

New galaxy formation simulations

NewHorizon2 & YZiCS2

Team



Jinsu, SFH, Velociraptor

Seonwoo: mass segregation

San: yOMP, NH2

Seyoung: SFH, HAGN, YZiCS

JK: morphology, SKIRT



Taysun: mentor



Ryan Jackson in October

Horizon-AGN

25 Mpc/h

New Horizon

7 Mpc

NewHorizon (Dubois et al. 2021, A&A)

- Cosmological zoom-in simulation
- 10 Mpc radius sphere (200 galaxies $> 10^9 M_{\odot}$)
- **Resolution:** $dx > 35\text{pc}$, $dm^* \sim 10^4$, $dm_{DM} \sim 10^6$
- Computing: 80 Mhr reaching $z=0.17$

NH

DM
Hot gas
Stars



5 cMpc

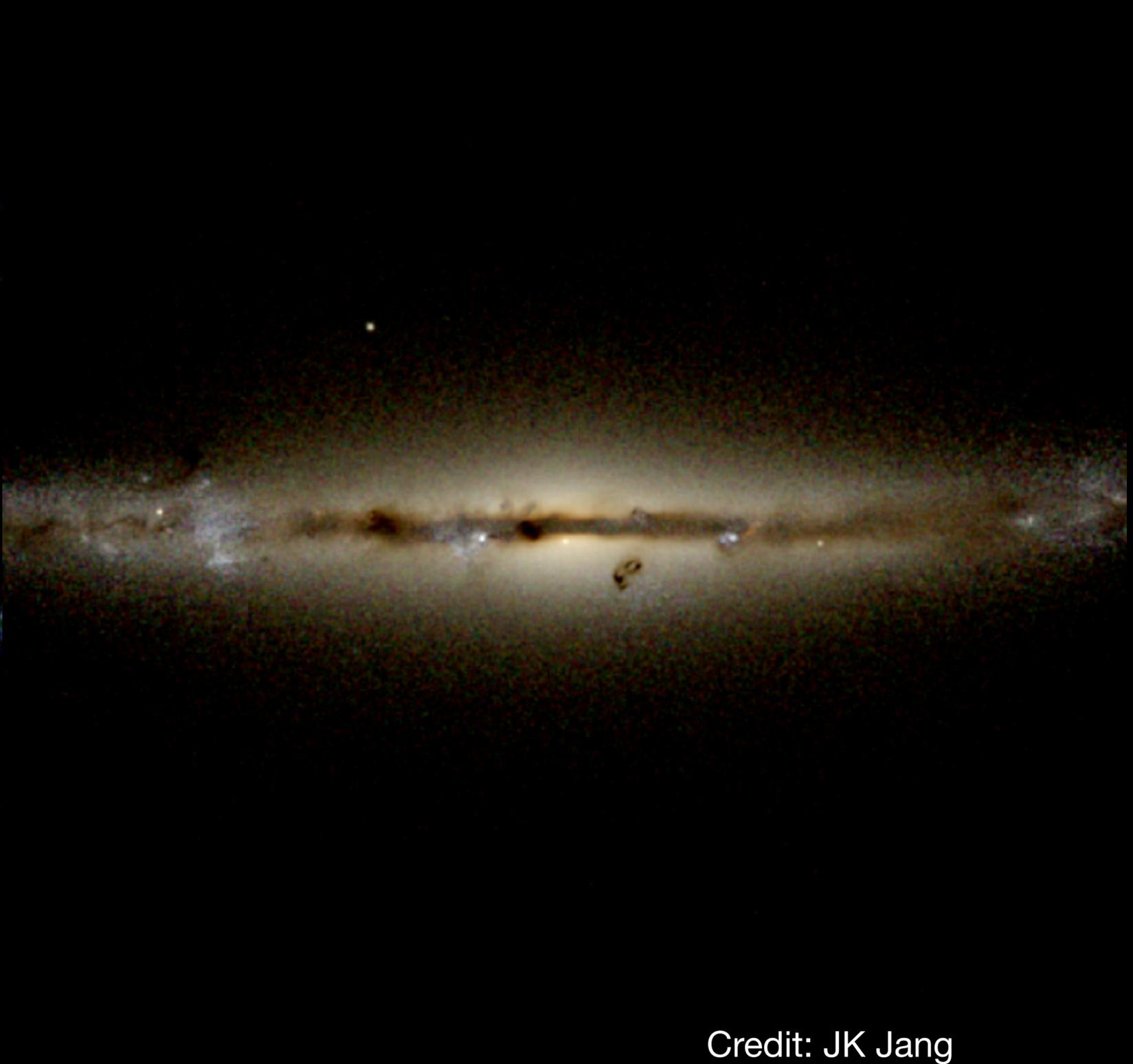
$a = 0.022$

NH
w/ SKIRT



Credit: JK Jang

NH
w/ SKIRT



Credit: JK Jang



Spiral Galaxy M101  HUBBLESITE.org

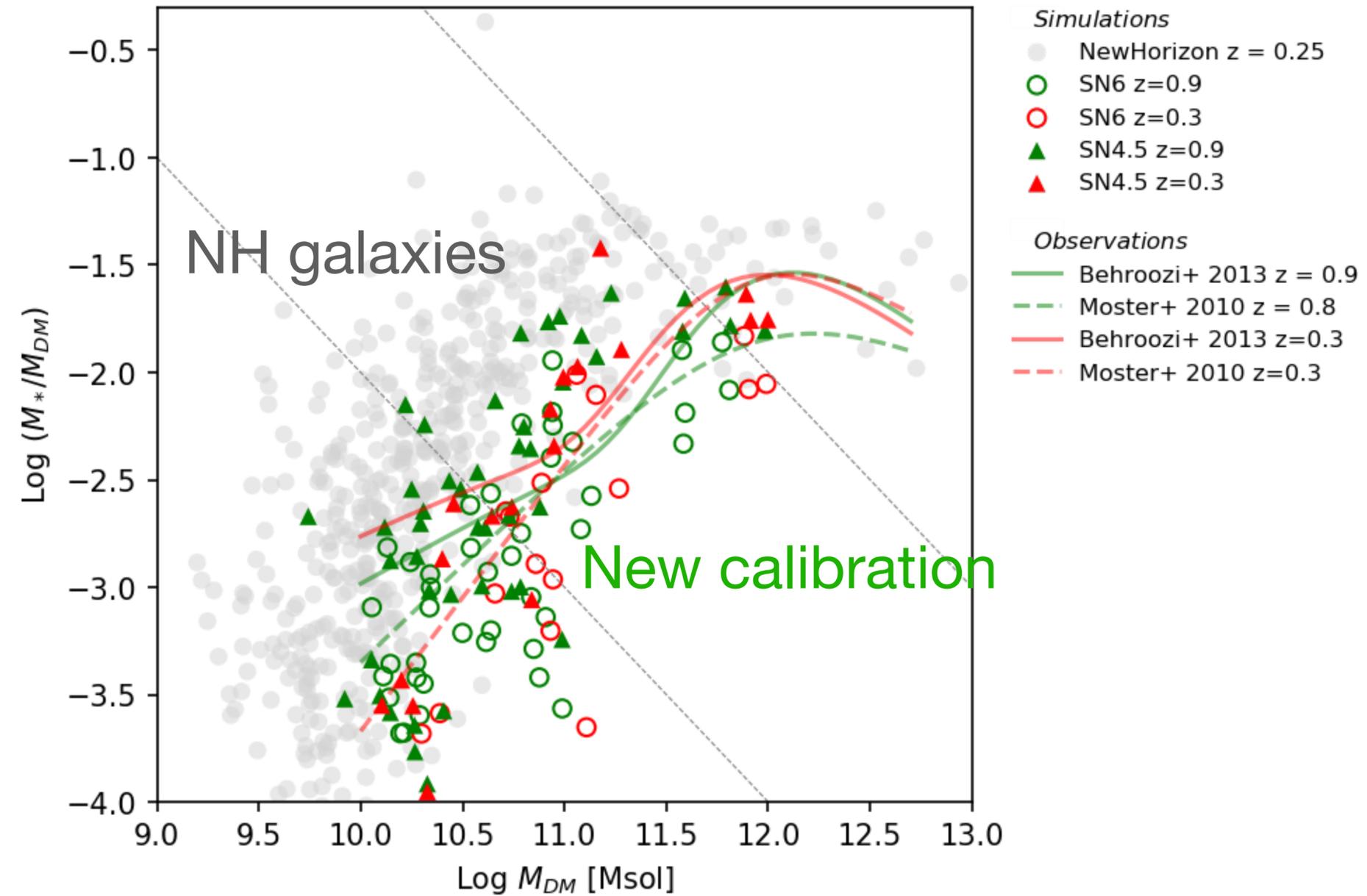


NGC 891

<http://www.caelumobservatory.com/obs/n891.html>

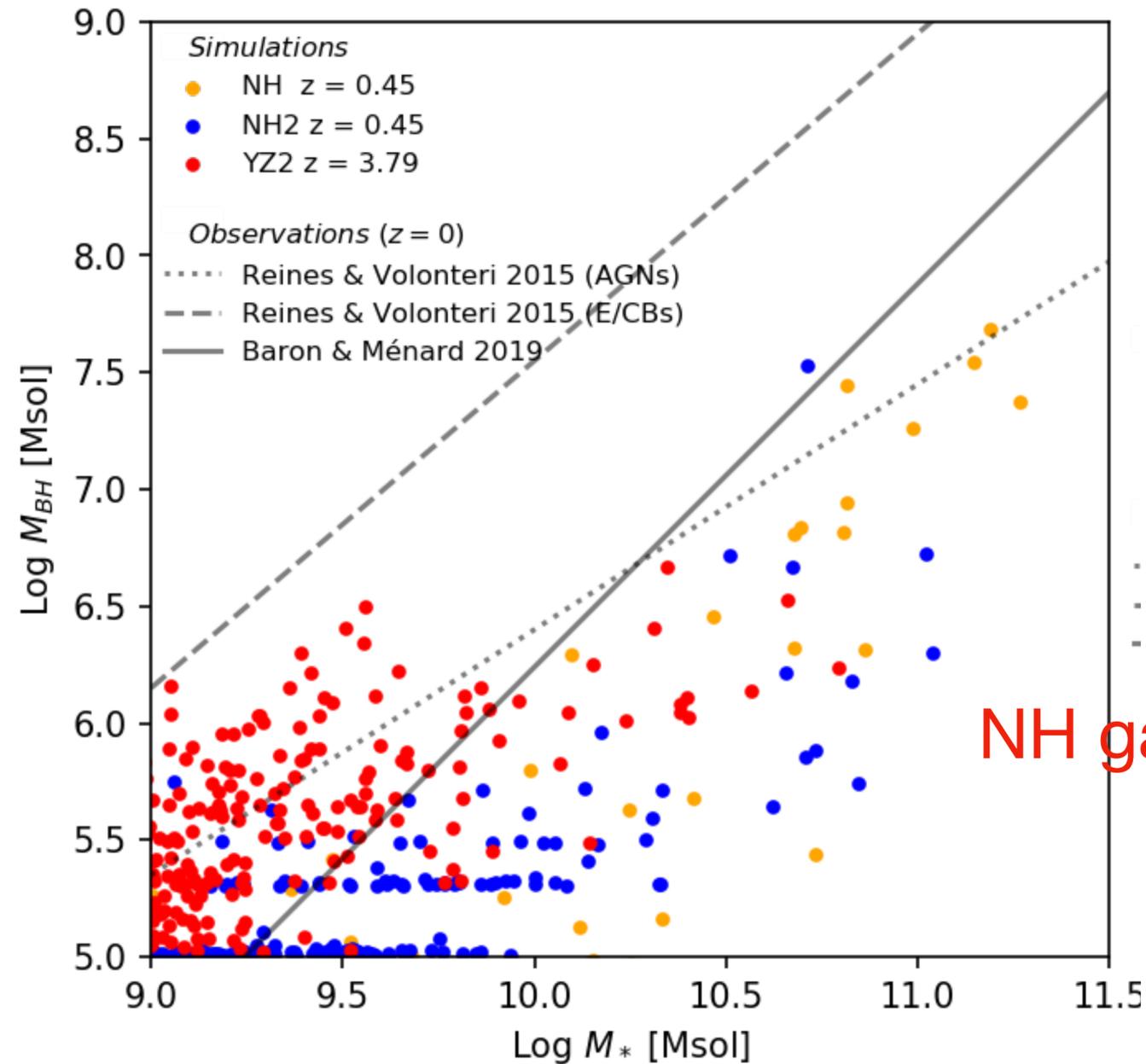
Issues of NH

M_s/M_{halo} too high

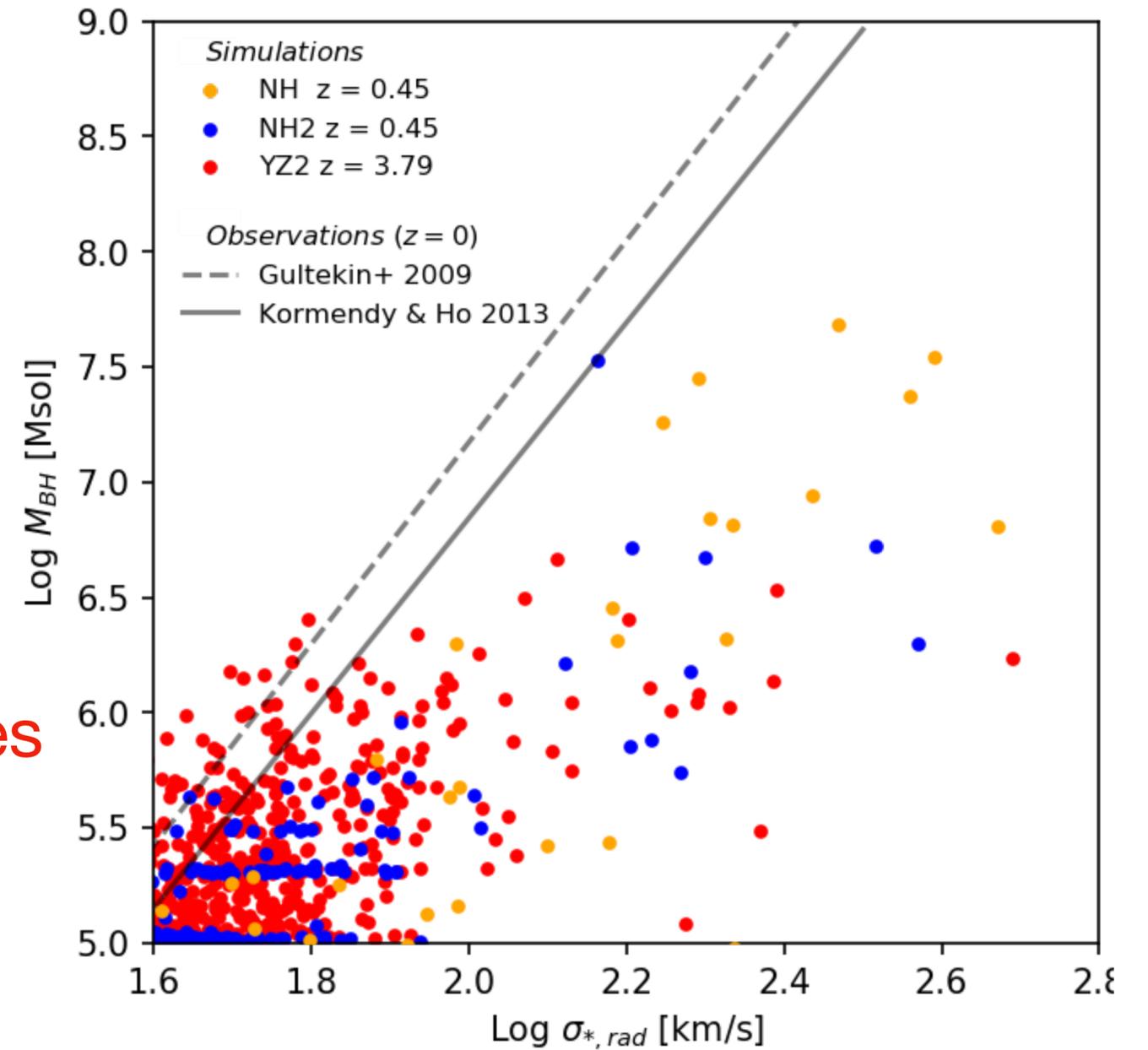


Issues of NH

BH rarely settles down



Stellar mass



$\log \sigma_*$

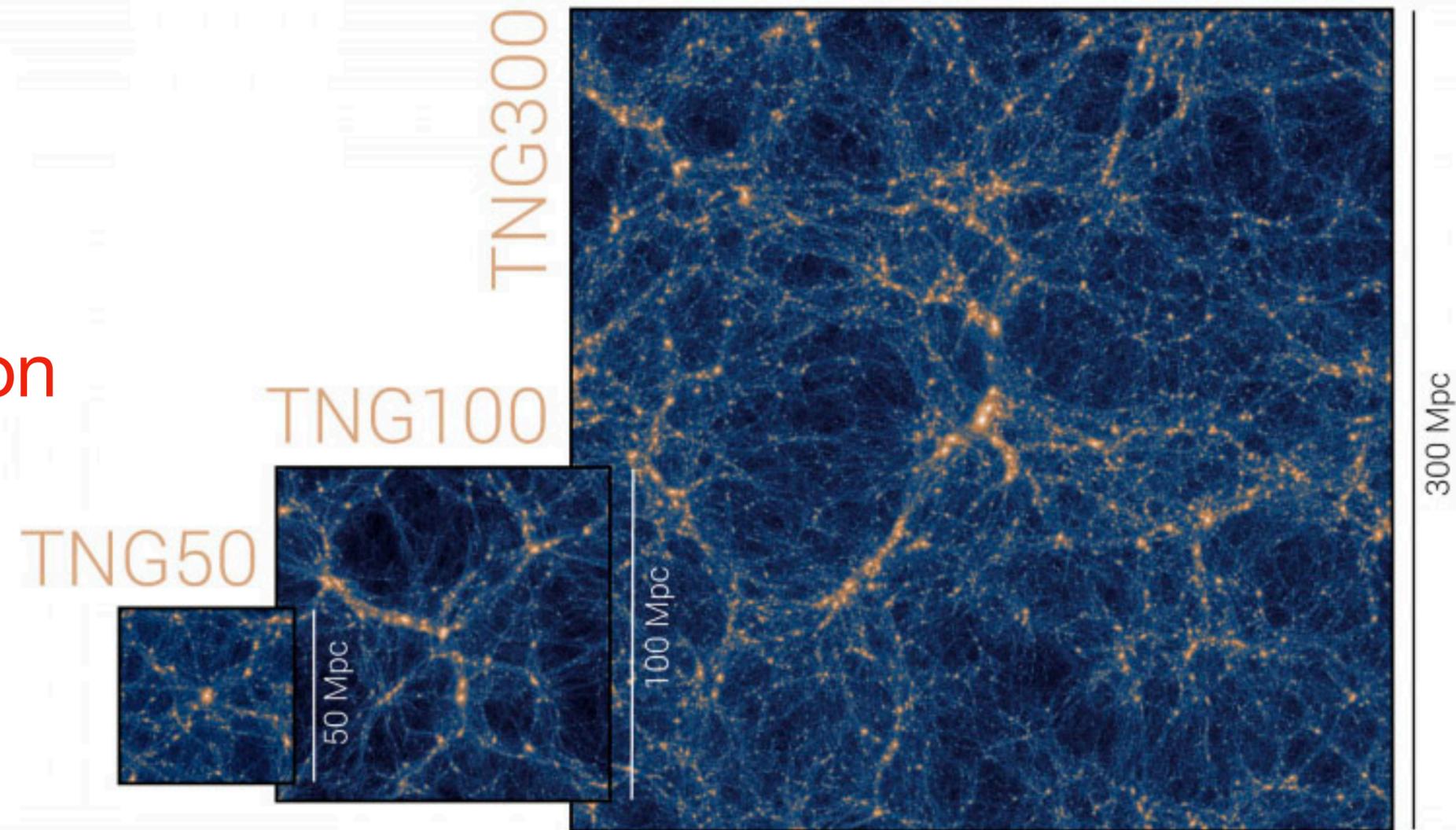
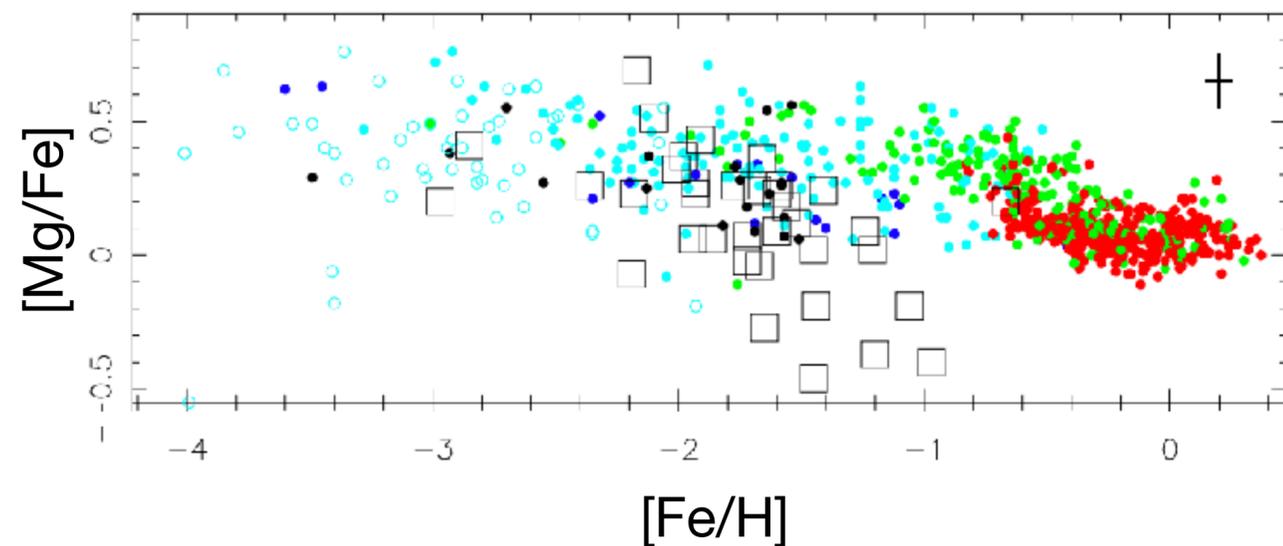
