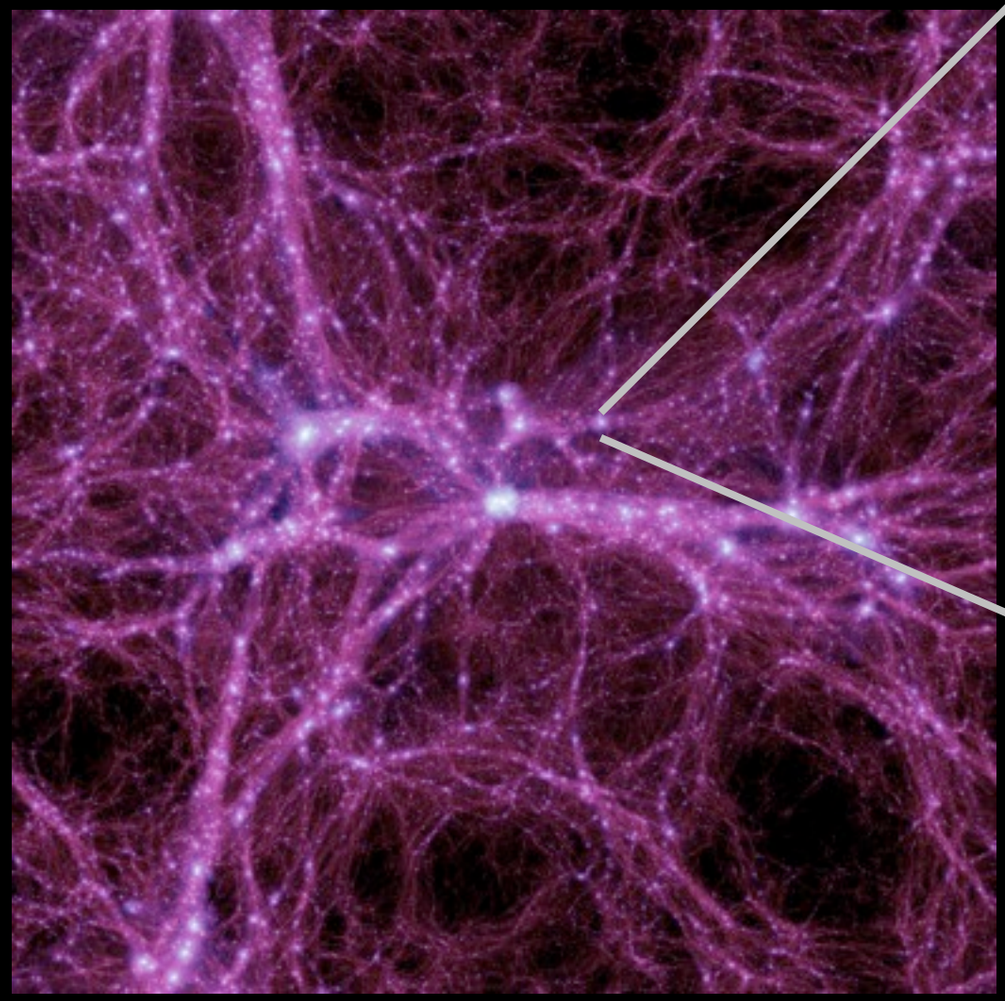
There's no place like home?
The Milky Way in cosmological context



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Gurtina Besla, Lars Hernquist

Southern California CGE Center for Galaxy Evolution

Future of AstroComputing, 16 December 2010

The Milky Way: Rosetta Stone

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Blueprint for understanding galaxy formation universally

Unrivaled ability to study details of stellar populations, star formation, faint stellar systems, supermassive BHs, ...

The Milky Way: Rosetta Stone or Red Herring?

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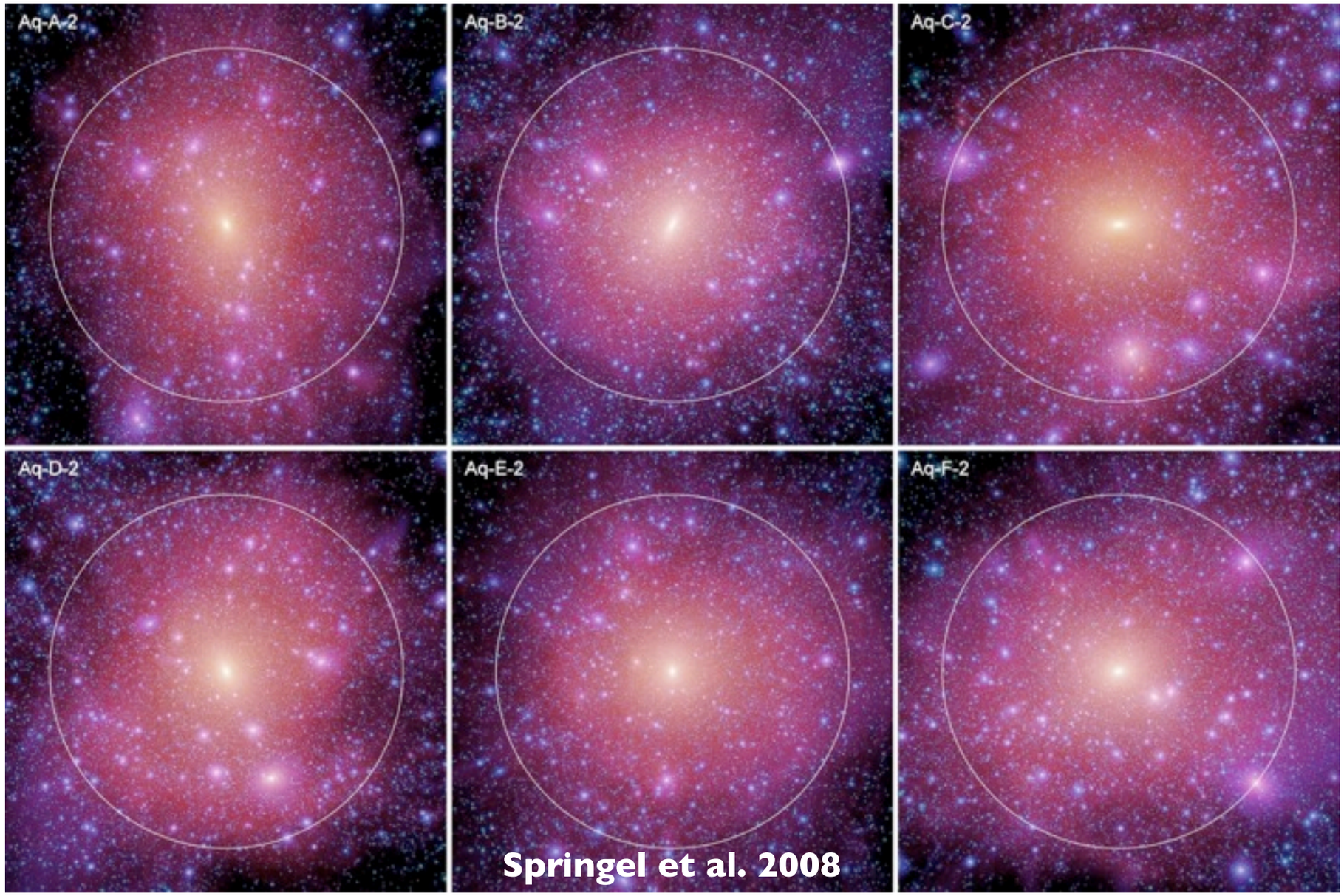
Requires detailed predictions in context of LCDM for MW-mass halos
→ large-scale, high resolution numerical simulations

Aquarius Project, Via Lactea I & II, G-Halo:
state-of-the-art predictions for individual MW-mass halos (N_{vir} =10^8-10^9)



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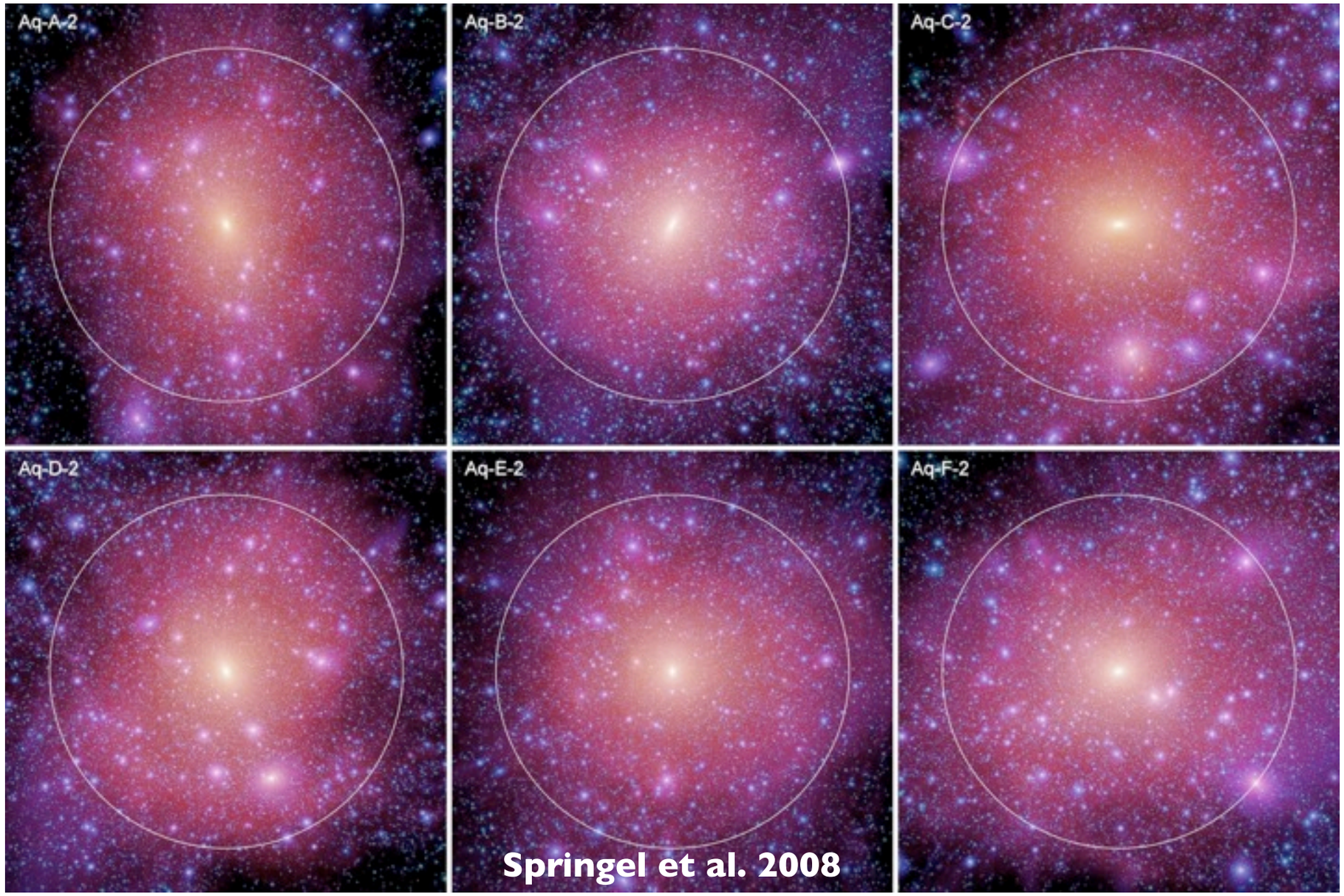

