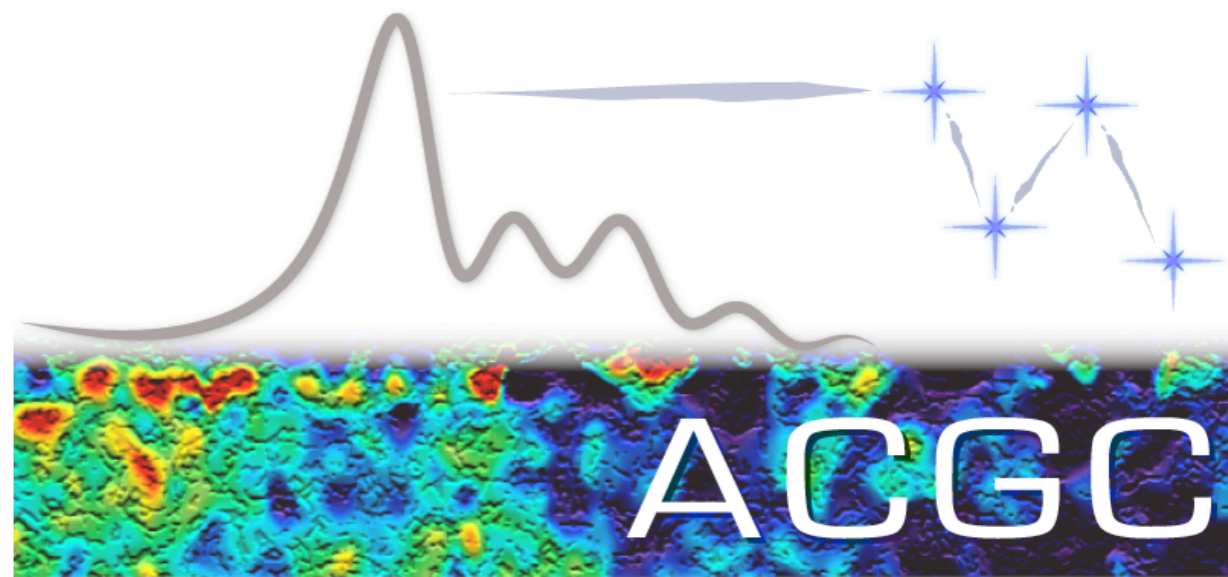


QUANTIFYING STAR FORMATION IN LVHIS :

A WISE PERSPECTIVE

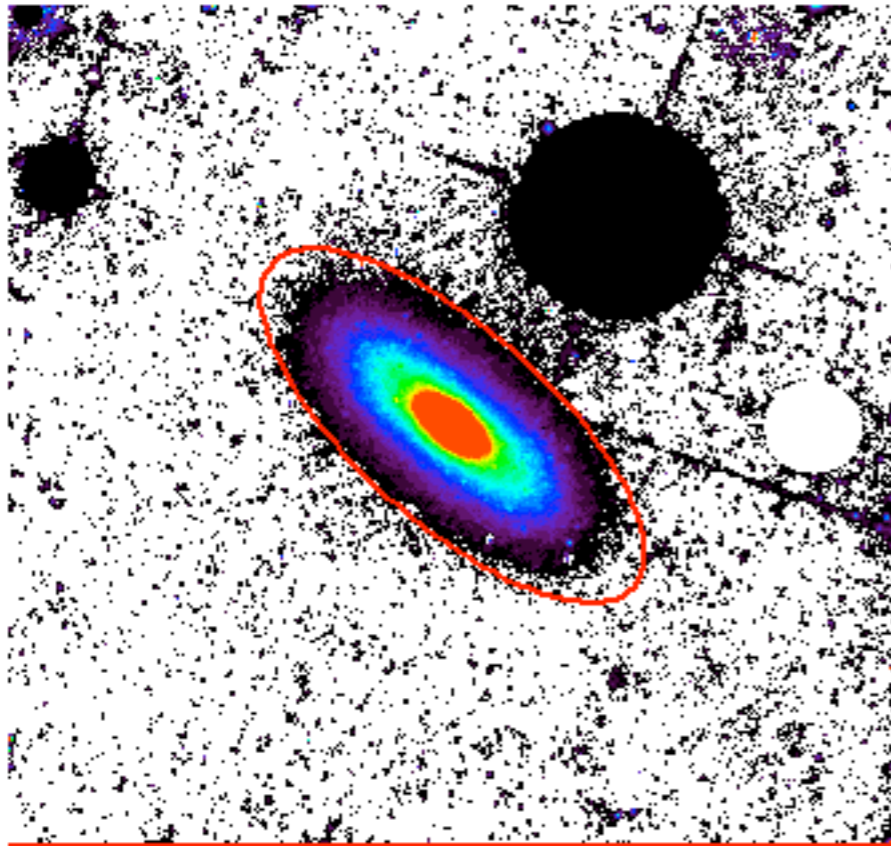
Ed Elson (UCT)
Tom Jarrett (UCT)



Introduction

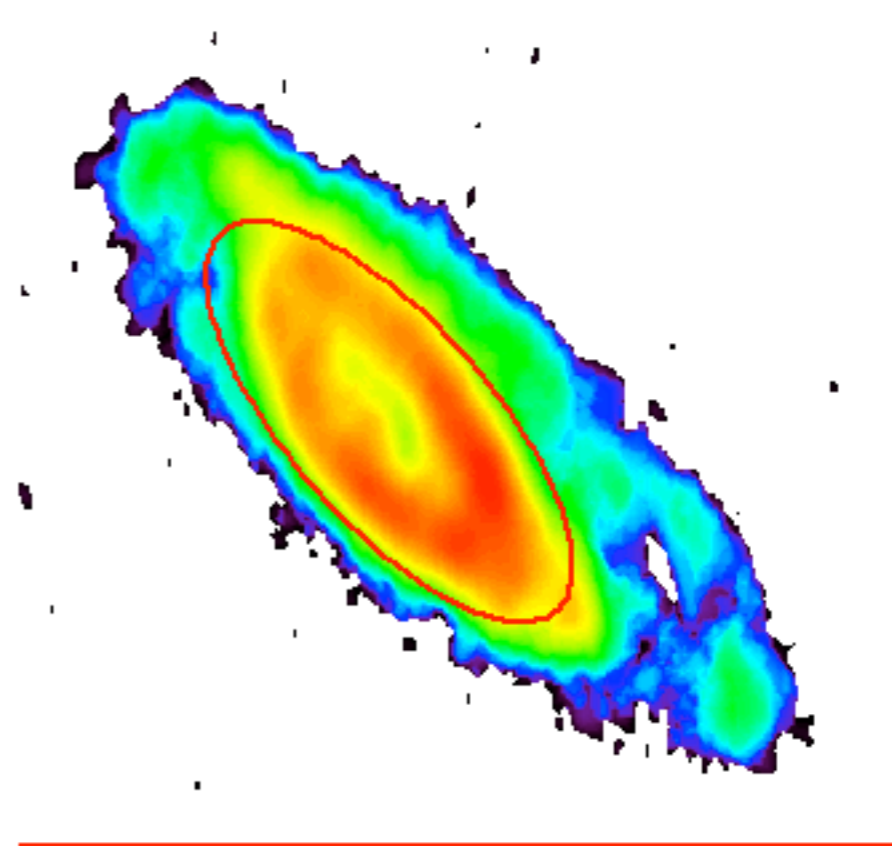
- We have WISE **mid-IR imaging** of nearby galaxies
- WERGA: Wise Enhanced Resolution Galaxy Atlas (Jarrett et al. 2013)
- “Super-resolution processing” → spatial resolutions similar to Spitzer ($\sim 5'' - 10''$)
- We also have **HI imaging** for LVHIS galaxies (Koribalski)
 - HI line and continuum imaging using ATCA

NGC5102 IR (W1) image



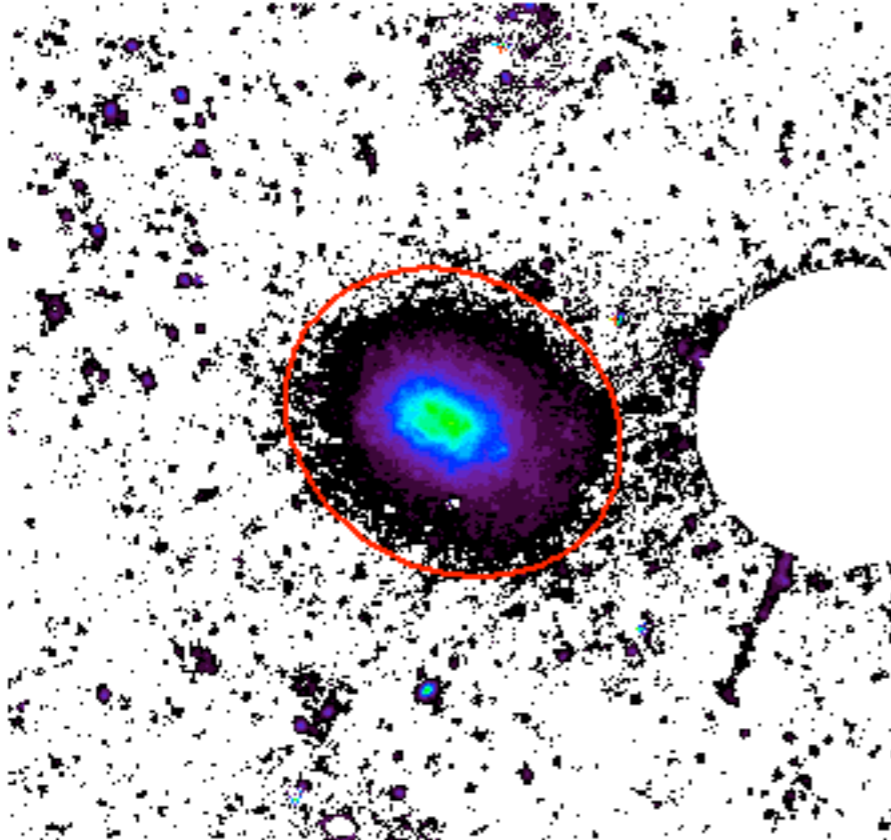
1188"

NGC5102 HI map



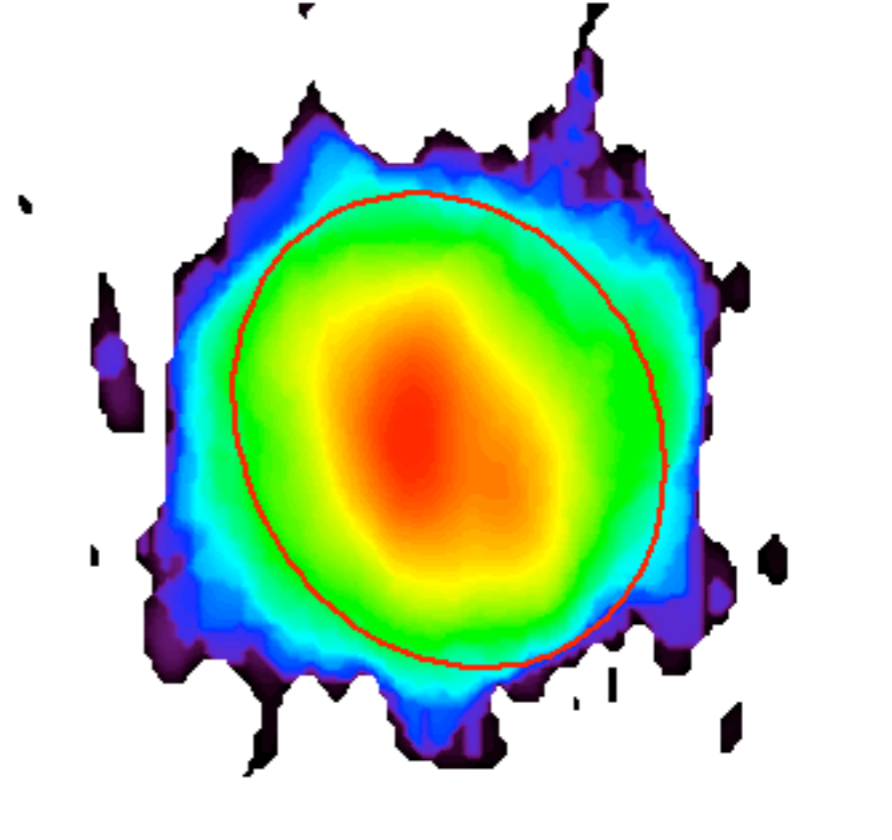
1250"

NGC5264 IR (W1) image



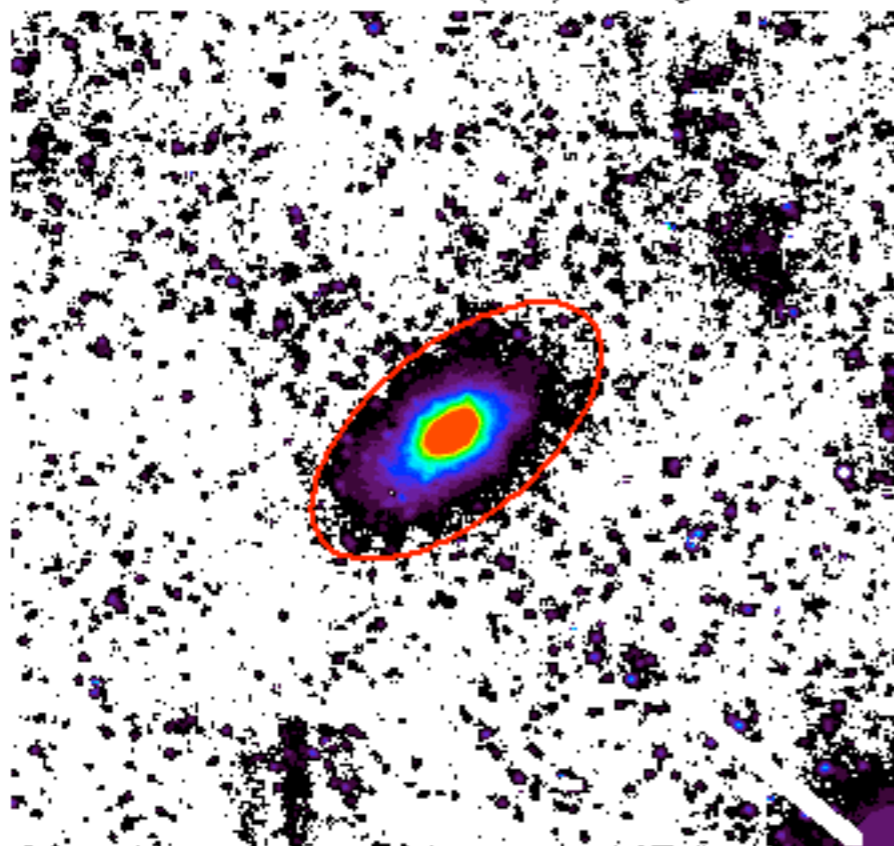
617"

NGC5264 HI map



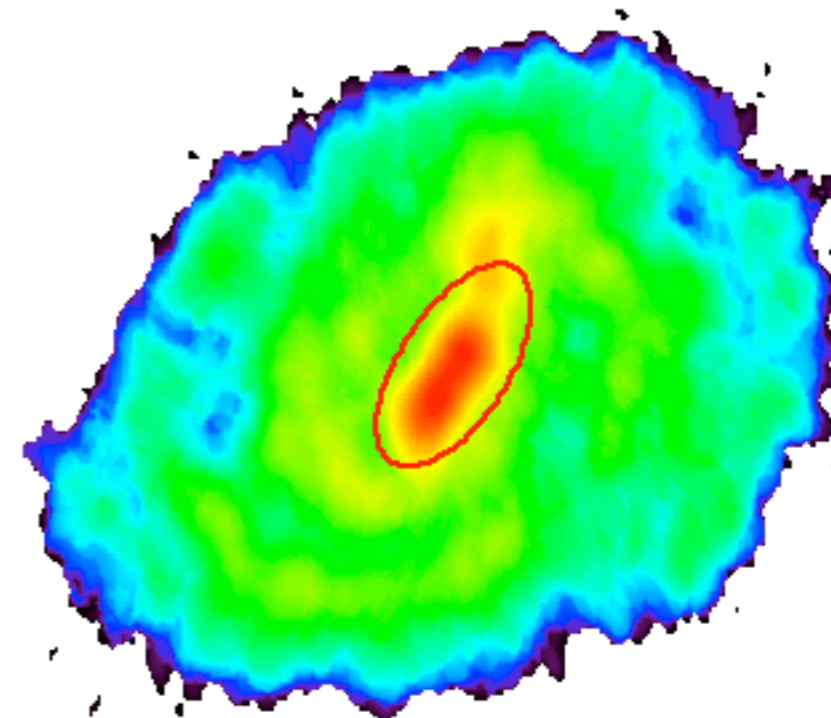
484"

NGC2915 IR (W1) image



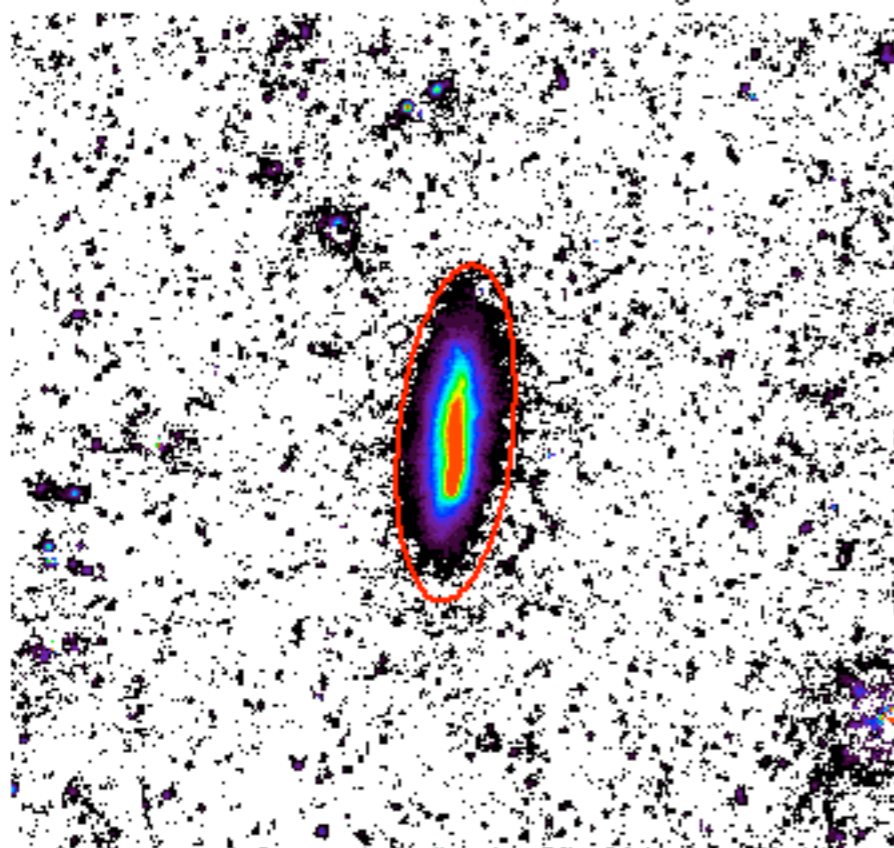
637"

NGC2915 HI map



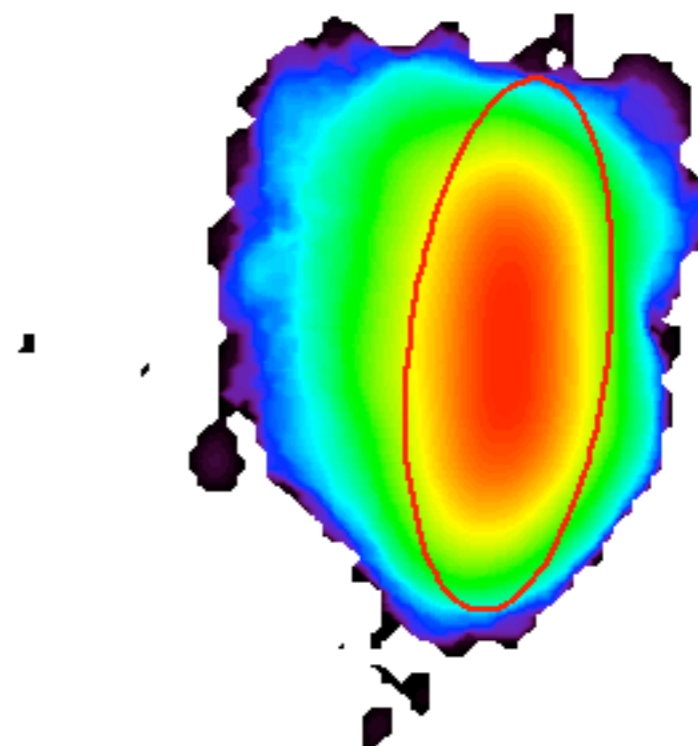
1195"

NGC2188 IR (W1) image



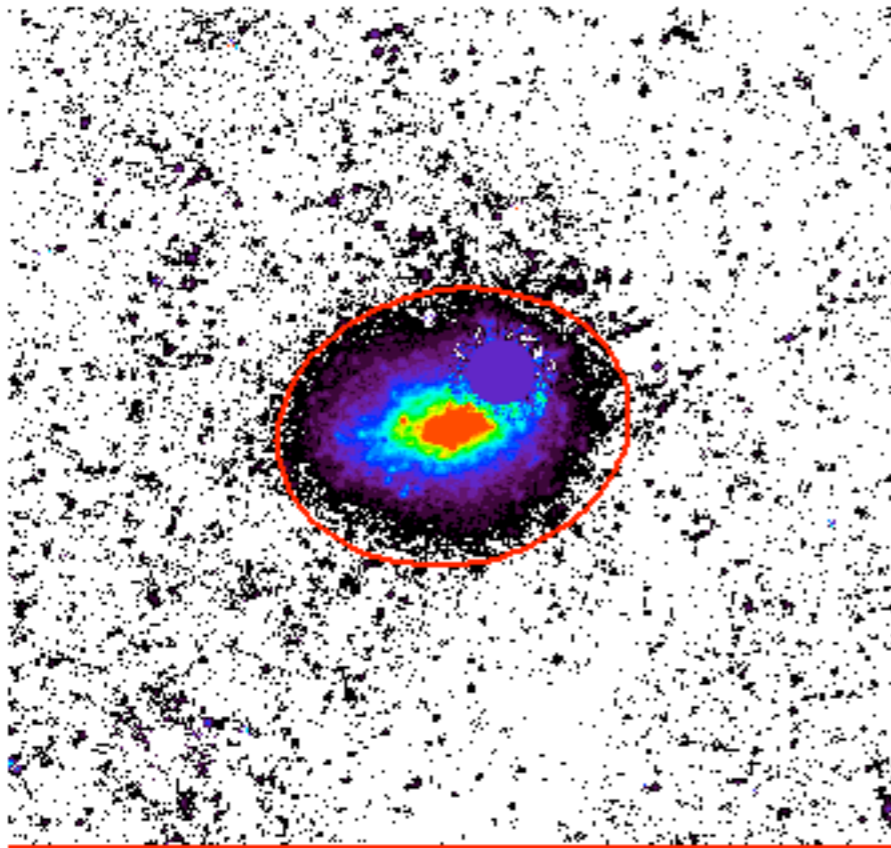
807"

NGC2188 HI map



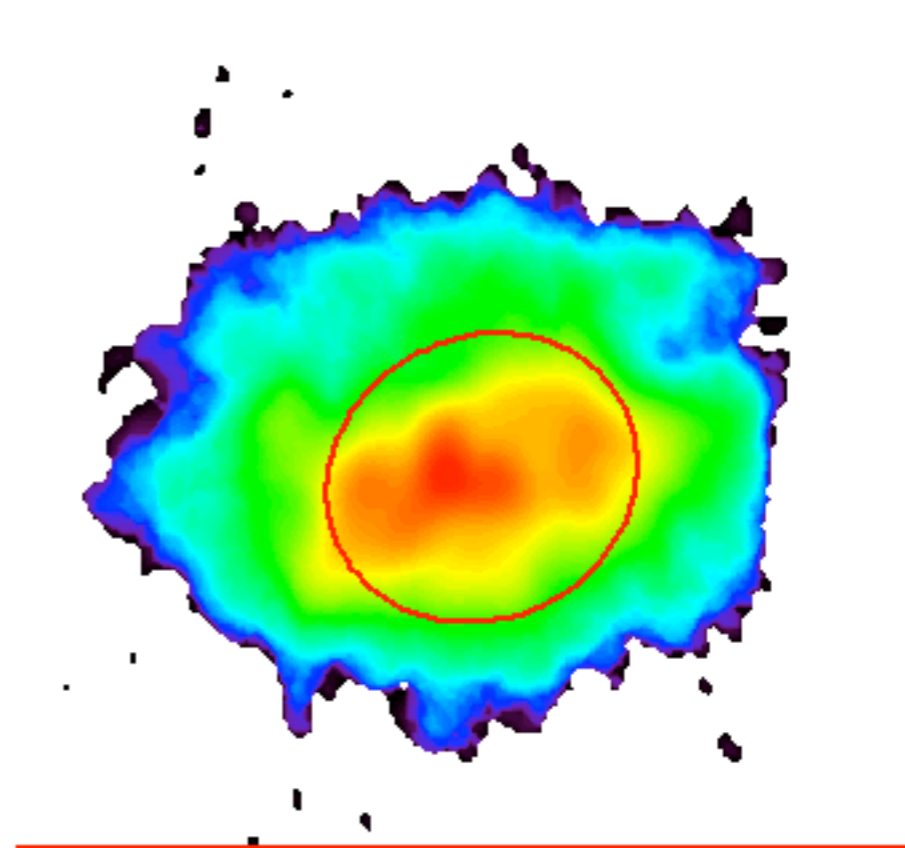
465"

IC5152 IR (W1) image



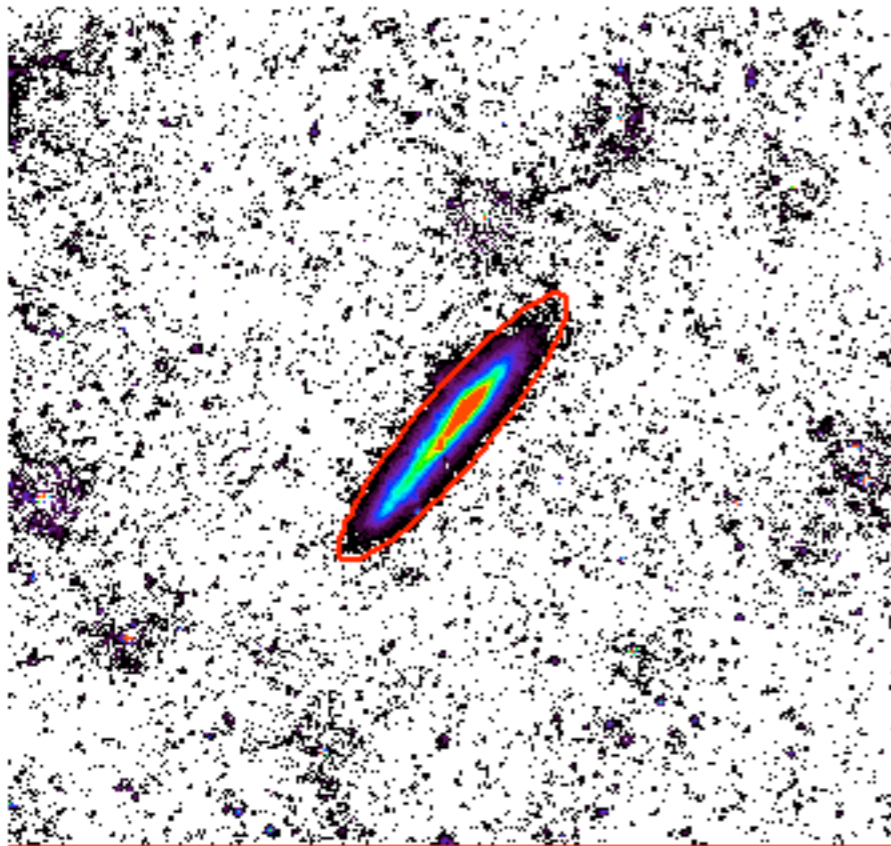
805"

IC5152 HI map



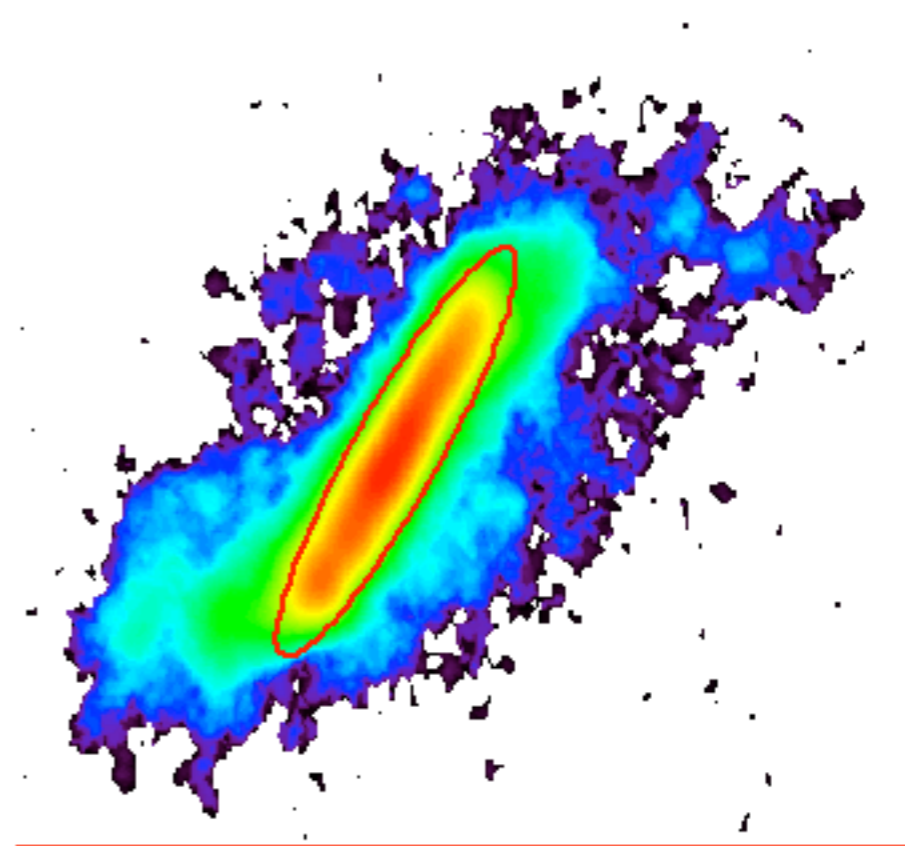
915"

IC5052 IR (W1) image



1151"

IC5052 HI map



1100"

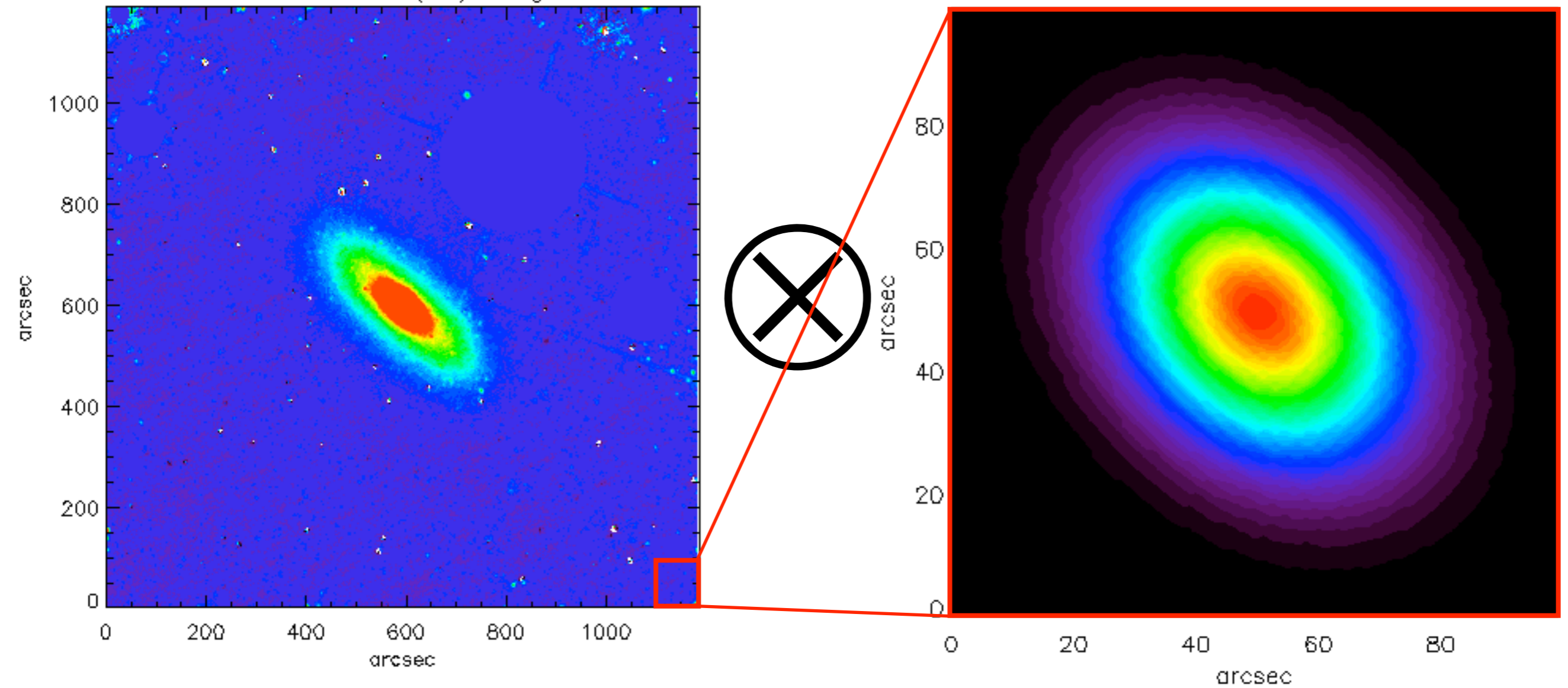
The project

- **Broad scope:** compare and combine mid-IR and HI observations for a morphologically diverse sample of galaxies in order to quantitatively study star-formation processes.
- WISE data are used to estimate SFRs, stellar masses, warm dust content
- HI line imaging is used to study distribution and kinematics of HI, as well as global dynamics

