+Non Cosmological Simulations with Self-Interacting Dark Matter

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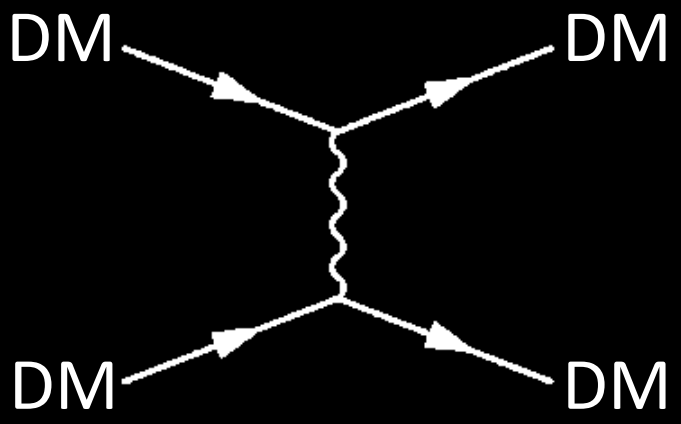
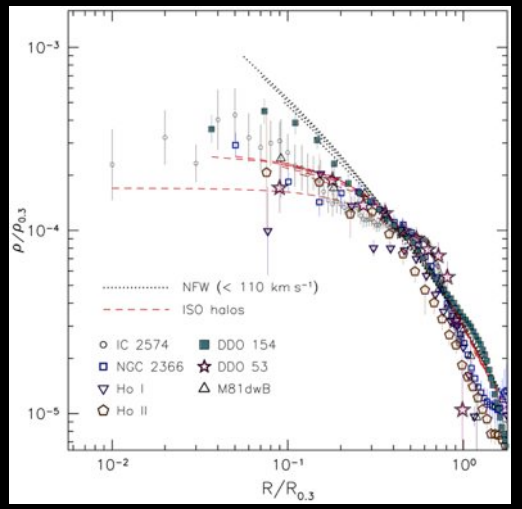
WHAT IS SELF-INTERACTING DARK MATTER?

- A form of Cold Dark Matter that has a significant cross-section for elastic scattering
- Natural in models with a rich dark sector which has new gauge forces
- Examples include:
  - "Fluid Dark Matter" (Peebles, 2000)
  - "Q-balls" (Kusenko and Steinhardt, 2001)
  - "Mirror Dark Matter" (Mohapatra+ 2001)
  - "Dark Electromagnetism" (Ackerman+ 2006)
  - "DM with Yukawa Potential" (Loeb and Weiner, 2011)
  - "Light Asymmetric Dark Matter" (Frandsen+ 2011)

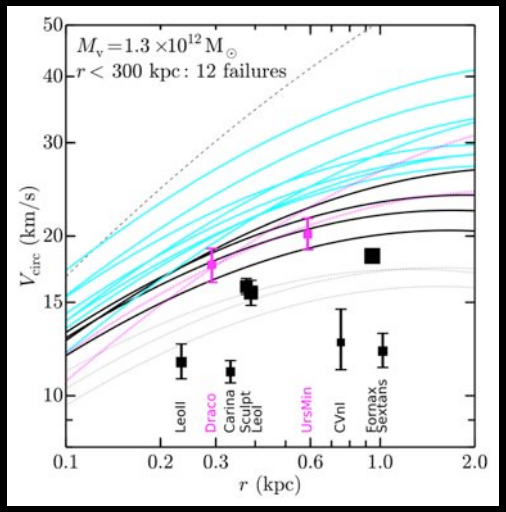


Core-Cusp Problem



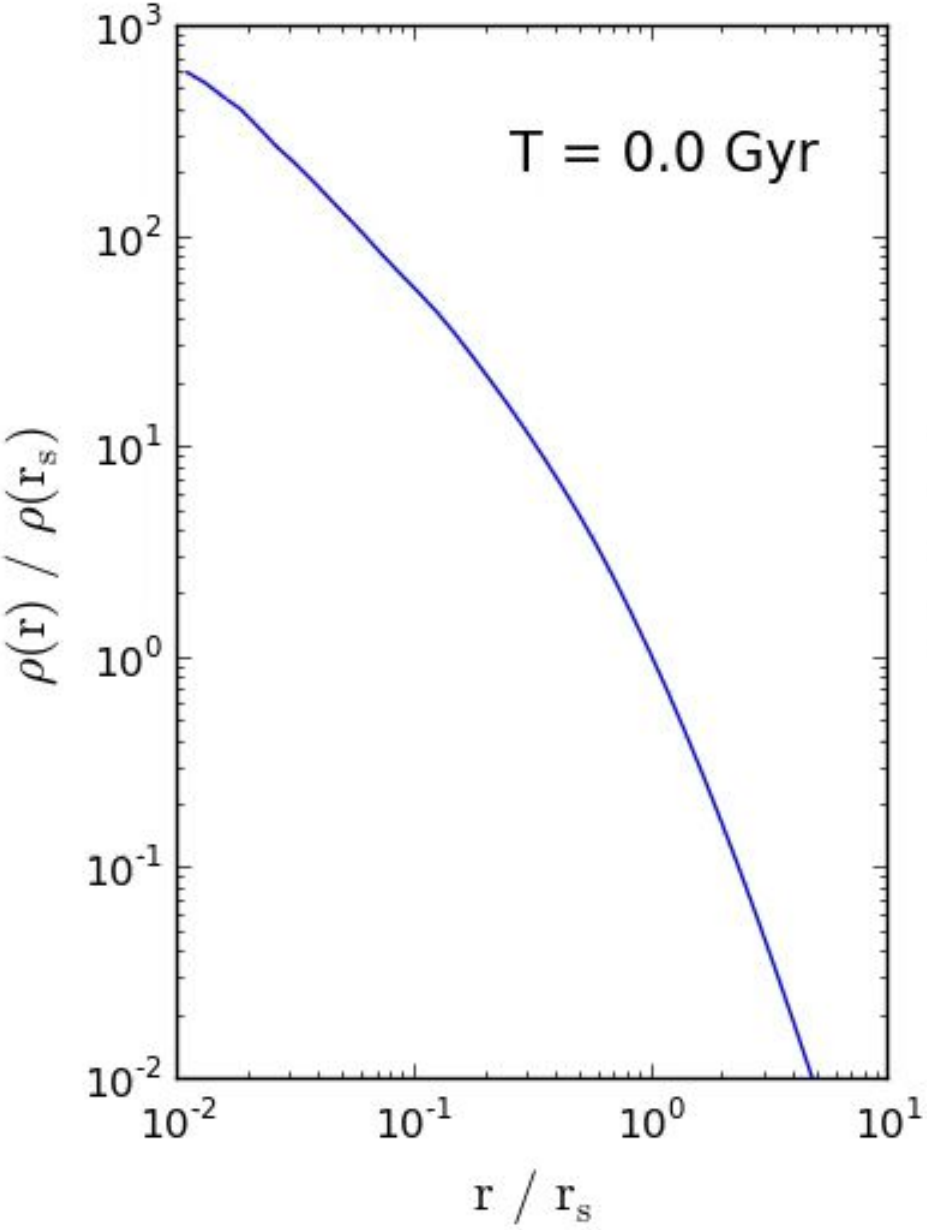
Oh+ 2011

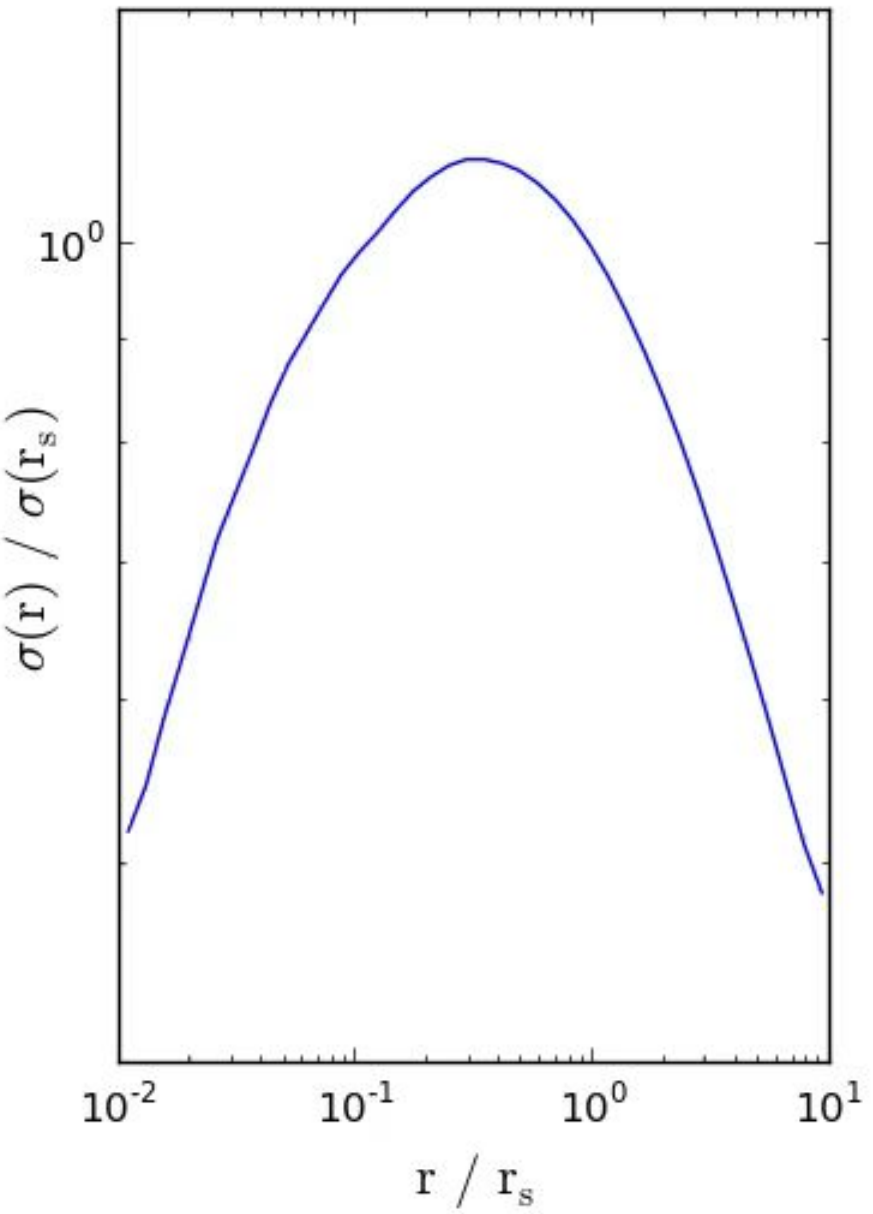
"Too Big to Fail"