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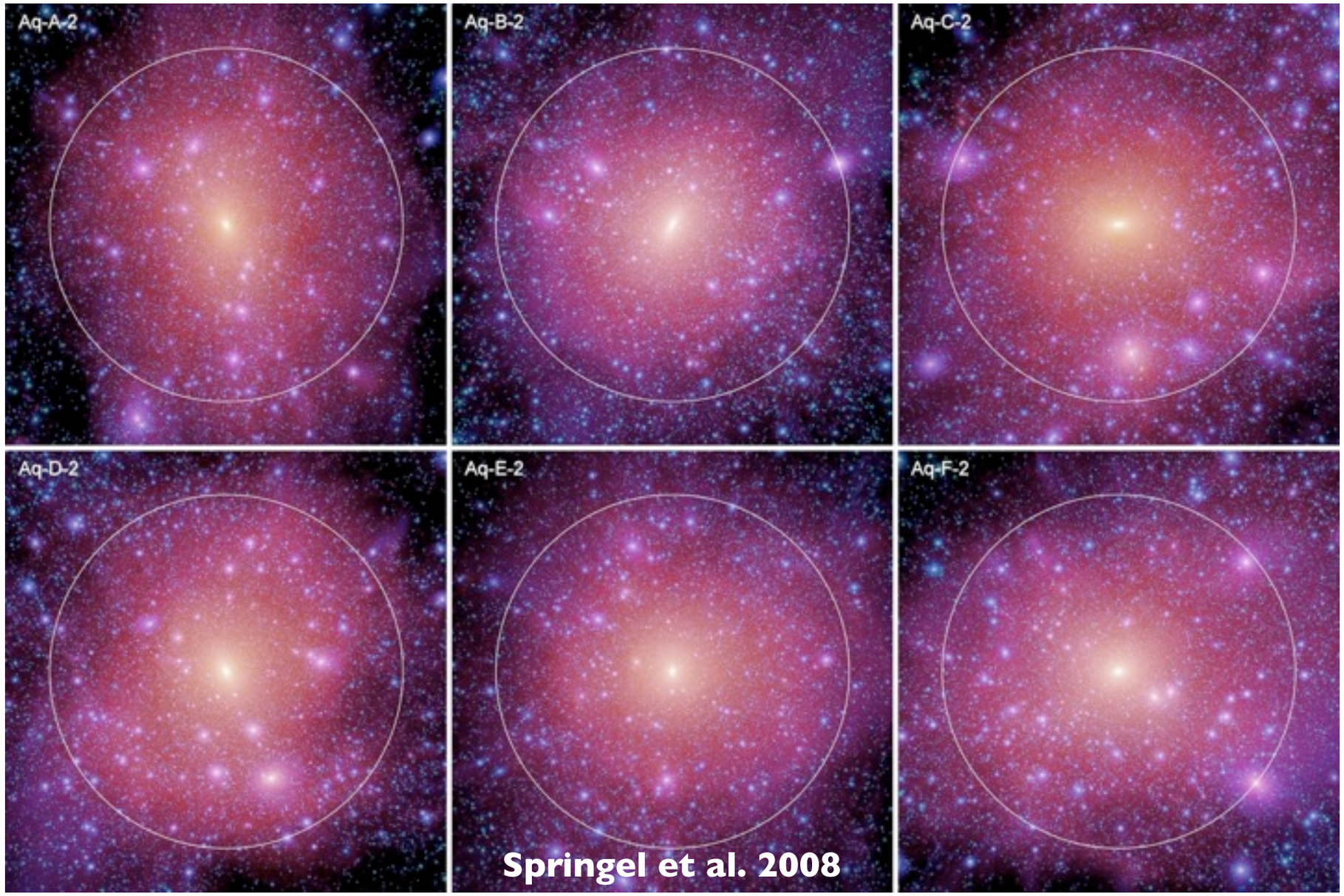

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Reality: resolve 10^6 MW-mass halos with ~1000 particles each in Millennium Run

Millennium-II Simulation

(MB-K, Springel, White, Jenkins, & Lemson 2009):

Same N_p — 2160^3=10.1 billion — as Millennium Run in smaller volume

→ go to length scales 5x smaller, mass scales 125x smaller

Thousands of MW halos with ≳10 resolved subhalos of V_{max} > 30 km/s

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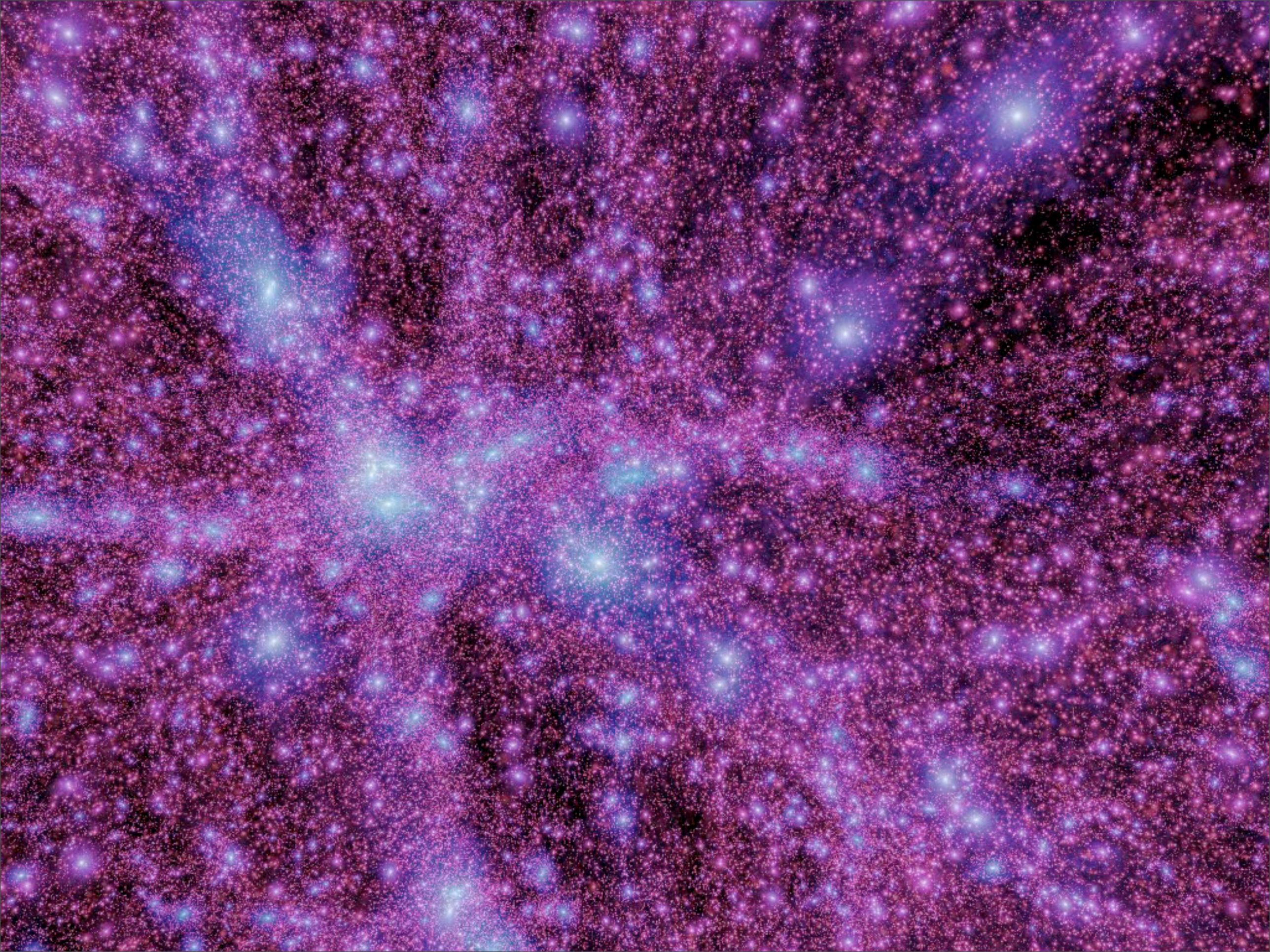
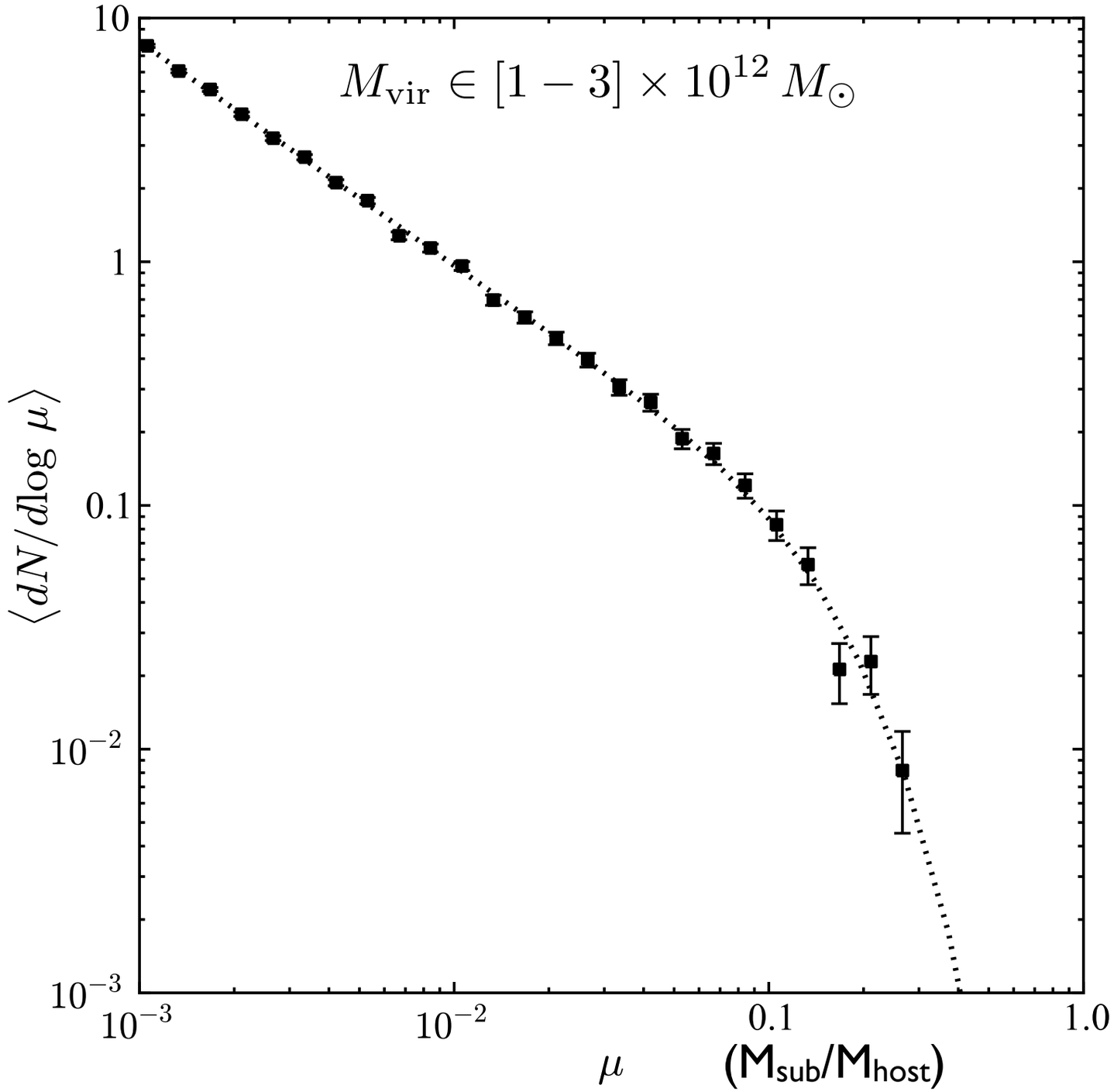


