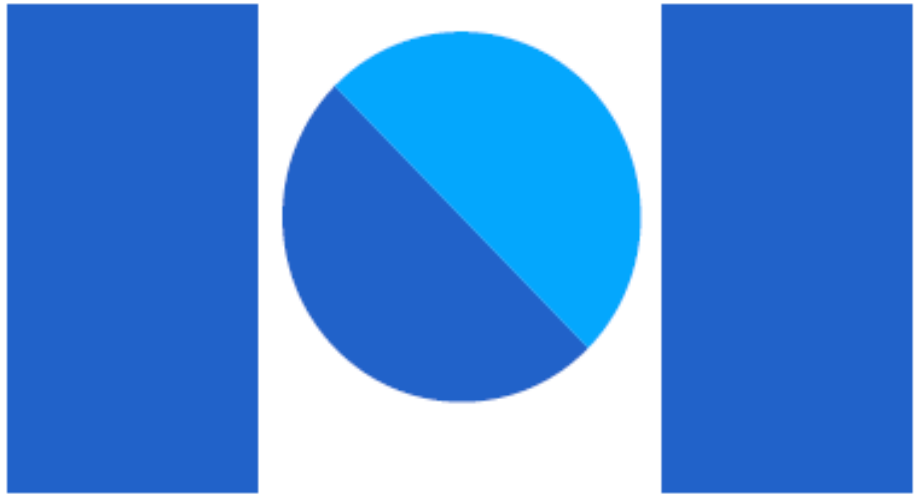
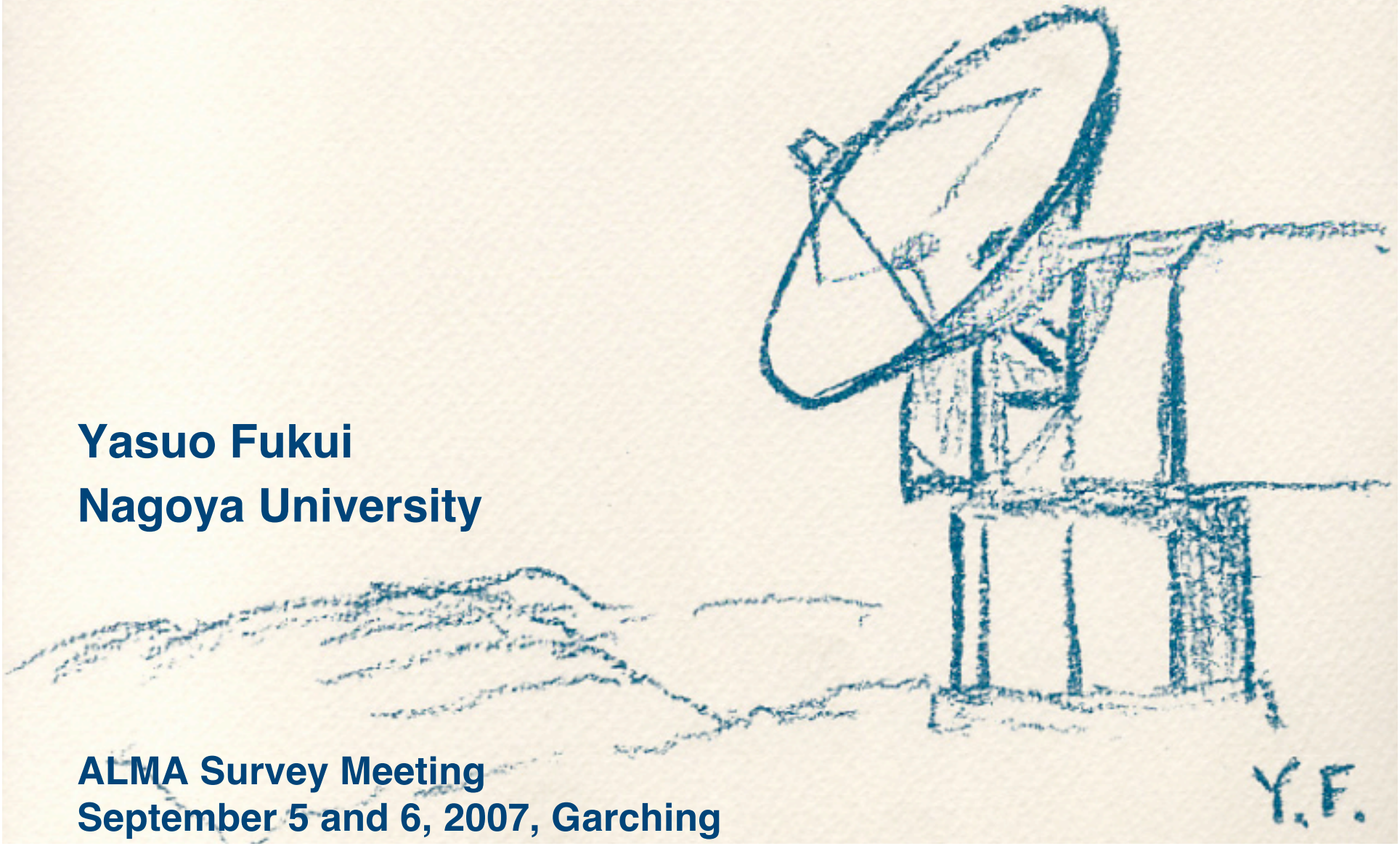


NANTEN

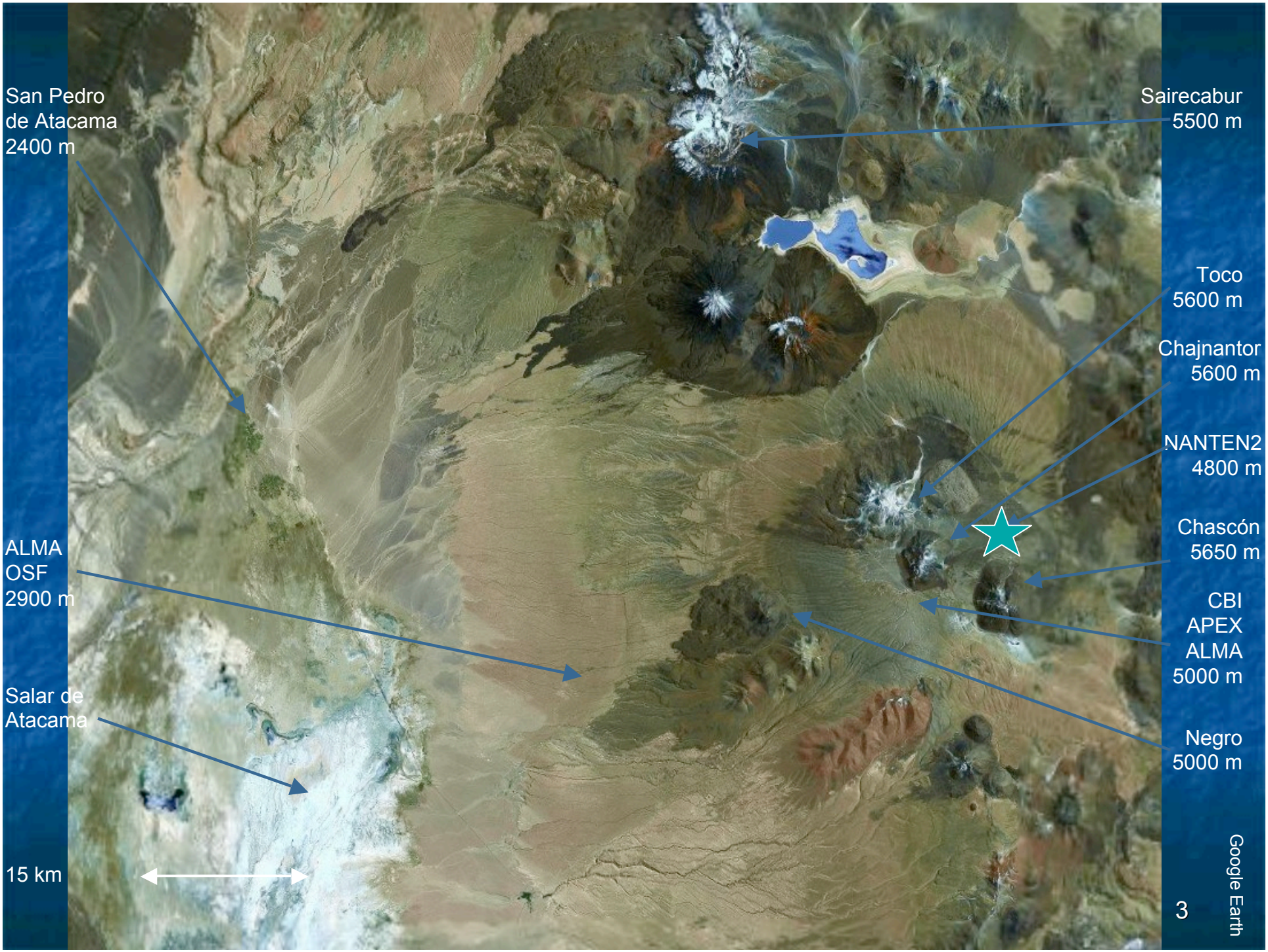
Submillimeter Observatory

NANTEN/NANTEN2 updated



Yasuo Fukui
Nagoya University

ALMA Survey Meeting
September 5 and 6, 2007, Garching


San Pedro
de Atacama
2400 m
Sairecabur
5500 m
Toco
5600 m
Chajnantor
5600 m
NANTEN2
4800 m
Chascón
5650 m
CBI
APEX
ALMA
5000 m
Negro
5000 m
ALMA
OSF
2900 m
Salar de
Atacama
15 km
Google Earth
3

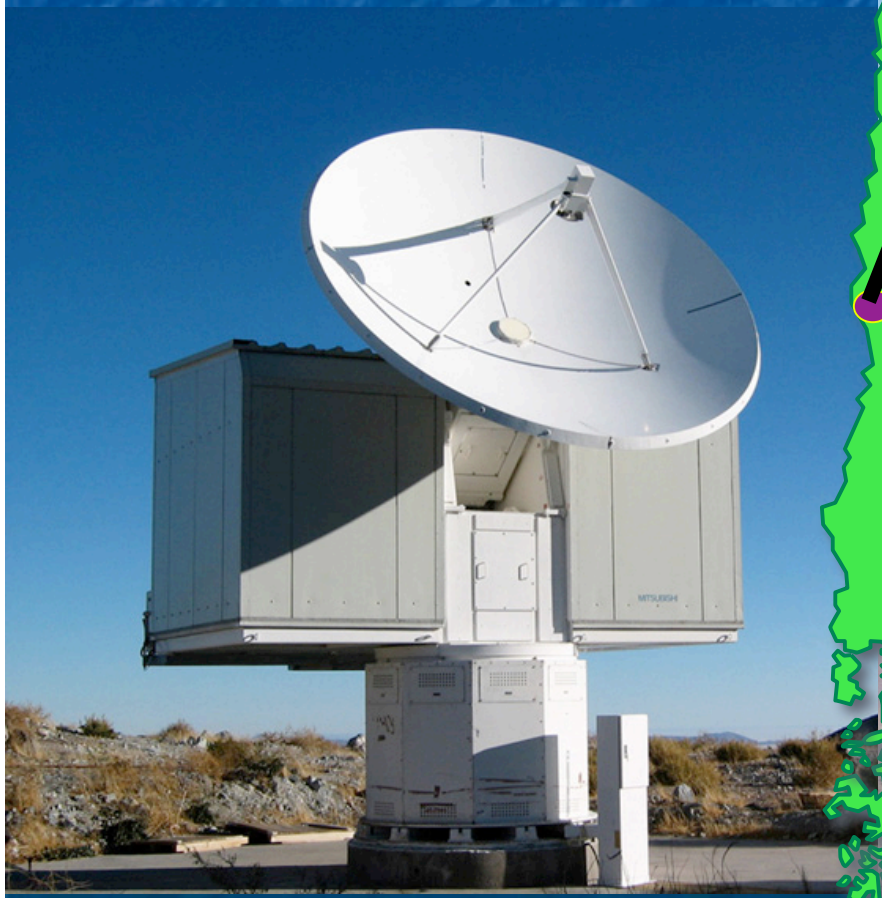
Collaborators

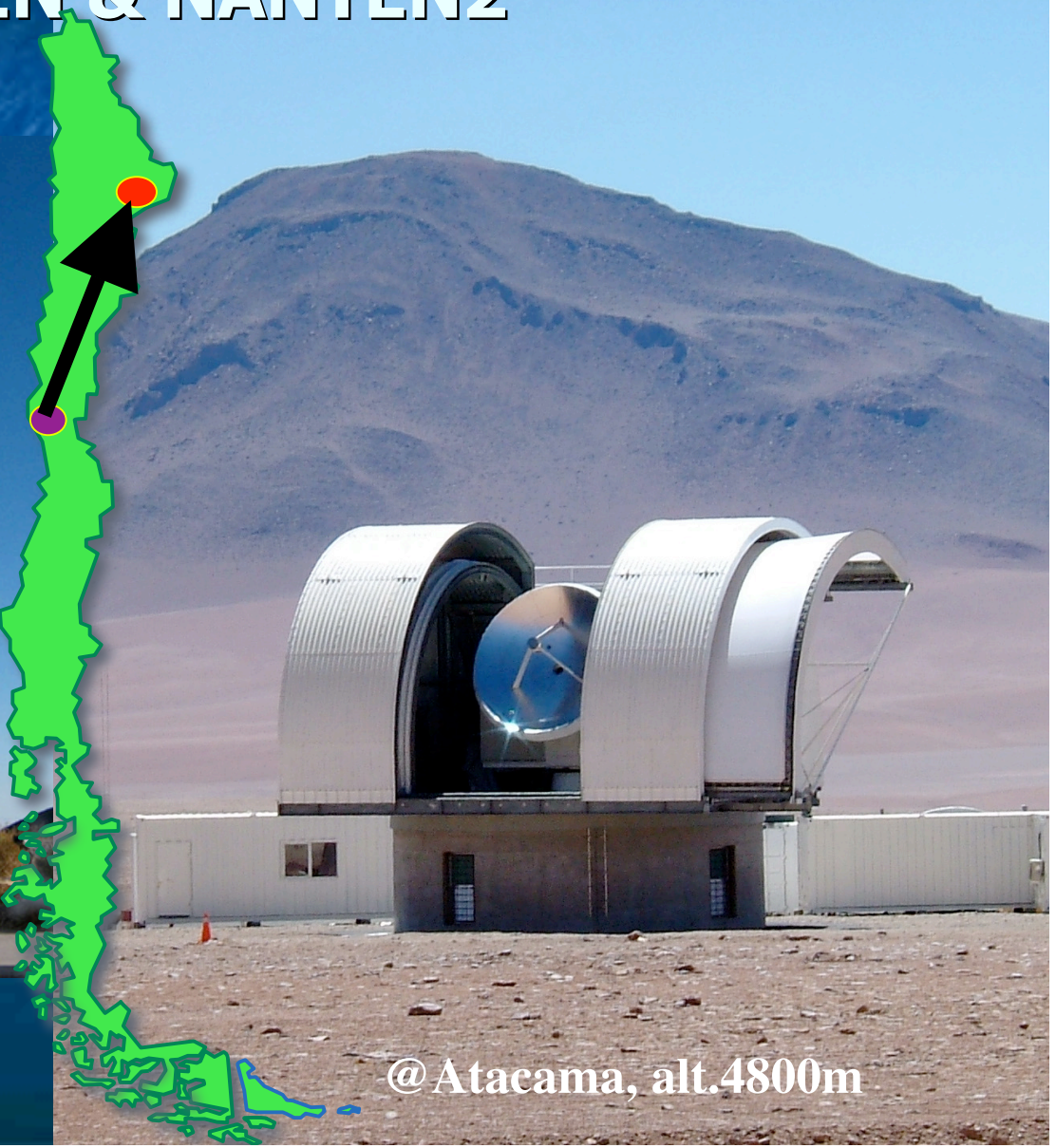
Nagoya University
Osaka Prefecture University
Universität zu Köln
Universität Bonn

Seoul National University
Universidad de Chile
University of New South Wales
Sydney University
Macquarie University