Issues of NH

M_s/M_{Halo} too high

BH rarely settles down

No resolution test

No chemical/elemental evolution



“NewHorizon2”

with

San Han (yOMP, calibration)

Jinsu Rhee (chemical evolution)

Taysun Kimm (chemical evolution, feedback)

Juhan Kim (OMP)

Basic information

Parameter	NH	NH2	Description
Minimum spatial resolution	~35pc	~70pc	Initial grid resolution is same
Total mass within the zoom-in region (Msol)	1.31E14	1.43E14	Zoom-in region re-selected to economically include galaxies that were previously contaminated.
Initial Shape of zoom-in region	Sphere	Convex hull	
Particle mass (Msol)	1.3E6 (DM), 1E4 (star)	1.3E6 (DM), 2E4 (star)	
Number of particles	136M (DM), 350M(star)	138M (DM), 85M?(star)	?estimated
Tracers per cell	1	0.5	Monte-Carlo tracer particle scheme
Cosmology	WMAP7	WMAP7	
Number of MPI domains	4800	480	8 threads (Ramses_yOMP)
Number of cores at parallel job	4800	3840	?estimated, note that Xeon phi cores are ~3x slower than conventional processors
Total core hours	40M (80M)	~20M? (Xeon phi)	

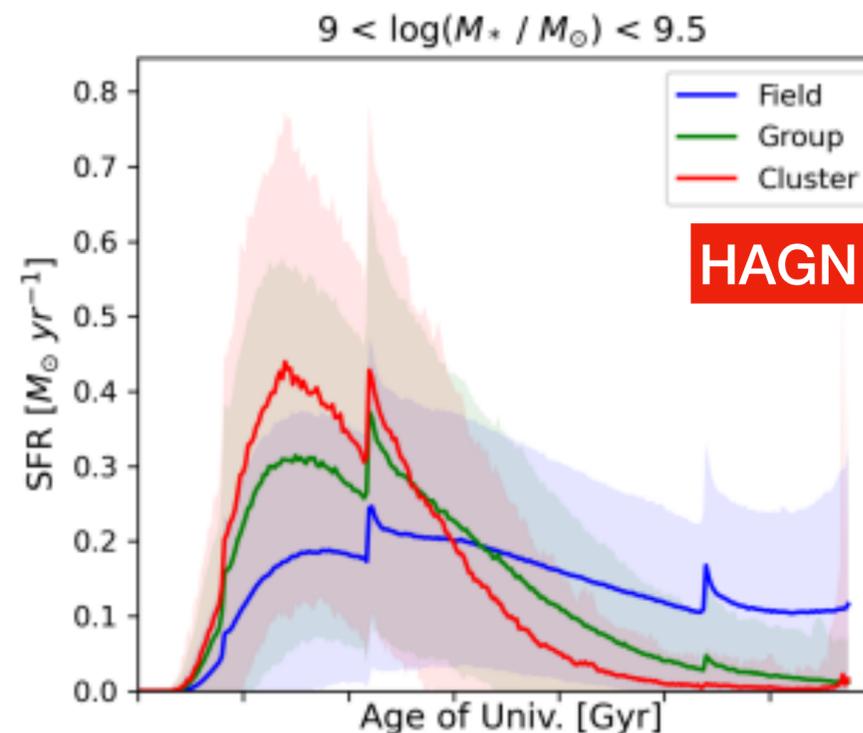
Sub-grid physics (SMBH)

Parameter	Unit	NH	NH2	Description
Quasar mode feedback efficiency		0.15	0.05	For better match with M-sigma relation
AGN-heated bubble size	dx	1 (35pc)	2 (140pc)	To increase the energy that can be released in single step
BH Seed mass	M_{sol}	10^4	10^5	For better settling of BH at initial formation stage
Formation density threshold (gas)	H/cc	10	50	
Formation density threshold (star)	H/cc	10	100	BH can only be formed in galaxies that has grown enough → prevents the formation of BHs in transient SF clumps
Formation sigma threshold (star)	km/s	-	50	
Max. acceleration from gas dynamical friction	km/s/Myr	-	100	Prevents BHs being kicked out from the center due to SN wind
Drag boost power factor from particle		-	2	Same scheme with the gas drag boost; to take account the strong drag force from particles that cannot be resolved in the simulation (e.g., nuclear star cluster)
Accretion boost power factor		0	0	Does not need anymore since particle drag boost already successfully fixes the BH motion at the galaxy center

