



NANTEN  
Submillimeter Observatory  
NANTEN

# Twenty years exploration of Chilean sky with the NANTEN telescope



Kengo Tachihara  
(Nagoya University)

# The NANTEN telescope



- 4m mm-wave telescope
- Installed @ Las Campanas observatory (alt ~ 2400 m) in 1996
- $(^{12}\text{C}^{13,18}\text{O})$  ( $J=1-0, 2-1$ ) ~ 110GHz, 230 GHz
- 2.6 arcmin (@115GHz)
- Freq. Reso. 0.1 or 0.6 km/s
- Band Width 100 or 500 km/s
- System Temp. (toward zenith) ~ 120K@110GHz, 230K@115GHz

# The NANTEN project

Chile Las Campanas, alt.2400m



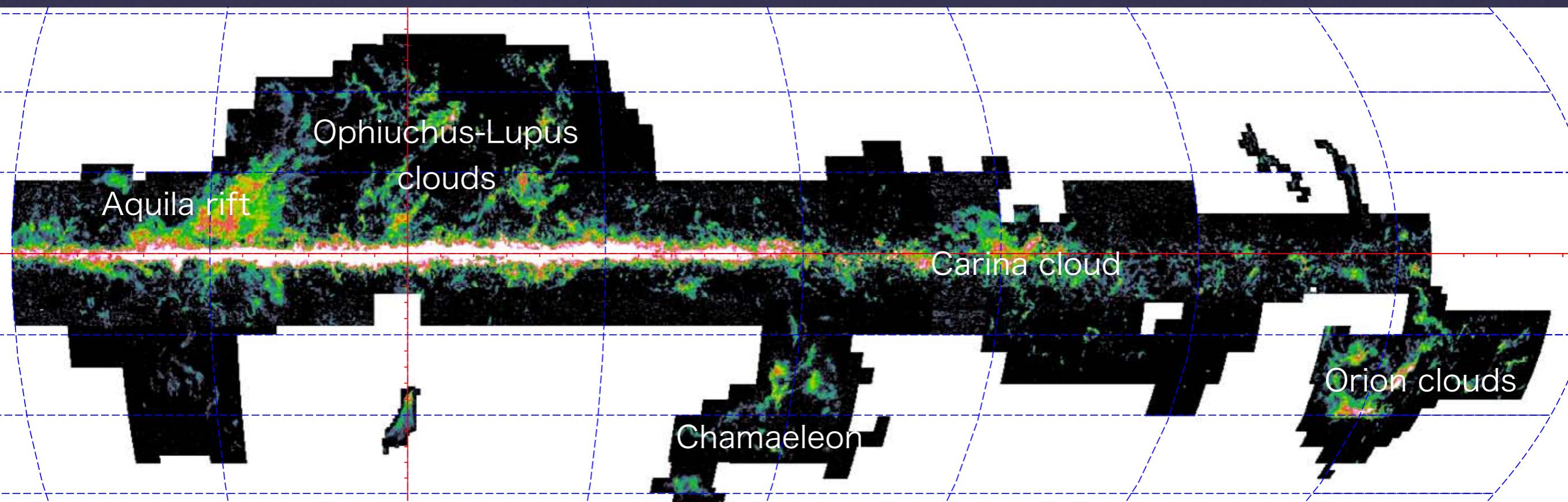
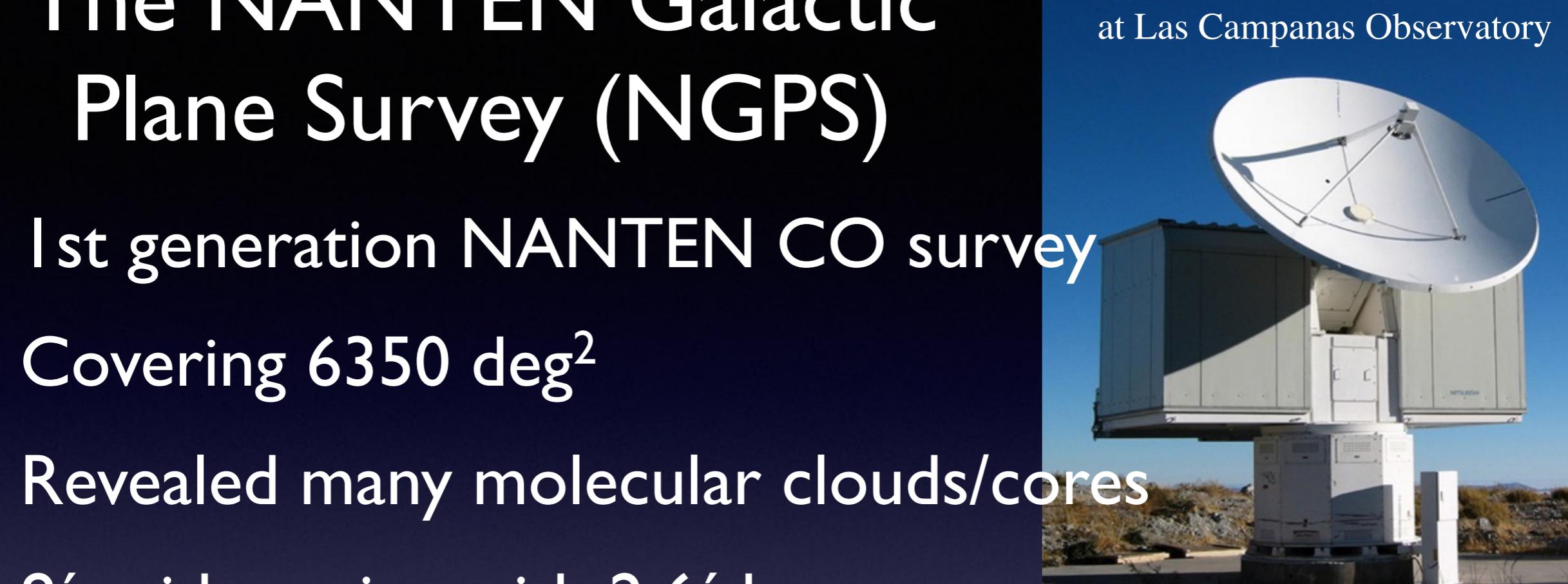
なんてん(NANTEN)  
from 1996



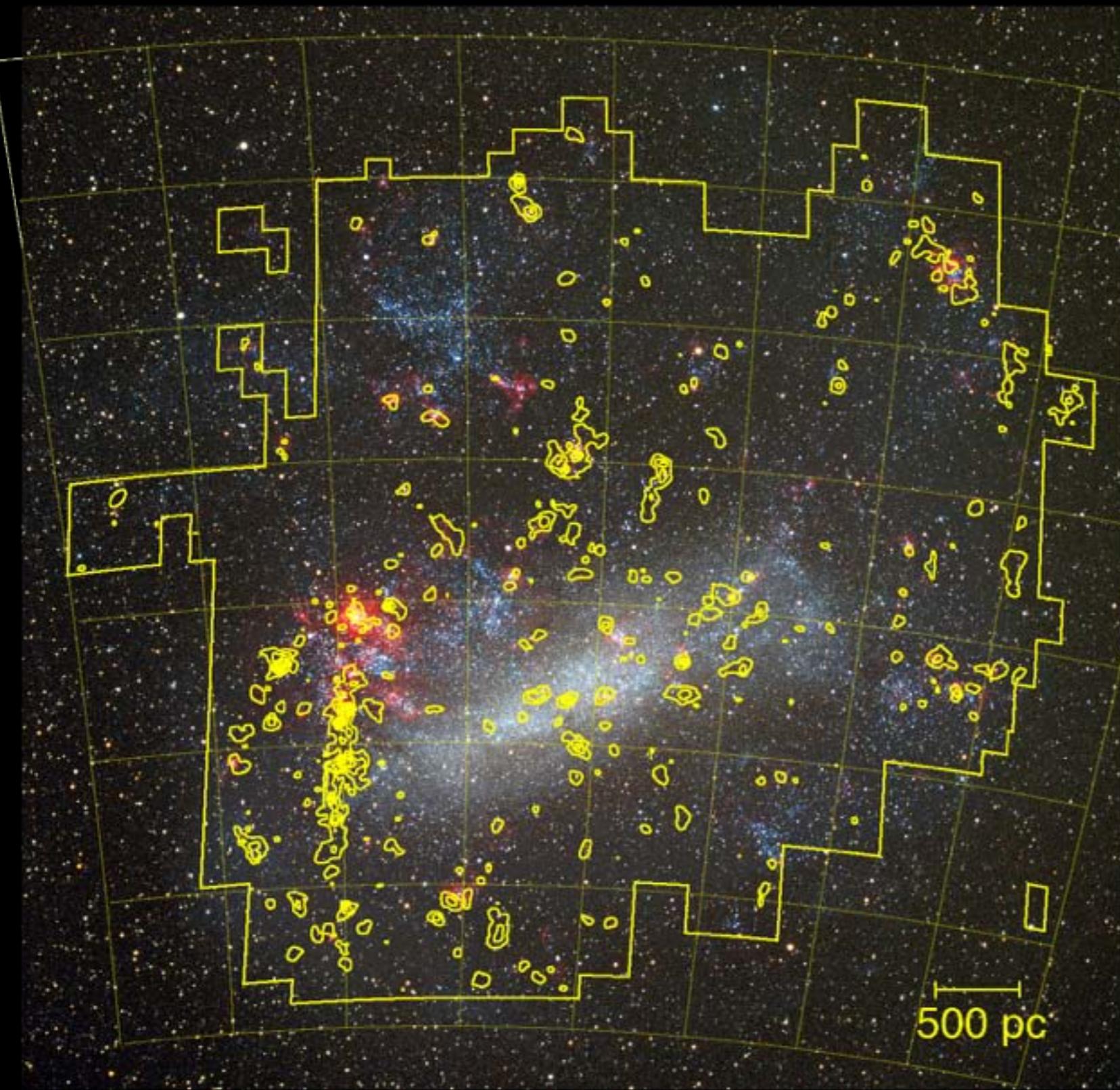
- 1996: Install at Las Campanas observatory
- 2004.8: Move to Pampa la Bola from Las Campanas observatory
- 2005.9: First light in mm
- 2007.10: Start remote observations
- 2009.4: Install of SMART submm receiver (450, 800 GHz) by Univ. of Cologne

