Satellites and Subhalos in LCDM

Garrison-Kimmel, Oñorbe et al.

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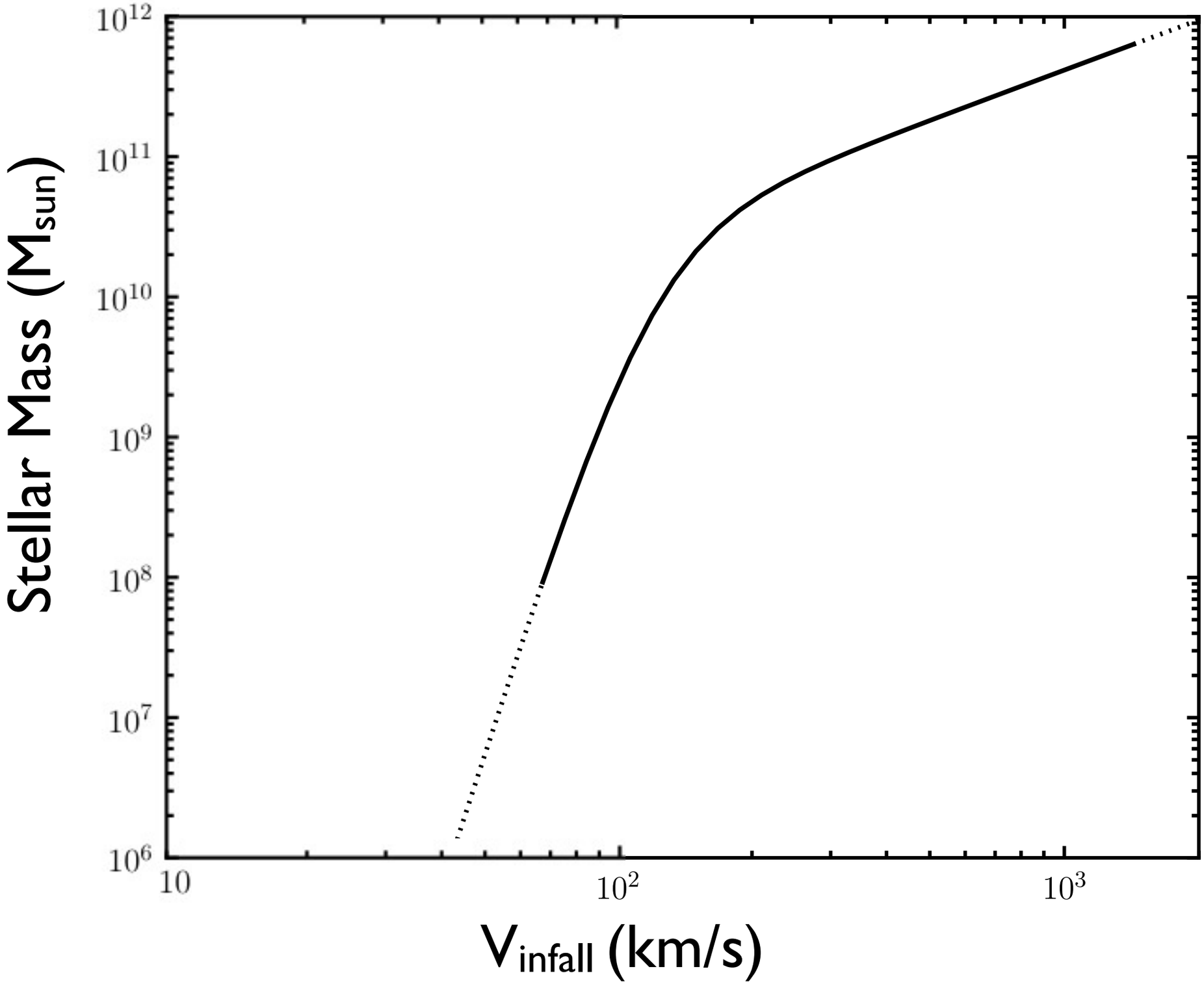
John **Phillips**

Mike **Boylan-Kolchin**
Betsy **Barton**

PrimackPalooza (2011)

Abundance Matching for Satellite Galaxies?



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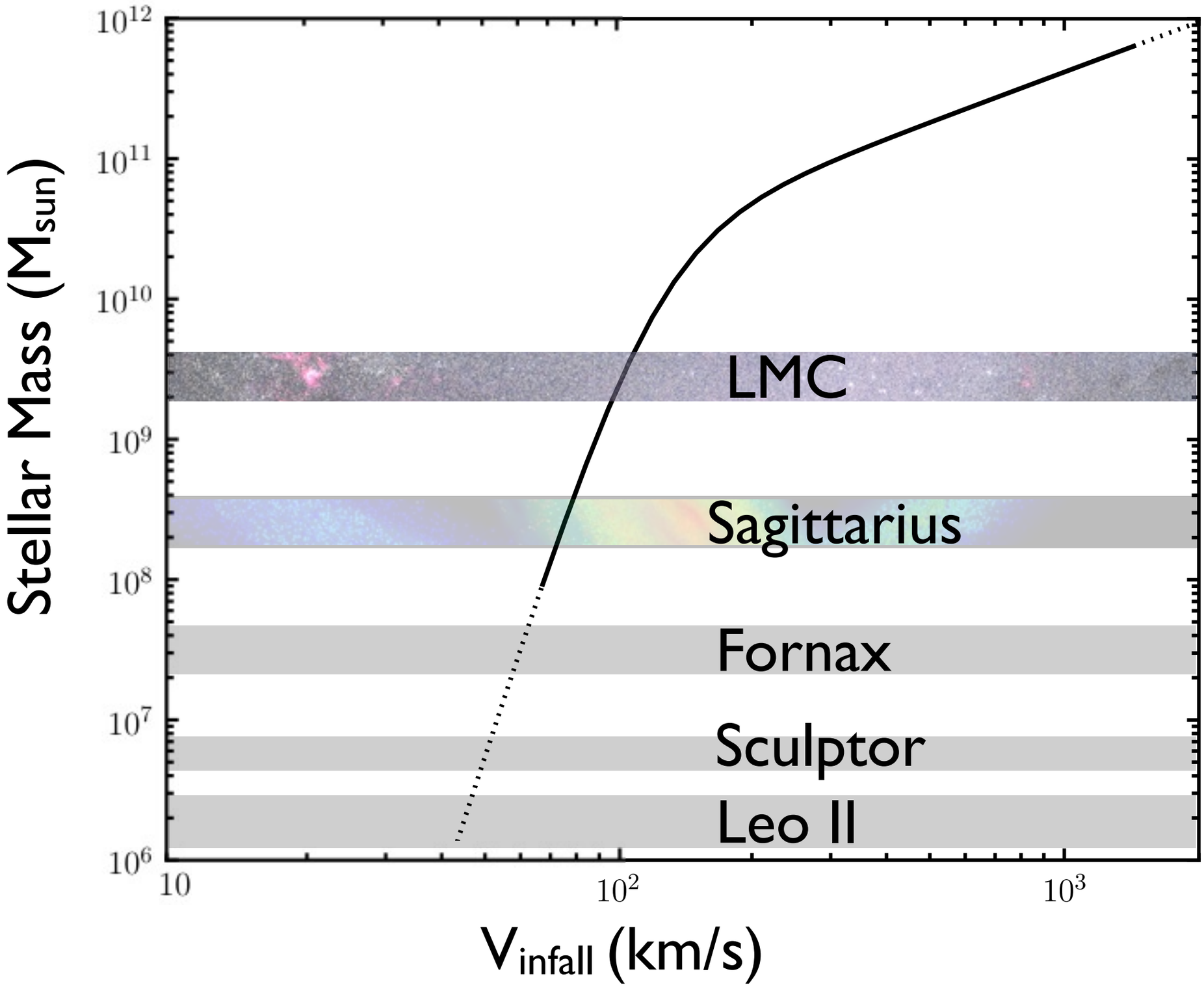

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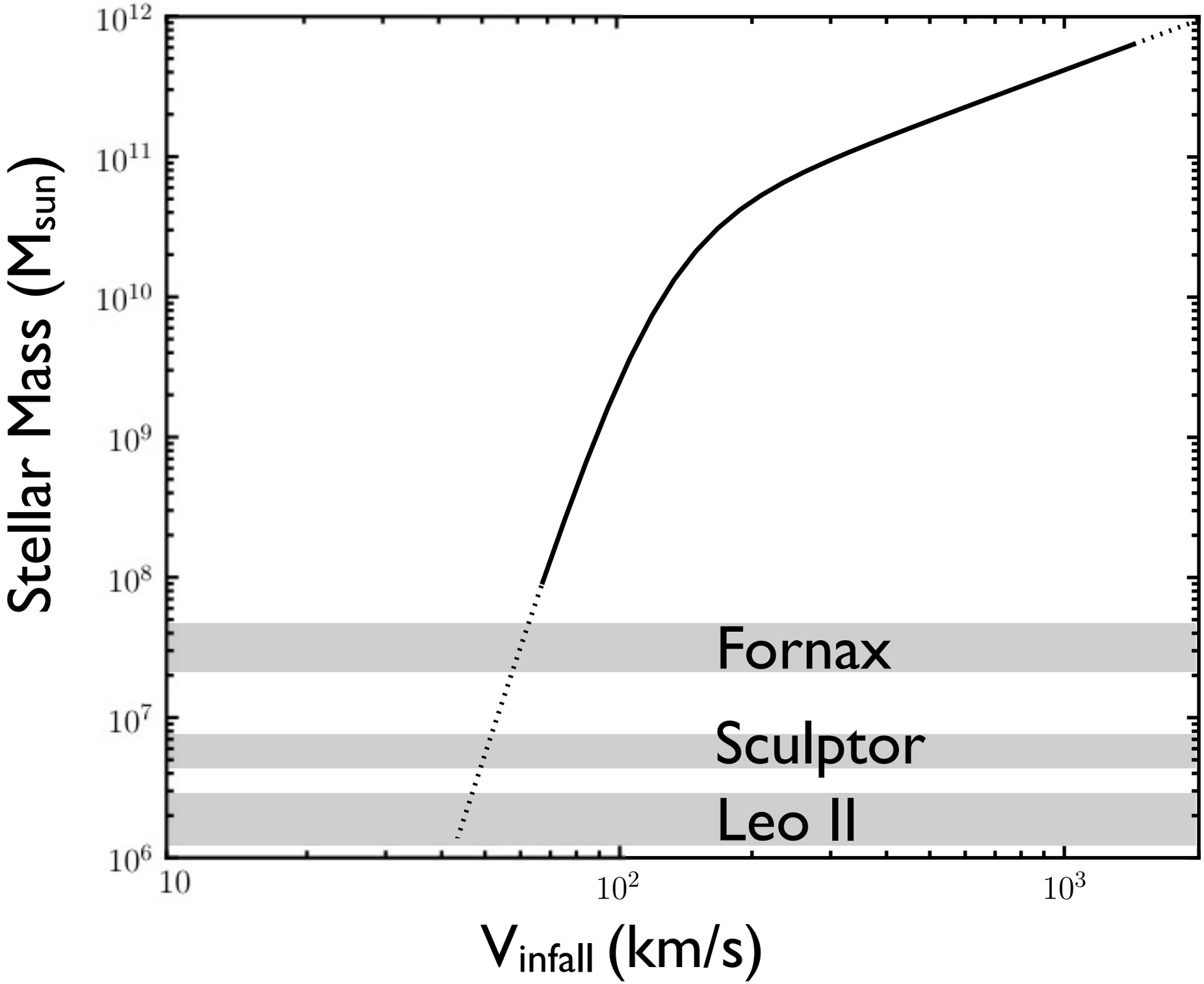

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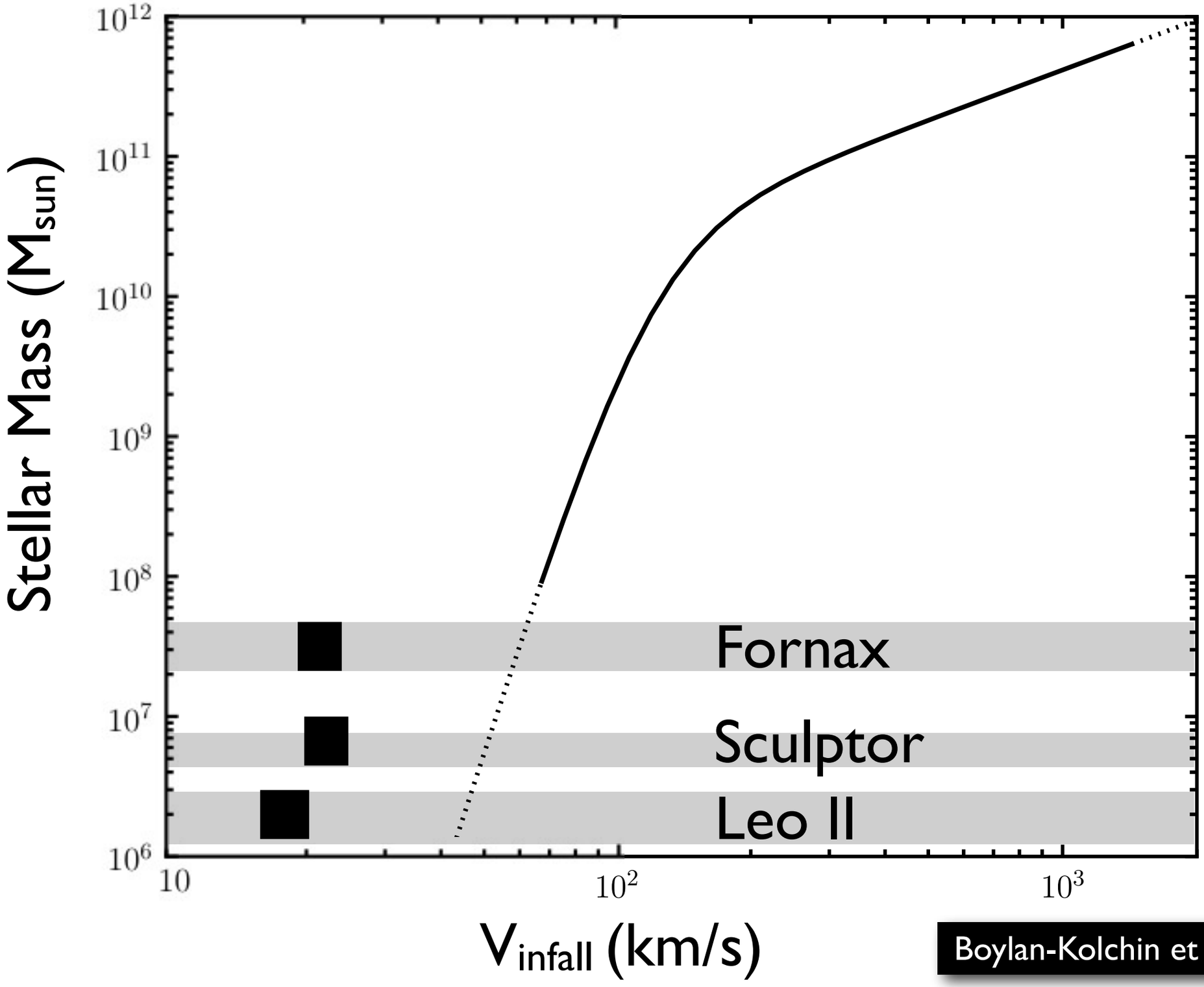

Boylan-Kolchin et al. 2011

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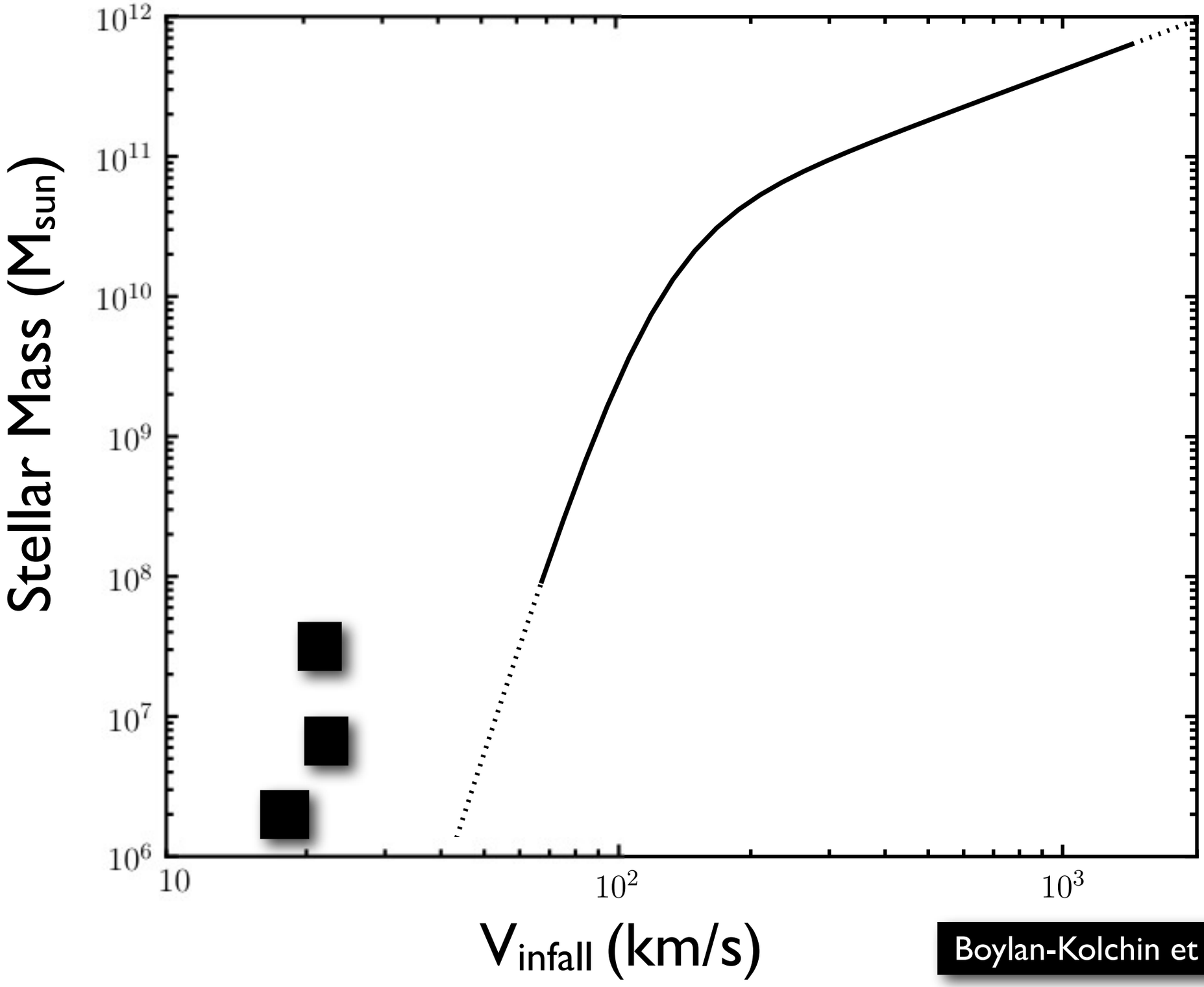

Boylan-Kolchin et al. 2011

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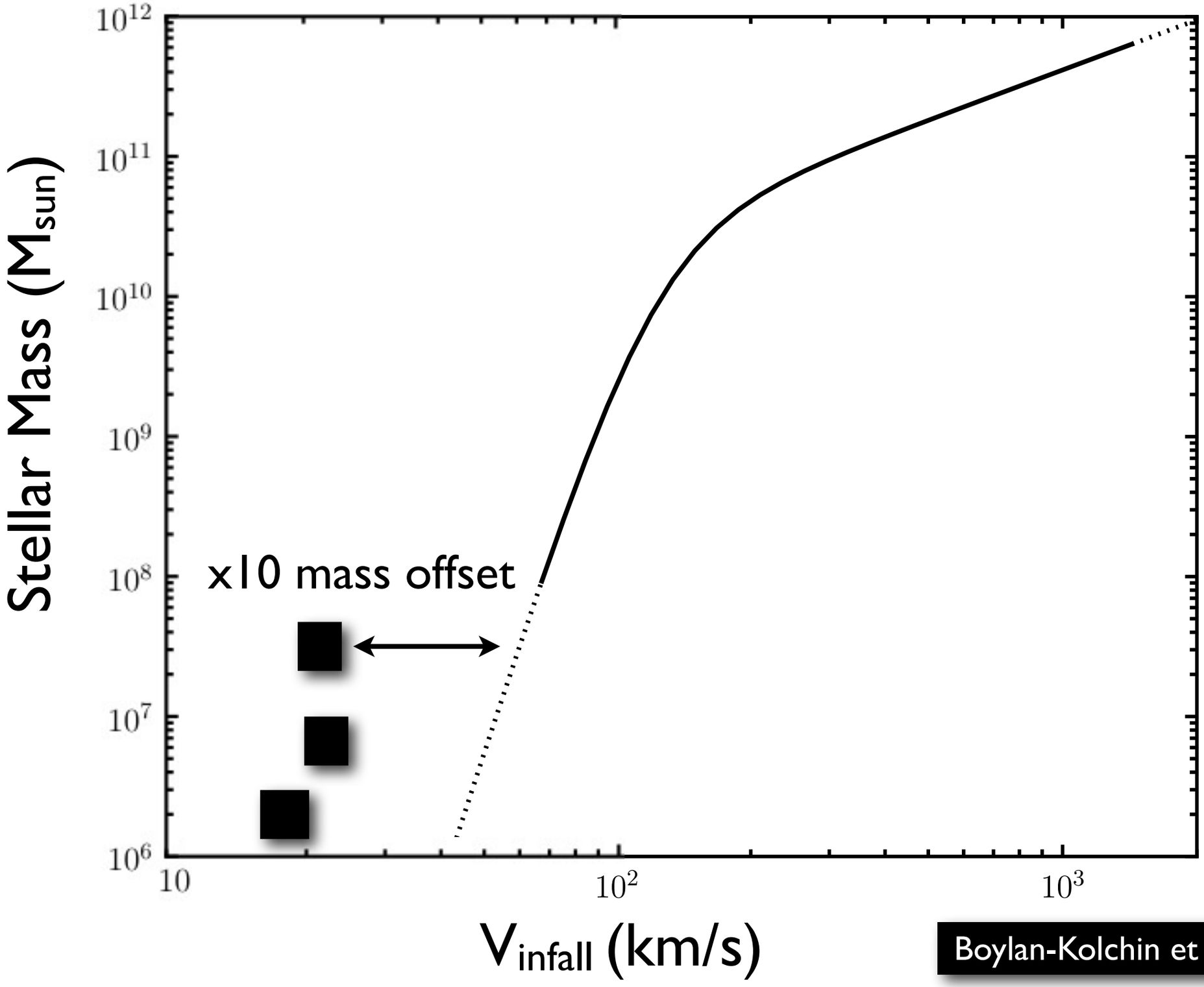

Boylan-Kolchin et al. 2011

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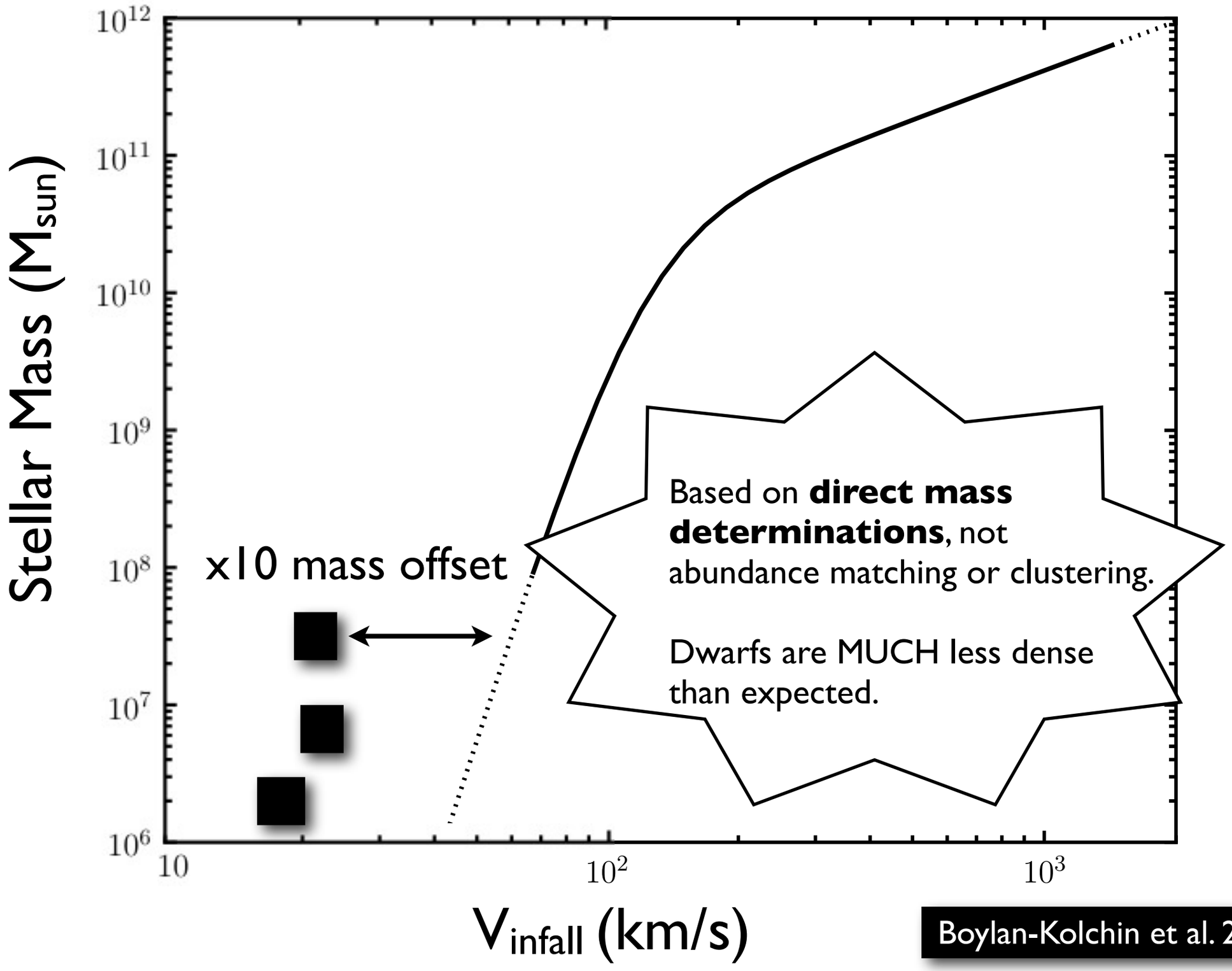

