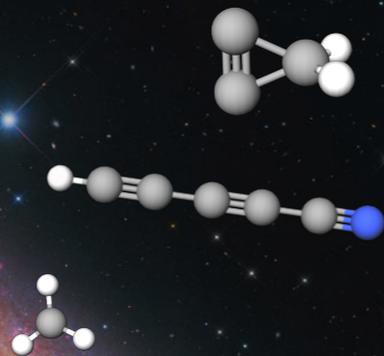
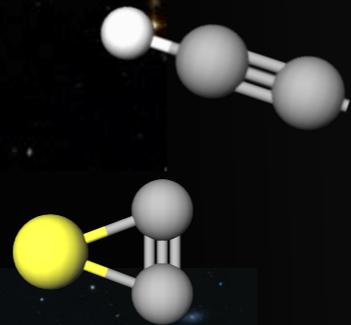


Extragalactic carbon chemistry in external galaxies (nearby)

Mathilde Bouvier
Postdoc @ Leiden Observatory



Feb. 25th 2026



Leiden Observatory



Carbon chain chemistry: why does it matter?



Fourth most abundant element in the local universe

~43% of ISM detected species

Plays a major role in interstellar chemistry and the formation of complex organic molecules, polycyclic aromatic hydrocarbons (PAHs), and carbonaceous grains

e.g. Thaddeus & McCarthy 2001, Balucani+2000, Balucani 2009, Jones 2012, Loison+2014, Taniguchi, Gorai & Tan 2024 and refs therein

Carbon chain chemistry: why does it matter?

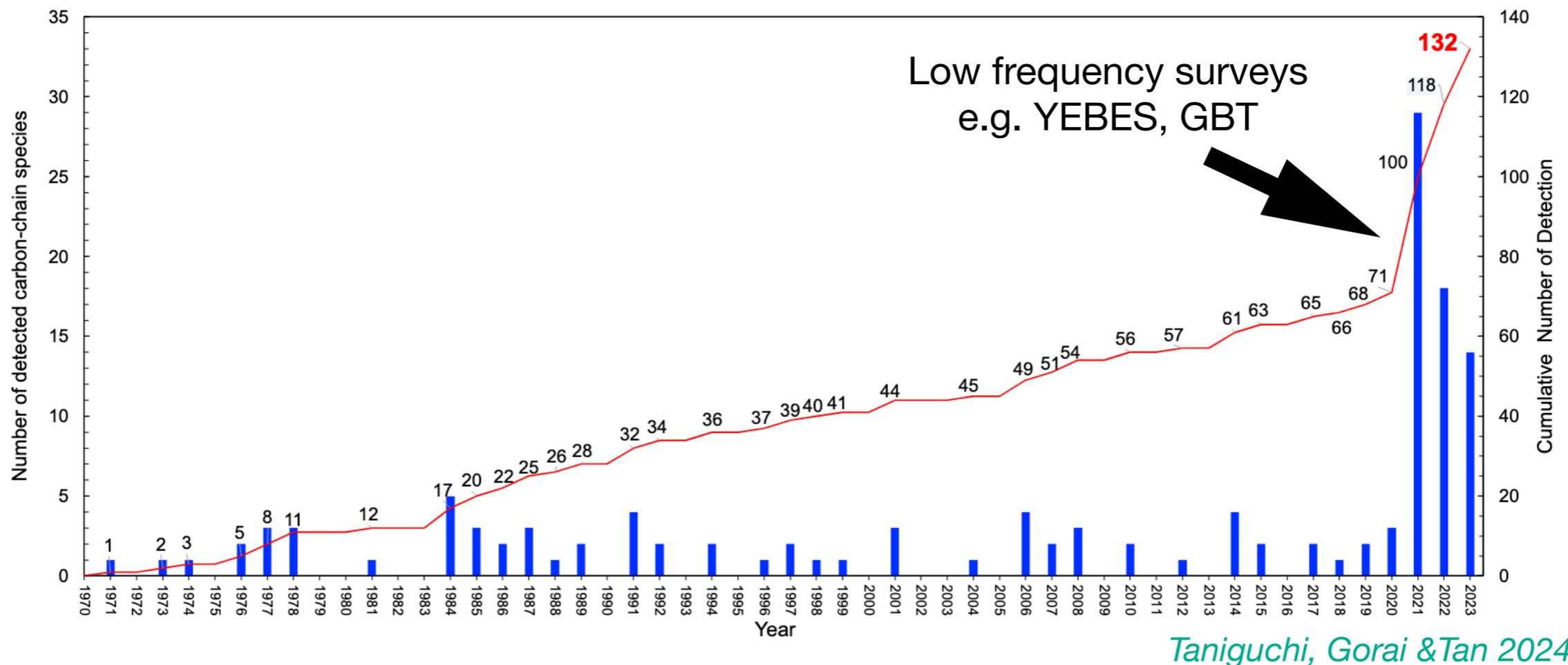


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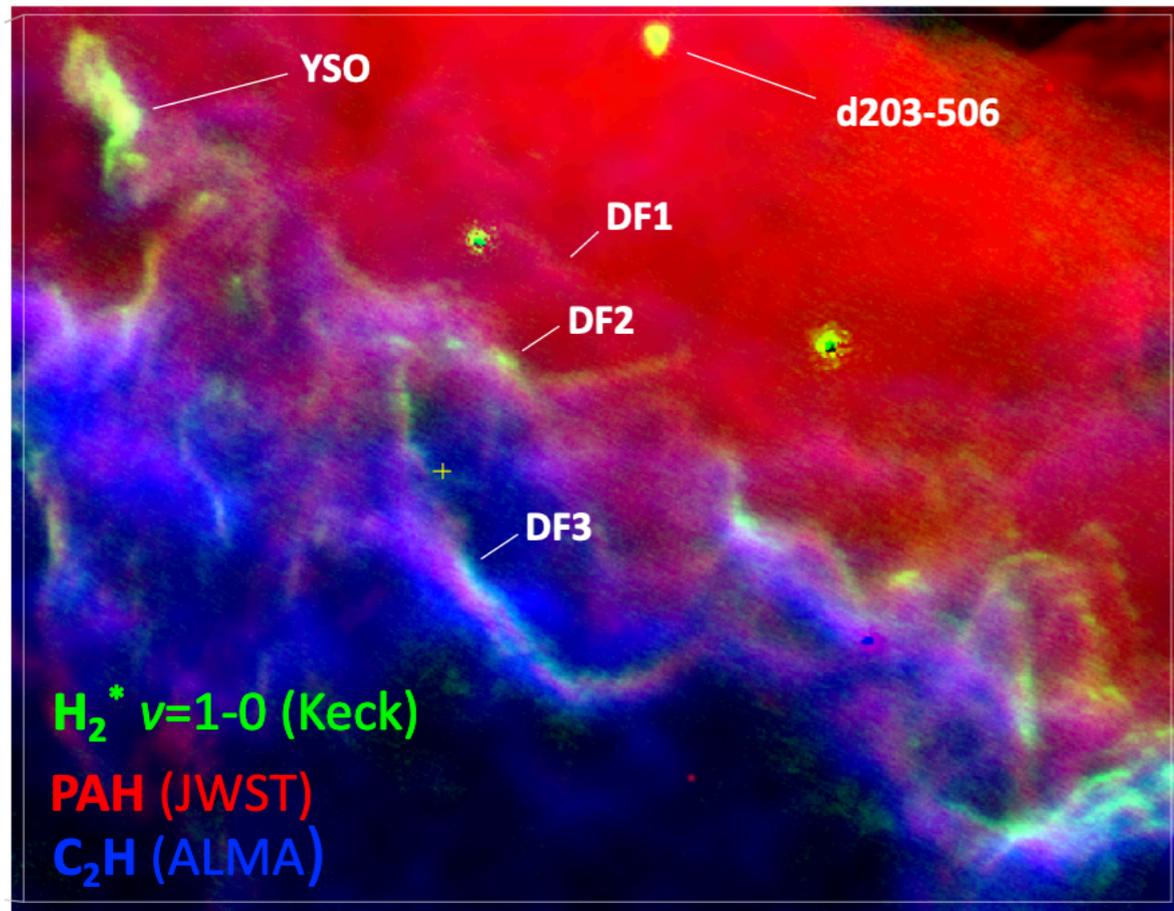


Carbon-bearing species: Useful diagnostic tools in our Galaxy

Carbon-bearing species: Useful diagnostic tools in our Galaxy

Tracers of UV-illuminated regions...

*e.g. Bizzocchi+2014, Guzman+2015, Fuente+1993,
Jansen+ 1995; Rodriguez-Franco+1998,
Pety+2005,2017, Pilleri+2013, Cuadrado+2015,
Guzman+2015, Spezzano+2016, Tiwari+2019,
Lin+2022; Bianchi+2023*



