Pa-alpha/beta imaging toward nearby starburst galaxy NGC 253

Kouichiro Nakanishi[1] & Nori Takahashi[2]

([1]NAOJ, [2]Univ. of Tokyo)

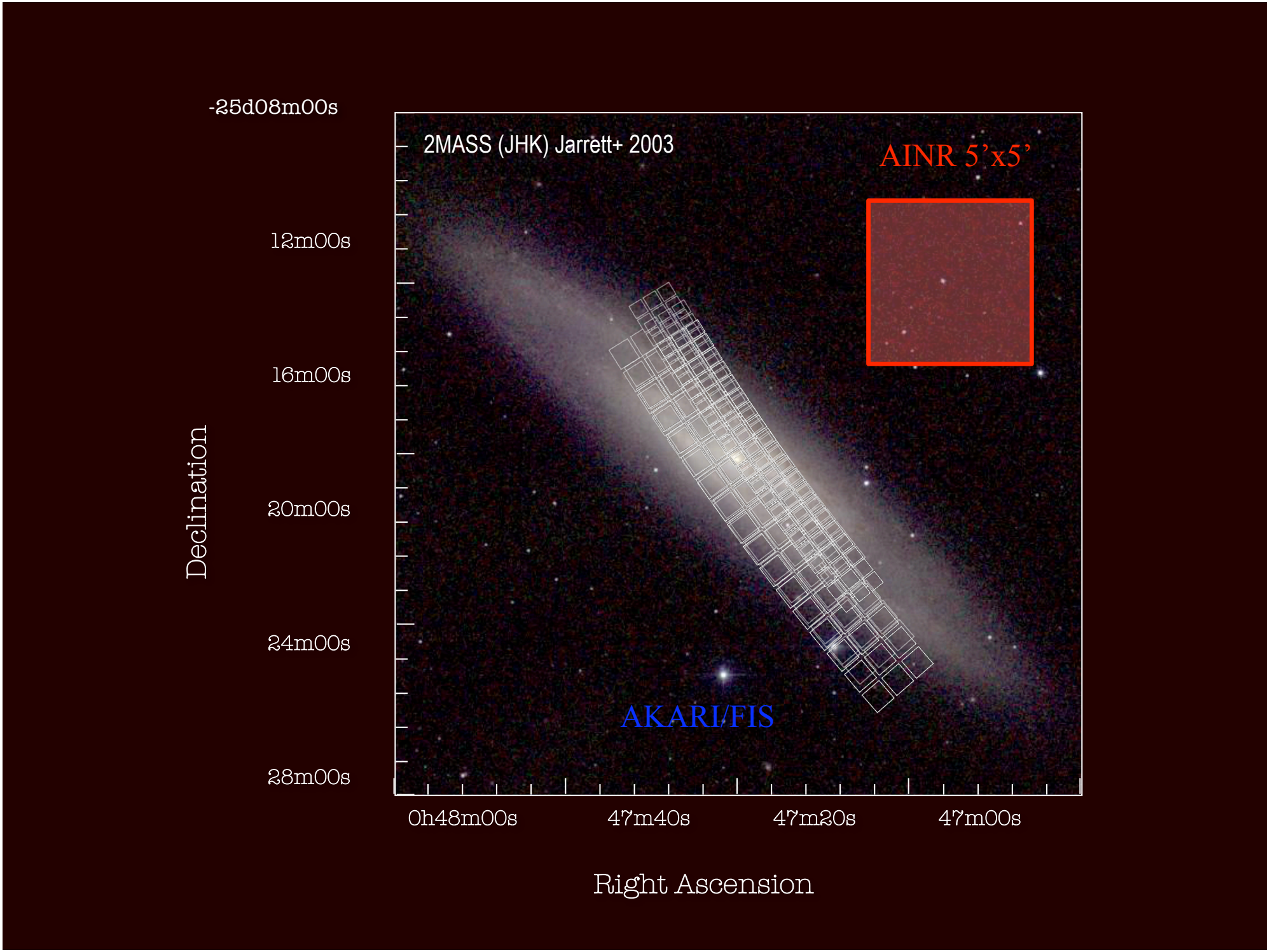
miniTAO WS 2013/3/15 at Mitaka

Abstract

- We propose observations of Pa-alpha/beta recombination lines toward the starburst regions in NGC 253.
- Primary aim of this study is revealing un-attenuated intensities and distributions of massive star-formation. Combining with our radio observation data, we will investigate necessary physical condition for starburst activity.

