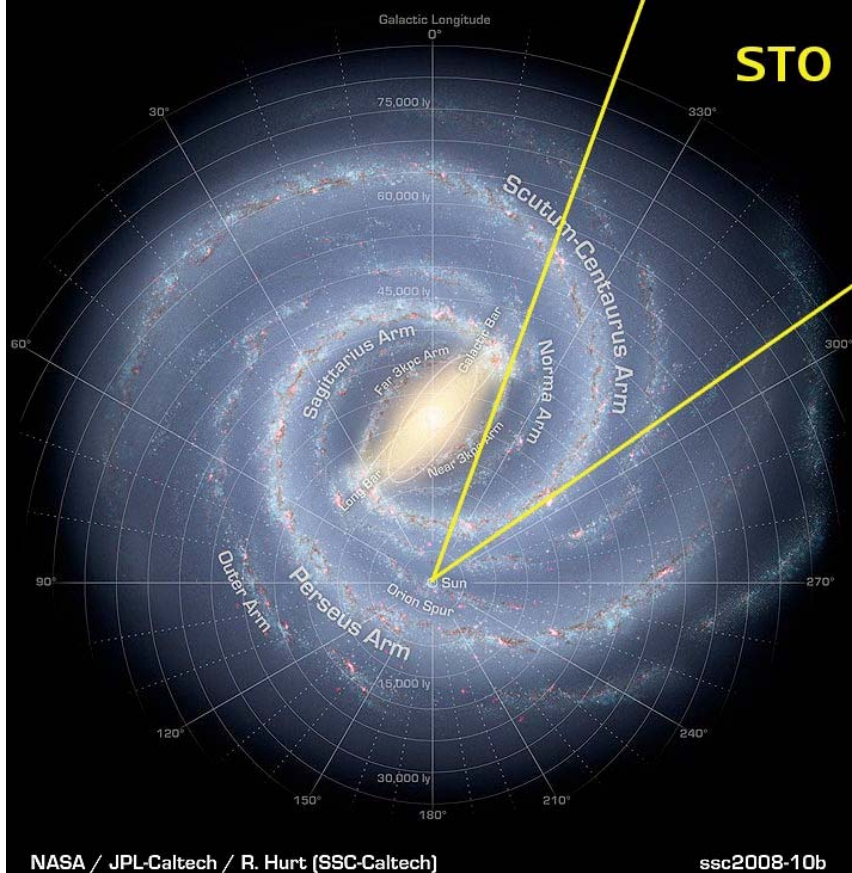
processed 60um IRAS maps courtesy Erick Young

**to this...**



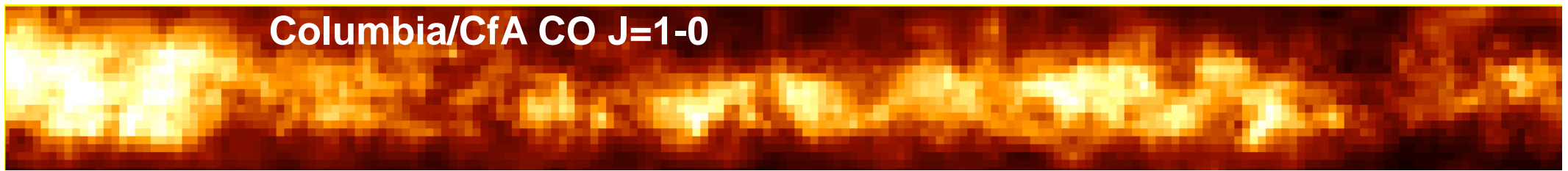
**... and with its 4 pixel arrays of heterodyne HEB receivers, every 'pixel' represents a high resolution spectrum!**





