The birth of the giants: Where do the first quasars form?

Emanuele Paolo Farina [MPIA]

THQ:
- Fabian Walter
- Bram Venemans
- Roberto Decarli
- Eduardo Bañados
- Chiara Mazzucchelli

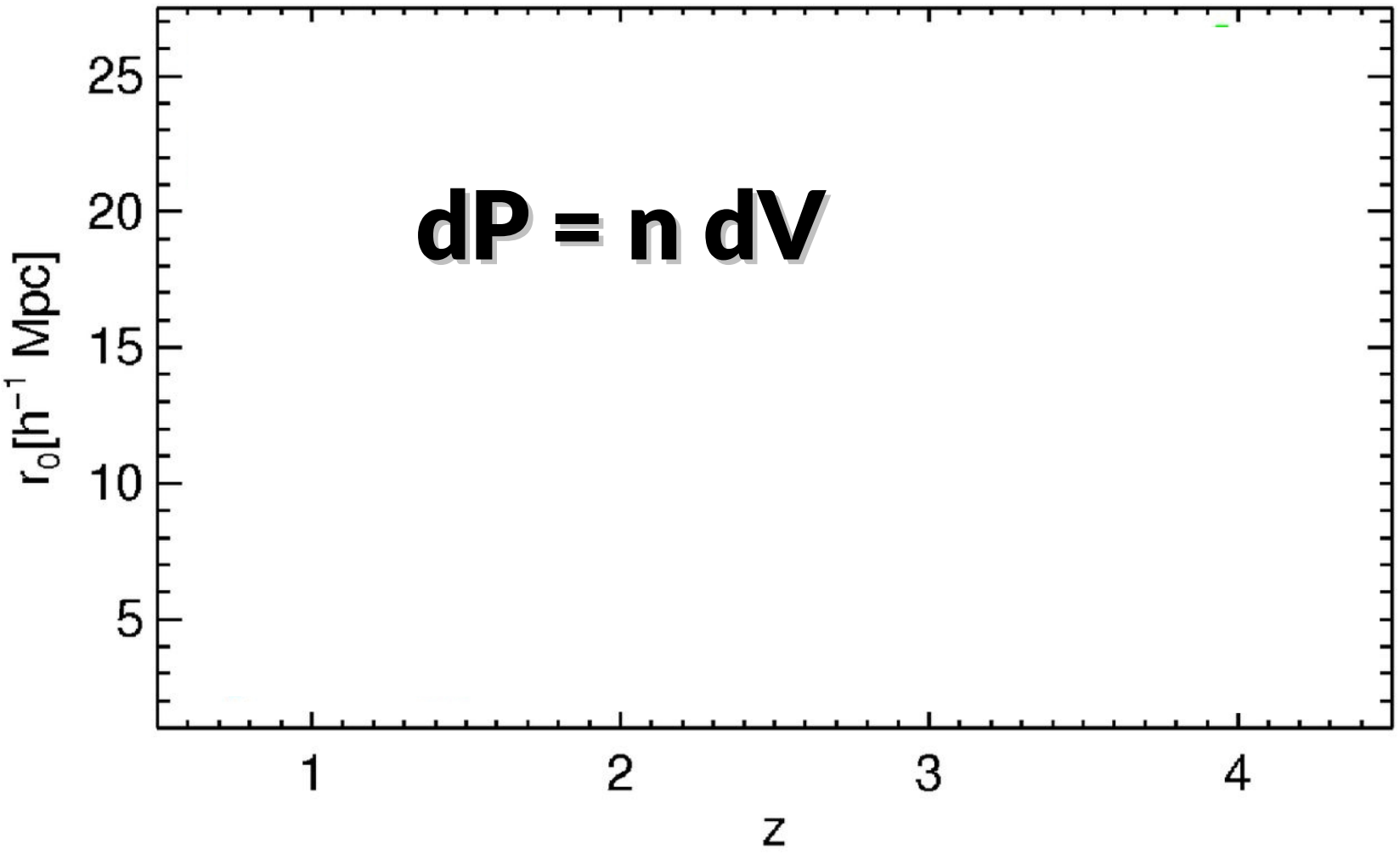
Extended THQ:
- Xiaohui Fan
- Benjamin Weiner
- Joe Hennawi
- Fabrizio Arrigoni-Battaia
- Sebastiano Cantalupo
- and many more..

ABELL 1689

$M_{vir} \sim 2 \times 10^{15} M_{sun}$ @ z~0.2

QSO Clustering

QSO-QSO Correlation Length vs. Redshift



Eftekharzadeh et al. 2015

QSO Clustering

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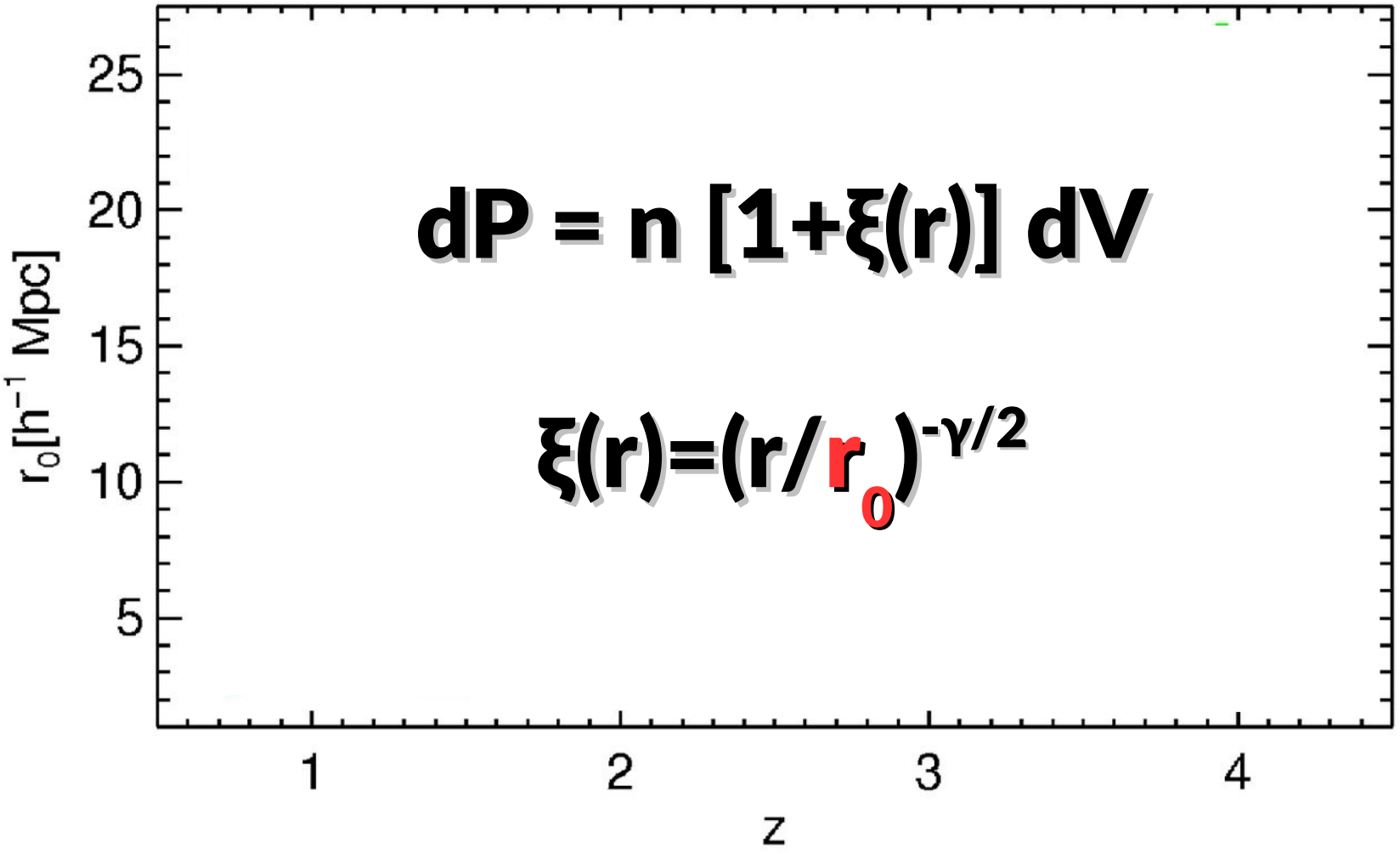

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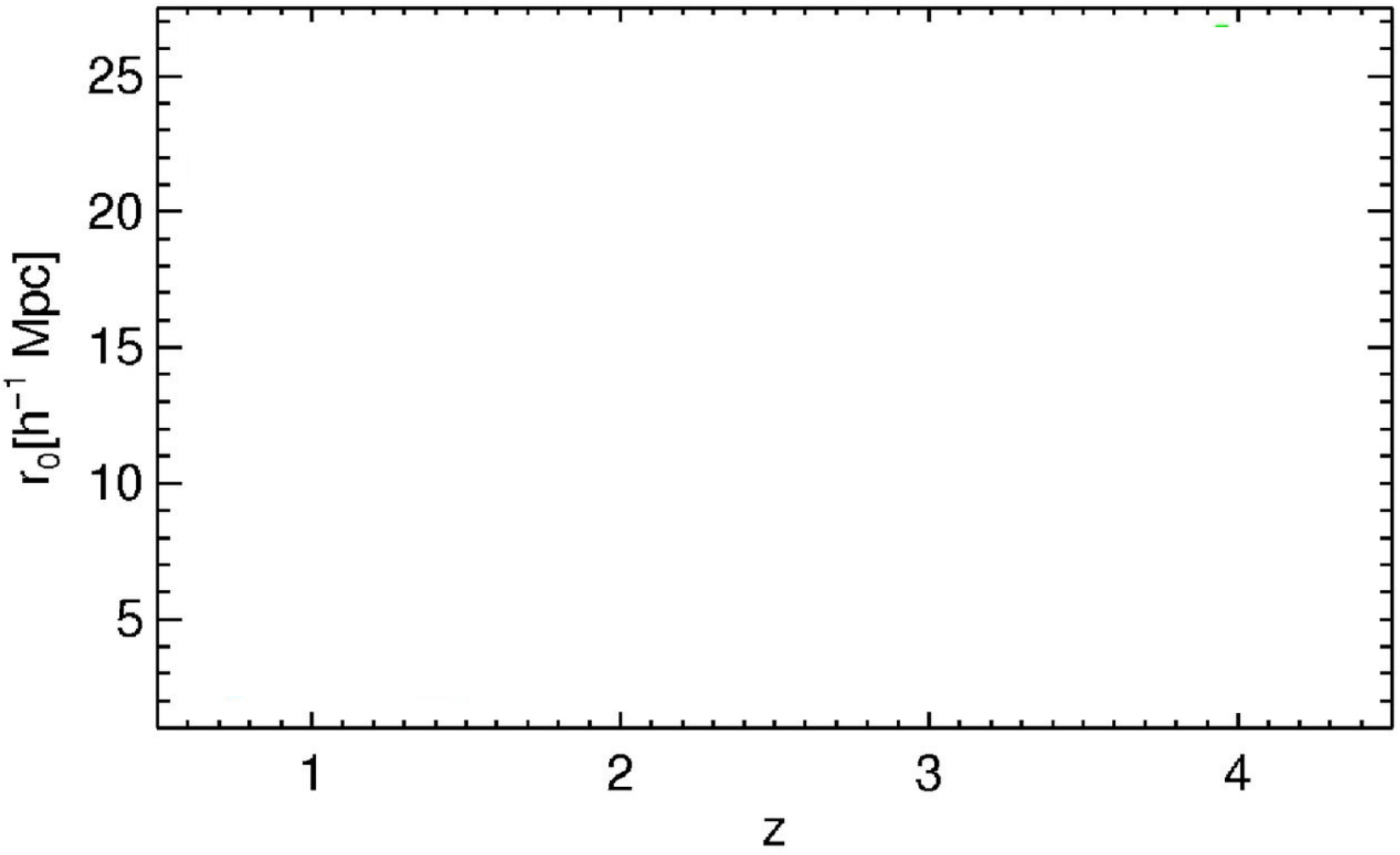

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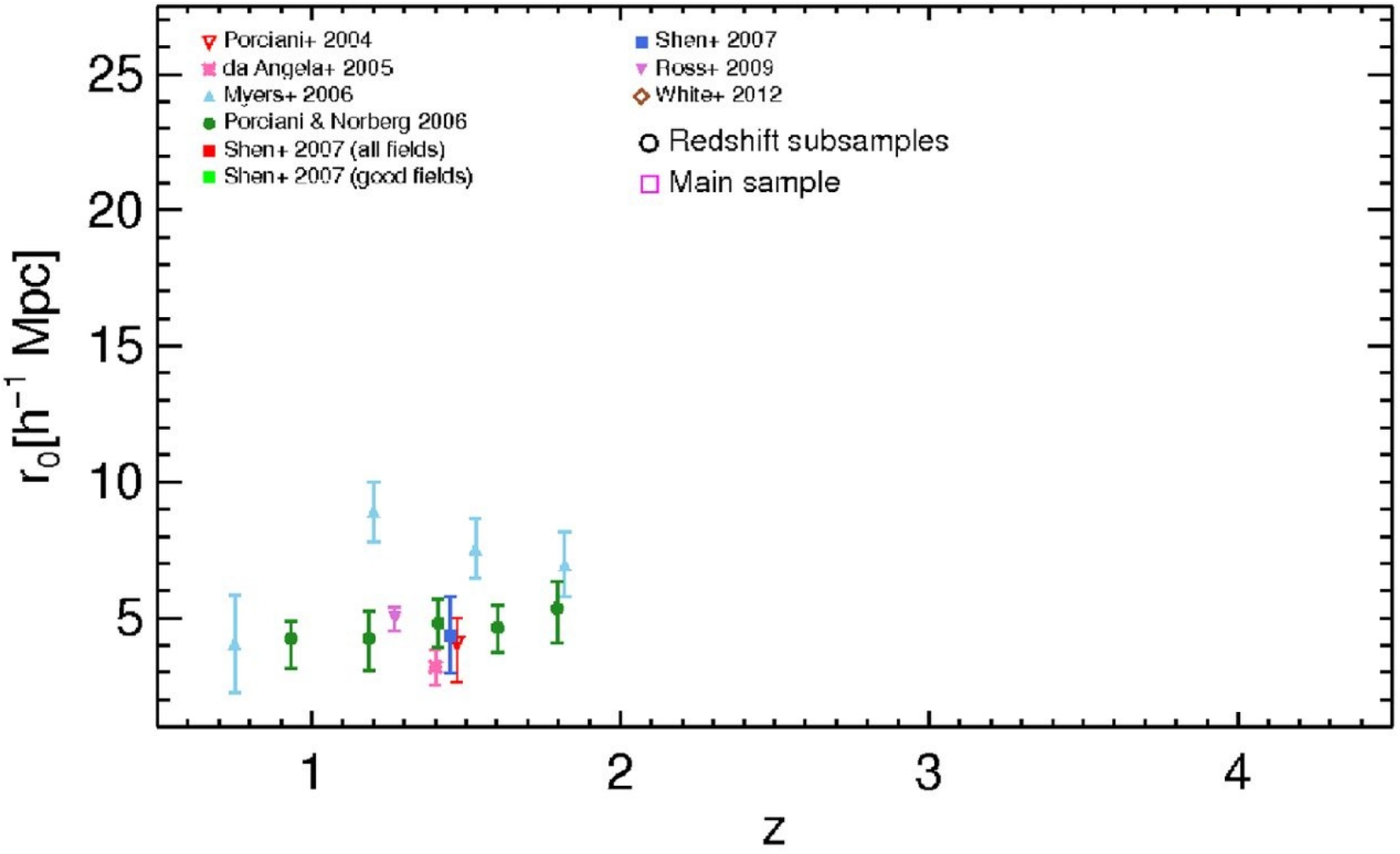

Eftekharzadeh et al. 2015

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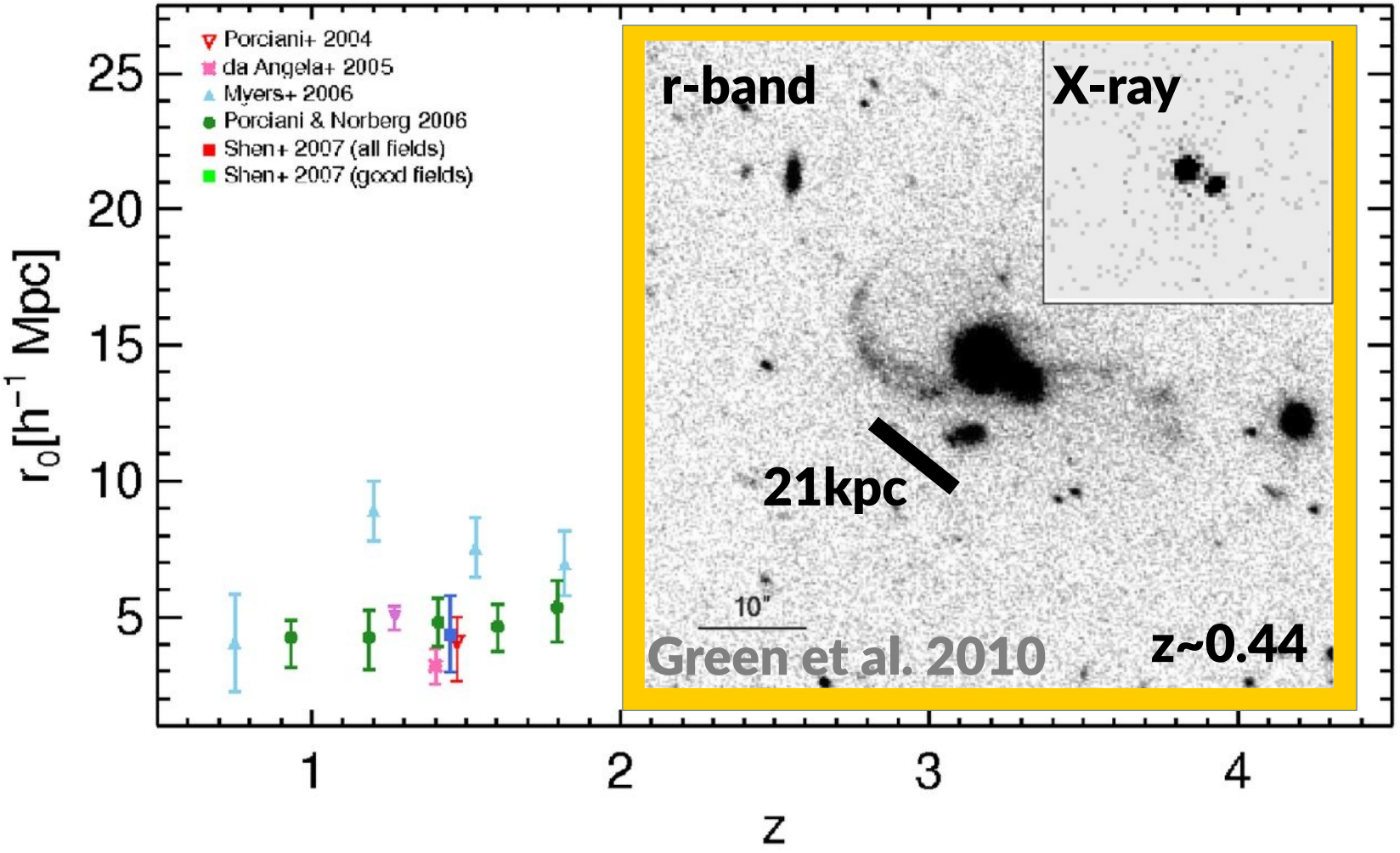

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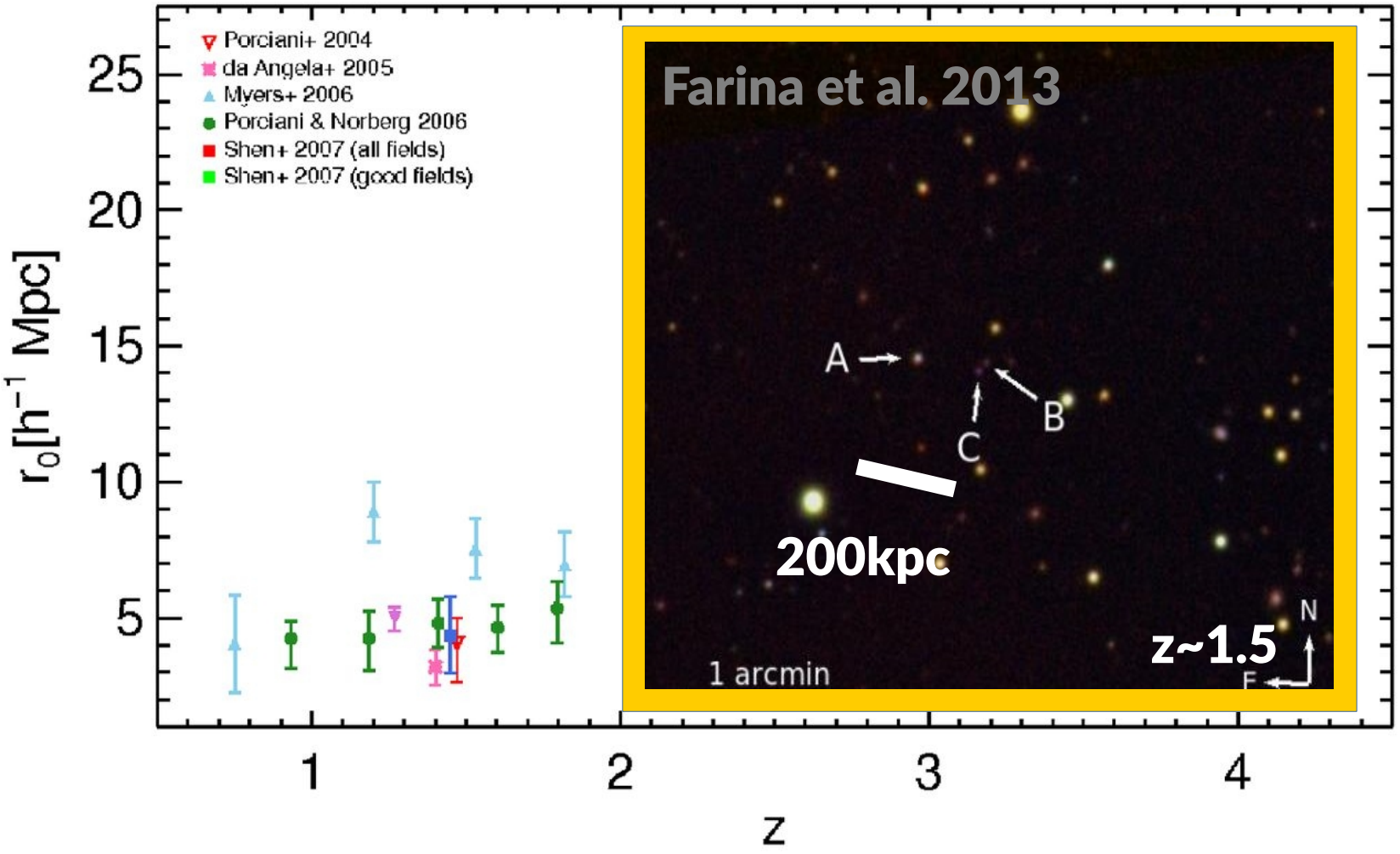

Eftekharzadeh et al. 2015

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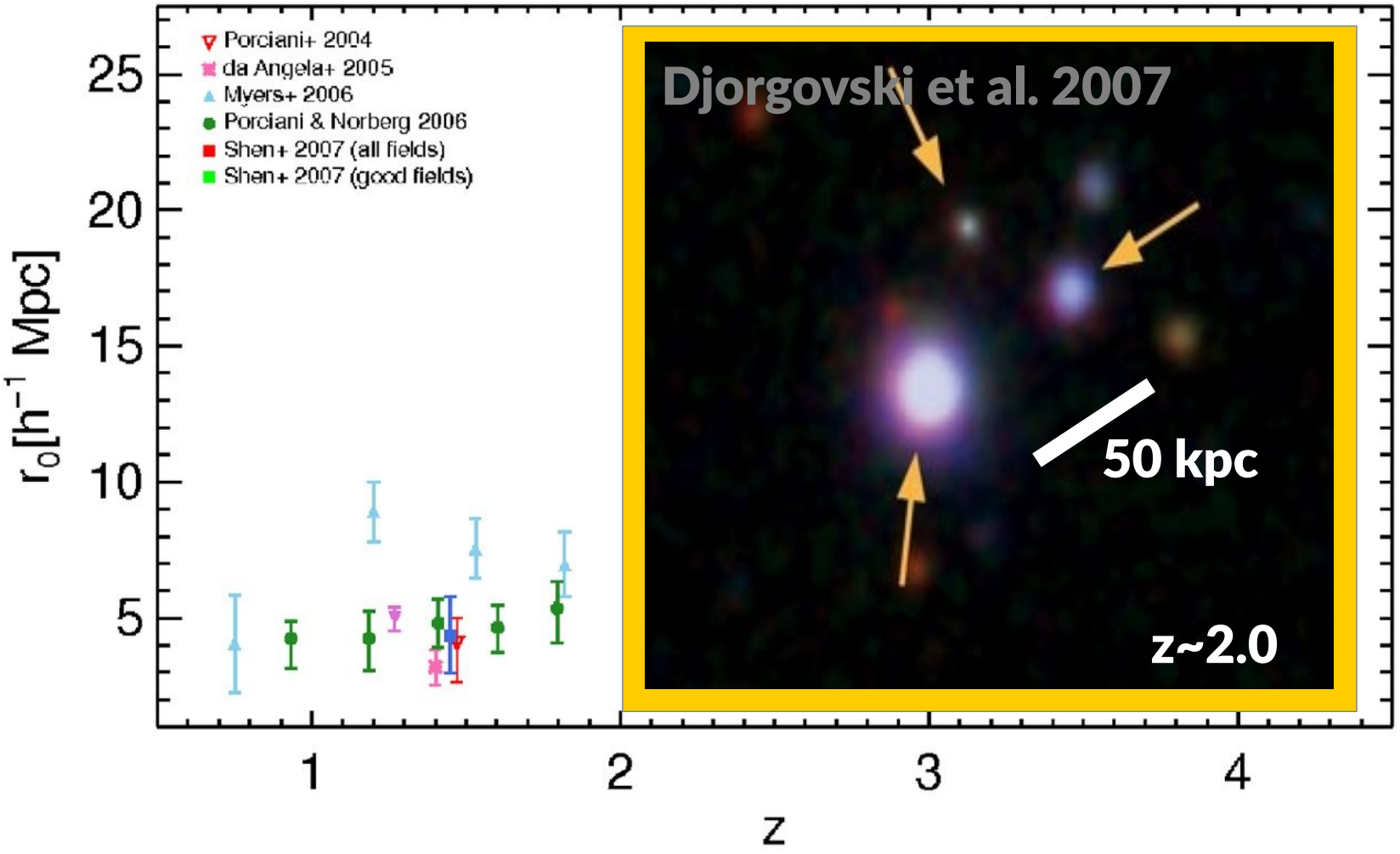

