



ASTE science II: Galactic Center

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The Advantage and mission

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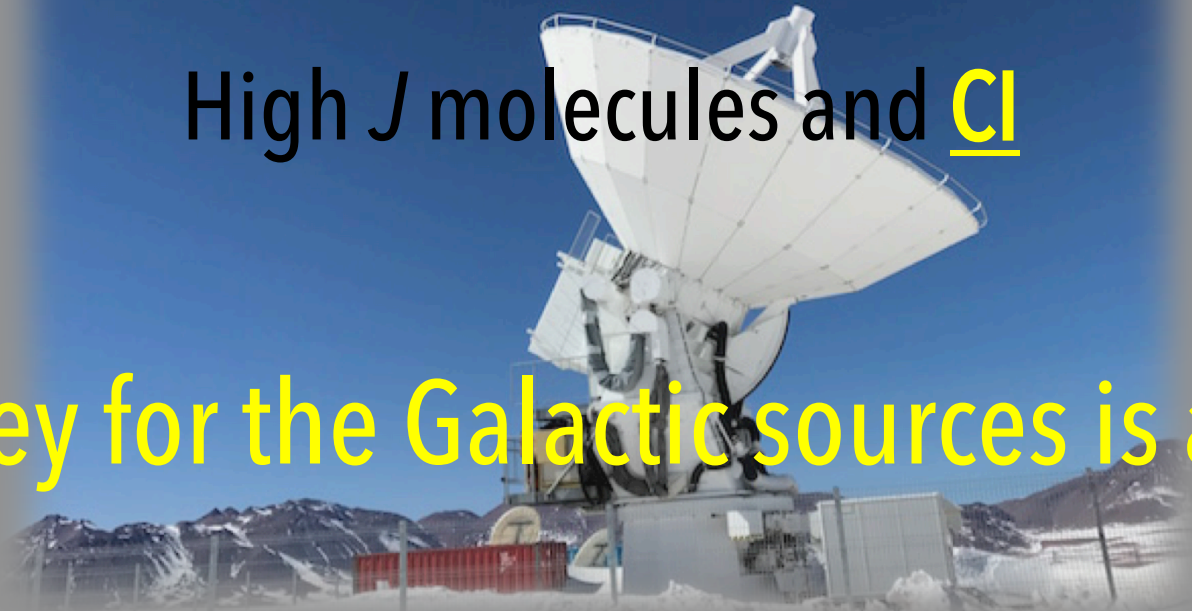
Clear sky



