



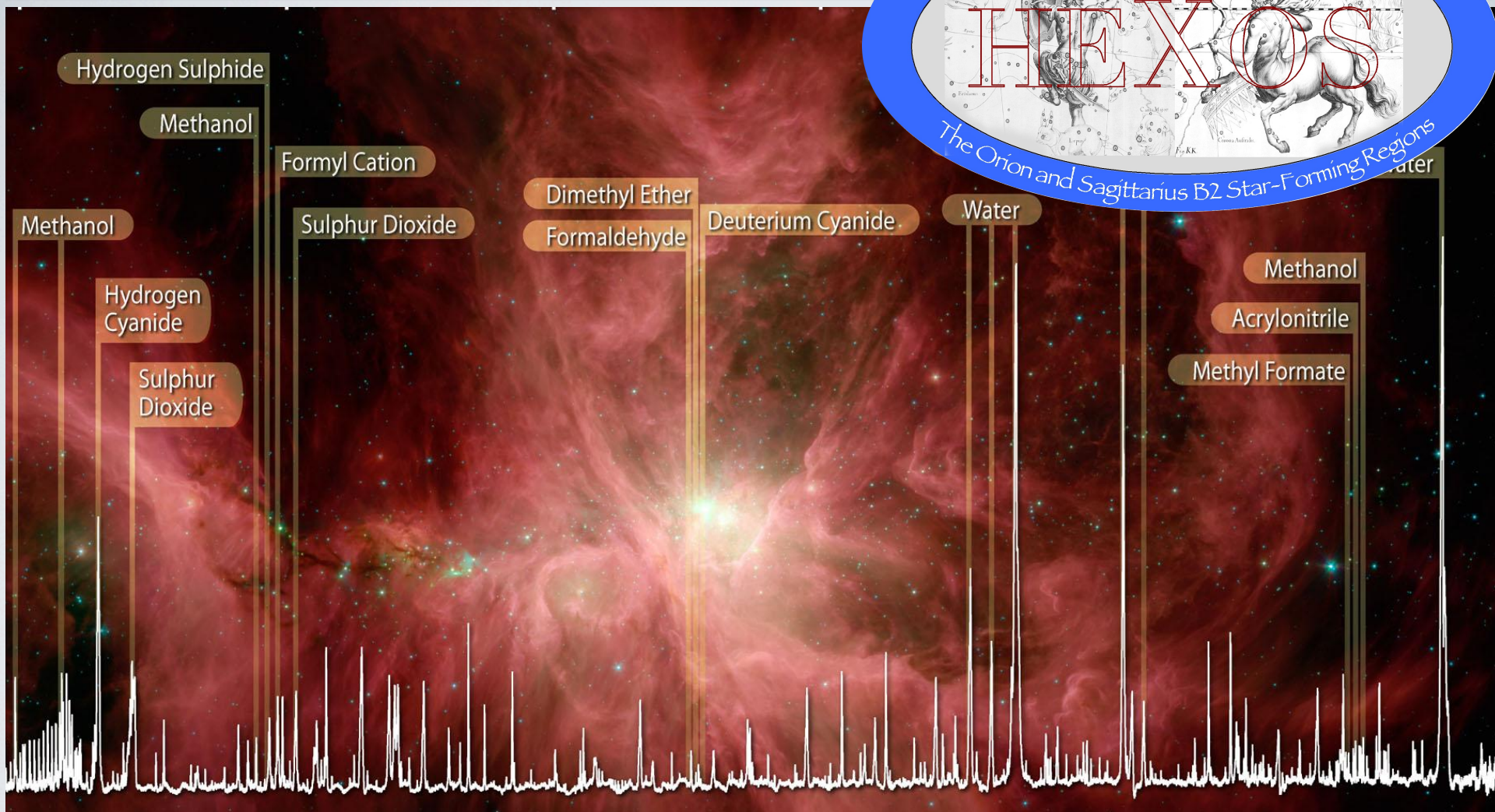
TRACING THE ORIGINS OF NITROGEN BEARING ORGANICS TOWARD ORION KL WITH ALMA

Brandon Carroll • Nathan R. Crockett • Masha Klescheva • Cecile Favre
Edwin A. Bergin • Geoffrey A. Blake

