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DI ASTROFISICA

The ionised Milky Way: the SKA survey of the continuum radio in the Galactic Plane

Chiara Mininni - INAF-IAPS

on behalf of Alessio Traficante

F. Cavallaro, G. Umana, S. Molinari, C. Trigilio, A. Ingallinera, C. Codella, E. Bianchi, G. Sabatini, L. Podio, M. Benedettini, S. Sottie, O. Smirnov, A. Ramaila, C. Bordiu, S. Loru, A. Nucara, M. Padovani, K. Rygl, A. Bracco, C. Buemi, F. Bufano, D. Galli, P. Leto, S. Riggi, A. Ruggeri et al.

image: SMGPS at 1.3 GHz and Hi-GAL 70 μm and 250 μm emission (Goedhart et al. 2024)

The 10-15 GHz radio continuum survey of the Galactic Plane with SKAO

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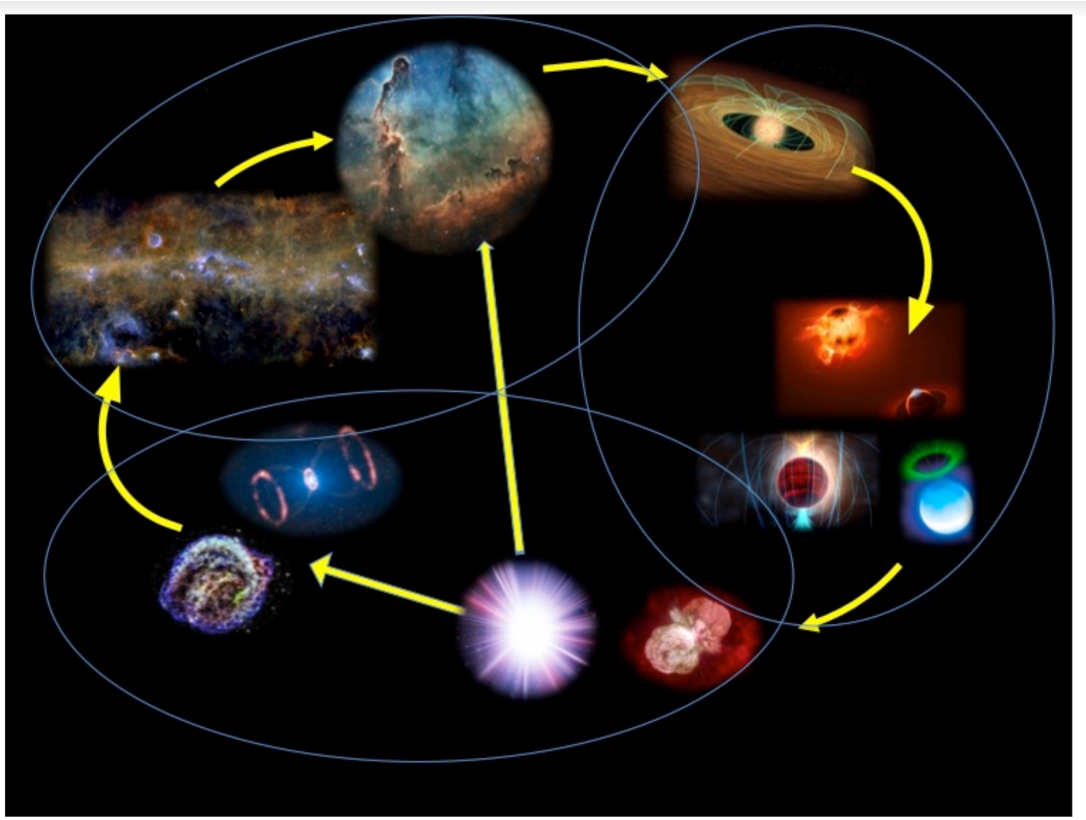
THE CYCLE OF STAR FORMATION



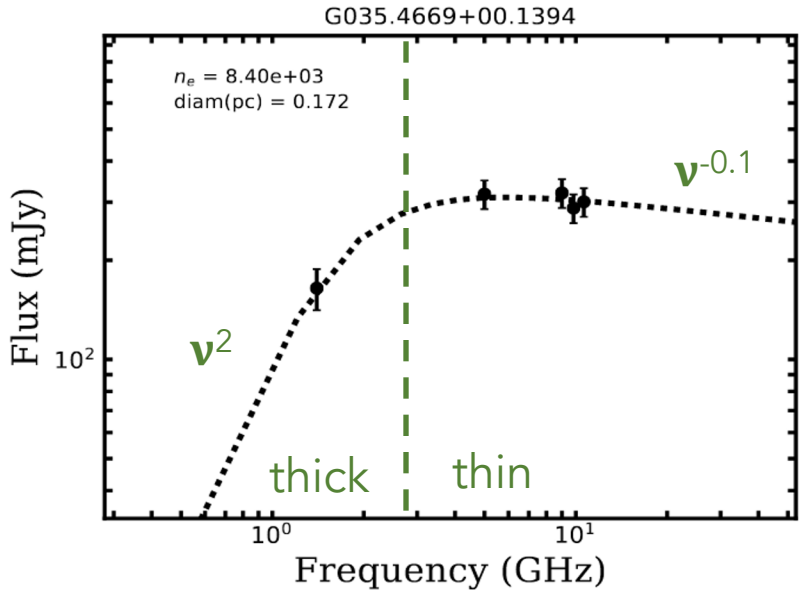
Star Formation is a highly inefficient process

Interplay of multiple forces and mechanism: Gravity, Turbulence, Magnetic Field, **Feedback**

The role of feedback from newly formed high-mass stars is still debated/ambivalent

THE CHALLENGE TO OBSERVE UC HII AND HC HII

Yang et al. 2021



$$\left[\frac{\nu_t}{\mathrm{GHz}}\right] = 0.082 \times \left[\frac{T_e}{\mathrm{K}}\right]^{-1.35} \times \left[\frac{n_e^2 \times \mathrm{diam}}{\mathrm{cm^{-3}\,pc}}\right]^{0.476}$$