NGC 253

- Nearby barred spiral at D=3.4Mpc (1"= 17pc)
  - velocity=50~450 km/s (240 km/s@galaxy center)
- Active star-formation in the galaxy center
  - a few~several Msun yr^{-1}, highest SFR (D<5Mpc,d<0)
  - huge amount of molecular gas, and high star-formation efficiency (Sorai+ 2001, Nakanishi+ in prep.)
  - super star cluster (Fernandez-Ontiveros+ 2009)
- Question: what makes it possible to activate starburst?

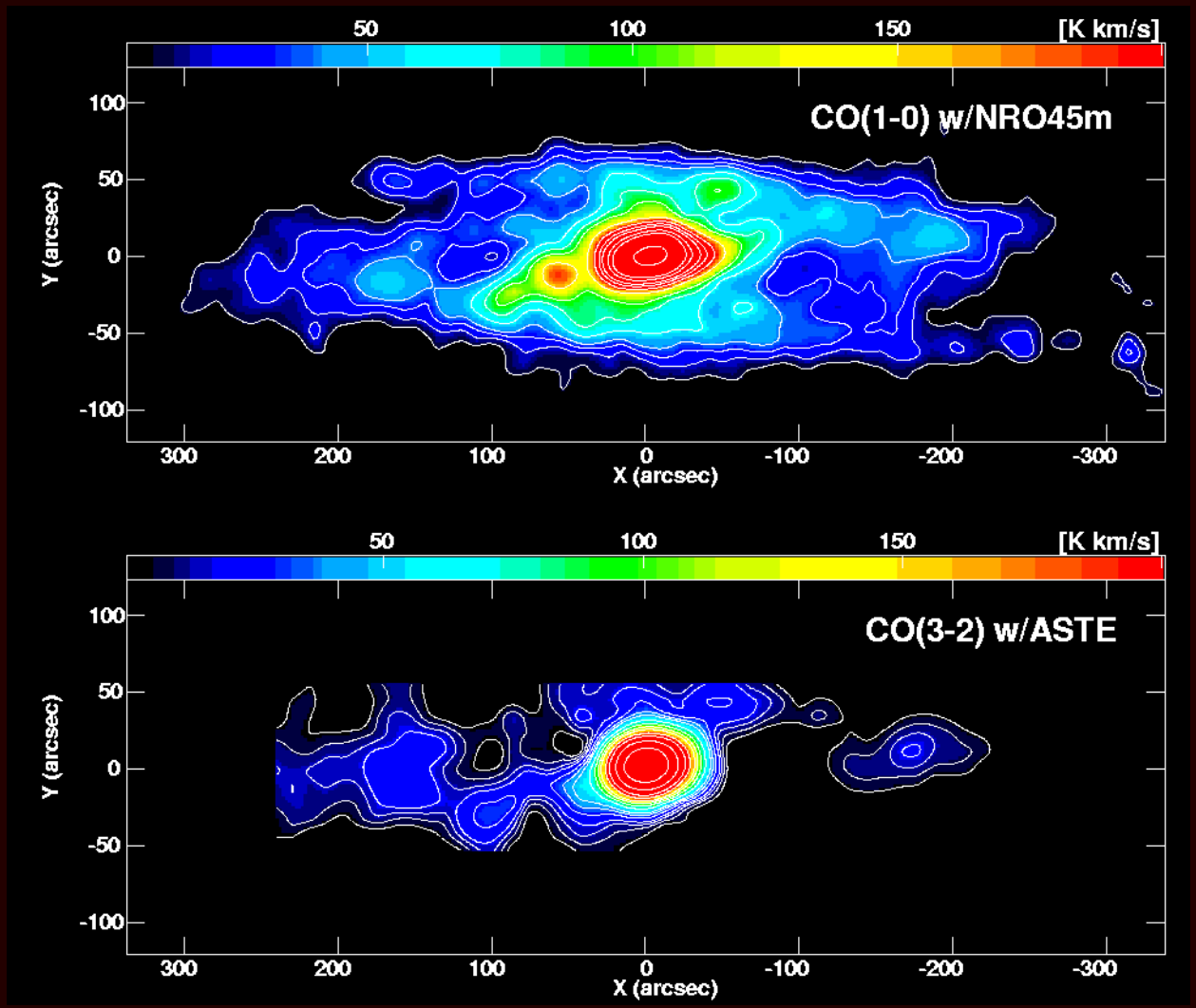

-25d08m00s
12m00s
16m00s
20m00s
24m00s
28m00s
Declination
2MASS (JHK) Jarrett+ 2003
AINR 5'x5'
AKARI/FIS
0h48m00s
47m40s
47m20s
47m00s
Right Ascension

