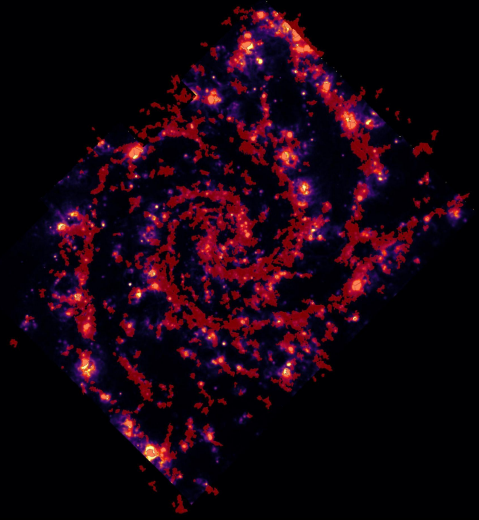
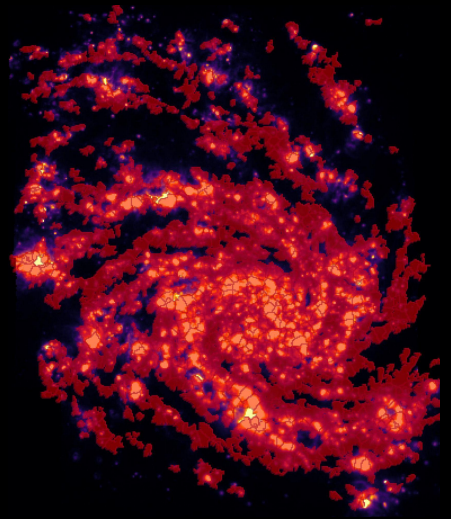
The impact of HII regions on Giant Molecular Cloud properties in nearby galaxies sampled by PHANGS ALMA and MUSE





Antoine Zakardjian, Jérôme Pety, Annie Hughes

Cinthya Herrera, Kathryn Kreckel, Elias Oakes

Simon Glover, Ralf Klessen, Sharon Meidt

And

Final stages of cloud evolution involve cloud disruption by stellar feedback

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→**Importance of pre-supernovae feedback ?**

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→**Importance of pre-supernovae feedback ?**

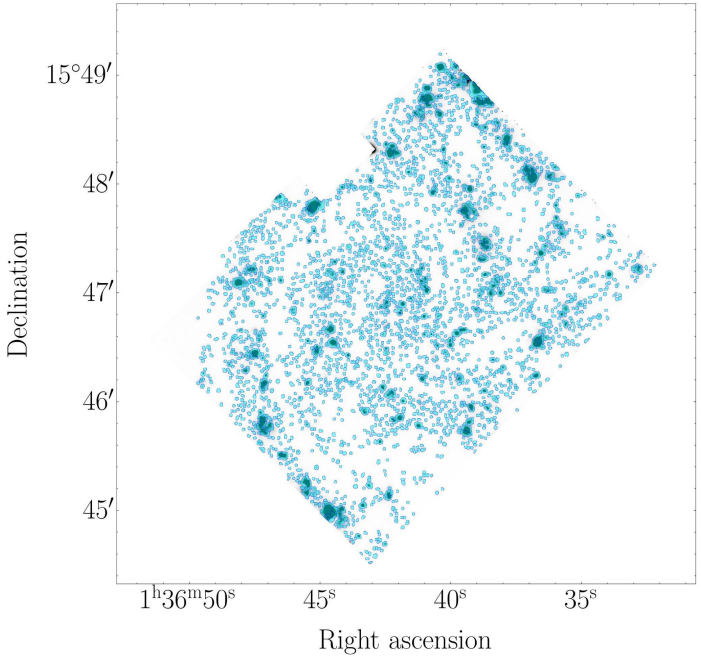
→Statistical study of a large sample of HII regions and GMCs

Santoro et al. (2022)

Emsellem et al. (2022)

HII regions:

- Nebulae catalogue from PHANGS-MUSE survey
- **32 000** HII regions
- Observed in Hα
- 19 nearby galaxies

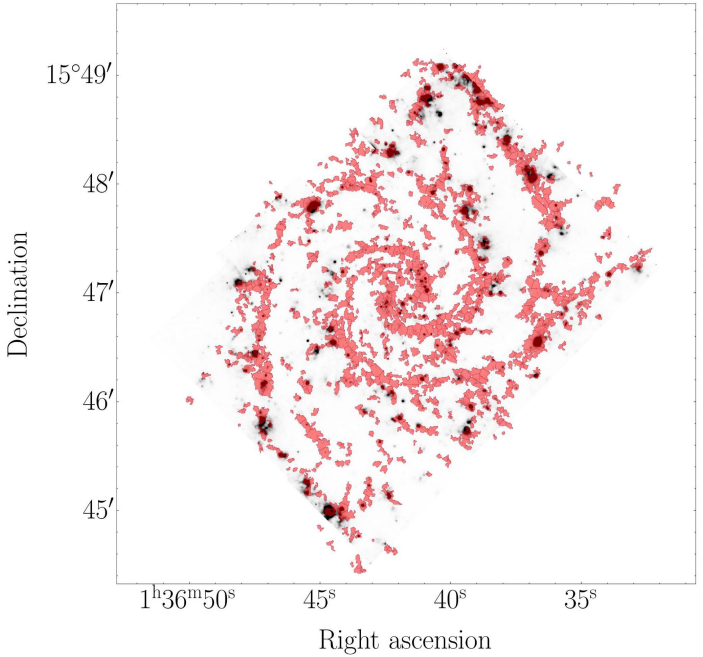


Rosolowsky et al. (2021)

Leroy et al. (2022)

Molecular clouds:

- Cloud catalogue from PHANGS-ALMA survey
- **11 000** molecular clouds
- Observed in 12CO(2-1)
- 19 nearby galaxies



Properties of interest:

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- **Hα luminosity**: Luminosity of an HII region in Hα

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- **Tpeak**: Maximum CO brightness temperature of the cloud

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- **Hα luminosity**: Luminosity of an HII region in Hα
- **Tpeak**: Maximum CO brightness temperature of the cloud
- **$\sigma_0 = \sigma_v / \sqrt{\text{Radius}}$:** Cloud normalized velocity dispersion