Swiss Federal Institute of Technology Zurich

NANTEN & NANTEN2





@Las Campanas, alt.2400m

@Atacama, alt.4800m

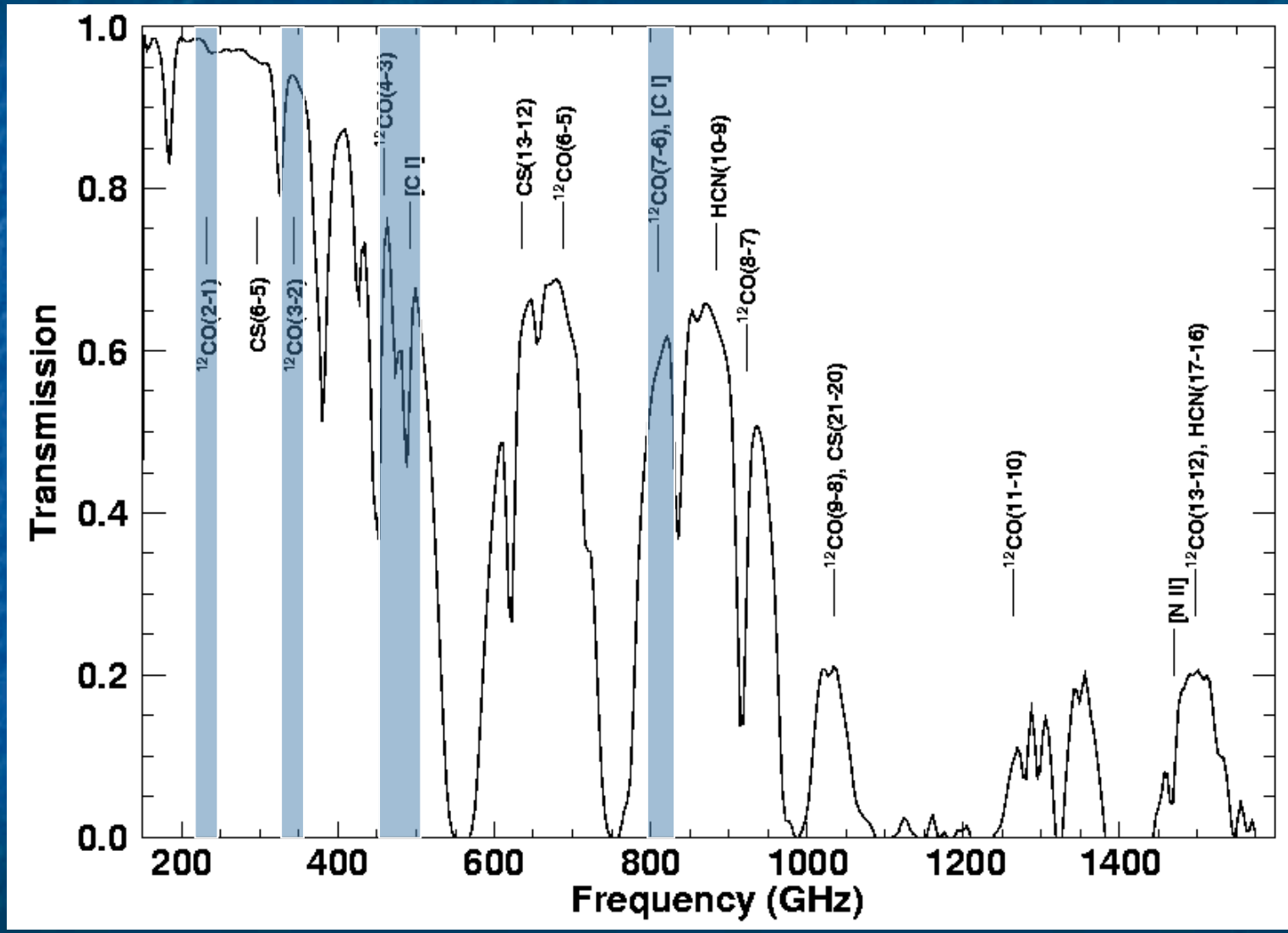
NANTEN2 Submillimeter Observatory

Since 2006

Frequency: 230, 490, 810GHz
CO(2-1, 4-3, 7-6), CI(1-0, 2-1)
Beam size 38" (460GHz)-27"(806GHz)
SMART 16 beam receiver at 500/800GHz

Beam efficiency
50% (460 GHz)–45% (806 GHz)
Position Switching or On The Fly

NANTEN2 bands



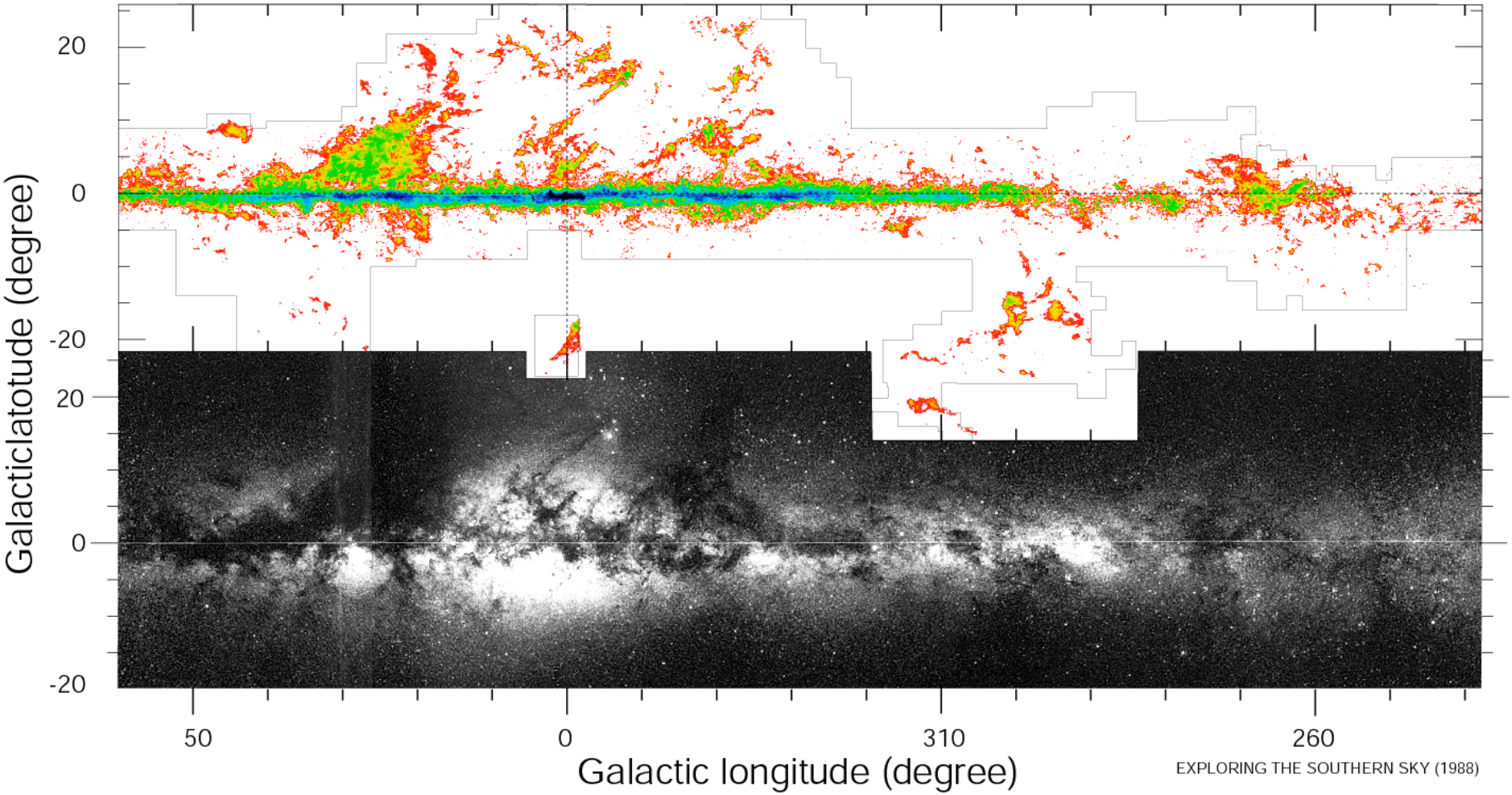
Matsushita et al.

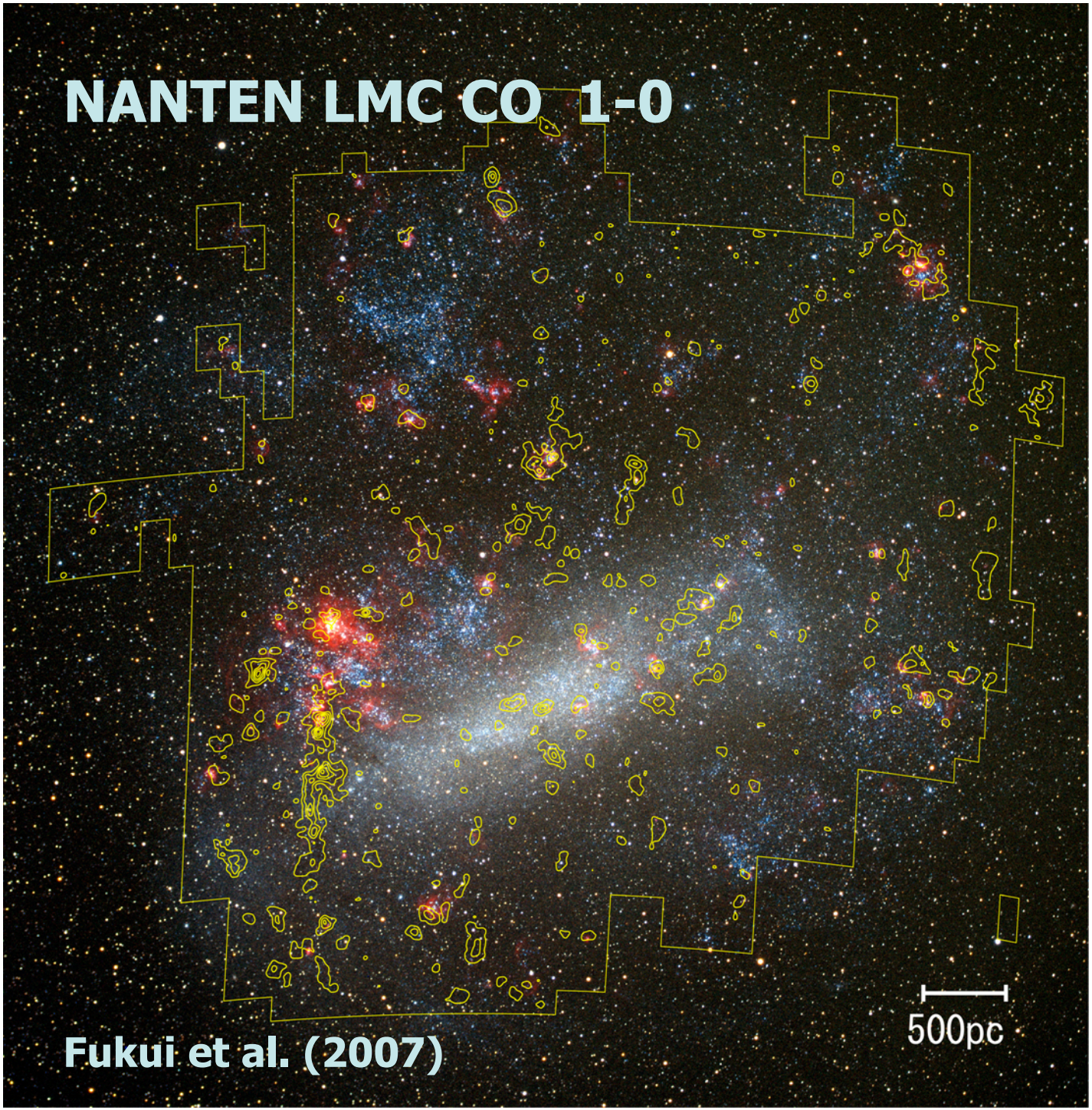
NANTEN Science
10 degree scale survey of molecular clouds, focusing the spots, contribute to ALMA science

- Magellanic Clouds (LMC, SMC and Bridge)
- Galactic Plane Survey in Southern Sky
- Galactic Center (Molecular loops)
- High-mass star forming region
  Carina, Centaurus, Orion, Bright-Rimmed Clouds
- Low-mass star forming region (Dense cores)
  Ophuichus, Lupus, Chamaeleon, Pipe Nebula
- High-Latitude Molecular Clouds
  Aquila, Infrared-Excess Cloud, High-Latitude
- SNRs and Supershells and CO jet
  TeV gamma SNR, Vela, Gum Nebula, Carina Flare Survey, SS433

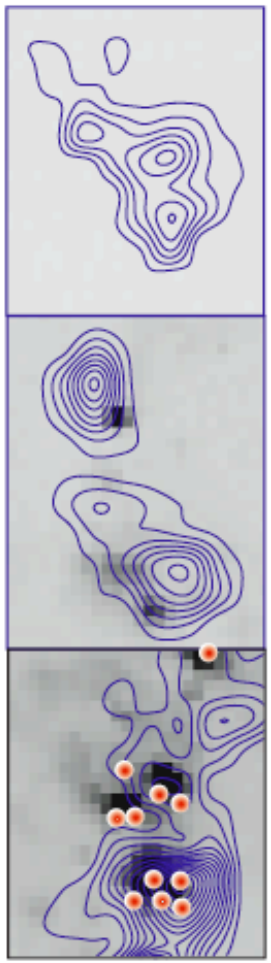
NANTEN Galactic Plane CO survey

^{12}CO(J=1–0),
Grid size ~ 4′ (|b| < 5°), 8′ (5° < |b| <10°), 2.’7 beam,
Integ. time (typ) ~ 5sec/point, ~1,000,000 observed points




NANTEN LMC CO 1-0
Fukui et al. (2007)
500pc

GMC TYPES and CLUSTER FORMATION in LMC



150 pc

Starless GMC
44 clouds (26 %)

Without O stars

Type I ~ 7 Myr

Only HII regions
88 clouds (51%)