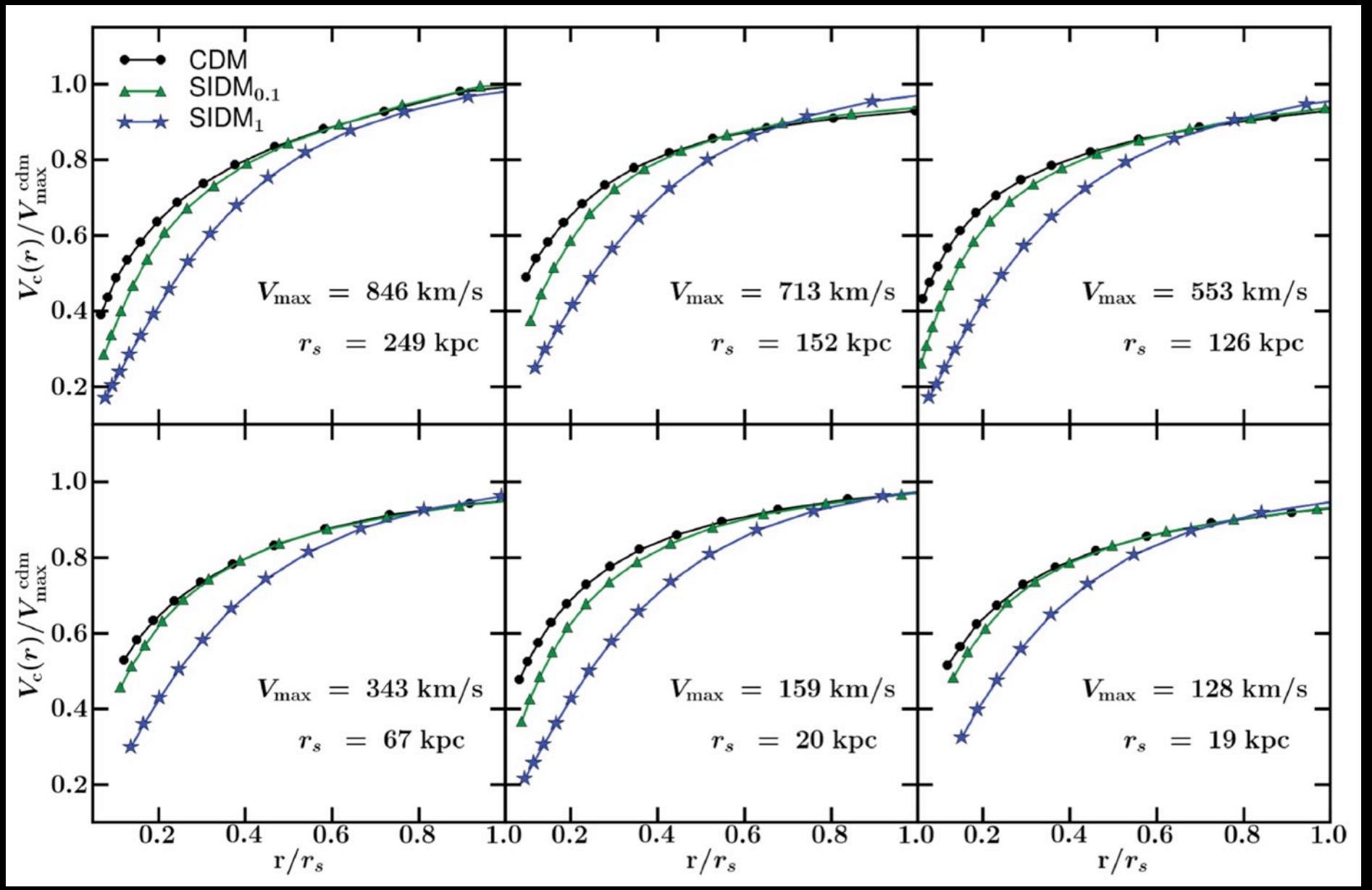
Garrison-Kimmel+ 2014

FORMATION OF A CORE



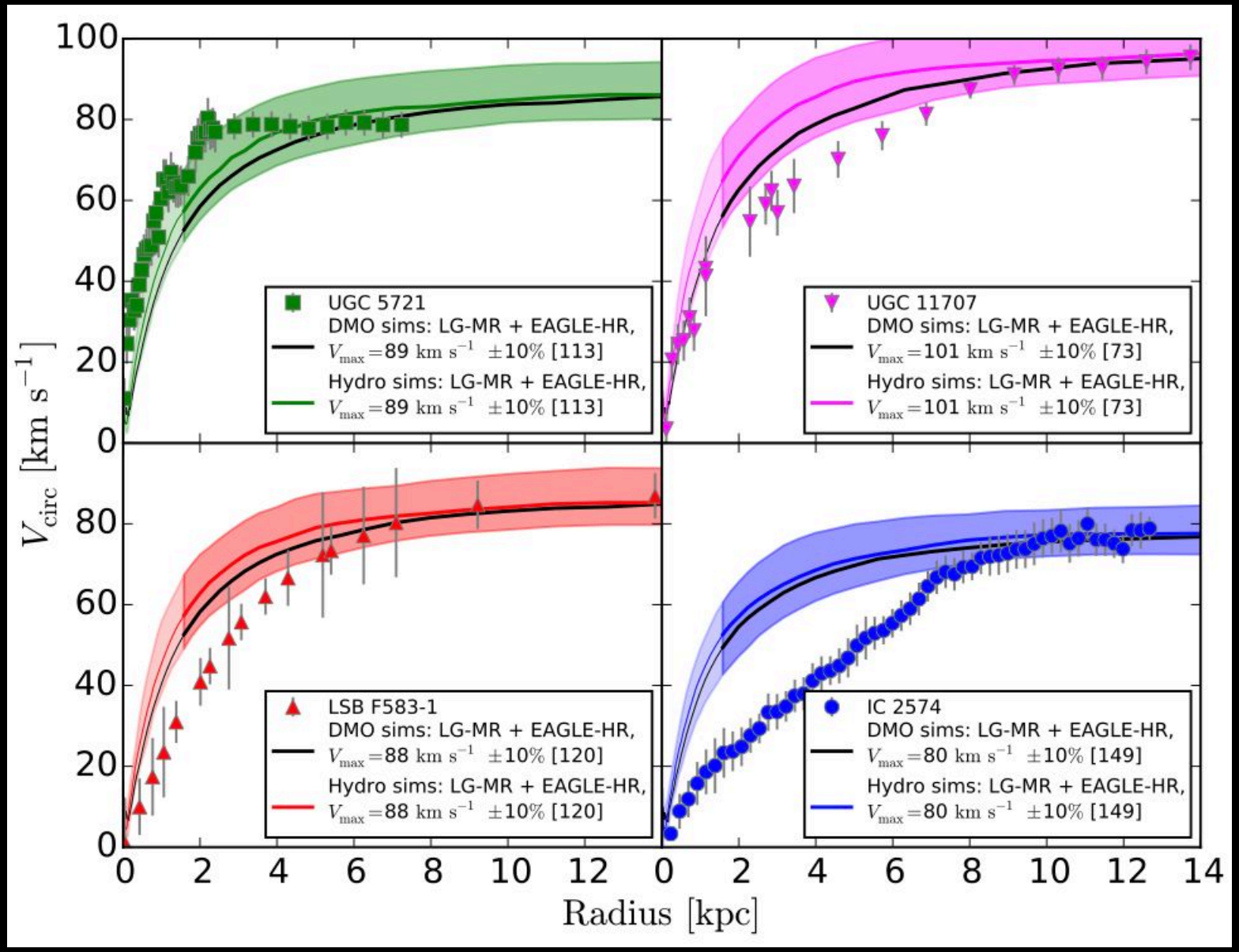


SIDM ROTATION CURVES



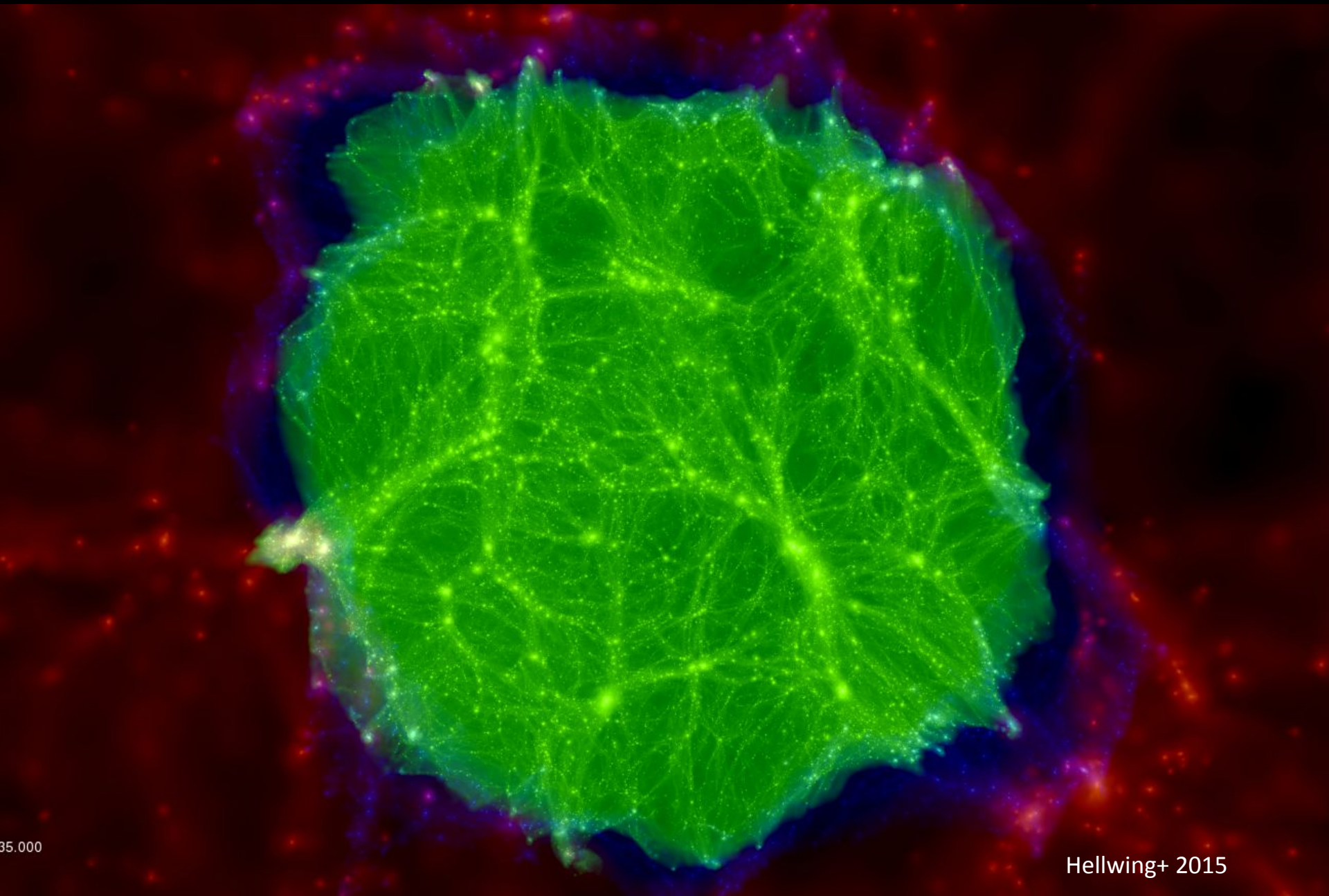
Rocha+ 2013

THE DIVERSITY OF OBSERVED ROTATION CURVES

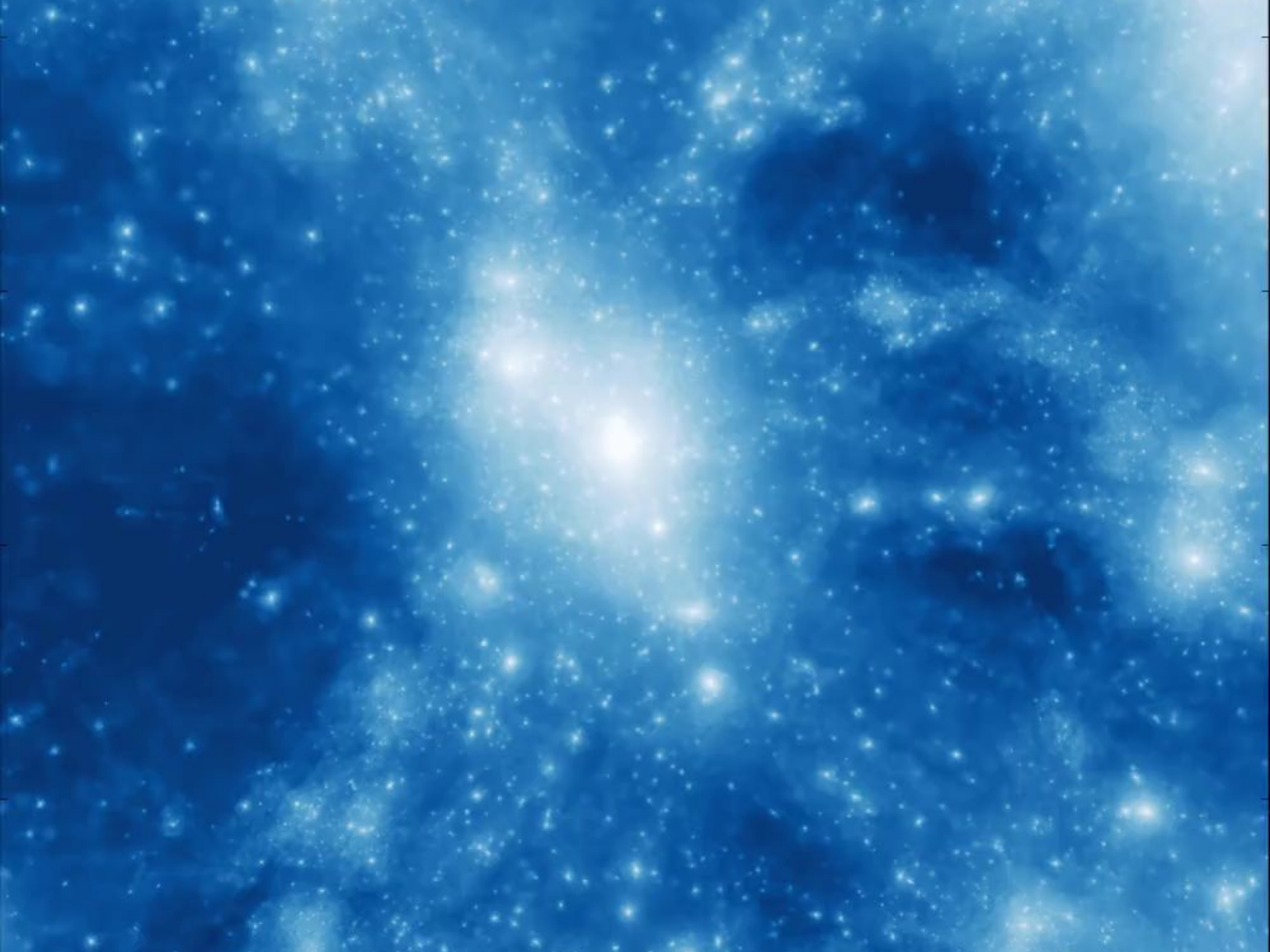


