# The Small-Scale Structure of the z~0.5 Circumgalactic Medium

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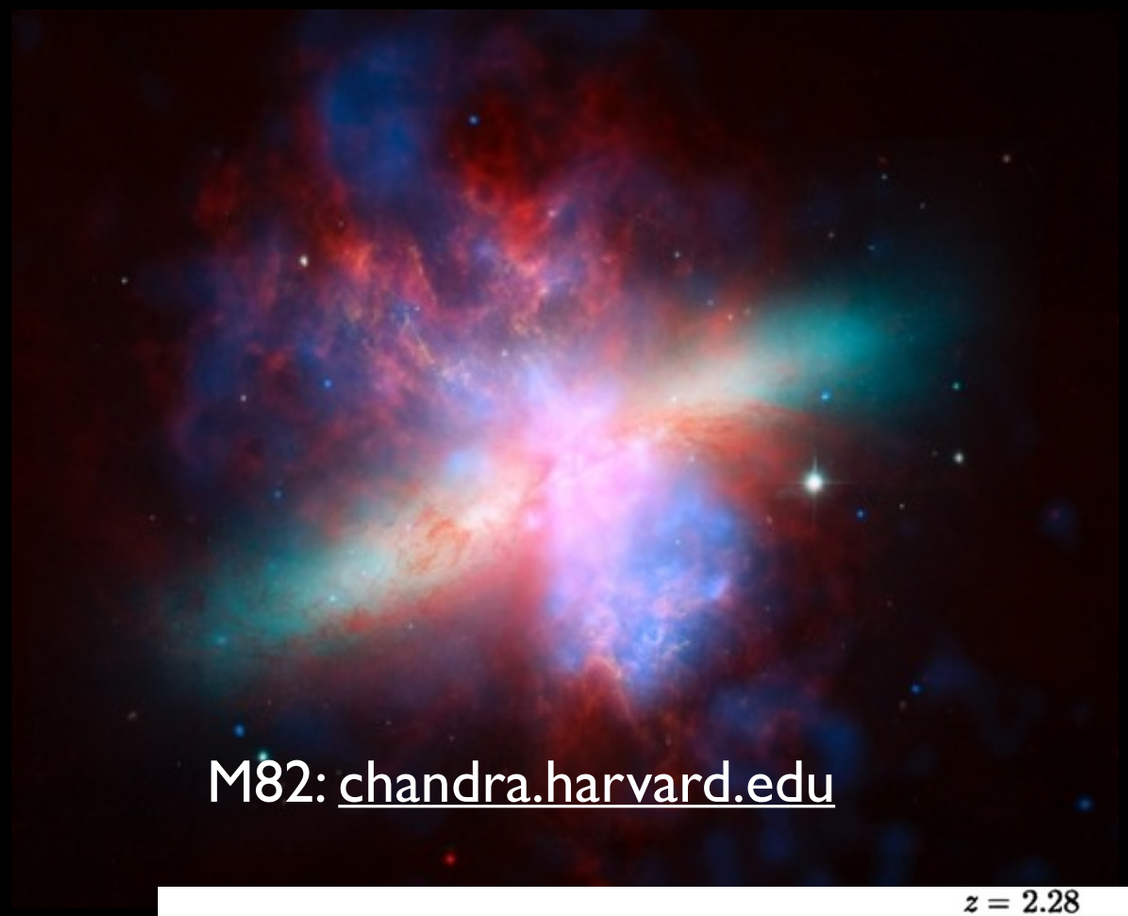
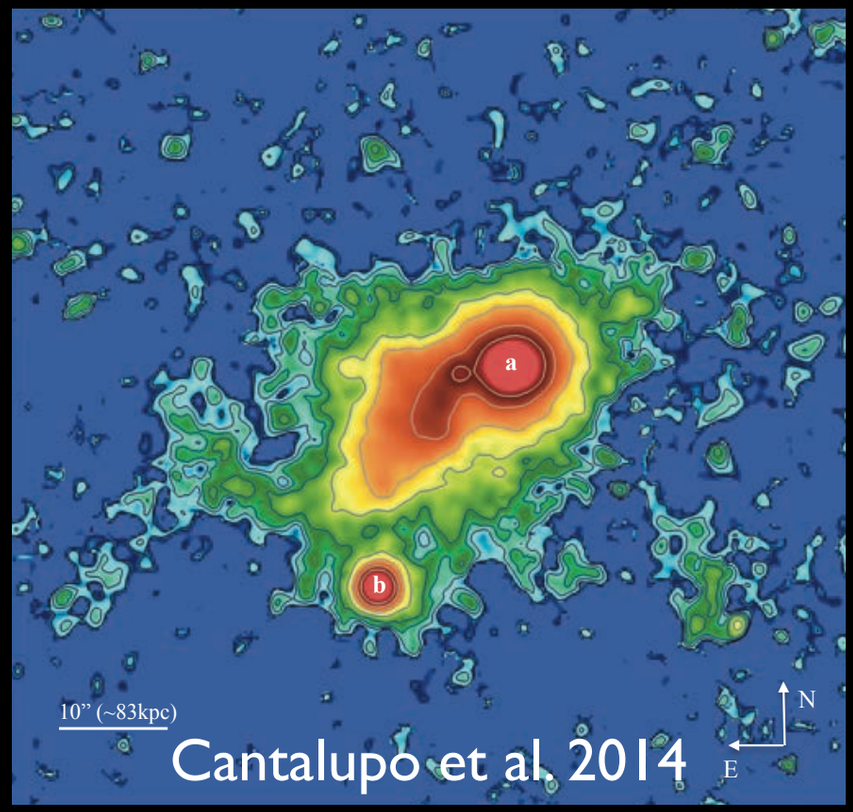
(CfA)

with Aleks Diamond-Stanic (UW Madison) and
Alison Coil (UCSD)

