



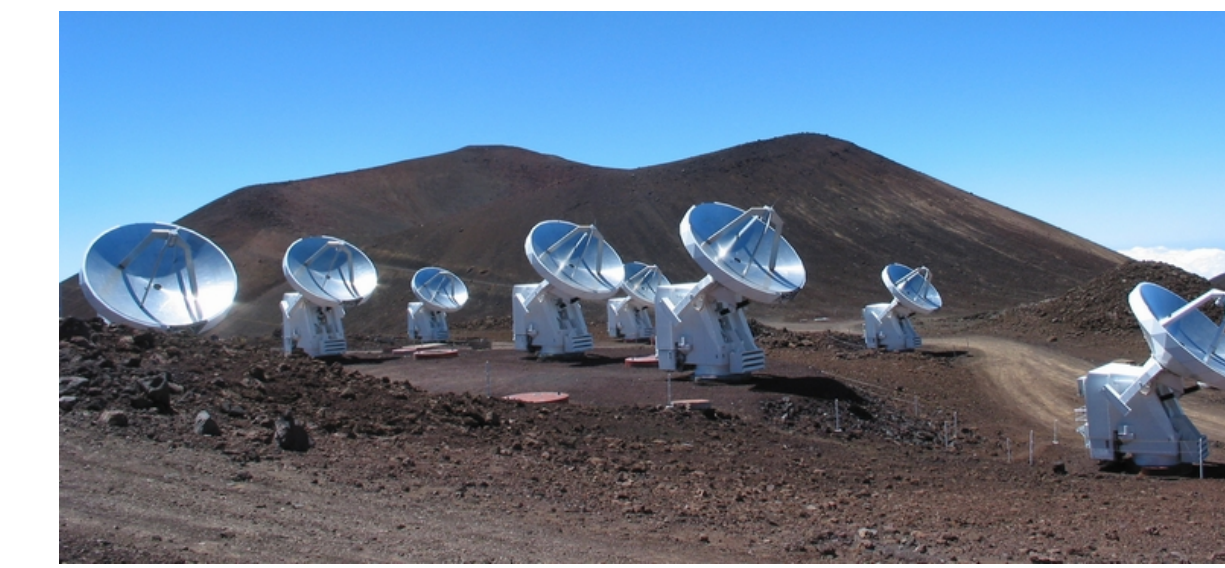
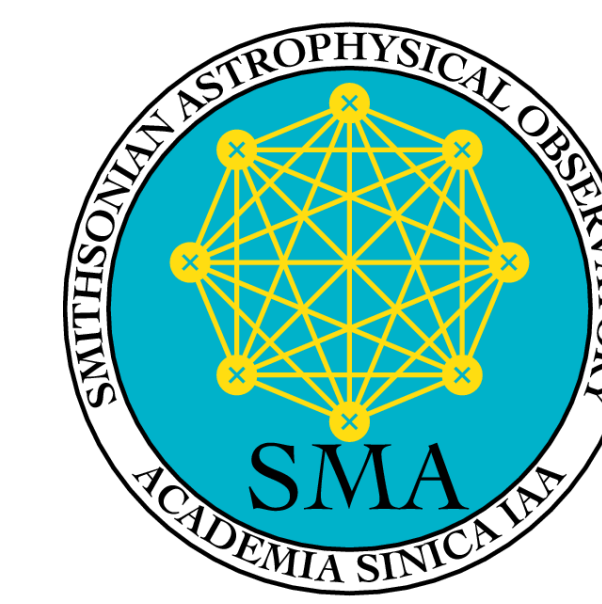
A Serendipitous Line Survey of Titan in the 1.3mm Band

Mark Gurwell¹, Bryan Butler², and Arielle Moullet³

¹Harvard-Smithsonian Center for Astrophysics, Cambridge, MA (mgurwell@cfa.harvard.edu)

²National Radio Astronomy Observatory, Socorro, NM (bbutler@nrao.edu)

³National Radio Astronomy Observatory, Charlottesville, VA (amoullet@nrao.edu)