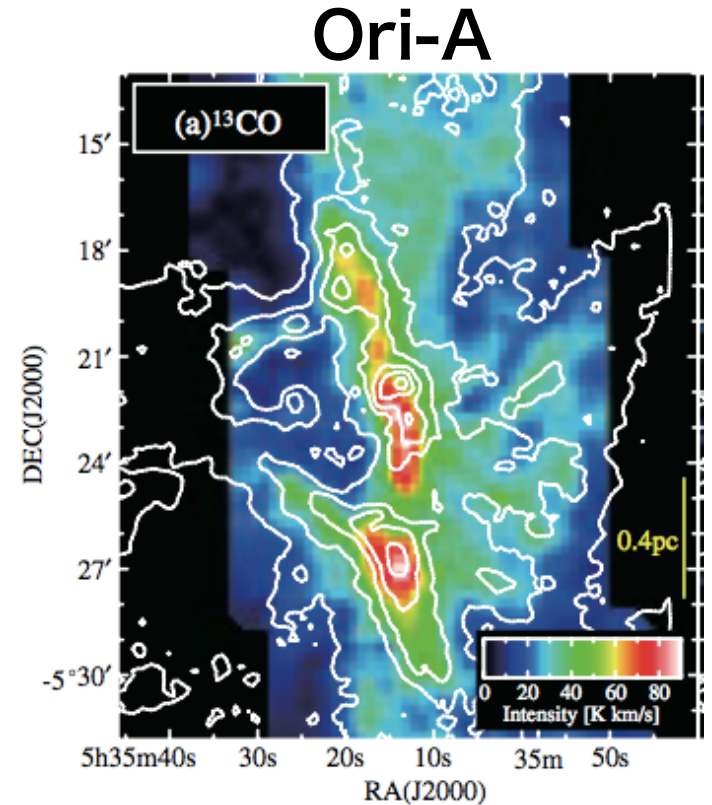
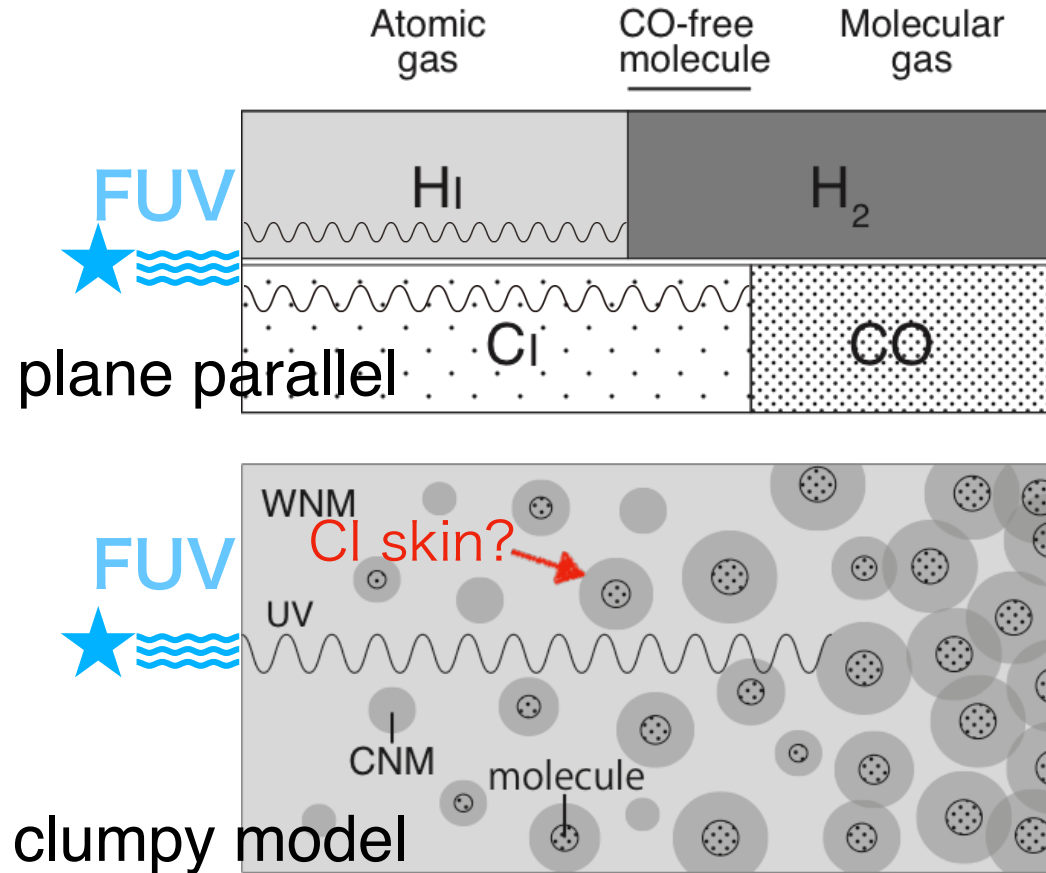
Sub-mm (band 8, 10)

