

DUET: the Band3 and Band6 Continuum Emission and Dense Cores in the Dust Ridge Cloud ‘e’

Xihe Liu¹, Xing Lu²

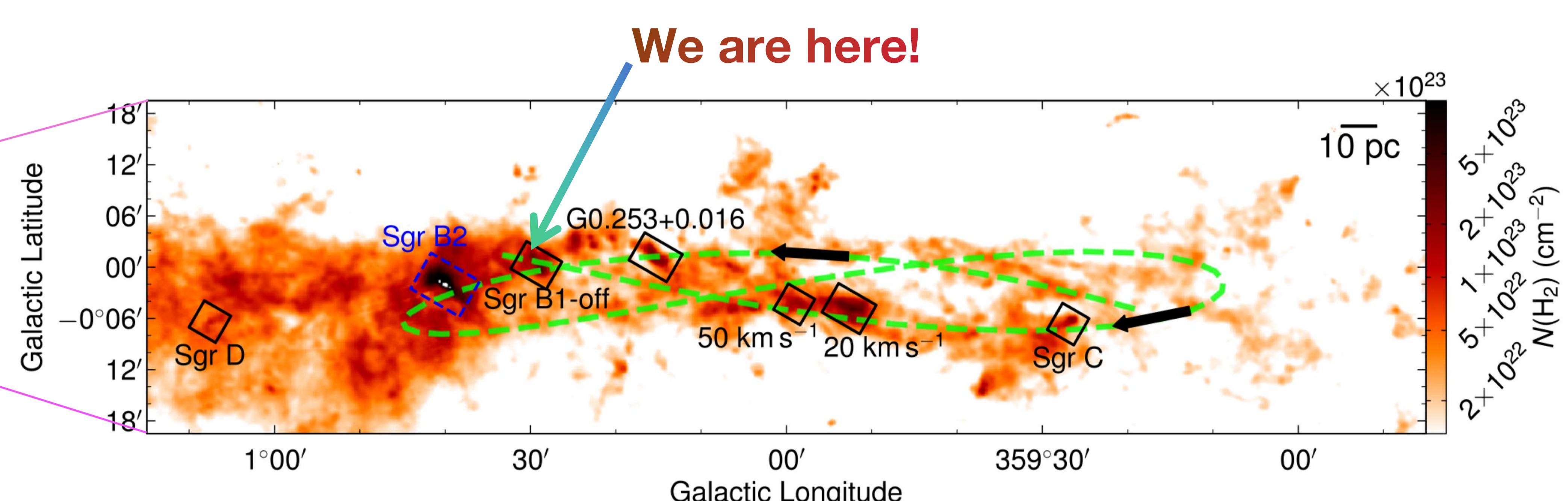
