

Group 2
Jae Yeon Mun
Jee Won Lee
Mina Pak

ALMA Data
Imaging of
Molecular
Gas in
NGC4321
& NGC1808



Introduction

- Morphology: SAB(s)bc
- Member of the Virgo cluster (d = 16.5 Mpc)
- A starburst galaxy with active star formation in the center!
- With ALMA, we can resolve molecular gas clouds, which are tightly correlated with star formation.



Credit: SDSS

Goals

- Gain experience with ALMA images
- Study the distribution and kinematics of molecular gas throughout the galaxy
- Look at the Kennicutt-Schmidt Law for NGC 4321

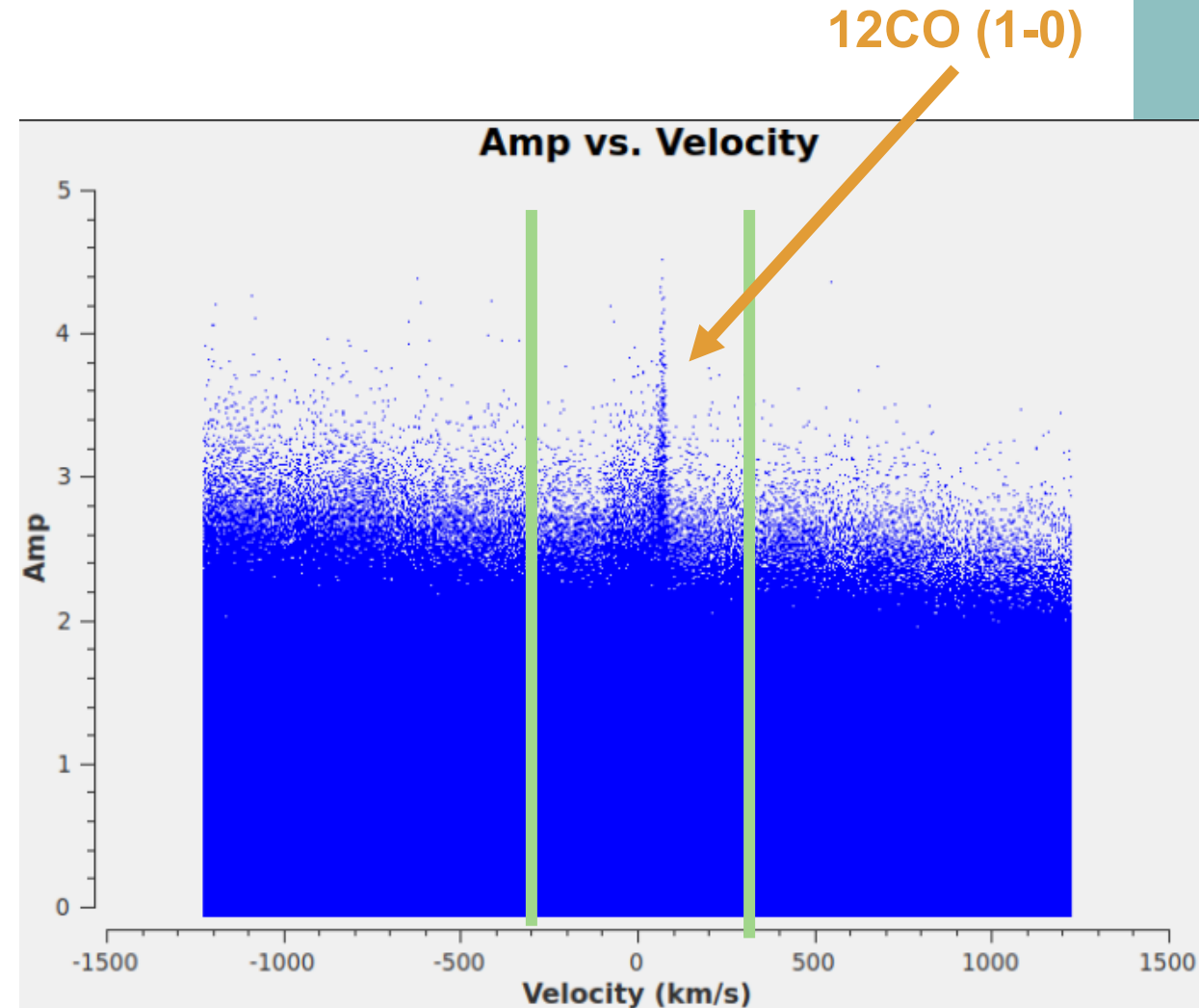
Observations

- ALMA Band 3
- $^{12}\text{CO}(1-0)$ (115.271 GHz)
- 12m array, 42 antennas used
- Integration time ~26 min
- Observations made in 2016; PI: Karin Sandstrom

Image cleaning 

Imaging

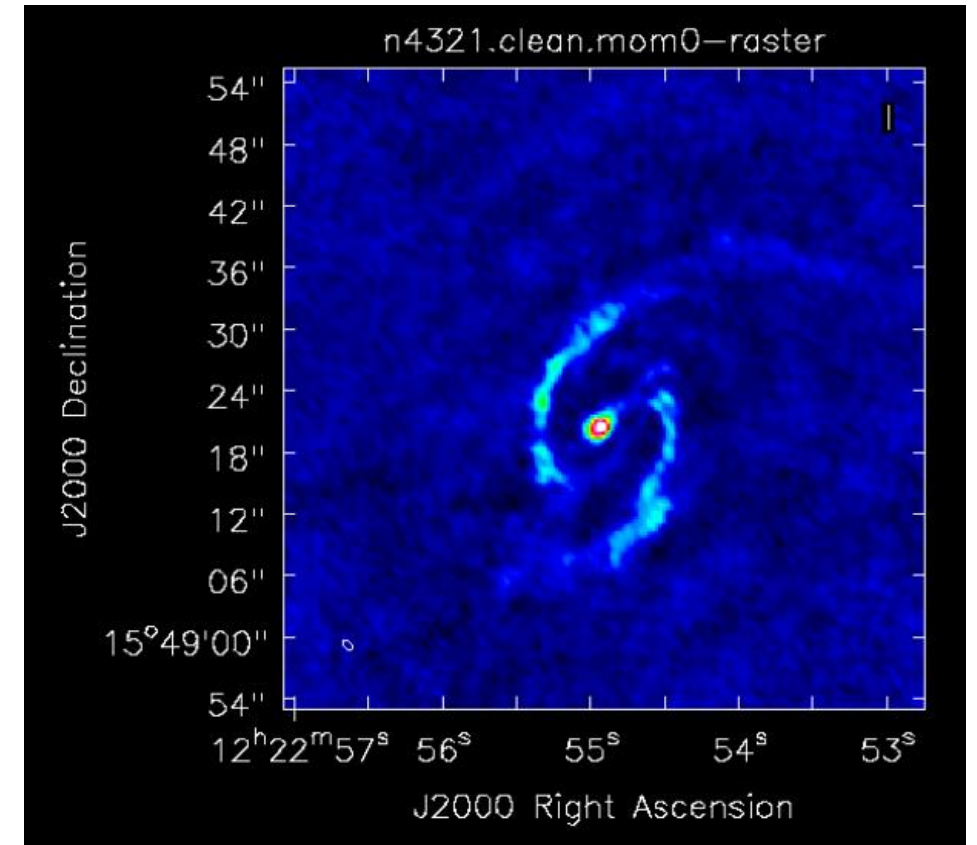
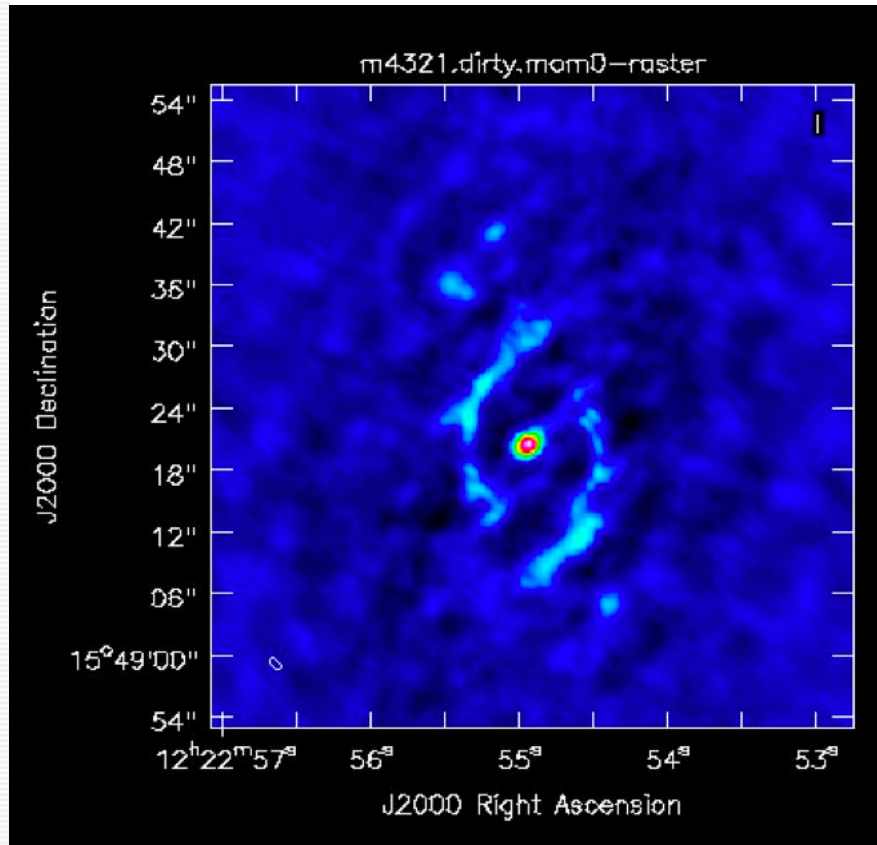
- Systematic velocity ~ 1600 km/s
- Cell size = $0.25''$
- Image size = 250 pixels



▶ Cleaning

- Create dirty image
- Clean image
 - start = 1300 km/s
 - width = 10 km/s
 - nchan = 60 (velocity width / channel width)
 - threshold = 4.39 mJy (3 * rms)
 - pbcor = True

Dirty and clean images



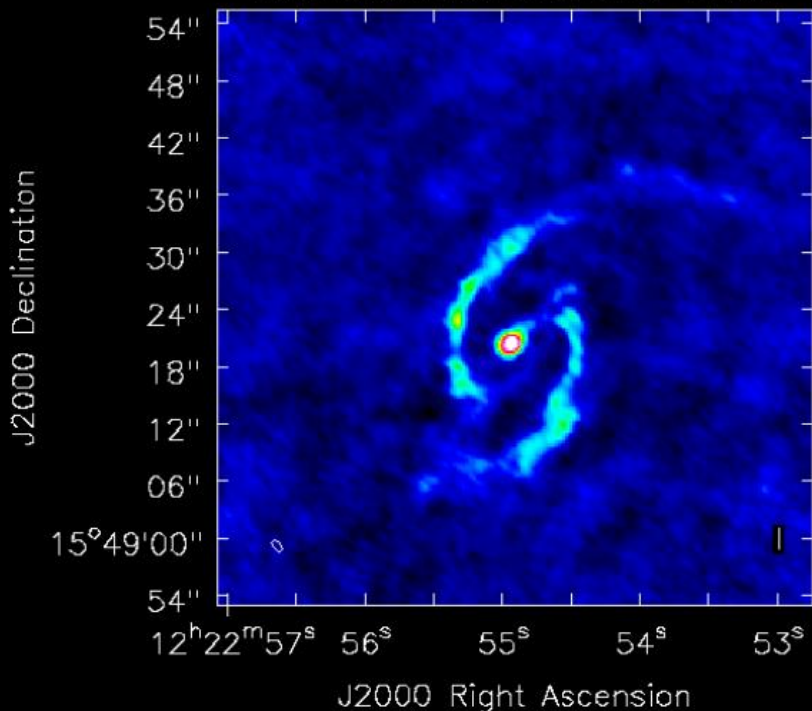
Effects of weighting

Natural
1.38" × 0.77"

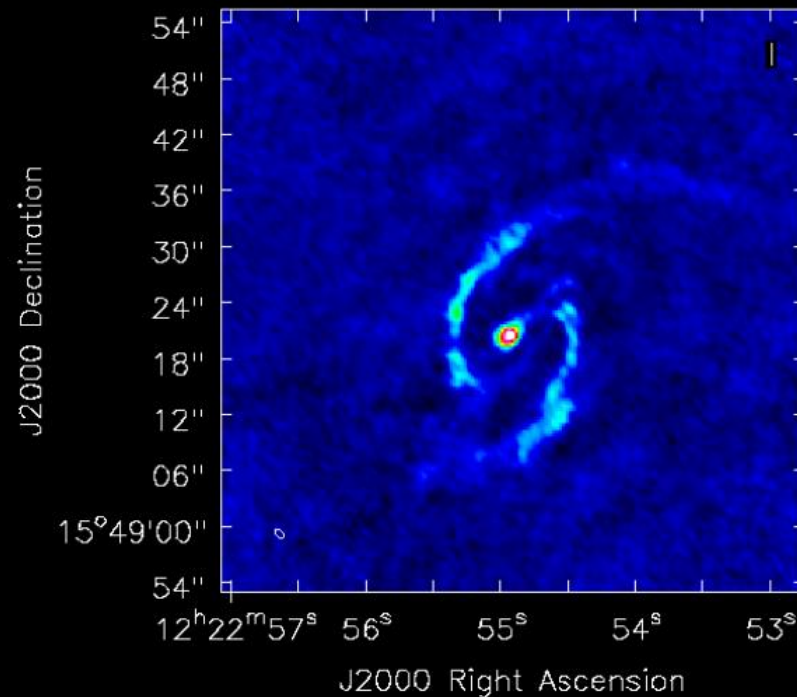
Briggs (robust)
1.22" × 0.70"

Uniform
1.09" × 0.62"

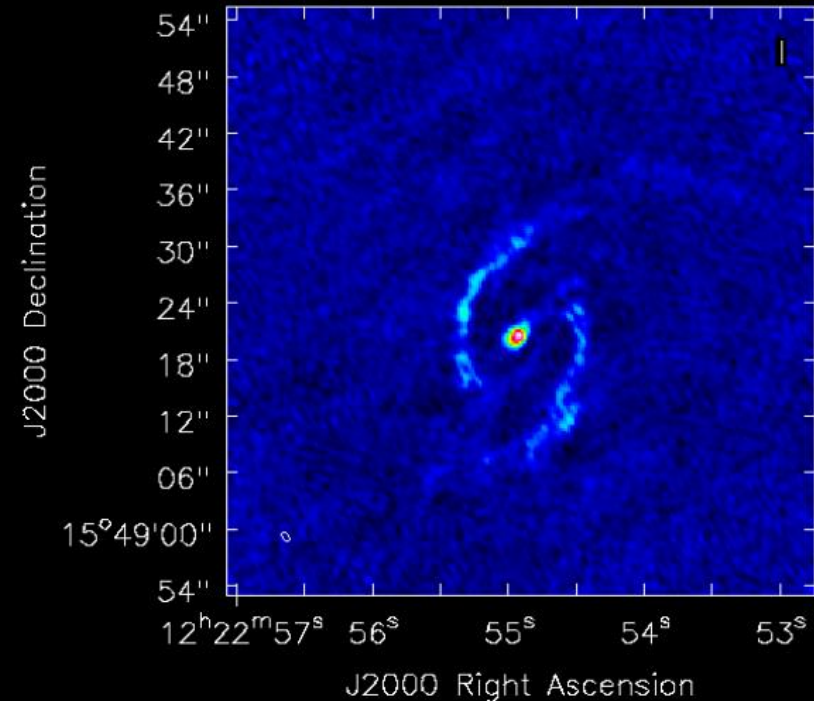
n4321.natural.clean.mom0-raster



n4321.clean.mom0-raster



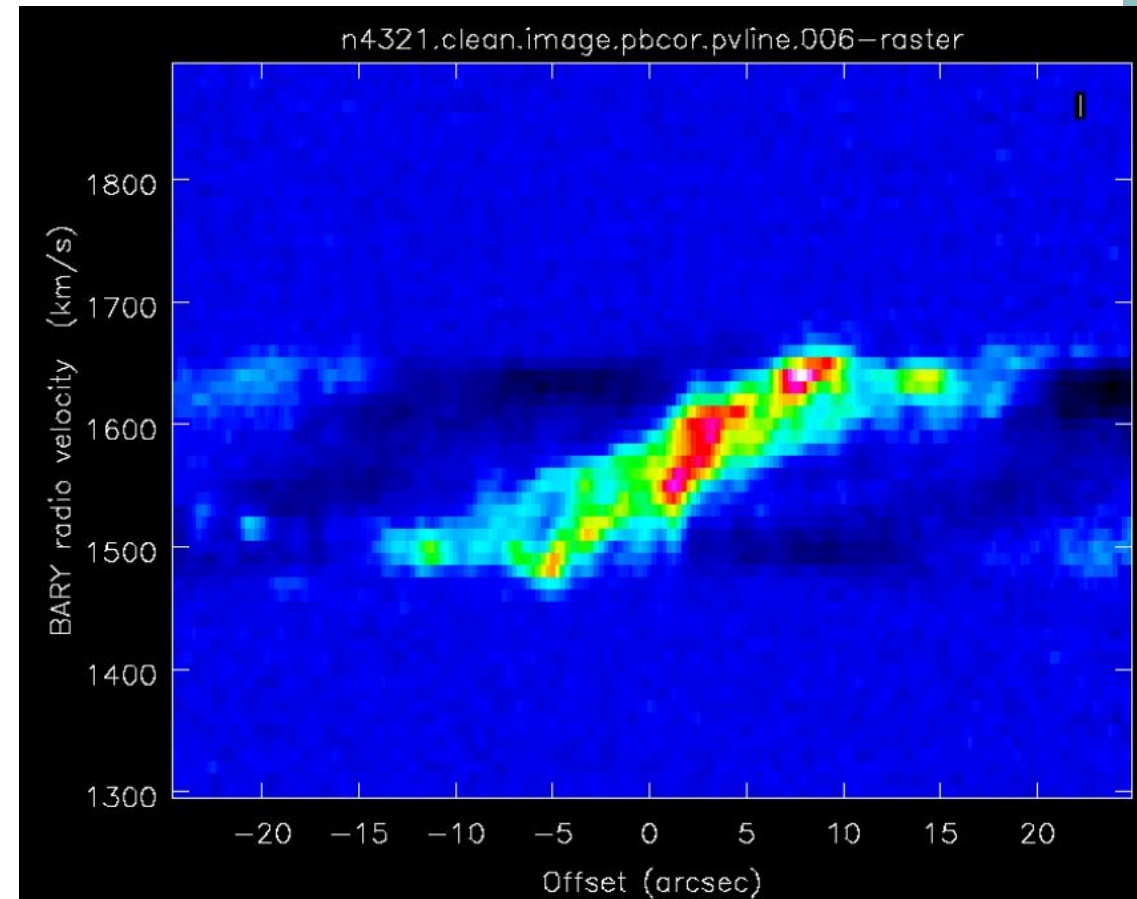
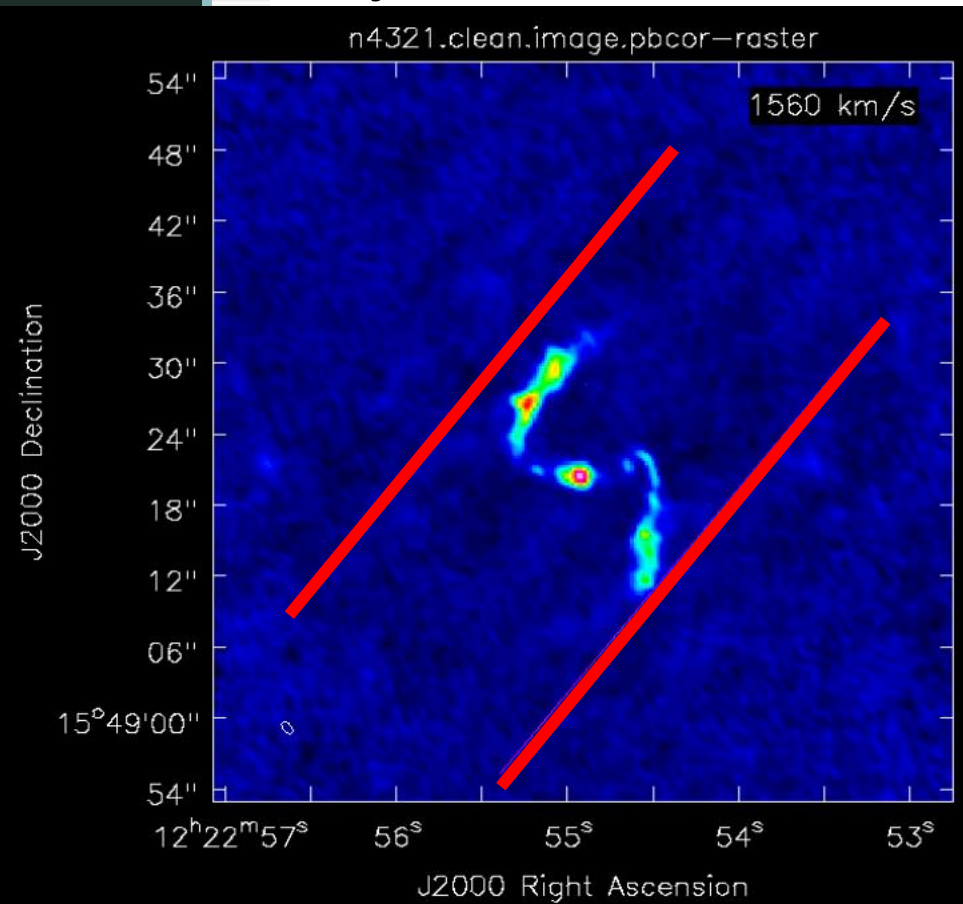
n4321.uniform.clean.mom0-raster



