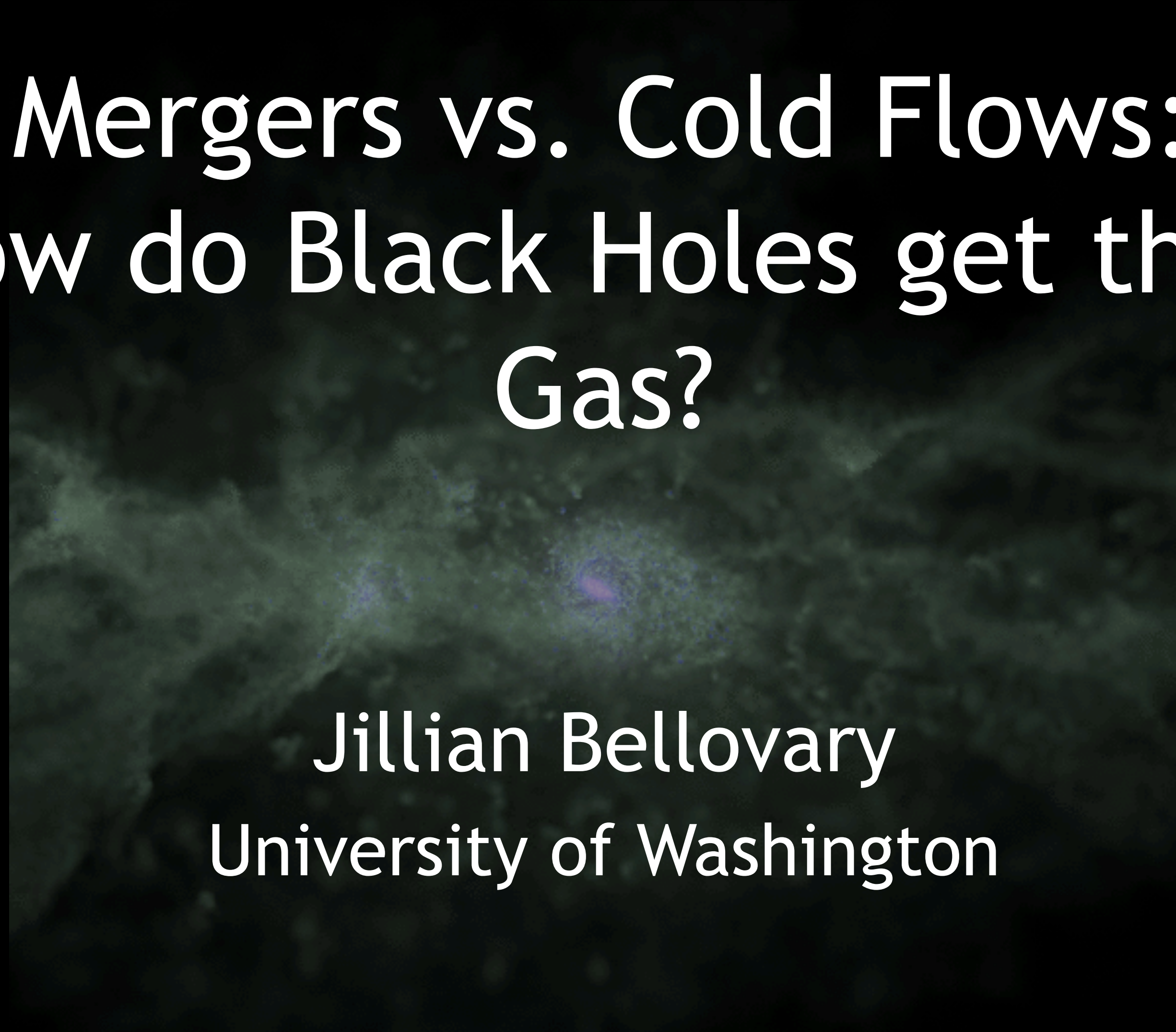
Mergers vs. Cold Flows: How do Black Holes get their Gas?



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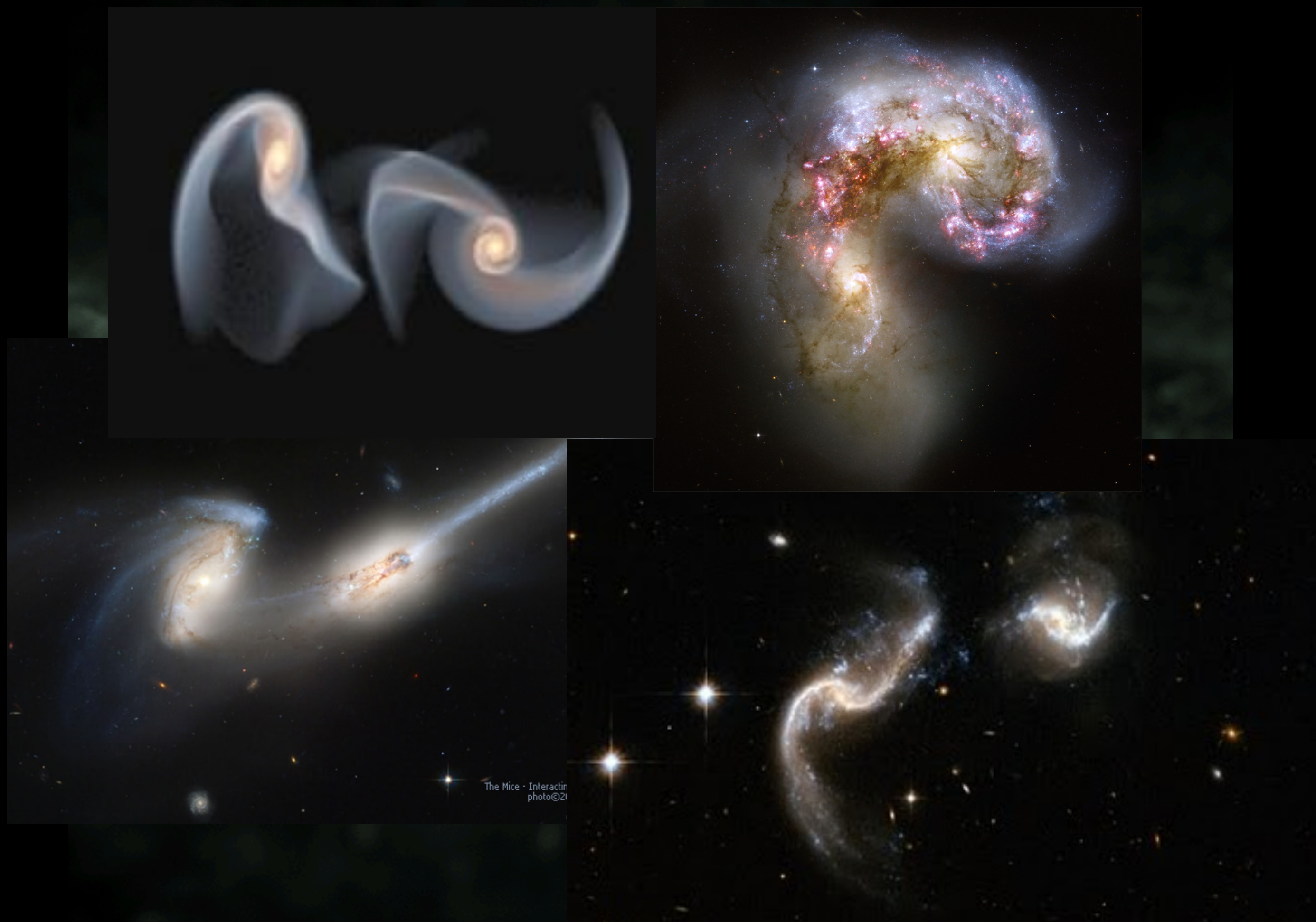
Mergers, or… ?



What role do they really play?

