



UNVEILING THE SELF-COUPLING OF DARK MATTER IN COLLIDING GALAXY CLUSTERS

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ANDREW ROBERTSON (DURHAM), JEAN-PAUL KNEIB (EPFL)
ANDY TAYLOR (EDINBURGH), ERIC TITTELY (EDINBURGH)
TOM KITCHING (MSSL)

WHAT IS THE MOTIVATION FOR
SELF-INTERACTING DARK MATTER?

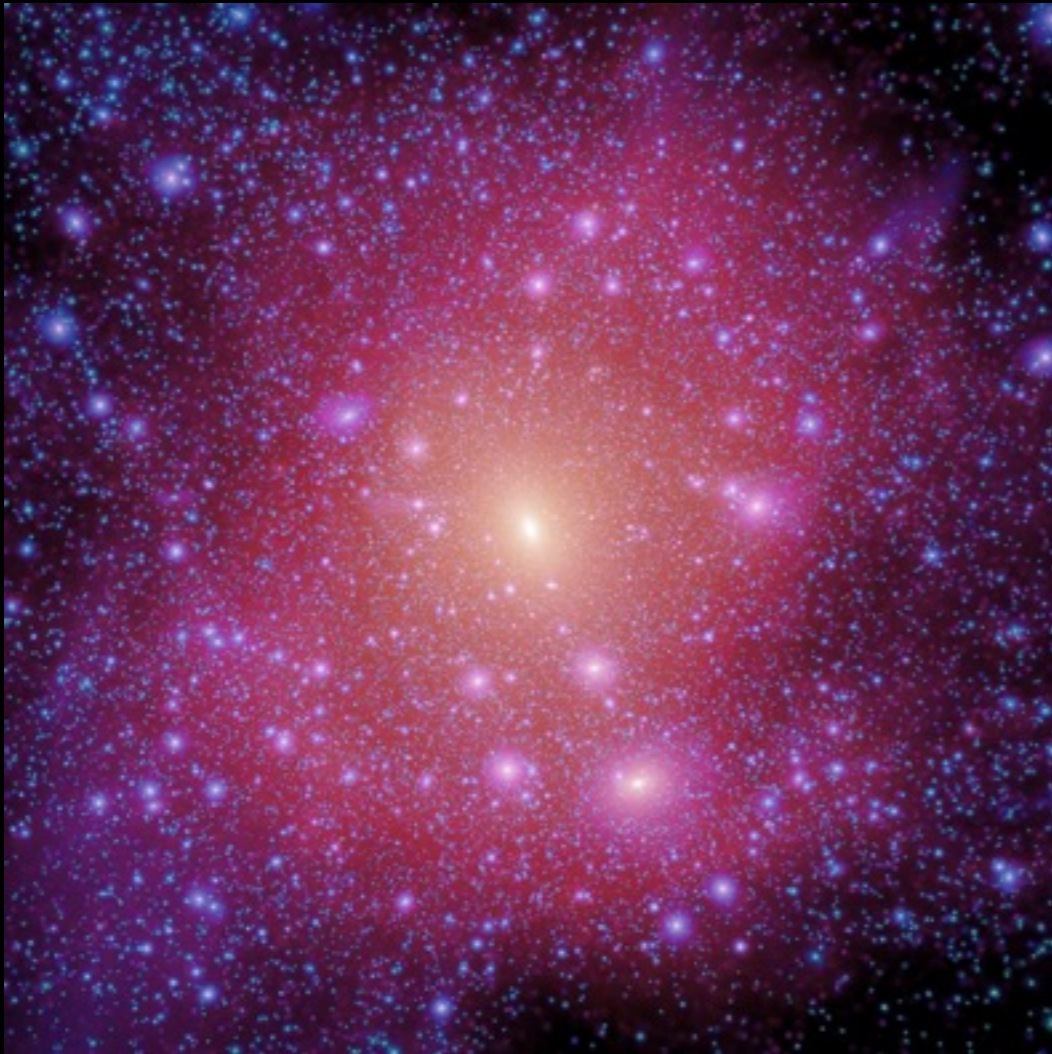
WHAT IS THE MOTIVATION FOR SELF-INTERACTING DARK MATTER?

OBSERVATIONAL MOTIVATION

THEORETICAL MOTIVATION

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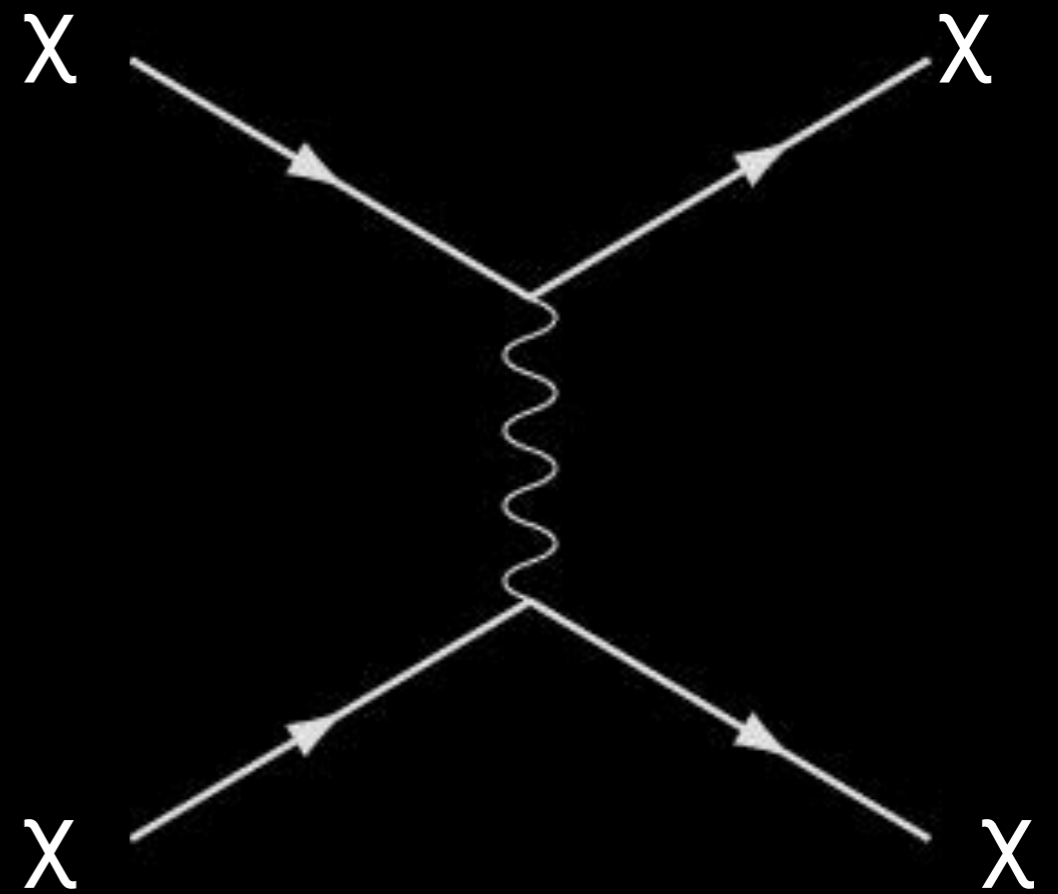
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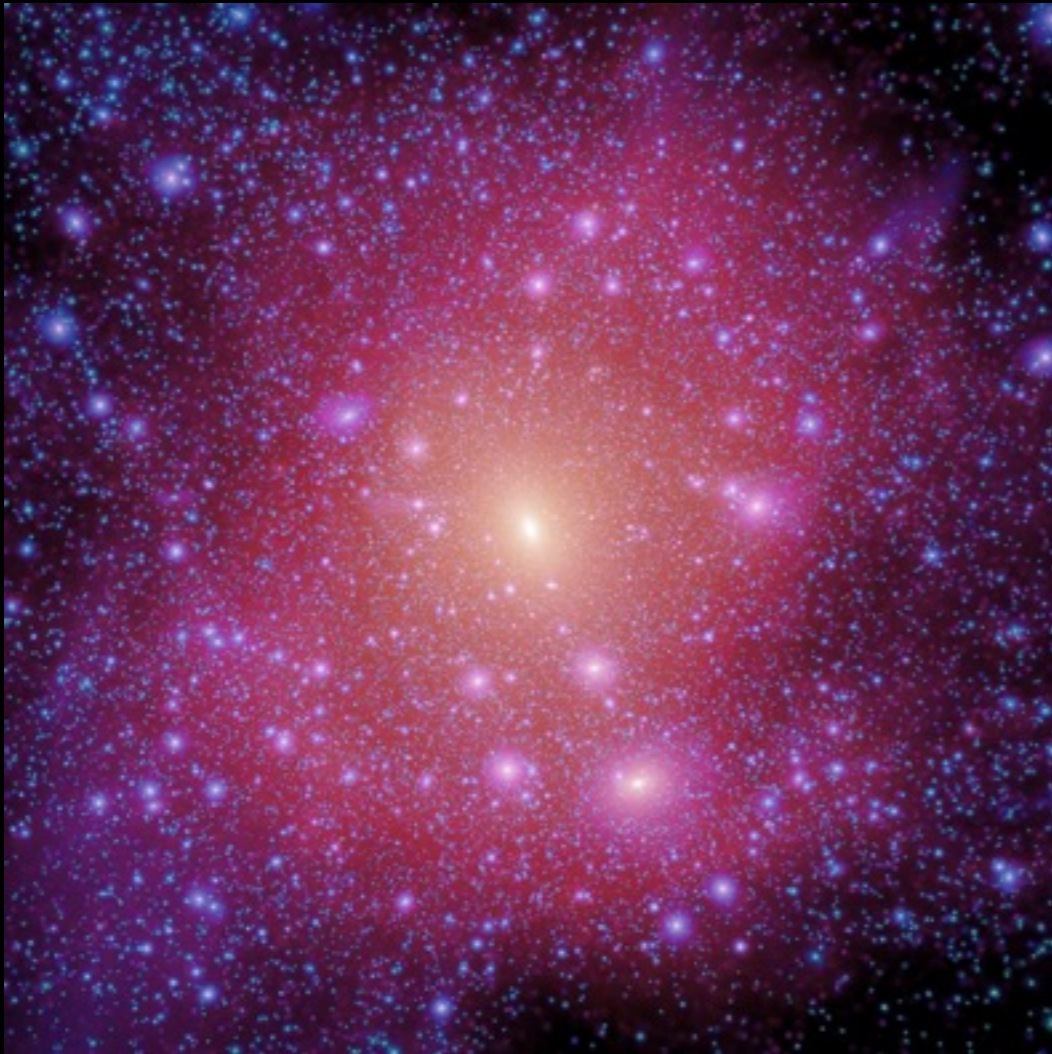


THEORETICAL MOTIVATION

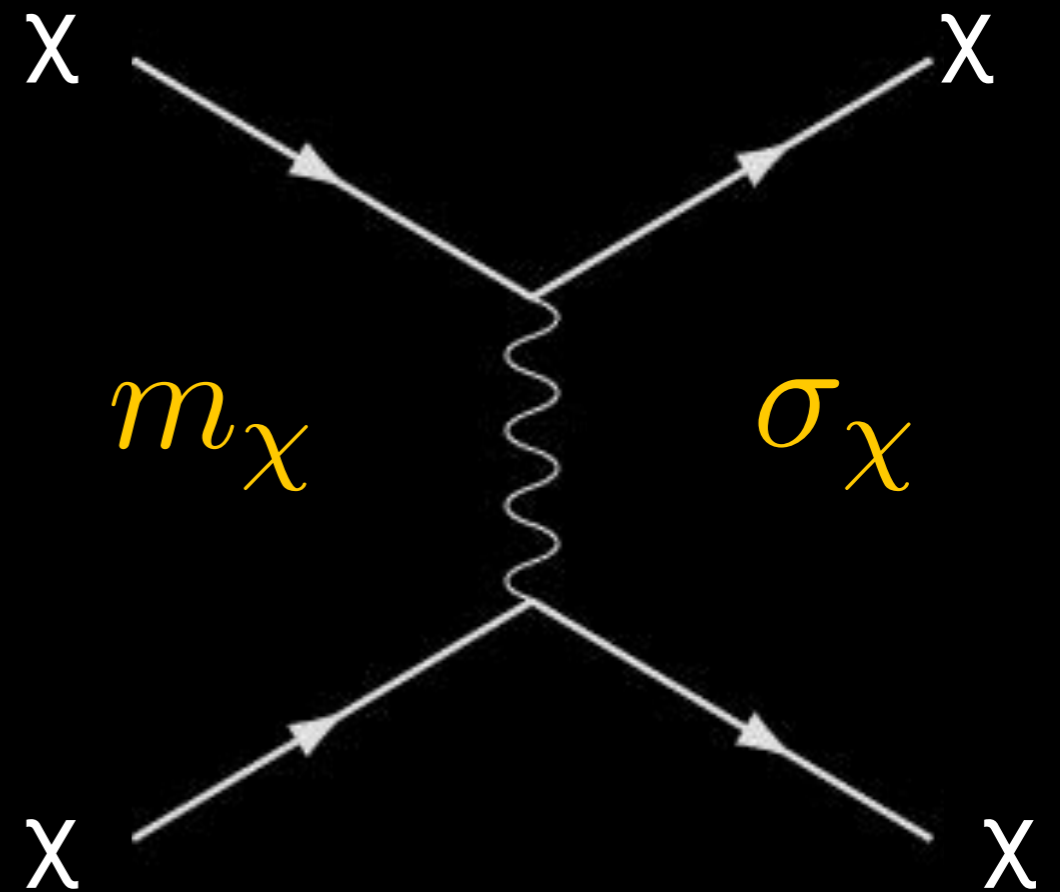


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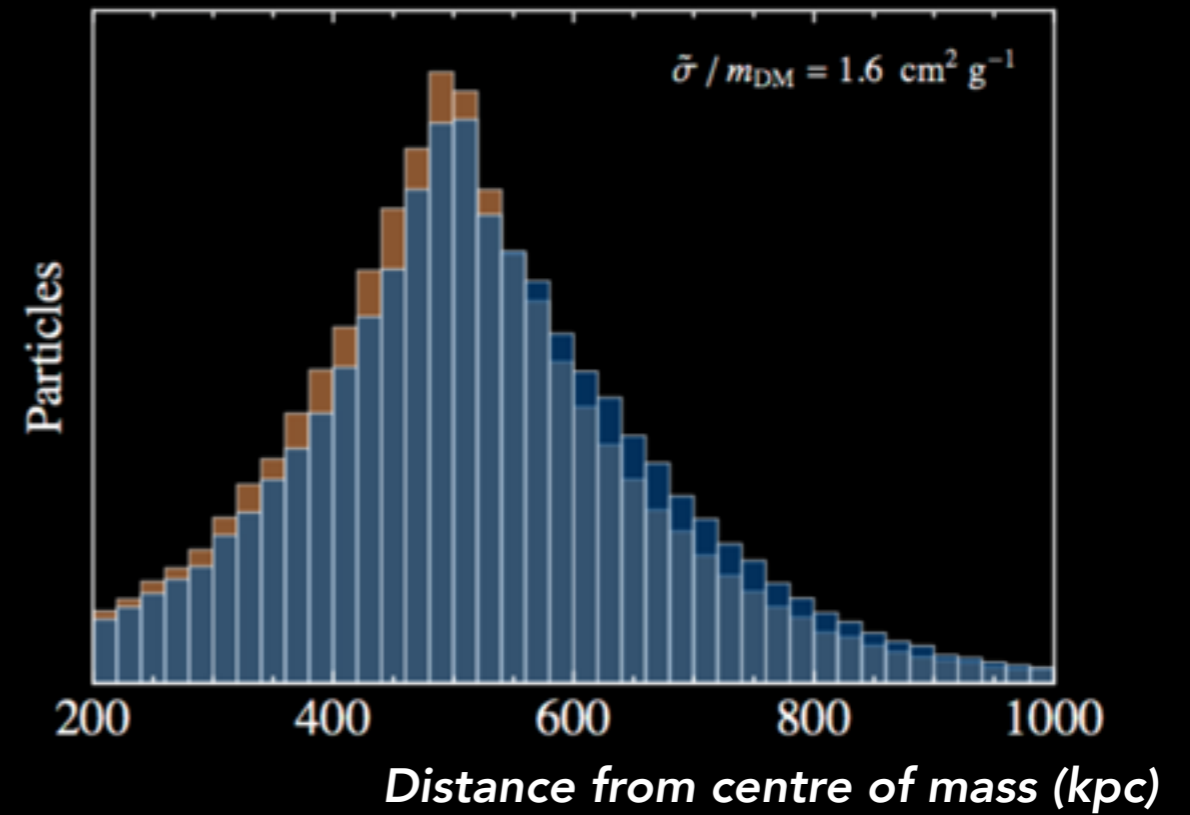
WHAT ARE THE OBSERVATIONAL MANIFESTATIONS OF
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IN COLLIDING CLUSTERS?



