# The Abundance of Dwarf Galaxies

Hot gas explodes out of
young dwarf galaxies

Simulation by **Andrew Pontzen**, **Fabio Governato** and
**Alyson Brooks** on the **Darwin Supercomputer**, Cambridge UK.

Simulation code **Gasoline** by **James Wadsley** and **Tom Quinn**
with metal cooling by **Sijing Sheng**.

Visualization by **Andrew Pontzen**.


Alyson Brooks

Rutgers, the State University of New Jersey


In collaboration with the University of Washington's N-body Shop™

*makers of quality galaxies*

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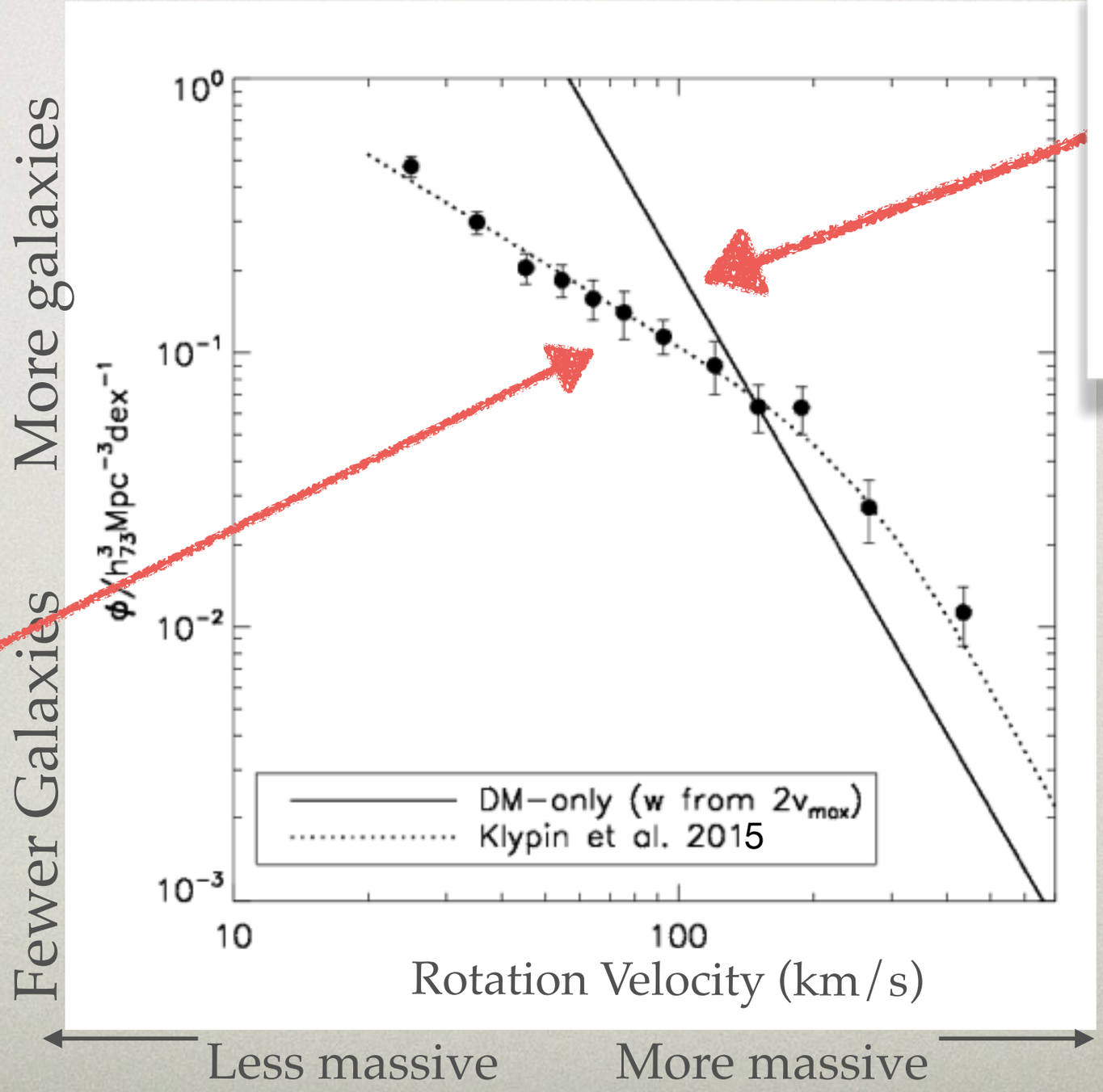
# The Missing Dwarf Problem in the Field

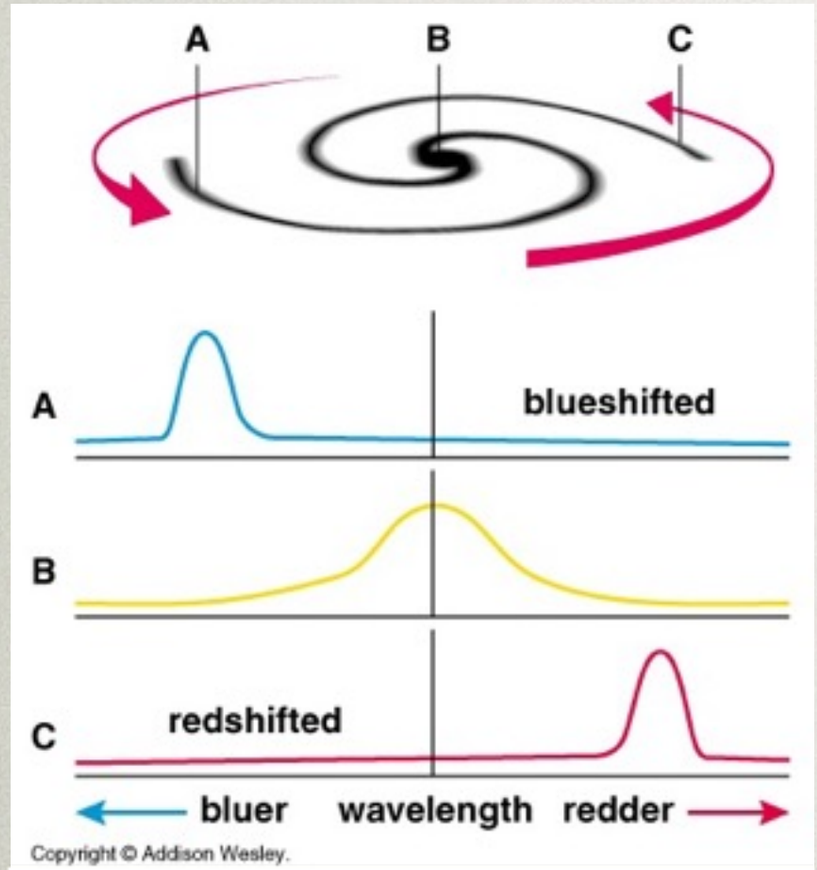
Predicted number of galaxies

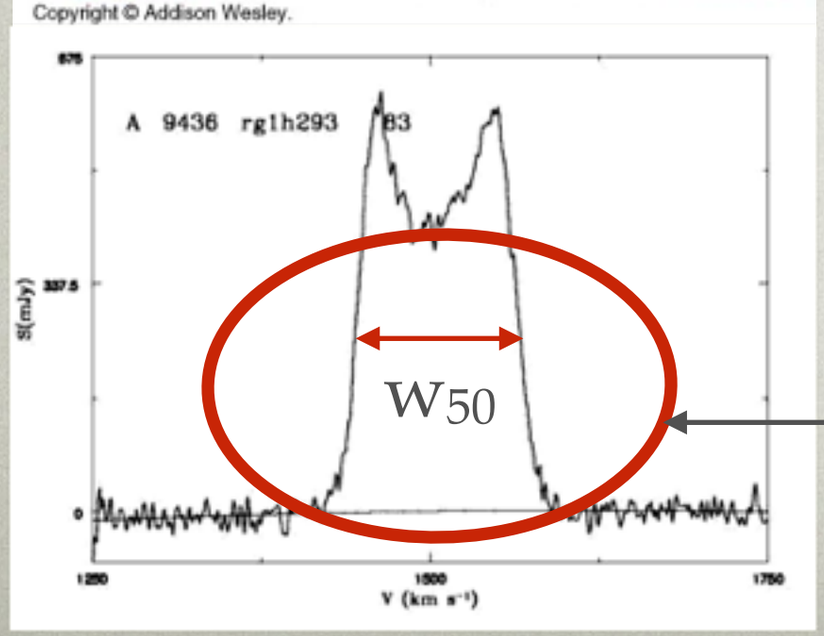
Observed number of galaxies




Klypin et al. (2015)

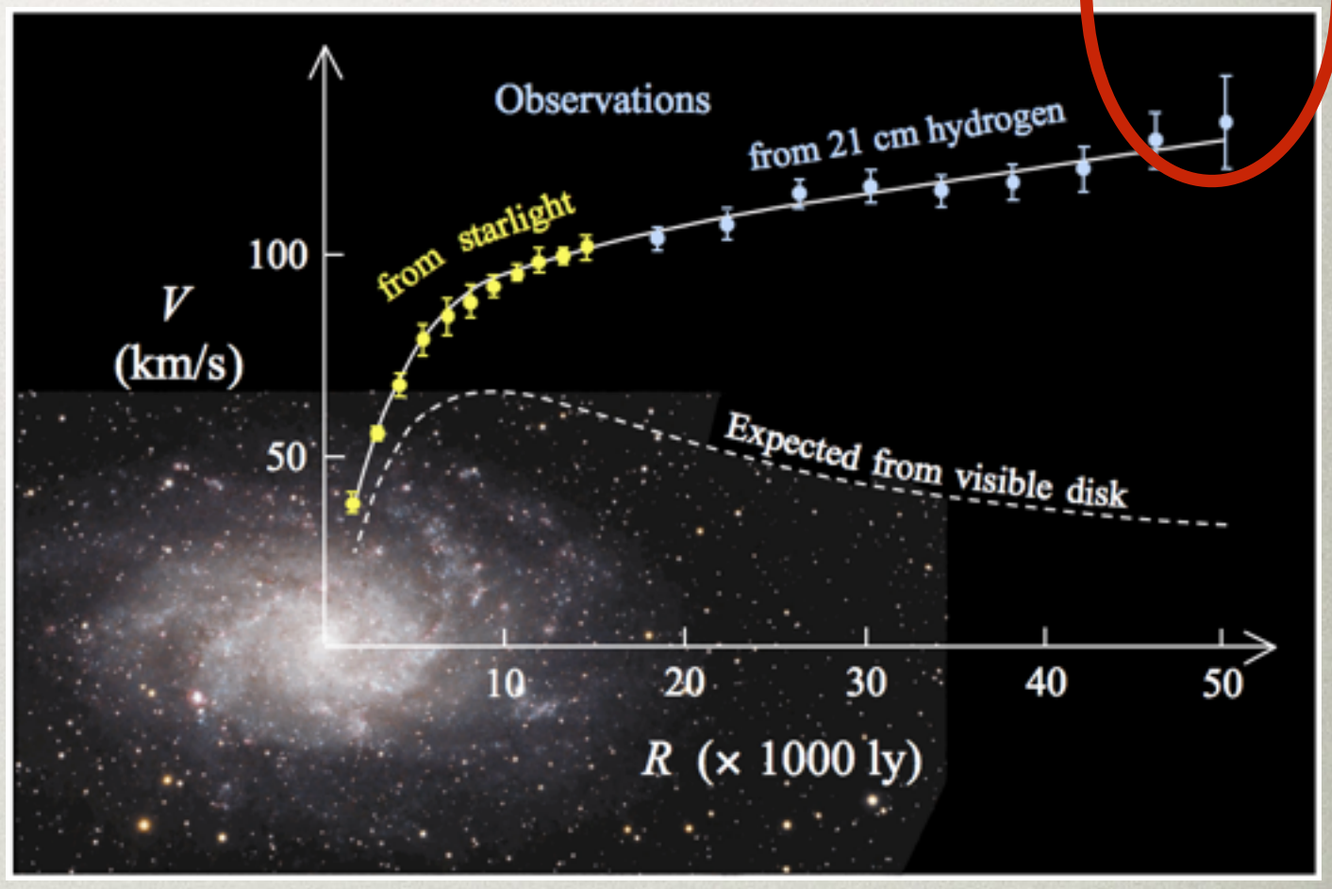
# BUT: Two Ways to Measure Rotation (Resolved vs Unresolved)