High J molecules and CI

CI survey for the Galactic sources is awaited



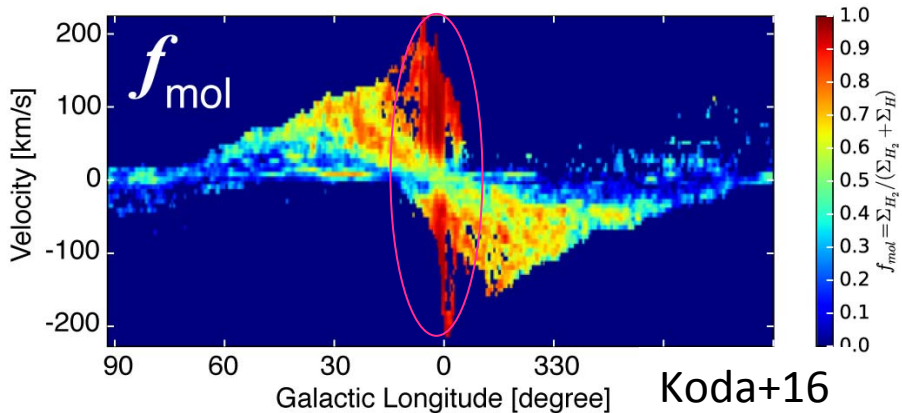
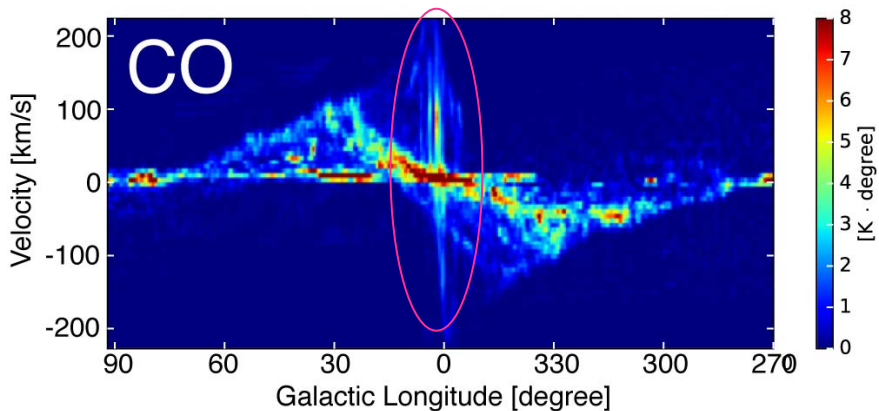
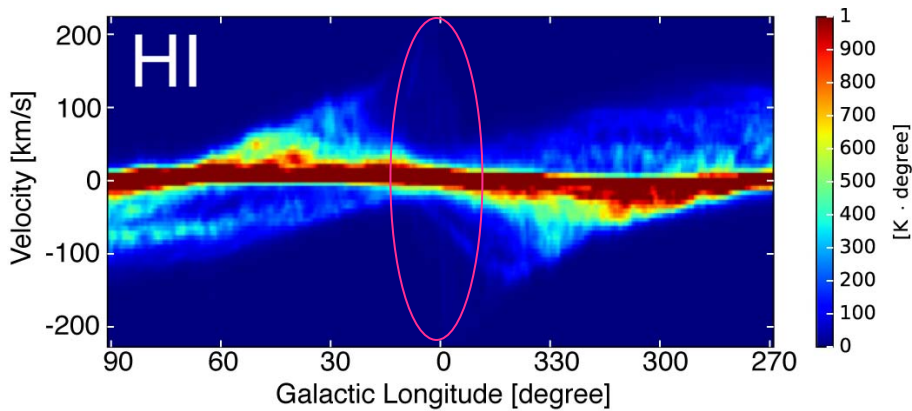
Clumpy PDR model



Contours: Cl , Image: ^{13}CO
Shimajiri+18

- Clumpy PDR model (e.g., Kosma- τ model; Störzer et al. 1996)
- FUV can penetrate inside (denser) region compared to the plane parallel model

