



The dark gas in the Milky Way

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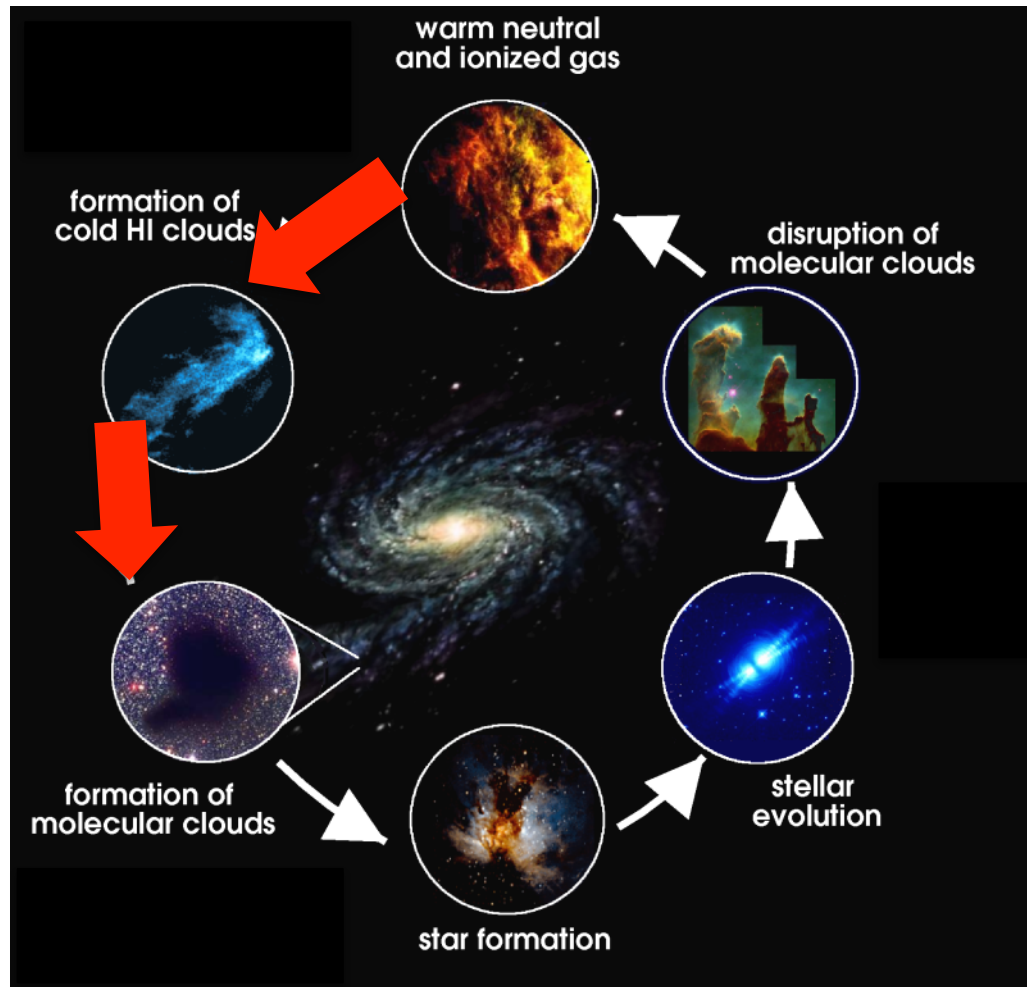
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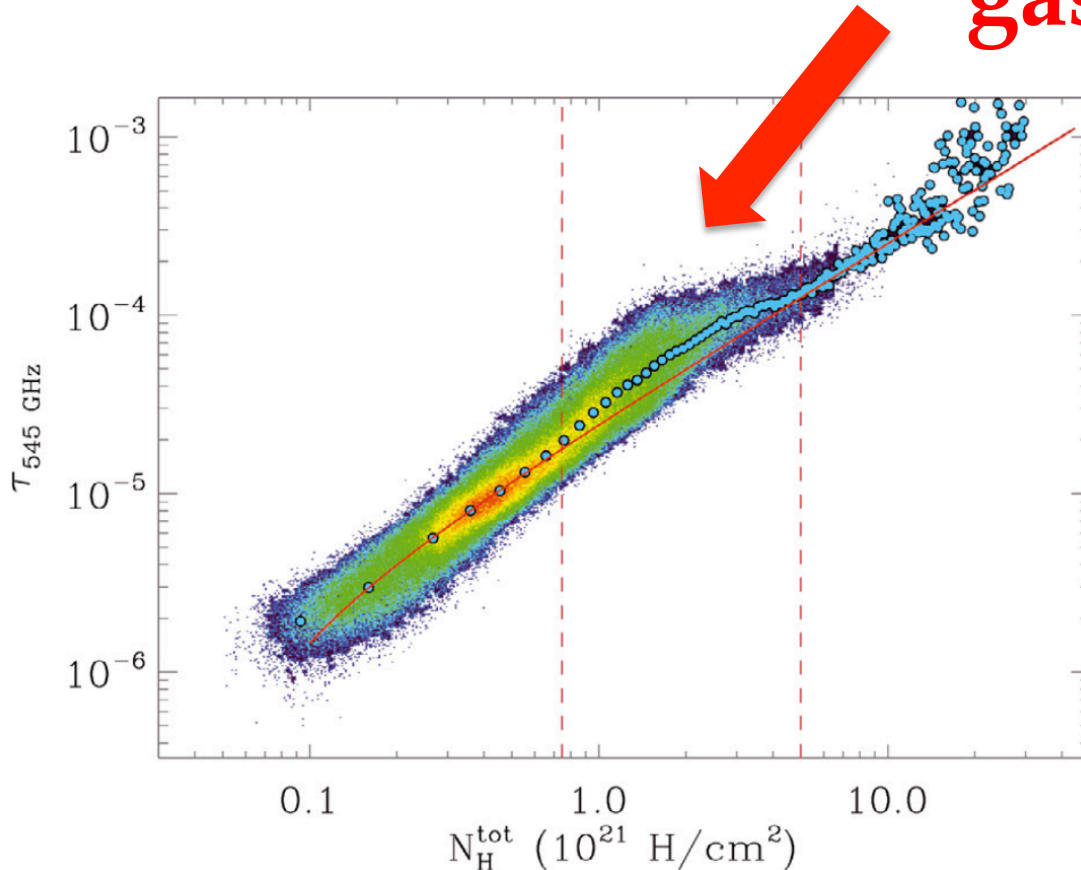
The gas cycle in galaxies