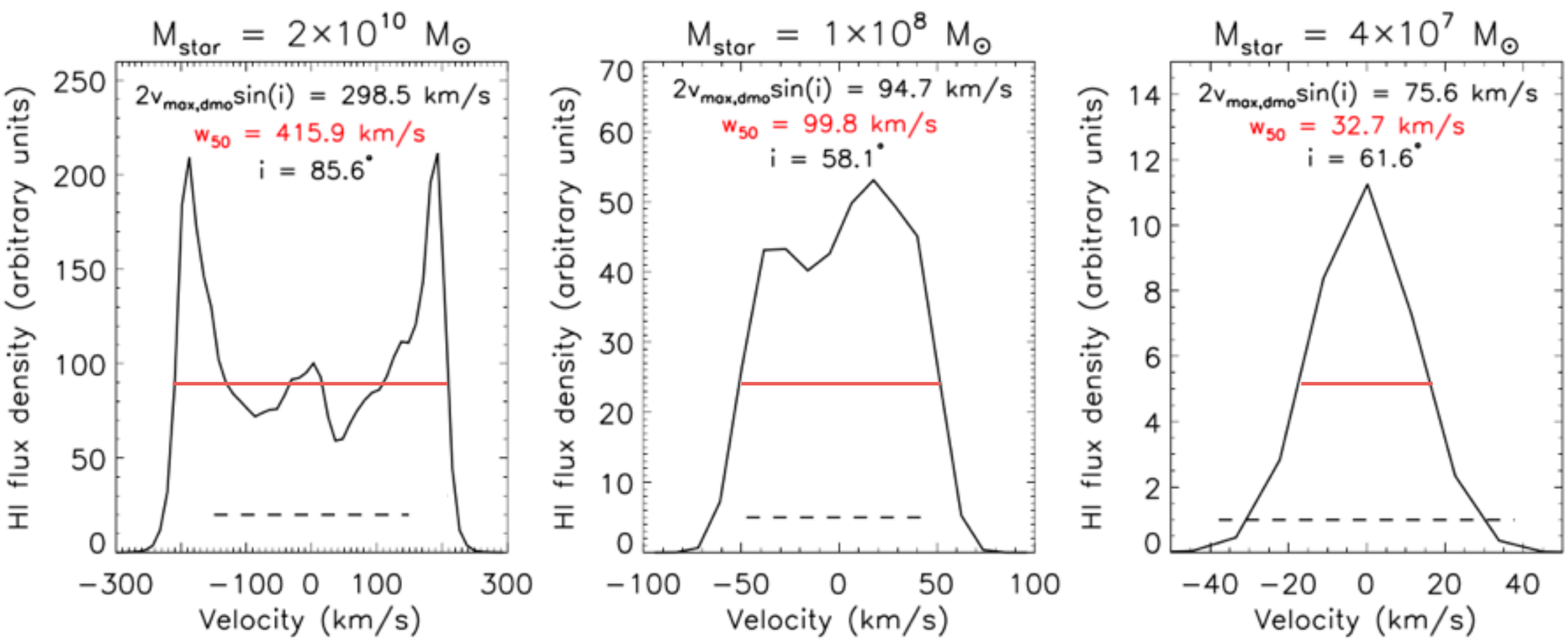




Observations

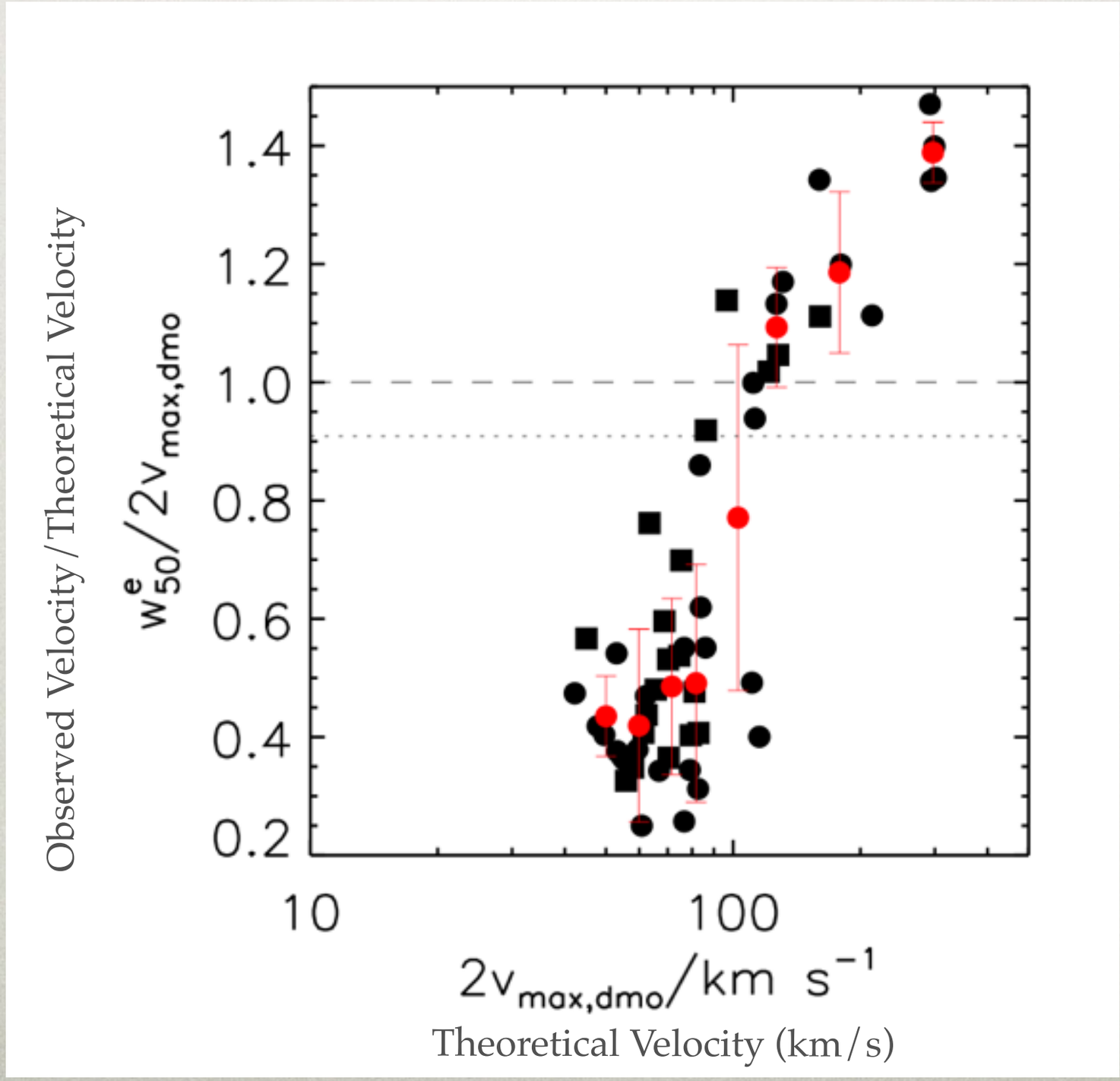
Theory → $v_{max}$



# Creating Mock Observations



# How Well Do Theory and Observation Match?

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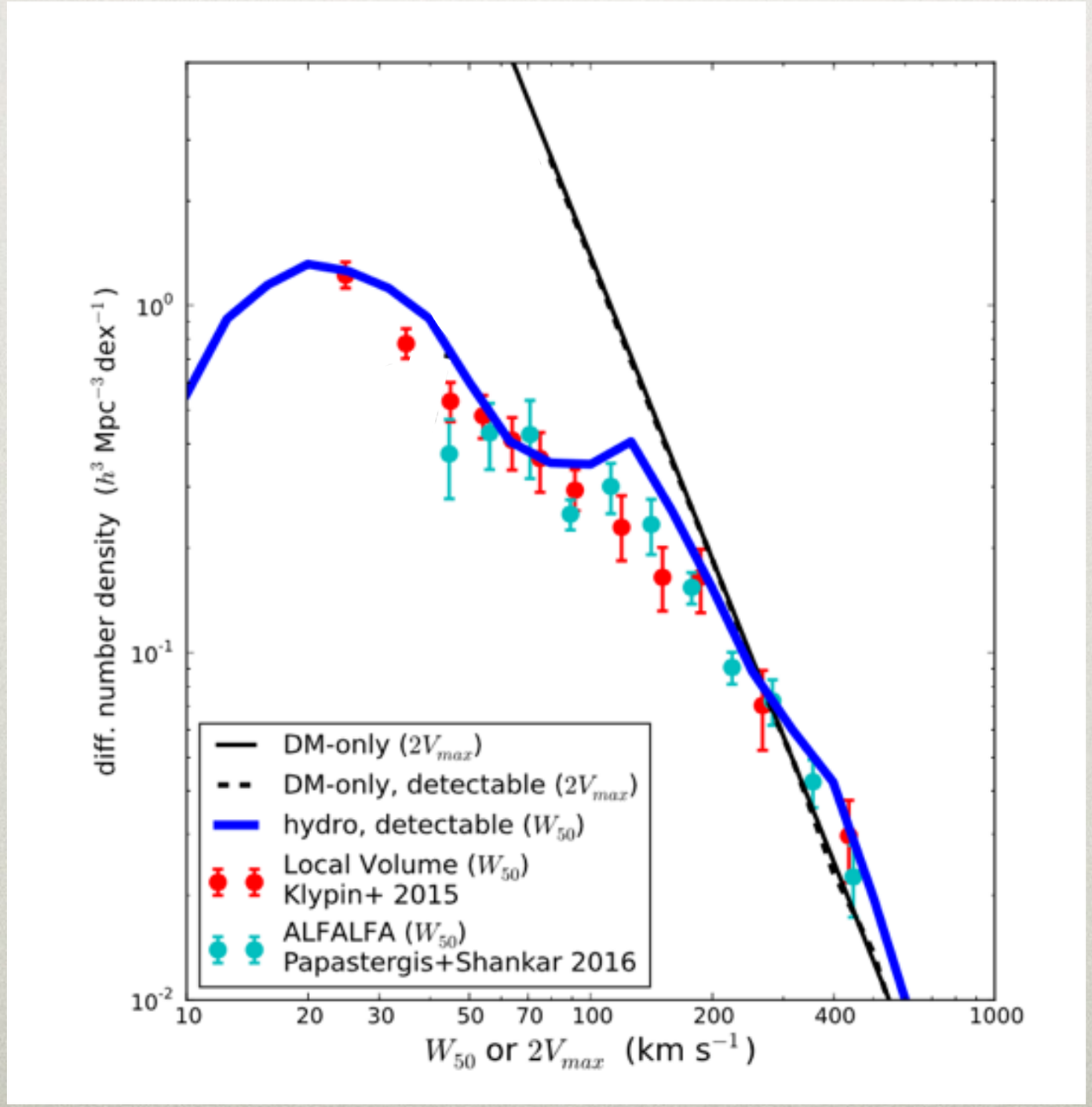
# No Missing Dwarfs: We Observe Them at Lower Velocities than Expected

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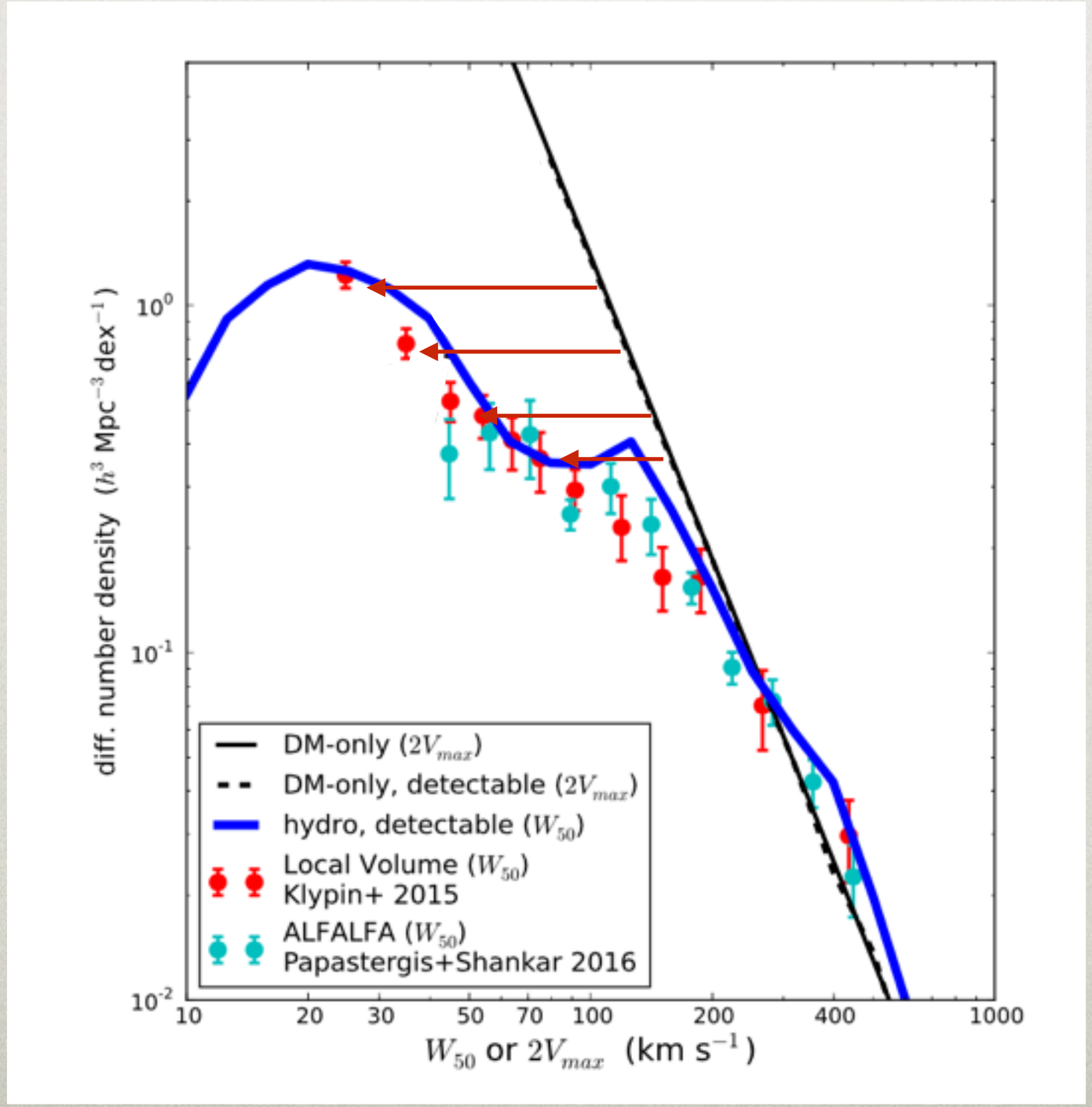


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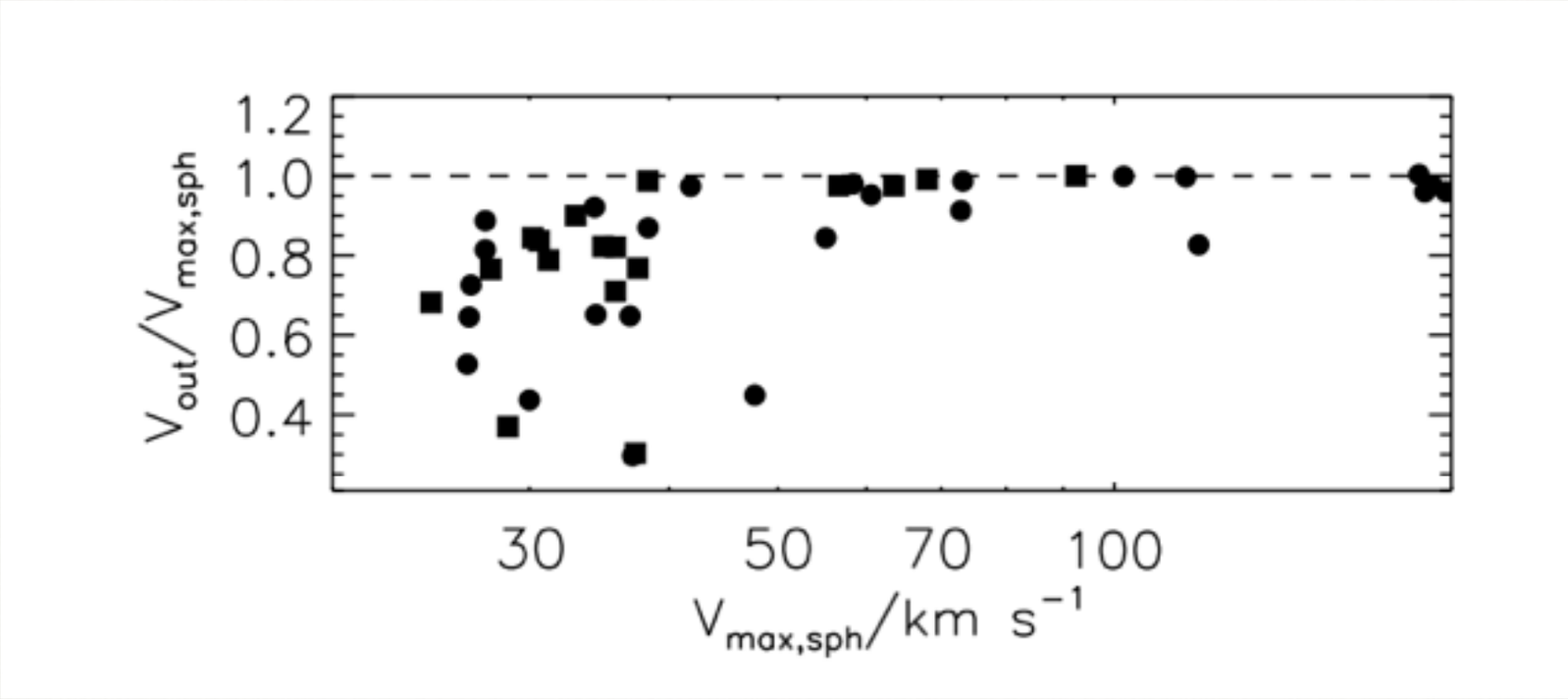
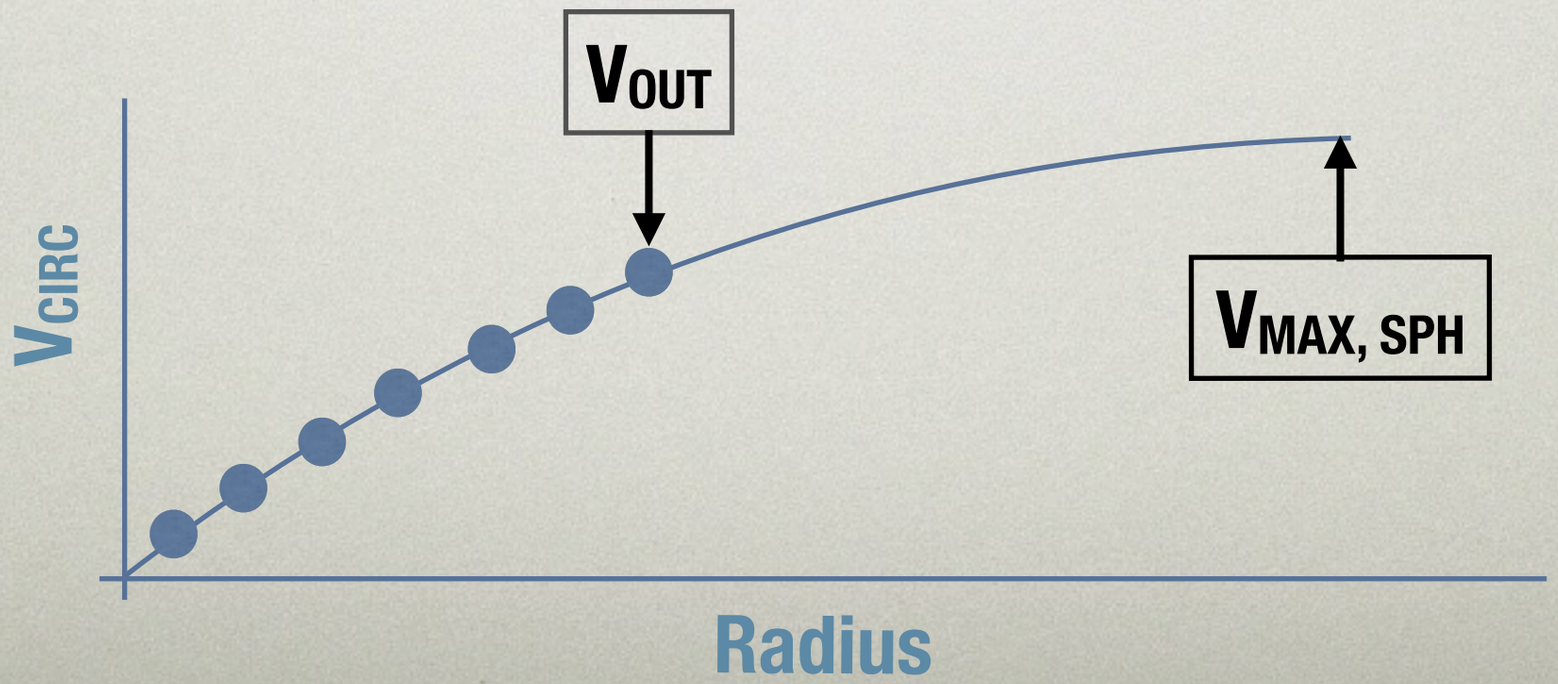
# Why the Velocity Shift?



