Stellar Feedback Up Close

Constraints from detailed MUSE and ALMA Observations of a Star-Bursting Nuclear Ring

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On Behalf of the TIMER Team

The TIMER Project

Time Inference with MUSE in Extragalactic Rings

http://www.muse-timer.org/

The TIMER Team

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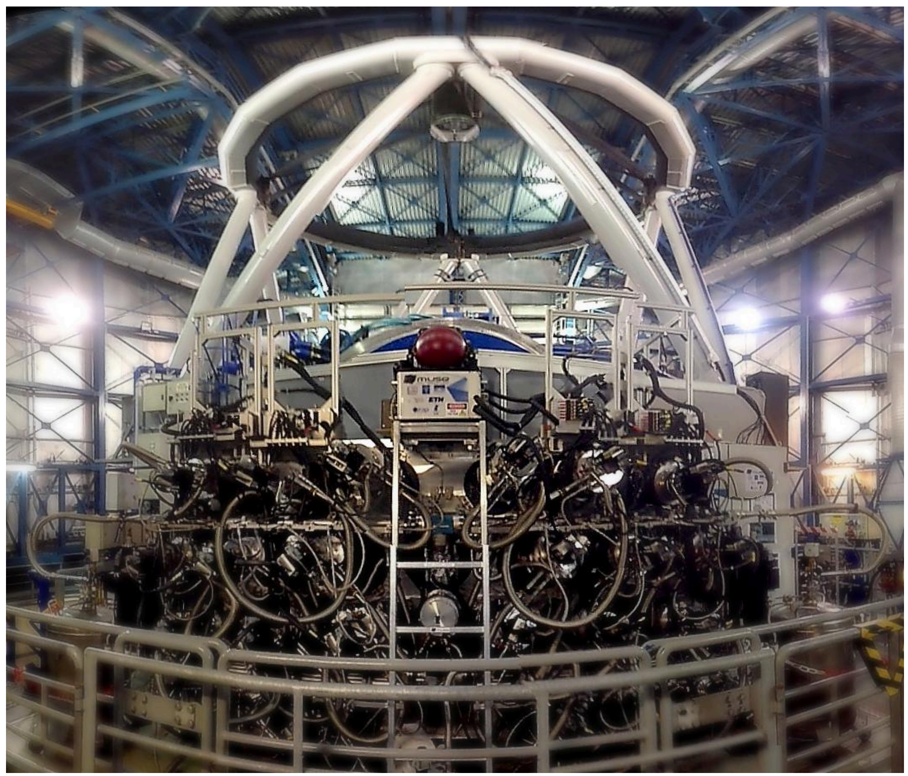
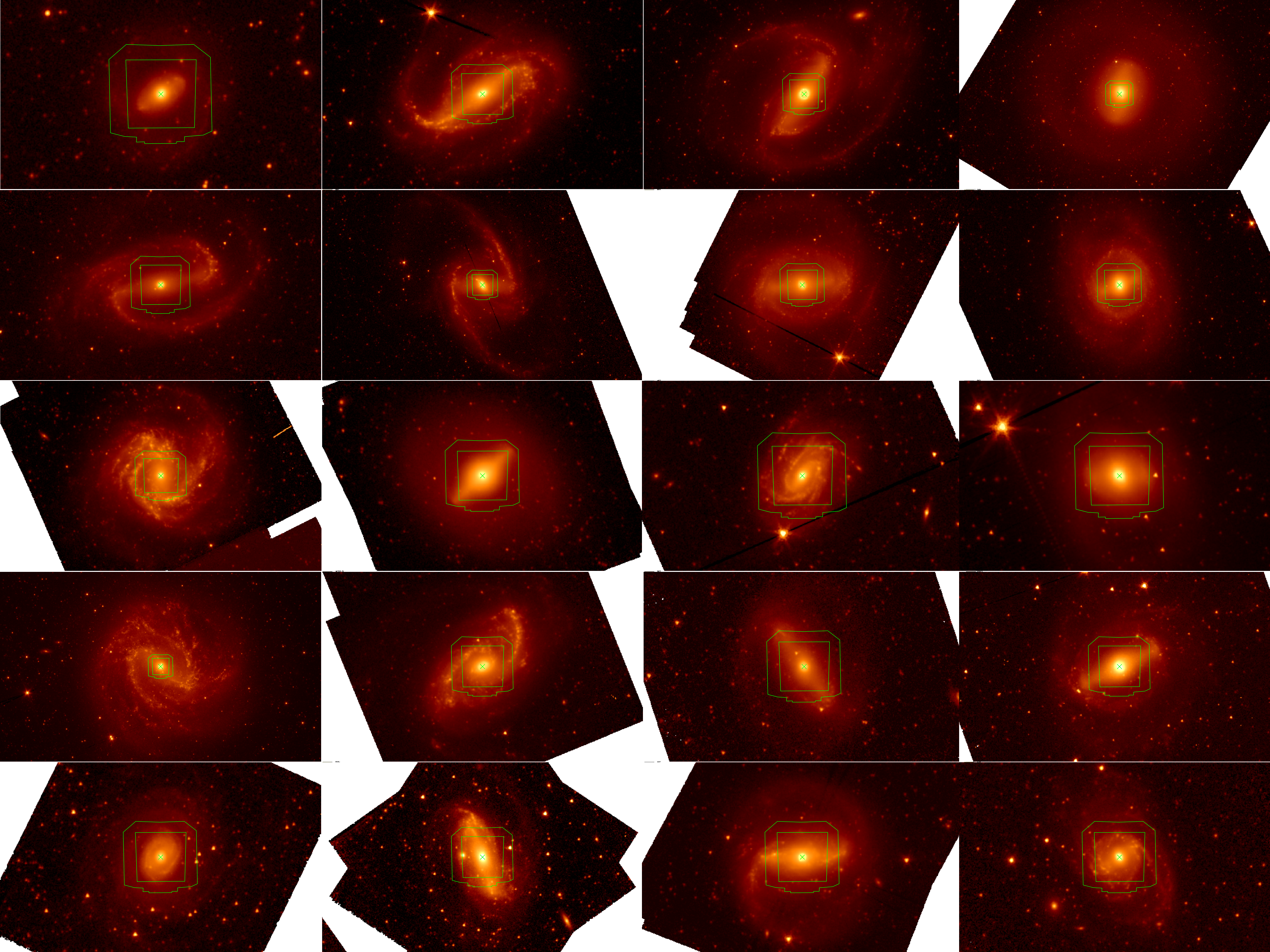
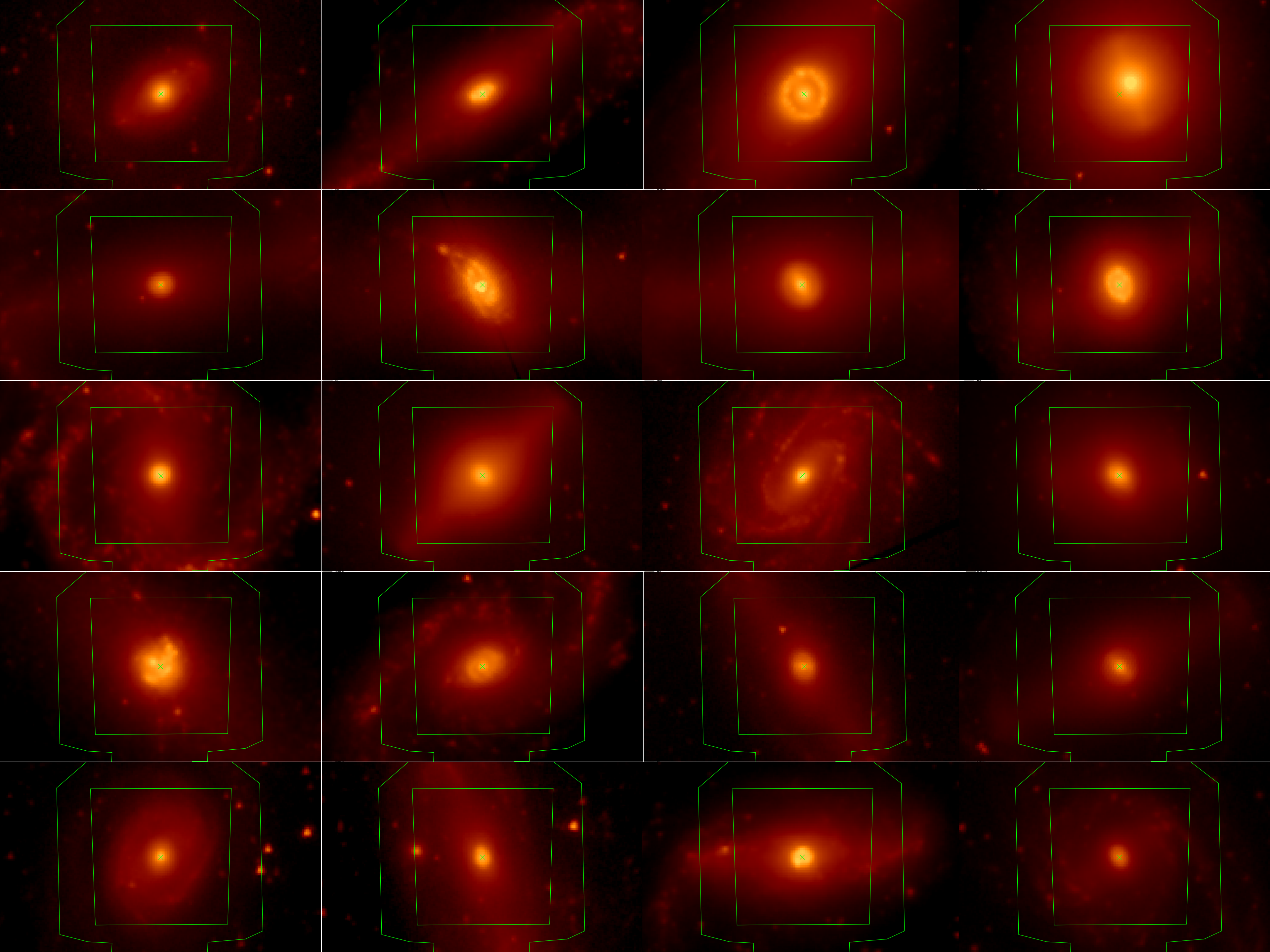
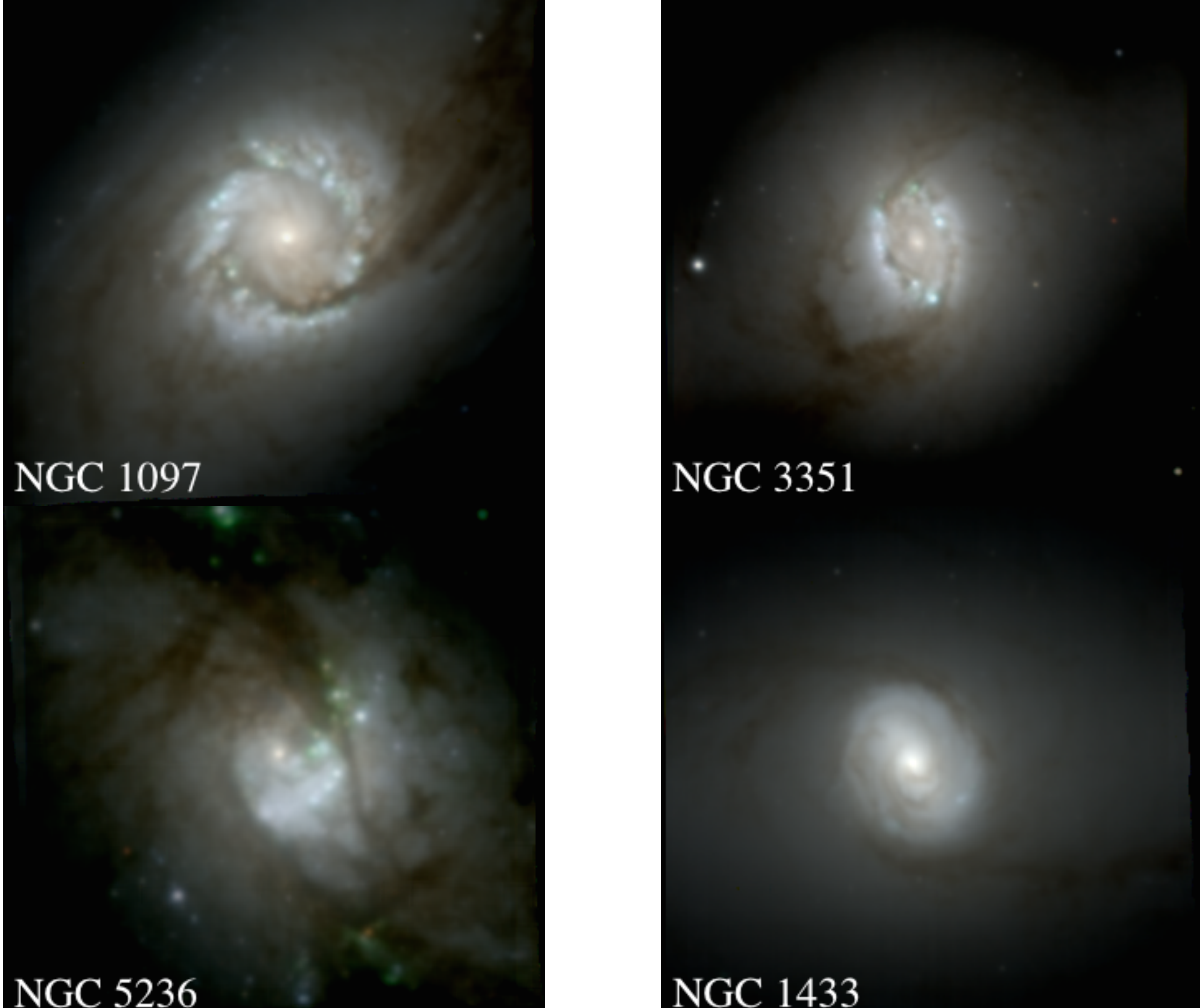
MUSE survey of the central region of nearby galaxies with bar-built nuclear structures (Gadotti+2017, in prep.)



