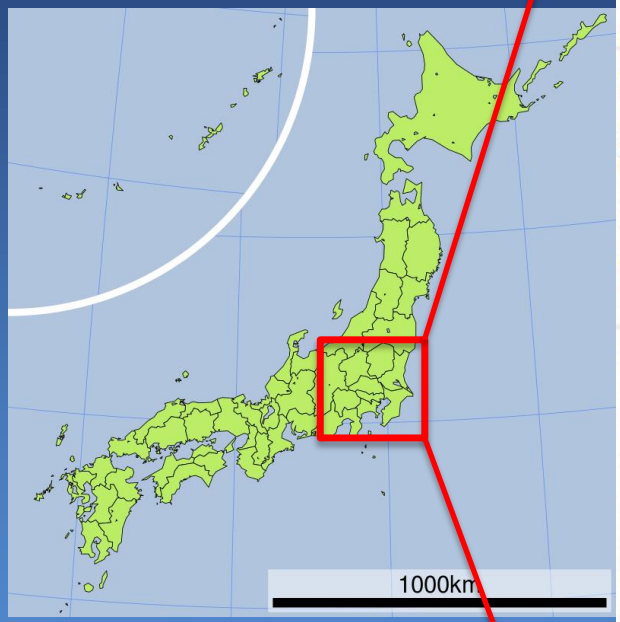
Activities of the observational astronomy group at Univ. of Tsukuba

Nario Kuno

Univ. of Tsukuba

University of Tsukuba



University of Tsukuba Astronomy group

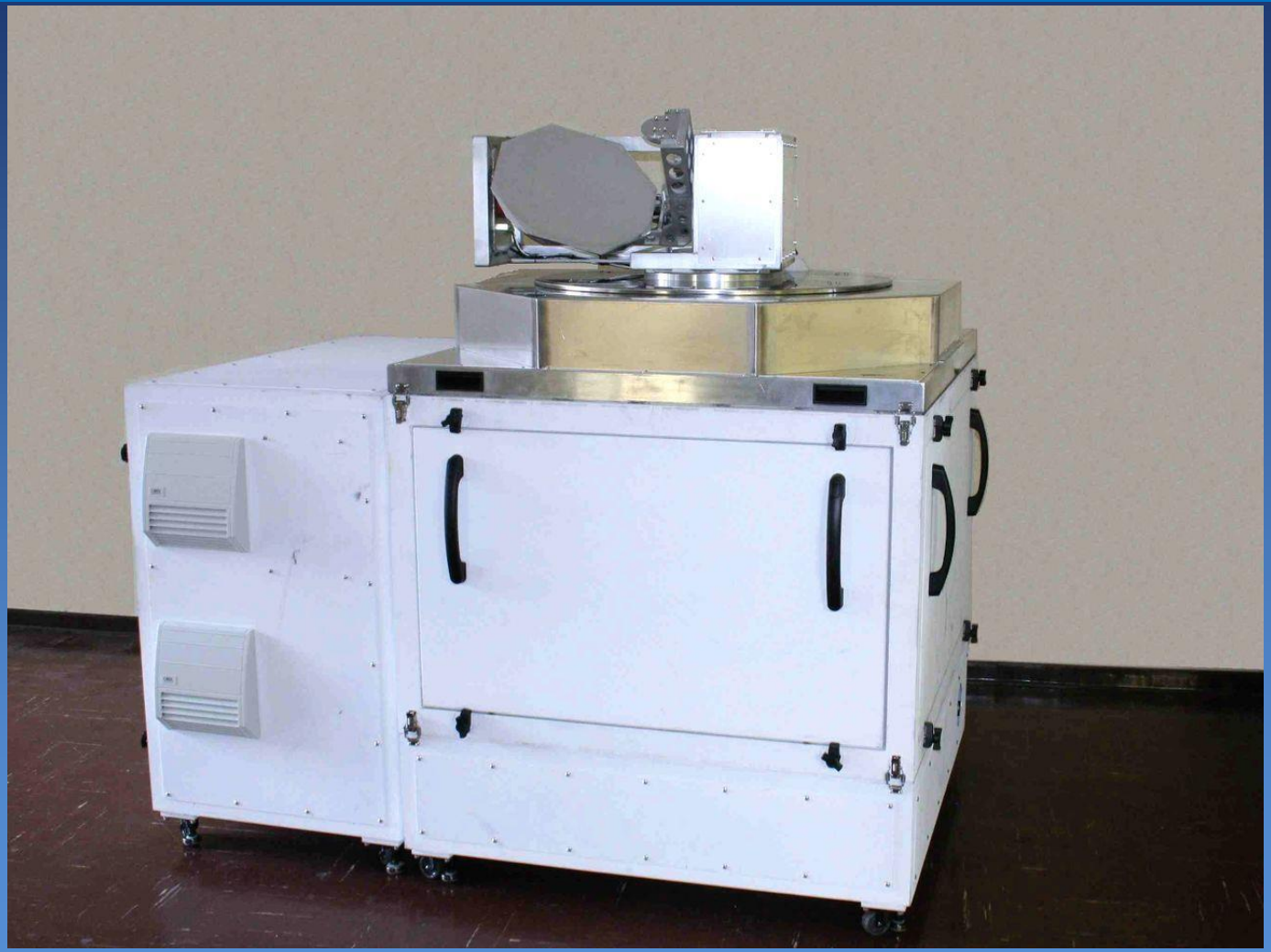
- Observational astronomy group
  - Nakai, N. (Group leader, professor)
  - Kuno, N. (professor)
  - Nitta, T (assistant professor)
  - Nagai, M., Saito,H. (postdoc)
  - Graduate student: 15 (3 foreign students)
  - Undergraduate student: 3
- Theoretical astronomy group
  - Umemura, M. (group leader, professor) et al.

Research and Development

1. Development of instruments
   - Tsukuba 30-cm Submm Telescope
   - Antarctic 10-m Terahertz Telescope
   - Radio Camera for Nobeyama 45-m Telescope

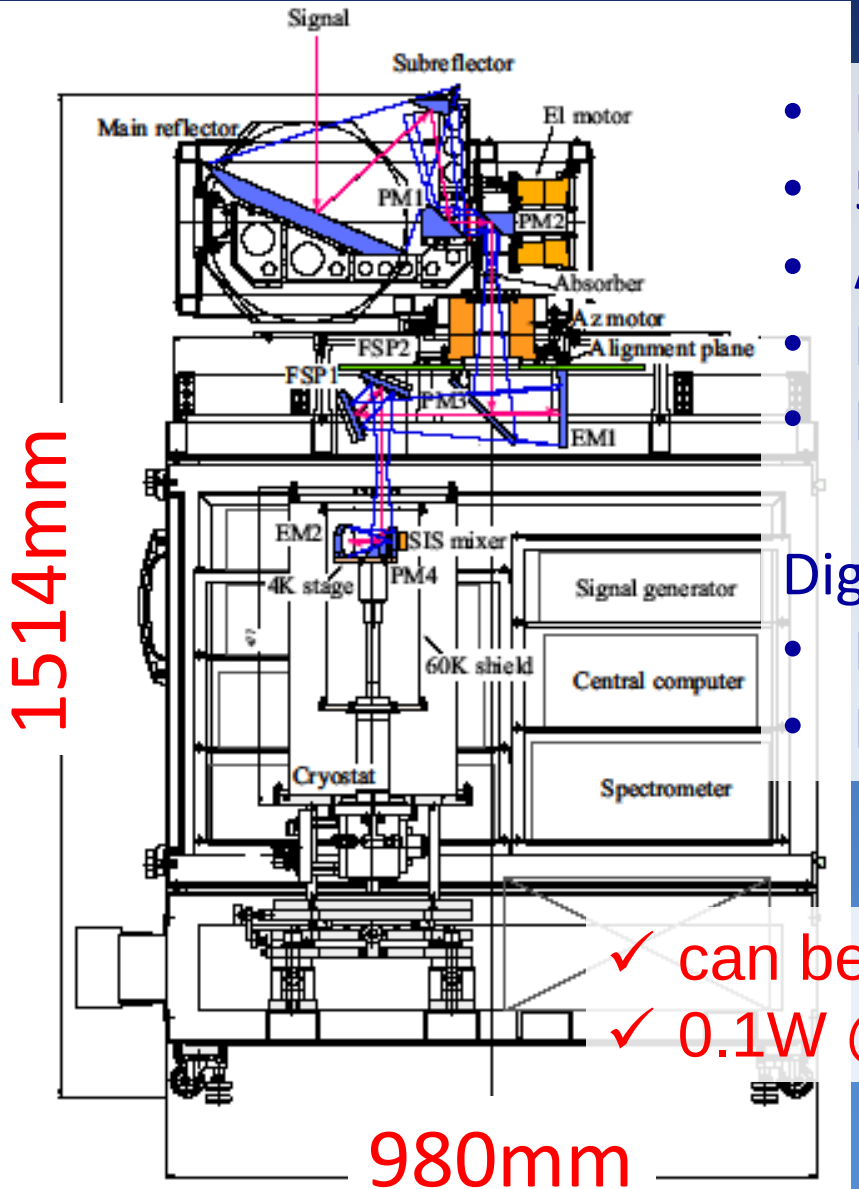
2. Observations with existing telescopes
   - Tsukuba 32-m Telescope
   - Nobeyama 45-m Telescope Legacy Projects
     - FUGIN (FOREST Ultra-wide Galactic Plane Survey In Nobeyama)
     - COMING (CO Multi-line Imaging of Nearby Galaxies)