Boylan-Kolchin et al. 2011

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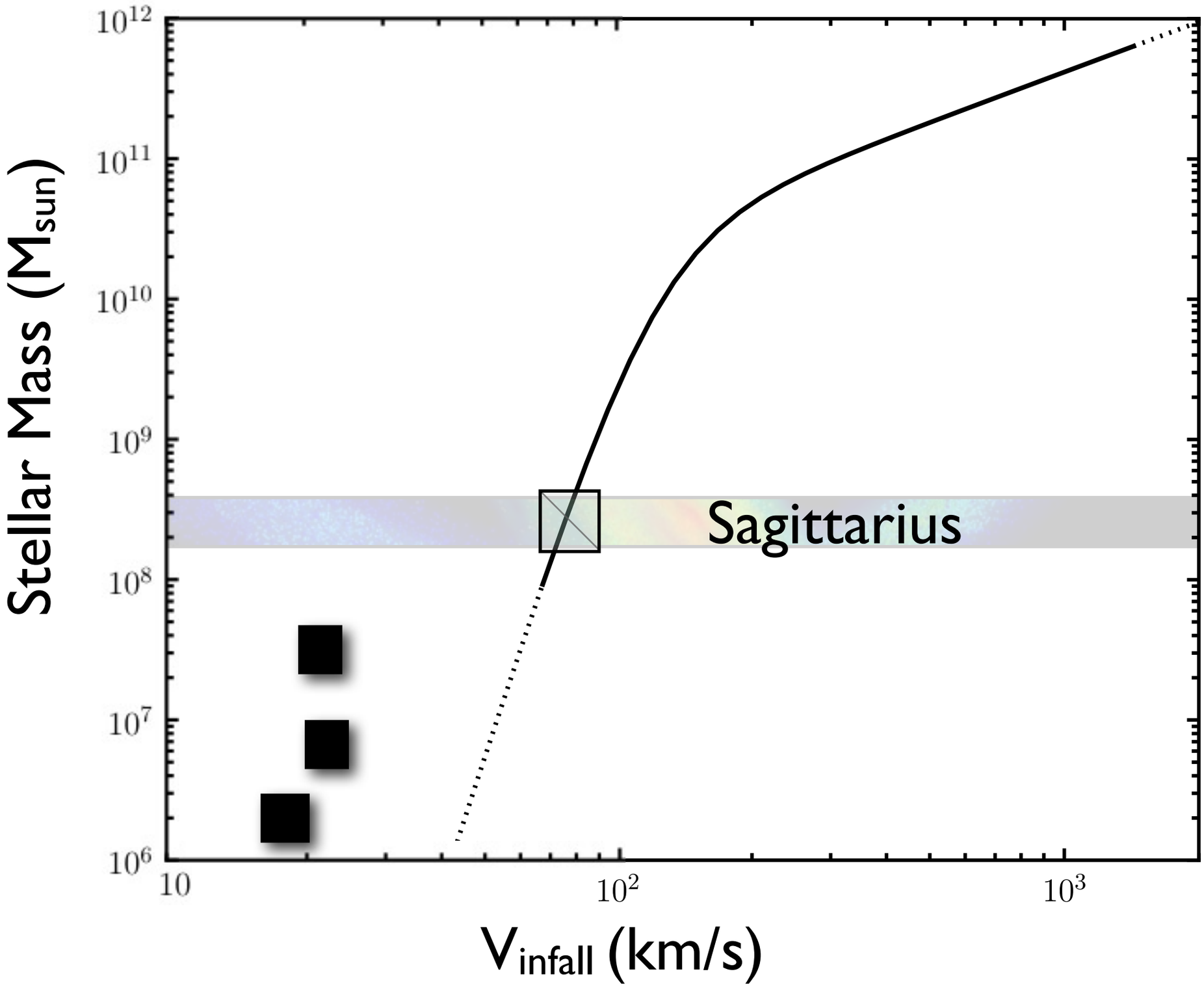

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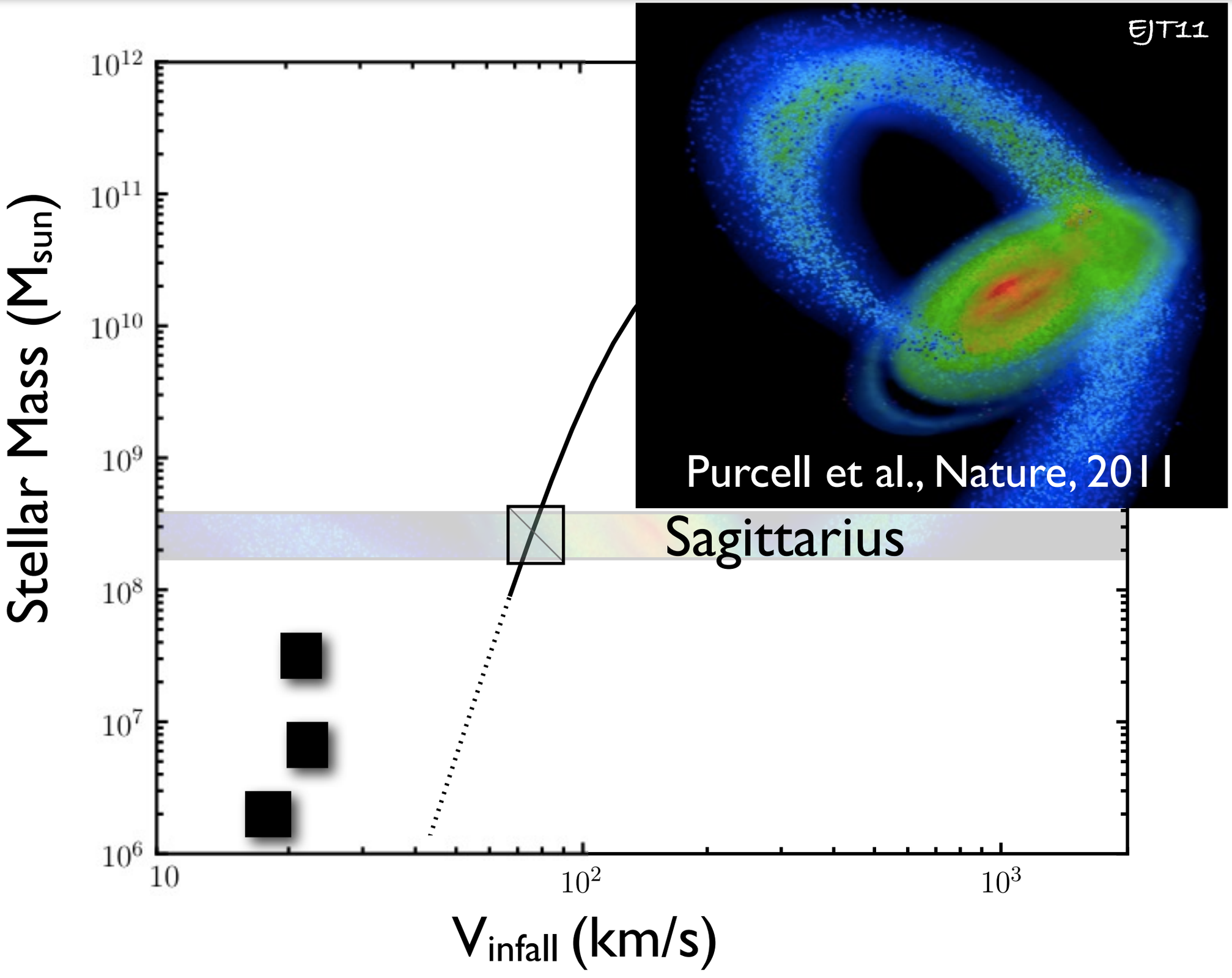

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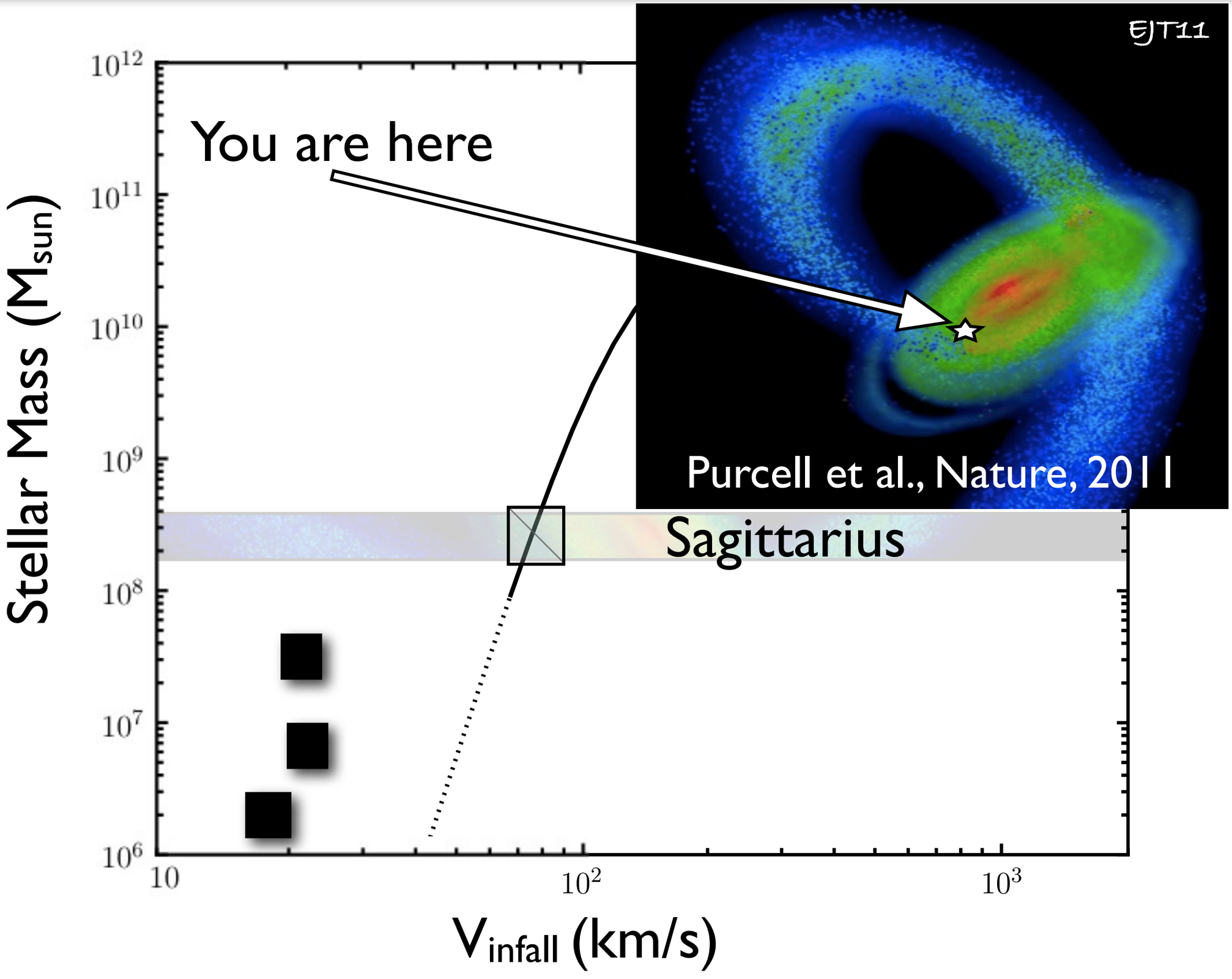

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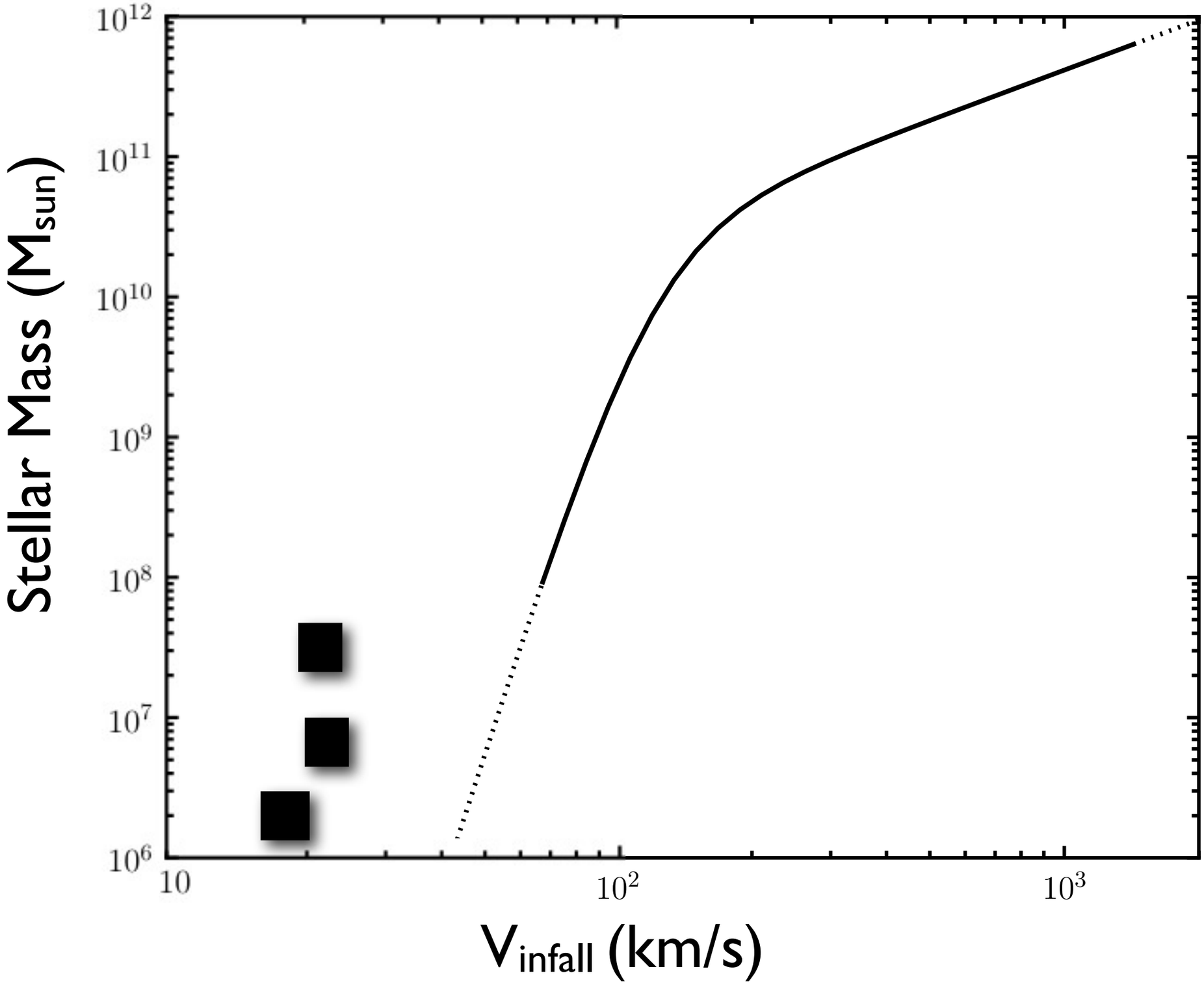

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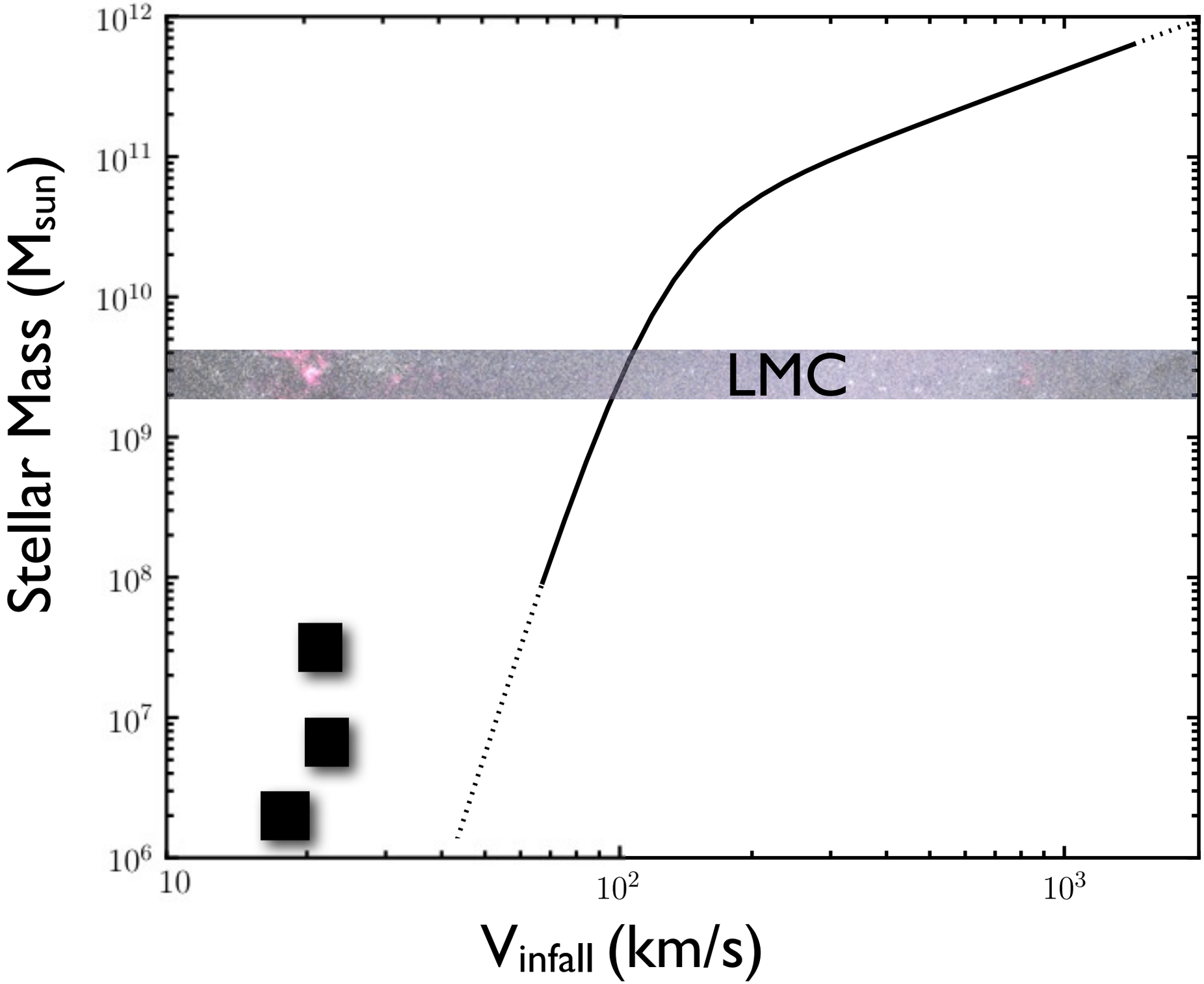

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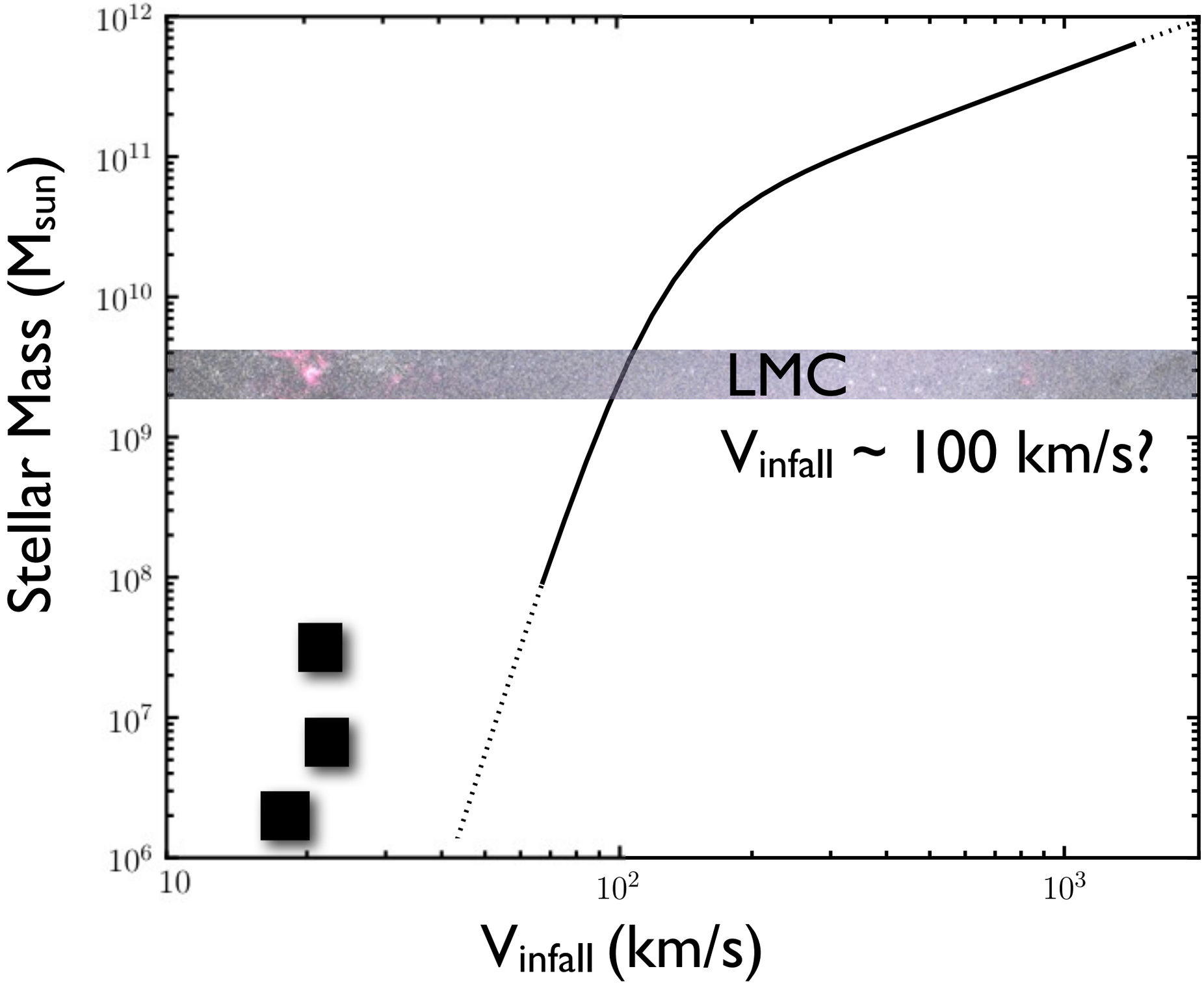

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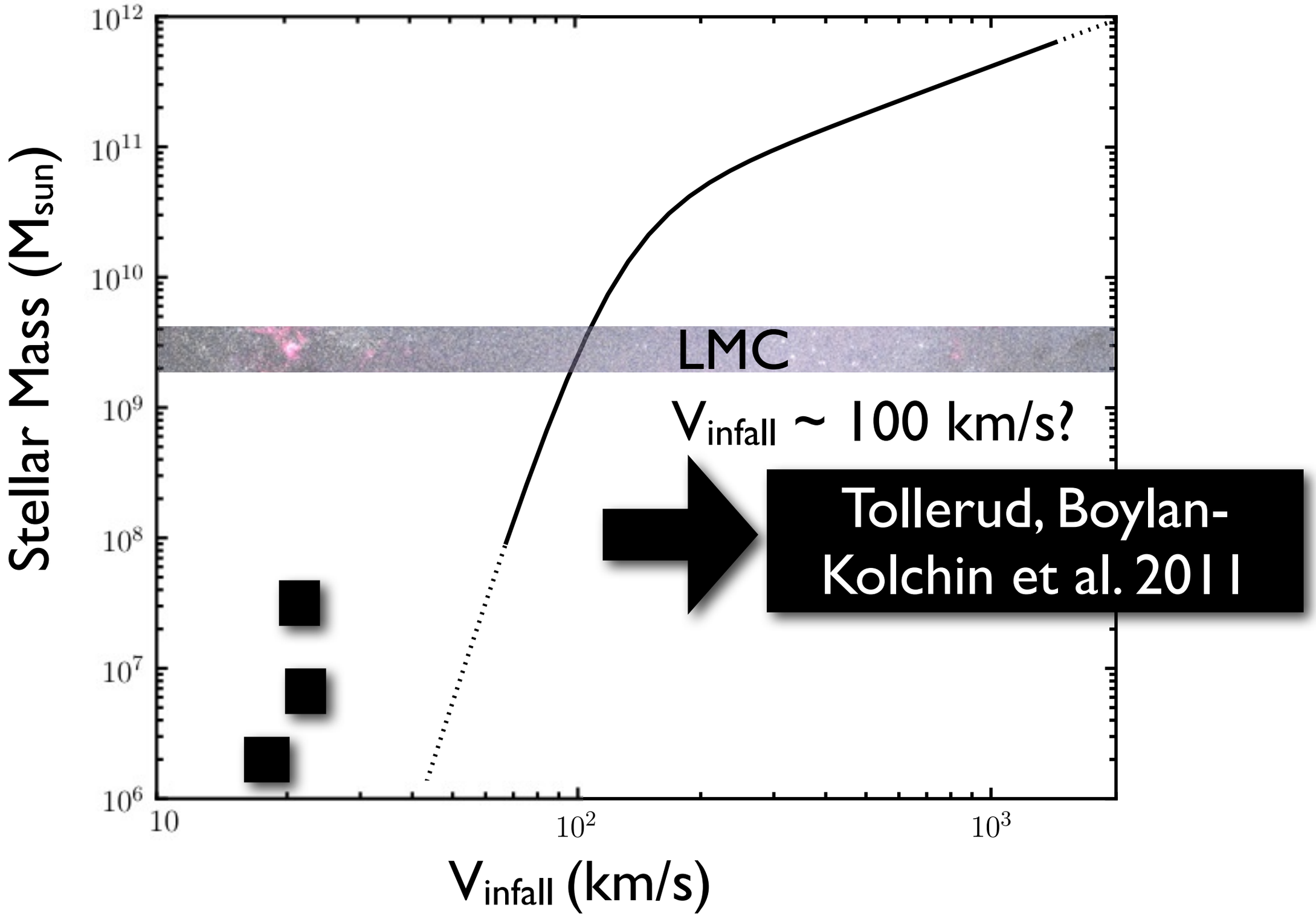
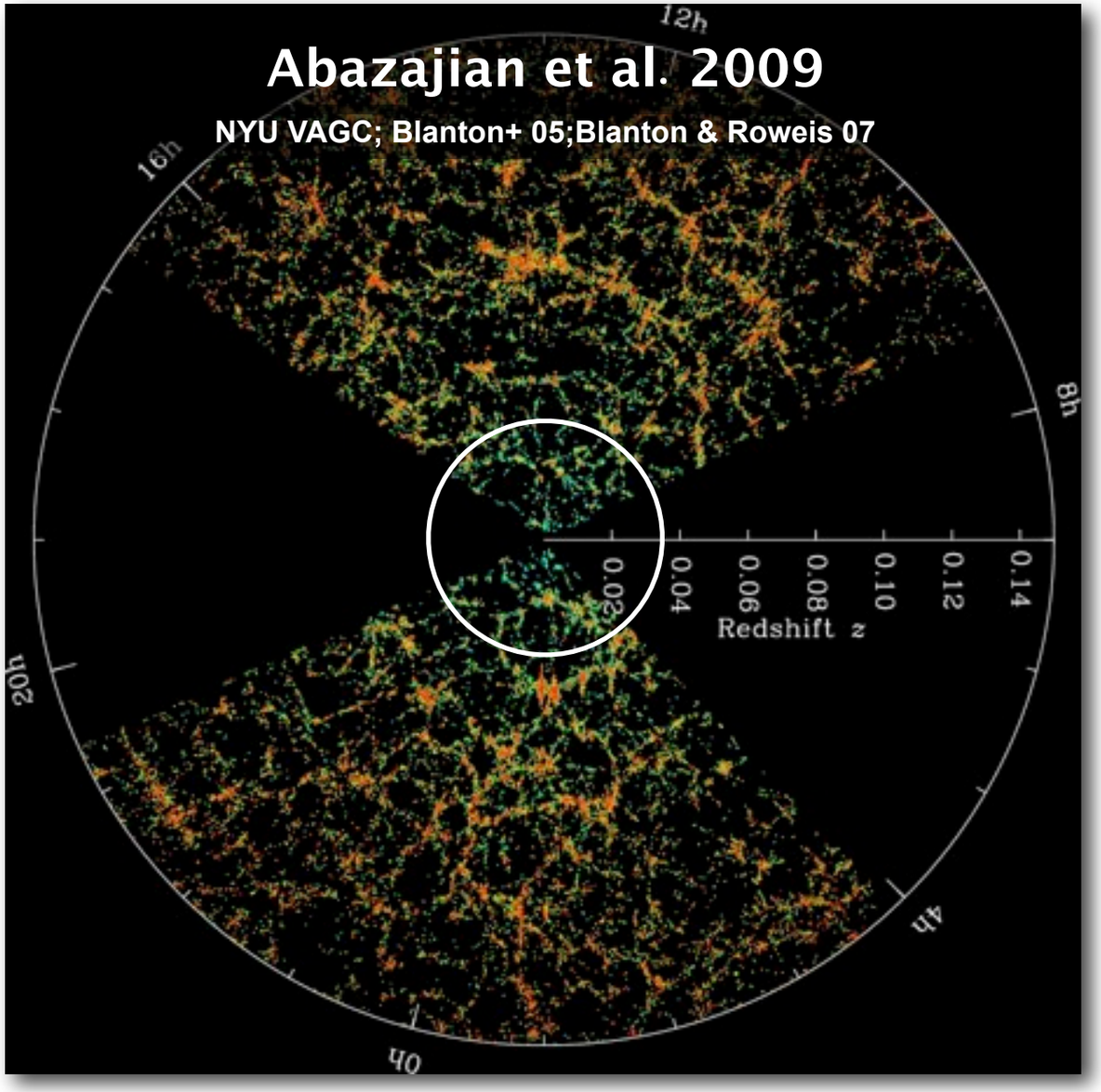


