

# Dense Gas Distribution and Excitation in the Nuclear Region of the Circinus Galaxy

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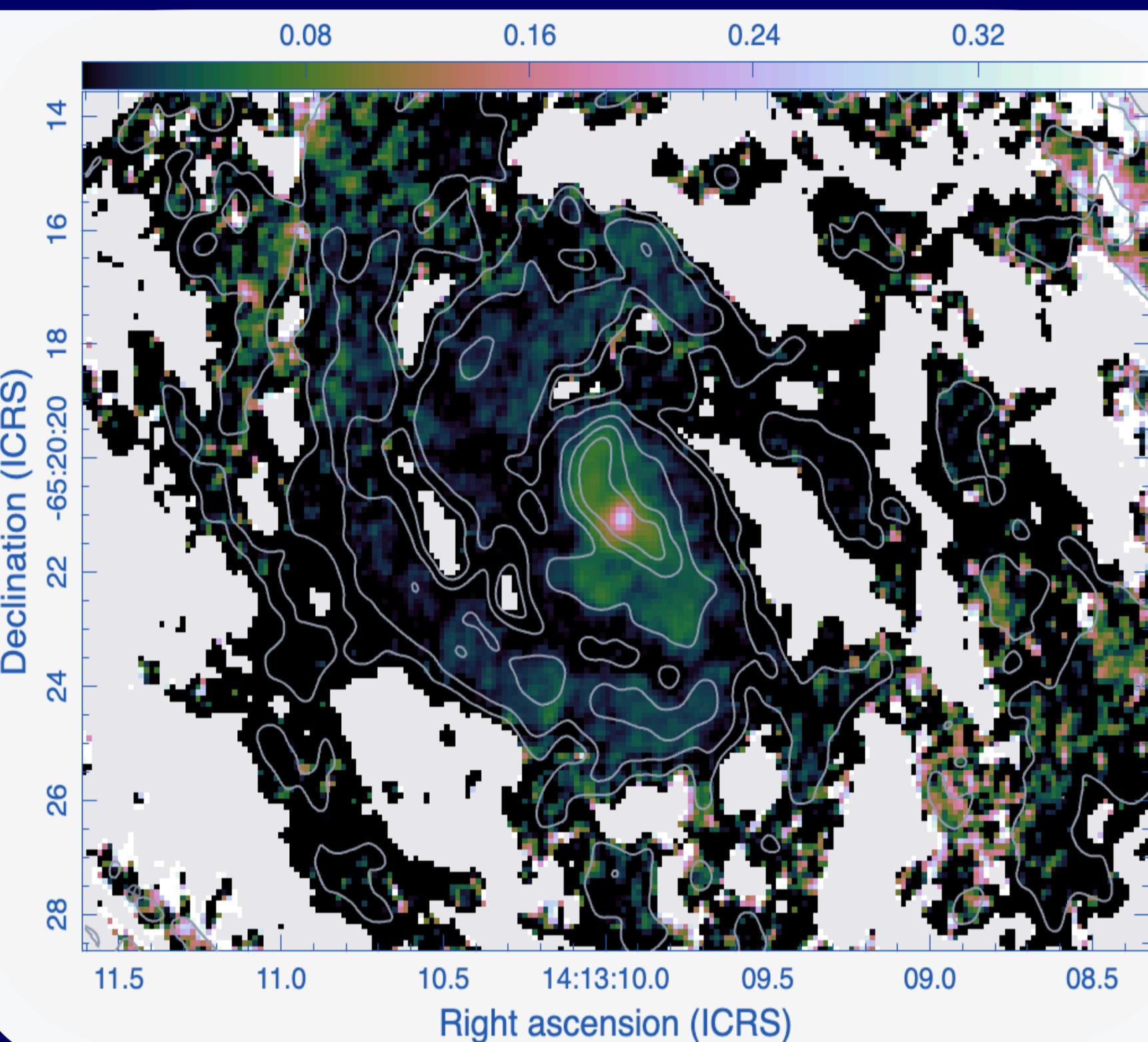
## Summary:

We used ALMA to map CO and dense gas tracers (e.g., HCN, HCO+...) in the Circinus Galaxy.

