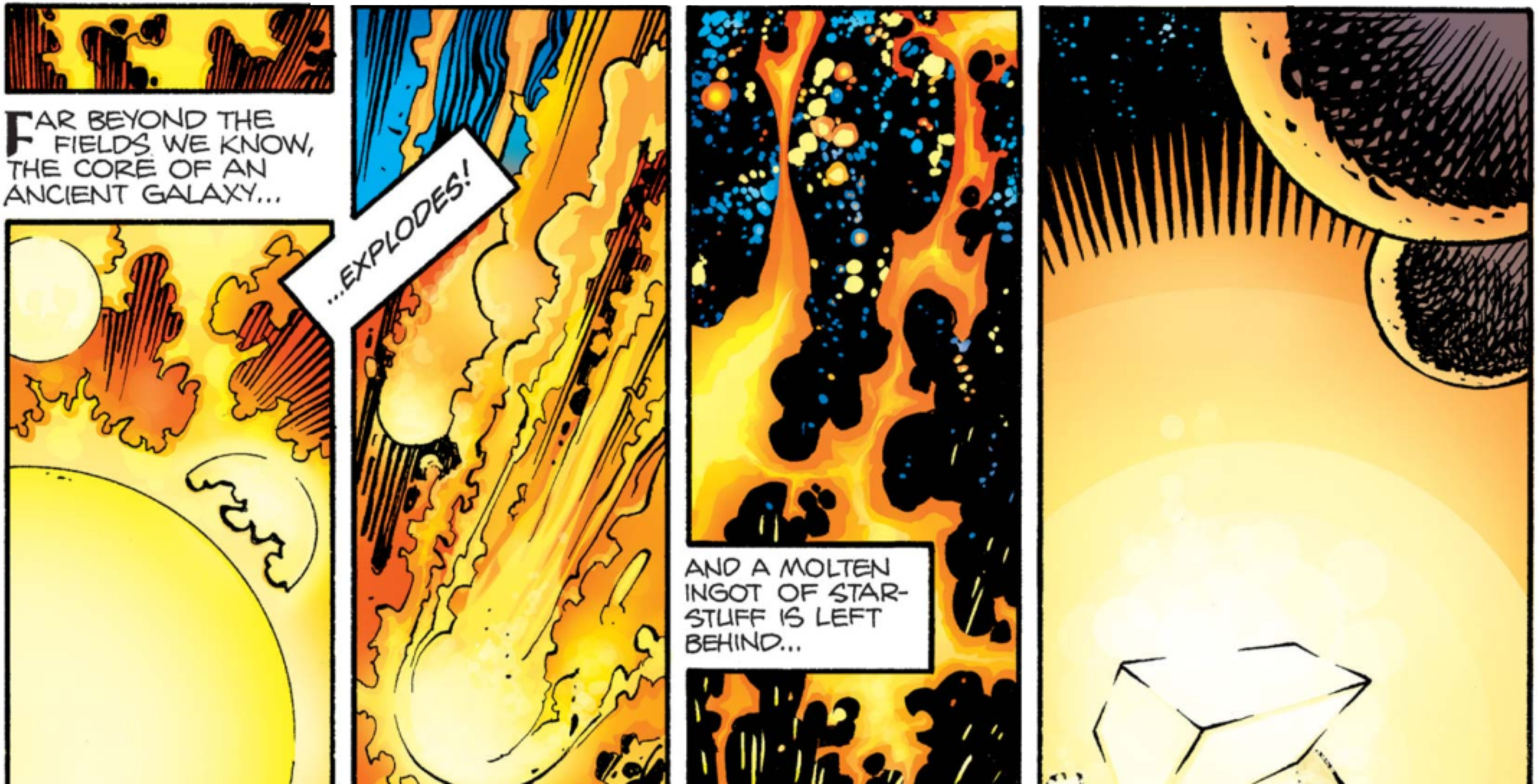
STAN LEE PRESENTS: THE MIGHTY GALACTIC NUCLEUS



3D Radiation hydrodynamics of dust and gas in the torus

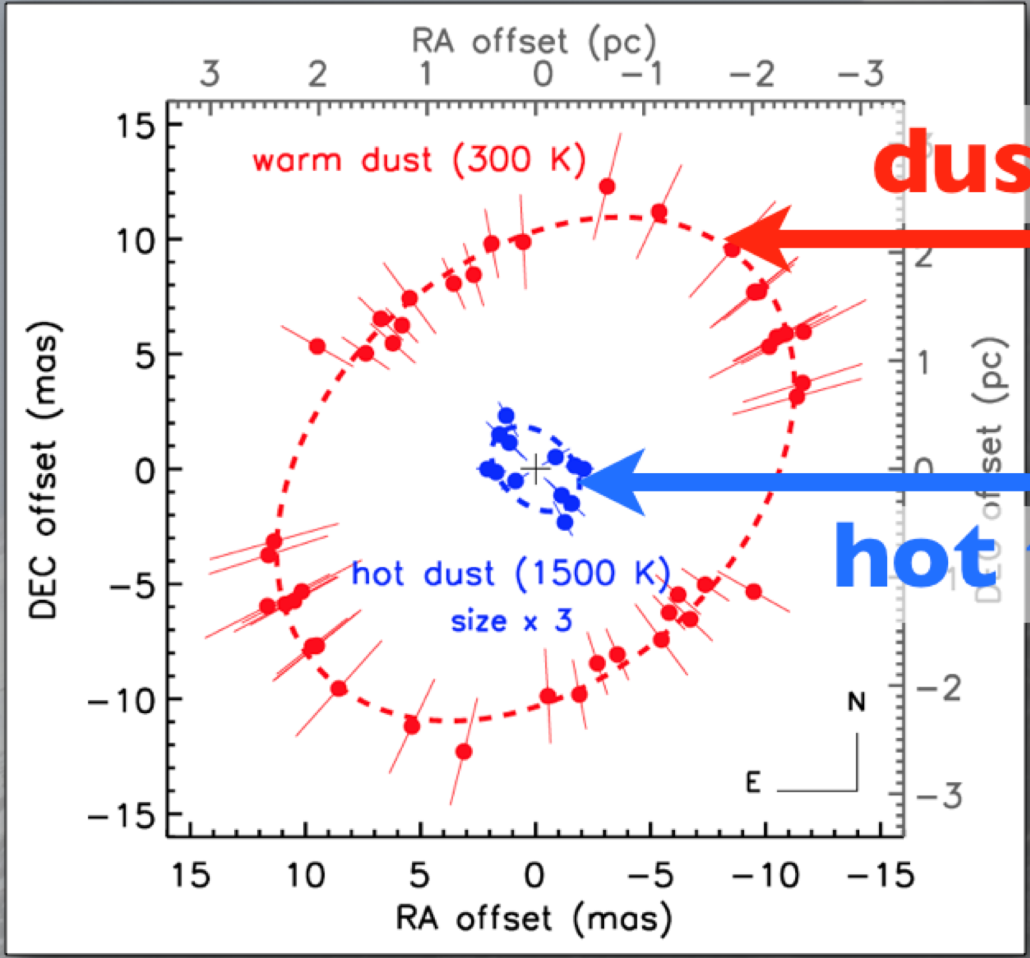
(AKA Yet Another Dynamical Torus Model)

David Williamson, Marta Venanzi, & Sebastian Hönig
University of Southampton

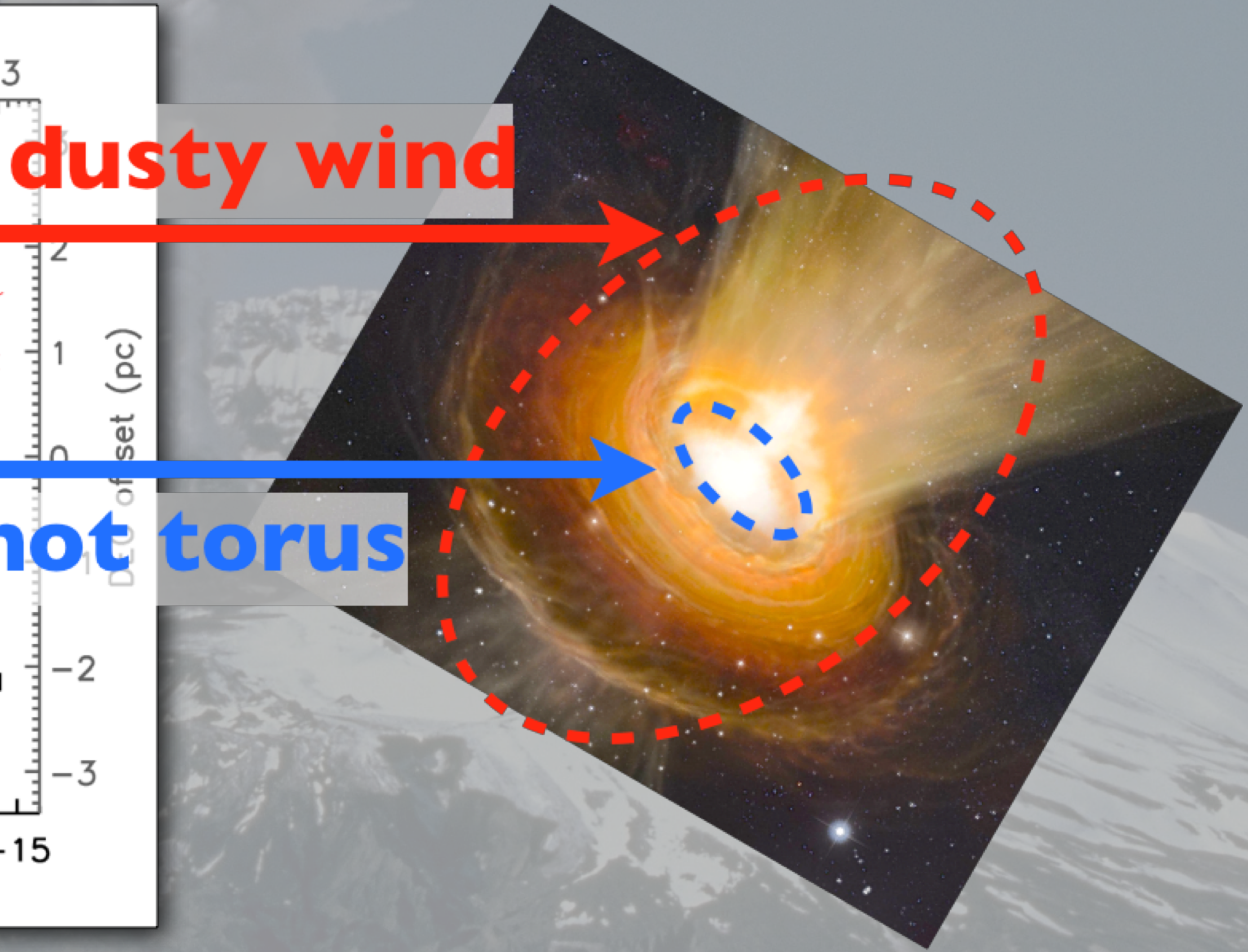
European Research Council
Established by the European Commission