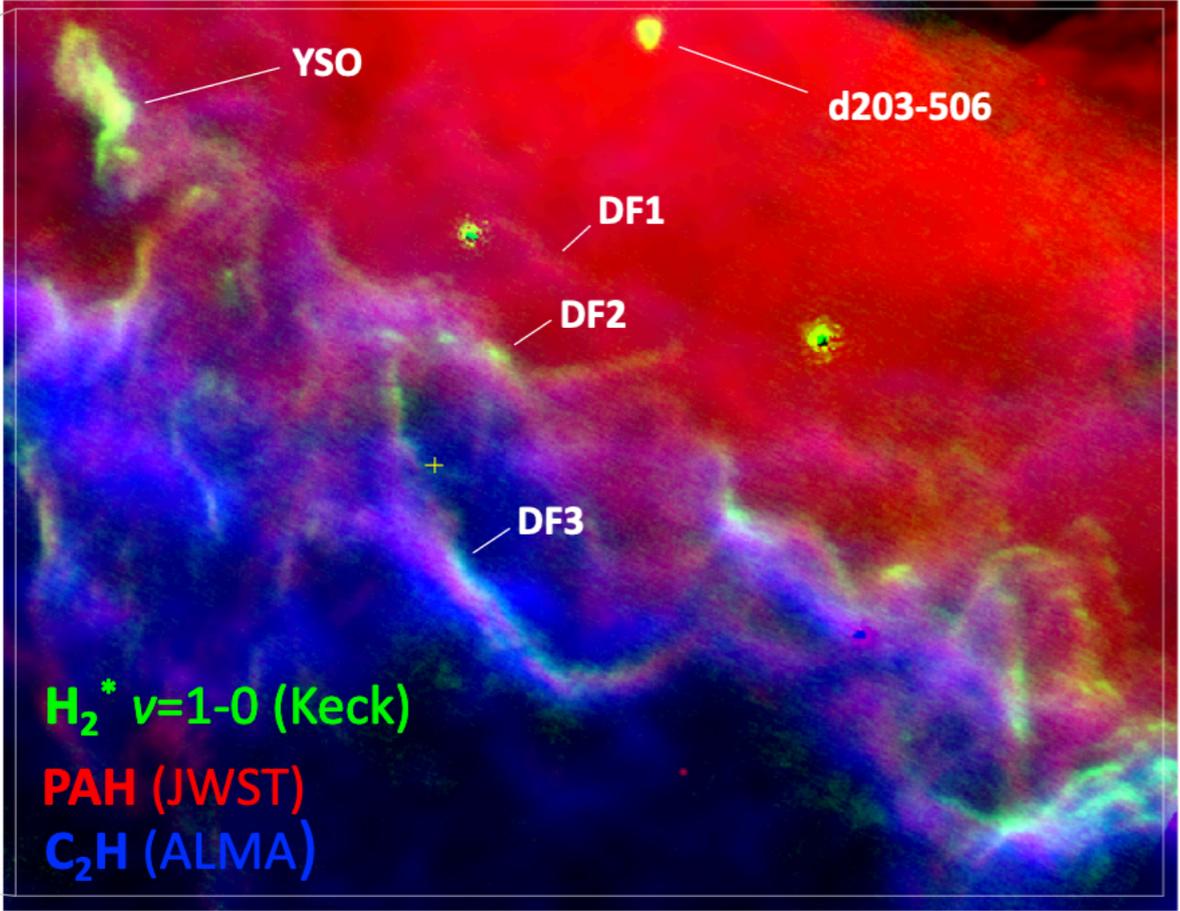
Link small carbon chain-PAHs

Goicoechea+2025 and refs therein

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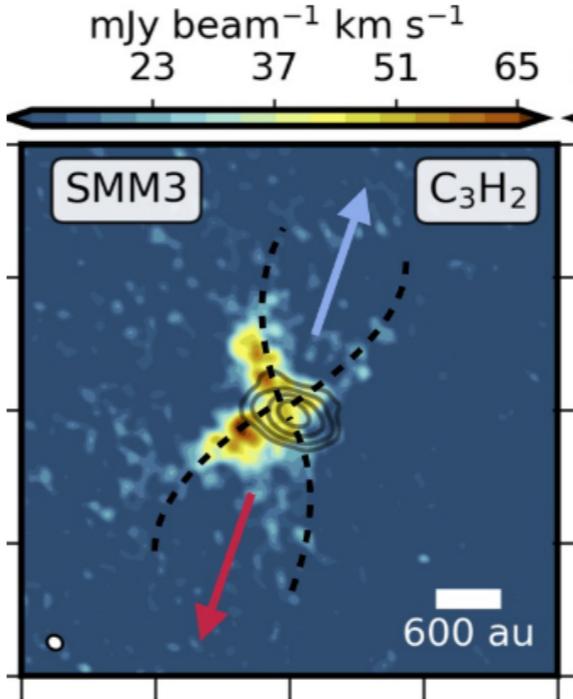
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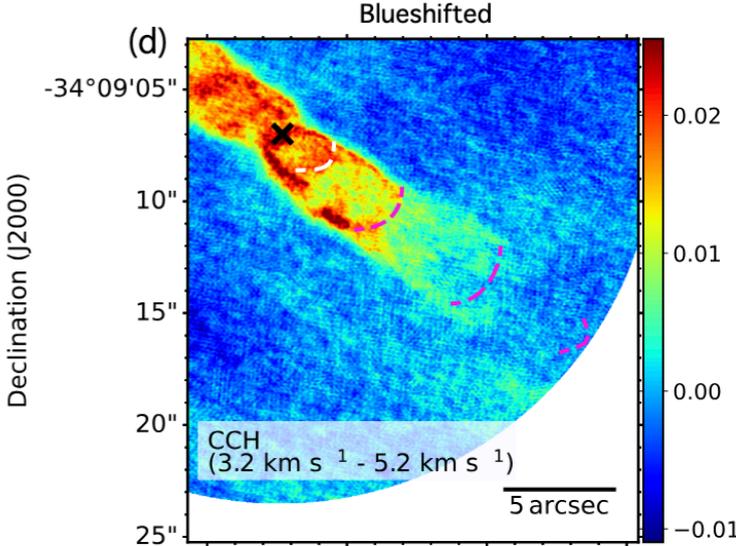
... and outflows/outflow cavities



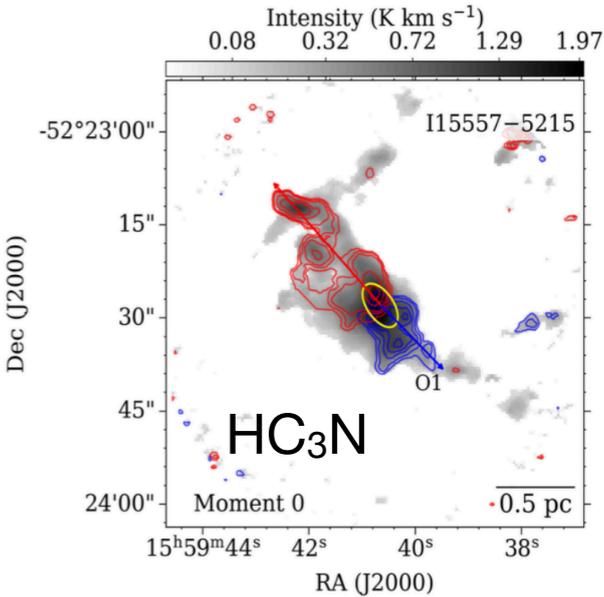
Tychoniec+2021

HC₃N: unbiased tracer of outflows (wrt evolutionary age)

Hoque+2025



Okoda+2025

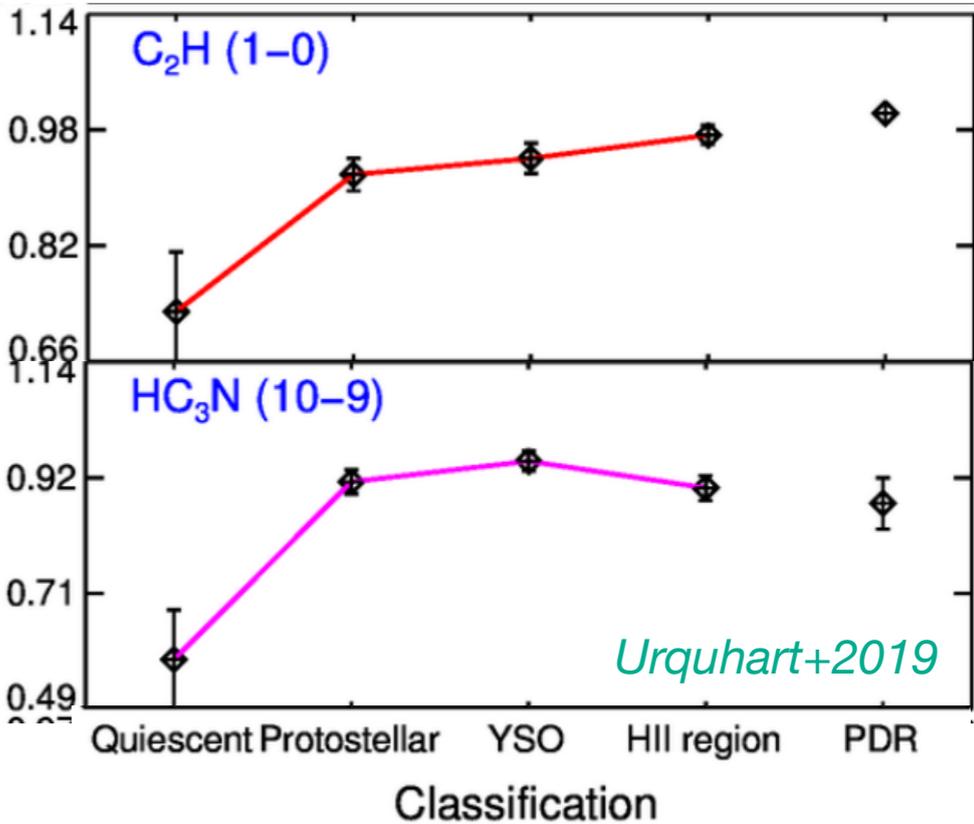
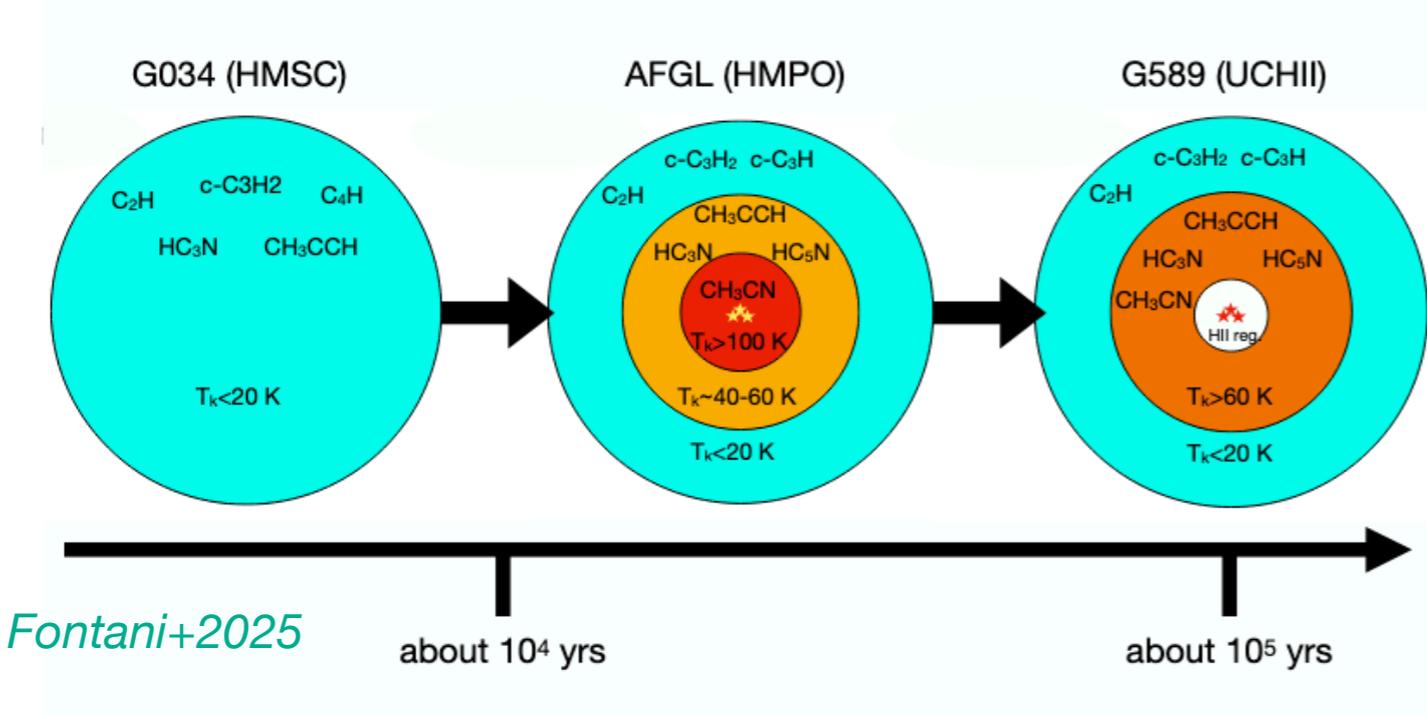


Also e.g. Oya+2014; Okoda+2018, Zhang+2018

Carbon-bearing species: Useful diagnostic tools in our Galaxy

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"Chemical clocks" for star formation

