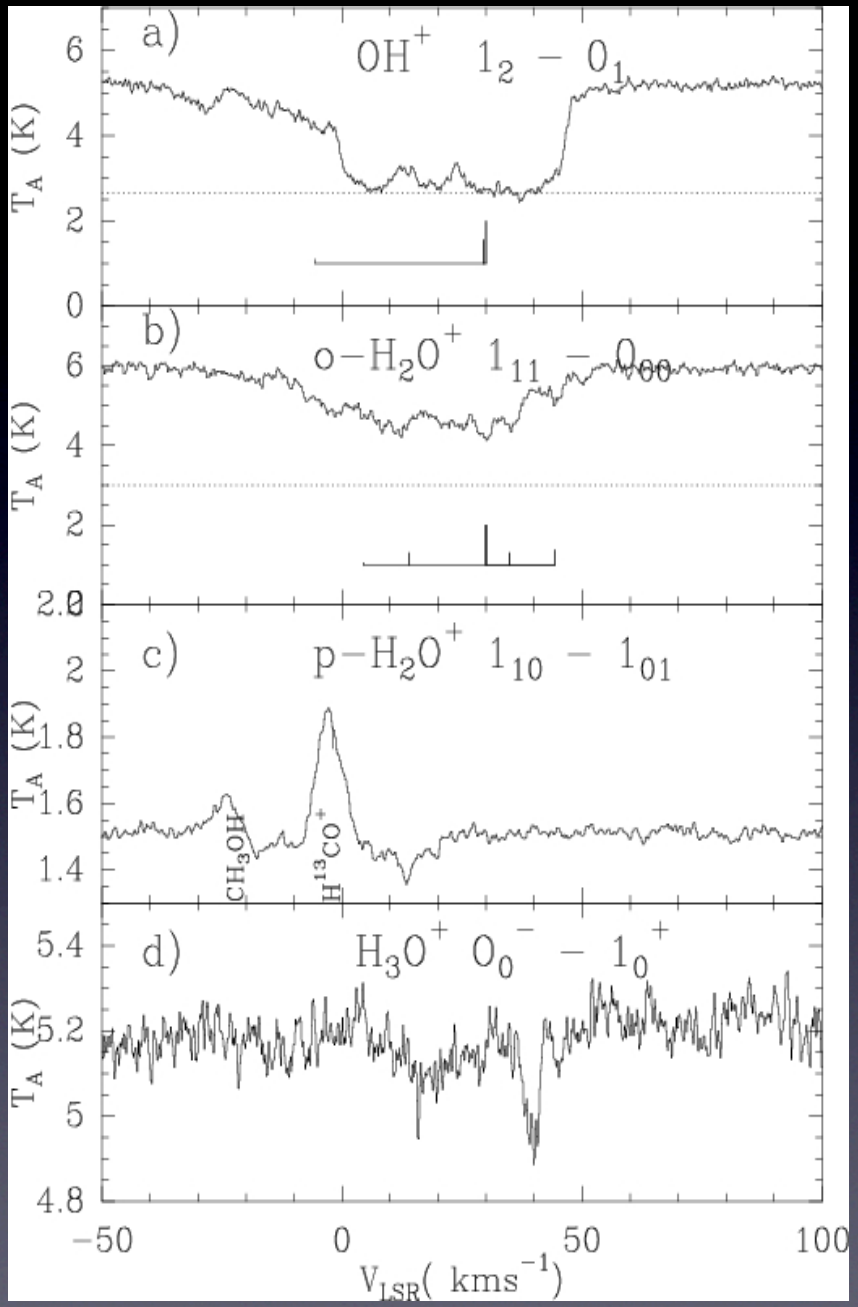
Herschel and Interstellar Chemistry
First Results

E. Bergin (Univ. of Michigan)
on behalf of the HIFI Consortium

HIFI GT Key Programs

- Water in star forming regions with Herschel (WISH): Ewine van Dishoeck PI
- Probing interstellar molecules with absorption line studies (PRISMAS): Maryvonne Gerin PI
- Herschel Chemical Survey of Star Forming Regions (CHESS): Cecilia Ceccarelli PI
- Herschel observations of extra-ordinary sources (HEXOS): Edwin Bergin PI

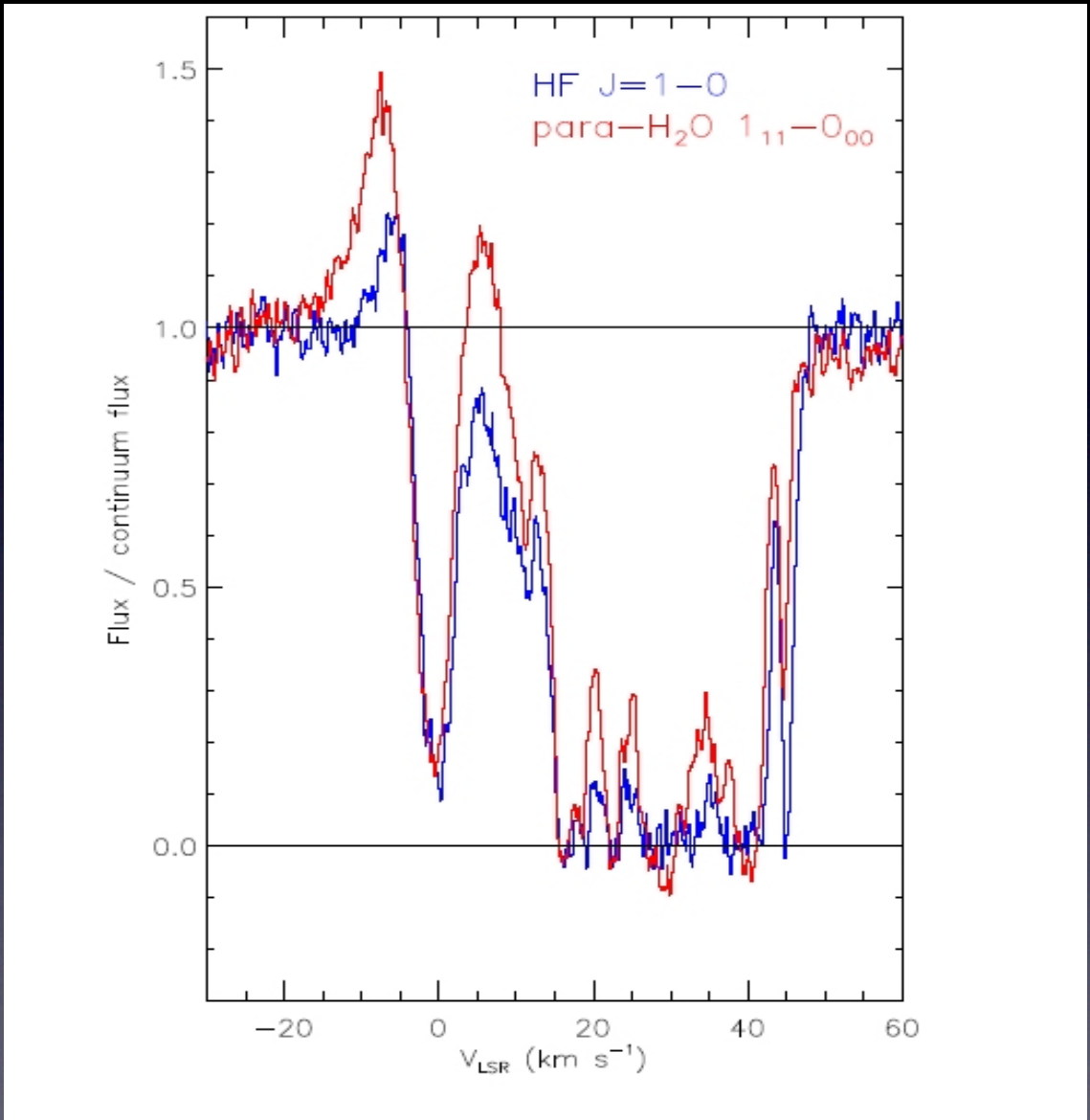


$OH^+ \Rightarrow H_2O^+ \Rightarrow H_3O^+$

- Abundant H_2O^+ and OH^+ in diffuse clouds
- Strong confirmation of the pathways to gas phase water

Gerin et al. 2010,
Benz et al. 2010,
Ossenkopf et al. 2010,
Schilke et al. 2010

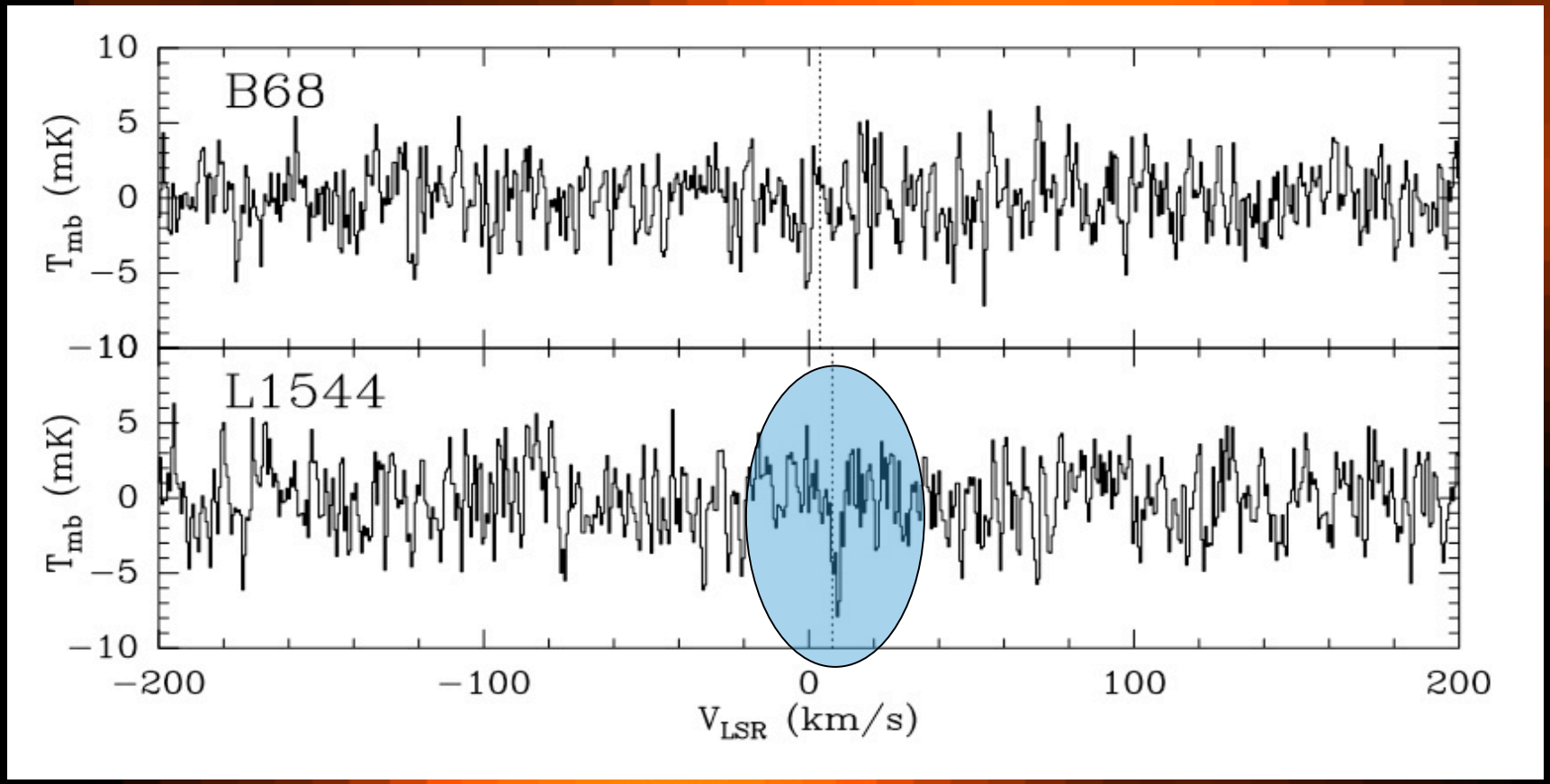
Interstellar HF



- F reacts exothermically with H_2
- unique tracer of H_2!