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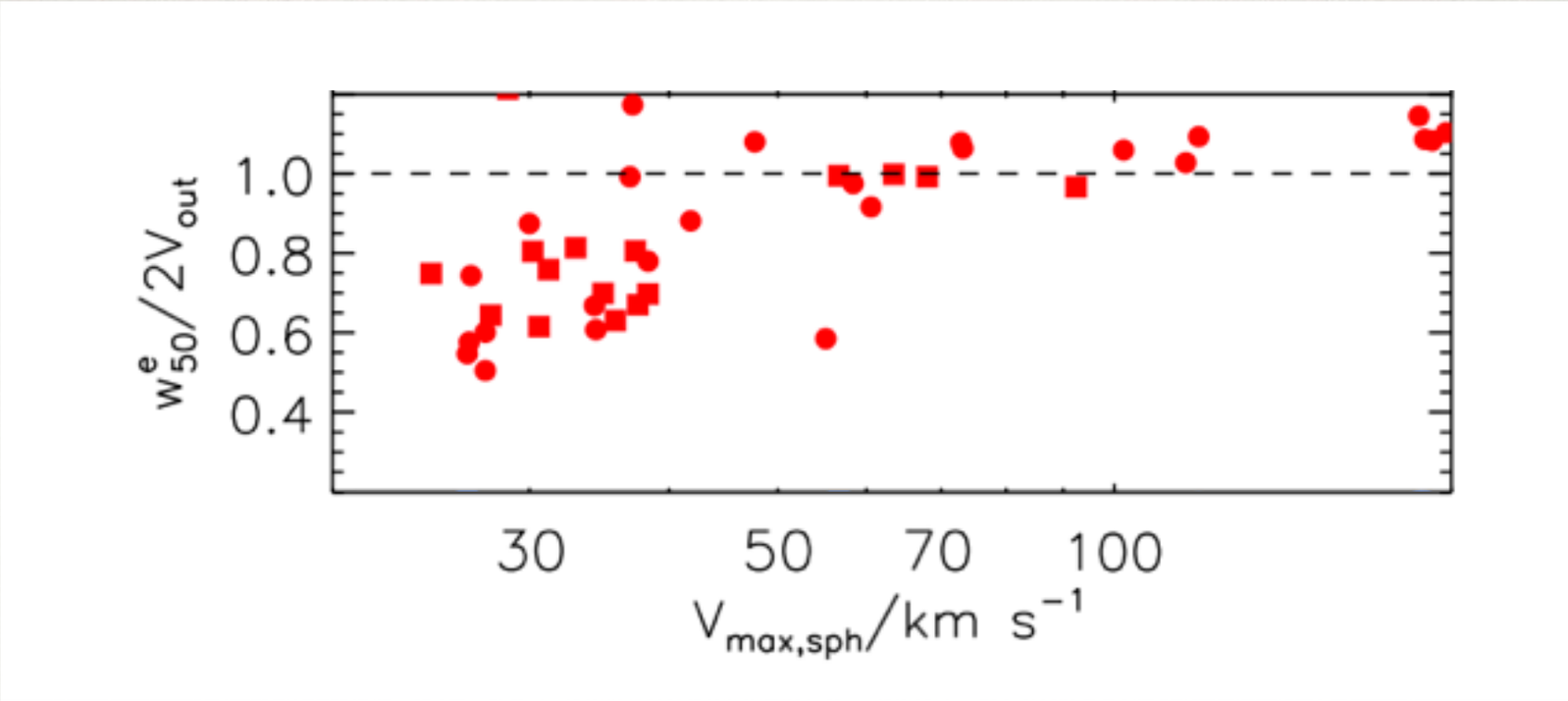


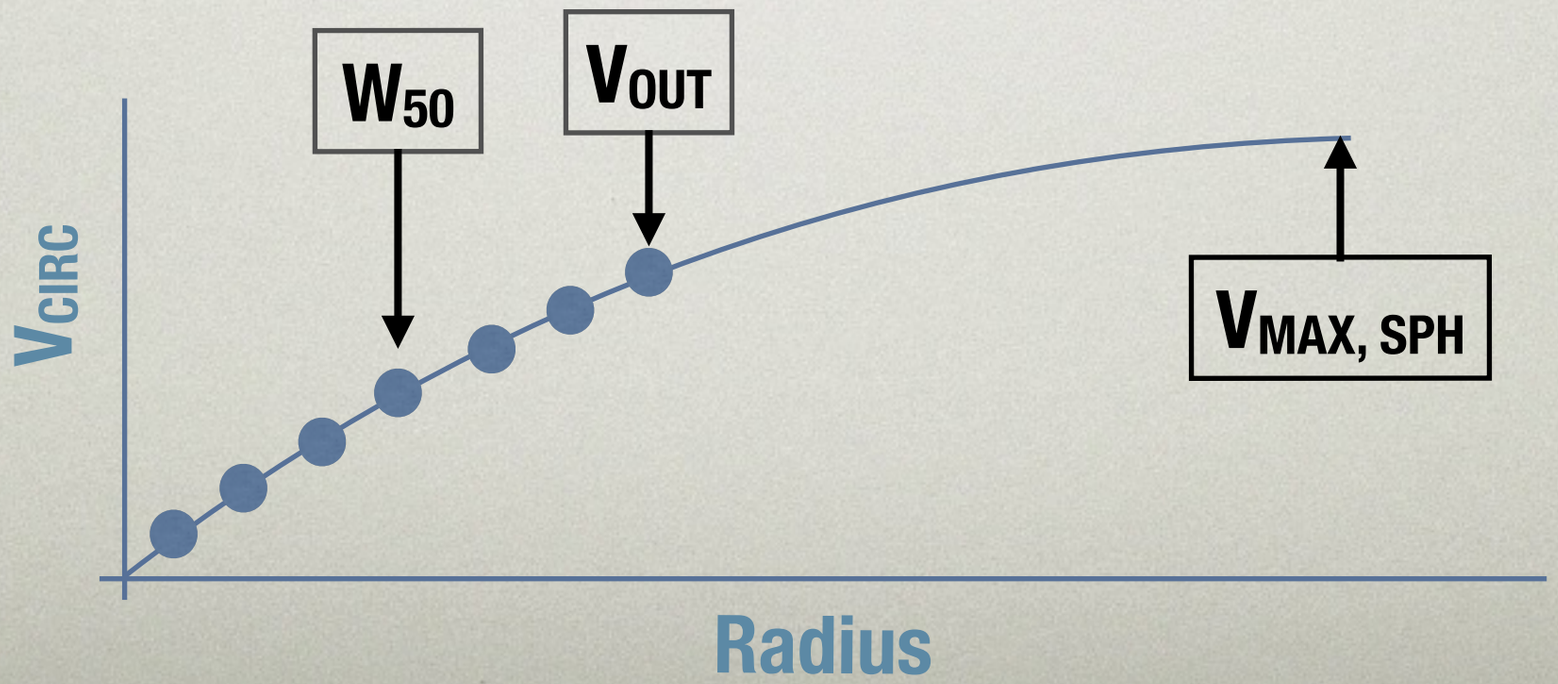

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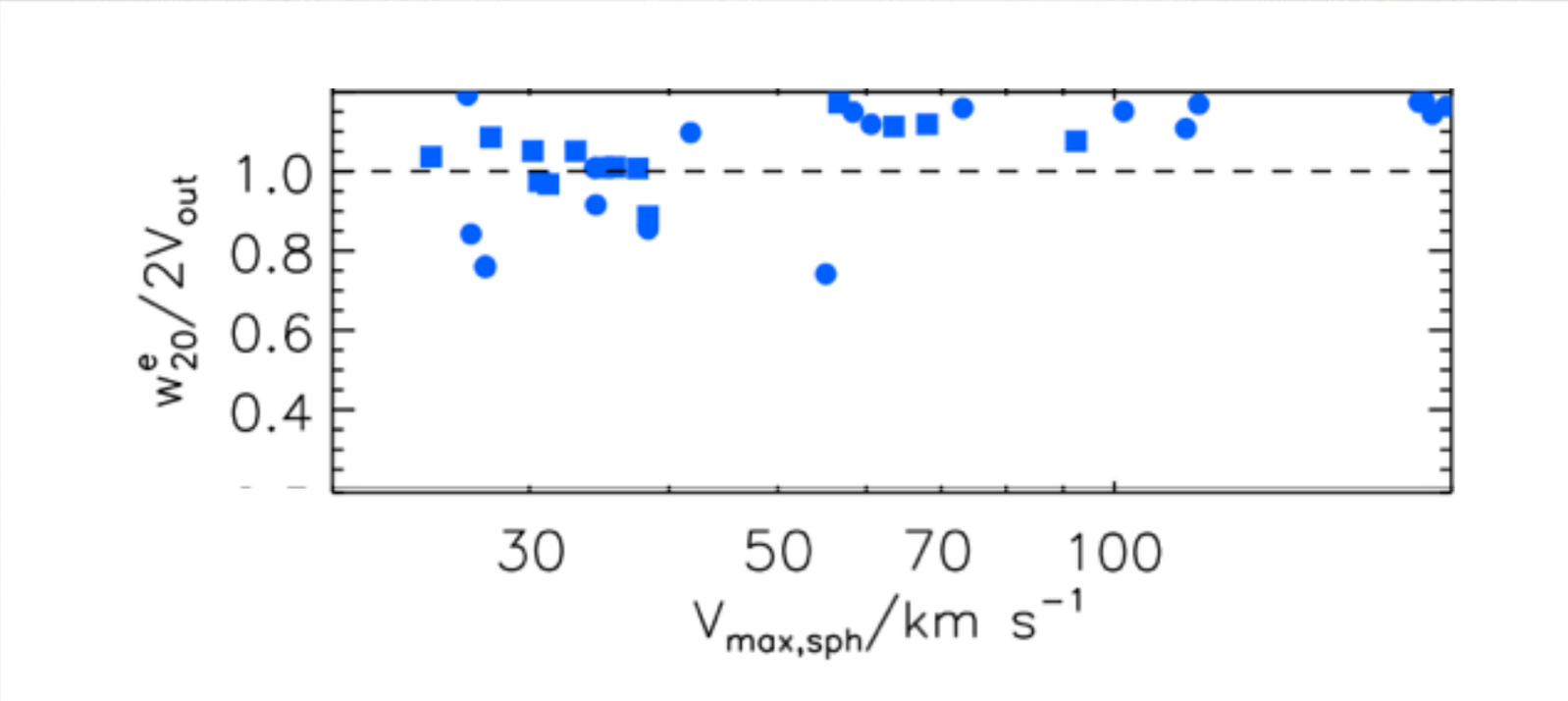