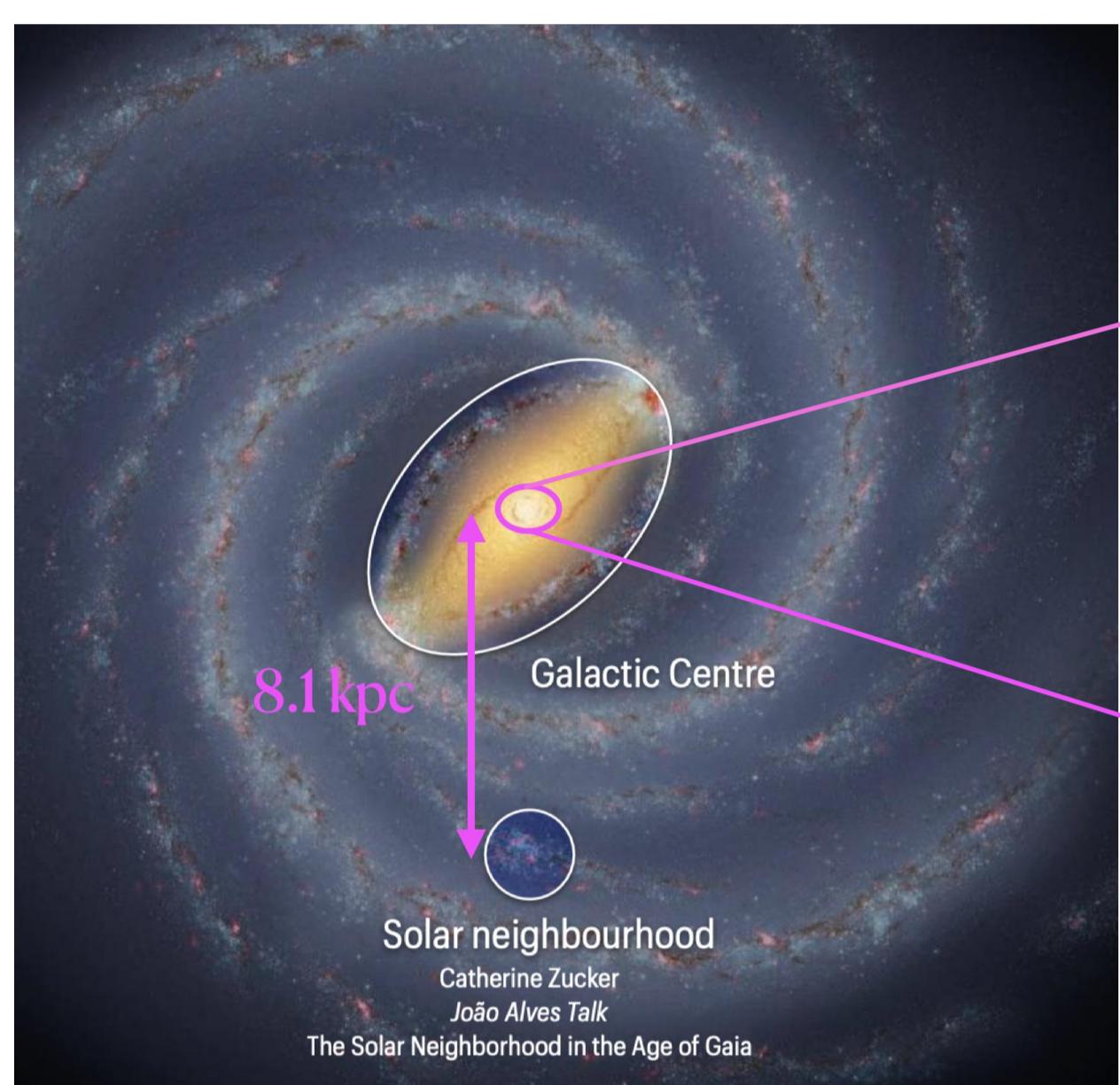
¹School of Physics, Shandong University, 27 Shanda Nanlu, Jinan, 250100, P. R. China

