# wSMA for Nearby Galaxies

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*"The overview talks should focus future discussion on what the upgrade will better enable in their particular area of expertise, rather than summarizing what has been done to date."* —SOC

⇨ Ideas for exciting science with wSMA on nearby galaxies?

# wSMA in the ALMA era

- Northern Sky, Nearby targets
  - $\delta$(ALMA) < +47°. $\Omega$(no ALMA)= 0.54 $\pi$ str = 13% of sky
    for el. > 20°
    or 20 % for el.(ALMA) < 30°
  - SMA ≈ ALMA
    for same linear resolution and $T_b$ sensitivity
    *when SMA targets are 5 times closer*

- High Site/Submm (compared to NOEMA)
- Wide Bandwidth (28 GHz compared to ~7GHz with ALMA)
- Wide FOV
- Intermediate Resolution (~3″)
- Path Finder (quick turnaround, easy access)
- Time Domain (UT coverage, high cadence)

afternoon session

# Northern Nearby Galaxies

- δ(ALMA) < +47°. Ω(no ALMA)= 0.54 π str = 13% of sky

for el. > 20° or 20 % for el.(ALMA) < 30°

No ALMA

| name | Dec.[°] | D [Mpc] | note |
|---|---|---|---|
| **M82** | +70 | 4 | nearest/protorype starburst |
| **M81** | +69 | 4 | LLAGN, variable |
| **IC 342** | +68 | 5 | face-on spiral, starburst |
| **Maffei 2** | +60 | 4 | starburst |
| **NGC 6946** | +60 | 5 | face-on spiral, starburst |
| **Arp 299** | +58 | 48 | merger, $L_{IR}=10^{11.9}L_{\odot}$ |
| **Mrk 231** | +57 | 172 | nearest quasar ($L_{IR}=10^{12.5}L_{\odot}$) |
| **Mrk 273** | +56 | 155 | ULIRG ($L_{IR}=10^{12.1}L_{\odot}$) |
| **M101** | +54 | 7 | face-on spiral |
| **M51** | +47 | 9 | face-on spiral, LLAGN |
| **NGC4051** | +45 | 13 | Seyfert |
| **NGC 1275** | +41 | 69 | 3C84, AGN(Sy) |
| **M31** | +41 | 1 | Andromeda galaxy |
| **NGC4151** | +39 | 19 | Seyfert (binary BH?) |