Type II ~ 14 Myr

Clusters and HII regions
39 clouds (23 %)
associated with 82 clusters

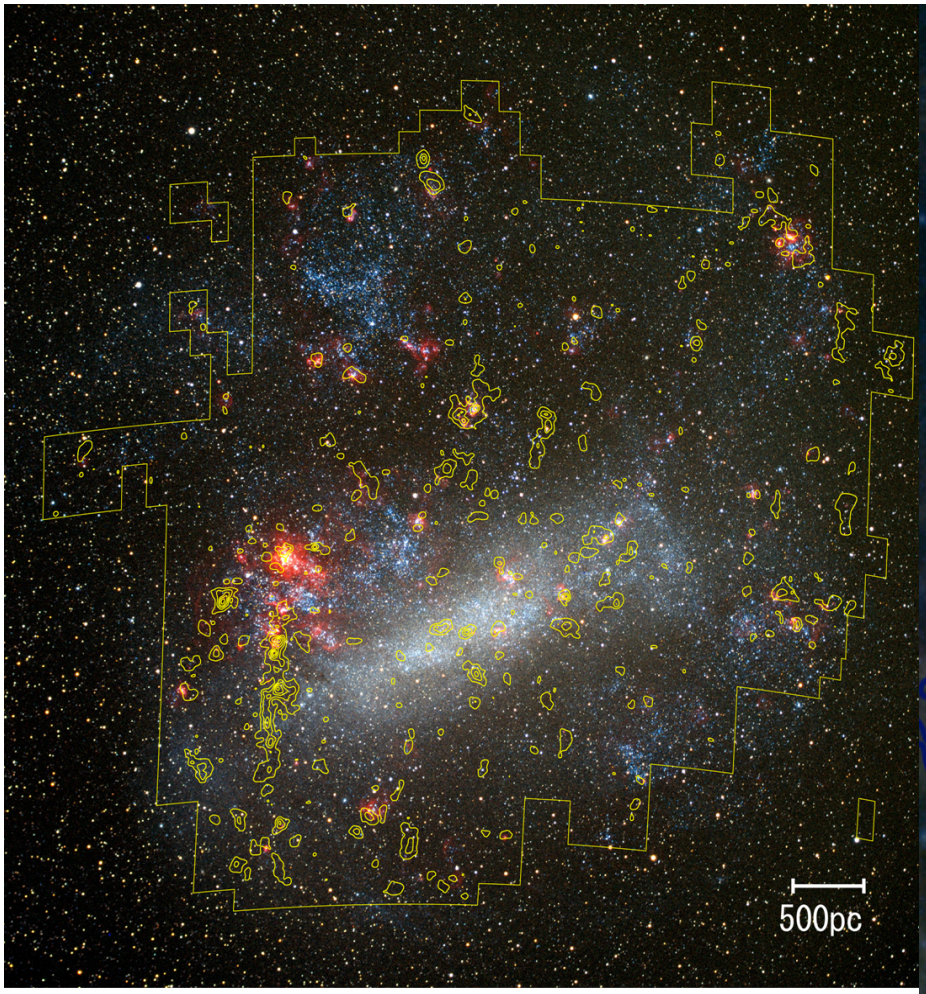
Type III ~ 6 Myr

10Myrs

Only clusters
55 cluster

~ 4Myr

NANTEN CO vs. Spitzer SAGE YSO



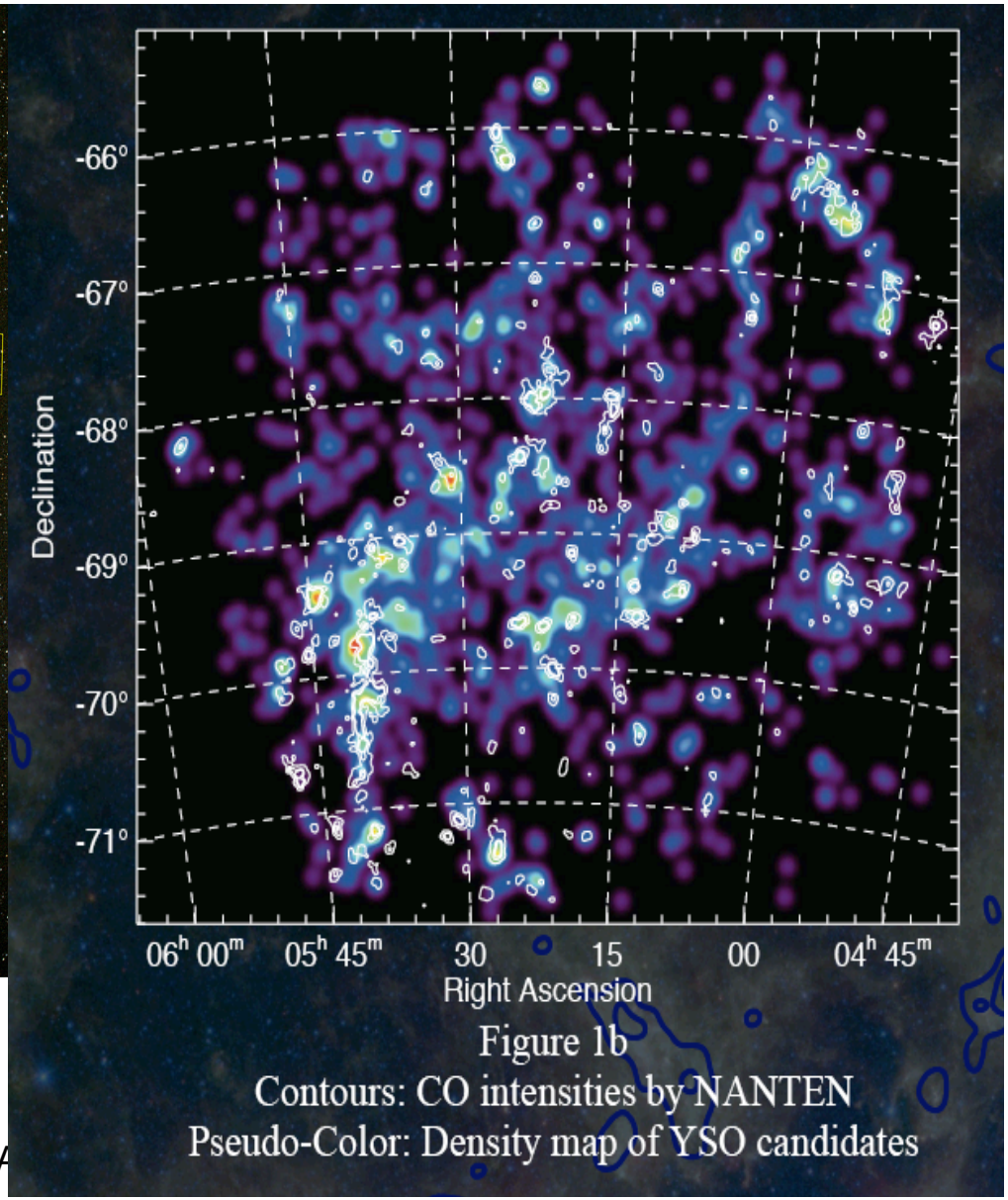
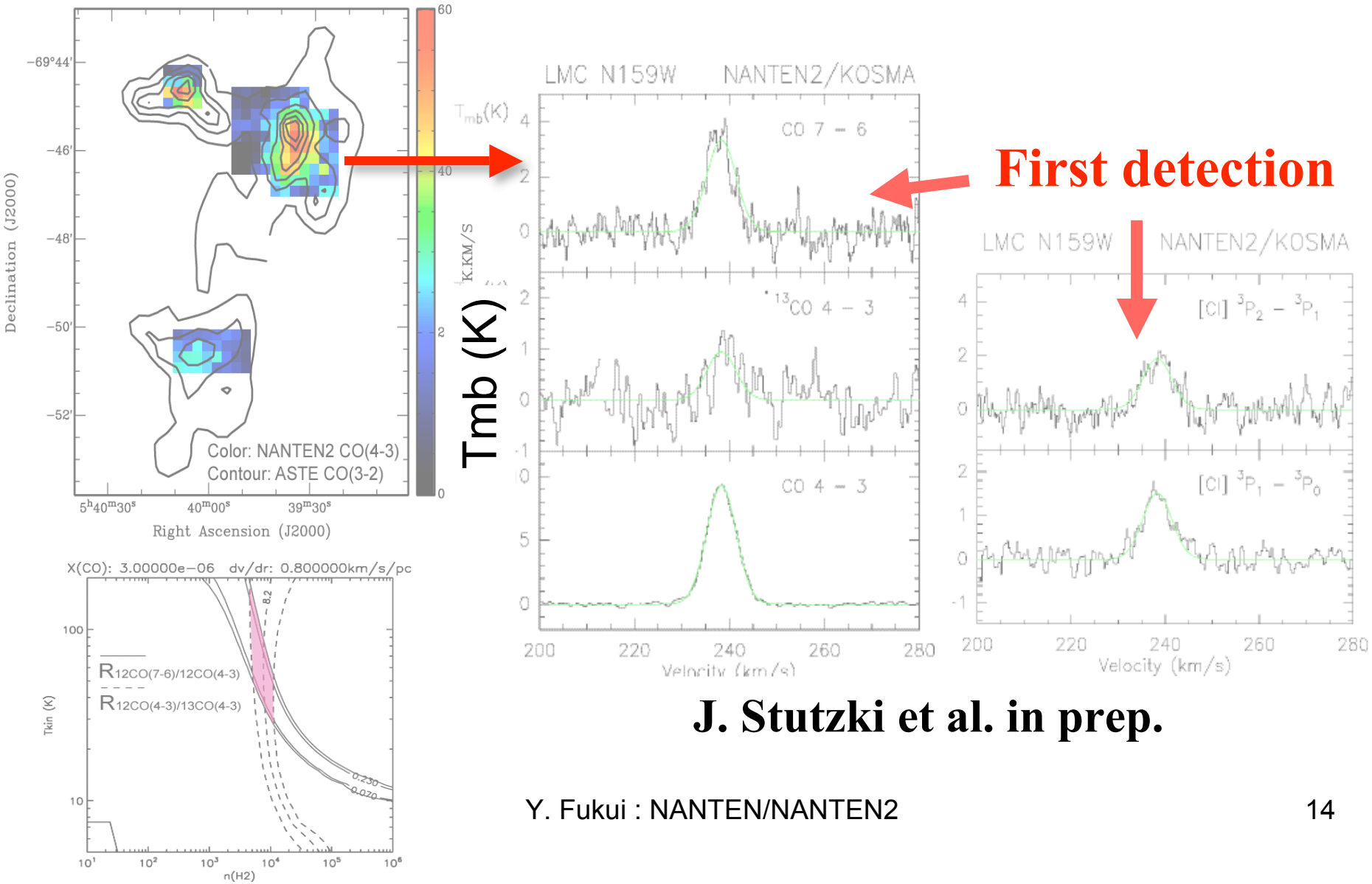


Figure 1b
Contours: CO intensities by NANTEN
Pseudo-Color: Density map of YSO candidates

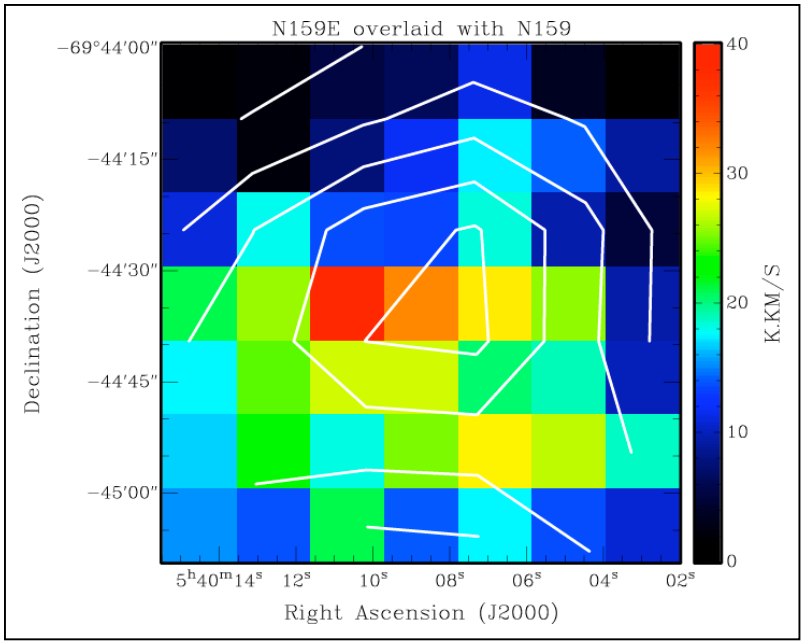
N159W NANTEN2 sub-mm results

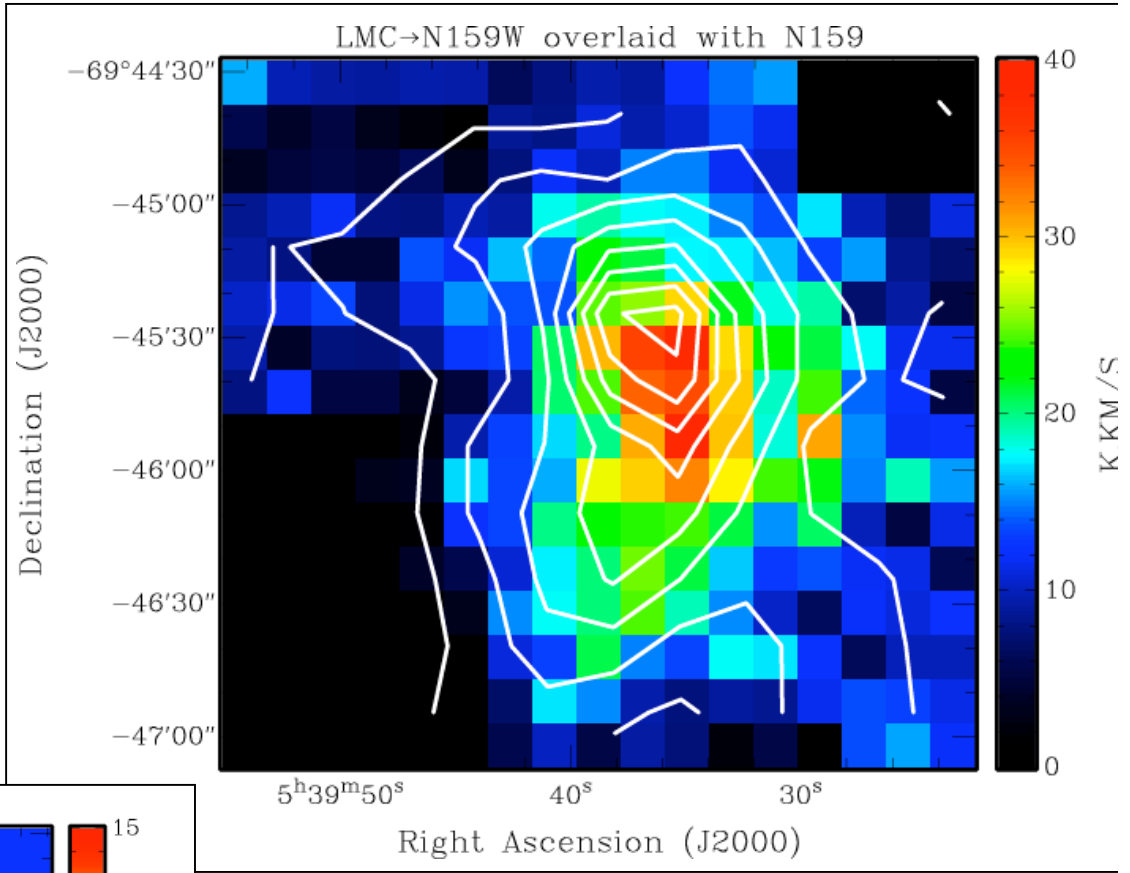


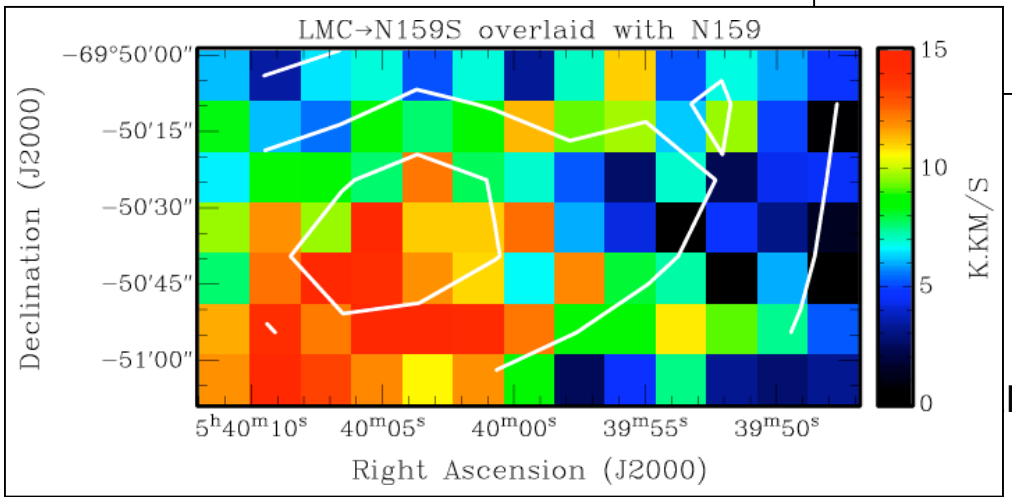
J. Stutzki et al. in prep.

CO(J=4-3) NANTEN2 Results in LMC

N159E







Color: ASTE CO(J=3-2)
Contour: CO(J=4-3)