72nd International Symposium on Molecular Spectroscopy – June 19, 2017



INTRODUCTION

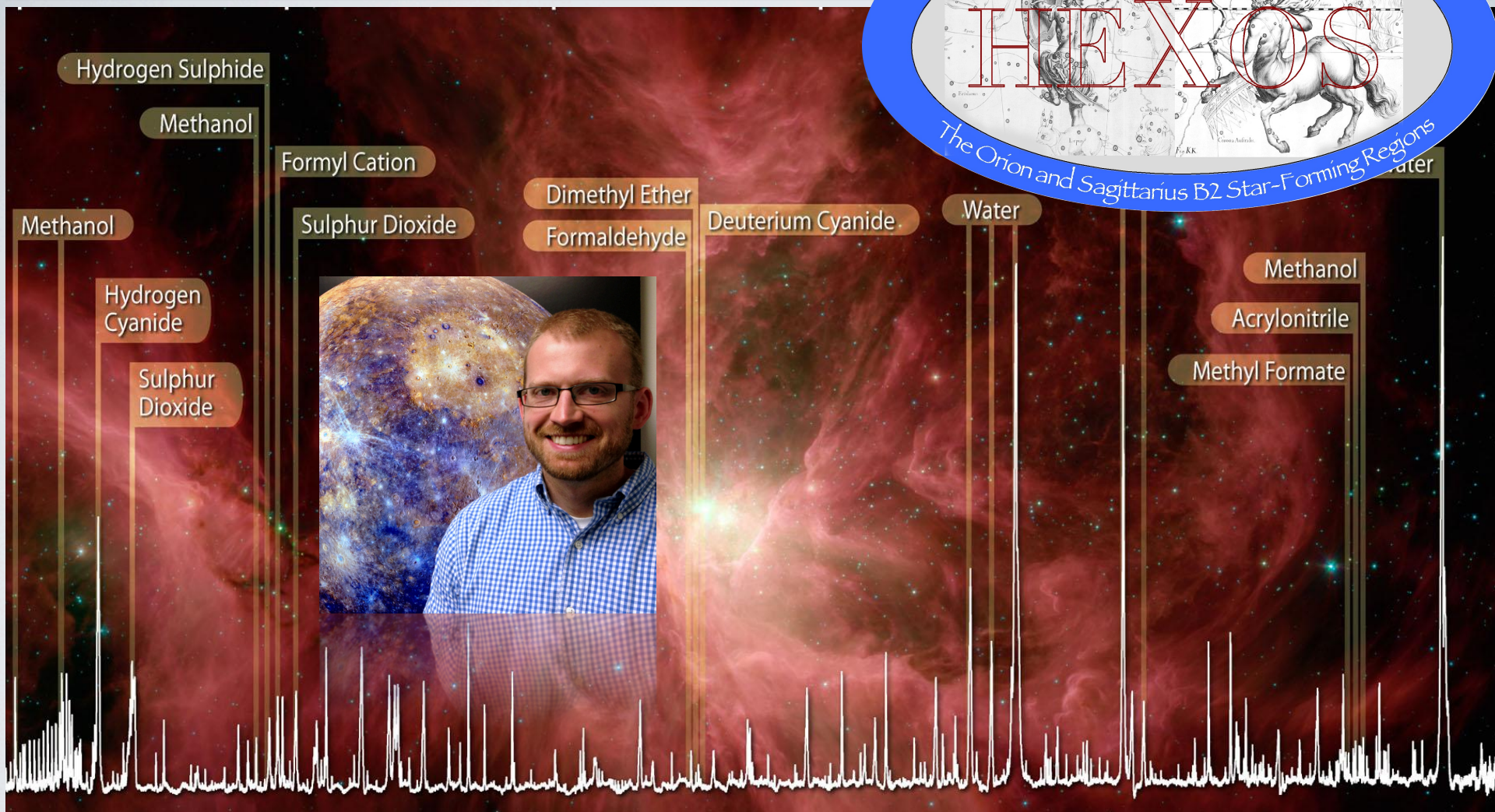


Caltech

Crocket et al. ApJ, 806 239 2015



INTRODUCTION



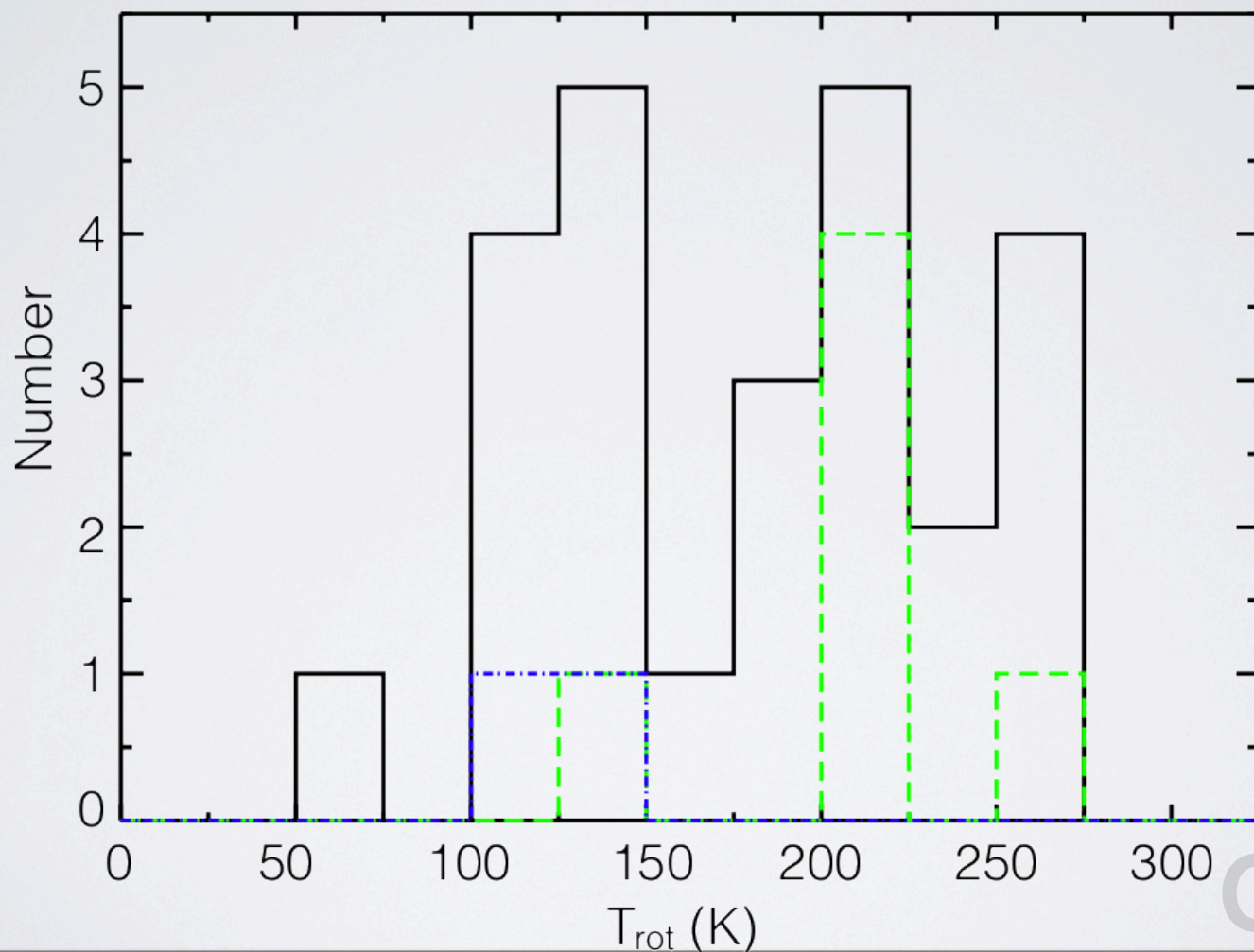
Caltech

Crocket et al. ApJ, 806 239 2015



MOLECULES DETECTED IN HEXOS

— All Molecules -.- O-Bearing -.- Cyanides

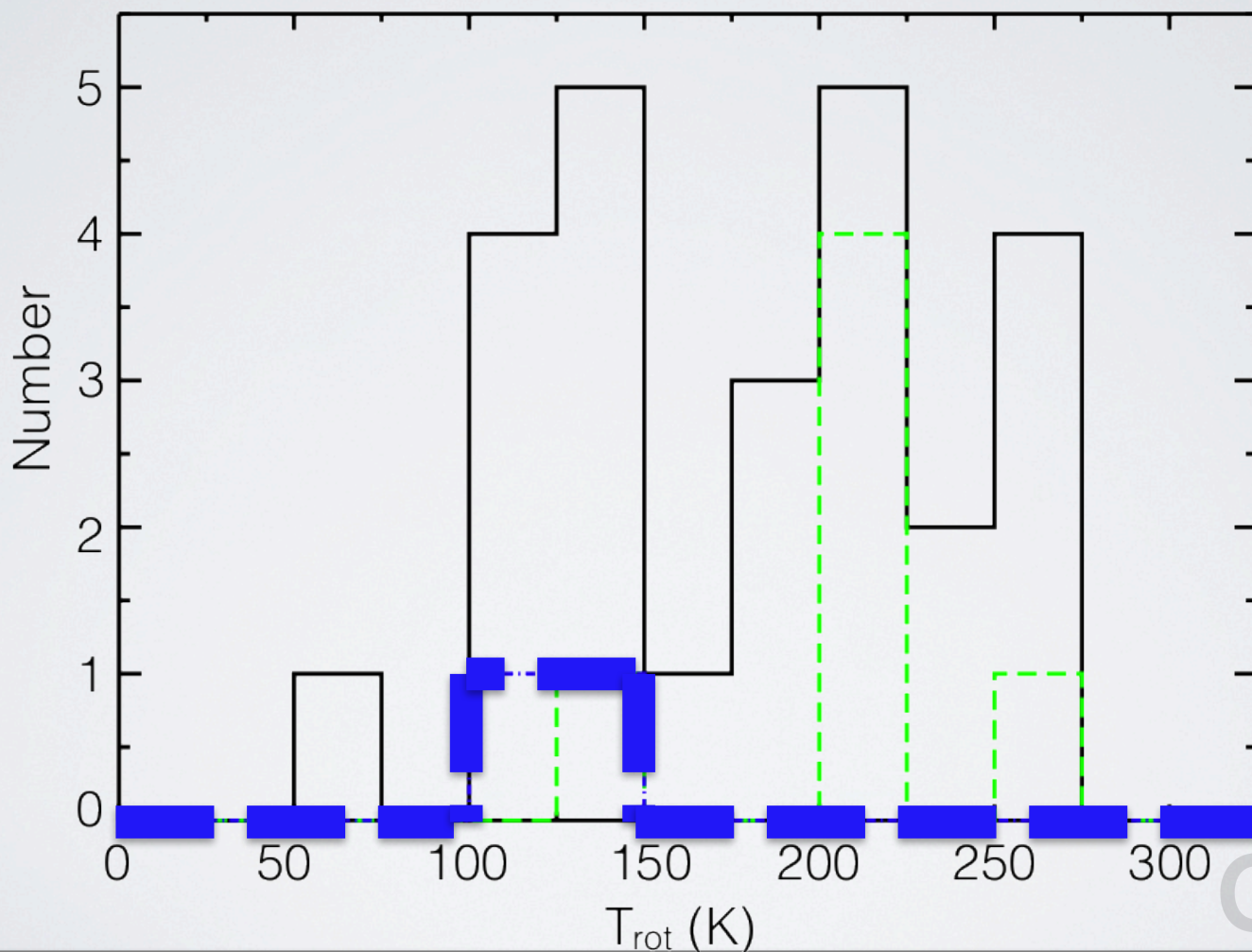


Caltech



MOLECULES DETECTED IN HEXOS

— All Molecules - - - O-Bearing - - - Cyanides