Other LIRGs
UGC5101,
VII Zw 031,
NGC6090,
NGC4194, …

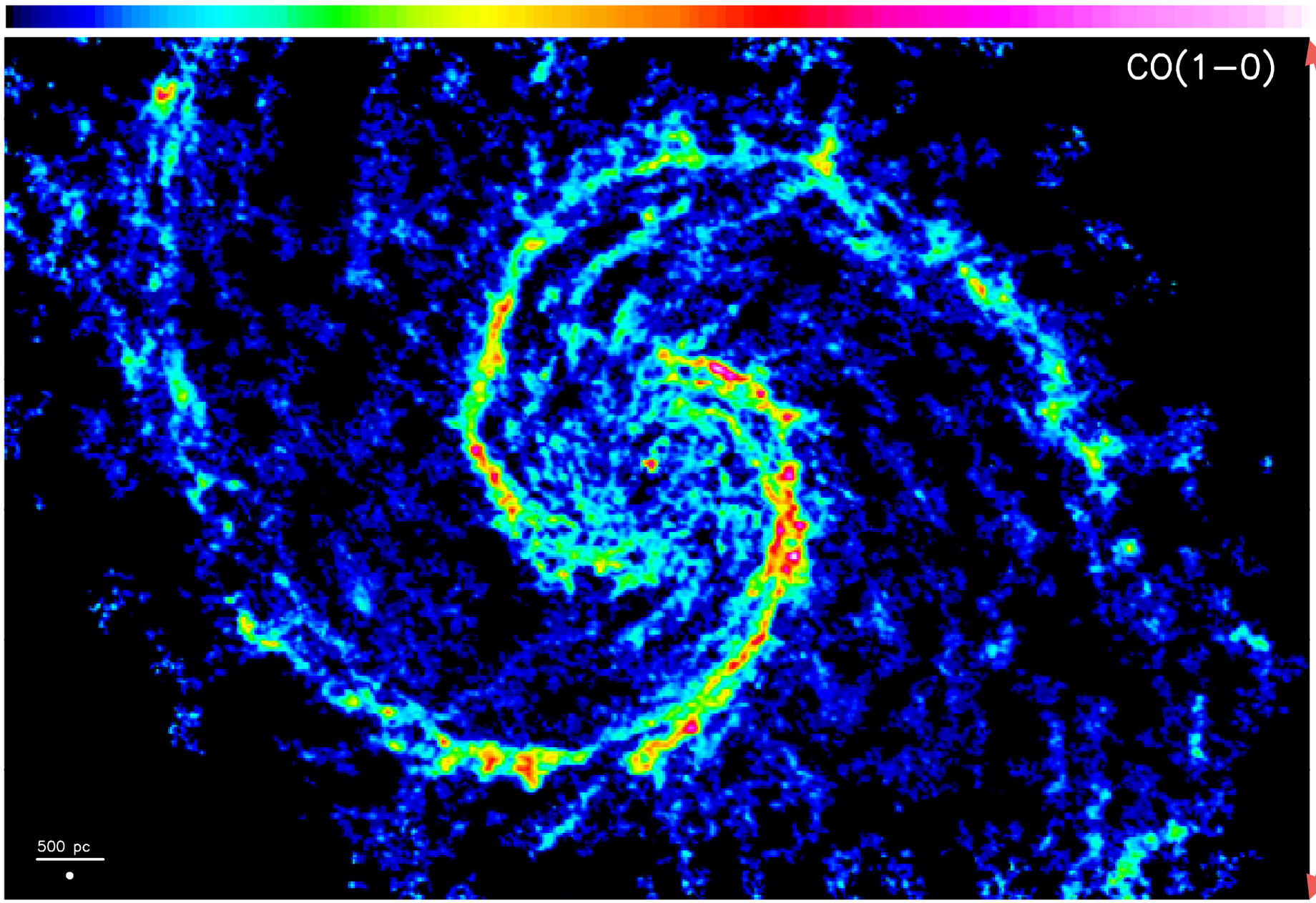
next talk

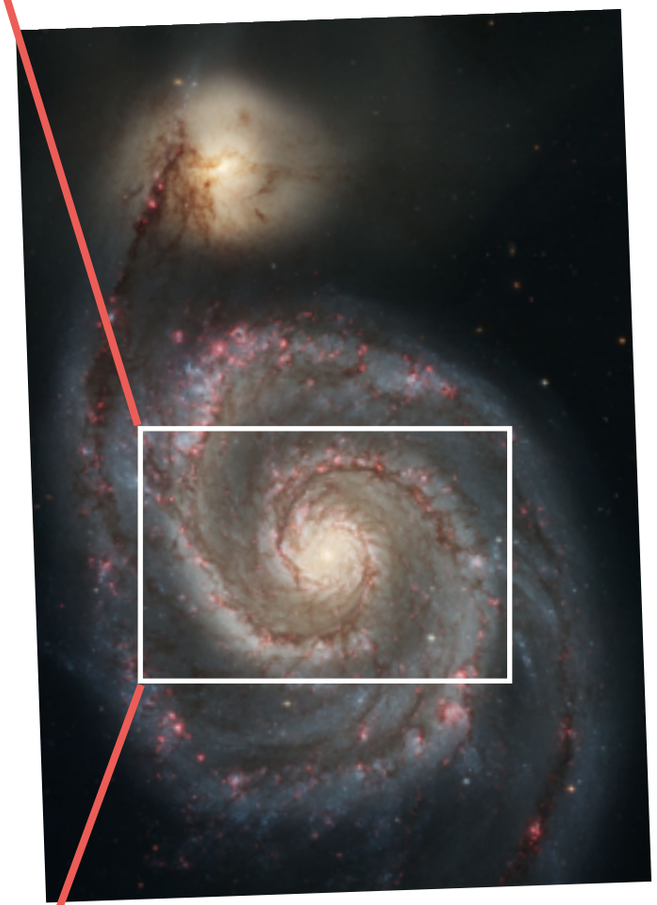
# Northern Nearby Galaxies

- **(face-on) spirals** : M31, M81, IC342, NGC6946, M101, M51
  - molecular cloud properties, SF-law, spiral arm/density wave
- **Starbursts** : M82, IC342, Maffei 2, NGC6946, …
  - elevated SF (SF-law, m.c. properties in SB), evolution (trigger, feedback, quenching)
- **Merger/U,LIRG**: Mrk 231, Mrk273, Arp 299 (NGC3690+IC694)
  - extreme SF (SF-law, mol. gas properties in extreme SB), evolution(trigger, feedback), Eddington-limit SF
- **AGN** : Mrk 231, NGC1275 (3C84), 3516, 4051, 4151; M81, M51
  - feeding/feedback, effects of AGN (X-ray, jet) on ISM, AGN time variability

# Northern Nearby Spirals

## M31, M81, IC342, NGC6946, M101, M51 (<10Mpc)



4′x2.5′ @ 1″ (40pc) in CO(1-0)  (Schinnerer+′13)

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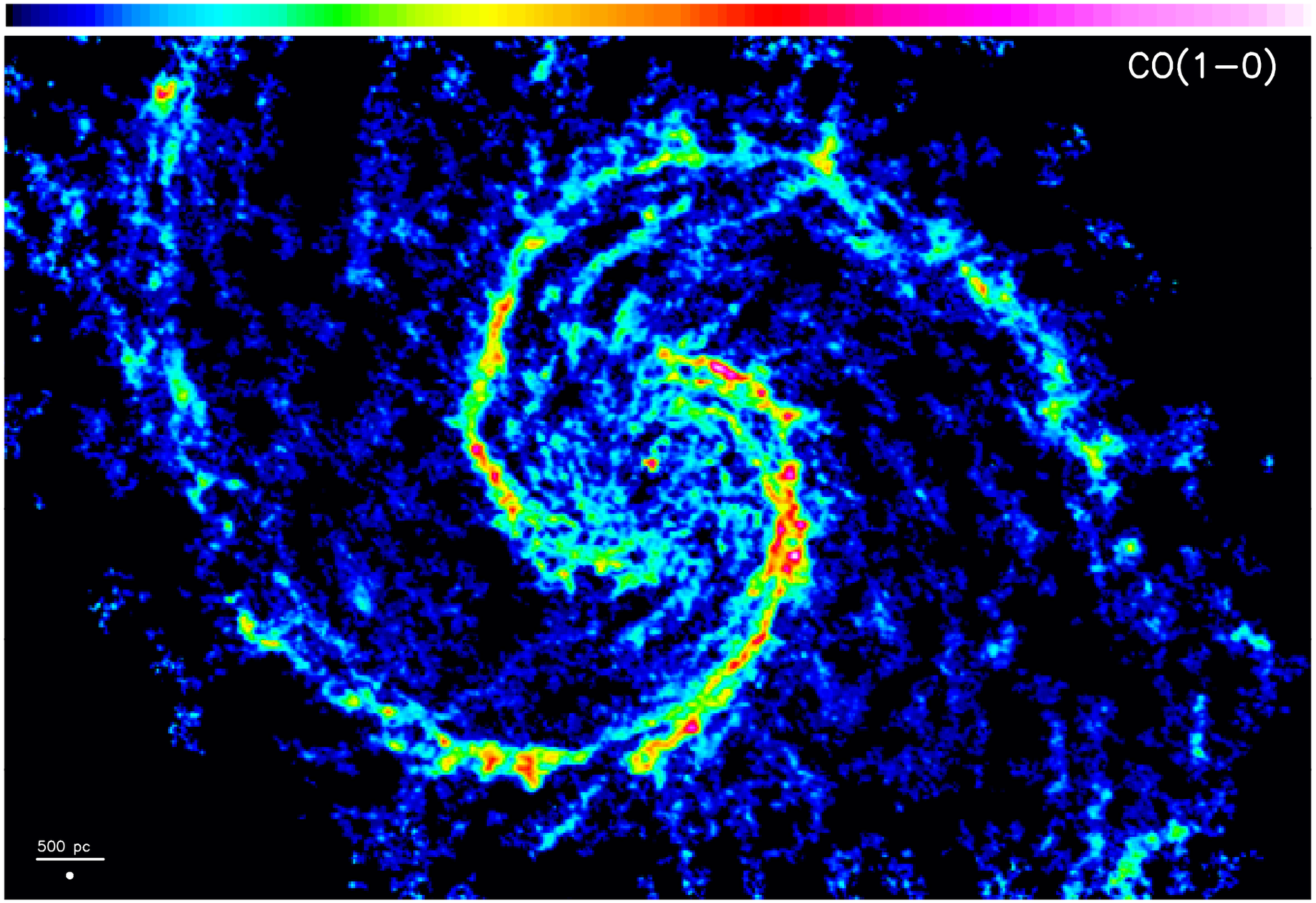
## M31, M81, IC342, NGC6946, M101, M51 (<10Mpc)