Kurtz et al. 2005

HC HII

D < 0.05 pc

$n_e > 10^6$ cm^{-3}

EM > 10^{10} pc cm^{-6}

ν_t ~ 10 - 50 GHz

UC HII

D < 0.1 pc

$n_e > 10^4$ cm^{-3}

EM ~ 10^8 pc cm^{-6}

ν_t ~ 1 - 10 GHz

HII

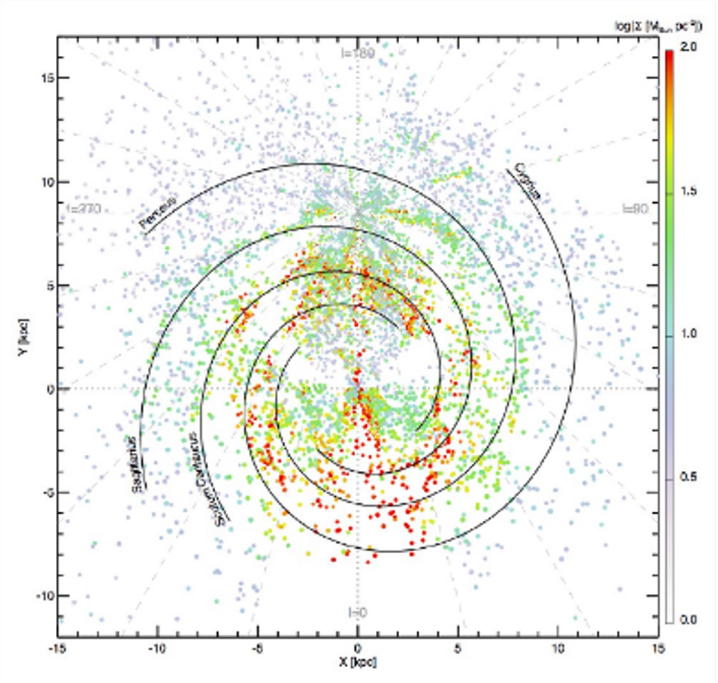
D > 1 pc

$n_e \sim 10^3$ cm^{-3}

EM < 10^5 pc cm^{-6}

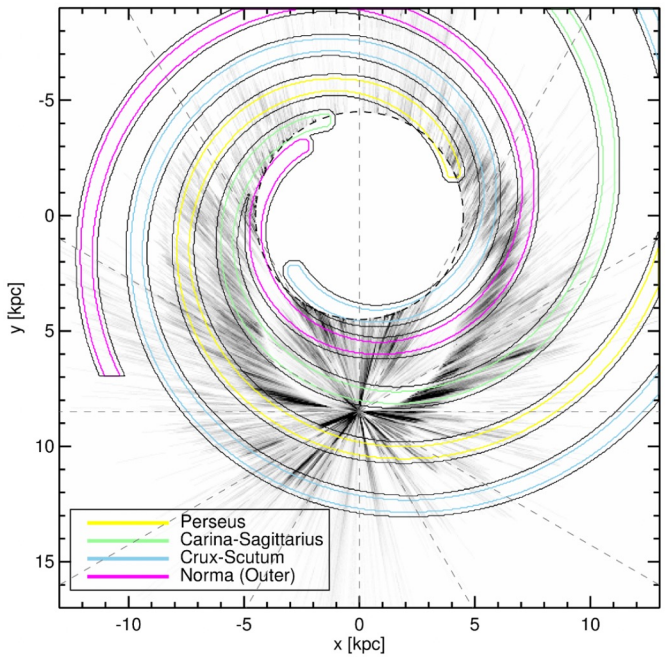
ν_t < 1 GHz

GP surveys as a tool to have a comprehensive view



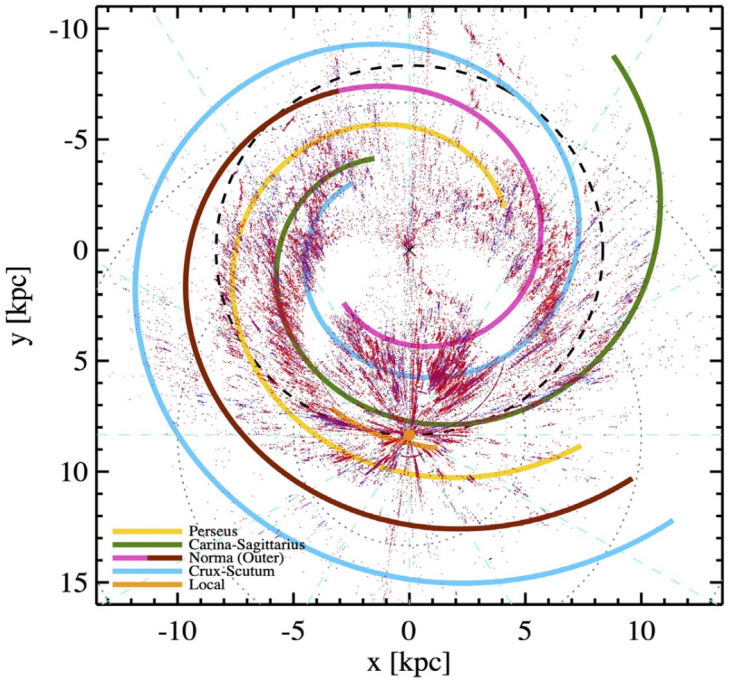
~8100 GMCs ^{12}CO (1-0)

Miville-Deschenes+17



~30000 filaments

Schisano+20



~150000 clumps

Elia+21

Large, Galactic Plane surveys allow us to investigate the roles of the various actors across the different Galactic environments

