SNO RAMSES 2025

ECOGAL – AN UPDATE OF MY CONTRIBUTION

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THE ECOGAL PROJECT

ERC synergy (PIs : Hennebelle, Klessen, Molinari, Testi)

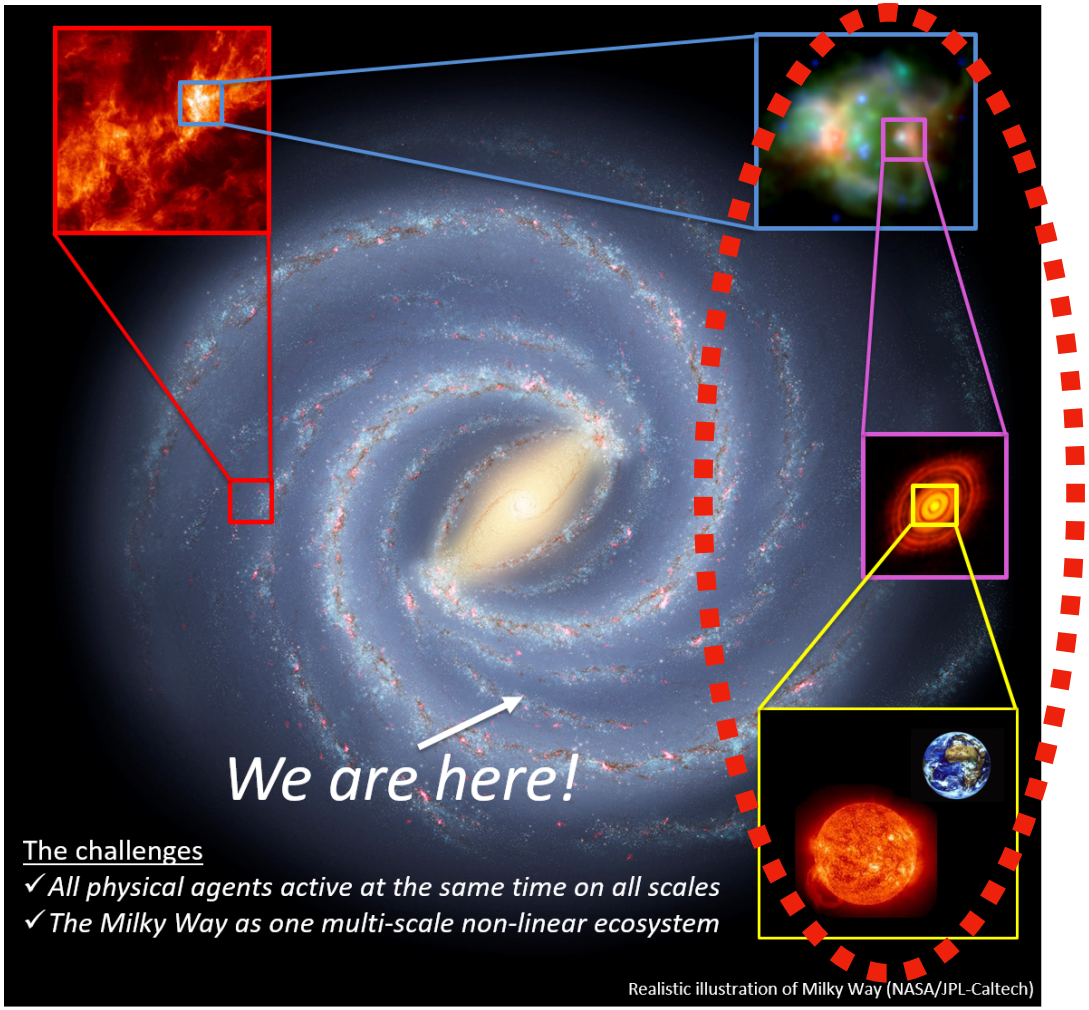
International collaboration (~100 researchers) between CEA, Heidelberg Univ, IAPS & ESO Munich/Florence Univ

Goal: A complete self-consistent modelling of the Milky-Way from galactic scales down to planetary systems.

Aim:

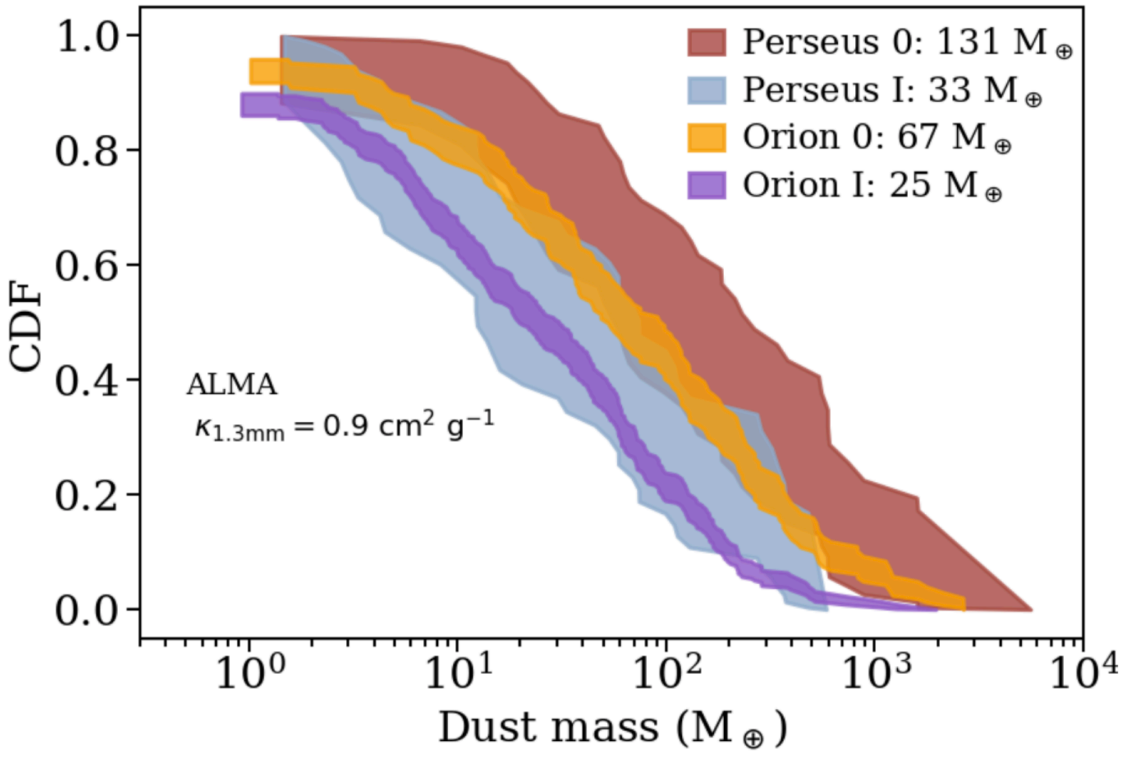
Multi-scale simulations of the galaxy including the impact of large scales on small scales and the feedback of small scale on large scales.