# The NANTEN Galactic Plane Survey (NGPS)

- 1st generation NANTEN CO survey
- Covering 6350 deg<sup>2</sup>
- Revealed many molecular clouds/cores
- 8' grid spacing with 2.6' beam



# CO cloud survey in the Large Magellanic Cloud



Dwarf irregular gal with  
 $M(\text{LMC}) = 1/100 M(\text{WM})$

Face-on view (no  
contamination )

Uniform distance (48 kpc)

Low metallicity

Very active ongoing  
cluster formation



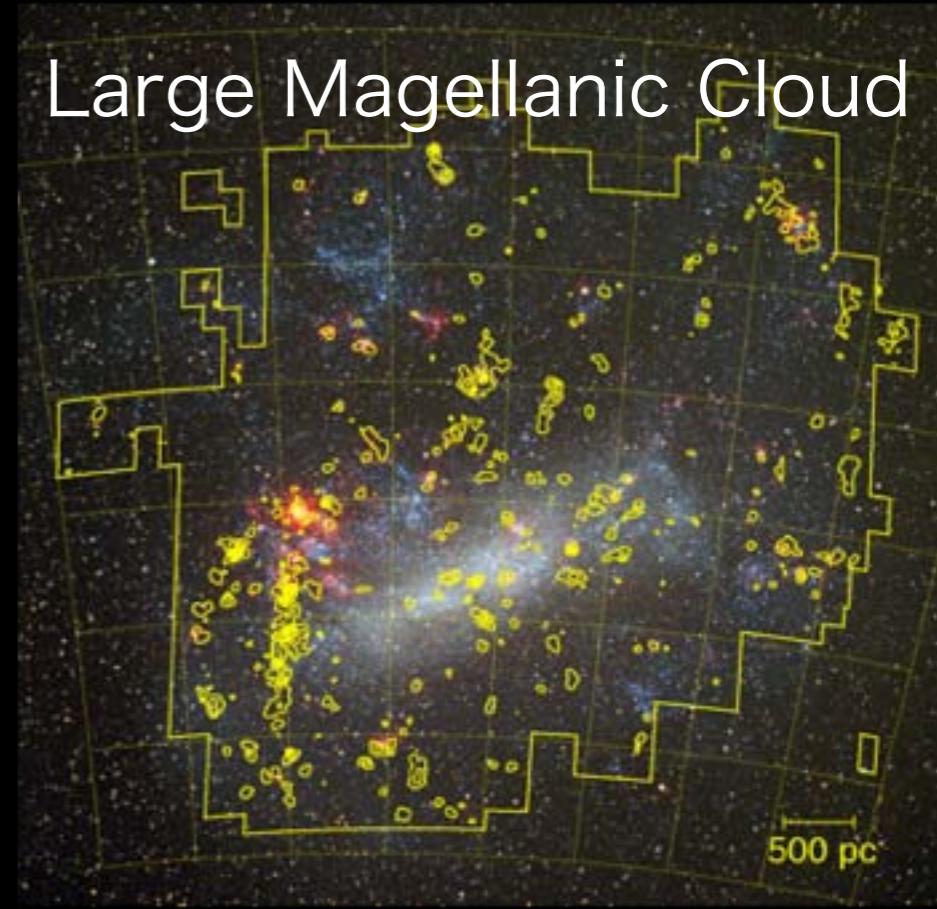
R136 cluster

# The two galaxies explored by NANTEN

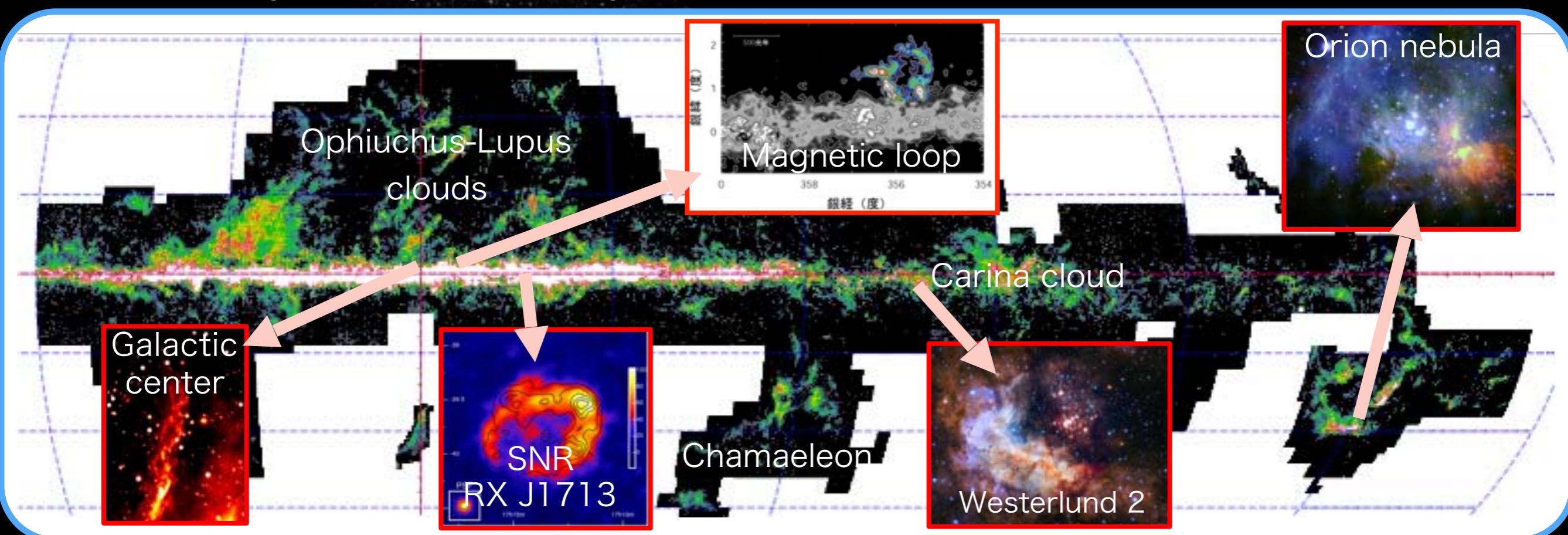
LMC : Very active star formation

vs

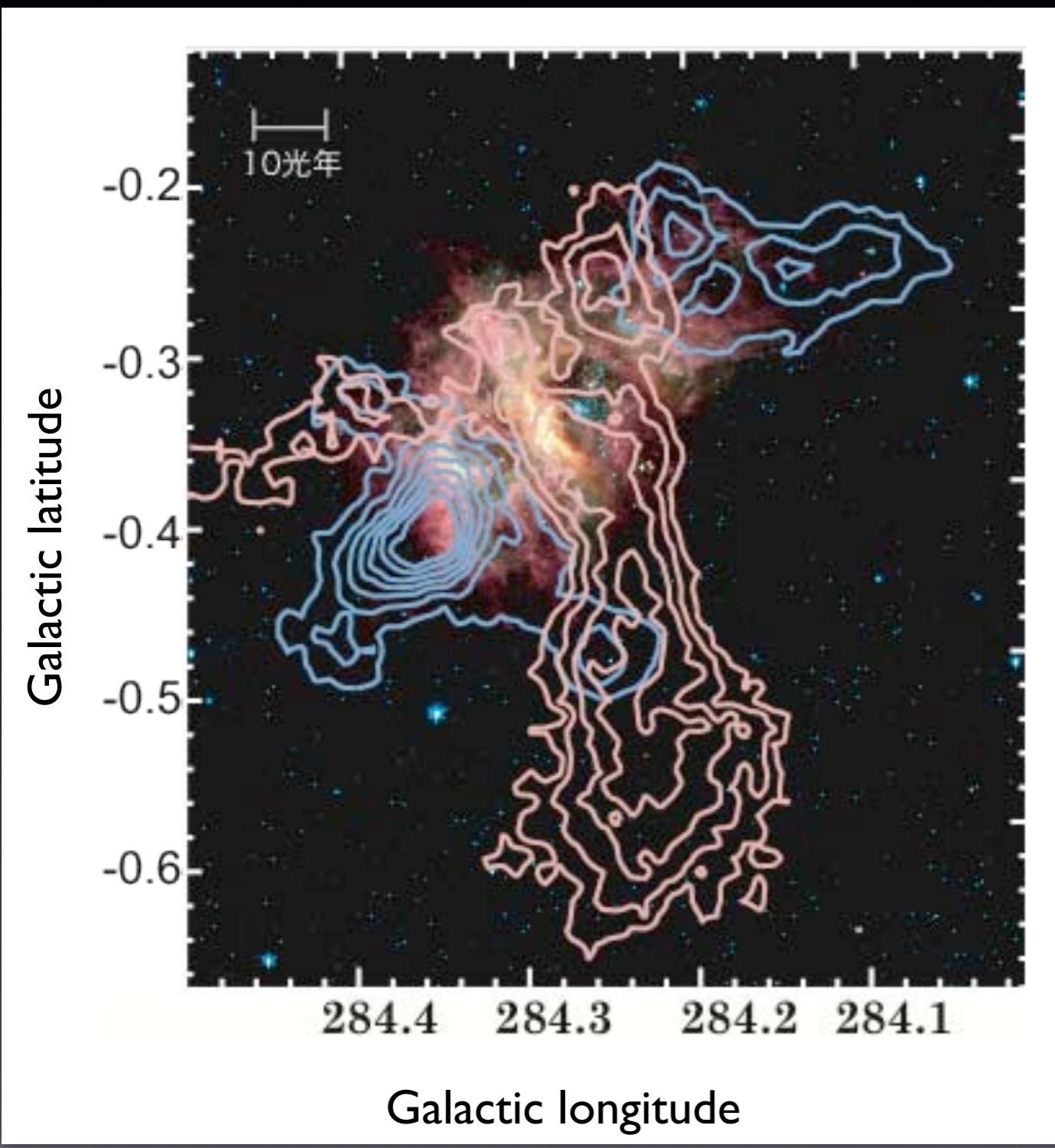
MW : Only active in the past when globular clusters were formed



