Strangulation in Galaxy Groups.

(Kawata & Mulchaey ApJL in press. ArXiv:0707.3814)

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(Carnegie Observatories,

⇒ Mullard Space Science Laboratory,

University College London from Oct.2008)

Environment effect on star formation of galaxies

"The predominance of early types is a conspicous feature of clusters in general"

(Hubble & Humason 1931)

Star formation is suppressed in groups? (e.g. Wilman et al. 2005)

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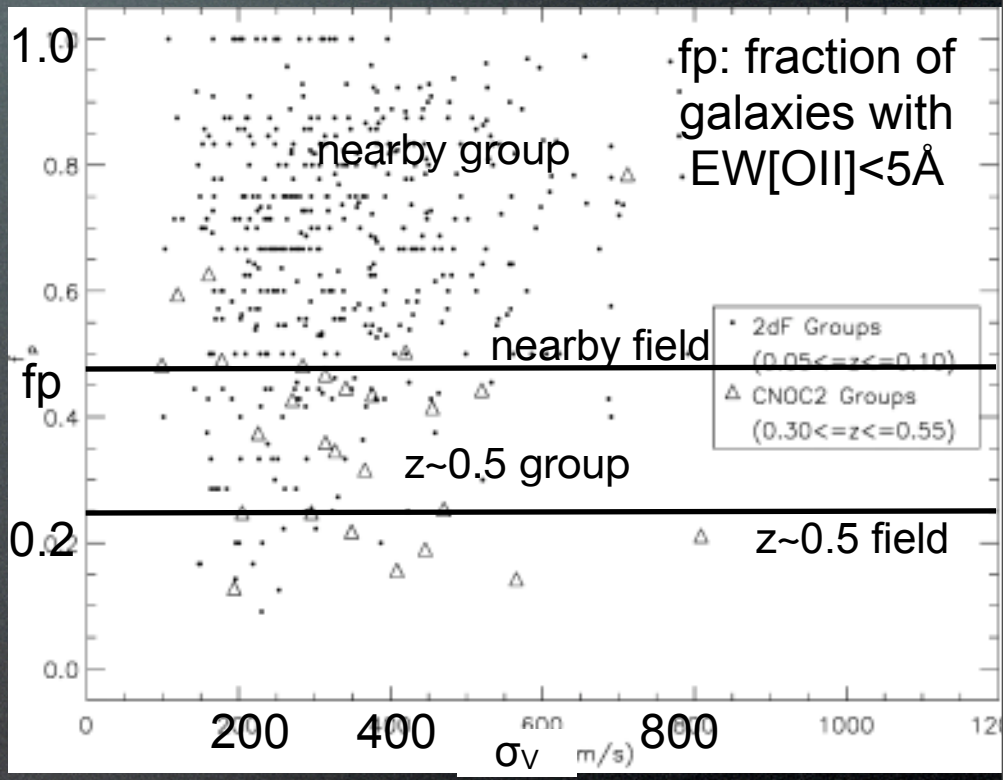
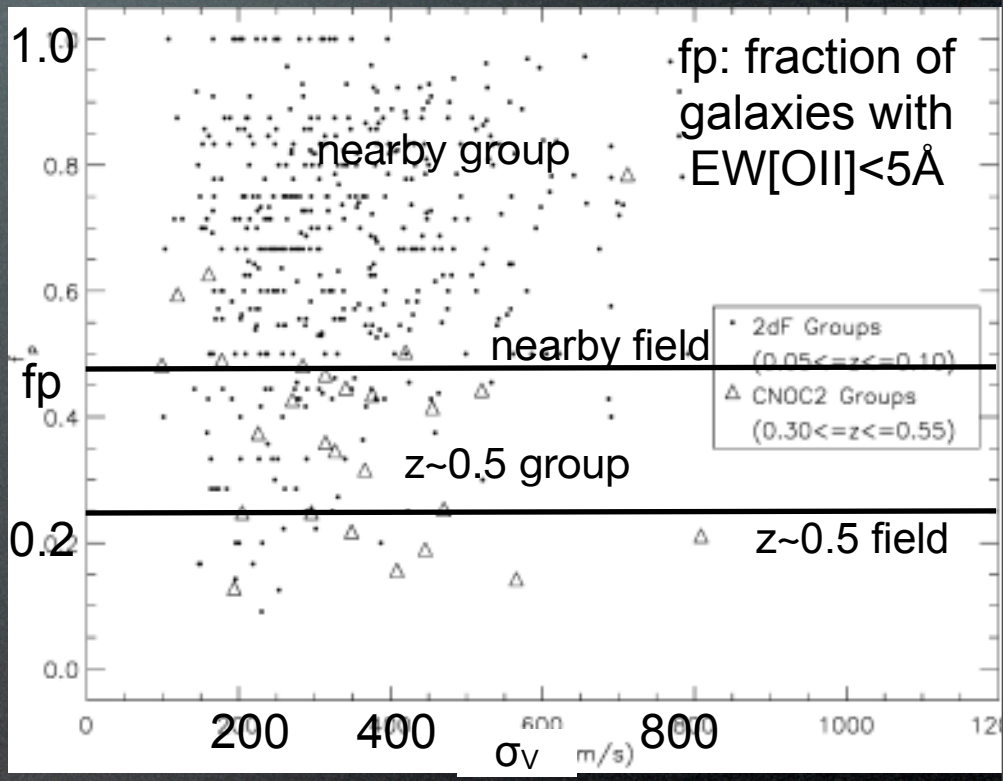


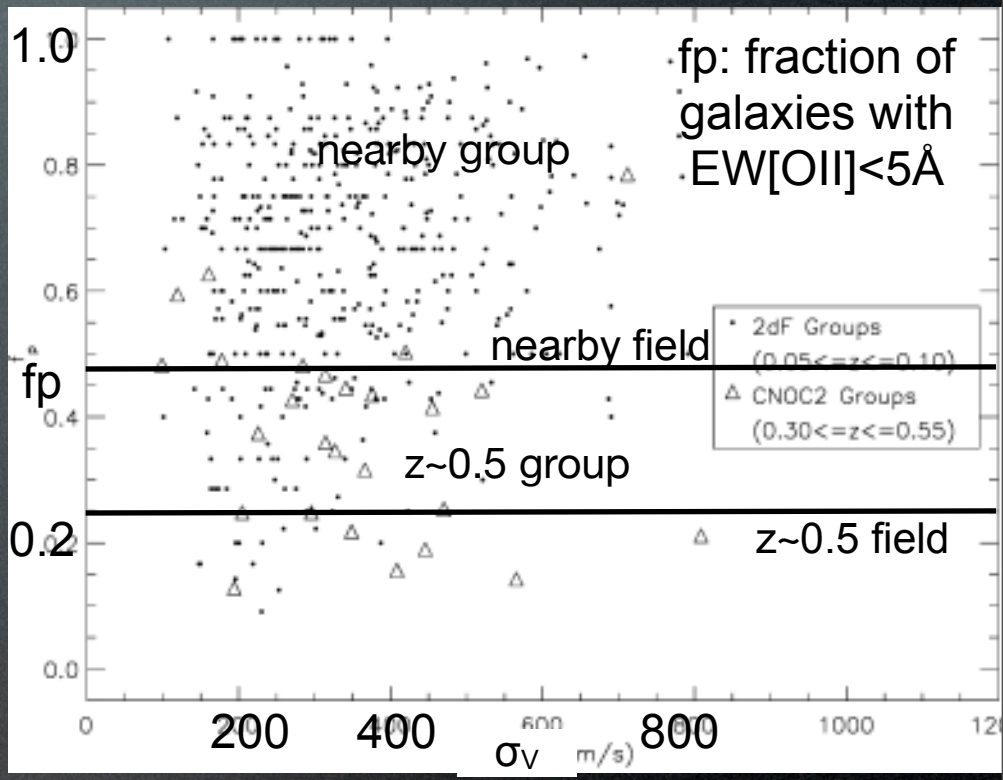
Star formation is suppressed in groups? (e.g. Wilman et al. 2005)

- fraction of passive (lack of SF) galaxies is significantly higher even in small groups than field.



Star formation is suppressed in groups? (e.g. Wilman et al. 2005)

- fraction of passive (lack of SF) galaxies is significantly higher even in small groups than field.
- some mechanism in group environment affects the evolution of galaxies.



3 major mechanisms to stop SF

- mergers/interactions
- ram-pressure stripping
- strangulation

mergers

Di Matteo et al. (2005)

mergers

- sturburst ⇒ using up the cold gas?

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- starburst + AGN heating
  ⇒ blowing up the gas?

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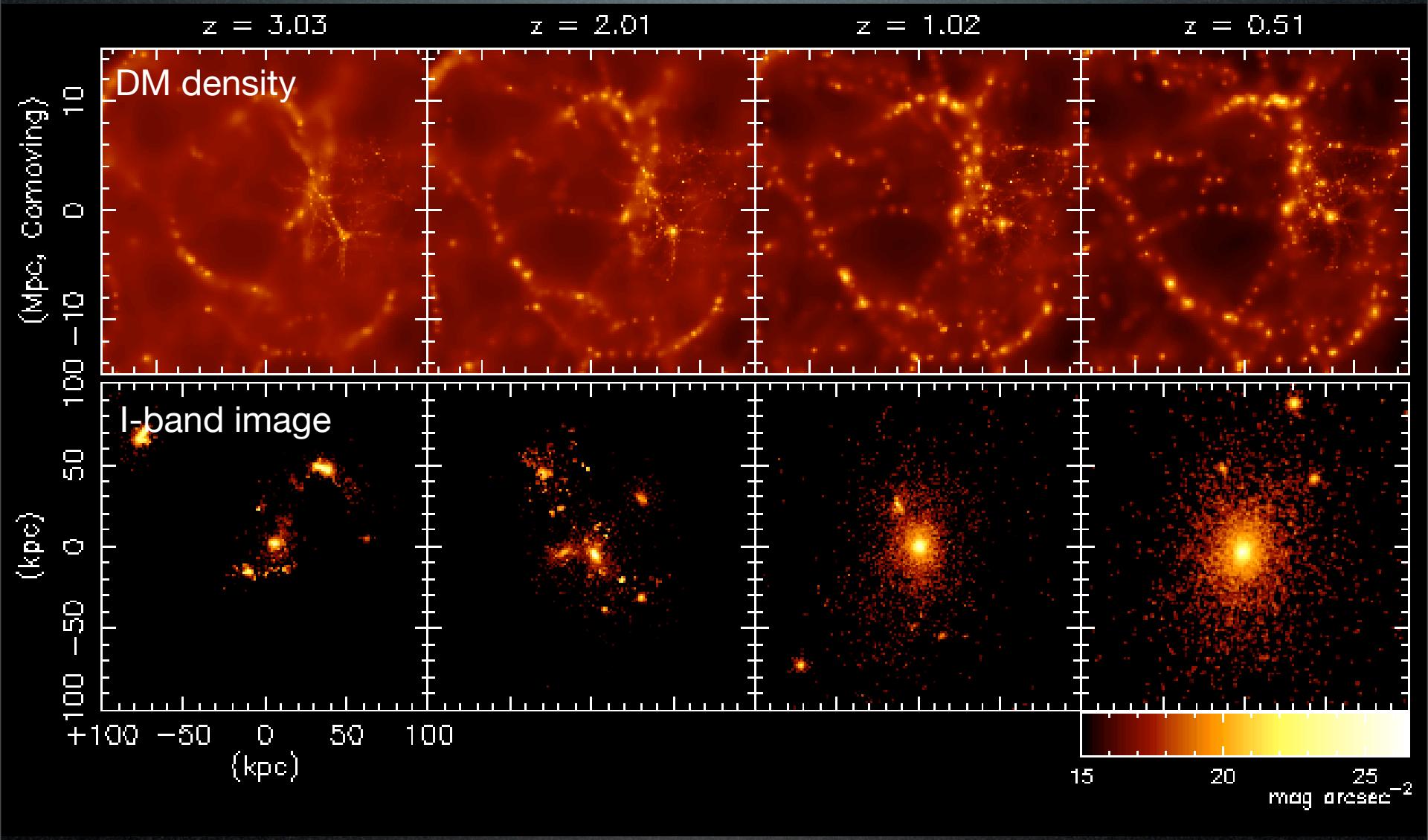
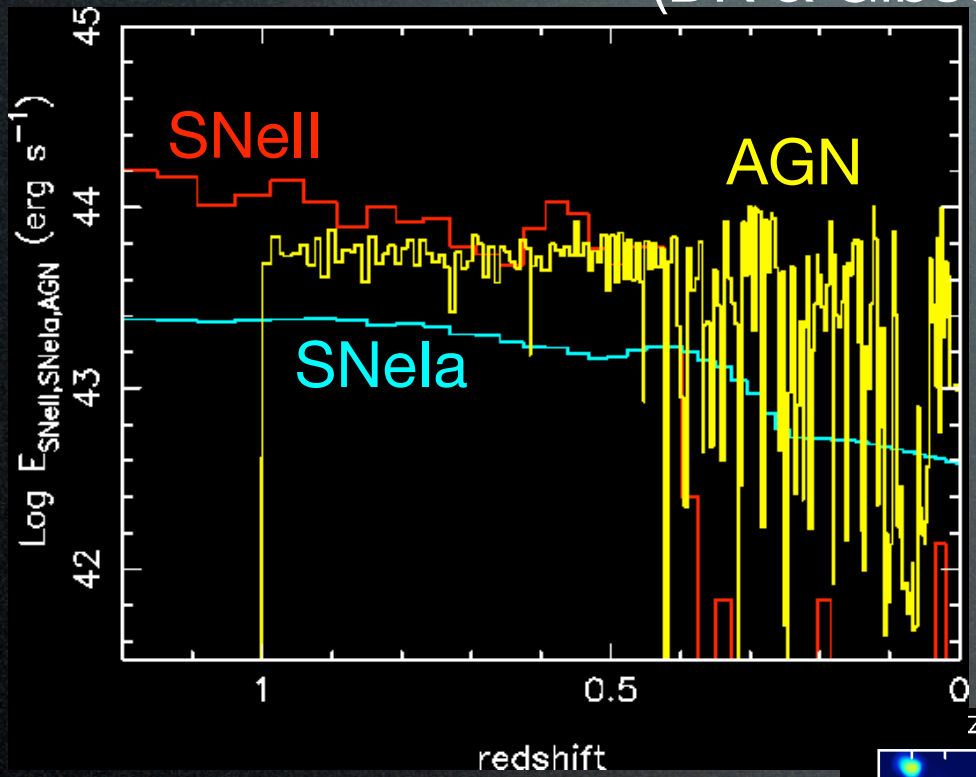
- starburst + AGN heating
  ⇒ blowing up the gas?
- later gas accretion from IGM/ICM?



