



First Results from the Herschel observations of EXtra-Ordinary Sources (HEXOS) Key Program

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on behalf of the HEXOS Team

Orion and Sgr B2: Extra Ordinary Objects

Contain THE CLASSIC EXAMPLES of phenomena found throughout the ISM

➔ Hot Cores: Orion KL, Sgr B2 N

➔ Photodissociation Region: The Orion Bar

➔ Shocks: Orion KL

➔ Diffuse gas in Milky Way: Sgr B2 M peers through the galaxy

- Main part of program:

➔ Full HIFI spectral scans of Orion KL, Orion S, Orion Bar, Sgr B2 (M), Sgr B2(N)

➔ PACS range scans of same sources

➔ Water Maps of shock/deep integrations/search for large molecules

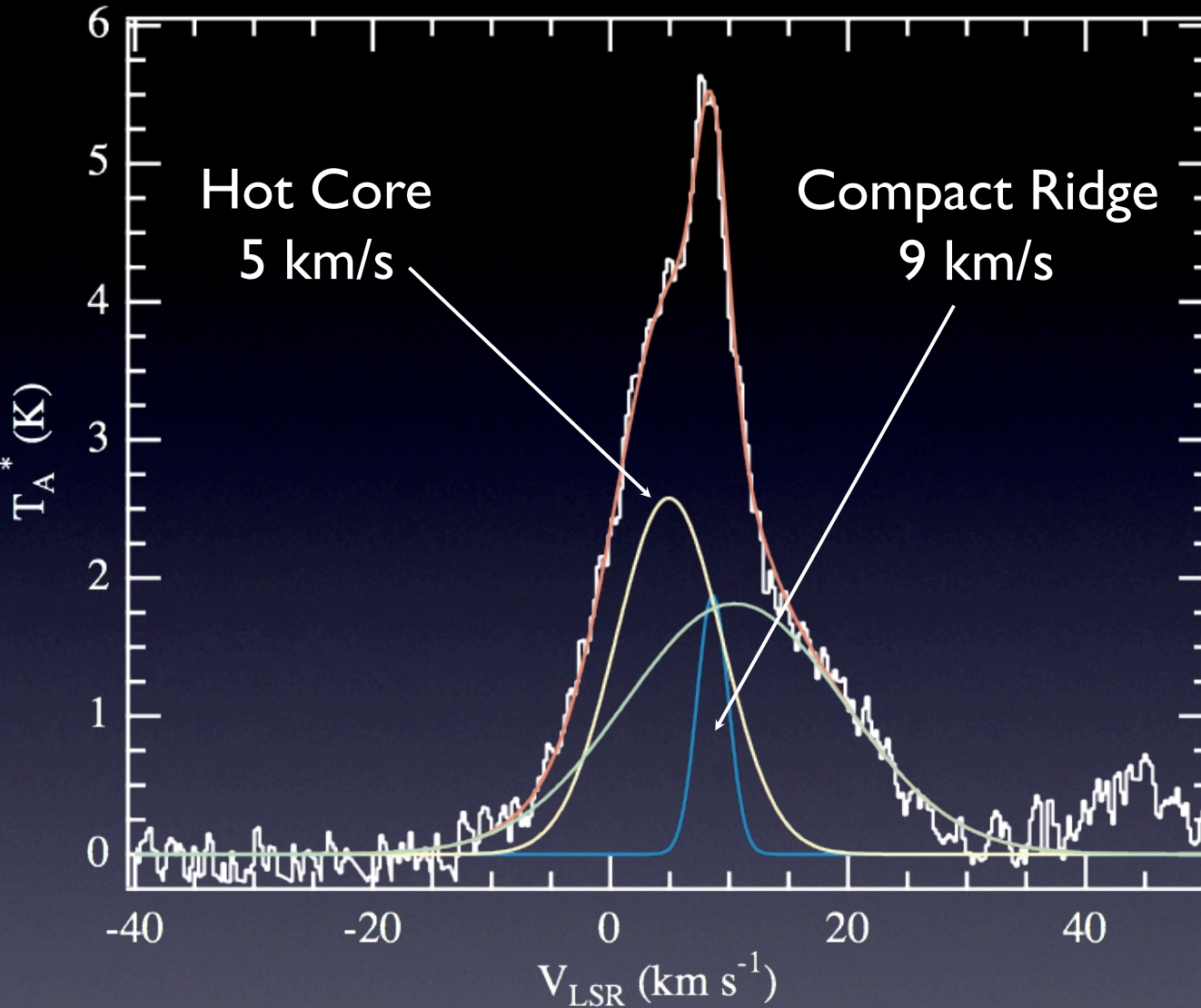
HEXOS Program Goals

- HEXOS unbiased spectral surveys:
 - ➔ Define the far-infrared molecular emission at high spectral resolution
 - ➔ Complete chemical and cooling line assay of hot cores, PDR, and shocked/outflowing gas
 - ➔ Access to light hydrides - at root of chemistry
 - ➔ Detect high energy transitions probing gas close to star
 - ➔ How does chemistry work? to what level of complexity? how does it respond to environment?
 - ➔ What is the physical perspective offered by detecting tens/hundreds of lines from a single molecule?
 - ➔ unbiased - possibility of unexpected results

HIFI and Spectral Surveys

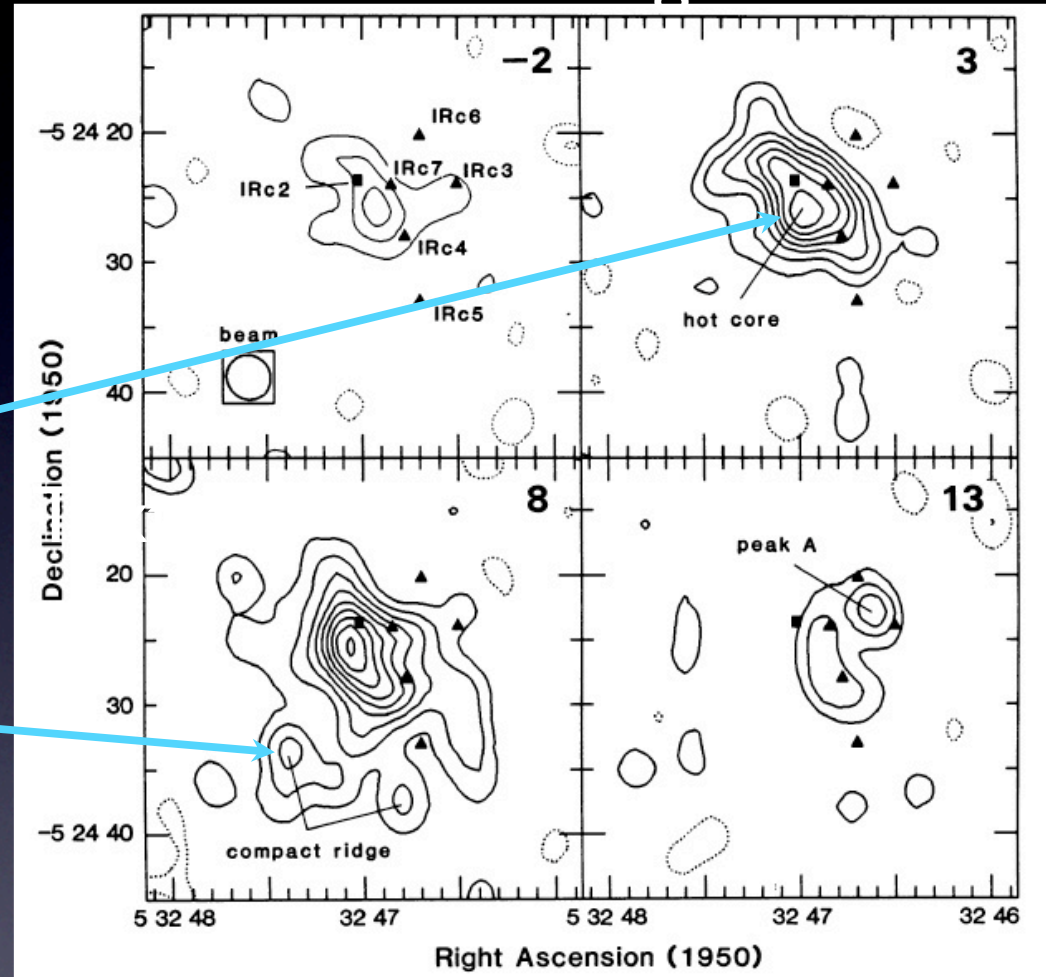
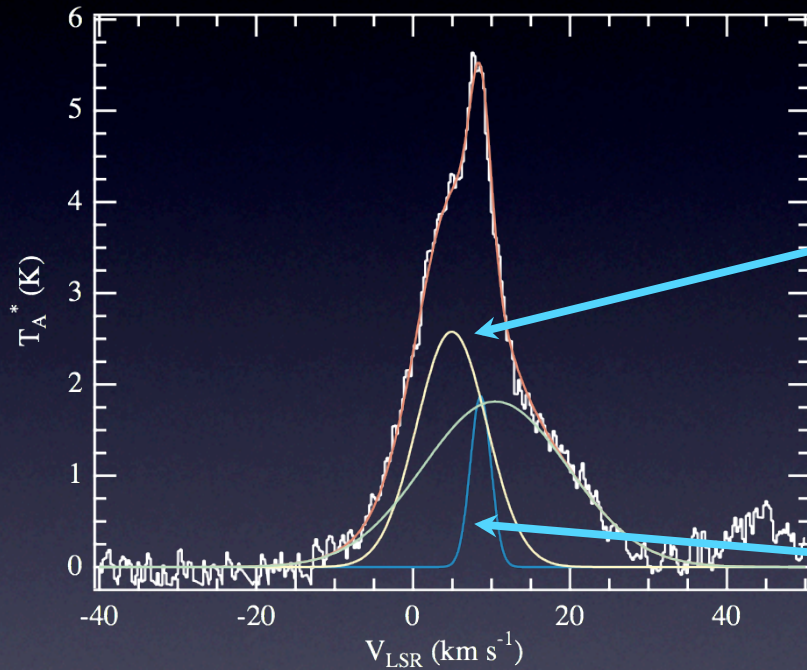
- Data quality is excellent - *we are very grateful to the instrument team*
- interesting fact: to cover 40 GHz with 30 mK rms at CSO takes ~ 36 hours. *In 50 hours of HIFI time we have covered 1150 GHz!*
- *Orion KL Spectrum: Most complete spectrum of molecular gas at high spectral resolution ever obtained.*