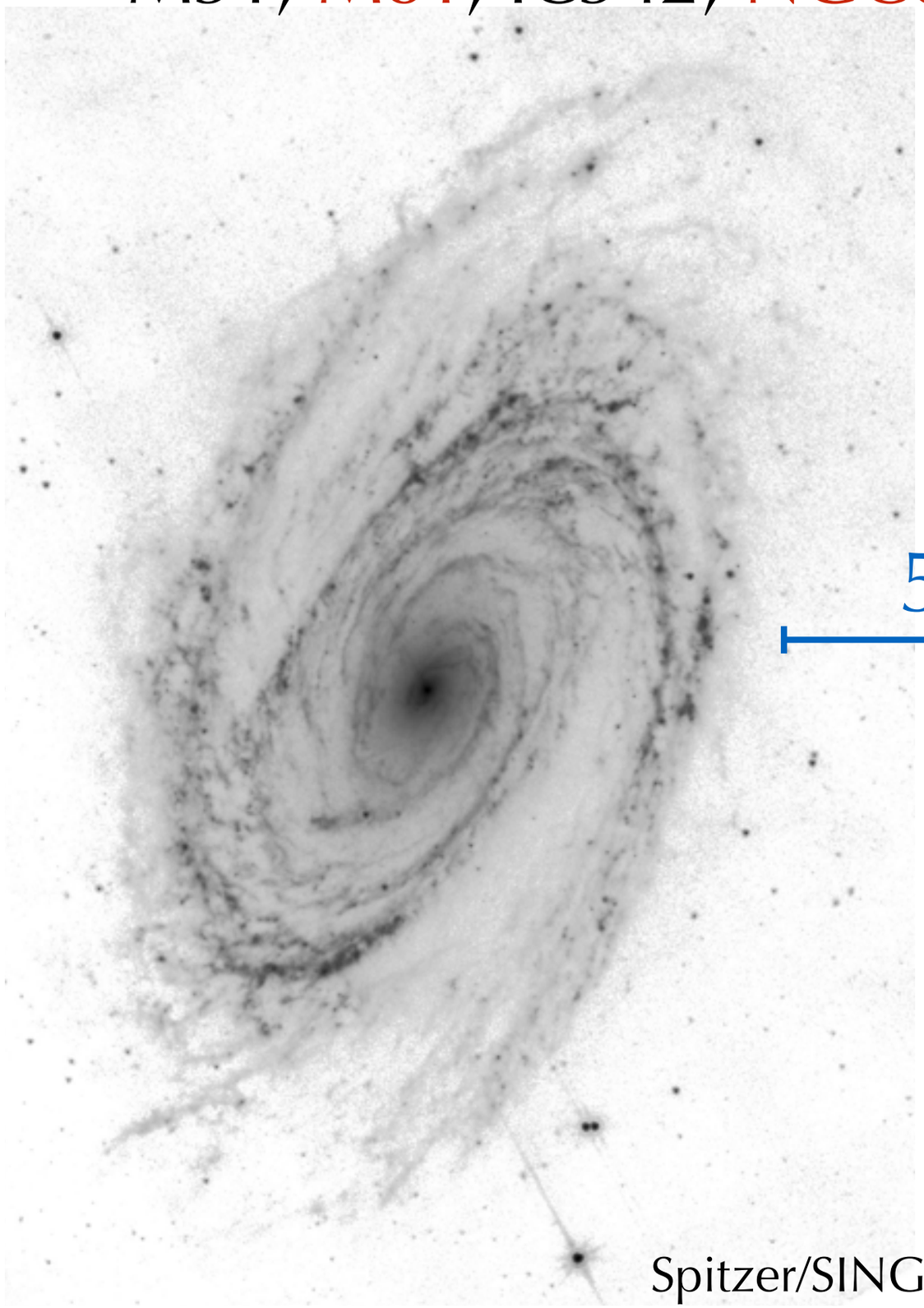

- fraction of CO in GMCs
- MC size, $L_{co}$, $T_b$, M fn.
- σ, α
- scaling relations
- $I_{CO}$ PDF
- SF law
- GMC lifetime
- local variation of these

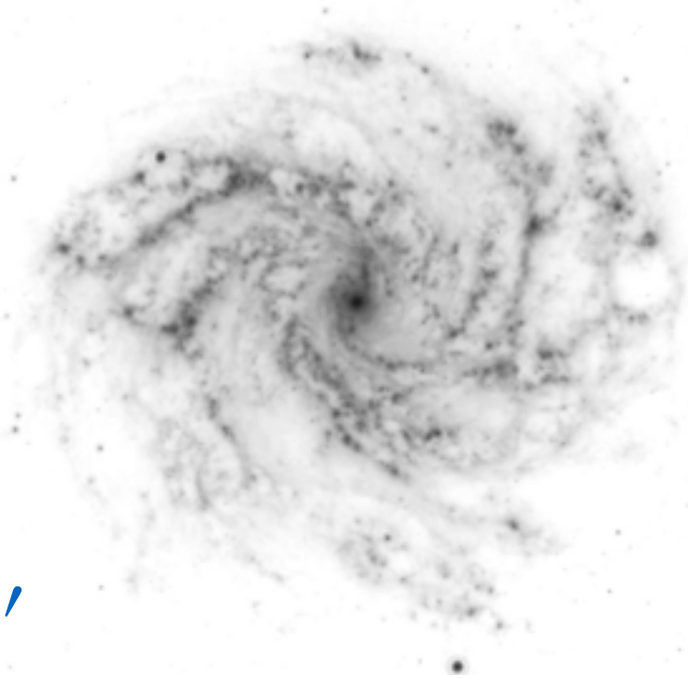
…

4′x2.5′ @ 1″ (40pc) in CO(1-0) (Schinnerer+′13)

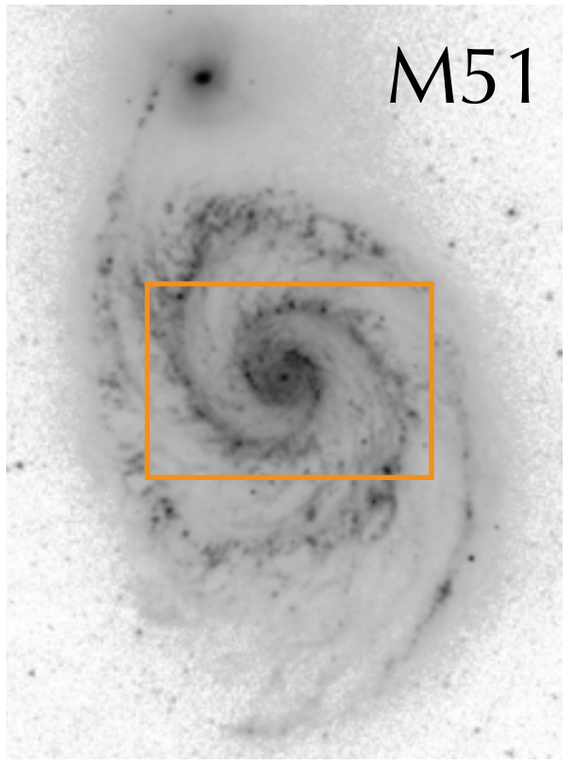
# Northern Nearby Spirals

M31, M81, IC342, NGC6946, M101, M51 (<10Mpc)





