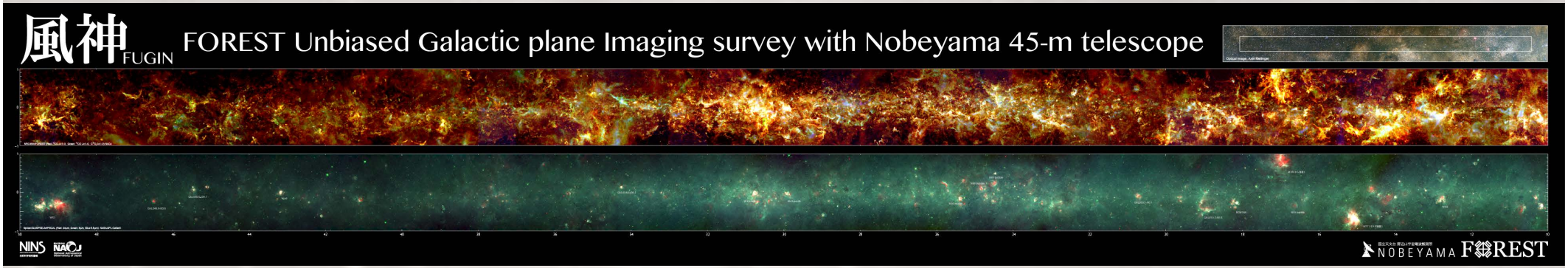


FUGINデータを用いた銀河系内の分子雲同定

Identification of molecular cloud inside the galaxy using FUGIN

Hiro Saito（南極）

00 Introduction

- Molecular clouds
  - * base structures of Star Formation
  - * Formed in the molecular arms of galaxy
- Molecular gas survey in our galaxy

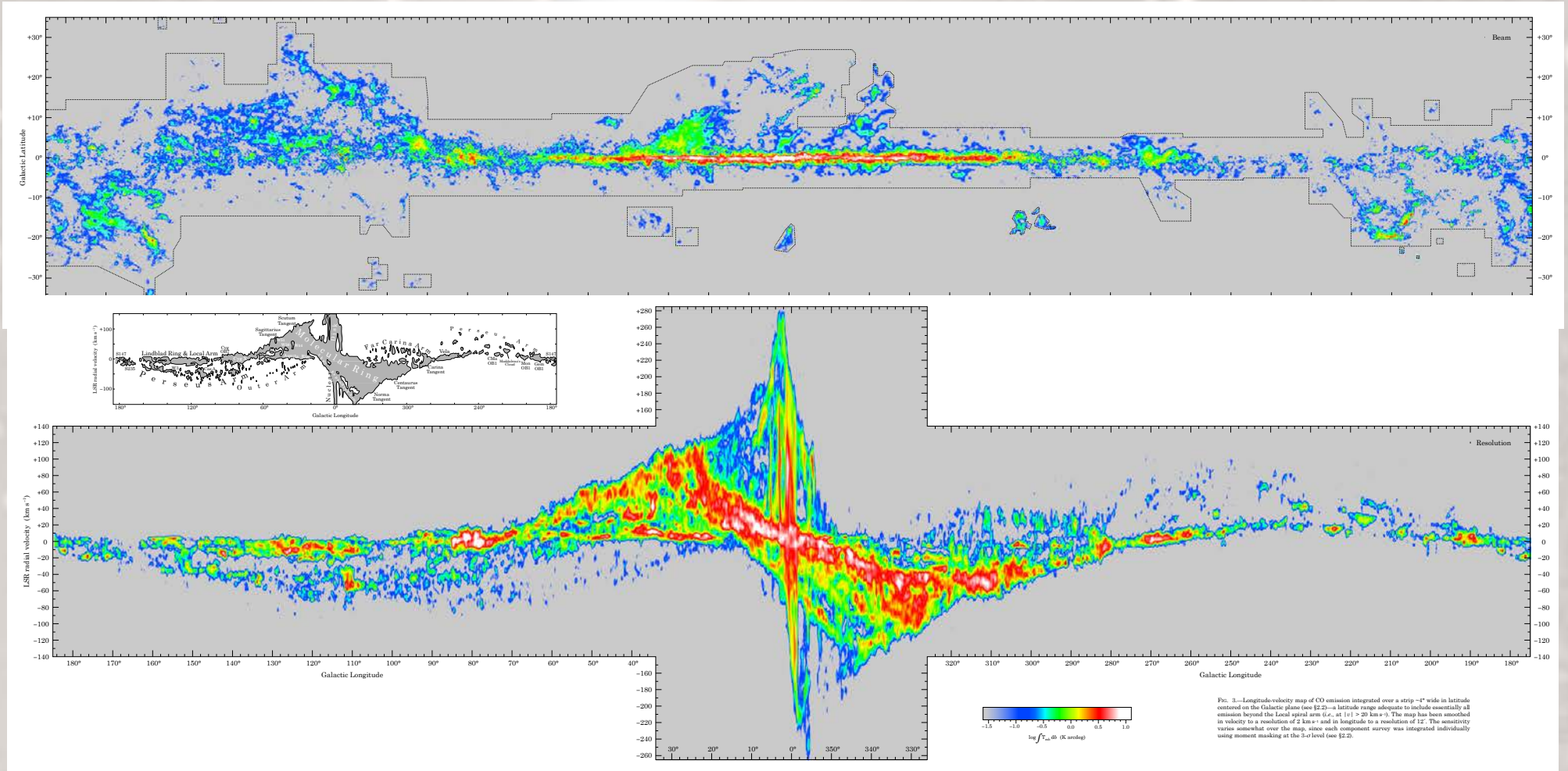


FIG. 3.—Longitude-velocity map of CO emission integrated over a strip −4° wide in latitude centered on the Galactic plane (see §2.2)—a latitude range adequate to include essentially all emission beyond the Local spiral arm (*i.e.*, at $|v| > 20$ km s^{-1}). The map has been smoothed in velocity to a resolution of 2 km s^{-1} and in longitude to a resolution of 12′. The sensitivity varies somewhat over the map, since each component survey was integrated individually using moment masking at the 3-σ level (see §2.2).