Sub-grid physics (stellar feedback)

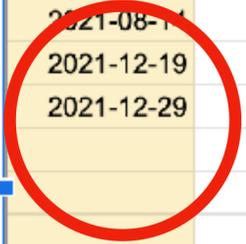
Parameter	Unit	NH	NH2	Description
SN II feedback efficiency ¹⁾	(1E51 erg) / Msol	0.0311	0.045	SNII_freq = eta_sn/M_SNII
Stellar Wind		Off	On	From Starburst99 table
SN Ia DTD amplitude ²⁾	(yr * 10 ¹⁰ Msol) ⁻¹	-	2.85 × 10 ⁻³	Scales the frequency of Type Ia supernova
Chemical elements		Metal	Metal + 8 elements	D (He) C N O Si S Mg Fe

Refinement at a=0.1, 0.2, 0.4, 0.8: Discrete => Smooth

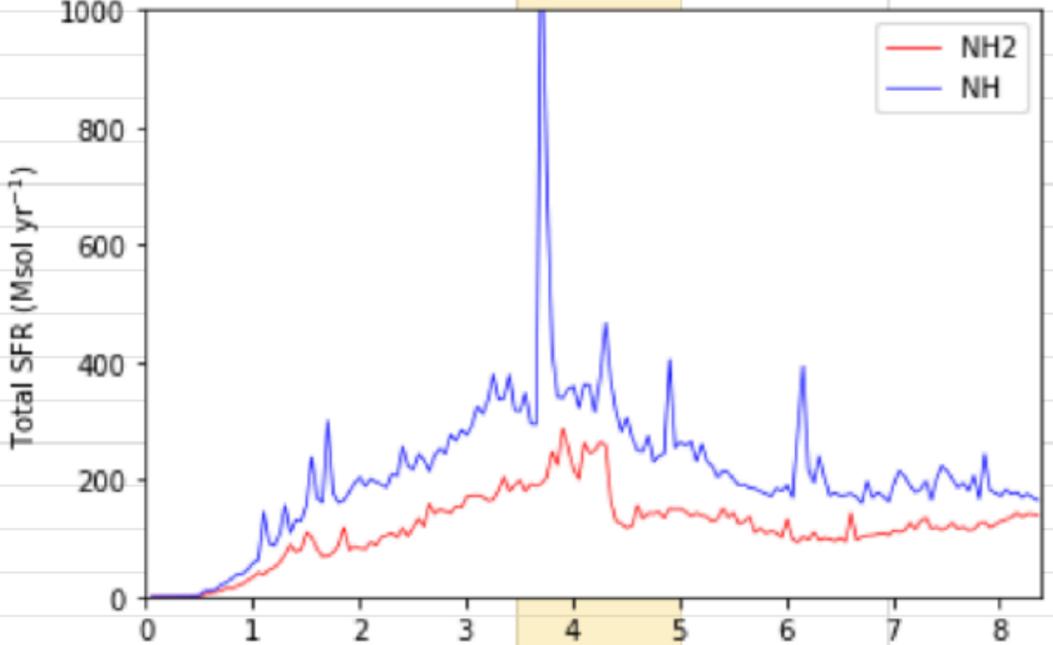
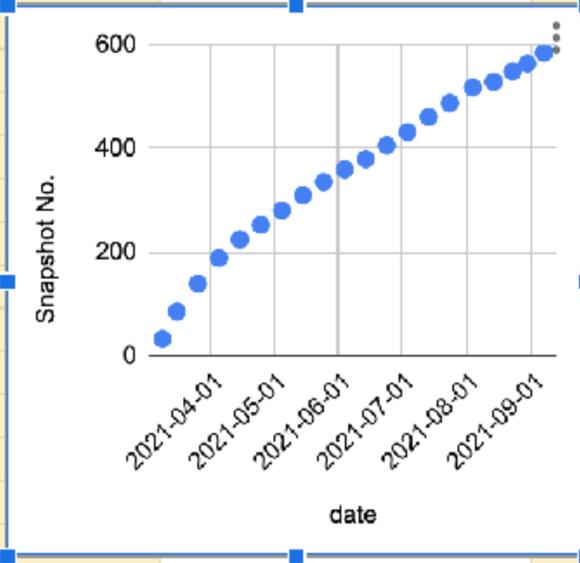


Current status

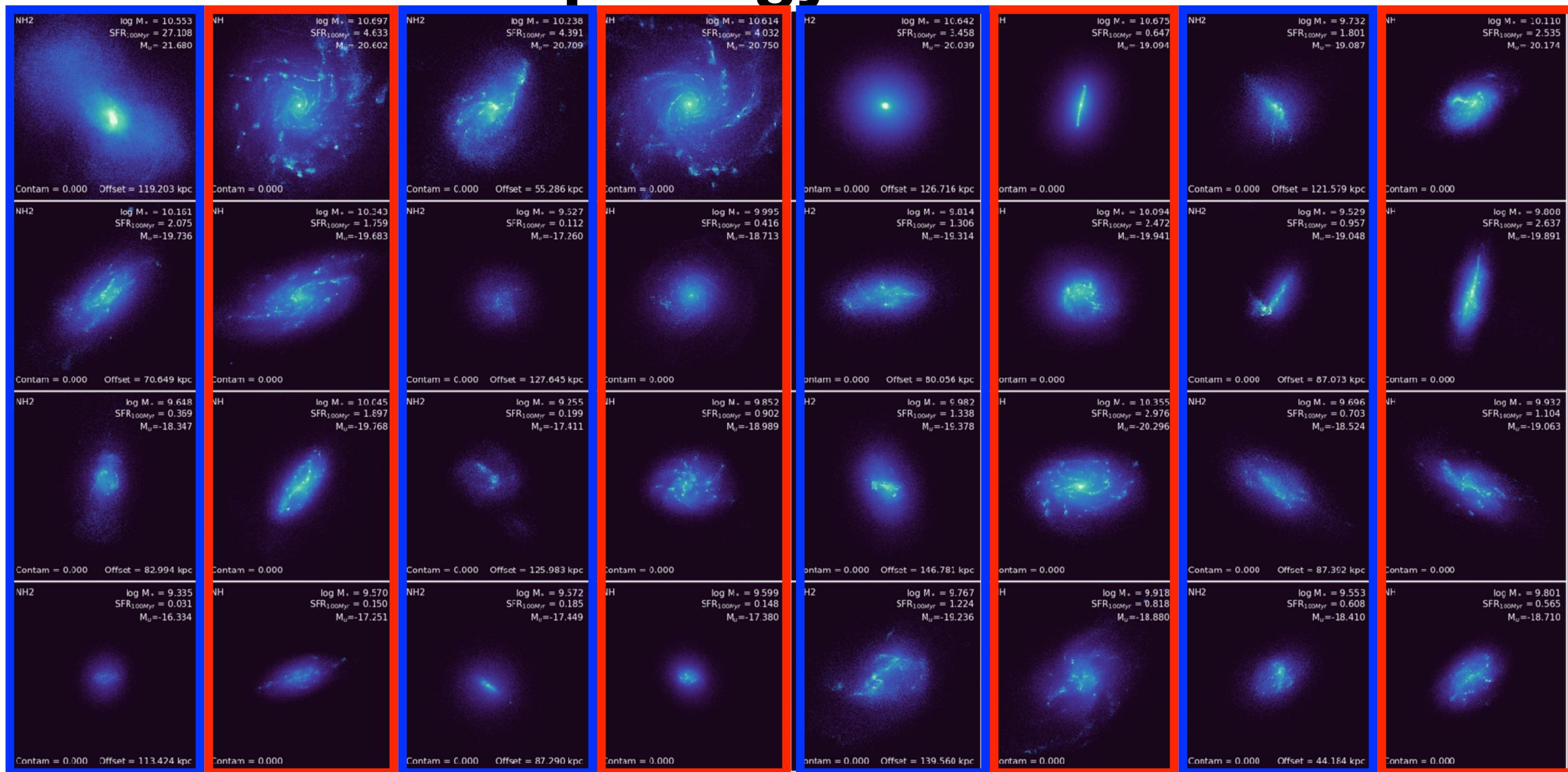
2	date	Start	r	SS	time per ss (hr)	a	z=1/a - 1	Age (Gyr)	time per MS (s)	N stars	SFR (Msol / yr)	N sinks	Mstar of the most massive galaxy	Finishing day (Linear projection)	Remarks	Core hours (hrs)
3	2021-03-09		33		2.5	0.0969	9.32	0.48	54	8546	0	2		2021-06-08		46,080
10	2021-03-16		86		4.5	0.1787	4.60	1.28	130	1797224	1.04E+02	138	9.03E+07	2021-08-18		645,120
20	2021-03-23		140		4.7	0.245	3.08	2.09	189	6971713	1.29E+02	683		2021-08-24		1,566,720
30	2021-04-05		189		5.5	0.3002	2.33	2.82	278	13968922	2.58E+02	898		2021-09-18		2,488,320
40	2021-04-15		225			0.3358	1.98	3.36		20801976		991		run queued		
50	2021-04-25		253		6.9	0.3641	1.75	3.78	365	27228448	3.82E+02			2021-11-01		
60	2021-05-05		281		7.8			4.20						2021-11-27		
70	2021-05-15		310		8			4.64						2021-12-02		
80	2021-05-25		336		10			5.03						2022-01-21		
90	2021-06-04		360		10.5			5.39						2022-02-01		
100	2021-06-14		380		8.7			5.69						2021-12-24		
110	2021-06-24		406		8.7			6.08						2021-12-25		
120	2021-07-04		432		8.2			6.47						2021-12-16		
130	2021-07-14		461		8.2			6.90						2021-12-16		
140	2021-07-24		488		8.6			7.31						2021-12-24		
151	2021-08-04		518		7.9		Z	7.76						2021-12-12		
161	2021-08-14		529					7.92						2021-08-14		
170	2021-08-23		549		7.8	0.6402	0.56	8.22		75087160				2021-12-19		
177	2021-08-30		564		8.3	0.654	0.53	8.45						2021-12-29	ETA	
178	2021-09-07		585													
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Snapshot steps are identical to NH!