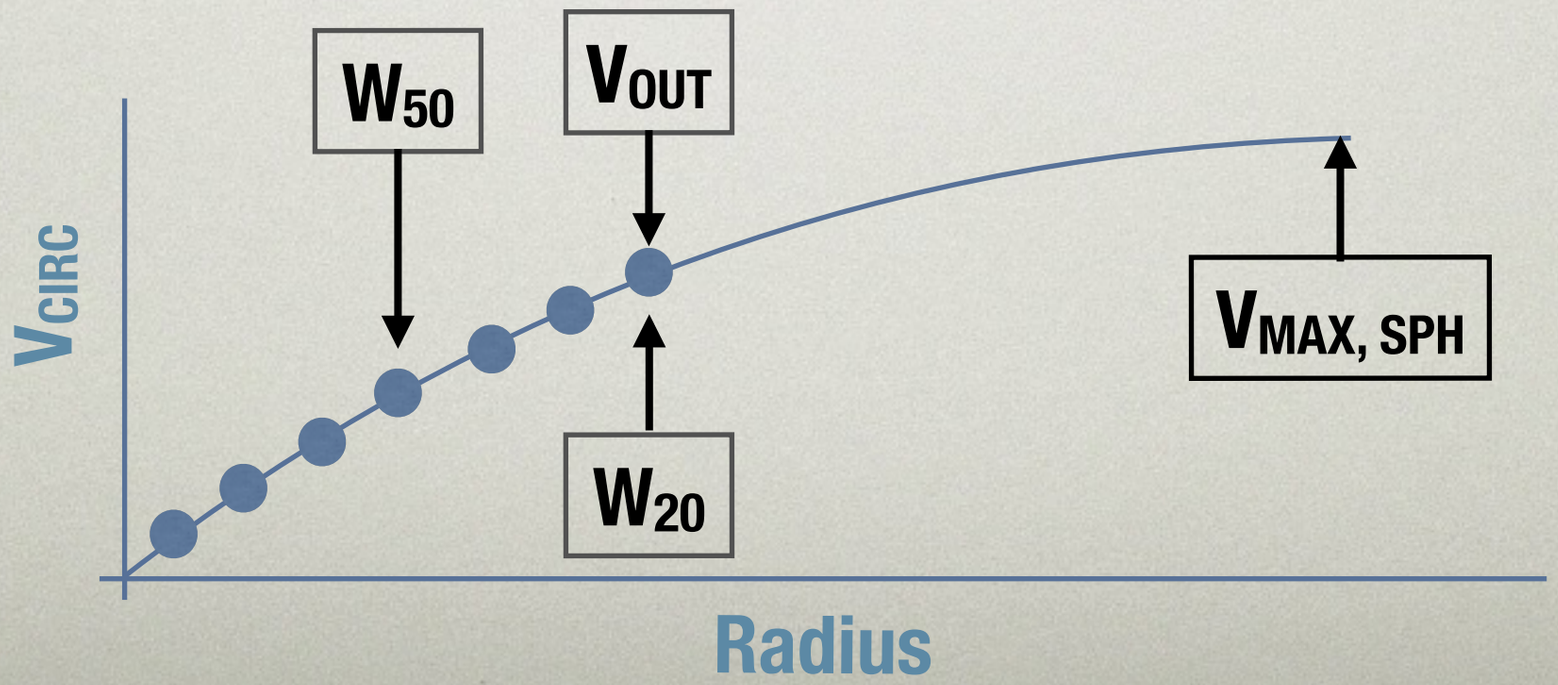

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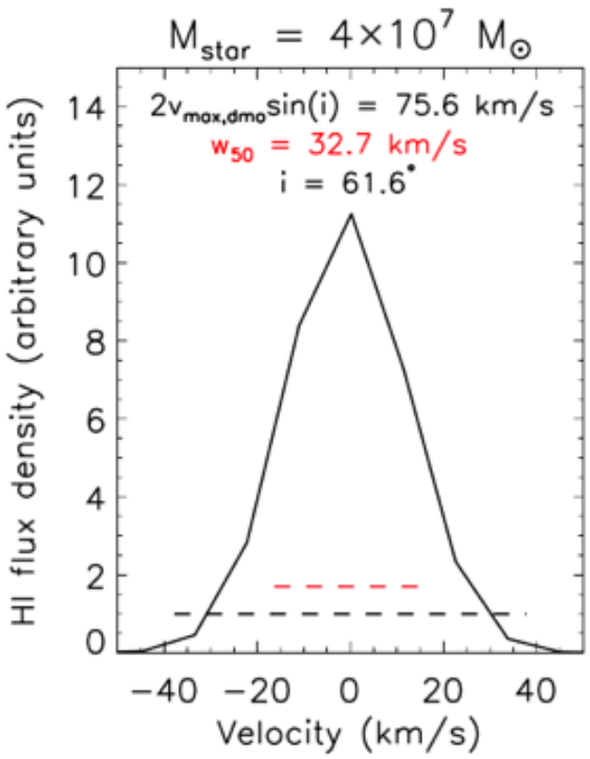
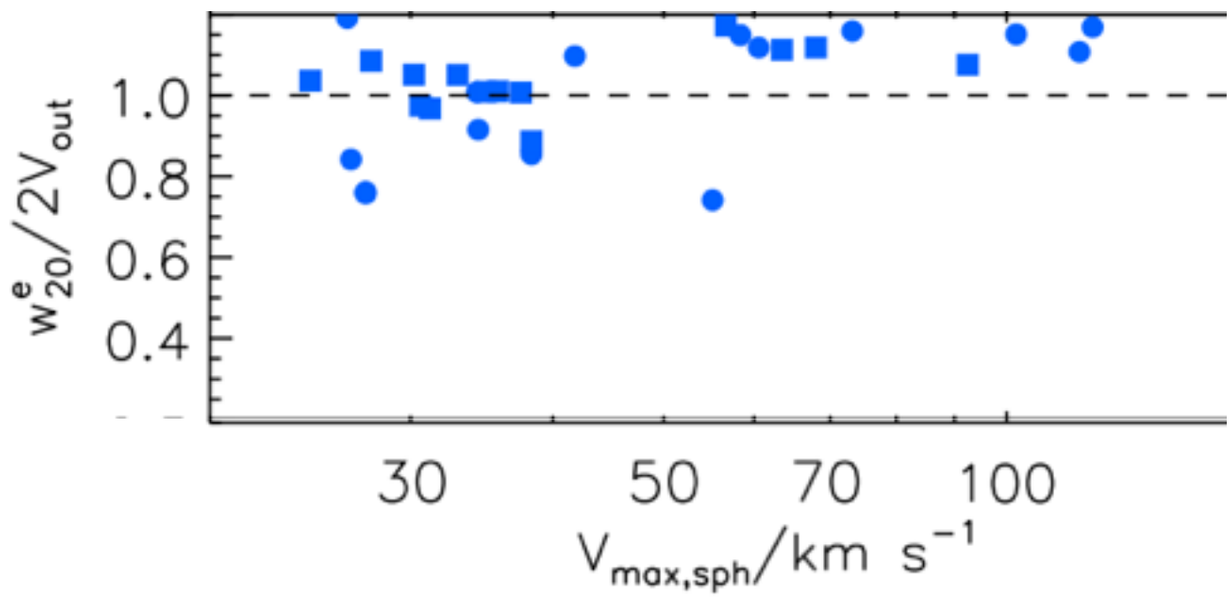
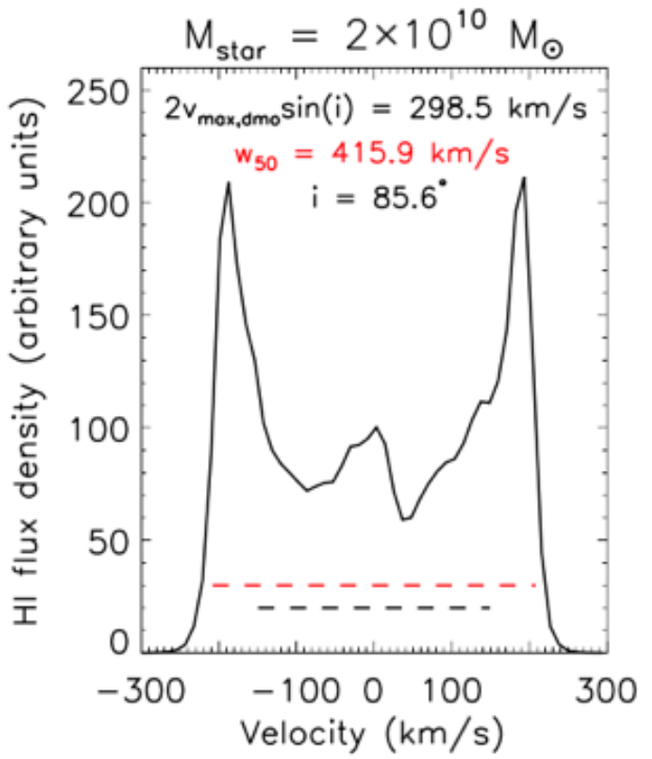
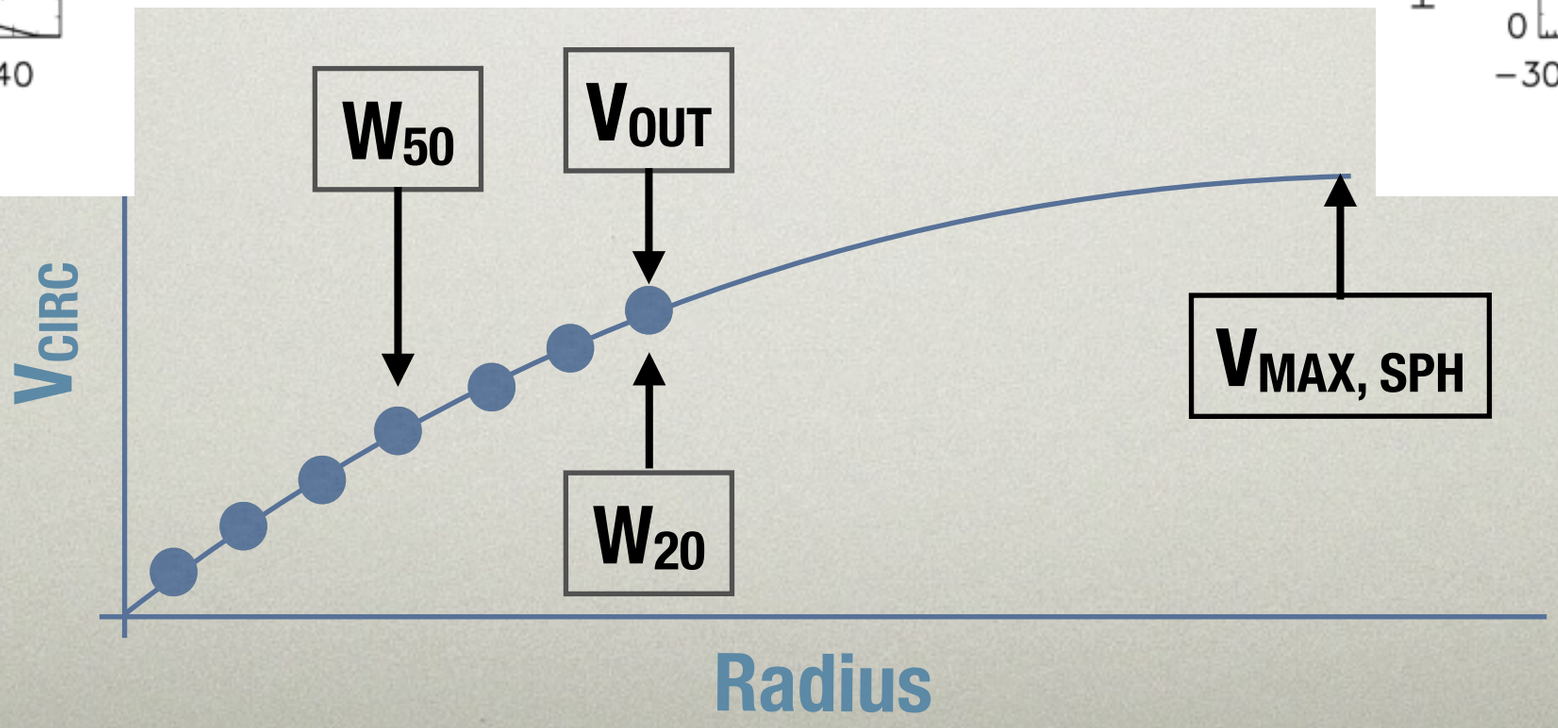
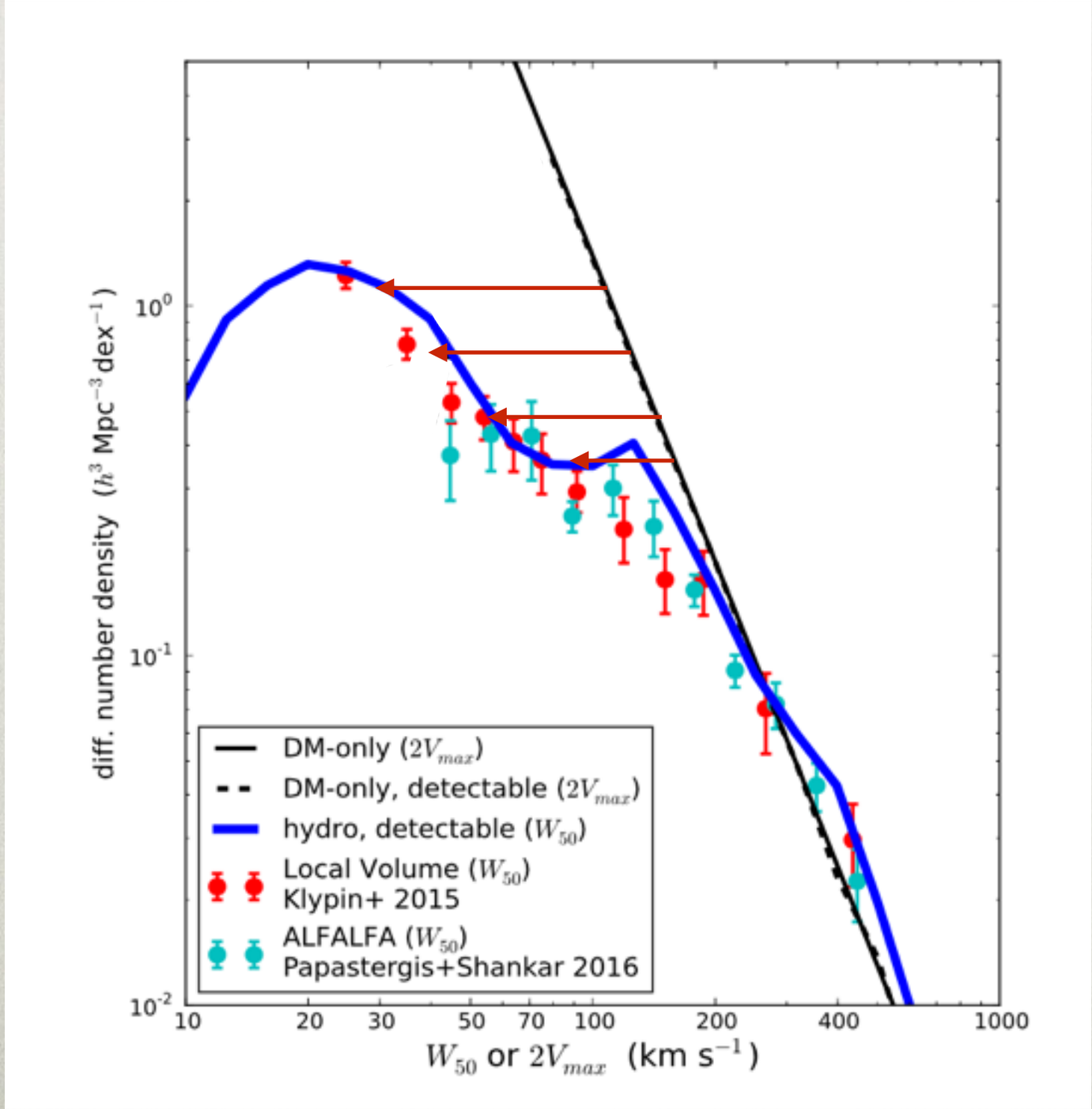


# Point: abundances are as expected in LCDM

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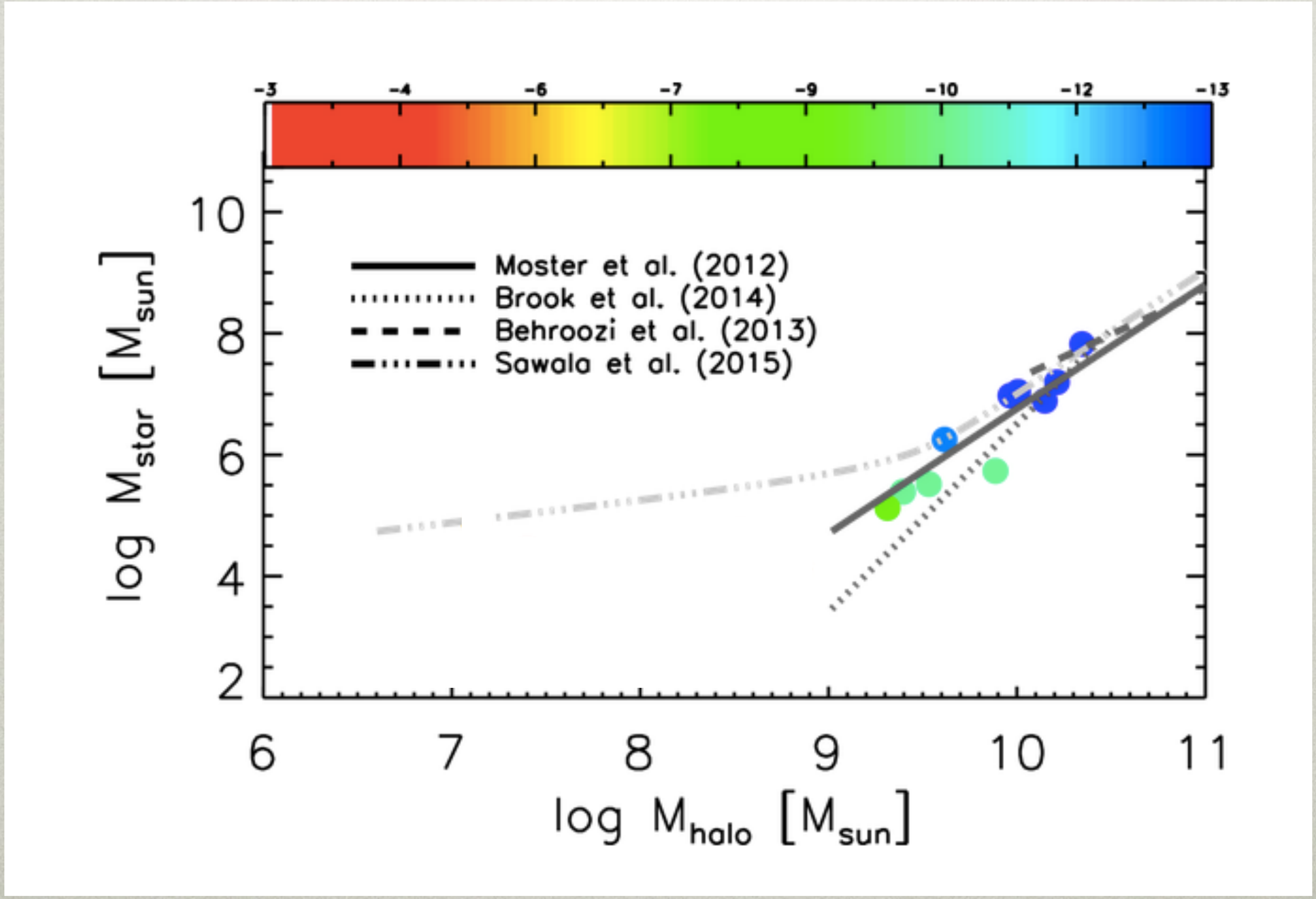
# The Stellar Mass — Halo Mass Relation at Low Masses




Munshi et al. (submitted)

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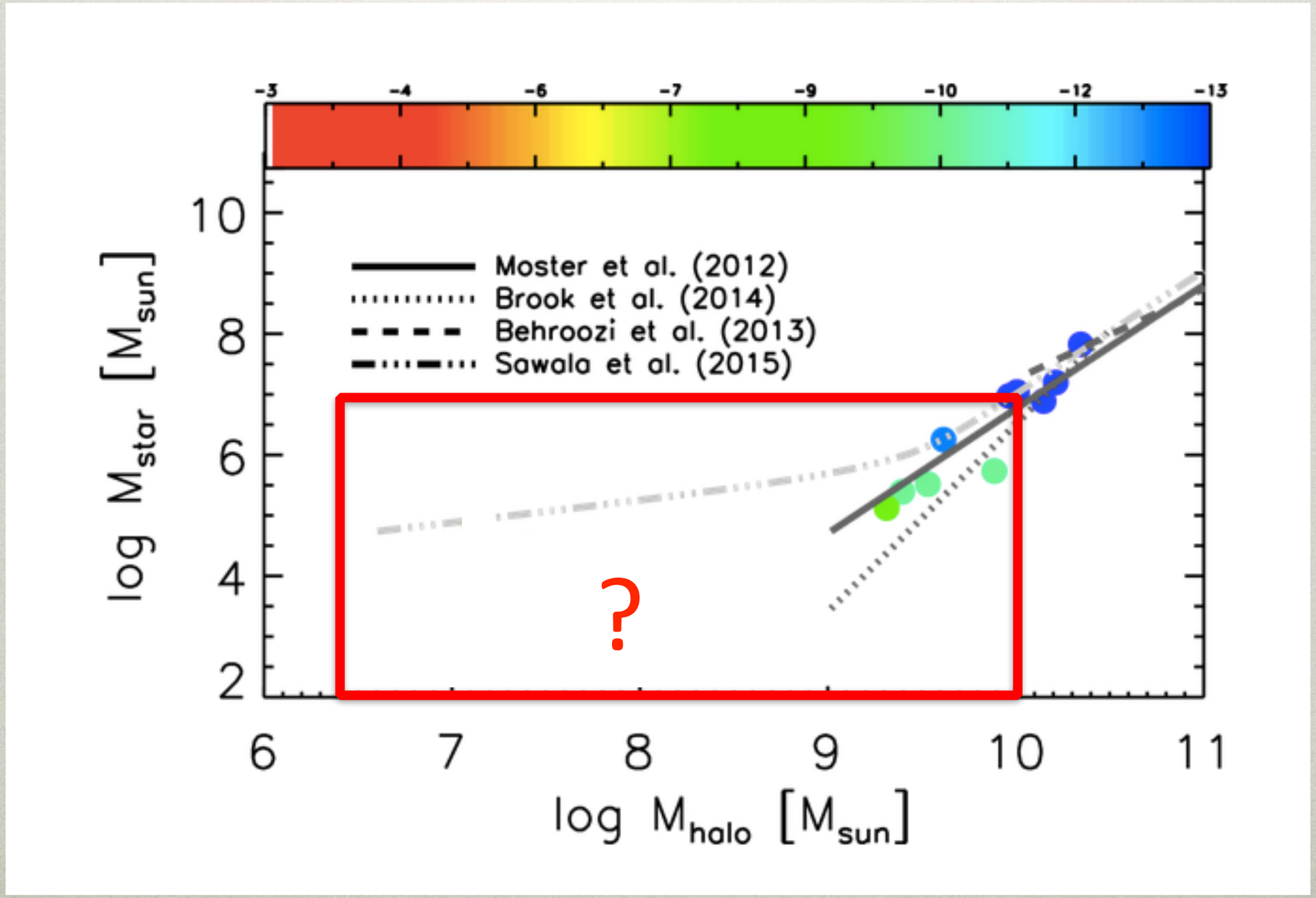