The Milky Way Galaxy



# Massive cluster formation

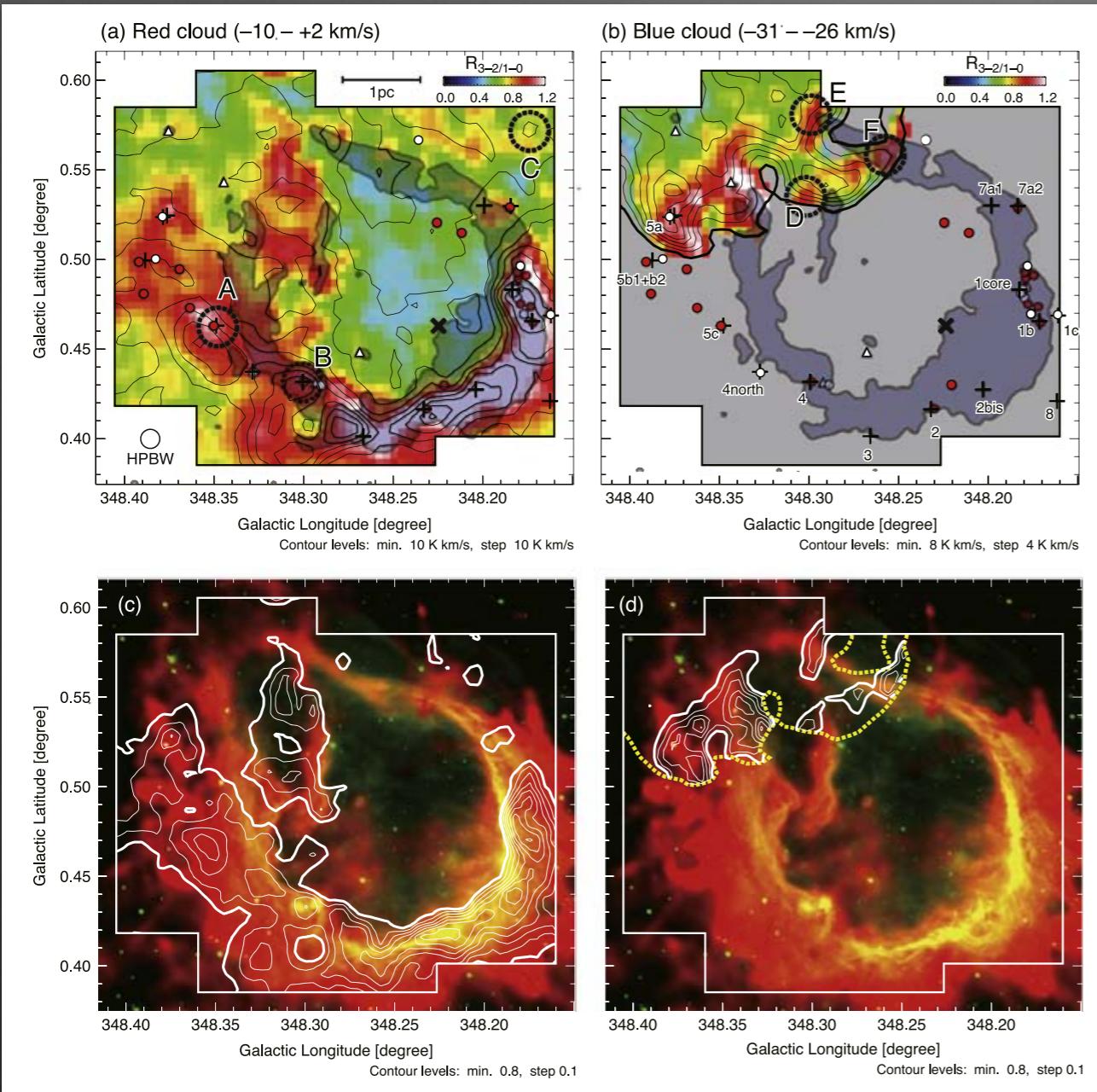


- Westerlund 2 cloud
- Clusters of  $\sim 300$  YSOs,  $5000 M_{\odot}$
- $M_{\text{cloud}} \sim 10^5 M_{\odot}$
- 2 molecular clouds with different V by  $\sim 16$  km/s
- Triggered formation by Cloud-cloud collision

(Furukawa+ 2009; Obama+ 2010)