I. Type 1 AGN NGC3783

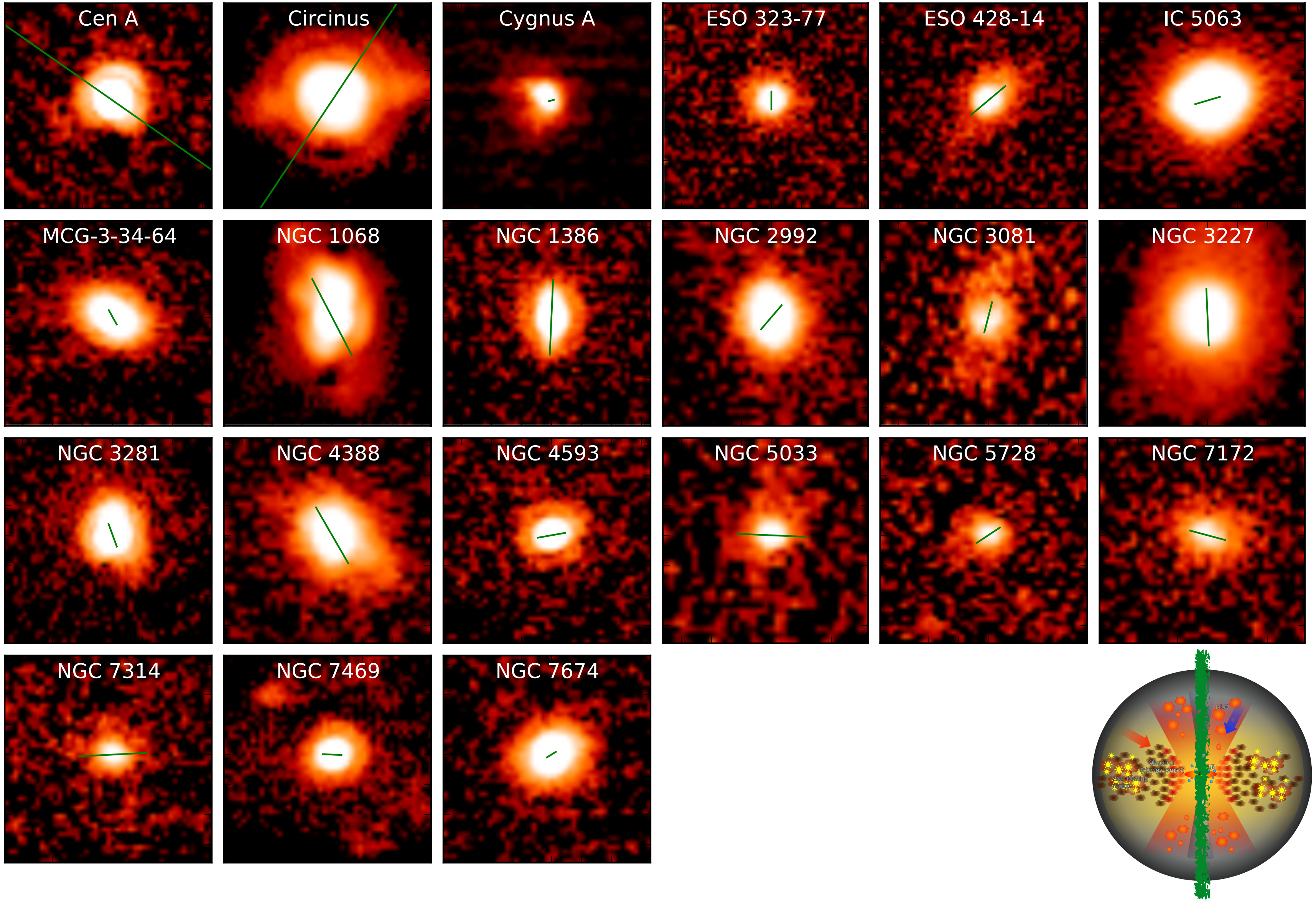
Infrared interferometry observations



Working hypothesis: disk + wind



Hoenig et al. 2013



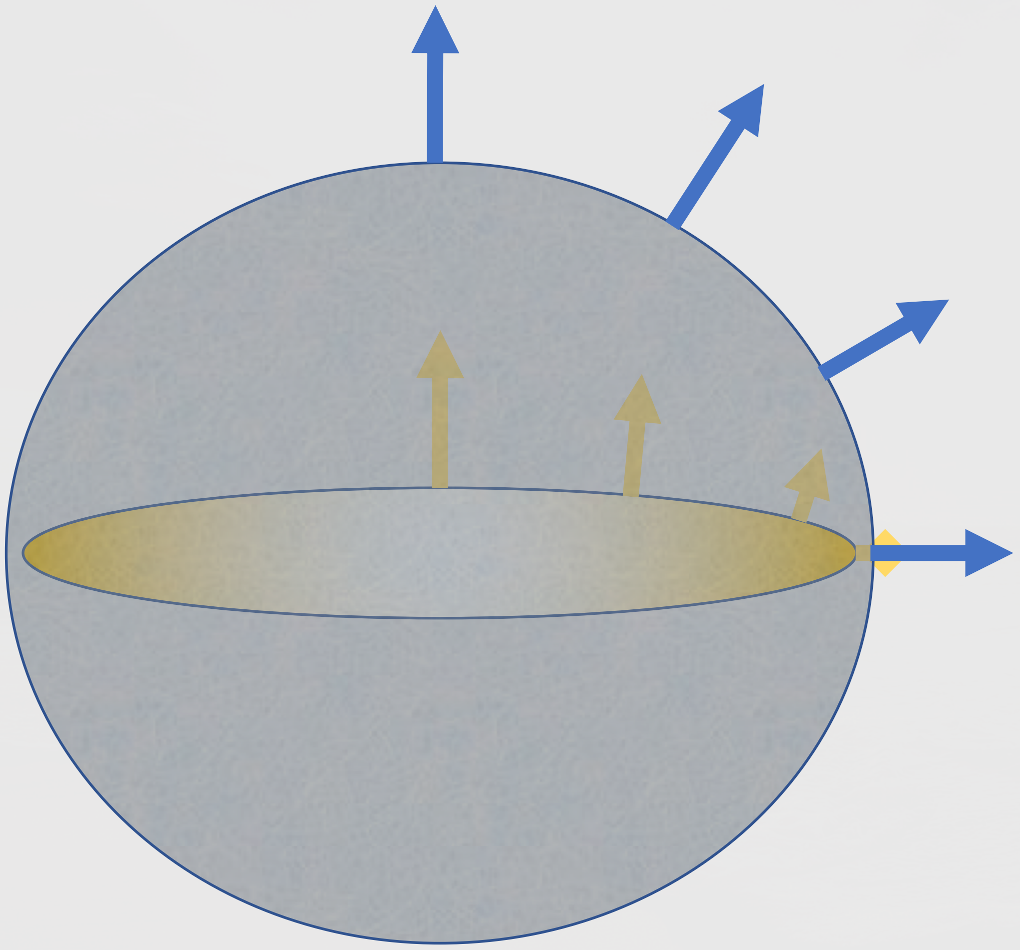
Asmus et al 2016

Simulation Code

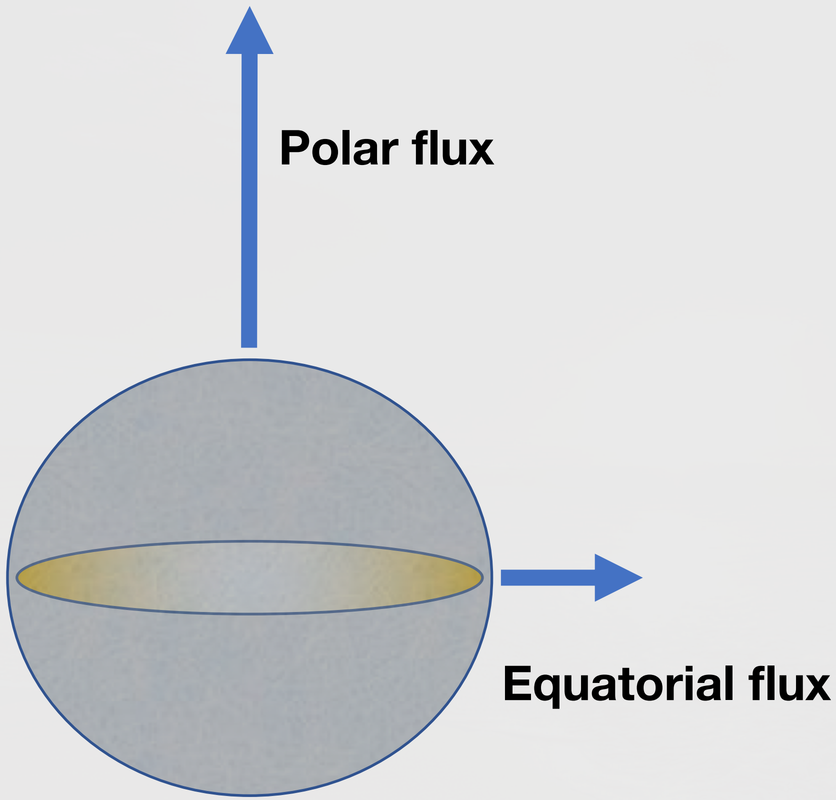
- Hydrodynamics: GIZMO (Hopkins) in modern P-SPH mode
- Self-gravity
- Star formation & supernova feedback (sometimes)

- Basic picture: dusty disk irradiated by central engine

Radiation

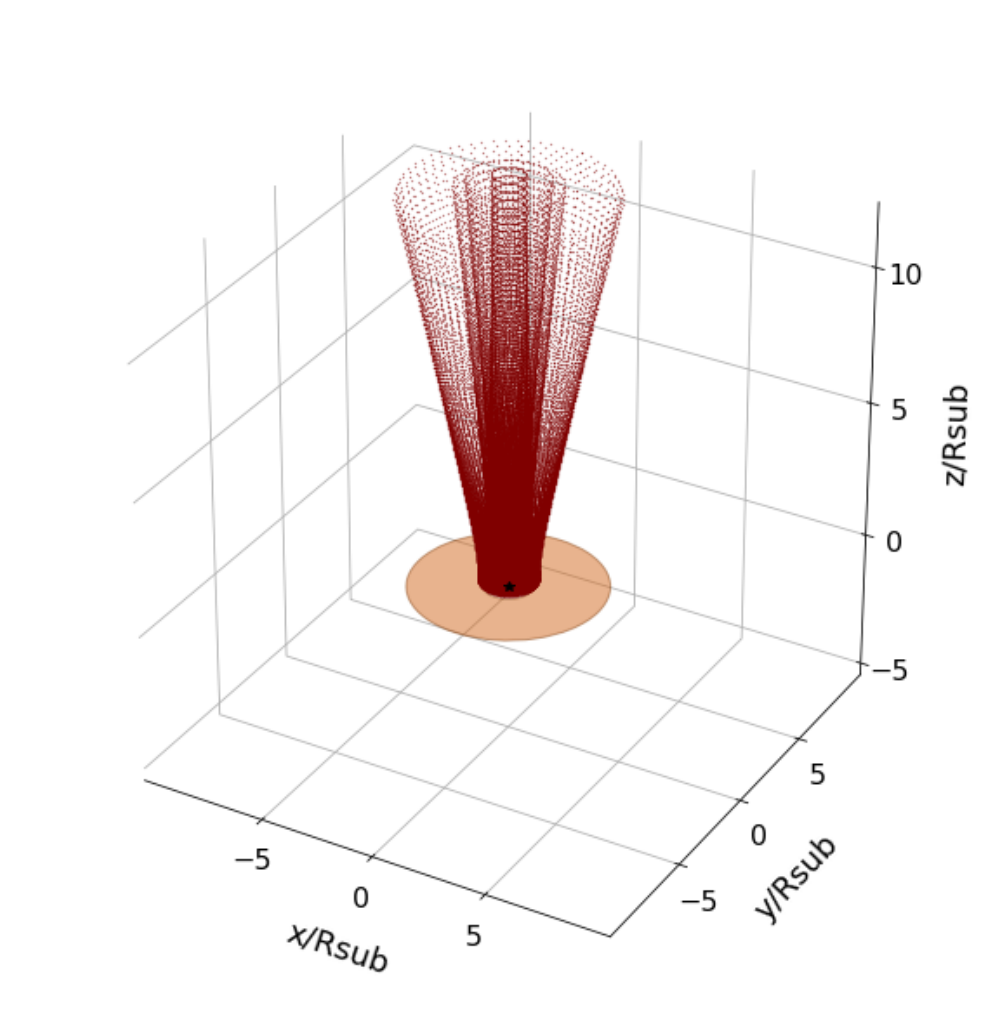


Radiation