Molecular gas observations

- Molecular gas (^{12}CO and ^{13}CO) observations have been made using NRO 45-m and ASTE
- Molecular gas at the galaxy center is denser and warmer than those at galaxy disk
- Star-formation activities are enhanced at the galaxy center, and star-formation efficiencies* are also enhanced.

  * star-formation rate per molecular gas mass

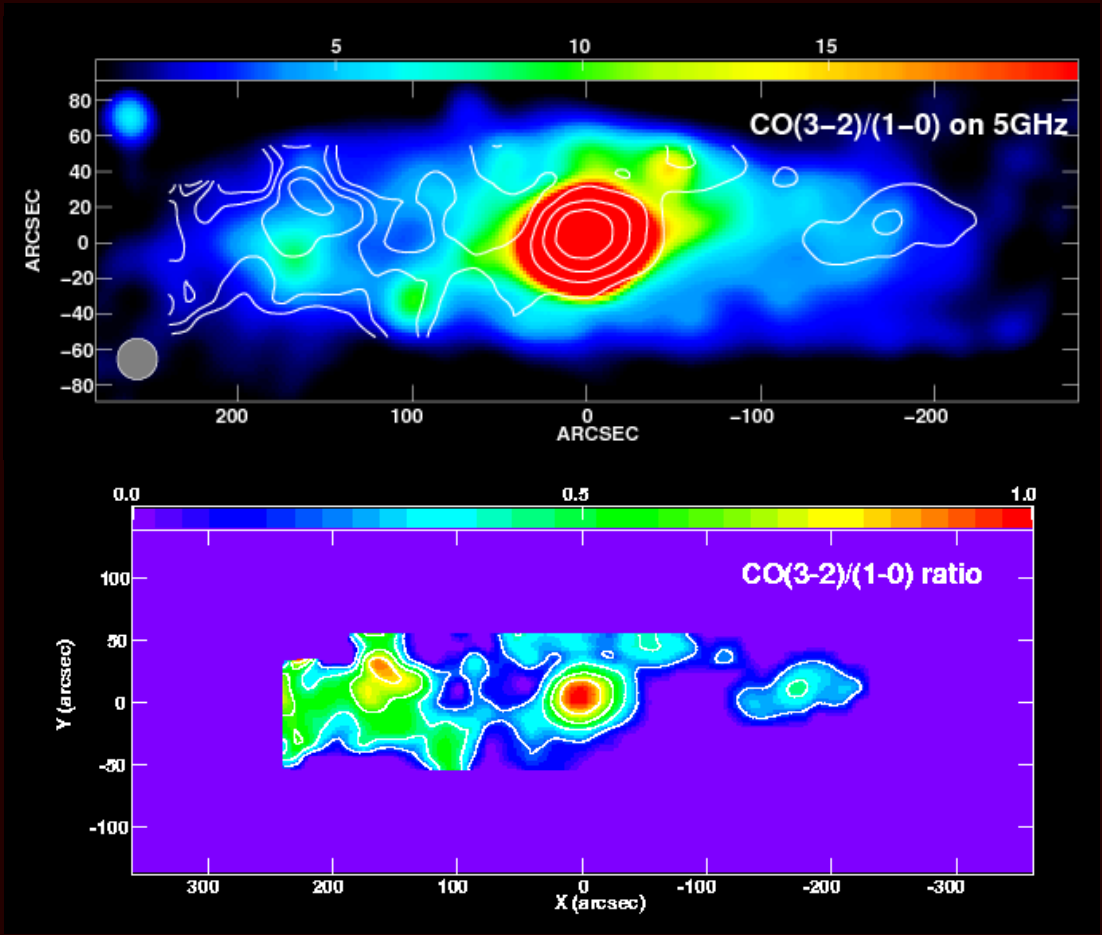
^{12}CO(1-0) and (3-2) maps on NGC253



- Center : Disk
  (r<500pc)
  = 1:2.6

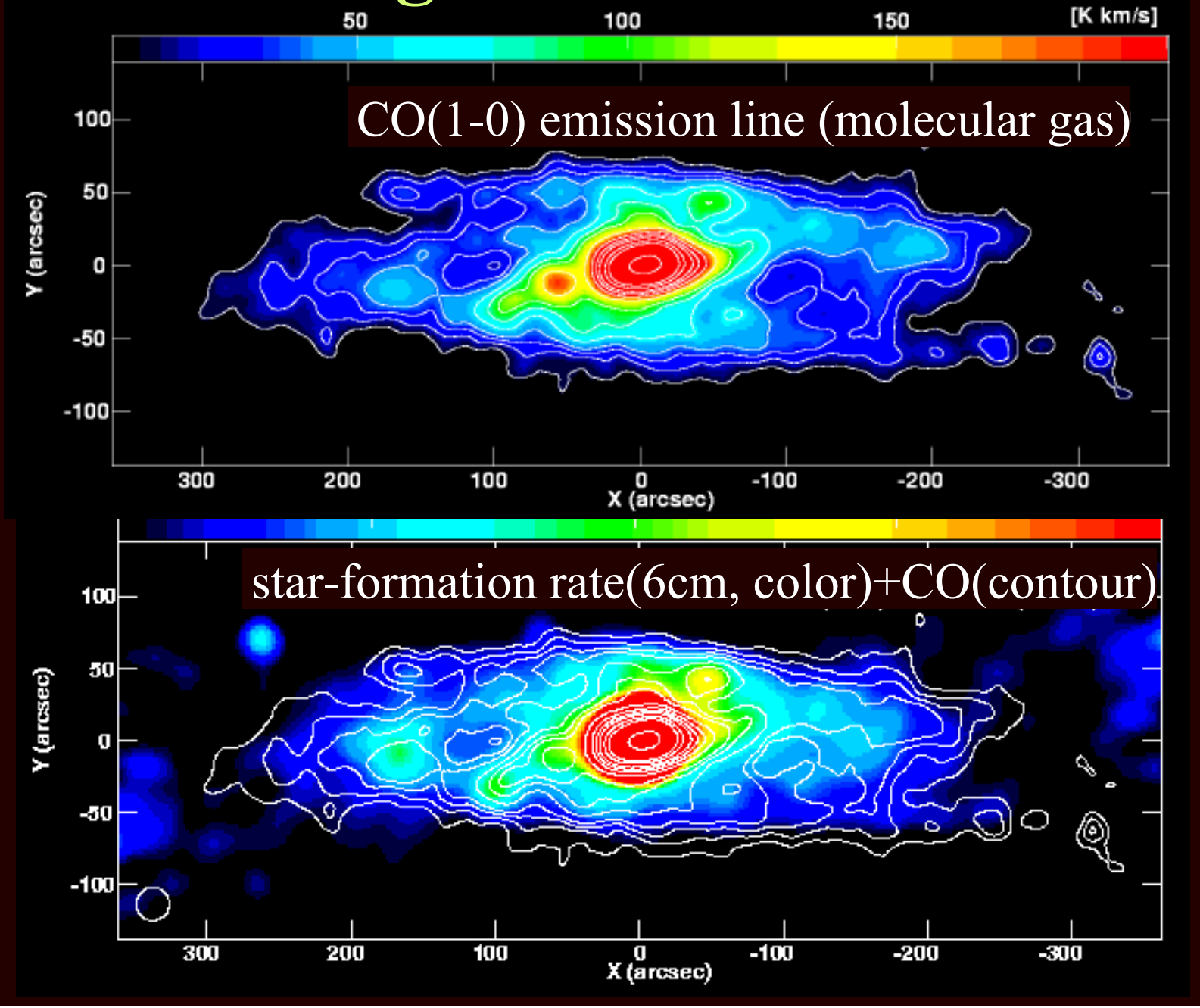
