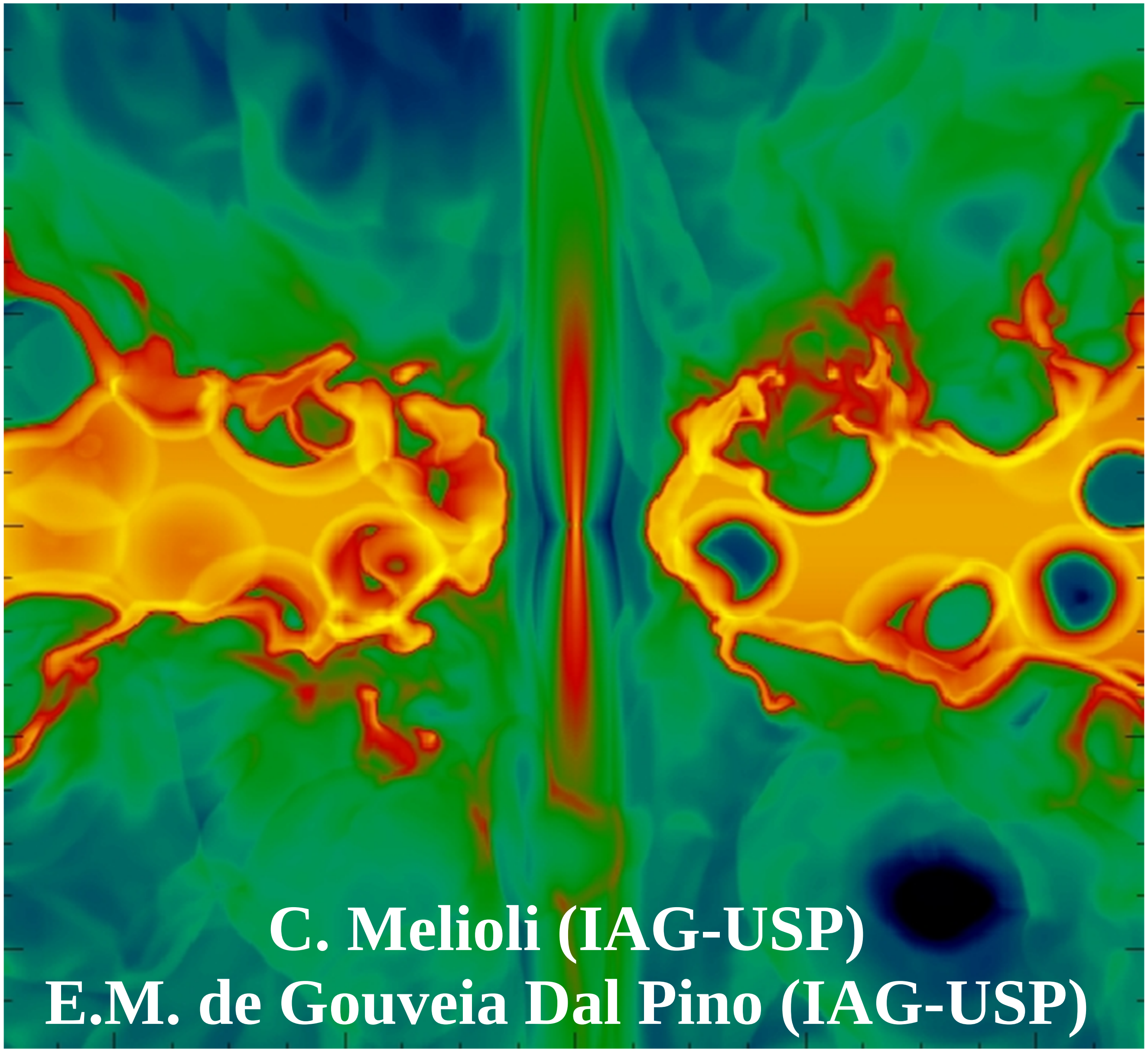
AGN jets and their interplay with the host galaxy and the central black hole



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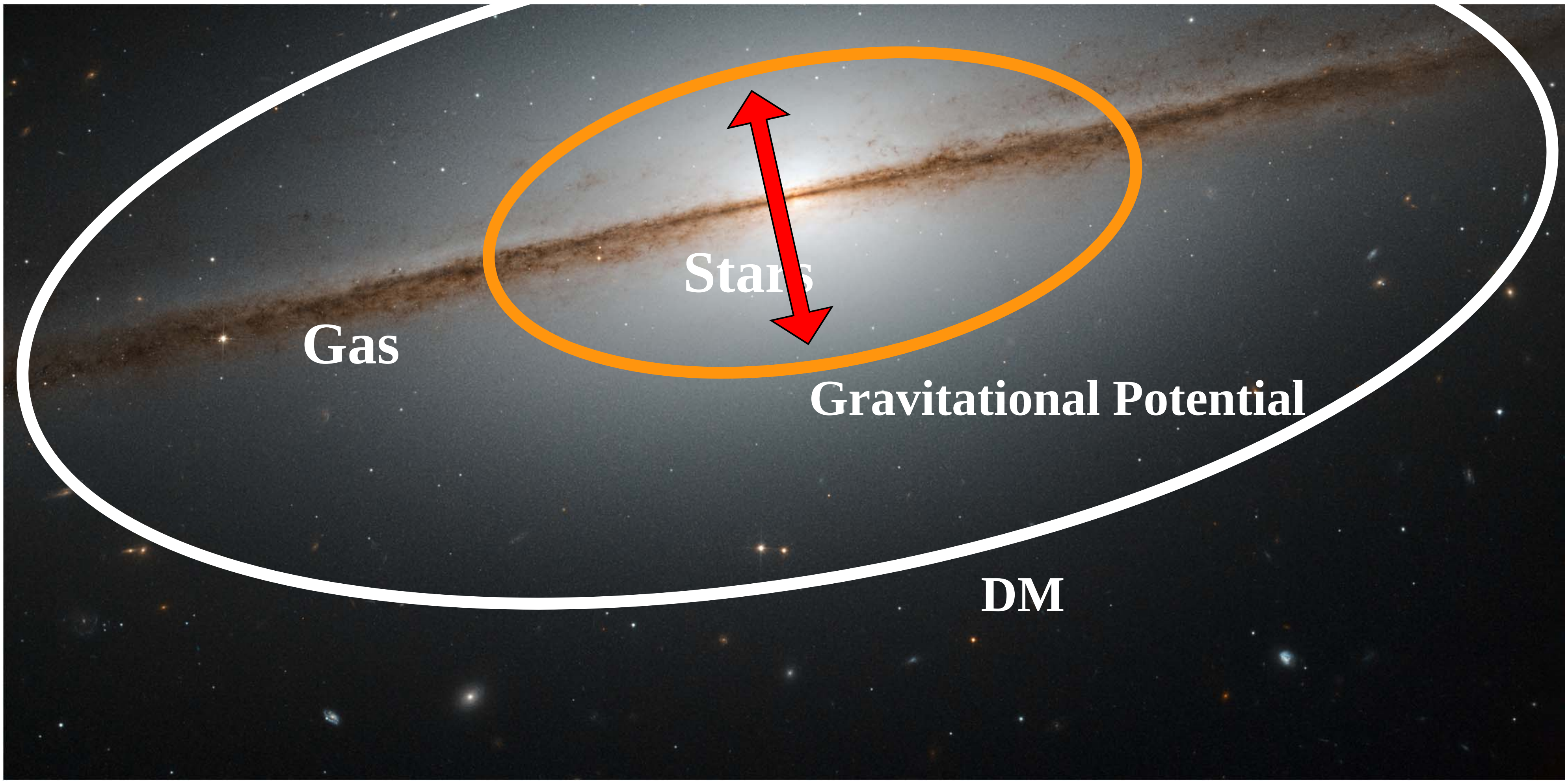
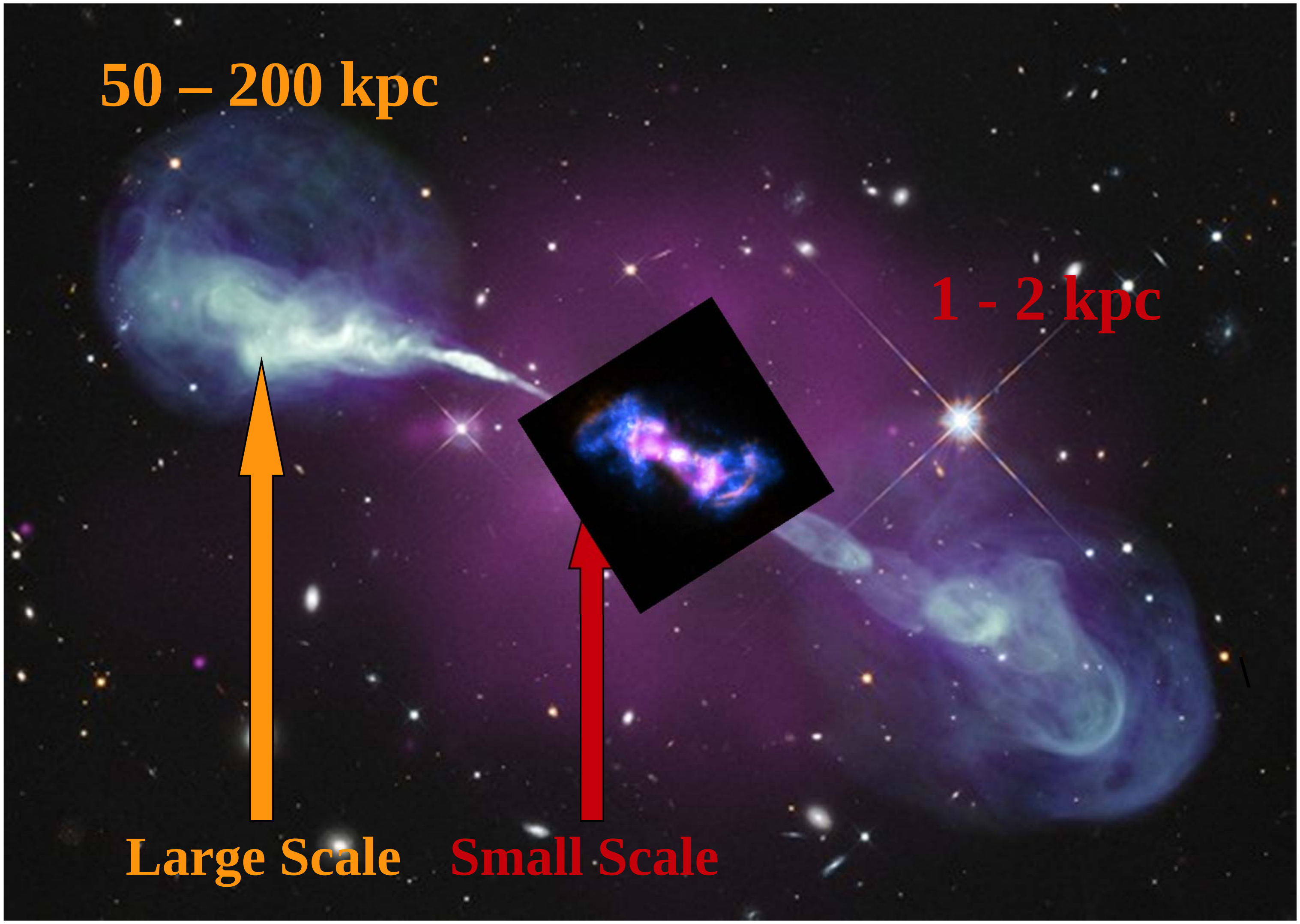
E.M. de Gouveia Dal Pino (IAG-USP)