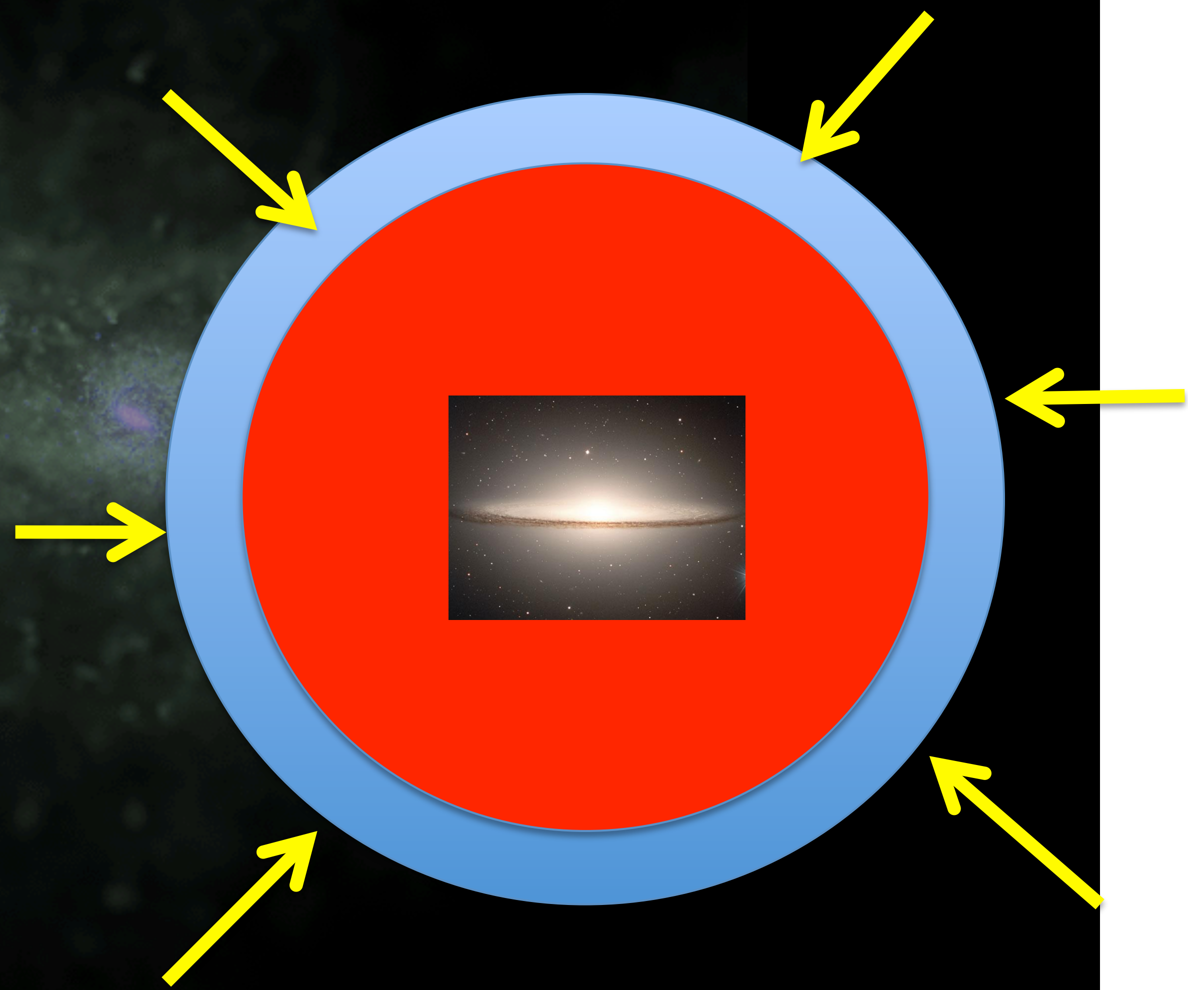
GASOLINE

- SPH *N*-body code (Wadsley et al. 2004)
  - Star formation, supernova feedback, metal diffusion, metal line cooling

    See Governato+09,10; Brooks+07,09; Zolotov+09; Pontzen+08,10; Stinson+06
- New additions:
  - Seed BH formation
  - BH mergers
  - BH accretion
  - BH blastwave feedback

How do galaxies get their gas?

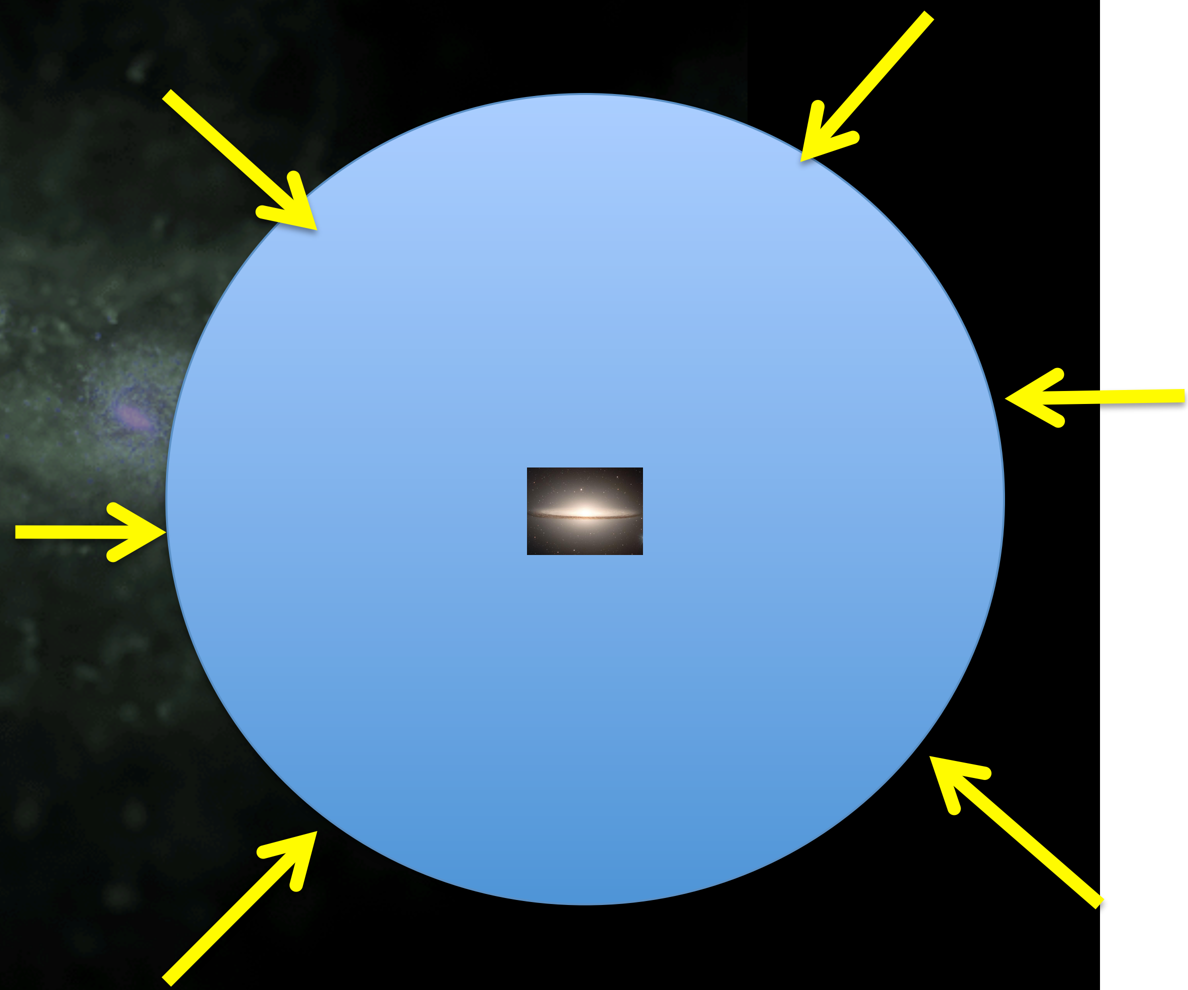
Gas enters the virial radius, shocks, and falls in to the disk



See Brooks et al. 2009

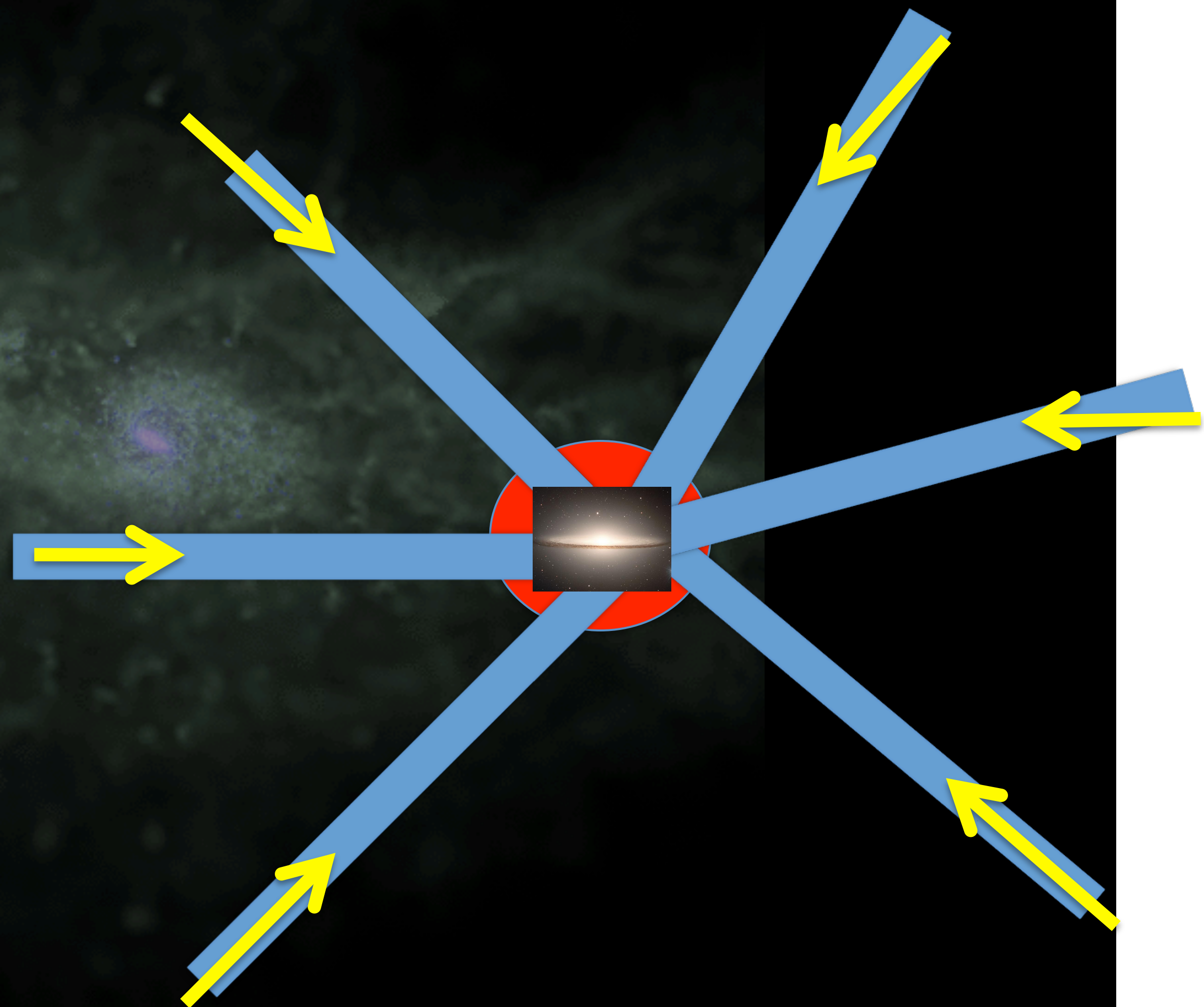
How do galaxies get their gas?