²Shanghai Astronomical Observatory, Chinese Academy of Sciences, 80 Nandan Road, Shanghai 200030, P. R. China

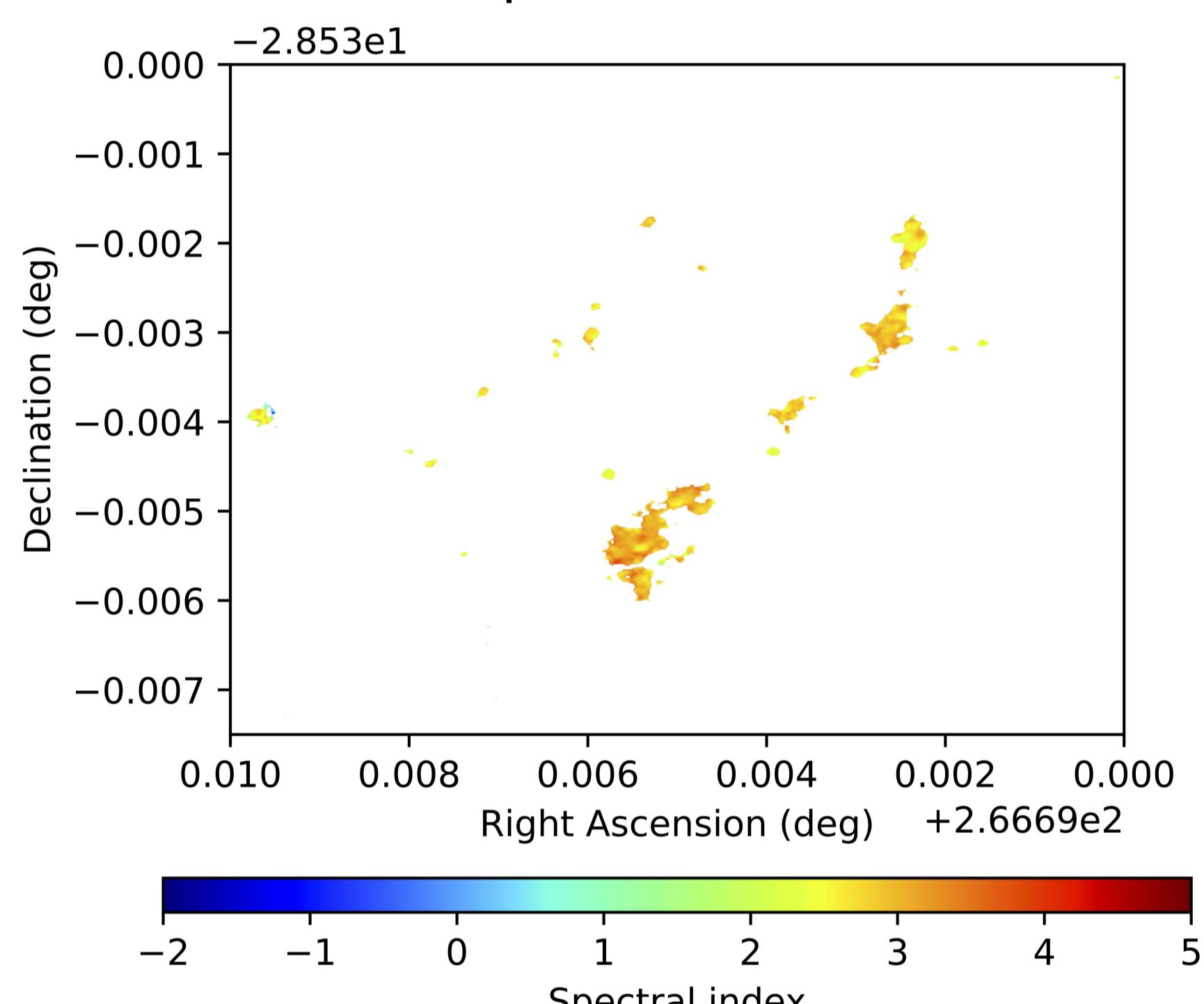


ABSTRACT

We use ALMA band 3&6 continuum data to identify and analyze dense cores and filamentary structures within the CMZ dust ridge Cloud ‘e’ in the Galactic Center region, to investigate its star formation. We employ **astrodendro** algorithm for core identification and determine their quantities and positions, and then we calculate their spectral indices. Additionally, we utilize isothermal cylindrical models to fit larger clumps within the cloud in order to analyze potential filament fragmentation. We also apply the **minimum spanning tree** algorithm to analyze Cloud ‘e’, and calculate its Q parameter to quantify spatial distribution of cores.