00 Introduction

- Molecular gas survey in our galaxy

  * Dame et al. 1986 ~

    data param : line = ^{12}CO, L = all, beam size = 8′

    Result : identified molecular complexes (GMCs)

      example : 26 complexes in L = 12 - 60 with masses > 5 x 10^5 Mo (1986)

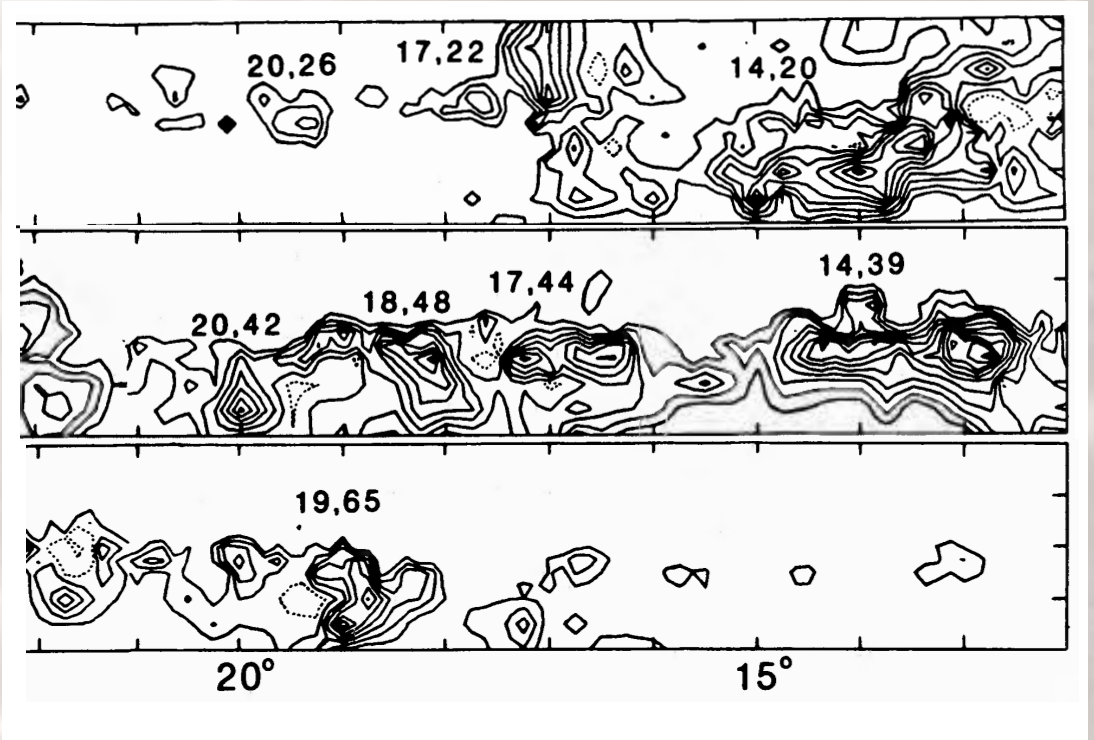
Dame et al. 1986

Velocity range

11 - 30 km/s

35 - 55 km/s

56 - 72 km/s



00 Introduction

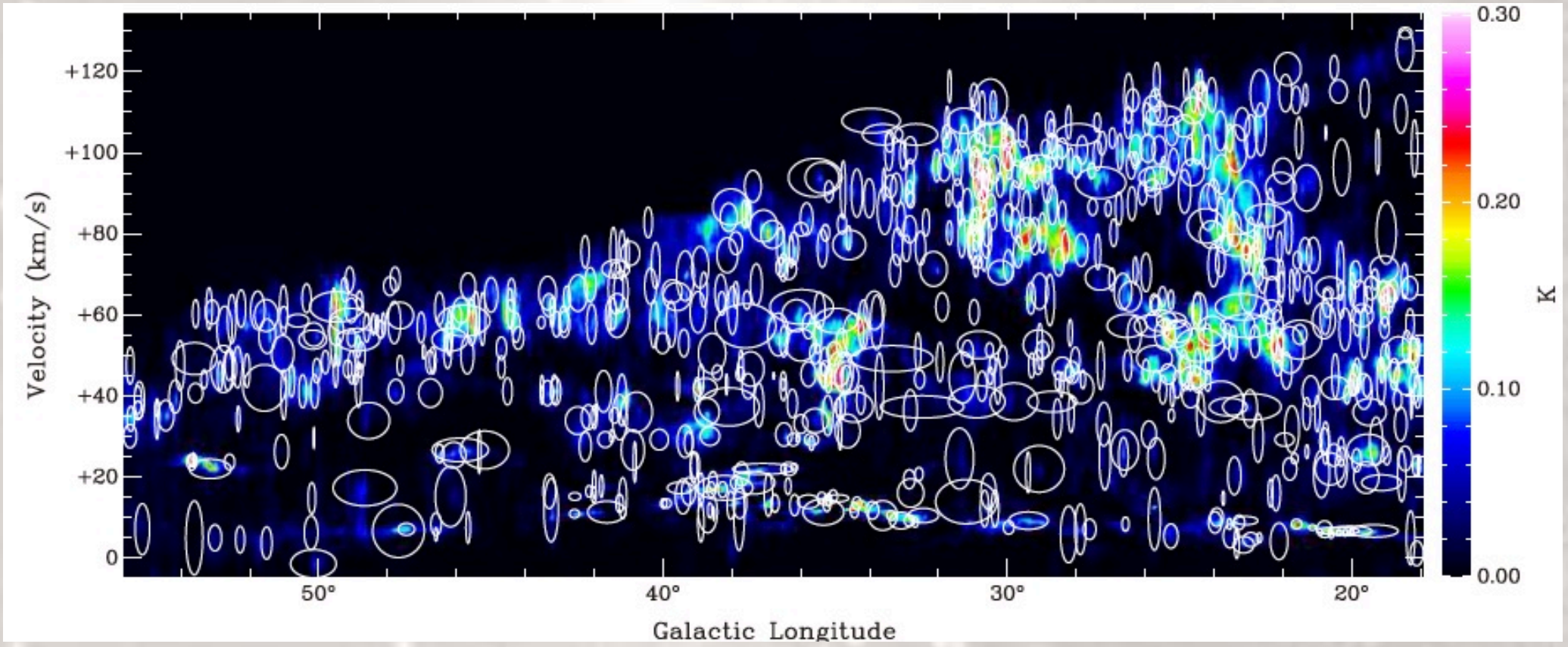
- Molecular gas survey in our galaxy
  * Rathborne et al. 2009 ~

    data param : line = ^{13}CO, L = 18 ~ 56, beam size = 46″

    Result : identified molecular clouds (CLUMPFIND)

    example : 829 complexes in L = 18 - 56

    R = 1.6 - 100 pc, log(M) = 2.2 - 5.7 Mo



00 Introduction

- Molecular gas survey in our galaxy

  * FUGIN : NRO45m + FOREST