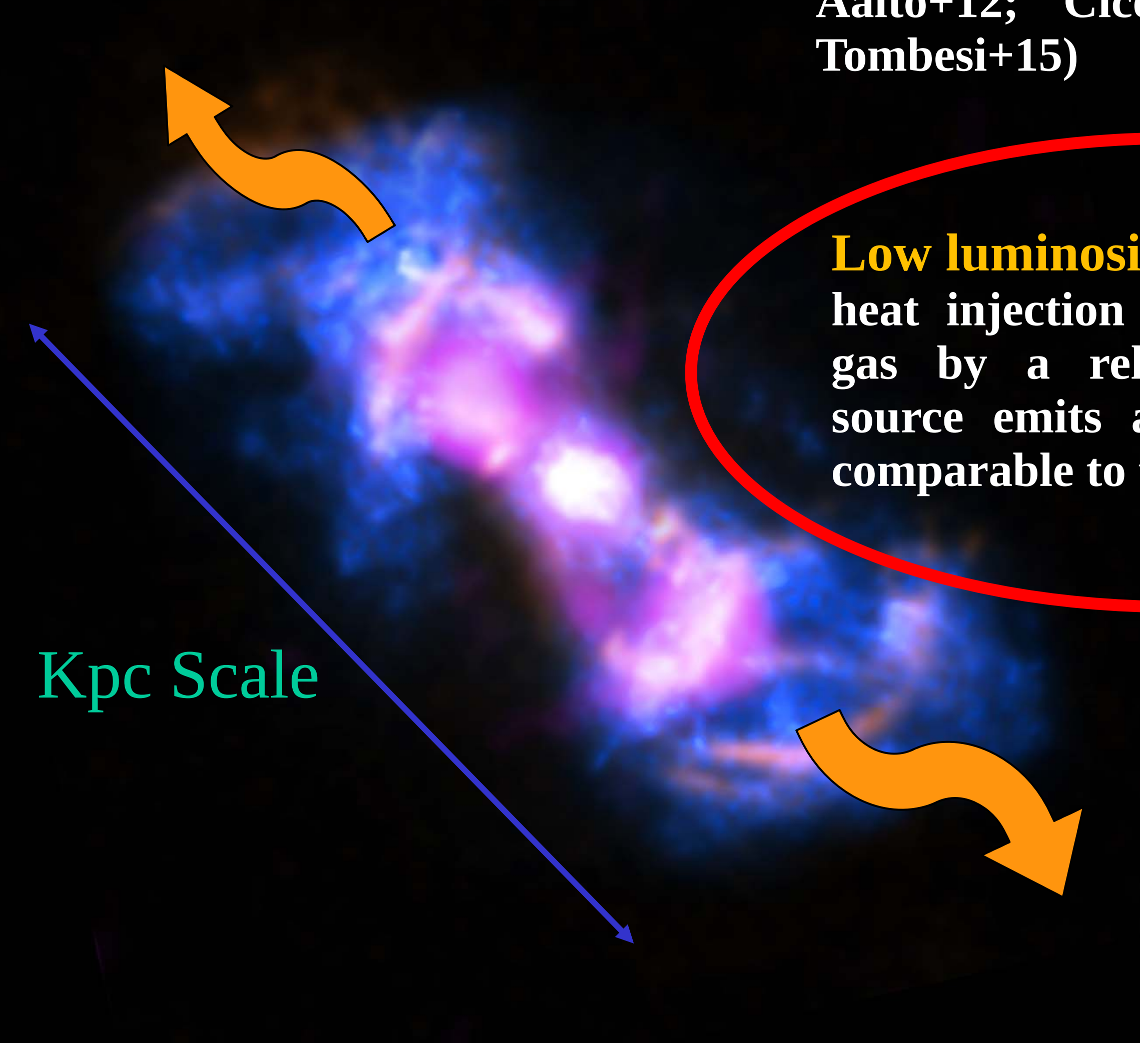
Overview

In the nuclear region of a galaxy, the conditions to have gas outflow are function of a number of different parameters:



Overview

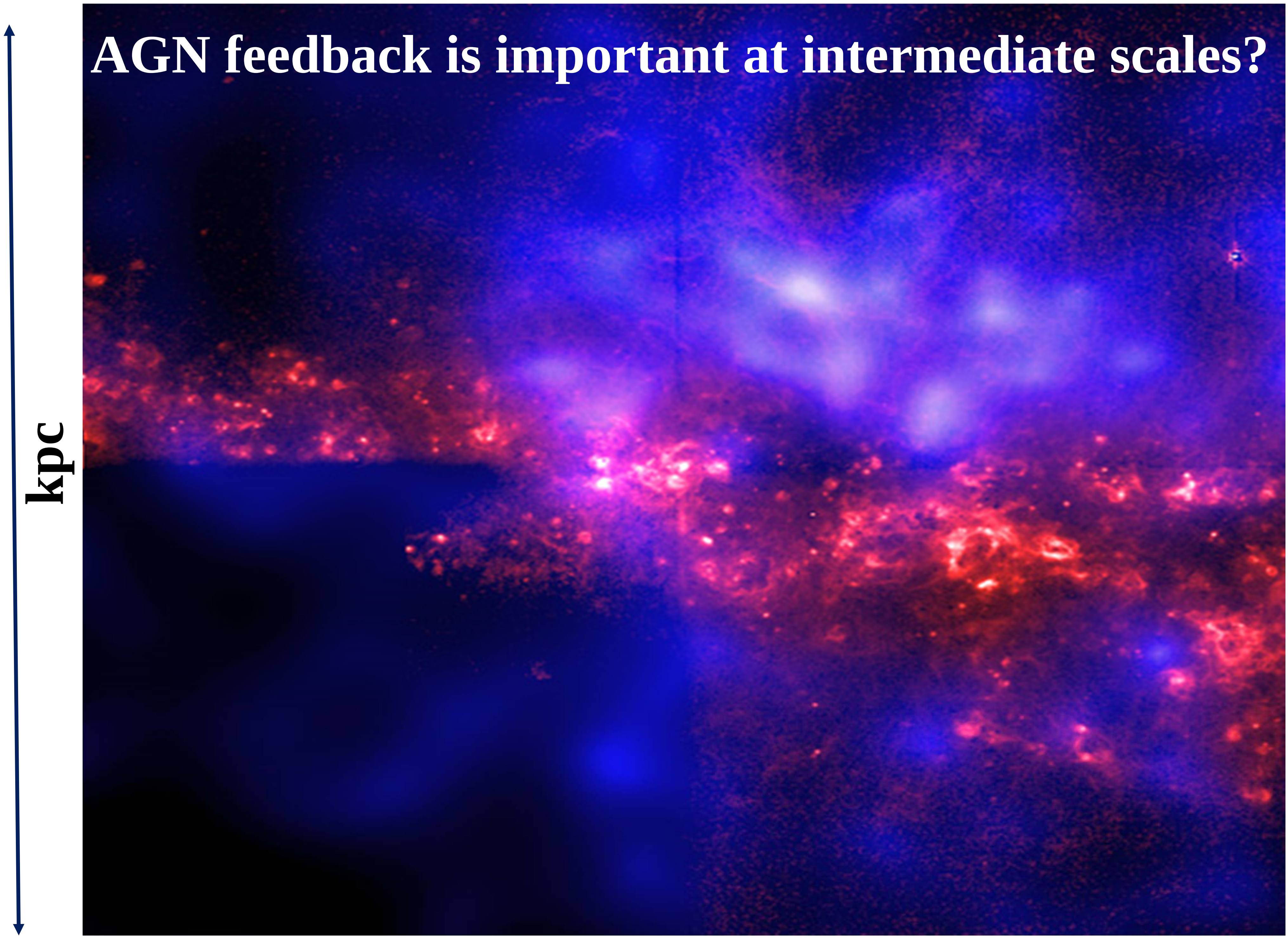




High luminosity ($L/L_{edd} > 0.1$):
the AGN power couples directly to the interstellar medium via radiation pressure or accretion disc winds (e.g. Aalto+12; Cicone+14; Genzel+14; Tombesi+15)

Low luminosity ($L/L_{edd} < 0.1$):
heat injection into the surrounding gas by a relativistic jet; nuclear source emits an amount of energy comparable to that of the host galaxy

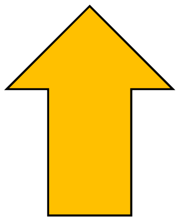
Mrk 573 (Seyfert galaxy at z=0.017)