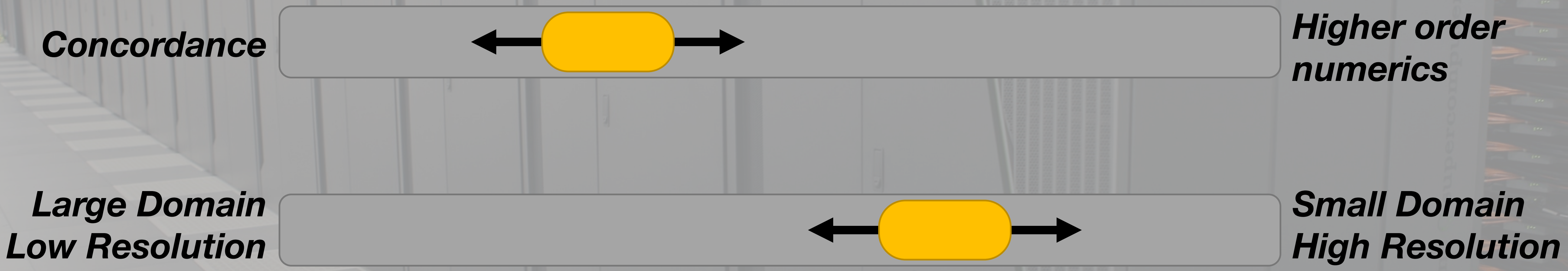
- Anisotropy factor = polar/equatorial flux ratio
- Raytracing with AGN SED (pretabulated with CLOUDY) -> radiation pressure, heating, opacities, chemistry etc

Radiation

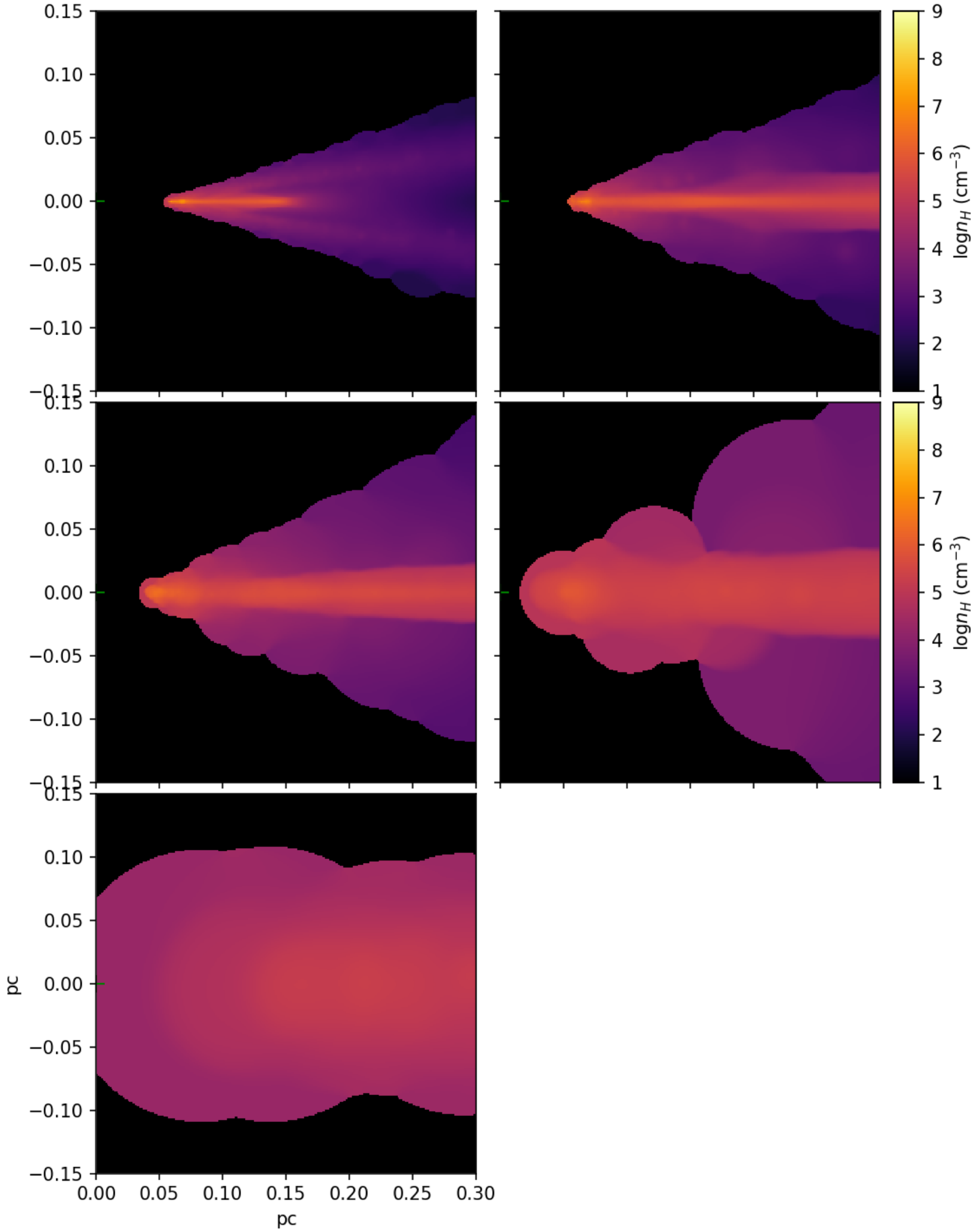


- Anisotropy factor = polar/equatorial flux ratio
- Raytracing with AGN SED (pretabulated with CLOUDY) -> radiation pressure, heating, opacities, chemistry etc
- Single radiation source (disc emission/re-emission TBD – but see poster by **Marta Venanzi**)