    NRO 45m : High spacial resolution (~ 15" @ 12CO)

    0.2 pc @ 2.0 kpc (sagittarius arm)

    —> detectable inner structures in clouds

    FOREST : detect multi lines simultaneously

    ^{12}CO : detect the structure with low column density

    ^{13}CO : detect the inner structure in the clouds

    $C^{18}O$: detect the dense gas in the clouds

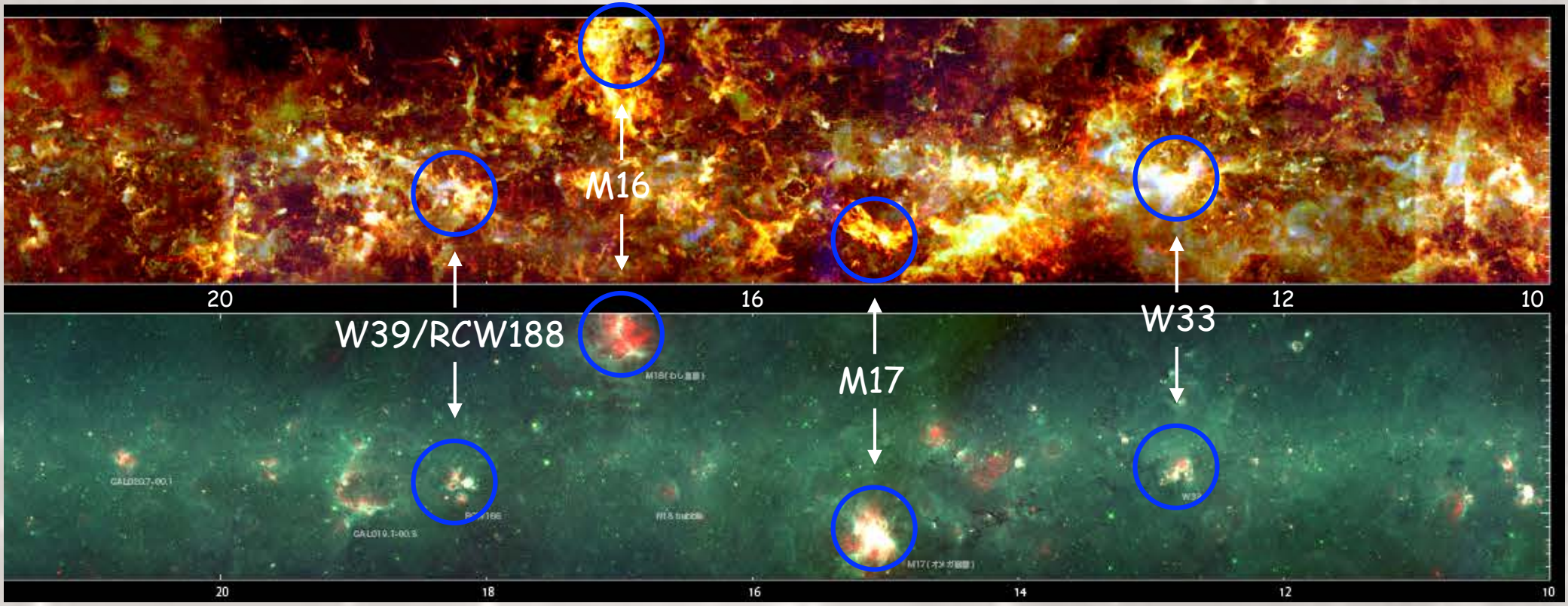
01 About FUGIN

Survey Strategy

- Area : the first quadrant (10d < L < 50d ; -1.0 < b < 1.0)
  the third quadrant (198d < L < 236d ; -1.0 < b < 1.0)
- Line : 12CO, 13CO, C18O
- effective velocity resolution : 1.0 km/s @ 3 mm
- effective angular resolution : 20" @ 12CO
- final map
  * l,b grid = 8".5, velocity grid = 0.65 km/s
    velocity range = -100 km/s < v < 200 km/s
    Noise level : 0.8 - 2.7 K @ dV = 1.0 km/s (12CO)