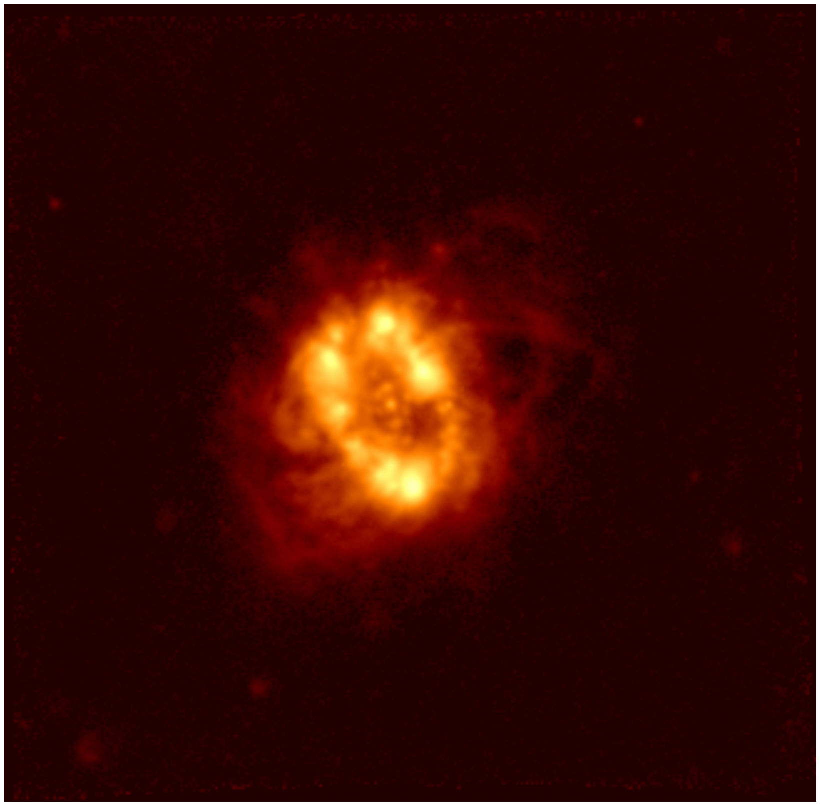


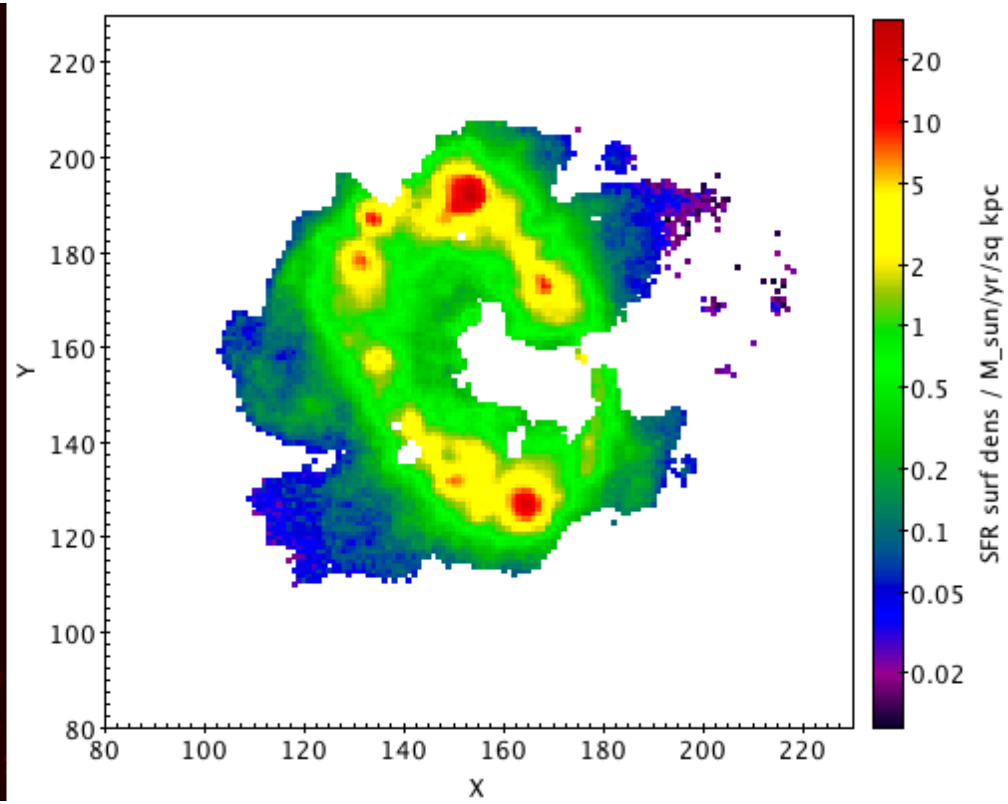



NGC 1097
NGC 3351
NGC 5236
NGC 1433

Stellar Feedback in NGC 3351

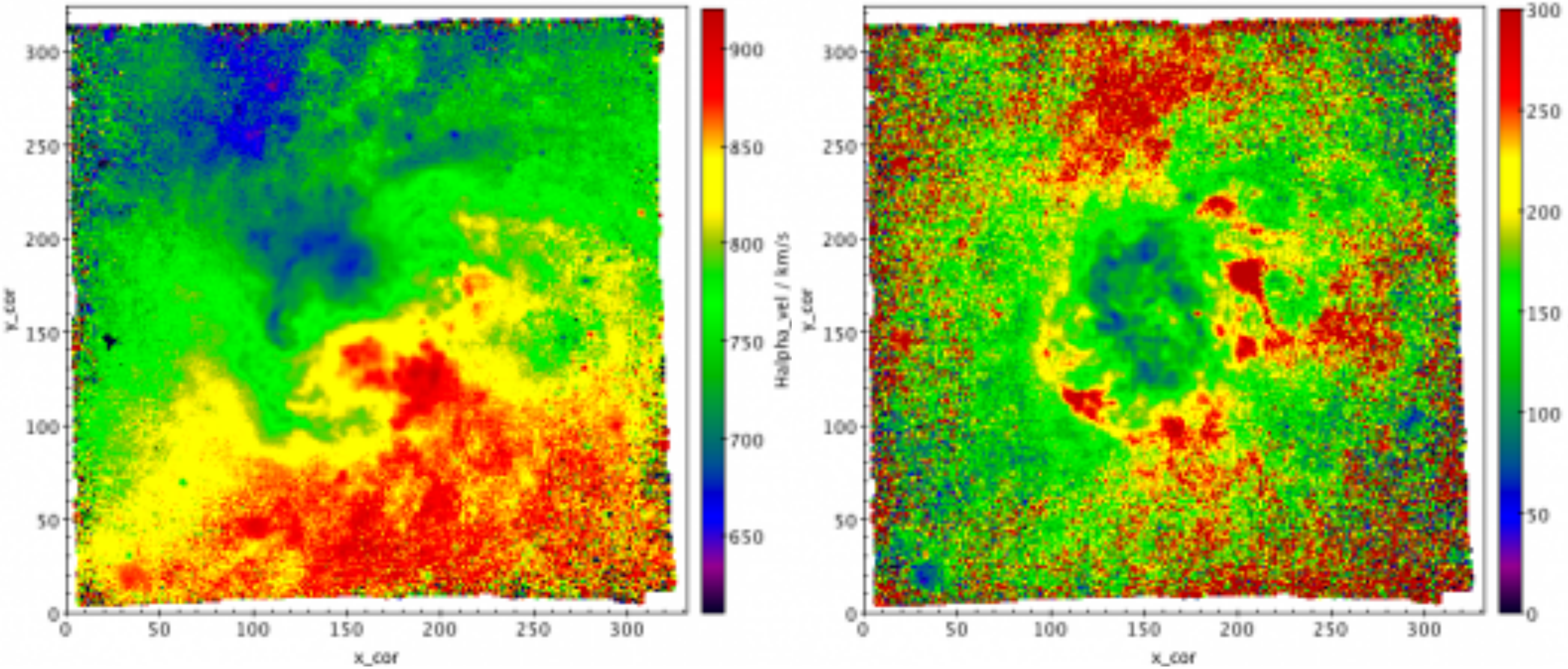
Diffuse, filamentary Hα emission and high SFR surface density in the MUSE cube (Leaman+2017, in prep.)





Stellar Feedback in NGC 3351

Clear non-gravitational component in the velocity field of the warm gas and presence of shocks