<http://soral.as.arizona.edu>

(CO) dark gas

How much extra gas is there?

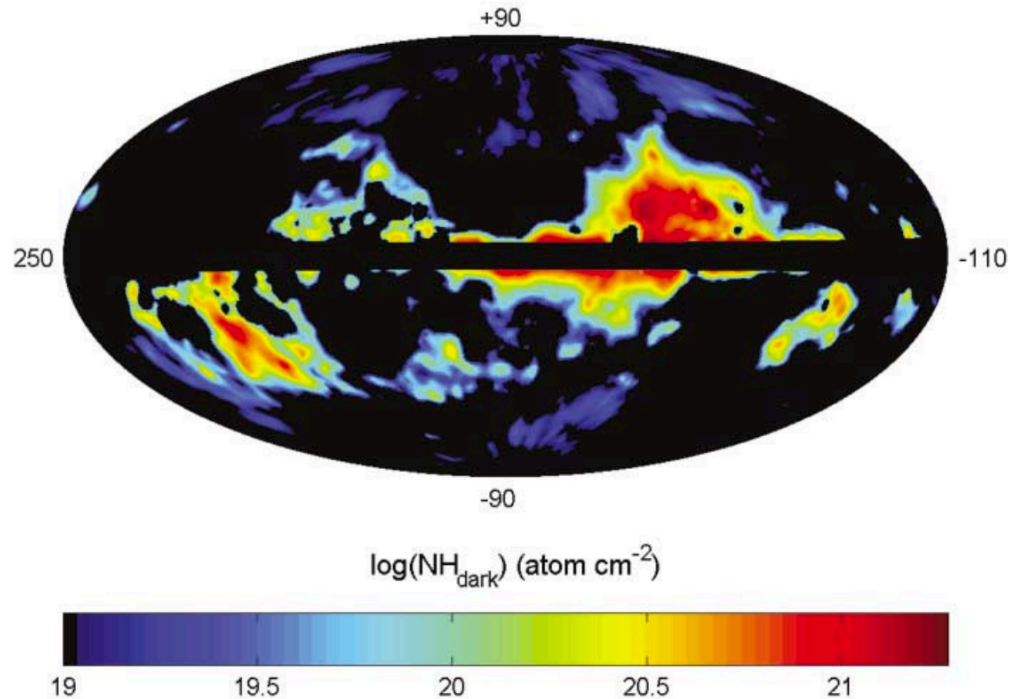


- ✦ Plank dust measurements
- ✦ Dust indicates more gas, than what we see in the HI and CO observation

Planck collaboration (2011)