Observations of the Galaxy at all scales



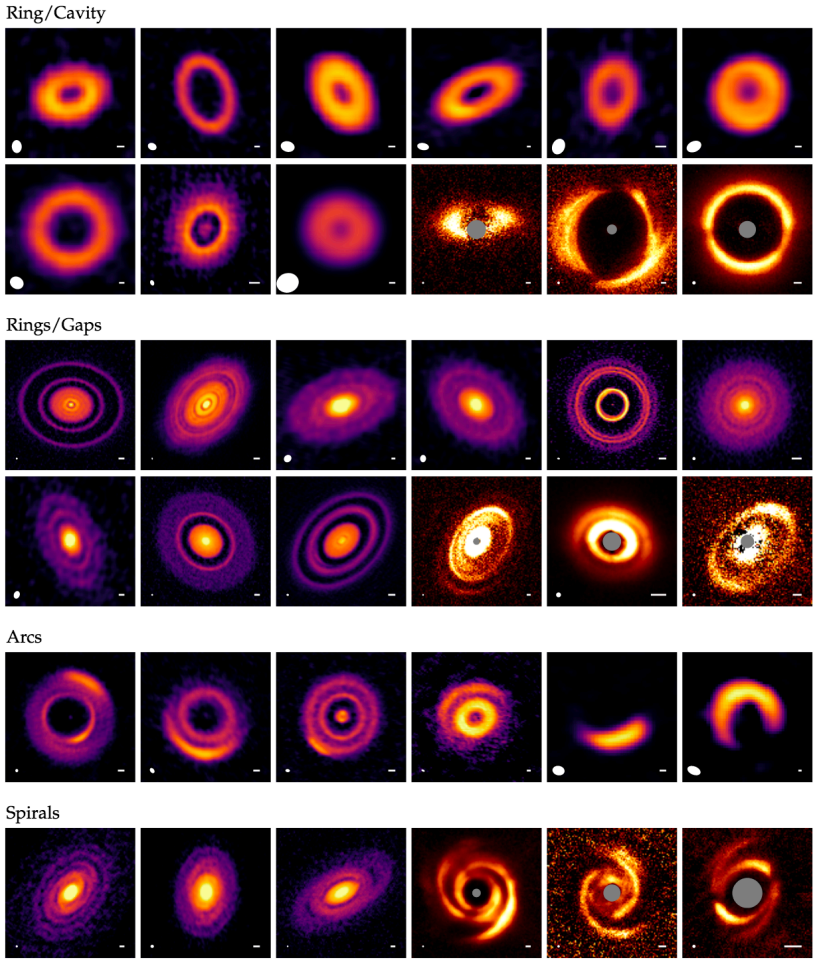
ON THE DIVERSITY OF PP. DISKS

Diversity of properties (mass, radius)



Tychoniec et al. (2020)
See also (among many others):
Segura-Cox et al. (2018), Maury et al. (2019), Tobin et al. (2020), Sheehan et al. (2022)

Diversity of structures (for evolved disks)



DSHARP survey : Andrews et al. (2018)

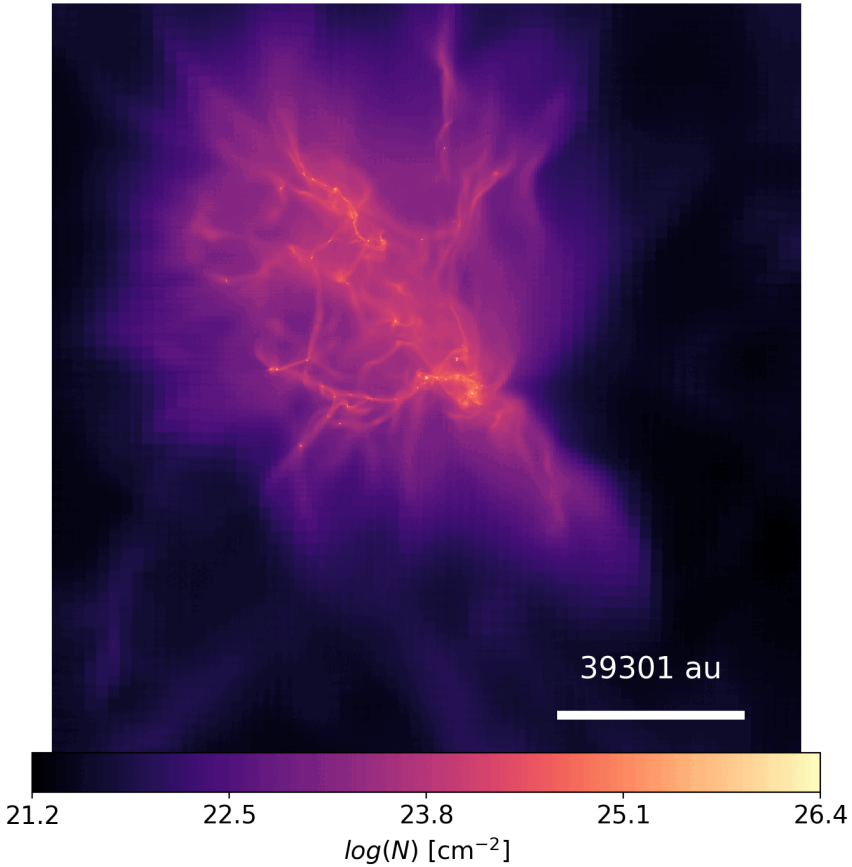
WE AIM TO RECOVER (AND EXPLAIN) THIS DIVERSITY WITH MHD MODELS

RAMSES (Teyssier 2002) simulations

- 500-1000 solar mass clouds (of ~pc size)
- Uniform initial density
- Supersonic turbulent velocities (Mach 7 & 14)
- Uniform magnetic field (mass-to-flux ratio: 10 & 50)
- Refinement of the grid up to **~1 au** (Jeans length based)
- Stars are represented by sink particles

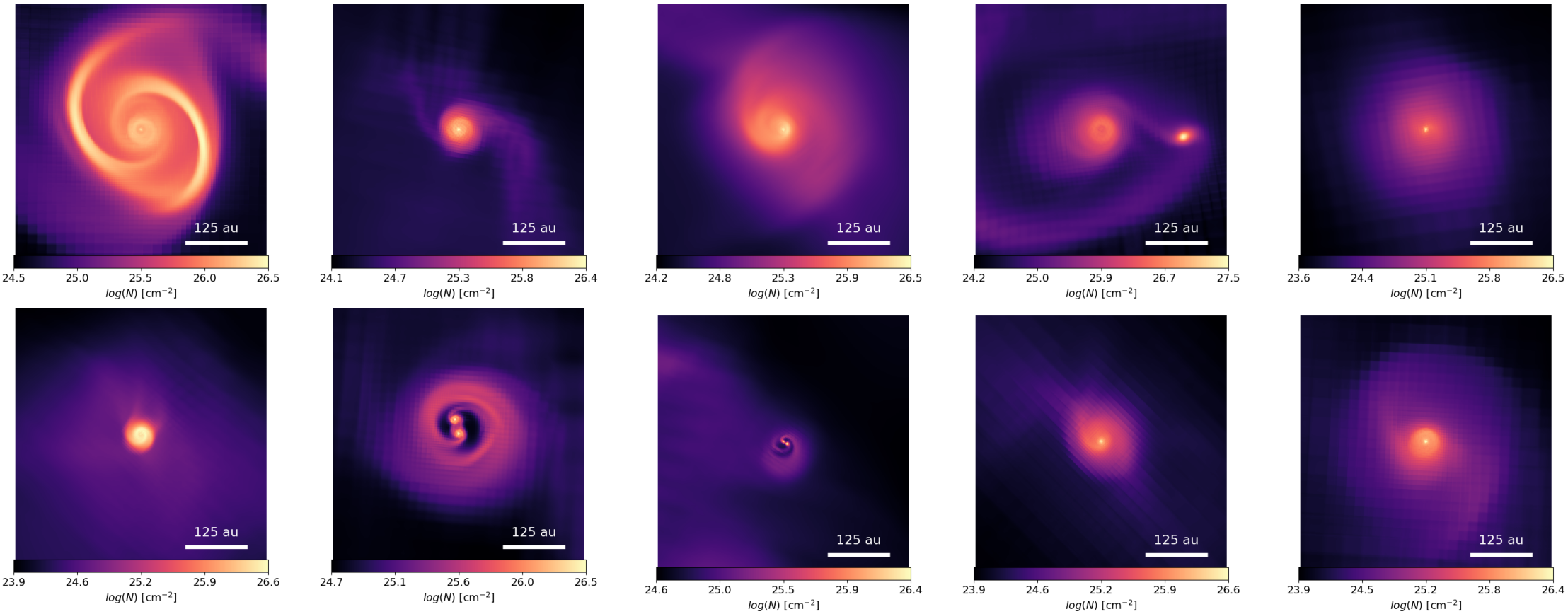
Physics included

- Self-gravity
- MHD (ambipolar diffusion)
- Radiation (FLD grey body + stellar radiative feedback)



