A ~100 pc scale view of CO J=2-1/J=1-0 in M51

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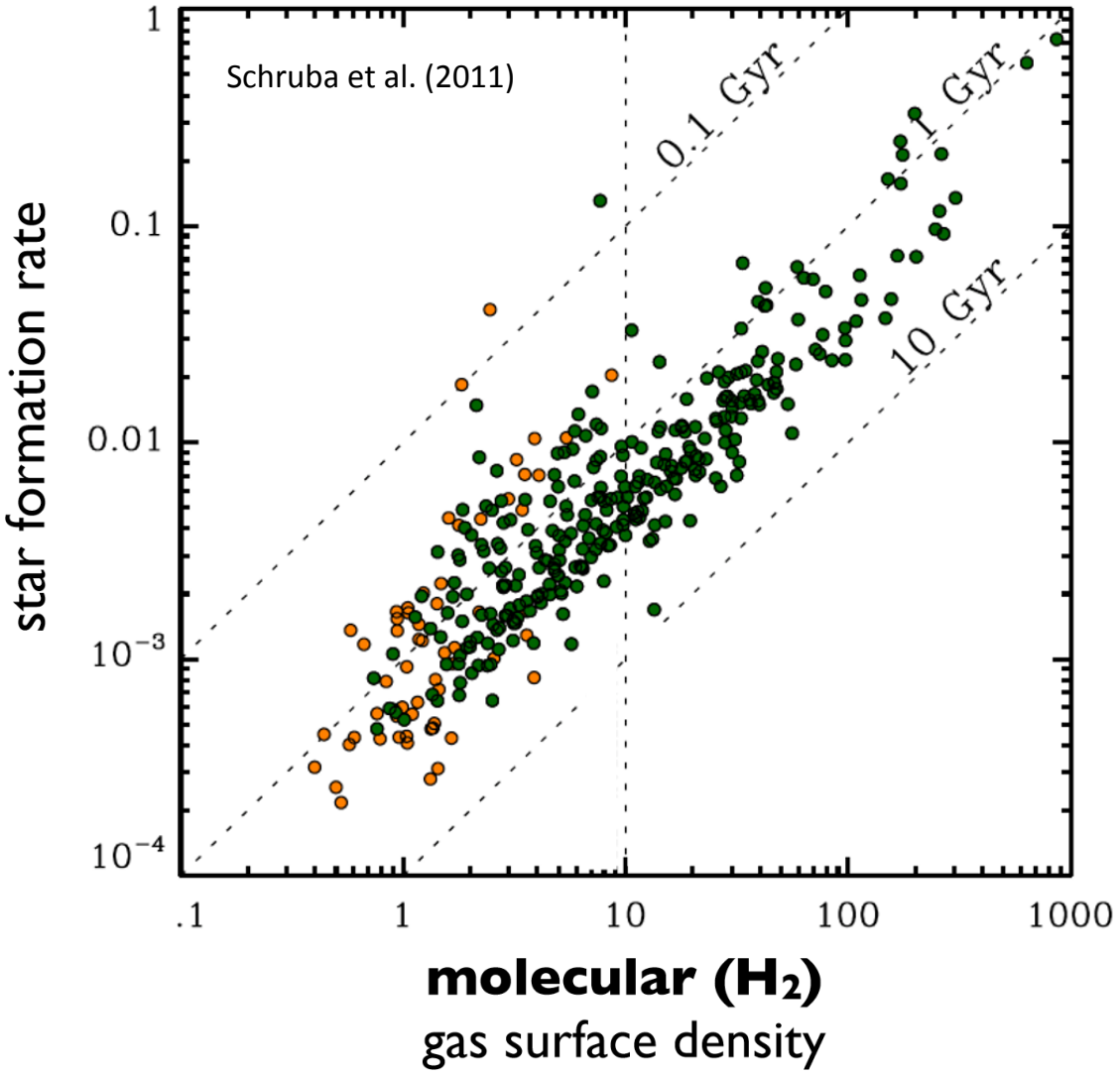
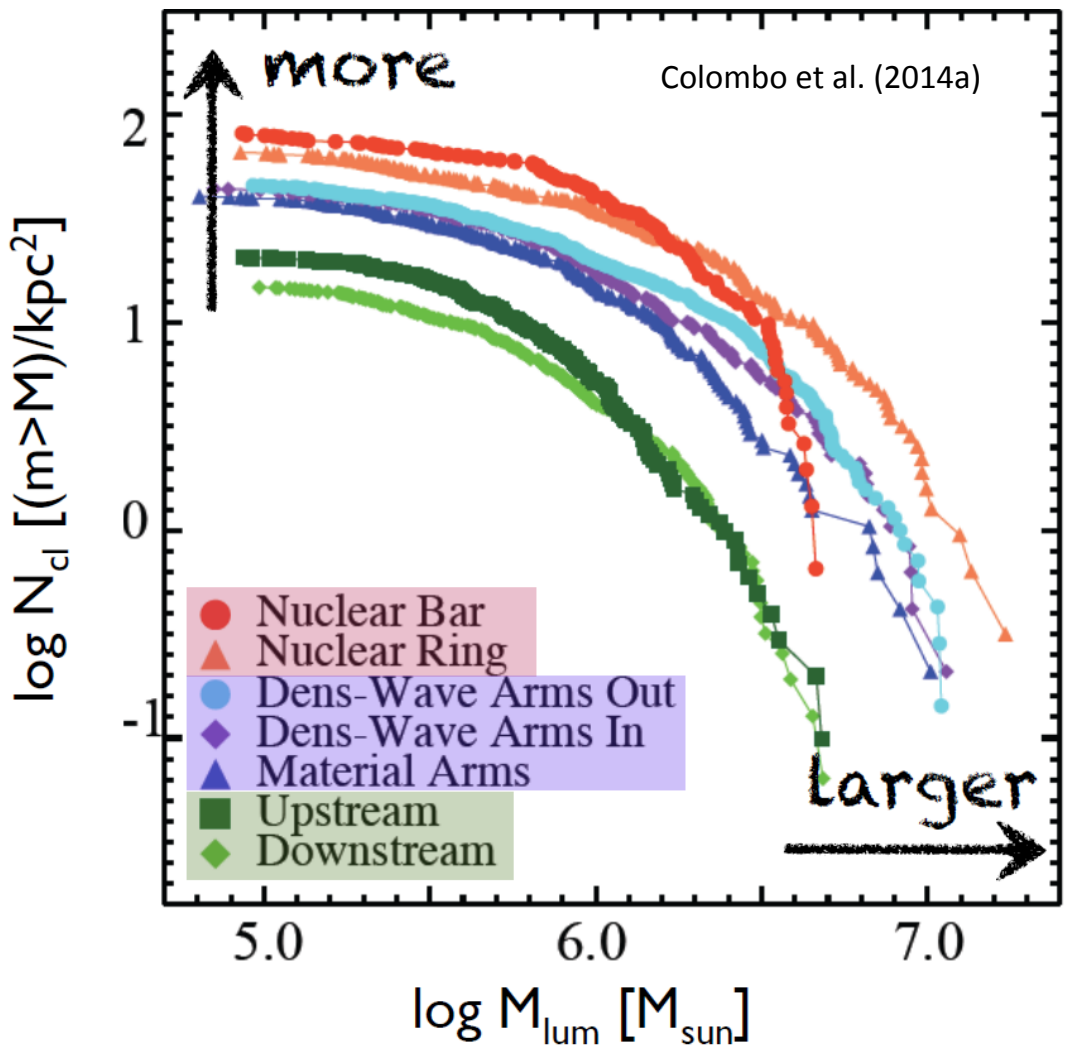
Star formation and galactic environment





Science goals:

- Understanding the role of molecular gas in spatially resolved nearby galaxies is essential to understanding galaxy evolution.

- SMA and ALMA routinely observe CO (2-1) and CO (3-2), especially at high-*z*. What drives the **observed variations in J=2-1/J=1-0** in different environments?

- **CO *J*-ladder + isotopologues** are needed to measure properties such as temperature, column density and opacity.

- **M51**: near+well studied, best target for SMA to understand molecular gas properties across environment at high spatial resolution.