AGN feedback is important at intermediate scales?
kpc

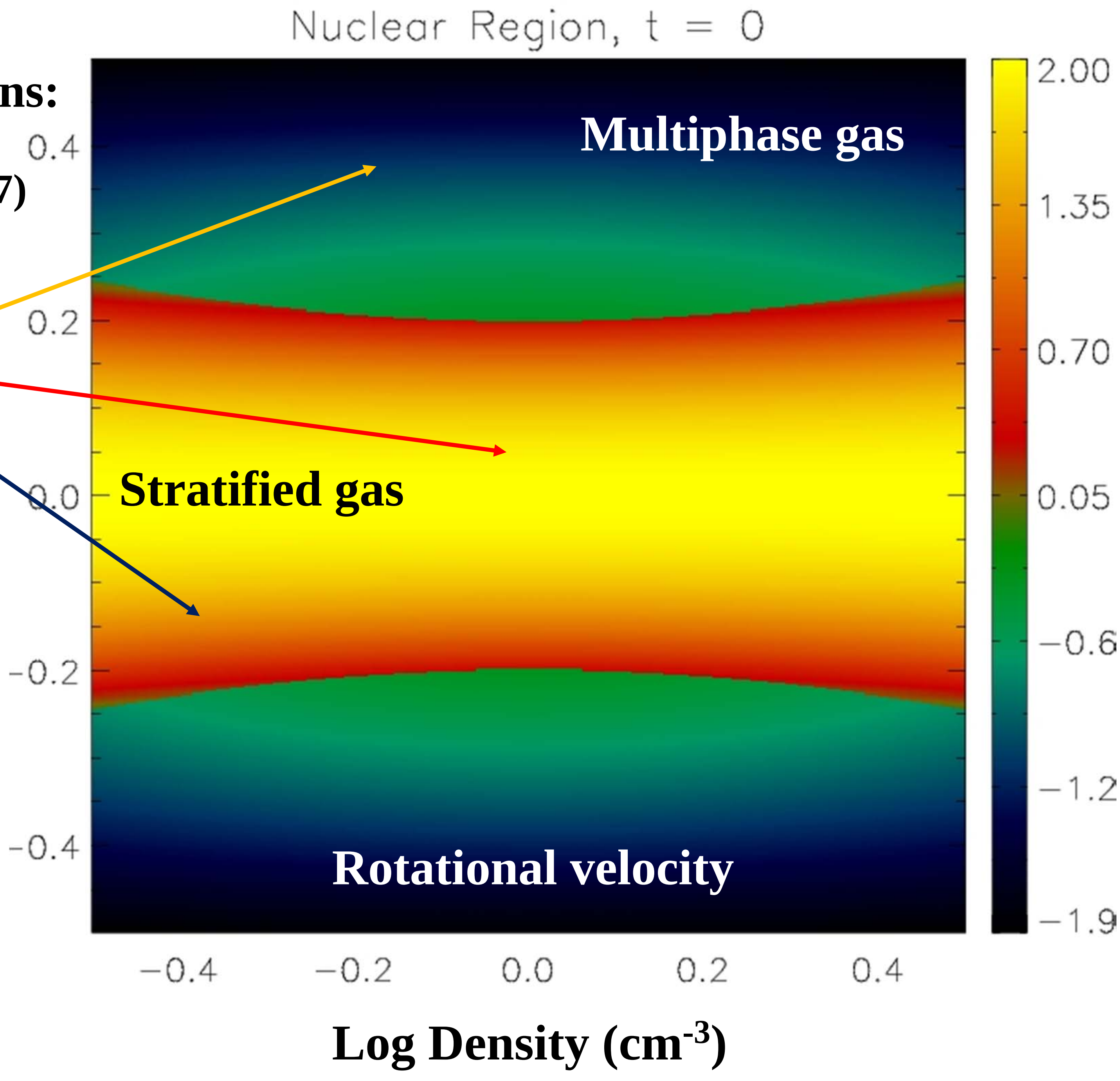
Model

3-D Numerical simulations:

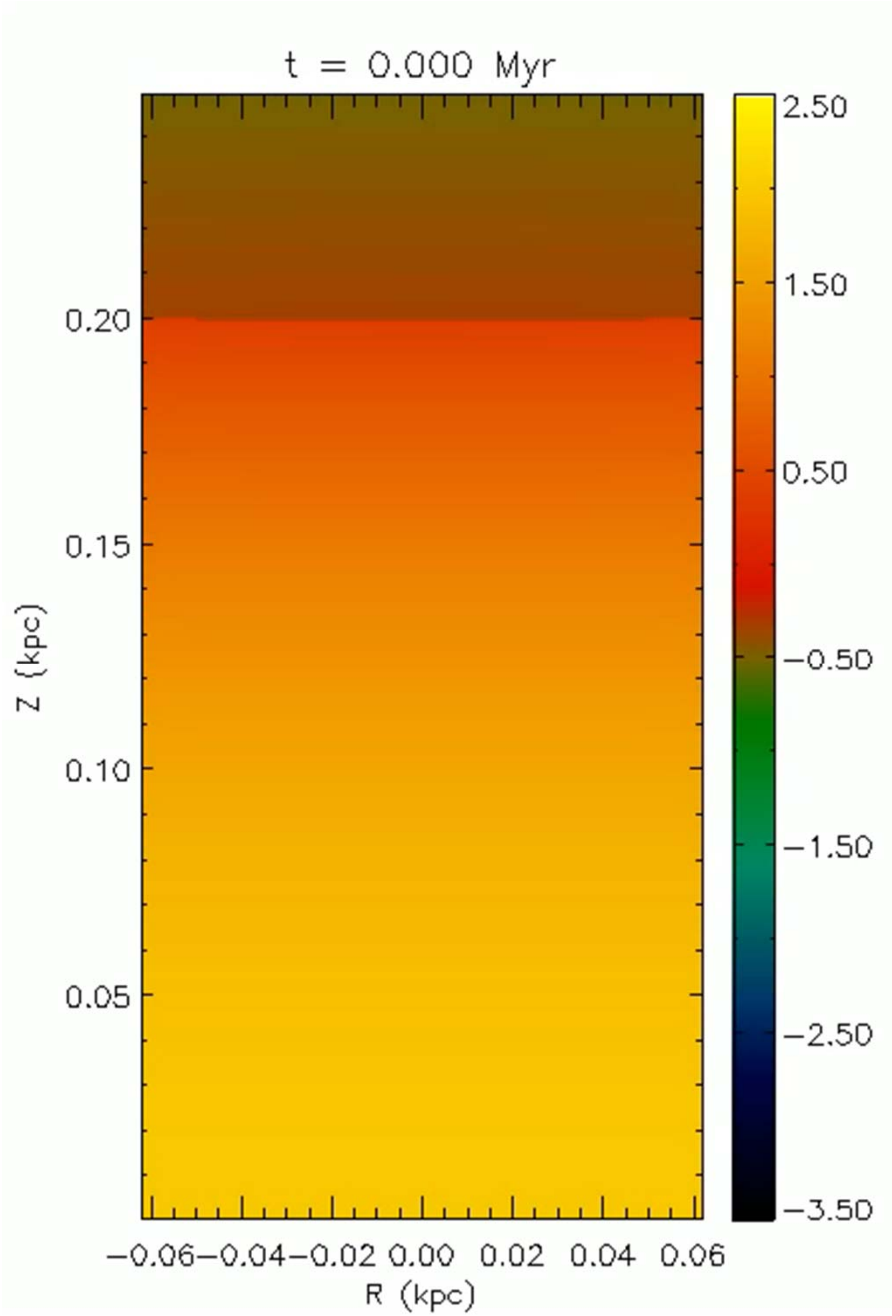
- **Godunov code (Kowal+07)**
- **Stellar disk**
- **Bulge**
- **DM**
- **Stellar feedback**
- **Collimated jet**



✓ **Cooling Function**
✓ **High resolution (1.9 pc)**



Model



Log Density (cm^{-3})

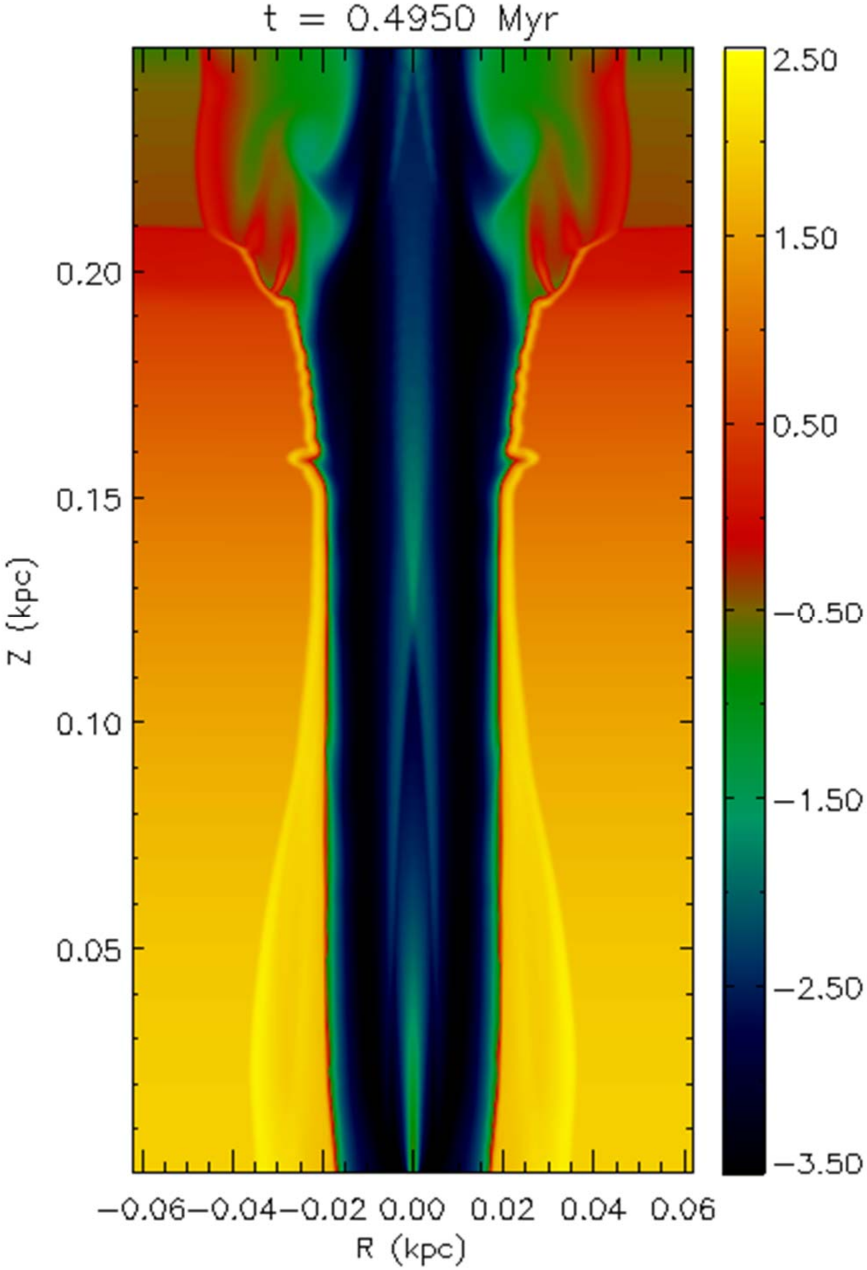
Jet:

v_{jet} = 0.07-0.2 c

$m_{jet}/dt = 10^{-3}\ M_{sun}\ yr^{-1}$

$E_k/dt = 2.5 \times 10^{41}$ erg s^{-1}

Model



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Model

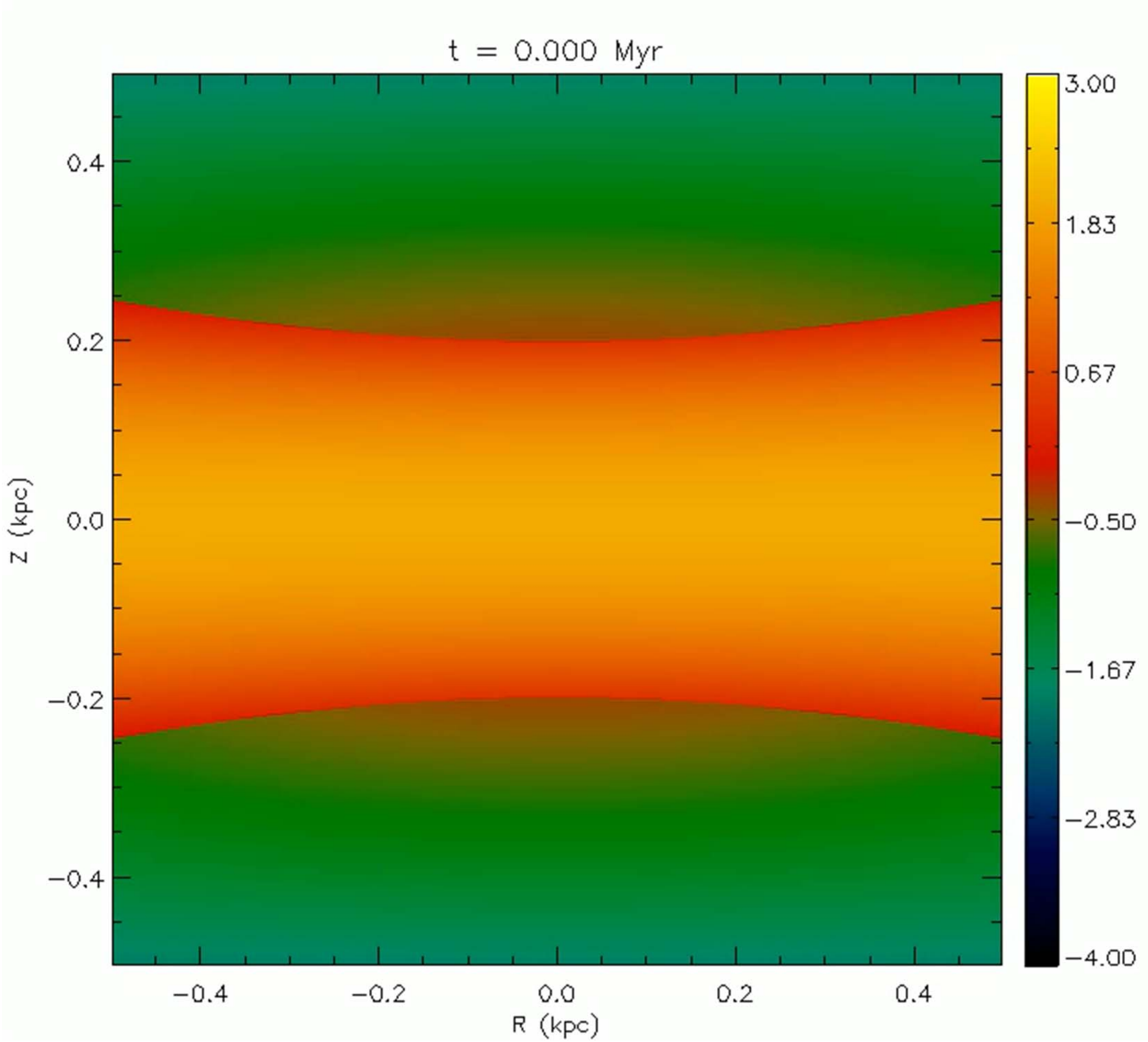
1) Stellar Feedback

2) SMBH Jet

3) Stellar Feedback + SMBH Jet

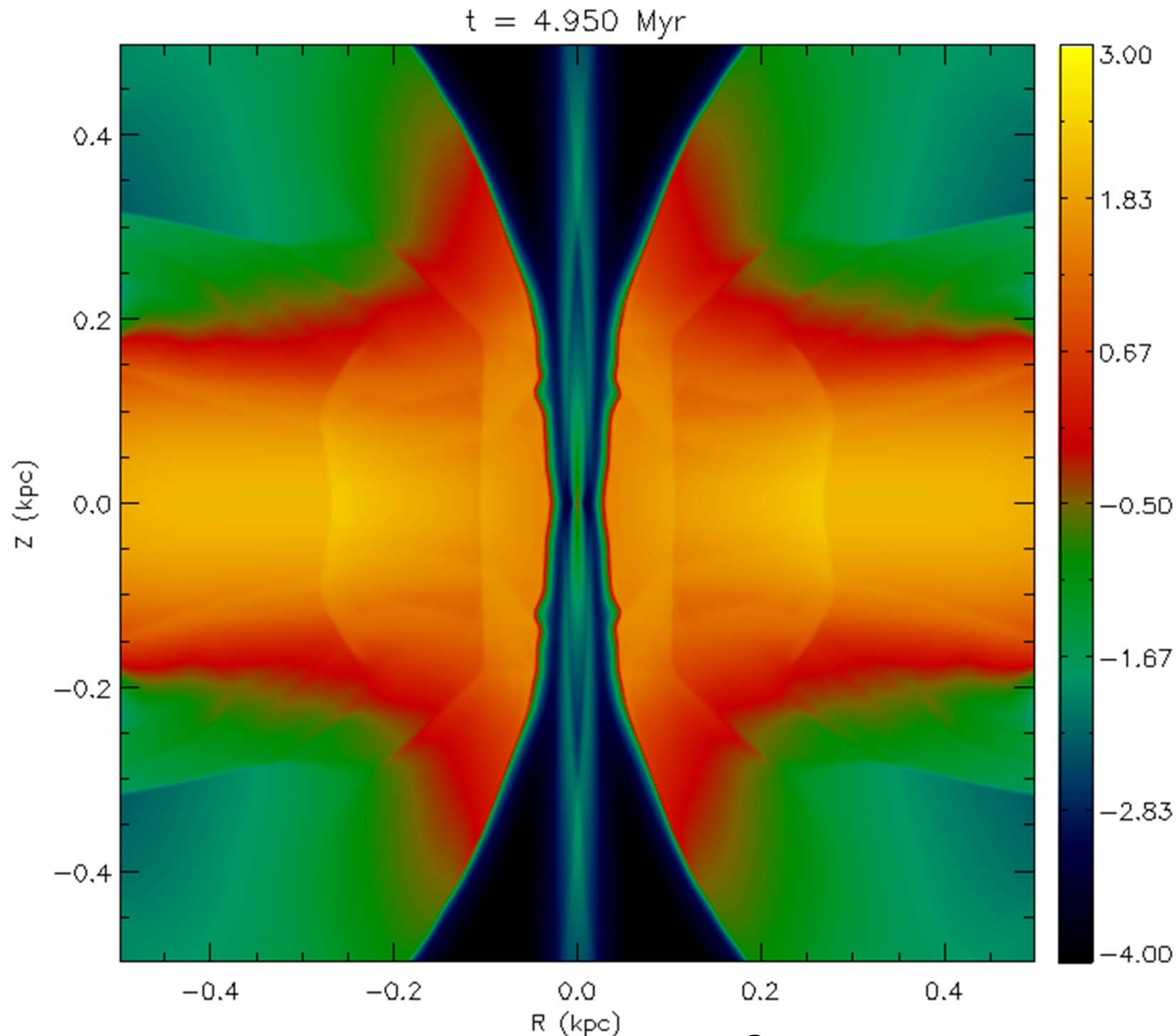
What kind of galaxy evolution?