TO SYSTEMATICALLY STUDY THE ROLE OF FEEDBACK FROM

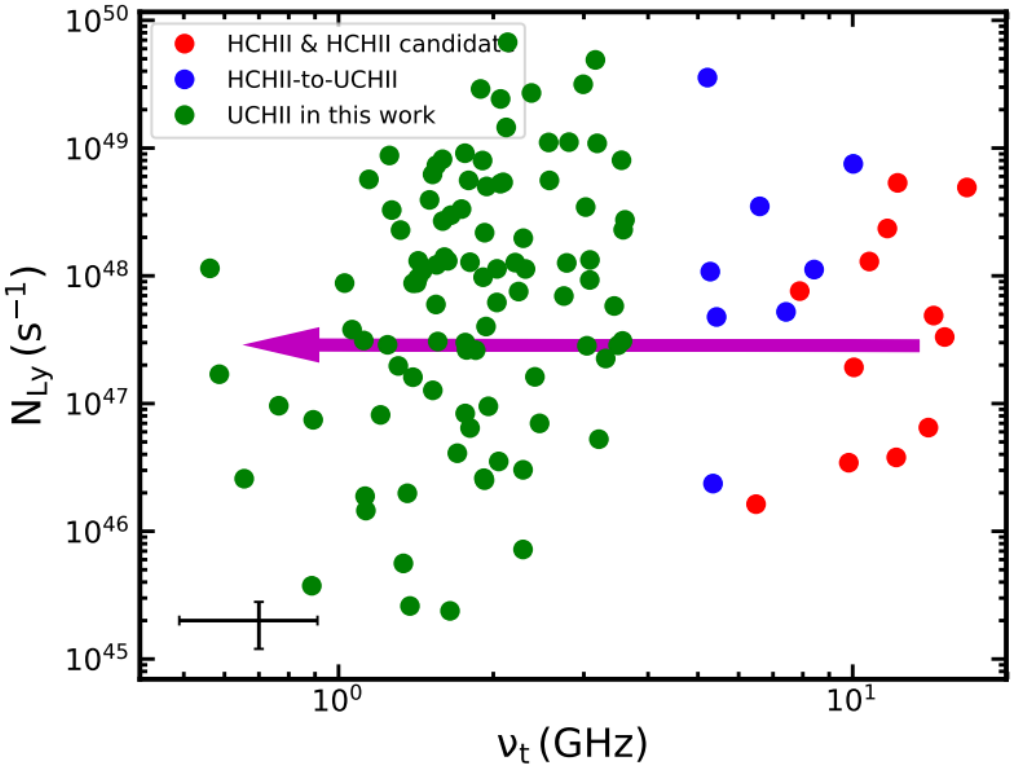
ITS EARLY STAGES OF UC HII AND HC HII REGIONS

WE NEED A 10-15 GHz SURVEY OF THE GP

WITH HIGH SENSITIVITY AND RESOLUTION

THE NEED FOR SKA-MID BAND 5B

sample of UC HII and HC HII of Yang et al. 2021



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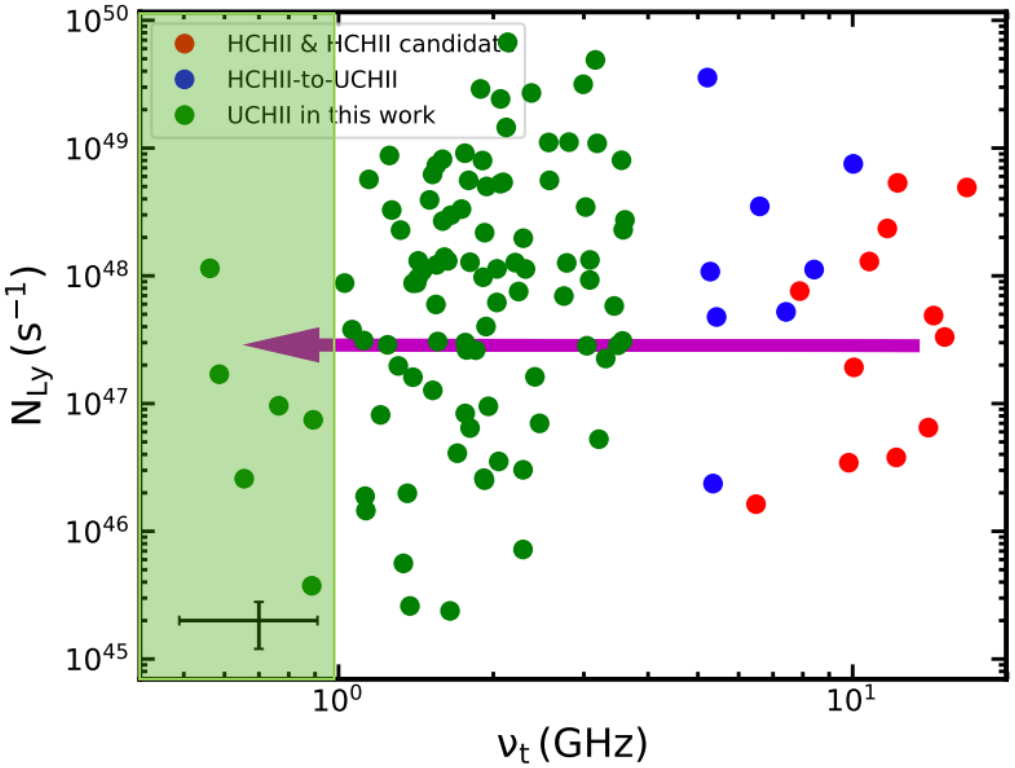

Band-L at 1.3 GHz

THE NEED FOR SKA-MID BAND 5B

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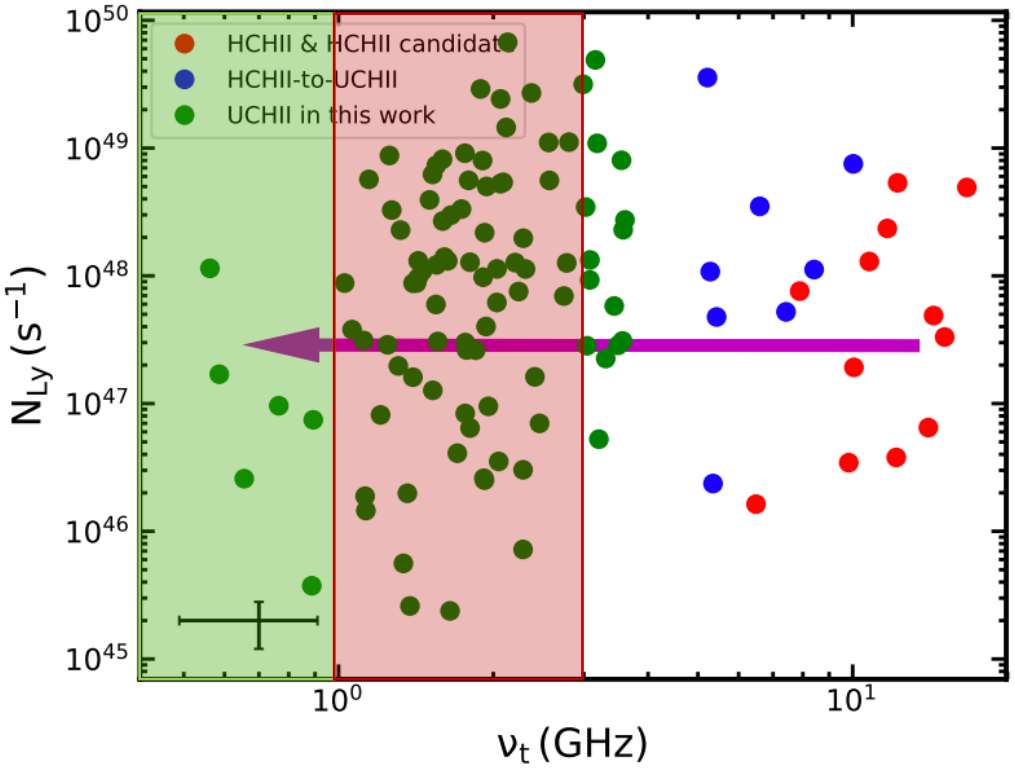


