

DETECTION OF FORMING INTRACLUSTER GAS IN A GALAXY PROTOCLUSTER AT $z \sim 2.16$

LUCA DI MASCOLO

MM UNIVERSE 2023

OBSERVING THE UNIVERSE AT MILLIMETRE WAVELENGTHS

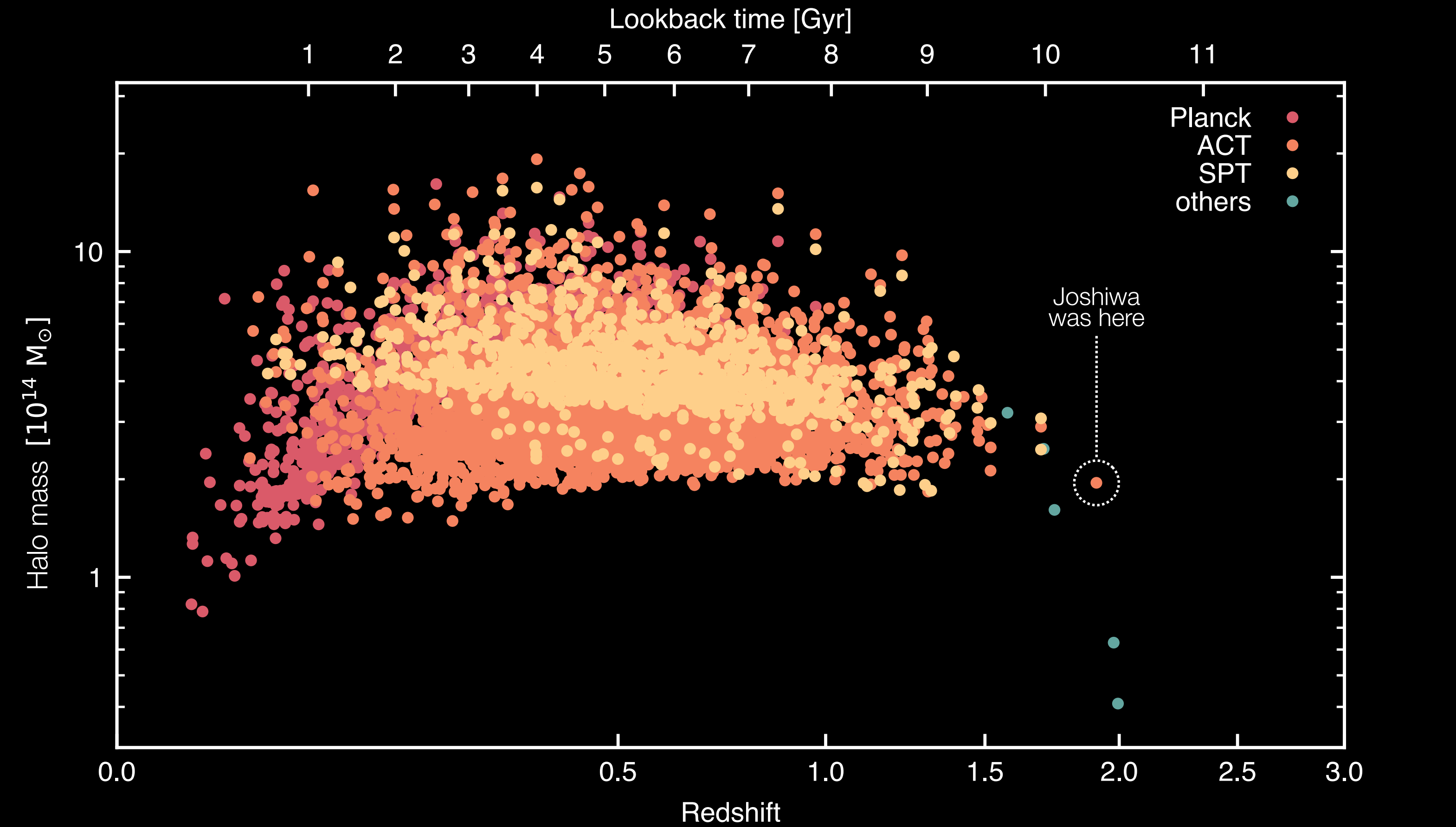
28-06-2023



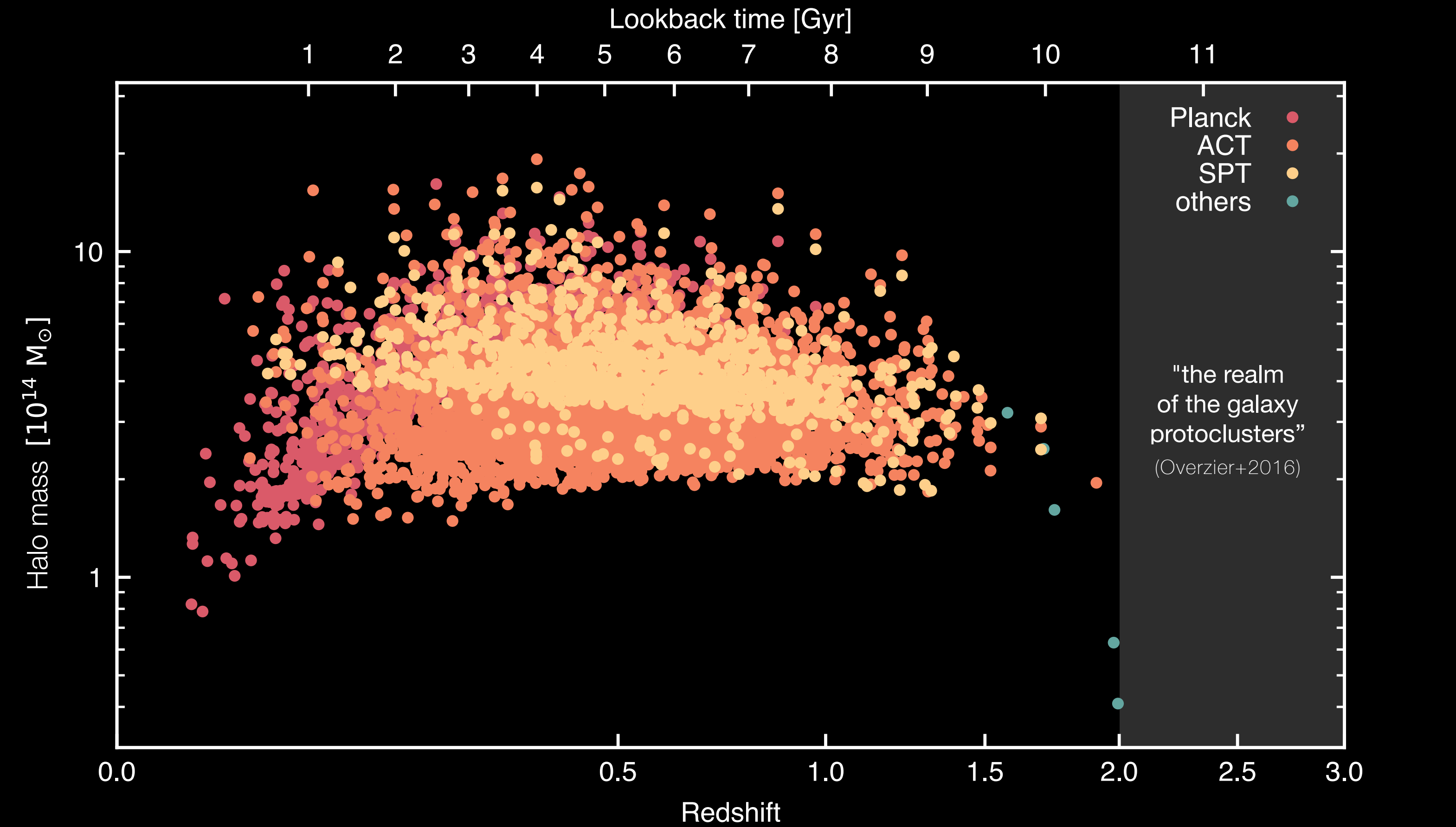
INAF
ISTITUTO NAZIONALE
DI ASTROFISICA



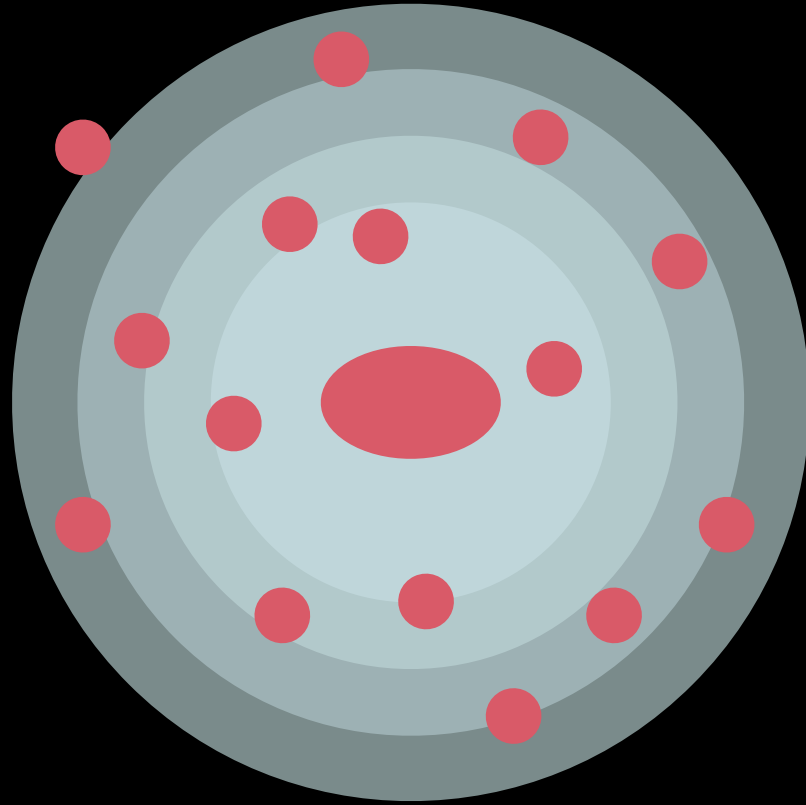
clusters across cosmic time



clusters across cosmic time

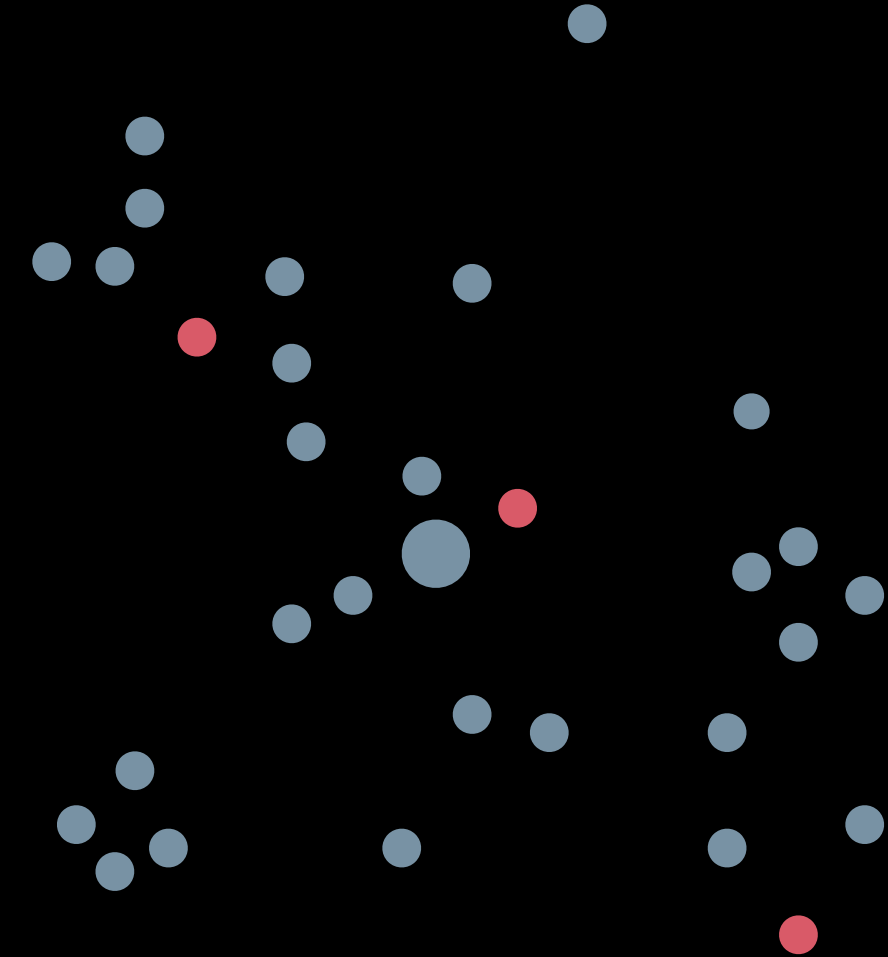


a turning point in cosmic history



mature clusters

environmental quenching
extended, thermalised haloes
of intracluster medium

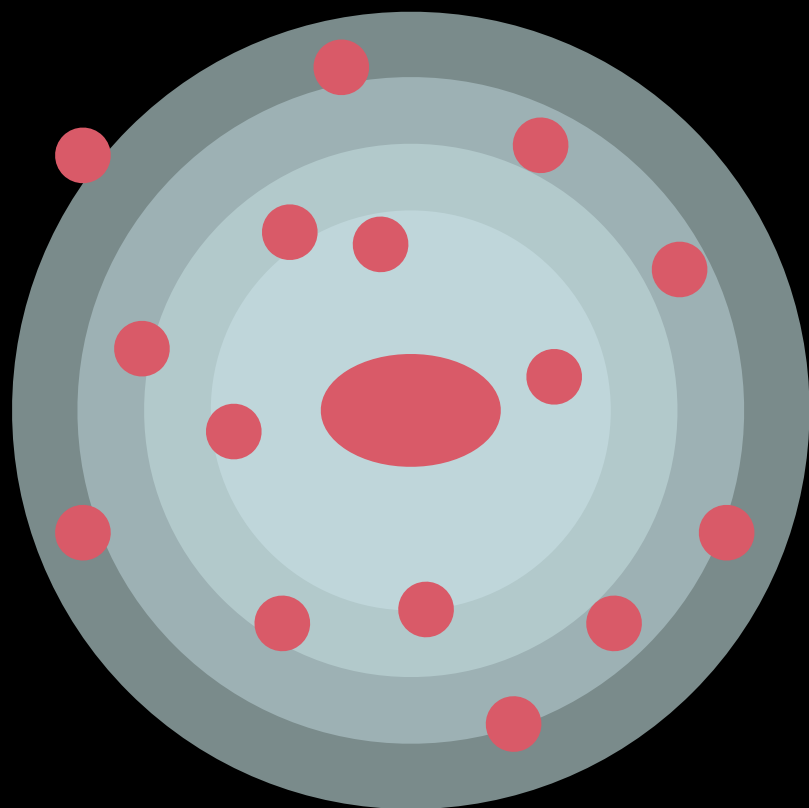


protocluster overdensities

energetic AGN feedback
sustained star formation

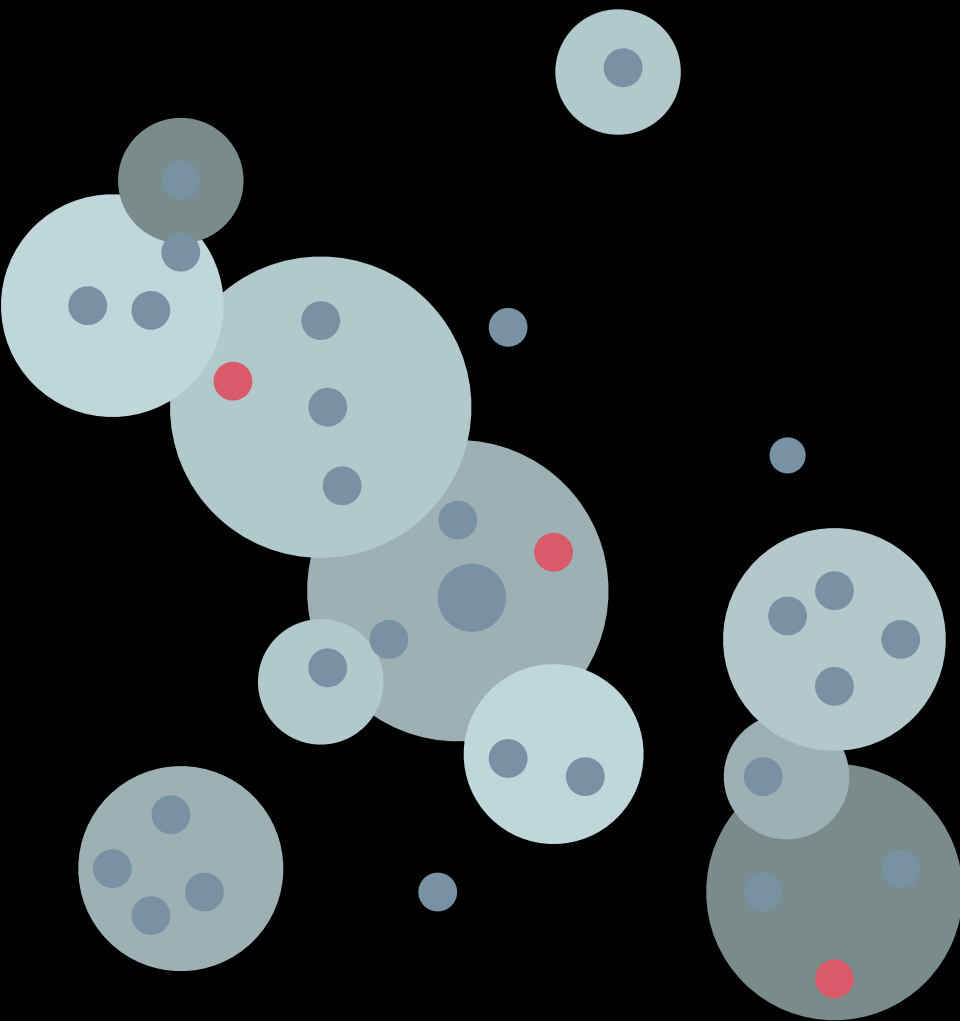


a turning point in cosmic history



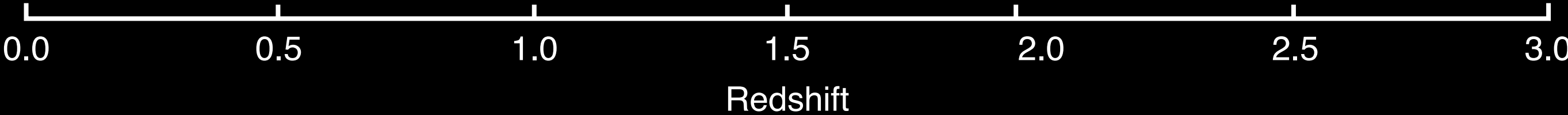
mature clusters

environmental quenching
