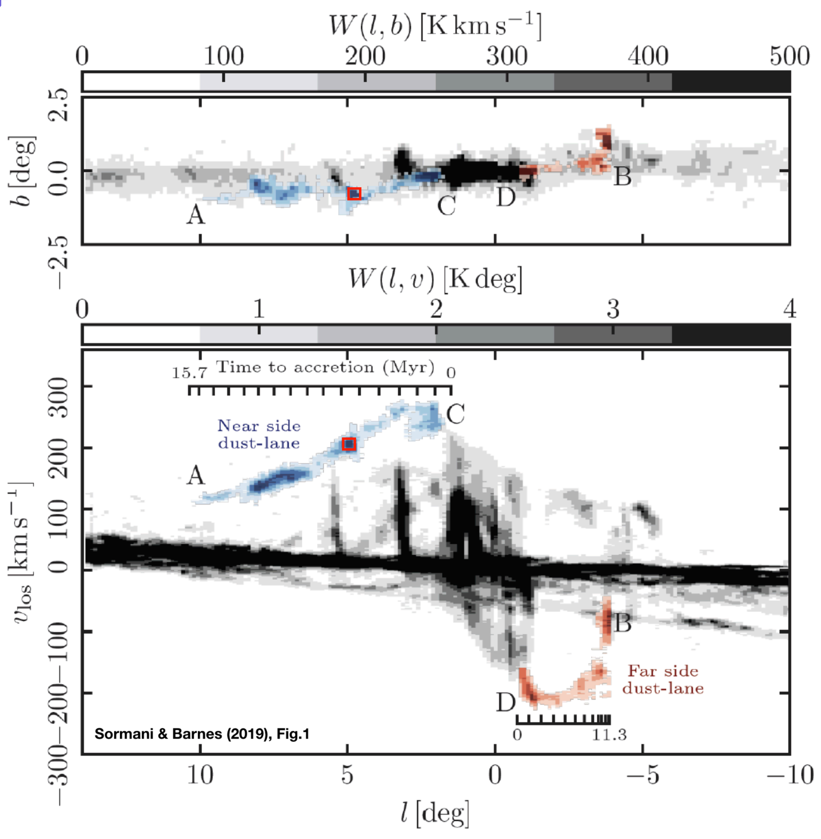
Milky Way Galactic Bar Dust Lanes: Feeding the CMZ

Authors: Natalie Butterfield (NRAO), Larry Morgan (GBO), Allie Costa (NRAO), Ash Barnes (ESO), Mattia Sormani (U.dell'Insubria), Adam Ginsburg (U.Florida), Betsy Mills (U.Kansas), Savannah Gramze (U.Florida), Juergen Ott (NRAO), Mark Morris (UCLA), Michael Rugel (NRAO), Cara Battersby (U.Conn)

GREEN BANK OBSERVATORY

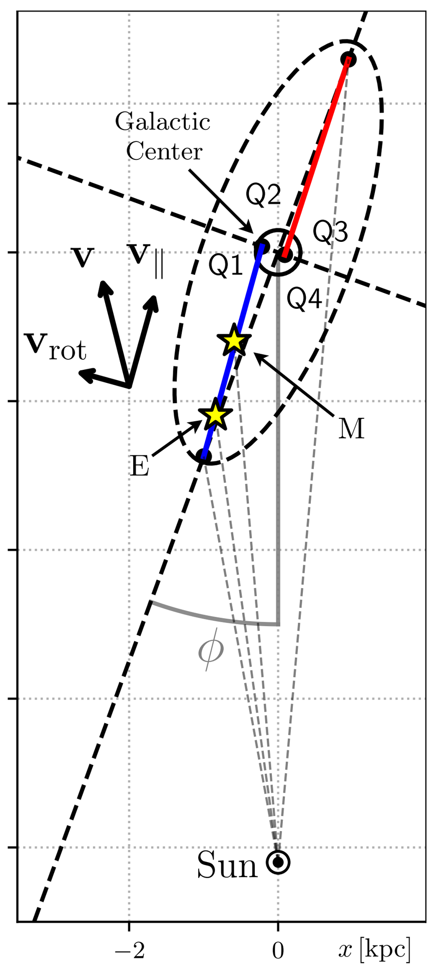


Milky Way Galactic Bar Dust Lanes

The Galactic Bar Dust Lanes are suggested to be feeding the CMZ with gas and dust needed to fuel star formation. However, the nature of this accreting material is not well understood. Observing the dust lanes is challenging due to our observing angle and line-of-sight confusion. Spectral line observations are necessary to isolate features in the dust lanes from the Disk in position-velocity space (left figure), due to the extreme velocities from our viewing angle (right figure). Despite the challenging nature of this analysis, it is important for our understanding of the initial conditions of gas accreting into the CMZ - raising these questions:

How do the dense gas properties compare to clouds in the Galactic Disk and the CMZ?