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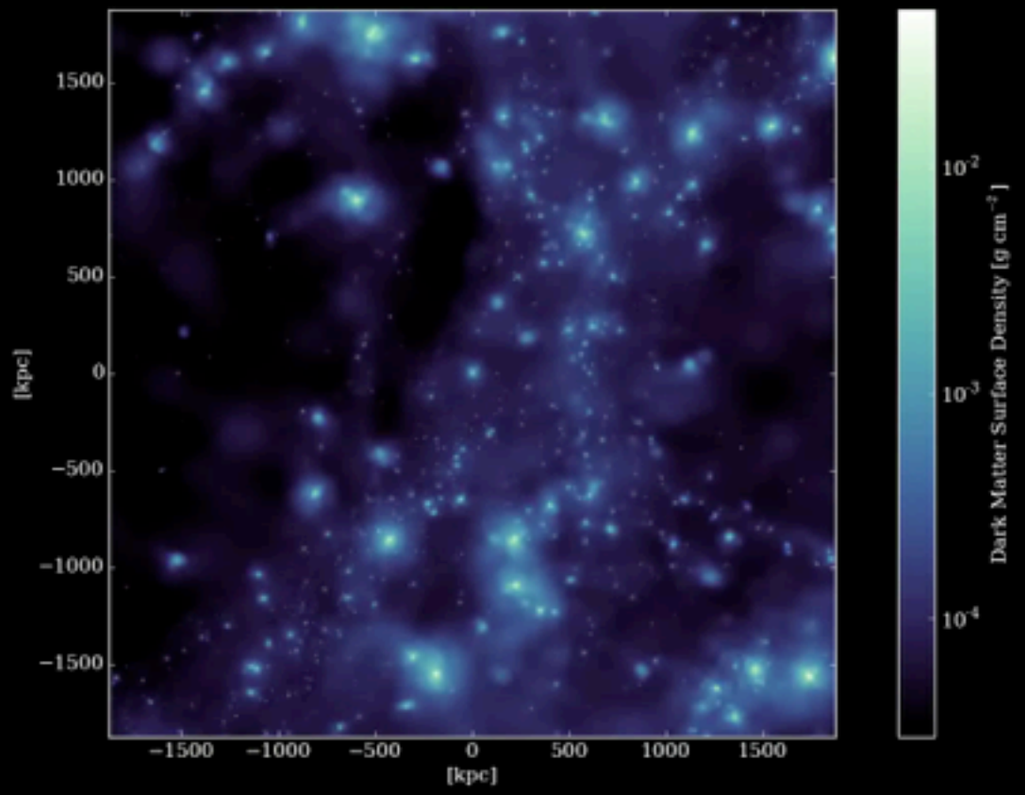
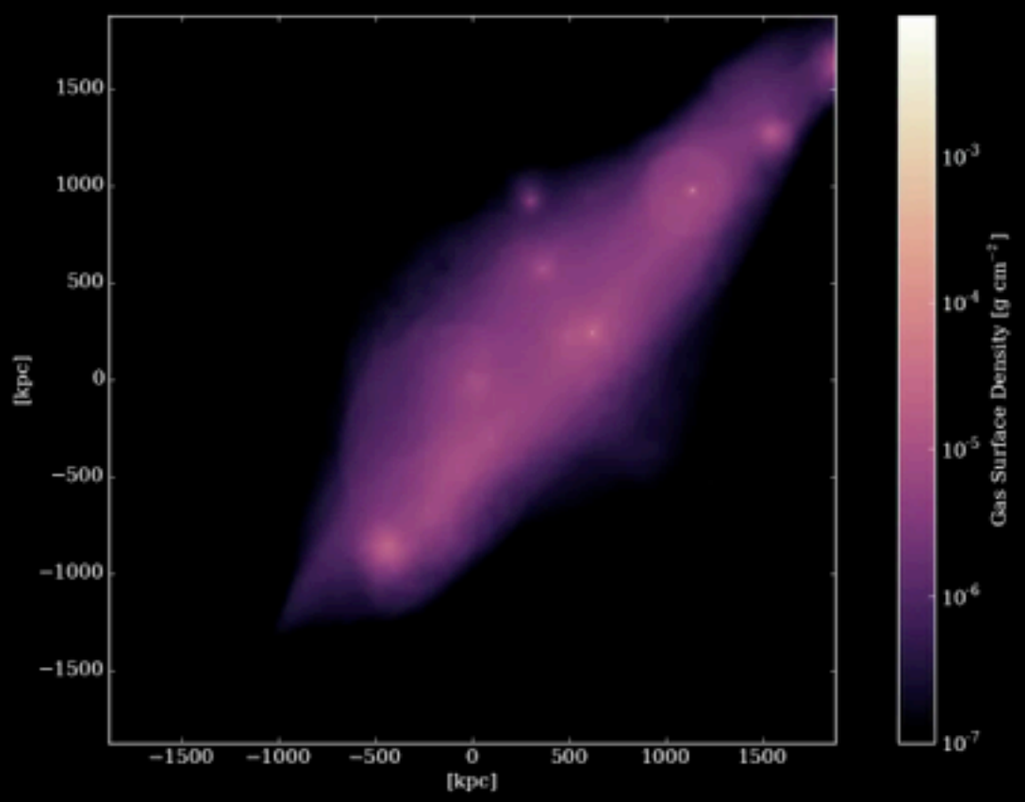
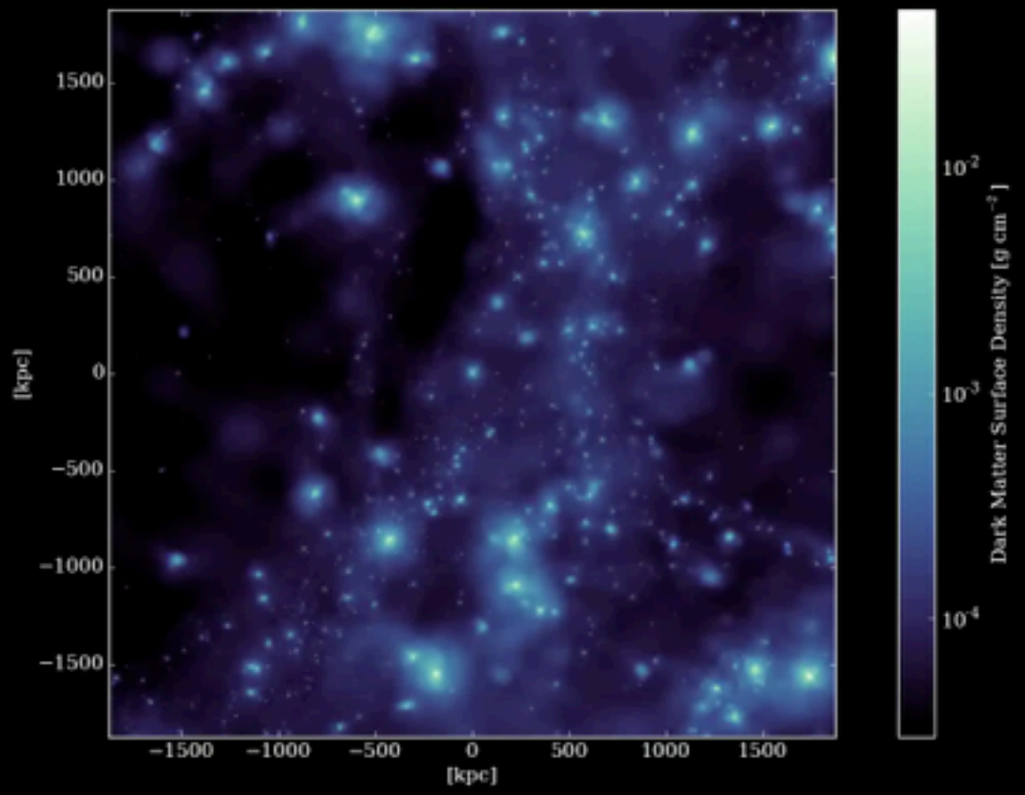



z=0 DM density




z=0 Gas density

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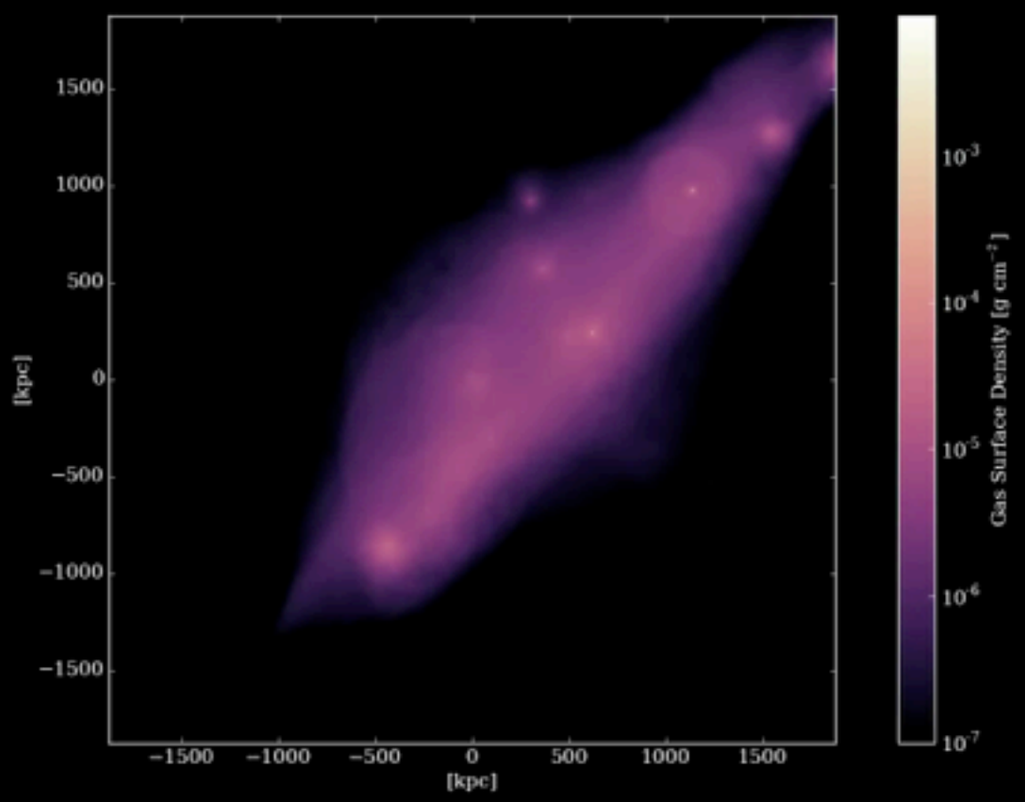


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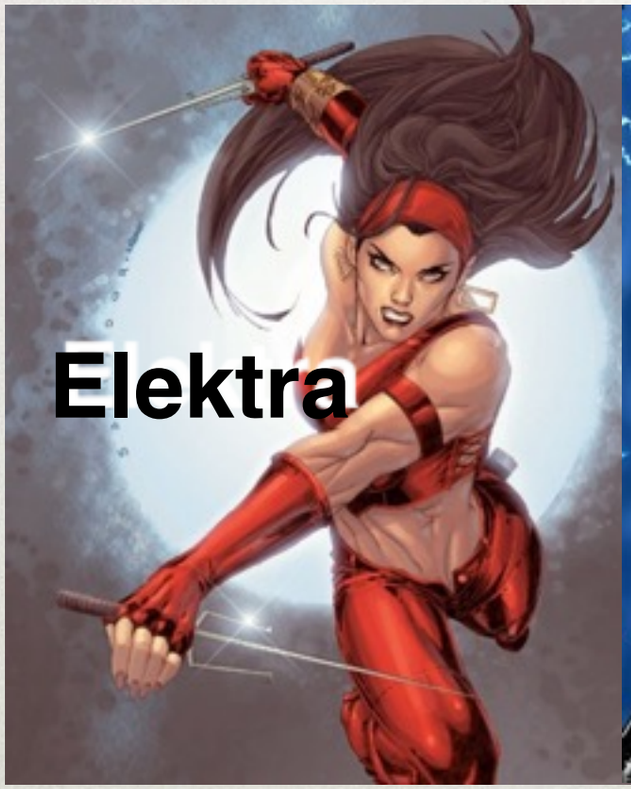
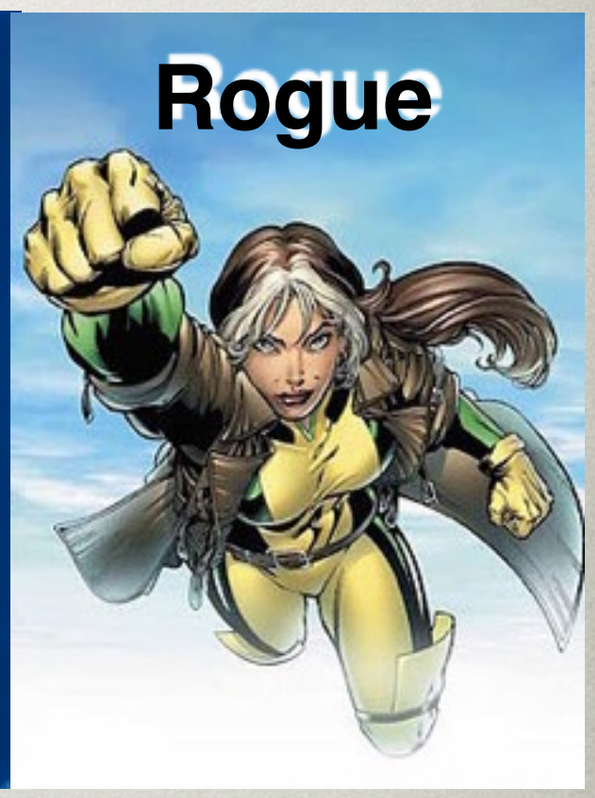
# The Dwarf Volumes

**Captain Marvel**

**COMPLETE**

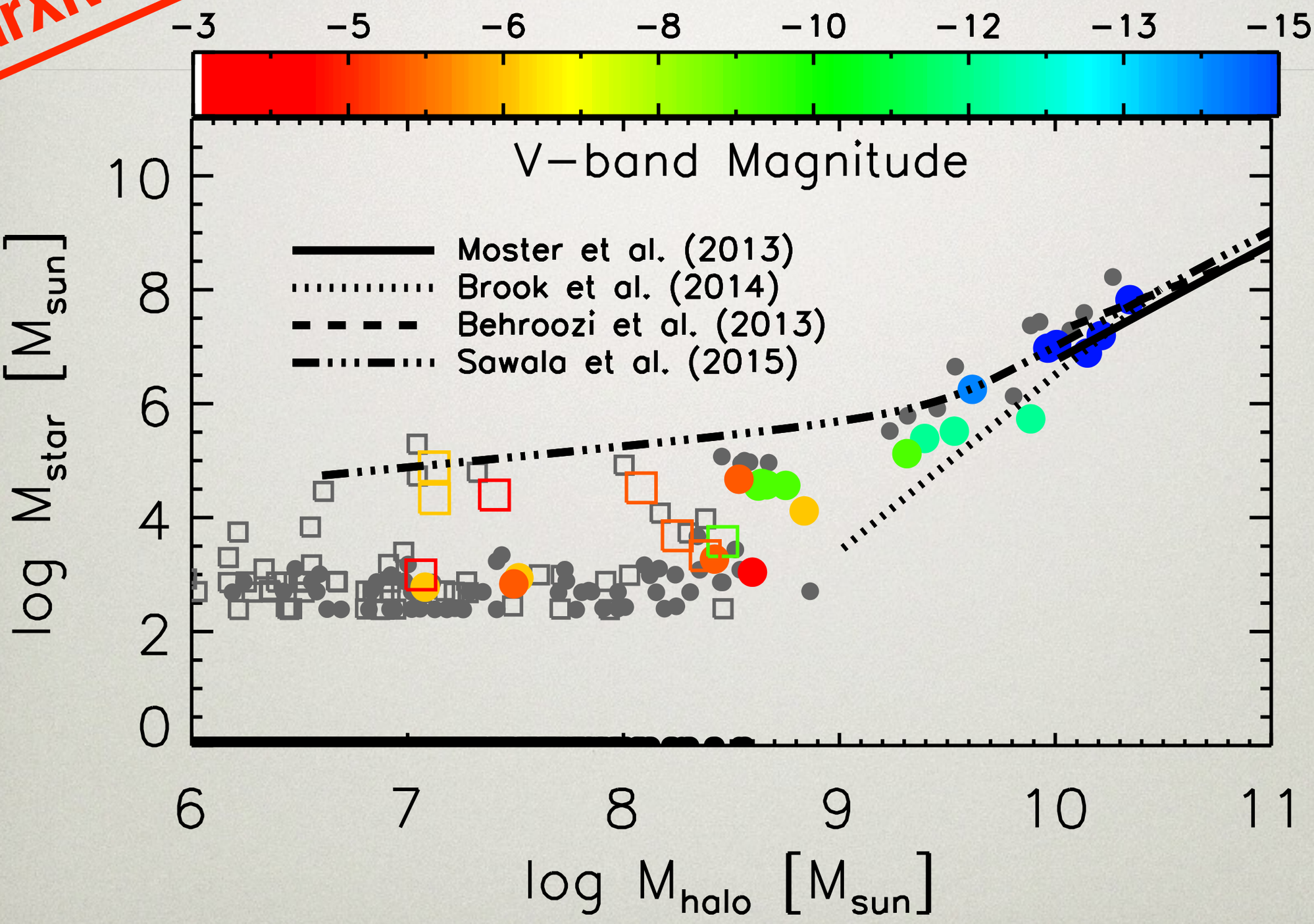
# The Dwarf Volumes






**COMPLETE**

On arXiv Tonight!