PV diagram & moment maps

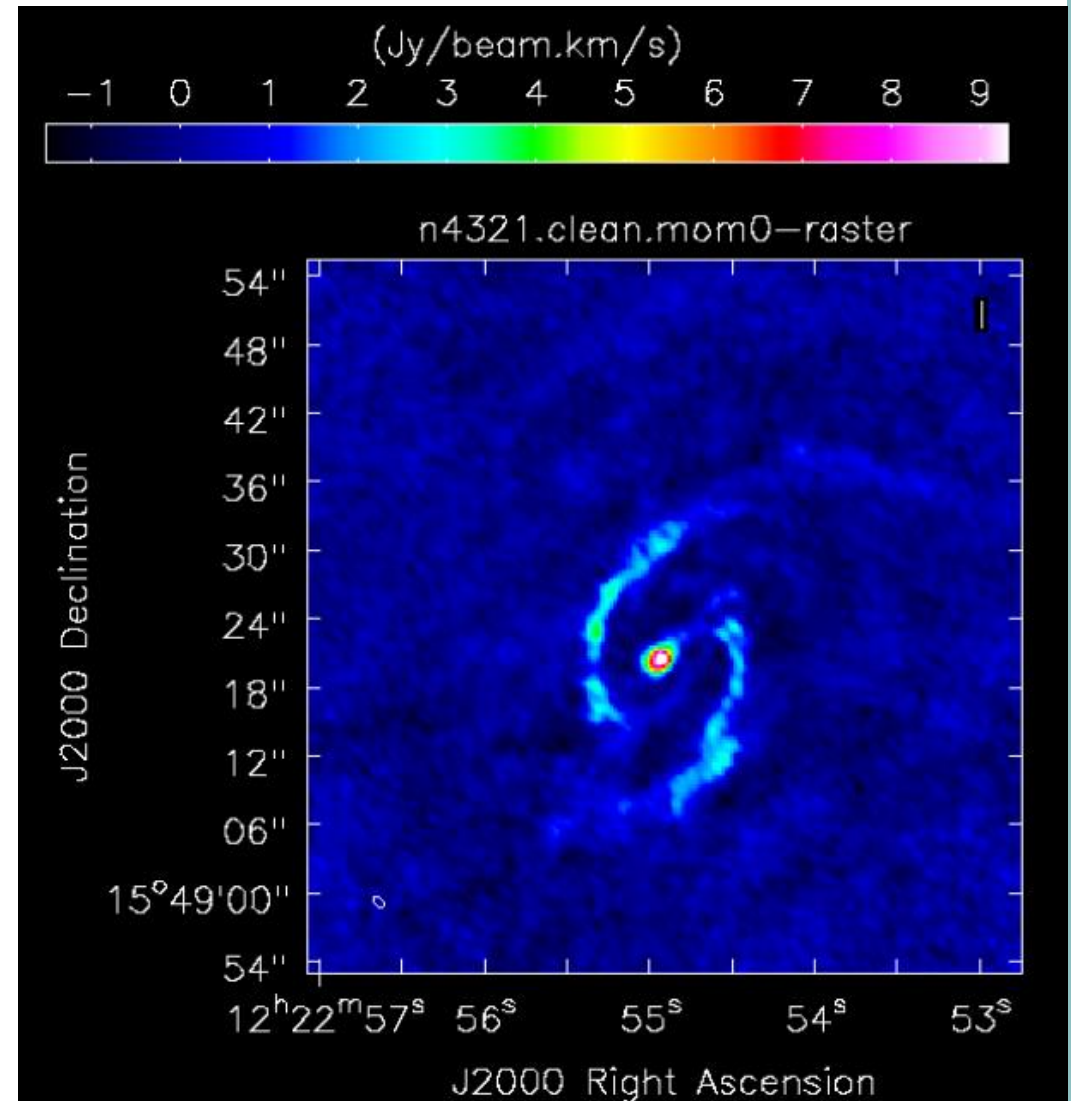
Position-velocity diagram

Major axis



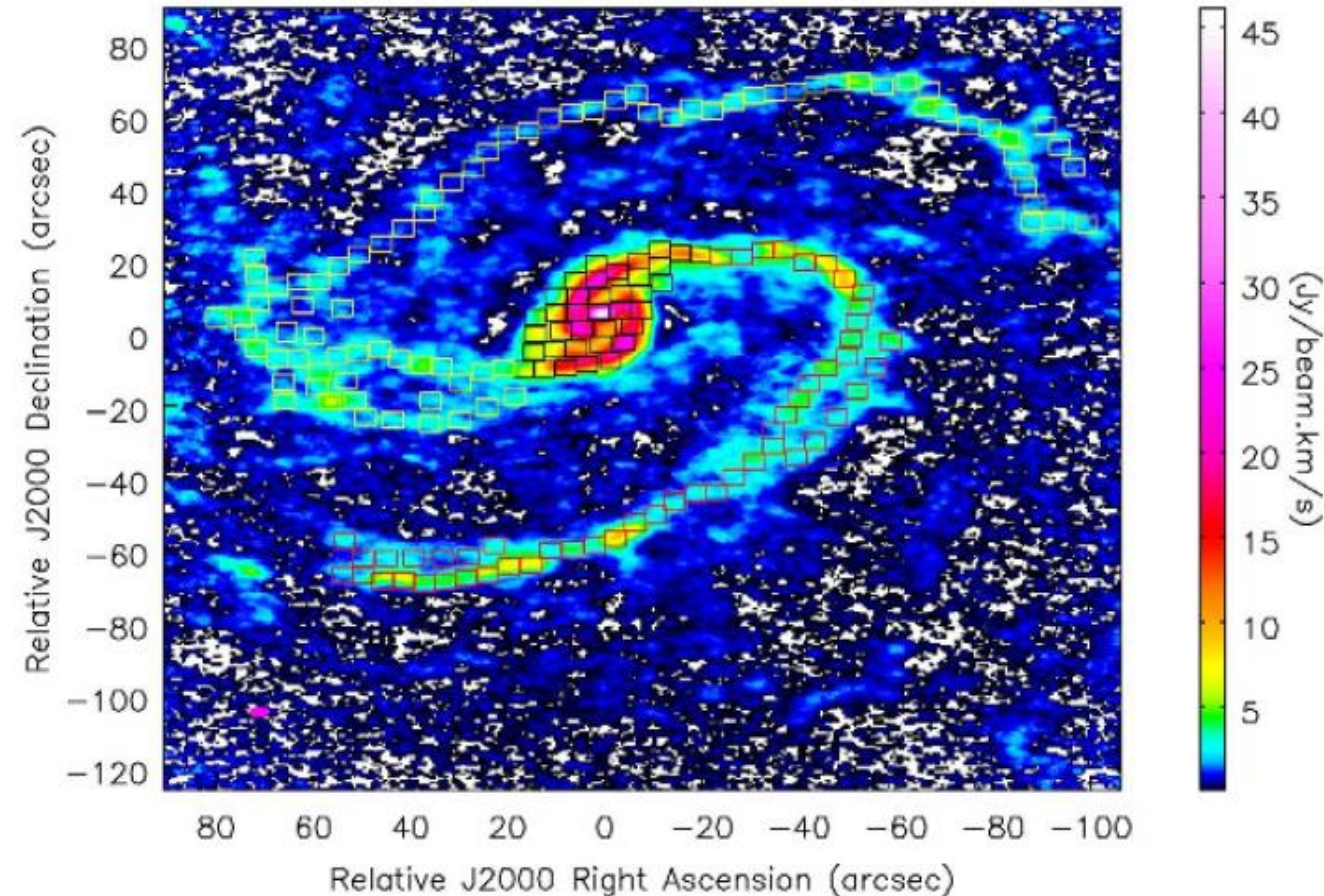
▶ Integrated intensity map

- Molecular gas primarily distributed in the core and along the spiral arms



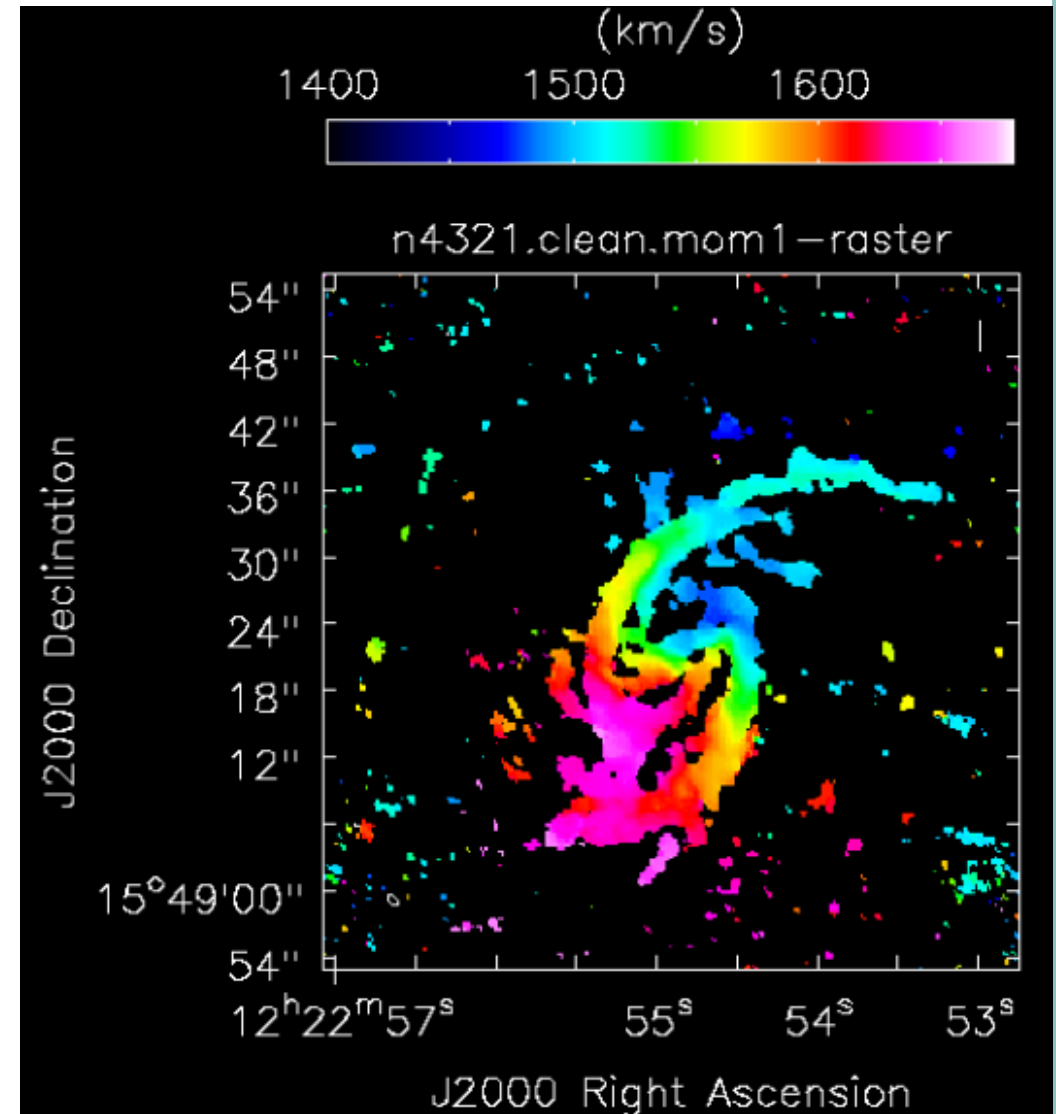
Integrated intensity map

- Observation time = 12900 s (~8 times that of this data)
- Better spatial resolution in the central region



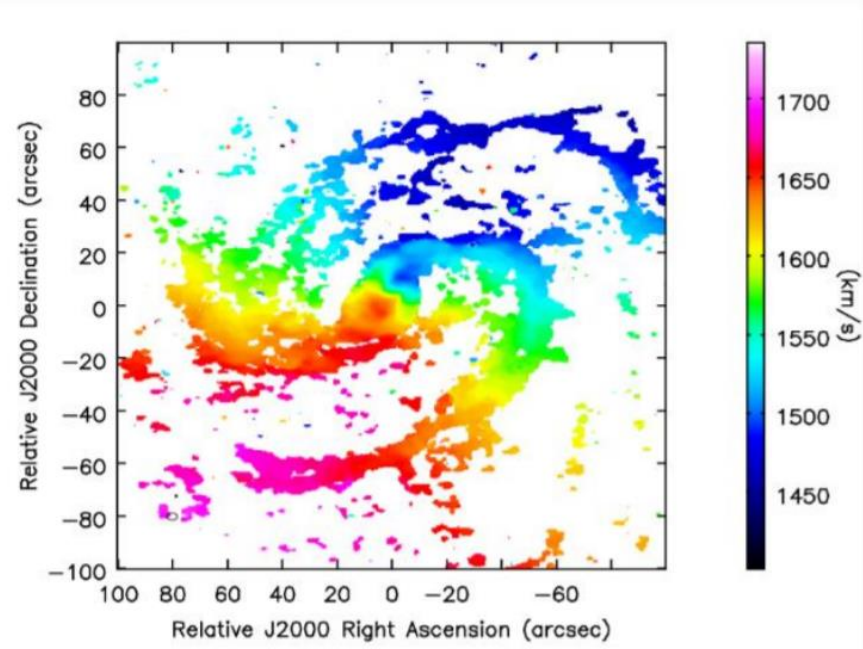
Velocity field map

- Gas kinematics show a regularly rotating disk

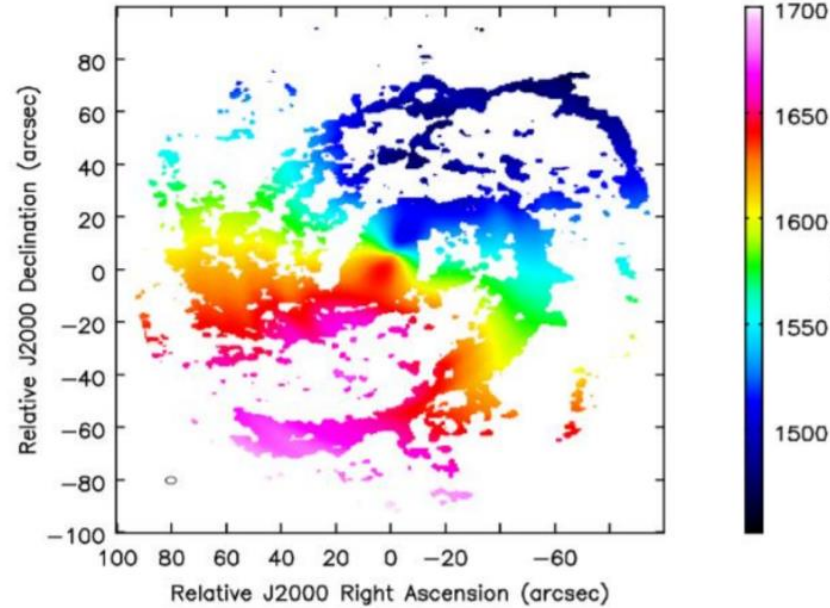


Velocity field map

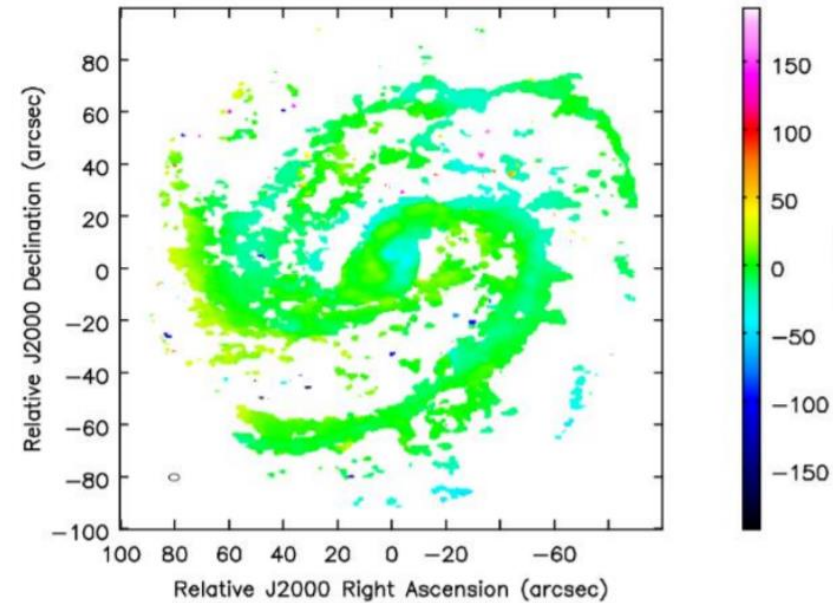
Ali+2018, submitted



Observed



Model

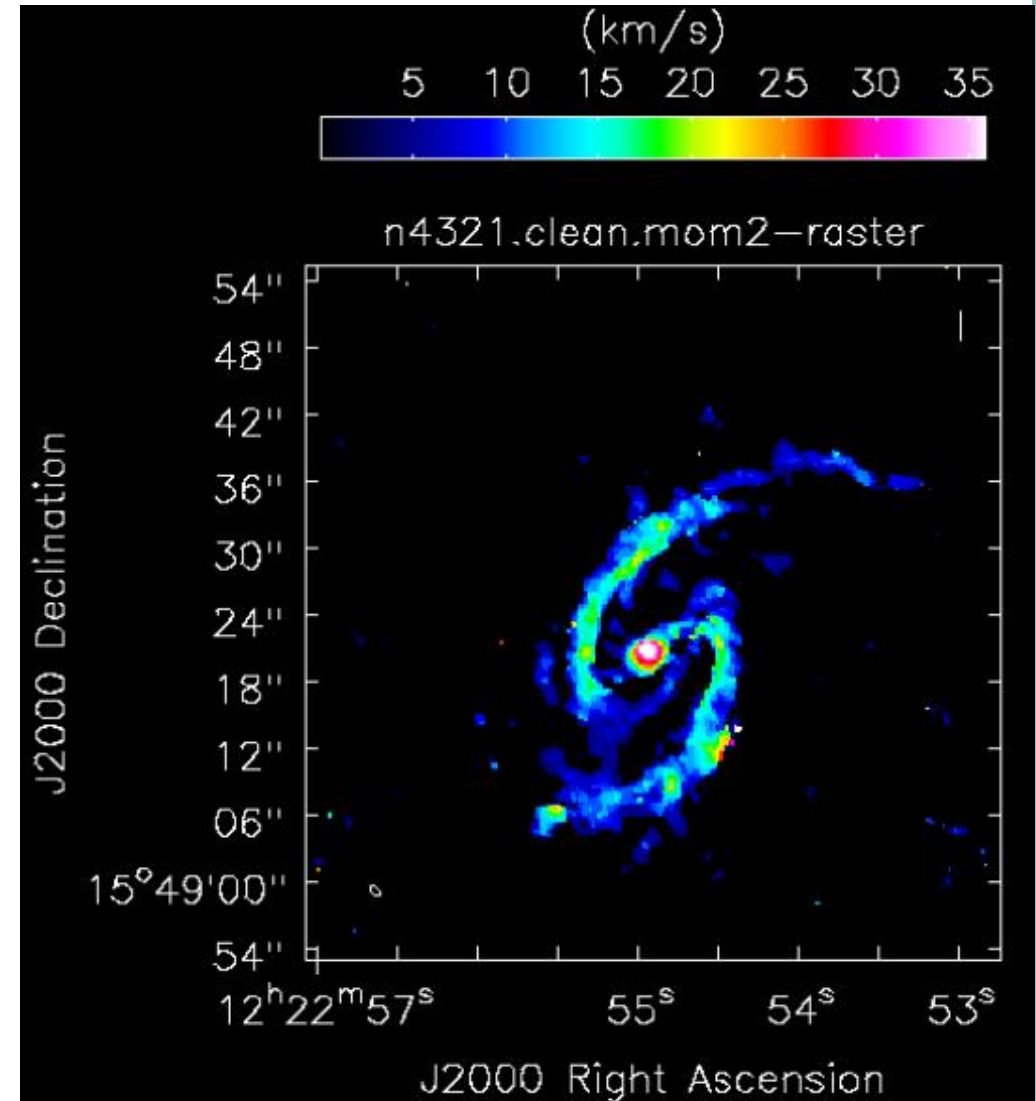


Residual

- Modeling with 3DBAROLO
- Residual velocity ~ 0 km/s \rightarrow rotating

▶ Velocity dispersion map

- Regions with relatively high velocity dispersions → relatively high gas densities