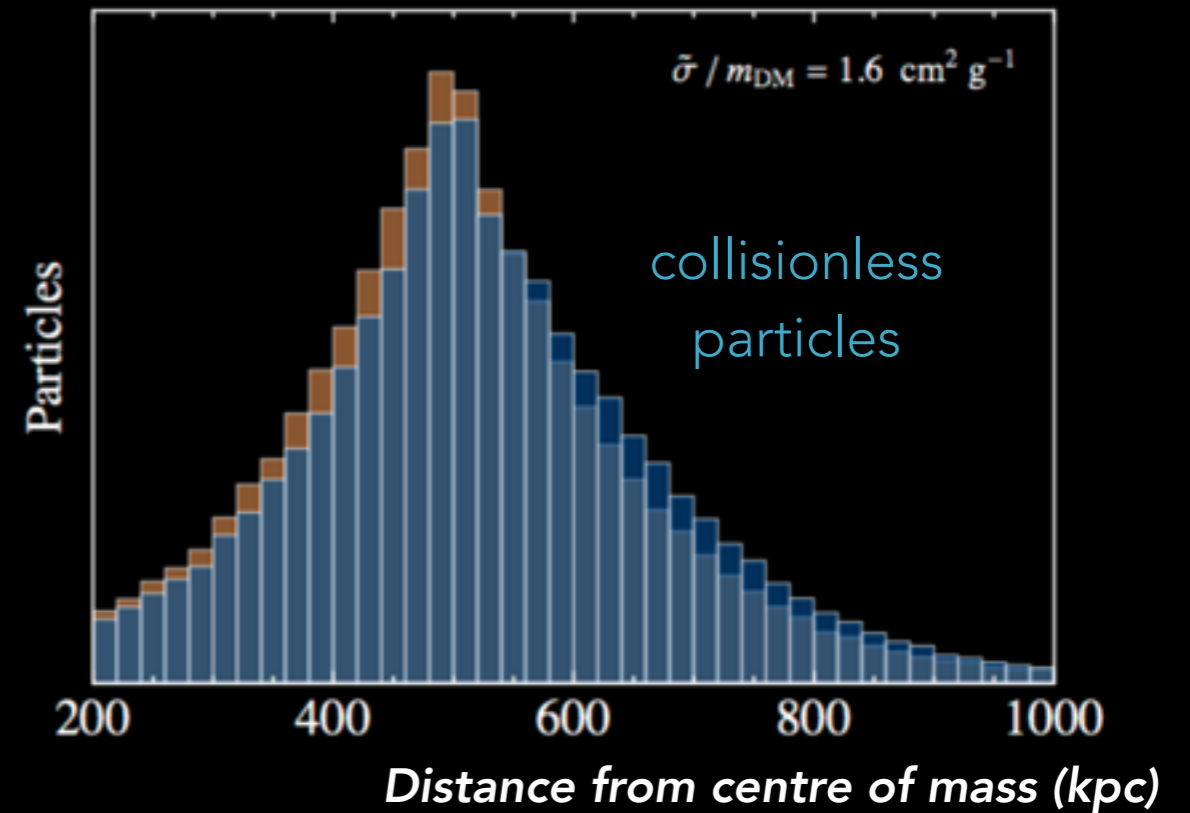
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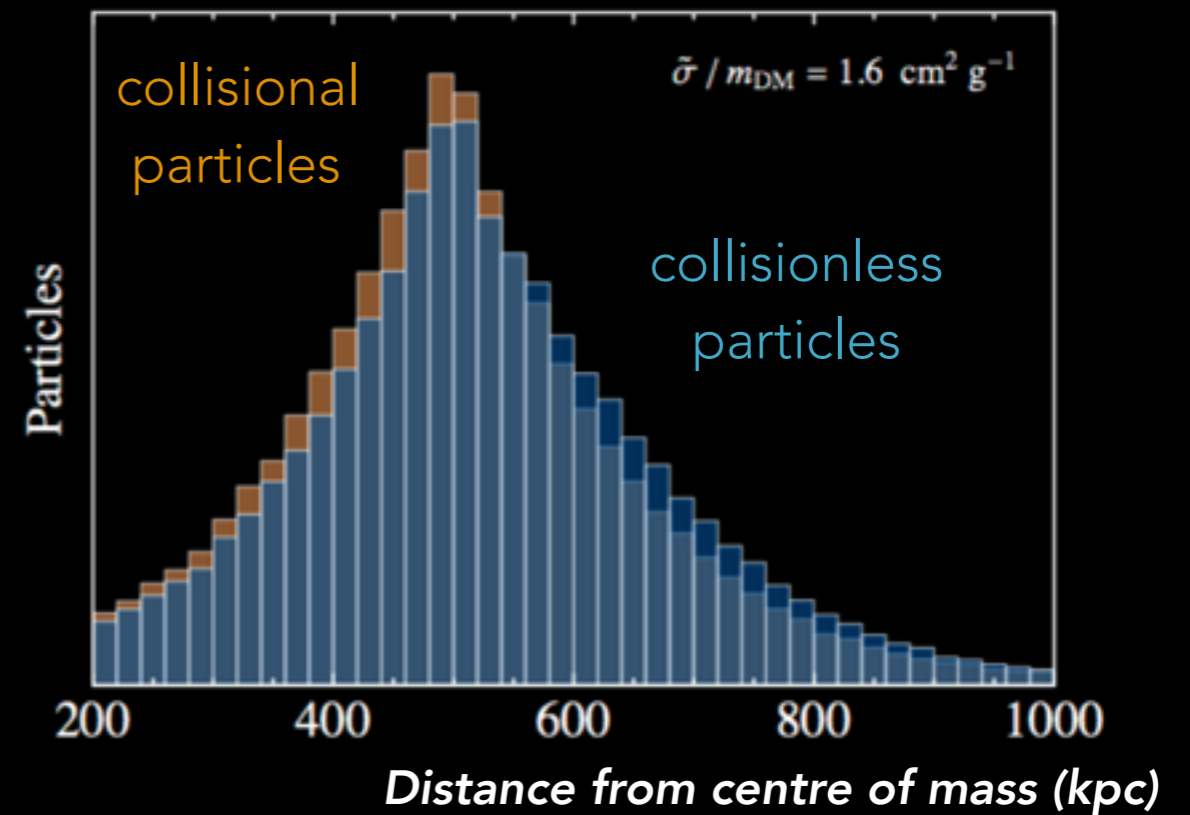
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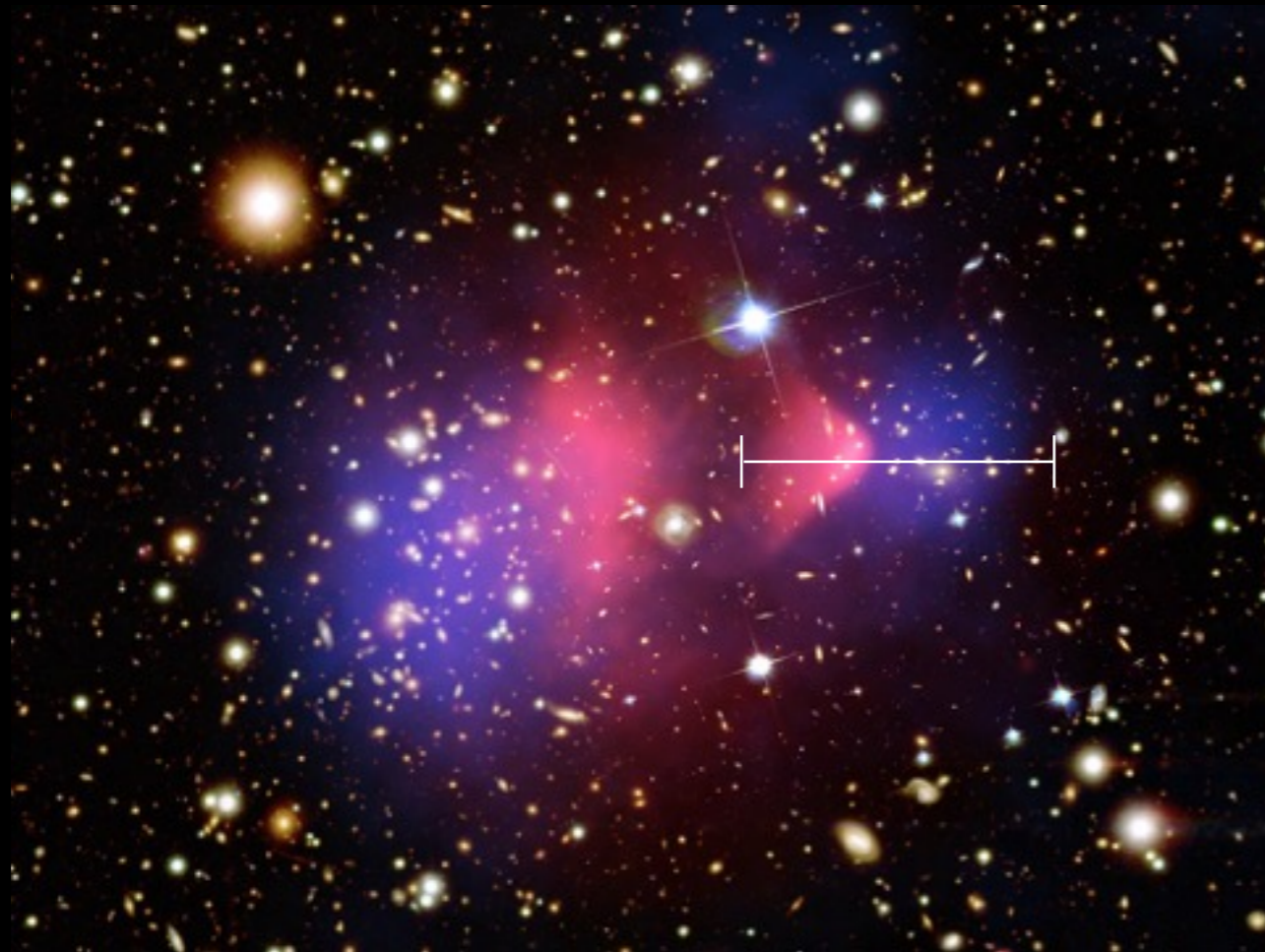
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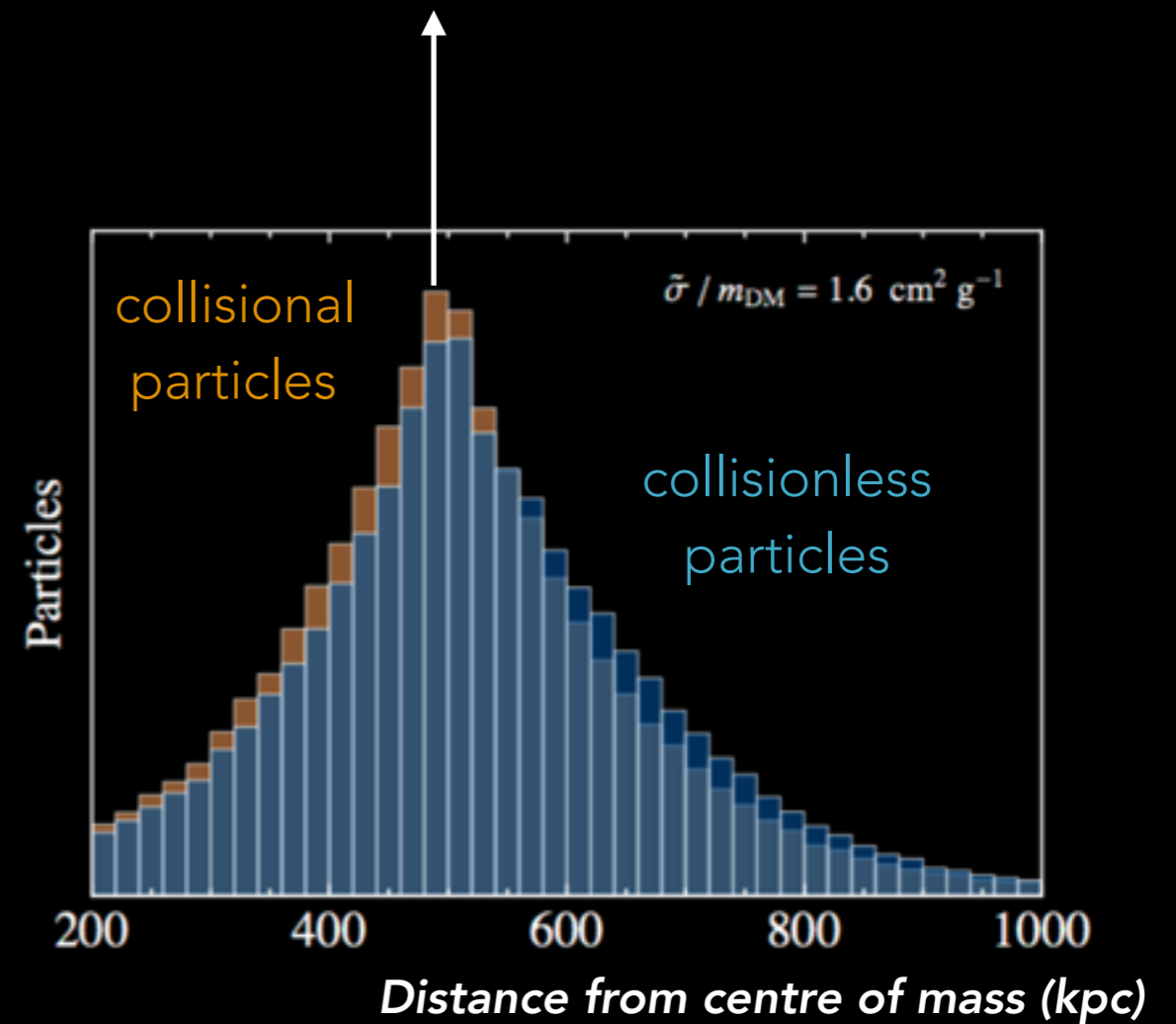
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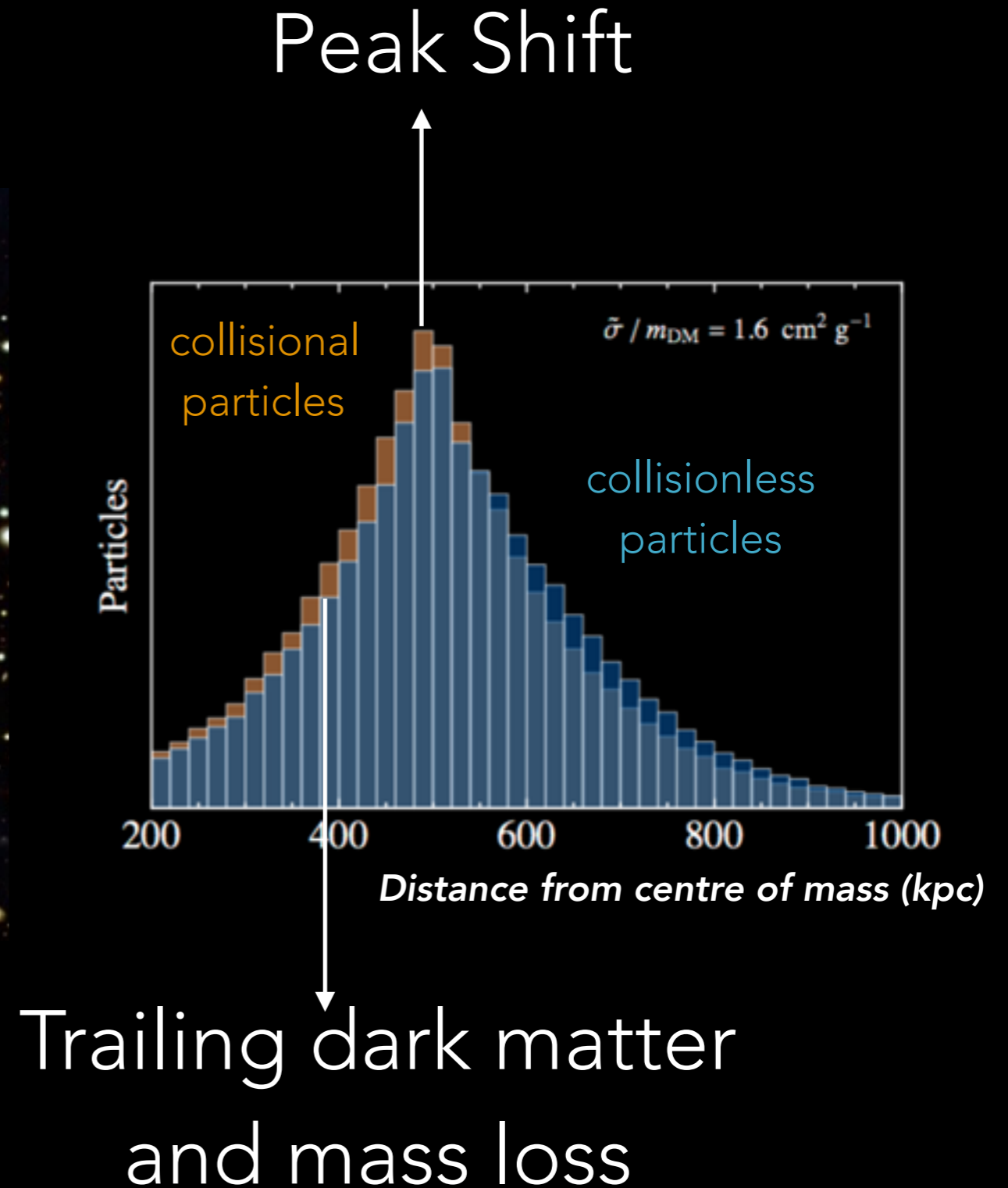
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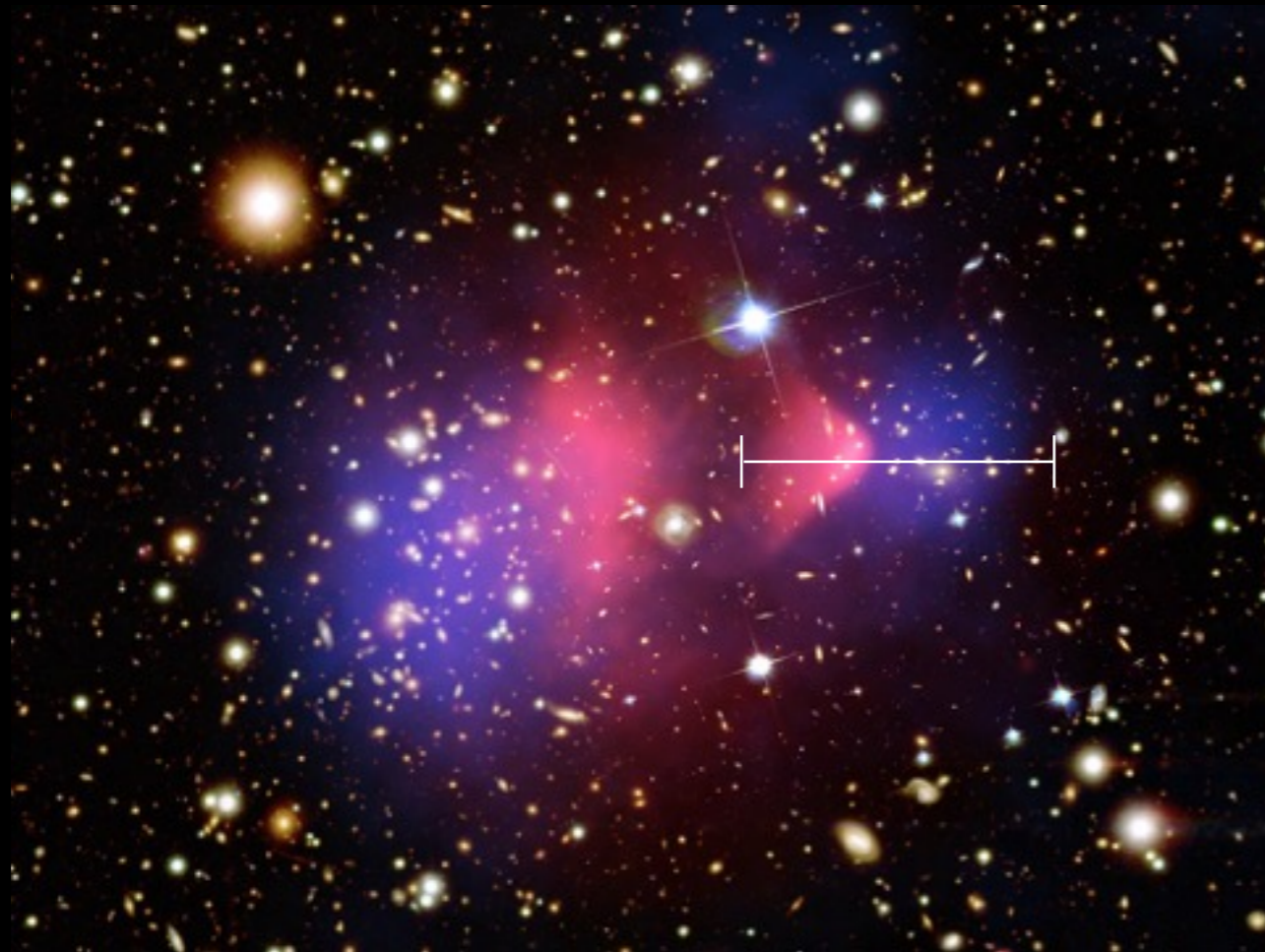
Peak Shift