- Center : Disk
  = 1:0.7

CO(3-2) / (1-0) line ratio

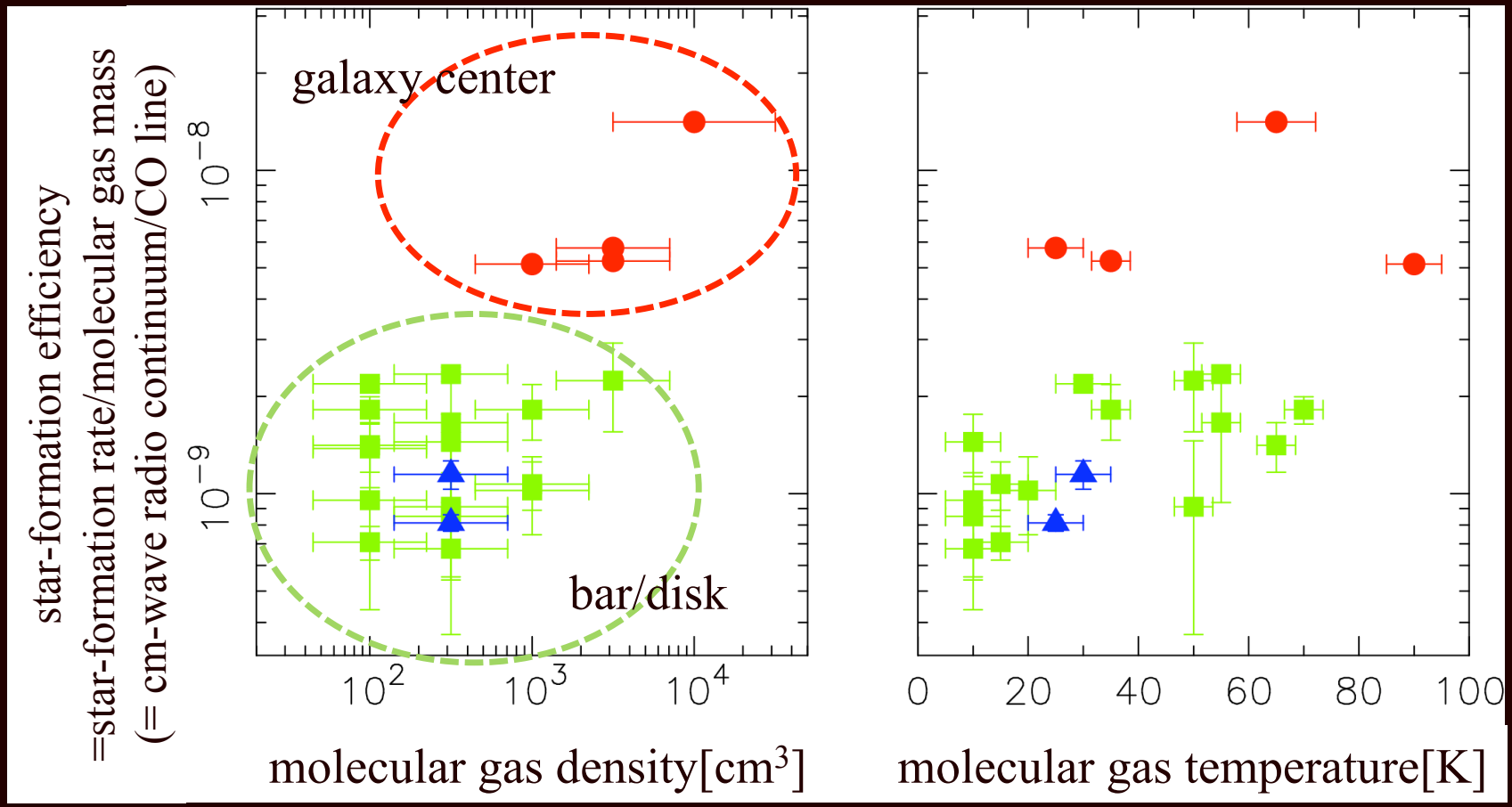


- Indicator of Density or Temperature of molecular gas
- Overall = 0.4
- Center ~ 1
- Starforming region (2kpc ring) = 0.4~0.7
- Disk region (non SFR) < 0.2