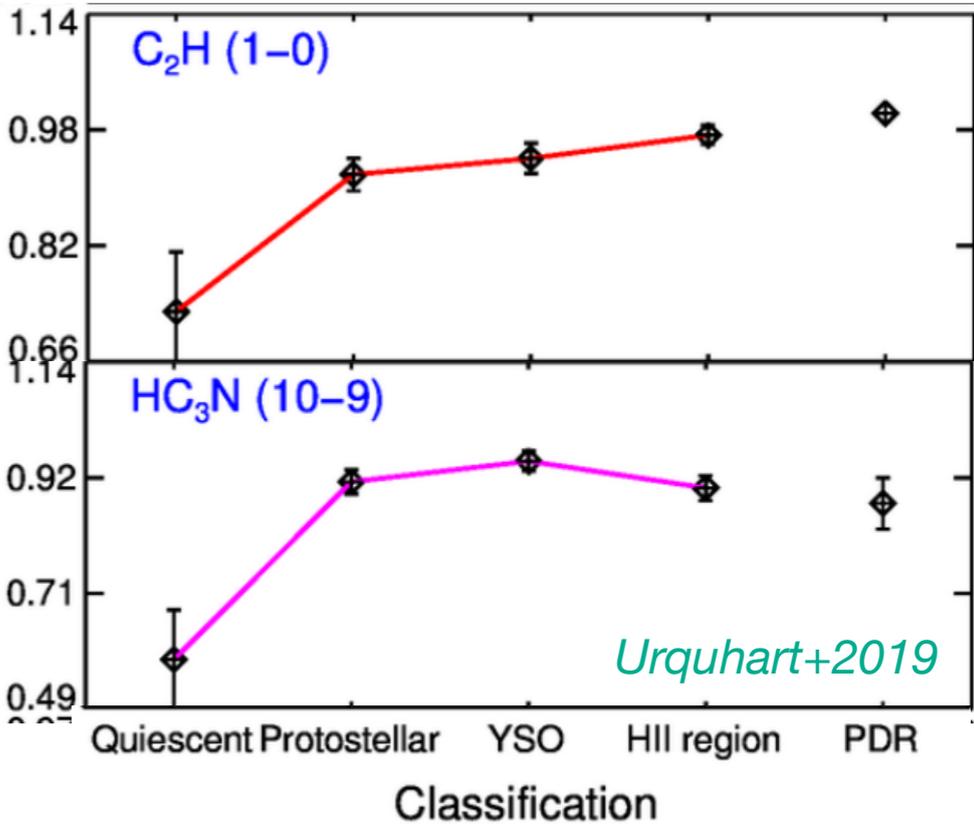
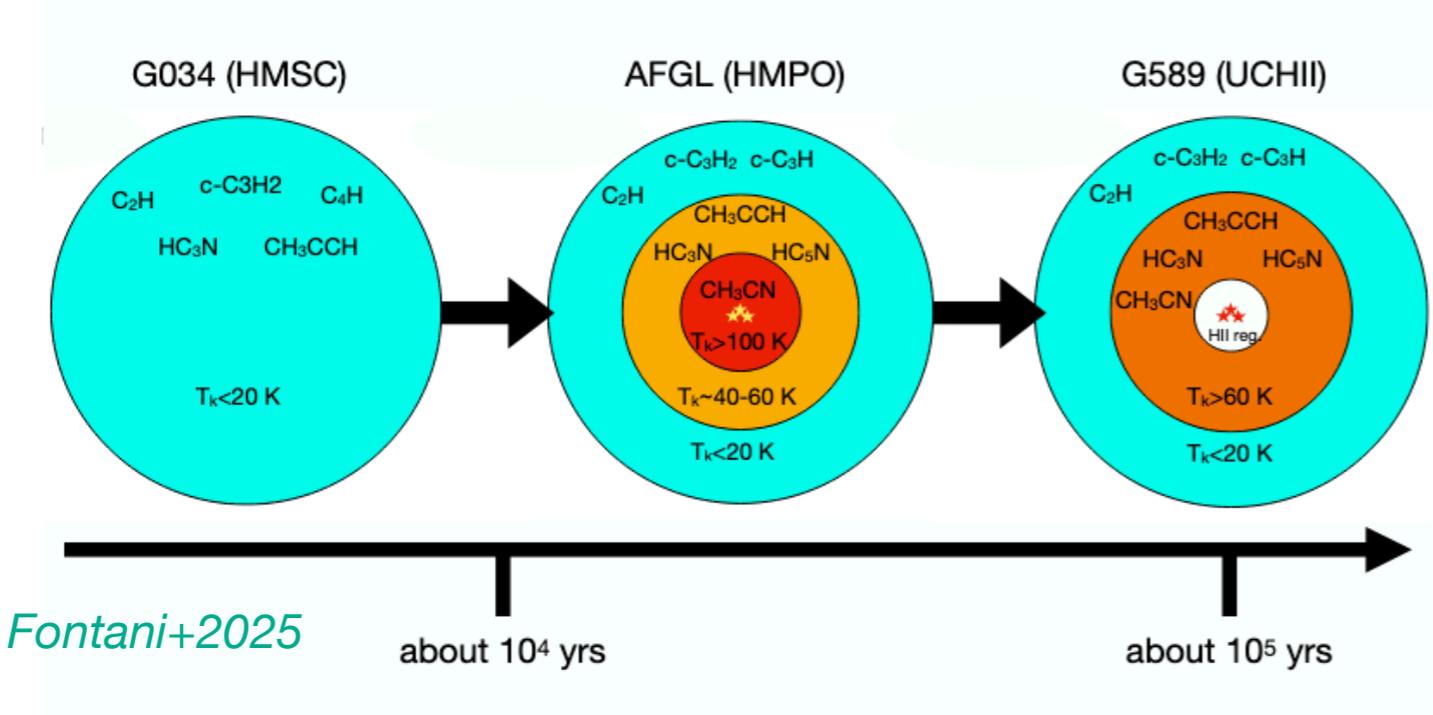


Increase in abundance ratios
 HC_3N/HC_5N
 $C_2H/c-C_3H_2$
Fontani+2025

e.g. Suzuki+1992, Benson+1998, Hirota+2009, Chapman+2009, Marka+2012, Nakamura+2014, Shimoikura+2018, 2019
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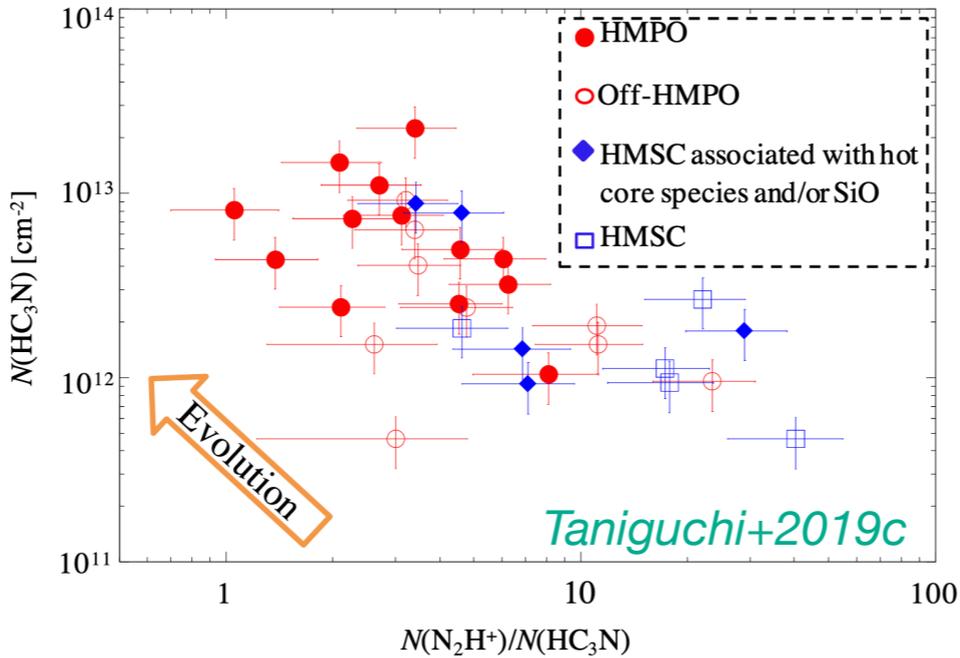
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In combination with other tracers: N_2H^+/HC_3N

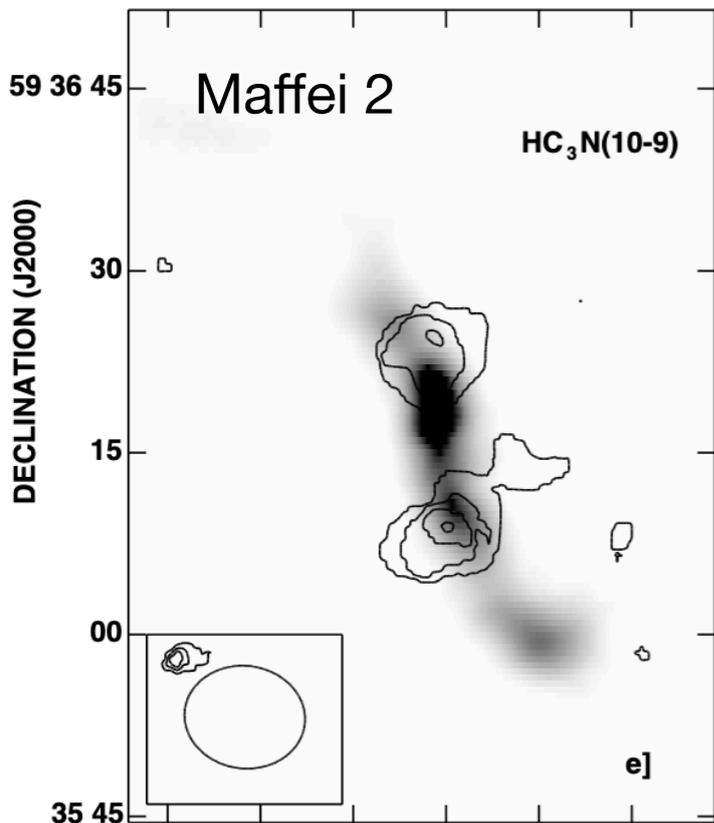
Other carbon chain:
 N_2H^+/CCS
Chen+2025



Increase in abundance ratios
 HC_3N/HC_5N
 $C_2H/c-C_3H_2$
Fontani+2025

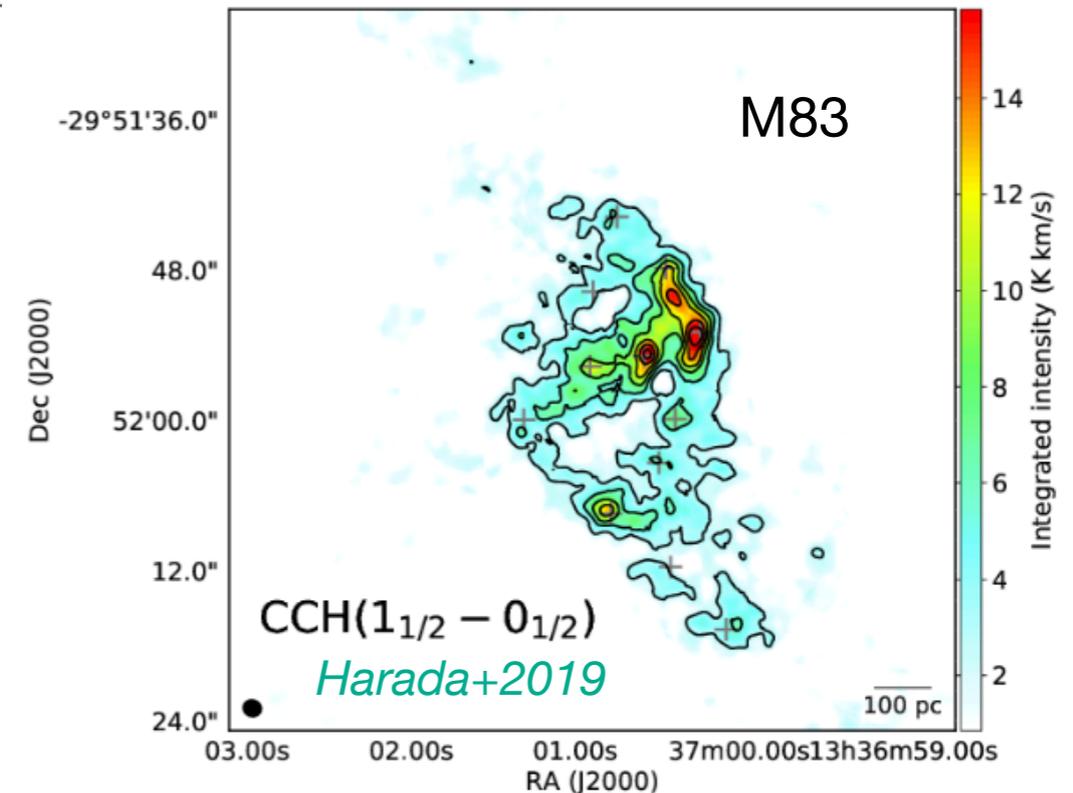
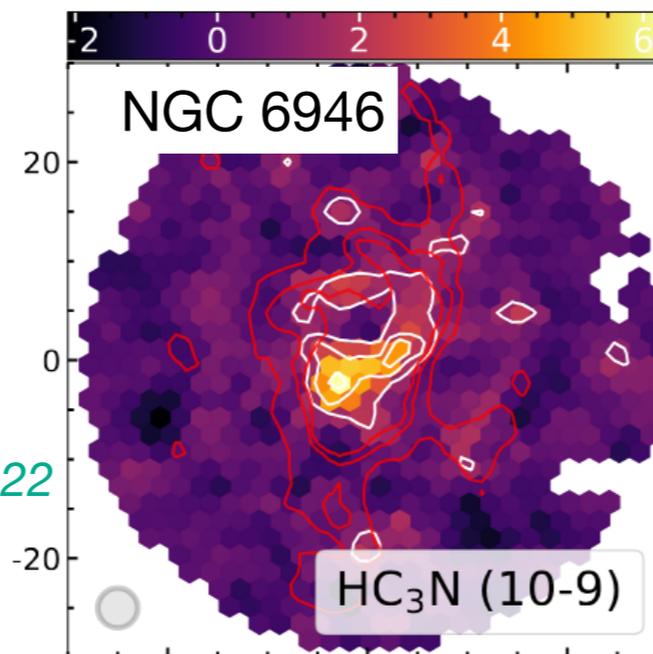
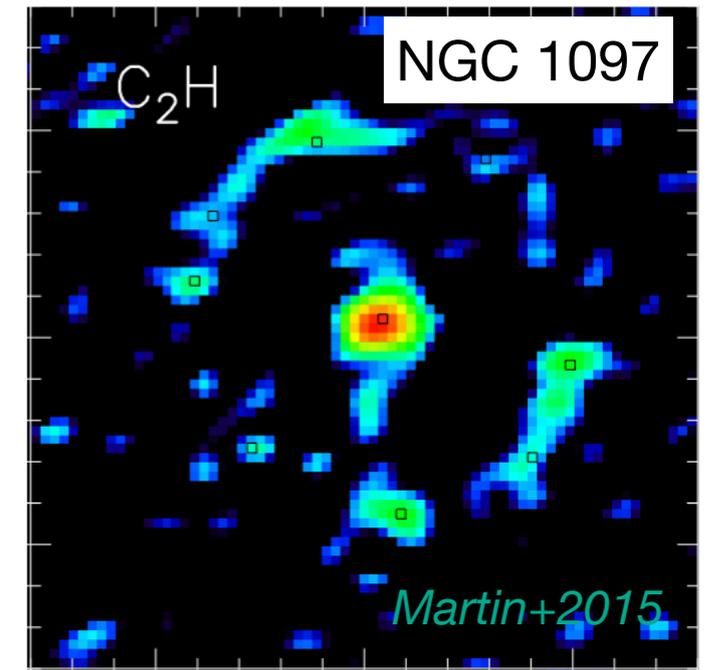
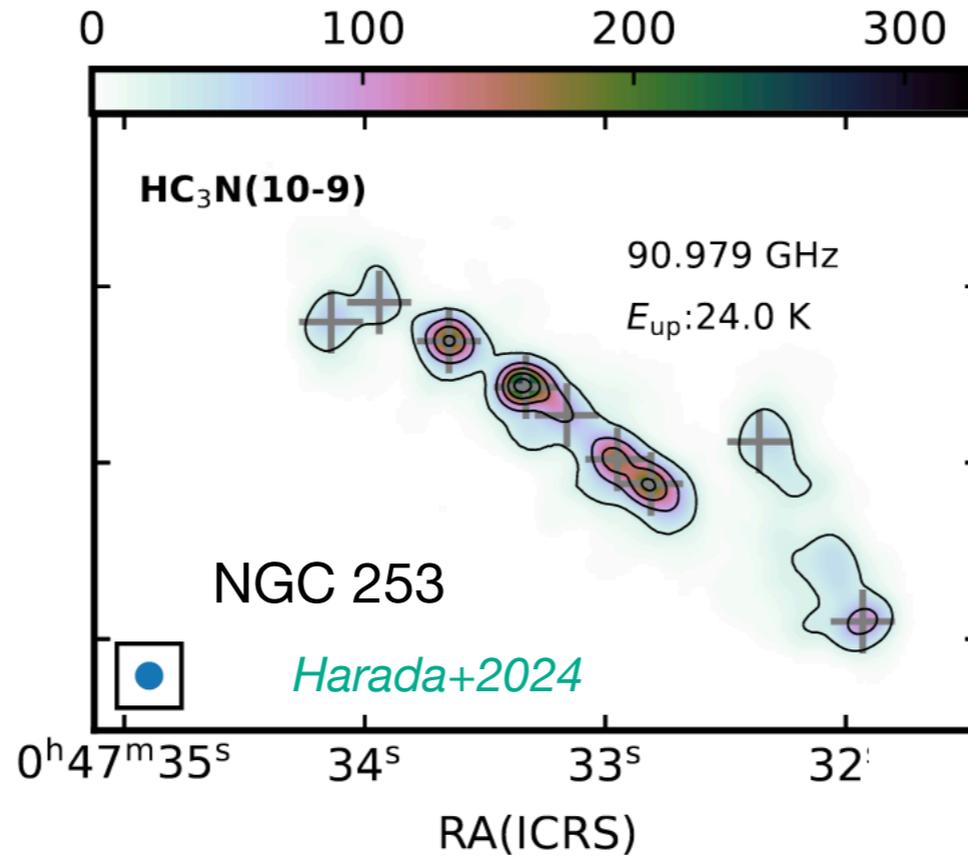
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Extragalactic detections of carbon chains