Eftekharzadeh et al. 2015

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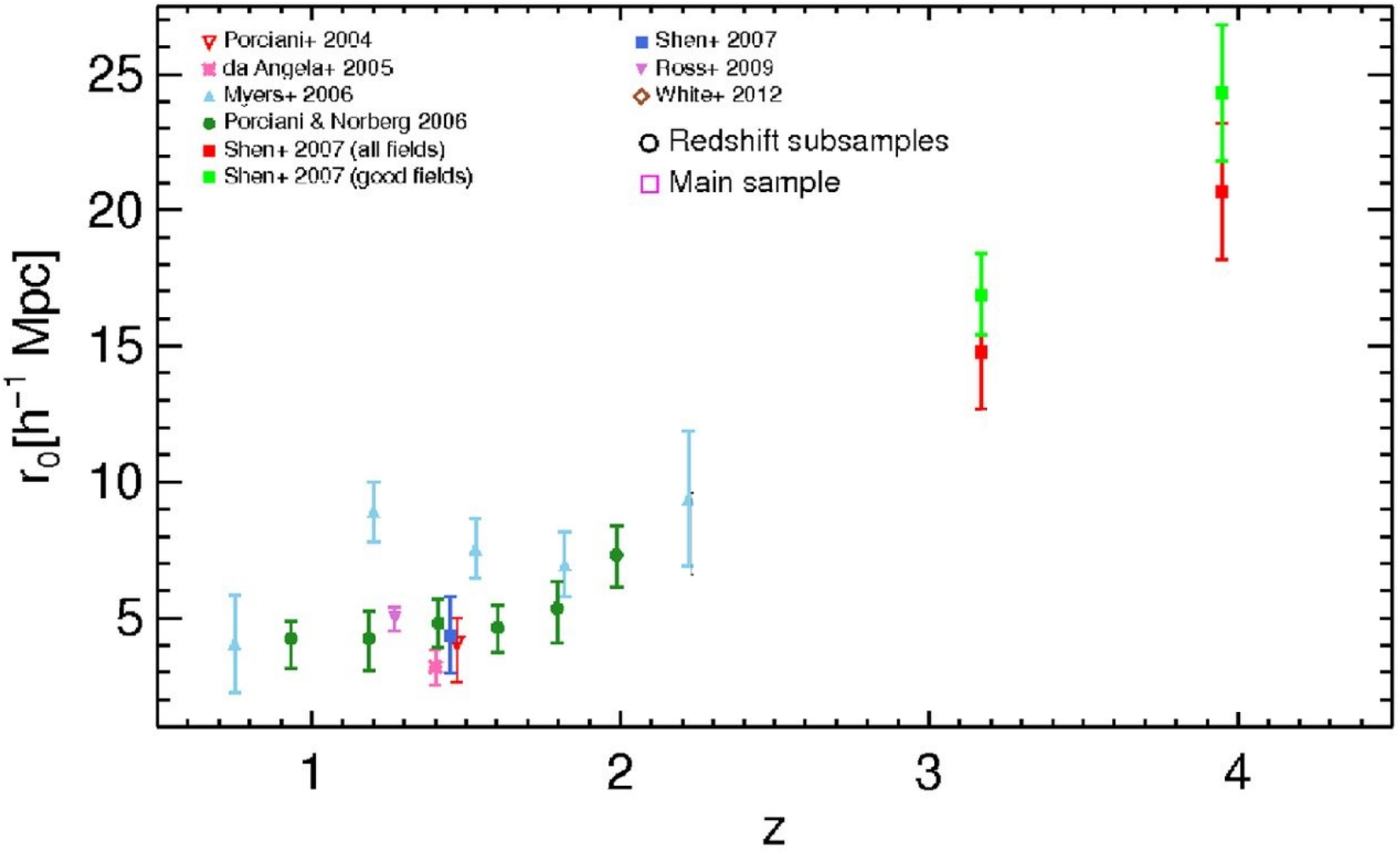

Eftekharzadeh et al. 2015

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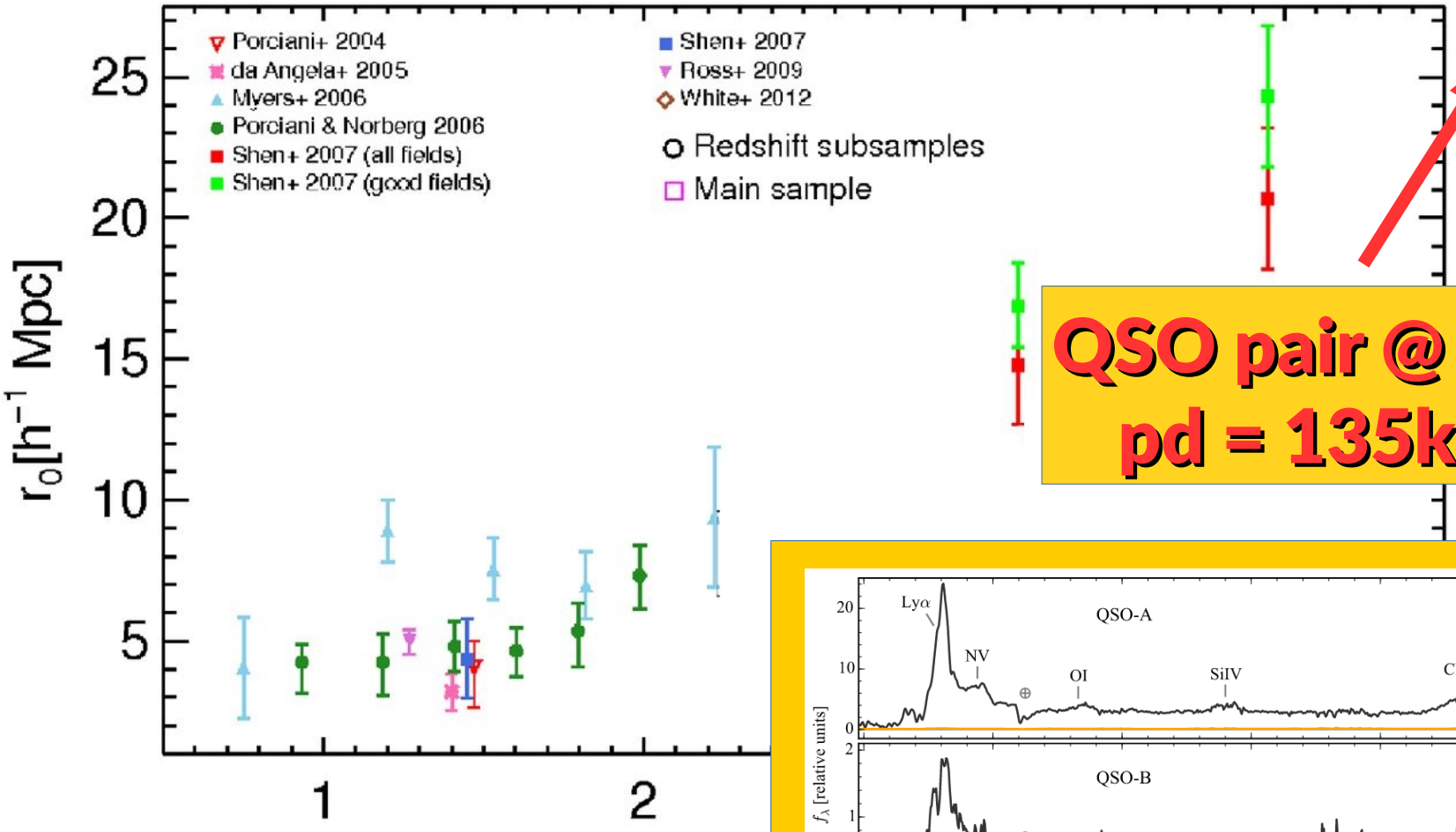
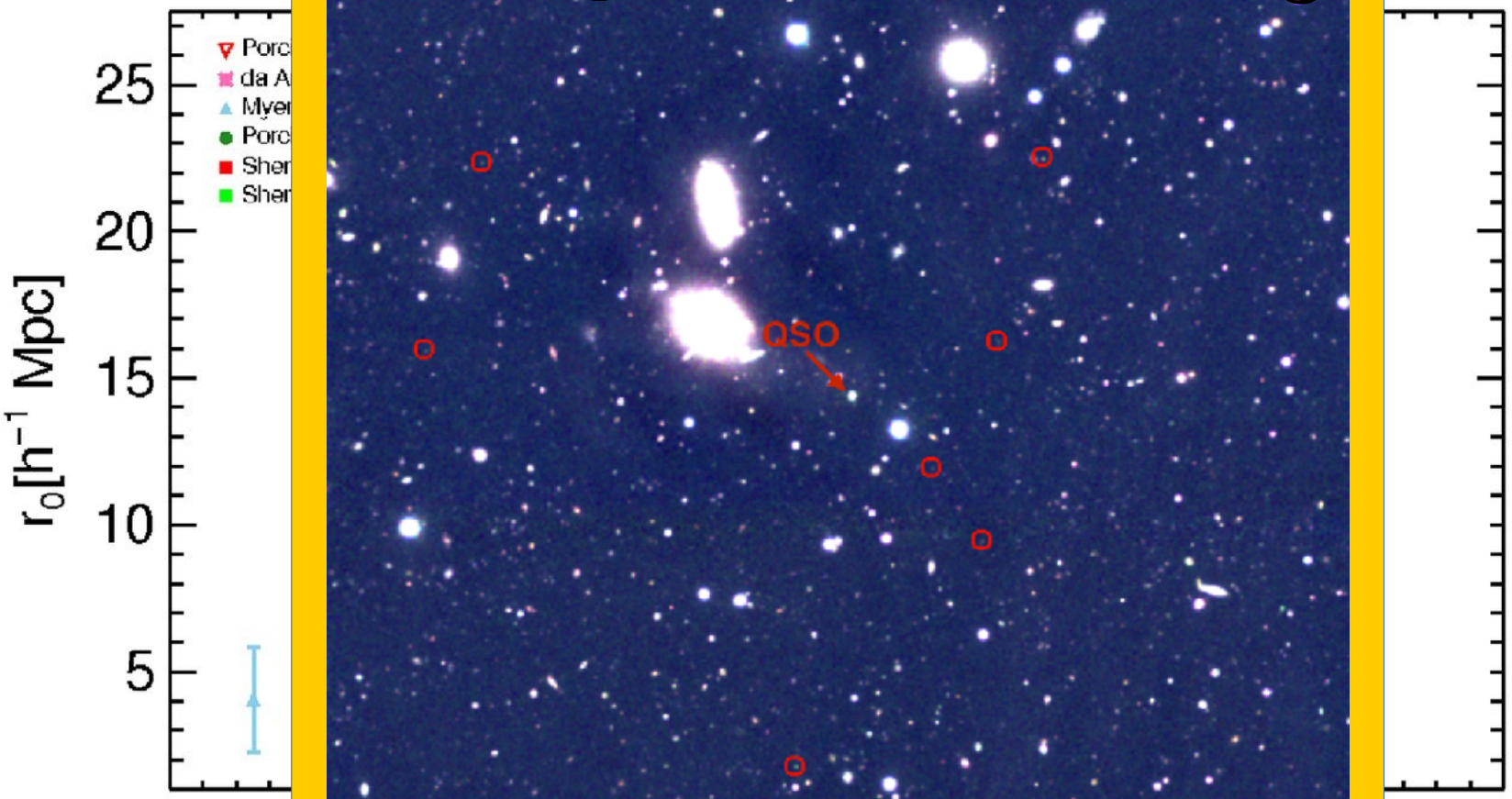


QSO pair @ z=5
pd = 135kpc

McGreer et al. 2016
Eftekharzadeh et al. 2015

QSO Clustering

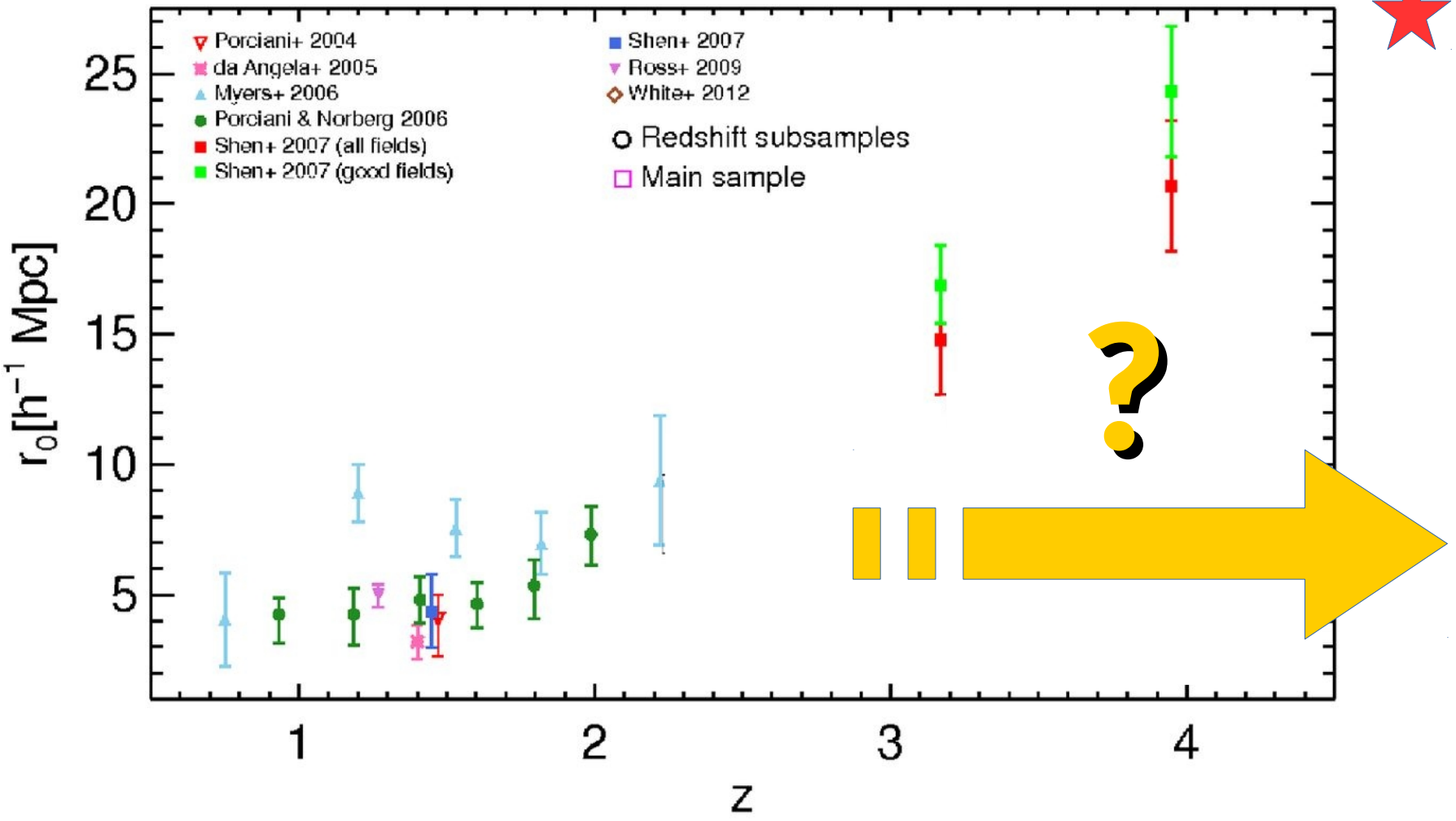
QSO-QSO



Garcia-Vergara et al. 2017

QSO Clustering

QSO-QSO Correlation Length vs. Redshift



QSO Clustering

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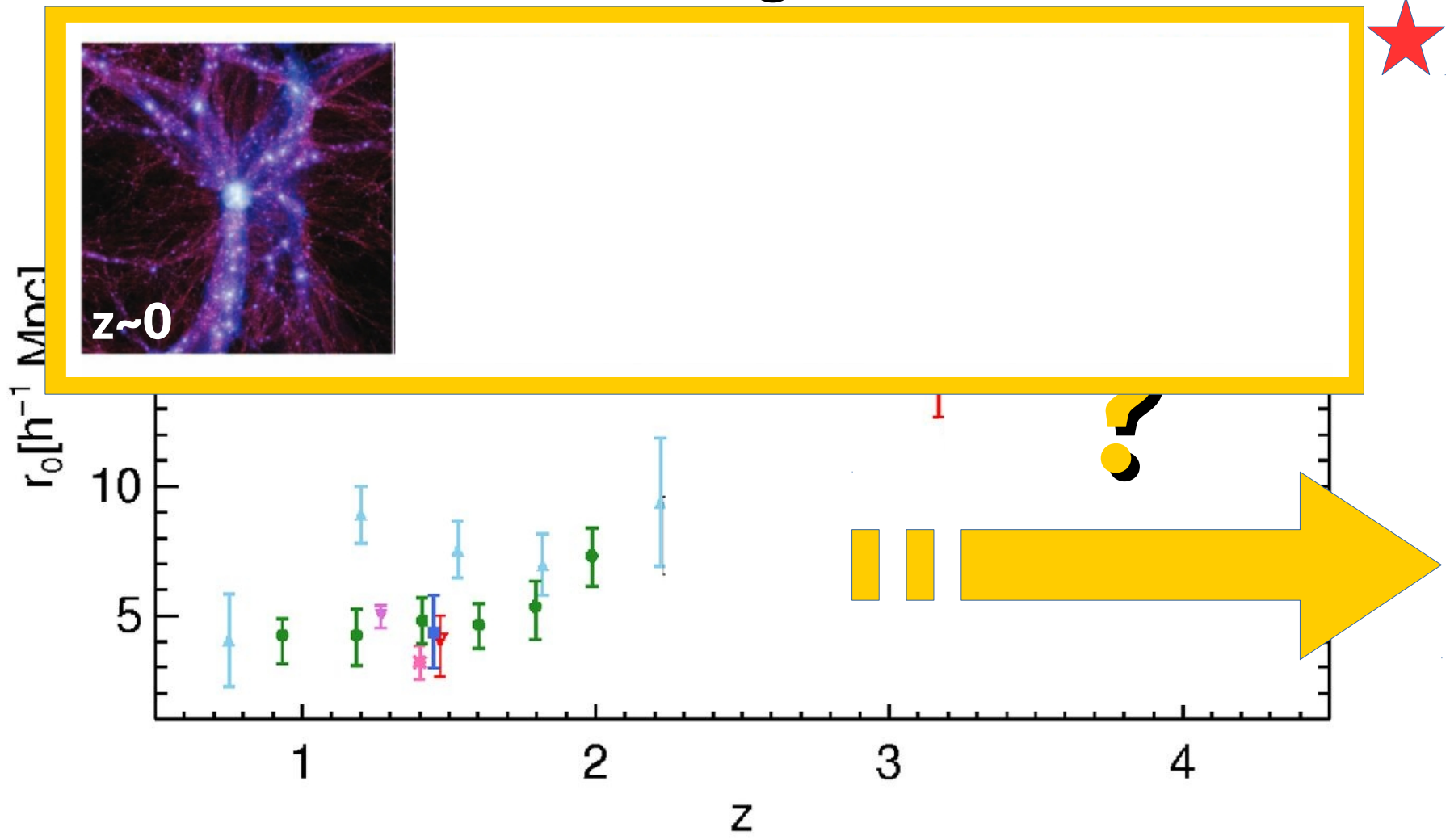

Boylan-Kolchin et al. 2009

QSO Clustering

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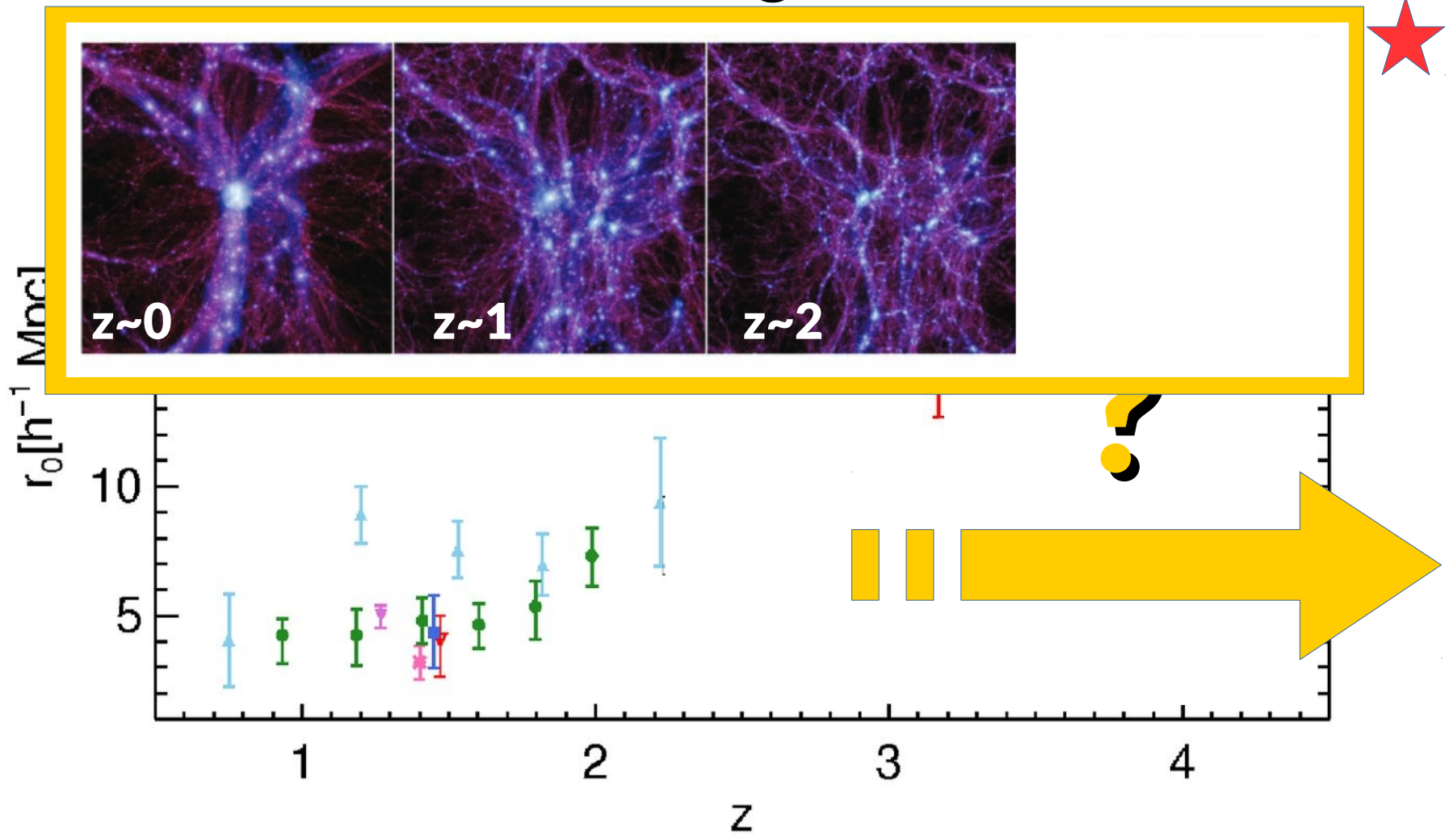

Boylan-Kolchin et al. 2009

QSO Clustering

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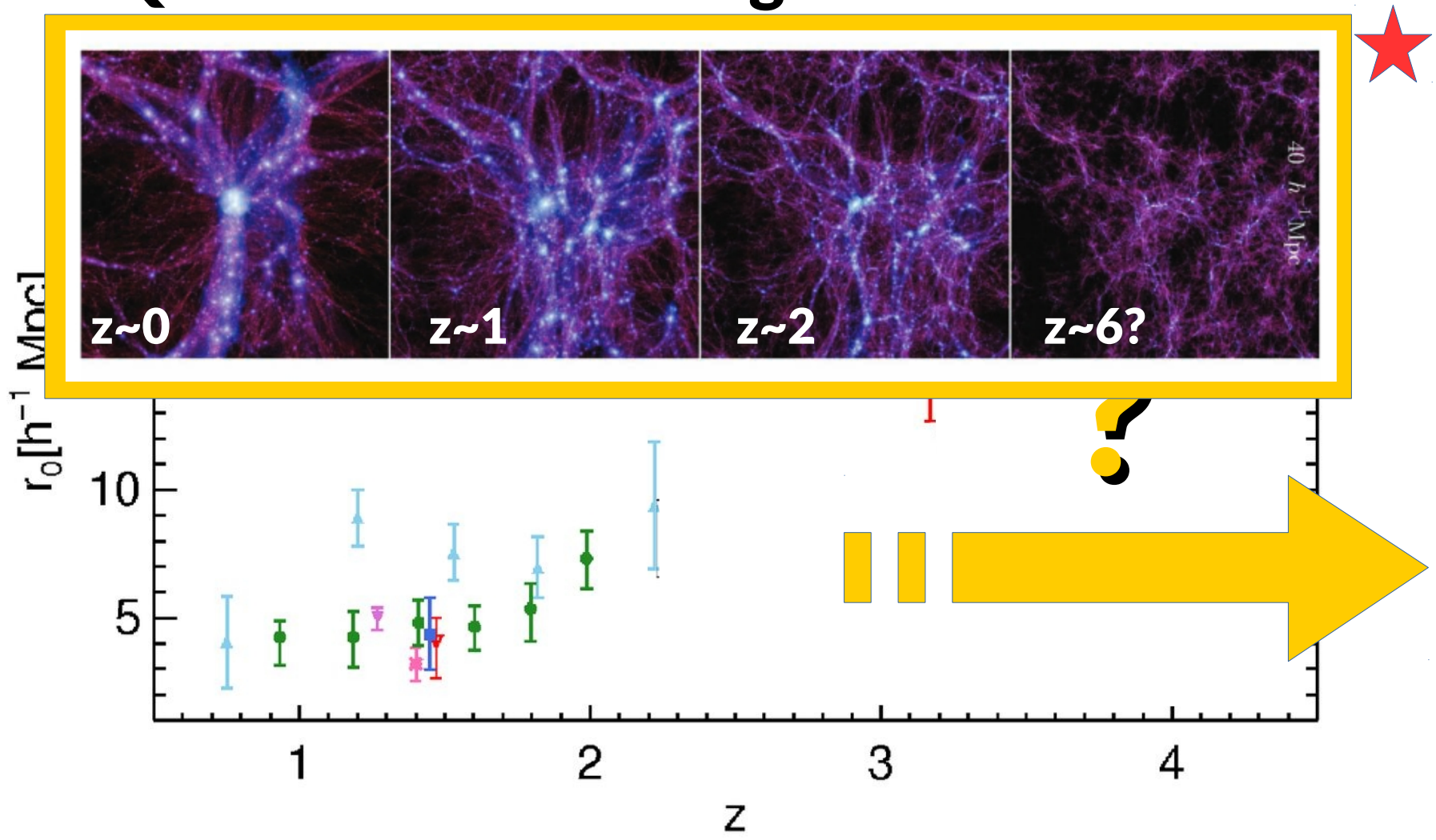
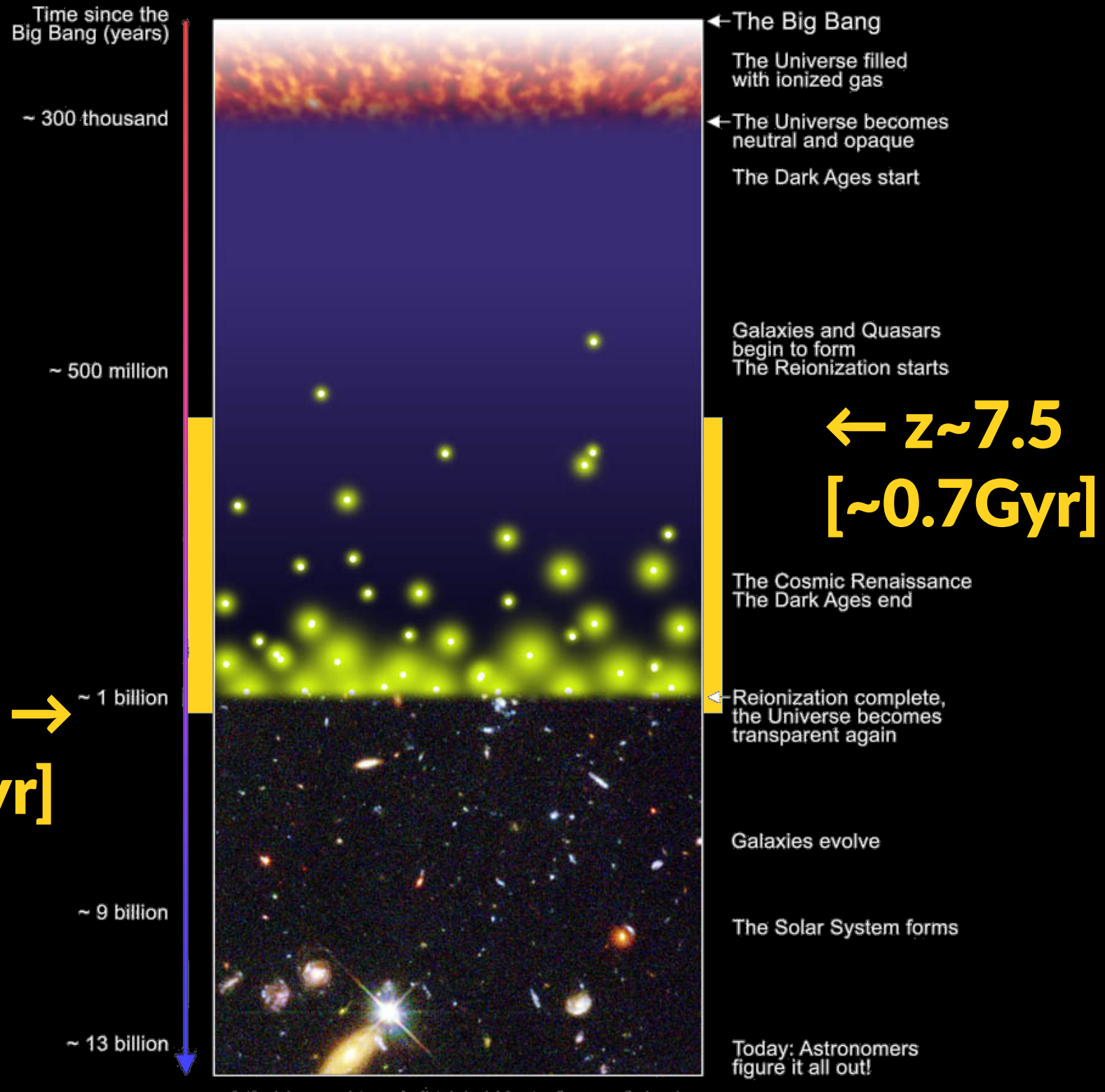