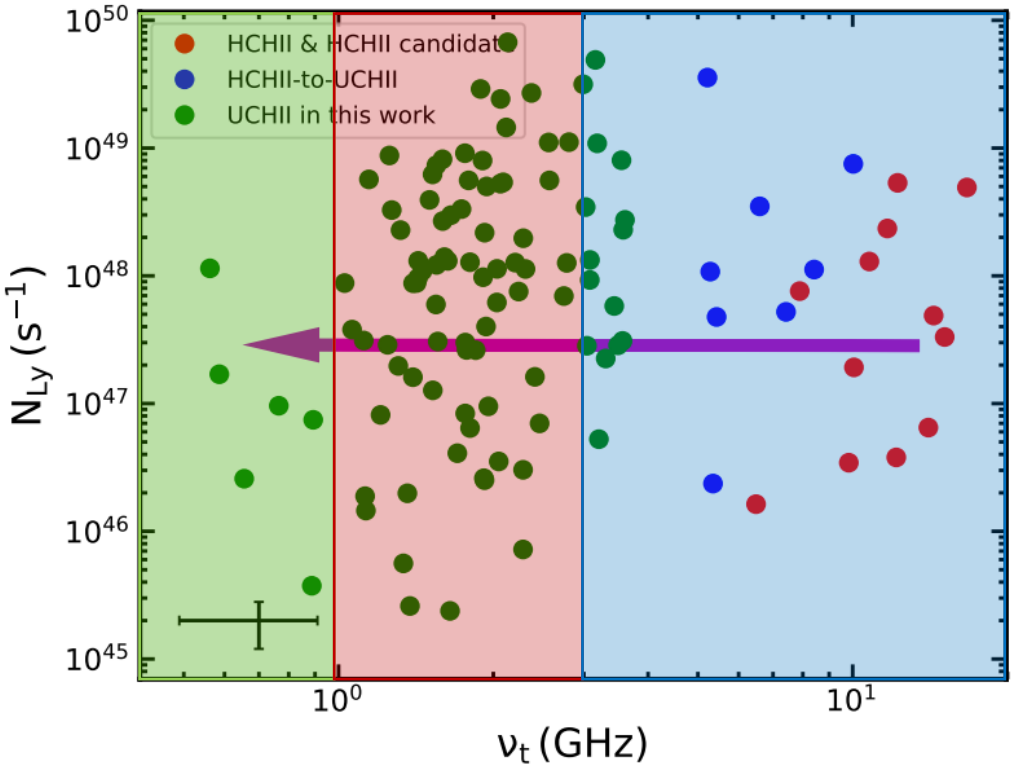
Band-L at 1.3 GHz Band-S at 3.1 GHz

SMGPS

Goedhart et al. 2024

THE NEED FOR SKA-MID BAND 5B

sample of UC HII and HC HII of Yang et al. 2021



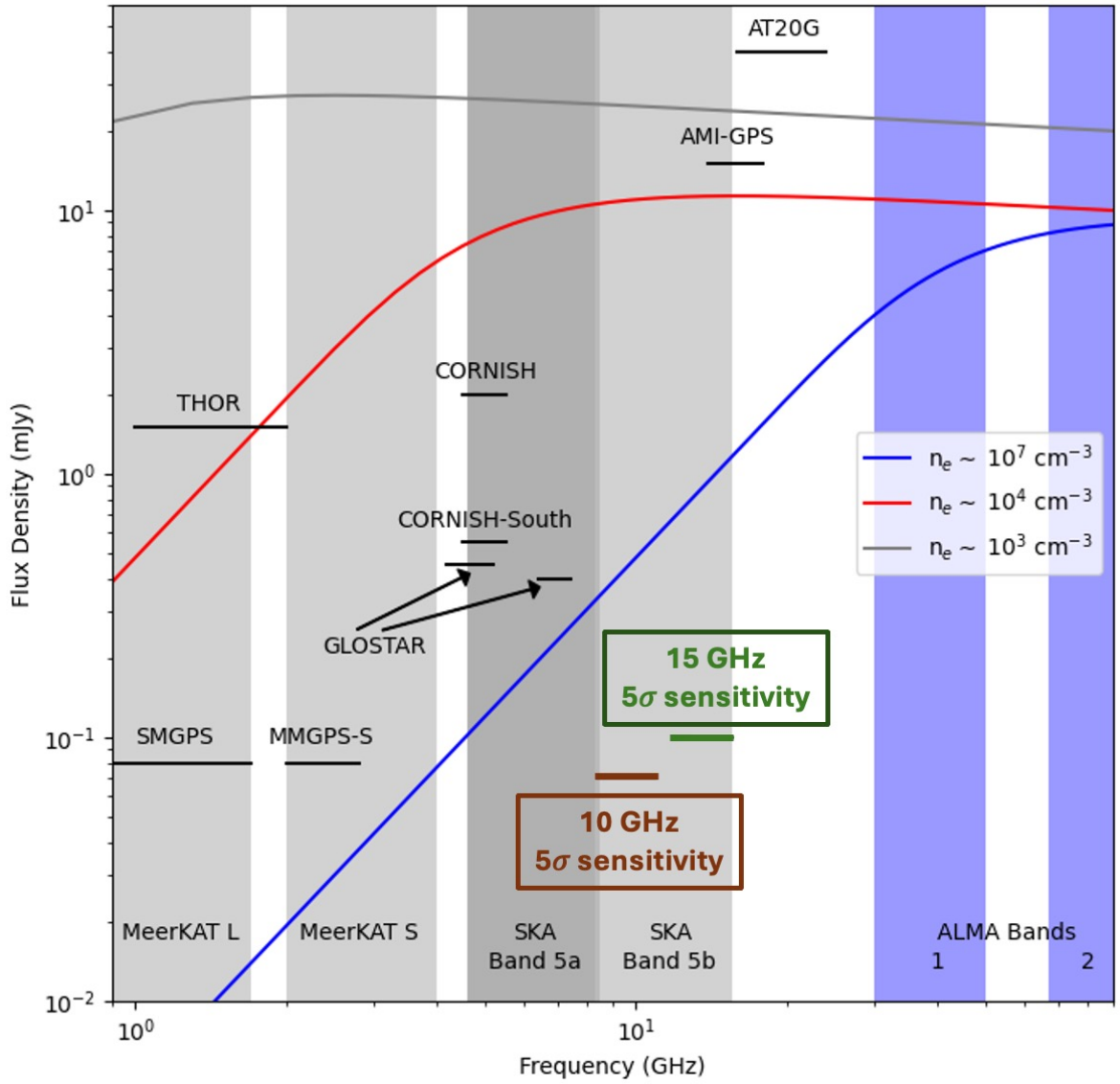
Band-L at 1.3 GHz Band-S at 3.1 GHz Band-X and Ku at 10 & 15 GHz

less affected by synchrotron emission

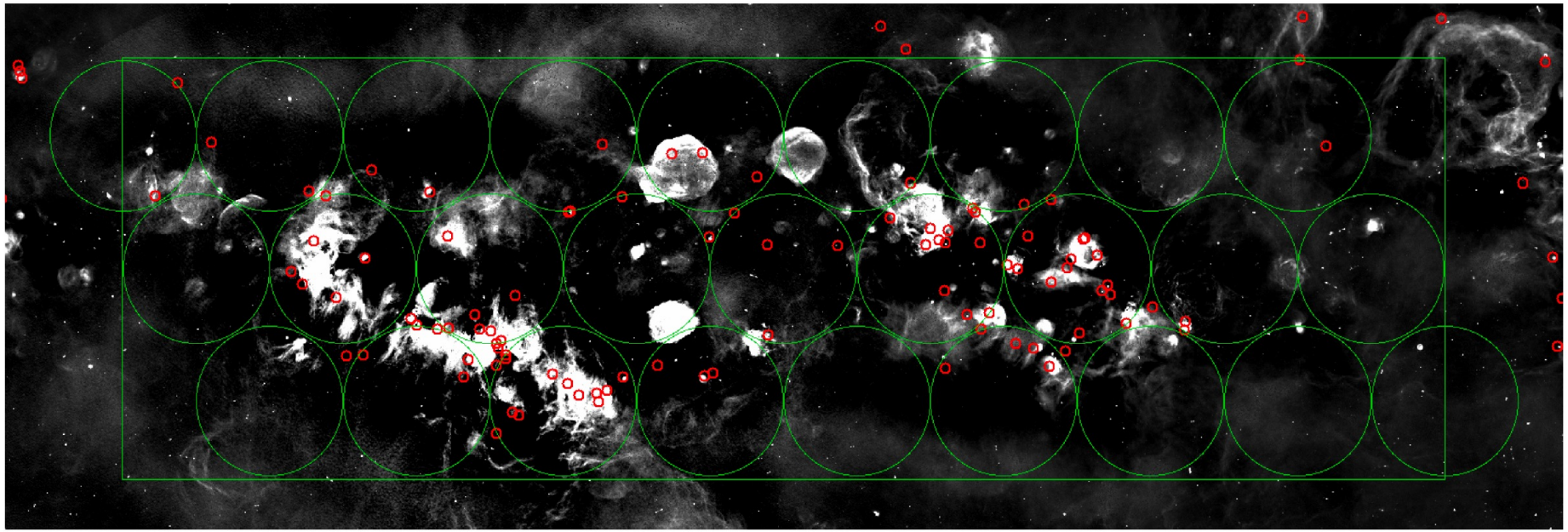
SKA-Mid resolution of ~0.07" @15 GHz and ~0.1" @10 GHz

at 10 kpc: resolve scales better than 10^{-2} pc

THE POWER OF A SKA BAND 5B GP SURVEY



MeerKAT pilot survey at 3.1 GHz in synergy with ALMAGAL



PIs: Alessio Traficante, F. Cavallaro

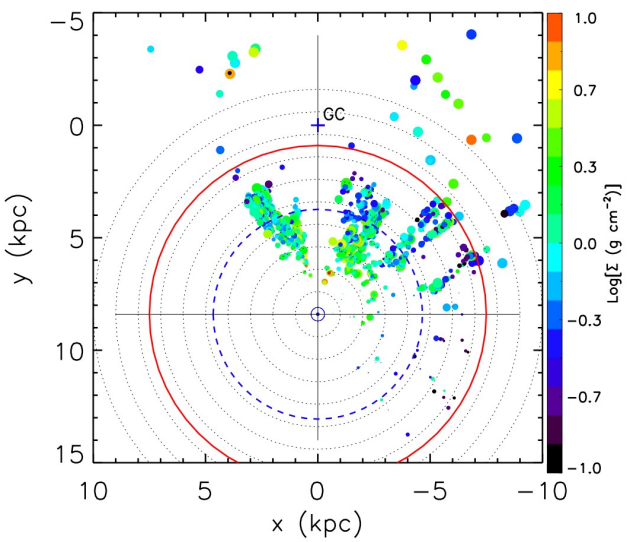
PhD student S. Sottie in co-tutorship with O. Smirnov (U. of Rhodes/SARAO)

