ORIGINS

LMU/USM

Galactic surface gravity waves

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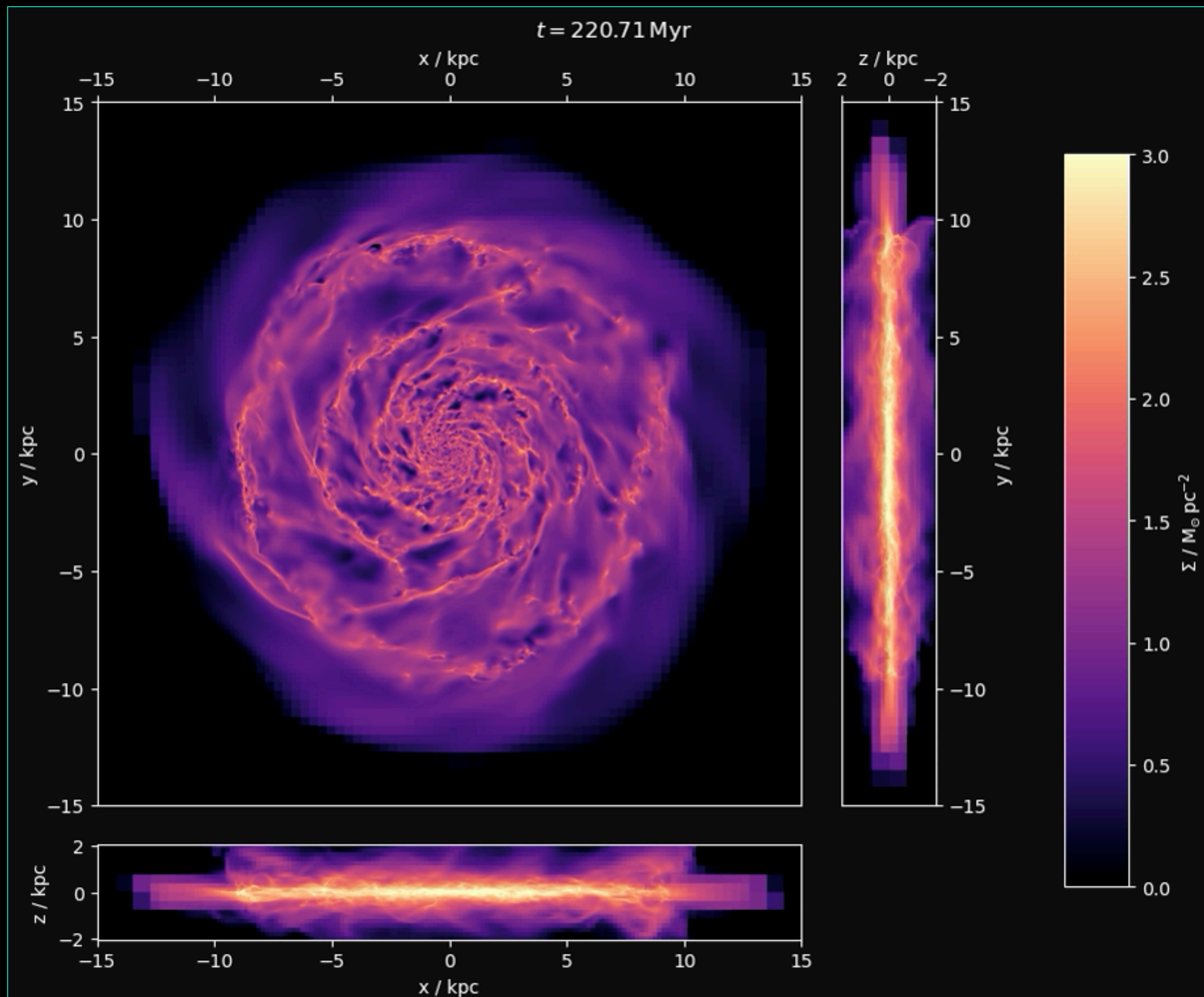

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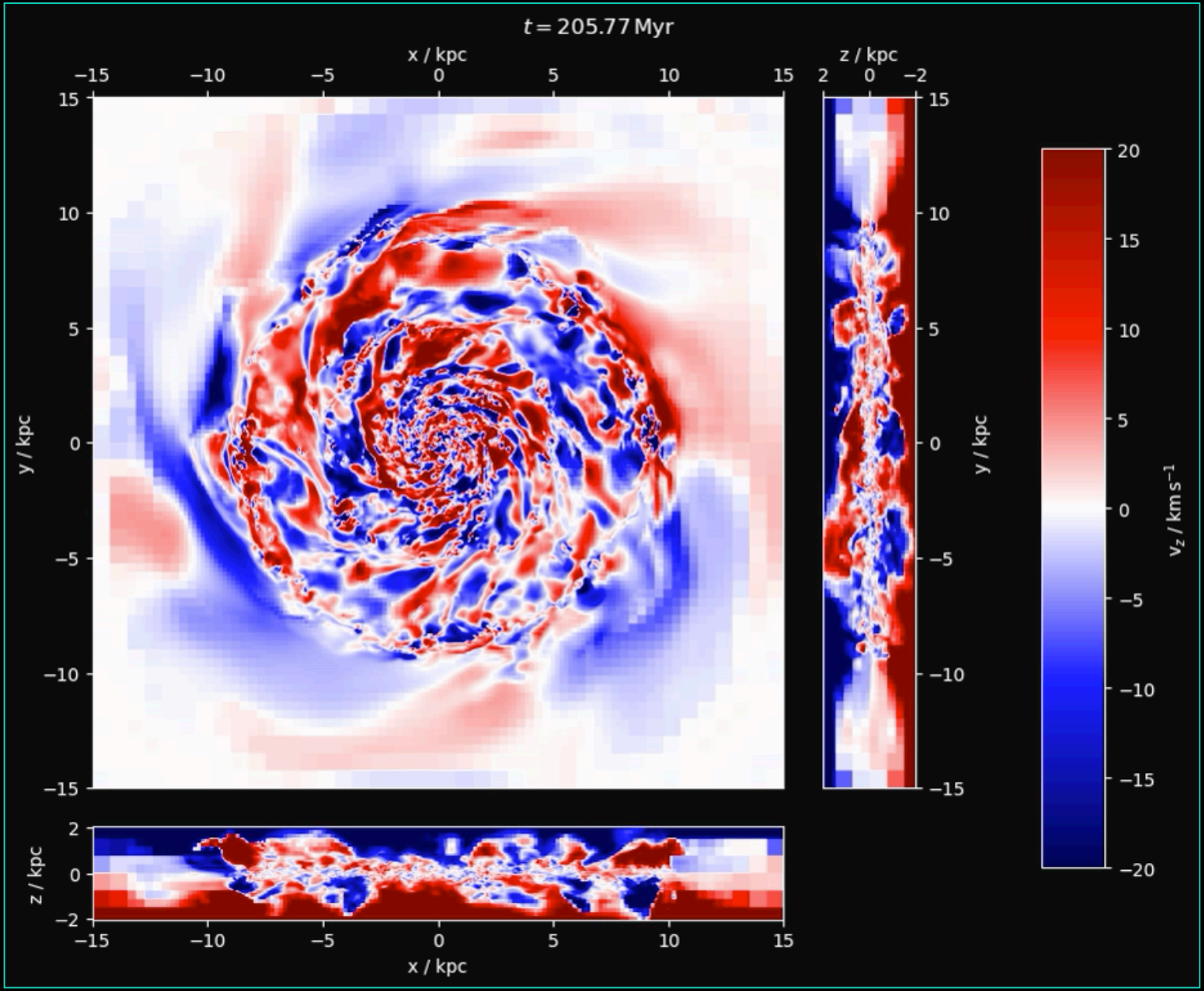

How can we detect surface gravity waves
in the Milky Way?