Boylan-Kolchin et al. 2009

History of the Universe

S.G. Djorgovski et al. & Digital Media Center, Caltech

History of the Universe



← z~7.5 [~0.7Gyr]

z~5.5 → [~1Gyr]

S.G. Djorgovski et al. & Digital Media Center, Caltech

History of the Universe

Time since the Big Bang (years)

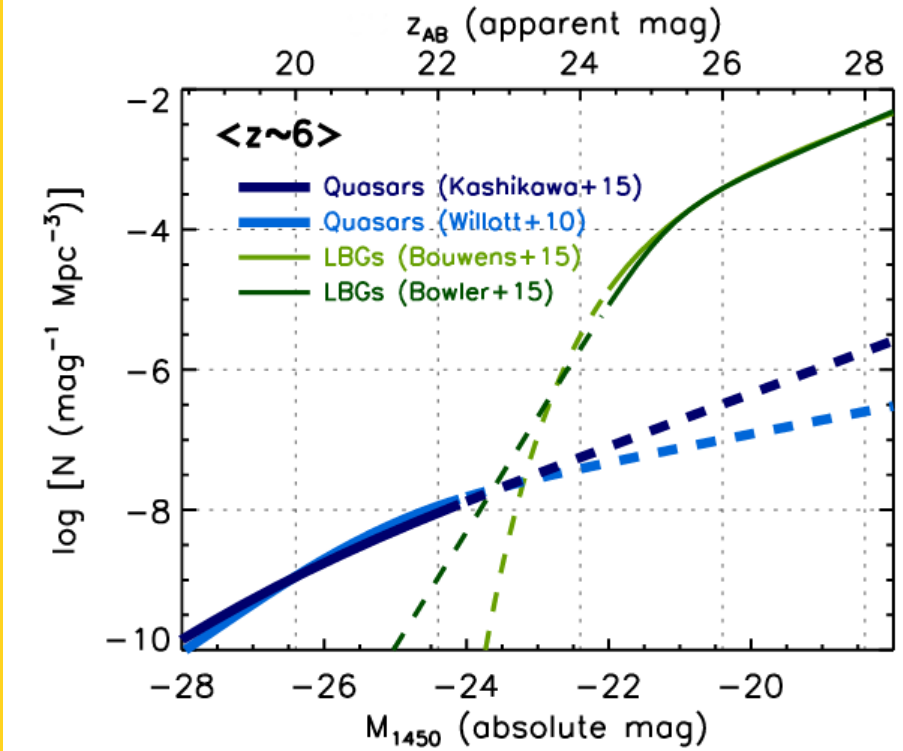
~ 300 thousand

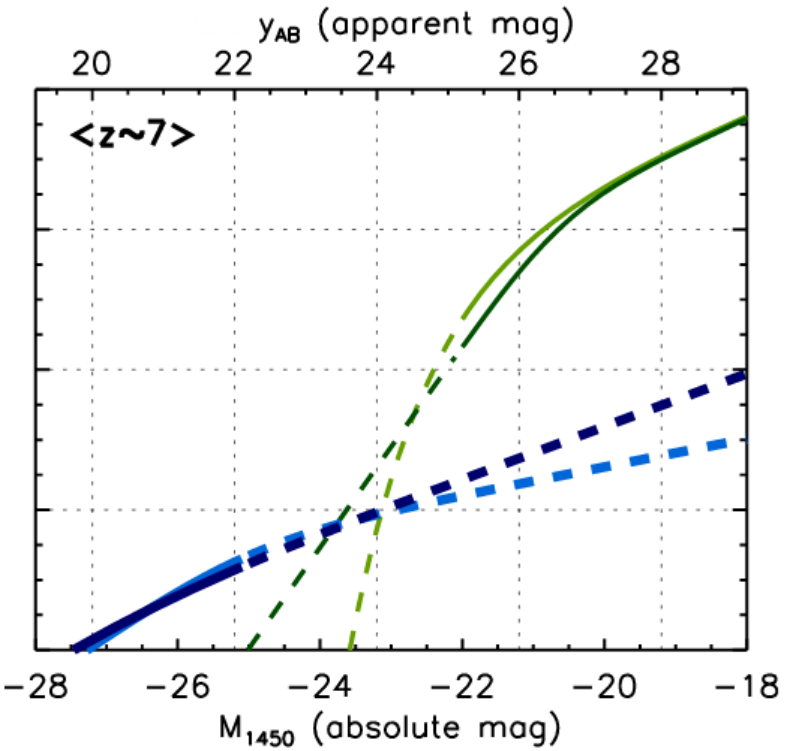
The Big Bang

The Universe filled with ionized gas

The Universe becomes neutral and opaque

The Dark Ages start





~ 9 billion

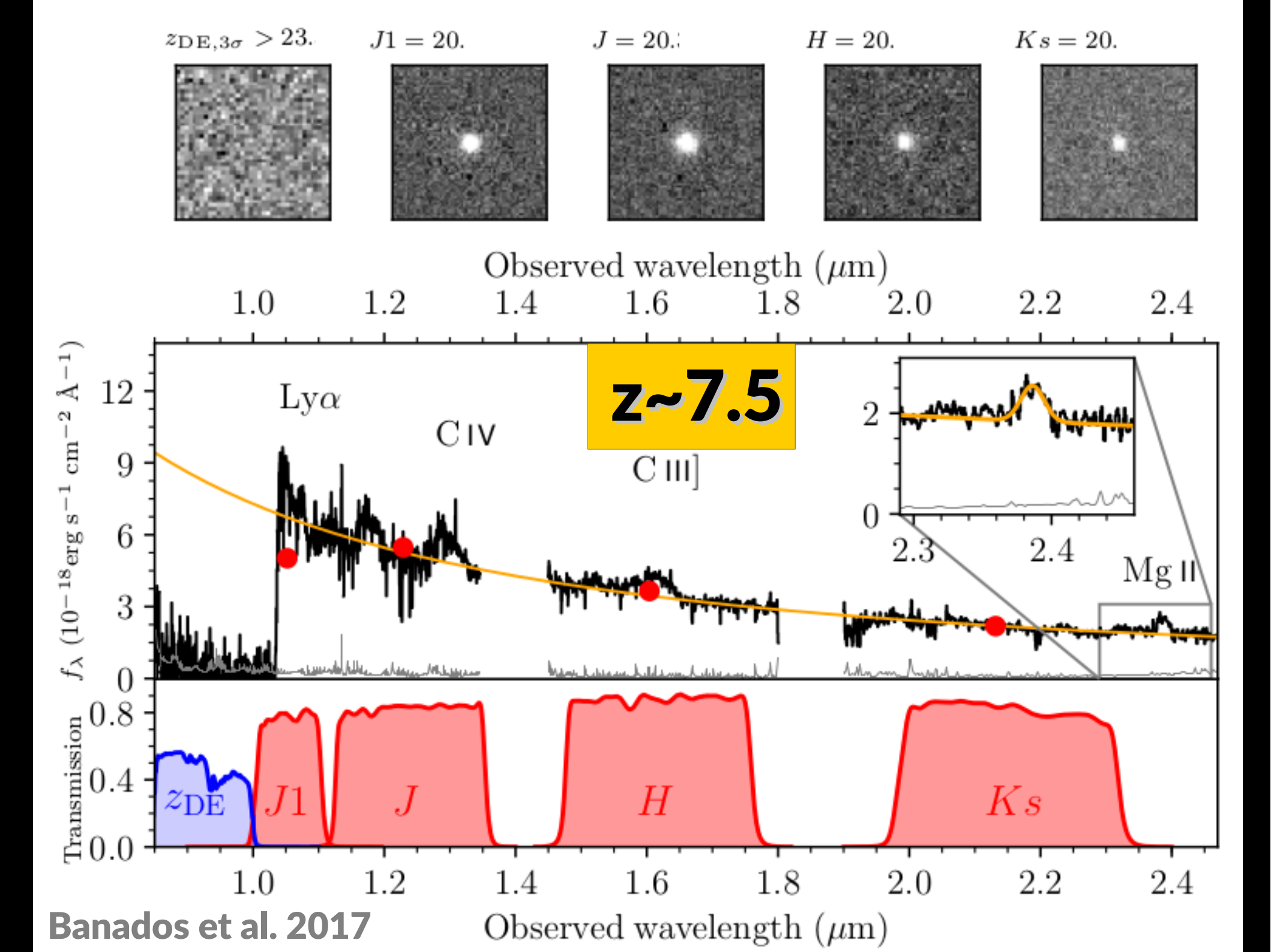
~ 13 billion

The Solar System forms

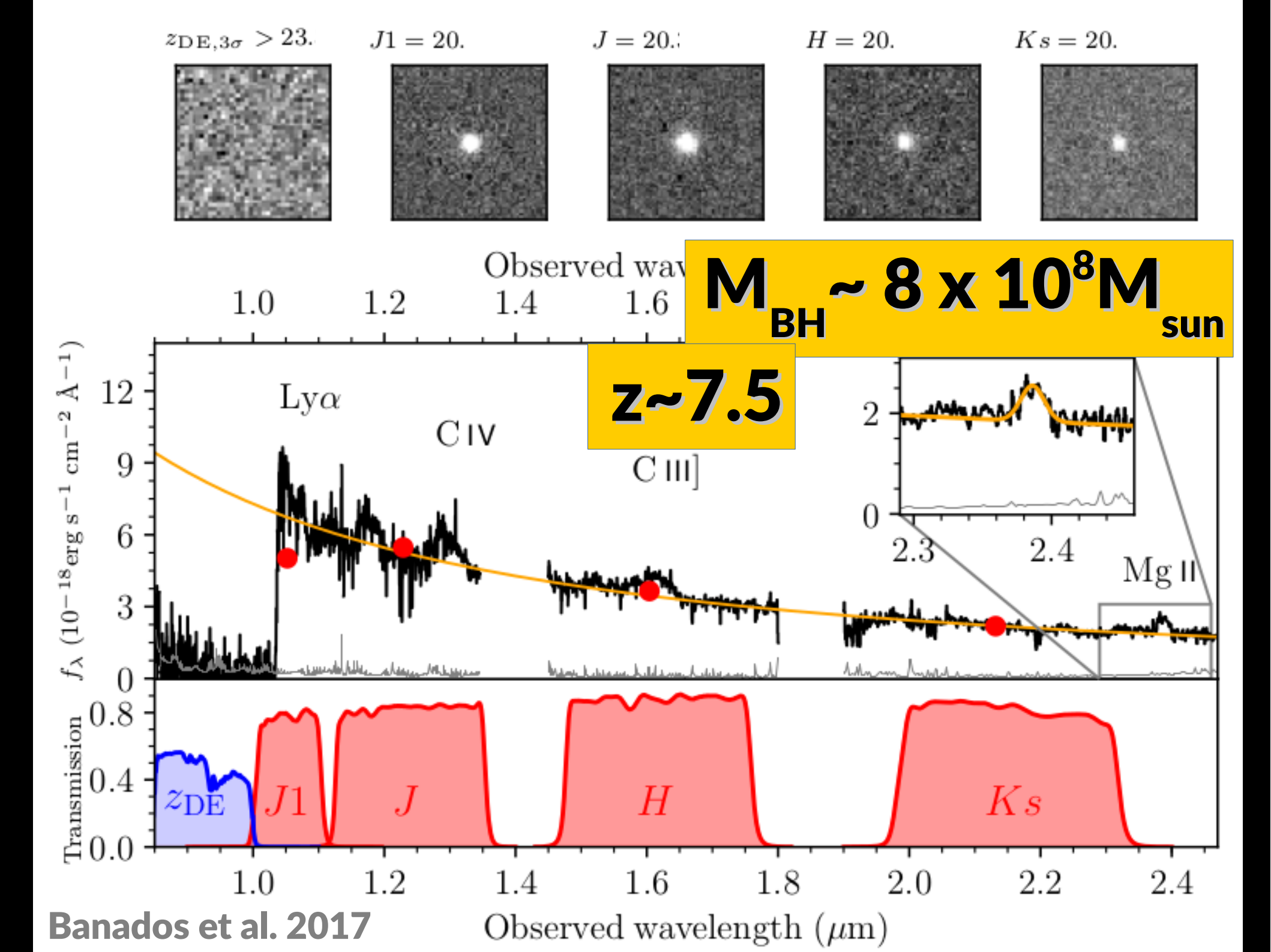
Today: Astronomers figure it all out!

S.G. Djorgovski et al. & Digital Media Center, Caltech

$z_{\mathrm{DE},3\sigma} > 23.$ $J1 = 20.$ $J = 20.$ $H = 20.$ $Ks = 20.$

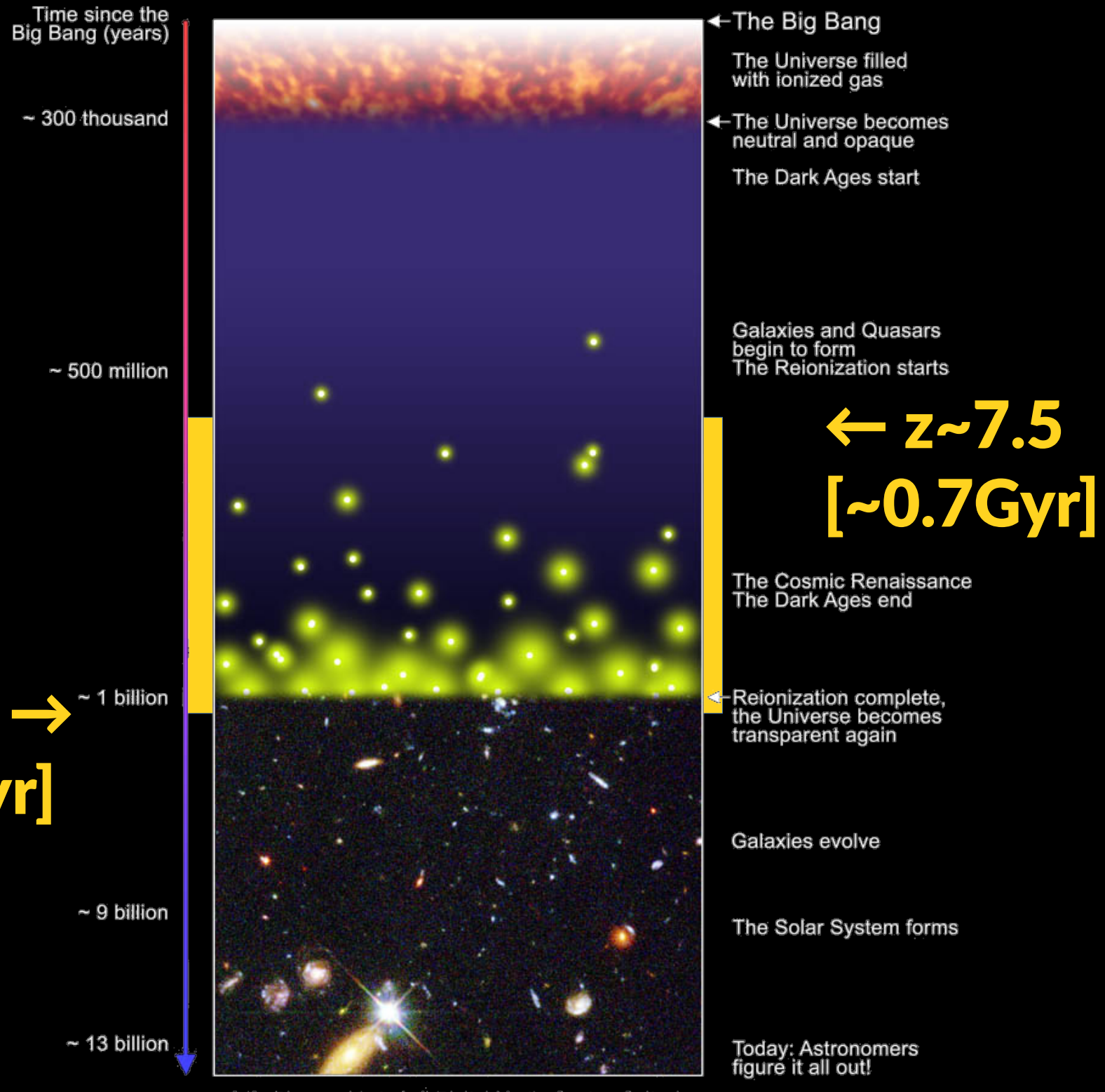


Banados et al. 2017



Banados et al. 2017

History of the Universe



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S.G. Djorgovski et al. & Digital Media Center, Caltech

History of the Universe

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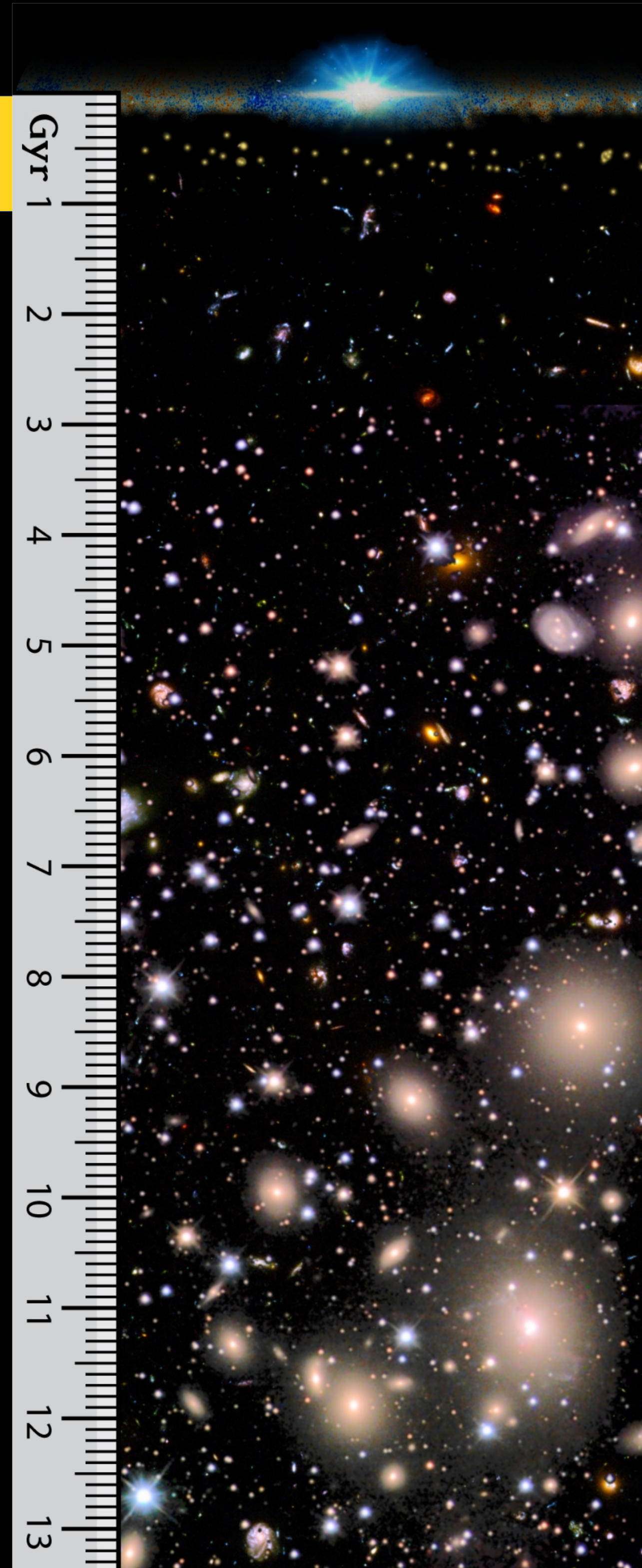
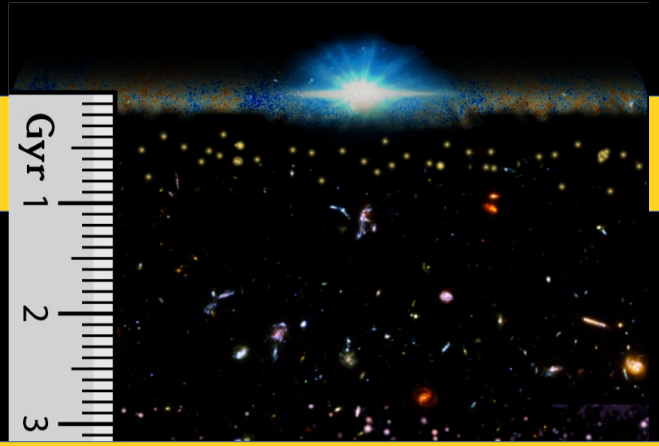


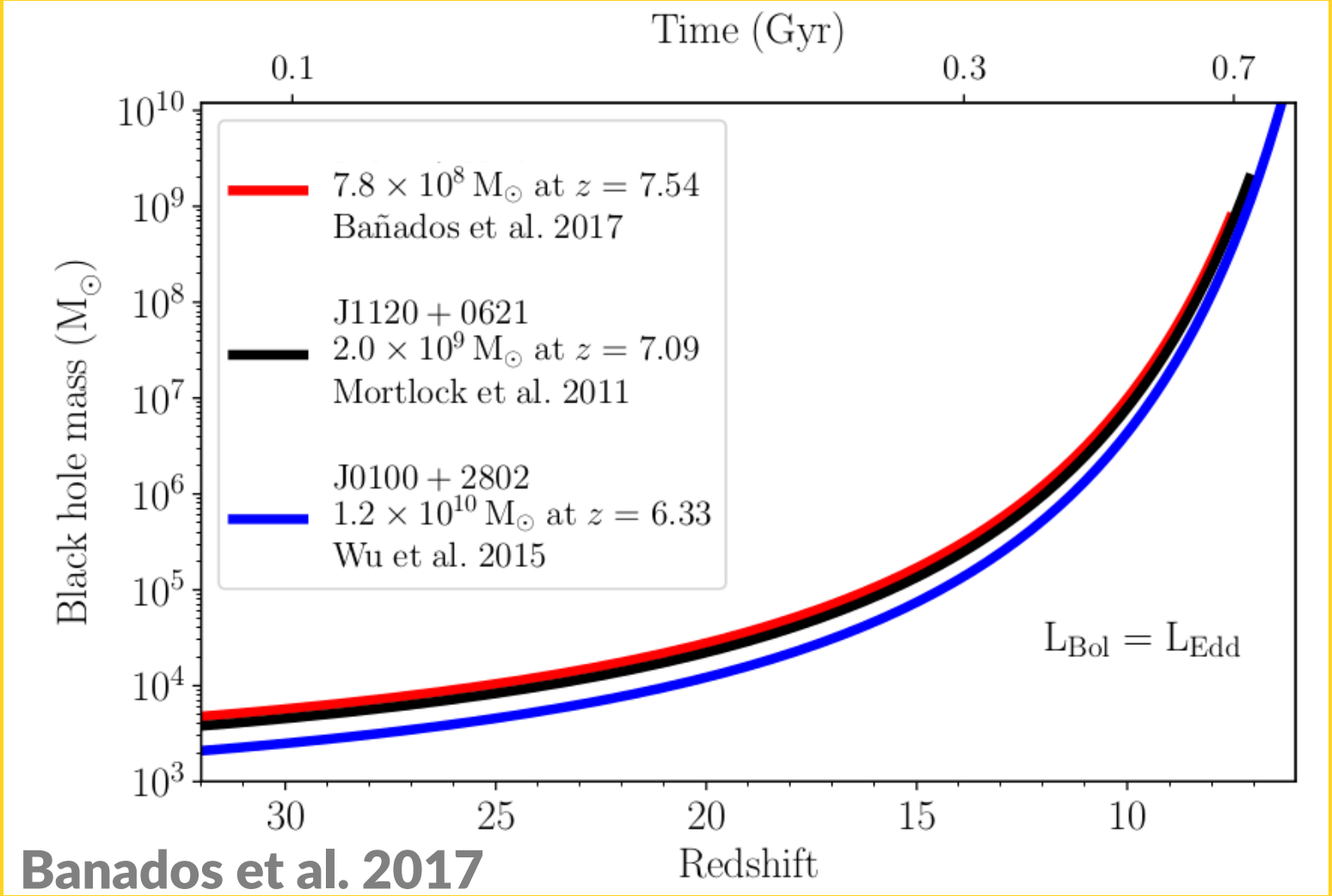
← z~7.5 [~0.7Gyr]

History of the Universe

z~5.5 → [~1Gyr]



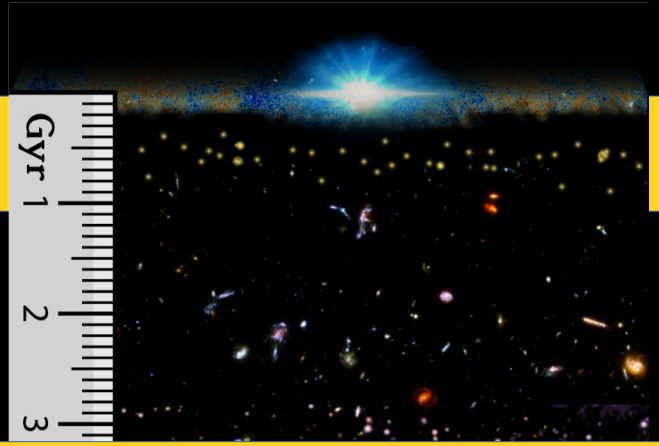
← z~7.5 [~0.7Gyr]



Banados et al. 2017

History of the Universe

z~5.5 →
[~1Gyr]



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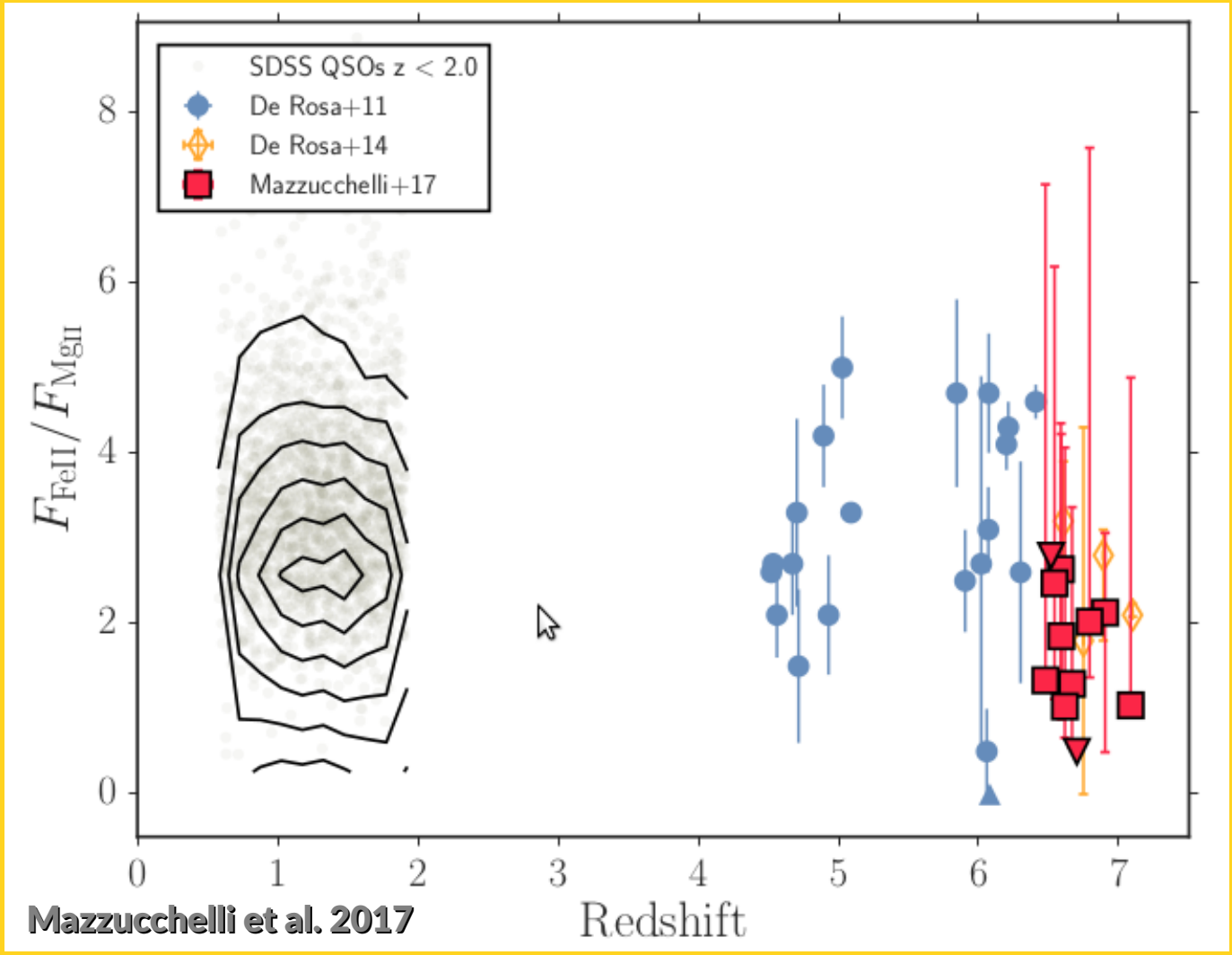
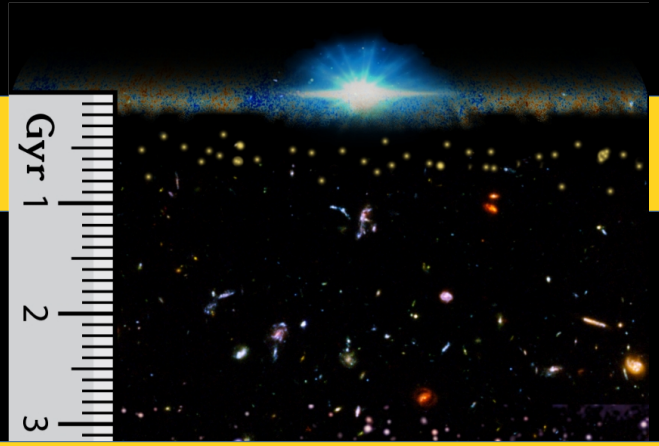
[~0.7Gyr]