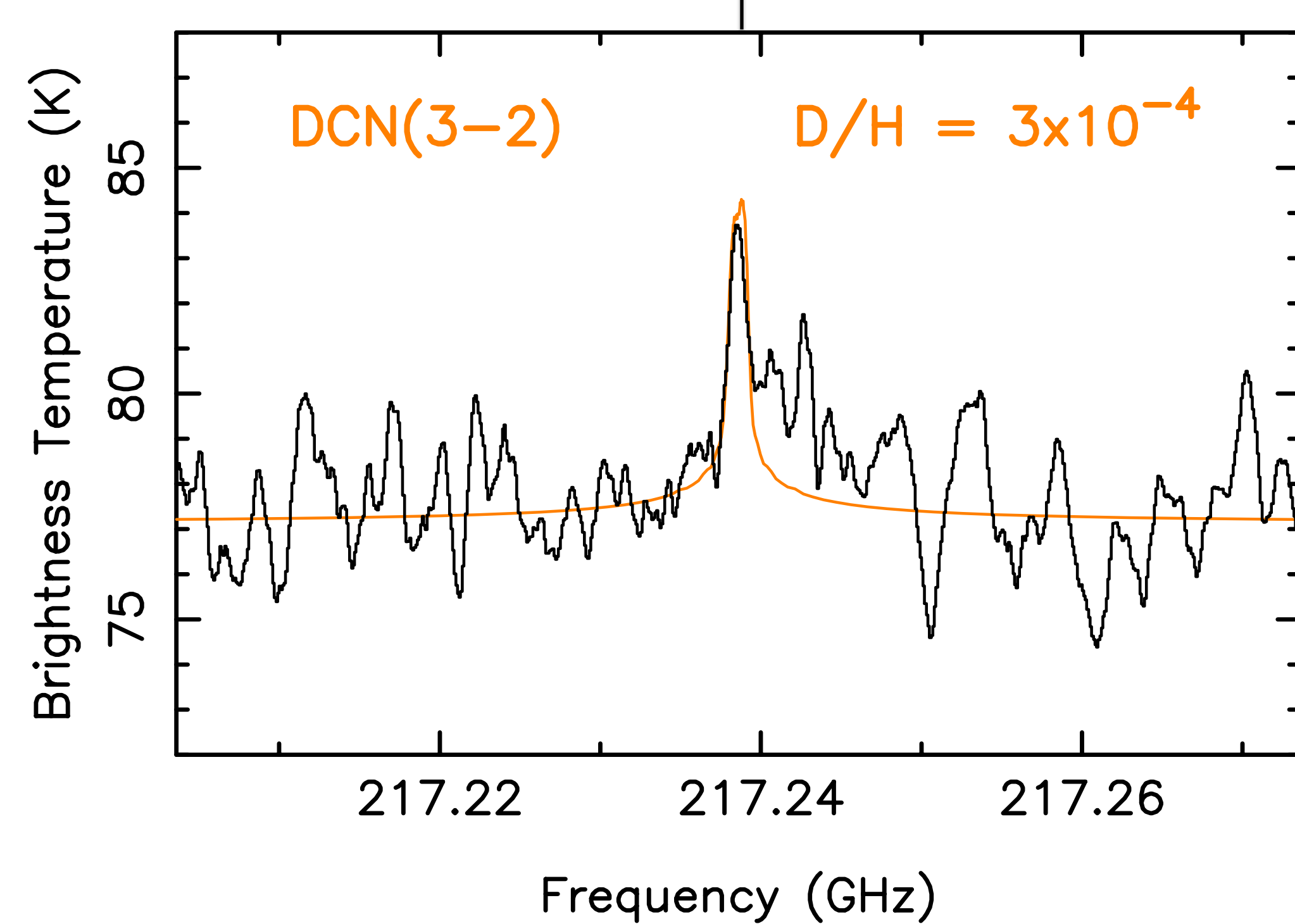