What are the initial conditions of the dense gas accreting into the CMZ?



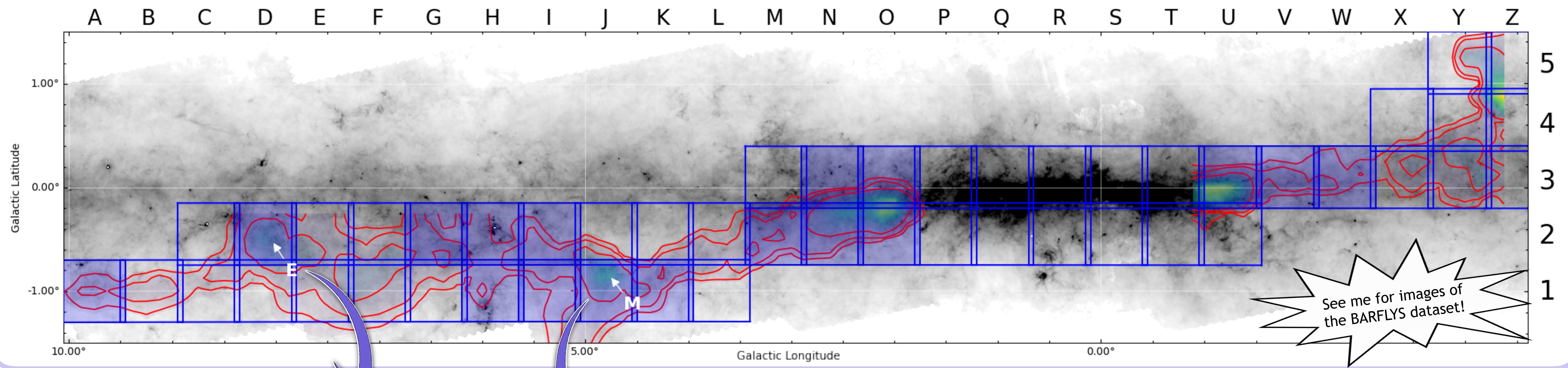
BARFLYS

Bar Ammonia Radiation in Filaments, Lanes and YSOs Survey

QR code for GBO survey page

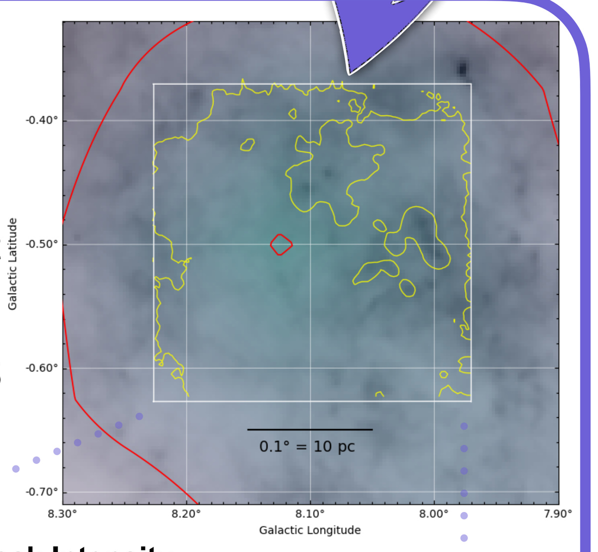
BARFLYS is an ongoing GBT large program that is covering the entirety to the Galactic Bar Dust Lanes (see blue tiles in figure below). BARFLYS is preceded by two pilot studies (E & M yellow stars in left figure) - which guided the observational setup of BARFLYS. The general results of the pilot studies are discussed below. BARFLYS covers 16.7 square degree and targets the lower NH_3 (1,1) and (2,2) transitions with a velocity coverage of ±1000 km/s. We have currently covered 17 of the proposed 50 tiles (as shaded). This complete survey will allow us to: 1) identify dense clouds embedded within the large structure, 2) disentangle continuum features (e.g., Herschel clouds, figure below) with velocity components along the line-of-sight, 3) measure the gas dynamics along the dust lane, 4) measure the gas temperature during accretion, 5) measure the dense gas fraction.