Neufeld et al. 2010

The prestellar core L1544

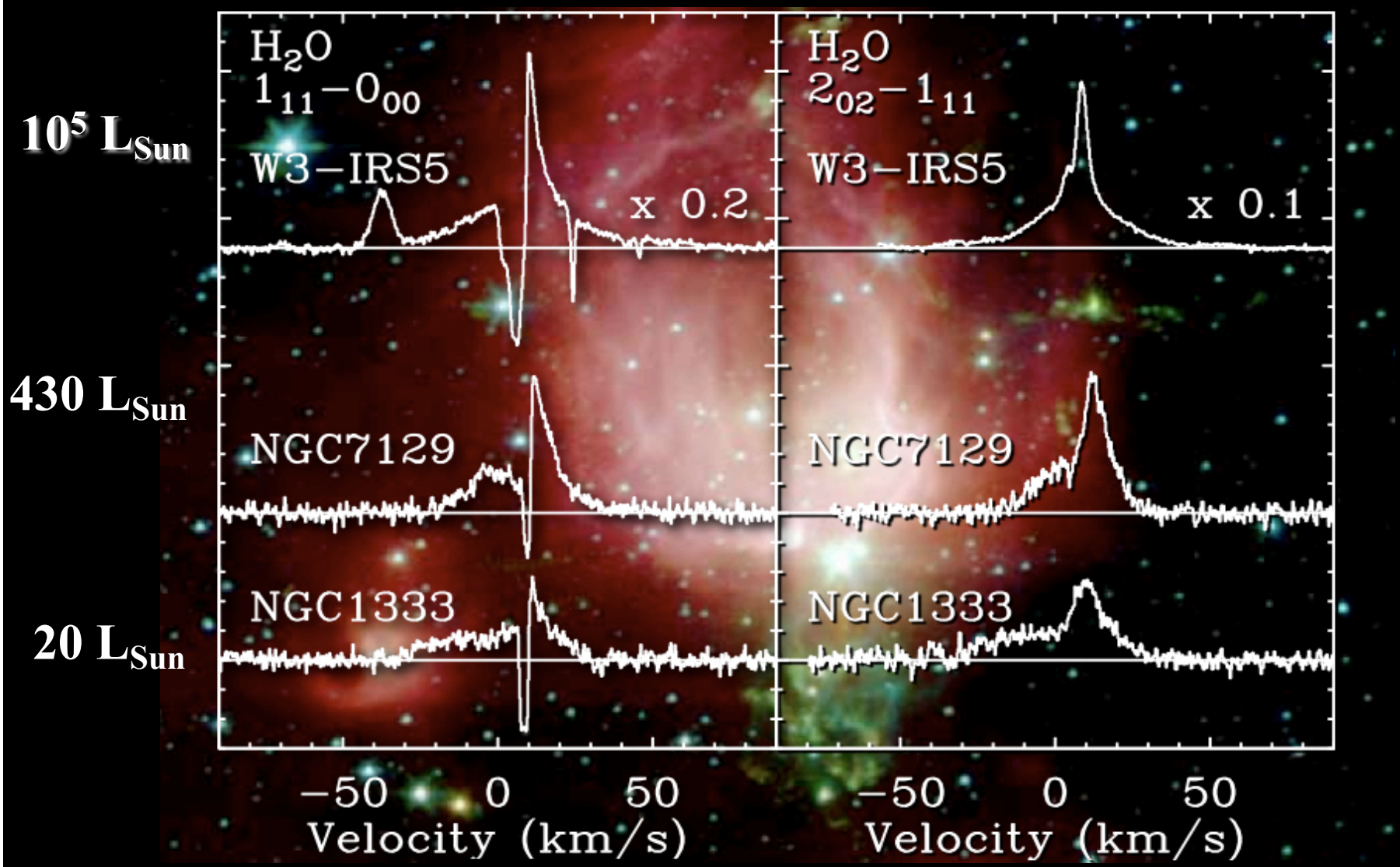


Caselli et al. in prep.

Limit implies water abundance < 10^{-9} for n=10^5 cm^{-3}

1.3 mm continuum map from Ward-Thompson et al. (1999)

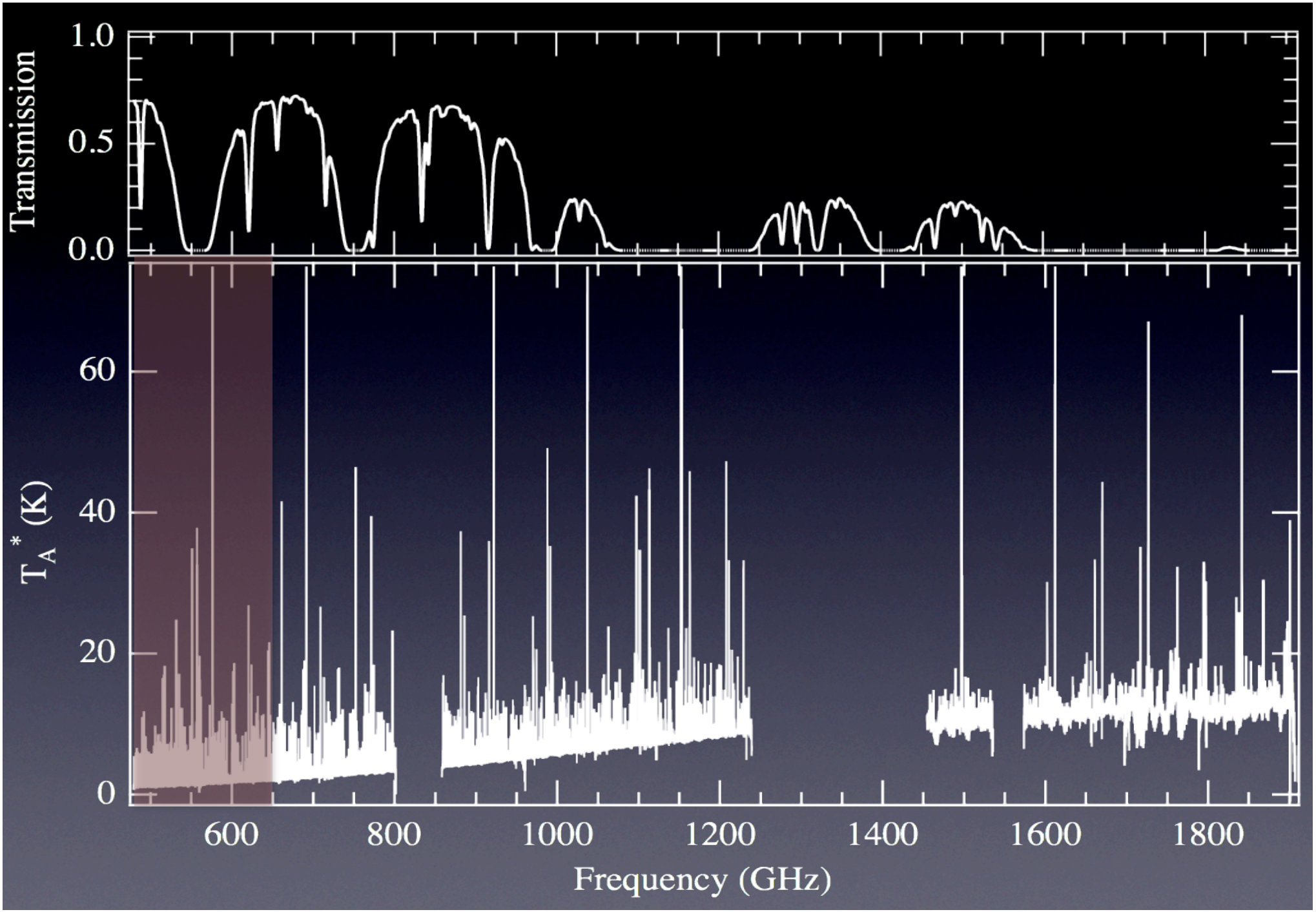
From low to high mass YSOs



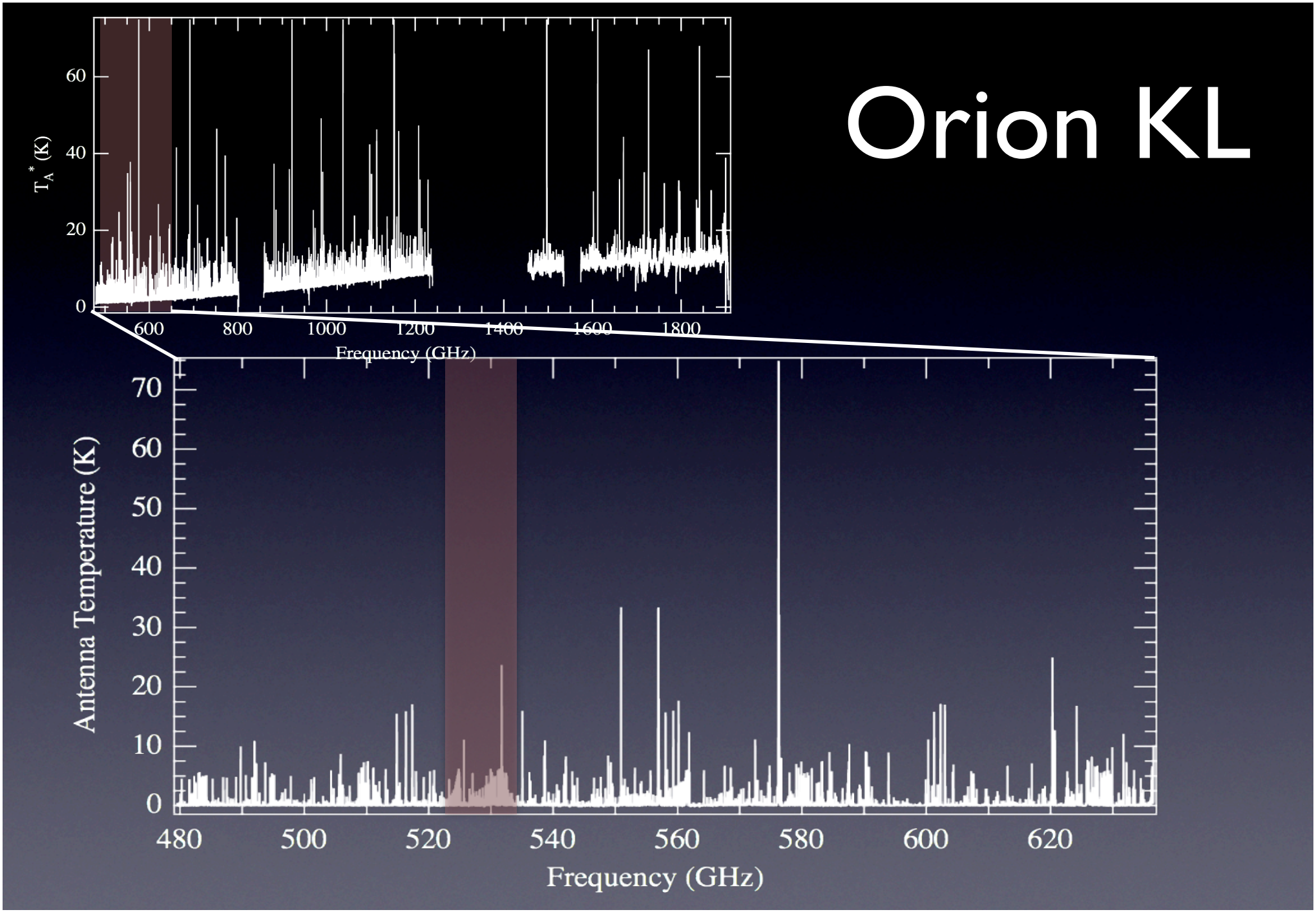
Low and intermediate YSOs similar but high-mass lines much stronger and more complicated line profiles