Stellar Feedback in NGC 3351

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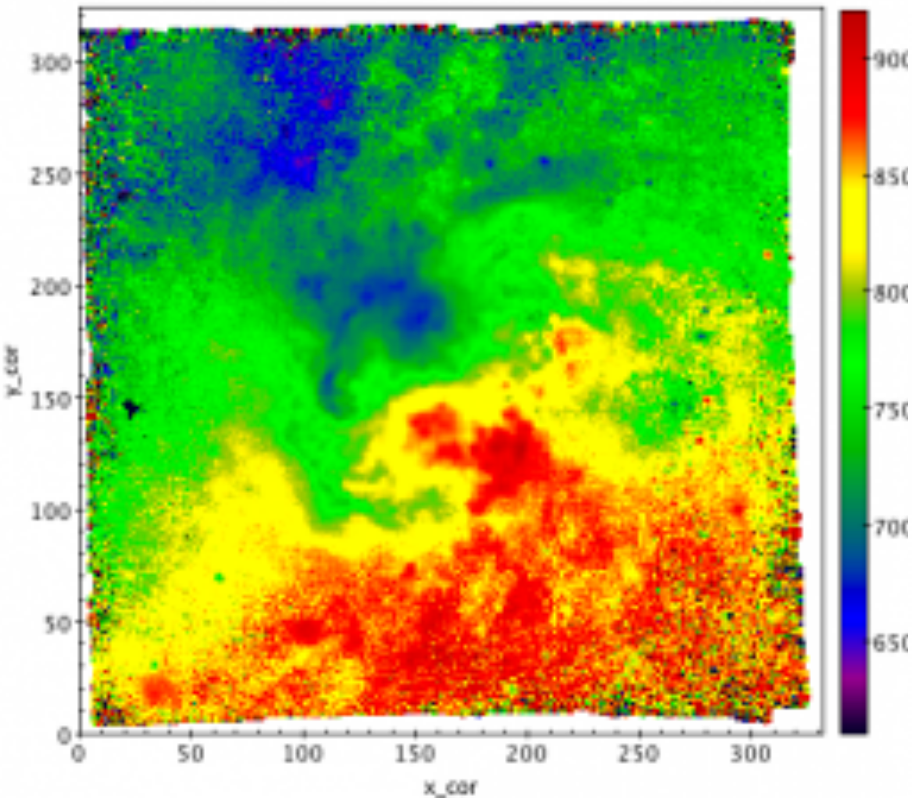
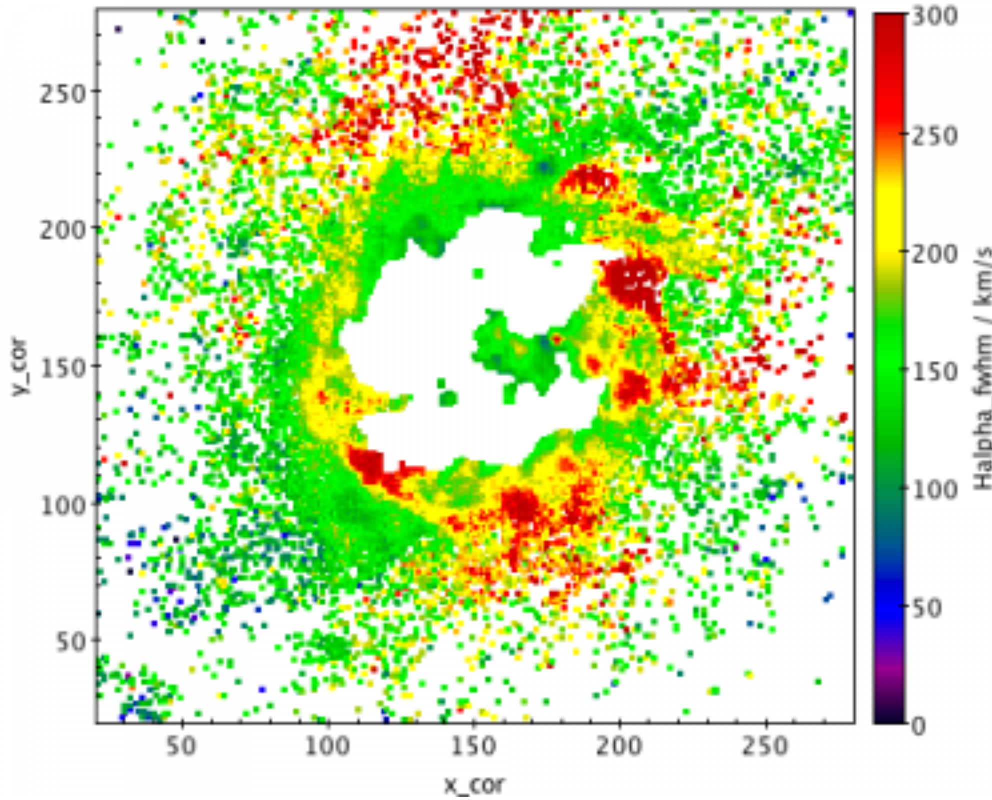


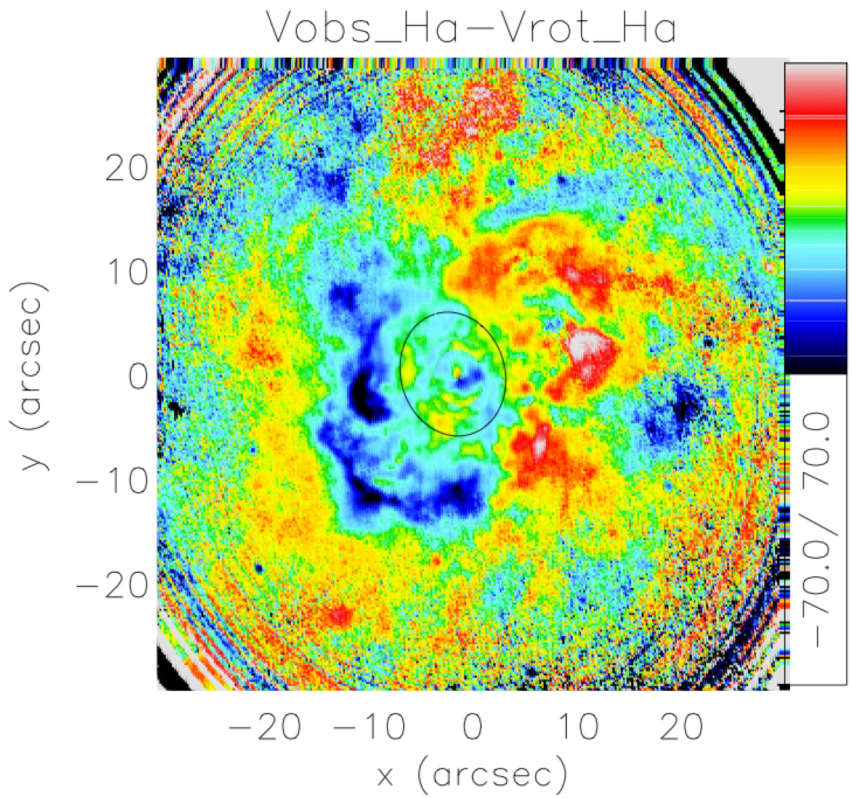


Stellar Feedback in NGC 3351

- Mean SFR surface density in the ring is $1M_{\odot}$/yr/sq. kpc, and the integrated SFR is $0.6M_{\odot}$/yr
- Core-collapse SNe rate is 5k/Myr (using a modified Salpeter IMF)
- Warm gas mass is 1.7×10^{6} $M_{\odot}$ (using the Hα luminosity)

Stellar Feedback in NGC 3351

- Radial expansion speed of the warm gas is about 70 km/s (see van de Ven & Fathi 2010 for details on the modeling)
- This speed matches modeling of the shocks from the emission-line ratios
- Not enough to overcome escape velocity and leave galaxy

