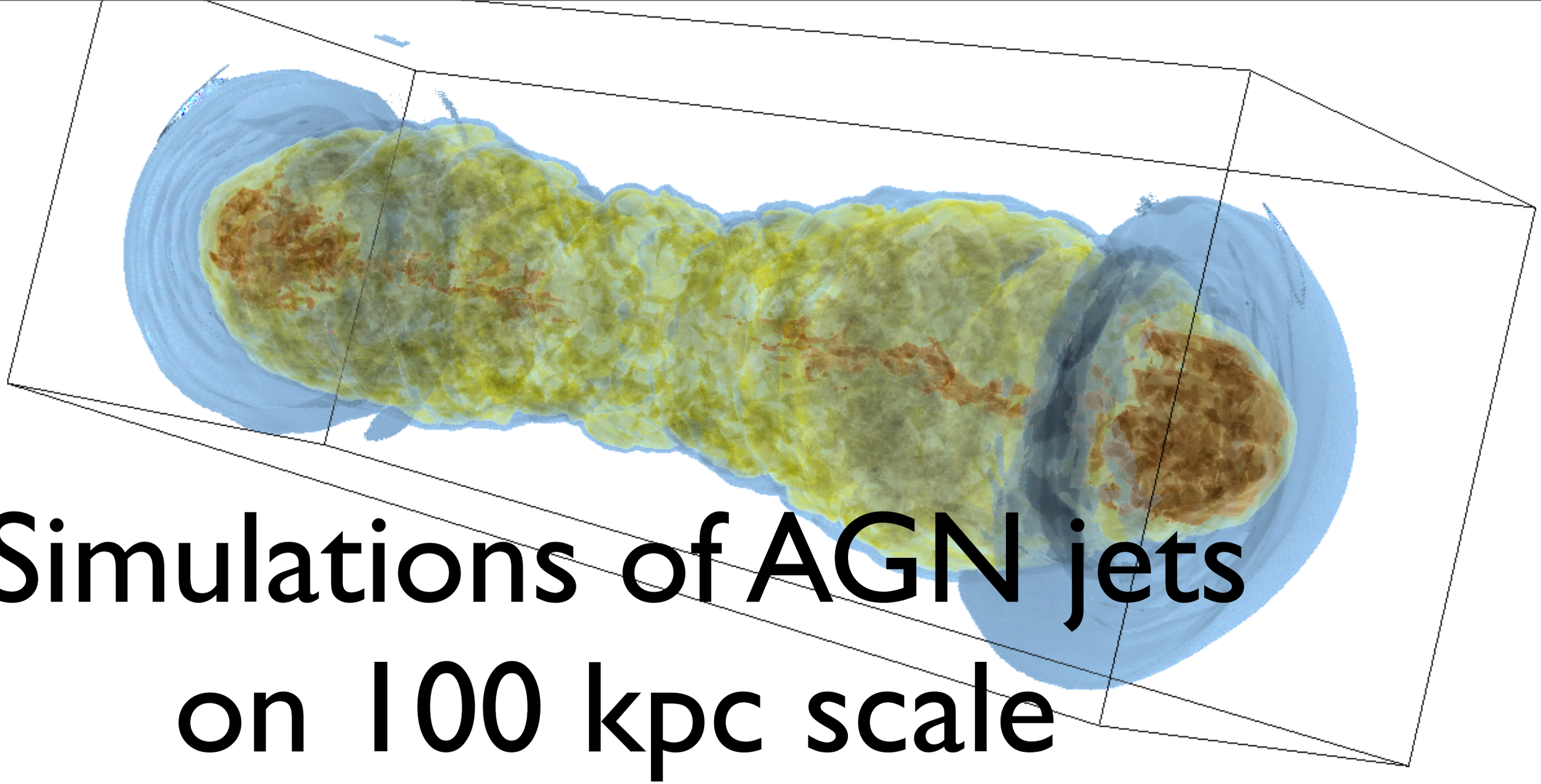

Simulations of AGN jets on 100 kpc scale

Salvatore Cielo, MPIA Heidelberg, DE
Andrea V. Macciò, MPIA Heidelberg, DE
Vincenzo Antonuccio-Delogu, INAF, Catania, IT

Why are Jets so mysterious?

Jet powers are well constrained, but ...

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Several unknowns

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Composition / EoS
light/hard:
Blandford-Znajek
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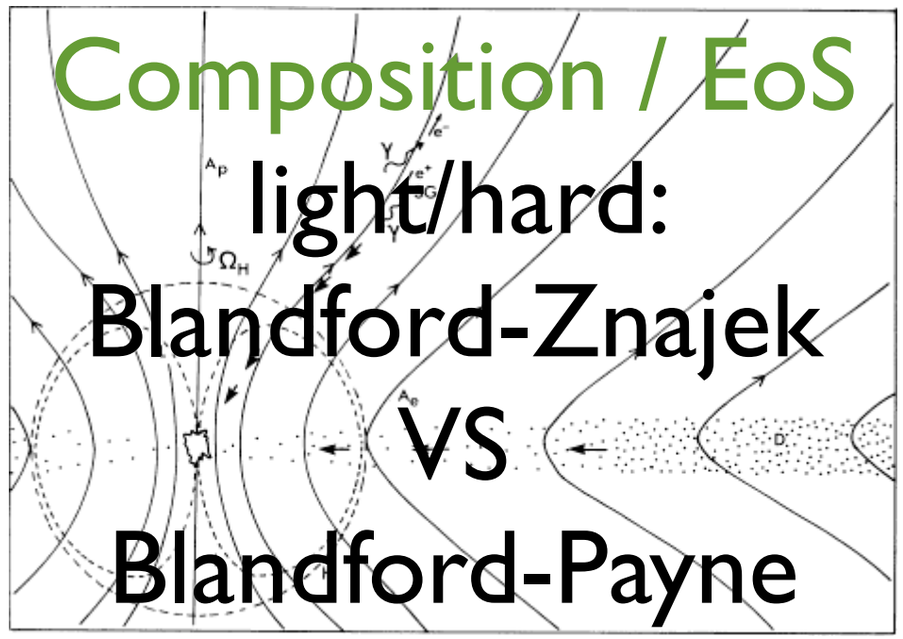

Blandford, Znajek 1977

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Jet powers are well constrained, but ...

Duty cycles
link to BH accretion

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FRI / FR II
intrinsic or environment?

Several unknowns

Observations: obscured, sparse, small scale gas.
Simulations: need to link several physical scales.

Composition / EoS
light/hard:
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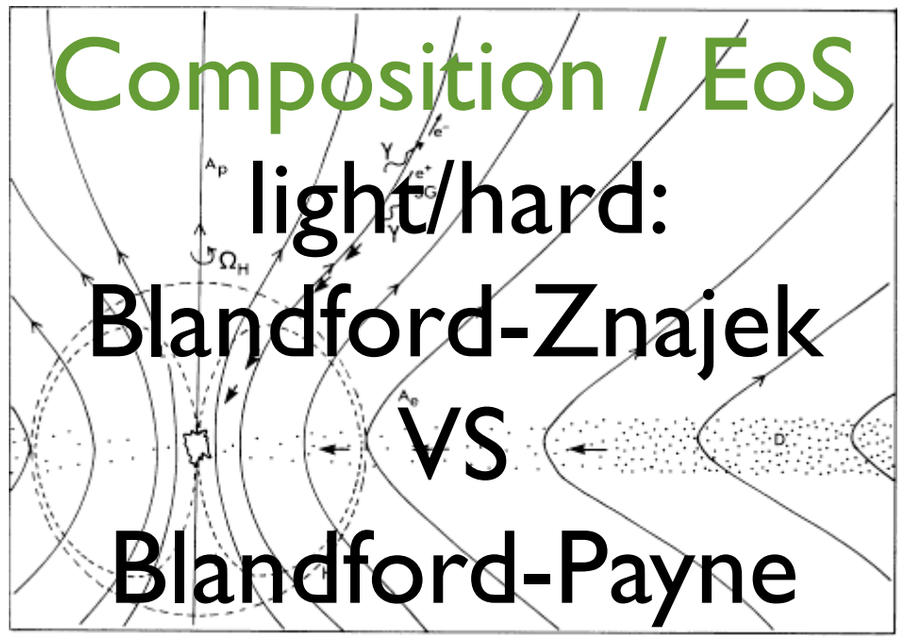

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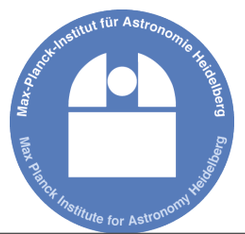
So, can jets from AGNs...

IN GALAXIES, few Myr

...directly reduce SF?