Step 1: Spatially smooth IR image

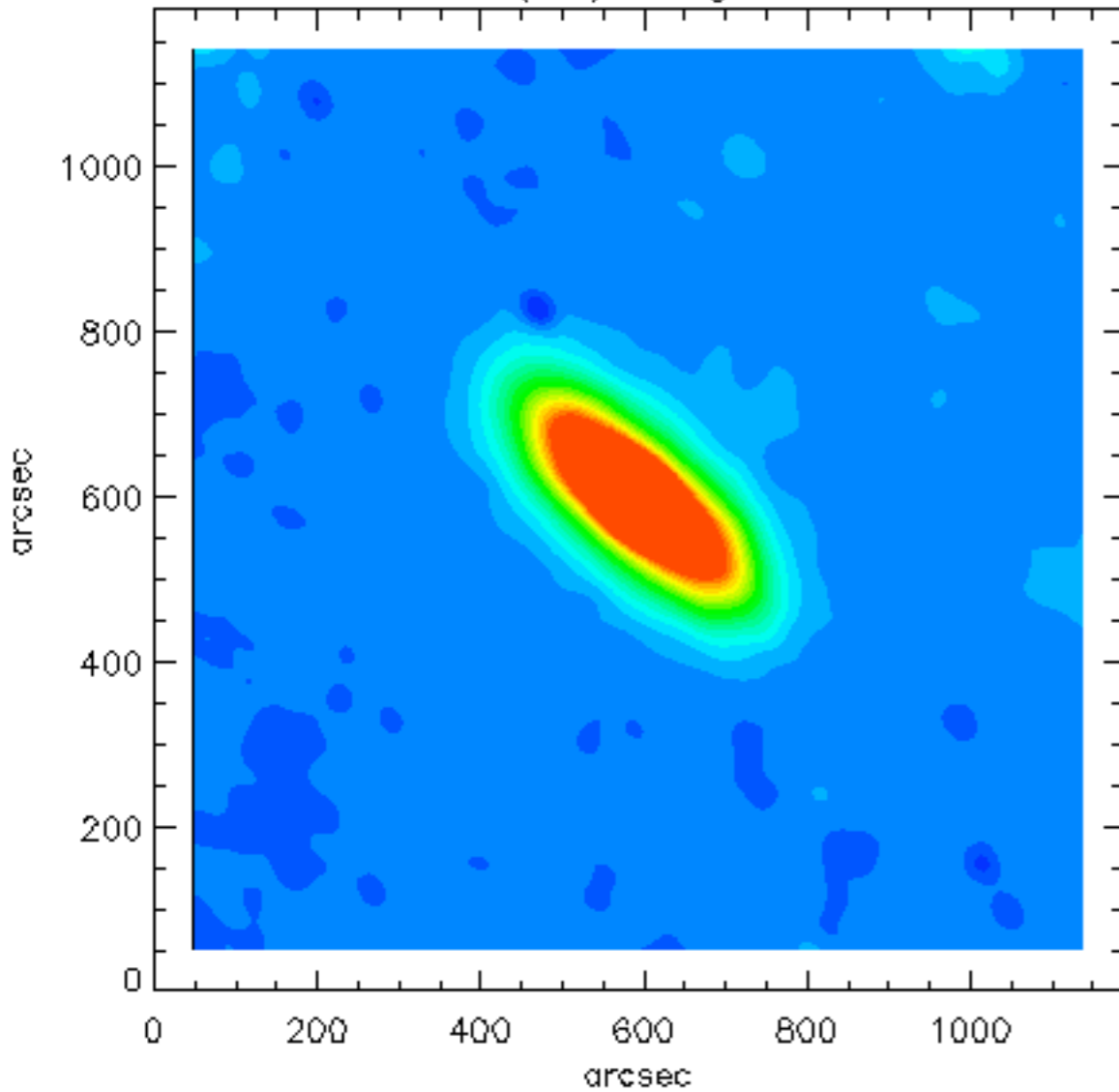
NGC5102 IR (W1) image

Convolution kernel

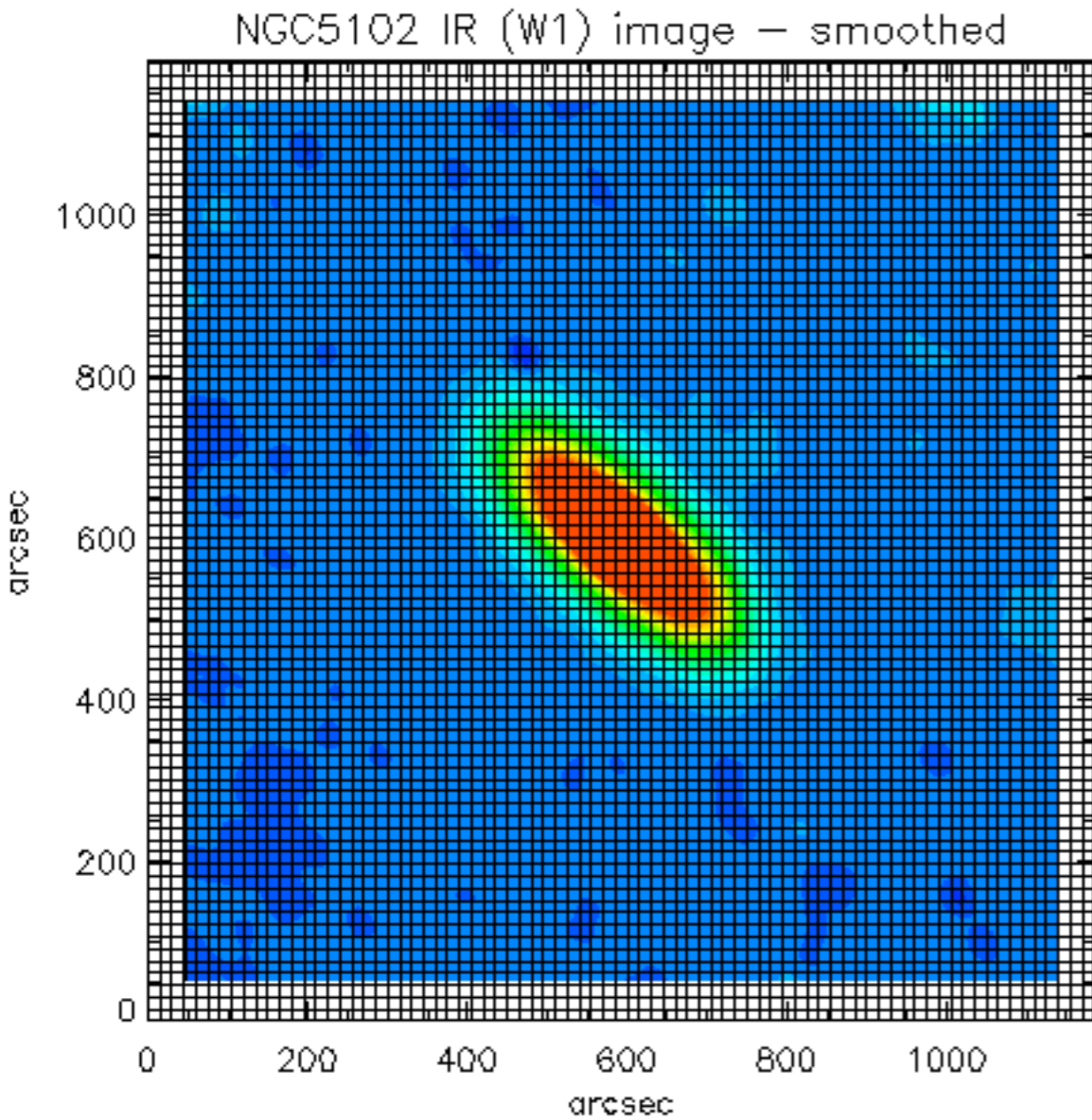


Step 1: Spatially smooth IR image

NGC5102 IR (W1) image — smoothed

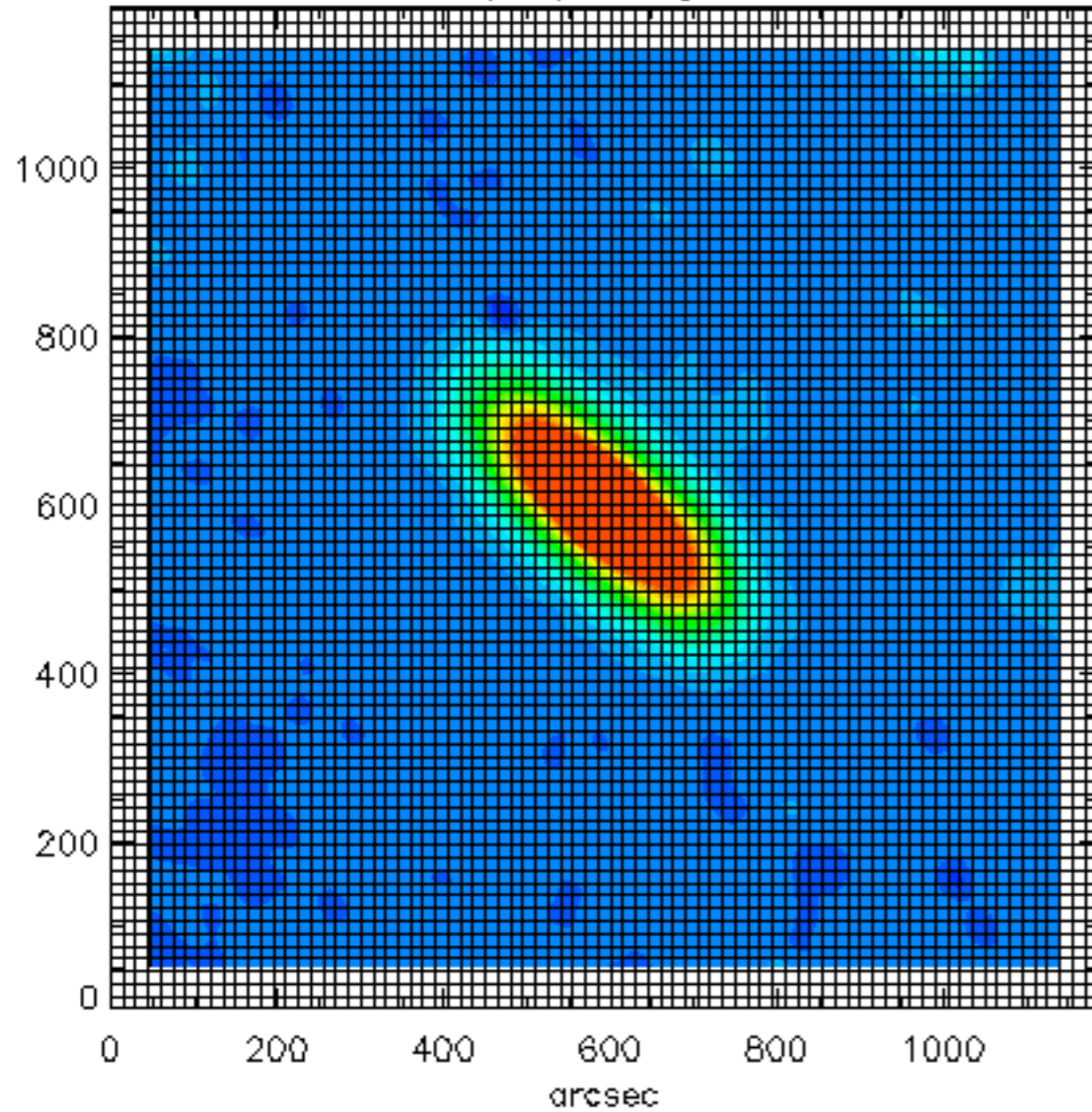


Step 1: Spatially smooth IR image

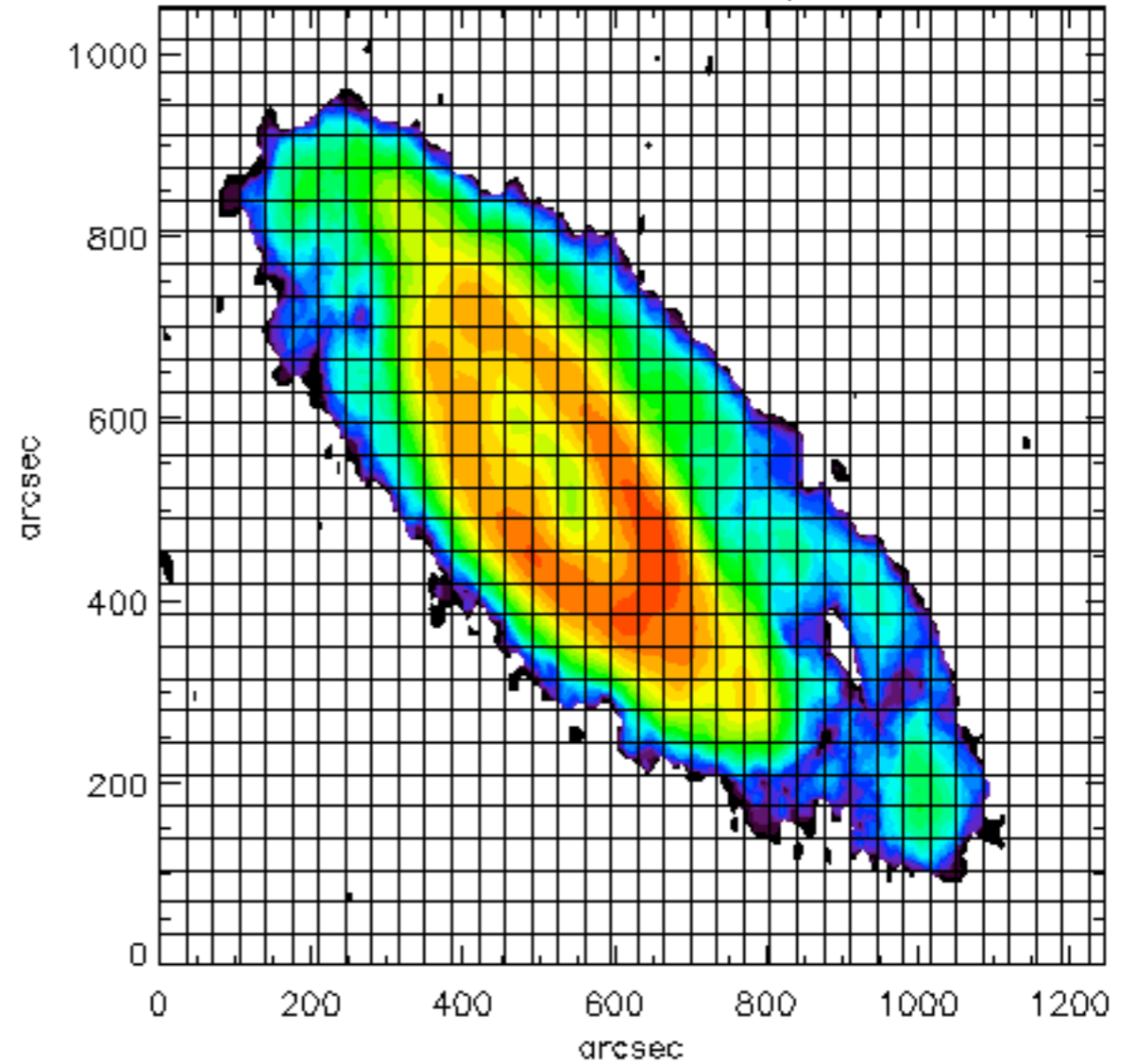


Step 2: Re-grid IR image

NGC5102 IR (W1) image — smoothed

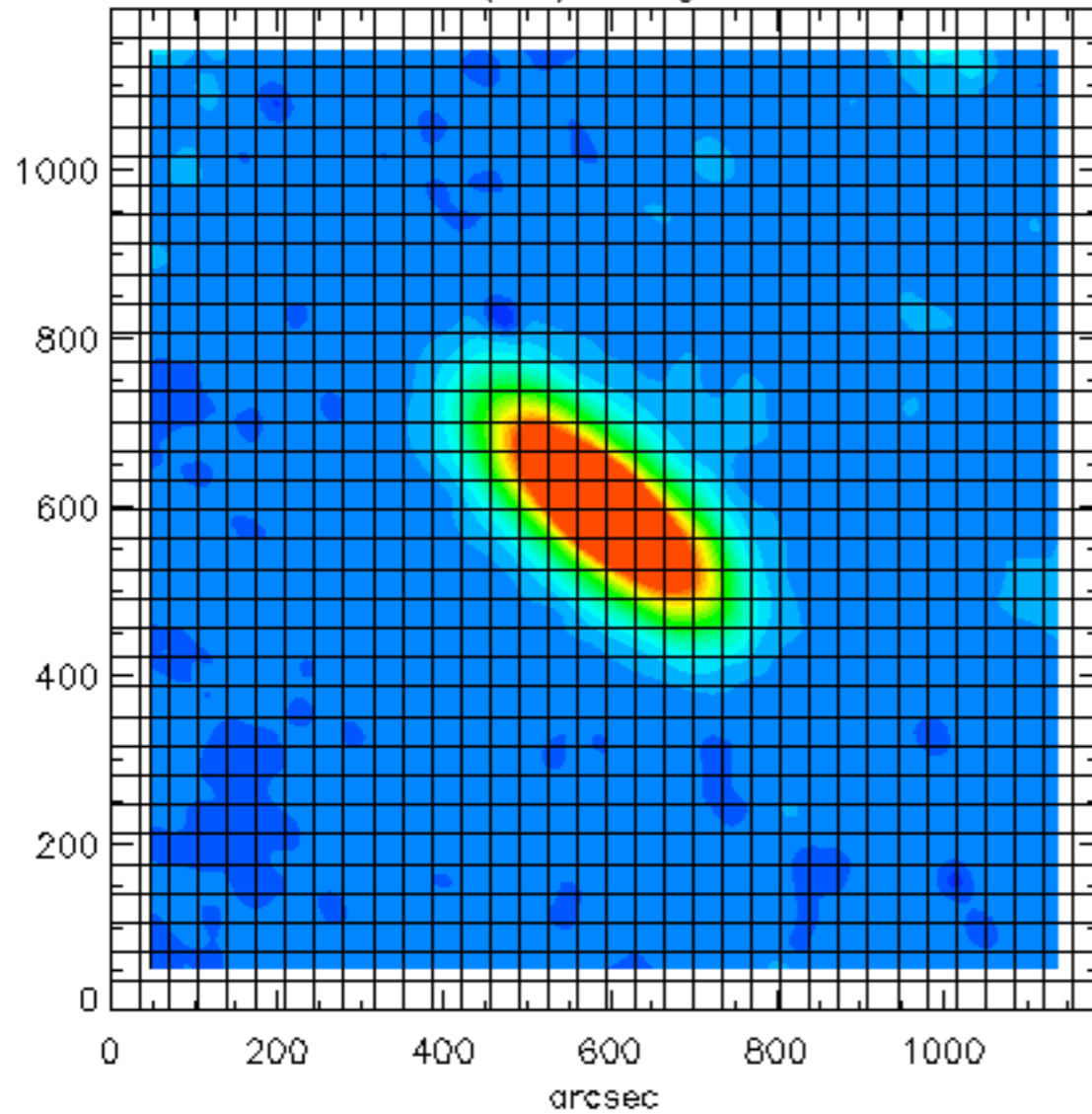


NGC5102 HI map

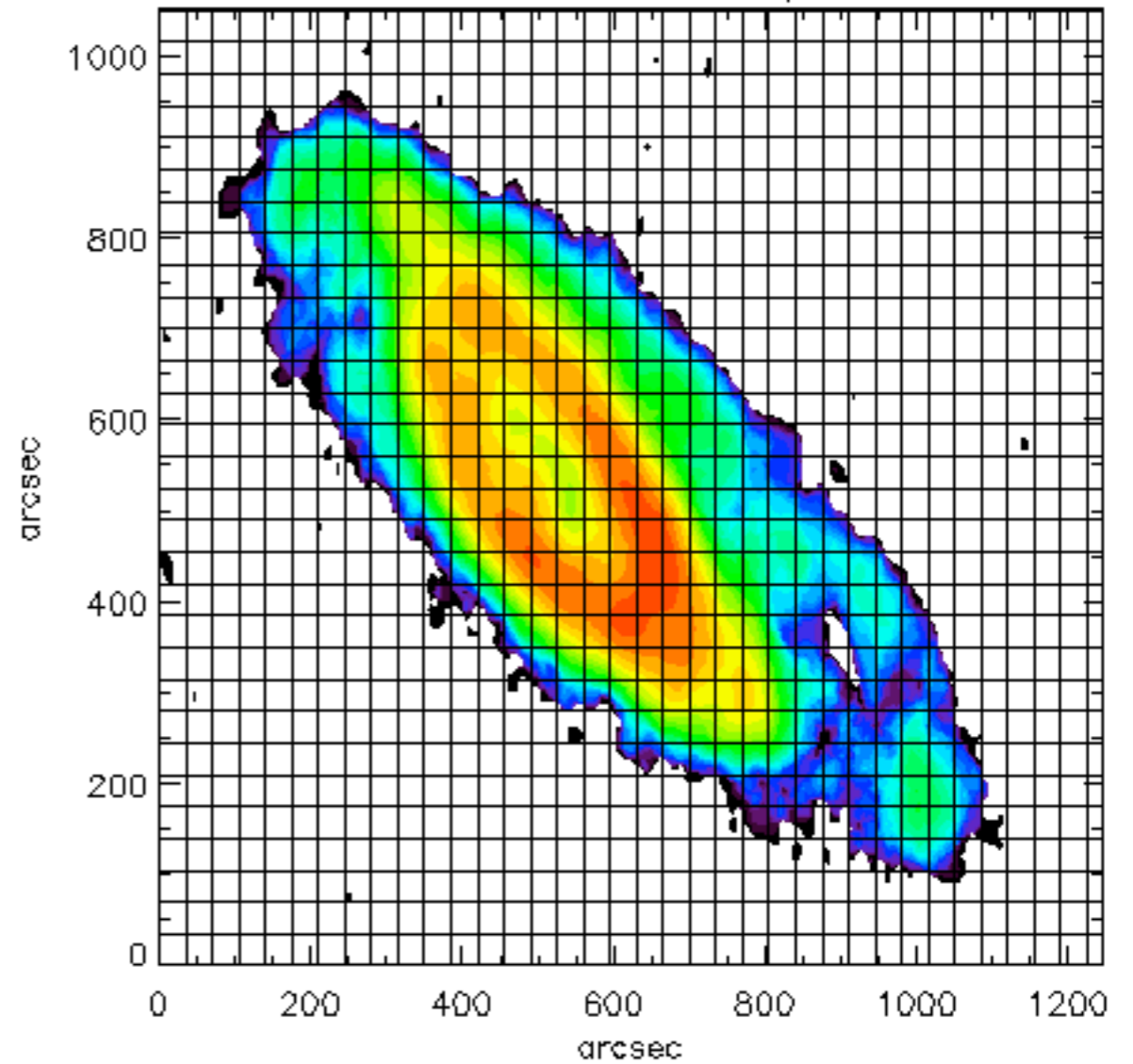


Step 2: Re-grid IR image

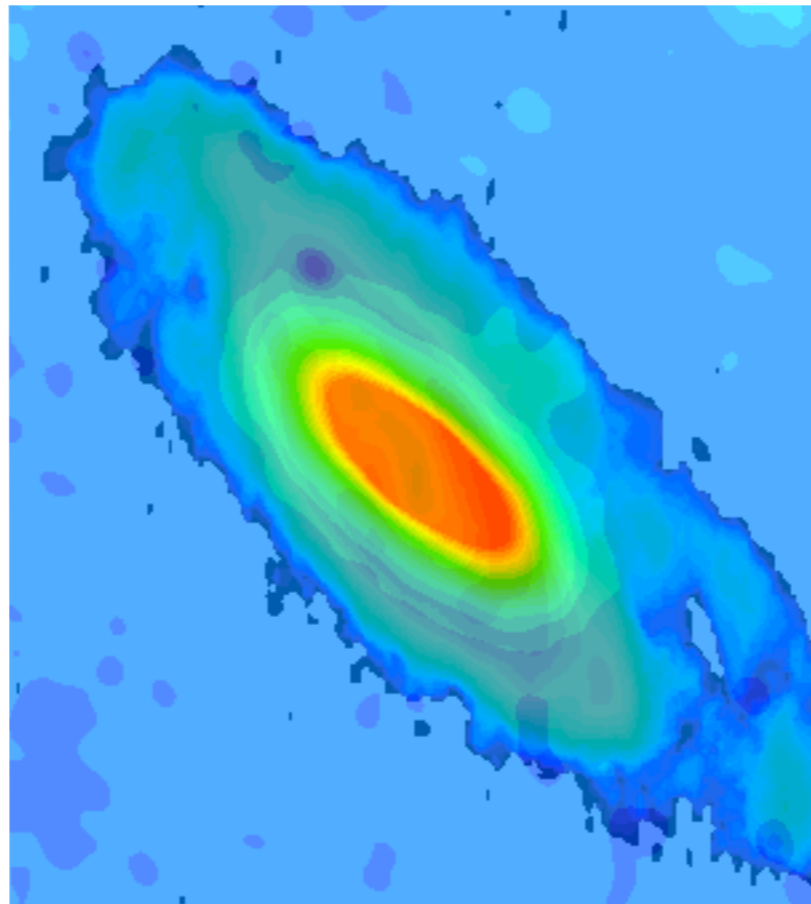
NGC5102 IR (W1) image — smoothed



NGC5102 HI map



Step 3: Combine IR and HI maps

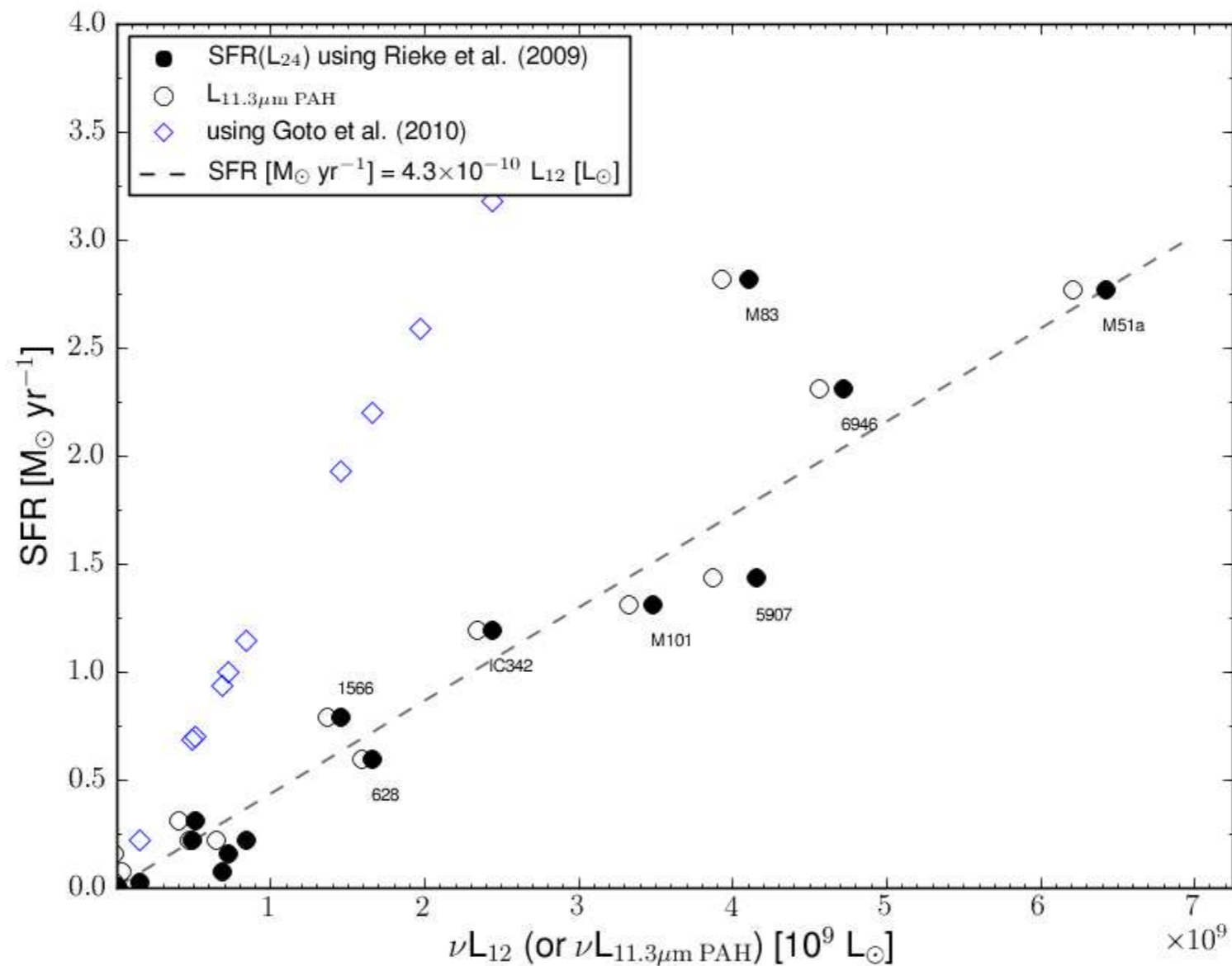


IR and HI maps are now directly comparable:

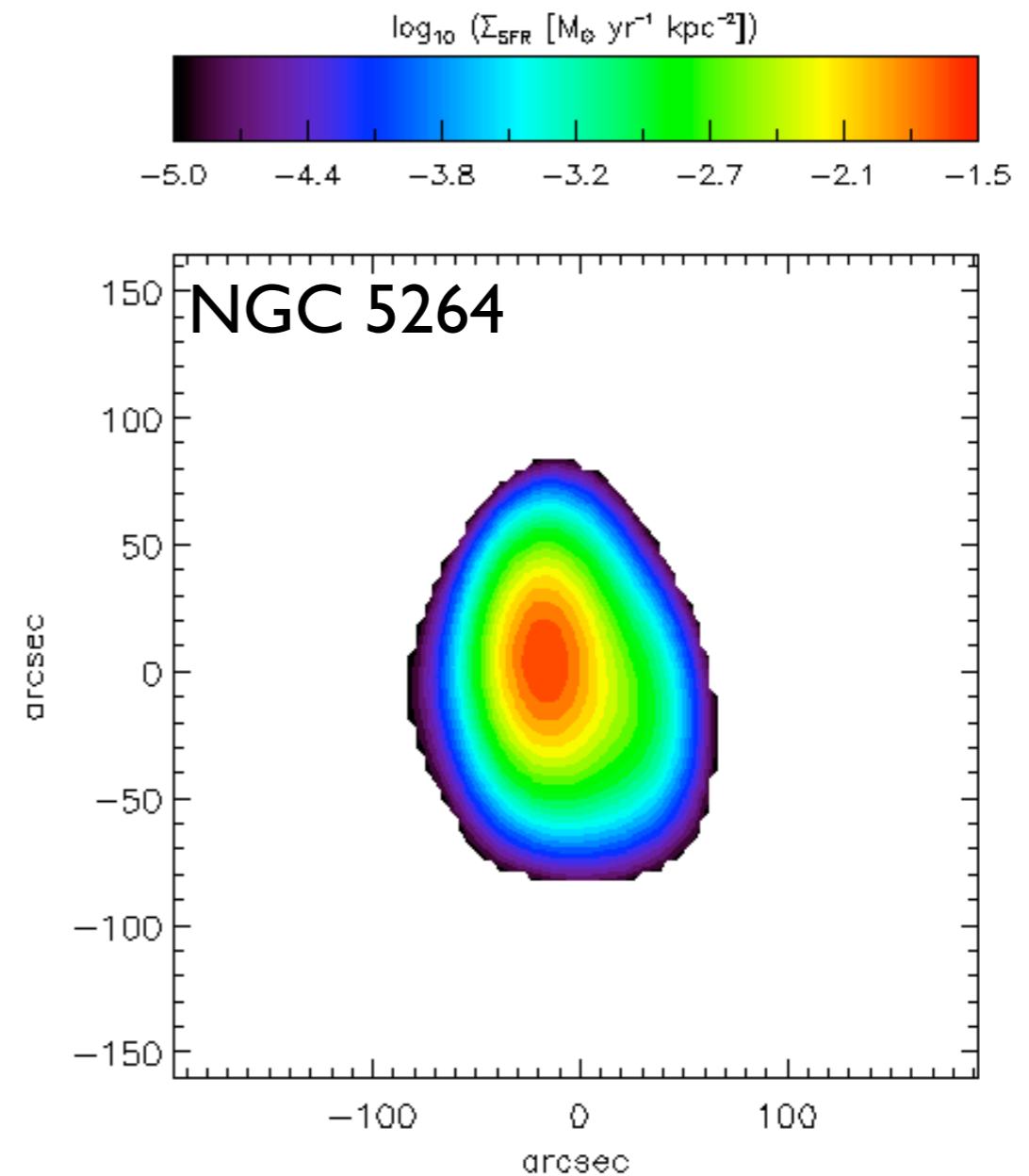
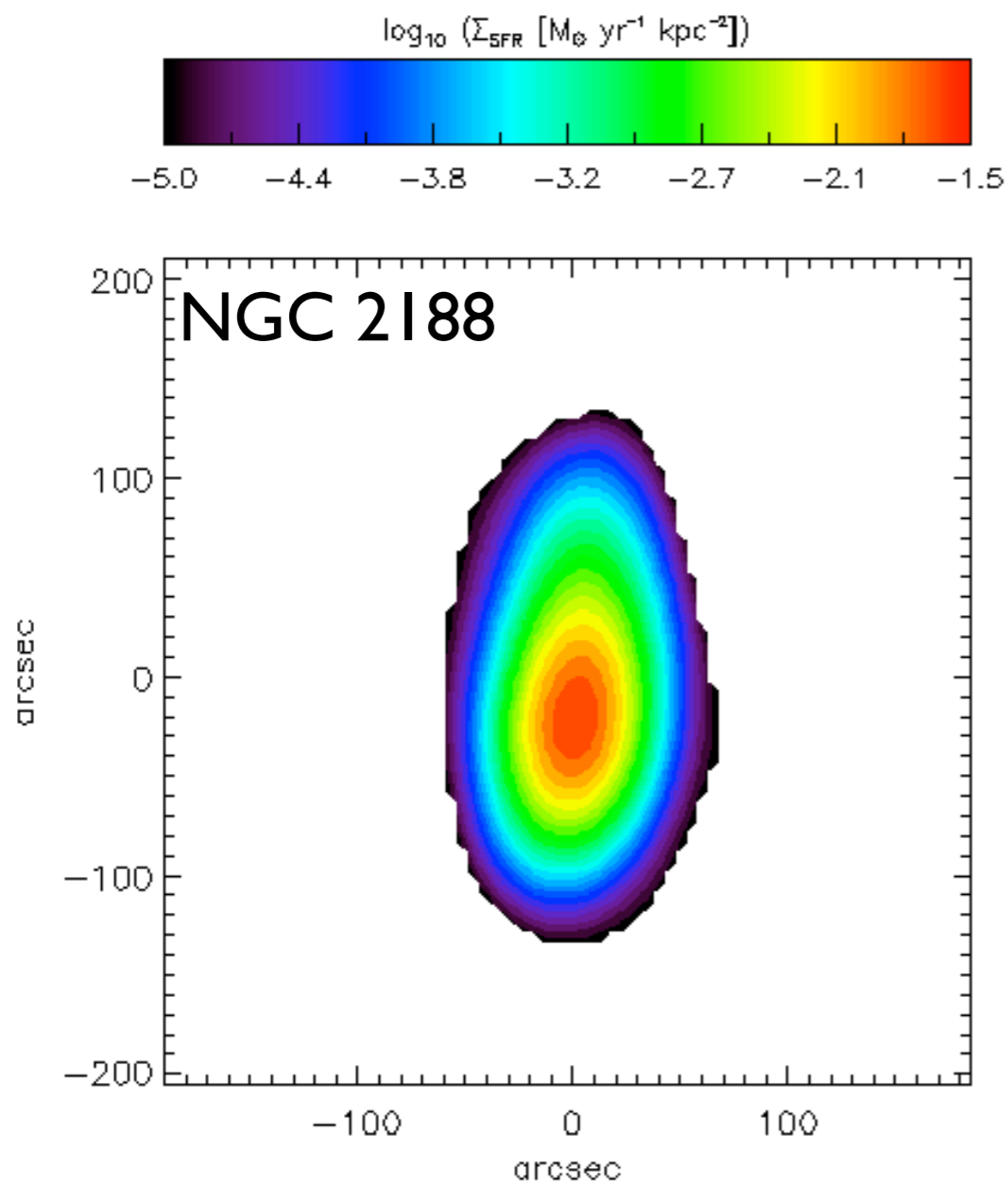
- same spatial resolution
- same astrometric grid

- SFR based on WISE 12 μm flux (Jarrett et al. 2013):

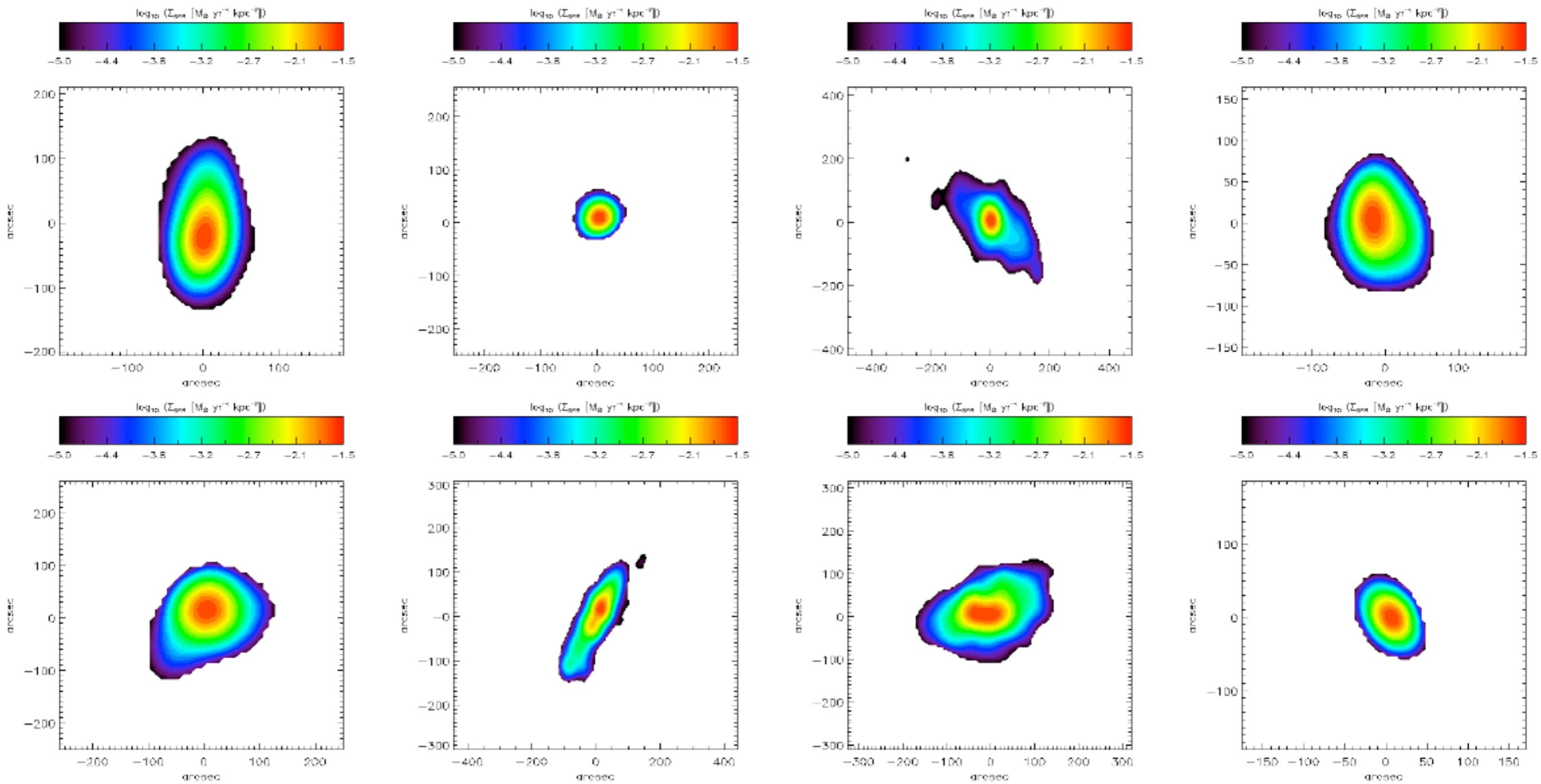
$$\frac{SFR_{12\mu m}}{M_{\odot} \text{ yr}^{-1}} = 4.91 \times 10^{-10} \frac{\nu L_{12\mu m}}{L_{\odot}}$$



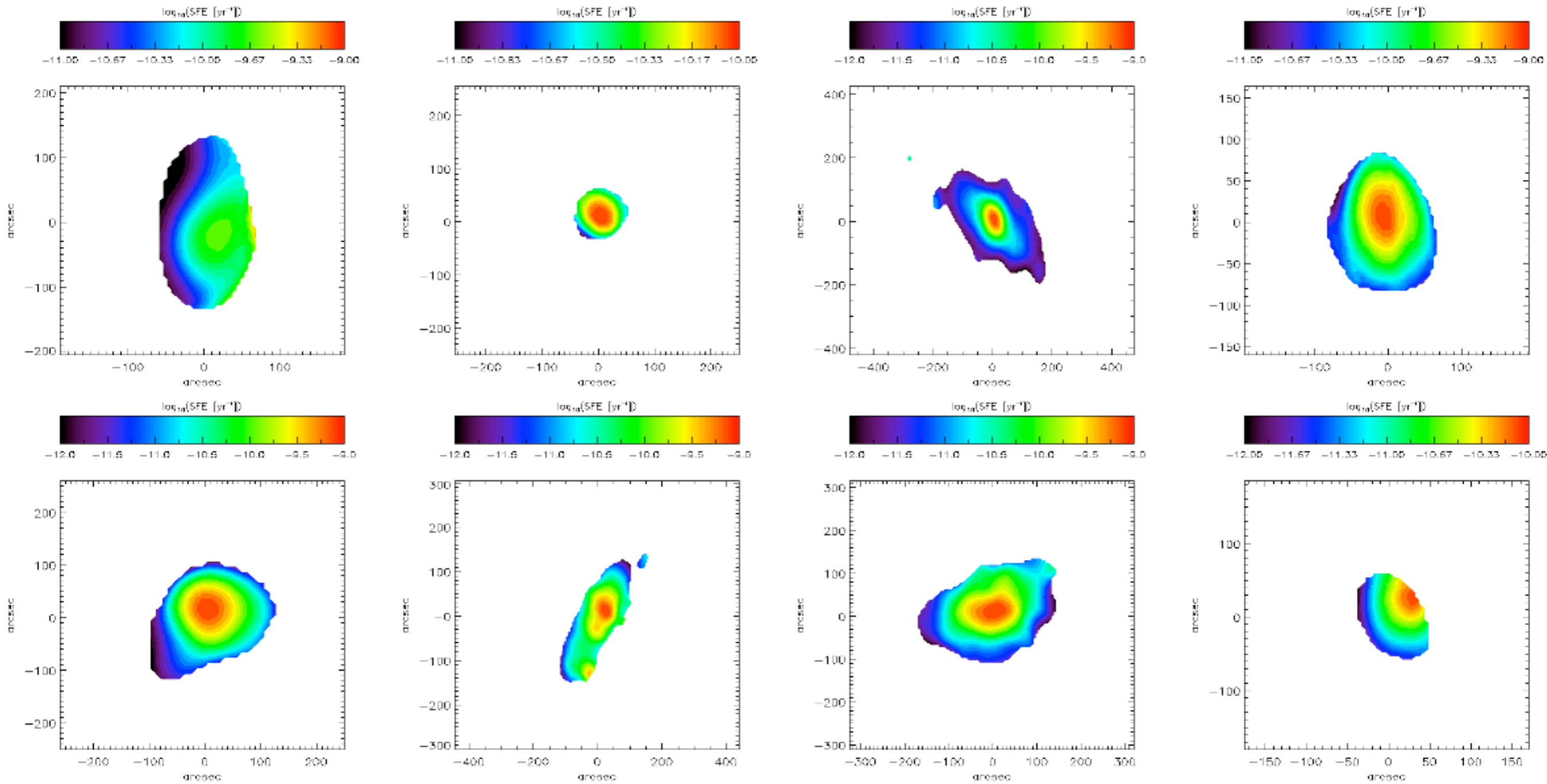
- SFR based on WISE 12 μm flux (Jarrett et al. 2013):



SFR density [$M_{\odot} \text{ yr}^{-1} \text{ kpc}^{-2}$]



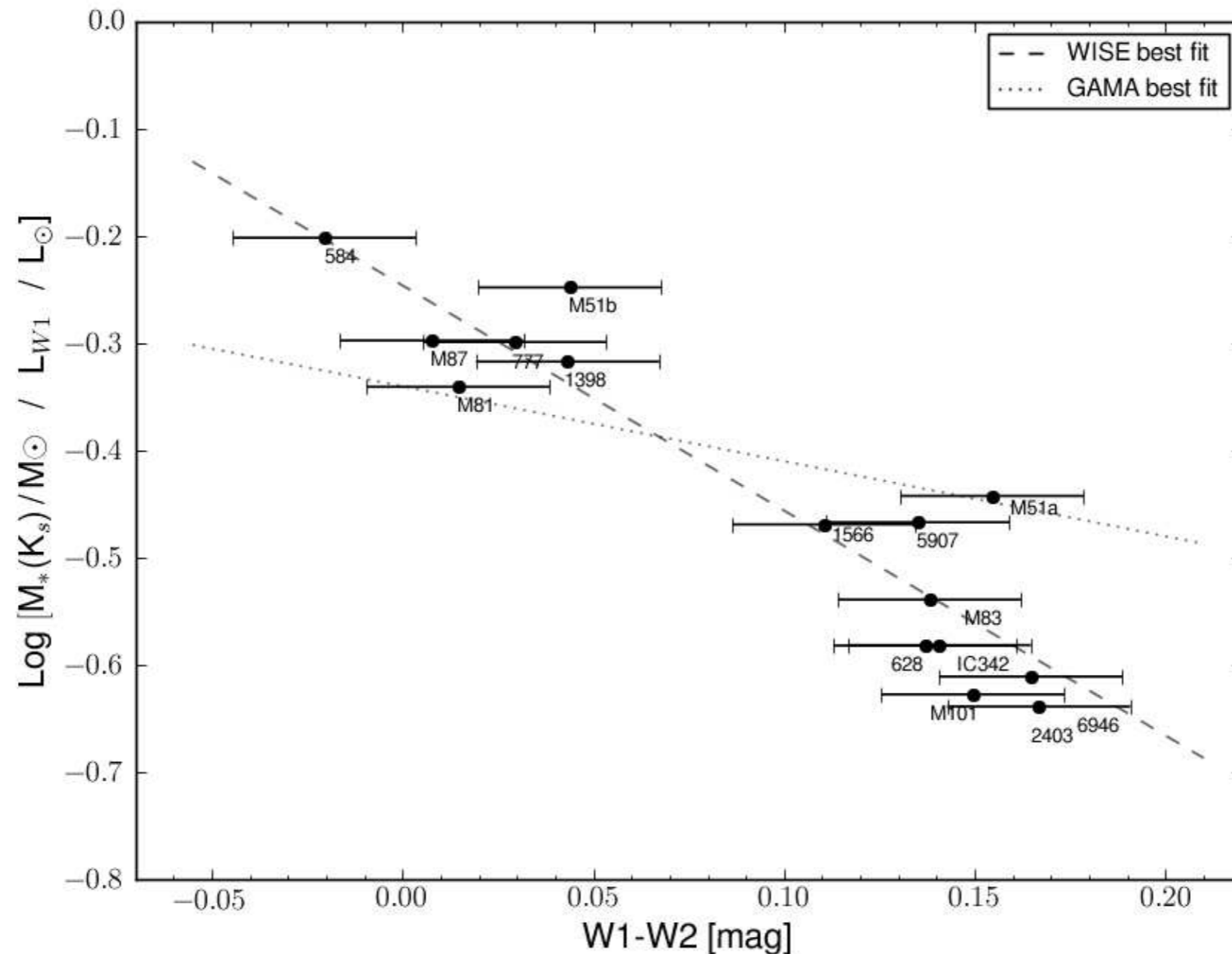
Star formation efficiency [yr⁻¹]



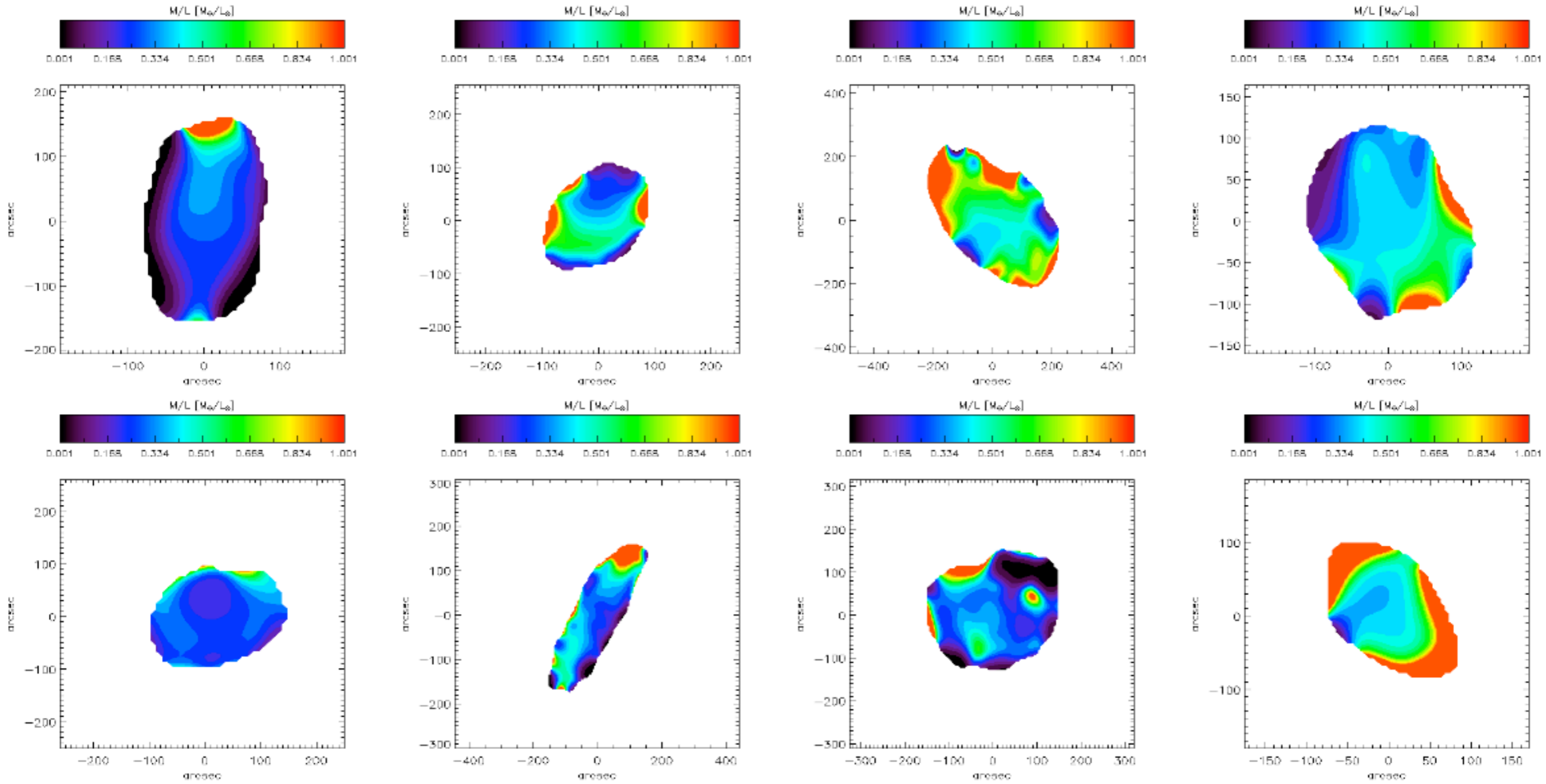
Stellar mass-to-light ratio [M_{\odot}/L_{\odot}]

- Stellar M/L based on WISE W1-W2 colours:

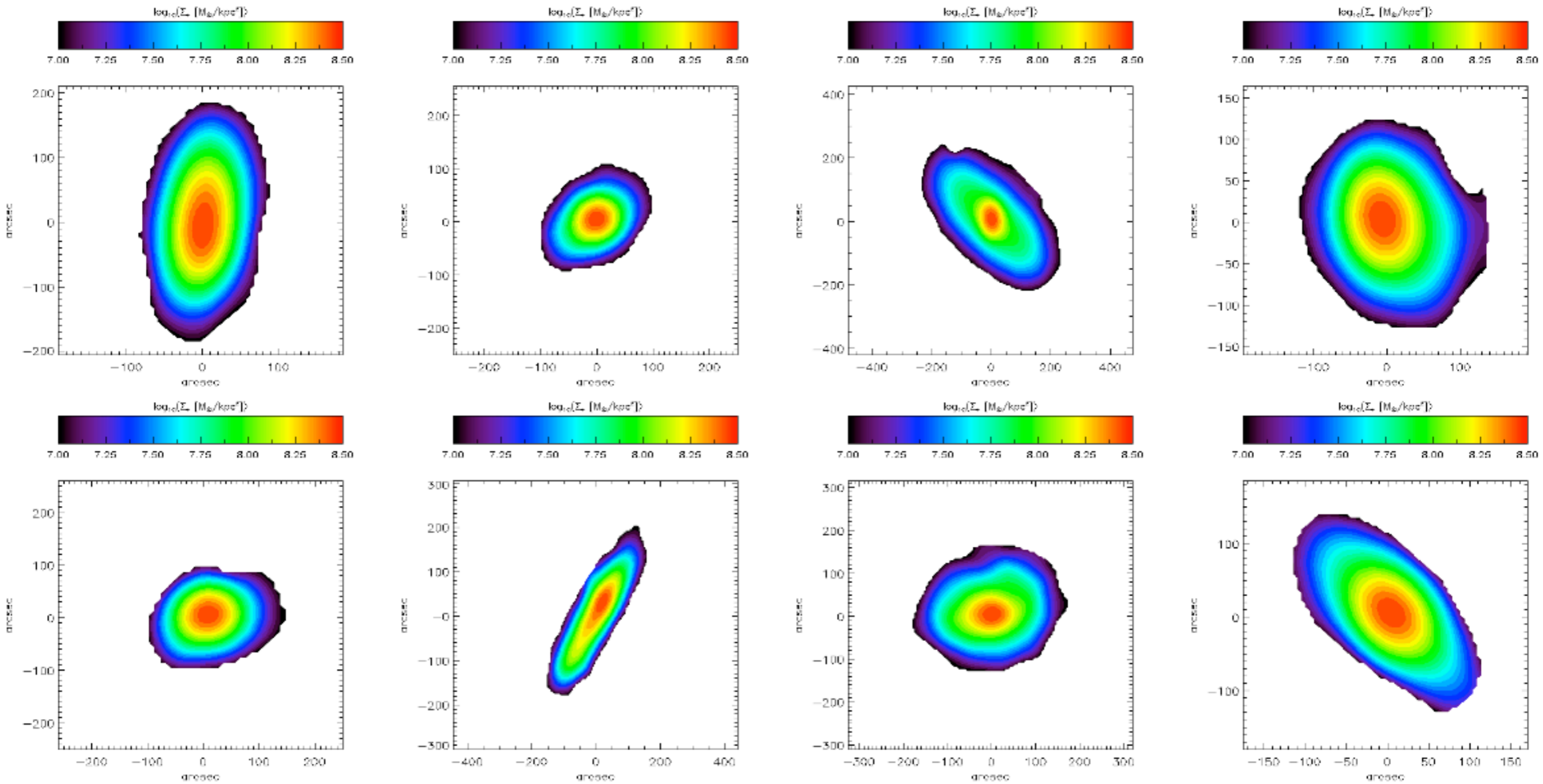
$$\log(M_*^{K_s} / L_{W1} [M_{\odot}/L_{\odot}]) = -0.246 - 2.10(W1 - W2)$$



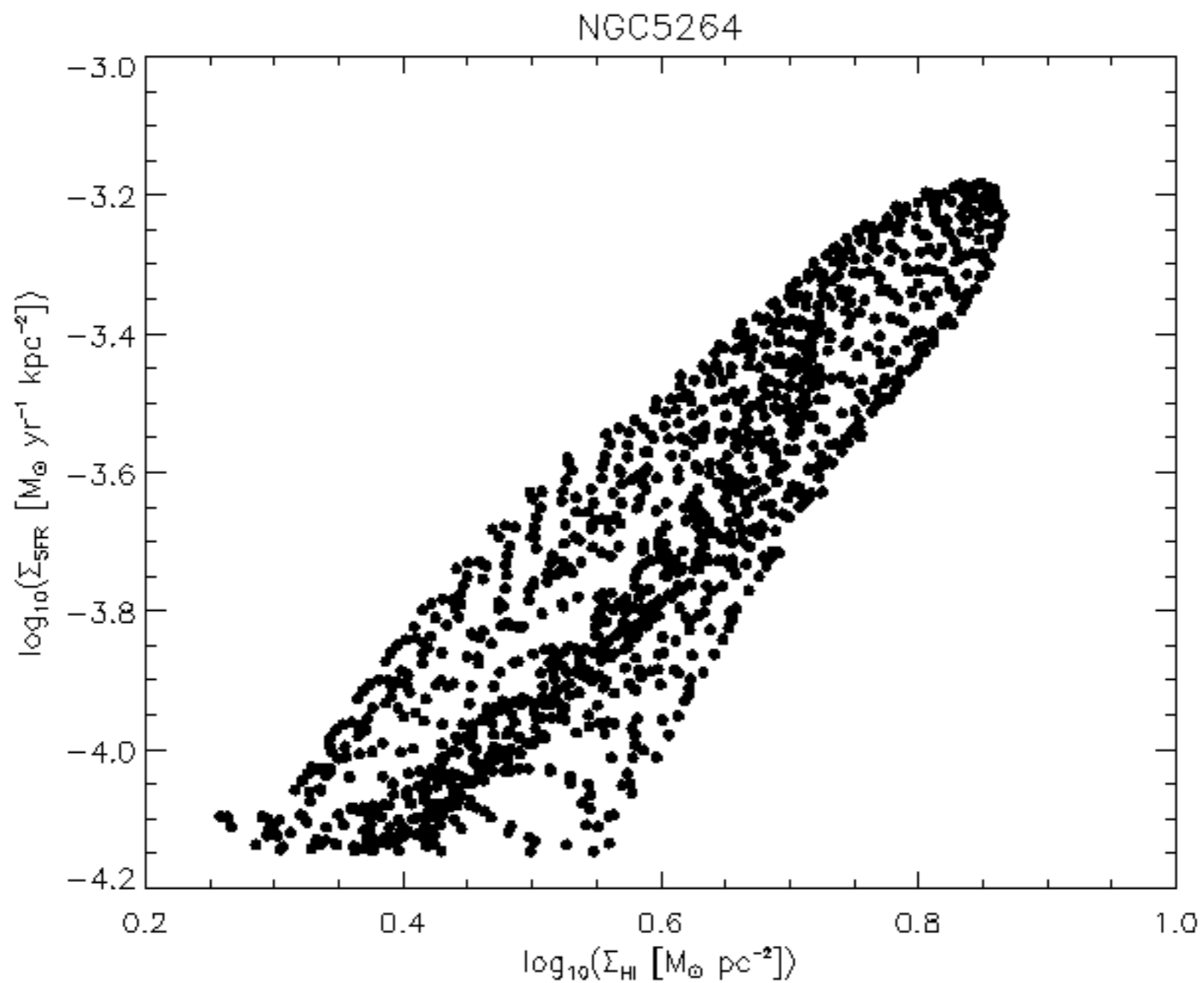
Stellar mass-to-light ratio [M_{\odot}/L_{\odot}]



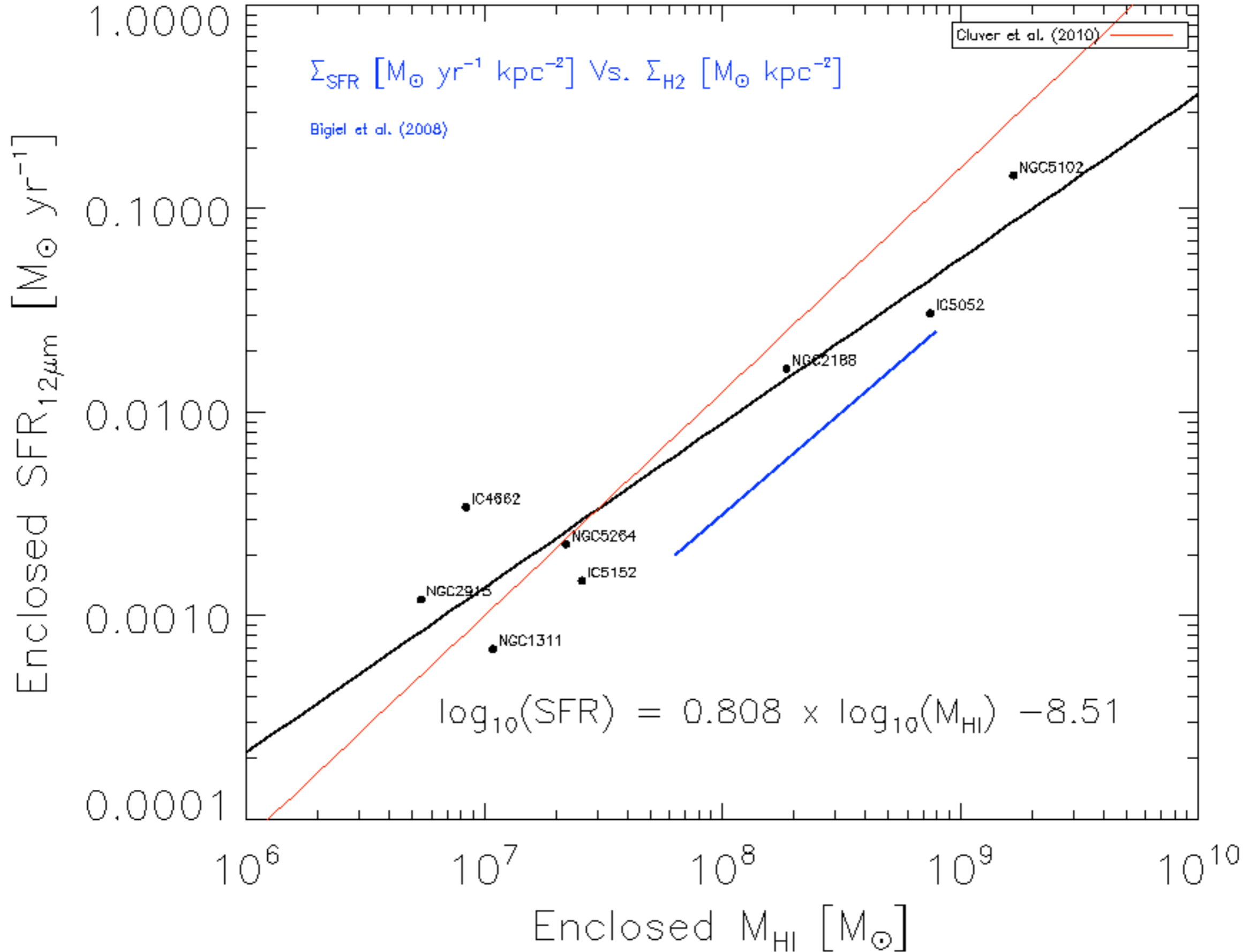
Stellar mass density [$M_{\odot} \text{ kpc}^{-2}$]