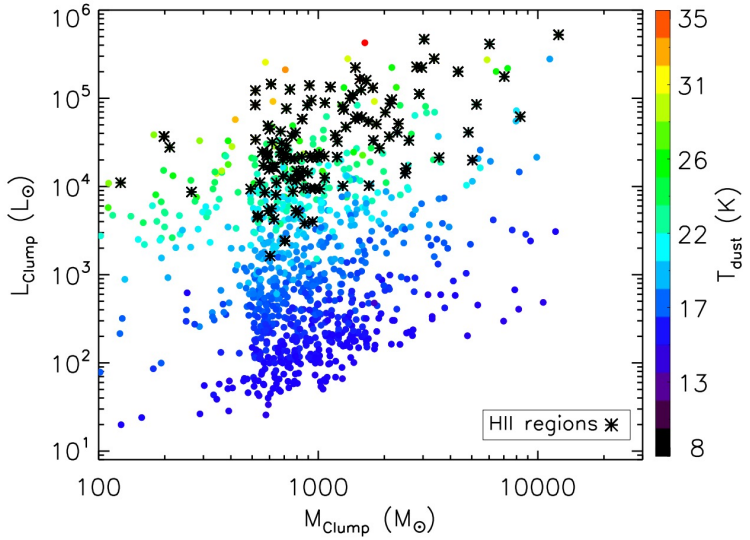
Just the field 330° ≤ l ≤ 334 ° contains :

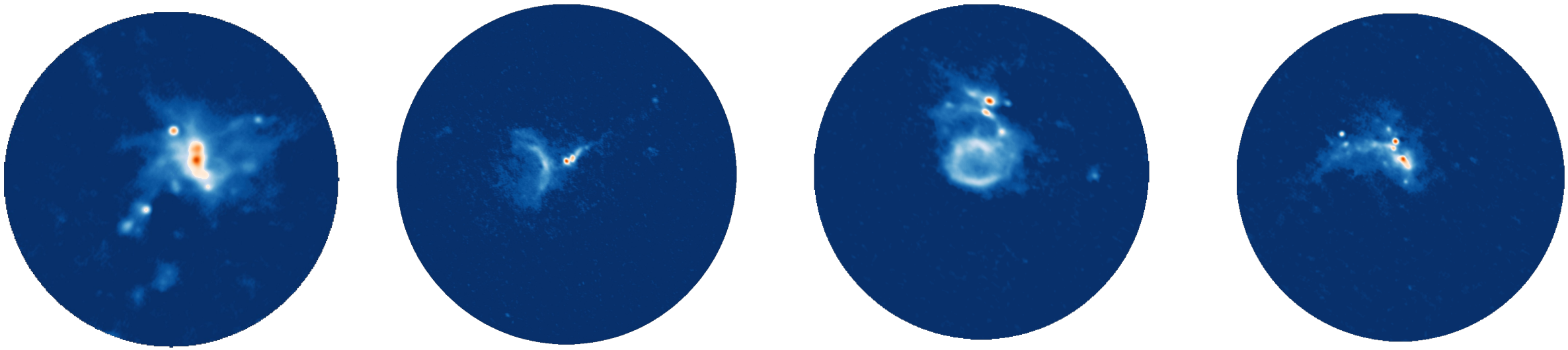
- **80** ALMAGAL sources
- **3** known SNRs (+**4** candidates)
- **5** Planetary Nebulae
- **>10** expected radio jets

CONNECTING ALL THE SCALES OF SF WITH FEEDBACK FROM SKA
ALMAGAL

- 1013 star forming CLUMP in the MW
- covering diff. environments & evolutionary stage
- ALMA Large Program Band 6
- linear resolution down to ~ 1500AU