Summary of SMA observations in M51:

- Awarded

K. Sliwa
CO (2-1)

2 x Subcompact tracks for PAWS area

8 x Compact tracks for PAWS area

1 x Extended track for pilot study of arm spurs

CO (3-2)
G. Petitpas

+4 Bonus Subcompact tracks to map entire disk

- Continued

1 x Subcompact track M51b (CO 2-1)

G. Petitpas

1 x Subcompact track M51b (CO 3-2)

AY191 Class
(Wagner & Ehrenberg)

M51

D = 7.6 Mpc
1” = 40 pc

HST

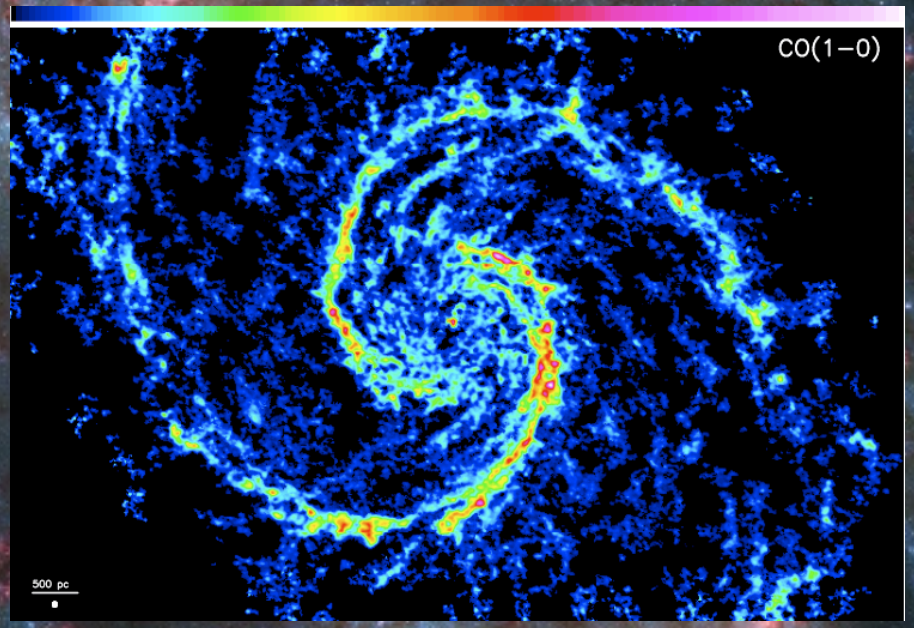
Region covered by NOEMA in CO *J* = 1-0 at 1”

Observed with SMA in CO *J* = 2-1 at 3”

~ 10 kpc x 6 kpc
(270“ x 170”)

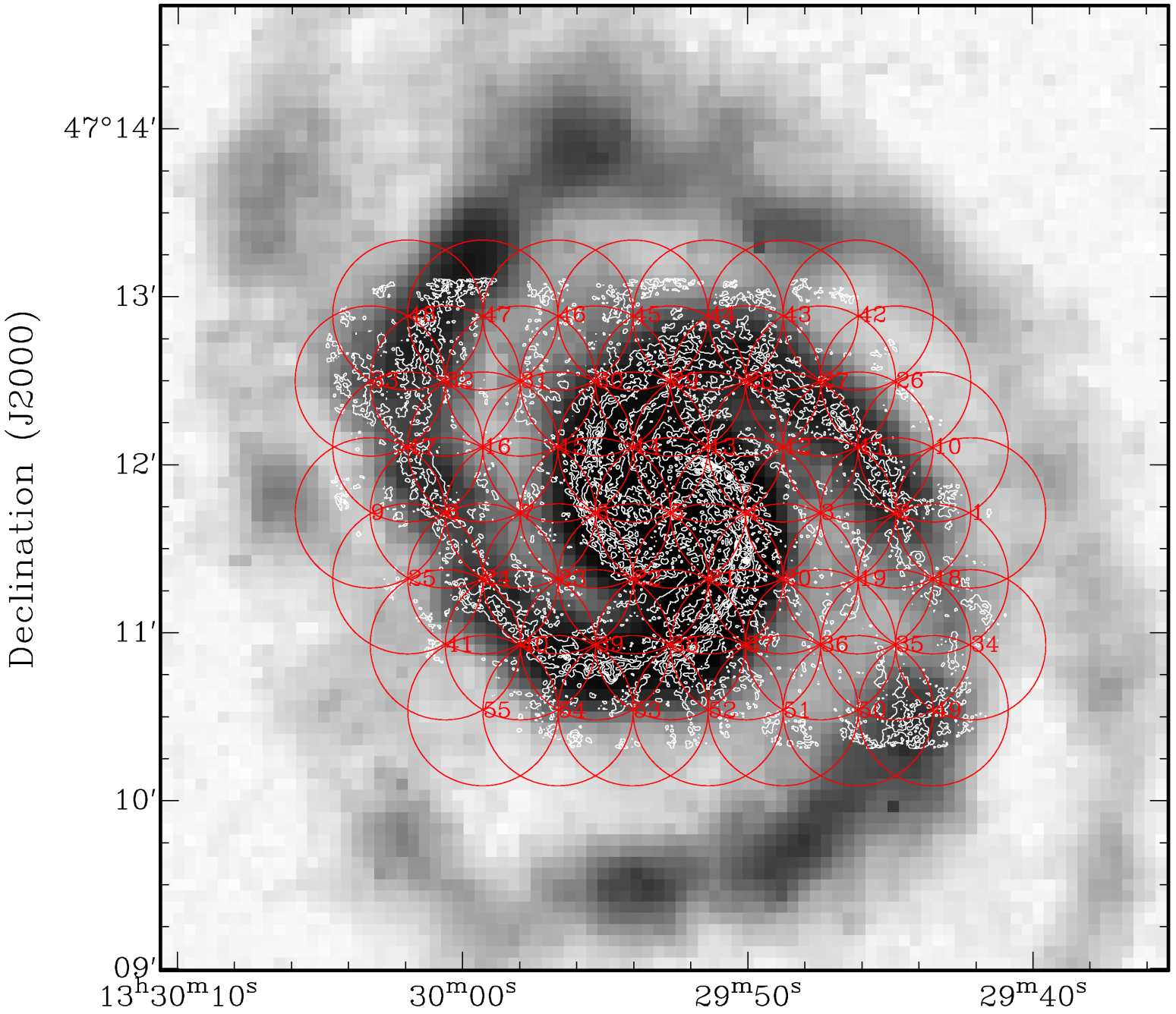
M51

D = 7.6 Mpc
1” = 40 pc



PdBI Arcsecond
Whirlpool Survey
(PAWS, Schinnerer+13)
CO J=1-0 (1” res)