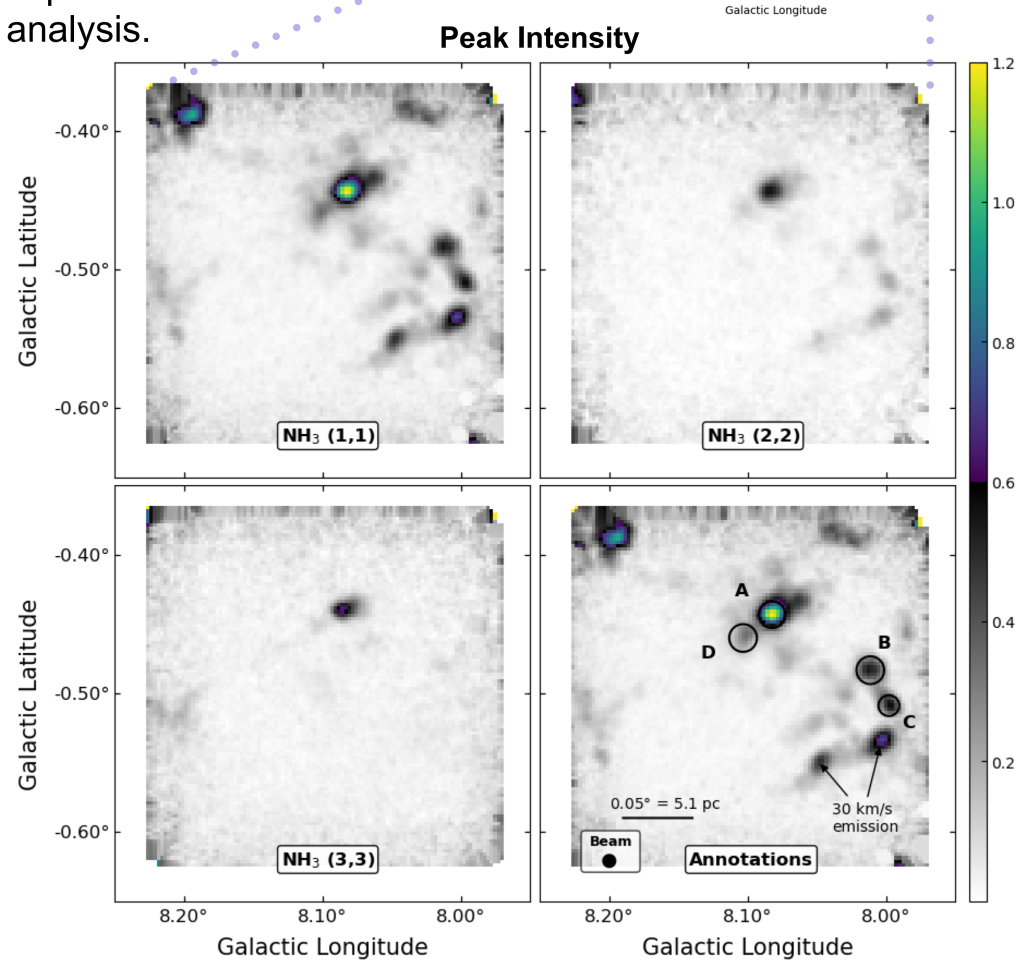
Herschel 250 micron grayscale with shaded contours showing the ^{12}CO (1-0) emission associated with the Galactic Bar Dust Lanes. The blue boxes ('tiles') show the proposed coverage of the BARFLYS dataset, with shaded boxes showing the completed tiles. The Edge ('E') and Midpoint ('M') correspond to the two pilot study regions targeted and are discussed in more detail below and shown as yellow stars in the figure above.