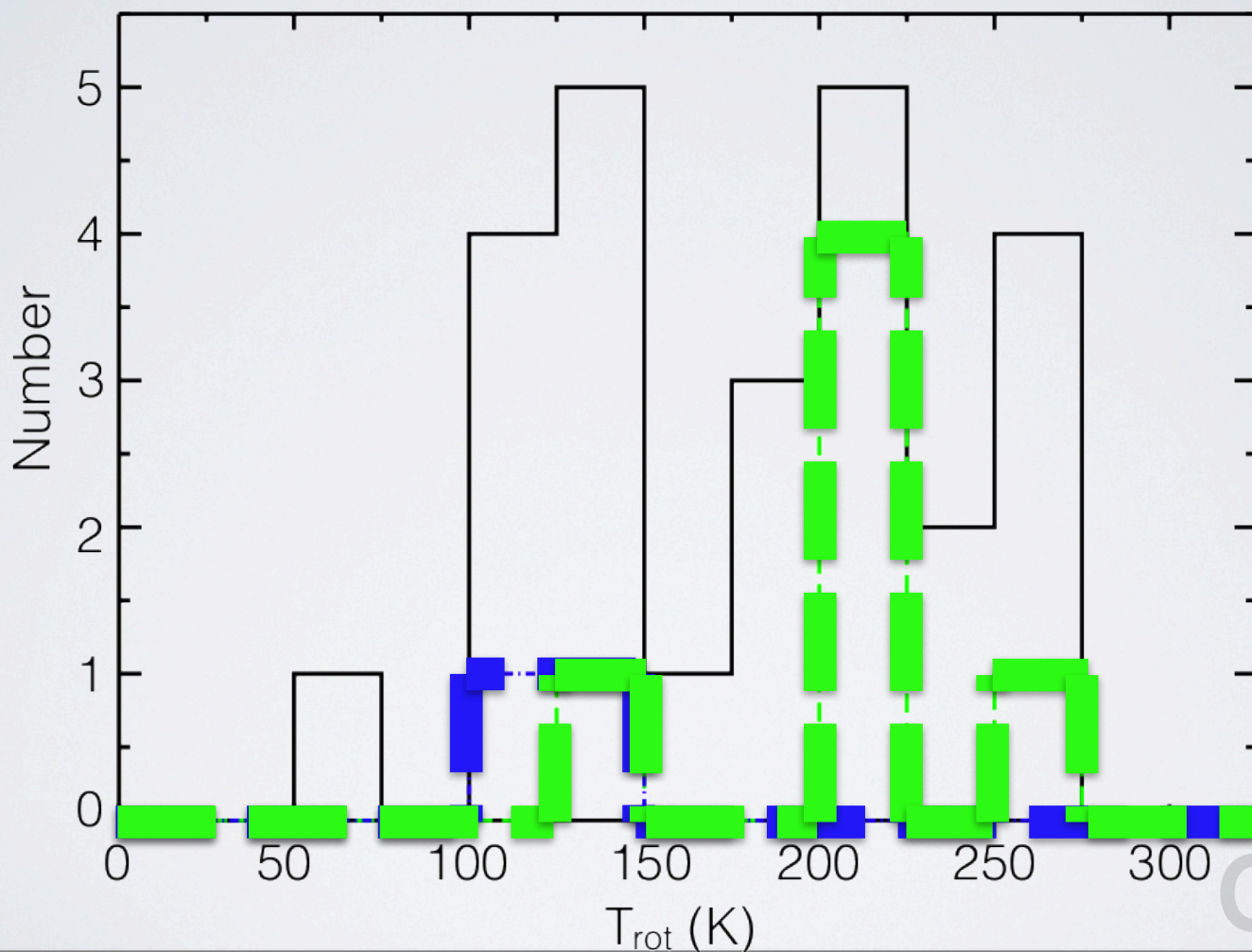
Caltech

Crocket et al. ApJ, 806 239 2015



MOLECULES DETECTED IN HEXOS

— All Molecules - - - O-Bearing - - - Cyanides



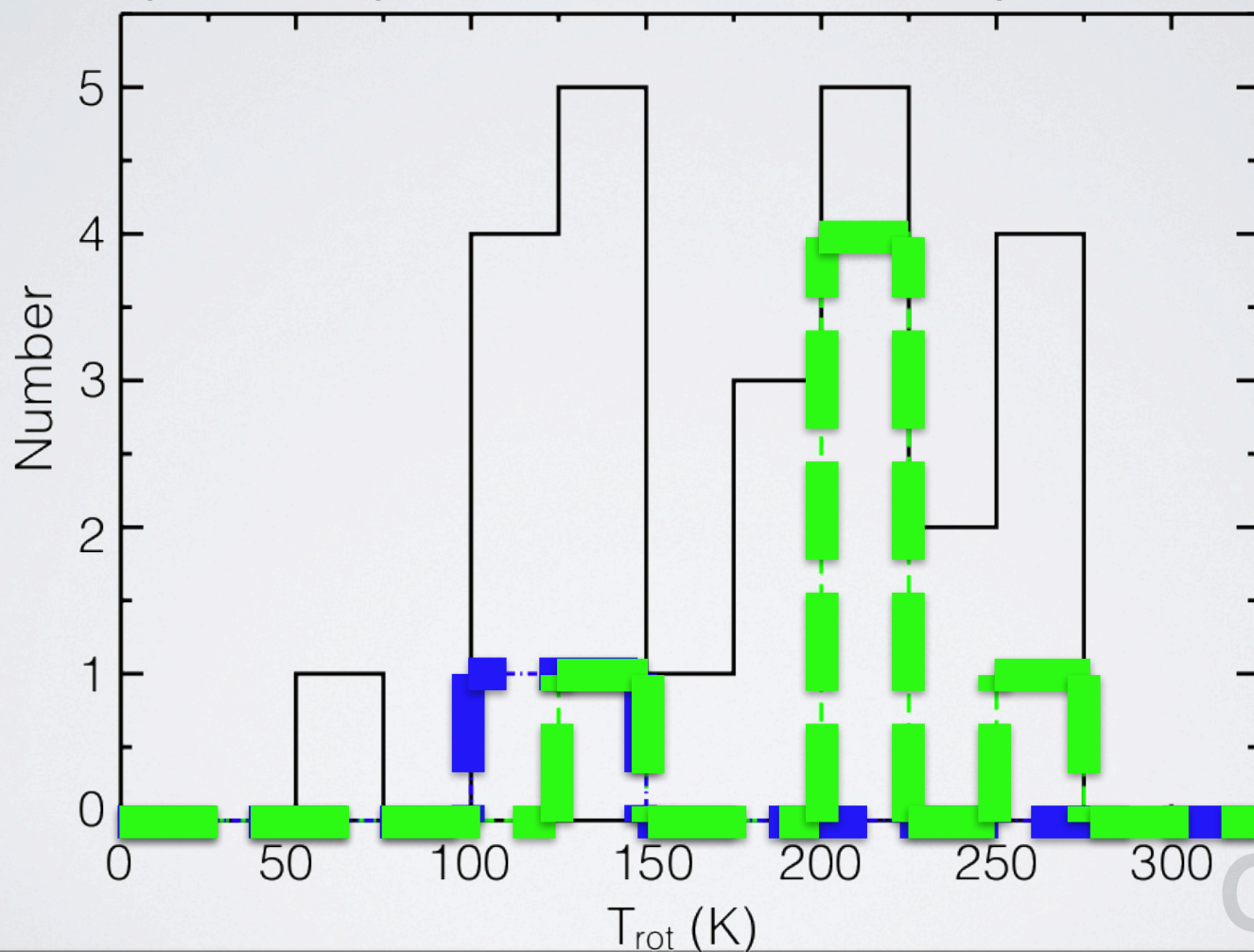
Caltech

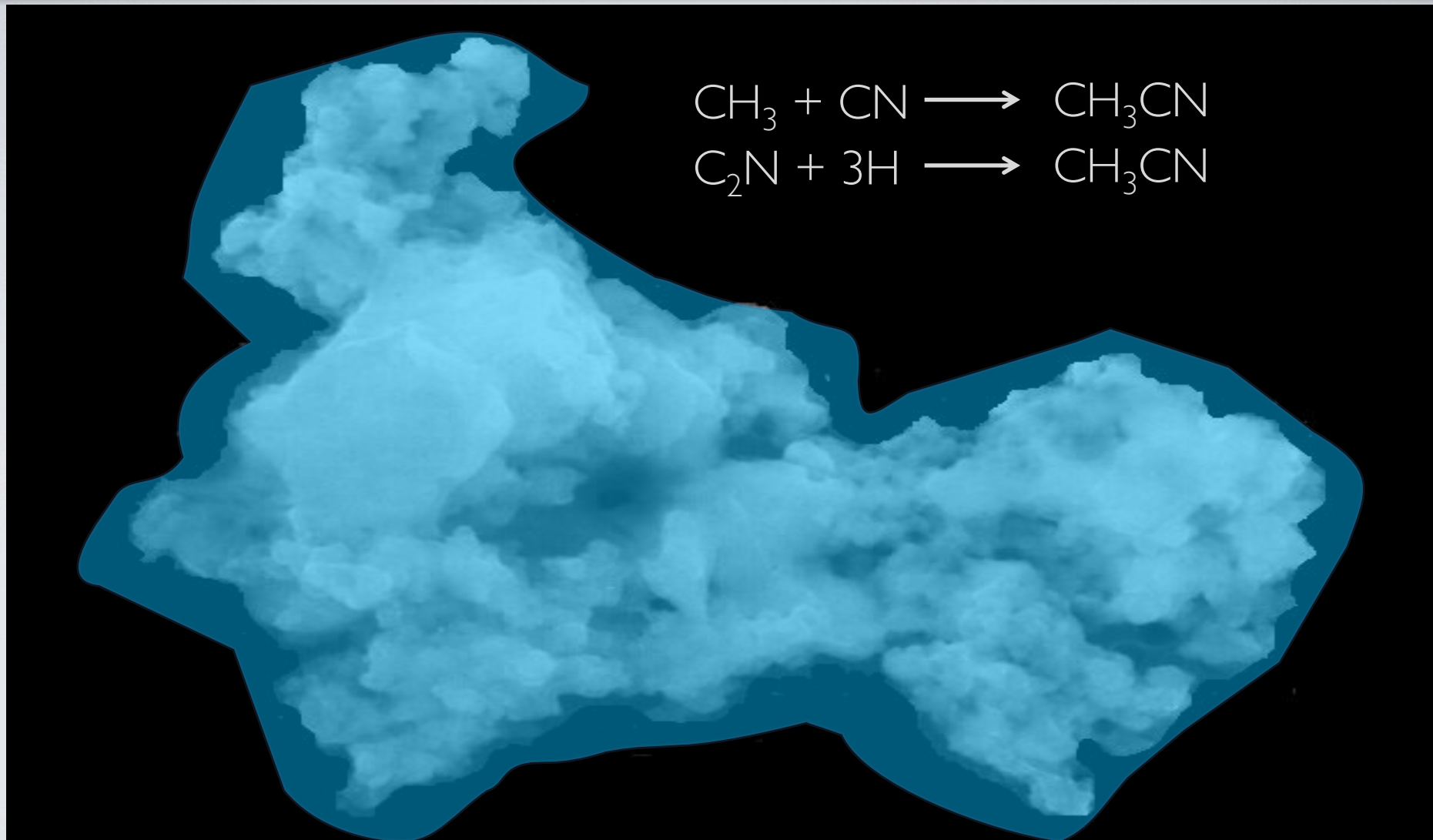
Crocket et al. ApJ, 806 239 2015

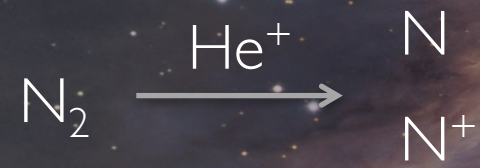


— All Molecules - - - O-Bearing - - - Cyanides

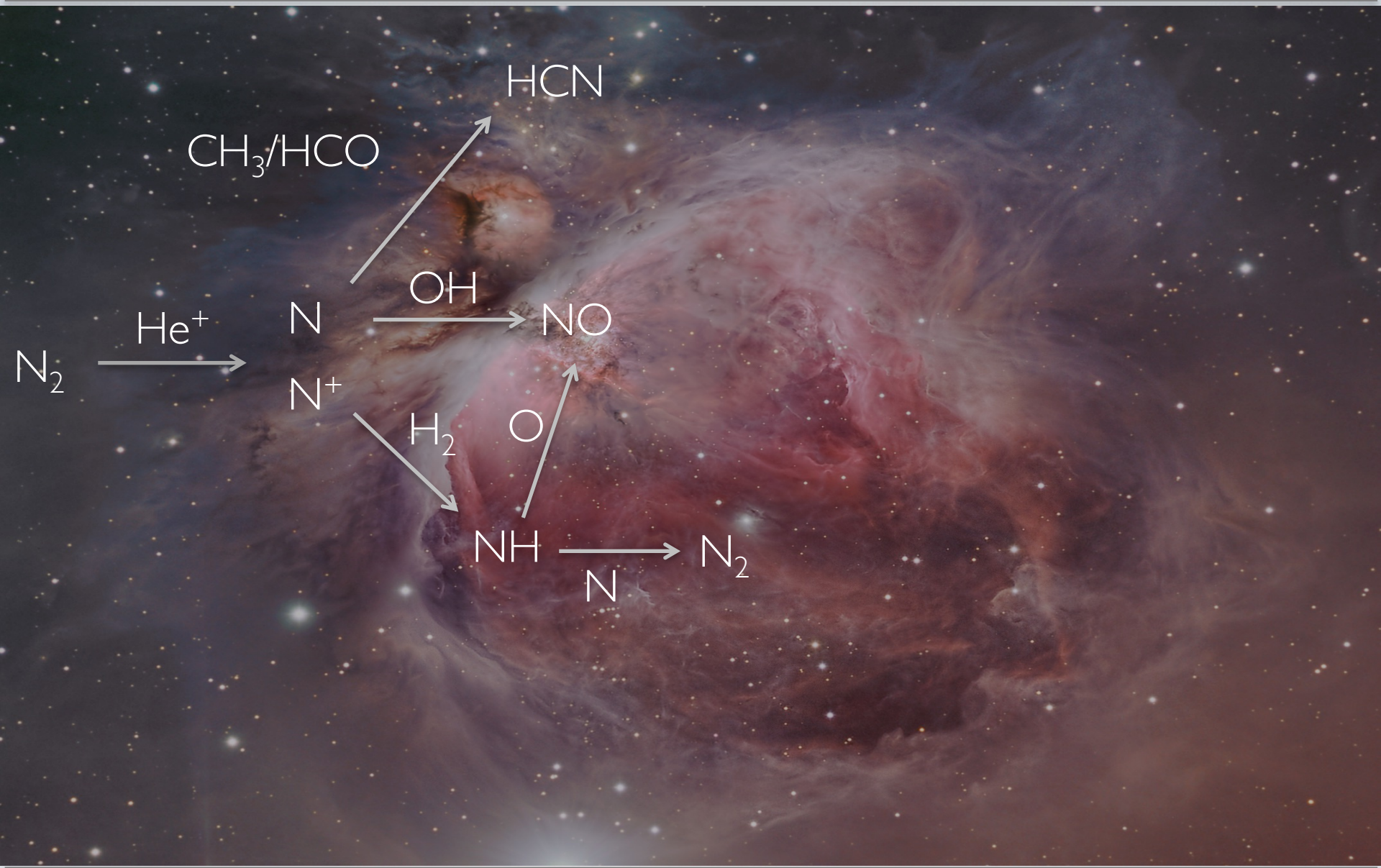
Why are cyanides consistently warmer?