Meier & Turner 2012

Eibensteiner+2022

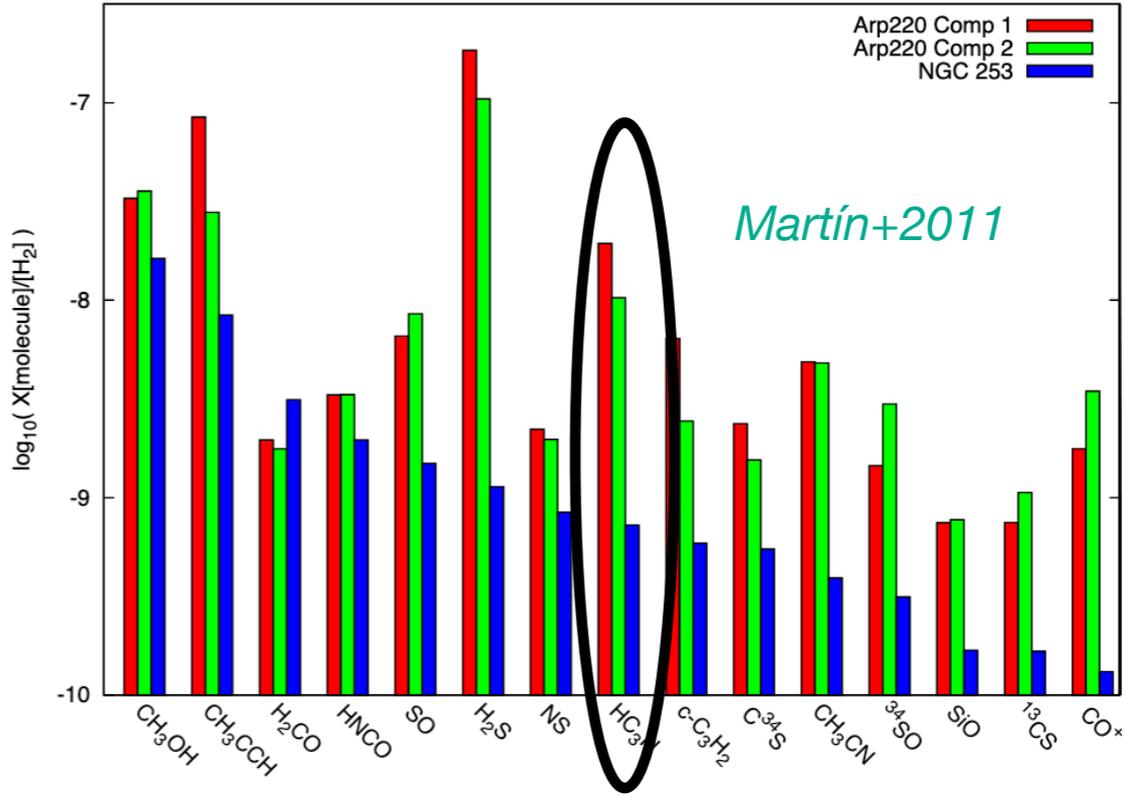
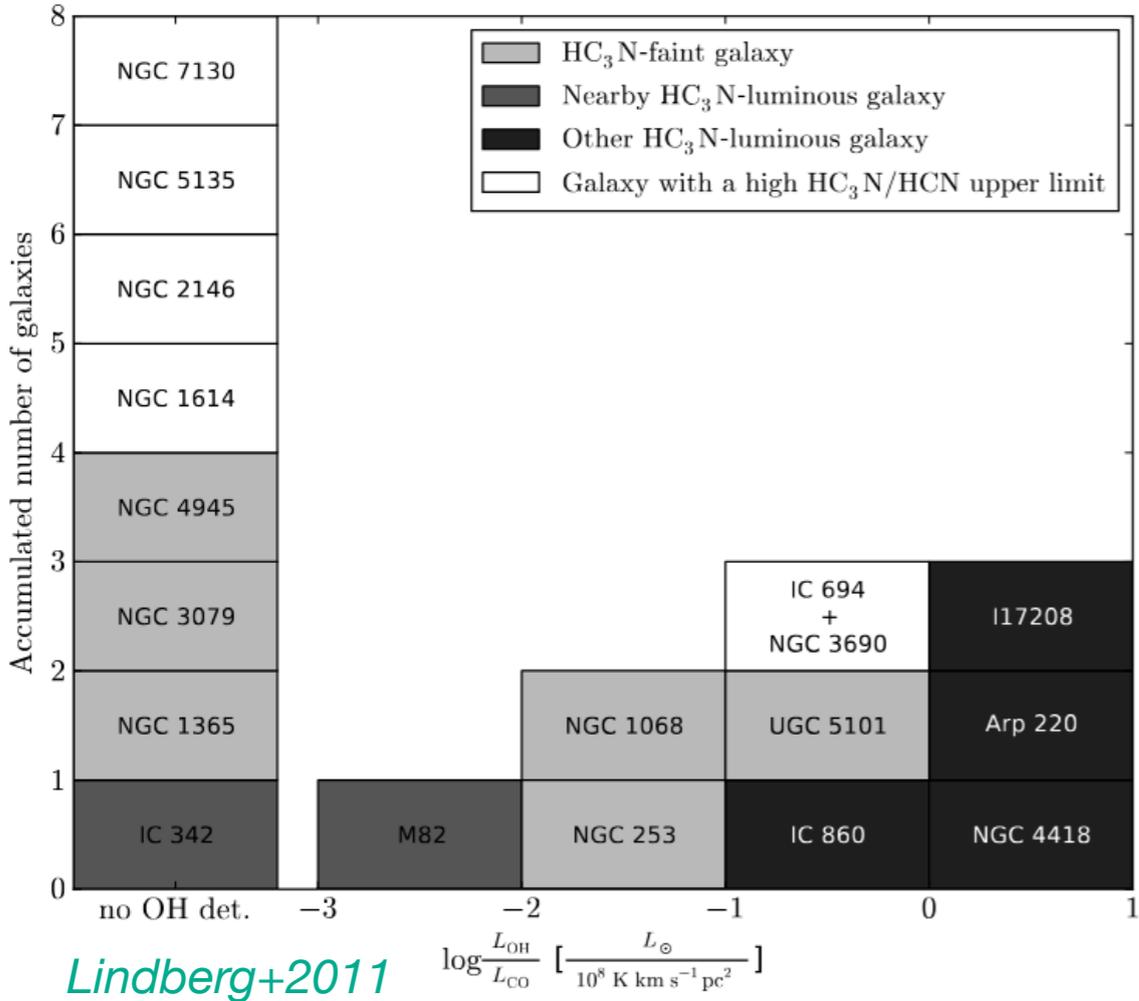


e.g. Seaquist & Bell 1986; Bell & Seaquist 1988, Mauersberger+1991, Meier & Turner 2005, 2012, Jiang+2011, Muller+2011, 2013, Takano+2014, Aladro+2011, 2015, Meier+2015, Ginard+2015, Costagliola+2015, Martin+2015, Takano+2019, Li+2024, Martin+2021, den Brok+2022