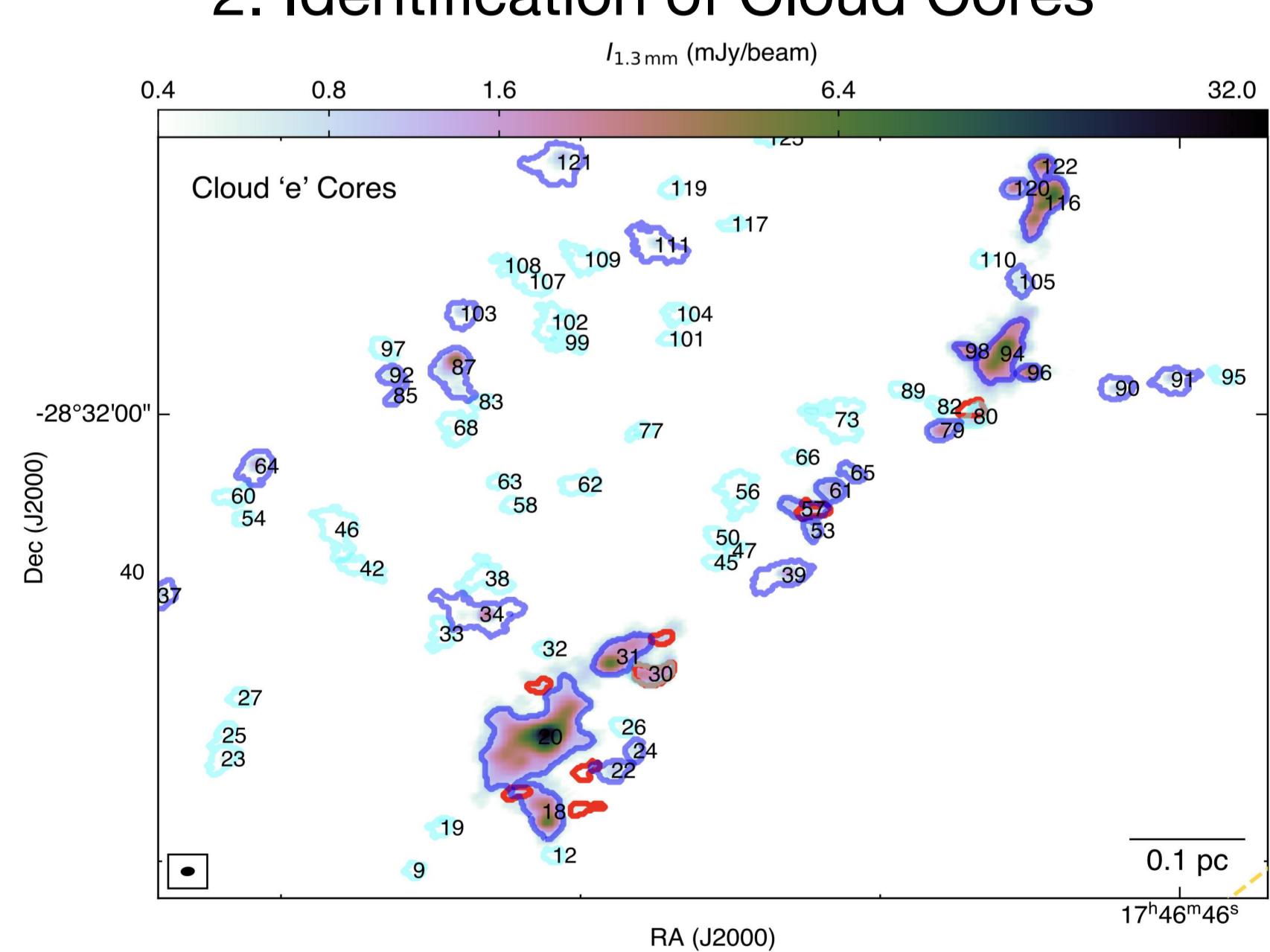
1. Calculation of Spectral Index in each Pixel



Based on the observational data obtained from **both ALMA's Band 3 and Band 6**, we have derived the flux values of Cloud ‘e’ at each pixel in both bands. These values were used to calculate the spectral index map at each pixel. Through color coding representation, most locations exhibit variations in spectral index between 2 and 5, indicating that radiation is primarily governed by **optically thin emission**.