HDO 321-312

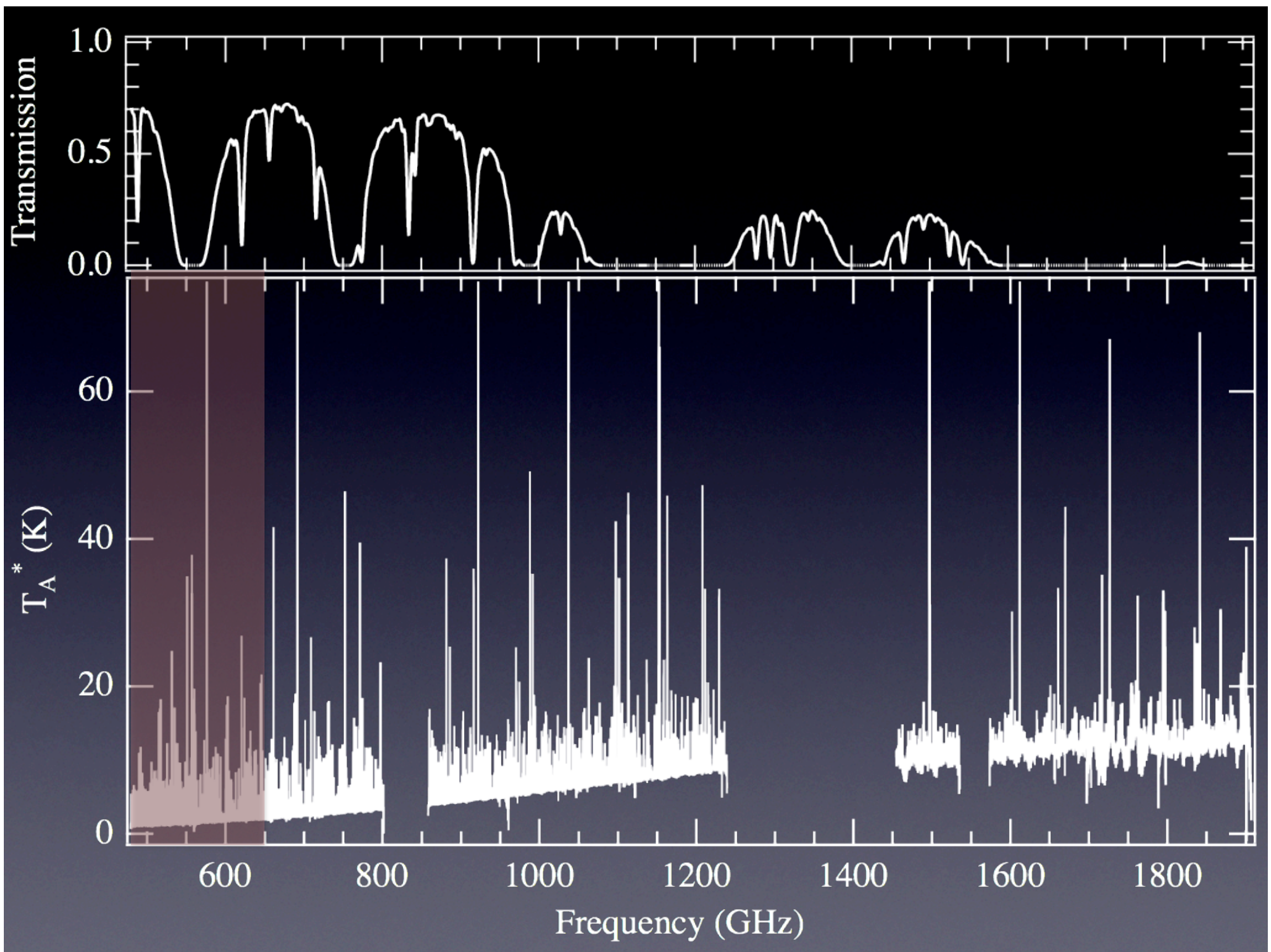


High Spectral Resolution with HIFI

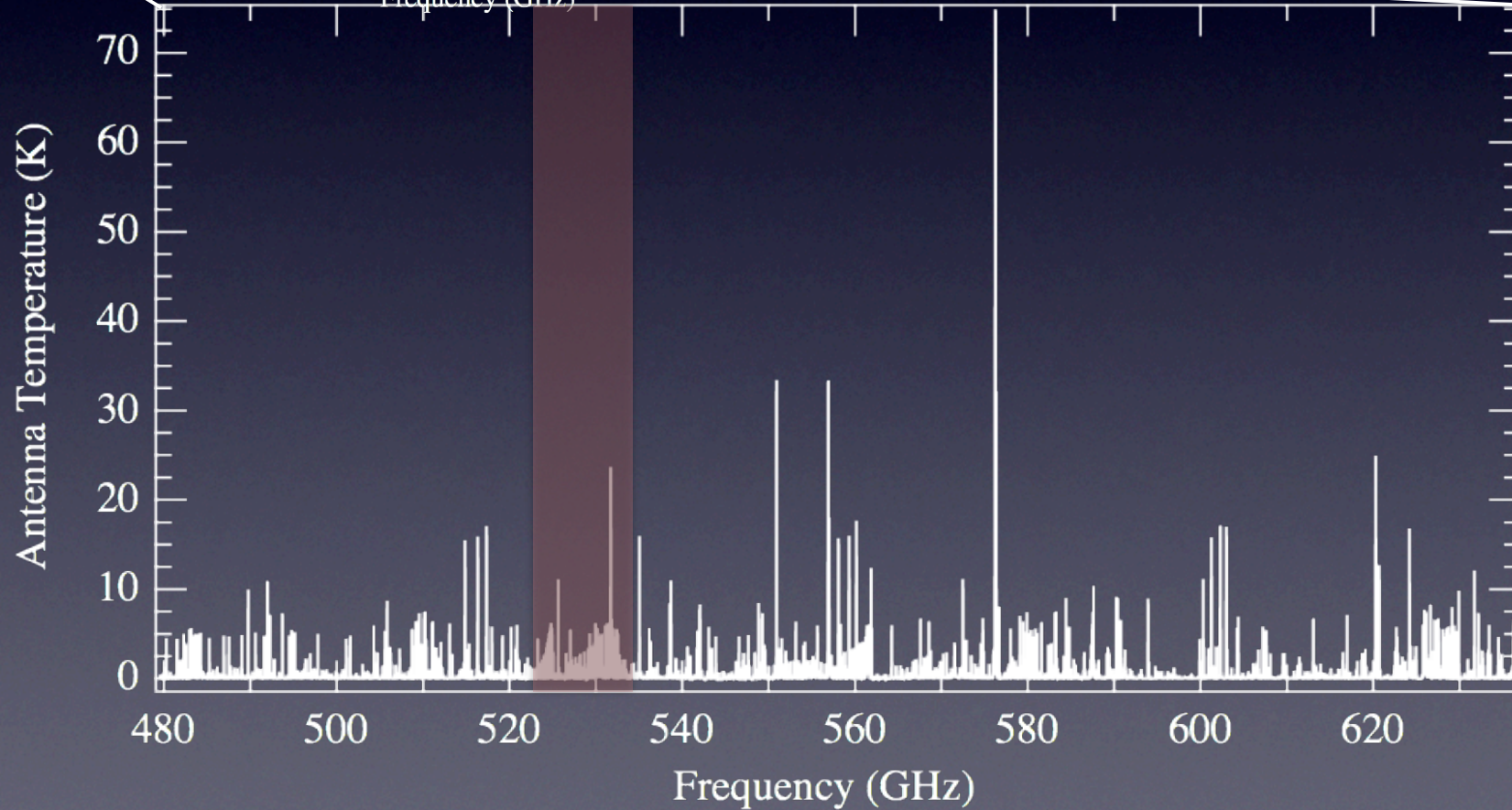
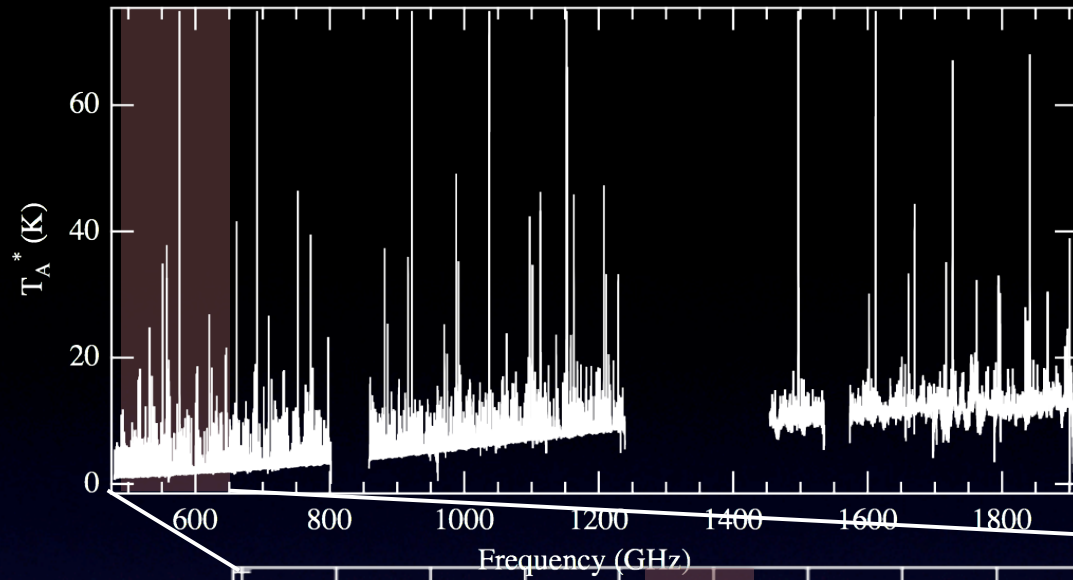
Plambeck & Wright 1987

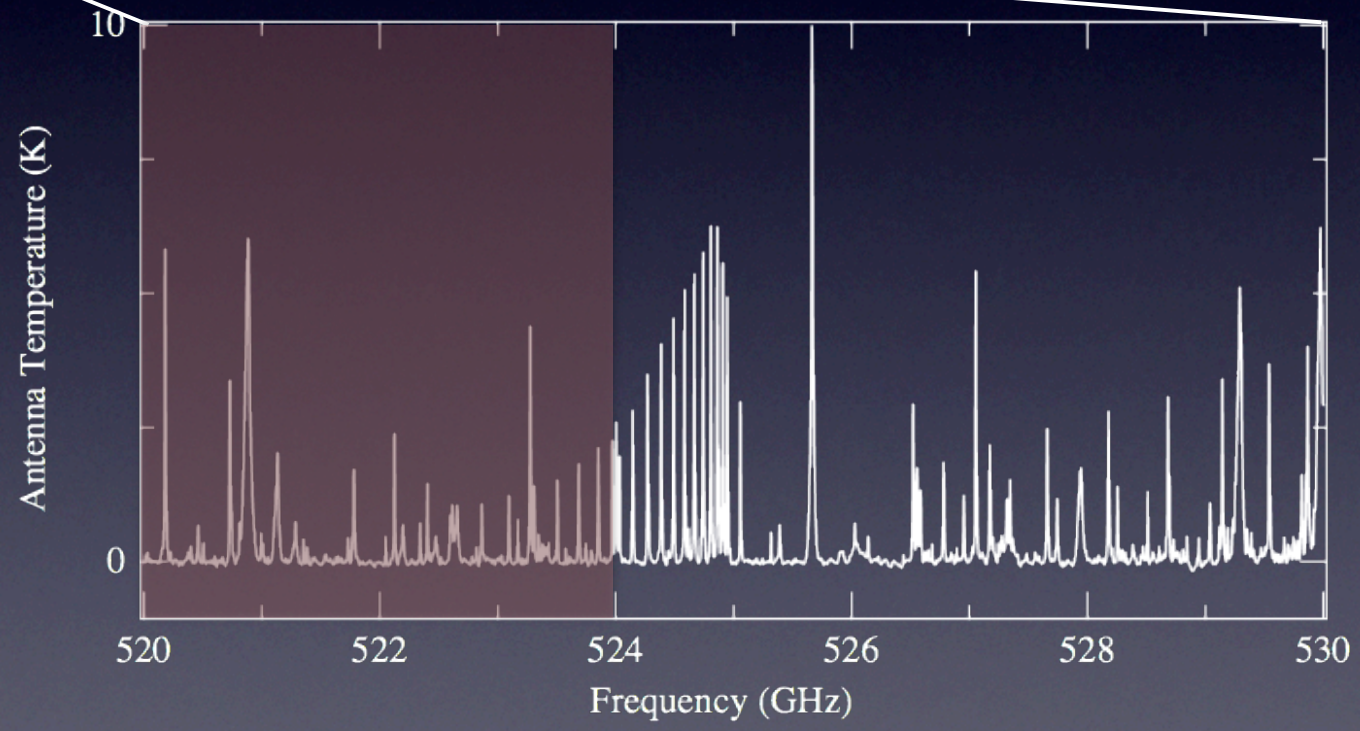
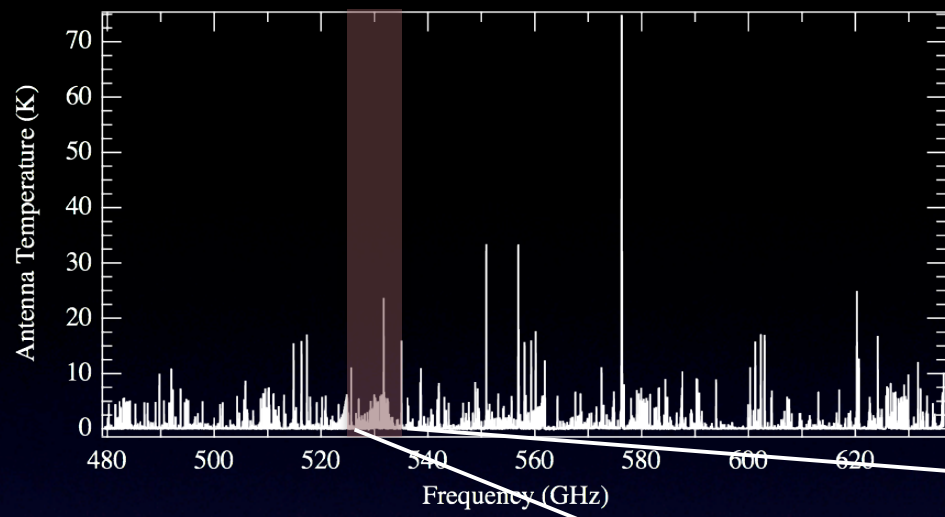


Spatial/Velocity Structure

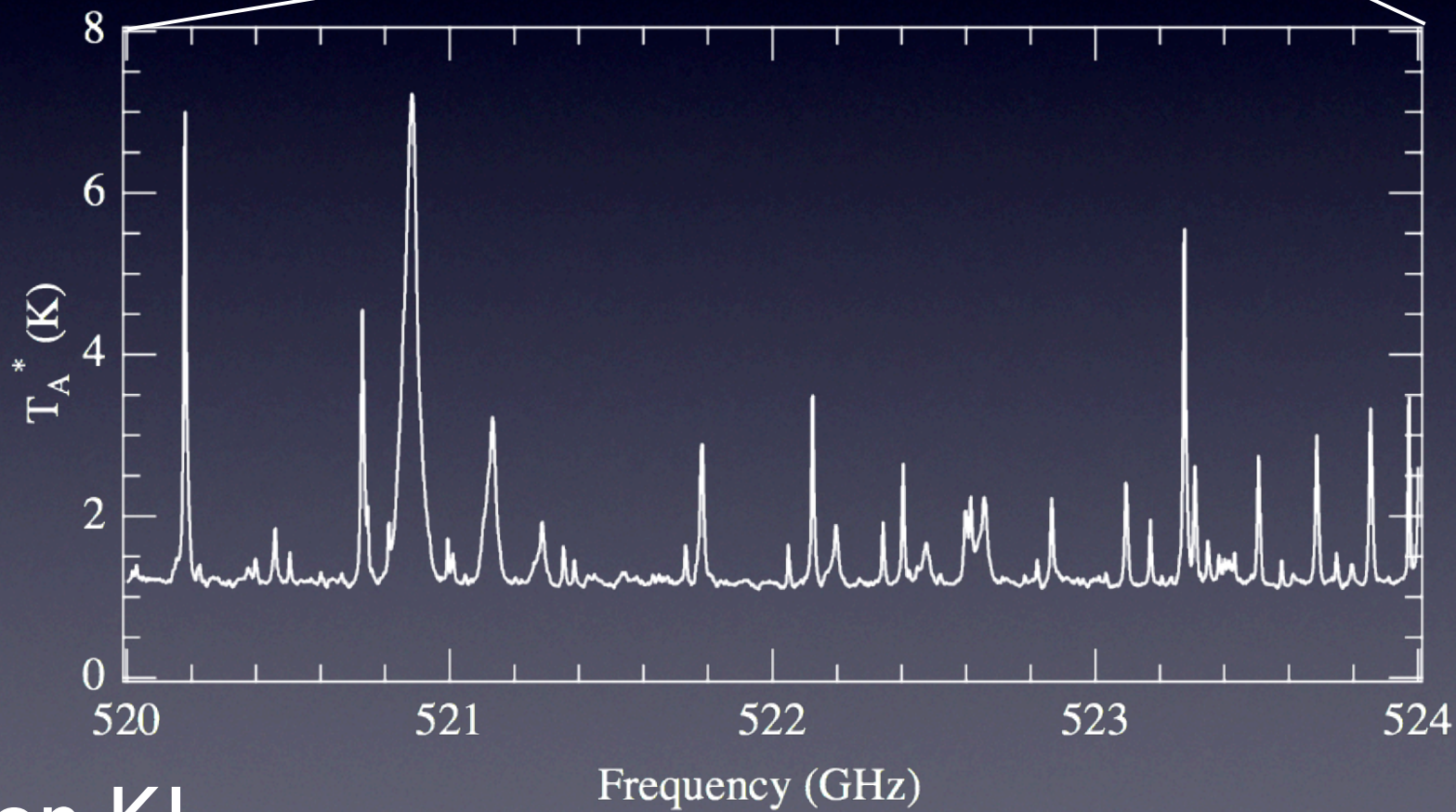
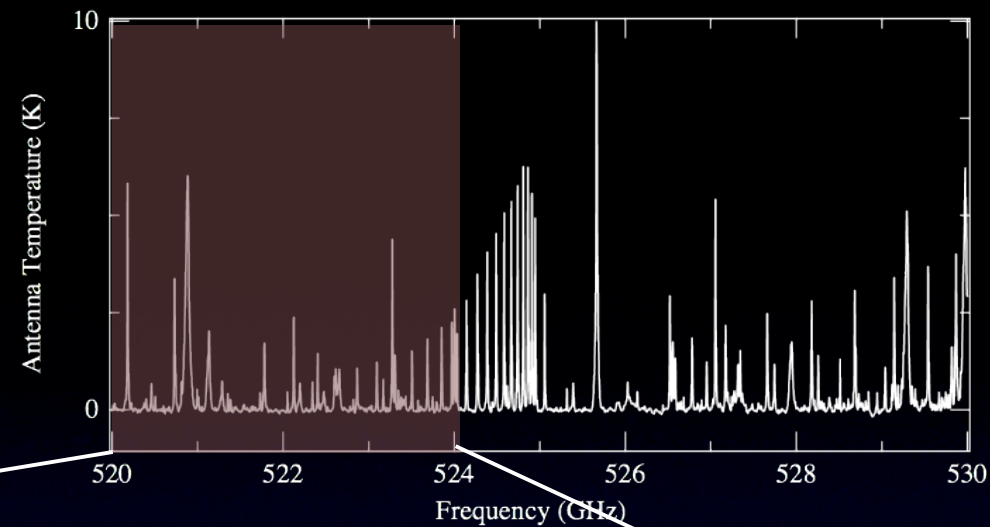
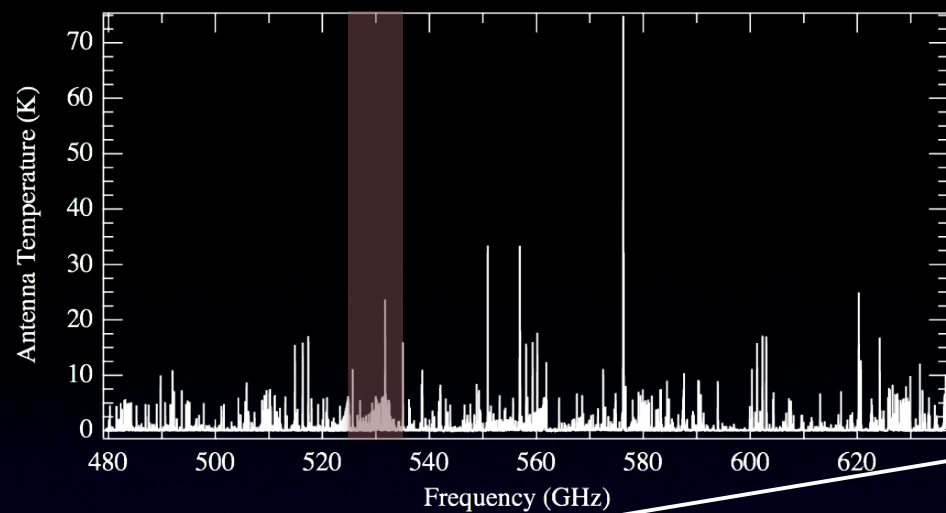