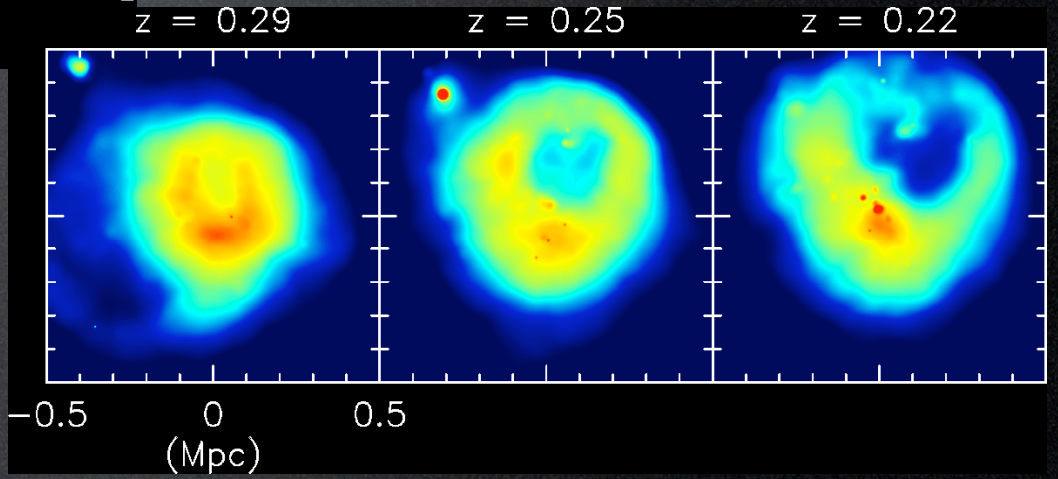
DK & Gibson (2003,2005)

self-regulated AGN heating

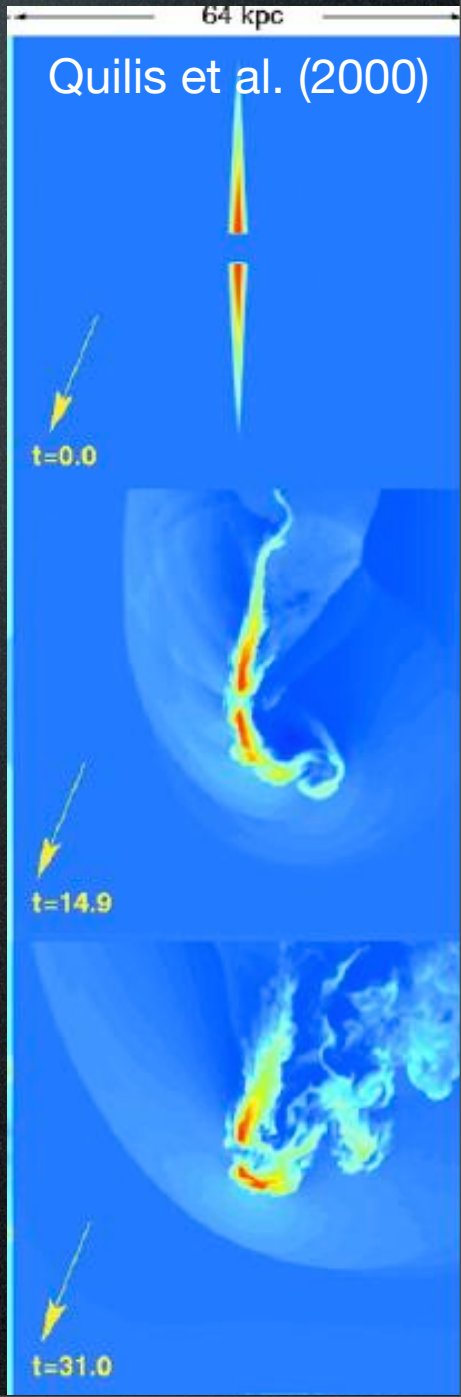
(DK & Gibson 2005)



Predicted X-ray image

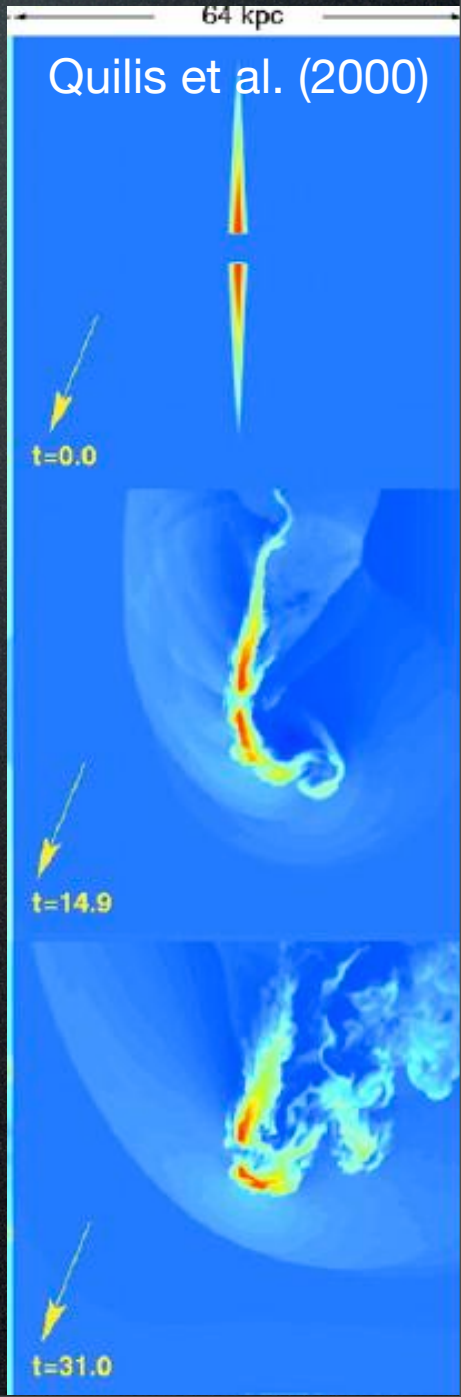


ram-pressure stripping



ram-pressure stripping

- Ram pressure from ICM or IGM ($\rho_{ICM}v^2$) strip the cold gas.



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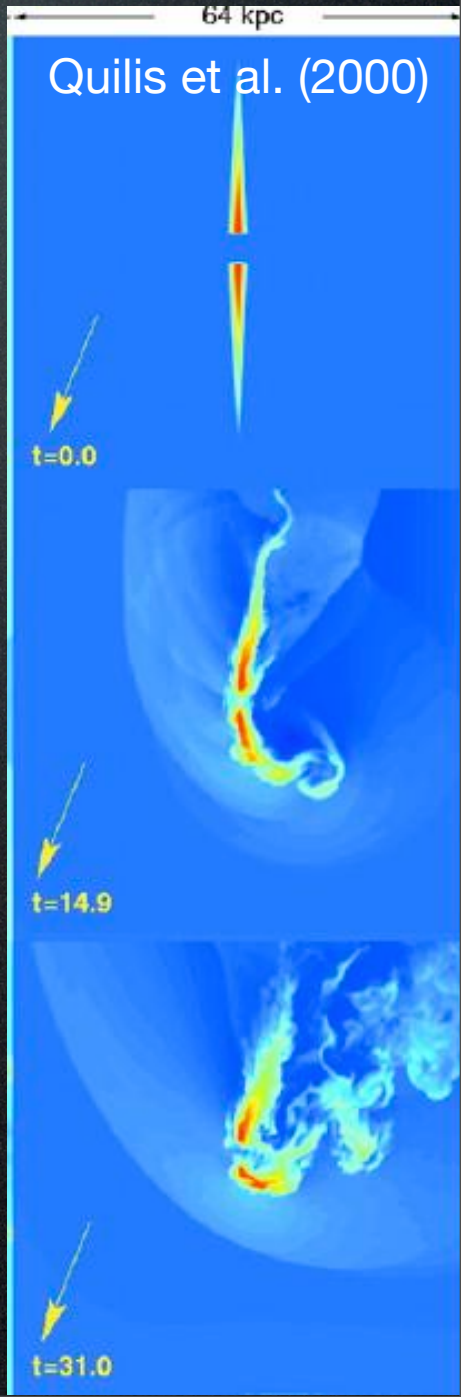
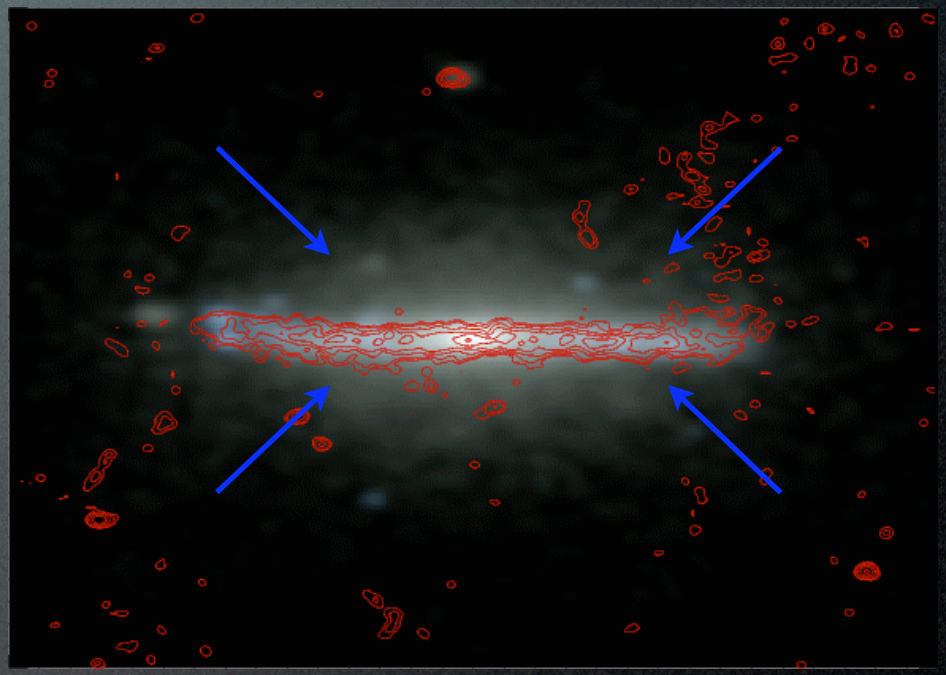
- require high density and high infall velocity = work in cluster, but not in groups?



strangulation
(Larson et al. 1980)



BVR color + cold gas contors
simulated galaxy (Bailin, DK et al. 2005)