Need to associate HII regions and Clouds to perform our analysis

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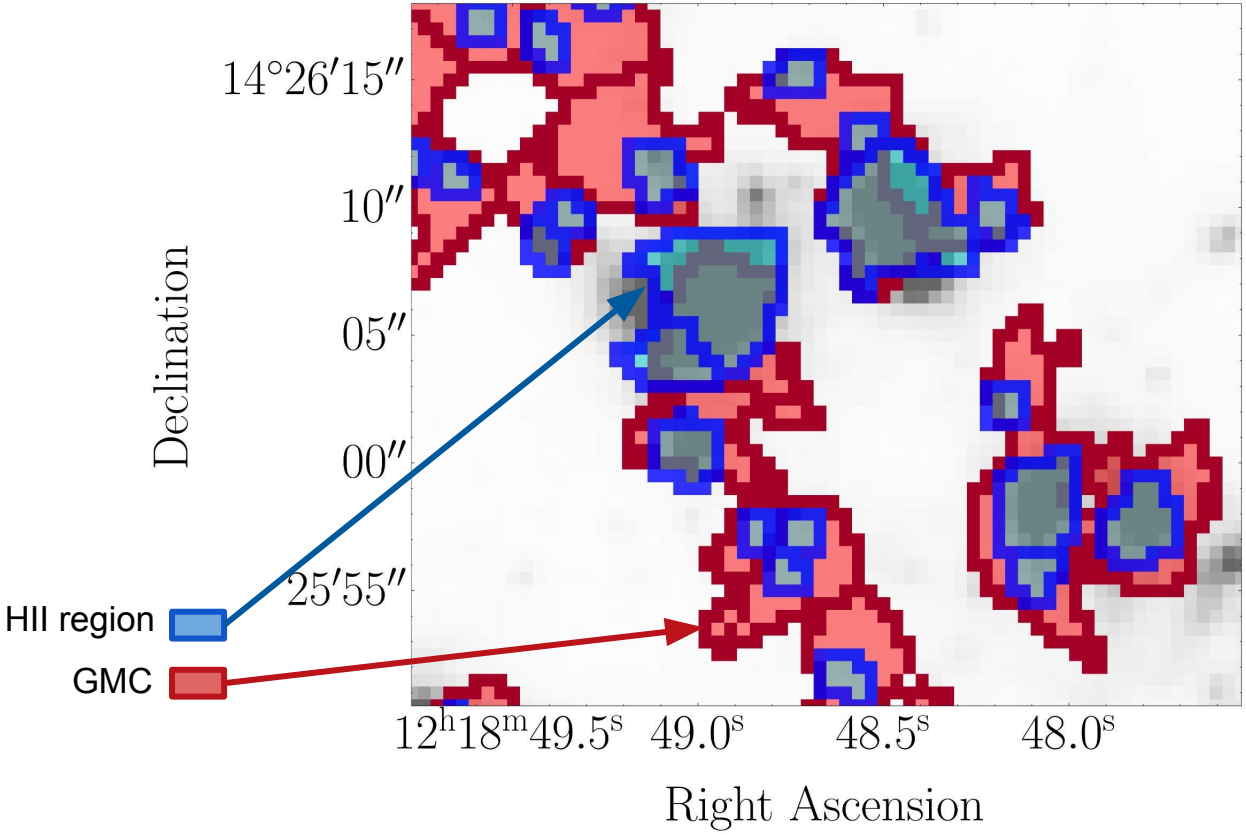
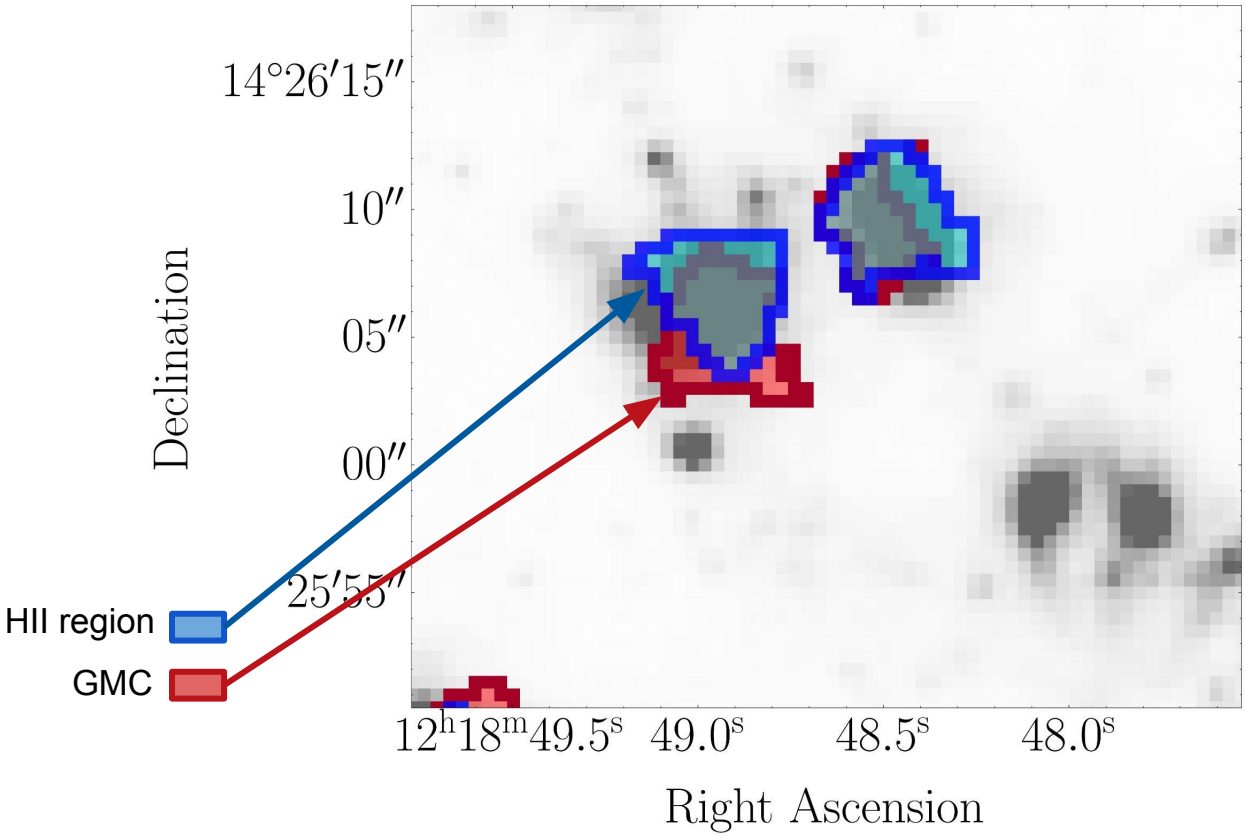
→**Matching** method based on **2D spatial overlap** of **clouds** and **HII regions**



Matching parameter :
Overlap percentage
=
overlap area / GMC area

Symmetry :
Several HII region
per GMC
&
1 GMC per HII region

Minimal Overlap Percentage = 10%



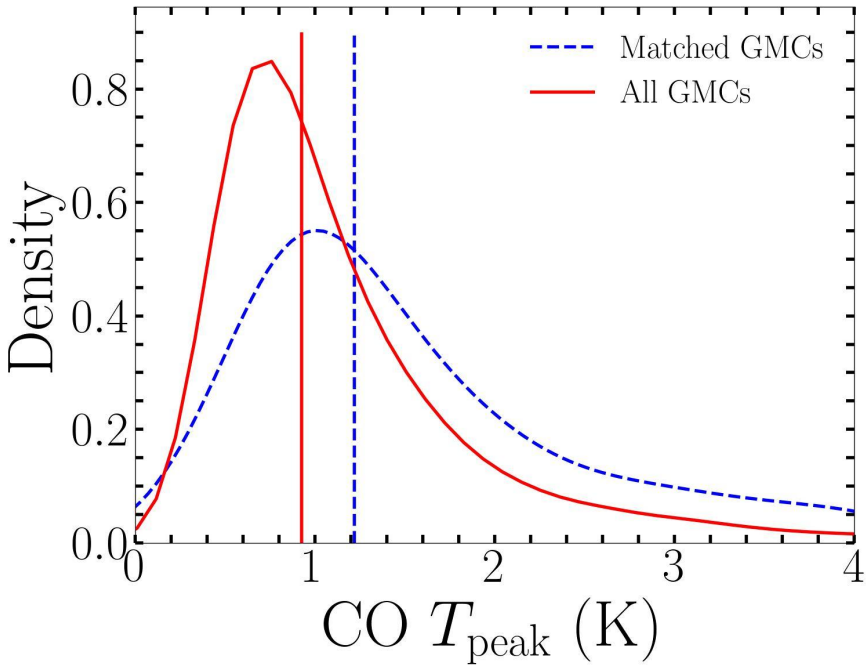
Matching parameter :
Overlap percentage
=
overlap area / GMC area