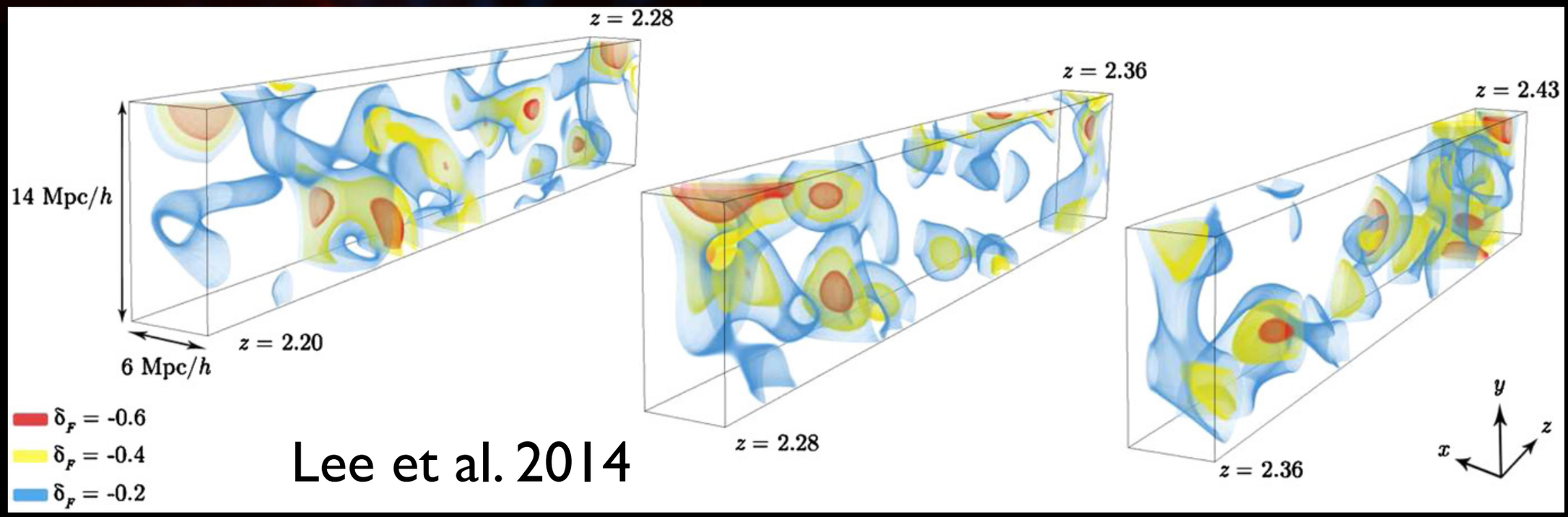
# The Dream: Image the CGM



M82: chandra.harvard.edu

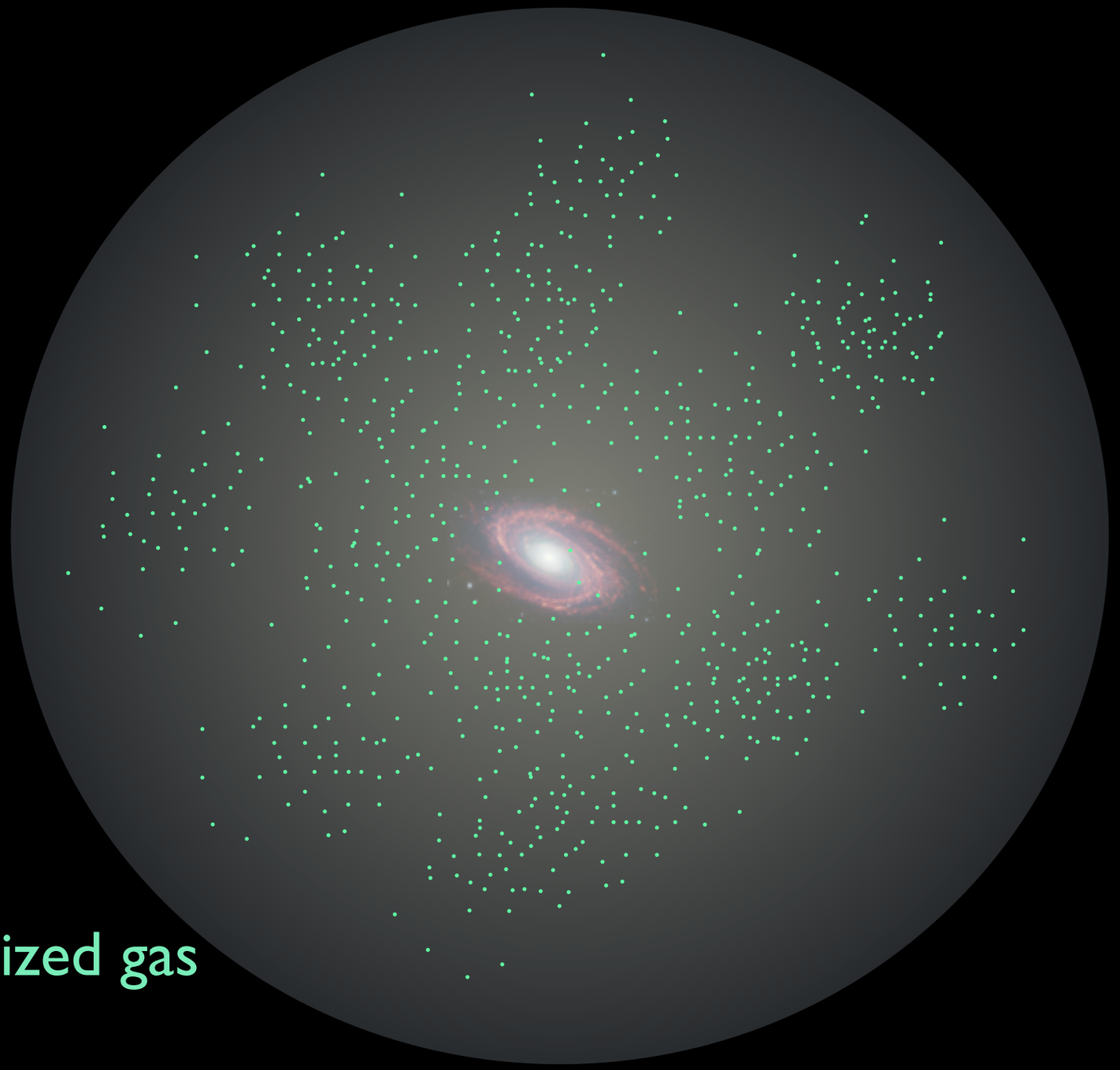



Cantalupo et al. 2014




Lee et al. 2014

# “Imaging” a typical galaxy CGM (cartoon version)



cool, photoionized gas

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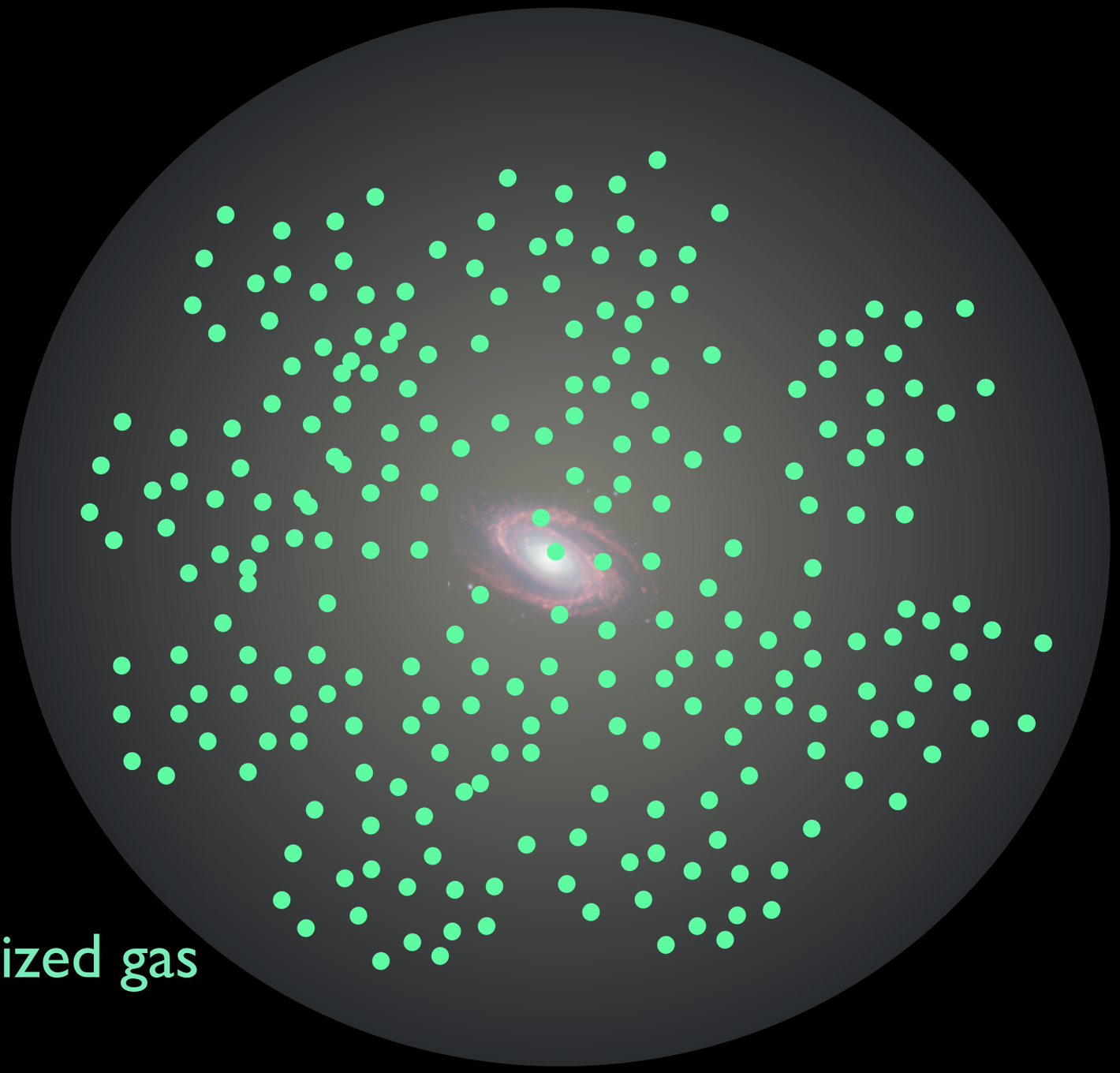
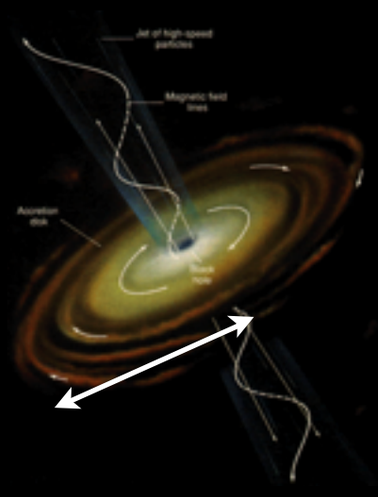


cool, photoionized gas

# Bright background sources: a few options

## QSOs



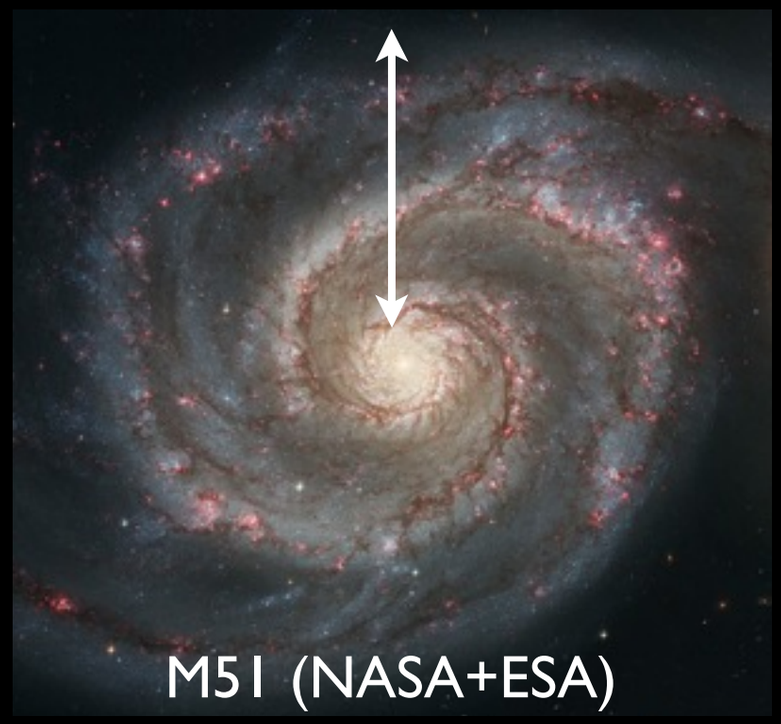
$R_{QSO} \sim 10^{-3}$ pc

Shakura & Sunyaev 1973
Frank+2007

## Stars

$R_B \sim 10^{-7}$ pc

## Galaxies

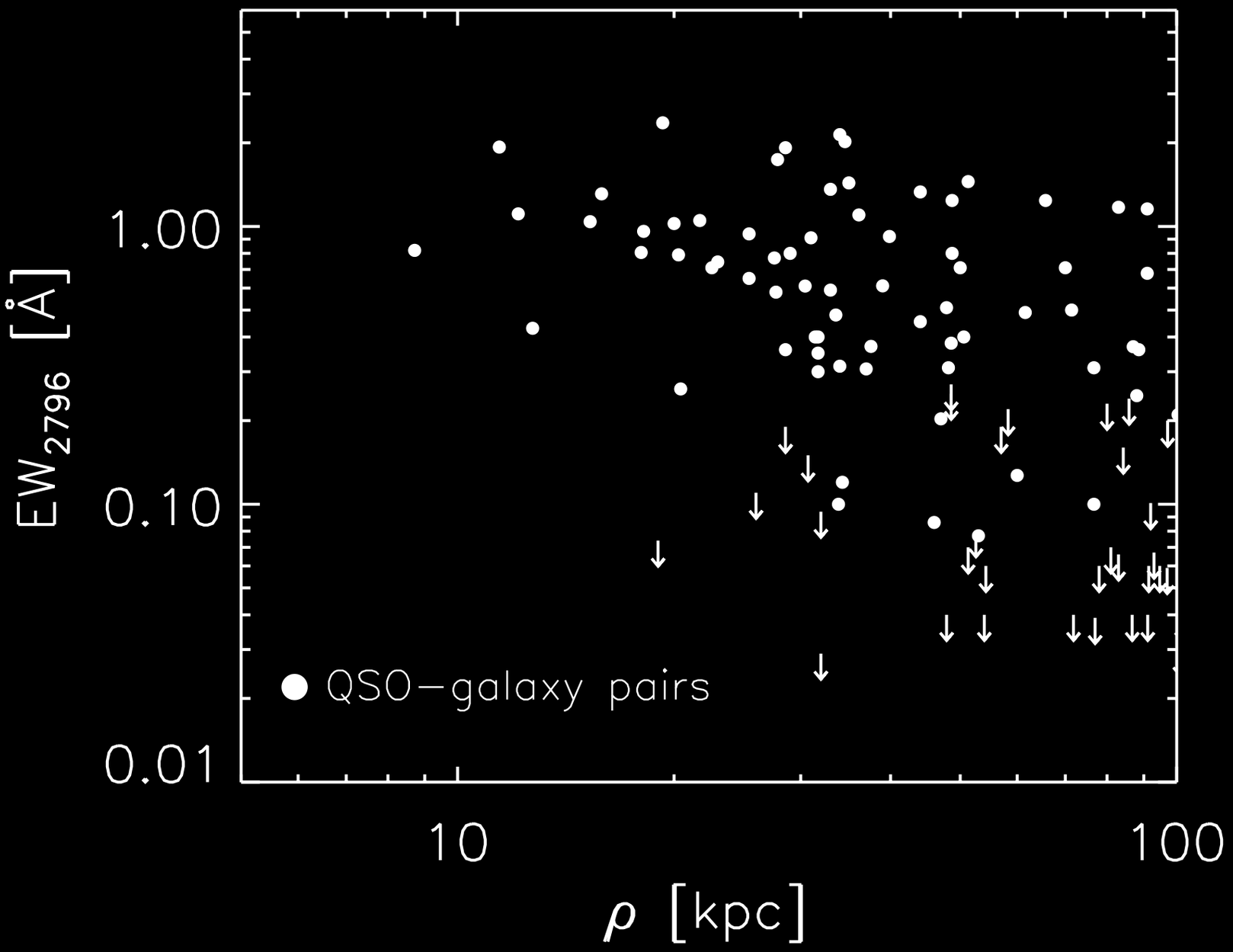


M51 (NASA+ESA)