02 Results of FUGIN data

FUGIN : 12CO (R) & 13CO (G) & C18O (B) : NAOJ



Spitzer : 24um (R) & 8um (G) & 5.8um (B) : NASA

03 Molecular Cloud Identification

Aims

- Establishment of method of molecular cloud identification
- Calculation of basic physical parameters of molecular clouds
- Reveal inner-structures of molecular clouds
- Identify far distant clouds
- Reveal size function and mass function of molecular clouds

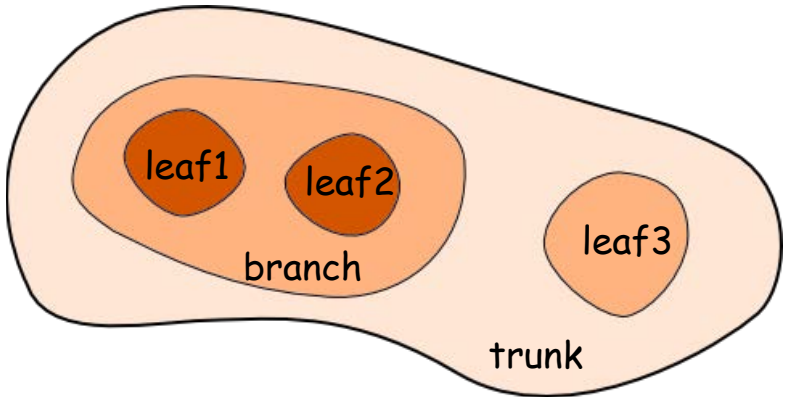
Verification of Identification method

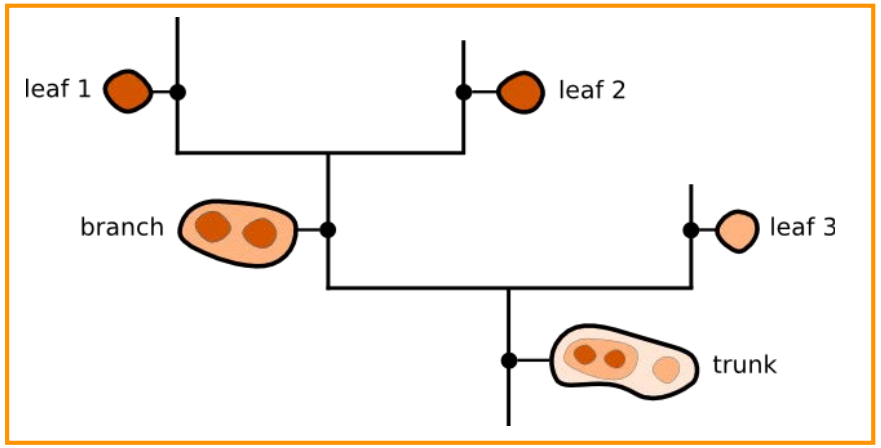
Identification Method using the results of Dendrogram