(positive VS negative FB)



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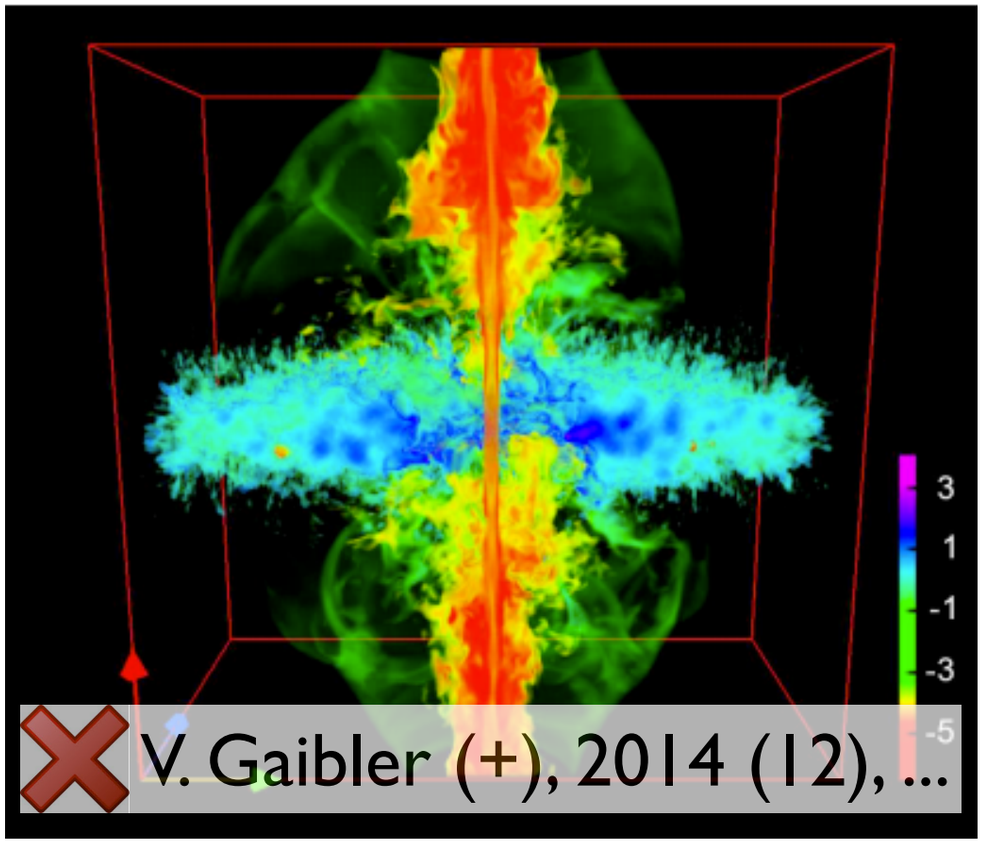

V. Gaibler (+), 2014 (12), ...

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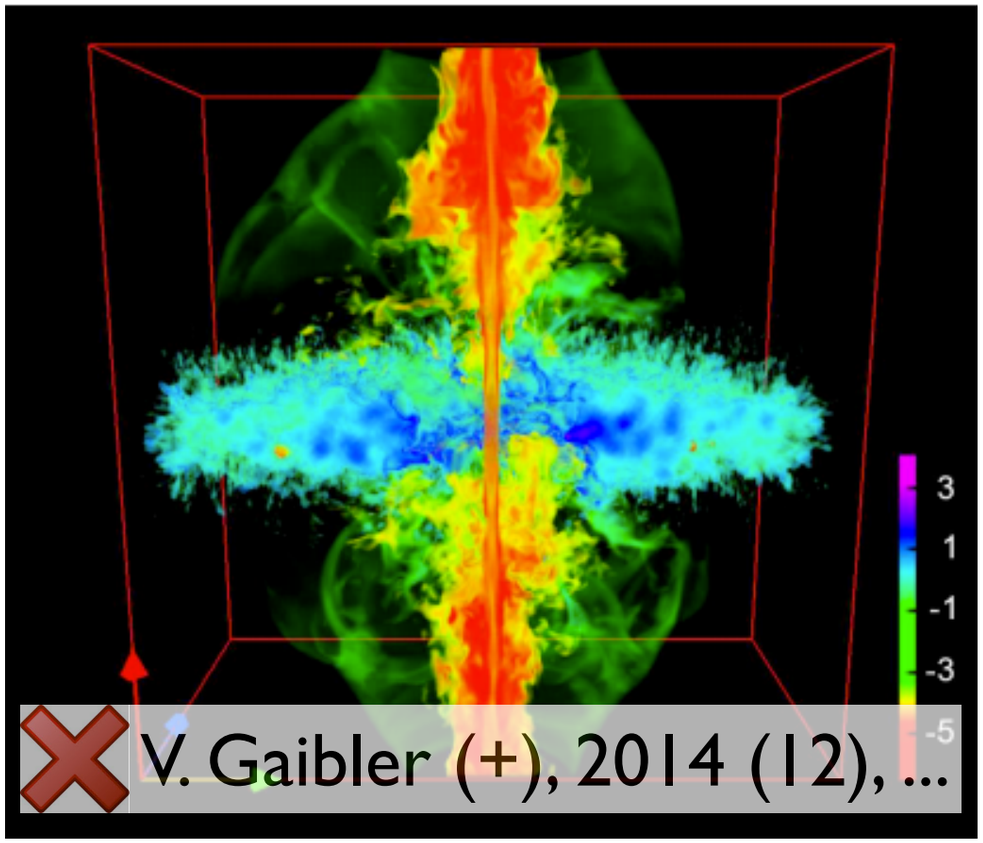

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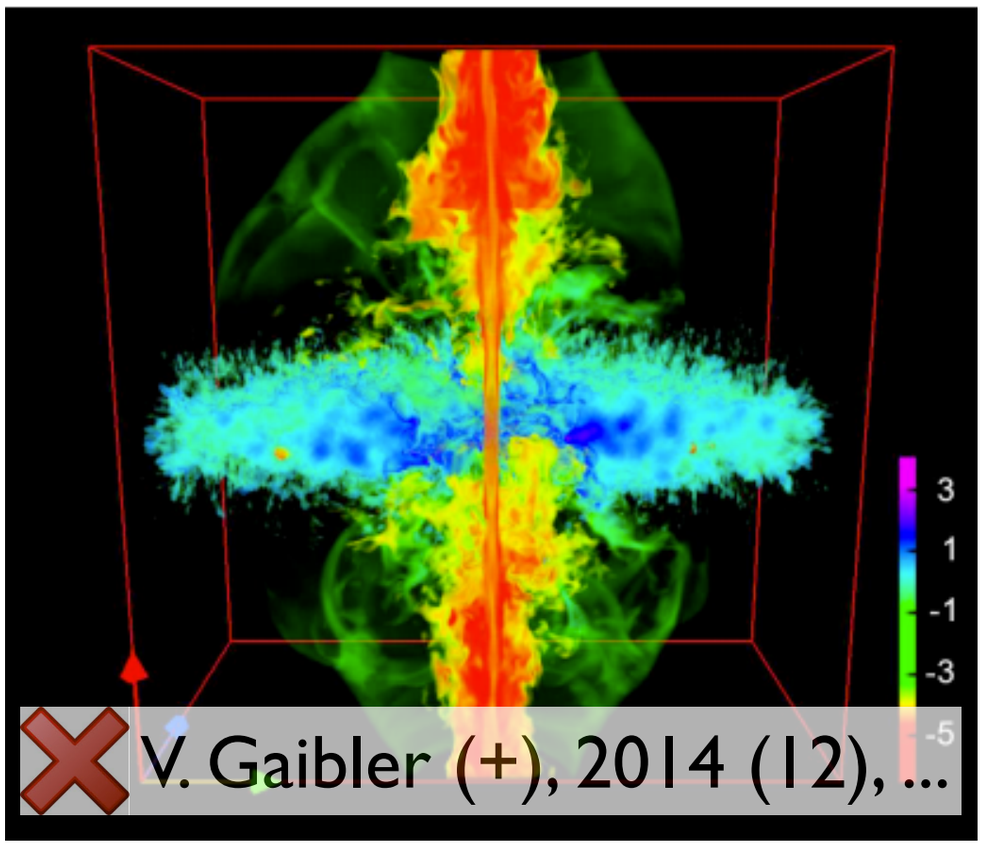