$R_{gal} > 1$ kpc
at $z \sim 1$

# Background QSO spectroscopy is ‘easy’.

## And at z~0.3-1, MgII 2796, 2803 is the transition of choice.




Barton & Cooke 09,
Chen+10,
Werk+13

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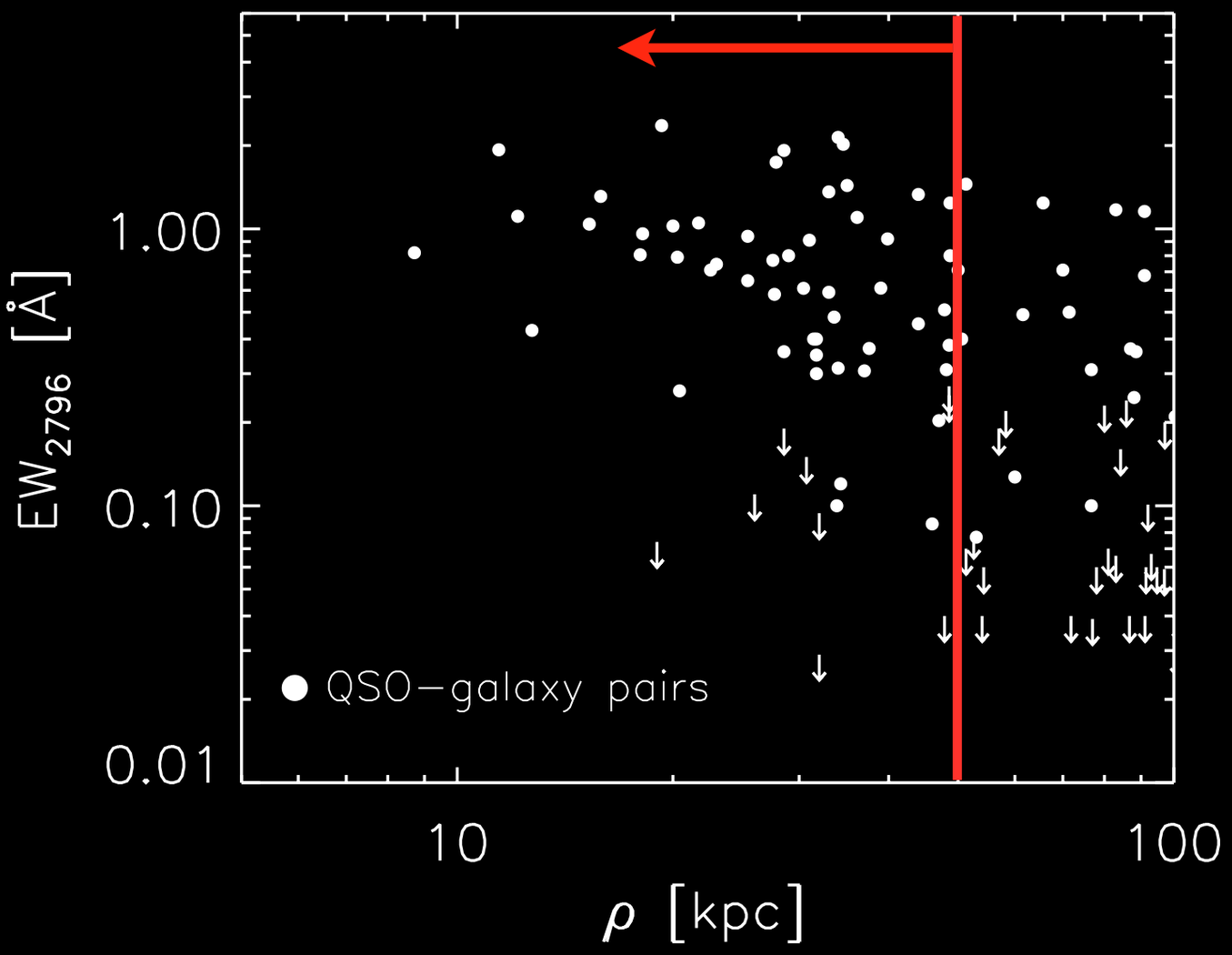

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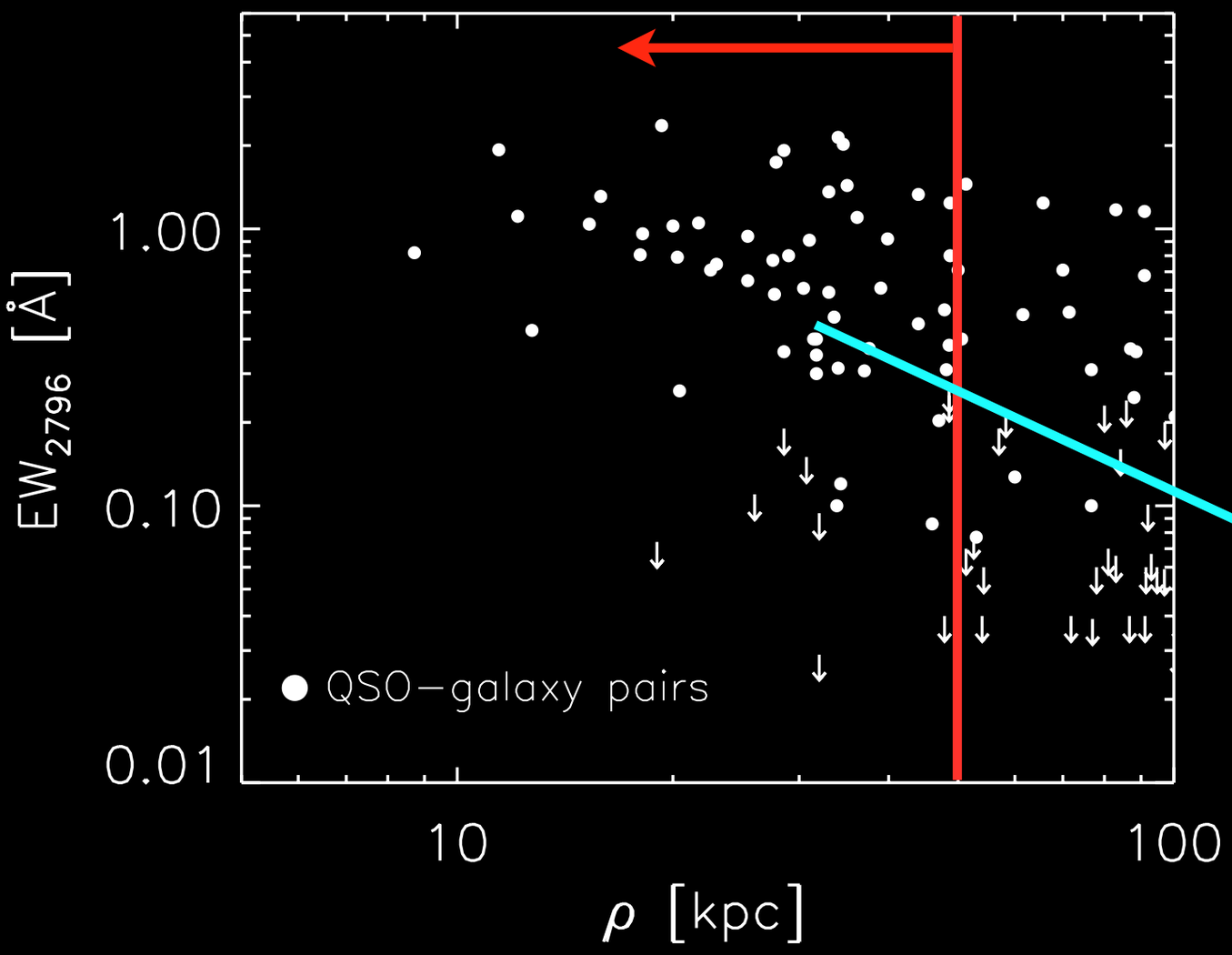
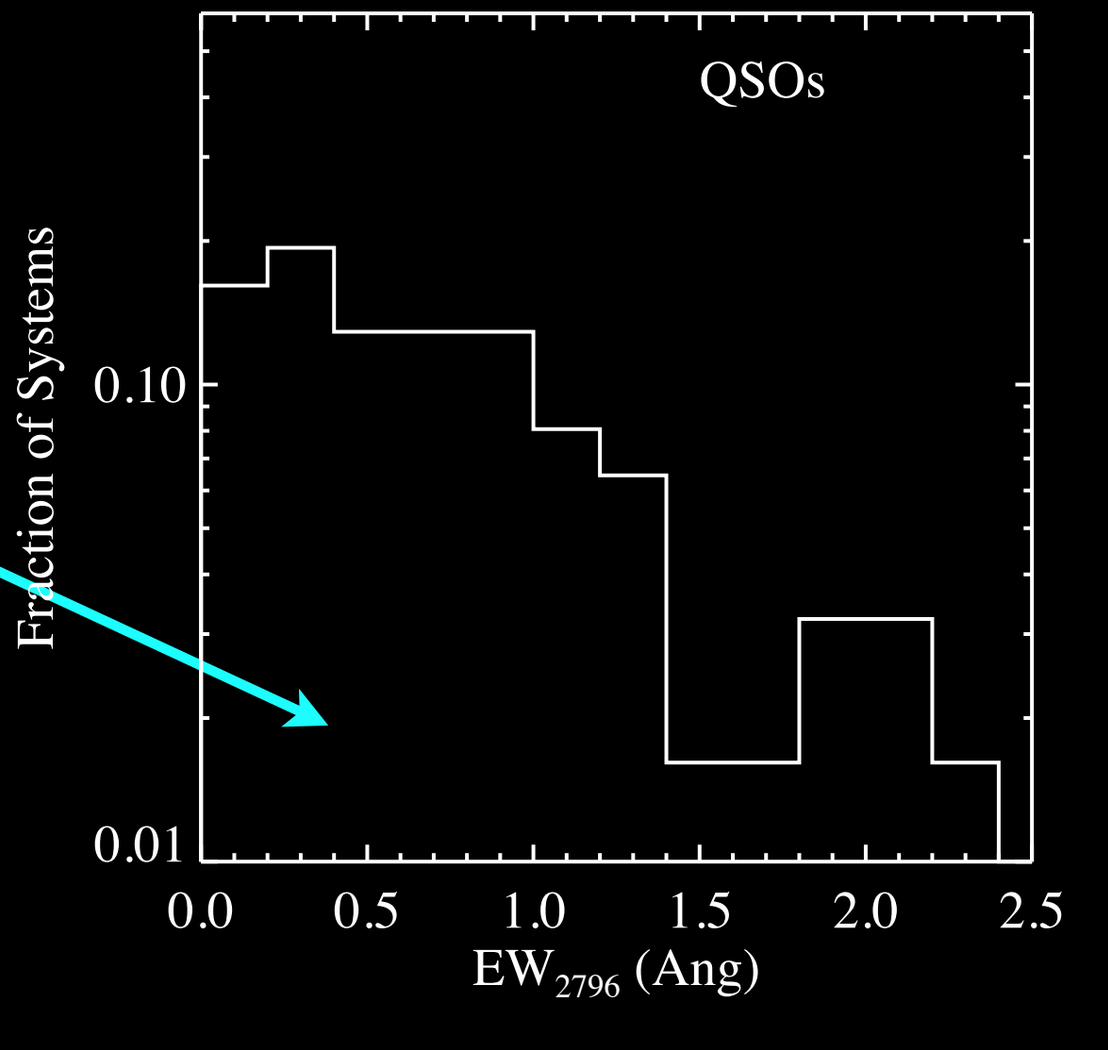
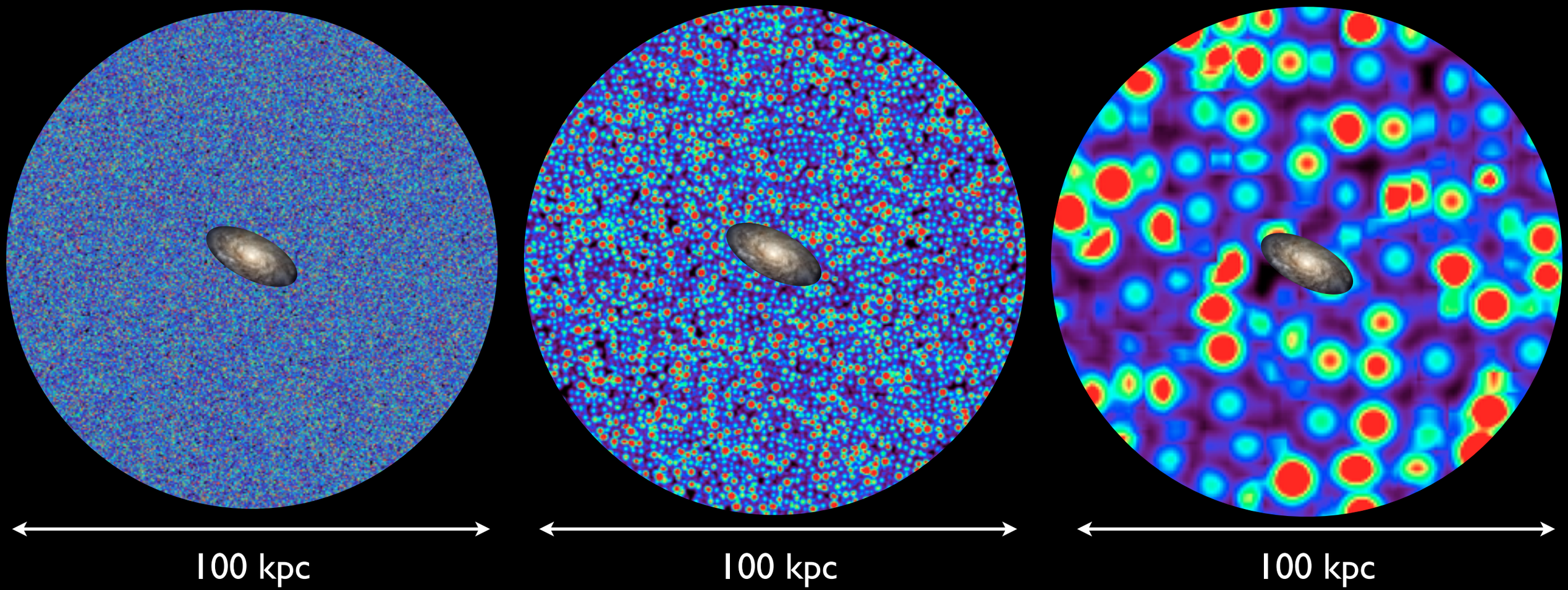