extended, thermalised haloes
of intracluster medium



protocluster overdensities

energetic AGN feedback
sustained star formation
pre-heated cores
(Saro+2009, Remus+2023)



Spiderweb protocluster: an overview

Spiderweb galaxy

Pentericci+1998 - Miley+2006 - Kuiper+2011 -
Emonts+2016,2018 - De Breuck+2022

protocluster galaxies

Kurk+2000 - Pentericci+2000 - Kurk+2004a -
Kodama+2007 - Ogle+2012 - Koyama+2013 -
Tanaka+2013 - Dannerbauer+2014,2017 -
Shimakawa+2015,2018 - Jin+2021 -
Perez-Martinez+2023

AGN activity

Carilli+1997,2022 - Pentericci+1997 - Seymour+2012 -
Gullberg+2016 - Anderson+2022 - Tozzi+2022a -
Shimakawa+2023

galaxy evolution studies



Spiderweb protocluster: an overview

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proto-ICM

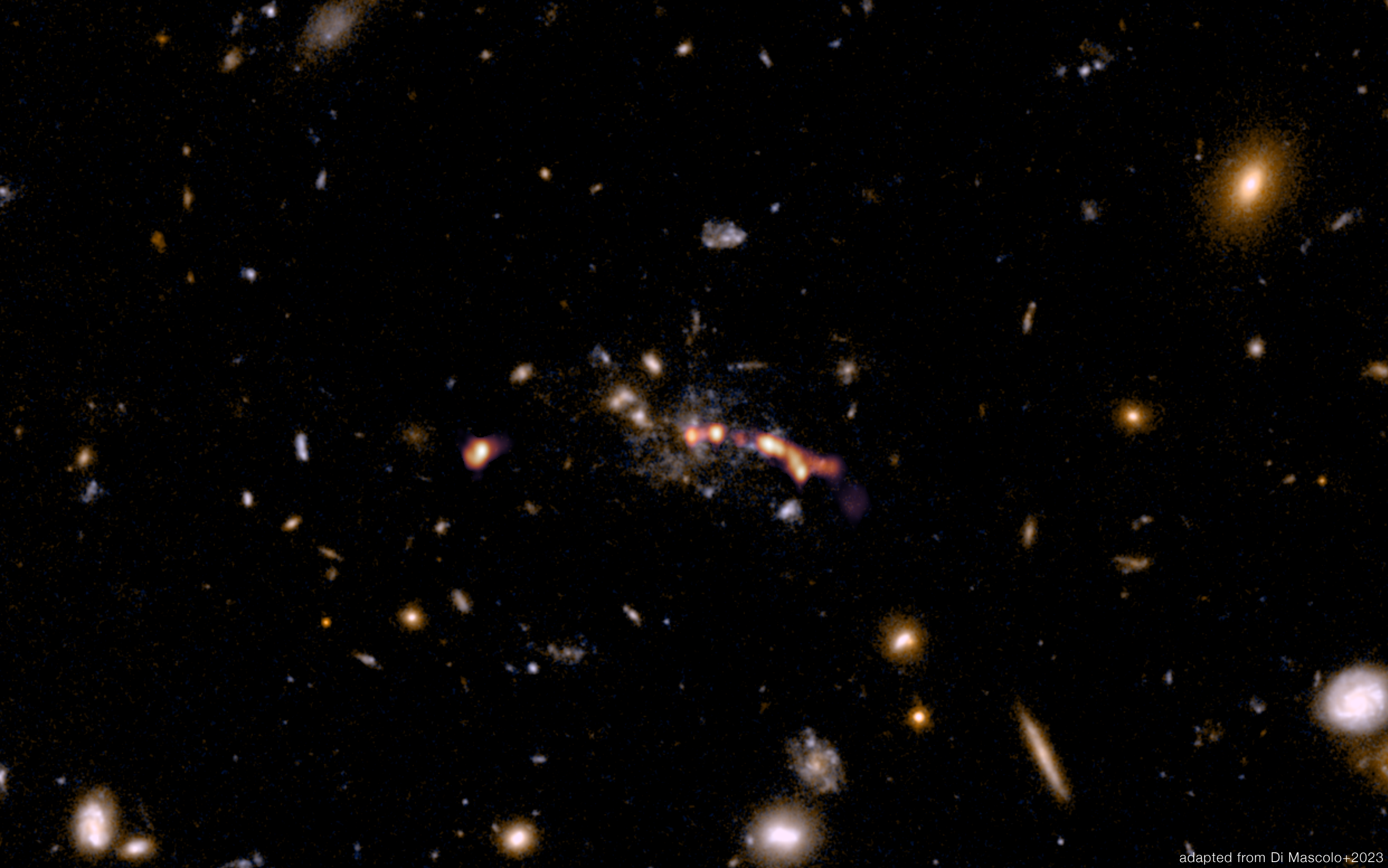
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galaxy evolution studies