Galactic surface gravity waves

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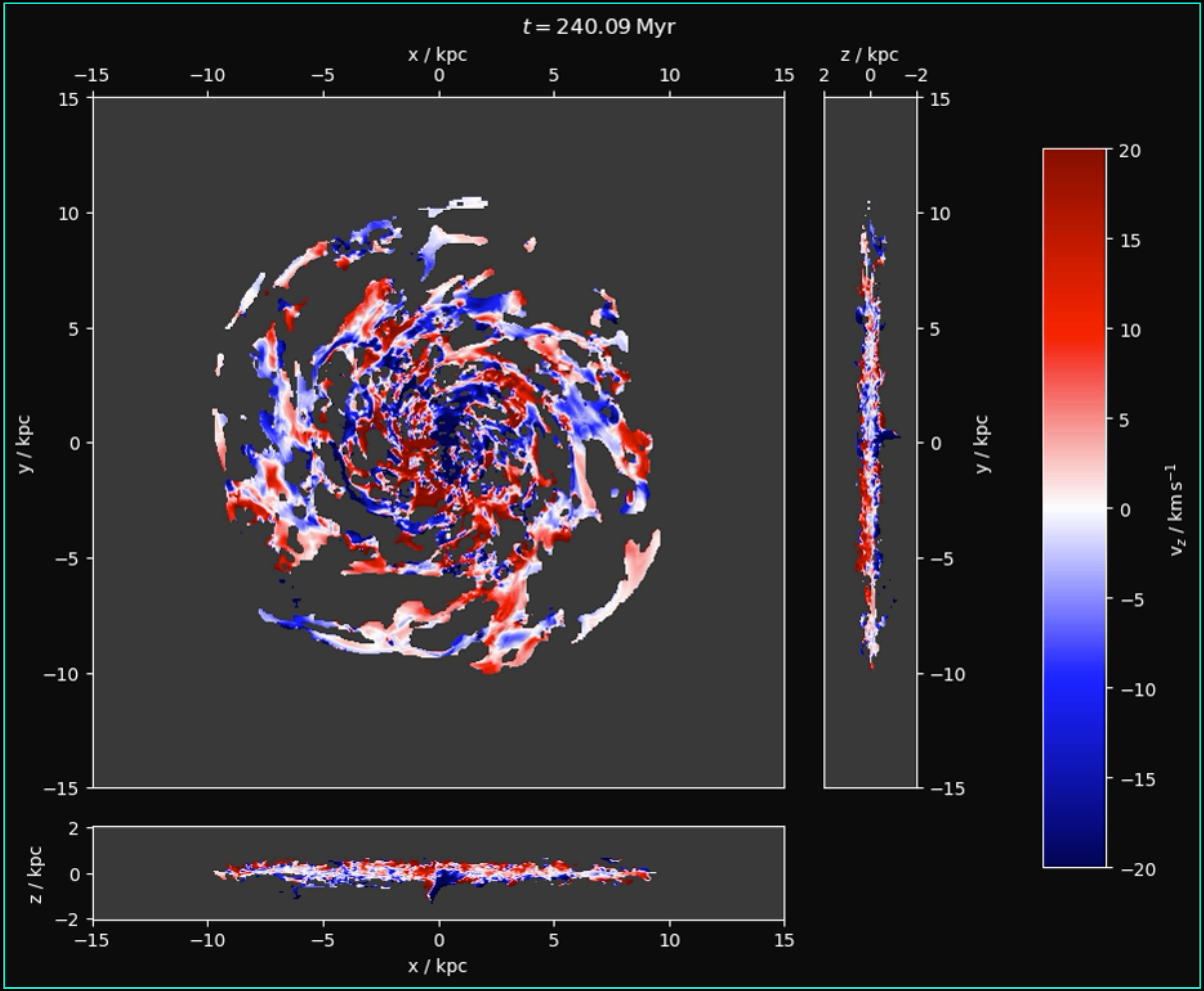
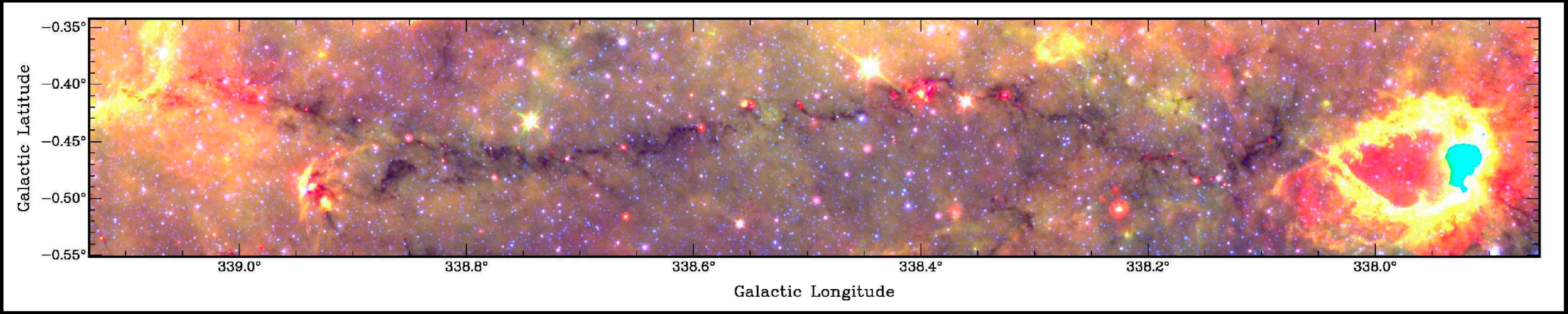


Nessie

Very long, clear absorption feature at mid IR



Jackson+20

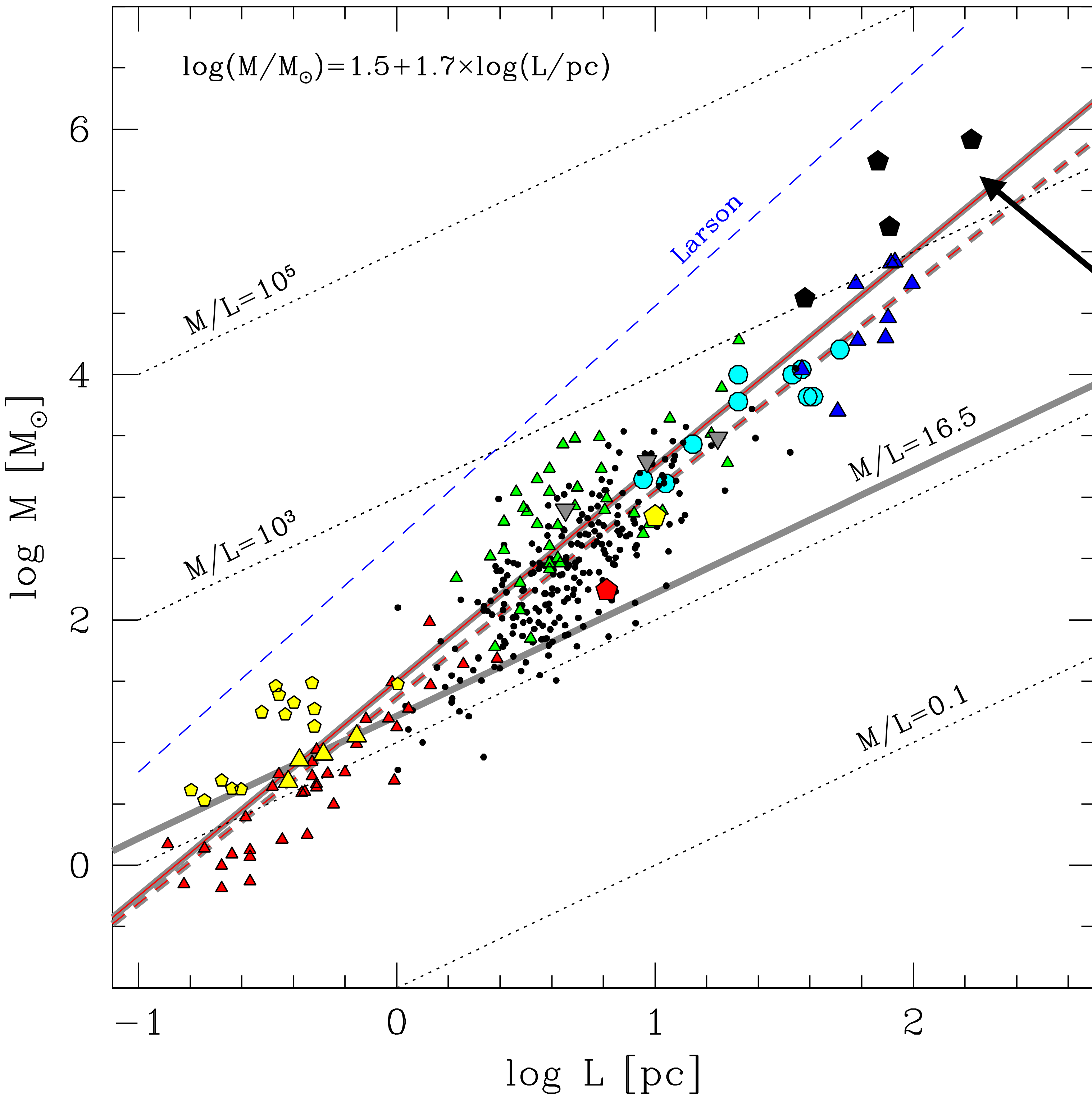
No chance alignment: the same radial velocity of -38 km/s everywhere