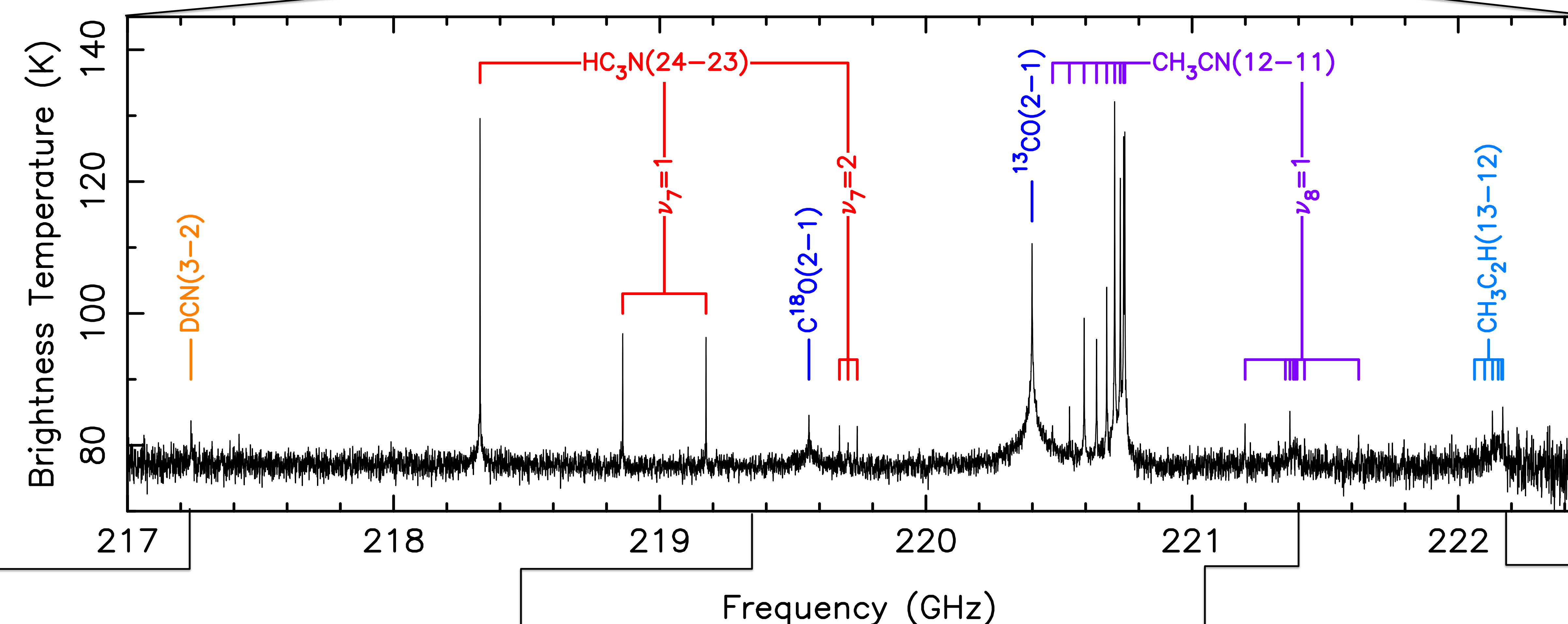