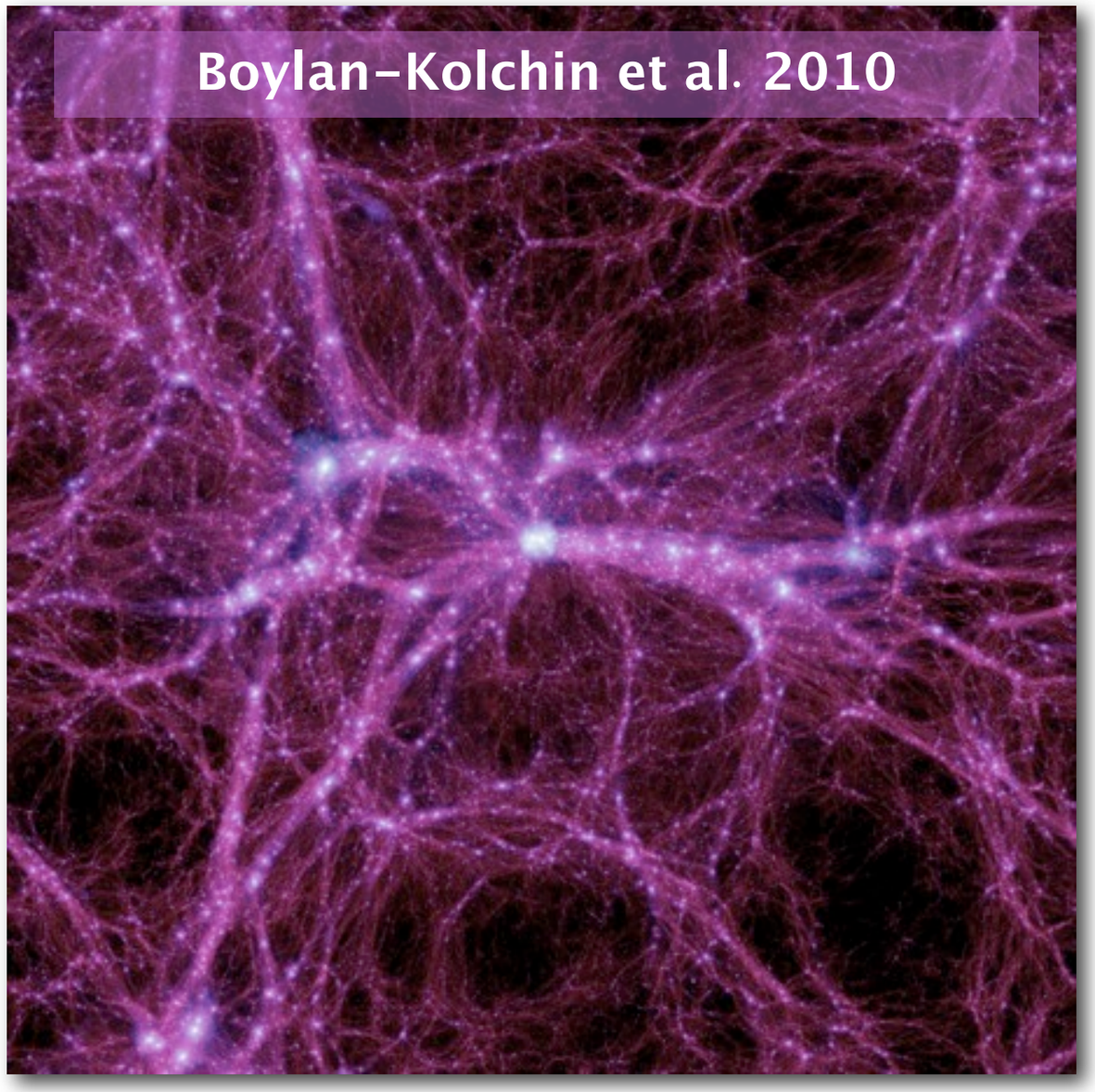
Tollerud, Boylan-Kolchin et al. 2011

Spectroscopic ~0.1 L_* satellites within ~L_* galaxy halos



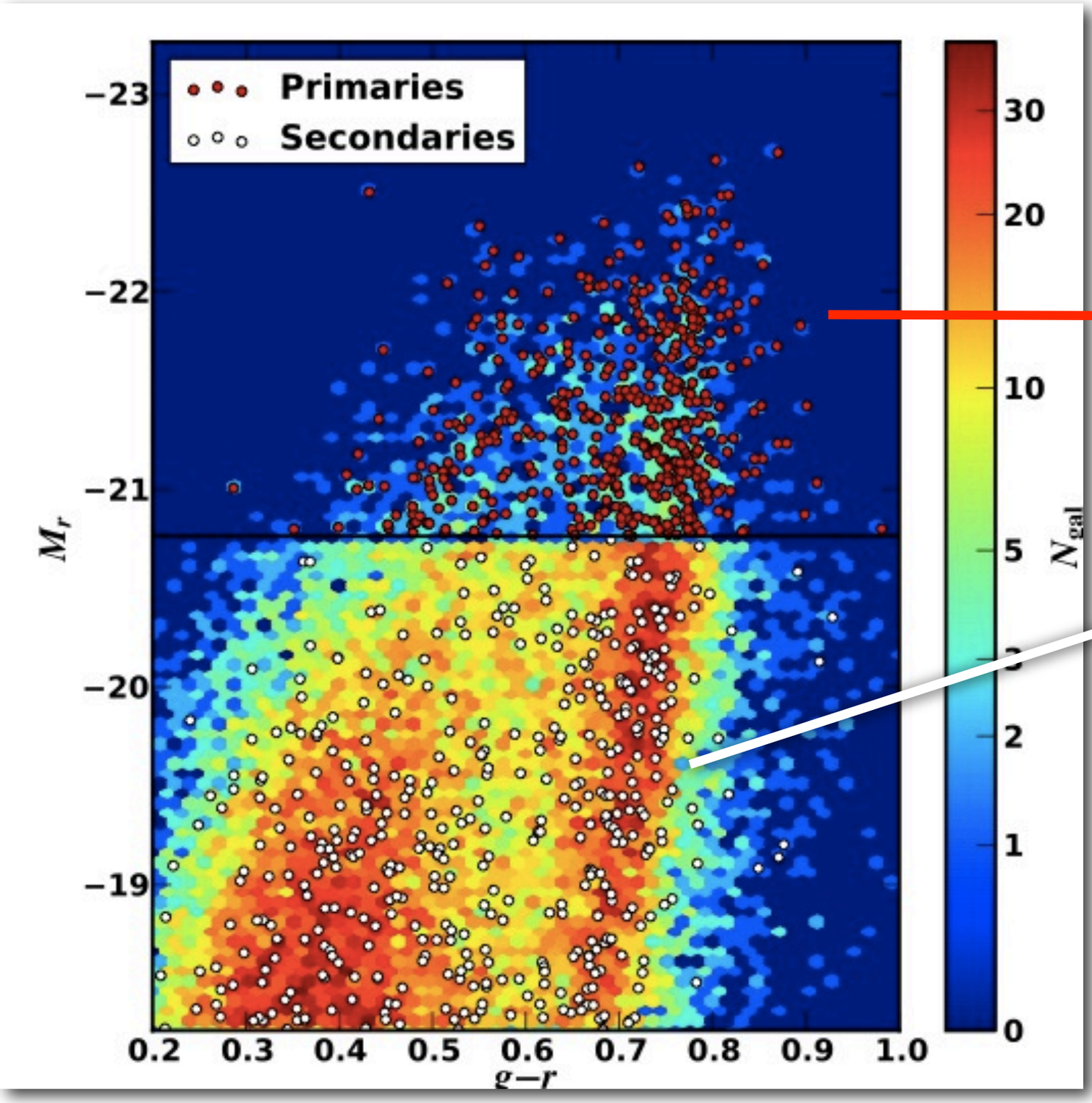
Volume-Lim. SDSS for ~0.1 L* satellites (z<.034)

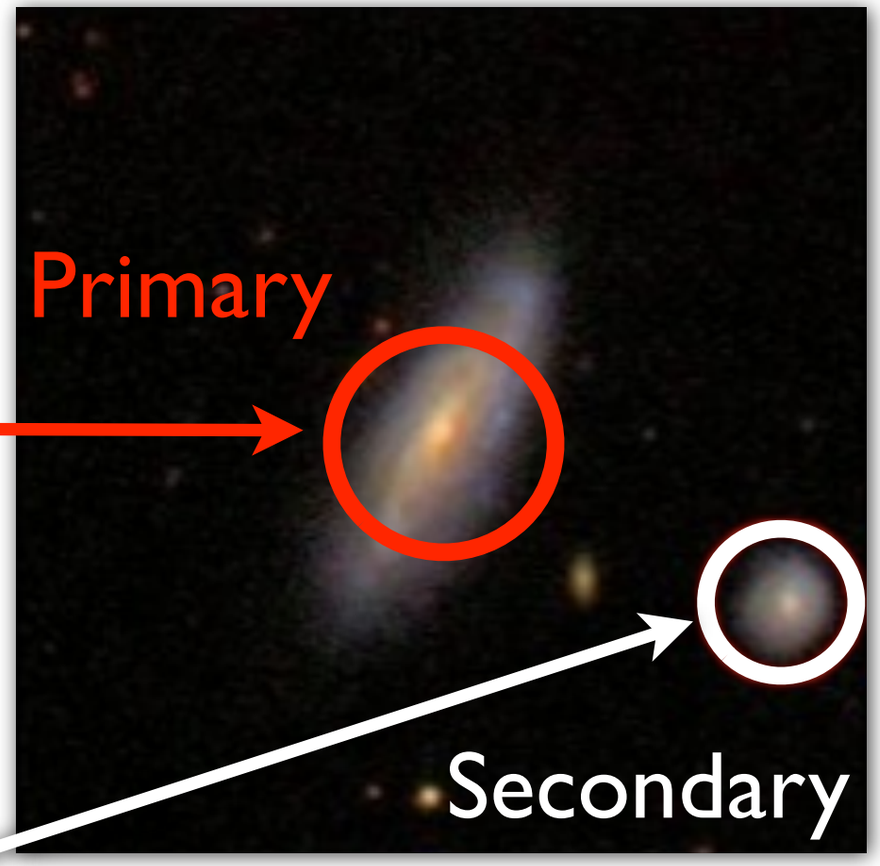
Around isolated L* galaxies (not in clusters)



Mill II simulation “observed” like SDSS sample

Tollerud et al. 2011: Spectroscopic Sample





Complete to Mr=-18.3 (z<0.034)

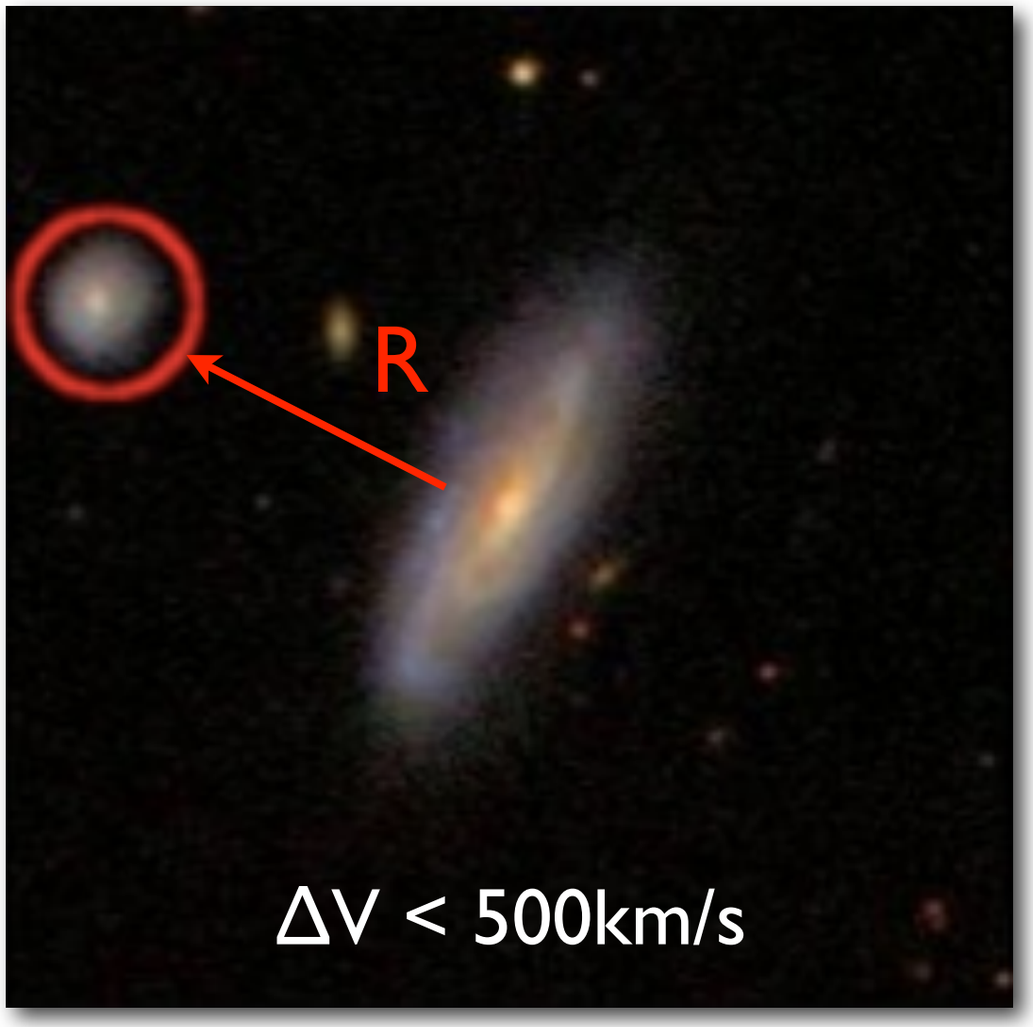
Primaries are isolated:
- none w/in 355kpc, at most one w/in 1Mpc (Barton et al. 07)

Pairs have $\Delta V < 500$ km/s

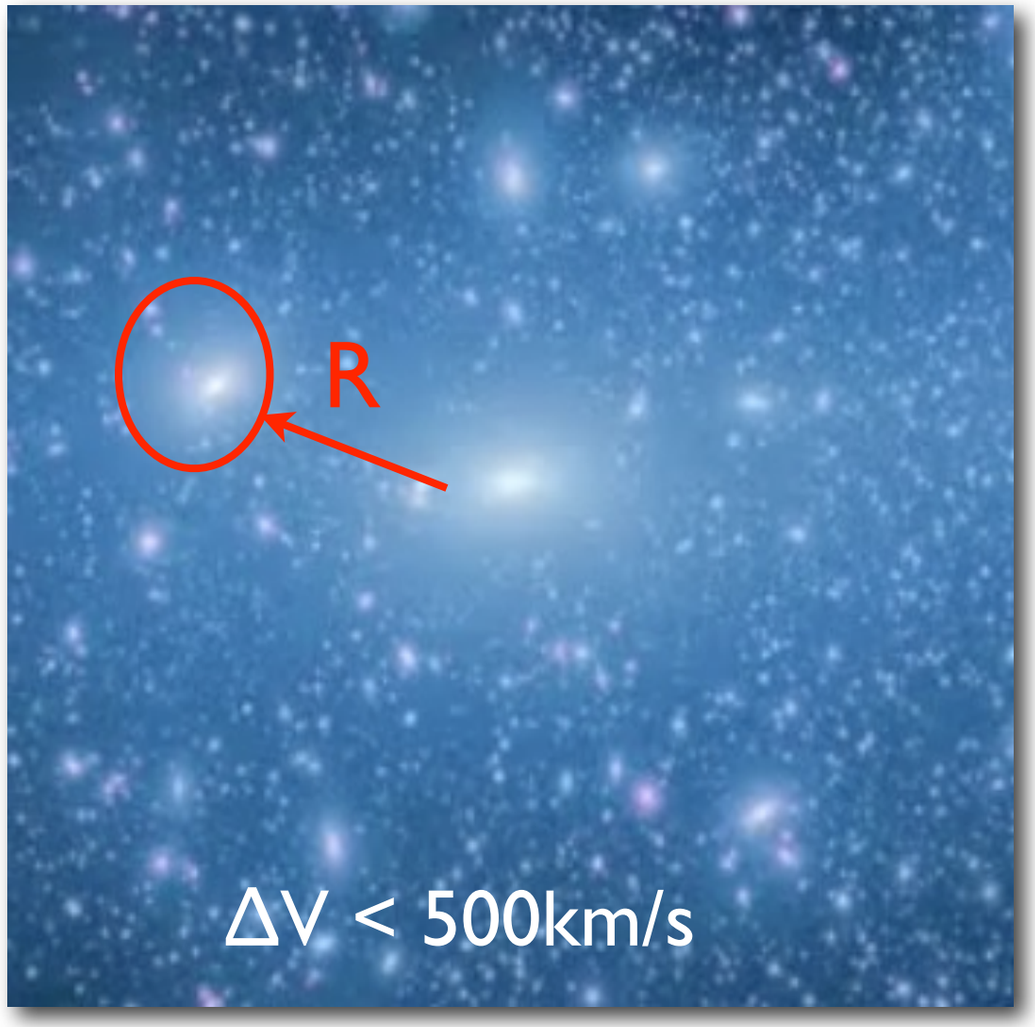
Tollerud, Boylan-Kolchin et al. 2011

~0.1 L_* satellites within ~L_* galaxy halos

Abazajian et al. 2009



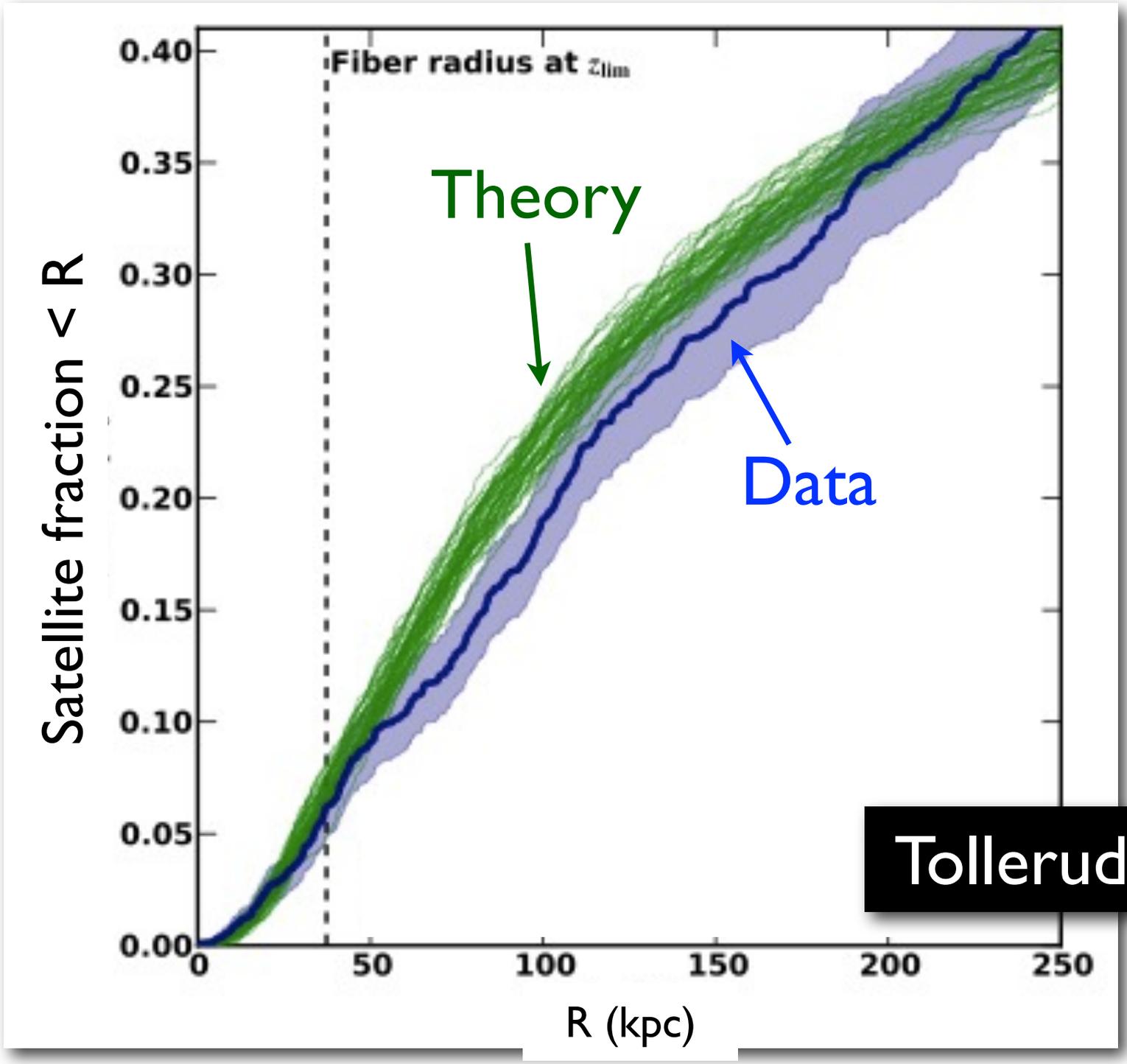
Boylan-Kolchin et al. 2010



Hosts: $M_r < -20.8 \longleftrightarrow V_{max} > 167$ km/s

Satellites: $M_r < -18.3 \longleftrightarrow V_{max} > 95$ km/s

40% of ~L* galaxies have a ~0.1L* satellite within 250 kpc



Tollerud et al. 2011

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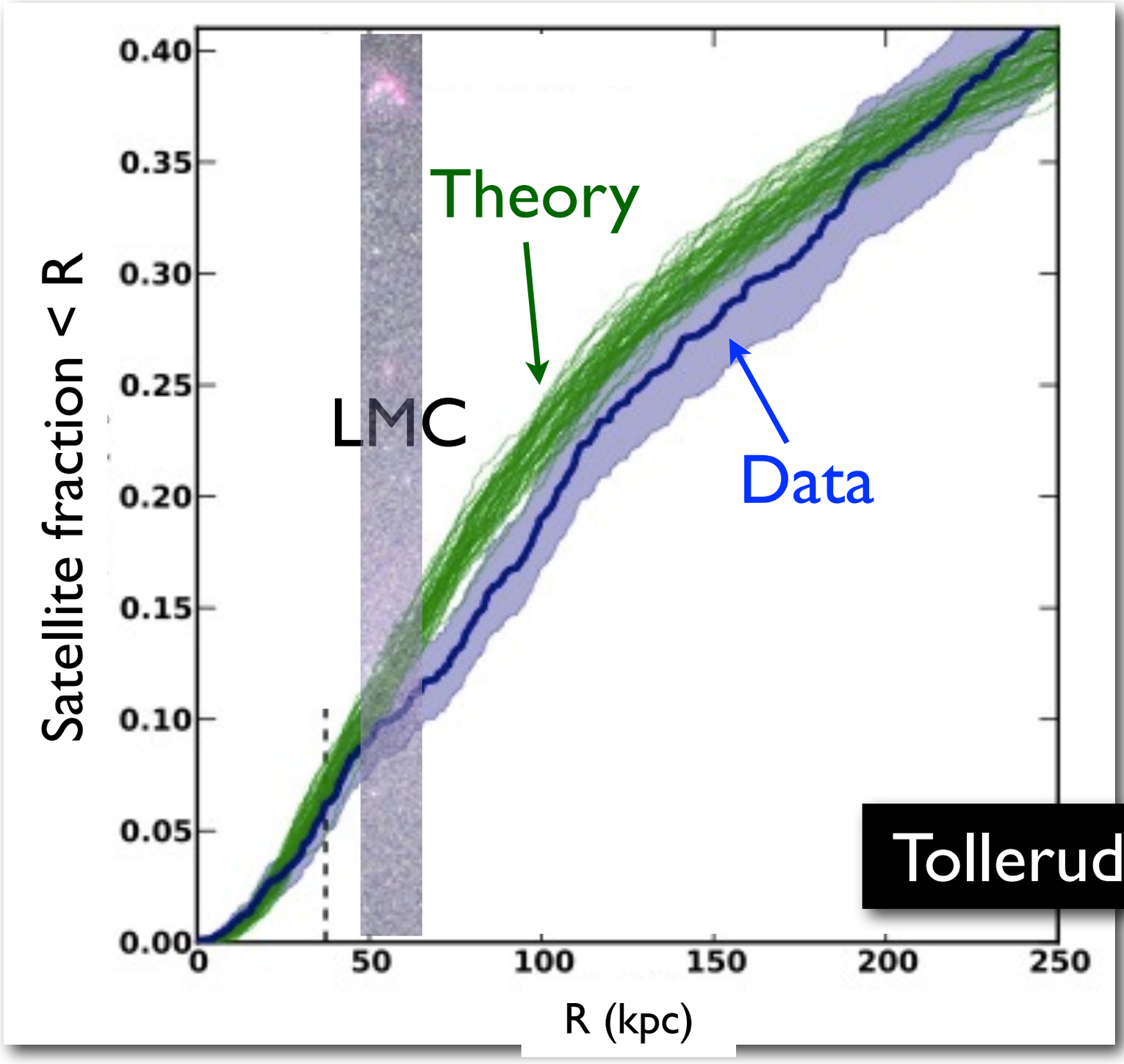

