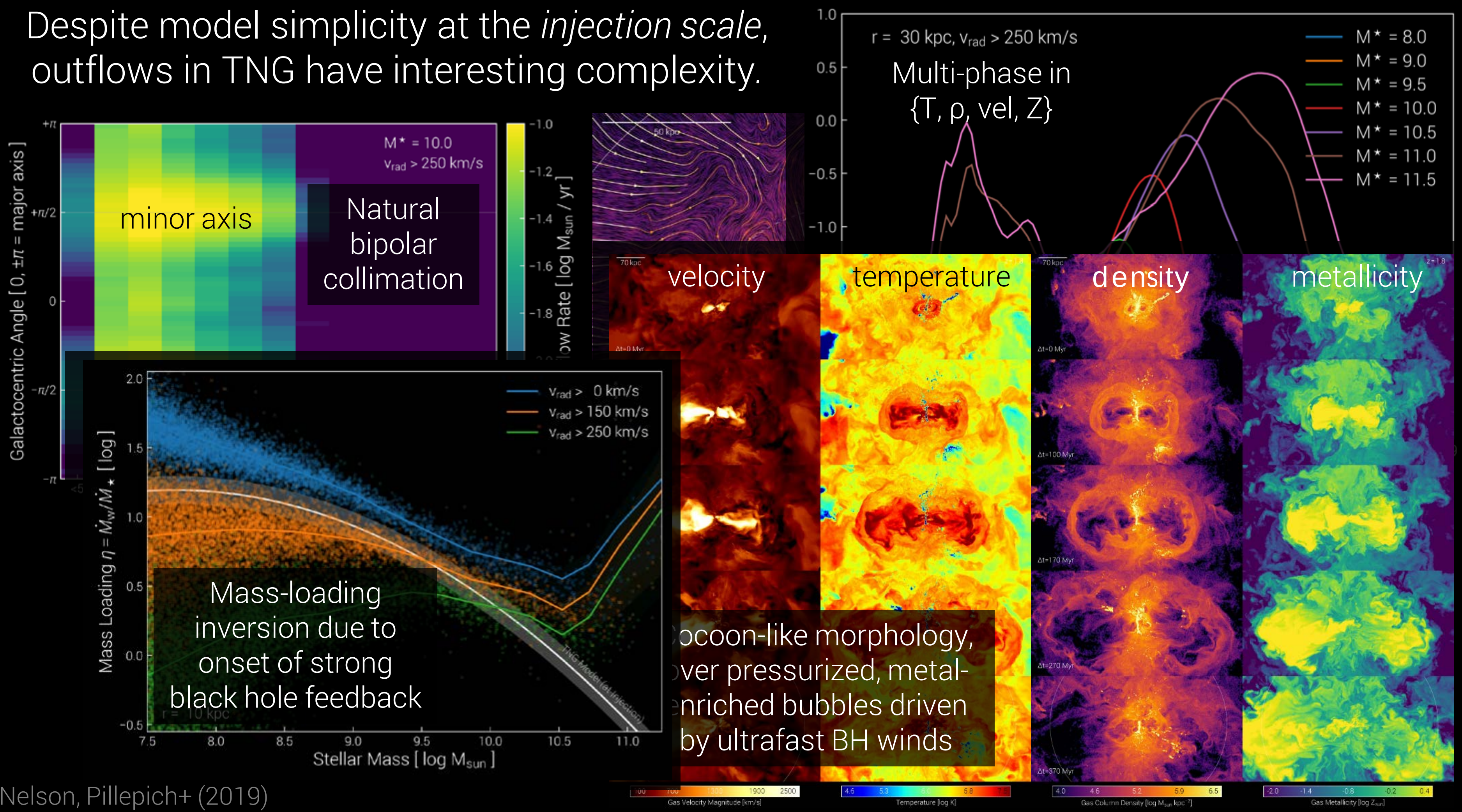
Dylan Nelson (MPA)

Harnack House, 3 Oct, 2019

What I’m not going to talk about:

galactic-scale outflows in TNG50

Despite model simplicity at the *injection scale*, outflows in TNG have interesting complexity.



Nelson, Pillepich+ (2019)

What I am going to talk about:

the cold-phase of the CGM, particularly in massive (LRG) halos

=

luminous red galaxies in SDSS

$z \sim 0.5$

$M_{halo} \sim 10^{13-13.5}\ M_{sun}$

$M^* \sim 10^{11-11.5}\ M_{sun}$

quiescent

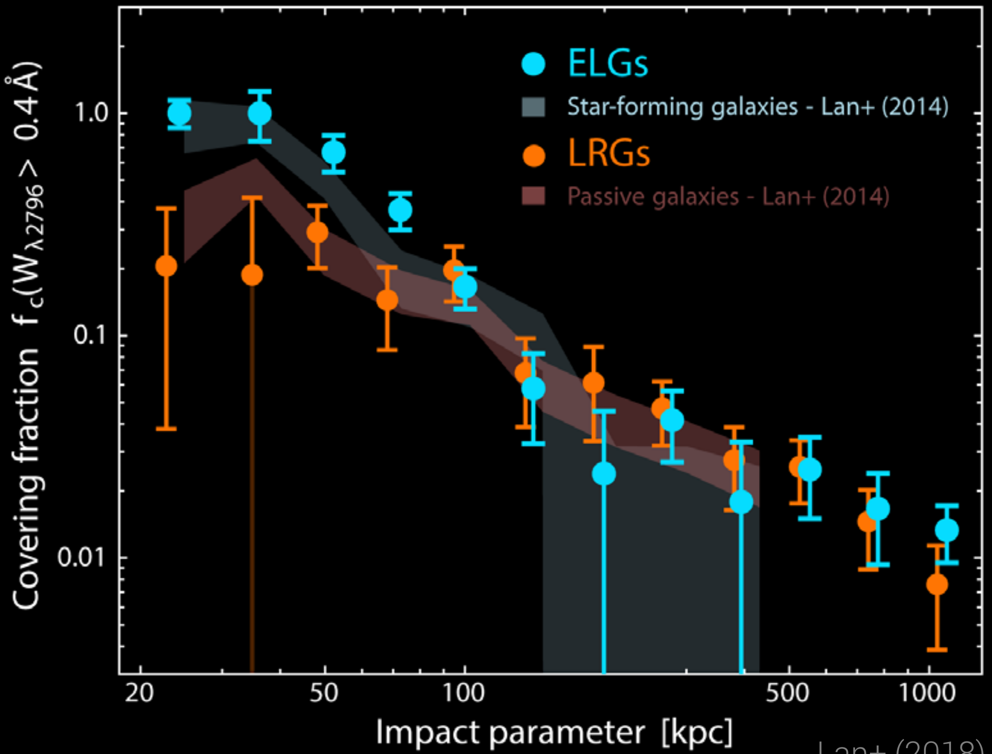
observations: the cold-phase of the CGM in massive (LRG) halos

Zhu+ (2014) – MgII and FeII [~35k b<1Mpc]
"the density of MgII clouds around LRGs is consistent with the cosmic value"

Lan+ (2018) – MgII and FeII [~190k <1Mpc]
"a non-negligible amount of cool gas is found around LRGs with no significant SF activity within 1-2 Gyr"

Berg+ (2019) – RDR-LRG: HI [21]
"plentiful dense, cold gas surviving deep in the halos of very massive galaxies"

Chen+ (2018), Zahedy+ (2019) – COS-LRG: HI and MgII [16]
"high N(HI) gas is common in these massive quiescent halos"



