



# Trunk, Branch, and Twig:

## Revealing the Dark Matter Structure of the Cosmos

Annika Peter, OSU



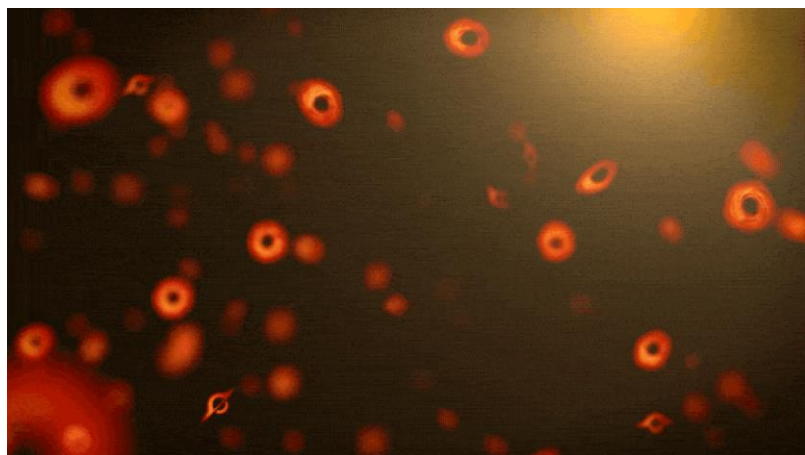


# Dark matter: holding us together since $z \sim 3400$

$\sim 1/4$  of the matter-energy budget today

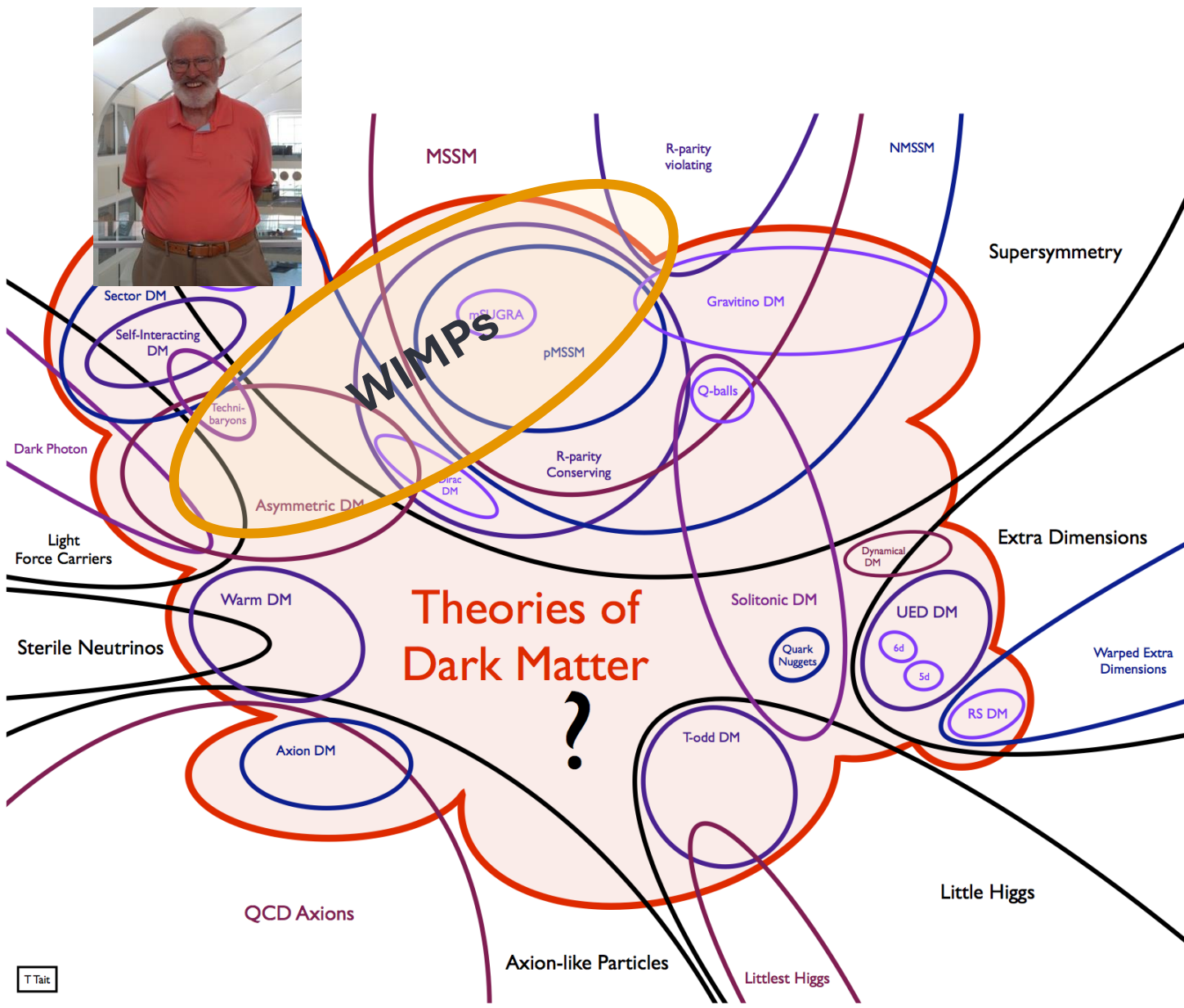
WAS closer to 100% of the matter-energy  
budget for most of cosmic history

# Particle models



Primordial Black Holes!

