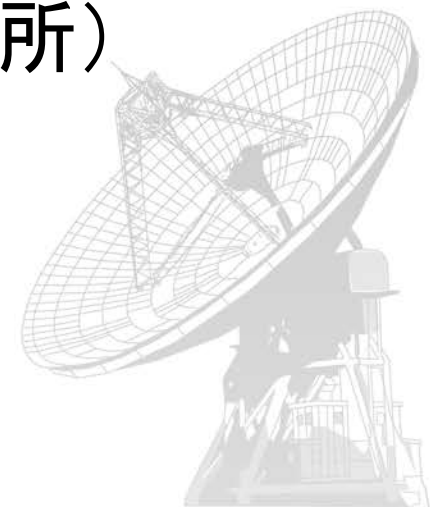


銀河系外縁部の低金属量分子雲と星形成

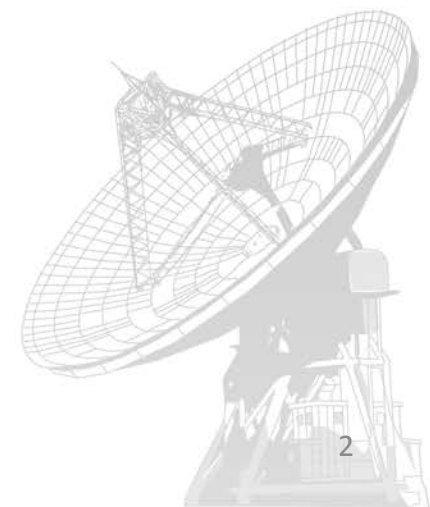
齋藤正雄

(国立天文台野辺山宇宙電波観測所)