Tsukuba 30-cm submm telescope



Ishii, Seta et al. (2016)

Tsukuba 30-cm Submm. Telescope



- Diameter : 30cm (offset Cassegrain)
- 500 GHz SIS receiver
- Angular resolution (HPBW) : 9’.4±0’.4
- Man beam efficiency : 0.87±0.10
- Receiver noise temperature : 900 K

Digital Spectrometer (FX)

- Bandwidth : 1 GHz
- Resolution : 61 kHz

✓ can be assembled by hands of 4 people

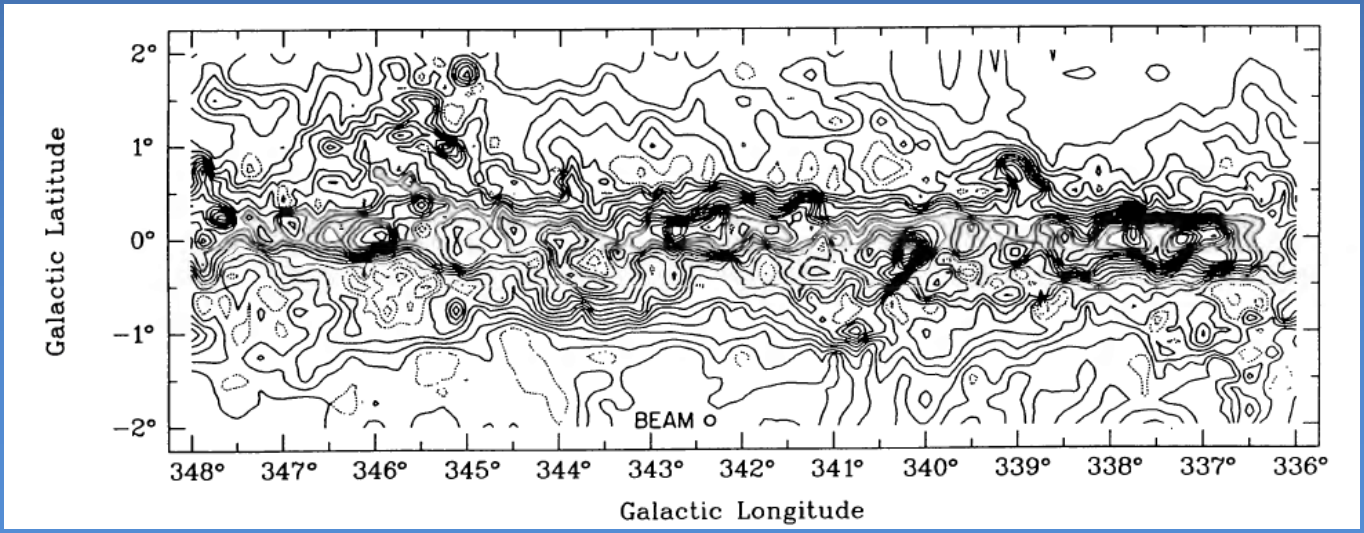
✓ 0.1W @ 4 K cooler

Mapping of the Milky Way in CO(4-3)

- Univ. Chile-Columbia-CfA CO(1-0) survey
  (Bronfman et al. 1988, 1989)
- Univ. Tokyo CO(2-1) survey (Sakamoto et al. 1995)

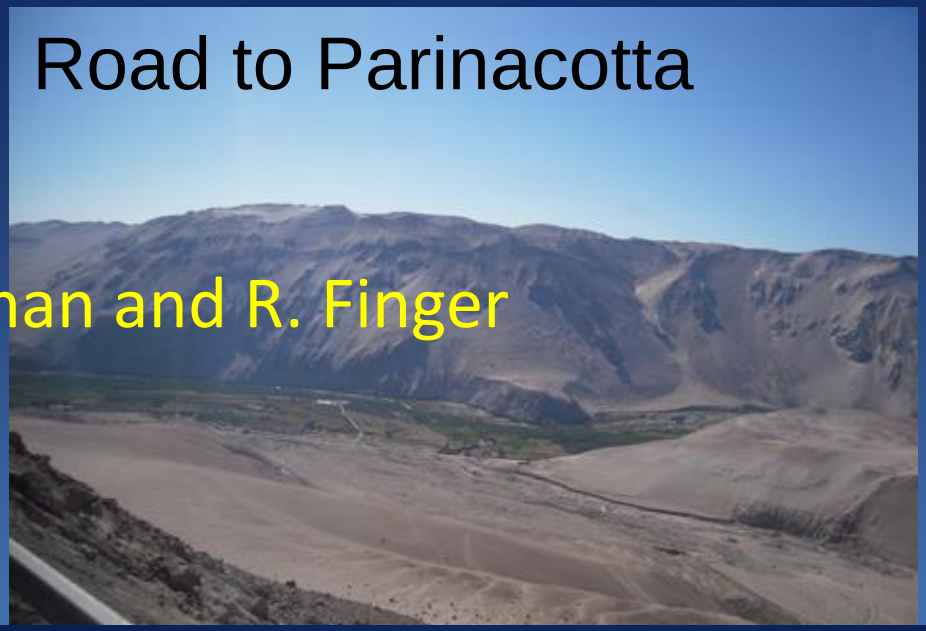
⇒ Same beam size (~9')

⇒ Physical condition (density, temp.) of molecular gas from the line ratios

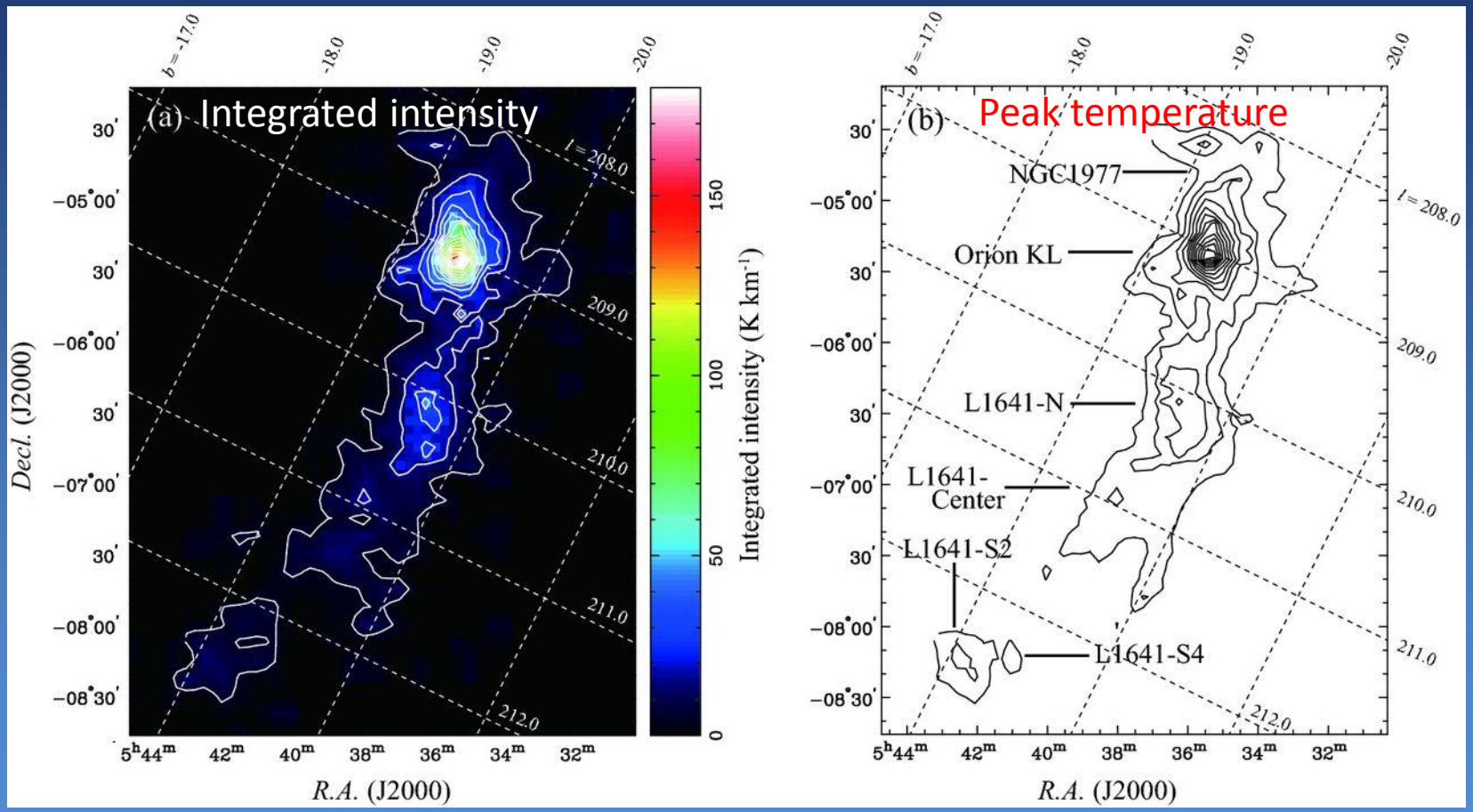


CO(1-0): Bronfman et al. (1989)