Min-maxing Modelling

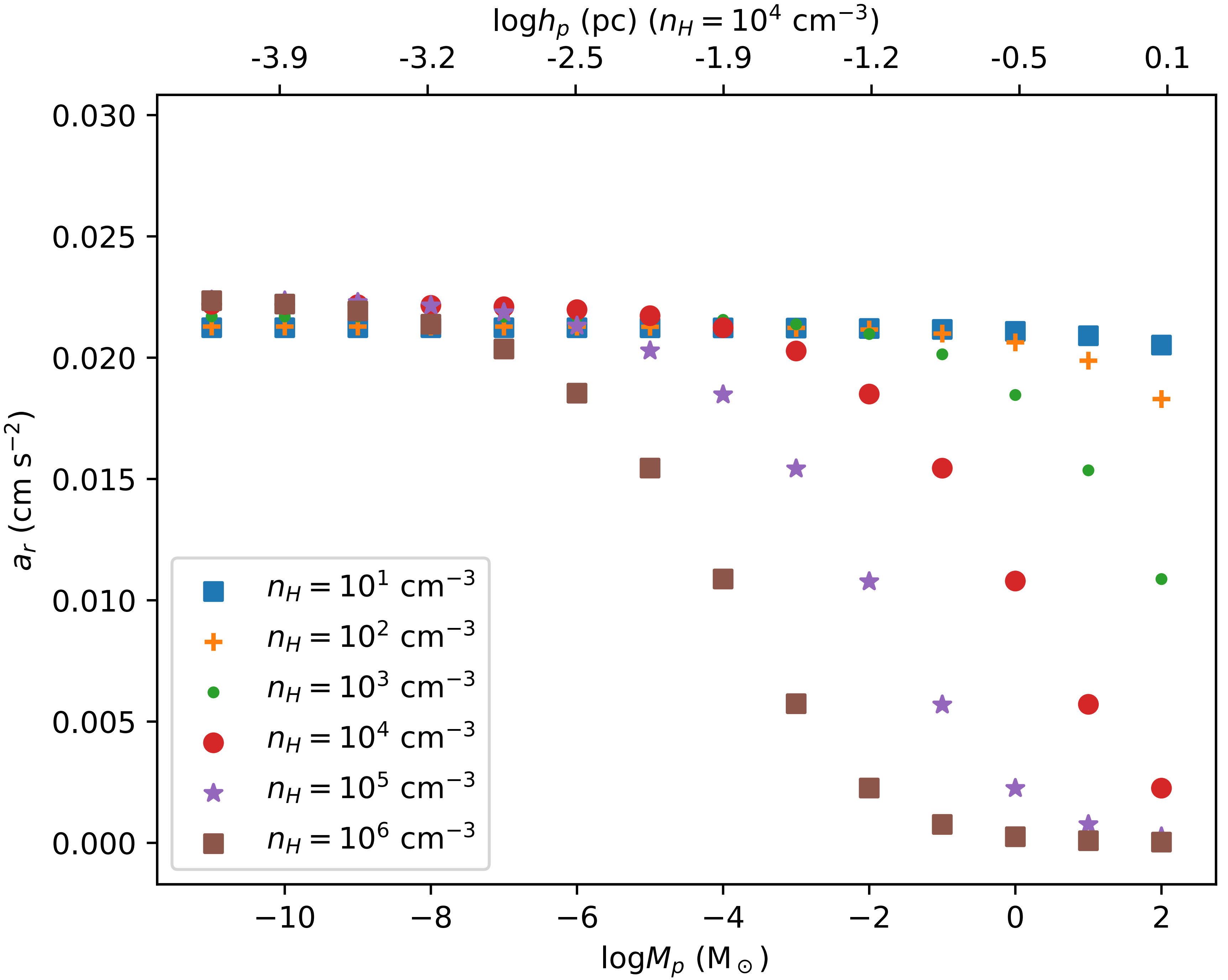


Resolution



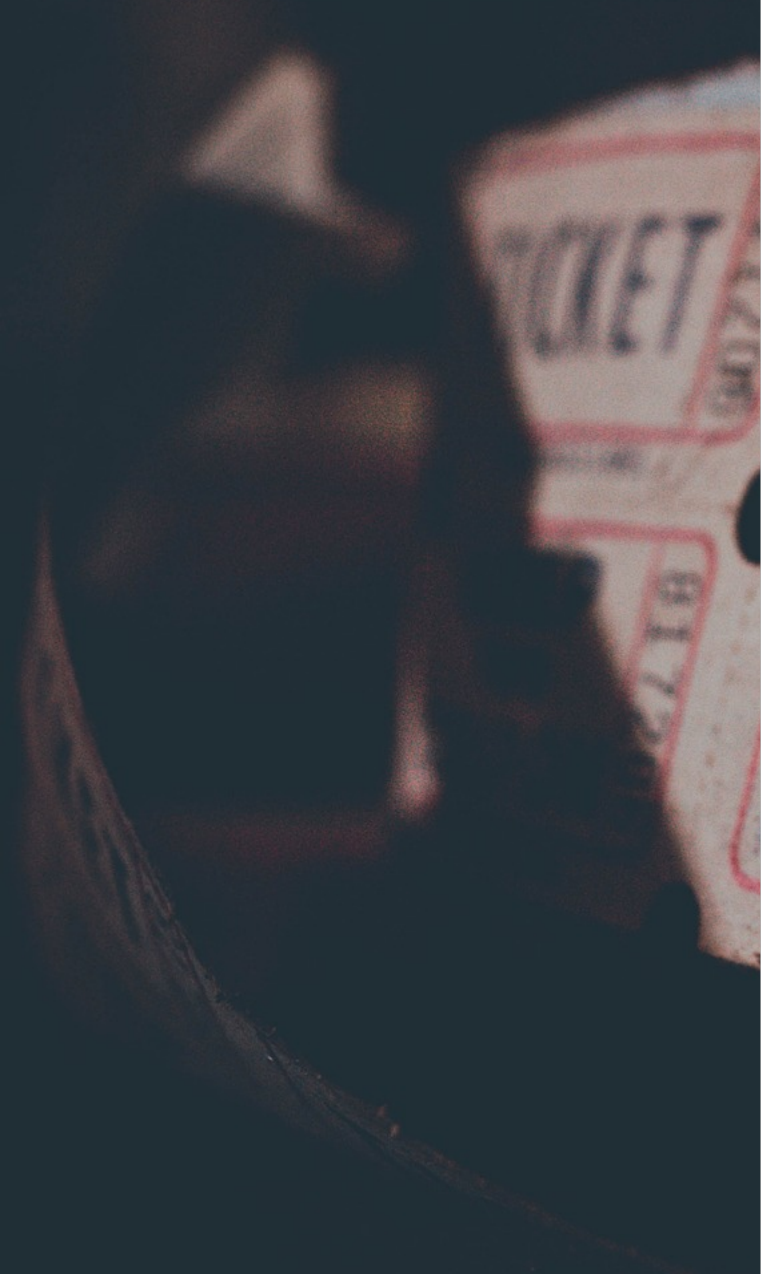
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
0.00 0.05 0.10 0.15 0.20 0.25 0.30
pc
pc
$\log n_H$ (cm^{-3})
1 2 3 4 5 6 7 8 9