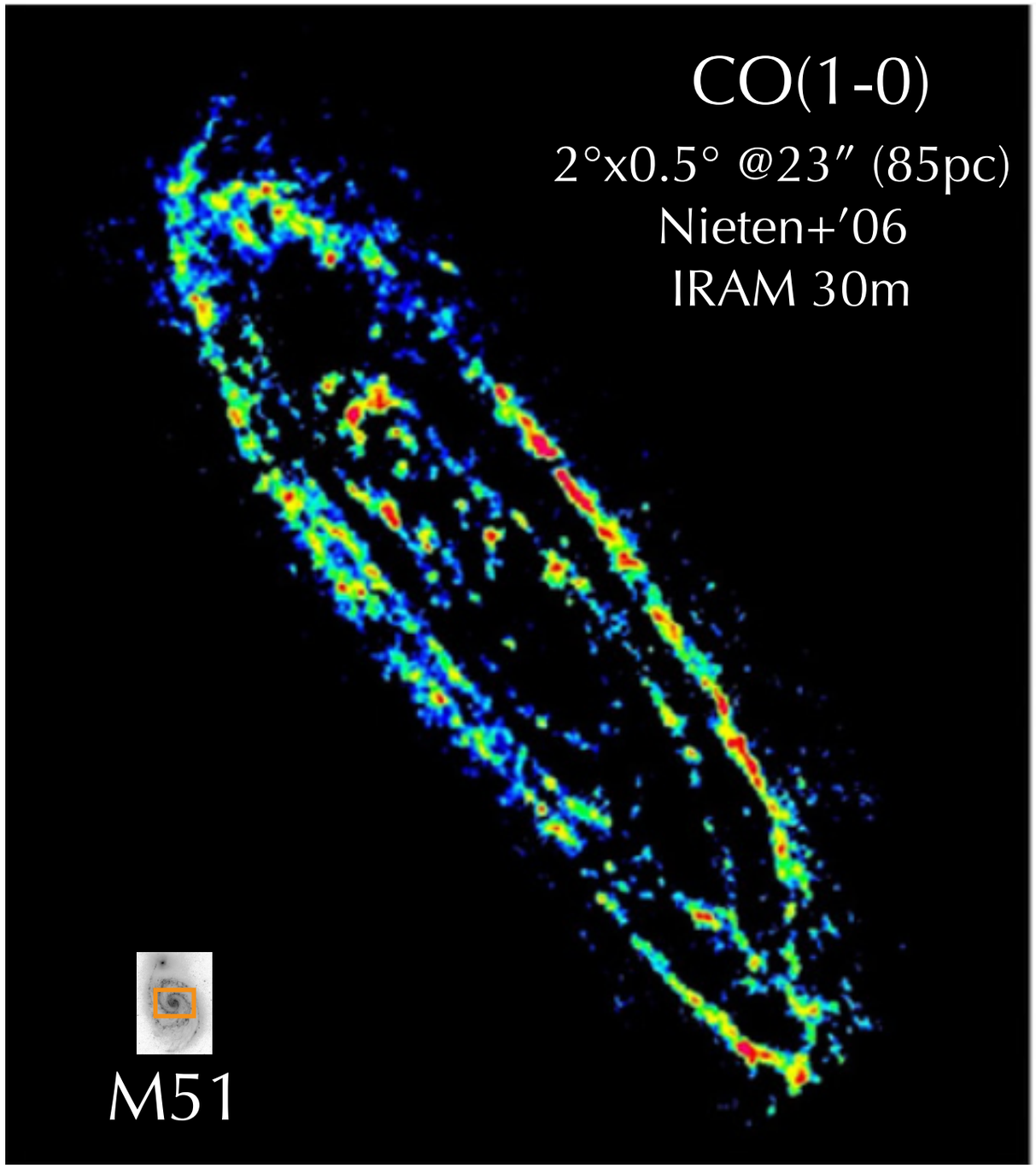
5′




Spitzer/SINGS,LVL

# Northern Nearby Spirals

## M31, M81, IC342, NGC6946, M101, M51 (<10Mpc)



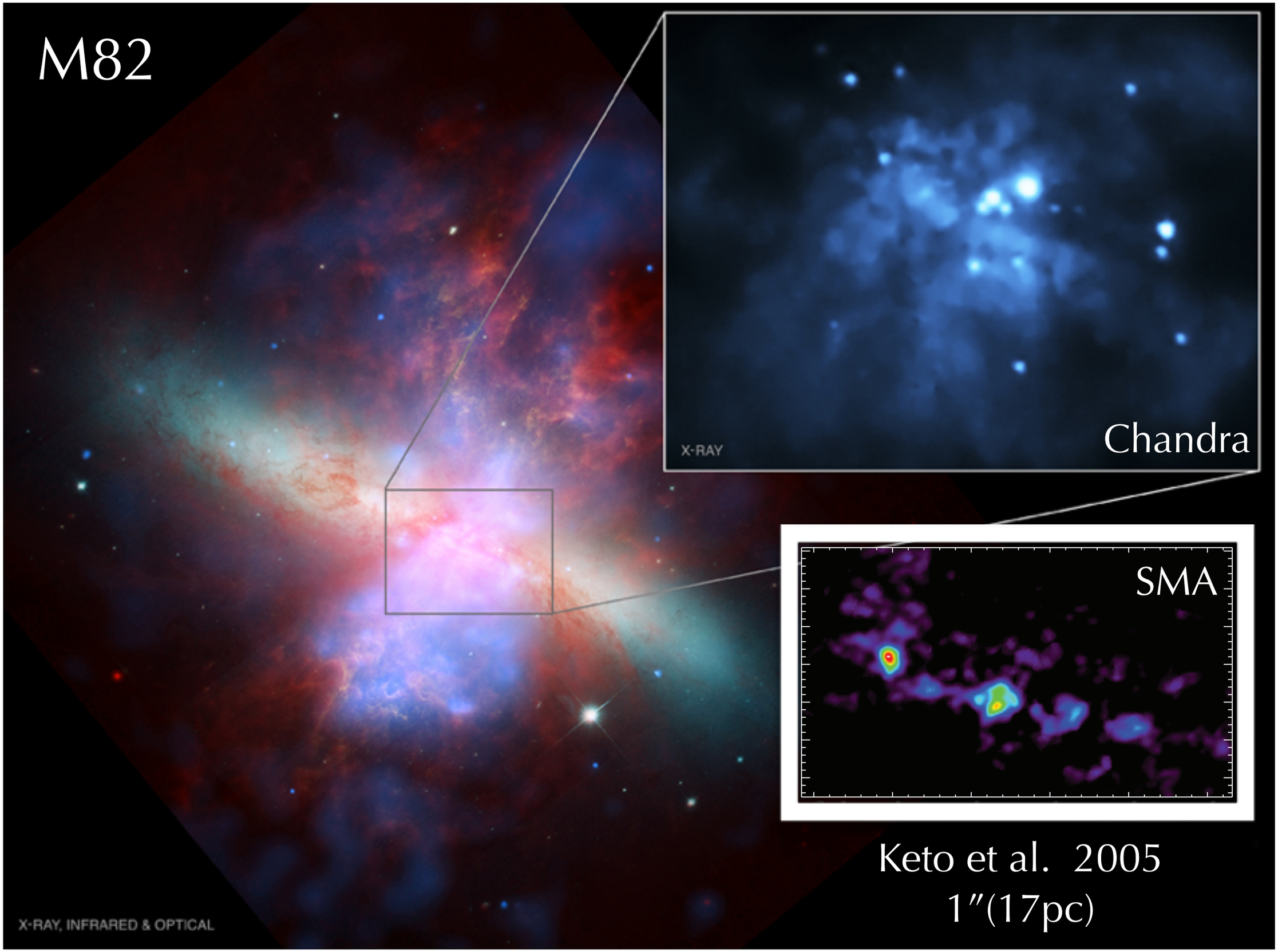

possible VERY-LARGE project

# Technical Wish List

- Fantastic to have multi-pixel receivers
- Nice to have IF=4-20 GHz for stacking analysis of non-$^{12}$CO lines