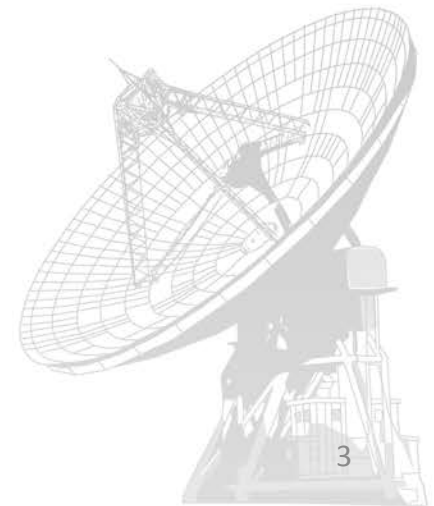


Contents

1. GMC Properties
2. Outer Galaxy
3. Future Observations with Nankyoku Telescope

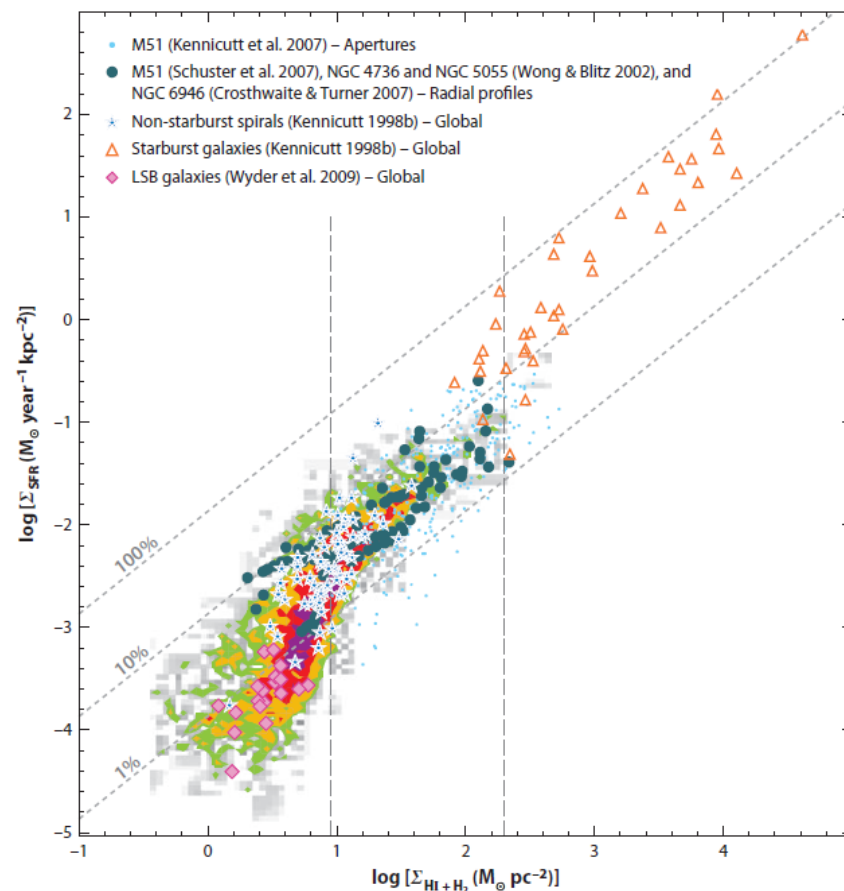


GMC AND STAR FORMATION



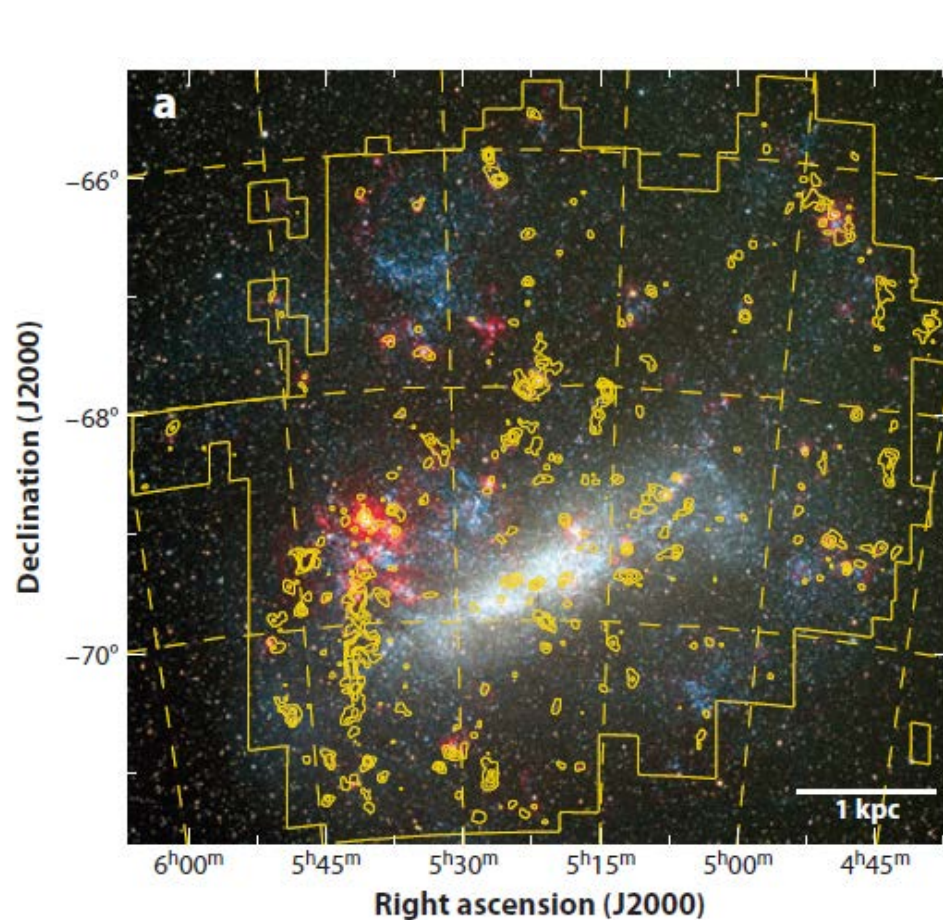
GMC and Star Formation

- Most stars form in GMCs
- GMC study important

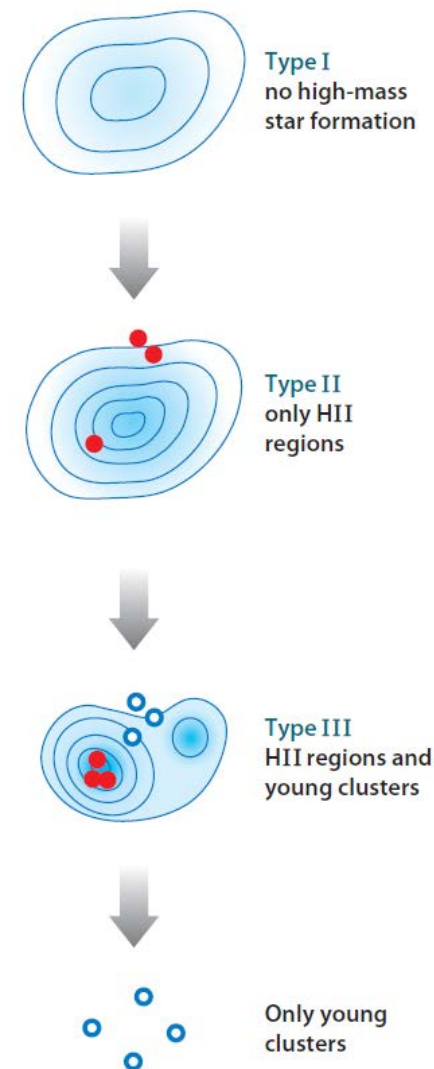


Kenincutt and Evans+14

GMC Evolution

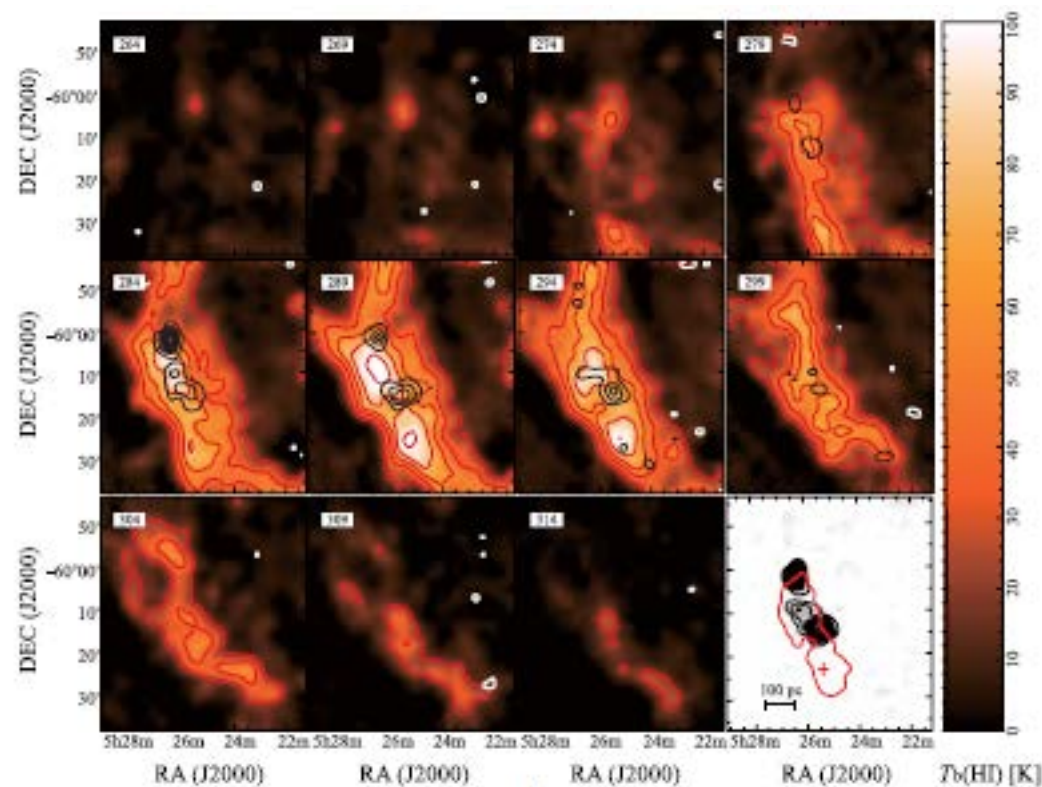


Fukui and Kawamura+11



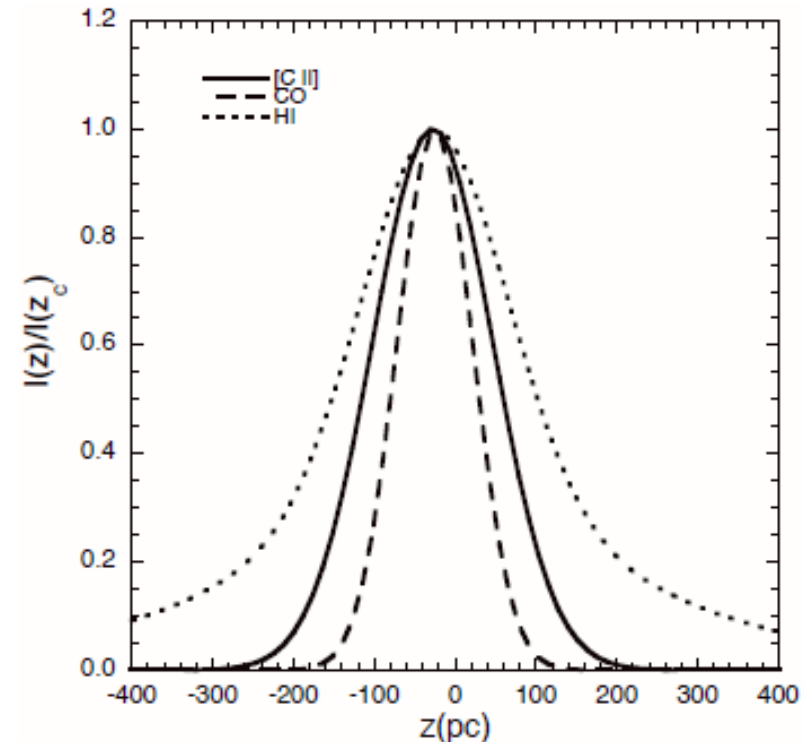
GMC and Composition

- HI and CO well correlated on 40 pc scale, but not well on 10 pc scale
- HI and CO peak velocities agree well.



Galaxy Component

- Molecular gas traced by CO
- Molecular gas unseen in CO??
- <= argued by Fukui+14
- Molecular/Atomic gas traced by [CII]
- Atomic gas traced by HI



Langer+14

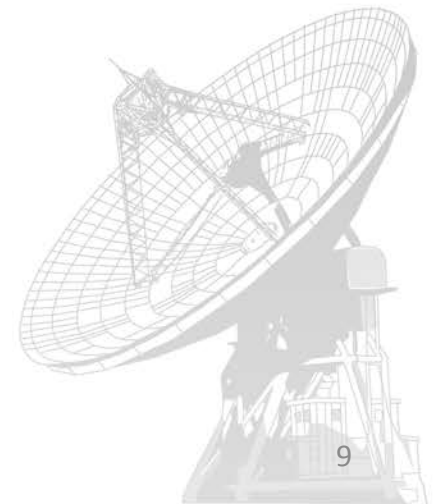
Key Question

- GMC Formation and Evolution
- GMC composition, H_2 tracer [CI]
- Structure of our Galaxy

Outer galaxy GMCs.