HIFI and 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
- 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.*


Transmission
1.0
0.5
0.0
T_A^* (K)
60
40
20
0
600
800
1000
1200
1400
1600
1800
Frequency (GHz)

Orion KL


T_A^* (K)
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Frequency (GHz)
Antenna Temperature (K)
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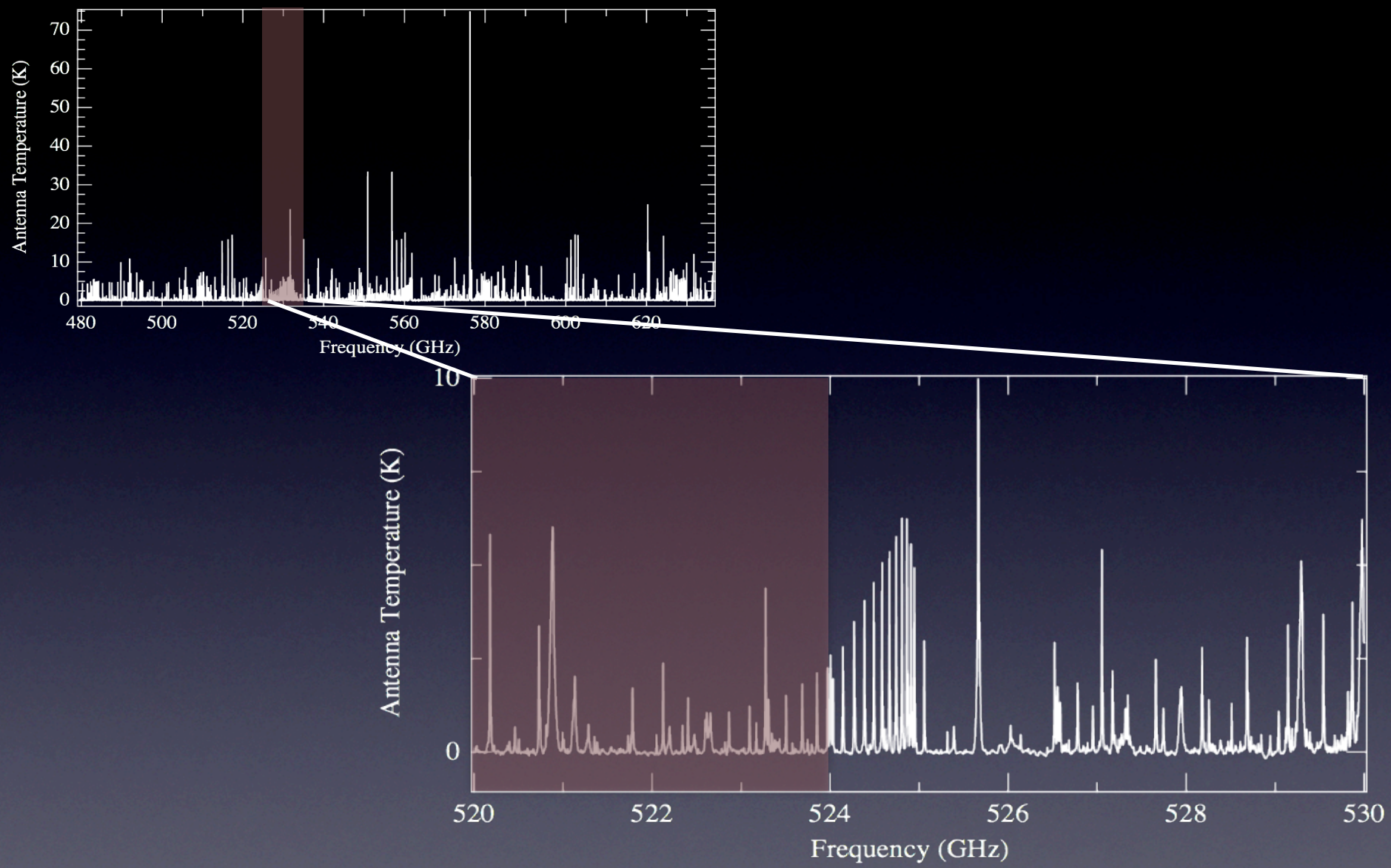
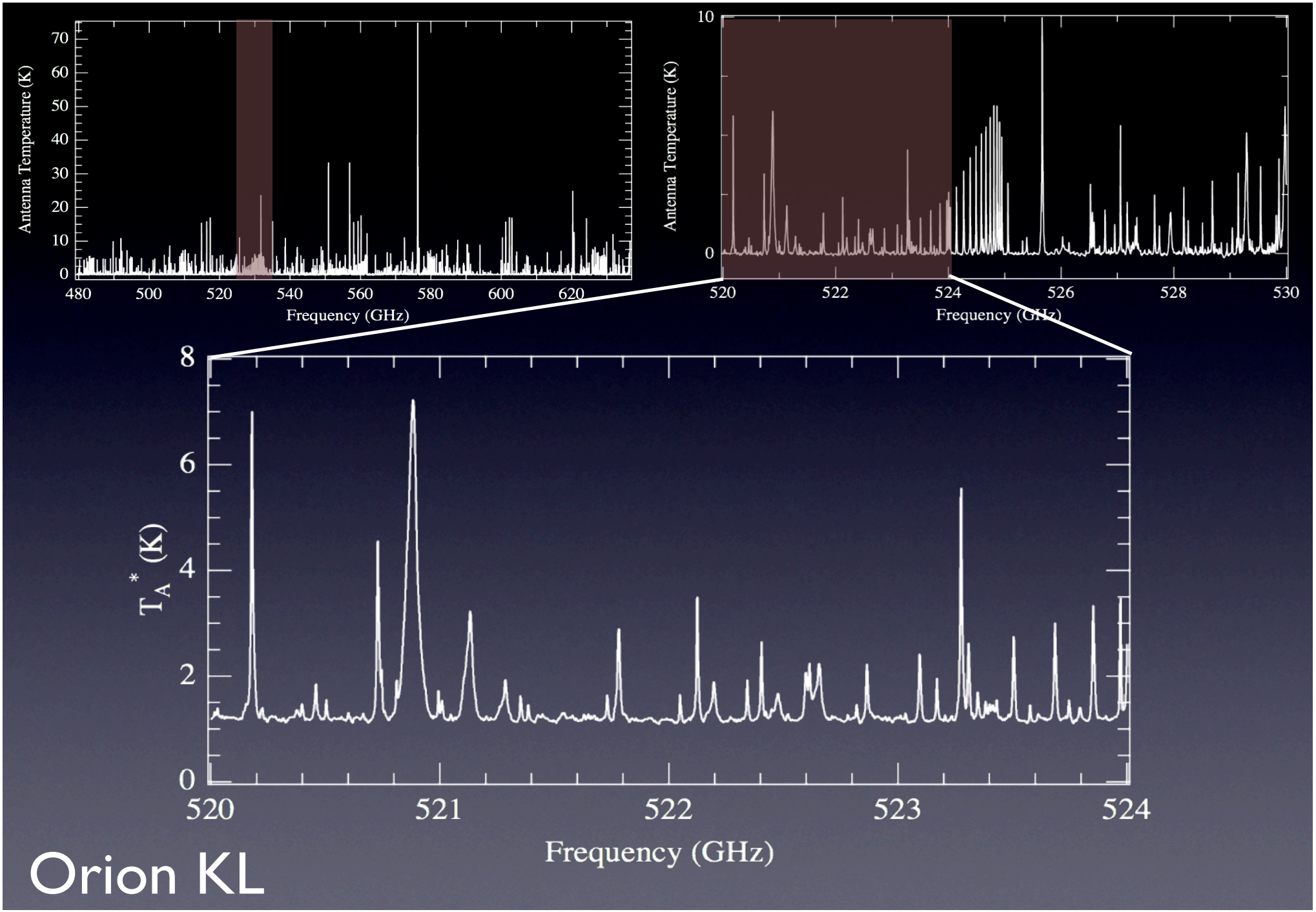
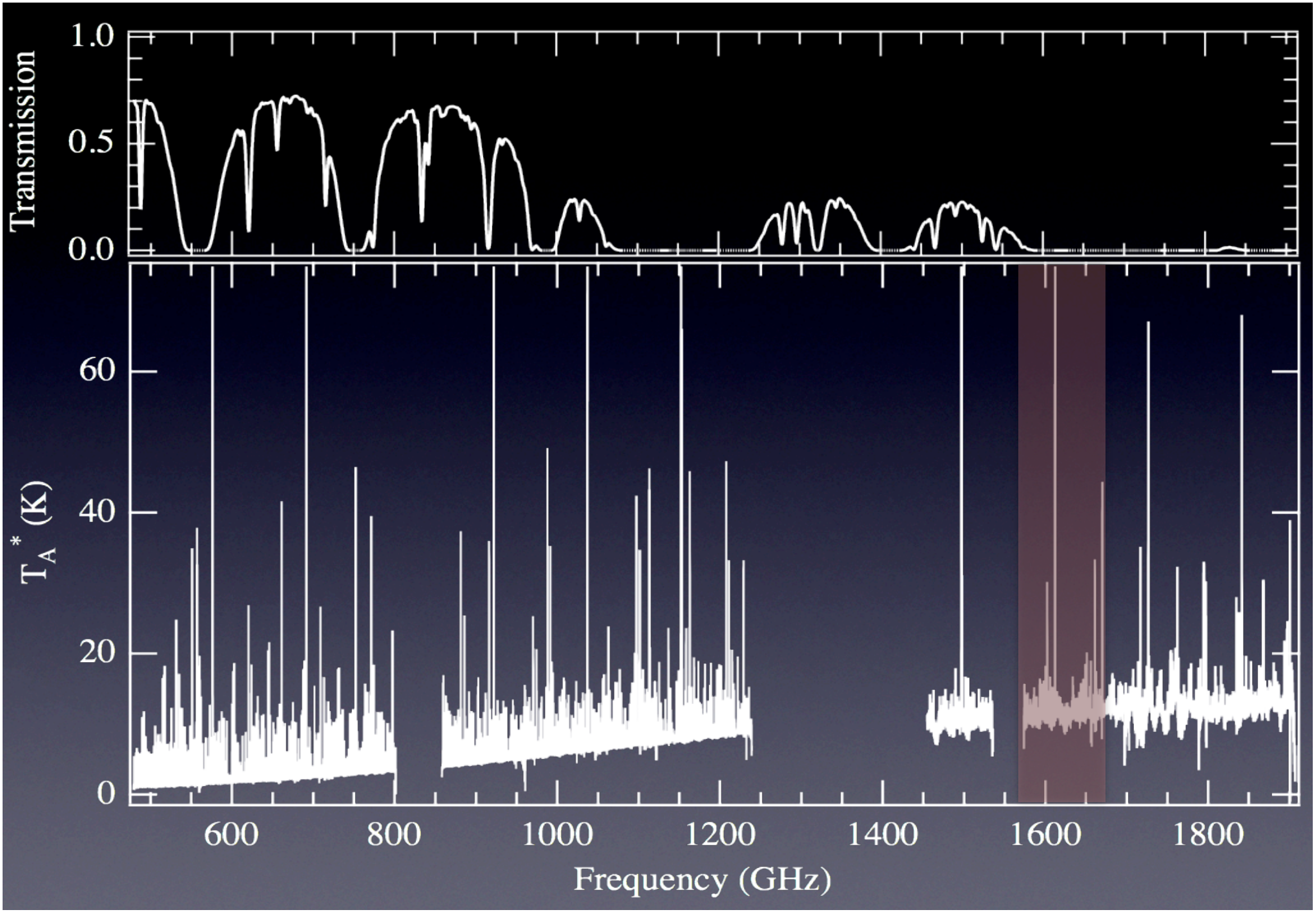
580
600
620
Frequency (GHz)