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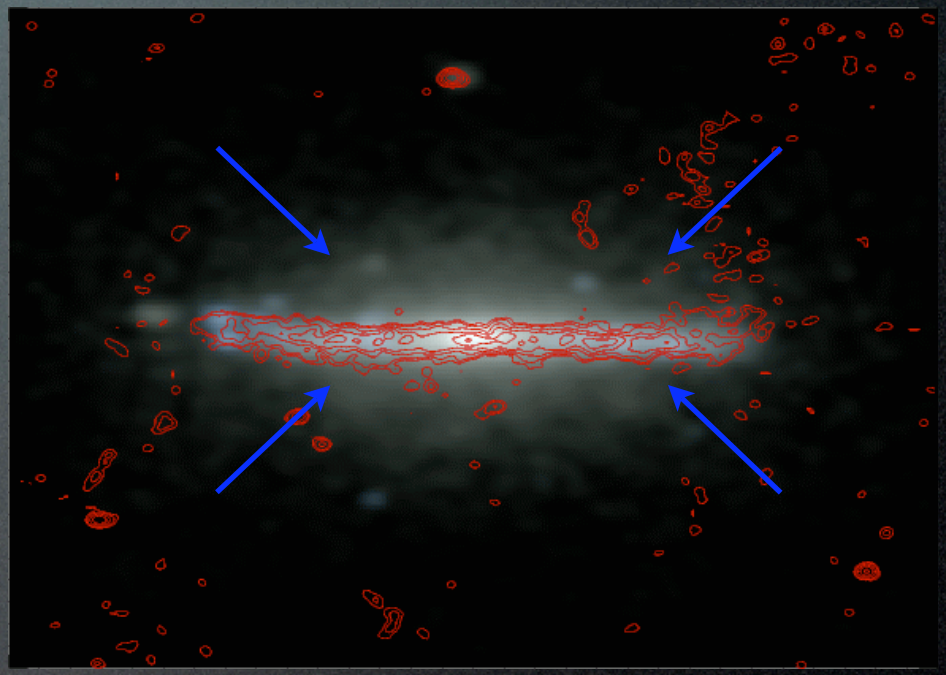

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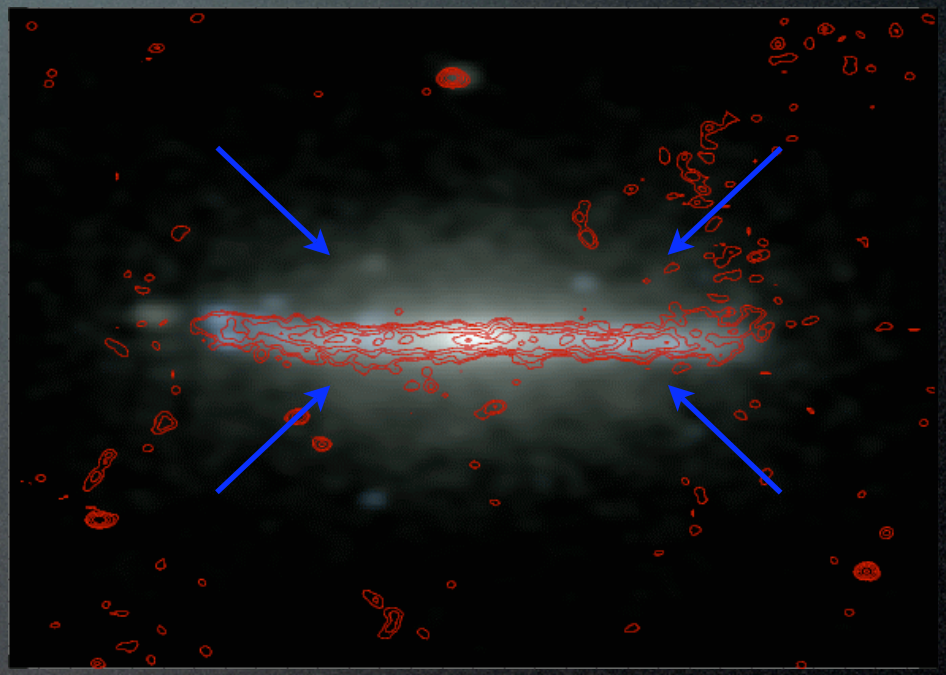

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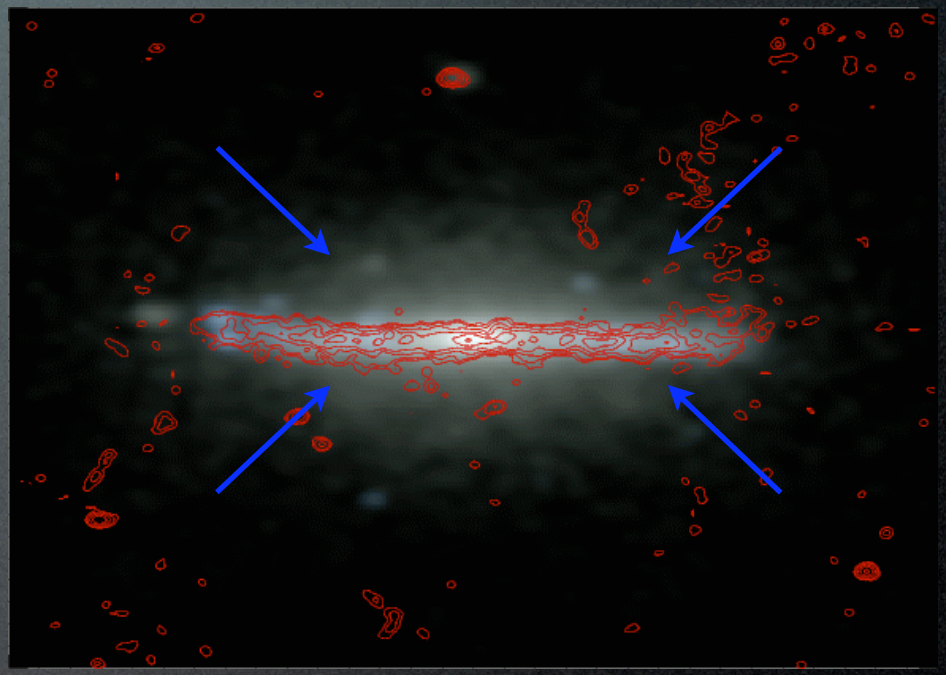

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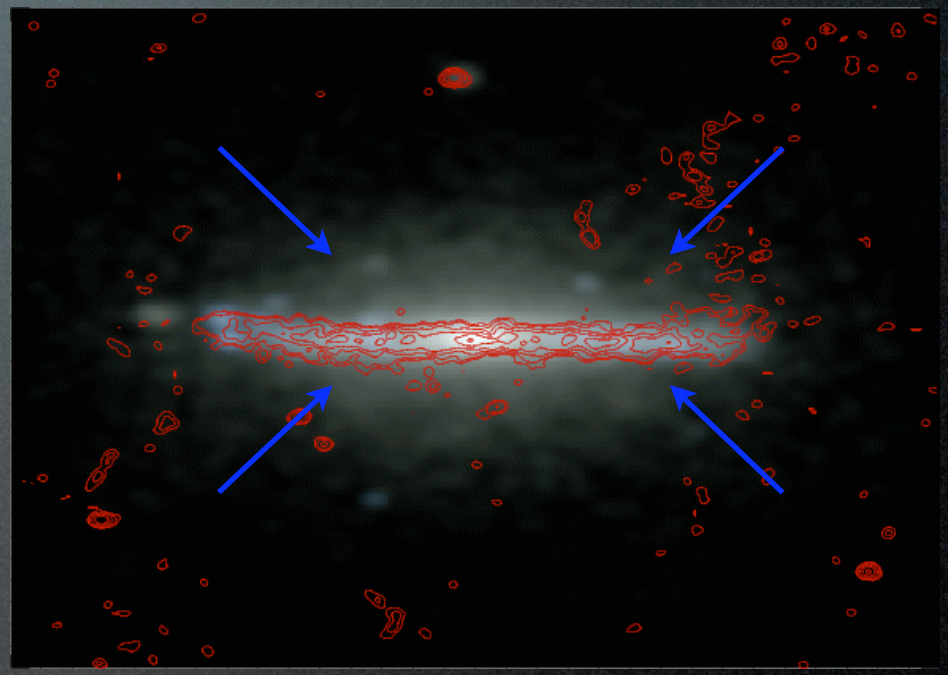

BVR color + cold gas contors simulated galaxy (Bailin, DK et al. 2005)

no self-consistent numerical simulation studies.

Cosmological Simulation of a group galaxy ($M_{vir}=8x10^{12}M_{\odot}$) formation

Strangulation for a disk galaxy falling into the group

GCD+

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(DK & Gibson 2003a)

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- 3D vector/parallel N-body/SPH code
- DM and stars: Tree N-body
- Gas: Smoothed Particle Hydrodynamics
  Radiative Cooling
  Star Formation
  SNe feedback
  Metal Enrichment

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  (Abel et al. 1997)
- equilibrium metal cooling
  (Cen et al. 1995)

Chemical Evolution

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- Star Formation: $SFR \propto \rho^{1.5}$

  if $n_H > 0.01 cm^{-3}$, $\nabla \cdot V < 0$, $t_c < t_{dyn}$
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- SNe feedback: energy and metals
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- Metal Enrichment
  from SNe II and I, mass loss from intermediate mass stars ($m < 8 M_\odot$)
  H,He,C,N,O,Ne,Mg,Si and Fe

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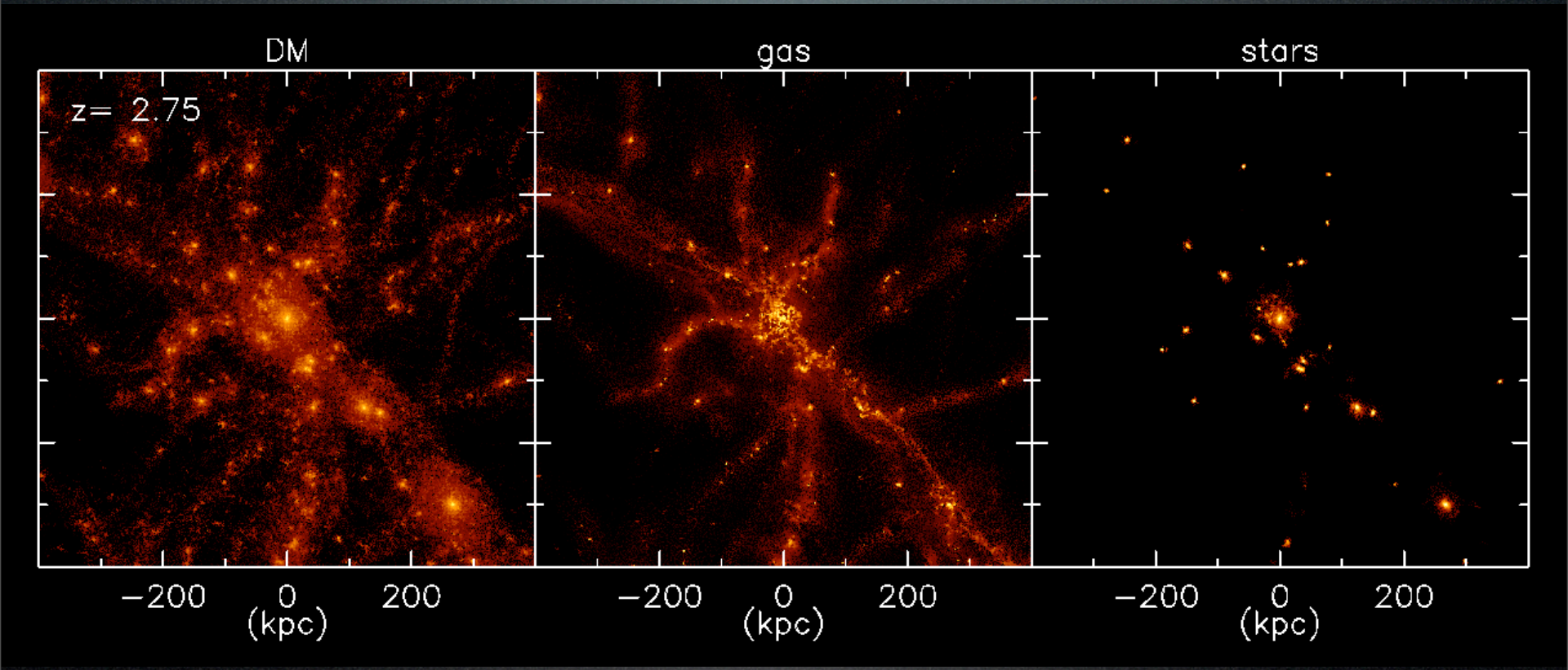
- $m_g=4x10^6\ M_{\odot}$, $\epsilon_g=0.96$ kpc