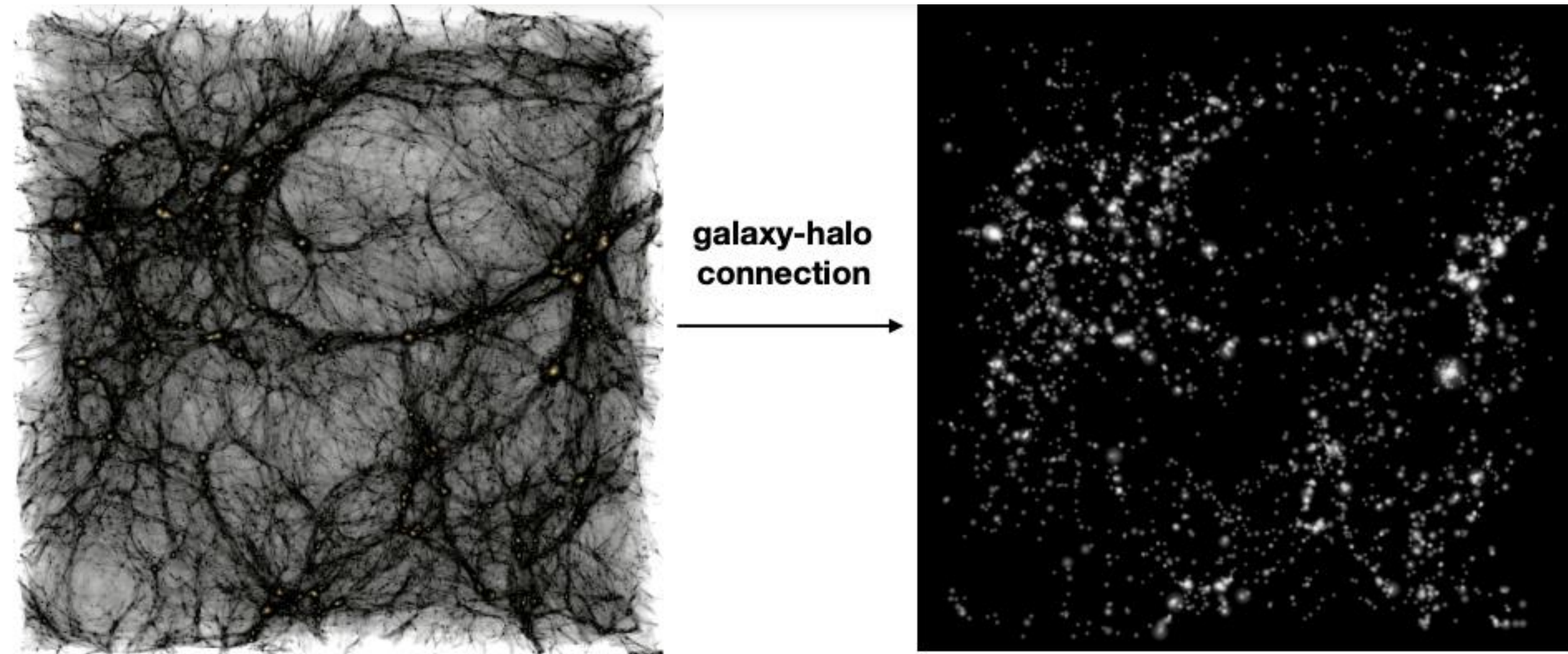
Credit: Scientific American





# Dark matter cosmology

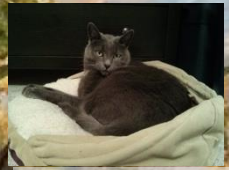
Wechsler & Tinker 1804.03097







Galaxies



Catstronomers

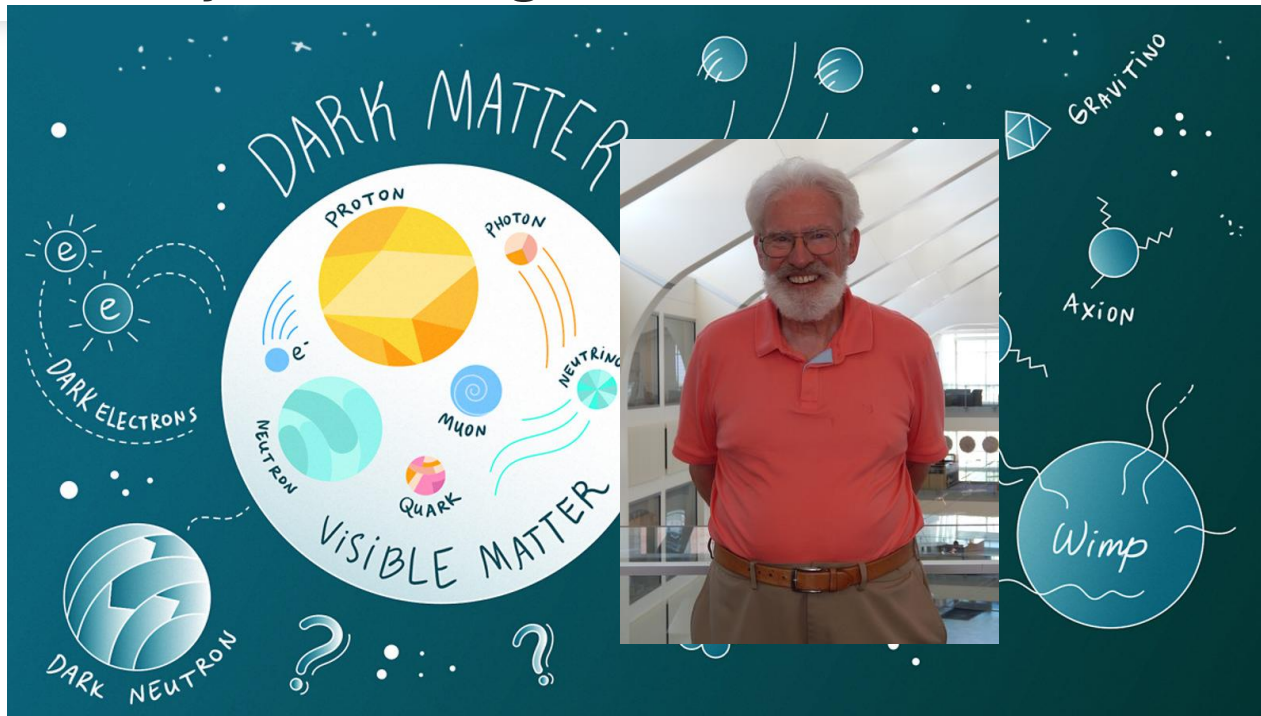