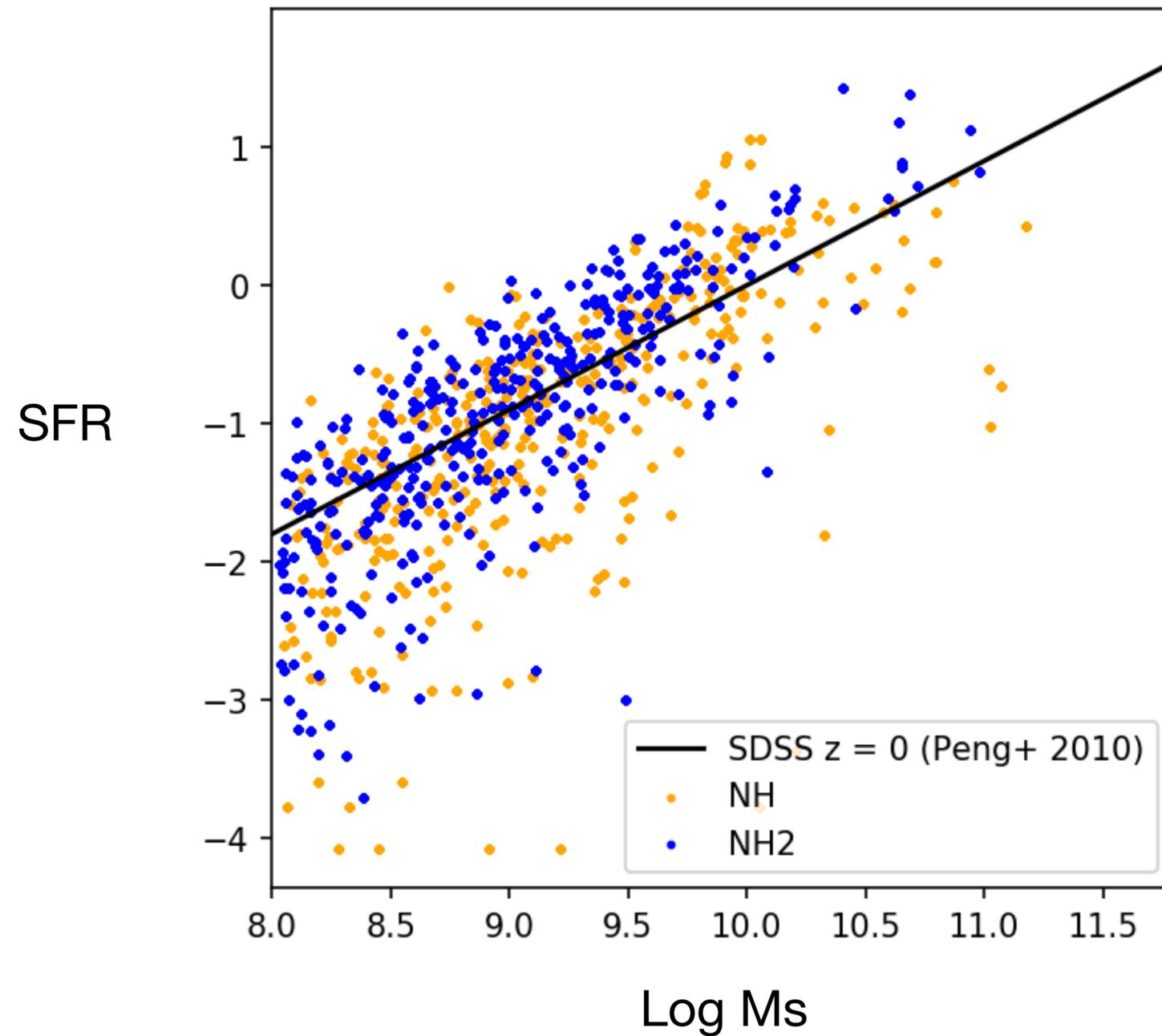


NH2 vs NH: morphology @ z=0.45



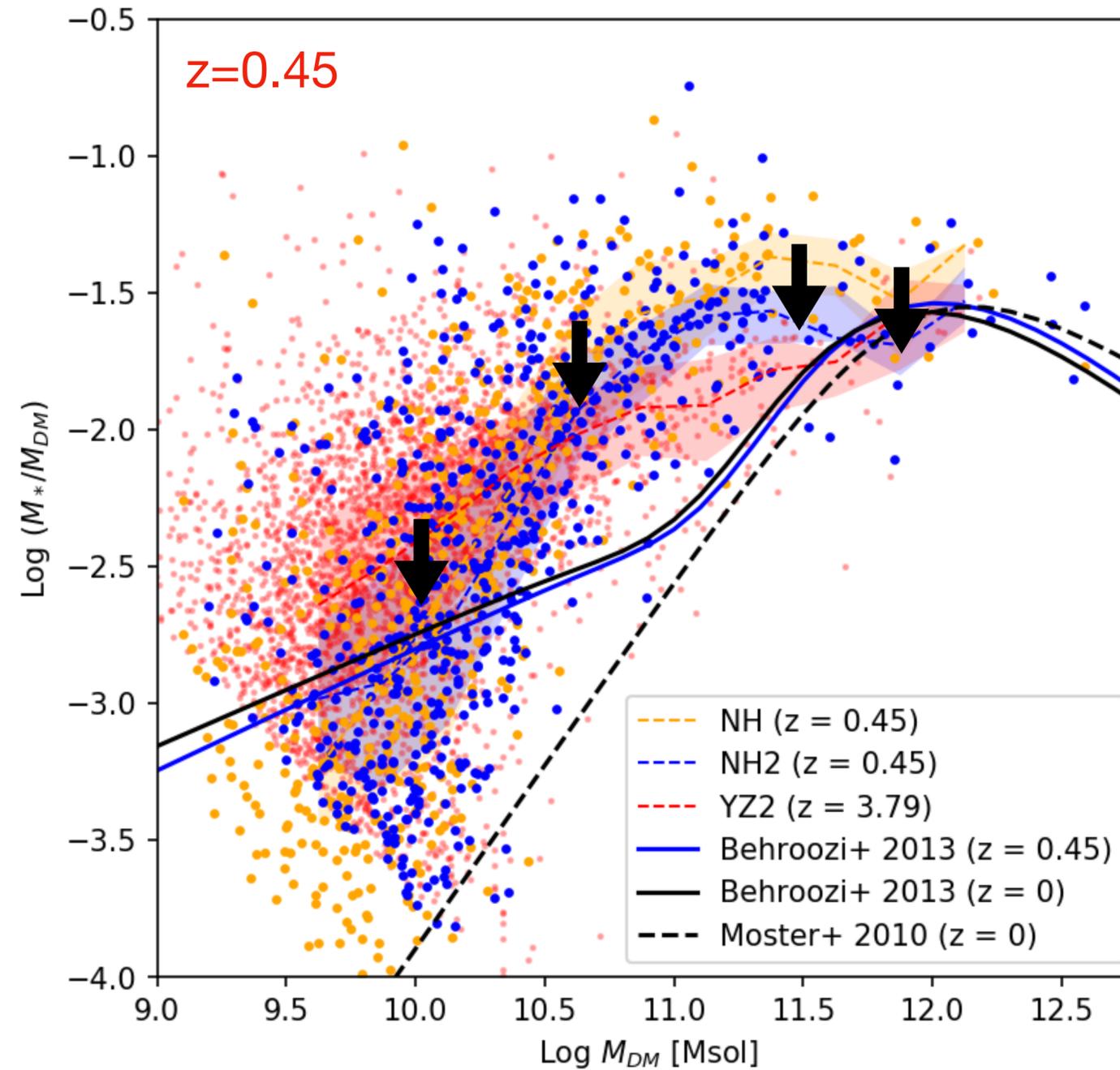
NH vs NH2

SF main sequence at $z=0.45$