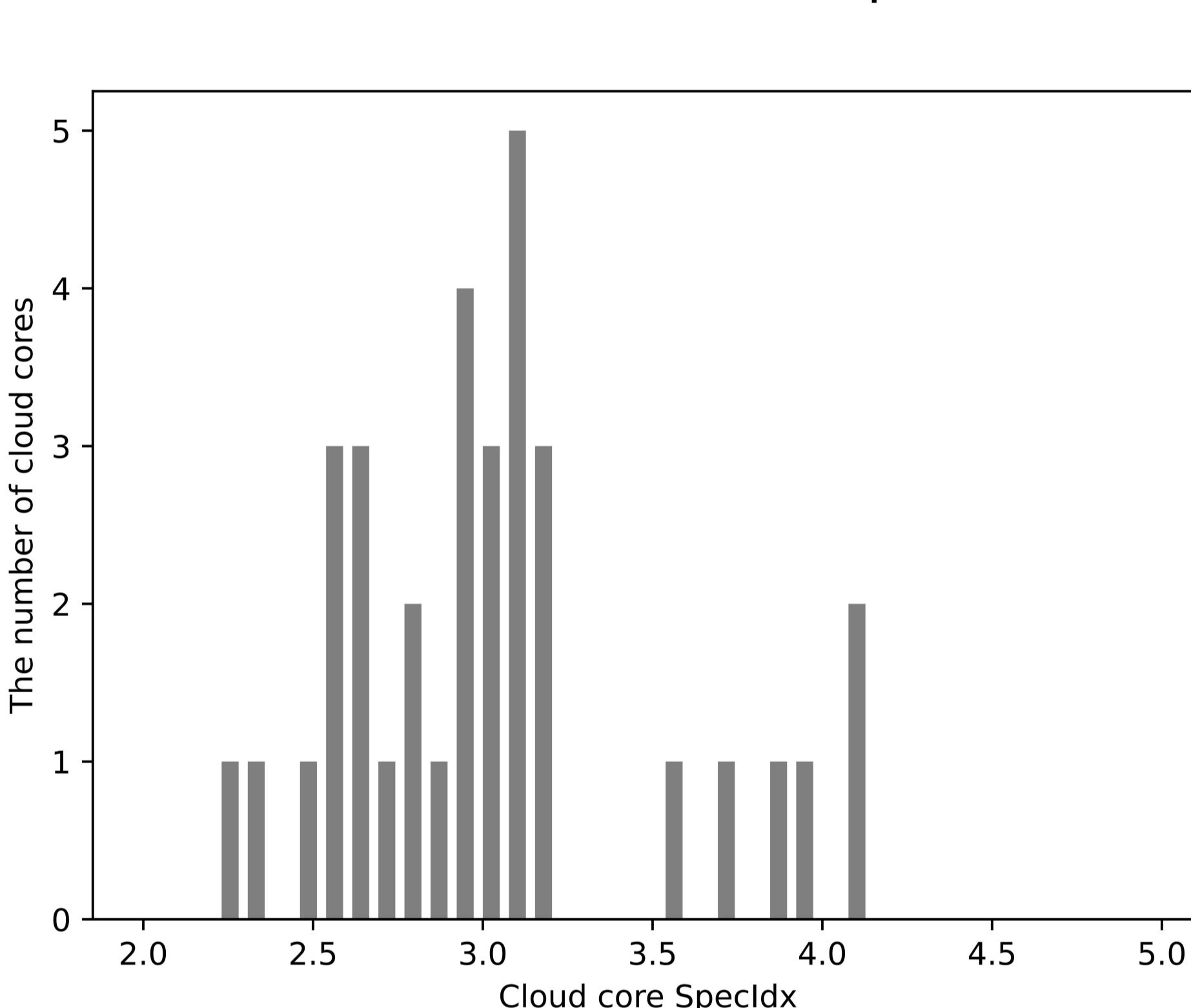
$$S_\nu \propto \nu^\alpha$$

2. Identification of Cloud Cores

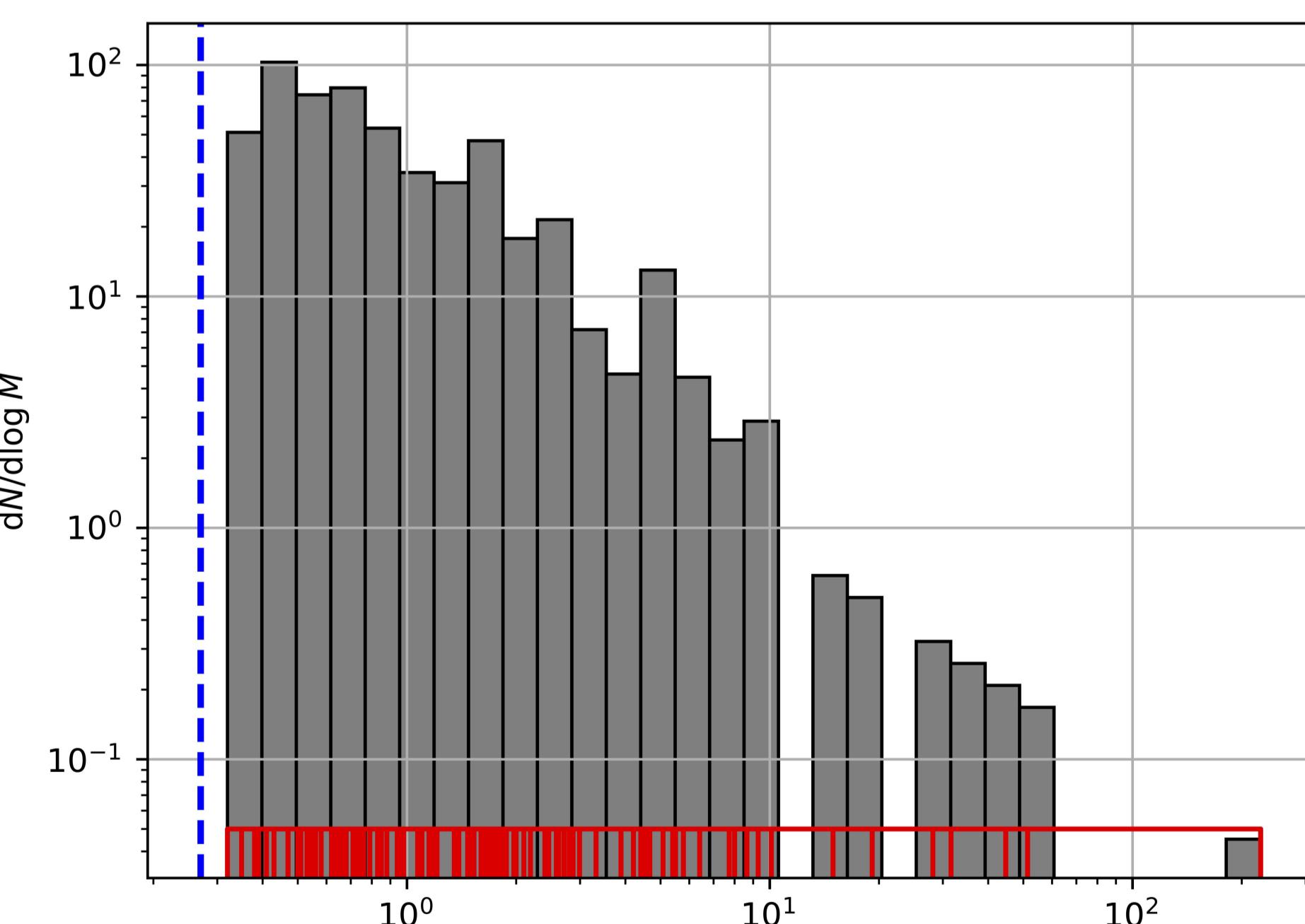


We smooth the band 3 & 6 continuum images to a common resolution (0.3'' * 0.2'', ~2000 AU), and then we use **astrodendro** identify **33 dense cores** simultaneously in two bands (purple contours) using a signal-to-noise ratio of 5. Additionally, **9 cores** are only detected in band3 (red contours), and **75 cores** are exclusively detected in band6 (cyan contours)(Rosolowsky et al. 2008).