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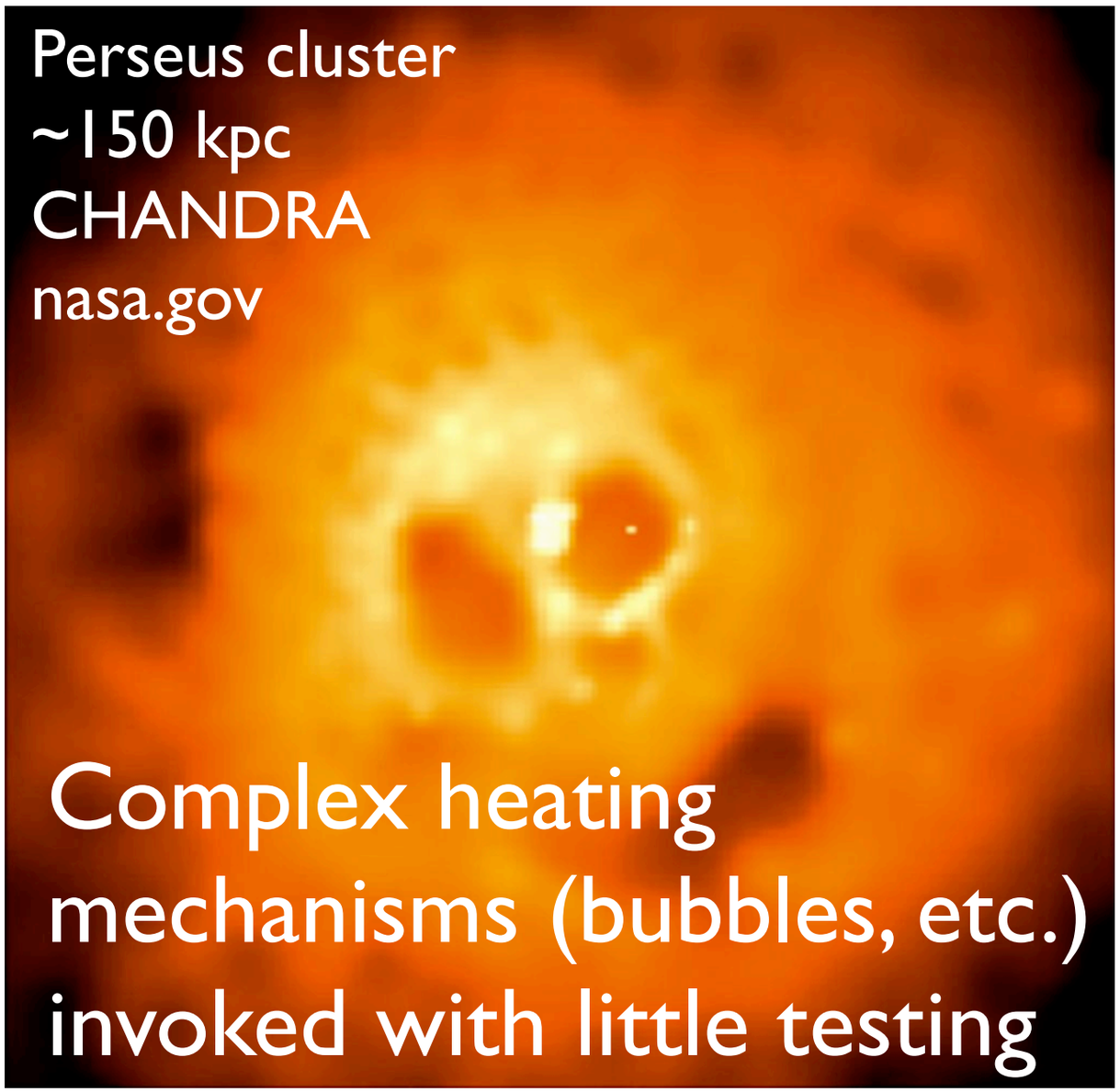


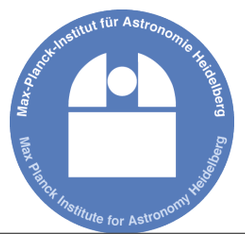
My setup, in the FLASH code

- Dark Matter
  NFW potential
  (static, spherical, external)

- Hot halo
  Isothermal, self-grav + DM
  hydrostatic equilibrium, rad. cooling

$$\rho_{\rm gas} = A \exp\left(-\frac{\bar{m}\Phi}{kT}\right) \qquad -\frac{\mu\Phi}{kT} = 3\frac{\ln(1+x)}{x}$$

(e.g. M_{halo} = 2e12 M_{sun} => T ~ 5e6 K)



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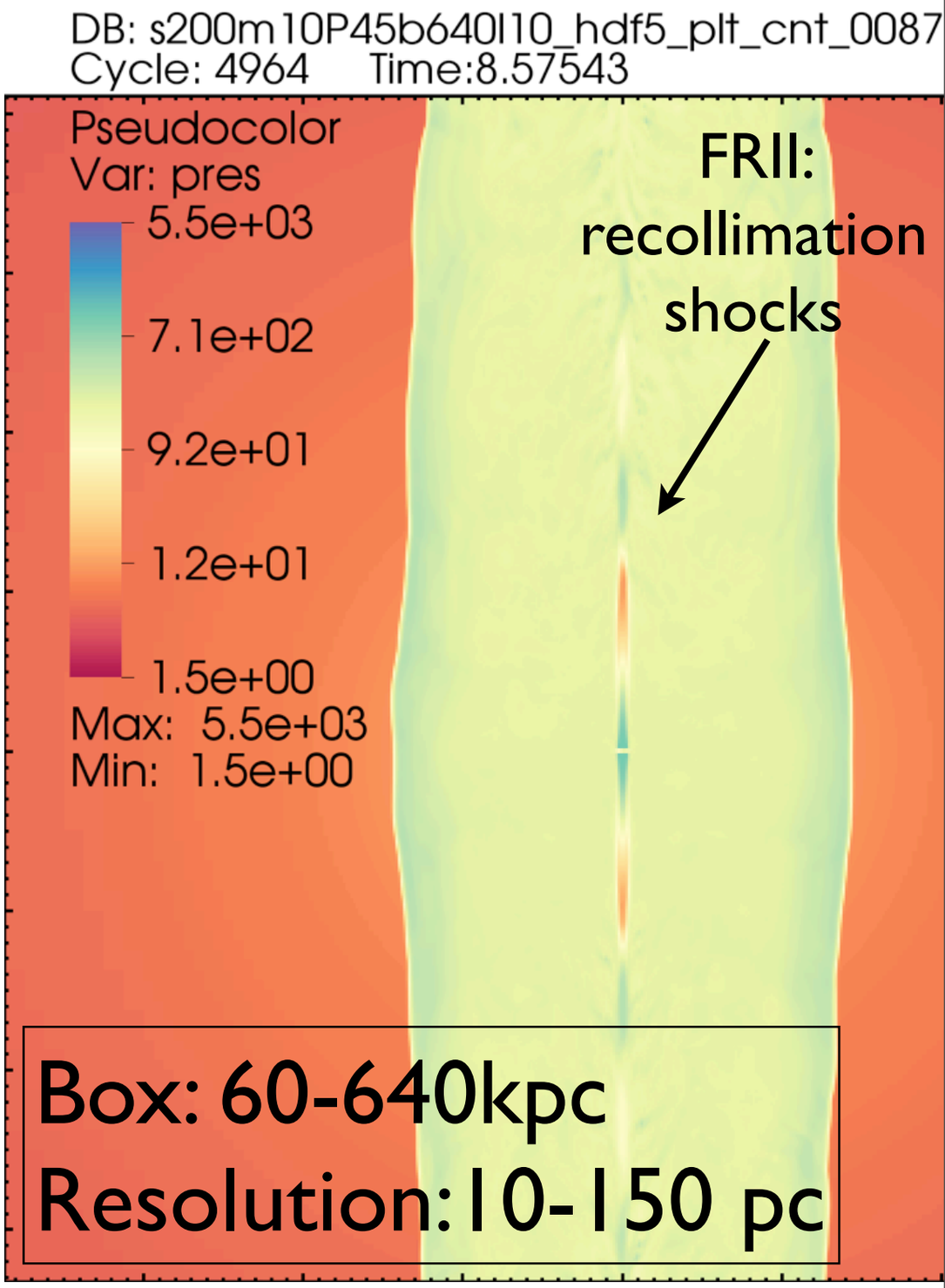
- Jet
  density contrast 1:100
  $P_{jet} = \rho_{jet}\, A\, v_{jet}^3$ = 1e42-1e46 erg/s
  FRI/FRII: Mach 5 - Mach 100
  on/off cycles: 1-100 Myr