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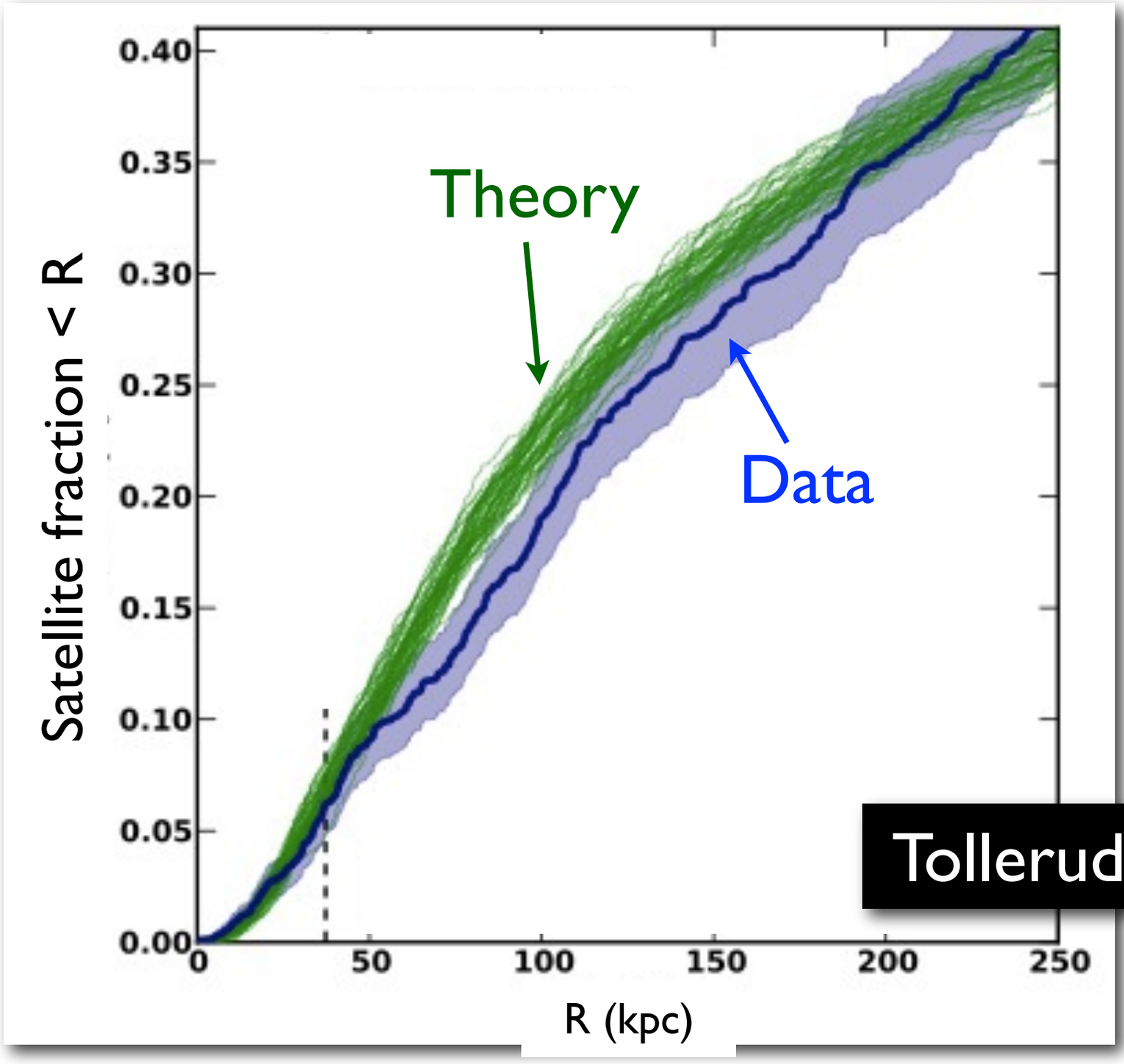

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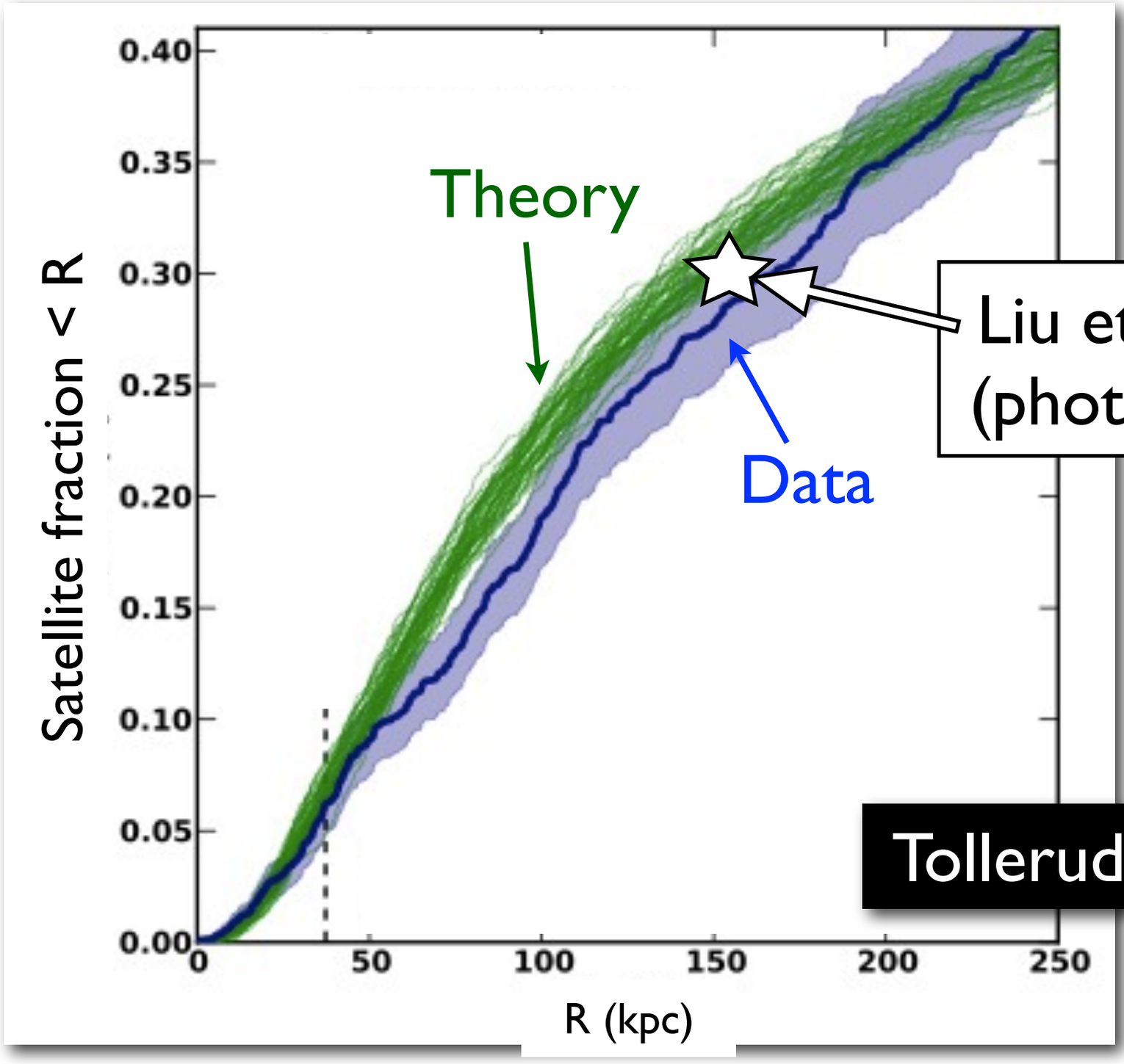
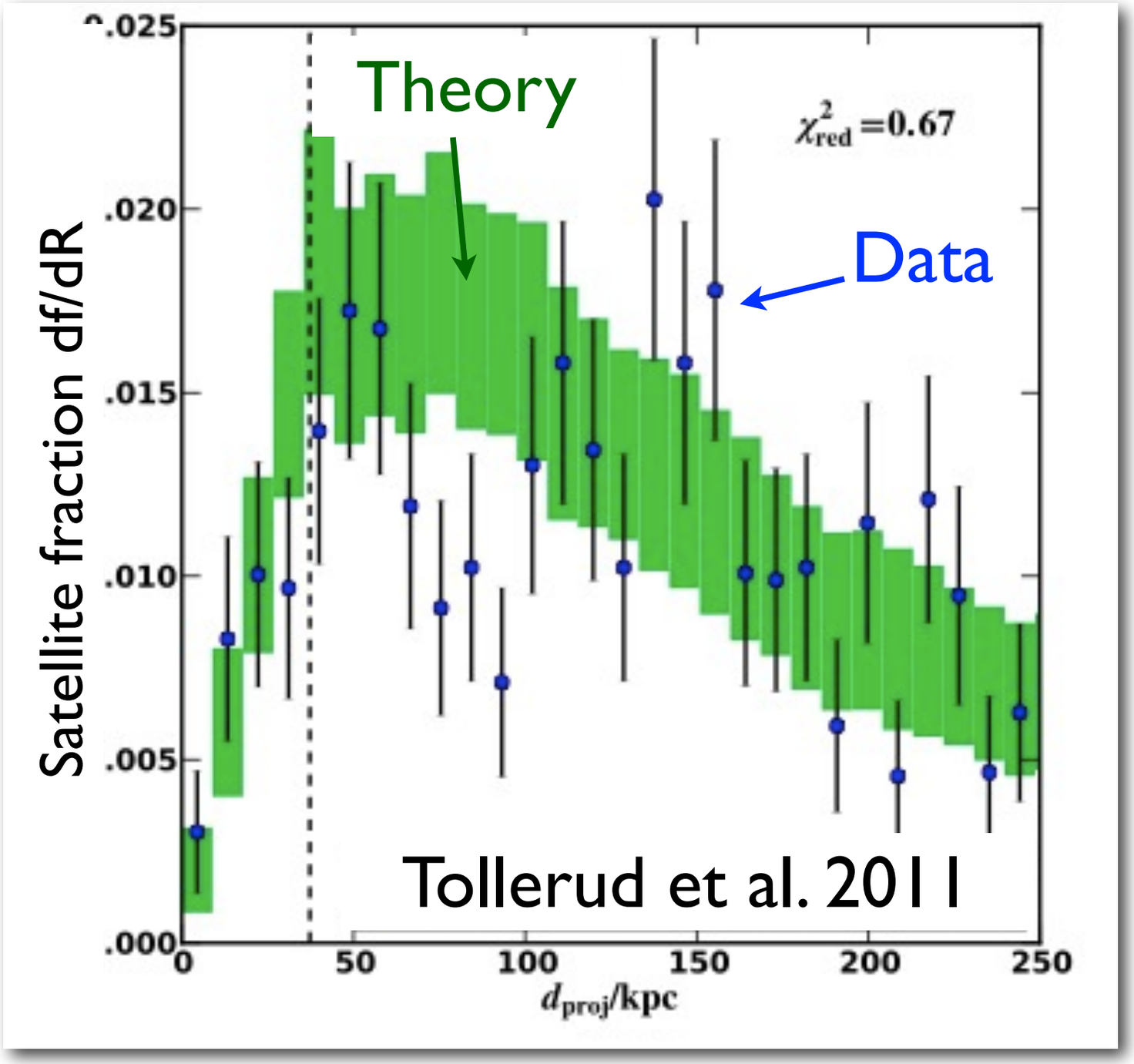
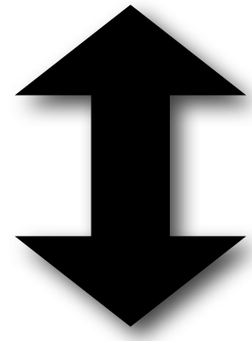


Abundance matching works at V_{infall}~100 km/s



~100 km/s subhalos



~0.1 L* satellites

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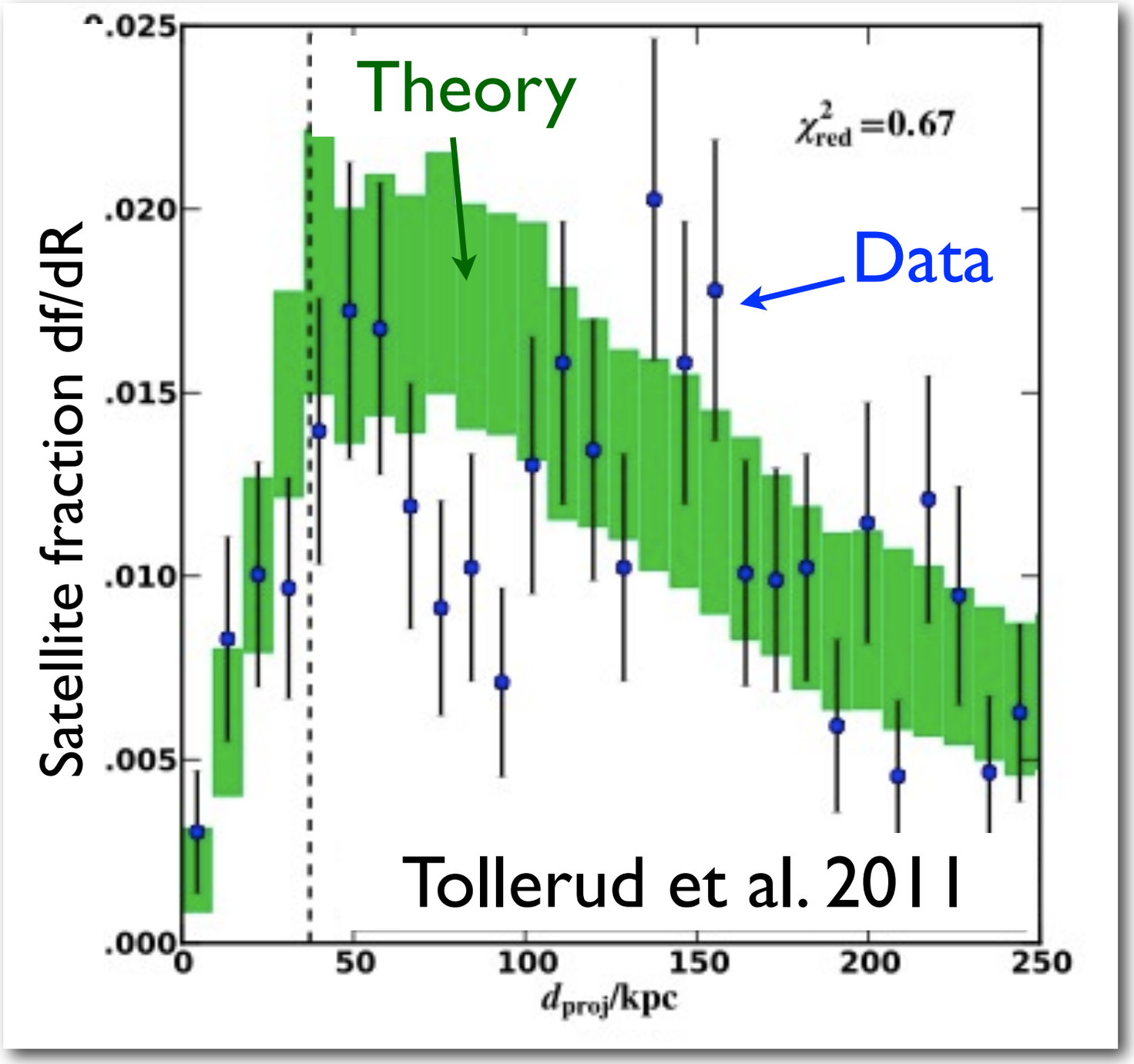

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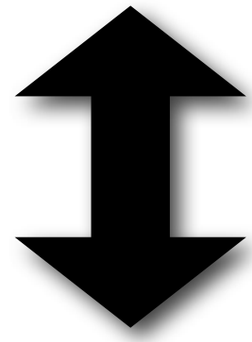
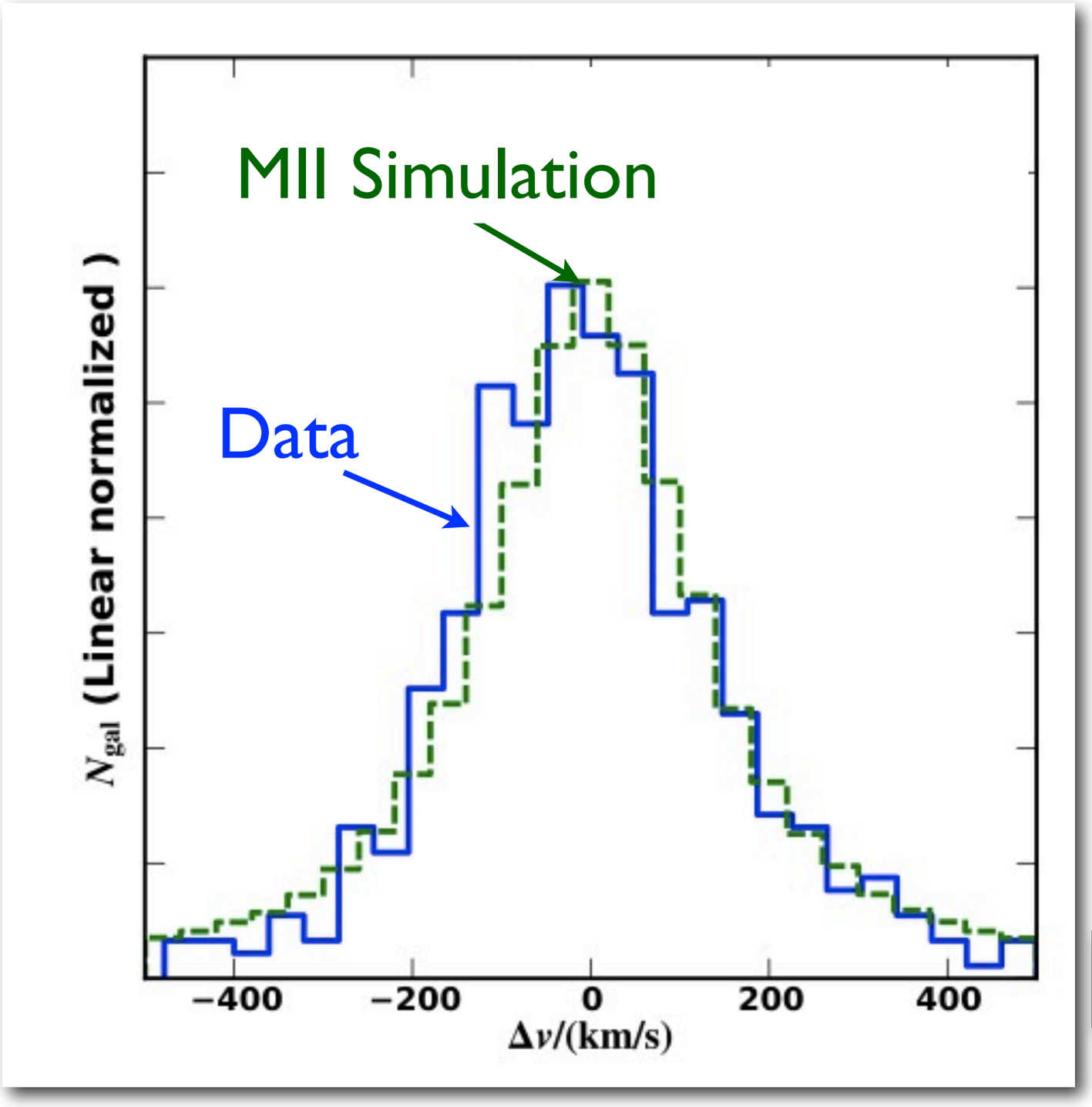


~0.1 L* satellites

Busha et al. 2011

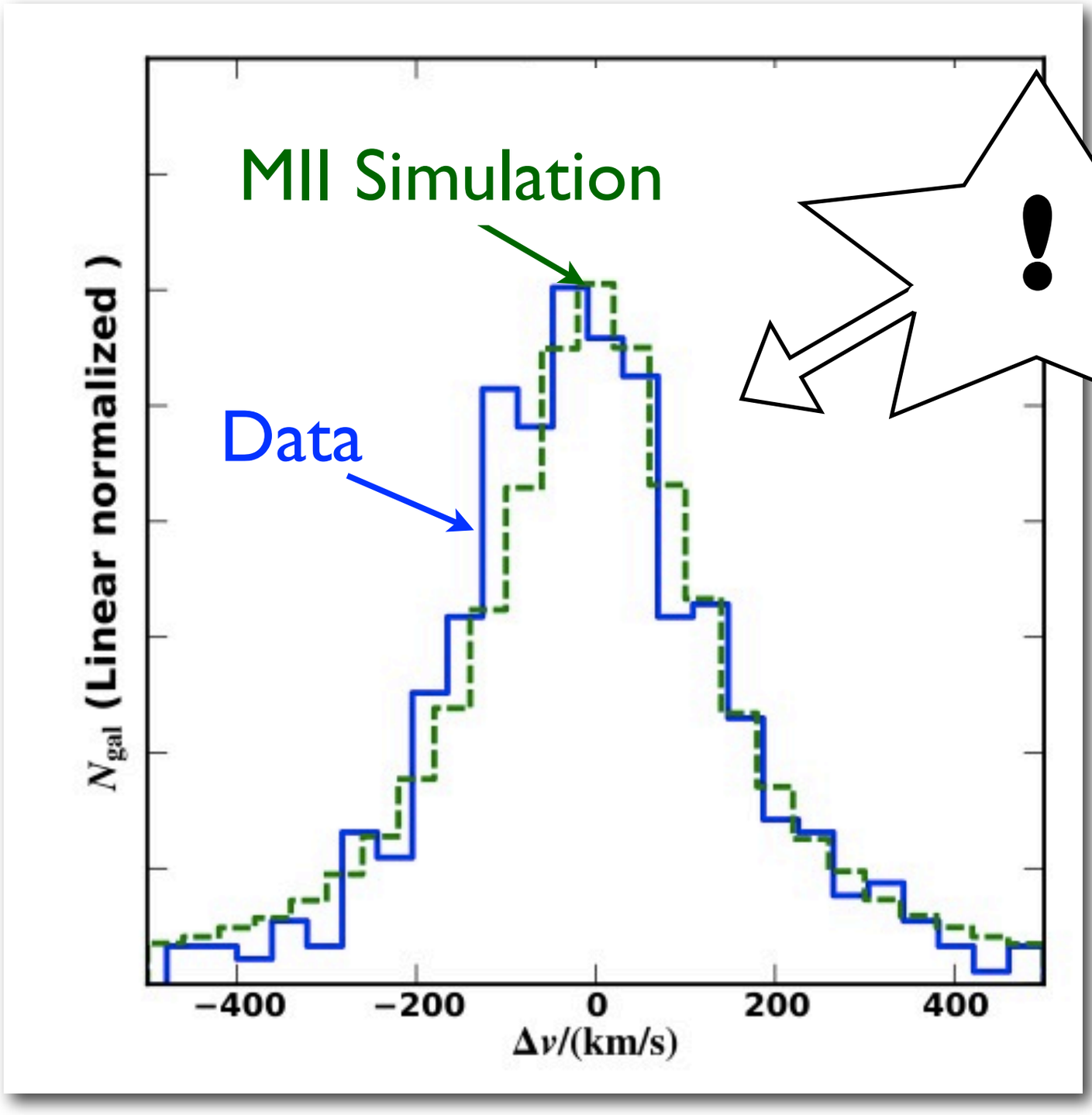
Similar agreement using Bolshoi vs. photometric sample:

Pair-wise velocity distribution



Tollerud et al. 2011

Pair-wise velocity distribution

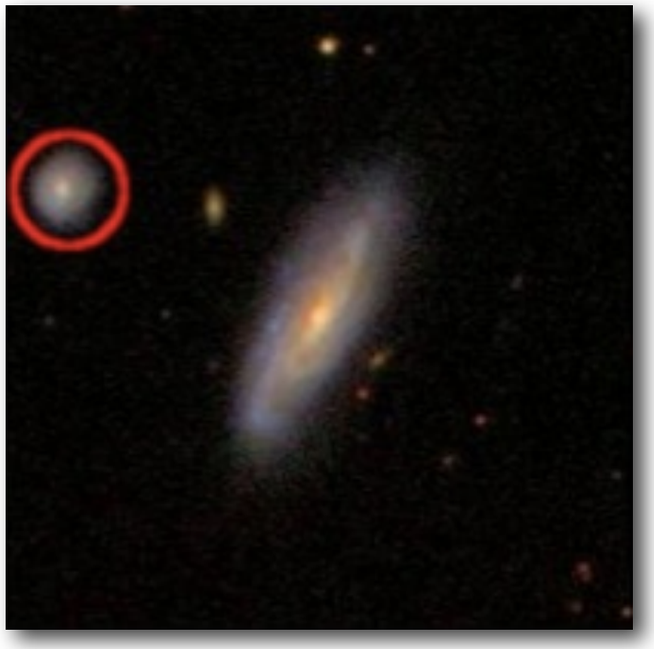


p_{KS} = 33%

If you didn't believe in ΛCDM already... time to get religion

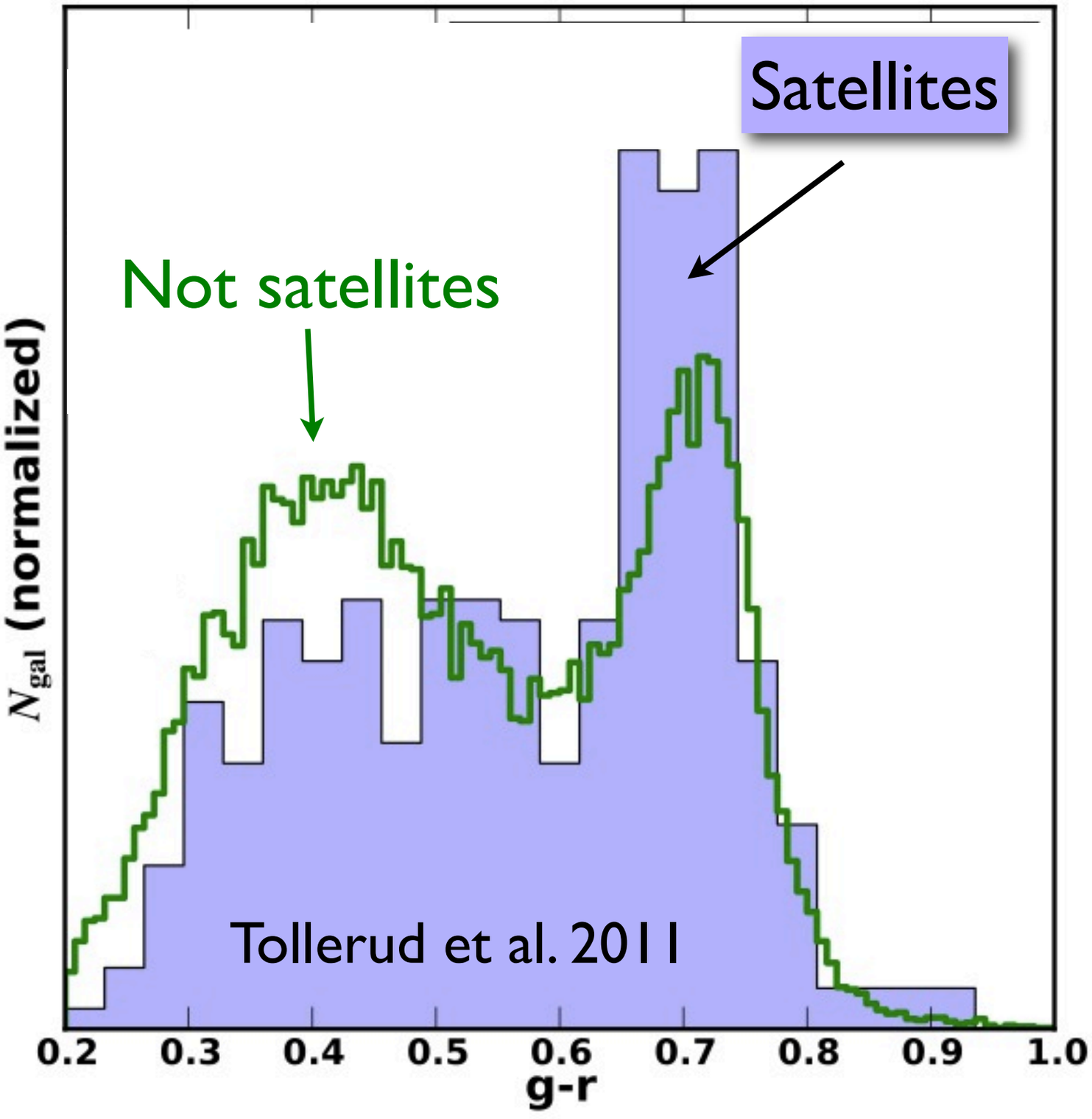
Tollerud et al. 2011

Bright satellites of isolated L* galaxies are RED

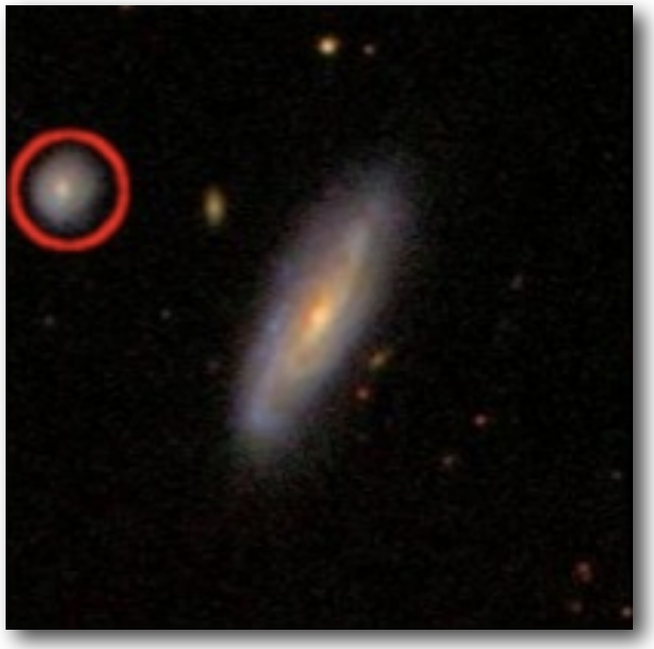


~0.1 L* satellites w/in
~L* galaxy halos
are **RED**

See also:
Wetzel et al. 2011



The LMC is unusually blue for a satellite



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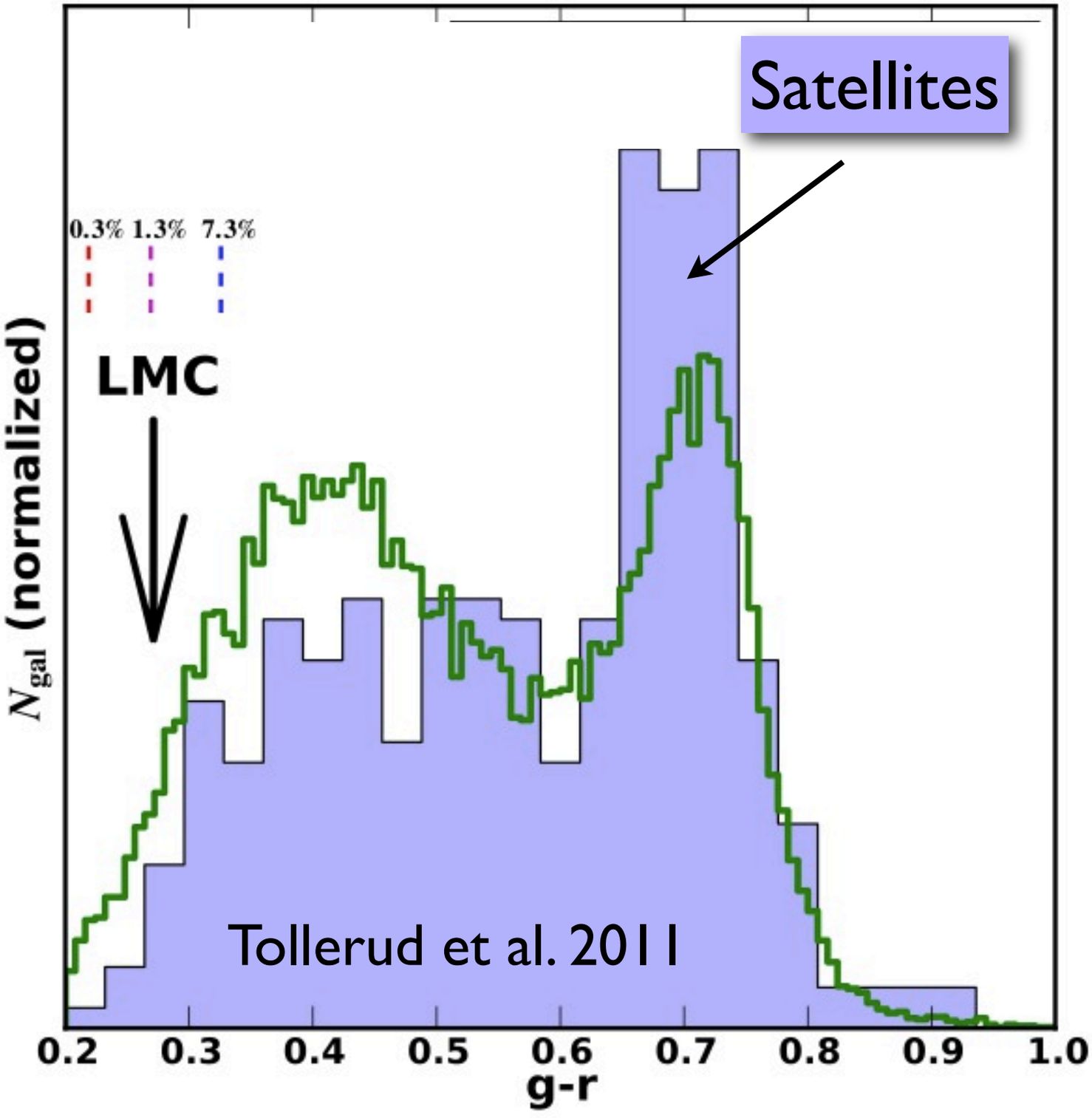
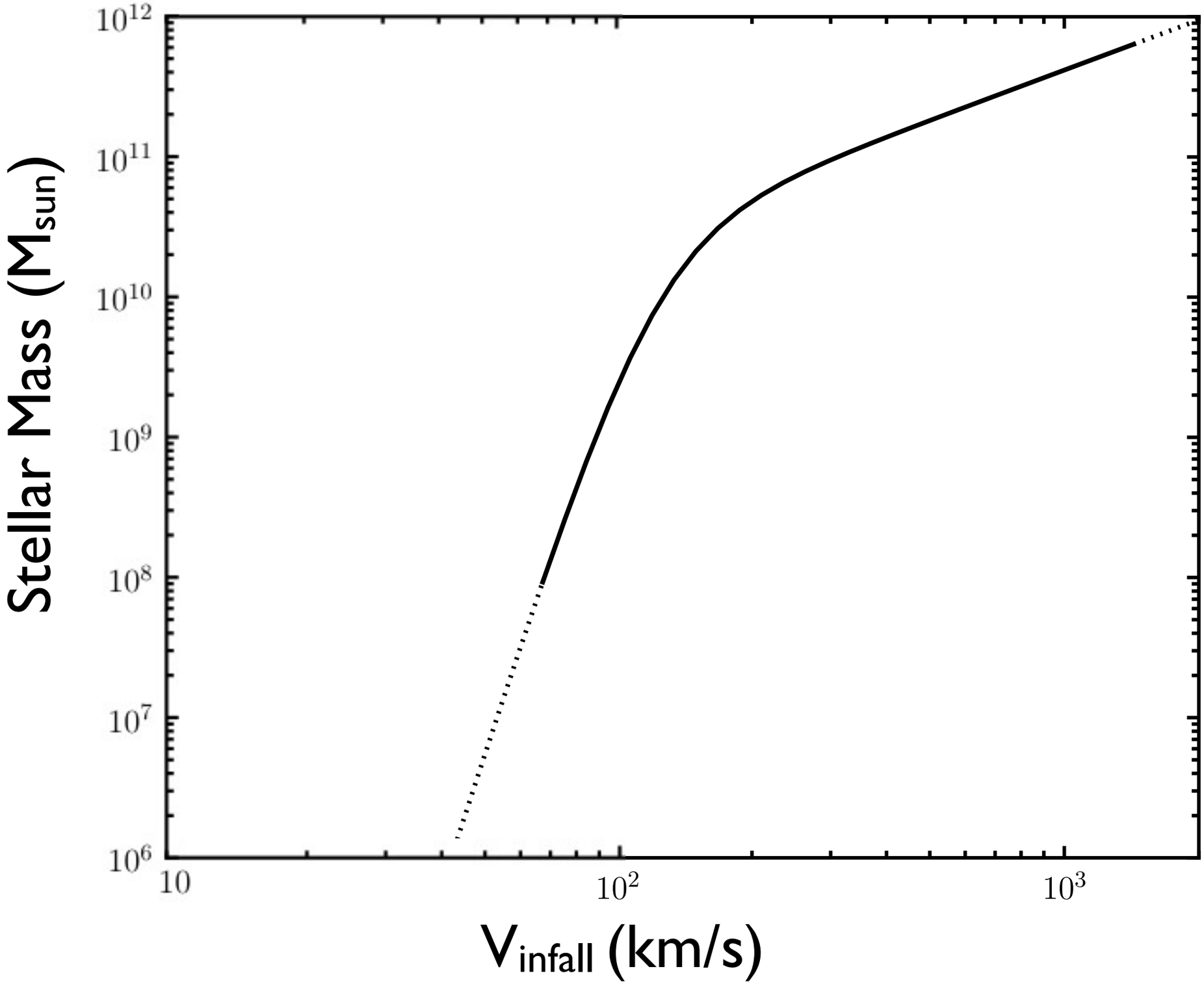


Quenching in Centrals and Satellites



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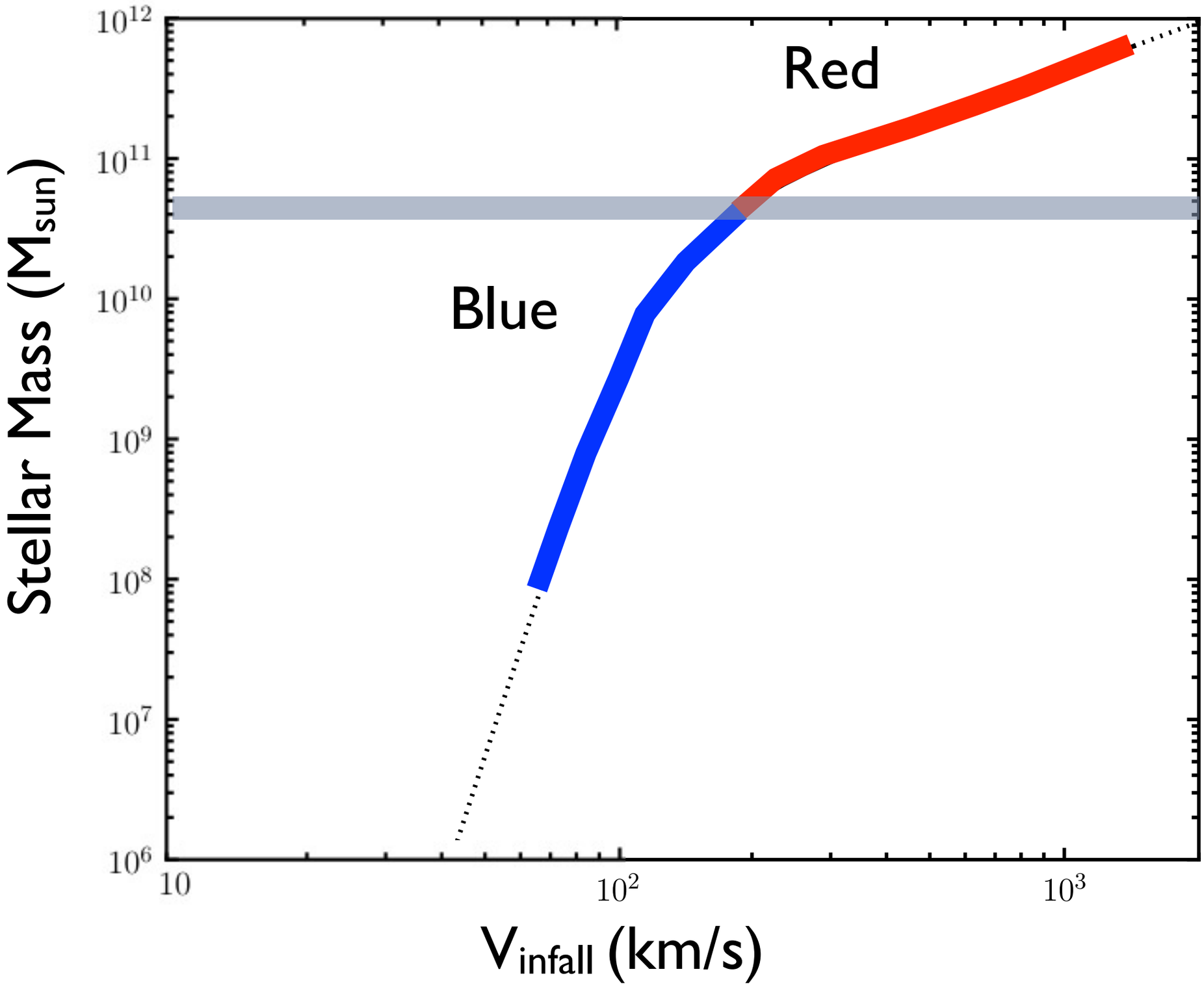

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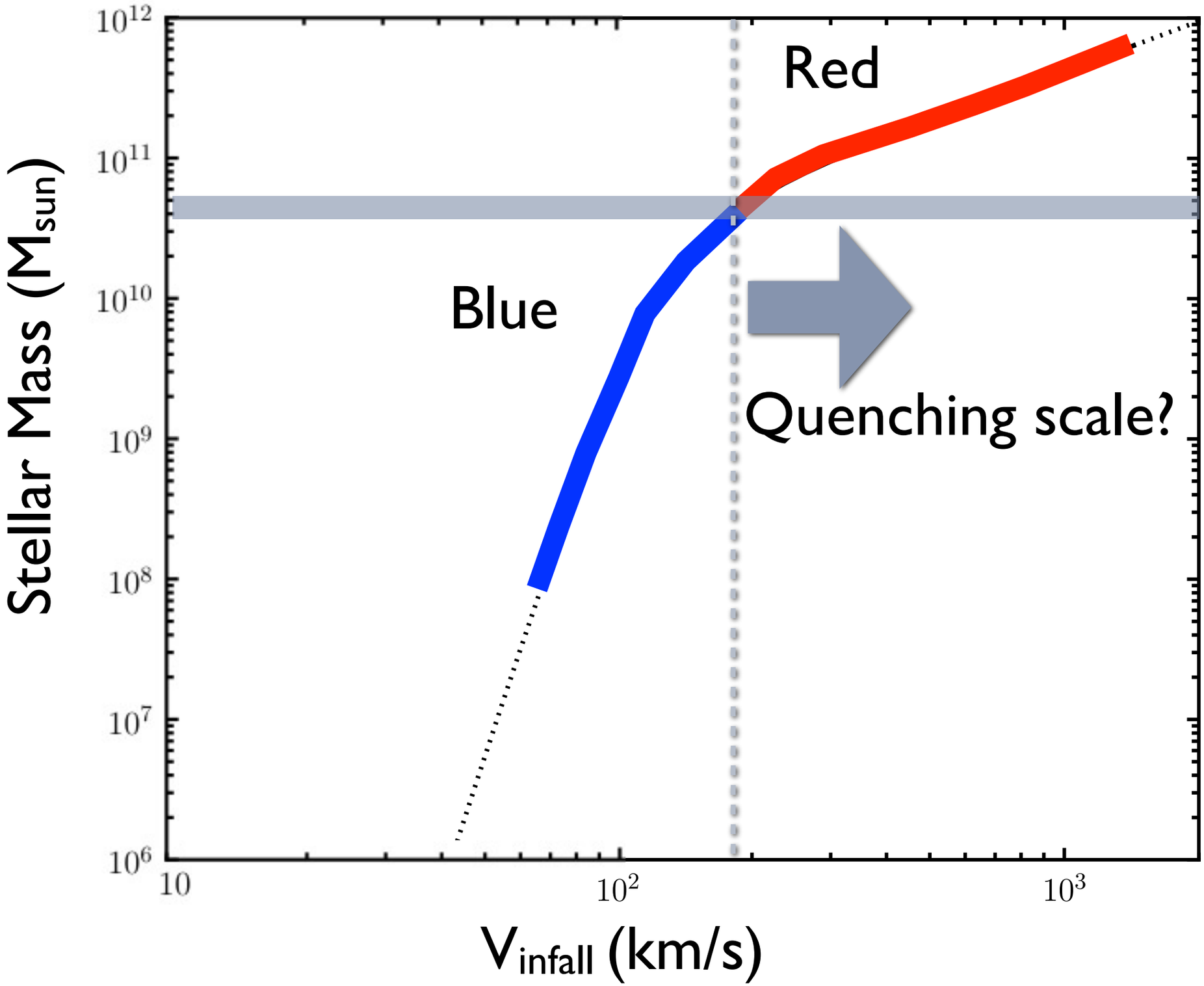

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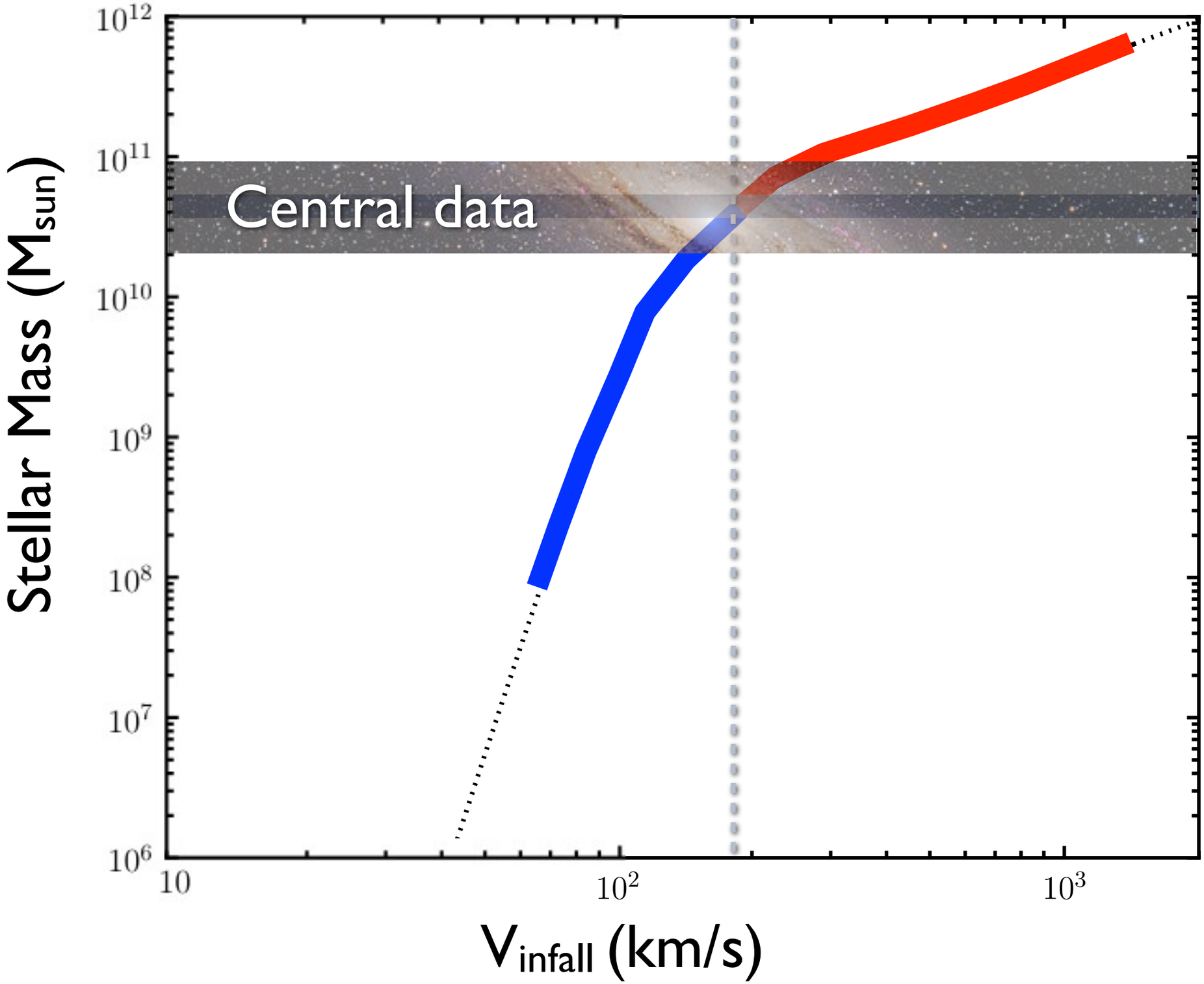