Comparisons of properties on $\sim 0.1 - 0.4$ kpc length scales

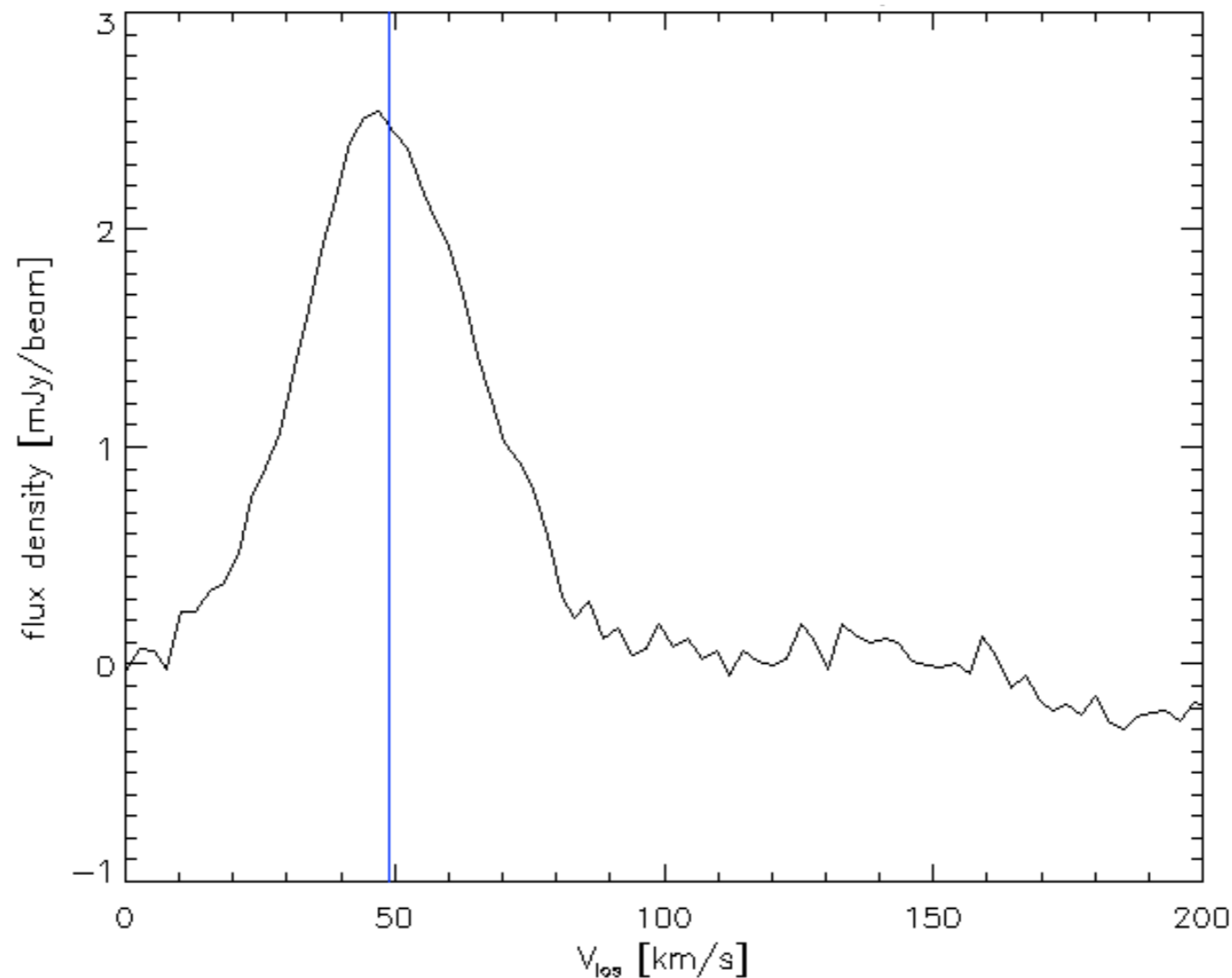


Comparisons of global properties



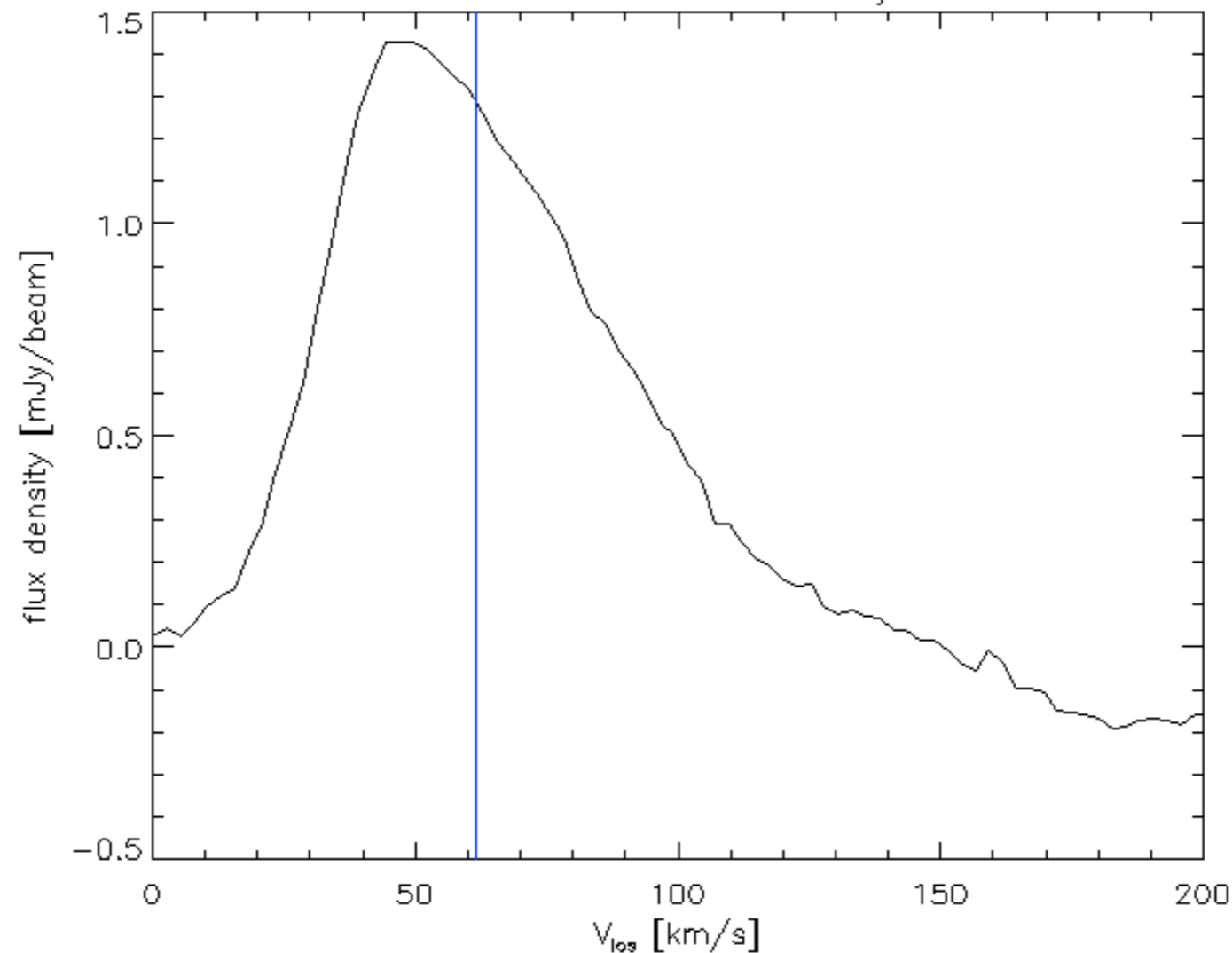
HI velocity fields

- A velocity field is a 2D compression of a 3D cube
- **Main idea:** estimate the line-of-sight velocity (V_{los}) corresponding to the peak flux



HI velocity fields

- Usual method: calculate 1st-order moment (IWM vel)
- Problem: Line profiles can be skewed $\rightarrow V_{\text{IWM}}$ does not accurately represent V_{los} at peak flux



HI velocity fields

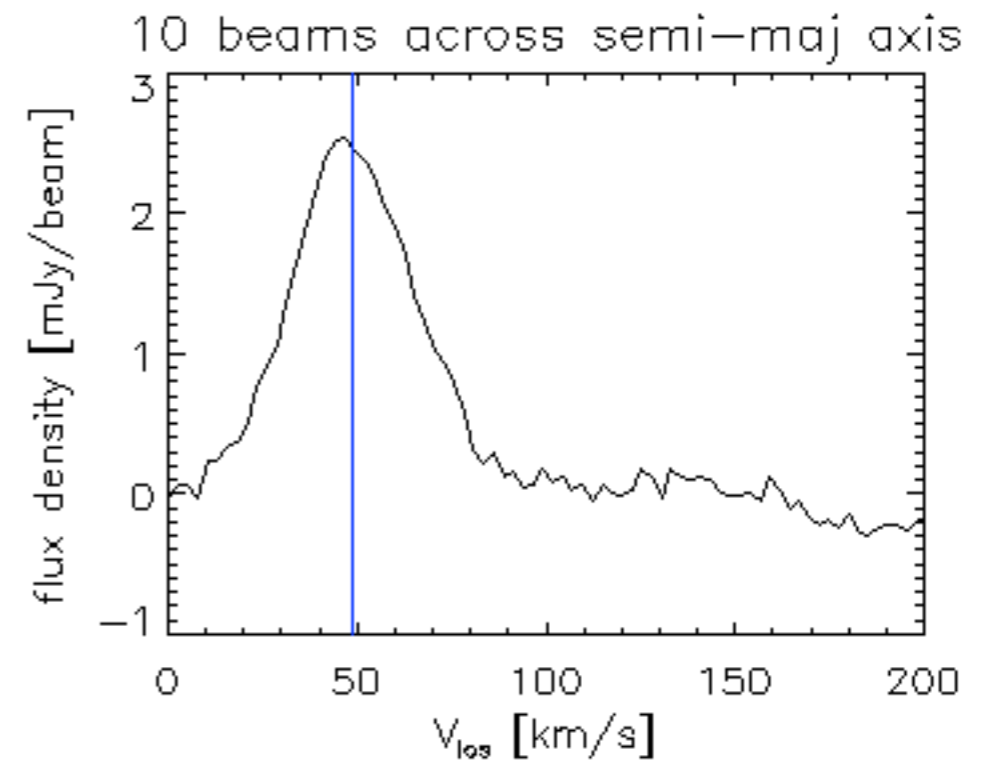
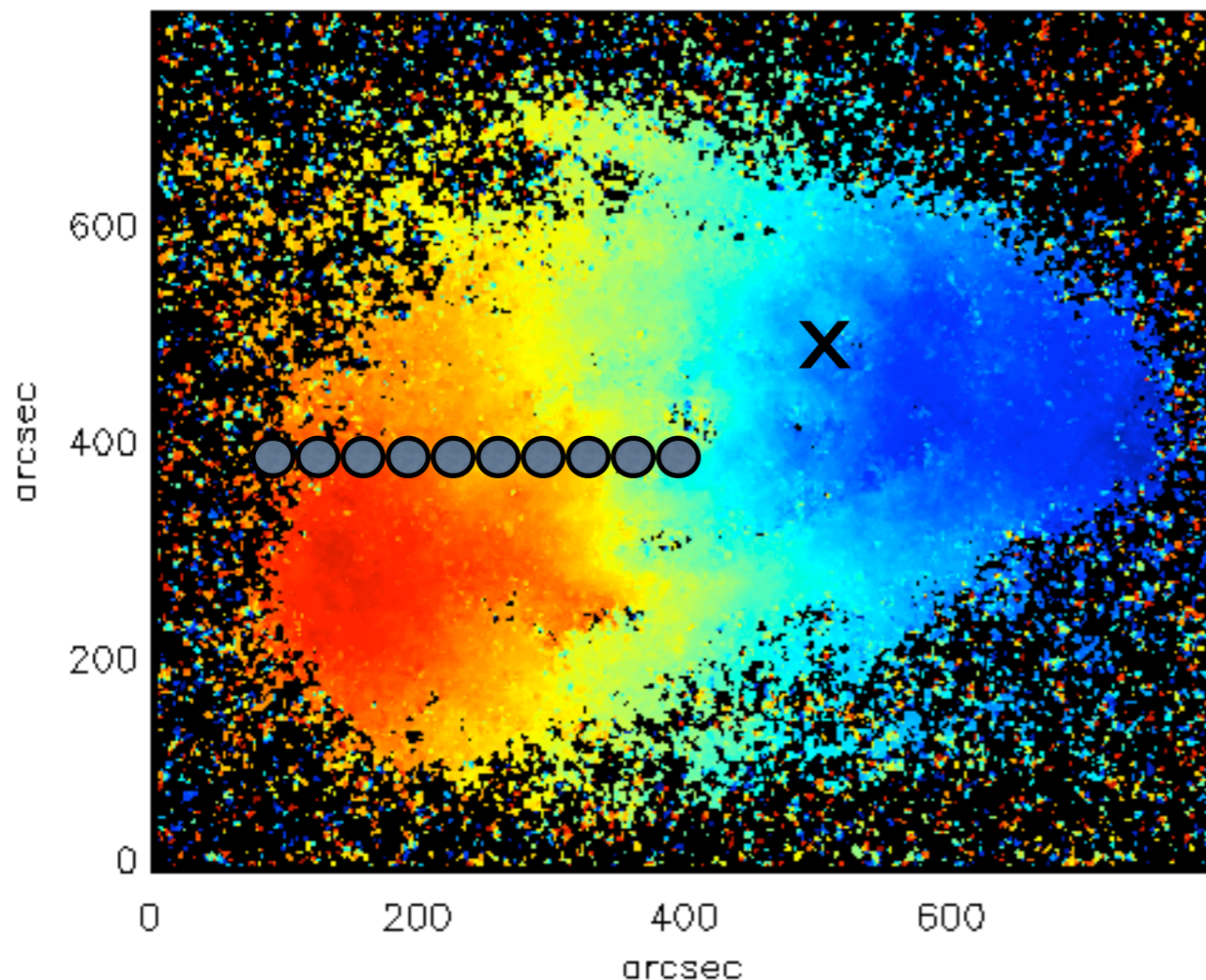
- Usual method: calculate 1st-order moment (IWM vel)
- Problem: Line profiles can be skewed $\rightarrow V_{\text{IWM}}$ does not accurately represent V_{los} at peak flux
- Line profiles might be skewed due to real dynamical processes within the galaxy
- or ...
- Line profiles can be **systematically skewed** towards systemic velocity \rightarrow beam smearing

Beam smearing

- A galaxy of small angular size sampled by a relatively large beam will suffer from beam smearing effects.
- Line profiles are systematically skewed towards V_{sys}

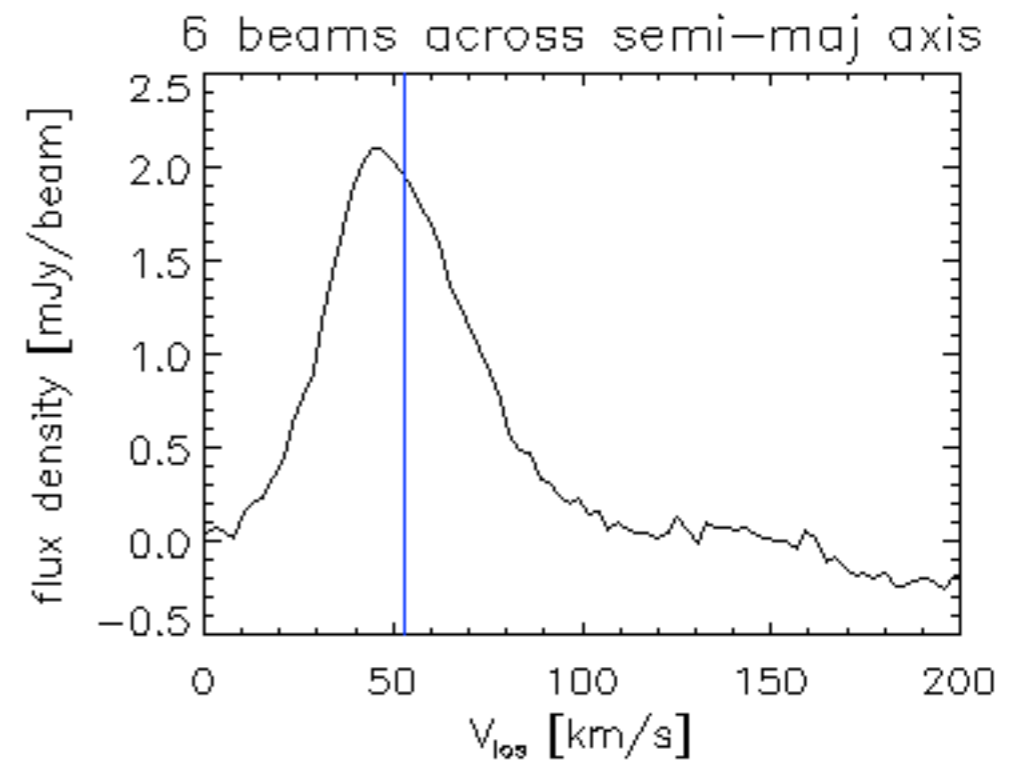
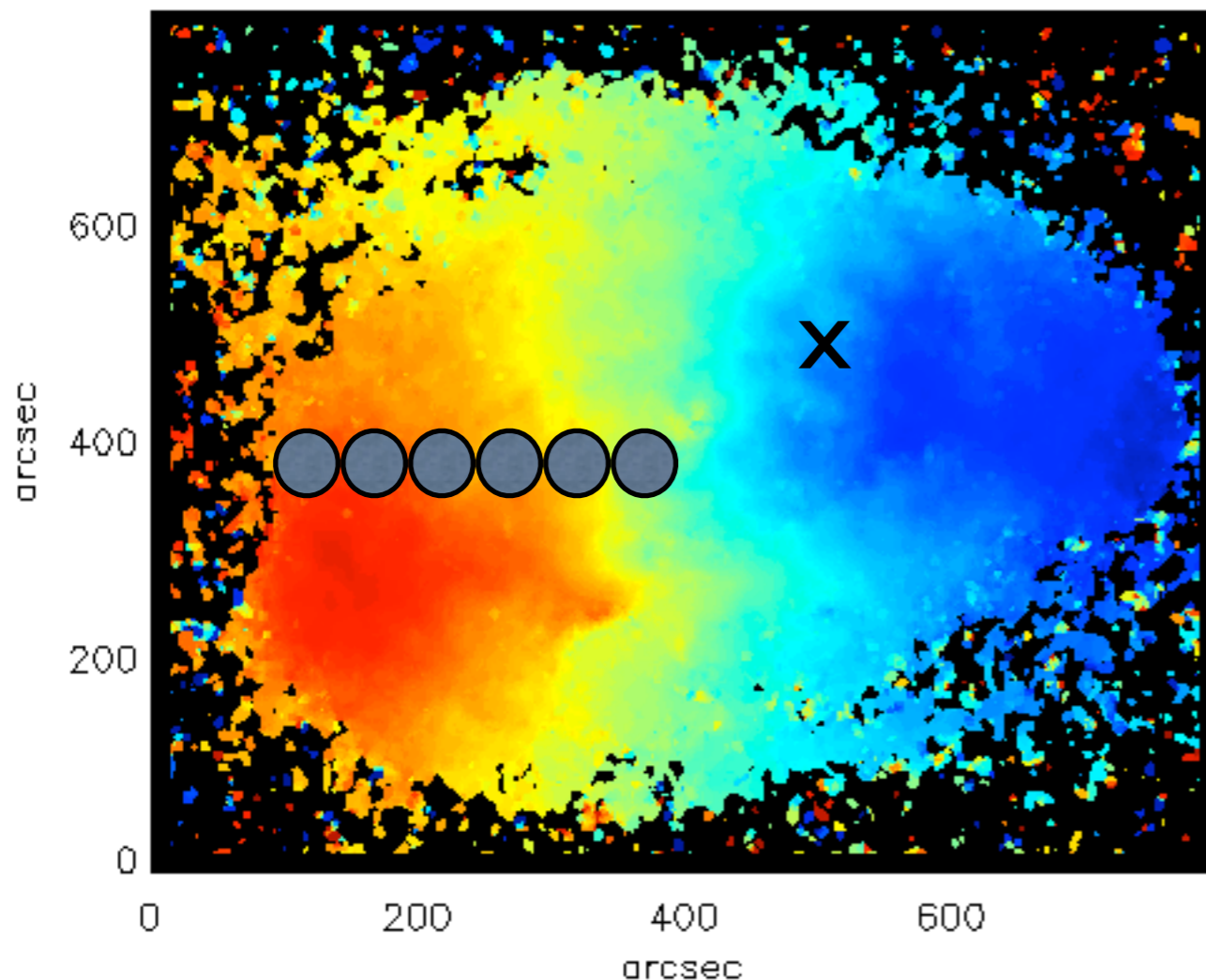
Beam smearing

- A galaxy of small angular size sampled by a relatively large beam will suffer from beam smearing effects.
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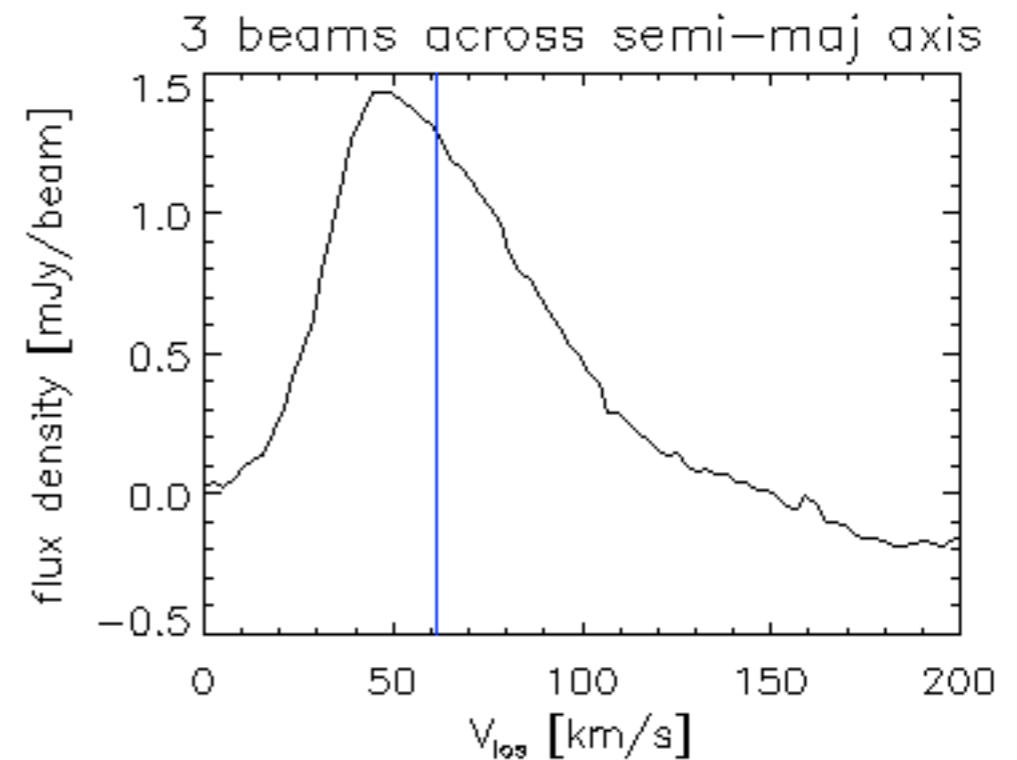
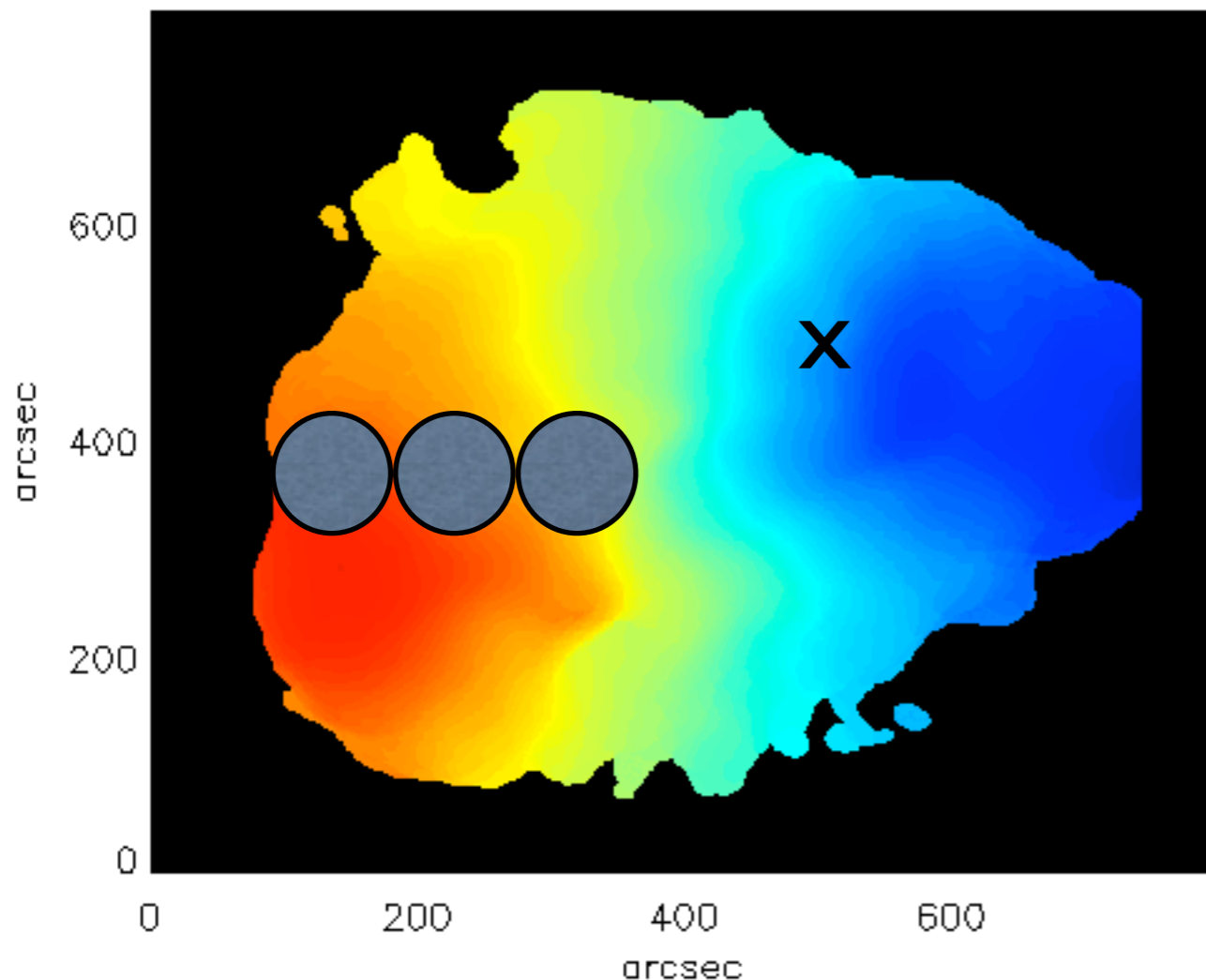
Beam smearing

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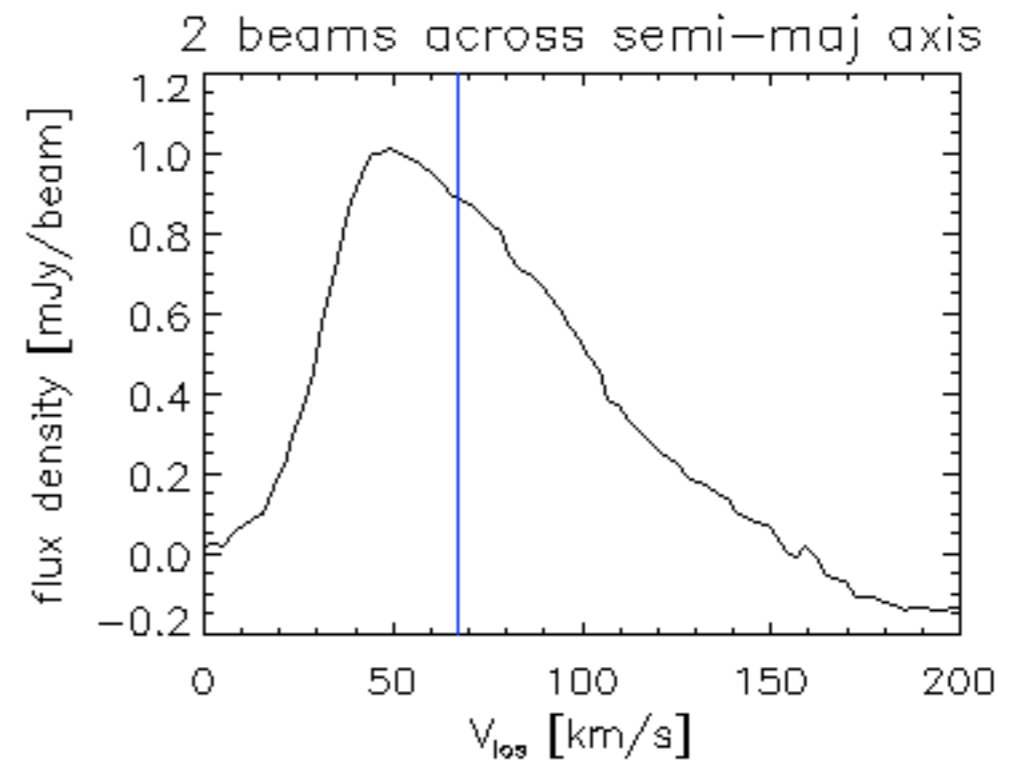
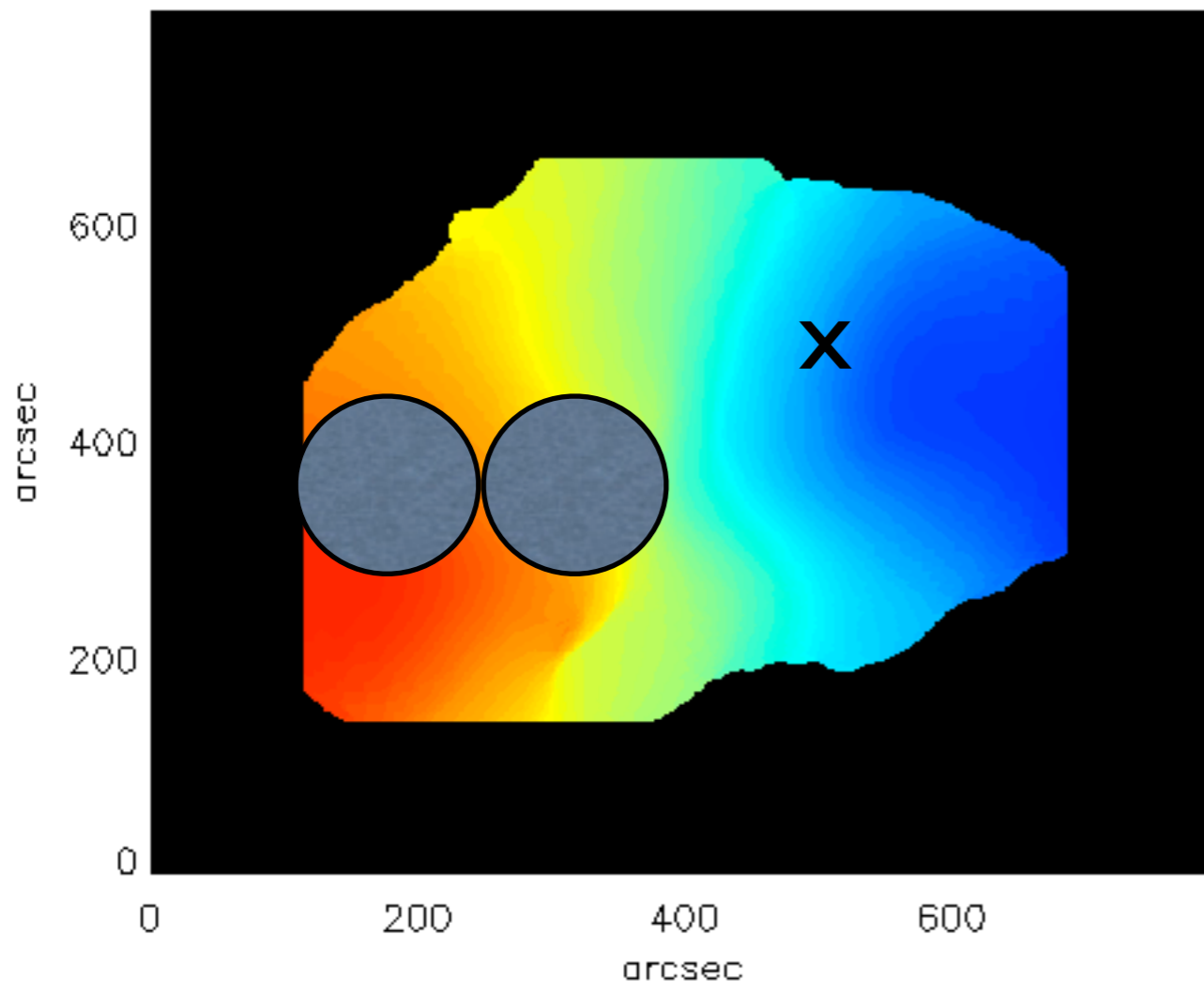
Beam smearing

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Beam smearing

- A galaxy of small angular size sampled by a relatively large beam will suffer from beam smearing effects.
- Line profiles are systematically skewed towards V_{sys}



Beam smearing

- **Net result:** (traditional) intensity-weighted-mean velocity fields can poorly represent the kinematics of moderately resolved galaxies.
- **Solution:** Parameterise the line profile by fitting an appropriate function to it. This will provide a robust estimate of the peak velocity.