First results from NANTEN2: Galactic high mass star formation

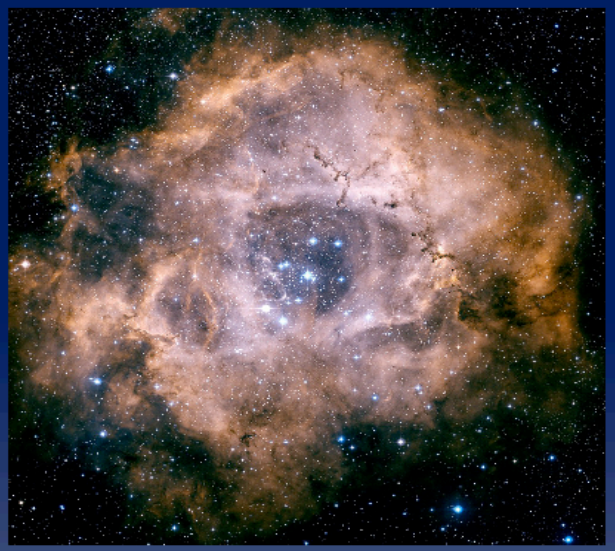
Carina

Distance 2.5 kpc
UV-field 10^3 – 10^4 G_0

NGC 3603

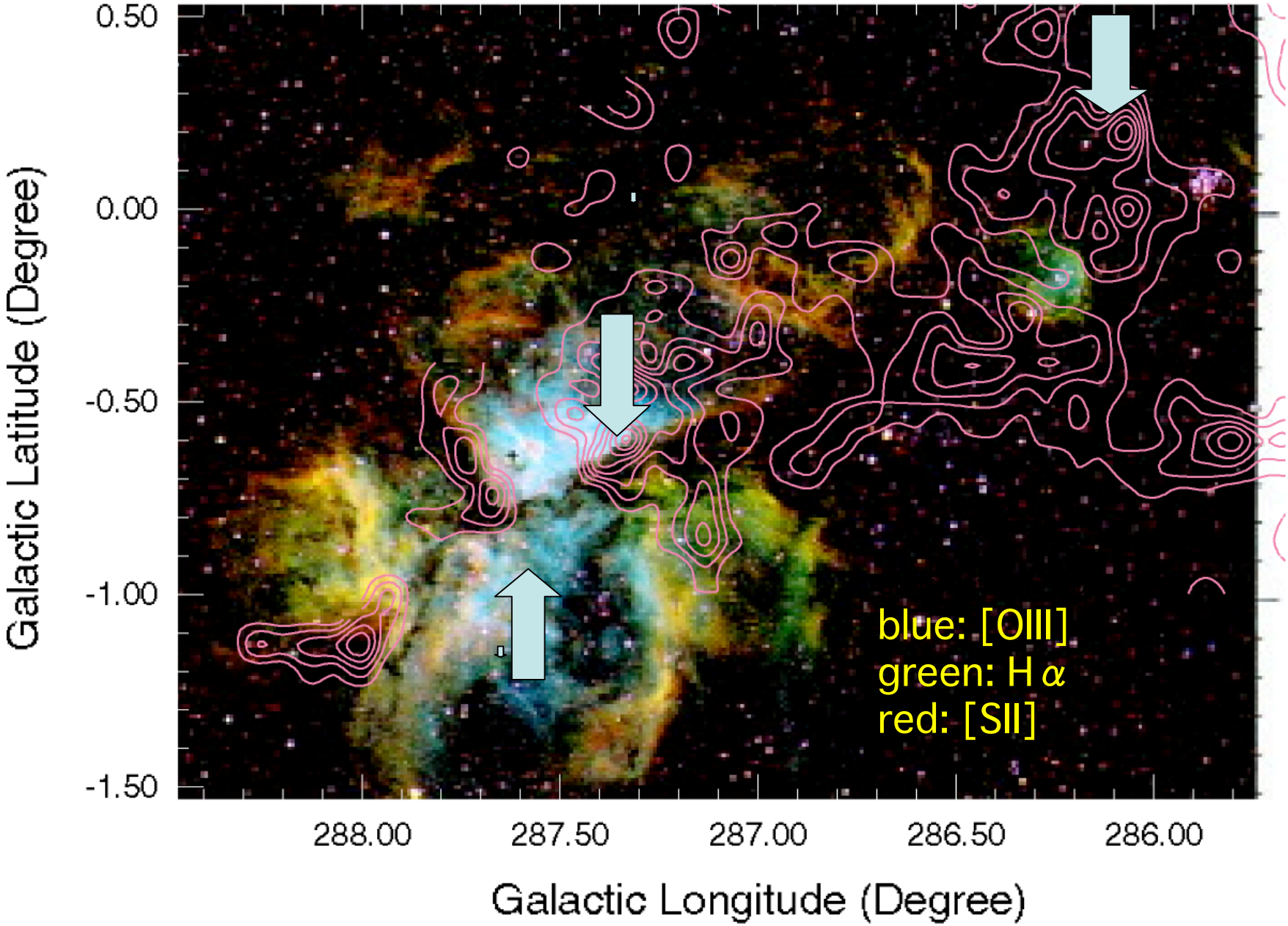
Distance 7 kpc
UV-field 10^4 – 10^5 G_0

Rosette

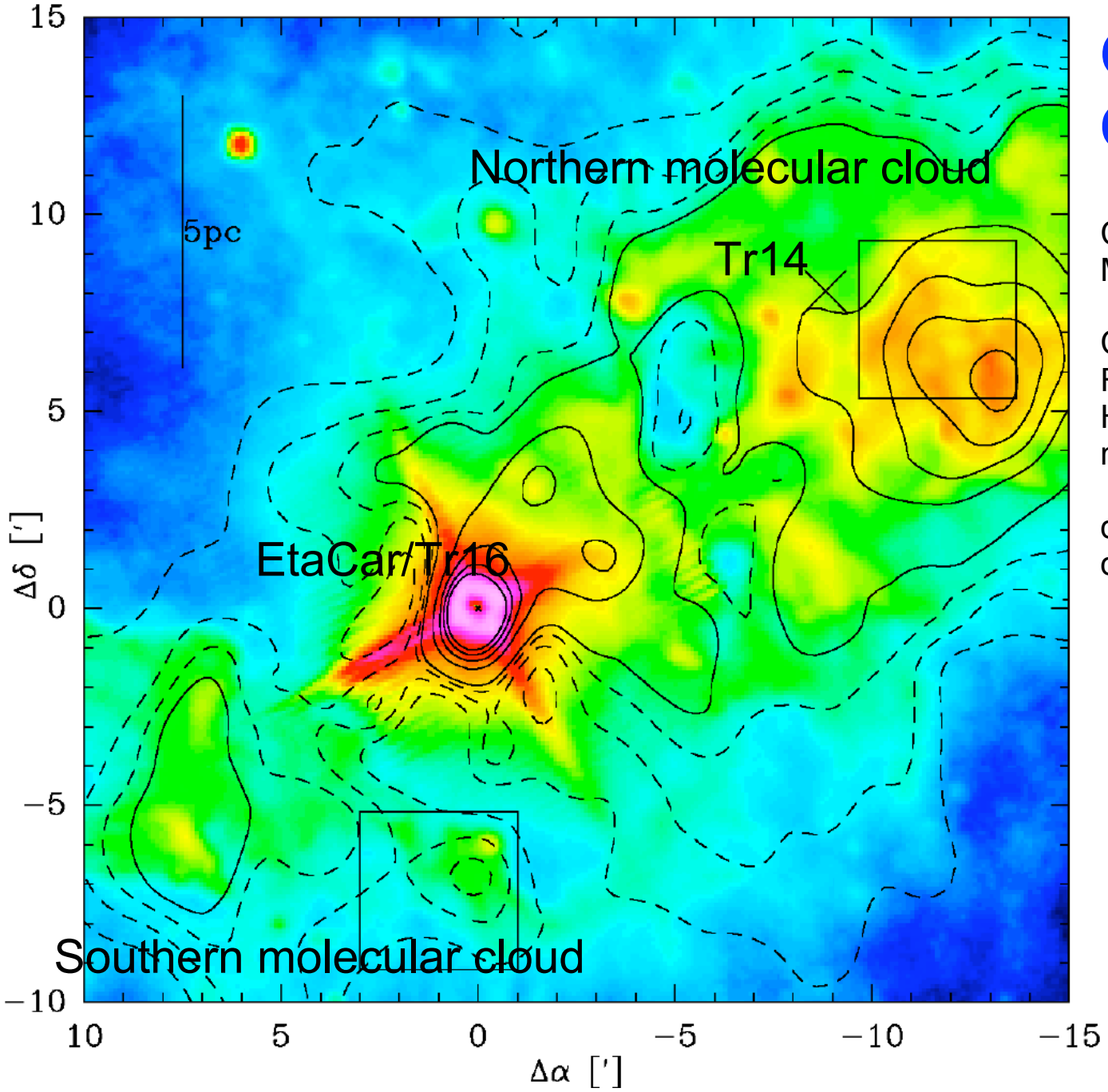


Distance 1.6 kpc
UV-field 150 G_0

η Car GMC (Yonekura et al. 2005)



Carina Overview

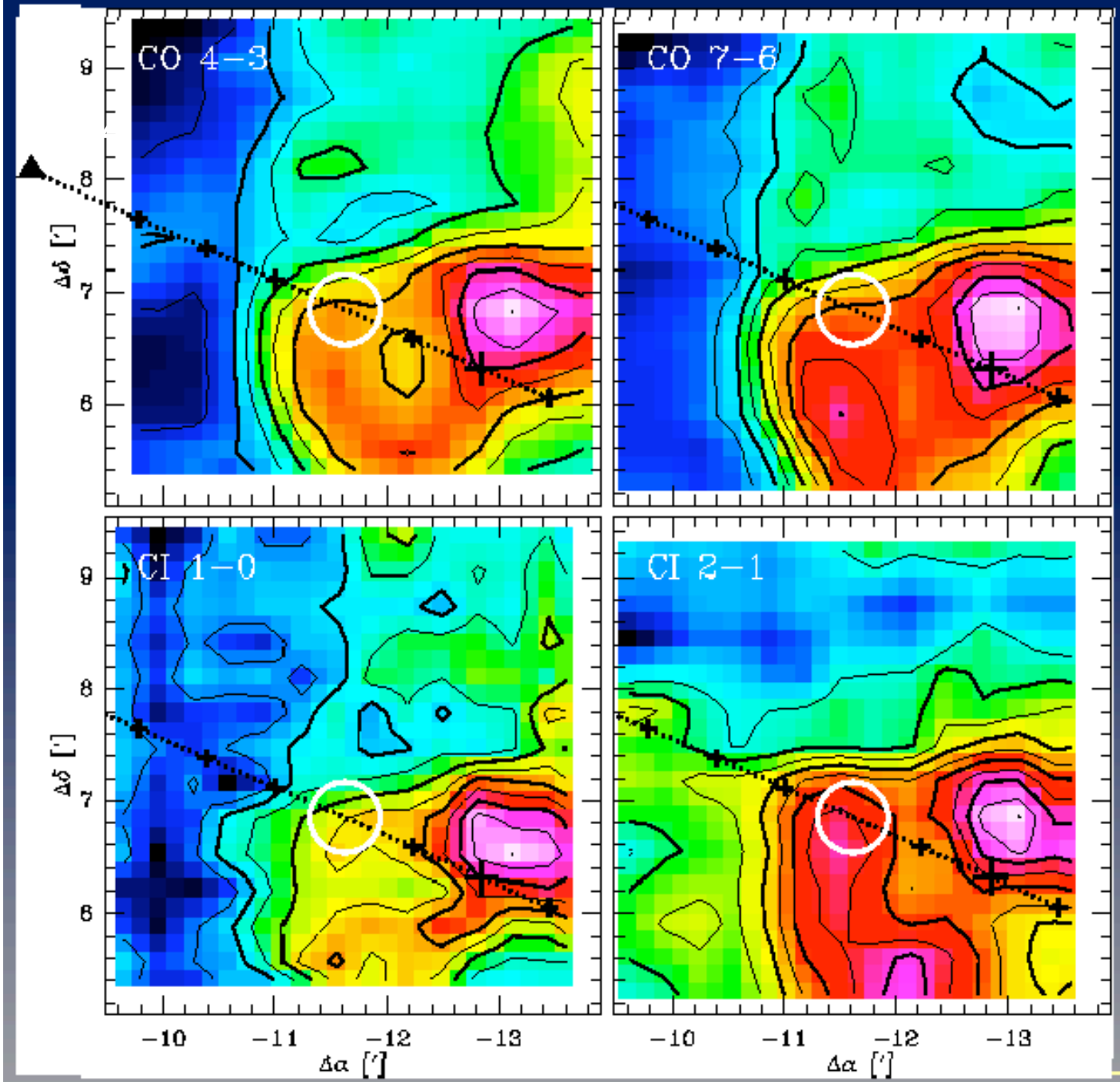


Colors:
MSX 8 micron

Contours:
FUV-field from
HIRES/IRAS 60+100
micron

dashed: 200, 300, 400
drawn: 500, 1000, ..., 2500

Carina-N

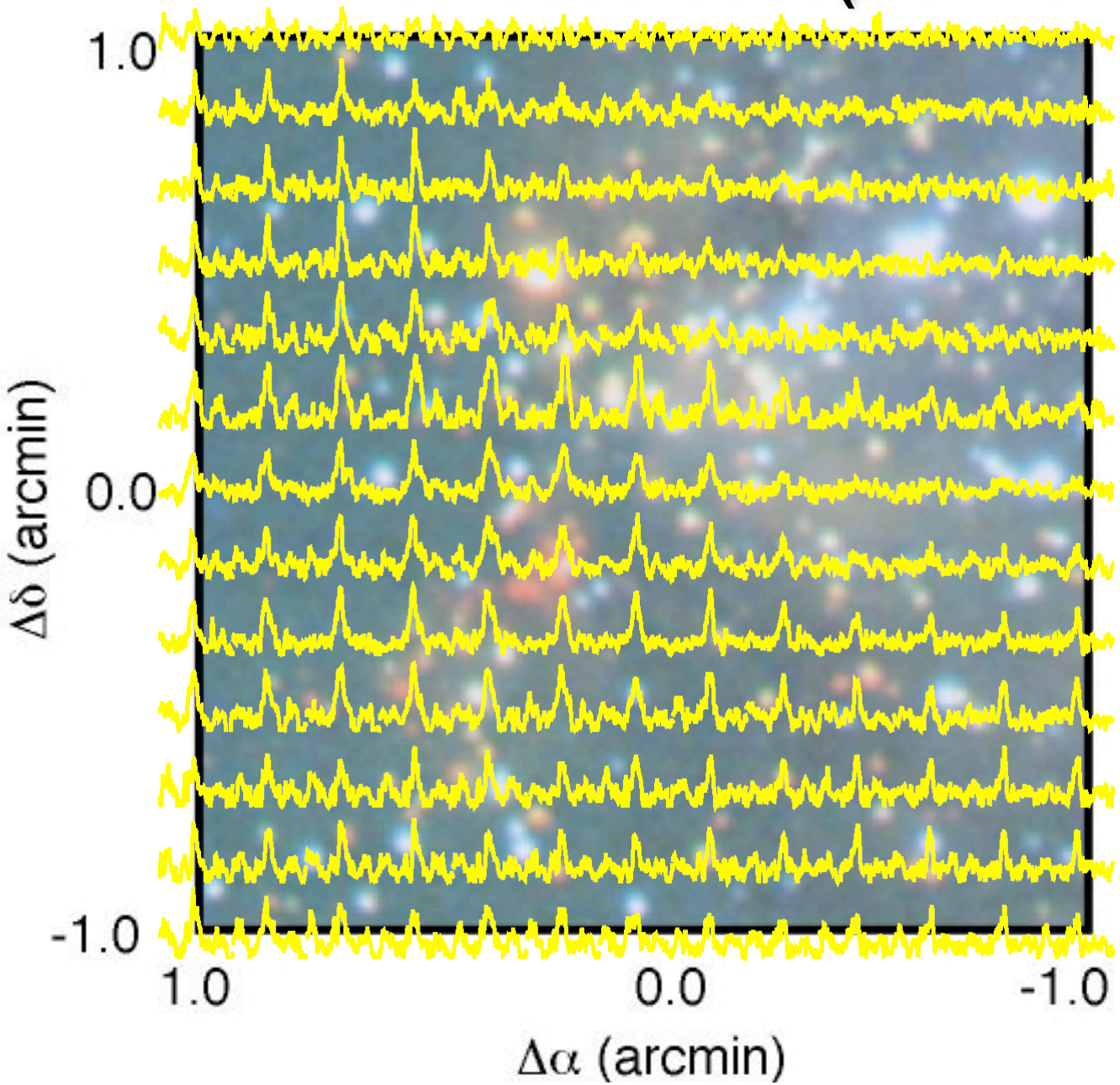


NANTEN2
4'x4' maps of

CO 4-3
CO 7-6
[CI] 1-0
[CI] 2-1

Kramer et al. 2007
Submitted to A&Ap

IRAS 10365-5803(Carina Core 5)



CO (7-6)

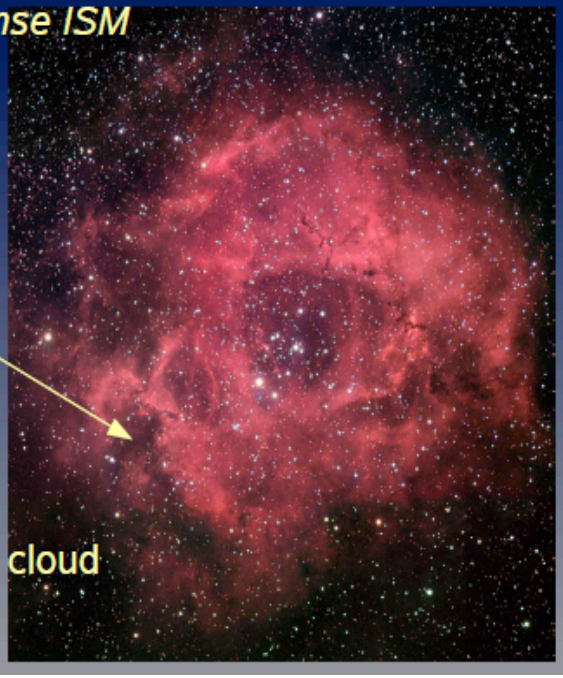
near IR image

Yonekura et al. 2007

CO and CI observations of the Rosette PDR

Rosette facts

- Distance: 1.5 kpc
- OB cluster NGC 2244, 20 pc projected distance to the cloud edge
- Edge-on PDR *Monoceros Ridge*, ~140 times Draine
- HIFI GT *Warm and dense ISM*



Rosette

CO and CI observations of the Rosette PDR

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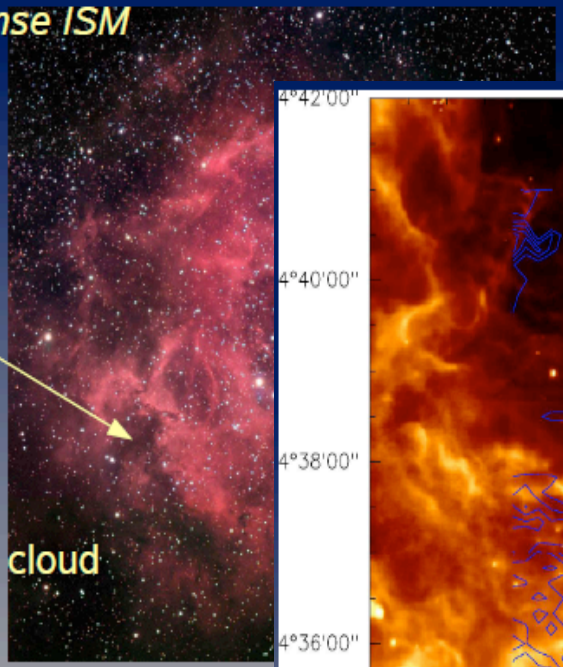
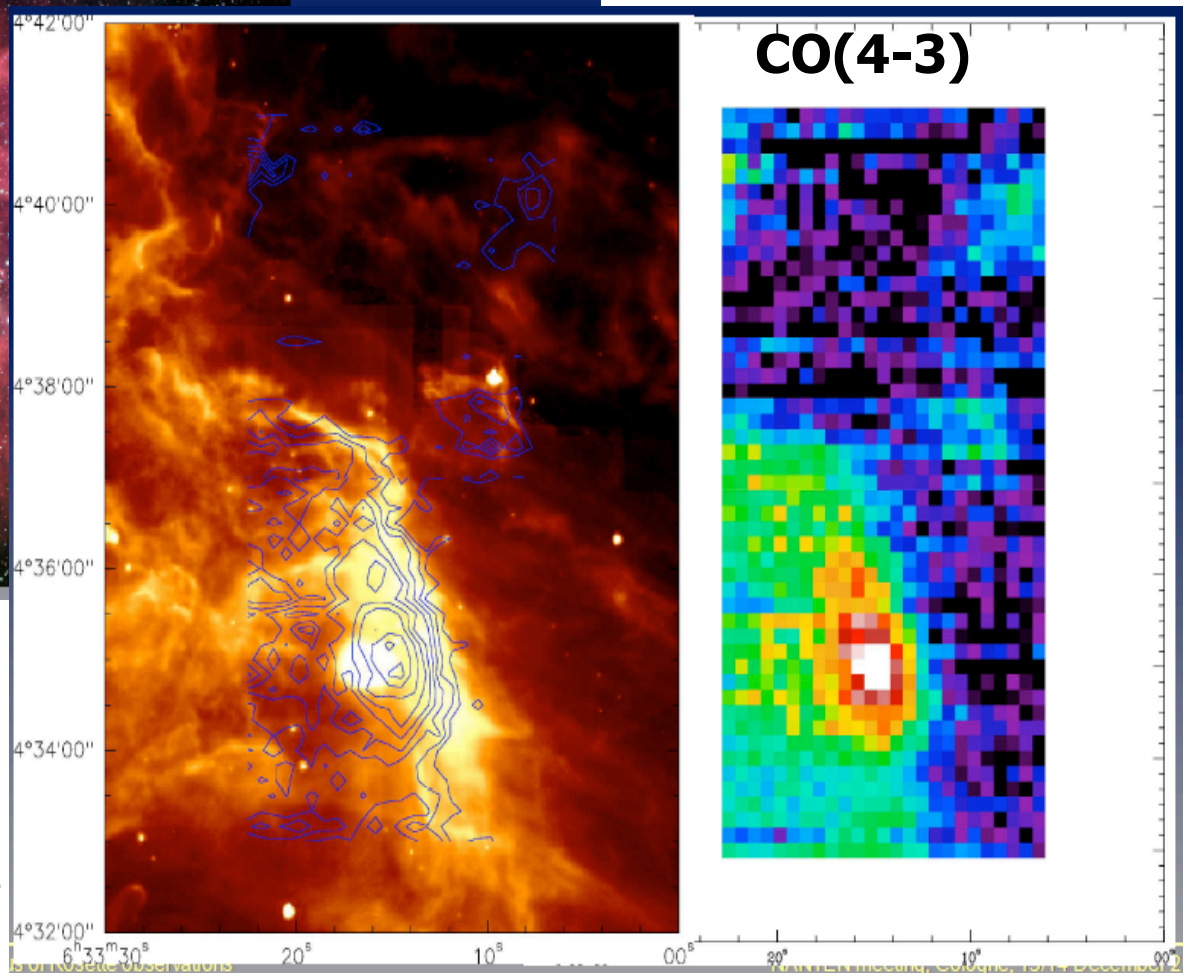