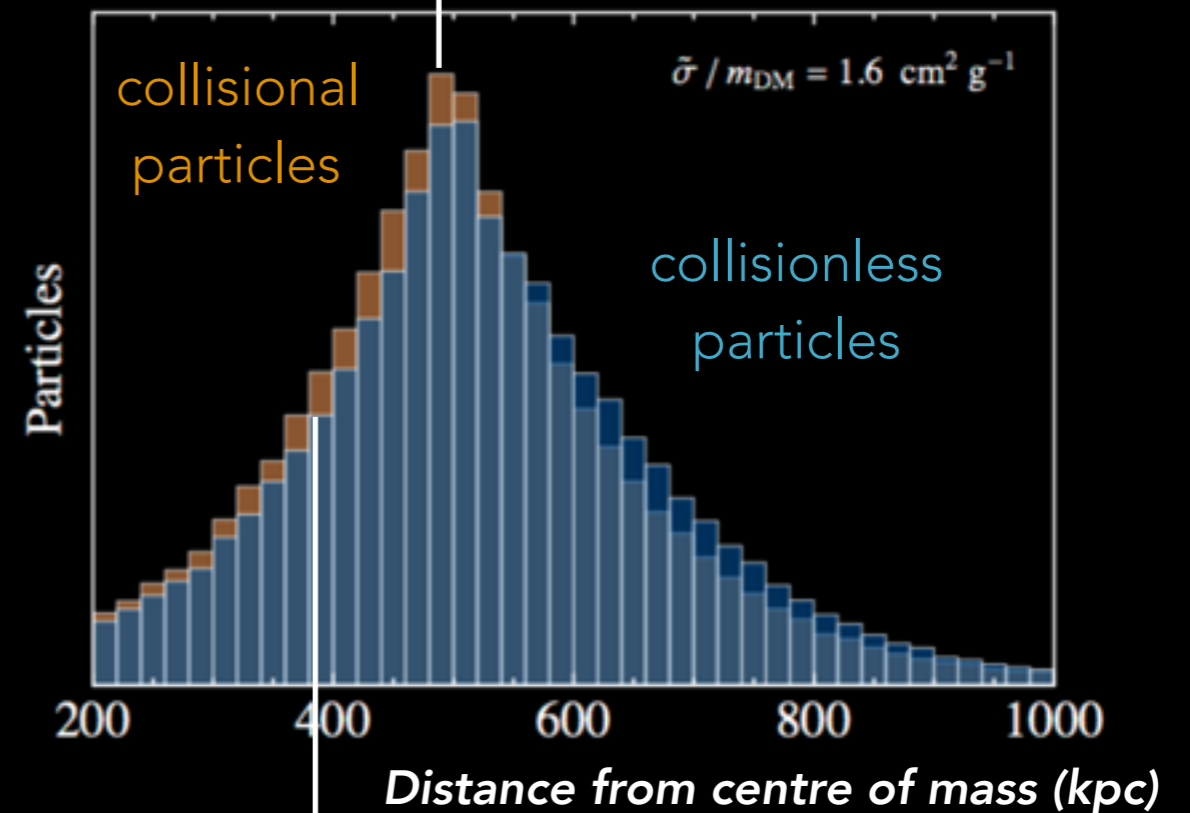
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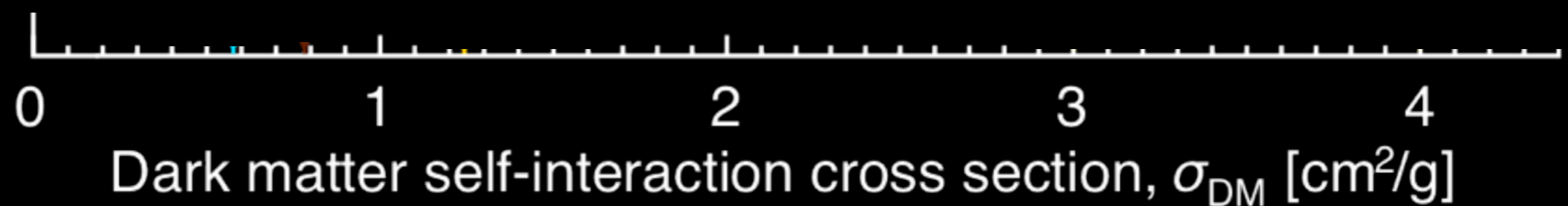


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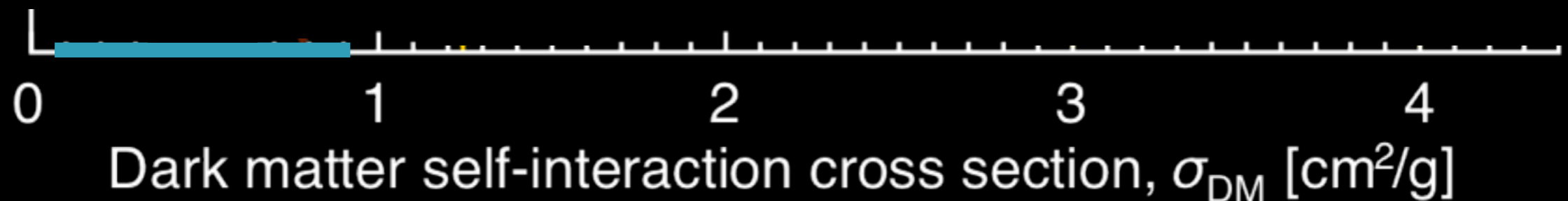
Trailing dark matter
and mass loss

CONSTRAINTS ARE LIMITED WITH SINGLE CLUSTER MERGERS

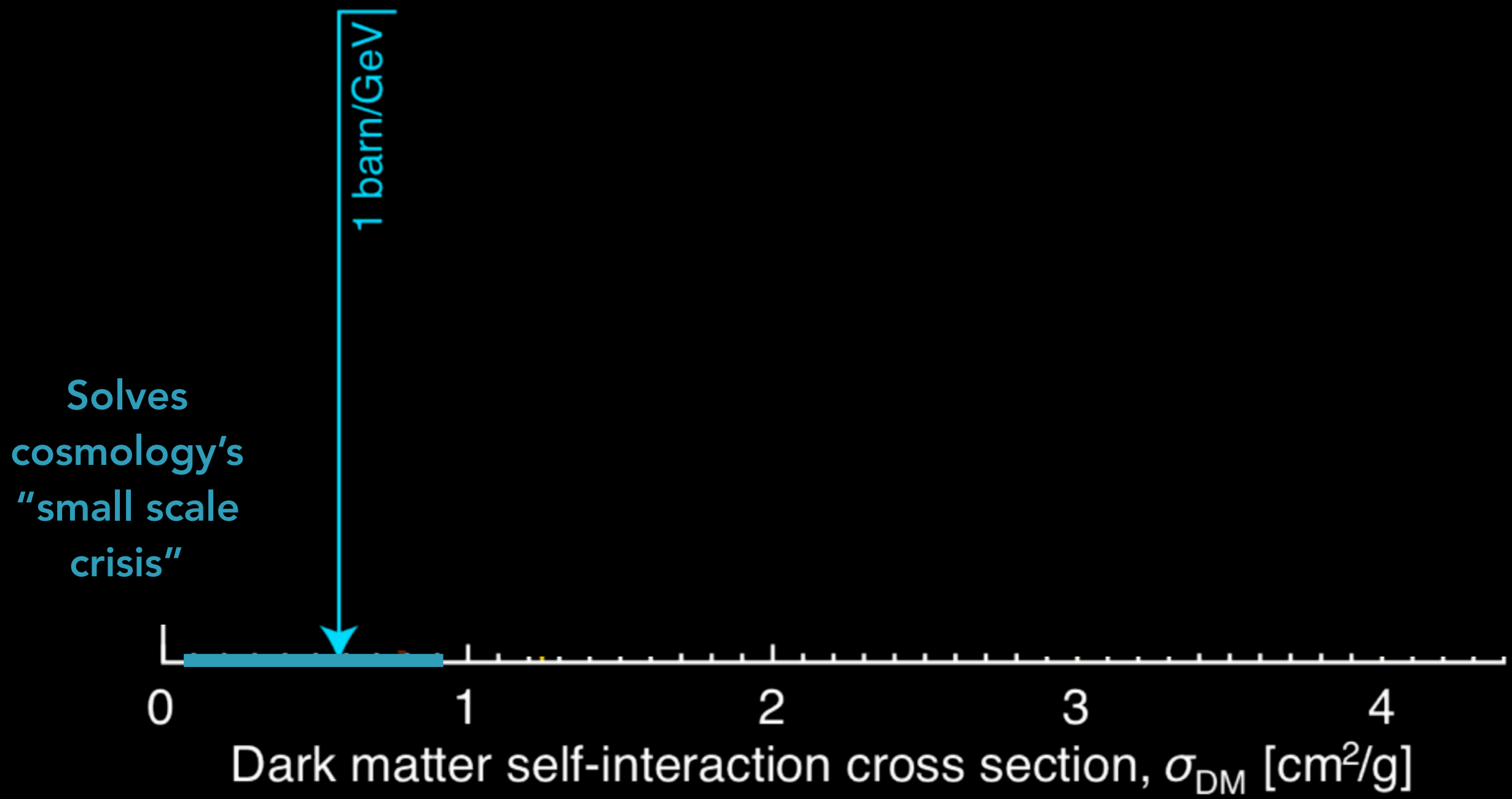


CONSTRAINTS ARE LIMITED WITH SINGLE CLUSTER MERGERS

Solves
cosmology's
"small scale
crisis"