Lebreuilly et al. (2024a,b); see also Lebreuilly et al. (2021)

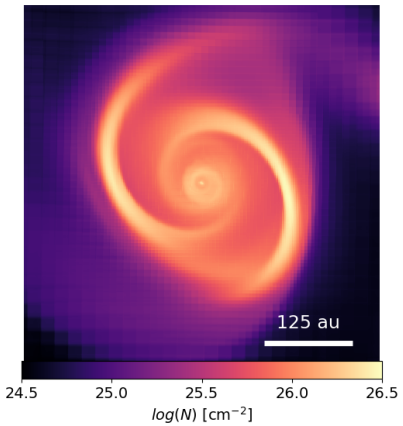
DISK DIVERSITY IN OUR MODELS

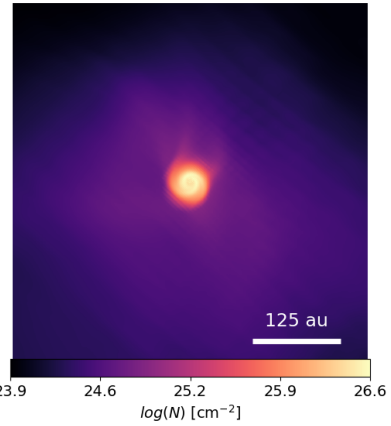


These disks are all taken from the same snapshot !

Lebreuilly et al. (2024a,b); see also Lebreuilly et al. (2021)

IMPACT OF MAGNETIC FIELDS





Large disks

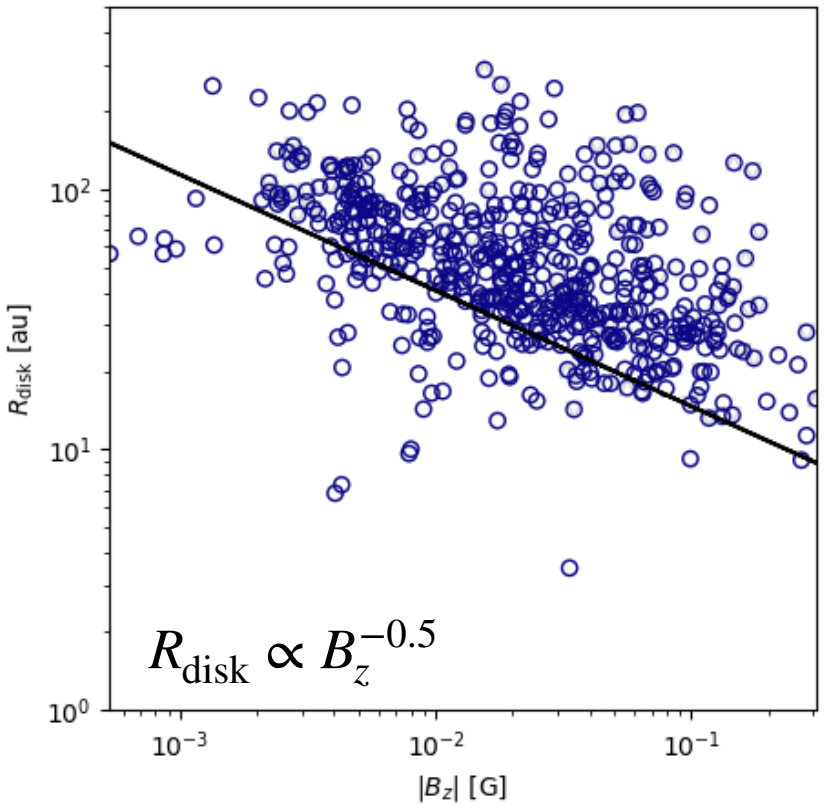
Angular momentum

Mediation by the charged particles
(Dust, ions & electrons):
Non-ideal MHD

Small disk

Magnetic braking

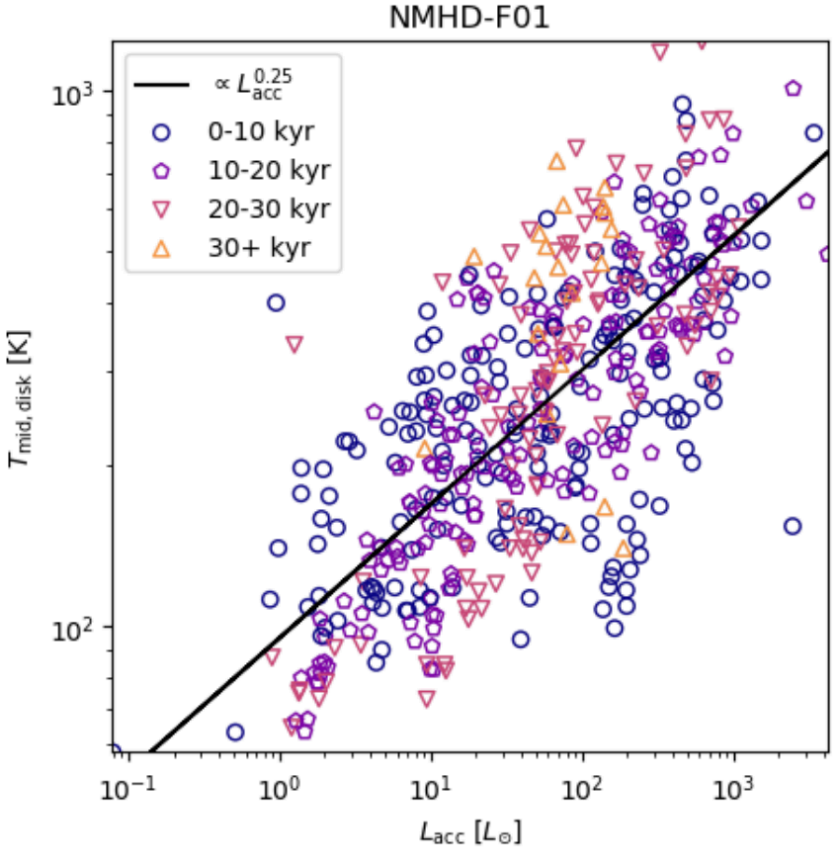
Disk size vs magnetic field



Generalisation of the impact of magnetic fields on disk sizes to disk populations

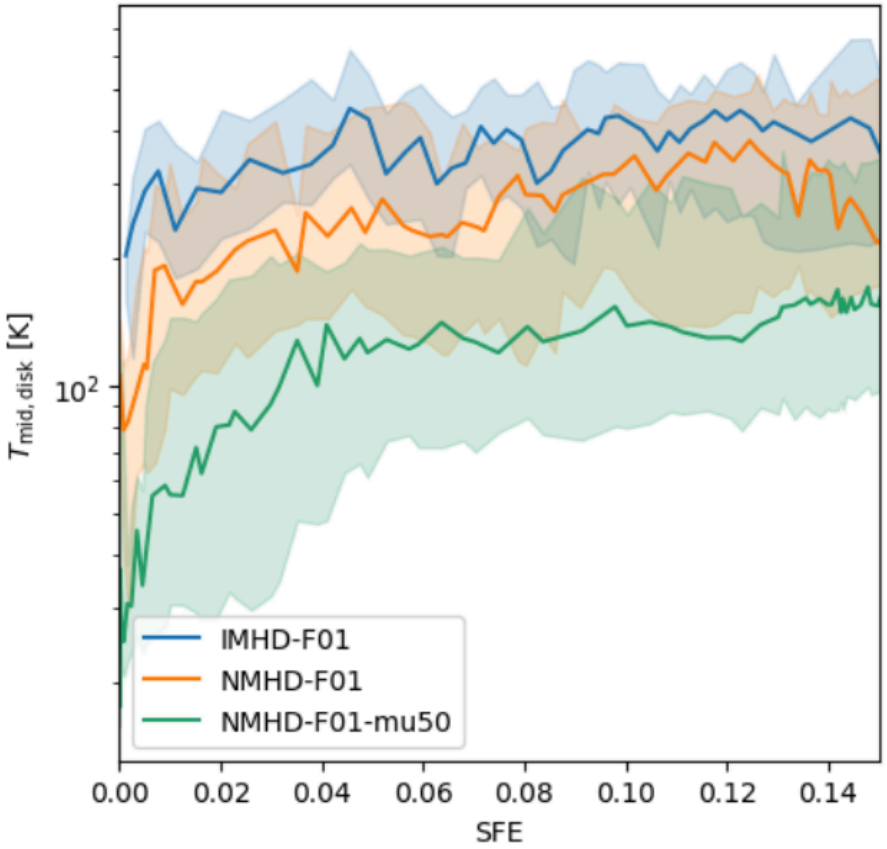
Lebreuilly et al. (2024a,b); see also Lebreuilly et al. (2021)

