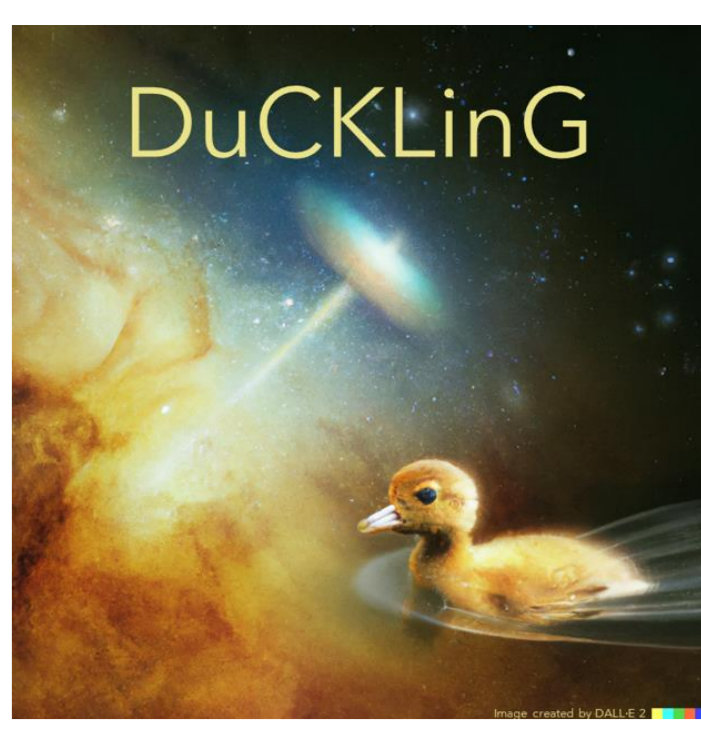


# DuCKLinG: Interpreting JWST/MIRI Spectra of Protoplanetary Disks

Till Kaeufer<sup>1,2,3,4</sup>, M. Min<sup>2</sup>, P. Woitke<sup>1</sup>, I. Kamp<sup>3</sup>, J. Kanwar<sup>3,1,4</sup>, and A. M. Arabhavi<sup>3</sup>

<sup>1</sup> Space Research Institute, Austrian Academy of Sciences, <sup>2</sup> SRON Netherlands Institute for Space Research, <sup>3</sup> Kapteyn Astronomical Institute, University of Groningen, <sup>4</sup> TU Graz



Till.kaeufer@oeaw.ac.at



tillkaeufer.github.io

## Introduction

JWST/MIRI spectra probe the chemistry of the inner regions of protoplanetary disks. The observed spectra show unprecedented details. This complicates interpretations that are mainly based on manual continuum subtraction and 0D slab model (assuming a single temperature and column density).

## Approach

We aim to analyse these spectra using Bayesian analysis. To do so, we introduce the Dust Continuum Kit with Line emission from Gas (DuCKLinG), a fast 1D model simultaneously describing the molecular line emission and the dust continuum of protoplanetary disks.