Star formation activity

Calculating SFRs

- Far-ultraviolet (FUV): tracer of young massive stars
- Mid-infrared (24 μ m): traces the stellar emission absorbed by dust
- Combination of FUV and 24 μ m captures both unattenuated and attenuated stellar light \rightarrow total SFR

Image smoothing

- Spitzer 24 μ m – image with the lowest angular resolution (beam size = 5.9")
- Convolve FUV and CO images with the same beam size to match the resolution
- Imsmooth task used

Image smoothing

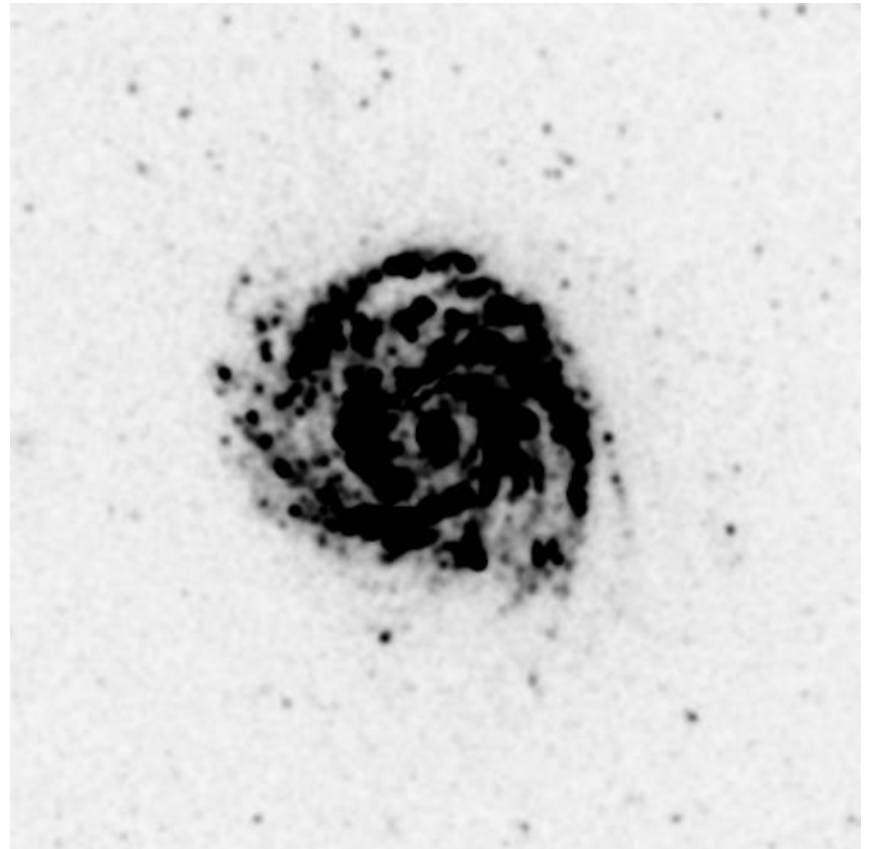
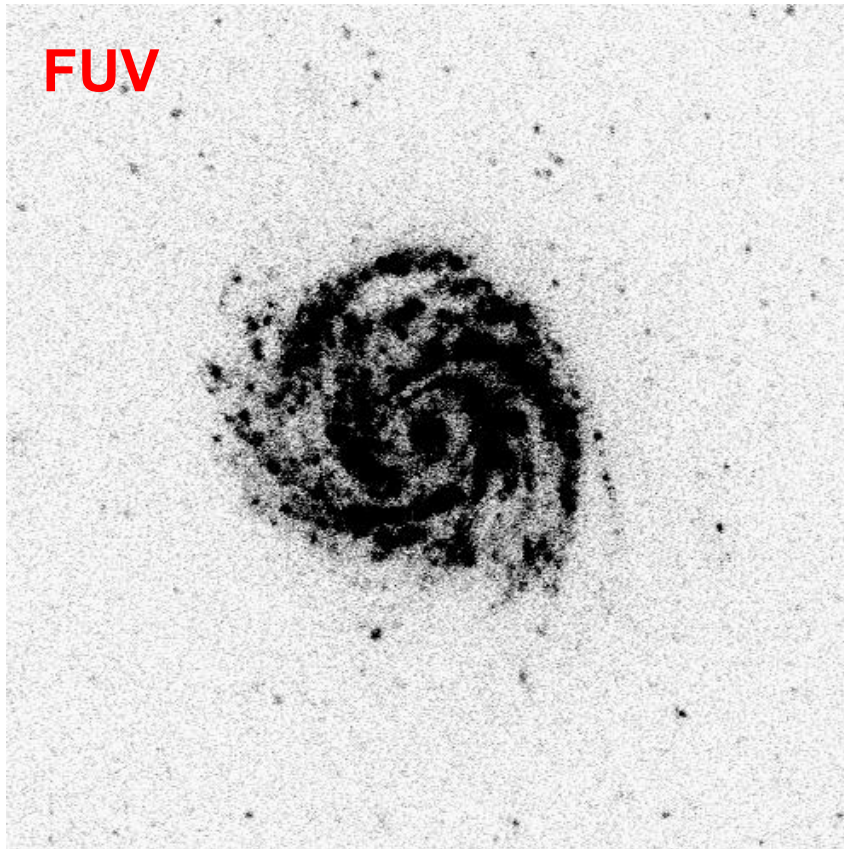
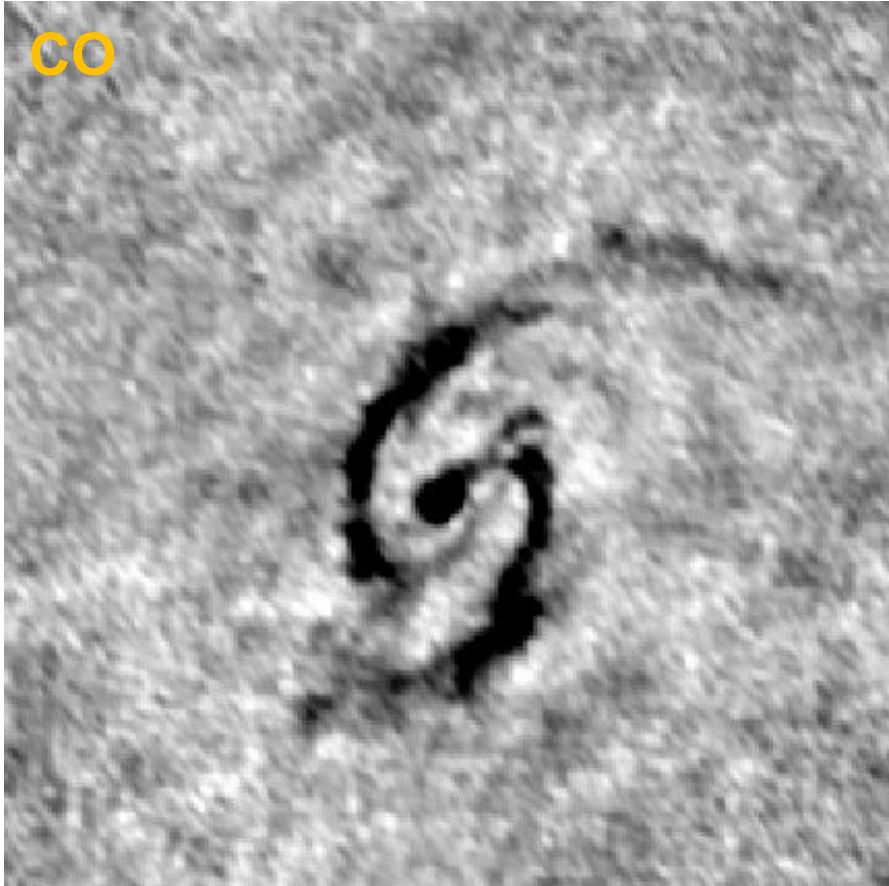
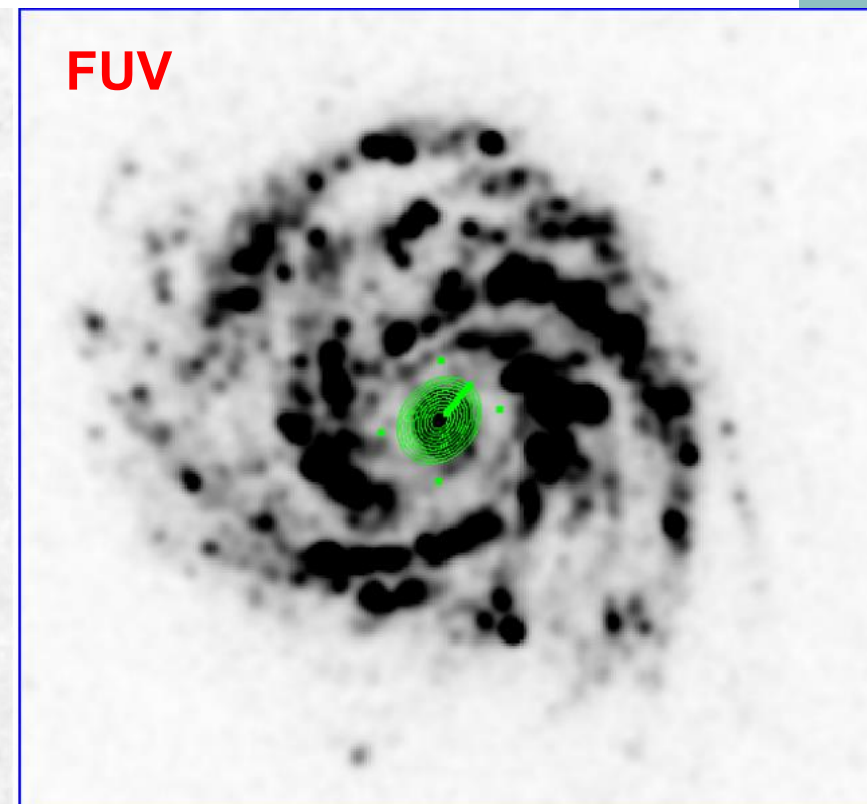
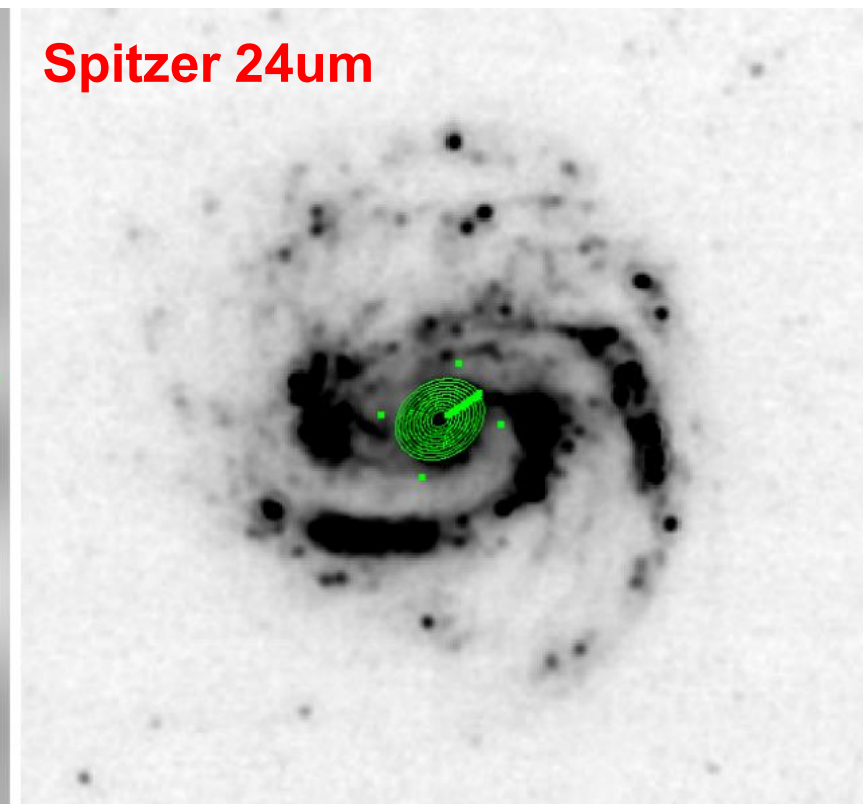
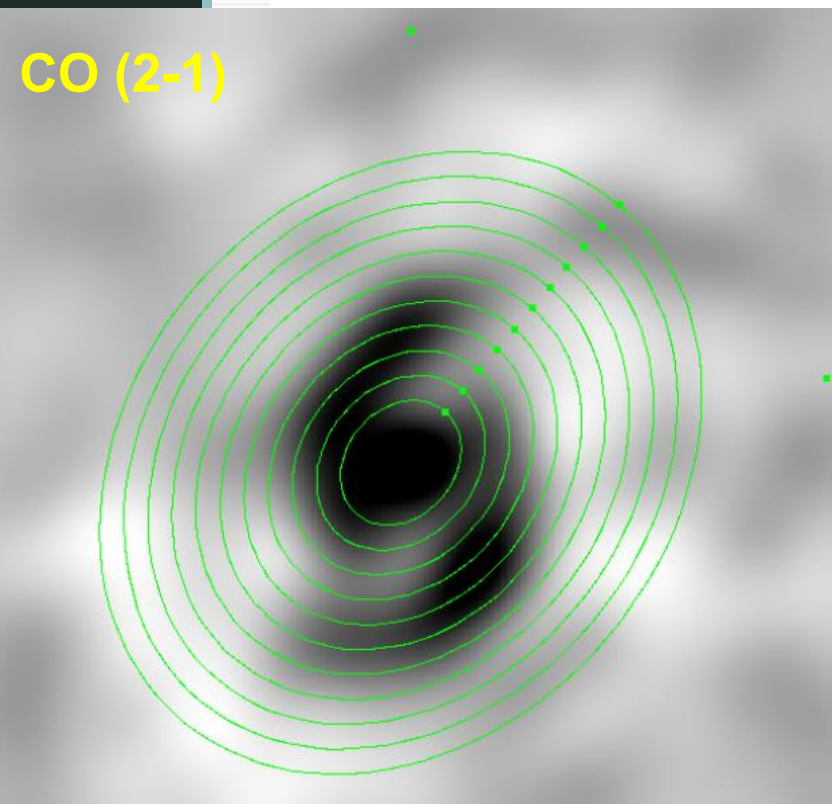


Image smoothing



Surface brightness profiles

- Radial profiles obtained in DS9 with elliptical annuli



▶ Star formation rates

- SFR density equation (Leroy+2008, Yim+2016)

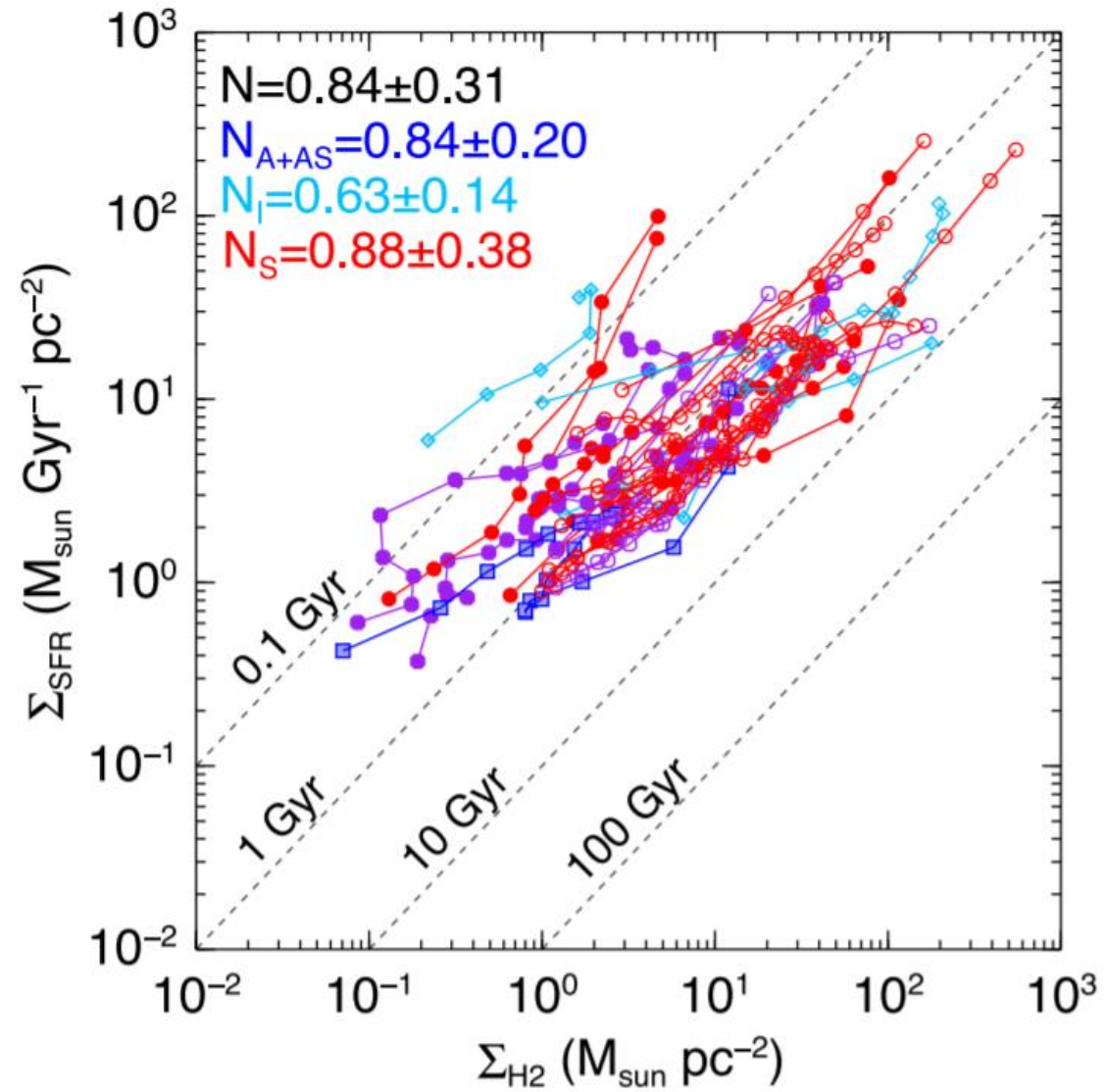
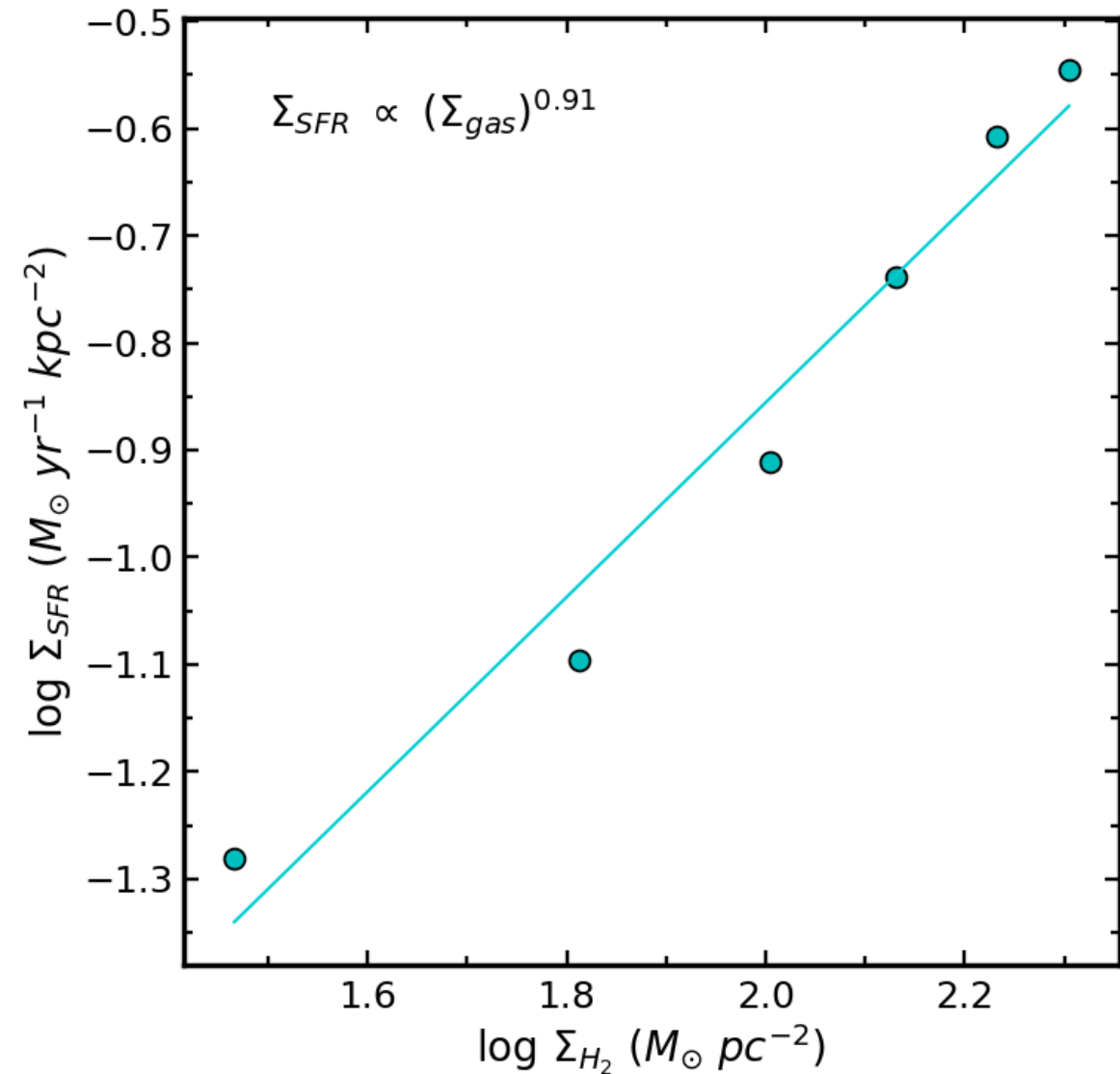
$$\Sigma_{\text{SFR}} (\text{M}_{\odot} \text{ kpc}^{-2} \text{ yr}^{-1}) = 0.081 I_{\text{FUV}} (\text{MJy sr}^{-1}) \\ + 0.0032 I_{24 \mu\text{m}} (\text{MJy sr}^{-1}).$$