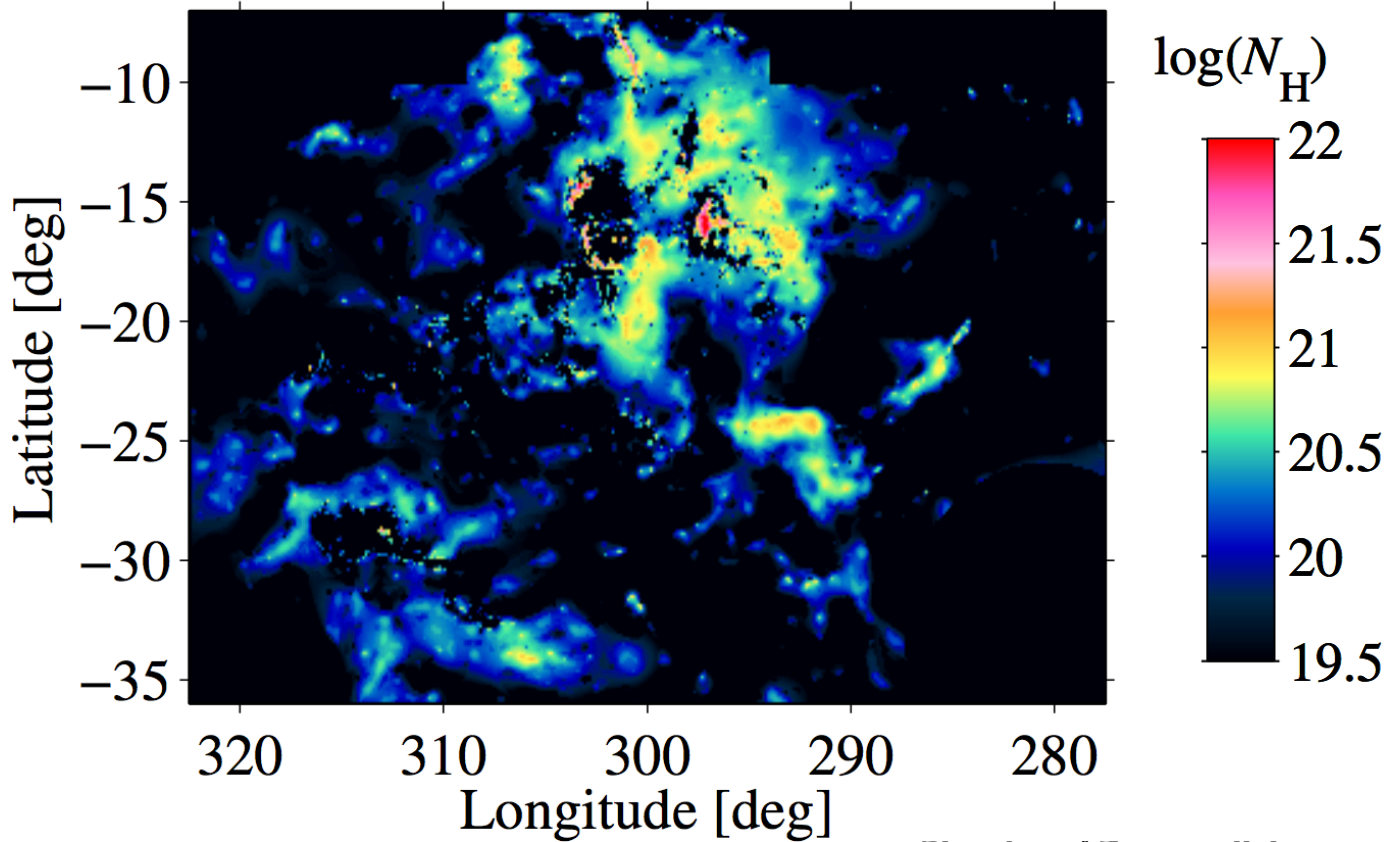
(CO) dark gas

- ✦ Grenier et al. 2005:
 - ✦ Excess dust emission compared to the detected HI and CO
 - ✦ More gas indicated by gamma rays



(CO) dark gas

- ✦ Dark gas in the Chamaeleon molecular cloud complex
- ✦ Based on Fermi gamma ray measurements