GMCS IN OUTER GALAXY



Outer Galaxy

- $R_G > 13.5$ kpc

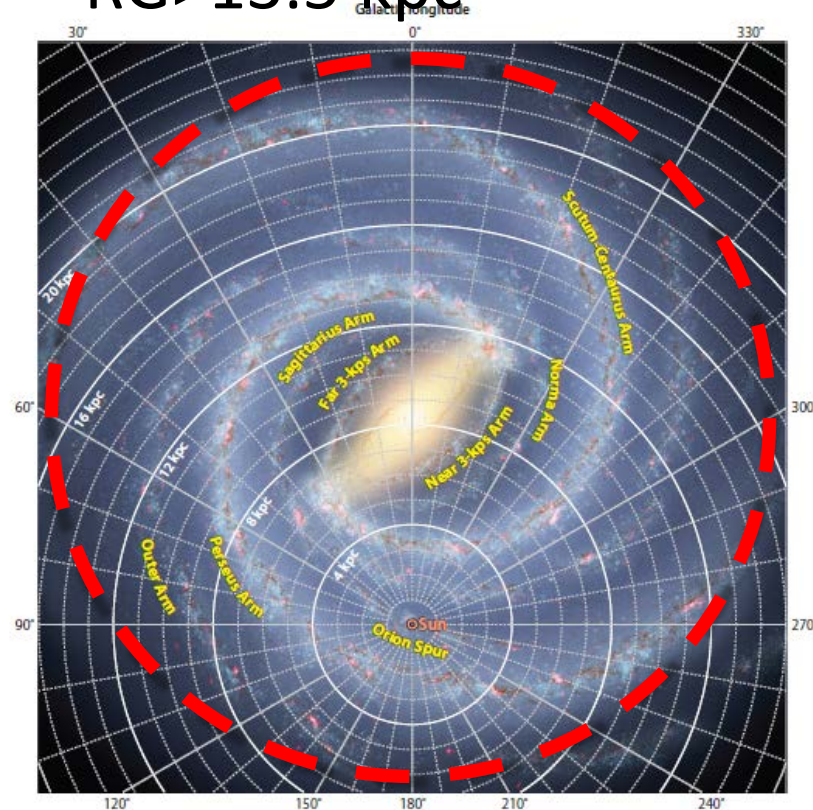
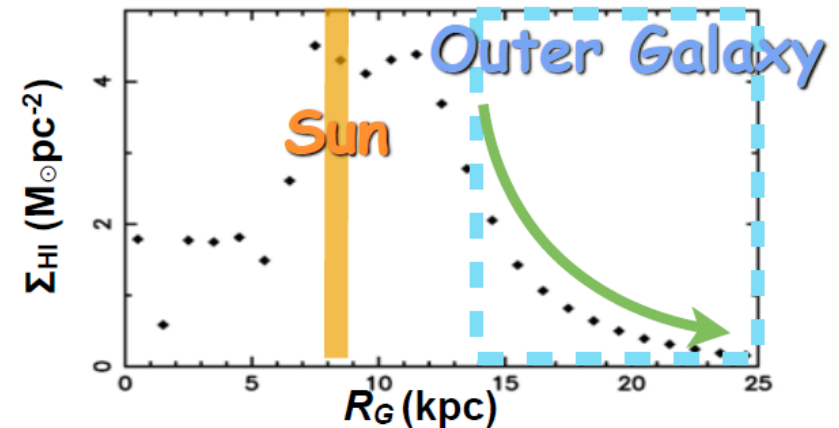


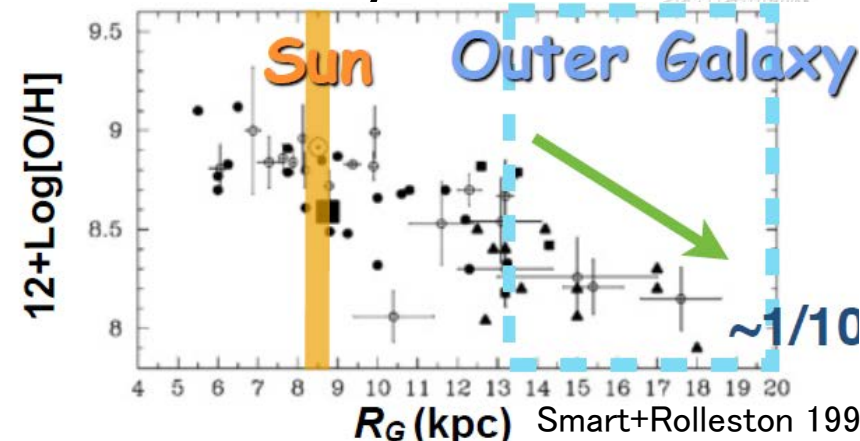
Figure 1 Similar to Dwarf galaxy e.g. LMC