Jet Feedback



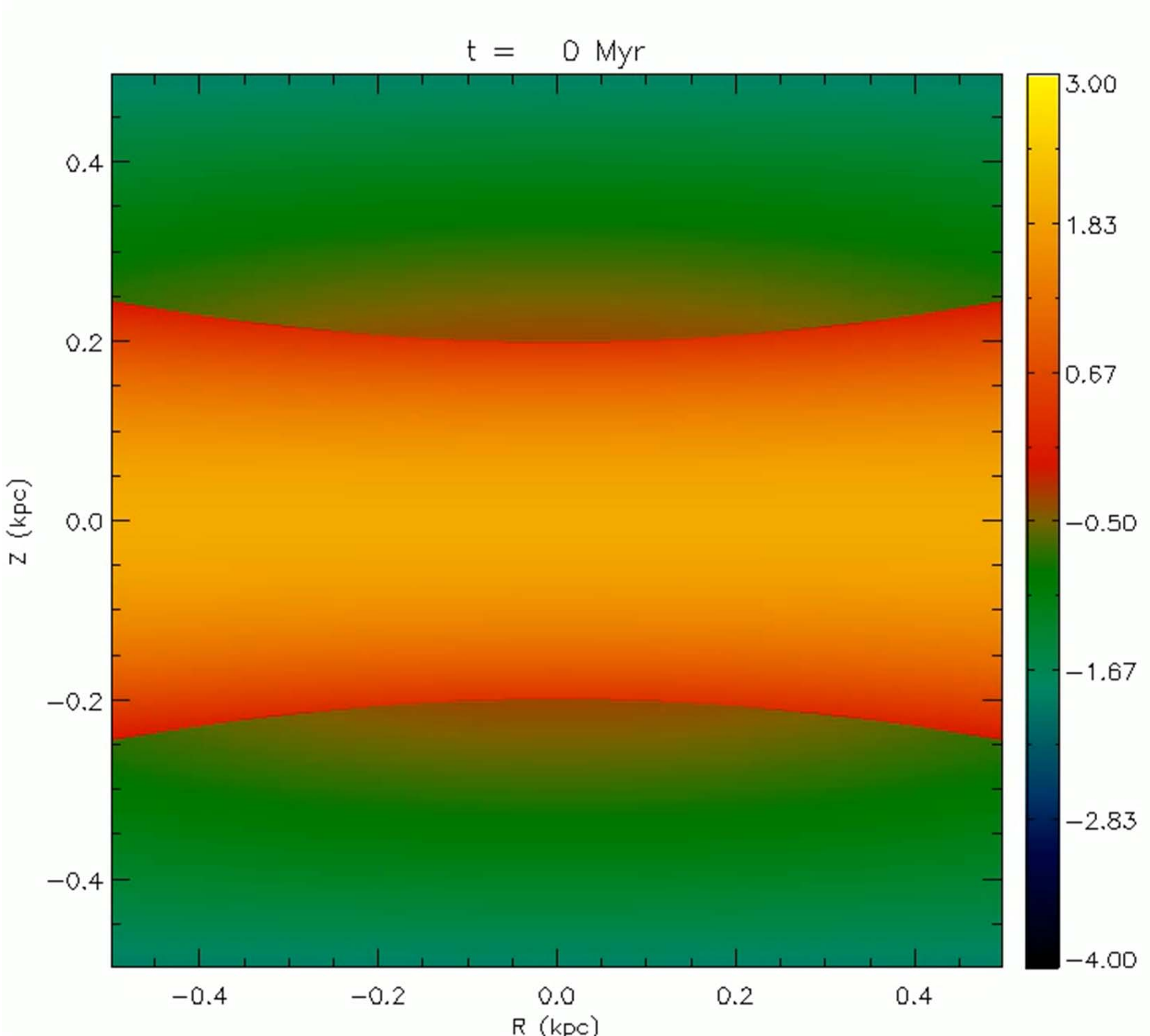
Log Density (cm^{-3})

Jet Feedback



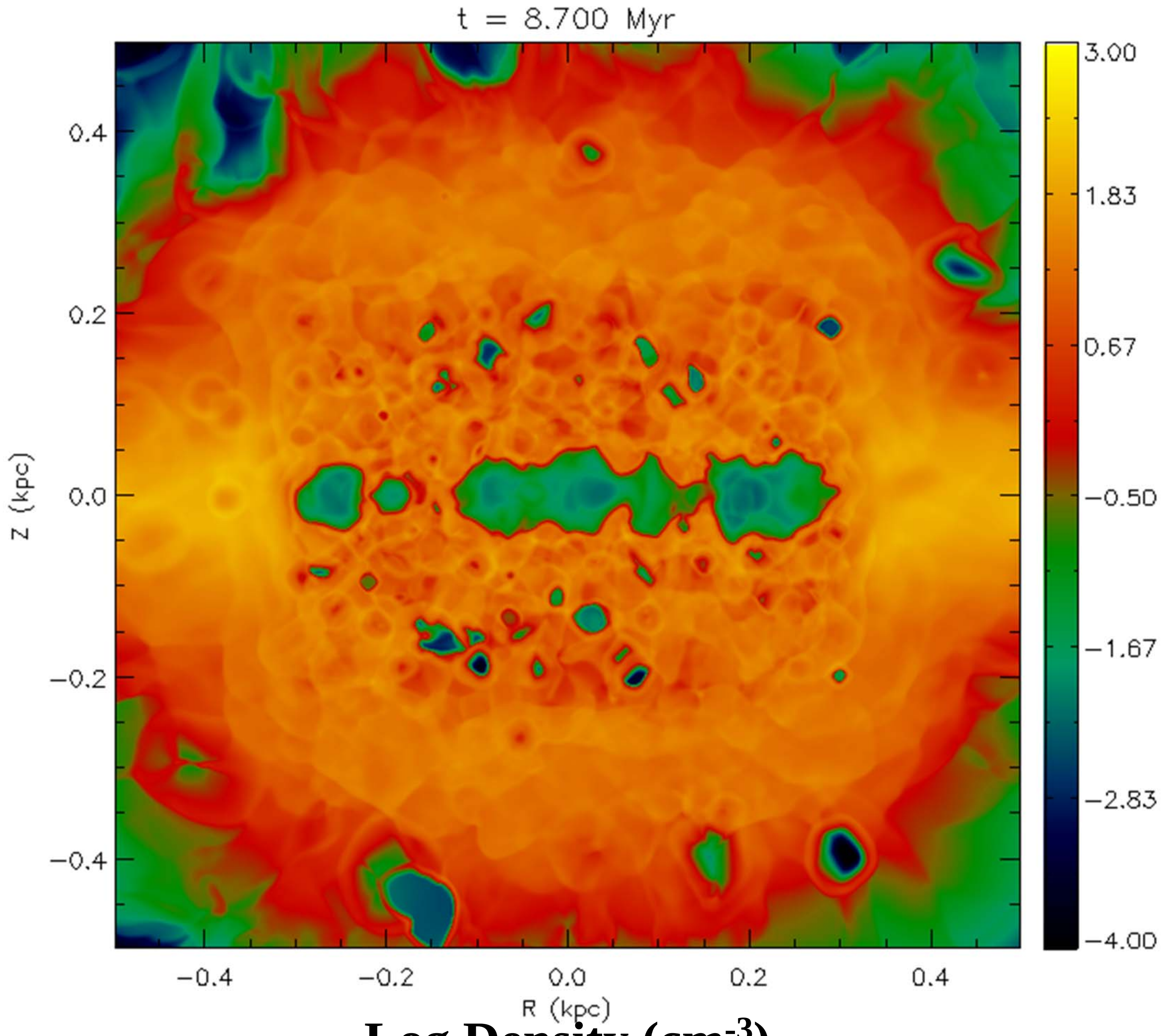
Log Density (cm^{-3})

Stellar Feedback



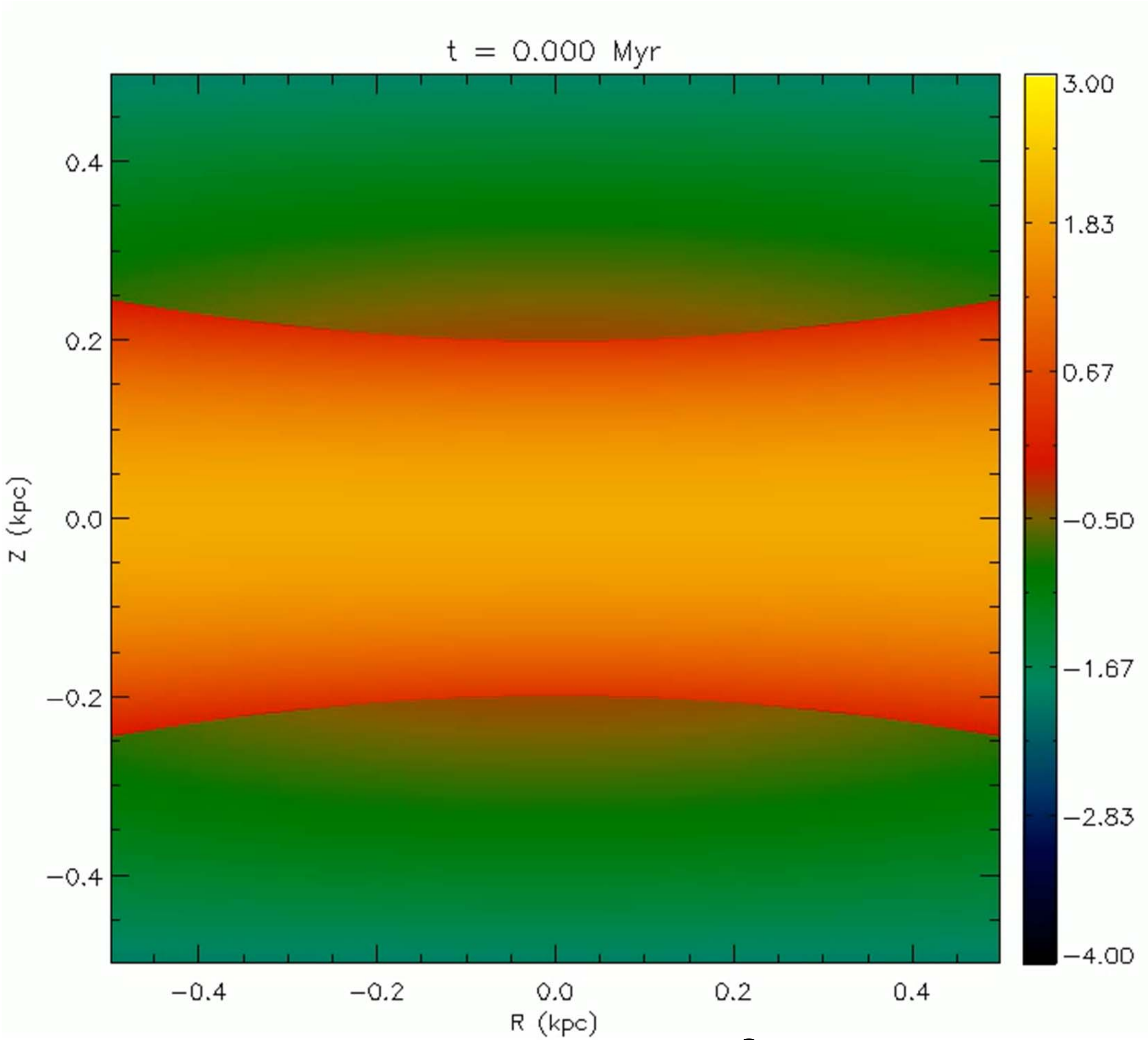
Log Density (cm^{-3})