IS IT ME OR IT'S HOT IN THERE ?



$$T \propto L^{1/4}$$

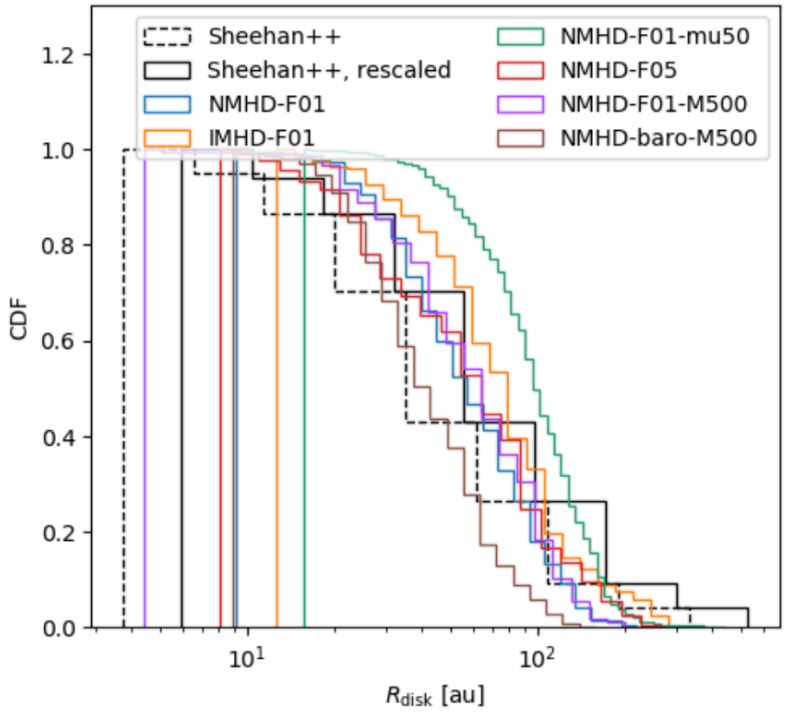
Impact of cloud conditions



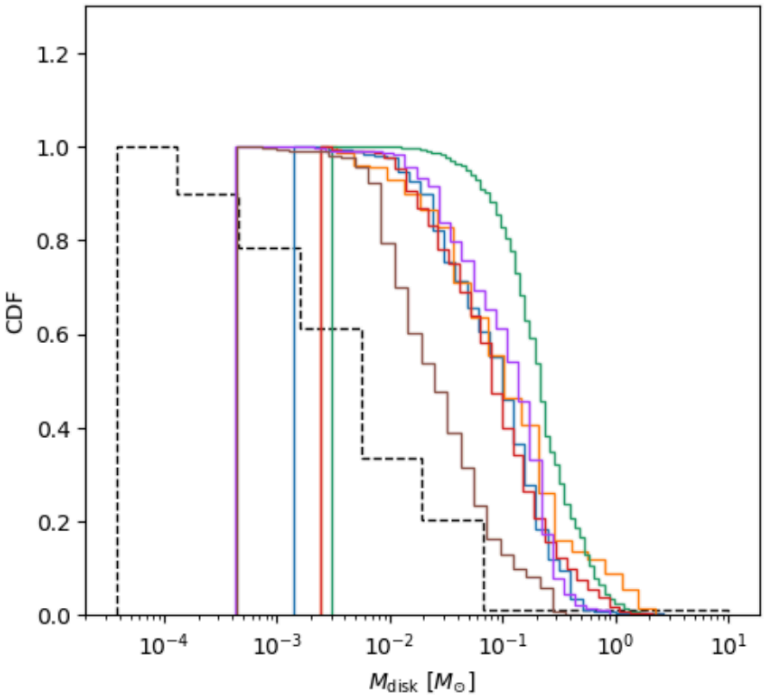
COMPARISON WITH OBSERVATIONS

Lebreuilly et al. (2024a)