3. Calculation of Core Mass and Spectral Index



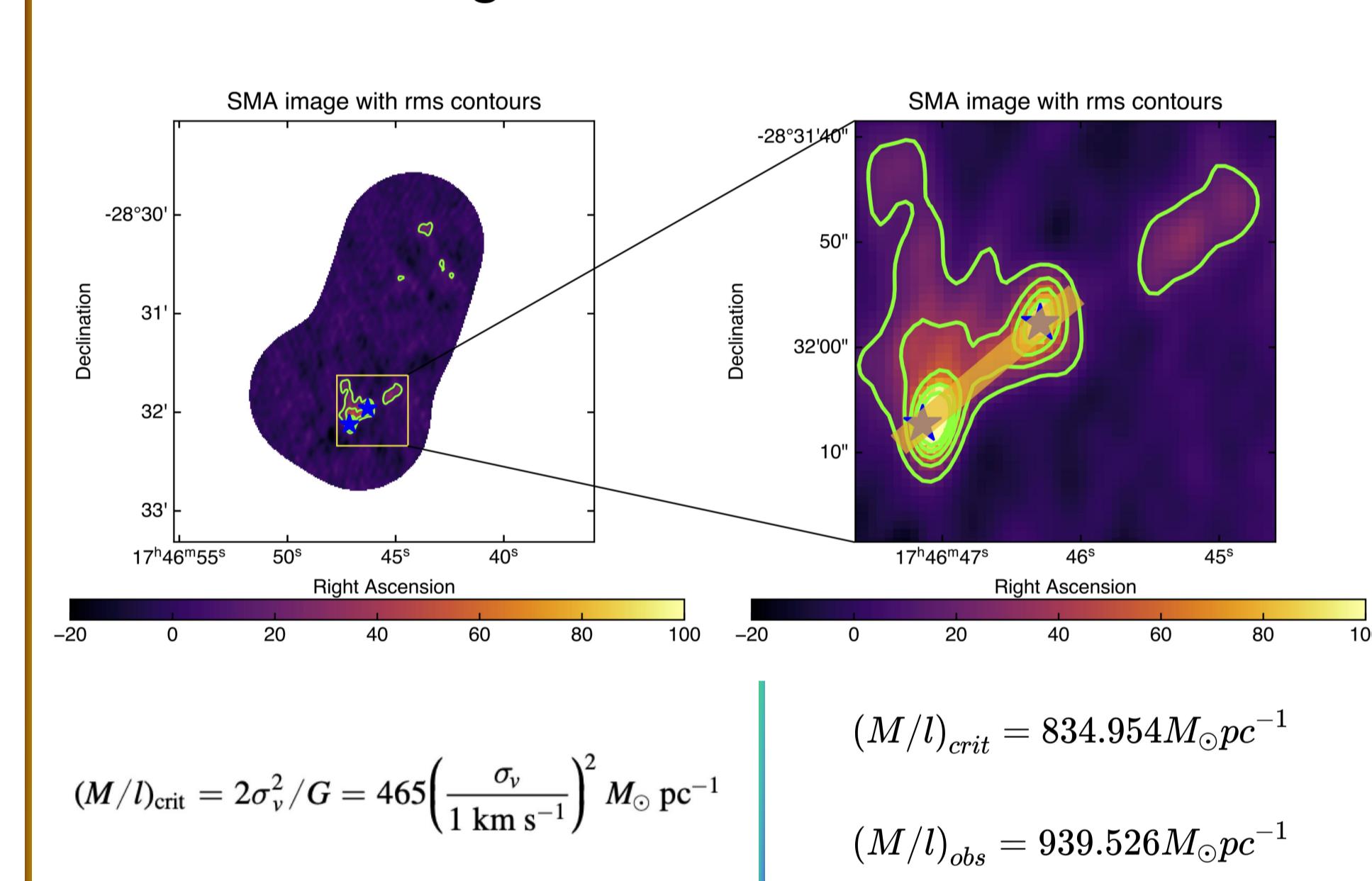
All core spectral indices are greater than 2, indicating that these radio sources are generated by **optically thin dust emission**.



$$M_{\text{core}} = R_{\text{g/d}} \frac{S_\nu d^2}{B_\nu(T_{\text{dust}}) \kappa_\nu},$$