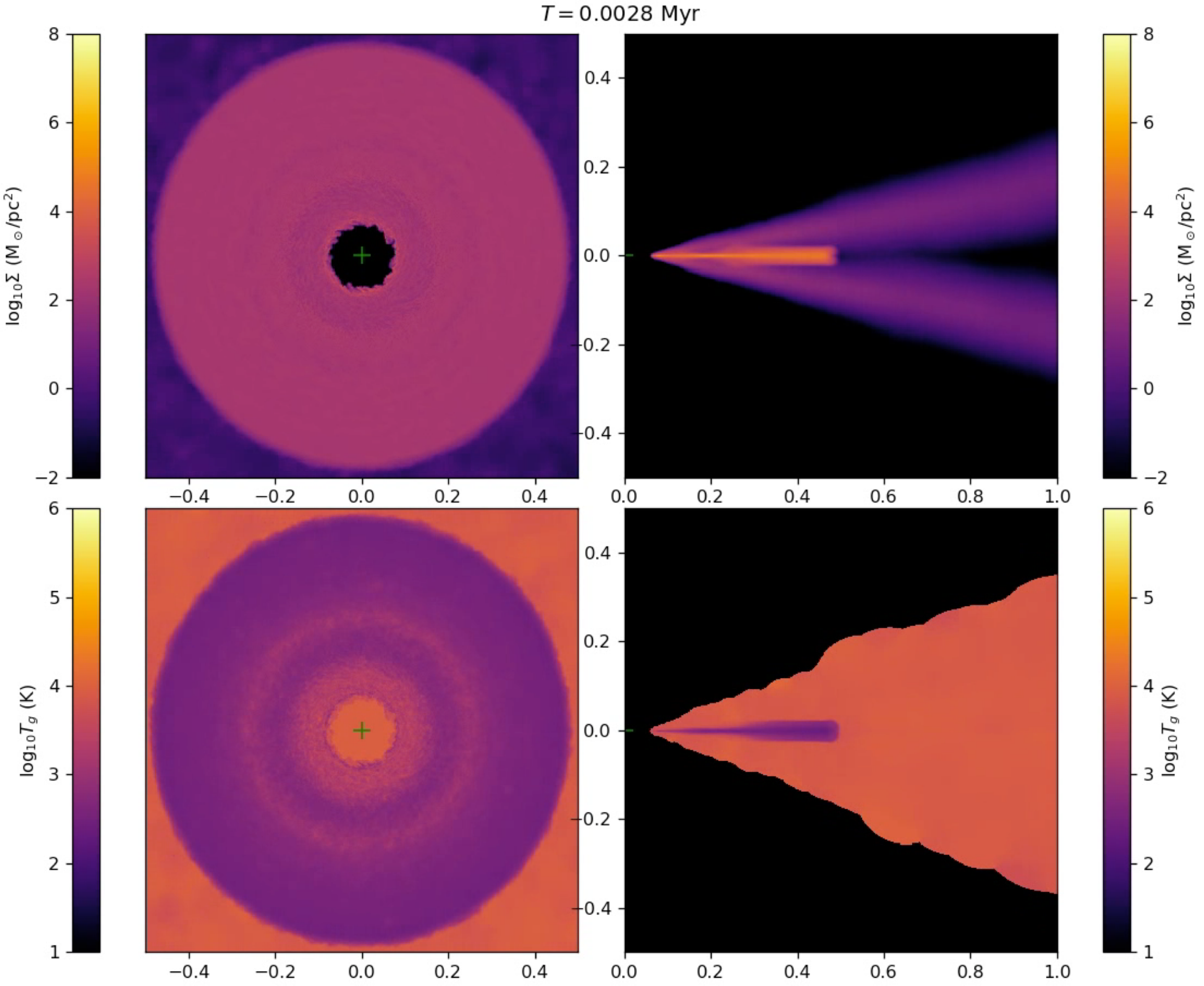
Resolution



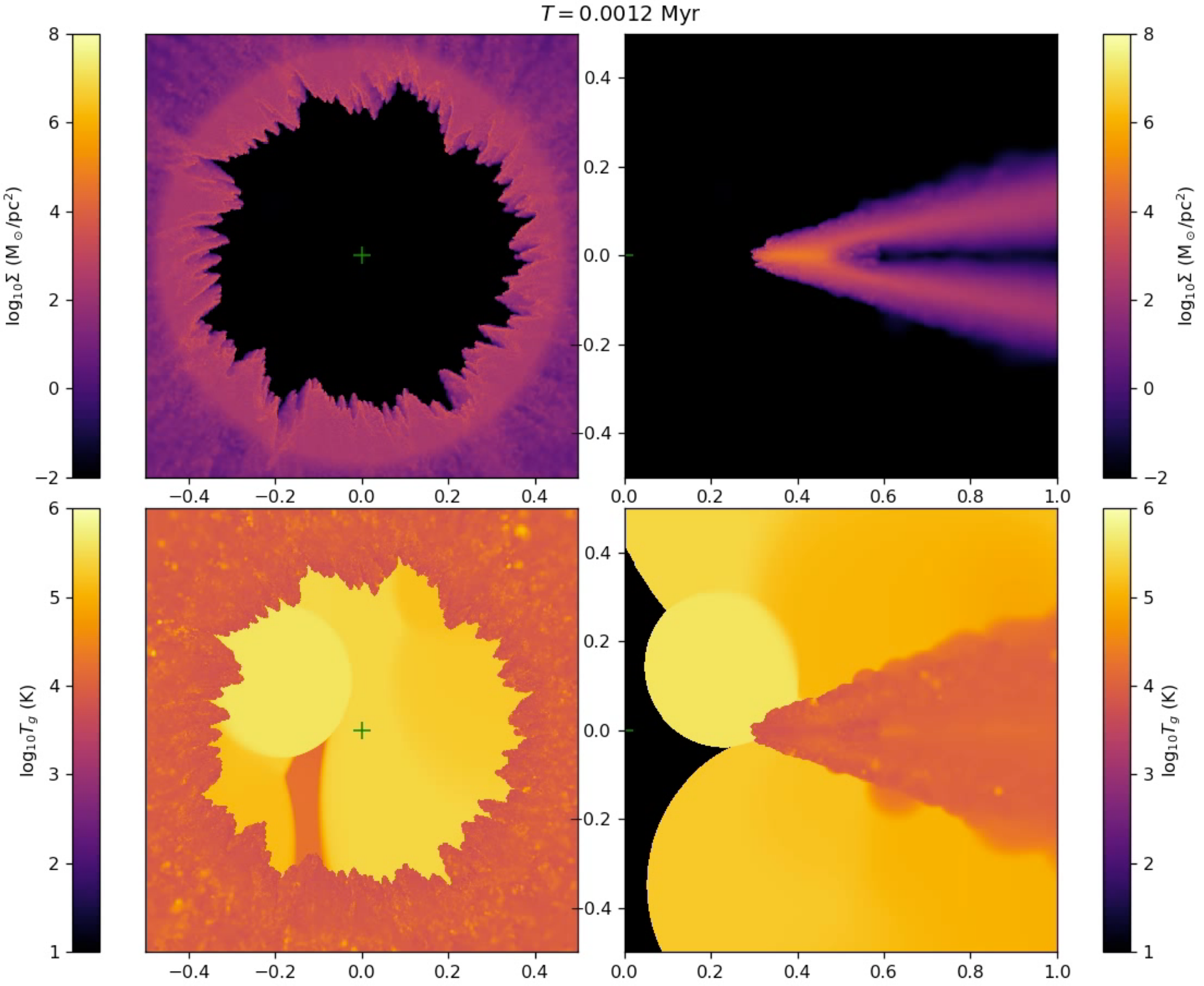
$\log h_p$ (pc) ($n_H = 10^4$ cm^{-3})
-3.9
-3.2
-2.5
-1.9
-1.2
-0.5
0.1
0.030
0.025
0.020
0.015
0.010
0.005
0.000
a_r (cm s^{-2})
$n_H = 10^1$ cm^{-3}
$n_H = 10^2$ cm^{-3}
$n_H = 10^3$ cm^{-3}
$n_H = 10^4$ cm^{-3}
$n_H = 10^5$ cm^{-3}
$n_H = 10^6$ cm^{-3}
−10
−8
−6
−4
−2
0
2
$\log M_p$ (M$_\odot$)