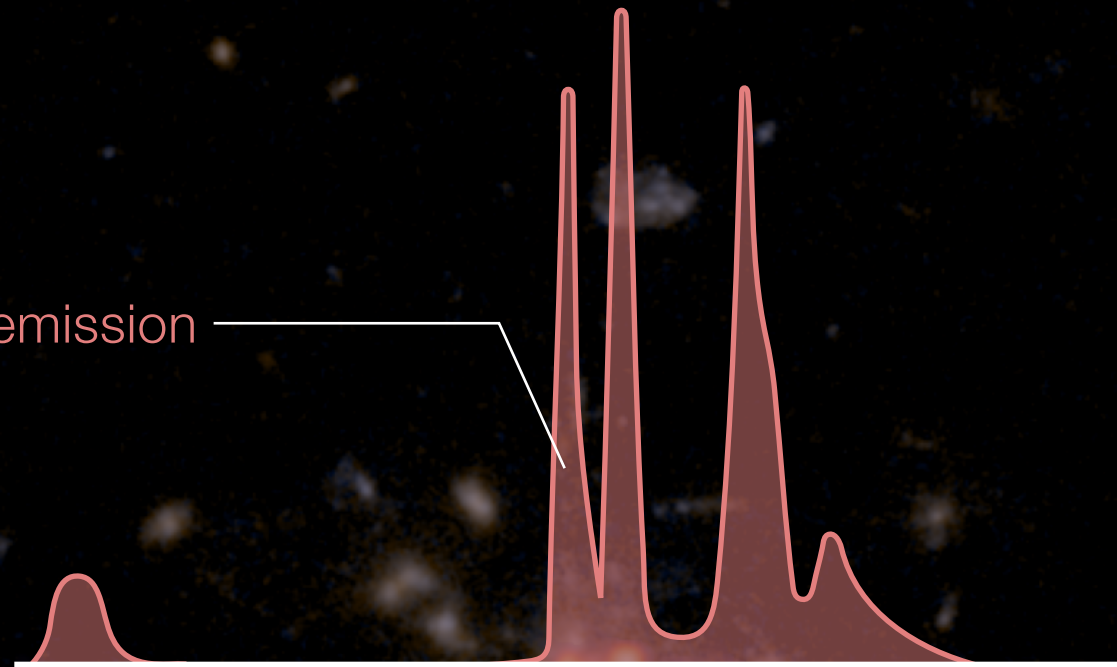
environment

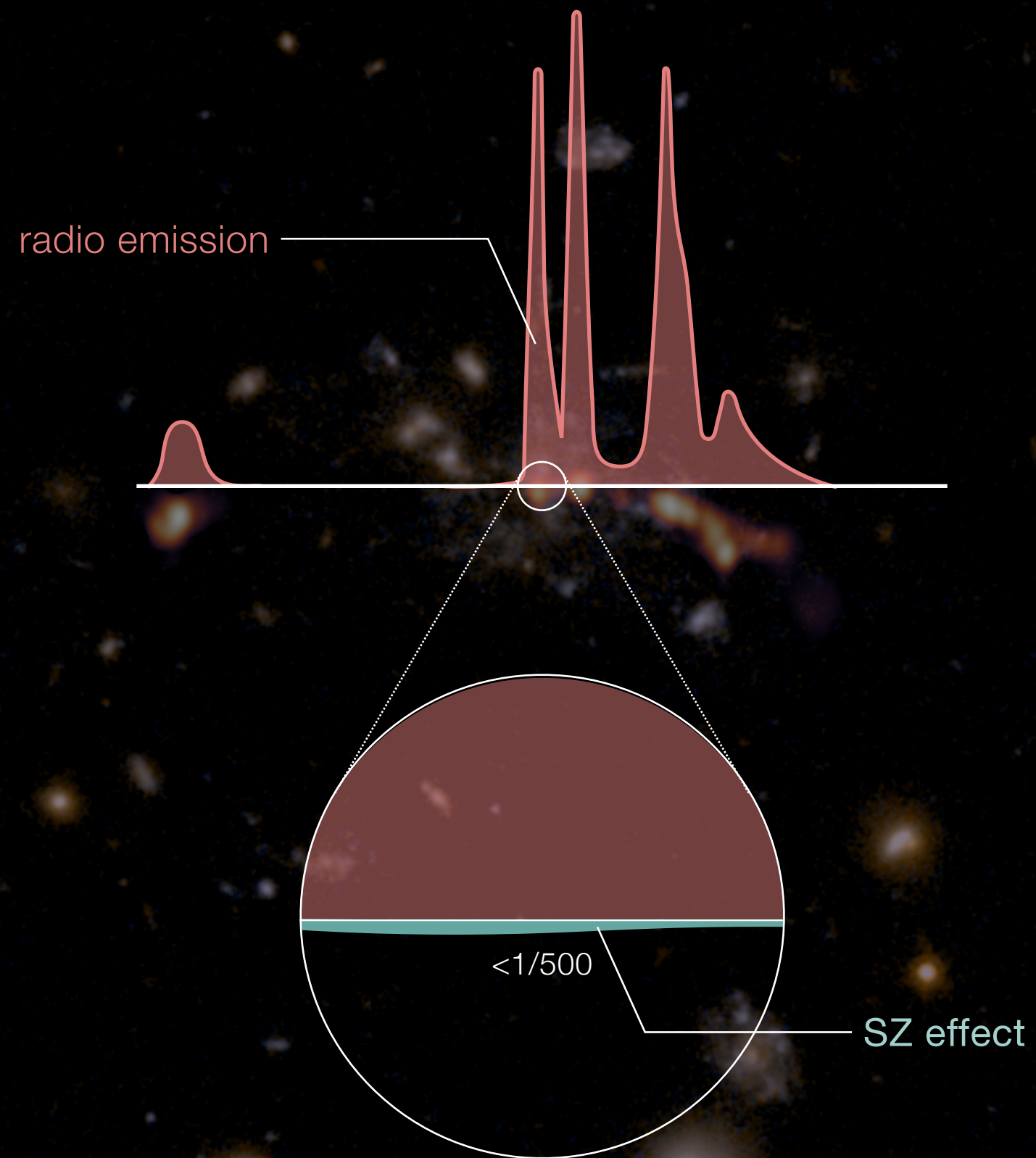




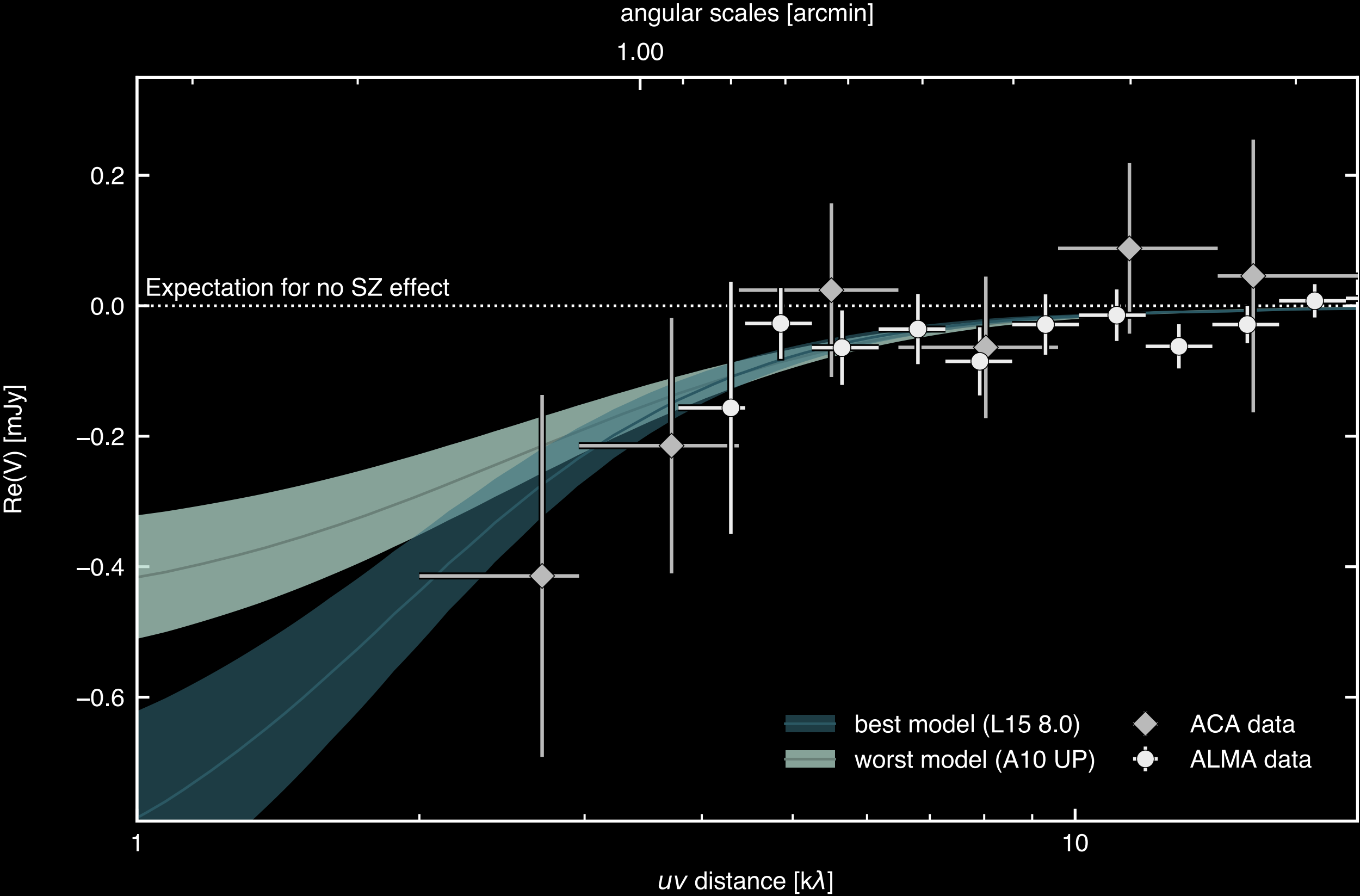


radio emission





let's put our Fourier glasses on

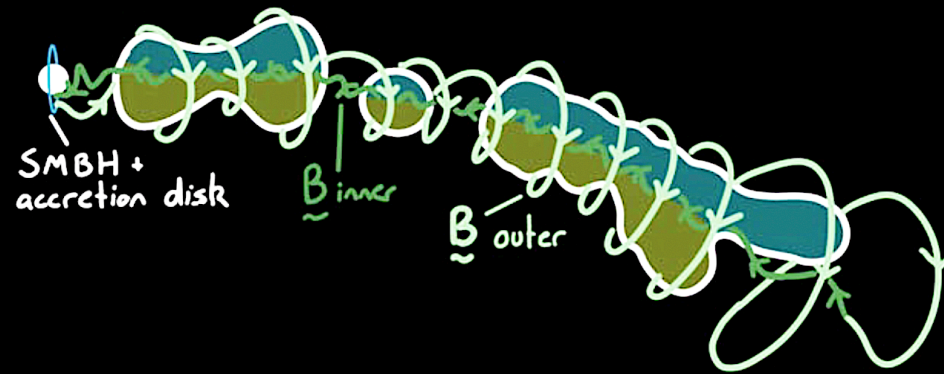


confirmation of long-standing predictions



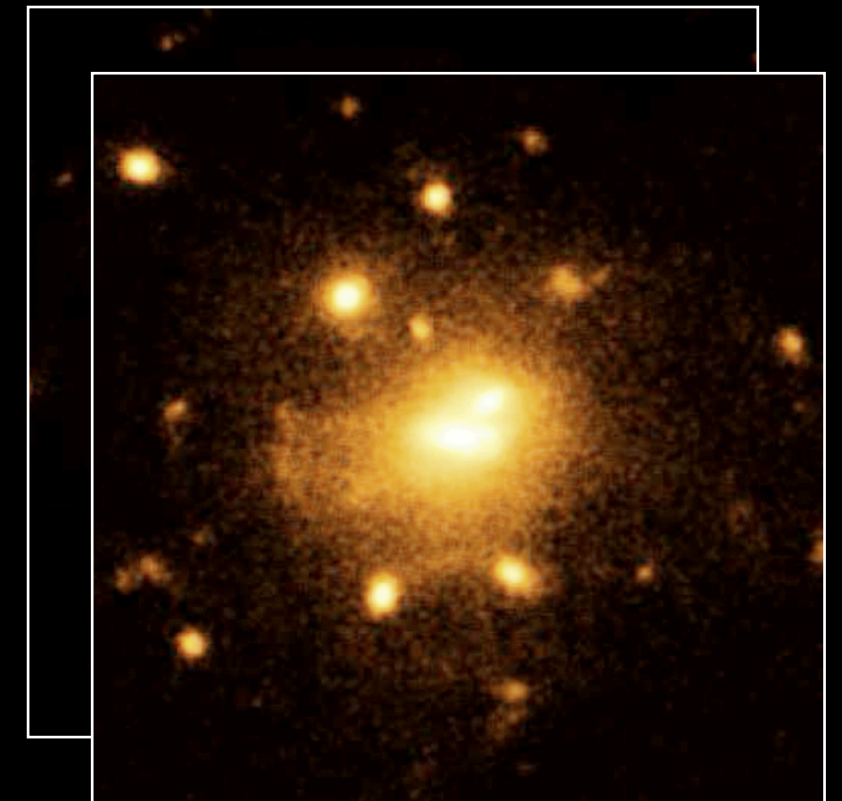
Pentericci+1997, Hatch+2009

Star-bursting proto-BCG fed by
“cooling flow”-like precipitation
(but not the only scenario)



Carilli+1997, Anderson+2022

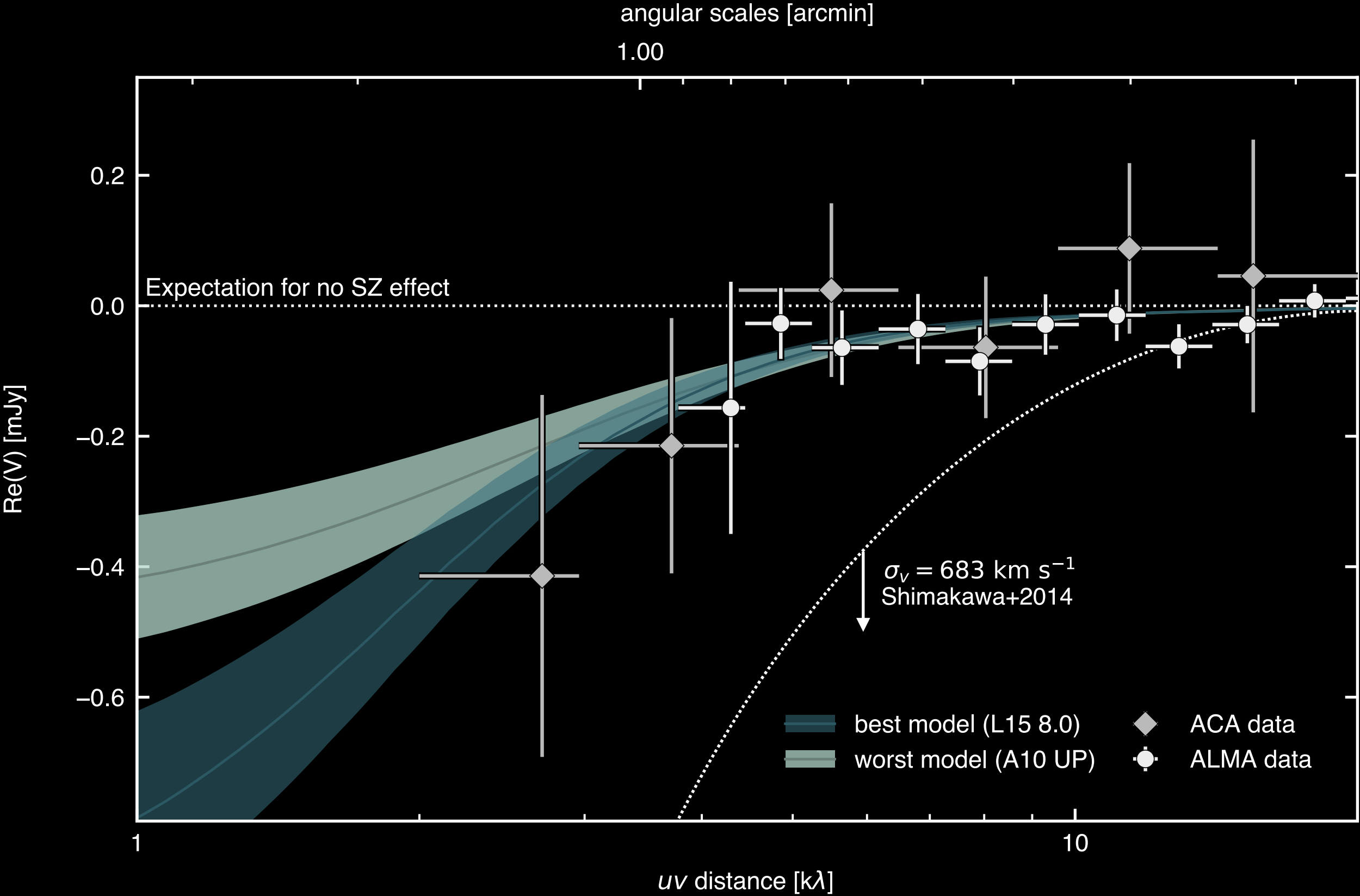
RMs generate in thin sheath of
hot gas around the radio jet