Orion KL

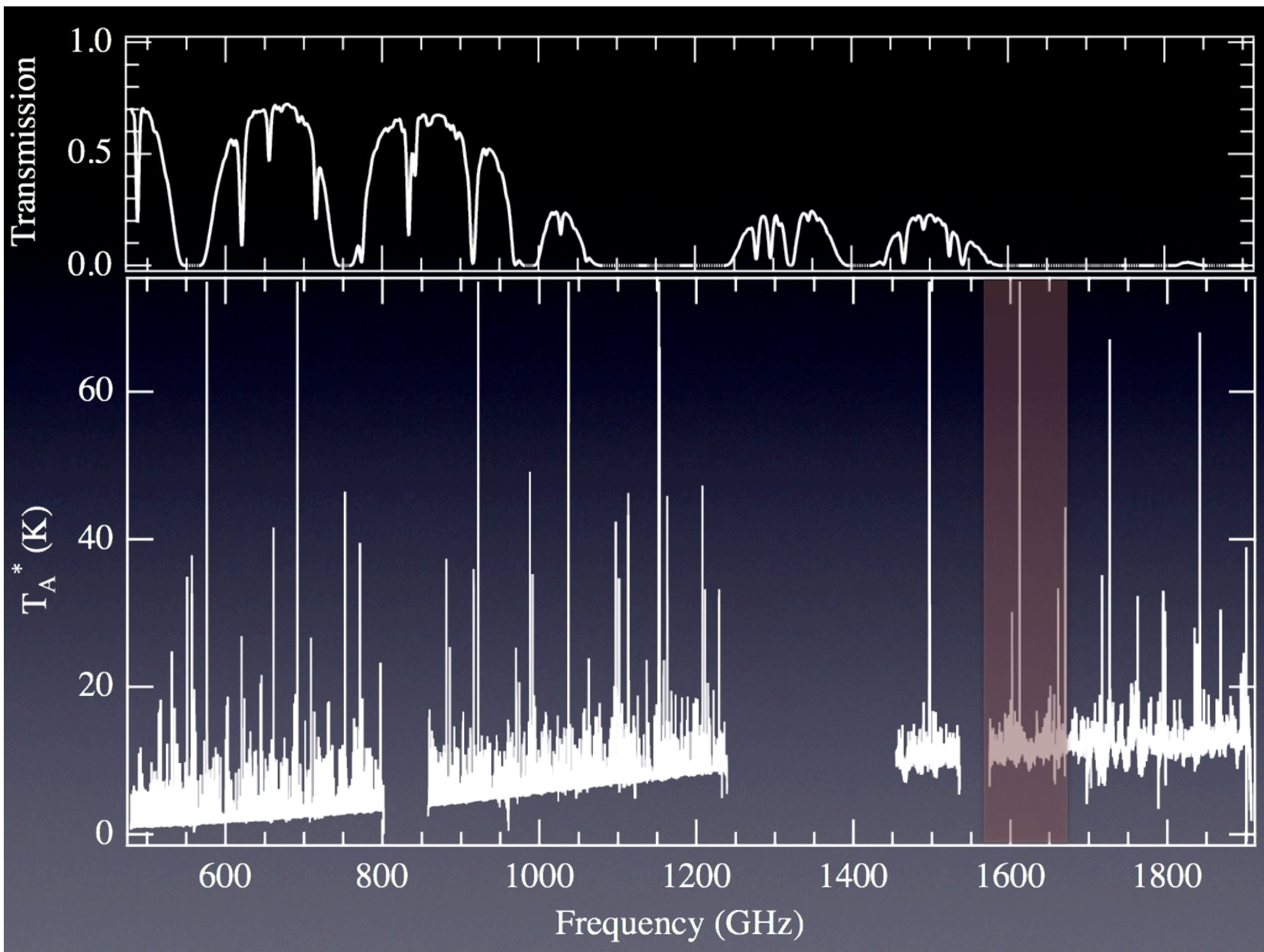


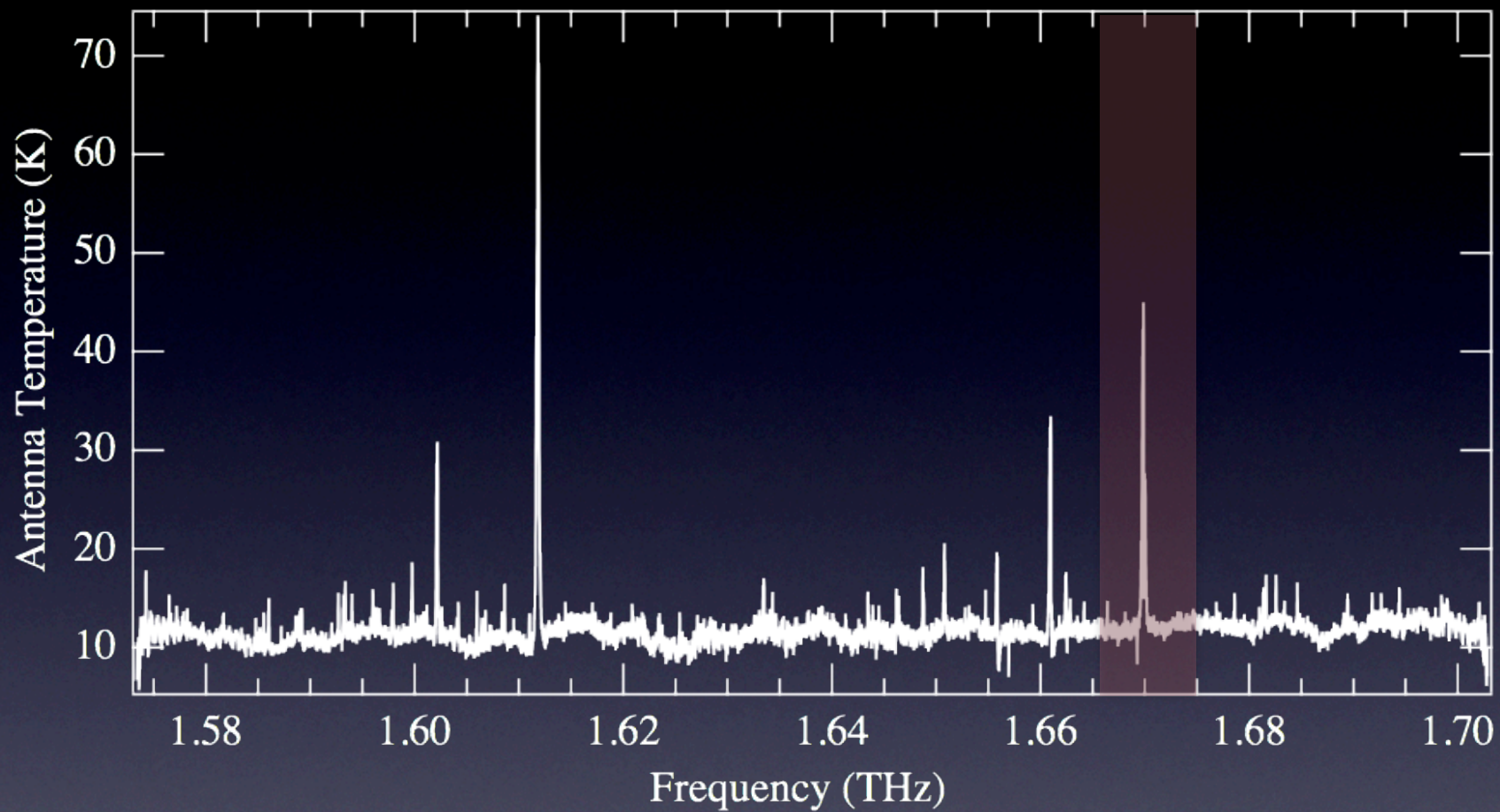


Orion KL - Band I



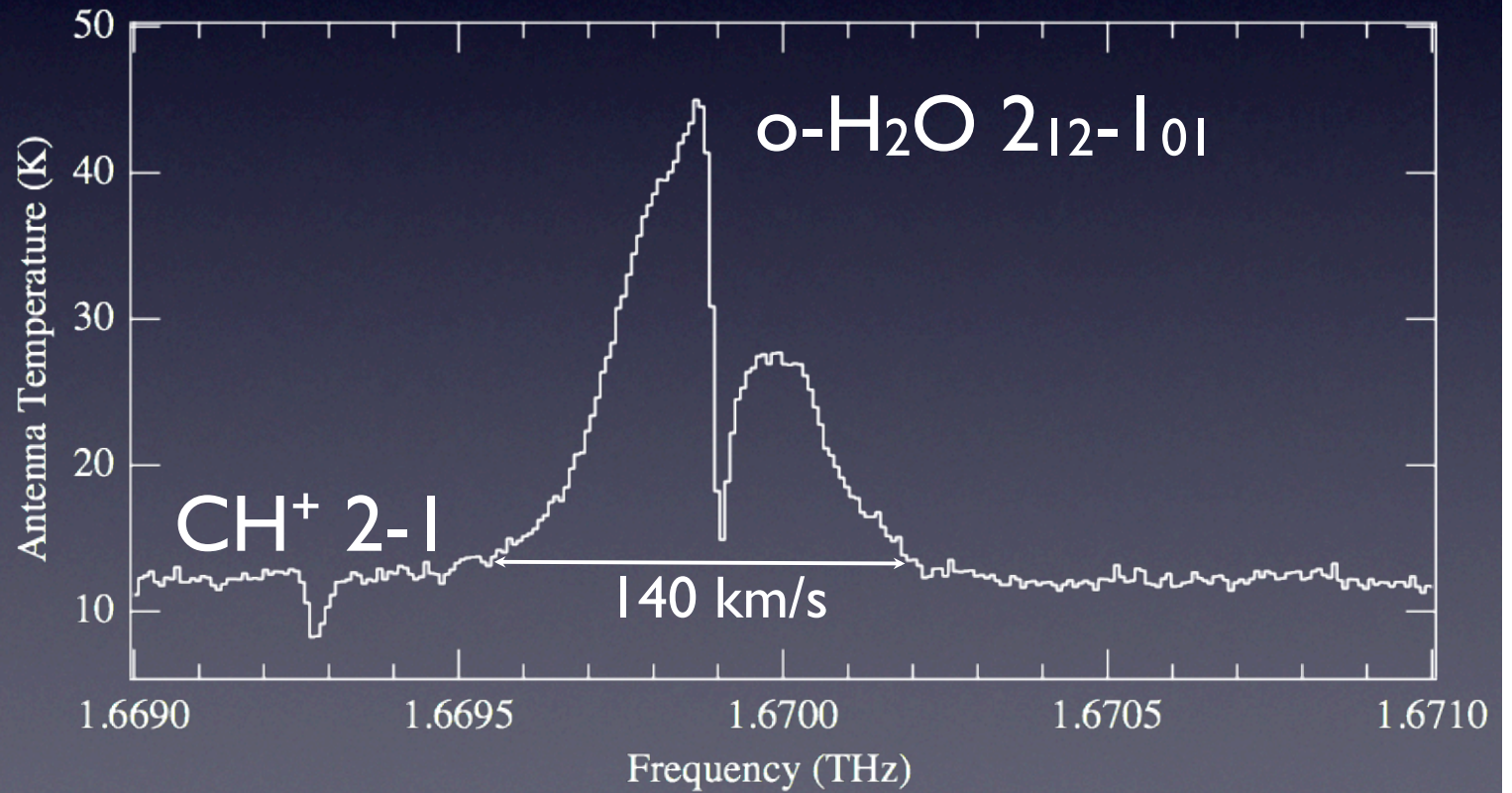
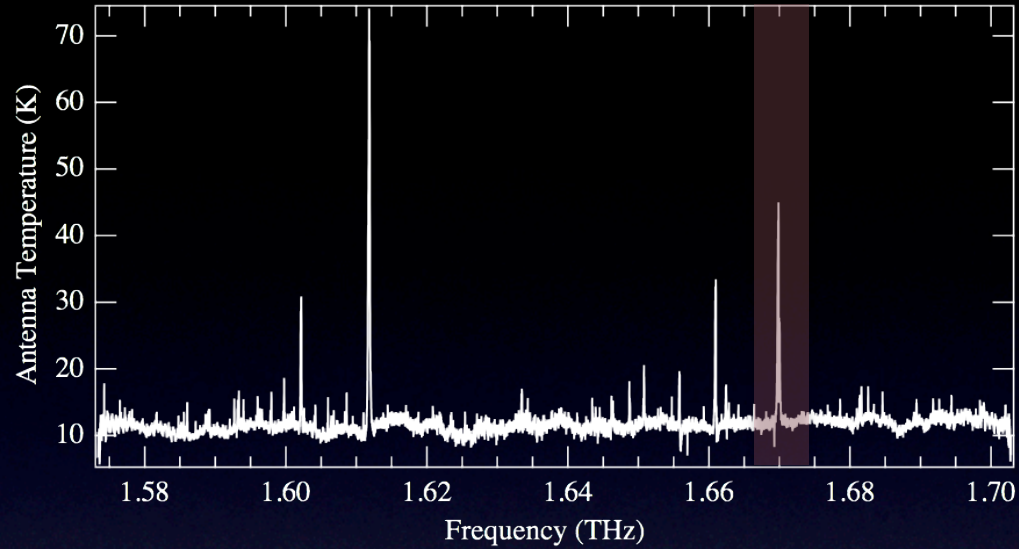
Orion KL