Low gas density



Nakanishi & Sofue 2003

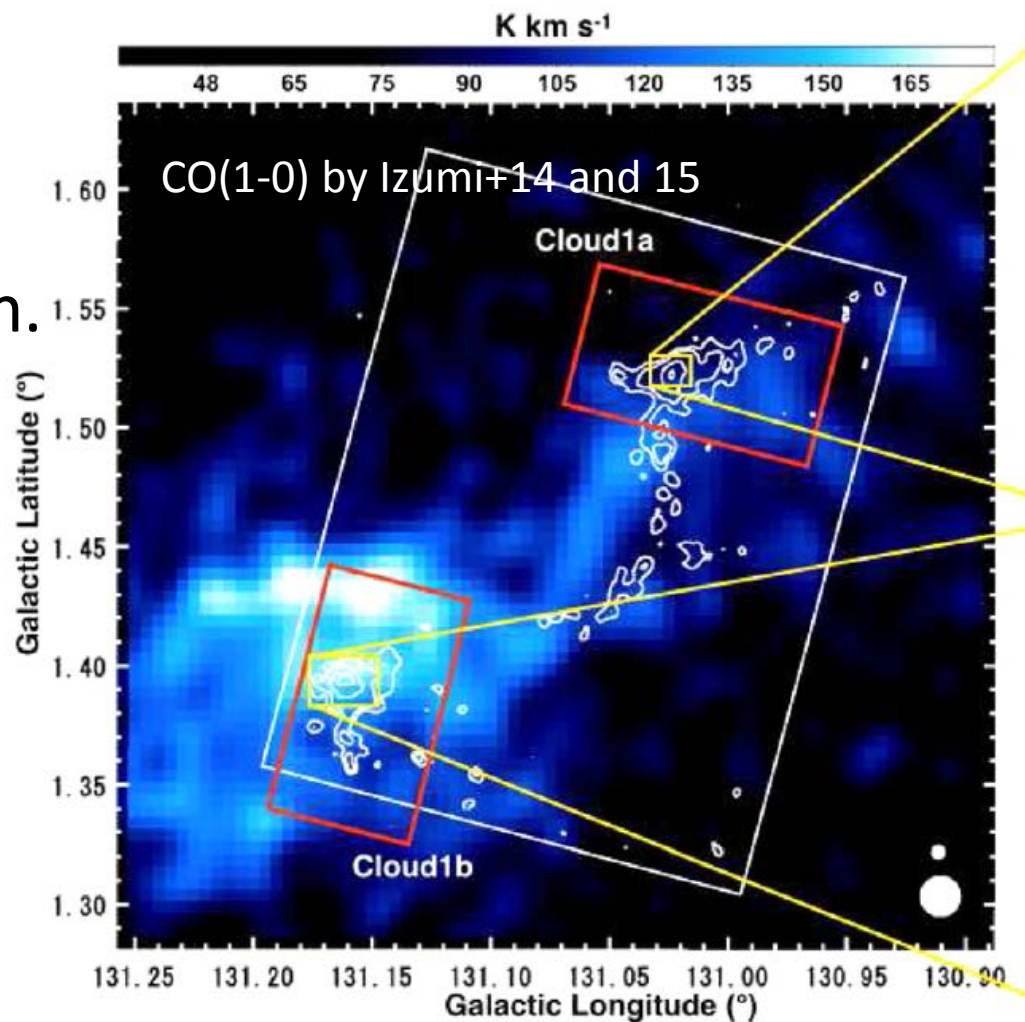
Low metallicity



Smart+Rolleston 199

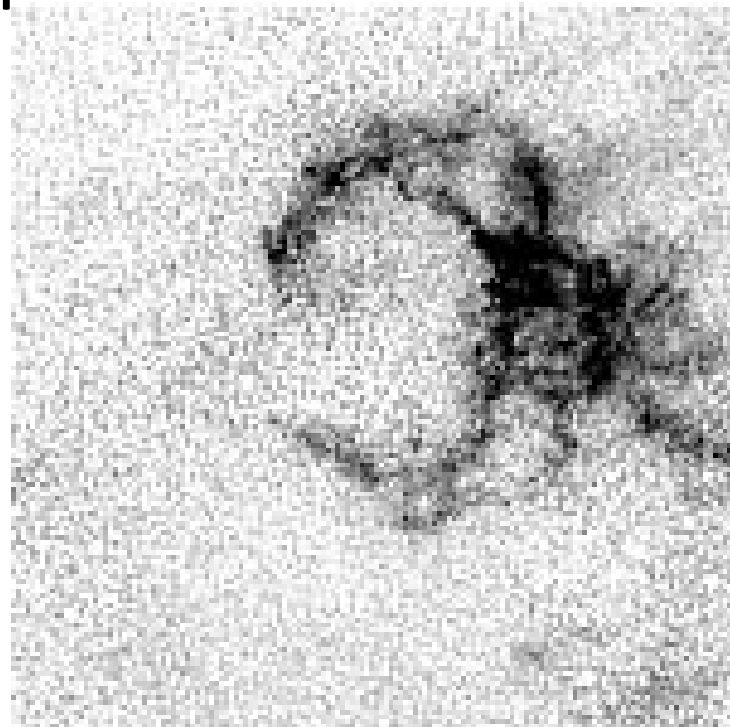
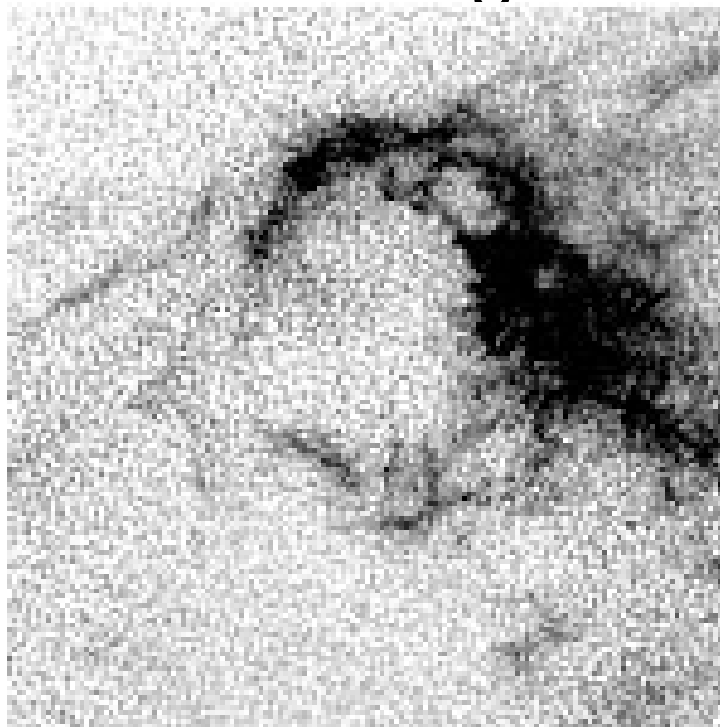
Our Work

- Digel Cloud 1 and 2 ($R_g > 18$ kpc)
- On-going star formation.
Not contaminated region.
- Low Metallicity

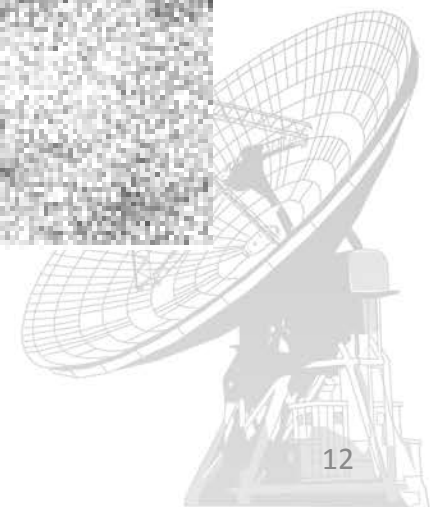


HI Shell and Cloud 2

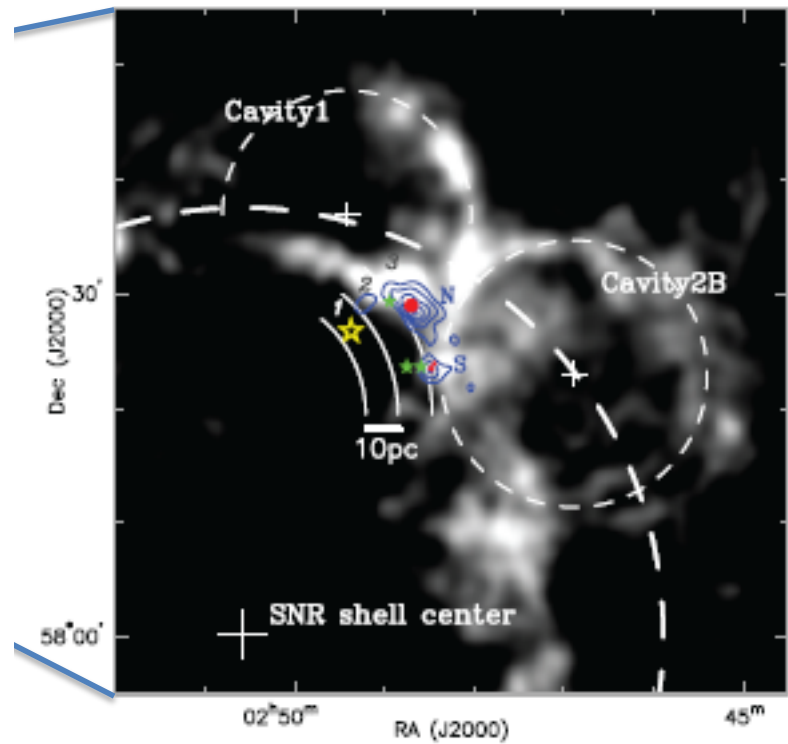
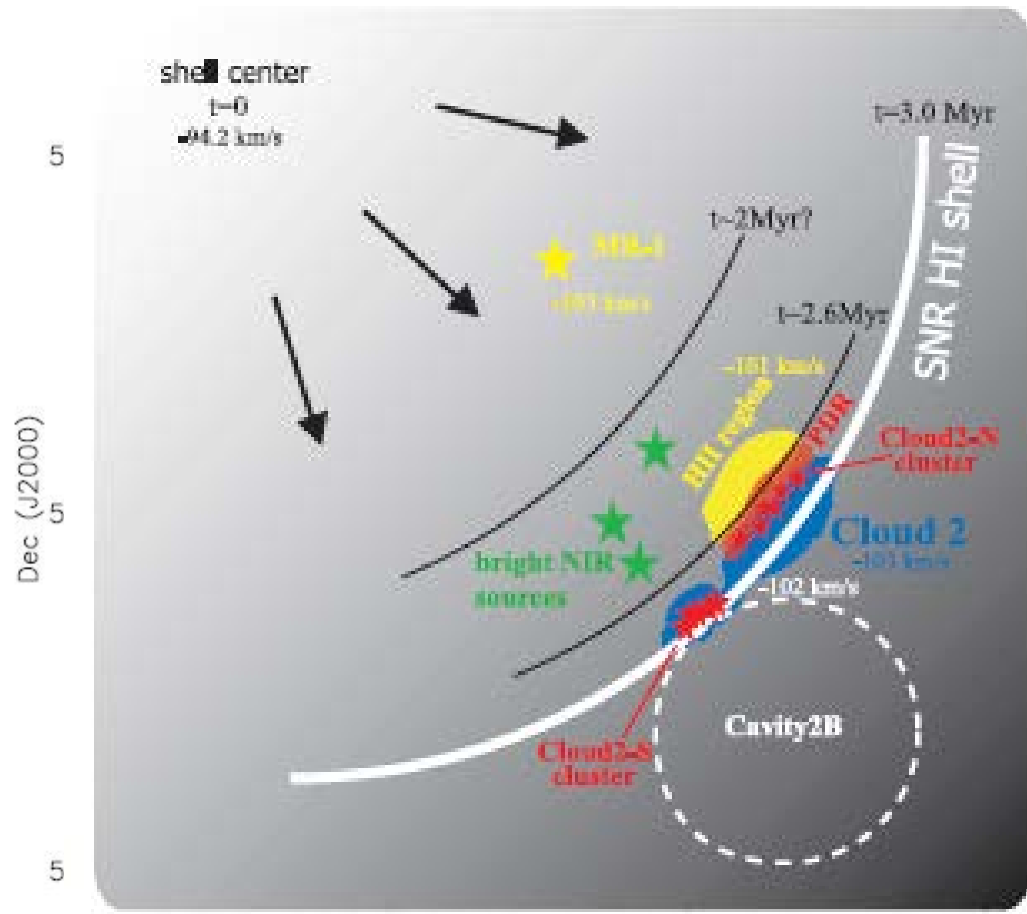
- HI bubble – $R_g \sim 19$ kpc