Mazzucchelli et al. 2017

History of the Universe

z~5.5 → [~1Gyr]



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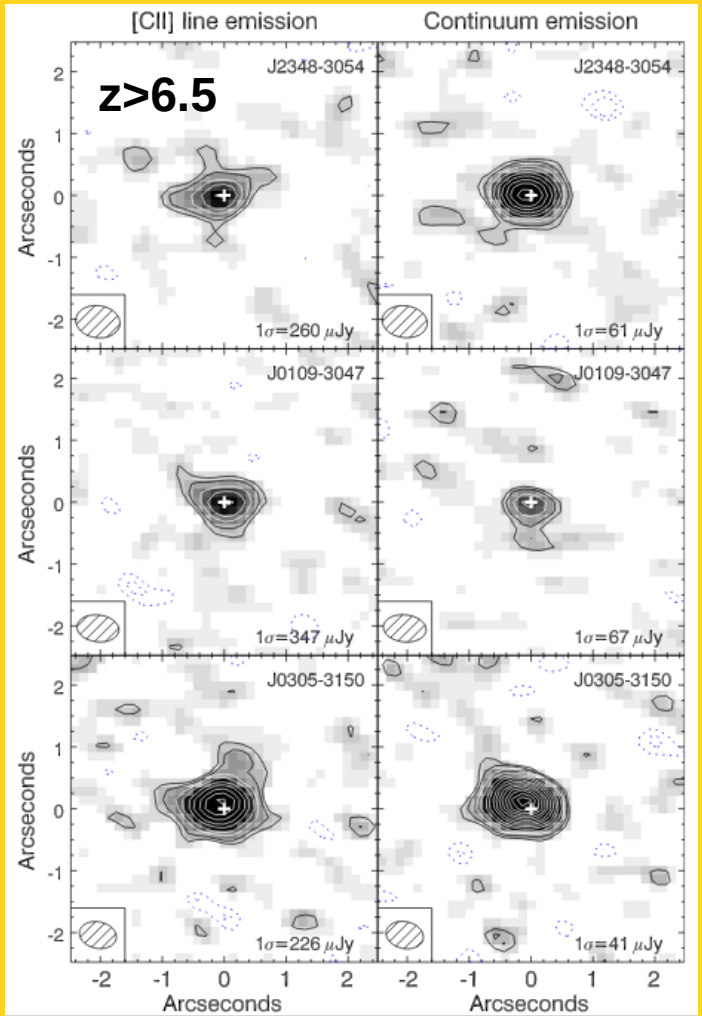
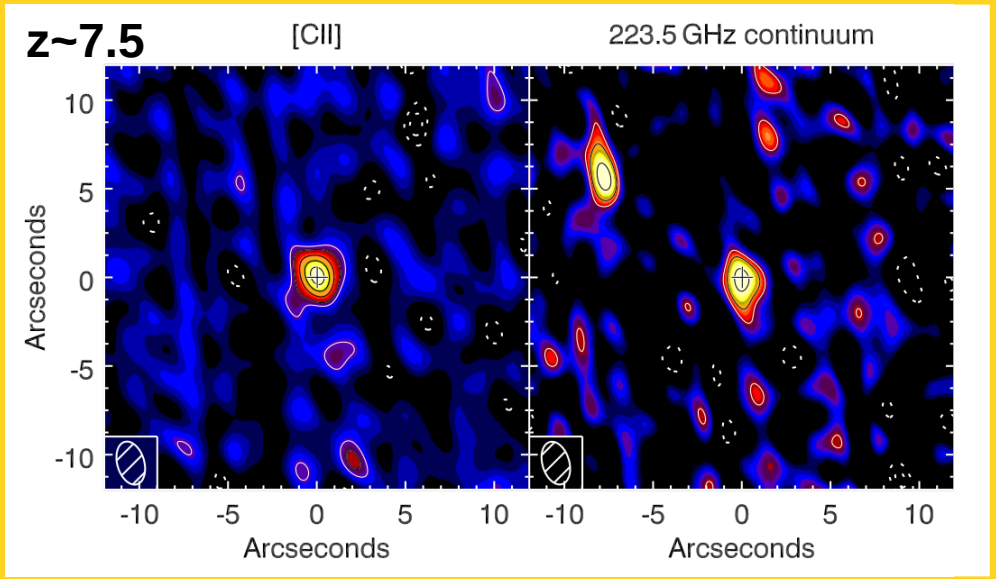
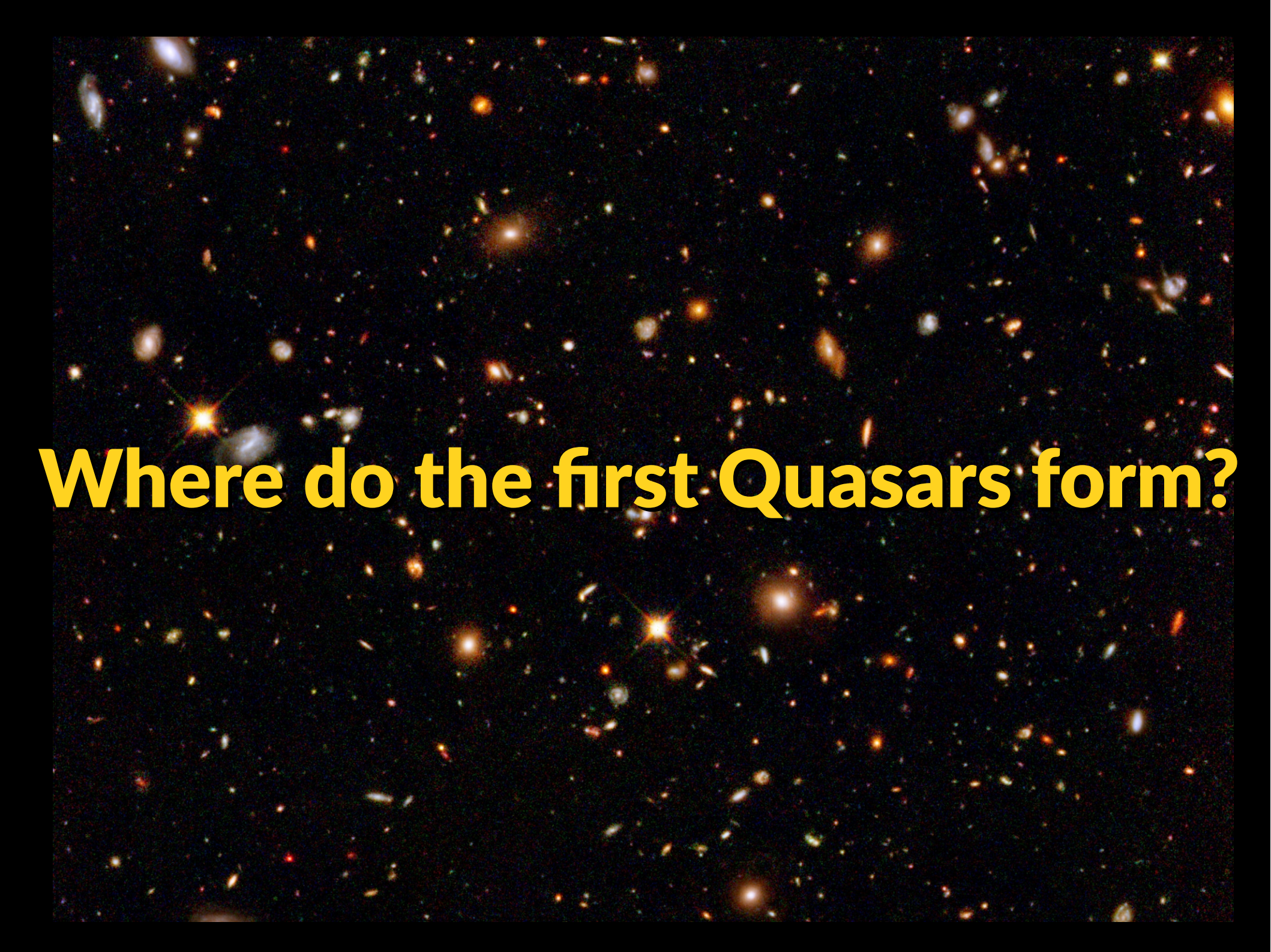


Venemans et al. 2016, 2017

$M_{dust} \sim 10^8 M_{sun}$

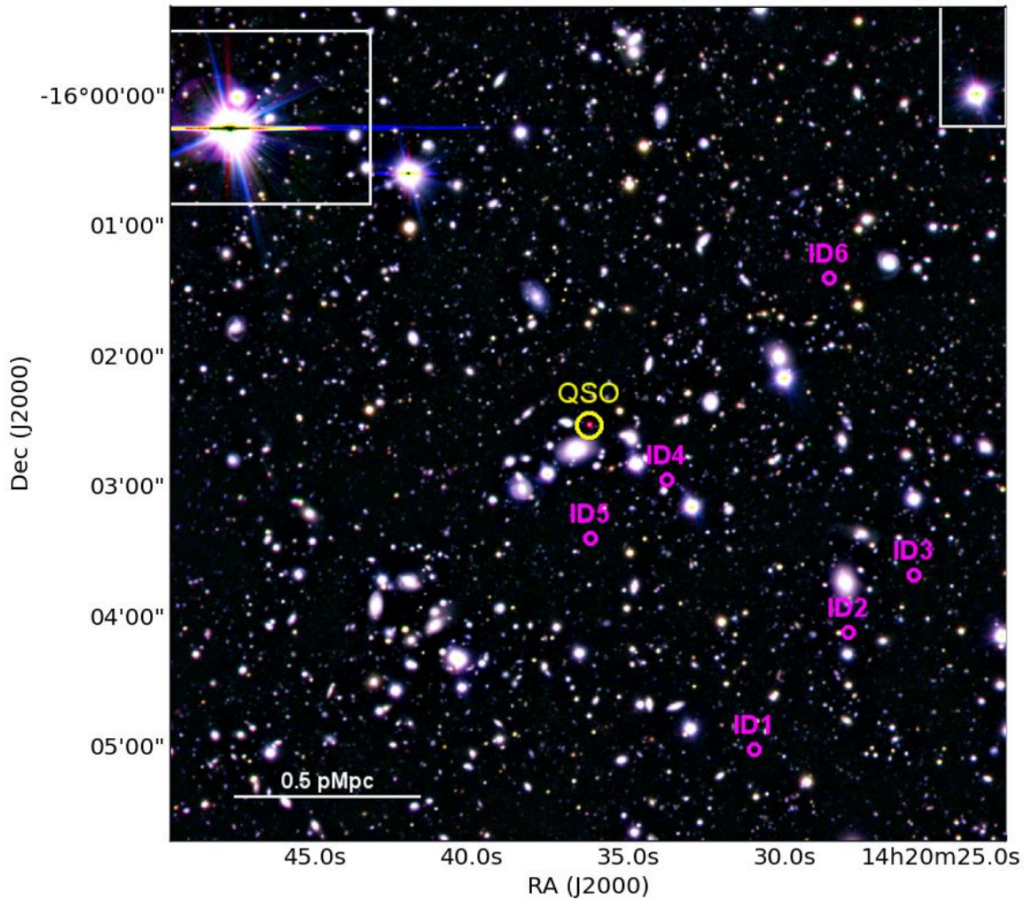


$SFR > 100\ M_{sun}\ yr^{-1}$


Where do the first Quasars form?

Large Scale Clustering

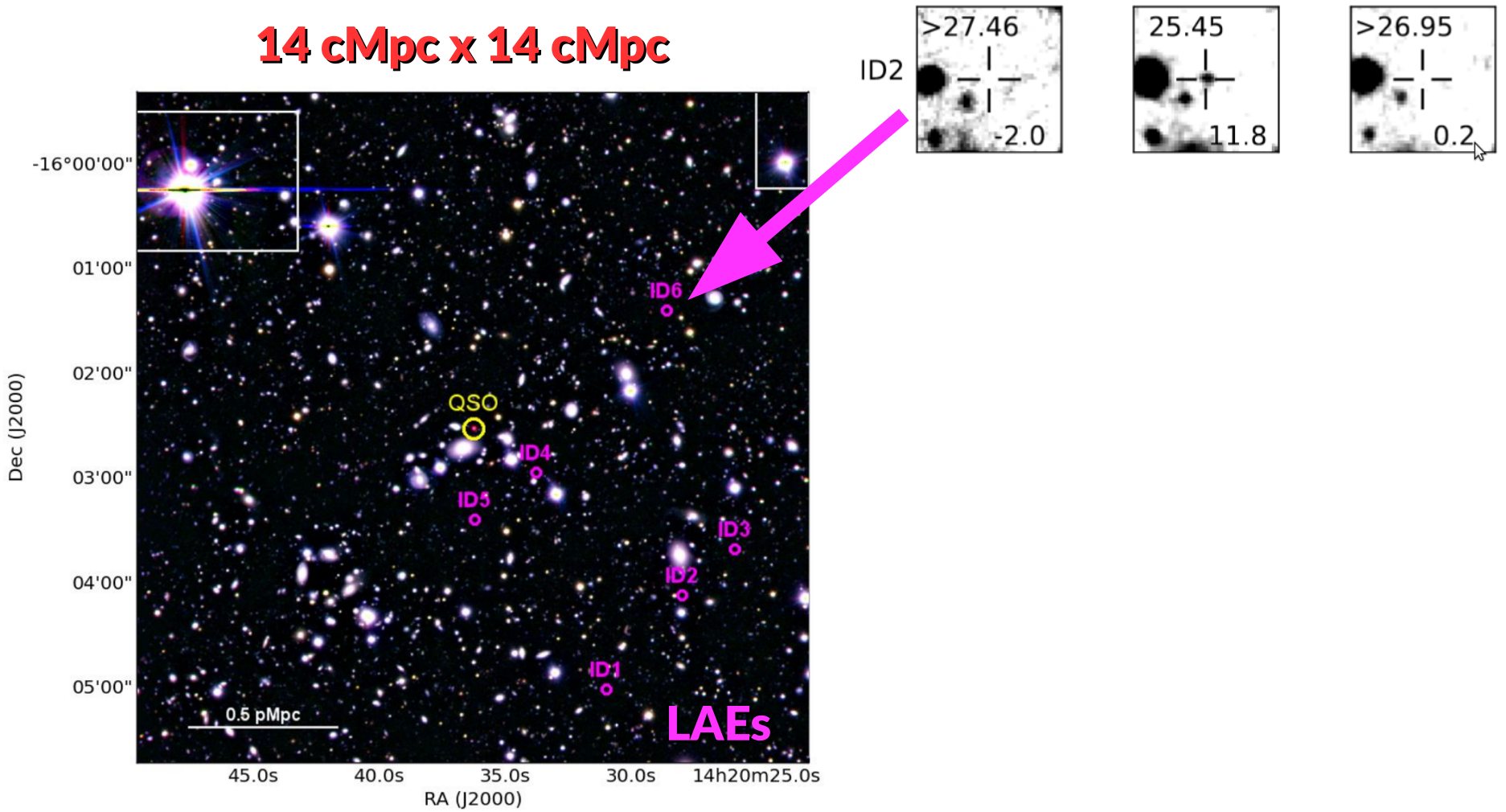
14 cMpc x 14 cMpc



$M_{BH} \sim 7 \times 10^9 M_{sun}$ @ z~5.7

Mazzucchelli et al. 2017

Large Scale Clustering



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Mazzucchelli et al. 2017

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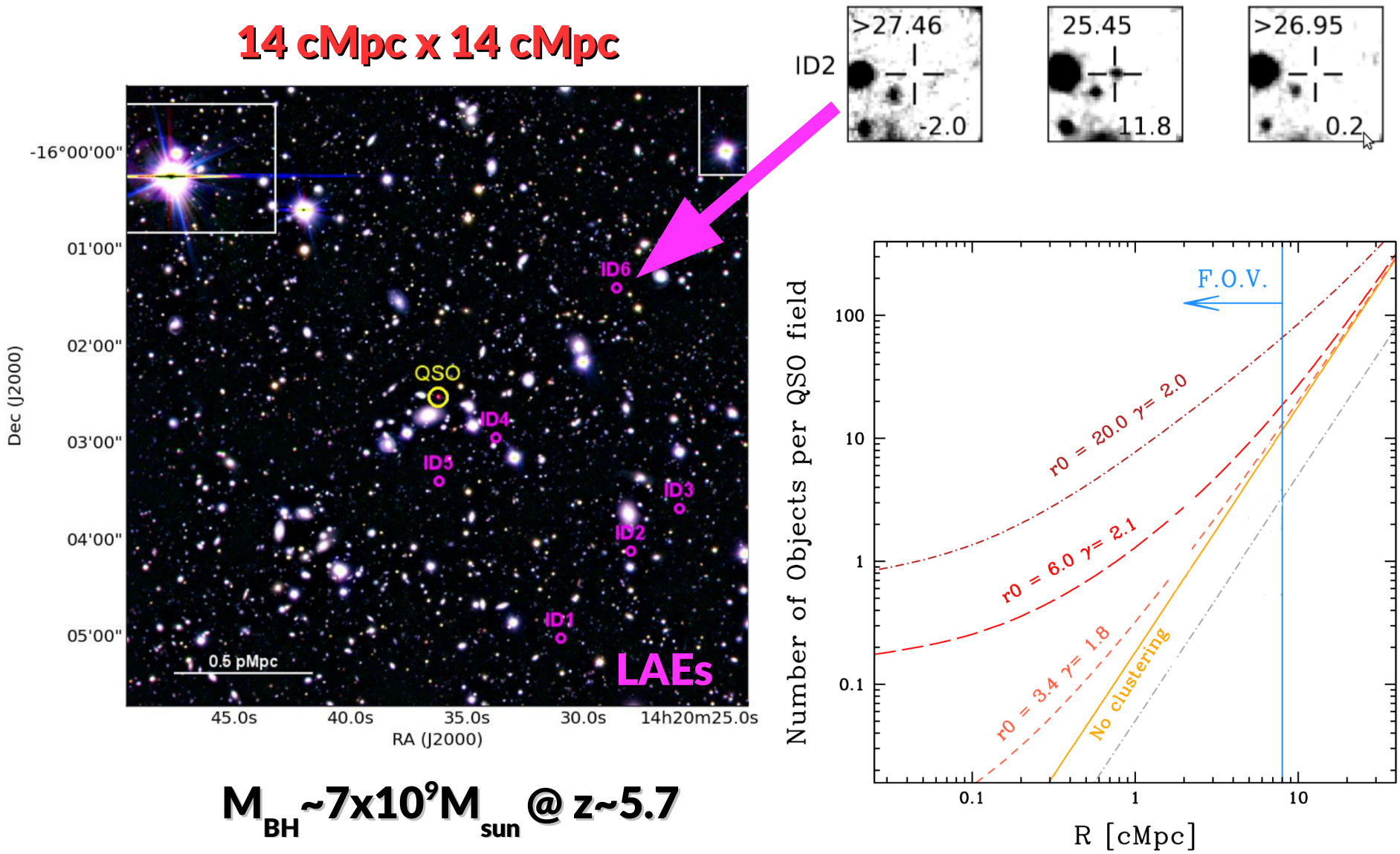

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Mazzucchelli et al. 2017

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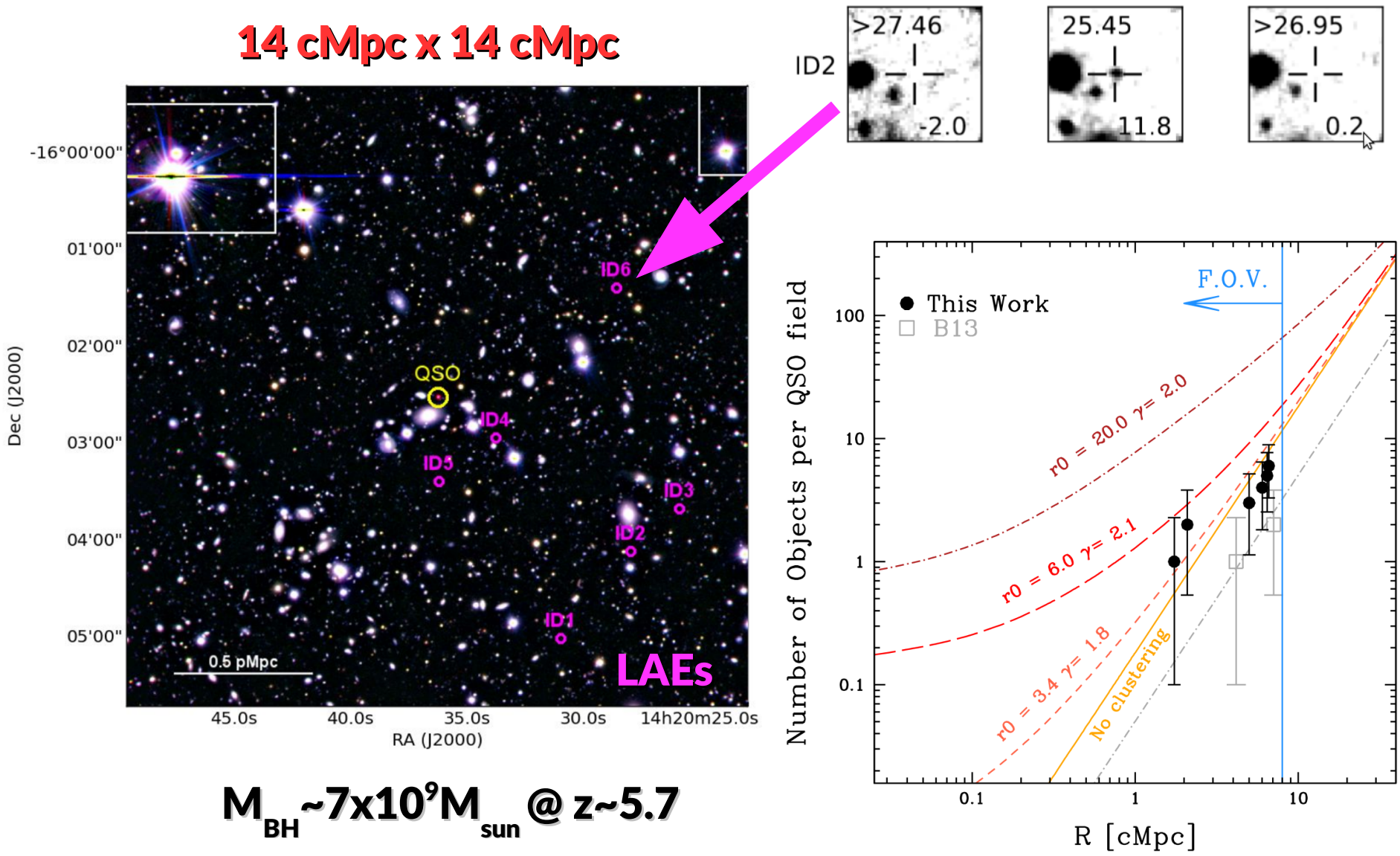

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Mazzucchelli et al. 2017

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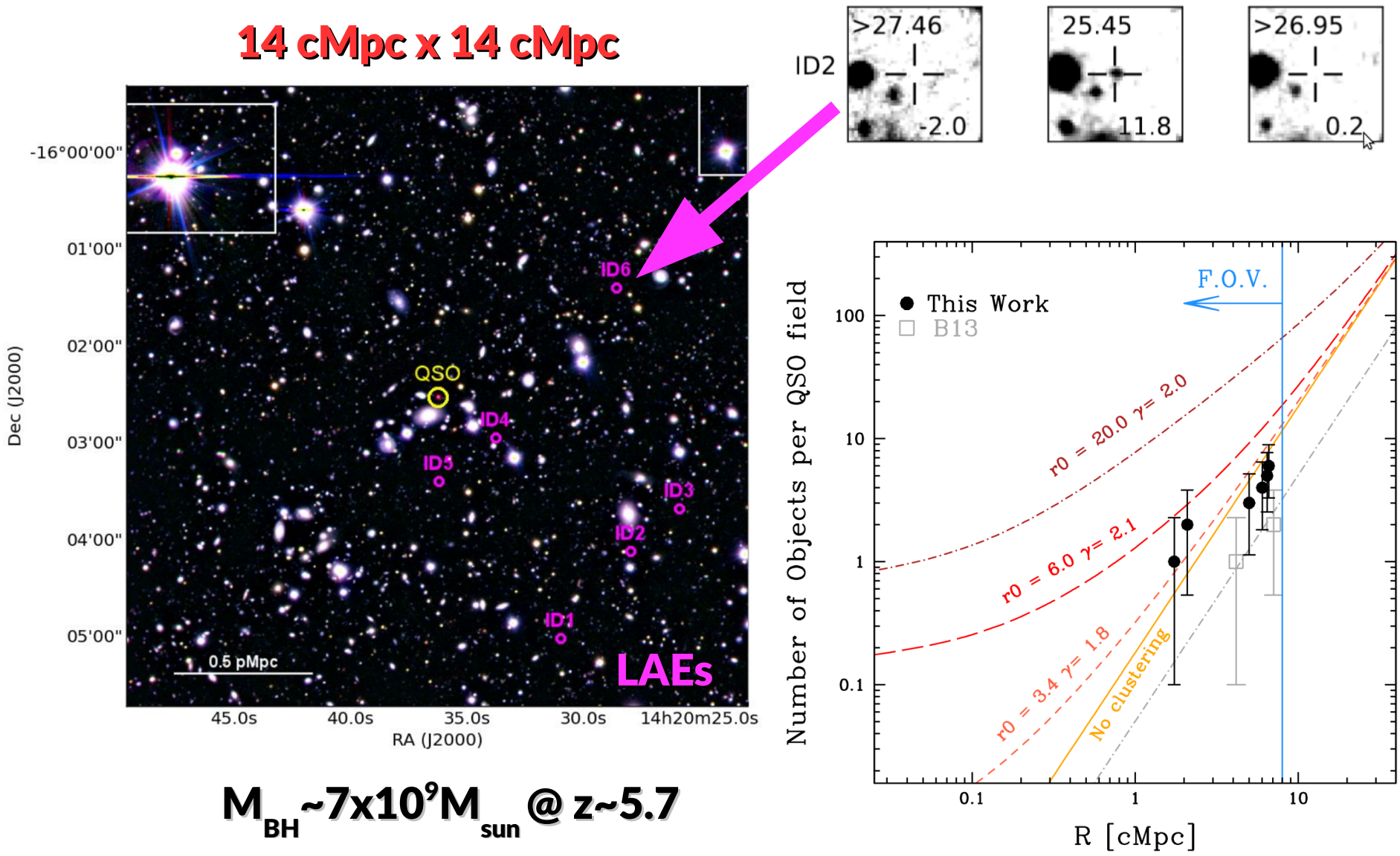