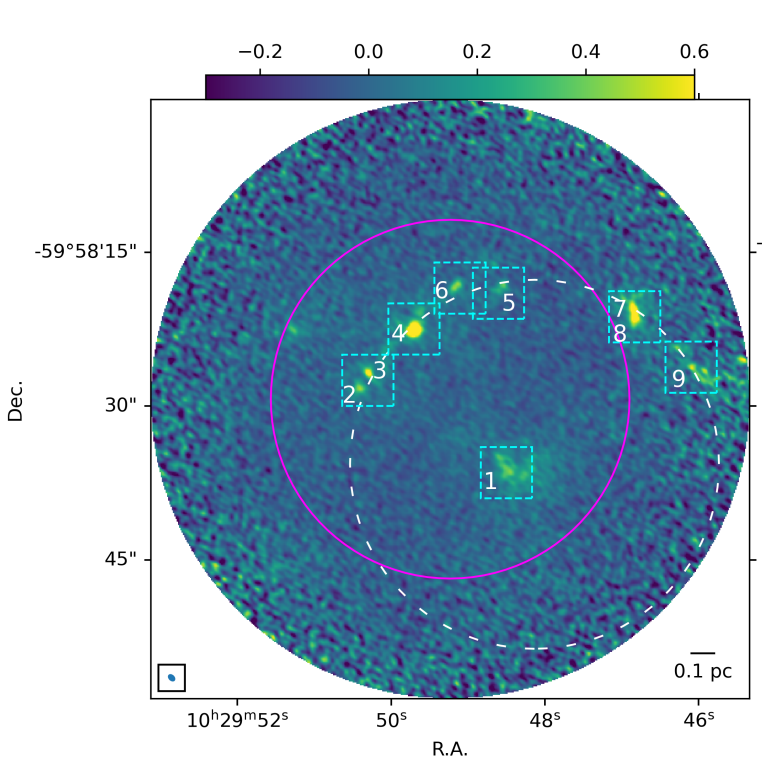


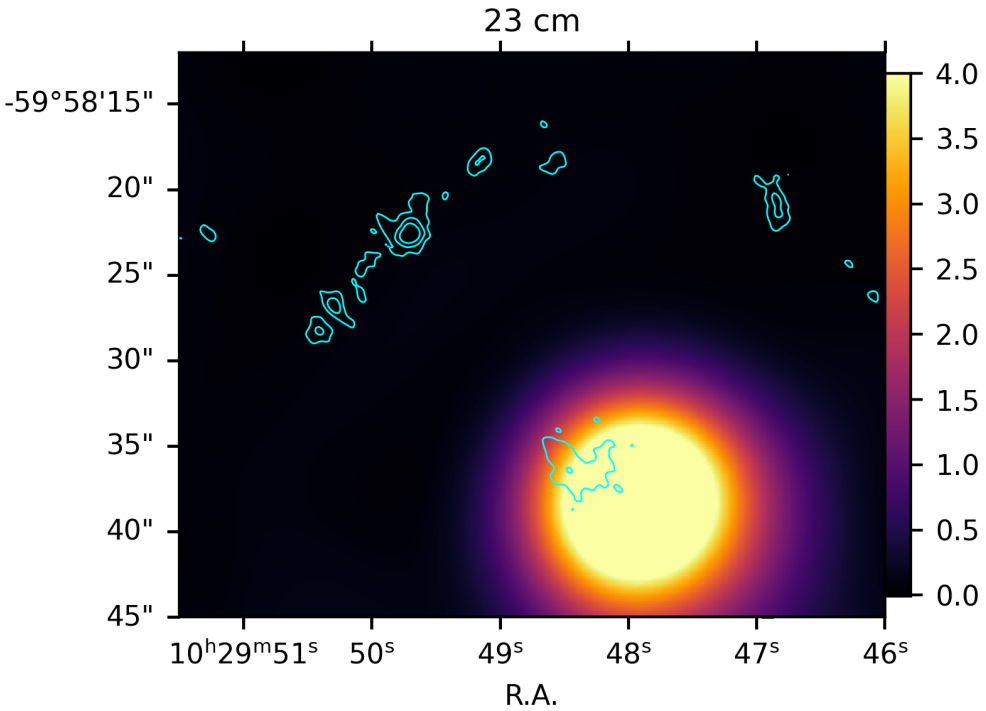


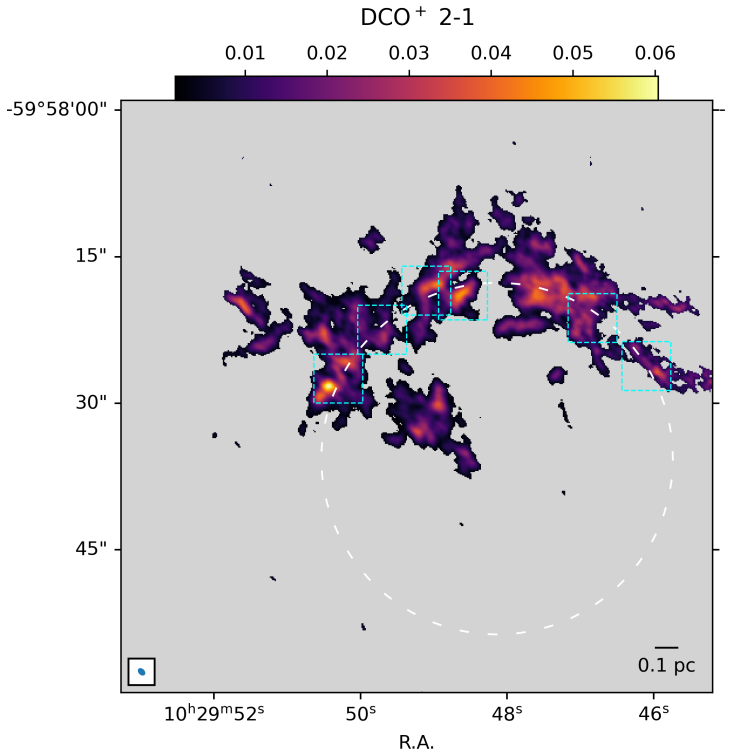


Molinari et al. 2025, Sanchez-Monge et al. 2025, Wells et al. 2024, Coletta et al. 2025, Mininni et al. 2025, Elia et al. 2025

EXAMPLE OF TRIGGERED STAR-FORMATION IN ALMAGAL







Mininni et al. (in prep.)

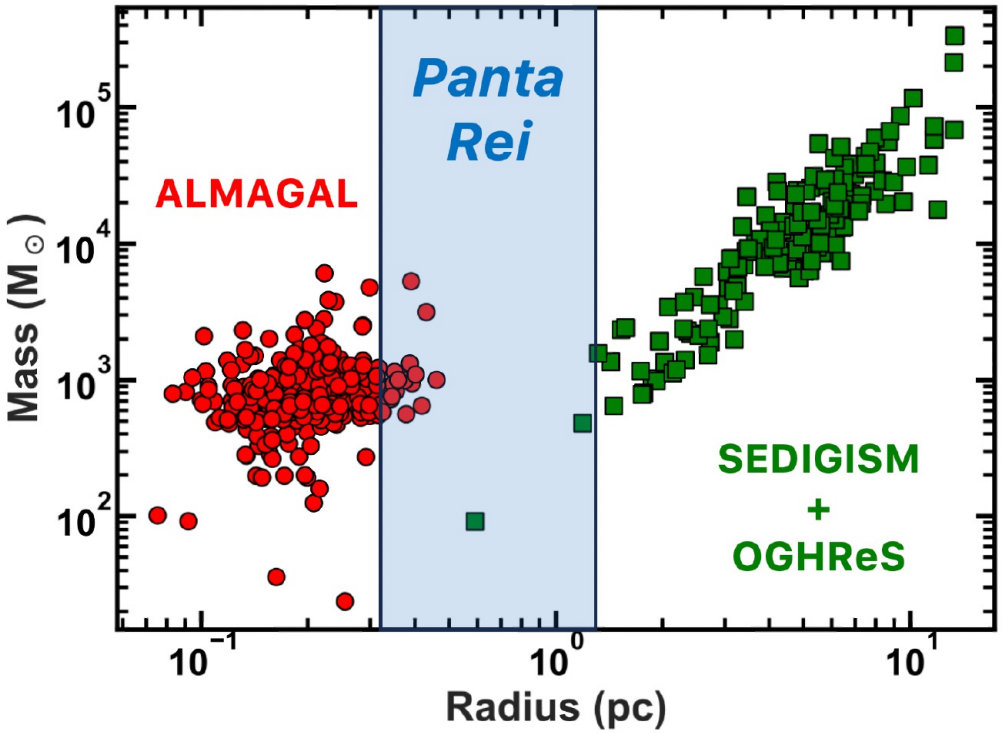
- ALMAGAL follow up in Band 4
- 8 compact cores on an arch shaped region of radius ~0.7 pc
- center close to the peak of bright emission at 1.3 GHz
- 1.3 GHz emission with spectral index ~ -0.1 - -0.4 and in Anderson et al. 2013 catalog
- bright DCO^+ (2-1) emission along the arch, with some cores in very early stages of SF