Low-mass galaxies simply accrete cold gas



How do galaxies get their gas?

Even when a shock develops, cold filaments can penetrate the shock

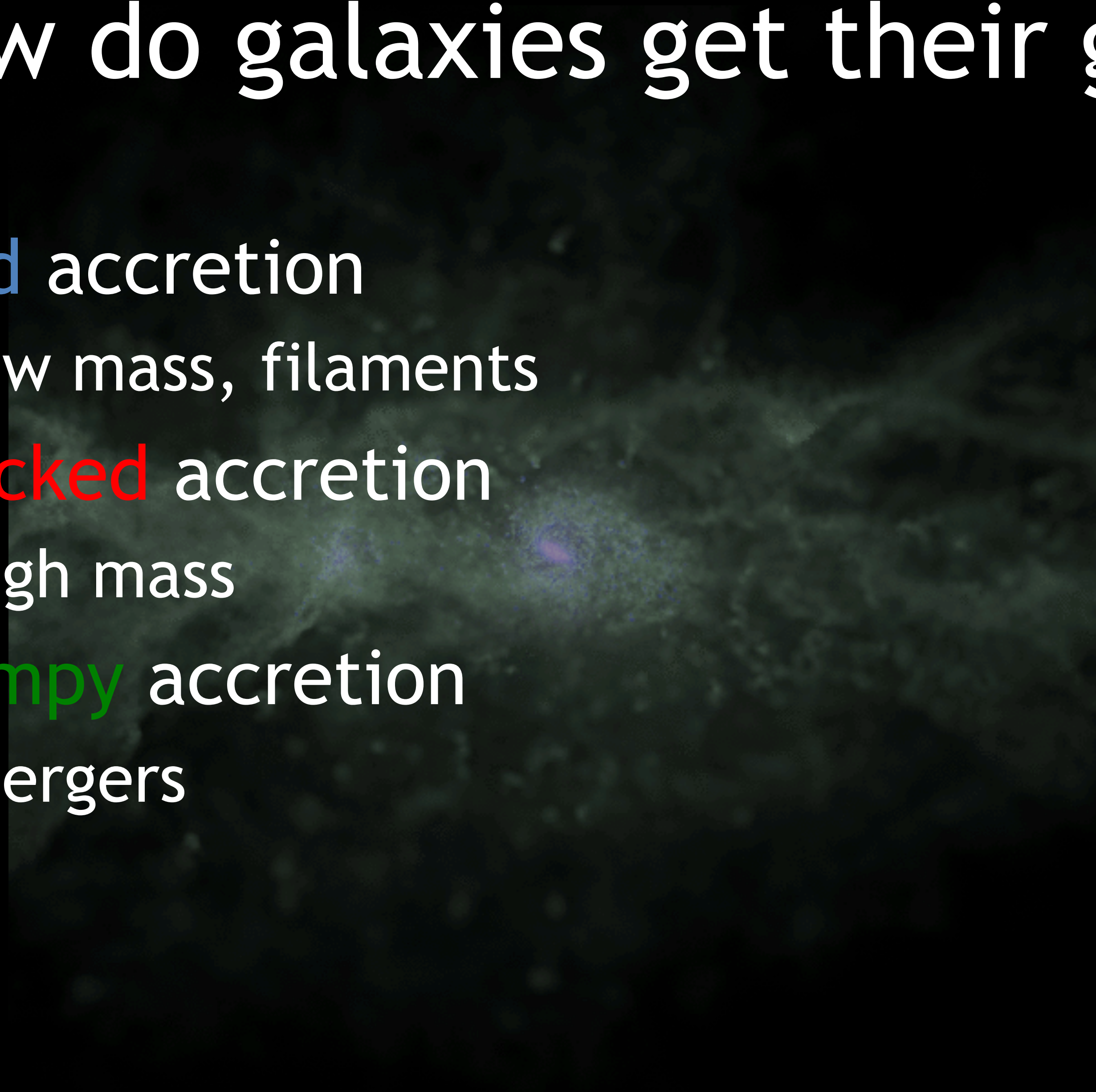


How do galaxies get their gas?

Of course, mergers deliver gas as well

How do galaxies get their gas?

- Cold accretion
  - low mass, filaments
- Shocked accretion
  - high mass
- Clumpy accretion
  - mergers



How do Black Holes get their gas?

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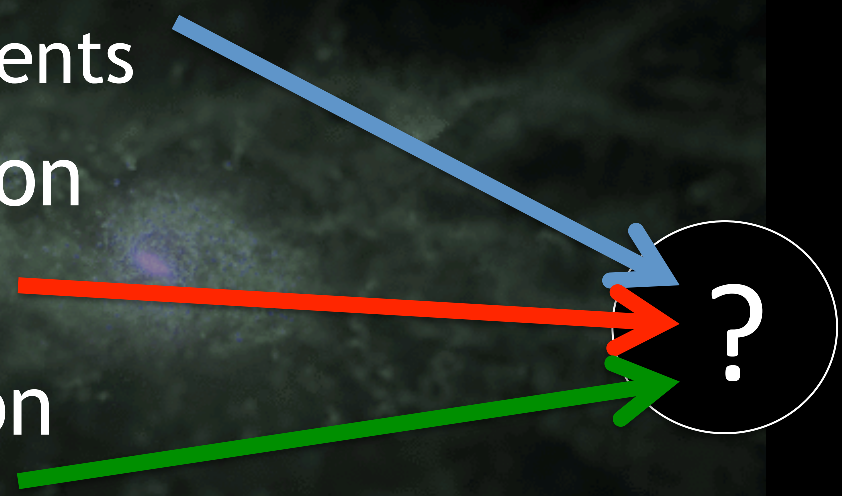
  - low mass, filaments
- Shocked accretion
  - high mass
- Clumpy accretion
  - mergers