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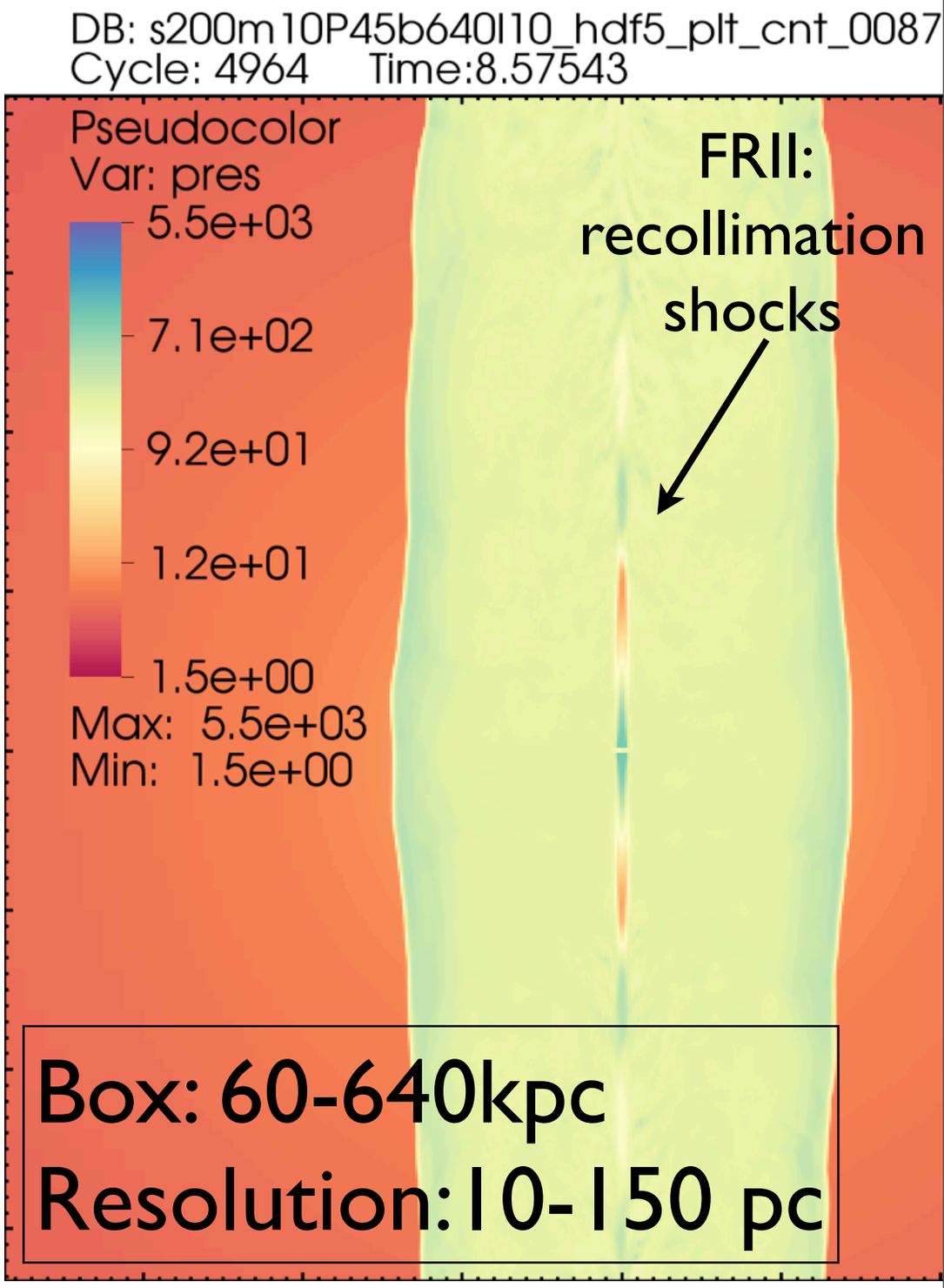
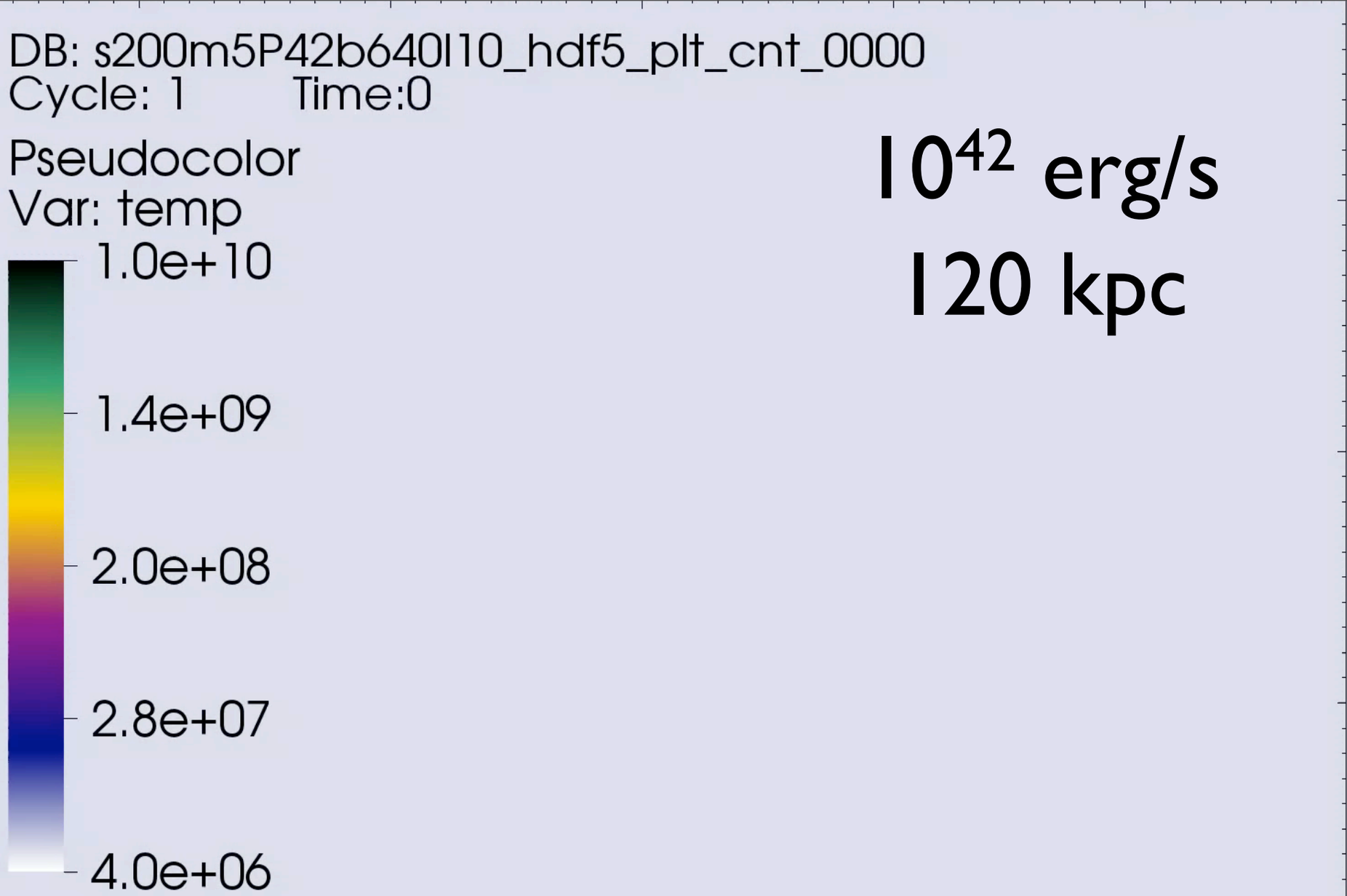
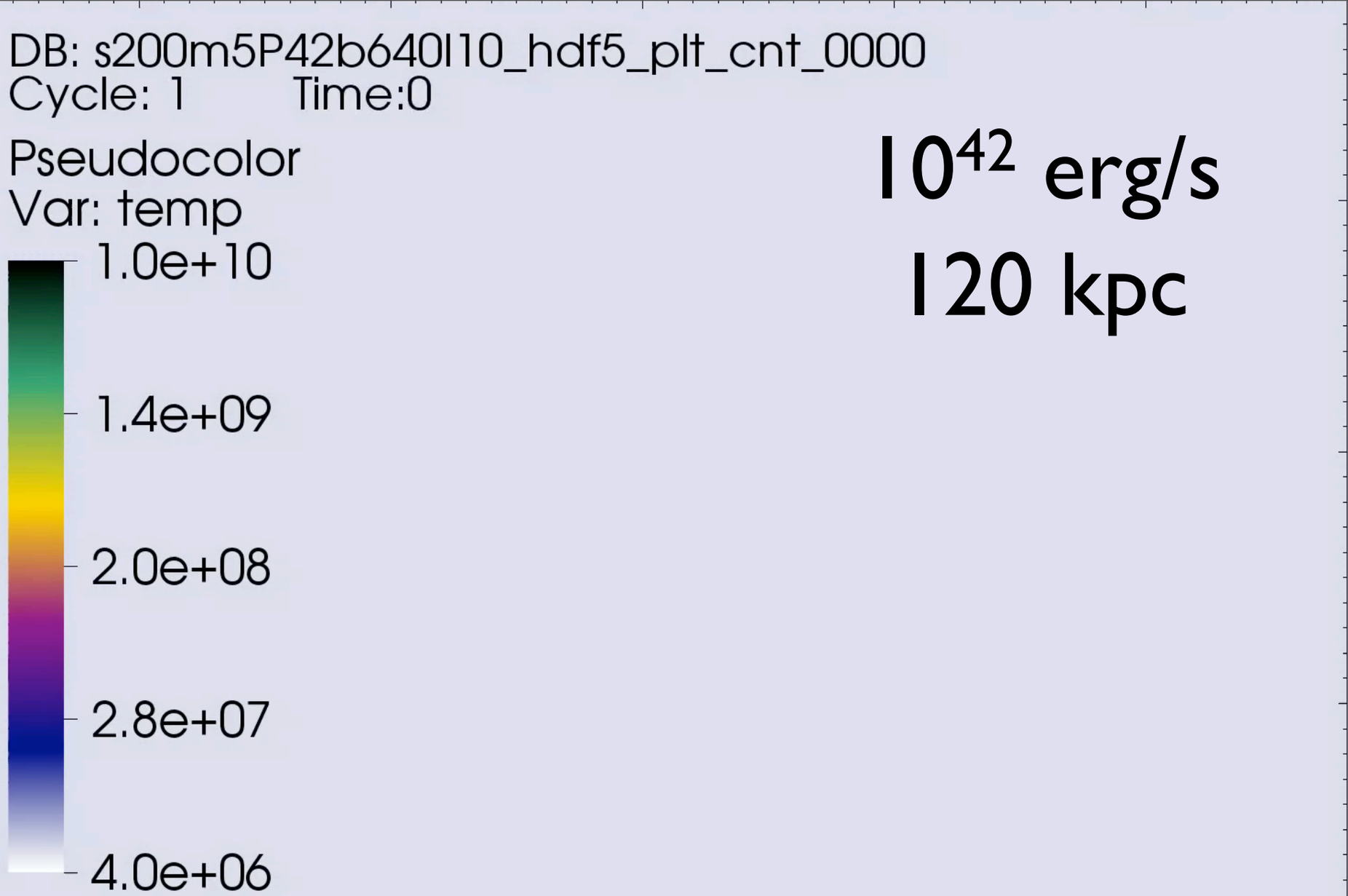
- Warm gas clouds (1e4 K)
  in a central galaxy + SF with
  sink particles. One day.