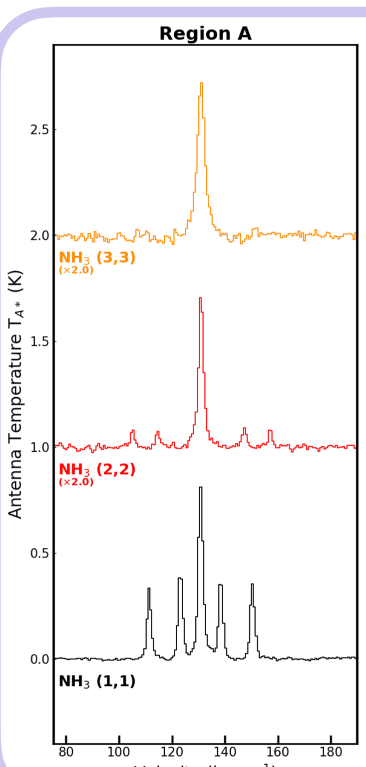
M8.1-0.5

M8.1-0.5 is comprised of several clump (1-5 pc in diameter) that will accrete into the CMZ in ~10 Myr. At this latitude, line-of-sight contamination can be problematic. Here, M8.1-0.5 overlaps with an HII region (v_{los}~30 km/s) which can impact continuum analysis.

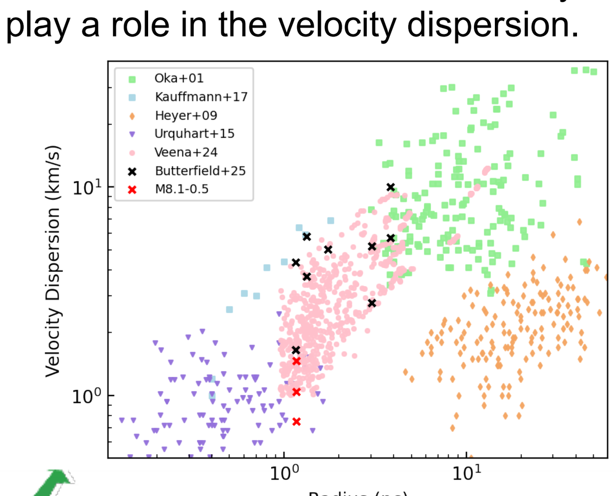


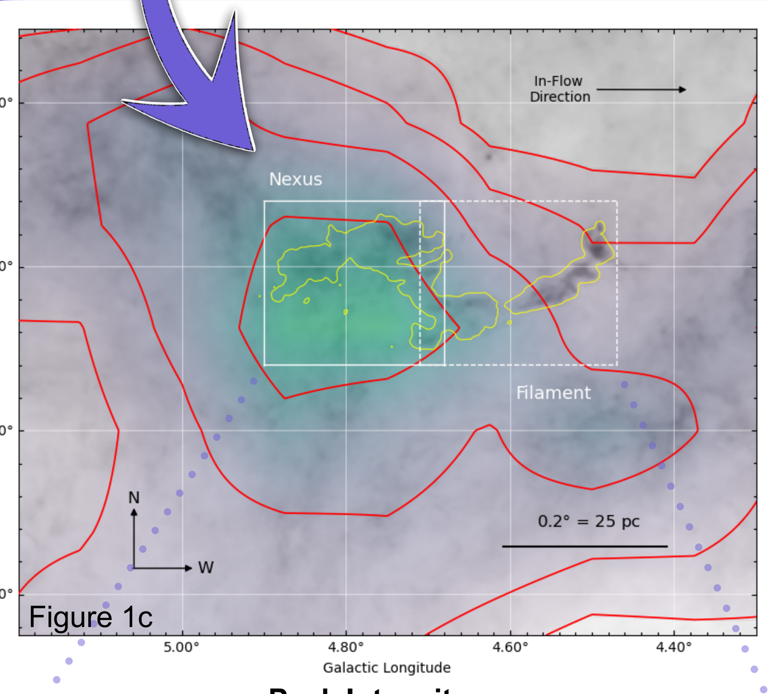


Unlike the Midpoint GMC, for which the NH_3 (3,3) is ~2x brighter than the (1,1) line, M8.1-0.5 is brightest in the NH_3 (1,1) line - similar to gas observed in the Galactic Disk.



M8.1-0.5 is observed to have narrower line widths than the M4.7-0.8 GMC - indicating a possible increase in turbulence during infall. The Larson-relation (below) shows this argument, however, the local environment may play a role in the velocity dispersion.