Kinematic distance: 3.1 kpc →

Length: L = 70 pc
Radius: R = 0.5 pc

Very large aspect ratio: L/R = 140

Scaling relation of the filamentary molecular web

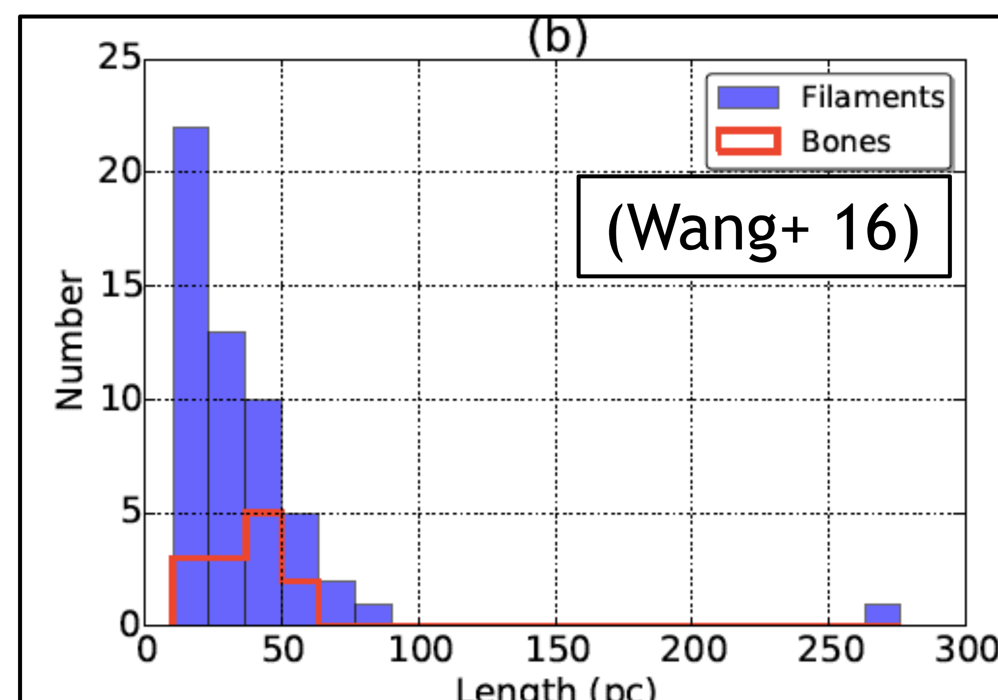


$$\log\frac{M}{M_\odot}=1.5+1.7\log\left(\frac{L}{pc}\right)$$

Maximum filament size

$$M\approx 10^6\,M_\odot$$

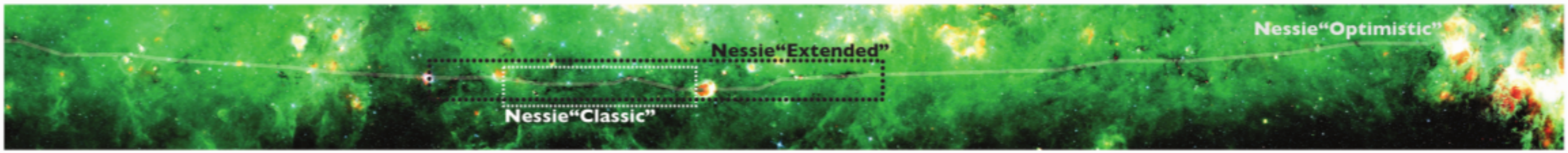
$$L\ \approx 100\,pc$$



Nessie @ EPOS 2012

Nessie @ EPOS 2012

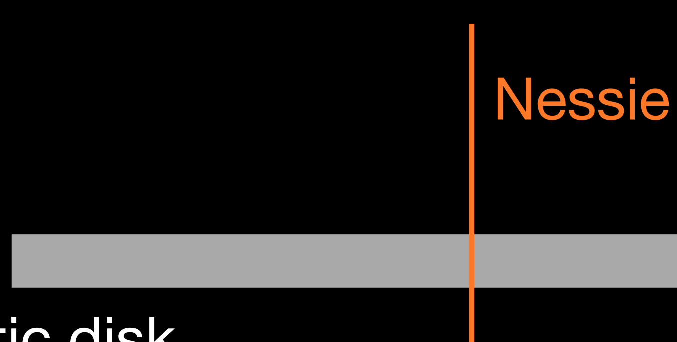
Goodman+14; Zucker+15, 18

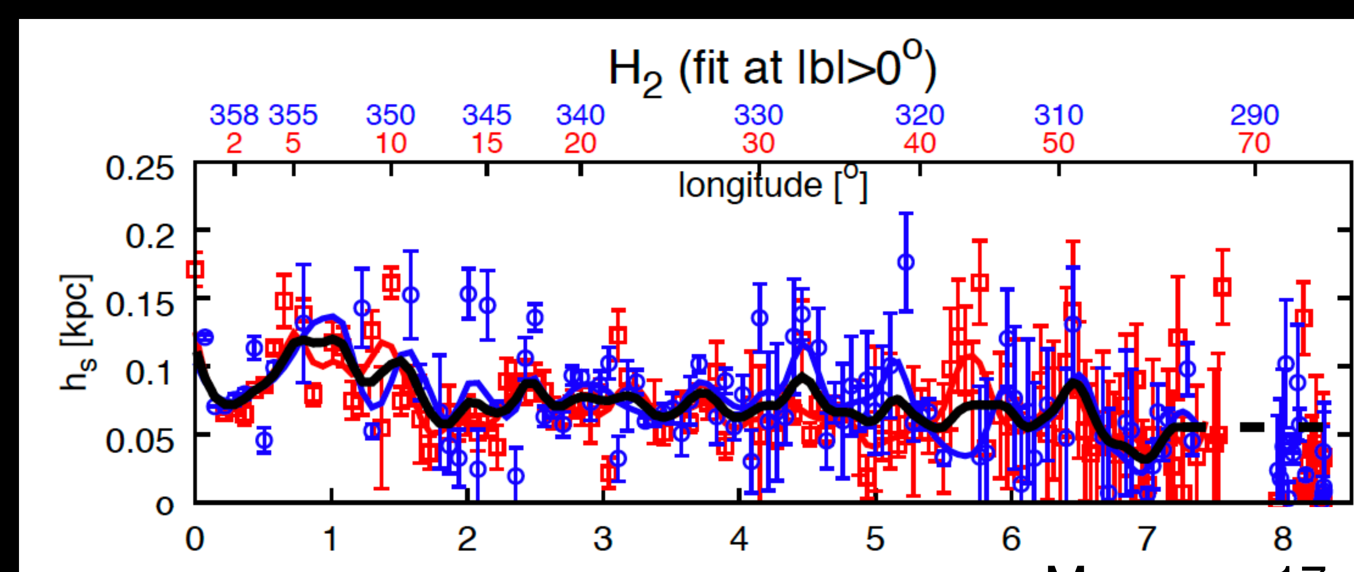


Nickname	Length *deg*	Radius *deg*	Length *pc*	Radius *pc*	Average density *cm^-3*	H2 column density *cm^-2*	Equiv. Av *mag*	Mass *Msuns*	Mass per unit length *Msuns/pc*	# to equal mass of Milky Way	aspect ratio
	for innermost Spitzer IRDC ...										
"Nessie Classic"	1.5	0.005	81	0.3	1E+5	8E+22	81	1E+5	1,208	1E+6	150
"Nessie Extended"	3	0.005	162	0.3	1E+5	8E+22	81	2E+5	1,208	6E+5	300
"Nessie Optimistic"	8	0.005	431	0.3	1E+5	8E+22	81	5E+5	1,208	2E+5	800

Scale height of molecular disk: 50 pc

Nessie must be fairly parallel to the disk plane

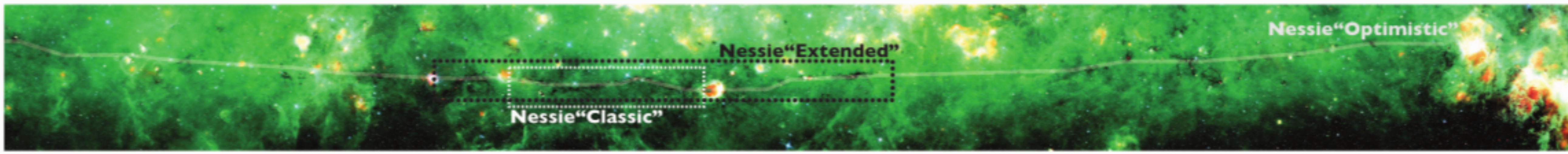




Marasco+17

Nessie @ EPOS 2012

Goodman+14; Zucker+15, 18



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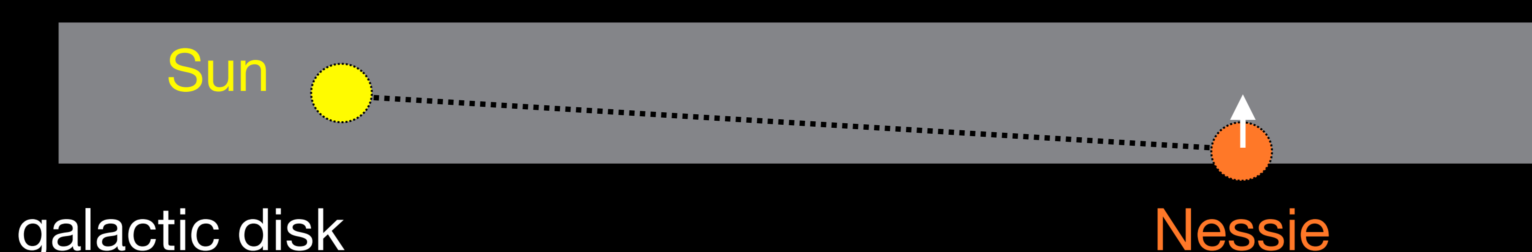
Galactic latitude:

$$b_{Nessie} = -0.4^{\circ}$$



Nessie @ EPOS 2012

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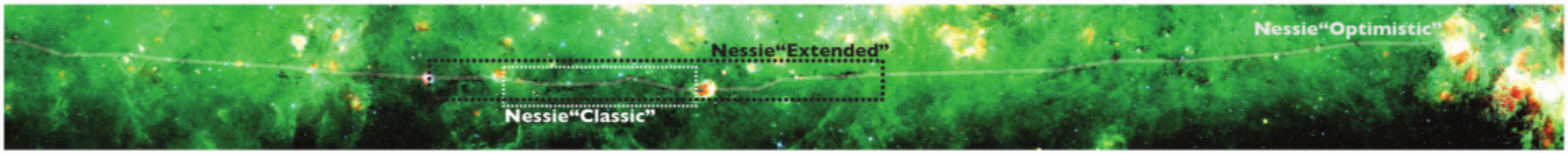