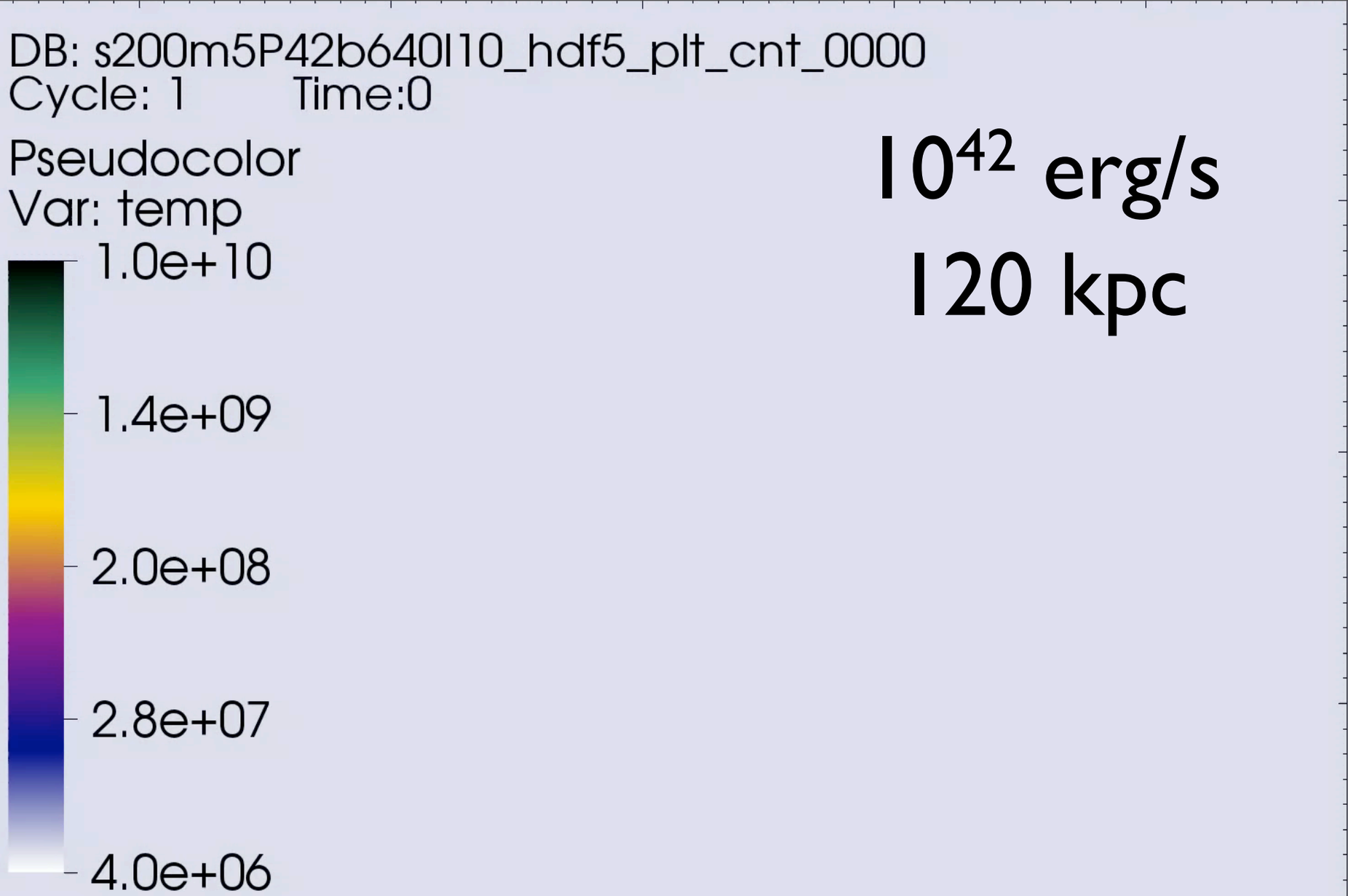


Results: Evolutionary stages



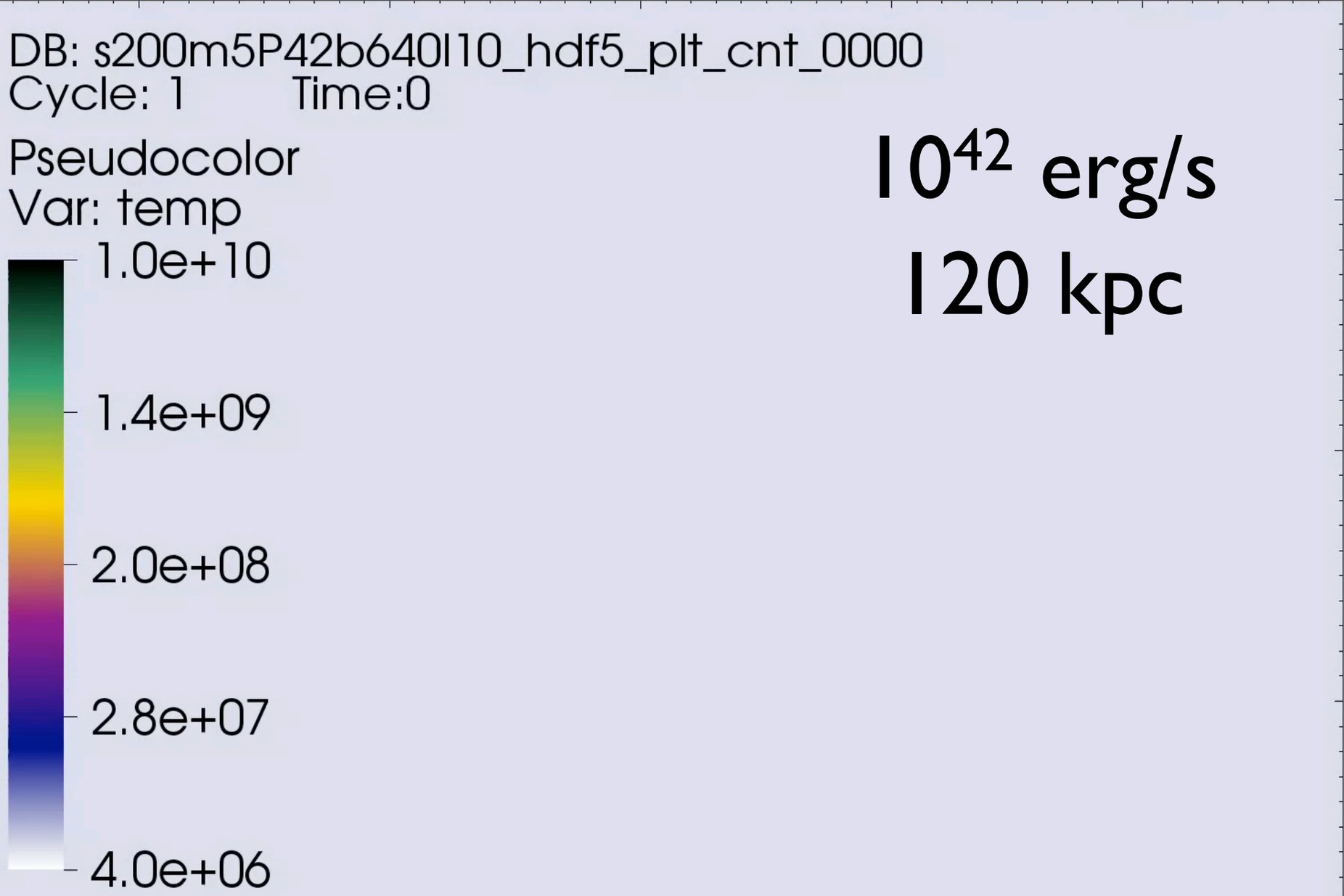
1. Cocoon and HS formation

Results: Evolutionary stages



1. Cocoon and HS formation
2. Forward propagation

Results: Evolutionary stages



10^{42} erg/s

120 kpc

1. Cocoon and HS formation
2. Forward propagation
3. Lobes inflation

Results: Evolutionary stages