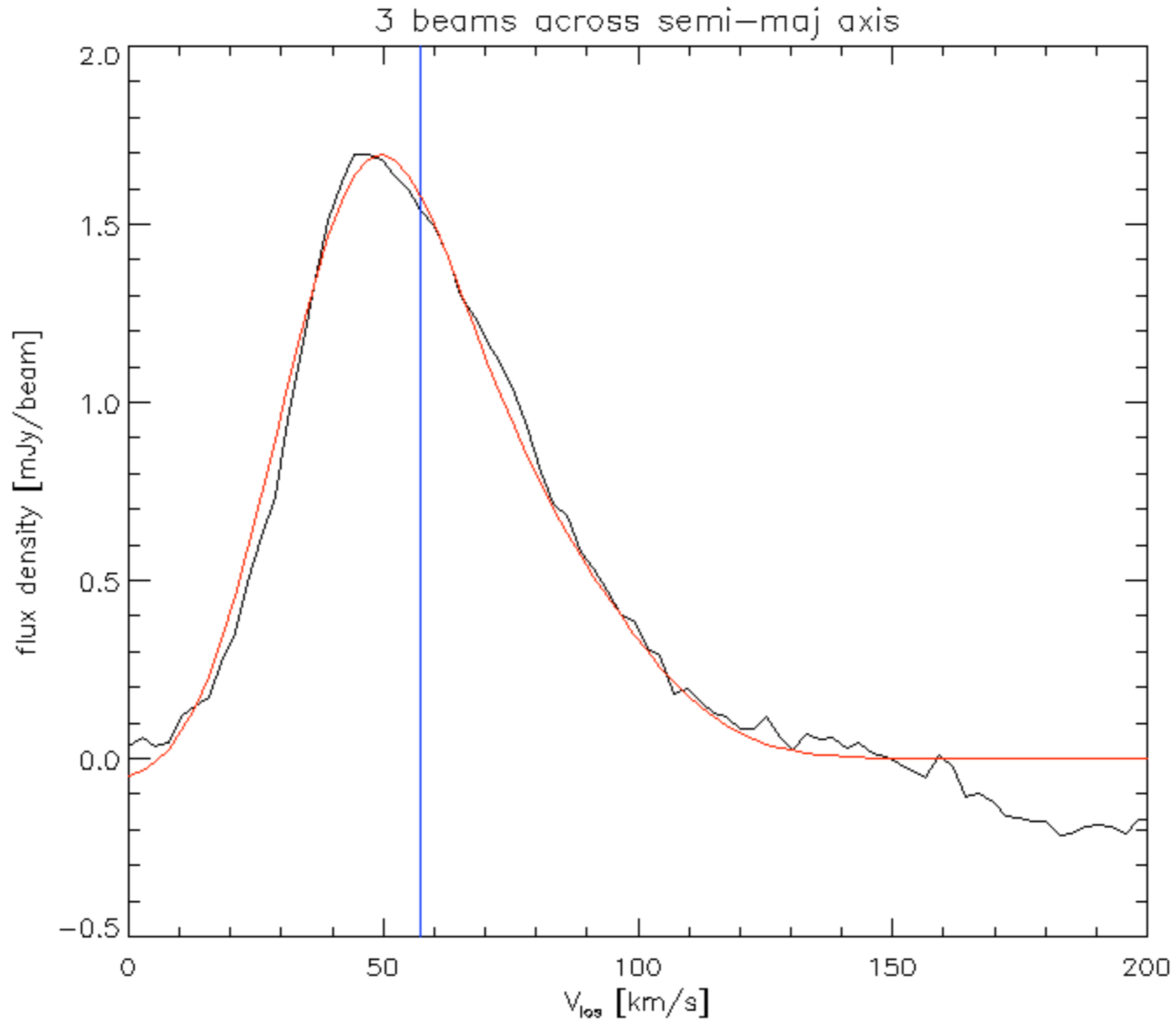
Profile parameterisation

- Fit a function that can accommodate skewed (asymmetric) profiles
- 3rd order Gauss-Hermite polynomial (van der Marel & Franx 1993)

$$\phi(y) = ae^{y^2/2} \left[1 + \frac{h_3}{\sqrt{6}} (2\sqrt{2}y^3 - 3\sqrt{2}y) \right]$$

- $y = (x-b)/c$
- $h_3 = 0 \rightarrow$ Gaussian profile
- $h_3 \neq 0 \rightarrow$ profile is asymmetric

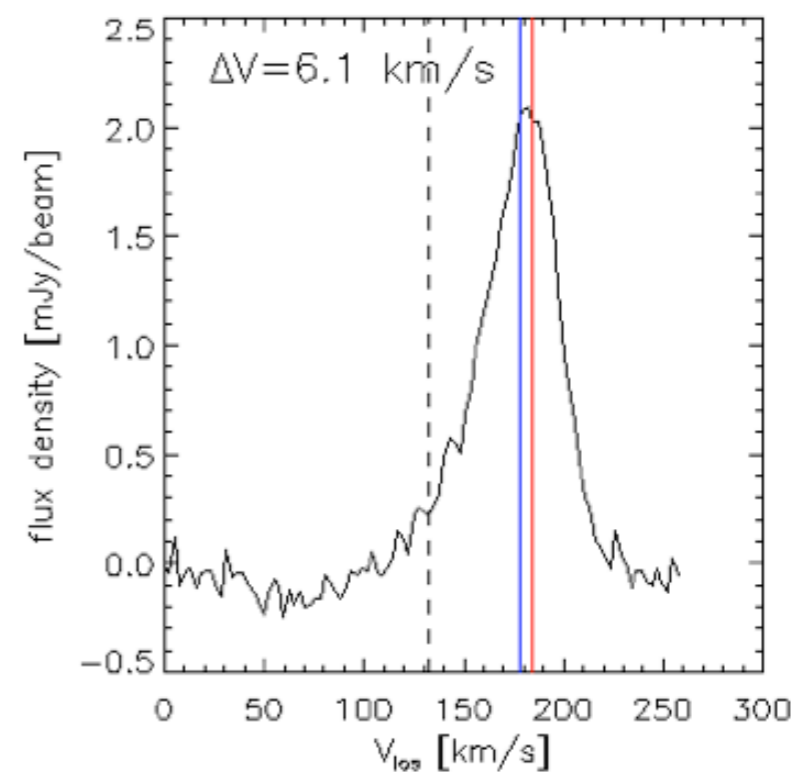
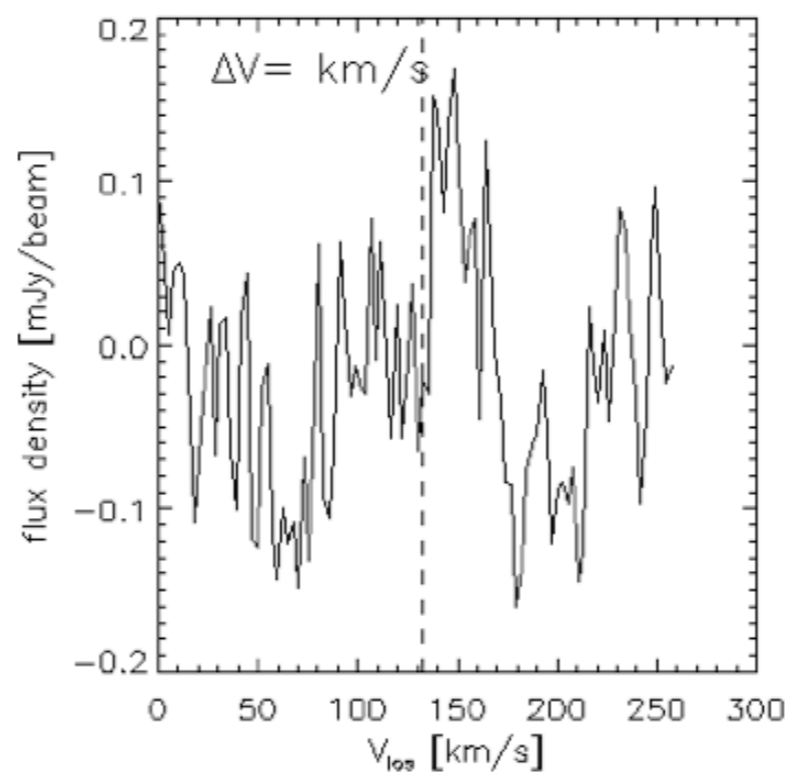
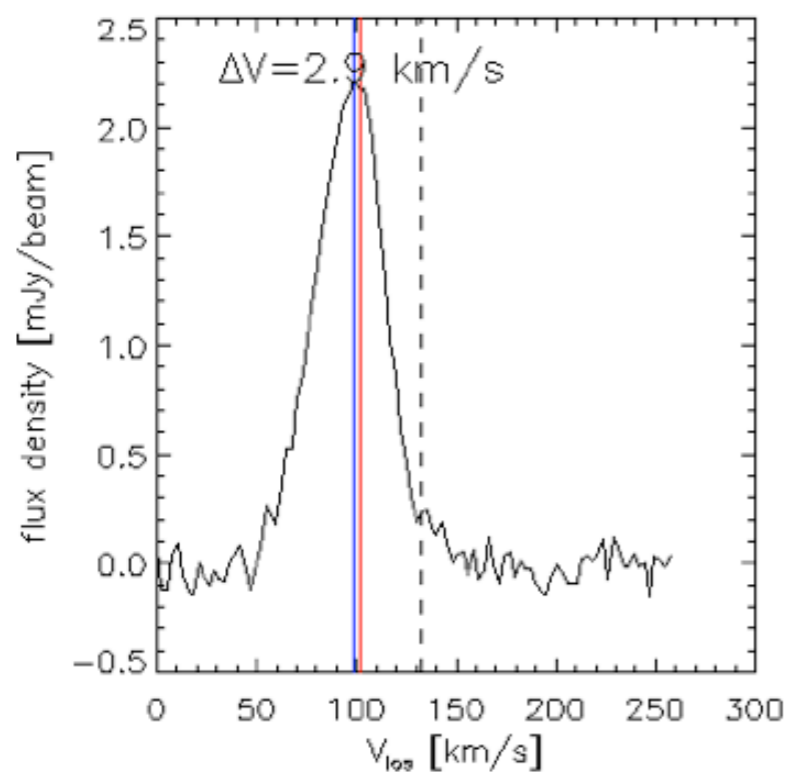
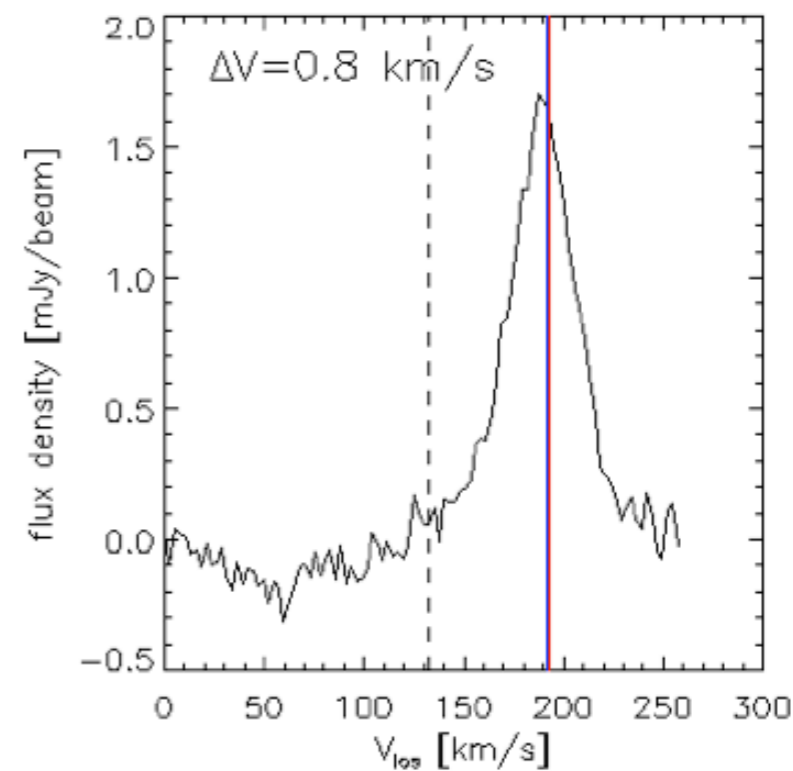
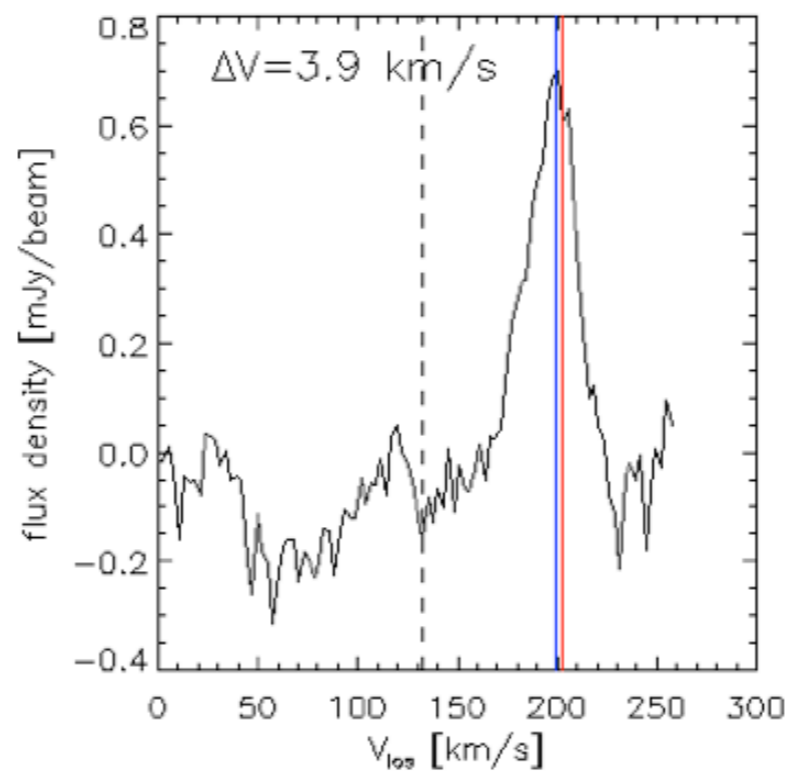
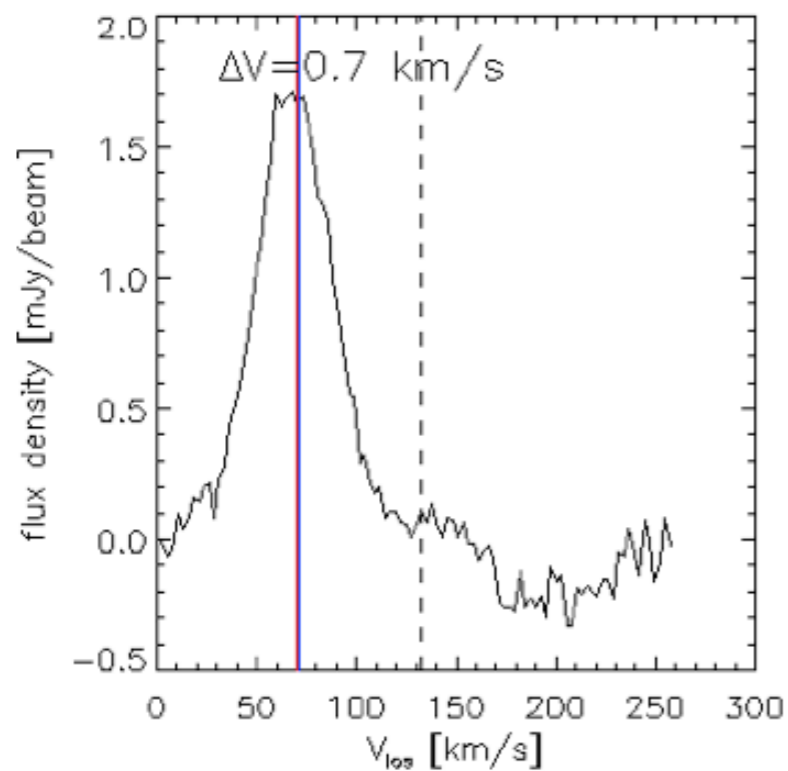
Profile parameterisation



Parameterisation demonstration

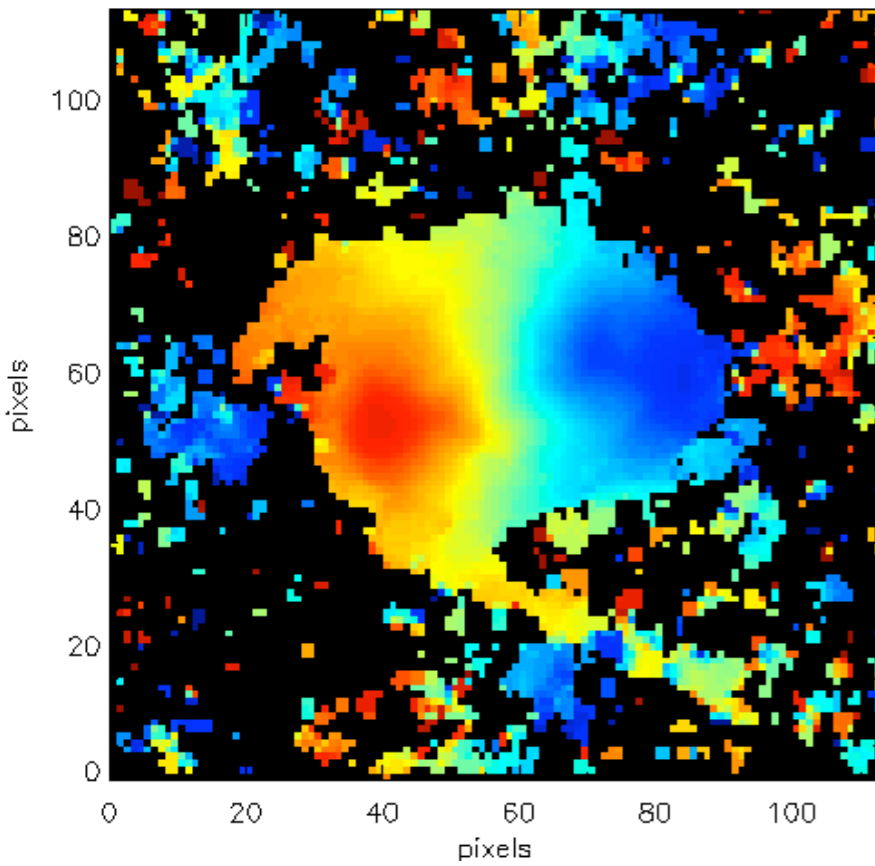
- Degrade the spatial resolution of a real (THINGS) galaxy so that it has 10, 5, 3, 2, 1 synthesized beam across its semi-maj axis.
- For each version of cube, calculate the IWM velocity and fit a GH3 polynomial to each line profile.
- Compare the V_{\max} estimates of individual profiles
- Compare the velocity fields

10 beams

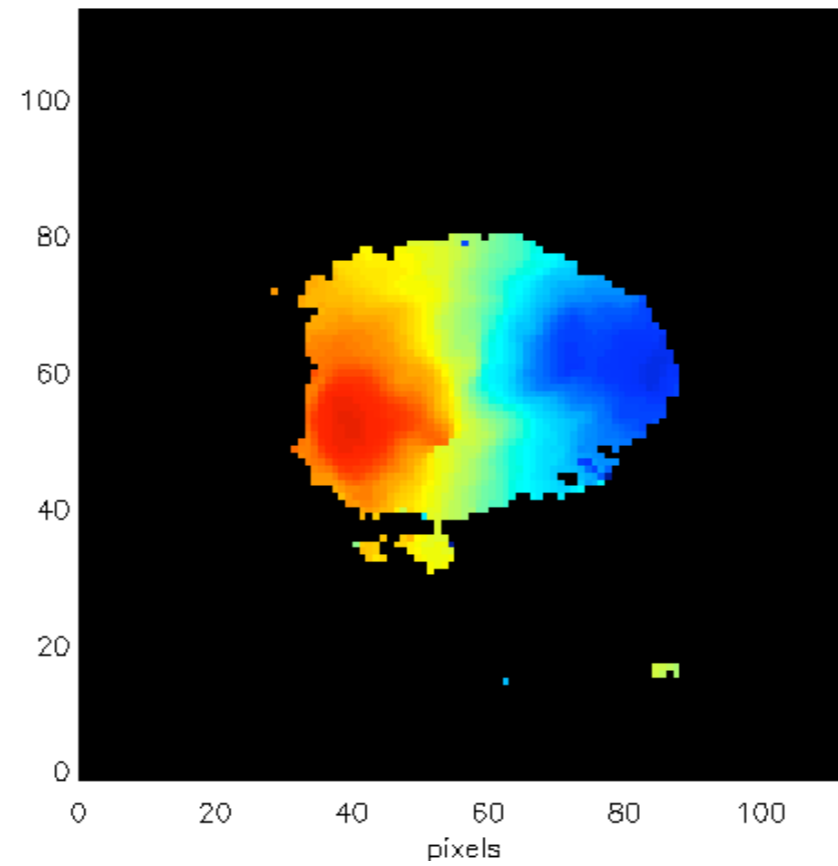


10 beams

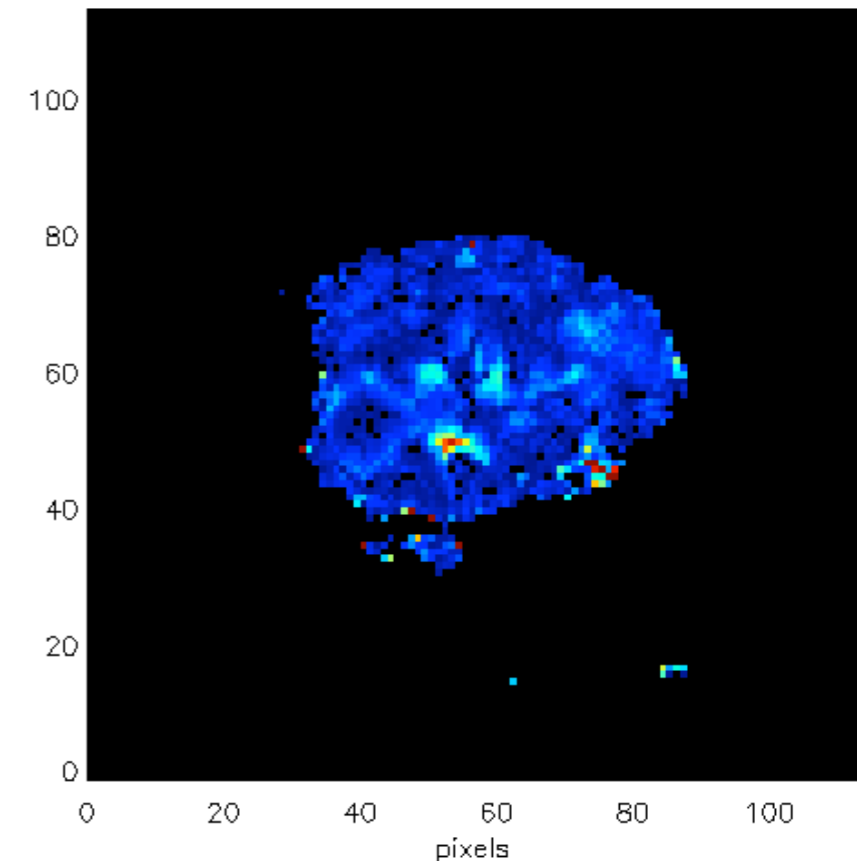
IWM vel field



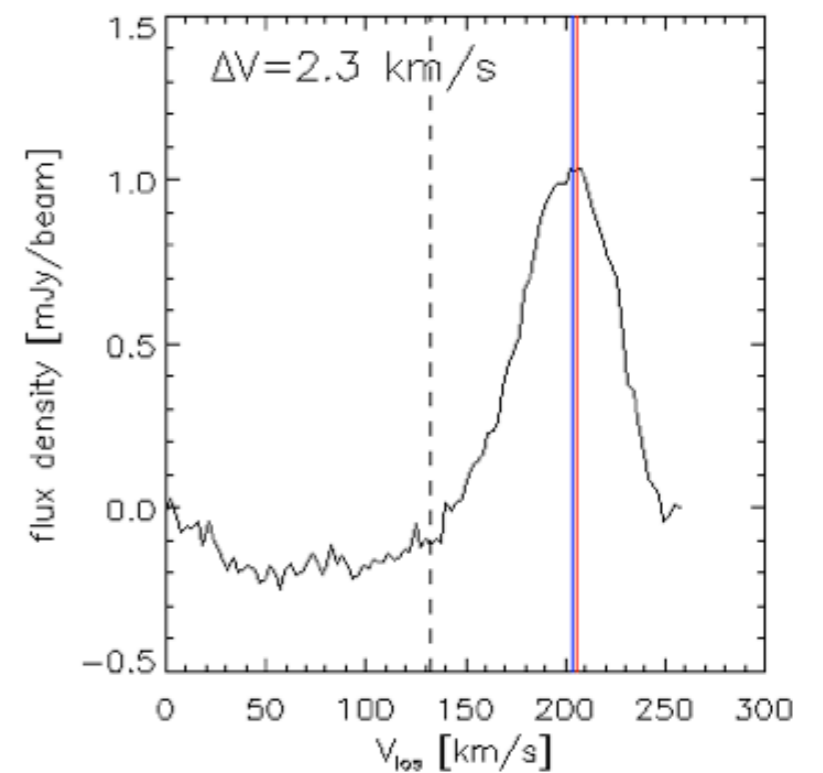
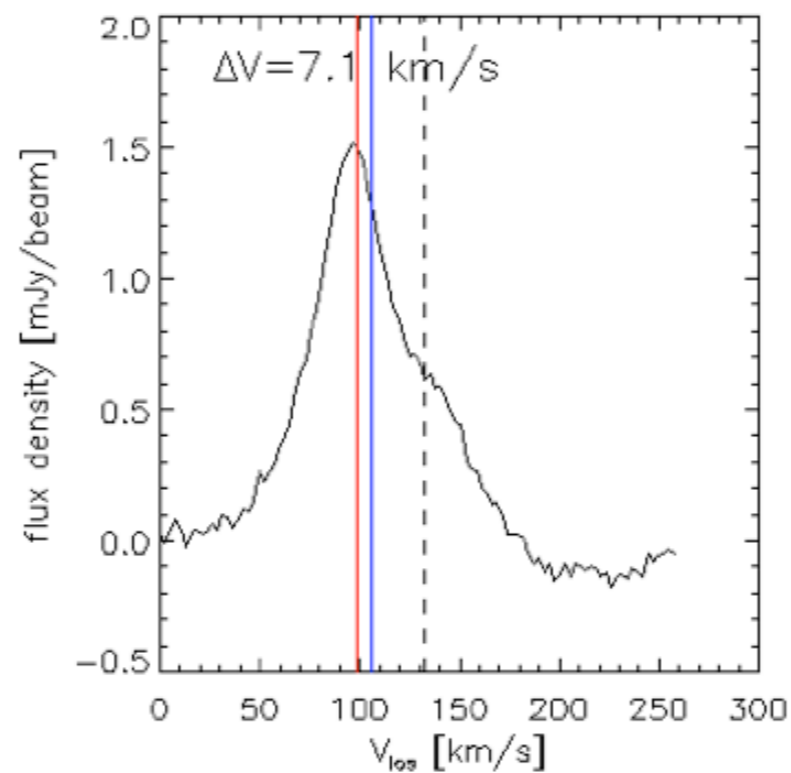
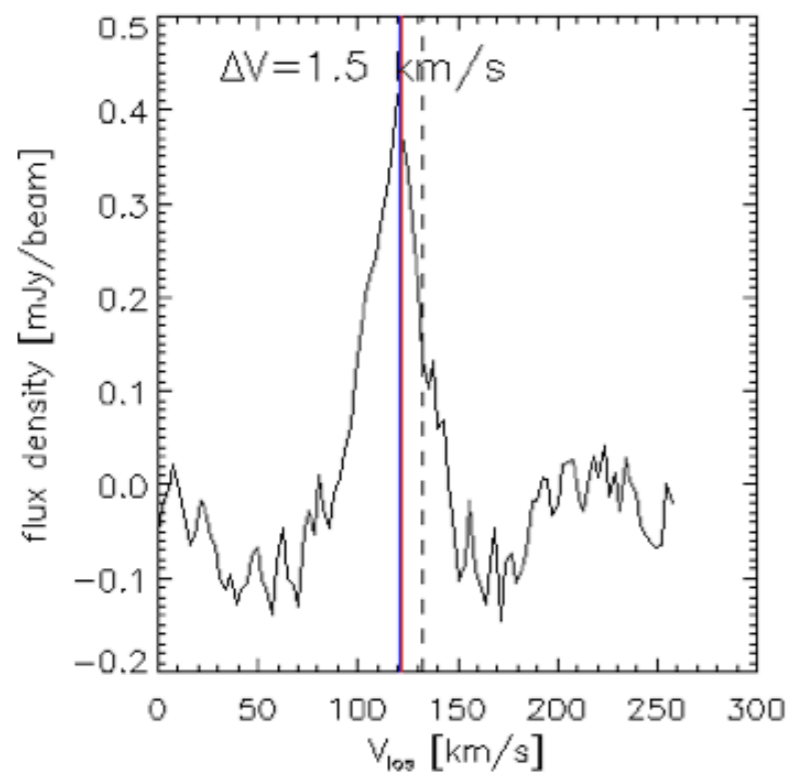
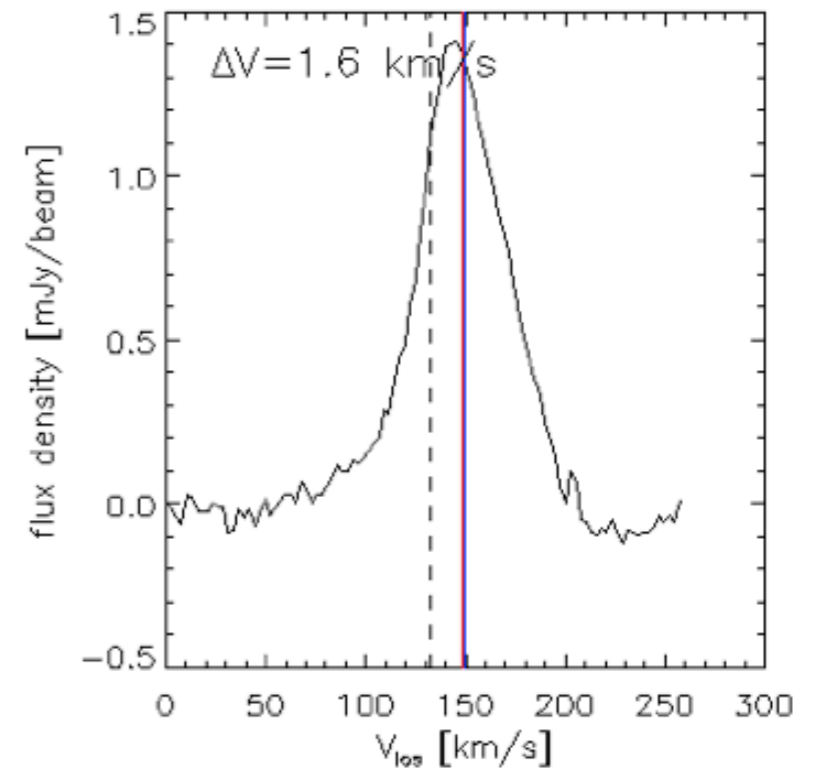
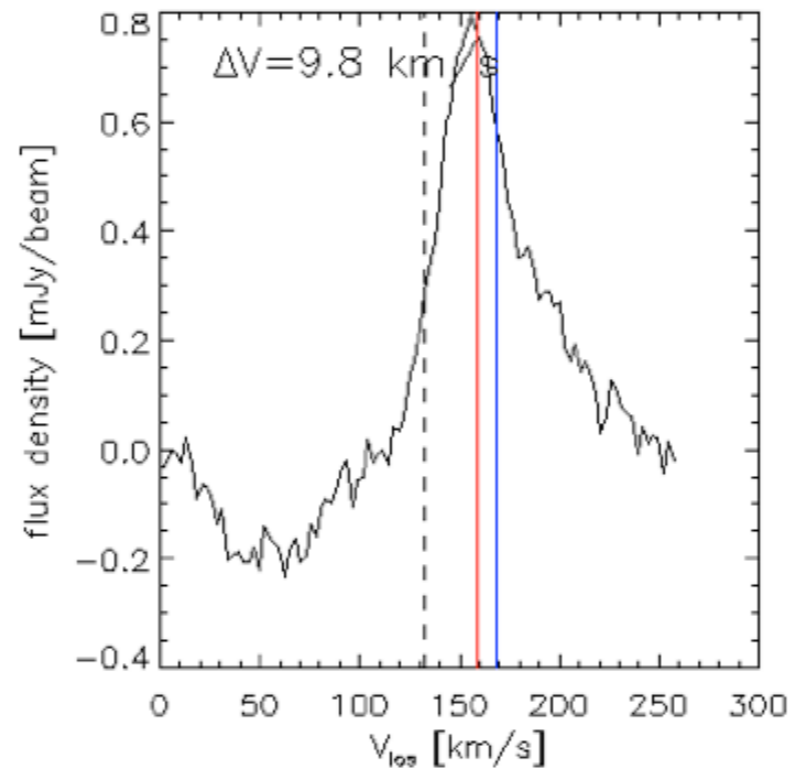
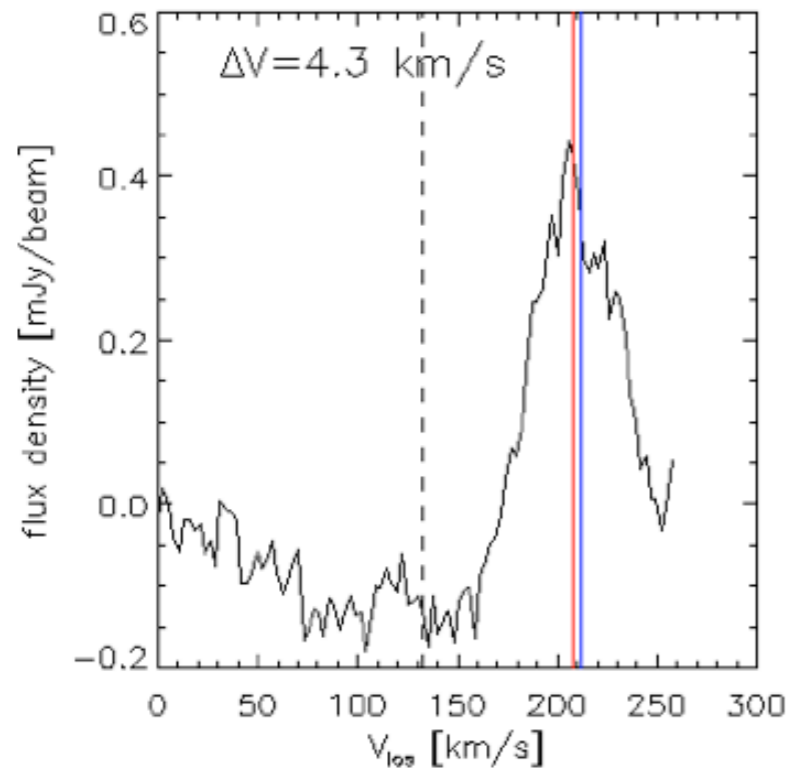
GH3 vel field