Differential subhalo abundance



squares: MS-II data
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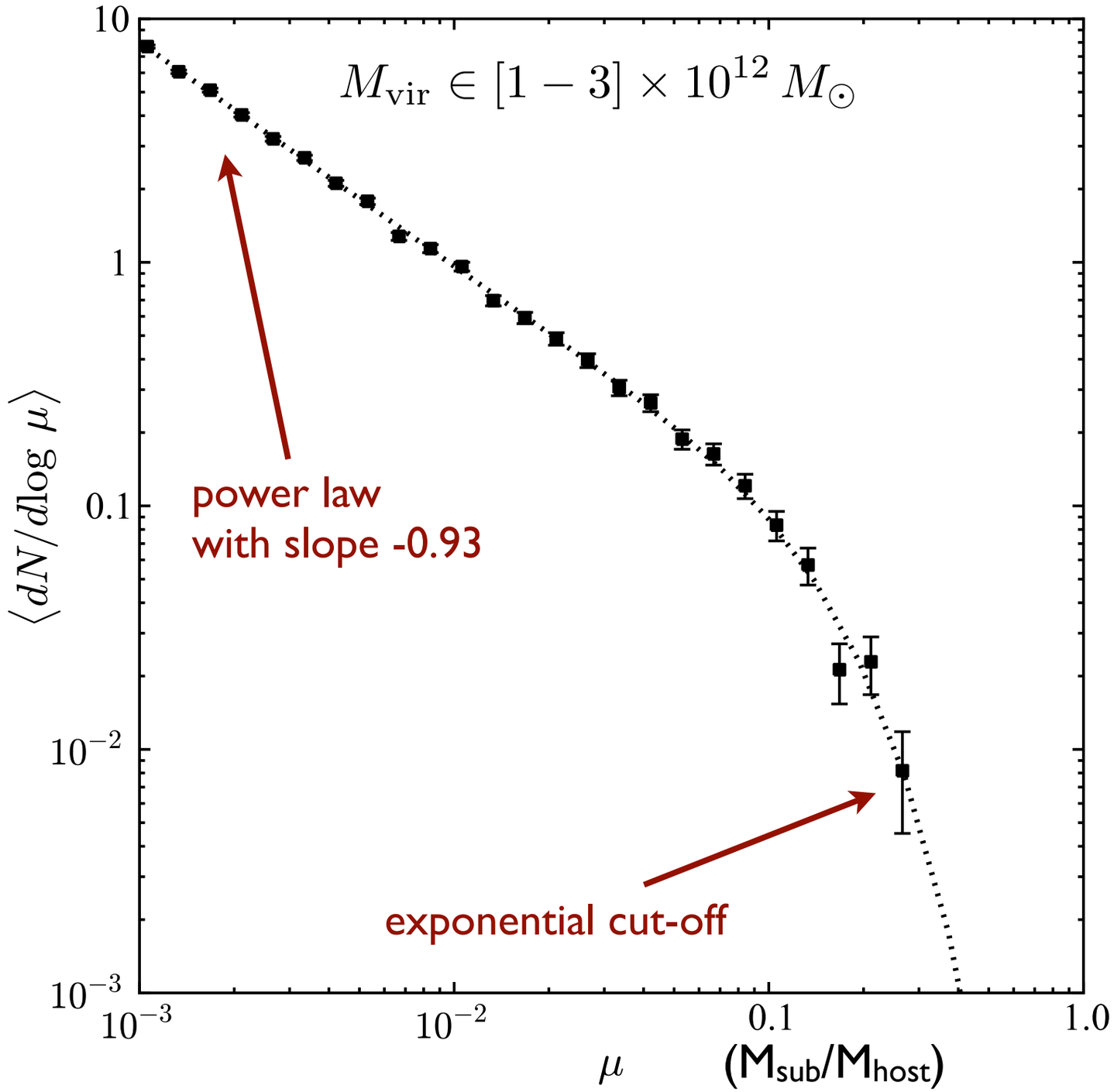

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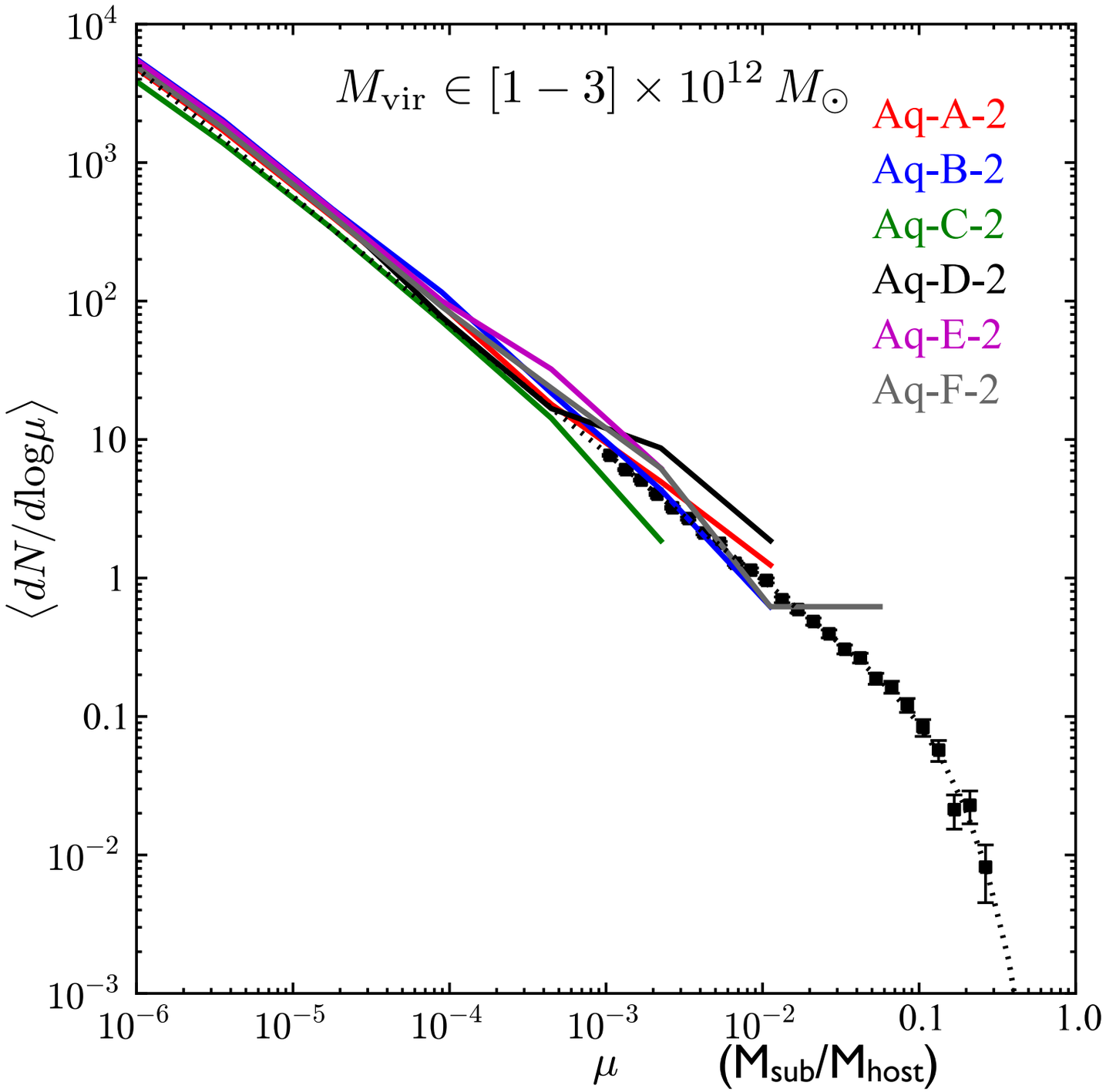