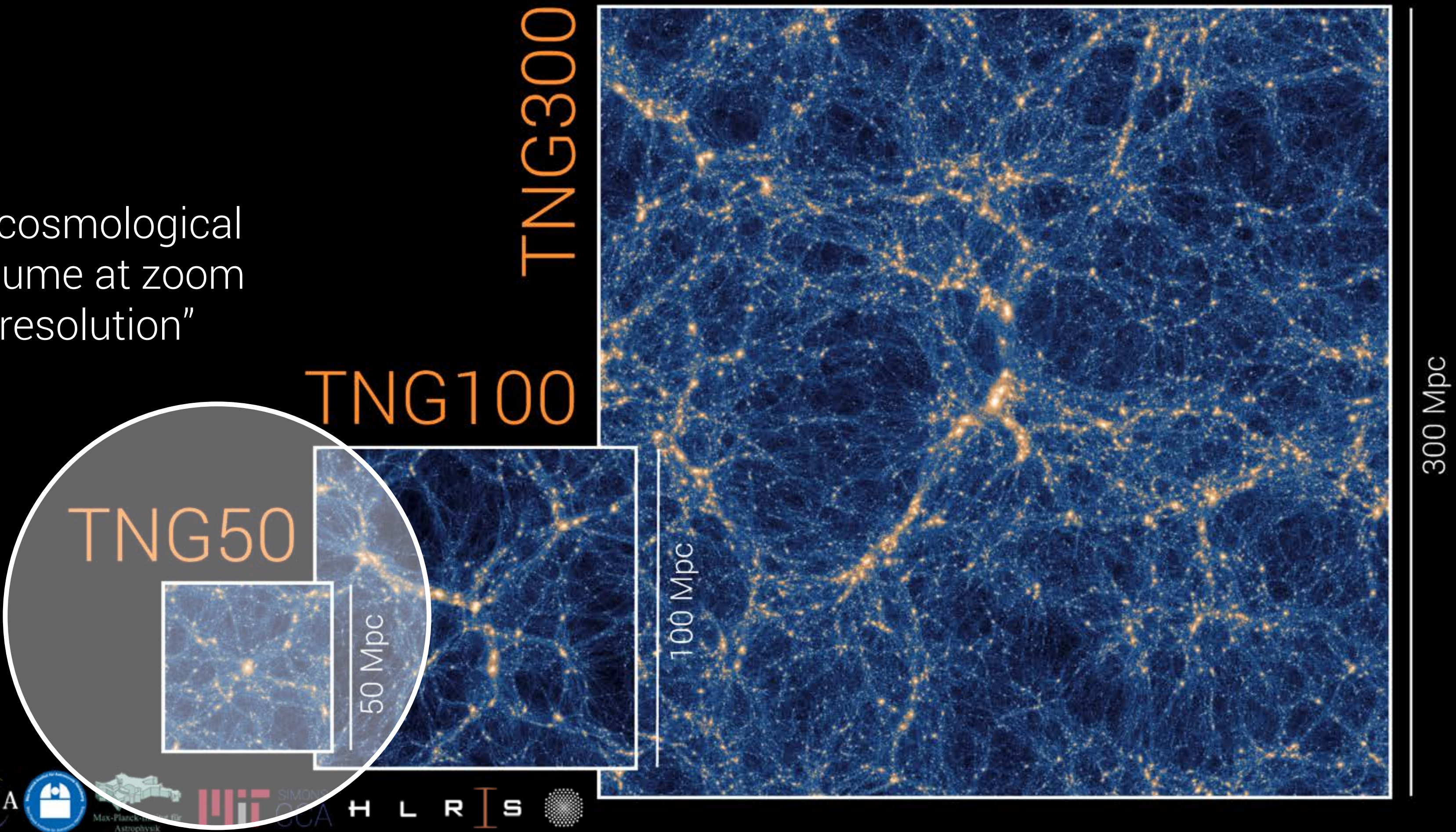
Lan+ (2018)

All cosmological hydro simulations of galaxy formation fail to reproduce the small-scale, cold-phase of the CGM.

?

The IllustrisTNG simulation suite: three volumes from 50 to 300 Mpc, at fixed model.

“a cosmological volume at zoom resolution”



TNG50 PIs:
Dylan Nelson (MPA)
Annalisa Pillepich (MPIA)
+ the TNG team

Run Name		**TNG50**	TNG100	TNG300
Volume	[Mpc^3]	**51.7^3**	110.7^3	302.6^3
L_{box}	[Mpc/h]	**35**	75	205
N_{GAS}	-	**2160^3**	1820^3	2500^3
N_{DM}	-	**2160^3**	1820^3	2500^3
N_{TR}	-	**2160^3**	2×1820^3	2500^3
m_{baryon}	[$M_\odot$]	**8.5×10^4**	1.4×10^6	1.1×10^7
m_{DM}	[$M_\odot$]	**4.5×10^5**	7.5×10^6	5.9×10^7
$\epsilon_{gas,min}$	[pc]	**74**	185	370
$\epsilon_{DM,stars}$	[pc]	**288**	740	1480
CPU Time	[Mh]	**130**	18	35