CONSTRAINTS ARE LIMITED WITH SINGLE CLUSTER MERGERS



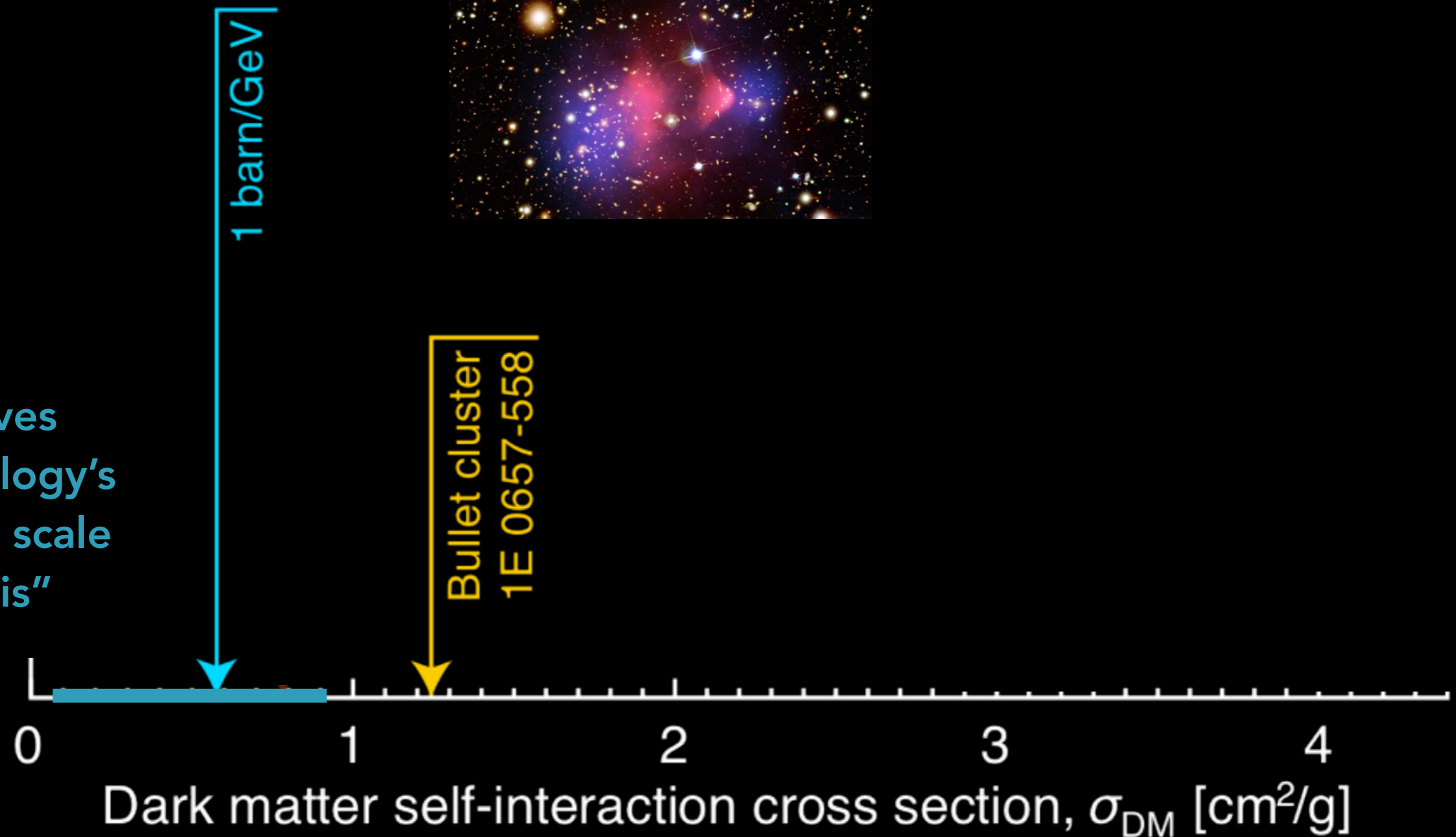
CONSTRAINTS ARE LIMITED WITH SINGLE CLUSTER MERGERS

Markevitch+ 2004

Randall+ 2008



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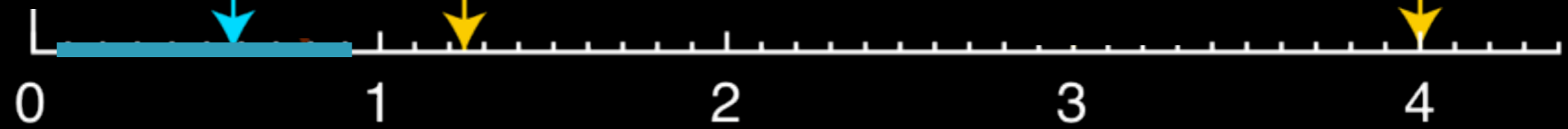


Solves
cosmology's
"small scale
crisis"

1 barn/GeV

Bullet cluster
1E 0657-558

Baby bullet
MACSJ0025



Dark matter self-interaction cross section, σ_{DM} [cm^2/g]

CONSTRAINTS ARE LIMITED WITH SINGLE CLUSTER MERGERS

Markevitch+ 2004
Randall+ 2008



Mertens+ 2011



Bradac+ 2008



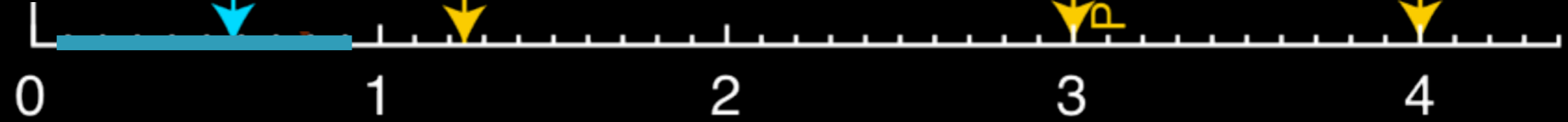
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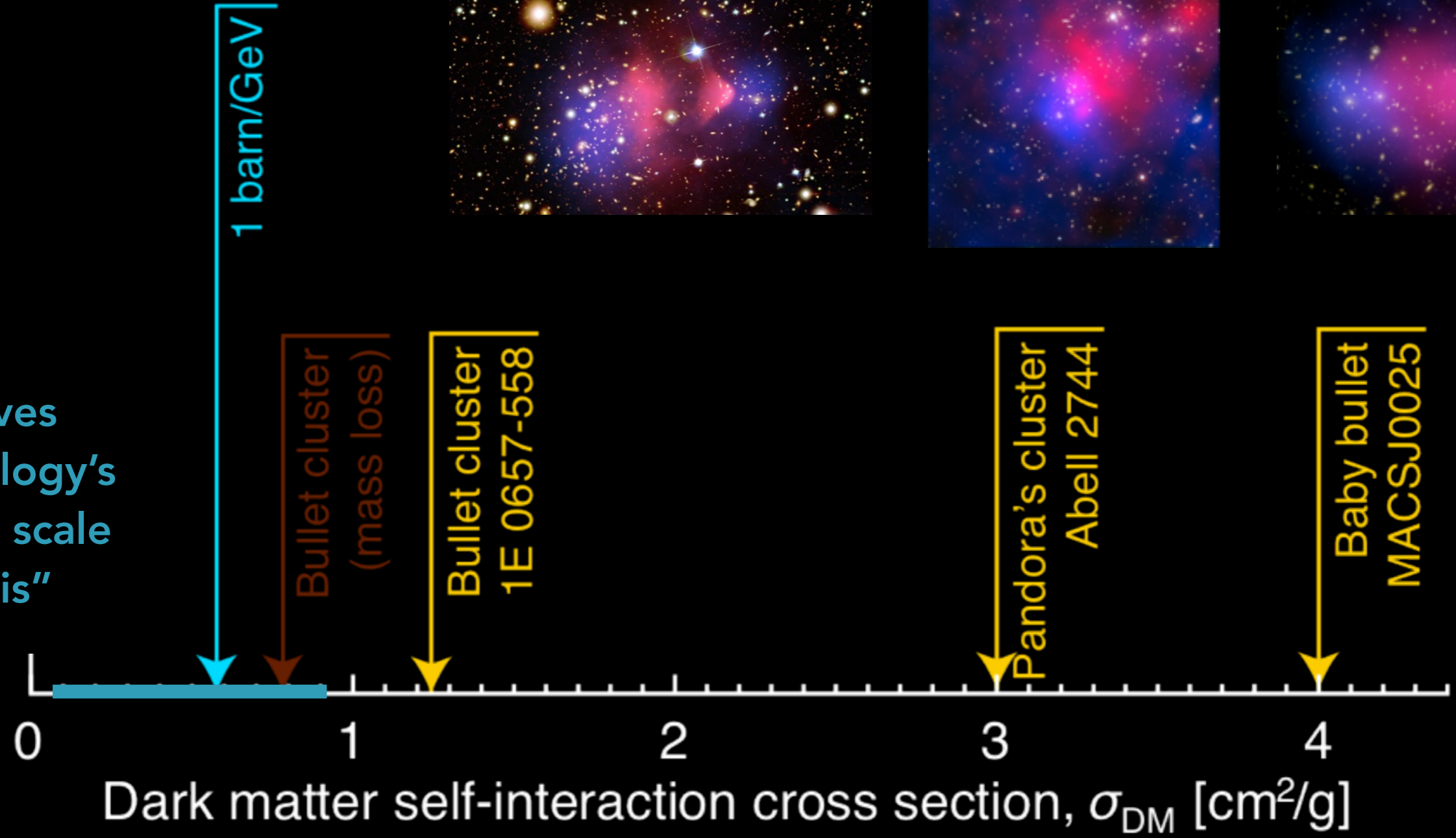
Mertens+ 2011



Bradac+ 2008

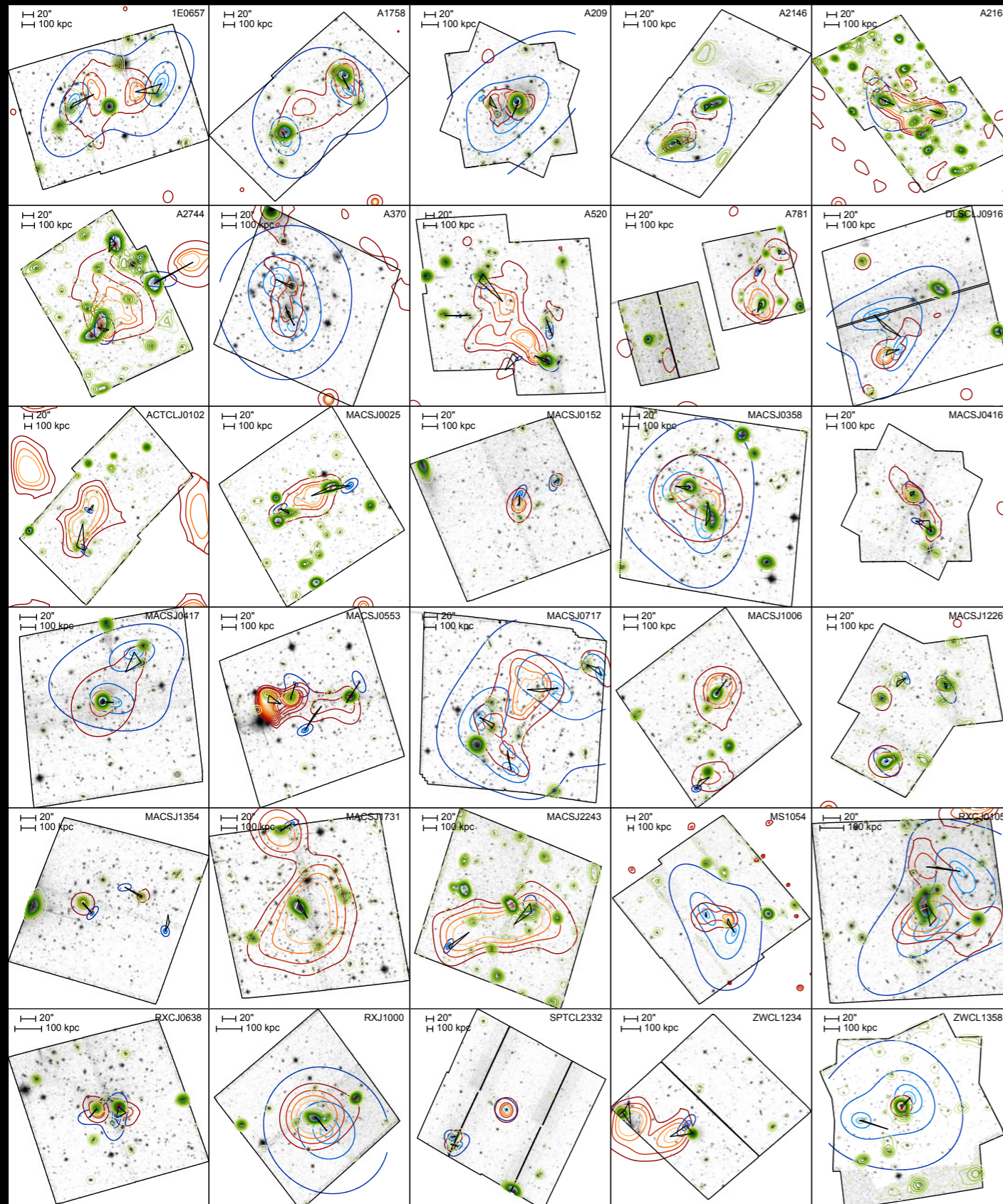


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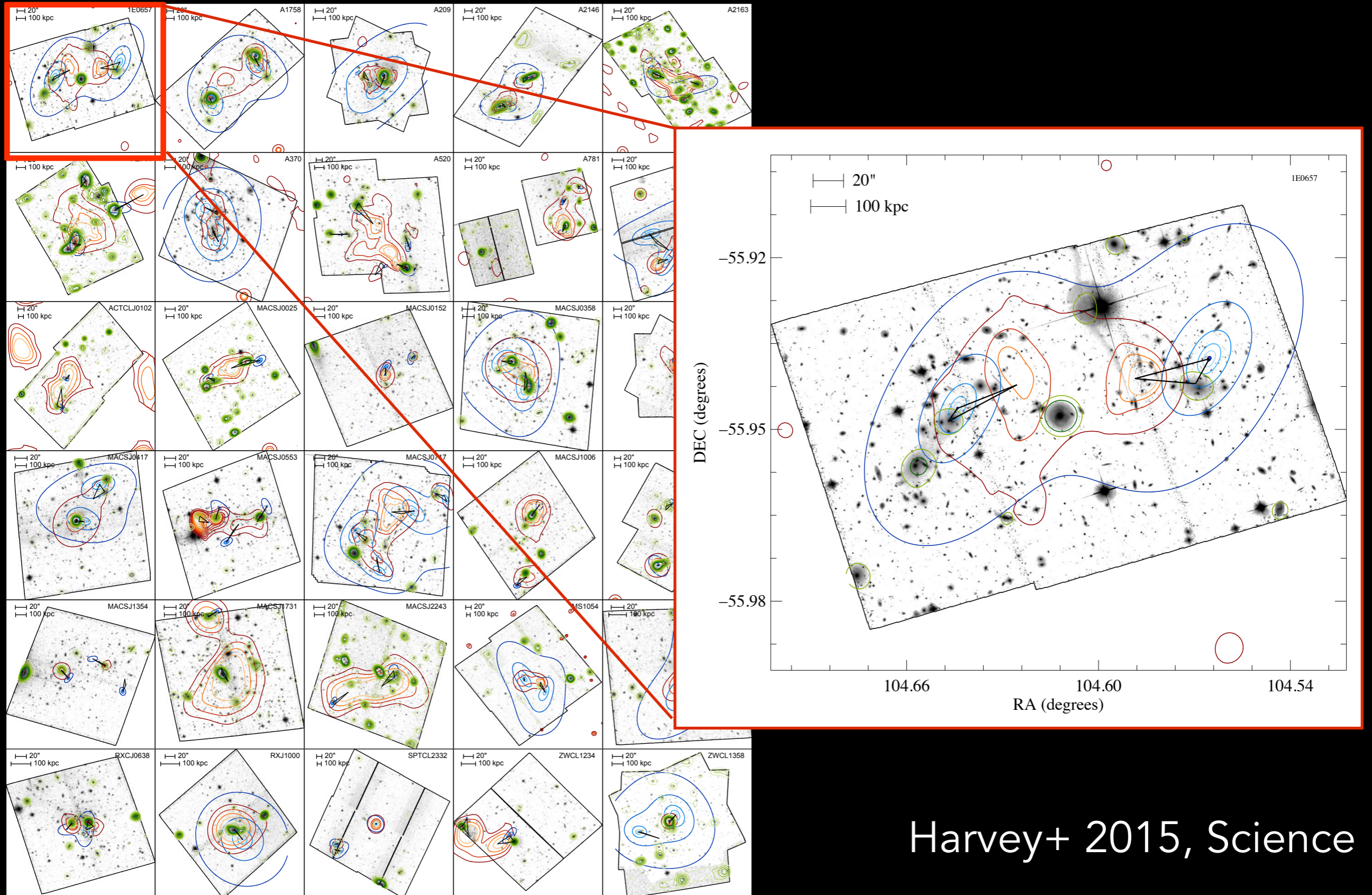
Dark matter self-interaction cross section, σ_{DM} [cm²/g]