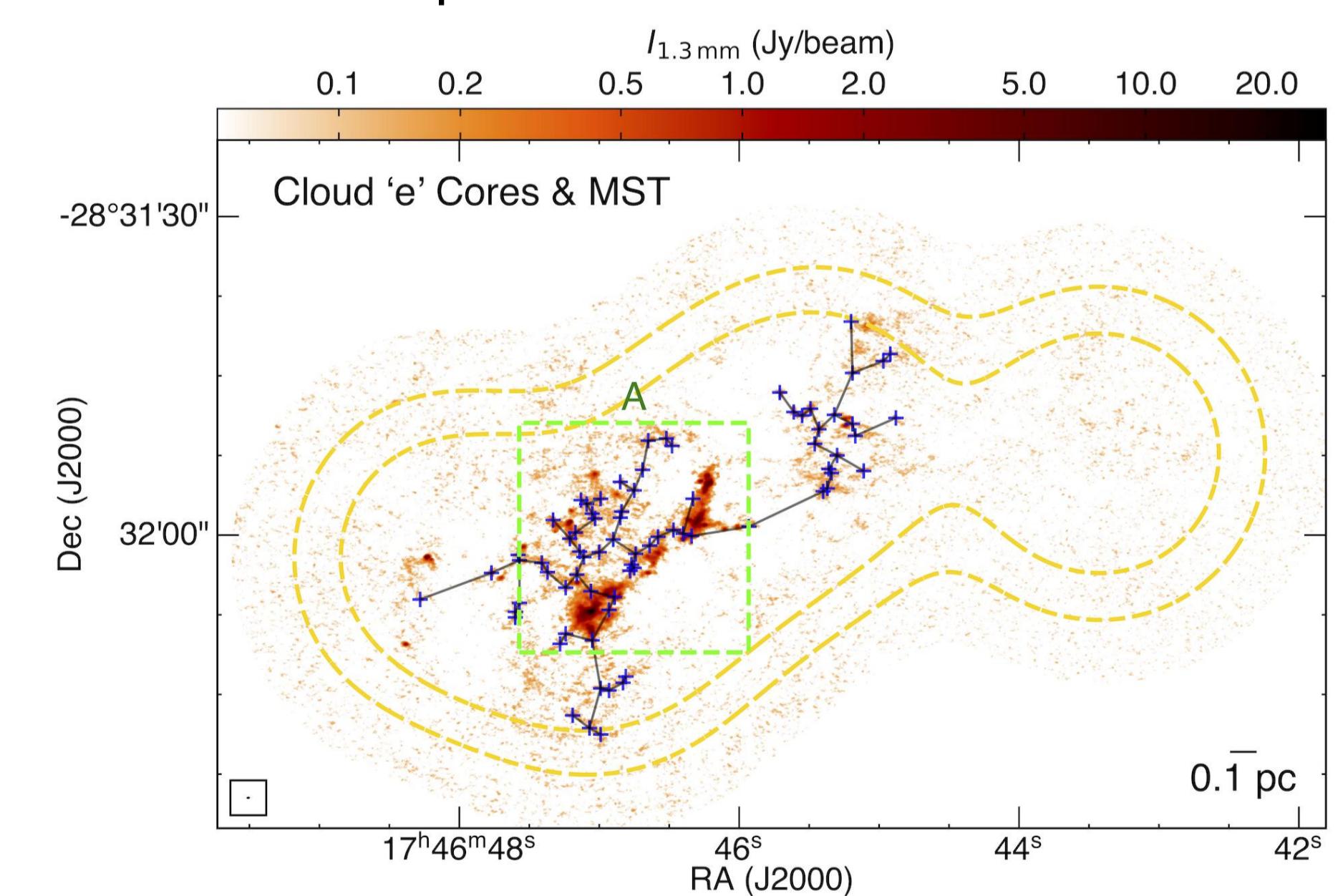
The mass distribution of the identified 34 dense cores is shown in the figure. The blue dashed line represents the mass threshold determined by rms. The red short lines below indicate the specific masses of each identified dense core. It can be clearly observed from the figure that the mass distribution of dense cores conforms well to a power-law behavior.

4. Fragmentation of Filaments



Due to the approximate equality between the critical value and the observed value, the structure is consistent with the **isothermal cylindrical model** and filamentary fragmentation scenario.

5. The spatial distribution of cores



‘+’ denotes the central positions of each cloud core drawn in ALMA band 6 data using **astrodendro**. These cloud cores are connected by black lines using the **Minimum Spanning Tree** algorithm.

$$\bar{m} = \sum_{i=1}^{N_c-1} \frac{L_i}{(N_c A)^{1/2}}, \quad \bar{s} = \frac{L_{\text{av}}}{R_{\text{cluster}}}, \quad Q = \frac{\bar{m}}{\bar{s}},$$

Here, \bar{m} represents the normalized average edge length of the minimum spanning tree, which is given by the formula below. \bar{s} refers to the normalized correlation length, which is defined as the ratio between the average inter-core spacing and the cluster radius(Cartwright & Whitworth 2004). $Q=0.64$, which means Q is associated with the fractal dimension.

References

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