bigger the better

smaller the better

Statistics/ability to make representative samples

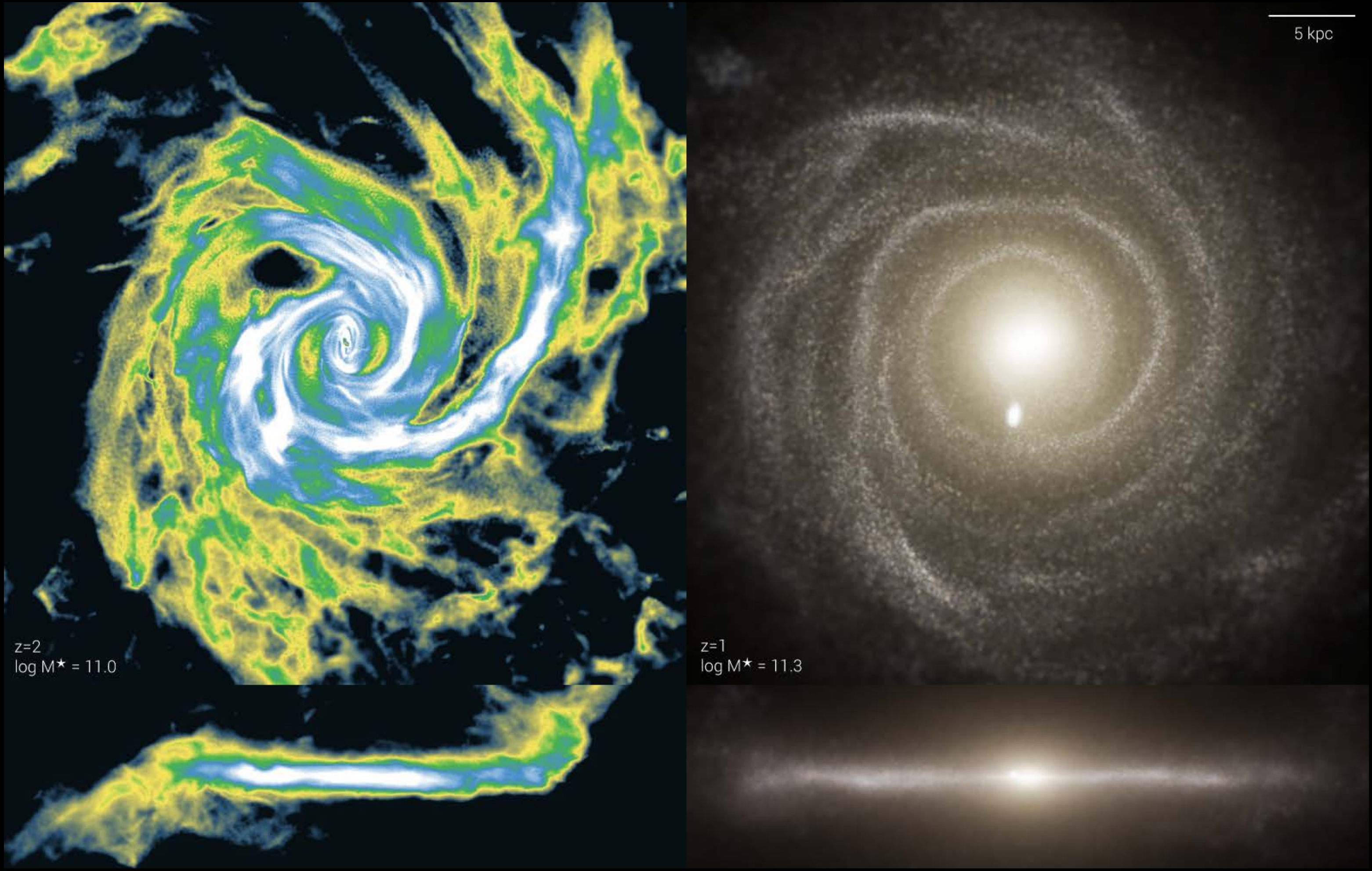
Same as original Millennium

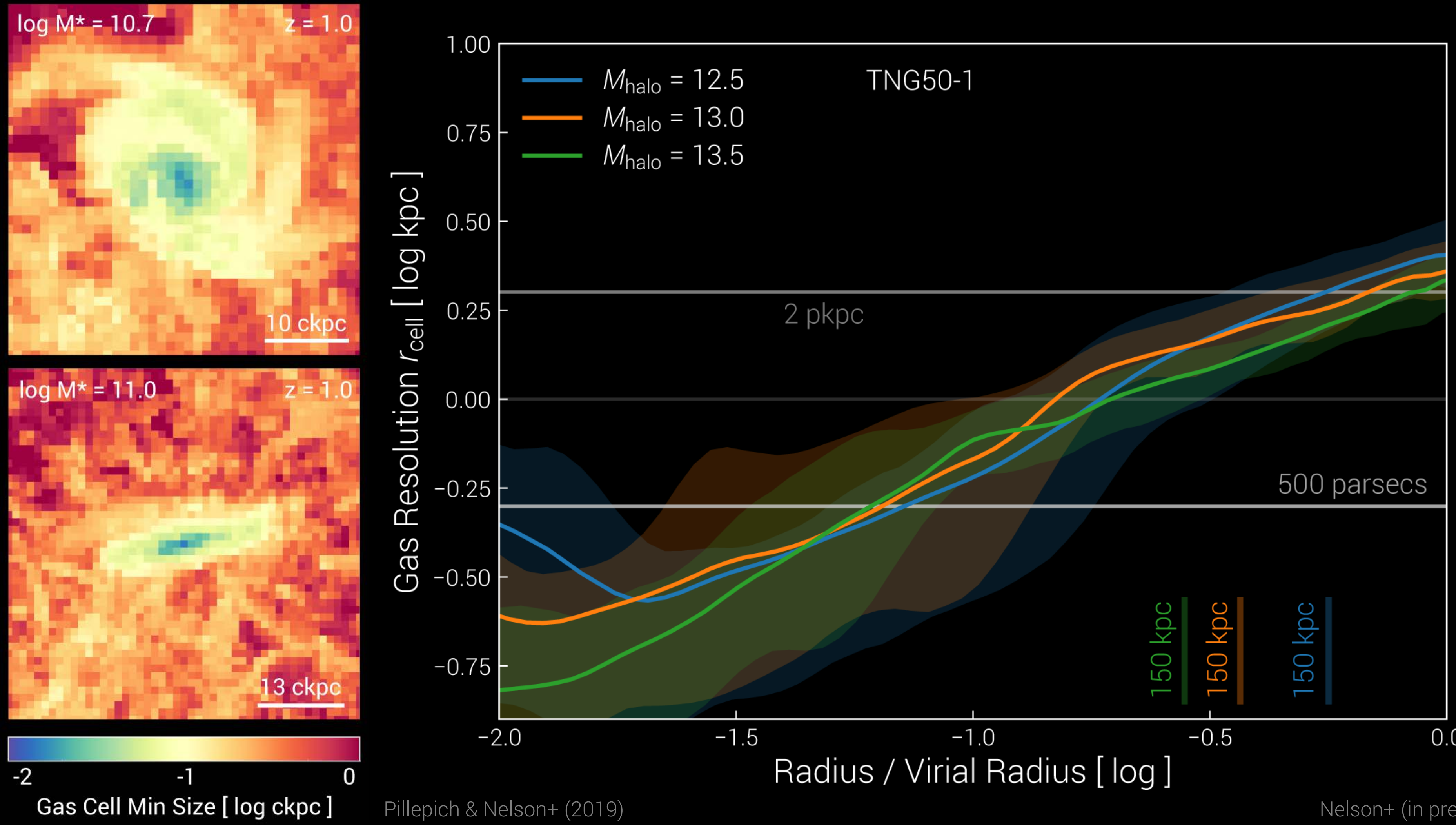
Average mass of a star particle or gas cell

'Spatial resolution'

This is not cheap.