  $m_{DM}=2x10^7\ M_{\odot}$, $\epsilon_g=1.61$ kpc


DM
gas
stars
z= 2.75
−200
0
200
(kpc)
−200
0
200
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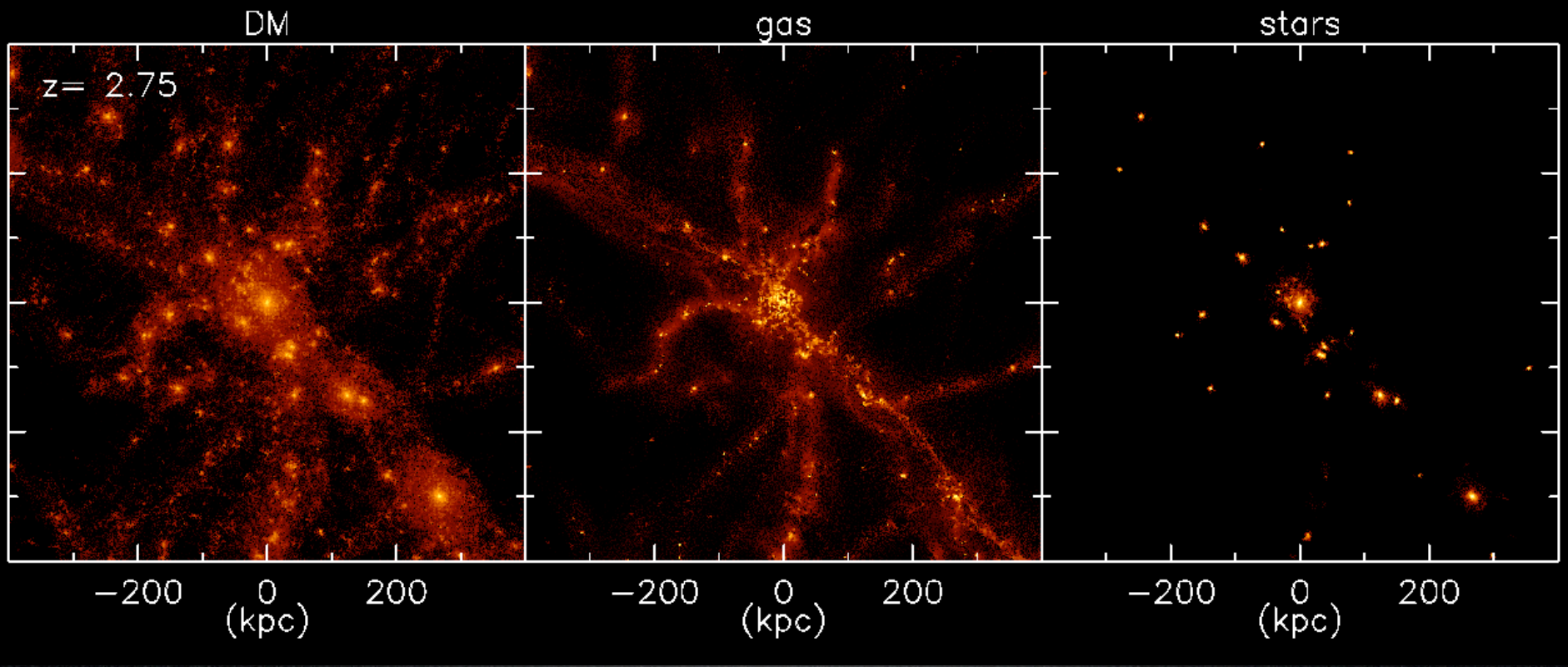
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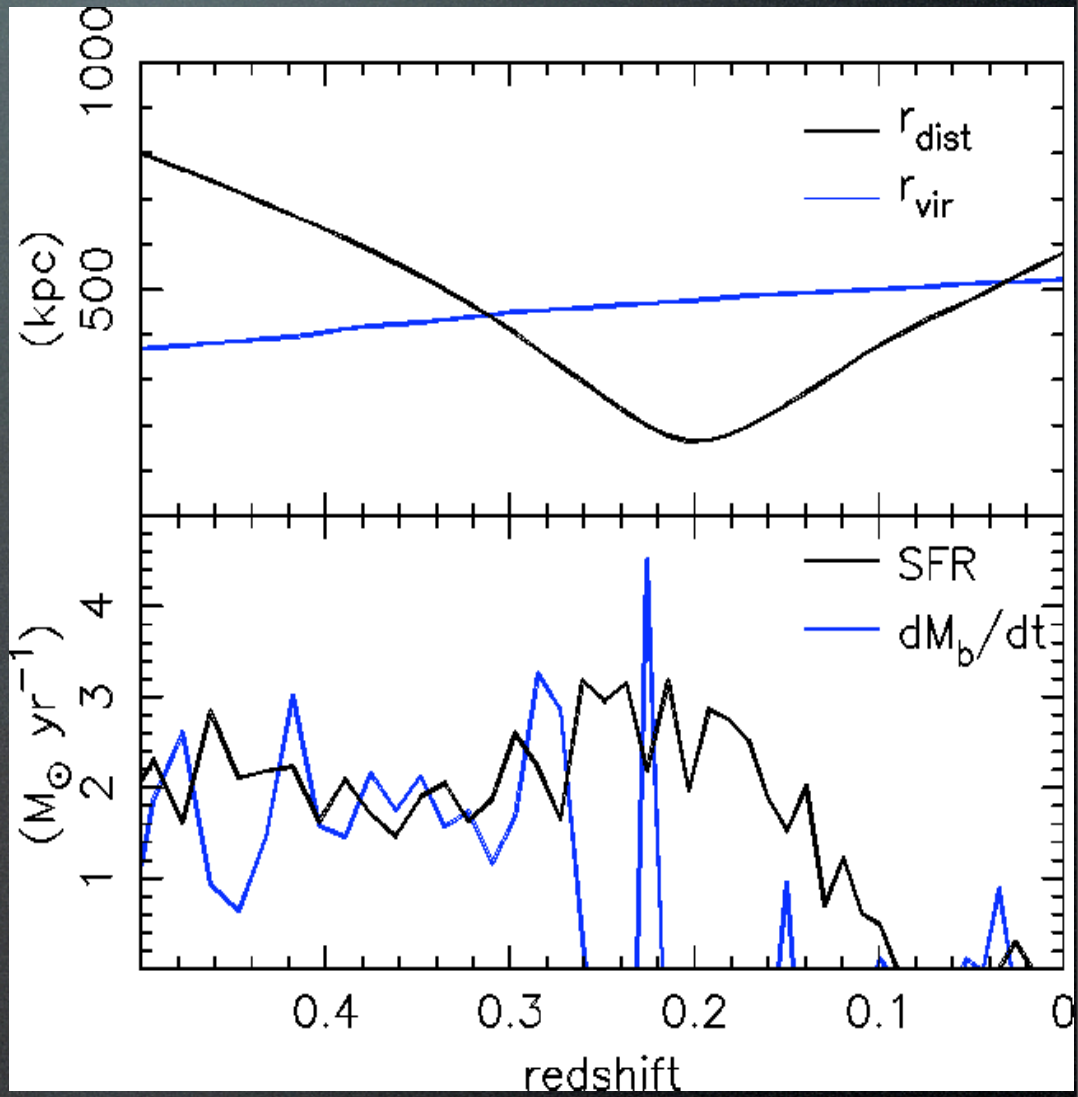
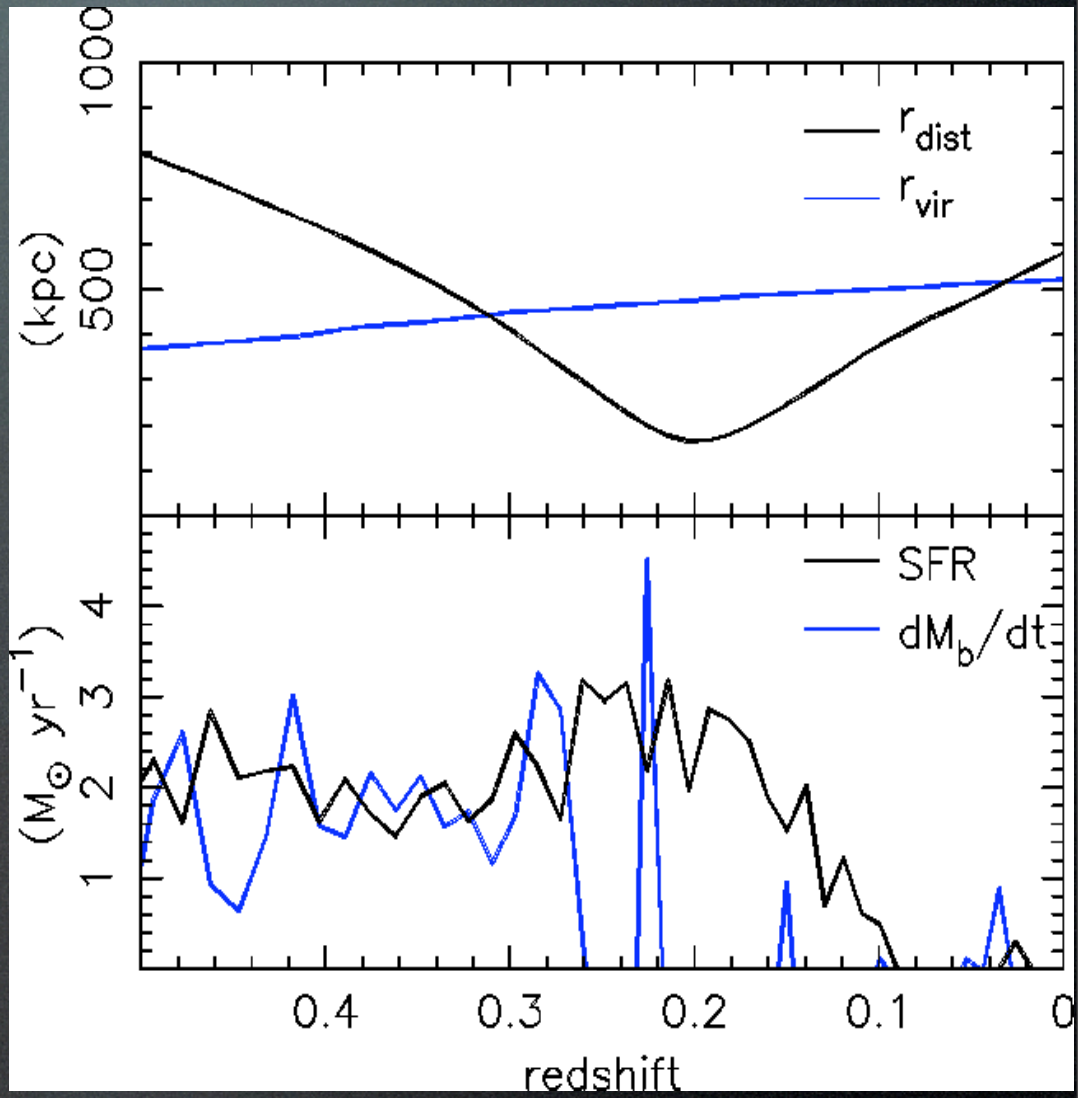
SF stops after the galaxy



SF stops after the galaxy

- the galaxy falls into the group around z=0.3.