Orion KL - Band 1


Antenna Temperature (K)
Frequency (GHz)
Antenna Temperature (K)
Frequency (GHz)
T_A^* (K)
Frequency (GHz)
Orion KL


Transmission
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T_A^* (K)
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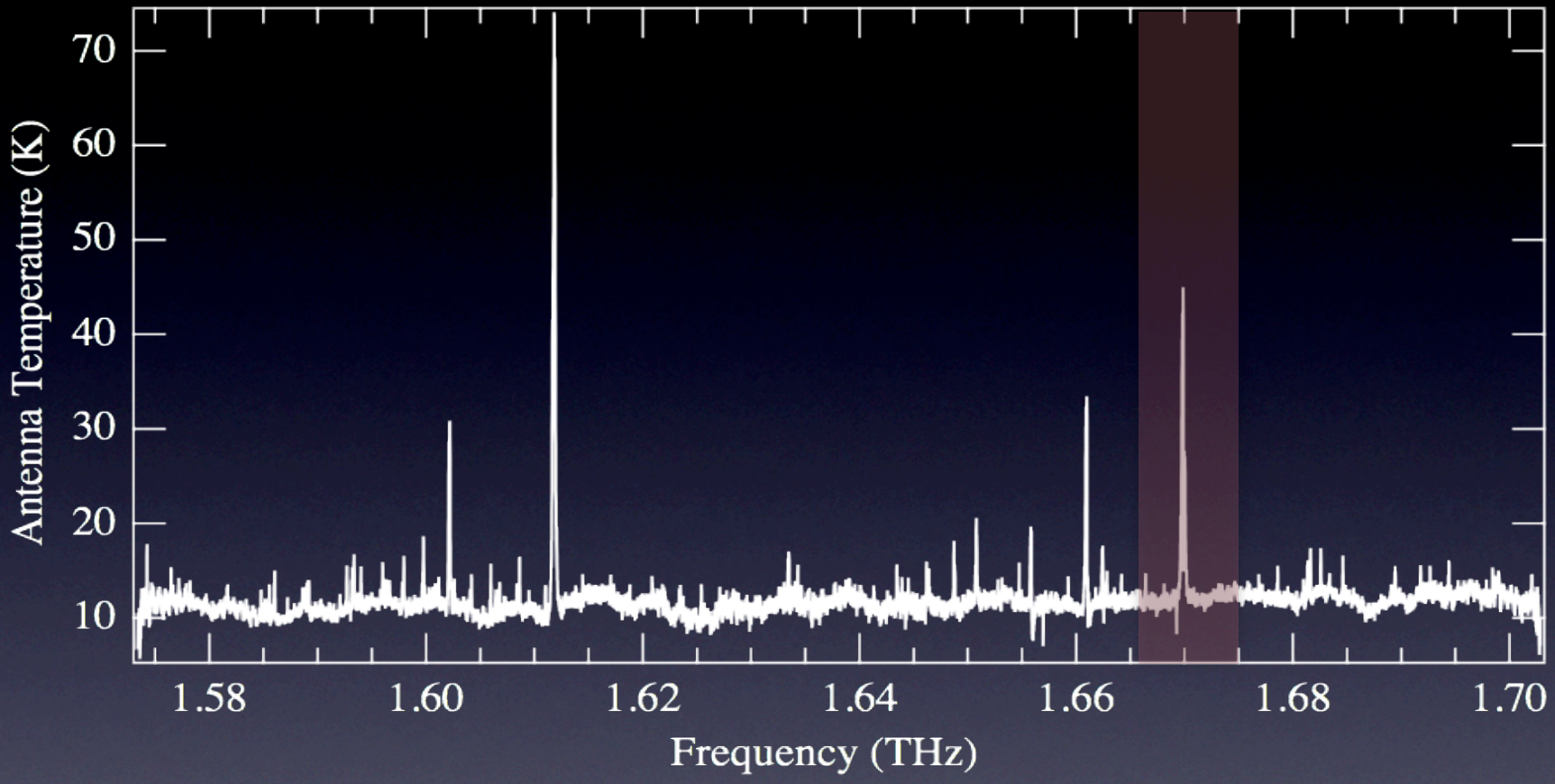
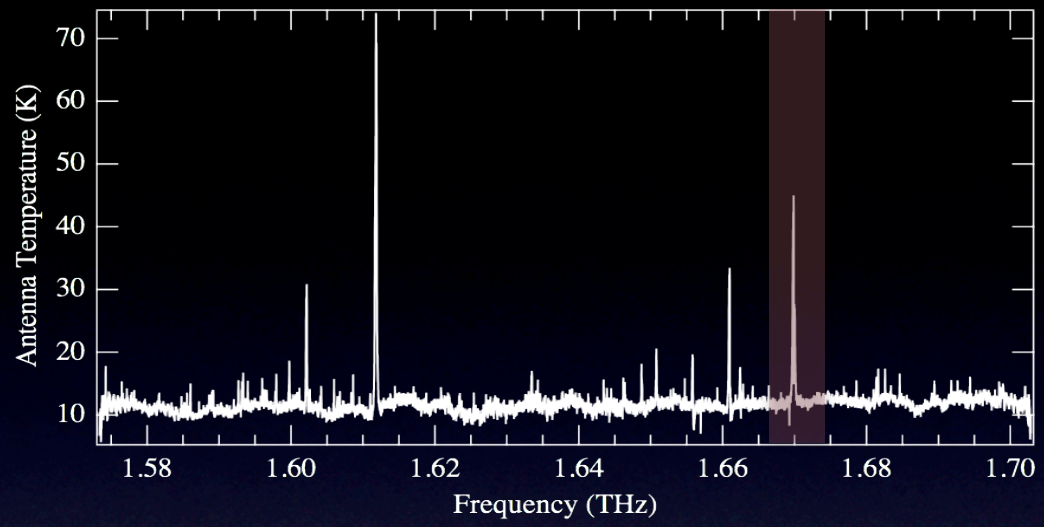
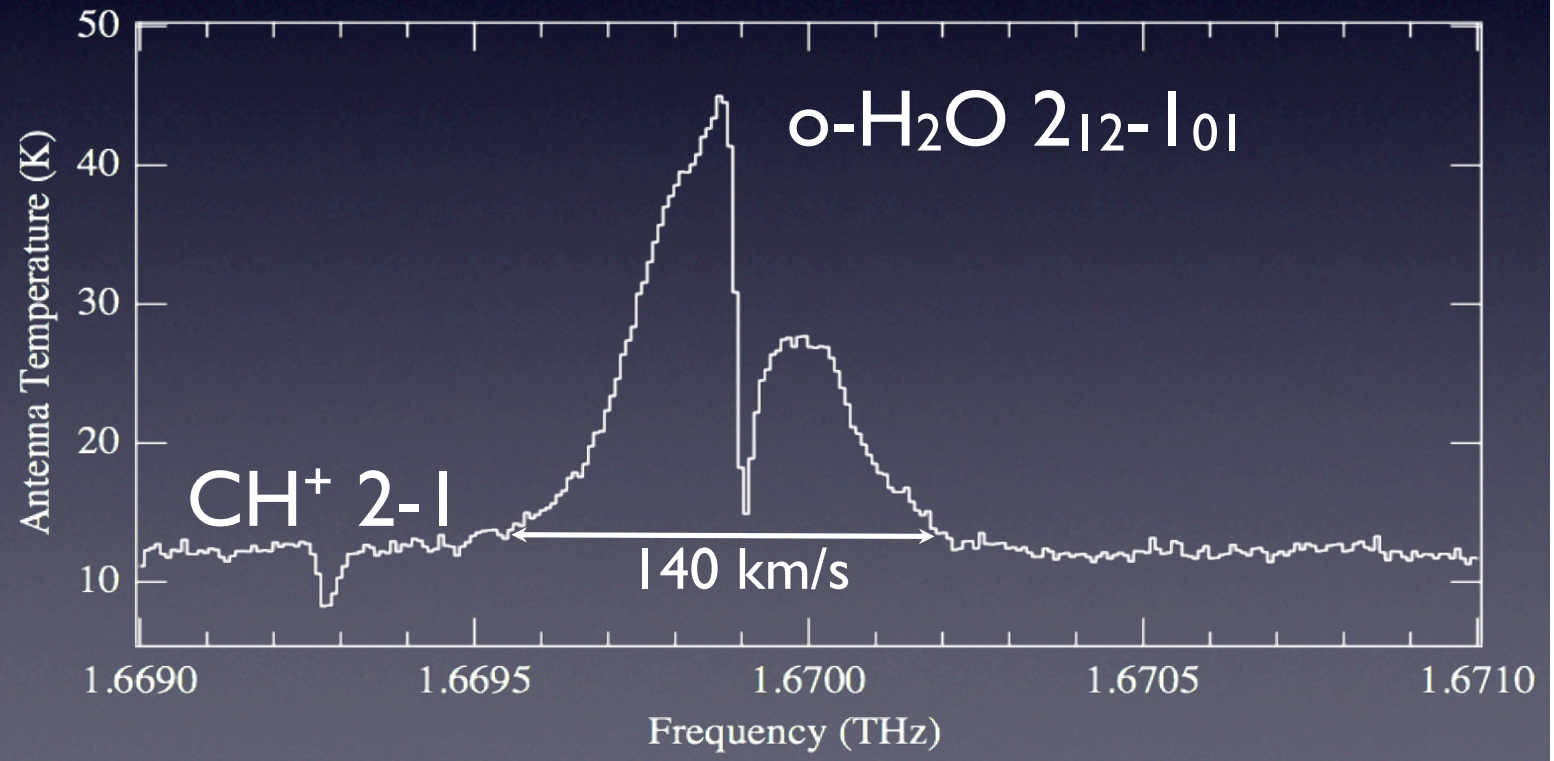
Frequency (GHz)