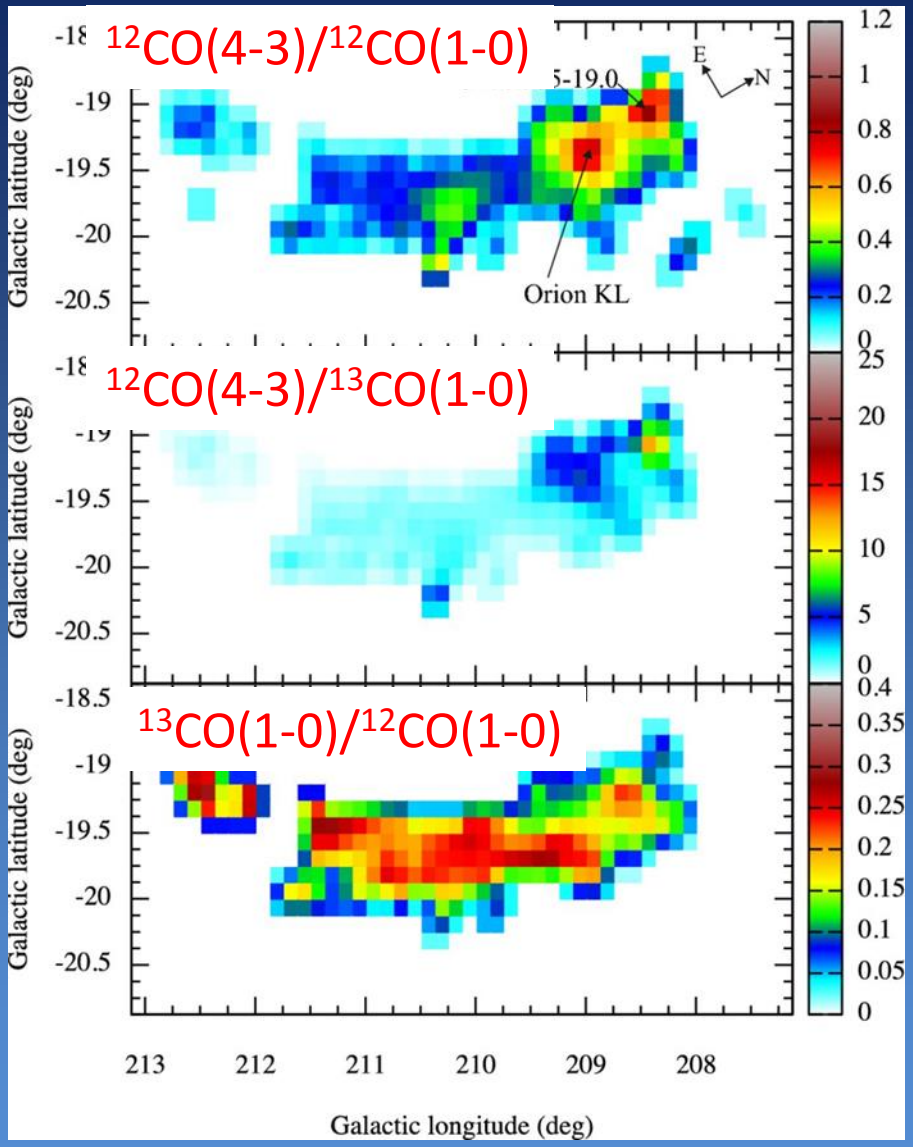
Observations with 30-cm telescope in Chile

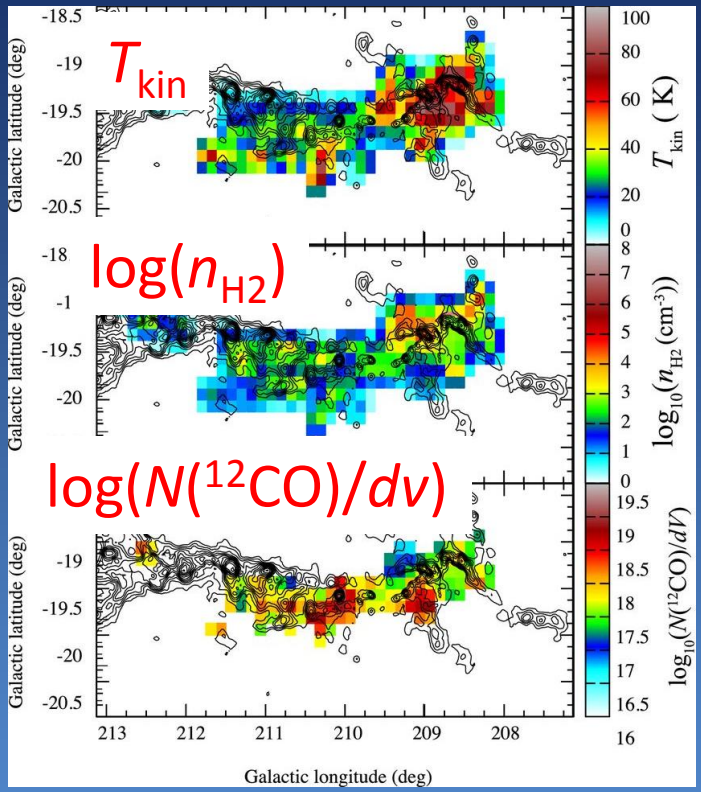


^{12}CO (J = 4–3) observations of Orion-A giant molecular cloud



Ishii, Seta et al. (2016)





Ishii, Seta et al. (2016)

Present status and future plan

- Test observations at Nobeyama Radio Observatory (2015)
  - Check of pointing model (@220GHz)

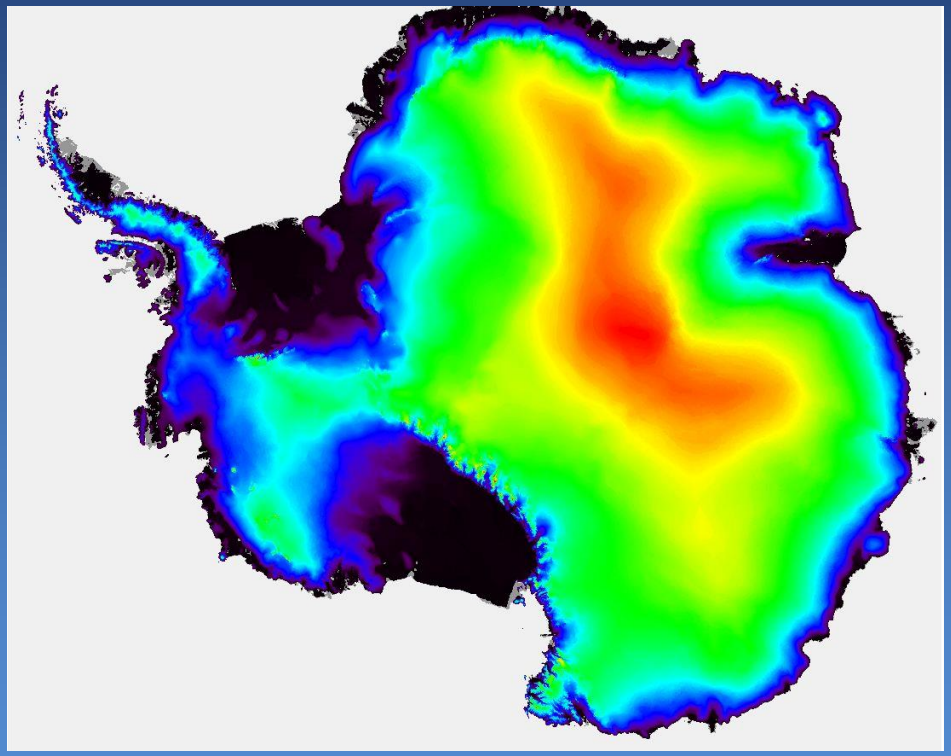
- Observations at a high site in Chile?
  - Collaboration with Seta, M. et al. (Kwansei gaikuin Univ.)
- Observations in Antarctica?