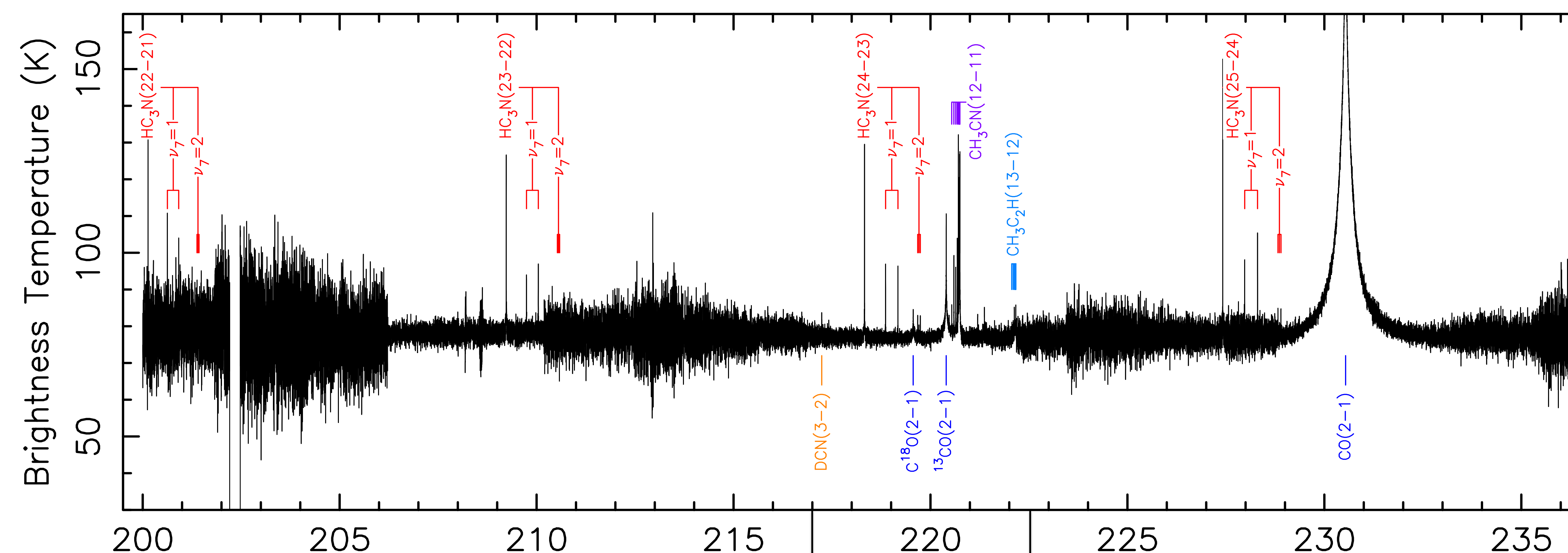