squares: MS-II data
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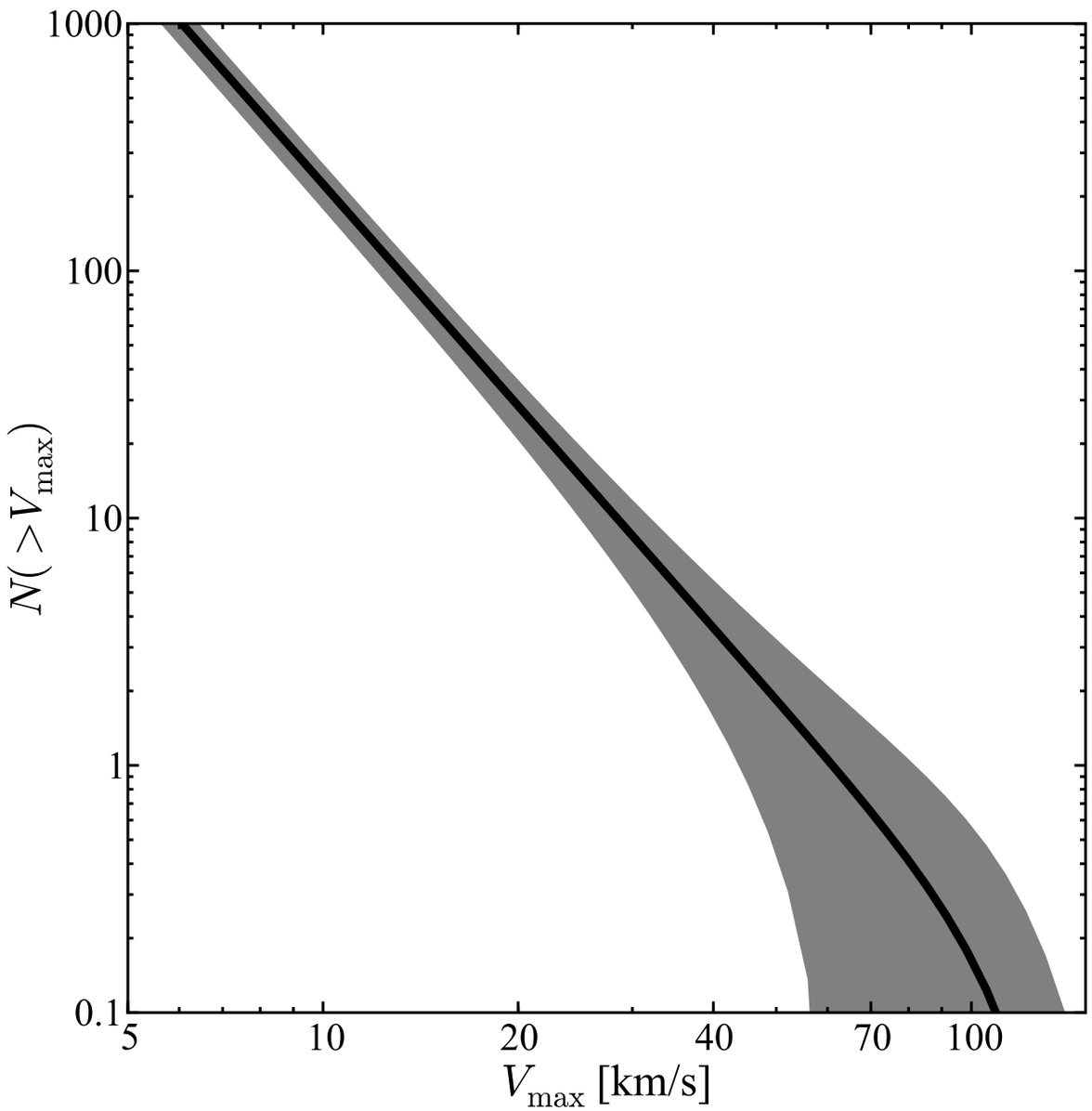
colors: Aquarius

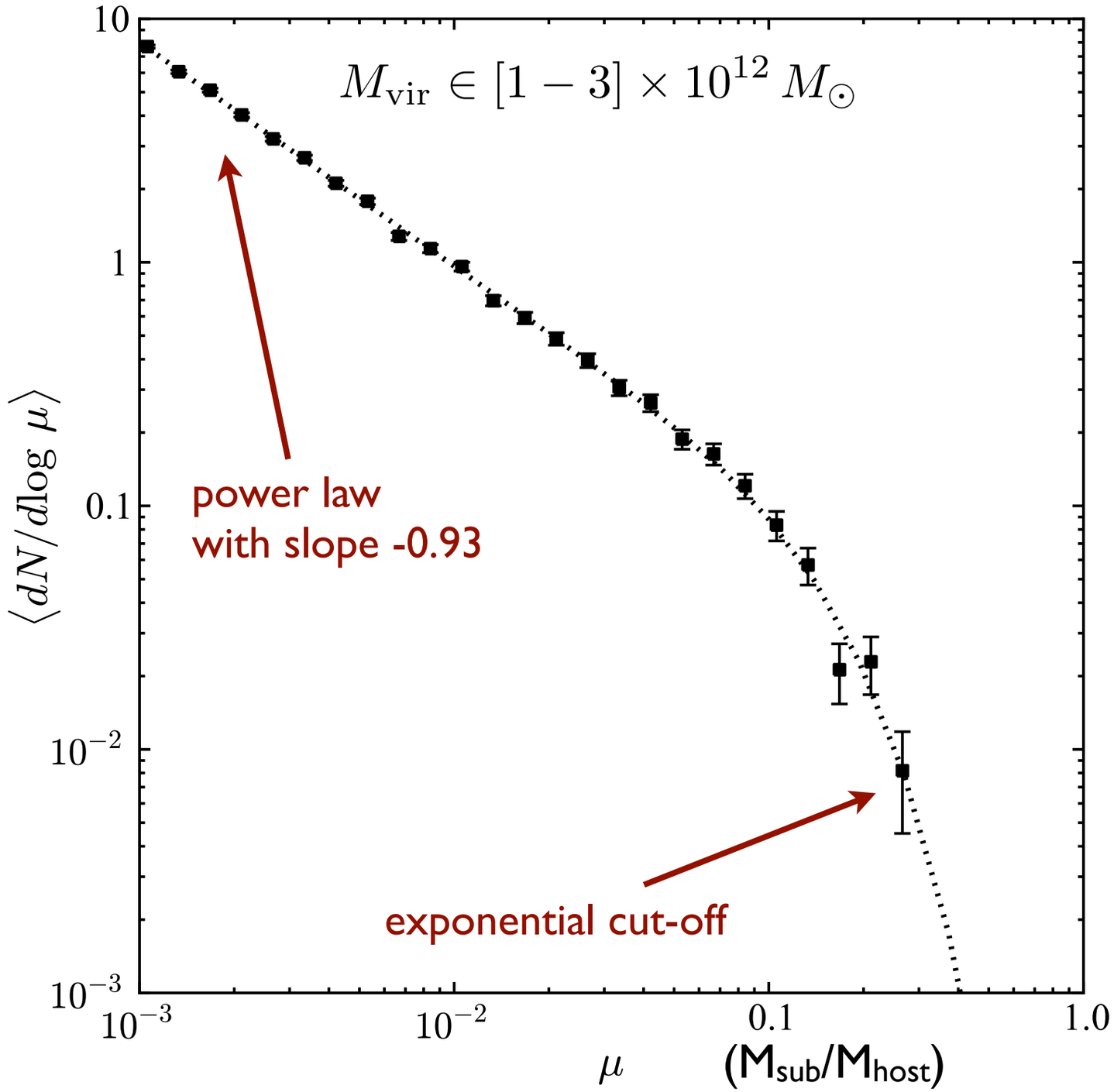
Halo-to-halo scatter: # of low-mass subhalos

Halo-to-halo variation includes ~20% intrinsic scatter at fixed subhalo mass.