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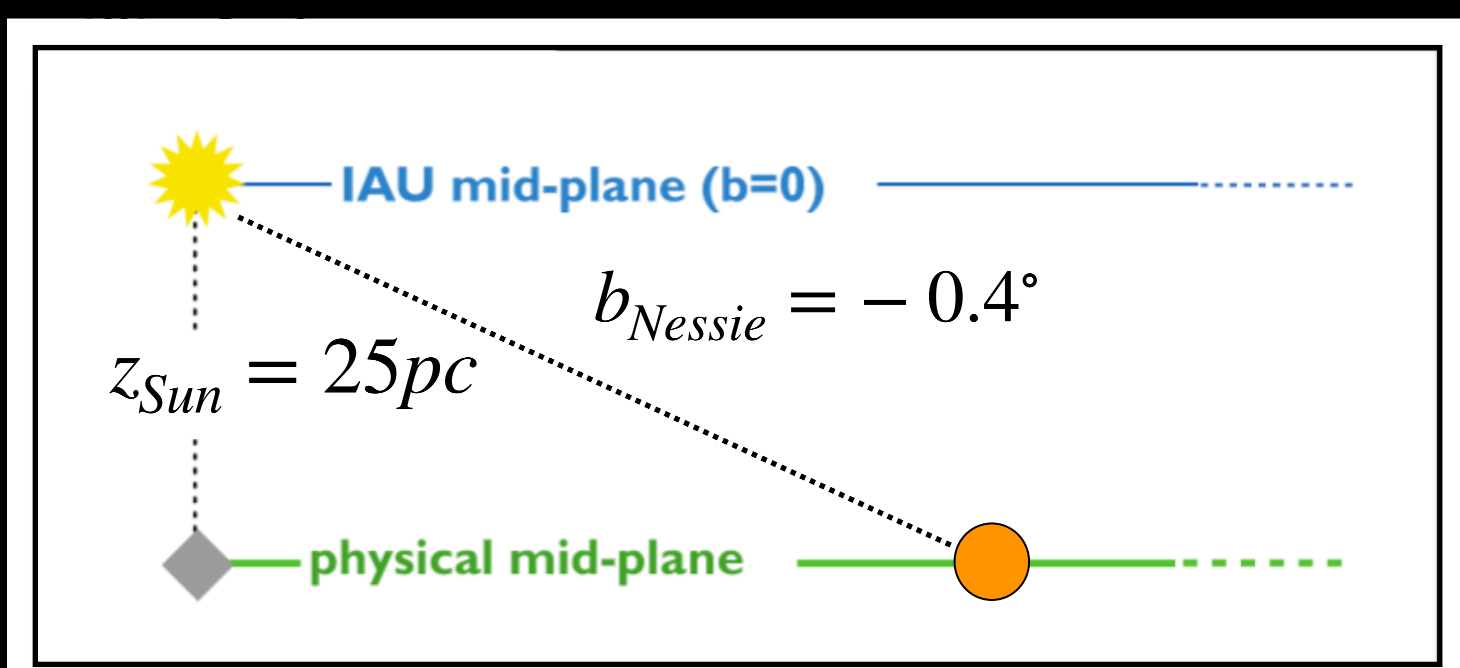
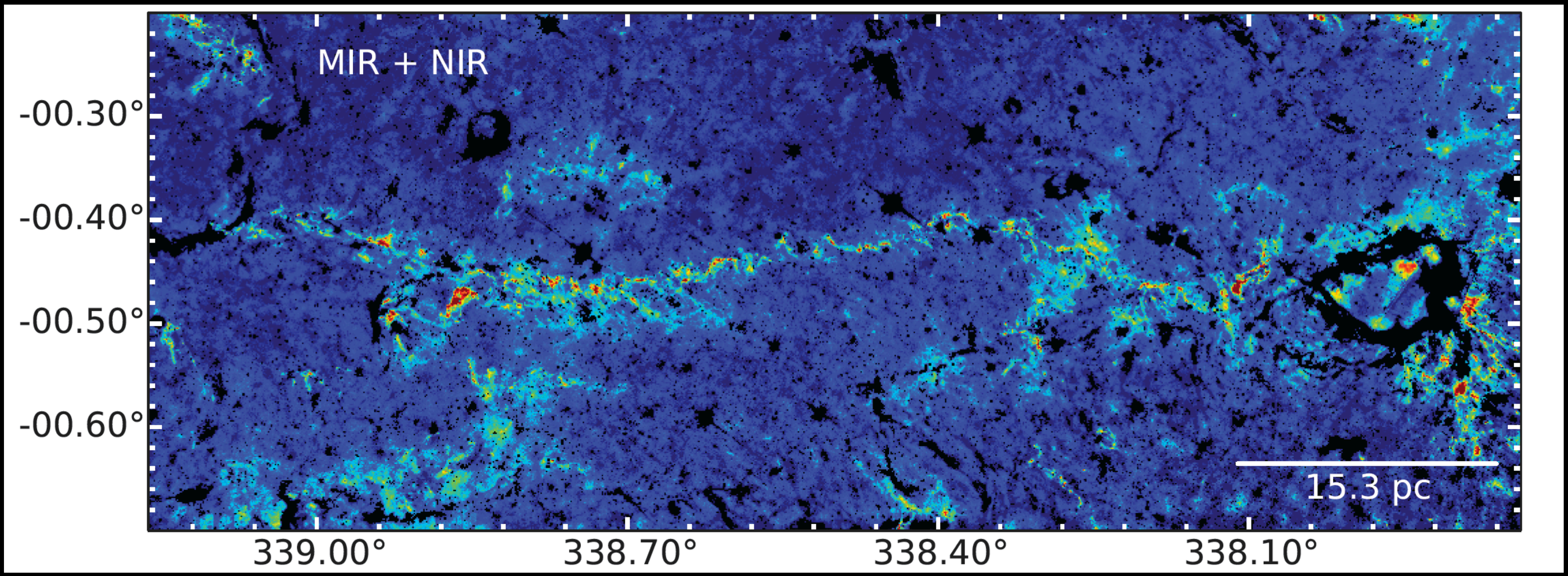


But see poster by Syed+
The Maggie filament

Nessie's substructure

Mattern, Kainulainen, Zhang & Beuther, 2018



$R \approx 1.5pc$

$L/R \approx 45$

$L \approx 67pc$

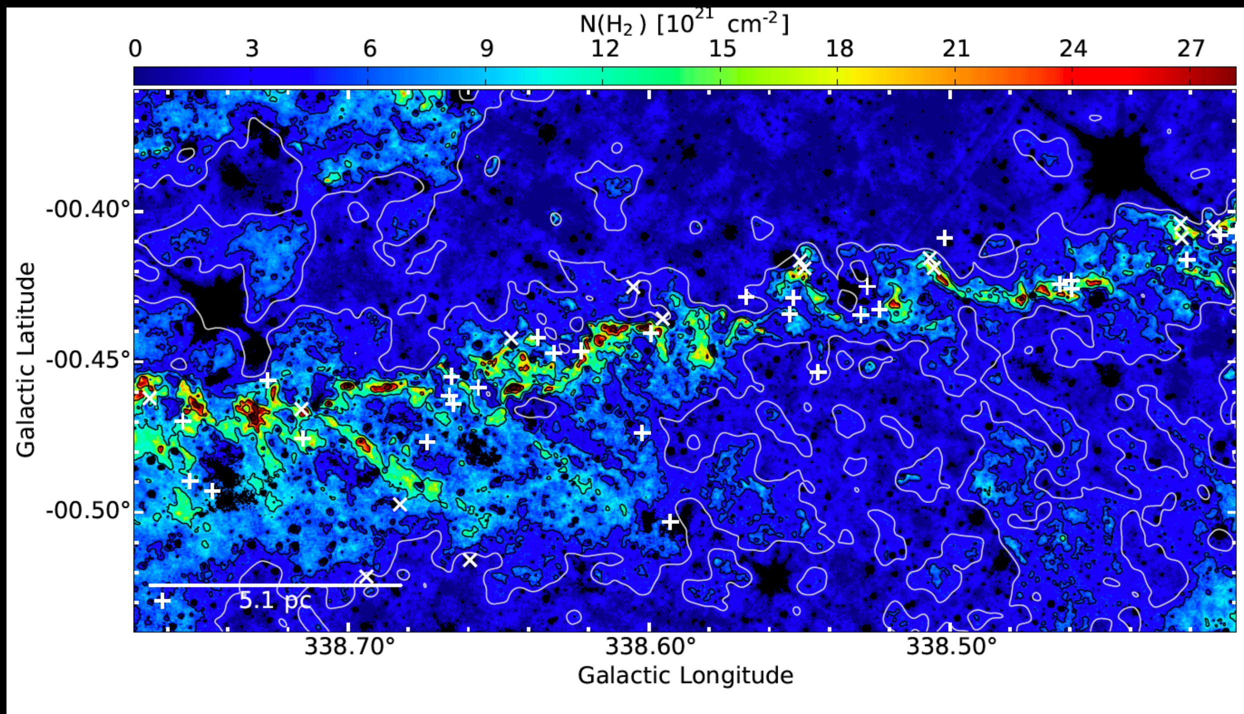
$M_{gas}/L \approx 625M_{\odot}/pc$

$M_{gas} \approx 4.2 \times 10^4 M_{\odot}$

$M_* \approx 800M_{\odot}$ → $SFE = M_*/M_{gas} \approx 0.02$

Fragmentation analyses

Mattern, Kainulainen, Zhang & Beuther, 2018



Large-scale properties along the ridge

$$n_c \approx 10^3 cm^{-3}$$

$$\lambda_{fragments} \approx 2pc$$

Sausage instability (Chandrasekhar & Fermi 53) :