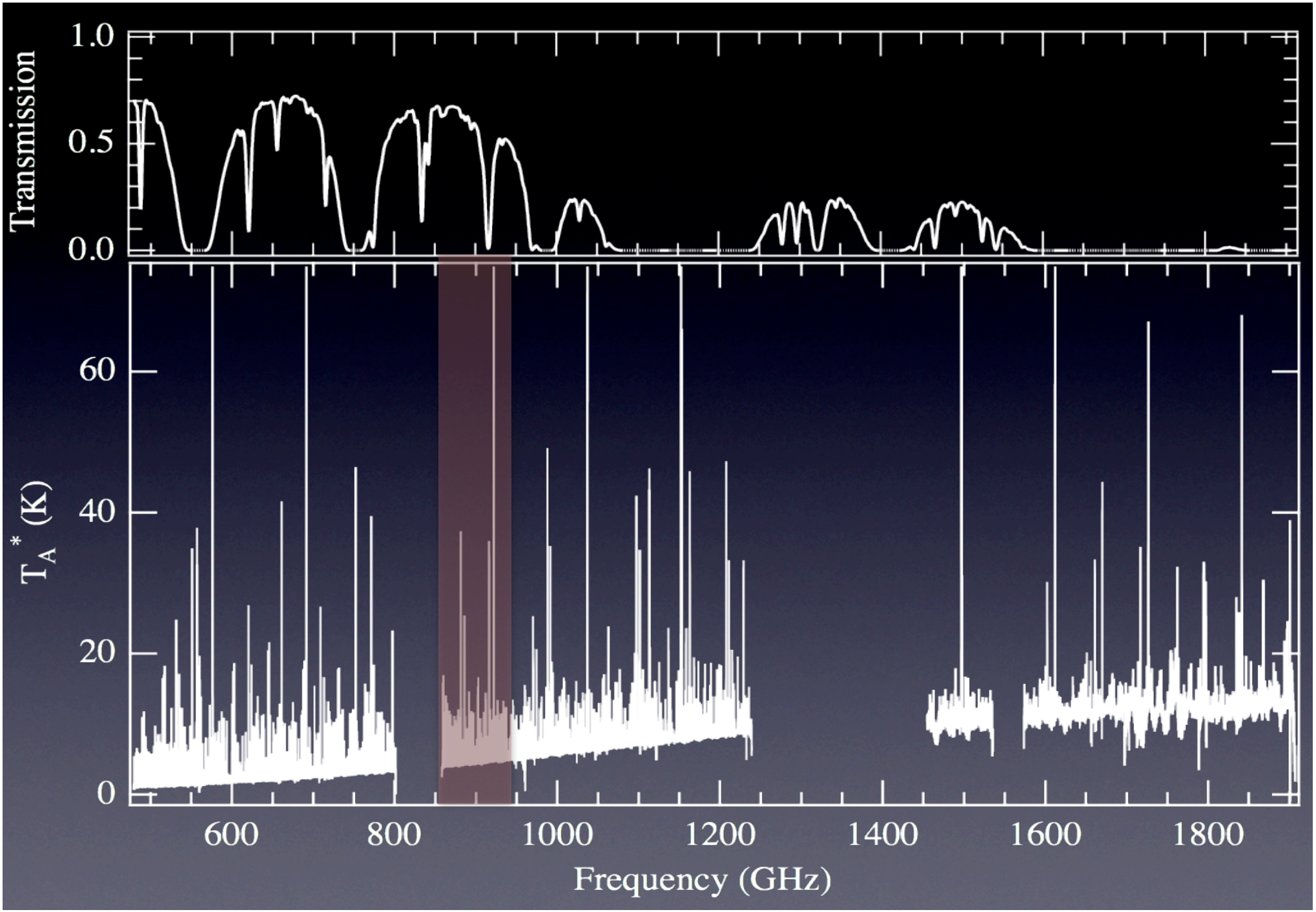


Orion KL Band 6b

Orion KL Band 6b






Transmission
1.0
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T_A^* (K)
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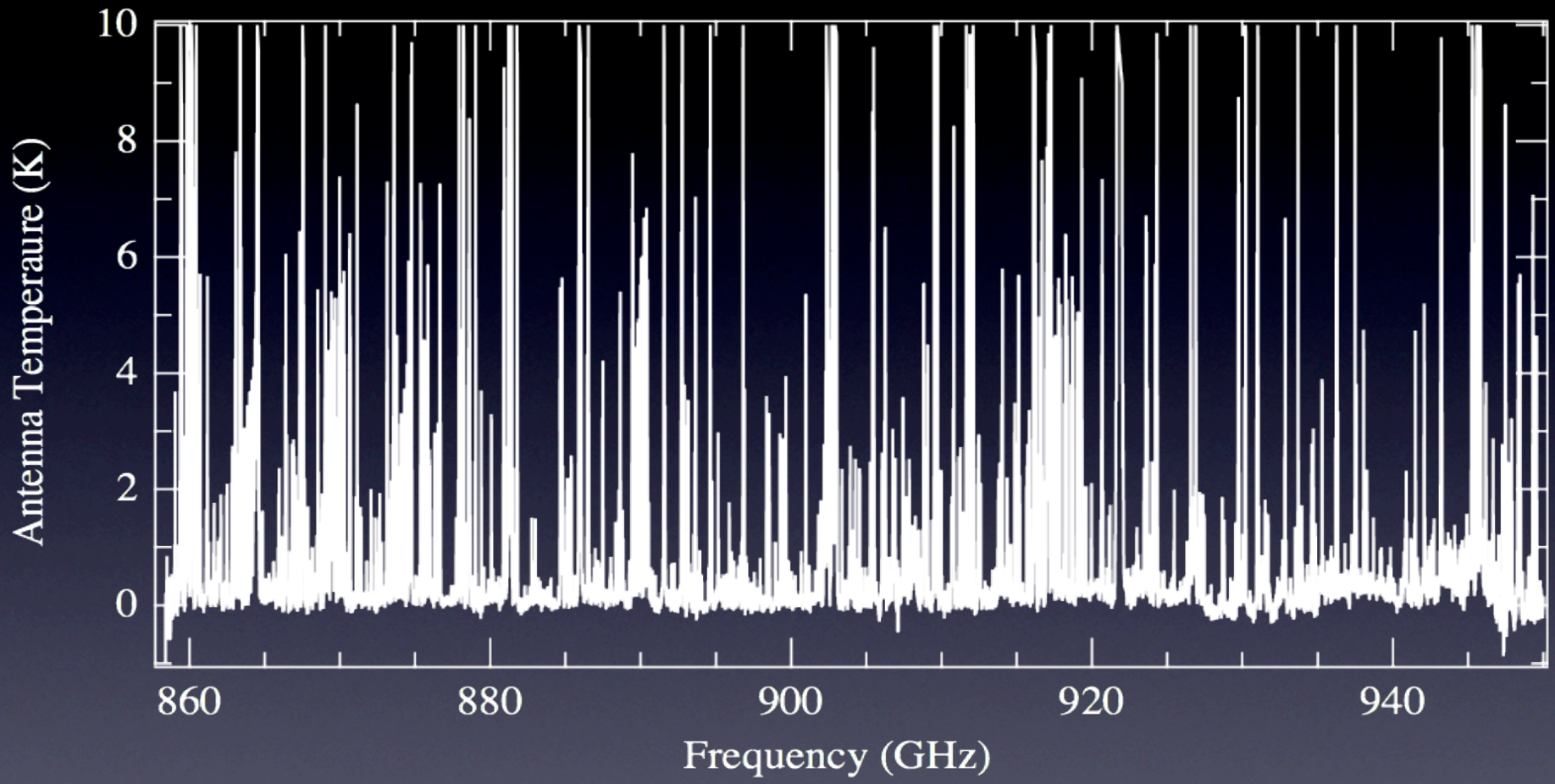
Frequency (GHz)