Stil and Irwin 01

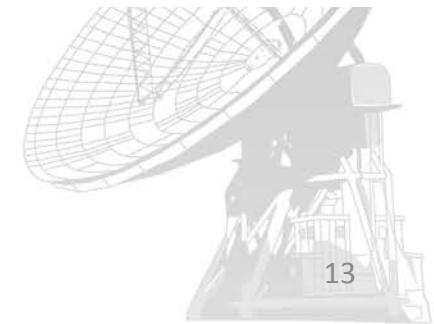


SN Triggered Formation



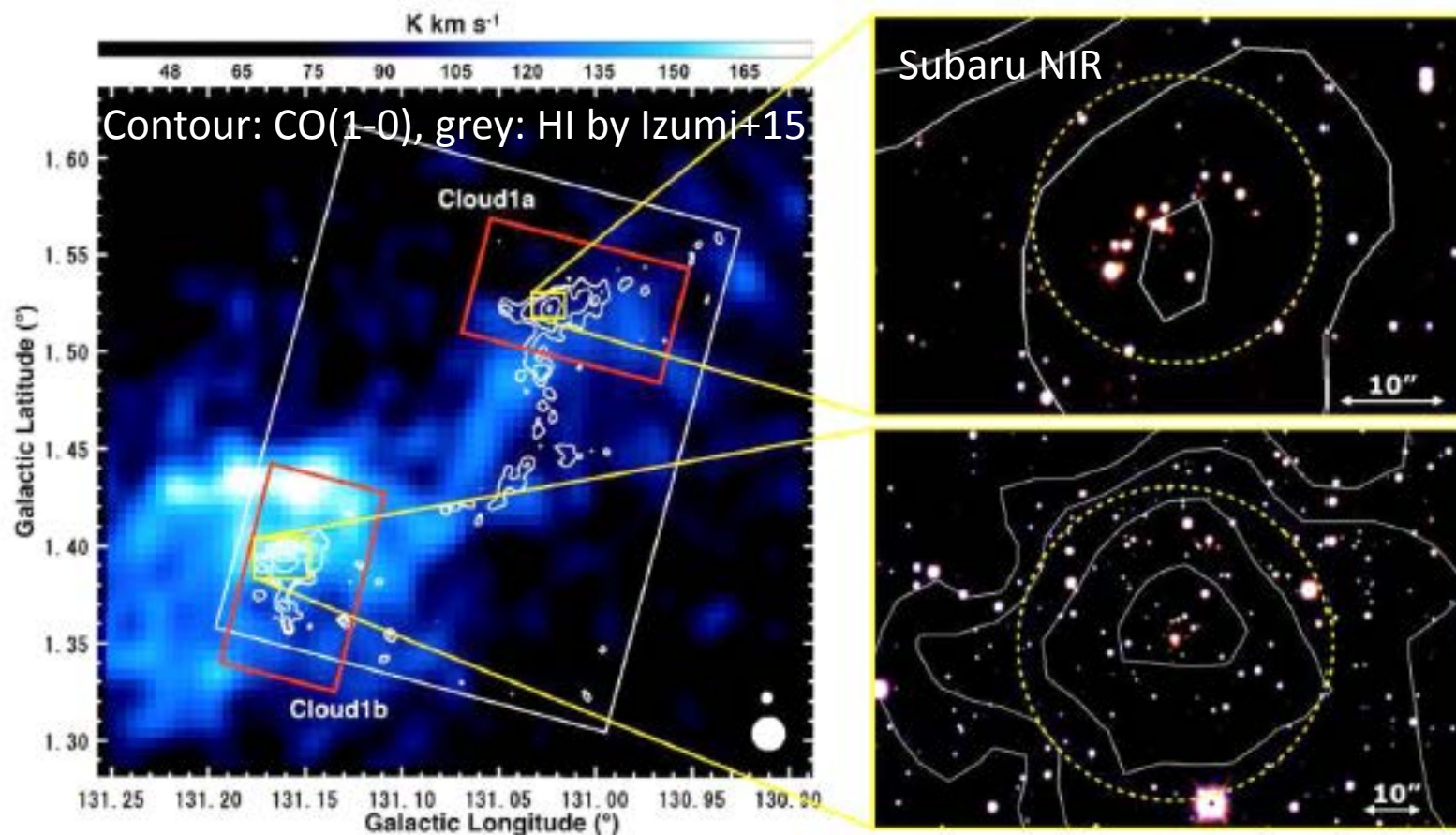
Observer

子雲と星形成

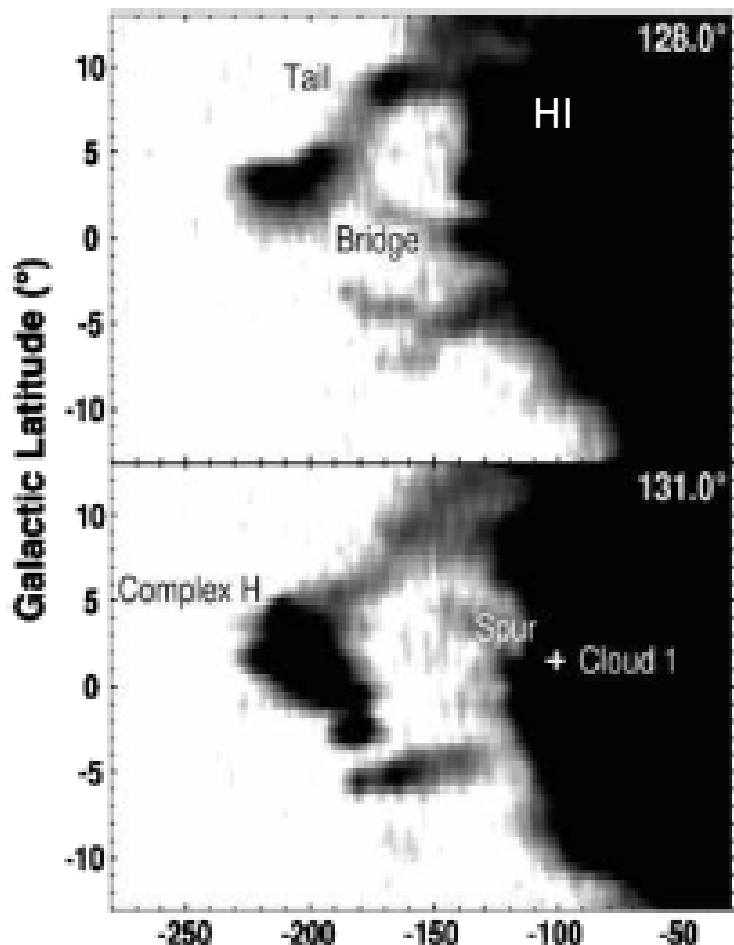


HI Cloud and Cloud 1

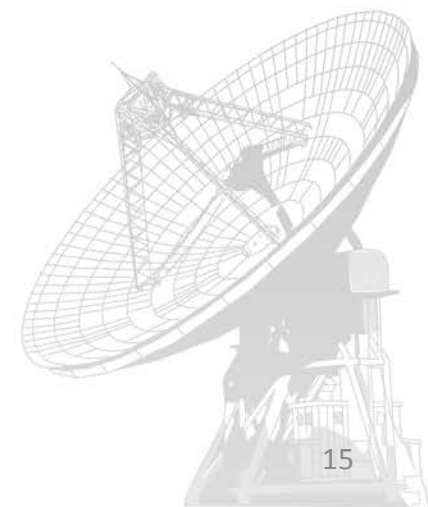
- Cloud 1 $R_g > 19$ kpc



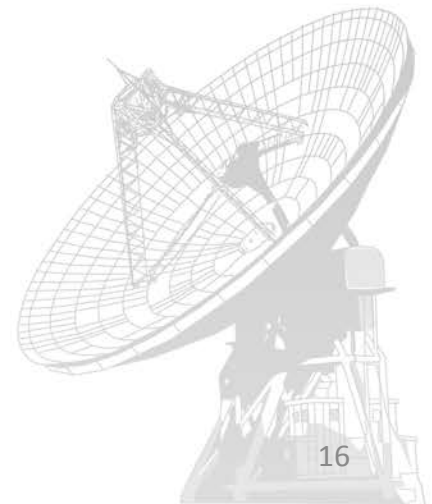
HVC collide with GP



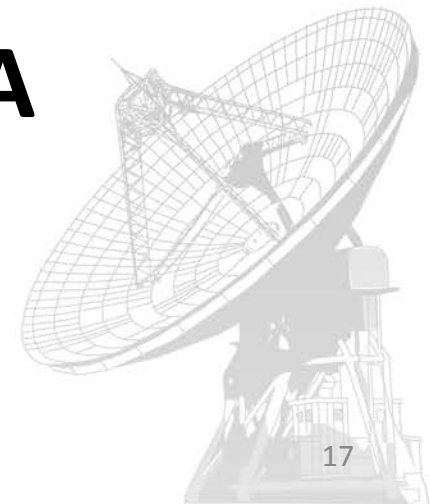
- Impact of HVC Complex H onto the outer part of the Galactic disk
- => Cloud 1 formation as well as star formation in Cloud 1.



- H_2 are really traced by CO?
- [C] also traces H_2 ?