Oman+ 2015

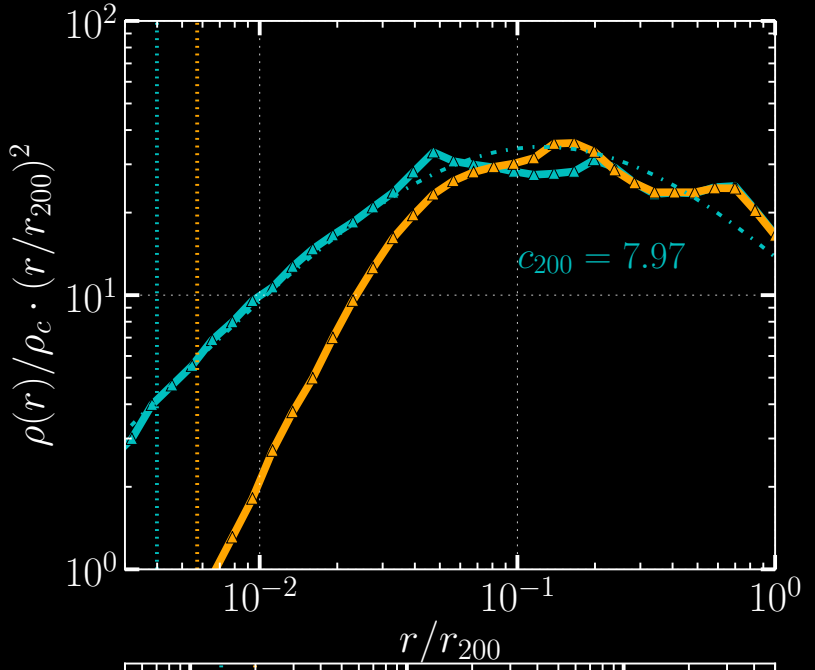
THE COCO SIMULATIONS

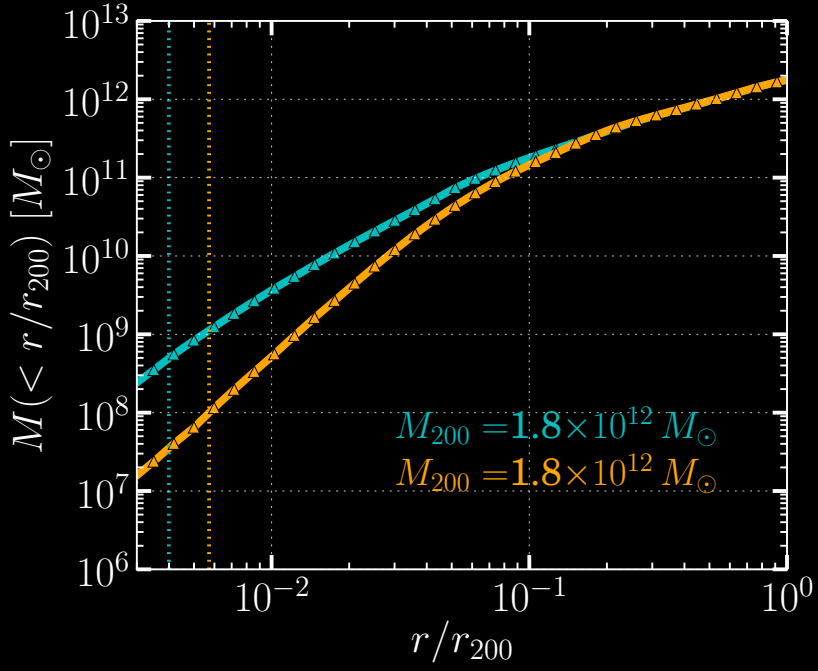


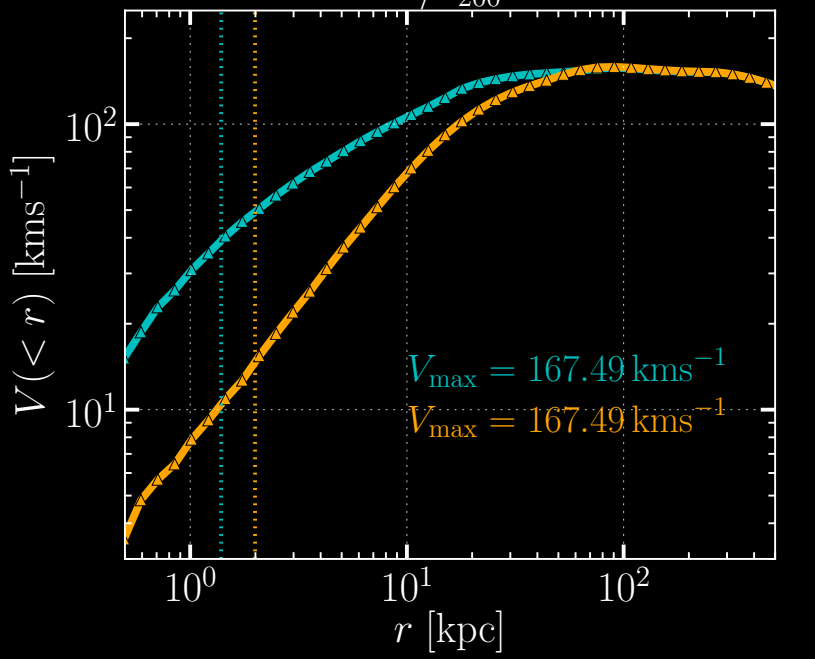
Hellwing+ 2015



A FIRST LOOK AT A COCO-SIDM MILKY WAY





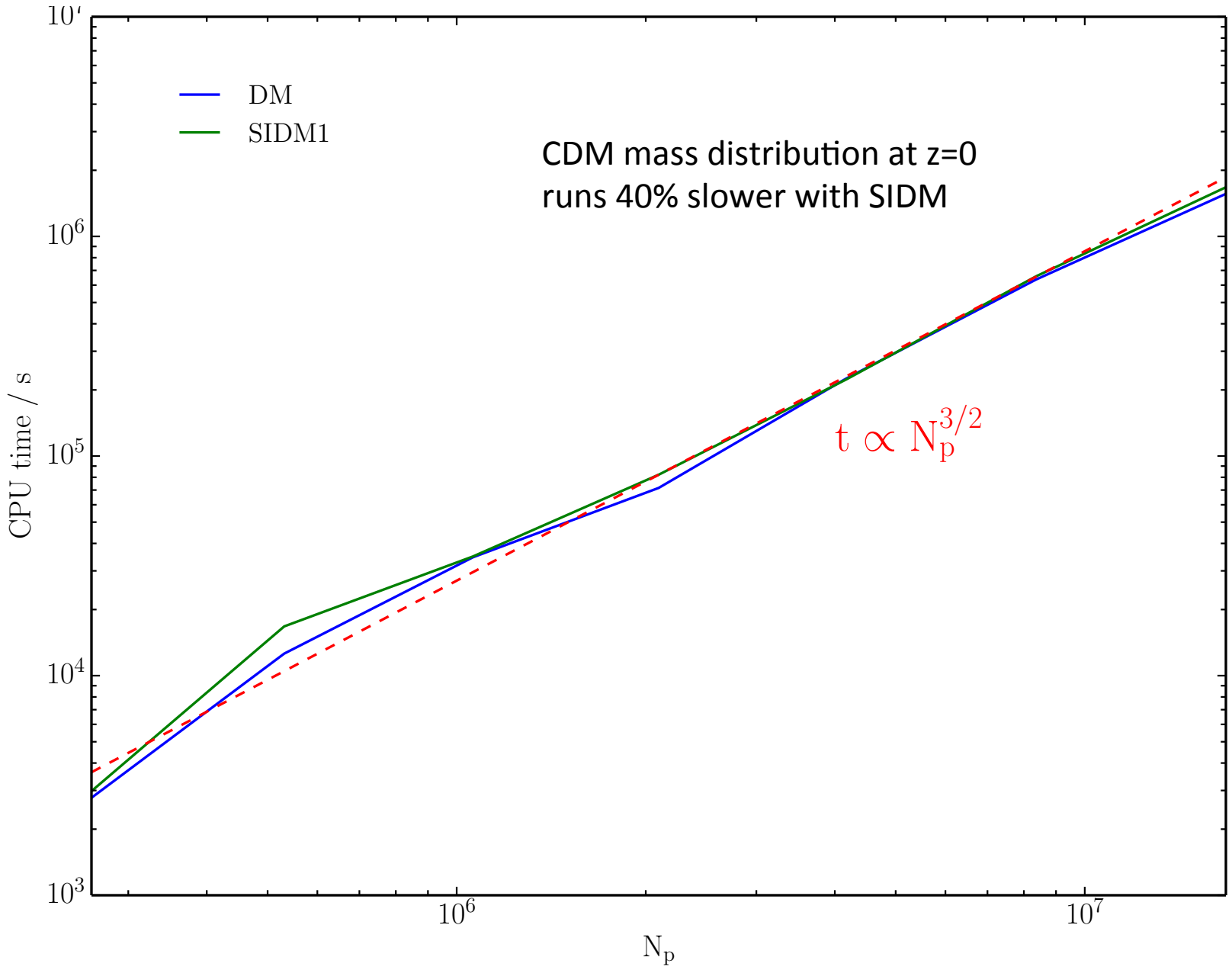


RUN TIMES