M51

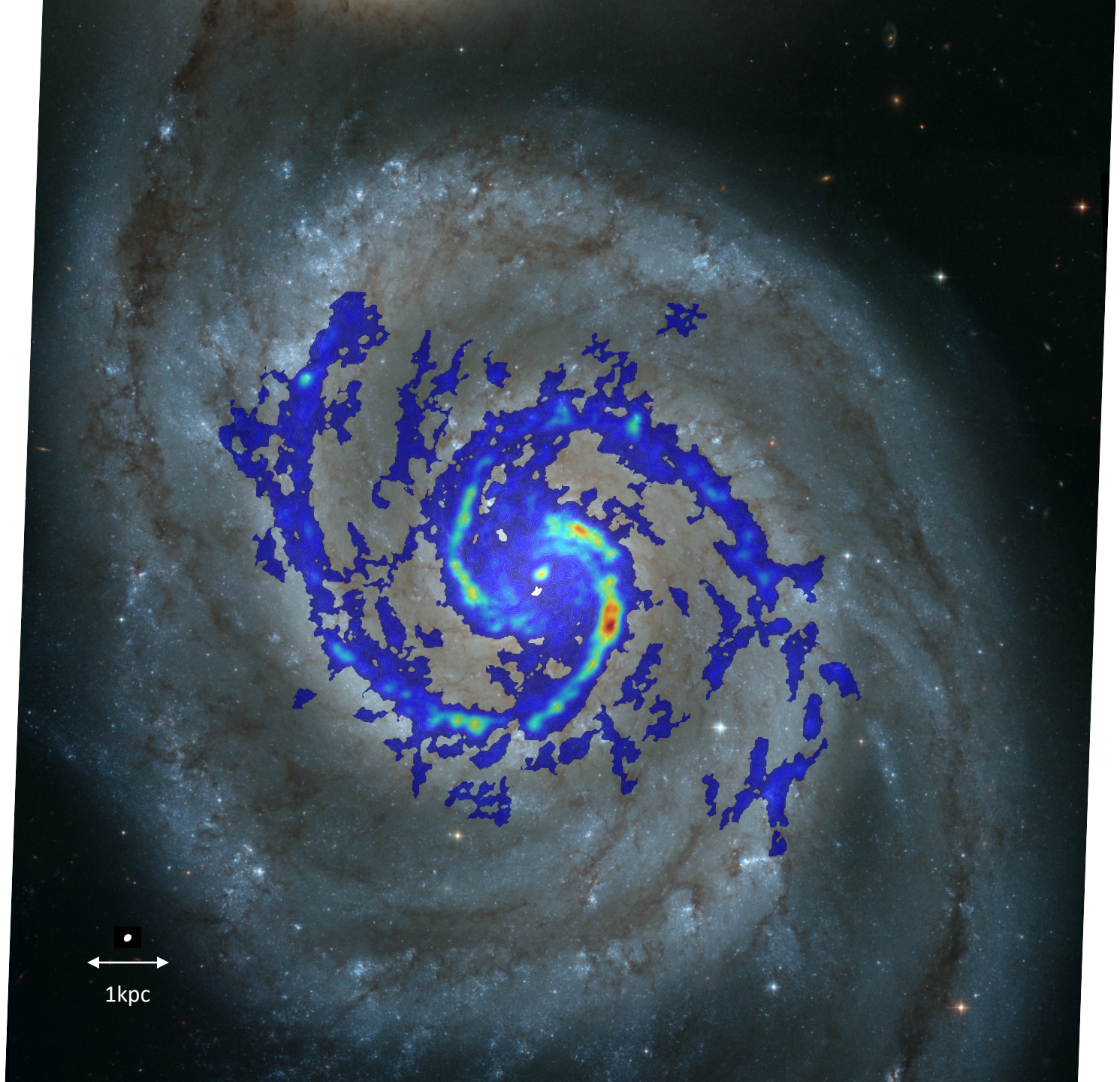


55 pointings needed to cover the same region as PAWS with the SMA at 230 GHz.

169 hours observing time
(126 hours ‘on-source’)

M51

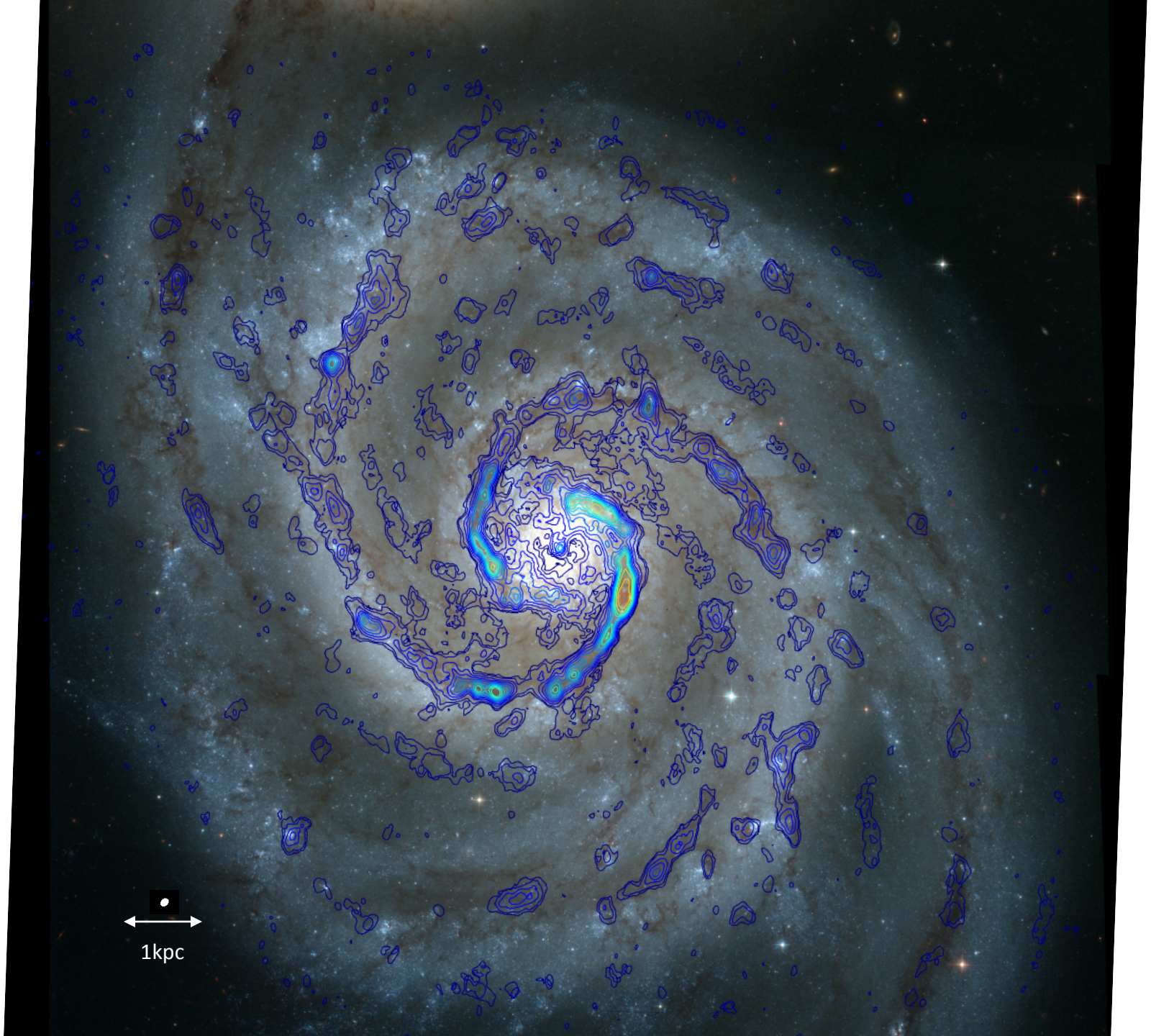
SMA ^{12}CO J=2-1
(~ 3” res)
(PAWS area)



Impressive results:
requested 4 more tracks
to map entire disk!