- <= Offner+14 claimed that [C] is a better H_2 column density tracer up to $6 \times 10_{23} \text{ cm}^{-3}$.



RESEARCH WITH ANTARCTICA TELESCOPE



Specification

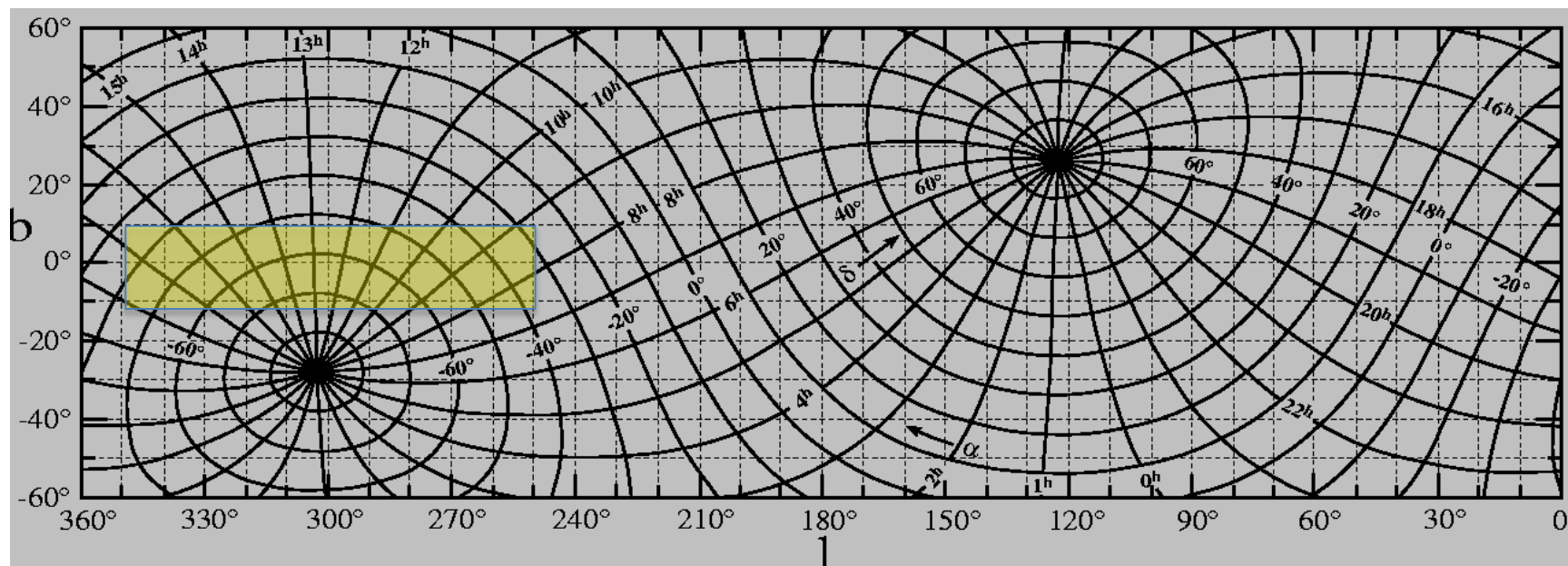
スペクトル線観測

(冬季 50%レベル@ ドームC)

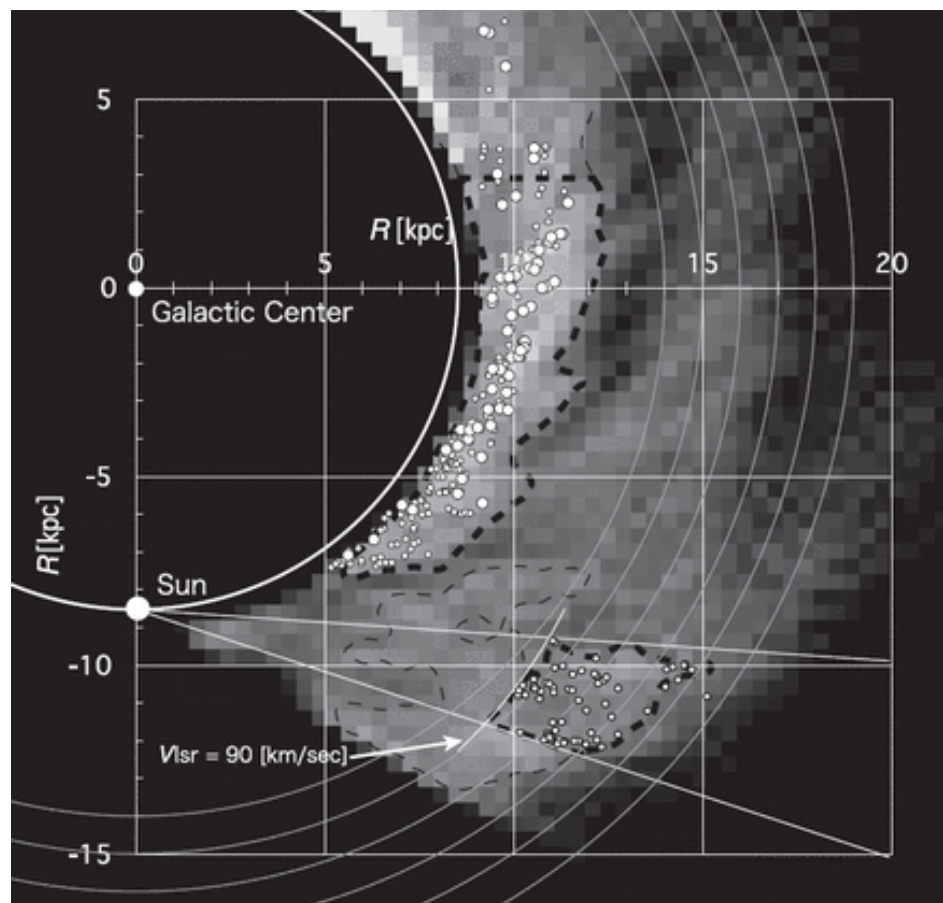
周波数帯	周波数範囲	感度(5σ rms for $\Delta V=1\text{km/s}$) *			角分解能
		$\tau=60\text{sec}$	1 hour	10 hours	
(220 GHz)	210-275	0.098 K	0.013 K	0.0040 K	34"
350	275-373	0.086	0.011	0.0035	21"
460	385-500	0.16	0.021	0.0065	17"
850	787-950	0.46	0.059	0.019	8.7"
1000	1010-1060	1.10	0.142	0.045	7.4
1300	1260-1380	1.47	0.190	0.060	5.7"
(1500)	1440-1540	2.36	0.305	0.096	5.0