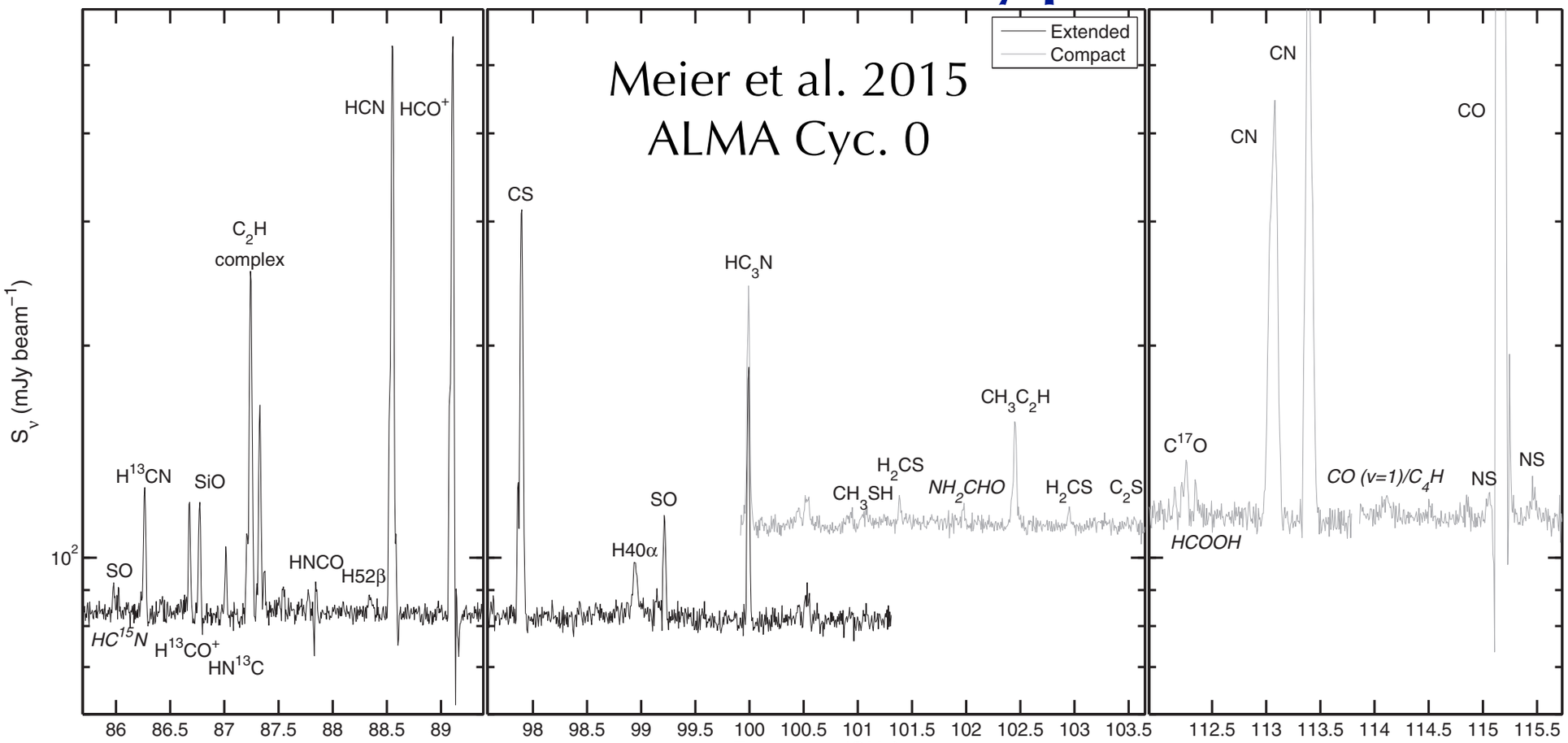
| RF=[230,246]+[254,270] | | RF=[330,346]+[354,370] | |
|---|---|---|---|
| CO(2-1) | @230.5 | *$^{13}$CO(3-2)* | *@330.6* |
| CS(5-4) | @244.9 | CO(3-2) | @345.8 |
| SiO(6-5) | @260.5 | HCN(4-3) | @354.5 |
| HCN(3-2) | @265.9 | HCO$^+$(4-3) | @356.7 |
| *HCO$^+$(3-2)* | *@267.6* | HNC(4-3) | @362.6 |