Rosette



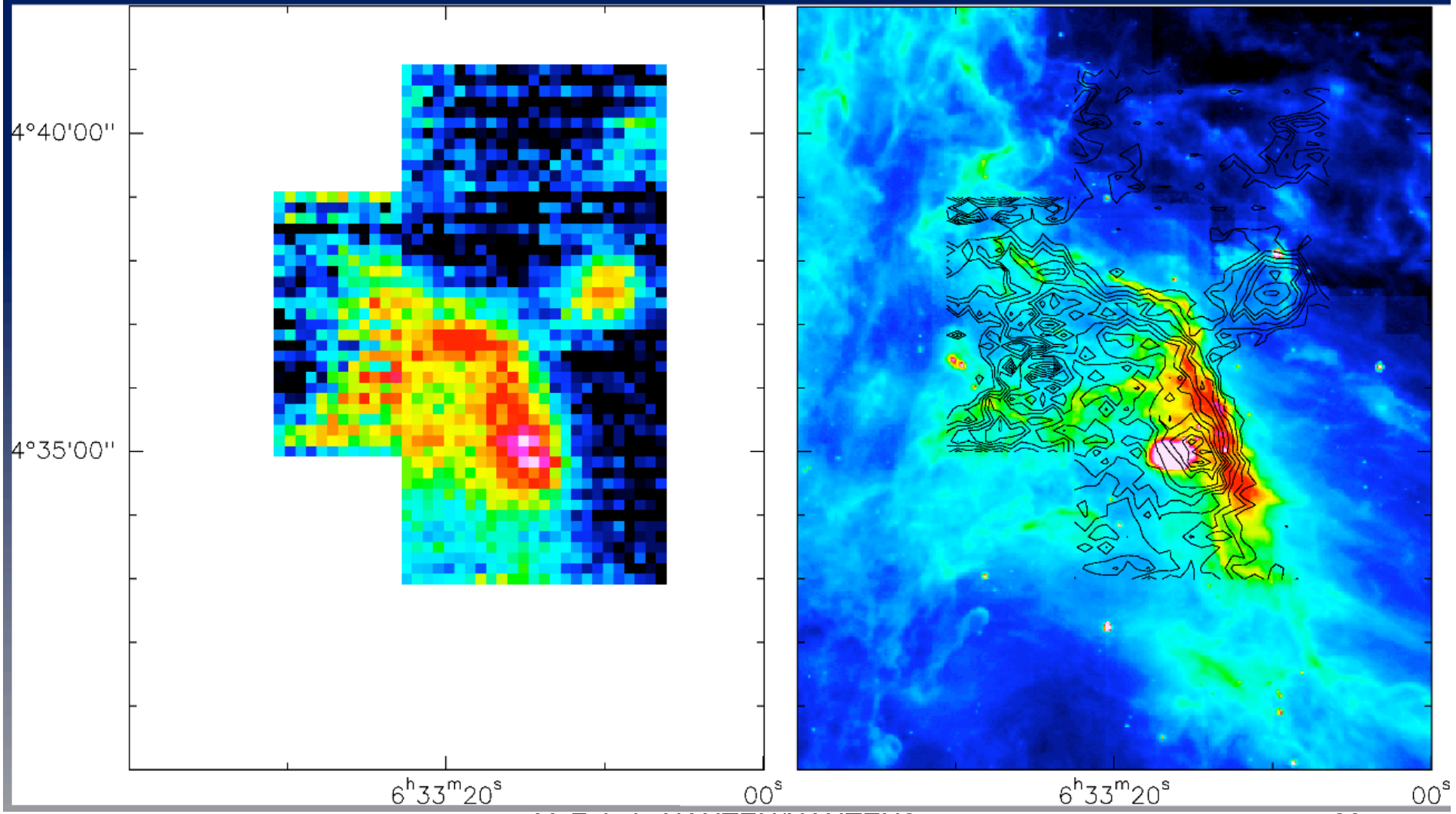
Contour : CO(4-3)
Color : Spitzer 24µm

Y.

Rosette PDR

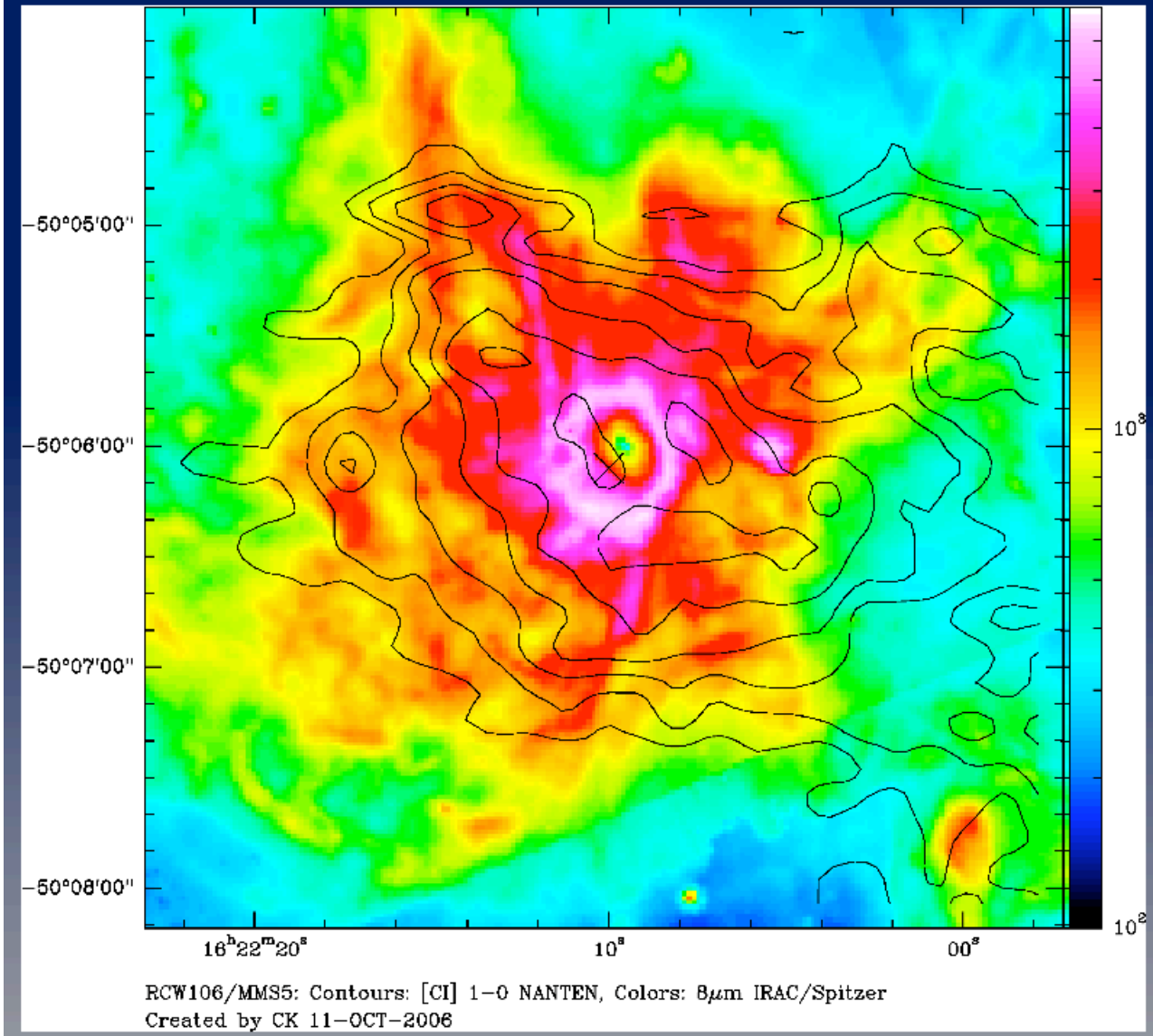
NANTEN CO 4-3 int. intensity

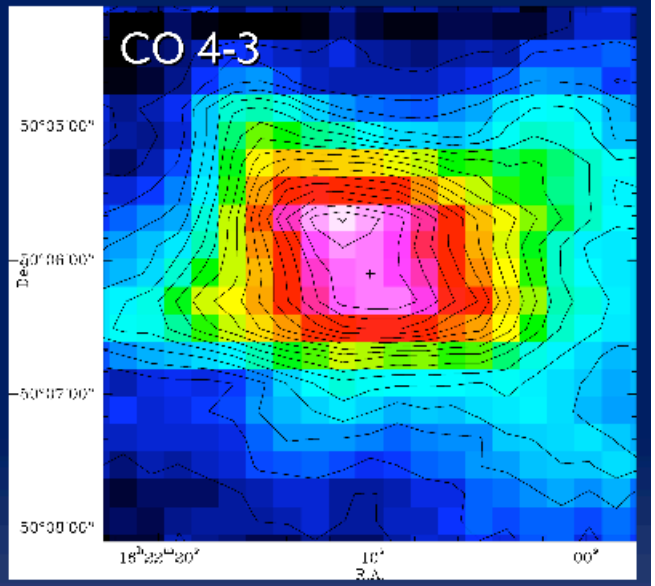
CO 4-3 contours on Spitzer/IRAC 8 micron