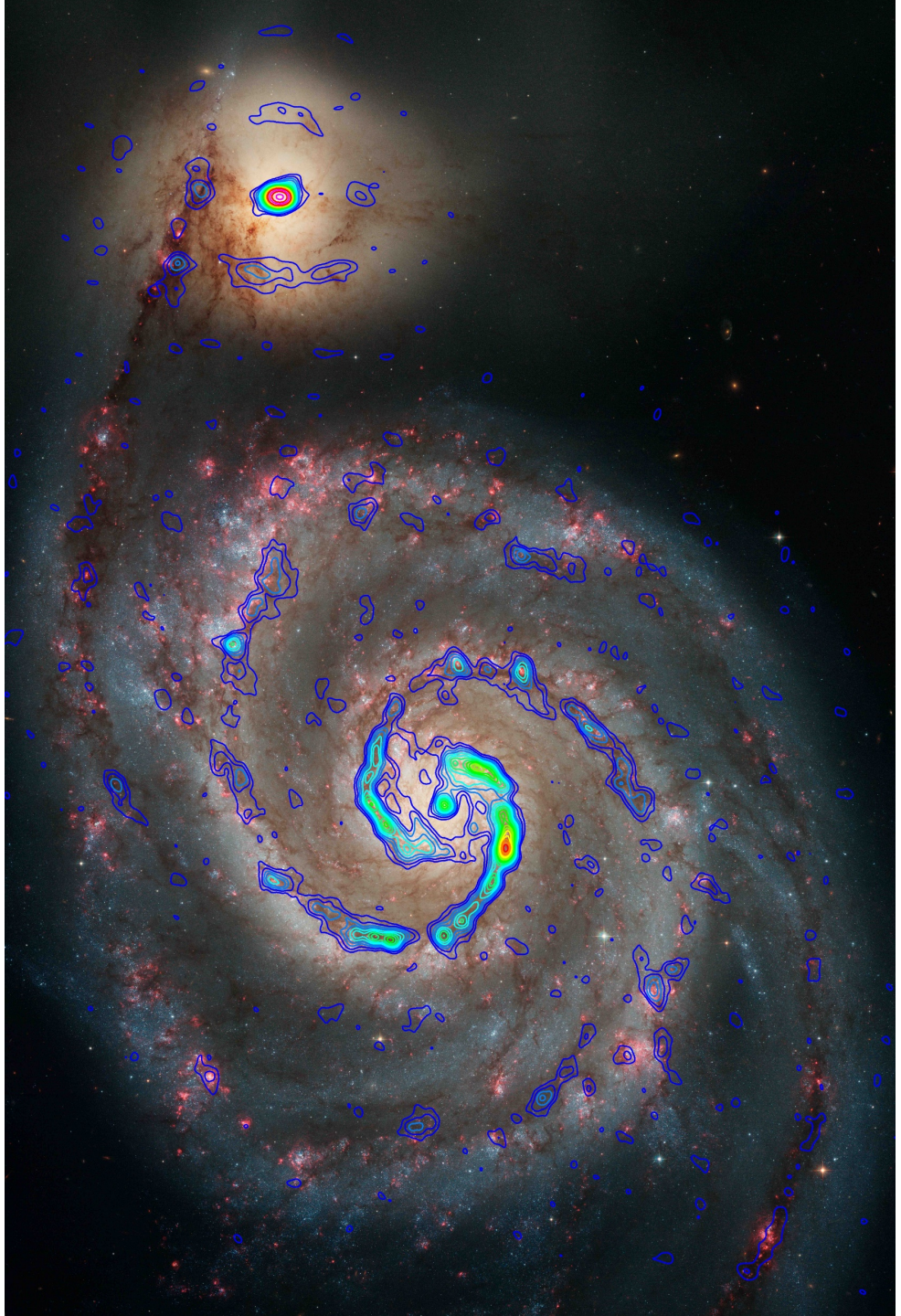
M51

SMA CO J=2-1
at 5” resolution



M51

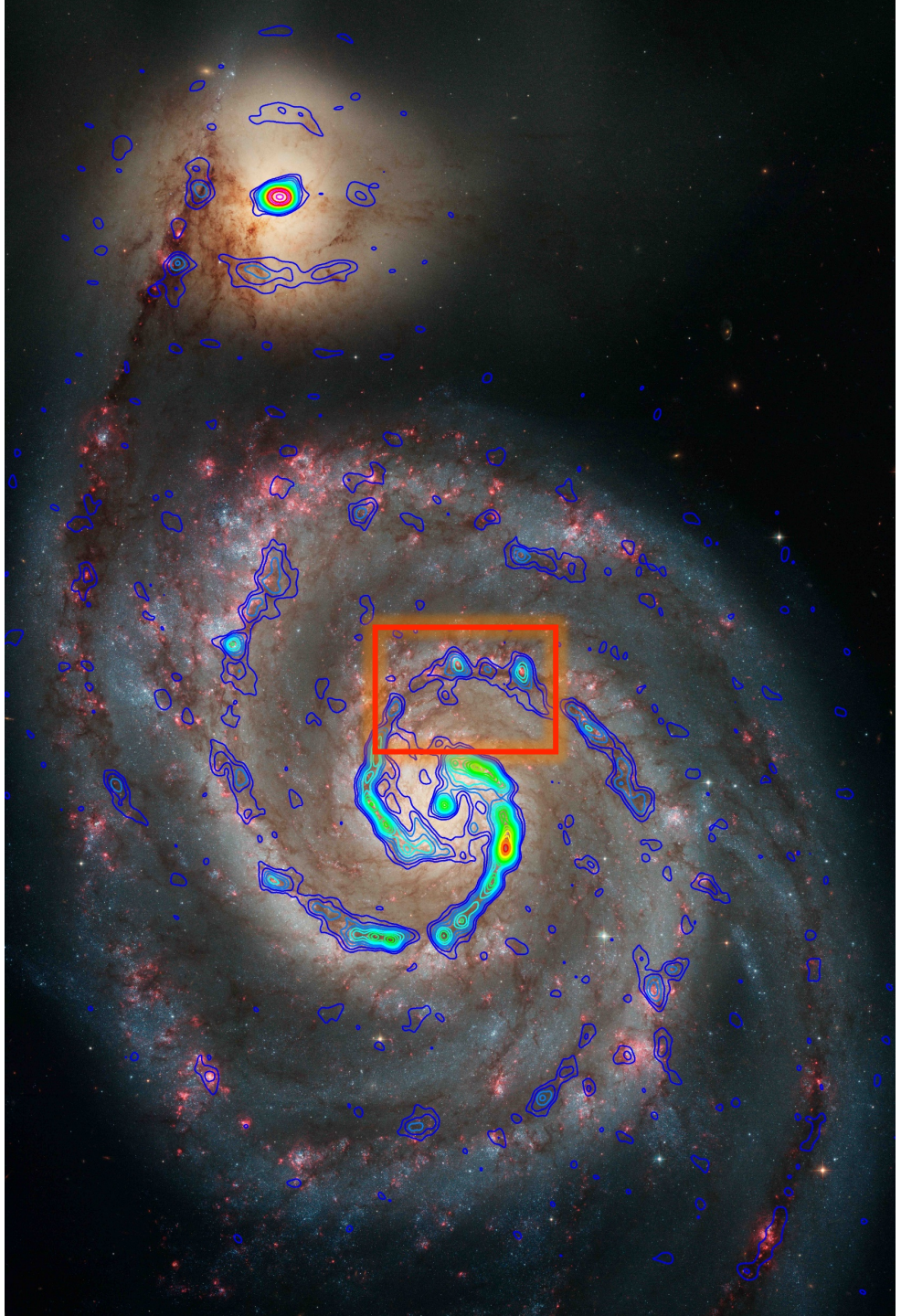
SMA CO J=2-1
at 5” resolution



Courtesy of Glen Petitpas

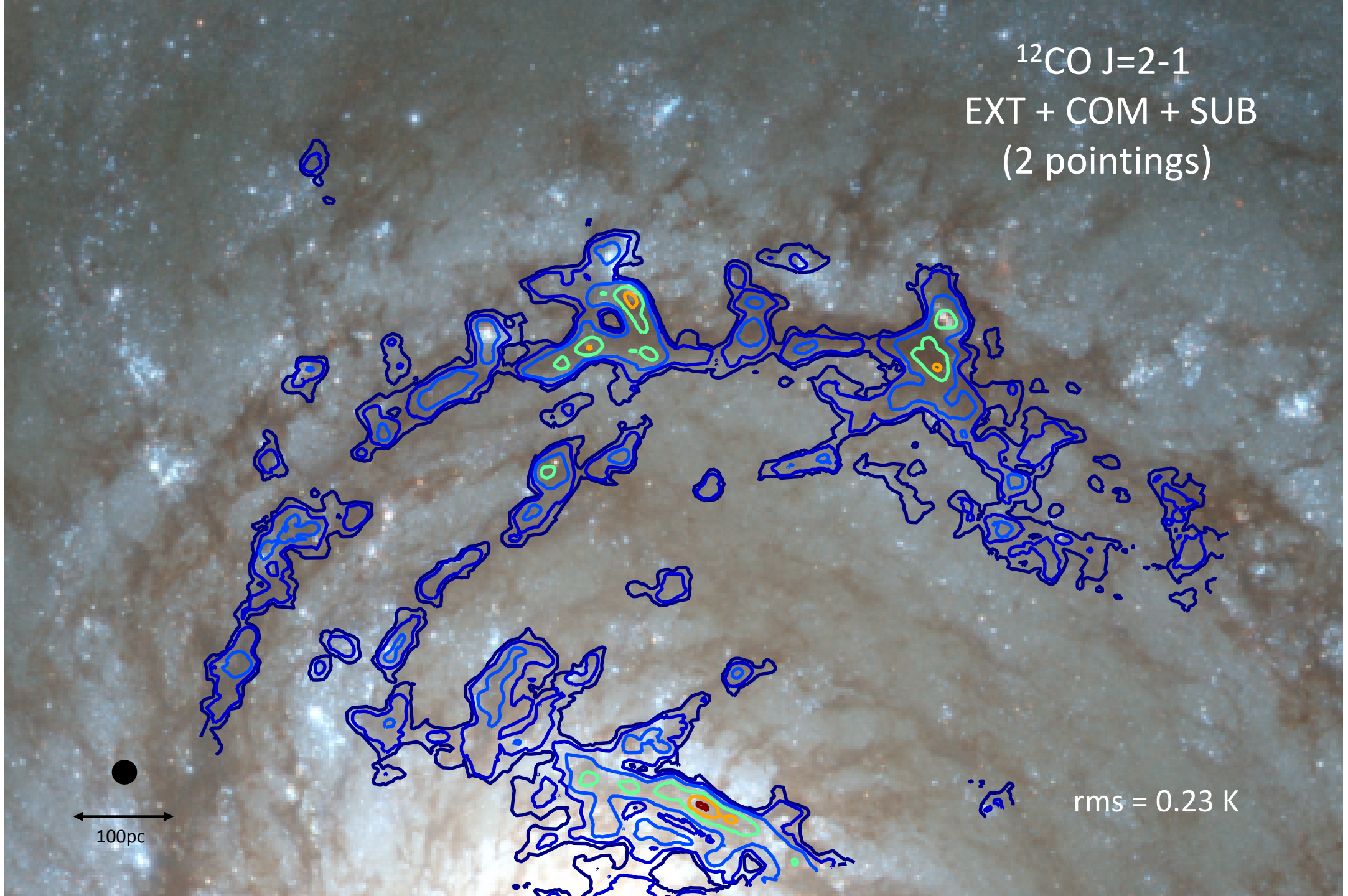
M51

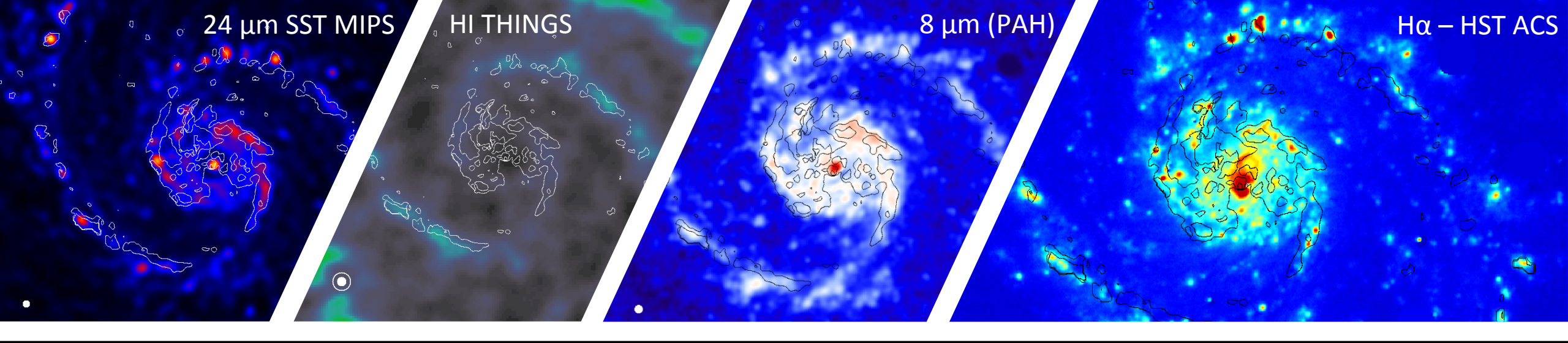
SMA CO J=2-1
at 5” resolution