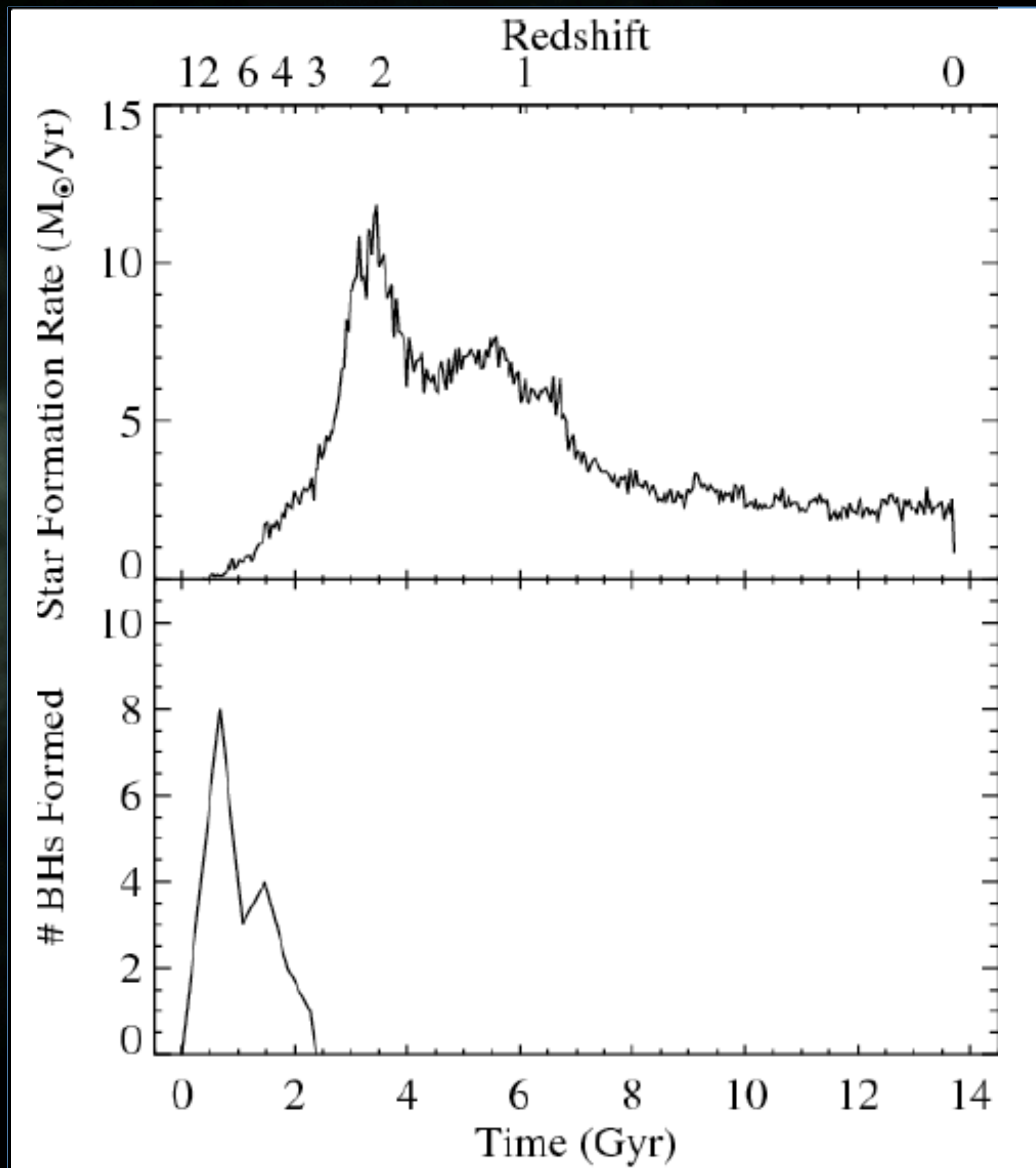


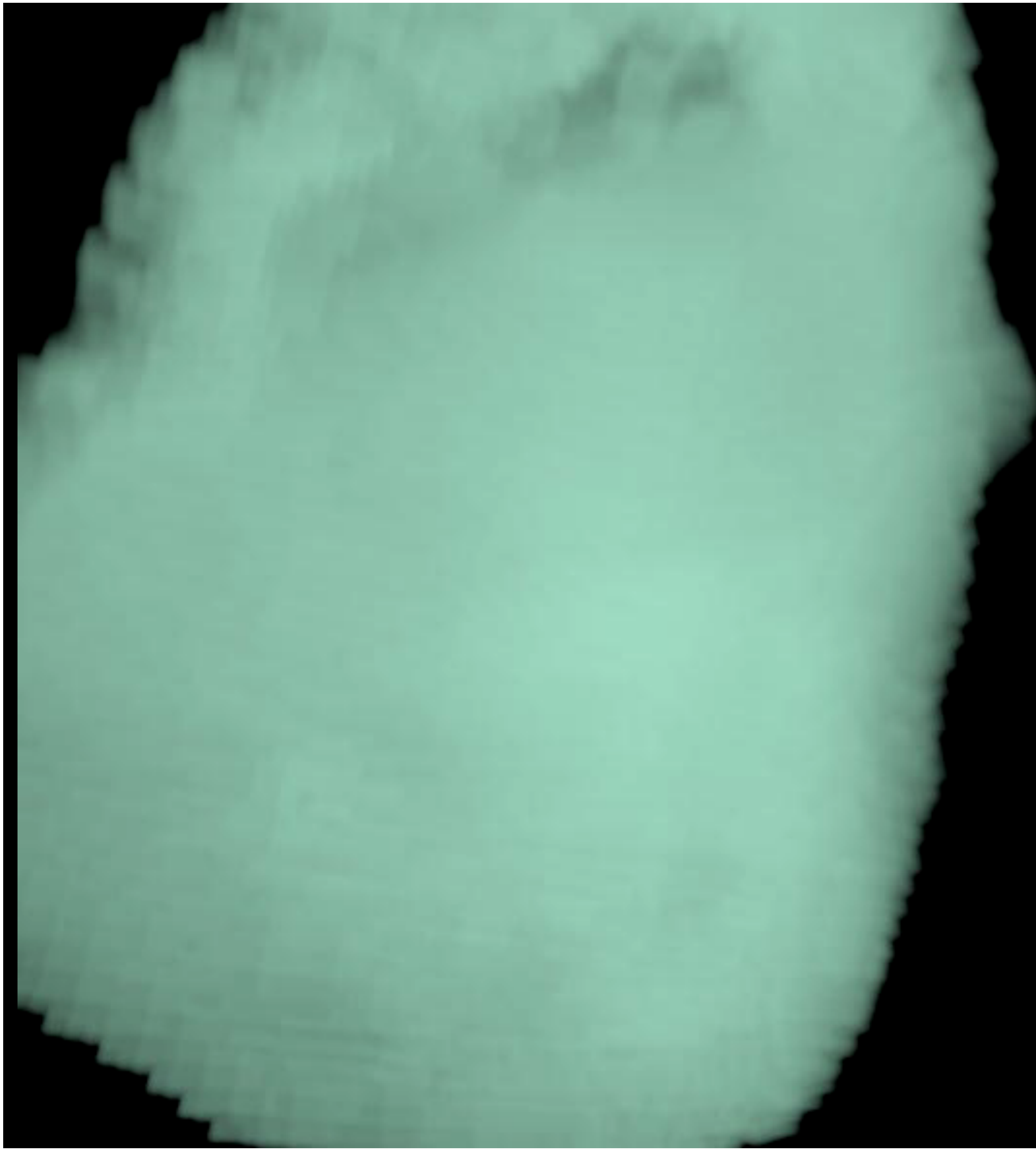
Seed BH Prescription

- Forming Seed BHs
  - Form seed black holes out of cold, dense, zero-metallicity gas
  - Seed mass same as gas particle
    (10^4 - 10^6 $M_\odot$)
  - Probability of forming star or black hole

Purely local prescription

Seeds form early





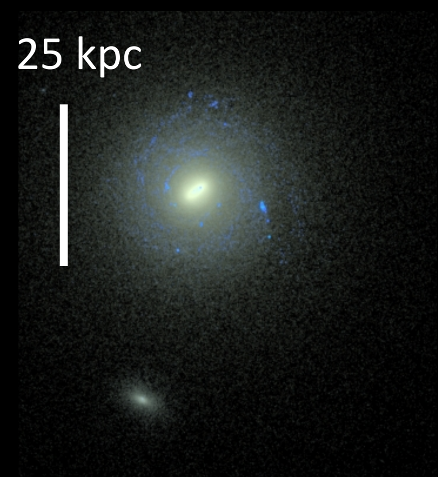
Milky Way - like galaxy

At z=0:

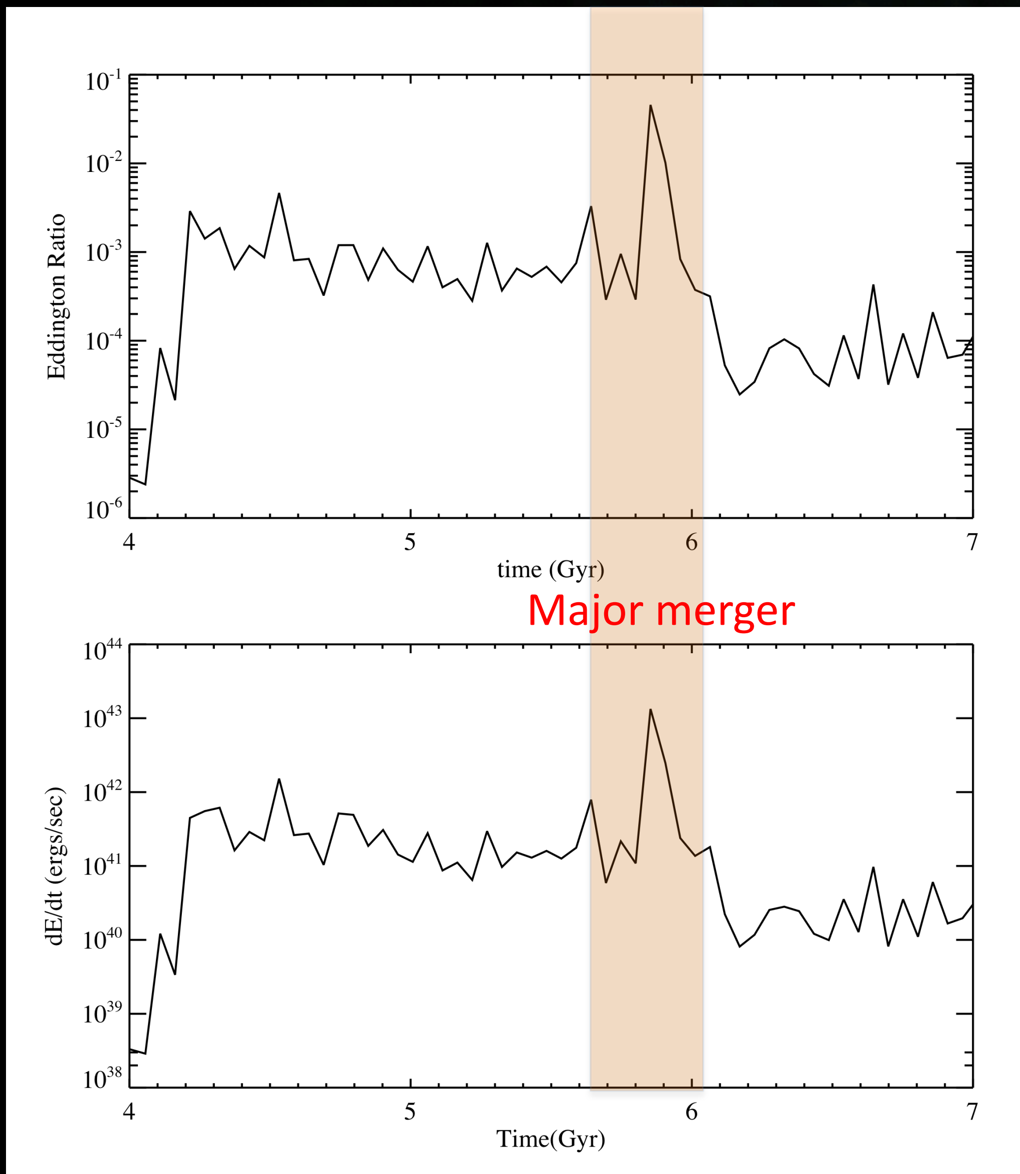
$M_{tot} = 8 \times 10^{11}\ M_{\odot}$

$M_{BH} = 1.7 \times 10^{7}\ M_{\odot}$

i = -22



MW galaxy to z=0

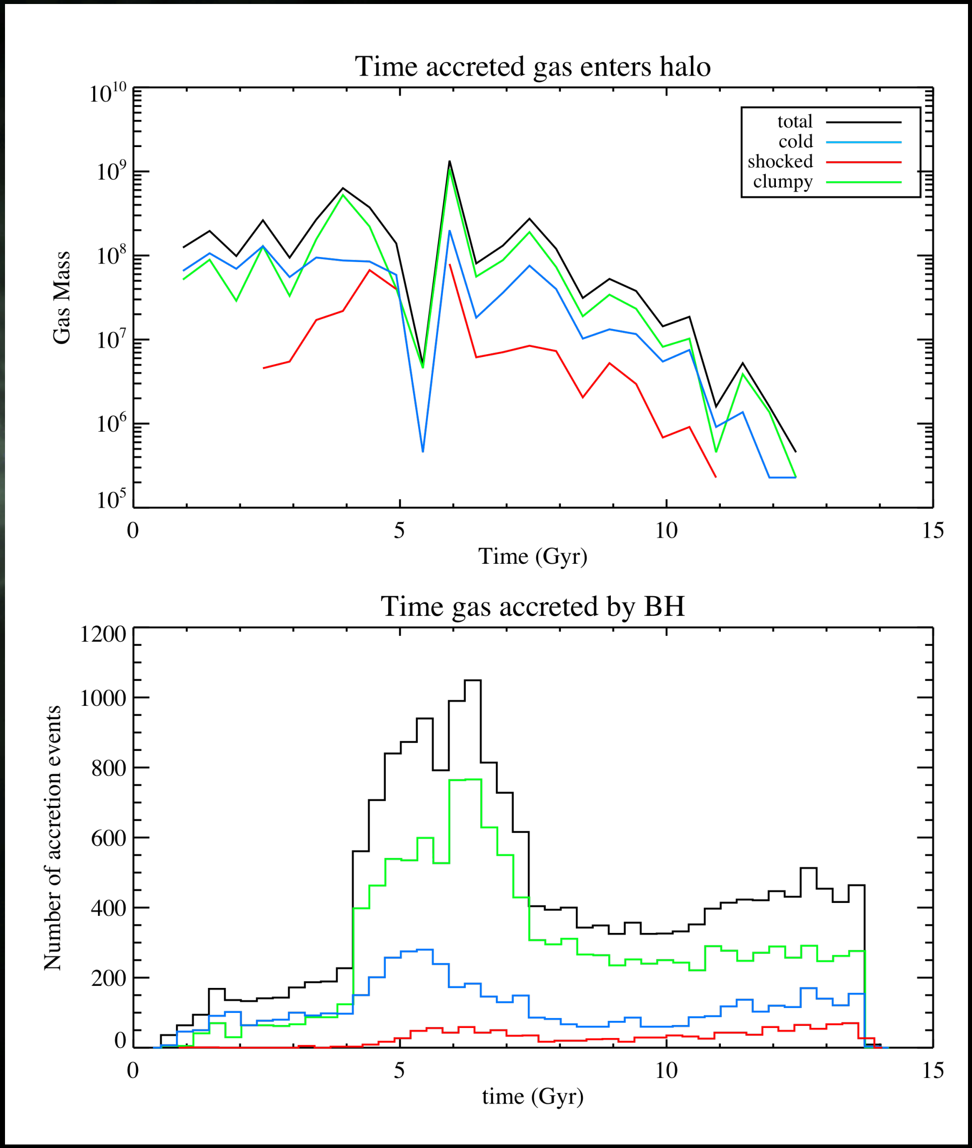


A few % of L/L_{edd}

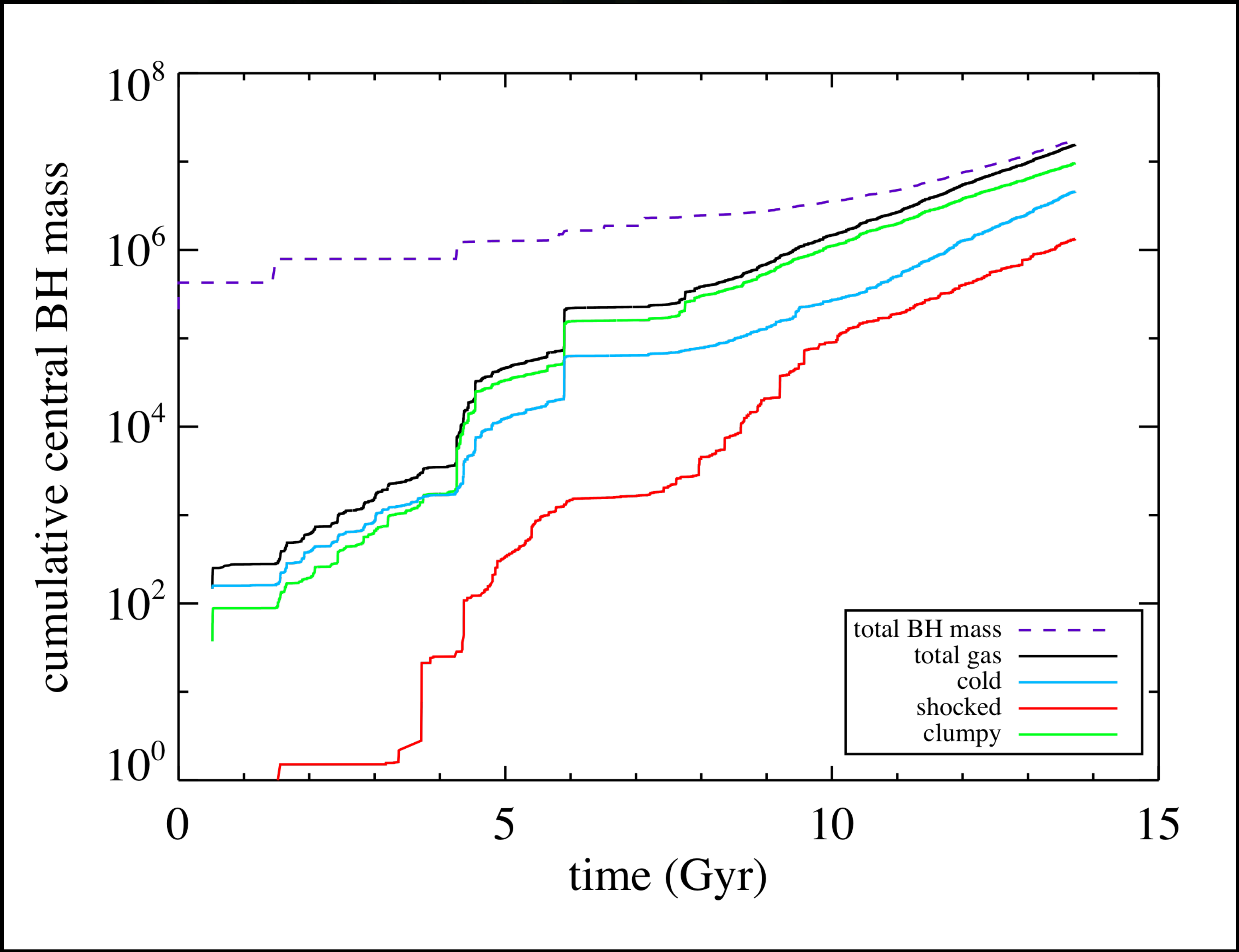