Antenna Temperaure (K)
10
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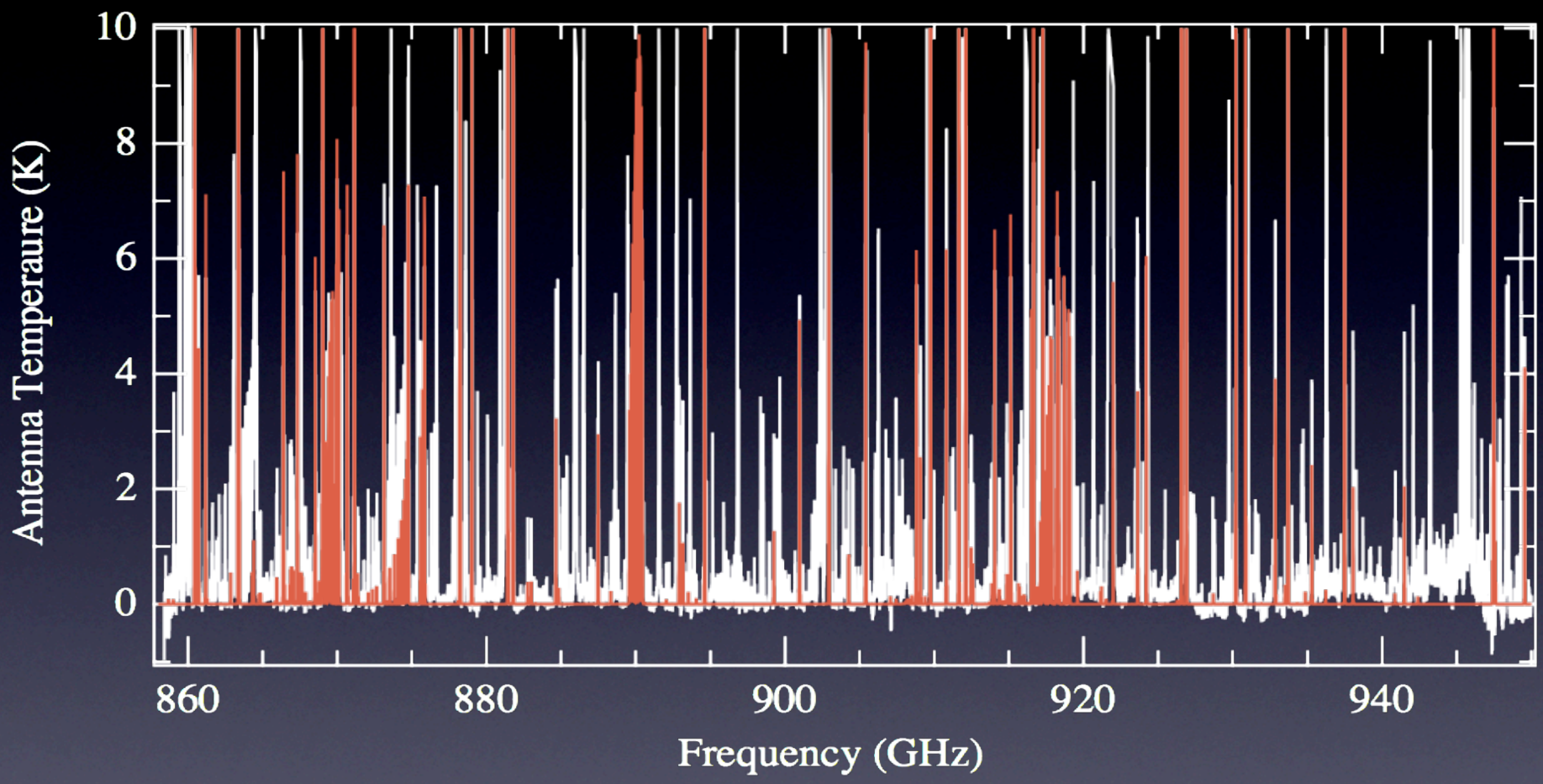
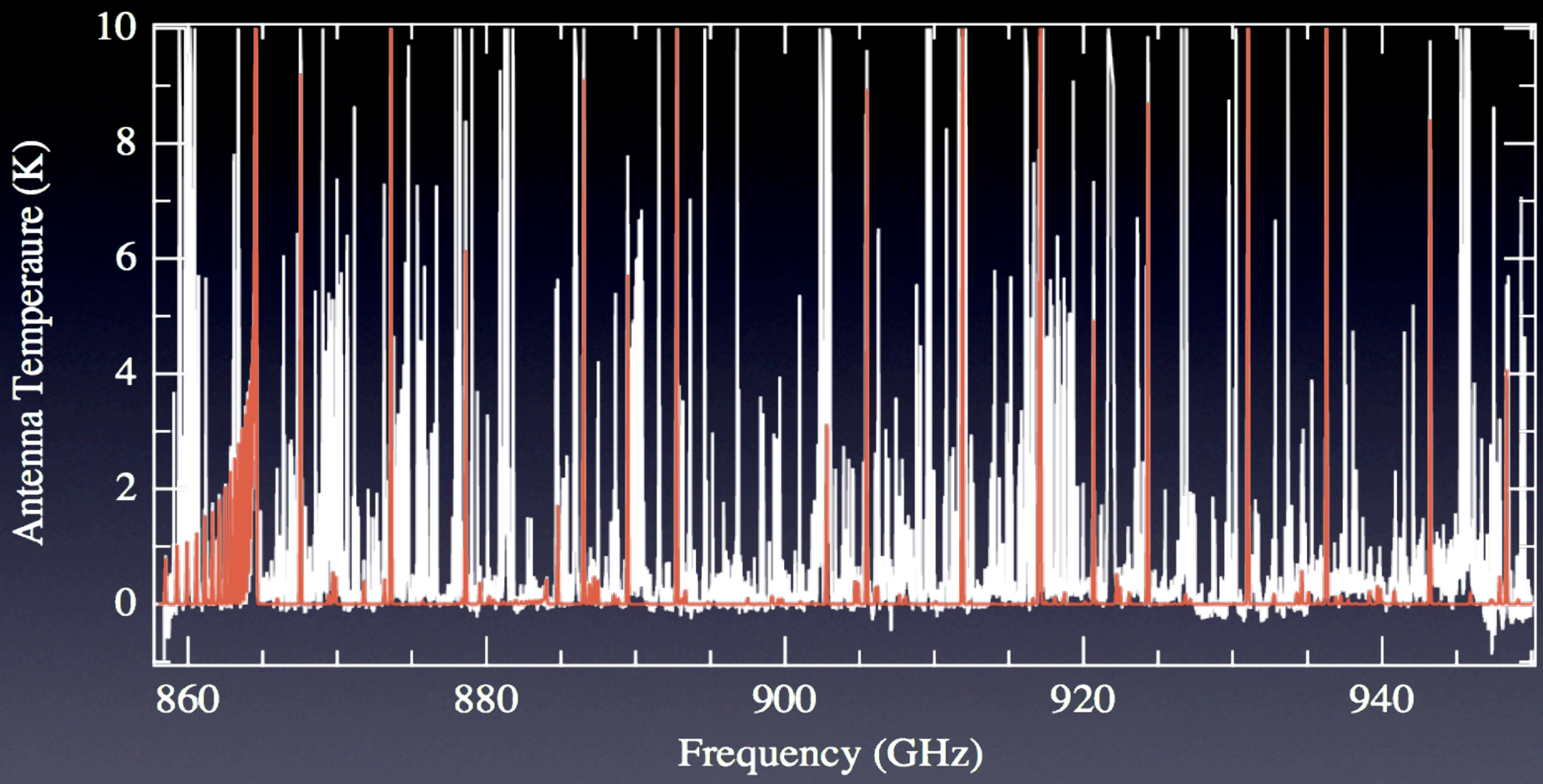
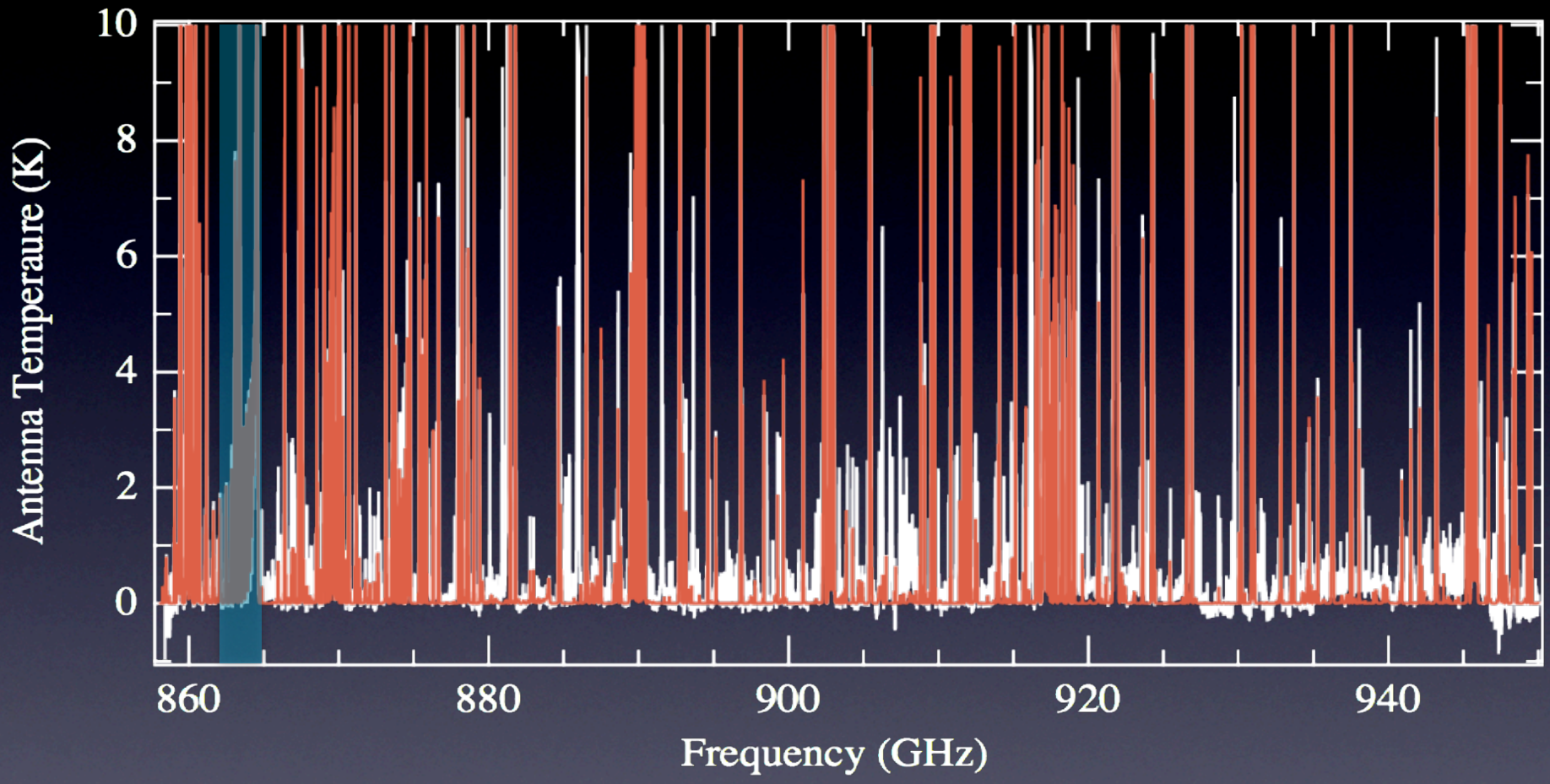
6
4
2
0
860
880
900
920
940
Frequency (GHz)



Methanol (CH_3OH) Emission



Sulfur Dioxide Emission


Antenna Temperaure (K)
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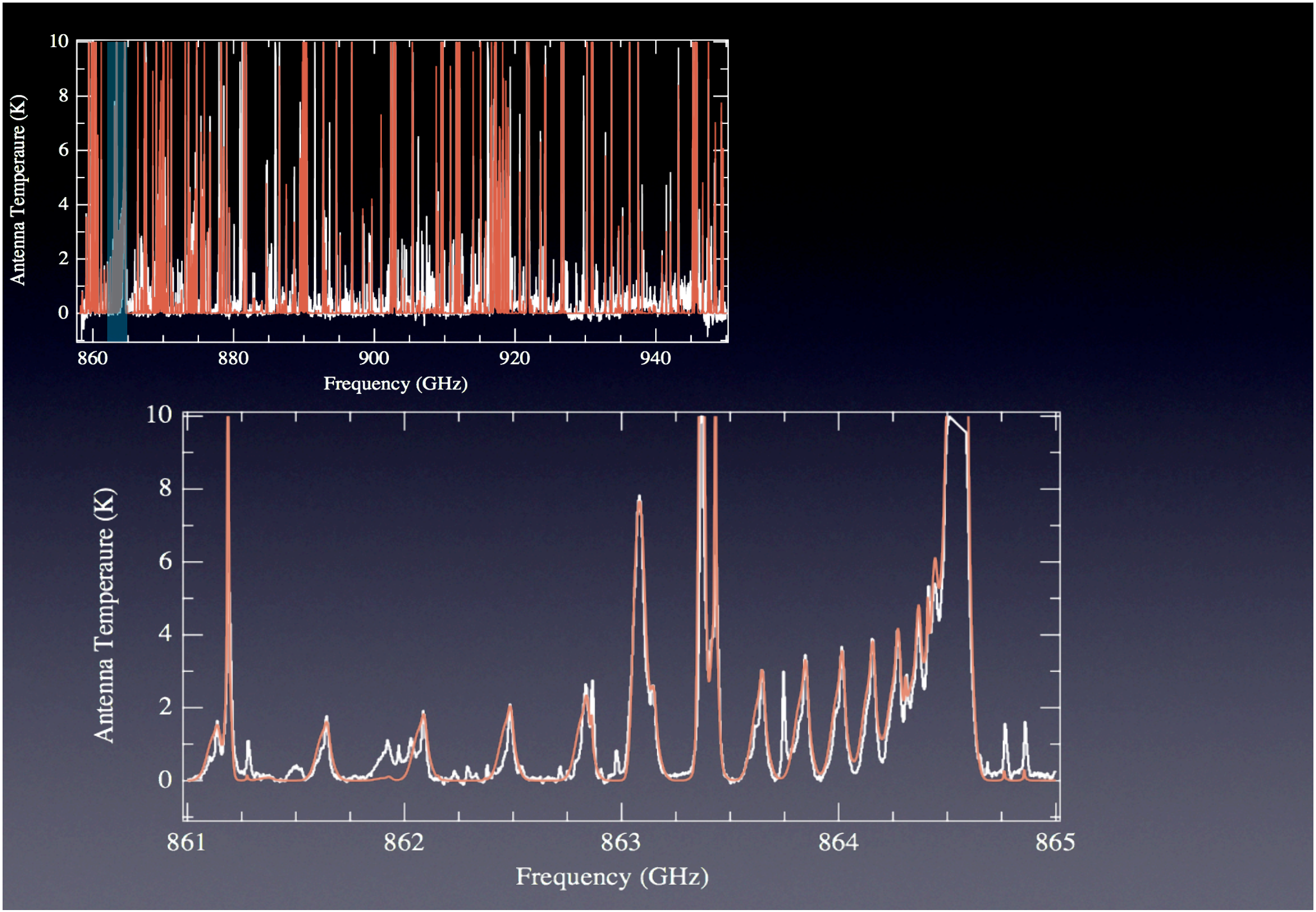
920
940
Frequency (GHz)