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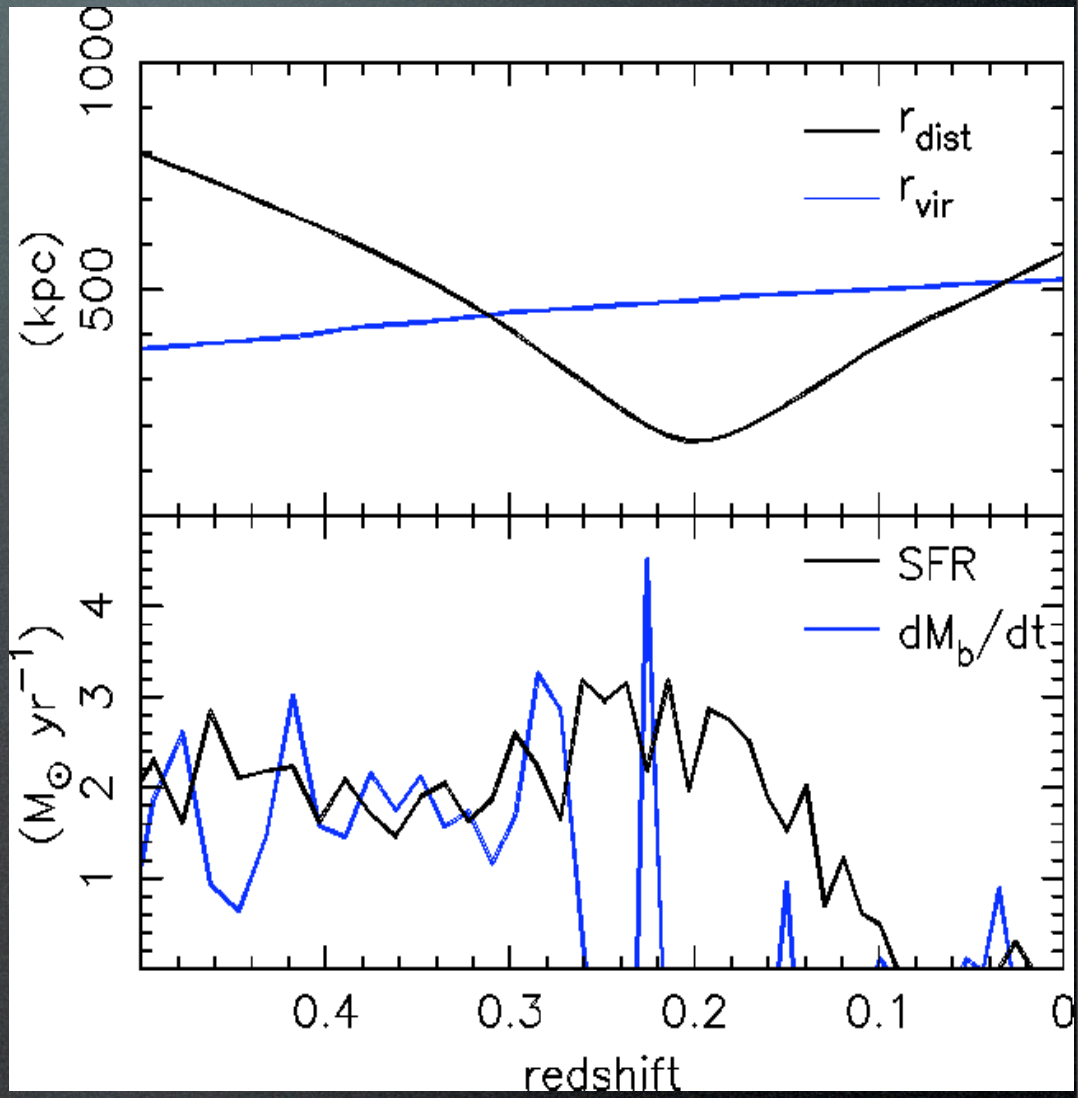
- the galaxy falls into the group around z=0.3.
- gas accretion stops around z=0.26.



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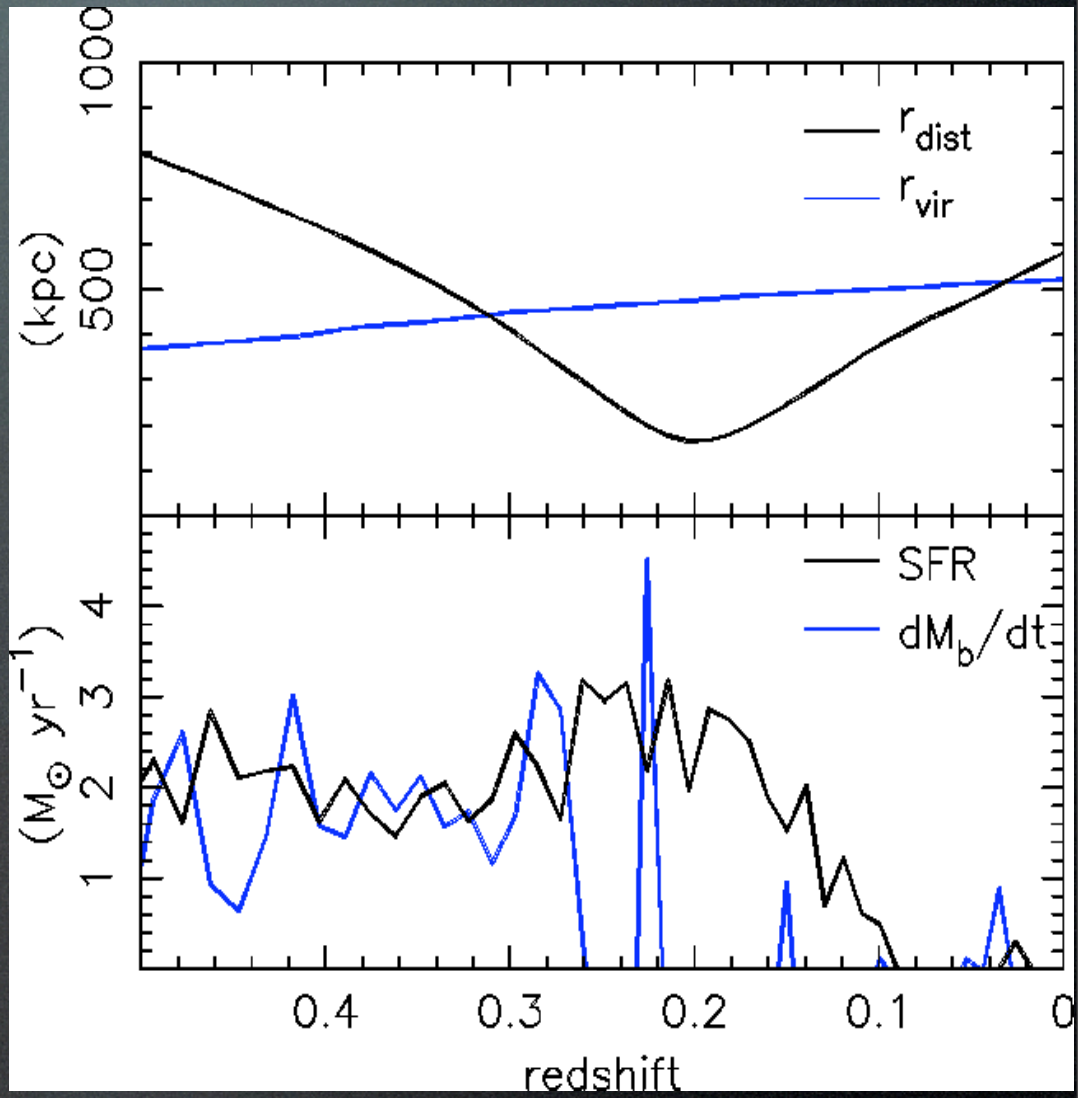
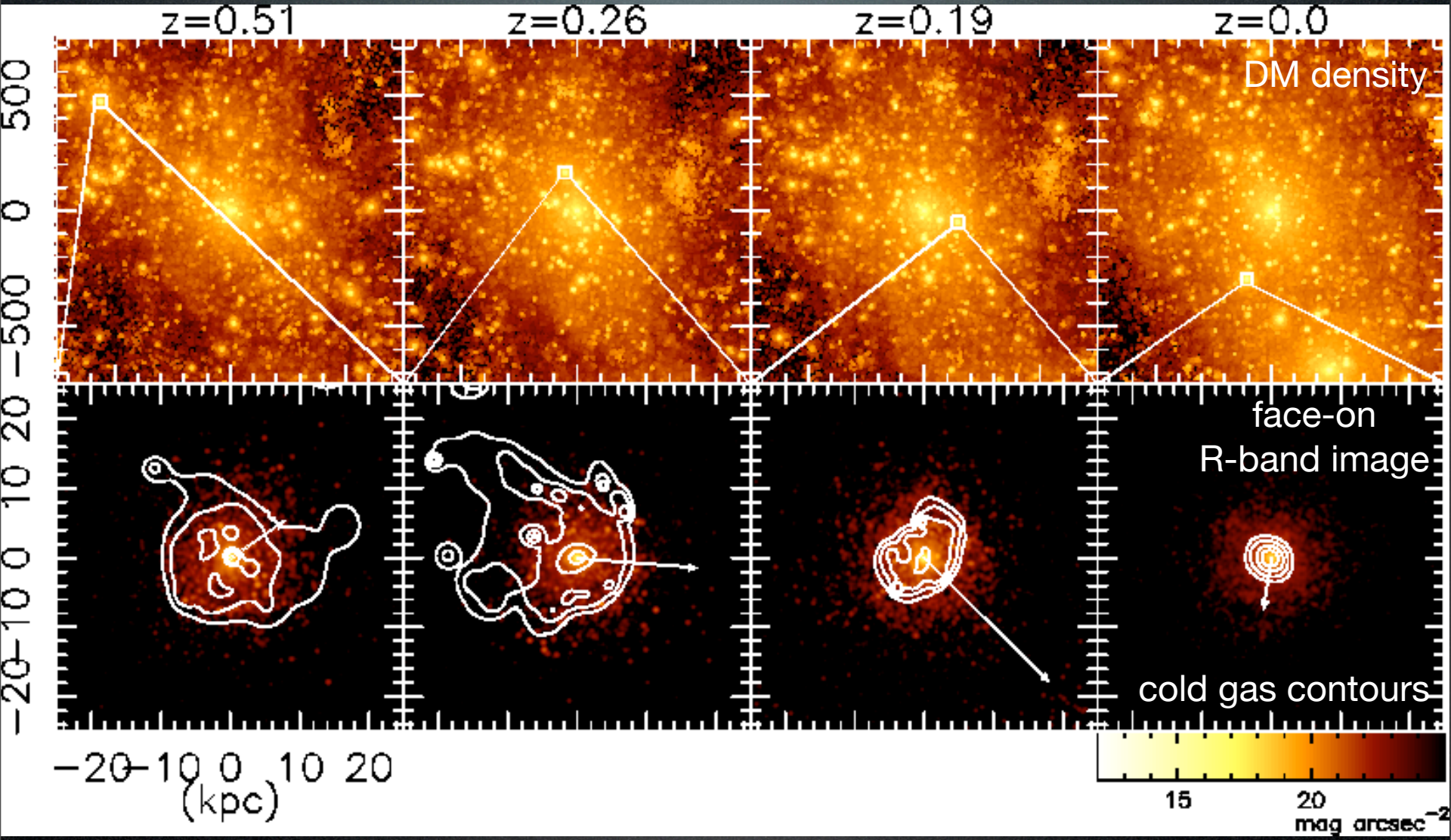
- SF stops around z=0.1.