Antarctic 10-m Terahertz Telescope

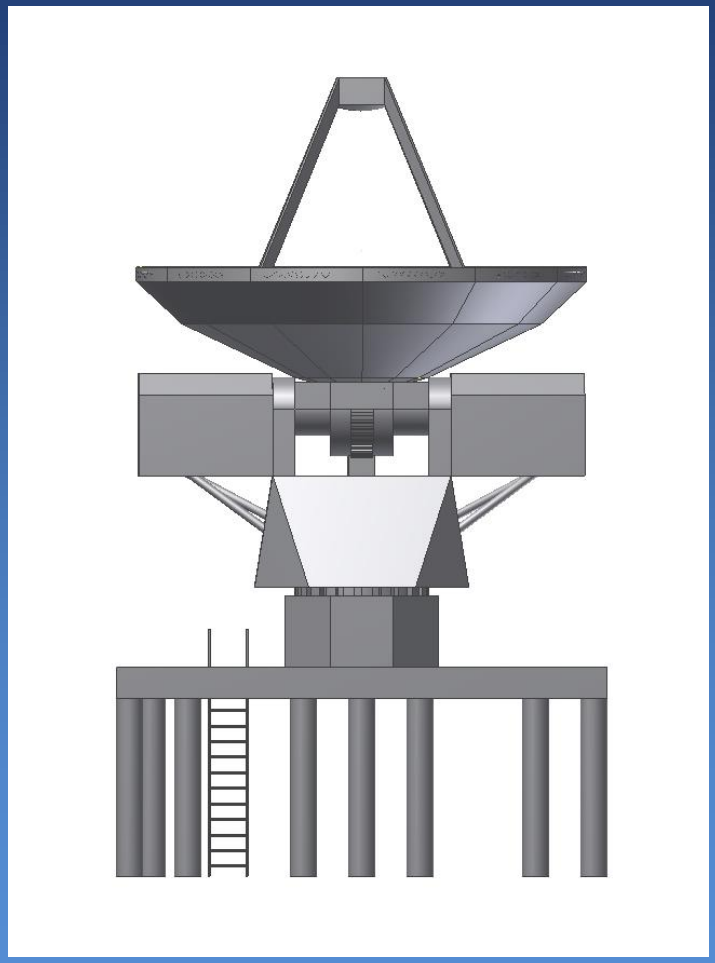
Collaborators of other institues

- Seta, M. (Kwansei Gakuin Univ.)
- Sorai, K. (Hokkaido Univ.)
- Sekimoto, Y. (National Astronomical Observatory of Japan)
- Kim (National Institute of Technology, Fukushima collage)
- Naruse, M. (Saitama University)
- Nishibori, T. (JAXA)

et al.



Antarctic 10-m Terahertz Telescope

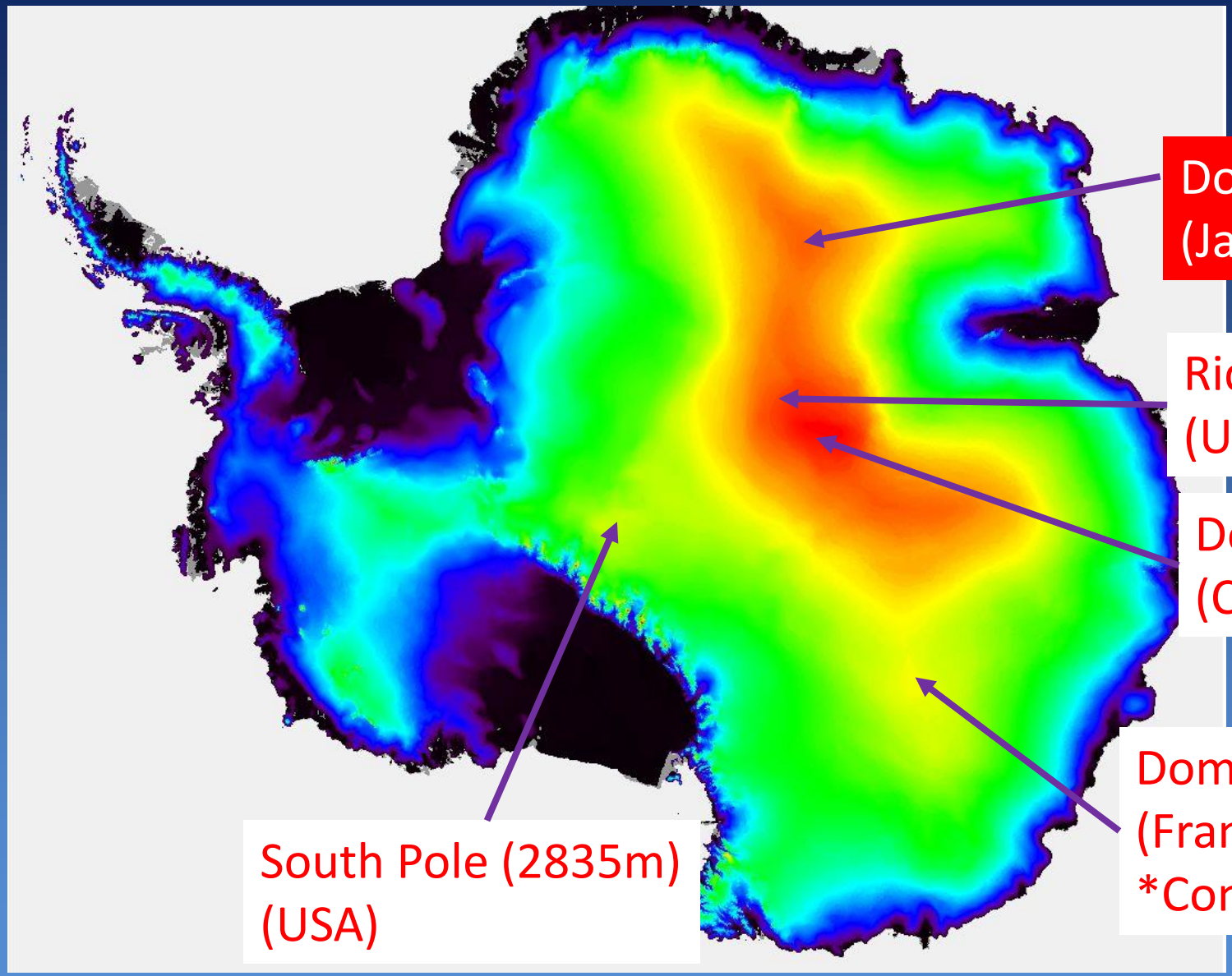


- Diameter : > 10m
- Ritchey–Chrétien
- Field of view : 1°
- Surface accuracy : < 20μm
- Frequency : 200GHz-1.3THz
- Pointing accuracy : 2″
- Tracking accuracy : 0.5″

Angular resolution

200GHz	800GHz	1.3THz
37″	9.3″	5.8″

Antarctica



Dome F (3810m)
(Japan)

Ridge A (4050m)
(USA)

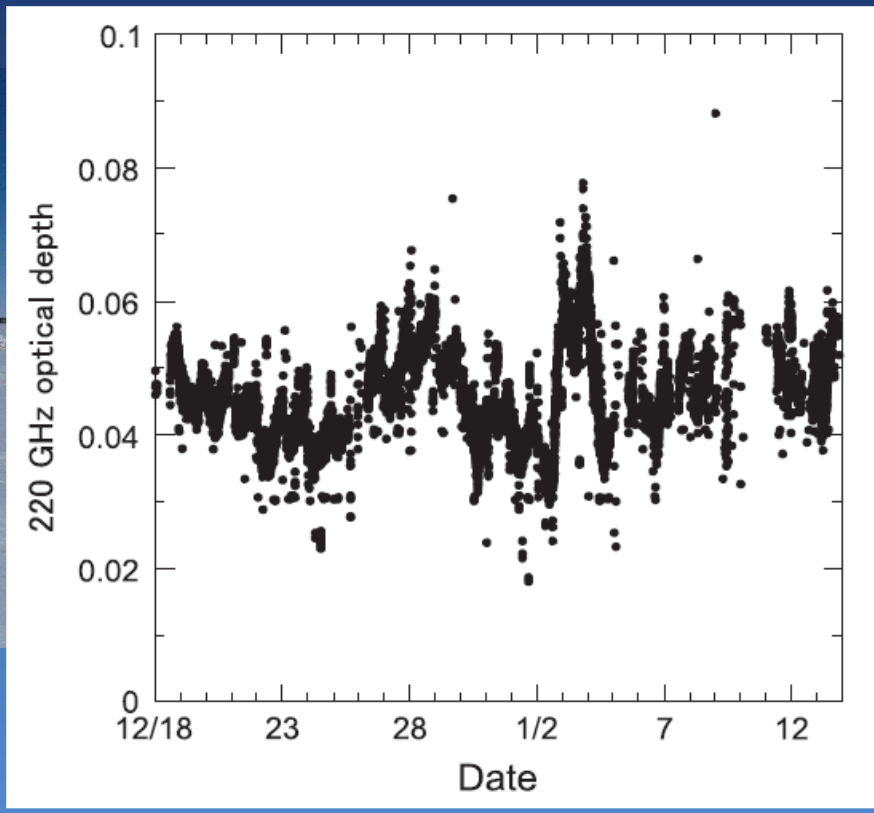
Dome A (4090m)
(China)