Antenna Temperaure (K)
10
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880
900
920
940
Frequency (GHz)
Antenna Temperaure (K)
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2
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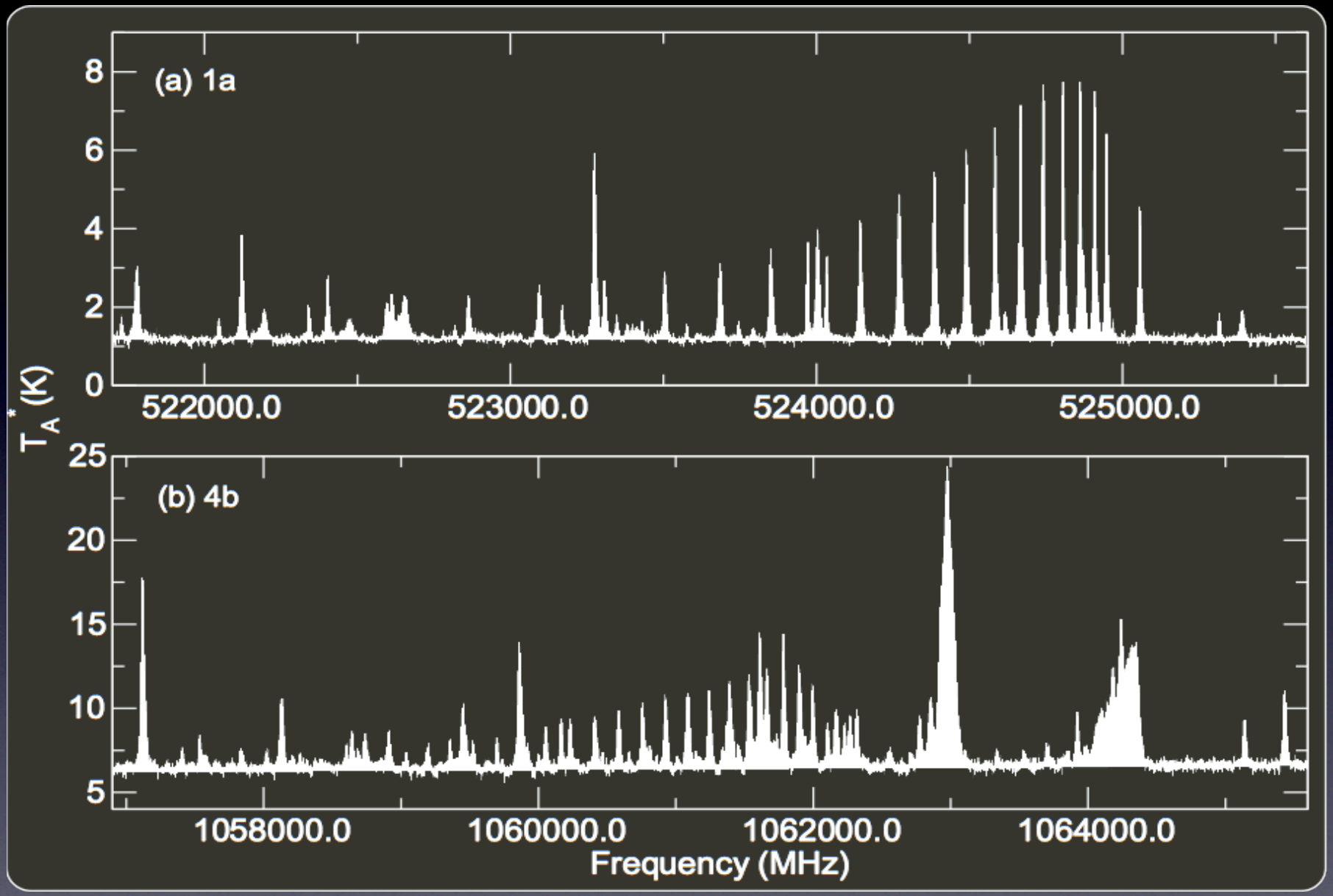
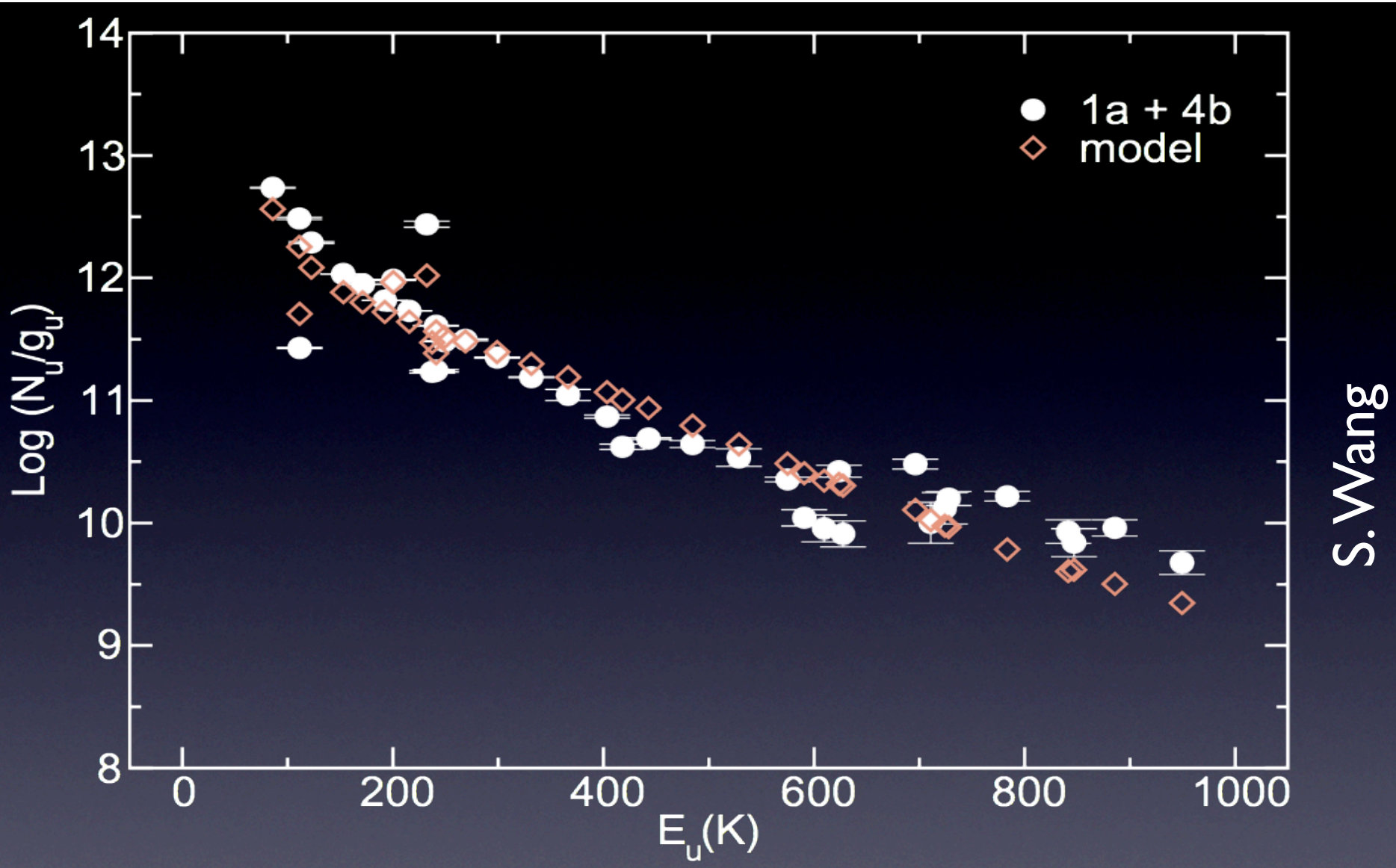
861
862
863
864
865
Frequency (GHz)

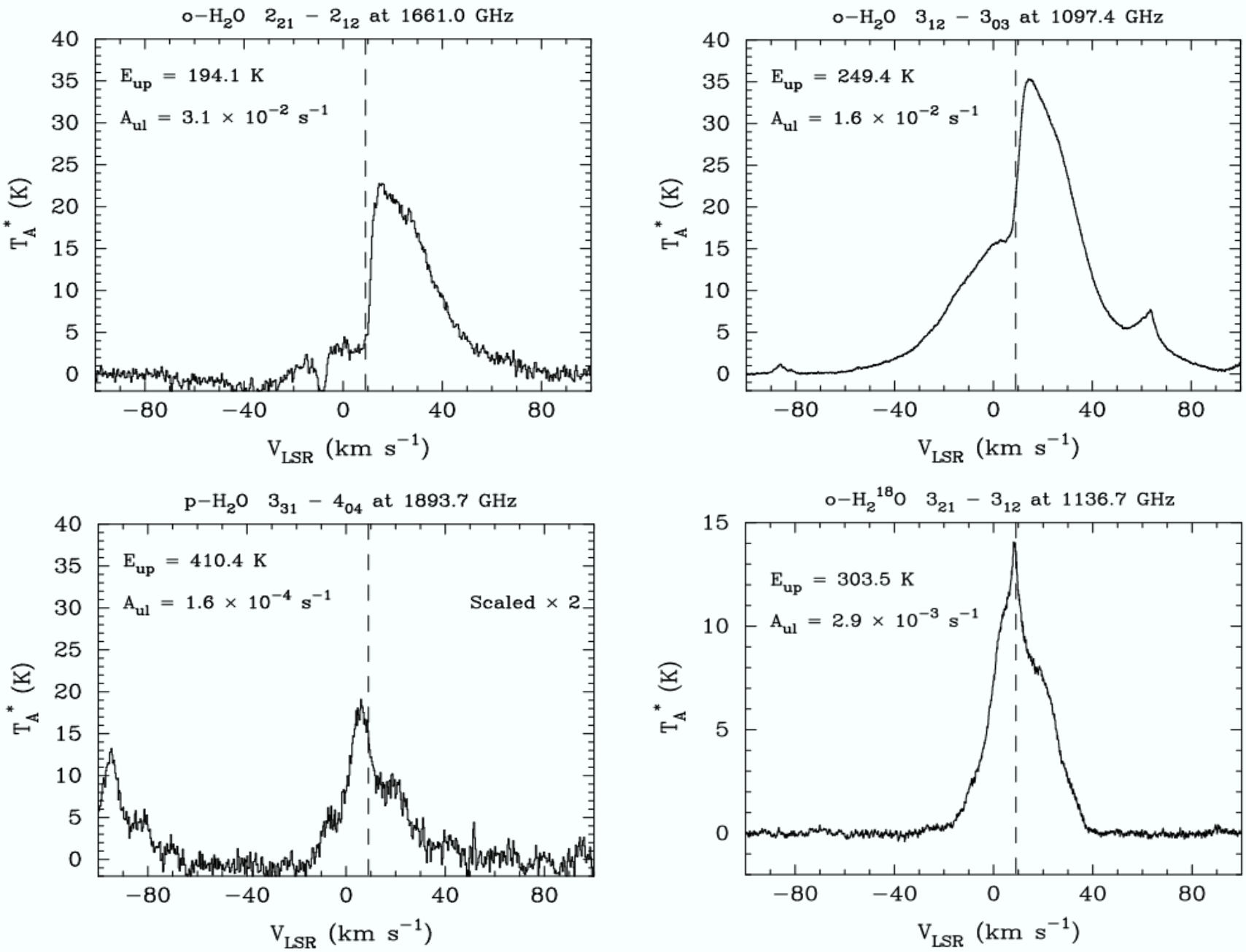


CH_3OH - Weed or ?



S. Wang

CH_3OH - Weed or ?