# What picture does this paint?
(Recall: QSOs have $R_{QSO} \sim 10^{-3}$ pc)



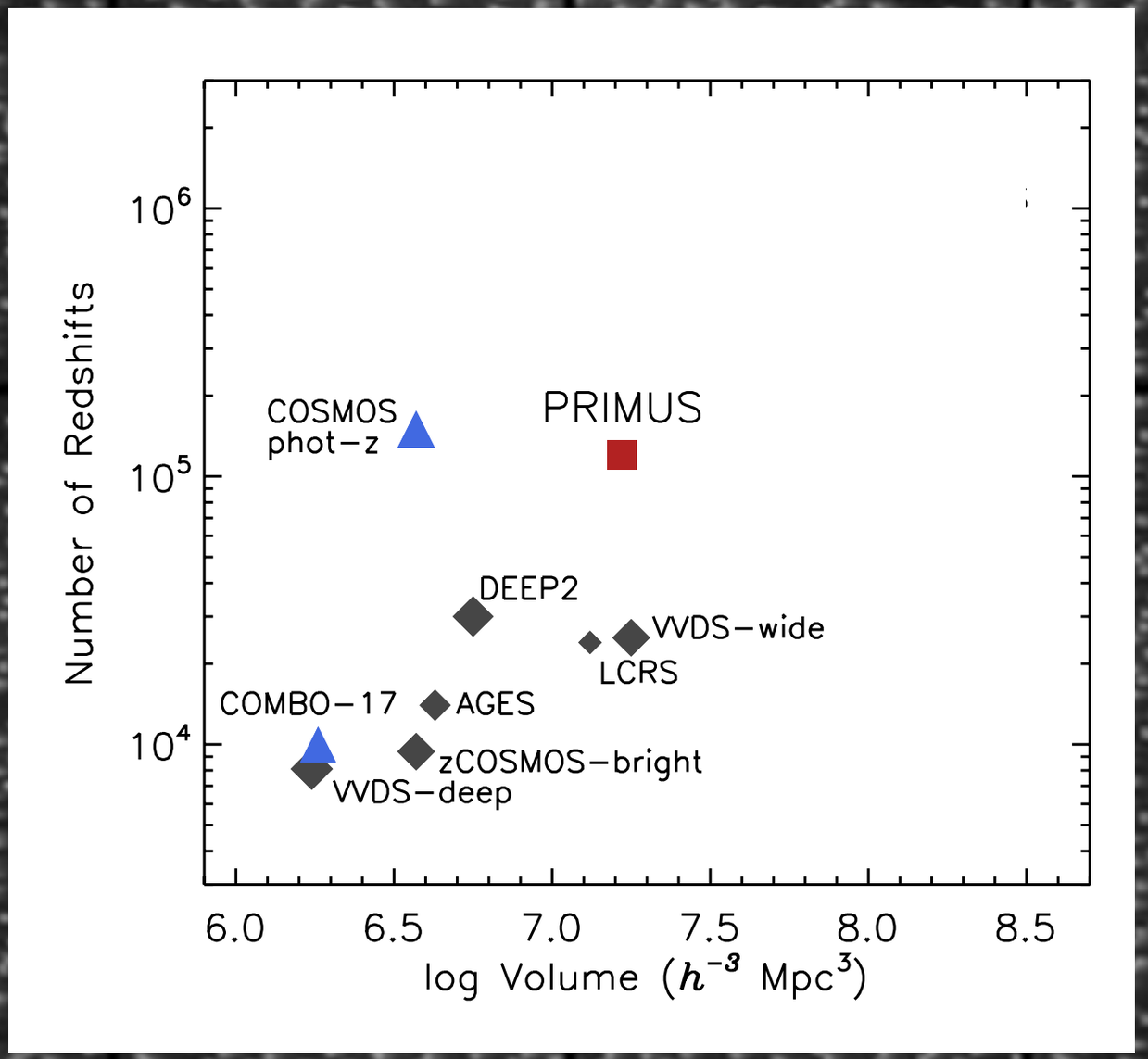
So, all we need are:

(1) Bright (g<22) blue galaxies at z~0.3-1

(2) which are also within 50 kpc (projected) of a foreground galaxy

# That is, we need PRIMUS:

(a Magellan/IMACS redshift survey)