The Megamaser VLBI Preparation (MVP) provides broadband observation with higher angular resolution, enabling us to make **ratio maps**. In particular, the HCO+(4–3) over CO(3–2) map reveals a sharp, pinpoint-like peak and clumpy features along the spiral arms, highlighting potential signatures of distinct excitation mechanisms.

Thanks to MVP's broadband observation, our next step is to model the local environments in the nuclear region using multiple dense gas tracers and multi-transitions. We aim to investigate whether **dense gas ratios correlate with physical conditions** and whether the correlation serves as a diagnostic of galactic environments.

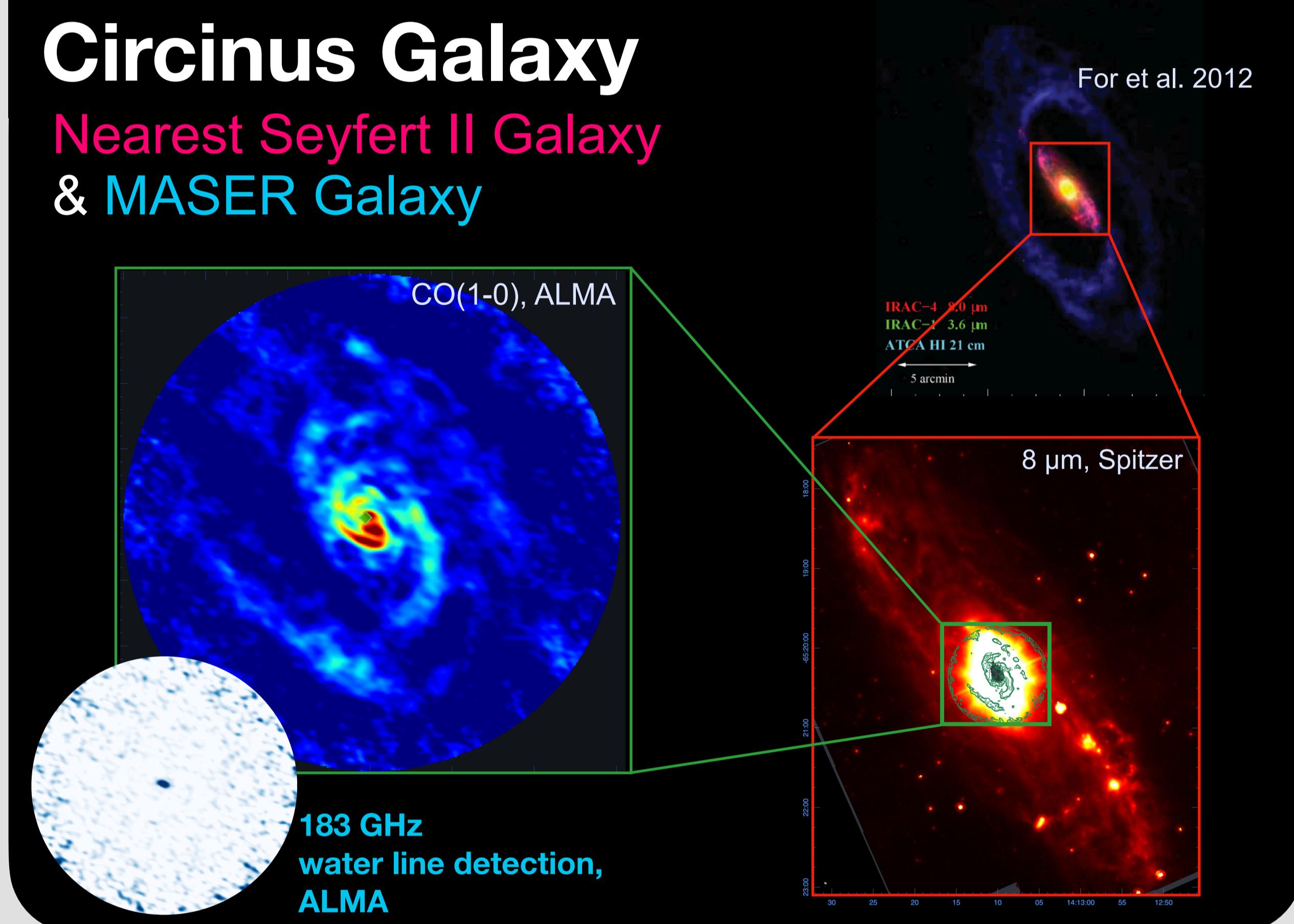
## Observation: HCO+ (4-3) / CO(3-2), beam=0.29 arcsec