HC₃N as tracers of warm dense shielded gas in galaxies

HC₃N as tracers of warm dense shielded gas in galaxies

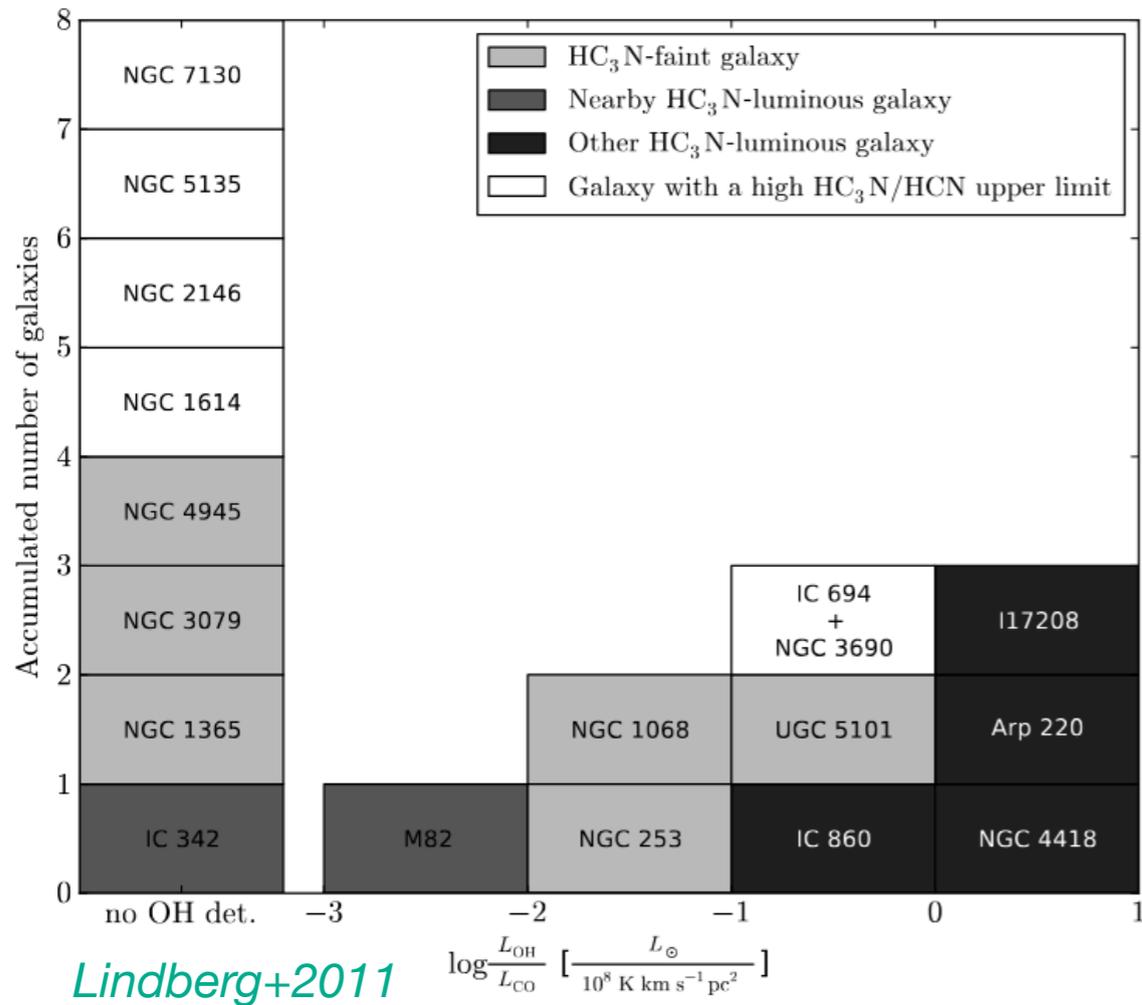
HC₃N (10–9) line luminous in (U-)LIRGS



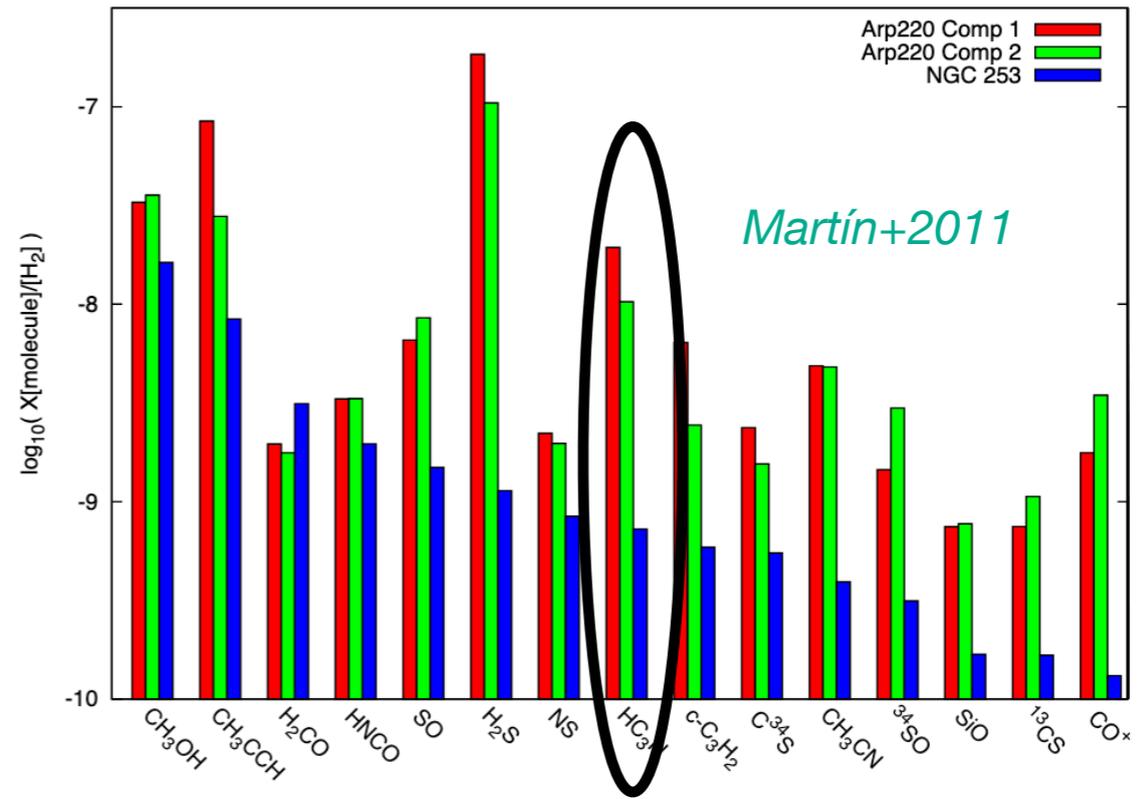
e.g. Aalto+2007, Lindberg+2011, Costagliola & Aalto 2010, Martín+2011, Costagliola+2015

HC₃N as tracers of warm dense shielded gas in galaxies

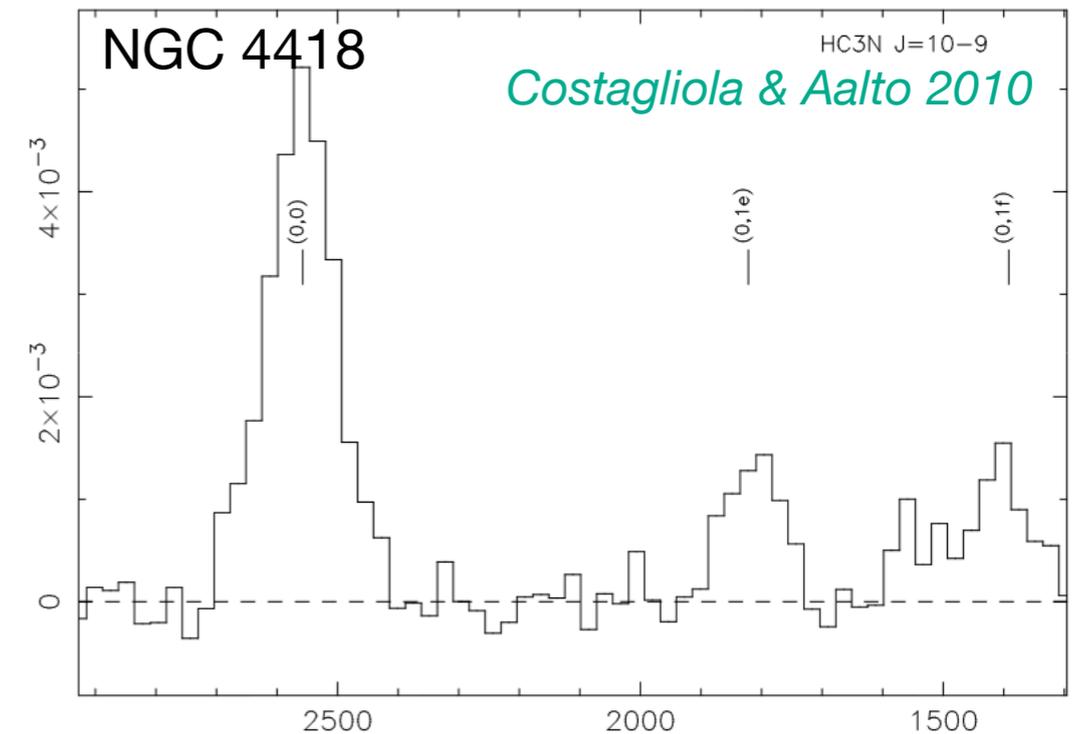
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High abundance of HC₃N in compact obscured nuclei



Hydrocarbons as tracers of extragalactic outflows?

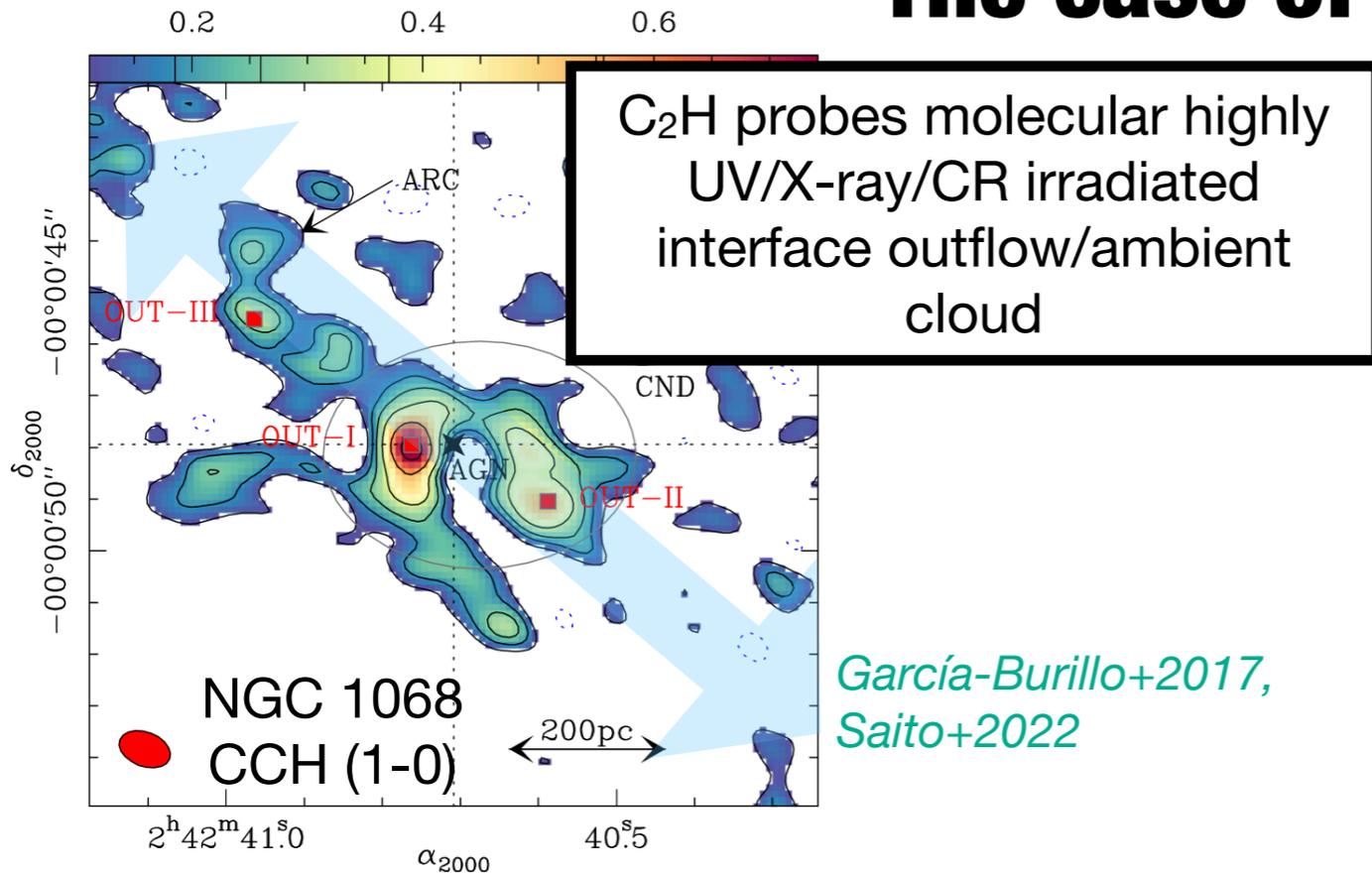
The case of C_2H (1-0)

Also Shimonishi+2020 (LMC)

Mathilde Bouvier - Feb. 25th 2026 - ALMA Band 2 workshop

Hydrocarbons as tracers of extragalactic outflows?