Stellar Feedback



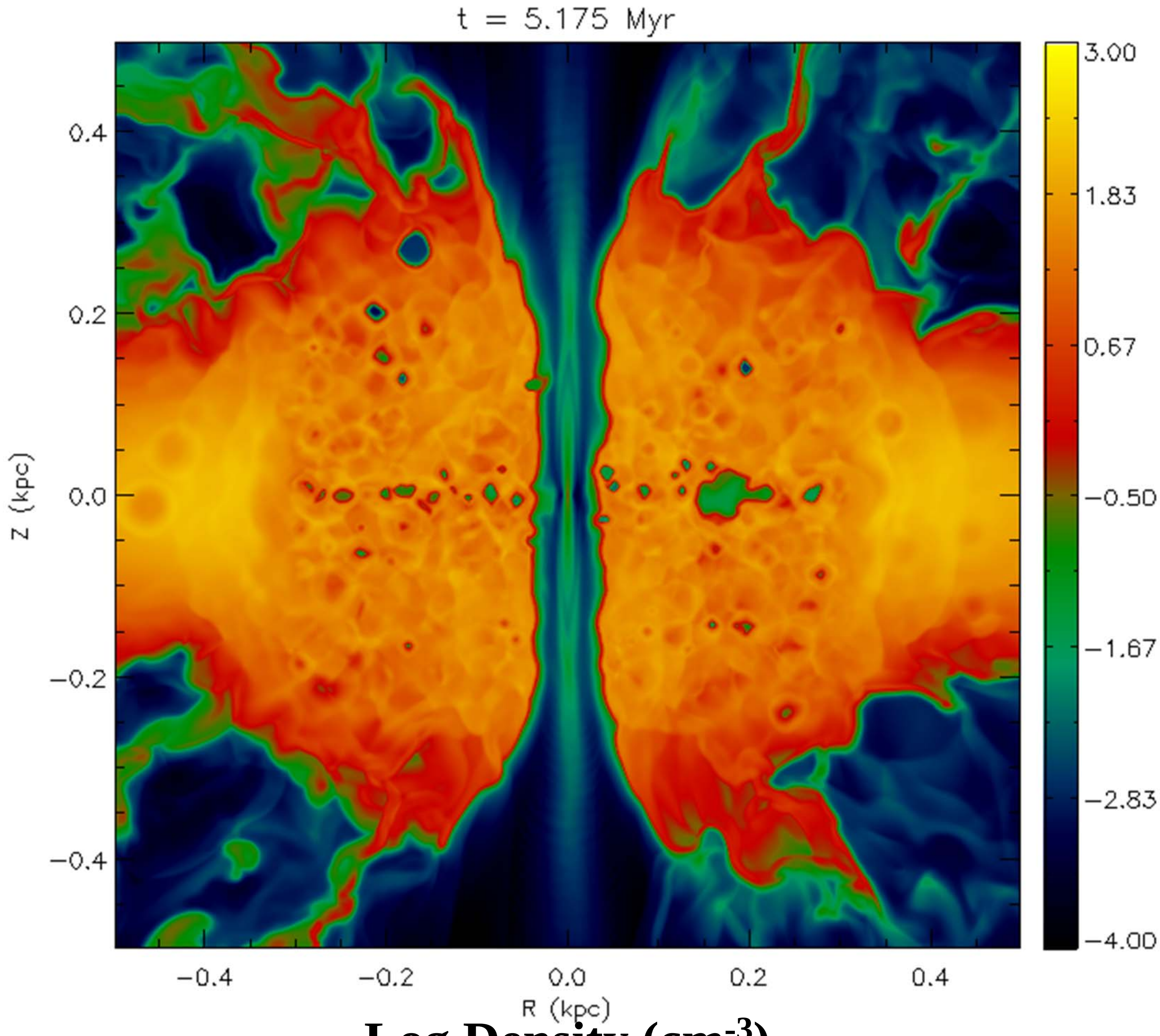
Log Density (cm^{-3})

Stellar + Jet Feedback



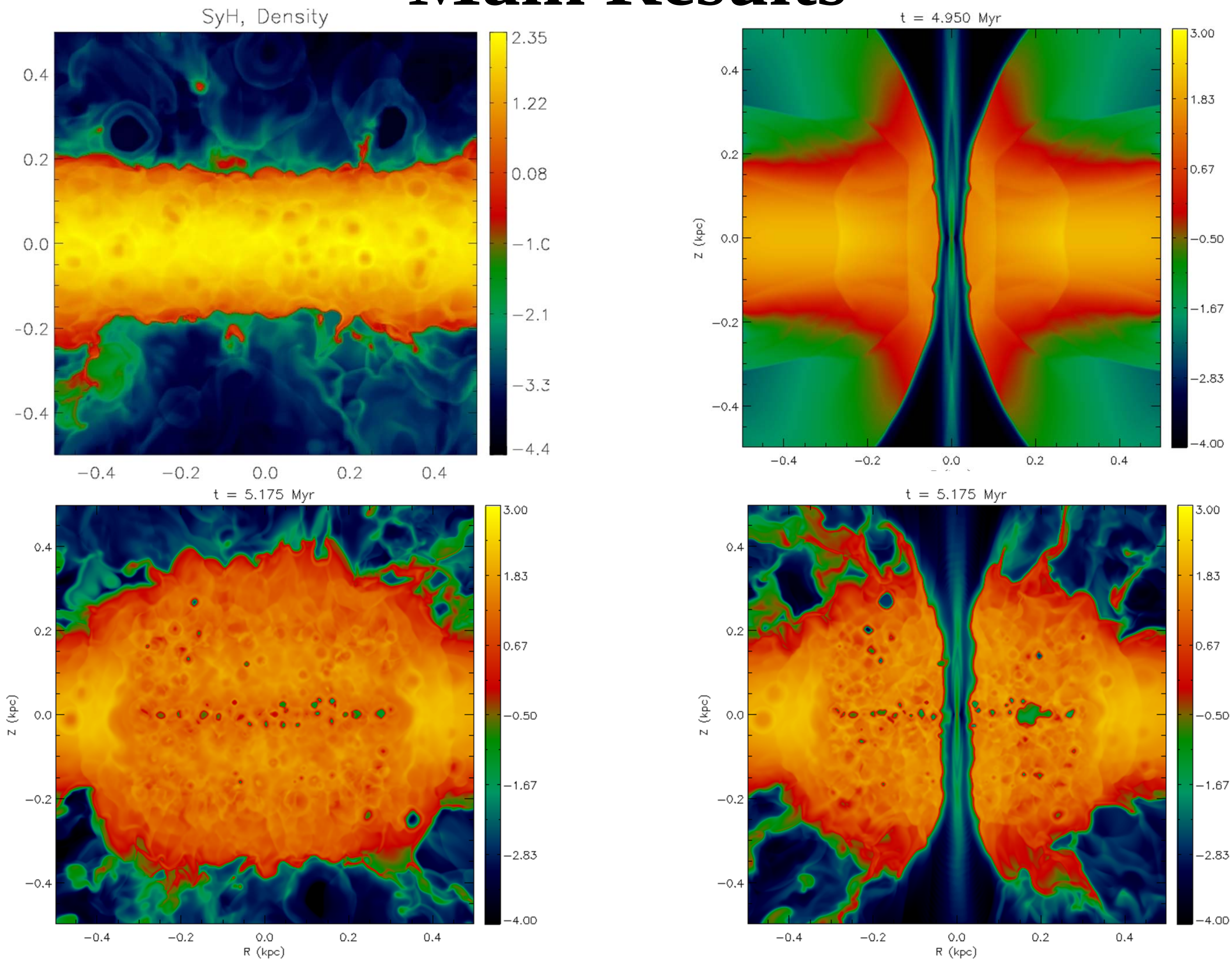
Log Density (cm^{-3})