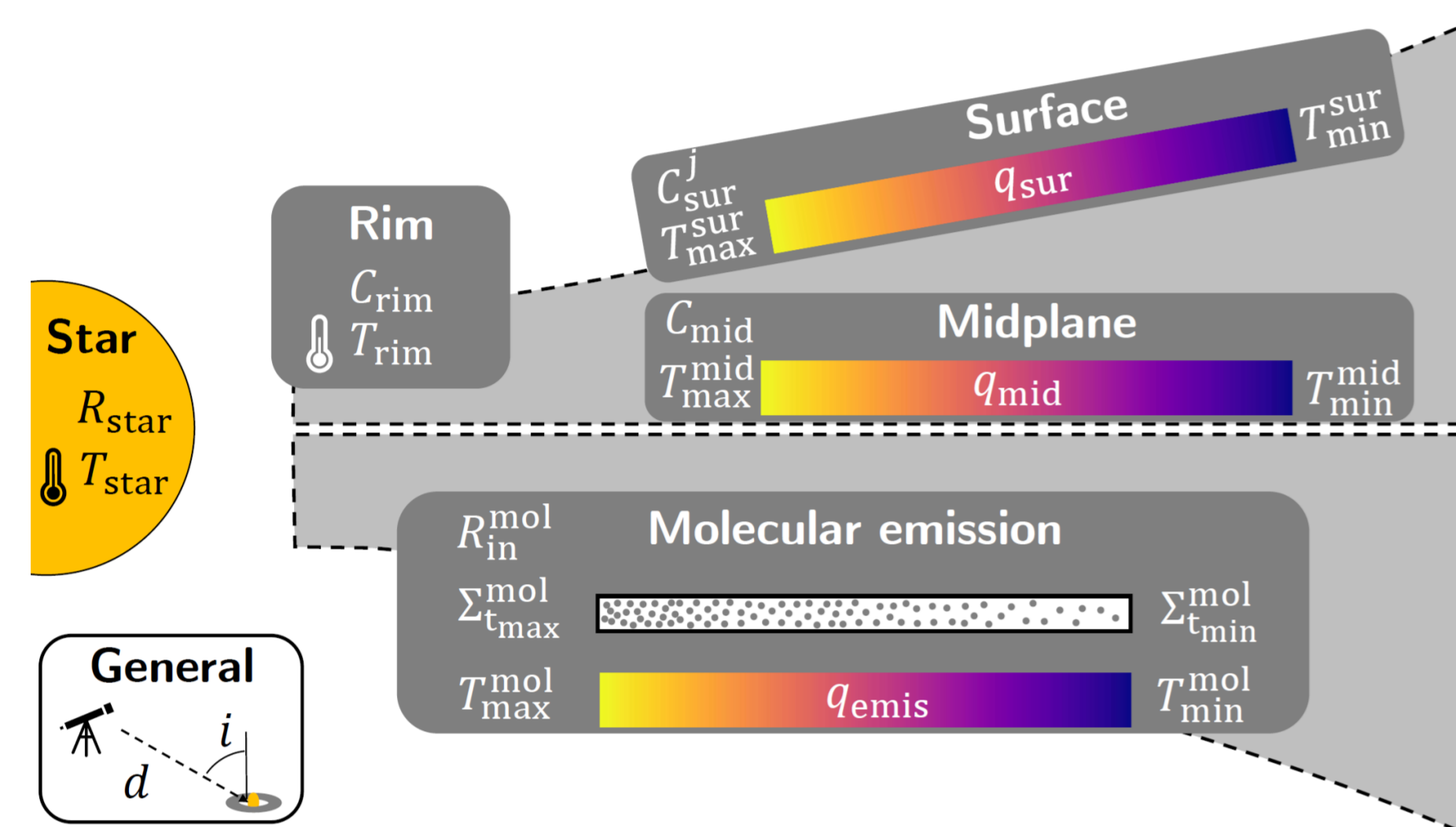


Fig.1: Sketch of a DuCKLinG model.

The model sums up 5 distinct 1D components: the star, the inner rim, the optically thick dust midplane, the optically thin dust surface layer, and the molecular emission layer (including radial gradients in temperature and column density).

## First application: GWLup

Kaeufer et al. (2024)

Fitting a small wavelength range (from 13.6 $\mu$ m to 16.3 $\mu$ m) of the JWST/MIRI spectrum of GWLup, we confirm the previous detections of H<sub>2</sub>O, CO<sub>2</sub>, HCN, and C<sub>2</sub>H<sub>2</sub>.