Dark matter cosmic structure

(Particle) dark matter models



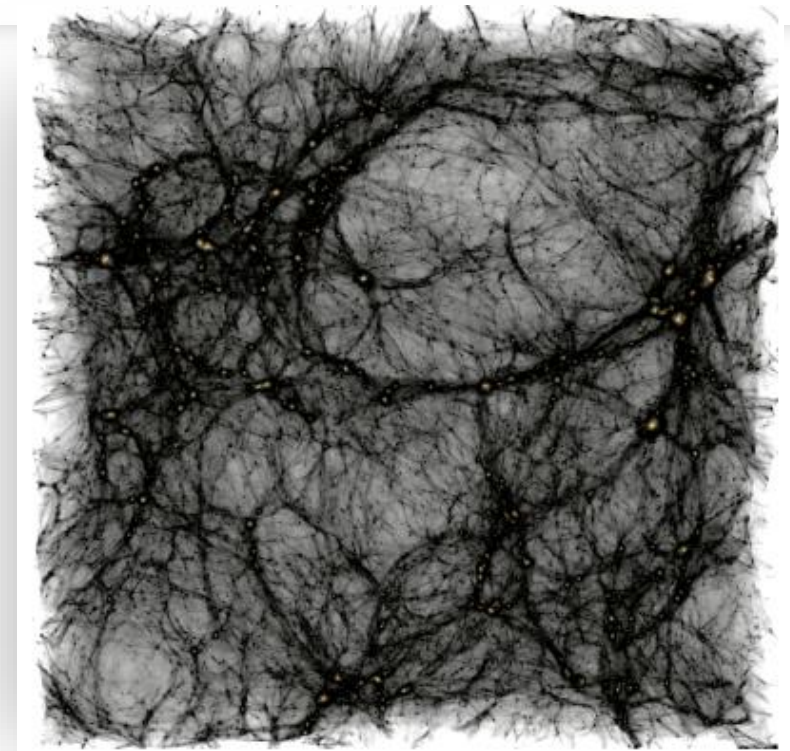
# Standard WIMP CDM paradigm

Weakly Interacting Massive Particle



Credit: Sandbox Studio, Chicago with Ana Kova

Cold dark matter

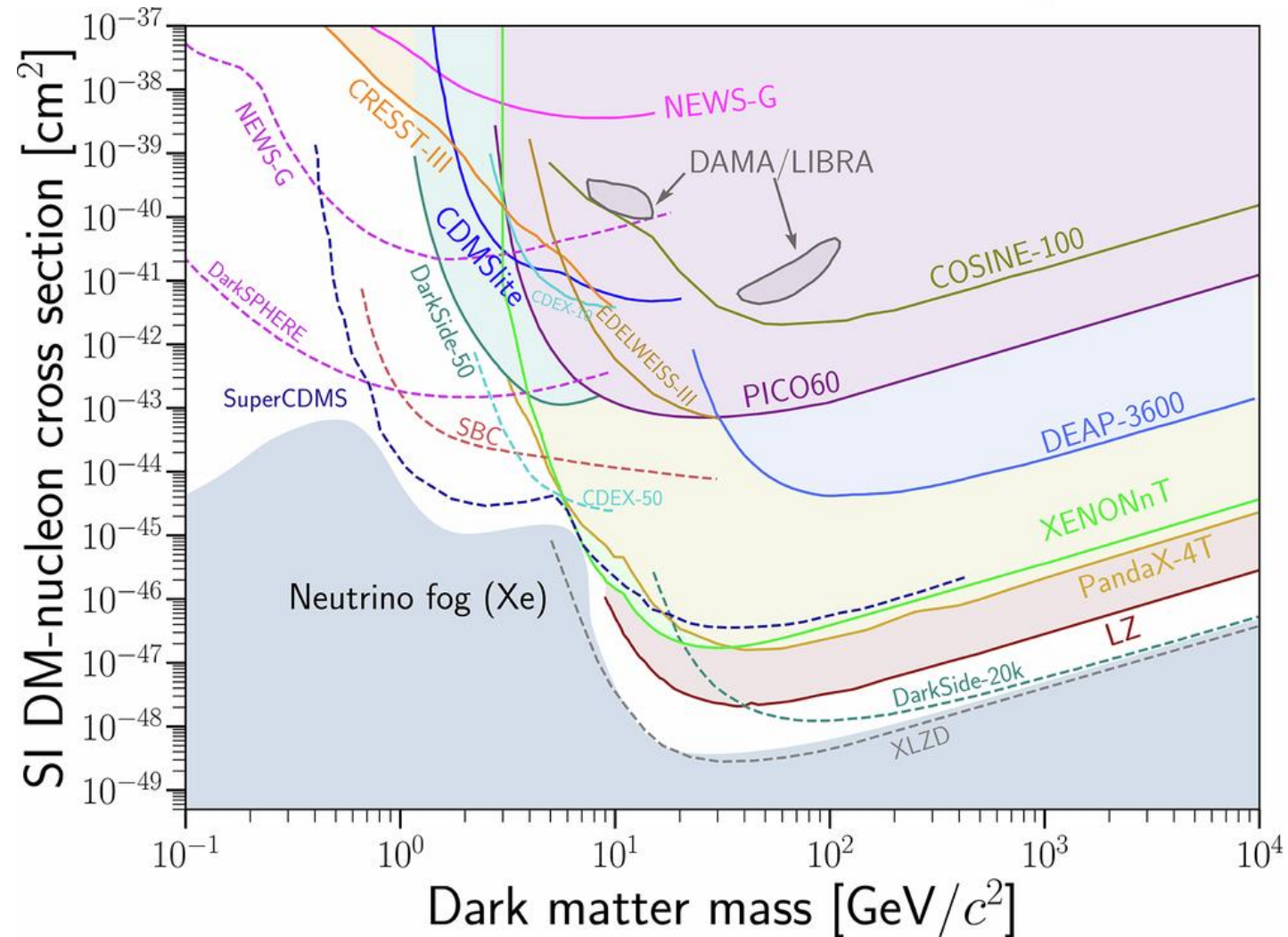