Dome C (3230m)
(France & Italy)
*Concordia Station

South Pole (2835m)
(USA)

Site test at Dome Fuji

220 GHz radiometer @ Dome F



220 GHz optical depth

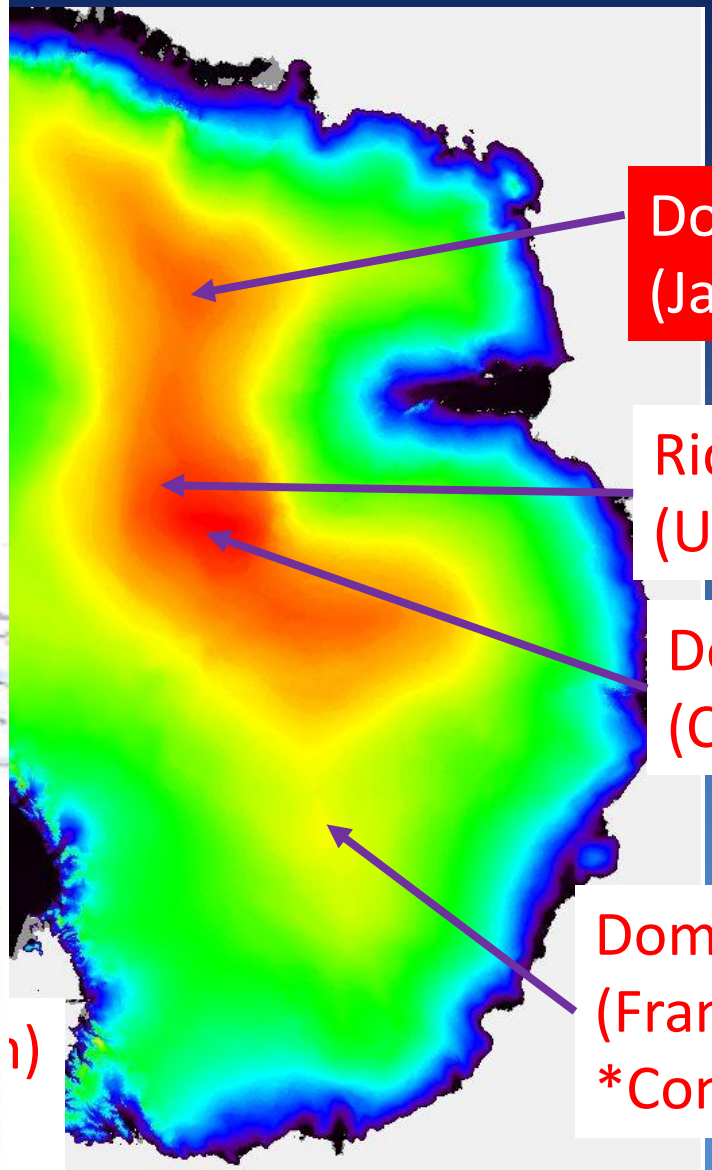
Ishii et al. (2010)

ntarctica

Jan. 1995

Feb. 2003

(from Kameda_2009_Seppyo)



Dome F (3810m)
(Japan)

Ridge A (4050m)
(USA)

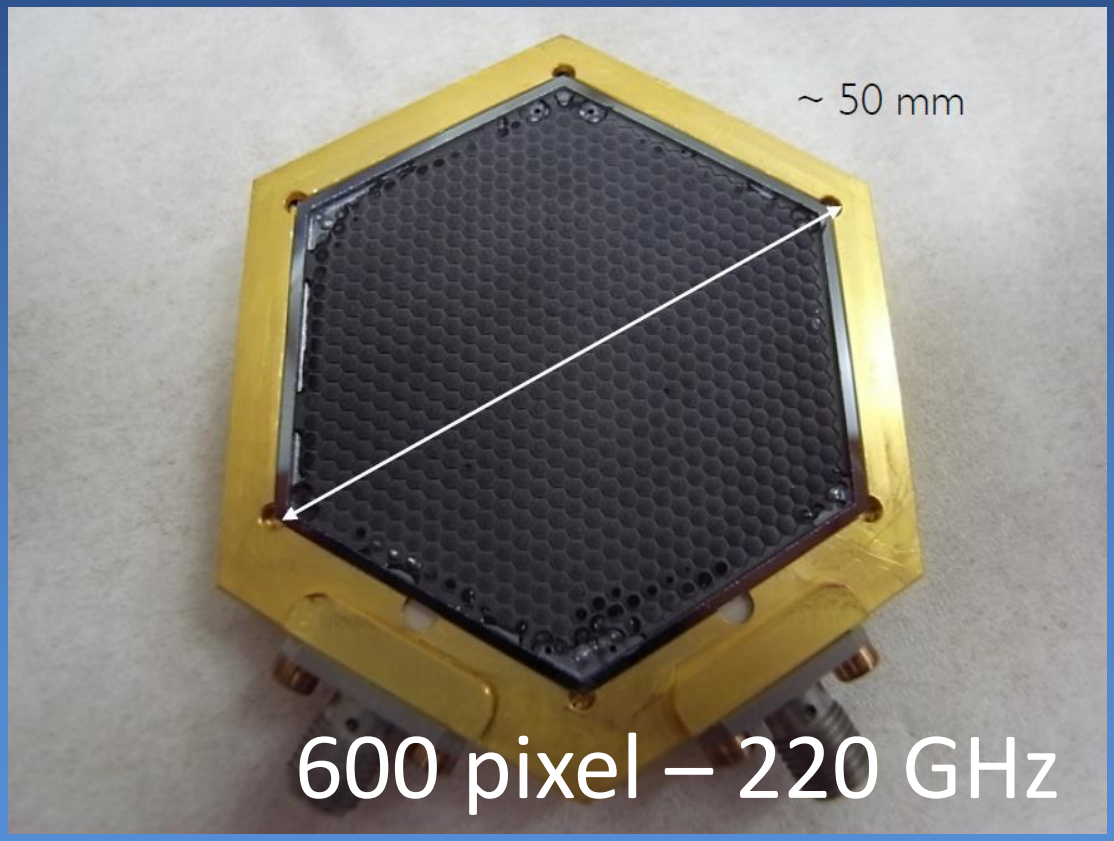
Dome A (4090m)
(China)

Dome C (3230m)
(France & Italy)
*Concordia Station

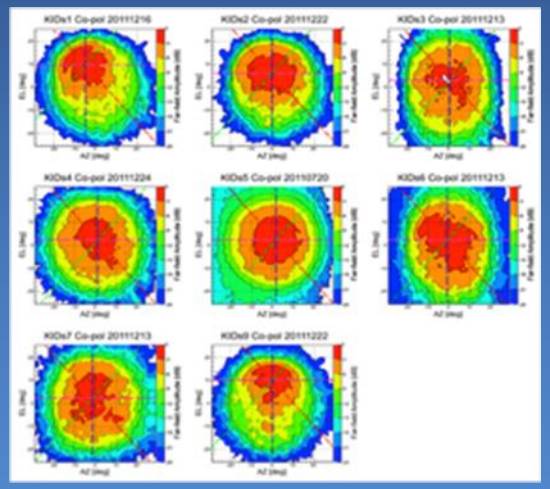
Antarctica

Wide Field Radio Camera

- MKID(Microwave Kinetic Inductance Detector)
  - NEP = $6 \times 10^{-18}\ \mathrm{W}/\sqrt{\mathrm{Hz}}$



600 pixel – 220 GHz

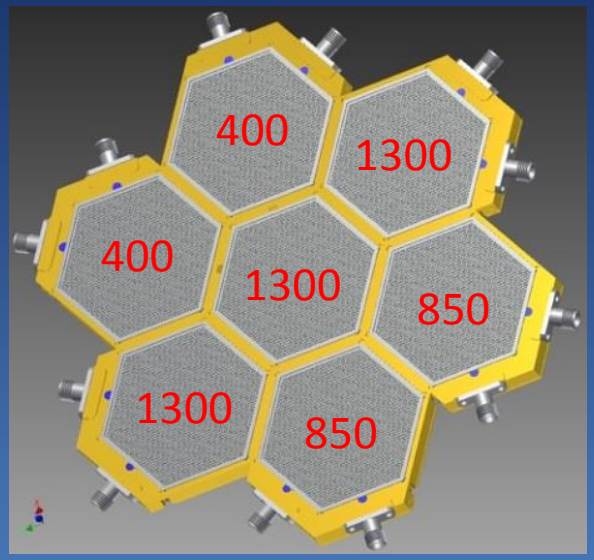


220 GHz Beam pattern

(Nitta et al. 2013)