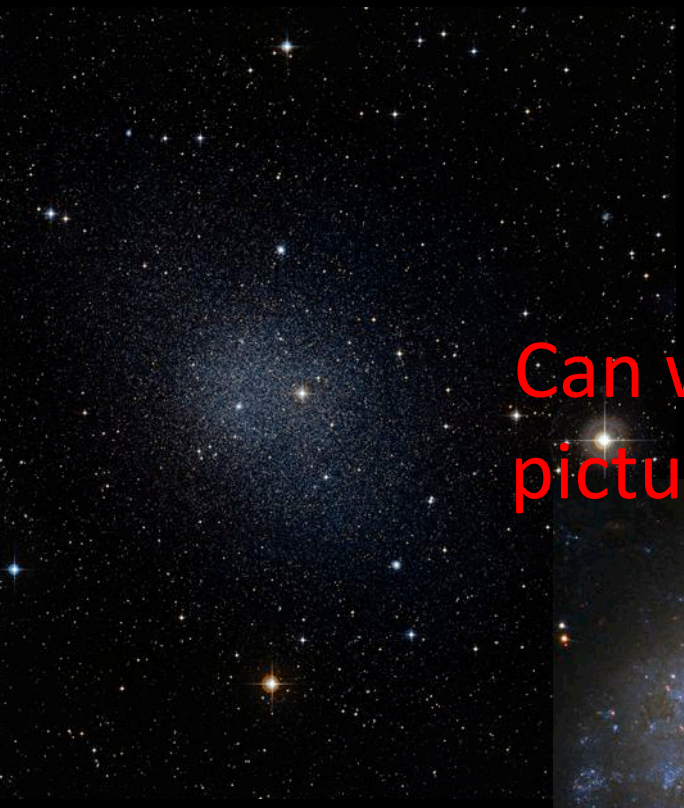
CDM – 171 hours

SIDM – 168 hours

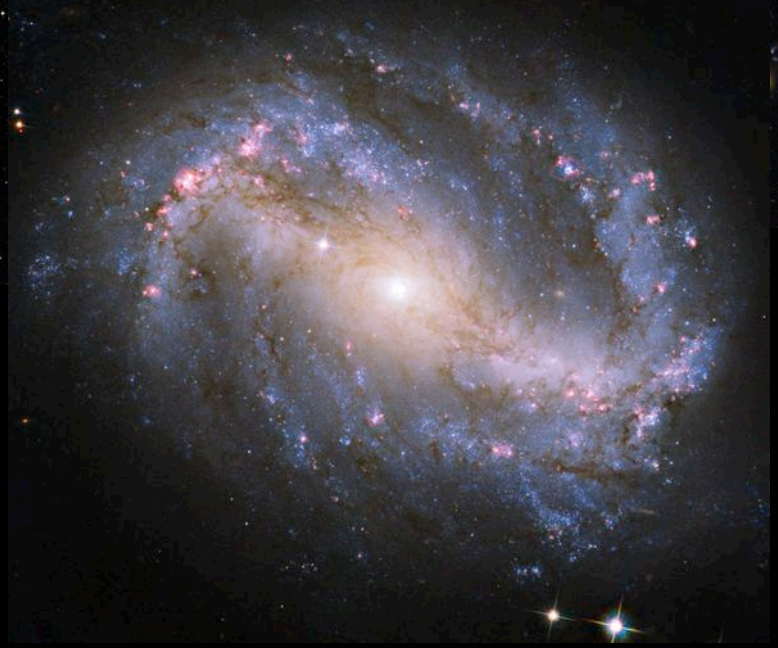
CODE RUN-TIMES



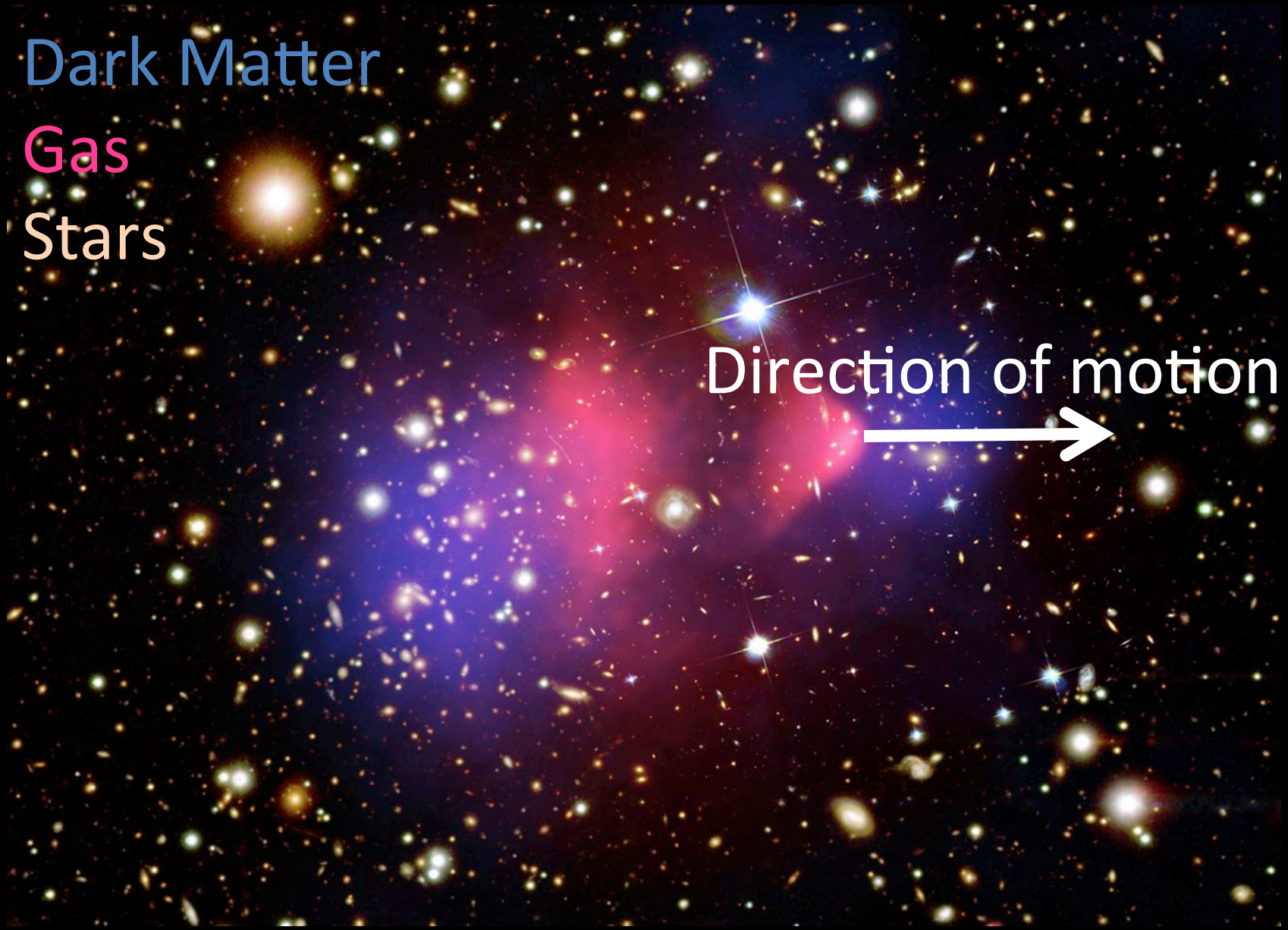
Testing for Self-Interactions on Different Scales



Can we build a coherent picture across all scales?