The case of C₂H (1-0)

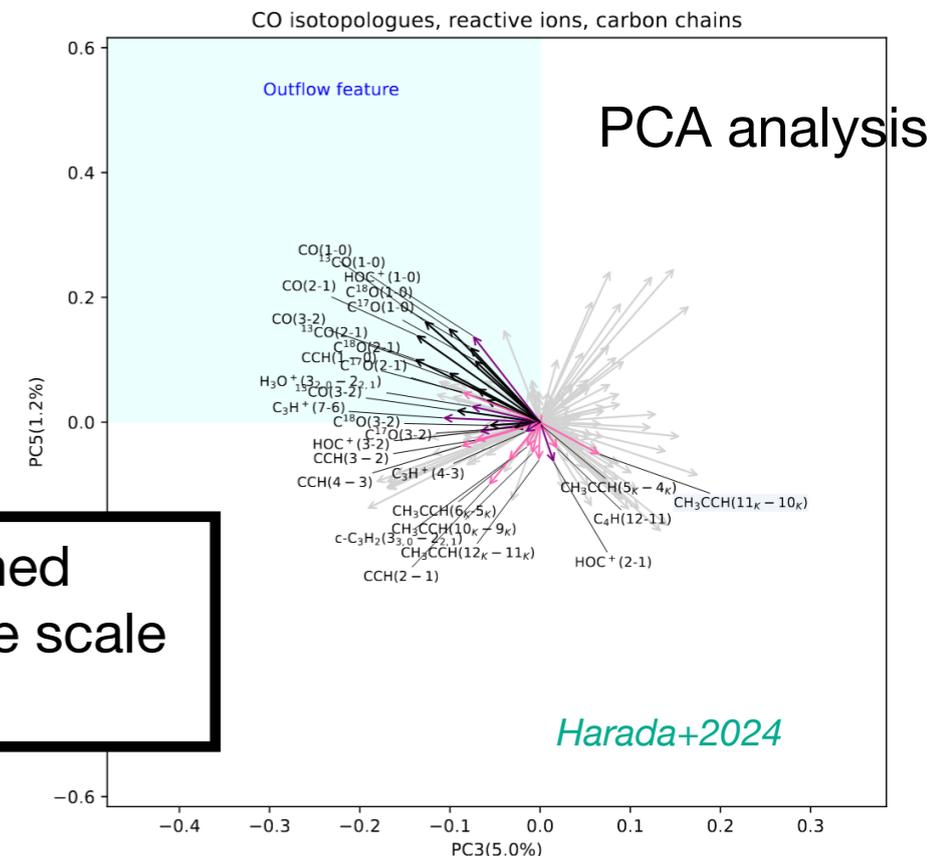
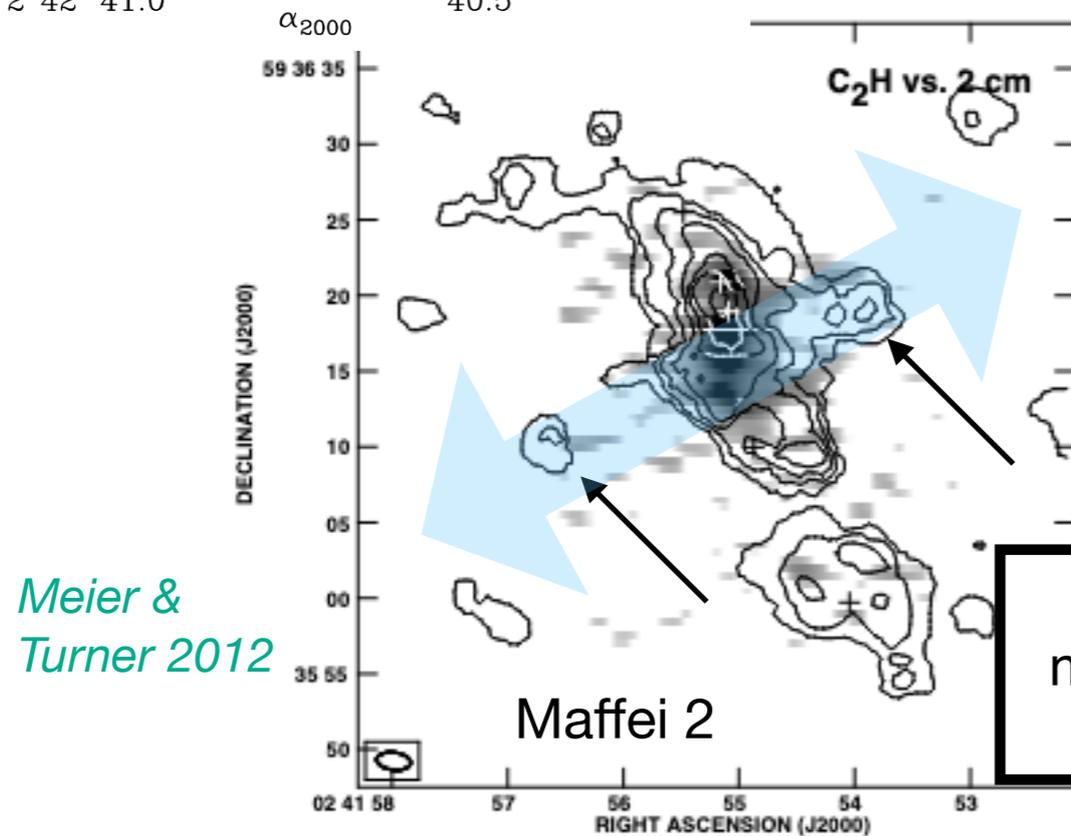
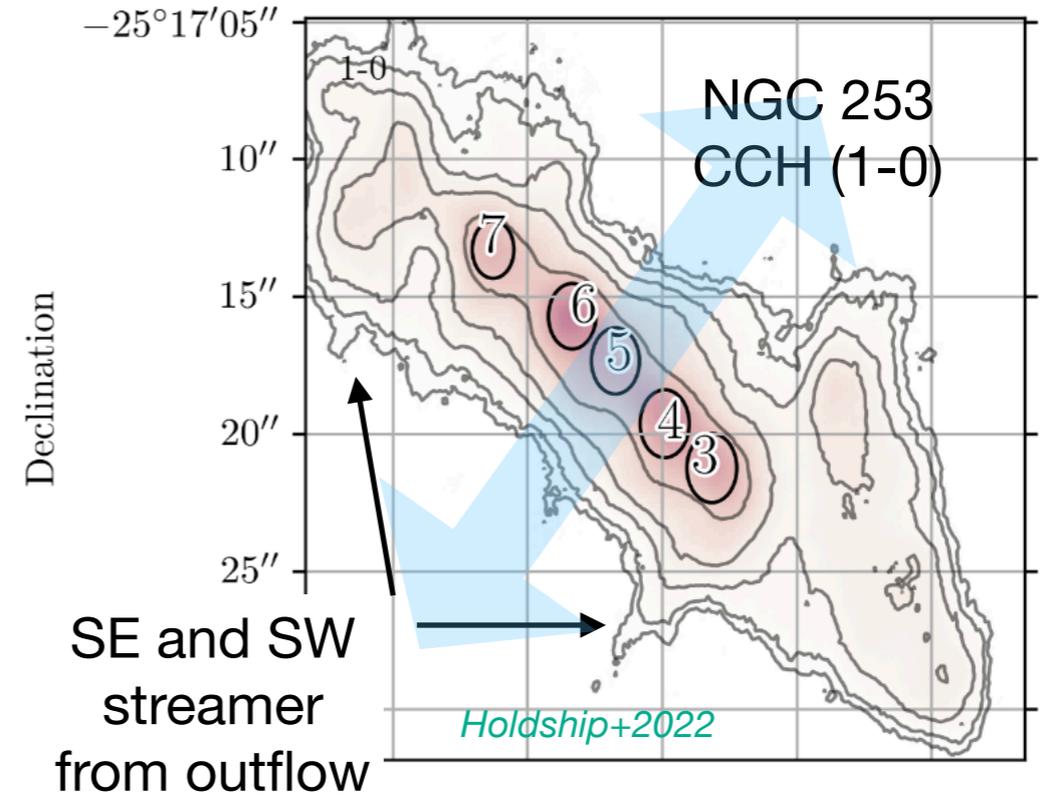
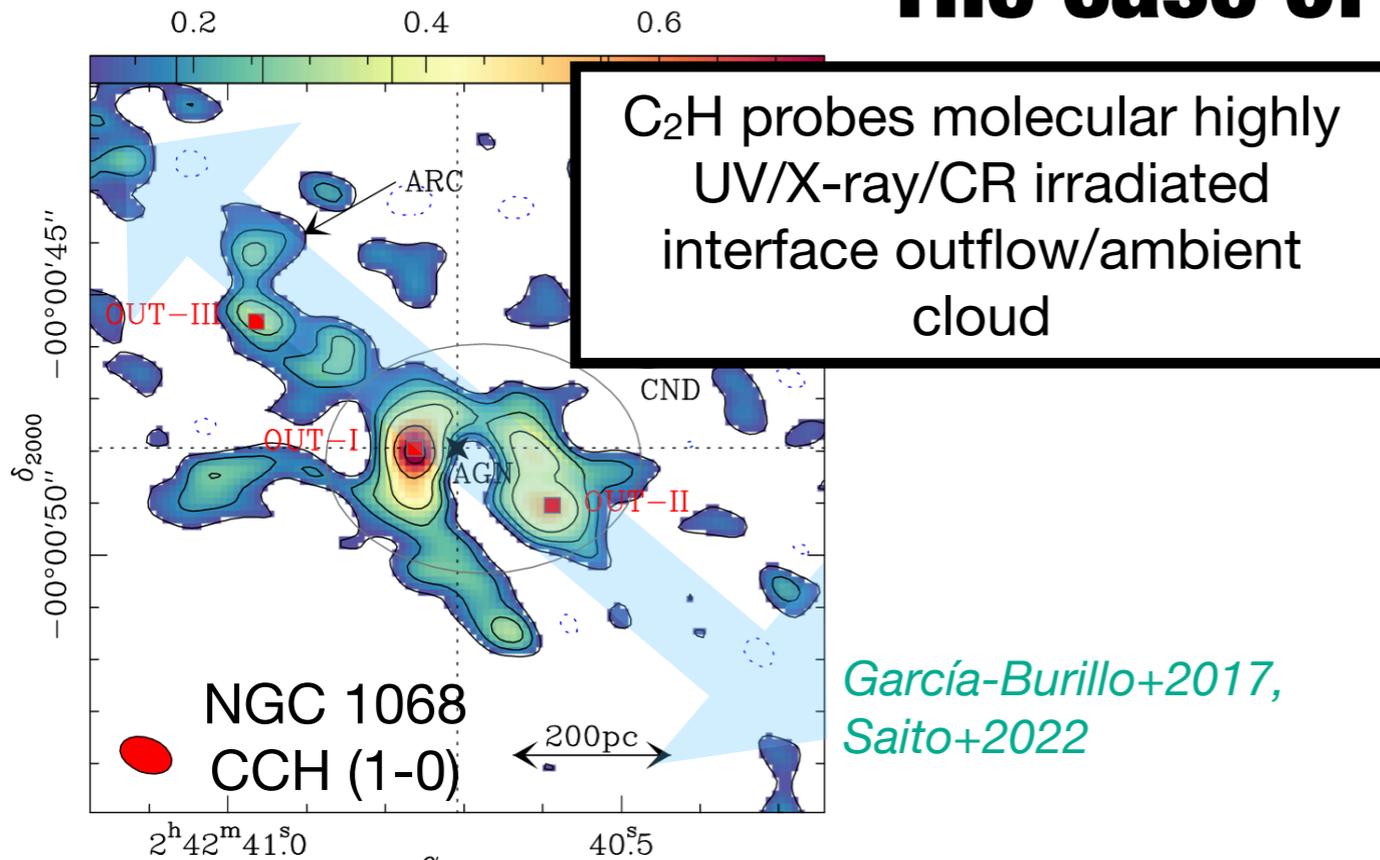


*García-Burillo+2017,
Saito+2022*

Also Shimonishi+2020 (LMC)

Hydrocarbons as tracers of extragalactic outflows?