# Spitzer bubble RCW 120

Torii et al. 2015

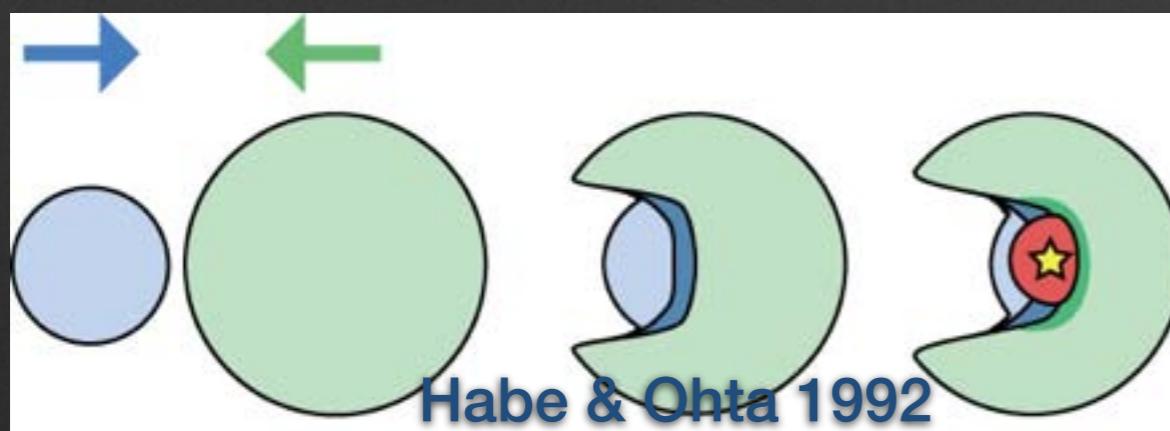


$4200 M_\odot$  red ring cloud  
+  $7500 M_\odot$  blue cloud

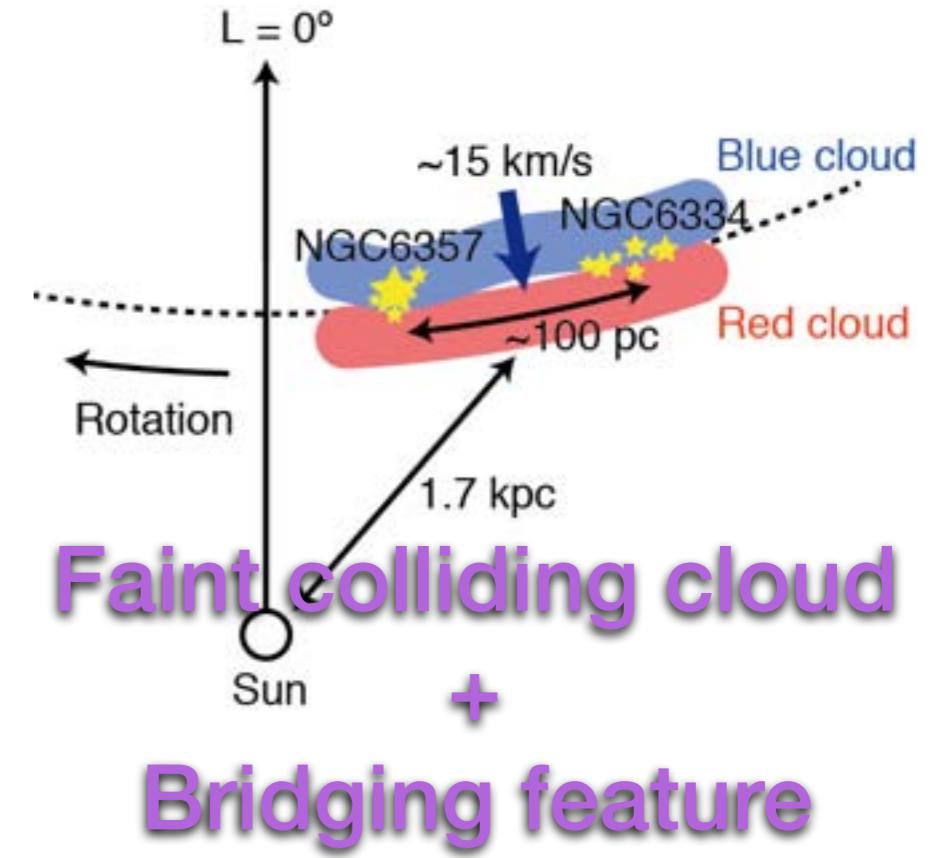
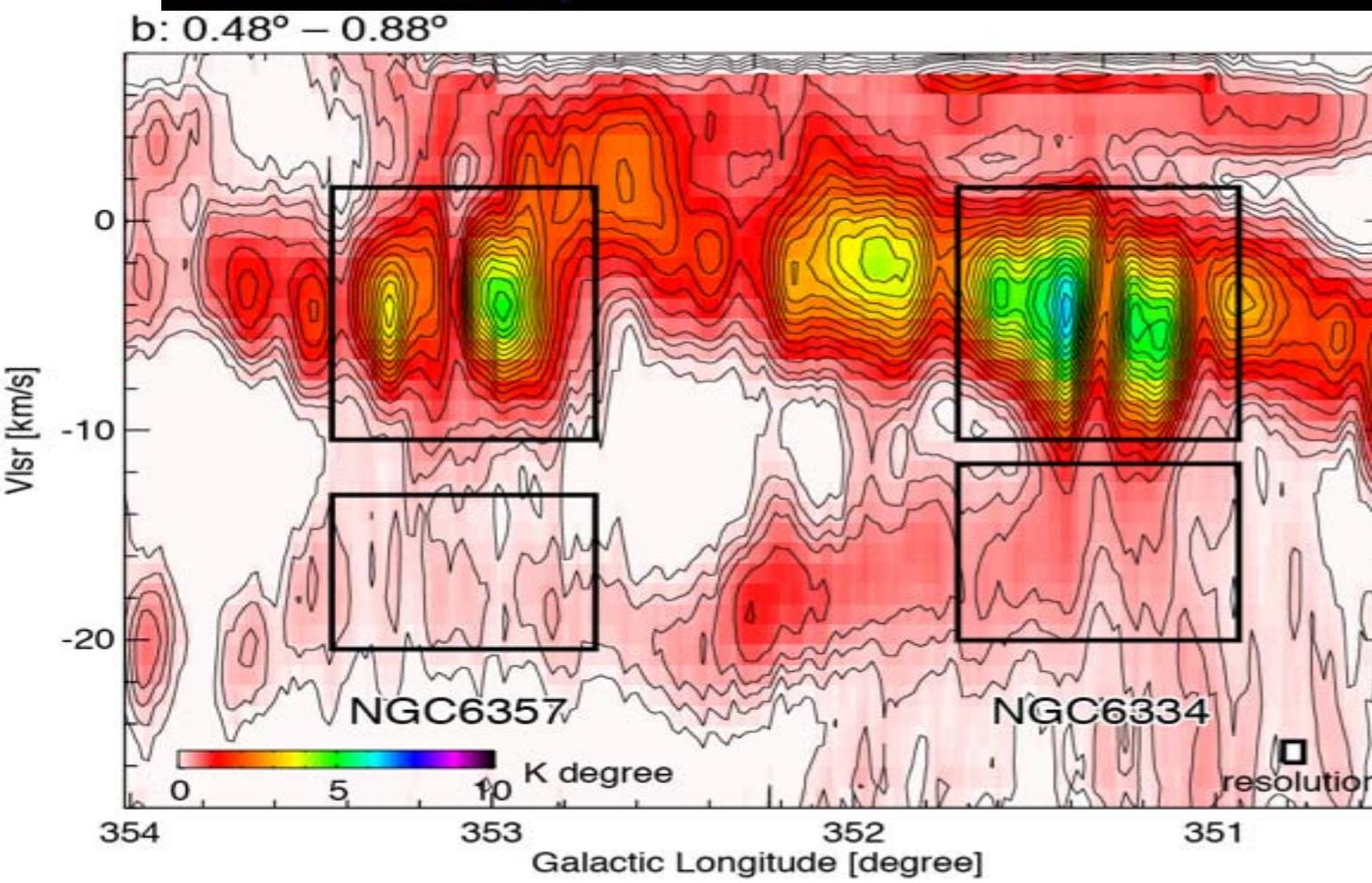
$\text{CO } R_{3-2/1-0}$   
Mopra + ASTE data

Physical association of  
the 2 clouds

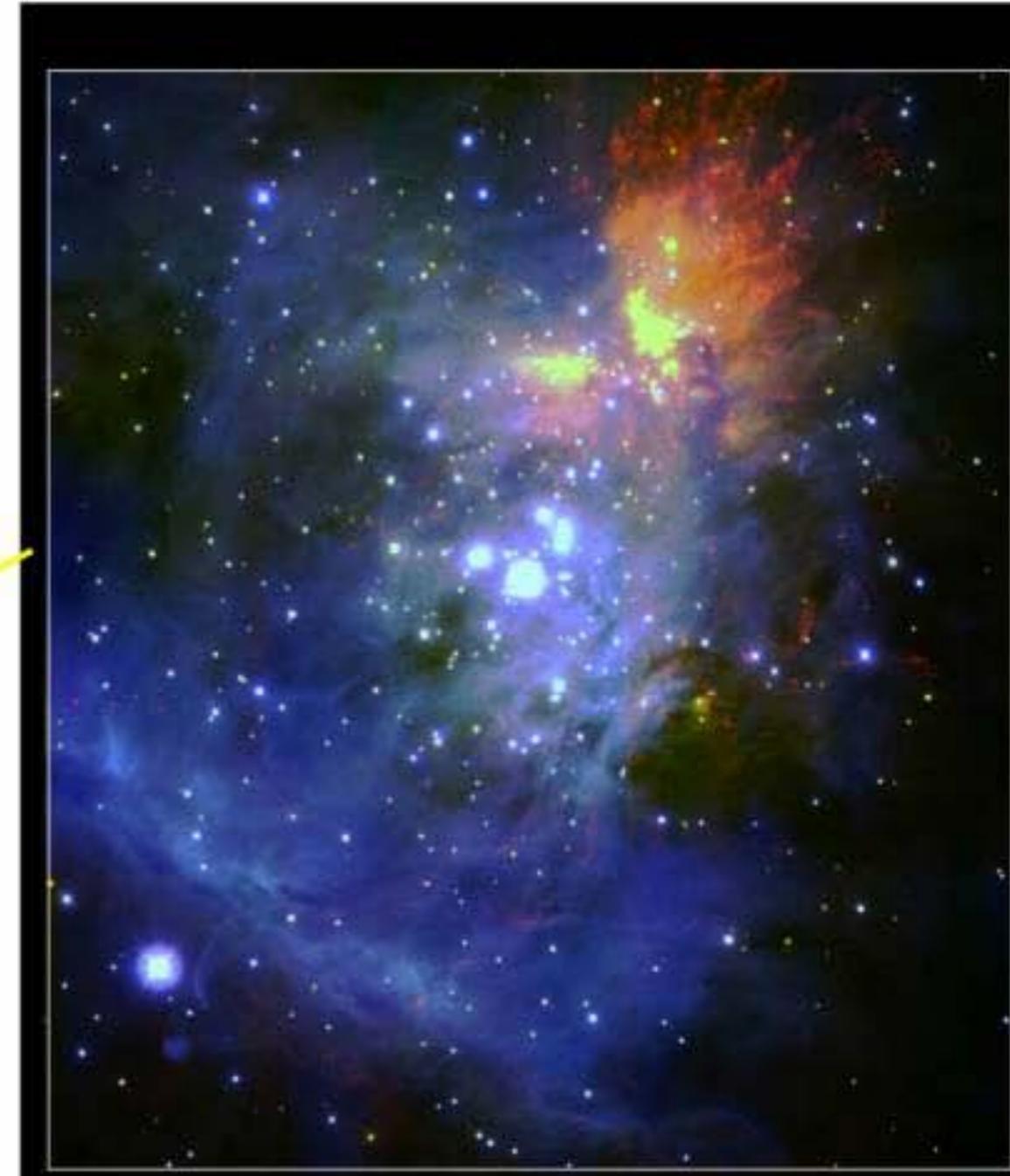
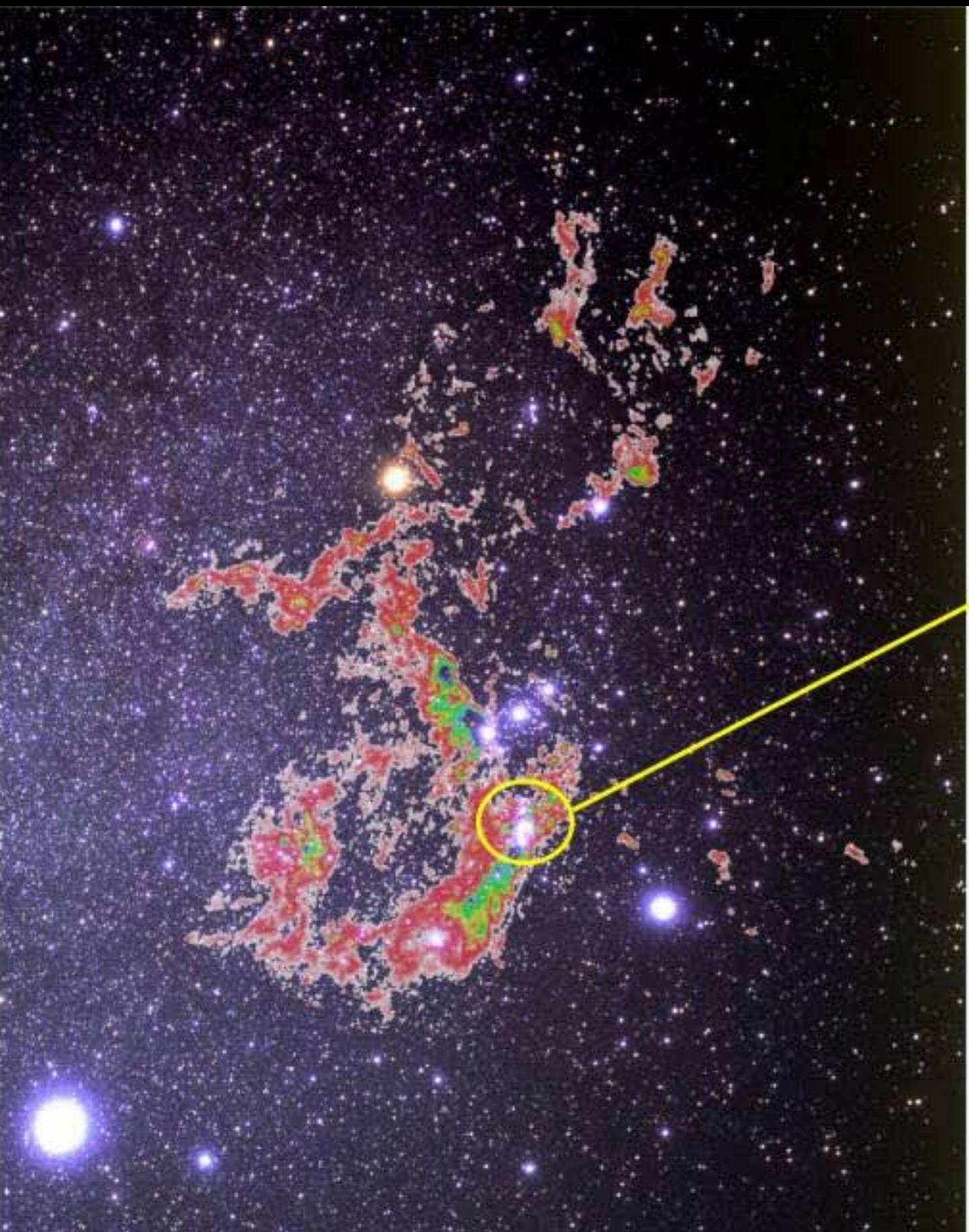
Triggered by Cloud-  
Cloud Collision