Residual

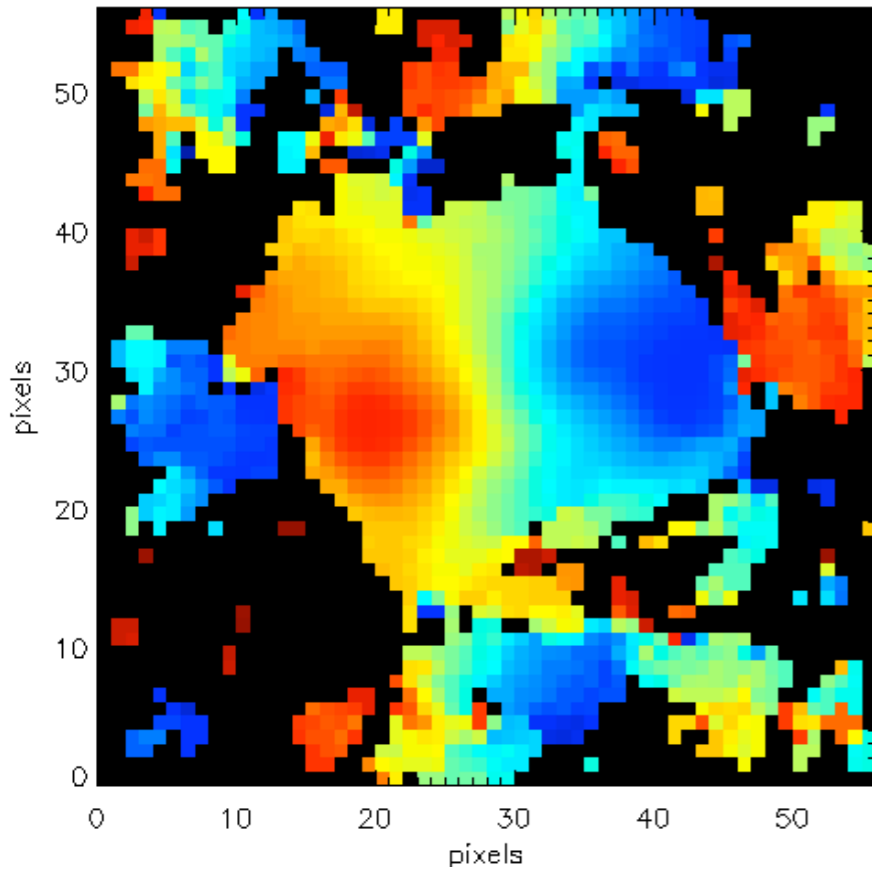


5 beams

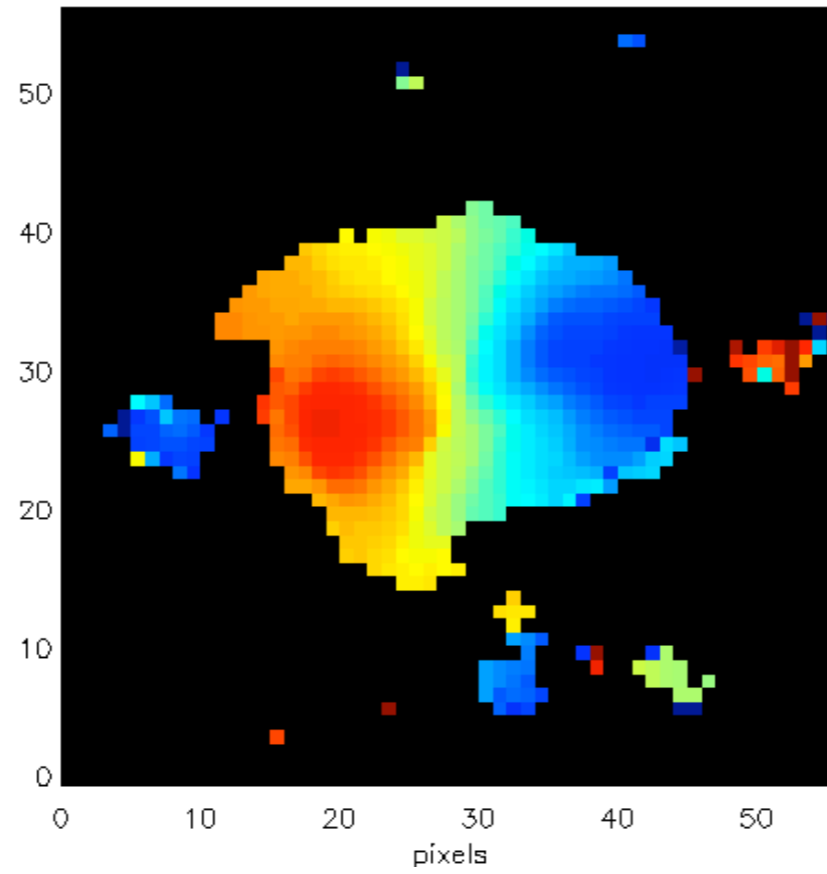


5 beams

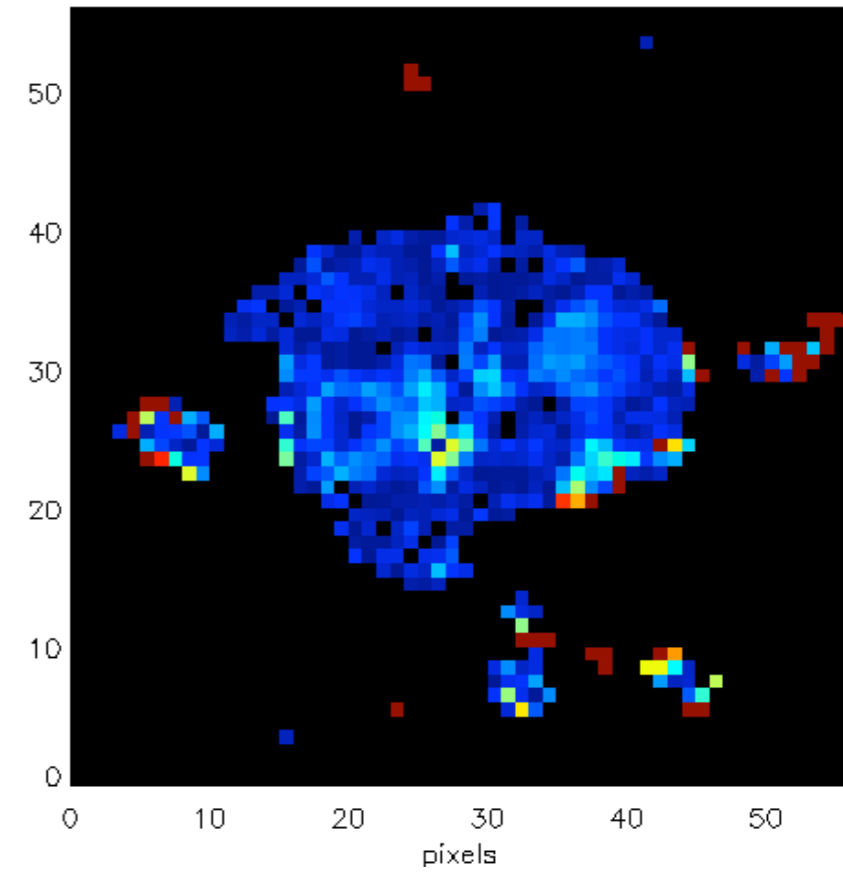
IWM vel field



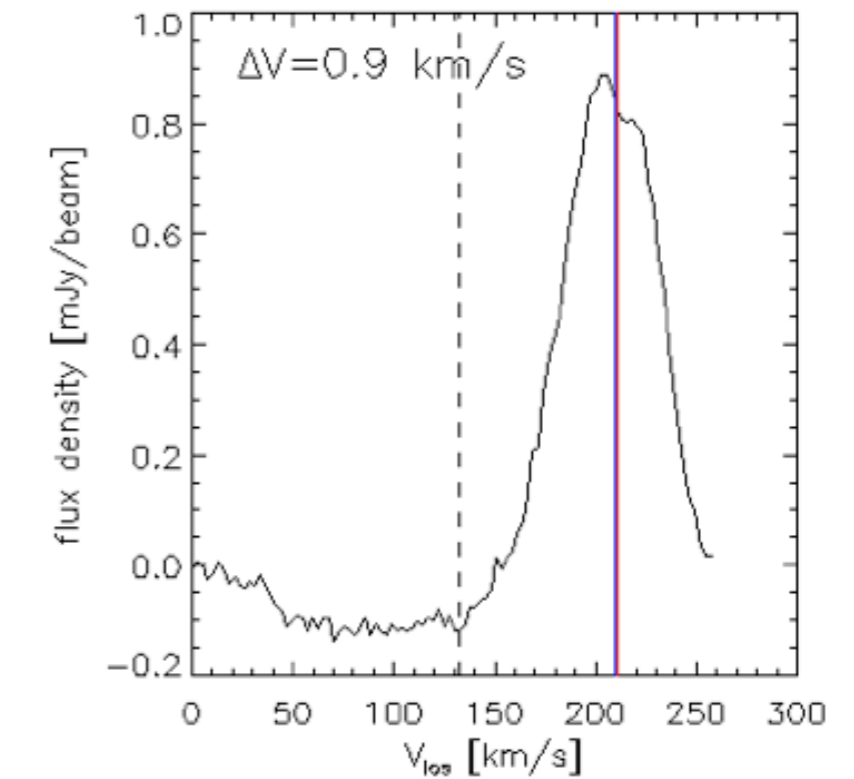
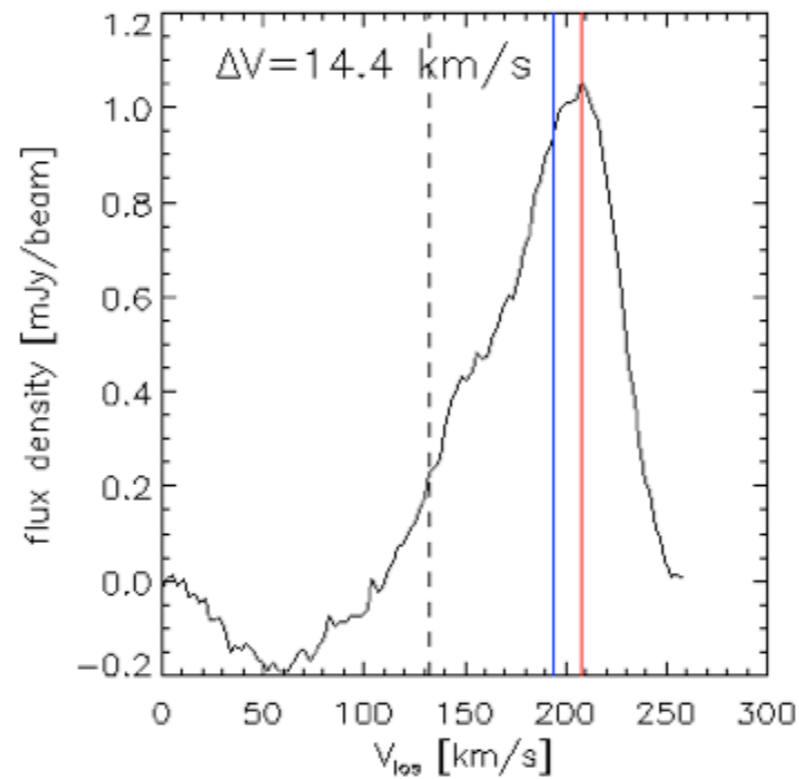
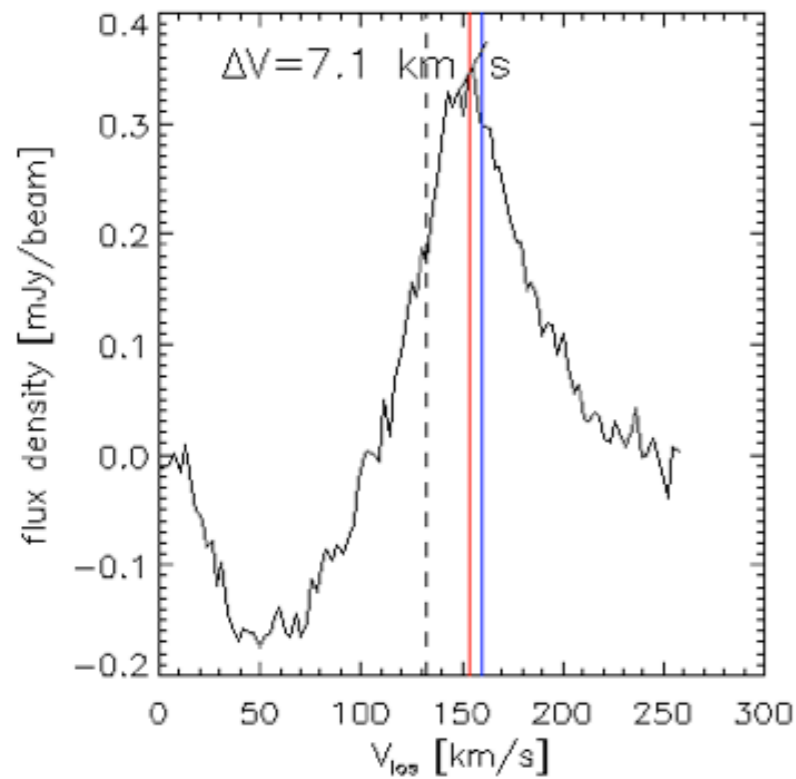
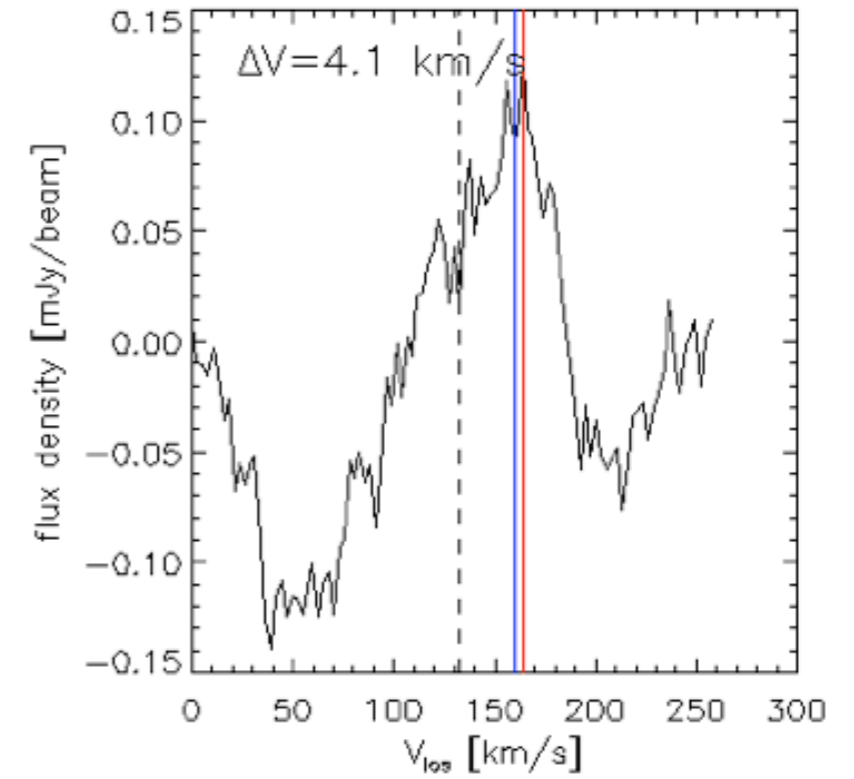
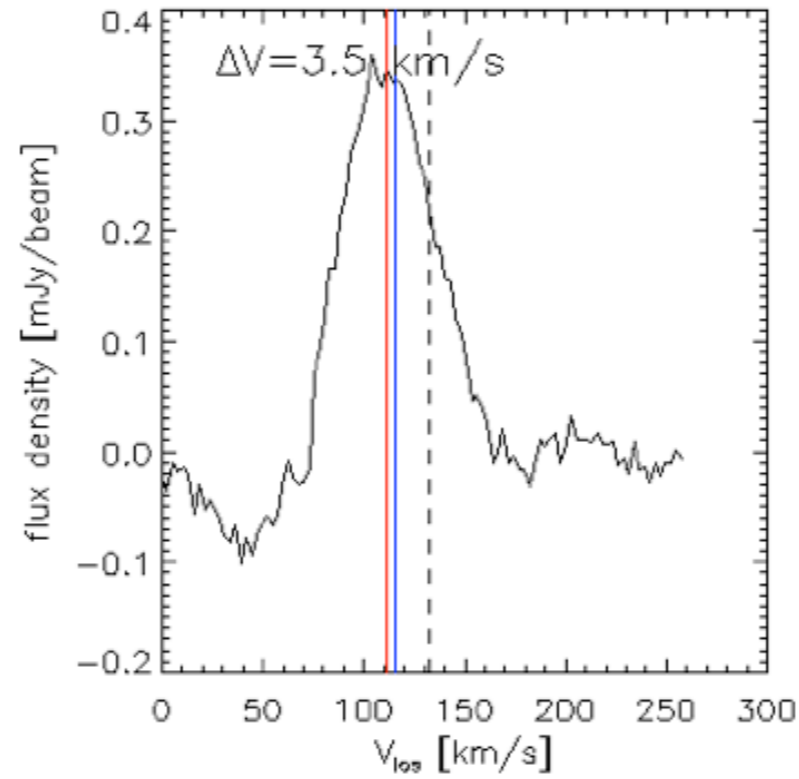
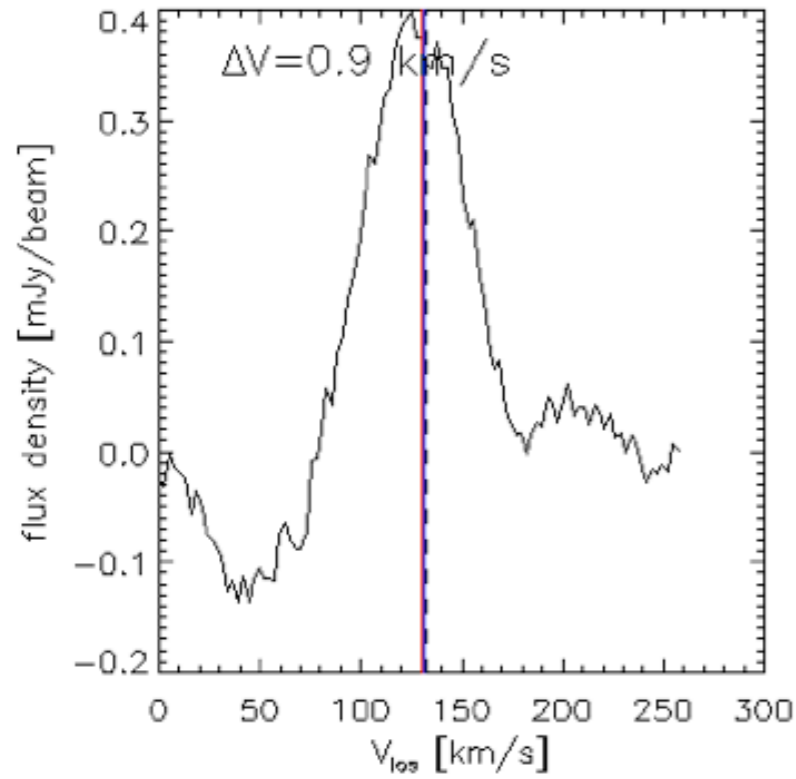
GH3 vel field



Residual

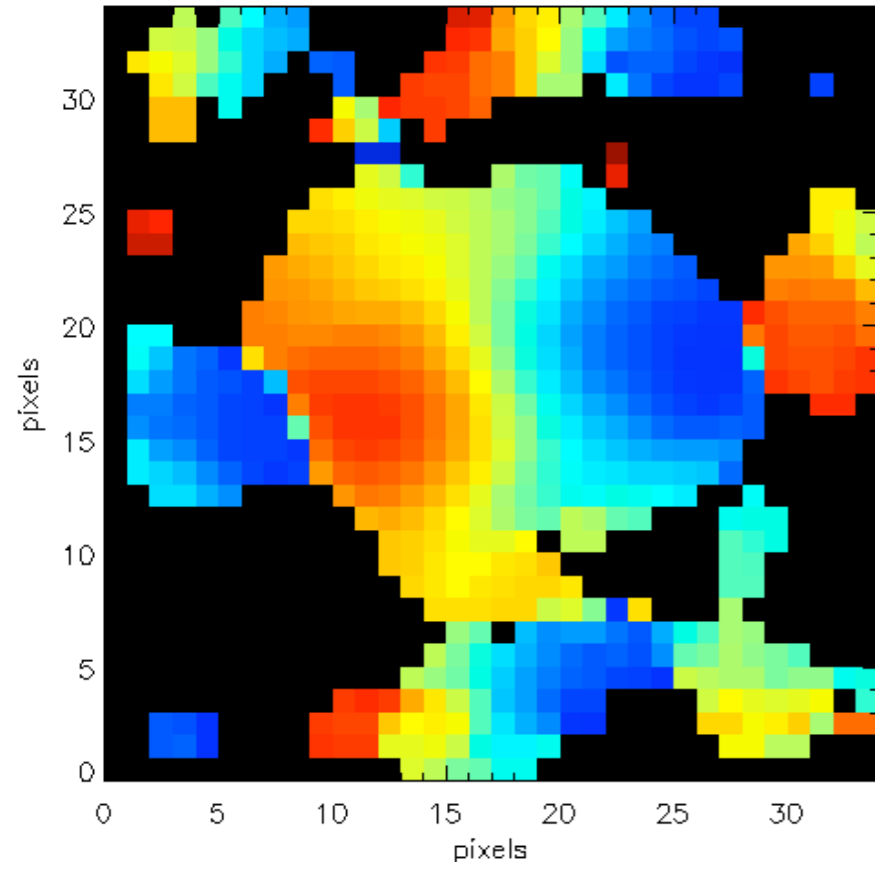


3 beams

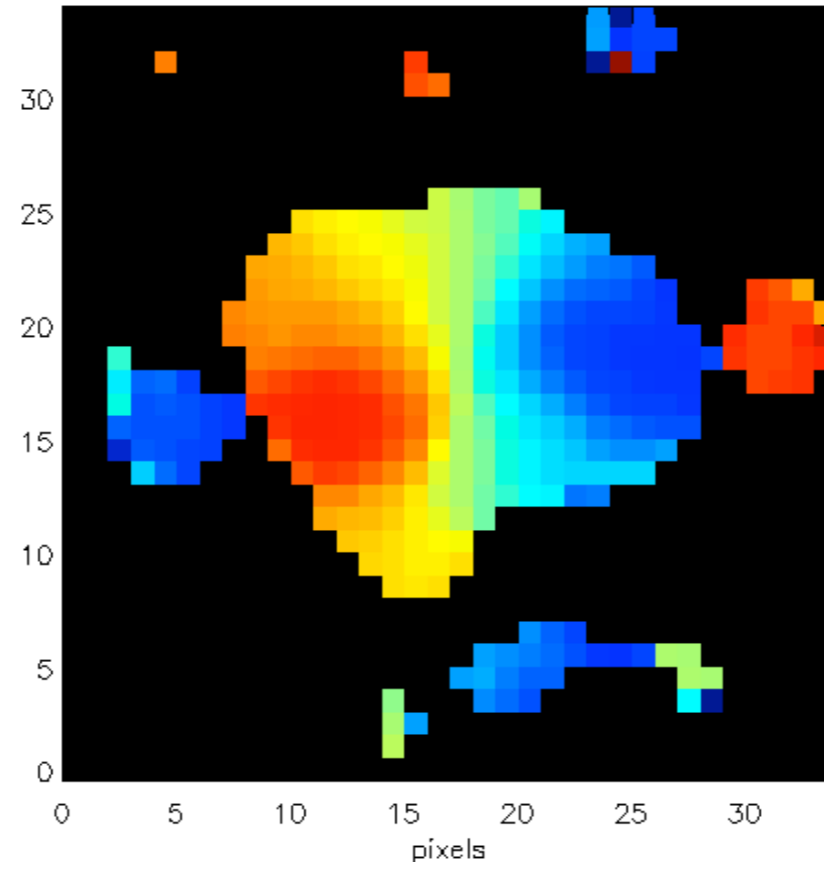


3 beams

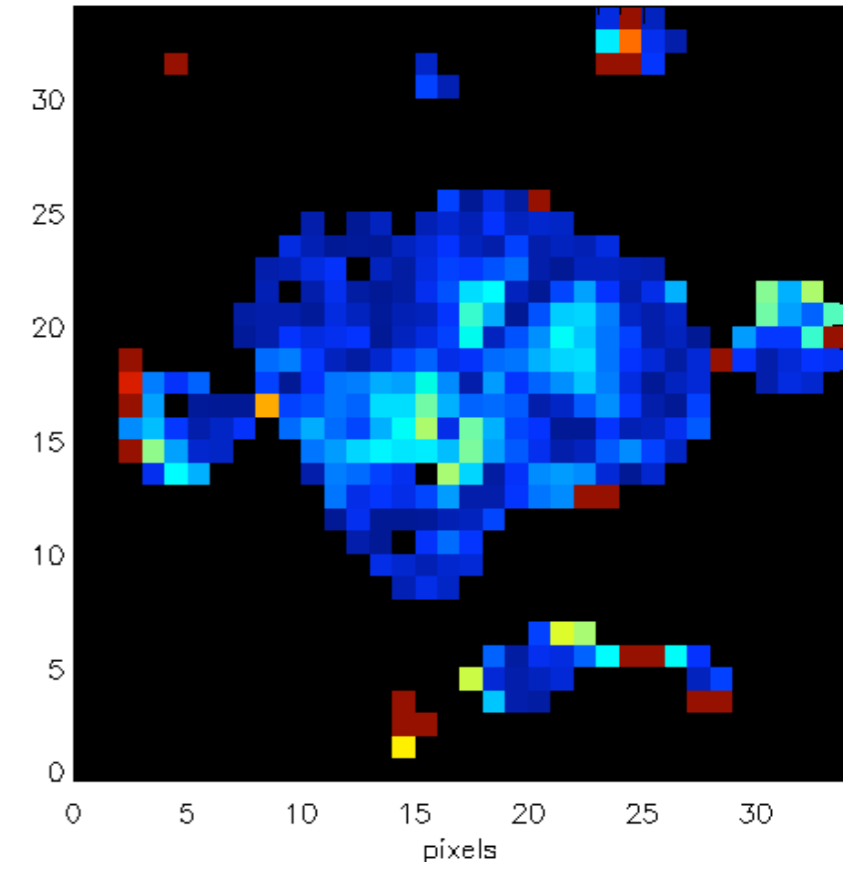
IWM vel field



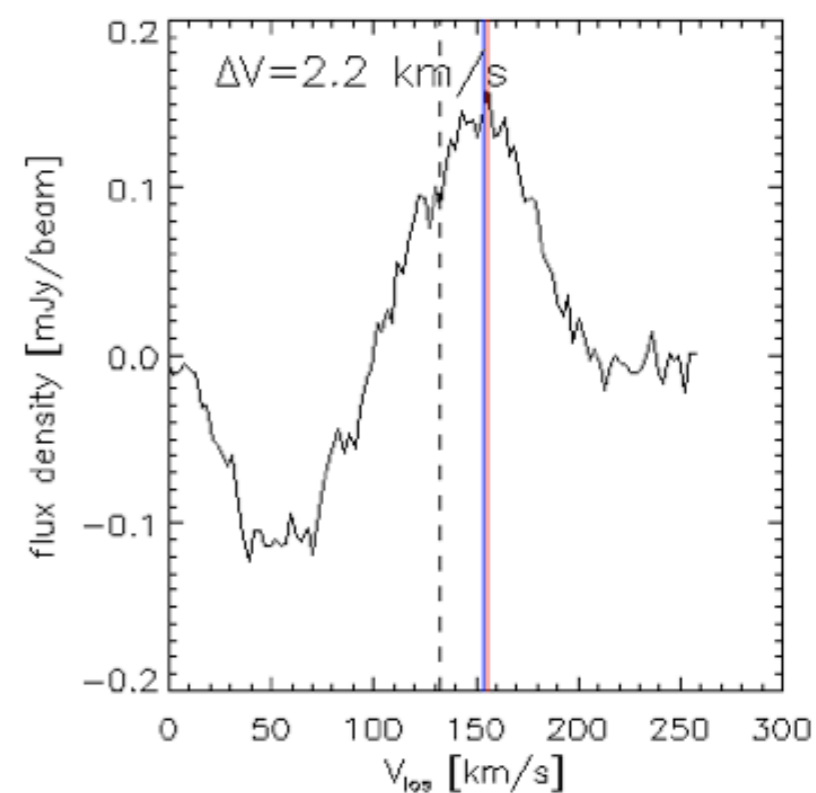
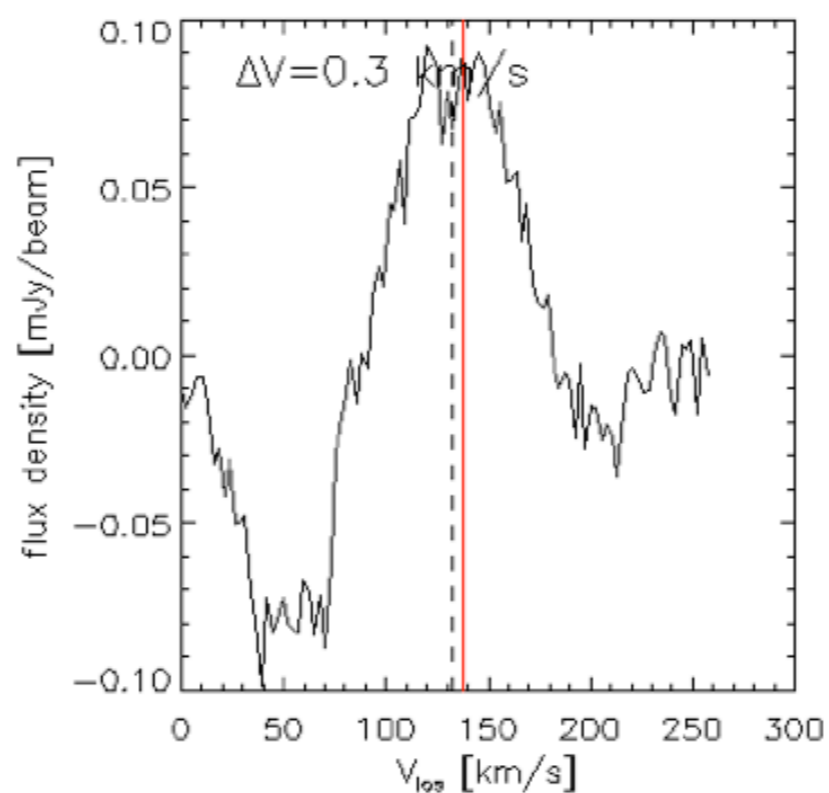
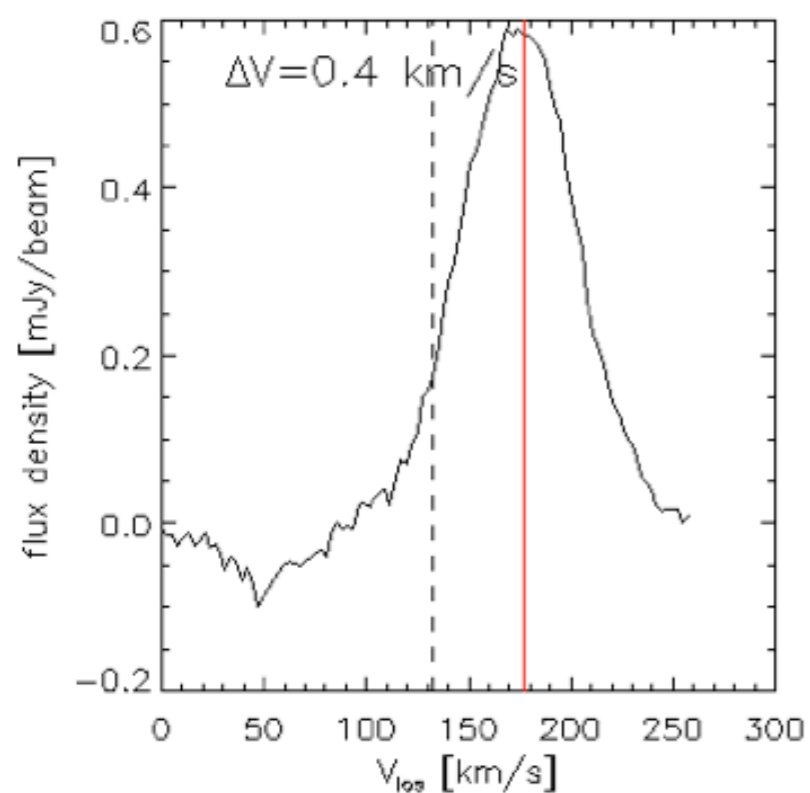
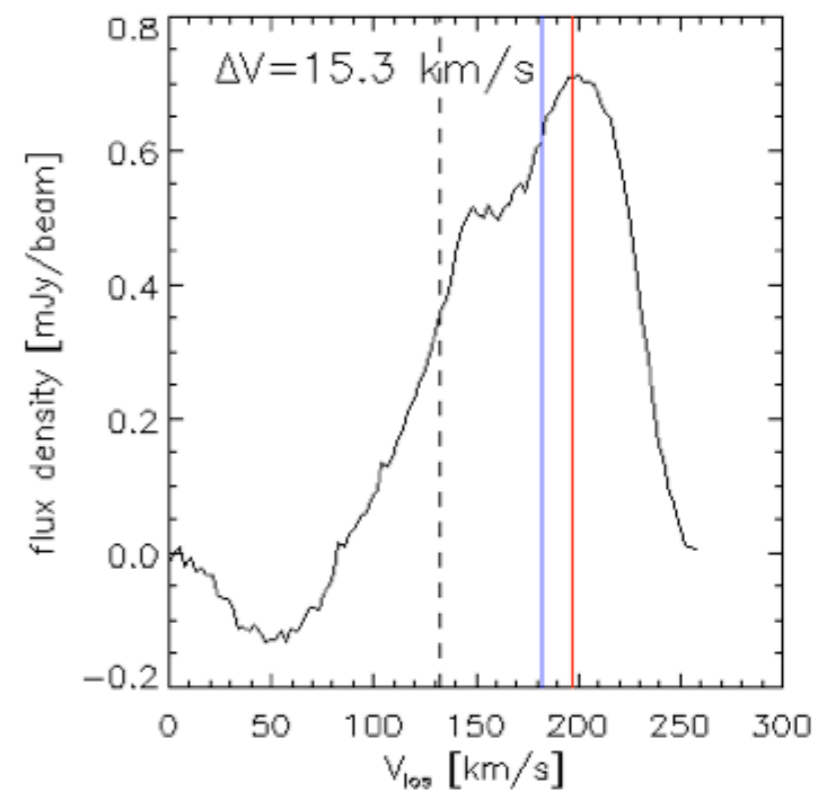
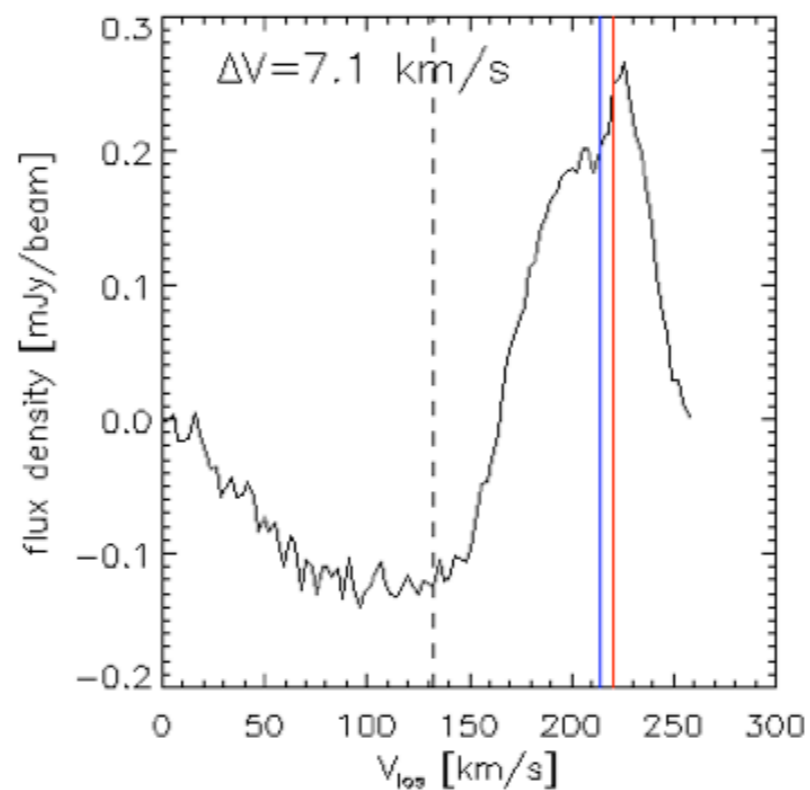
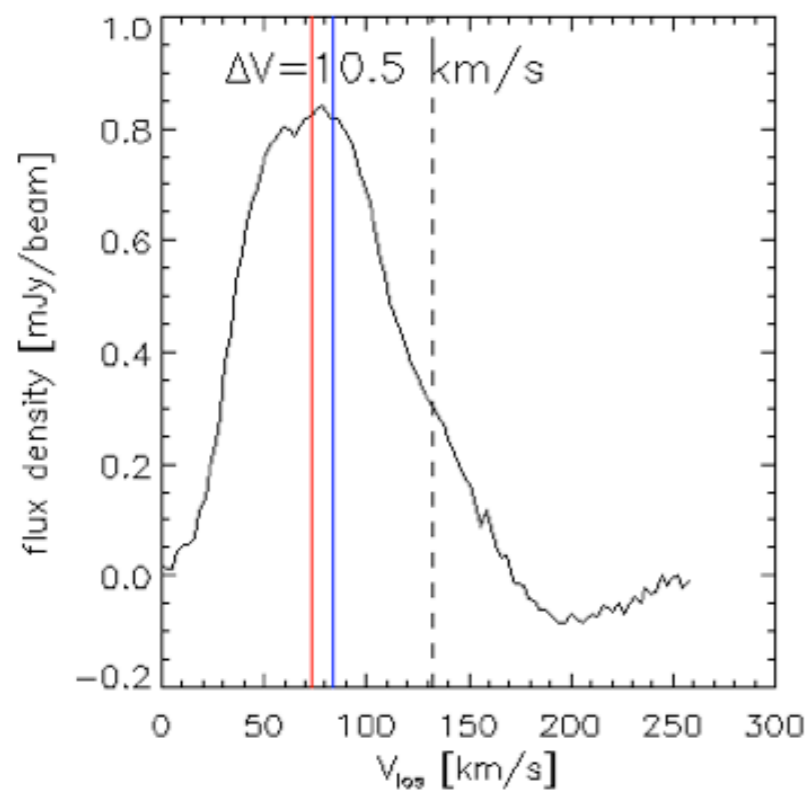
GH3 vel field