Observable Galactic Plane

- $l=250-350$ deg $b=\pm 10$ deg



Pioneer Work with Nanten



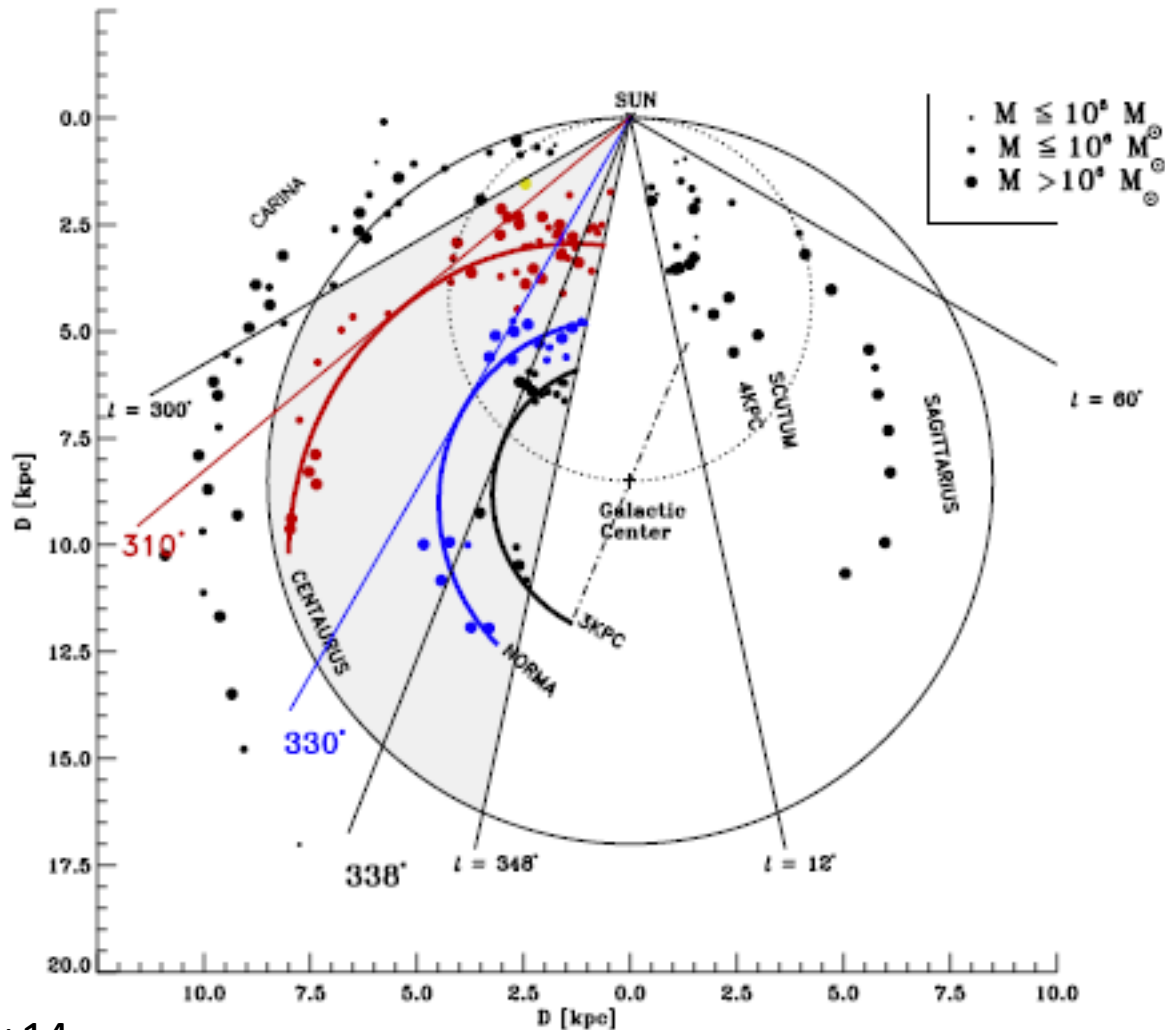
Nakagawa+05

2015/11/19

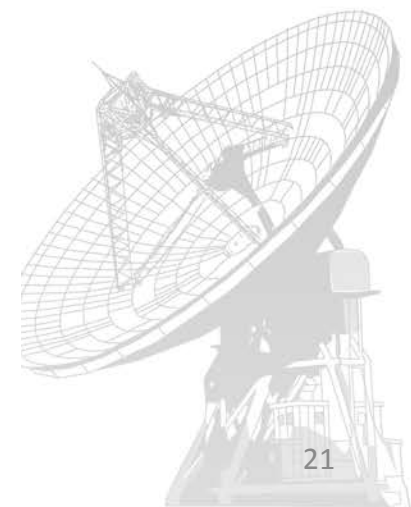
銀河系外縁部の低金属量分子雲と星形成



Recent Results

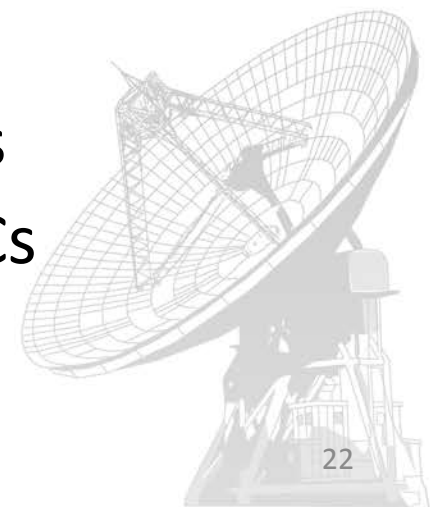


Garcia+14

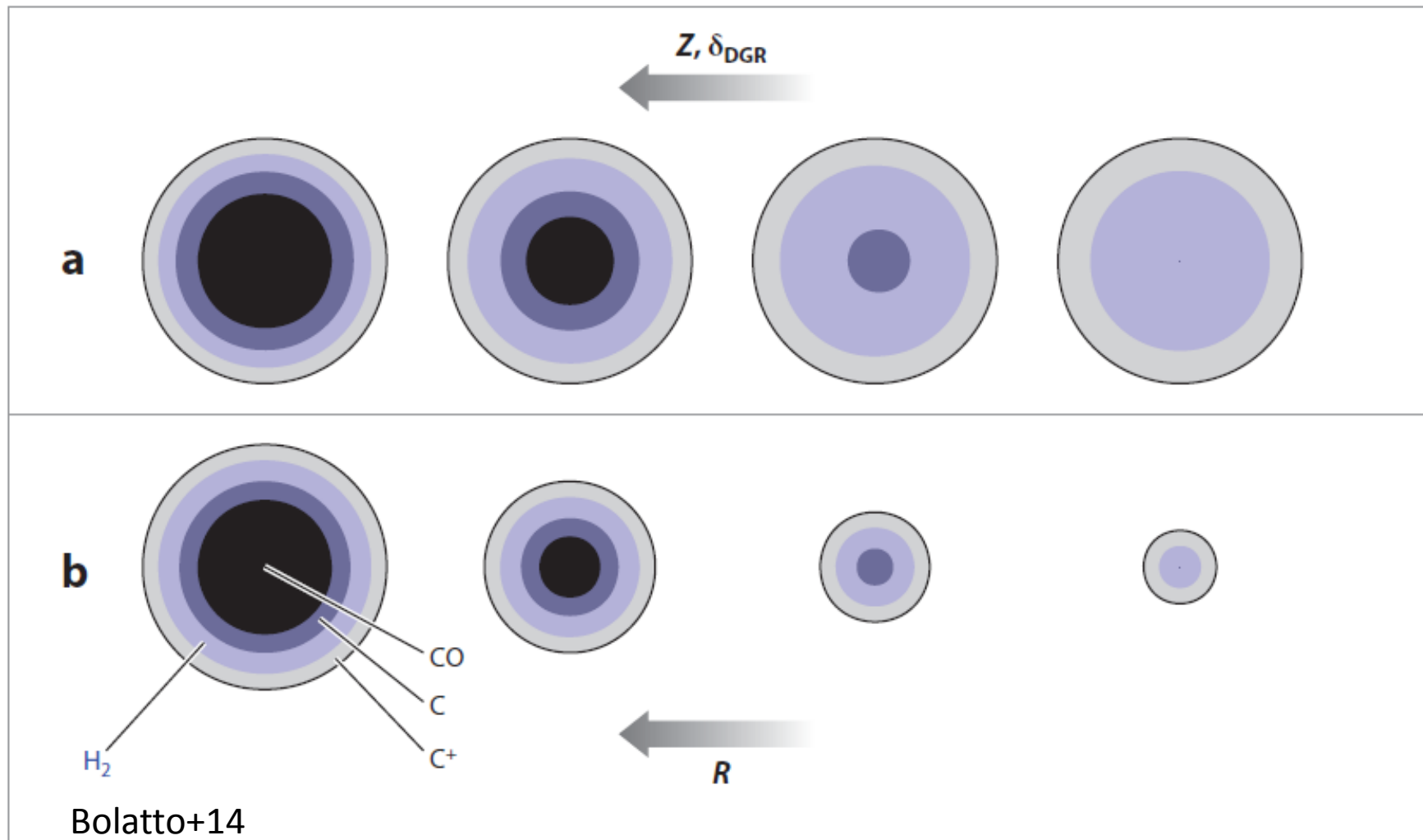


Proposed Observations

- Target: GMCs in Outer Galaxy at 25 kpc
- $1'' \sim 0.12$ pc
- Line: CO(3-2)/[CI]
- $dV = 1$ km/s
- OTF map covering 100 pc x 100 pc ($800'' \times 800''$)
- Goal
 - To study Evolution of metal-poor GMCs
 - To study Formation of metal-poor GMCs

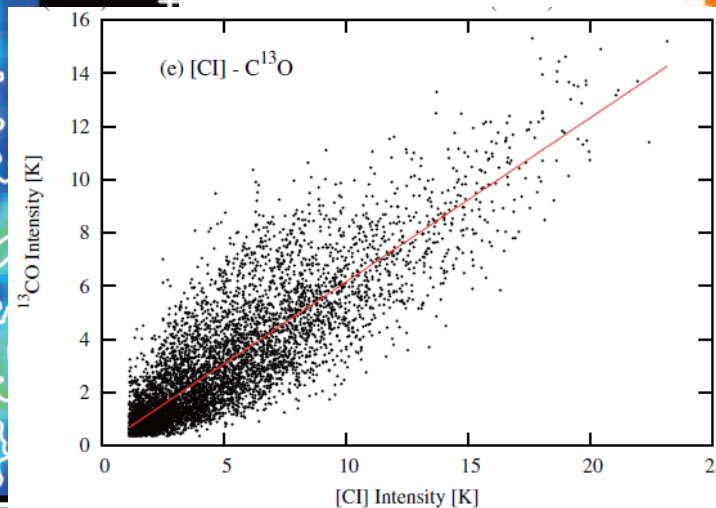
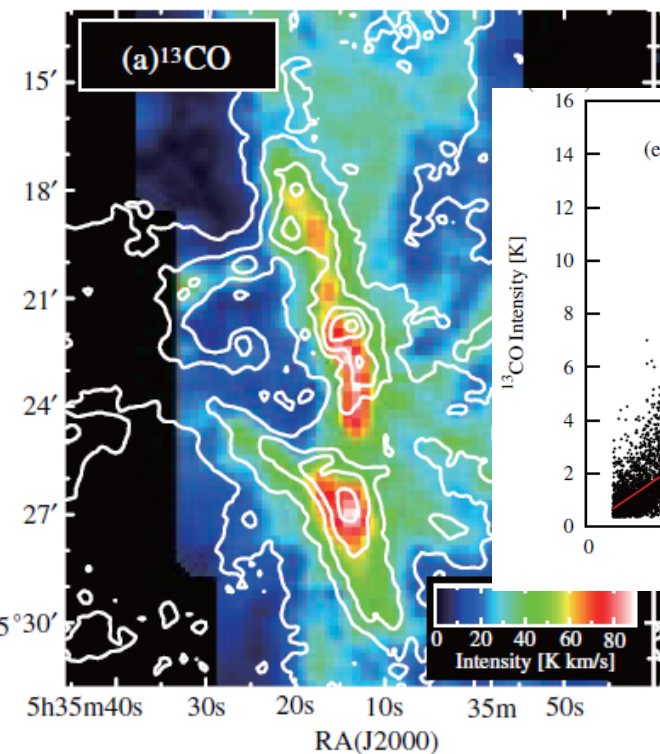


C+/C/CO layers

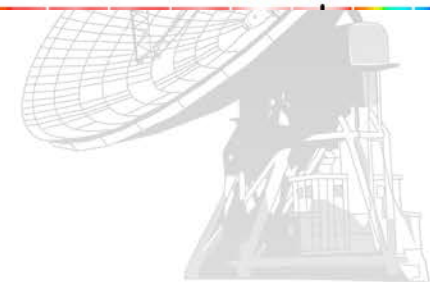