* Dendrogram : treat as a tree that represents the hierarchy of the structures

03 Molecular Cloud Identification

Structure Identification using the results of Dendrogram





Dendrogram can identify the structures with various scales at the same time

—> We can identify the molecular cloud as well as the internal structures

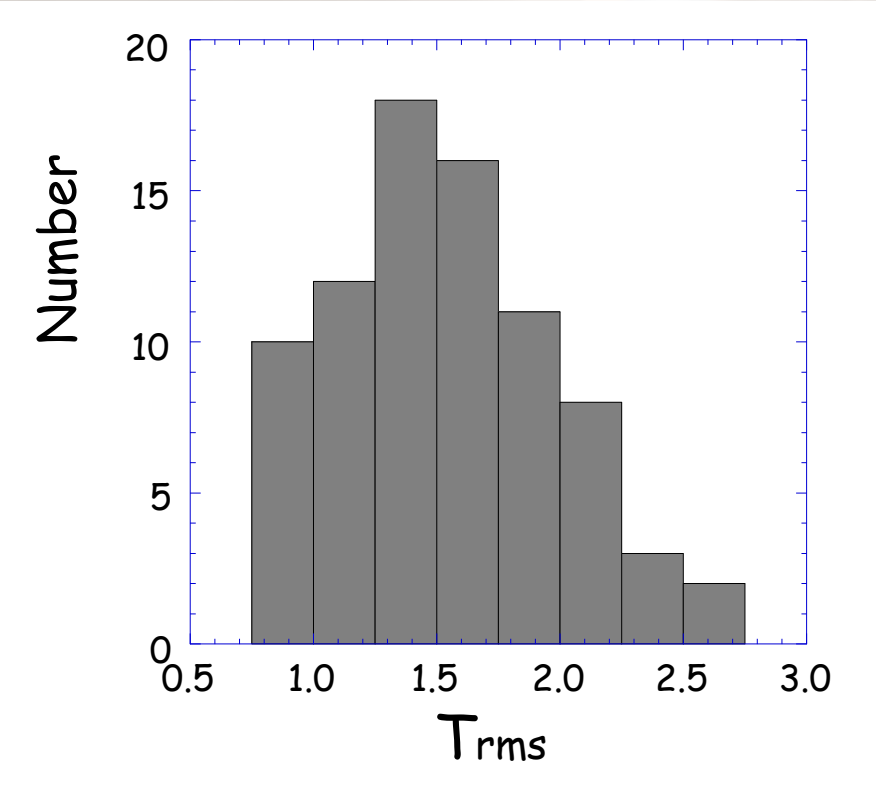
04 Molecular Cloud Identification

Trunk & Leaf : depend on the noise level of image

- Trunk : depend on minimum value (m.v.) of dendrogram param.
- Leaf : deppend on minimum delta (m.d.) of dendrogram param.

Fugin data : unit = 1 deg x 1deg

T_{rms} = 0.8 - 2.7 K



Max of T_{rms} = 2.7 K

—> m.v. = 3 x 2.7 K = 8.1 K

—> very high value …

m.v. = 3 x 2.0 K = 6.0 K

Min of T_{rms} = 0.80 K

m.d. = 0.8 K

04 Molecular Cloud Identification

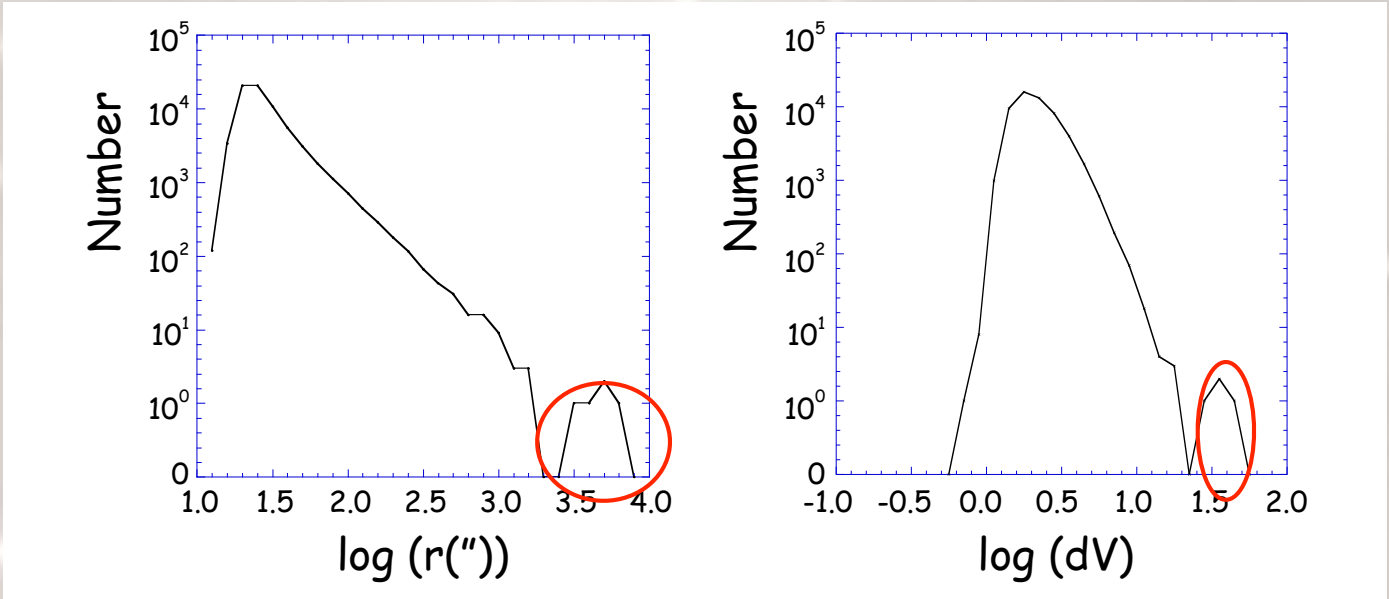
Identified Clouds : Using 12CO data

< Used area : L = 10 - 50 deg >

identified structures

- Trunk = 54044
- Physical parameters of Trunks

dV = 1.0 - 39.0 km/s, R(") = 19.8 - 6600" , N(H2) = 3.8×10^{22} - 4.1×10^{28} cm^{-2}