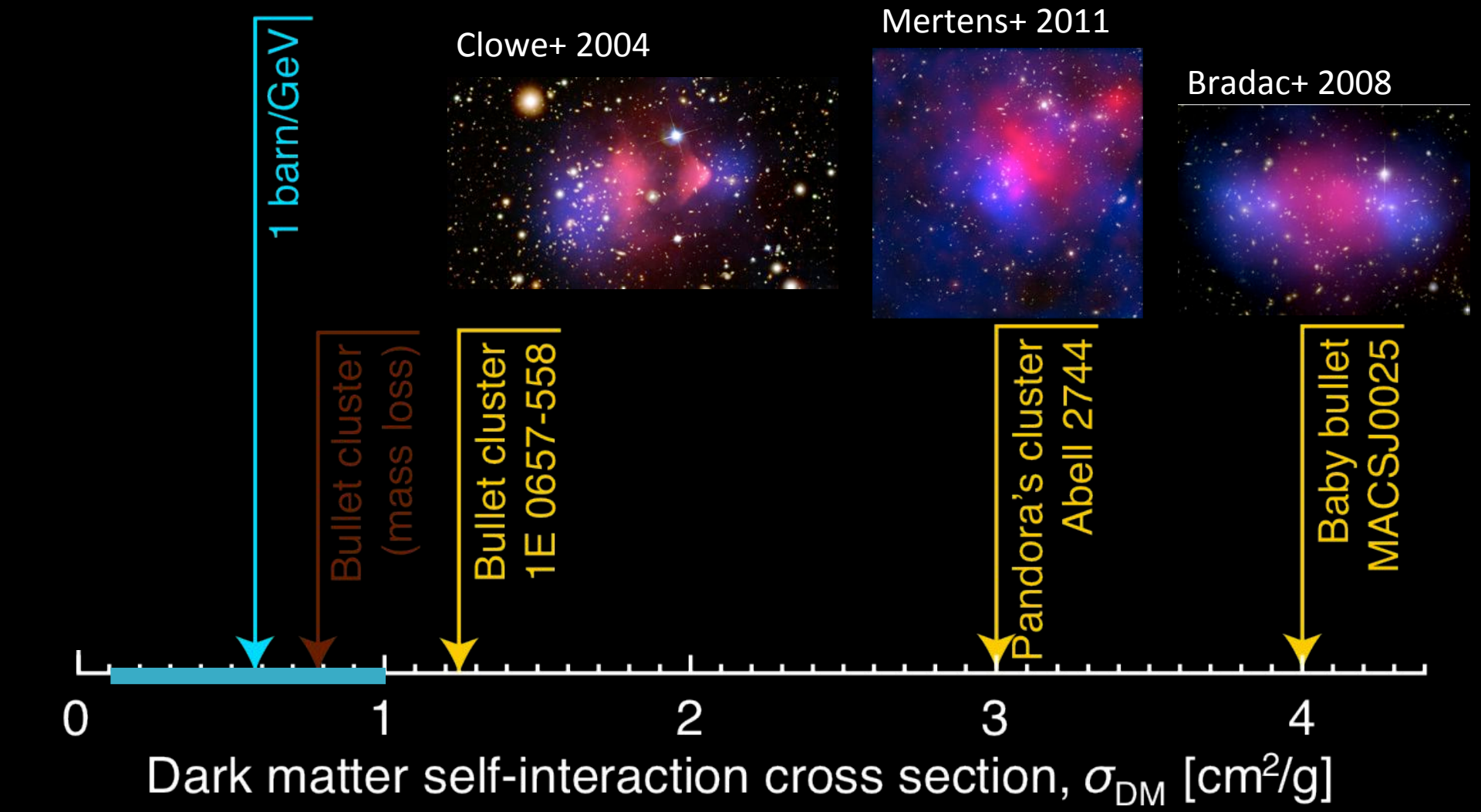
COSMIC PARTICLE COLLIDERS



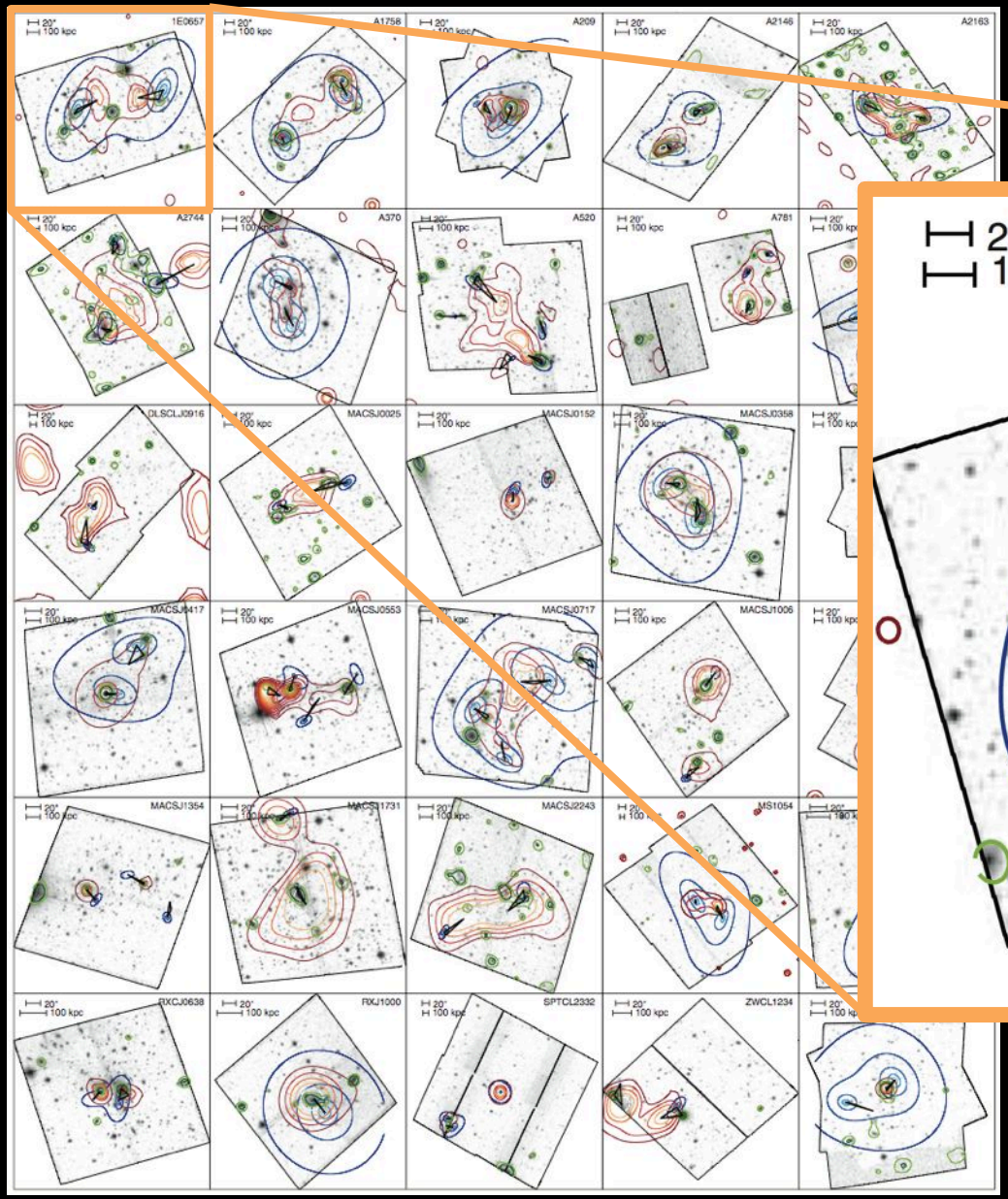
CURRENT MERGING-CLUSTER CONSTRAINTS

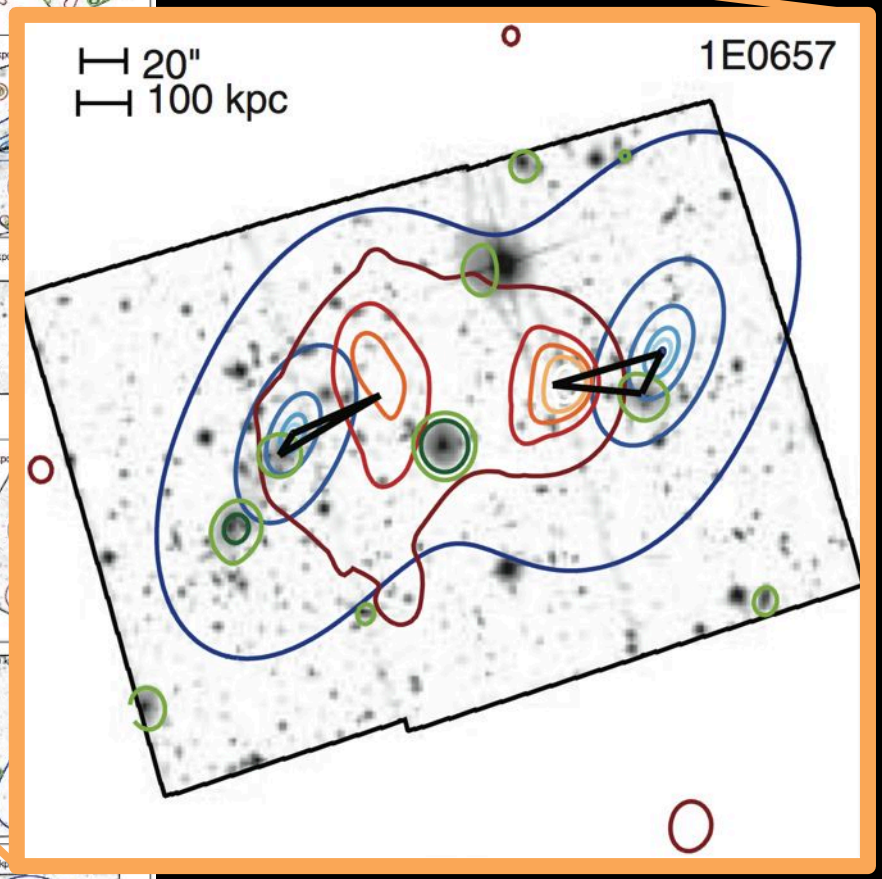
Potential to solve cosmology's "small scale problems"