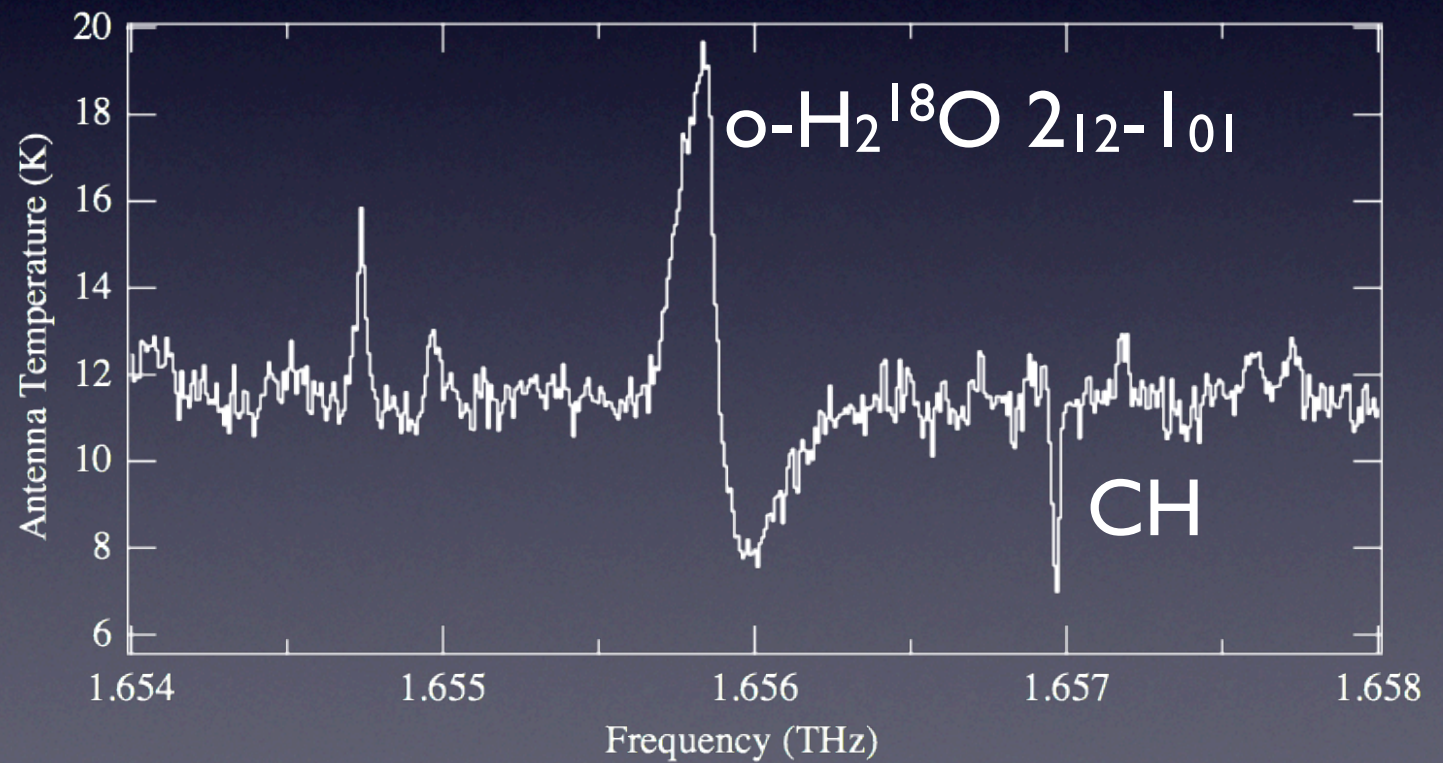
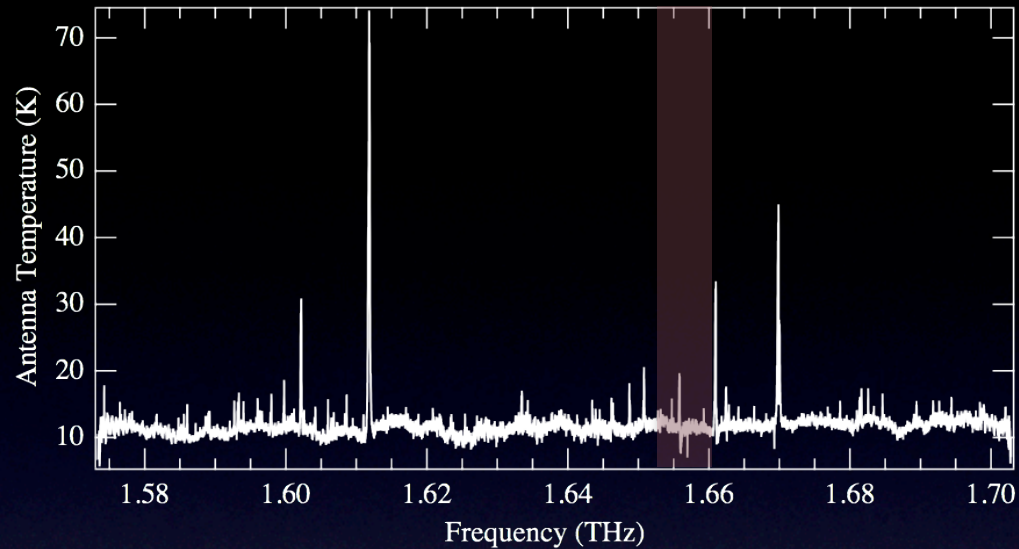