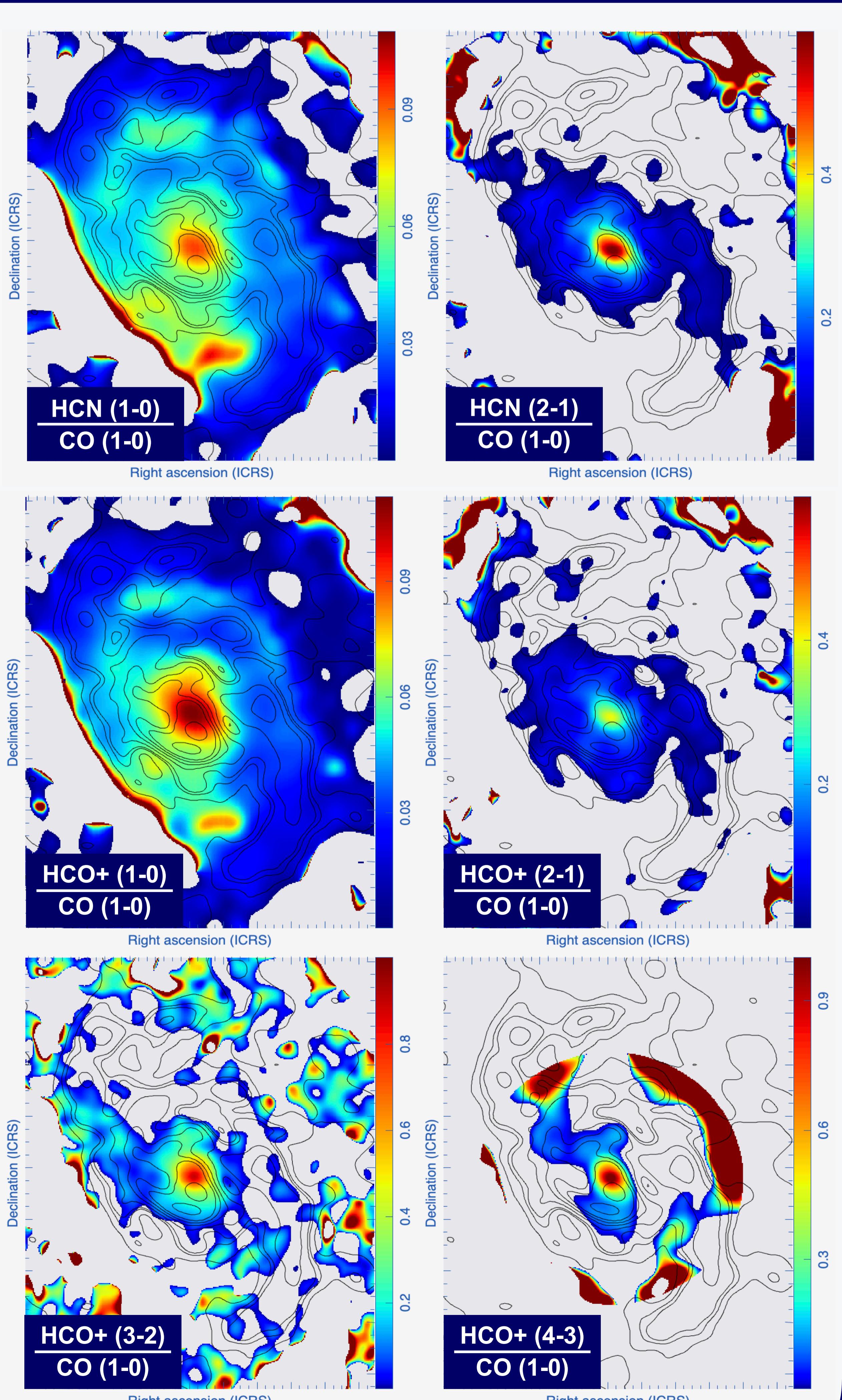
- Ratio spike: AGN?**  
Compact and violent effects in the center of the galaxy.
- Extended Ratio Enhancement:**  
Both outflow and star formation can be taken into consideration.
- Scattered patches along arms:**  
Star formation? or shaped by environmental conditions?