Results



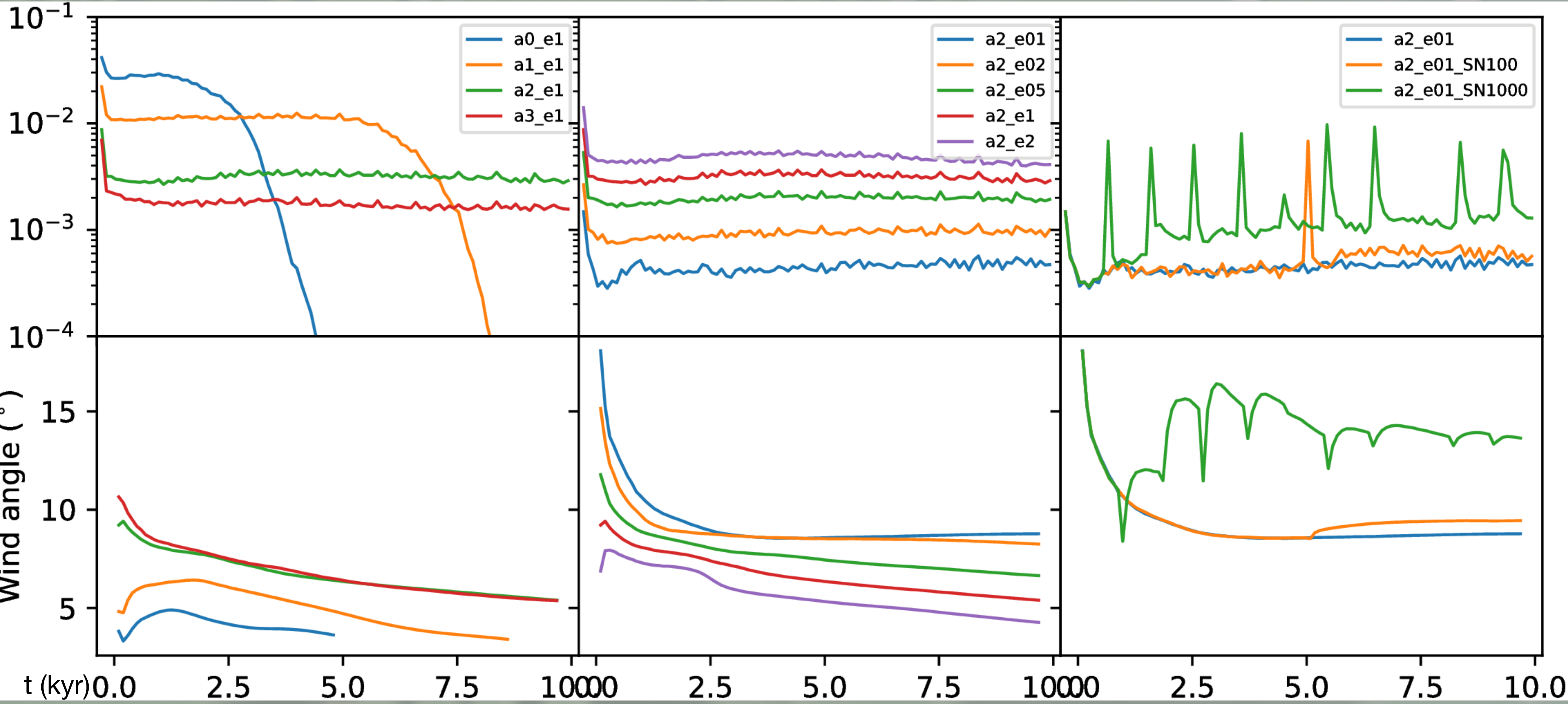


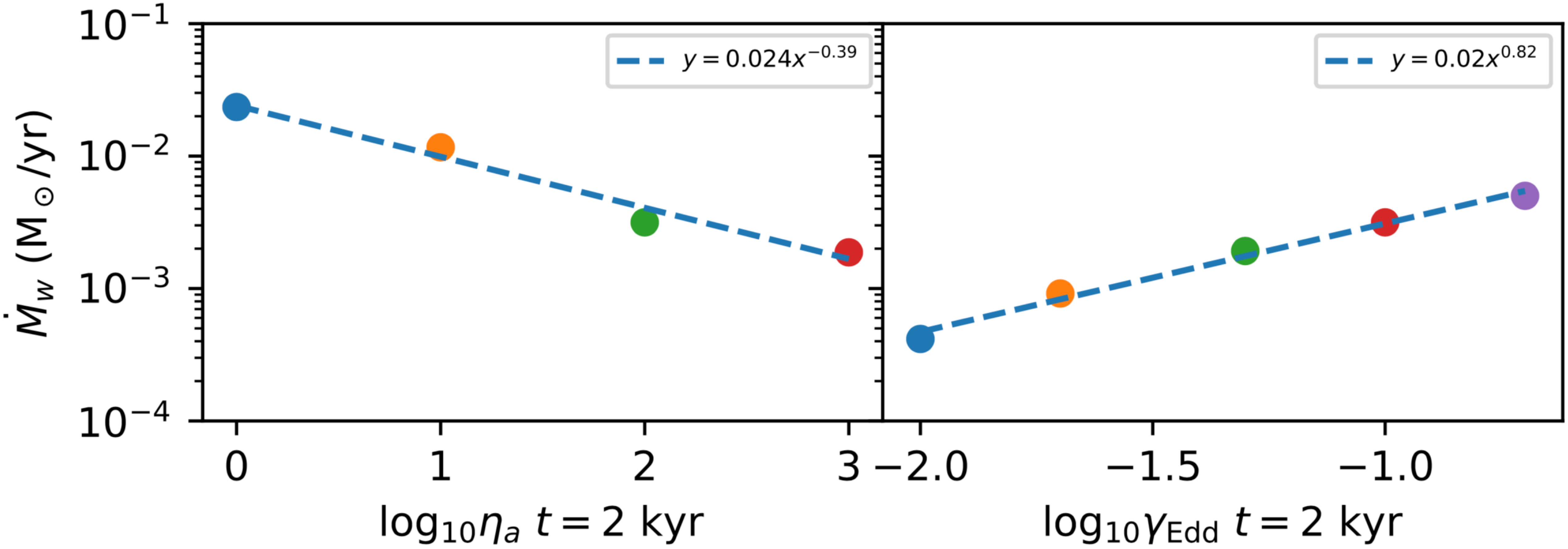
Results



$T = 0.0012$ Myr
$\log_{10}\Sigma$ ($M_\odot$/pc^2)
$\log_{10}T_g$ (K)
8
6
4
2
0
−2
1
3
5
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
1.0

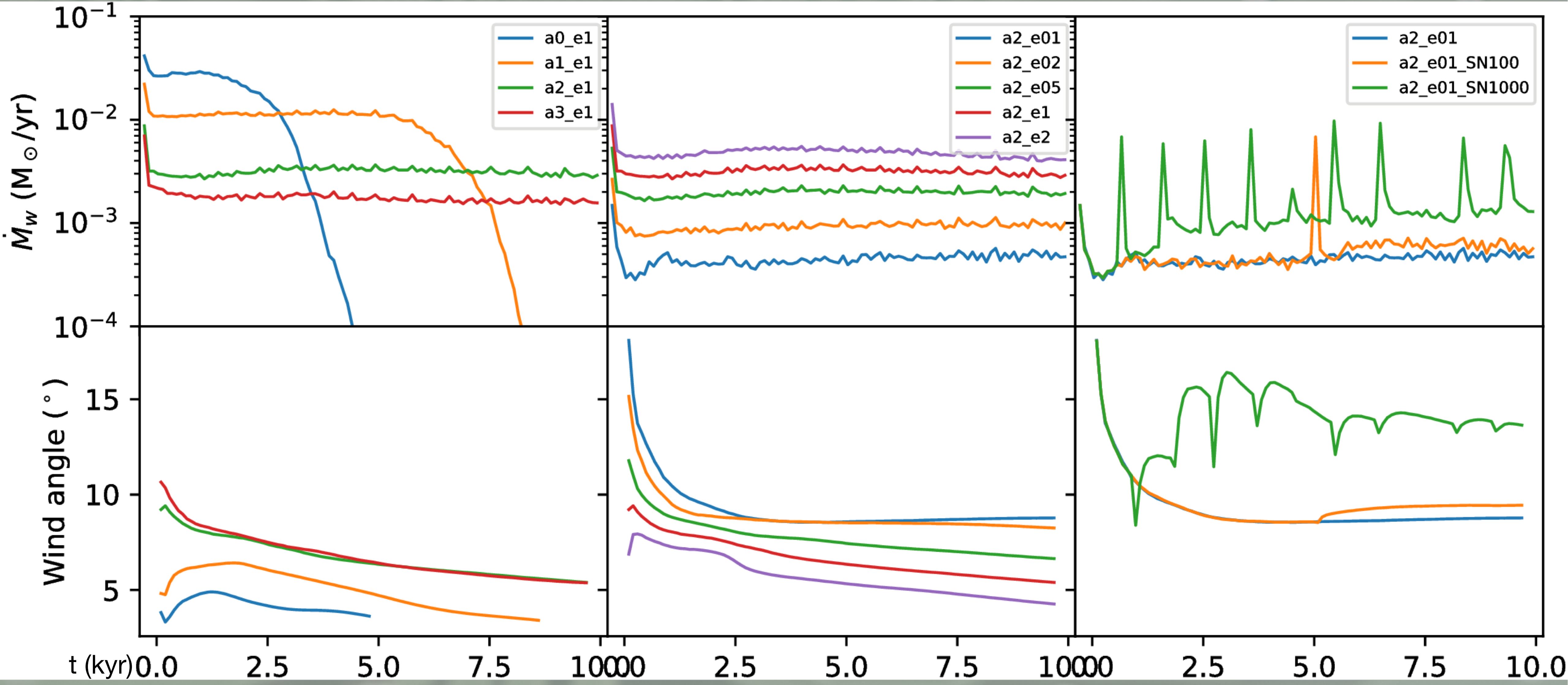
Anisotropy   Eddington Factor   Supernova Rate