a disk galaxy with Vrot~150 km/s



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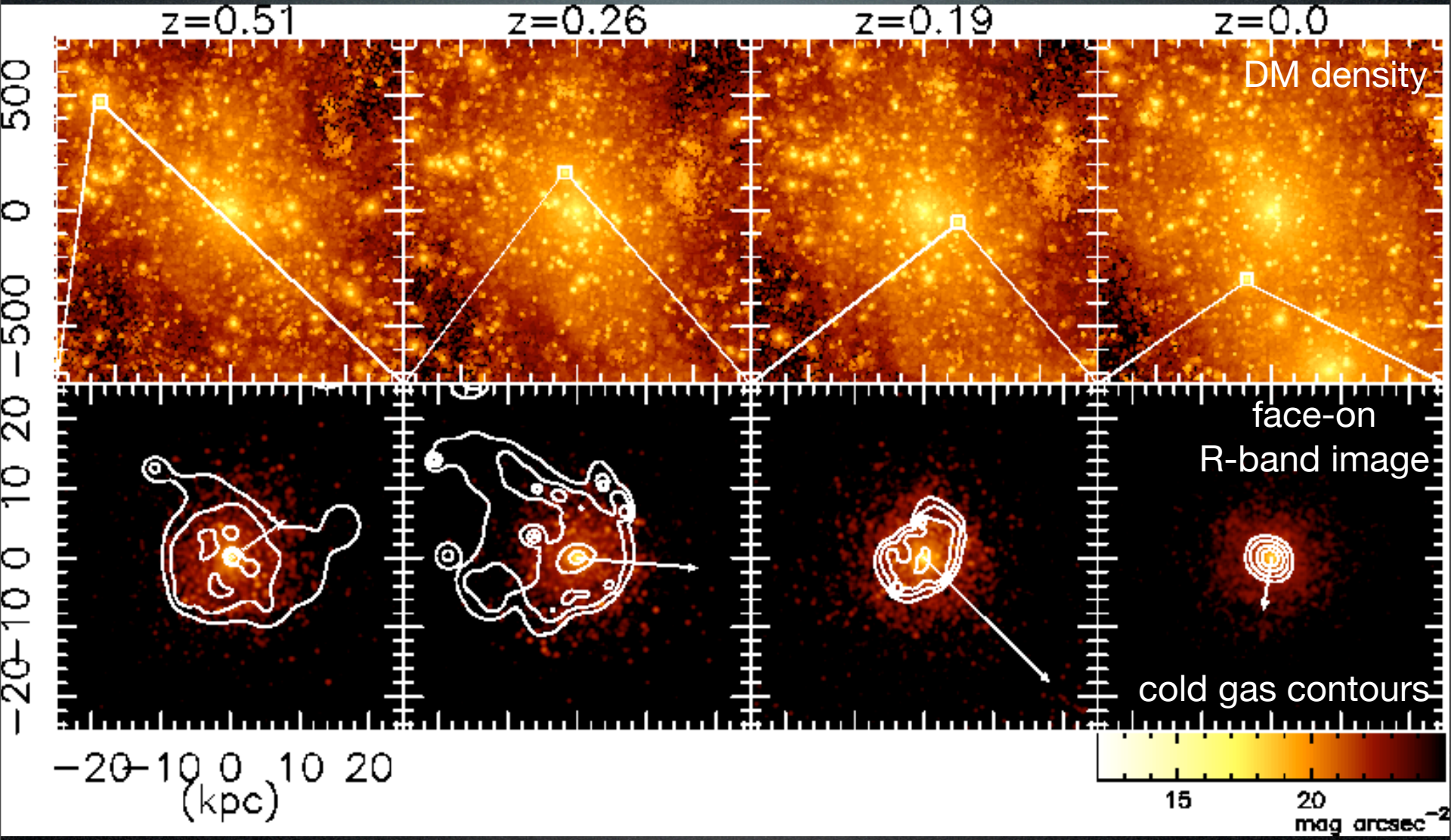
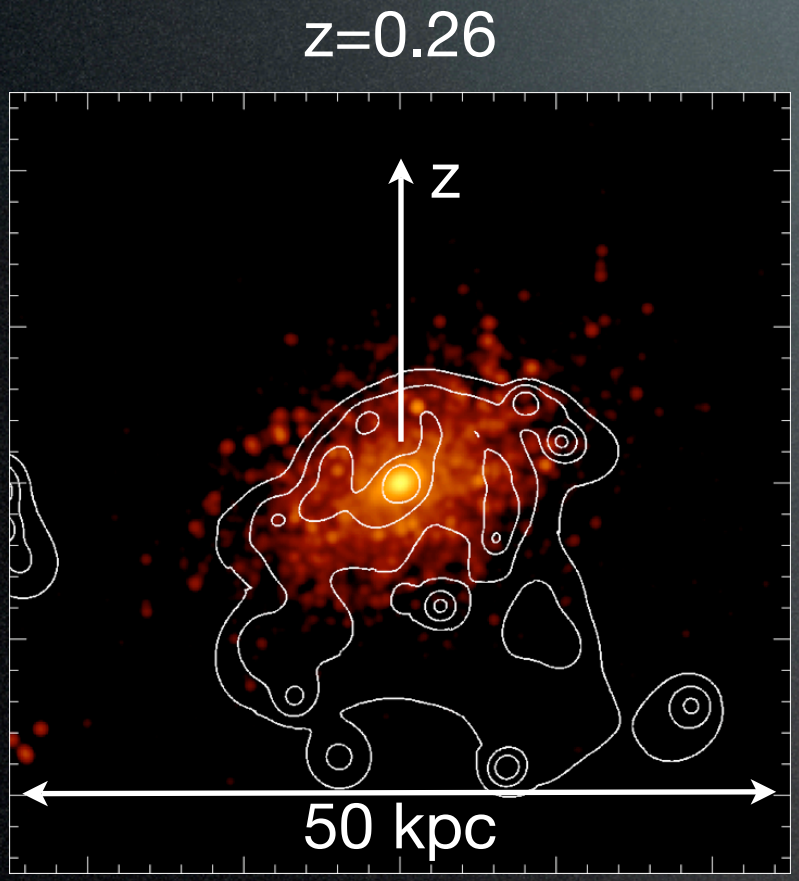


cold gas stripping after the galaxy infalled?

Ram pressure is not strong enough to strip the cold gas, but enough for the hot gas.



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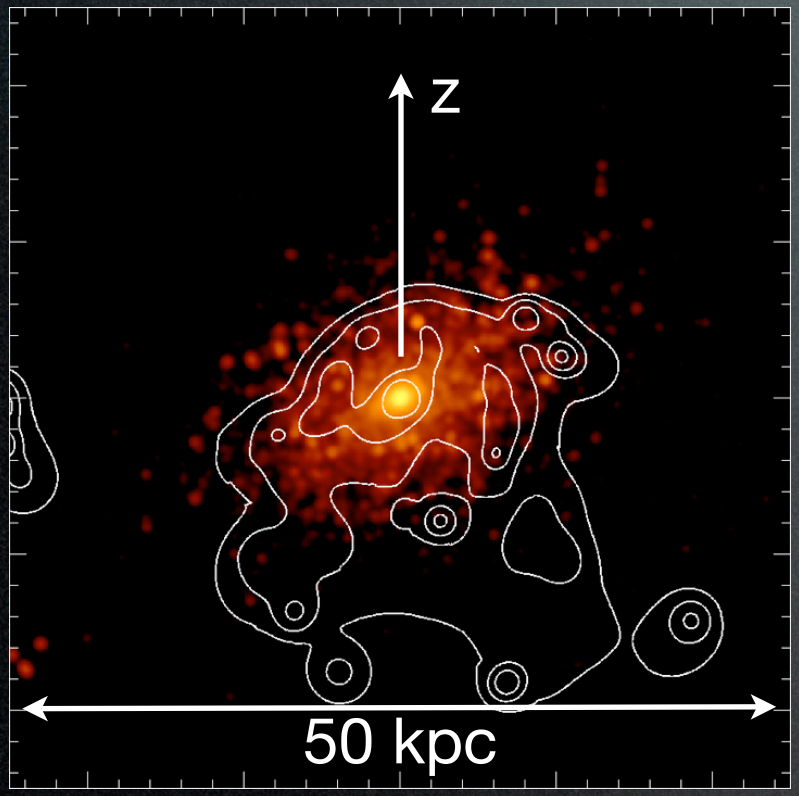
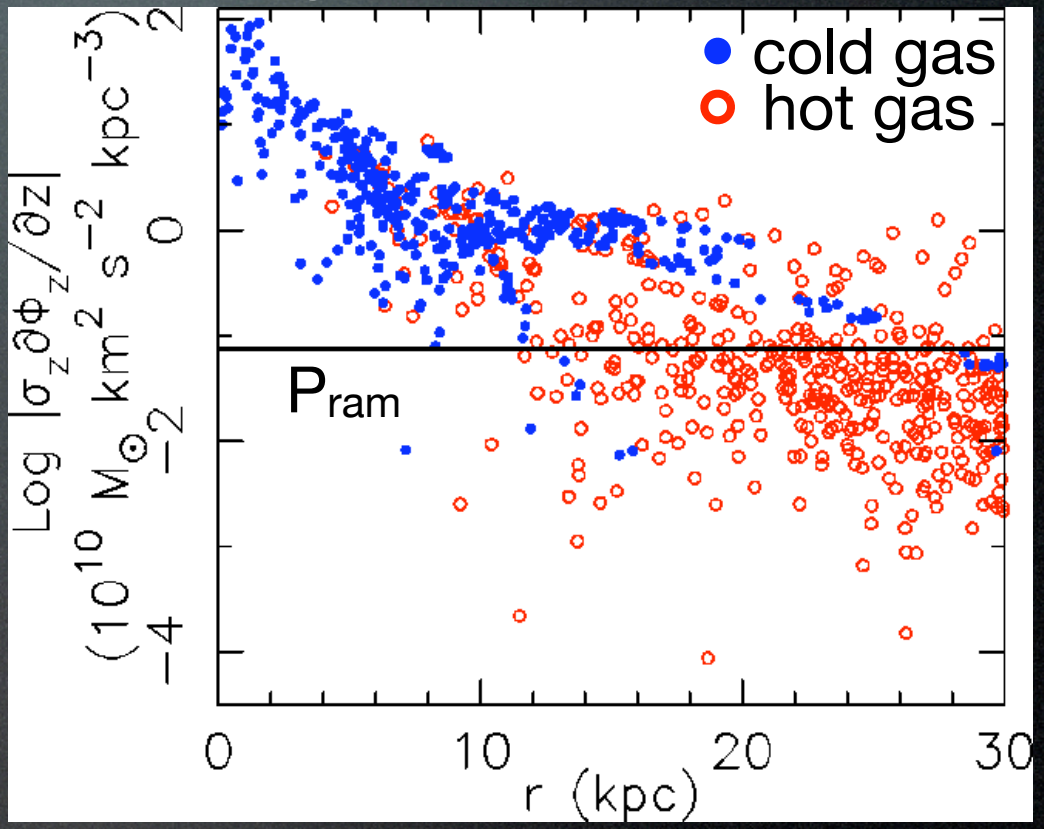
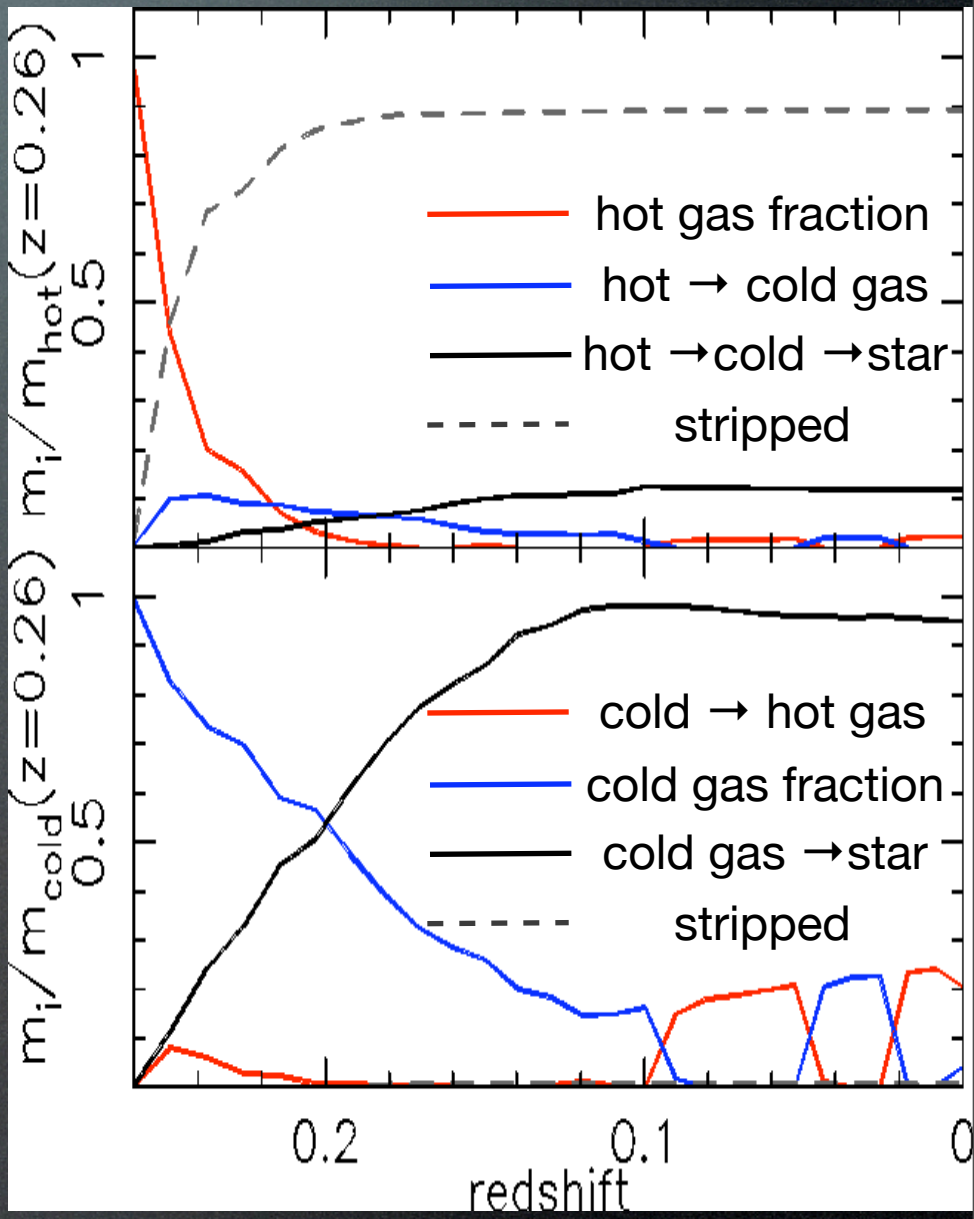
z=0.26