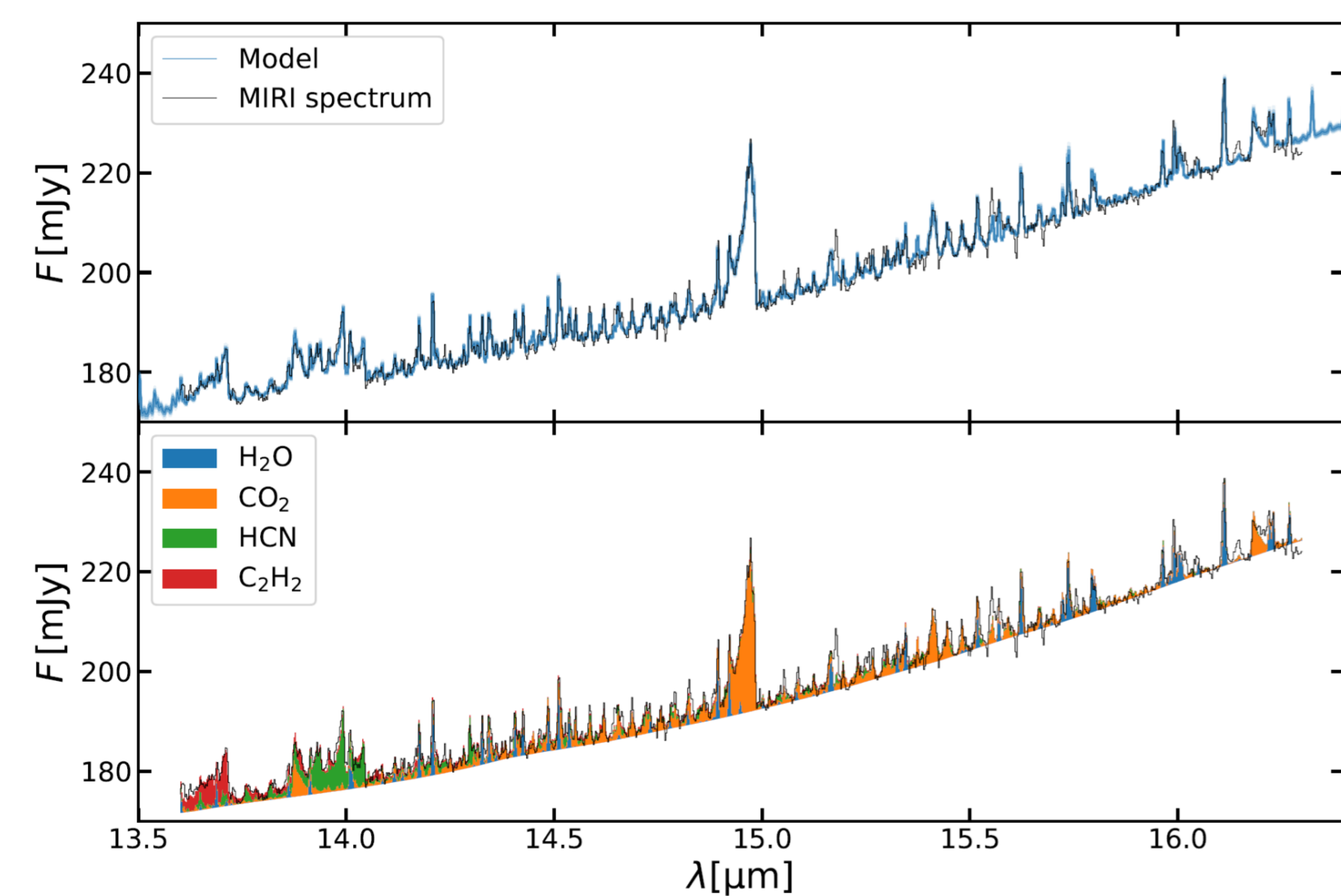


Fig.2: Bayesian retrieval of the JWST/MIRI spectrum of GWLup.