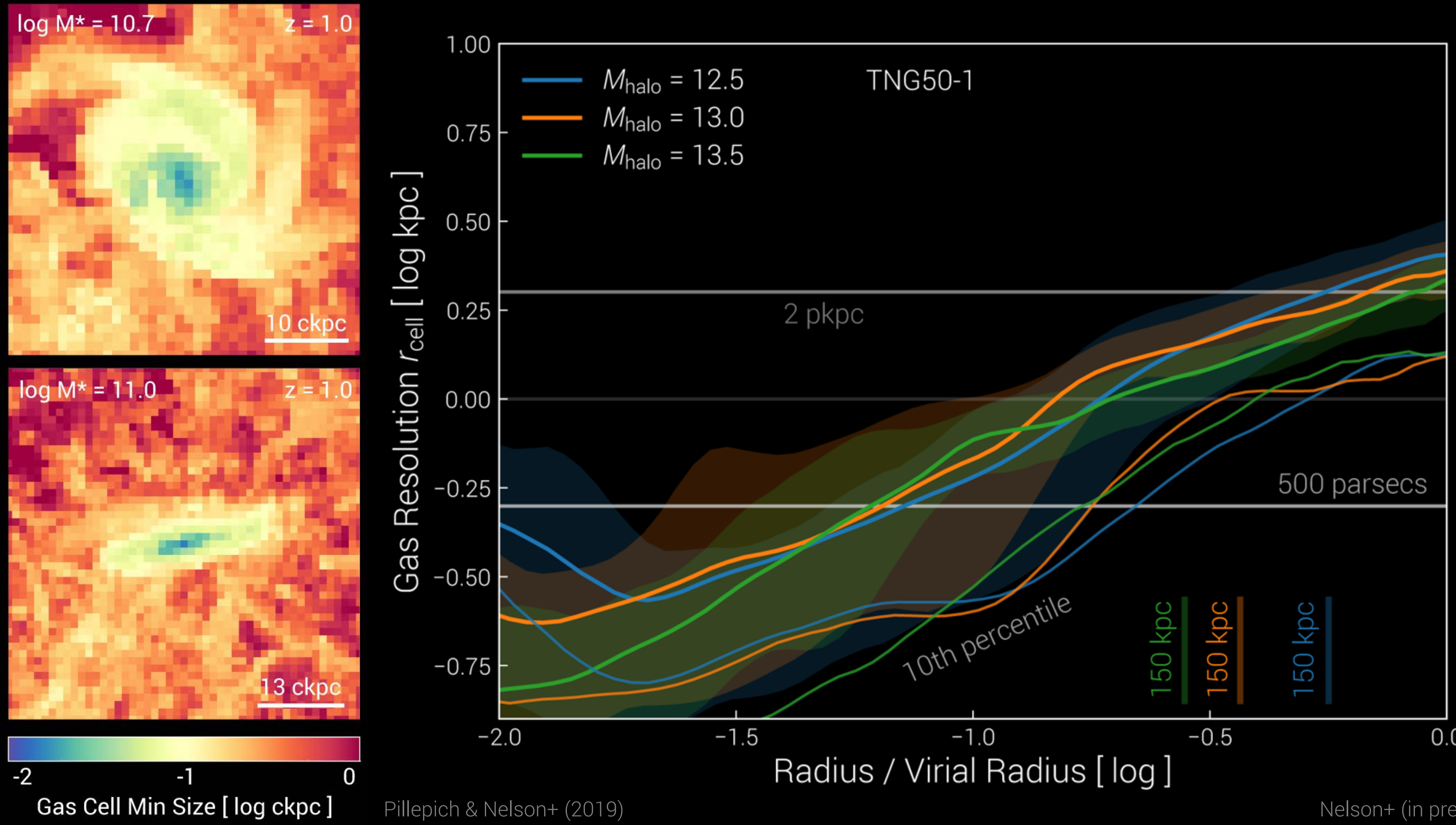
TNG50: internal structural detail of galaxies at the ~100-200pc scale





Pillepich & Nelson+ (2019)

Nelson+ (in prep)



Pillepich & Nelson+ (2019)

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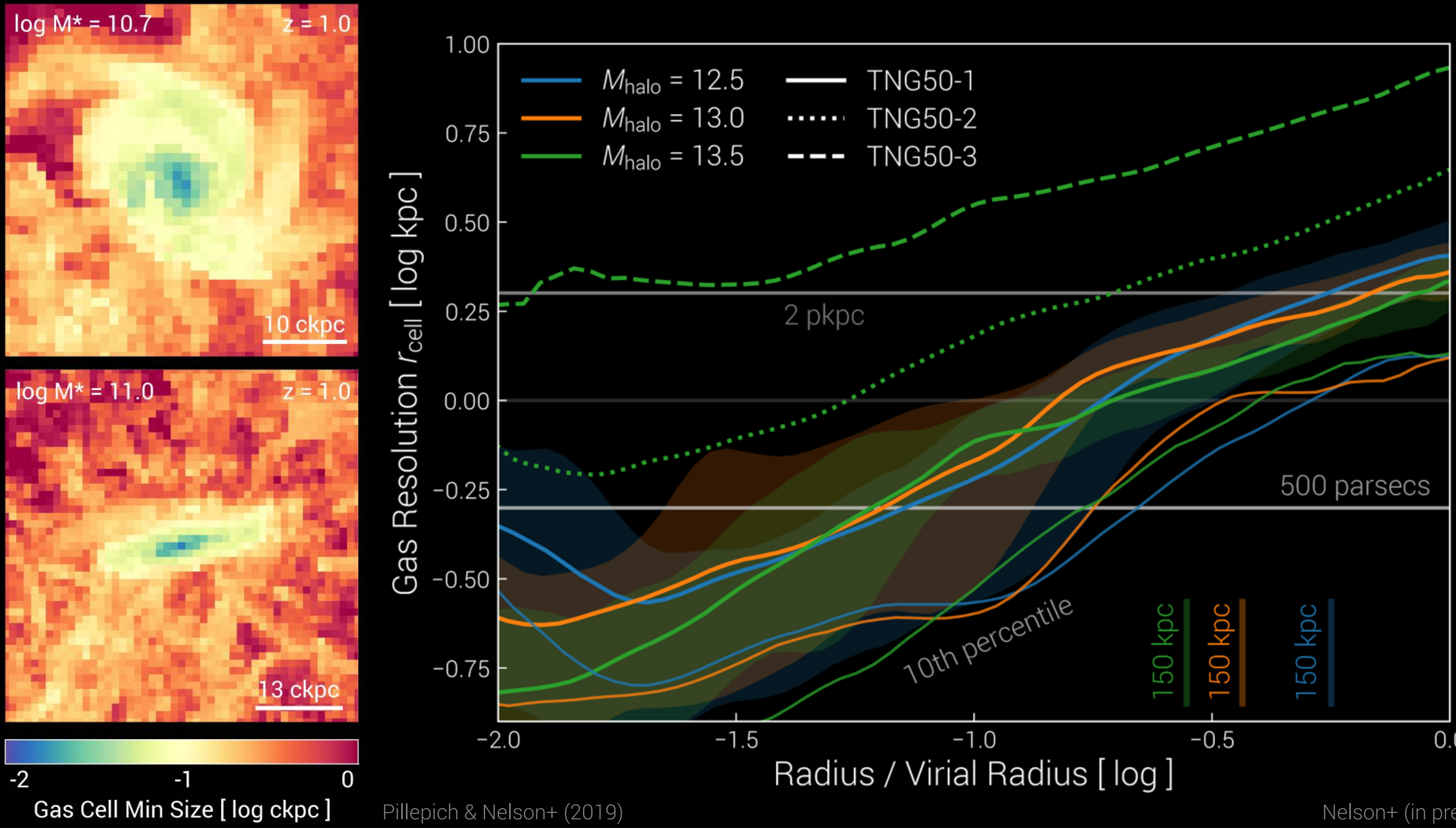

Pillepich & Nelson+ (2019)