Wide Field Radio Camera

600 pixels
FoV ~ 0.1˚



～20,000 pixels
FoV ~ 1˚

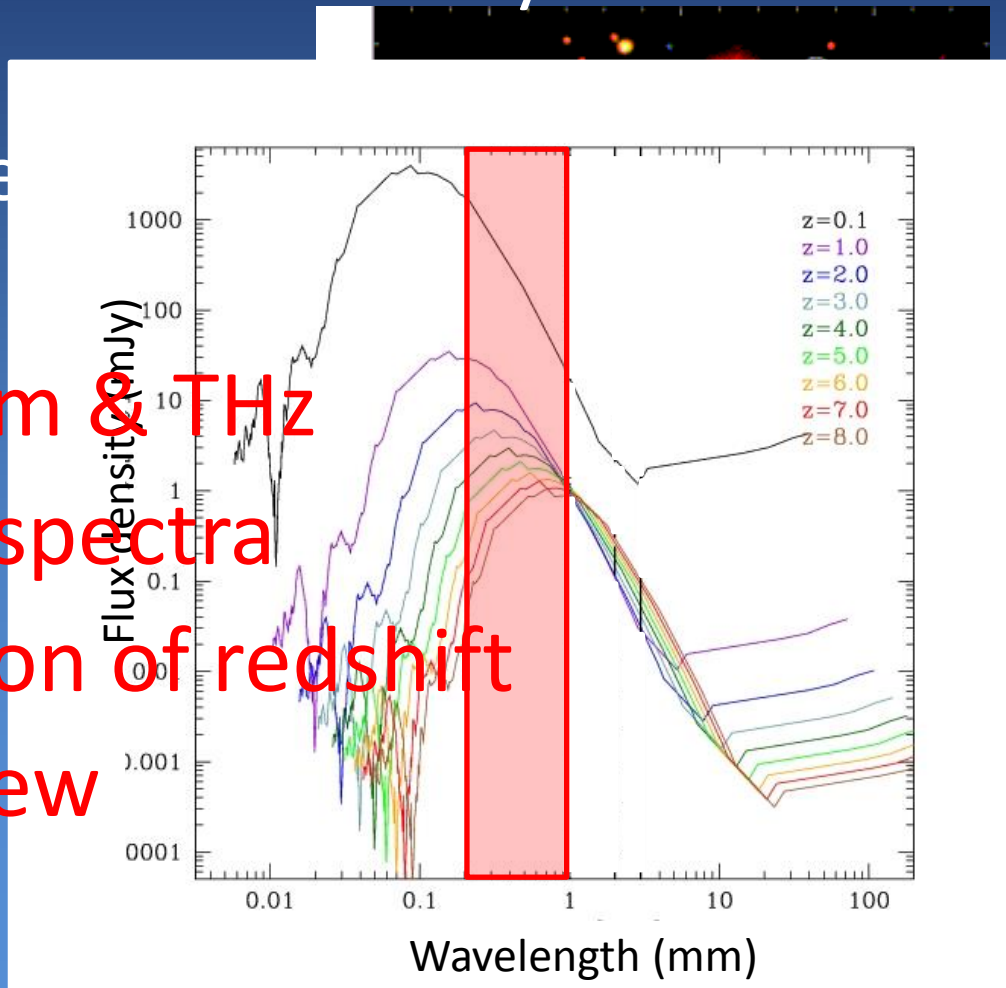
- 400GHz, 850GHz, 1.3THz
  - simultaneous observations

Survey of distant galaxies

- Submm galaxies

  ⇒ Young distant galaxies obscured by interstellar dust

  ⇒ evolution of galaxie



✓ Survey at Submm & THz

✓ THz ⇒ Peak of spectra

⇒ rough estimation of redshift

✓ Wide field of view

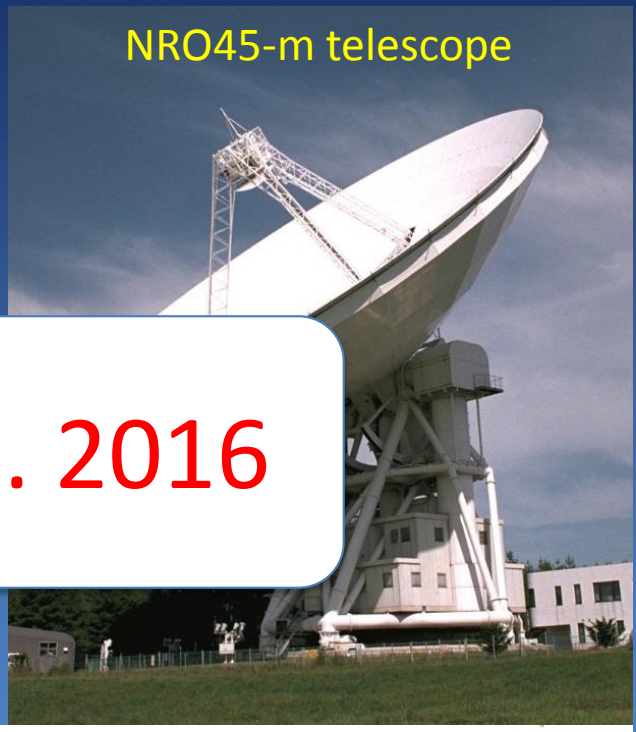
Schedule

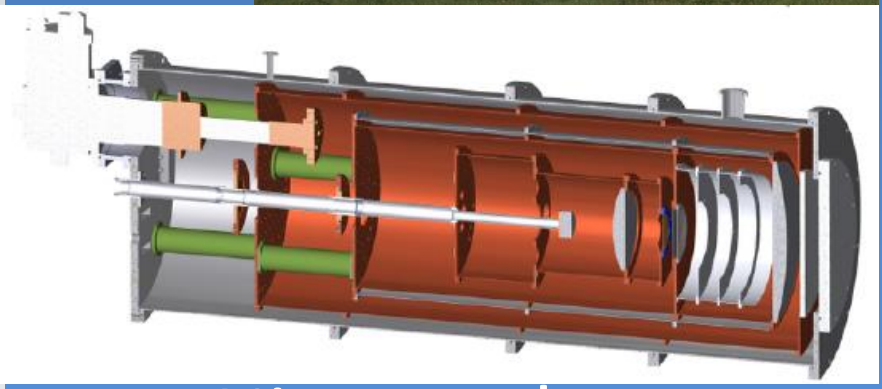
- 2017 Budget request
- 2018 Design & Fabrication
- 2019 ⬇
- 2020 Construction @ Univ. of Tsukuba
- 2021 Tests & Adjustments
- 2022 ⬇
- 2023 Transport to Antarctica
- 2024 Construction @Dome C