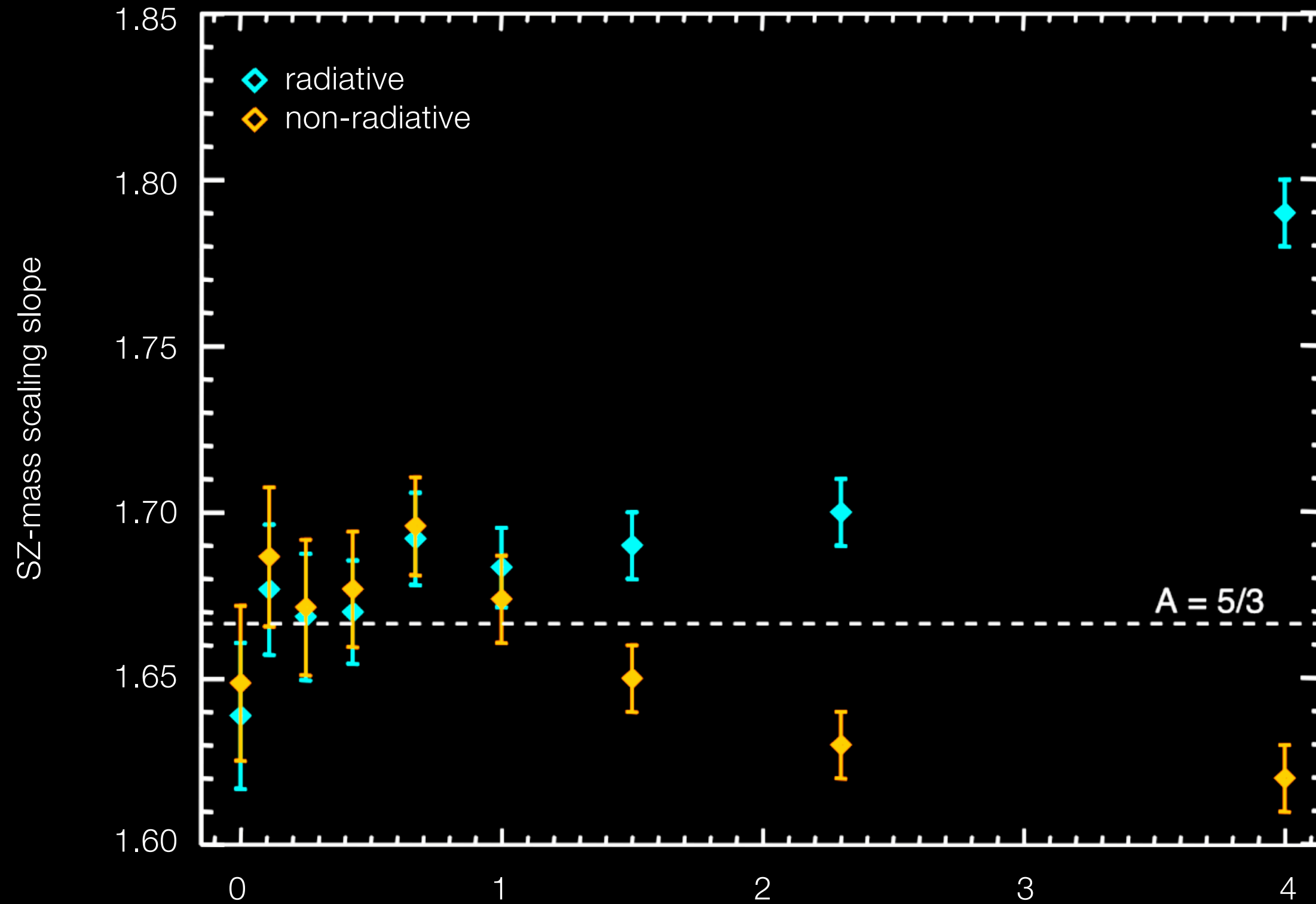
Saro+2009

simulated protoclusters with
gravitational potential permeated
by ICM at 2-5 keV

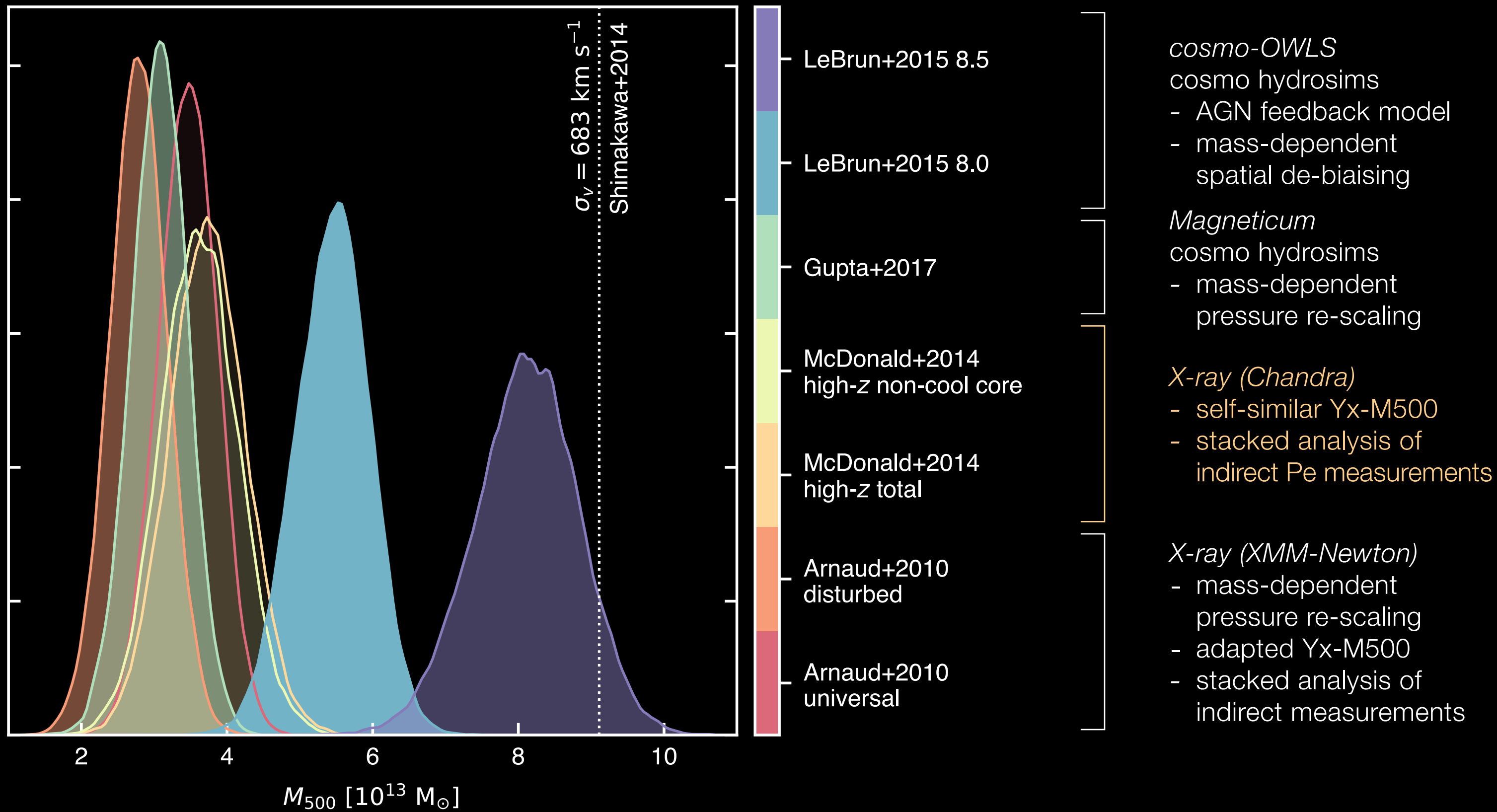
faint SZ signal



faint SZ signal...or deviation from self-similarity?

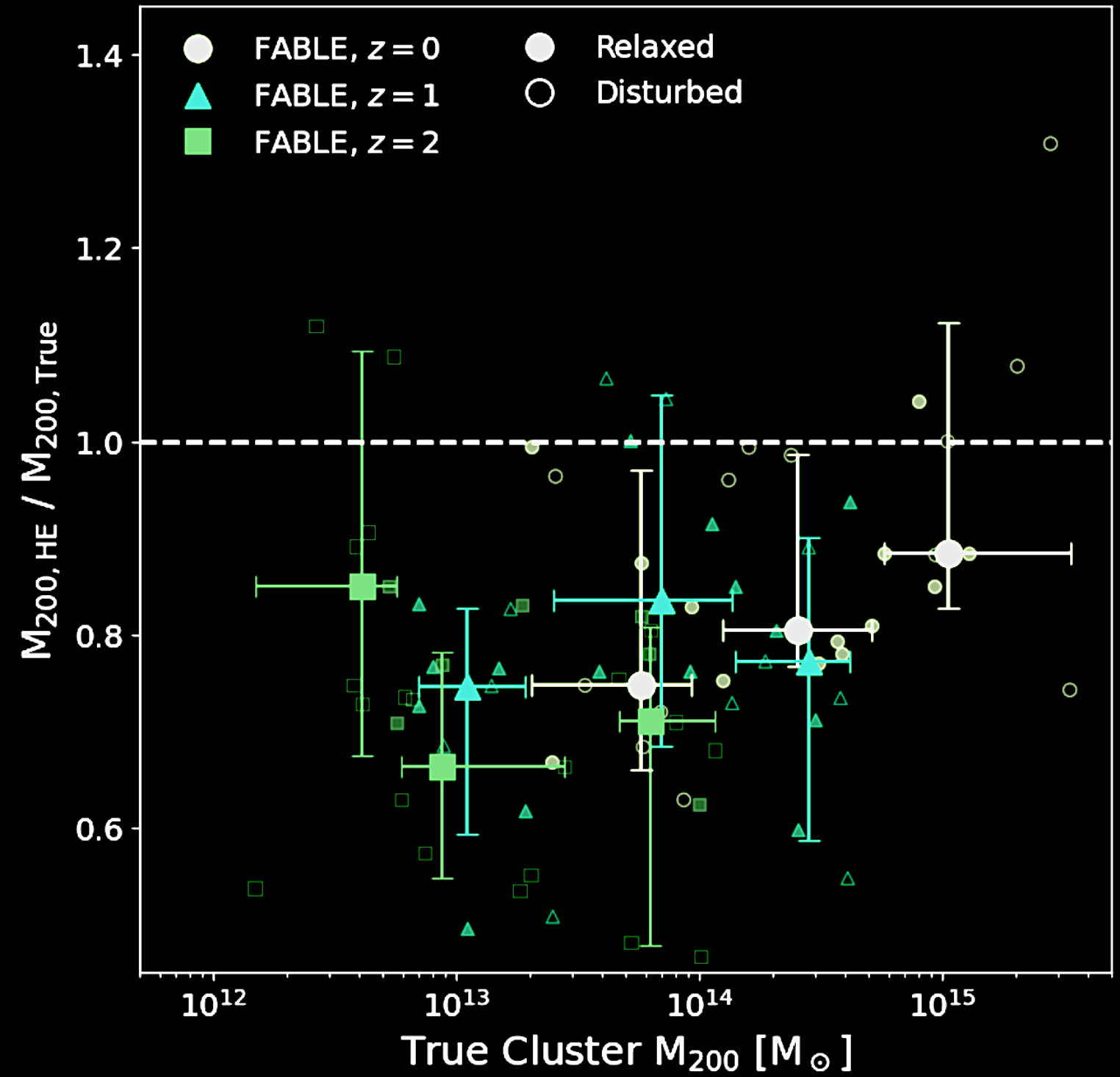
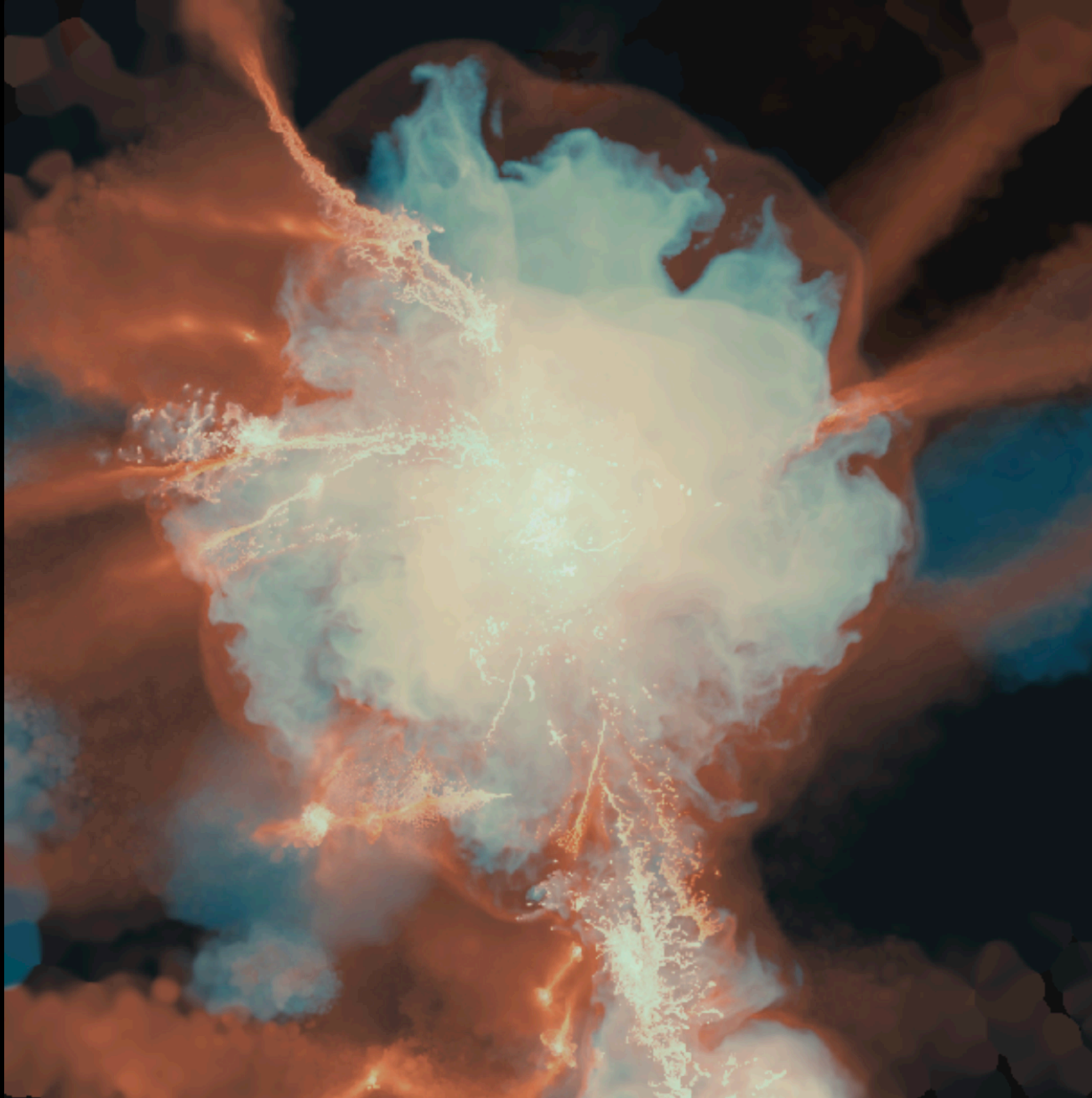