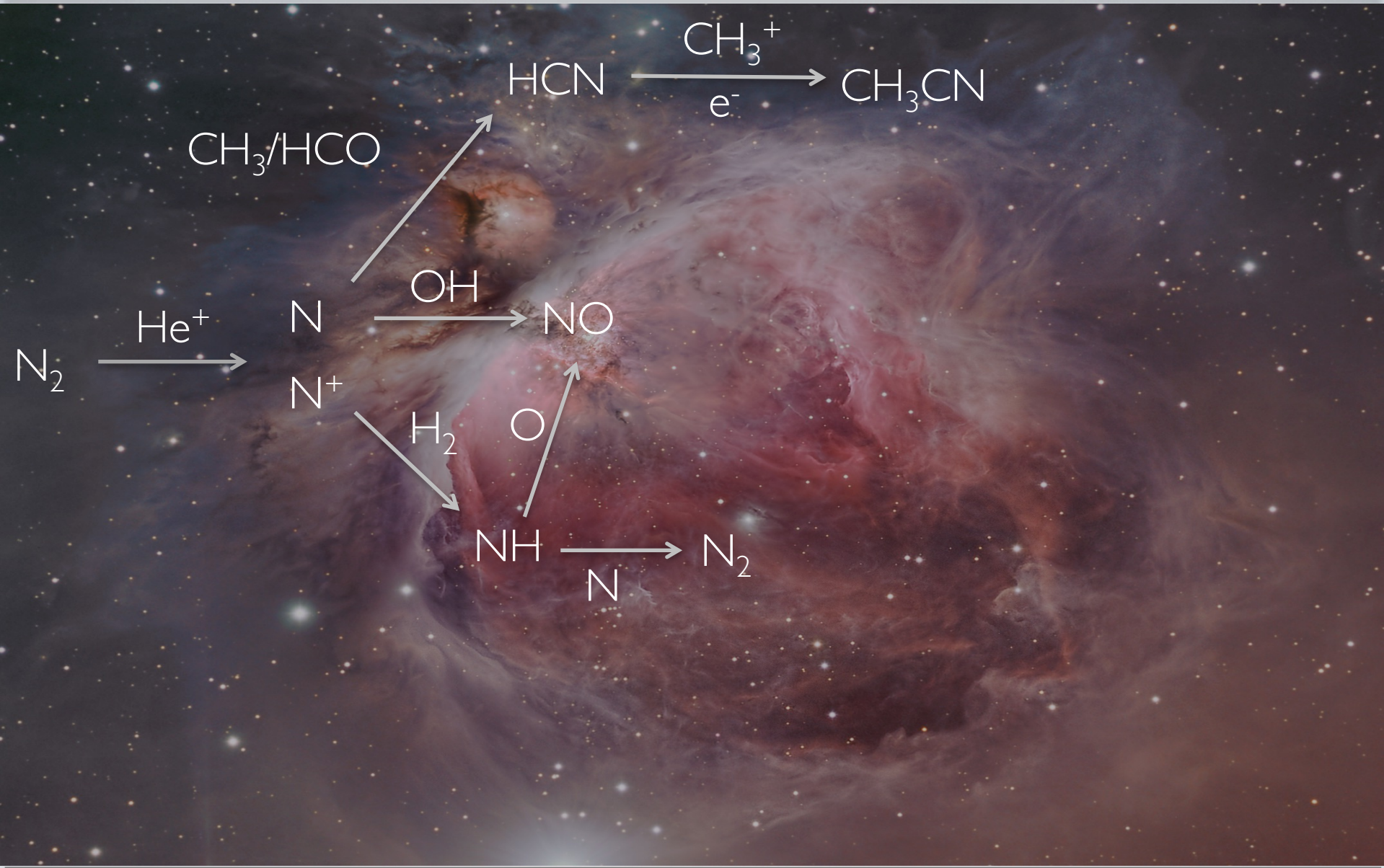


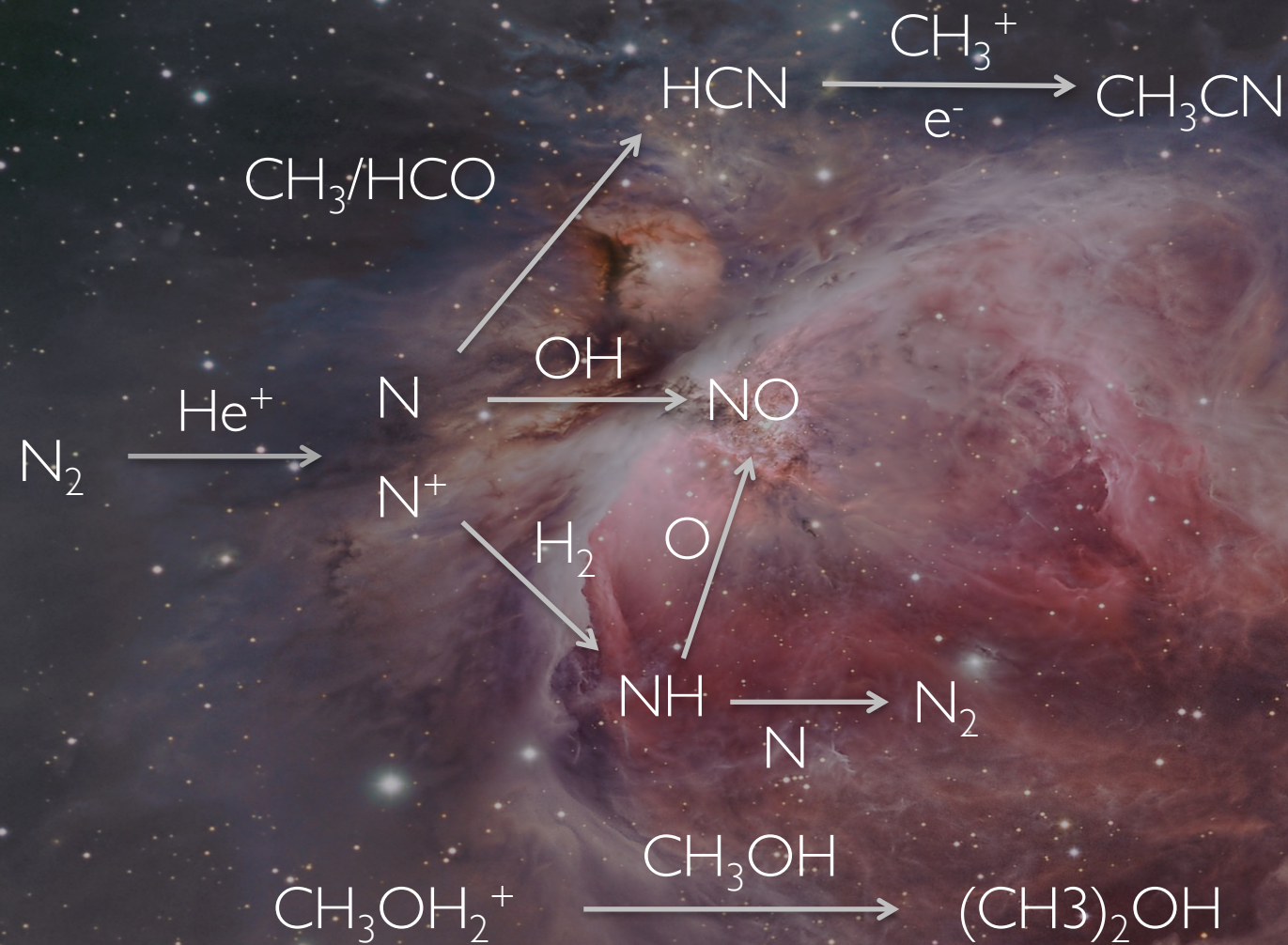














CYANIDE FORMATION CHEMISTRY



Rodgers & Charnley *ApJ*, 546 : 324-329, 2001



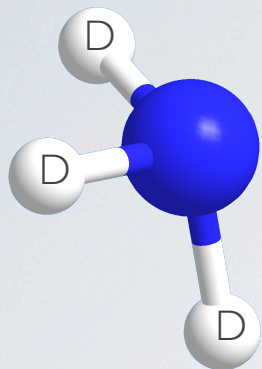
THE ASTROPHYSICAL JOURNAL, 571:L55–L58, 2002 May 20

© 2002. The American Astronomical Society. All rights reserved. Printed in U.S.A.

DETECTION OF TRIPLY DEUTERATED AMMONIA IN THE BARNARD 1 CLOUD

D. C. LIS,¹ E. ROUEFF,² M. GERIN,³ T. G. PHILLIPS,¹ L. H. COUDERT,⁴ F. F. S. VAN DER TAK,⁵ AND P. SCHILKE⁵

Received 2002 March 11; accepted 2002 April 10; published 2002 April 19





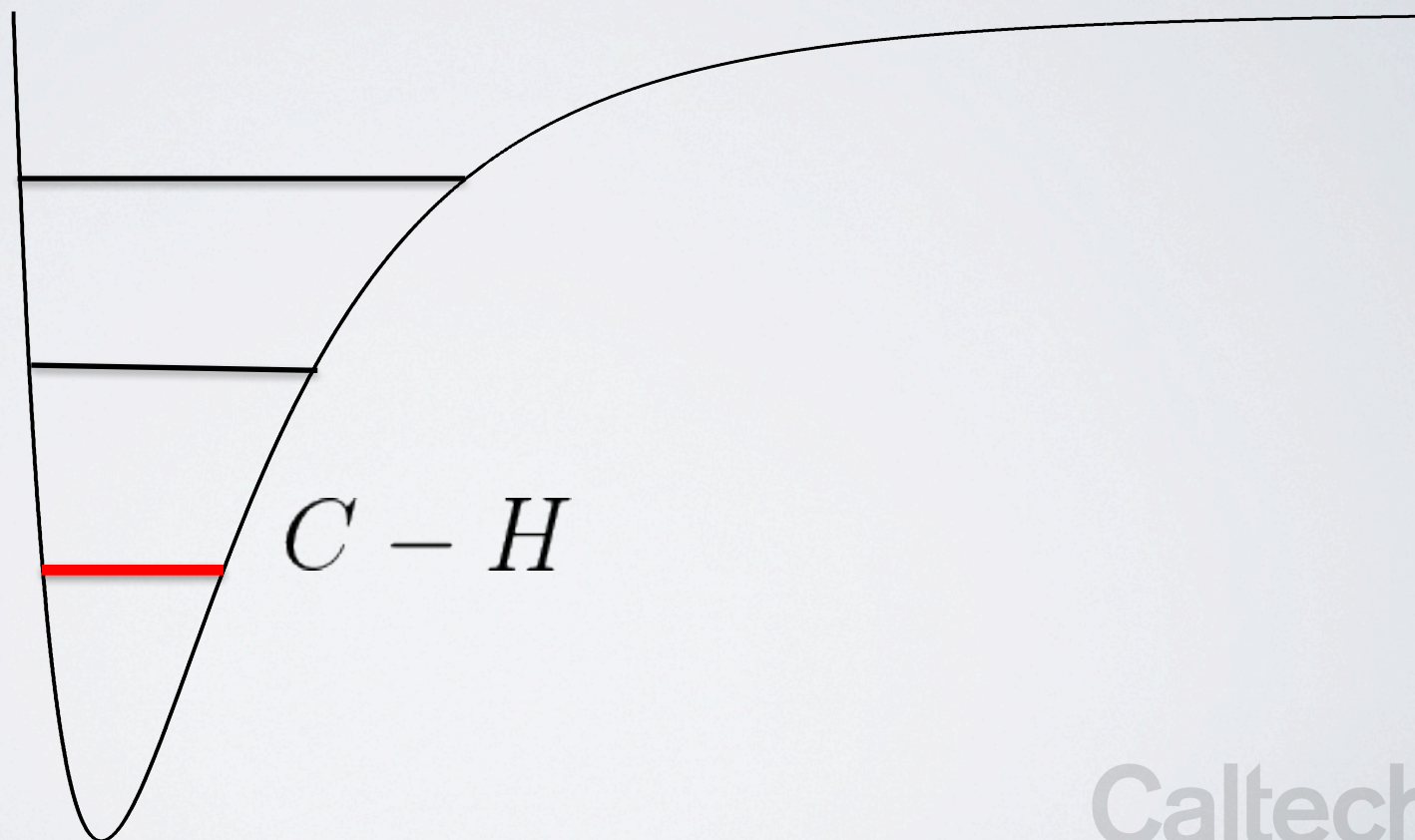
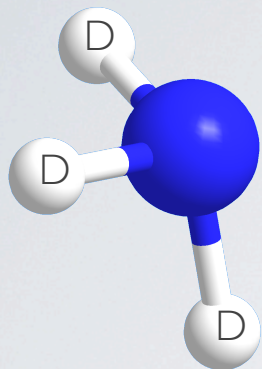
THE ASTROPHYSICAL JOURNAL, 571:L55–L58, 2002 May 20

© 2002. The American Astronomical Society. All rights reserved. Printed in U.S.A.