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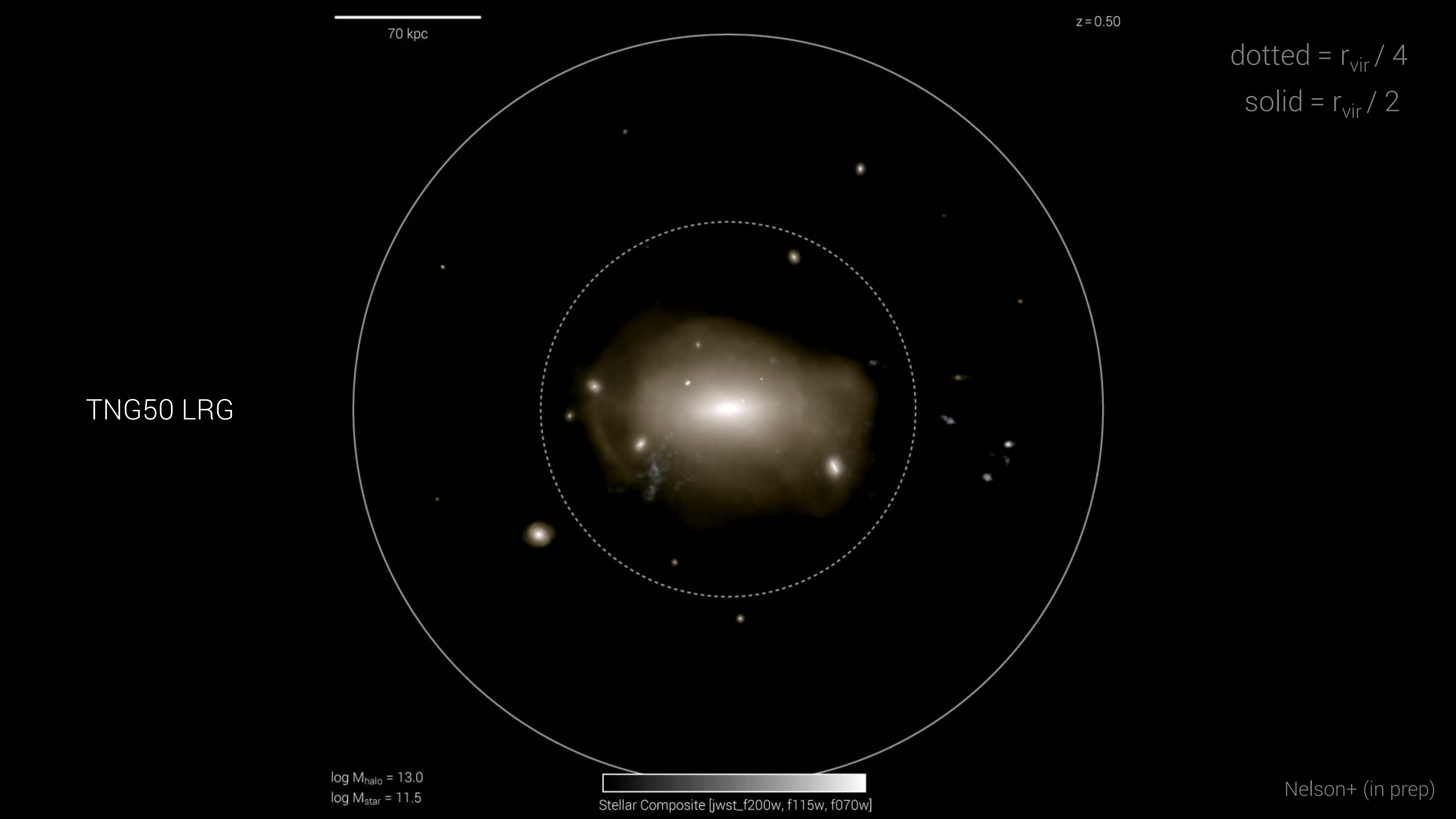
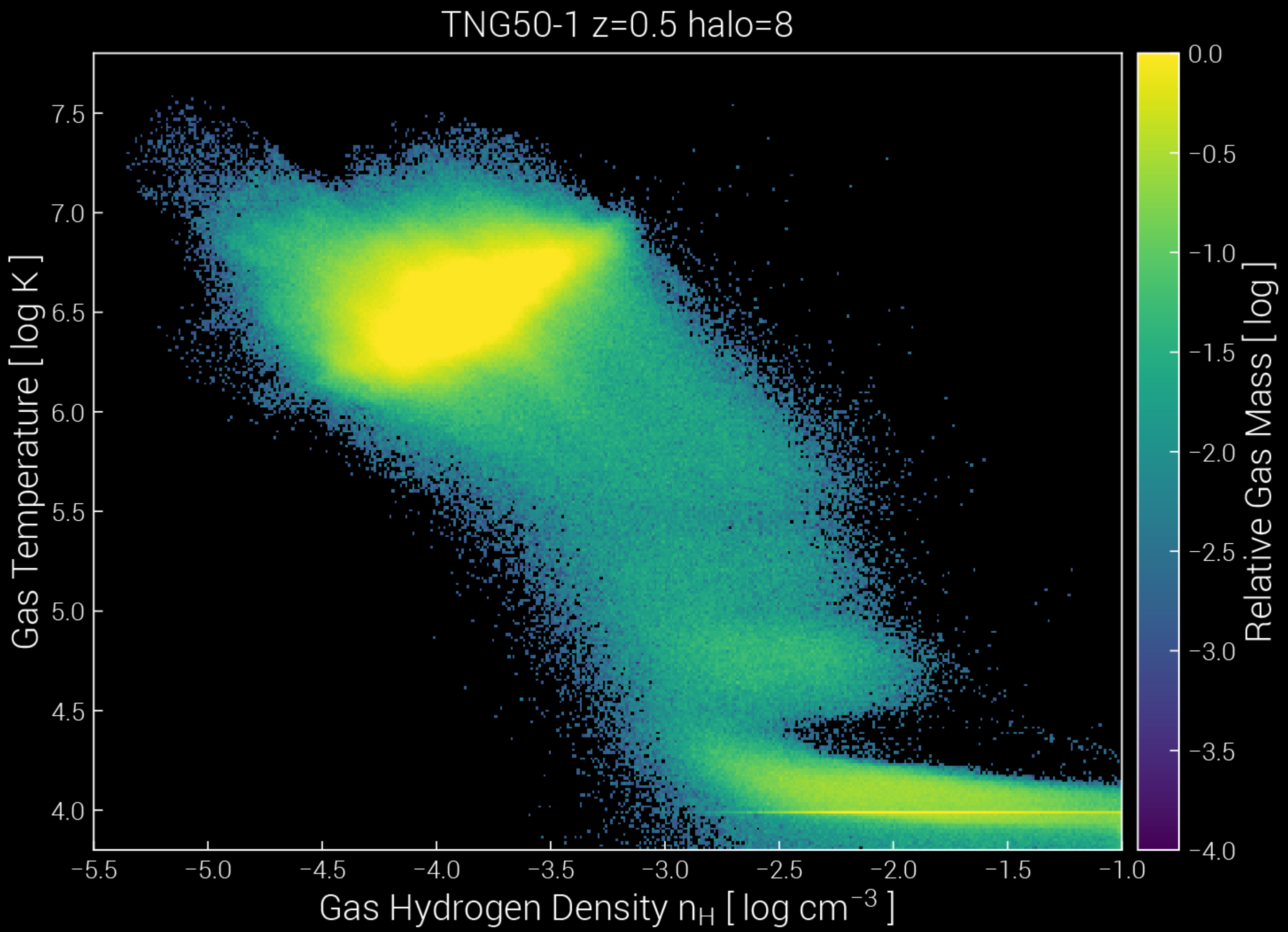