Molecular gas and star-formation

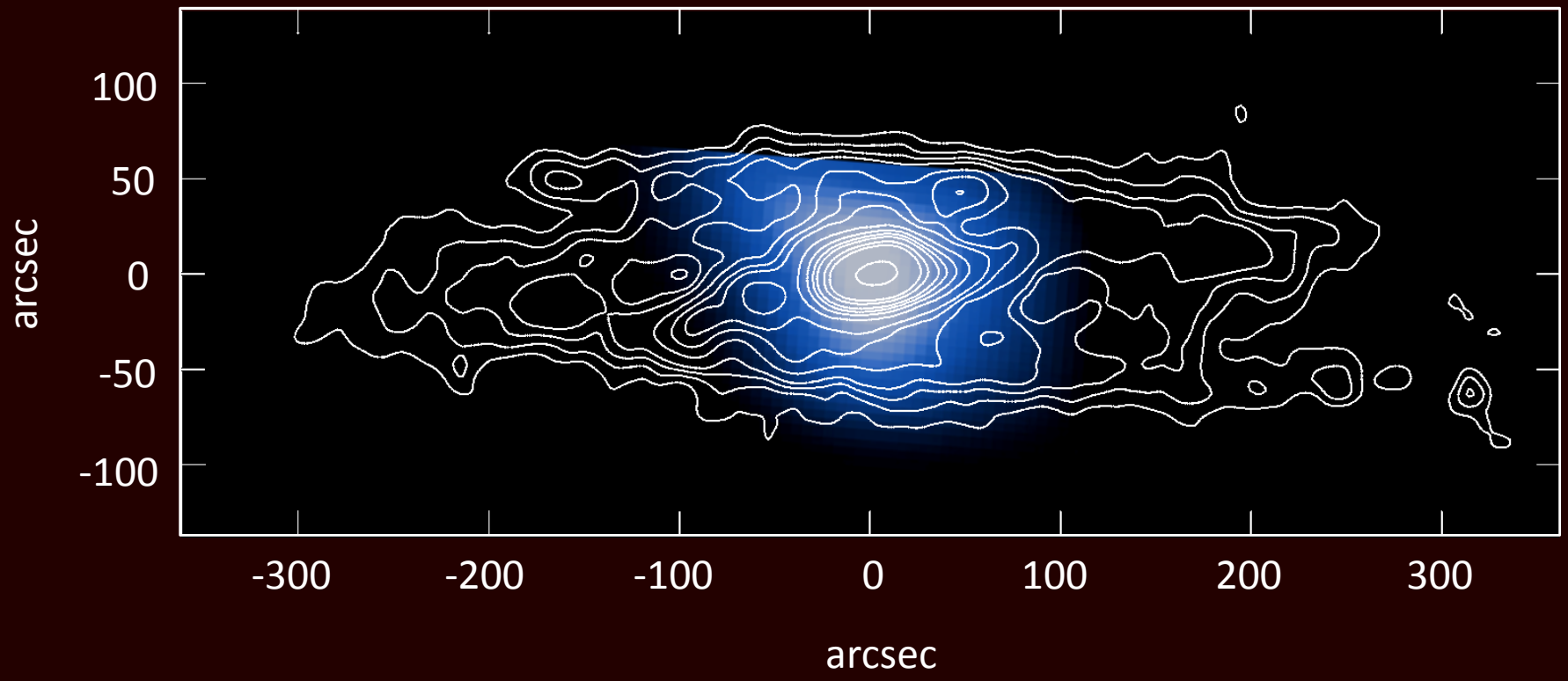


Higher star-formation efficiency at the galaxy center



Molecular gas property (gas density) relates to higher star-formation efficiency, and it may one of trigger of intense starburst

NGC253 [CII]158um map on 12CO (1-0) contour



Sub-mm & radio：Temperature and density of molecular gas which is extended around disk → **Cause of Starformation**

FIS line：Pressure, Temperature, and Density of Gas
FIS continuum : Temperature from dust SED & Total luminosity → **Results of Starformation**

Caveats

- Star-formation rate may be inaccurate
  - cm-wave radio continuum trace longer time-scale phenomena than lifetime of OB stars, and it suffers contamination by free-free emission
- Other star-formation rate indicators?
  - we don't have reliable image of mid-infrared continuum (e.g. 24um) due to severe saturation at the galaxy center and ghosts
  - H-alpha emission suffer from large extinction (A_v>10 at most)