- CO → H₂ conversion factor (Strong & Mattox 1996, Dame+2001)

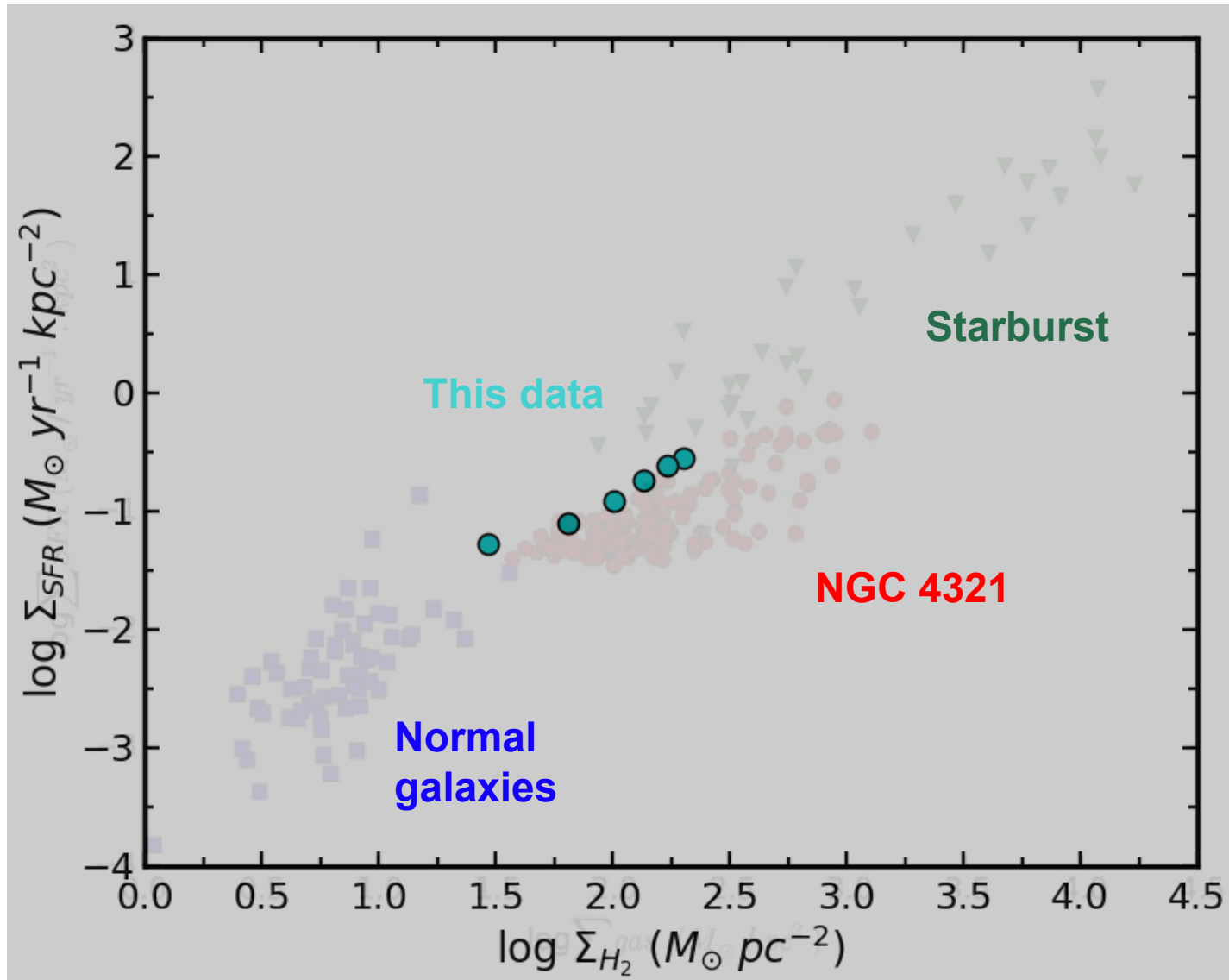
$$\Sigma_{\text{H}_2} [\text{M}_{\odot} \text{ pc}^{-2}] = 3.2 I_{\text{CO}} (\text{K km s}^{-1}),$$

► Kennicutt-Schmidt Law

Yim+2016



► Kennicutt-Schmidt Law



Azeez+2016

NGC 1808

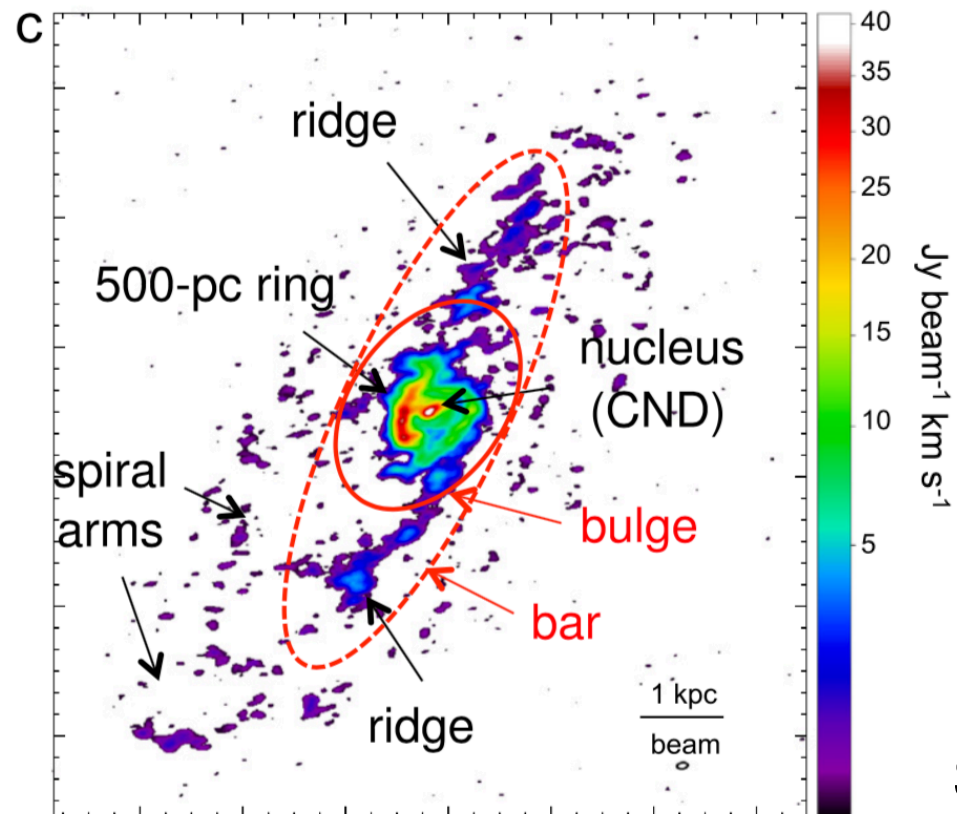
Contents

1. Spiral galaxy NGC1808
2. Observations
3. Imaging
4. Gas kinematics
5. Star formations

1. Spiral galaxy NGC1808



- ☉ R.A. = 76.926417
- ☉ Dec. = -37.513056
- ☉ Redshift : 0.00332 ± 0.00001
- ☉ Systematic velocity (LSR) : 995 ± 4
- ☉ Position angle : -82.9 deg
- ☉ Ellipticity ~ 0.7
- ☉ Inclination = 82.7 deg
- ☉ Morphological type: SBb
- ☉ Seyfert 2, starburst, SNR
CND (200pc), ring (500pc)

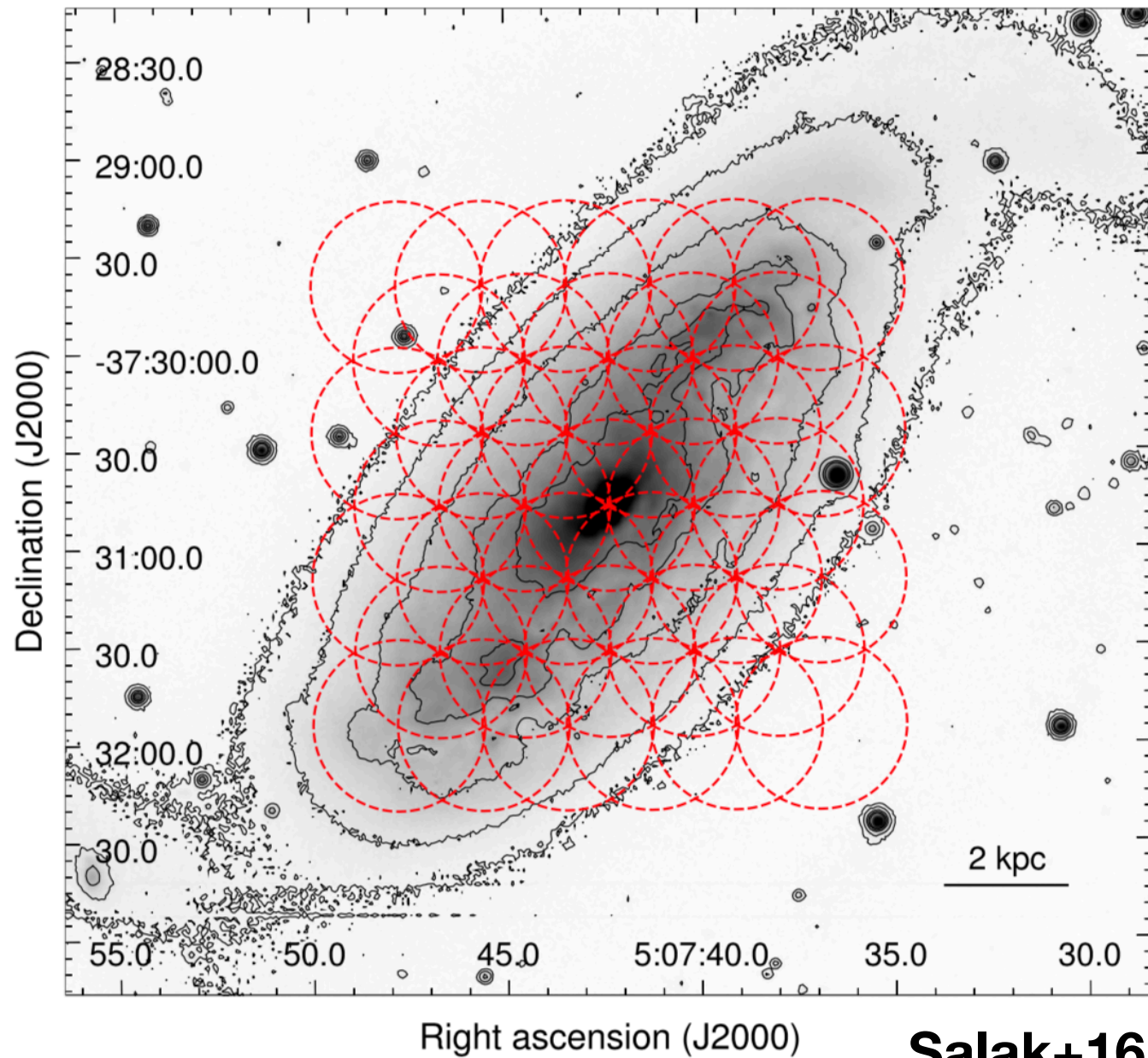


1. Spiral galaxy NGC1808

: Goal

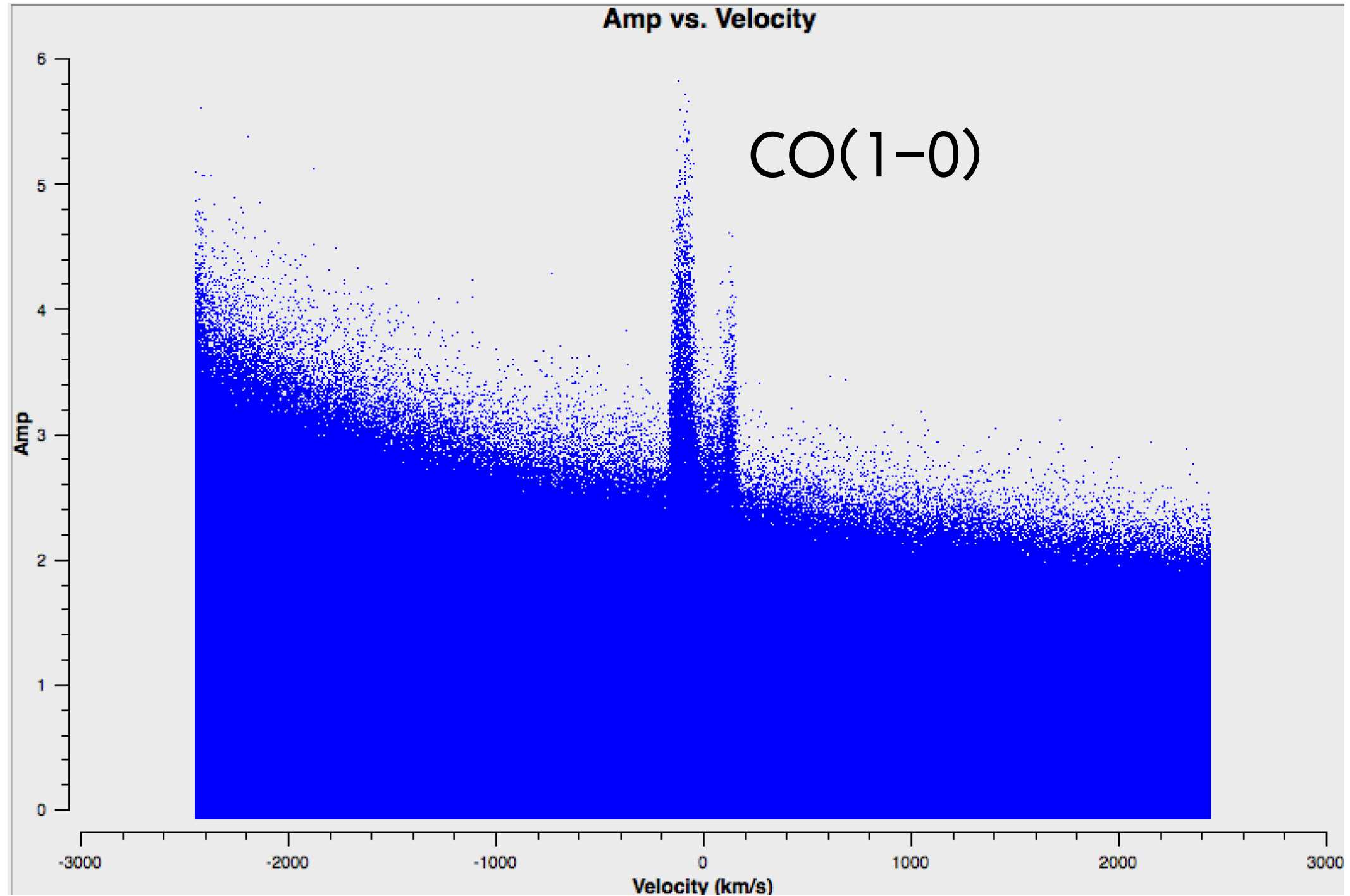
- 🇺🇸 Analysing ALMA 12CO (1-0) data
- 🇺🇸 Studying gas distribution and kinematics
- 🇺🇸 See the gas dynamics and star formations of N1808

2. Observations



- ALMA 12m Array
- Number of Antennas : 27
- Primary Beam FWHM = 52"
($\lambda = 2.7\text{mm}$)
- Total time = 2777.9 seconds
- Mosaic 39 fields

4. Imaging : amp vs. velocity

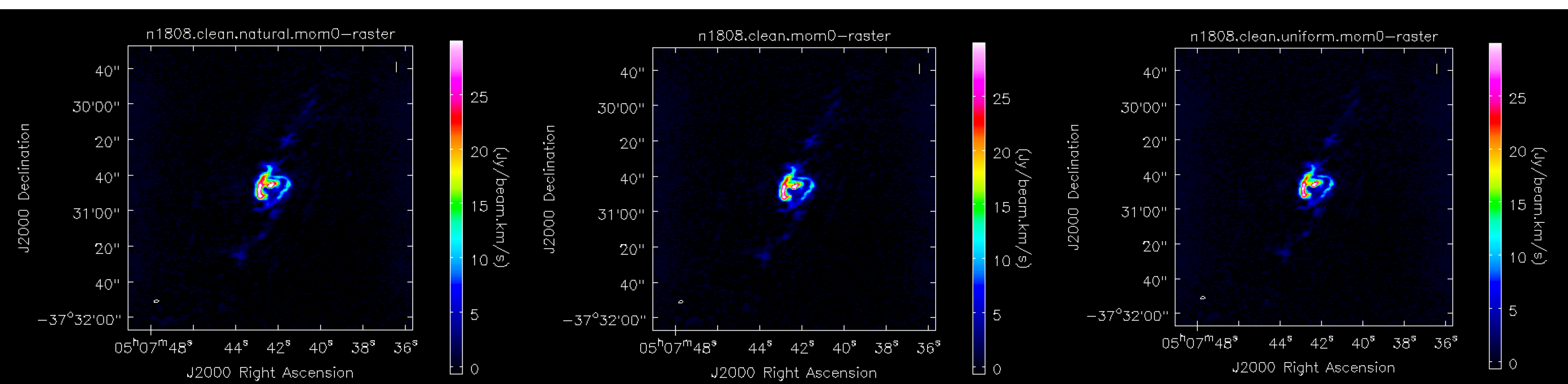
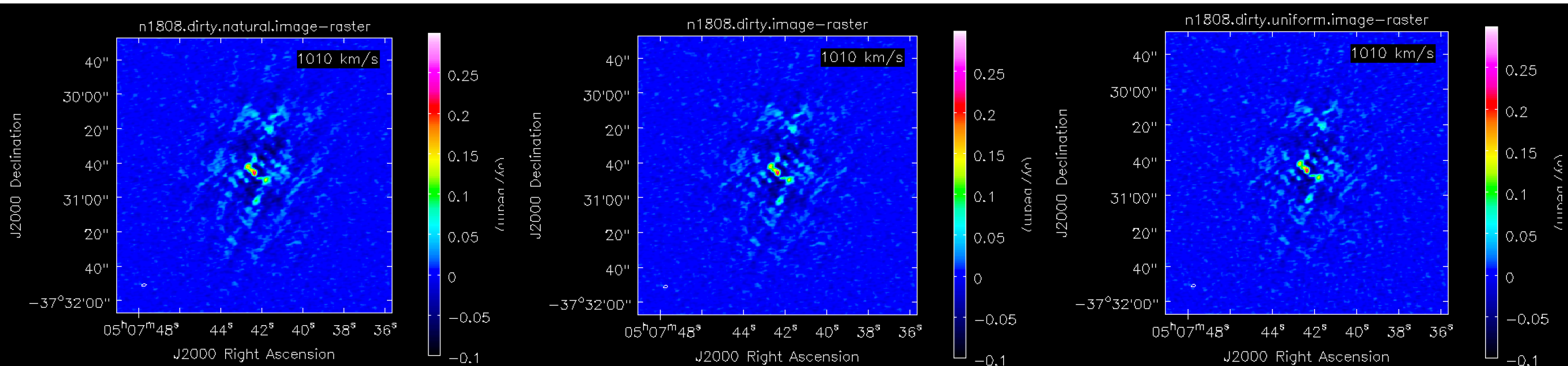