The Galactic Center



Koda+16

1. Strong FUV field ($G_0 \sim 10^{3-5}$)[†]
2. Molecular rich[†]
3. Strong magnetic field ($> 50\mu\text{G}$)^{††}

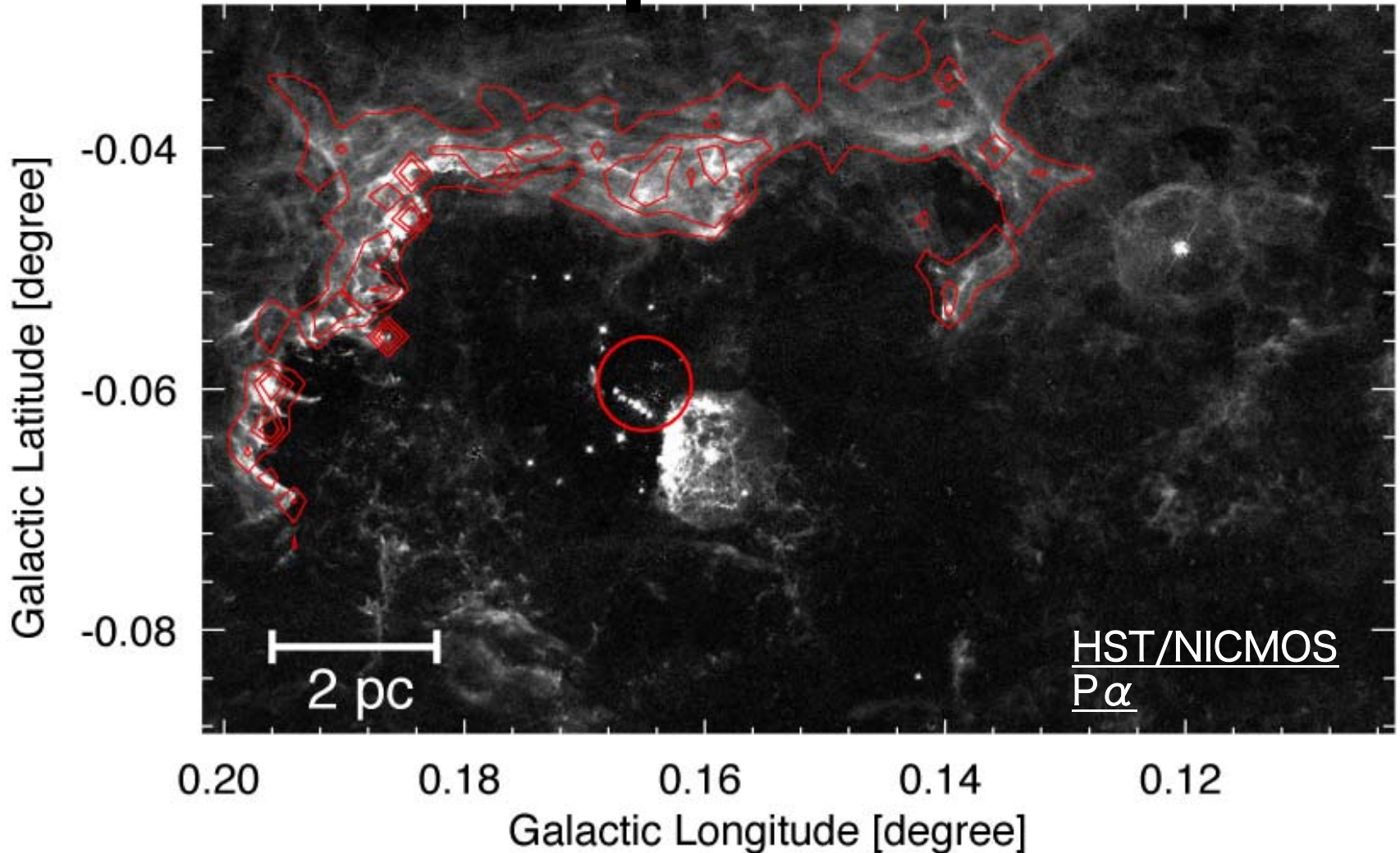
Properties of MCs

- **dense** : $n_{H_2} \sim 10^4 / \text{cm}^3$ ^{†††}
- **warm** : 30 – 200 K ^{†††}
- **large dV** : 15 – 50 km/s ^{†††}

[†] Wolfire et al. (1990)