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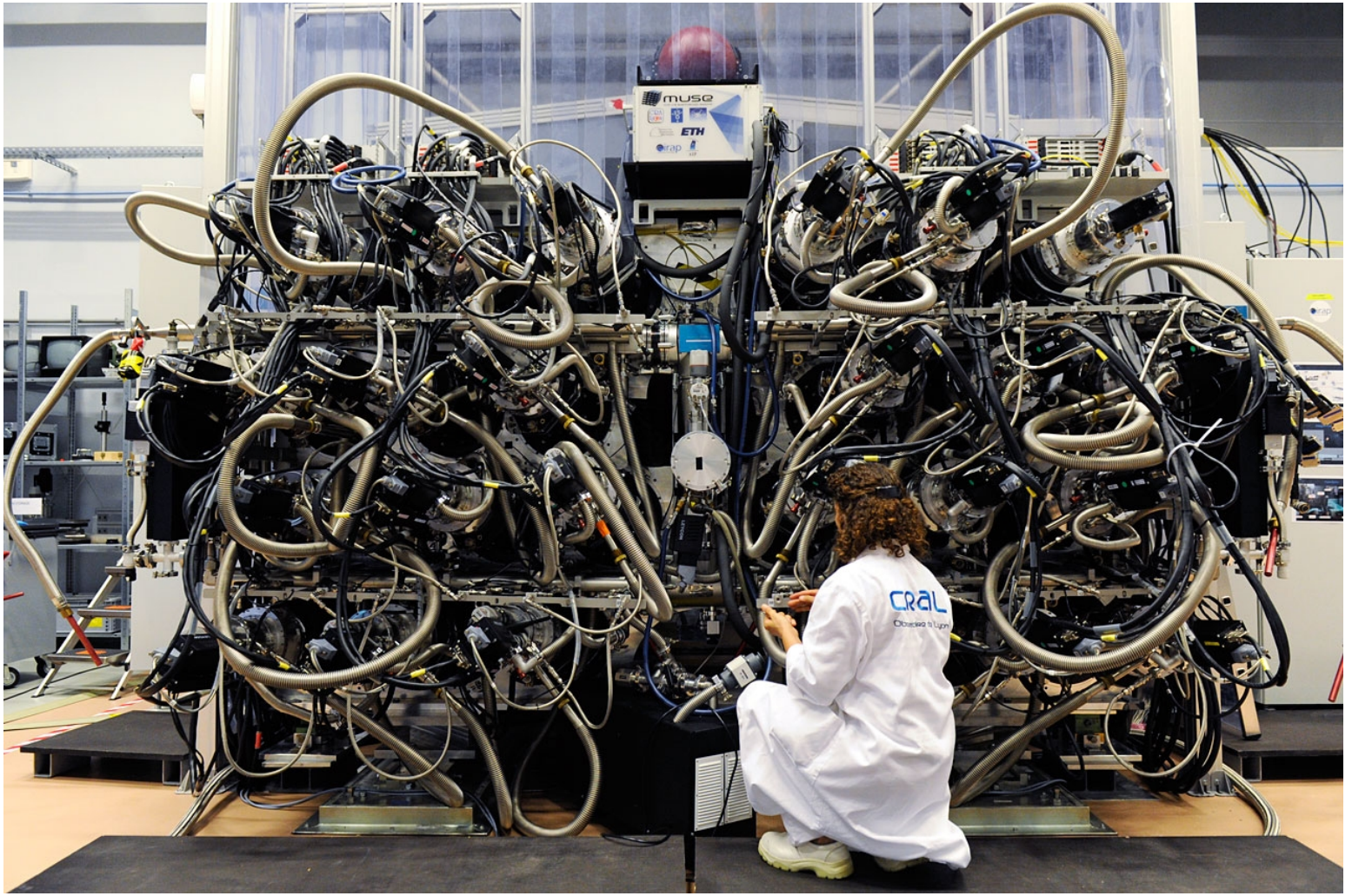
Mazzucchelli et al. 2017

Small Scale Clustering → MUSE



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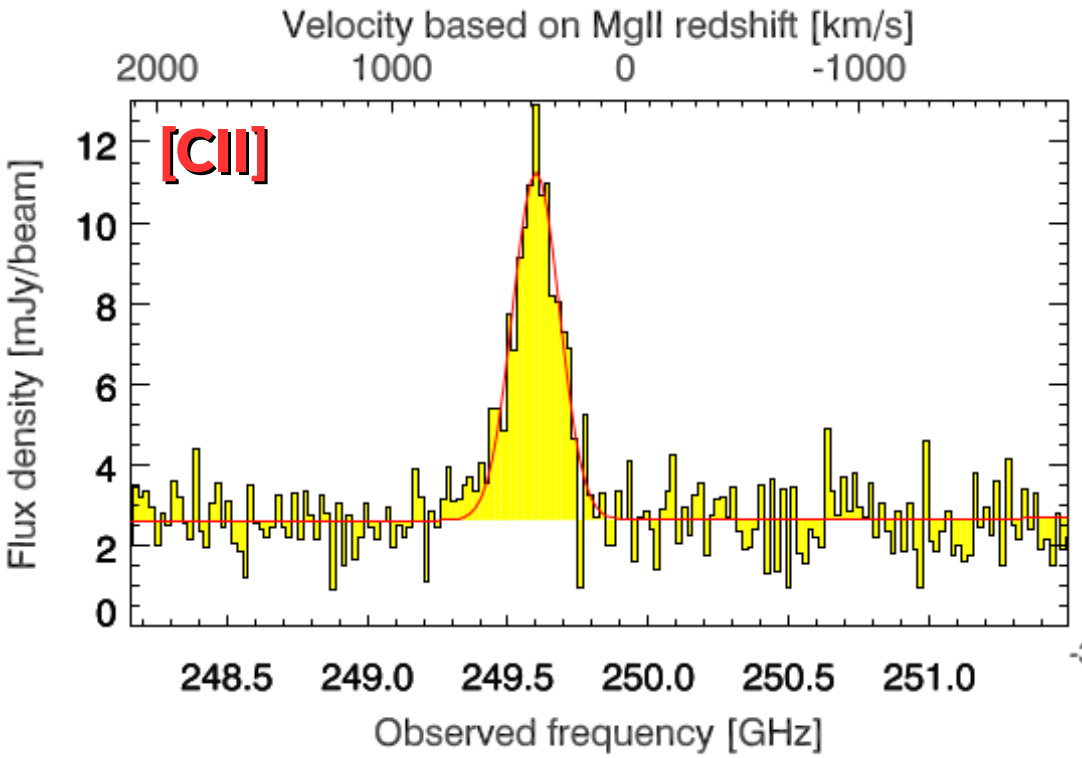
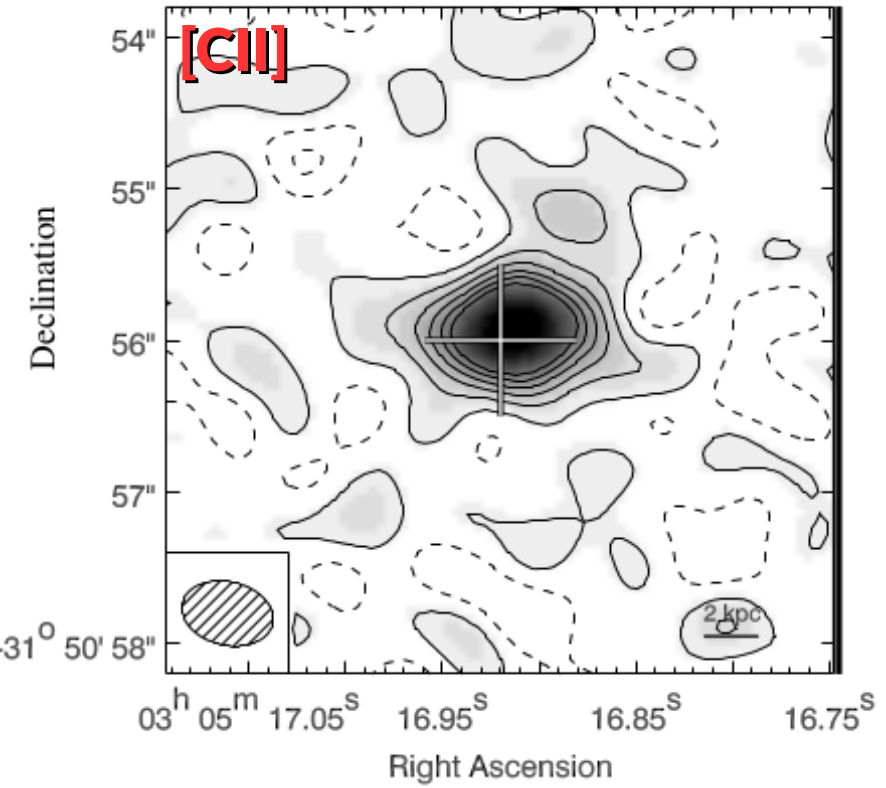




z~6.6

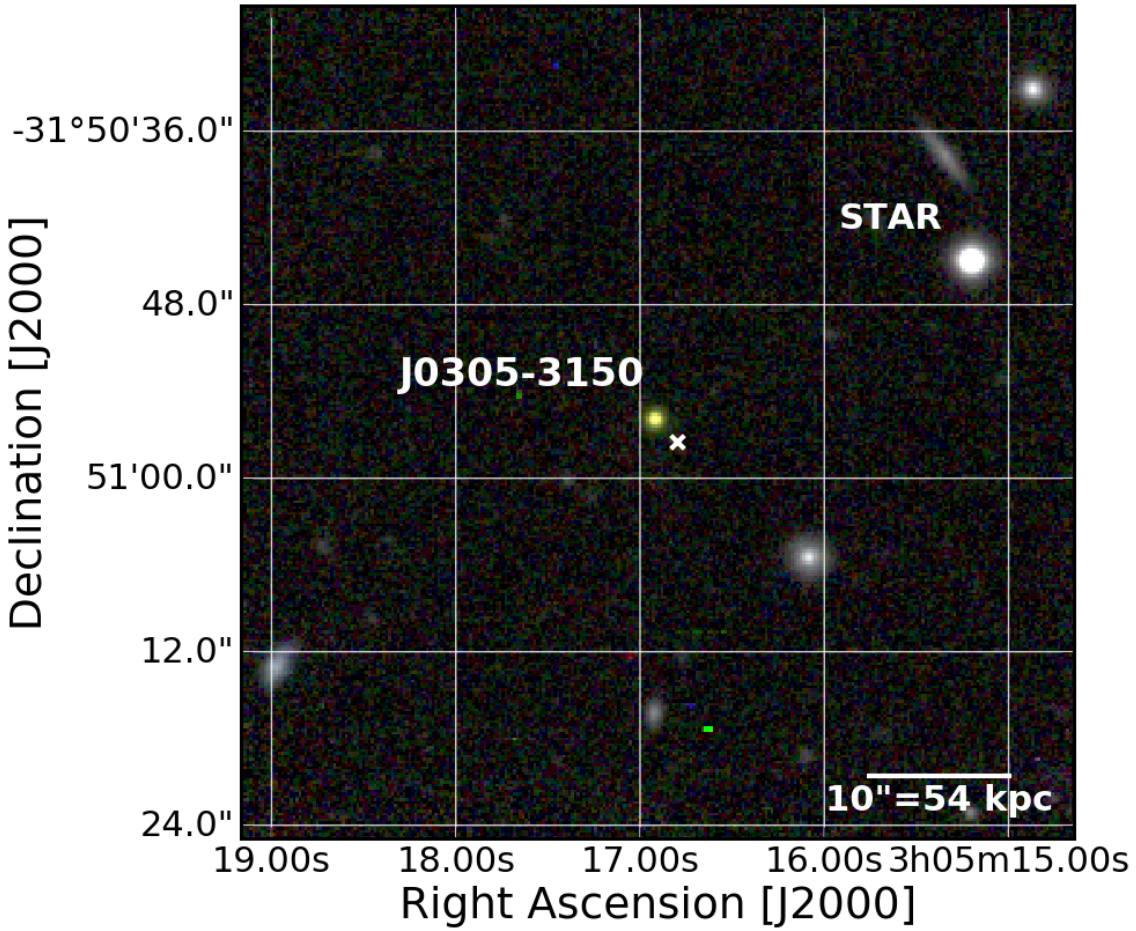
Age of the Universe: 800Myr

SFR~600M_{SUN}/yr

M_{BH} ~ 10^9 M_{SUN}

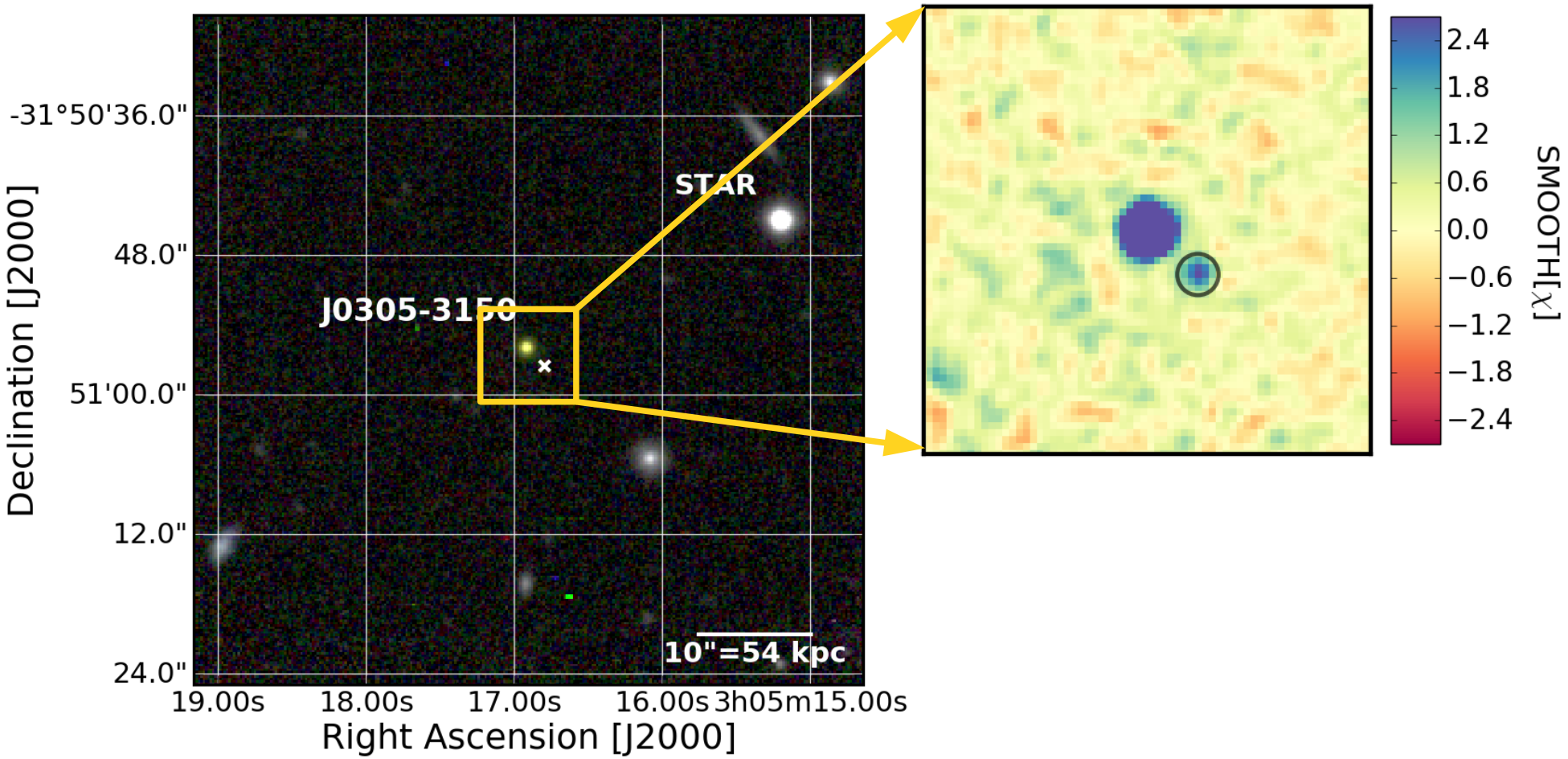
Venemans et al. 2016

Small Scale Clustering → MUSE



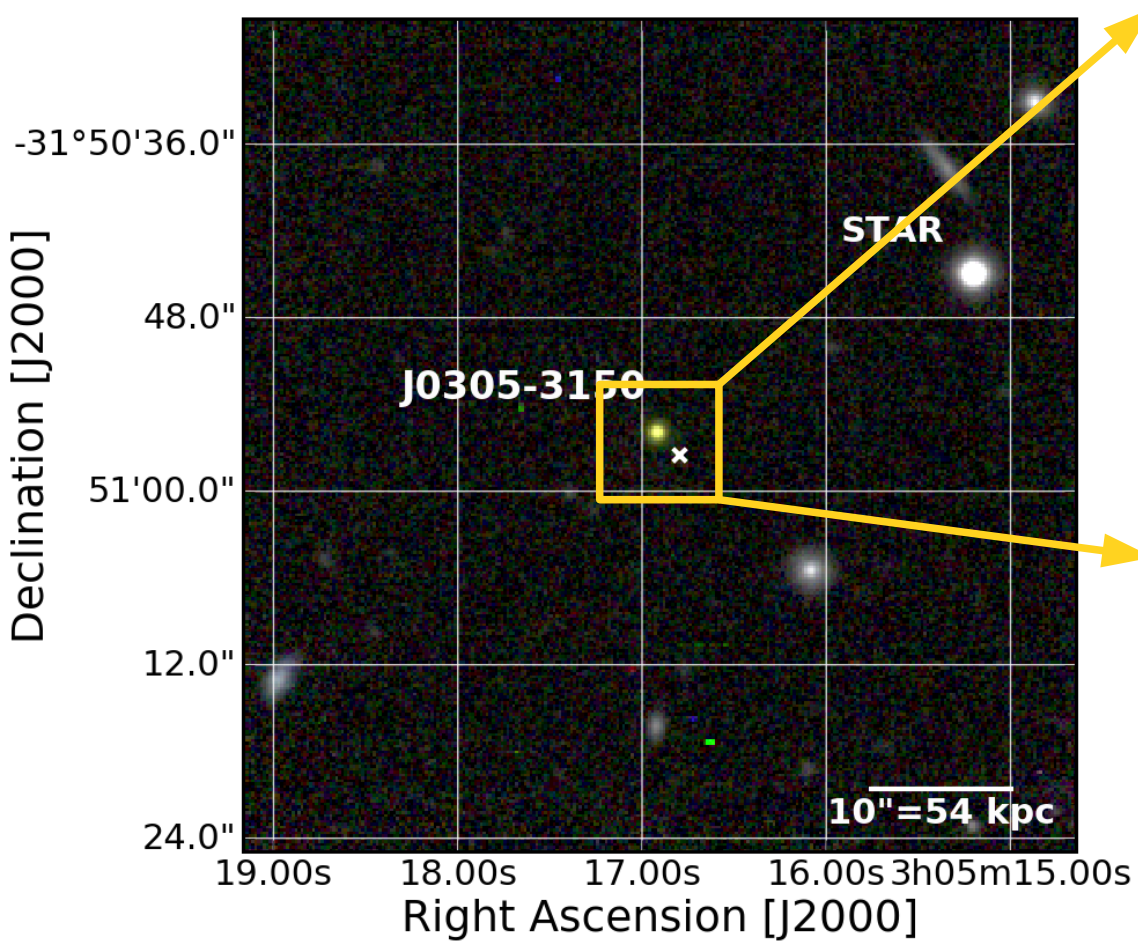
Farina et al. 2017

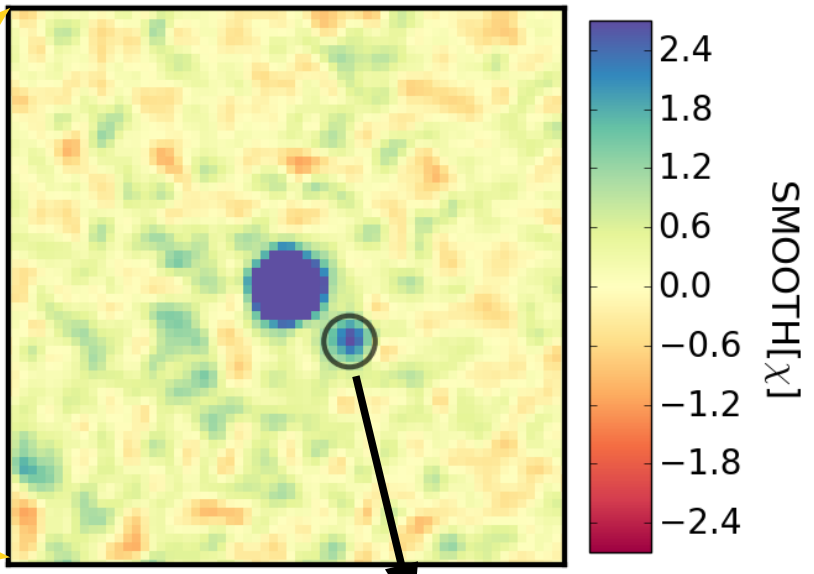
Small Scale Clustering → MUSE

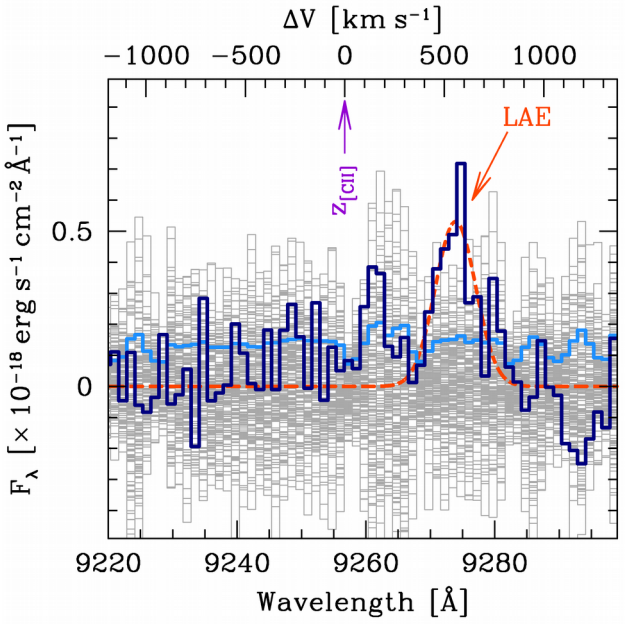


Farina et al. 2017

Small Scale Clustering → MUSE





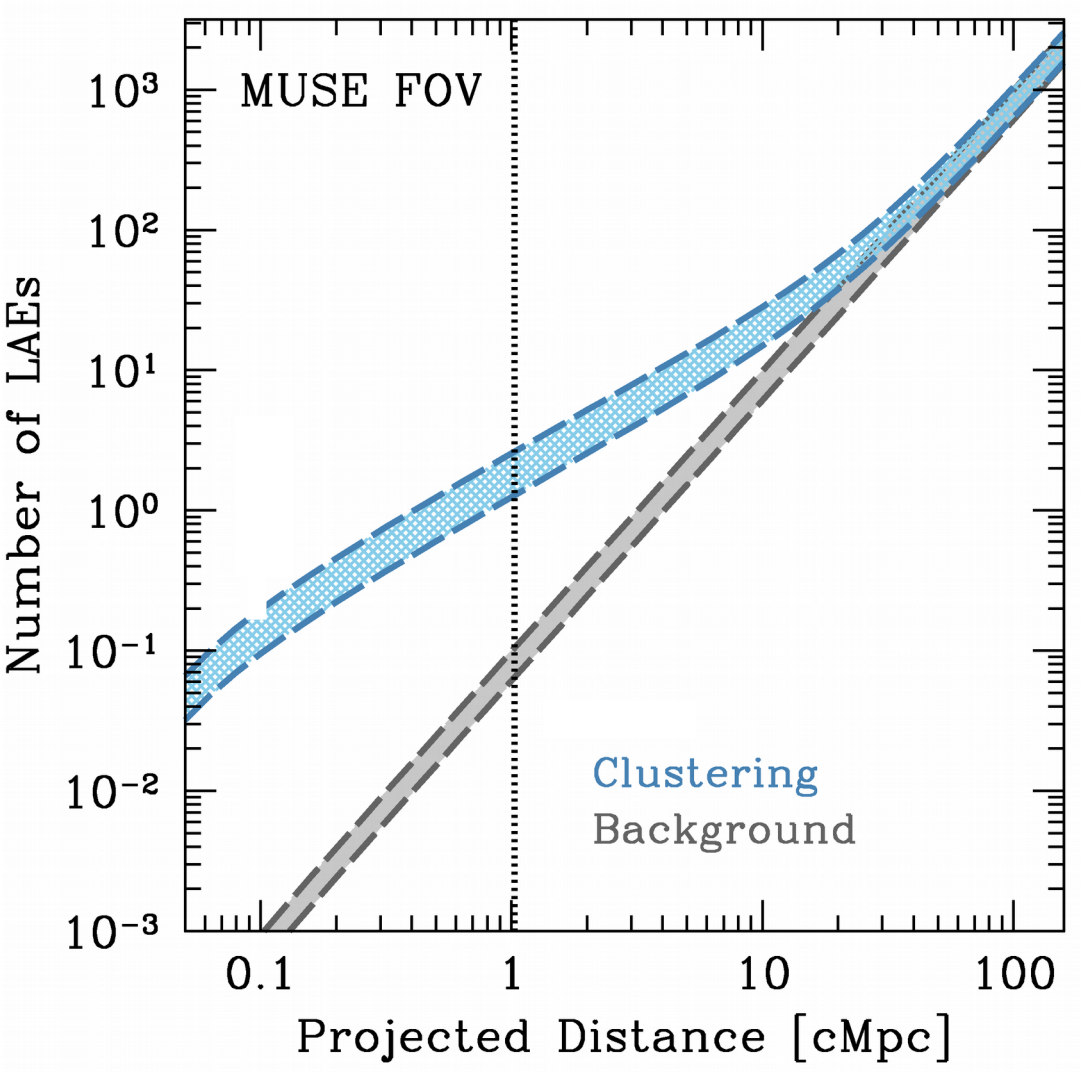


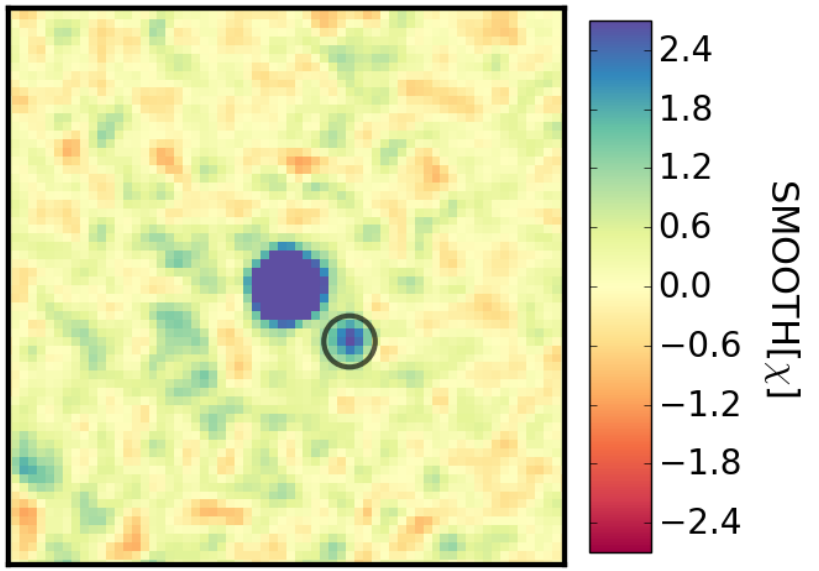
LAE:

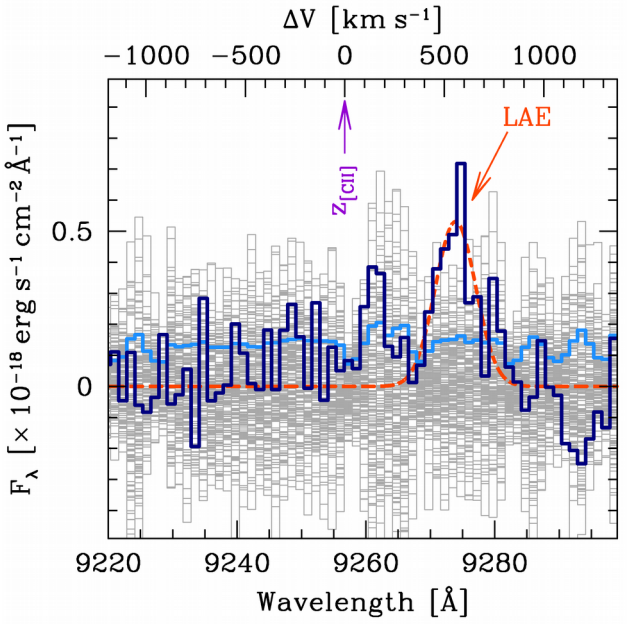
pd = 12.5kpc

ΔV = 560km/s

Small Scale Clustering → MUSE

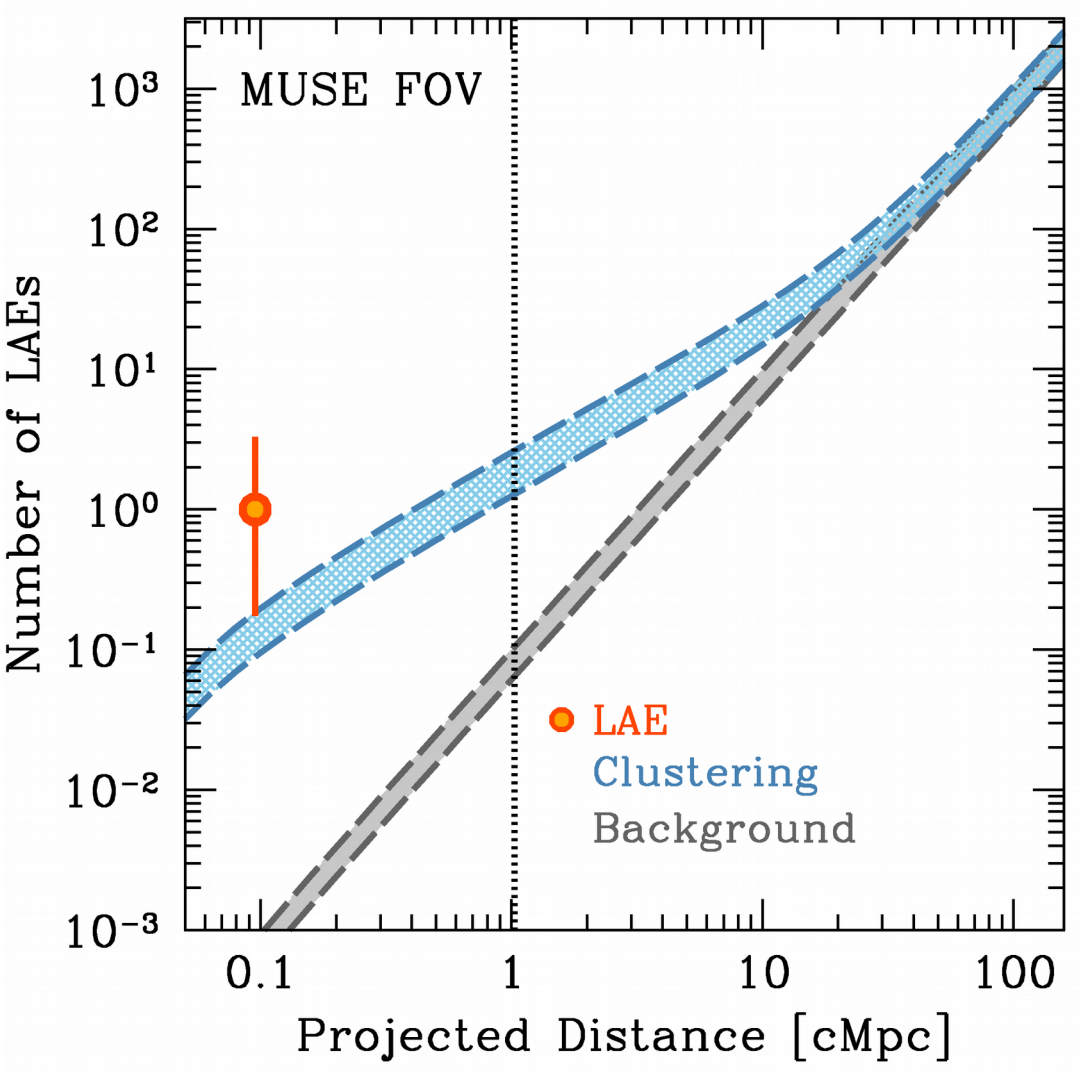


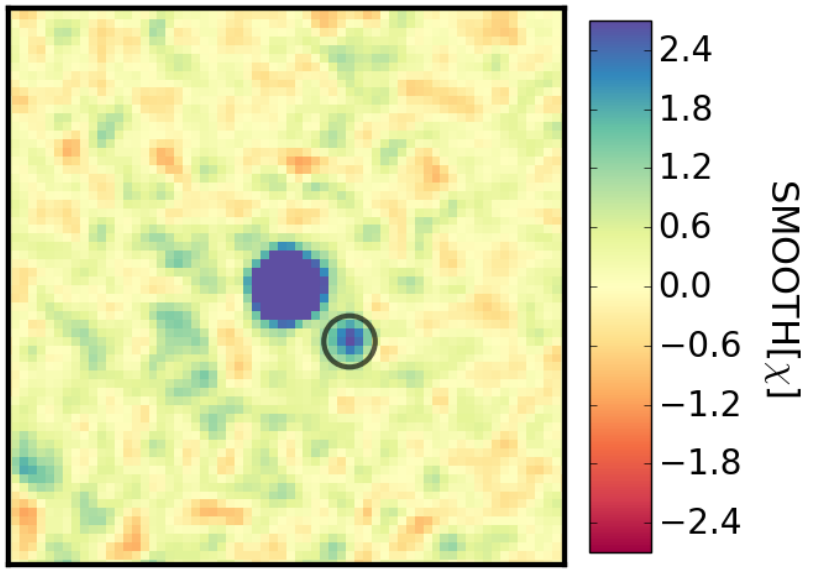


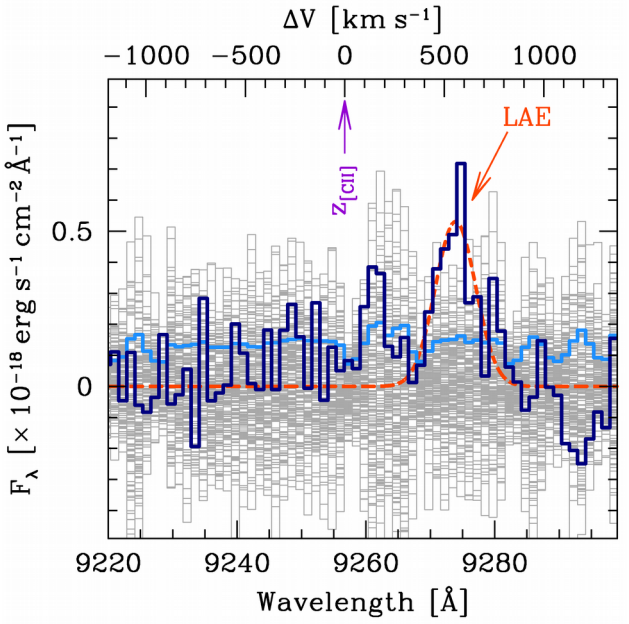


Farina et al. 2017

Small Scale Clustering → MUSE

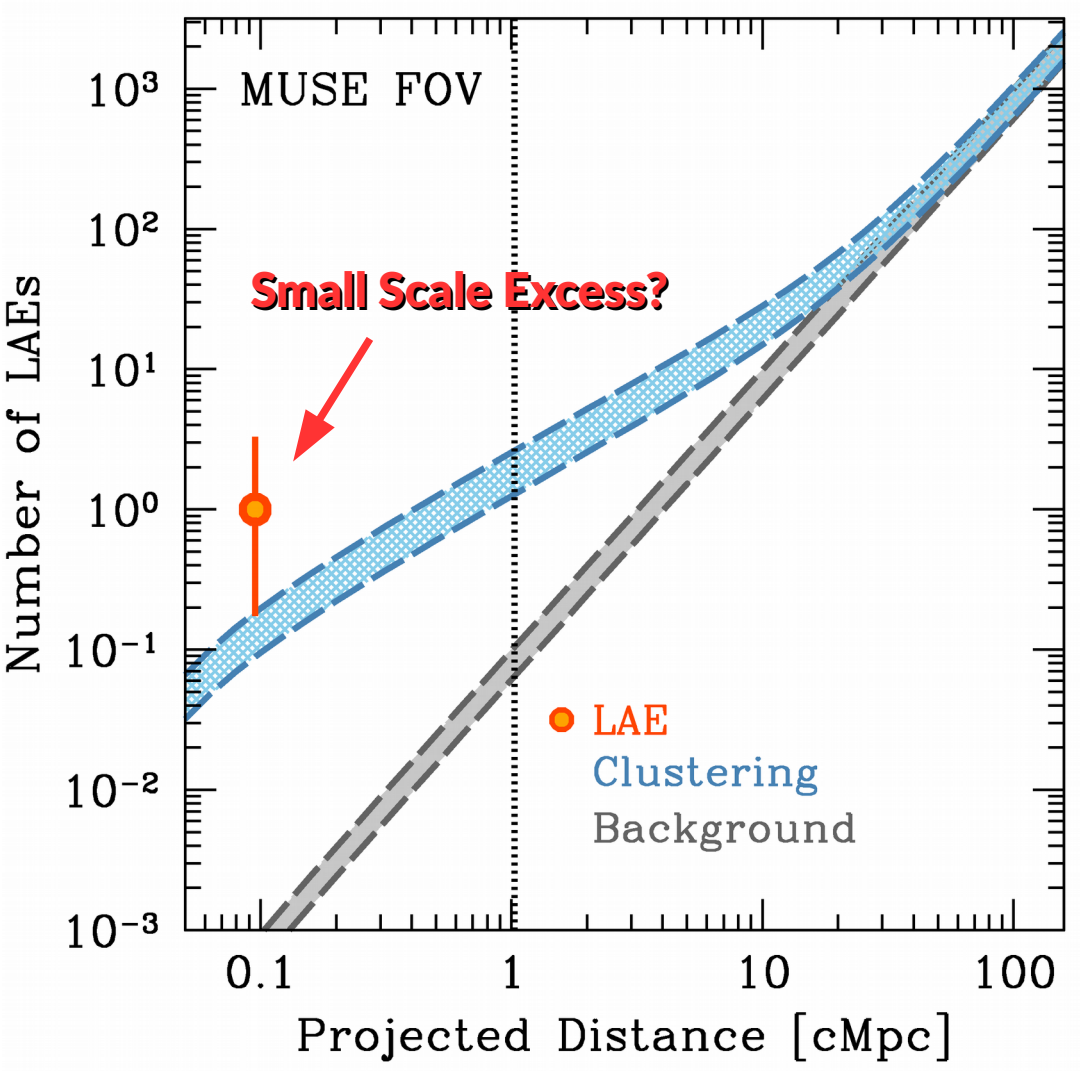


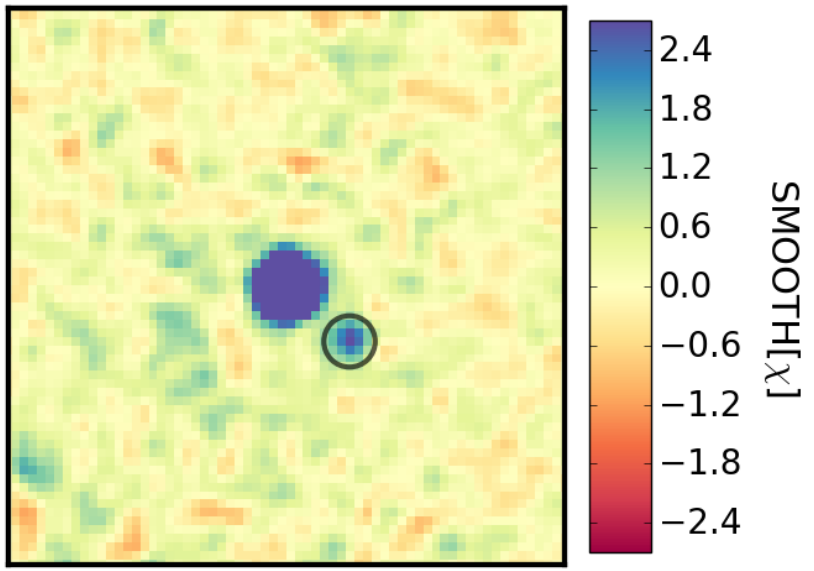


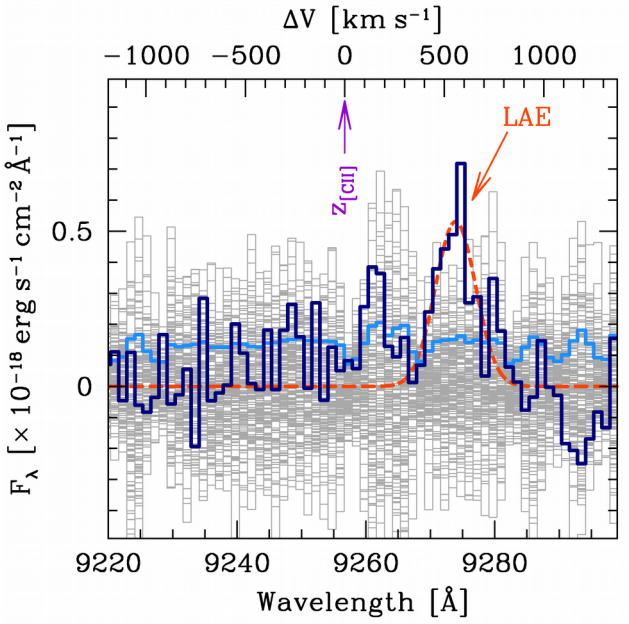


Farina et al. 2017

Small Scale Clustering → MUSE



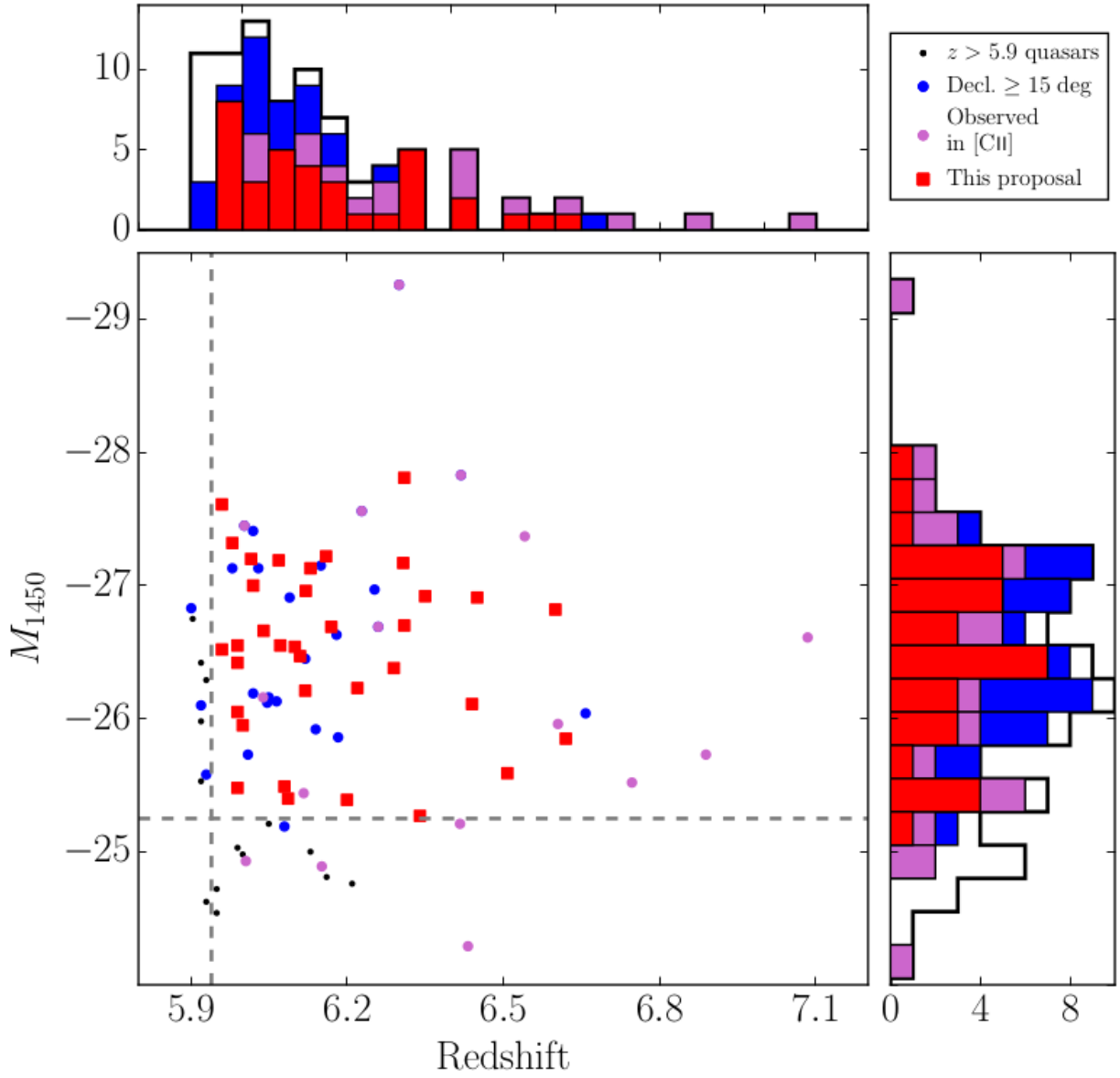




Farina et al. 2017

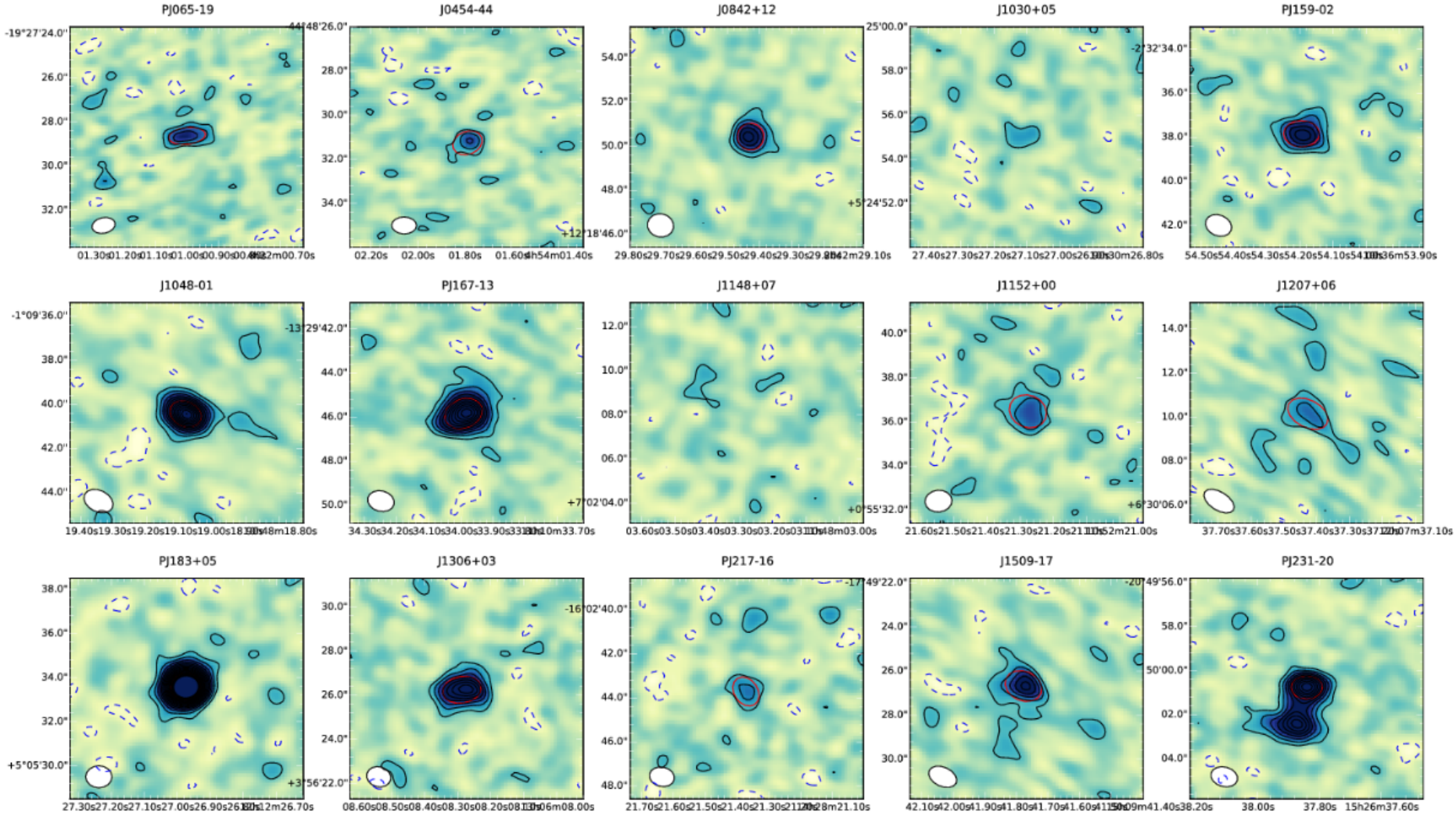
Small Scale Clustering → ALMA

Small Scale Clustering → ALMA



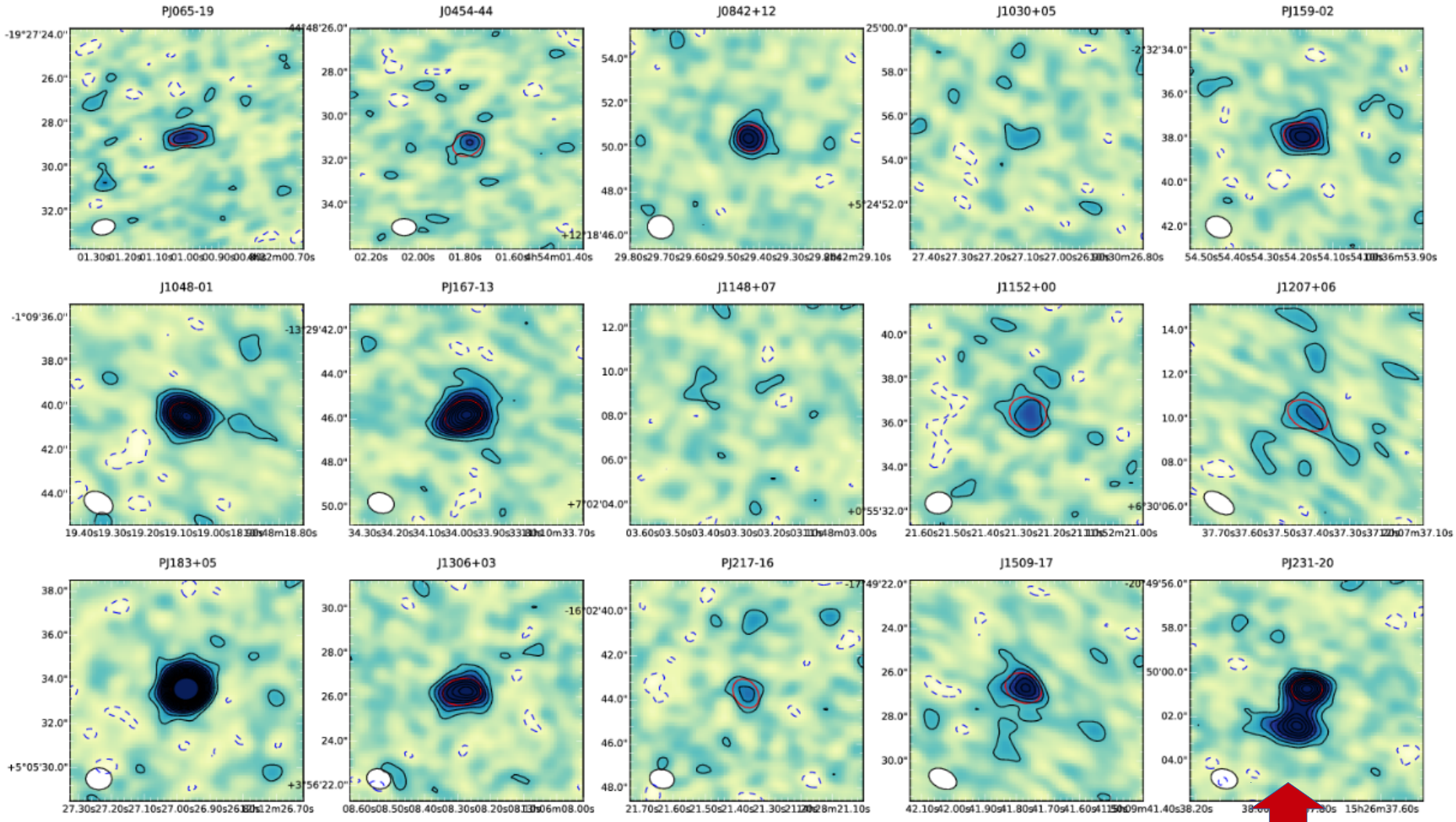
Decarli et al. + Venemans et al.

Small Scale Clustering → ALMA



Decarli et al. + Venemans et al.