restoring force vs. $P_{ram} = \rho_{IGM} v^2$



gas (r<30 kpc) evolution since z=0.26



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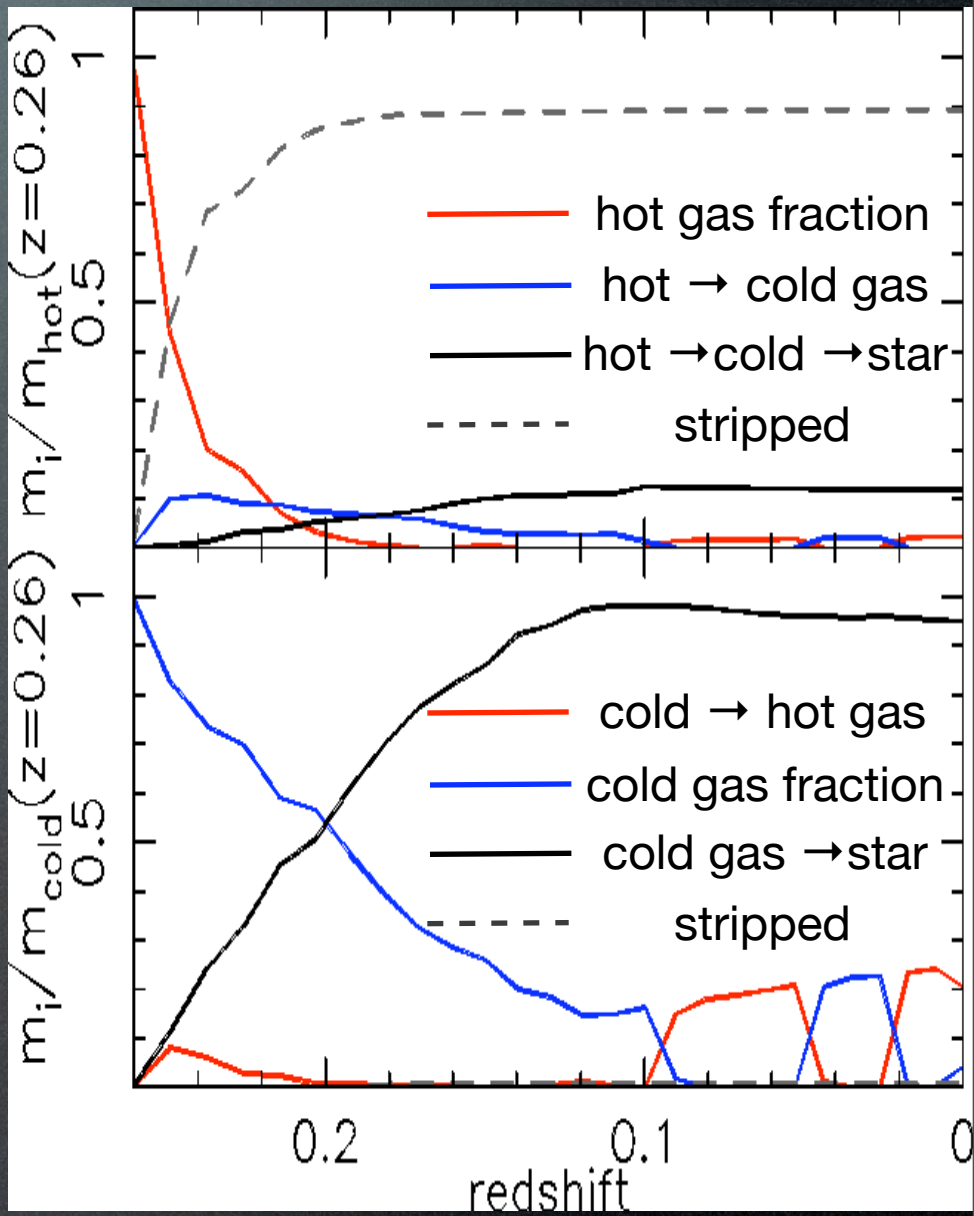

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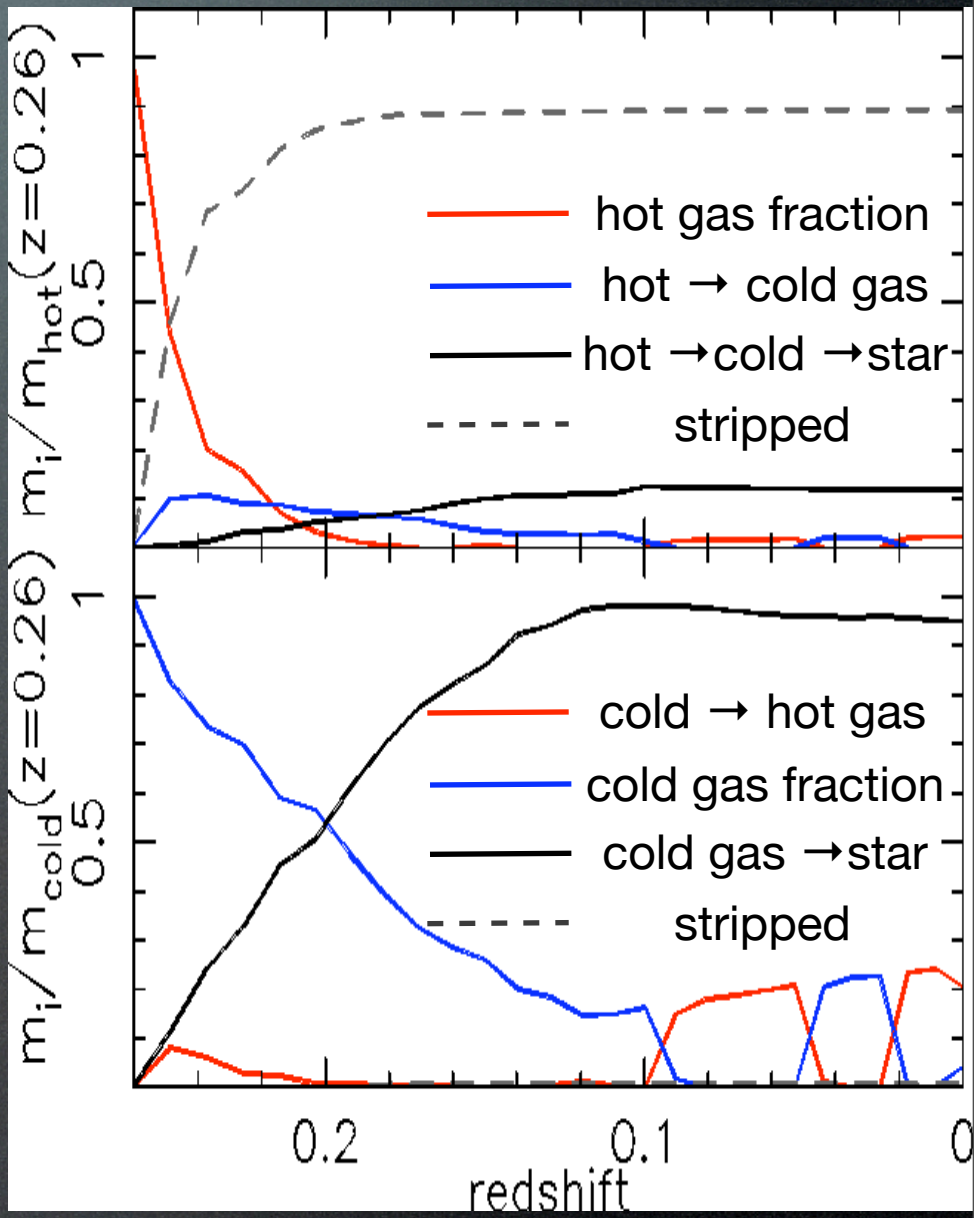

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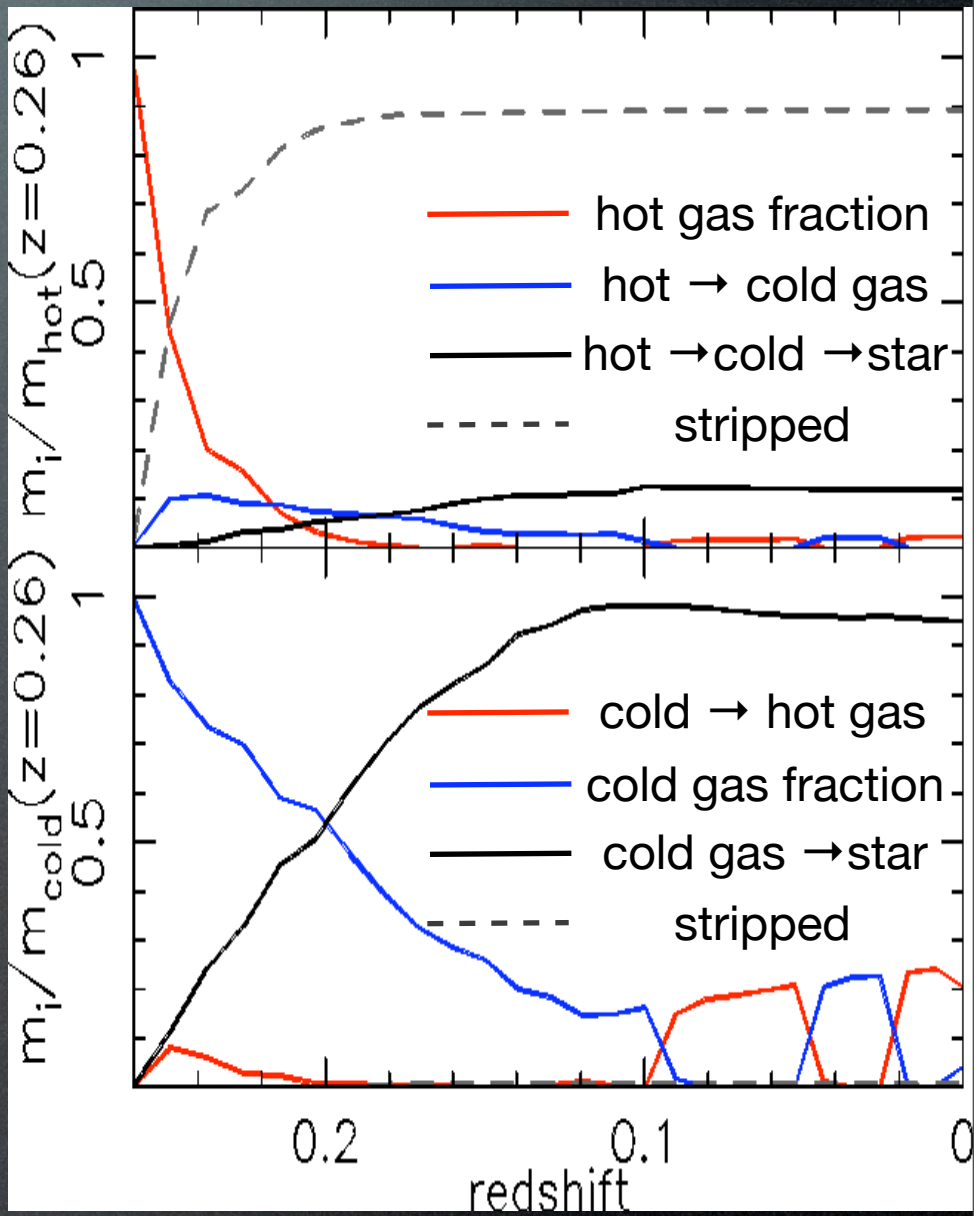

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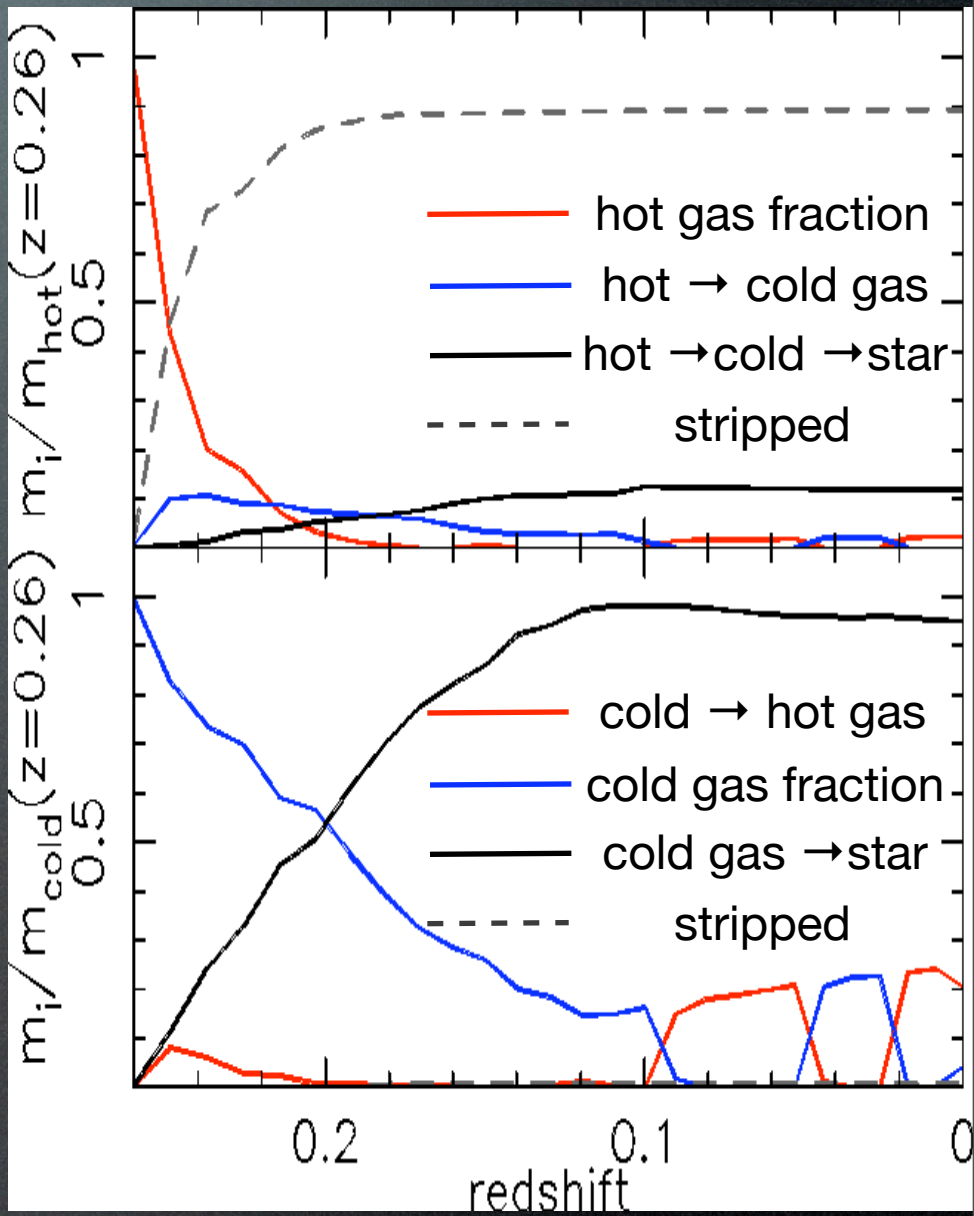
- *Strangulation!*