"Missing satellites" in the Milky Way **not** due to halo-to-halo scatter (from, e.g., low density environment)

Differential subhalo abundance



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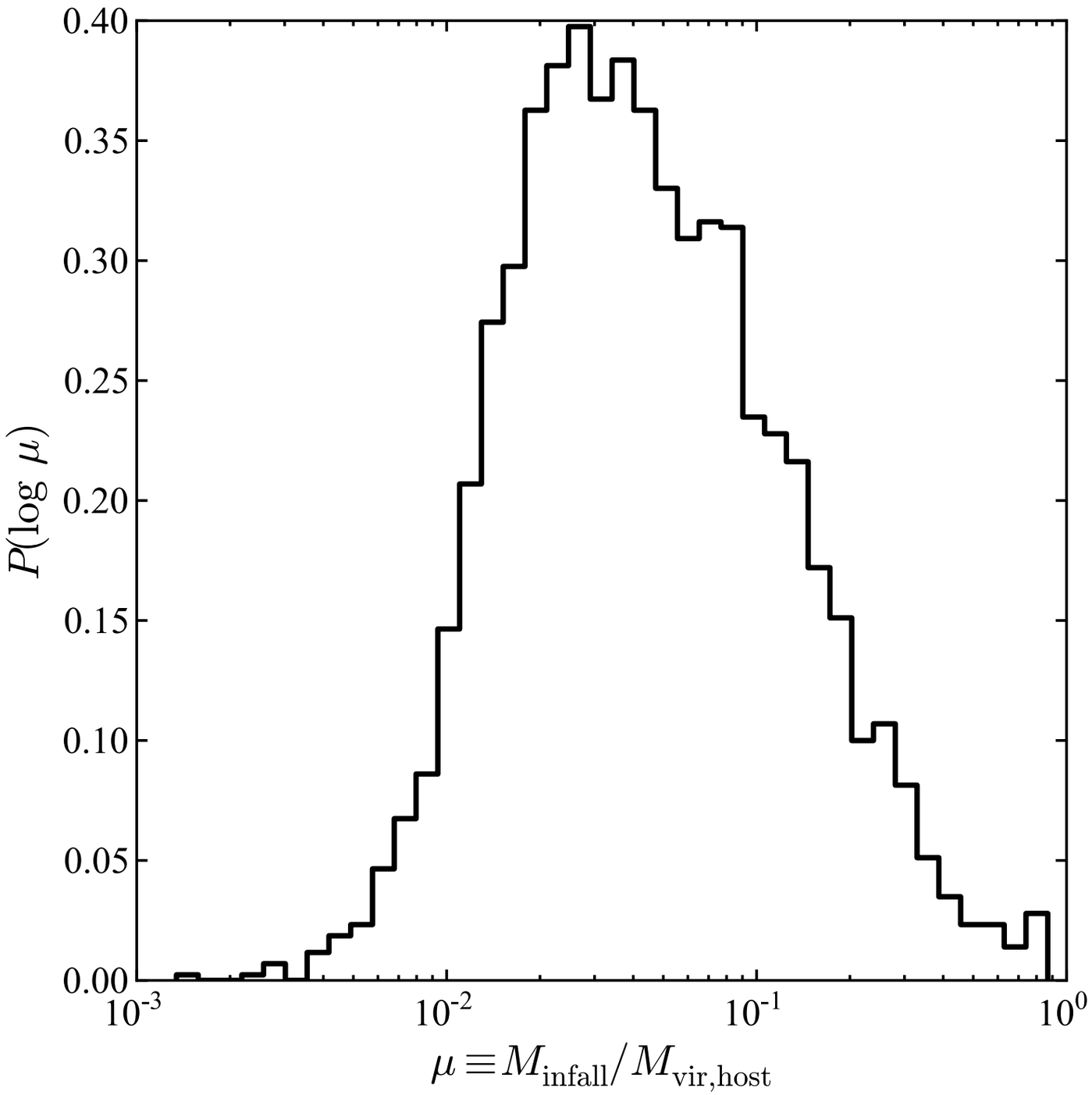
Massive subhalos: How common is the LMC?



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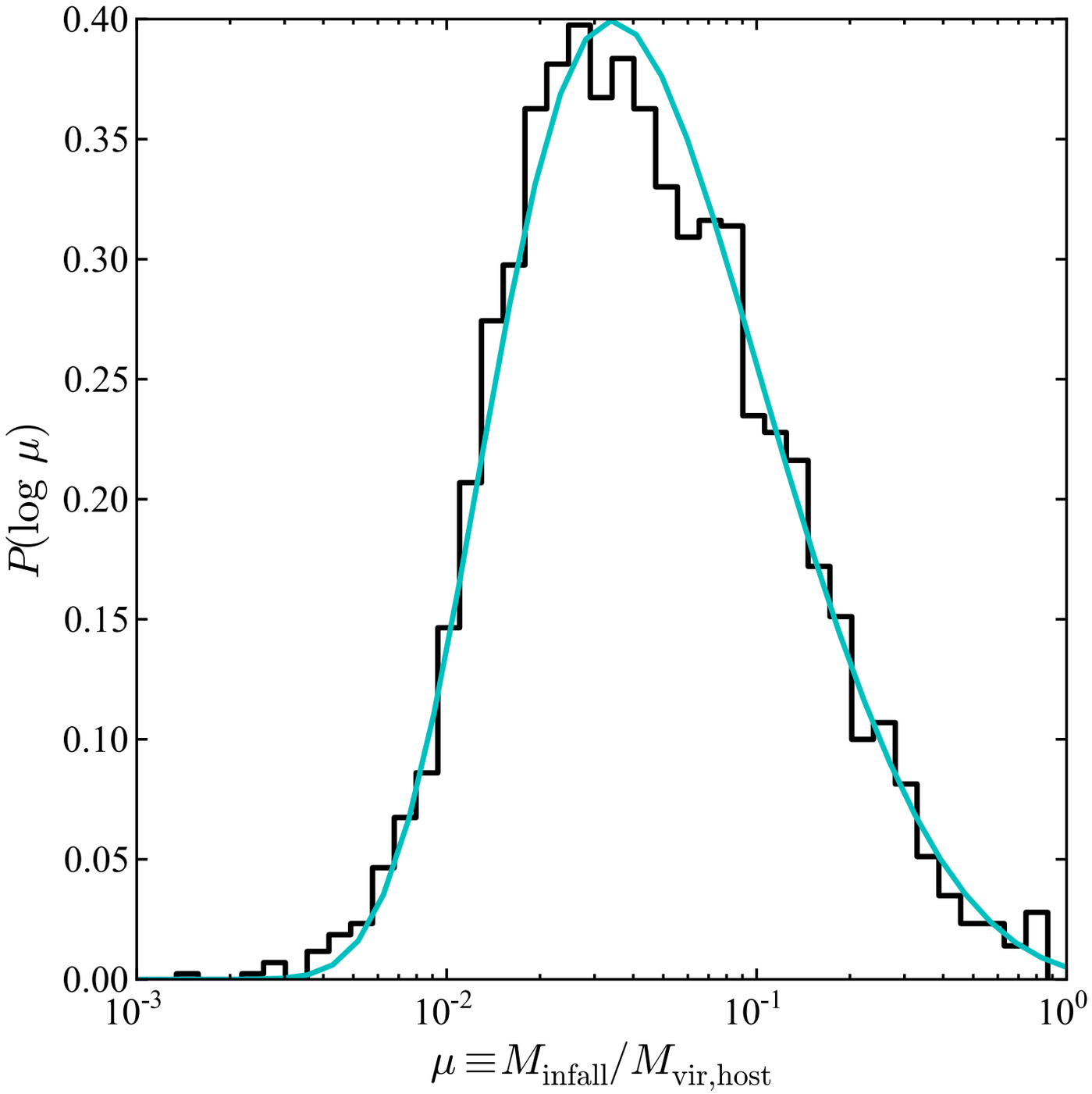

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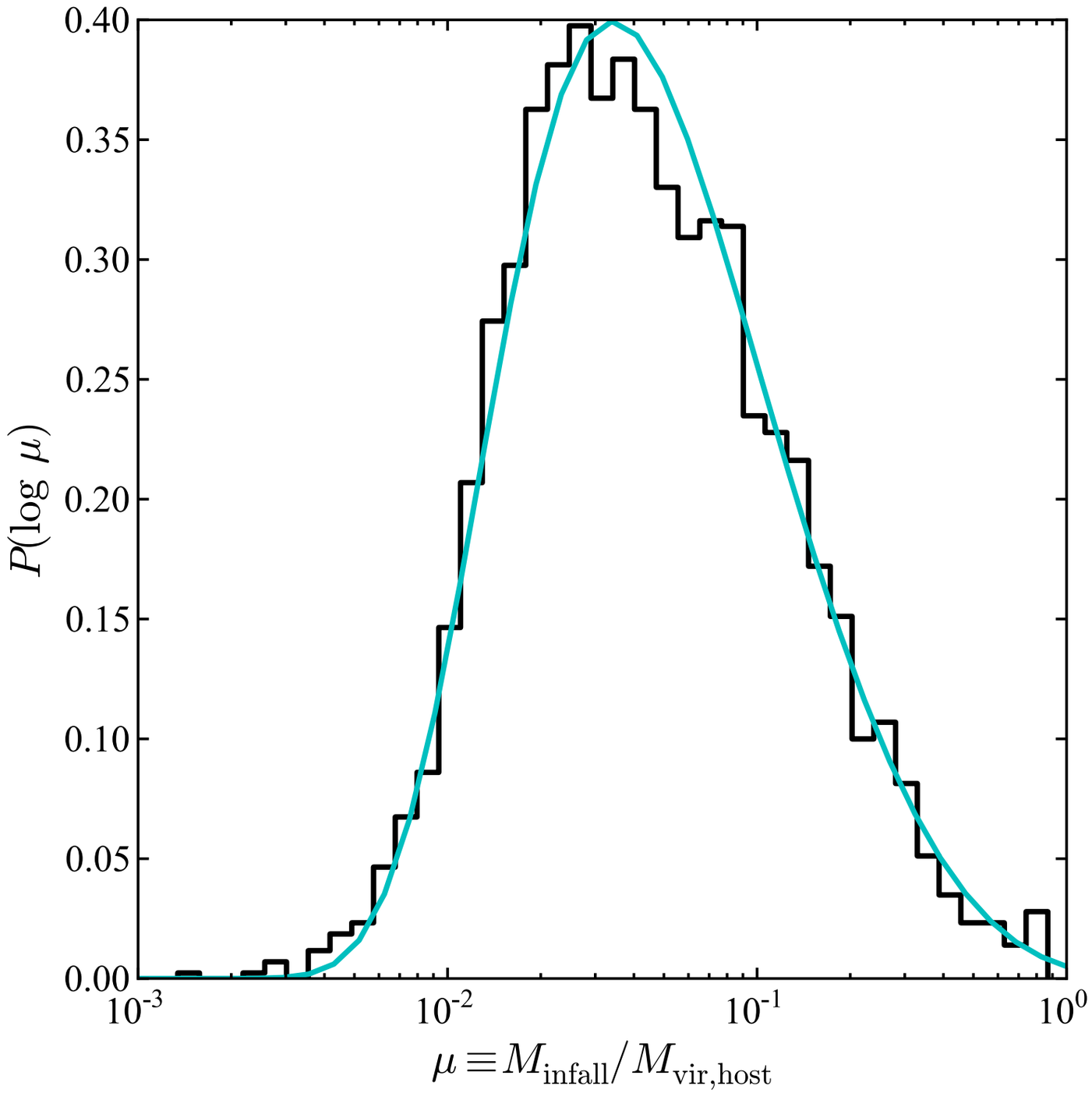