$\tau_{\text{dynamical}} \sim 0.4 \text{ Myr}$  and  
 $\dot{M} \sim 0.5 \text{e-4 } M_\odot/\text{yr}$



# The Orion cloud



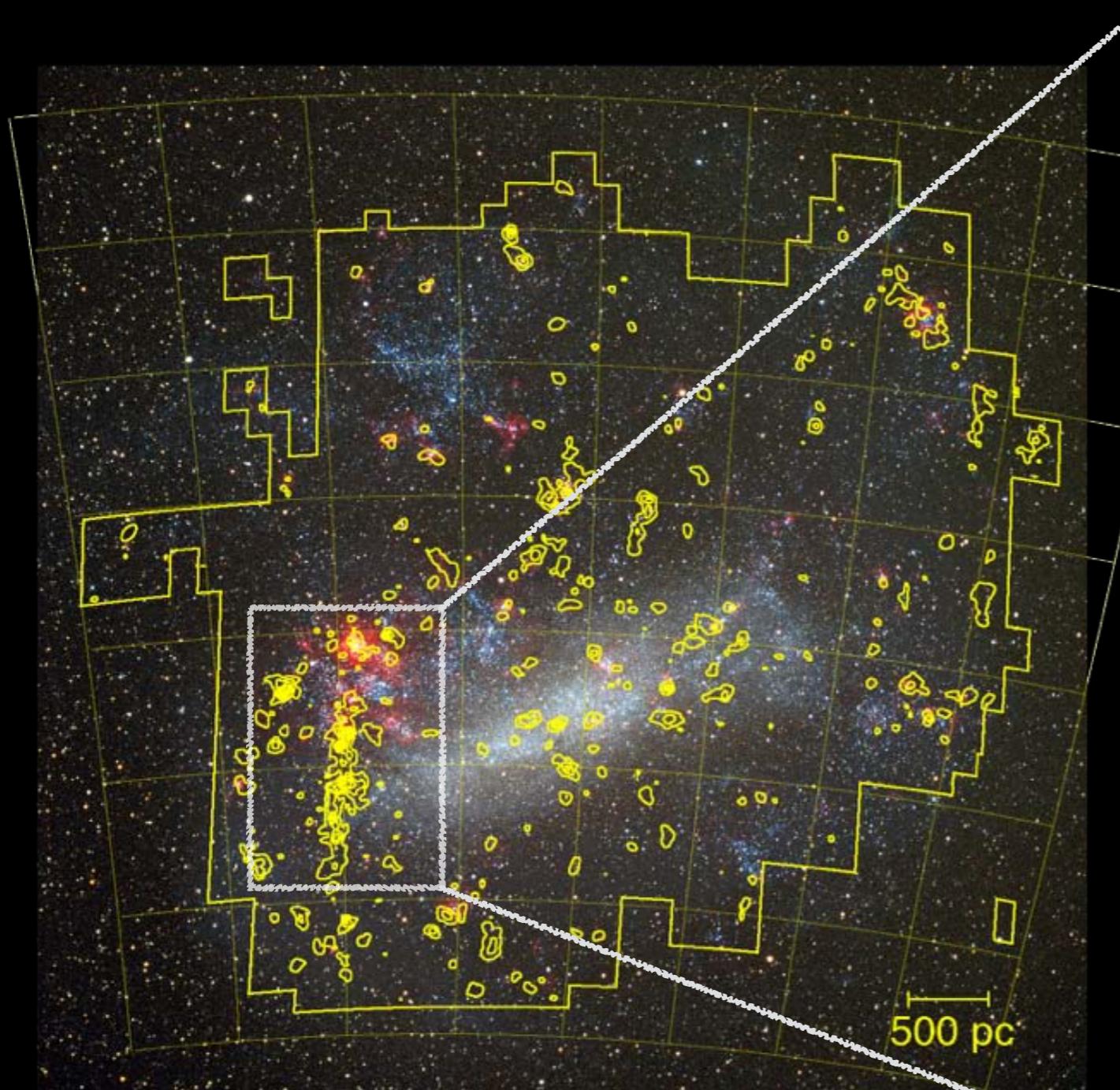
Orion Nebula

Subaru Telescope, National Astronomical Observatory of Japan

CISCO (J, K' & H<sub>α</sub> (v=1-0 S(1))