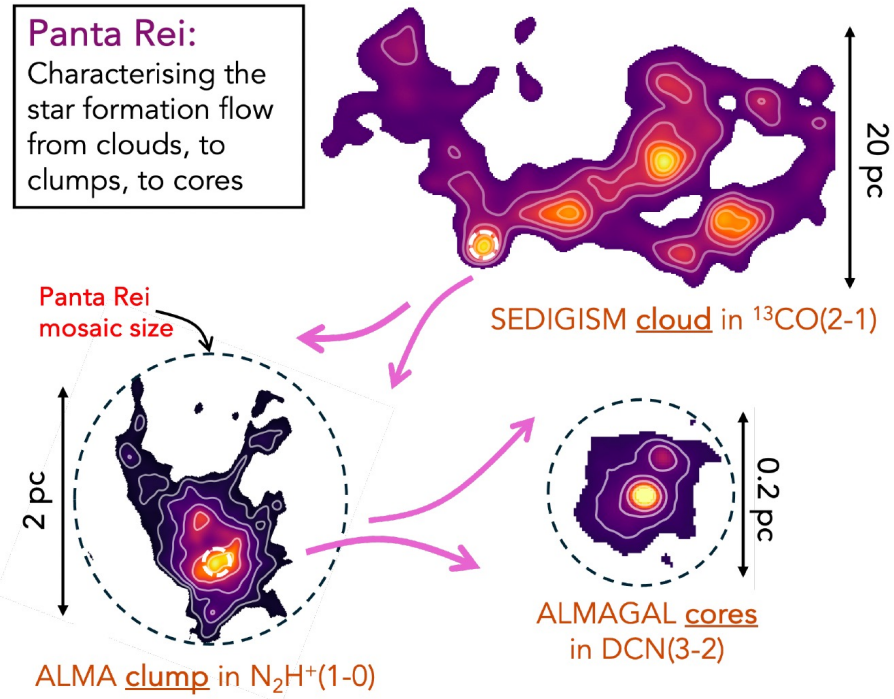
INAF MiniGrant RS2: ZODYAC

CONNECTING ALL THE SCALES OF SF WITH FEEDBACK FROM SKA
PANTA REI

ALMA Cycle 12 Large project
(PIs: N. Peretto, A. Traficante, S. Clarke, M. Merello)

ALMA **Band 3** mosaics around **259 ALMAGAL clumps** with SEDIGISM+OGHrES counterparts 7M (83h) +ACA (256h)+TP (426h)



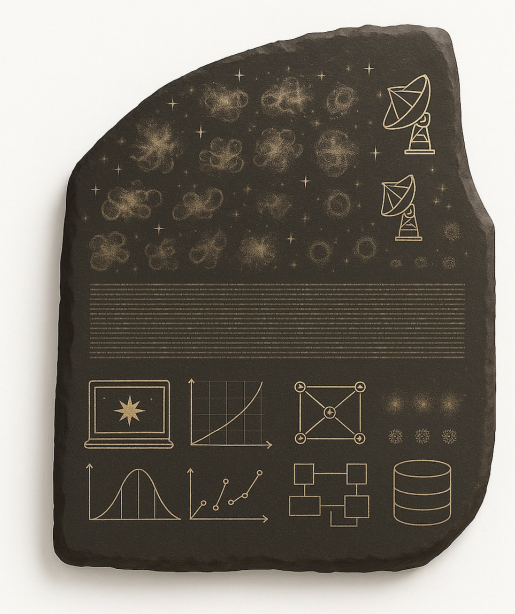


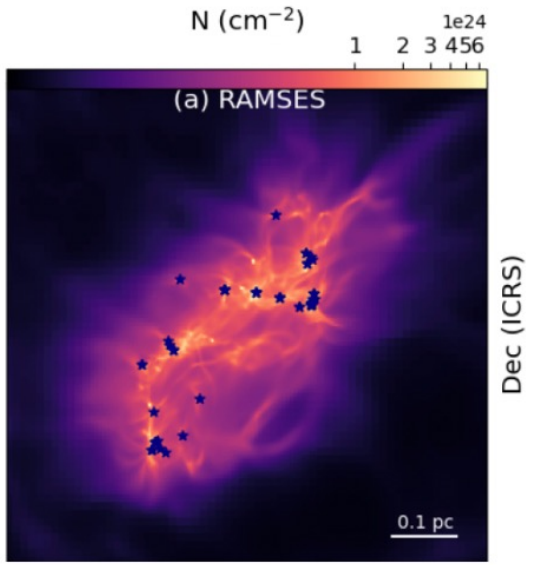
- Covering all angular scales from ~2.5" -> 120"
- N_2H^+ (1-0); HNC (1-0); HCN (1-0); HCO^+ (1-0); $H^{13}CO^+$ (1-0); $H^{13}CN$ (1-0); SiO (2-1), …

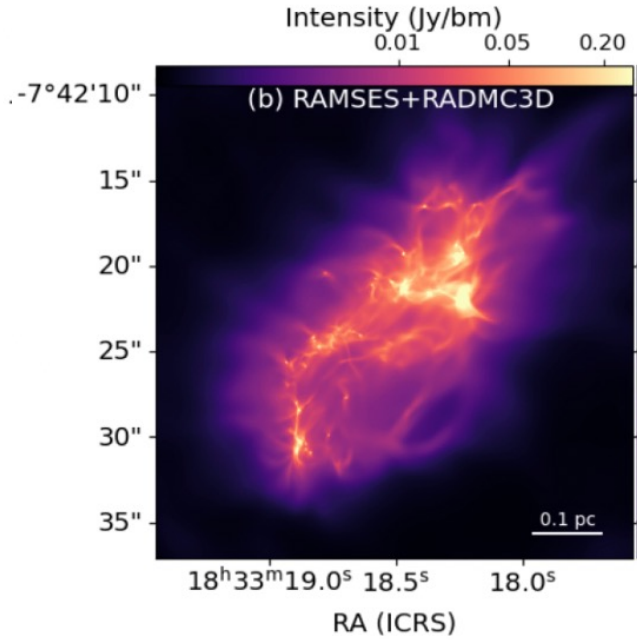
dynamics, infall, turbulence and outflow feedback

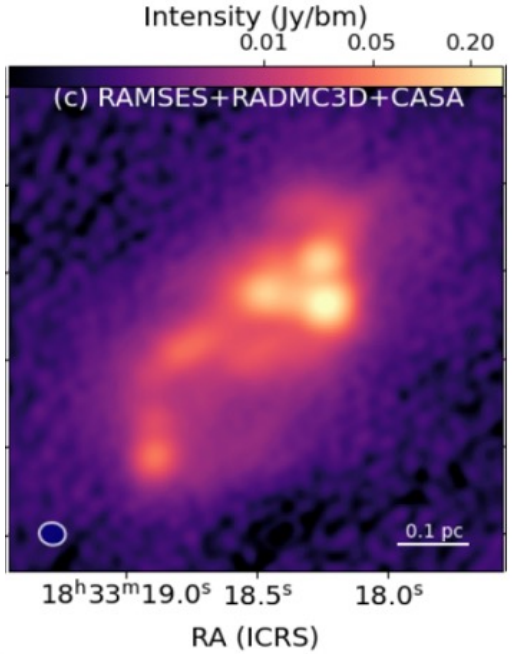
The Rosetta Stone project

A complete end-to-end (simulations ⇔ observations) framework based on the systematic production of realistic synthetic observations of clump fragmentation and their comparison with real data.









Suite of 30+ simulations
2 masses, 2 radius,
2 mach numbers,
2 magnetic-to-flux mass ratio

Lebreuilly, Traficante, et al. 2025: «The Rosetta Stone Project I»