Small Scale Clustering → ALMA



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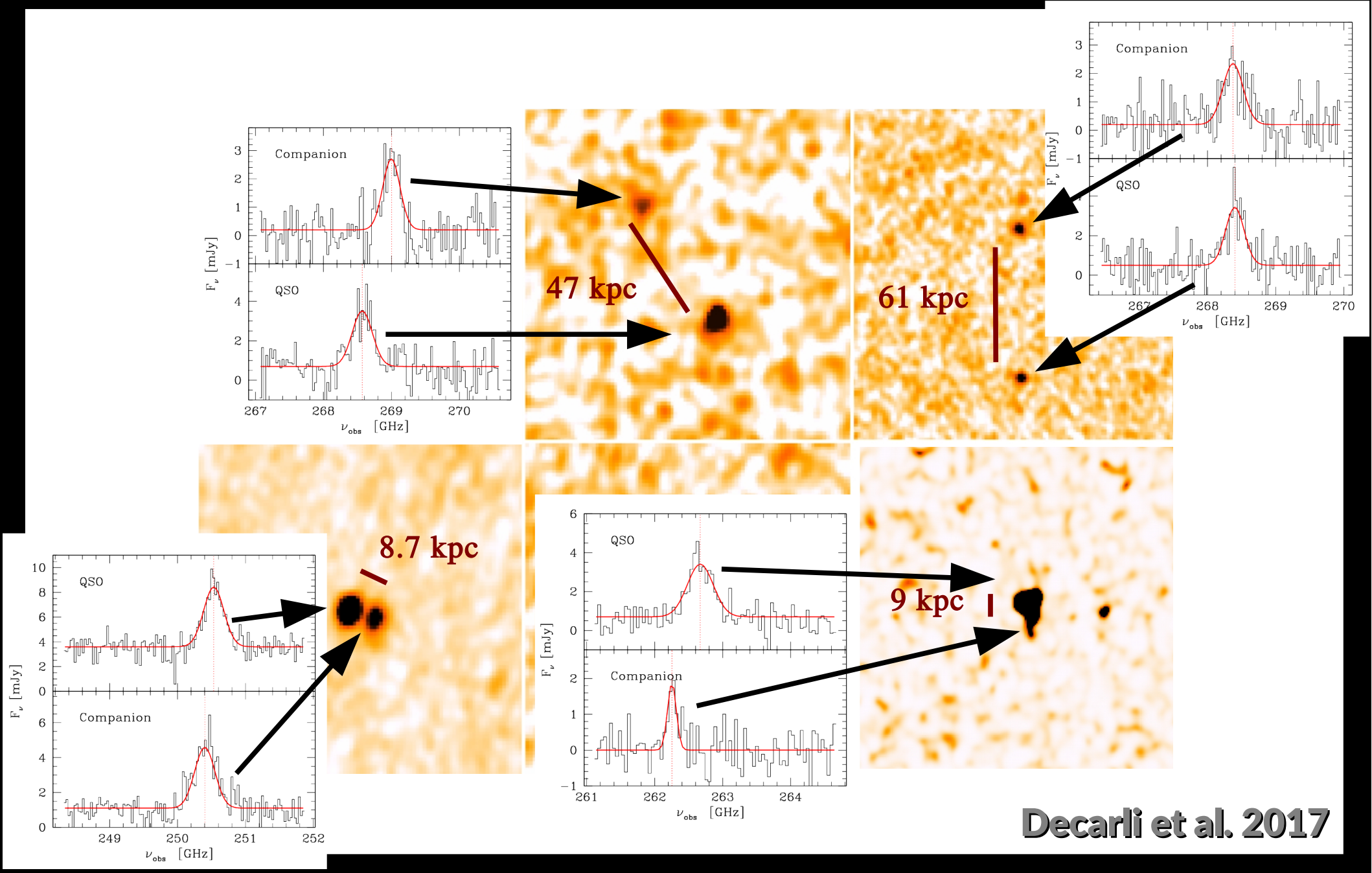
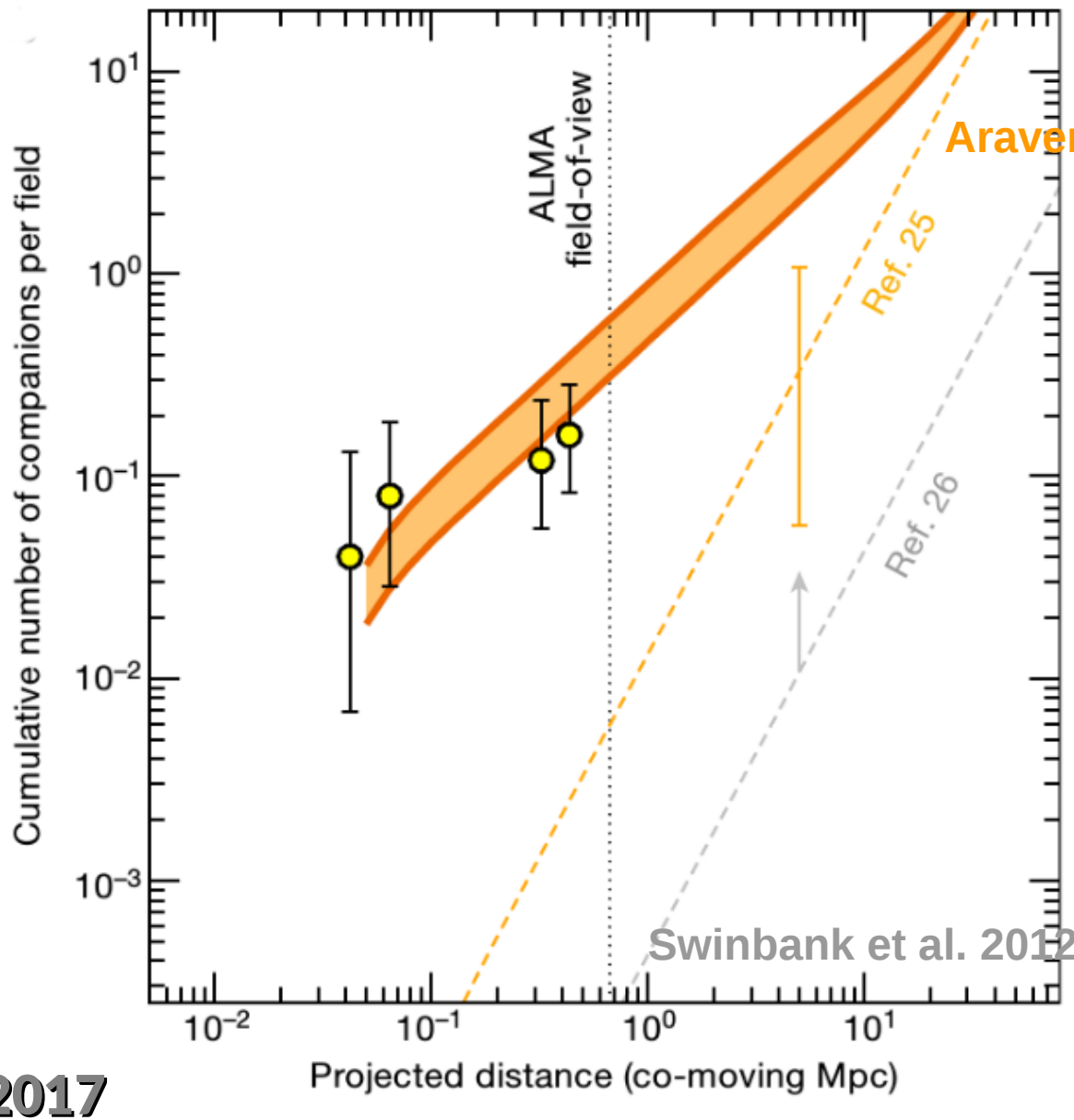
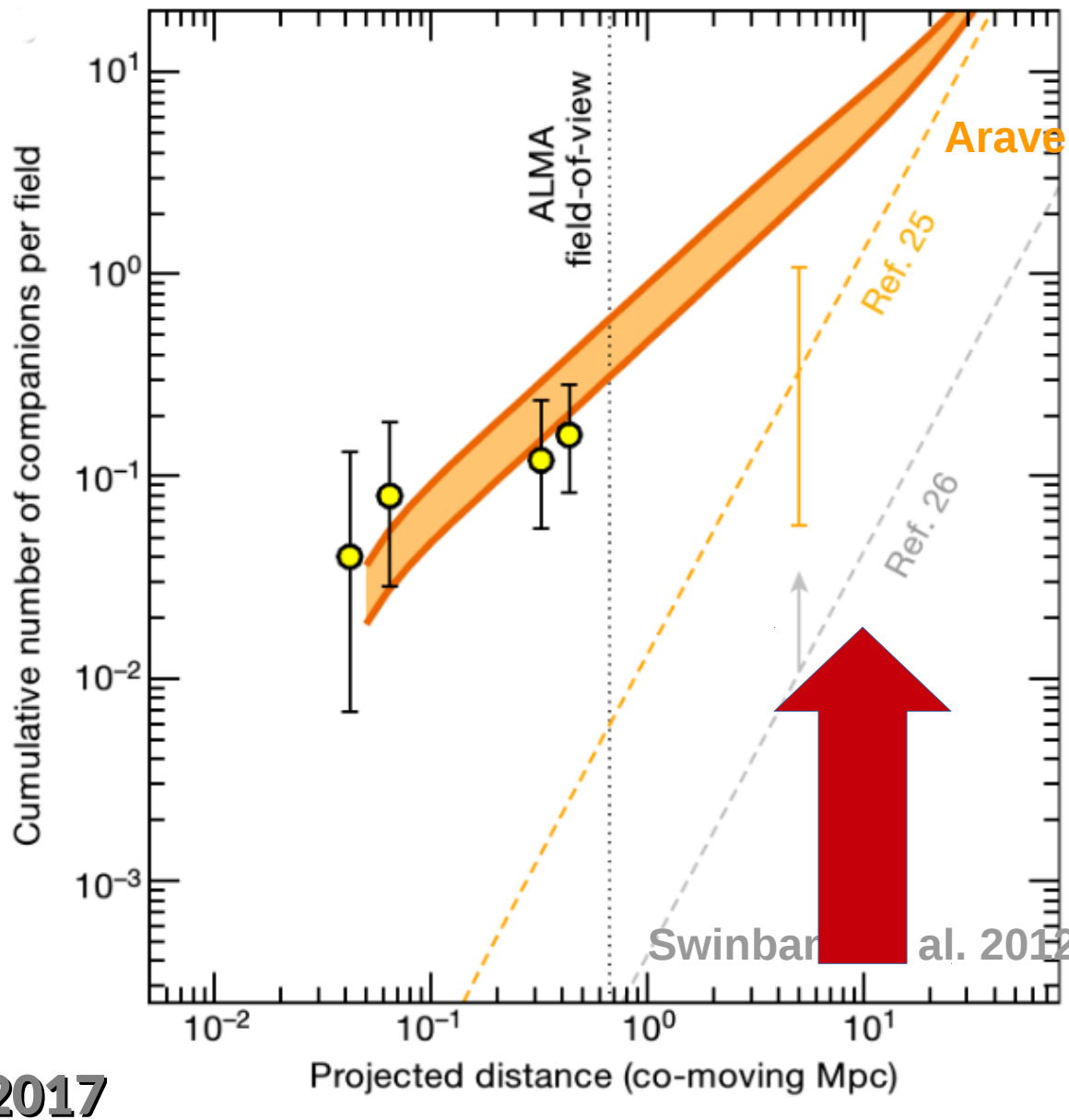


Small Scale Clustering → ALMA



Decarli et al. 2017

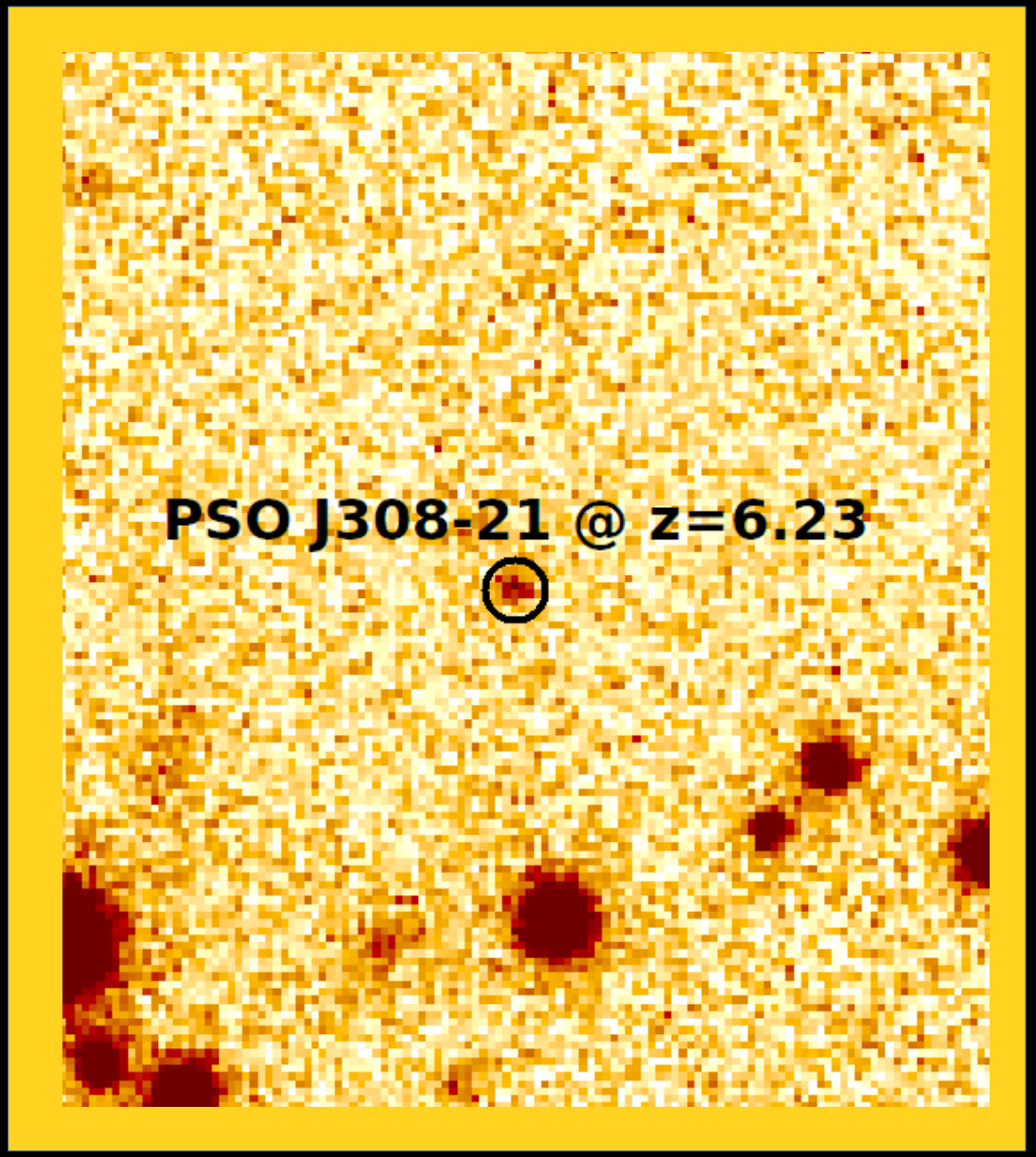
Small Scale Clustering → ALMA



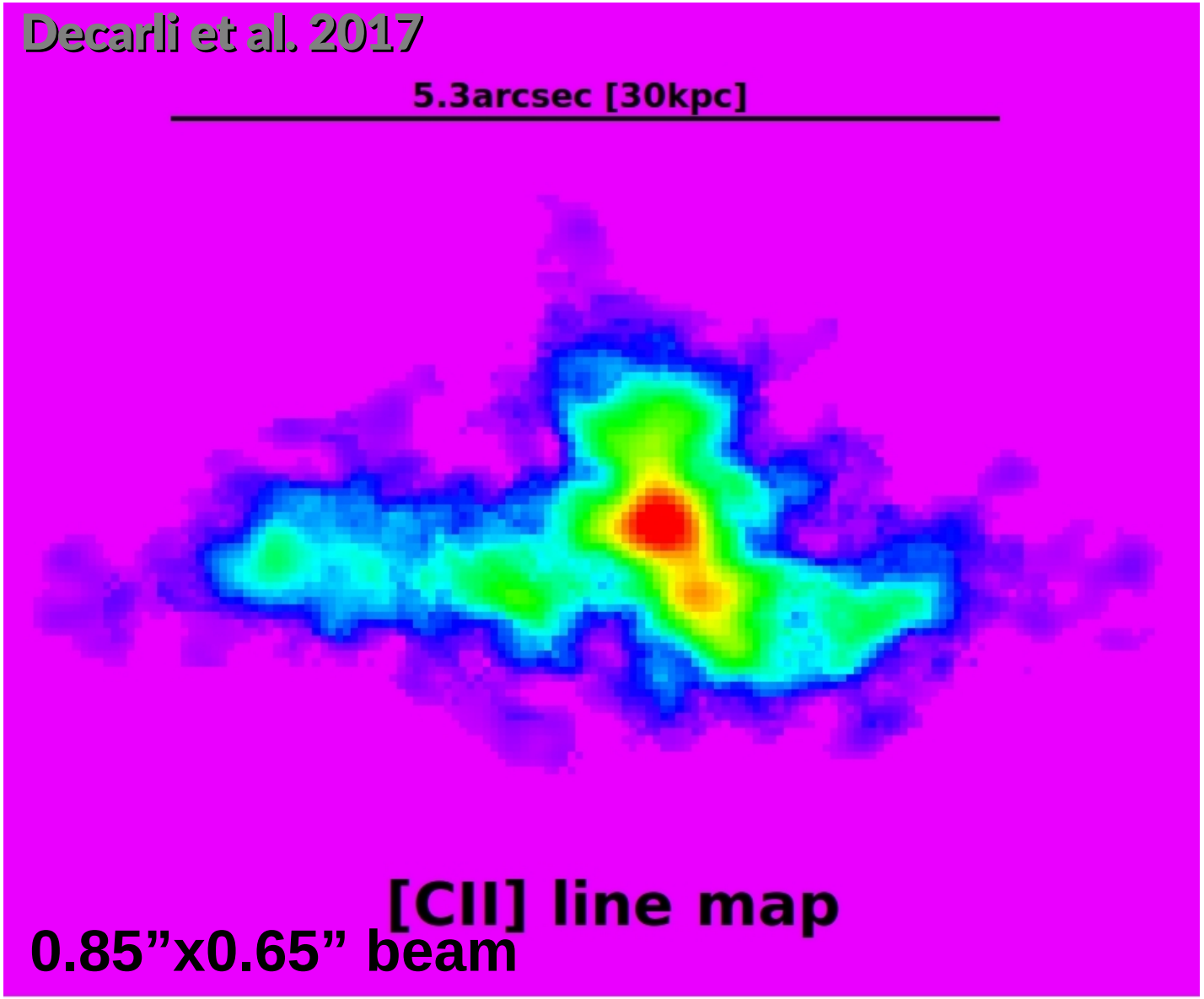
Aravena et al. 2017

Decarli et al. 2017

Evidence for Mergers?



Evidence for Mergers!