# CCAPP greatest hits

---

Testing the WIMP-CDM paradigm

# “WIMPs are NOT dead”

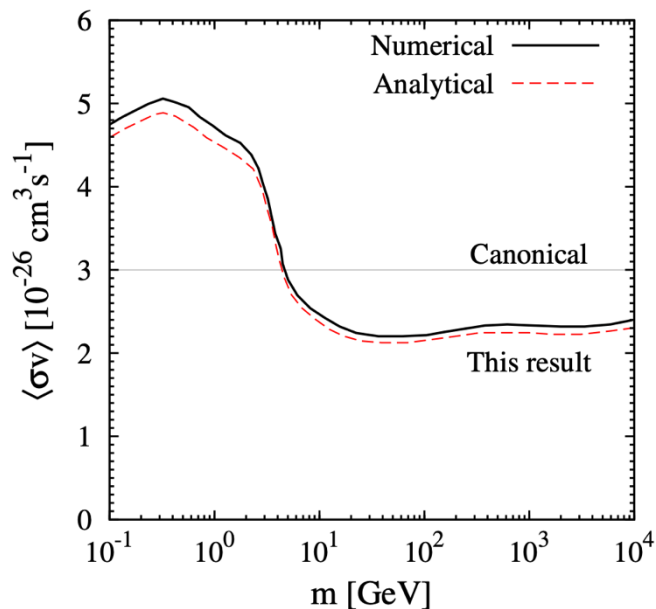


Xia & Canonica Nature review  
article, March 2026



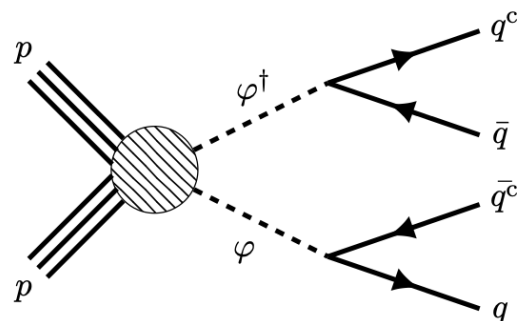
# “WIMPs are NOT dead”