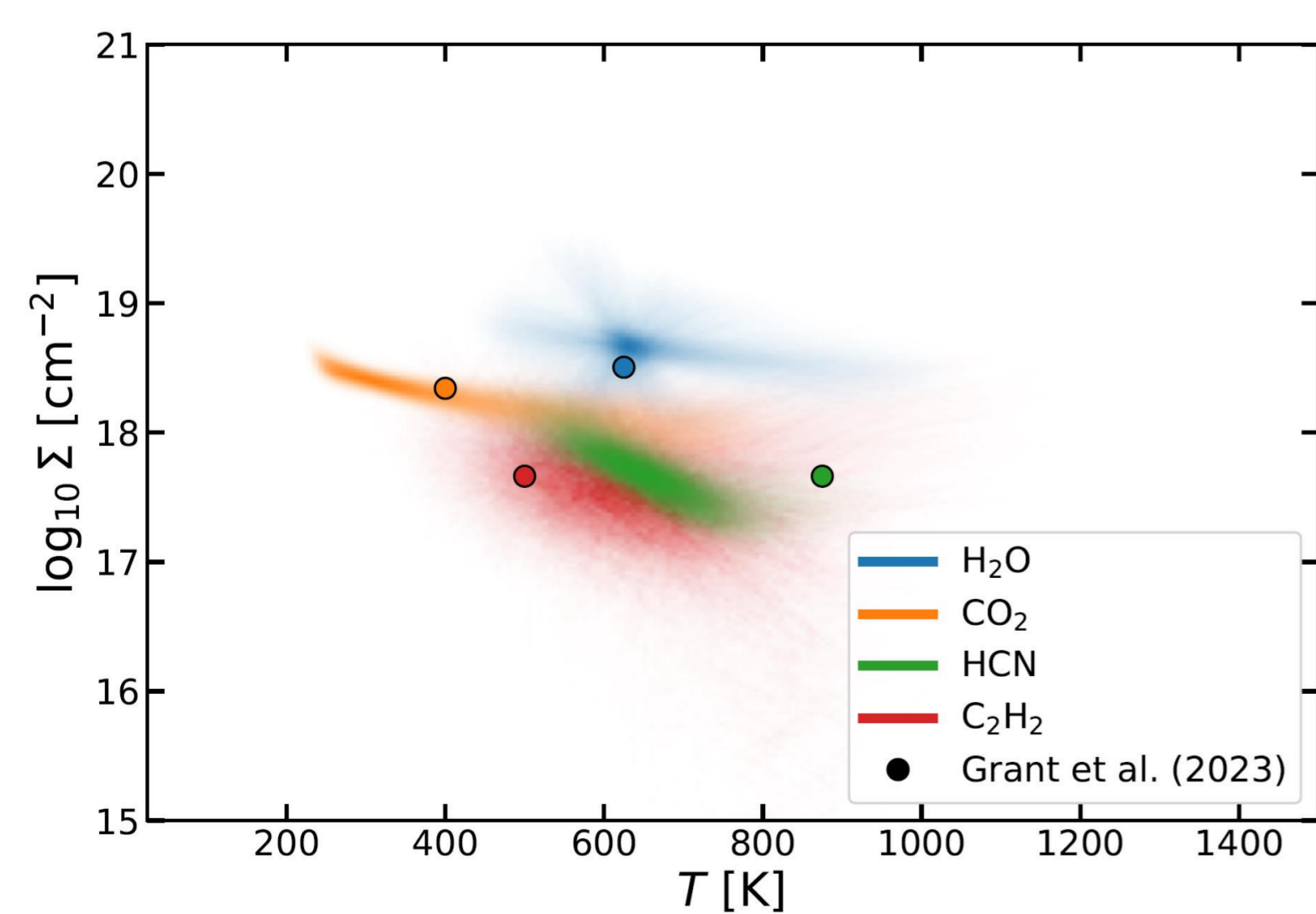


Fig.3: Posteriors of the retrieved molecular emission conditions (T: temperature,  $\Sigma$ : column density) for GWLup.

For this simple observation (small wavelength region with only a few molecular features) 0D slab models might be sufficient.

We find a large overlap between the retrieved molecular conditions and previous 0D slab model results. However, the change in retrieved temperature of HCN might originate from the improved fitting strategy.

## Second application: Sz28

Kaeufer et al. (submitted)

Spectra of disks around very low-mass stars reveal many overlapping hydrocarbon features that complicate the fitting procedure with 0D models. We run a Bayesian analysis (optimizing 81 parameters) of the JWST/MIRI spectrum of Sz28 to disentangle the dust and gas contributions and compare the results to previous fitting attempts.