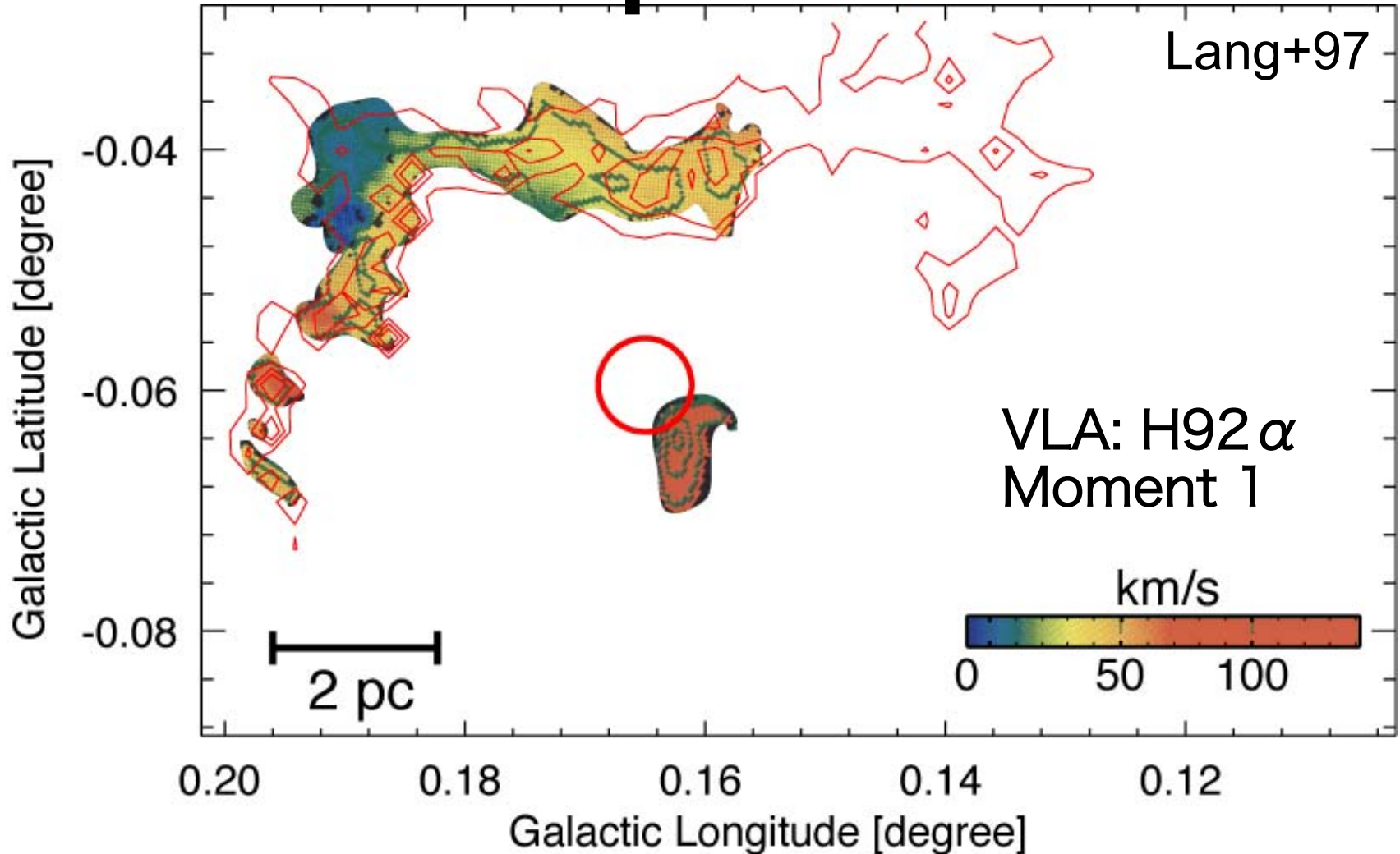
^{††} Crocker et al. (2006), ^{†††} Morris & Serabyn (1996)

Quintuplet cluster



1. Age of 4 Myr. Including 60 O-type stars (Figer +99,+04, **red circle**)
2. located in the Galactic Center
3. The PDR (=Sickle) is clearly seen (**red contours**)