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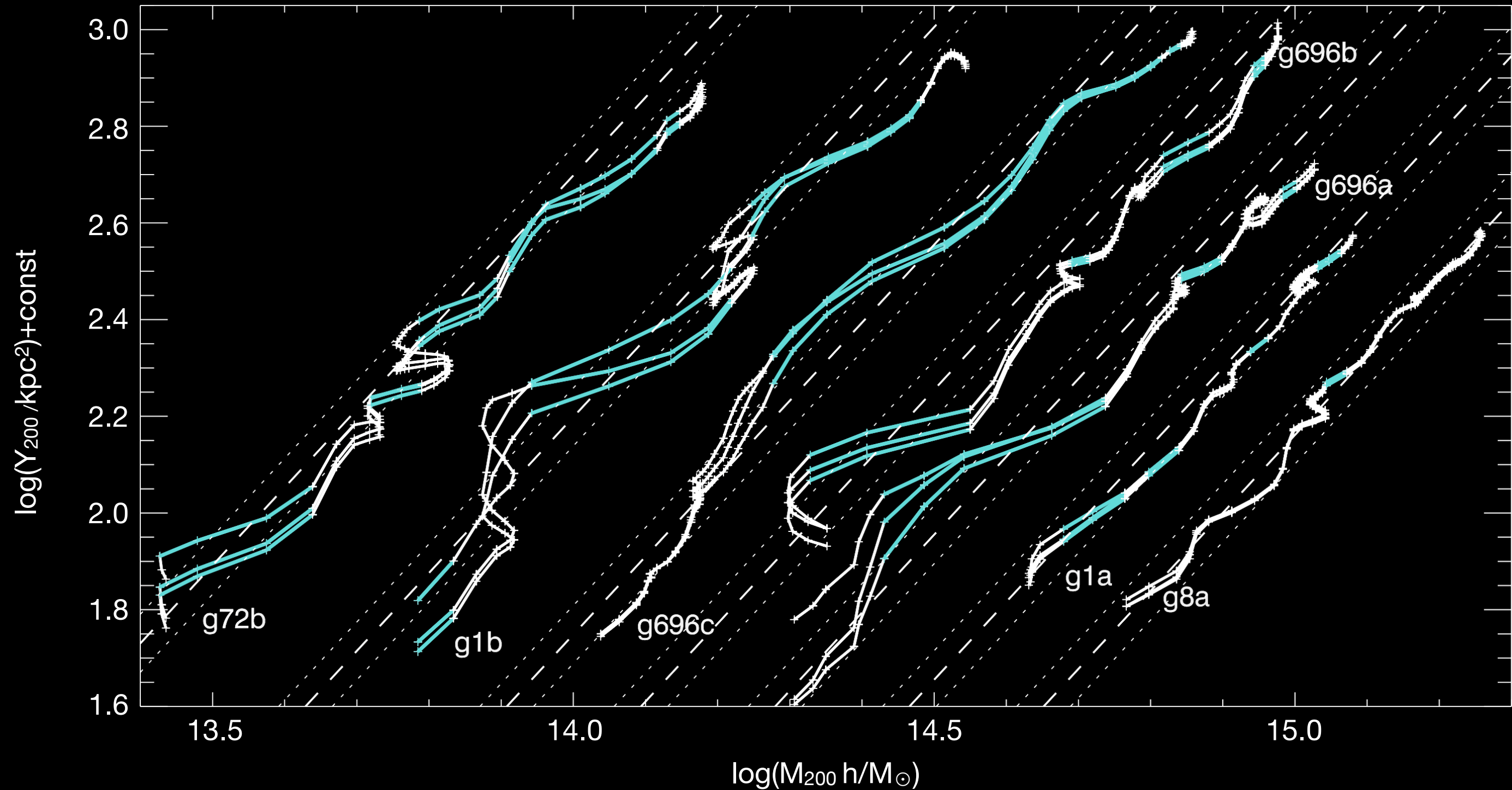
faint SZ signal...or systematics?

1. non-thermal pressure support



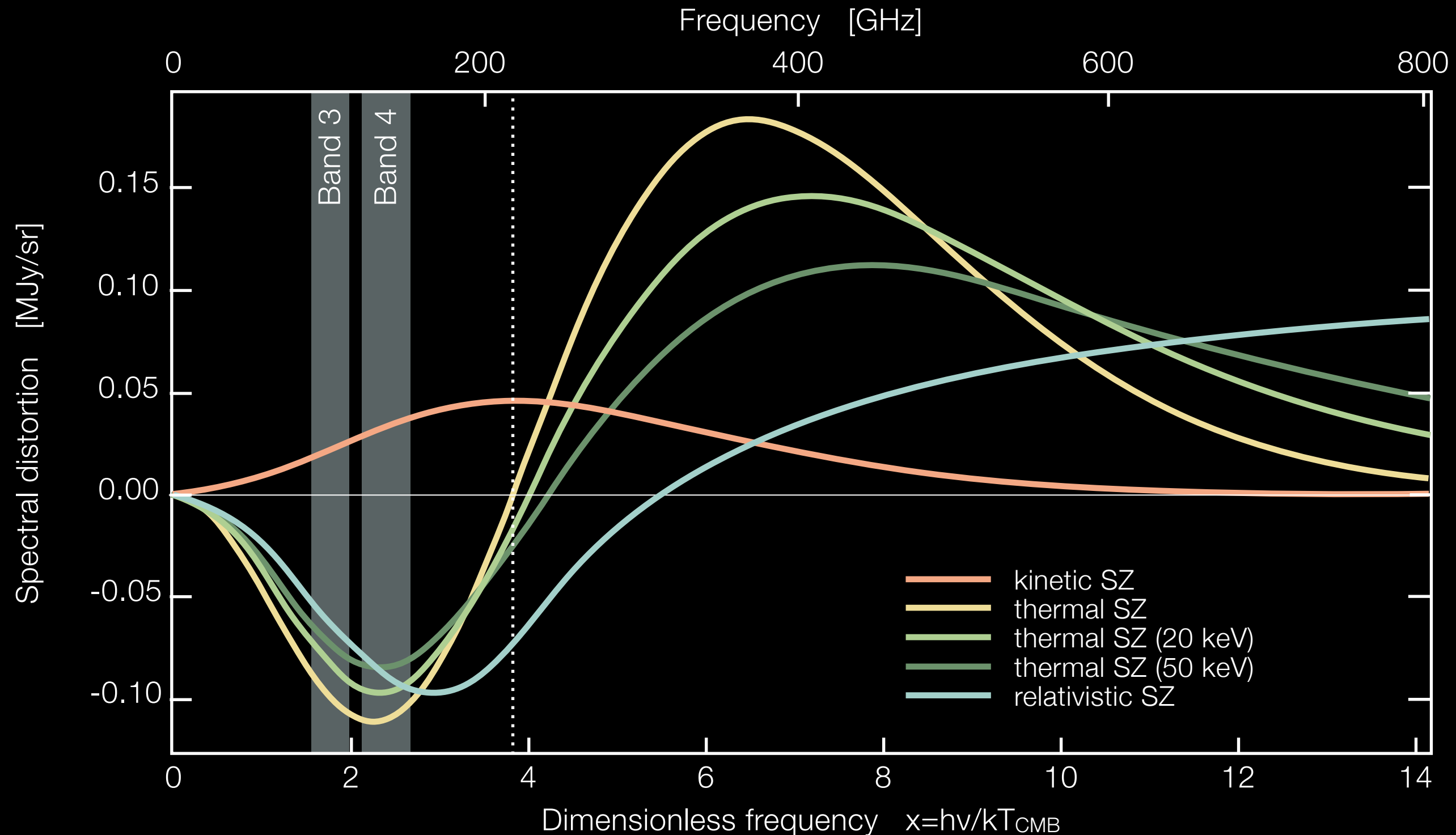
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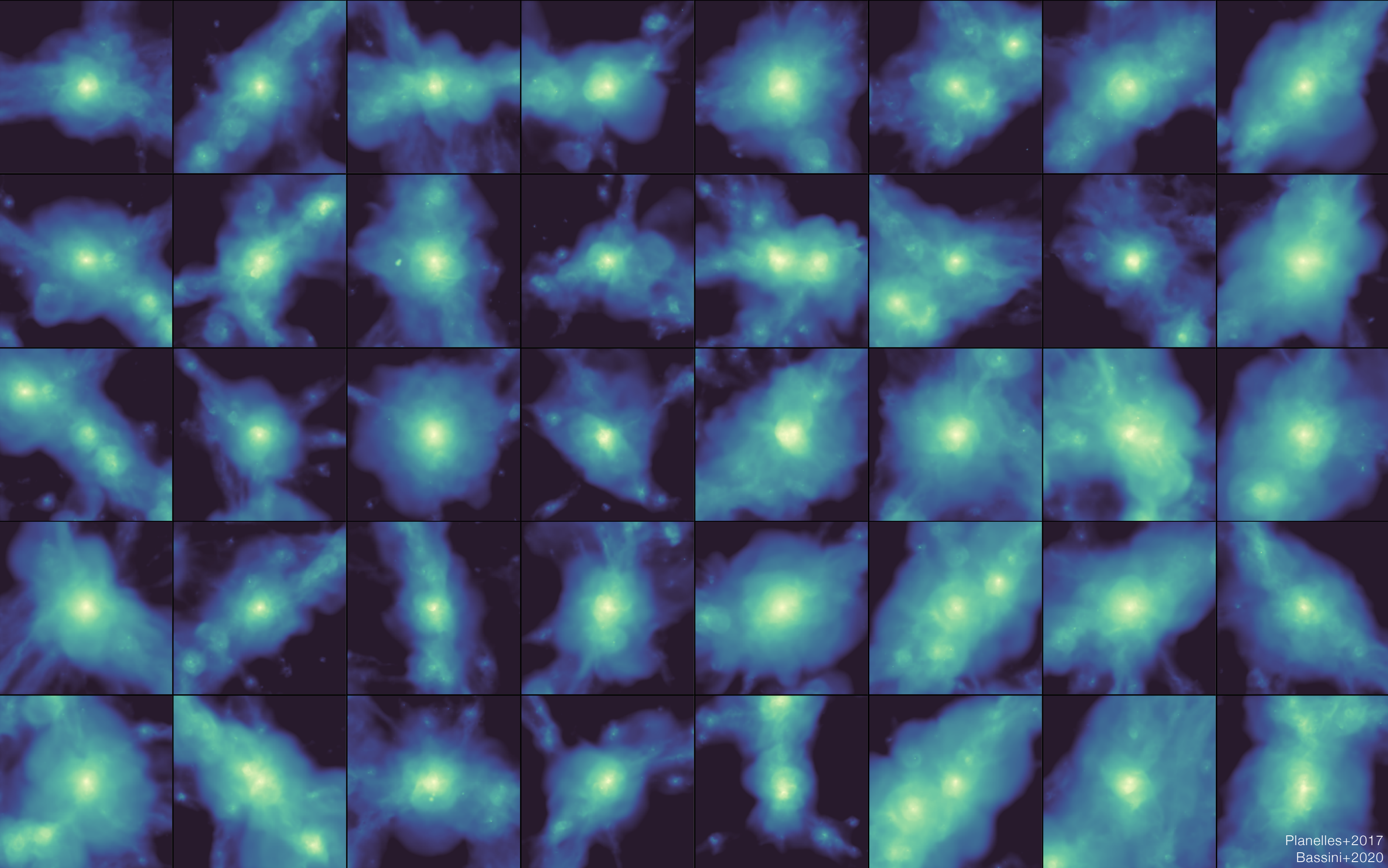
1. non-thermal pressure support
2. dynamical effects



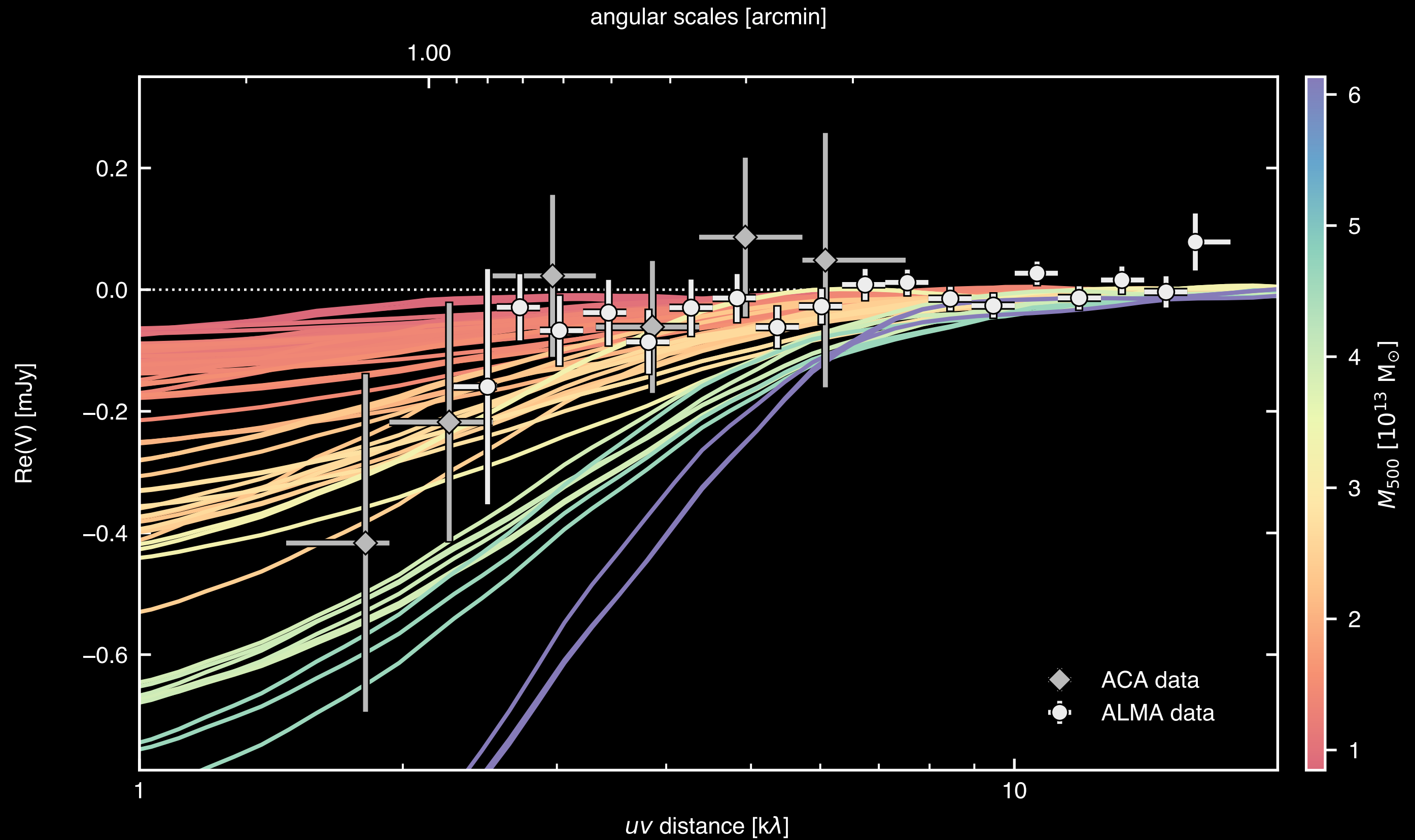
faint SZ signal...or systematics?