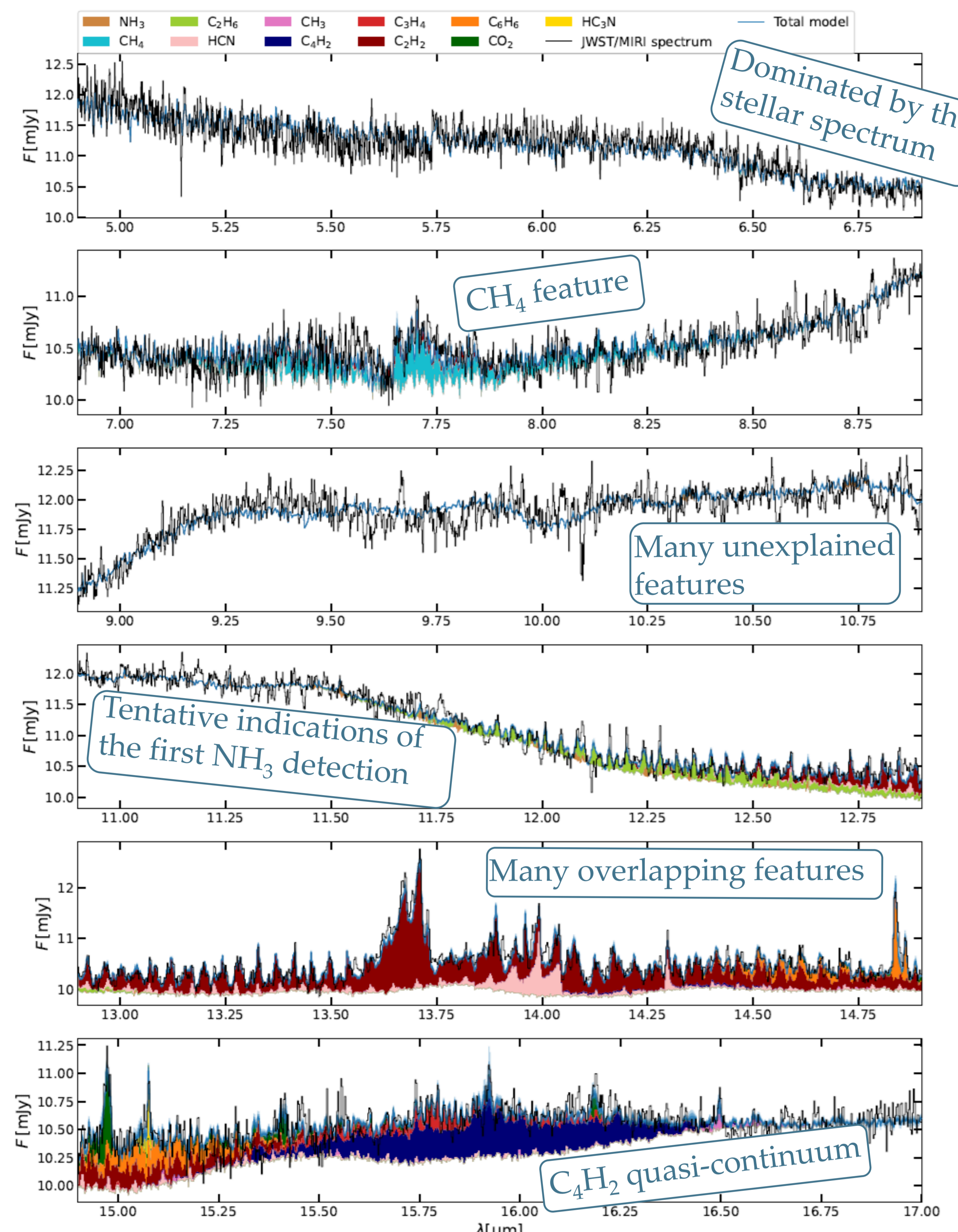


Fig.4: Retrieved molecular contributions for Sz28 based on the JWST/MIRI spectrum.