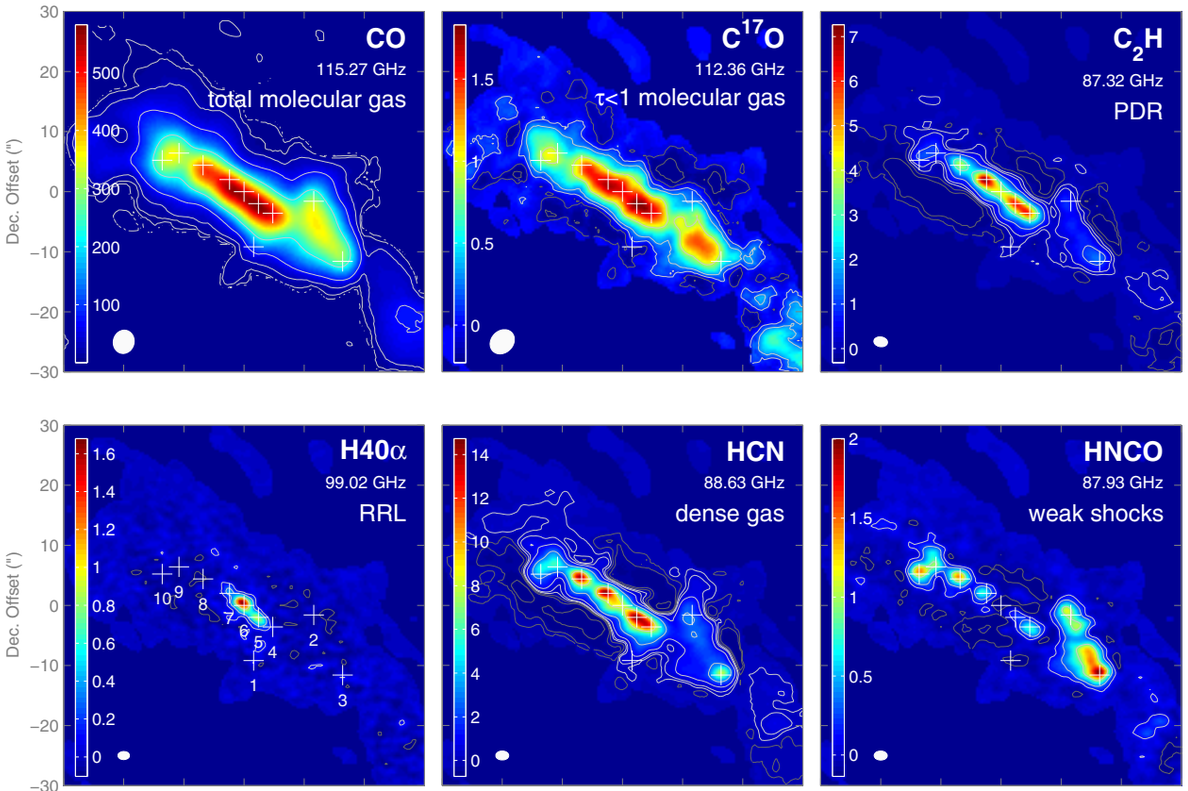
# Starburst-Prototype : M82

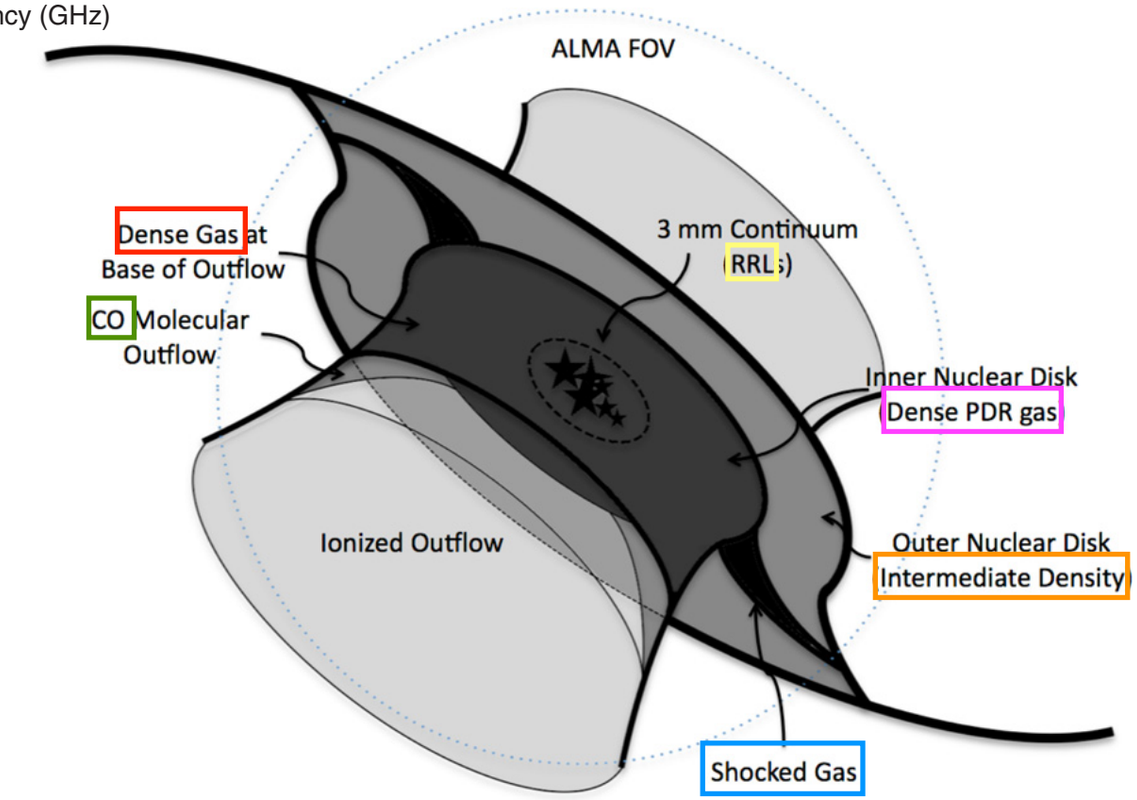



Keto et al. 2005
1″(17pc)

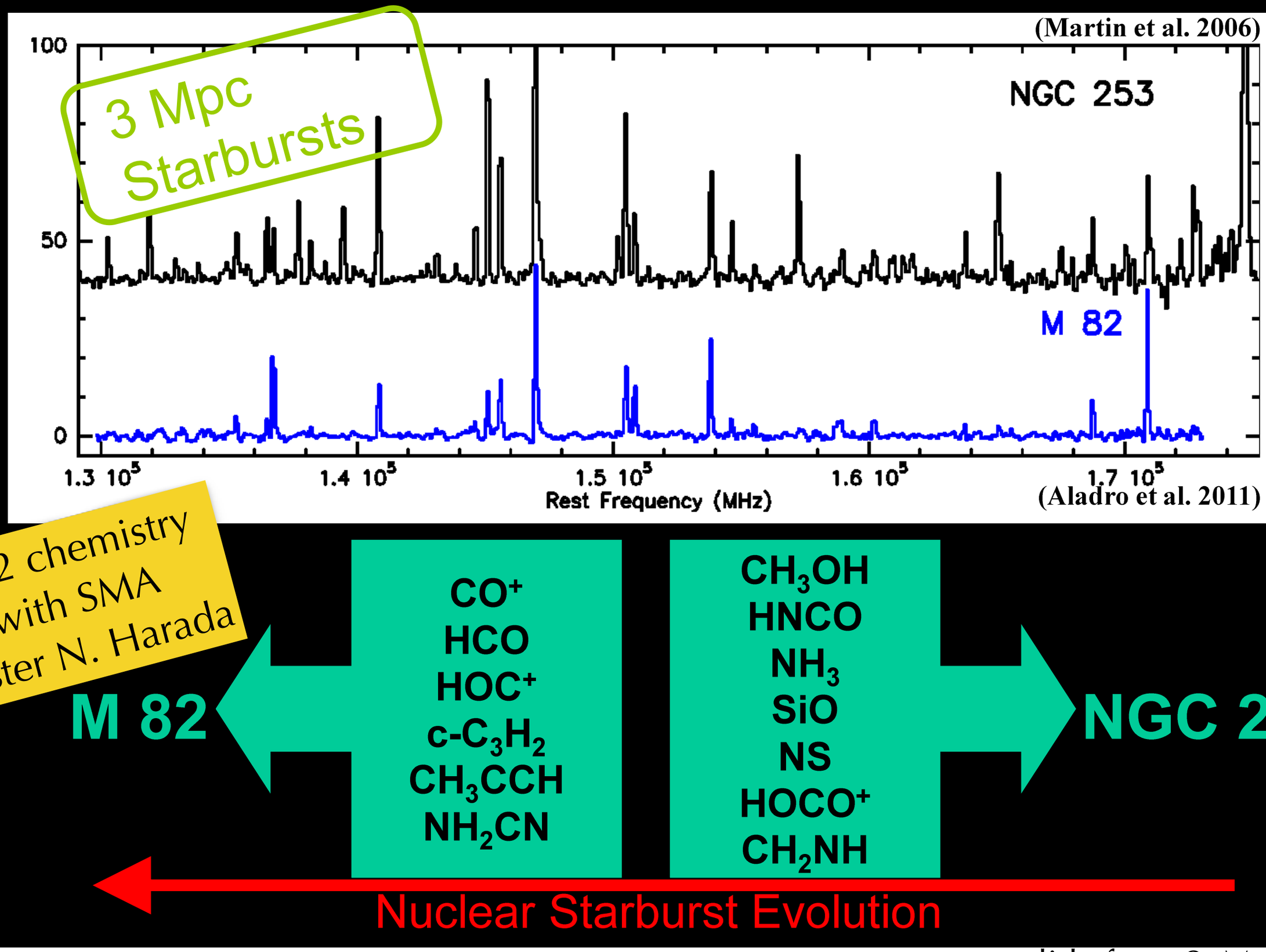
# Southern Starburst-Prototype : NGC 253