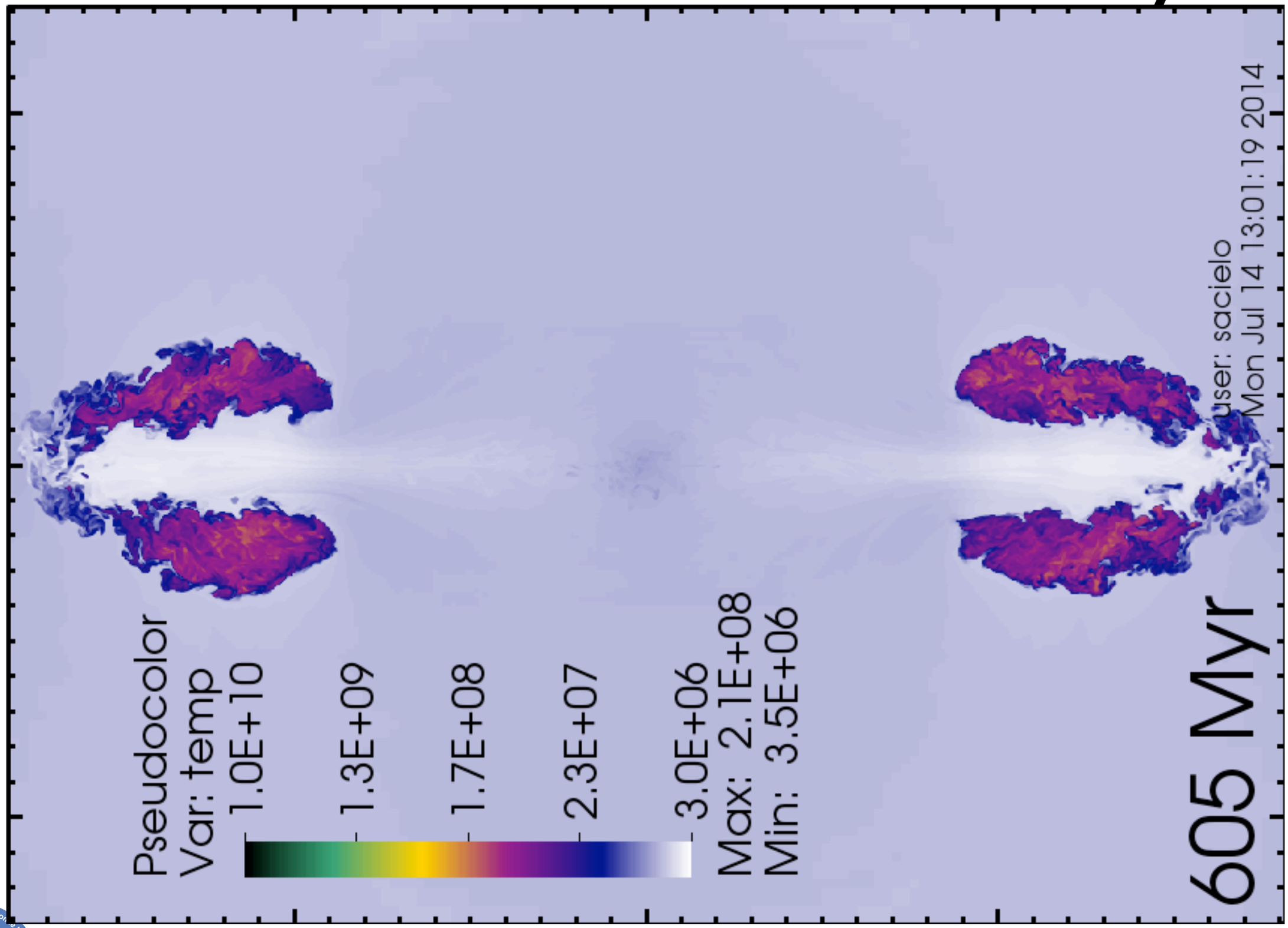
10^{42} erg/s

120 kpc

1. Cocoon and HS formation
2. Forward propagation
3. Lobes inflation
4. Bubbles (jet off)

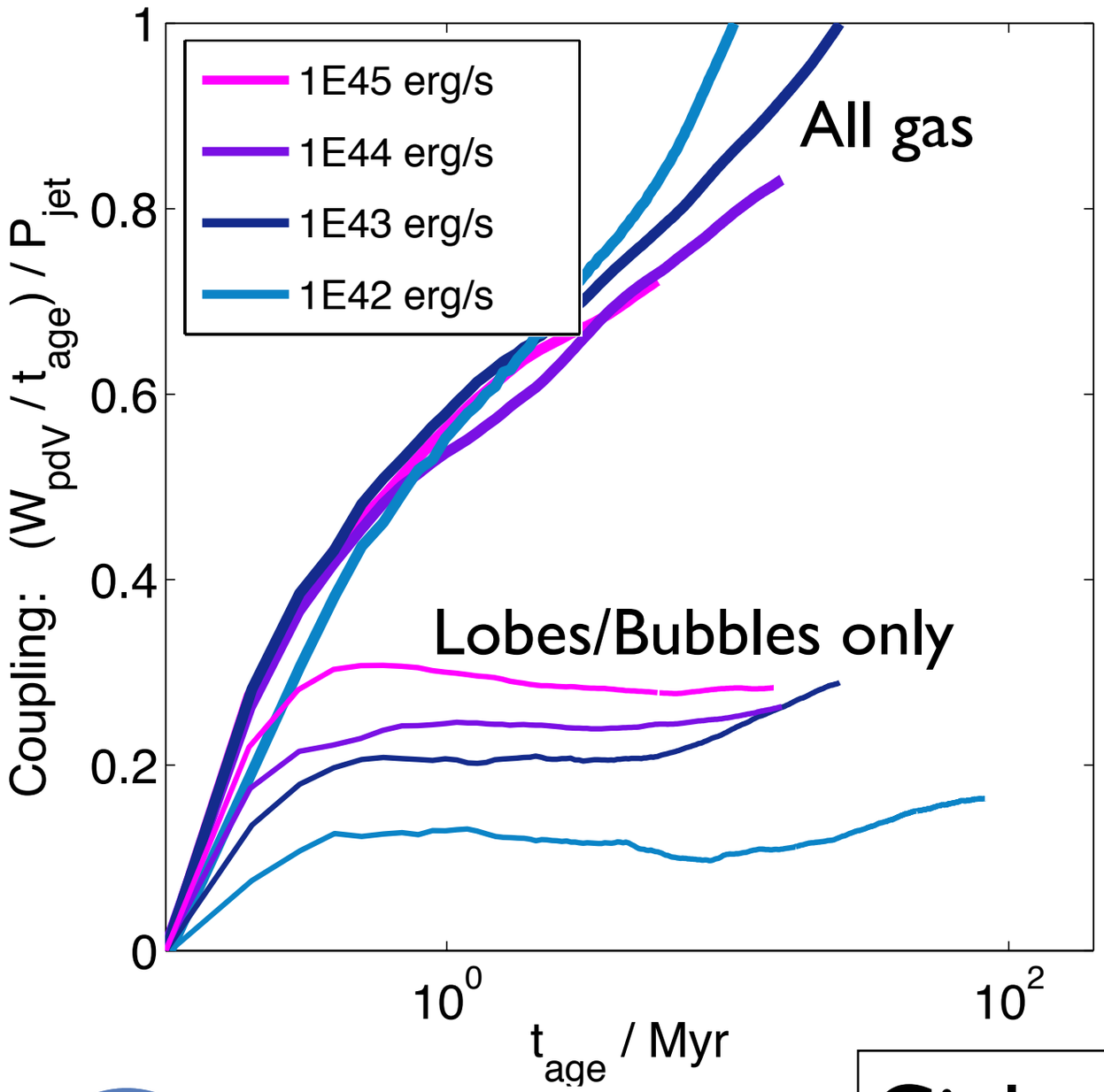
Results: Evolutionary stages

Bubbles still there after .6 Gyr



Results: Energy and Volume Coverage

"p dV" Mechanical Work as fraction of P_{jet}



Cielo +, in prep.