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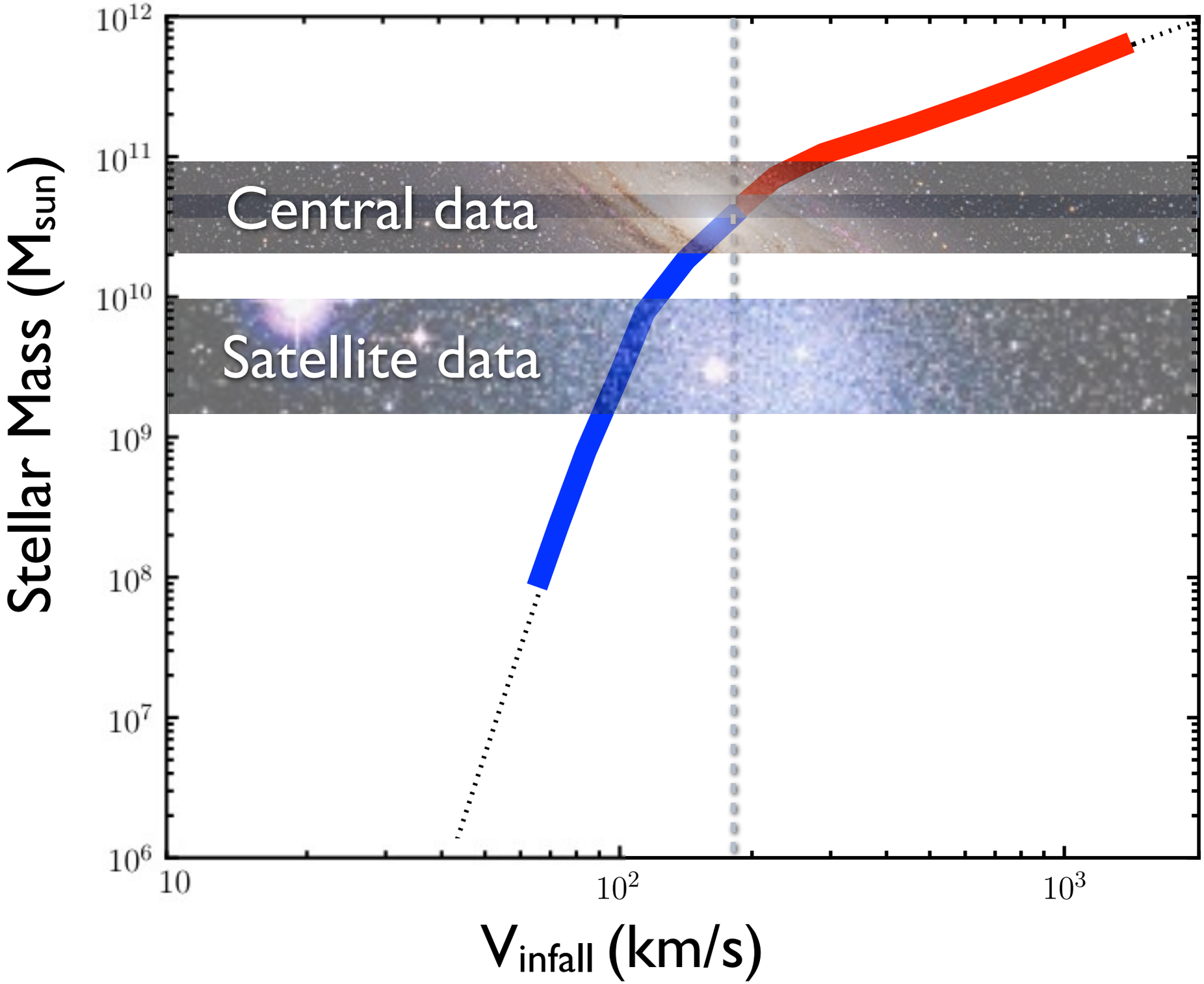

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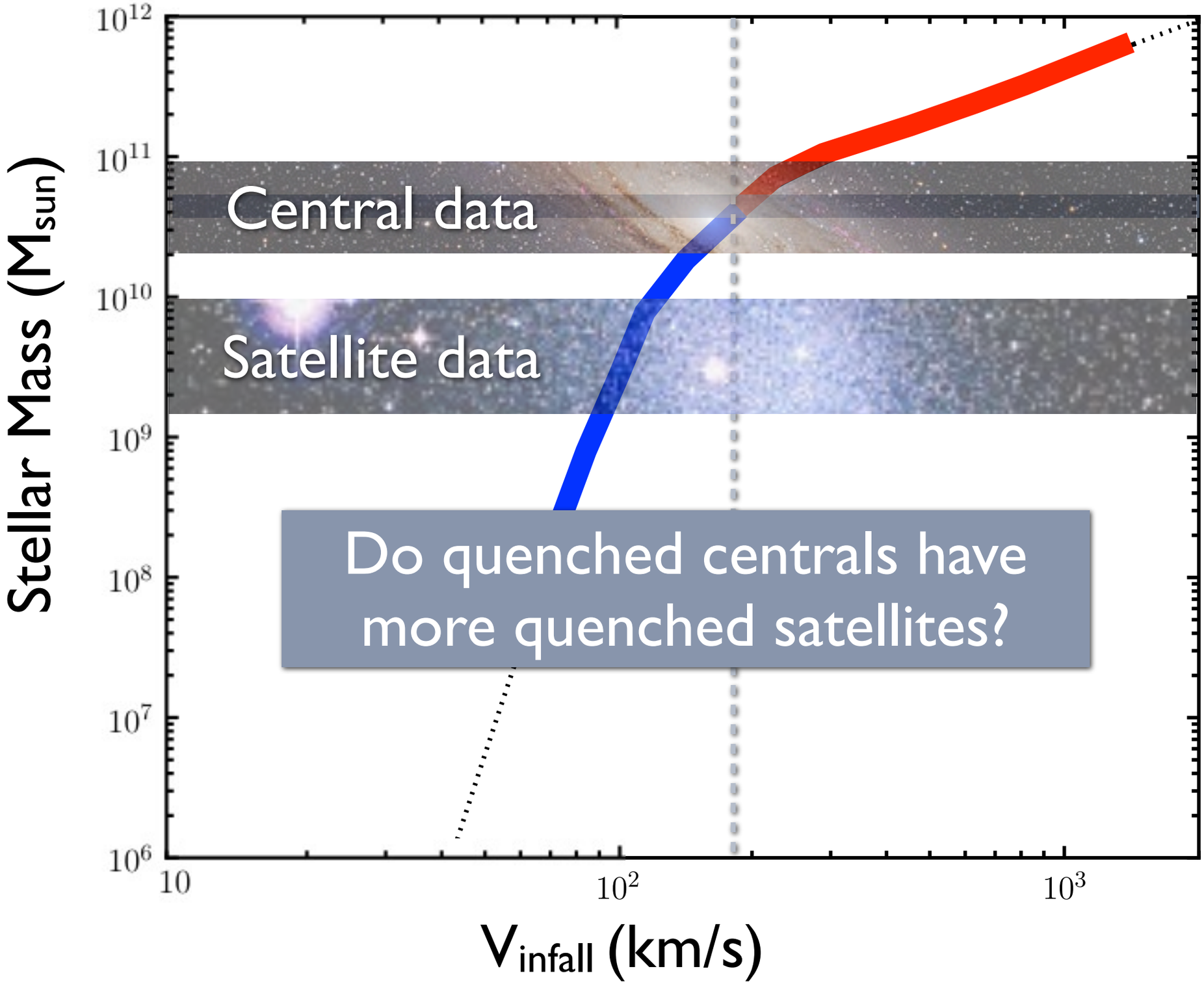
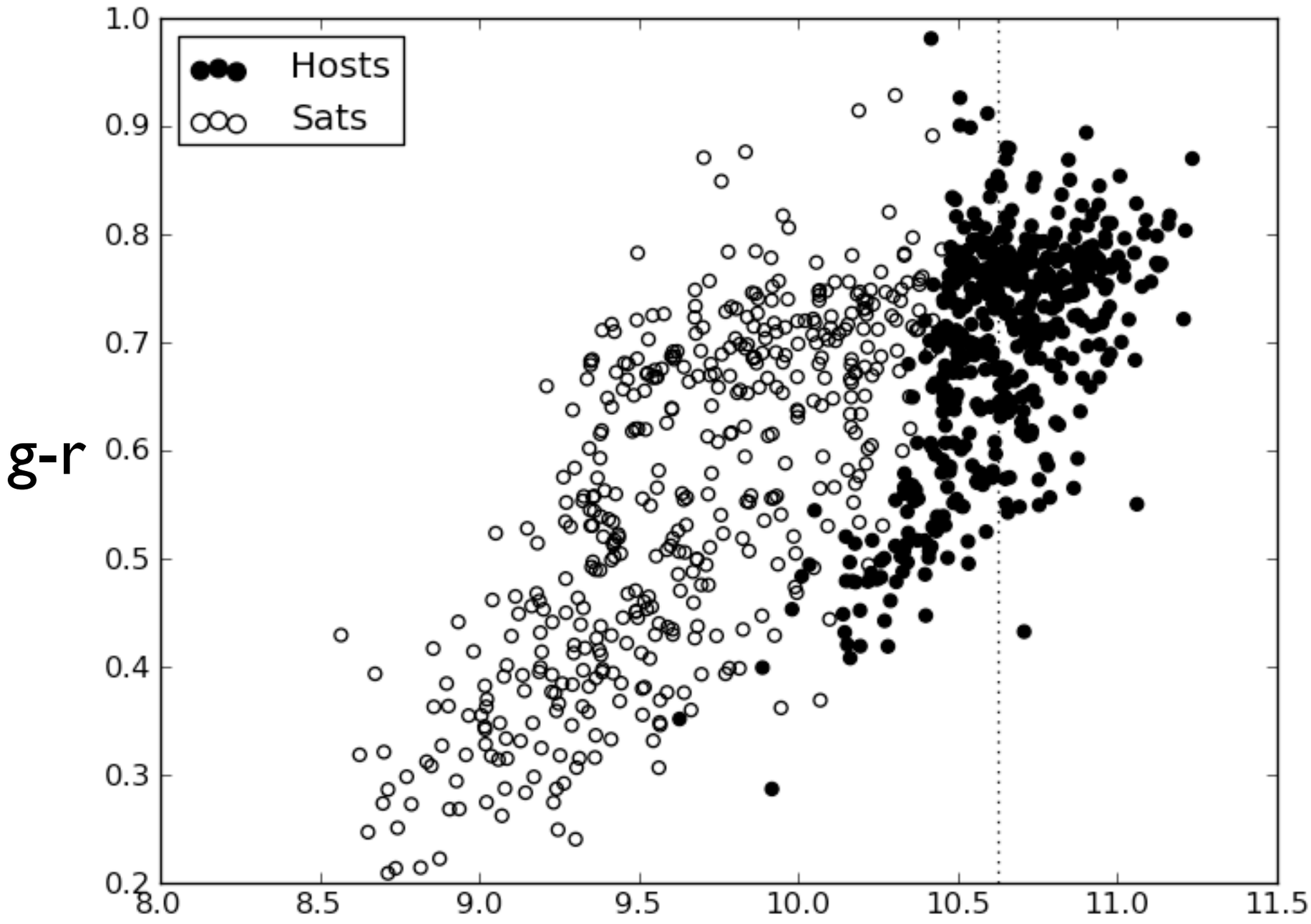
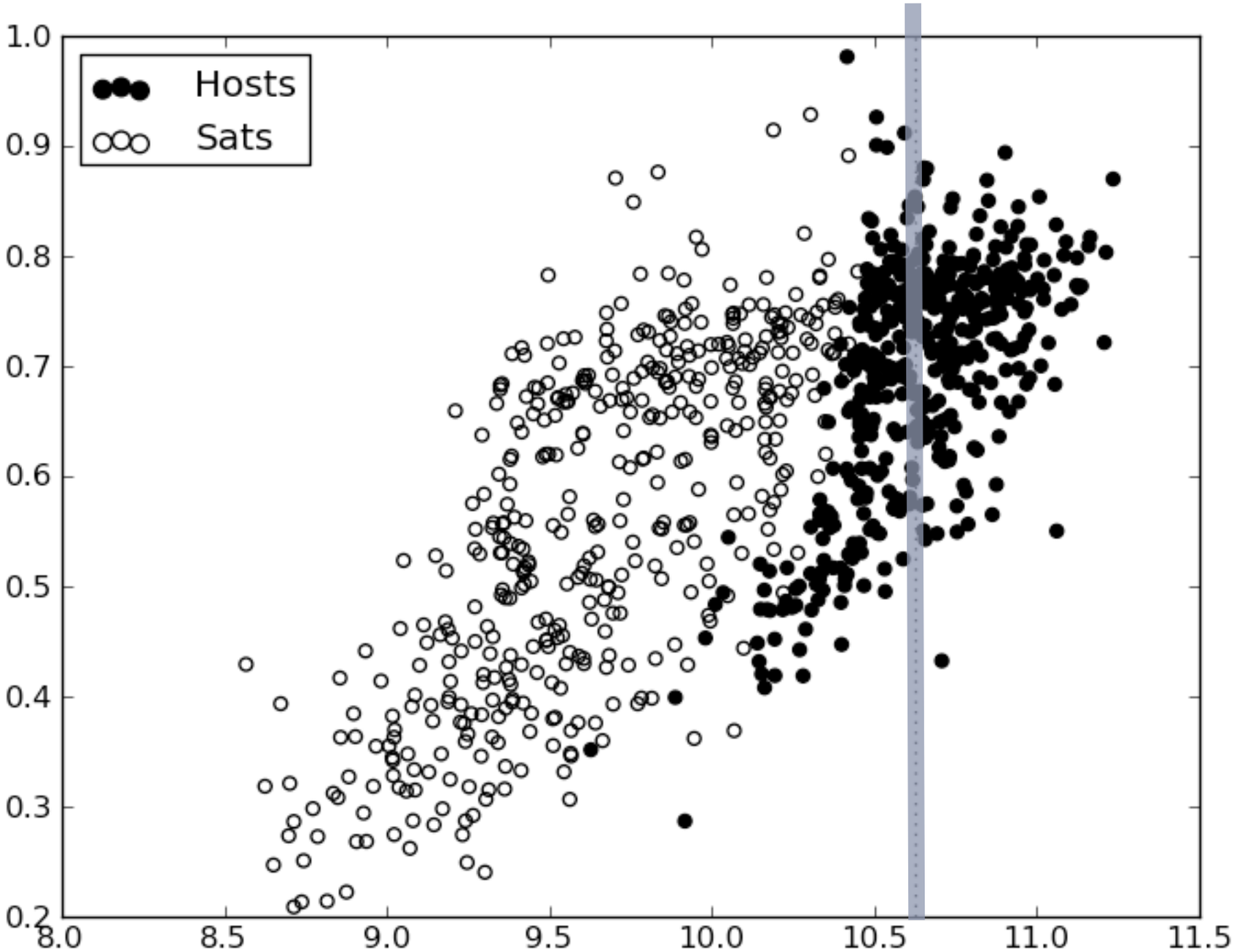
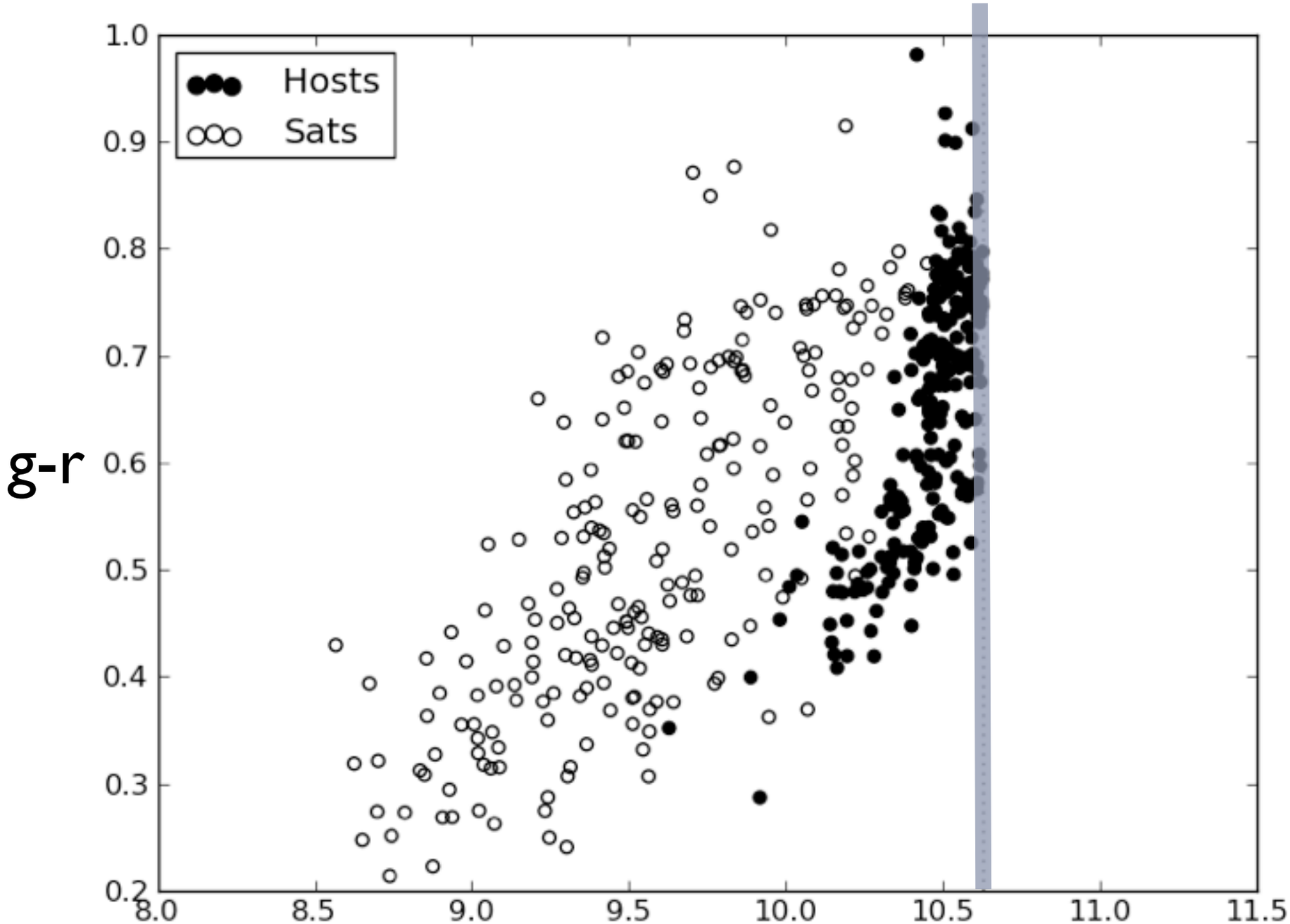



Hosts
Sats
g-r
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
stellar mass, log (M⋆/M⊙)

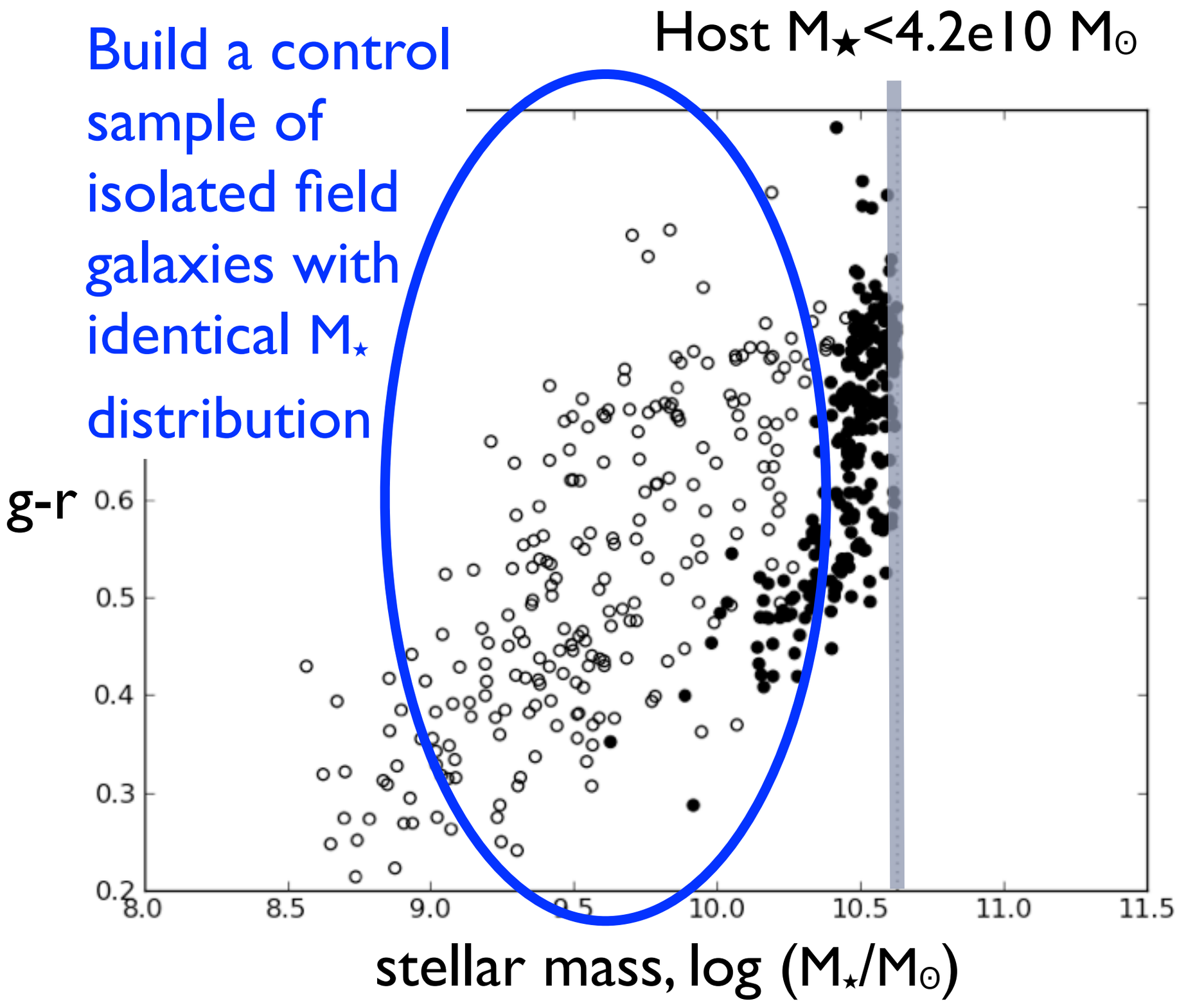
Host $M_\star$~4.2e10 $M_\odot$



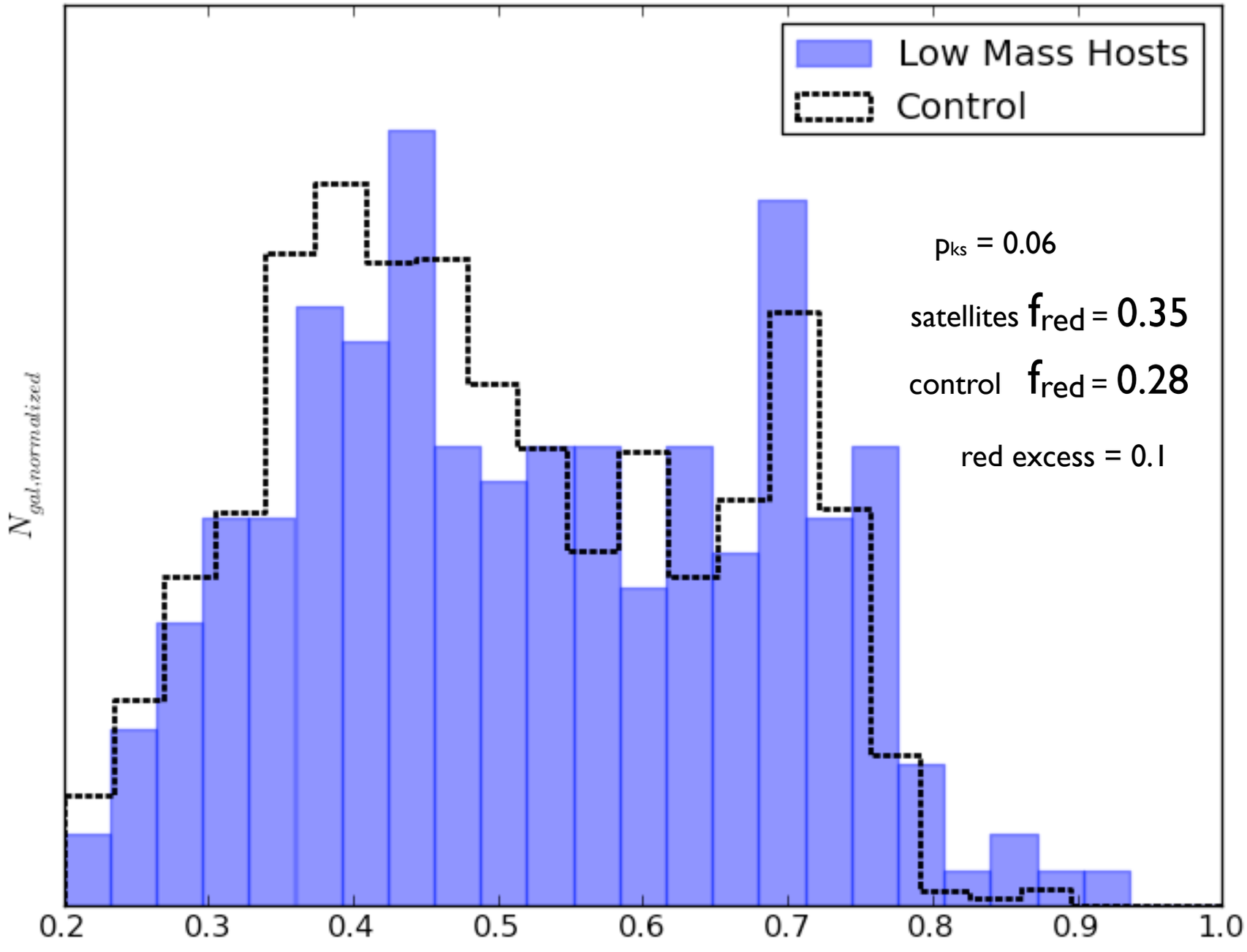
Host $M_\star$<4.2e10 $M_\odot$



Build a control sample of isolated field galaxies with identical $M_\star$ distribution

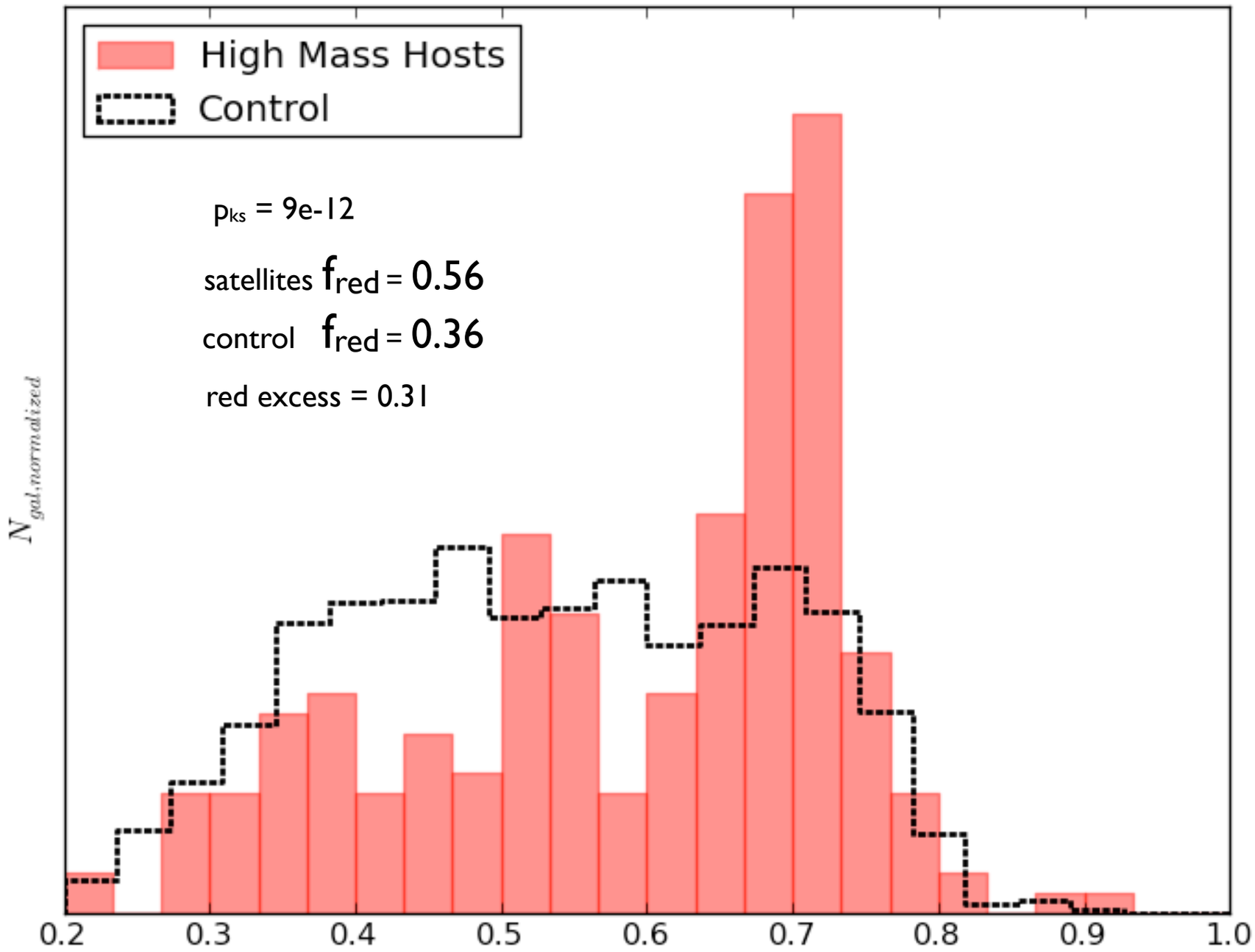


Satellites of isolated **Low Mass** ($M_\star$~3.5e10 $M_\odot$) hosts



Phillips, Tollerud et al., in prep.