DETECTION OF TRIPLY DEUTERATED AMMONIA IN THE BARNARD 1 CLOUD

D. C. LIS,¹ E. ROUEFF,² M. GERIN,³ T. G. PHILLIPS,¹ L. H. COUDERT,⁴ F. F. S. VAN DER TAK,⁵ AND P. SCHILKE⁵

Received 2002 March 11; accepted 2002 April 10; published 2002 April 19





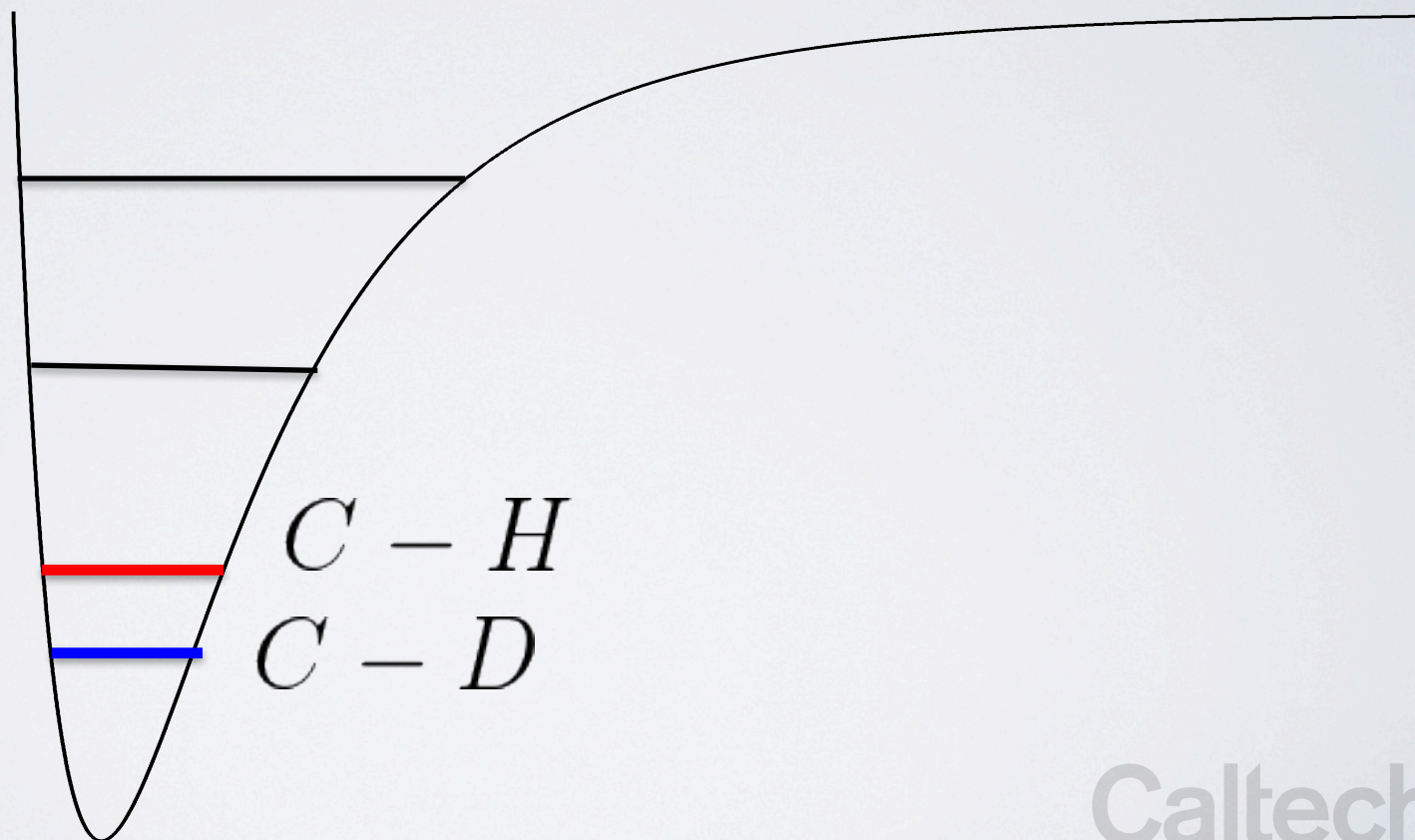
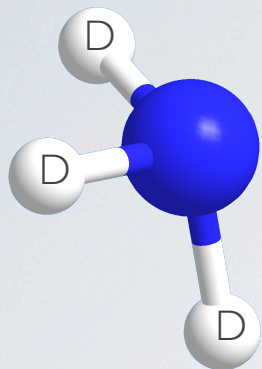
THE ASTROPHYSICAL JOURNAL, 571:L55–L58, 2002 May 20

© 2002. The American Astronomical Society. All rights reserved. Printed in U.S.A.

DETECTION OF TRIPLY DEUTERATED AMMONIA IN THE BARNARD 1 CLOUD

D. C. LIS,¹ E. ROUEFF,² M. GERIN,³ T. G. PHILLIPS,¹ L. H. COUDERT,⁴ F. F. S. VAN DER TAK,⁵ AND P. SCHILKE⁵

Received 2002 March 11; accepted 2002 April 10; published 2002 April 19





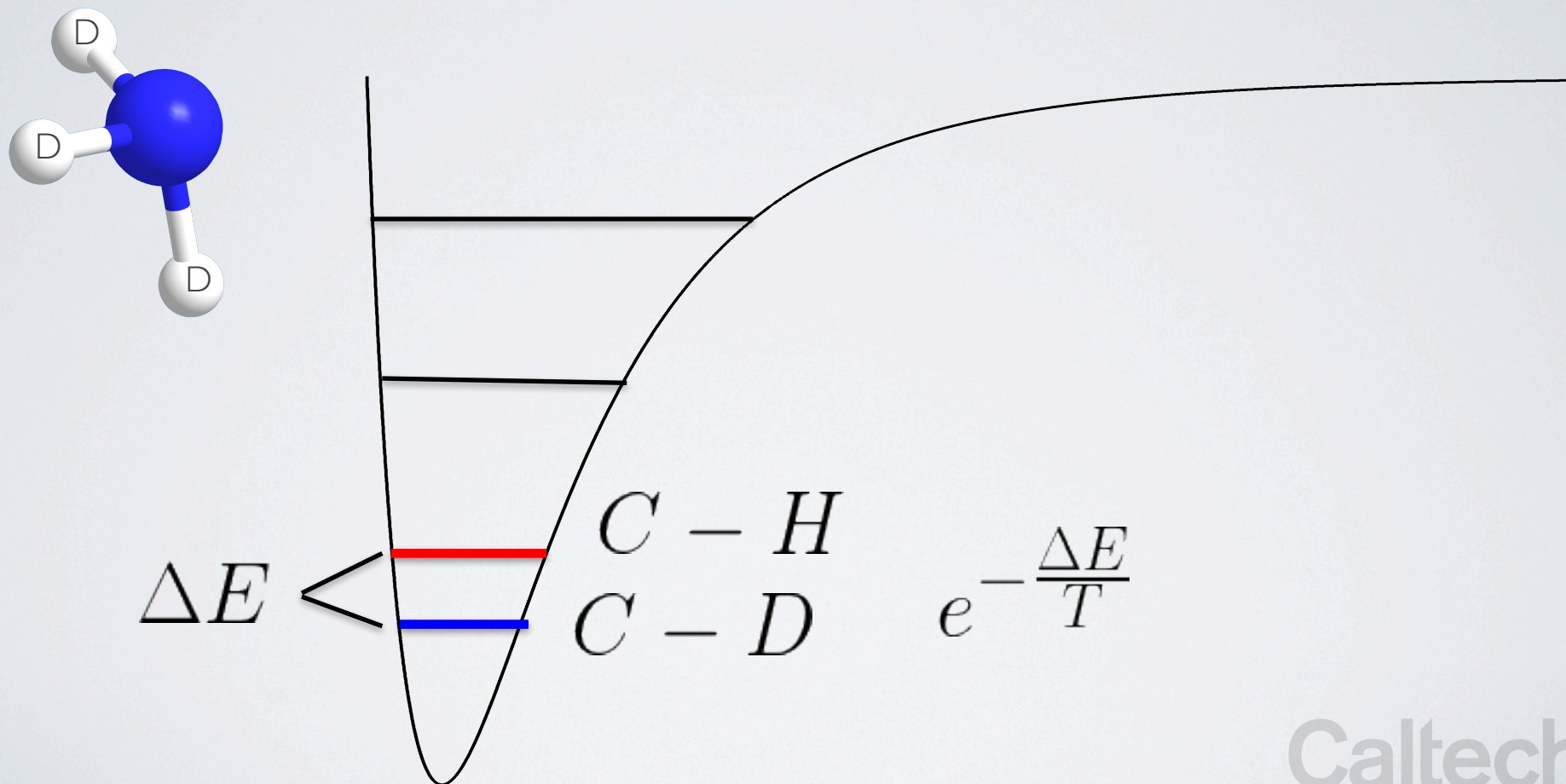
THE ASTROPHYSICAL JOURNAL, 571:L55–L58, 2002 May 20

© 2002. The American Astronomical Society. All rights reserved. Printed in U.S.A.

DETECTION OF TRIPLY DEUTERATED AMMONIA IN THE BARNARD 1 CLOUD

D. C. LIS,¹ E. ROUEFF,² M. GERIN,³ T. G. PHILLIPS,¹ L. H. COUDERT,⁴ F. F. S. VAN DER TAK,⁵ AND P. SCHILKE⁵

Received 2002 March 11; accepted 2002 April 10; published 2002 April 19





ALMA

- Image D/H ratio and CH_3CN T_{ex} *simultaneously*
- High angular resolution required ($1.8'' \times 1.2'' <$)

Grain Surface Formation

D/H Constant

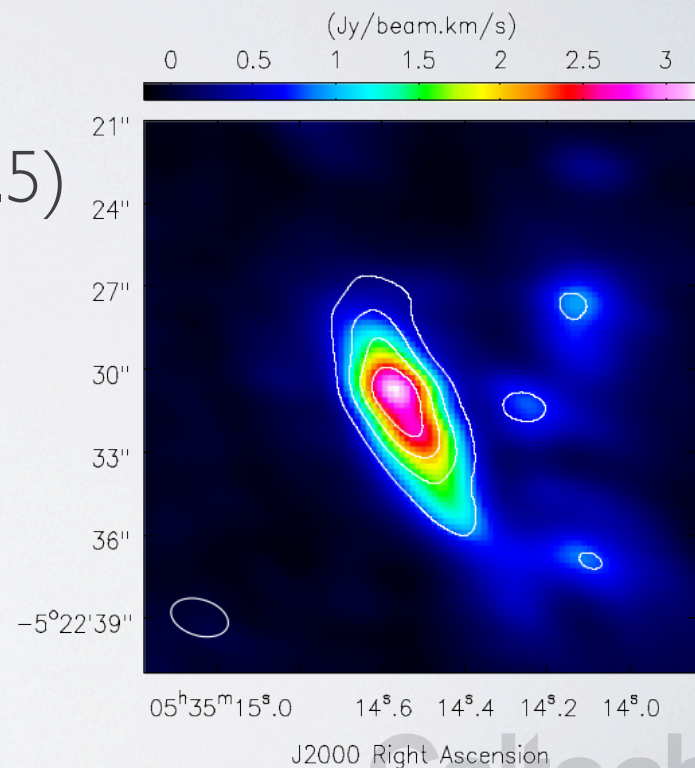
Gas Phase Formation

D/H Proportional to T_{ex}





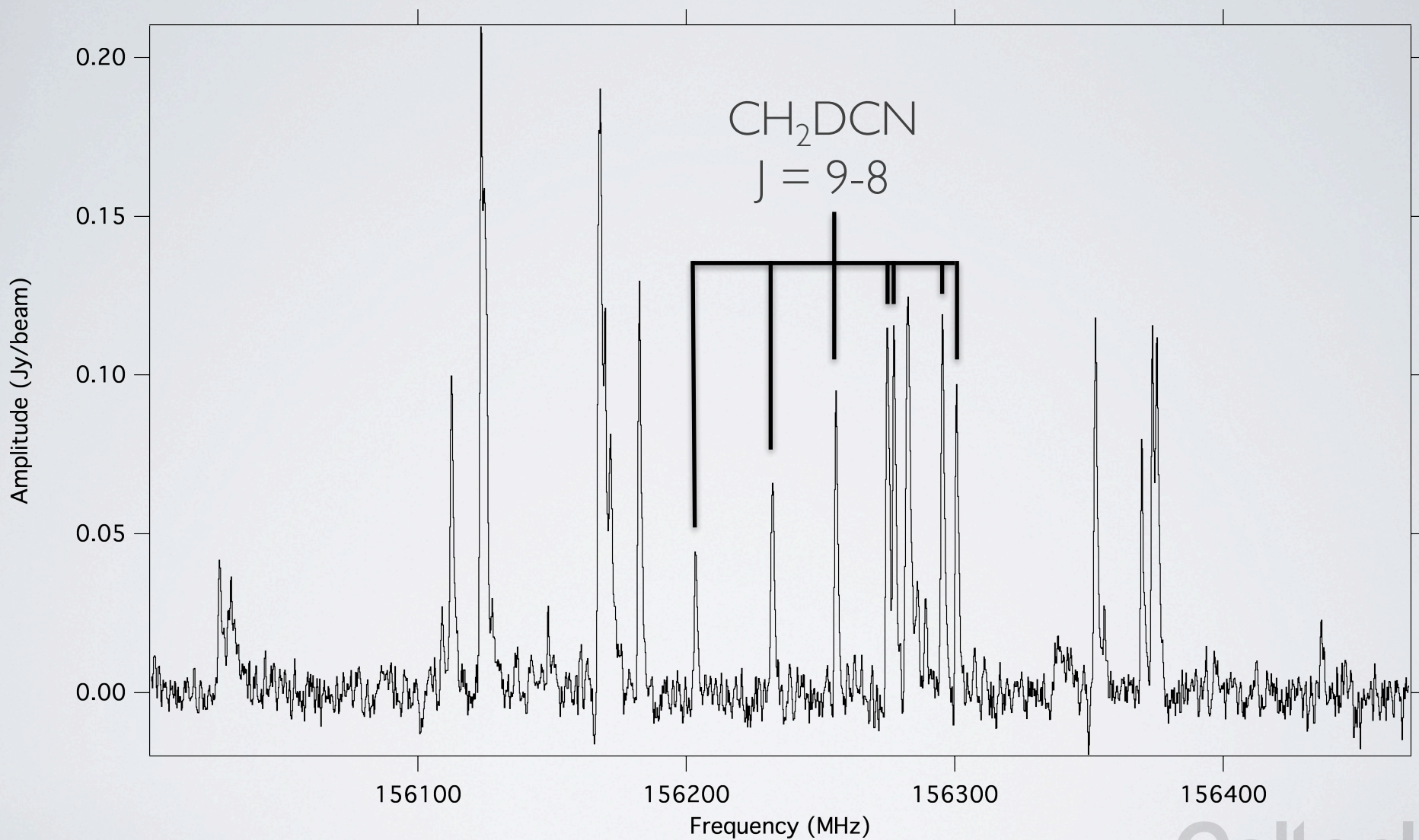
- 2 LO settings in Band 4 (146 GHz)
- Low resolution ($2.3'' \times 1.3''$) Cycle 2
 - Clear detection of $\text{CH}_2\text{DCN}/^{13}\text{CH}_3\text{CN}$ & $\text{CH}_3^{13}\text{CN}$
- High resolution taken Cycle 3
 - $0.35'' \times 0.3''$ synthesized beam ($S=0.5$)
 - C34-7
 - Max Baseline 1.6km(825k λ)
 - 33 antennas
 - RMS $\sim 5\text{mJy}$