INTRODUCTION

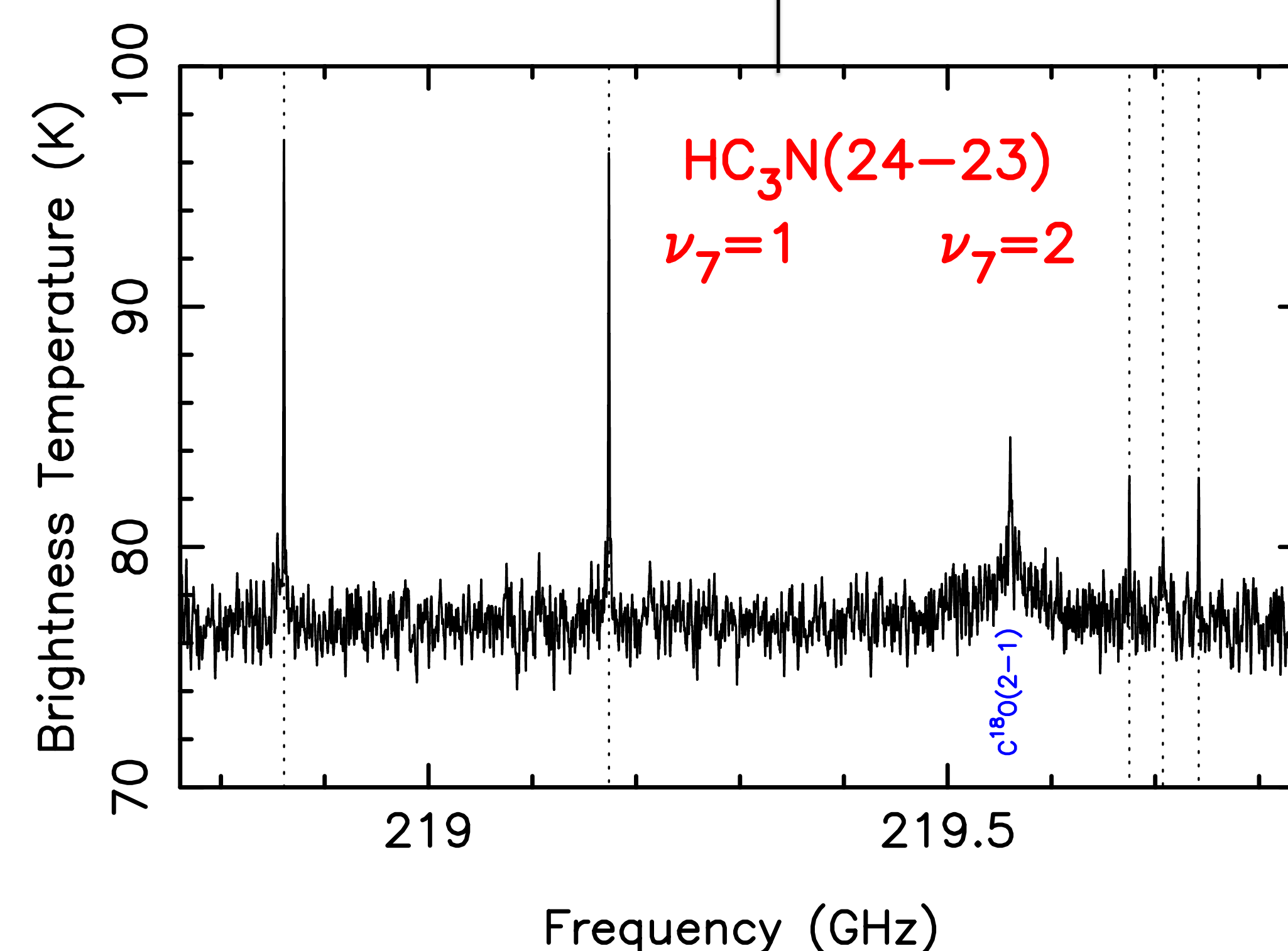
Titan is utilized as one of the Submillimeter Array primary standards for flux calibration in the 1.3mm, 1.1mm and 870 μ m transmission windows. Each observation is typically just 5 to 30 minutes long, with frequency coverage (either 2 or 4 GHz bandwidth in each of two sidebands) and resolution governed by the science project active at the time. Although non-uniformly distributed in frequency, this set of Titan calibration data represents significant telescope time.