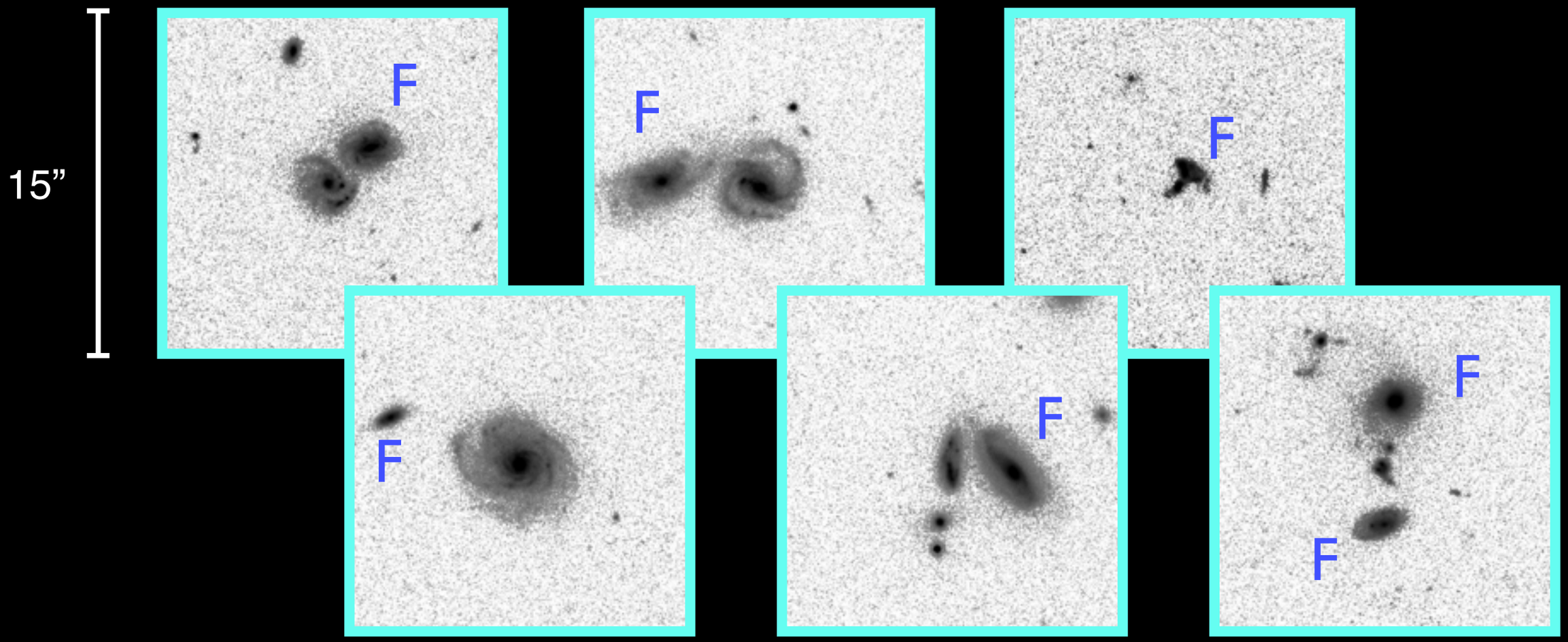

Coil et al. 2011

# The PRIMUS Pairs:

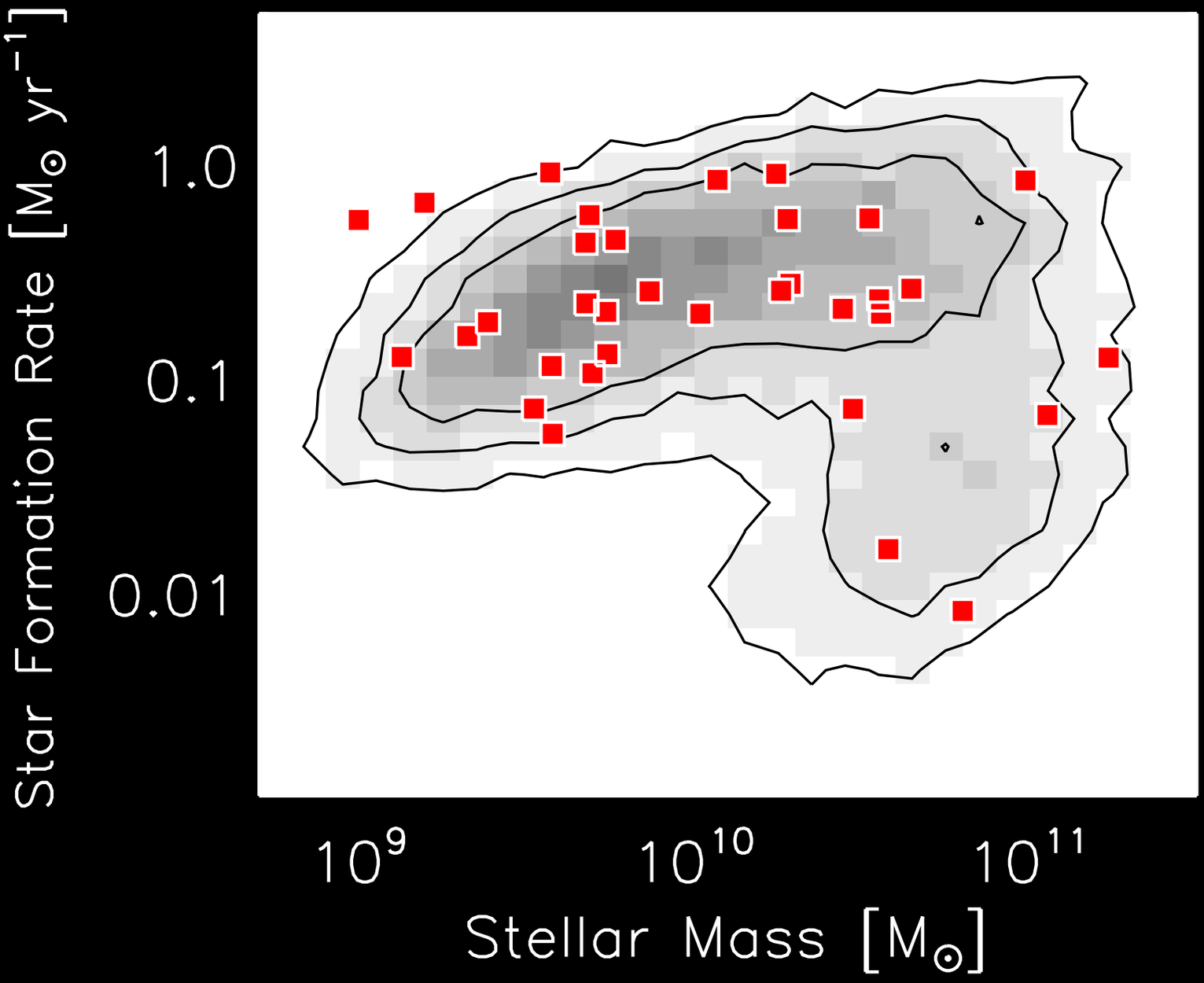
All projected pairs within 50 kpc with

— background objects having g<22.3

— foreground objects having r<23, 0.35<z<1.2



# The PRIMUS foreground galaxies:



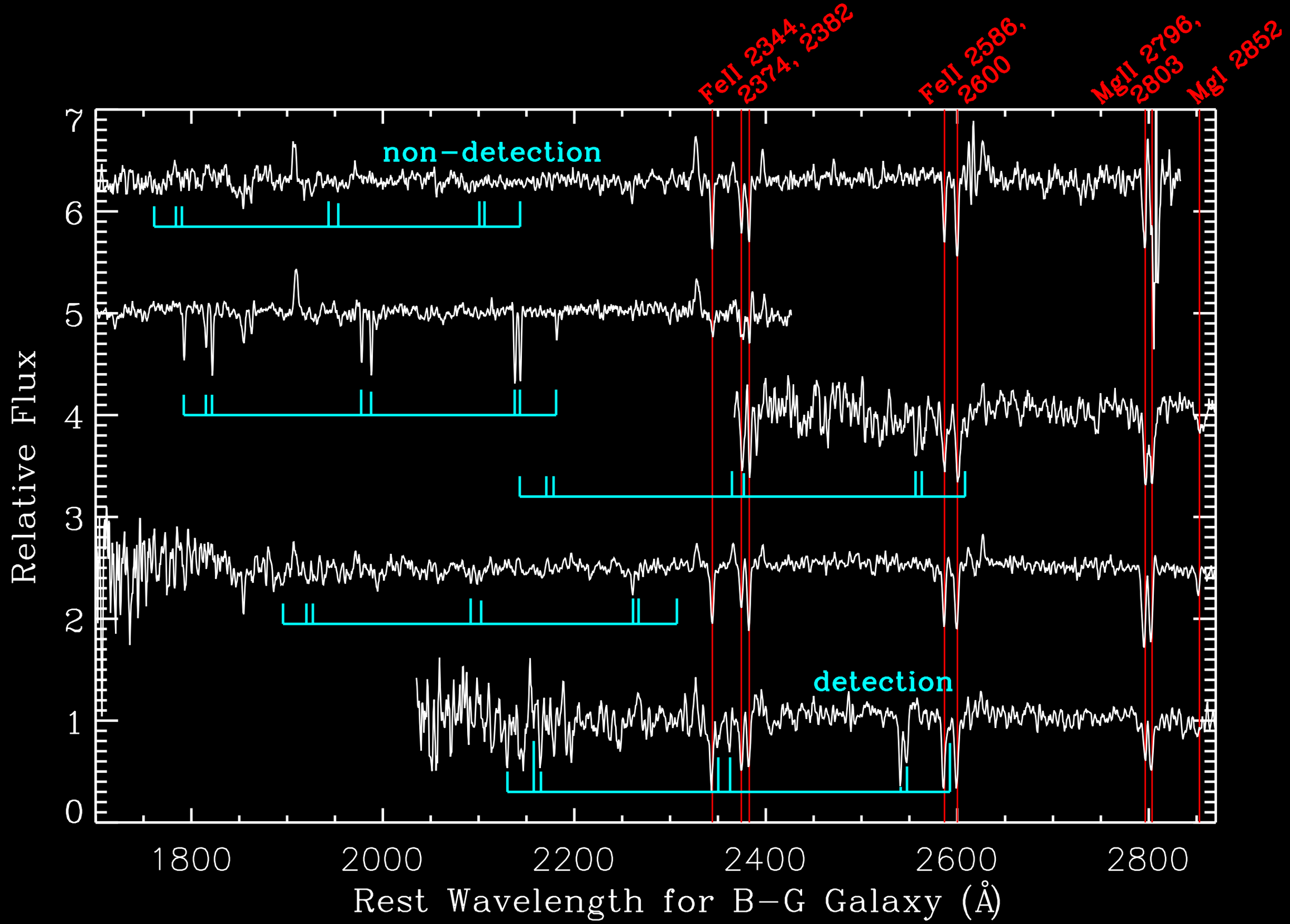
# The PRIMUS galaxy pair spectroscopy

~40 pairs observed over 9 nights on Keck/