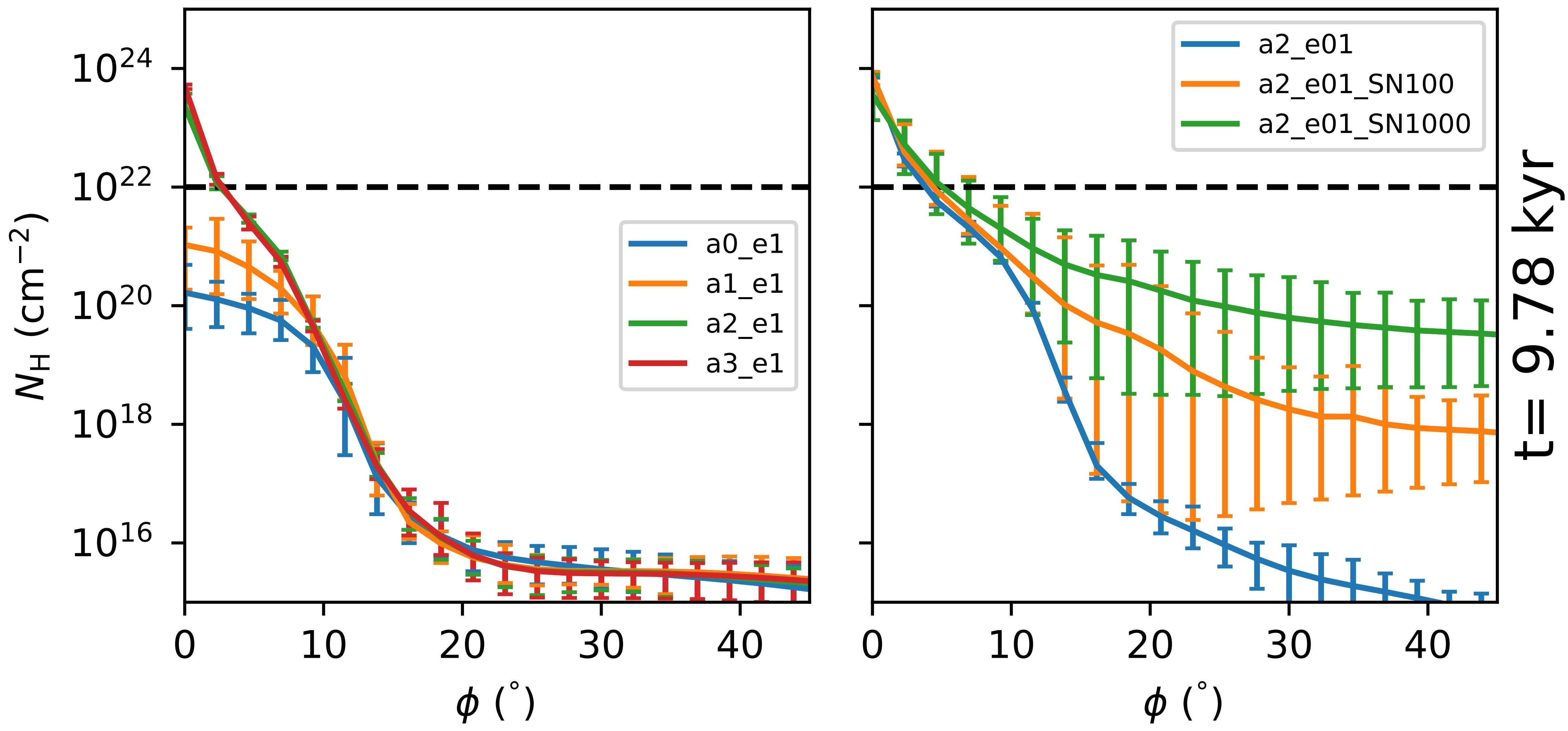




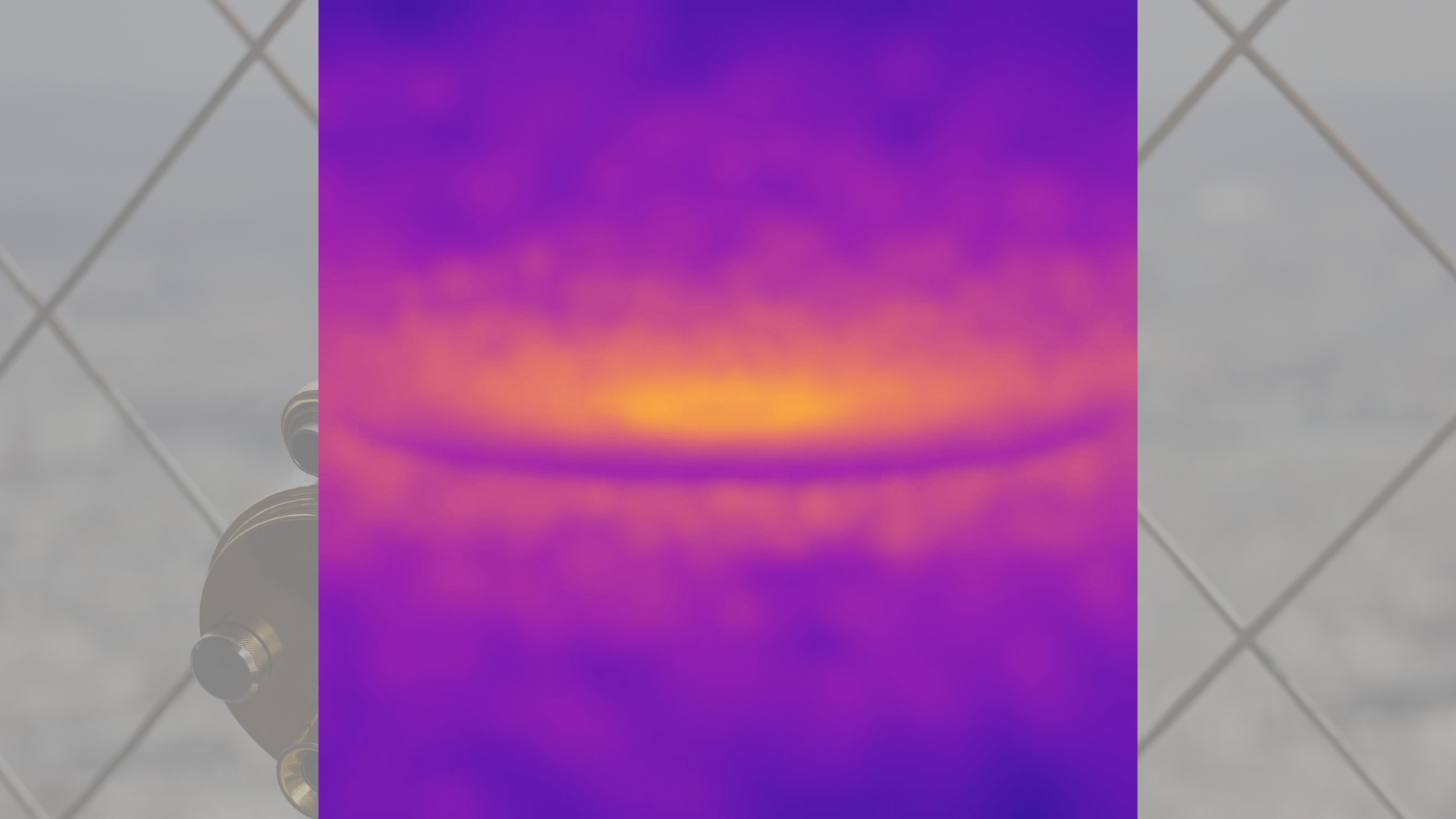
$\dot{M}_w$ ($\mathrm{M}_\odot$/yr)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$y = 0.024x^{-0.39}$
0
1
2
3
$\log_{10}\eta_a$ $t = 2$ kyr
$y = 0.02x^{0.82}$
−2.0
−1.5
−1.0
$\log_{10}\gamma_{\mathrm{Edd}}$ $t = 2$ kyr

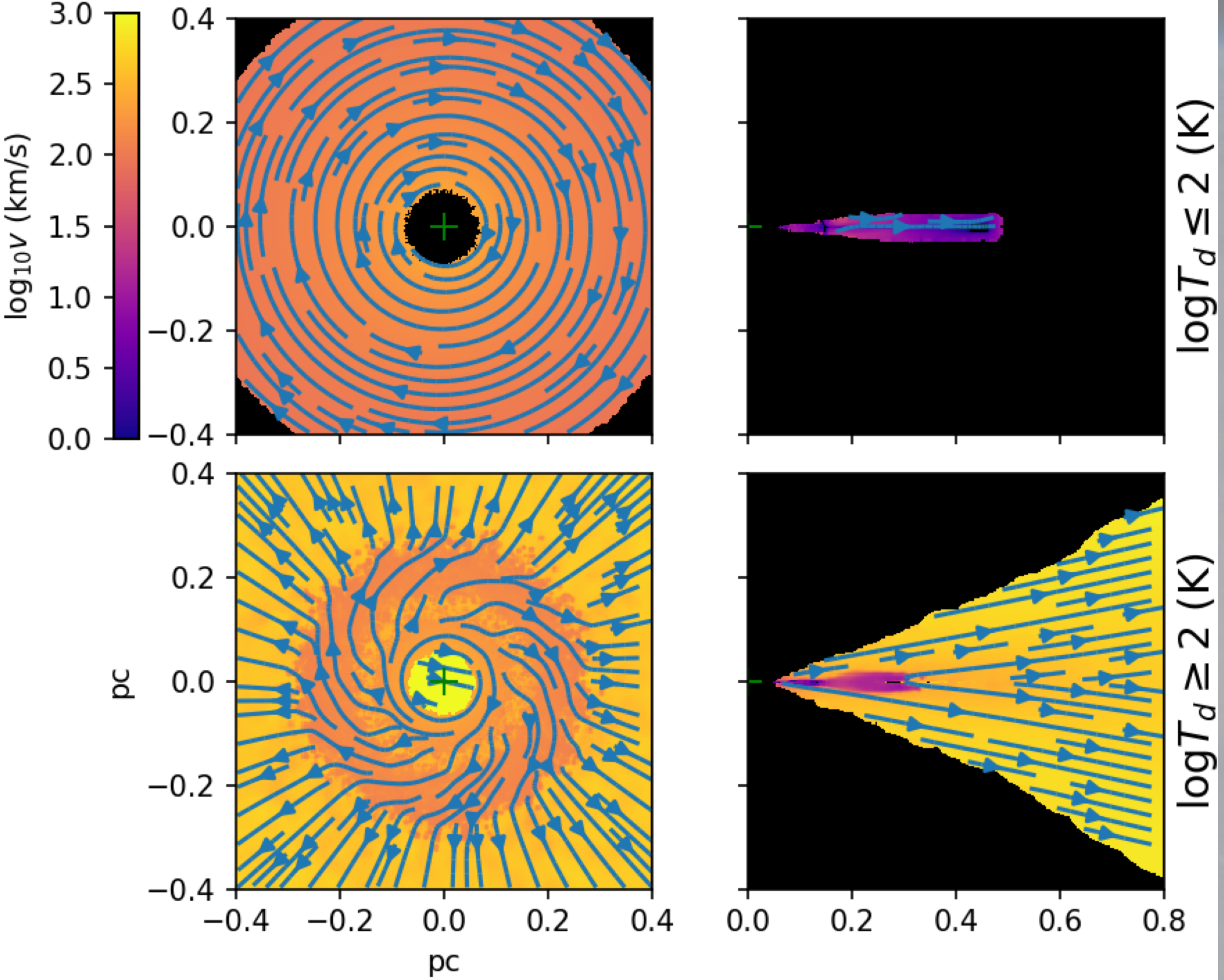
Anisotropy   Eddington Factor   Supernova Rate