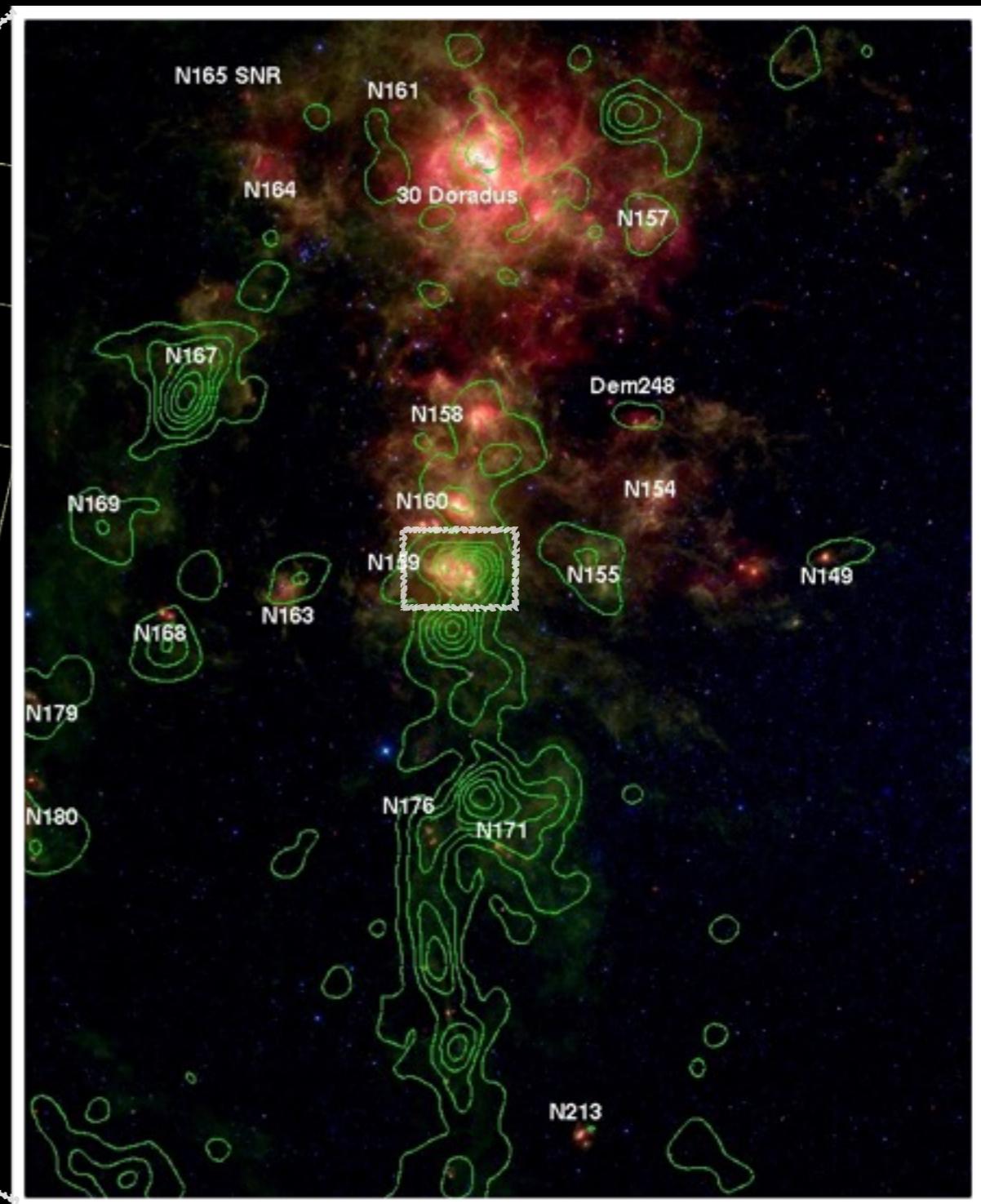
January 28, 1999

# THE MOLECULAR RIDGE OF LMC

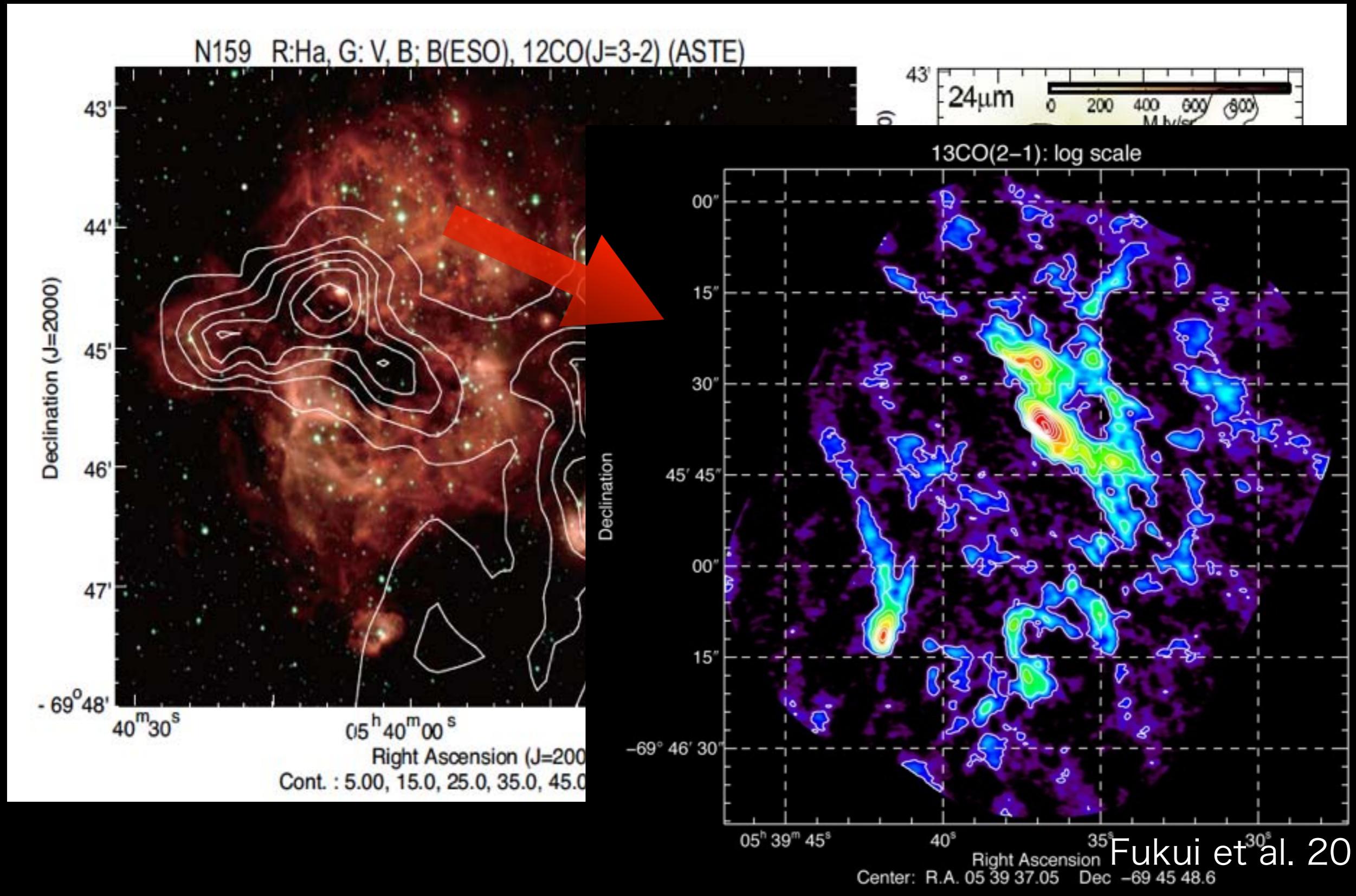


500 pc

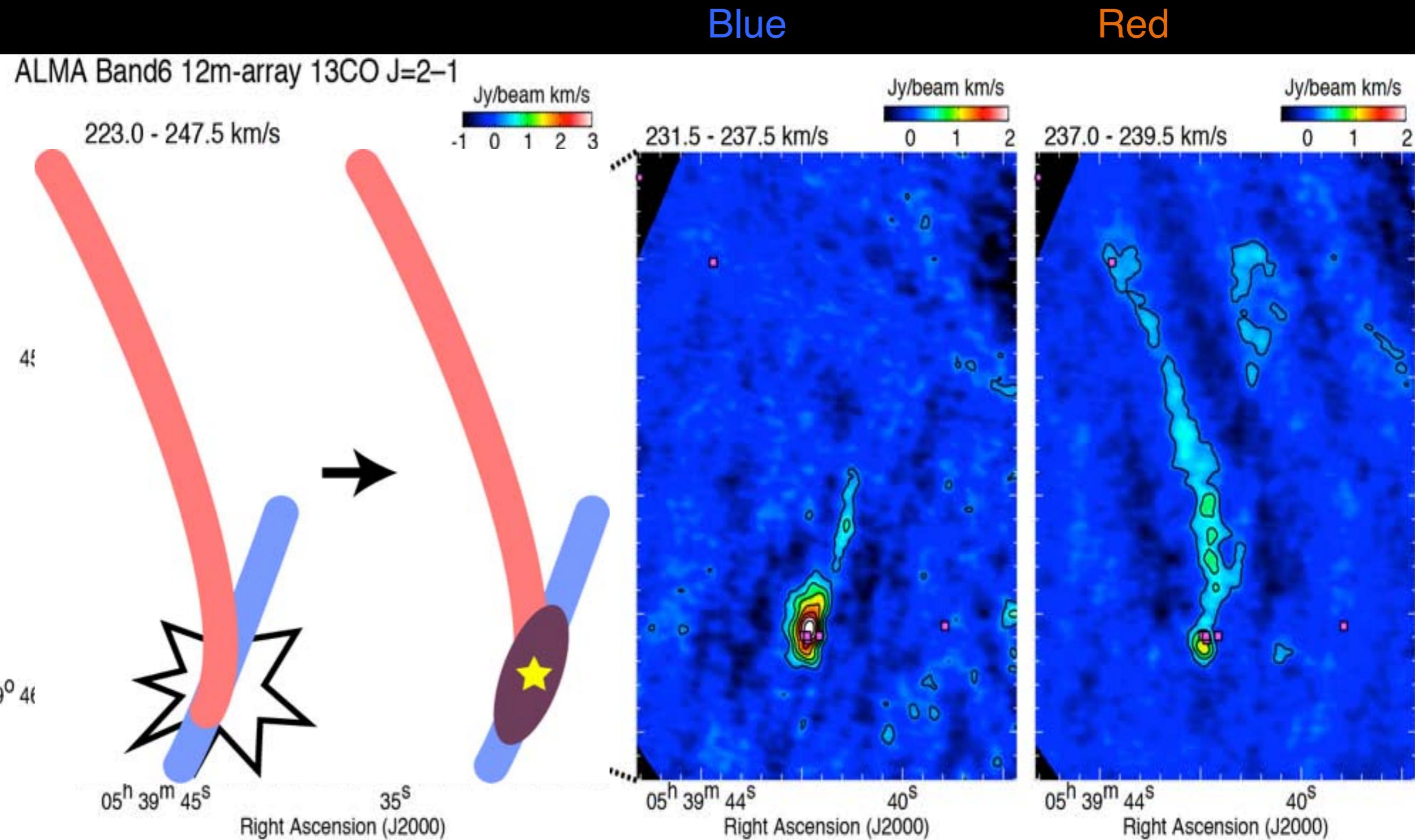
Fukui et al. 1999