EXTENDING THE STUDY TO 30 CLUSTER MERGERS



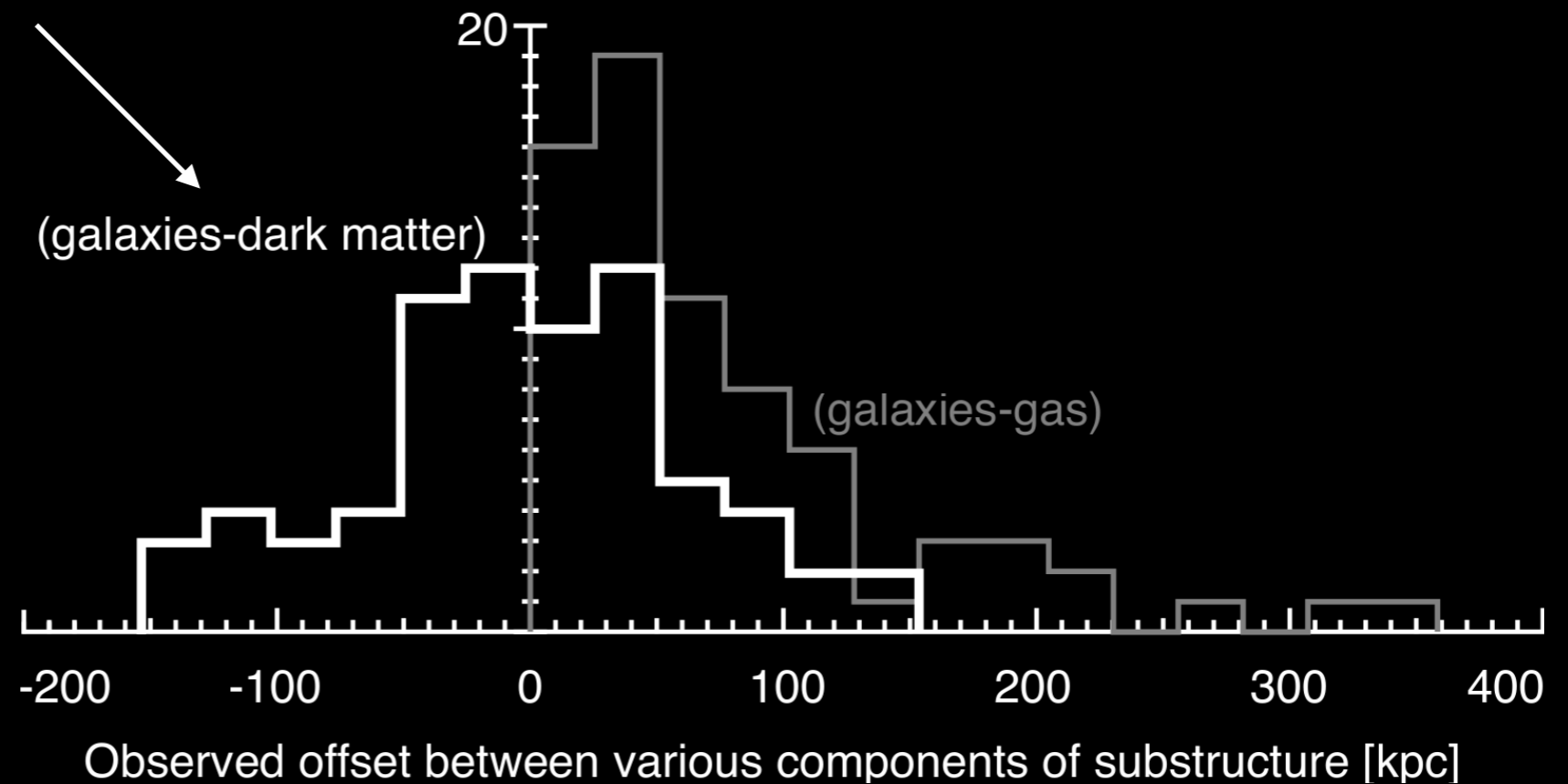
Harvey+ 2015, Science

EXTENDING THE STUDY TO 30 CLUSTER MERGERS



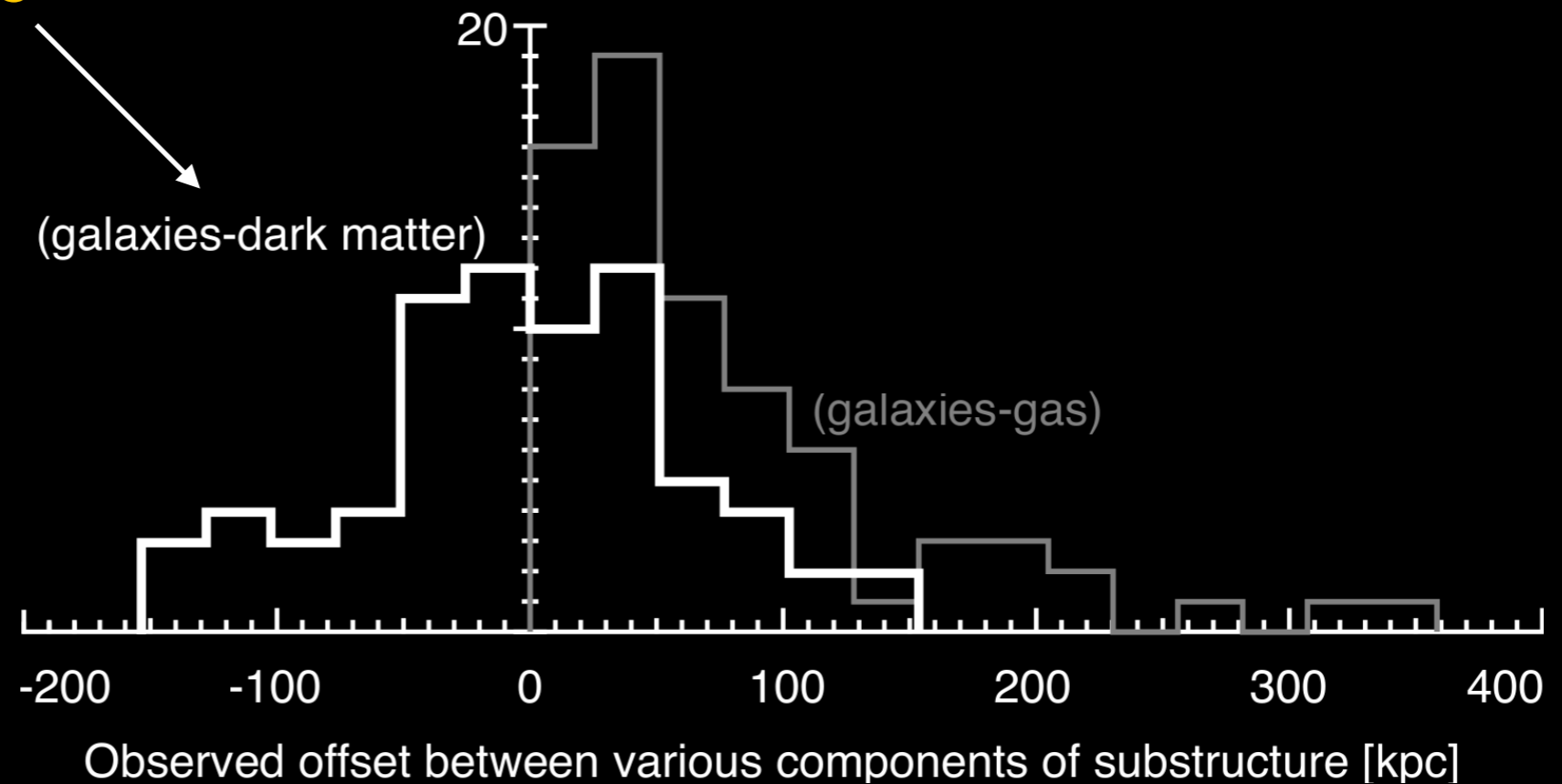
Harvey+ 2015, Science

DARK MATTER — GALAXY OFFSETS FROM 72 MERGING SYSTEMS



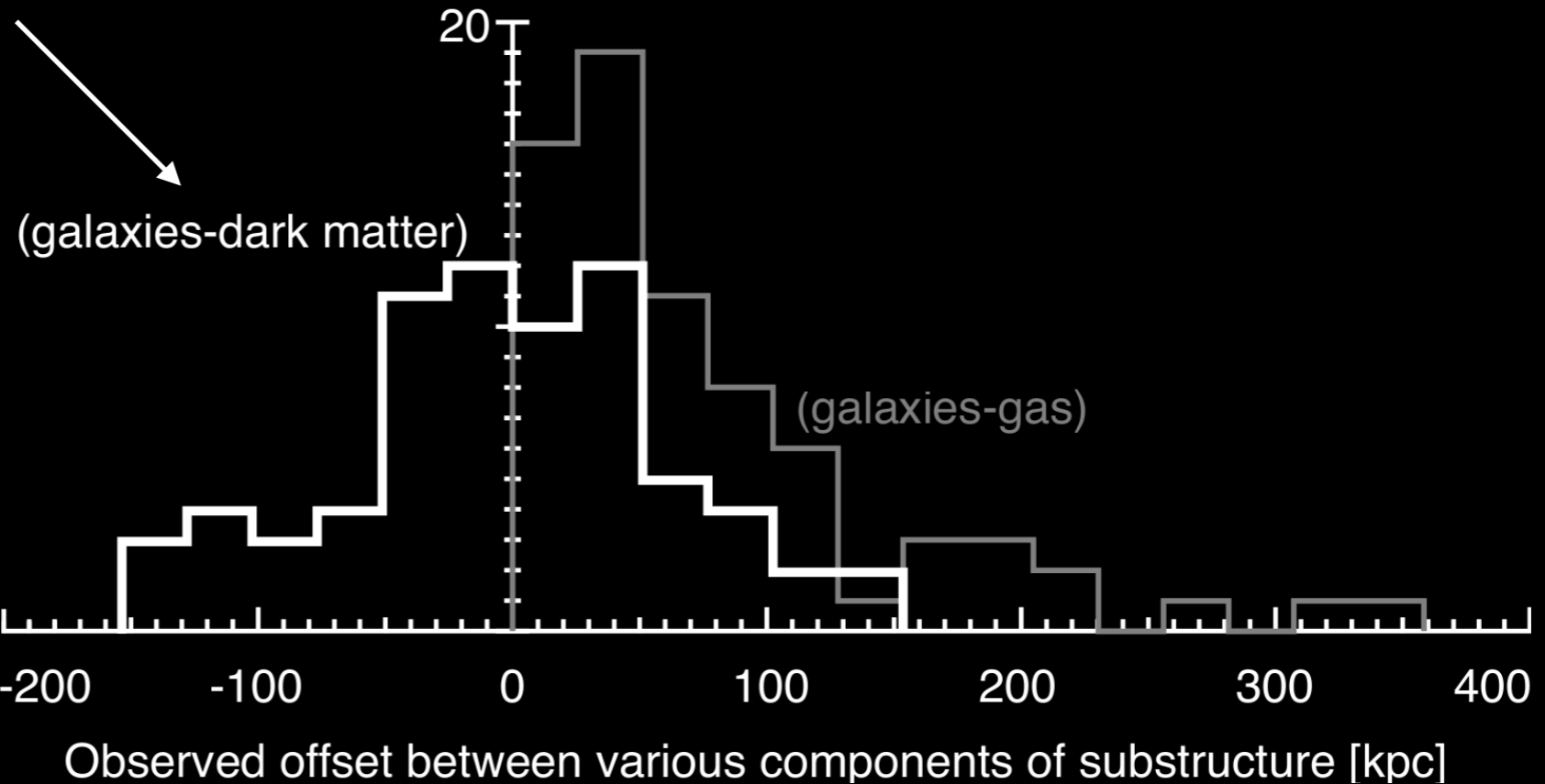
DARK MATTER — GALAXY OFFSETS FROM 72 MERGING SYSTEMS

$5.8 \pm 8.2 \text{kpc}$



DARK MATTER — GALAXY OFFSETS FROM 72 MERGING SYSTEMS

$5.8 \pm 8.2 \text{ kpc}$



$25 \pm 29 \text{ kpc}$
(Bullet Cluster)

IMPROVING THE CONSTRAINTS ON THE SELF-INTERACTIONS CROSS-SECTION

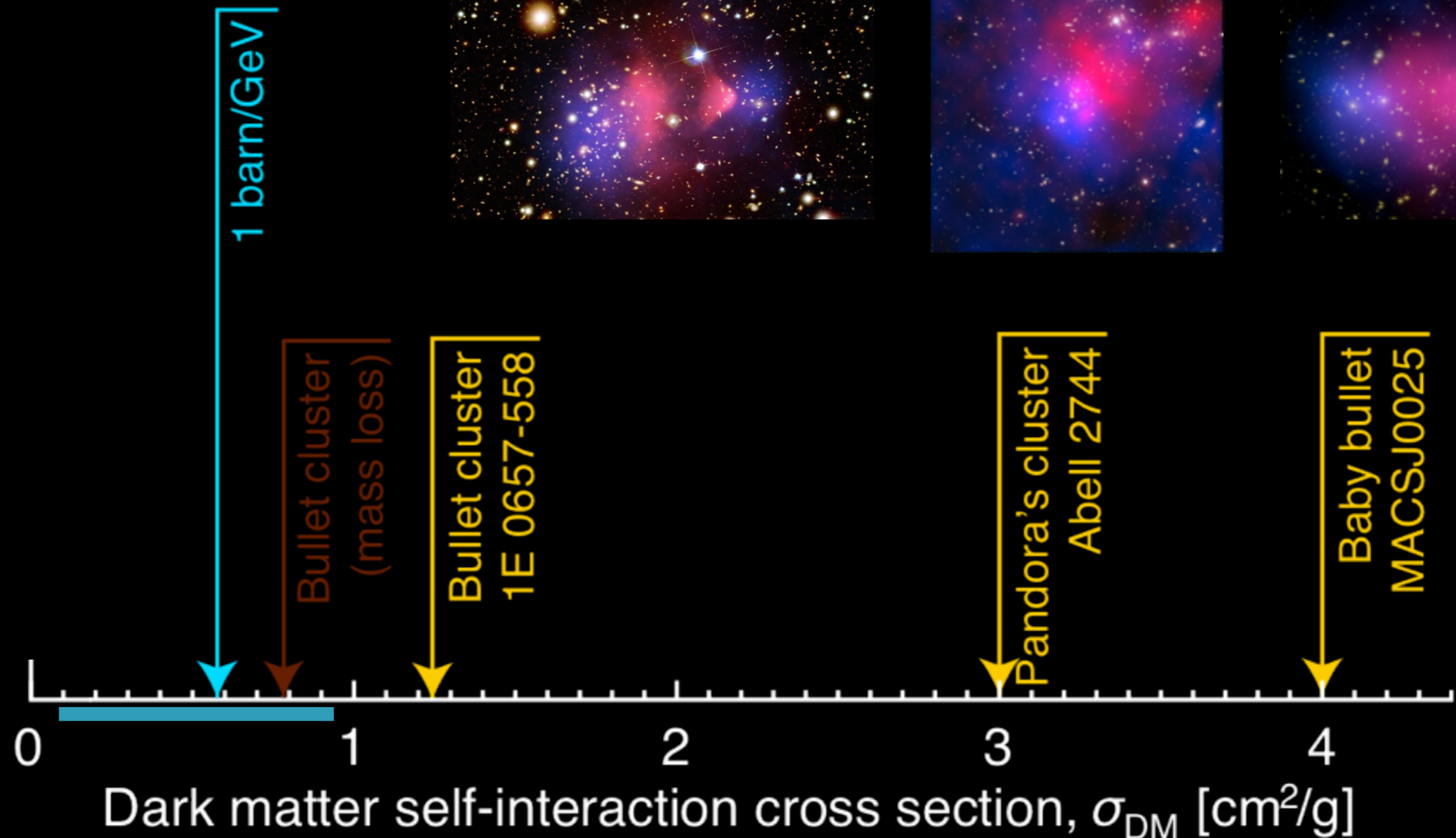
Markevitch+ 2004
Randall+ 2008



Mertens+ 2011



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IMPROVING THE CONSTRAINTS ON THE SELF-INTERACTIONS CROSS-SECTION

$0.47 \text{ cm}^2/\text{g}$

Markevitch+ 2004
Randall+ 2008

Mertens+ 2011

Bradac+ 2008



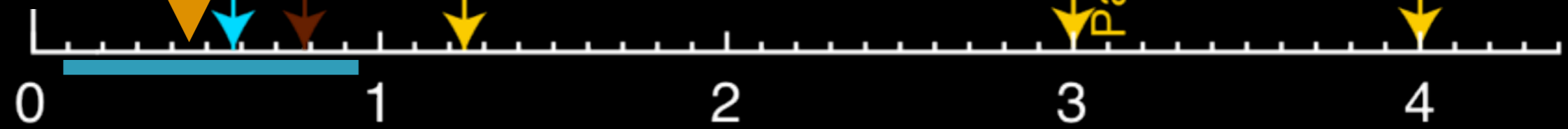
30 Cluster Mergers
1 barn/GeV

Bullet cluster
(mass loss)

Bullet cluster
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Baby bullet
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Dark matter self-interaction cross section, σ_{DM} [cm^2/g]