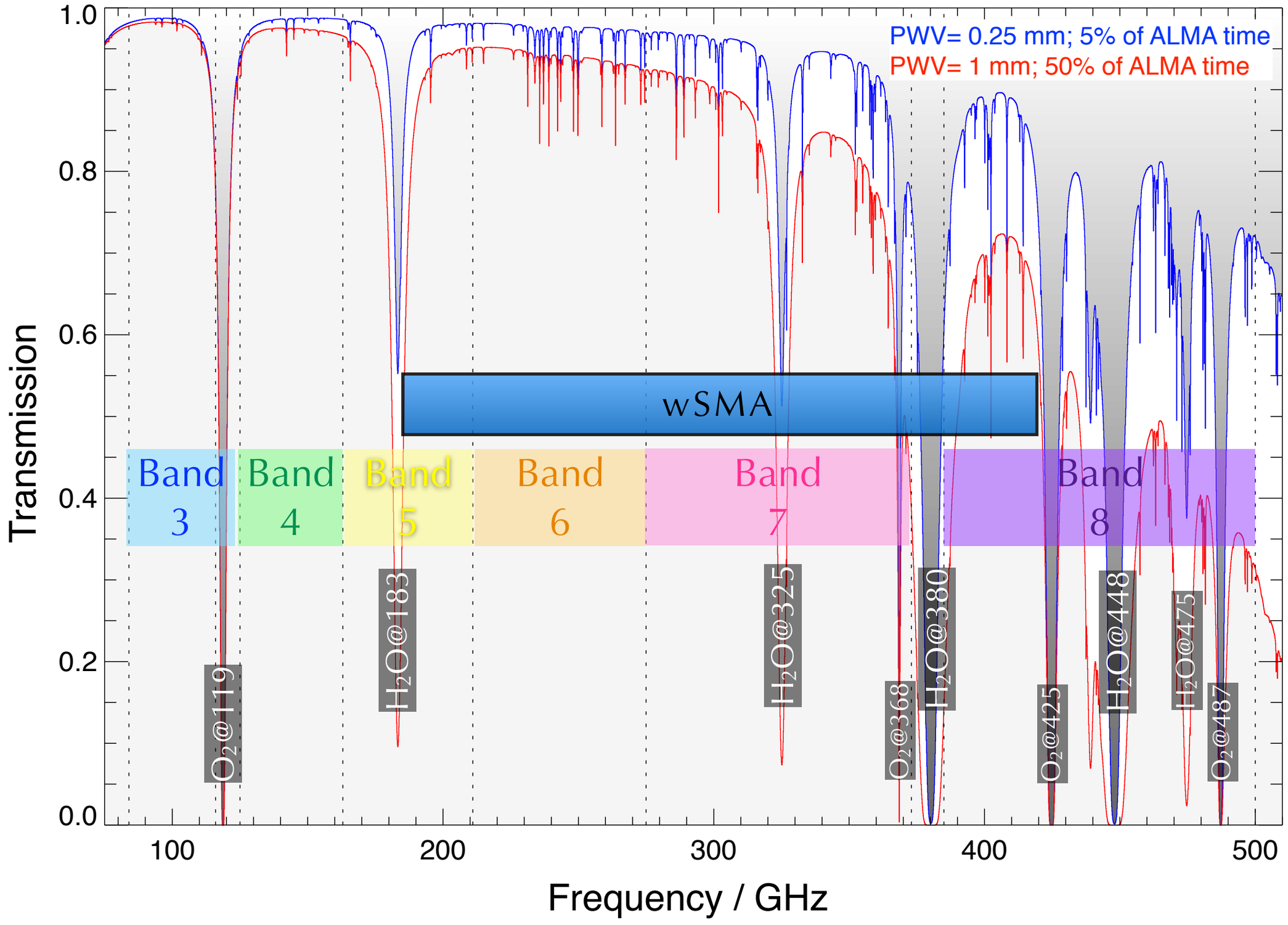



# Not all starbursts are the same




slide from S. Martin

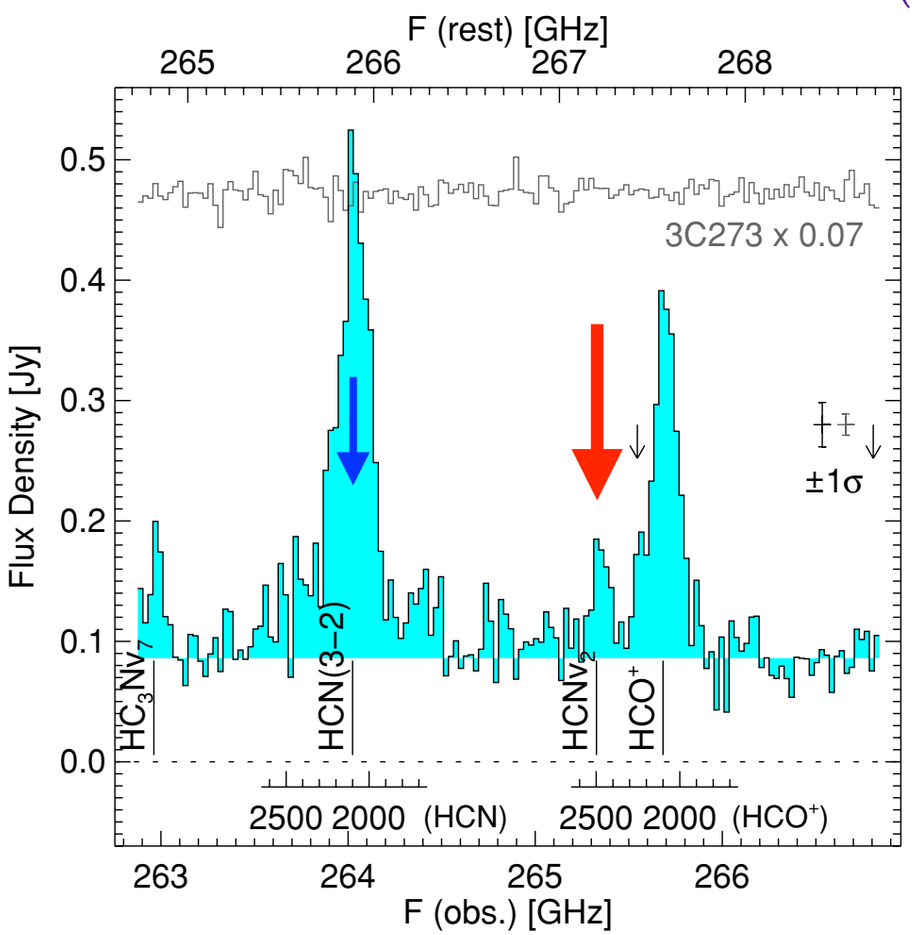
# Spatially-resolved Wide-band Spectroscopy on Starbursts

