December 2nd 2025

INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

UNIVERSITÀ
DEGLI STUDI
FIRENZE

Physics and chemistry of star formation in the outer Galaxy

PhD student: Diego Gigli
Supervisor: Francesco Fontani

A little bit of me

who: Diego Gigli
where: Ronta (Mugello valley)
when: March 1998

2021: Bachelor's degree in Physics and Astrophysics

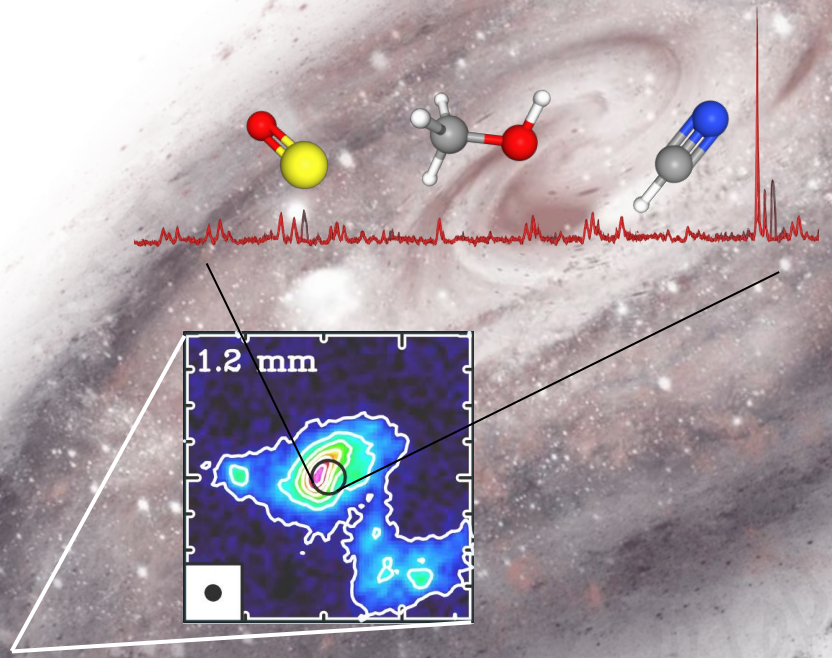
2024: Master's degree in Physical and Astrophysical Sciences

????: PhD in Physics and Astronomy

The project CHEMical complexity of star-forming regions in the OUTer galaxy (CHEMOUT)

Scientific goal

Understanding how chemistry changes throughout the Milky Way and revealing the chemical composition of star-forming regions in the outer Galaxy



Fontani+2022a; Fontani+2022b; Colzi+2023; Fontani+2024; Gigli+2025

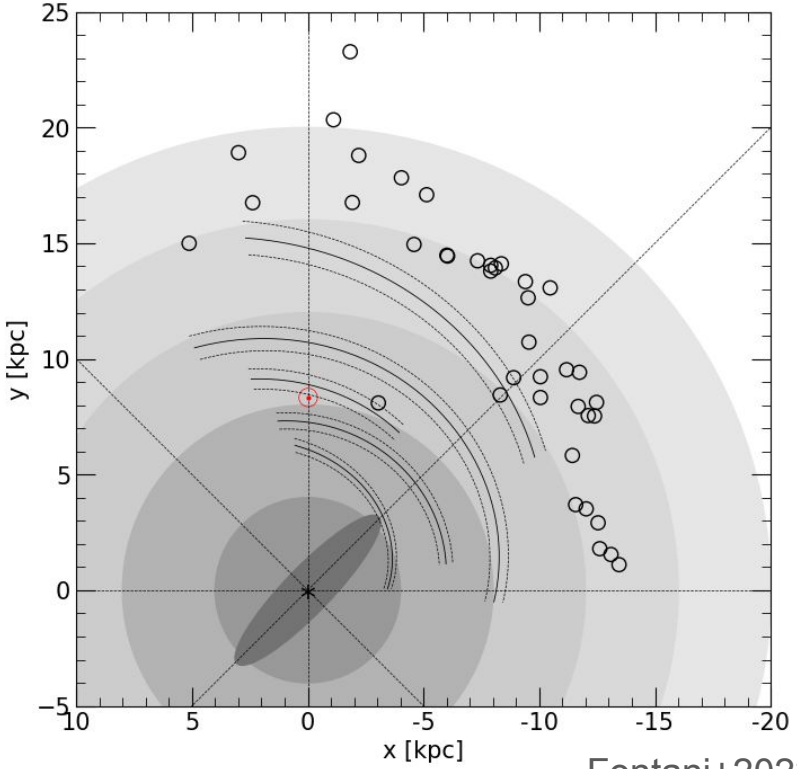
The CHEMOUT project

Observation sample

35 star-forming regions in the outer Galaxy between 9 and 24 kpc from the Galactic center