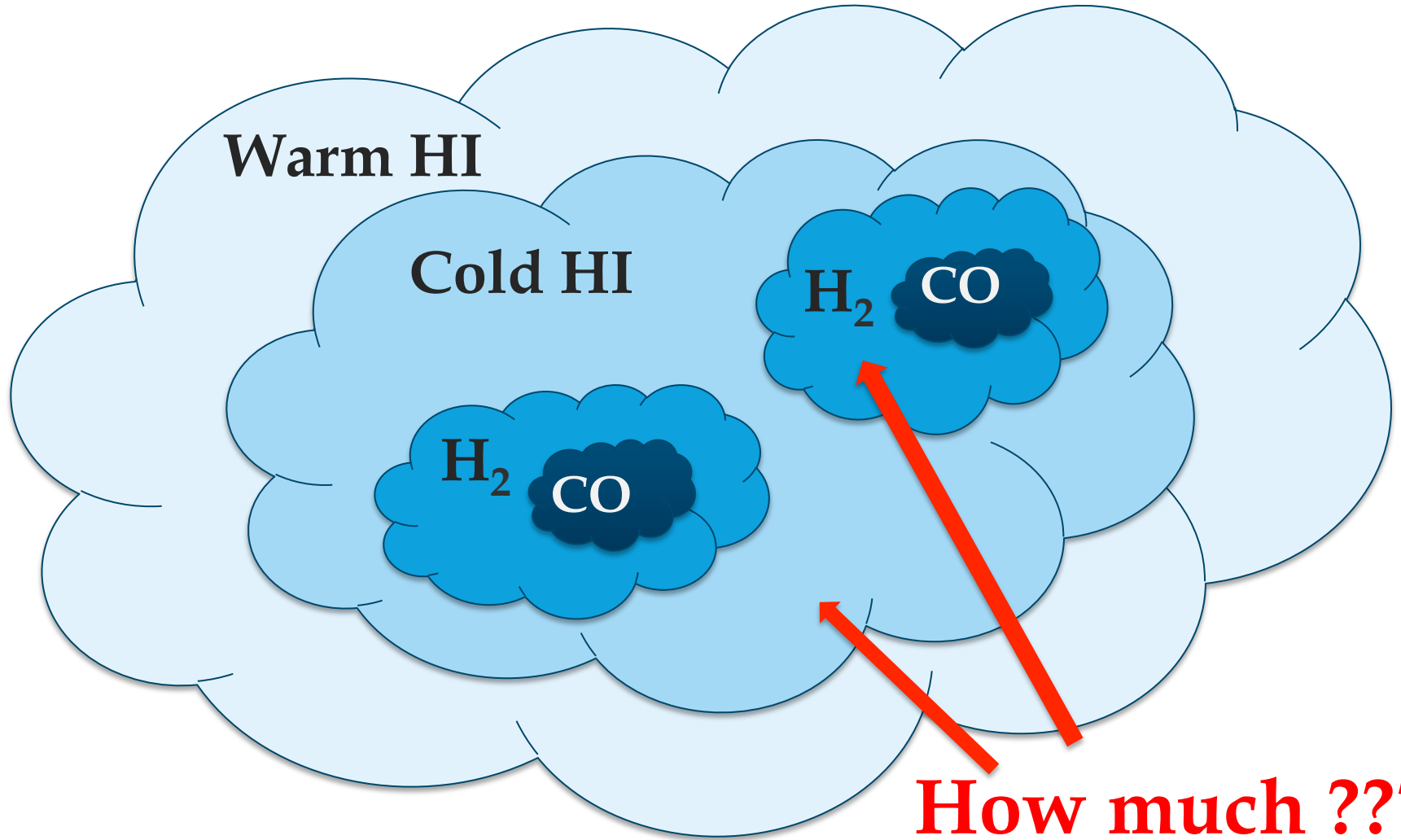


Planck and Fermi collaboration (2015)

What is the (CO) dark gas?

- Fukui et al. (2014) compared Planck dust optical depth with HI column density towards a high latitude molecular clouds.
 - 85% of the data points have HI optical depths $\tau > 0.5$ and HI spin temperature (T_s) < 40 K.
 - Suggest that the **local interstellar medium (ISM)** may be dominated by the high optical depth HI.
- Stanimirovic et al. (2014) and Lee et al (2015) measured HI absorption around the nearby Perseus molecular cloud
 - **High optical depth** $\tau > 0.5$ was only observed towards **20%** of the detected HI Gaussian components.