Stellar + Jet Feedback



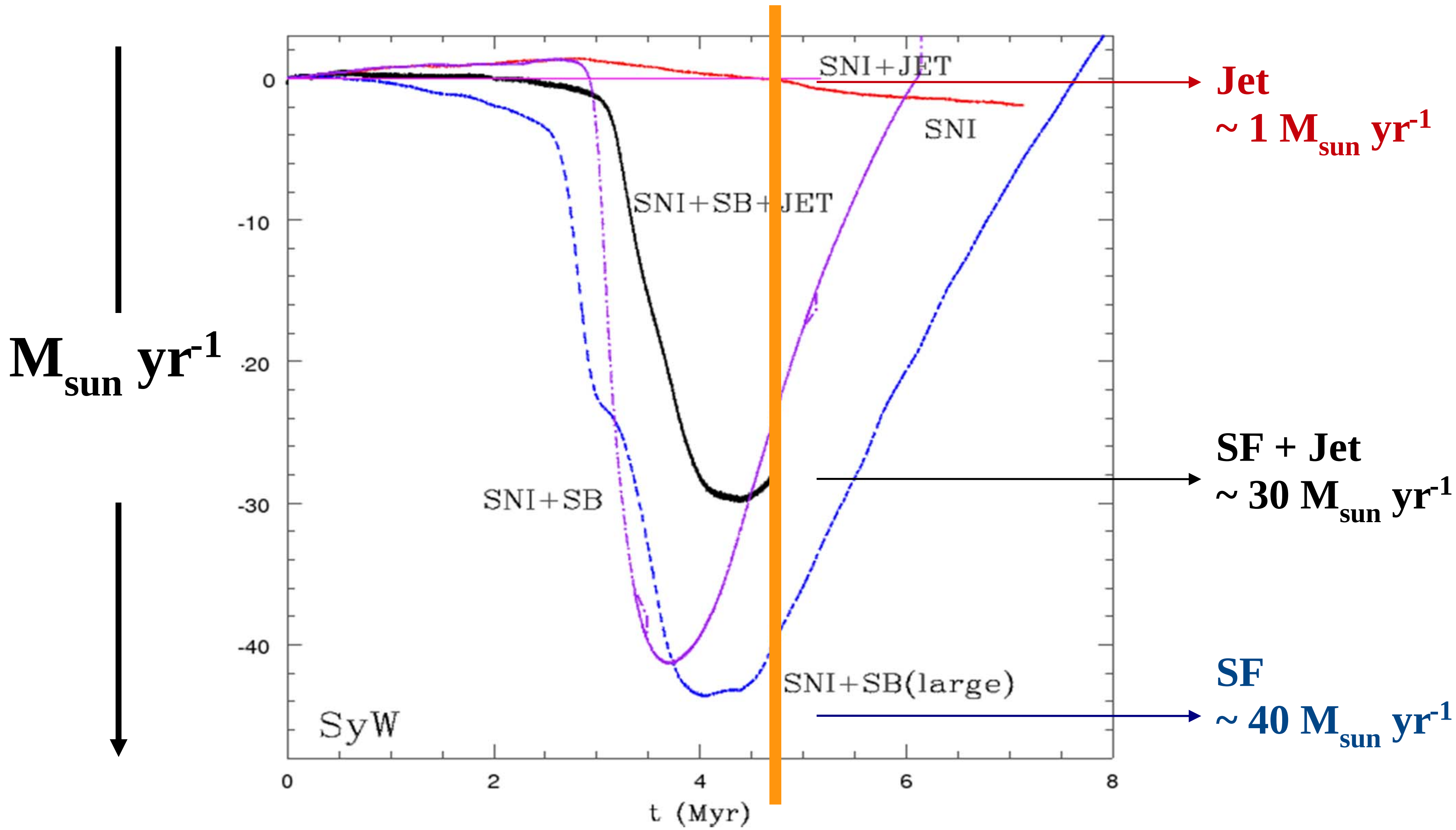
Log Density (cm^{-3})

Main Results



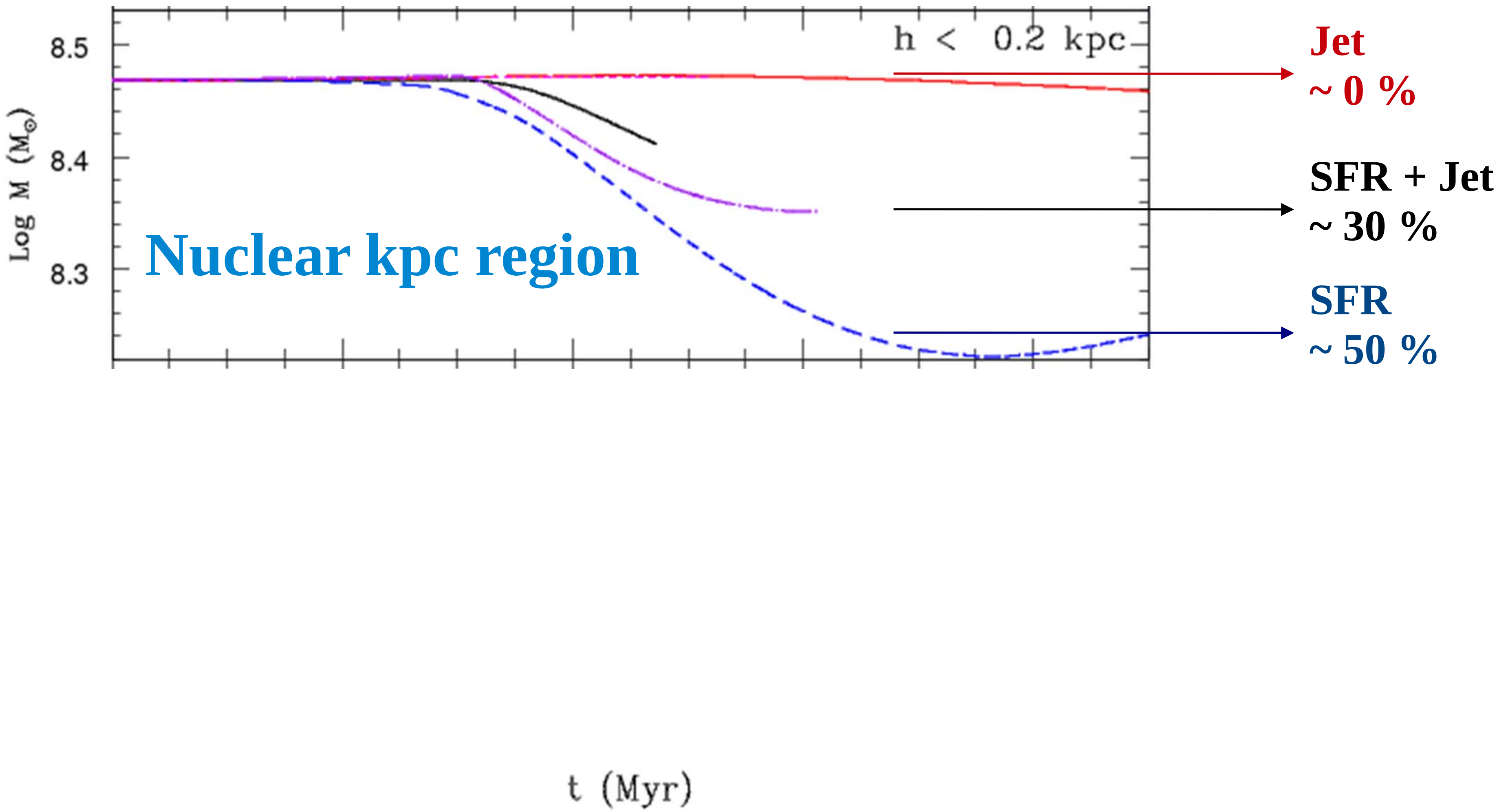
Main Results

1) Mass Evolution: mass loss rate



Main Results

1) Mass Evolution: gas mass lost



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1) Mass Evolution

AGN (highly collimated) jets play an important role at very small and large scales,

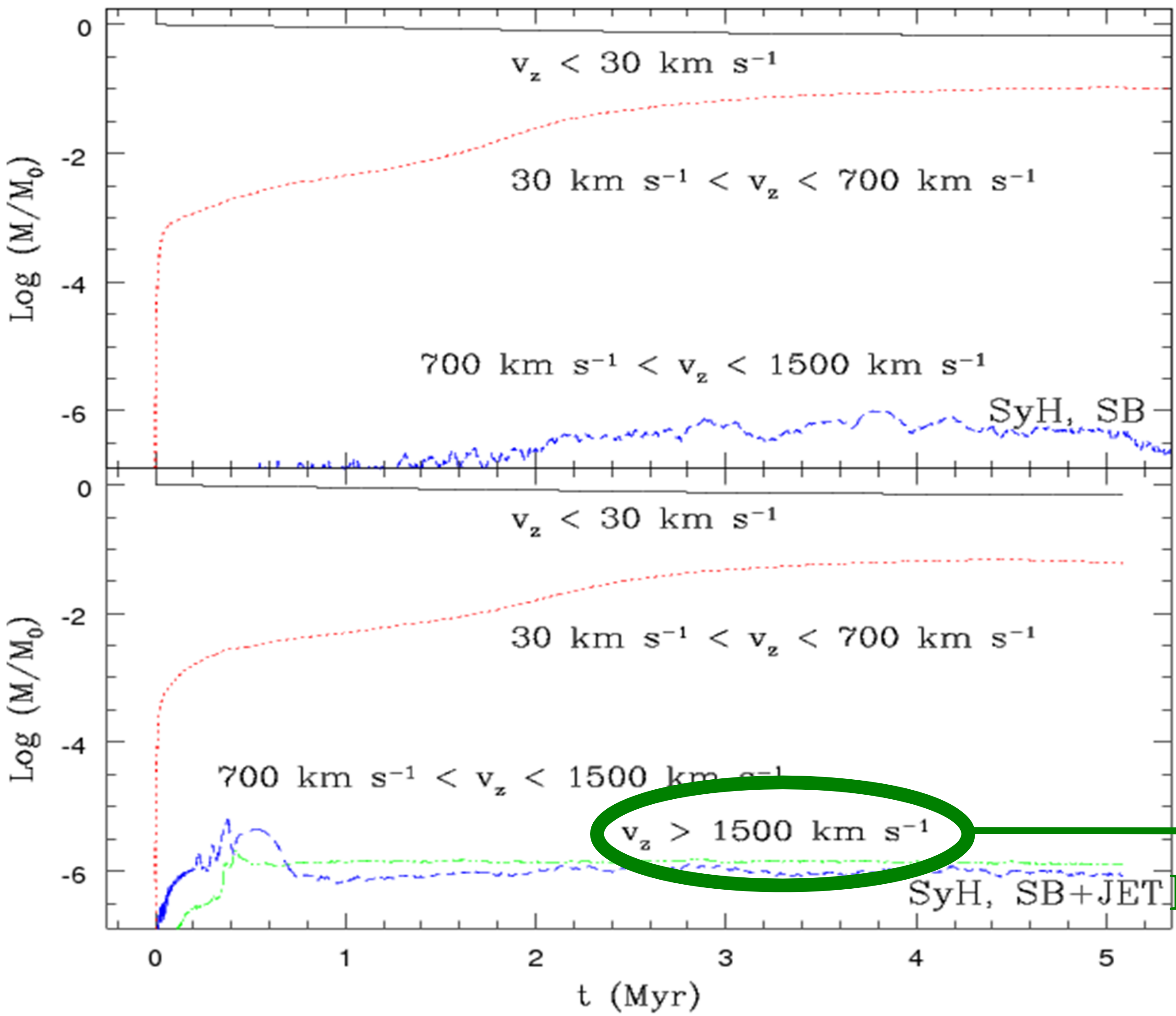
but they are not important in the evolution of the nuclear (kpc) region of the galaxies