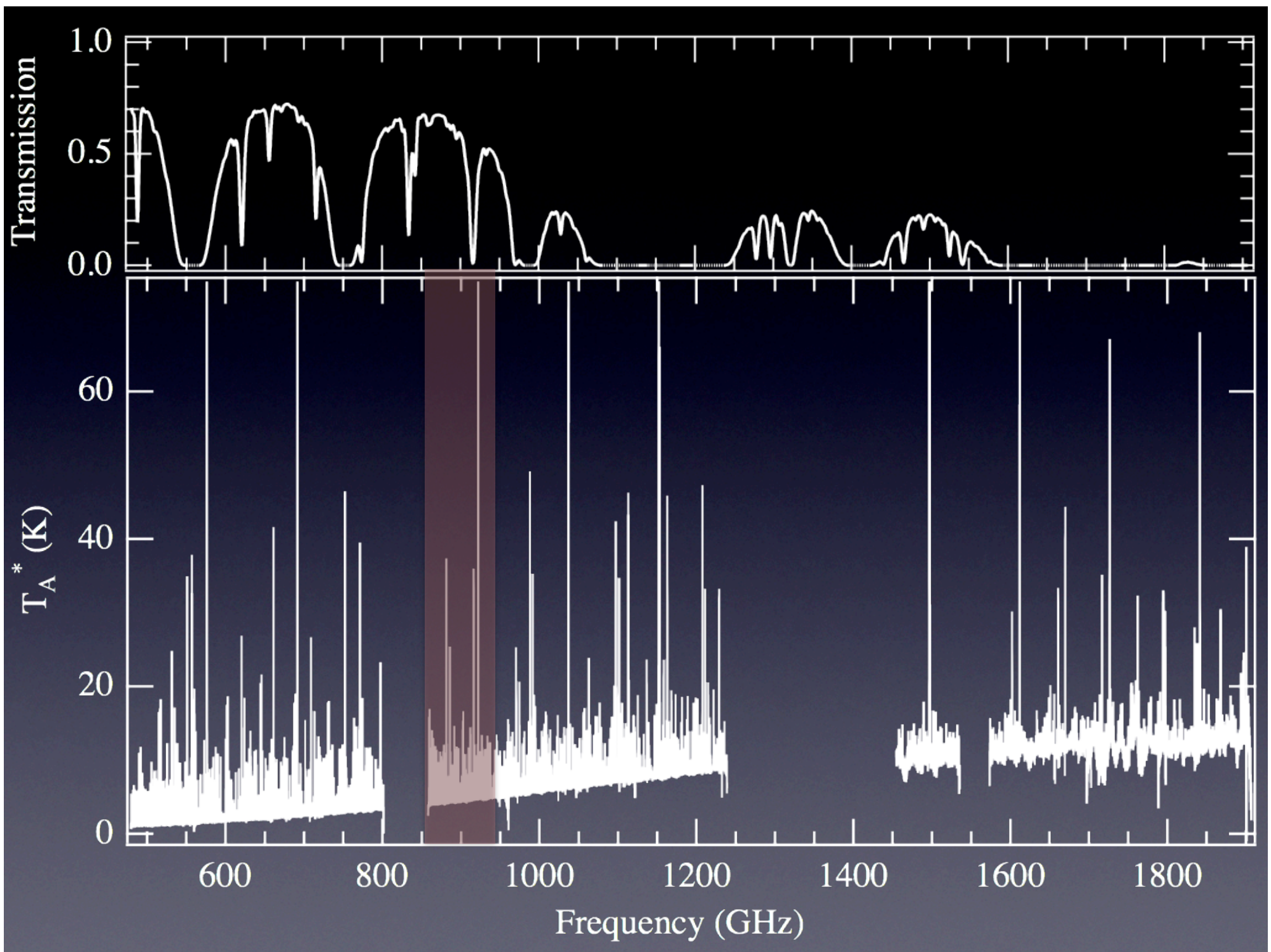
Orion KL Band 6b

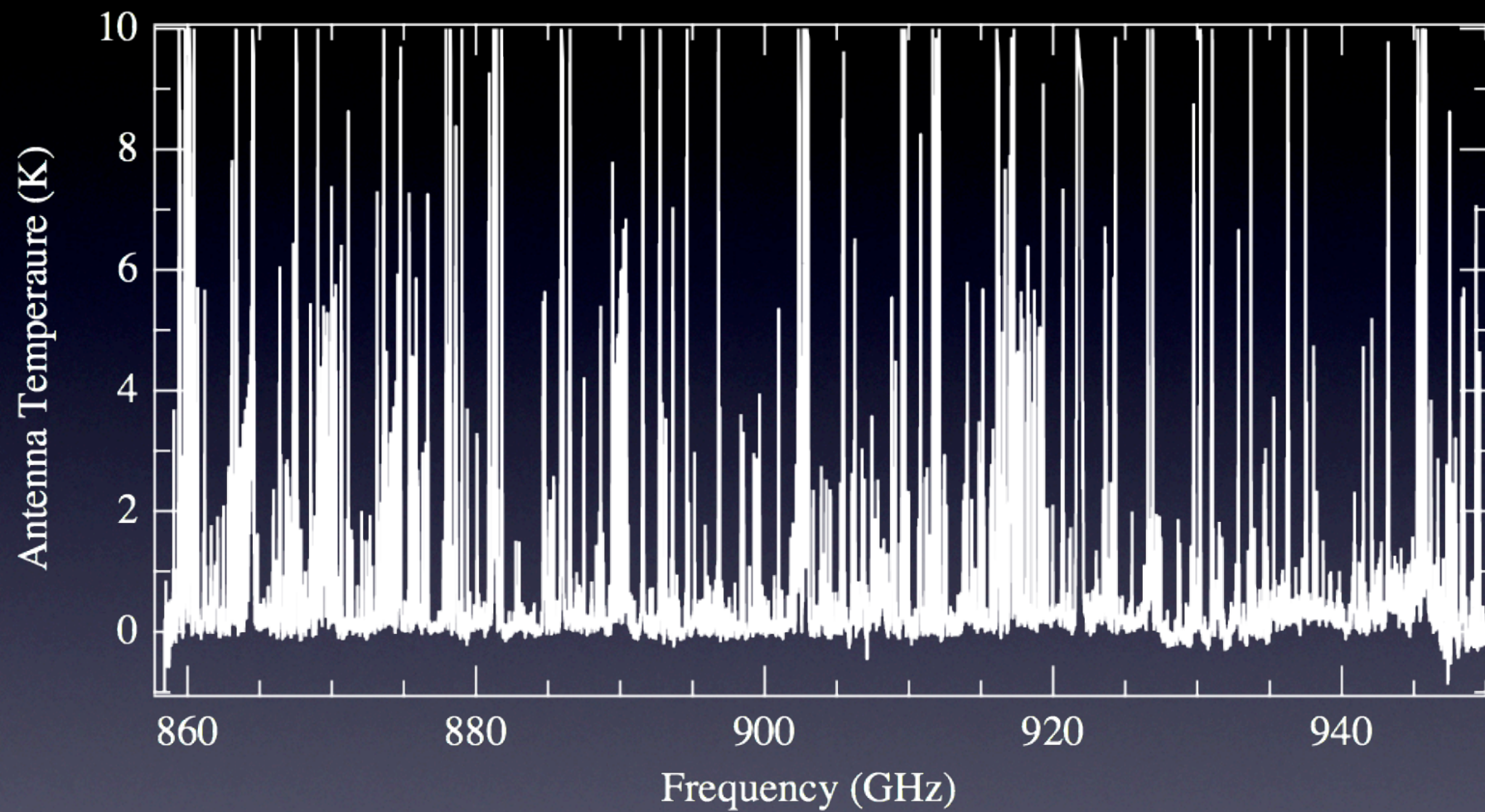
Orion KL Band 6b

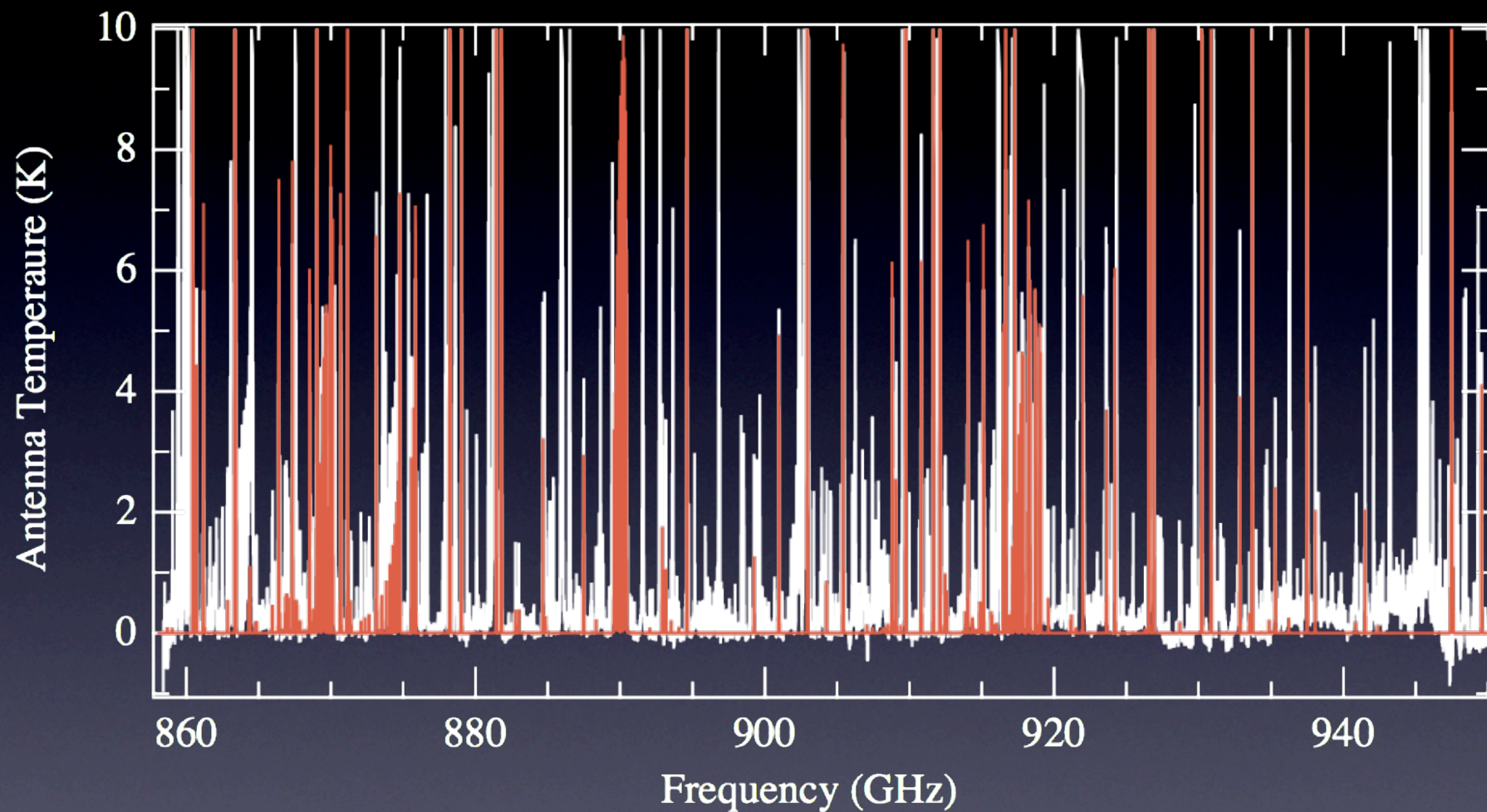


Orion KL Band 6b

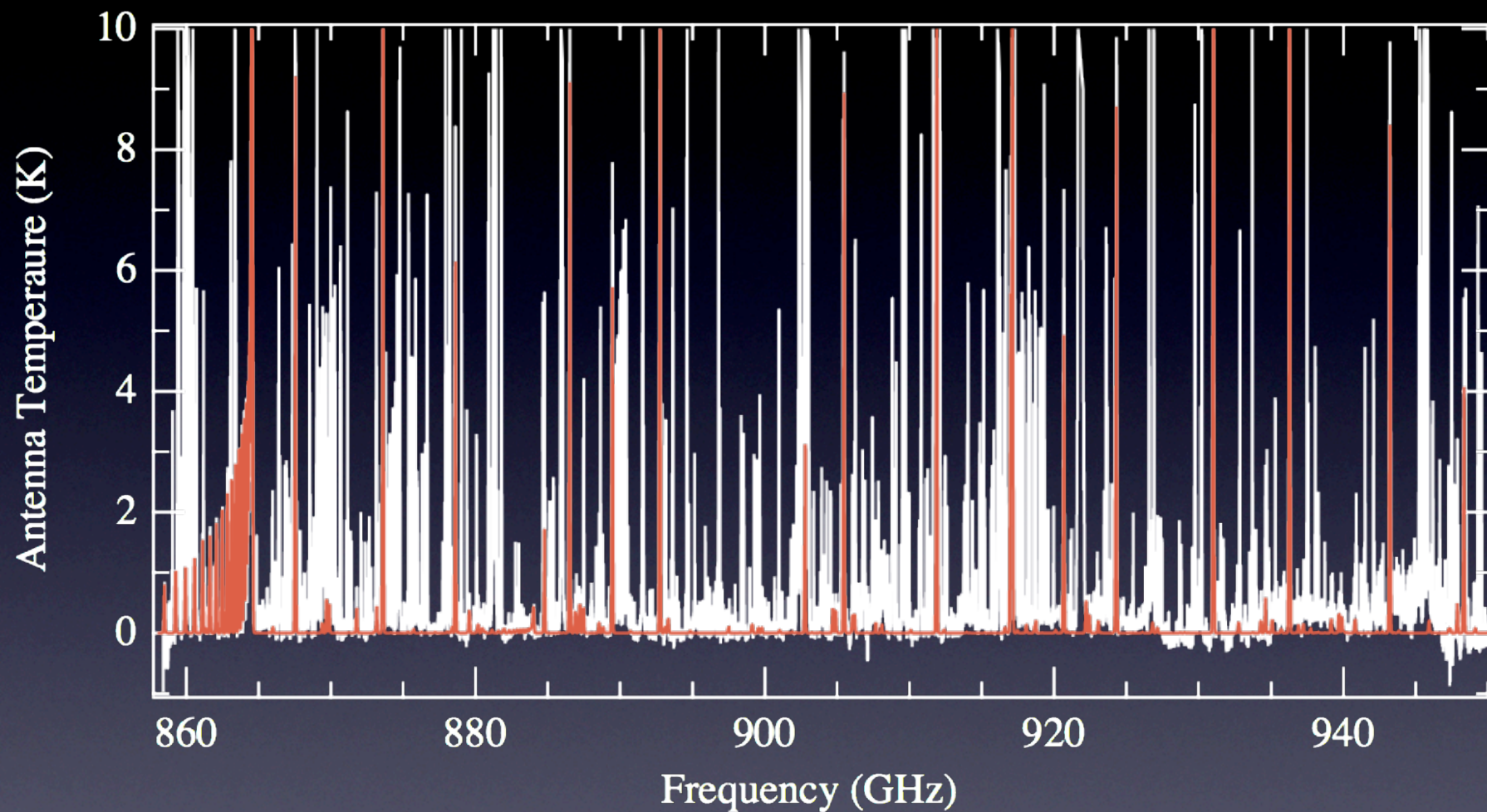




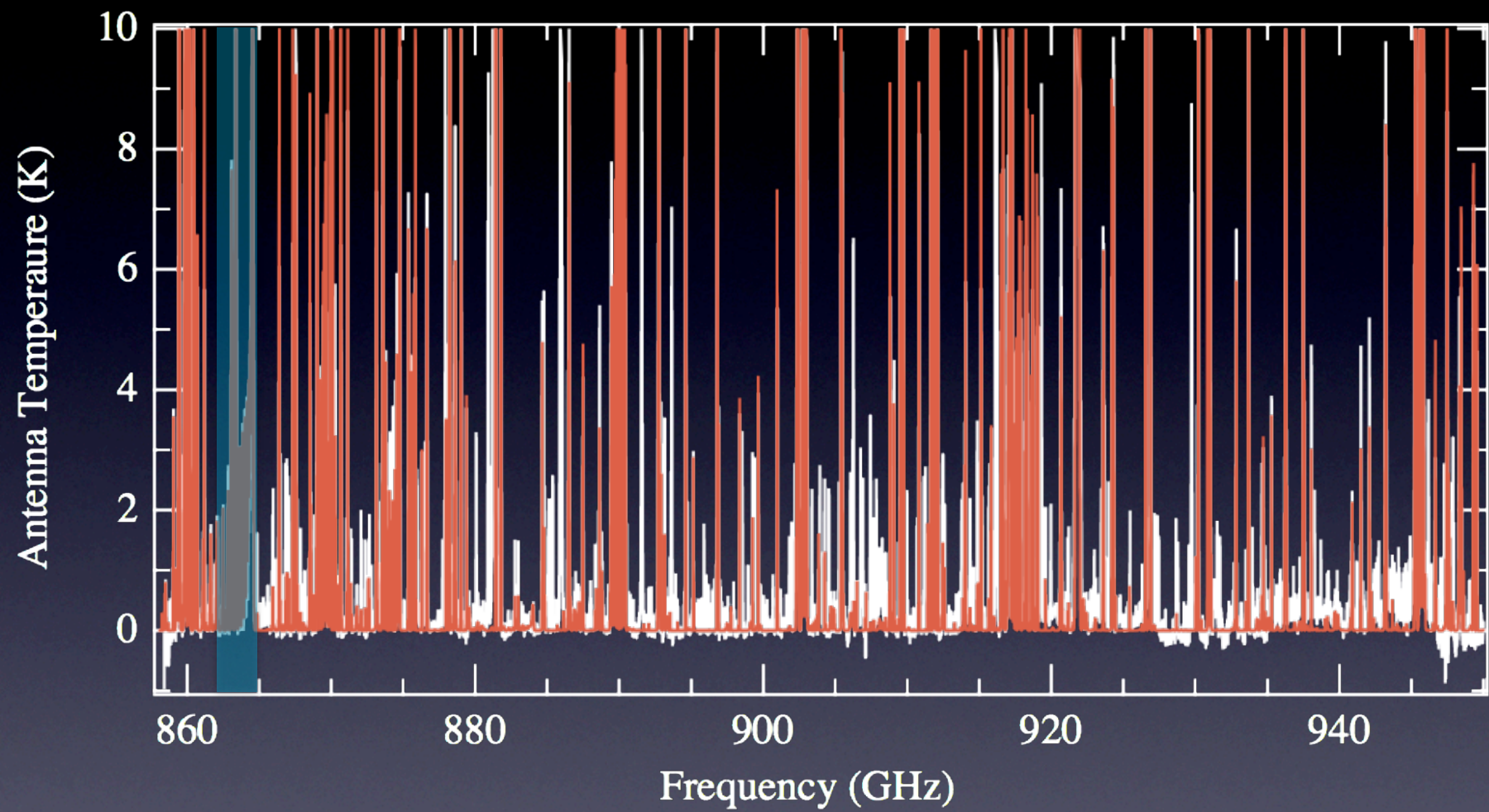


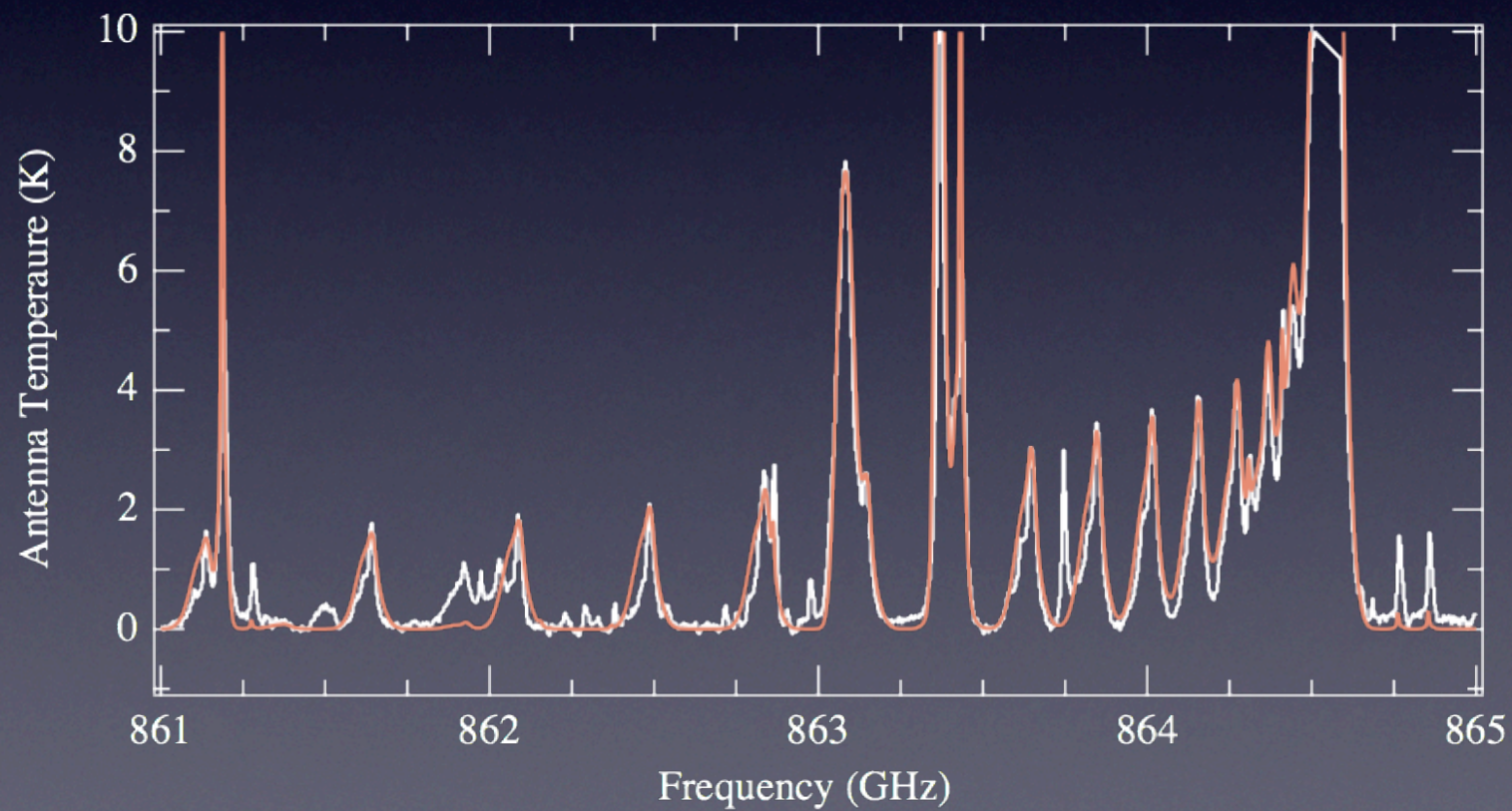
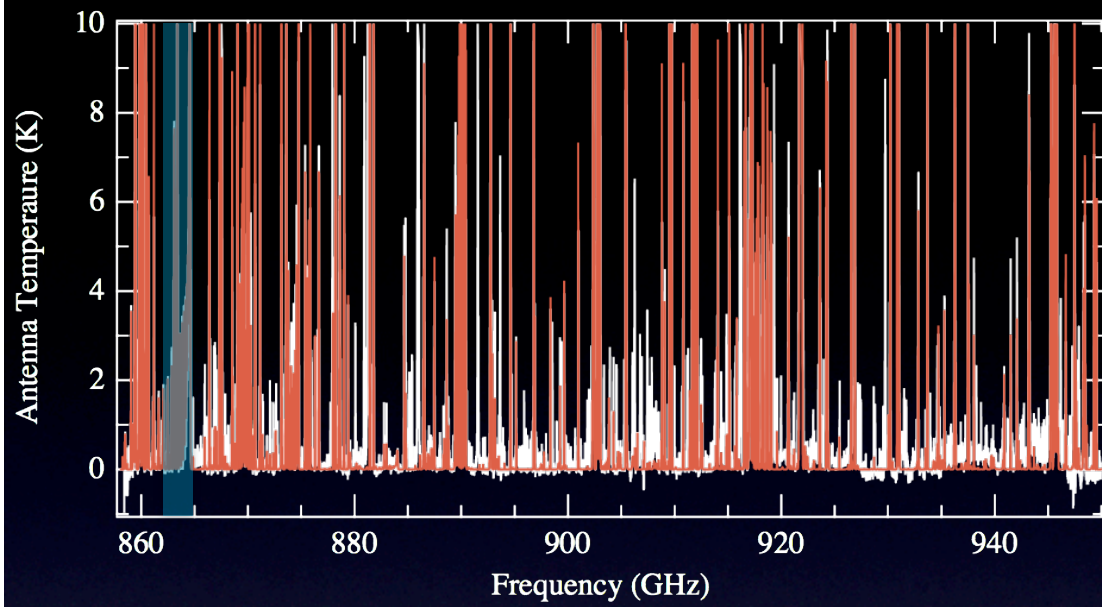