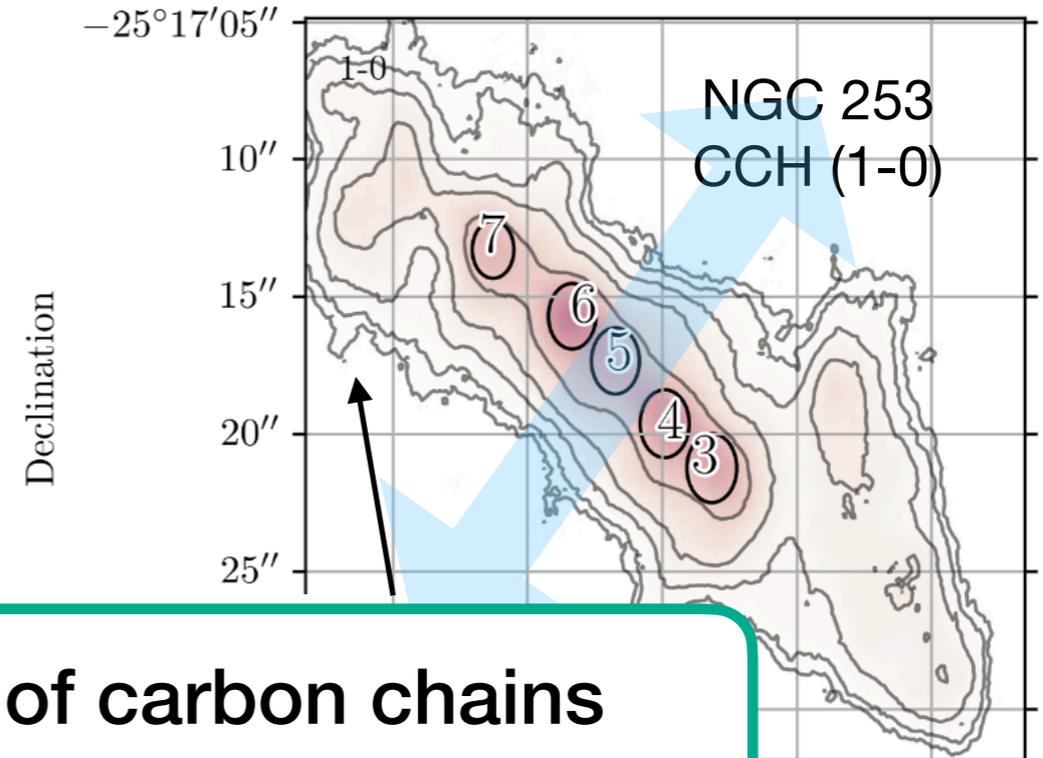
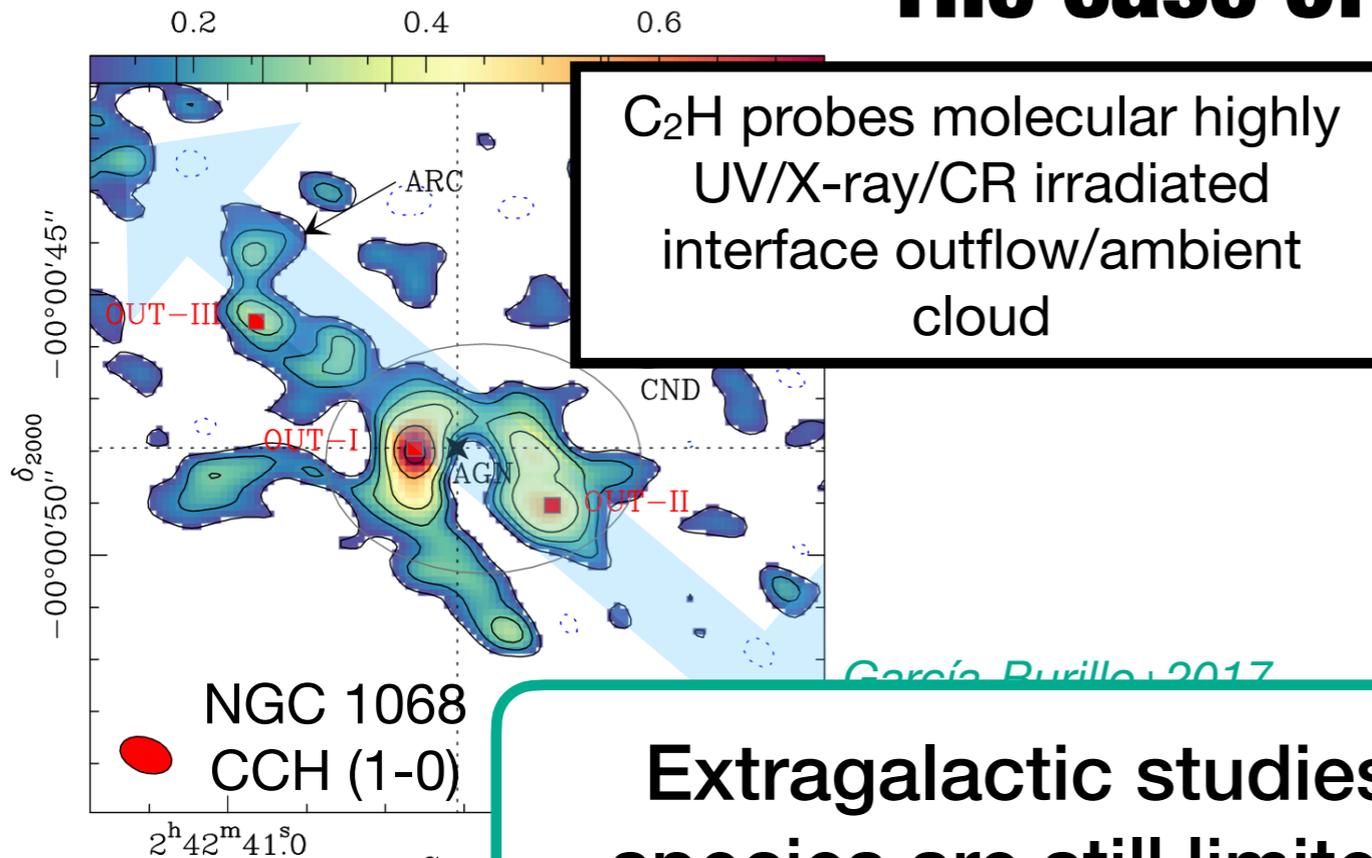
The case of C₂H (1-0)



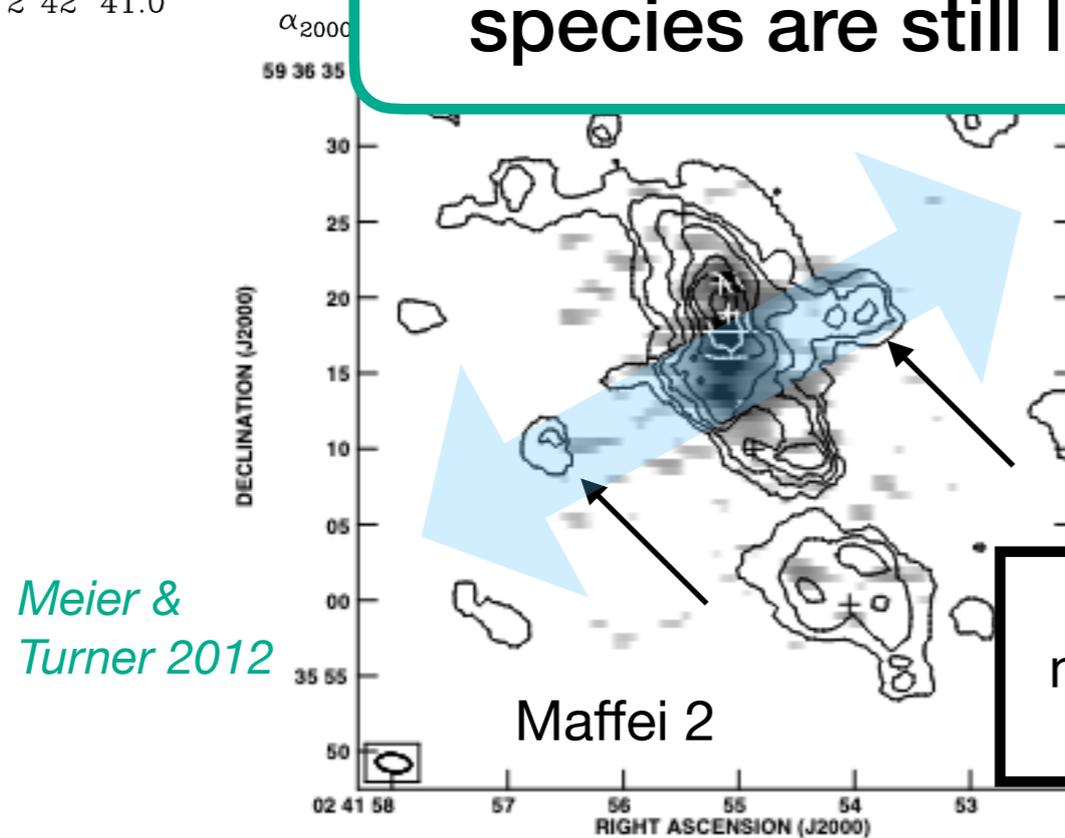
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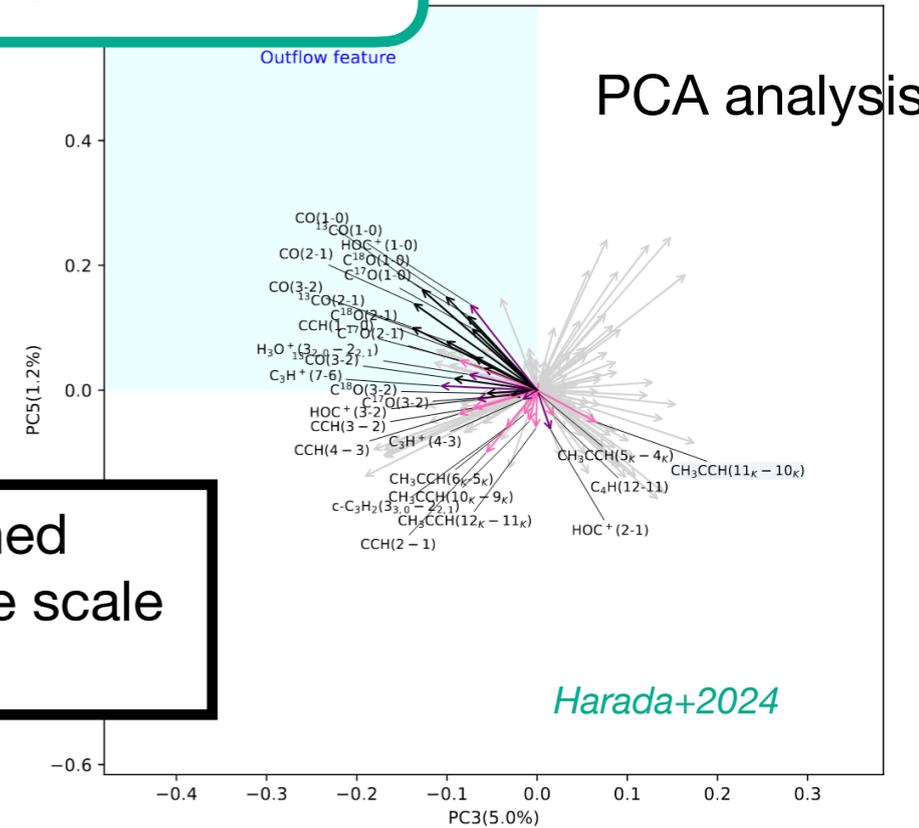
The case of C₂H (1-0)



Extragalactic studies of carbon chains species are still limited to a few galaxies