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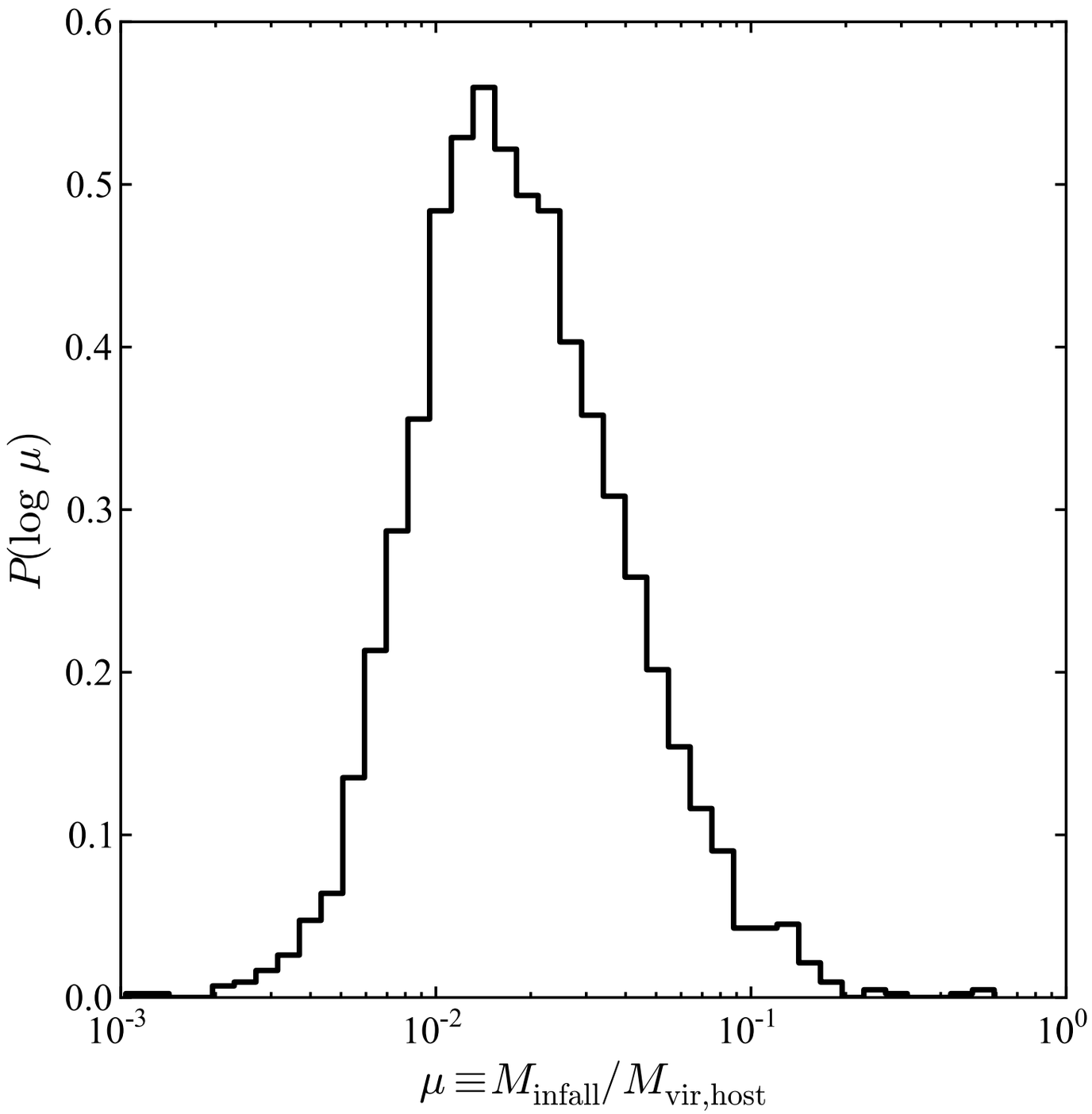
LCDM expectation for galaxy with LMC's stellar mass:

$$M_{\rm infall} \approx 1.5 \times 10^{11}\, M_\odot$$

$$\mathrm{P(LMC)} = \begin{cases} 11.4\% & M_{\rm MW} = 10^{12}\, M_\odot \\ 27.3\% & M_{\rm MW} = 2 \times 10^{12}\, M_\odot \end{cases}$$

Massive subhalos: How common is the SMC?



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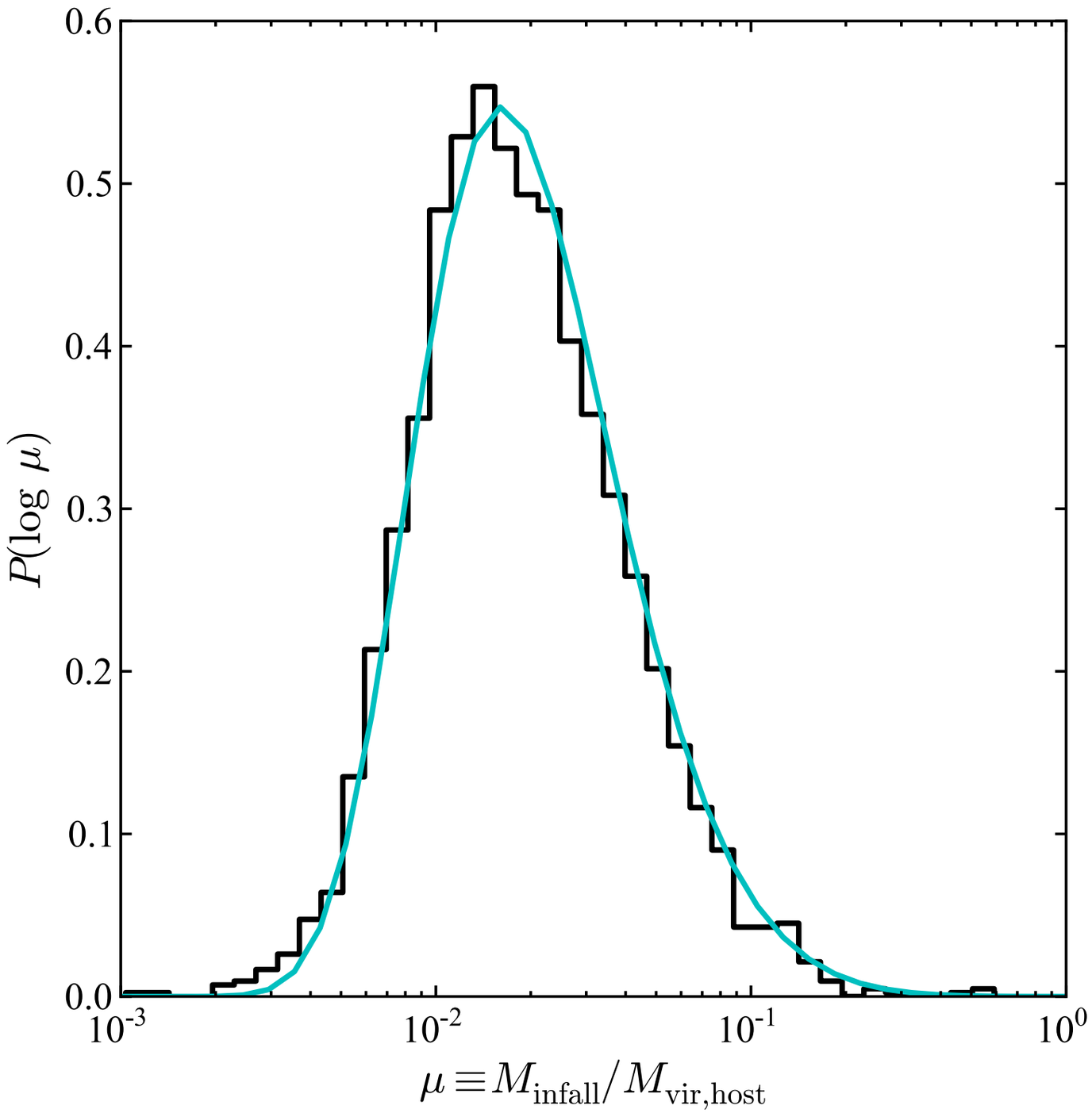