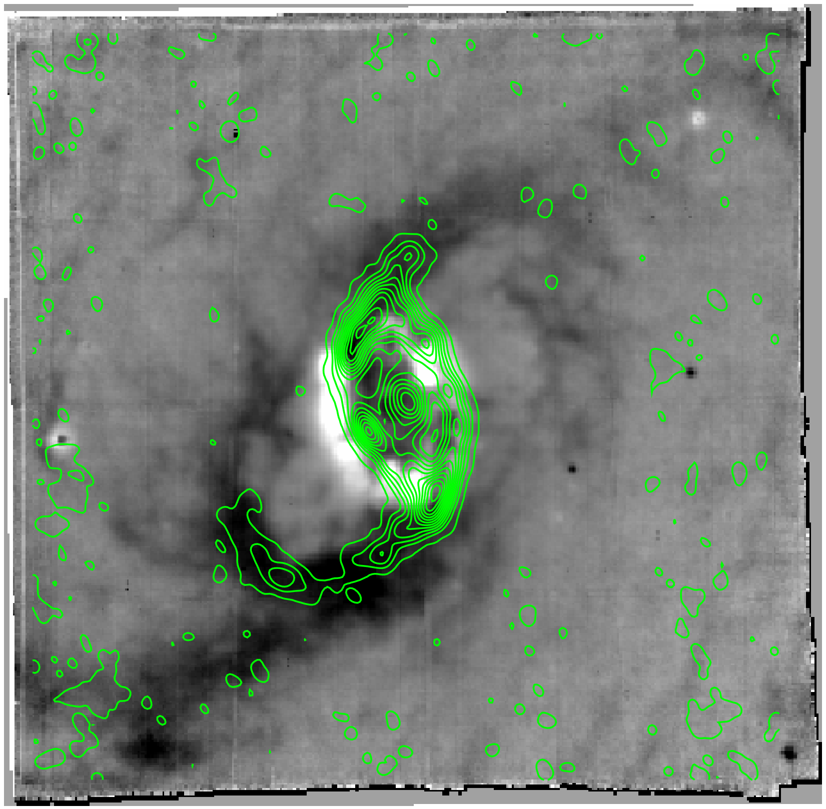


Stellar Feedback in NGC 3351

- With the warm gas mass and its speed we can roughly derive the kinetic energy as 8 x 10^{52} erg
- Matches estimate from Cheung+2016 for low-luminosity AGN

What about the cold gas?

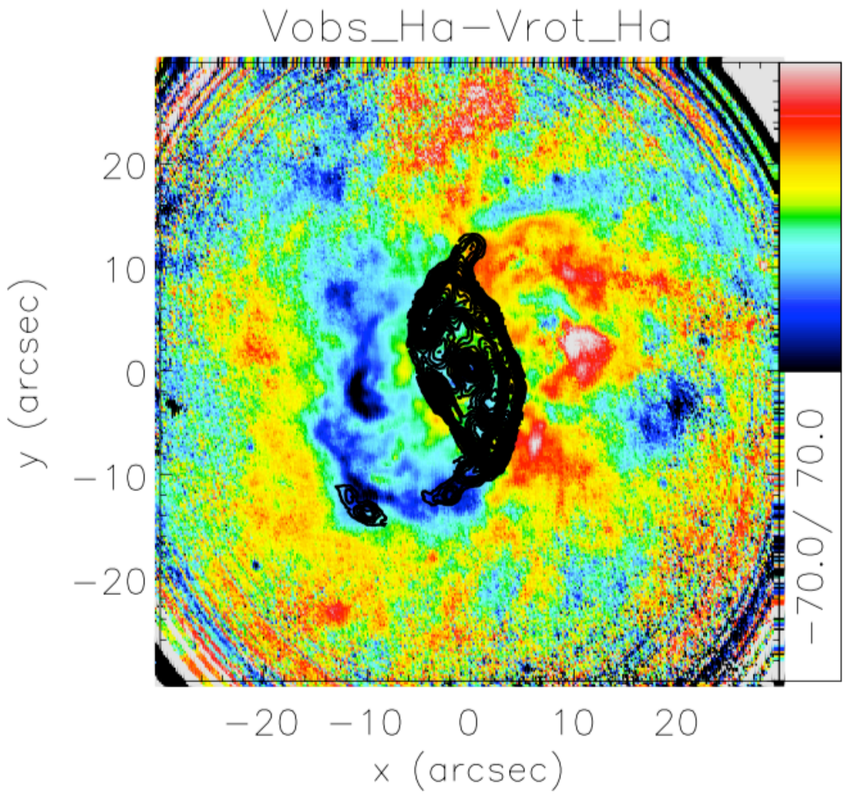
12CO(1-0) ALMA data from PI Karin Sandstrom

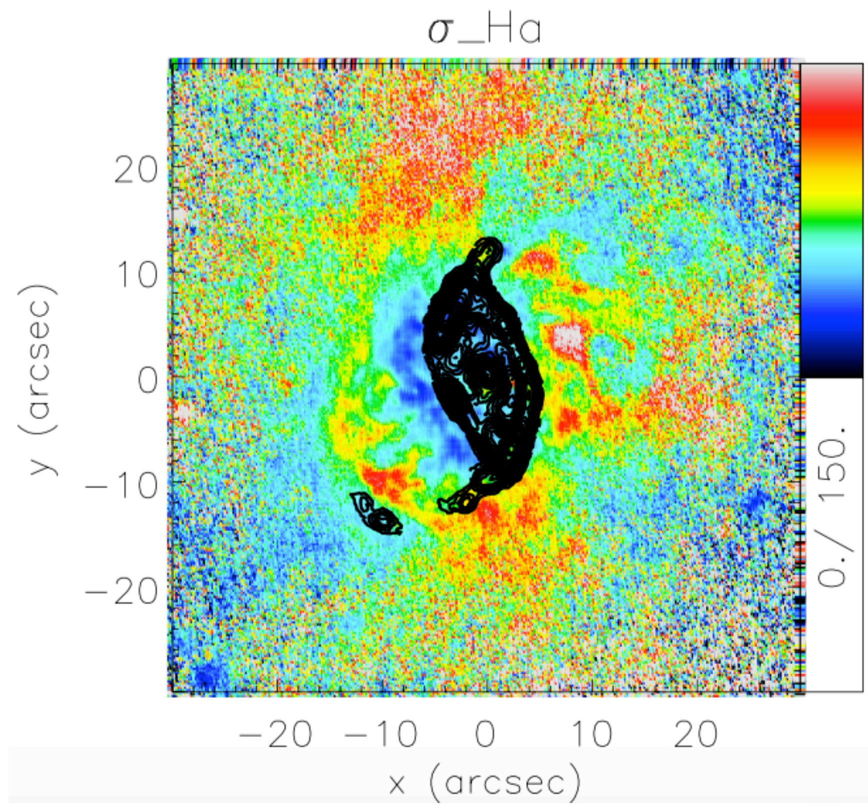


What about the cold gas?