LRIS and VLT/FORS2

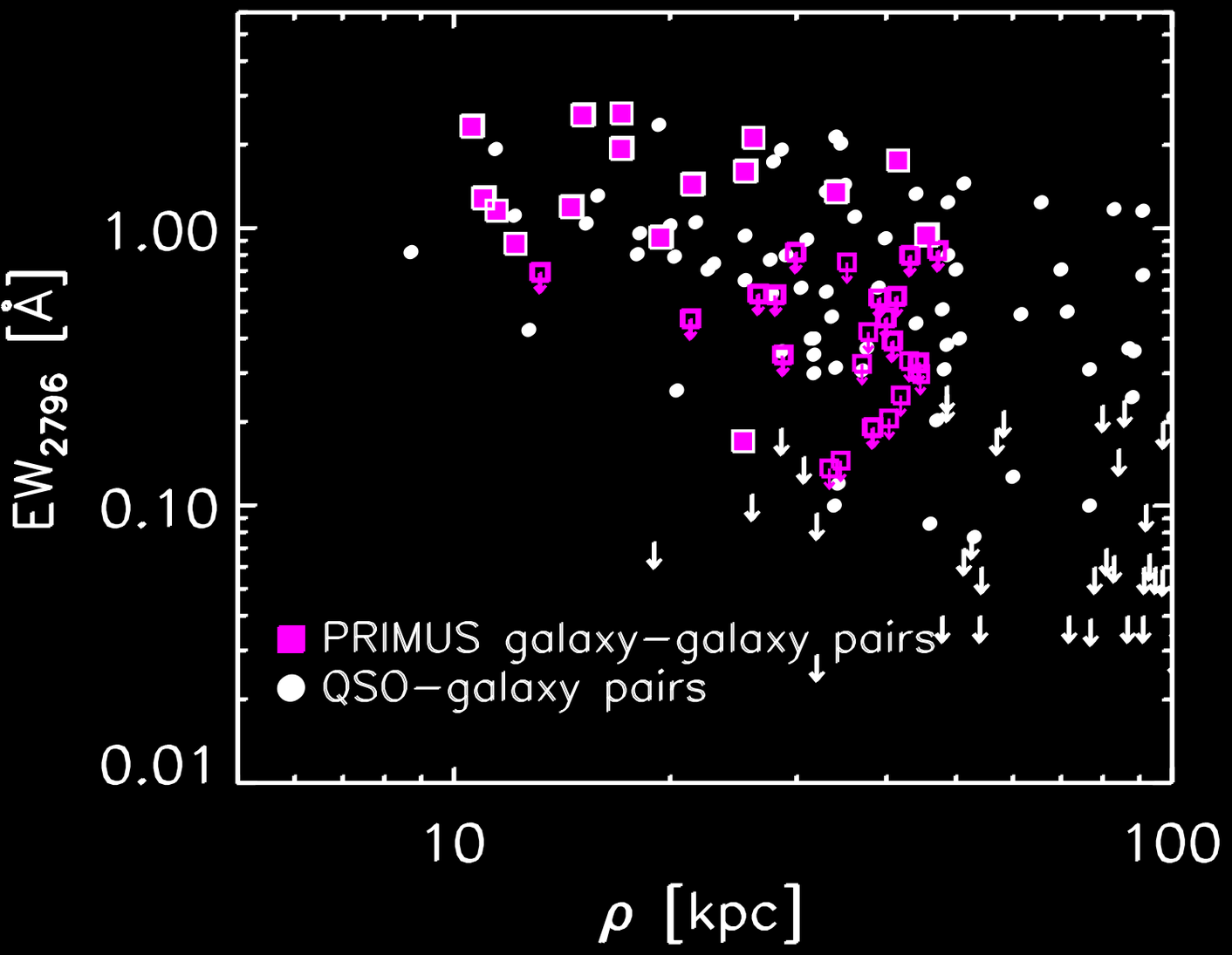
180 - 300 km/s FWHM resolution

cover at least f/g MgII 2796, 2803, often
FeII 2586, 2600

# The PRIMUS galaxy pair spectroscopy



# The MgII-absorbing CGM, but with background galaxy beams.



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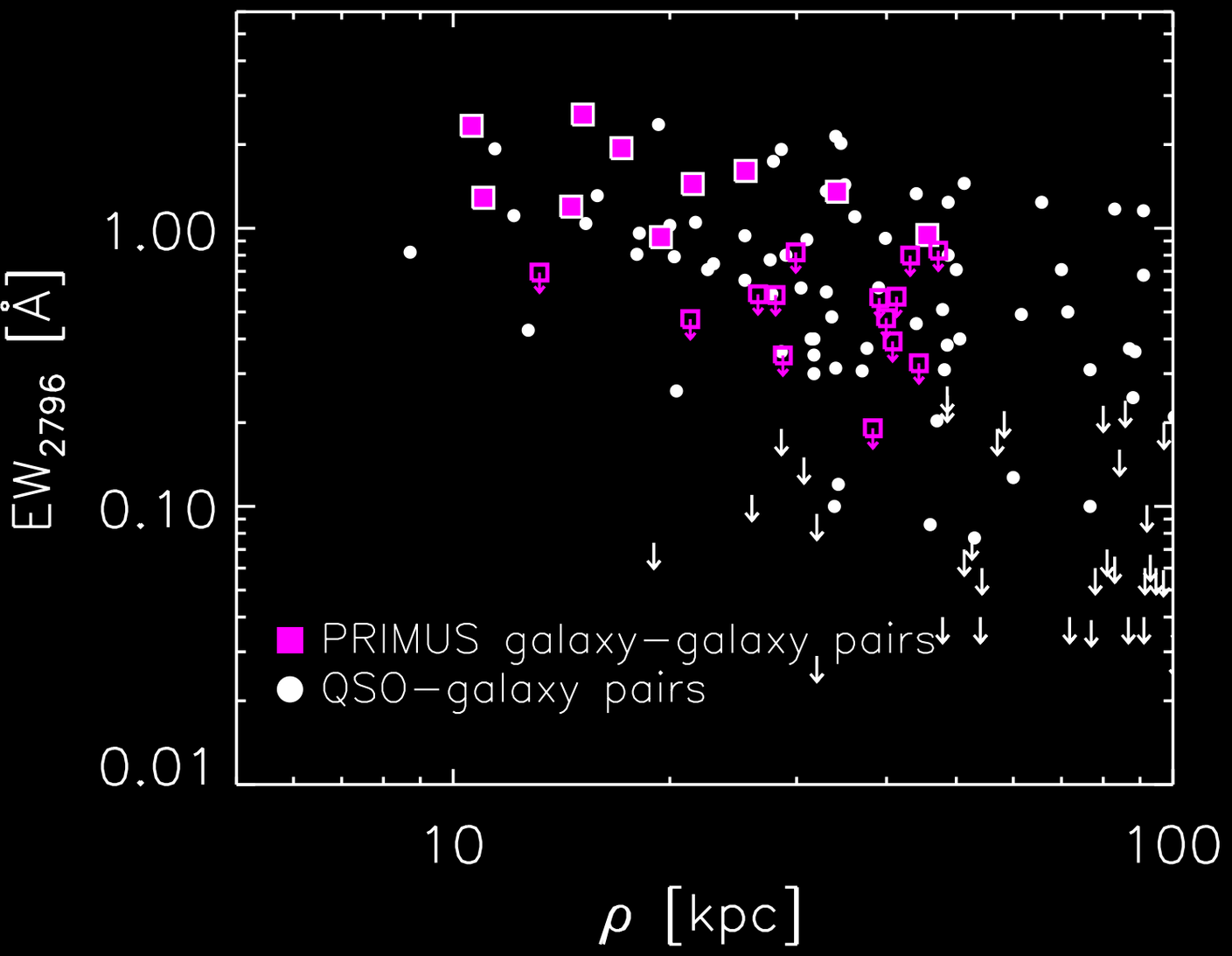