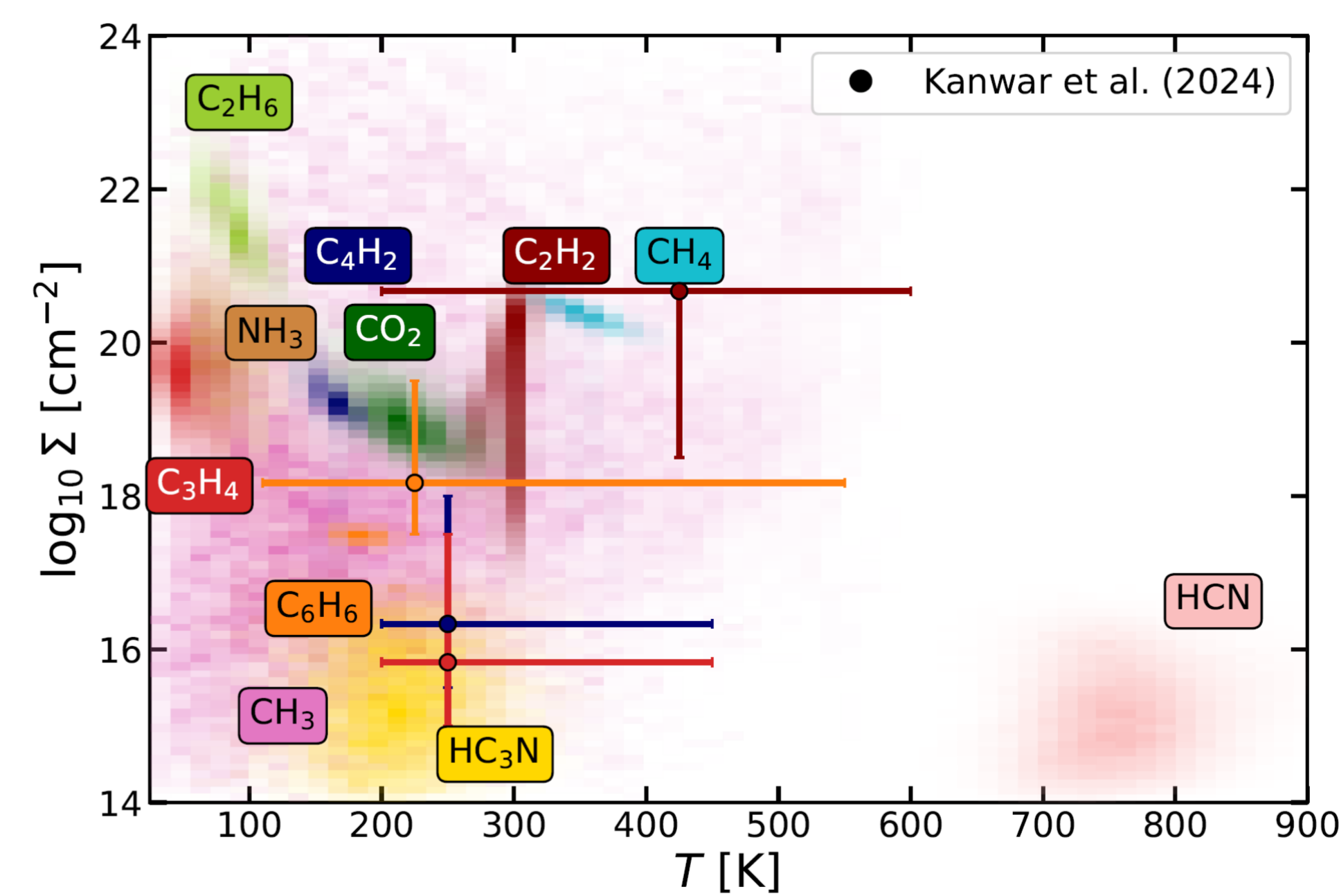


Fig.5: Posteriors of the retrieved molecular emission conditions (T: temperature,  $\Sigma$ : column density) for Sz28.

We find significant differences for C<sub>4</sub>H<sub>2</sub> and C<sub>3</sub>H<sub>4</sub> comparing the retrieved conditions to previous 0D slab results.

This shows the benefit of a simultaneous Bayesian retrieval of dust and gas properties.

If you want to know more:



Paper introducing DuCKLinG and fitting GWLup