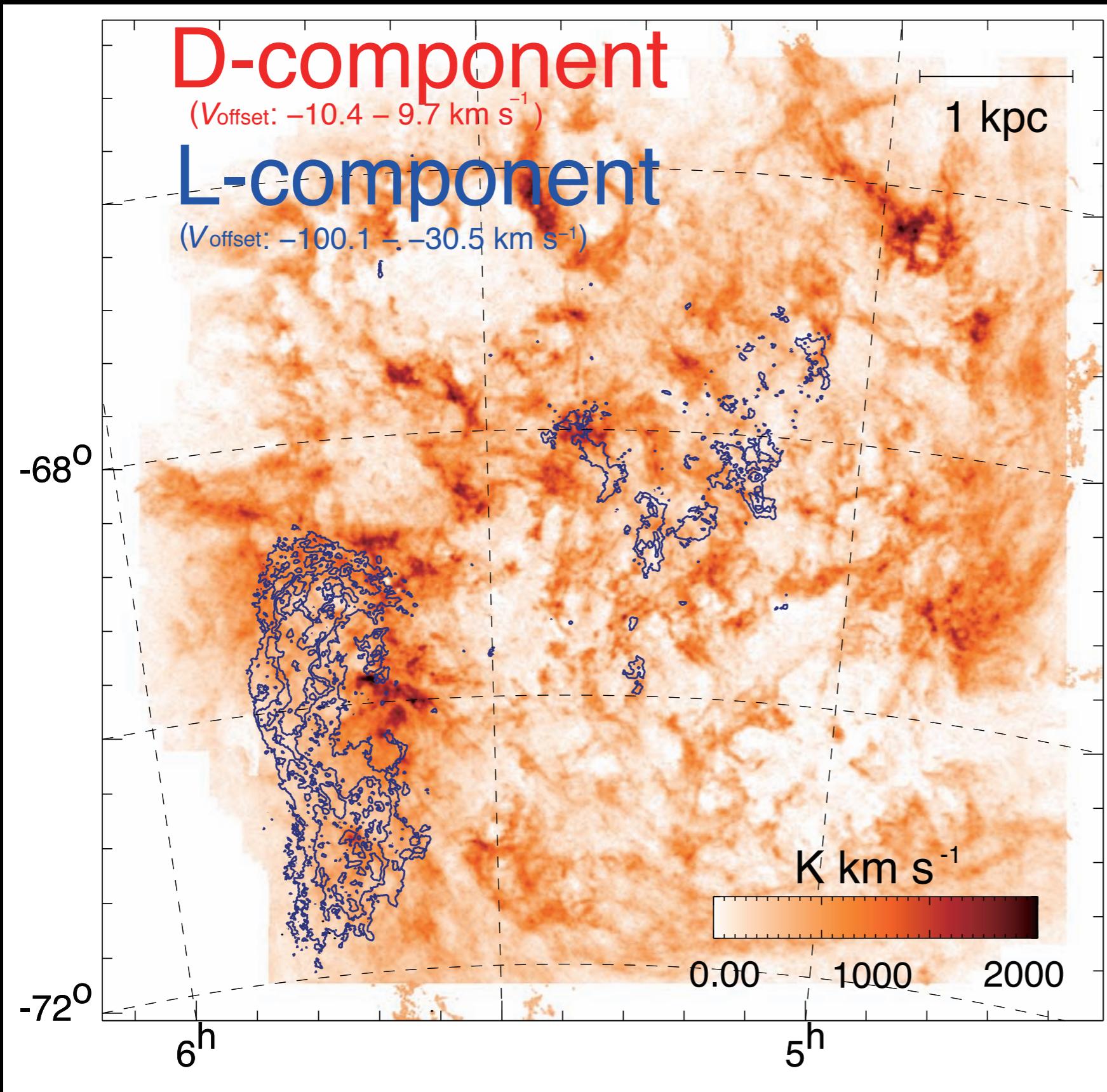
# N159 CLOUD BY ASTE AND ALMA



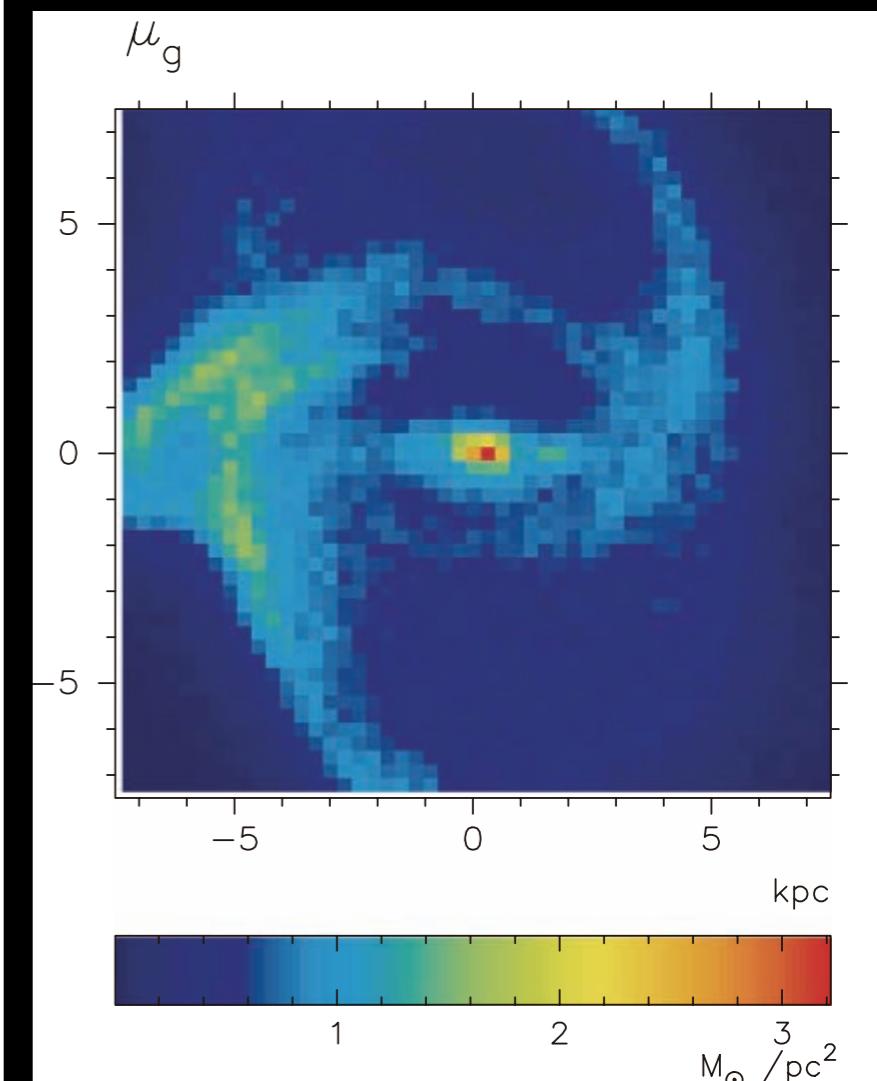
# Y-SHAPE FILAMENT



# LMC atomic H gas

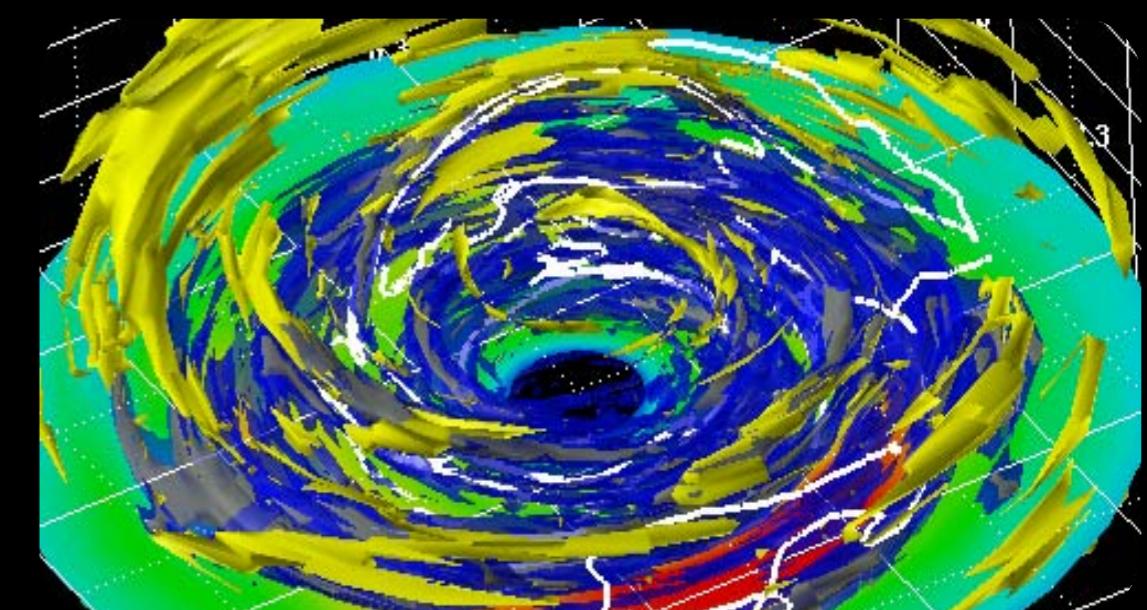
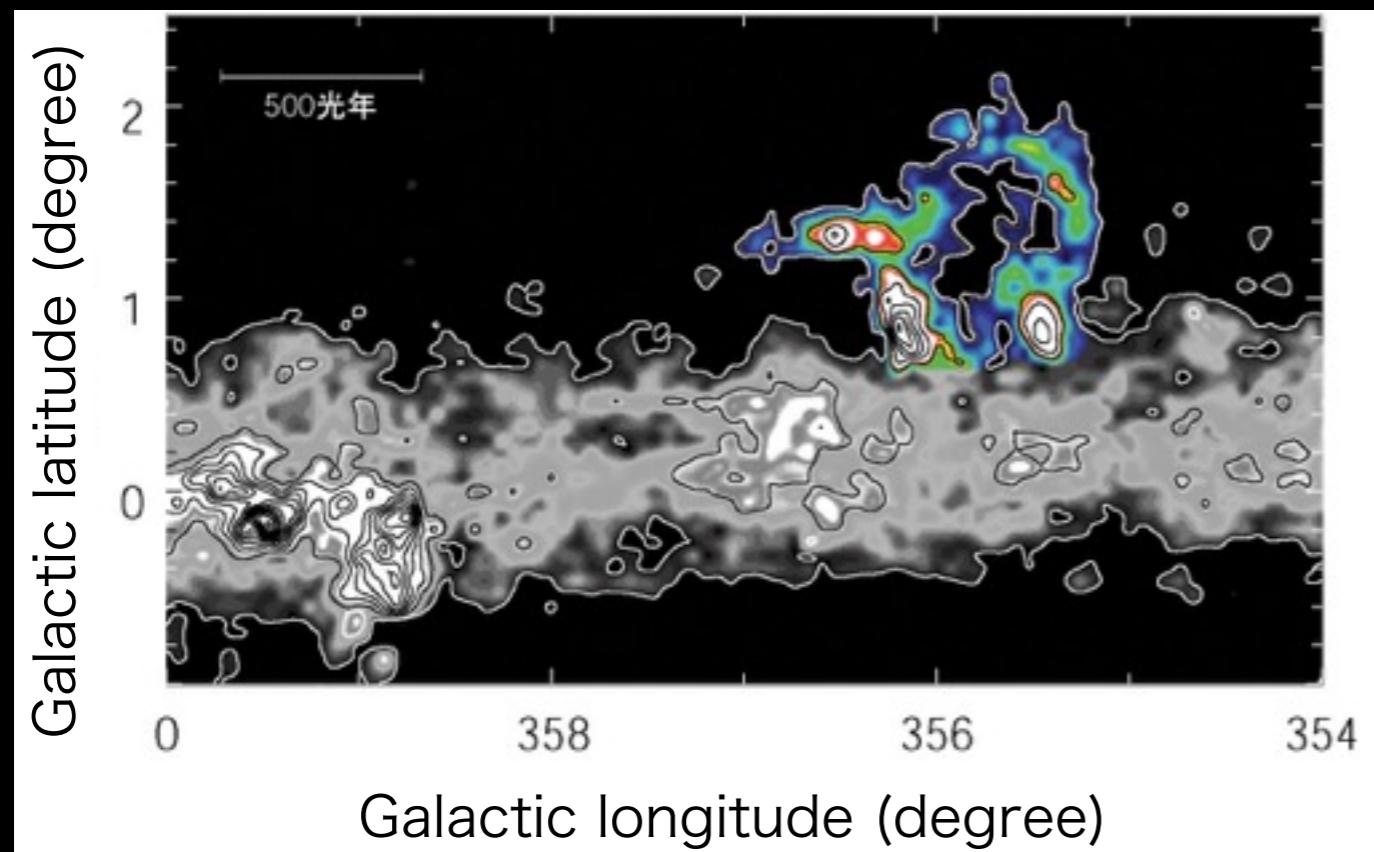