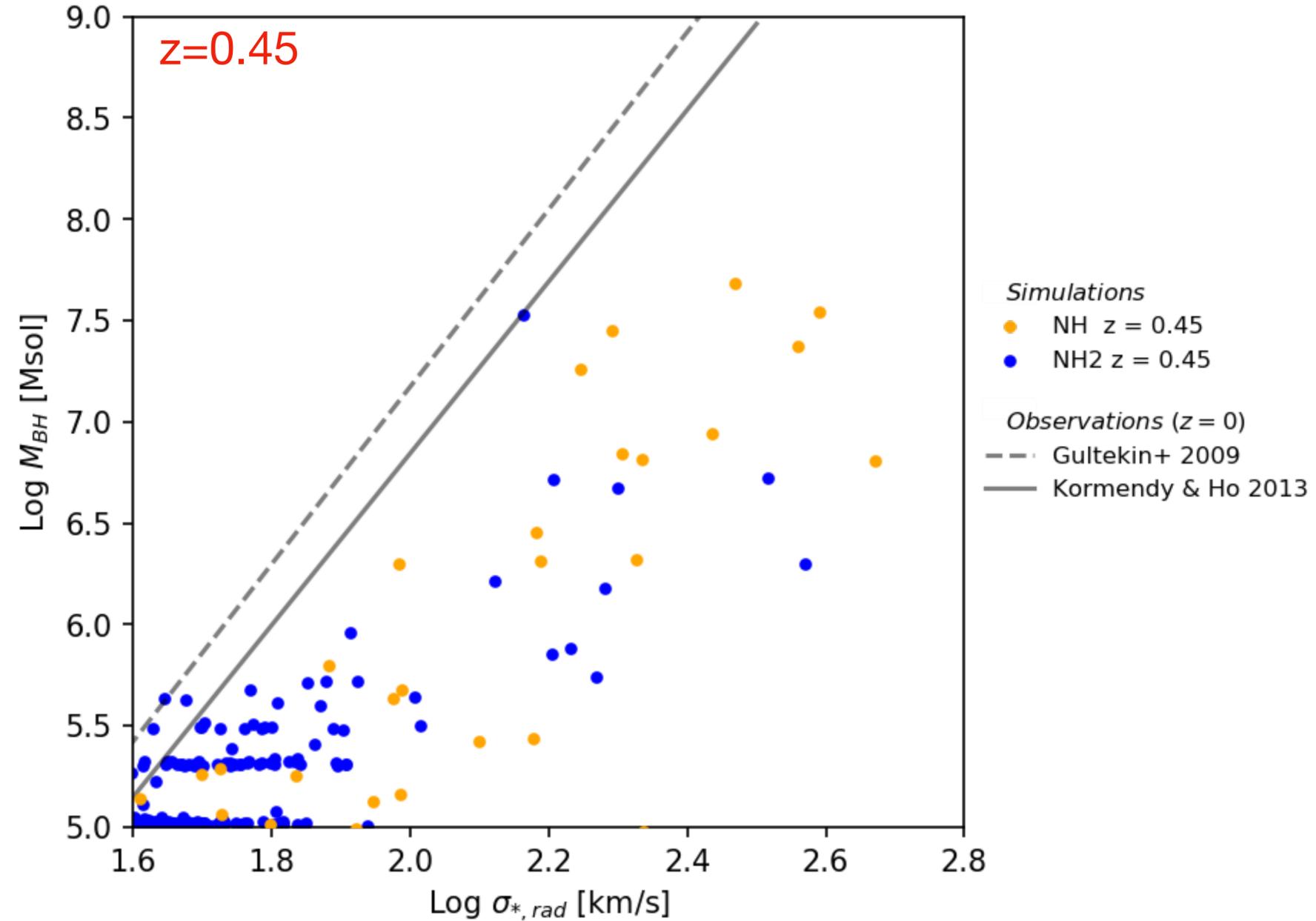
NH vs NH2

M_s/M_{halo} small reduction

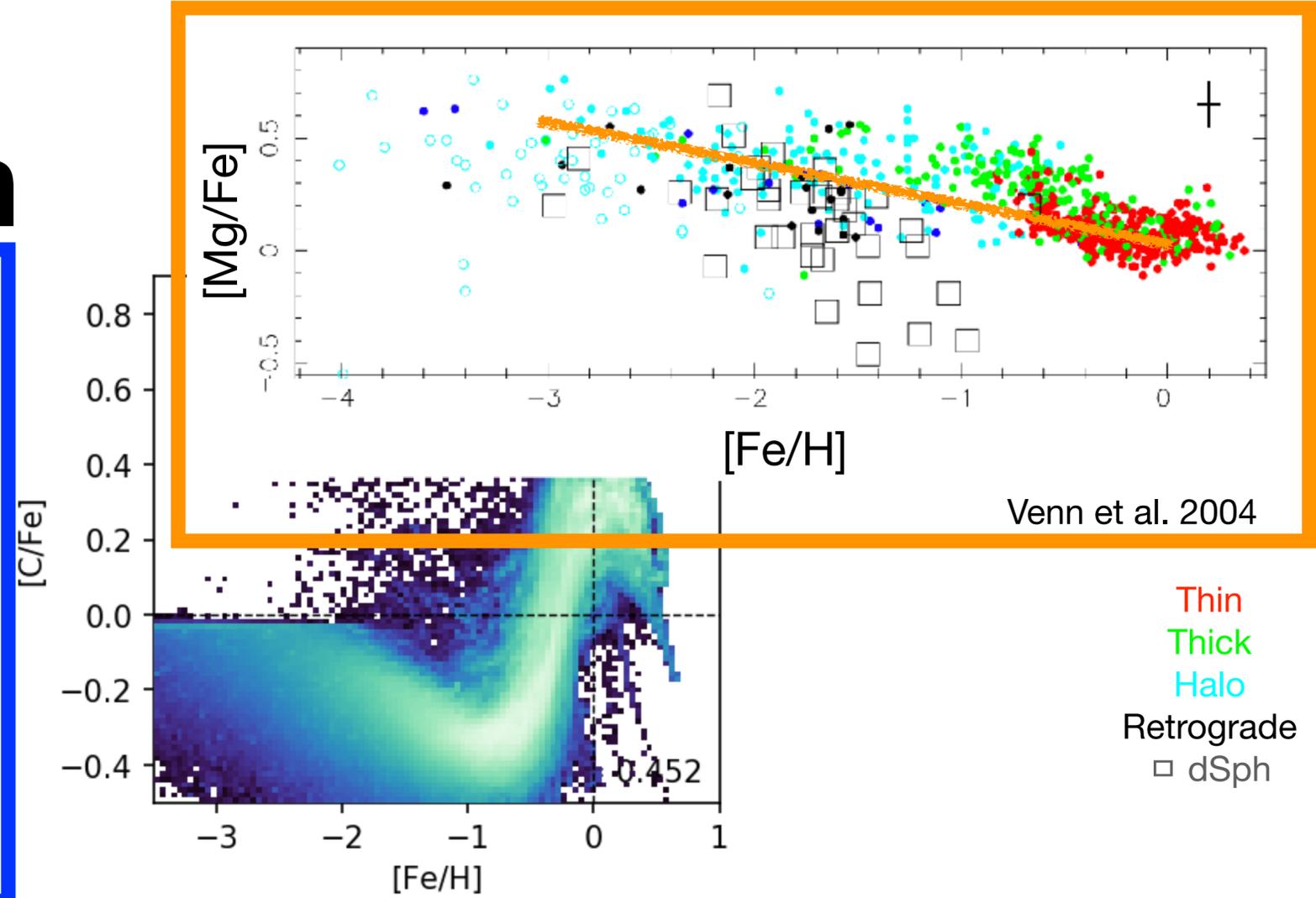
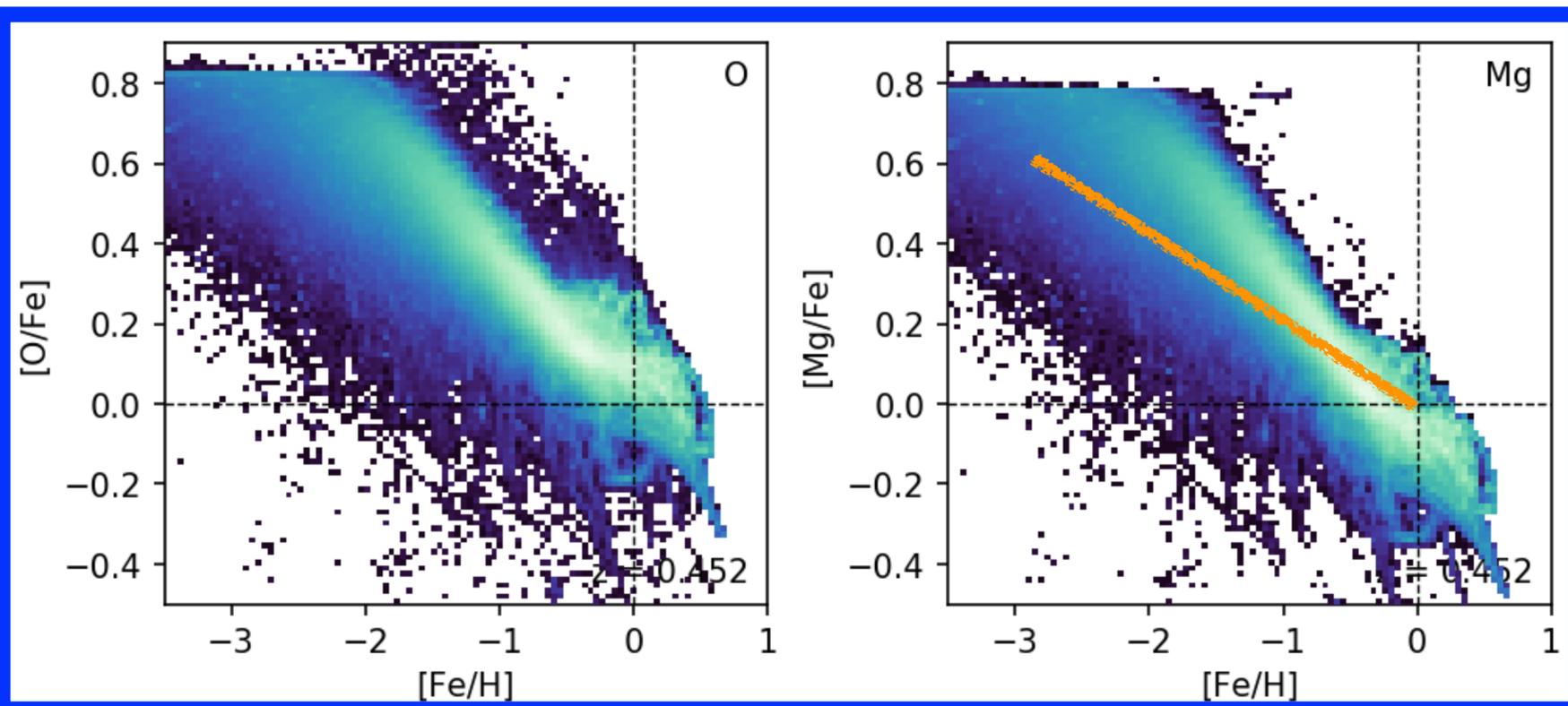