Radio camera for NRO 45-m telescope

- Lens-coupled MKID camera
- 109 pixels
- 100 GHz
- FoV

will be installed in Dec. 2016



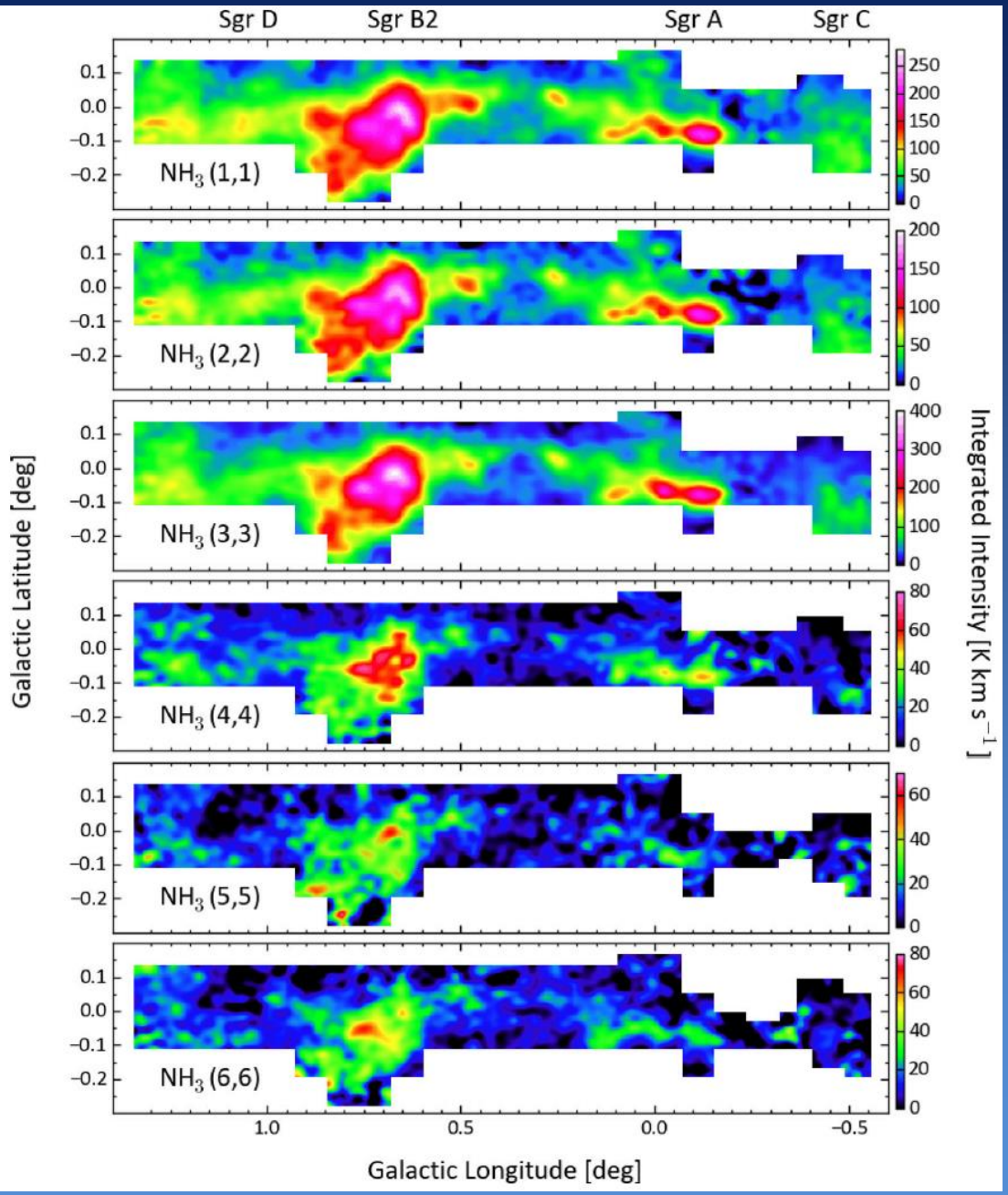


Nitta et al.

Tsukuba 32m Telescope

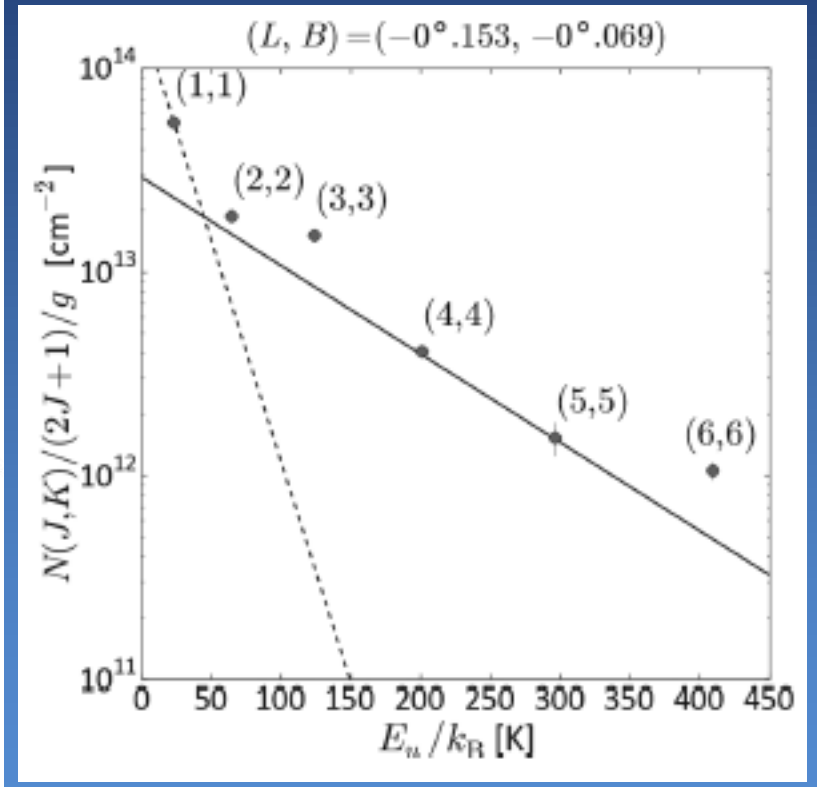
- The Geospatial Information Authority of Japan (Geodetic VLBI)
- Single dish（20 GHz）
  - NH_3 mapping of star forming regions
  - NH_3 survey of the Galactic Plane
- will be closed in 2017

The Galactic center



$NH_3(1,1)$-$(6,6)$

⇒ Temperature



Arai et al. (2016)

NRO Legacy Projects

- NRO 45-m telescope
  - ~15”@115 GHz
- FOREST: new multi-beam receiver
  - 4 beam x 2 pol. x 2 SB
- Multi-line mapping with high angular resolution

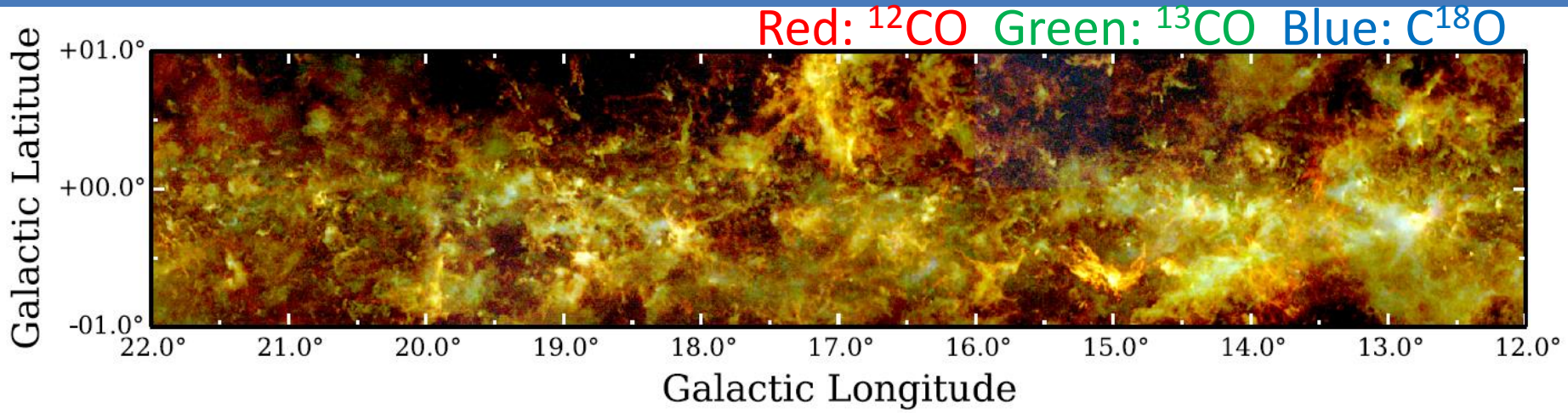
➢ FUGIN

➢ COMING

FUGIN

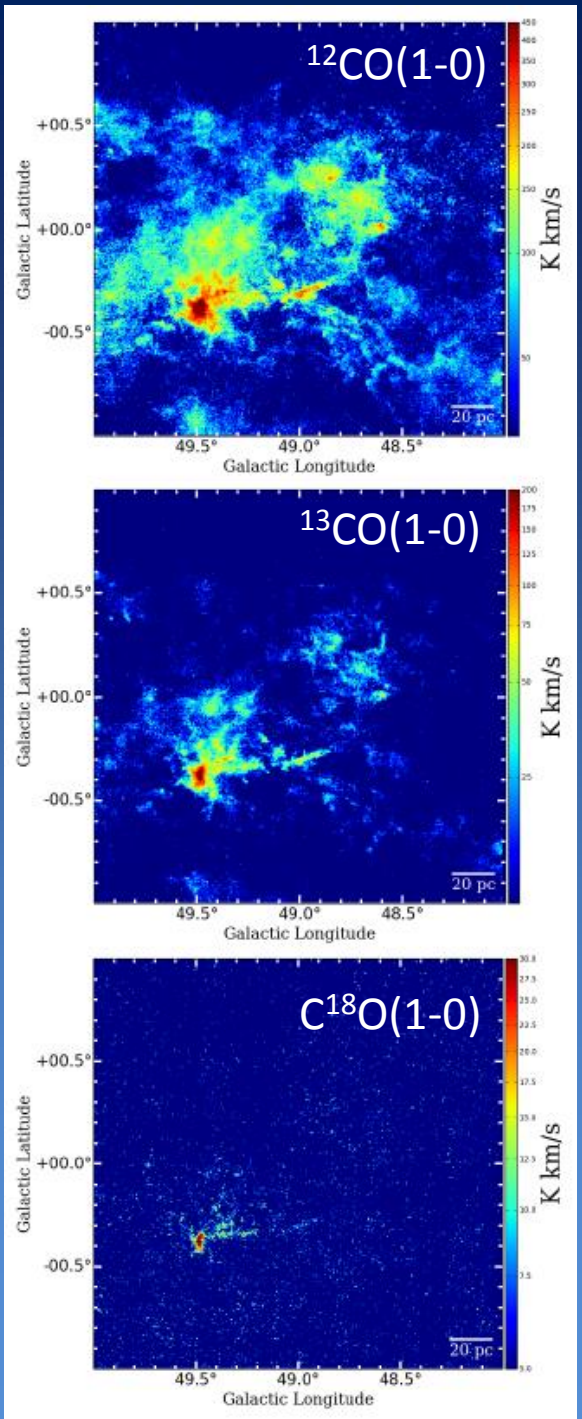
(FOREST Ultra-wide Galactic Plane Survey In Nobeyama)