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- How does the remnant galaxy look like? S0?
- How strangulation depends on the group and galaxy's mass and the infall orbits?

gas stripping in groups?
(Rasmussen, Ponman, & Mulchaey 2006)

NGC 2300 group (NOAO)

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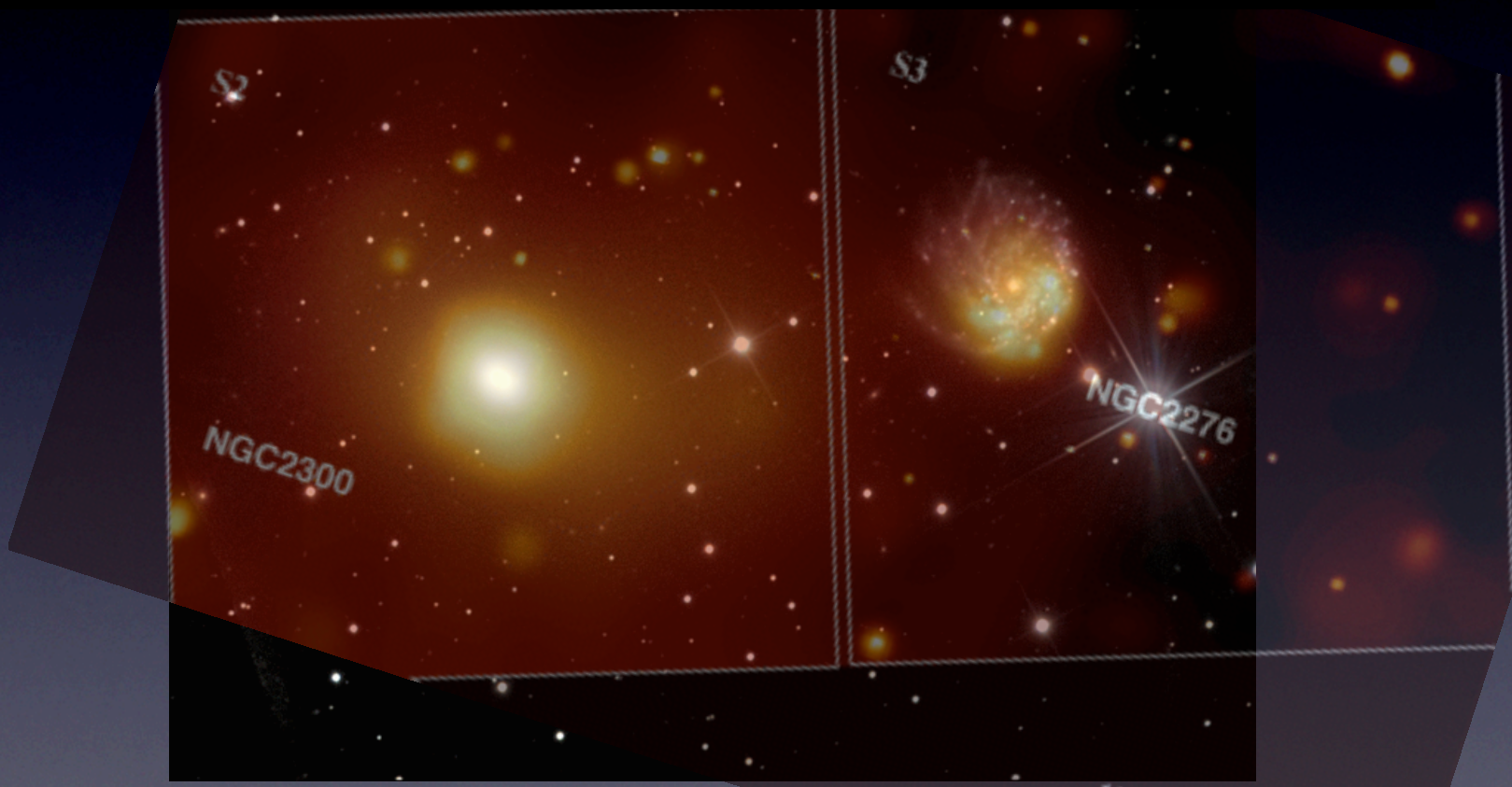

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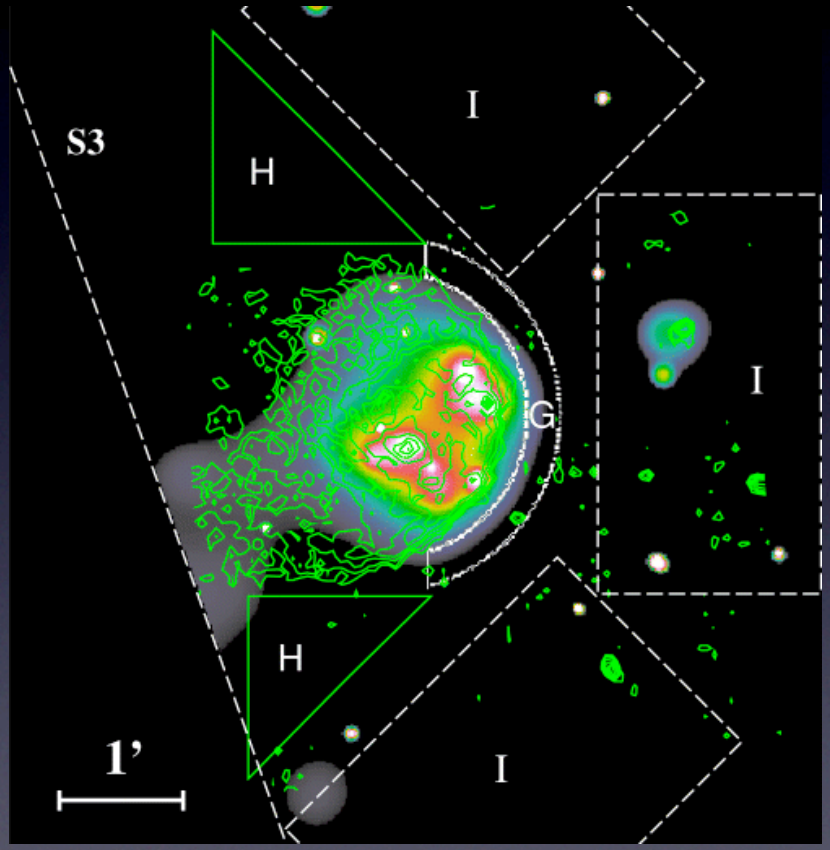

NGC 2276: Chandra X-ray image +
VLA 1.49 GHz contors

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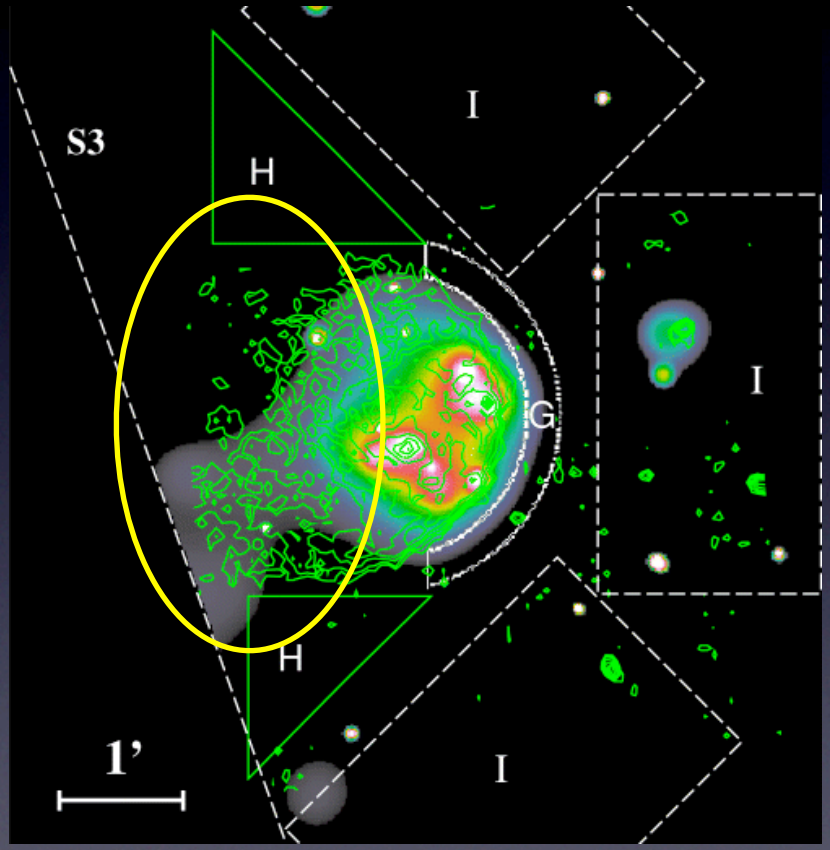

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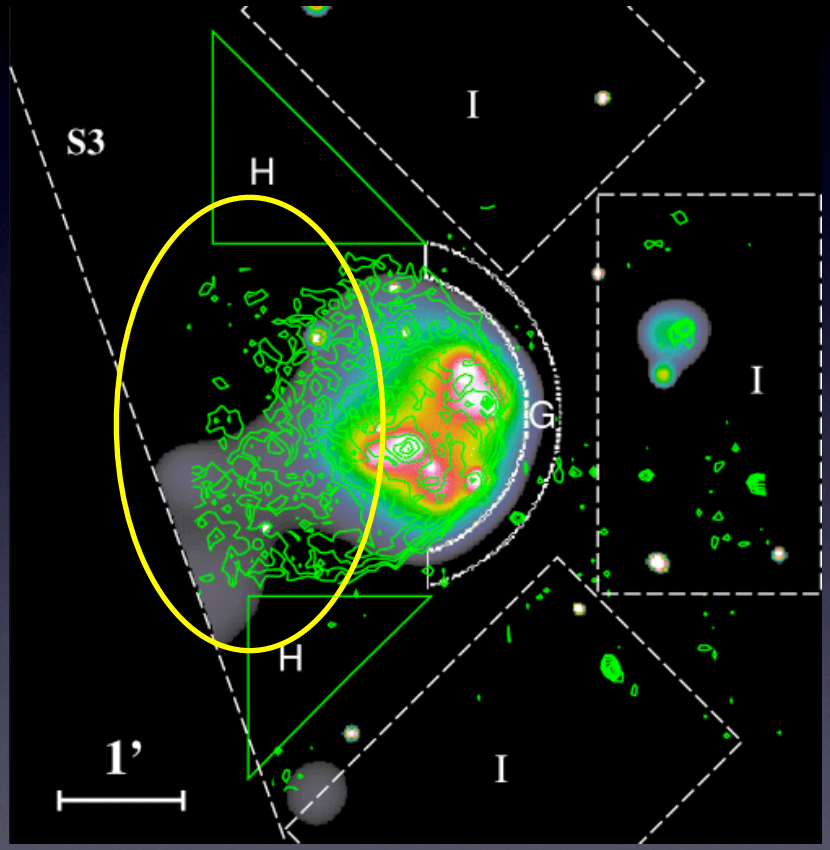

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