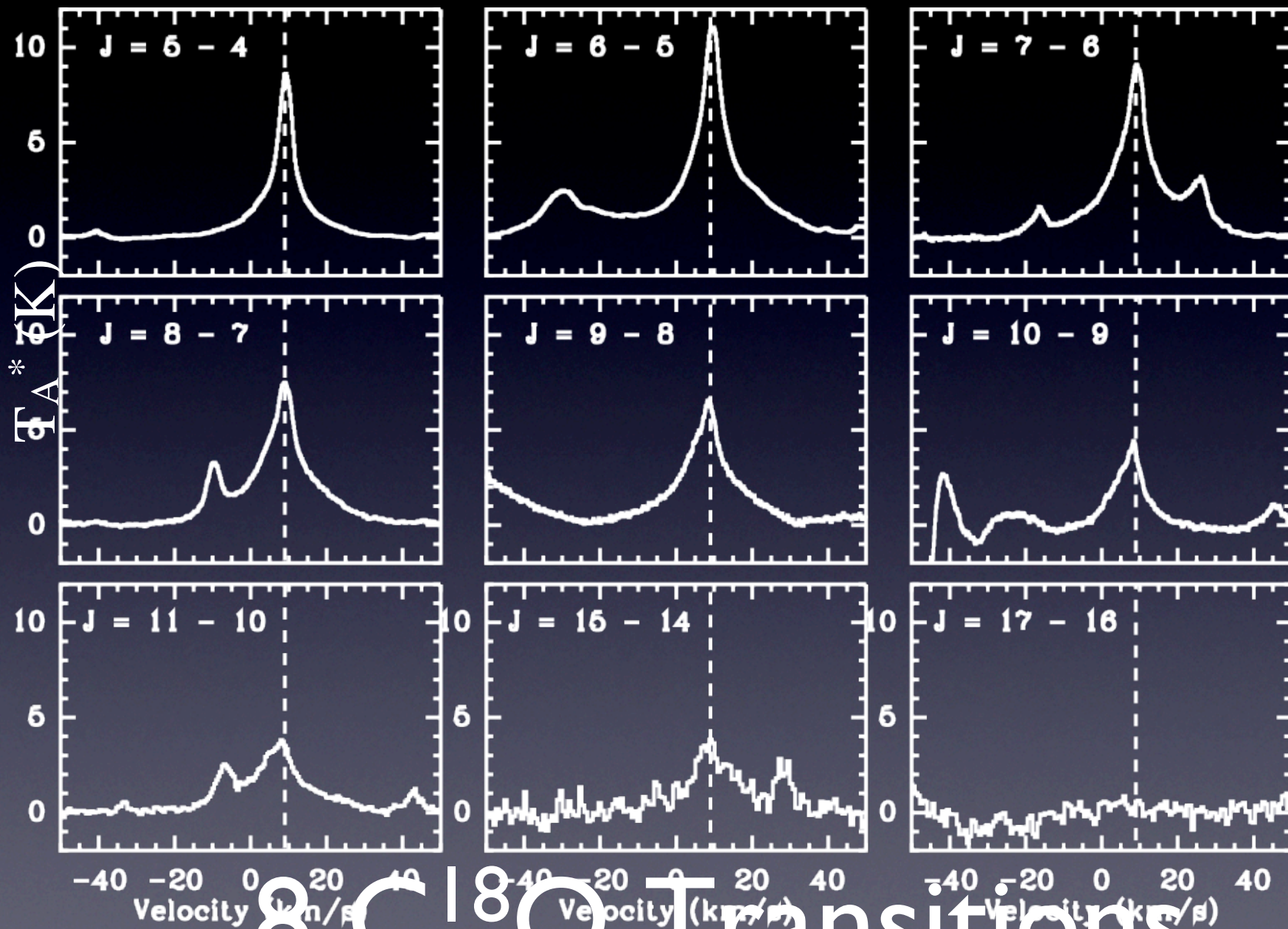
Methanol (CH₃OH) Emission



Sulfur Dioxide Emission







$8C^{18}O$ Transitions

C¹⁸O Column

$$N_u \propto \int T dv$$

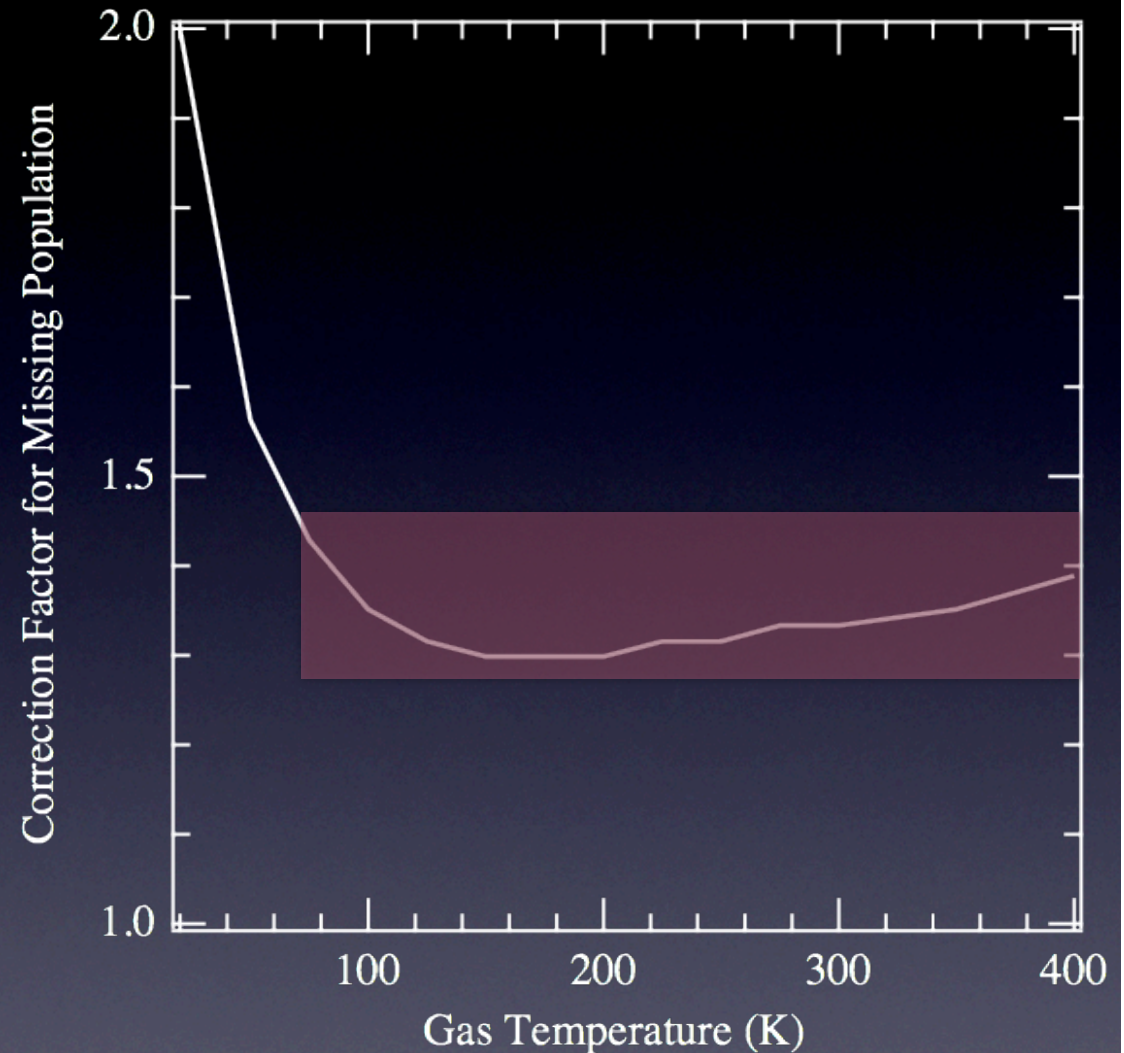
$$N_{\text{tot}} = CF(T) \times \sum N_u(J)$$

Hot Core:

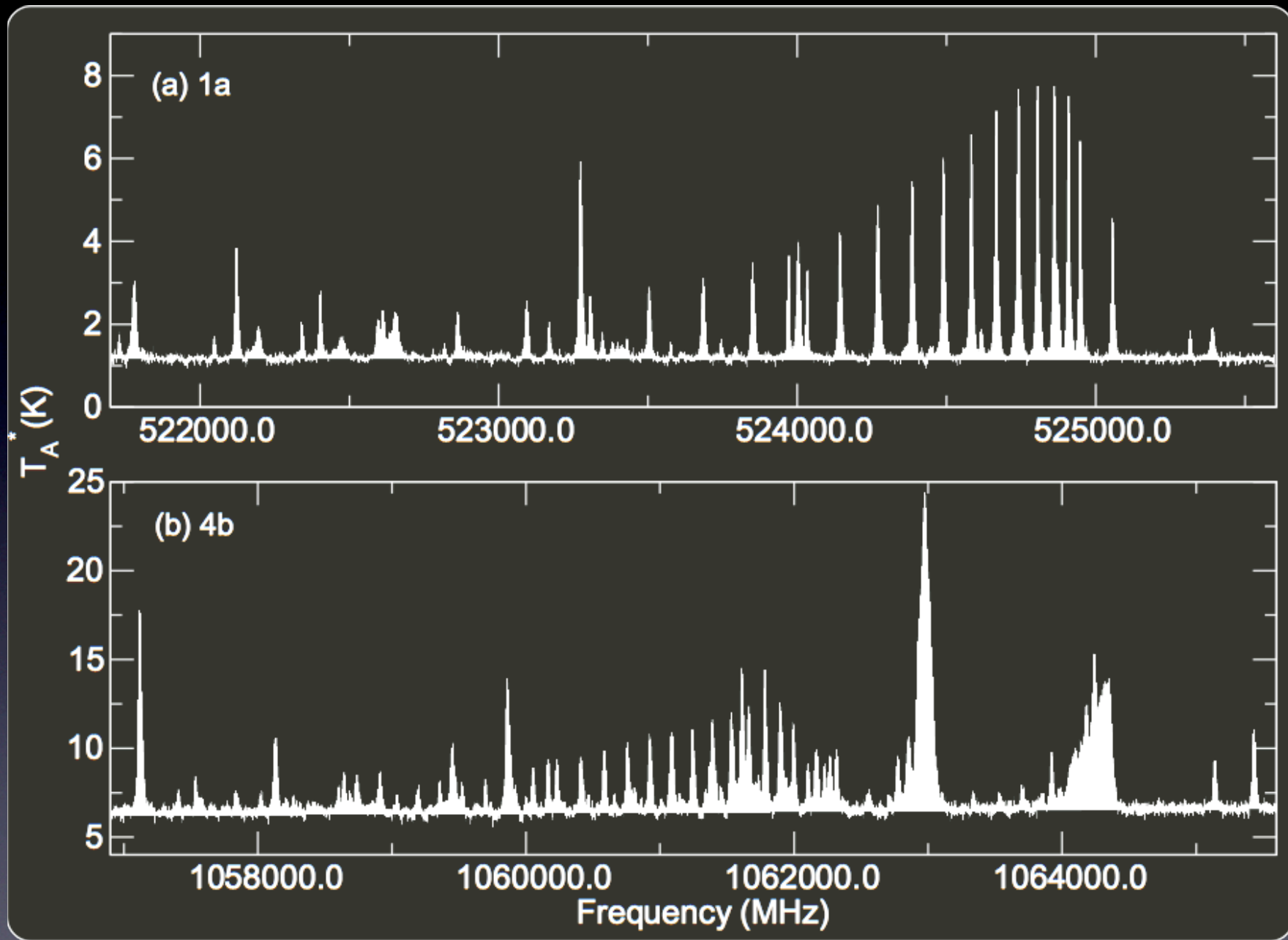
$$N(\text{C}^{18}\text{O}) = 5.8 \times 10^{16} \text{ cm}^{-2}$$

Compact Ridge:

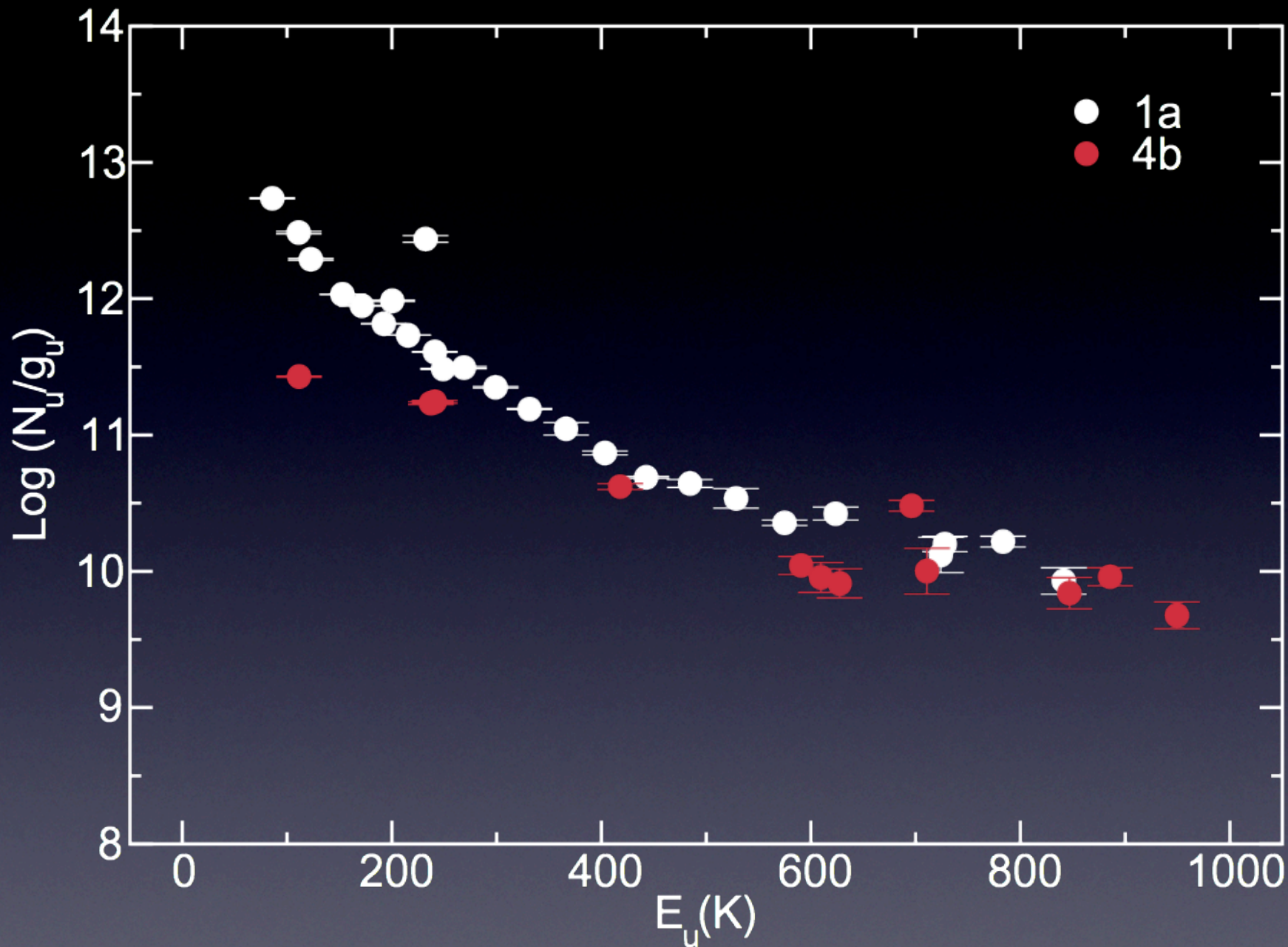
$$N(\text{C}^{18}\text{O}) = 3.2 \times 10^{16} \text{ cm}^{-2}$$



R. Plume

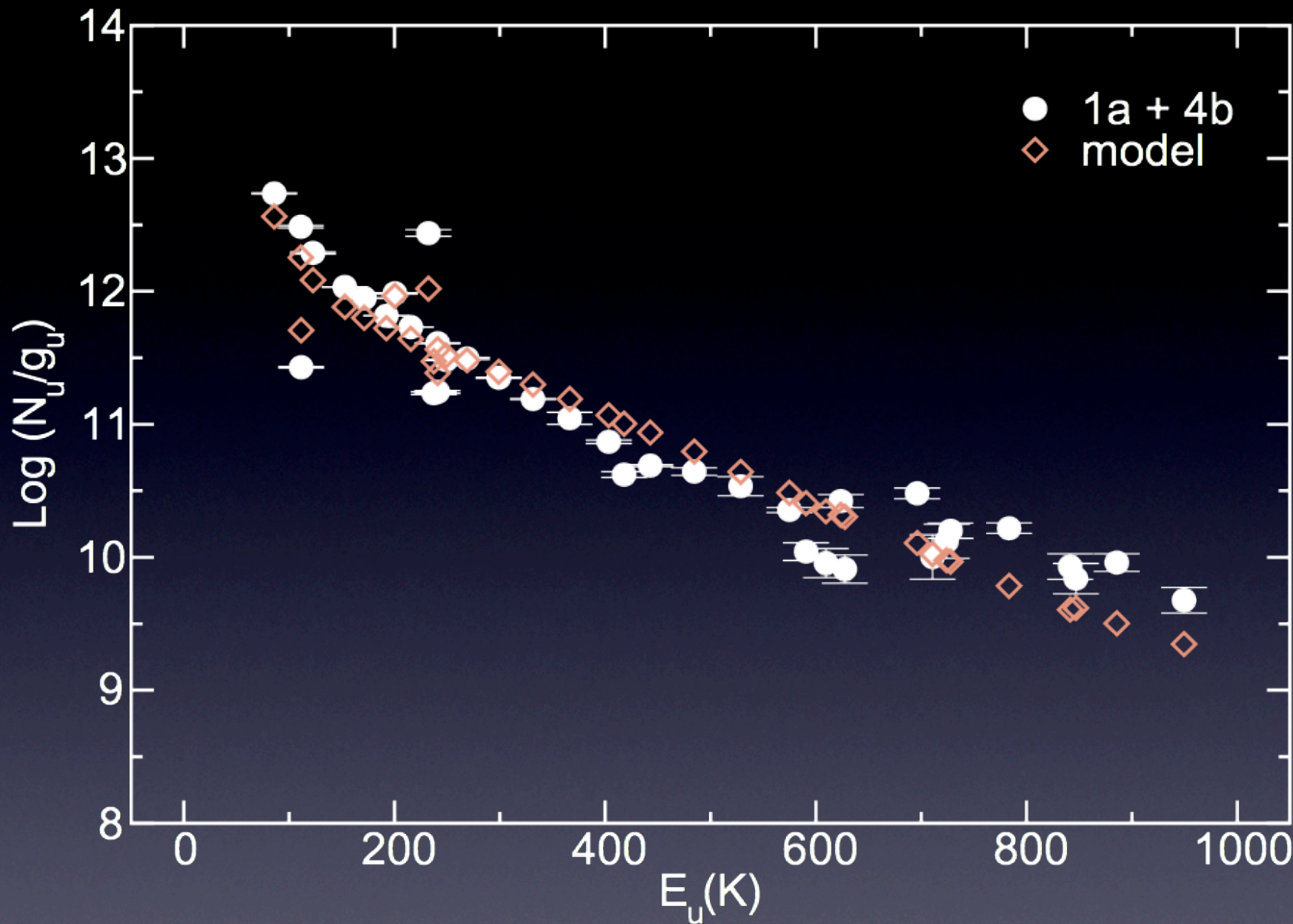


CH₃OH - Weed or ?