Limited by the small number of systems



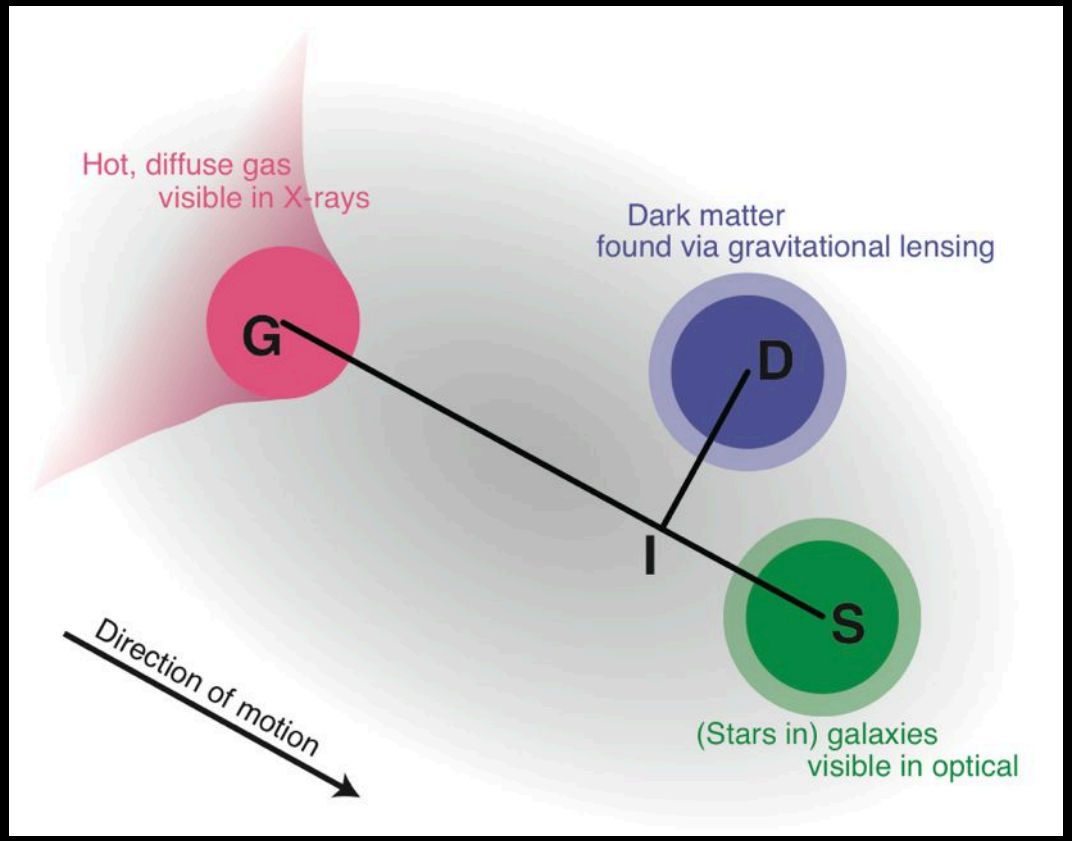
30 MERGING GALAXY CLUSTERS





Harvey+ 2015

BULLETICITY: THE OBSERVABLES



$\delta\mathrm{SG}$ Always positive

$\delta\mathrm{DI}$ The null test

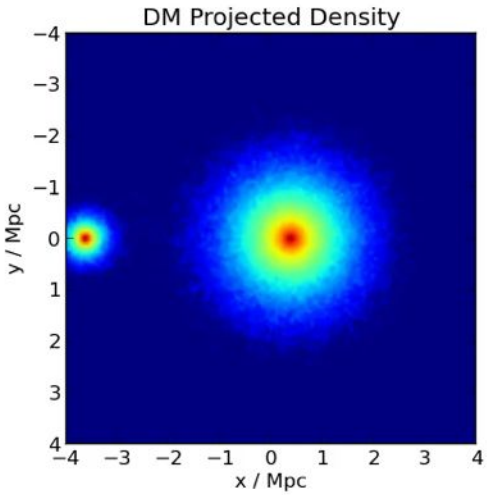
$\delta\mathrm{SI}$ Interacting DM?

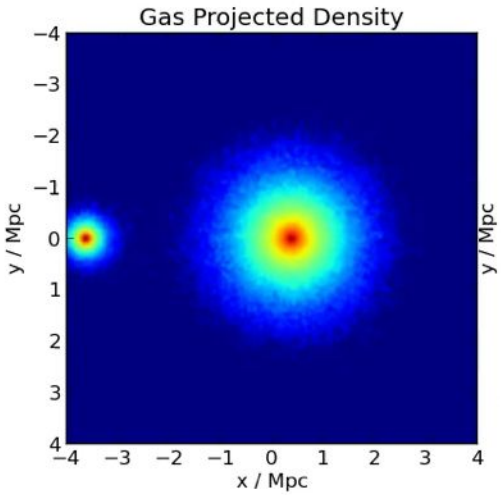
$$\beta = \frac{\delta\mathrm{SI}}{\delta\mathrm{SG}}$$

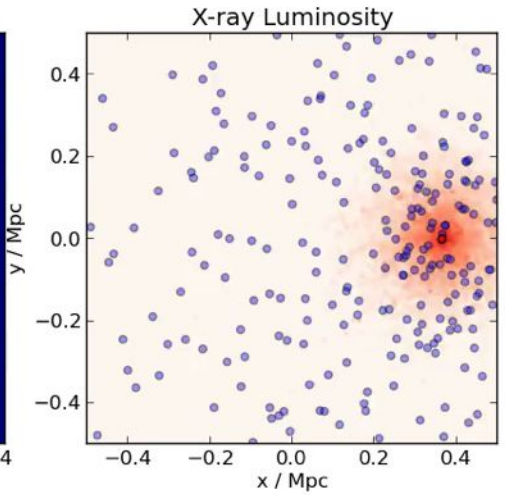
$$\langle\beta\rangle = -0.04 \pm 0.07$$
$$(68\%\mathrm{CL})$$