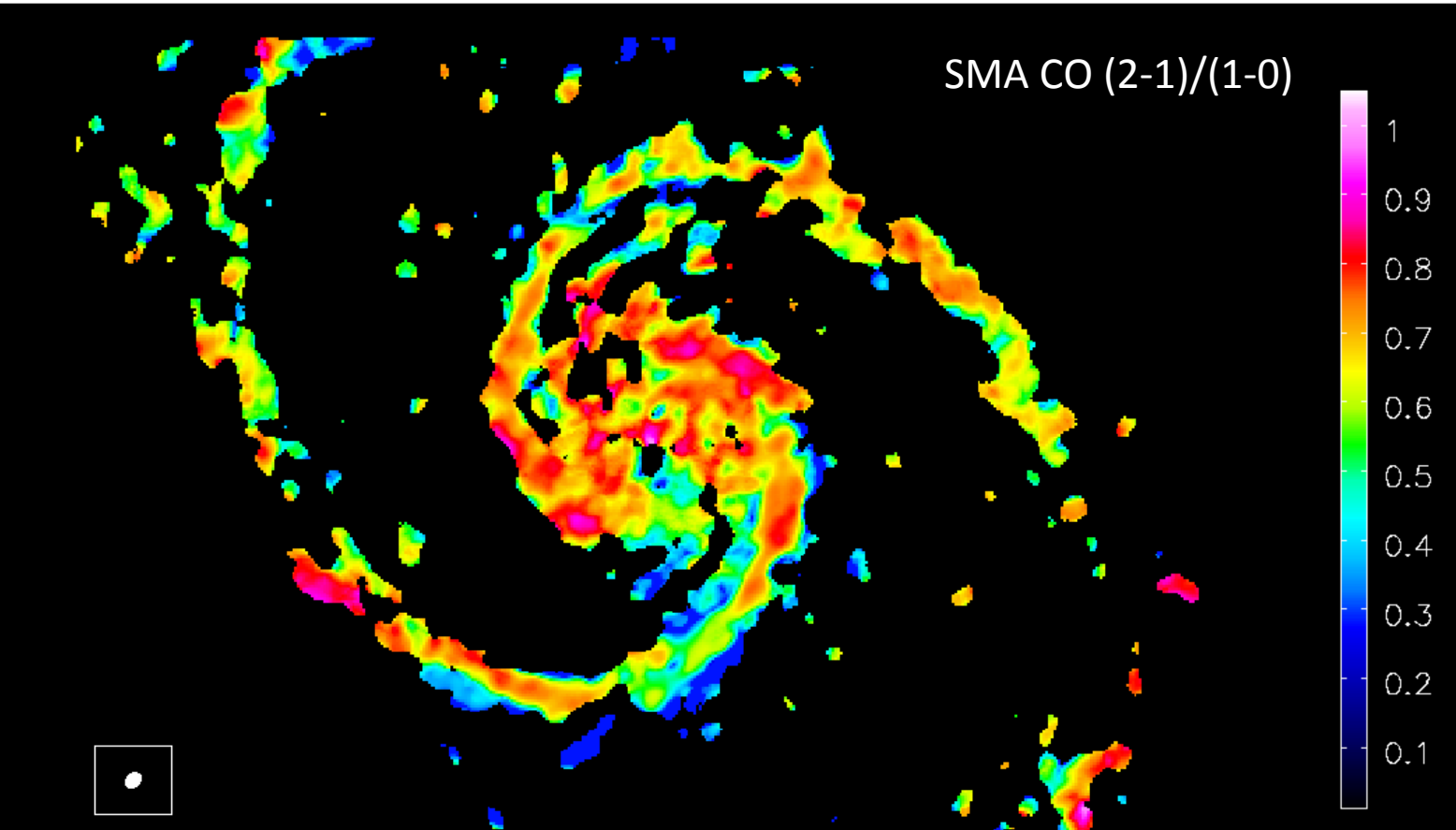


SMA EXT field to
study gas spurs
at 1” resolution

Courtesy of Glen Petitpas


^{12}CO J=2-1
EXT + COM + SUB
(2 pointings)
100pc
rms = 0.23 K

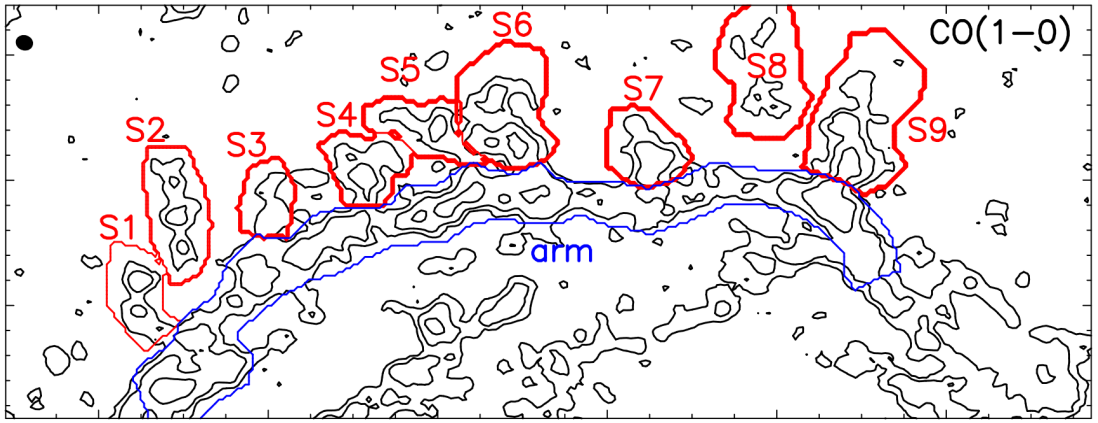


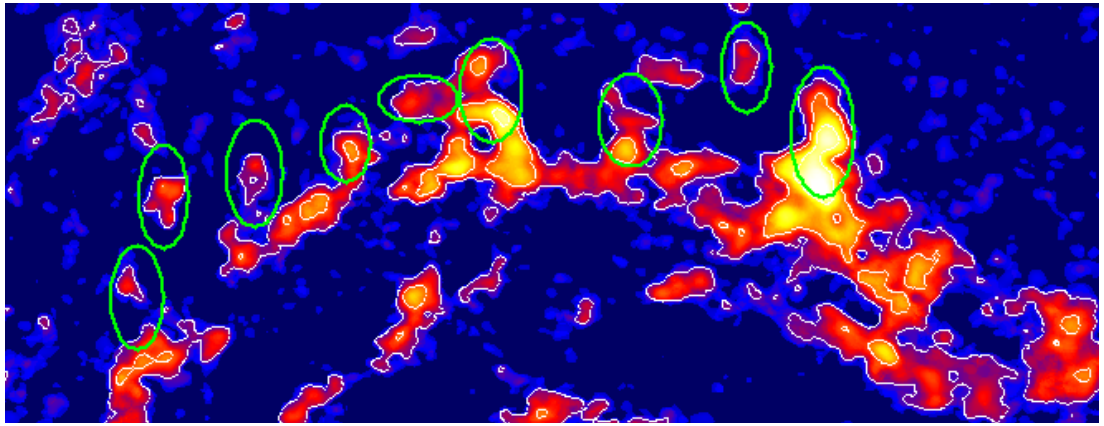


How does CO (2-1)/(1-0) vary with environment and scale?