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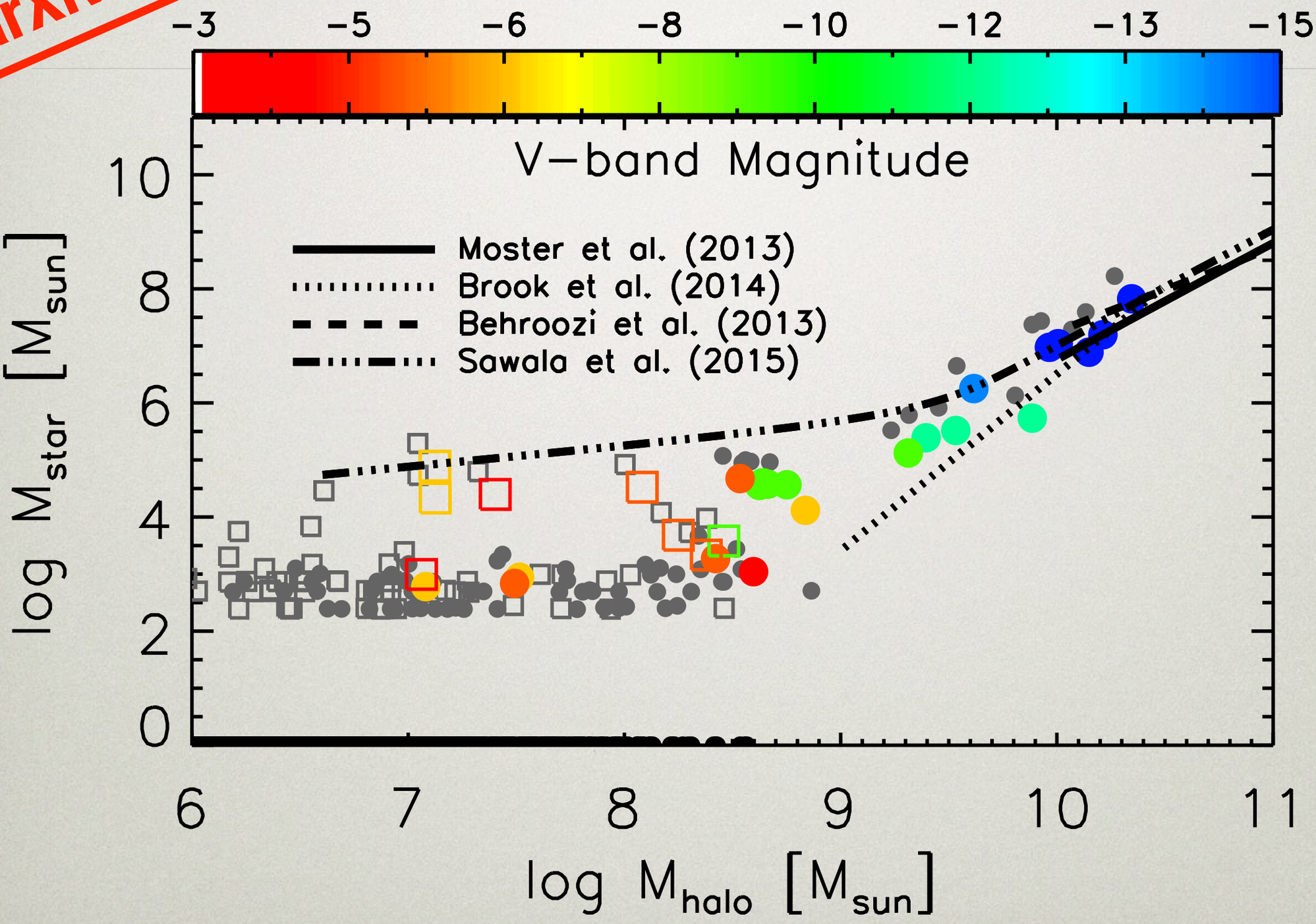
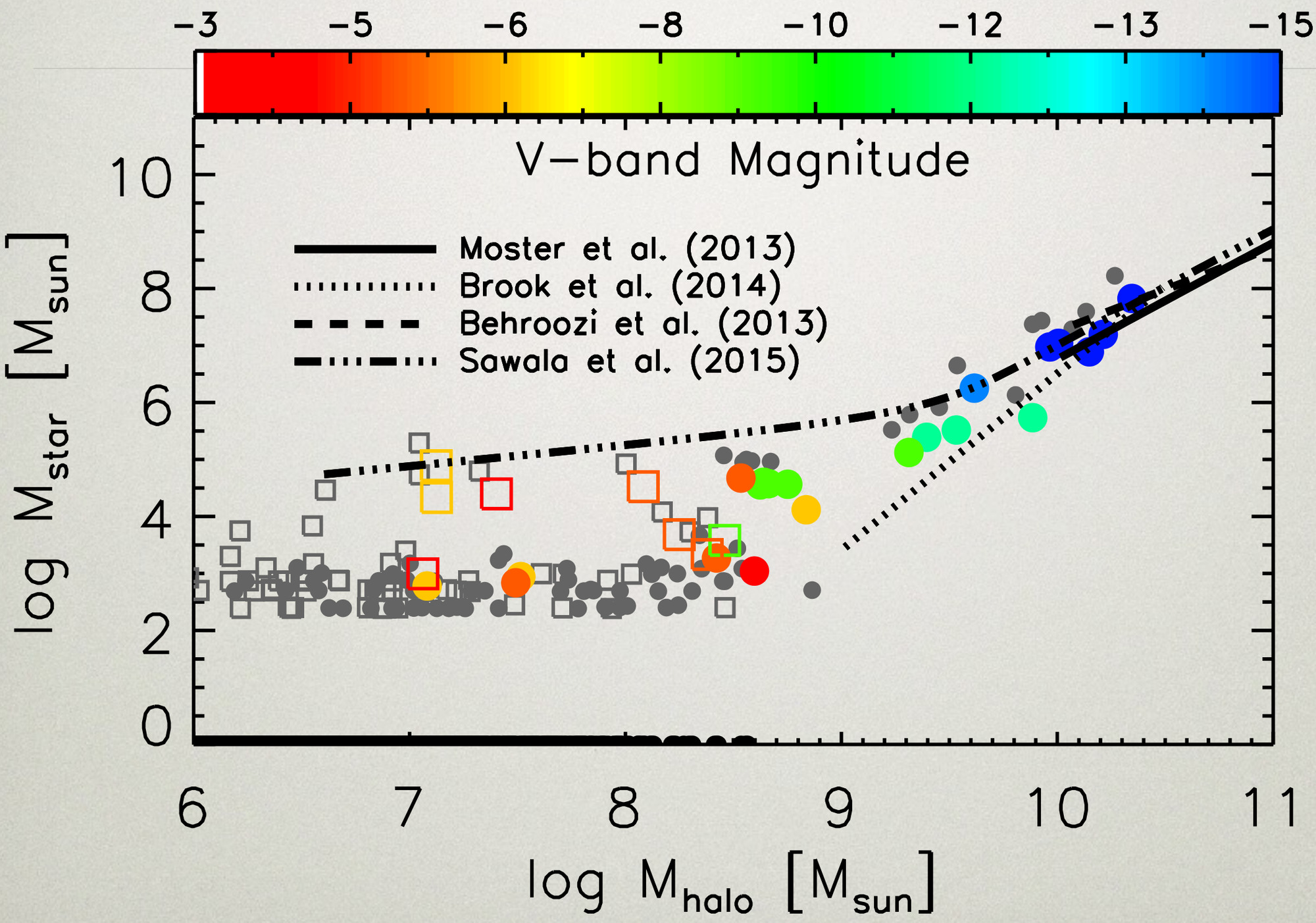
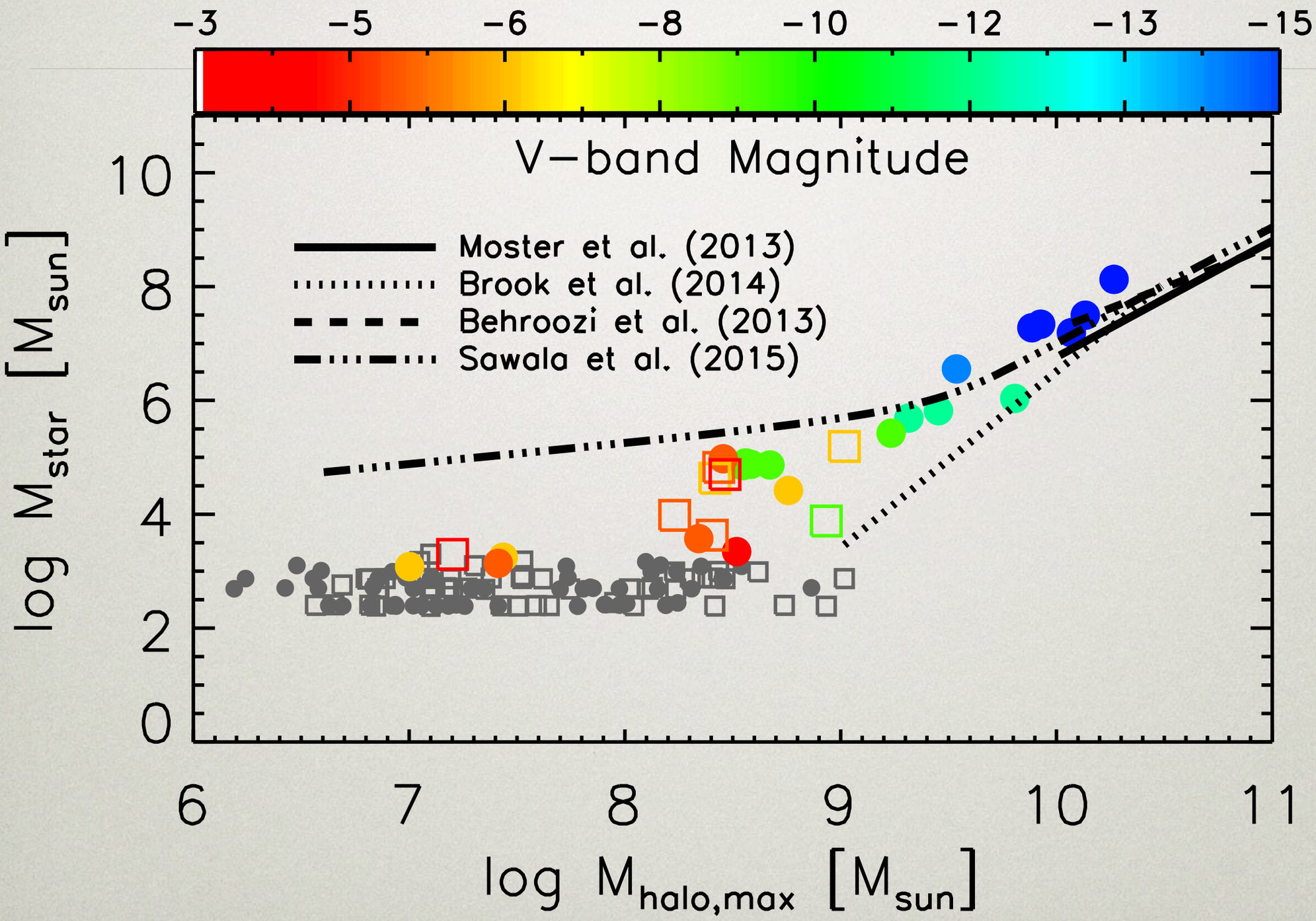



**1-to-1 assumption of Abundance Matching break down at the low mass end!**

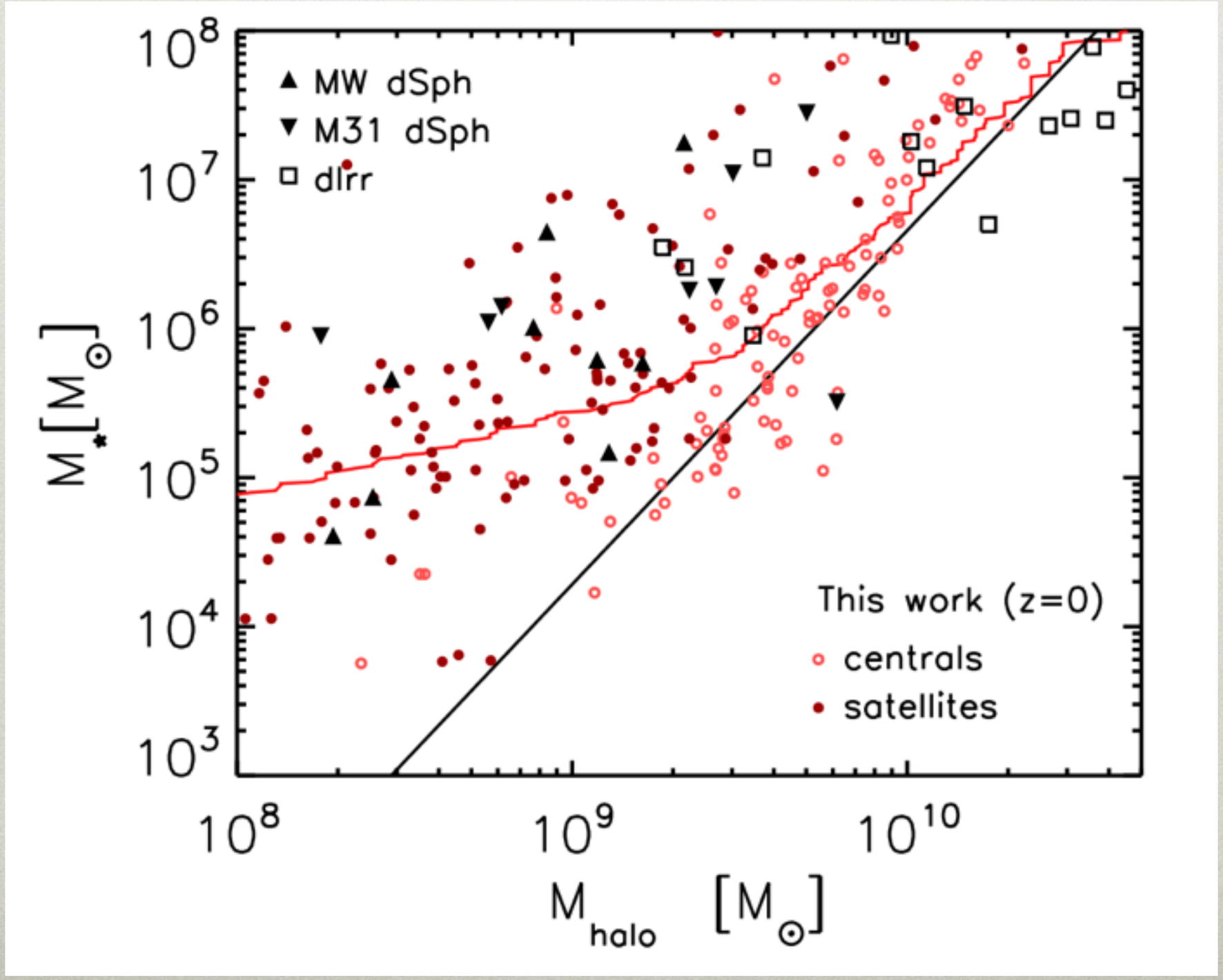



Munshi et al. (submitted)