Inside the clouds



Measuring gas temperatures



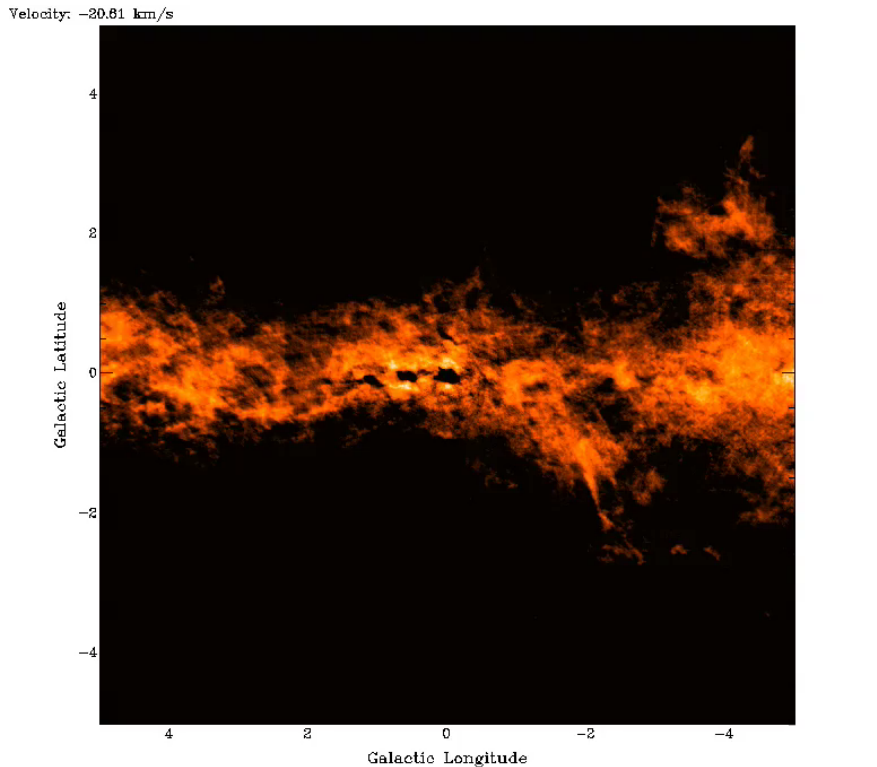
$$T_{\text{src}}(\nu) = T_{\text{exp}}(\nu) + T_{\text{src}}e^{-\tau(\nu)}$$

HI Emission

HI Absorption

$$T_s(\nu) = \frac{T_B(\nu)}{(1 - e^{-\tau(\nu)})}$$

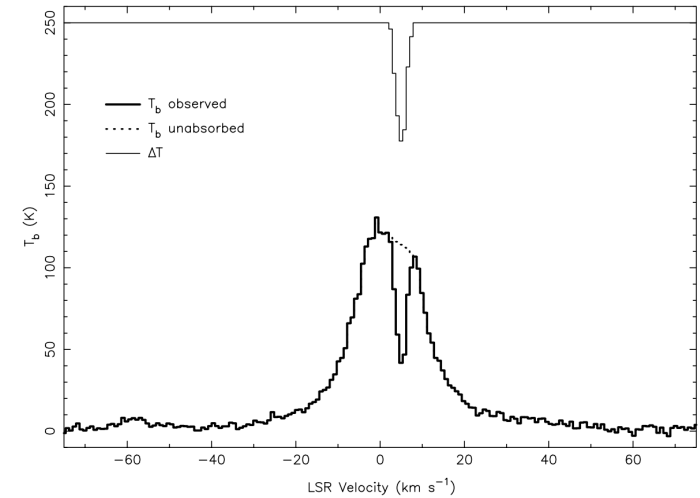
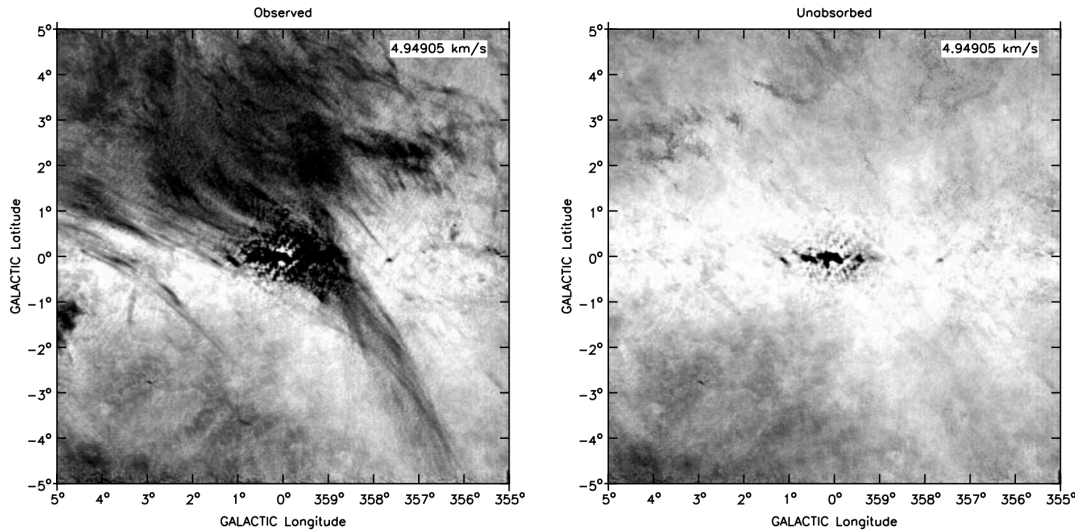
The Riegel-Crutcher cloud