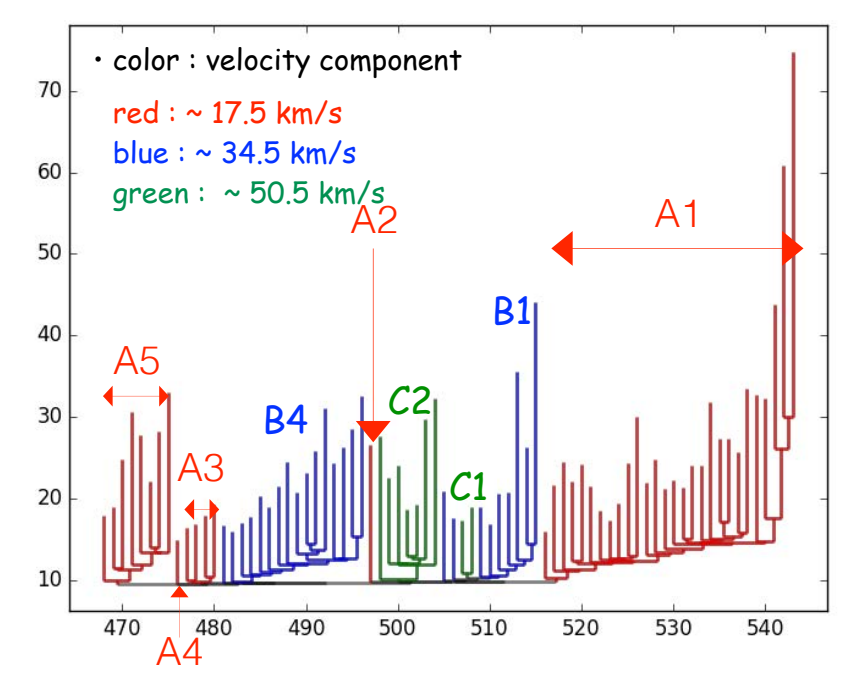


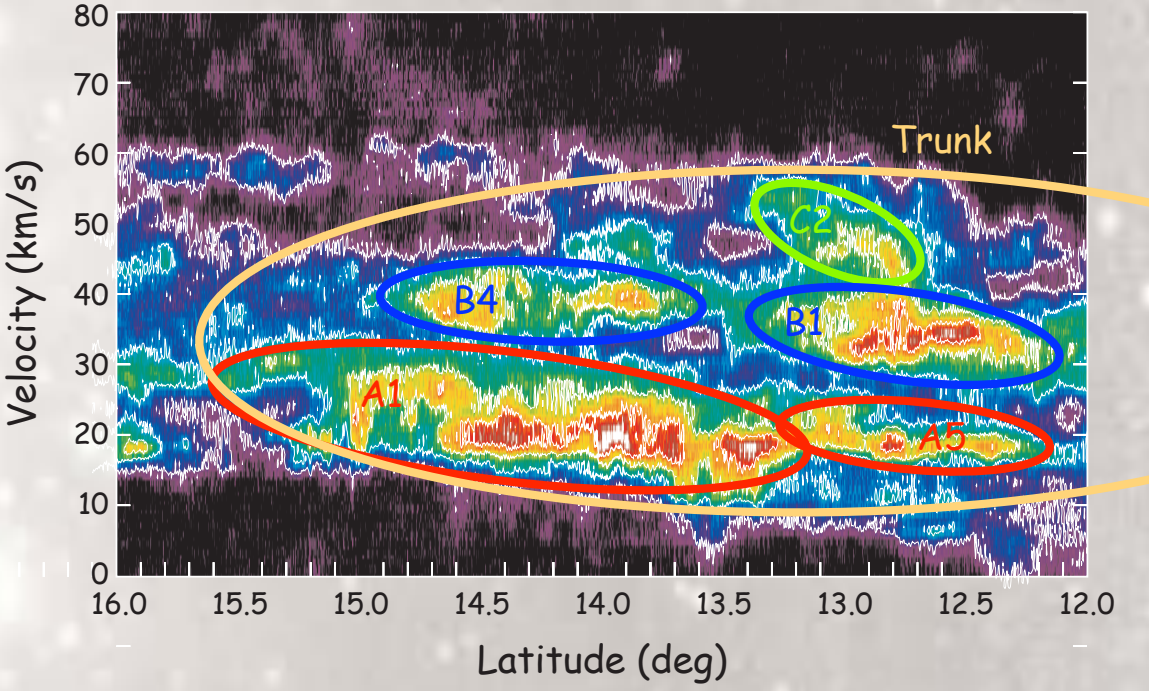
Trunks with multi-velocity components

04 Molecular Cloud Identification

Verification of Identification method

< e.g. identified clouds (on Tree) >





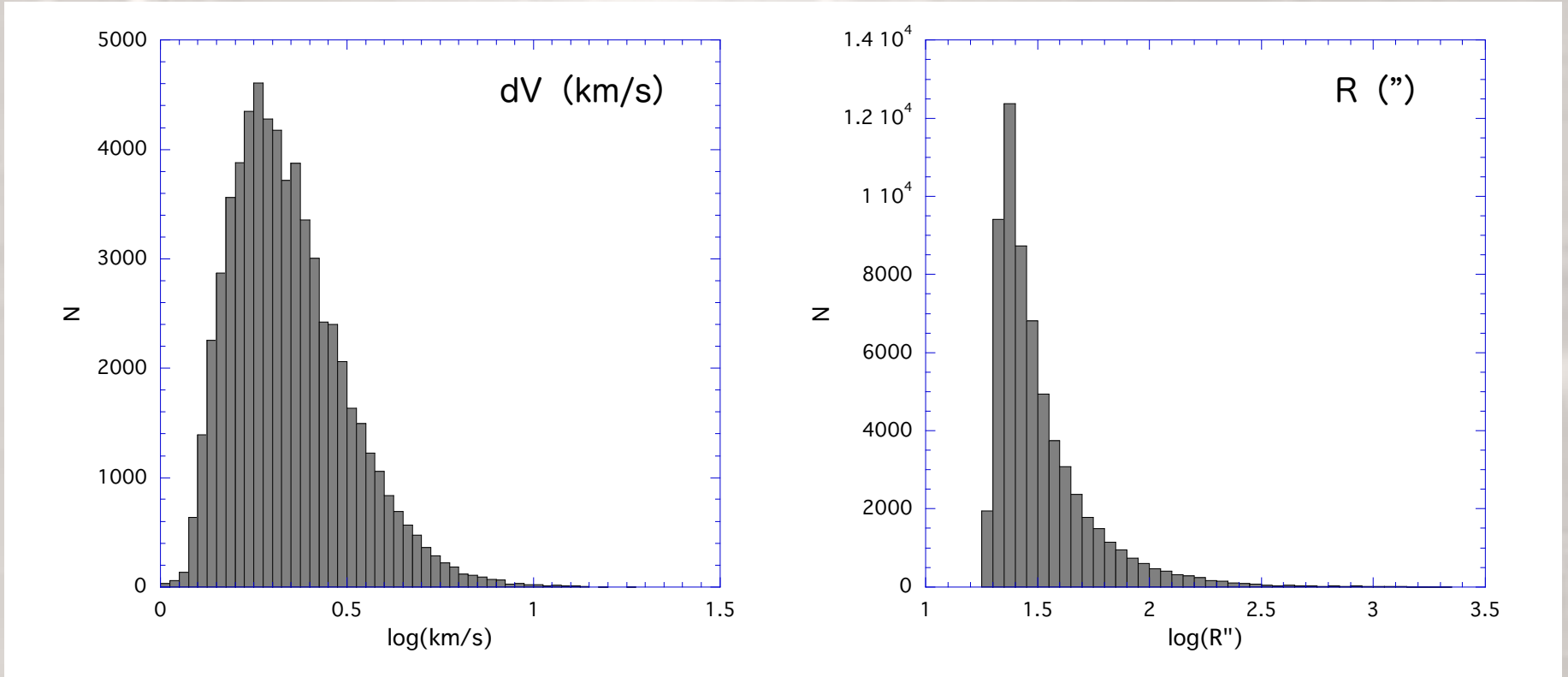
clouds in -20 km/s component : A1, A2, A3, A4, A5
clouds in -35 km/s component : B1, B2, B3, B4, B5