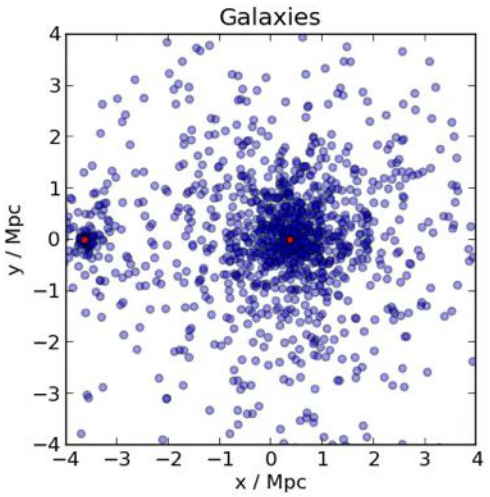
Harvey+ 2013

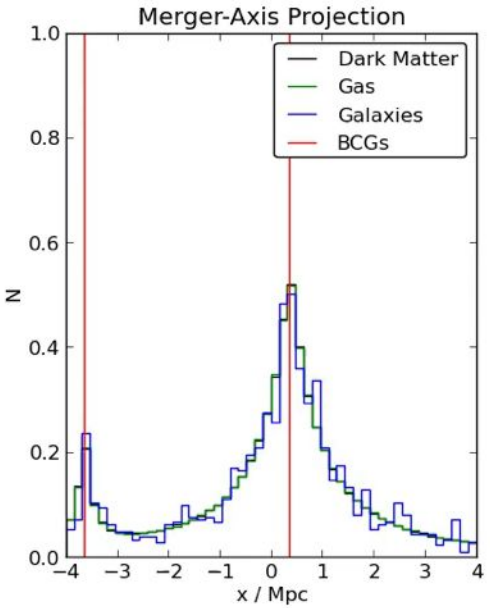
SIMULATING MERGERS

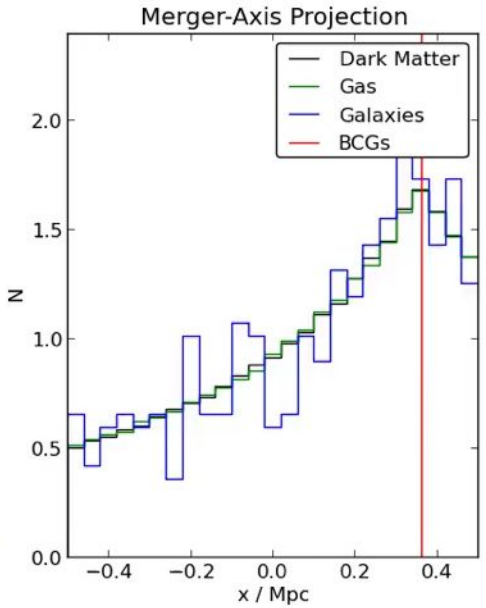




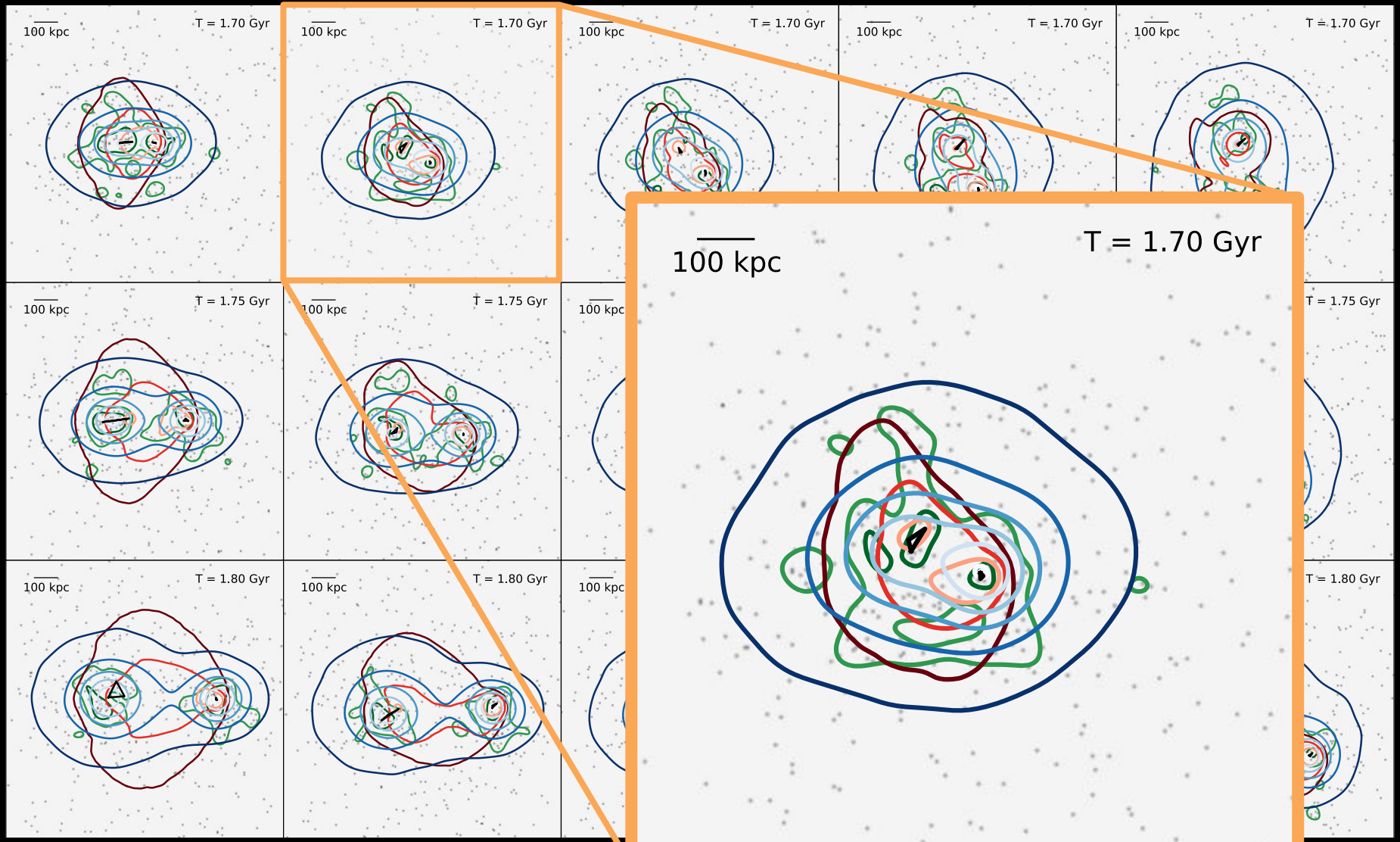




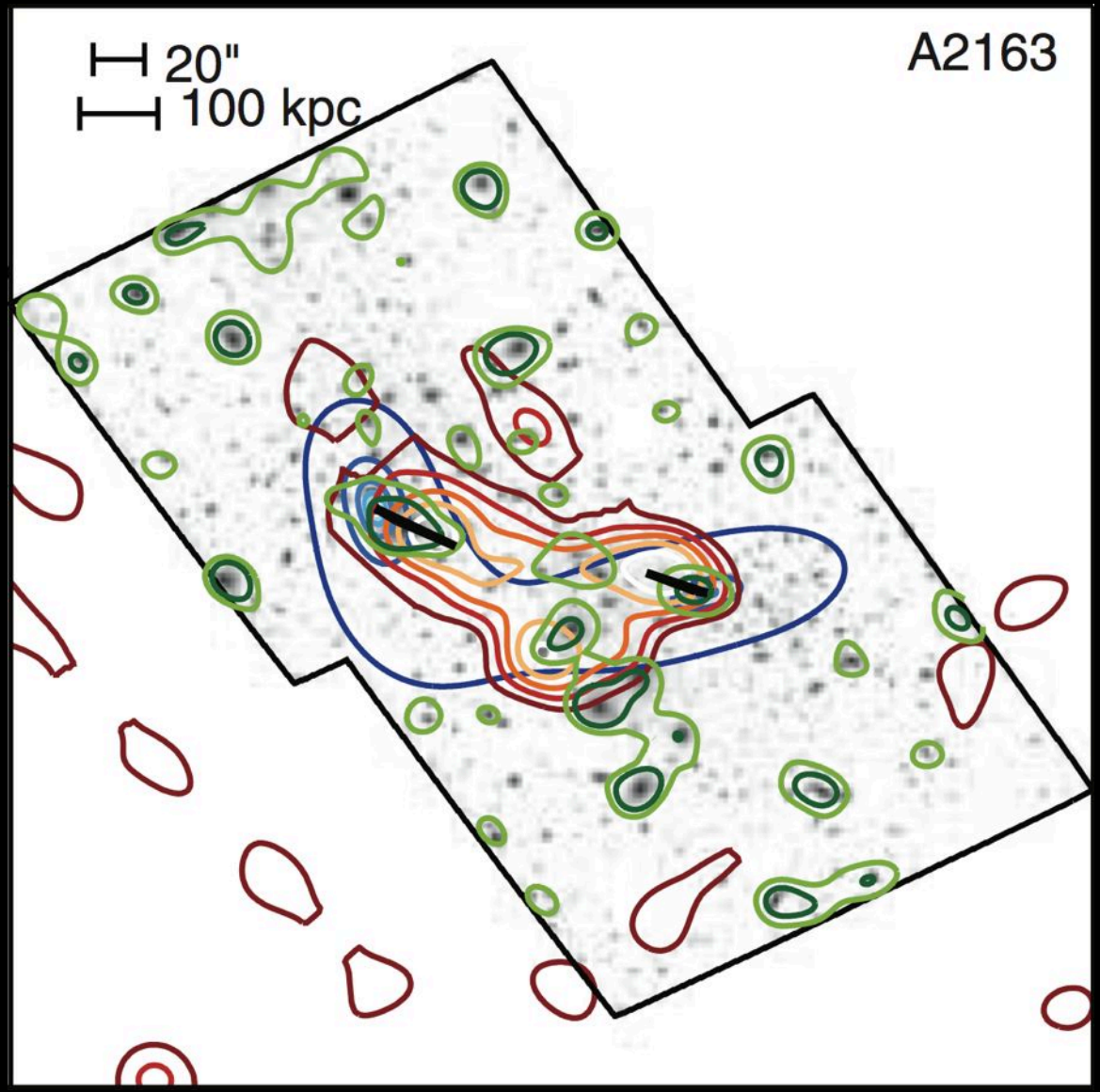




CALIBRATING BULLETICITY MEASUREMENTS



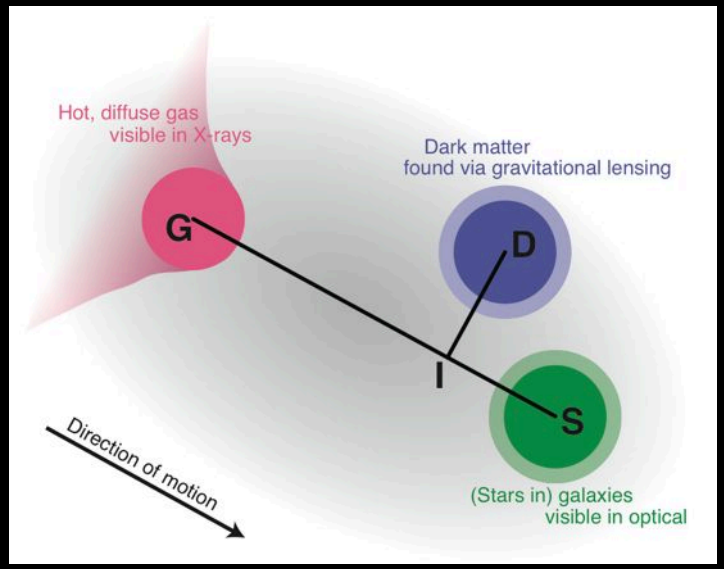
POTENTIAL BIAS (1)