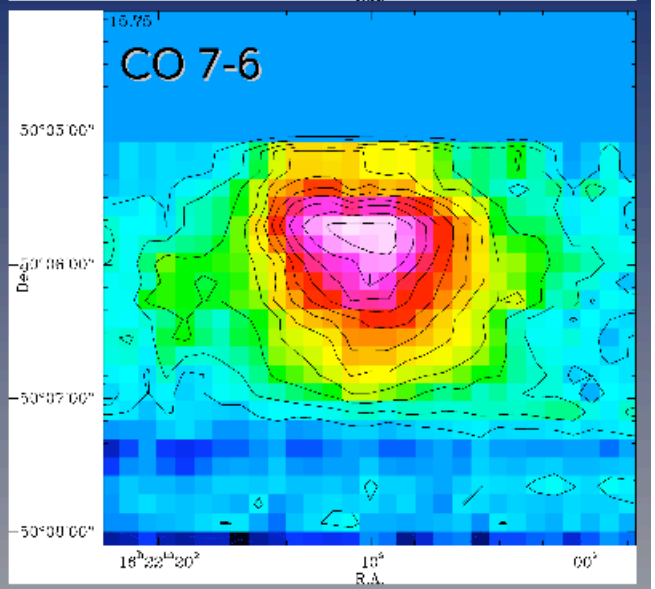


Simon et al. 2007

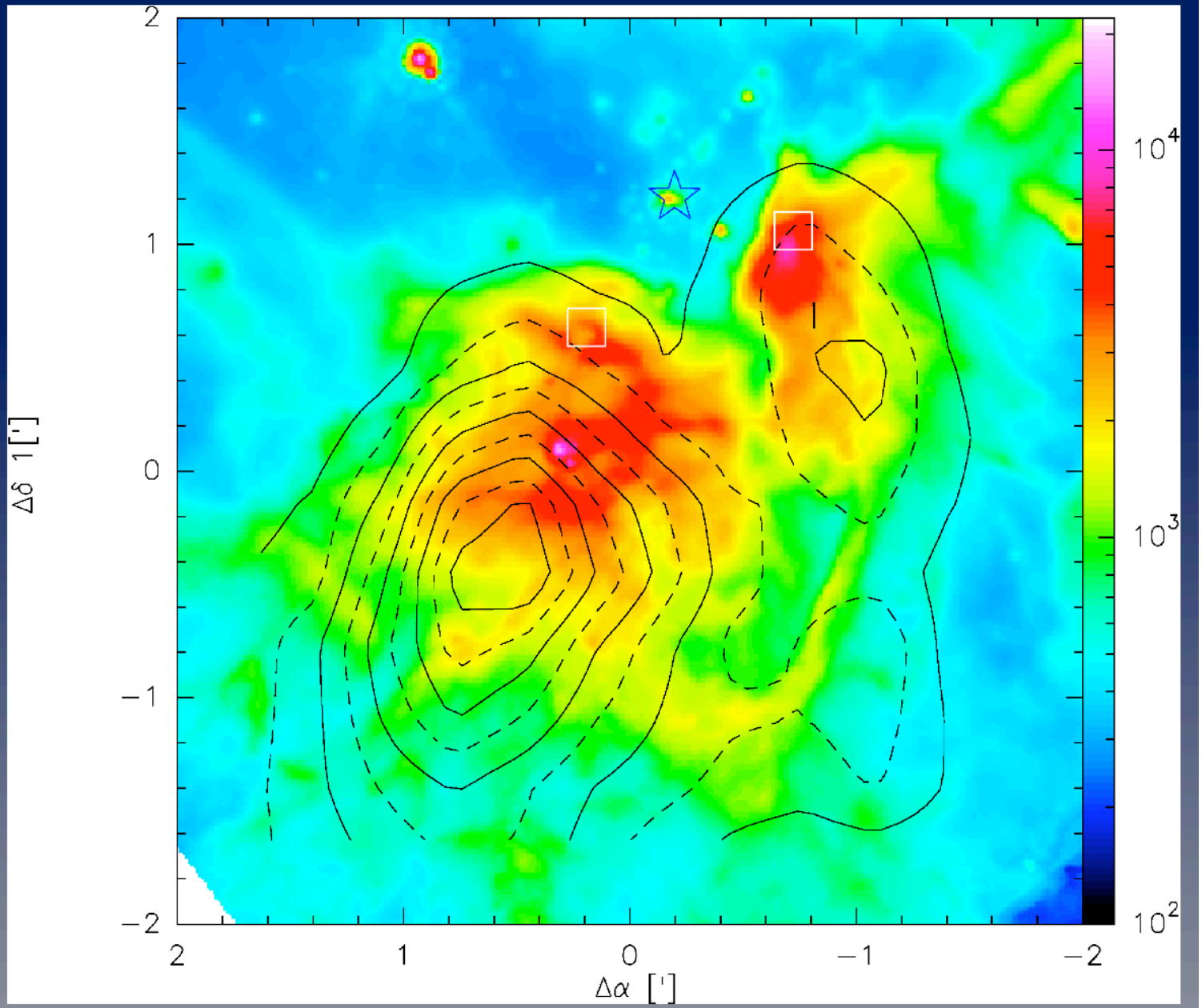
G333/RCW 106

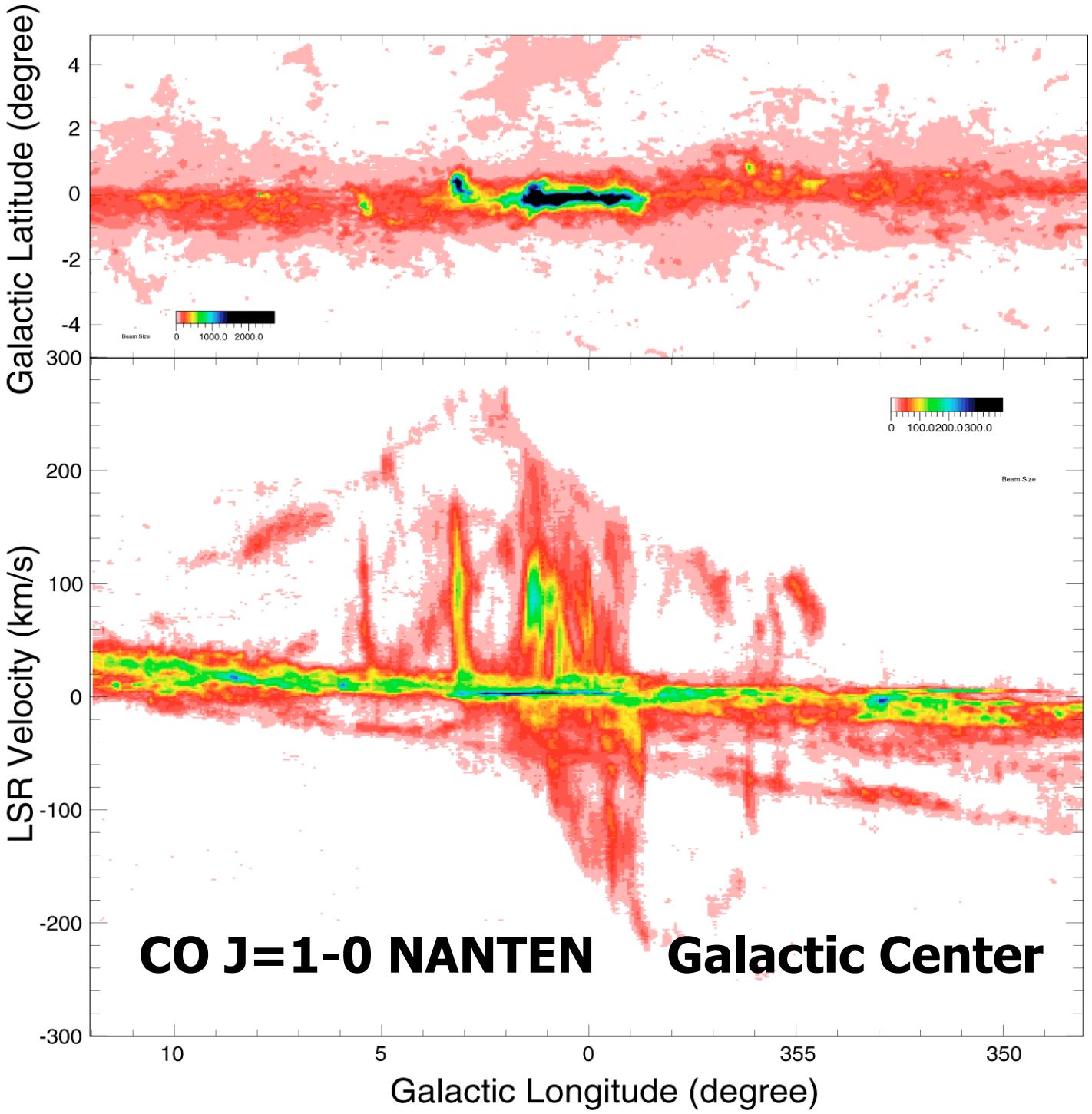

−50°05'00"
−50°06'00"
−50°07'00"
−50°08'00"
16h22m20s
10s
00s
10³
10²
RCW106/MMS5: Contours: [CI] 1−0 NANTEN, Colors: 8μm IRAC/Spitzer
Created by CK 11−OCT−2006


CO 4-3
50°05'00"
50°06'00"
50°07'00"
50°08'00"
Dec
16h22m20s
10s
00s
R.A.


CO 7-6
15.75
50°05'00"
50°06'00"
50°07'00"
50°08'00"
Dec
16h22m20s
10s
00s
R.A.

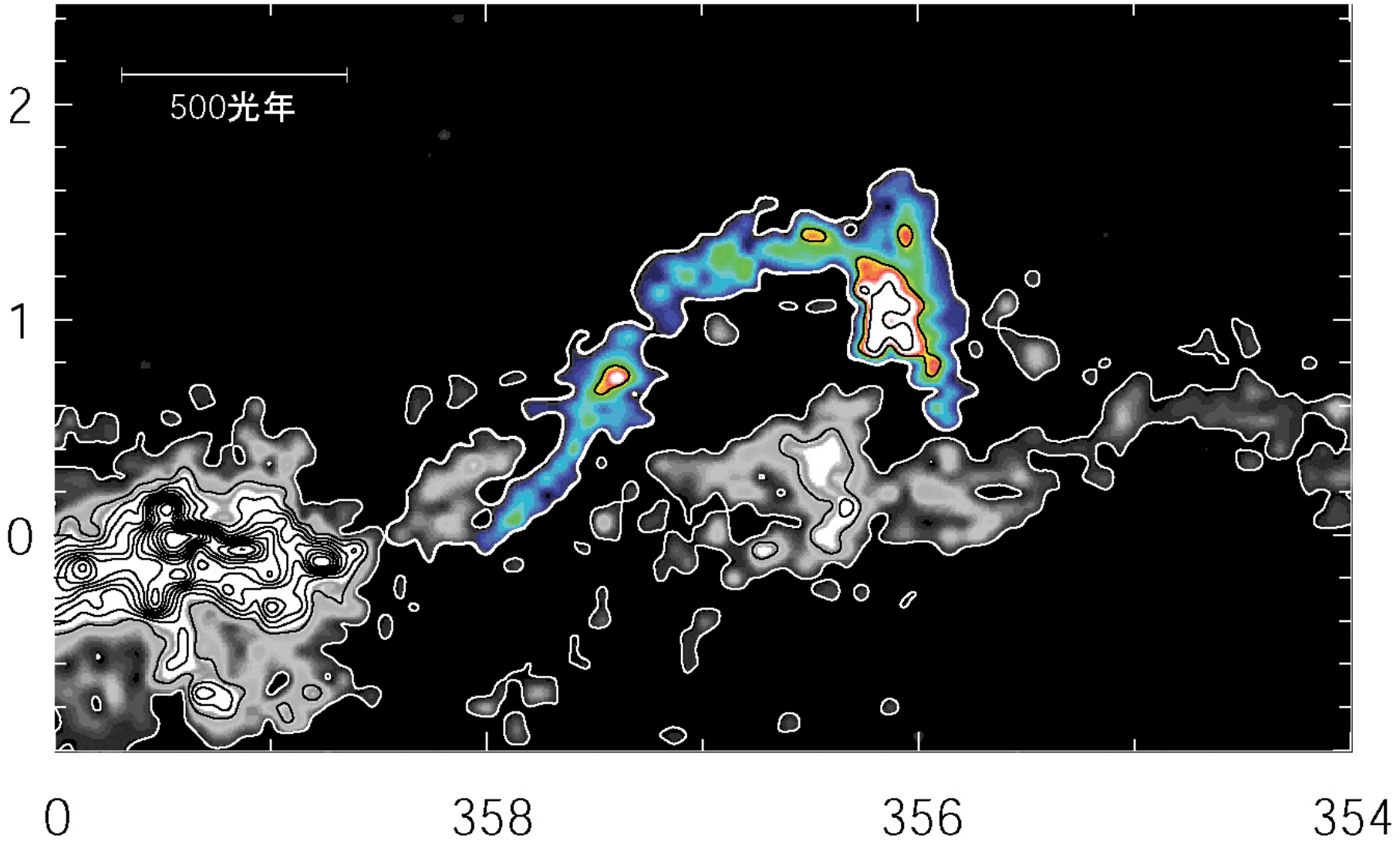
CO 4-3 contours on Spitzer 8 micron NGC3603



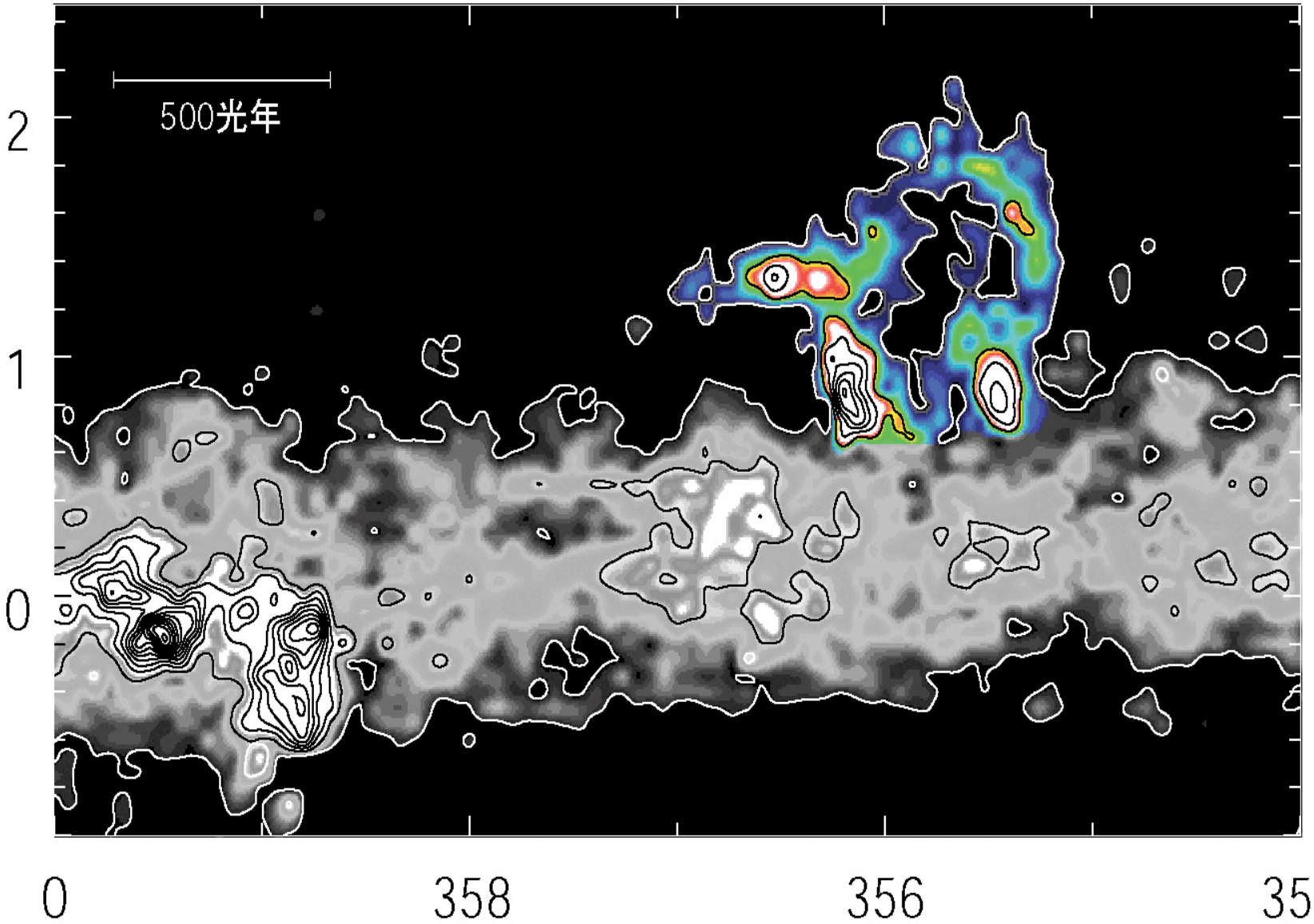

Galactic Latitude (degree)
4
2
0
-2
-4
Beam Size
0 1000.0 2000.0
300
200
100
0
-100
-200
-300
LSR Velocity (km/s)
0 100.0200.0300.0
Beam Size
CO J=1-0 NANTEN Galactic Center
10
5
0
355
350
Galactic Longitude (degree)

Loop 1 discovered by NANTEN

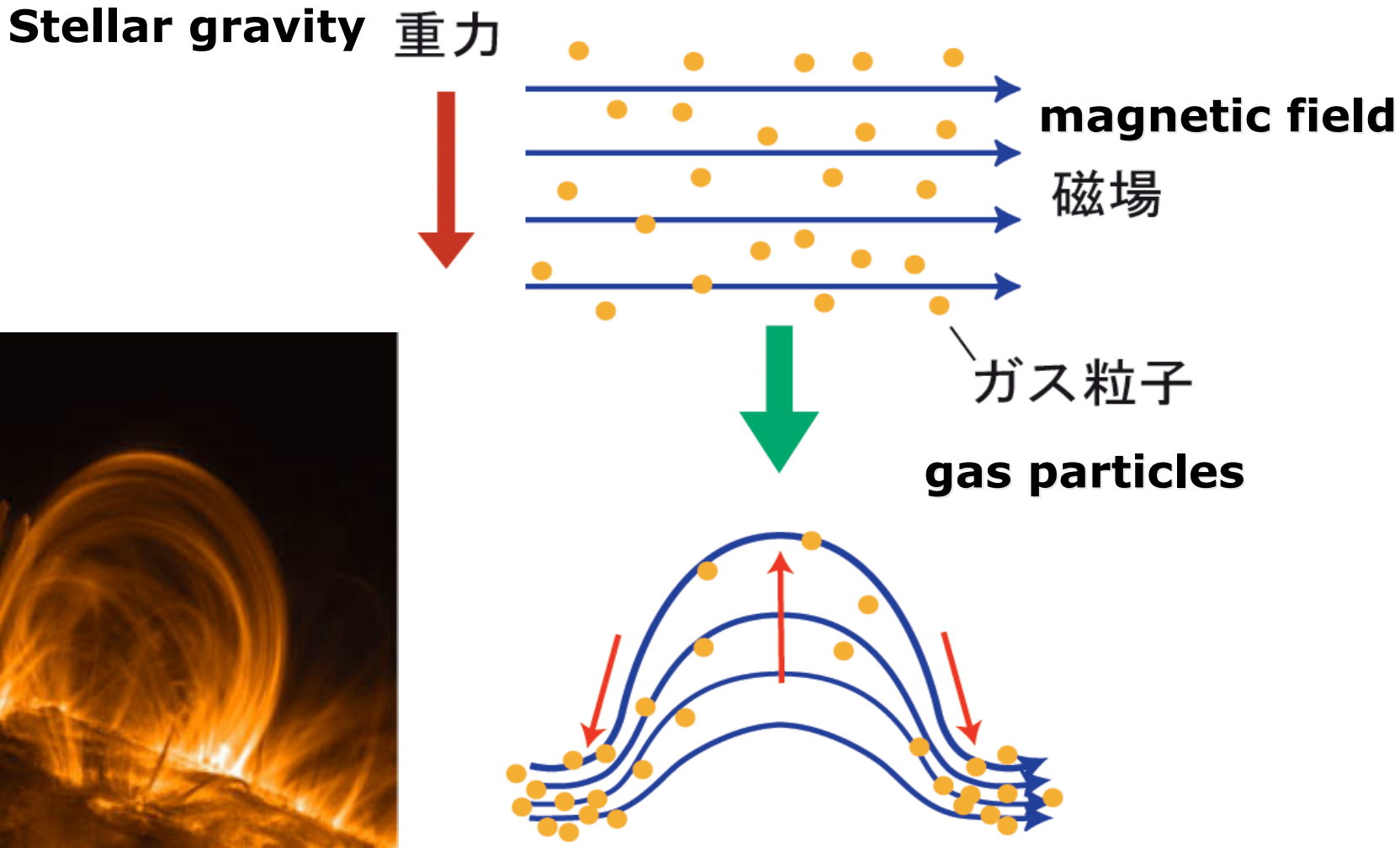
Y. Fukui et al. 2006, in Science 314, 106