Quintuplet cluster

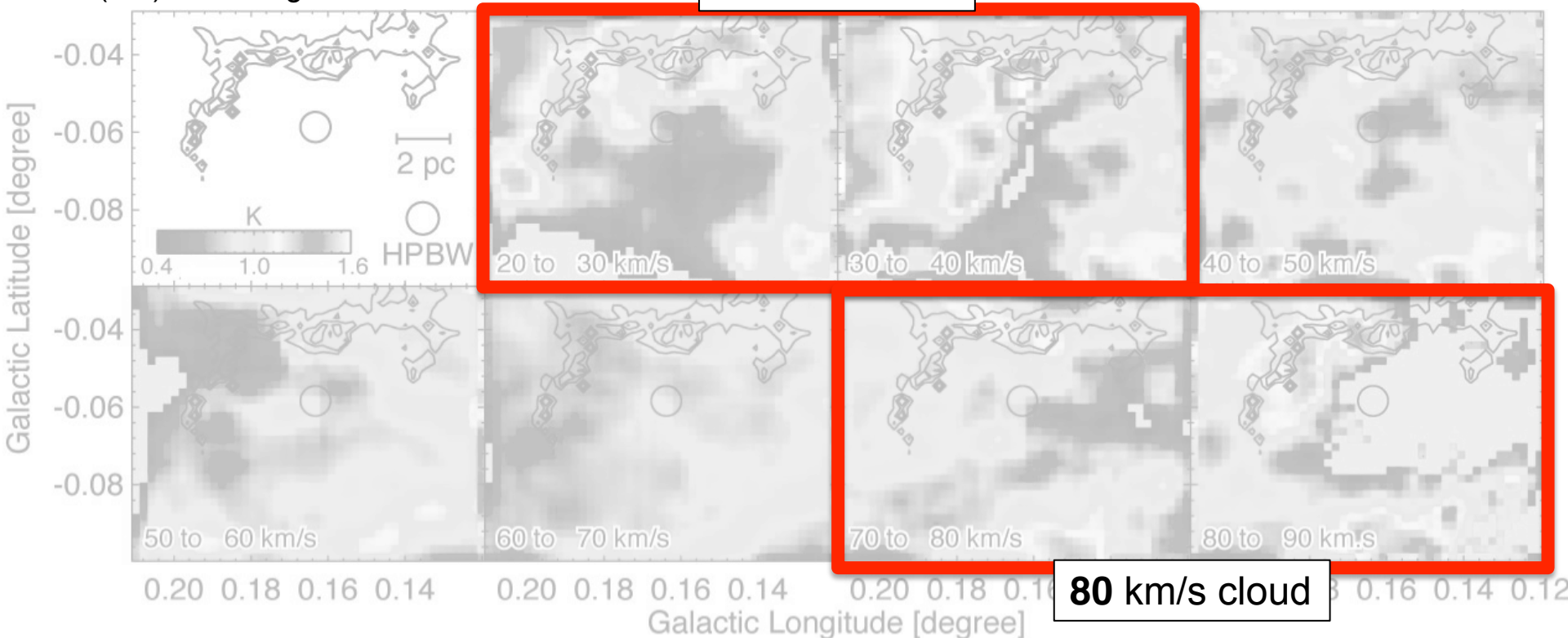


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$^{13}\text{CO}2-1/1-0$

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$^{13}\text{CO}(1-0)$: Tokuyama+19
 $^{13}\text{CO}(2-1)$: Ginsburg+16



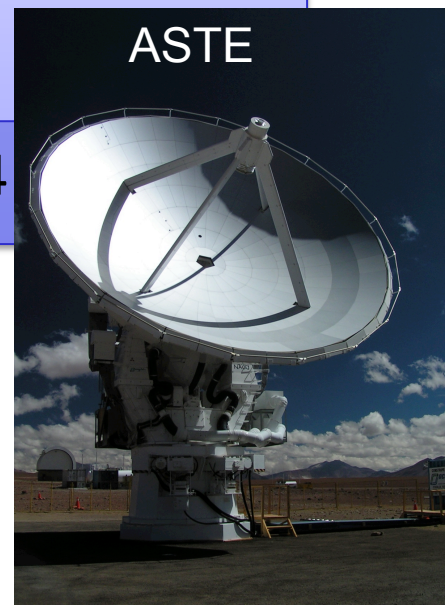
High $^{13}\text{CO}(2-1/10)$ values at some points

- 20 – 50 km/s: a associated cloud previously suggested† (25 km/s cloud)
- 50 – 90 km/s: a shell-like cloud (80 km/s cloud)

† Serabyn and Gusten (1991)

Pilot observations of atomic gas⁸

line	CI (1-0)	13CO(3-2)
frequency	492.16 GHz	330.58 GHz
Rx	ASTE Band8	DASH345
Ang. resolution	17" (=0.684 pc @GC)	22" (=0.885 pc @GC)
Vel. resolution	1.0 km/s	1.0 km/s
Obs. period	2019/8/21, 2019/9/24	2019/9/24