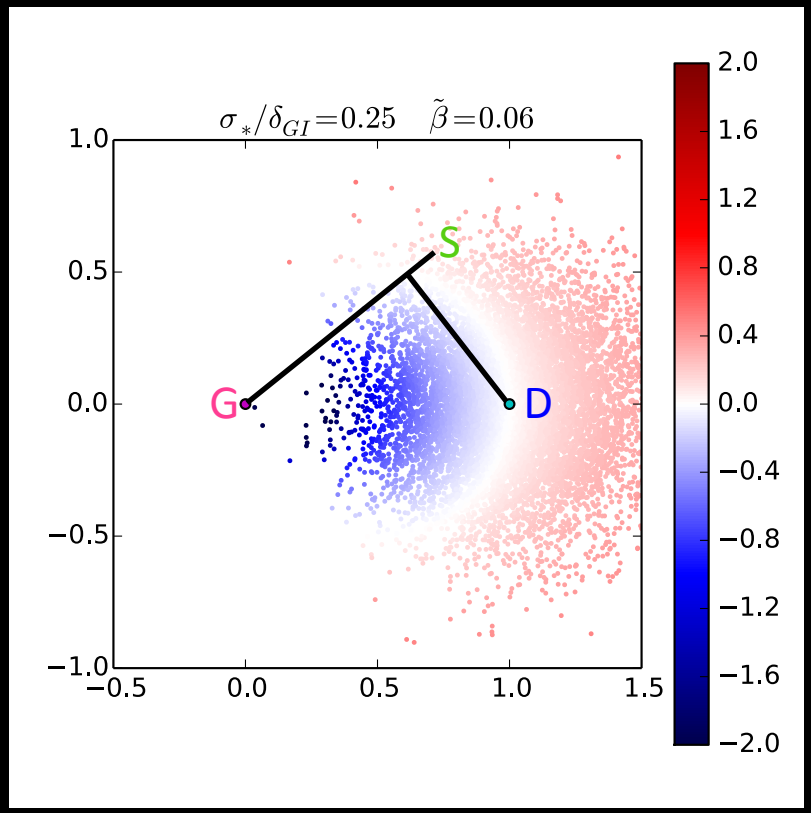
Matching stellar peaks to both dark matter and X-ray leads to preferentially finding the galaxies to lie between the gas and dark matter.

This leads to a bias towards negative β

POTENTIAL BIAS (2)



$$\beta = \frac{\delta \mathrm{SI}}{\delta \mathrm{SG}}$$



FUTURE WORK

EAGLE + SIDM = S-EAGLE

THANKS FOR LISTENING