Symmetry :
Several HII region
per GMC
&
1 GMC per HII region

Minimal Overlap Percentage = 50%

1. Clouds peak temperature:

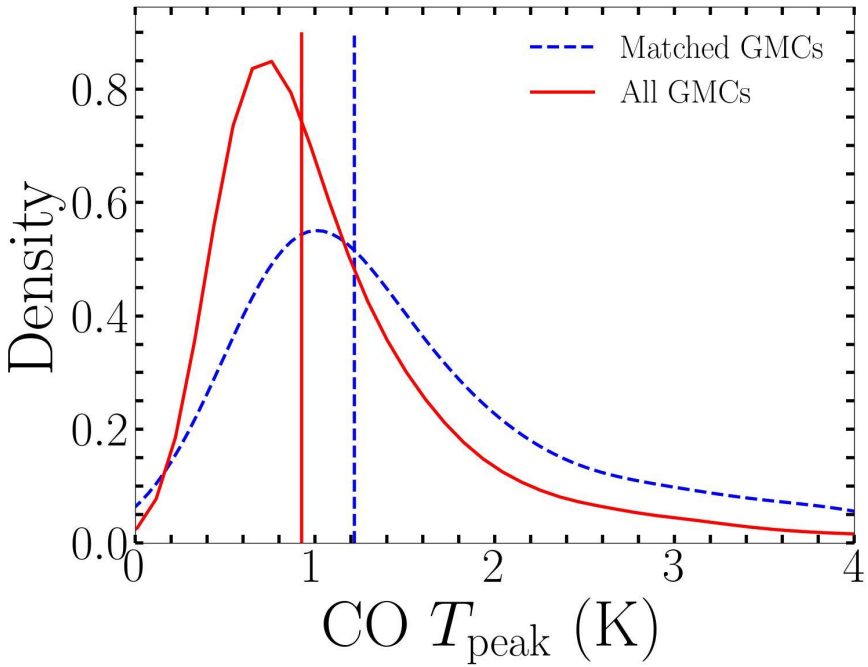
Minimal overlap = 70%



1. Clouds peak temperature:

→ **Matched clouds** have median **peak temperature higher** than global sample

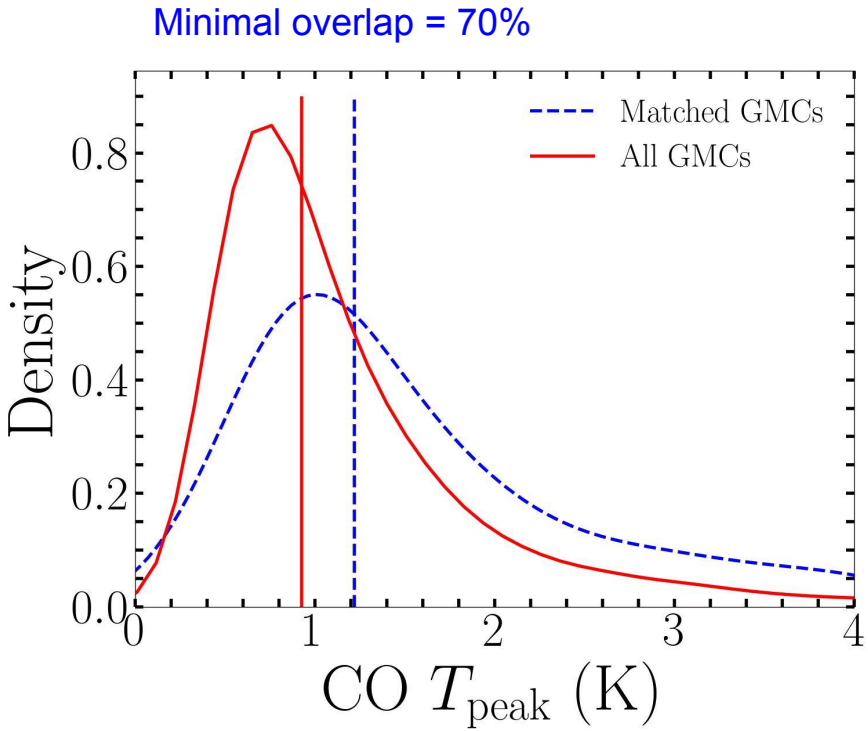
Minimal overlap = 70%



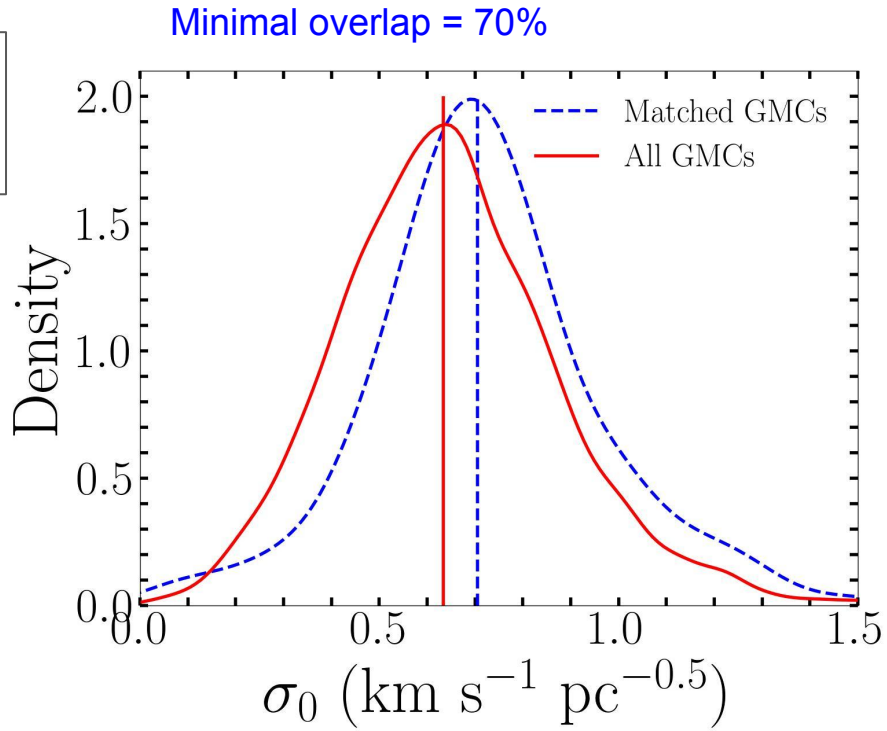
1. Clouds peak temperature:

→ **Matched clouds** have median **peak temperature higher** than global sample

→ Shift increases with overlap

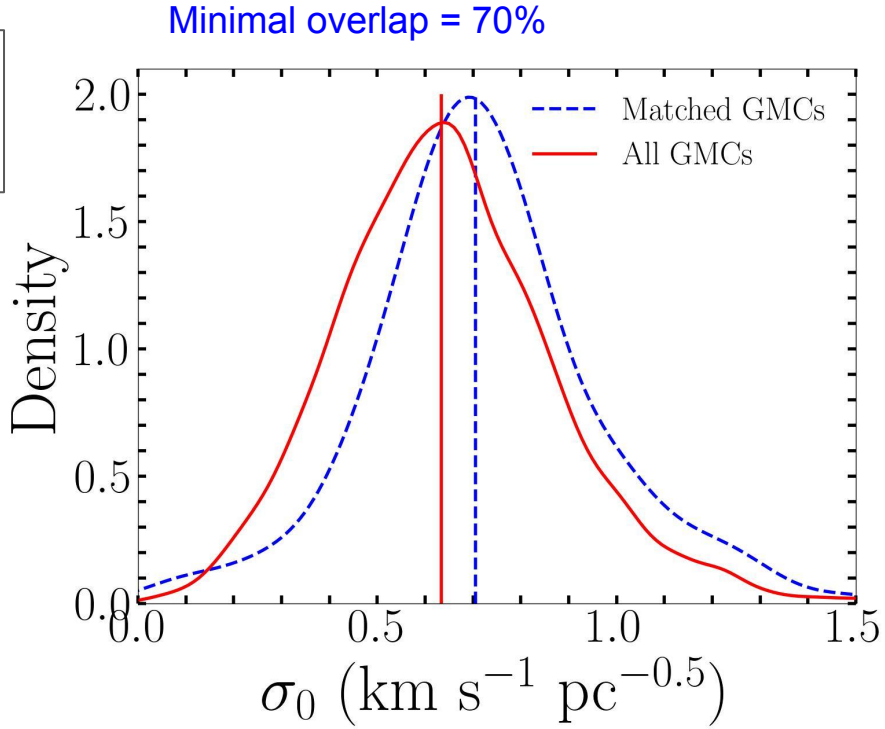


1. Clouds normalized velocity dispersion (σ_0):



1. Clouds normalized velocity dispersion (σ_0):

→ **Matched clouds** have median σ_0 **higher** than global sample

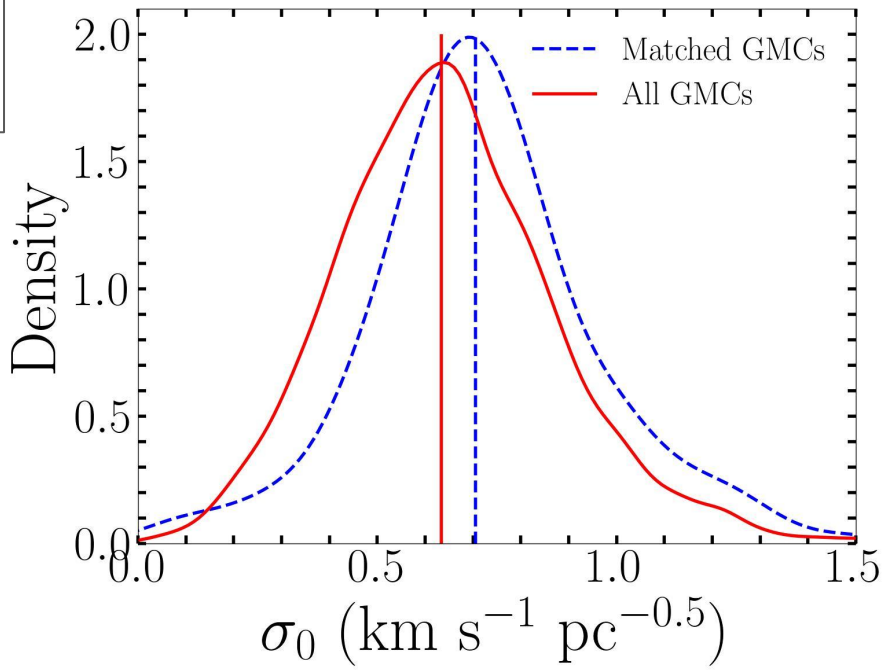


1. Clouds normalized velocity dispersion (σ_0):

→ **Matched clouds** have median **σ_0 higher** than global sample

→ Shift increases with overlap

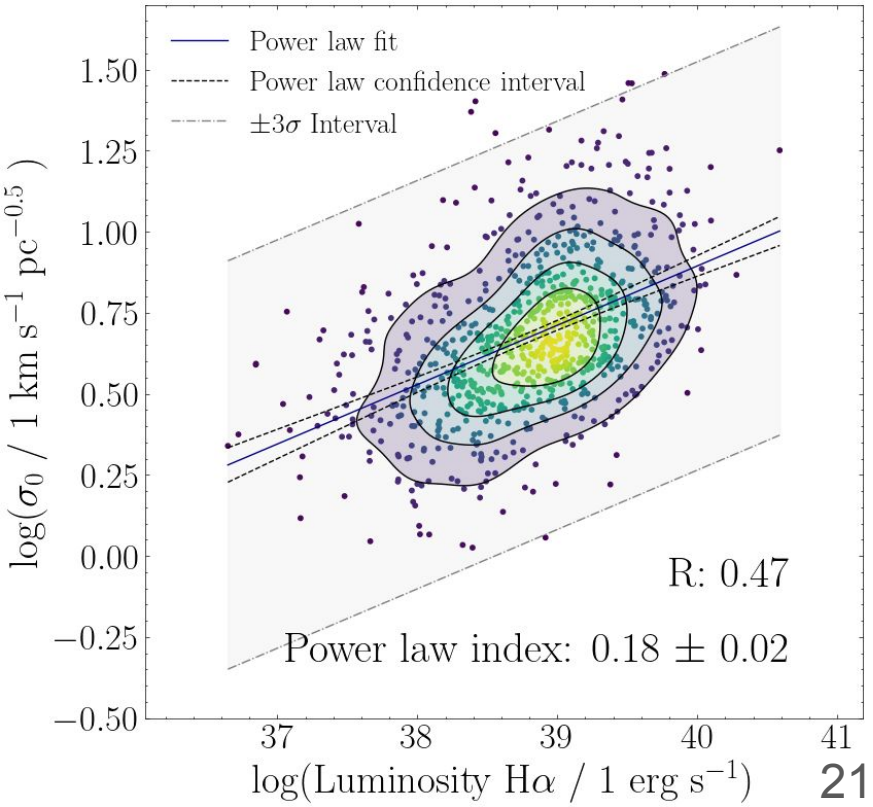
Minimal overlap = 70%



2. Normalized velocity σ_0 and Hα luminosity correlation:

All matched clouds and HII regions from all 19 galaxies

Minimal overlap = 40%