THE PROGRAM

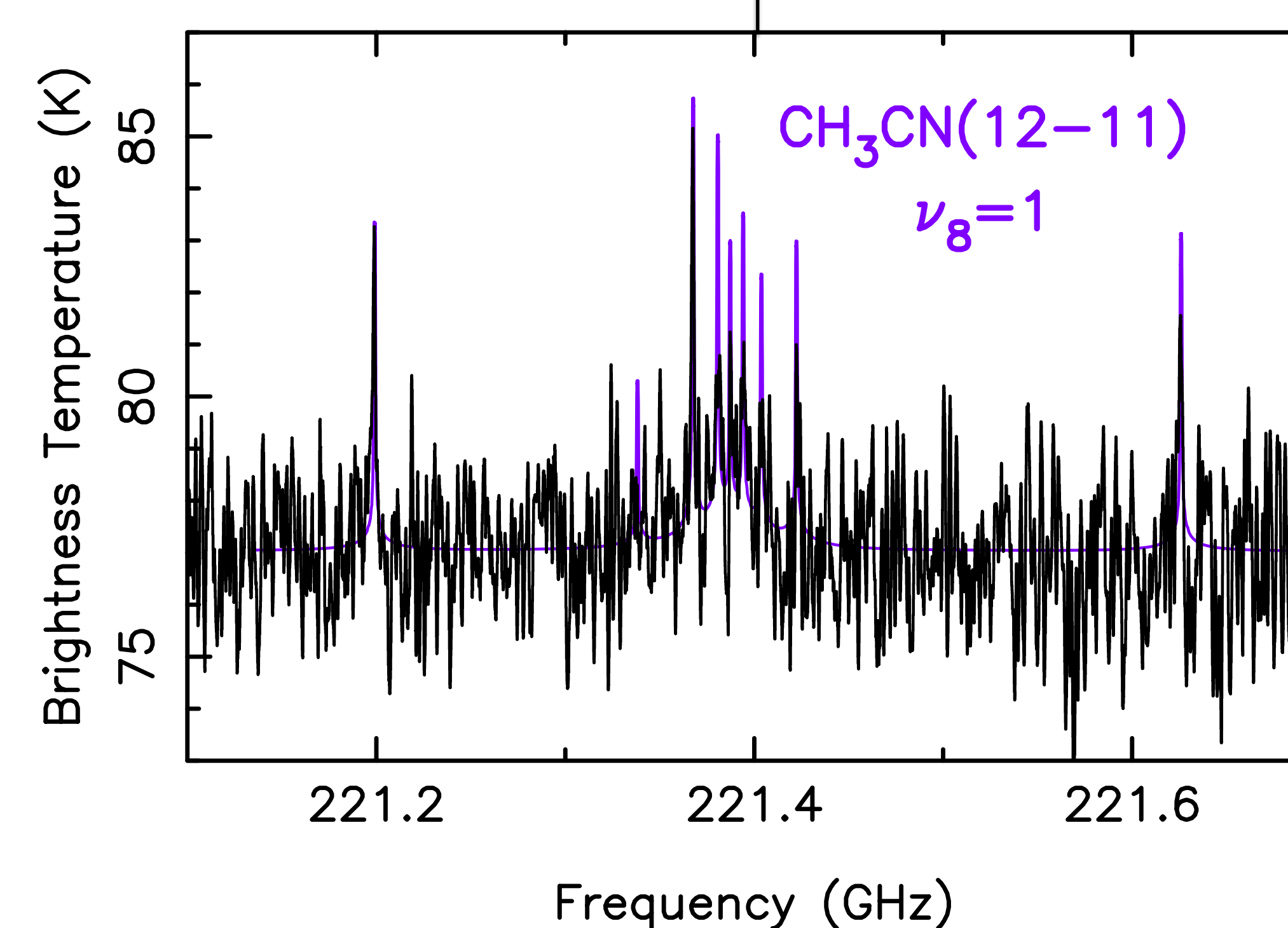
There have been many such observations over the past six years which are available in the SMA data archives. We developed an archival research program to locate, calibrate, align, extrapolate to disk-average (e.g. zero-spacing) spectra, and merge much of this data for use in detecting spectral lines from trace atmospheric species. We present here preliminary results from the first phase of this program, focusing on the 1.3mm band (200-250 GHz).