$$\lambda_{fragments} = \frac{22 \times c_s}{(4\pi G\rho_c)^{0.5}} \approx 2pc$$

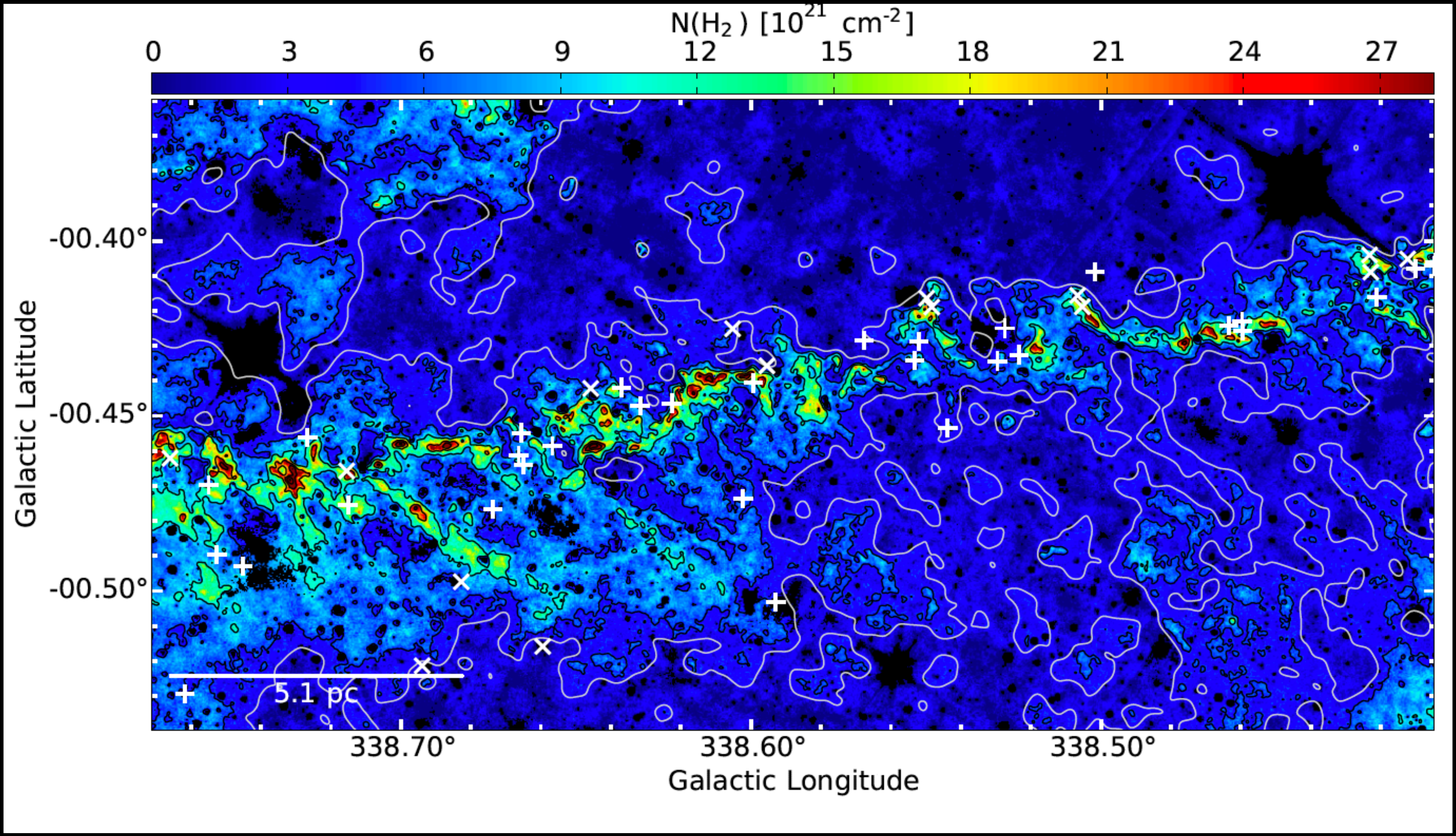
Critical line mass: (Hacar+22)

$$(M/L)_{crit} = 16.4 \times \left(\frac{\sigma}{c_s}\right)^2 M_\odot/pc$$

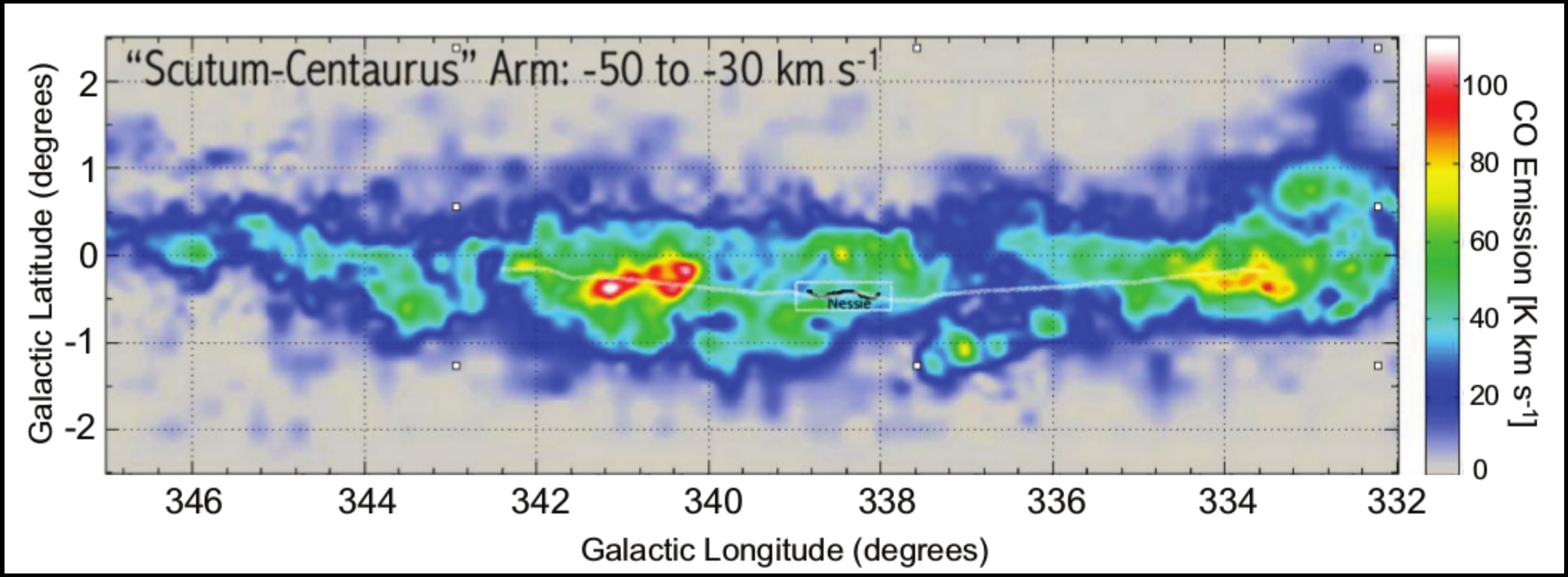
$$(M/L)_{crit} > 625 M_\odot/pc \longrightarrow \sigma > 6.2 c_s \approx 1.2 km/s$$

$$\lambda_{fragments} > 12pc$$

Nessie is not an fragmenting isolated filament.
It instead might trace gas interacting with a galactic gravity wave