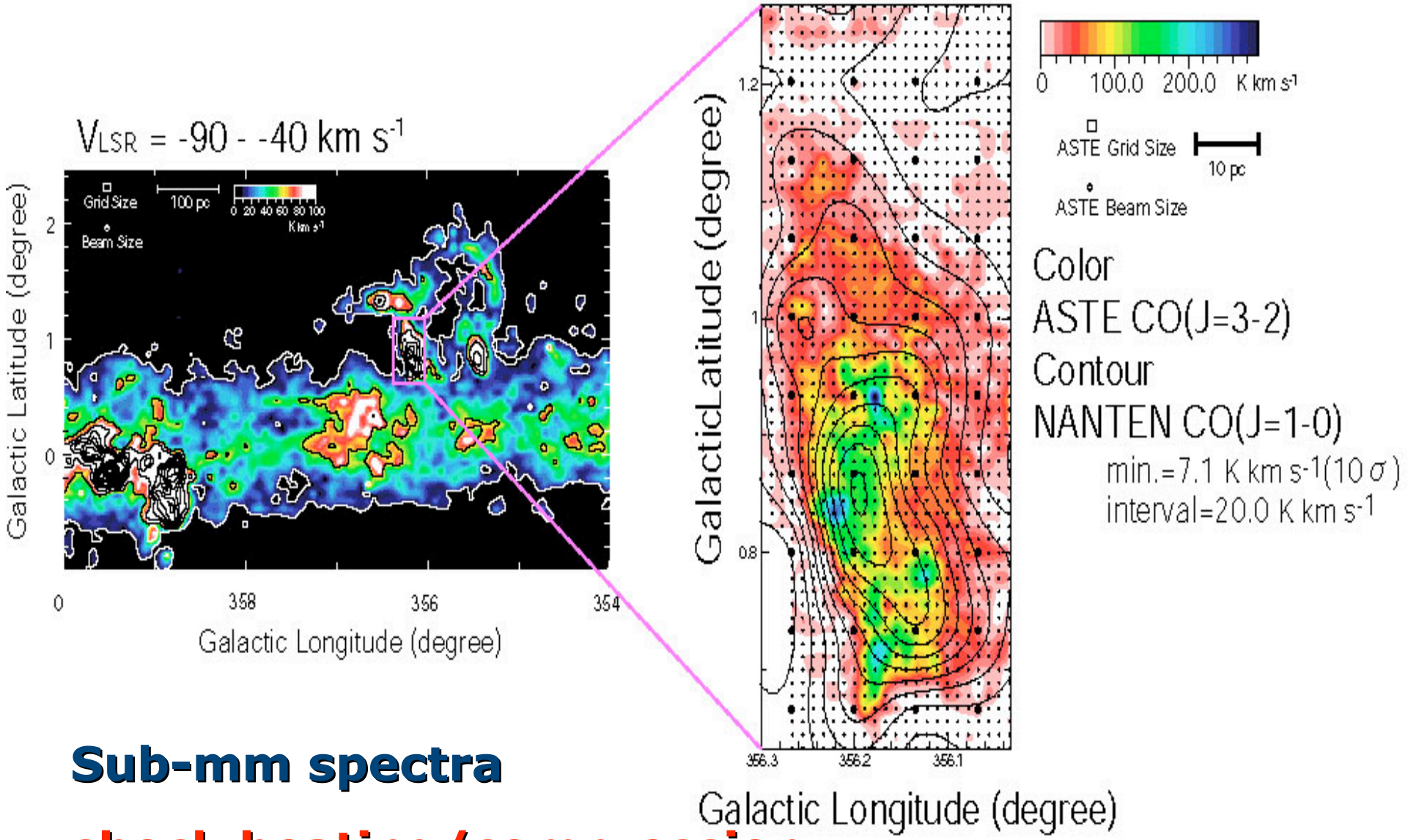


Loop 2 discovered by NANTEN



Parker instability





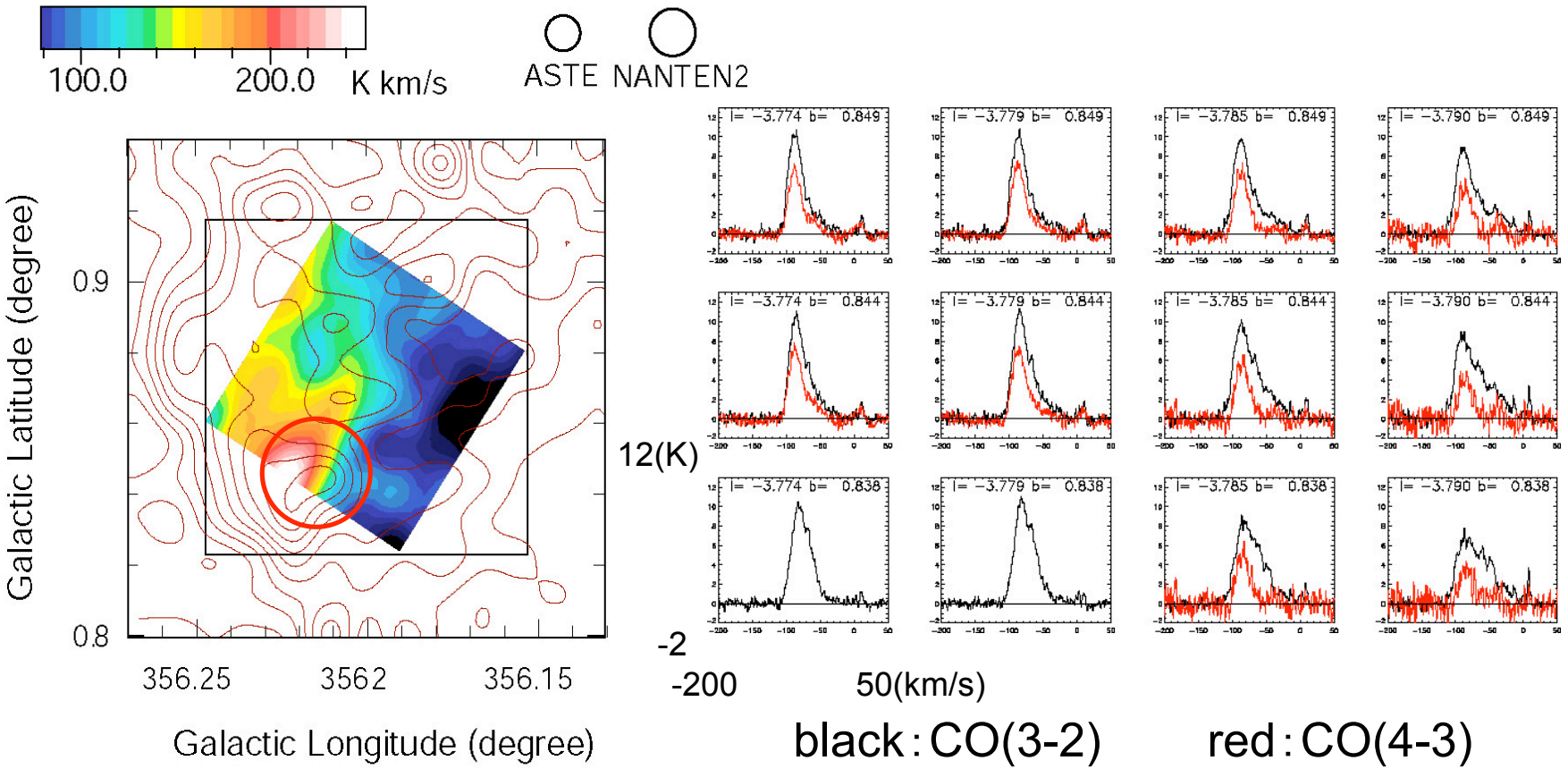
Sub-mm spectra

shock heating/compression

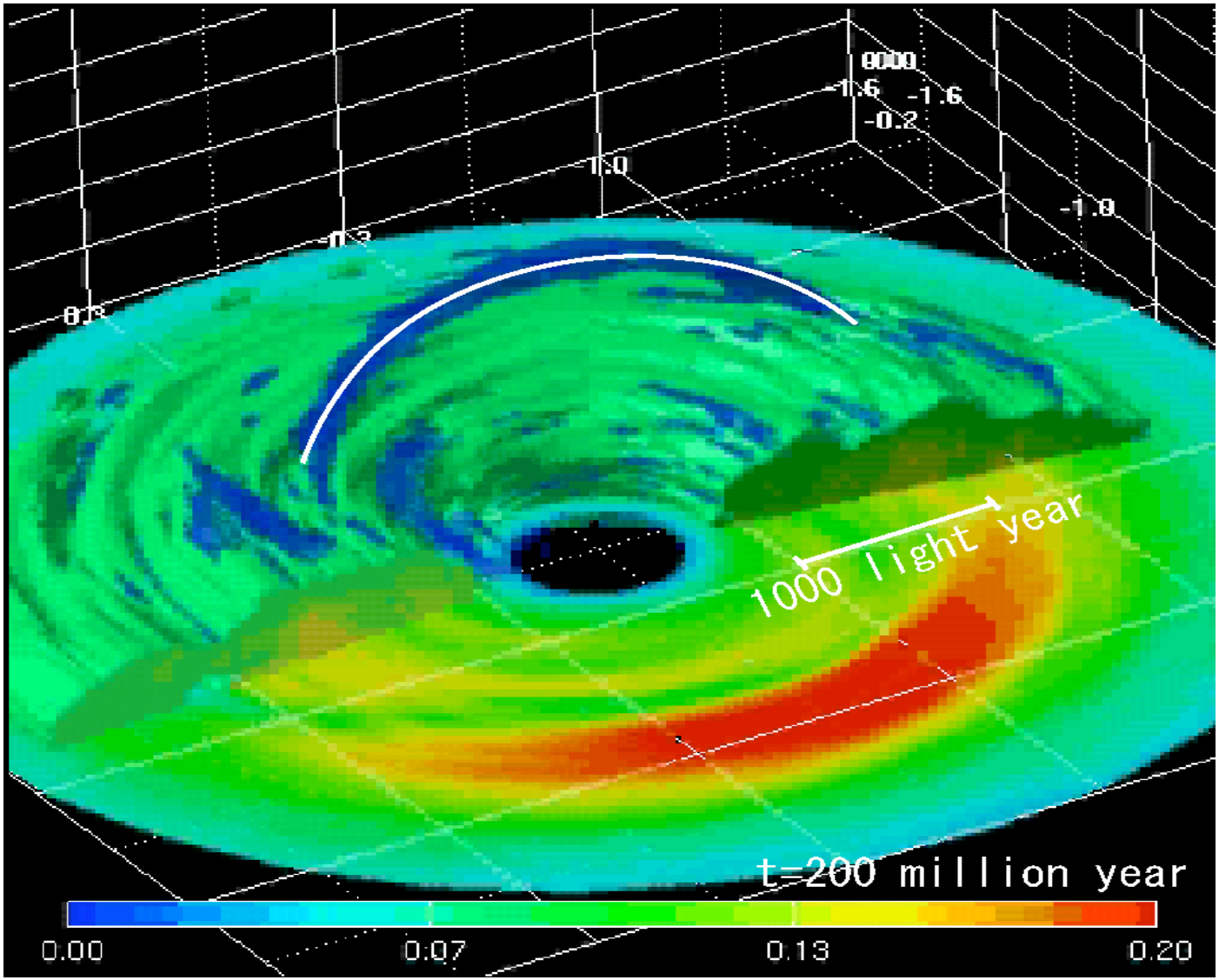
at the foot points of loops

Loop foot point by NANTEN2: CO(4-3)

NANTEN2(color)+ASTE(contour)



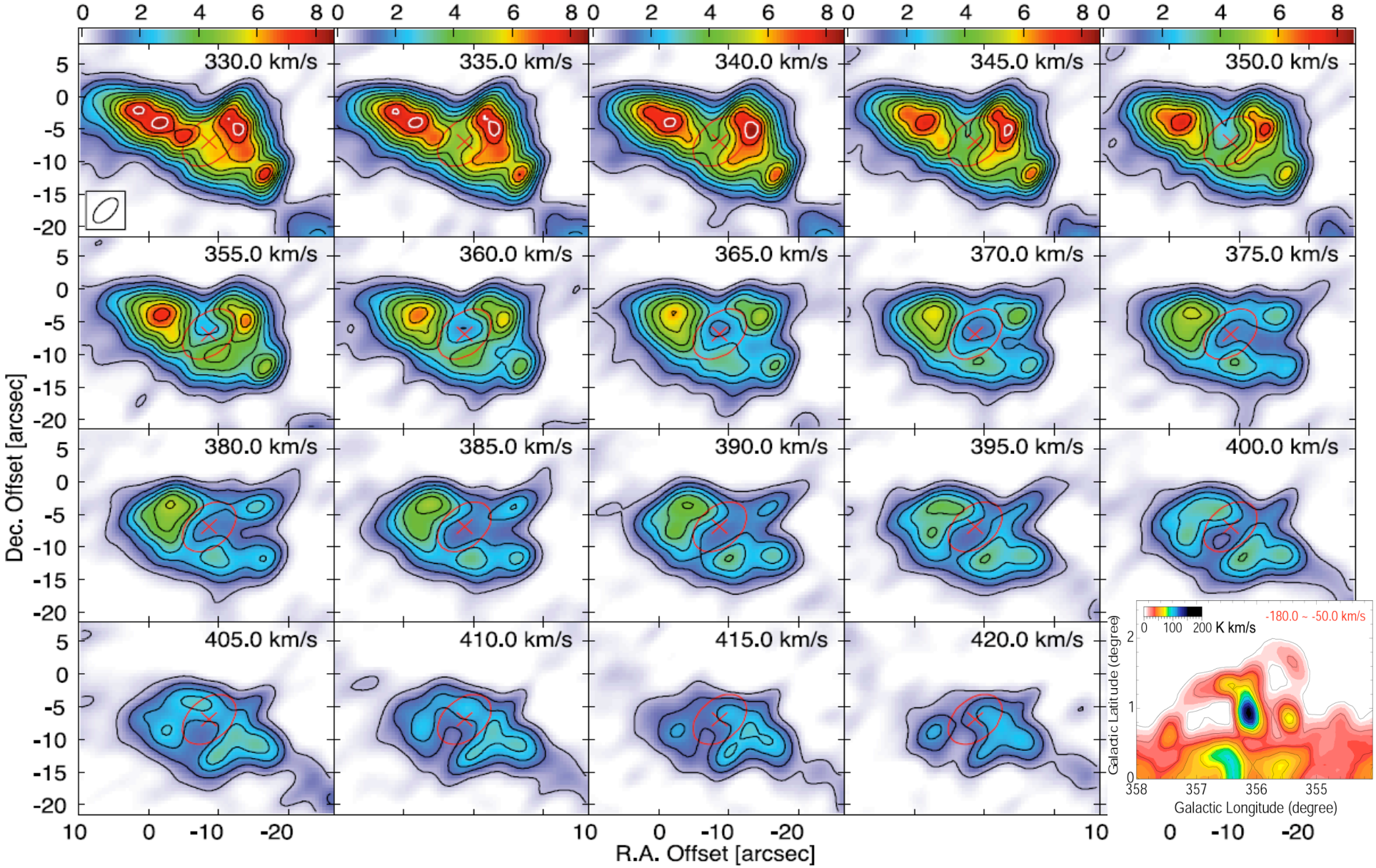
Molecular loops in the GC: global view



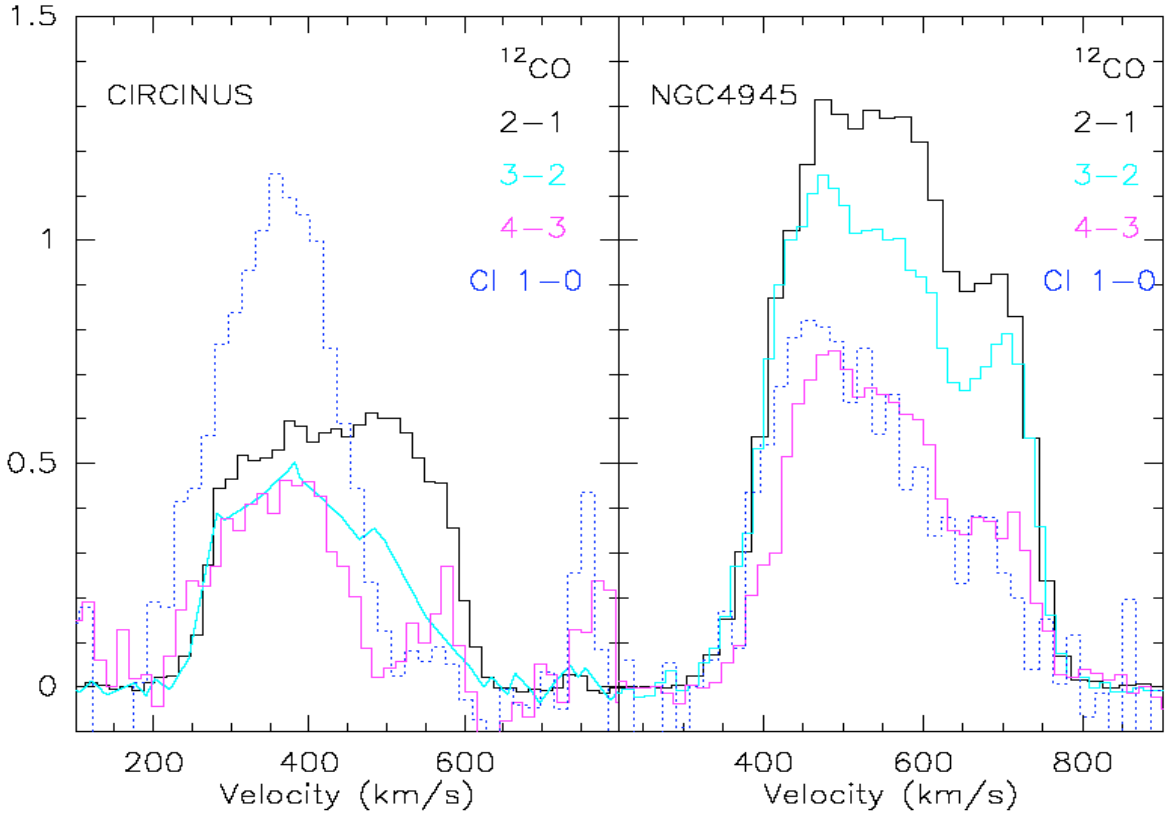
Machida et al. 2007

Molecular Loops in Galaxies? NGC253

Sakamoto et al. 2006



Nearby galaxies（~4Mpc） by NANTEN2



High CI/CO (0.5-1.0)