4. Imaging : dirty map & clean image

natural

briggs

uniform



beamsize

$$2.59 \times 1.39 = 3.61$$

$$2.53 \times 1.37 = 3.47$$

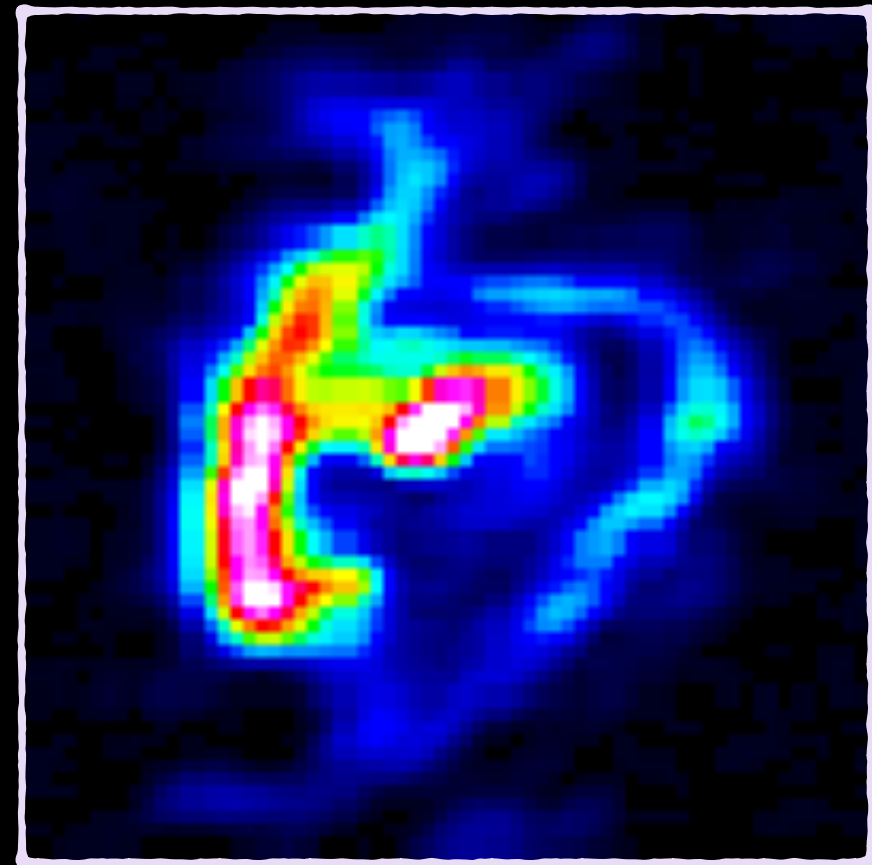
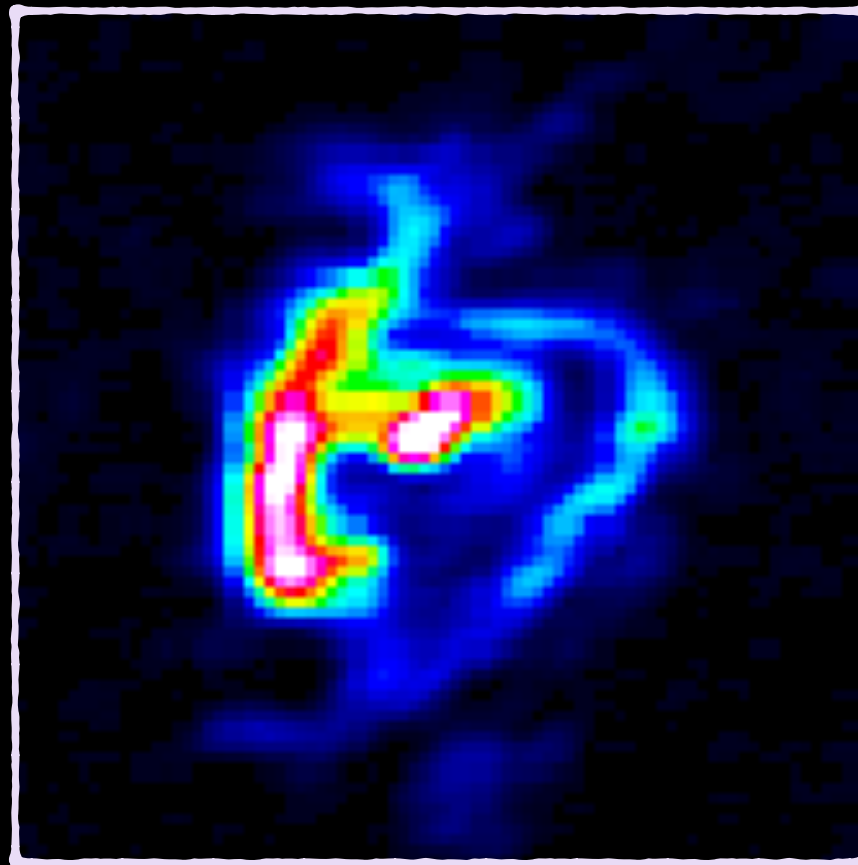
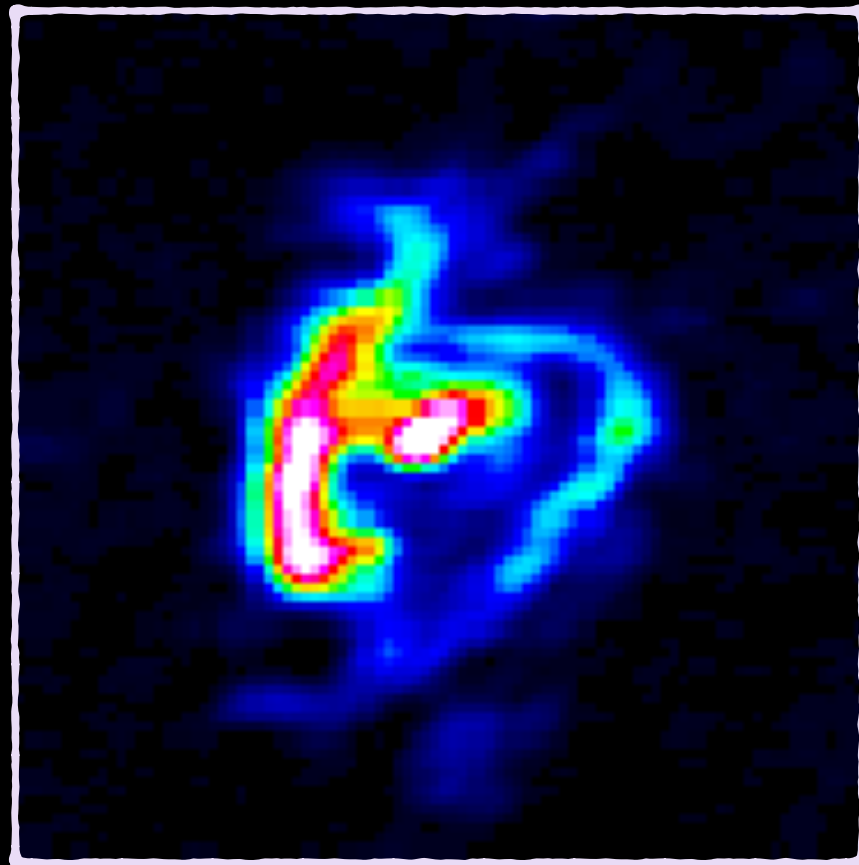
$$2.48 \times 1.36 = 3.38$$

4. Imaging : dirty map & clean image

natural

briggs

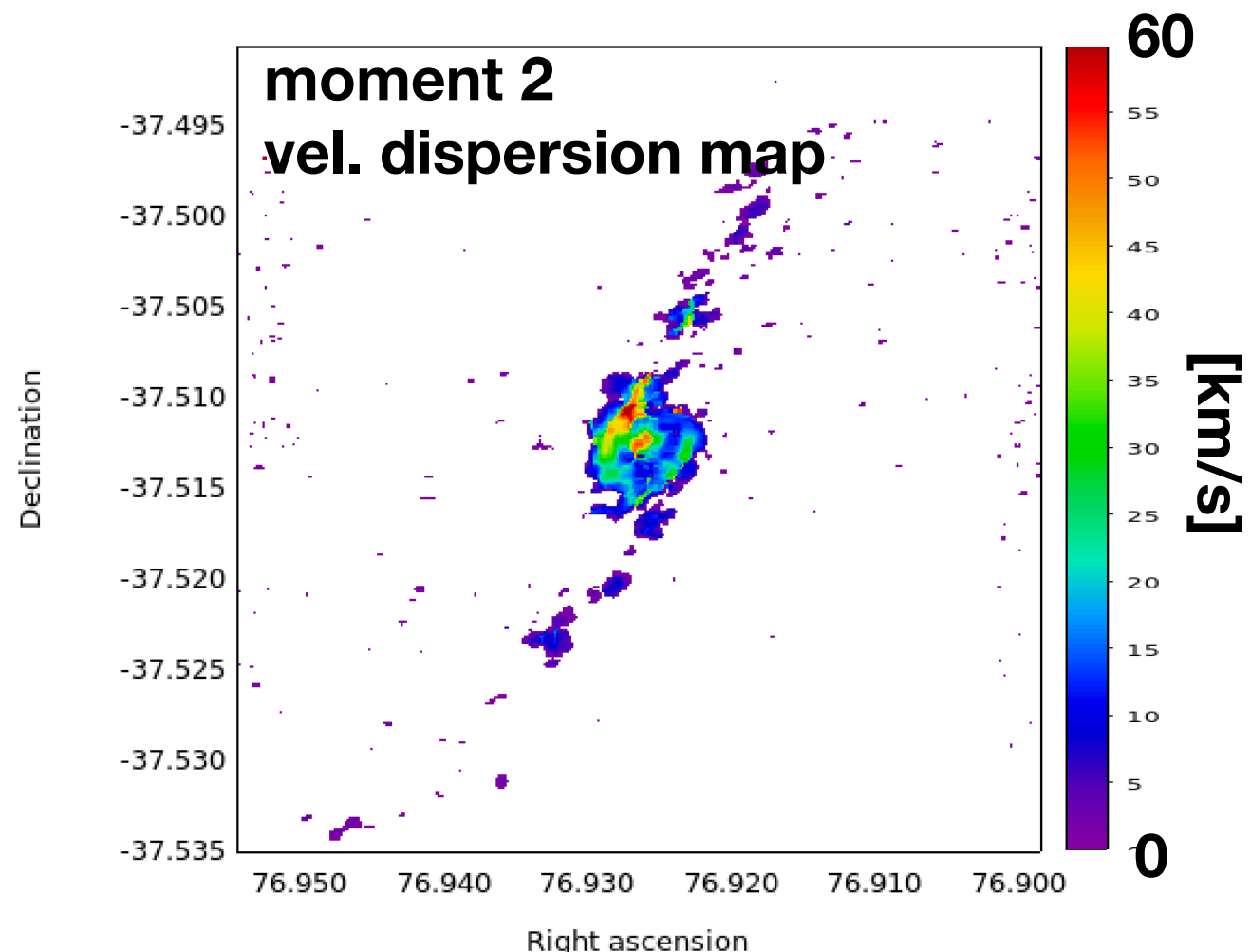
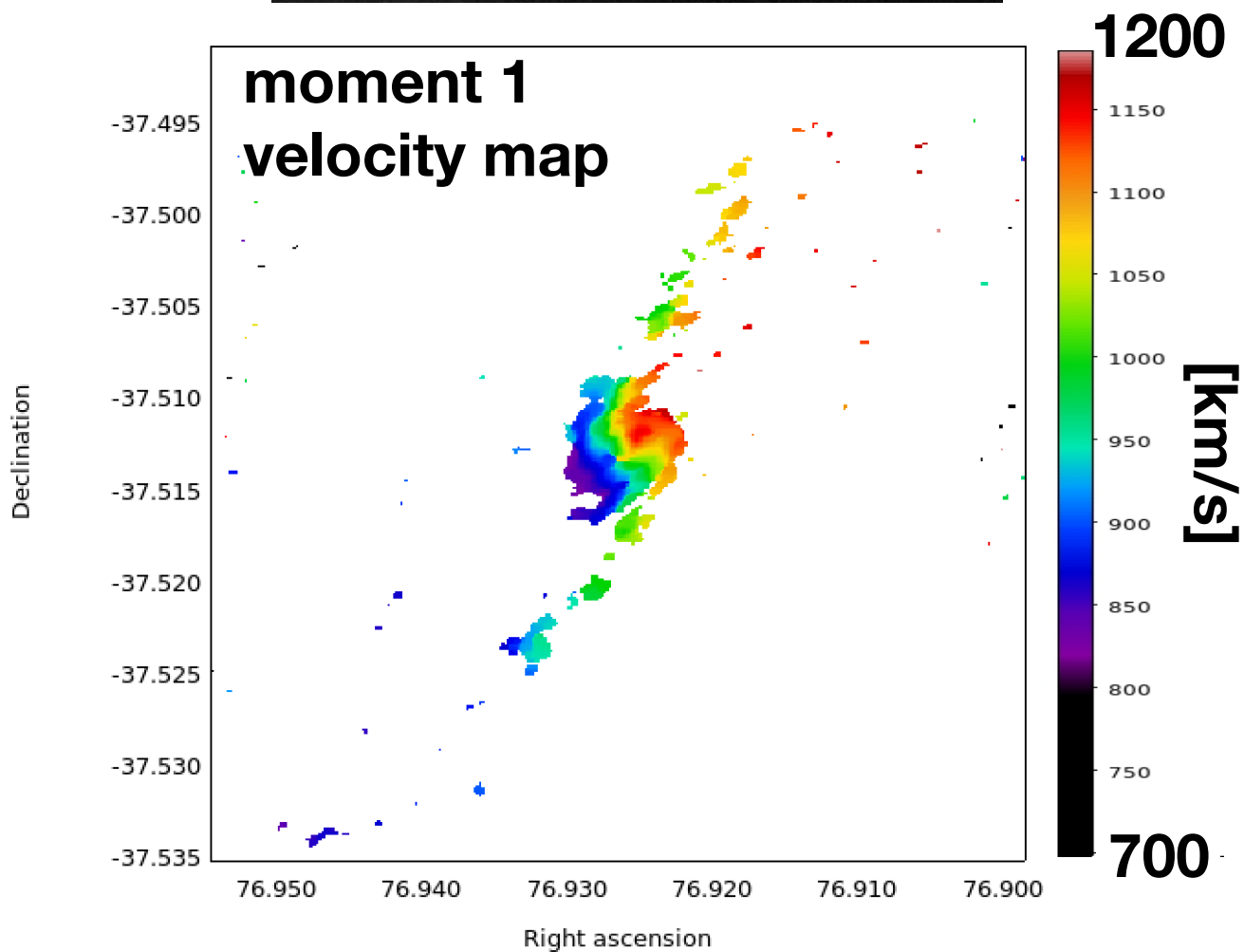
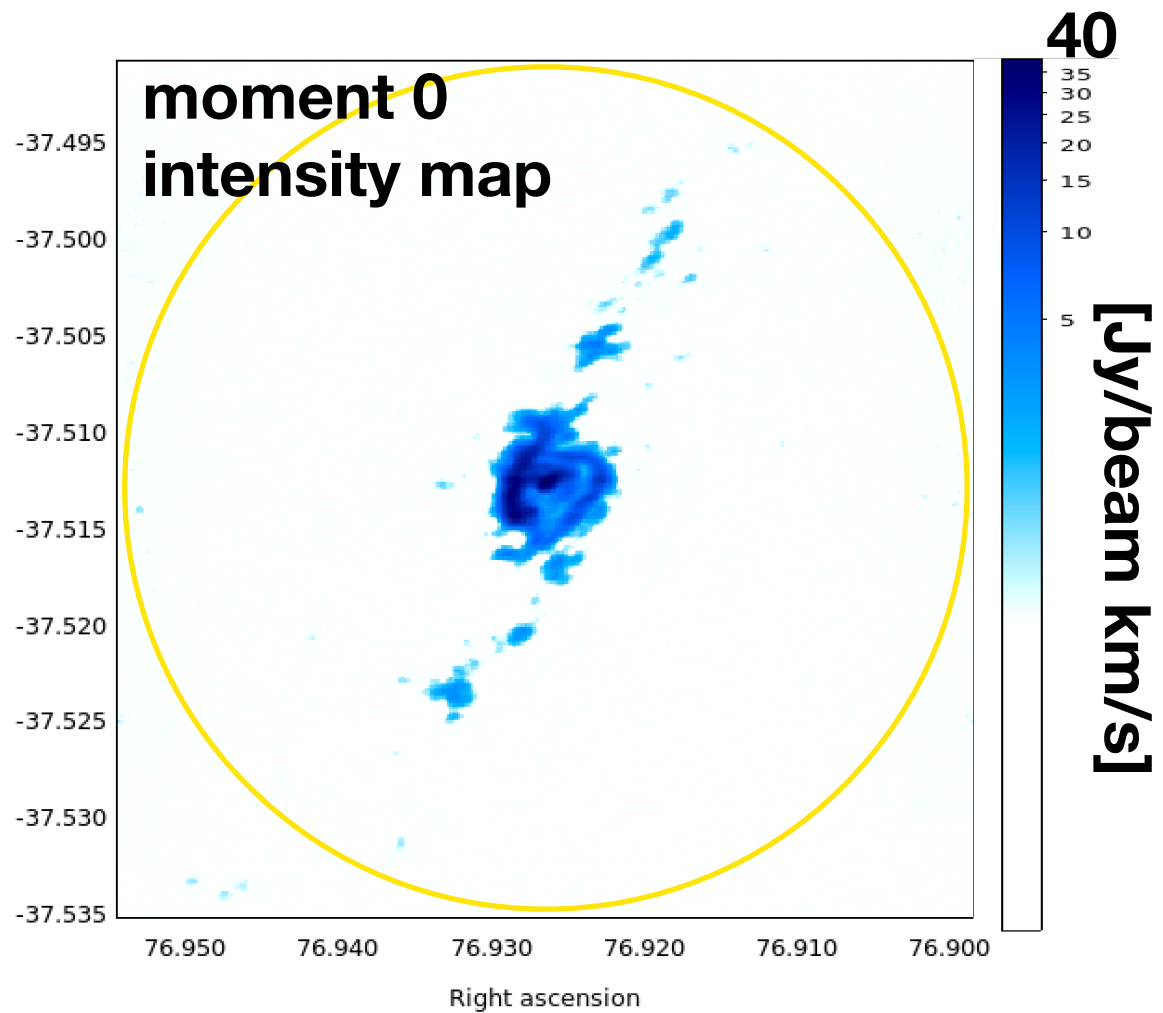
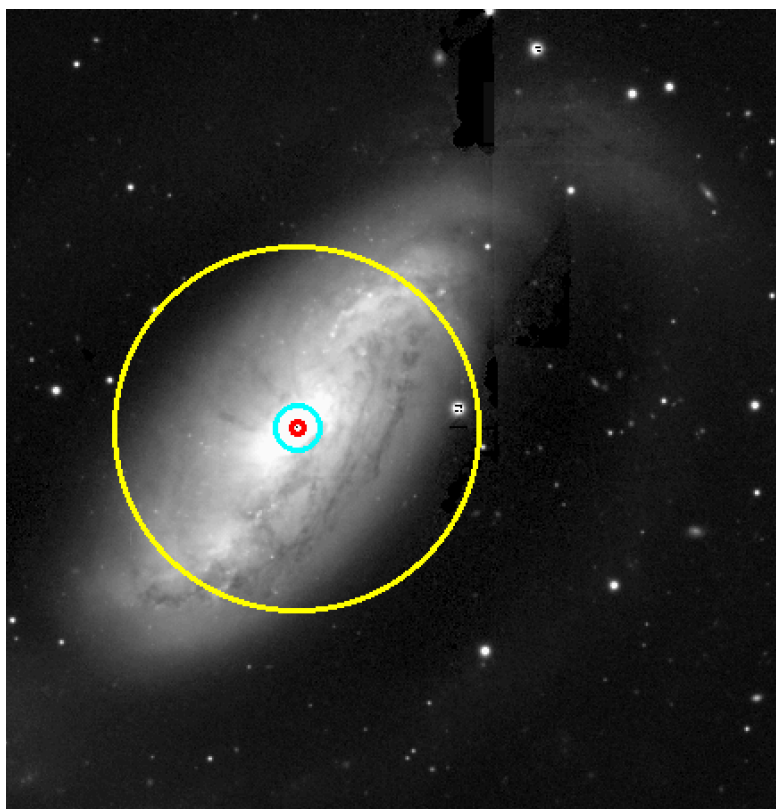
uniform