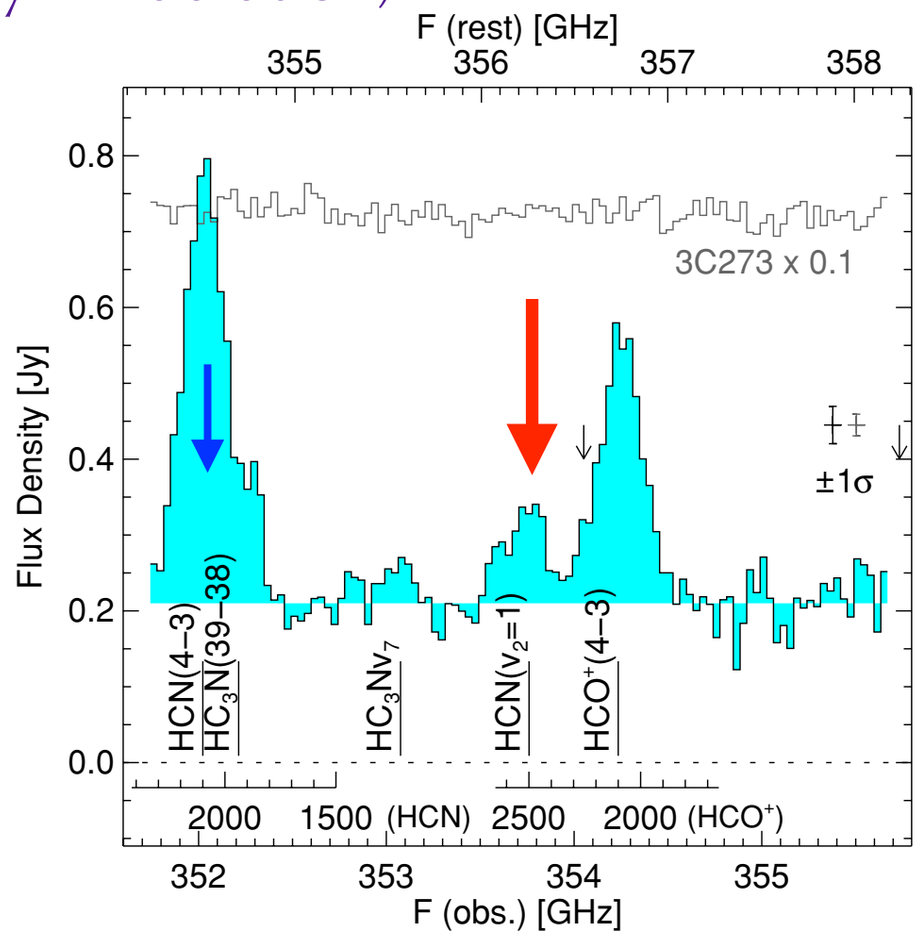


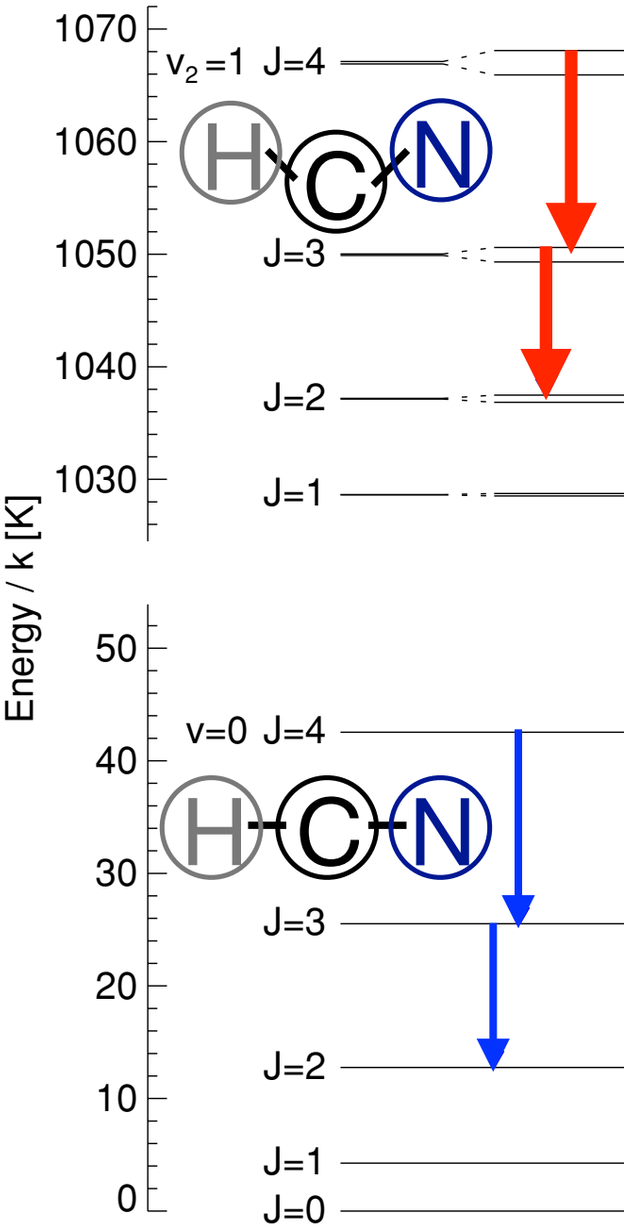

full scan or selected lines ?

# Path Finder (for ALMA)

First extragalactic detection of
rotational lines from vibrationally-excited HCN
(by IR radiation)




Sakamoto+2010, SMA **filler** program

➡ ~10 ALMA projects have been approved for HCN-vib.

- Also, 0.5″-1″ SMA very useful to justify higher-res. ALMA obs.

# Intermediate Resolution

**Table A-1: Angular Resolutions (AR) and Maximum Recoverable Scales (MRS) for the Cycle 4 Array configurations**

| Config | Lmax | Band | Band 3 | Band 4 | Band 6 | Band 7 | Band 8 | Band 9 | Band 10 |
|---|---|---|---|---|---|---|---|---|---|
| | Lmin | Freq | 100 GHz | 150 GHz | 230 GHz | 345 GHz | 460 GHz | 650 GHz | 870 GHz |
| C40-1 | 155 m | AR | 3.7" | 2.5" | 1.6" | 1.1" | 0.80" | 0.57" | 0.42" |
| | 15 m | MRS | 29.0" | 19.4" | 12.6" | 8.4" | 6.3" | 4.5" | 3.3" |
| C40-2 | 273 m | AR | 2.4" | 1.6" | 1.0" | 0.69" | 0.52" | 0.37" | 0.27" |

At 250-350 GHz

lowest resolution of ALMA main array ~ 1-1.5″

single-dish beam ≥ 5″

whereas

SMA beam ~ 2.5-3″ (COM@250, SUB@350)

any unique science at ~3″ ?

10 pc @M31, 0.1 pc @G.C.

# Some Suggestions

- Requests for the upgrade
  - Minimize *T*sys. Maximize stability & efficiency (8-ant op.)
  - Dual-freq. not needed, multi-pix great (but too risky?)
  - seeing-correction WVR?
- Programs
  - Large/legacy projects (e.g., for N-targets)
  - Flexible, pilot/exploratory projects (leading ALMA)
- Data Reduction
  - CASA (data translator)
    - MIR/MIRIAD an obstacle to new users
- Coordination with other facilities
  - GLT. ICMT. LMT. NOEMA. etc.

# wSMA for Nearby Galaxies

## Summary

- ~15% of the sky is w/o ALMA. It has nearest L* galaxy (M31), nearest starburst (M82), nearest quasar (Mrk 231) as well as many local face-on spirals (M81, M101, IC342, ...), starbursts and Seyferts.
- Legacy projects for these N sources
  e.g. large-area mapping, spectral scans
- Path finder to lead ALMA projects
- New ideas
  (~3″ res. targets, time-domain, ...)