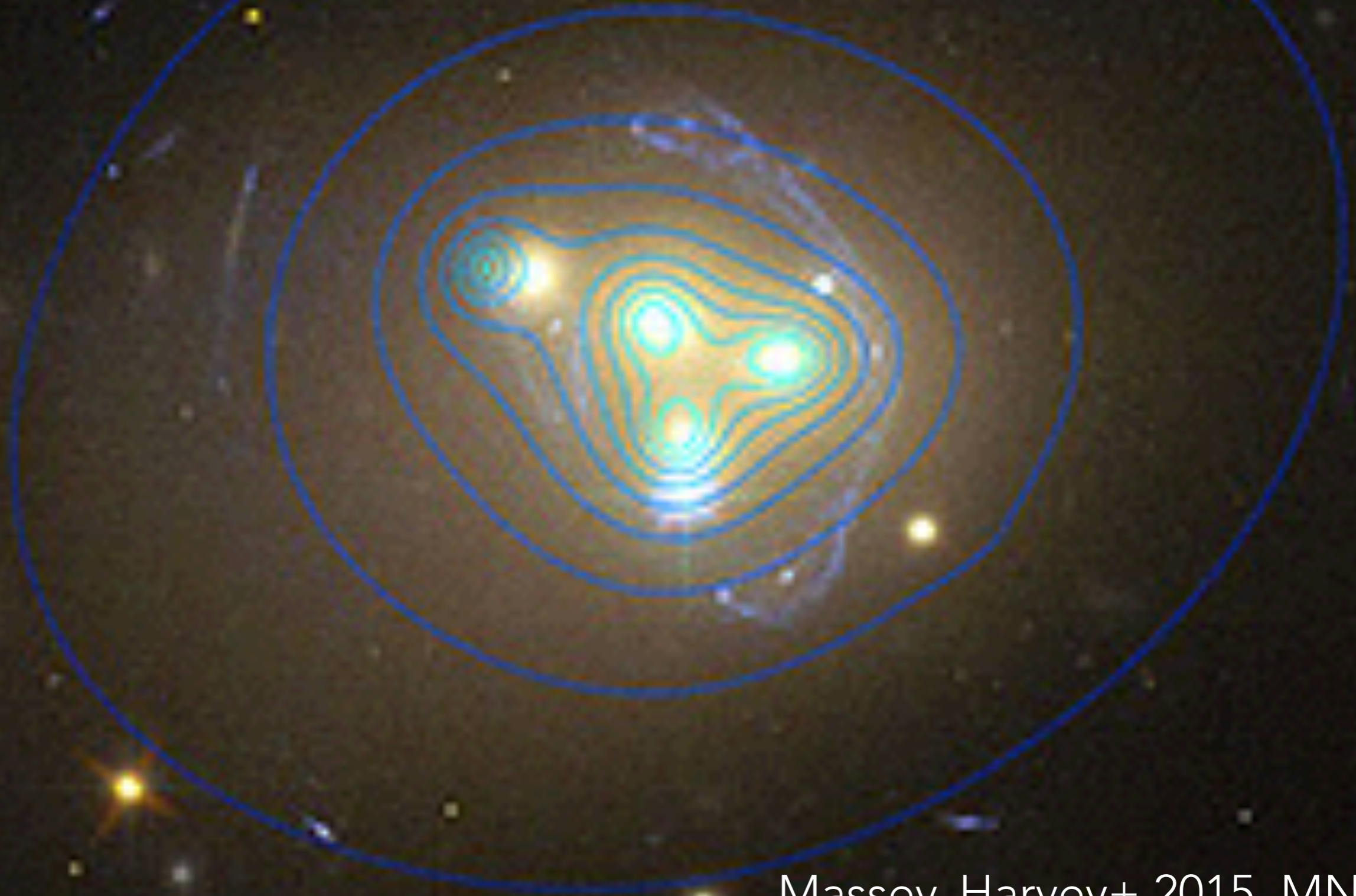
THE CURIOUS CASE OF A3827



Williams & Saha 2011, MNRAS

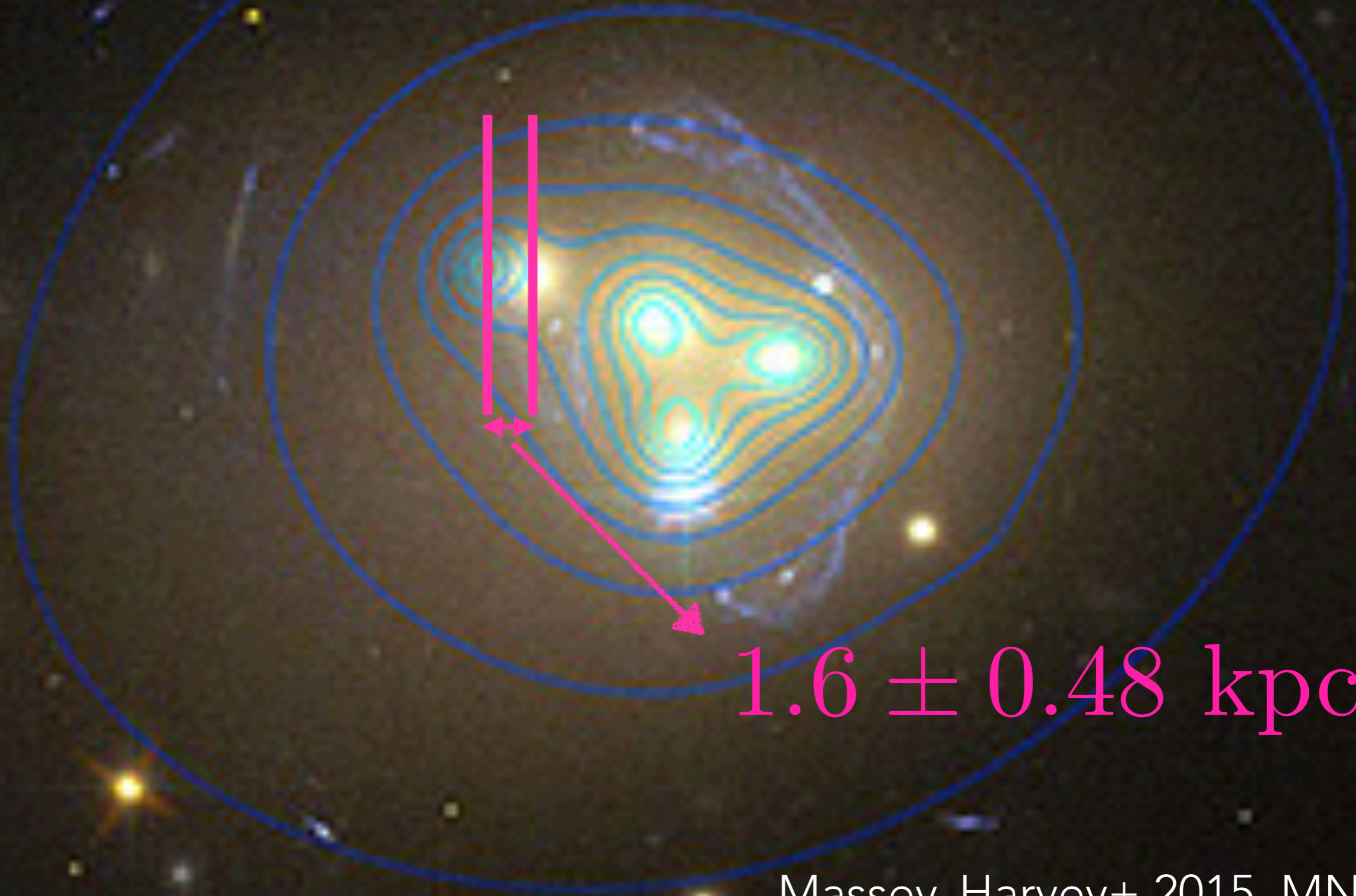
Massey+ 2015, MNRAS

FIRST SIGNS OF NON-GRAVITATIONAL INTERACTIONS OF DARK MATTER?



Massey, Harvey+ 2015, MNRAS

FIRST SIGNS OF NON-GRAVITATIONAL INTERACTIONS OF DARK MATTER?



$1.6 \pm 0.48 \text{ kpc}$

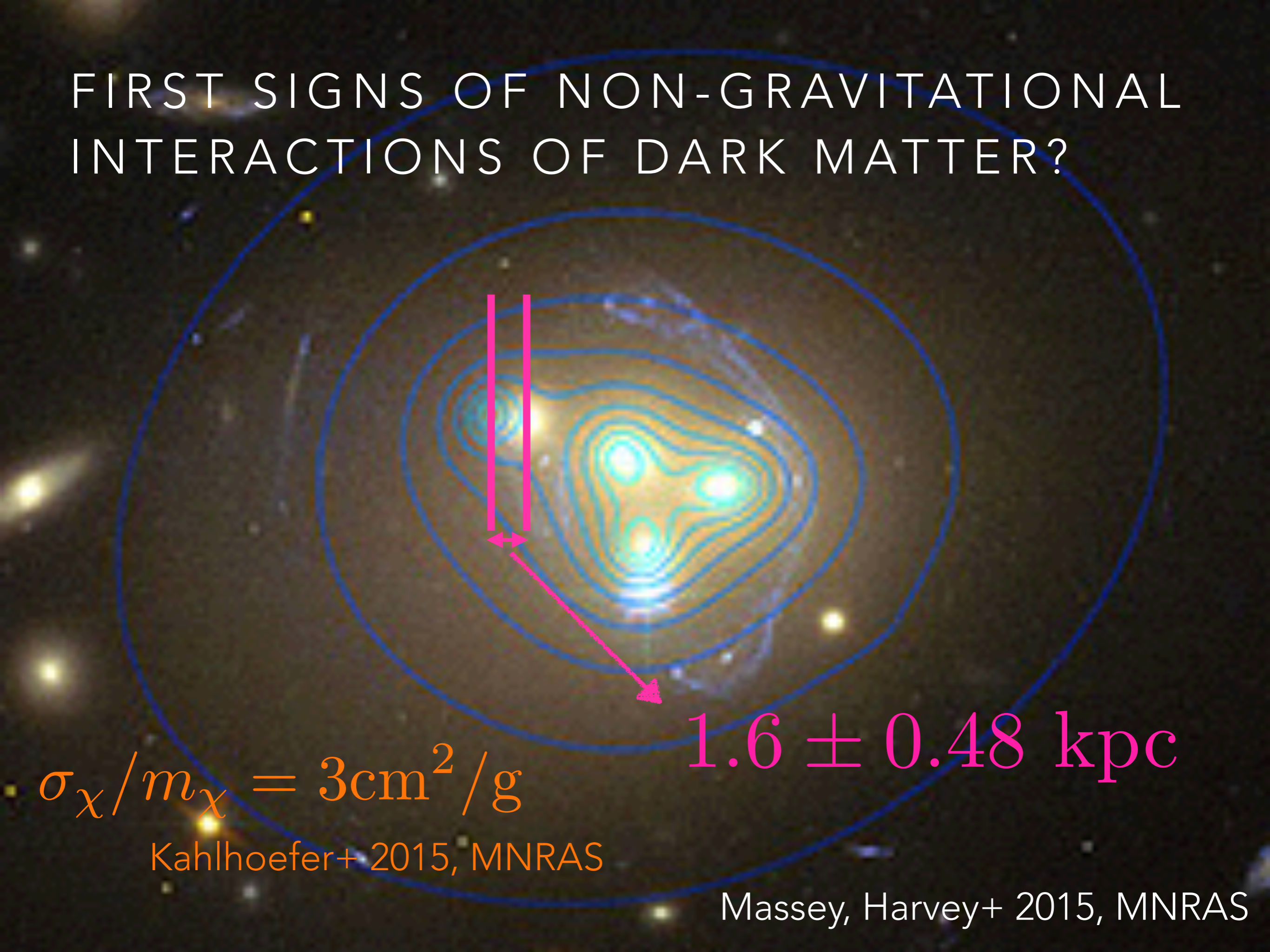
FIRST SIGNS OF NON-GRAVITATIONAL INTERACTIONS OF DARK MATTER?

$$\sigma_\chi / m_\chi = 3 \text{ cm}^2 / \text{g}$$

Kahlhoefer+ 2015, MNRAS

$1.6 \pm 0.48 \text{ kpc}$

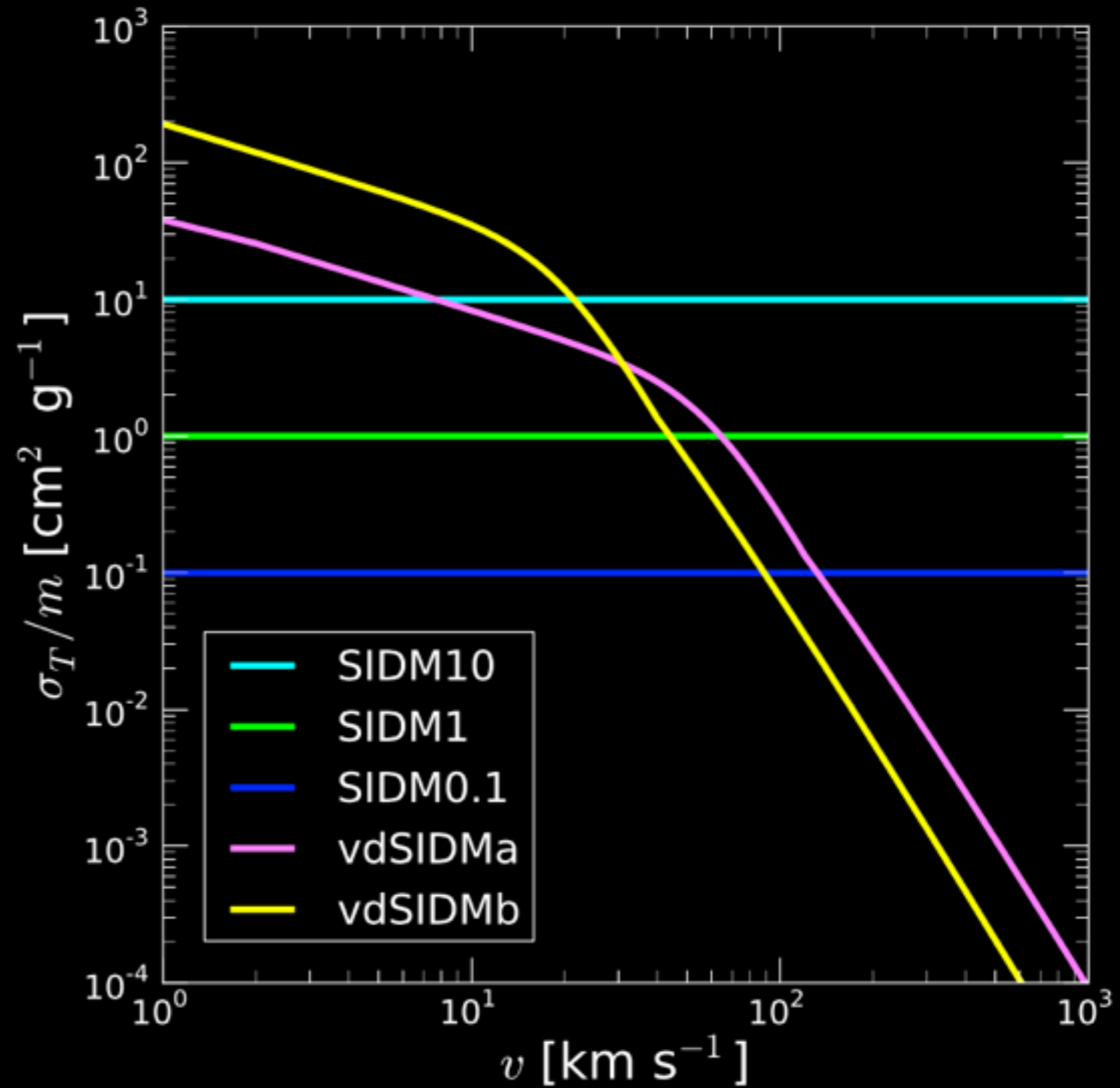
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IS THERE A TENSION BETWEEN CLUSTER
MERGER CONSTRAINTS AND A3827?