ATCA + Parkes  
Numerical Simulation  
close encounter with SMC  
0.2 Gyr ago



# Magnetic activity in the MW

- Besides the differential rotation, magnetic field works
- Magnetic floatation by the Parker instability
- Clouds are falling down onto the galactic disk
- Magneto Rotational Instability (MRI)



Magnetic loop (Fujishita et al. 2009)

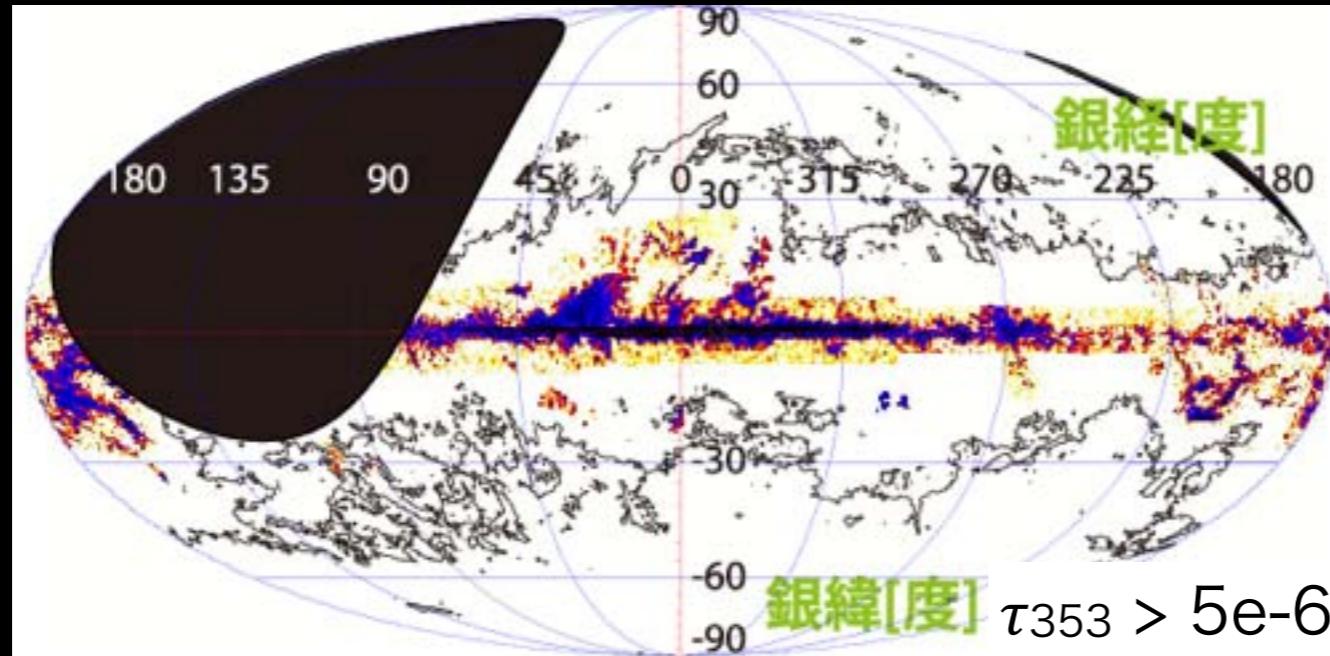
(Machida et al. 2009)

# (Tentative) Conclusions

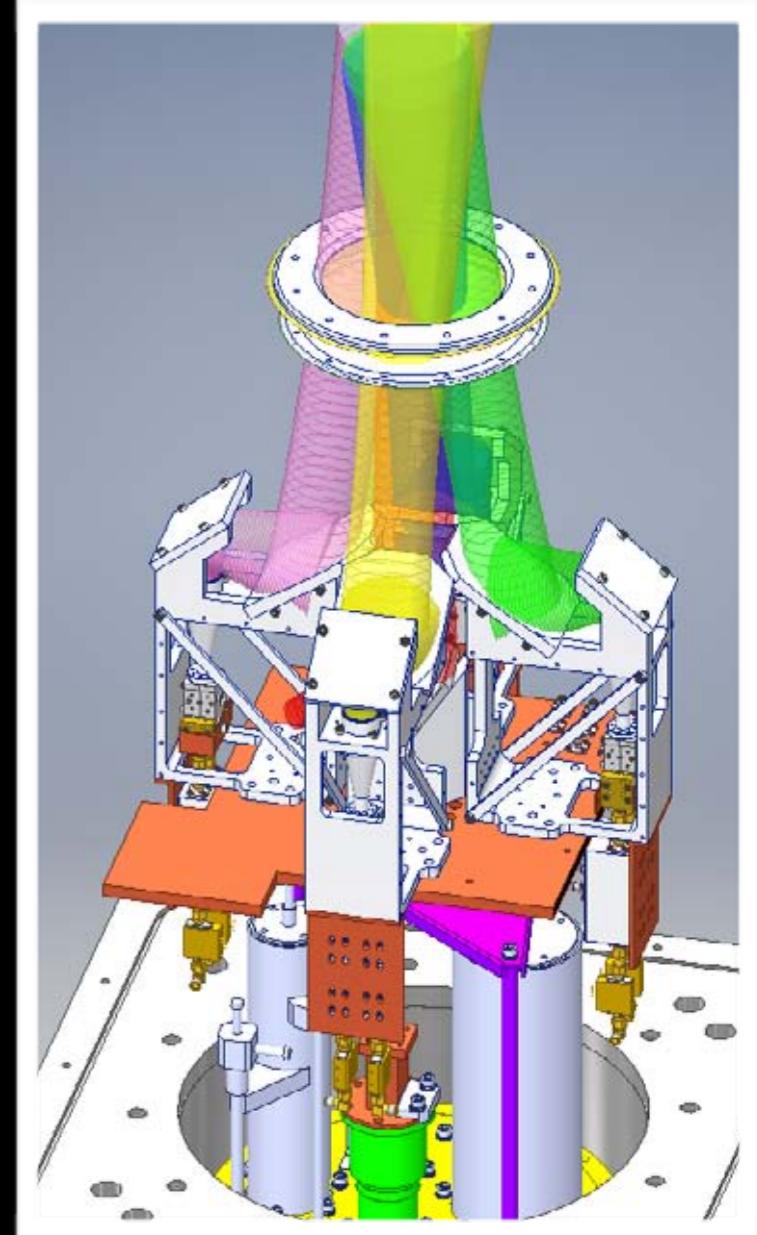
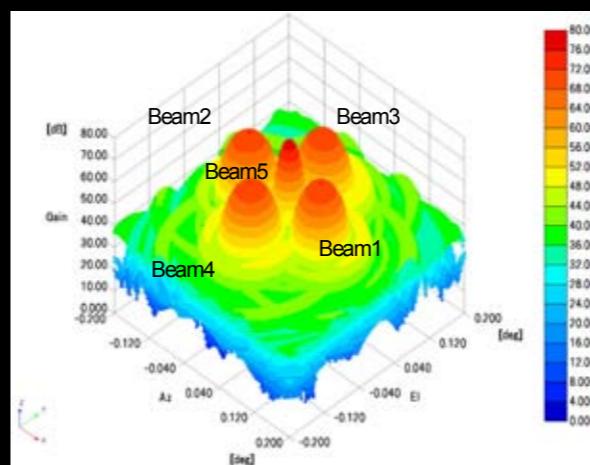
- We have explored the MW Galaxy and LMC with the NANTEN telescope for 20 years
- Molecular clouds exhibits dynamic picture of galaxies
- Galaxy evolution is driven by dynamic activity (tidal and magnetic) via cloud-cloud collisions
- MW galaxy is less, but still dynamically active

# Upgrading project of NANTEN2

## NAnten Super CO (NASCO) survey



- Cover 37% of whole sky in CO (1-0)
- Develop unique multi-beam receiver in 100 and 230 GHz with 2 pol.
- On-The-Fly mapping



The NASCO receiver  
with cold optics

	Observed area	grid (')	V reso. (km/s)	Sensitivity (K)	Points (million)
NANTEN GPS	200<L<60, IBI < 10	4-8	1.0	~0.35	1.1
NASCO	37% of sky	1	0.24	~0.8	12 (OTF)

# NASCO Galactic Plane Pilot Survey (by OTF)