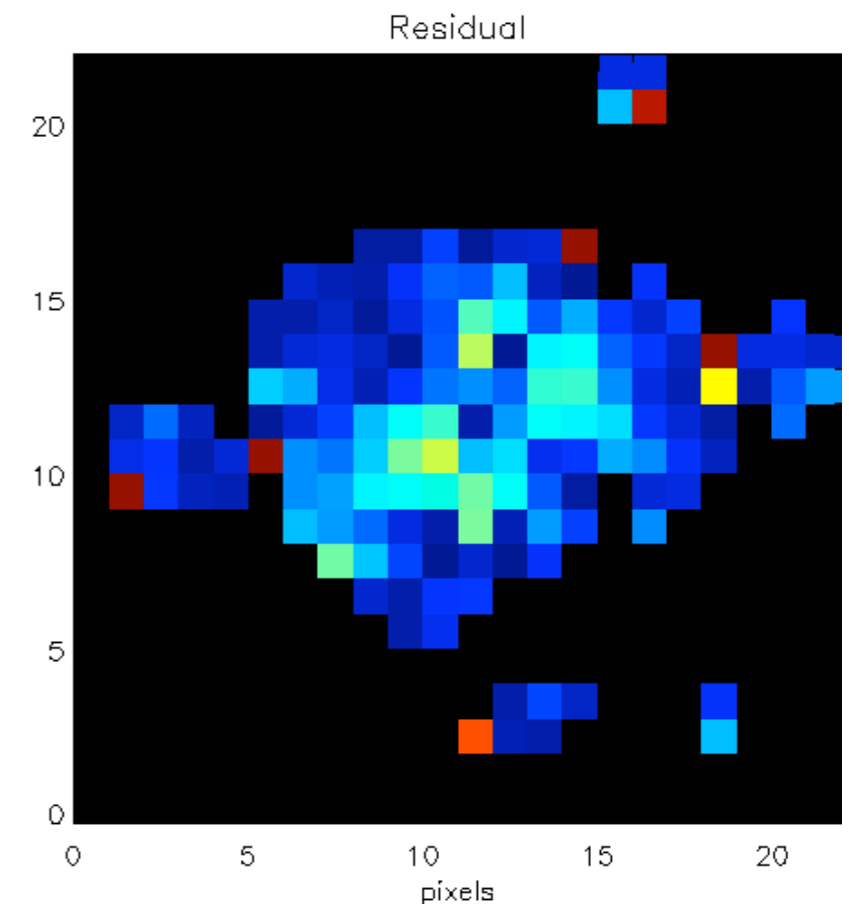
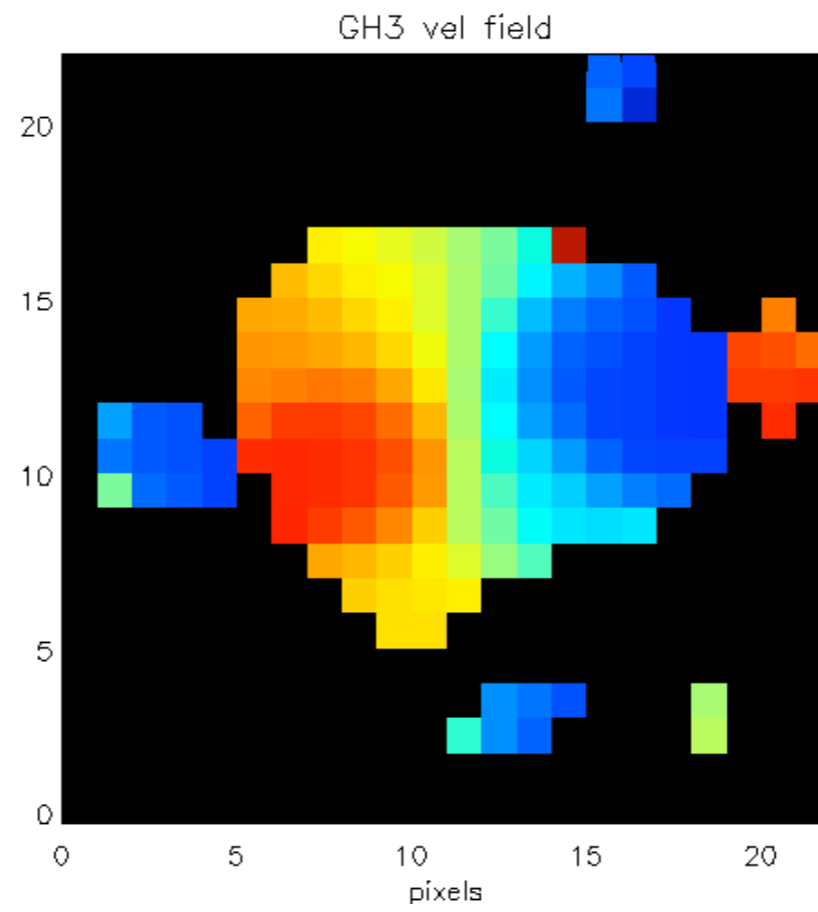
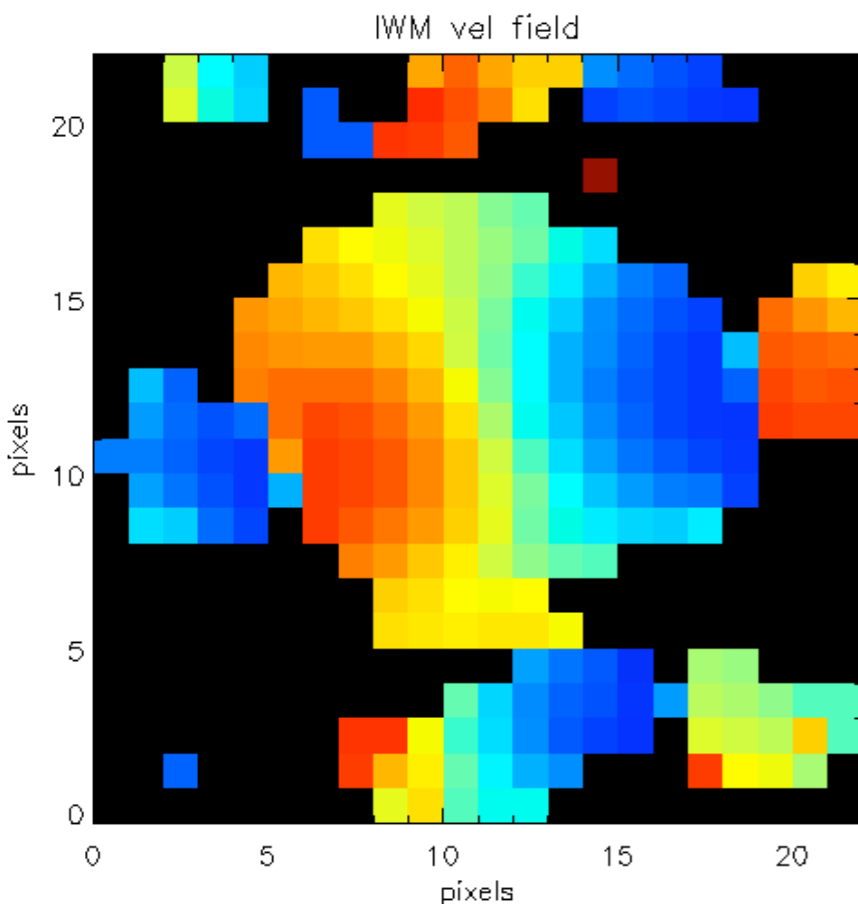
Residual



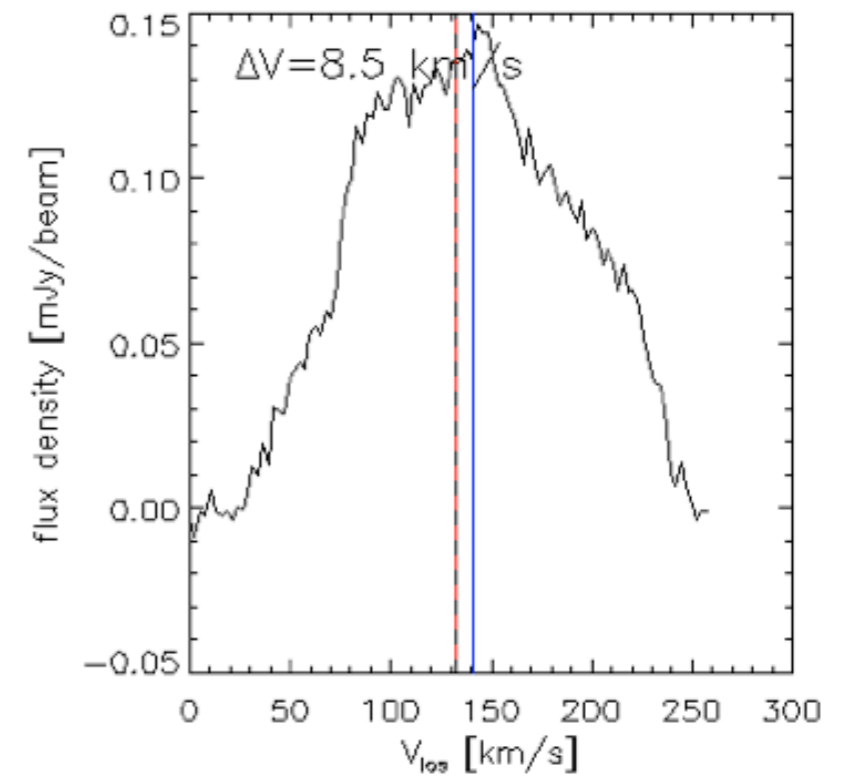
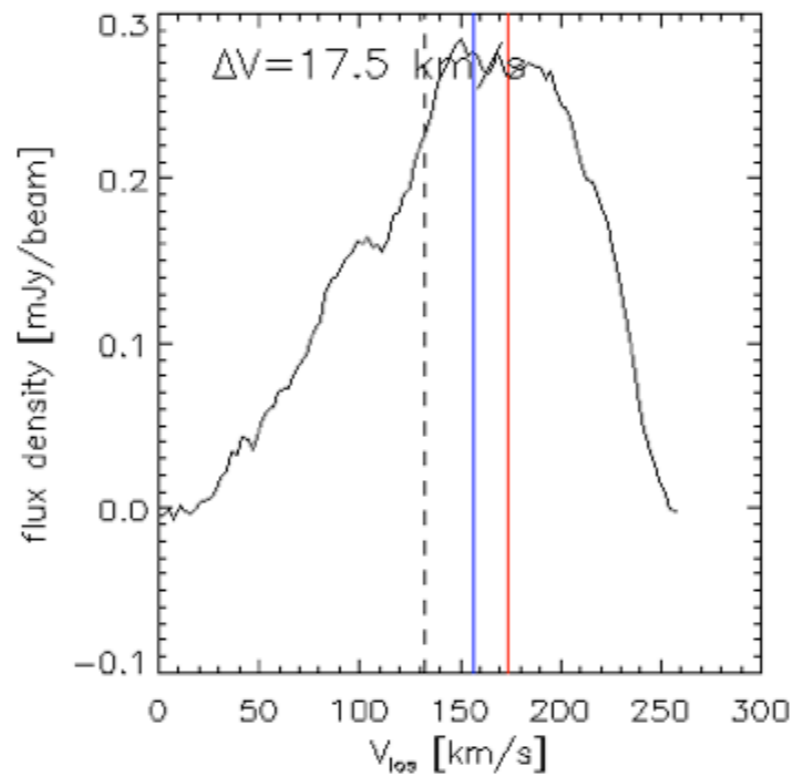
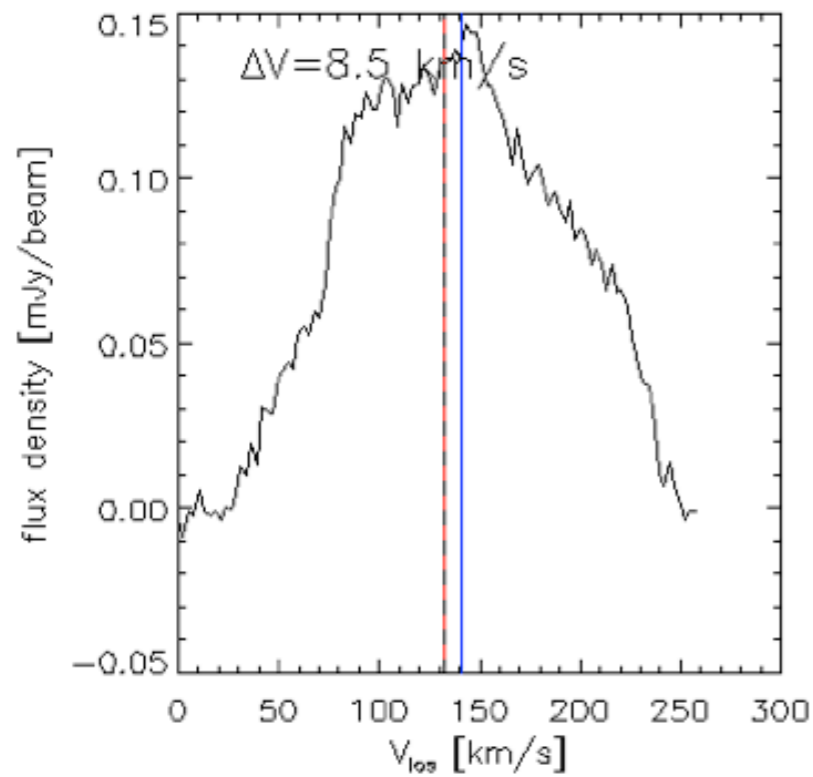
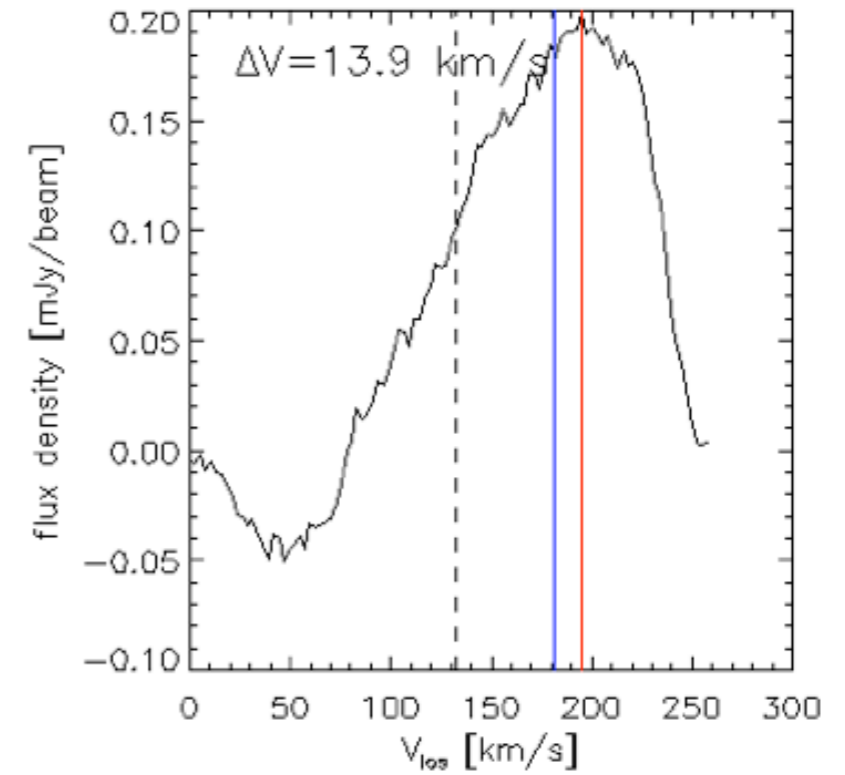
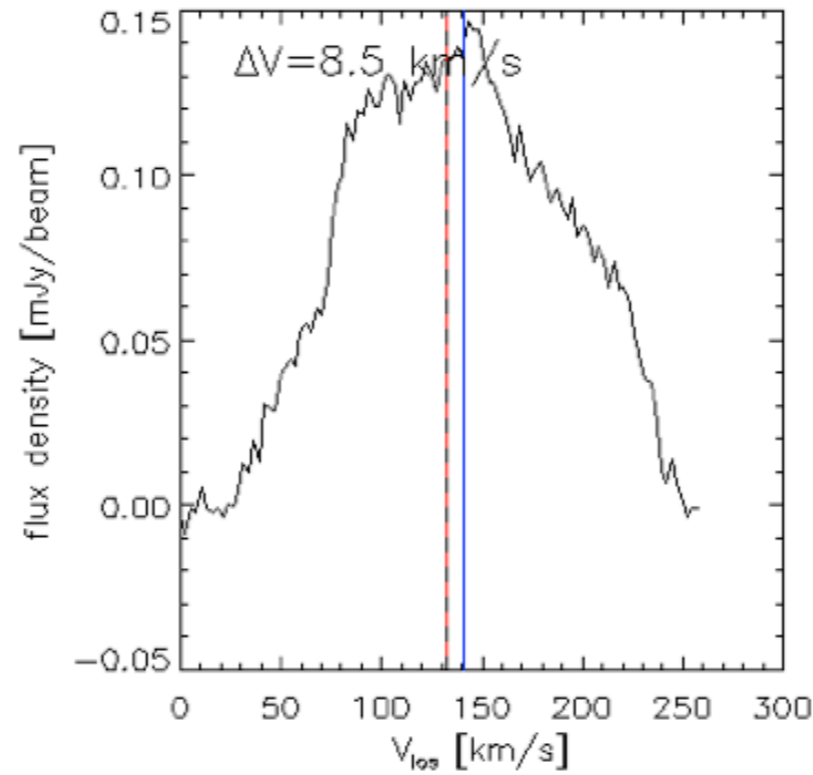
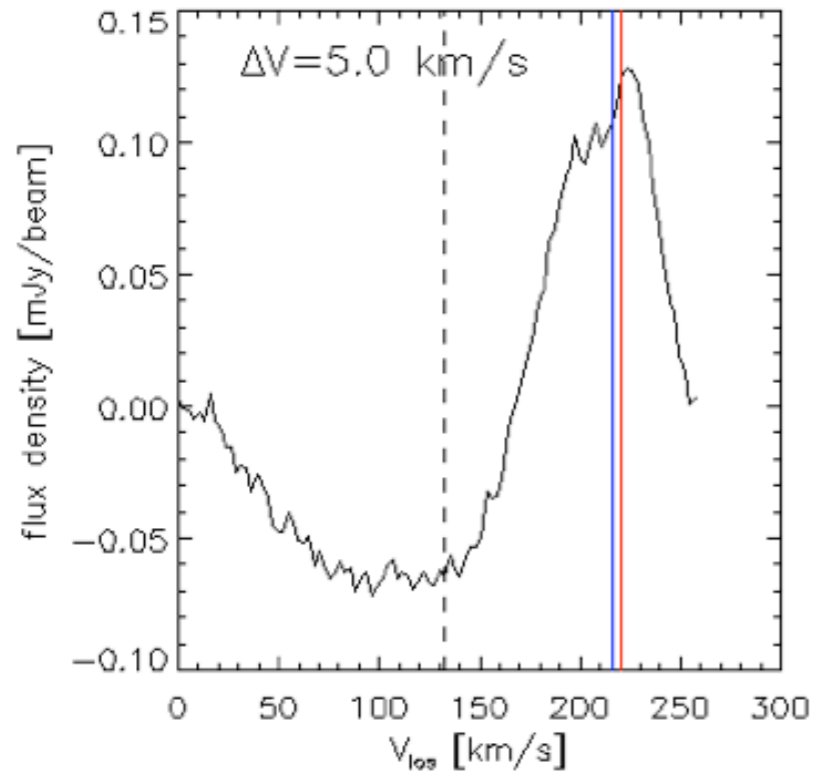
2 beams



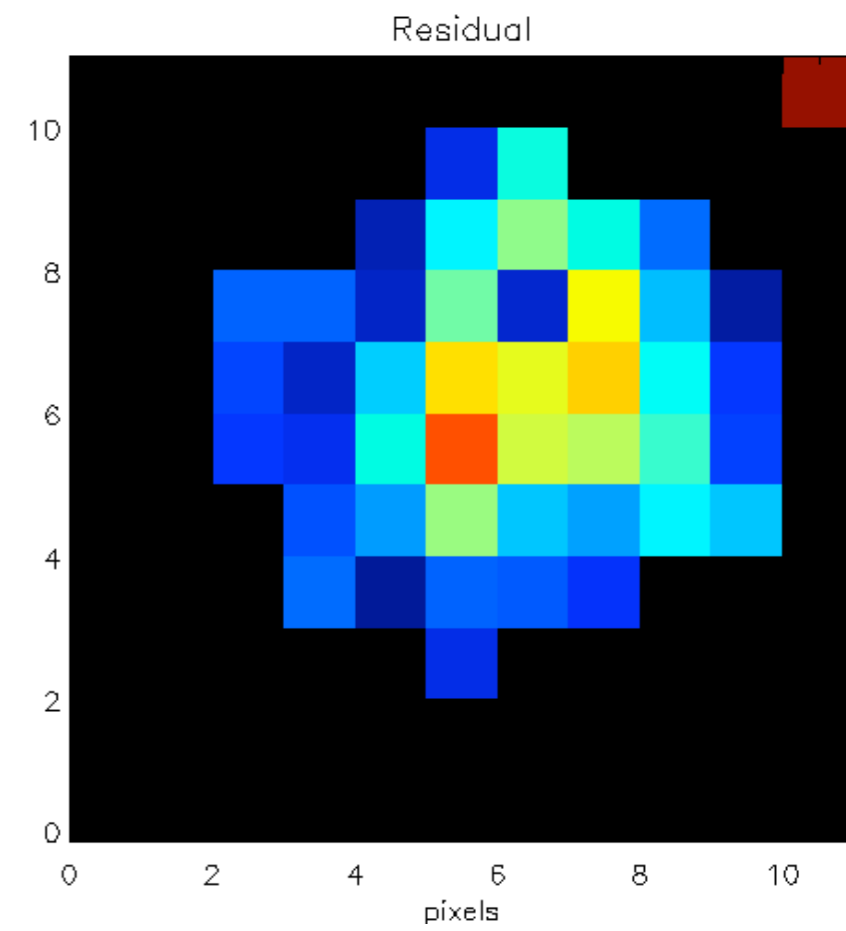
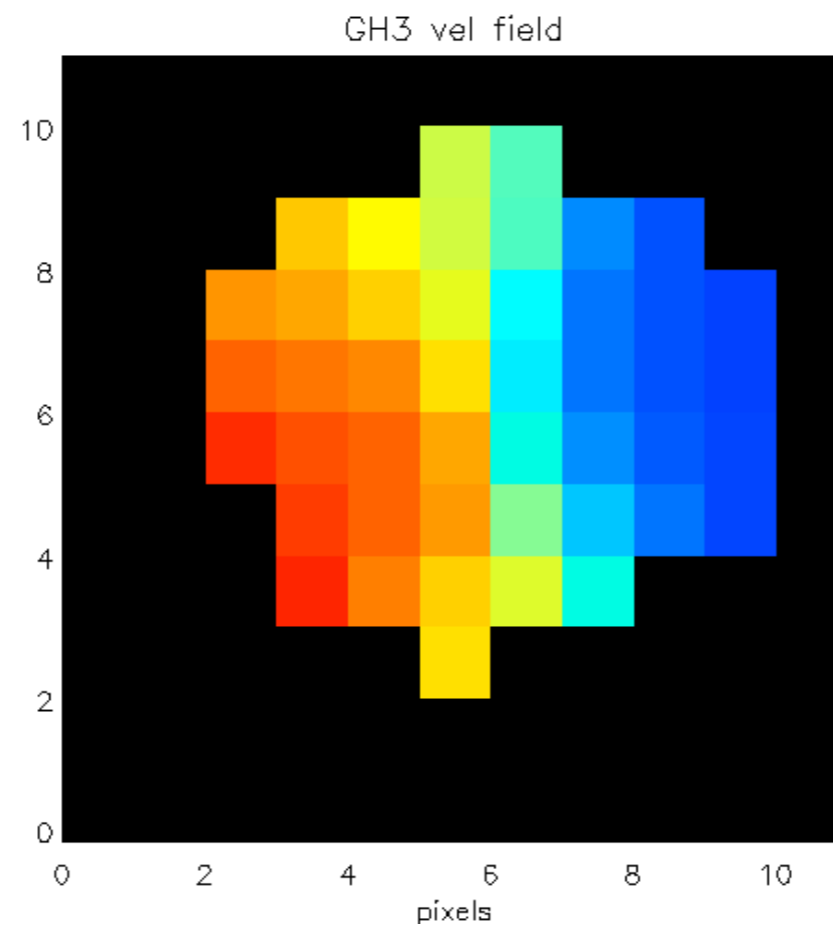
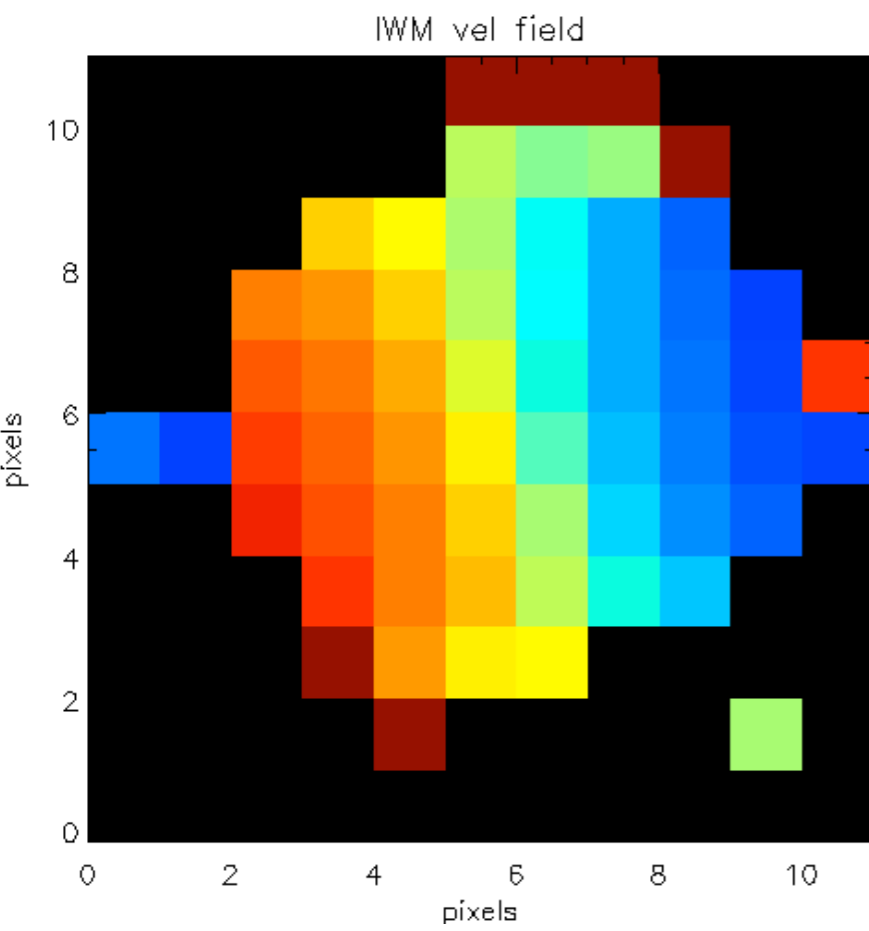
2 beams



I beam



I beam

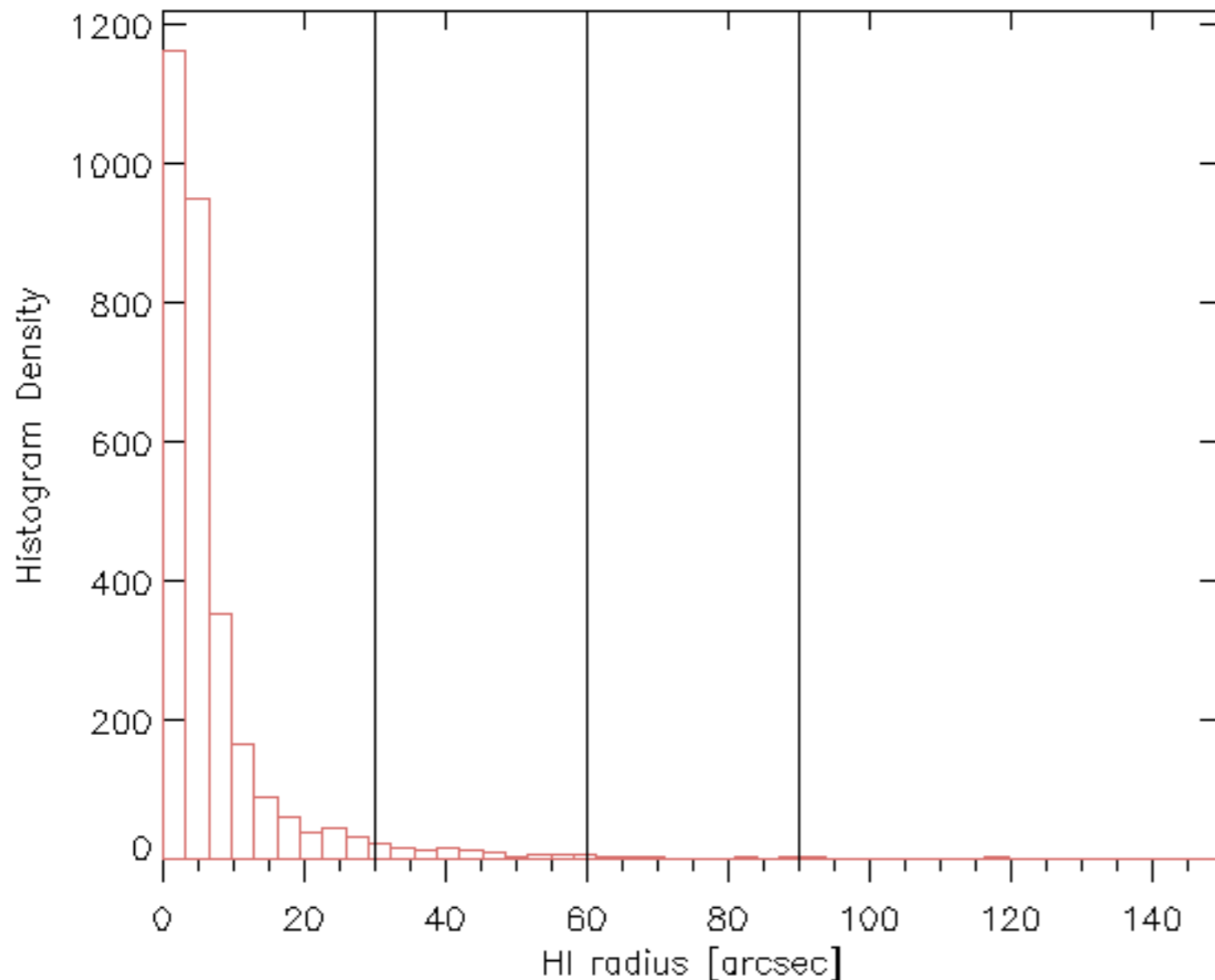


Parameterisation demonstration

- The IWM velocity fields of moderately resolved (2-3 beams across semi-maj axis) galaxies are poor representations of the true kinematics.
- GH3 velocity fields serve as more robust representations.
- Who should care about this?