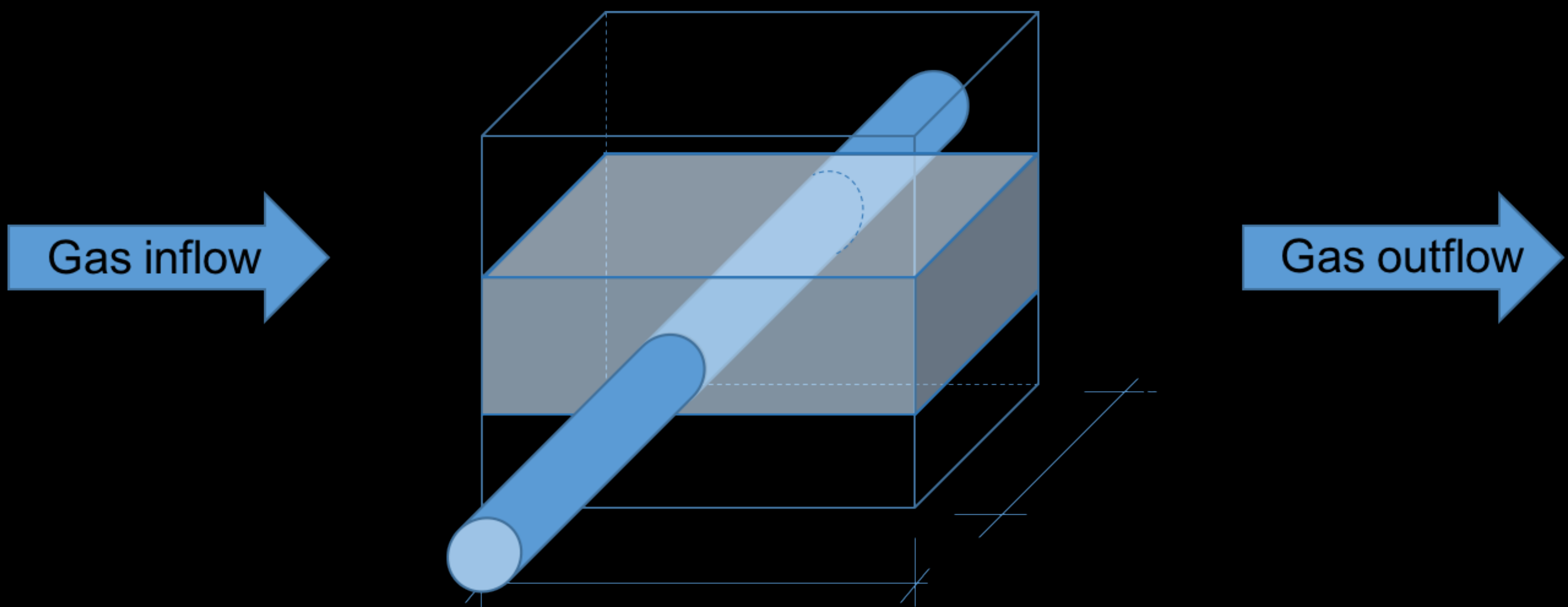


Tracing Bones (the sceleton) of the Milky Way



Inflow driven self-regulated structure- and star formation

Fatih Turan
Christian Alig, Marc Schartmann, Andi Burkert

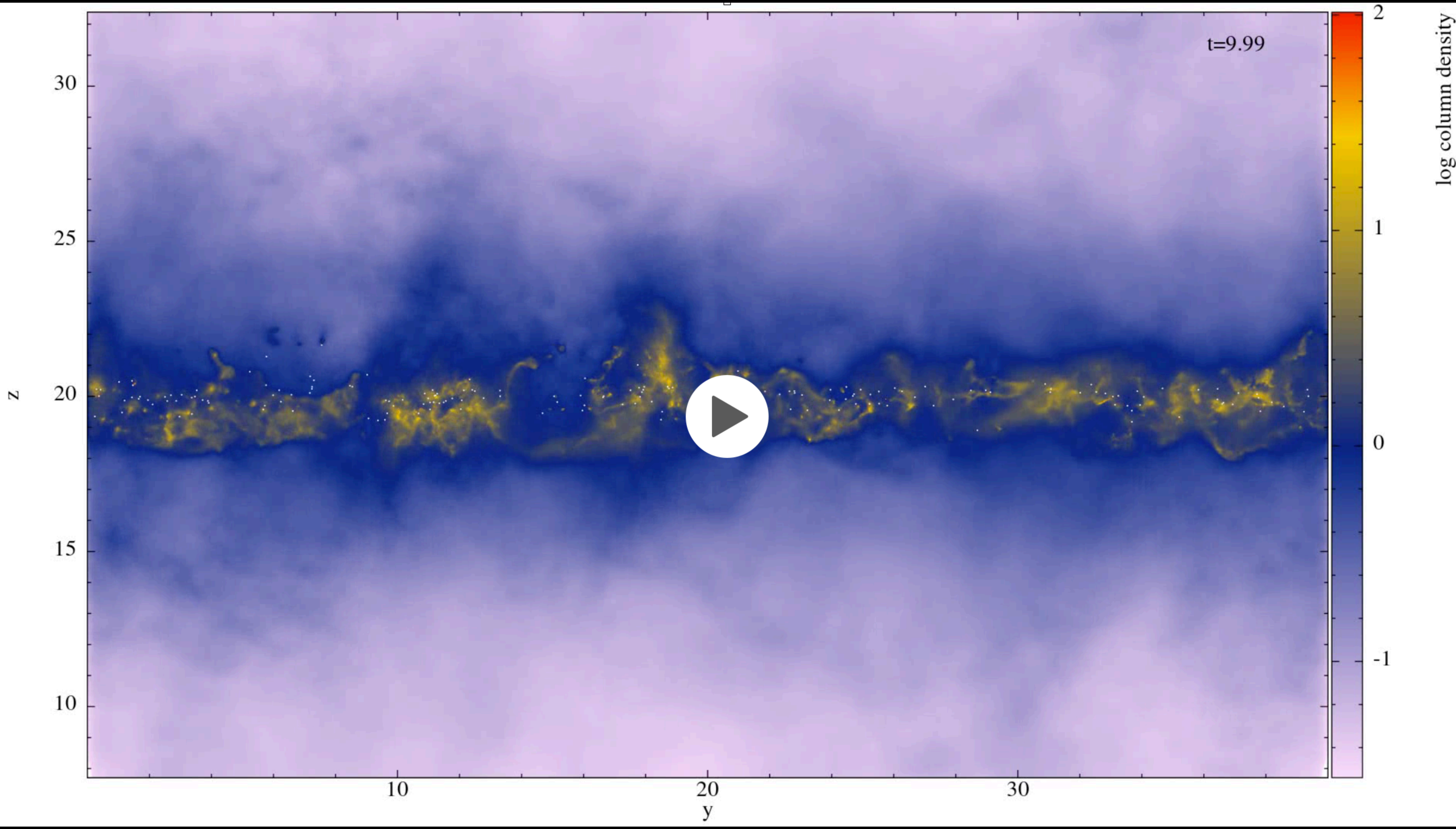


Low Density Injection

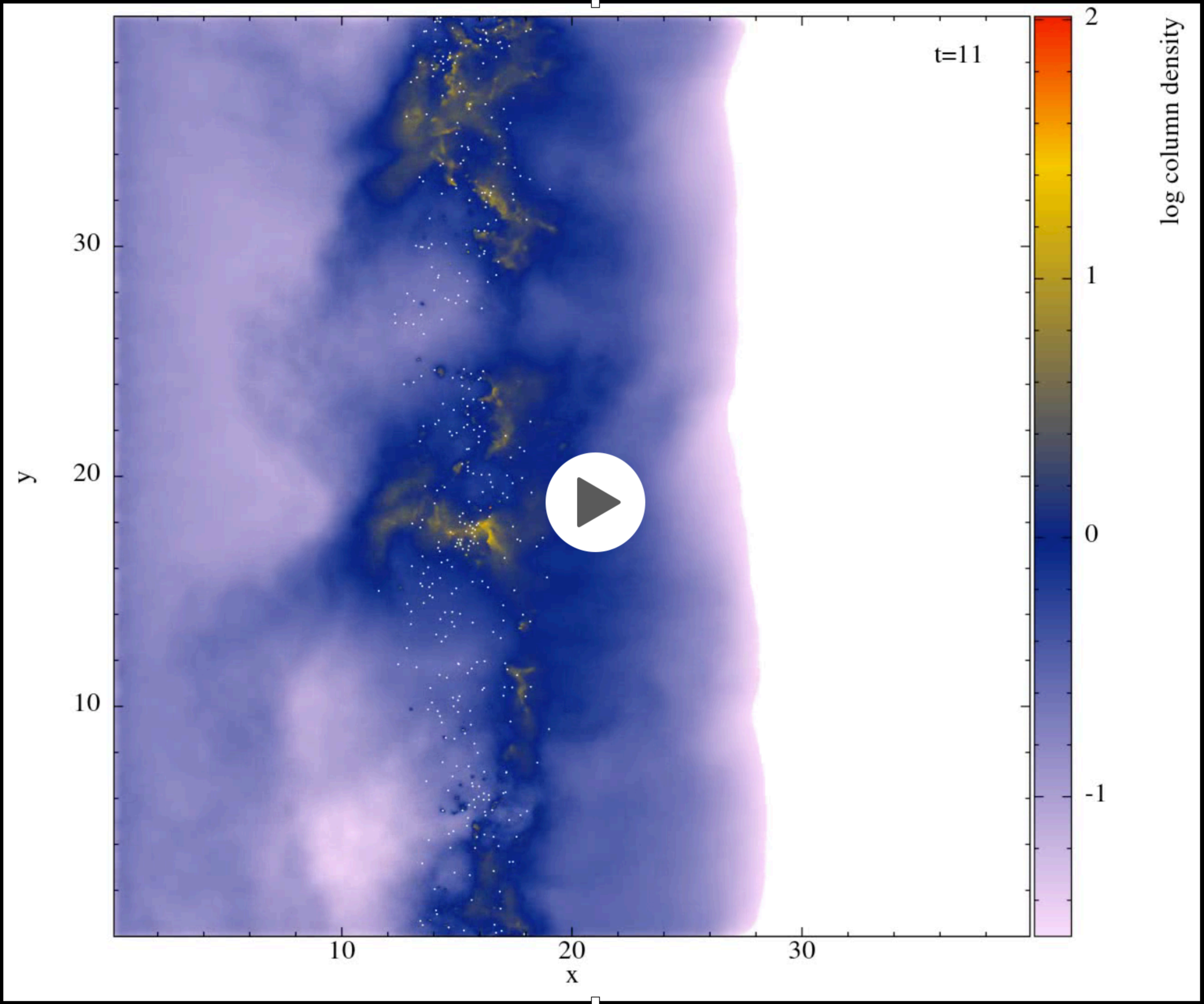
Injection Velocity: 15 km/s

Injection Density: $0.5 cm^{-3}$

Potential: Spiral Arm



t=9.99
z
y
log column density



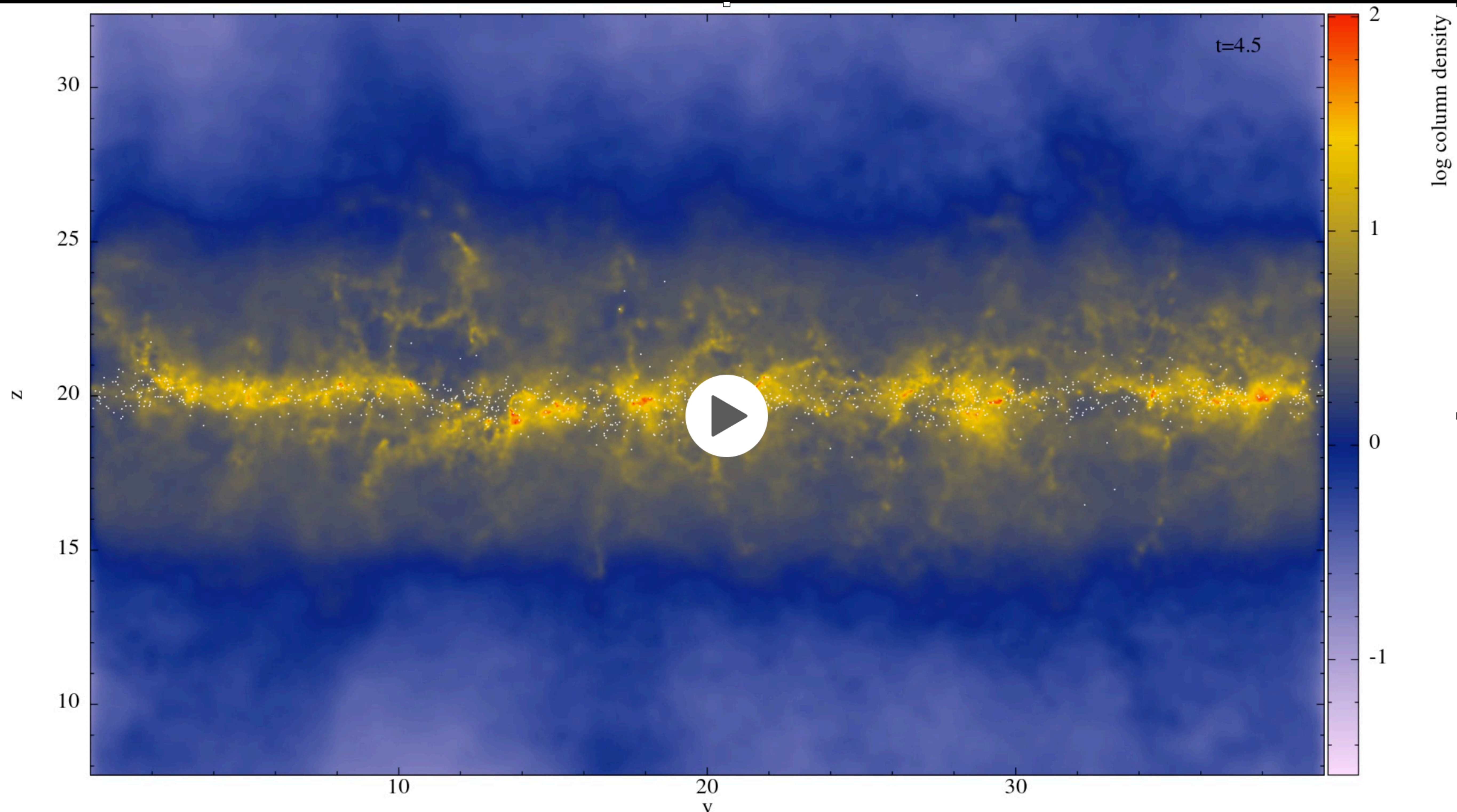
t=11
log column density
2
1
0
-1
y
x
10
20
30