clouds in -50 km/s component : C1, C2

04 Molecular Cloud Identification

‹ Trunk with multi-velocity component (4 trunks) ›

- select separate velocity
- identified total 8800 structures
- final identified structures : 62670
- Physical parameters of Trunks

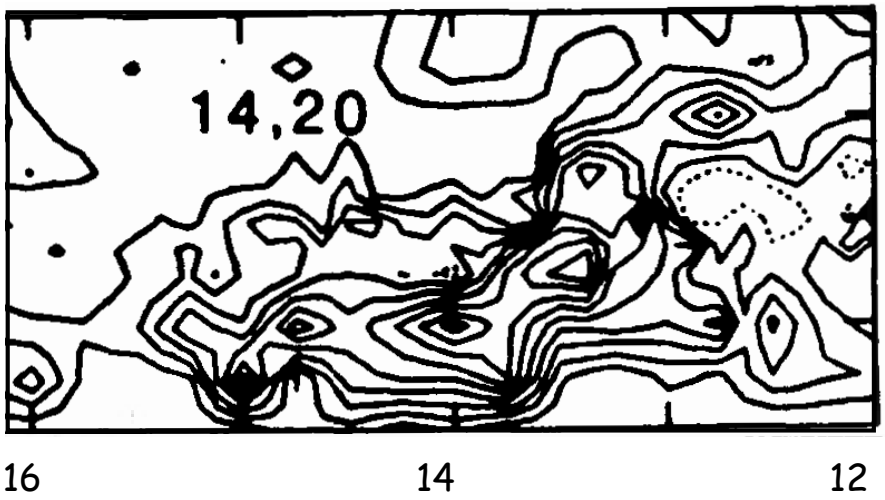
dV = 1.0 - 18.3 km/s, R(") = 19.8 - 2190" , $N(H_2)$ = 3.8×10^{22} - 3.4×10^{27} cm^{-2}