McClure-Griffiths et al. (2006)

- ✦ HI absorption cloud
- ✦ Discovered by Heeschen (1955)
- ✦ Towards the galactic center
 - ✦ Bright background emission
 - ✦ $v = 5$ km/s
 - ✦ Distance: 125 pc
 - ✦ Thickness 1-5 pc (6 km/s)
 - ✦ highly filamentary tendrils
 - ✦ Filaments align with the magnetic field
- ✦ small amount of detected ^{12}CO emission

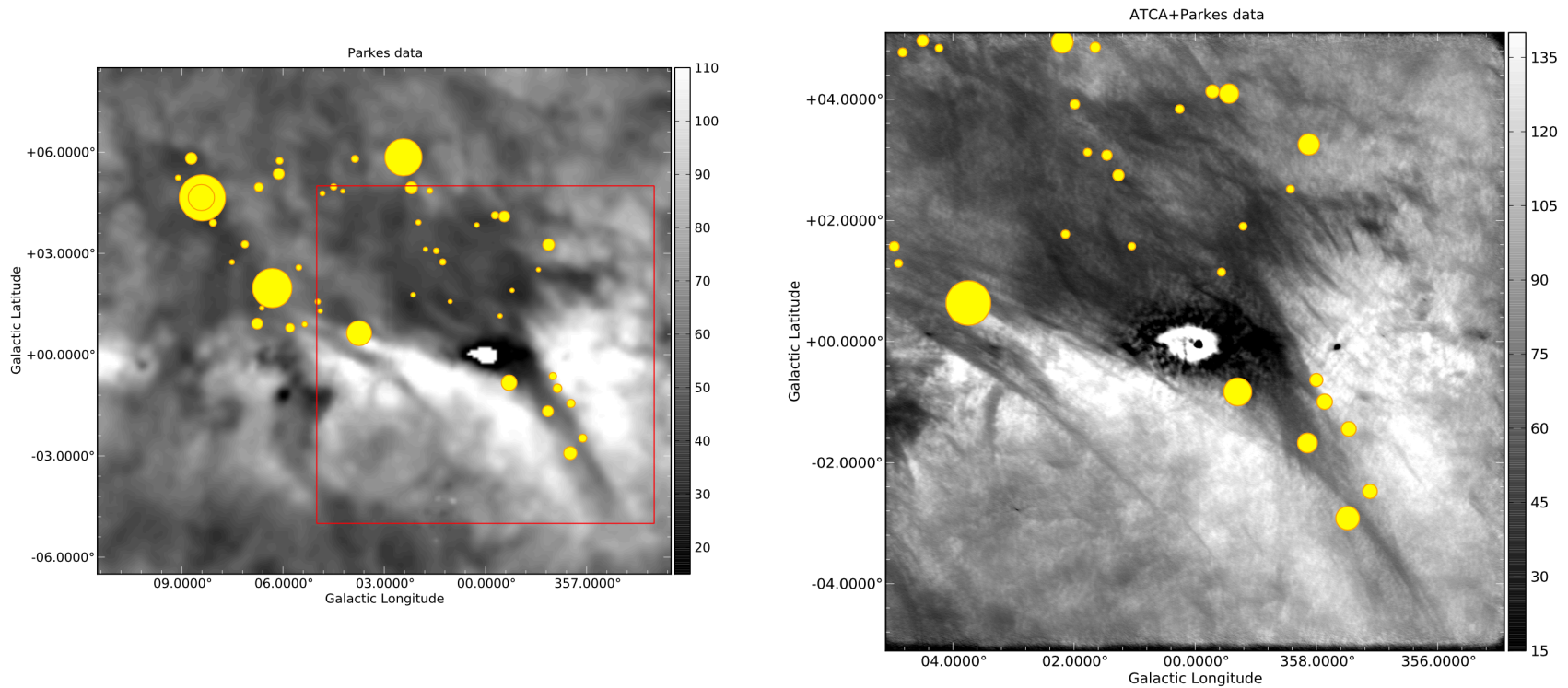
Previous temperature estimations



McClure-Griffiths et al. (2006)