## The STO Survey

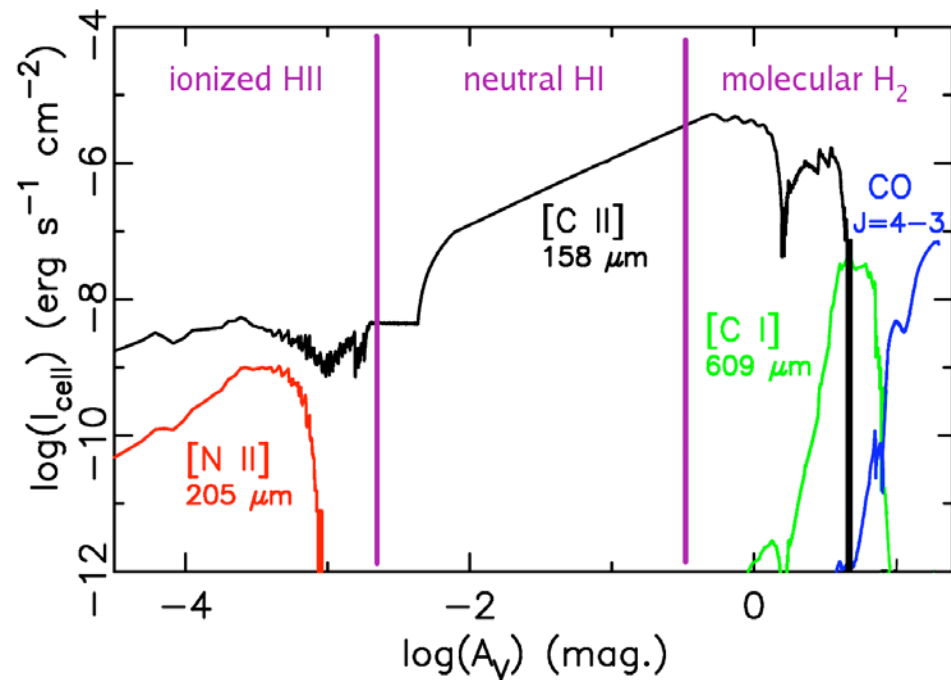
STO will perform a midplane Galactic survey from  $l = -20^\circ$  to  $l = -55^\circ$ , and  $|b| < 1^\circ$  spanning the Molecular Ring through the Scutum-Centaurus spiral arm and two interarm regions.



*[C II] emission comes from every component of the warm and cold ISM, so ancillary data is absolutely critical for its proper interpretation!*

We need maps of:

- $^{12}\text{CO}$  and its isotopologues
- 21 cm HI
- infrared continuum

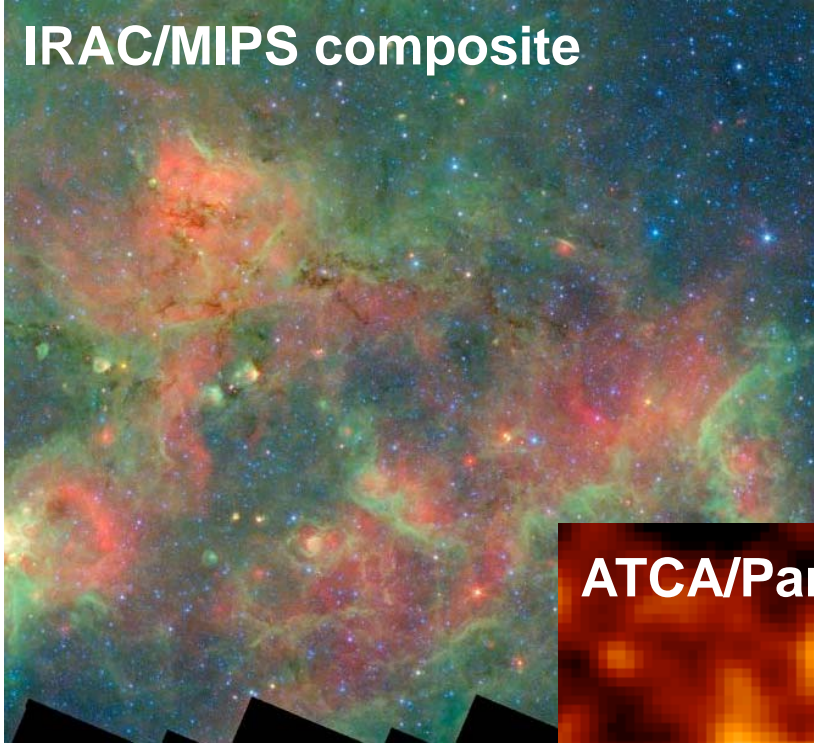


Without HI, we cannot constrain the mass ratio of warm neutral medium gas ( $T\sim 8000\text{K}$ ,  $n\sim 1\text{ cm}^{-3}$ ) to cold neutral gas ( $T\sim 80\text{K}$ ,  $n\sim 100\text{ cm}^{-3}$ ).

Without CO, [CII] emission alone won't distinguish between atomic clouds and surfaces of molecular clouds. This is crucial to witnessing the formation of molecular clouds! With [CII], we can measure the amount of 'missing  $\text{H}_2$ ' from CO surveys.

**A comprehensive view of the interstellar medium requires HI, CO, [CII] and [NII] data with comparable sensitivity and angular resolution.**

**IRAC/MIPS composite**

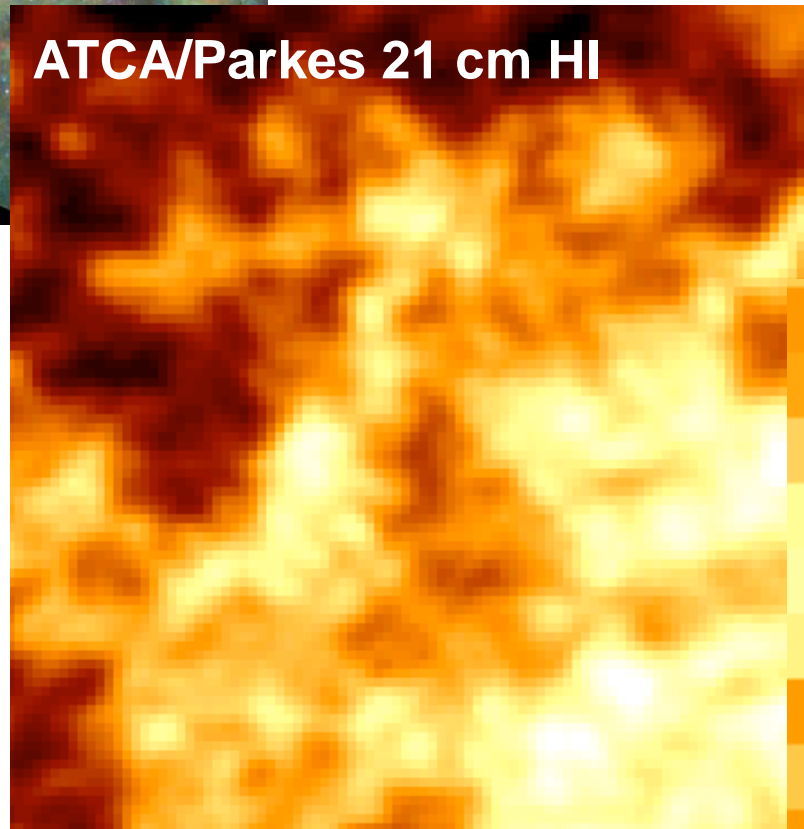


**But not all surveys are comparable...**

Let's take a sample 1 sq degree around  $l=-33.3$ ,  $b=-0.3$  to illustrate.