cf.Gerin & Philipps （2000）

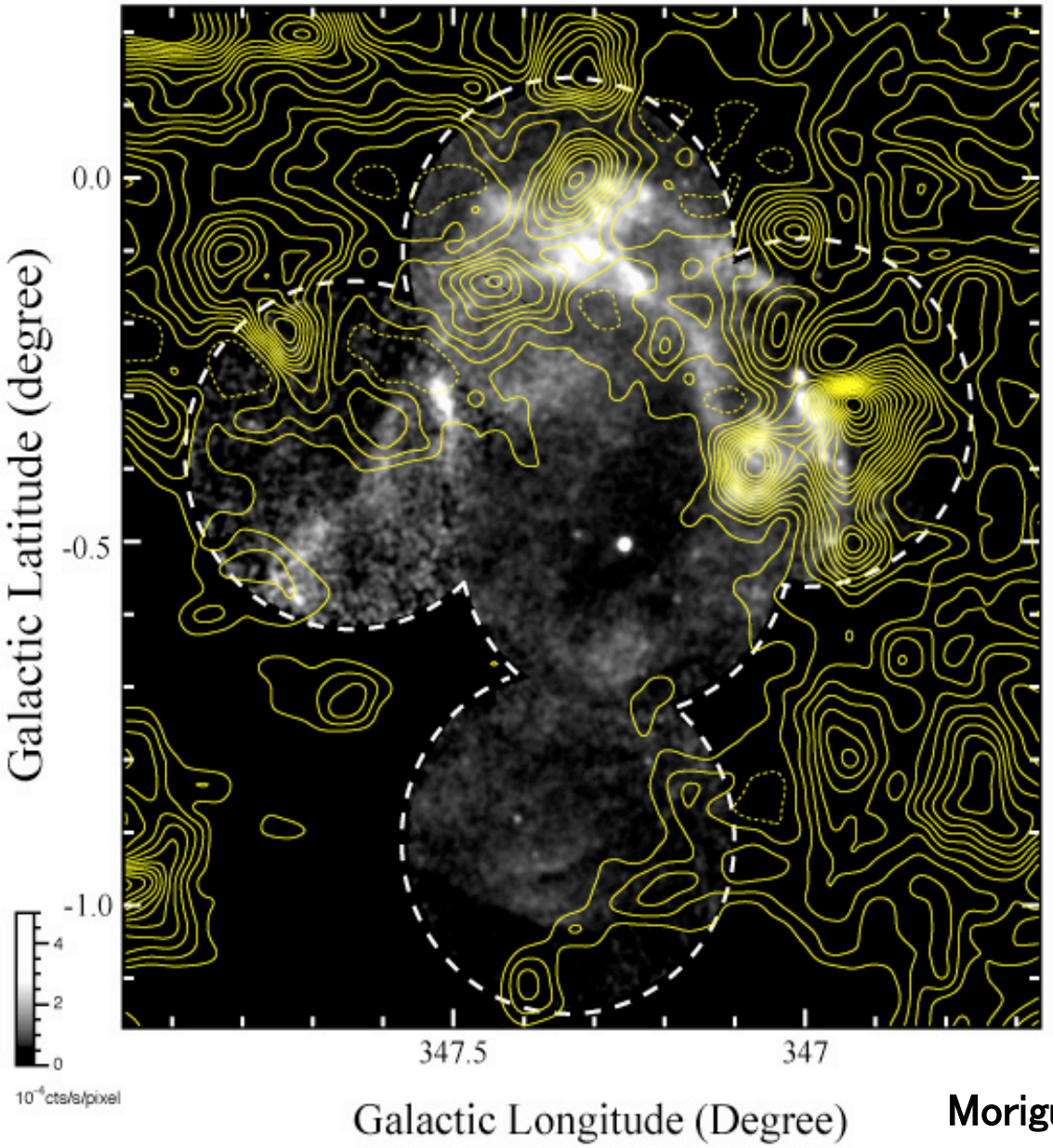
20 galaxies

CI/CO ~0.2

Others: M83, NGC 253, CenA, Antennae,NGC2559,NGC6000, NGC4321(M100), NGC2909

Hitschfeld et al. 2007 submitted to A&Ap

TeV Gamma SNR: XMM and NANTEN CO 1-0

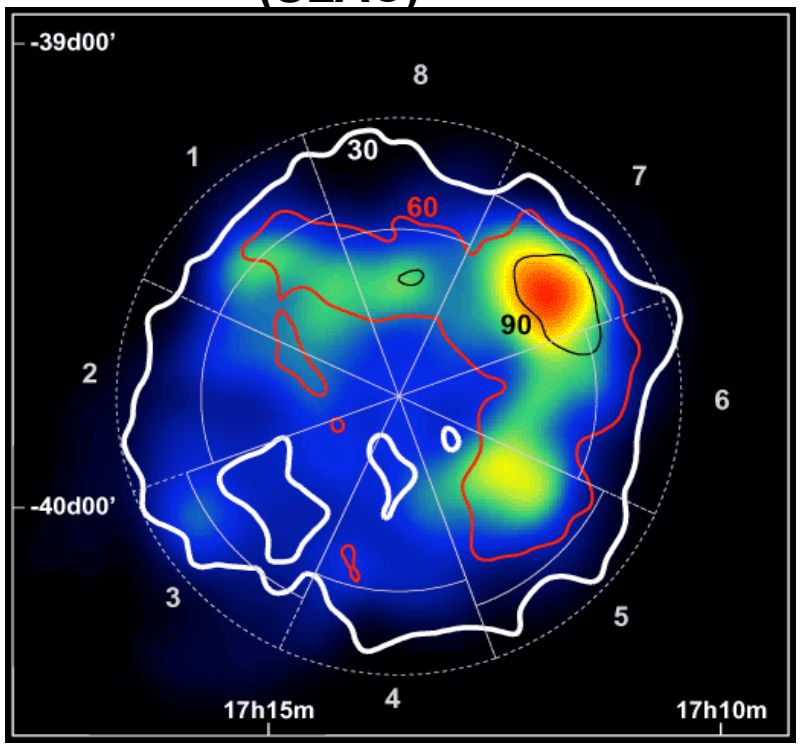


Moriguchi et al. 2005

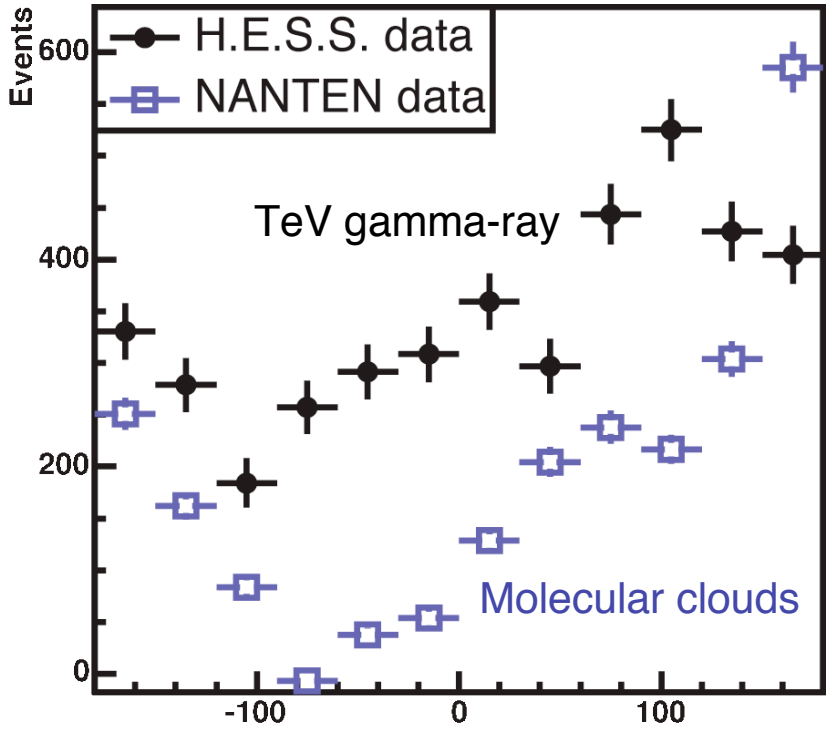
TeV Gamma-ray from SNR

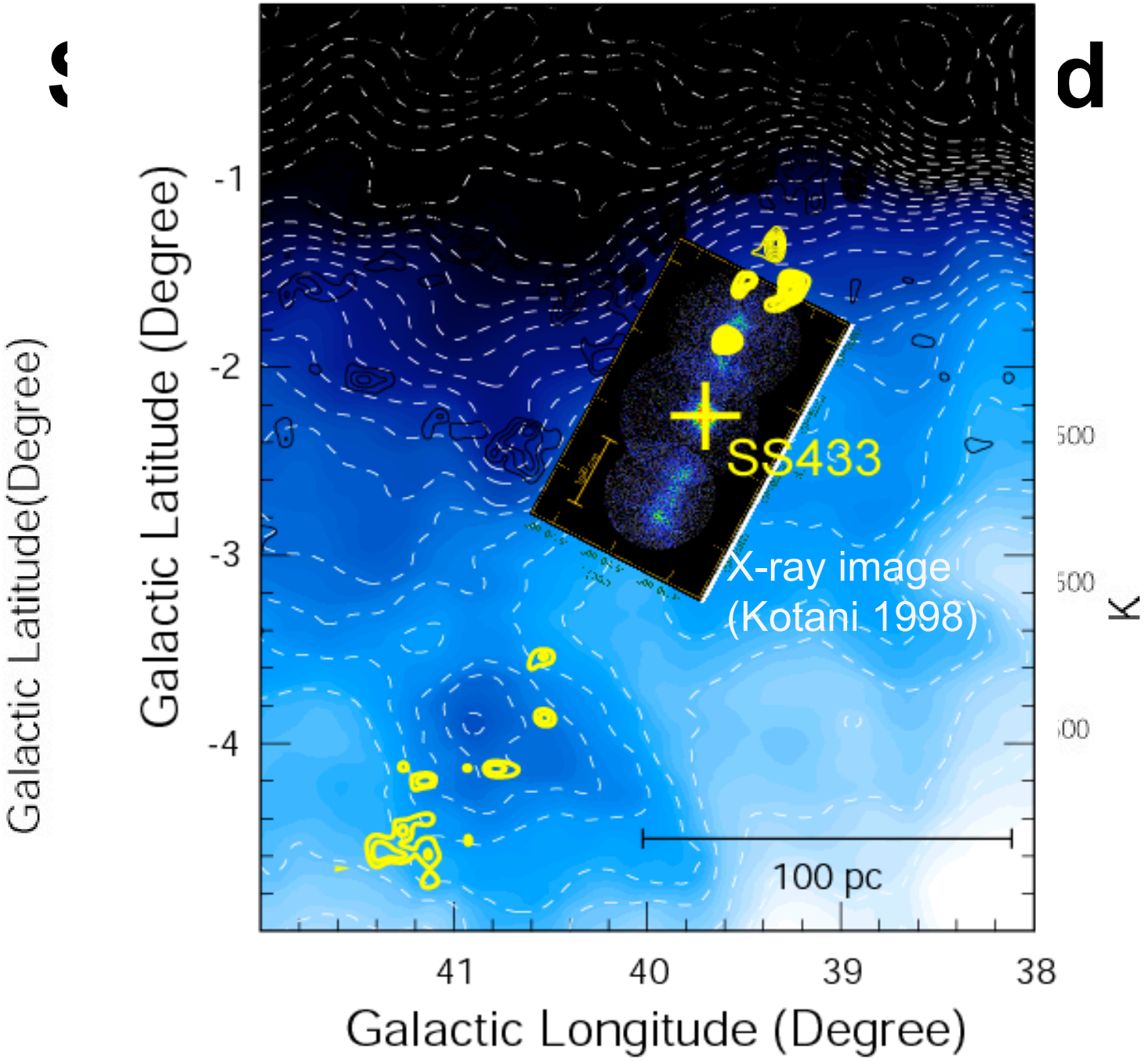
- **HESS TeV gamma-ray observation of RX J1713-3946**
  - **Evidence for particle acceleration > 100 TeV.**
  - **Azimuth profile does not match very well with molecular clouds.**
    - **Detailed 3D molecular cloud map (Nagoya Univ.)**
    - **Angular distribution from new particle interaction model (SLAC)**

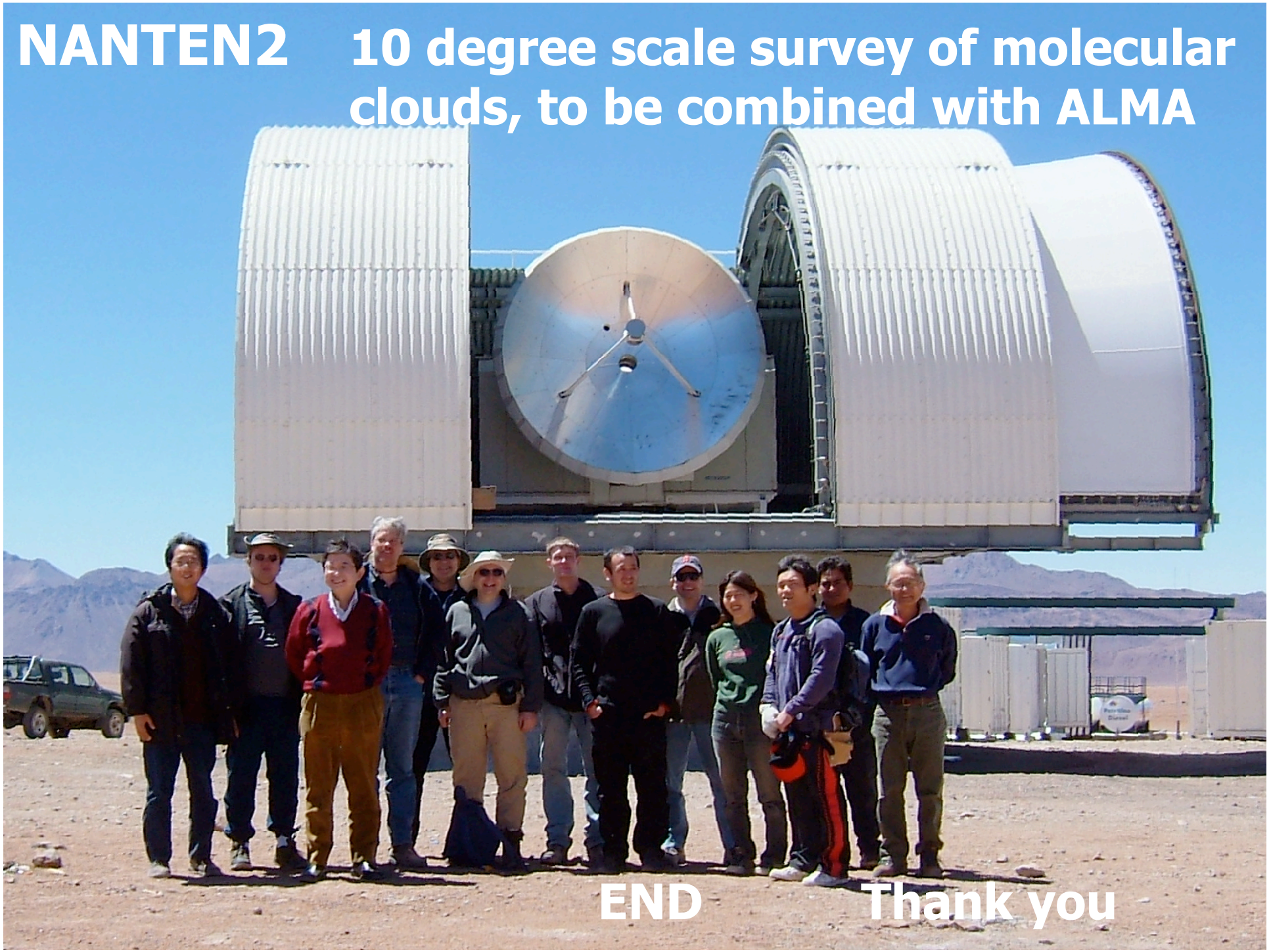
Aharonian et al. 2005

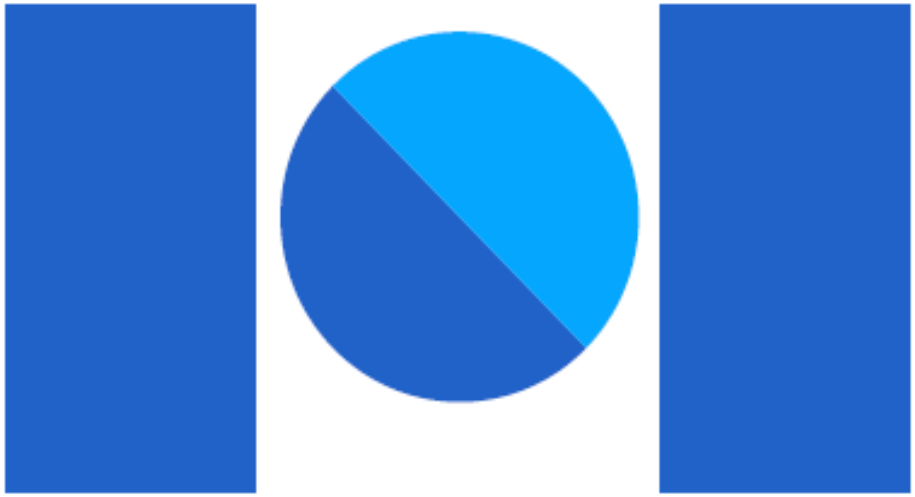


Aharonian et al. 2005




Galactic Latitude(Degree)
Galactic Latitude (Degree)
-1
-2
-3
-4
SS433
X-ray image
(Kotani 1998)
100 pc
500
500
K
41
40
39
38
Galactic Longitude (Degree)


NANTEN2
10 degree scale survey of molecular clouds, to be combined with ALMA
END
Thank you



NANTEN
Submillimeter Observatory