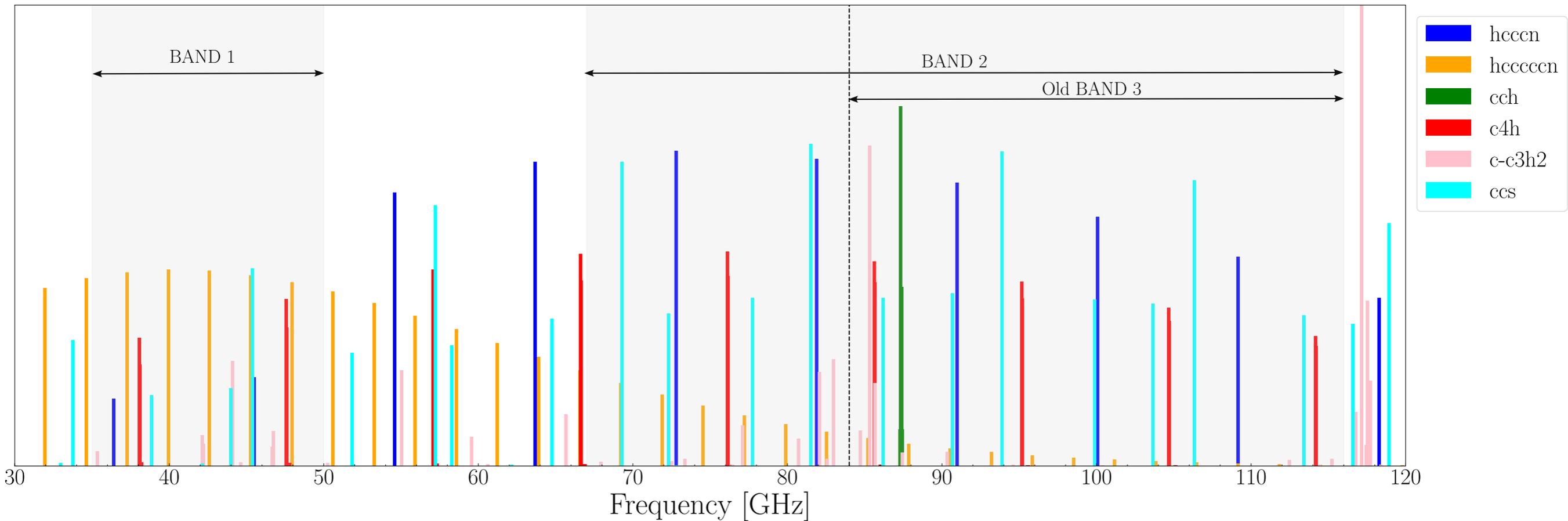


C₂H traces entrained molecular gas by large scale outflows



Also *Shimonishi+2020 (LMC)*

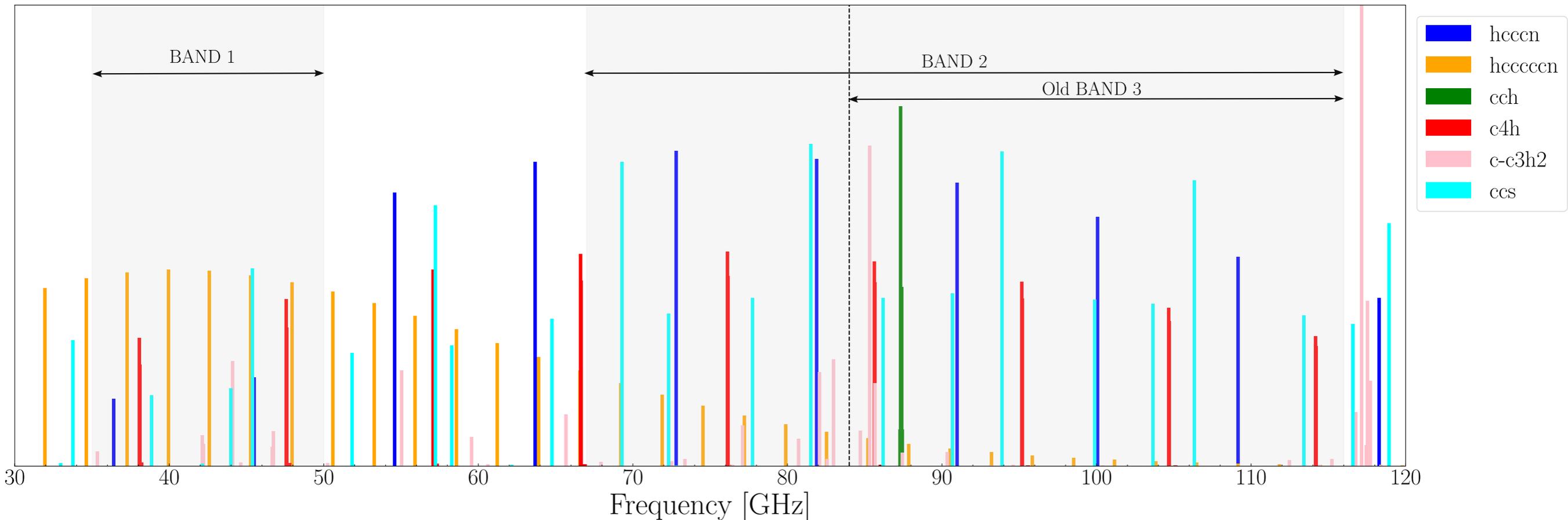
Carbon chemistry & ALMA band 2



HC₃N, C₄H, and CCS: peak of emission in Band 2

Bright CCH(1-0) and c-C₃H₂ (2_(1,2)- 1_(0,1)) in Band 2

Carbon chemistry & ALMA band 2

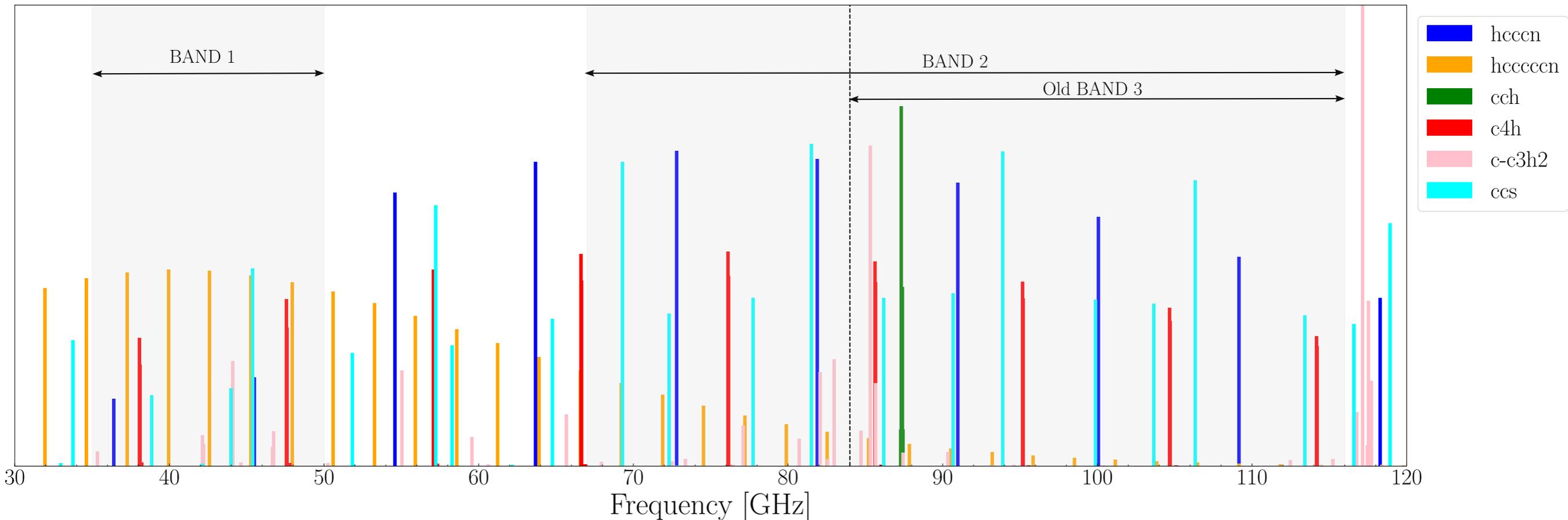


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HC₅N: peak of emission in Band 1

Carbon chemistry & ALMA band 2



HC₃N, C₄H, and CCS: peak of emission in Band 2

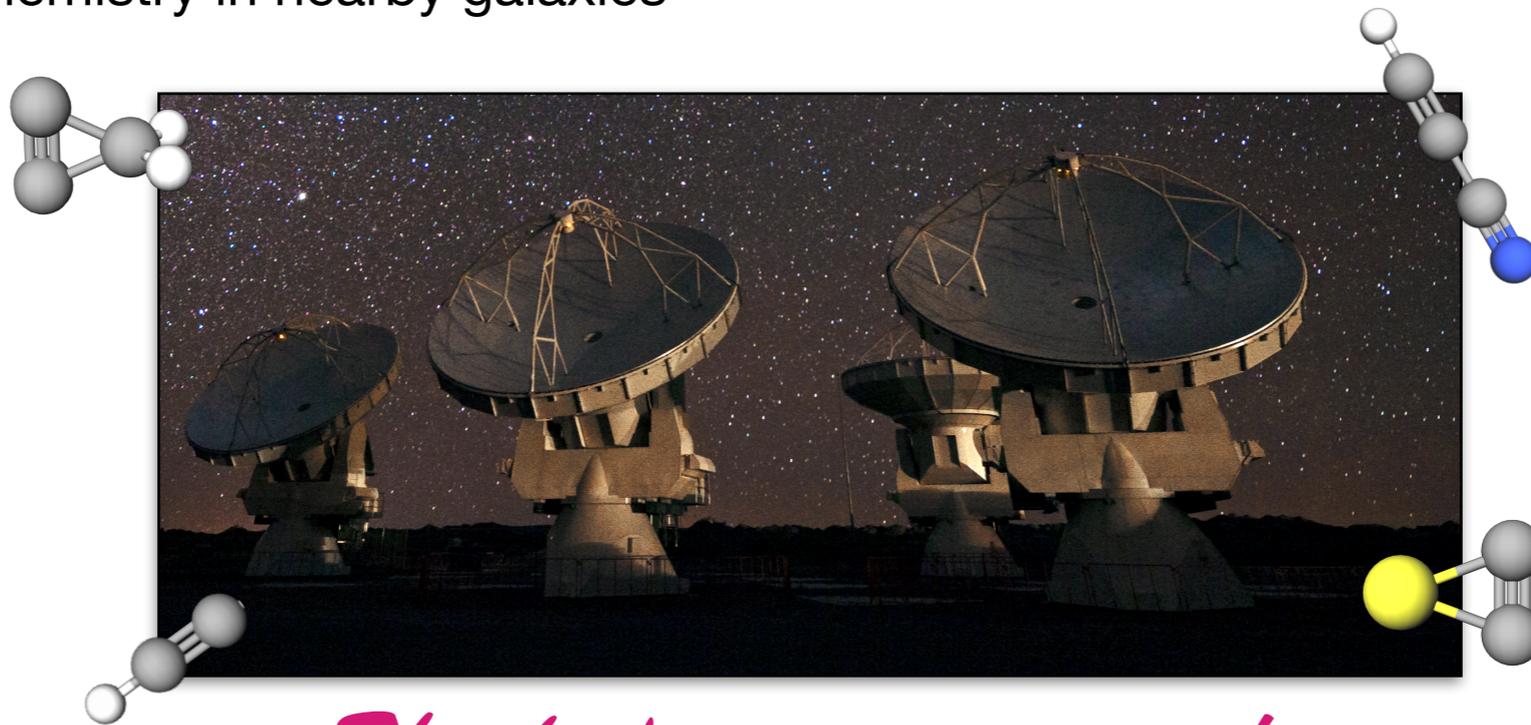
Bright CCH(1-0) and c-C₃H₂ (2_(1,2)- 1_(0,1)) in Band 2

HC₅N: peak of emission in Band 1

Band 2 (+Band 1), allows to get the brightest transitions of several small carbon chain species.

Take-out messages

- Carbon-chain species are important for interstellar chemistry
- Excellent diagnostic tools from Galactic studies: cyanopolyynes (HC_3N , HC_5N) to probe dense warm shielded gas or outflows, hydrocarbons (CCH , $\text{c-C}_3\text{H}_2$) to trace outflow/ISM interface or UV-irradiated regions
- A few extragalactic studies of carbon chain species already exists but still very limited to a handful well-known or nearby sources
- Band 2 (also in combination with Band 1) offers a unique opportunity to expand studies of carbon chain chemistry in nearby galaxies



Thanks for your attention!