Main Results

2) Velocity distribution

SF

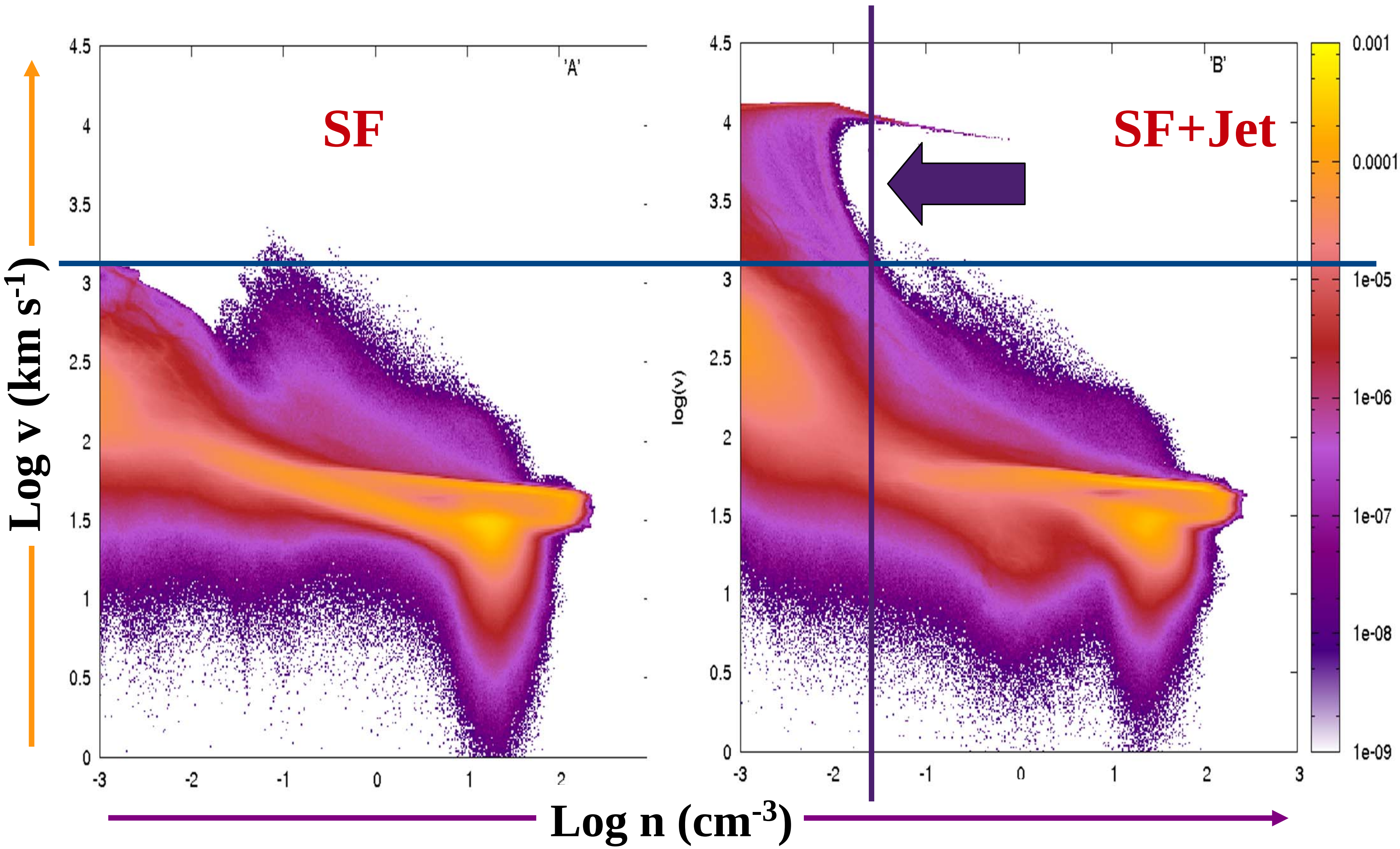
SF+JET



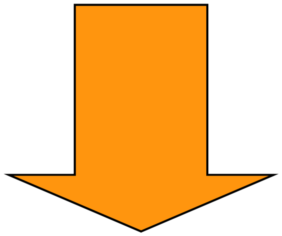
SFR + Jet:
High V. gas ~ 10^{-5}

Main Results

2) Velocity distribution



2) Velocity distribution

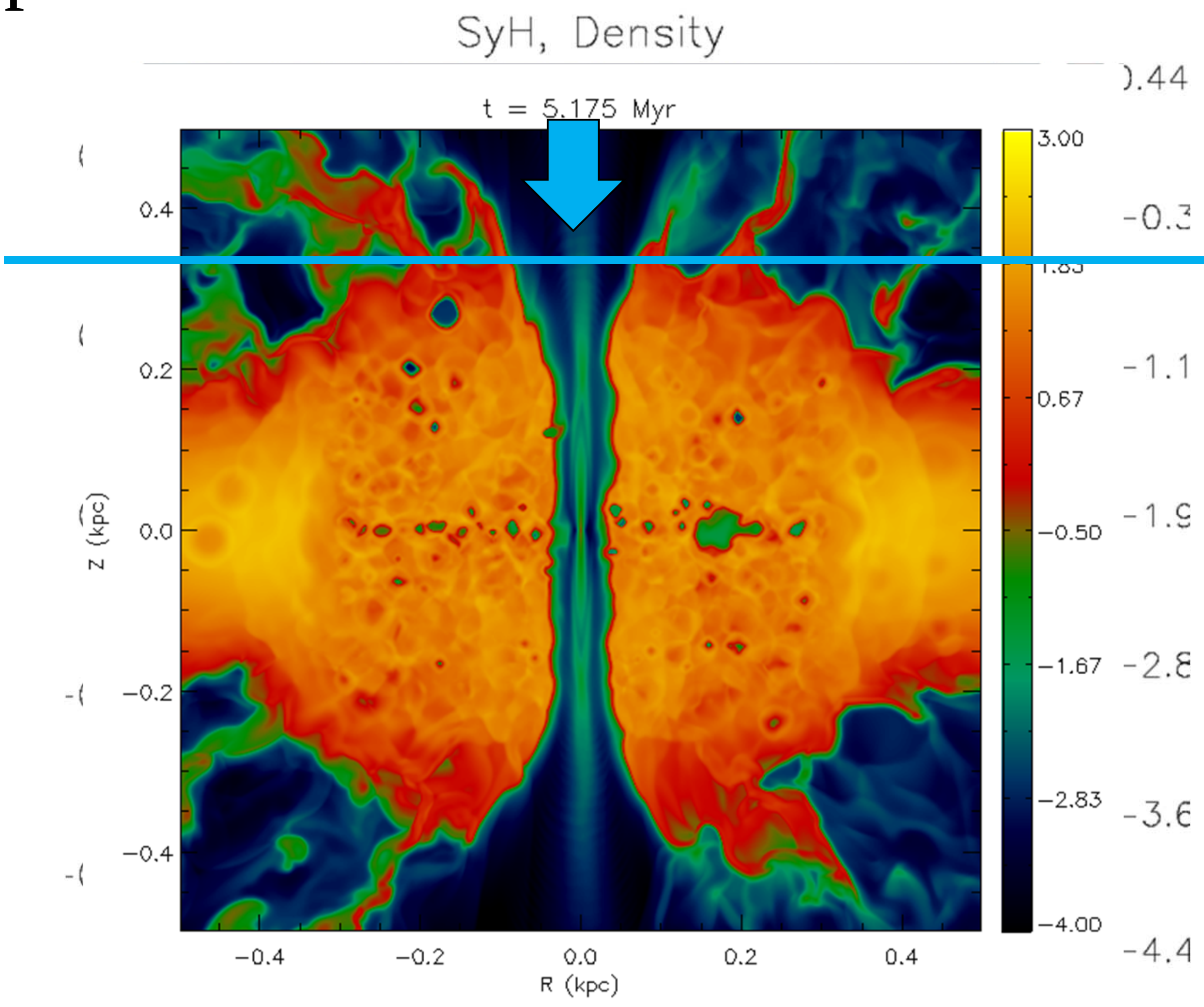


Gas with velocity signatures larger than 1500 km s^{-1}

but the gas mass with these very high velocity corresponds to ~ 1000 M_{sun} only

Main Results

3) Multiphase outflow



30% of the gas

Clouds/Clumps

Face-on view at z=350 pc

3) Multiphase ambient

Clouds and clumps are mostly formed by the fragmentation of the shocked gas compressed by the supernova shock fronts,

and no clouds are observed when we have considered the jet feedback only

Summary

Our results basically reproduce a Seyfert nuclear structure:

- ✓ **an extended gas outflow with systemic velocity around the nucleus;**
- ✓ **a broader biconical component perpendicular to the disk;**
- ✓ **an inner component due to the interaction between the jet and the galactic disk material.**

Summary

- **the nuclear galactic gas evolution of a Seyfert is almost insensitive to the passage of the jet;**

- **the nuclear region needs an intense and more widespread source of energy injection to generate gas outflows;**

- **the jet plays an important role in producing the very high gas velocities observed in the expanding nuclear regions**

- **stellar feedback determines the formation of a multiphase ambient and the formation of clouds and clumps which can be continuously generated and steadily carried away**