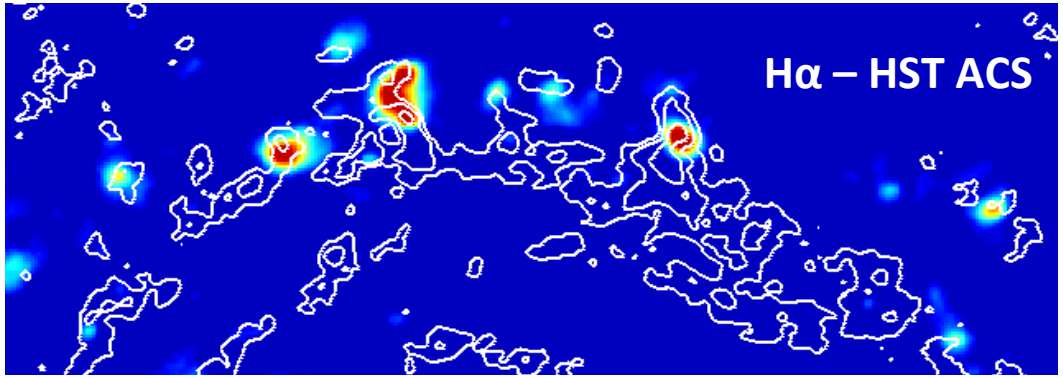
Cloud-scale mapping & spurs

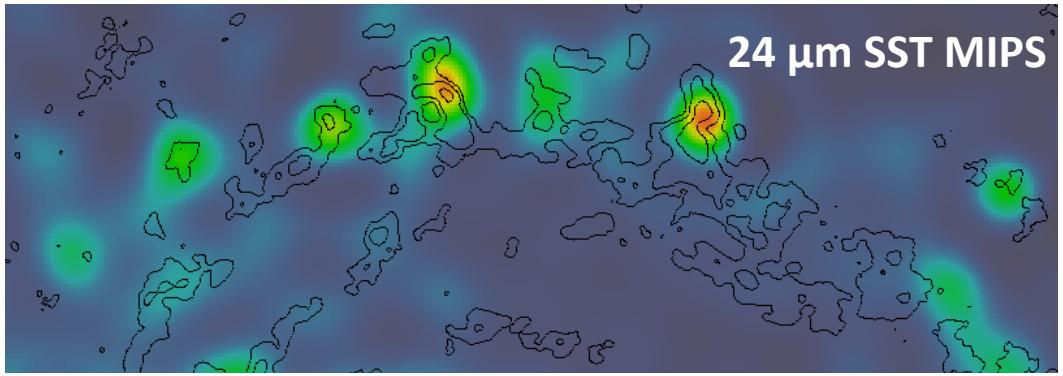
Schinnerer+17

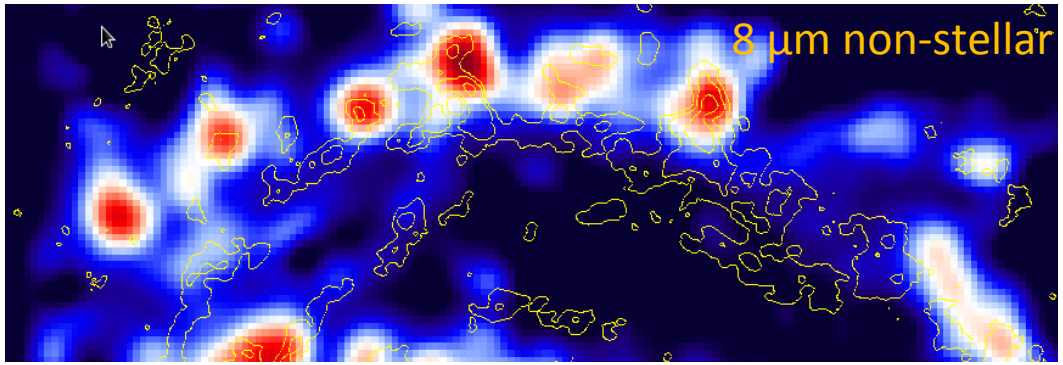




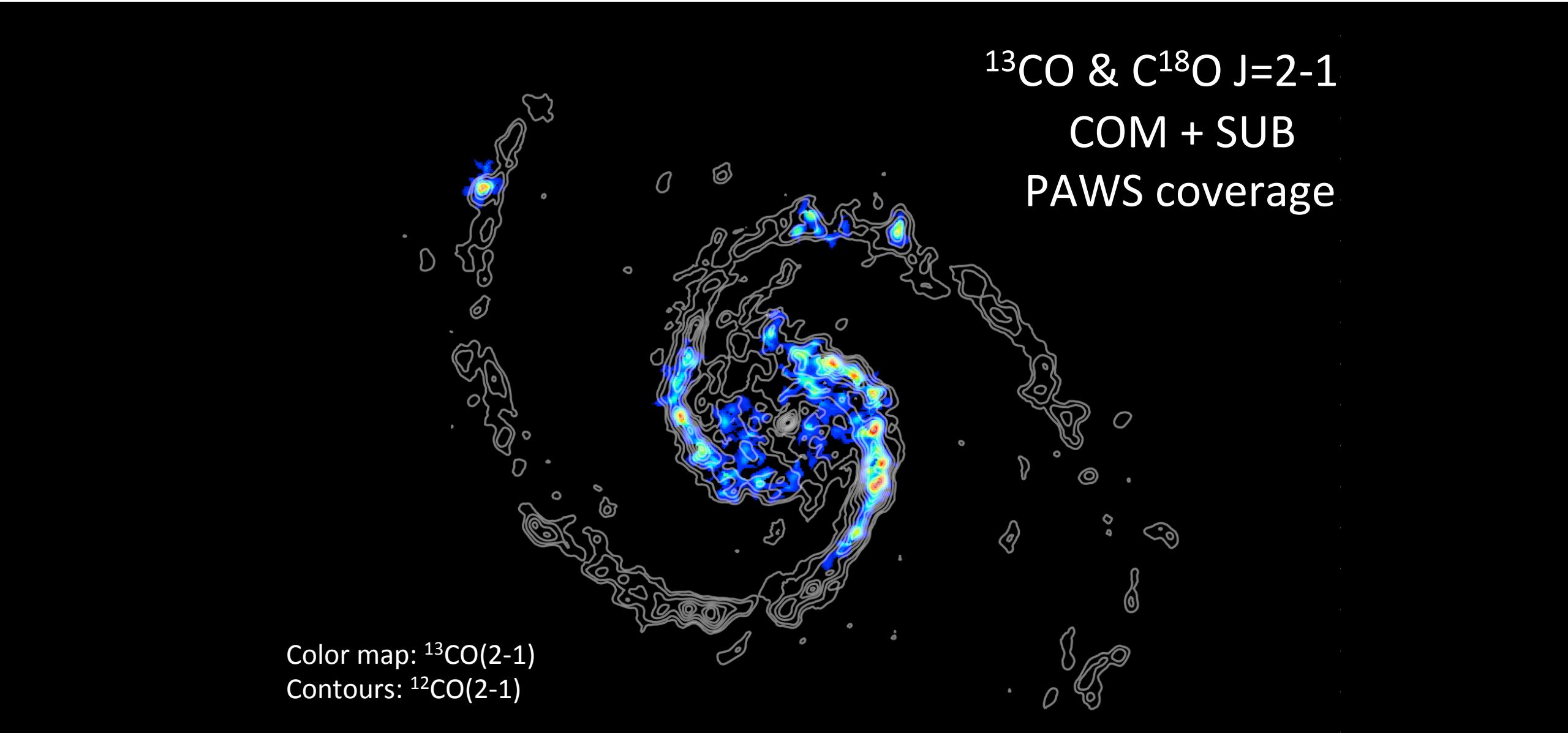
SMA CO(2-1)