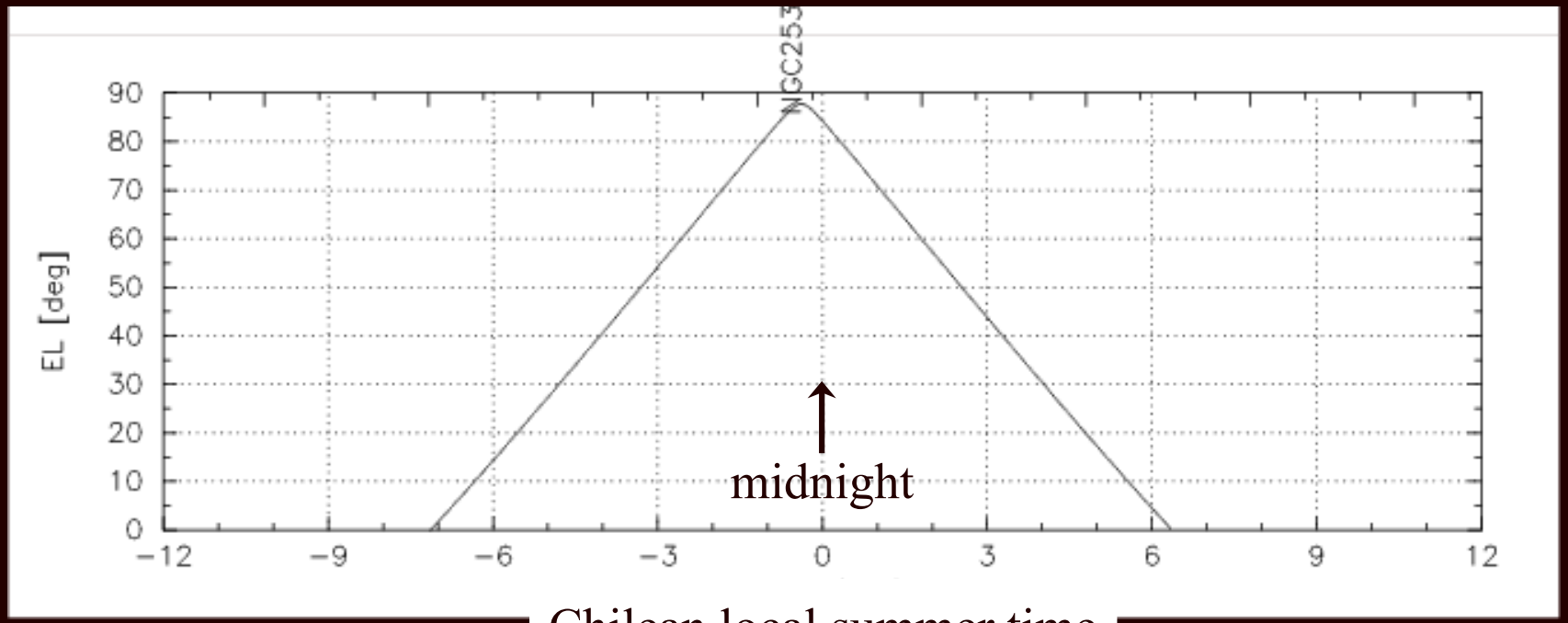
Proposed observations

- Pa-alpha/beta observations toward starburst regions of NGC 253 using mini-TAO/ANIR
  - unattenuated intensities/distributions of starburst
- We will be able to obtain more accurate relationship between star-formation activities and physical properties of interstellar matter
  - it should be a clue to prove an origin of starburst

Observation strategy

- High priority
  - Pa-alpha(on-band), Pa-beta(on): 1hr on-source integration, 9-points dither
  - J, Ks: 15 min on-source integration, 9 pts. dither
  - need sky flames (target is very extended)
  - request: 5 hrs observations in total
- Medium priority
  - Pa-alpha(off-band), Pa-beta(off): 1hr on-source integration, 9-points dither + sky frames
  - request: 4 hrs observations in total

Target visibility (2013/11/1)



optimal season for observations: August - December

ALMA Cycle 1 Observation

- Our proposal (high-resolution (0.″5) radio recombination line (H30alpha) and molecular line observation) has been ranked "highest priority"
- H30alpha line is mostly extinction free, but H30alpha emission line intensity is weak. Observation is limited to narrow area (30″f)
- miniTAO/ANIR observation will cover much wider area (3′-4′=3-4kpc) which includes not only the galaxy center but also bar/disk region. Wider range of star-formation activities can be investigated by the proposed observation.

最後に...

- 今回のWSも不参加で申し訳ありません。
- 観測させていただけると、とても有難いです。
- よろしくお願いいたします。

中西康一郎@サンチャゴ