1. non-thermal pressure support
2. dynamical effects
3. many SZ flavours, residual contamination, ...





consistent results from cosmo hydrosims



SupReMo: a novel free-form modelling tool

l1 reweighting

proximal update

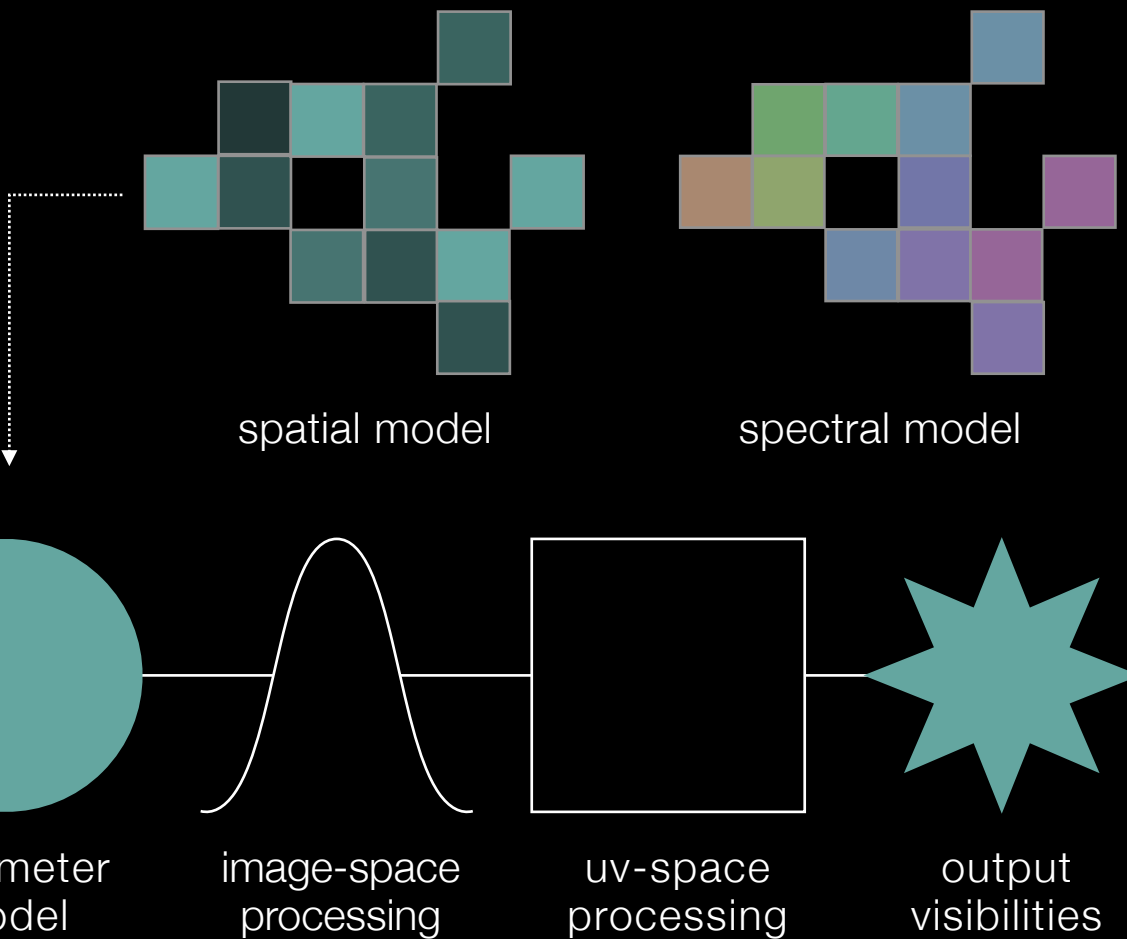
block selection

**free-form
reconstruction**

*extended
radio emission*

**analytical
modelling**

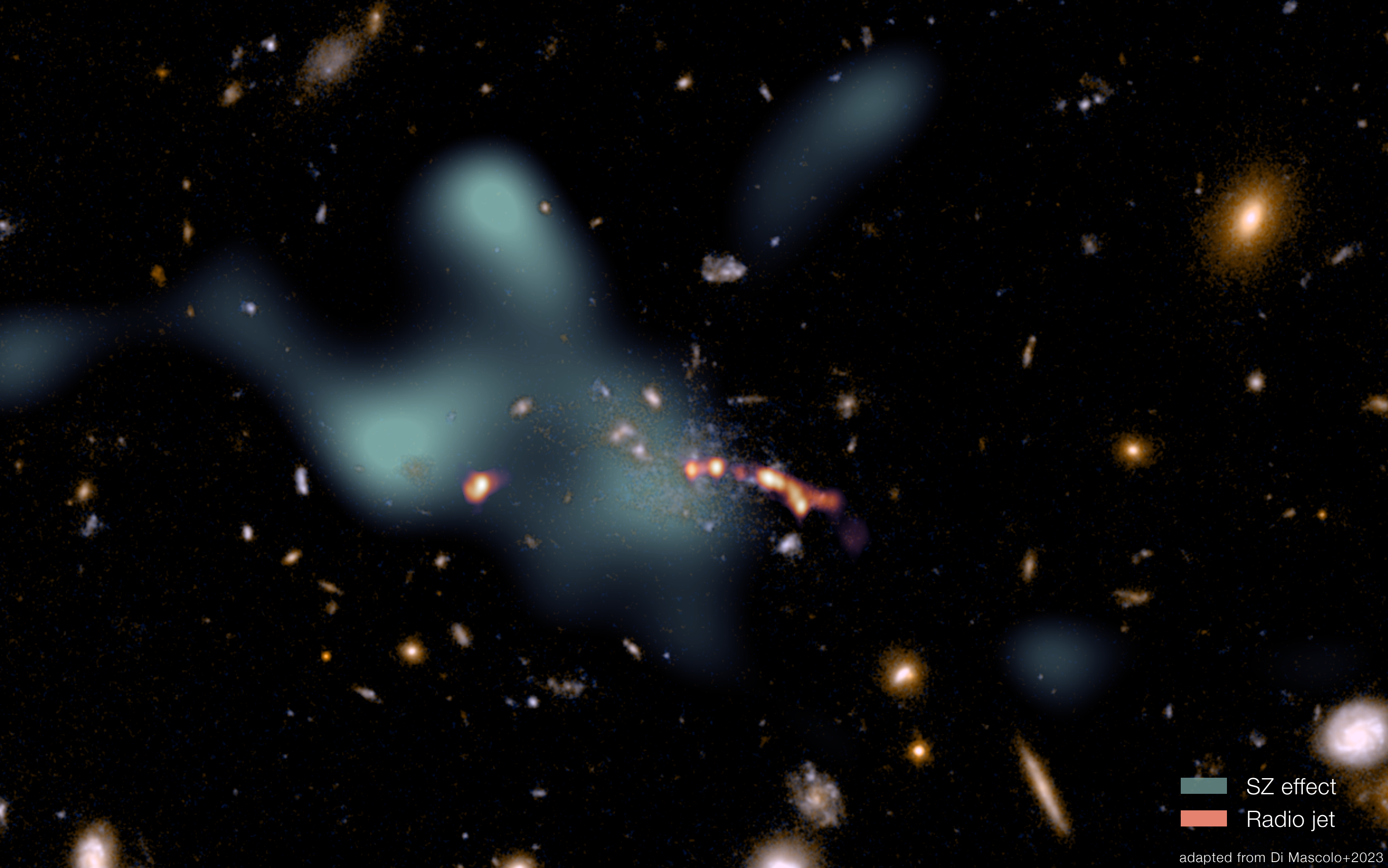
*SZ effect and
compact sources*





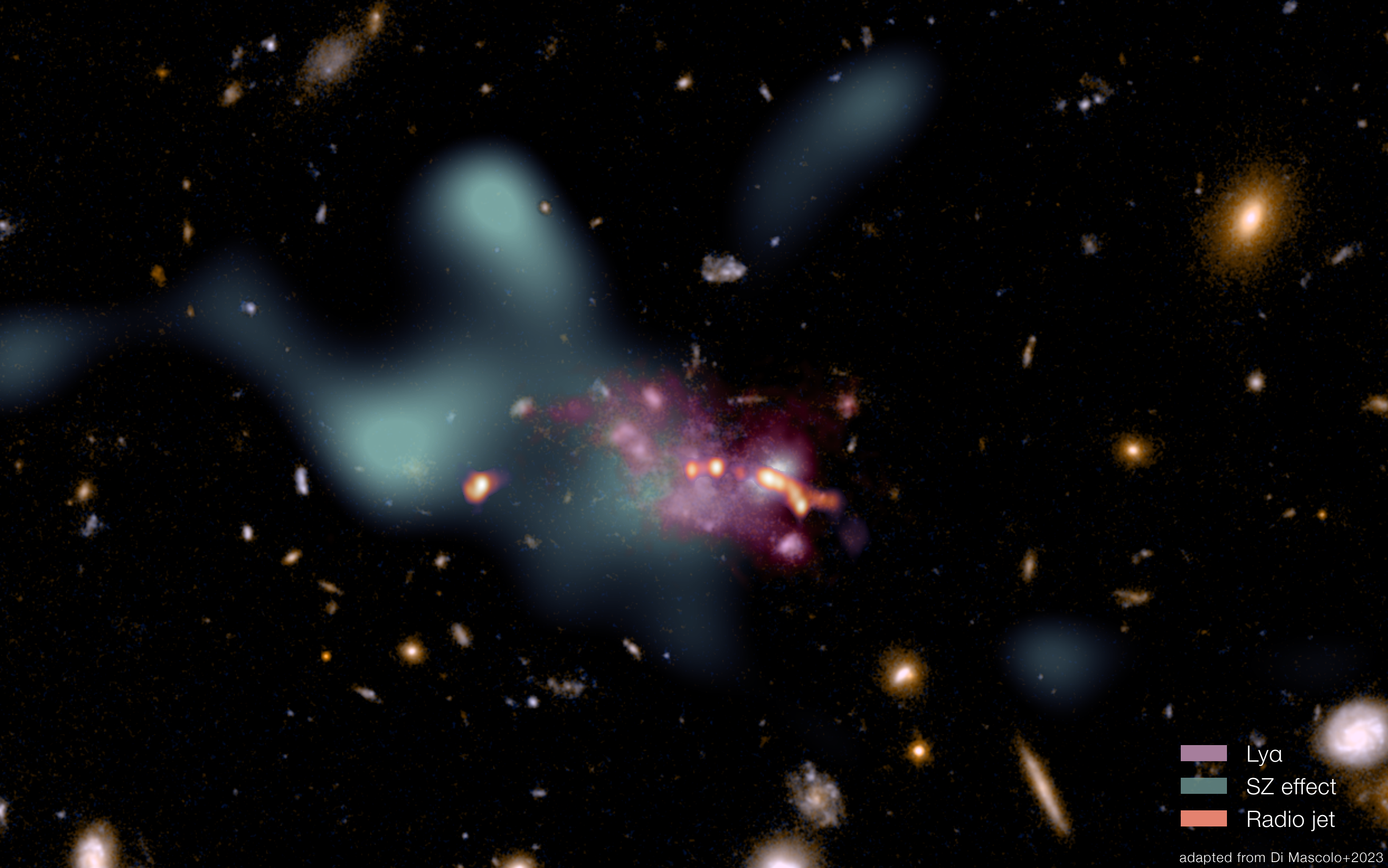
Radio jet

adapted from Di Mascolo+2023



SZ effect
Radio jet

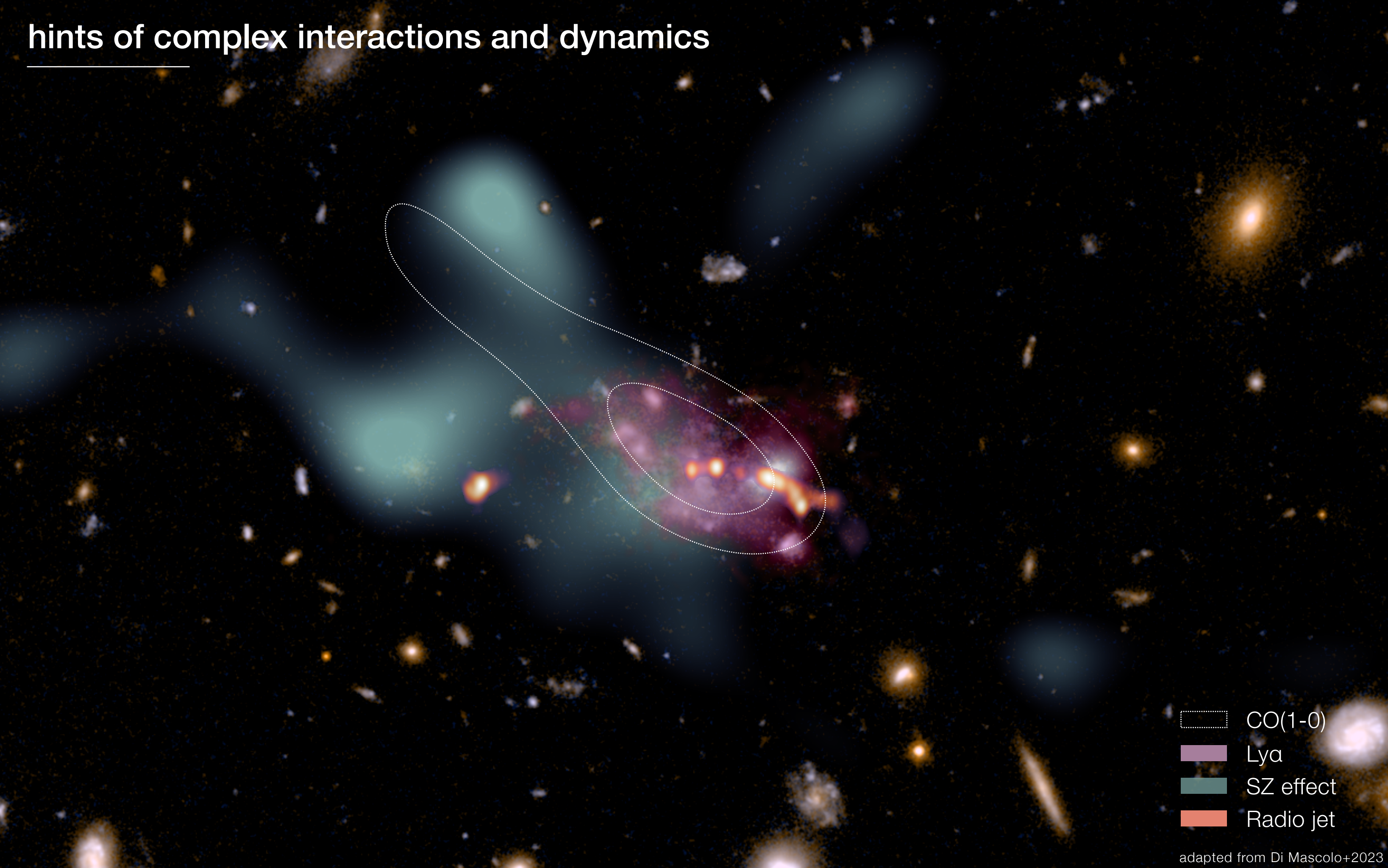
adapted from Di Mascolo+2023



Ly α
SZ effect
Radio jet

adapted from Di Mascolo+2023

hints of complex interactions and dynamics



- CO(1-0)
- Ly α
- SZ effect
- Radio jet

hints of complex interactions and dynamics

extended CO tail
(Emonts+2013)

asymmetric
Ly α morphology
(Miley+2006, Anderson+2022)

hybrid morphology
(Pentericci+1997, Carilli+2022)

- CO(1-0)
- Ly α
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hints of complex interactions and dynamics