S. Wang

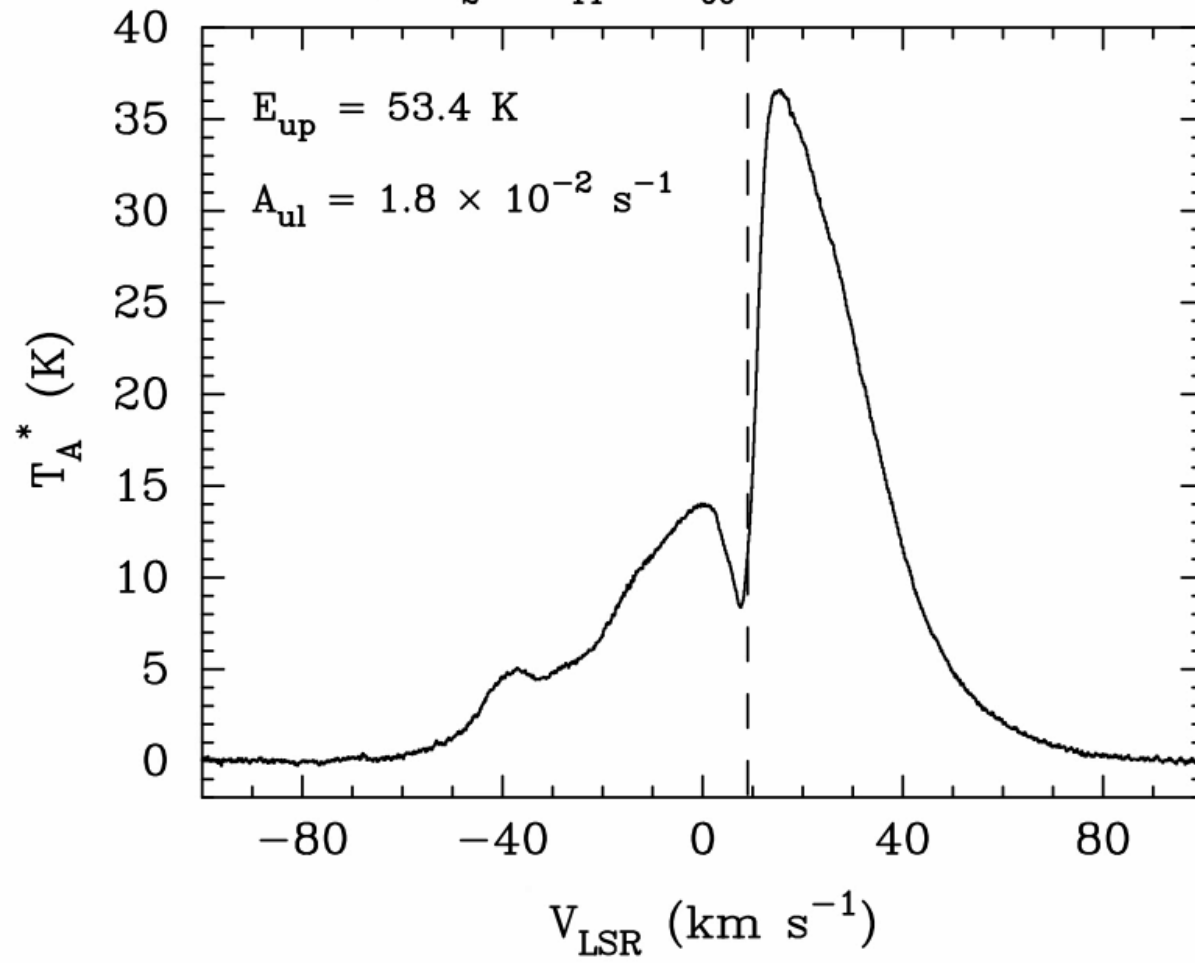
CH_3OH - Weed or ?

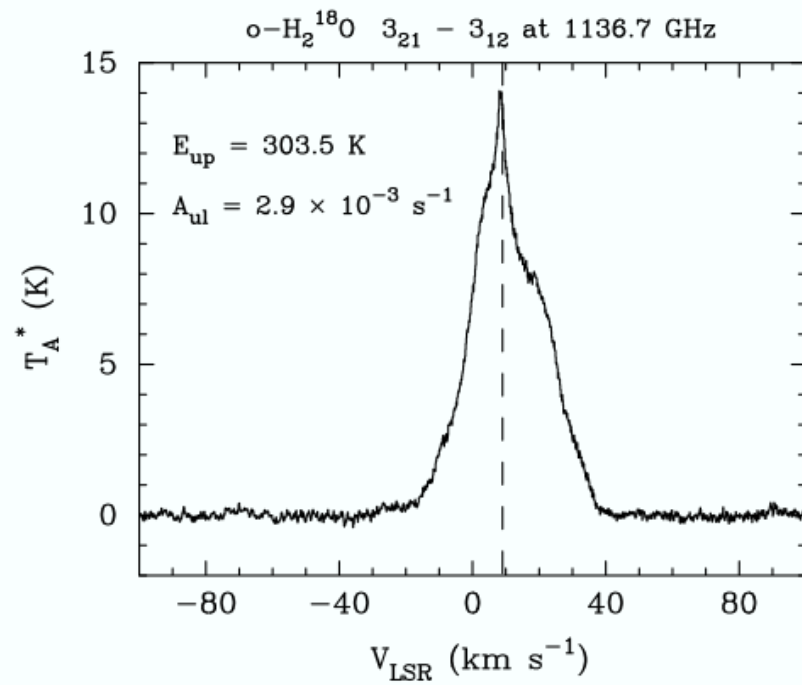
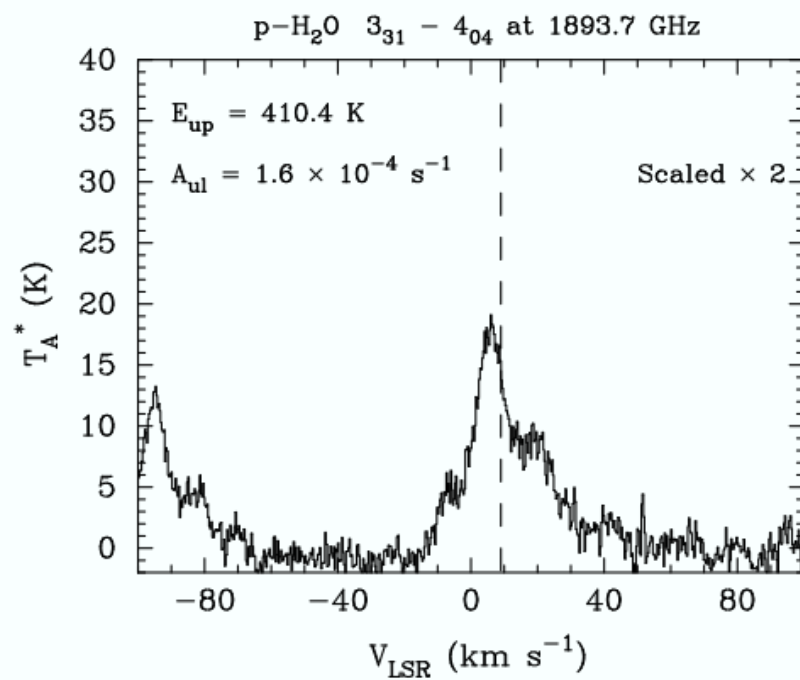
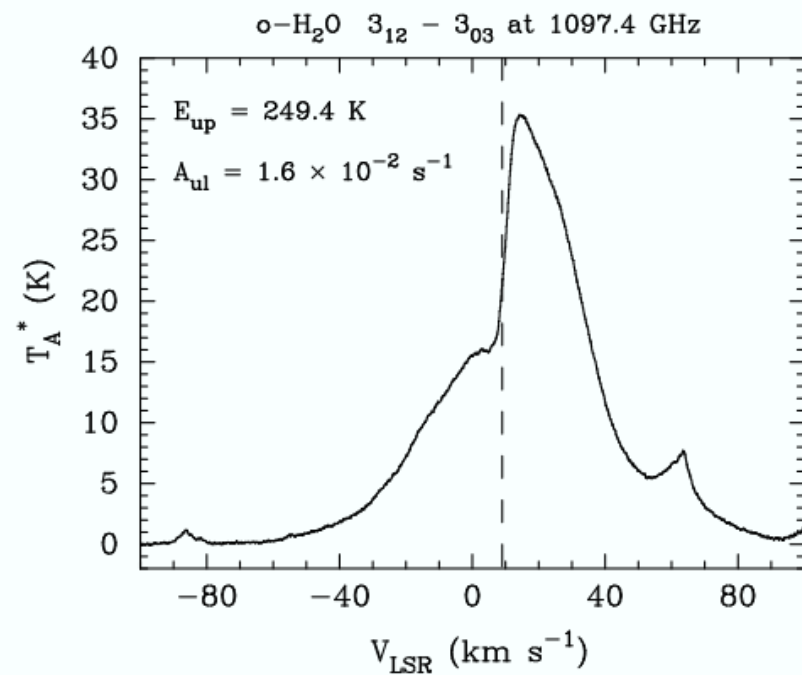
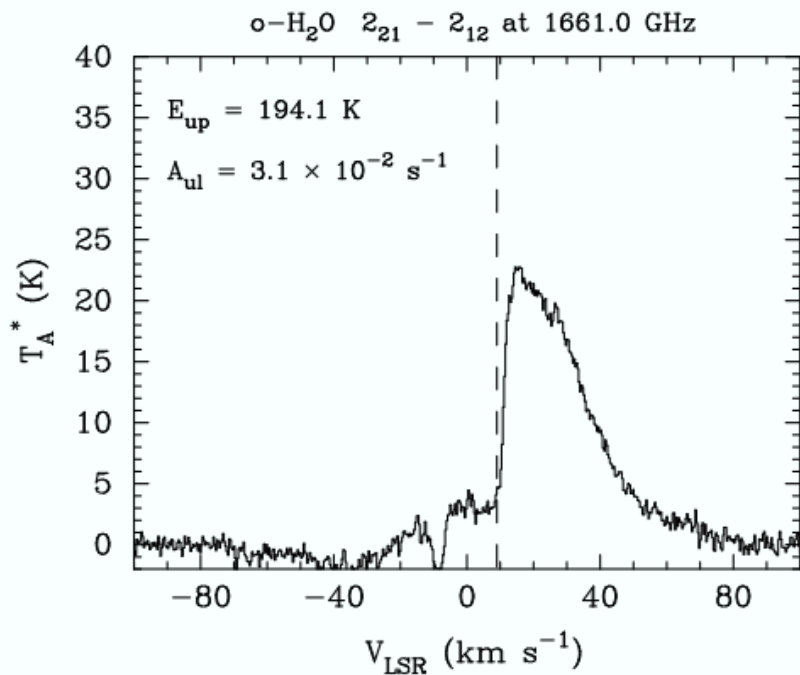


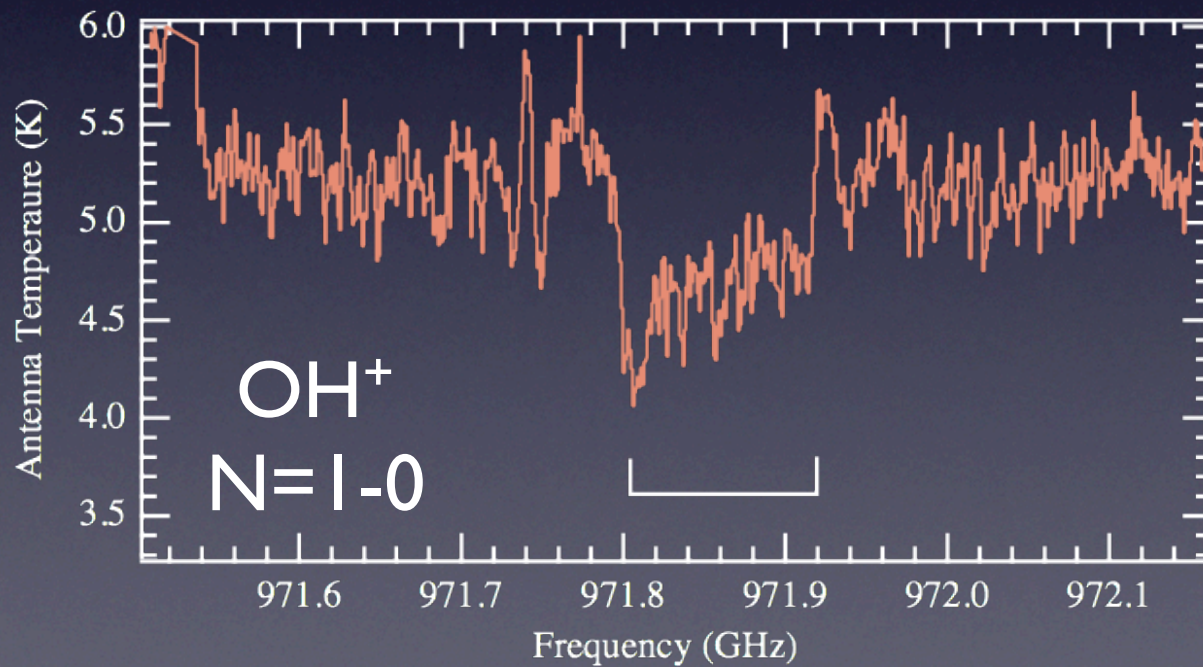
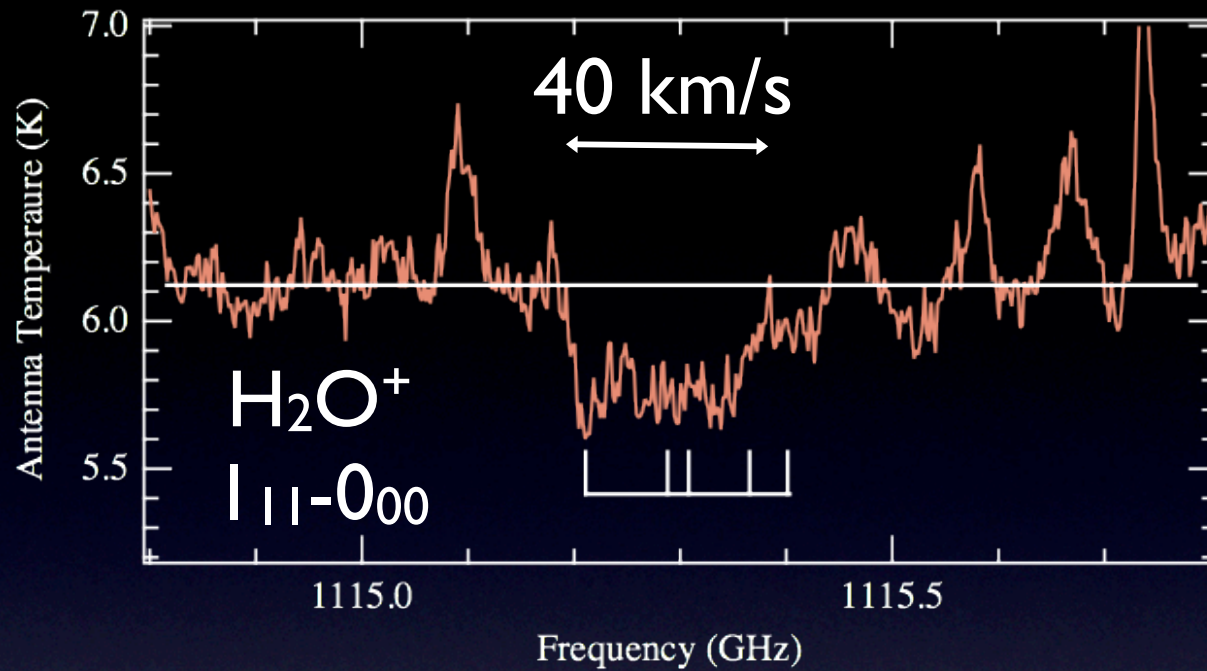
S. Wang