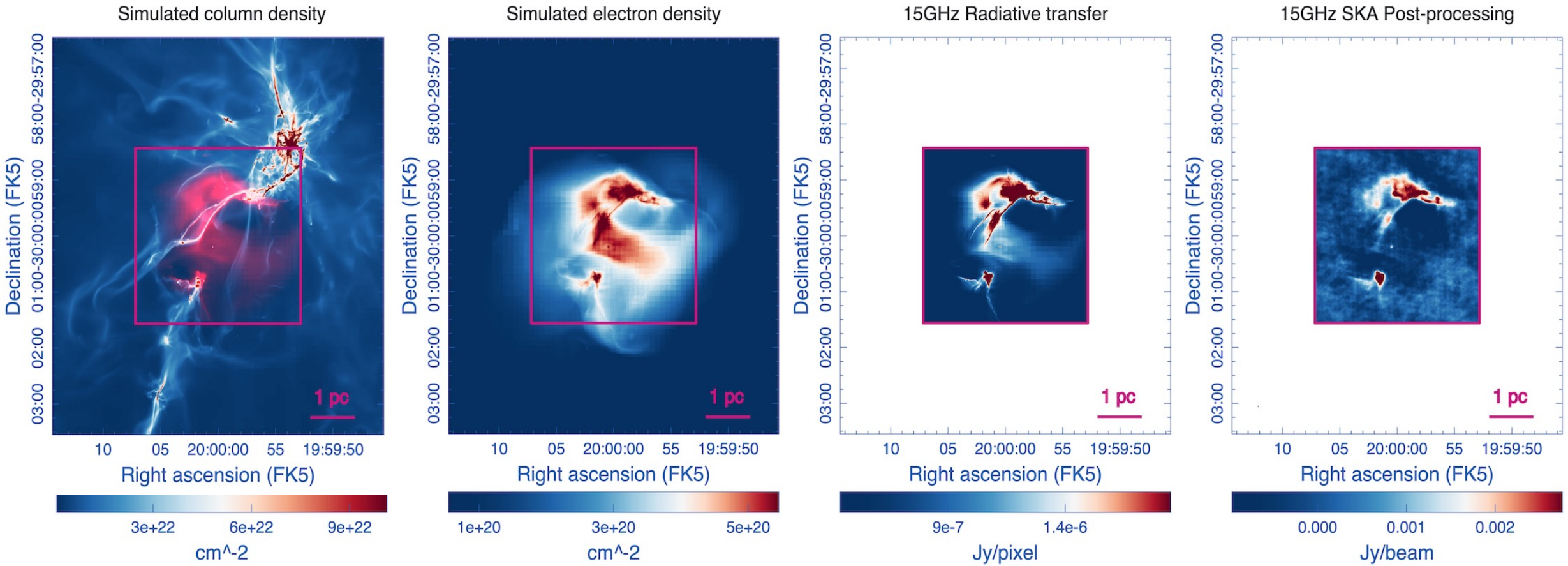
Synthetic observations
24, 70, 160, 250, 350, 500 μm & ALMA 1.3mm

Tung, Traficante, et al. 2025: «The Rosetta Stone Project II»

CASA Post-processing
to mimic with the maximum accuracy real ALMA observations

Nucara, Traficante, et al. 2025: «The Rosetta Stone Project III»

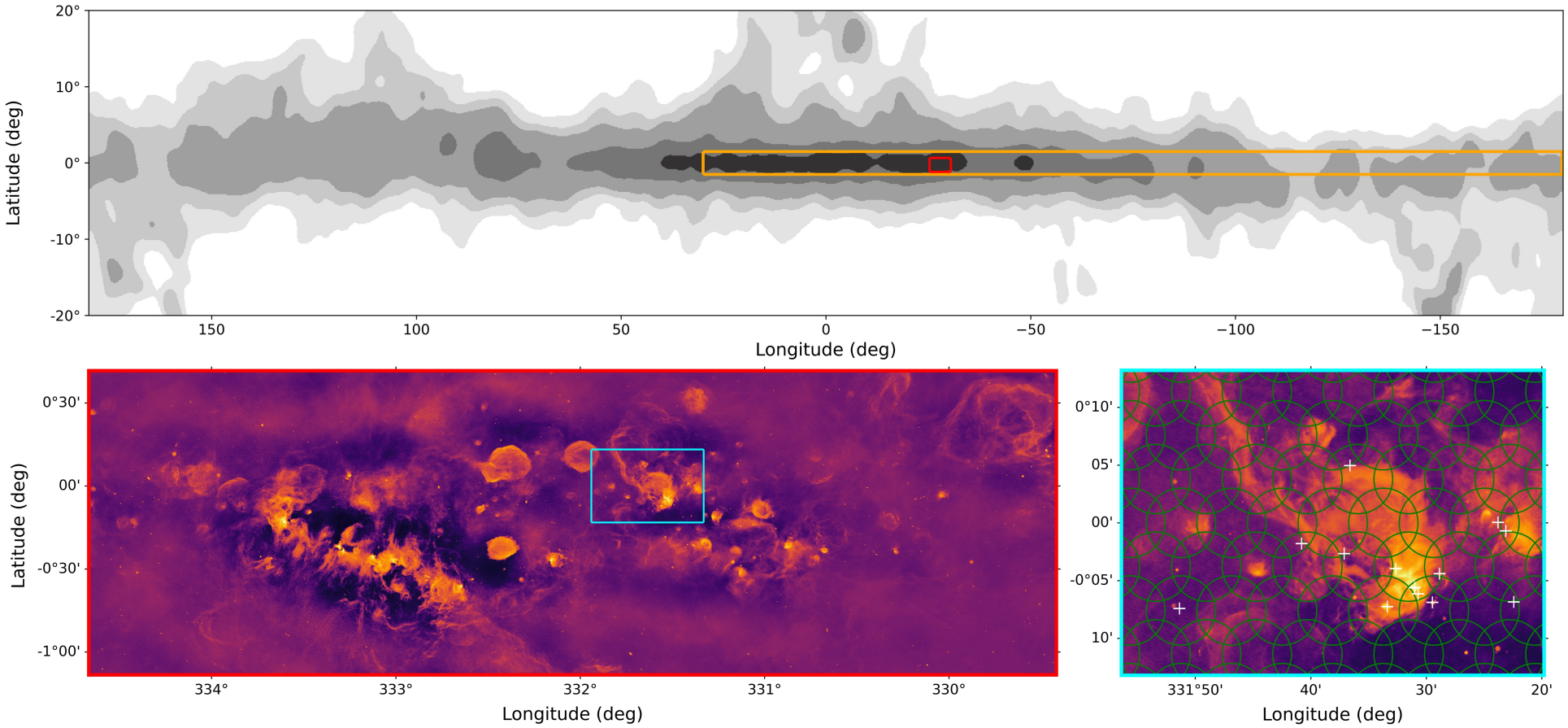
WE CAN MODEL FREE-FREE EMISSION FROM HII REGIONS



In preparation for future MeerKAT/MeerKAT+/SKA radio surveys @1.3-15 GHz, we are developing a new module in the POLARIS post-processing software (Reissl+12) **able to reproduce the free-free emission from ionised gas** (and coupled with the already implemented synchrotron emission)

(Reissl, Traficante, Suin, Nucara, Pelkonen in prep.)

The Galactic Plane Survey design



longitude range: -180° – 30° & latitude range: -1.5° – 1.5°

total of 630 deg² of coverage

2 spws of 2.5 GHz centered at ~9.5 GHz and ~14 GHz in AA4 conf.

total of 600 h to reach sensitivity of ~20 μJy @14 GHz and ~14 μJy @9.5 GHz

resolution of ~0.07" @14 GHz and ~0.1" @9.5 GHz

SYNERGIES WITH OTHER SCIENTIFIC CASES: THE IMPORTANCE FOR THE ENTIRE COMMUNITY

- Radio jets from massive regions: radiojets with $L_{bol} > 14\ L_{sun}$ @1kpc
- Supernova remnants: reliable spectral index, confirm candidates and discover new SNR
- Planetary Nebulae: detected number way lower then expected (already improved with SMGPS)
- Evolved massive stars: mass loss through winds emission and shells
- RRL: 17 Hα RRLs alone available band 5b
- Masers emissions: 9.9 and 12.2 GHz CH_3OH and 14.5 GHz H_2CO
- Galactic Center

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THANK YOU!