Disk radii

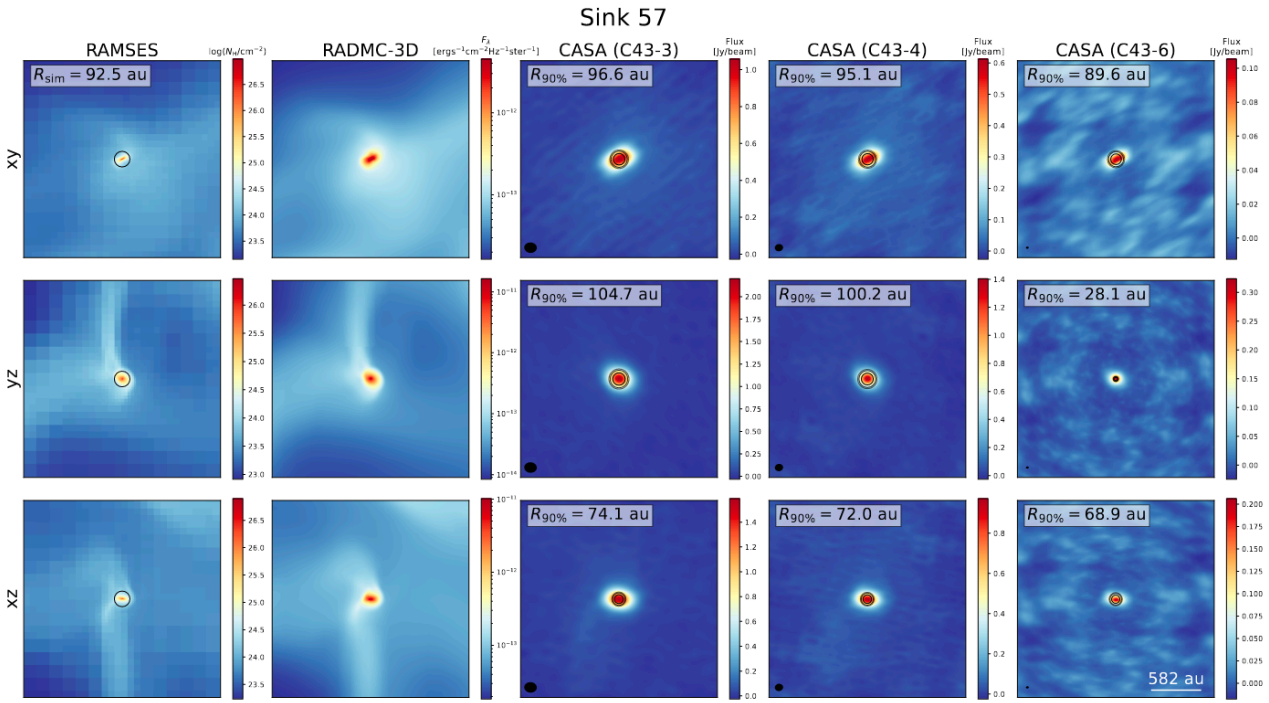


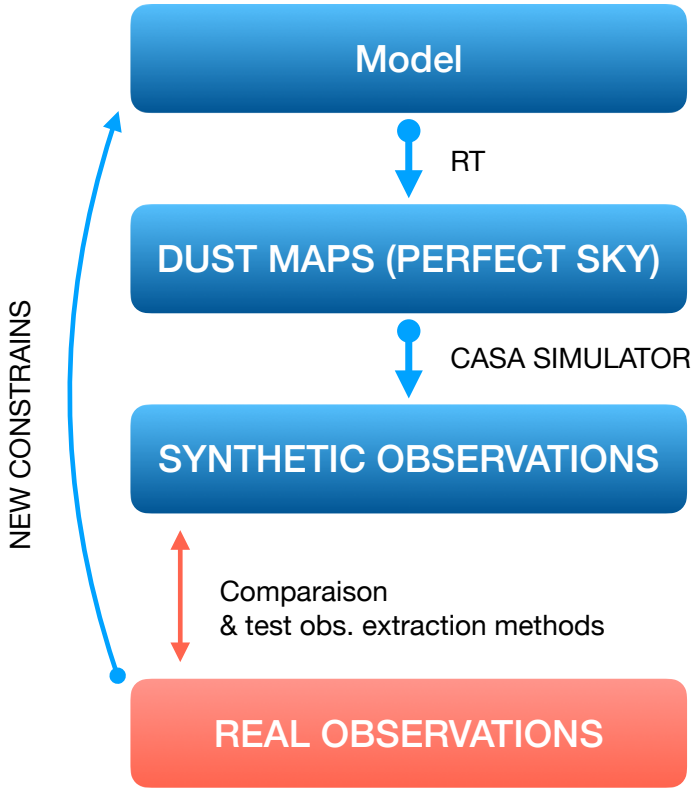
Disk masses



REAL COMPARISON WITH OBSERVATIONS

Tung et al. (2024)





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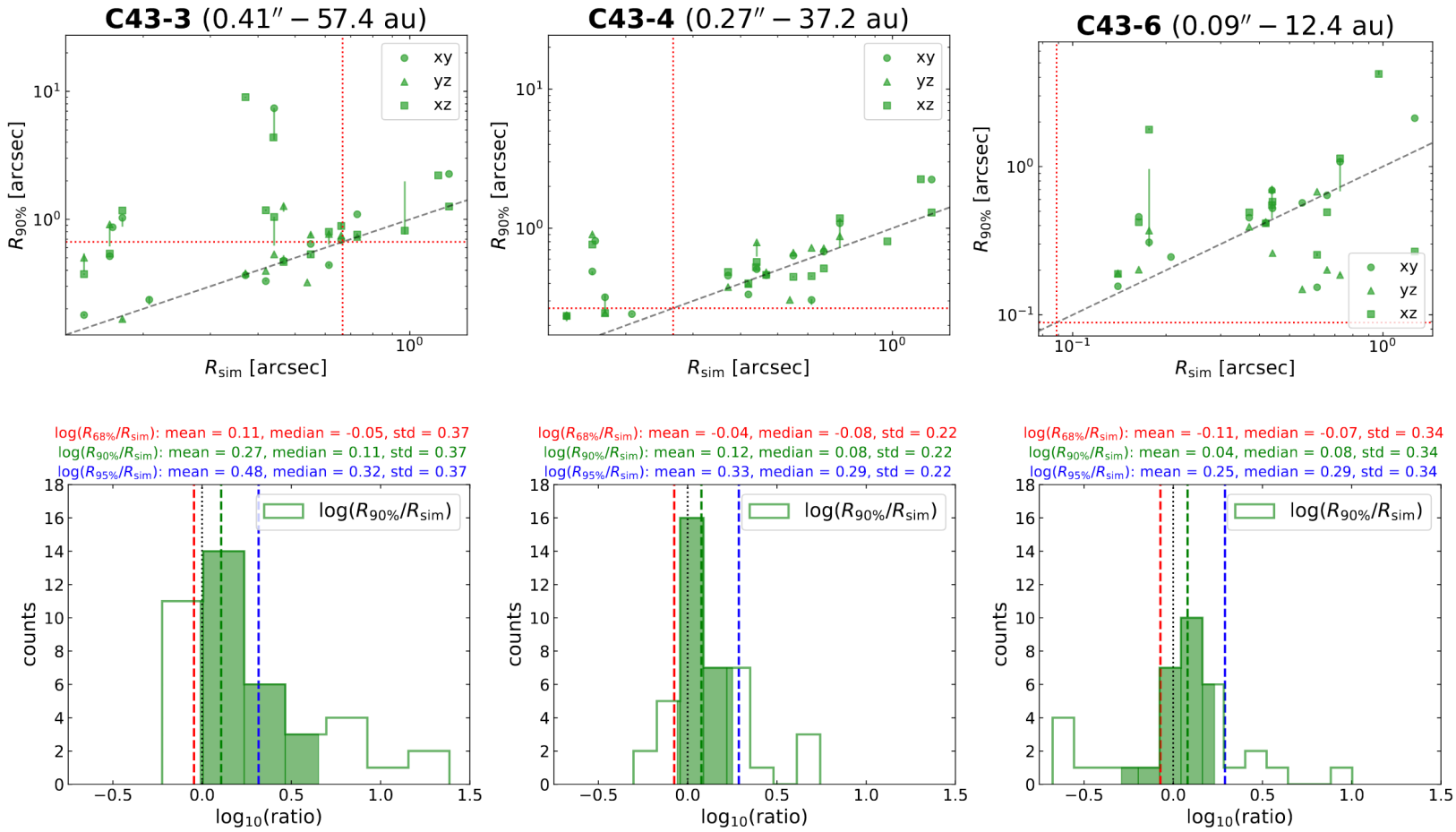