12CO(1-0) ALMA data from PI Karin Sandstrom

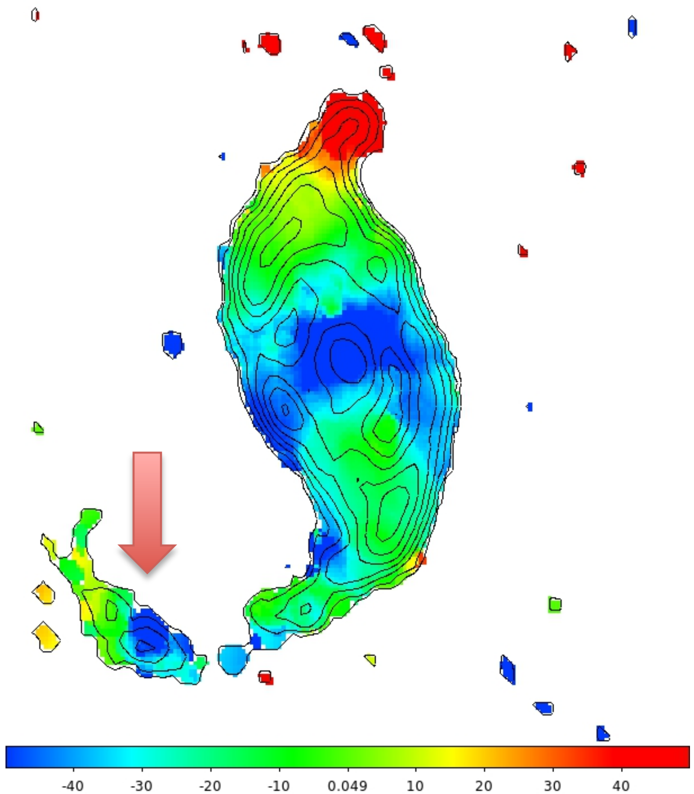
HERACLES data (Leroy+2009): 2.7 x 10^8 $M_\odot$ of molecular gas within 25”



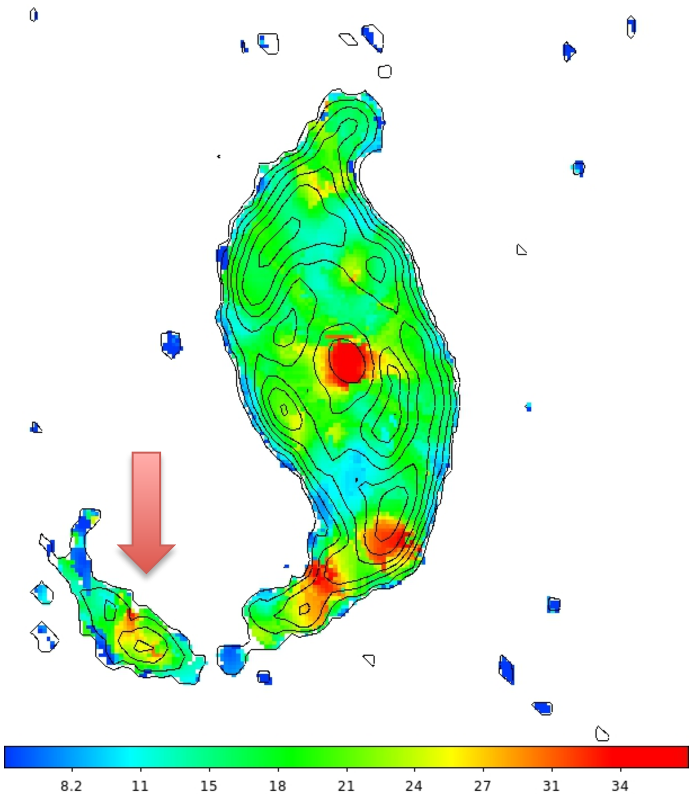


What about the cold gas?