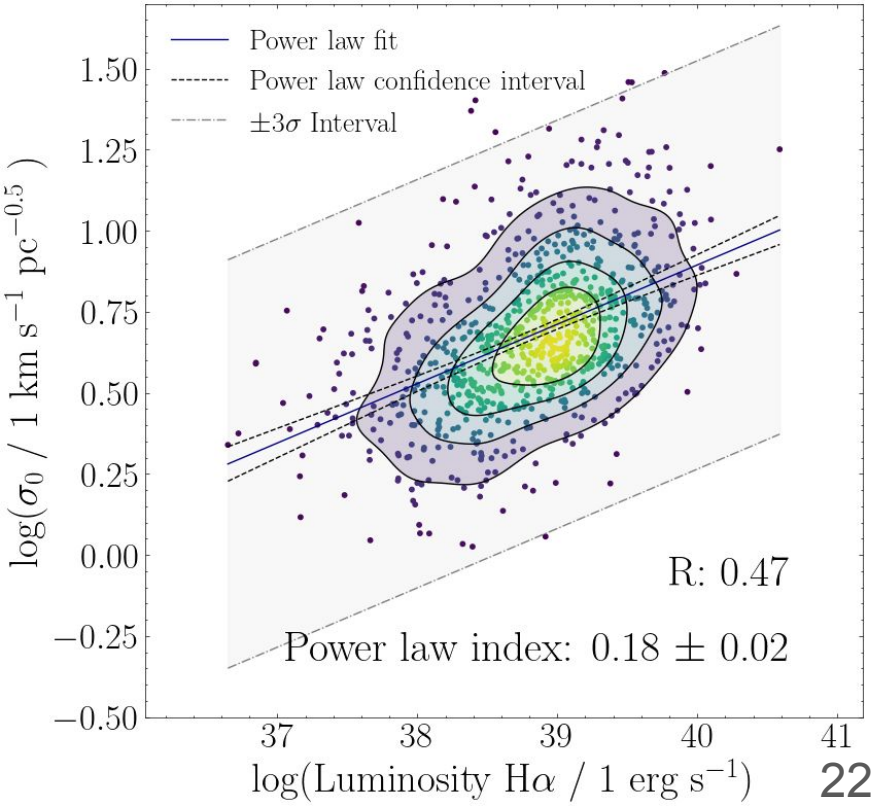


2. Normalized velocity σ_0 and Hα luminosity correlation:

All matched clouds and HII regions from all 19 galaxies

→ **R = 0.47:** Significant correlation

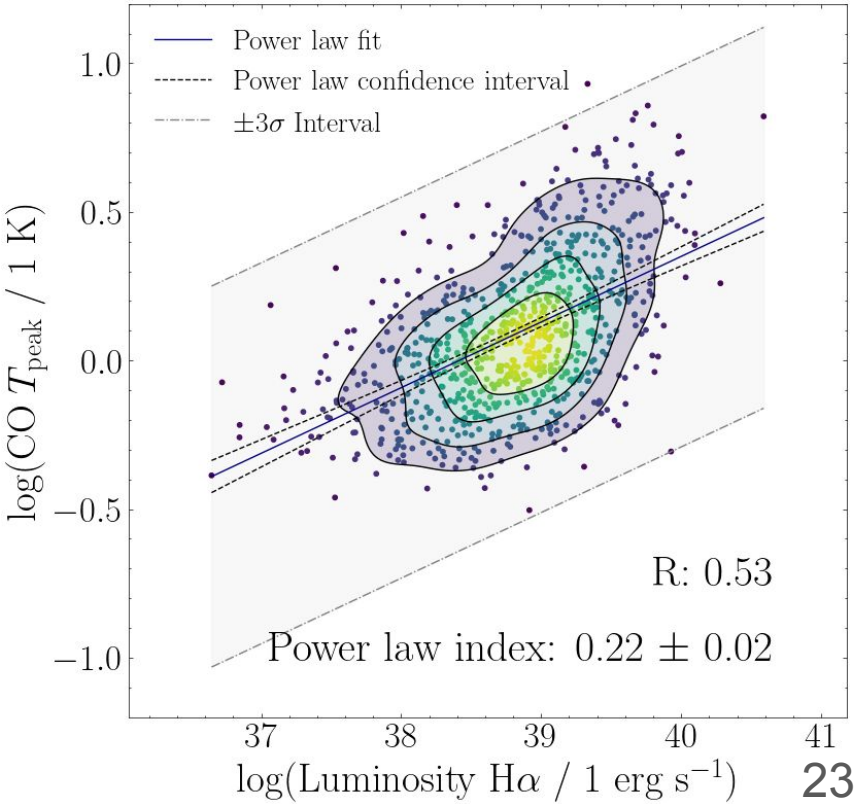
Minimal overlap = 40%



2. Peak temperature and Hα luminosity correlation:

All matched clouds and HII regions from all 19 galaxies

Minimal overlap = 40%

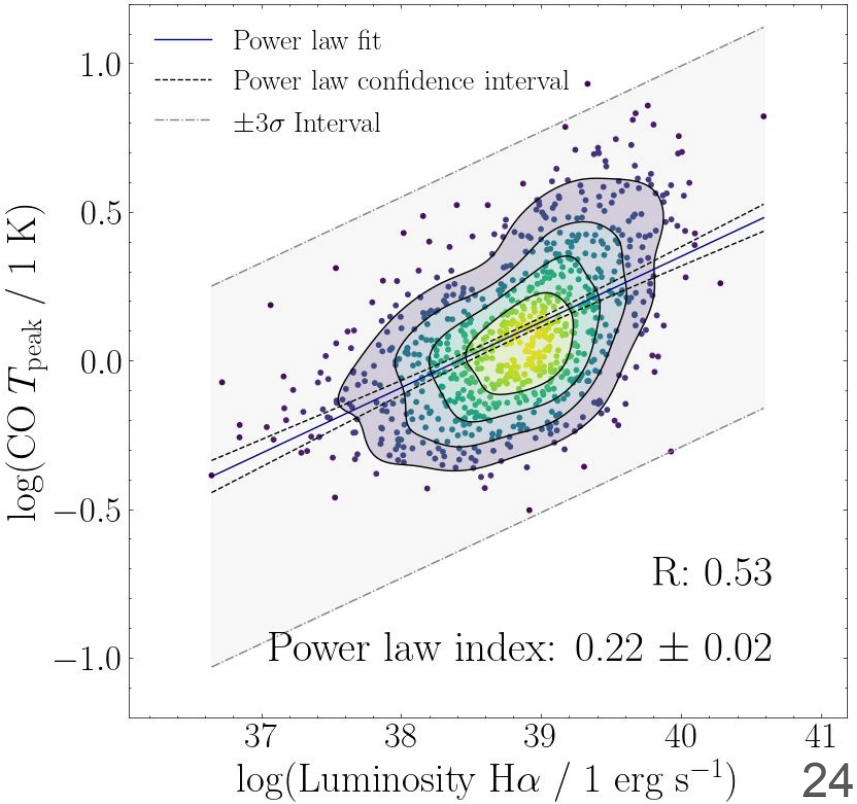


2. Peak temperature and Hα luminosity correlation:

All matched clouds and HII regions from all 19 galaxies

→ **R = 0.53:** Significant correlation

Minimal overlap = 40%

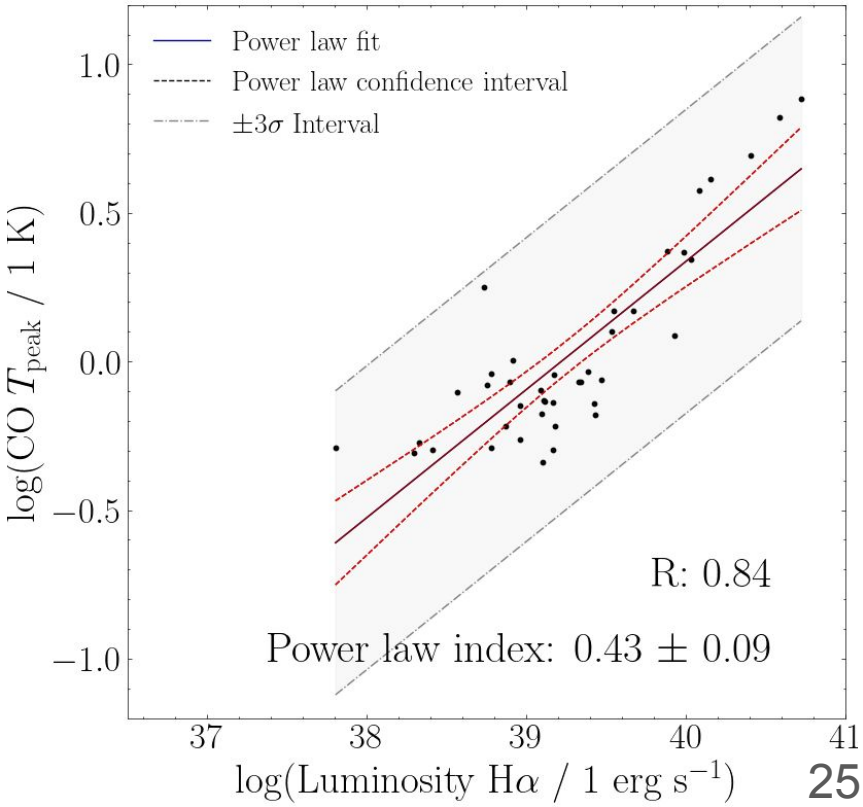


3. Correlations changes with galaxy

→ **Strong** correlation (**R = 0.84**)