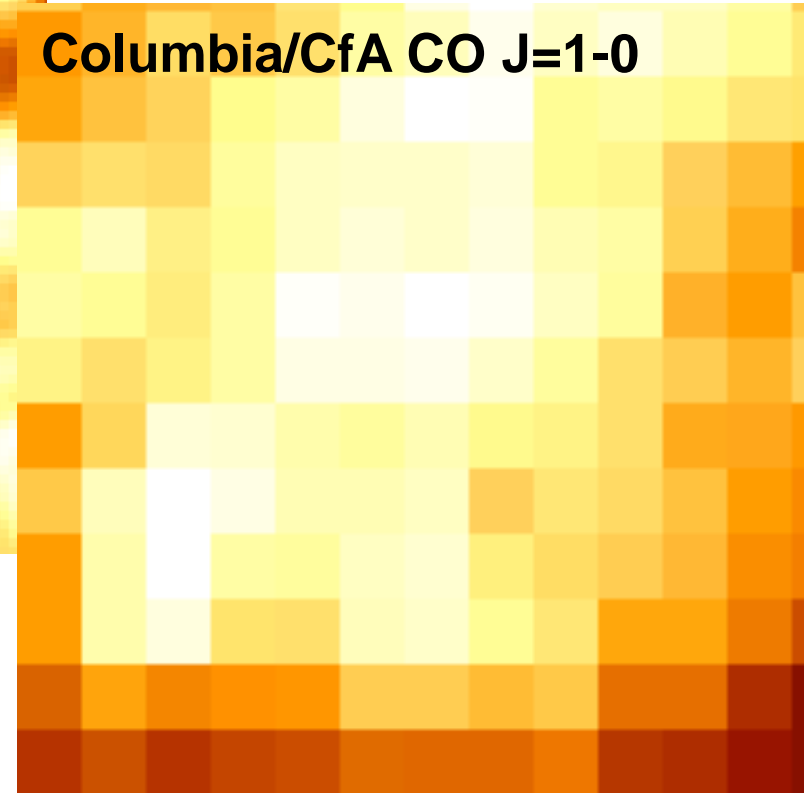
3-10'' resolution

**ATCA/Parkes 21 cm HI**



2' resolution

**Columbia/CfA CO J=1-0**



**WE NEED MOPRA! ->**

10' resolution



## Mopra represents a perfect match

Survey	Coverage	Angular Resolution	Sensitivity
	(square degs)	(arcmin FWHM)	(K km/s)
ATCA/Parkes 21 cm	155	2	1
STO G.Plane Survey	30	1.5	0.3
NANTEN2 CO,[CI]	30	0.3 – 0.6	0.1
<b>Mopra CO 1-0 Survey</b>	<b>30</b>	<b>0.5</b>	<b>0.2 Fast-Mapping</b>

*4-months of Mopra time with Fast-Mapping!*

A Mopra CO survey performed in concert with the STO Galactic Plane Survey and NANTEN2 would lead to the most comprehensive study of ionized, atomic and molecular gas in the Southern sky – a treasure-trove for star formation, galaxy evolution, stellar and interstellar feedback, and the global interstellar structure of the Milky Way.

For more information on the STO Survey: <http://soral.as.arizona.edu/STO/>

# Result: A Breakthrough Study in 'Galactic Ecology'

A Super-survey consisting of HI from ATCA/Parkes, [CII] and [NII] from STO, CO/<sup>13</sup>CO/<sup>18</sup>O from MOPRA, with high-J lines from NANTEN2, would:

- Map the dominant cooling lines of the cold and warm ISM.
- Reveal formerly invisible components of interstellar matter: clouds of H<sub>2</sub> without CO.
- Witness directly the formation and destruction of GMCs.
- Disentangle warm diffuse gas from cold atomic & molecular clouds in the Galaxy.
- Depict how/where interstellar clouds are made in the Galaxy and how long they live.
- Clarify the intricate 'feedback' between star forming clouds, the stars that form in them, and their Galactic environment.
- Allow construction of a Milky Way template that can be used to interpret the unresolved emission from distant galaxies: e.g. ALMA, SMA, Herschel, and SOFIA.