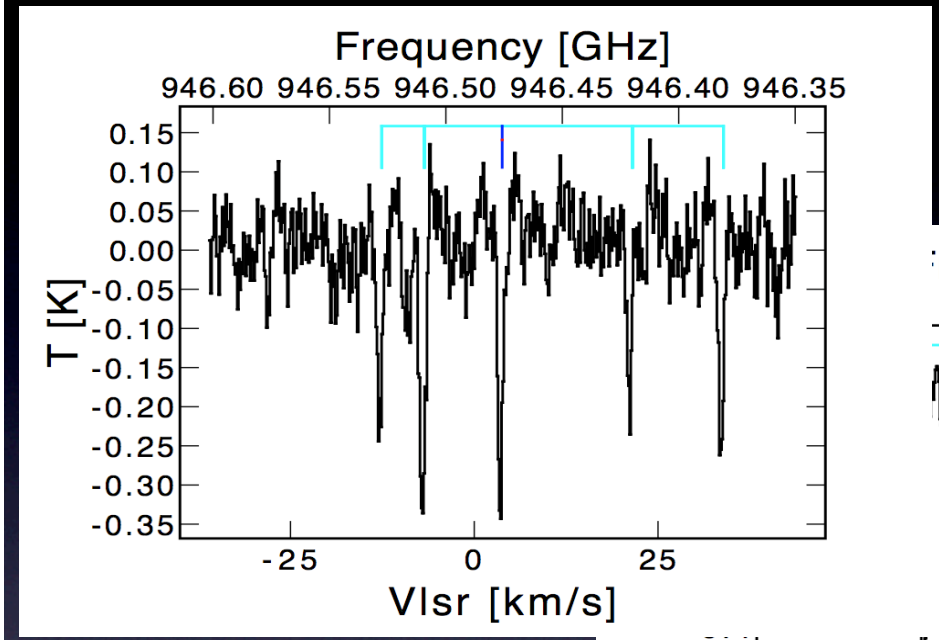

o−H2O 221 − 212 at 1661.0 GHz
Eup = 194.1 K
Aul = 3.1 × 10−2 s−1
o−H2O 312 − 303 at 1097.4 GHz
Eup = 249.4 K
Aul = 1.6 × 10−2 s−1
p−H2O 331 − 404 at 1893.7 GHz
Eup = 410.4 K
Aul = 1.6 × 10−4 s−1
Scaled × 2
o−H2 18O 321 − 312 at 1136.7 GHz
Eup = 303.5 K
Aul = 2.9 × 10−3 s−1
TA* (K)
VLSR (km s−1)

Herschel and Interstellar Chemistry

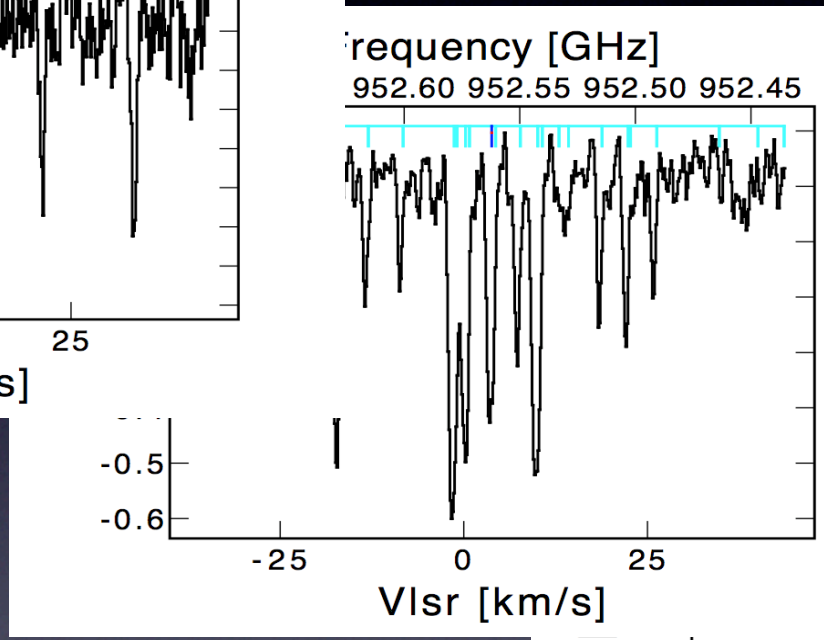
- HIFI is a fantastic tool to explore the molecular spectrum
- We are just beginning to sample the data we have in hand
- H_2O^+ present in every diffuse cloud between us and GC
- Water is everywhere - but seeing lots of outflow emission. Quiescent gas is harder.
- Have not detected cold water in disks (5 sigma tentative dectection)
- Have detected $HD^{18}O$ in Orion KL and p/o D_2O in IRAS 16292
- Have begun to define the far-IR with lots more to come

N-Species

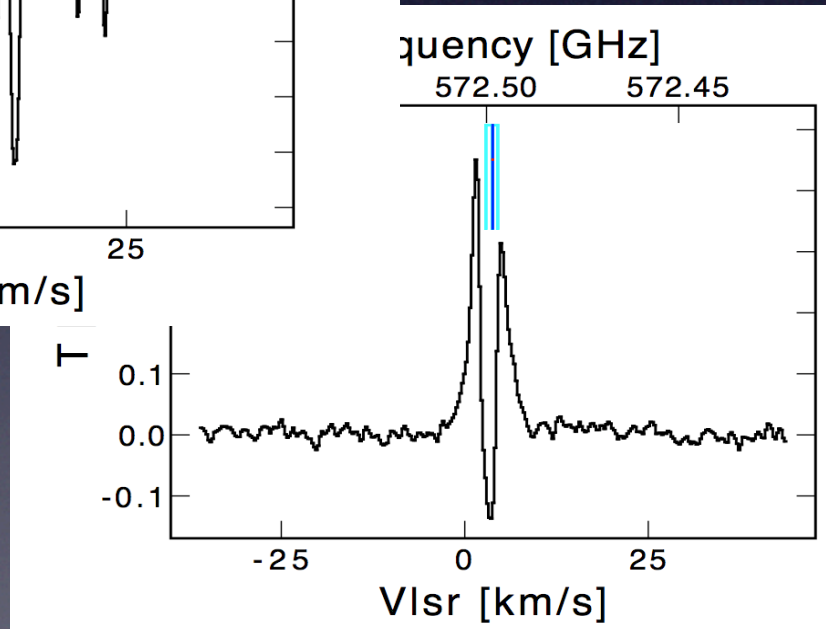
NH



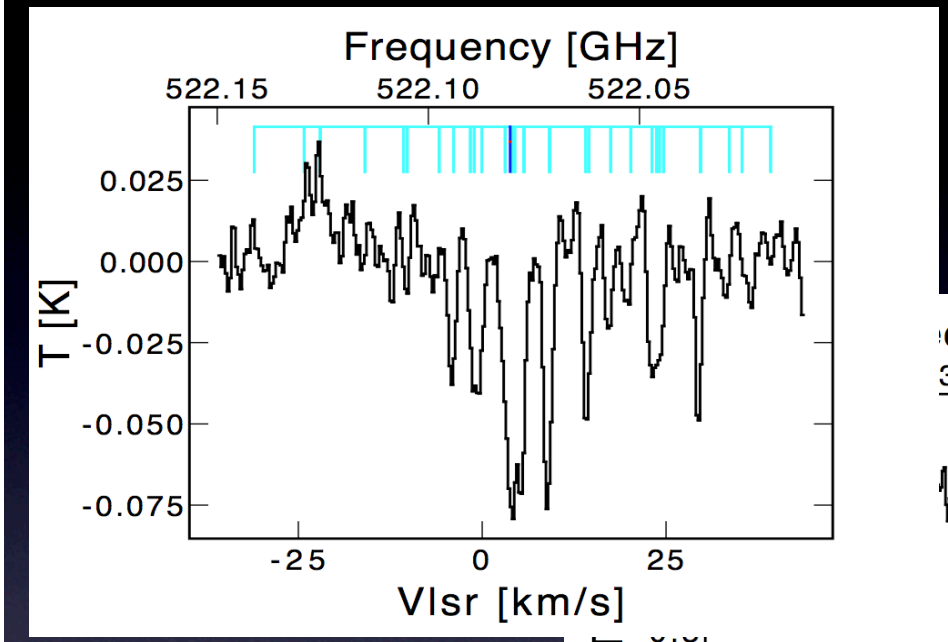
NH_2



NH_3

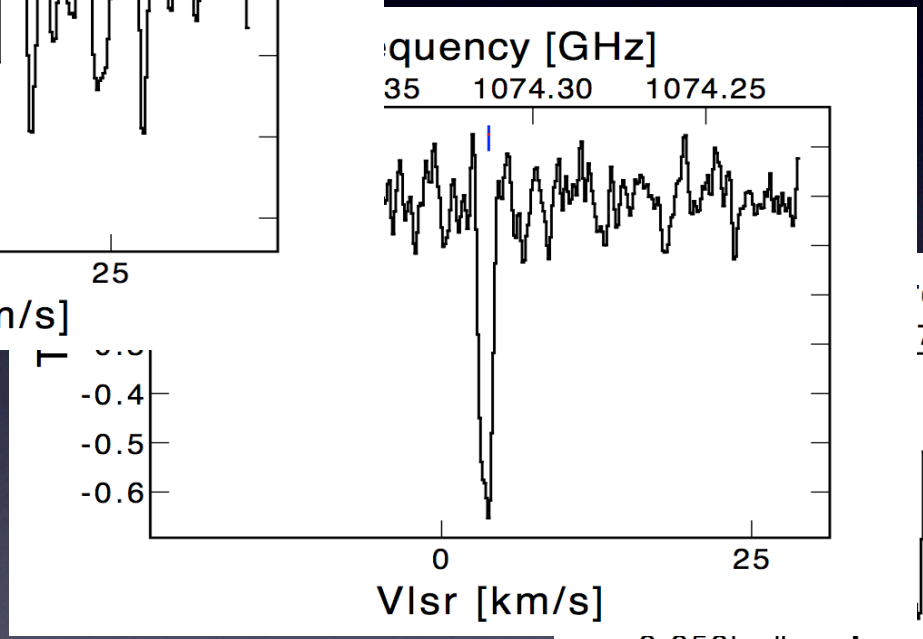


Deuterated N-Species



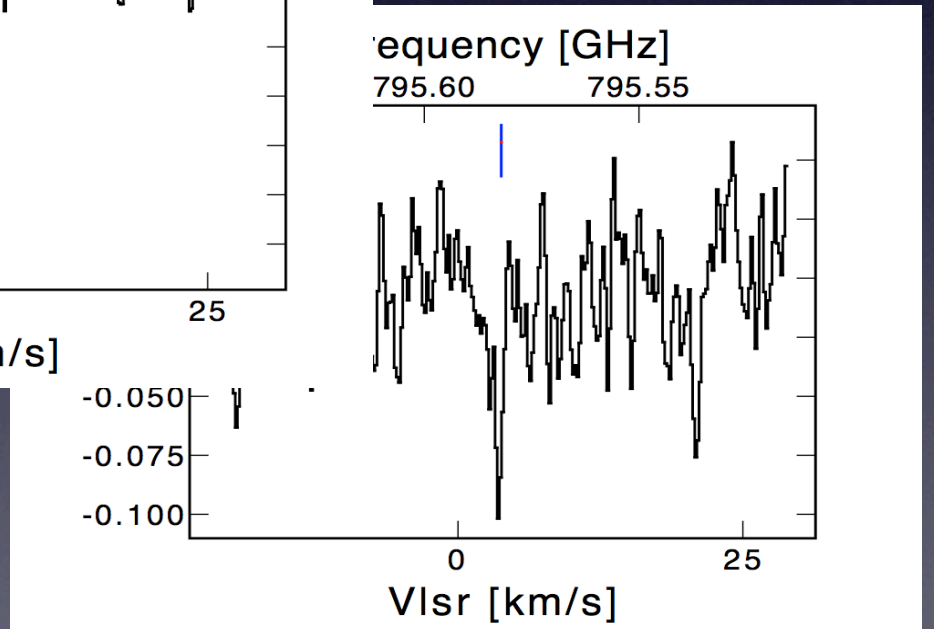
ND

First detection of the ND radical (one tentative detection in Orion KL with Odin by Olofsson et al. 2007)



NH_2D

NHD_2



$N(NH) \sim 2\ 10^{14} cm^{-2}$

$N(ND) \sim 8.5\ 10^{13} cm^{-2}$

$ND/NH \sim 45\%$

Bacmann et al. 2010, in prep