● **WALLABY:**

- Vast majority of galaxies will be unresolved
- +/- 20 000 - 30 000 moderately resolved galaxies



- Distribution of HI diameters (Duffy et al. 2012)
- 50 square deg
- $z < 0.04$
- 3000 galaxies

- **WALLABY:**

- Vast majority of galaxies will be unresolved
- +/- 20 000 moderately resolved galaxies

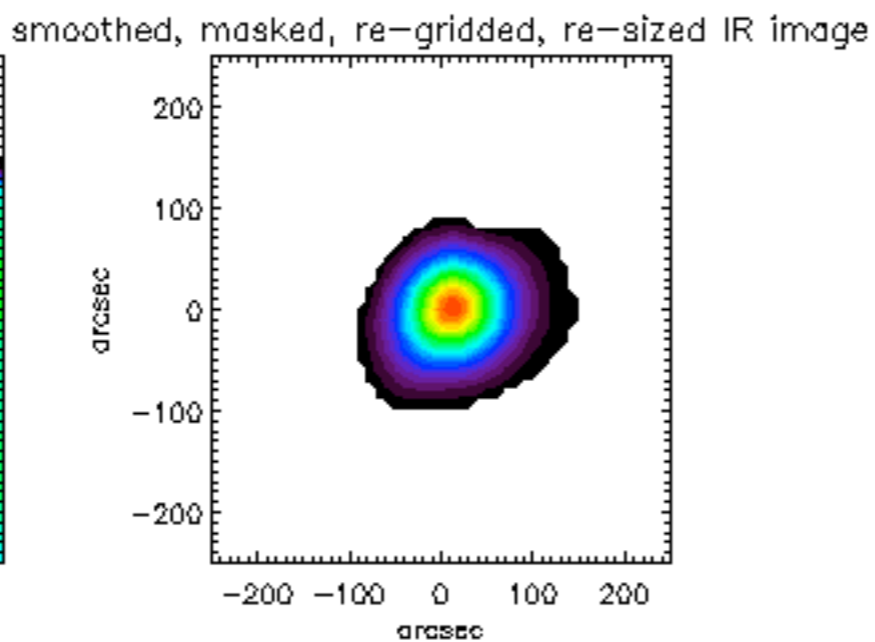
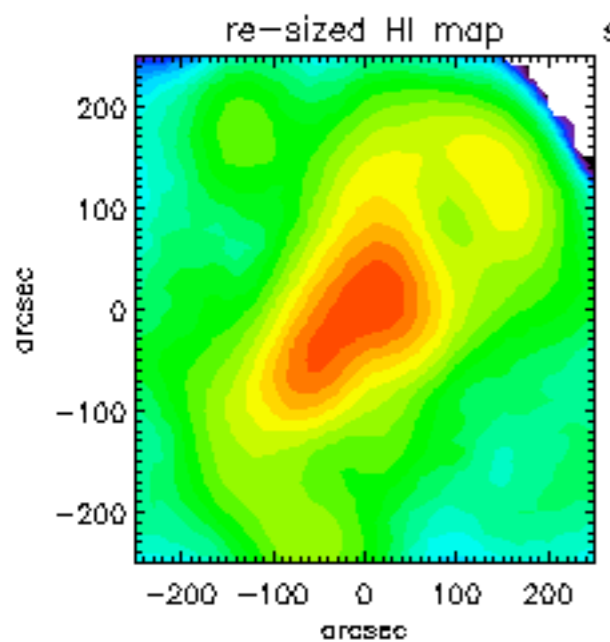
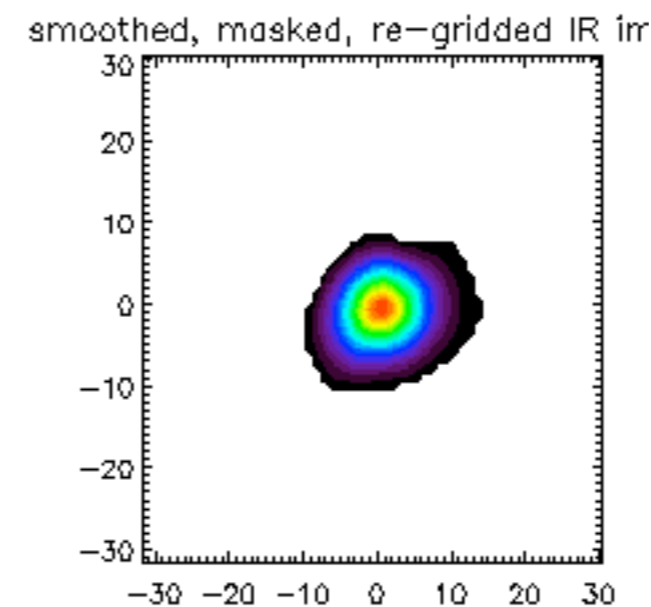
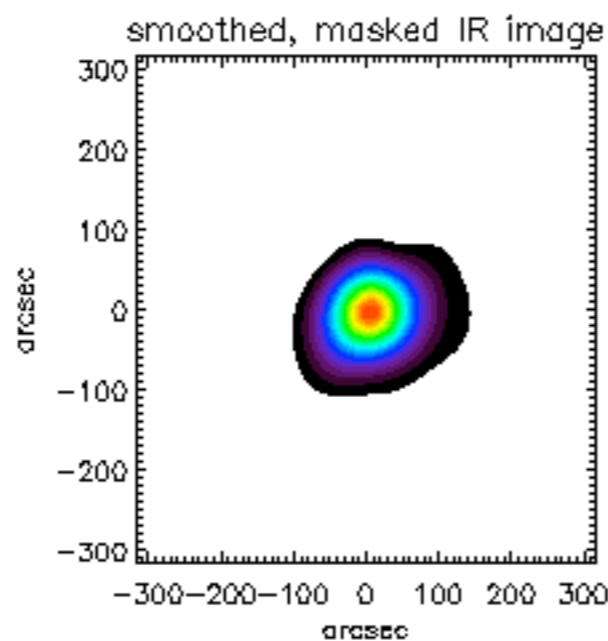
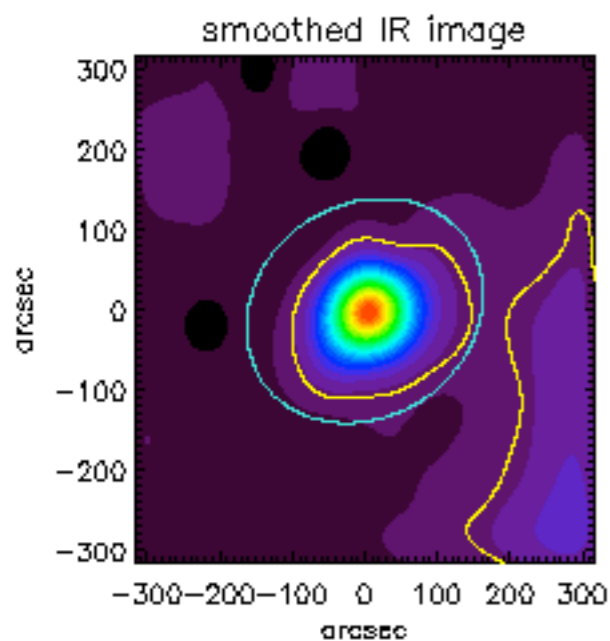
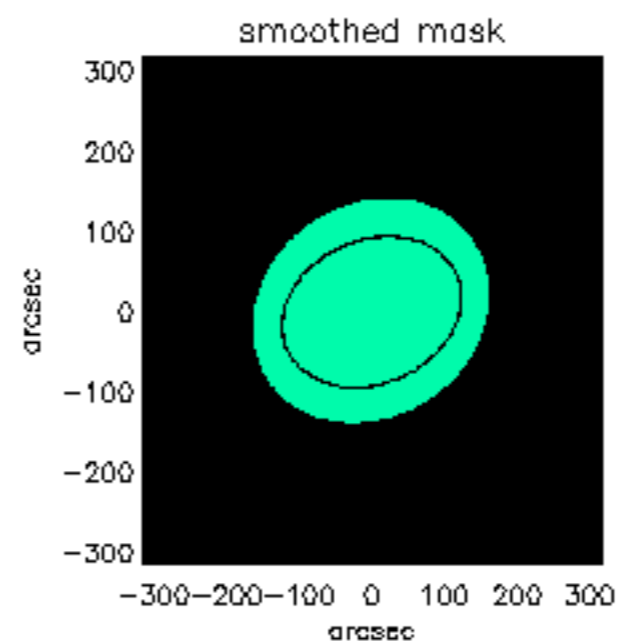
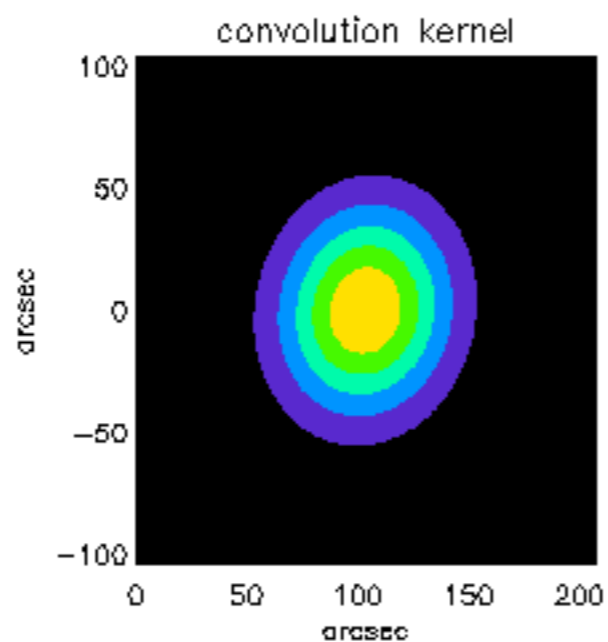
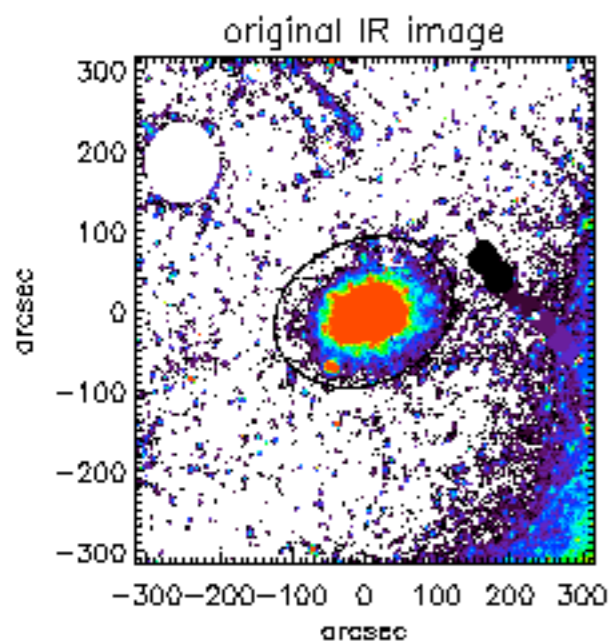
- **LVHIS:**

- Volume limited sample → most galaxies are small dwarfs
- LVHIS synthesized beam ~ 40''

- **ASKAP and MeerKAT kinematics teams:**

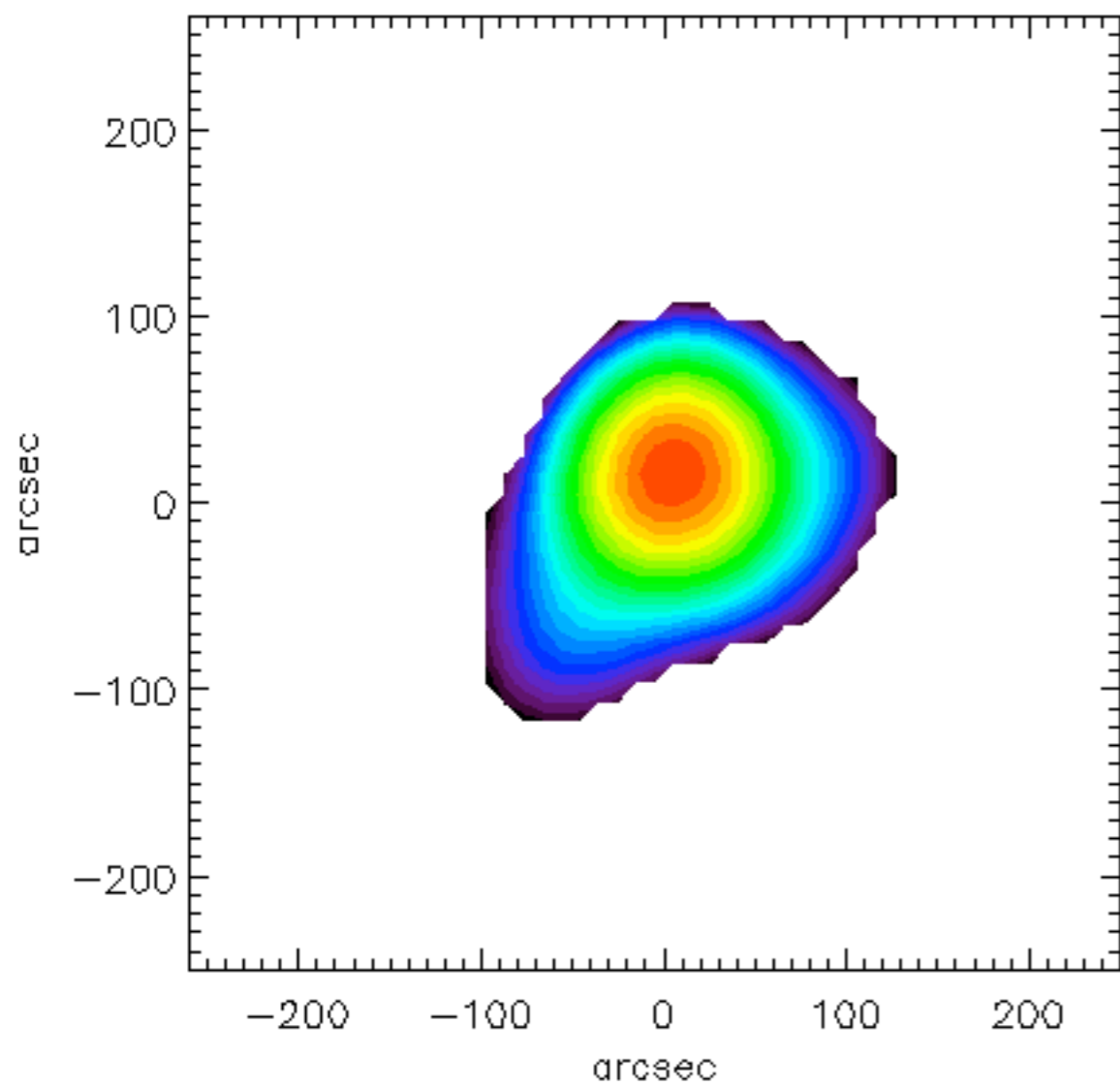
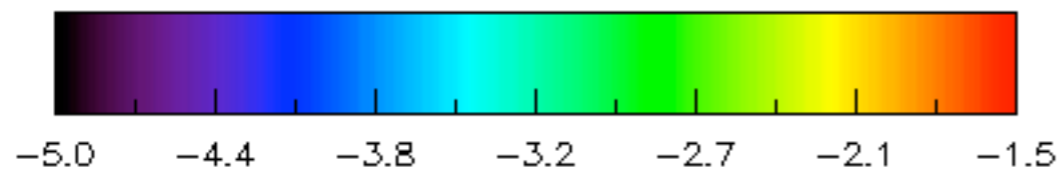
- Go to the effort of generating reliable velocity fields
- Sophisticated parameterisation extraction pipelines will otherwise be wasted.

Thank you

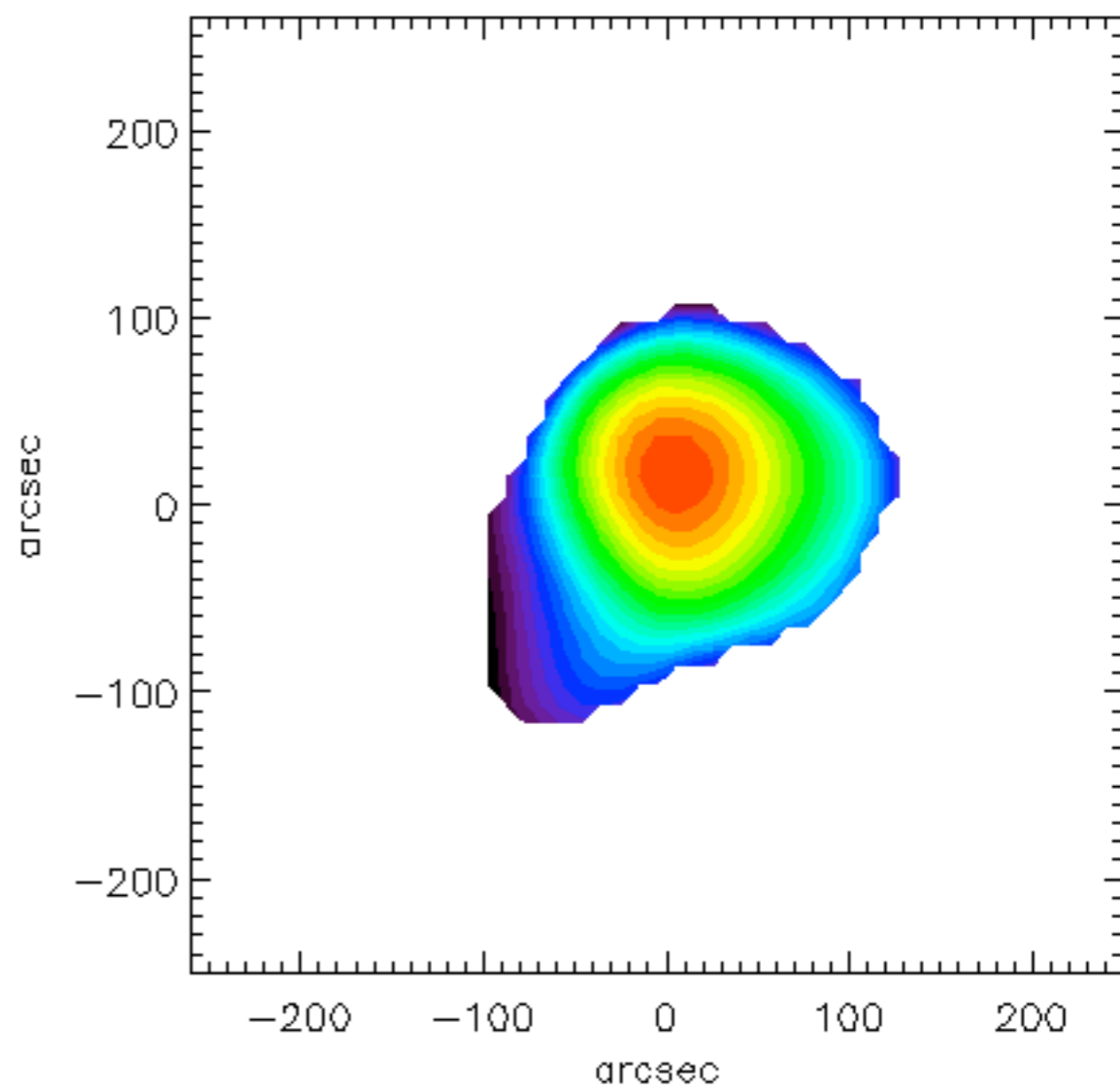
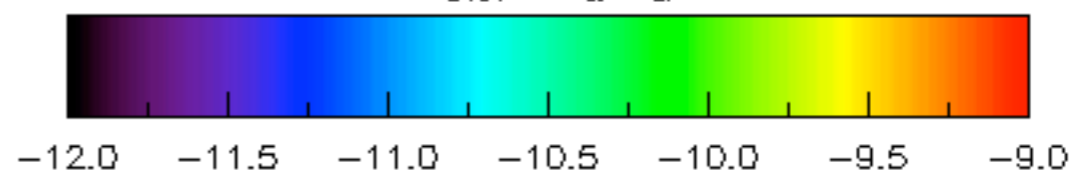


IC 4662
WISE W1 maps

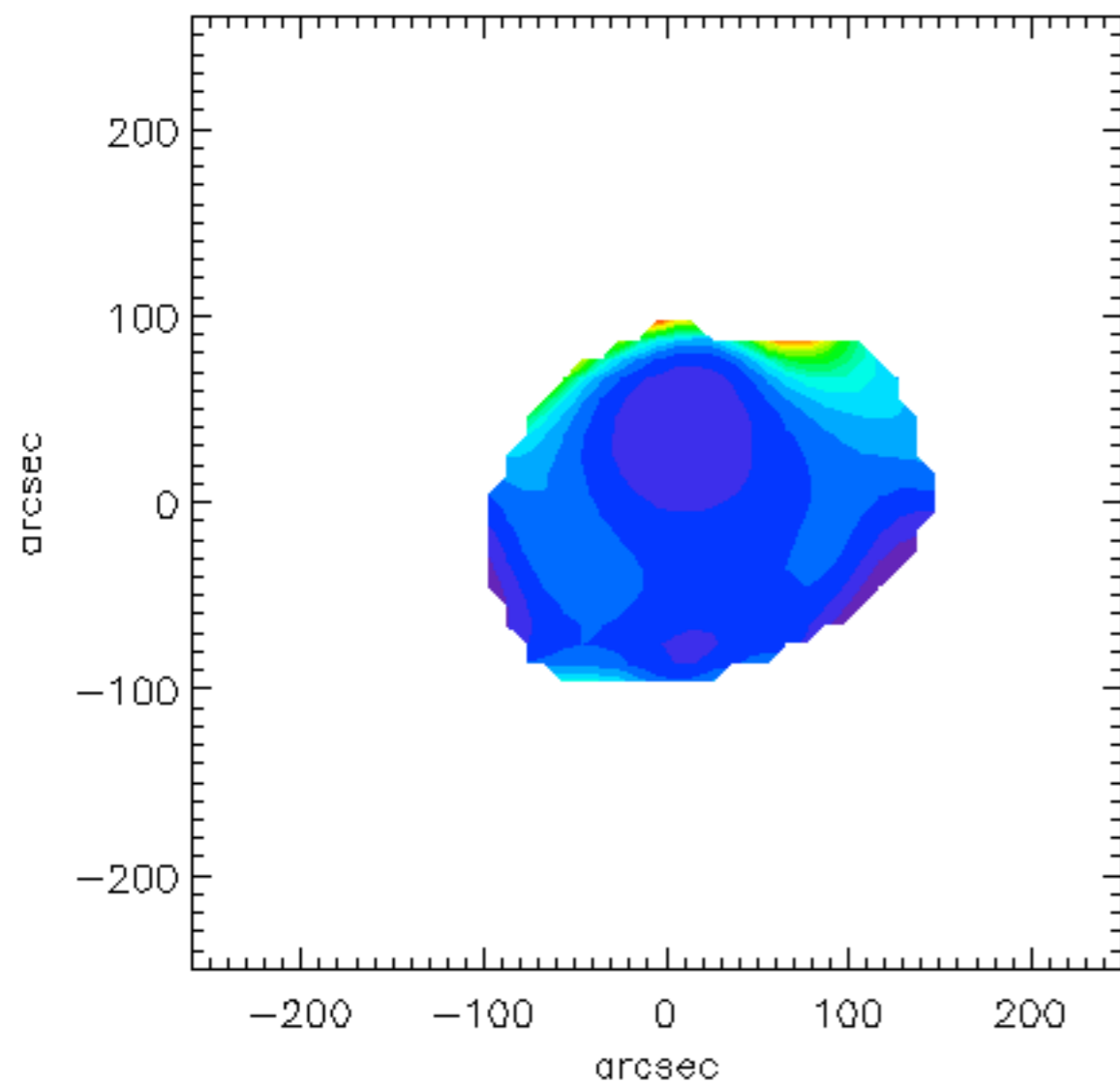
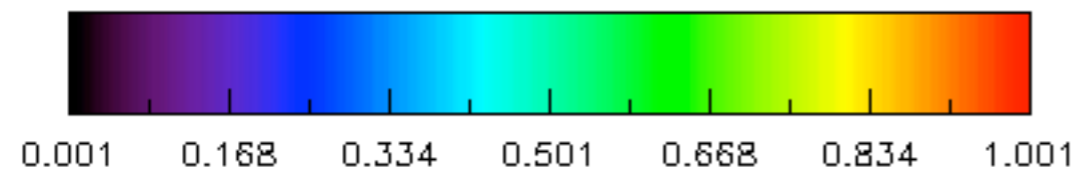
$\log_{10}(\Sigma_{\text{SFR}} [\text{M}_{\odot} \text{ yr}^{-1} \text{ kpc}^{-2}])$



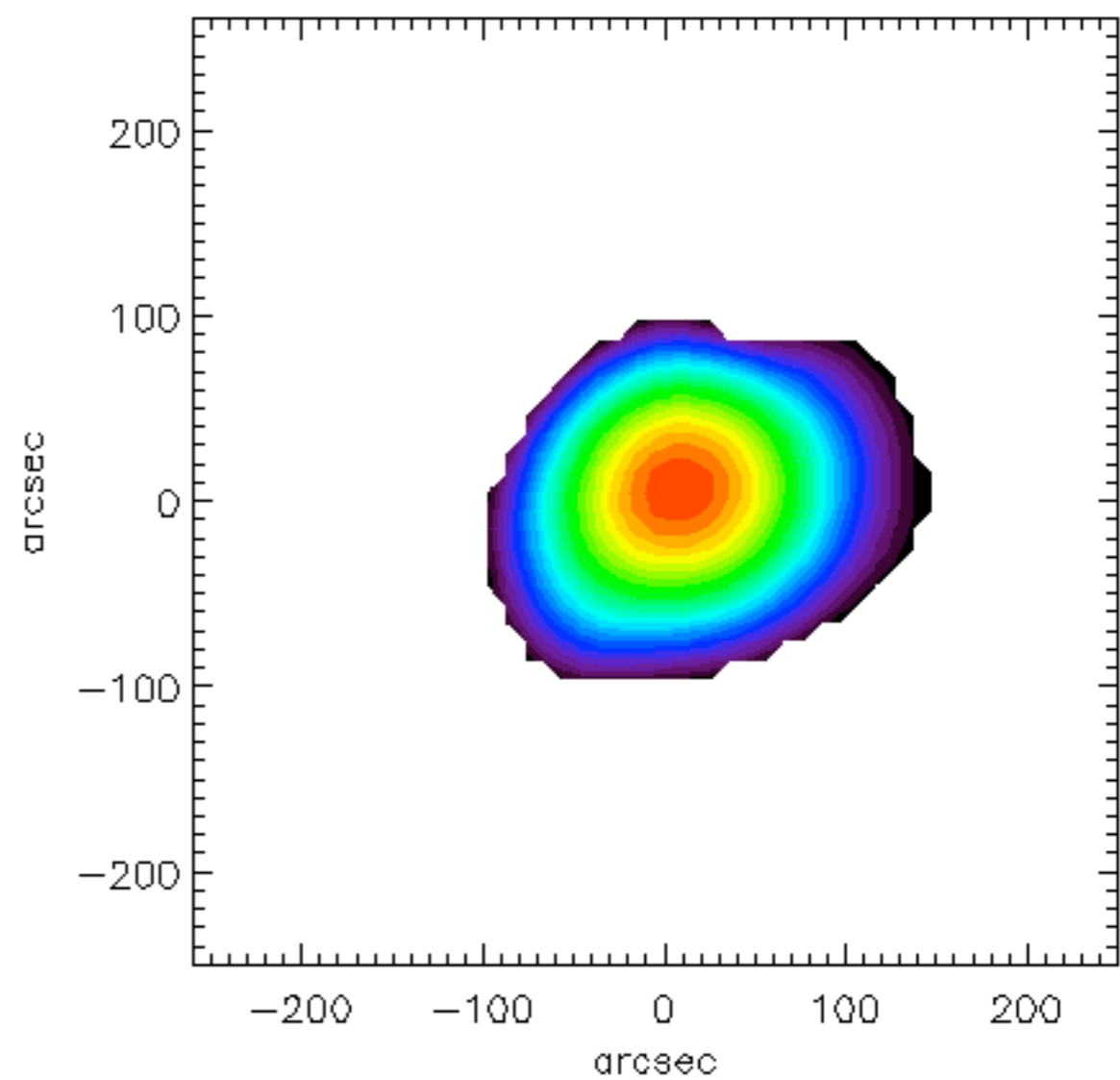
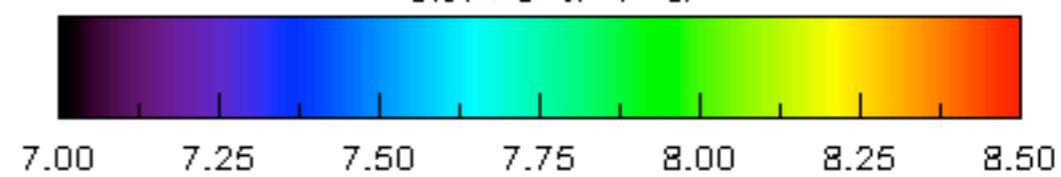
$\log_{10}(\text{SFE} [\text{yr}^{-1}])$



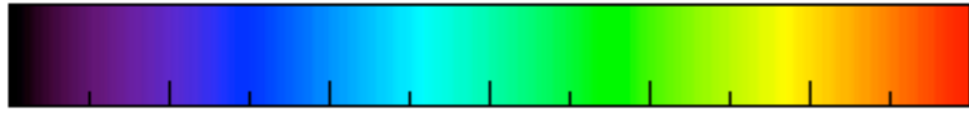
M/L [M_{\odot}/L_{\odot}]



$\log_{10}(\Sigma_{*} [M_{\odot}/\text{kpc}^2])$



$\log_{10}(\text{SSFR} [\text{yr}^{-1}])$



-11.07 -10.94 -10.80 -10.67 -10.54 -10.41 -10.27