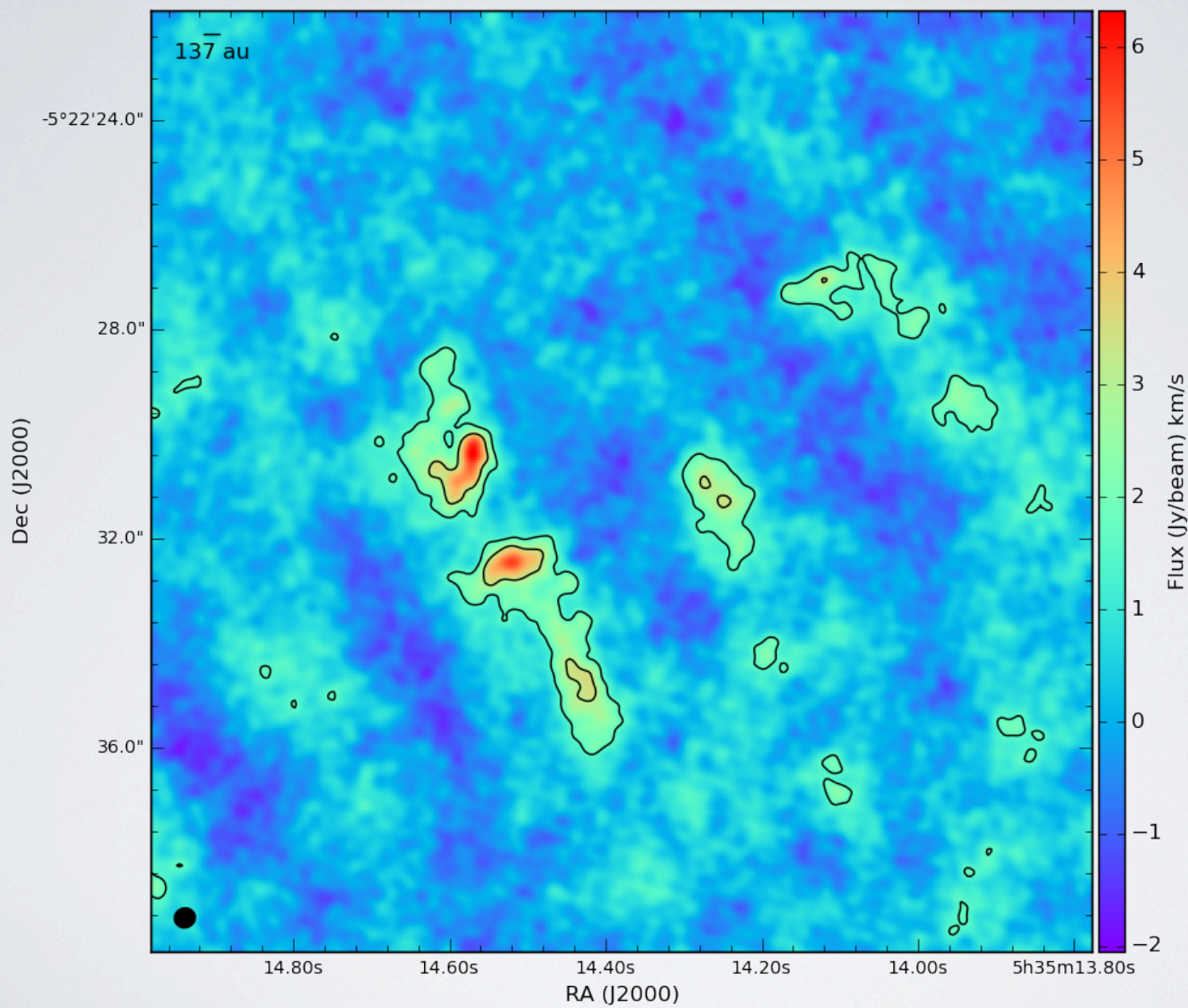
Species	Transition	Frequency (MHz)	Upper State Energy (K)	Line Strength (D ²)	A log(s ⁻¹)
¹³ CH ₃ CN	8 ₇ –7 ₇	142793.94160	381.29879	57.68051	-4.24039
¹³ CH ₃ CN	8 ₆ –7 ₆	142828.80880	288.39069	215.33644	-3.96901
¹³ CH ₃ CN	8 ₅ –7 ₅	142858.33610	209.74043	149.96124	-3.82485
¹³ CH ₃ CN	8 ₄ –7 ₄	142882.51140	145.36583	184.56079	-3.73447
¹³ CH ₃ CN	8 ₂ –7 ₂	142914.85	59.49889	230.69417	-3.63728
CH ₂ DCN	9 _{1,9} –8 _{1,8}	155614.87	42.74	136.60057	-3.50121
CH ₂ DCN	9 _{1,8} –8 _{1,7}	156970.26	43.06	136.59778	-3.48992
CH ₂ DCN	9 _{2,7} –8 _{2,6}	156304.638	59.08	131.48	-3.51206
CH ₂ DCN	9 _{3,6} –8 _{3,5}	156278.889	54.588	86.03938	-3.54140
CH ₂ DCN	9 _{3,7} –8 _{3,6}	156278.85	54.588	86.03938	-3.54140
CH ₂ DCN	9 _{4,5} –8 _{4,4}	156259.7696	123.77664	110.98263	-3.51206
CH ₂ DCN	9 _{4,6} –8 _{4,5}	156259.7696	123.77664	110.98263	-3.51206
CH ₂ DCN	9 _{5,5} –8 _{5,4}	156236.13200	172.28359	95.61108	-3.65097
CH ₂ DCN	9 _{5,4} –8 _{5,3}	156236.13200	172.28359	95.61108	-3.65097
CH ₂ DCN	9 _{6,3} –8 _{6,2}	156207.55840	231.55057	76.83619	-3.74615
CH ₂ DCN	9 _{6,4} –8 _{6,3}	156207.55840	231.55057	76.83619	-3.74615