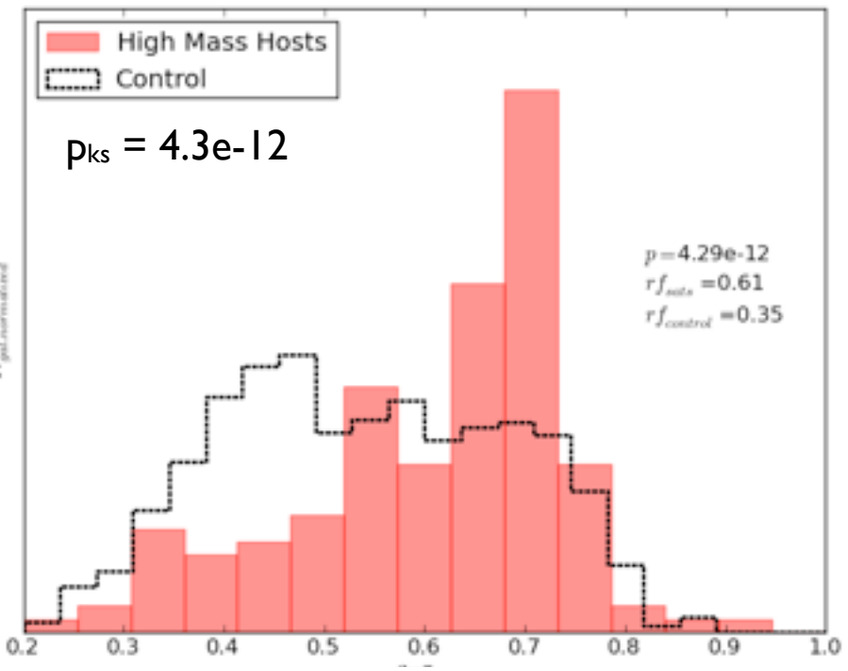
Satellites of isolated **Massive** ($M_\star$~6e10 $M_\odot$) hosts



Phillips, Tollerud et al., in prep.

Decreasing central galaxy mass

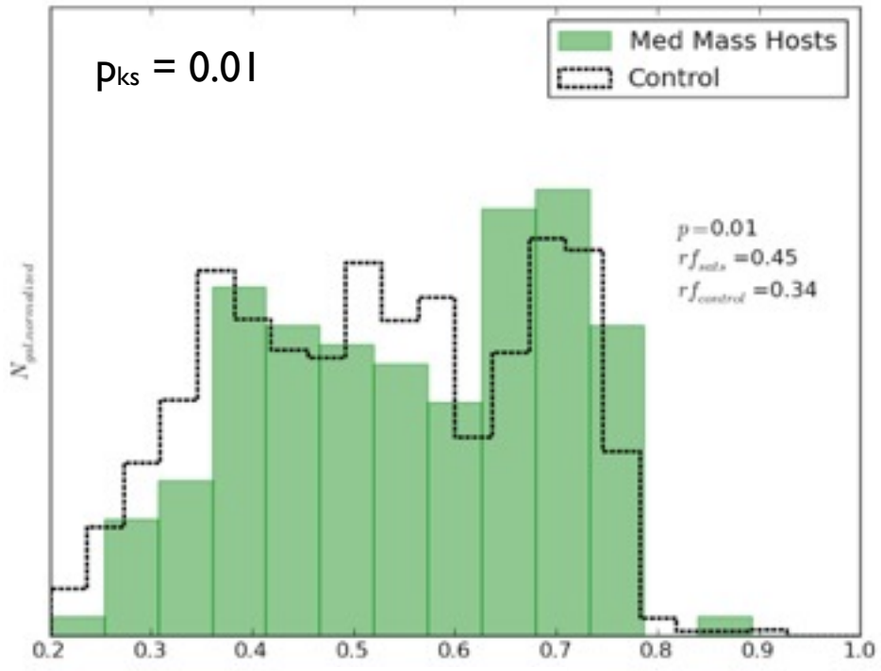
$M_\star$~7.4e10 $M_\odot$



g-r

Big Quench

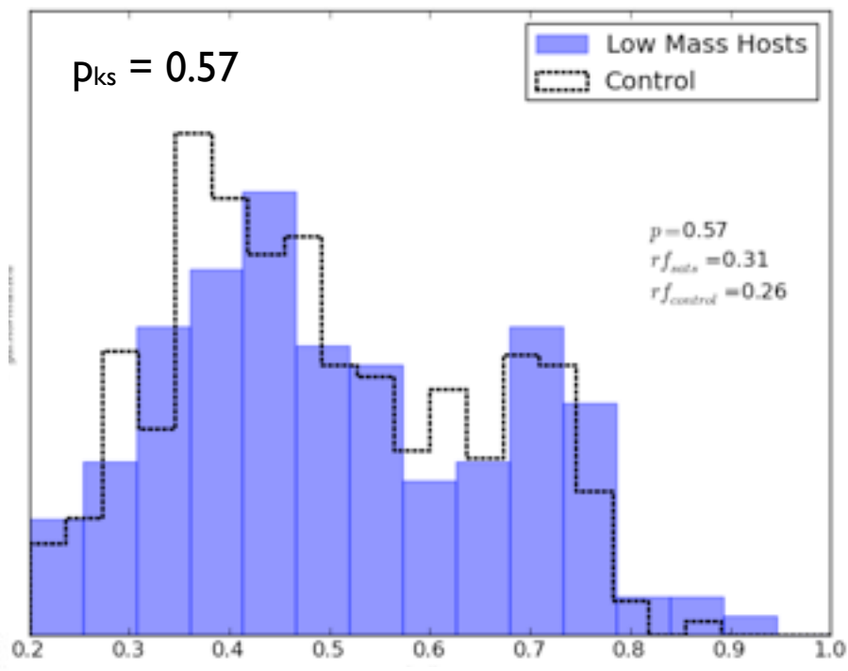
$M_\star$~4.2e10 $M_\odot$



g-r

Little Quench

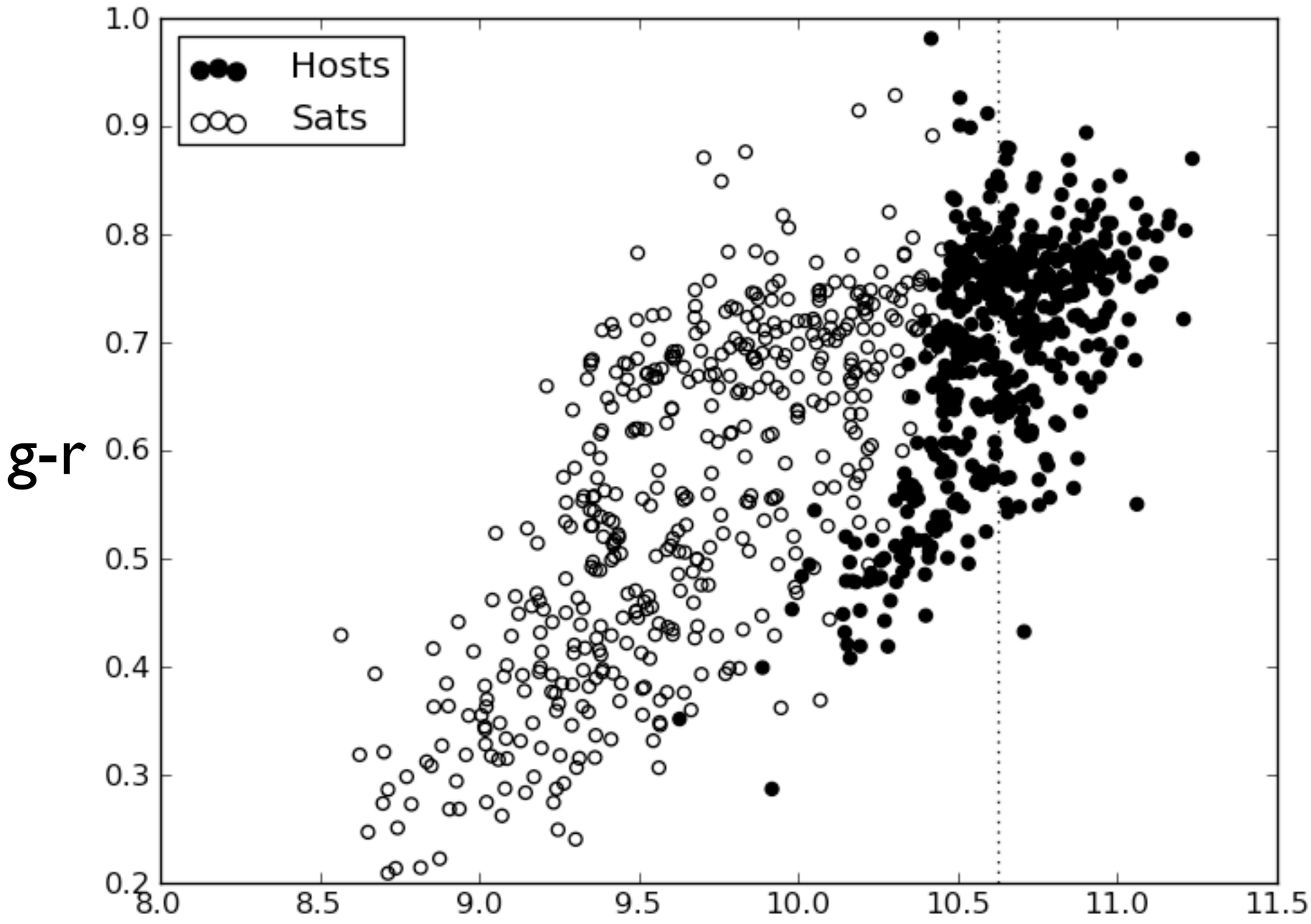
$M_\star$~2.8e10 $M_\odot$



g-r

No? Quench

Phillips, Tollerud et al., in prep.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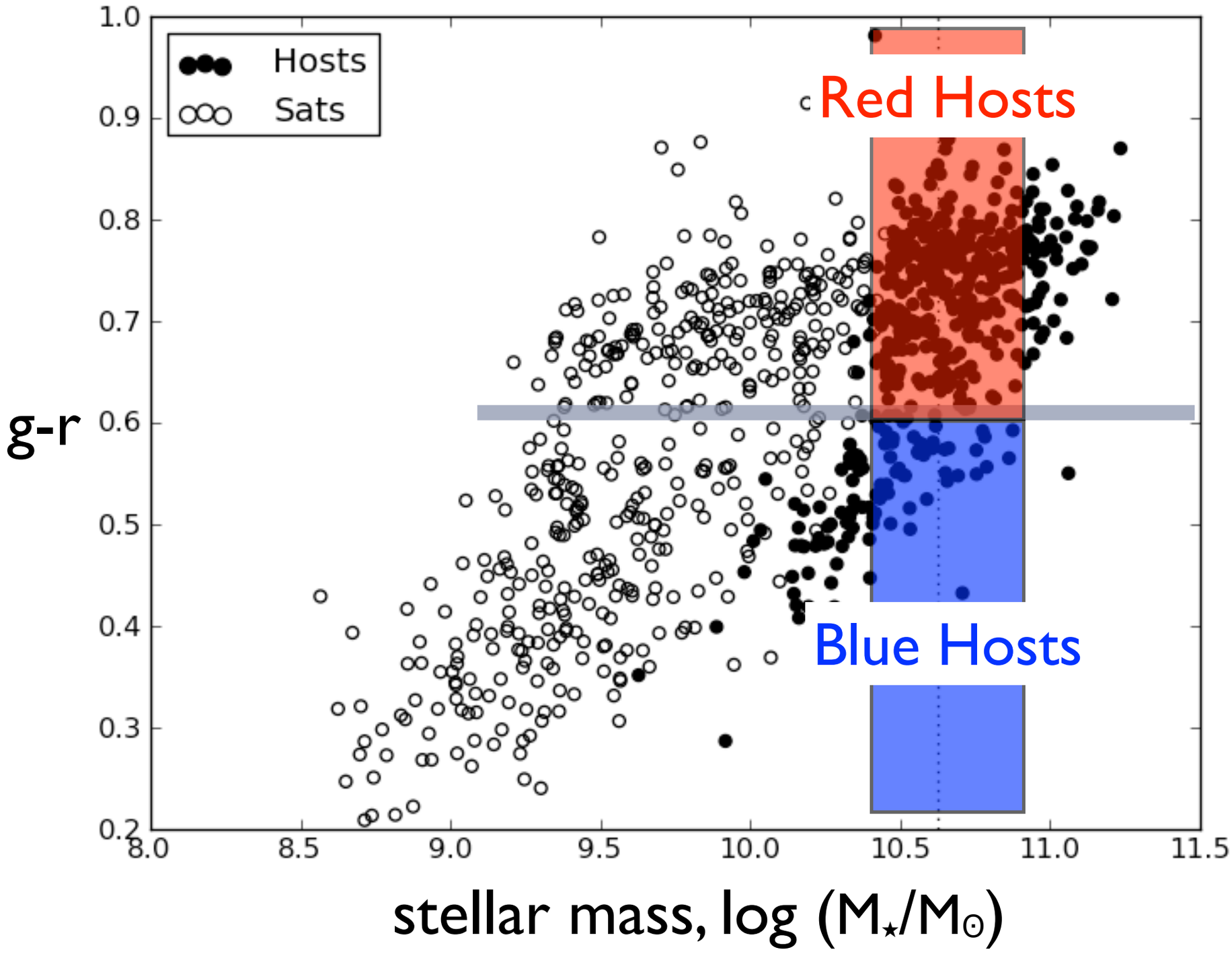
Hosts
Sats
Red Hosts
Blue Hosts
g-r
stellar mass, log (M⋆/M⊙)
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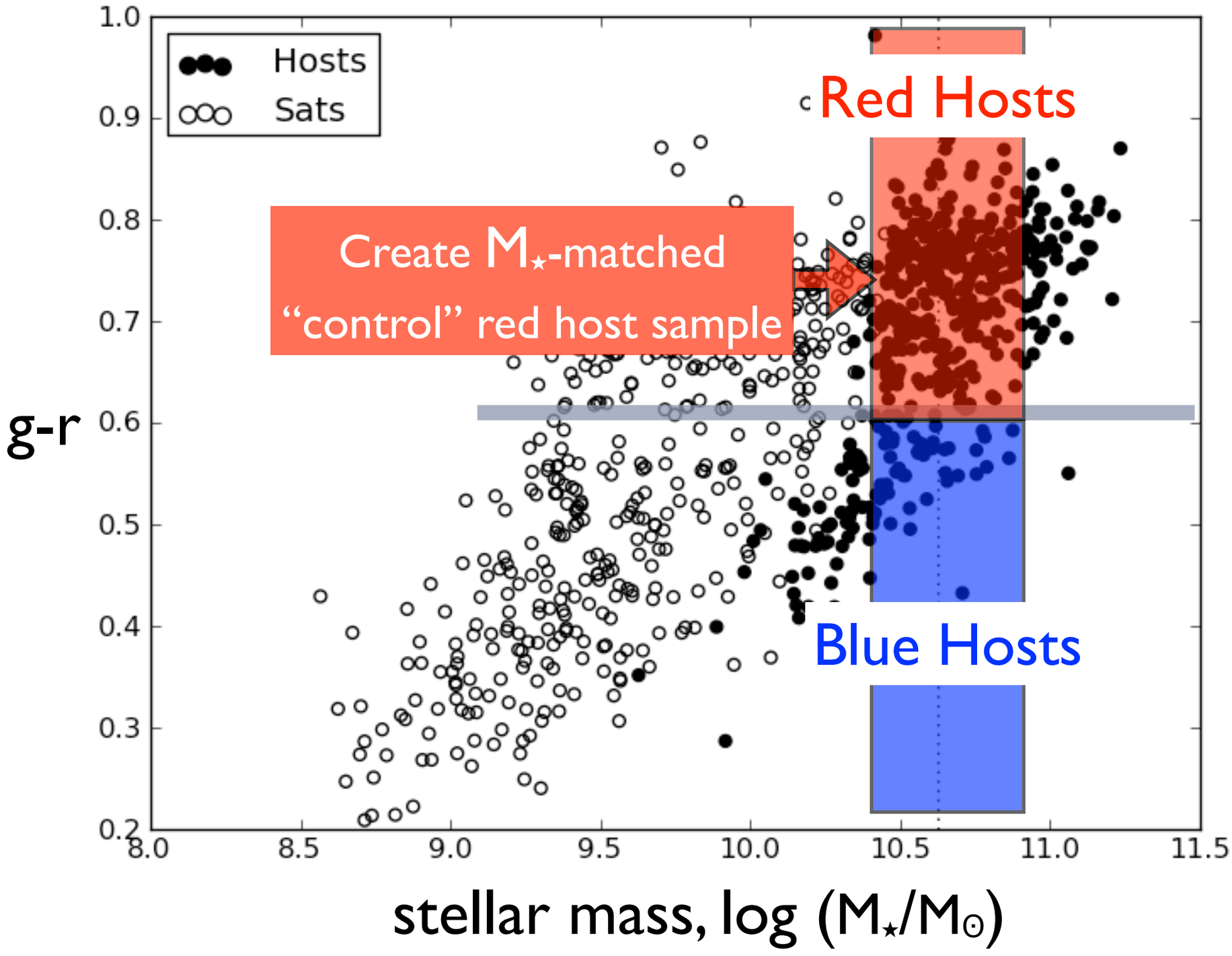
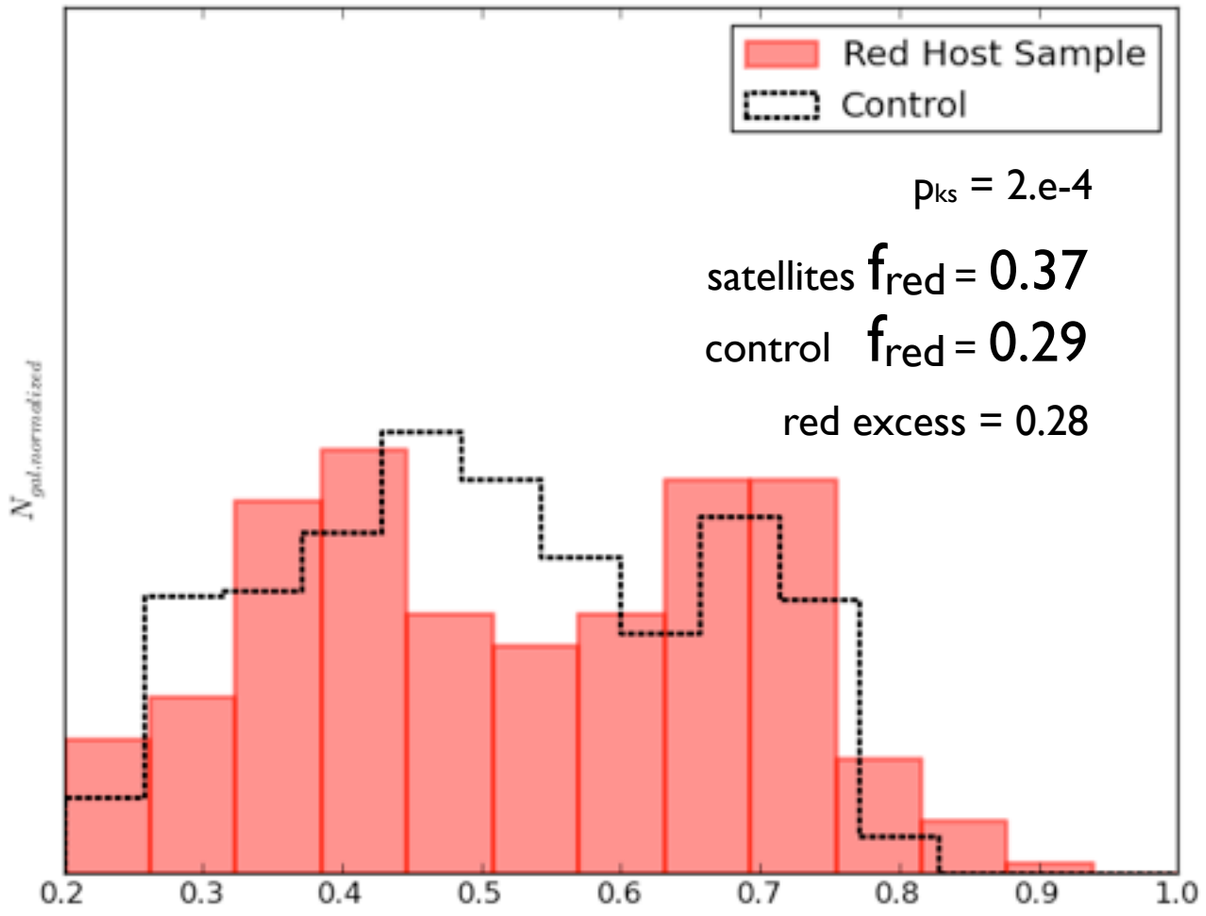
0.2
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5


Hosts
Sats
Red Hosts
Create M⋆-matched
"control" red host sample
Blue Hosts
g-r
stellar mass, log (M⋆/M⊙)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5