- Interpolating the HI emission
 - estimating the temperature:
 - ~40 K (Montgomery et al. 1995; McClure-Griffiths et al. 2006)

Temperatures with absorption lines

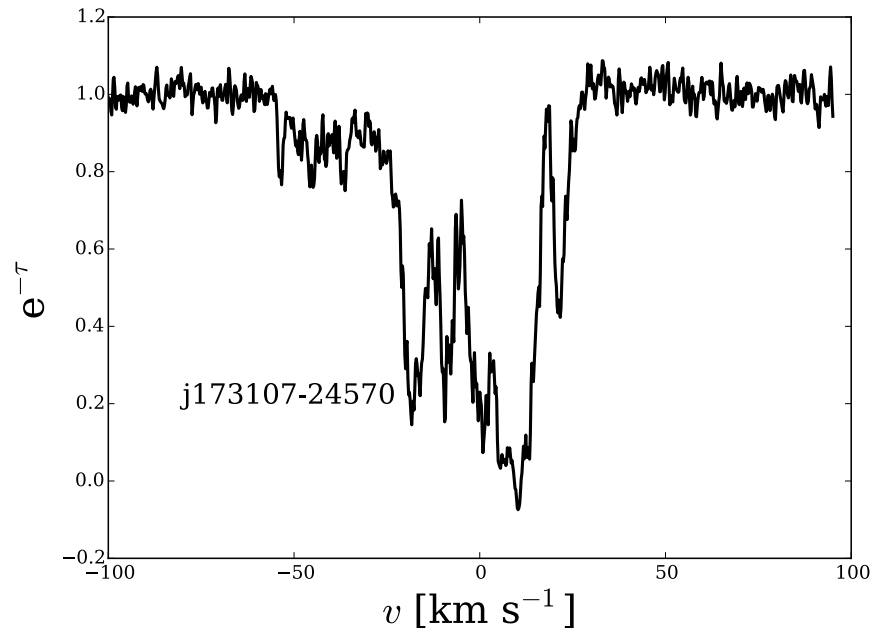
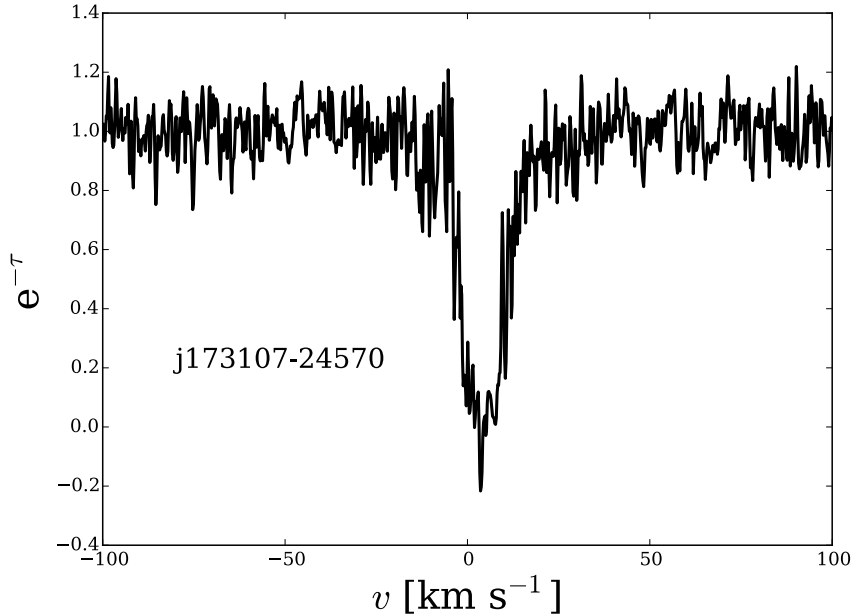


- ✦ 47 NVSS background continuum sources
- ✦ $S > 200$ mJy
- ✦ Unresolved ($< 45''$)
- ✦ Observed for 100 minutes with ATCA