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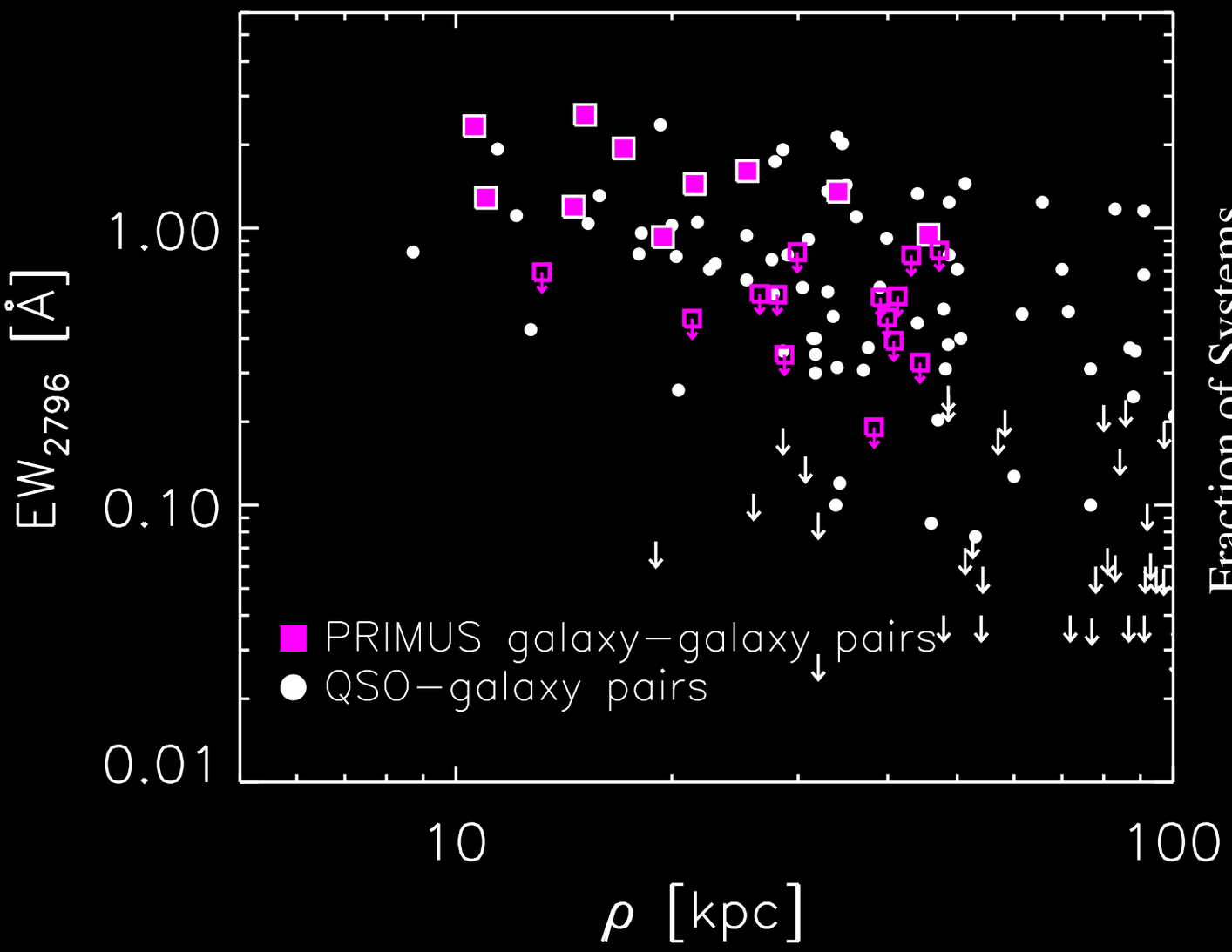
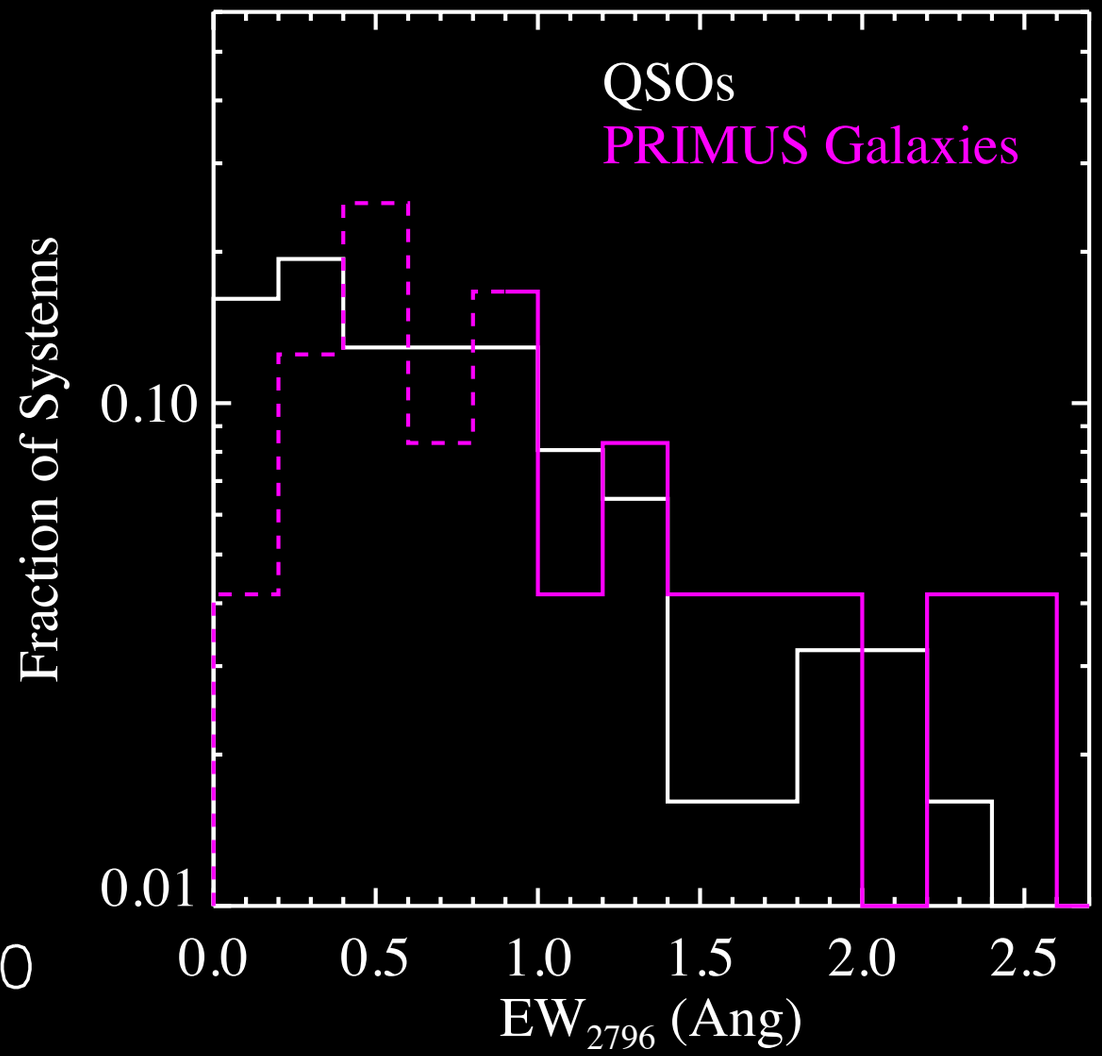
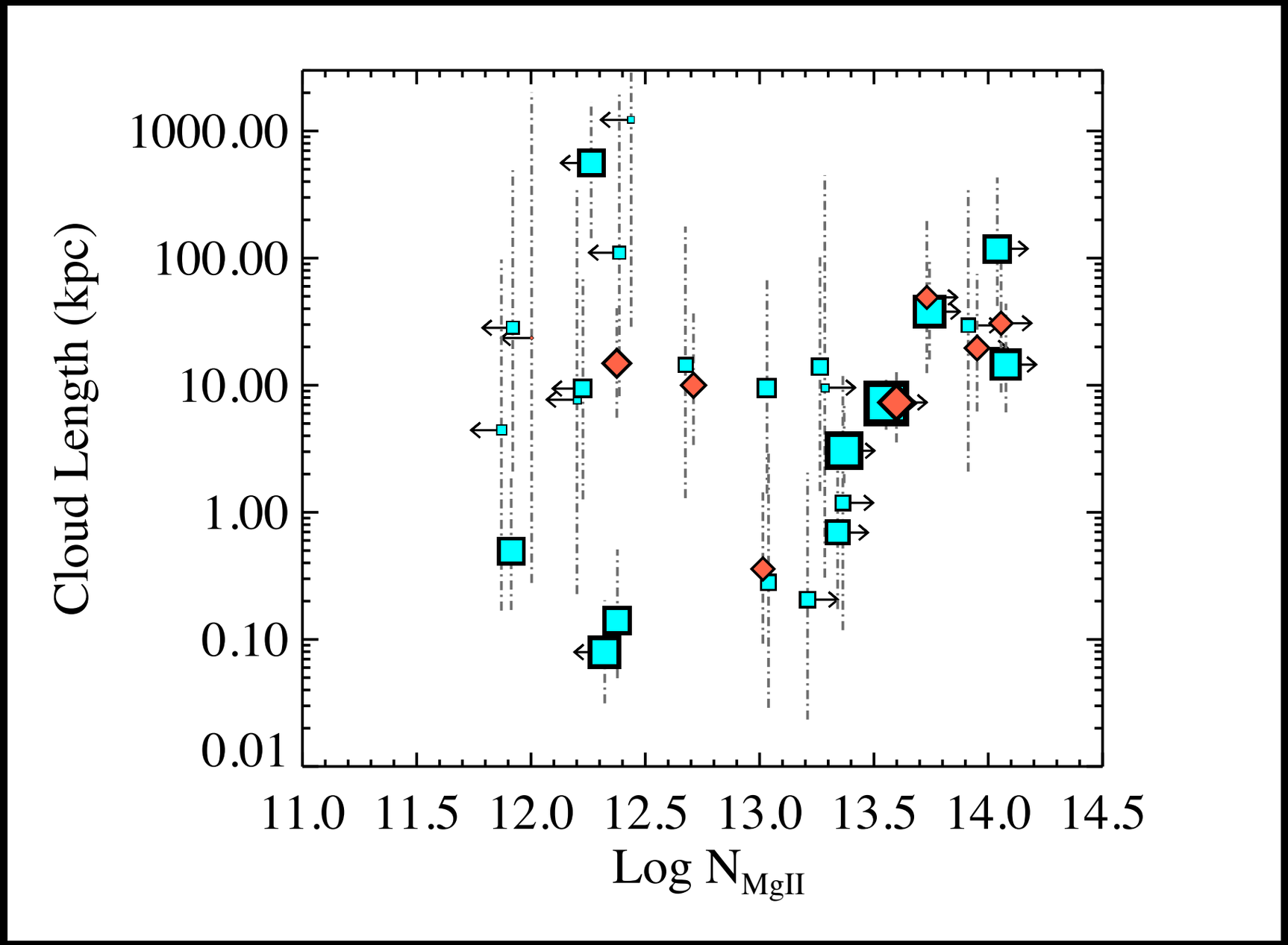