NH vs NH2

BH centering, No improvement!?

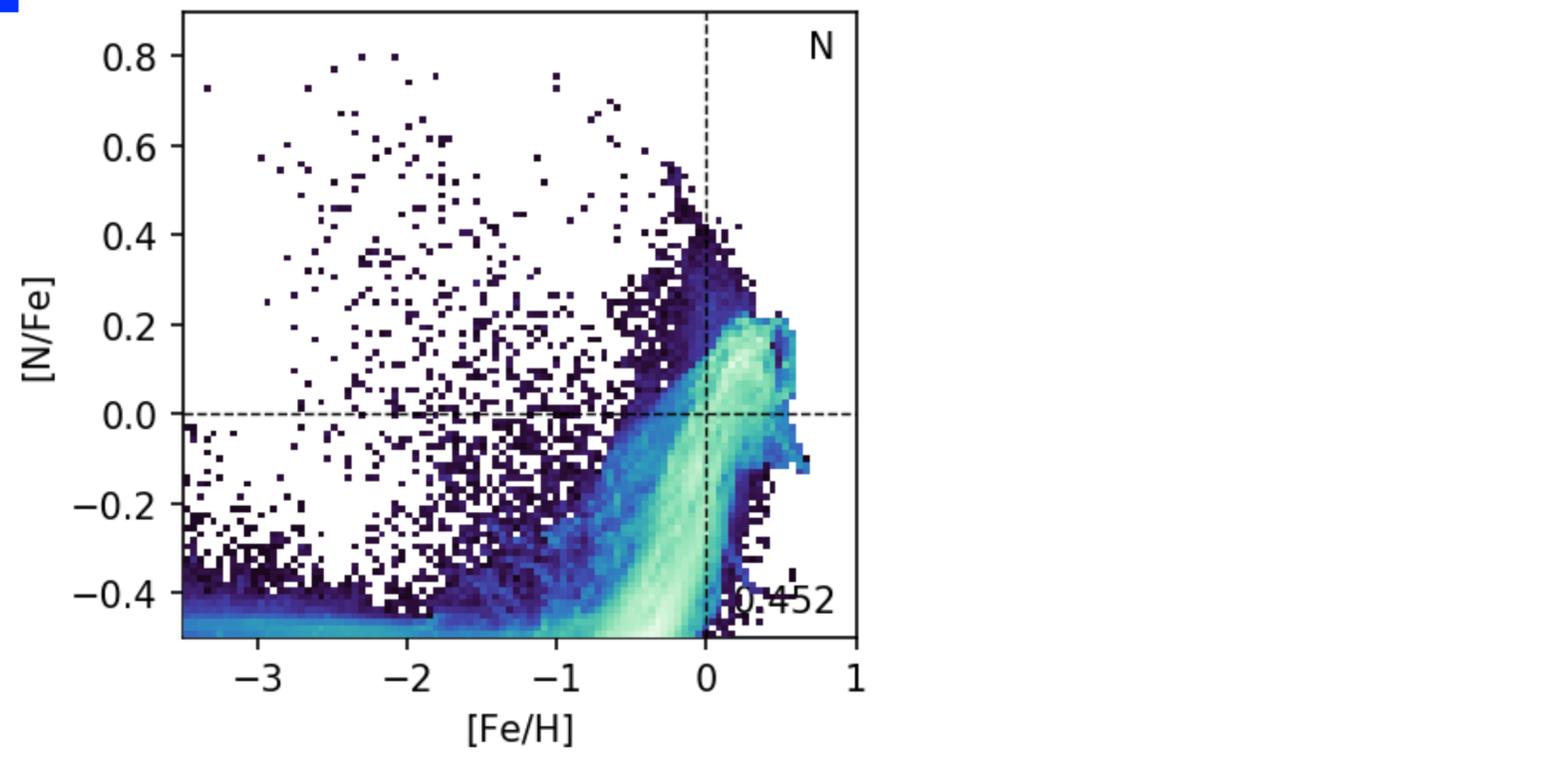
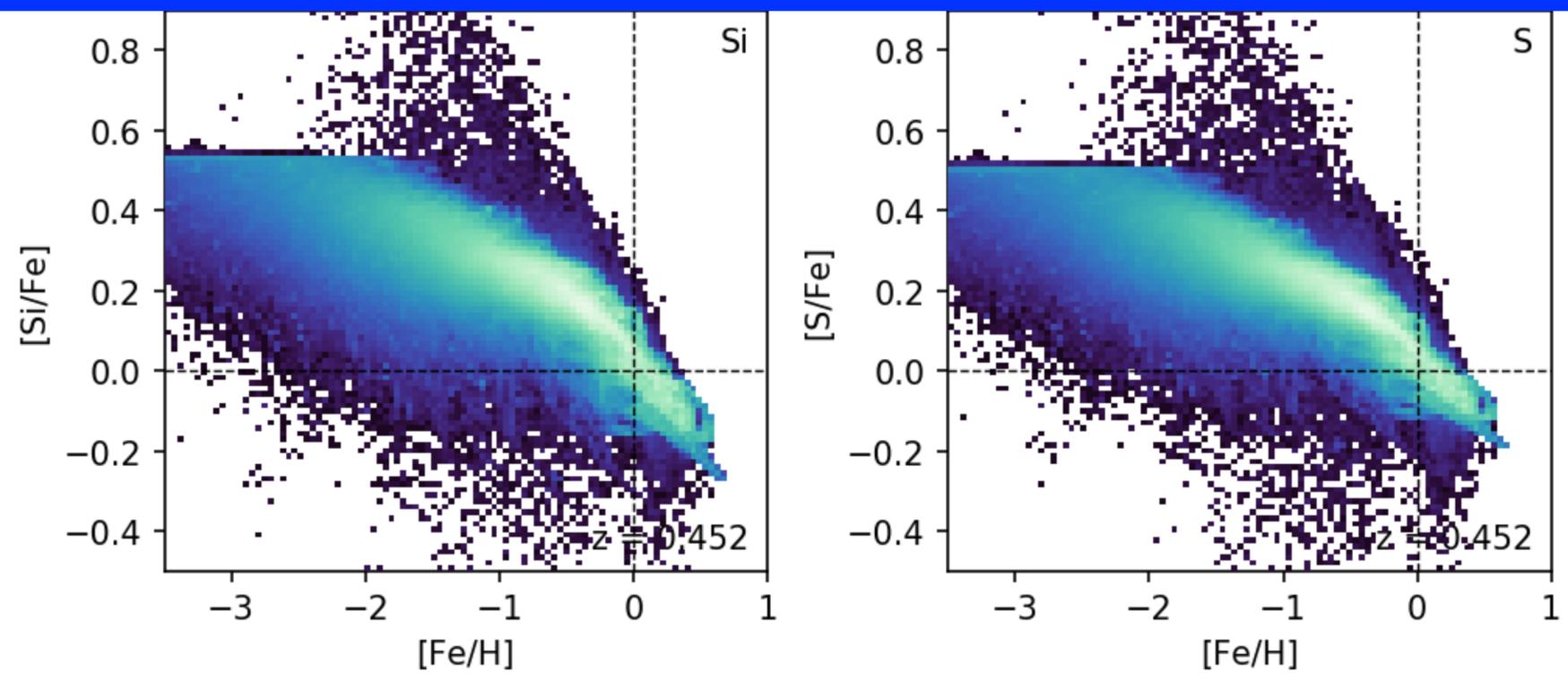