extended CO tail
(Emonts+2013)

asymmetric
Ly α morphology
(Miley+2006, Anderson+2022)

buoyant cavities?
(Tozzi+2022)

hybrid morphology
(Pentericci+1997, Carilli+2022)

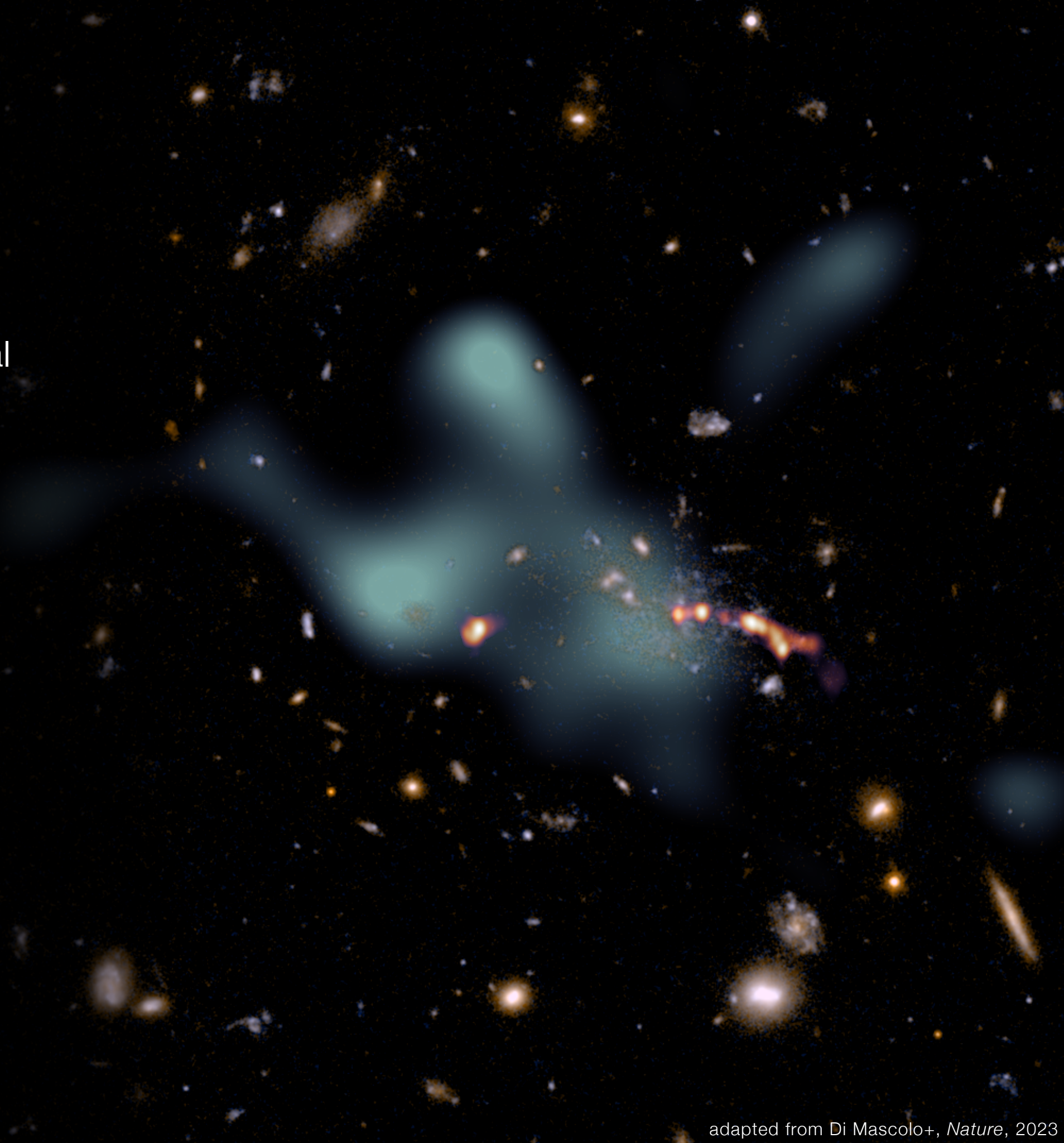
- CO(1-0)
- Ly α
- SZ effect
- Radio jet

conclusions

For the first time, ALMA is allowing us to witness the **emergence of proto-ICM** in a protocluster complex

The SZ effect provides a reliable observational probe for detecting hot (thermalised) gas with **virtually no limit in redshift**

A multiwavelength characterisation highlights an **extreme dynamical state**, with complex interplay between multiple gas phases



conclusions

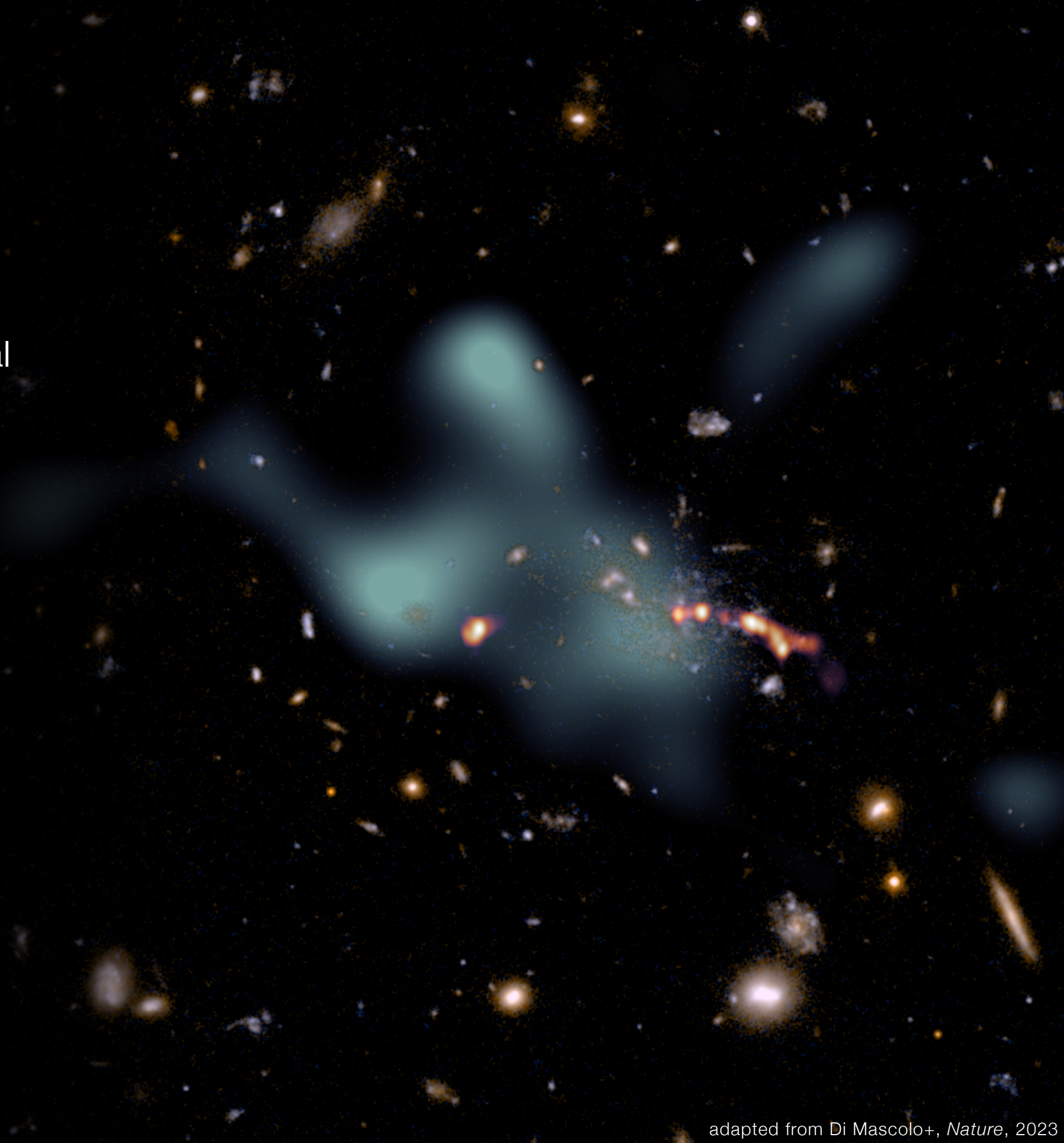
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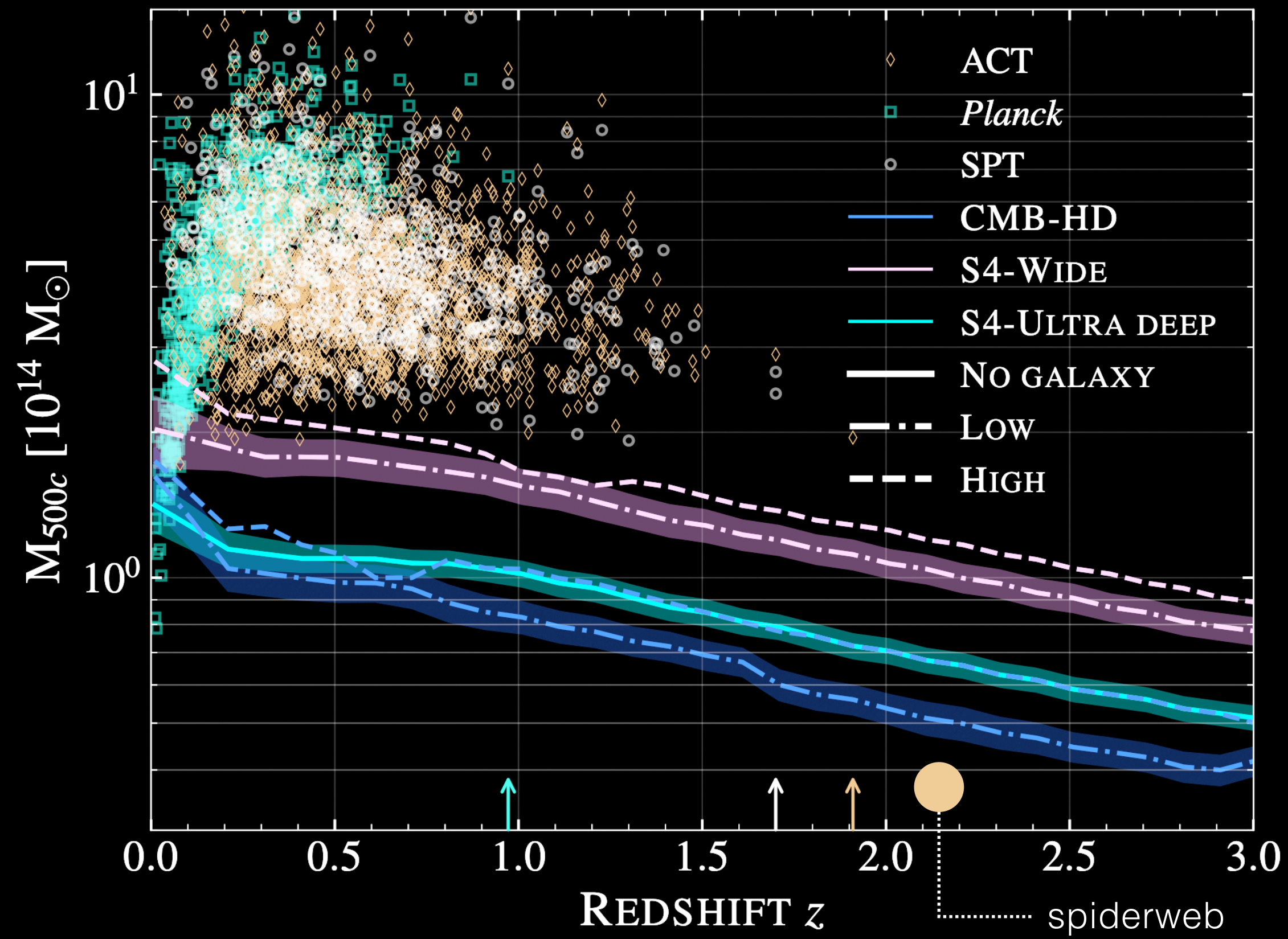
A multiwavelength characterisation highlights an **extreme dynamical state**, with complex interplay between multiple gas phases

how and **when** the multi-phase protocluster gas turn into extended ICM?