Higher-density injection

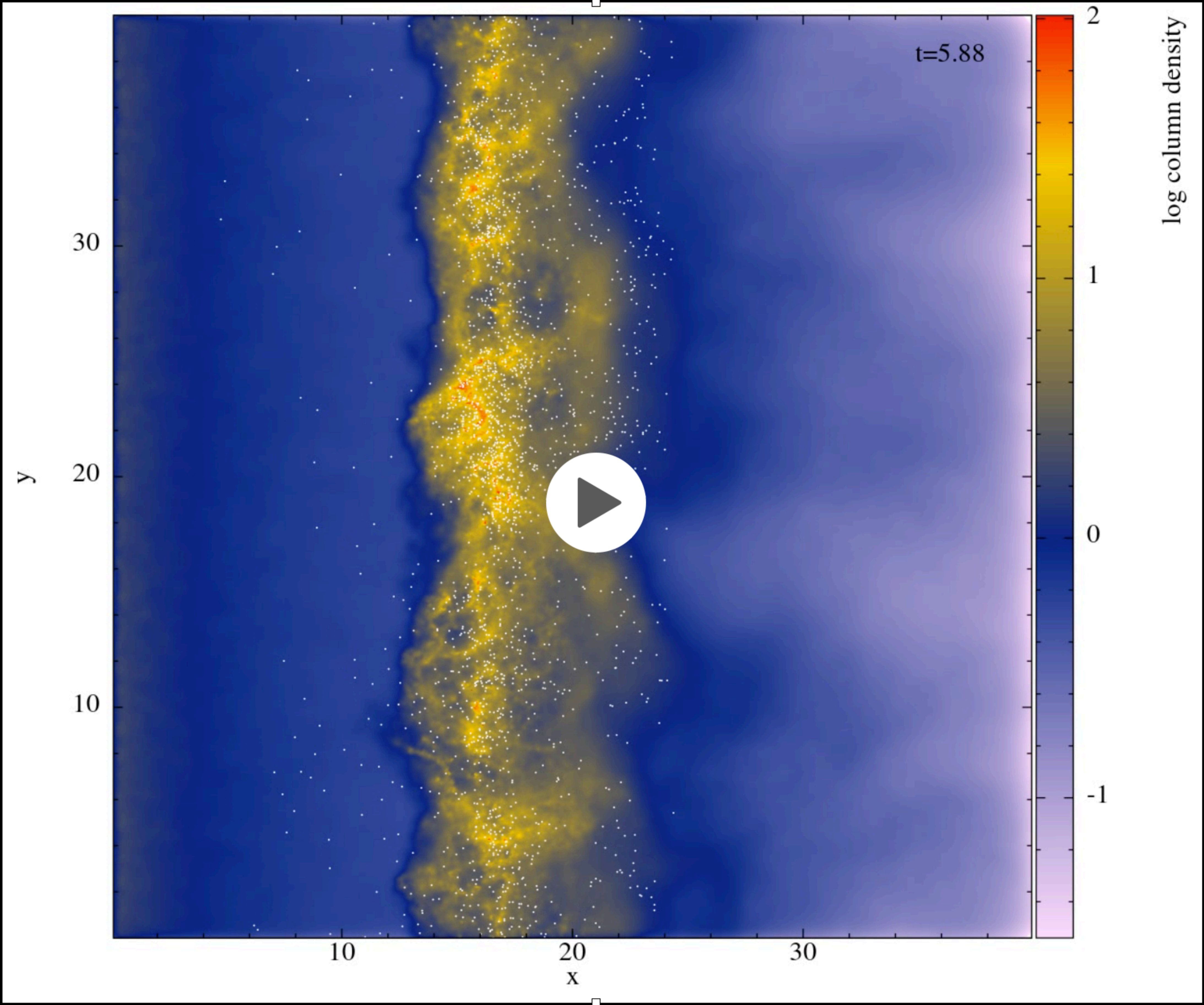
Injection Velocity: 15 km/s

Injection Density: $2cm^{-3}$

Potential: Spiral Arm



t=4.5
log column density
2
1
0
-1
30
25
20
15
10
z
10
20
30
y

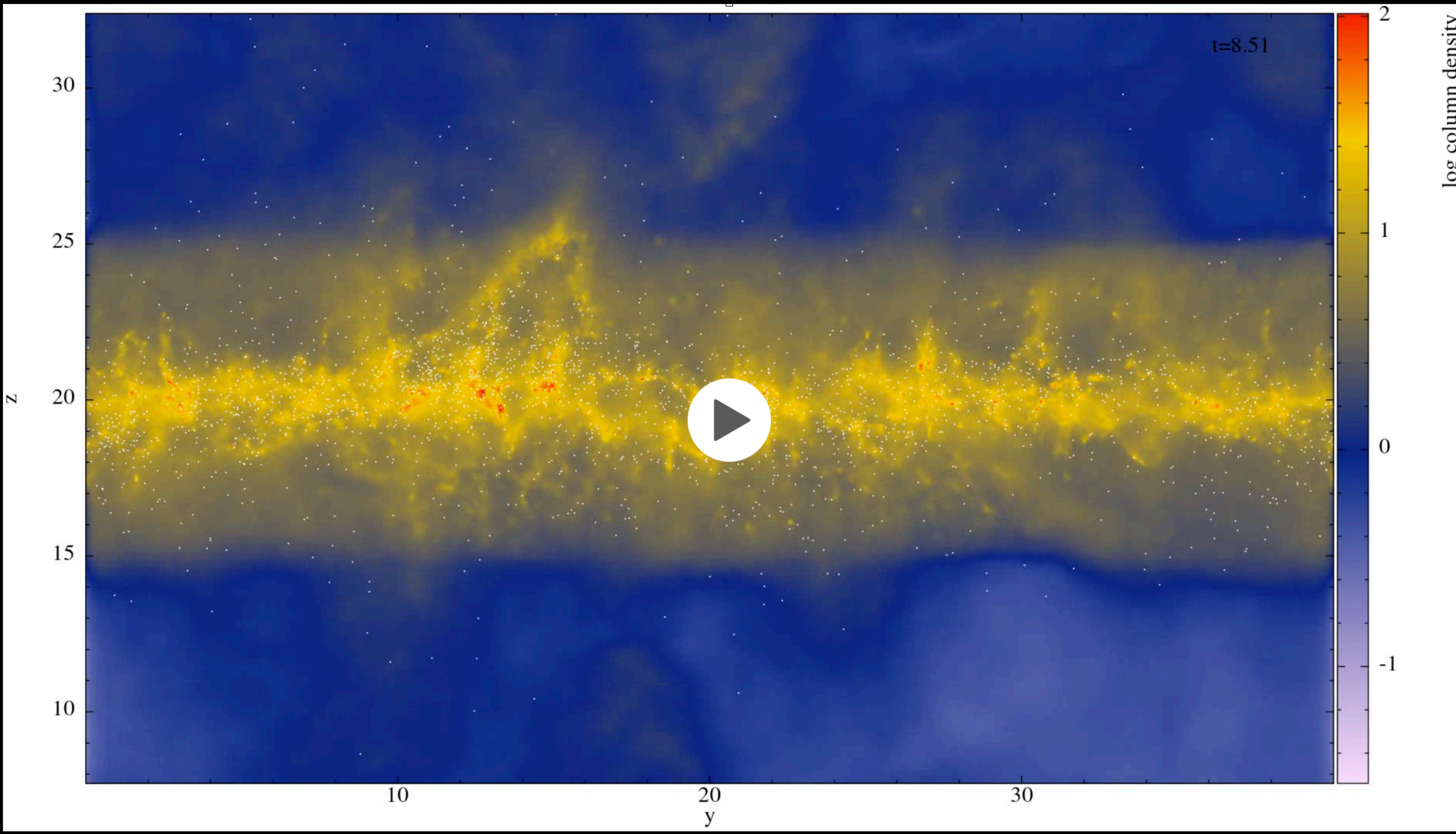

t=5.88
log column density
2
1
0
-1
y
30
20
10
x
10
20
30

Large injection velocity

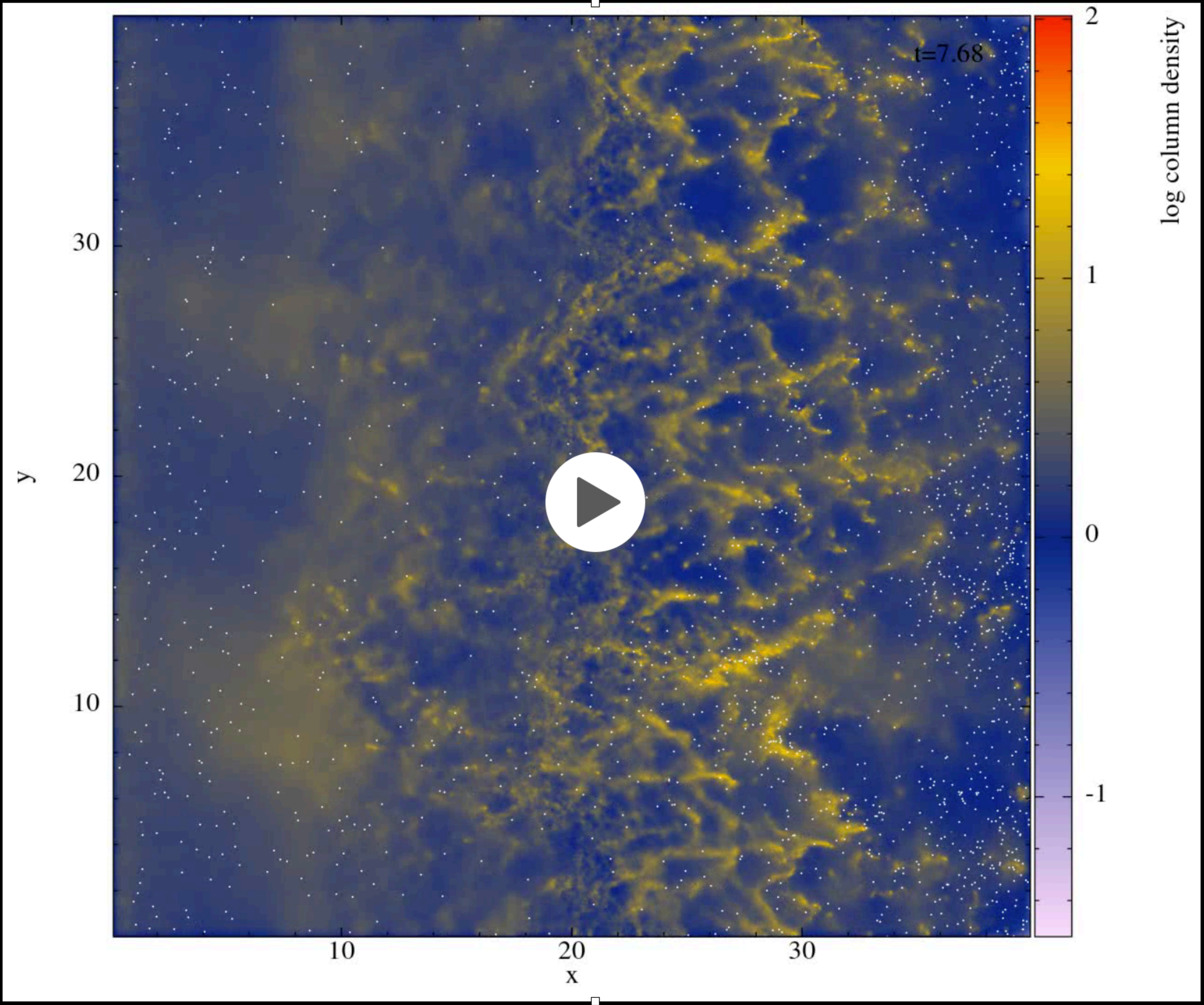
Injection Velocity: 30 km/s

Injection Density: $2cm^{-3}$

Potential: Spiral Arm



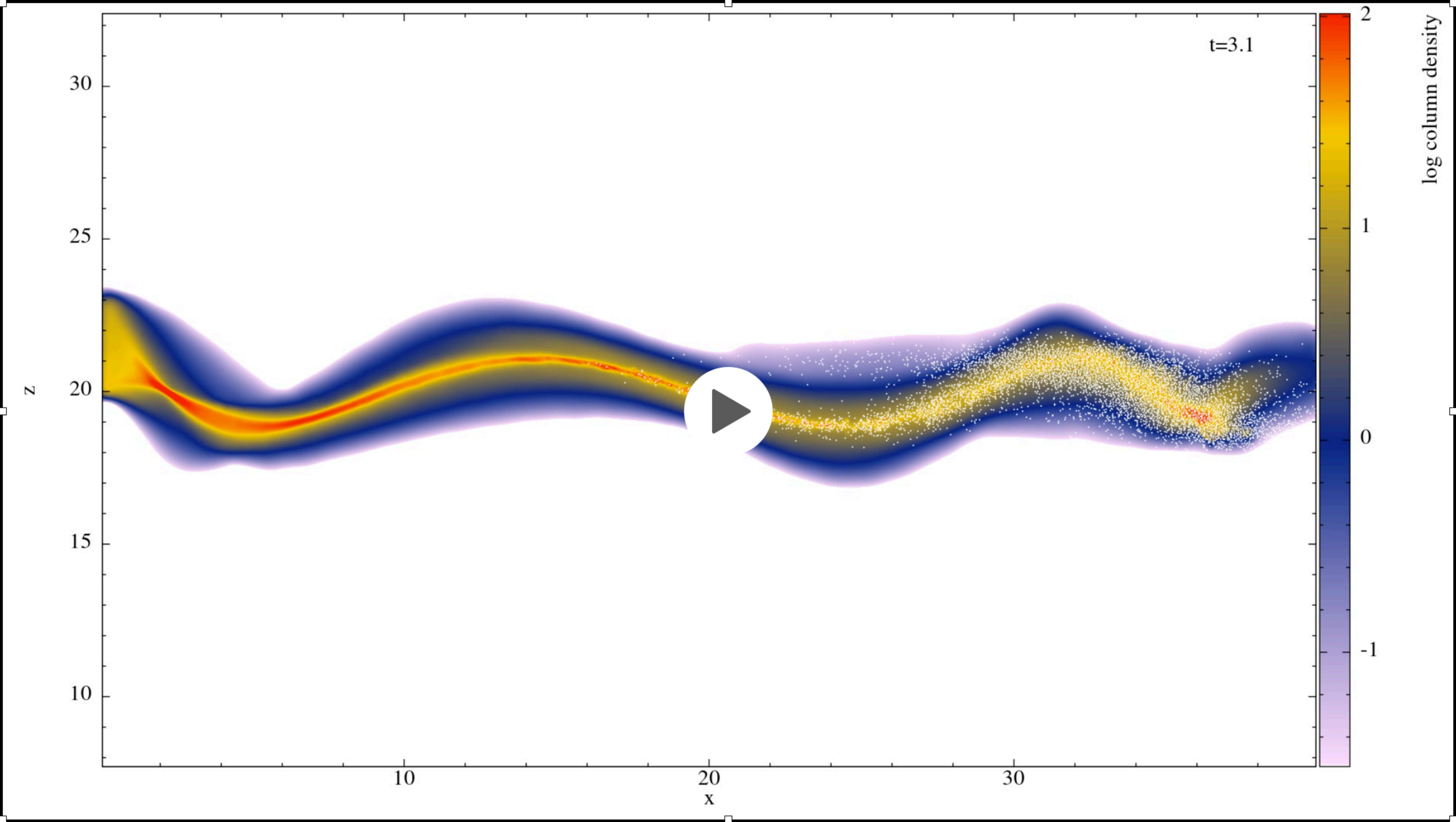
t=8.51
z
y