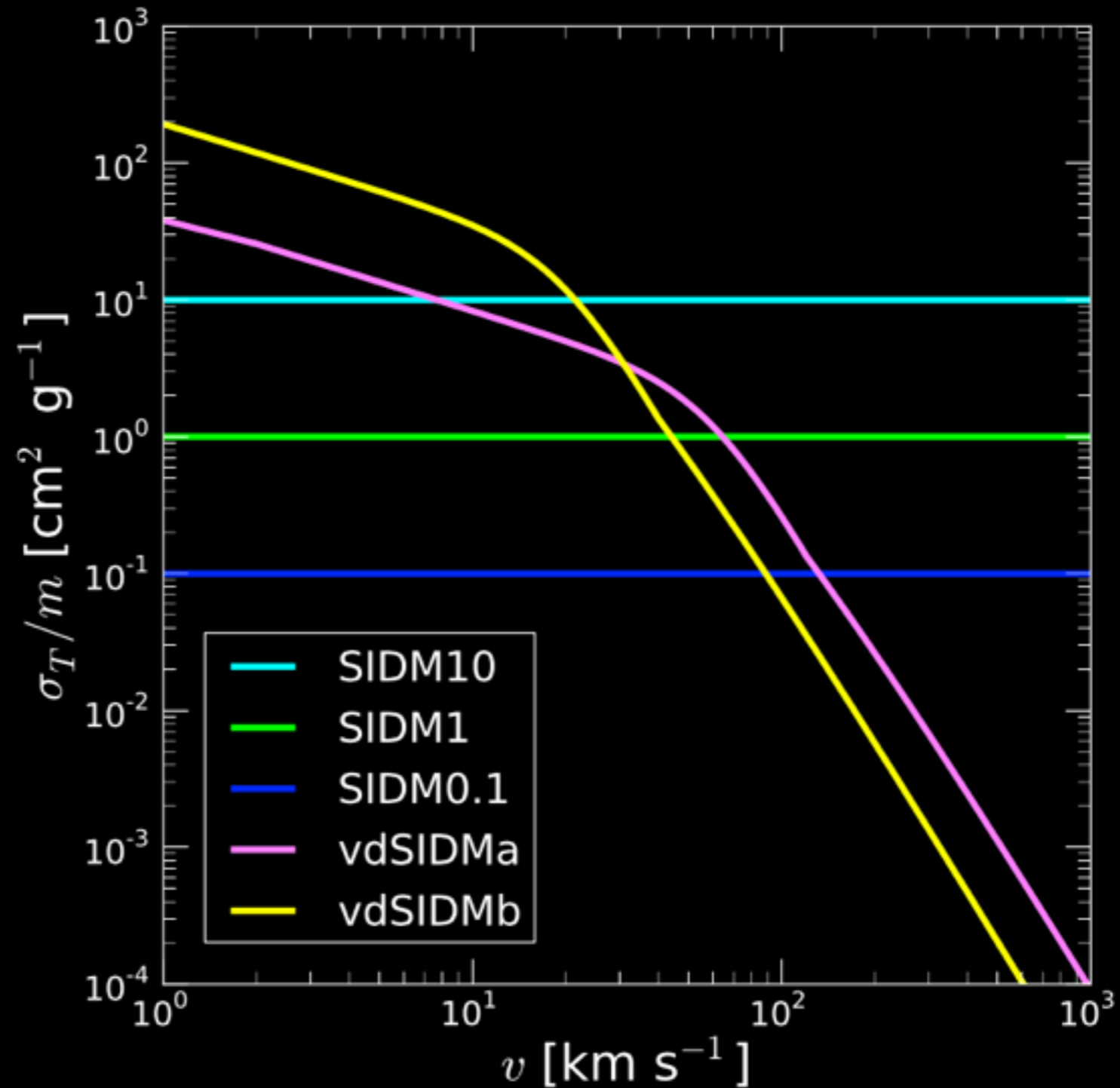
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- Velocity dependence



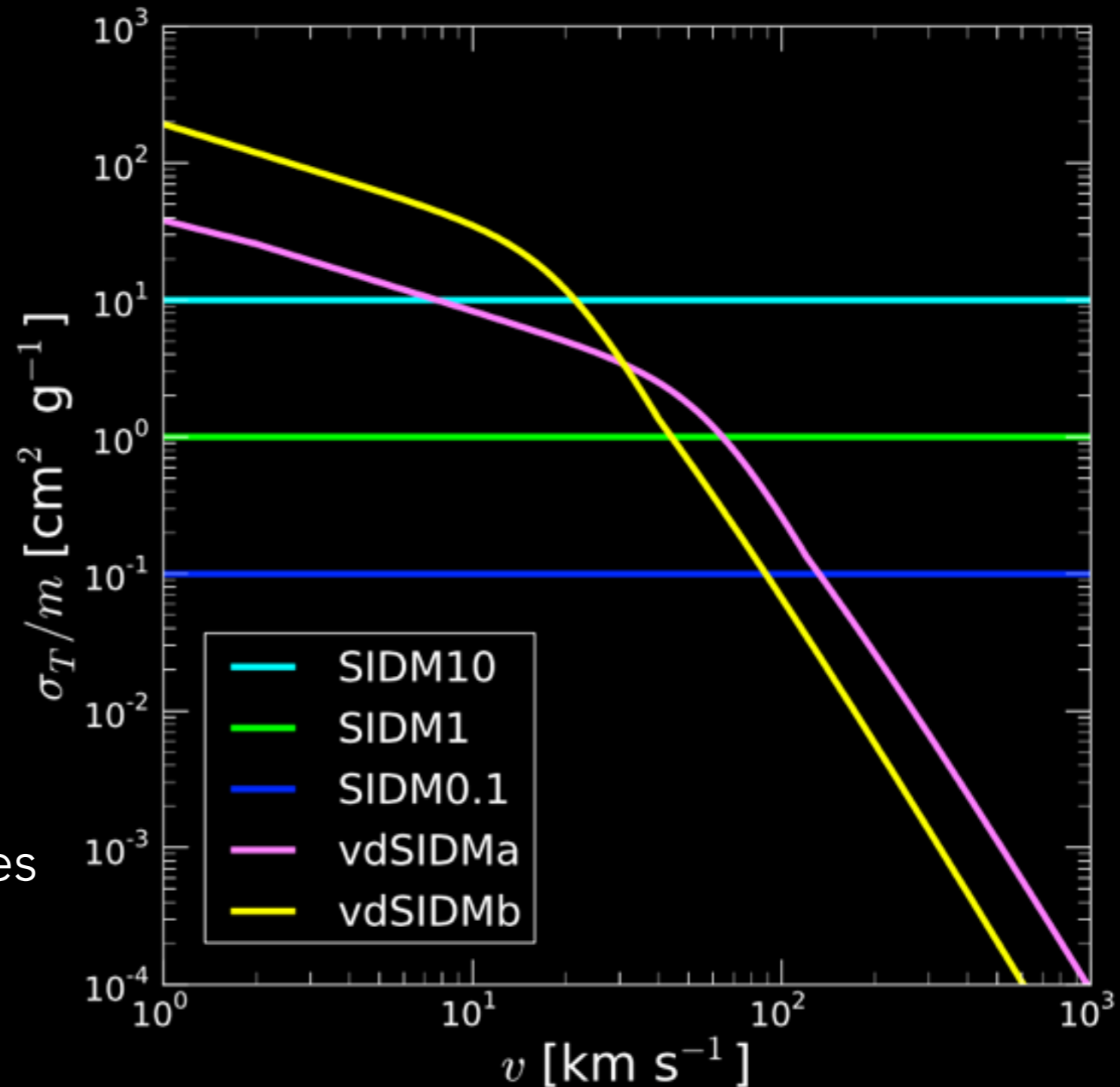
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- Velocity dependence
- Dynamical friction

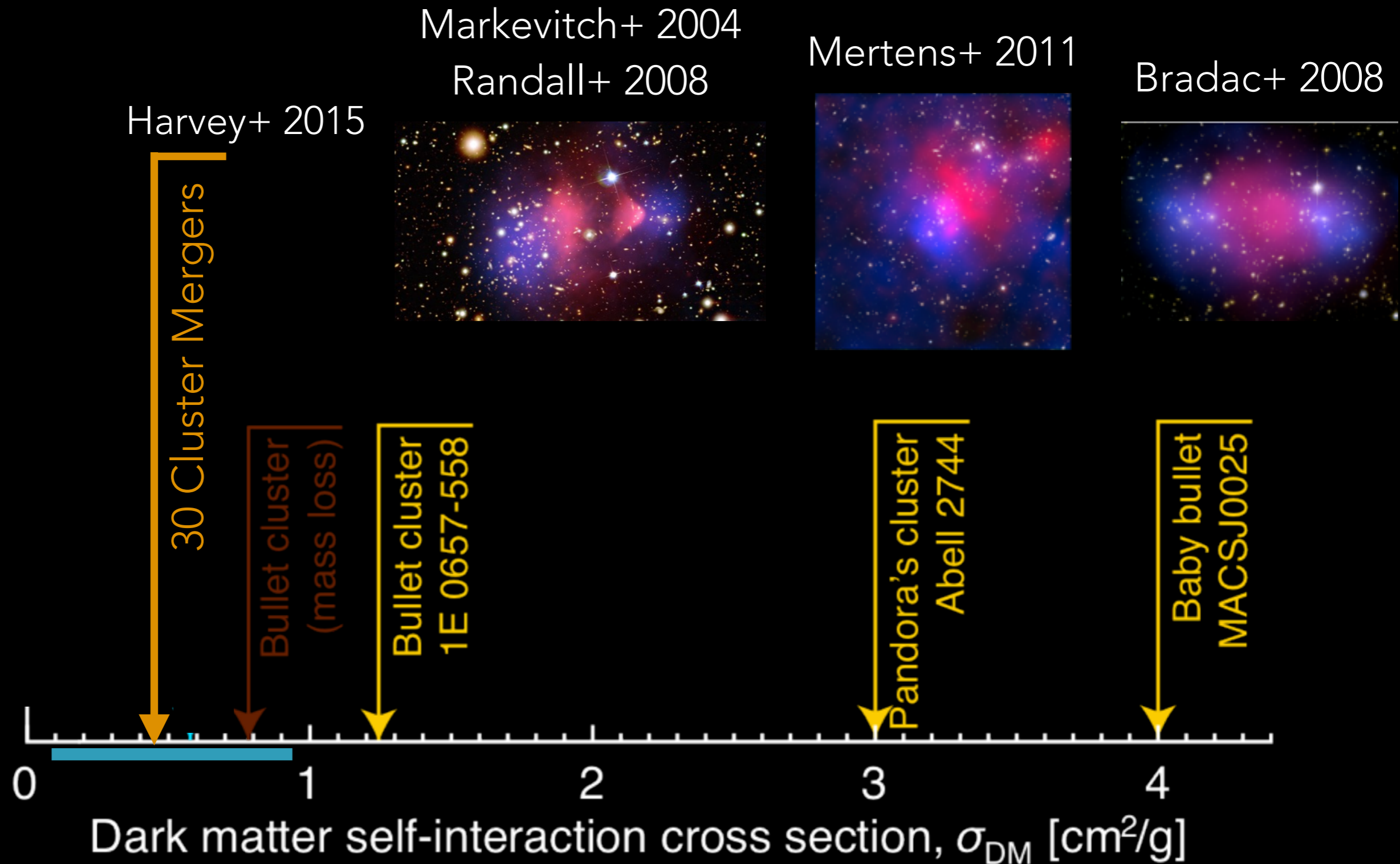


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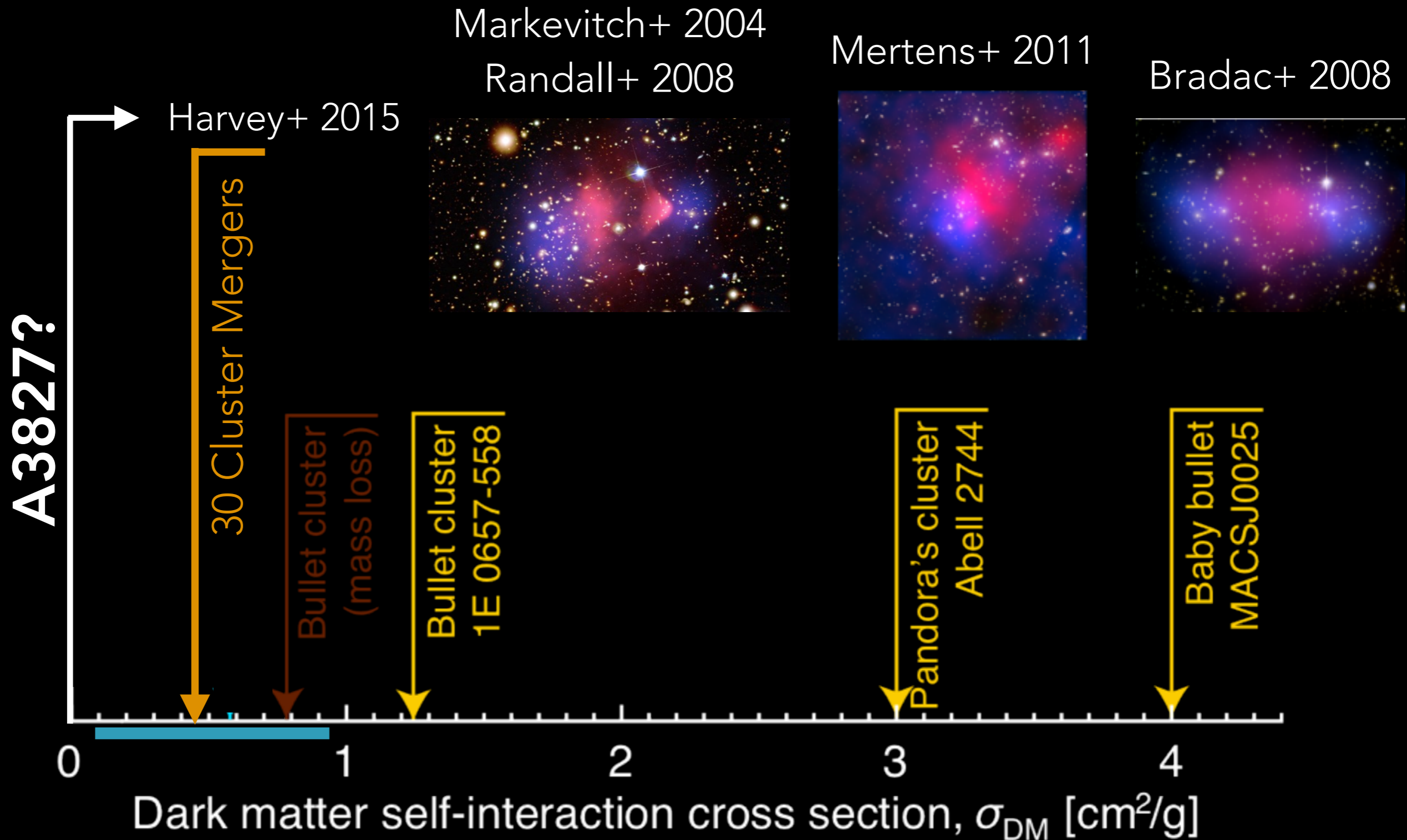
- Velocity dependence
- Dynamical friction
- Systematics
 - A. Foreground structure
 - B. Source-lens degeneracies



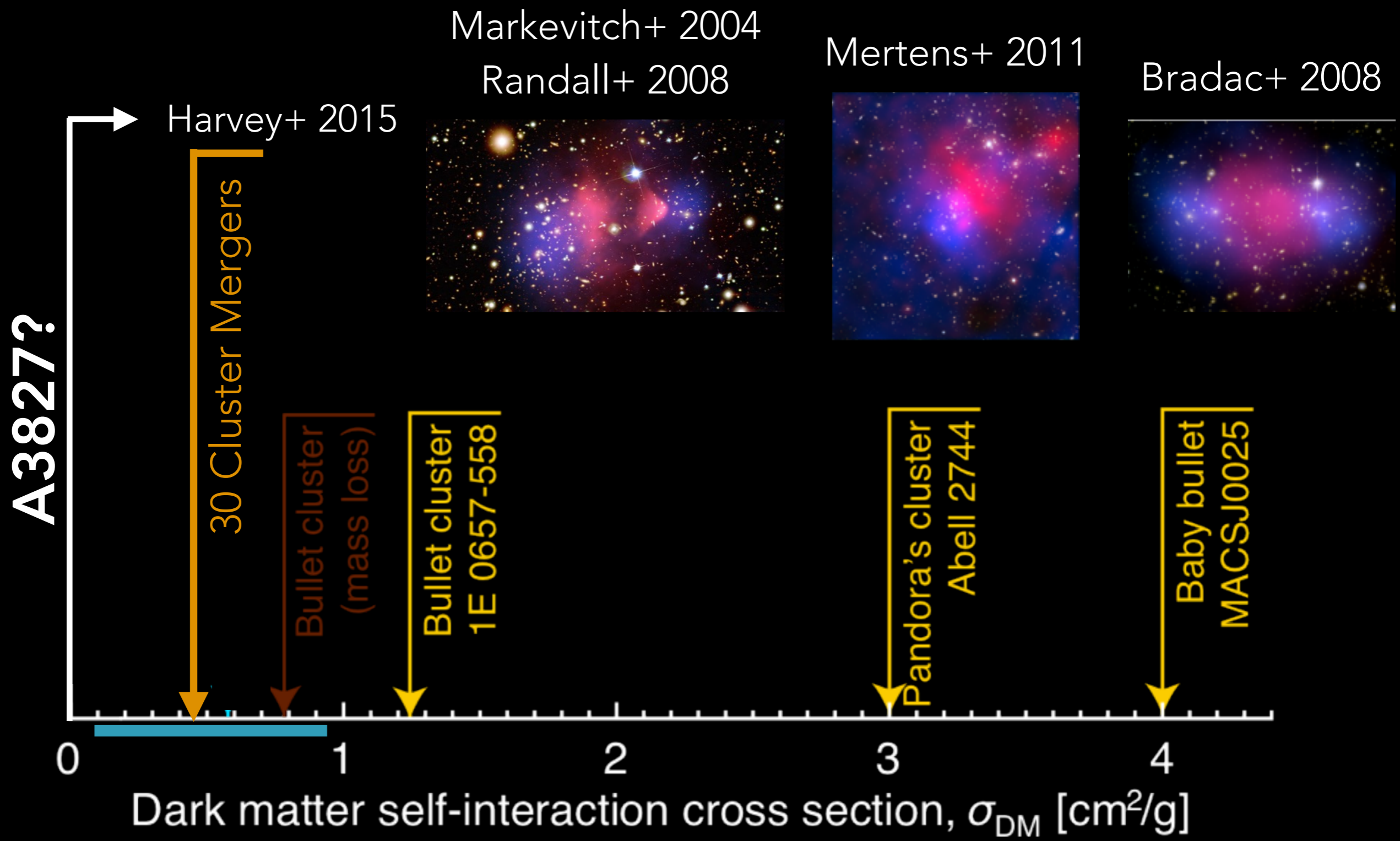
CLOSING IN ON THE CROSS-SECTION OF DARK MATTER