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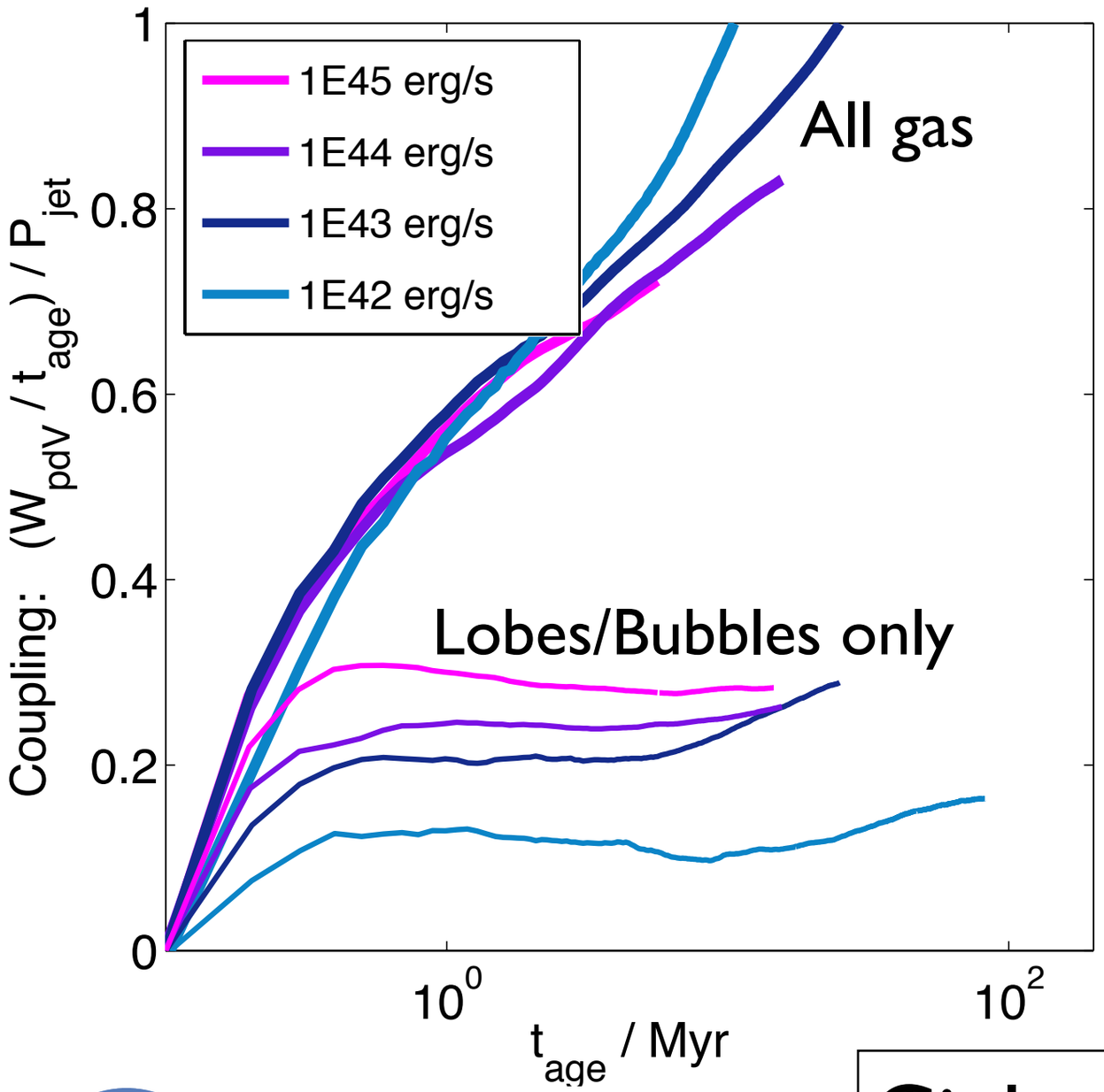
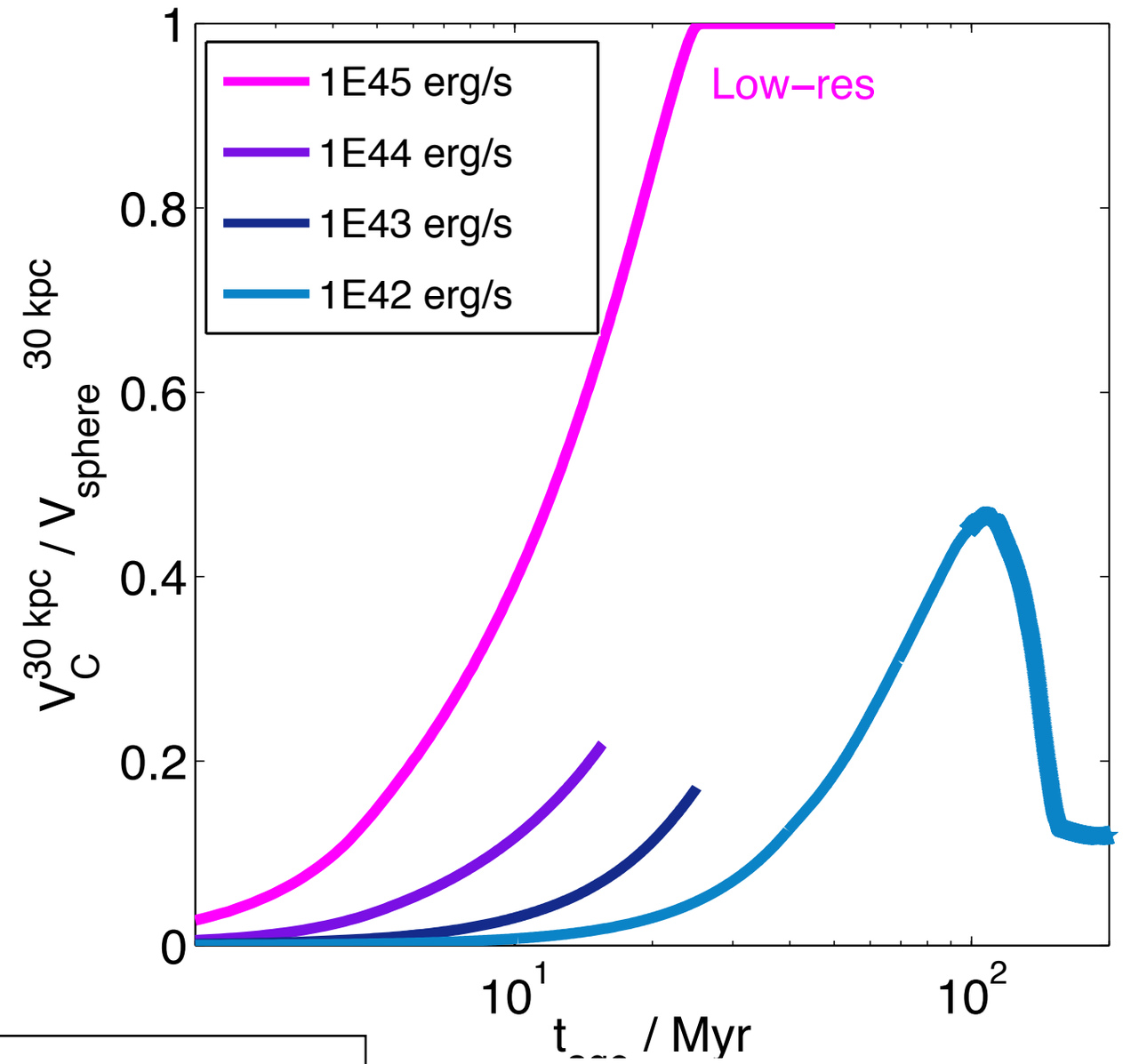


Volume coverage within r_{Cool} ~30kpc (2e12 M_{Sun})



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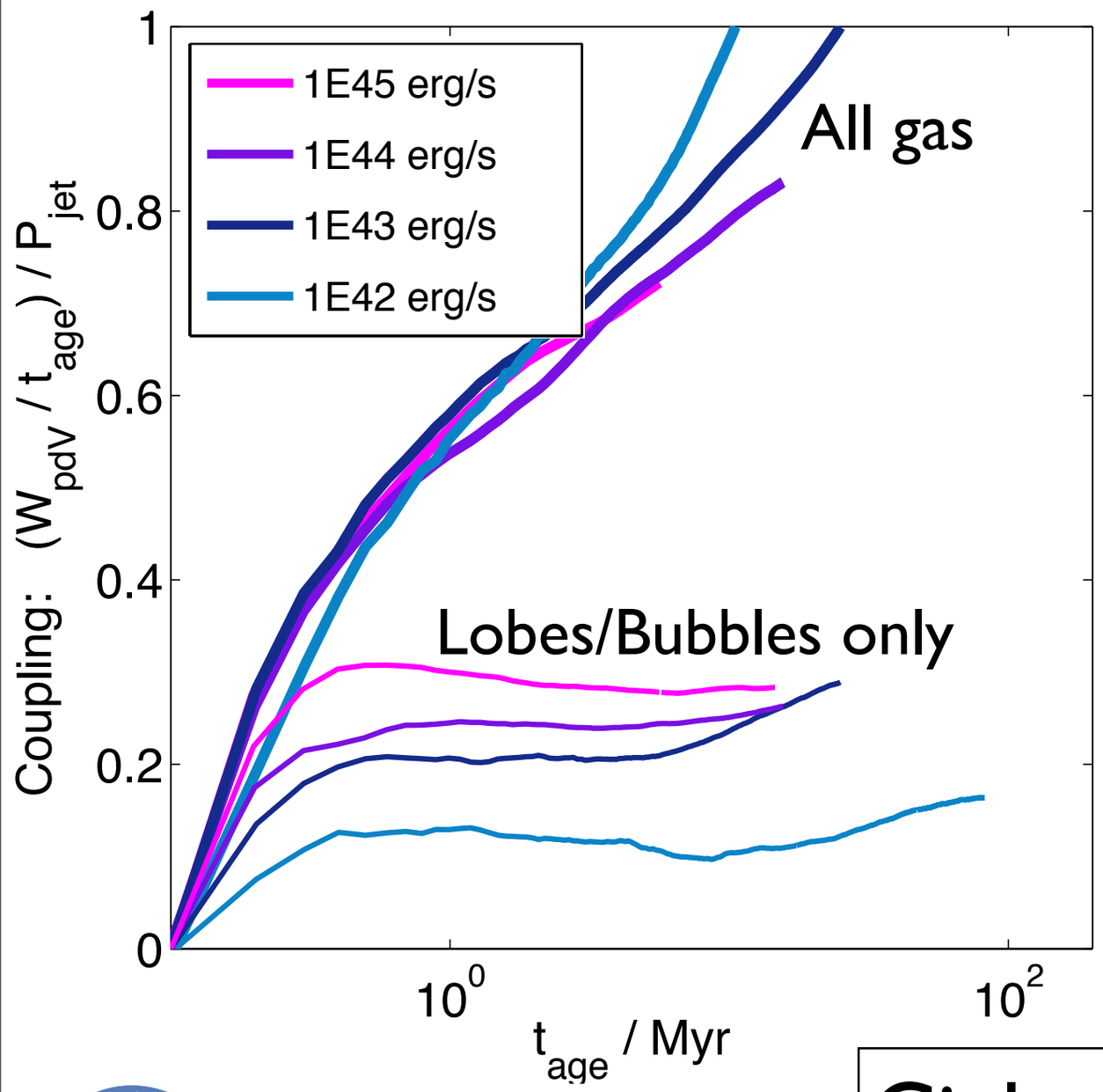