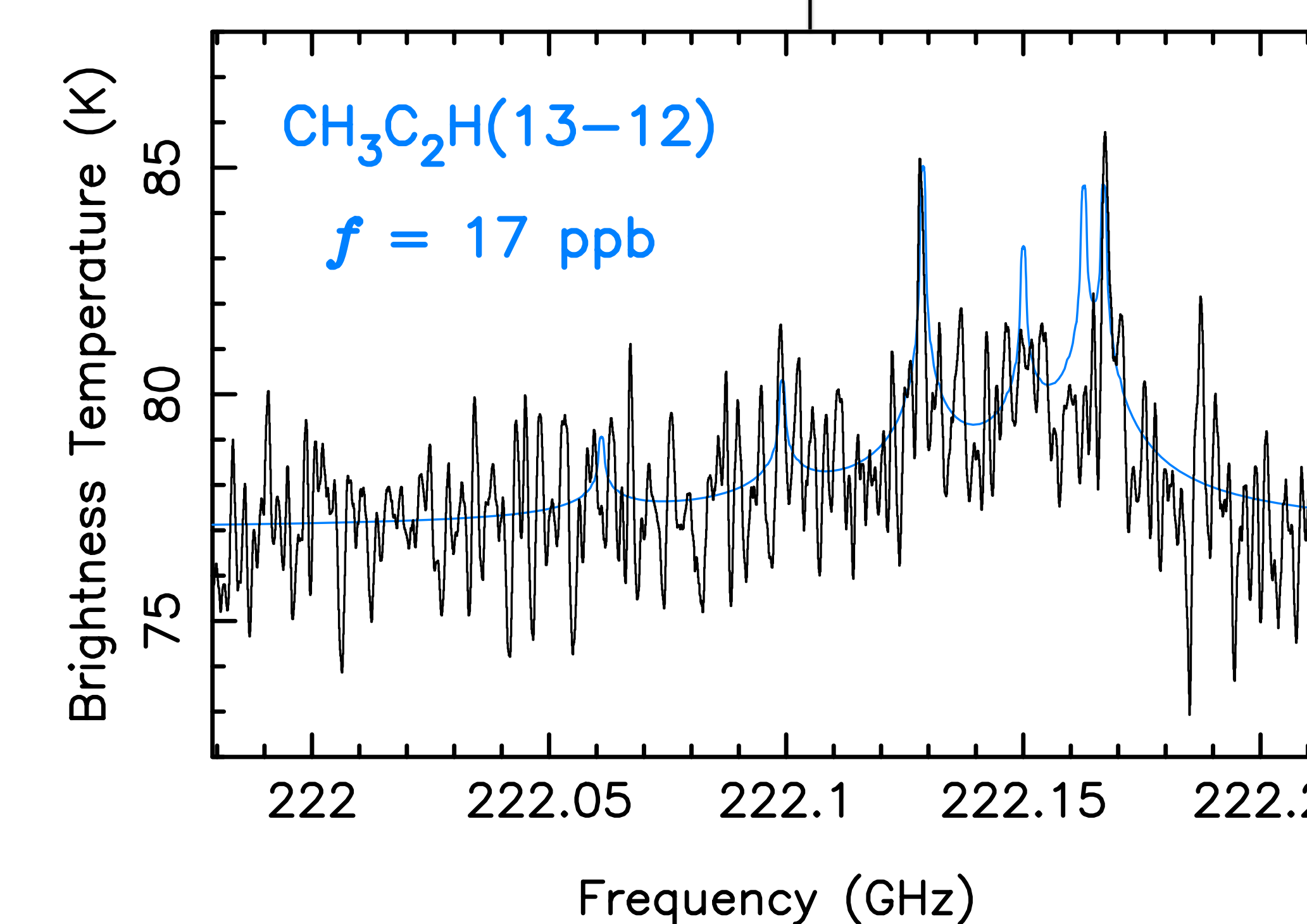
First detection of DCN in Titan's atmosphere. Model spectrum shown for D/H ratio in HCN twice that in methane ($1.59 \pm 0.33 \times 10^{-4}$, Nixon et al 2012), assuming HCN profile of Gurwell et al 2011).



First mm/submm detections of vibrationally excited lines of HC₃N from Titan's stratosphere, including several $\nu_7=1$ and $\nu_7=2$ bands, complementing the pure rotational lines.



First detection of vibrationally excited CH₃CN on Titan, with 8 components of the (12-11) $\nu_8=1$ band, complementing the nearby pure rotational (12-11) band.



First mm/submm detection of CH₃C₂H from Titan. The model spectrum shown is for 17 ppb above 150 km, in agreement with measurements obtained by Cassini/CIRS (Vinatier et al 2010).

THE DATA

We located several hundred observations of Titan in the 1.3mm band. Discarding data adversely affected by weather or Saturn left 218 data sets with a combined integration time of **110.5 hours**. Each spectrum was calibrated, aligned, smoothed to 1 MHz resolution, and scaled to a common reference diameter (0.8"). Merged, they produce a continuous spectrum from 200 to 249 GHz.

THE SPECTRUM

At upper left is a portion of the 1.3mm band spectrum (200 to 236 GHz), and below that an expanded view (217 to 222.5 GHz), with quasi-uniform sensitivity (1.8 K/MHz) derived from 149 different observations (82.9 hours).

THE DETECTIONS

Previously detected species include CO, ¹³CO and C¹⁸O (2-1), CH₃CN (12-11) and (13-12) (not shown), and five lines of HC₃N (four shown). See Marten et al. (2002), Gurwell et al (2004, 2009, 2011), Vinatier et al (2010), and Courtin et al (2012). **New detections** are highlighted in the four expanded spectral panels below.