Observational facilities

IRAM 30m, Yebes 40m, GBT, ALMA, and NOEMA (so far…)



Fontani+2022

CHEMOUT: results

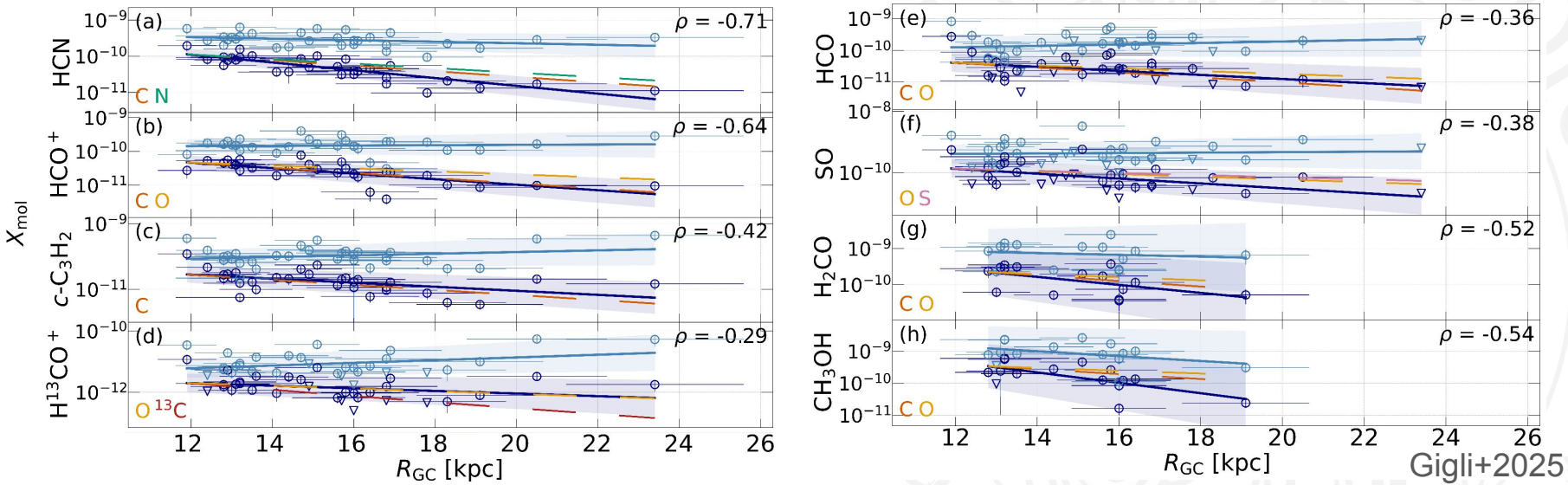
Fontani+2022,2022b. CHEMOUT I, and II
Abundances of key organic species does not vary significantly with Galactocentric radius

Colzi+2023. CHEMOUT III
$^{14}N/^{15}N$ ratio supports the hypothesis that ^{15}N isotopes comes from novae explosions

Fontani+2024. CHEMOUT IV
The outermost region (WB89-670 @ 23.4 kpc) shows local chemical differentiation and an unexpectedly high Carbon [C/H] abundance

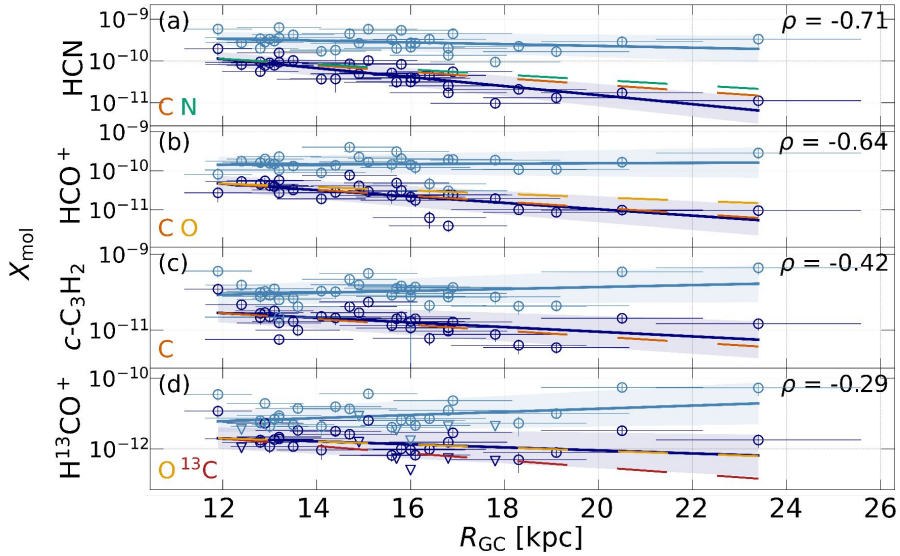
CHEMOUT V. Chemical composition gradients as a function of the Galactocentric radius