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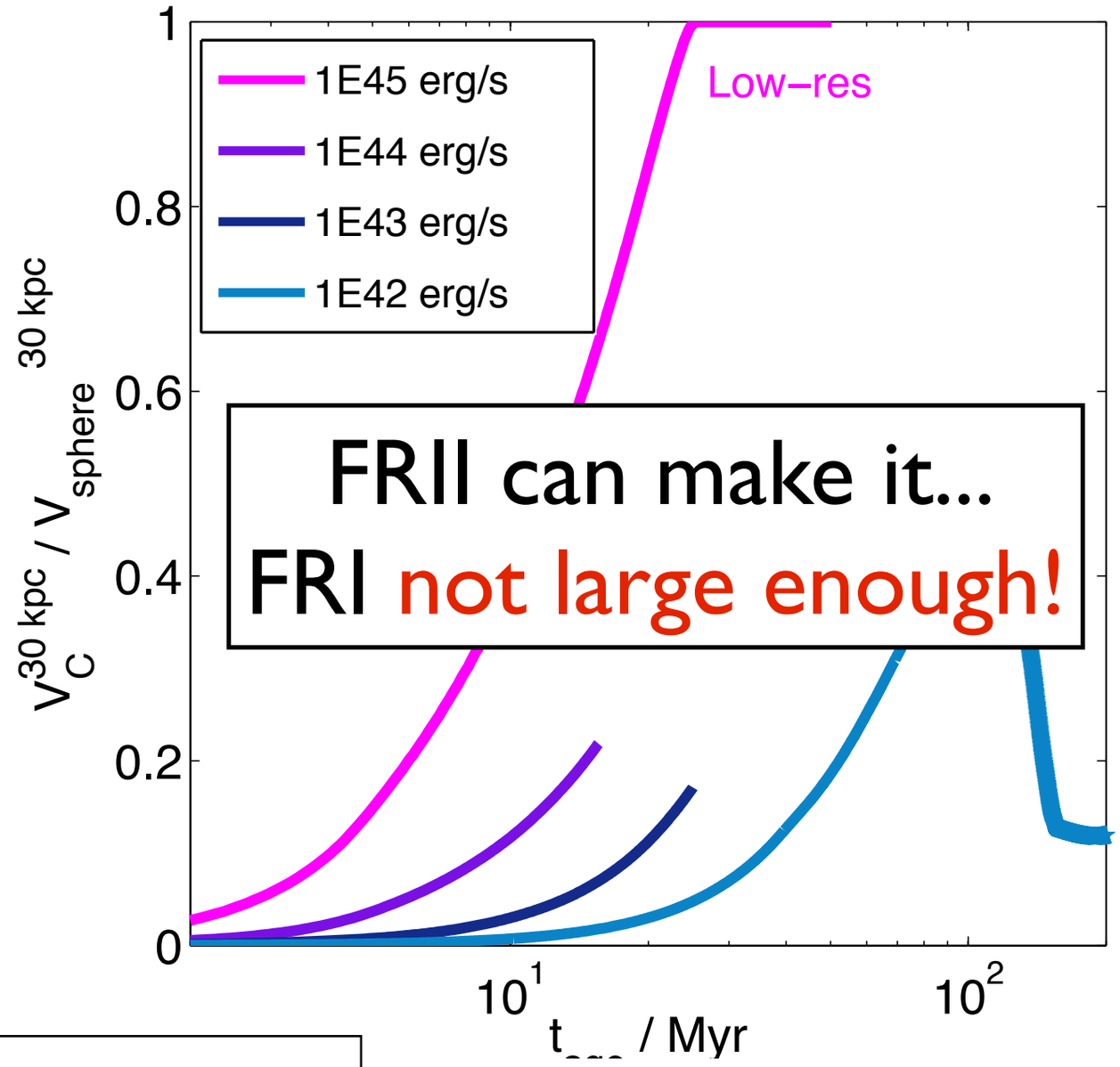

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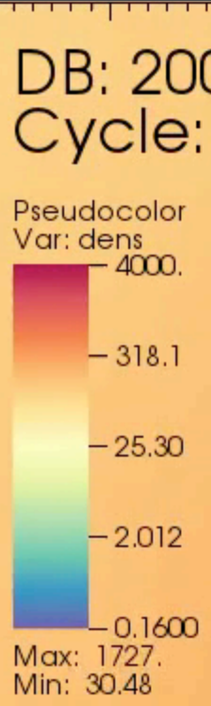
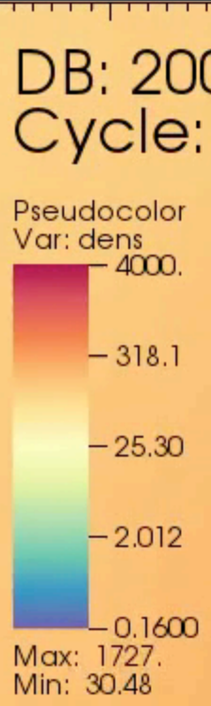


Results: angle flip

10^{45} erg/s

~150 kpc

Can the volume fraction increase with multiple injections?



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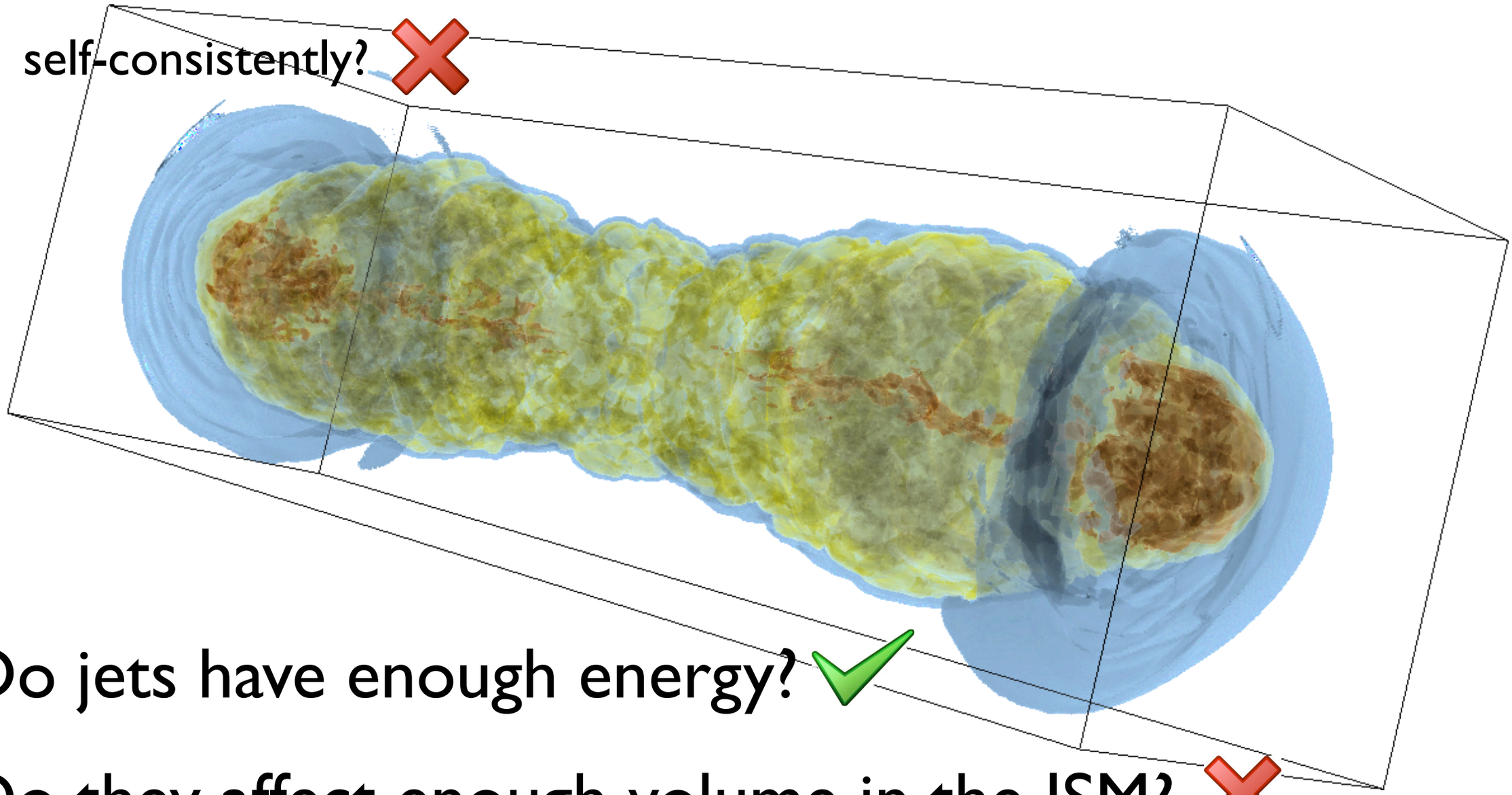
Can the volume fraction increase with multiple injections?

Not really... :(

Summary

- Can we simulate AGNs radio mode with AMR? ✓
  - self-consistently? ✗



- Do jets have enough energy? ✓
- Do they affect enough volume in the ISM? ✗