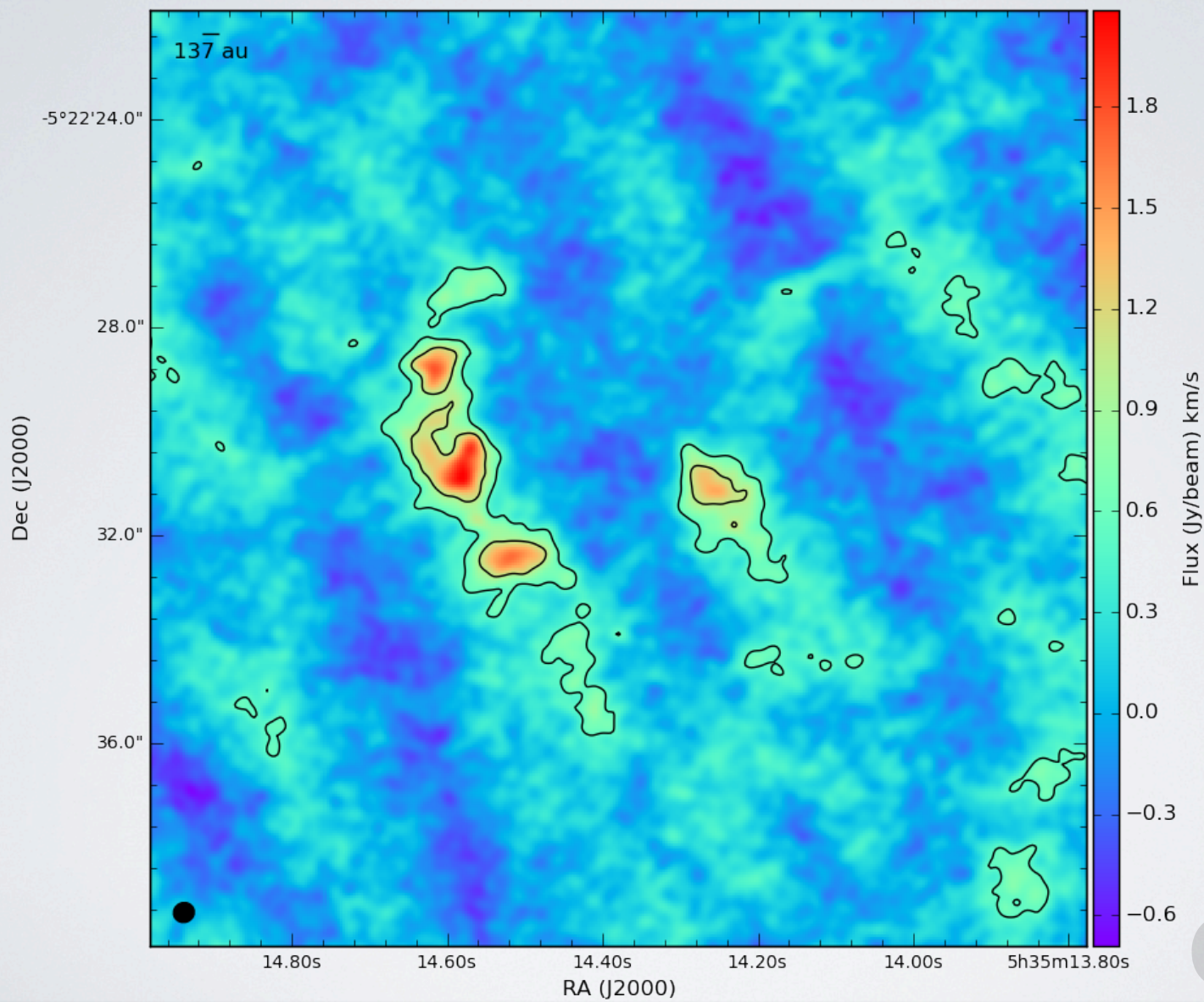


CH₂DCN DISTRIBUTION



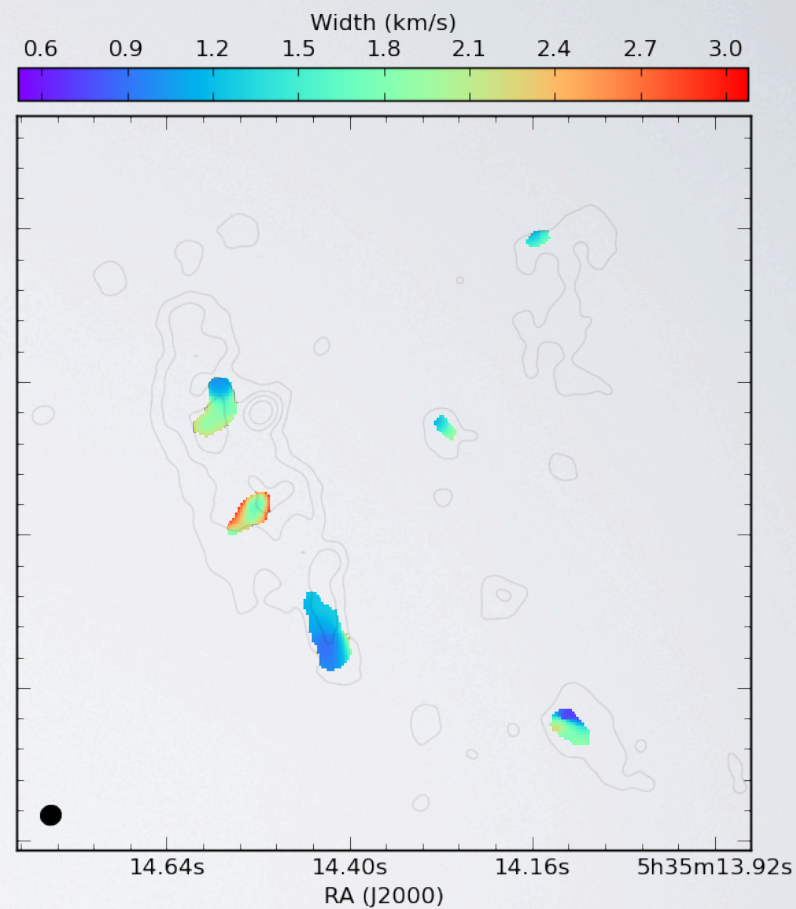
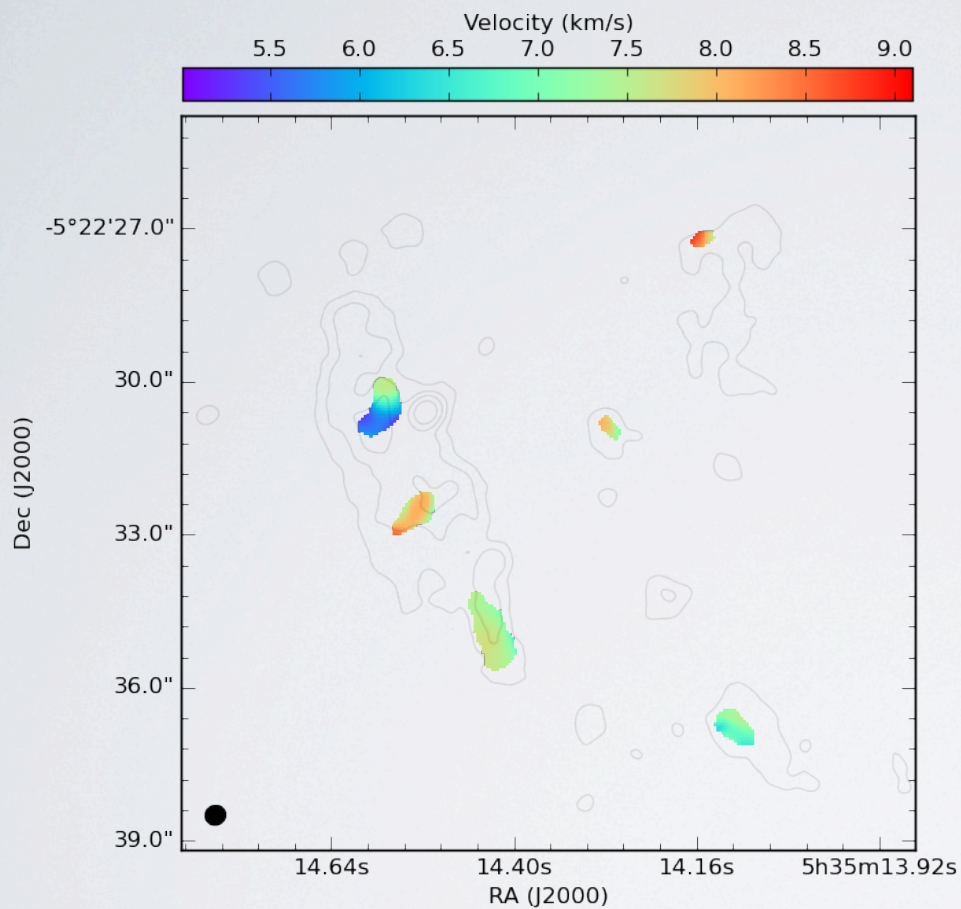


$^{13}\text{CH}_3\text{CN}$ DISTRIBUTION



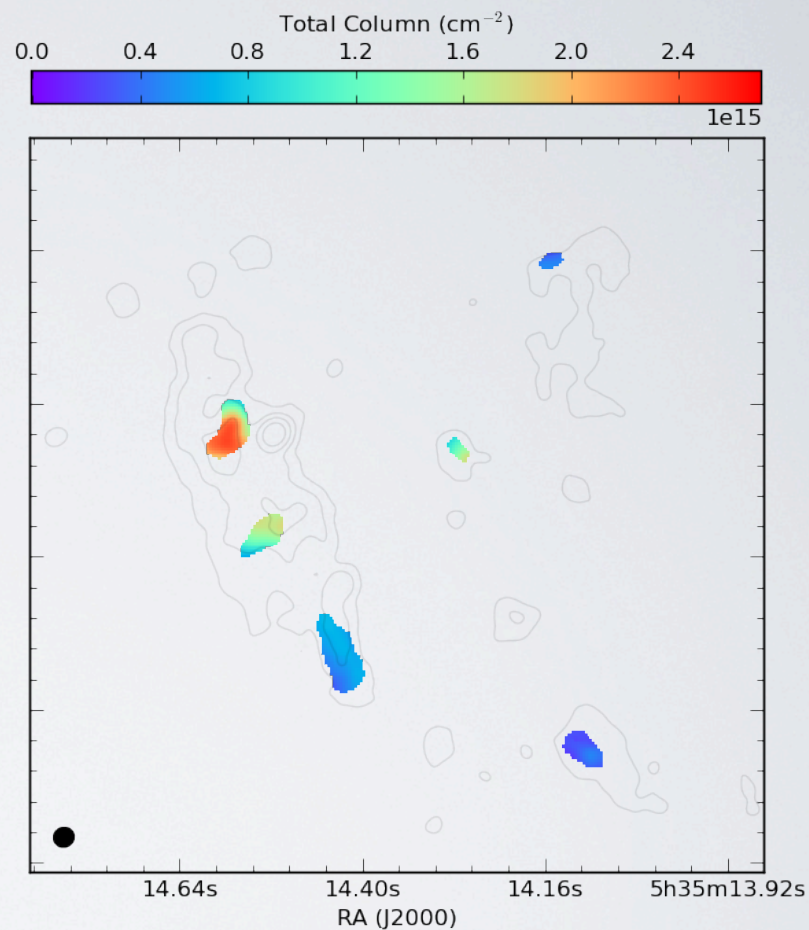
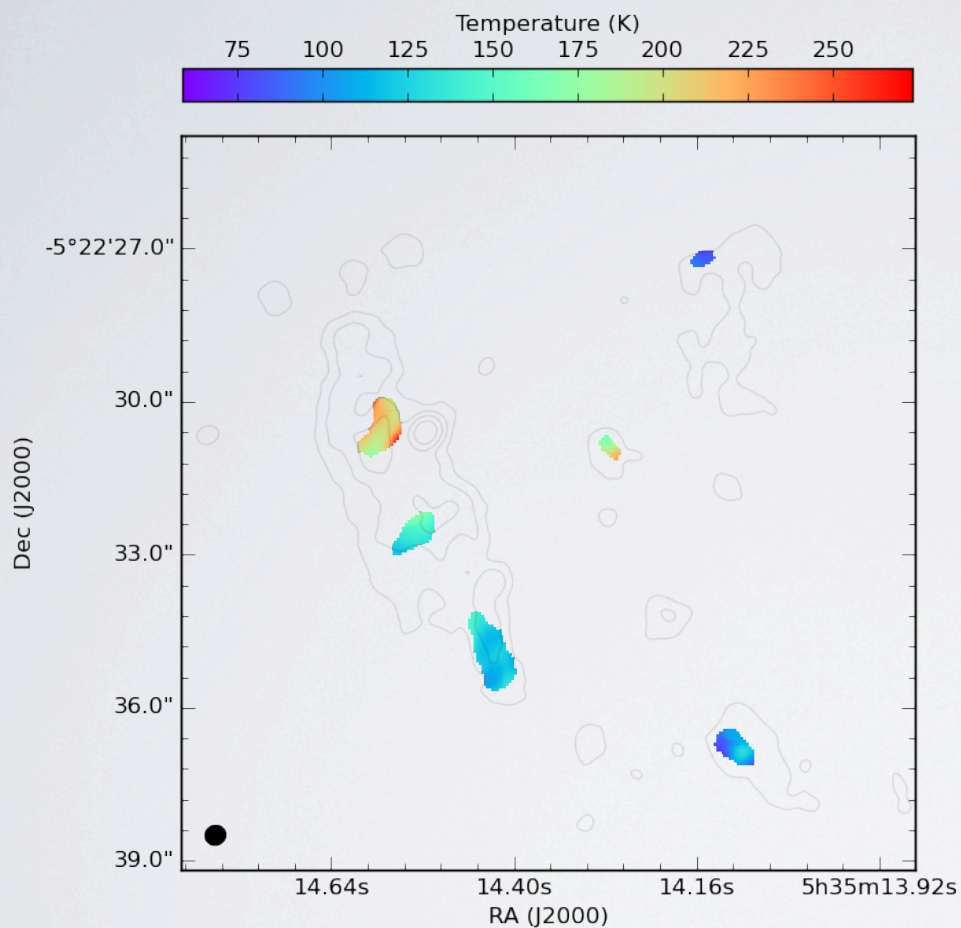