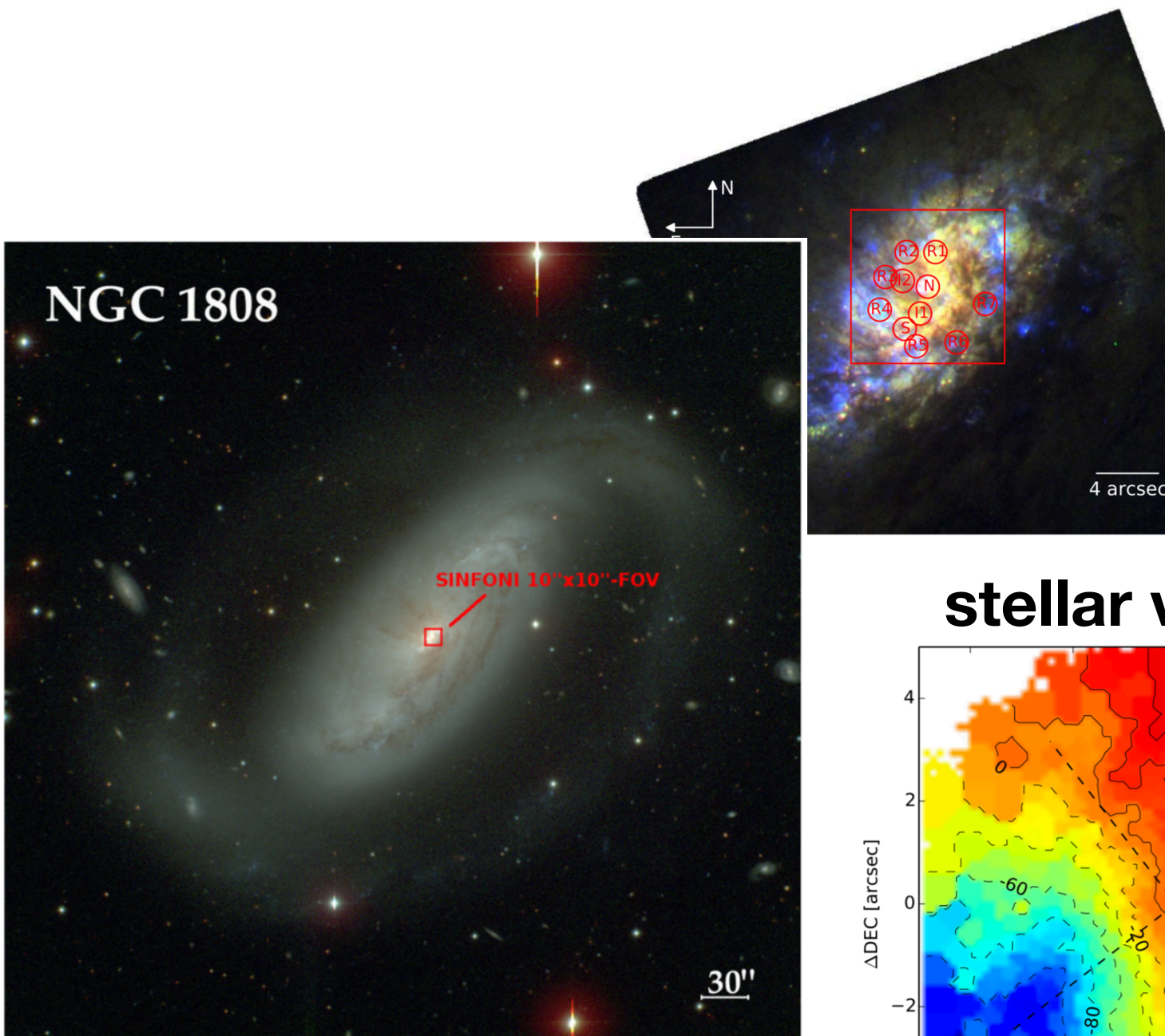
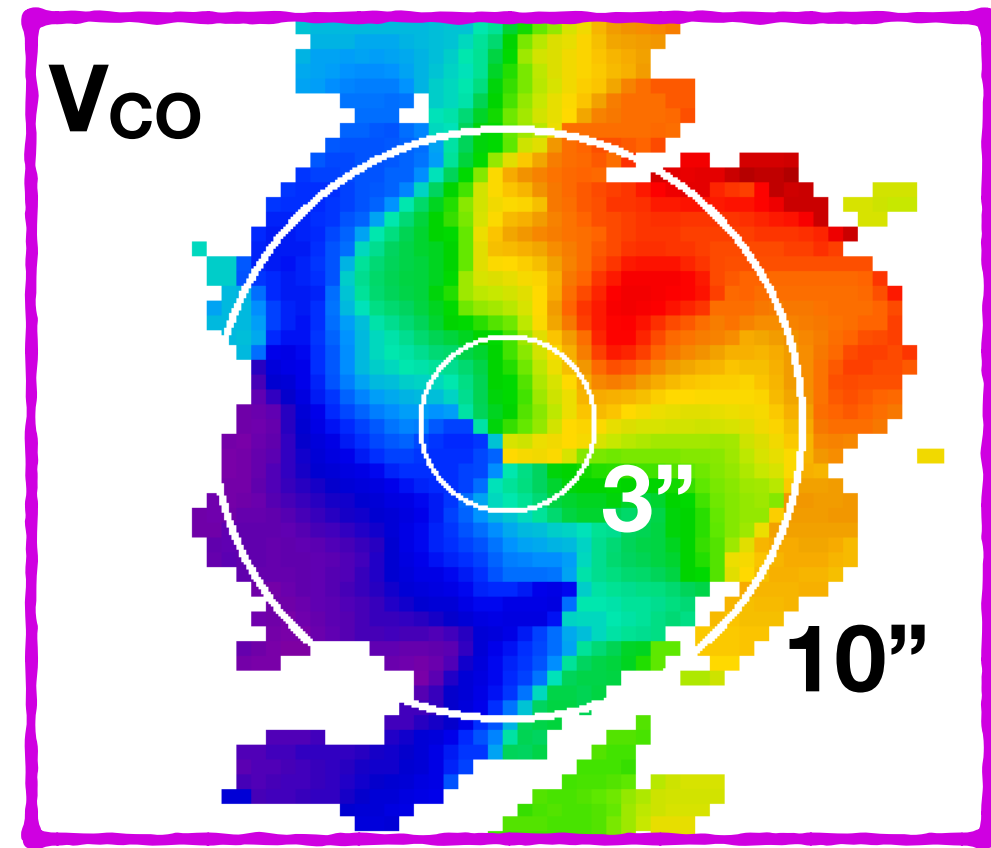
show larger scale
structures

resolve smaller scale
structures

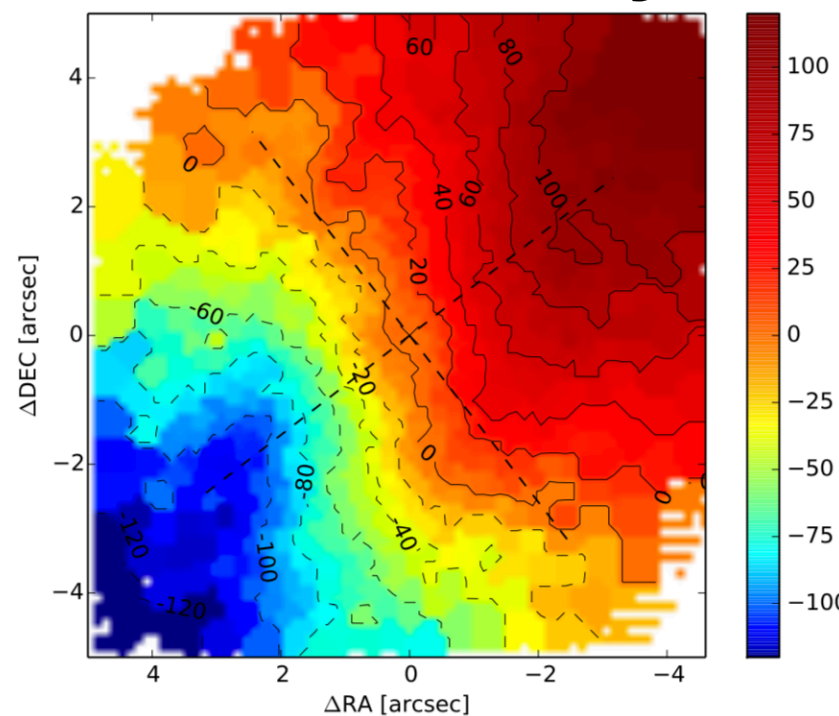
5. Gas kinematics



5. Gas kinematics : comparison with stellar kinematics



stellar velocity



gas - stars

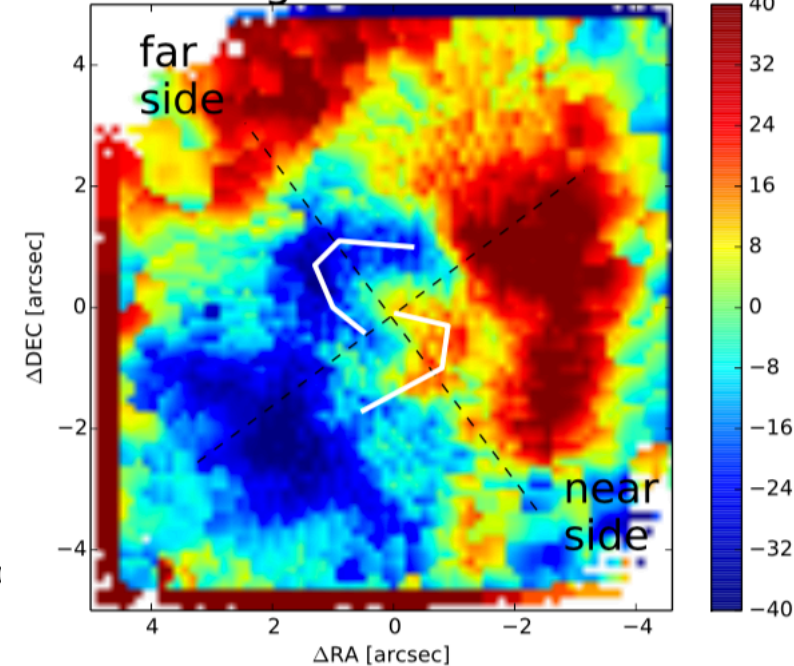


Fig. 1. Optical image of the barred spiral galaxy NGC 1808. The 10" \times 10" field of view of SINFONI is indicated. Image courtesy: Carnegie-Irvine Galaxy Survey (Ho et al. 2011).