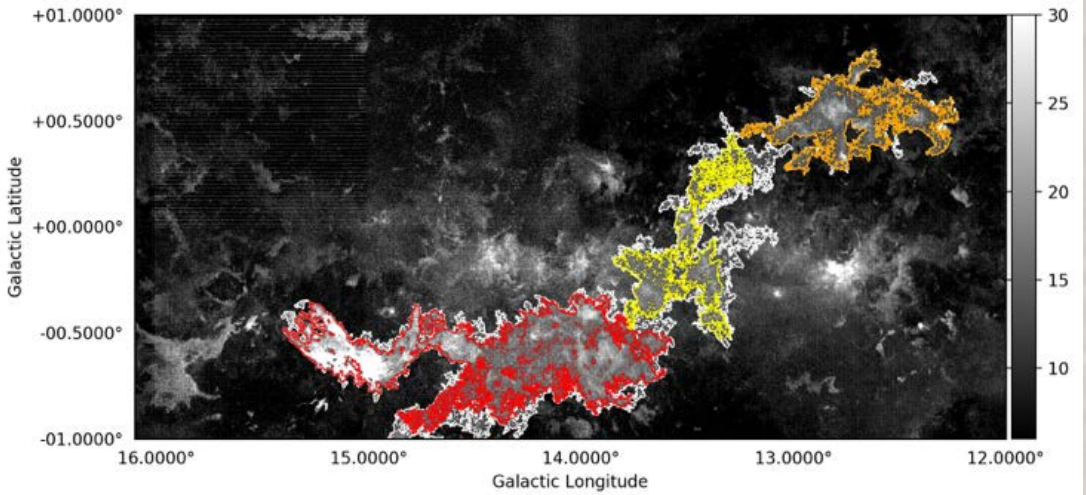
04 Molecular Cloud Identification

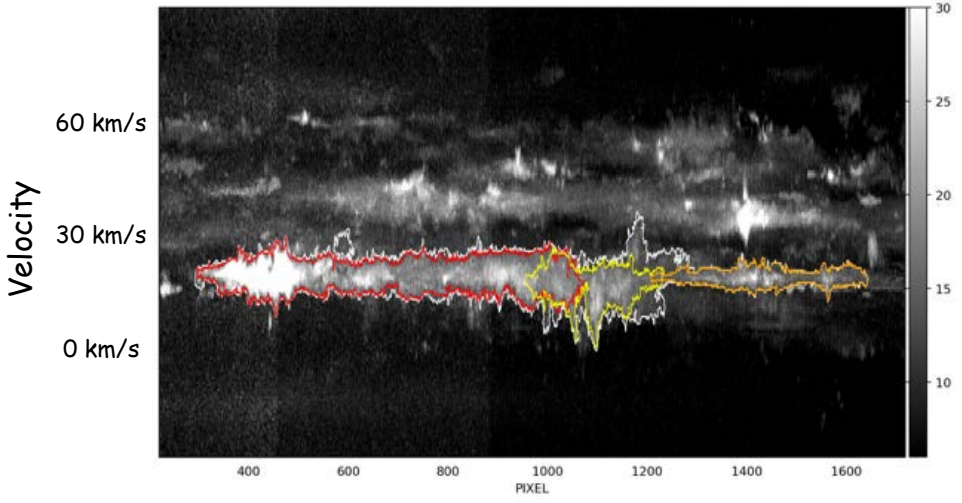
‹ Example of Identified Structures ›

Dame et al.



This Study



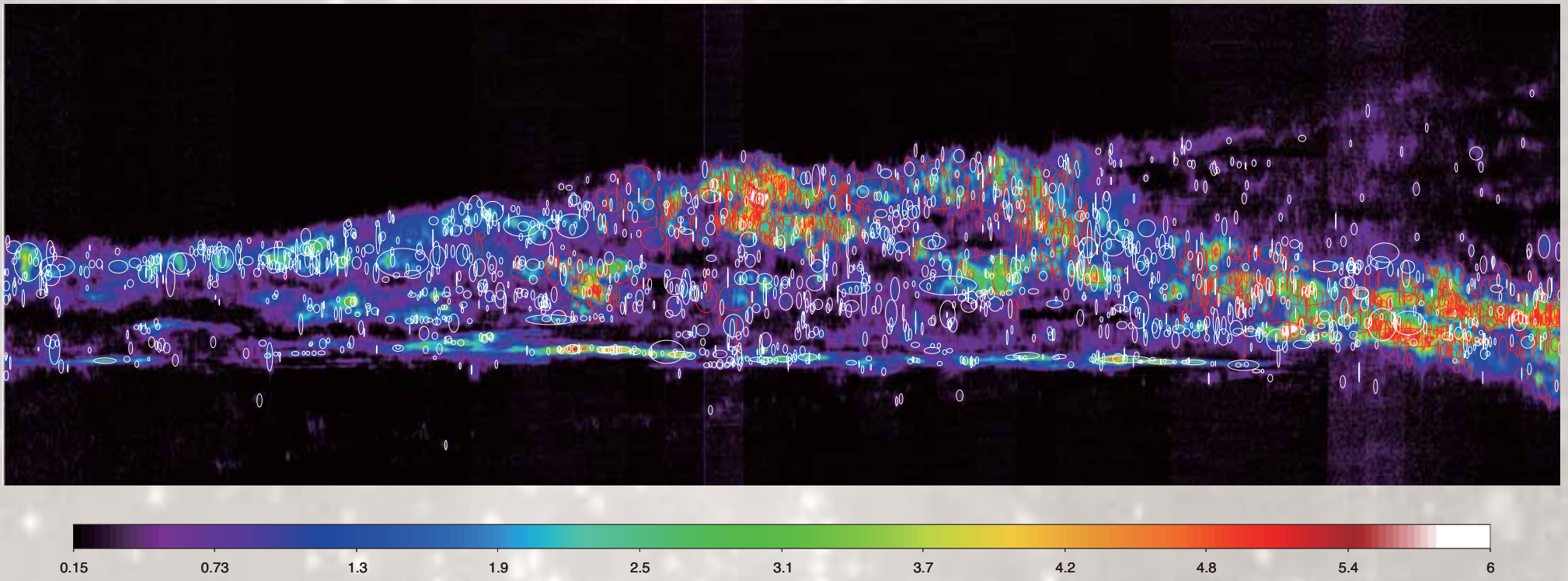


M17 GMC

- Dame et al. : R ~ 33 pc
  Mc ~ 6.2 x 10^5 Mo
- This Study : R ~ 22 pc
  Mc ~ 5.7 x 10^5 Mo

04 Molecular Cloud Identification

‹ Example of Identified Structures ›



Conclusion

Cloud Identification

- Using Dendrogram Program
- Identified many molecular gas structures
  * Total number of Trunks (clouds ?) : 62670
  * Parameter range
    - dV = 1.0 - 18.3 km/s ; R(") = 19.8 - 2190" ; $N(H_2) = 3.8 \times 10^{22} - 3.4 \times 10^{27}$ cm^{-2}