in **NGC1672**

Minimal overlap = 40%



3. Correlations changes with galaxy

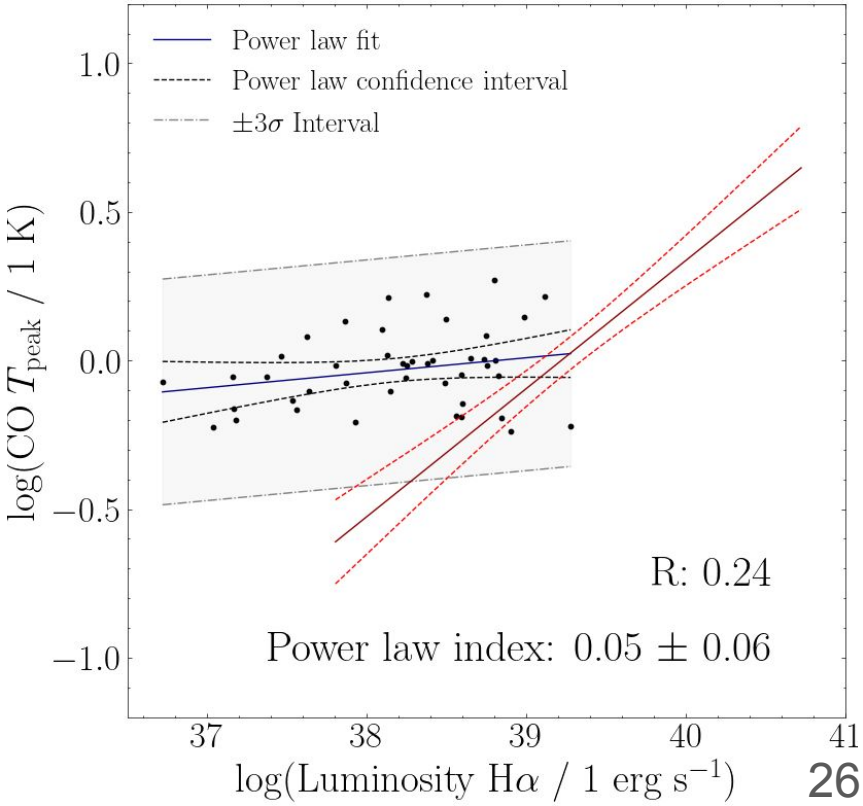
→ **Strong** correlation (**R = 0.84**)

in **NGC1672**

→ **Negligeable** correlation (**R = 0.24**)

in **NGC1433**

Minimal overlap = 40%



Conclusion

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Conclusion

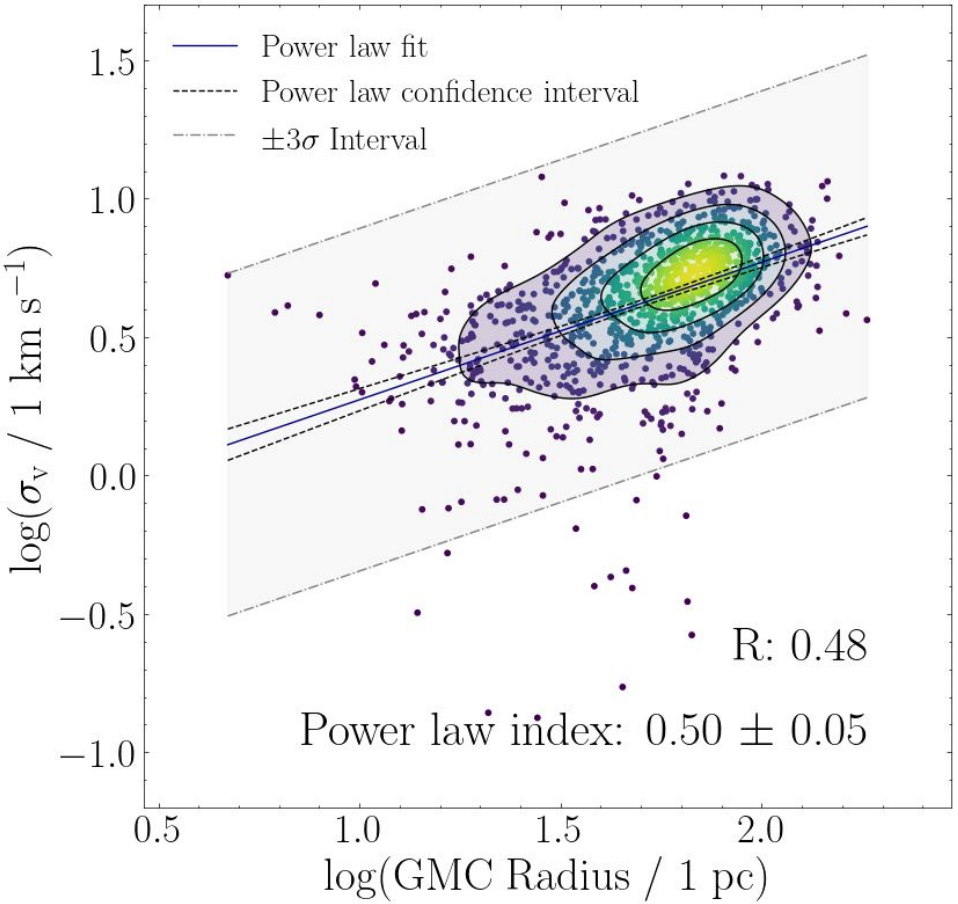
- Clouds associated with an HII region have on average a higher peak brightness temperature and normalized velocity dispersion
- There is a correlation of HII region luminosity with cloud peak temperature and with cloud normalized velocity dispersion
- **There is a large variability of the correlations galaxy by galaxy**

Annexes

Annexes

Larson law:

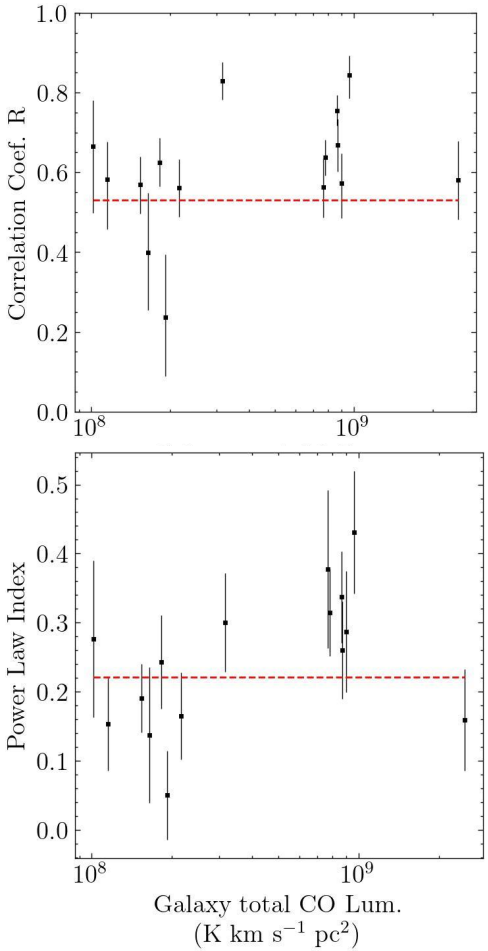
- $\sigma_v \propto \sqrt{\text{Radius}}$