## 1. More accurate calculations



Beacom, Dasgupta, Steigman 2012  
Also: Boveia, Carpenter, Hirata, Peter

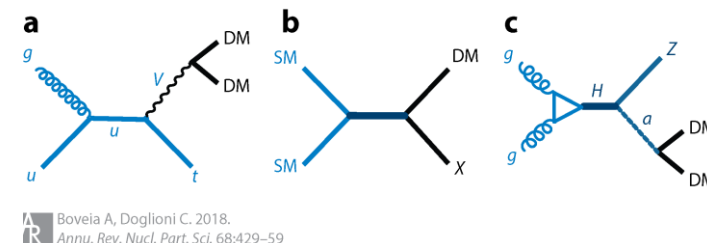
## 2. New interactions



Carpenter+ 2022

Also: Beacom, Boveia, Walker

## 3. New searches



Boveia A, Doglioni C. 2018.  
Annu. Rev. Nucl. Part. Sci. 68:429–59

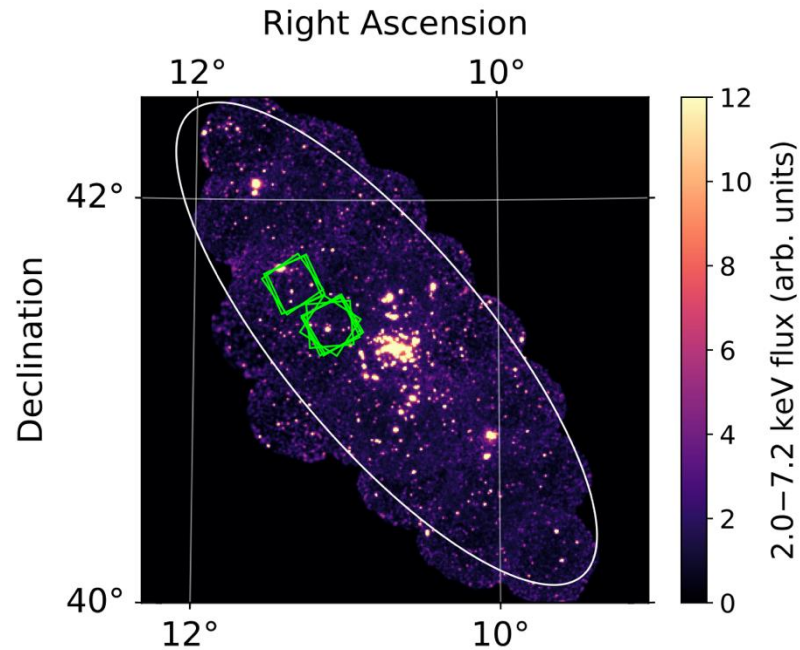
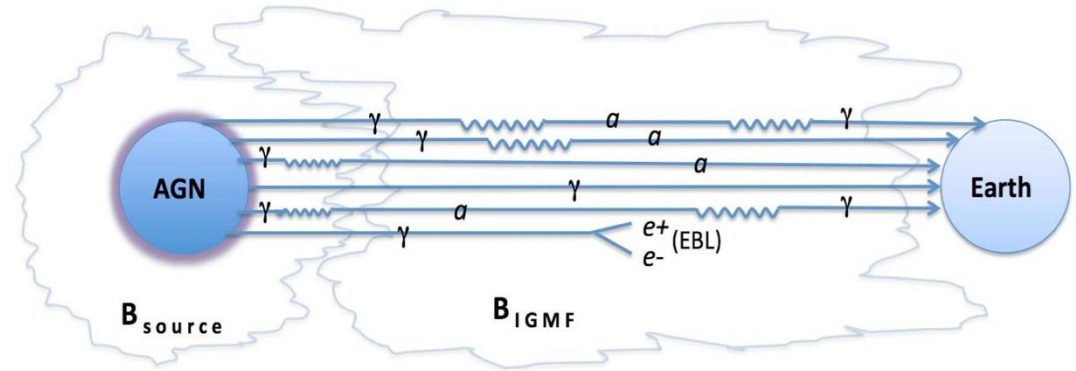
Boveia & Doglioni 2018

Also: Beacom, Carpenter,  
Hughes, Peter, Steigman,  
Walker, Winer

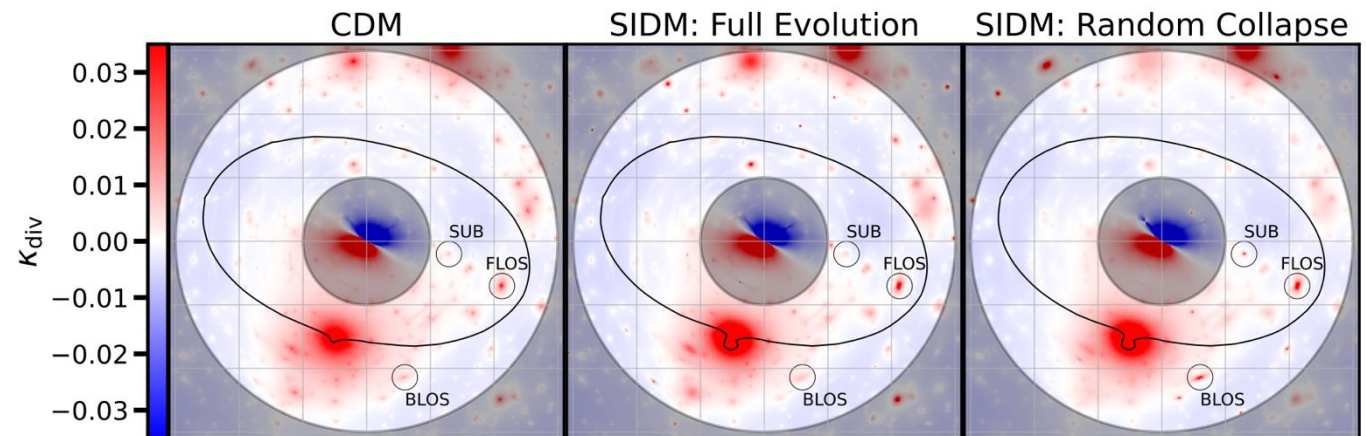


“...but we are a little worried.  
New searches for new  
candidates!”