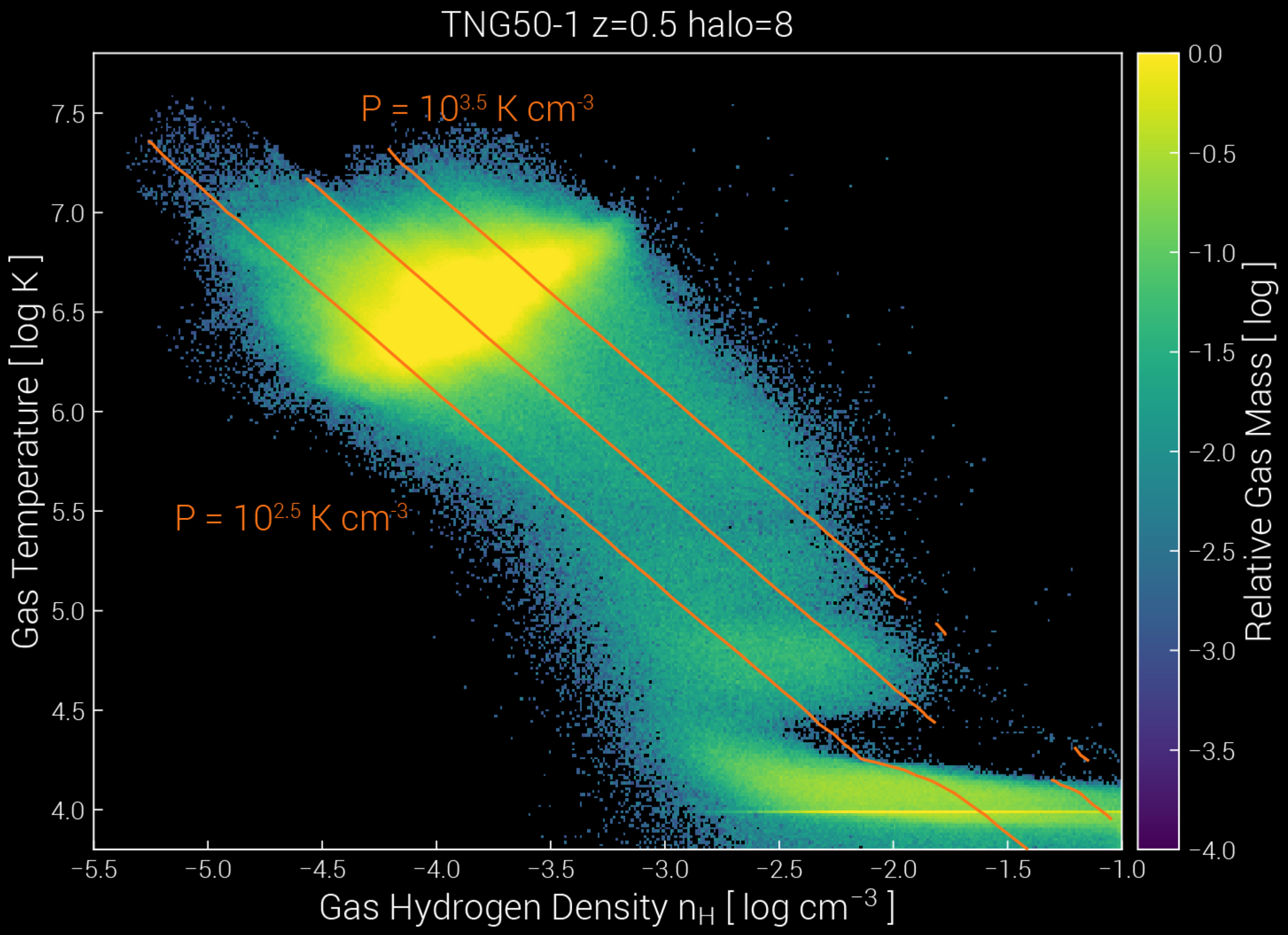
70 kpc
z = 0.50
dotted = r_vir / 4
solid = r_vir / 2
TNG50 LRG
log M_halo = 13.0
log M_star = 11.5
Stellar Composite [jwst_f200w, f115w, f070w]
Nelson+ (in prep)

... Slides on the TNG50 small-scale CGM ...

(work in progress)

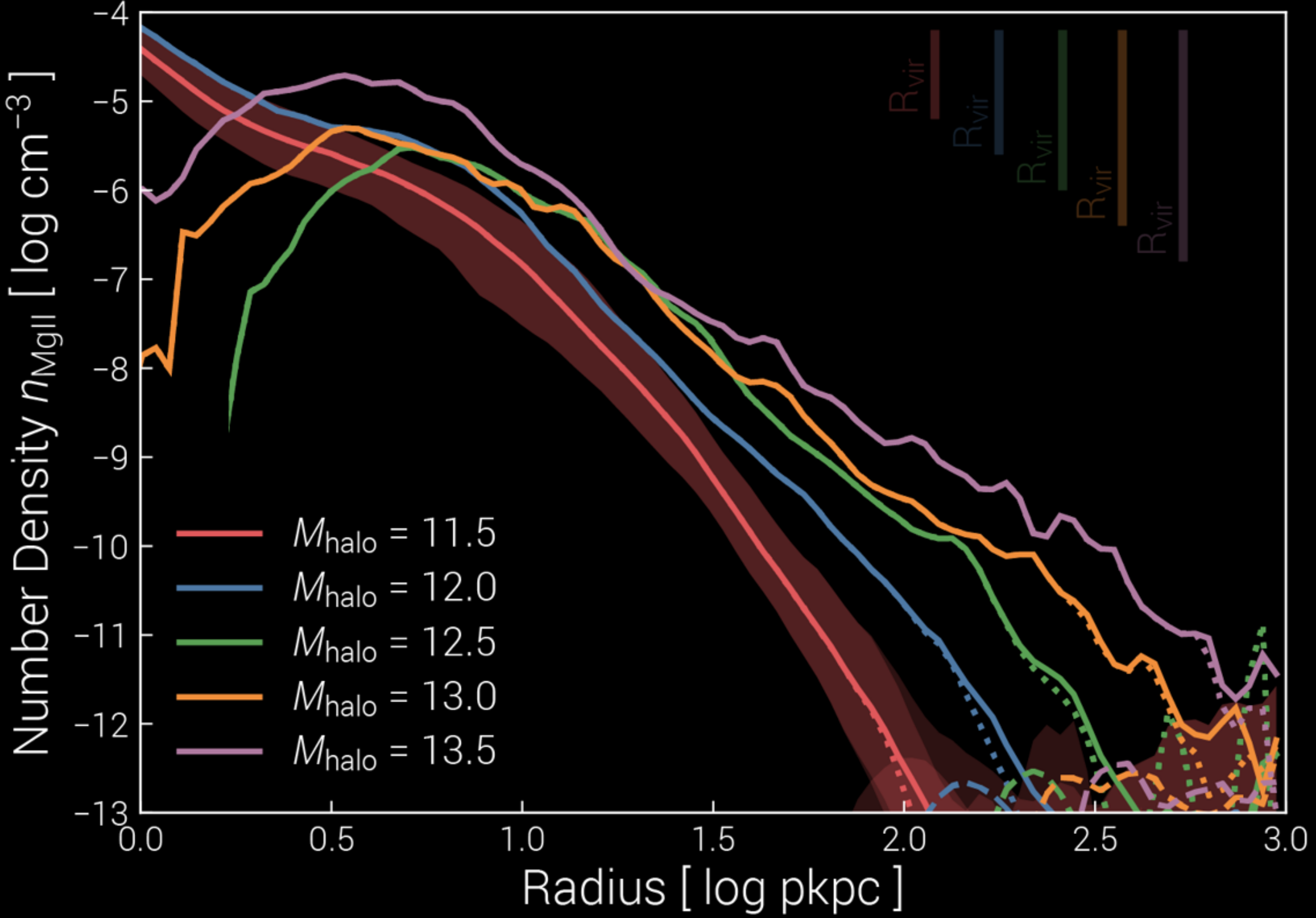


Nelson+ (in prep)