REAL COMPARISON WITH OBSERVATIONS

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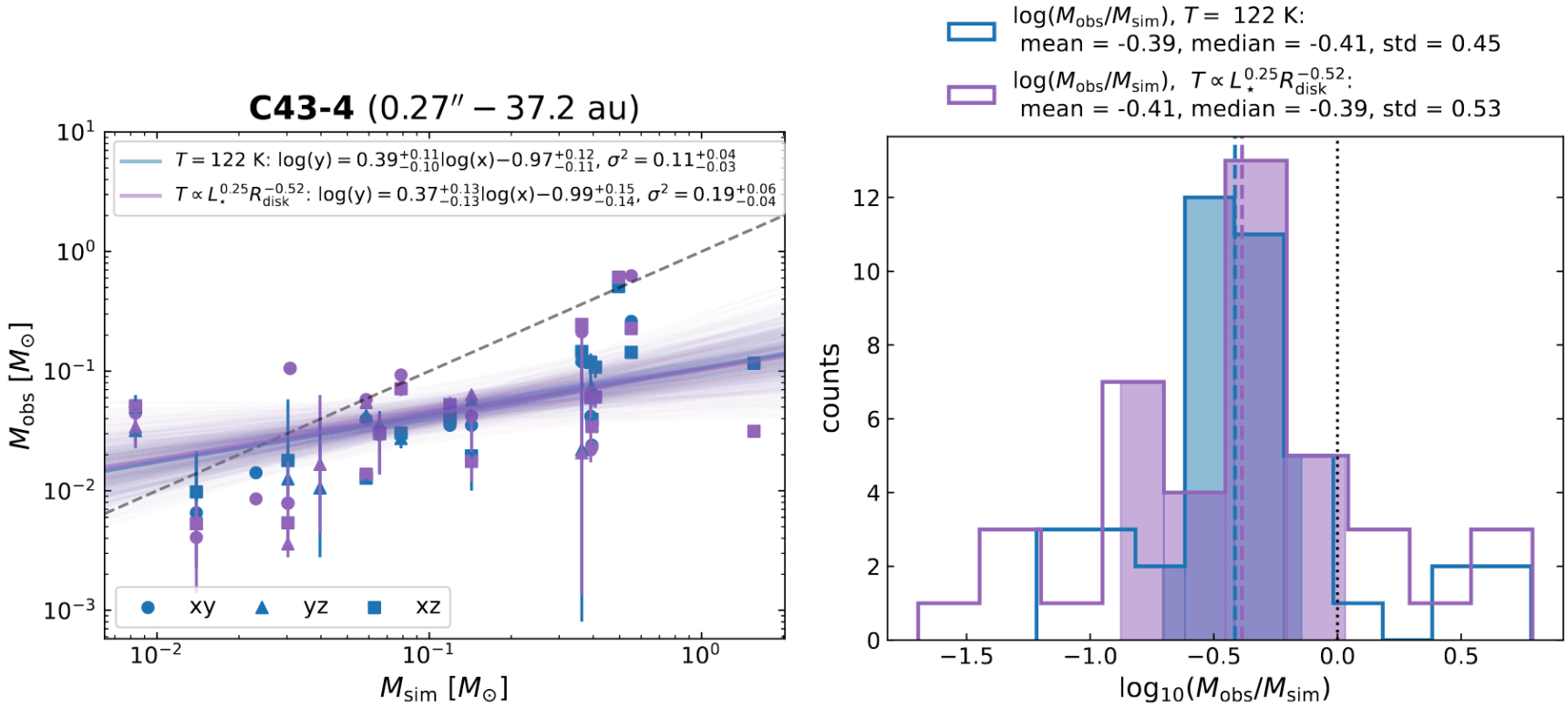
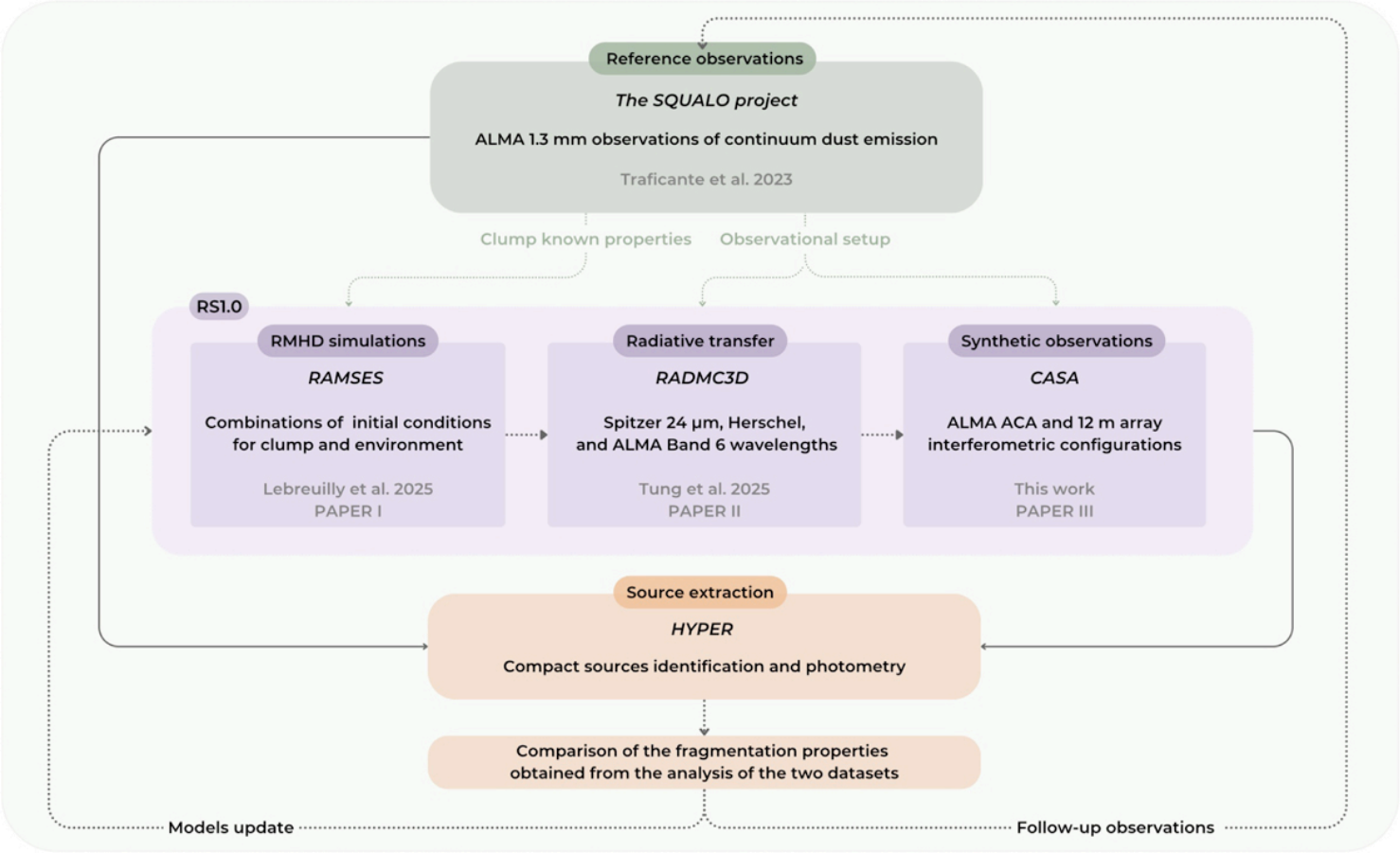


Problem : *emission opt. thick at 0.9 mm —> need to go for longer wavelength*

THE ROSETTA STONE PROJECT: HOW TO MAKE OBSERVER AND THEORETICIANS TALK TOGETHER ?

Lebreuilly et al. 2025, Tung et al. 2025, Nucara et al. 2025



THE ROSETTA STONE PROJECT: PRESENTATION OF THE SIMULATION CATALOGUE

Lebreuilly et al. 2025, Tung et al. 2025, Nucara et al. 2025

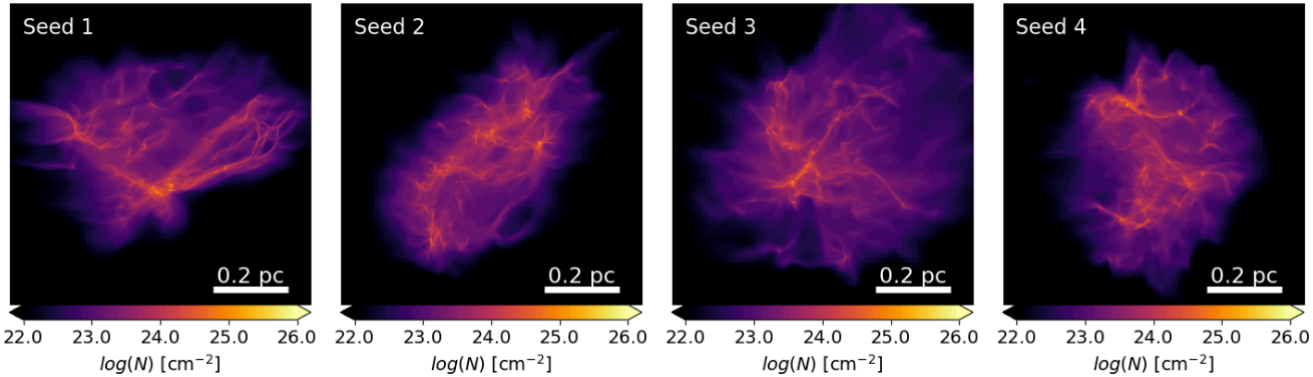
Table 1: Parameters range of the 24 RS1.0 catalog. The bold value designed the parameter choice for our reference model.