$M_\star$~4e10 $M_\odot$

Red Hosts

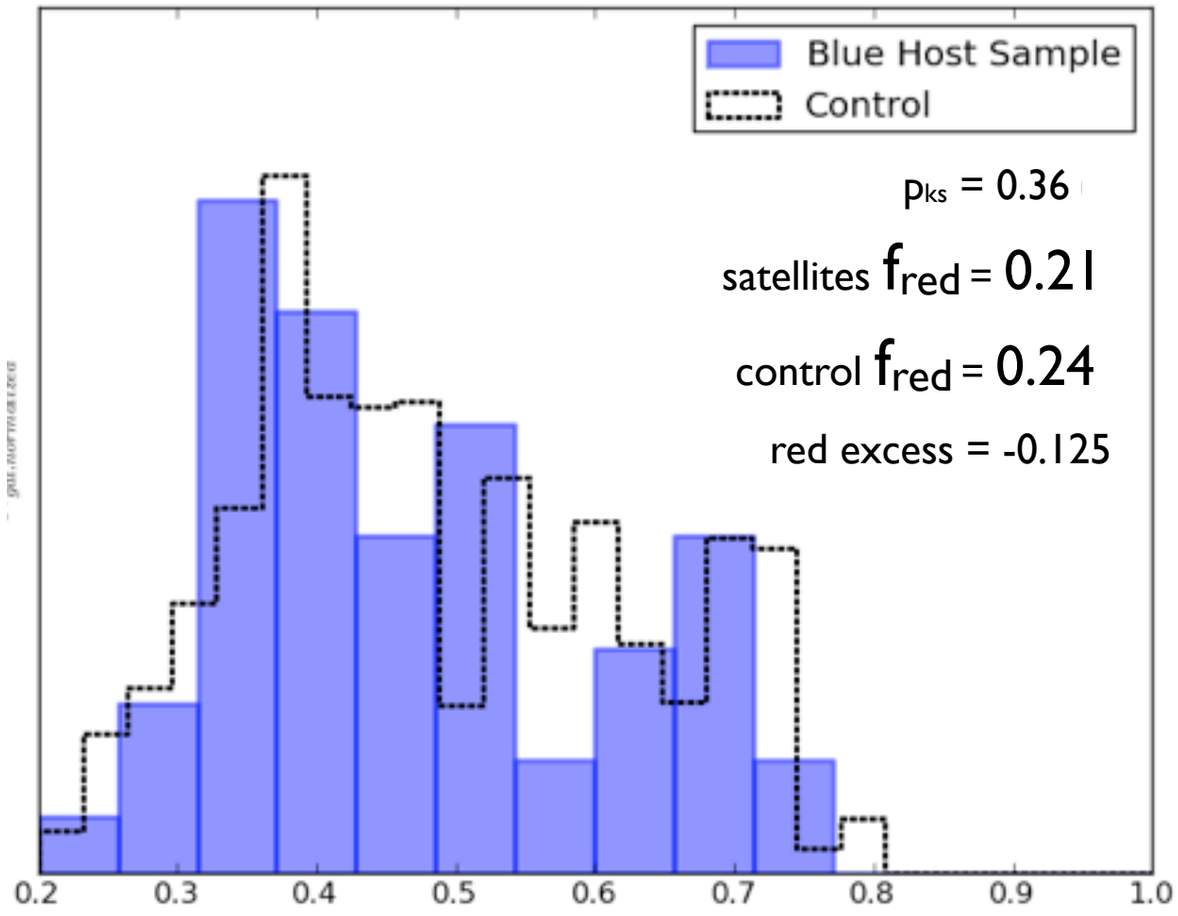


g-r

Quench

$M_\star$~4e10 $M_\odot$

Blue Hosts

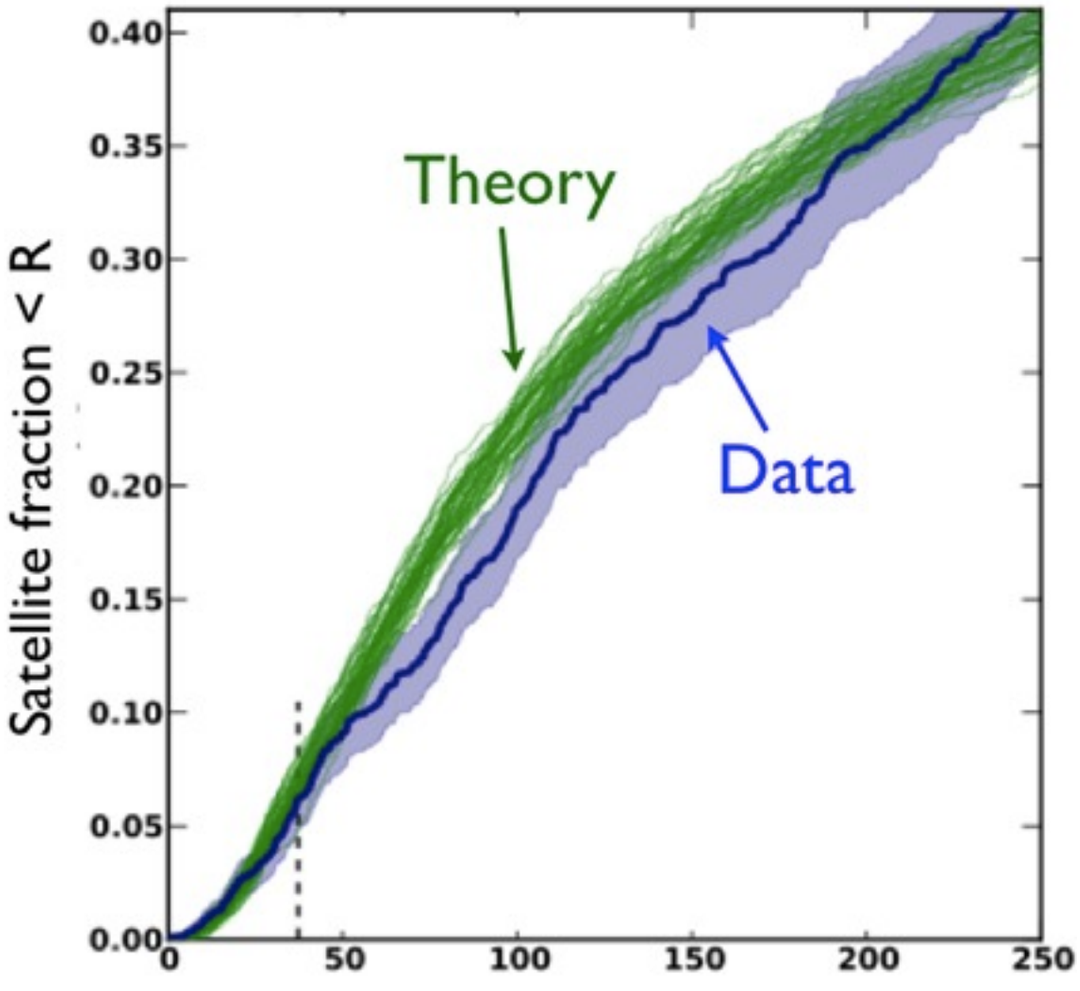


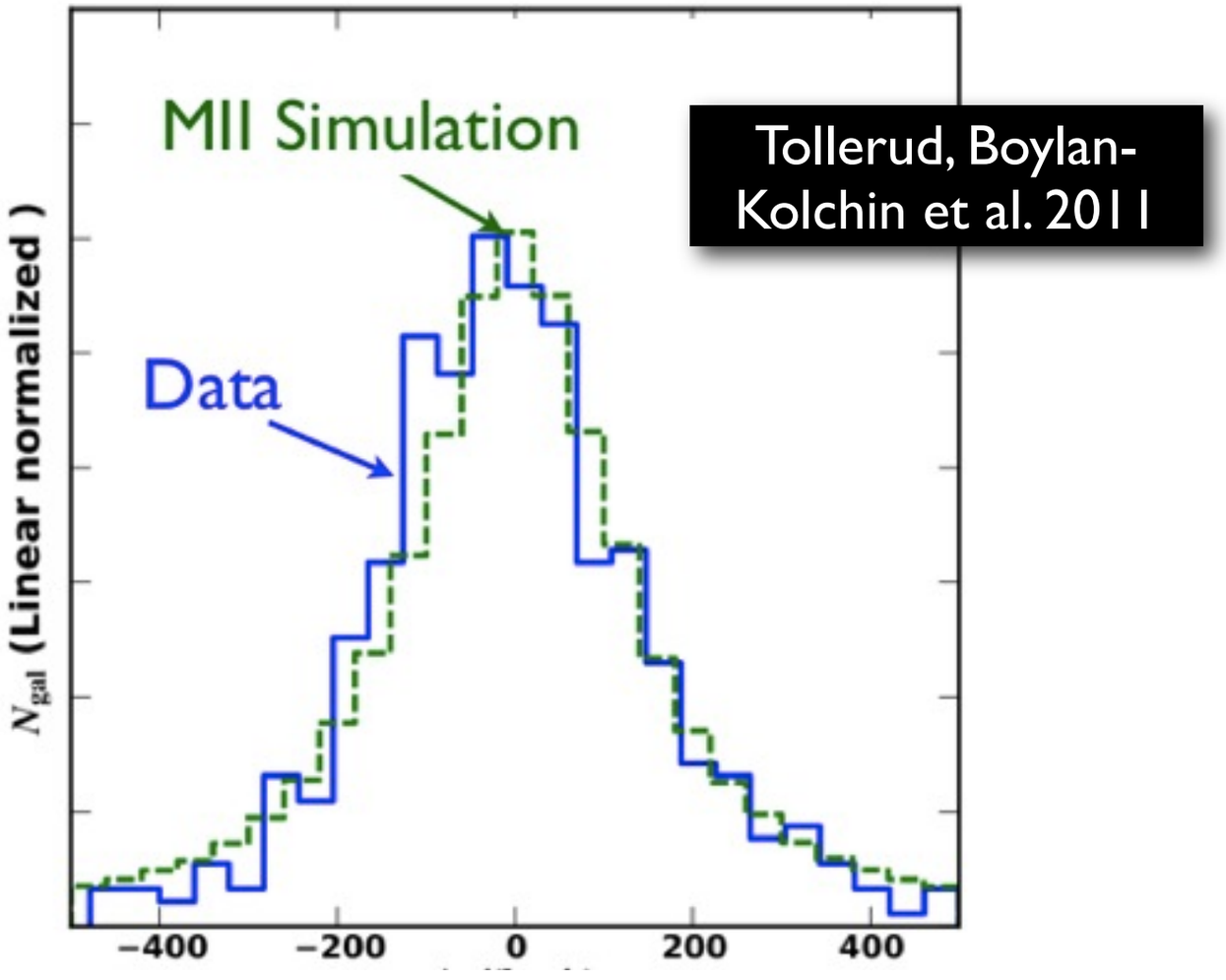
g-r

No? Quench

Conclusions 1

Counts, **radial profile**, and **velocity distribution** of ~0.1L* satellites match ~100km/s subhalos down to **~50 kpc**





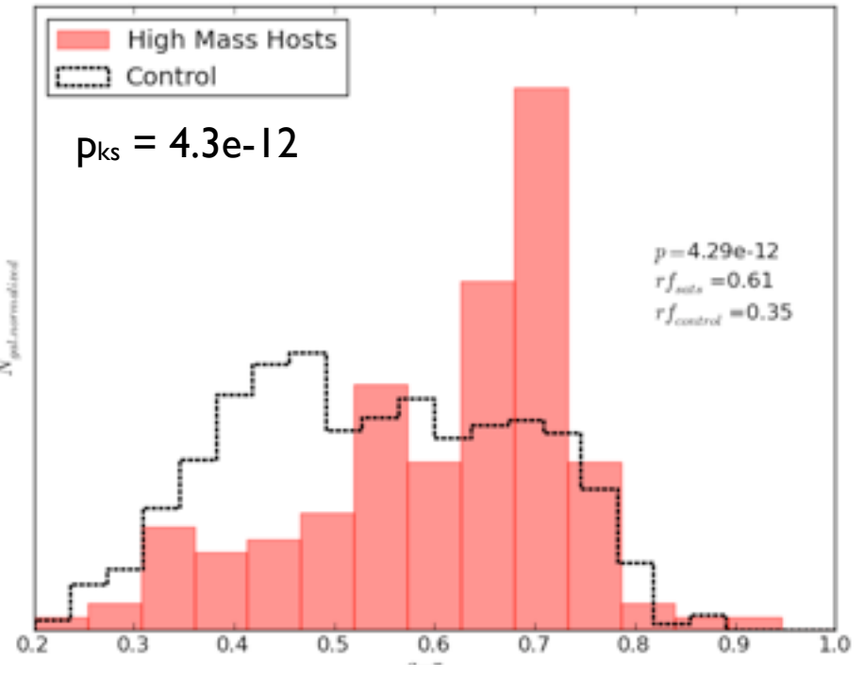
Tollerud, Boylan-Kolchin et al. 2011

Conclusions 2

~0.1L* satellites of isolated ~L* hosts are REDDER than field.

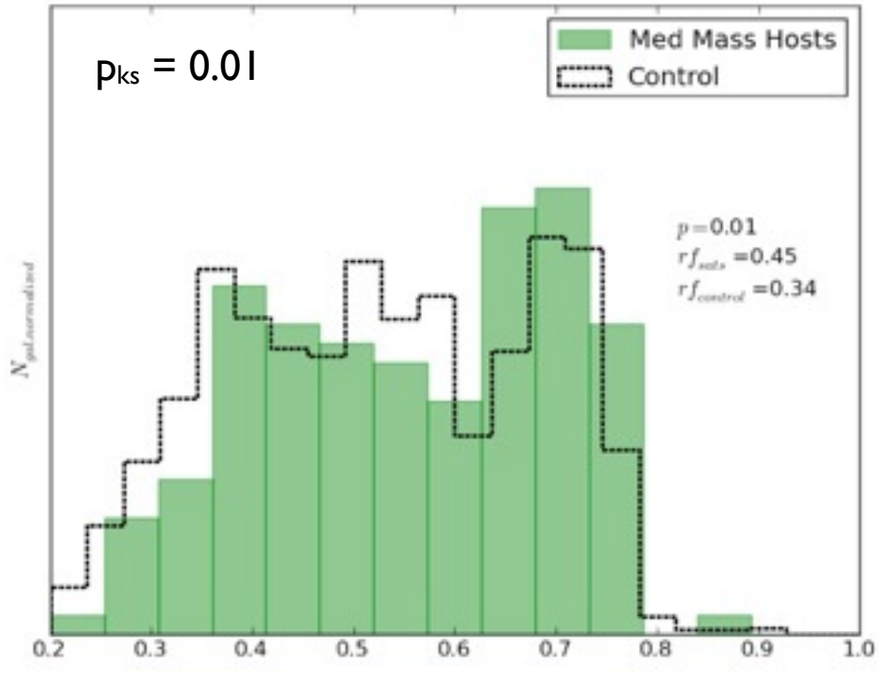
More massive centrals have more quenched satellites:
Scale of quenching is **$M_\star$~4e10 $M_\odot$ ⇔ V_{max} ~ 200 km/s**

$M_\star$~7.4e10 $M_\odot$



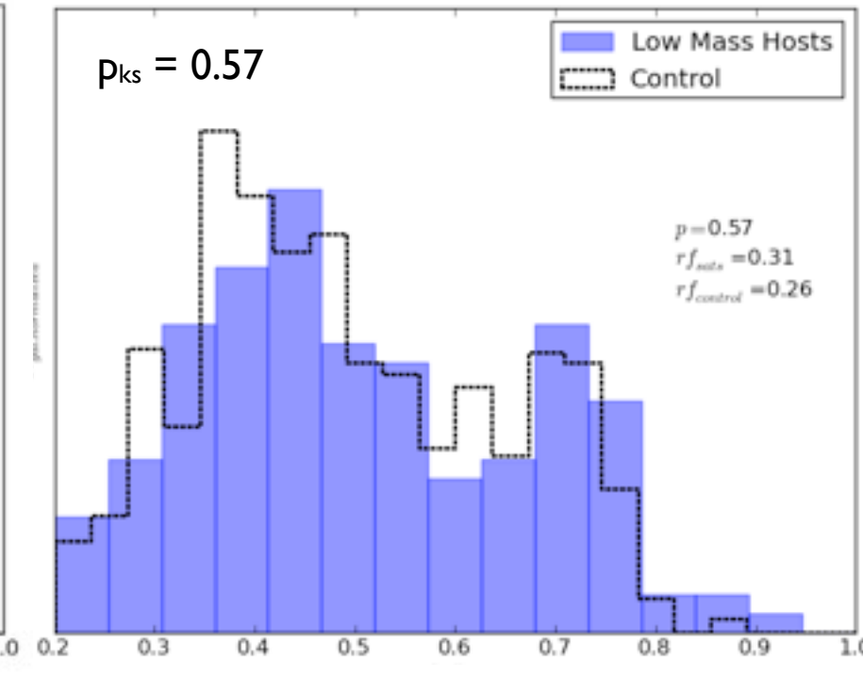
g-r

$M_\star$~4.2e10 $M_\odot$



g-r

$M_\star$~2.8e10 $M_\odot$



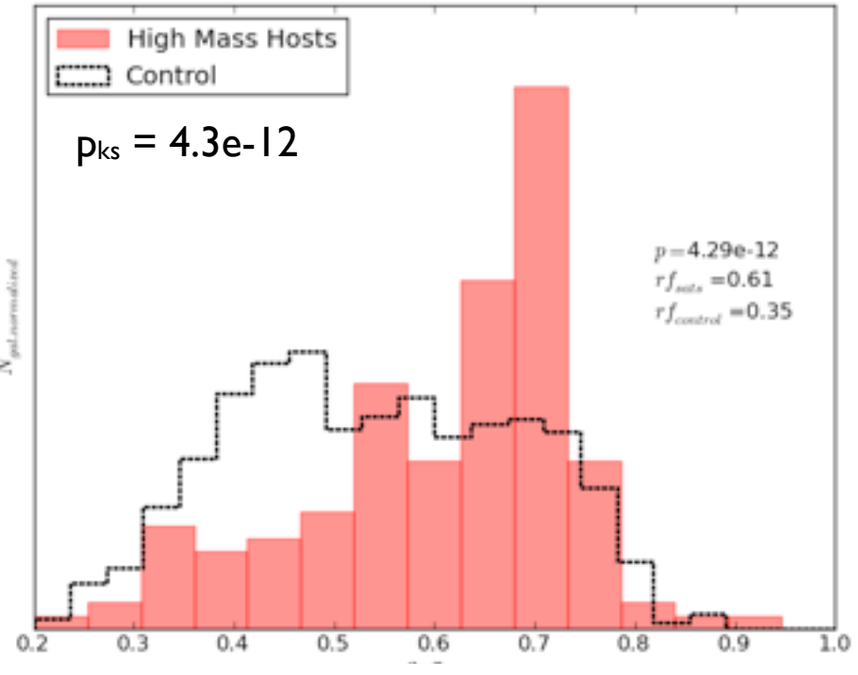
g-r

Phillips, Tollerud et al., in prep

Conclusions 2

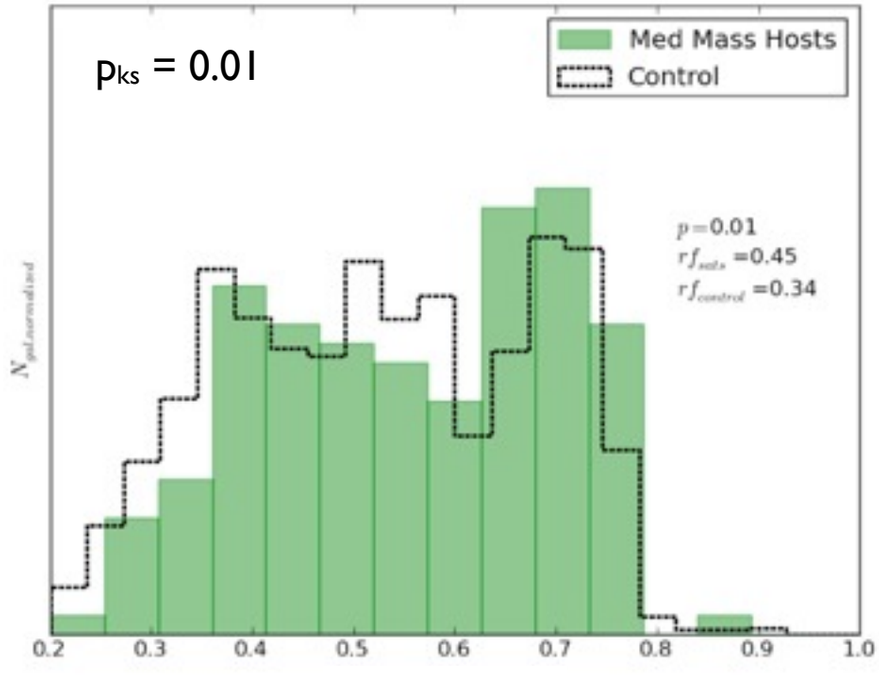
Caveat:
We have defined satellites to be objects within a fixed physical radius of 250kpc. Quenching is likely a strong function of R/R_{vir} (Wetzel et al. 2011). This will bias our results towards less quenching @ small $M_\star$.

$M_\star$~7.4e10 $M_\odot$



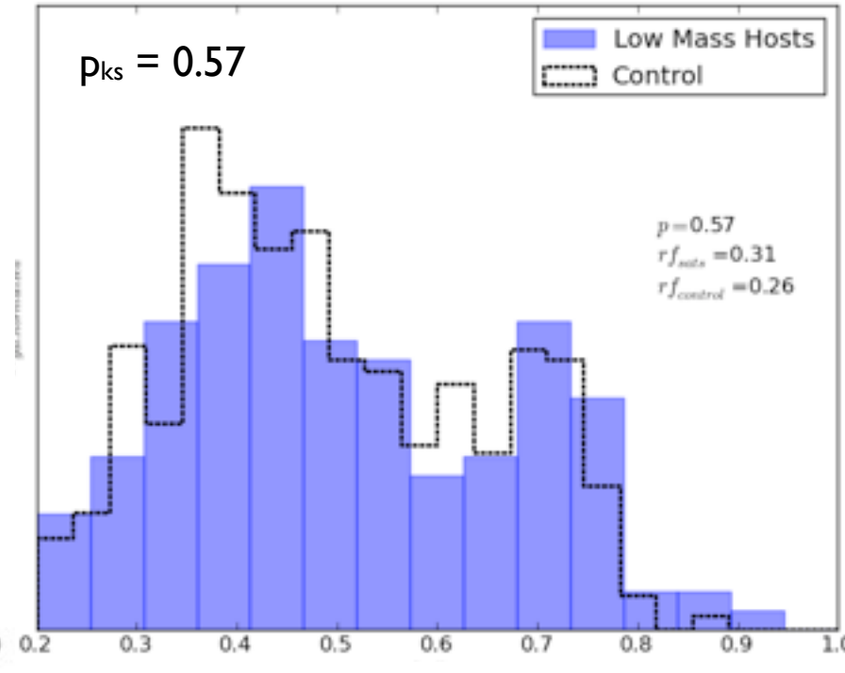
red excess = 0.74 g-r

$M_\star$~4.2e10 $M_\odot$



red excess = 0.32 g-r

$M_\star$~2.8e10 $M_\odot$



red excess = 0.19 g-r

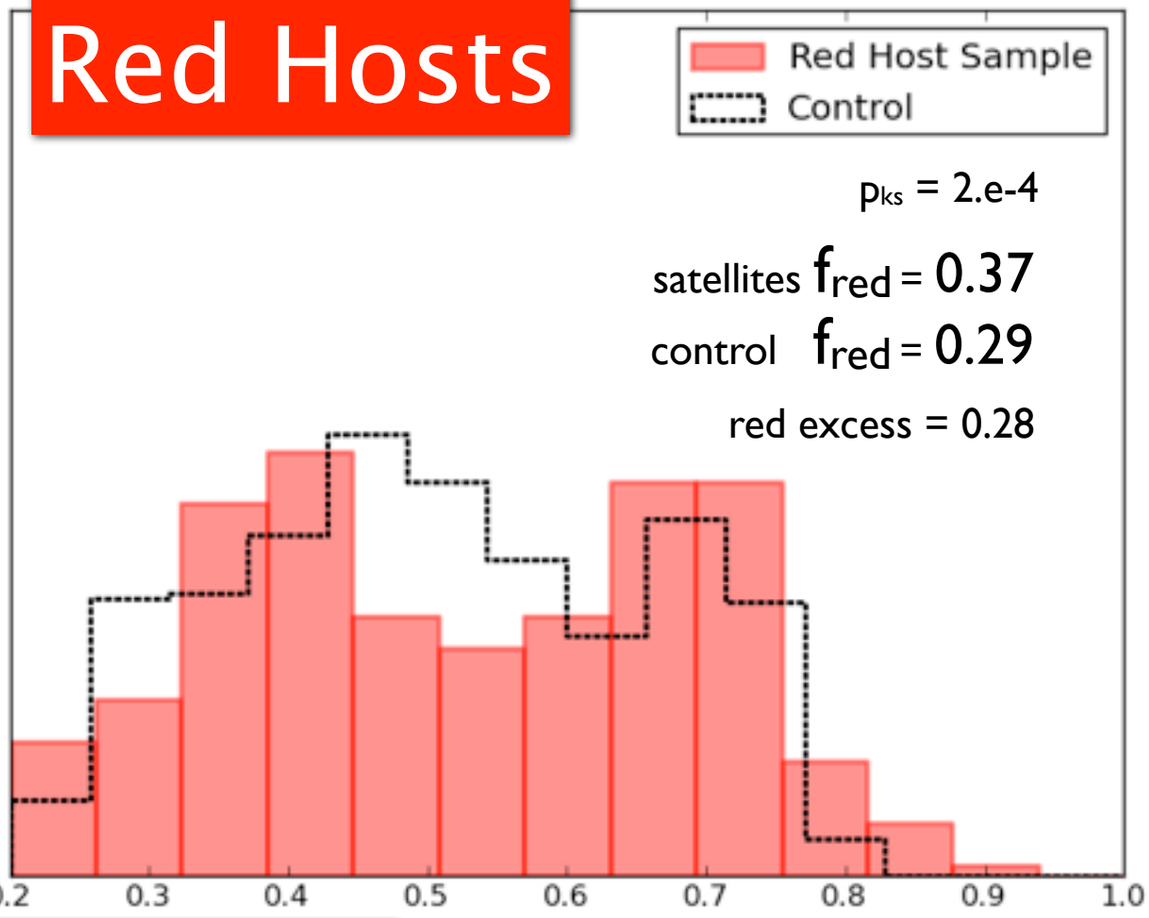
Phillips, Tollerud et al., in prep

Conclusions 3

At fixed stellar mass, red hosts have quenched their satellites more than blue hosts.

$M_\star$~4e10 $M_\odot$

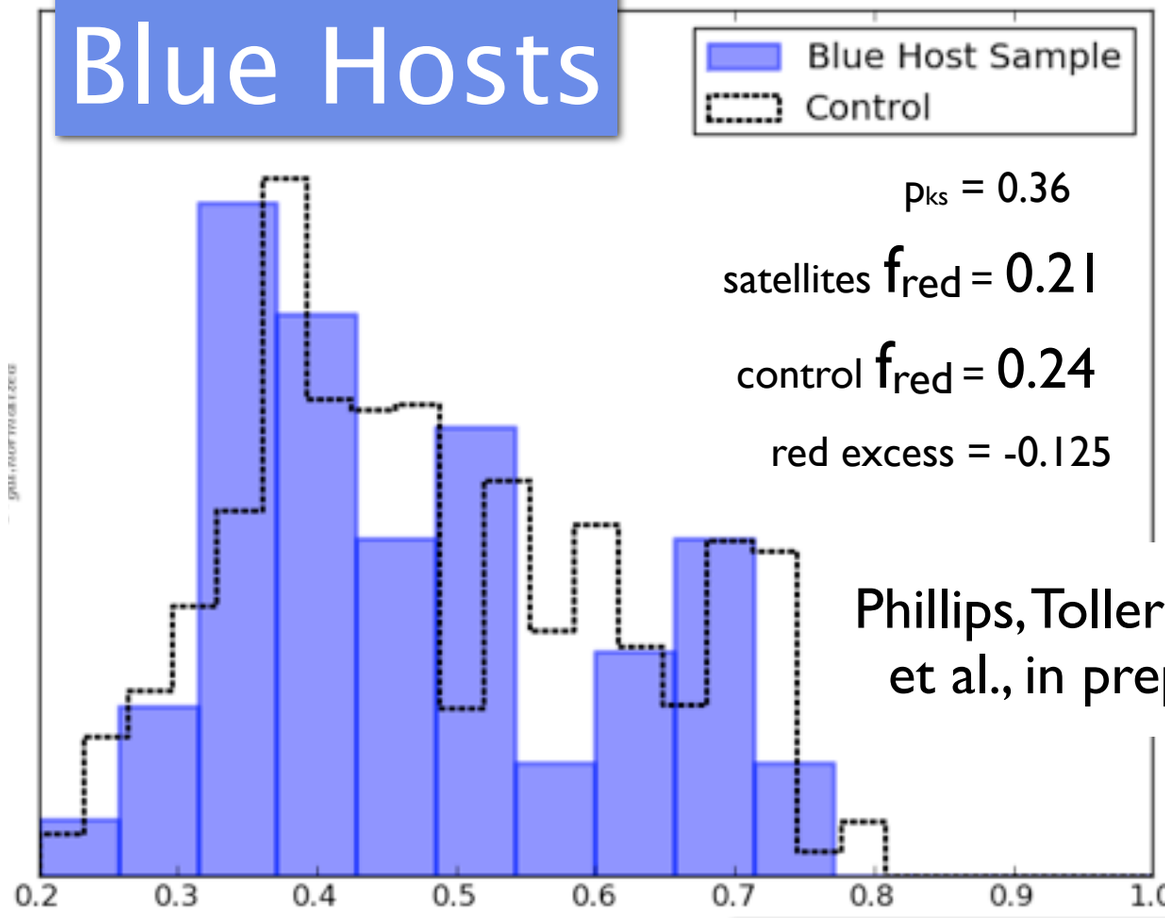
Red Hosts



Quench

$M_\star$~4e10 $M_\odot$

Blue Hosts



No? Quench