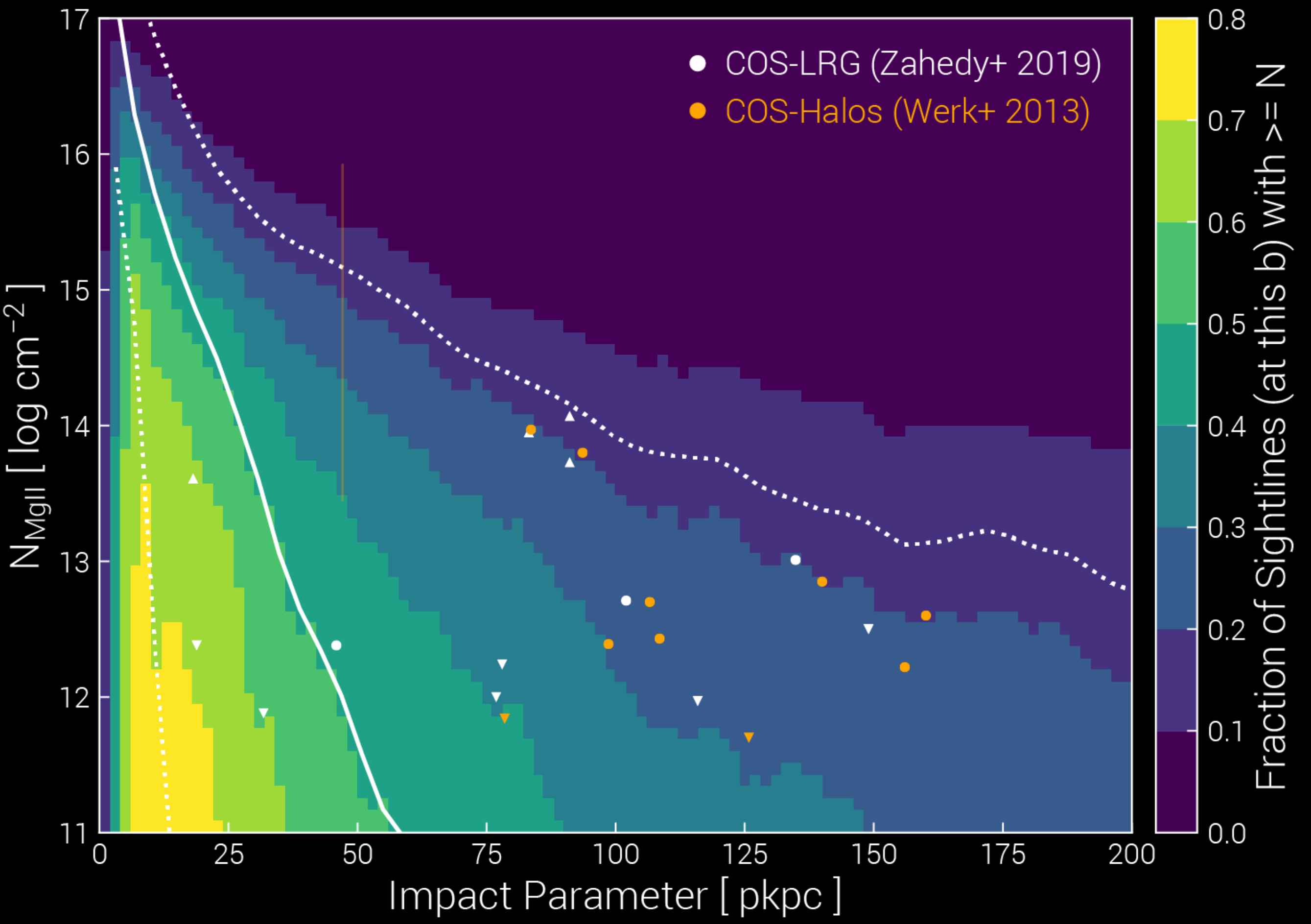
Nelson+ (in prep)

Q: How much cold gas is there?



Q: What fraction of sightlines, at a given impact parameter, have a column of N_{MgII} or higher?

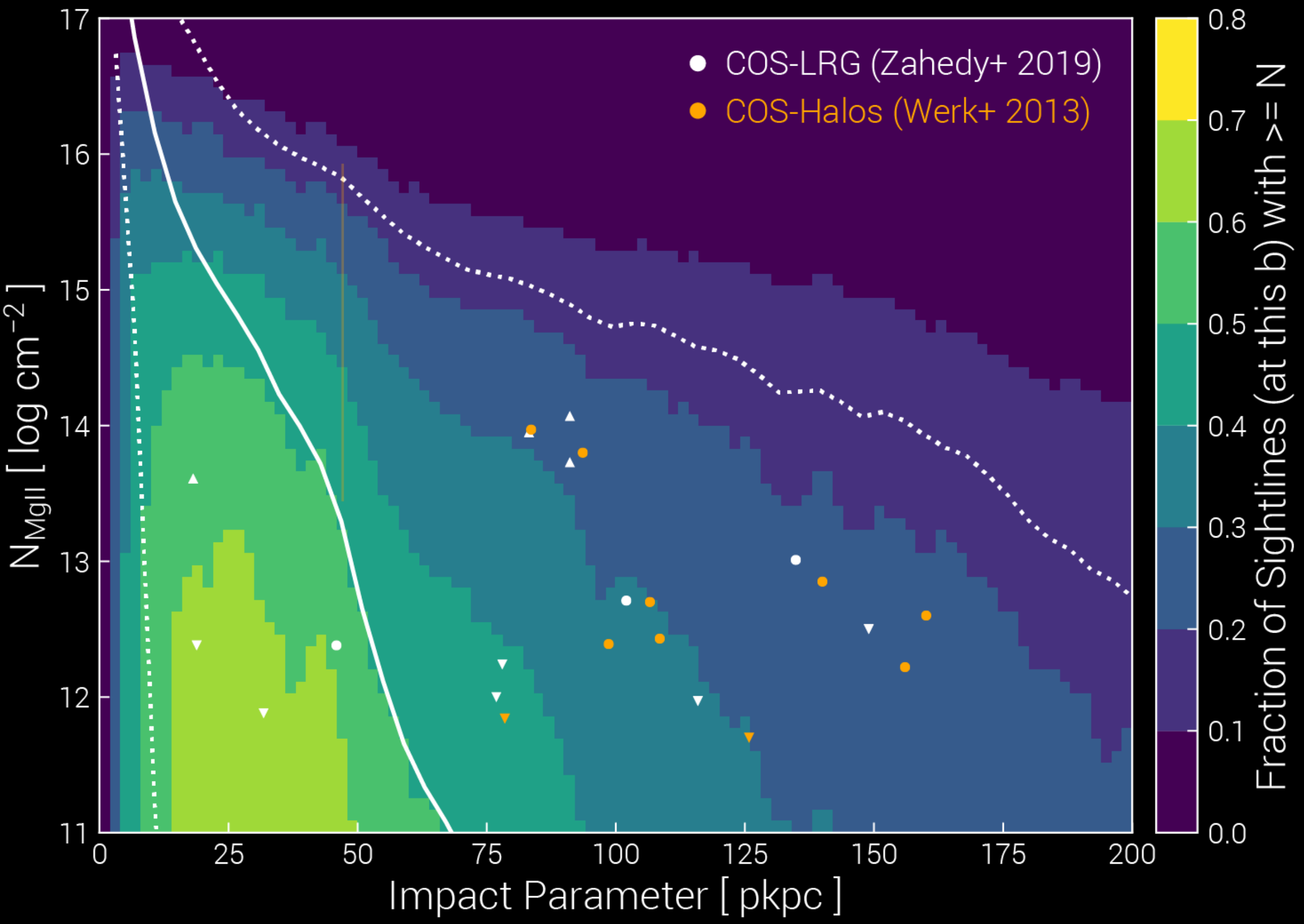
$M_{halo} \sim 10^{13.0}\ M_{sun}$



Nelson+ (in prep)