## Circinus Galaxy

Nearest Seyfert II Galaxy  
& MASER Galaxy

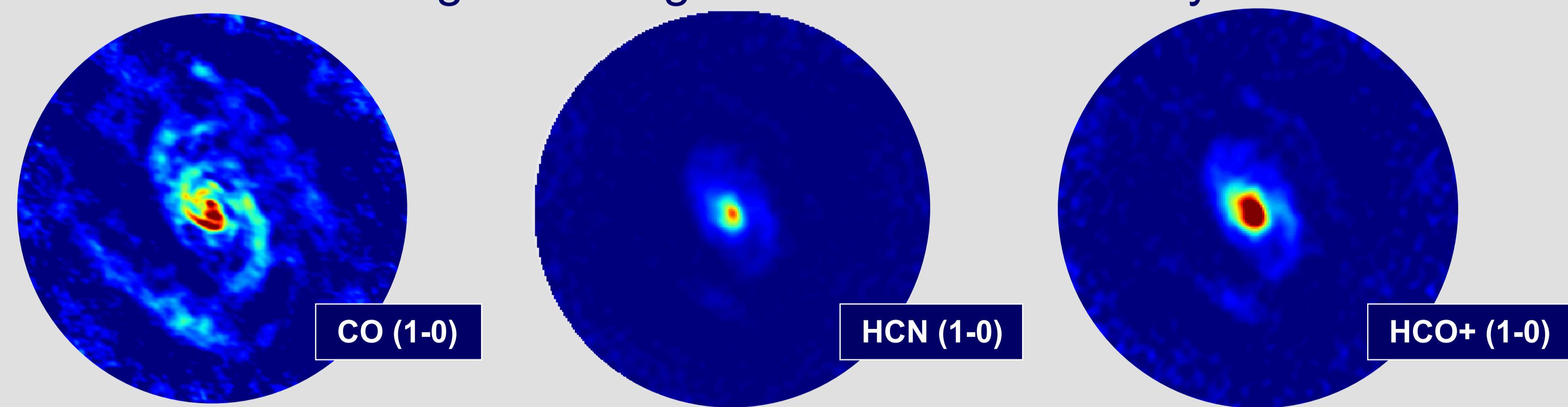


## Dense Gas Ratios



## Insights from Ratio Maps:

- Arm-like structures:**  
The arm features in ratio maps and mom0 are somewhat different. The ratio arm in the top-left **appears in the region where the molecular gas is not strongly concentrated**, suggesting that its origin may be related to elevated excitation conditions, rather than simply tracing the bulk molecular gas distribution. This feature is observed in both HCN(1-0) and HCO+(1-0) ratios.
- Ratio maximum:**  
All ratio maps show that the **ratio maximum is offset from the CO(1-0) emission peak**. This feature shows that gas ratios are not simply following the molecular gas distribution that traced by CO(1-0), but are linked to regions of high excitation and density.



## Future Work: Modeling with the “BASIL”

As the project progresses, more CO transition data will be available.

- Modeling will recover the distribution of low-J CO without being limited by resolution.
- By **constraining the physical conditions** with line ratios, we can test whether dense-gas ratios provide a practical diagnostic of galactic environments. If confirmed, this approach could reduce the need for detailed modeling in similar systems.

Method: Bayesian Active Spectral-cube Inference and Learning

BASIL is an LTE-based framework that estimates physical conditions in line-rich spectral cubes, operating several orders of magnitude faster than traditional MCMC fitting (Lin et al. 2025).