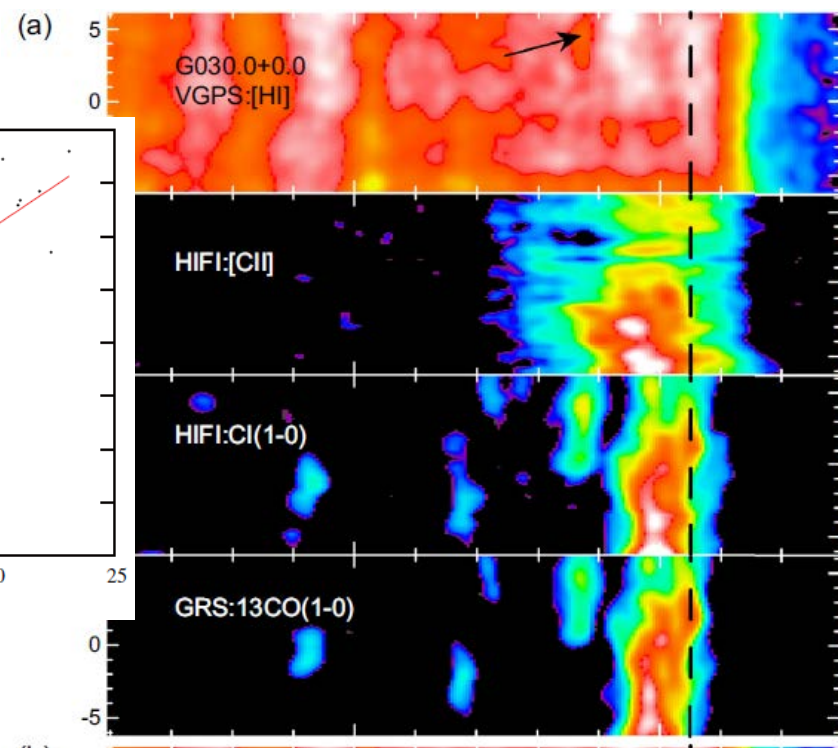


[CI] is not well understood

Shimajiri+14



Velusamy+14



Expected Results

- GMC formation through shock with [CI] as a potential C-shock tracer
 - SNR interaction with atomic cloud
 - HVC collision with GP
- GMC Evolution in terms of composition ([CI]/CO).
- Carbon in GMC, HVC, galactic fountain in outer Galaxy. NII may be also interesting.
- Implication to nearby XUV and LMC/SMC with 30m Nankyoku Telescope



Summary

- GMC evolution and star formation is a key issue in astrophysics.
- Outer galaxy is a unique and unexplored lab to study low-metalllicity clouds.
- [C I] is a potential probe to understand GMC formation and evolution.
- This study is naturally extended to LMC/SMC, dwarf galaxies, or possibly high- z galaxies.