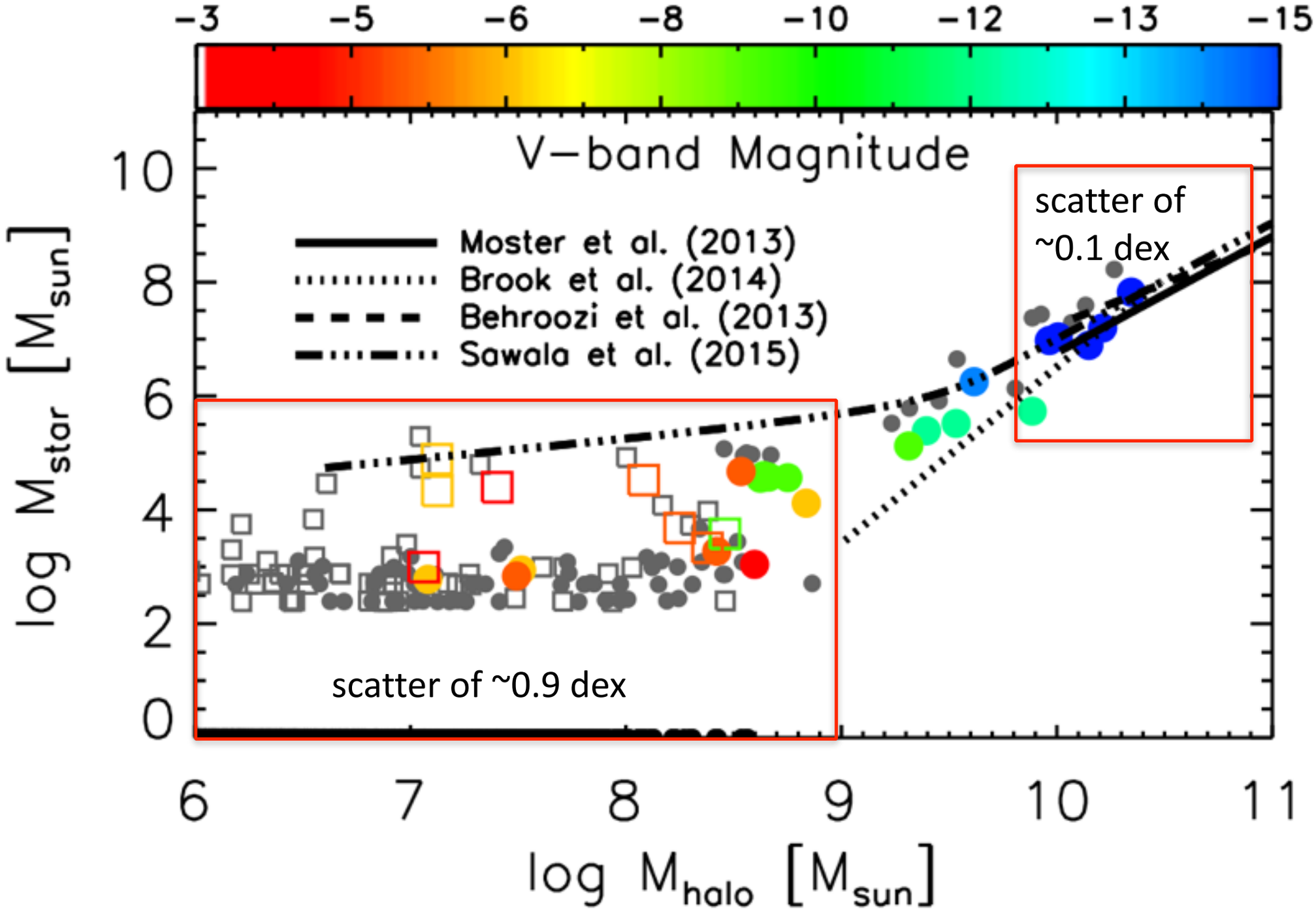



Munshi et al. (submitted)

# The "BEND" is due to the Inclusion of Satellites

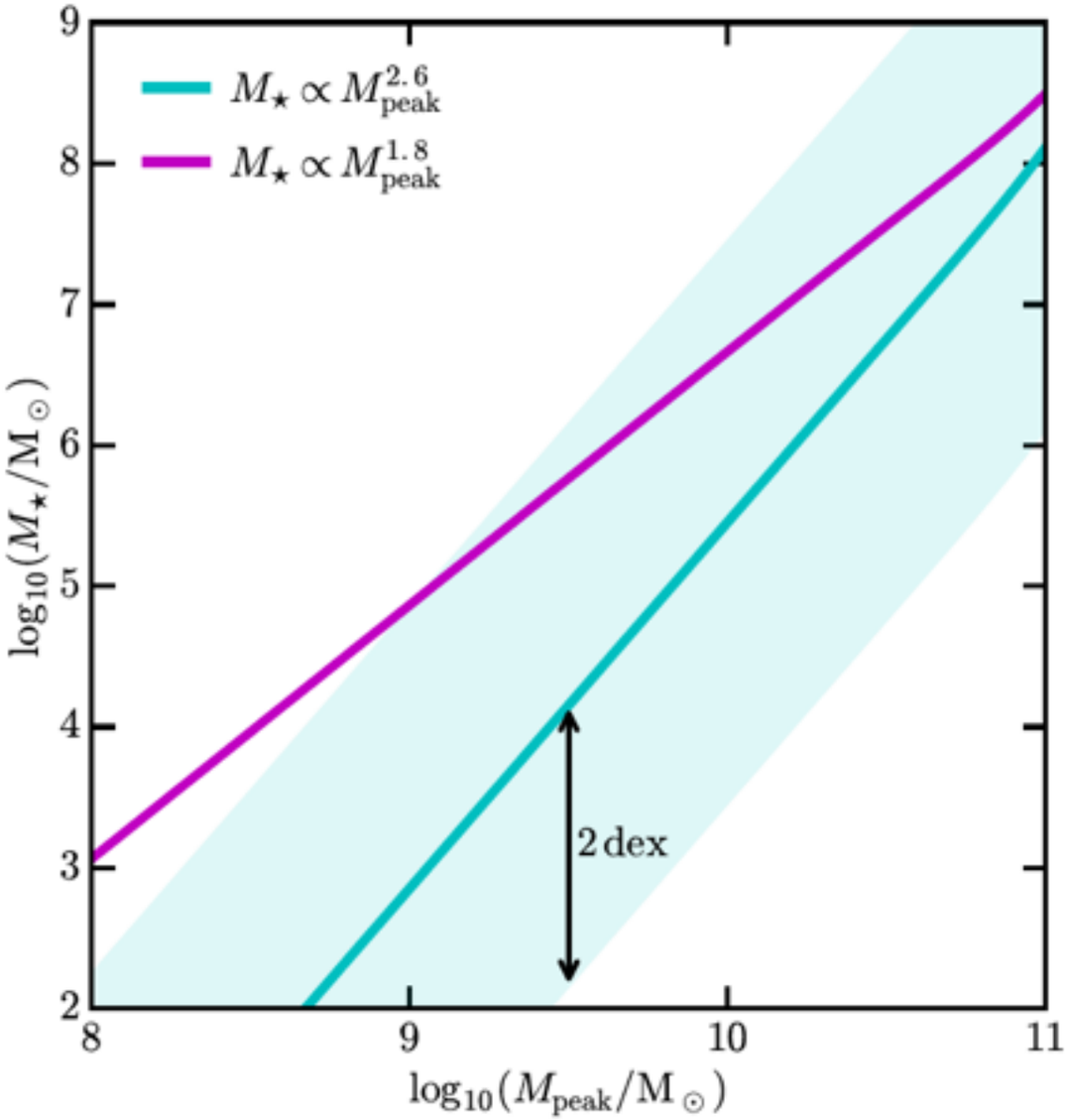


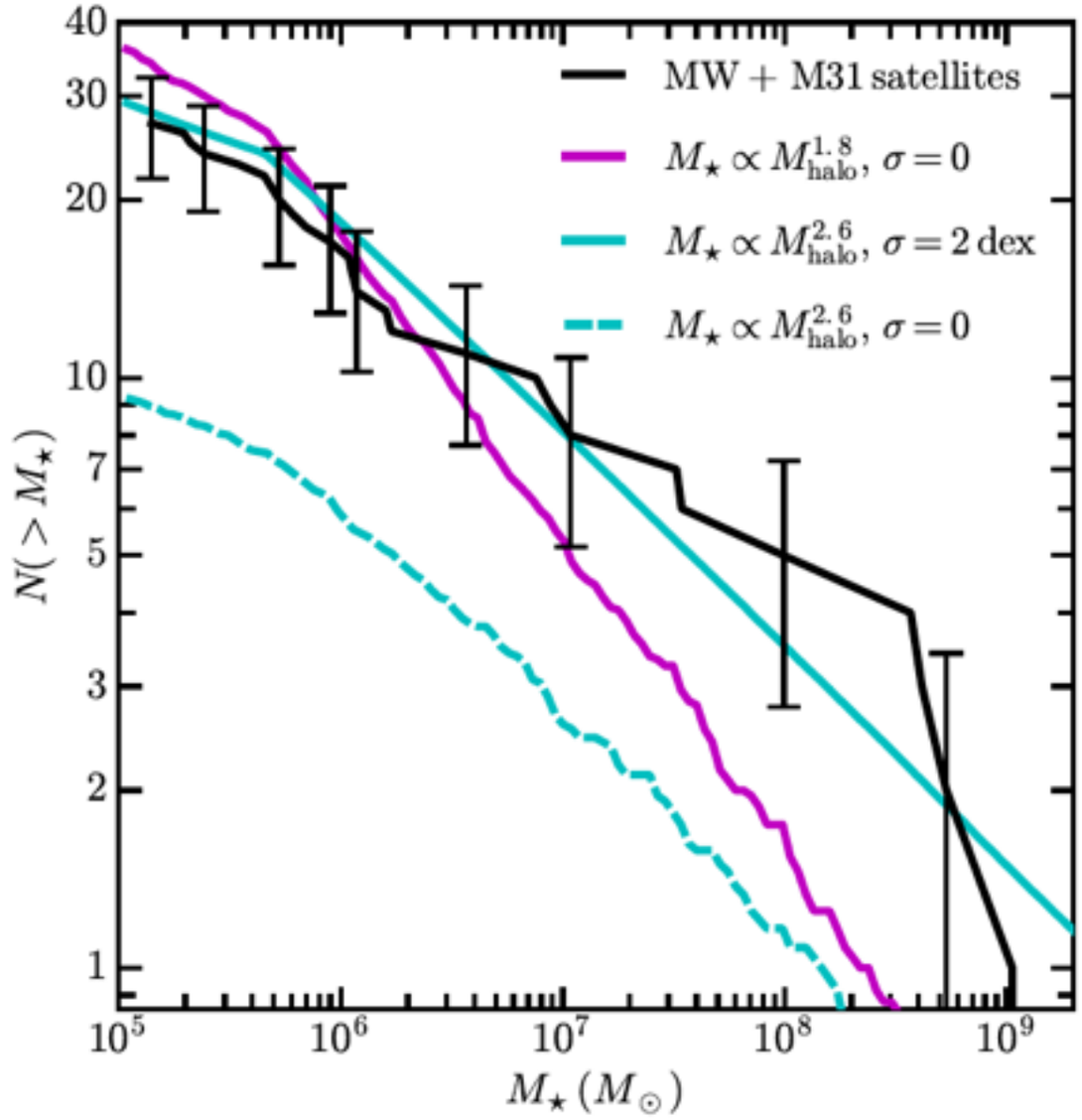

Sawala et al. 2015




Munshi et al. (submitted)