Dynamics of molecular gas is perturbed by the warm gas expansion



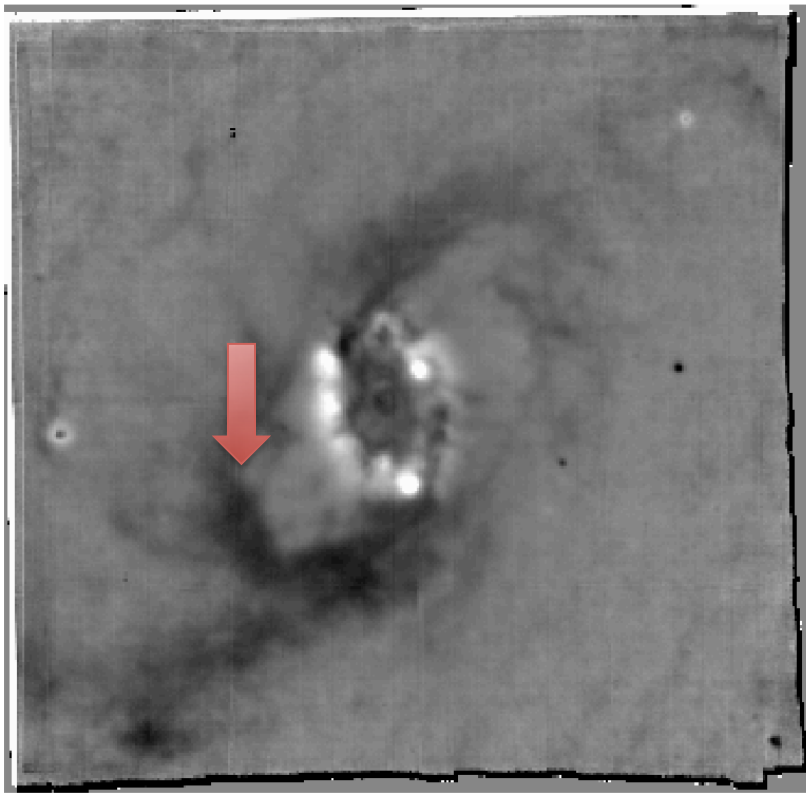
CO Residual Velocity Field



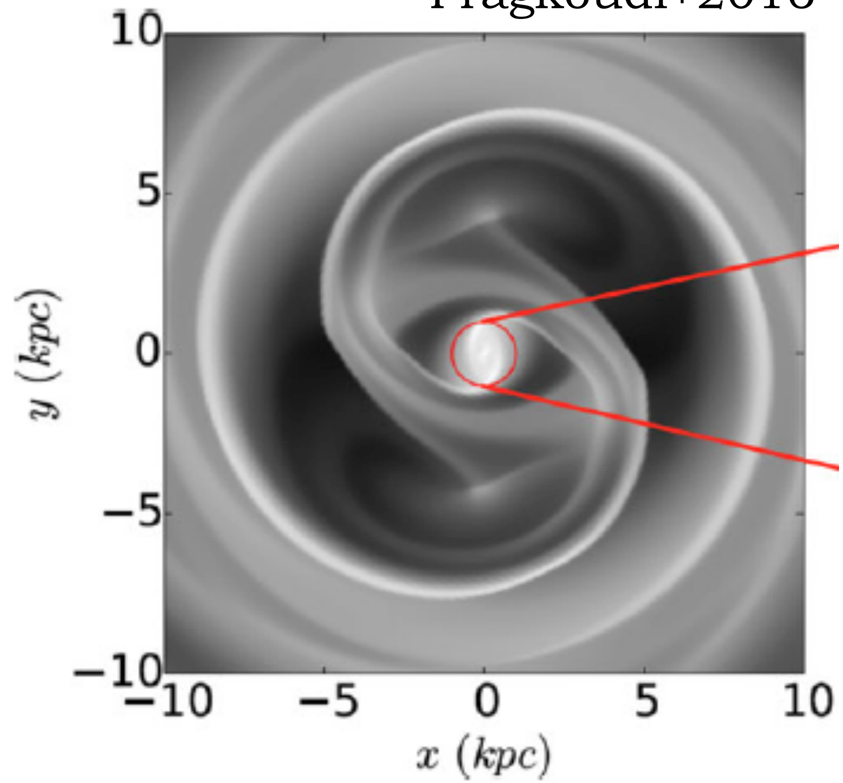
CO Velocity Dispersion

The Transversal Dust Lane

Simulations only form dust lanes along the leading edges of the bar.
How did it form?

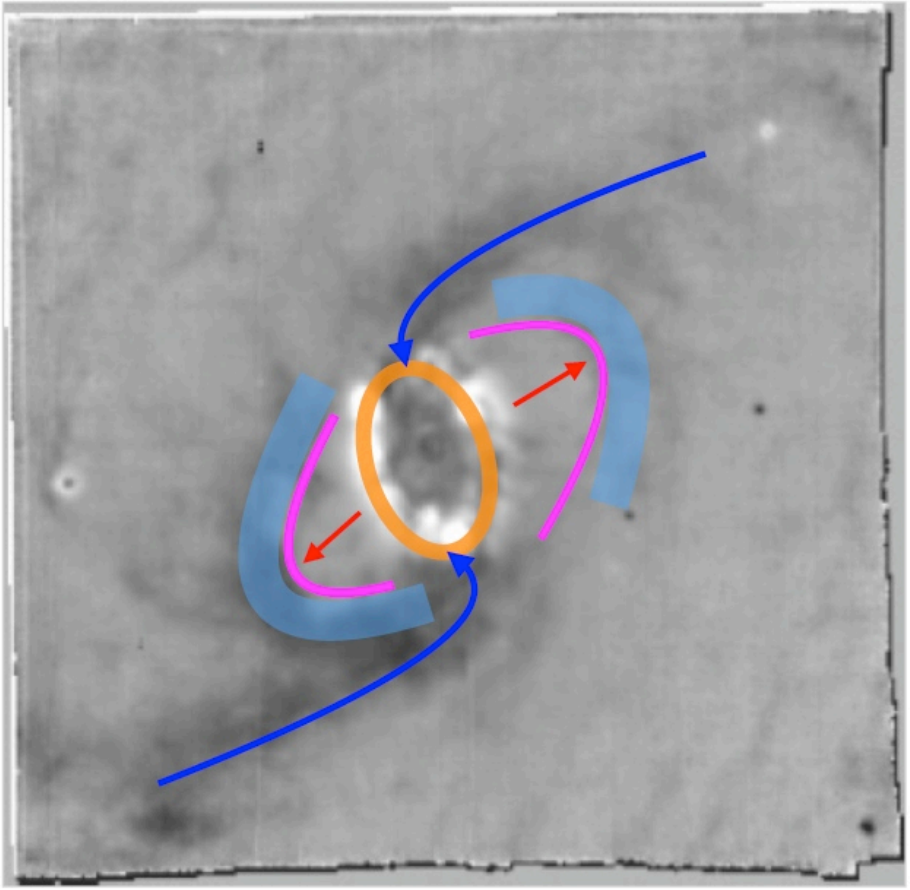


Fragkoudi+2016



The Transversal Dust Lane

Is it a result from the feedback?



Feedback Mechanisms

- Using STARBURST99 (Leitherer+1999)
  - Input: SFR, metallicity, emission line ratios, molecular gas surface density, extinction
  - Assumed: Kroupa IMF, 10 $M_{\odot}$ SNe, function for photon scattering (Hopkins' FIRE simulations)

- We derive the maximum fractional contributions of the four feedback mechanisms to the total momentum flux:

  - Direct photoionisation pressure: 60%
  - SNe: 27%
  - Photoionisation heating: 12%
  - Stellar winds: 1%

- In this high metallicity environment (log M/H = +0.4), photon pressure on dust from hot stars seems the dominating feedback mechanism