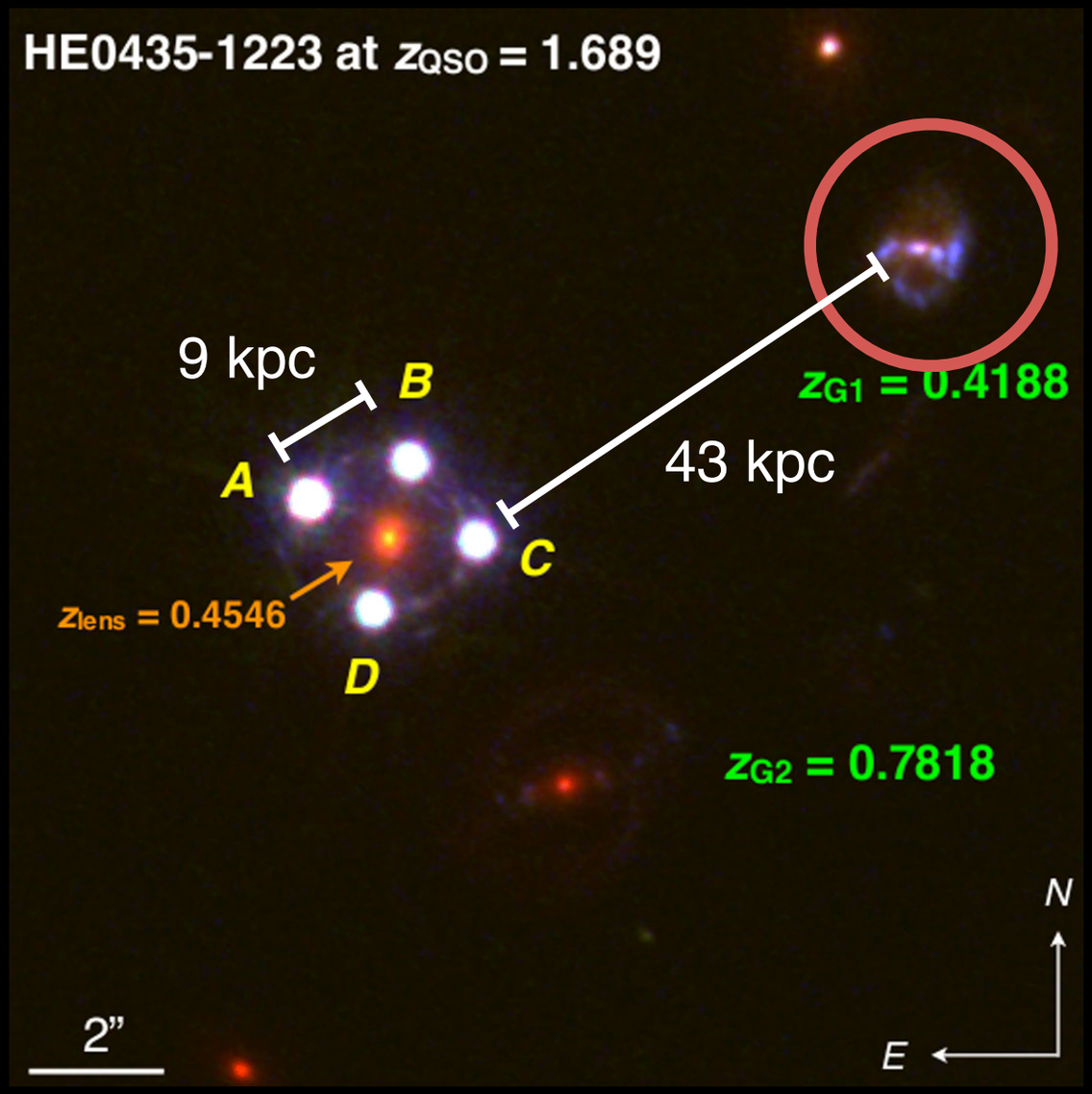



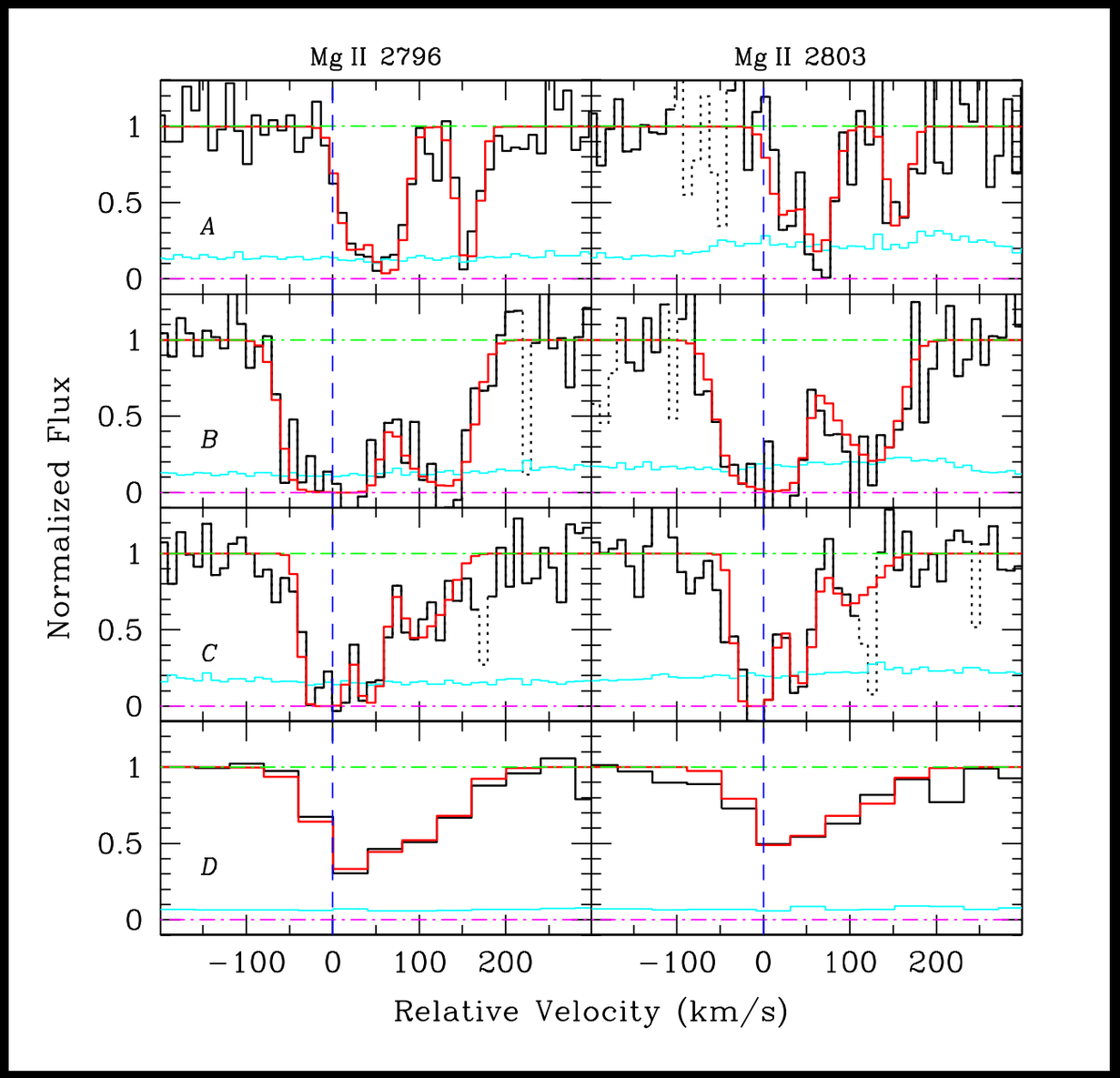
# And, photoionization modeling of low-z absorbers yields consistent sizes




(but see also Crighton et al. 2014, Prochaska & Hennawi 2009…)

# Lensed QSOs offer complementary constraints:



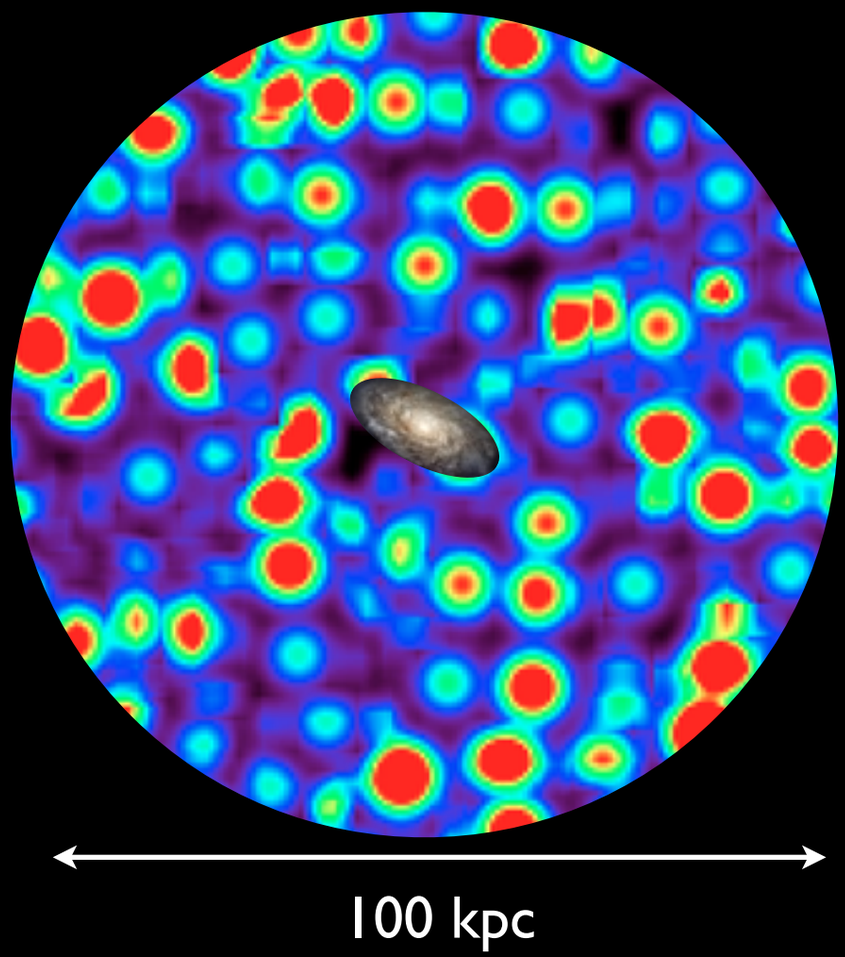

Chen et al. 2014

# And, these structures are on the verge of being resolved…

If $N(MgII) > 10^{14}$ cm$^{-2}$

At solar metallicity (and with no ionization correction)

$N(H) > 10^{18.5}$ cm$^{-2}$

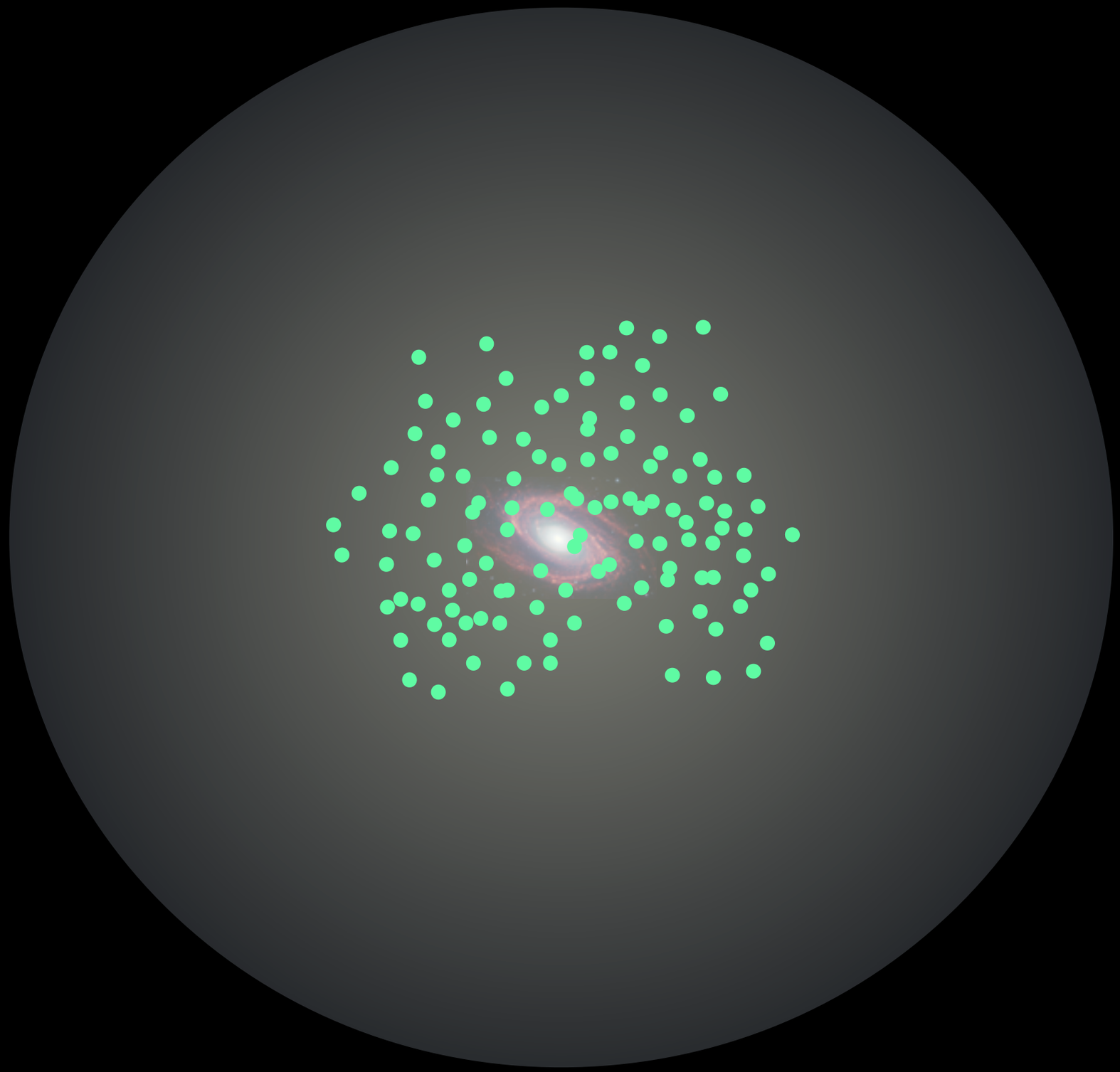



If cloud is 1 kpc$^3$, $M_{cloud} \sim 2.5 \times 10^4$ $M_{sun}$

$10^{12}$ $M_{sun}$ FIRE halos have particle mass of ~ $10^4$ $M_{sun}$

(Hopkins, Keres, Onorbe, CAFG et al. 2014)

# Conclusions

1. Background galaxies offer some of the first direct constraints on the size of cool CGM "clouds"

2. They are coherent over > 1 kpc (within 50 kpc of bright galaxies)