3. Correlations changes with galaxy

→ **Larger variability** galaxy by galaxy than by environment

→ **Main driver** is the galaxy's **total CO luminosity**

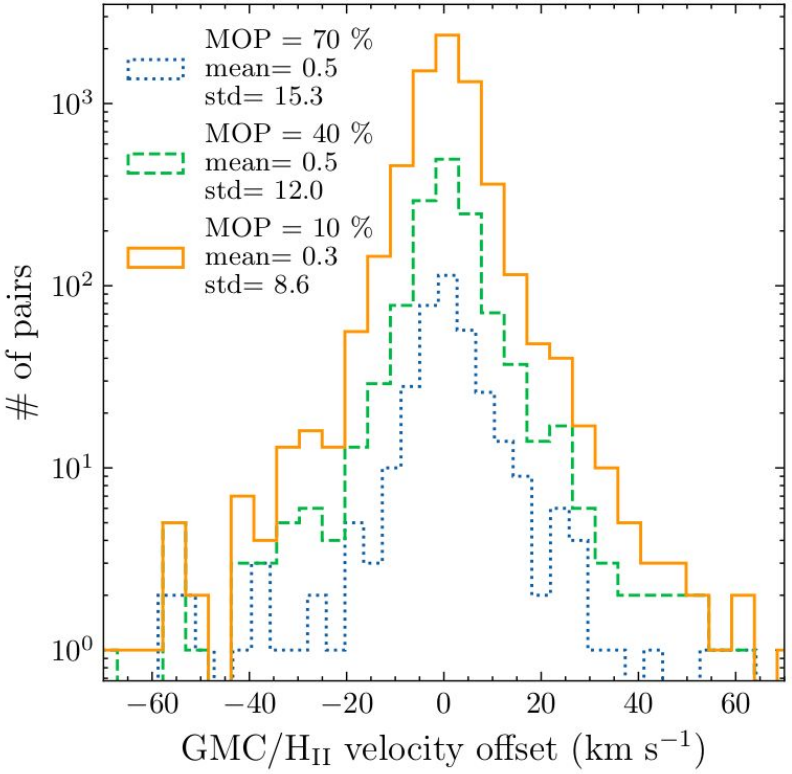


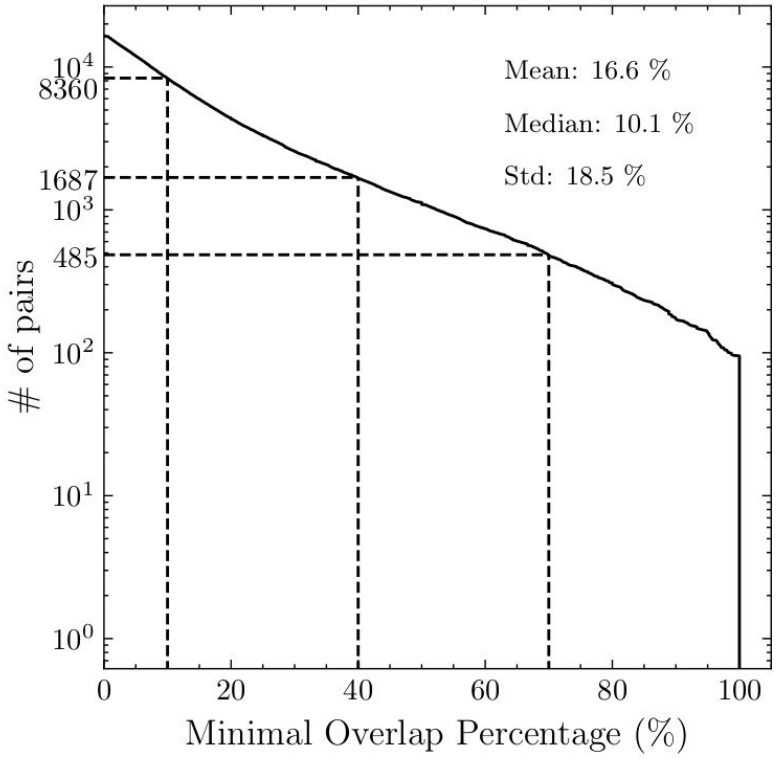
Minimal overlap = 40%

Annexes

Galaxy	Distance [Mpc]	Incl. [deg]	Morph.	Stellar Mass [$\log_{10} M_\odot$]	Linear Res. [ALMA, pc]	Linear Res. [MUSE, pc]
IC 5332	9.0	27	SABc	9.7	32	38
NGC 0628	9.8	9	Sc	10.3	53	44
NGC 1087	15.8	43	Sc	9.9	123	71
NGC 1300	19.0	32	Sbc	10.6	112	82
NGC 1365	19.6	55	Sb	11.0	131	109
NGC 1385	17.2	44	Sc	10.0	106	56
NGC 1433	18.6	29	SBa	10.9	98	82
NGC 1512	18.8	42	Sa	10.7	115	114
NGC 1566	17.7	30	SABb	10.8	95	69
NGC 1672	19.4	43	Sb	10.7	182	90
NGC 2835	12.2	41	Sc	10.0	50	68
NGC 3351	10.0	45	Sb	10.4	70	51
NGC 3627	11.3	57	Sb	10.8	89	58
NGC 4254	13.1	34	Sc	10.4	113	57
NGC 4303	17.0	24	Sbc	10.5	152	64
NGC 4321	15.2	38	SABb	10.7	126	86
NGC 4535	15.8	45	Sc	10.5	119	43
NGC 5068	5.2	36	Sc	9.4	26	26
NGC 7496	18.7	36	Sb	10.0	152	81

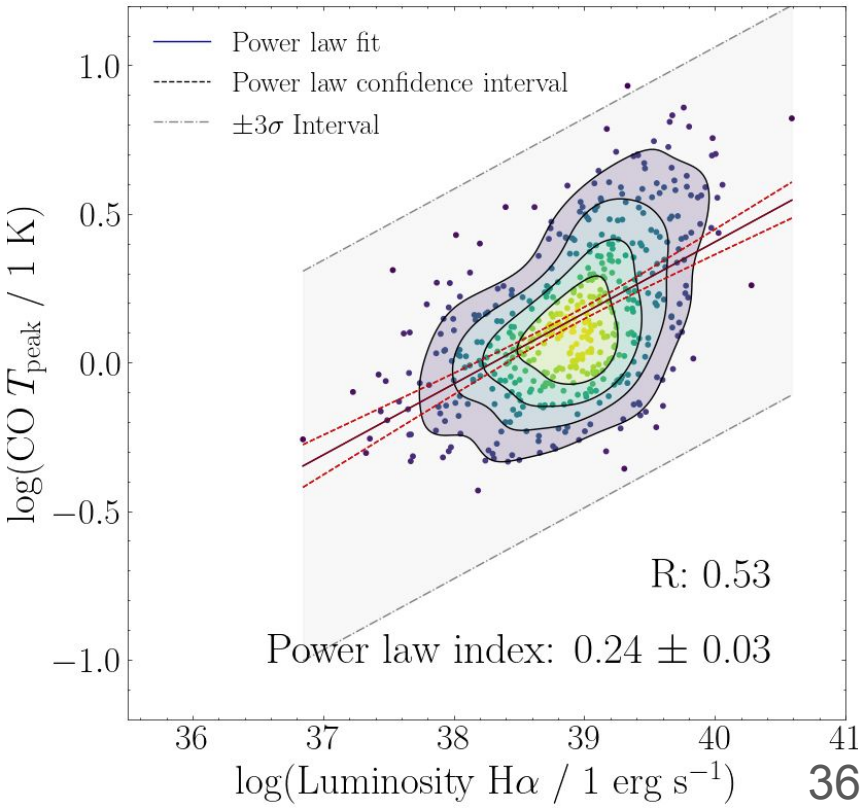
Annexes


MOP = 70 %
mean= 0.5
std= 15.3
MOP = 40 %
mean= 0.5
std= 12.0
MOP = 10 %
mean= 0.3
std= 8.6
# of pairs
GMC/H$_{II}$ velocity offset (km s^{-1})


Mean: 16.6 %
Median: 10.1 %
Std: 18.5 %
8360
1687
485
# of pairs
Minimal Overlap Percentage (%)