ALPs; Reesman & Walker

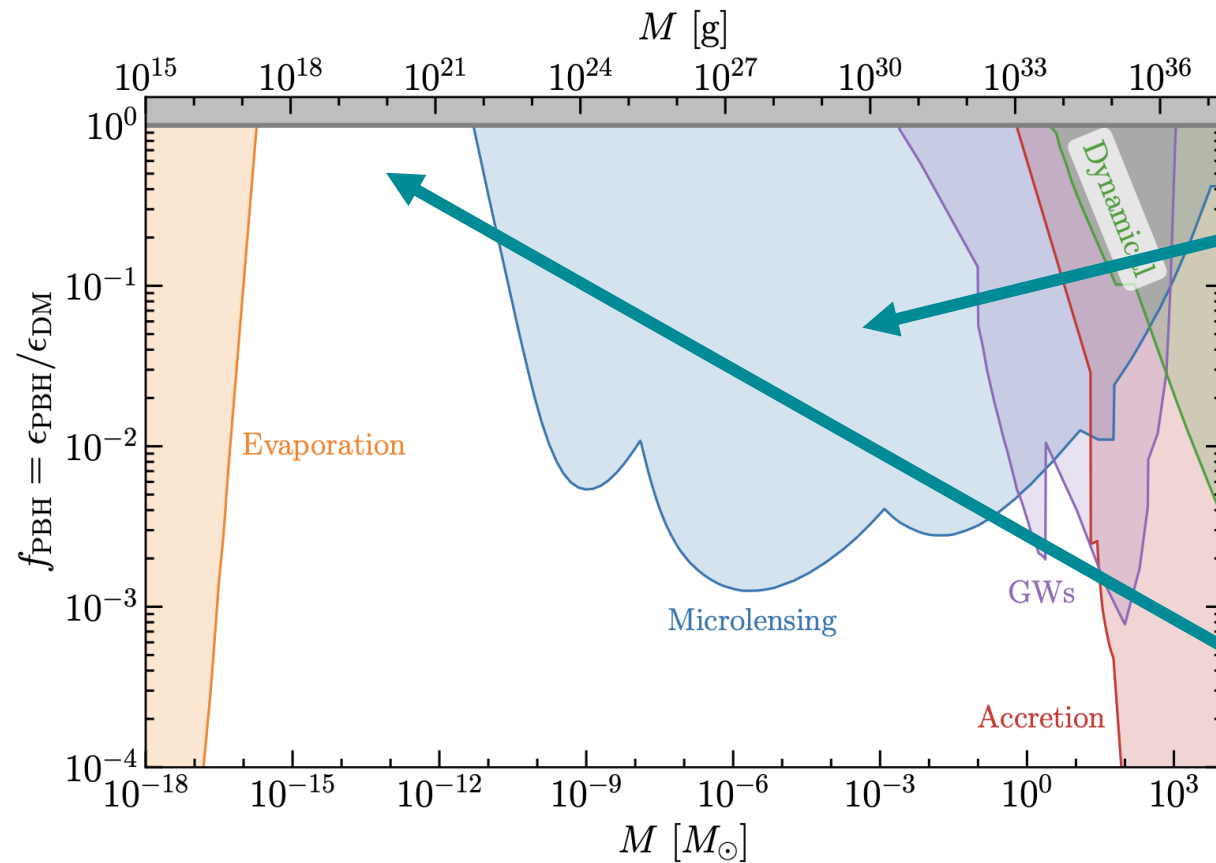


Hidden-sector dark matter; Mace+



Sterile neutrinos; Ng+

# “Primordial black holes are NOT dead”



Anne Green 2025

Gould

Hirata group  
(Camacho, Chen, Fang,  
Fulsundar, Koivu, Nel,  
Silva, Vasquez...)

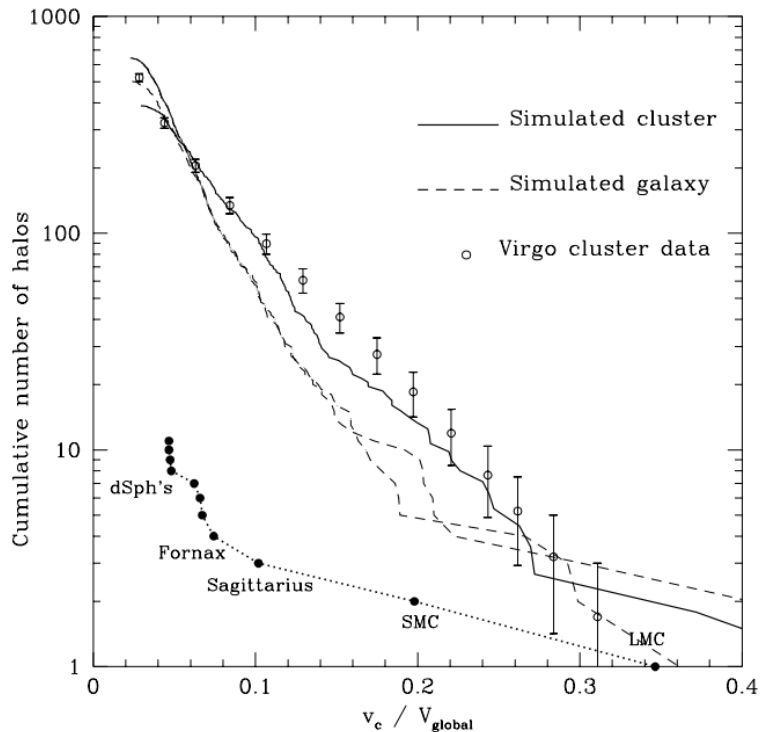


# “Missing satellites problem?!?”

## How about a too many satellites problem?”

2000ish: simulators of CDM find that Milky Way-like halos have more subhalos than the observed number of satellites: “missing satellites problem”.

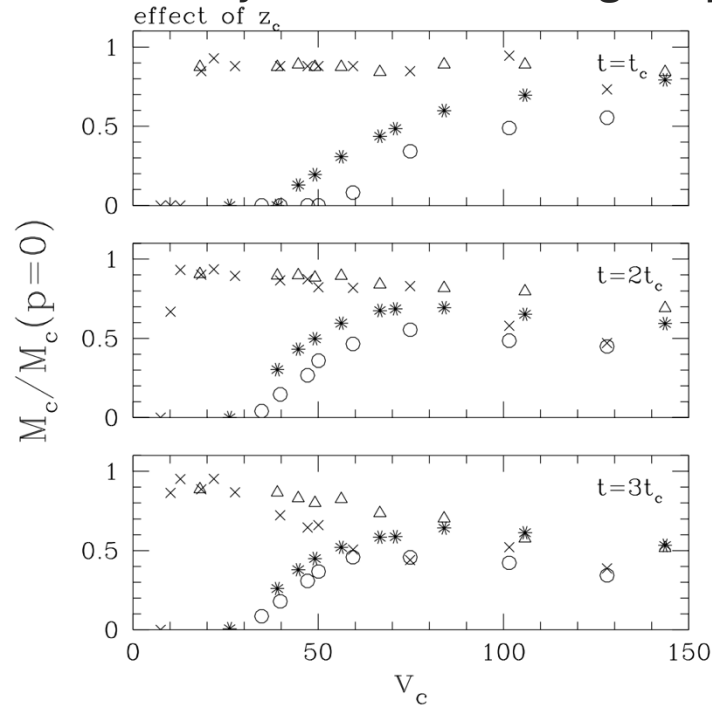
(Moore+, Klypin+ 1999)