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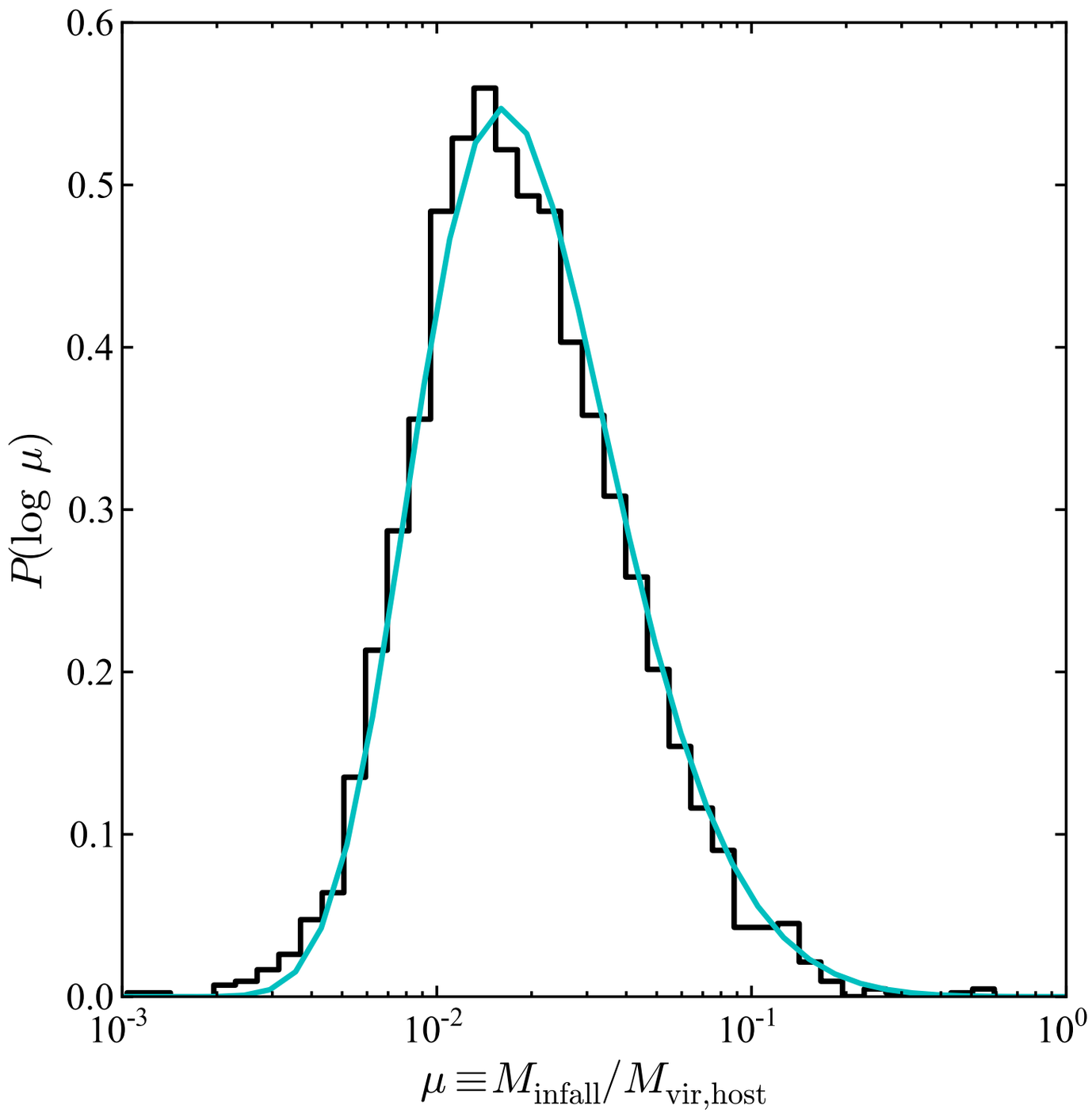

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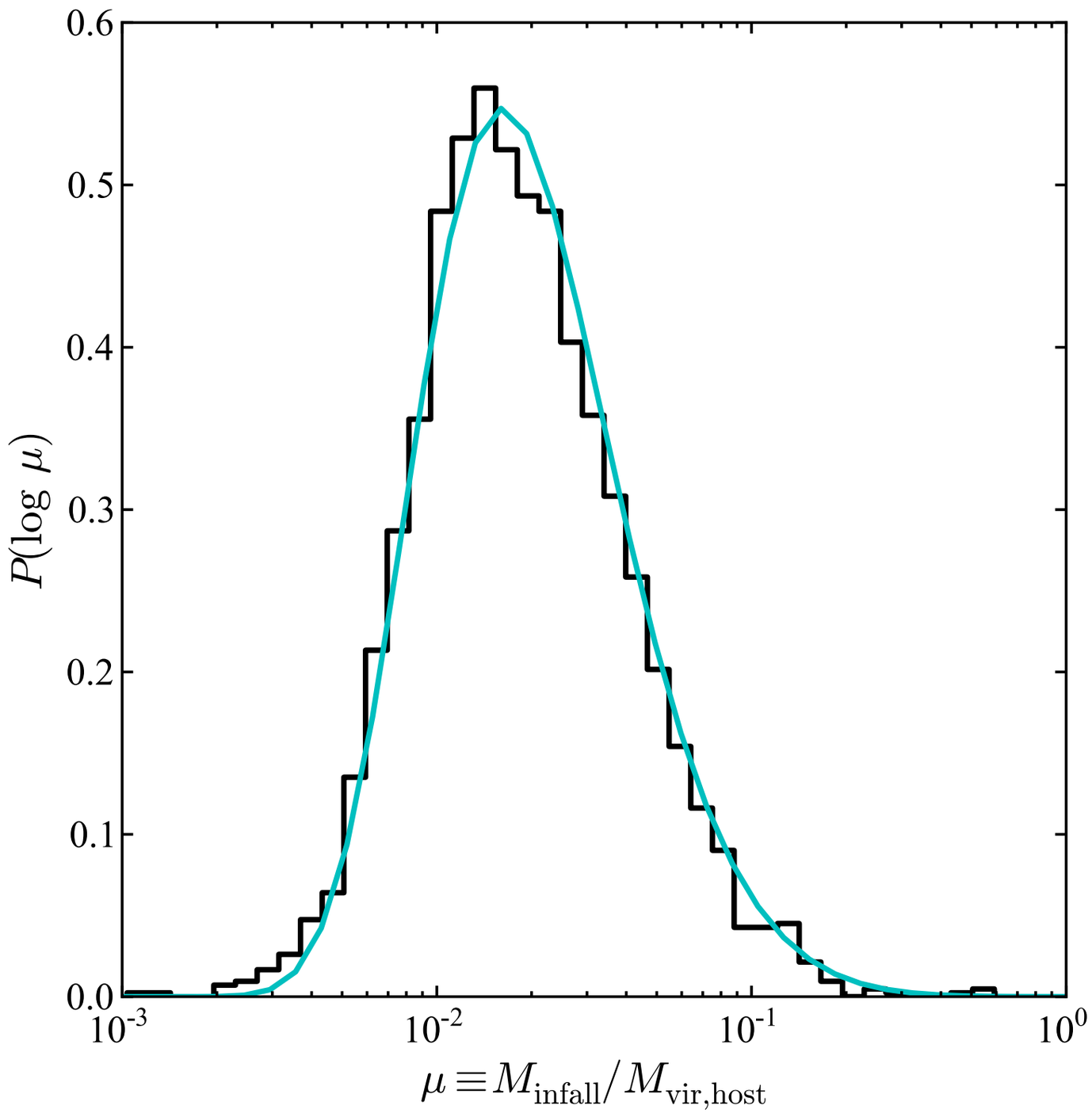

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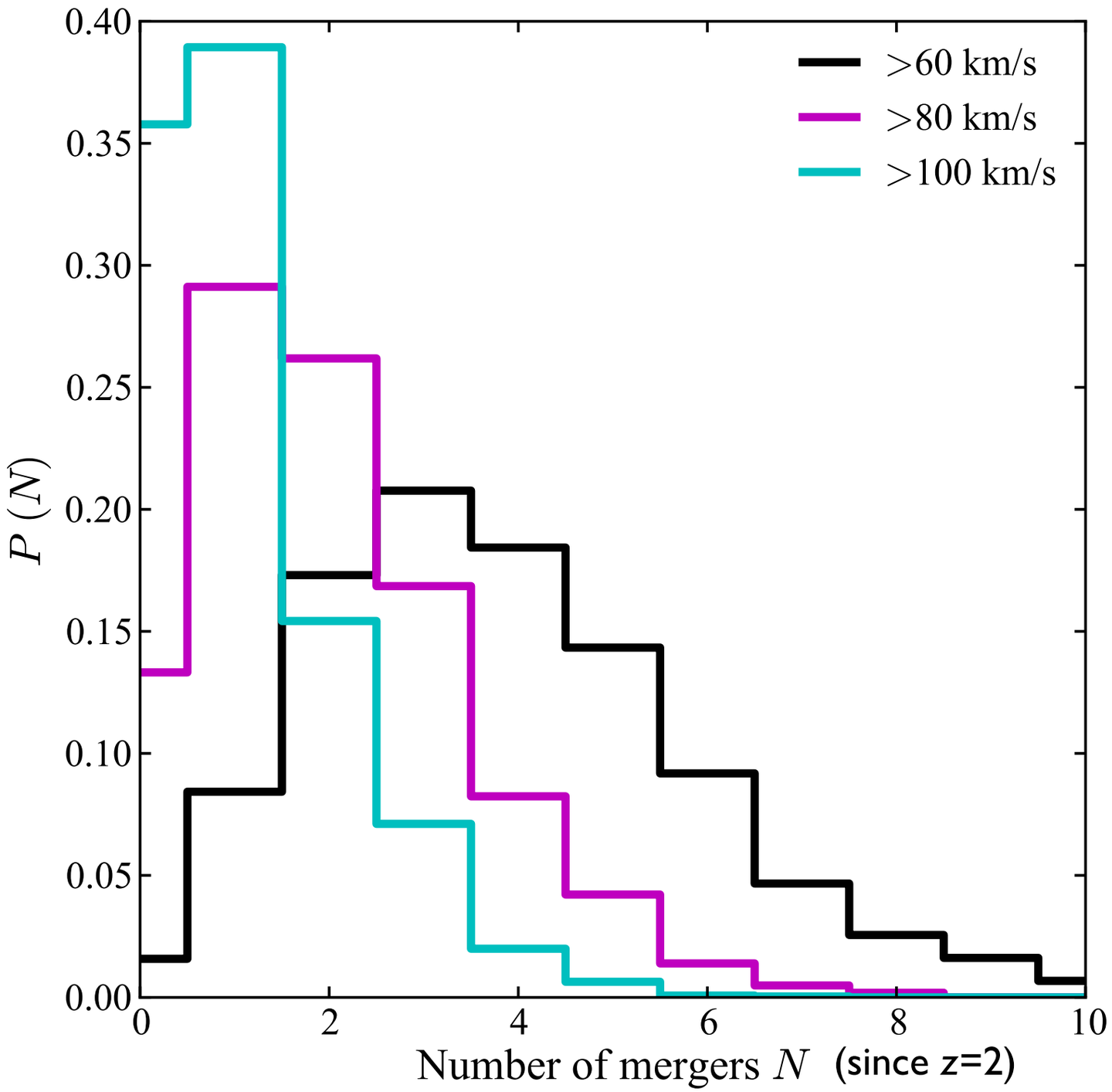
See also: recent paper by Busha et al. (Bolshoi simulation), observational comparisons by Liu et al. and Tollerud et al. (in prep.)