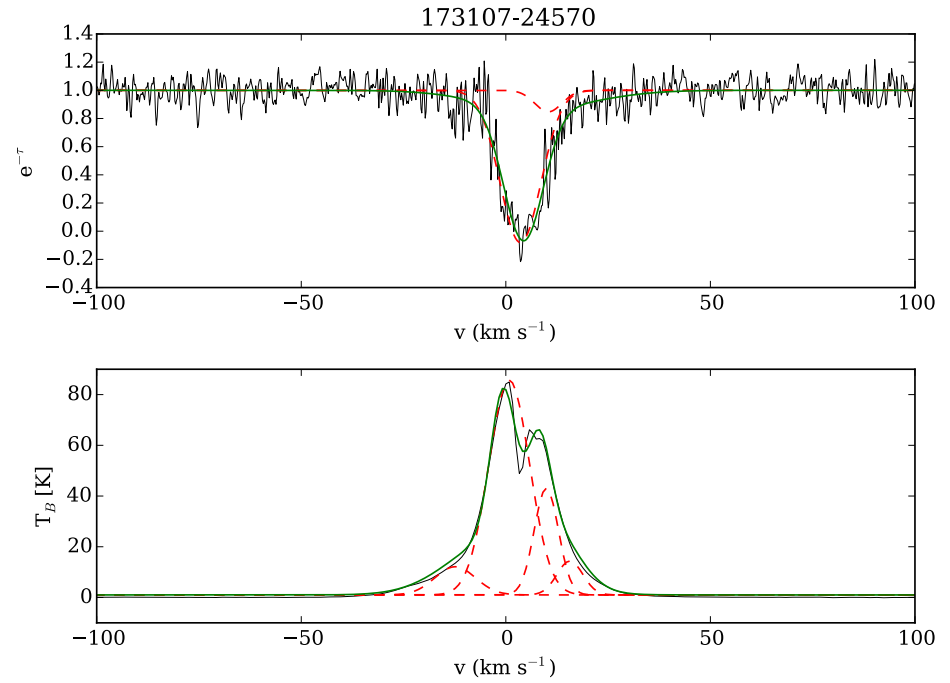
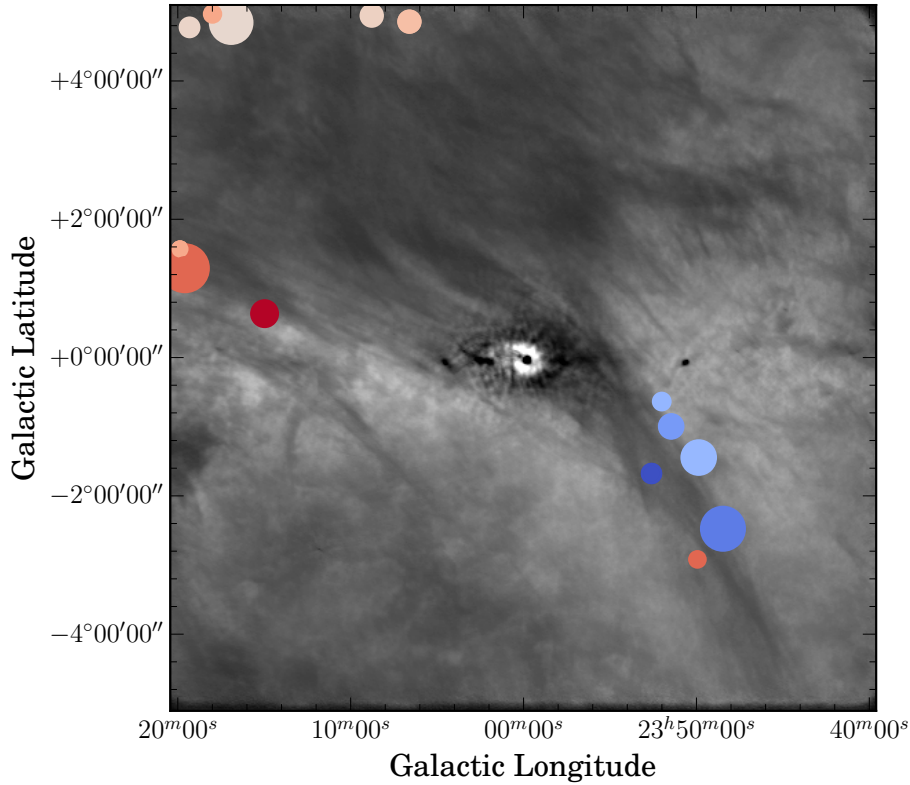
Fitting spectra

- ◆ 47+ sources
- ◆ Using Gausspy the Autonomous Gaussian Decomposition (Lindtner et al. 2015)



Preliminary results

Preliminary



Temperatures $\sim 50 - 160$ K
Optical depth (τ) $\sim 0.8 - 1.08$

Summary

- ✦ Measuring the temperature of gas clouds can help us understand how much of the (CO) dark gas is HI and how much is H₂.
- ✦ Preliminary results show that the gas in the Rigel-Crutcher cloud has temperatures between 50 – 160K, and suggest a temperature gradient.

- ✦ Future plans
 - ✦ Derive temperatures and column densities for the whole cloud
 - ✦ Compare results to simulations
 - ✦ Measure temperatures in other regions (molecular clouds)

Thank you

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