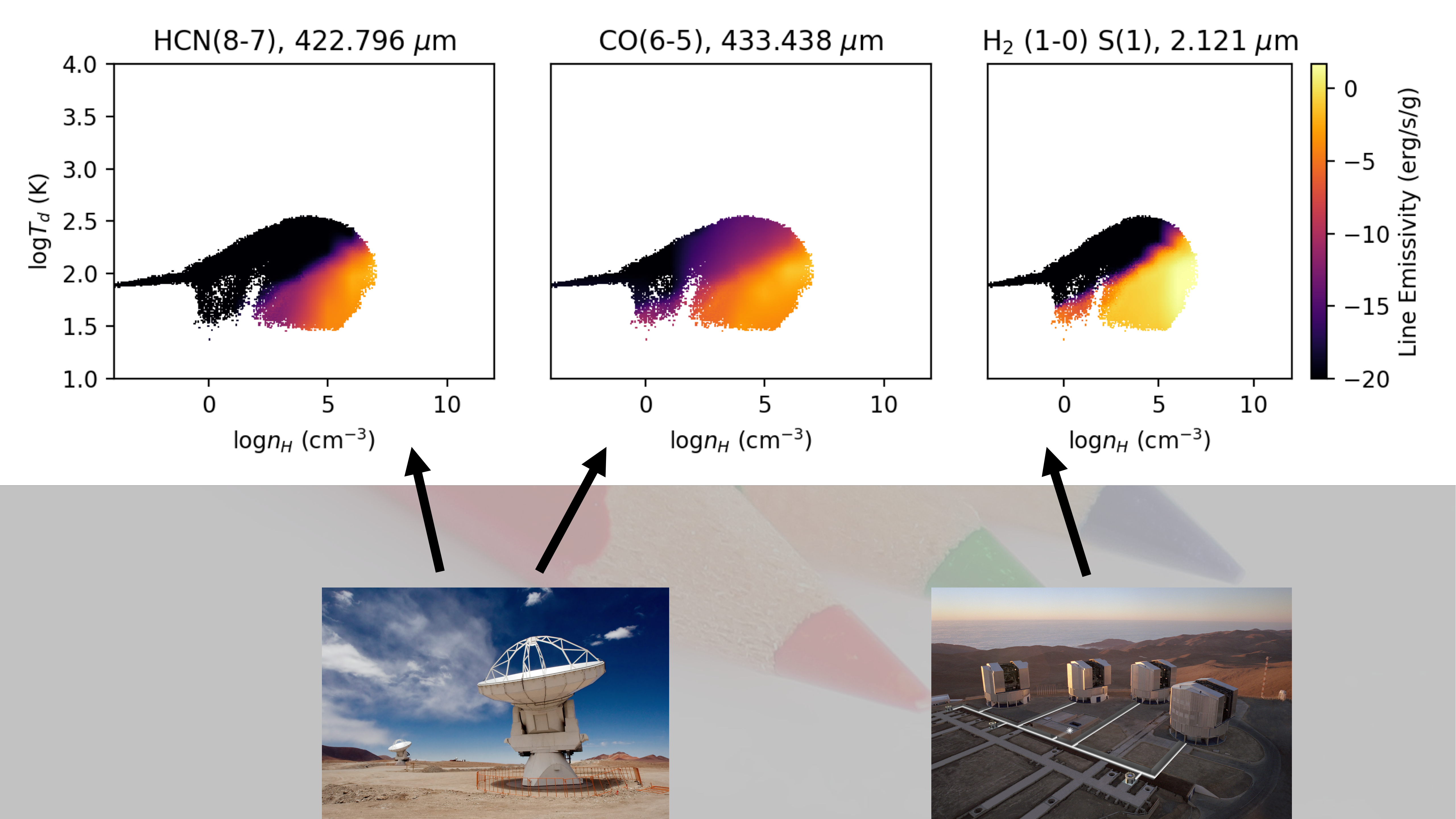


10^{24}
10^{22}
10^{20}
10^{18}
10^{16}
N_{H} (cm^{-2})
a0_e1
a1_e1
a2_e1
a3_e1
a2_e01
a2_e01_SN100
a2_e01_SN1000
0
10
20
30
40
ϕ (°)
t= 9.78 kyr

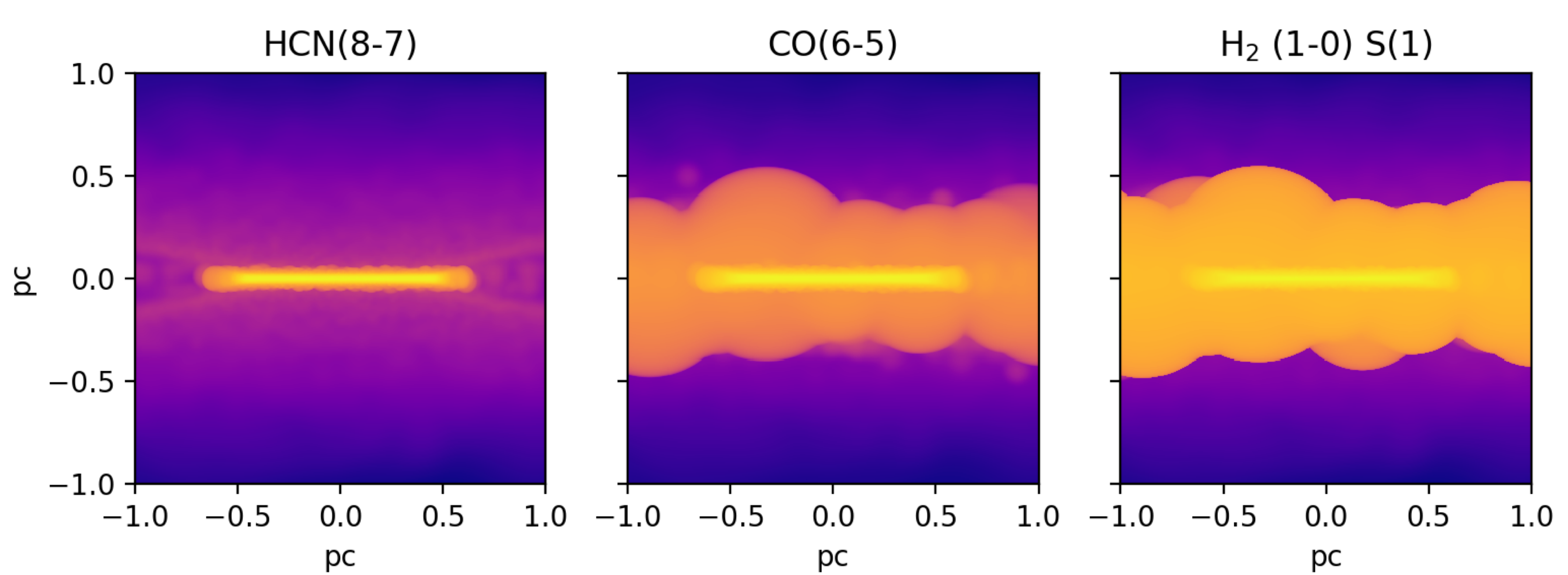




log$_{10}v$ (km/s)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.4
0.2
0.0
−0.2
−0.4
log$T_d \leq 2$ (K)
log$T_d \geq 2$ (K)
pc
−0.4
−0.2
0.0
0.2
0.4
pc
0.0
0.2
0.4
0.6
0.8



HCN(8-7), 422.796 μm
CO(6-5), 433.438 μm
H_2 (1-0) S(1), 2.121 μm
$\log T_d$ (K)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
5
10
$\log n_H$ (cm^{-3})
Line Emissivity (erg/s/g)
0
−5
−10
−15
−20


HCN(8-7)
CO(6-5)
H2 (1-0) S(1)
pc
1.0
0.5
0.0
−0.5
−1.0
pc

Summary & Conclusions

- Dynamical torus model driven by radiation pressure
  - Anisotropy matters!
- SNe can be somewhat significant (at very high SF densities)
- Get similar general picture to observations:
  - Hot dusty inner region
  - Warm dusty outflow (n.b. $T_{dust}<T_{gas}$)
  - Cool rotating dusty disc
- Wind is fairly equatorial (no polar dust) -> IR boosts vertical motion? (cf Marta Venanzi's poster)
- **PAPER BEING SUBMITTED** – keep an eye on arXiv!