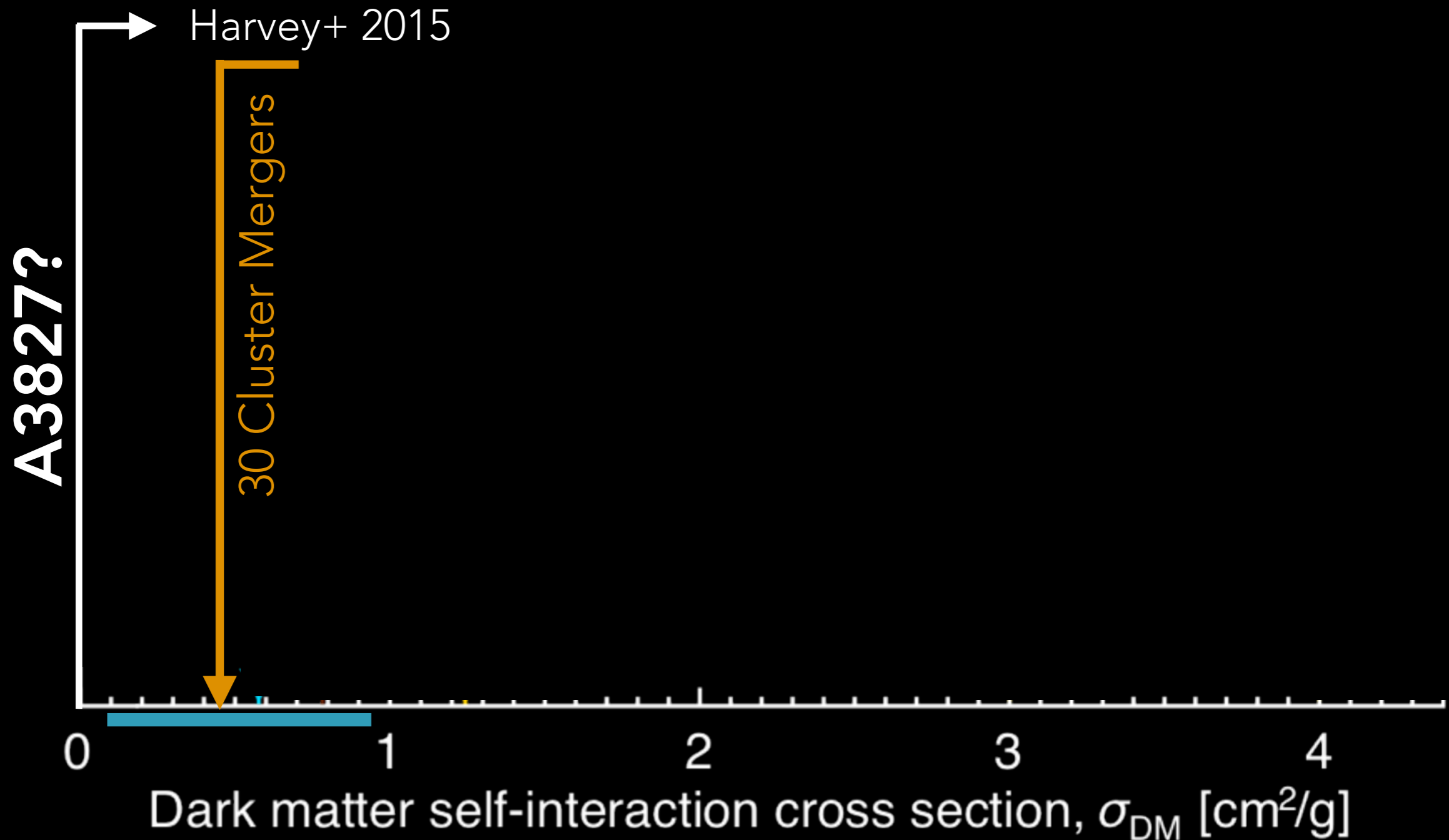
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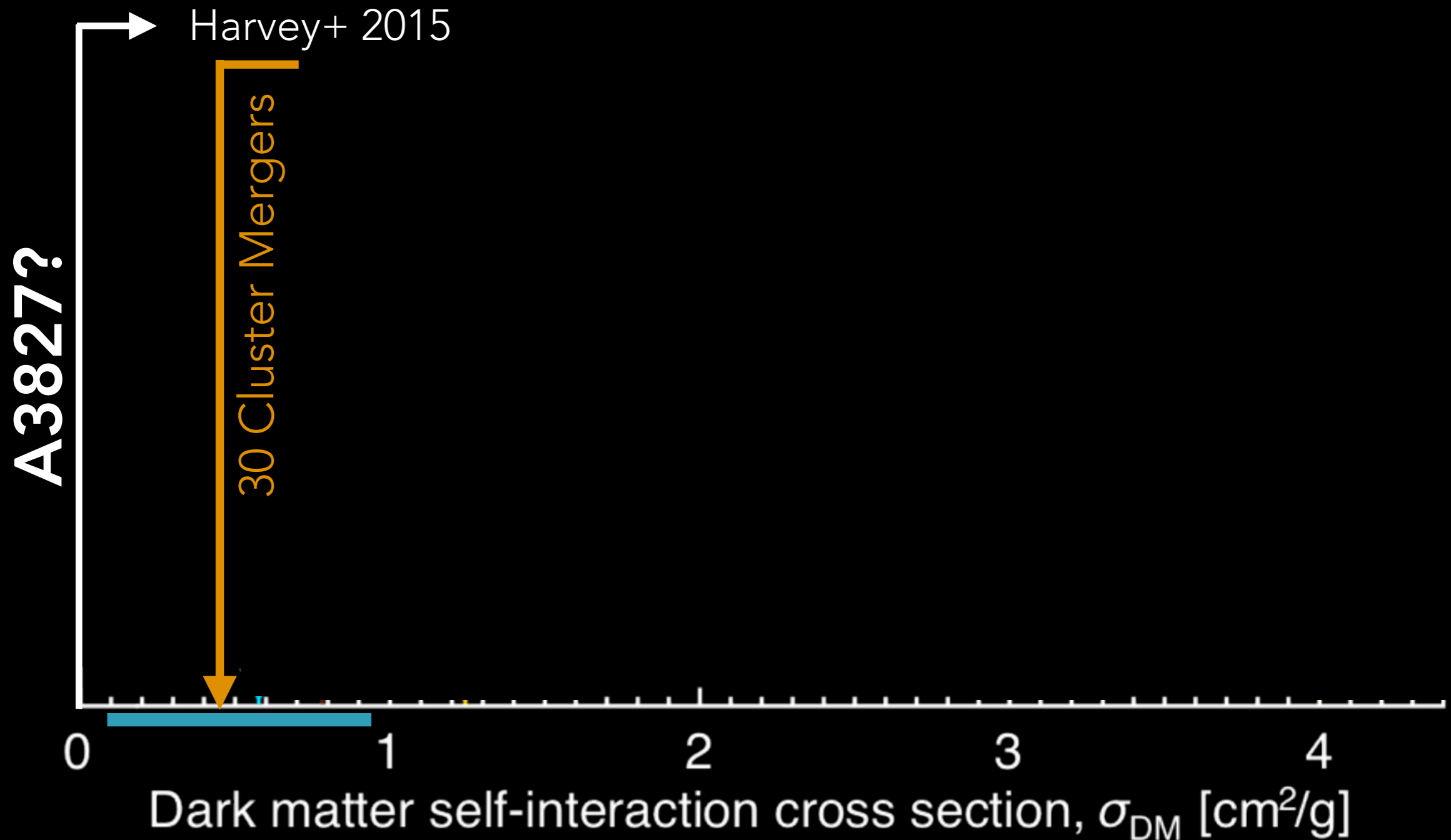
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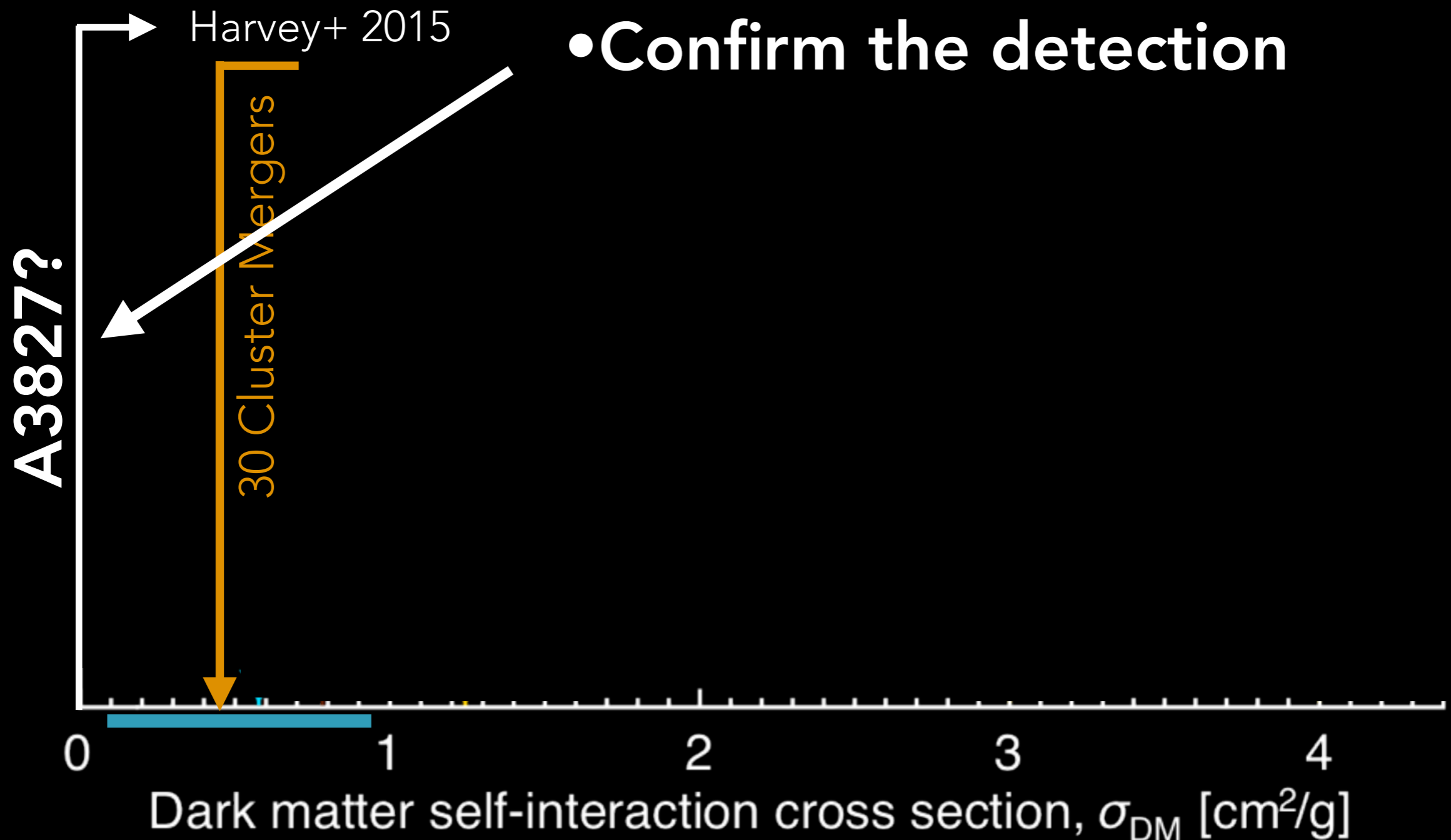
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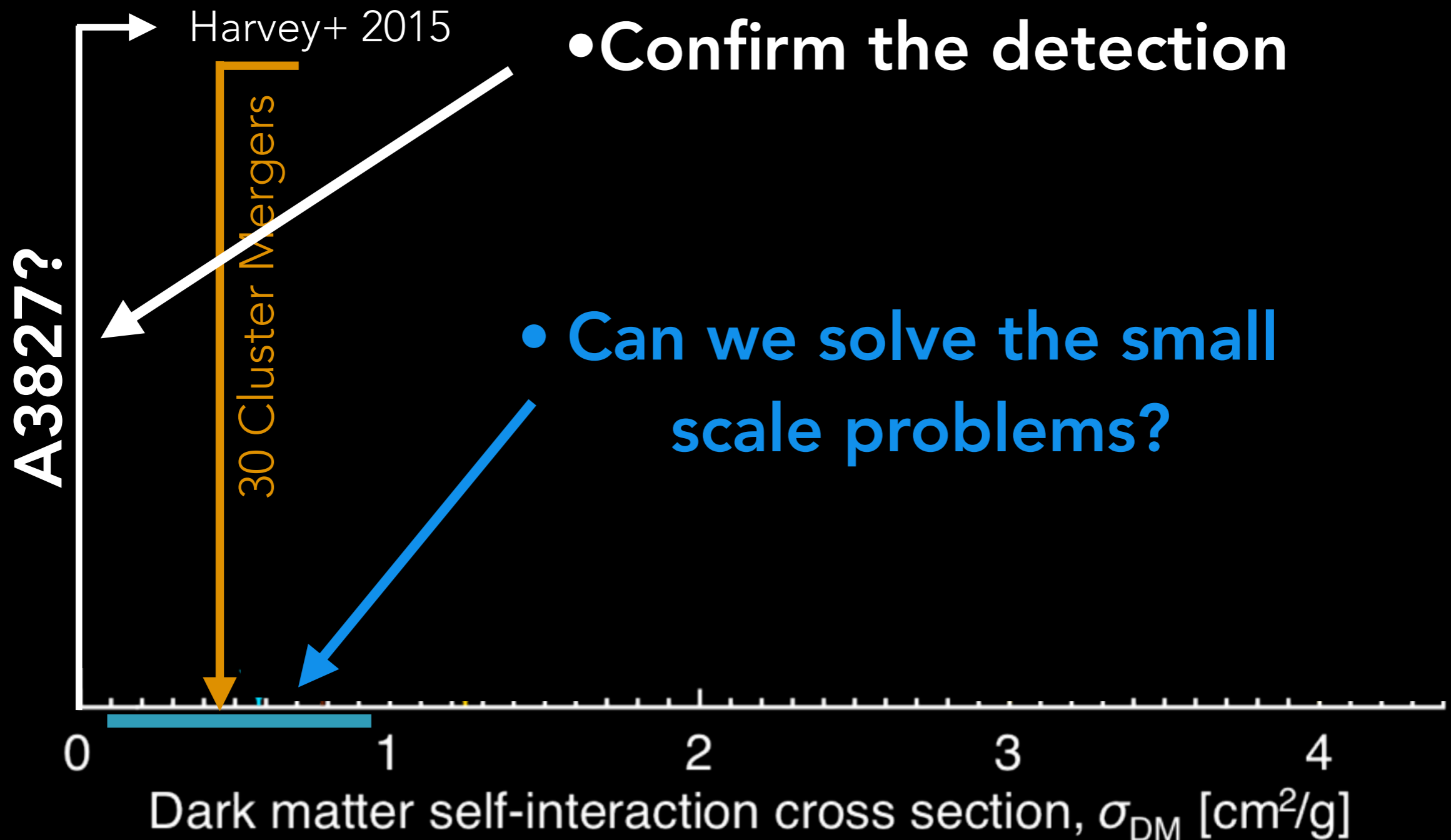
WHAT ARE THE TWO PRIMARY AIMS FOR FUTURE WORK?



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