Parameters	Values
Mass [$M_\odot$]	[500,**1000**]
Radius [pc]	[**0.38**]
Mach	[**7**, 10]
μ	[3, **10**, 100]
Seed	[**1** , 2]

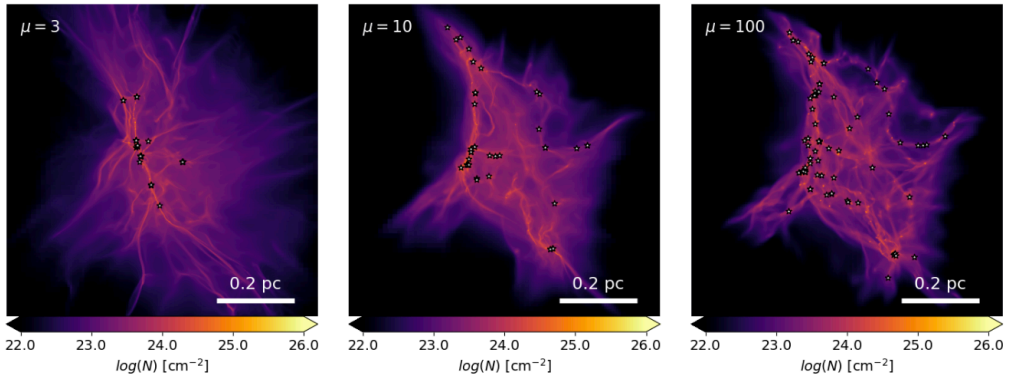
Table 2: Additional individual runs explored investigated for this study. These runs were all computed with a cloud mass of $1000 M_\odot$, a radius of 0.38 pc, and Mach number of 7 and a mass-to-flux ratio of 10

Seed	$N_{\rm jeans}$	$n_{\rm sink}$ [cm^{-3}]
3	10	10^9
4	10	10^9
1	20	10^9
1	10	10^{10}

Impact of the turbulent Seed

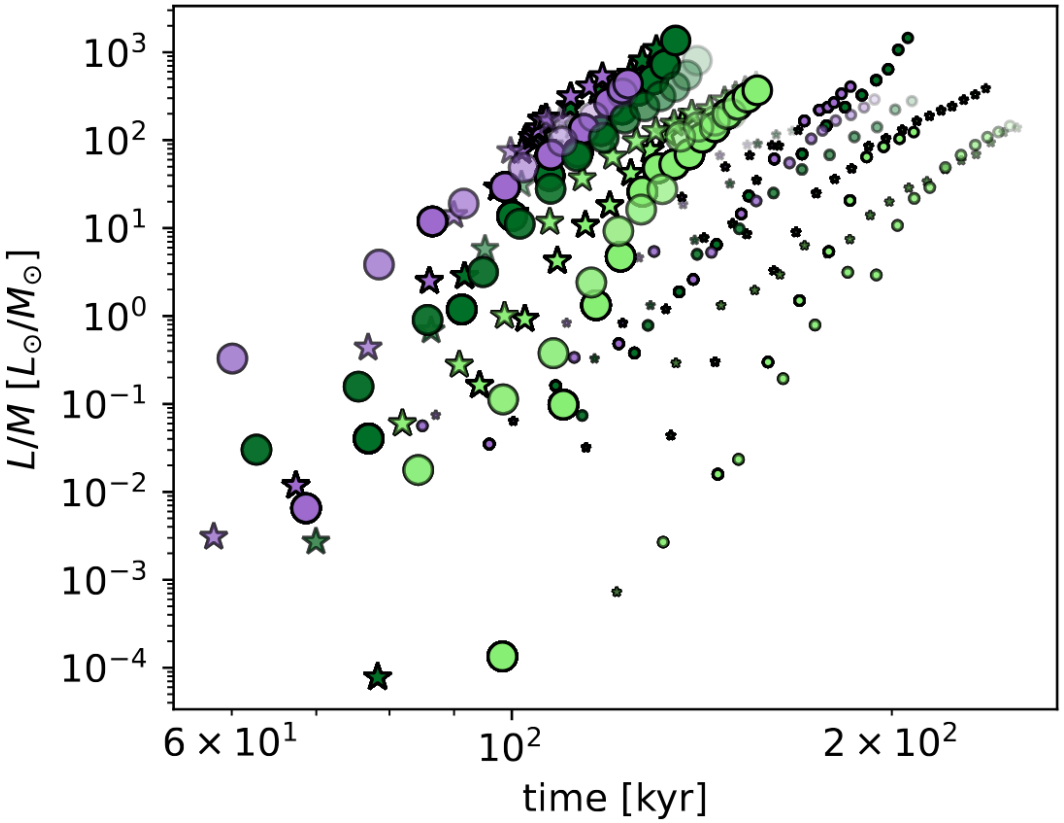


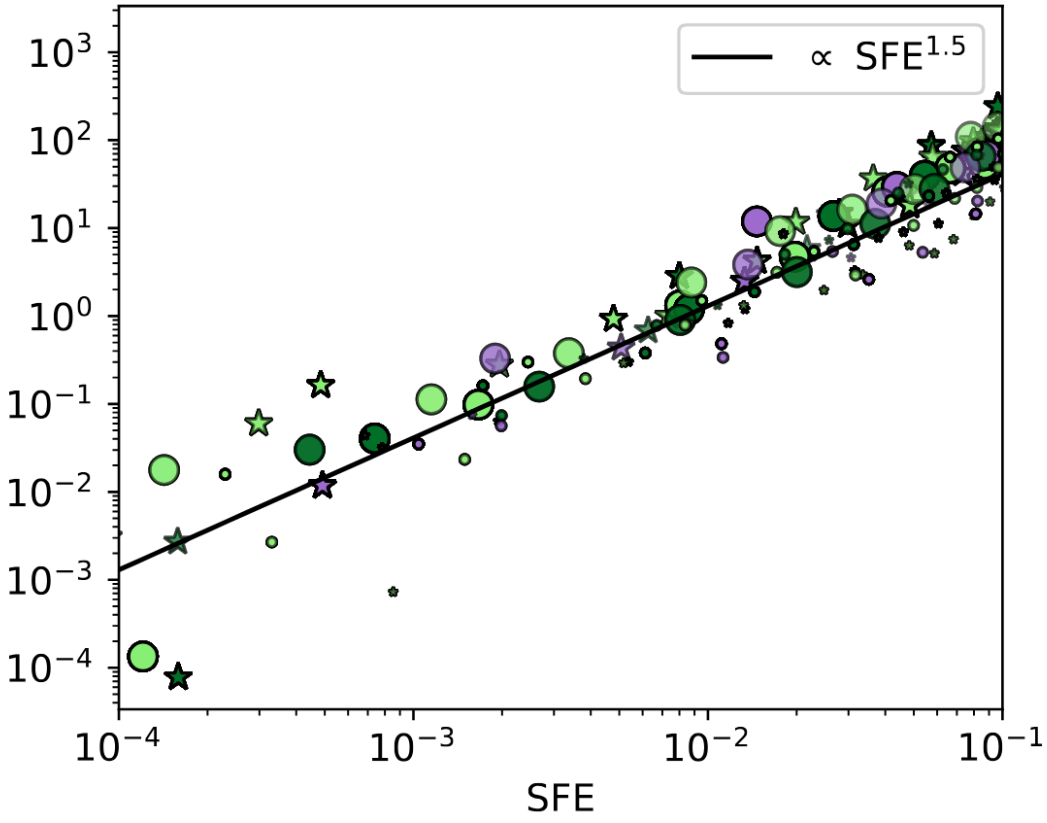
Impact of the magnetic field strength



THE ROSETTA STONE PROJECT: PRESENTATION OF THE SIMULATION CATALOGUE

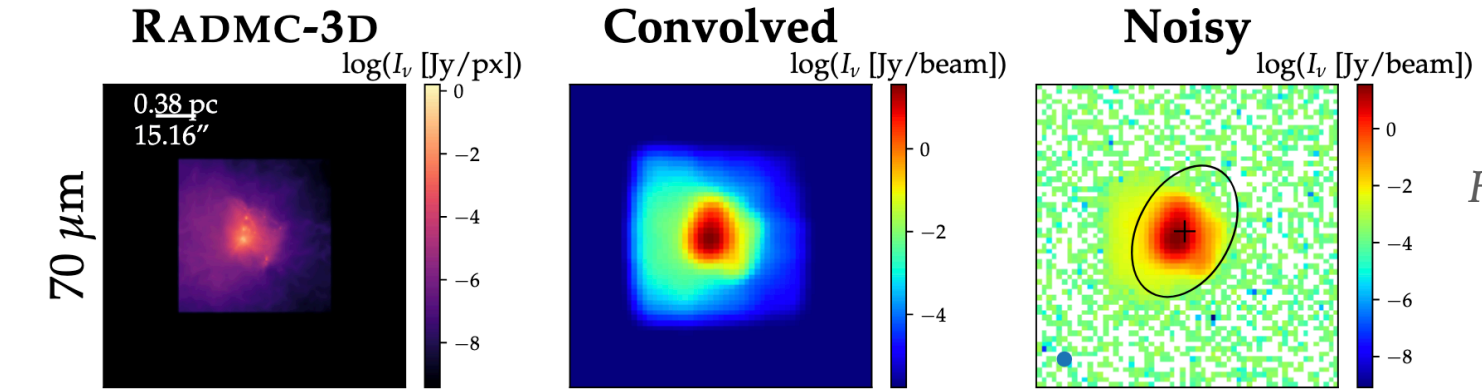
Lebreuilly et al. 2025, Tung et al. 2025, Nucara et al. 2025