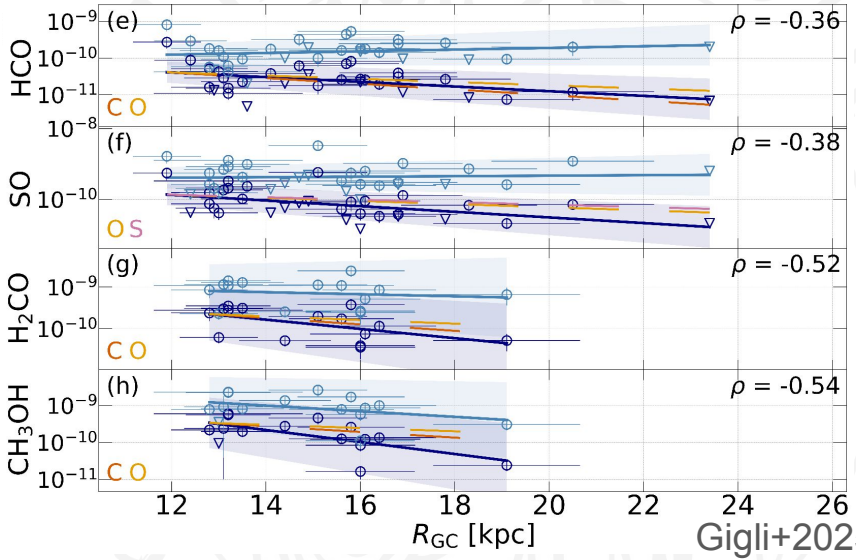
We estimated how the abundances of some species changes through the Galactic disk, comparing them with the elemental abundances



CHEMOUT V. Chemical composition gradients as a function of the Galactocentric radius

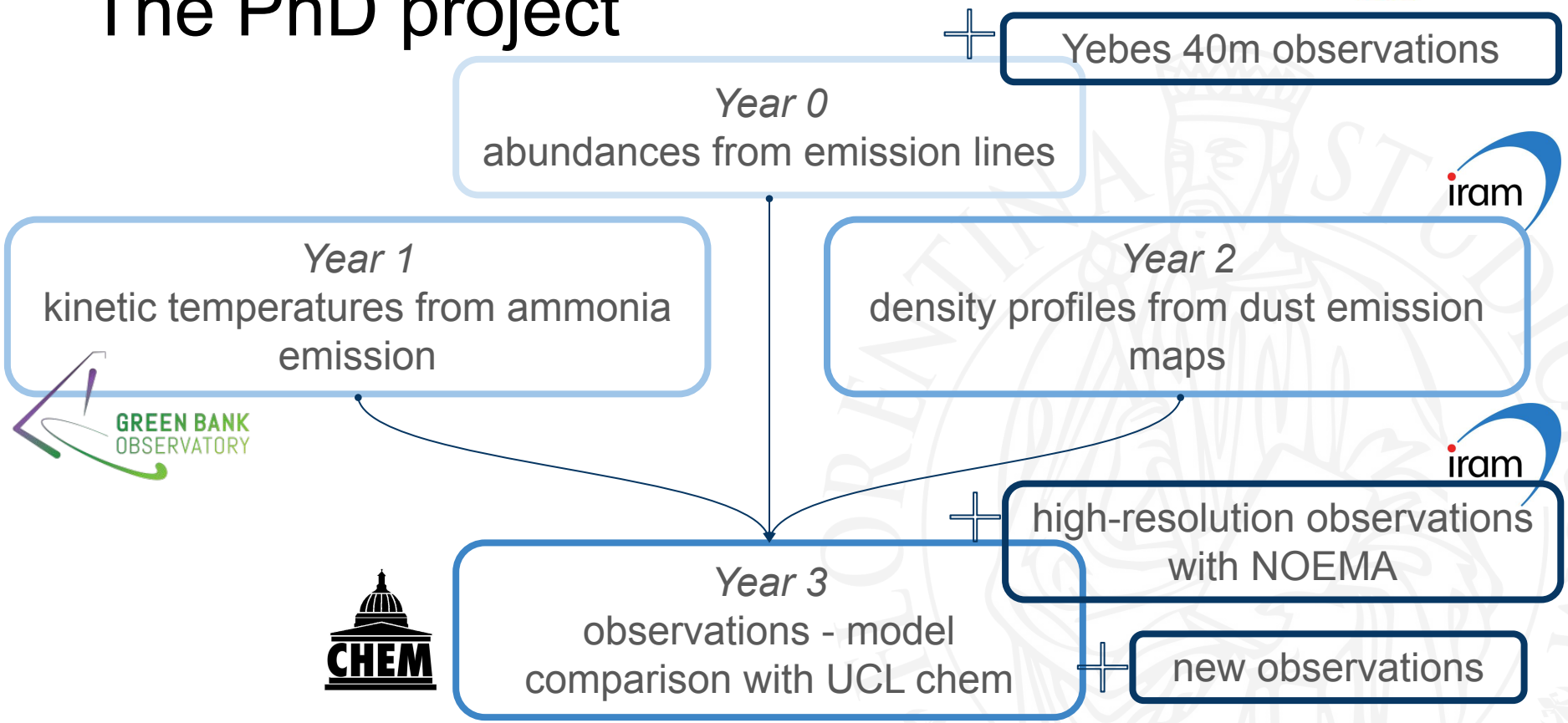
The abundances of most of the species scales at most as the elemental abundance of their parent element. The formation efficiency of these species is constant throughout the Galaxy.