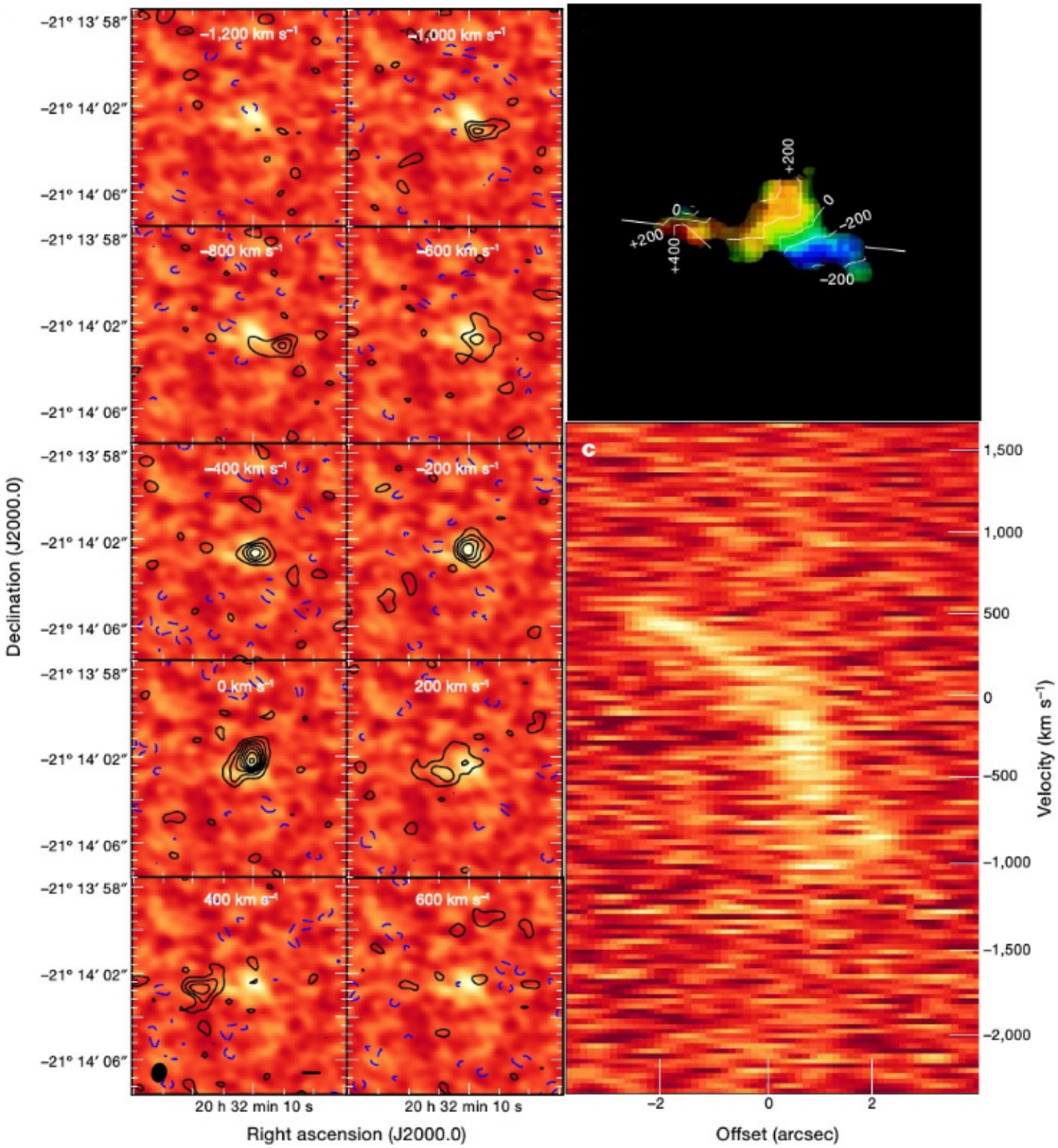


A merger at z=6.23

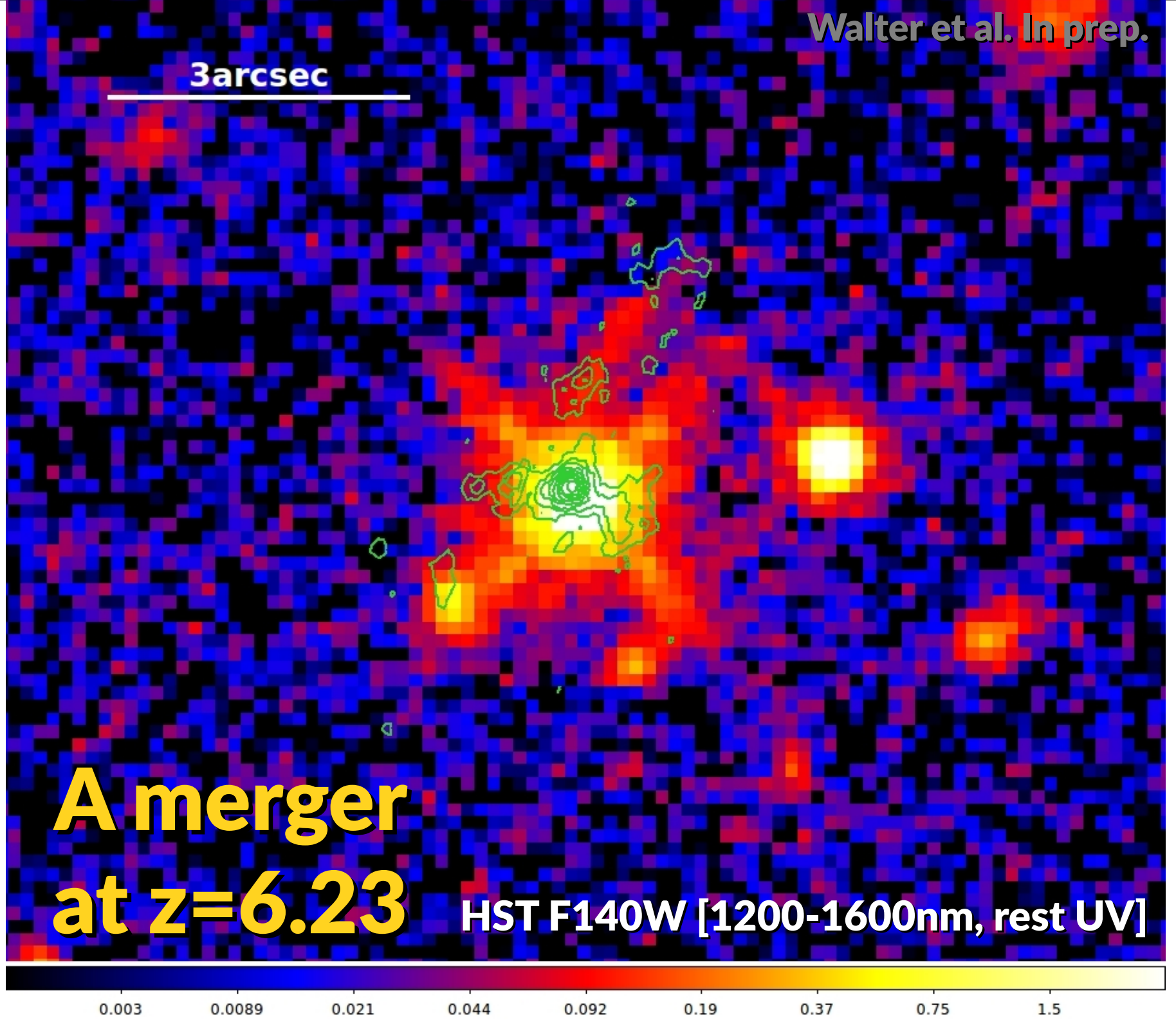
Extended for 25kpc

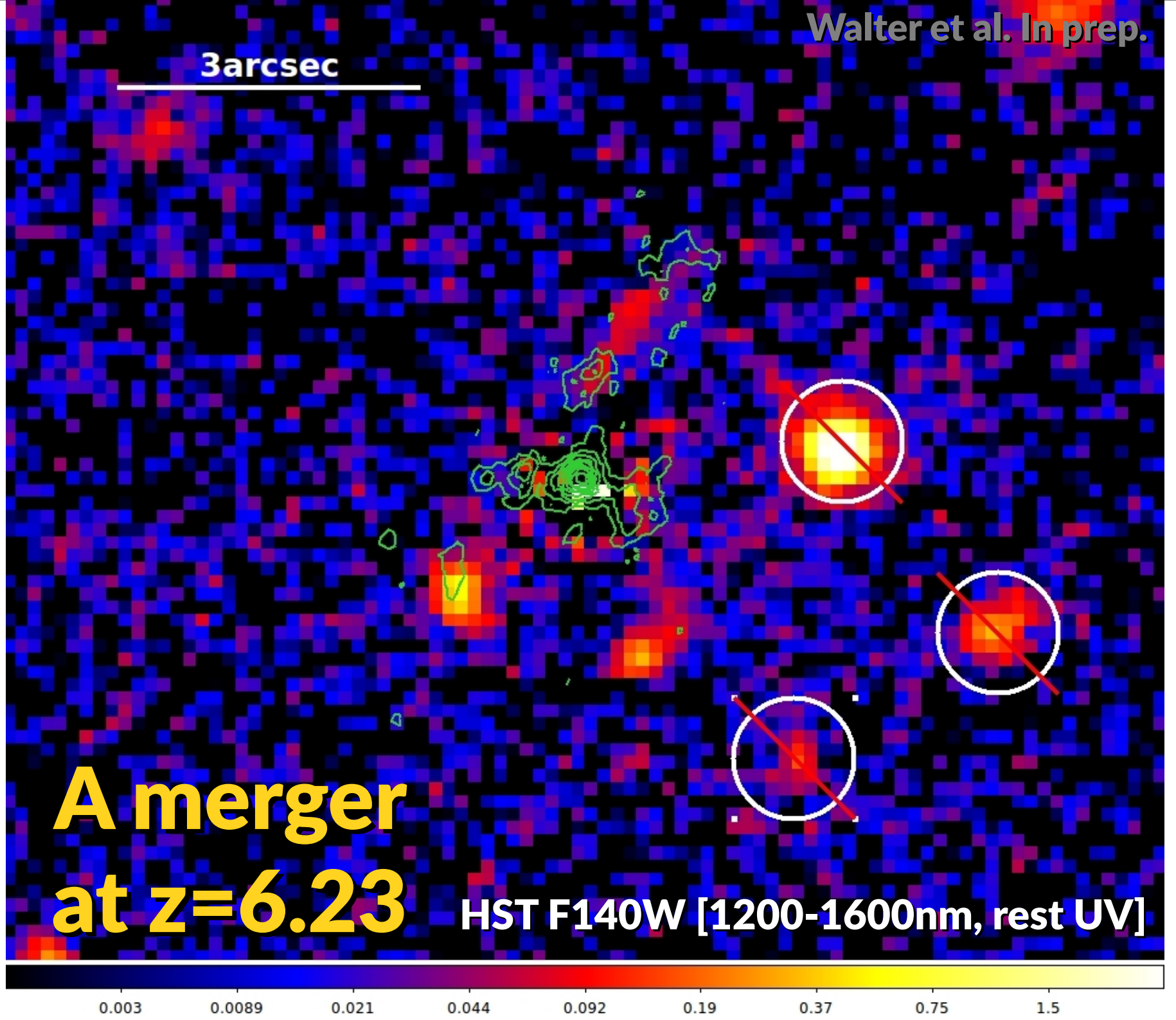
ΔV>1000km/s

$L_{[CII]}$~1.9x10⁹Lsun



Decarli et al. 2017


Walter et al. In prep.
3arcsec
A merger
at z=6.23
HST F140W [1200-1600nm, rest UV]
0.003
0.0089
0.021
0.044
0.092
0.19
0.37
0.75
1.5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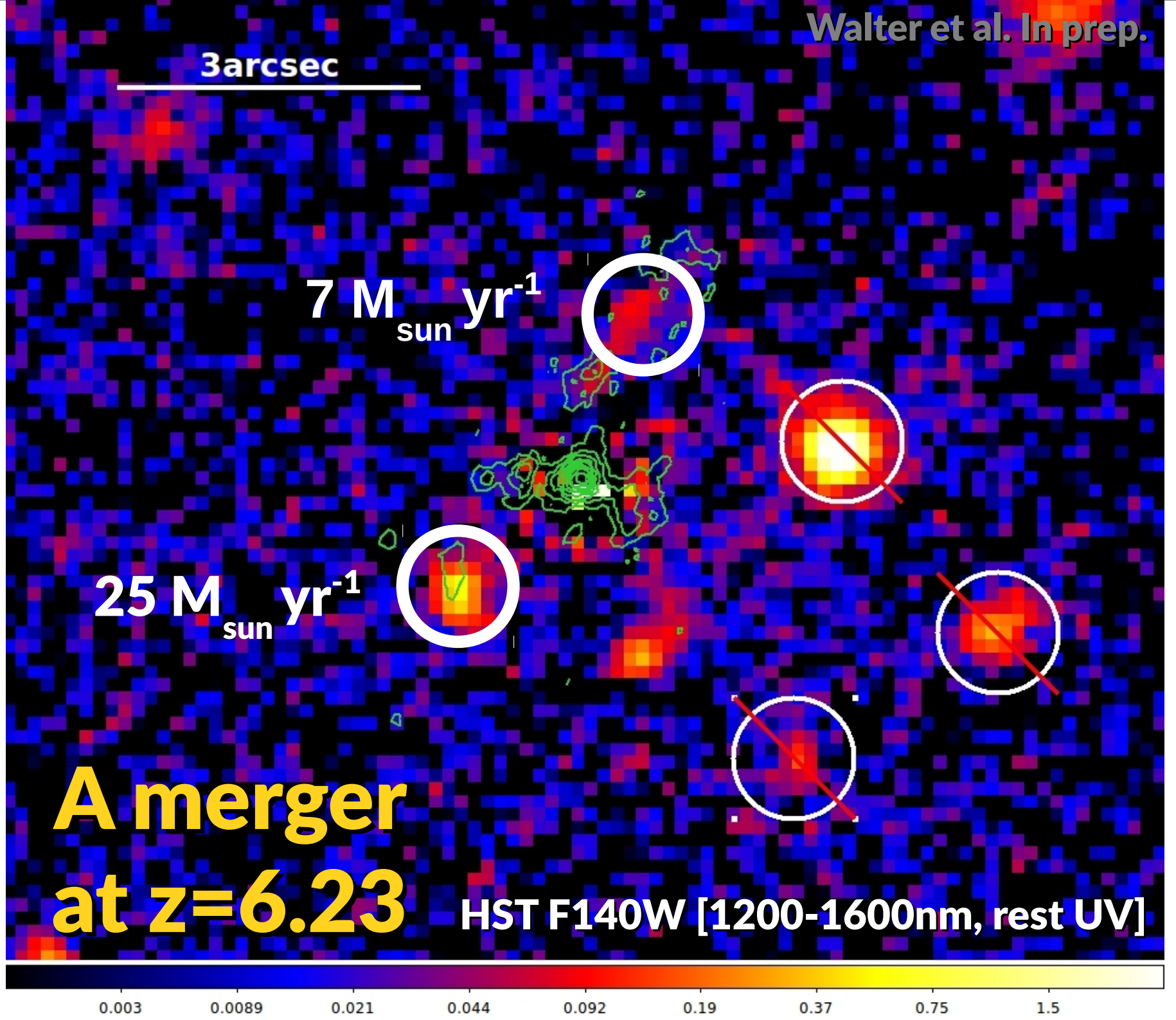
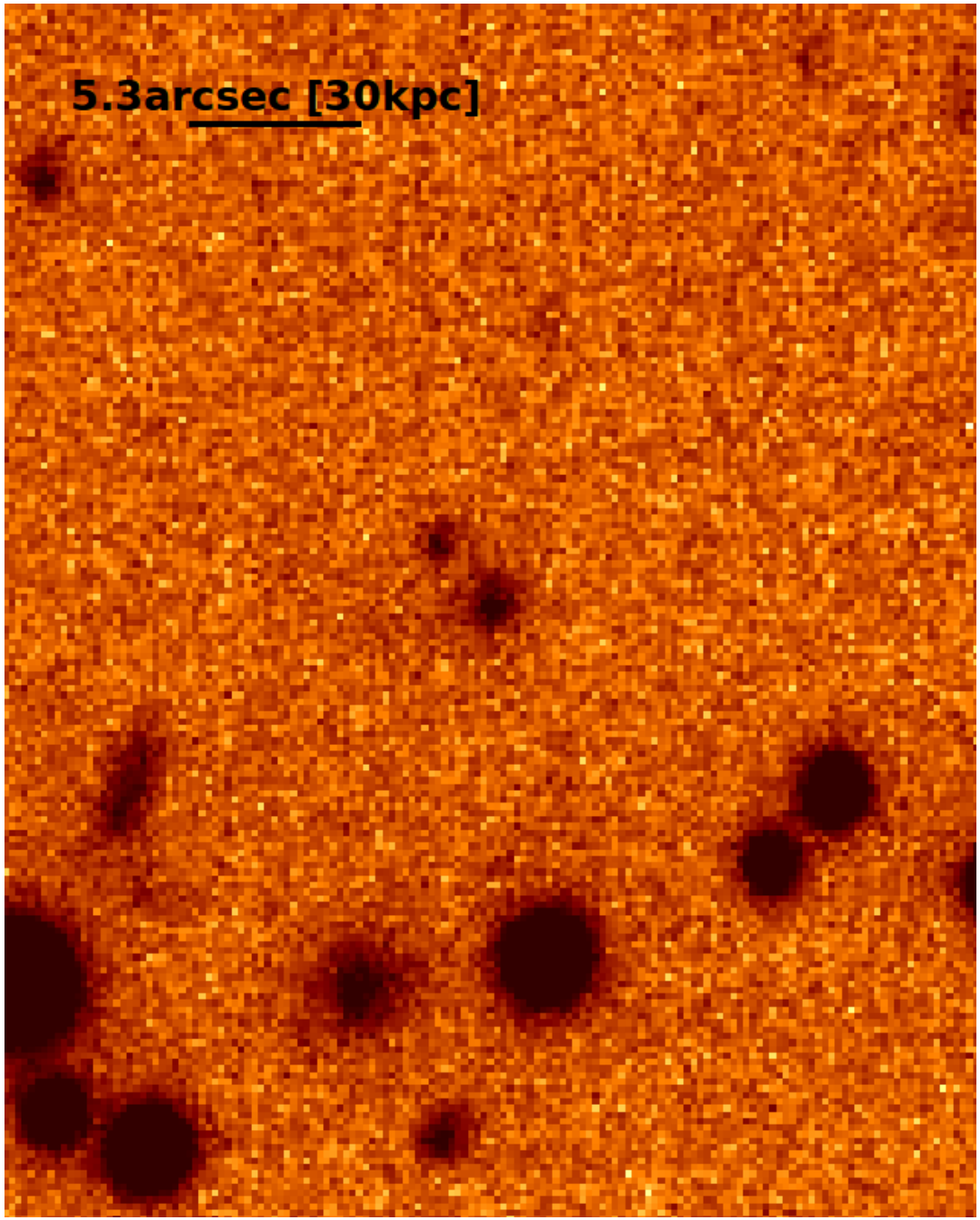

Walter et al. In prep.
3arcsec
7 M sun yr-1
25 M sun yr-1
A merger at z=6.23
HST F140W [1200-1600nm, rest UV]
0.003
0.0089
0.021
0.044
0.092
0.19
0.37
0.75
1.5



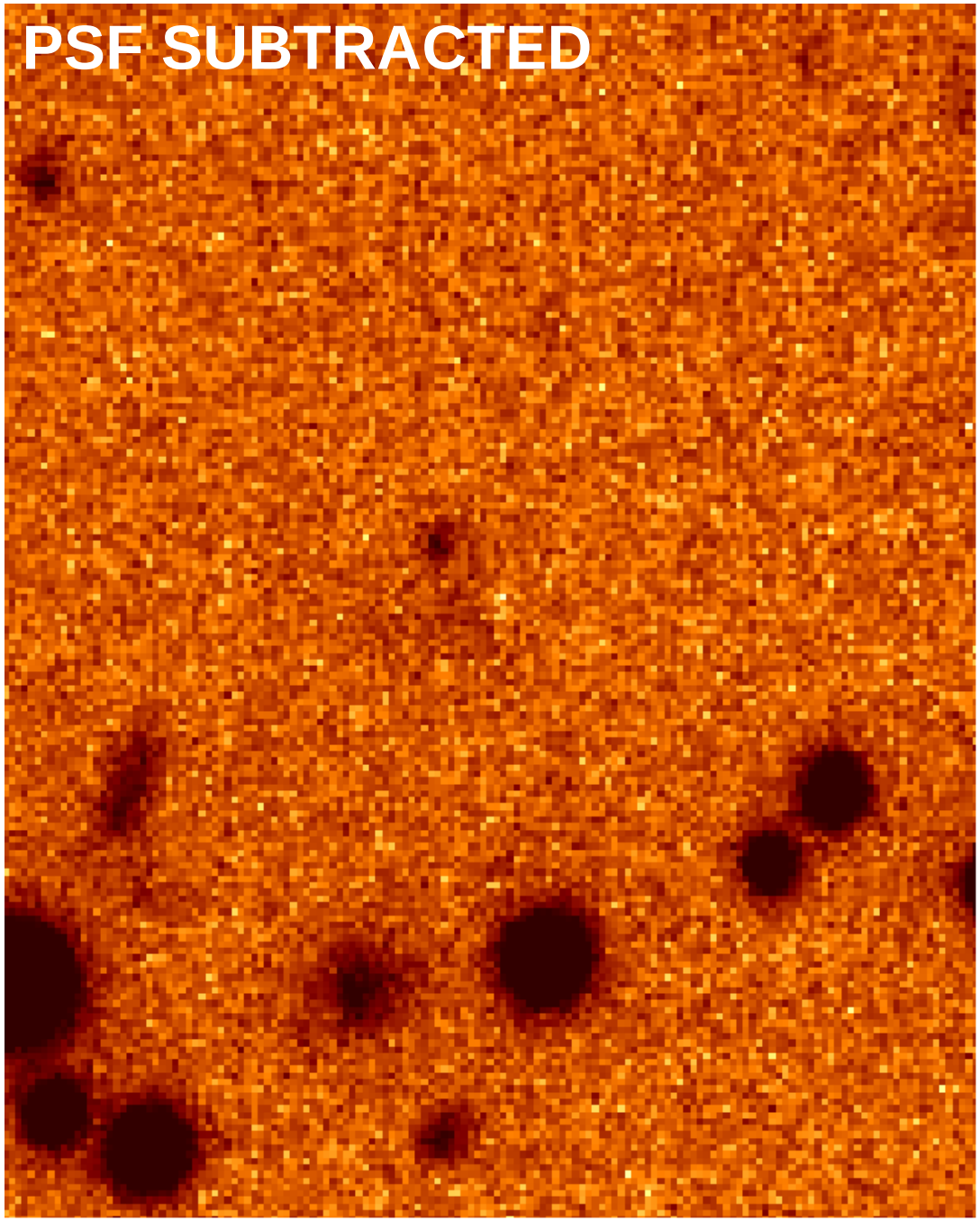
6h of VLT/MUSE

NB image @ z_{merger}

SB_{lim}~1.3x10^{-18}erg/s/cm^2/$arcsec^2$

A merger at z=6.23

Farina et al. in prep



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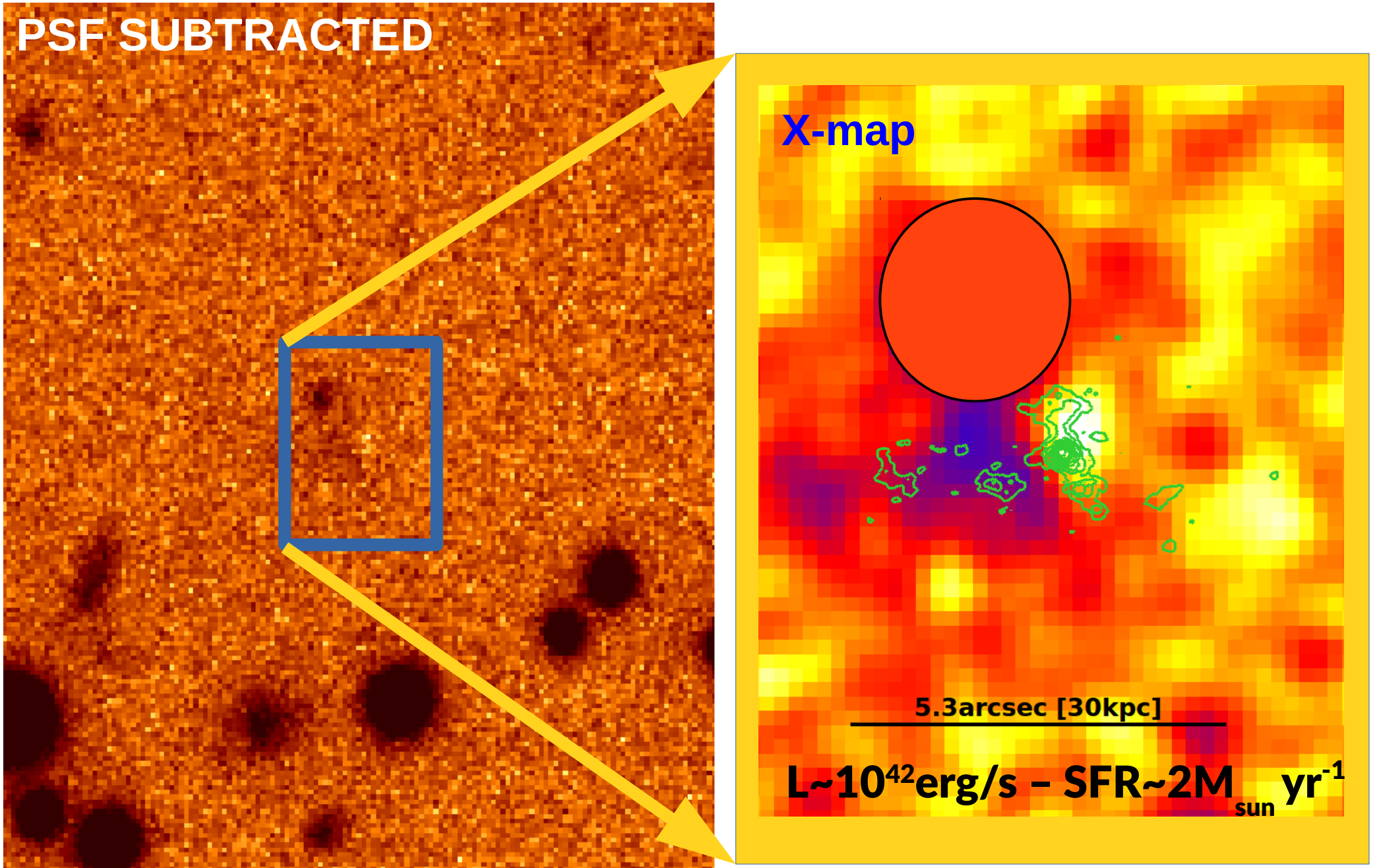
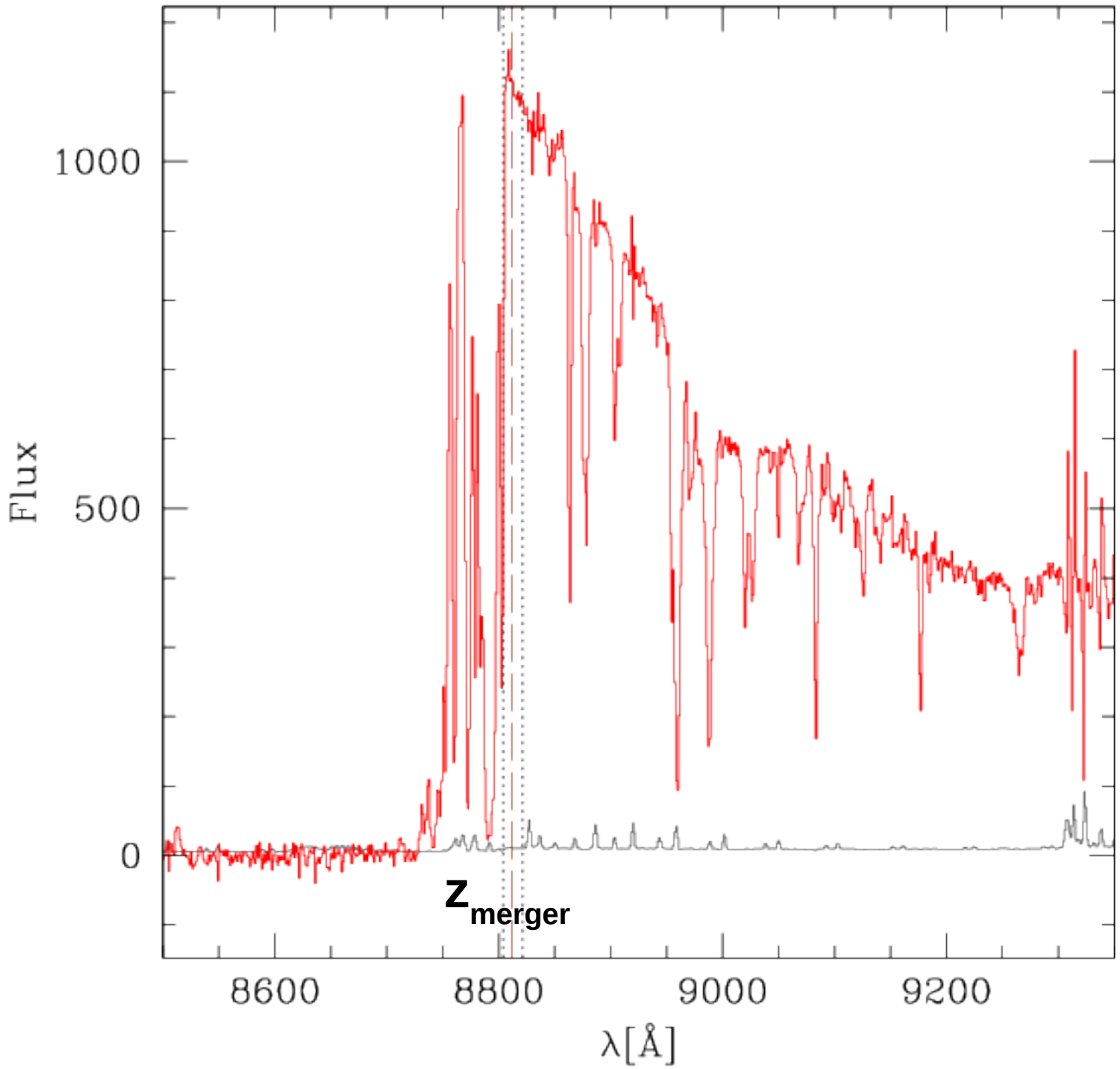


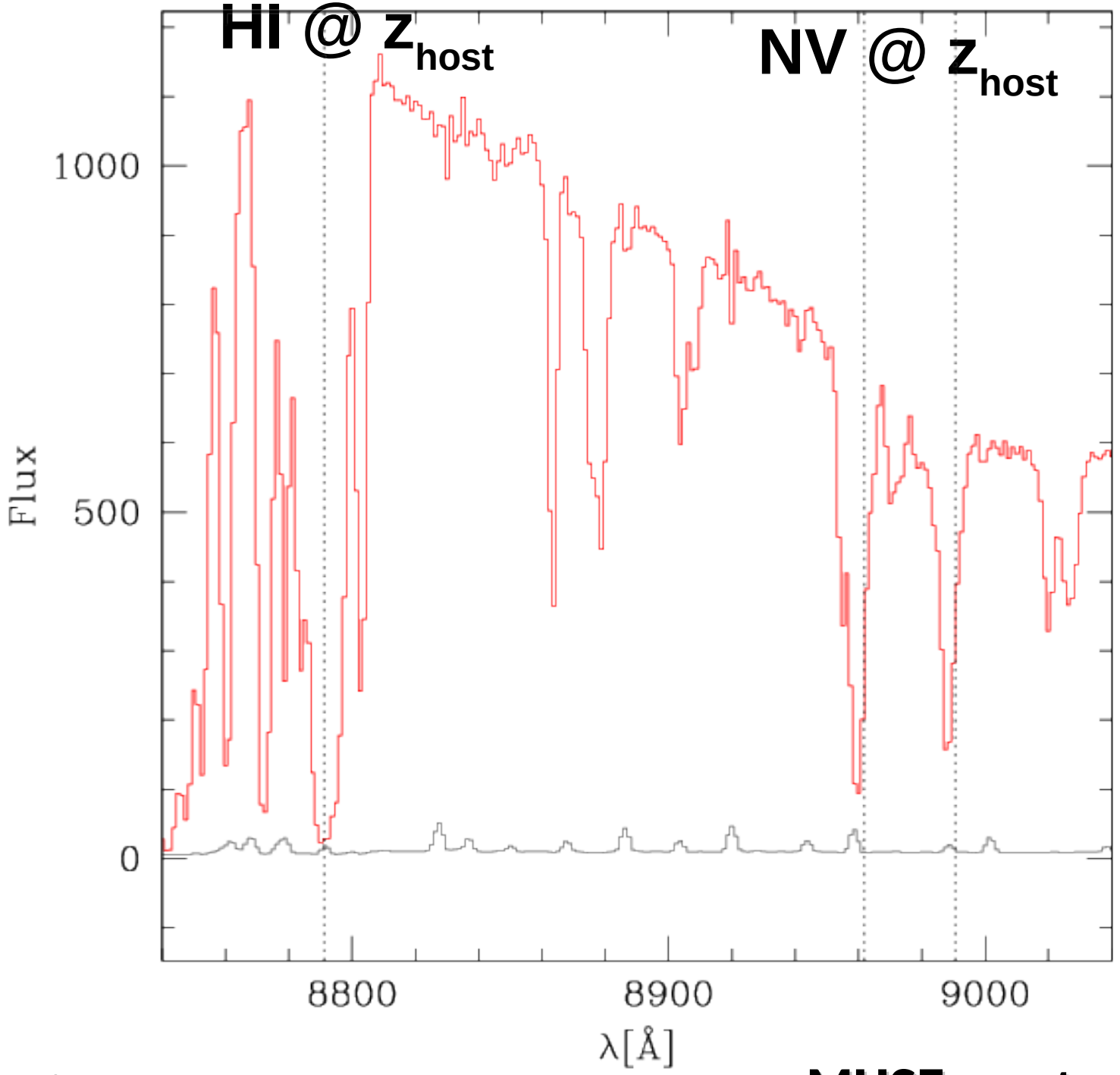
A merger at z=6.23

Farina et al. in prep



Farina et al. in prep

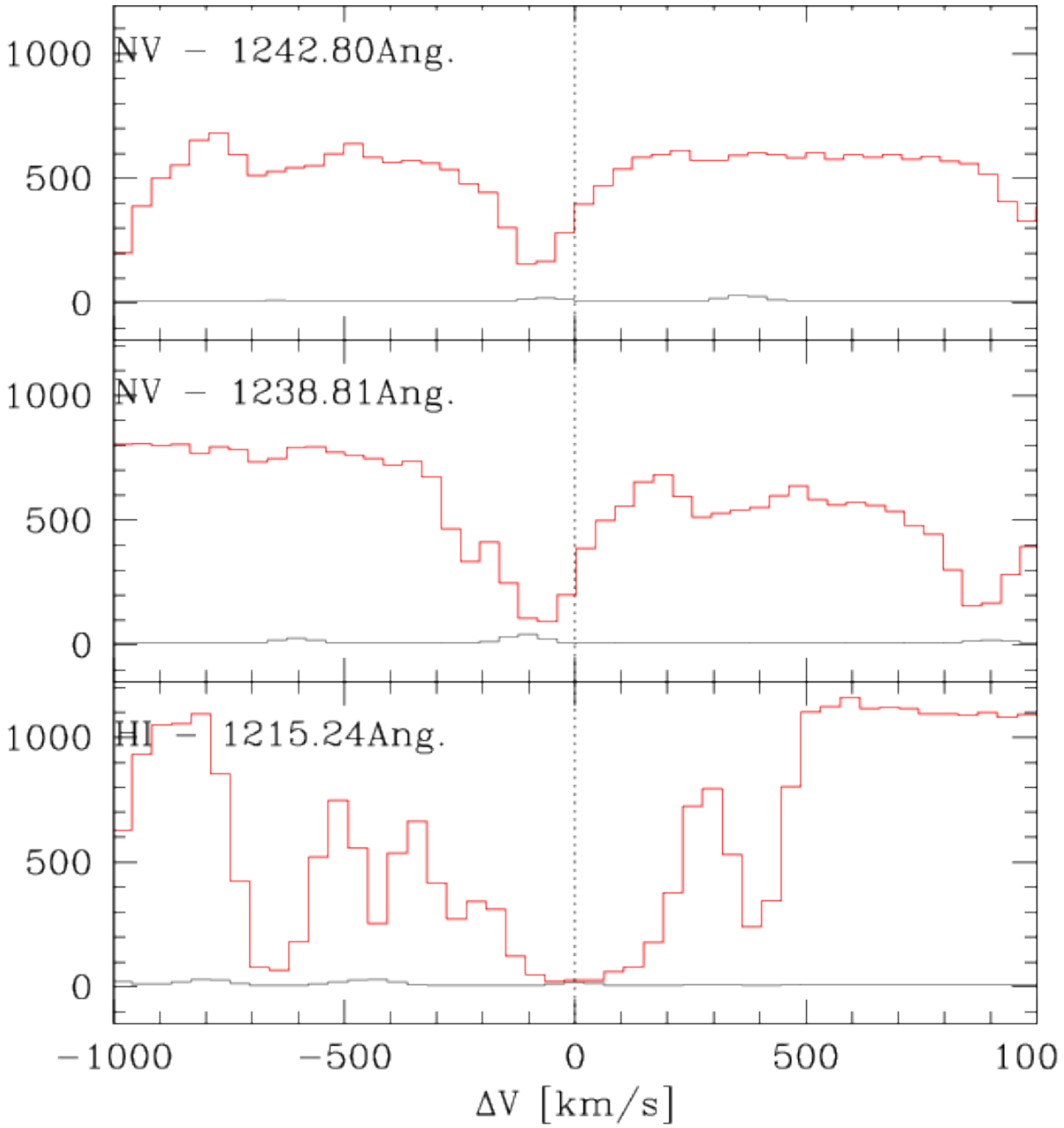
MUSE spectrum



Farina et al. in prep

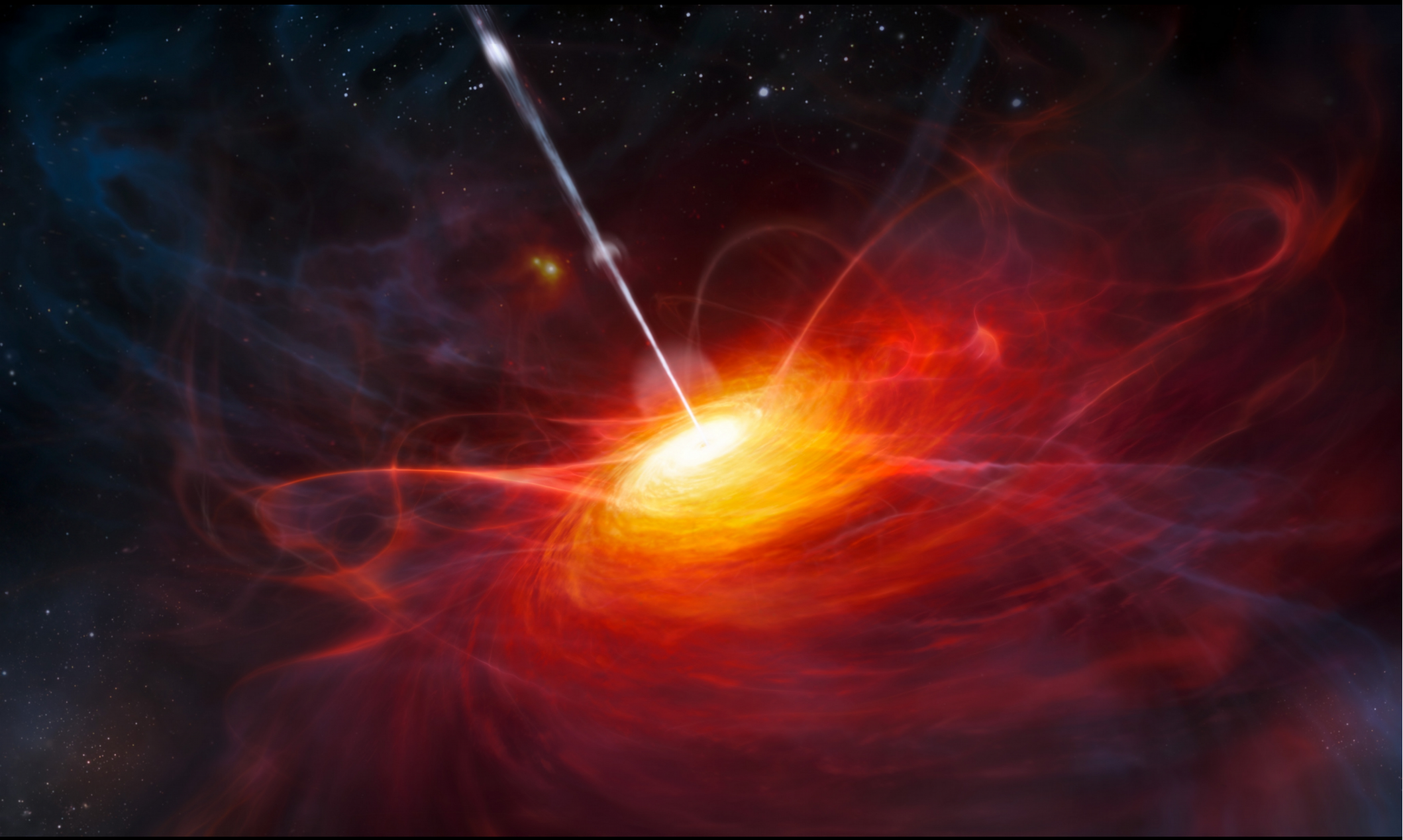
MUSE spectrum

~100km/s outflow?



Farina et al. in prep

MUSE spectrum



The First QSOs live in High Density Environment

[protoclusters?]

..looking forward to JWST..