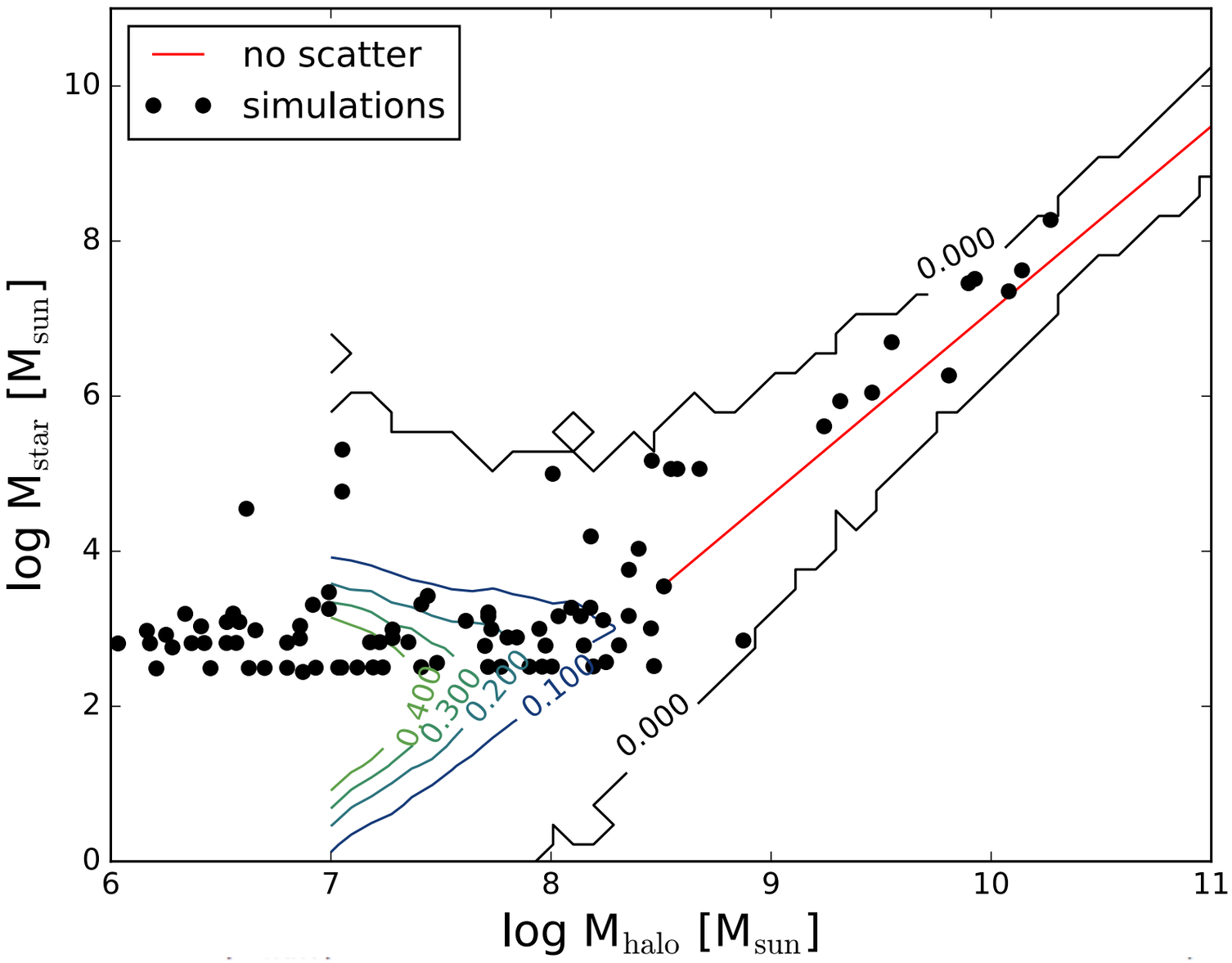
# Effect of Scatter

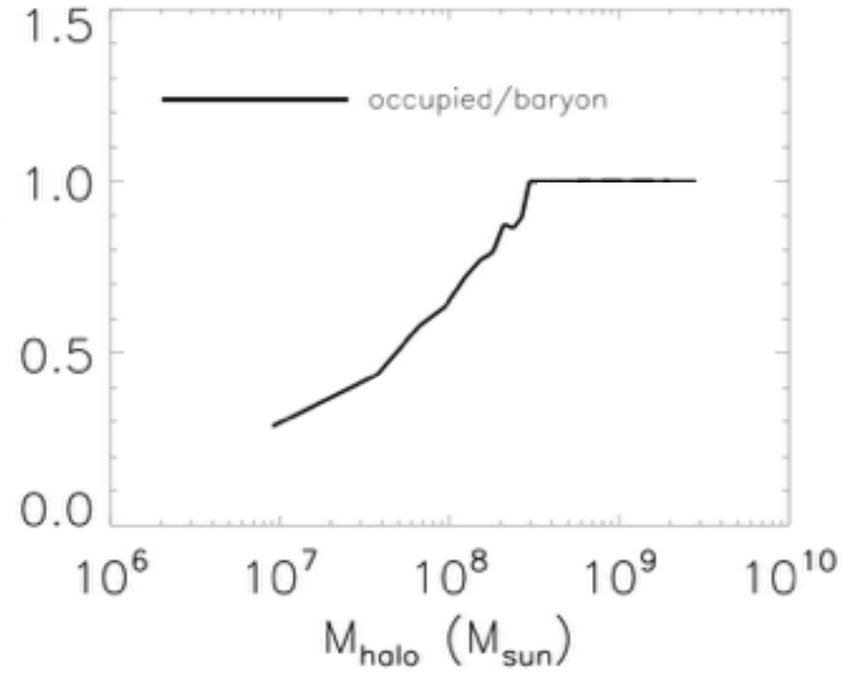



Garrison-Kimmel et al. 2017

# A Tool to Populate Low Mass Halos

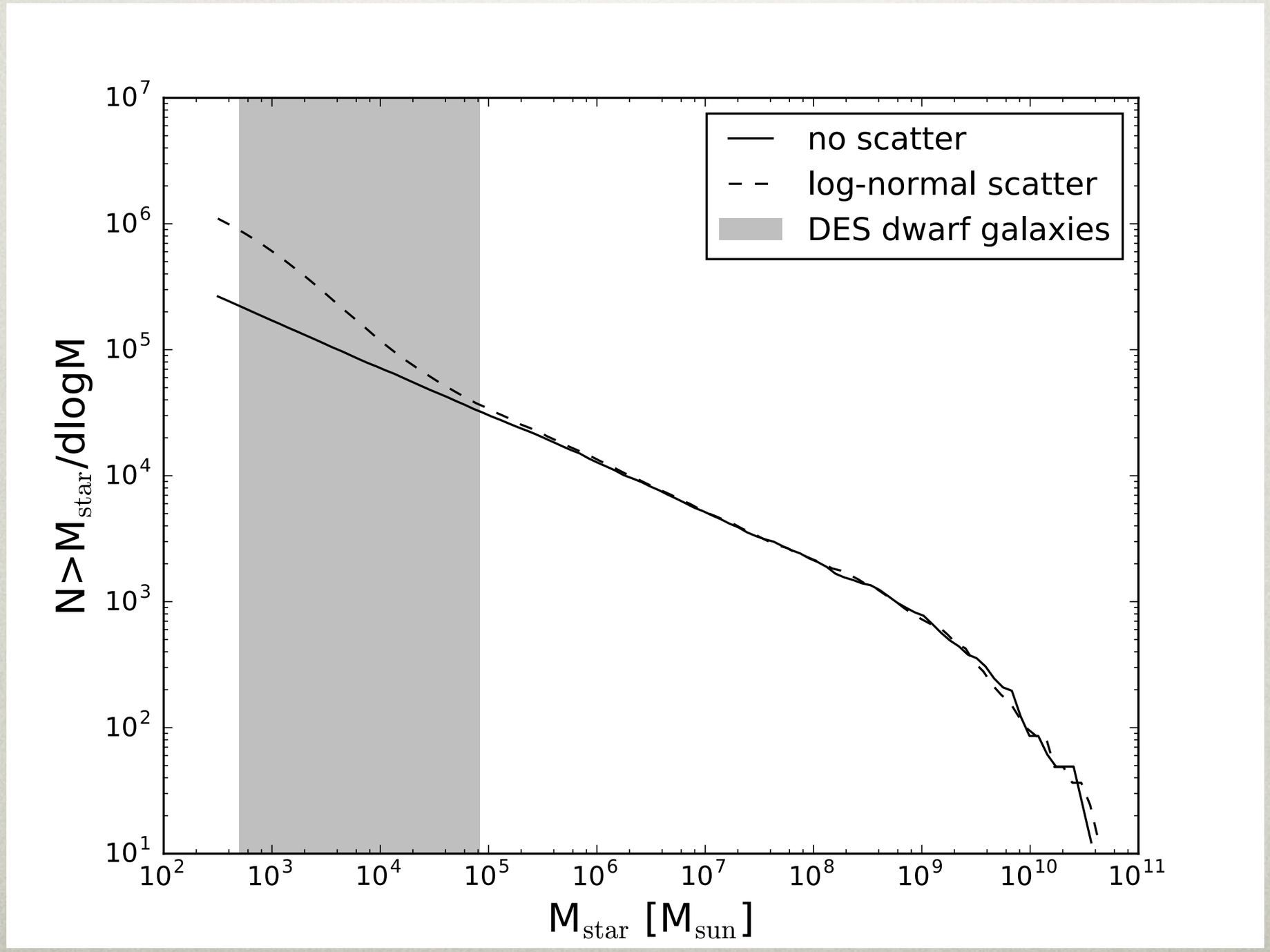



We adopt the trends defined for our well-resolved halos: a slope of the SMHM $\alpha = 2.4$ for $8.4 < log(\mathrm{M}_{halo}) < 11.5$ (shown by the red dashed line), with a shallower slope of $\alpha = 0.64$ at lower halo masses. The scatter is fixed to a constant 0.2 above $\mathrm{M}_1 = 5 \times 10^9$ $\mathrm{M}_\odot$, and linearly grows below this halo mass so that $\gamma = -0.26$.

$$\sigma = 0.2 + \gamma(\log_{10}\mathrm{M}_{\mathrm{halo}} - \log_{10}\mathrm{M}_1)$$

# Predicted Stellar Mass Function

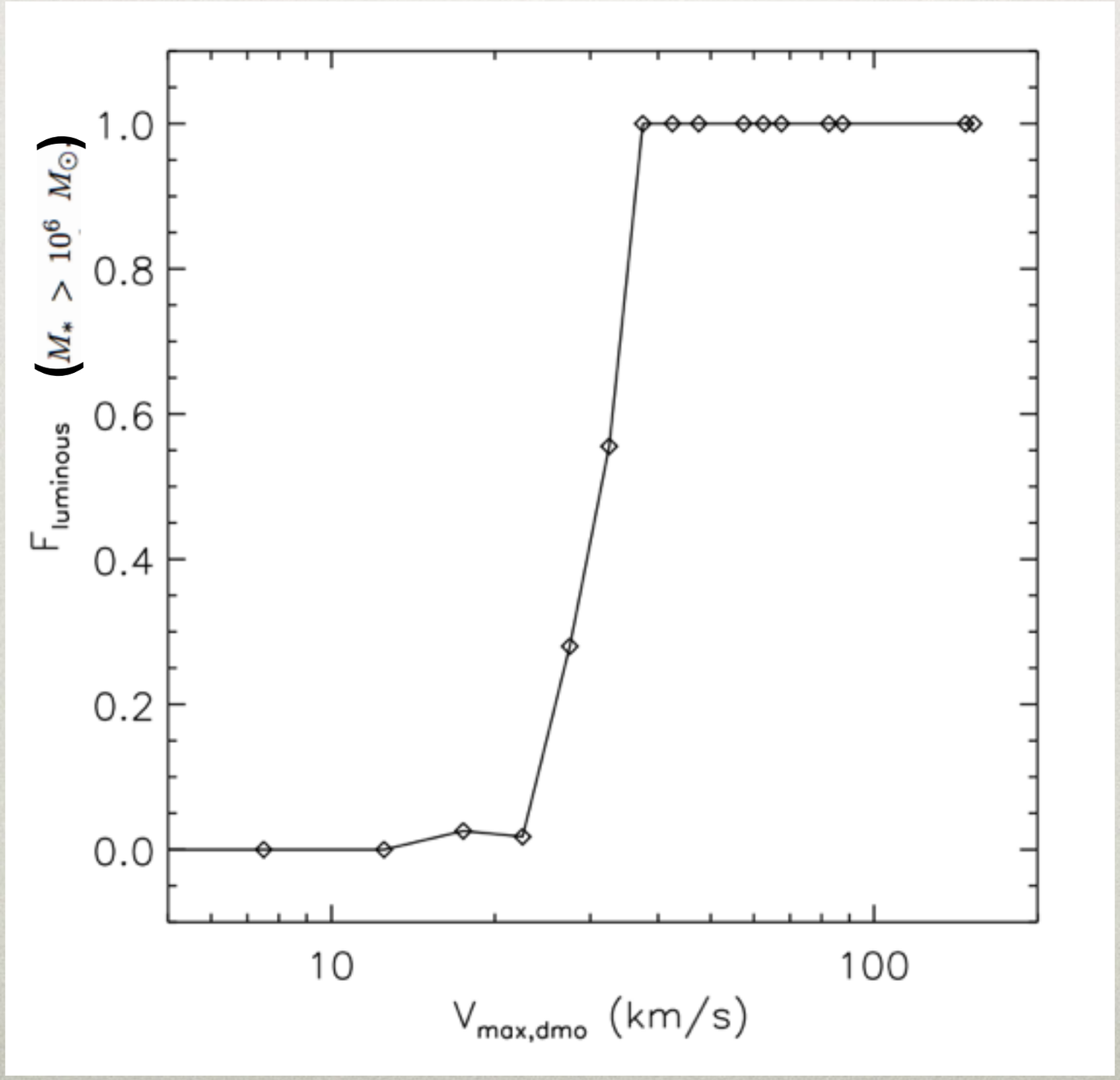



Munshi et al. (submitted)

# Conclusions

- Starting from the *abundance* of dwarf galaxies predicted in LCDM, the HIVF can be recovered. There is no missing dwarf problem in the field.
- The scatter in the SMHM relation in low mass halos increases with decreasing halo mass. There is no one-to-one assignment of stellar mass to halo mass.
- The "bend" at low halo masses found by Sawala et al. (2015) is due to the inclusion of satellites.
- The increased scatter at low masses leads to a prediction of a steeper stellar mass function in the ultra-faint dwarf galaxy mass range, currently being probed by DES, HSC, MagLiteS, etc, and by LSST in the future.

# Also Consider Detectability




Brooks et al. (2017), arXiv:1701.07835

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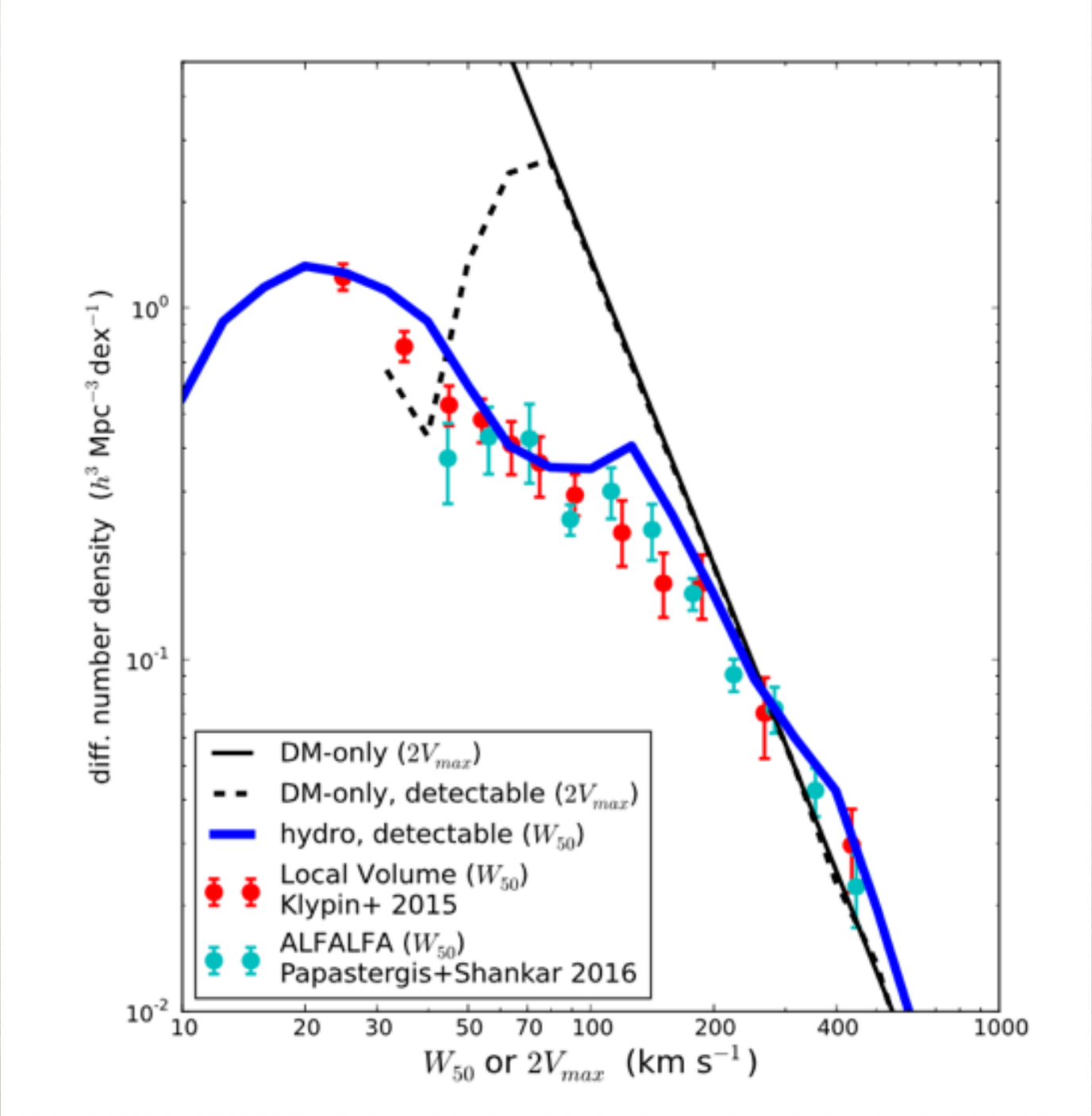


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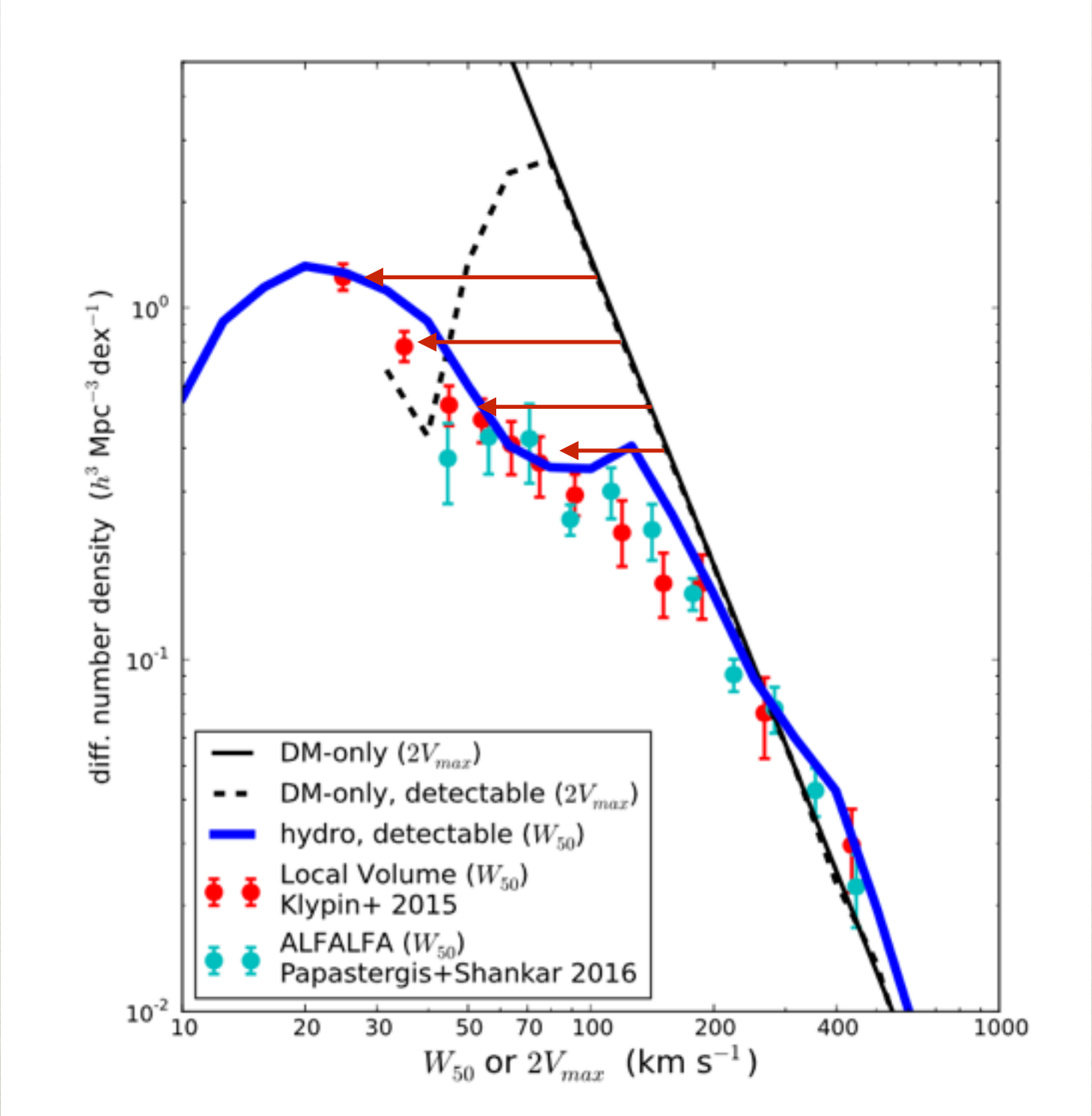


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