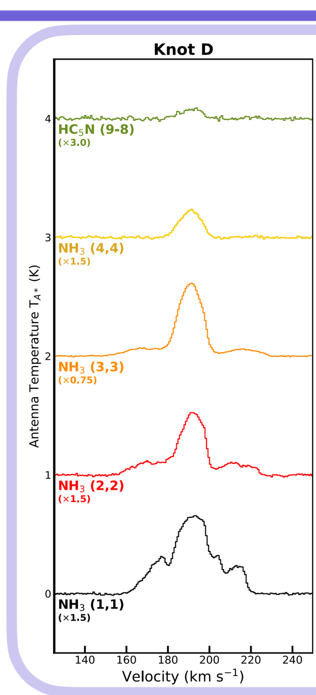




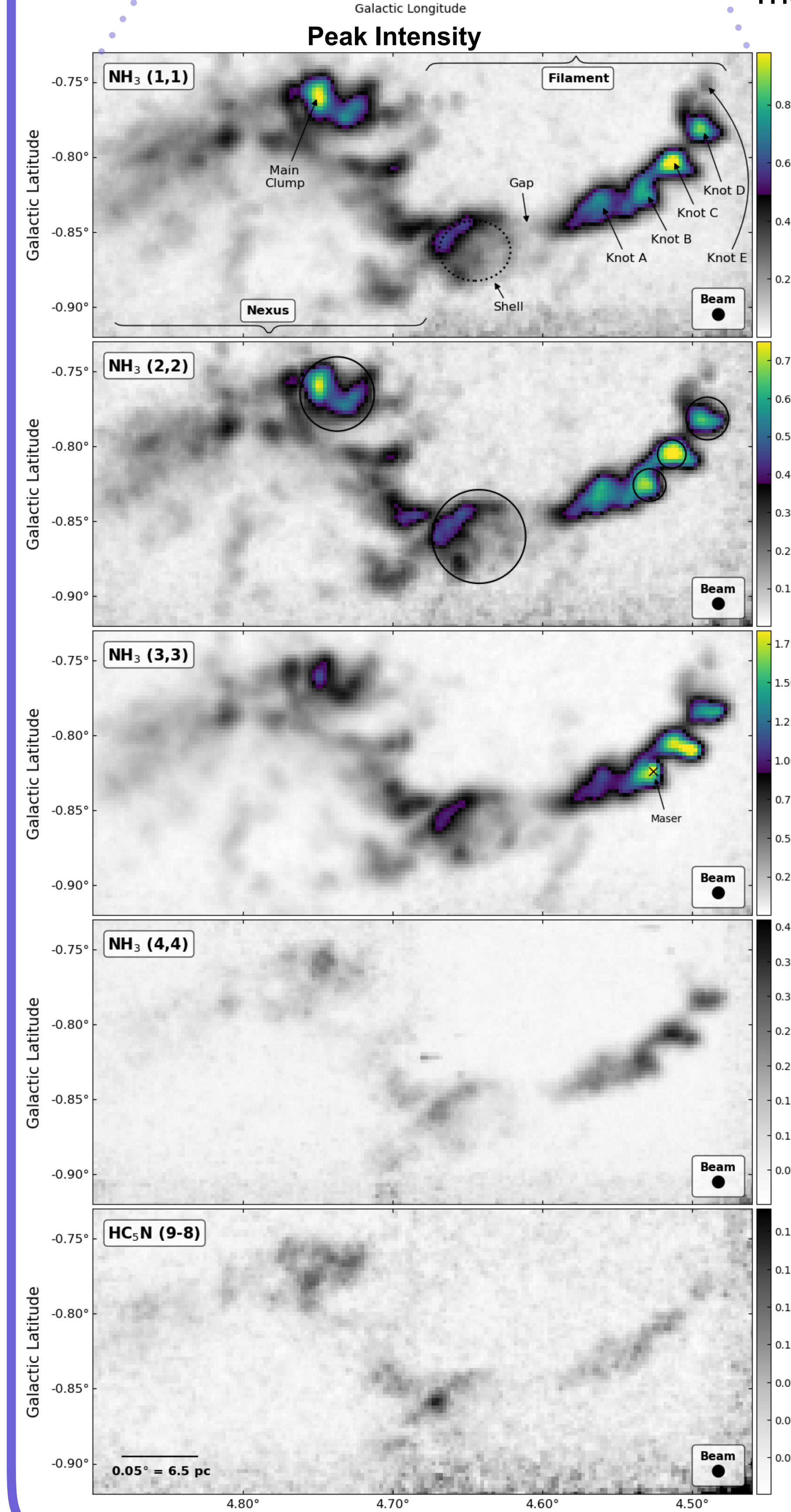
M4.7-0.8: A GMC at the Midpoint

Butterfield et al. (2025), ApJ, 988, 99

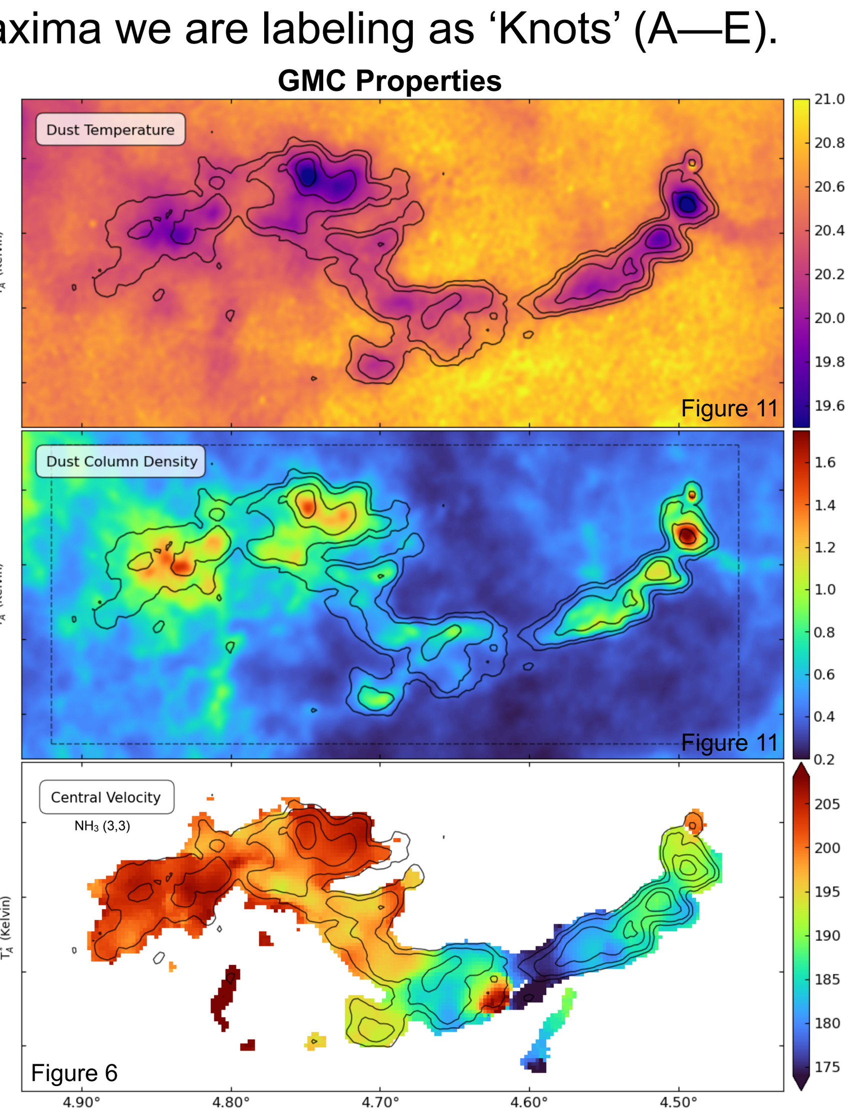
Our team recently discovered a giant molecular cloud (GMC) located ~1.3 kpc from the GC on the near-side Dust Lane (Butterfield et al. 2025). This GMC contains ~10^5 $M_\odot$ of material that is suggested to accrete into the CMZ in ~5 Myr. This GMC is observed to be abundant in molecular gas (NH_3 & HC_5N) and is optically thick at mid-IR wavelengths. The GMC is quite extended (~60 pc) and contains a 'Nexus' and 'Filament' - within which there are several local maxima we are labeling as 'Knots' (A—E).



Integrated spectra over the Knot D aperture. Line widths appear quite broad and, in most regions, have a secondary component. Spectra are shown in paper Figures 4-5 and Table 2.