5. Gas kinematics : comparison with stellar kinematics

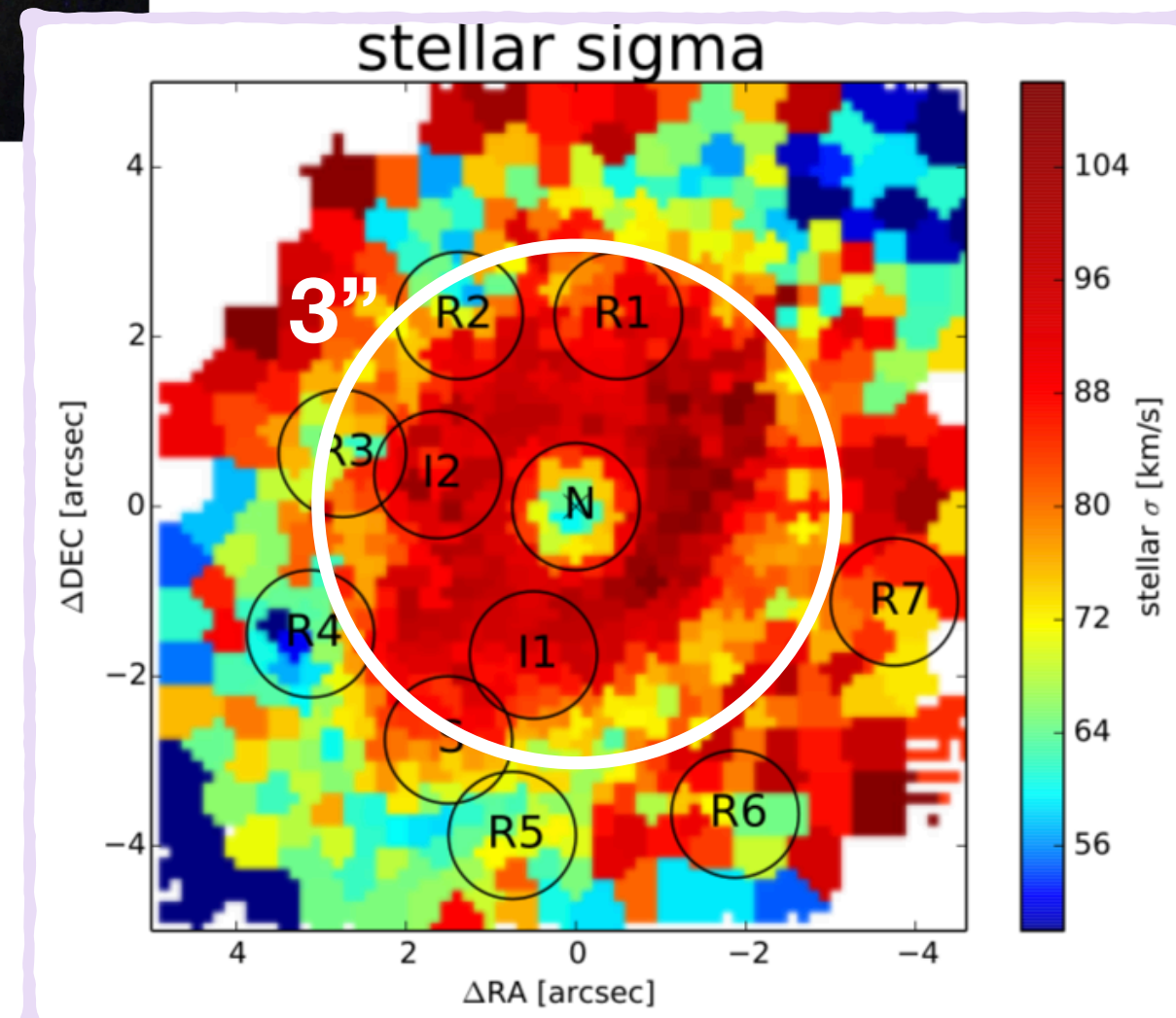
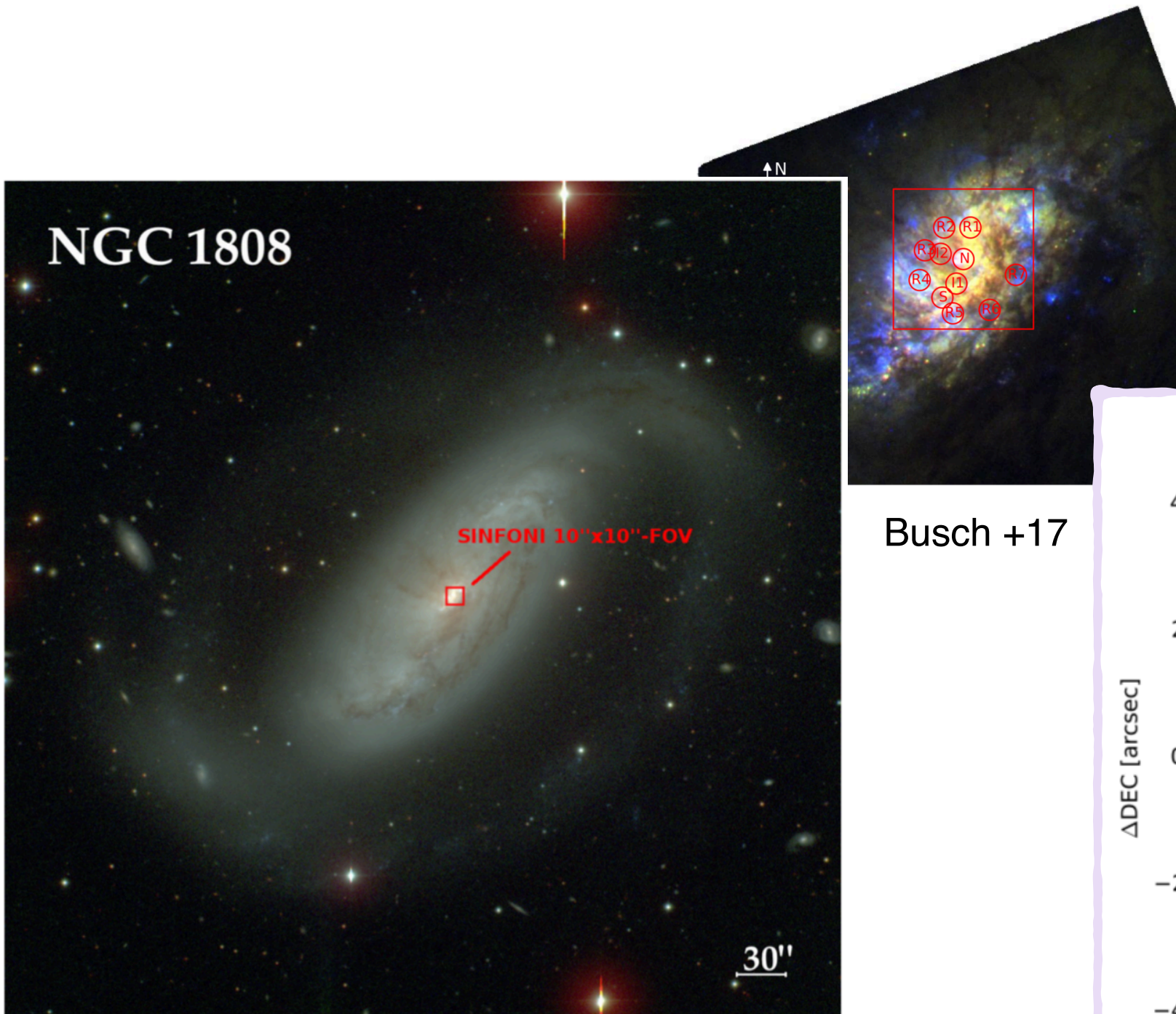
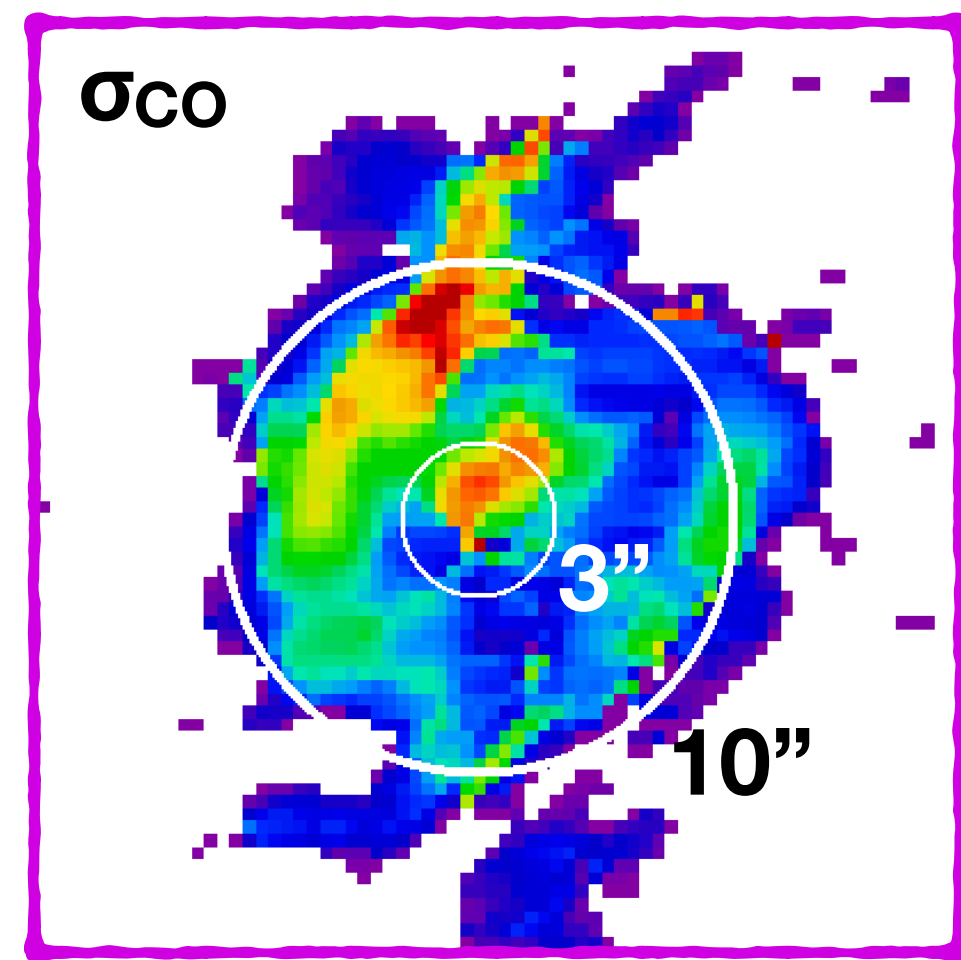
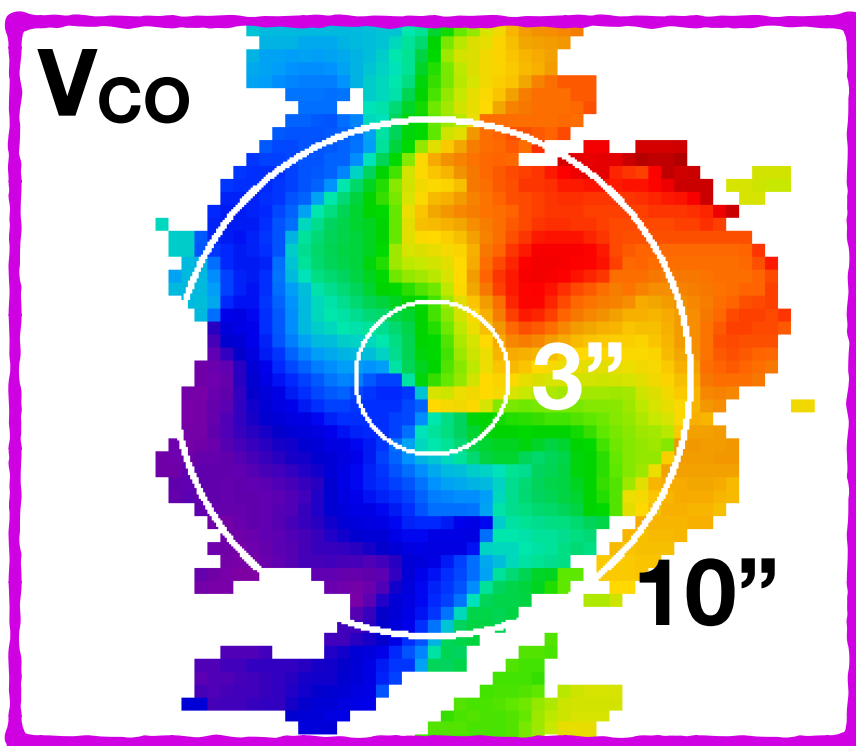
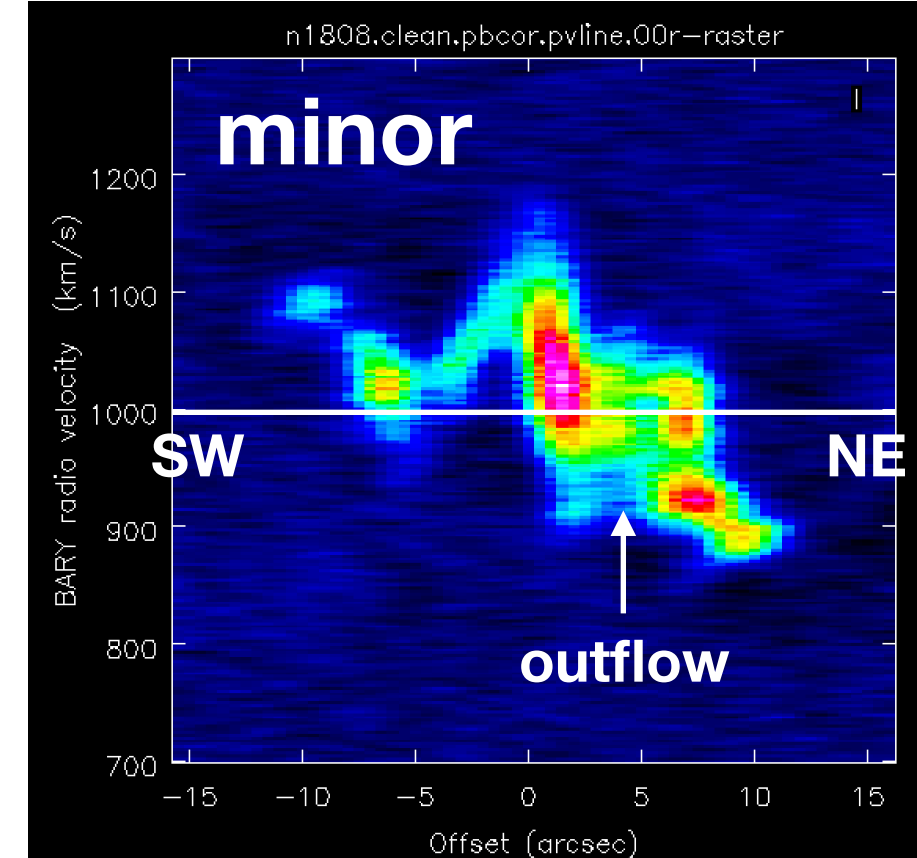
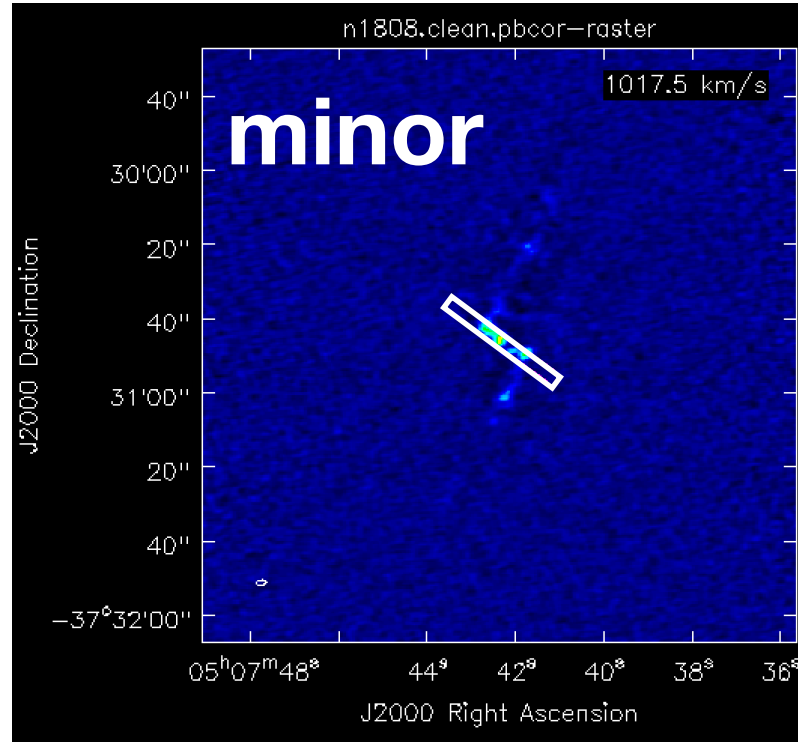
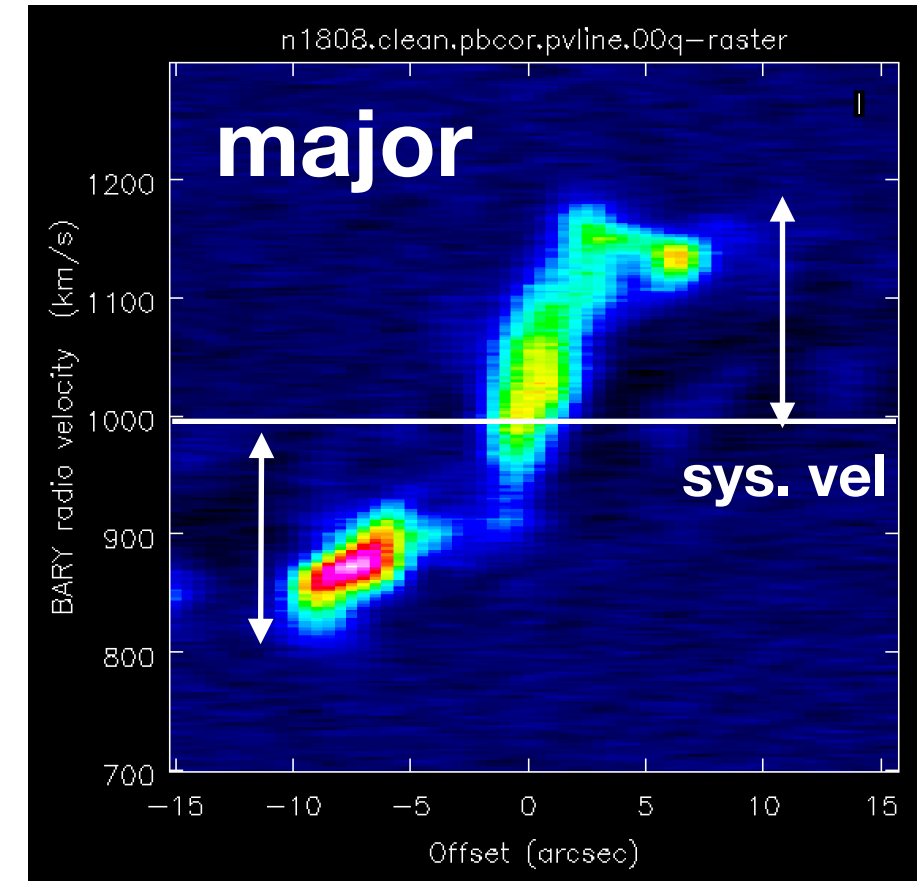
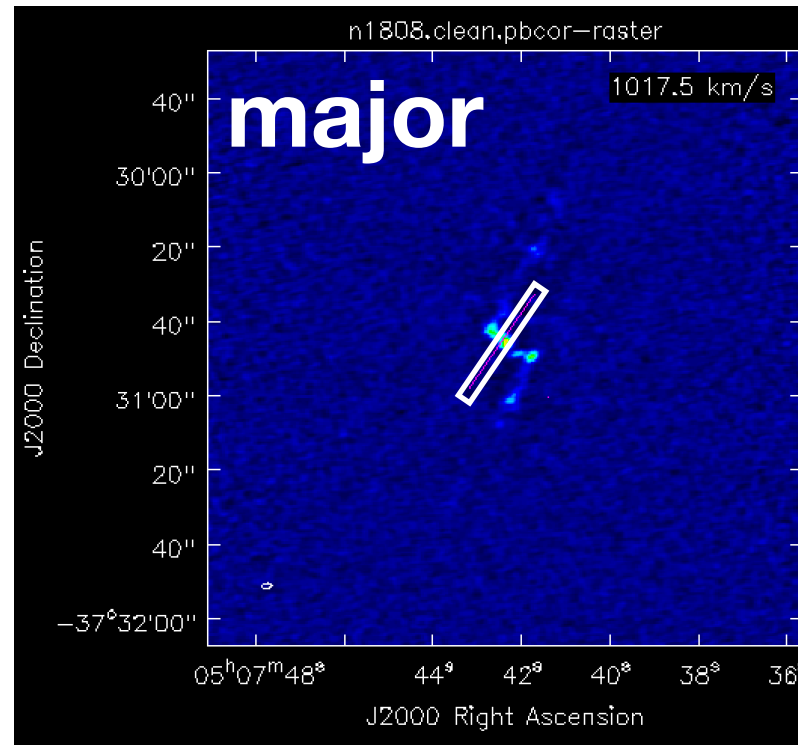
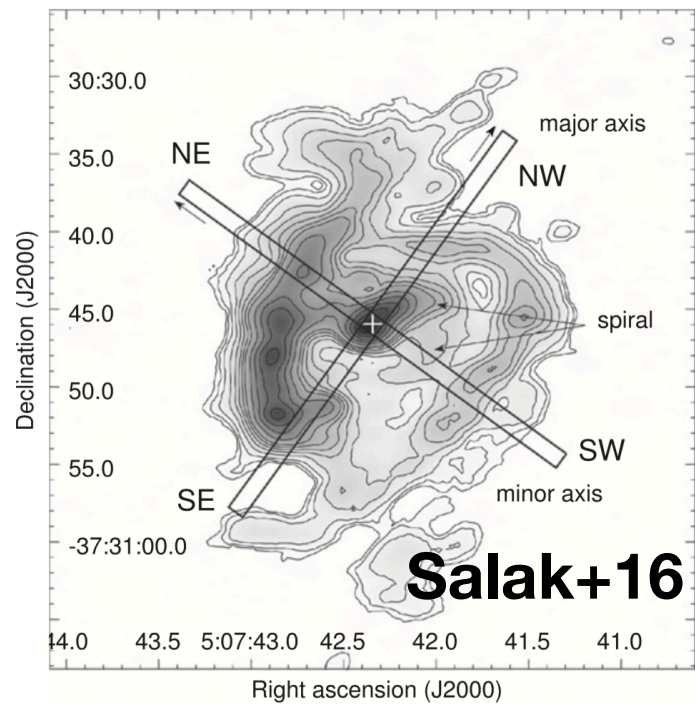
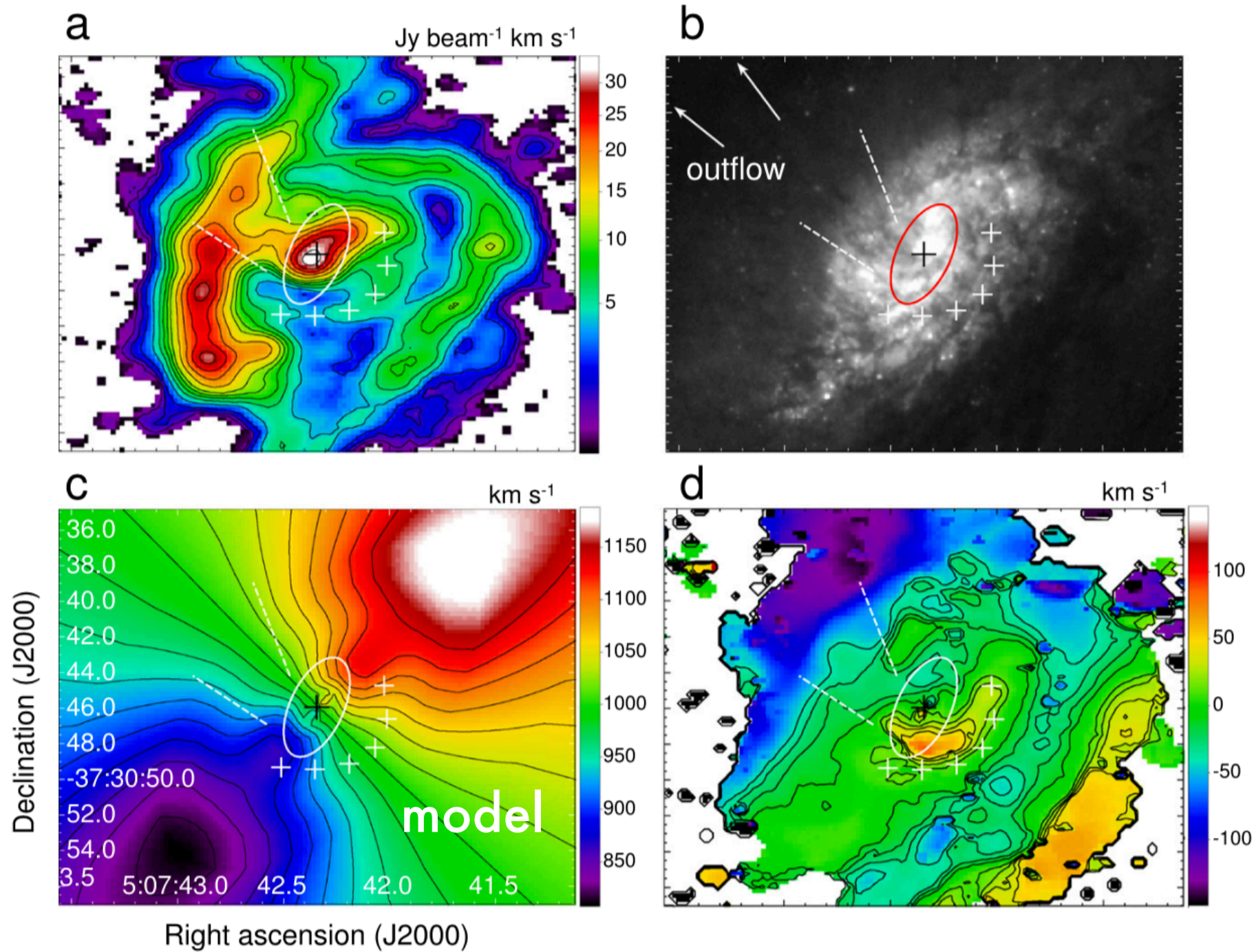


Fig. 1. Optical image of the barred spiral galaxy NGC 1808. The 10'' \times 10'' field of view of SINFONI is indicated. Image courtesy: Carnegie-Irvine Galaxy Survey (Ho et al. 2011).