L_{BOL} comparable to a Seyfert galaxy

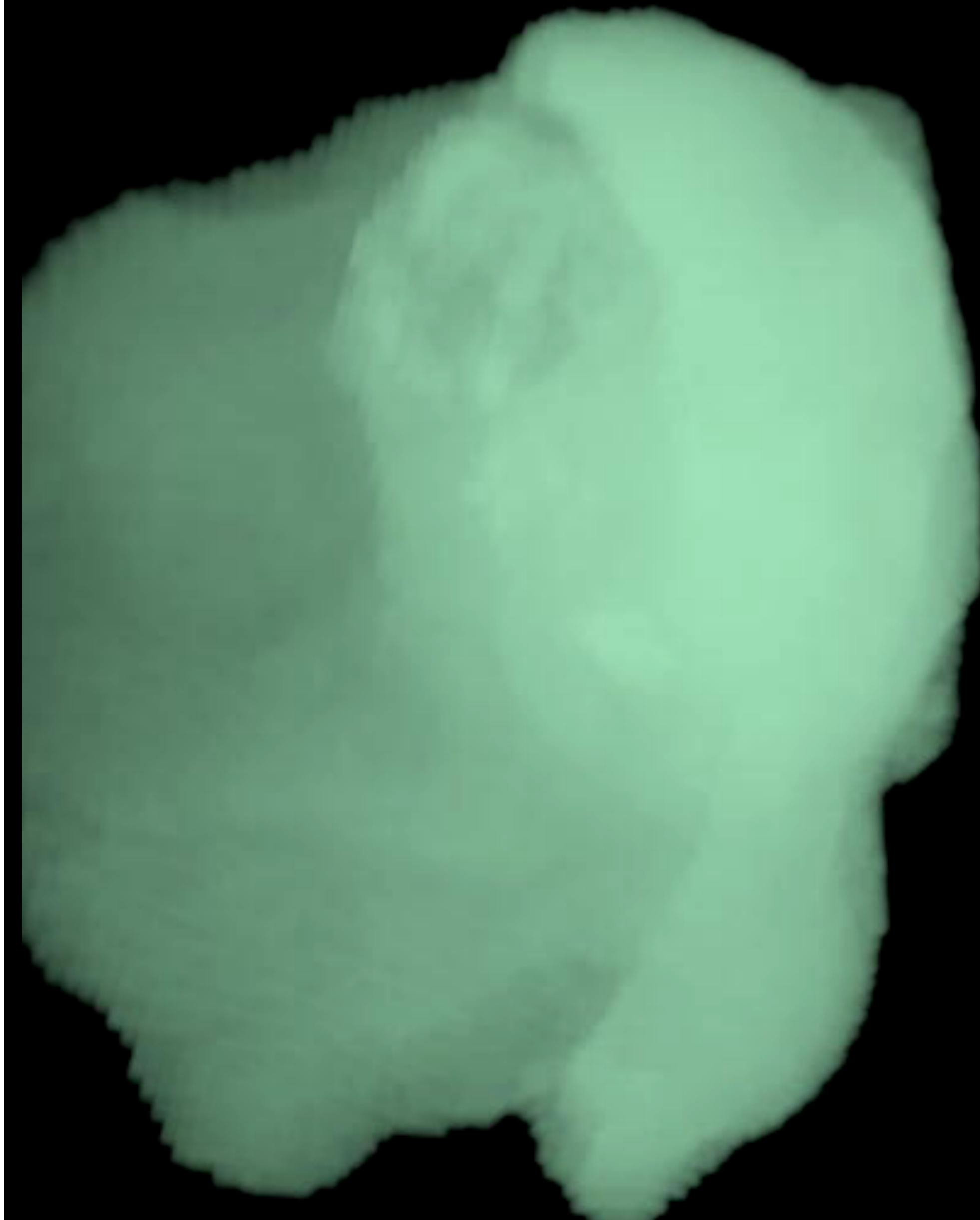
MW galaxy to z=0

Once major mergers begin, the central BH predominantly accretes clumpy gas



MW galaxy to z=0





High redshift galaxy:

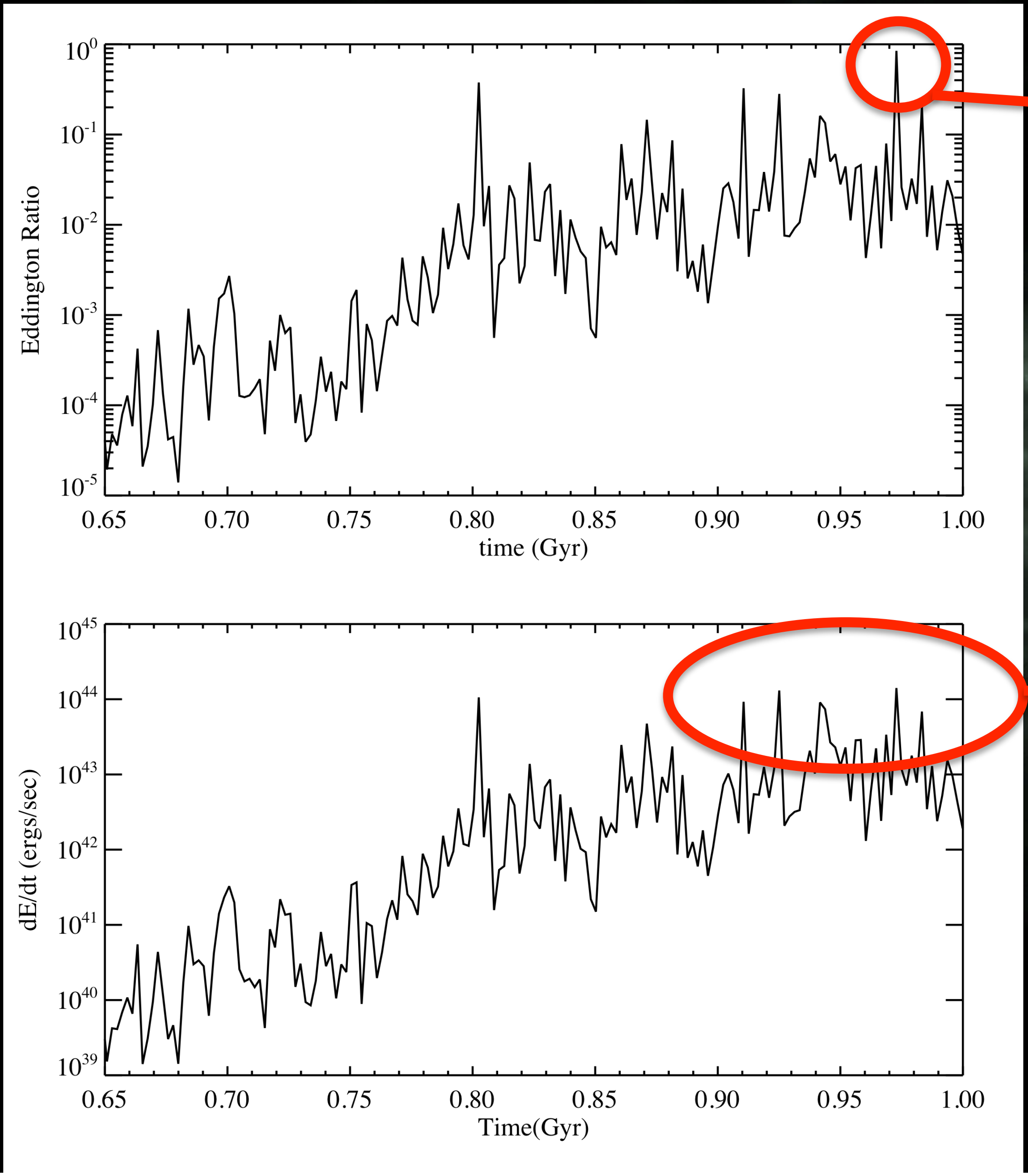
At $z = 6$:

$M = 1.4 \times 10^{11}\ M_{\odot}$

$M_{BH} = 6.4 \times 10^{6}\ M_{\odot}$

$SFR = 20\ M_{\odot}/yr$

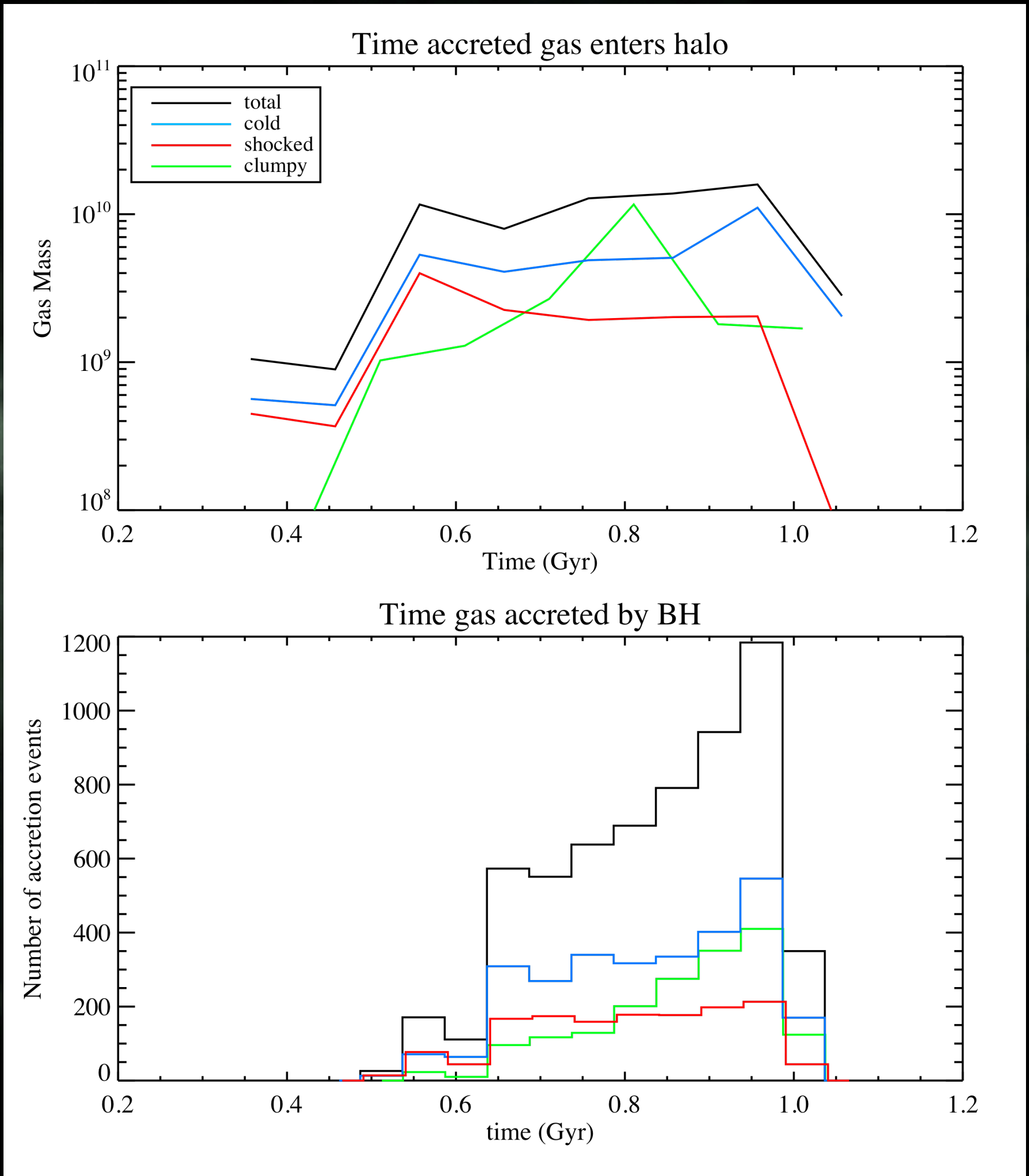
High z BH history



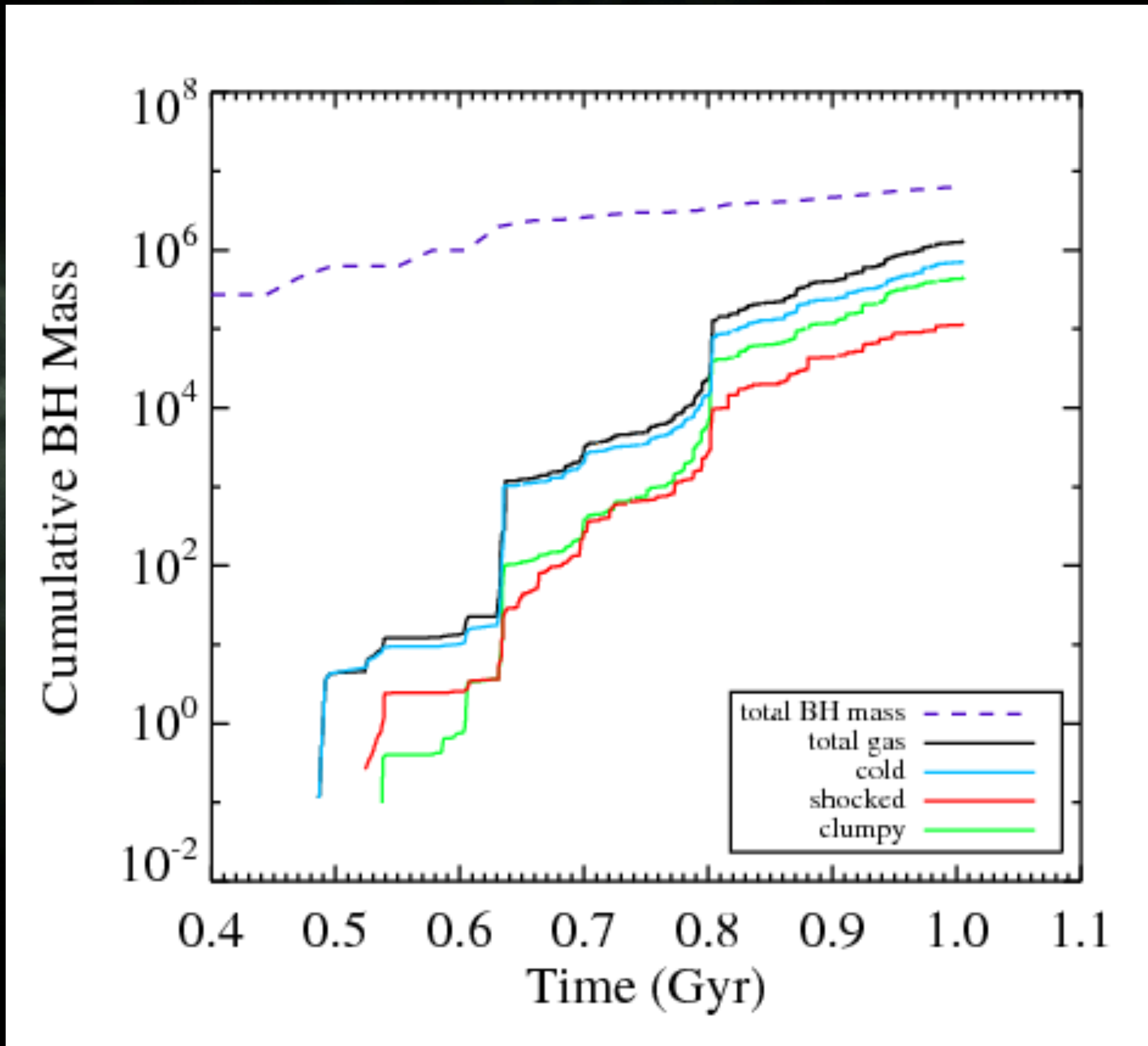
Approaches Eddington-limited accretion

$L_{BOL} \sim 10^{44}$ ergs/s

High z gal to z=6



High z gal to z=6



What does it all mean…

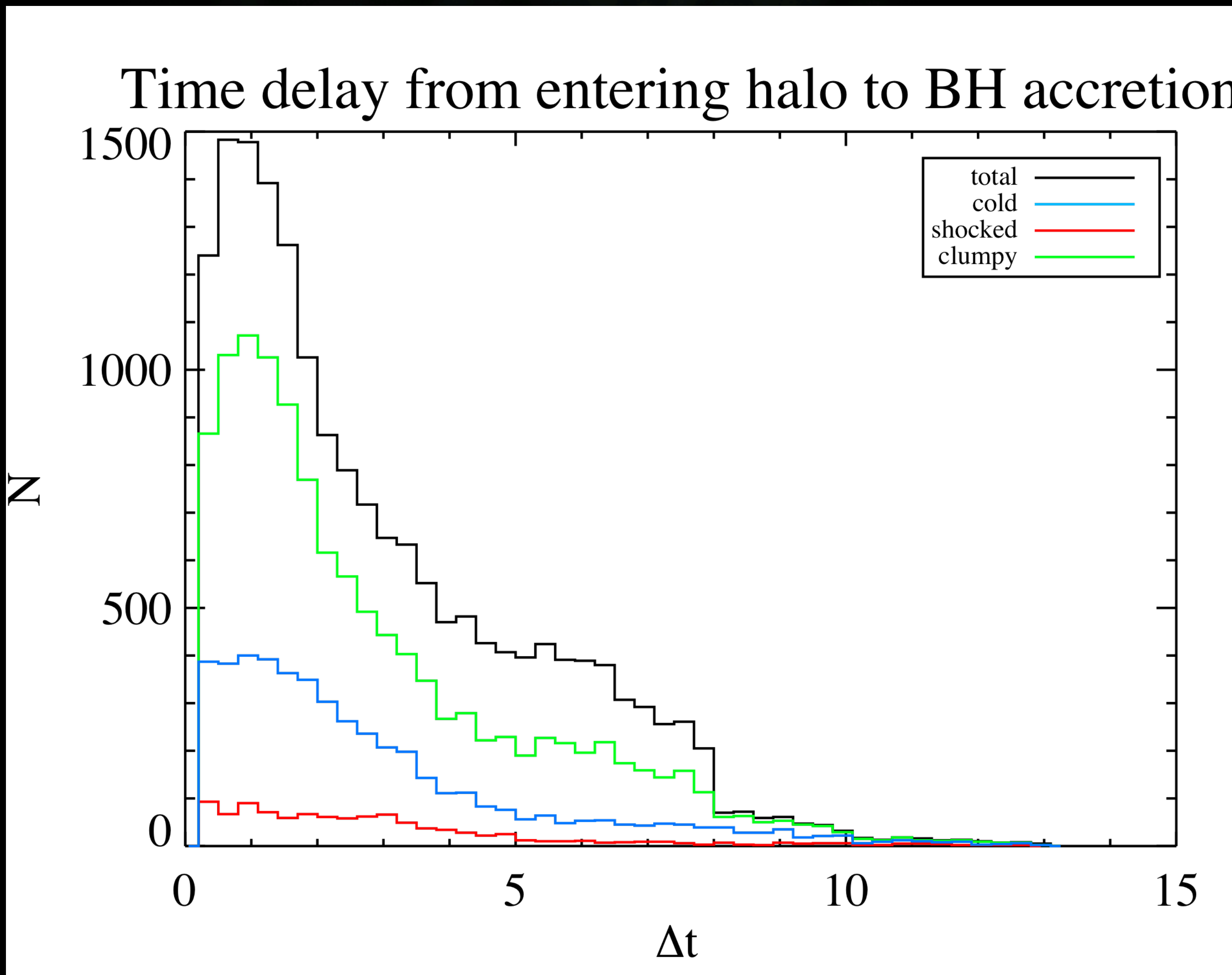
	MW halo	MW BH	High z halo	High z BH
Cold	37%	30%	63%	56%
Clumpy	45%	61%	30%	34%
Shocked	18%	9%	6%	9%