FIT RESULTS – KINEMATICS



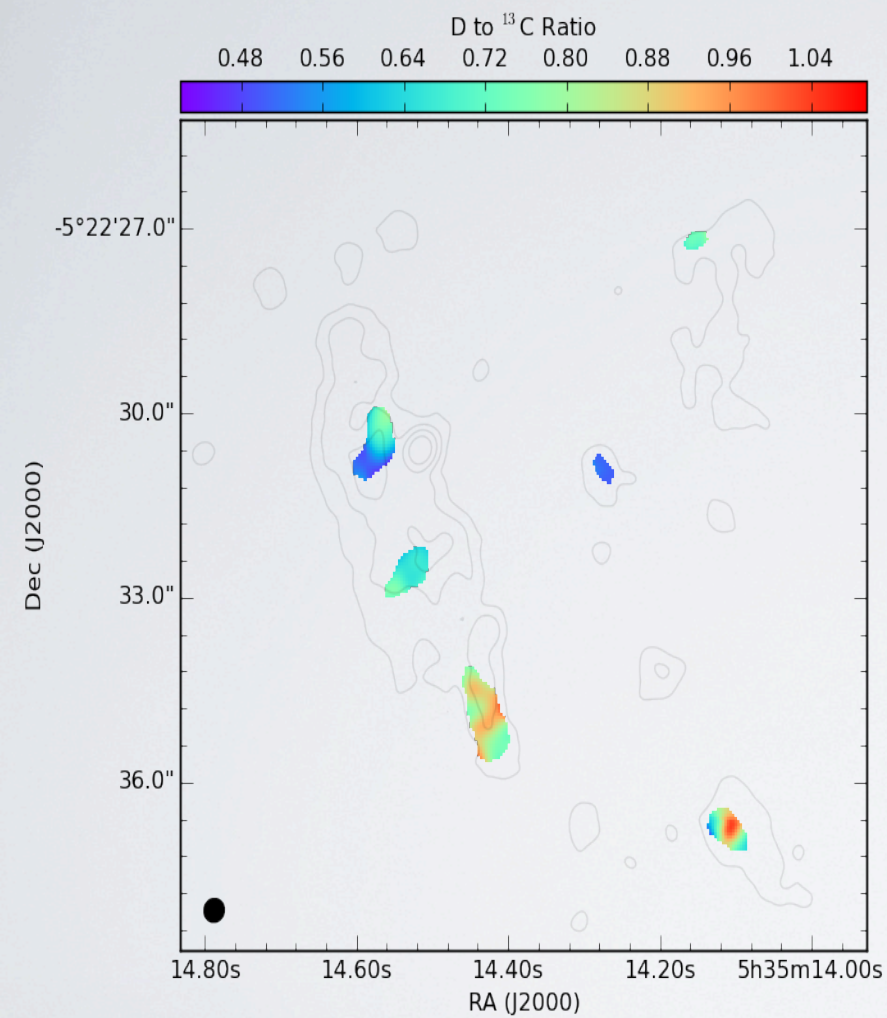


FIT RESULTS - CH₃CN



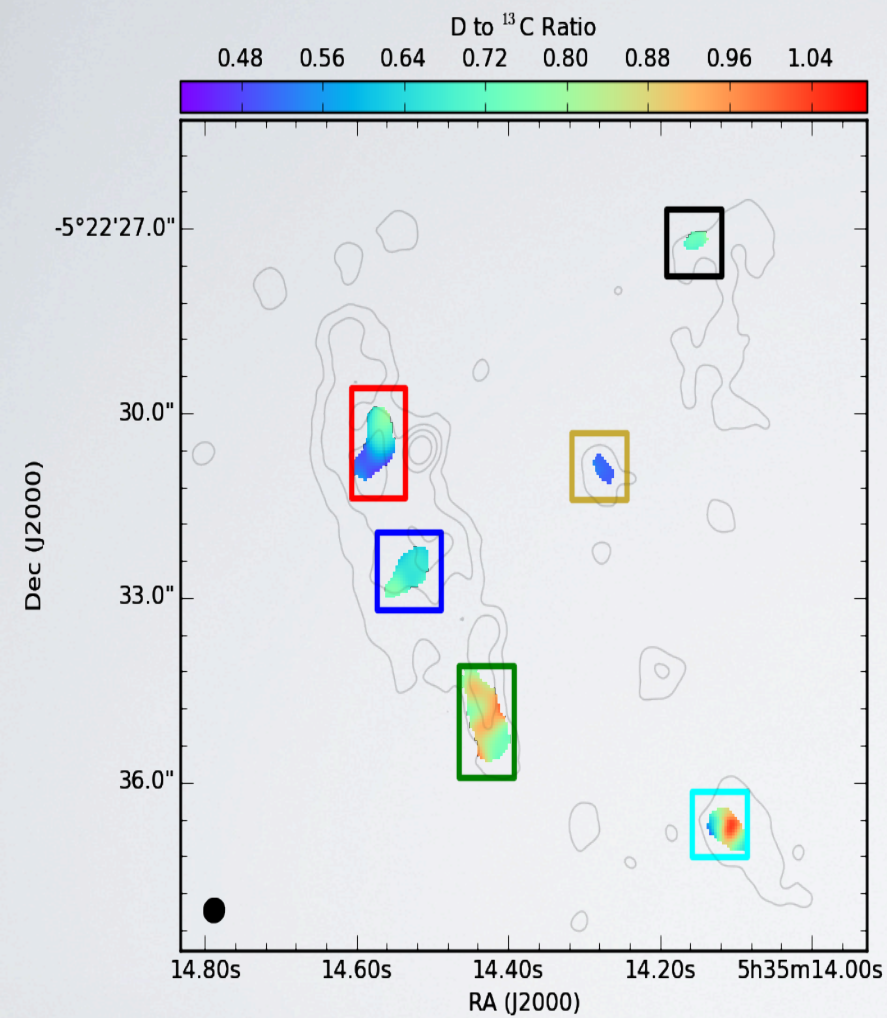


FIT RESULT - DEUTERIUM FRACTIONATION



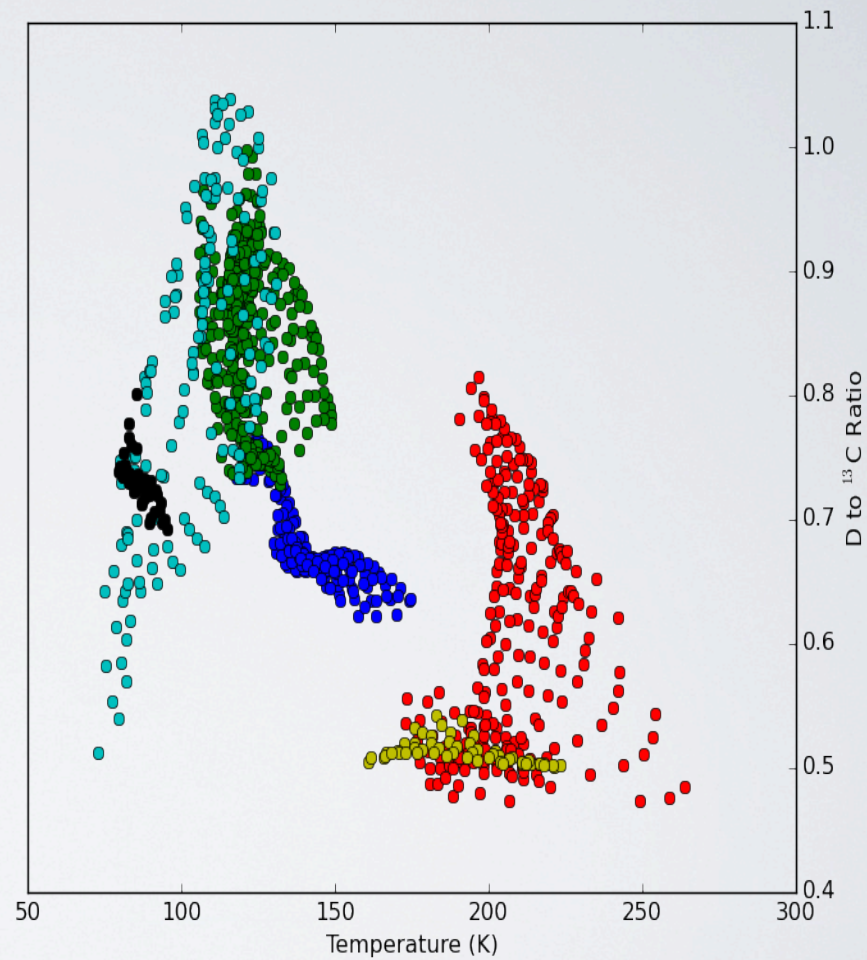
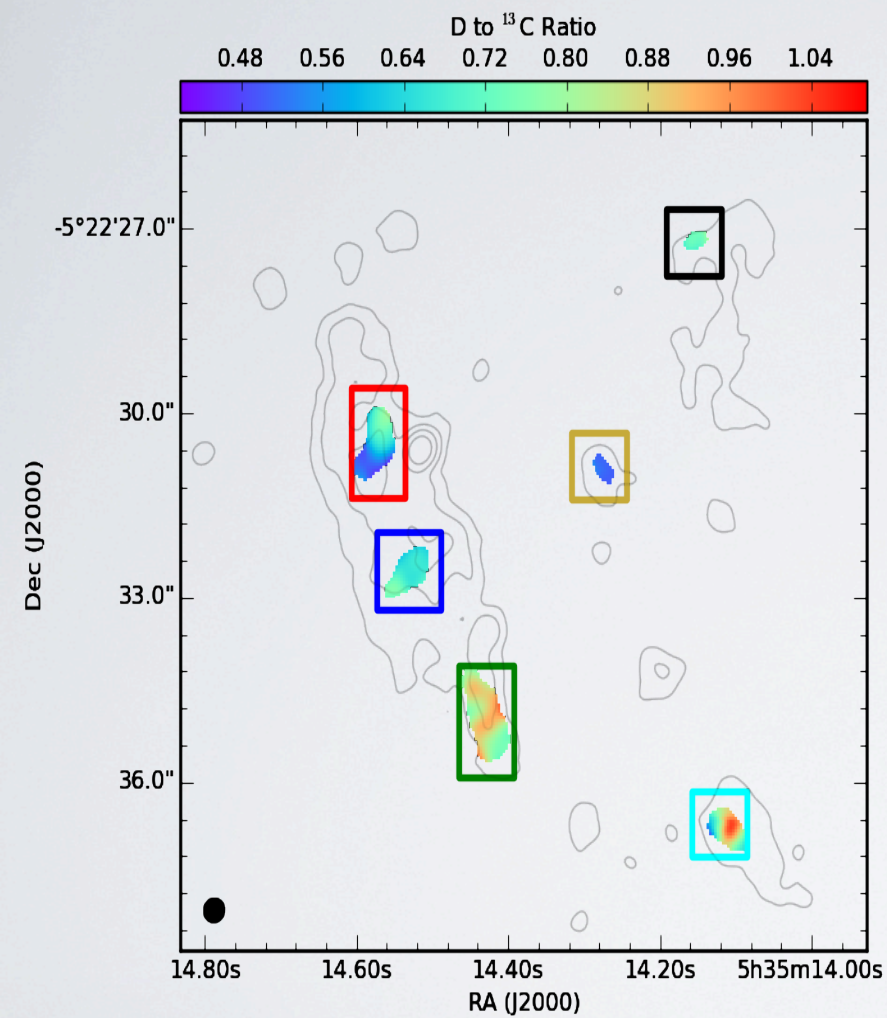


FIT RESULT - DEUTERIUM FRACTIONATION





FIT RESULT - DEUTERIUM FRACTIONATION



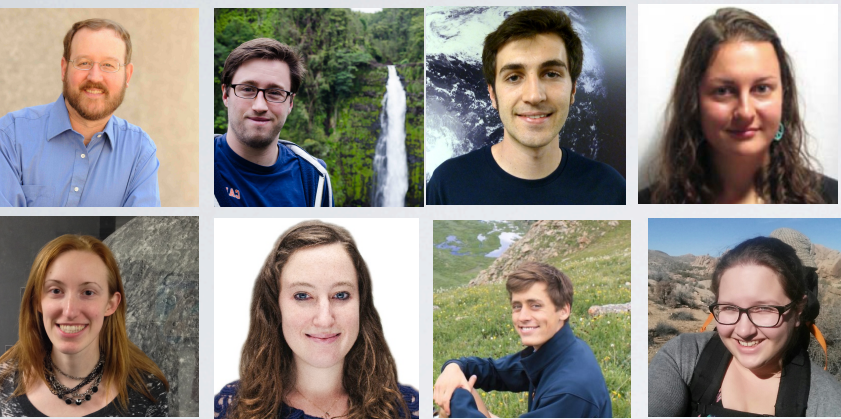


- Spatially resolved detections of CH_2DCN and $^{13}\text{CH}_3\text{CN}$
- Derived temperature and $\text{D}/^{13}\text{C}$ ratio
- Short and complex-scale gradients in kinematics, temperature and deuterium fraction
- Individual sources are chemically and physically distinct
- Regions of fractionation correlated and uncorrelated with temperature



ACKNOWLEDGEMENTS

The Blake Group



Ian Finneran, Masha
Kleshcheva, Dana Anderson,
Danielle Piskorz, Griffin
Mead, Olivia Wilkins, Geoff
Blake

Collaborators

Nate Crockett
Cecile Favre



Ted Bergin



Caltech