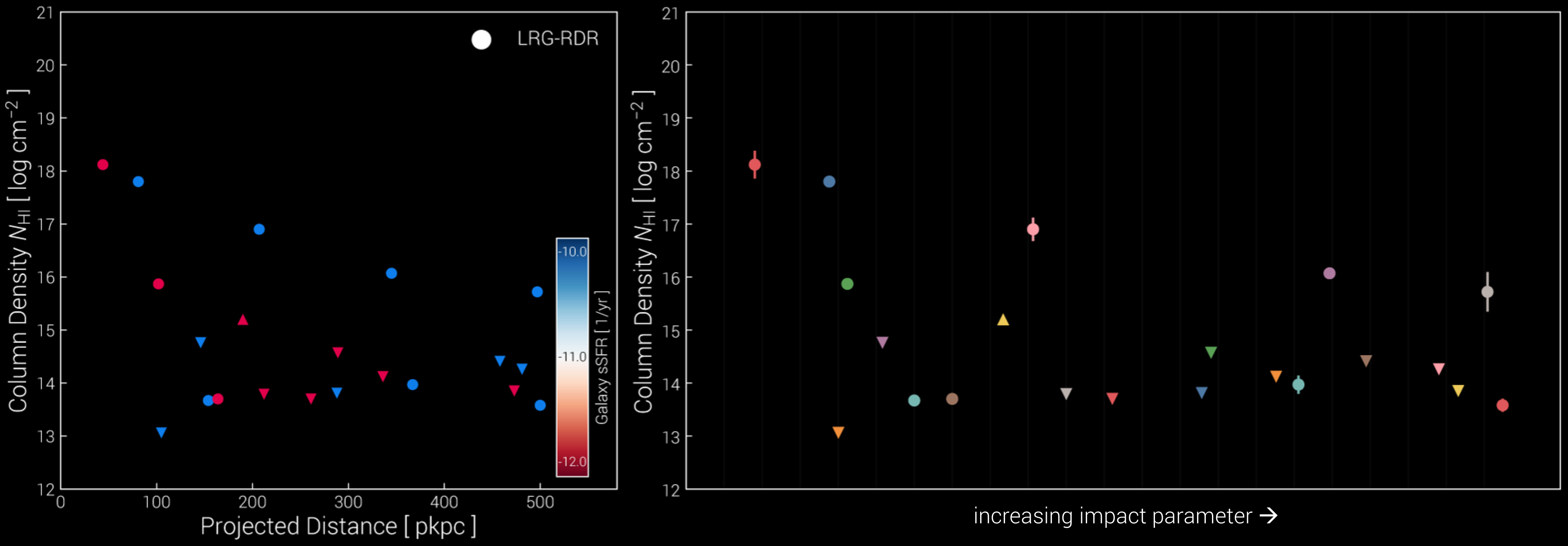
Q: What fraction of sightlines, at a given impact parameter, have a column of N_{MgII} or higher?

$M_{halo} \sim 10^{13.5}$ M_{sun}



Nelson+ (in prep)

Q: Are the column densities and covering fractions (MgII, HI) reasonable vs. observations?



Contrast against the 'LRG-RDR' survey (Berg+19) = 21 LRGs with M* ~ $10^{11.4}$ M_{sun} at z~0.5 with measured N_{HI}.

- For each observed pair, randomly select 100 analogs and measure sightlines at matched (b) around each.

Nelson+ (in prep)

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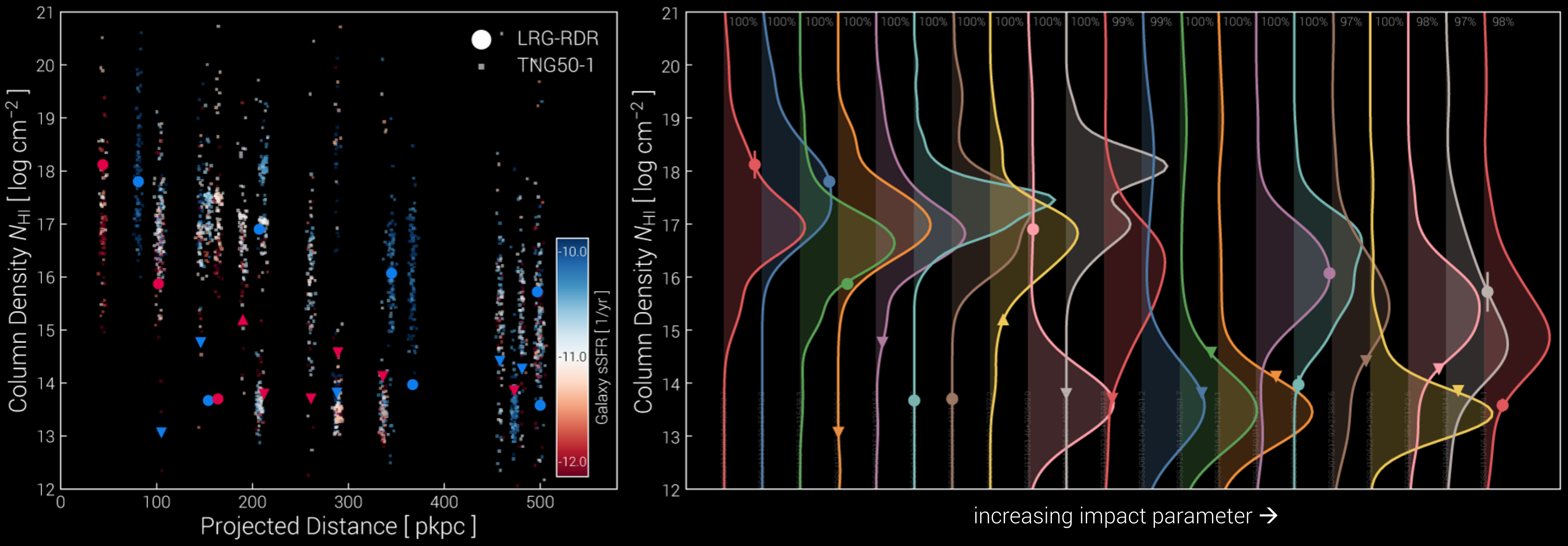

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- For each observed pair, randomly select 100 analogs and measure sightlines at matched (b) around each.
- Compare PDFs of predicted N_{HI} versus each data point.
- Strong dichotomy: (i) halos with high-N_{HI} centered distributions vs. (ii) halos with *always* lower columns.

Nelson+ (in prep)

conclusions

- the high Lagrangian resolution of TNG50 appears to resolve an interesting, dynamic cold-phase in the CGM of massive LRGs
- TNG50 gas resolution in such dense CGM structures is ~200-500 physical pc
- there is a large mass of cold HI/MgII gas at $\sim 10^4$ K embedded in $\sim 10^7$ K virialized hot halos, total cold-phase mass always increases with halo mass
- far from volume filling, size scale is ~ kpc
- not in pressure equilibrium
- strongly [over]magnetized, $P_B >> P_{gas}$
- sightlines will either see a [very] strong absorber, or no absorption at all

to-do

- origin (formation mechanism) & fate
- kinematics
- dichotomy: thermal or assembly state?
- statistical comparison to obs