# “Missing satellites problem?!? How about a too many satellites problem?”

1

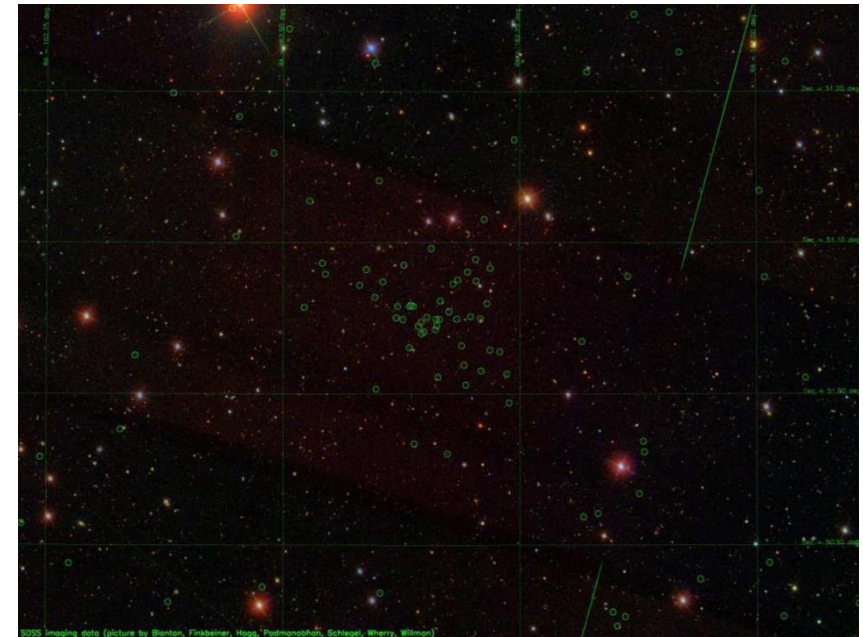
Not every halo can host a galaxy



Thoul & Weinberg

2

Find more and weirder satellites



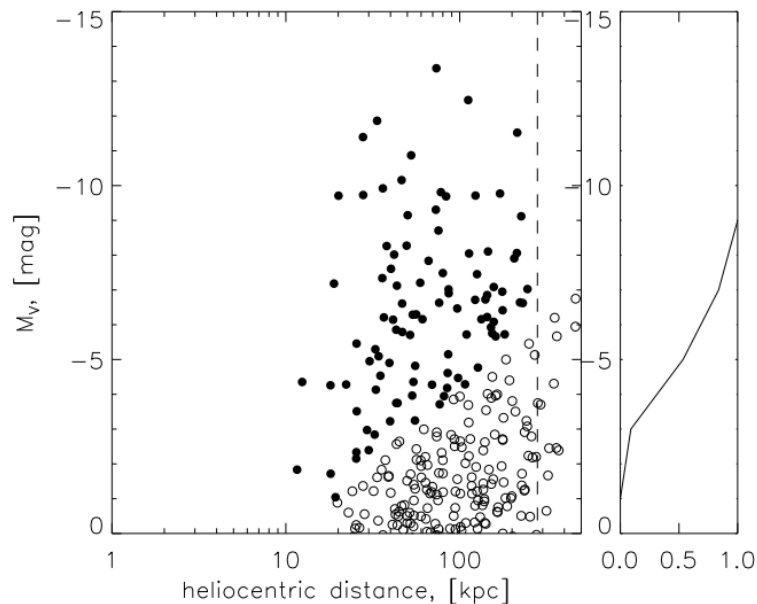
Willman+ w/SDSS;  
later Peter group w/other surveys