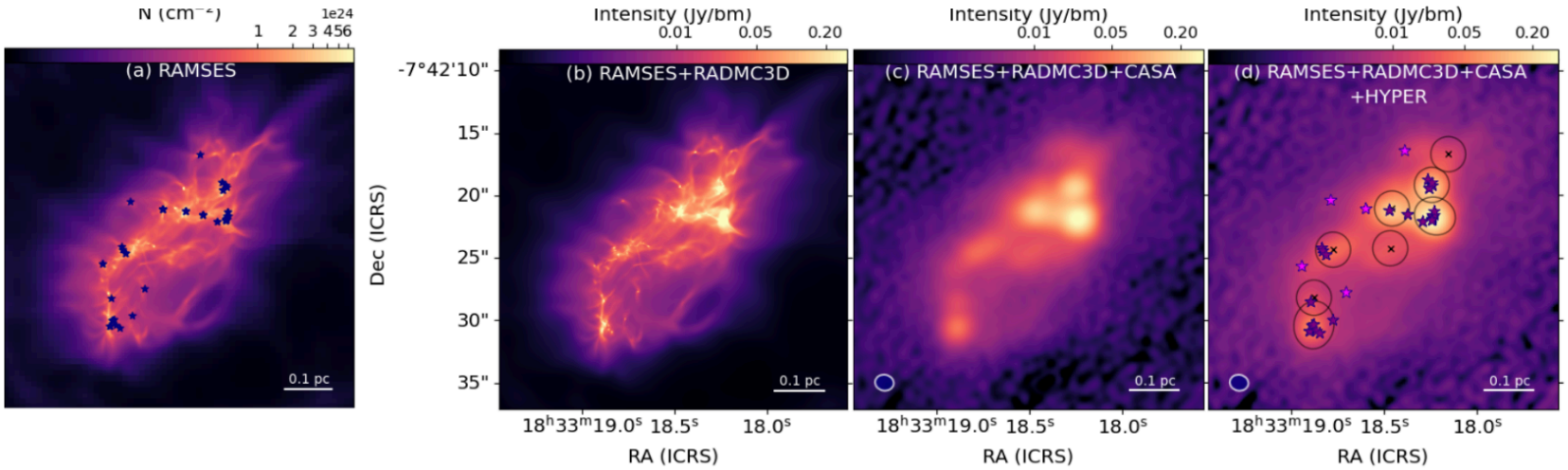


THE ROSETTA STONE PROJECT: POST PROCESSING OF THE SIMULATIONS

Lebreuilly et al. 2025, Tung et al. 2025, Nucara et al. 2025



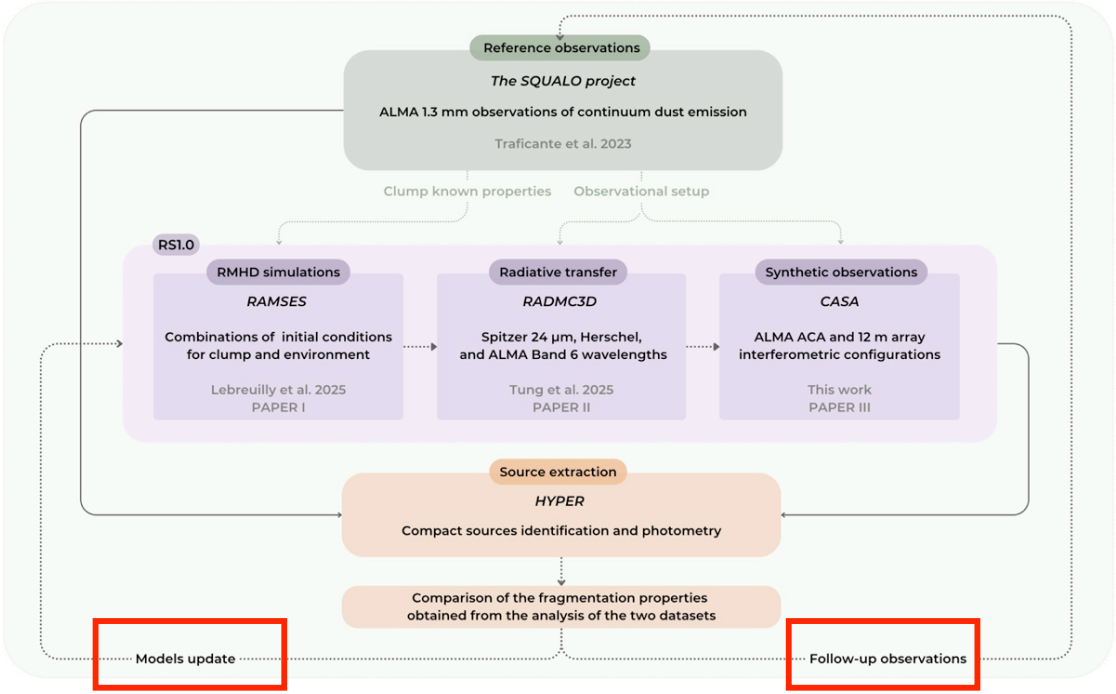
Herschel & Spitzer bands

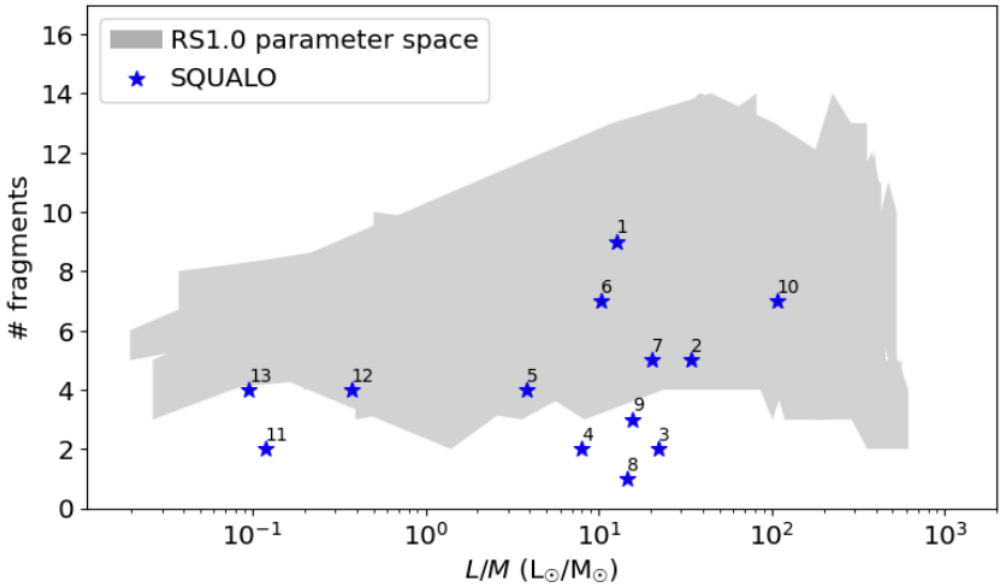


ALMA band 6

THE ROSETTA STONE PROJECT: COMPARISON BETWEEN SIMULATIONS AND OBSERVATIONS

Lebreuilly et al. 2025, Tung et al. 2025, Nucara et al. 2025





Too much fragmentation in simulation. What is the cause ? B-field ? Large scales ? Stay tuned

WHAT'S NEXT ?