BHs accrete clumpy gas more efficiently than cold gas

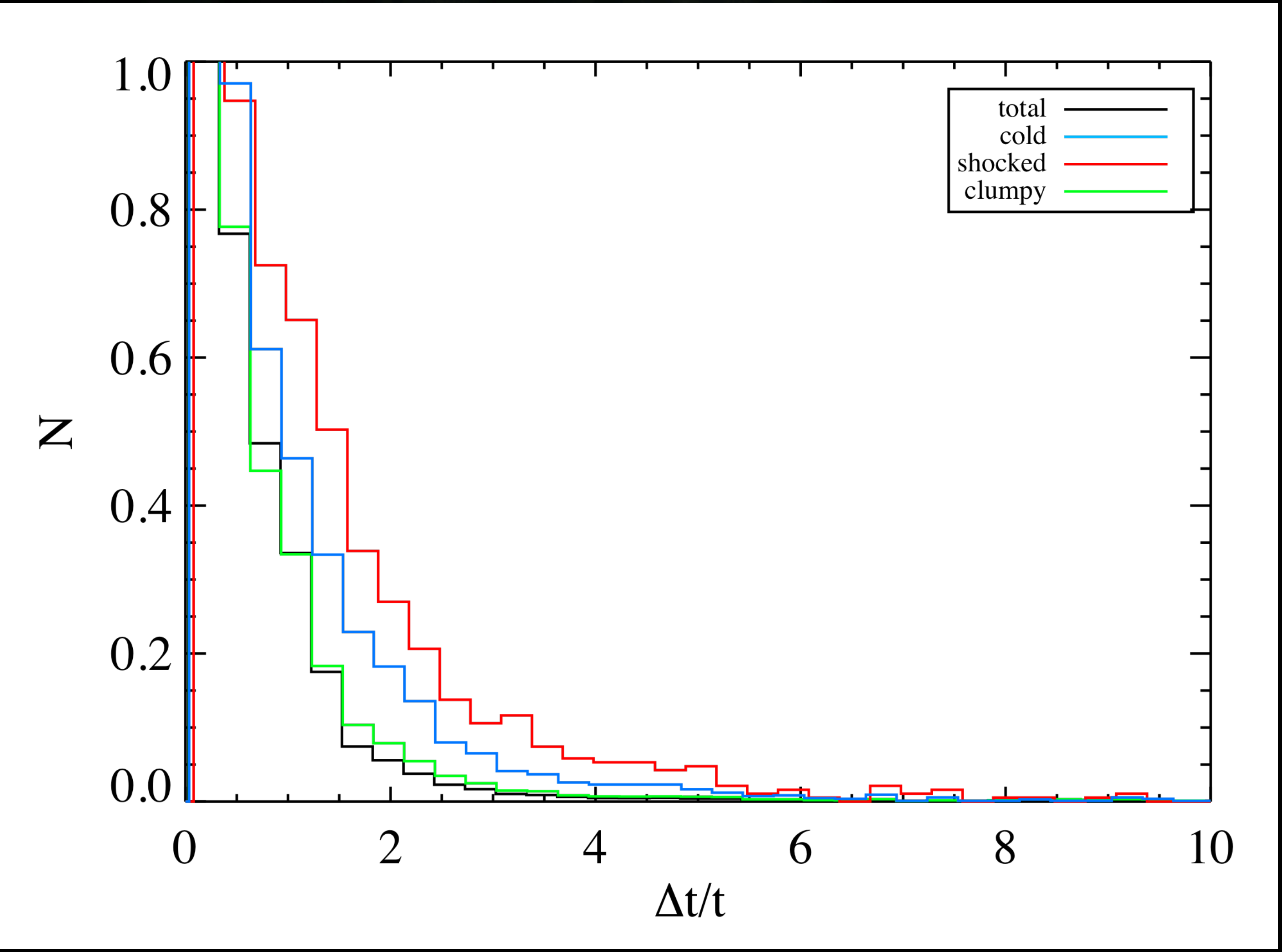
Summary

- A Milky Way-like galaxy's BH grows mainly through clumpy accretion (i.e. gas from mergers)
- Clumpy gas more efficient at fueling BHs
- BUT! secular processes (i.e. smooth gas accretion) can fuel a quasar at high z!

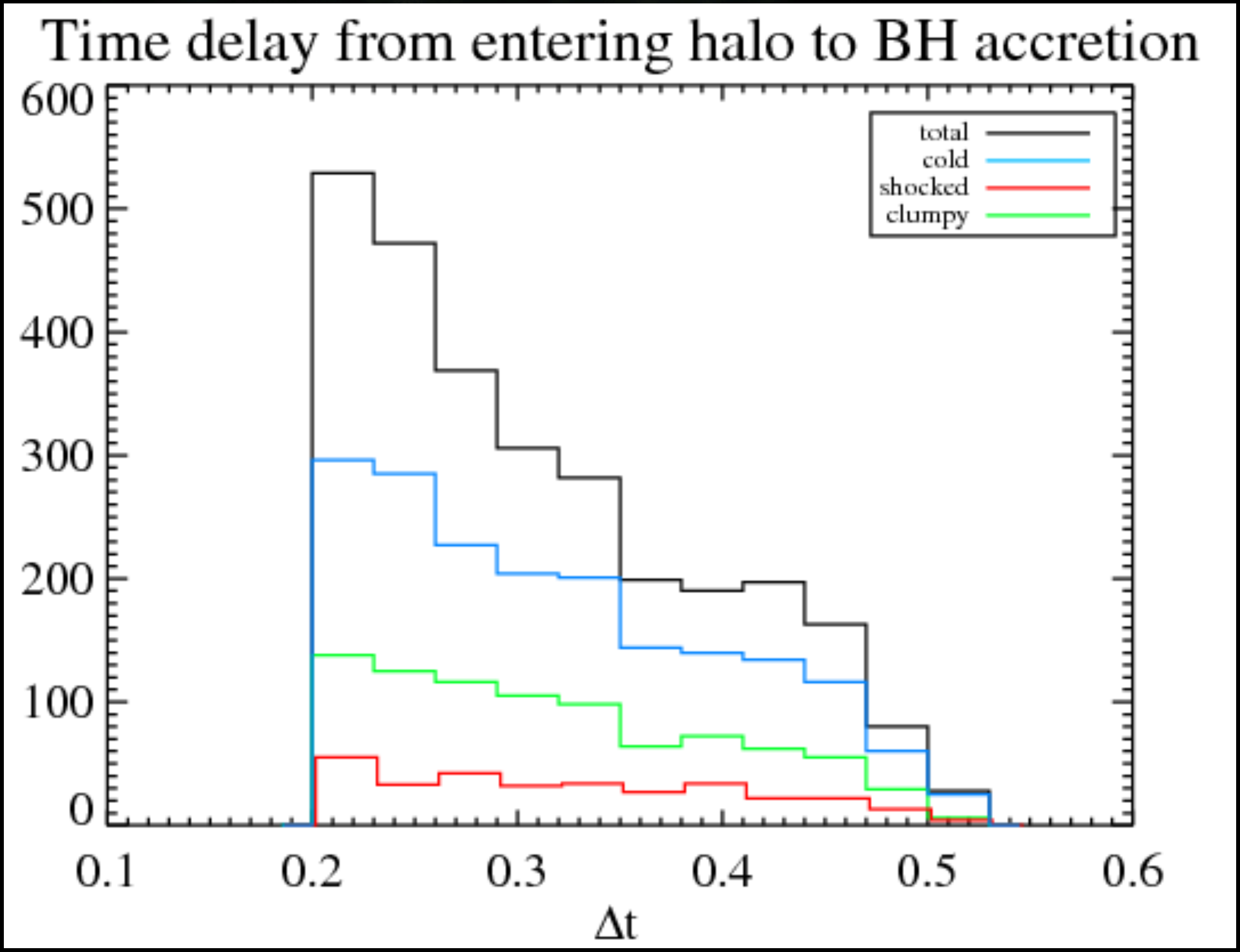
Time Delays


Time delay from entering halo to BH accretion
total
cold
shocked
clumpy
N
Δt
0
500
1000
1500
0
5
10
15

Normalized Time Delay



High z gal to z=6



Bulge Morphology