# “Missing satellites problem?!? How about a too many satellites problem?”

3

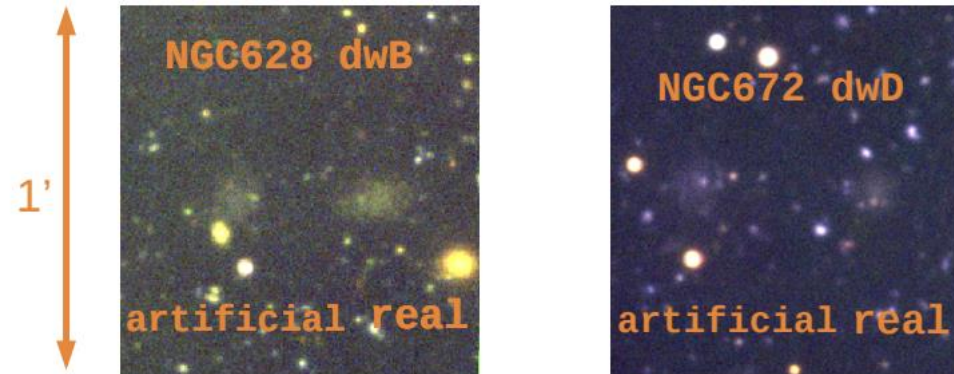
Selection functions



Koposov, Weinberg+; also Peter group

4

Look outside the Milky Way

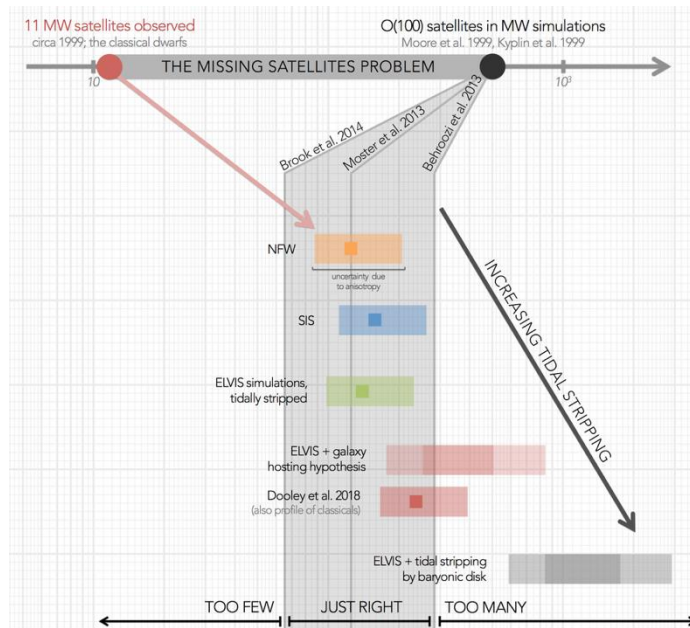


LBT-SONG; Davis+; many members of Peter group,  
Greco, Nierenberg, Sardone

# “Missing satellites problem?!? How about a too many satellites problem?”

5

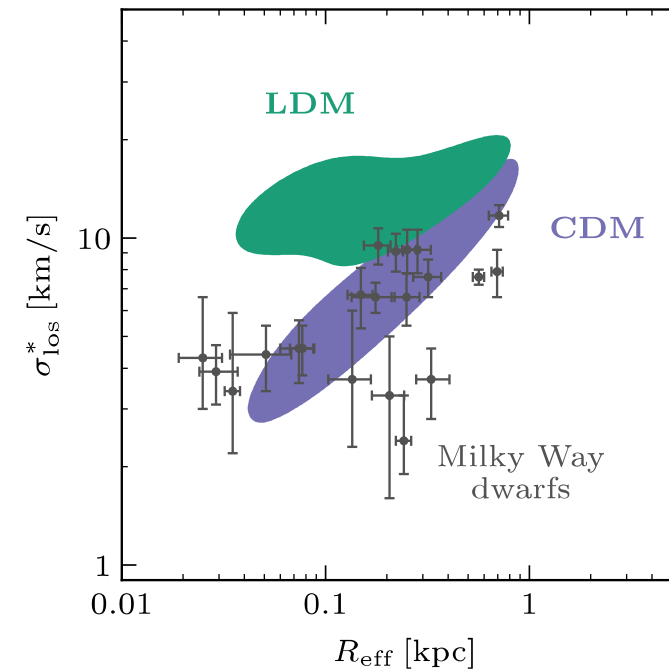
A too many satellites problem?



Kim, Peter, Hargis

6

Do we also have a density problem?



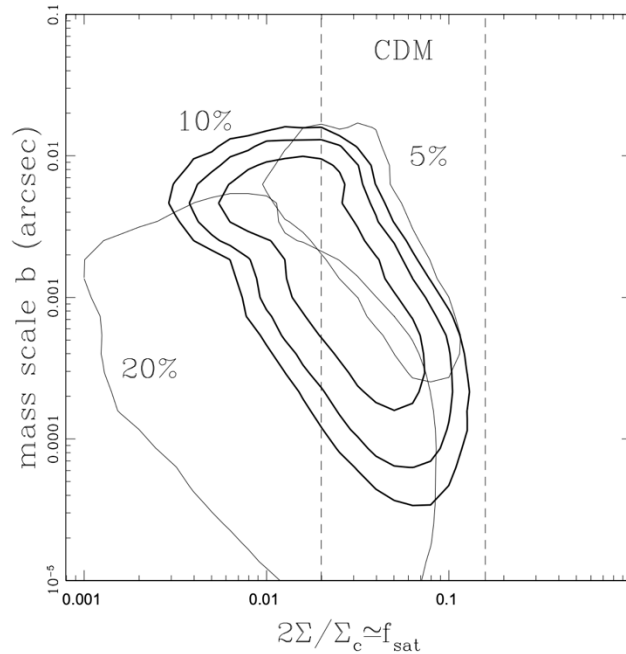
Esteban, Kim, Peter; now Dhital, Gountanis, Miller



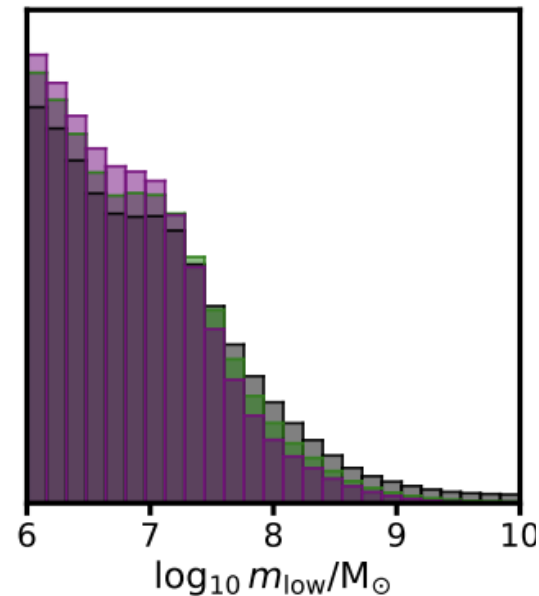
# “Missing satellites problem?!? How about a too many satellites problem?”

7

You should have listened to the lensers all along



Kochanek & Dalal



Nierenberg+