5. Gas kinematics : position velocity diagram



5. Gas kinematics

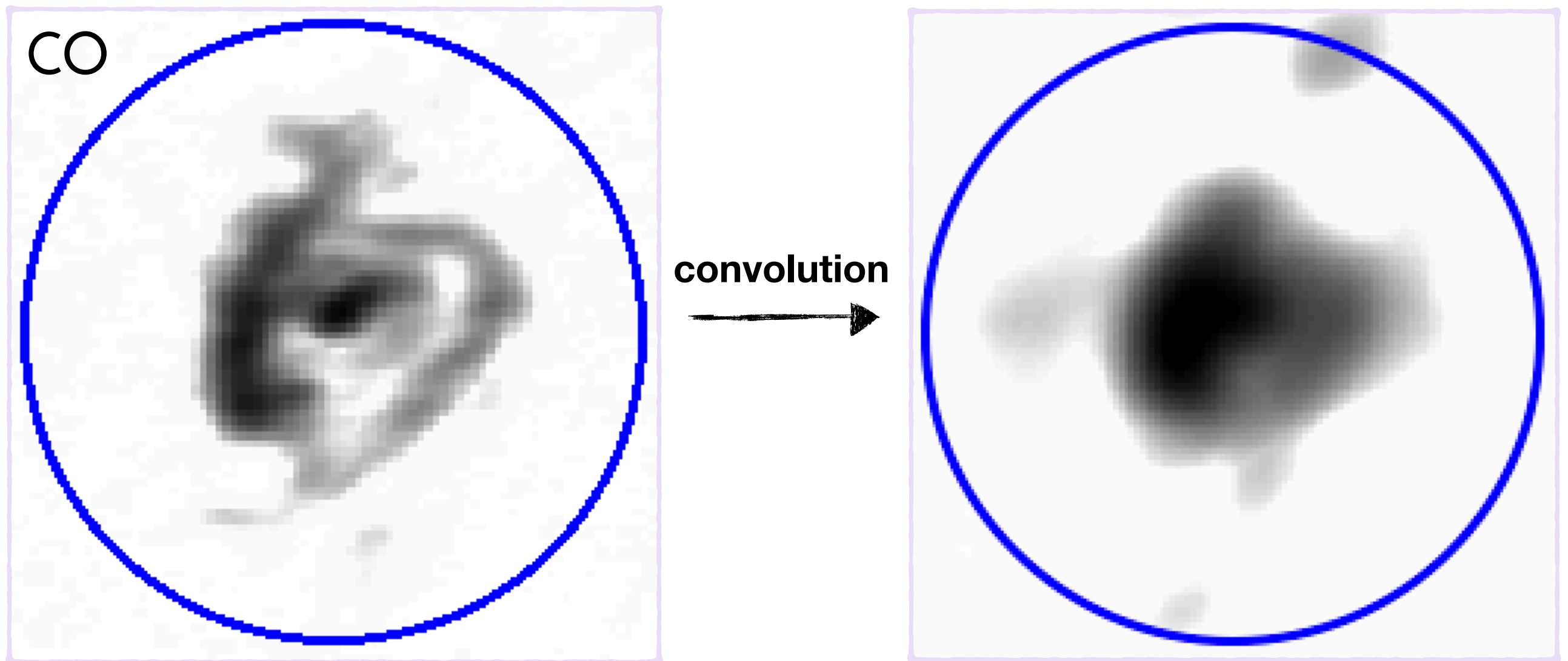


Salak+16

residual velocity field

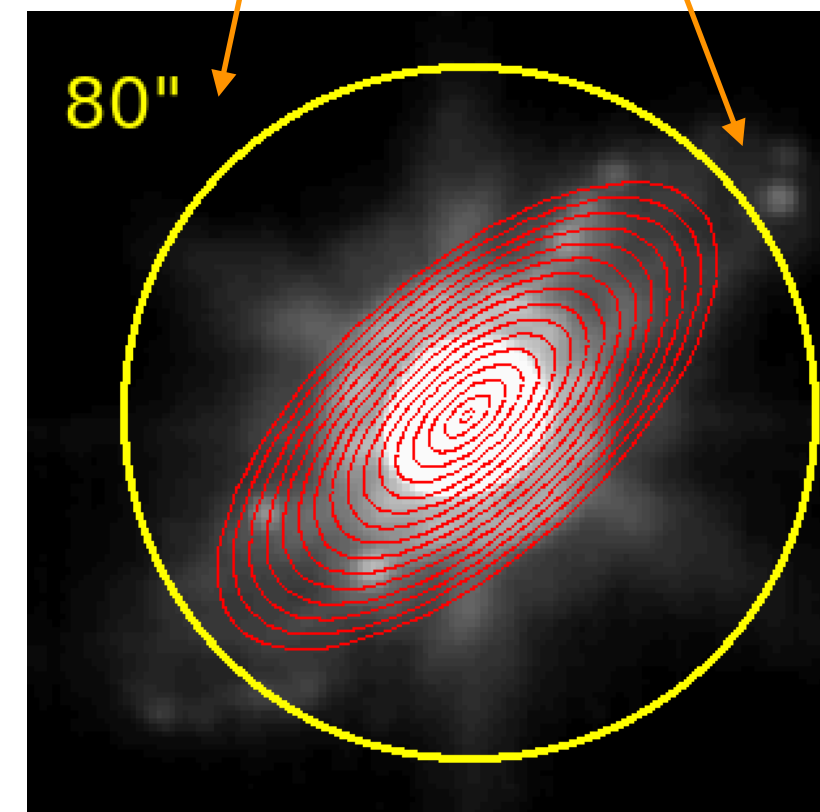
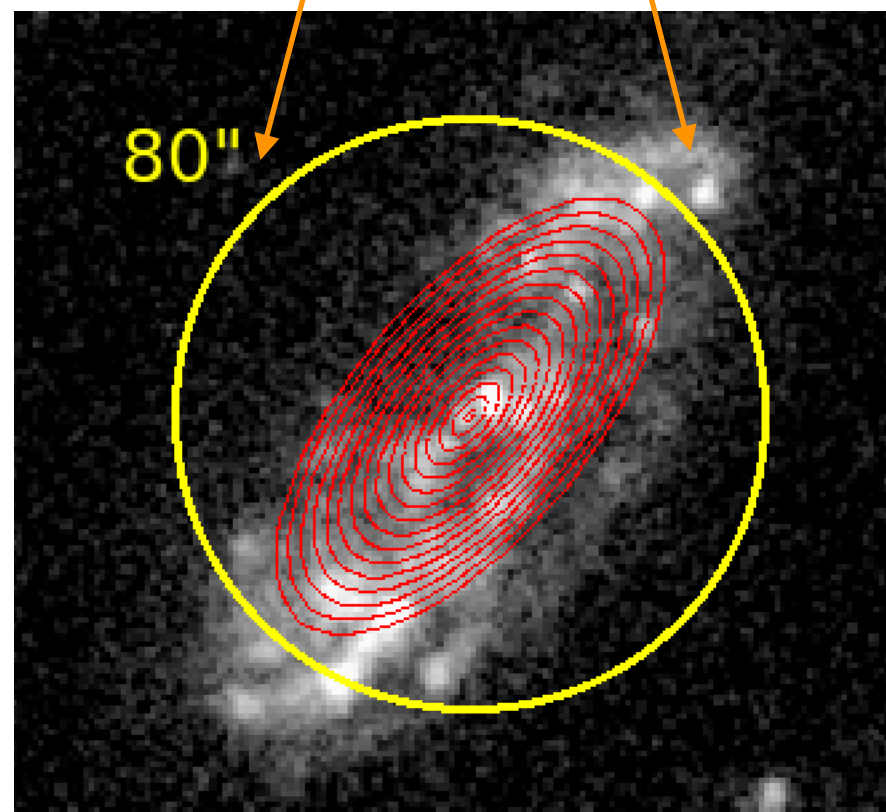
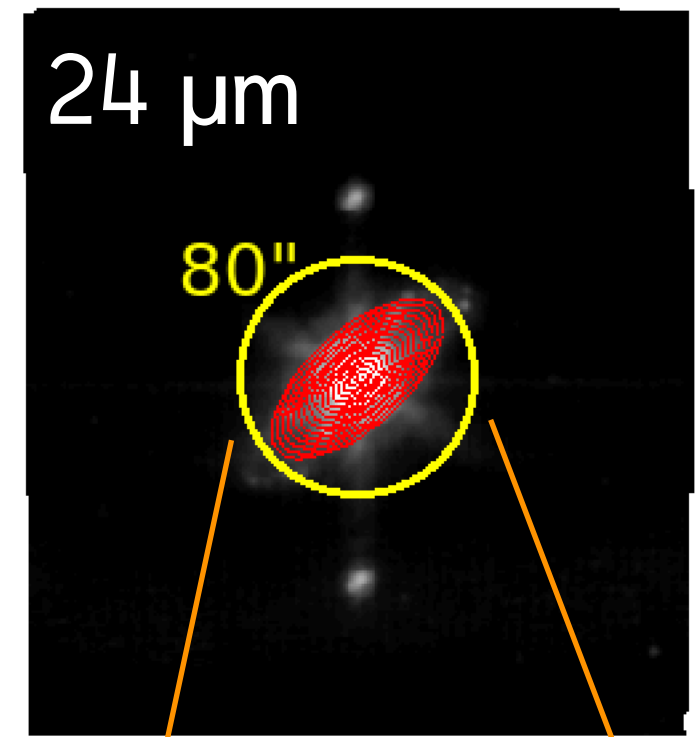
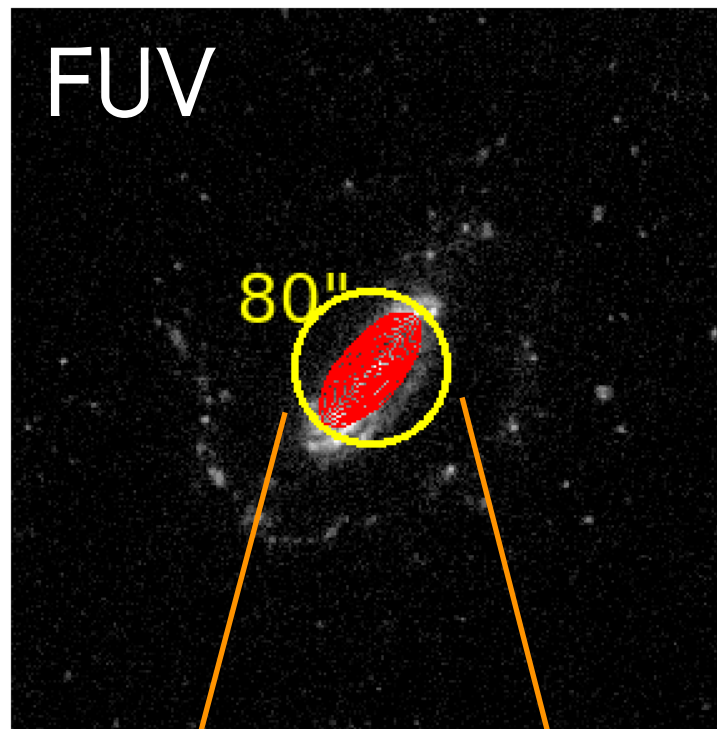
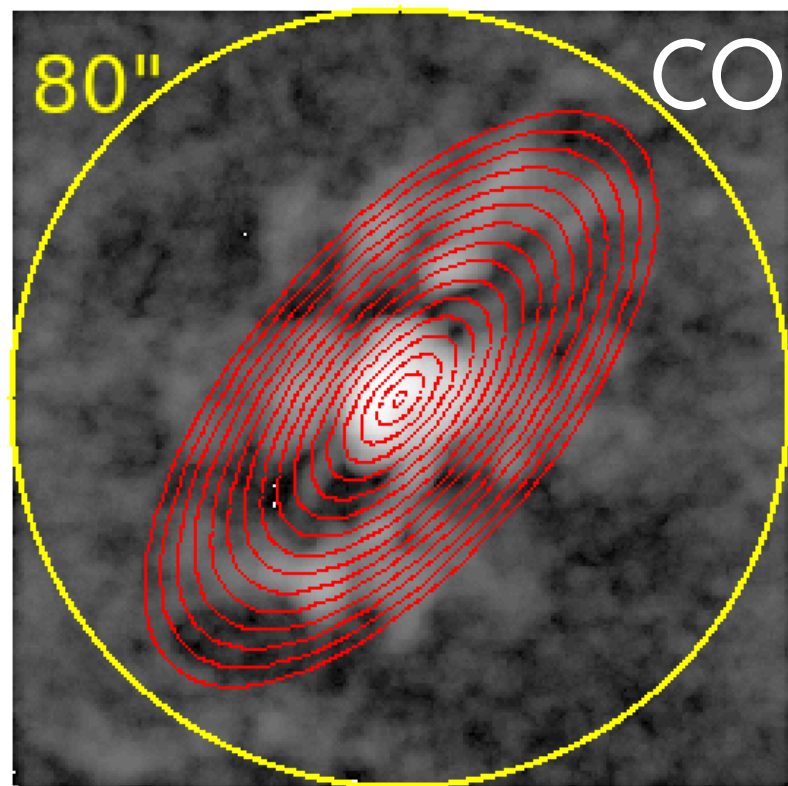
5. Star formations : Kennicutt-Schmidt Law

(1) Matching a resolution of images different observations

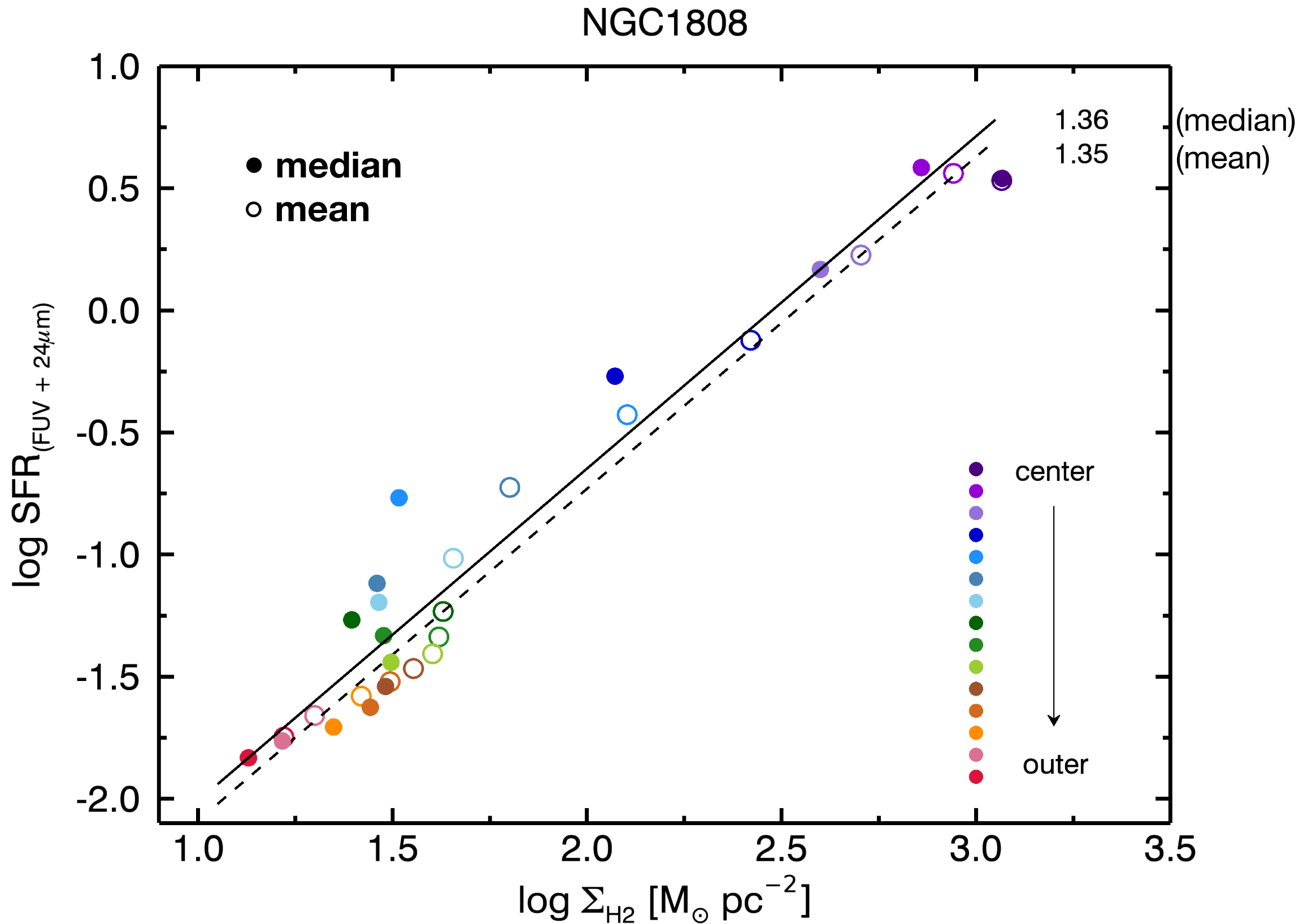


5. Star formations : Kennicutt-Schmidt Law

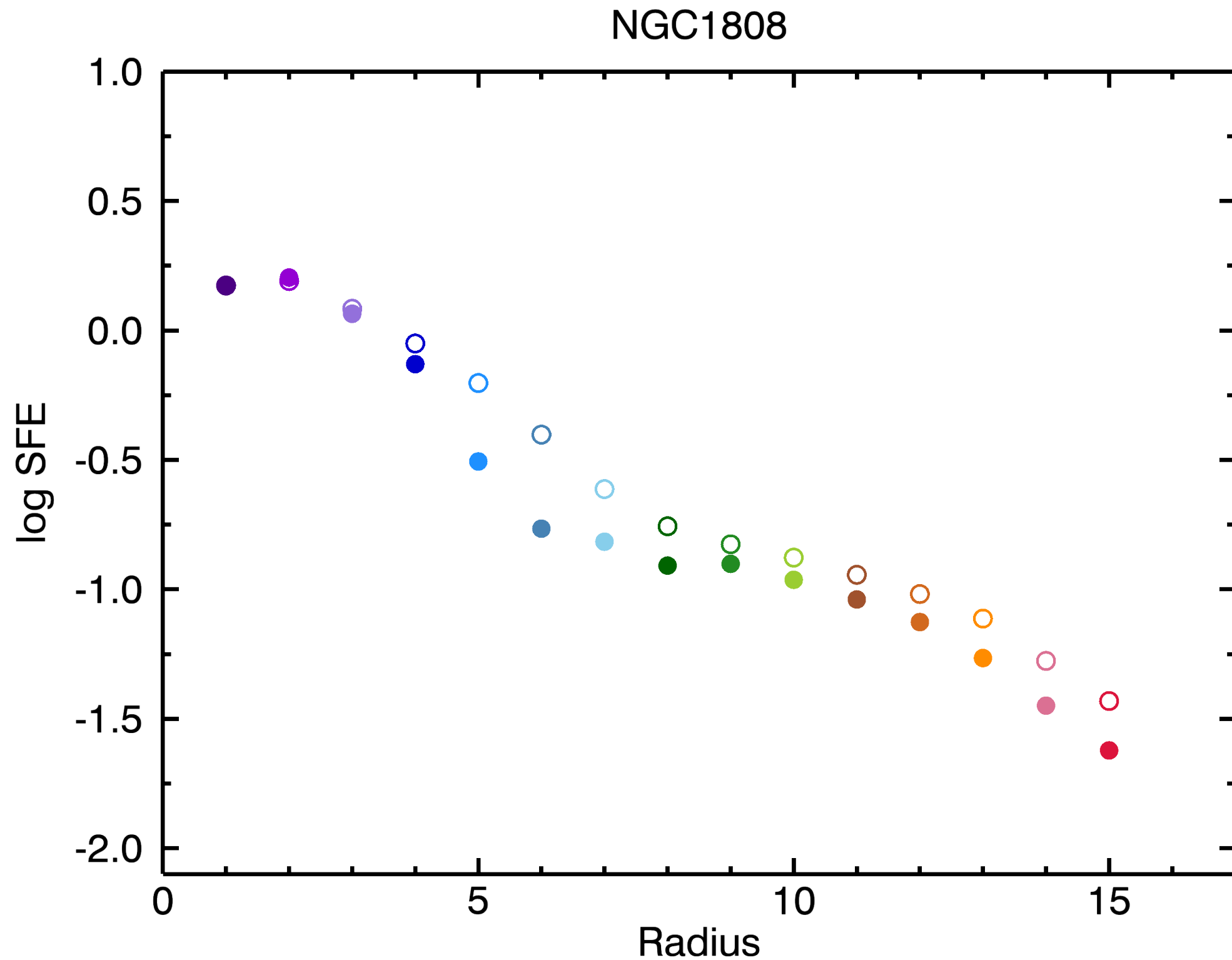
(2) Measurements of isophotal surface brightness along the same elliptical annuli



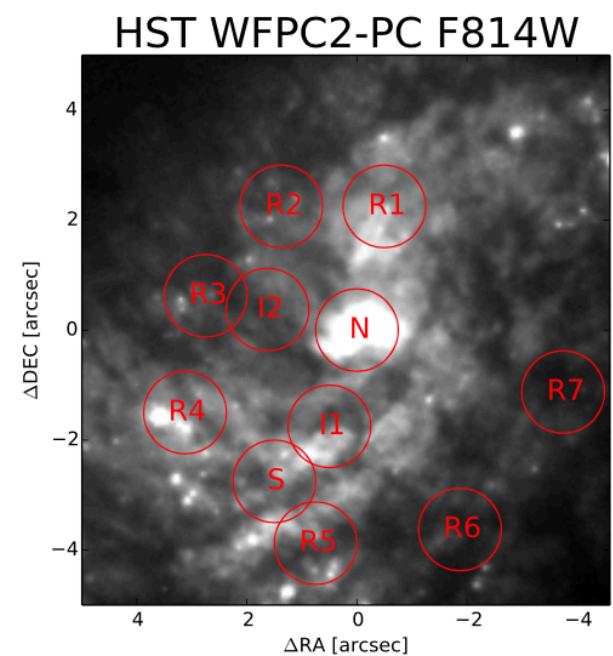
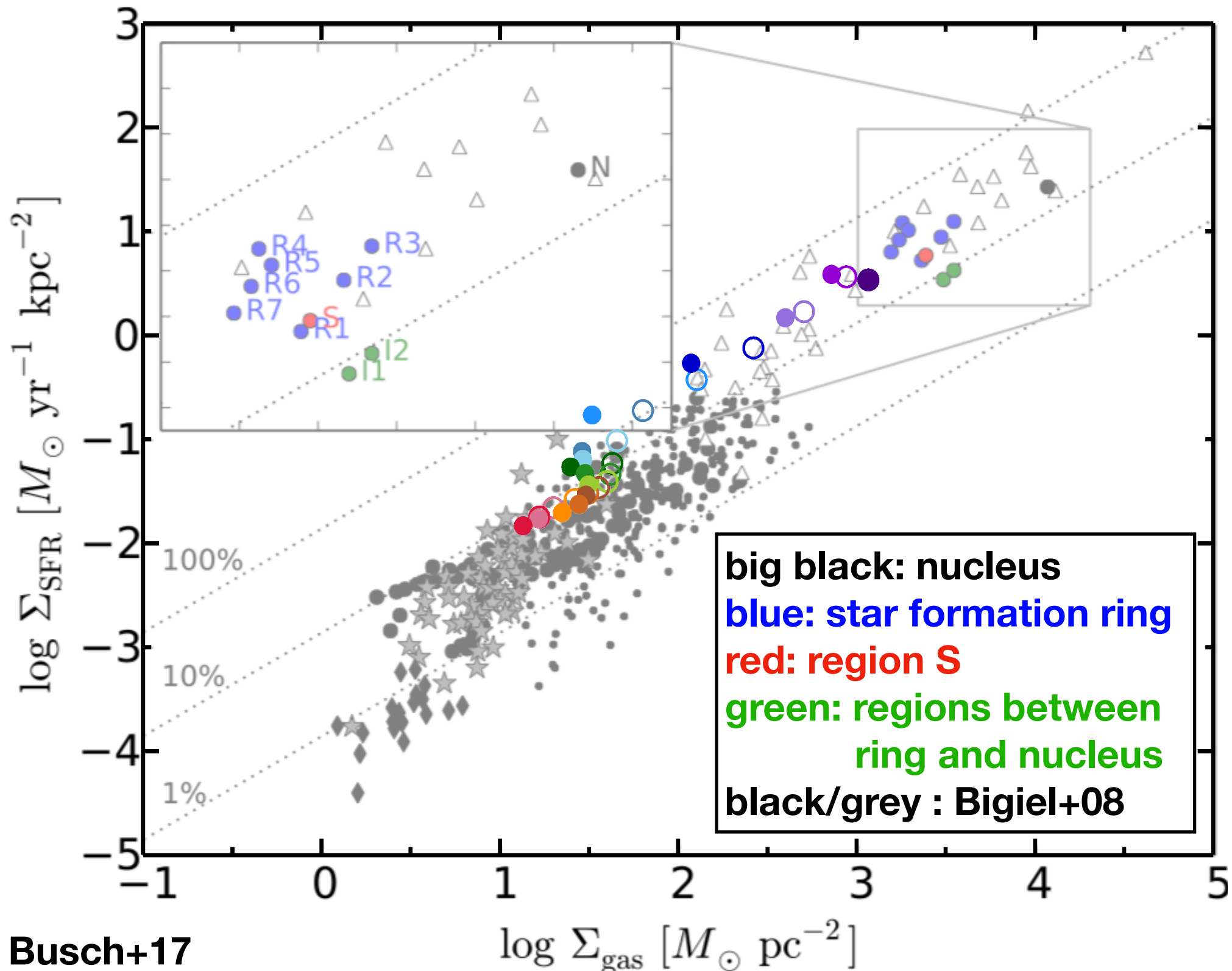
5. Star formations : Kennicutt-Schmidt Law



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5. Star formations : Kennicutt-Schmidt Law

Comparison with NGC4321 and other galaxies