Mergers and disk heating



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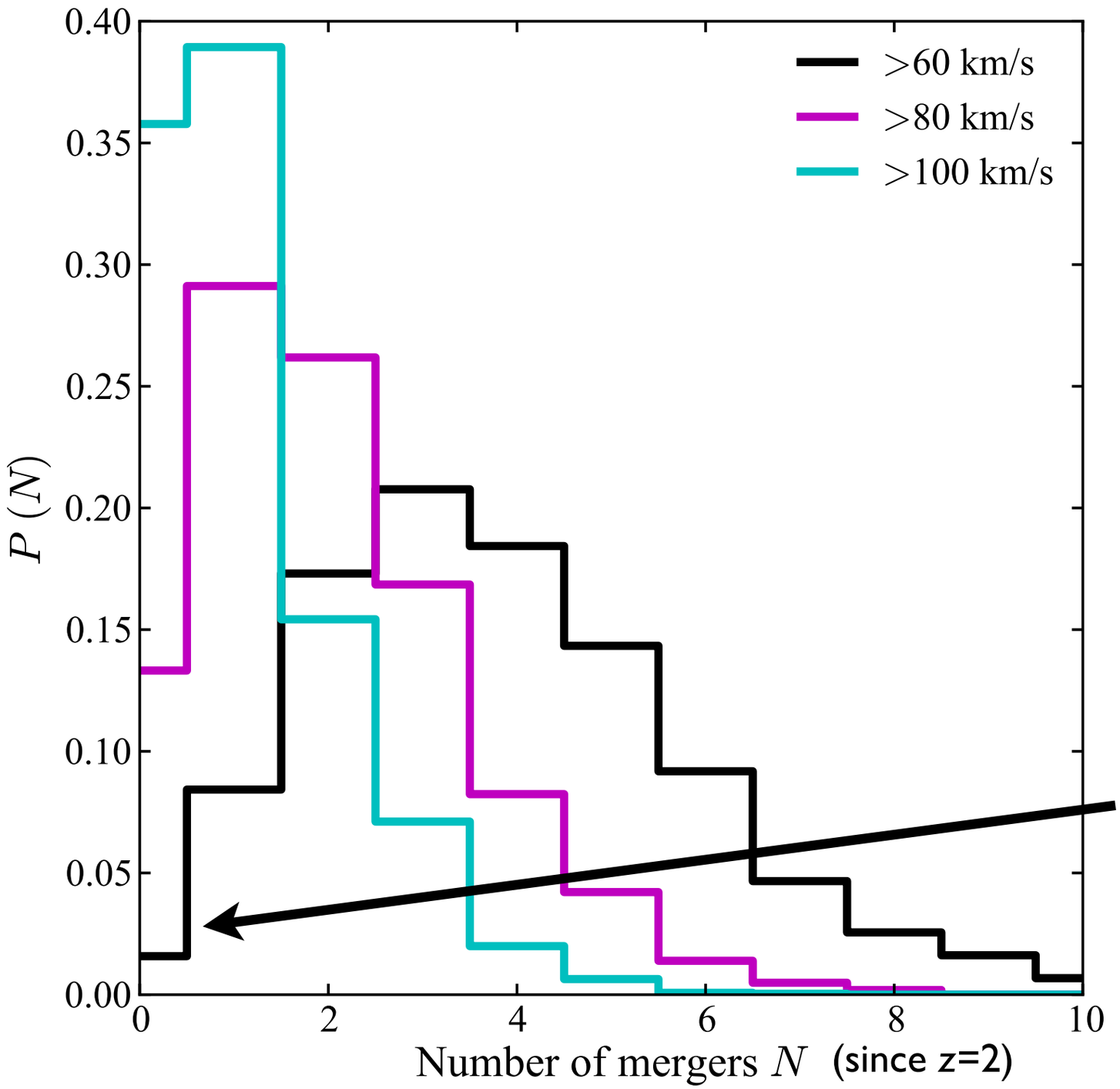

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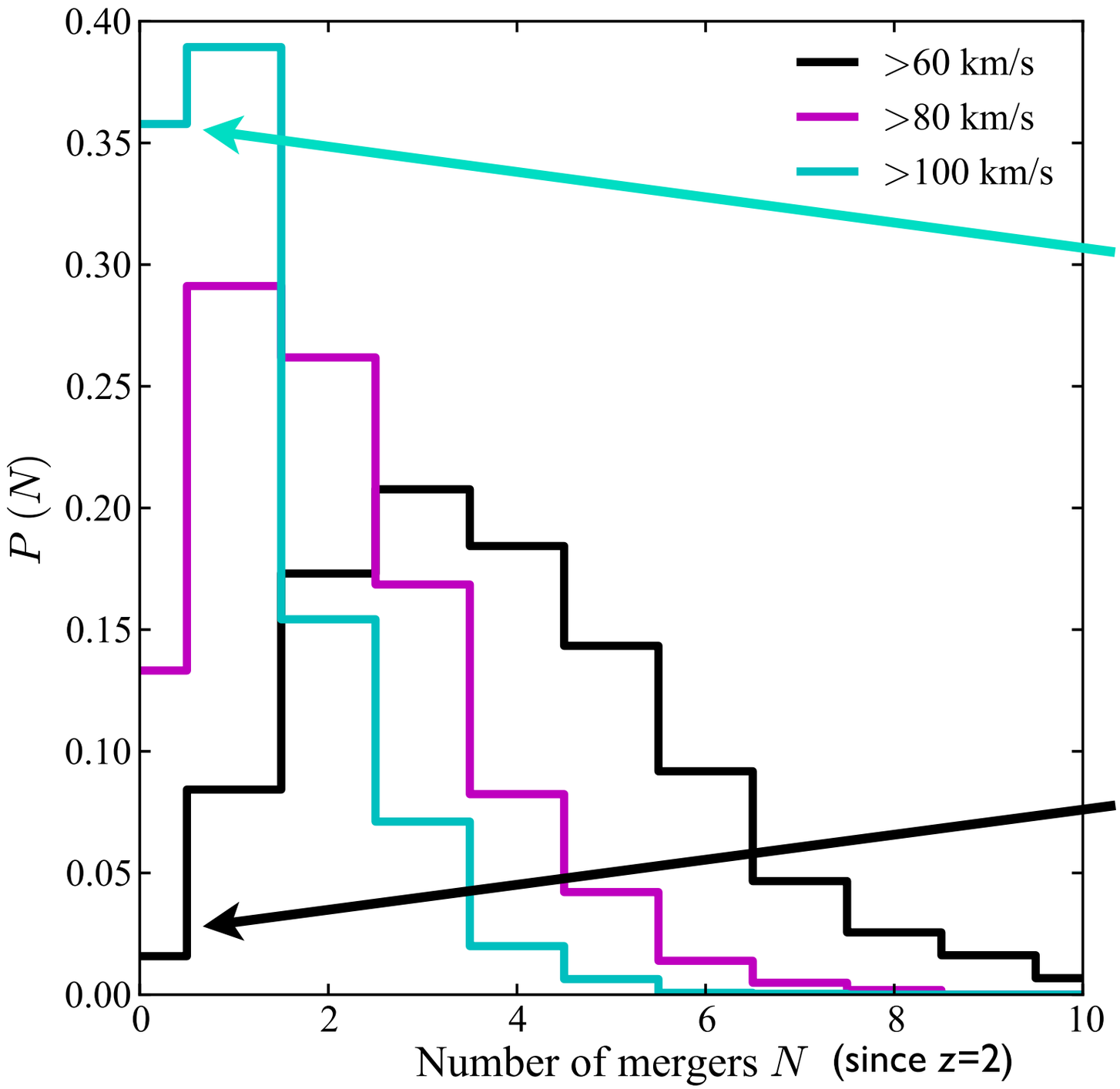

If disk heating requires a 100 km/s satellite:
no problem for LCDM

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- **Future goals / requirements**:
  - improve mass resolution, volume in full cosmological *N*-body simulations
  - improved treatment of hydrodynamical processes
  - make data publicly available and *easily searchable* (Millennium / Millennium-II: halos, subhalos, merger histories in SQL databases)