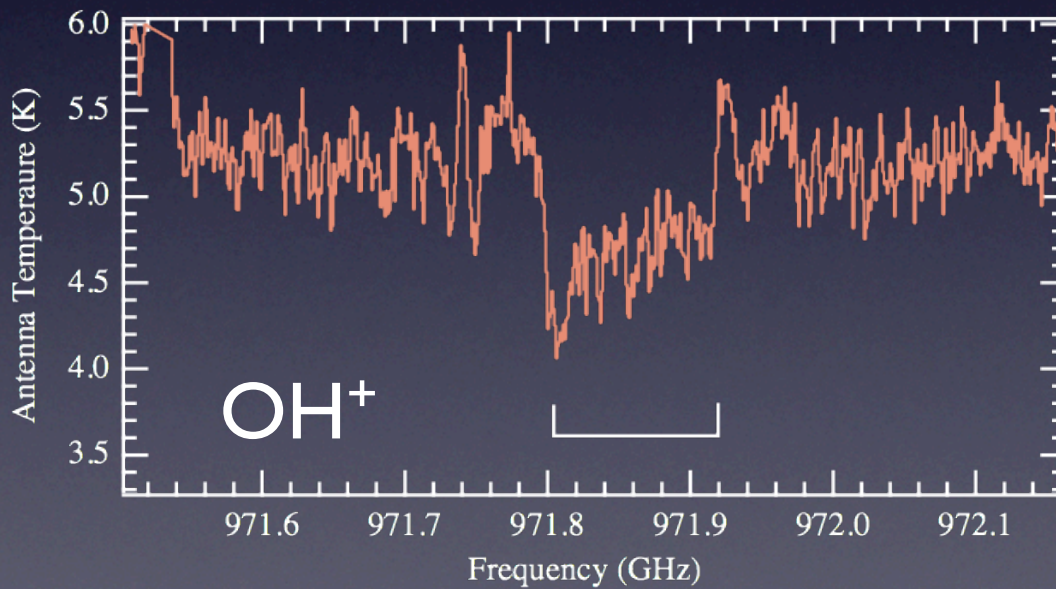
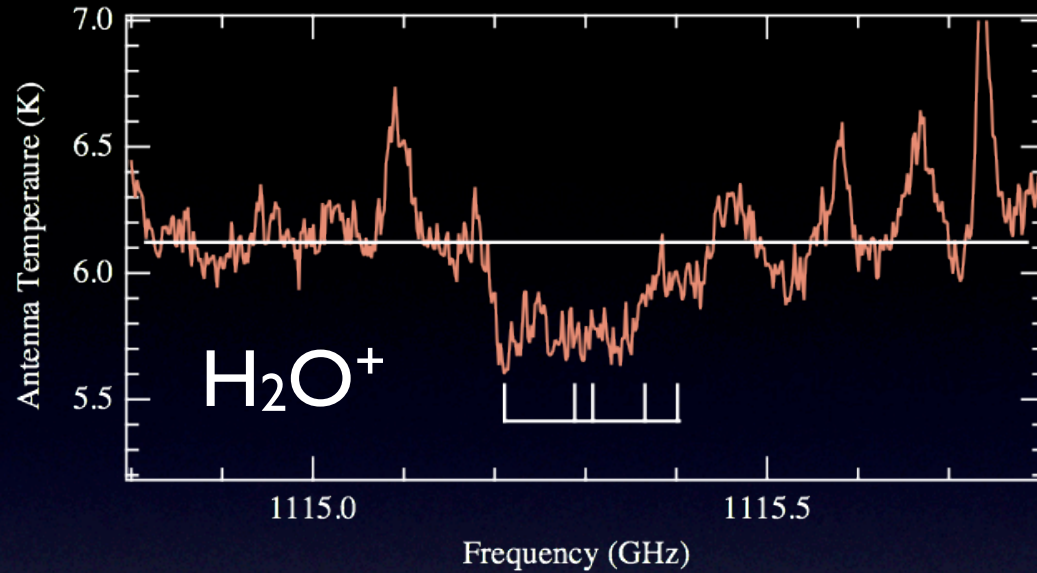
CH_3OH - Weed or ?

p-H₂O 1₁₁ - 0₀₀ at 1113.3 GHz





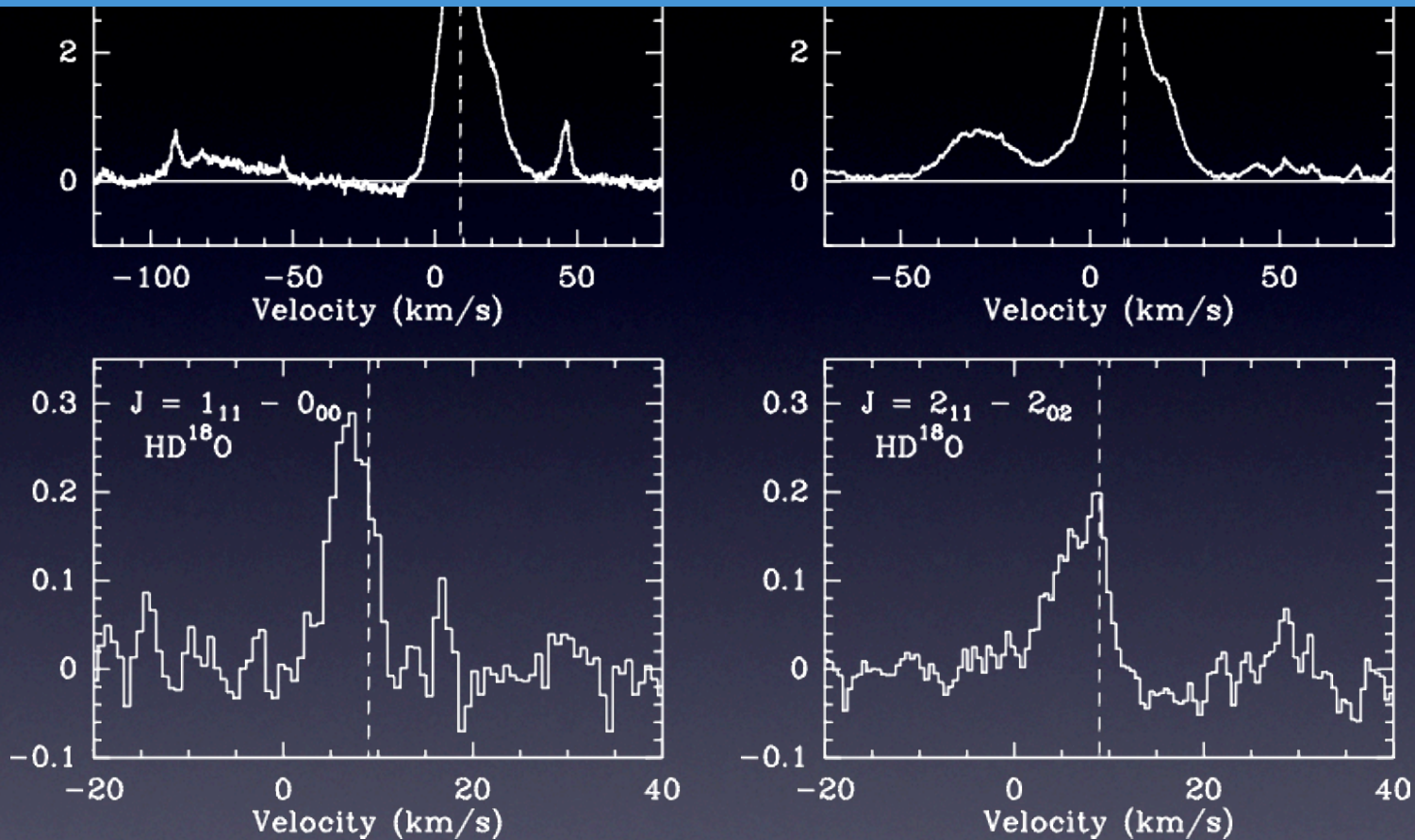




- $\text{H}_2\text{O}^+/\text{OH}^+ \sim 1$
- Greater than seen in diffuse clouds
- No hint of H_3O^+
- Exploring the possibility of H_2O in outflow dissociated by enhanced UV

Preliminary Estimate: $\text{HDO}/\text{H}_2\text{O} \sim 3 \times 10^{-3}$
Previous value $\sim 10^{-4}$

T_A^* (K)



E. Bergin

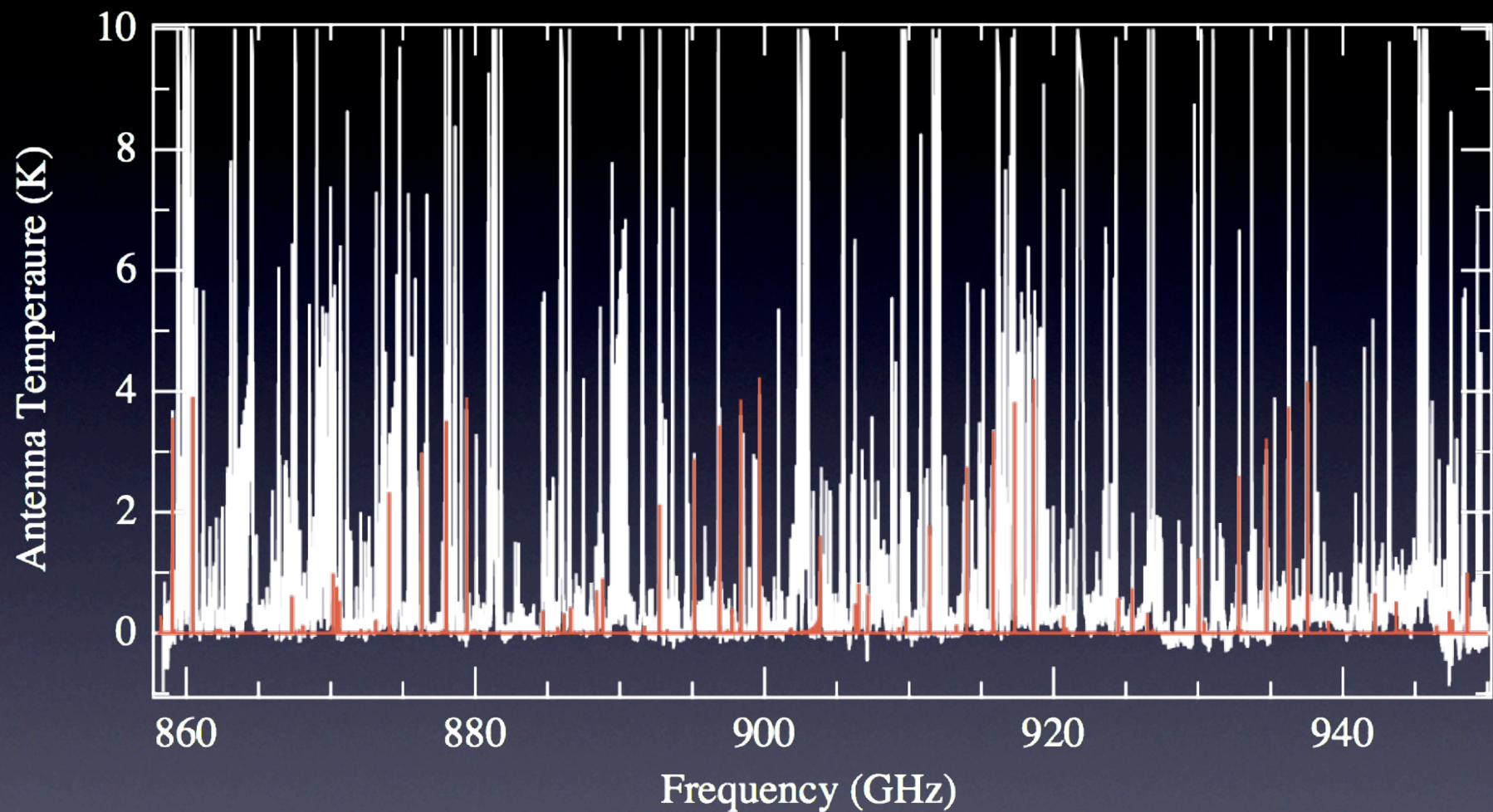
Detection of HD^{18}O

HEXOS Summary

- HIFI is a fantastic tool to explore the molecular spectrum.
- Look forward to extending the survey to other template objects and to include PACS spectra.
- Survey will define the far-IR spectrum of molecular gas.
- Science snippets from Orion (just beginning!):
 - ➔ Very hot water seen in all spatial/velocity components
 - ➔ D/H ratio of water will be revised
 - ➔ CH₃OH provides a powerful tool to explore gas physical state
 - ➔ and more (HF/C¹⁸O/H₂O⁺,.....)

People and institutes instrument development/ICC

- Th. deGraauw, F.P.Helmich, T.G. Phillips, J. Stutzki, E.Caux, A.G.G.M.Tielens, N.D.Whyborn, P. Dieleman, P.R.Roelfsema, H.Aarts, R.Assendorp, R. Bachiller, W.Baechtold, A. Barcia, D.A.Beintema, V. Belitsky, A.Benz, R. Bieber, A.Boogert, C.Borys, B. Bumble, P.Cais, M. Caris, P.Cerulli-Irelli, G. Chattopadhyay, S.Cherednichenko, M. Ciechanowicz, O.Coeur-Joly, C.Comito, A. Cros, A. de Jonge, G. de Lange, B.Delfrges, Y.Delorme, T. den Boggende, J.-M.Desbat, C.Diez-Gonzalez, A.M.DiGiorgio, L.Dubbeldam, K. Edwards, M. Eggens, N. Erickson, J. Evers, M. Fich, T. Finn, B. Franke, .Gaier, C.Gal, Gao, J.R., J.-D.Gallego, S.Gaufr, J.J.Gill, S.Glenz, H.Golstein, H.Goulooze, T.Gunsing, R Guesten, P.Hartogh, W. A.Hatch, R.Higgins, E.C.Honingh, R.Huisman, B.D. Jackson, H. Jacobs, K. Jacobs, C. Jarchow, H. Javadi, W. Jellema, M. Justen, A.Karpov, C.Kasemann, J.Kawamura, G.Keizer, D.Kester, T.M.Klapwijk, Th.Klein, E.Kollberg, J.Kooi, P.-P.Kooiman, B.Kopf, M.Krause, J.-M.Krieg, C.Kramer, B.Kruizenga, T.Kuhn, W. Laauwen, R. Lai, B. Larsson, H.G. Leduc, C. Leinz, R.H. Lin, R. Liseau, GS Liu, A. Loose, I. Lopez-Fernandez, S. Lord, W. Luinge, A.Marston, J.Martin-Pintado, A.Maestrini, F.W.Maiwald, C.McCoey, A.Megej, M.Melchior, L.Meinsma, H.Merkel, M.Michalska, C.Monstein, D.Moratschke, I.Mehdi, P.Morris, H.Muller, J.A.Murphy, A.Naber, E.Natale, W.Nowosielski, F.Nuzzolo, M.Olberg, M.Olbrich, R.Orfei, P.Orleanski, V.Ossenkopf, T. Peacock, J.C. Pearson, I. Peron, S. Phillip-May, L. Piazza, P. Planesas, M. Rataj, L.Ravera, C.Risacher, M. Salez, L.A. Samoska, P. Saraceno, R. Schieder, E. Schlecht, F. Schloeder, F. Schmuelling, M. Schultz, K. Schuster, R.Shipman, O. Siebertz, H. Smit, R. Szczerba, R. Shipman, E. Steinmetz, J.A. Stern, M. Stokroos, R. Teipen, D. Teyssier, T. Tils, N. Trappe, C. van Baaren, B.-J. van Leeuwen, H. van de Stadt, H.Visser, K.J.Wildeman, C.K.Wafelbakker, J.S.Ward, P.Wesselius, W.Wild, S.Wulff, H.-J.Wunsch, X. Tielens, P. Zaal, H. Zirath, J. Zmuidzinas, and F. Zwart
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- And many people in the workshops of all the institutes involved
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DiMethyl Ether (CH_3OCH_3) Emission