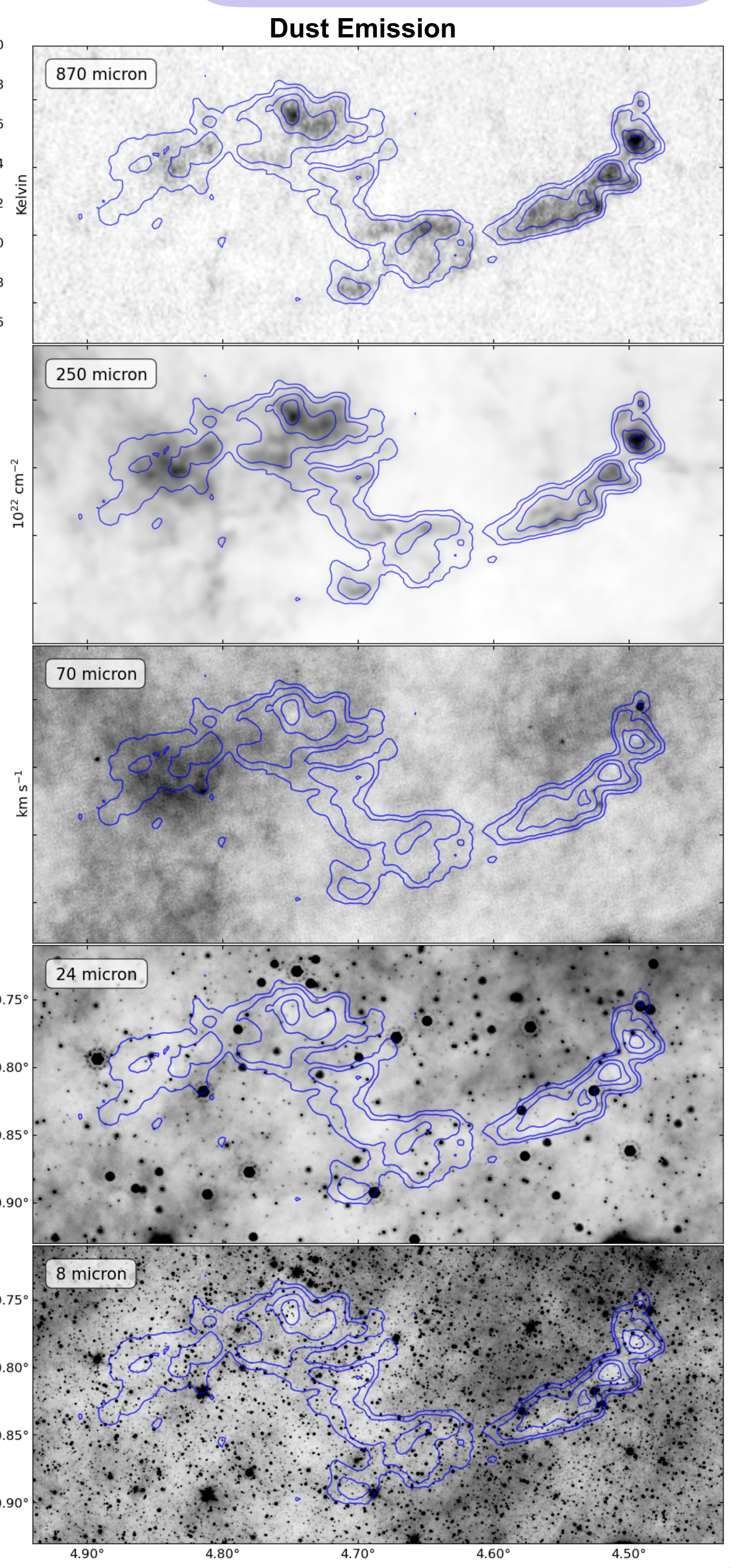


Figures 2-3



The GMC is observed to have high column densities (10^{22} cm^{-2}) and cooler cloud cores. The Filament shows a large-scale velocity gradient. The GMC contains several sites of possible star formation (Section 5.3). Follow up higher resolution ALMA & VLA observations are underway to investigate these sites.

See my Thursday talk discussing star formation in Knots D and E using an ALMA+VLA dataset!



From Figures 8-10

The Green Bank Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.