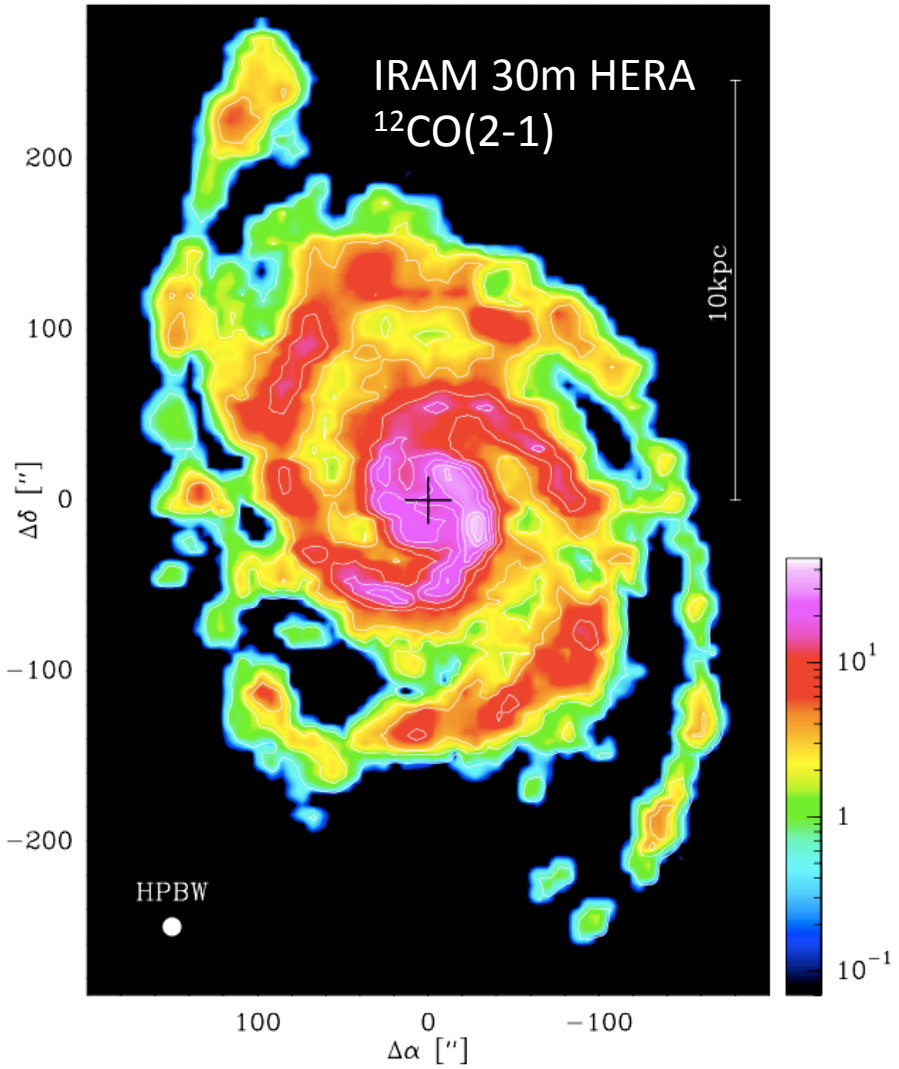




Carbon isotopologues in M51



Combining the SMA+IRAM in M51



Schuster+2007

- IRAM 30m large program (175h, K. Sliwa) to observe **^{12}CO, ^{13}CO and C^{18}O(2-1)** and **C^{18}O(1-0)**
- How large is the diffuse component for **^{13}CO and C^{18}O (2-1)**?
- How do the **line ratios** vary with different scales? How does this compare to trends found at low resolution in nearby galaxies? (EMPIRE Jimenez-Donaire+17a,b, Cormier+18)

Summary & follow-up

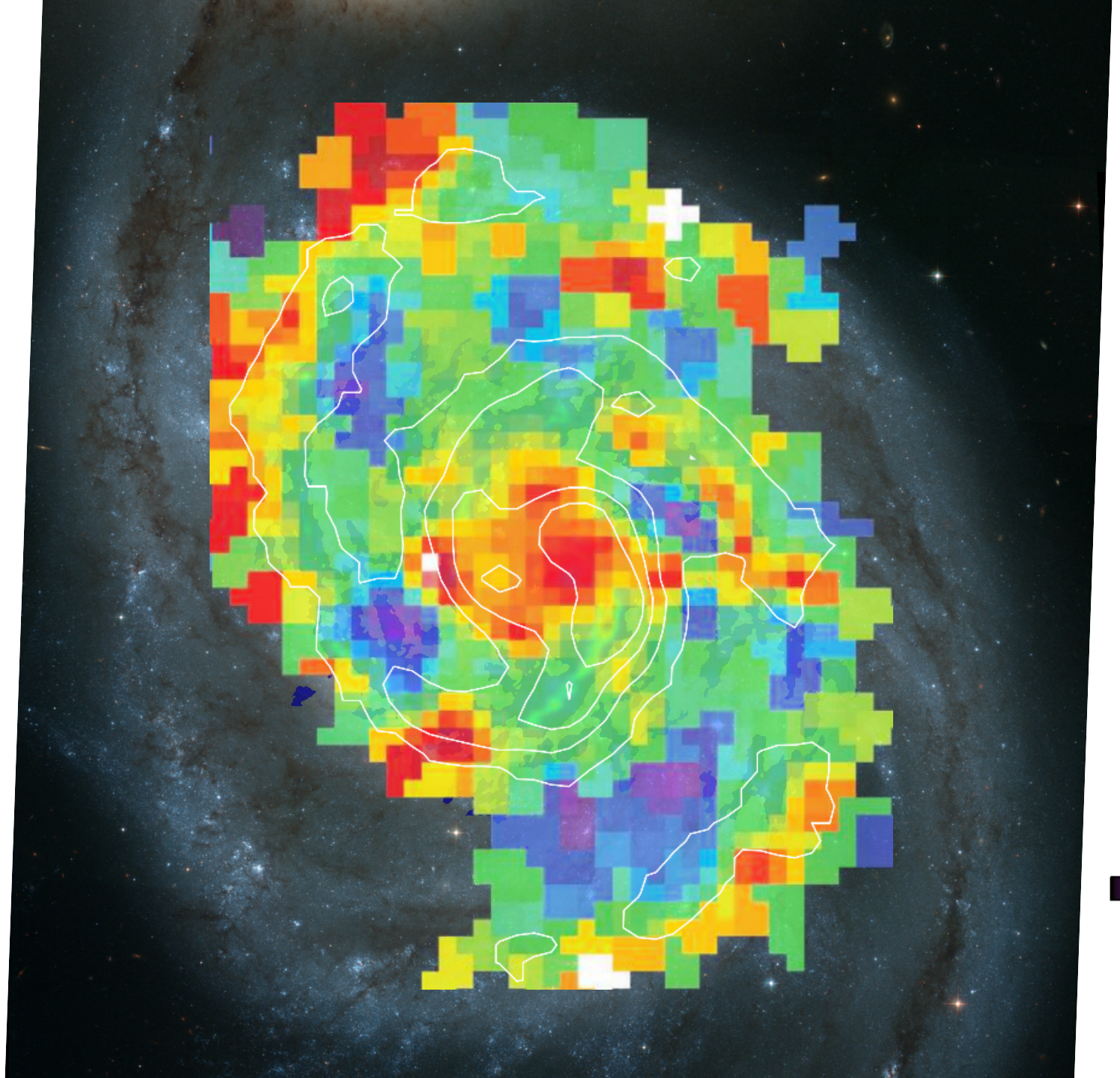
- For the first time we can study variations in the canonical ^{12}CO (2-1)/(1-0) as function of ISM environments (ionized, atomic, dusty…) and scales of observations (40 pc – 100 pc – 1 kpc).

- Huge legacy dataset, extremely useful for e.g. dynamical modeling

- Expect publications soon!

1. Technical paper to introduce the data (Petitpas+in prep.)
2. Paper on CO (2-1)/(1-0) ratio (Jiménez-Donaire+in prep.)
3. Paper on ^{12}CO/ ^{13}CO and ^{13}CO/C^{18}O ratio trends
4. Letter on gas spurs (EXT data)
5. Paper on CO lines in M51b
6. …