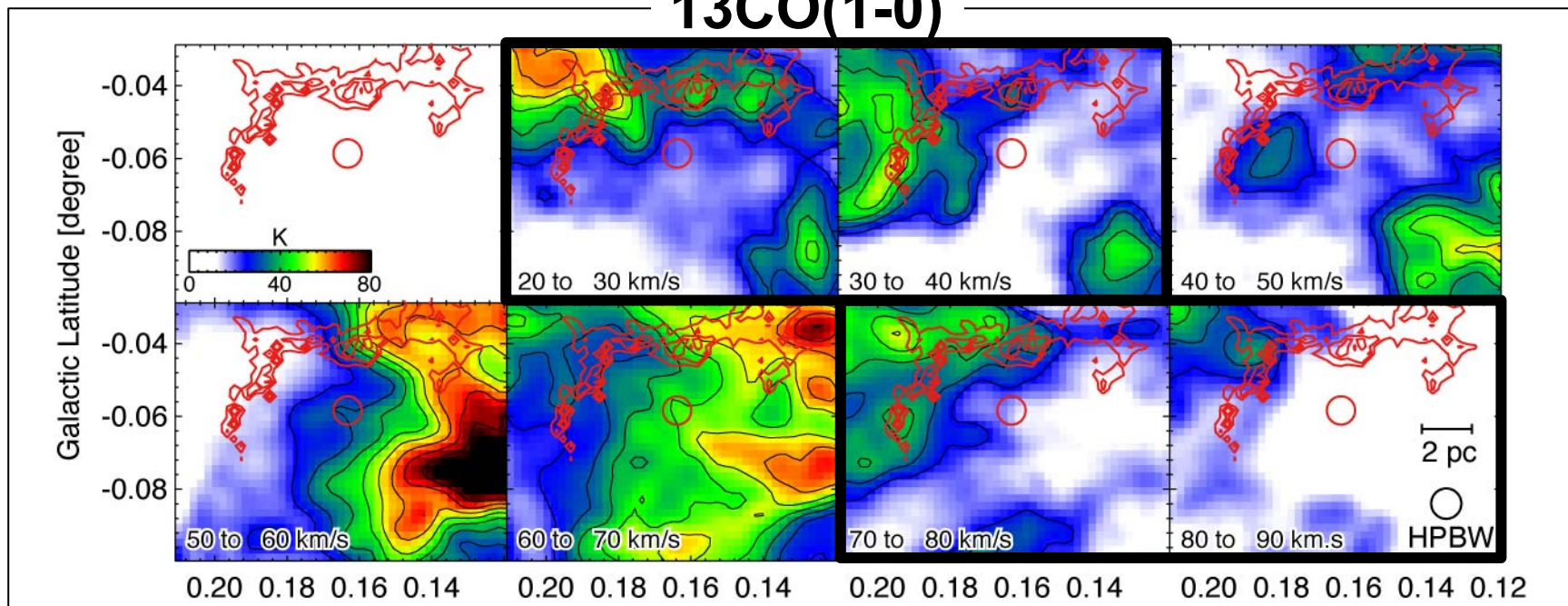


CI(1-0)

25 km/s cloud

80 km/s cloud

Very similar distributions

 $^{13}\text{CO}(1-0)$ 

CI/13CO(1-0)



- High values in the vicinity of sickle (disk typical ~ 0.8 ; shimajiri+02 @Orion)
- Higher values toward the cluster

➔ Atomic/molecular transition layer?

Any differences between the disk clouds and GC clouds ?

Physical state in the transition layer¹¹

RCW38 (d=1.7 kpc)

Quintuplet cluster

Transition layer

Transition layer

Izumi+21

The quintuplet has

- higher column density of the transition layer
- lower ratios in the high column region

Thinner CI skin?
Due to high density
environment in the GC ?

Enokiya+ in prep.

Interpretation based on Clumpy PDR

Summary

- Discovered two possible CO counterparts to the sickle (25, 80 km/s clouds)
- ASTE CI(1-0) observations revealed that the column density of the transition layer in the Quintuplet cluster is twice than typical value.

Future

- High resolution follow-up observations with ALMA, SKA
 - ➔ to test if tiny clumps exist in the transition layer
- Follow-up CI(2-1) observations with ASTE
 - ➔ to compare densities of CO and CI through the LVG analysis of CI
- Velocity Analysis of CO, CI, and RRL
 - ➔ to reveal gas dynamics of molecular/atomic/ionized gas and their inter-relations