3. Correlations changes with galactic environment:

Minimal overlap = 40%

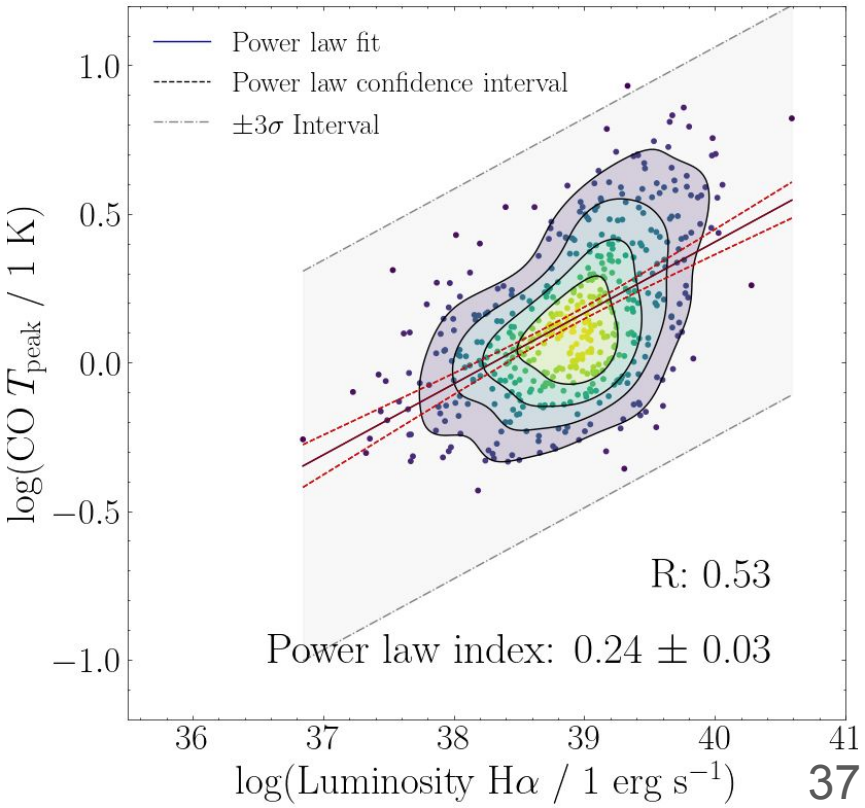


3. Correlations changes with galactic environment:

→ **Significant** correlation (**R = 0.53**)

in galaxies **centers** and **arms**

Minimal overlap = 40%



3. Correlations changes with galactic environment:

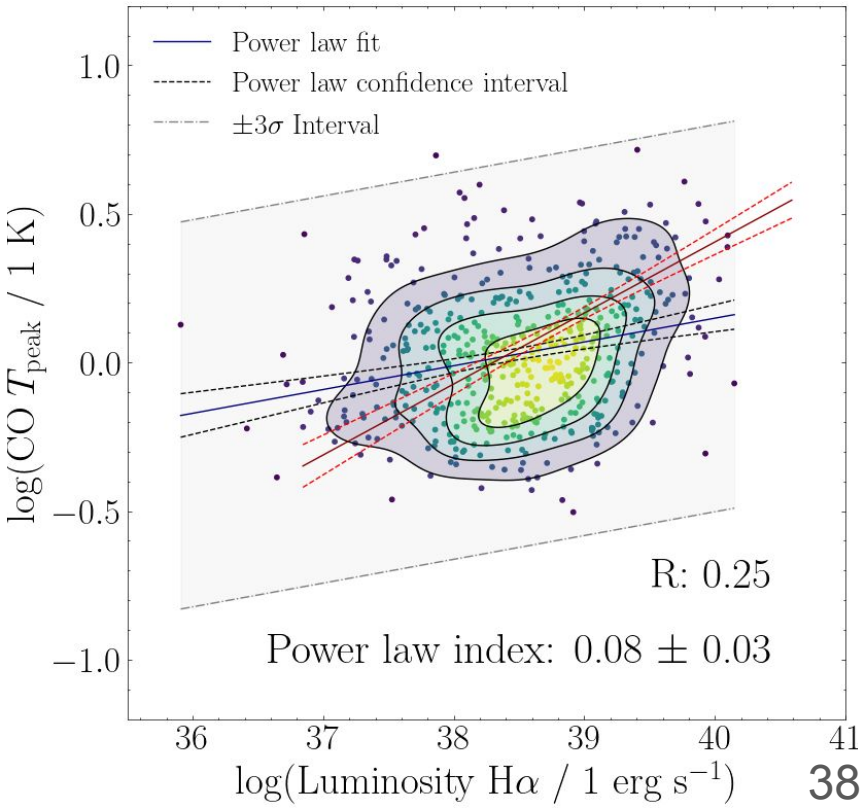
→ **Significant** correlation (**R = 0.53**)

in galaxies **centers** and **arms**

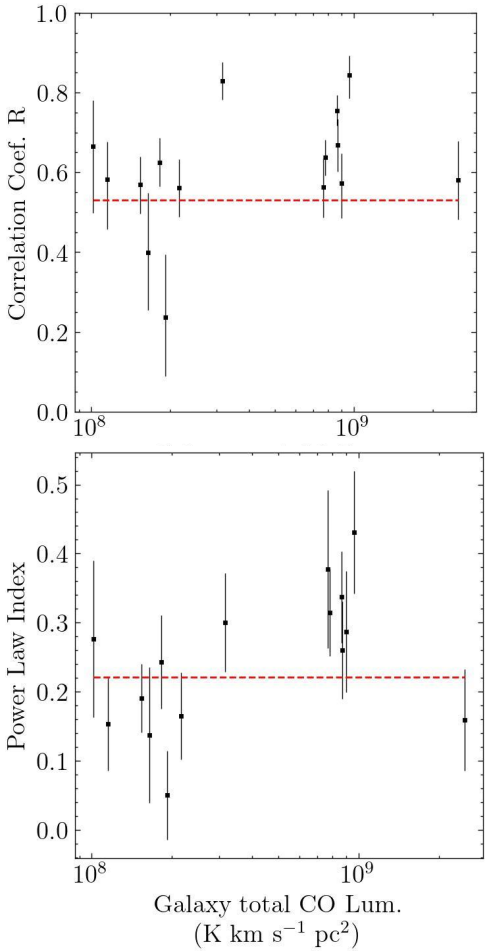
→ **Negligeable** correlation (**R = 0.24**)

in galaxies **disks** and **interarms**

Minimal overlap = 40%



3. Correlations changes with galaxy

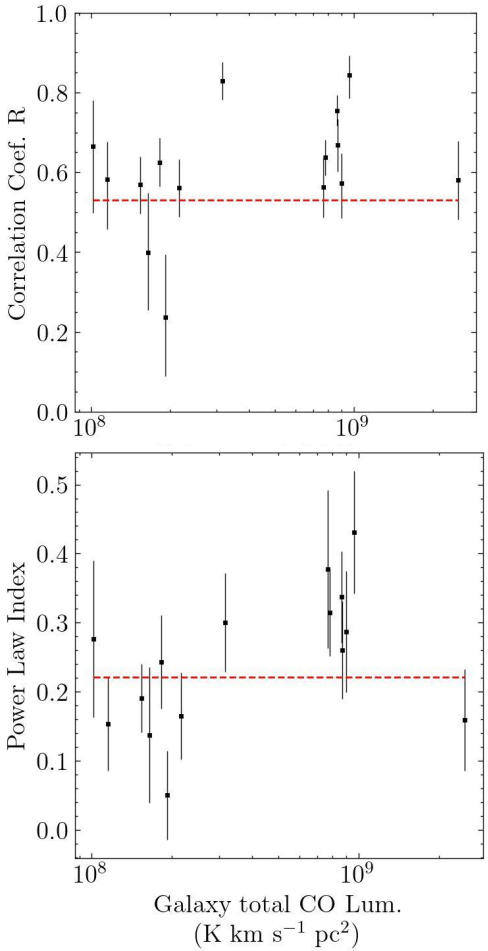


Minimal overlap = 40%

3. Correlations changes with galaxy

→ **Larger variability** galaxy by galaxy

than by environment



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