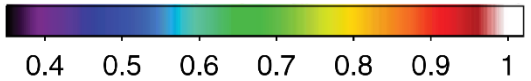
CO J=2-1/1-0



CO 1-0 from CARMA
CO 2-1 from NRO 45m

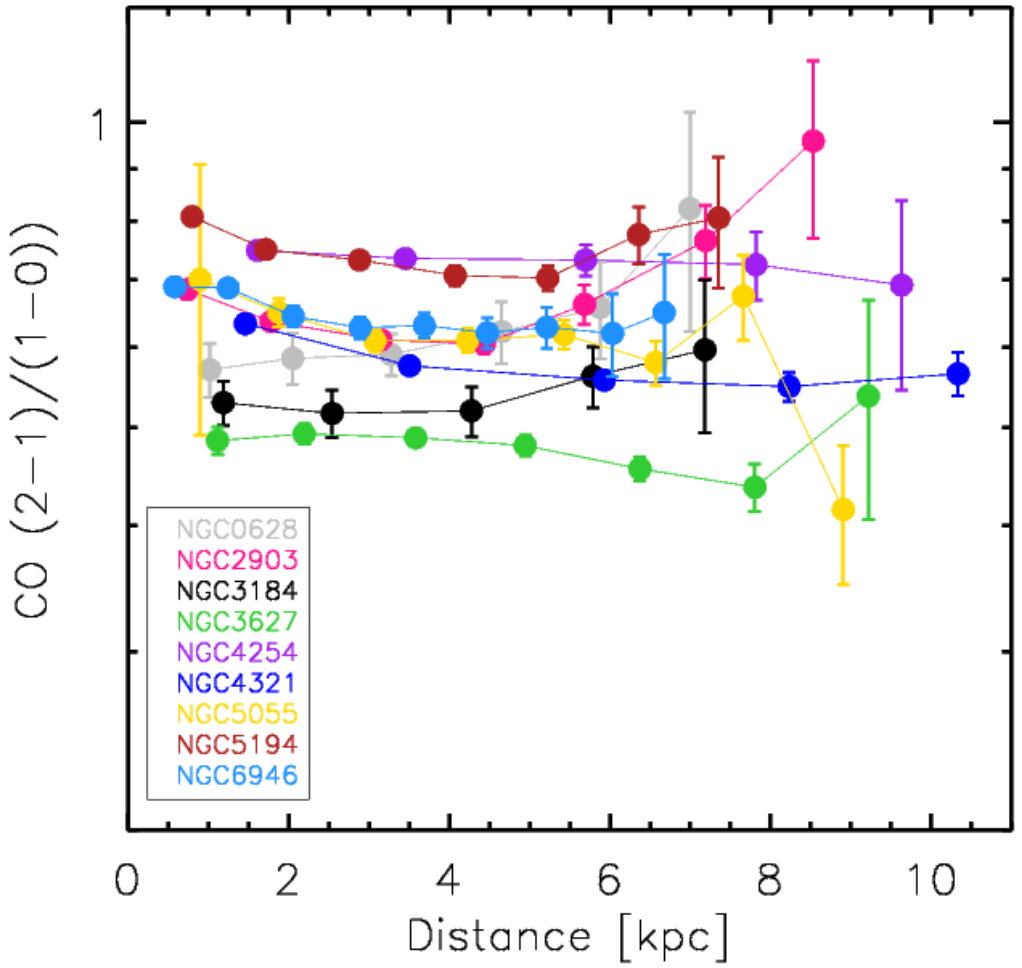
FWHM ~ 20”

Koda et al. 2012



^{12}CO (2-1)/(1-0) in galaxies

No strong, systematic trends of ^{12}CO line ratio across EMPIRE disks on ~kpc scales

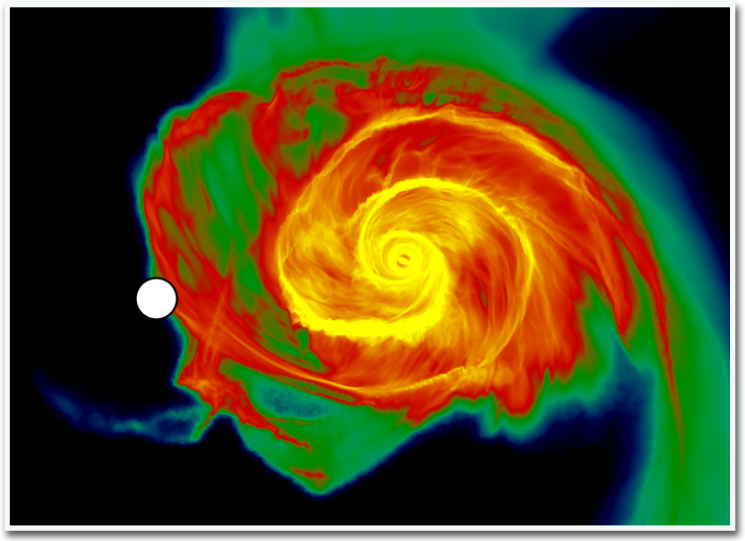


The EMPIRE Survey (Jimenez-Donaire et al. in prep.)

Summary & follow-up

Isothermal model comparison
and synthetic maps.

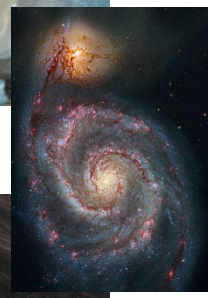
Tress, Glover et al (in prep.)



CO Cloud-scale mapping

NOEMA

PAWS: PdBI Arcsecond Whirpool Survey
CO (1-0) @1”, Schinnerer+13



ALMA

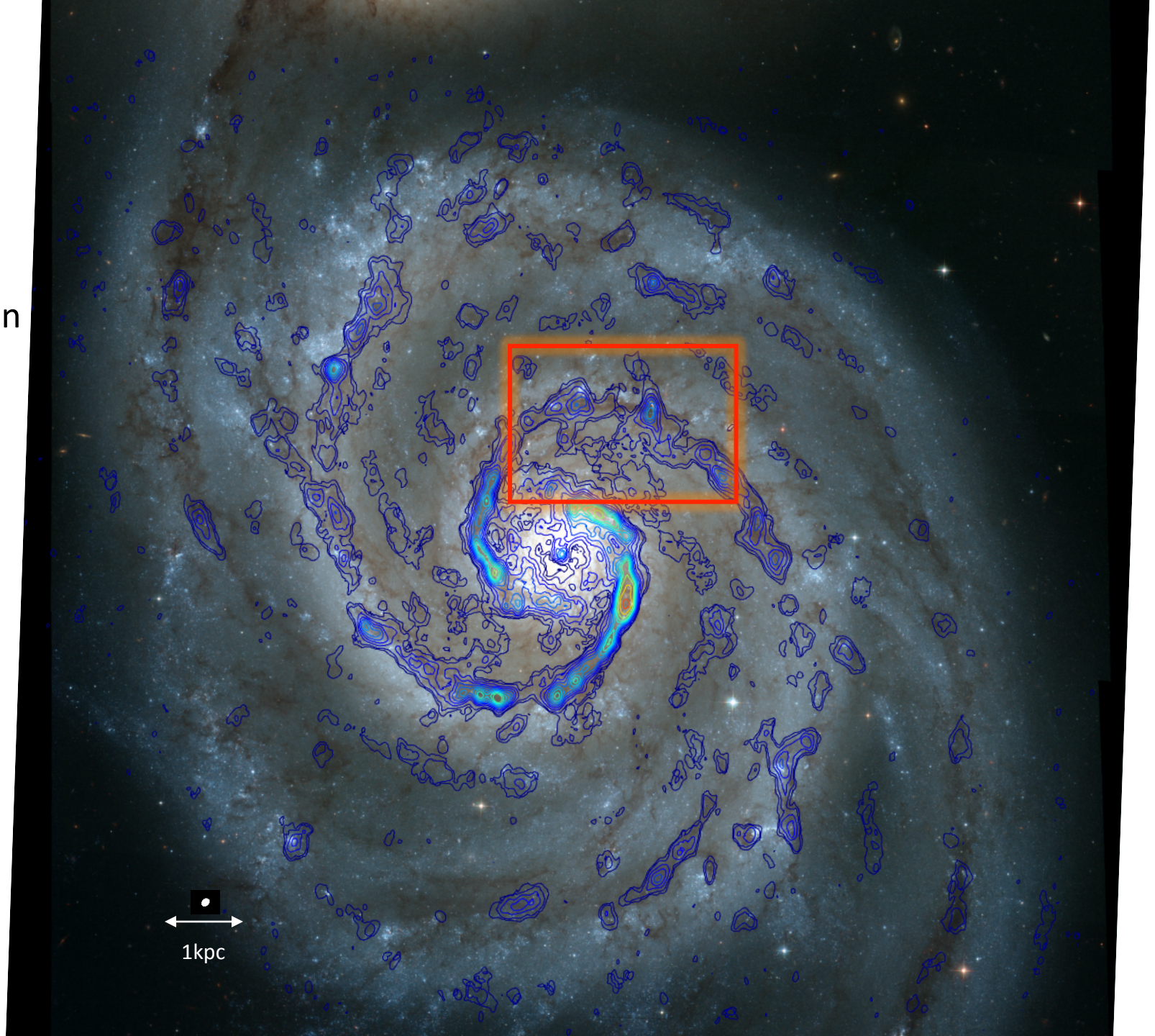
PHANGS: Physics at High ANGular ReSolution
CO (2-1) @1”, Leroy+in prep.

SMA

Cloud scale view of M51
CO (2-1) @1-3”

M51

SMA CO J=2-1
at 5” resolution



SMA EXT field
to study spurs
at 1” resolution