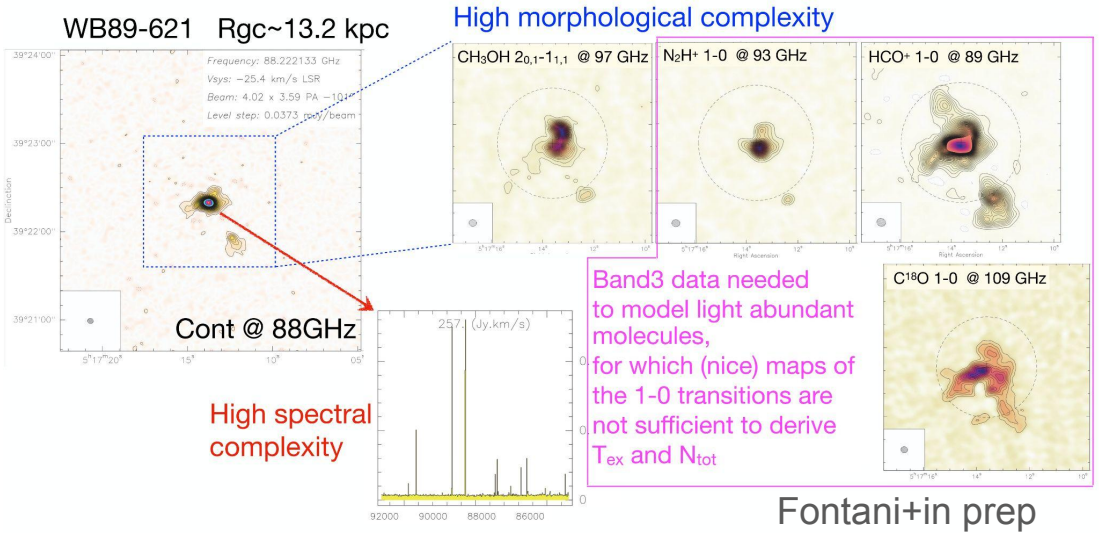
Gigli+2025

The PhD project

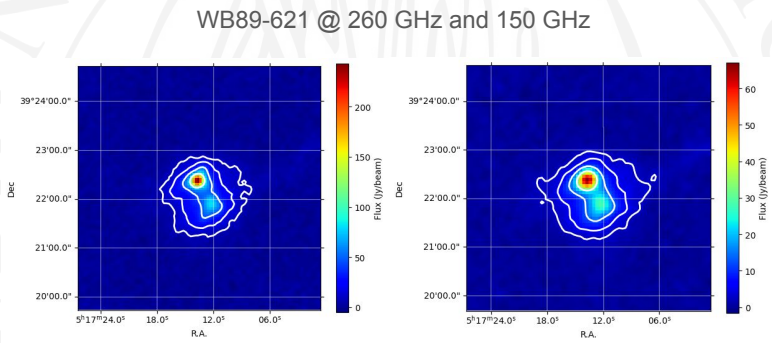


What's next?

Spaccino+in prep → Estimating the gas-to-dust ratio in the outer Galaxy
Gigli+in prep → Ammonia analysis for the gas temperature
Gigli+in prep → Morphology study from the continuum maps
Fontani+in prep → MORGAN project: NOEMA high-resolution analysis of WB89-621
Colzi+in prep → $^{13}C/^{12}C$ ratio in the outer Galaxy



Fontani+in prep



Gigli+in prep

A broader impact

- Redefine the concept of Galactic Habitable Zone
- Identify prime targets for next-generation radio/mm telescopes (ngVLA, SKA)
- Study low-metallicity environments as the early Milky Way

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Thank you for your attention

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Diego Gigli (diegogigli.dg@gmail.com)