log column density


t=7.68
y
x
log column density
10
20
30
2
1
0
-1

Injection only in Upper Half

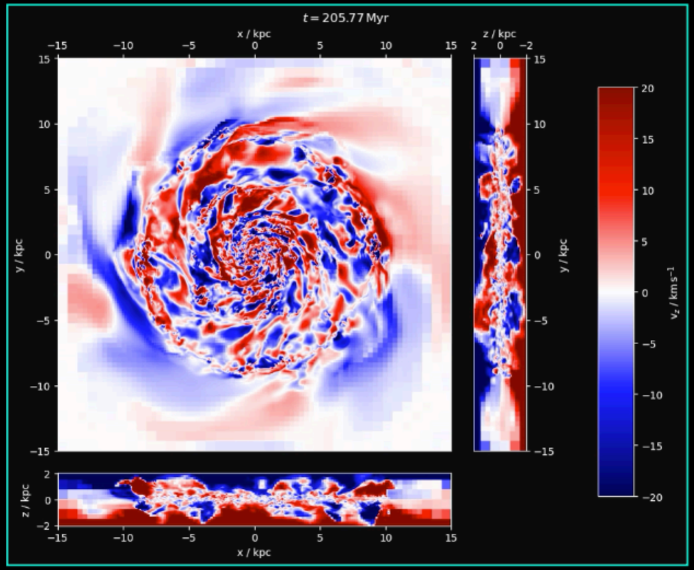
Injection Velocity: 15 km/s

Potential: Spiral Arm + Disk Potential


t=3.1
log column density
2
1
0
-1
30
25
20
15
10
z
10
20
30
x

Summary

- Surface gravity waves (SGWs) might play an important role in shaping the ISM and regulating star formation.
- Star formation might in turn trigger SGWs.



- Infrared dark filaments (Nessie) might be ideal tracers of the galactic SGW-spectrum