- Umemoto, Minamidani (NRO) et al.
- ^{12}CO(1-0), ^{13}CO(1-0), C^{18}O(1-0) survey of the Galactic Plane
  - l = 10°-50°, 198°-236°　|b| ≦ 1˚
  - Beamsize　～15”



Univ. Tsukuba

- W51 GMC (Fujita et al.)
- SNR Kes79 (Kuriki et al.)



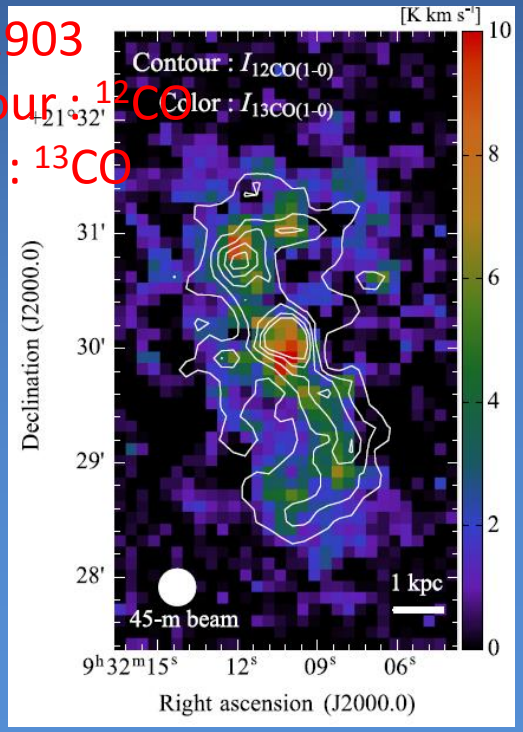
W51
(Fujita et al.)

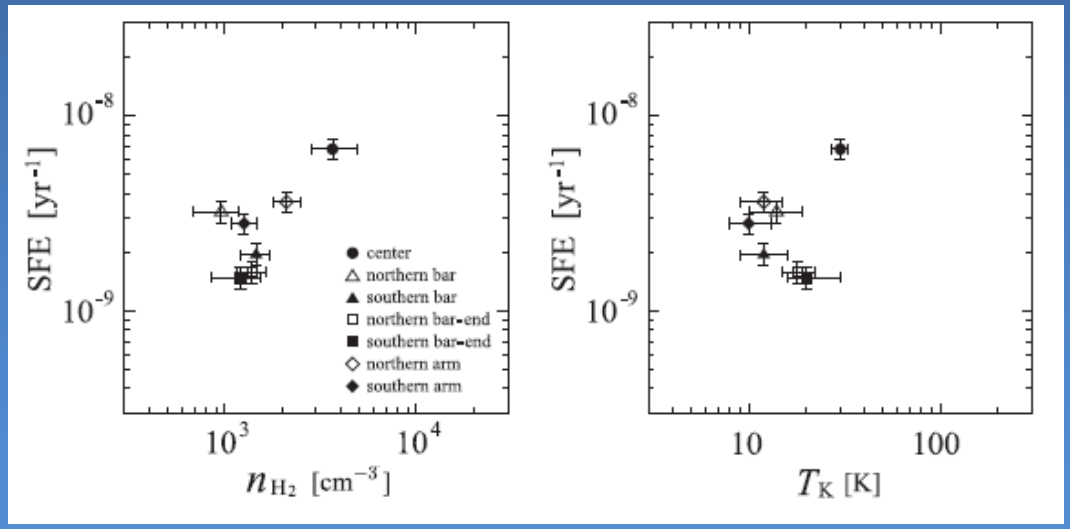
COMING

(CO Multi-line Imaging of Nearby Galaxies)

- Sorai (Hokkaido Univ.) et al.
- ^{12}CO(1-0), ^{13}CO(1-0), C^{18}O(1-0) mapping of nearby galaxies (more than 200 galaxies)

NGC2903
Contour : ^{12}CO
Color : ^{13}CO

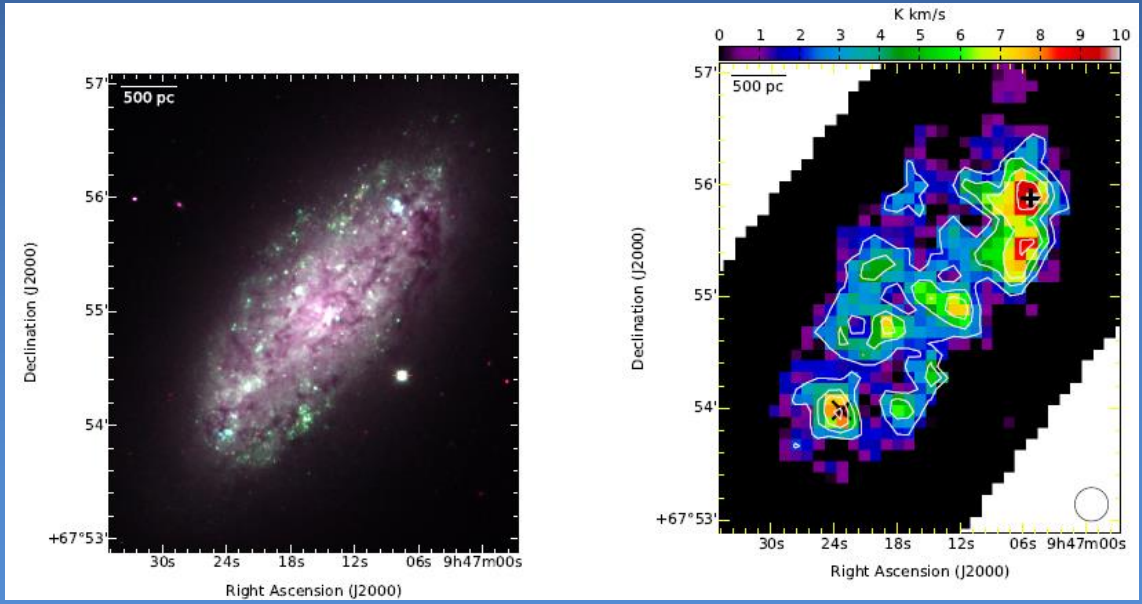


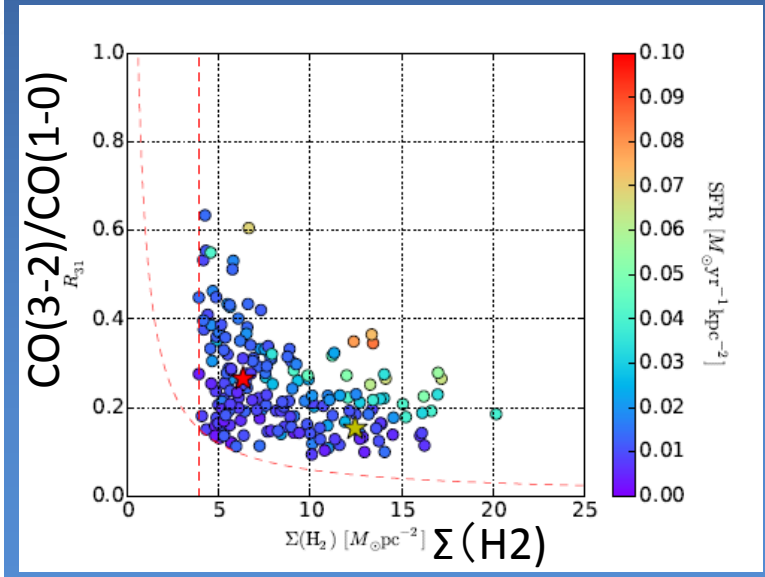


Muraoka et al. (2016)

Univ. of Tsukuba

- NGC 2976 (Hatakeyama et al. 2016, submitted to PASJ)
- ^{13}CO vs SFR (Sato et al.)
- GMCs in NGC 2976 (Yasuda et al.)





NGC 2976 (Hatakeyama et al. 2016)

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