how different mechanisms contribute to **heating** the proto-ICM?



looking forward, at last

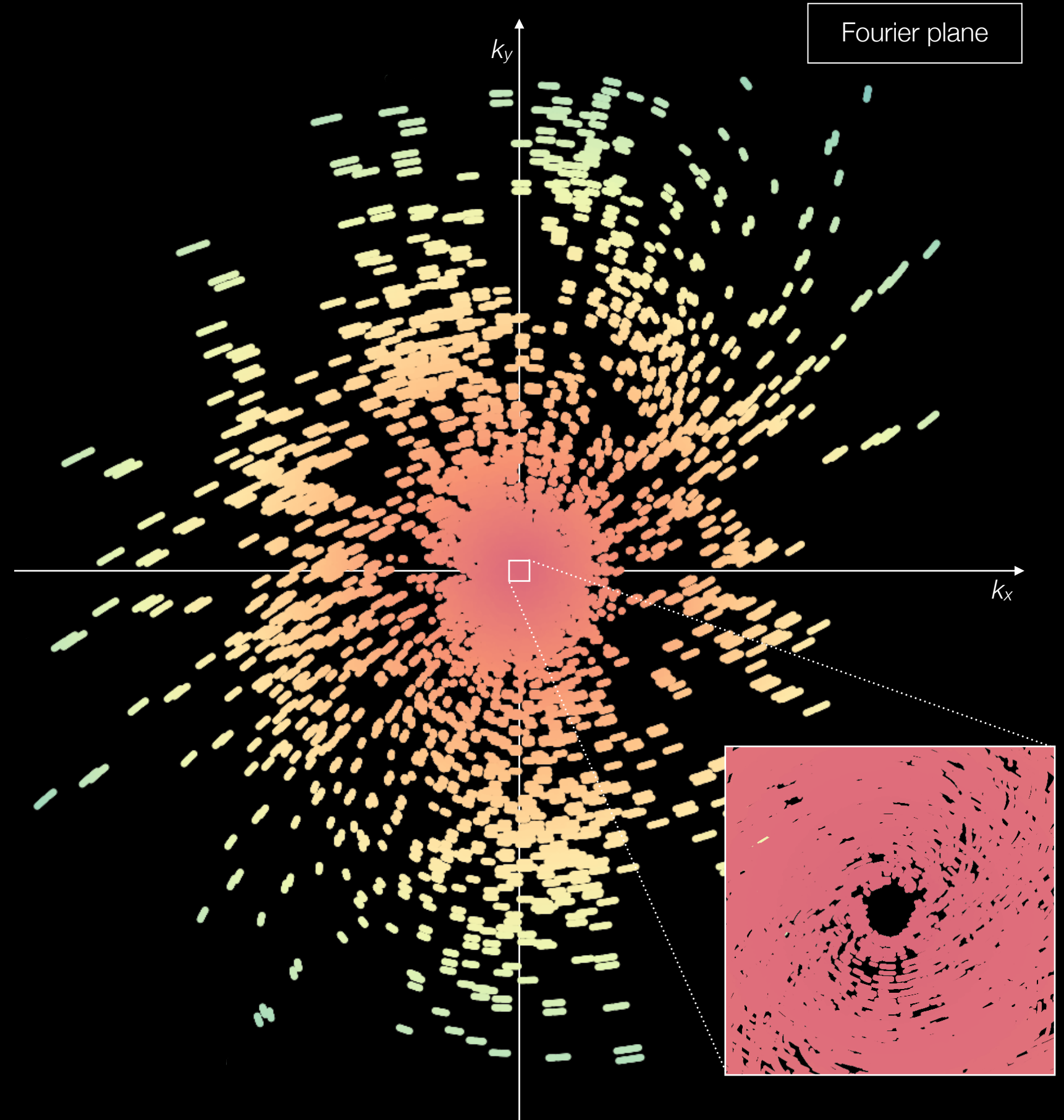


a high-pass filtered view of the Universe

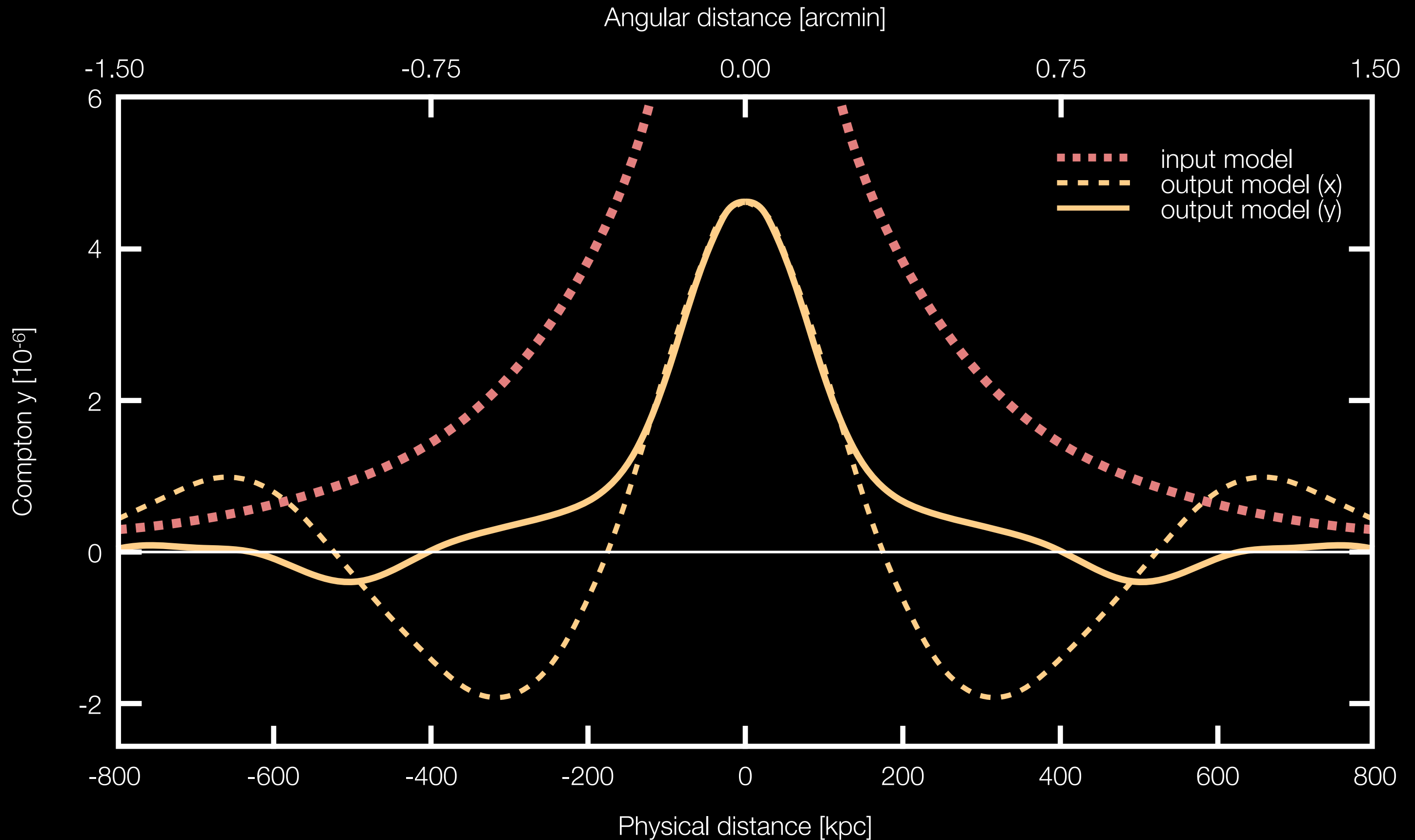
large-scale Fourier modes not observed,
resulting in **dramatic information loss**

existing imaging tools not optimised
for reconstruction of large-scale/SZ signal

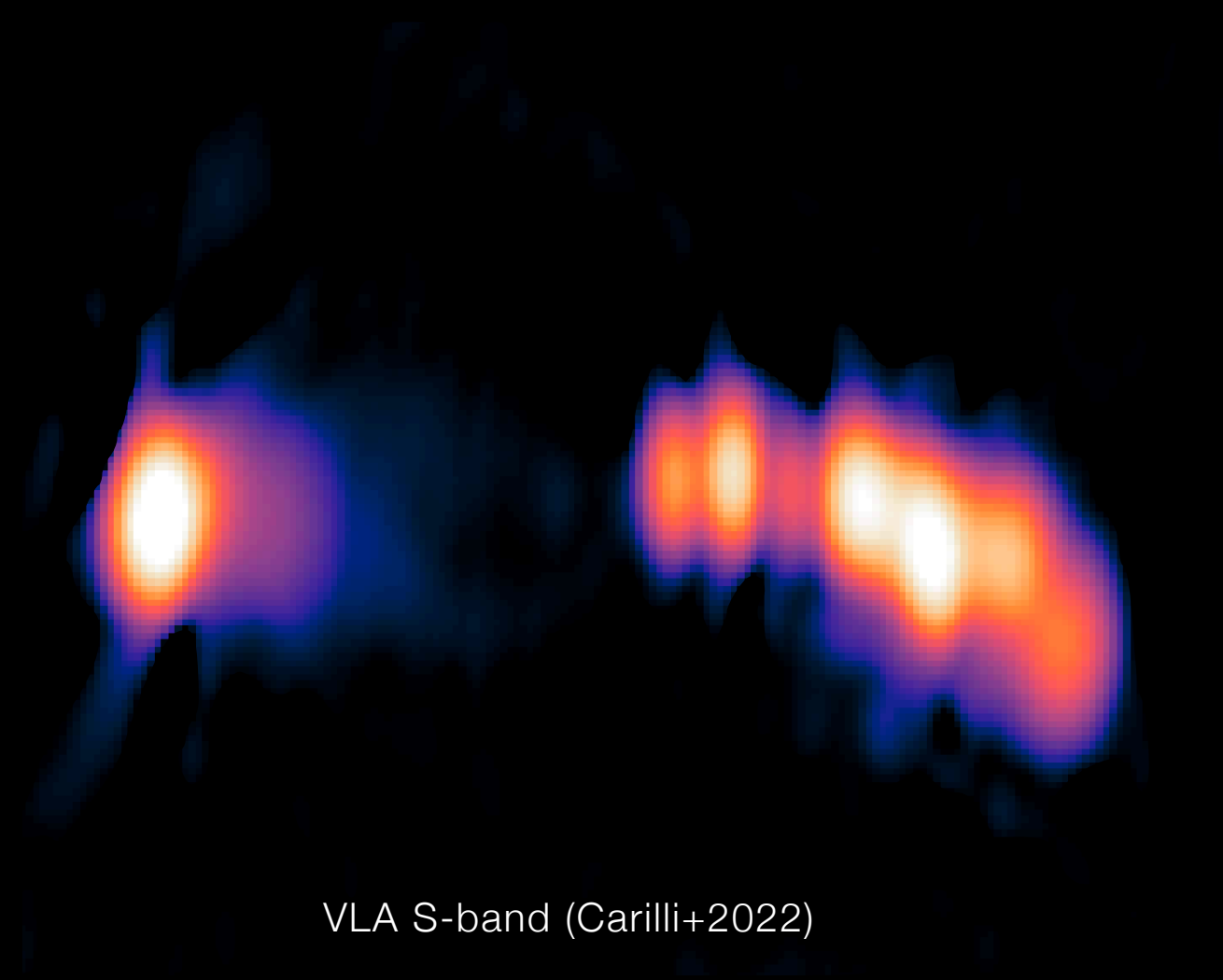
modelling techniques limited by
lack of adequate descriptions



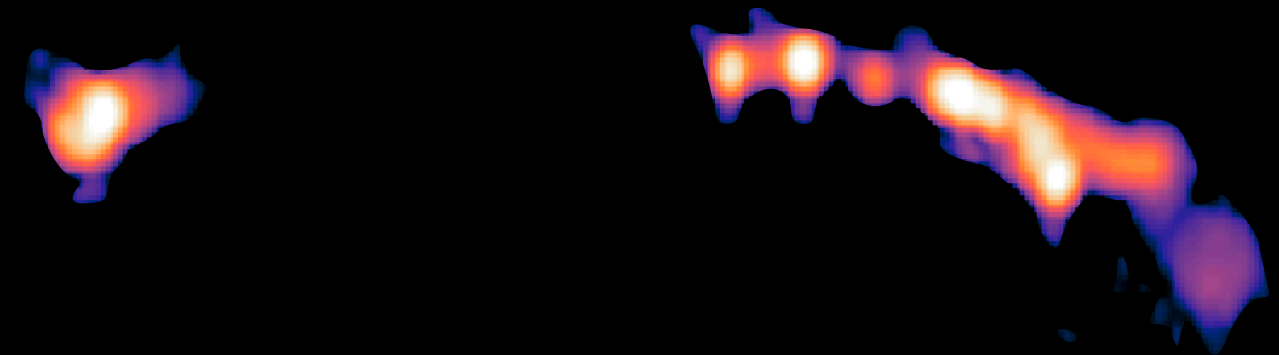
a high-pass filtered view of the Universe



morphologically complex “contamination”



VLA S-band (Carilli+2022)



VLA X-band (Carilli+2022, Anderson+2022)

multiwavelength support