NH2 chemical evolution



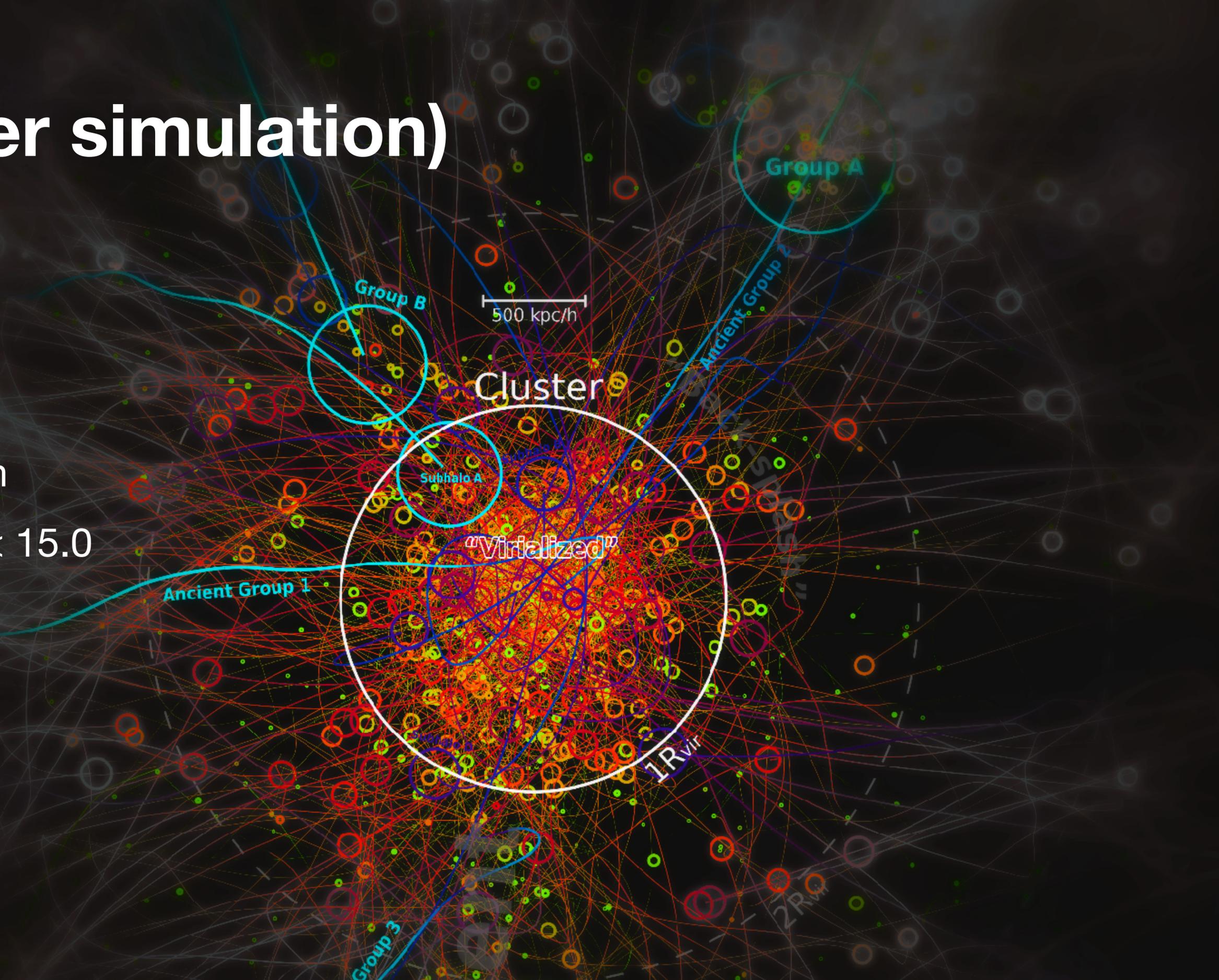
Venn et al. 2004

Thin
Thick
Halo
Retrograde
□ dSph



YZiCS (cluster simulation)

- RAMSES-HAGN
- 16 clusters in 200Mpc/h
- M_{200} : $13.5 < \log M/M_{\odot} < 15.0$
- $M_s \sim 4 \times 10^5 M_{\odot}$
- $dx > 1 \text{ kpc}$ (3000 ly)

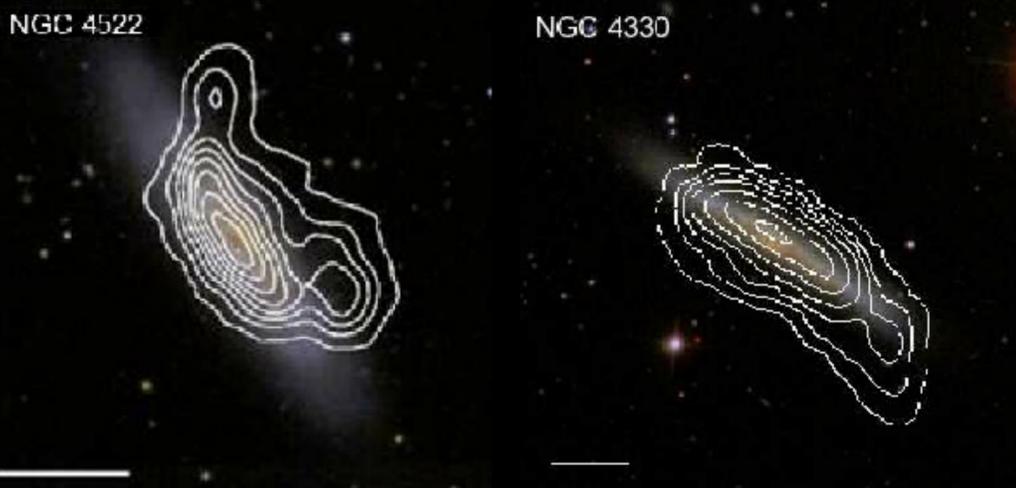
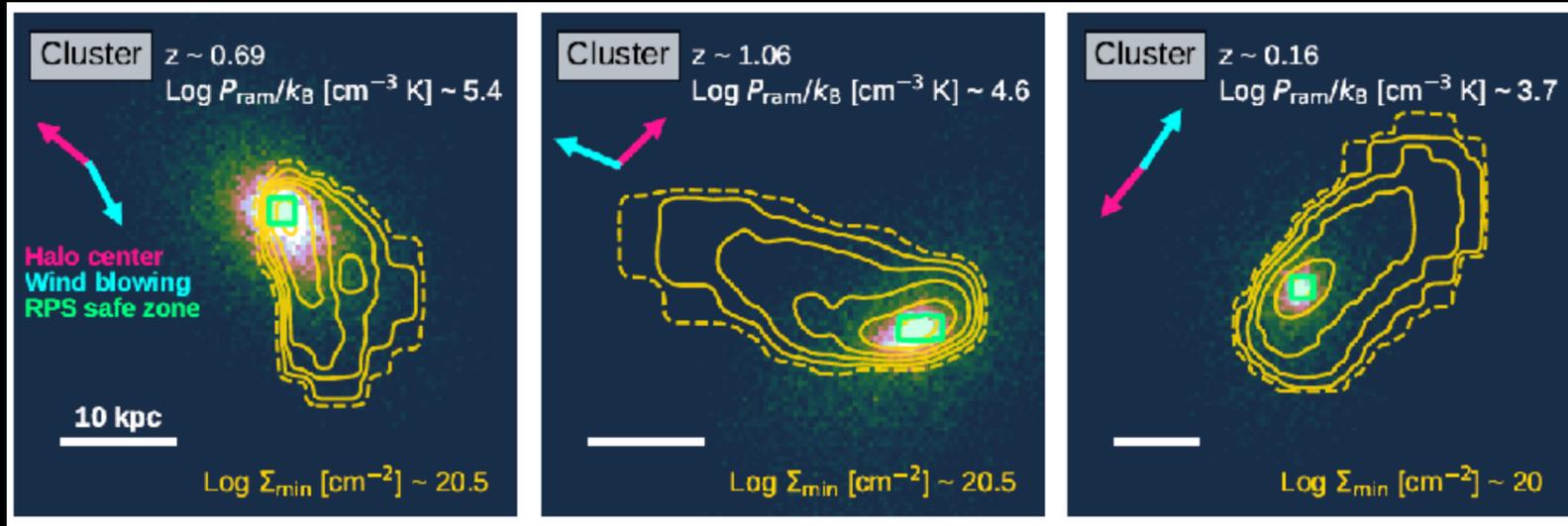


Ram pressure stripping

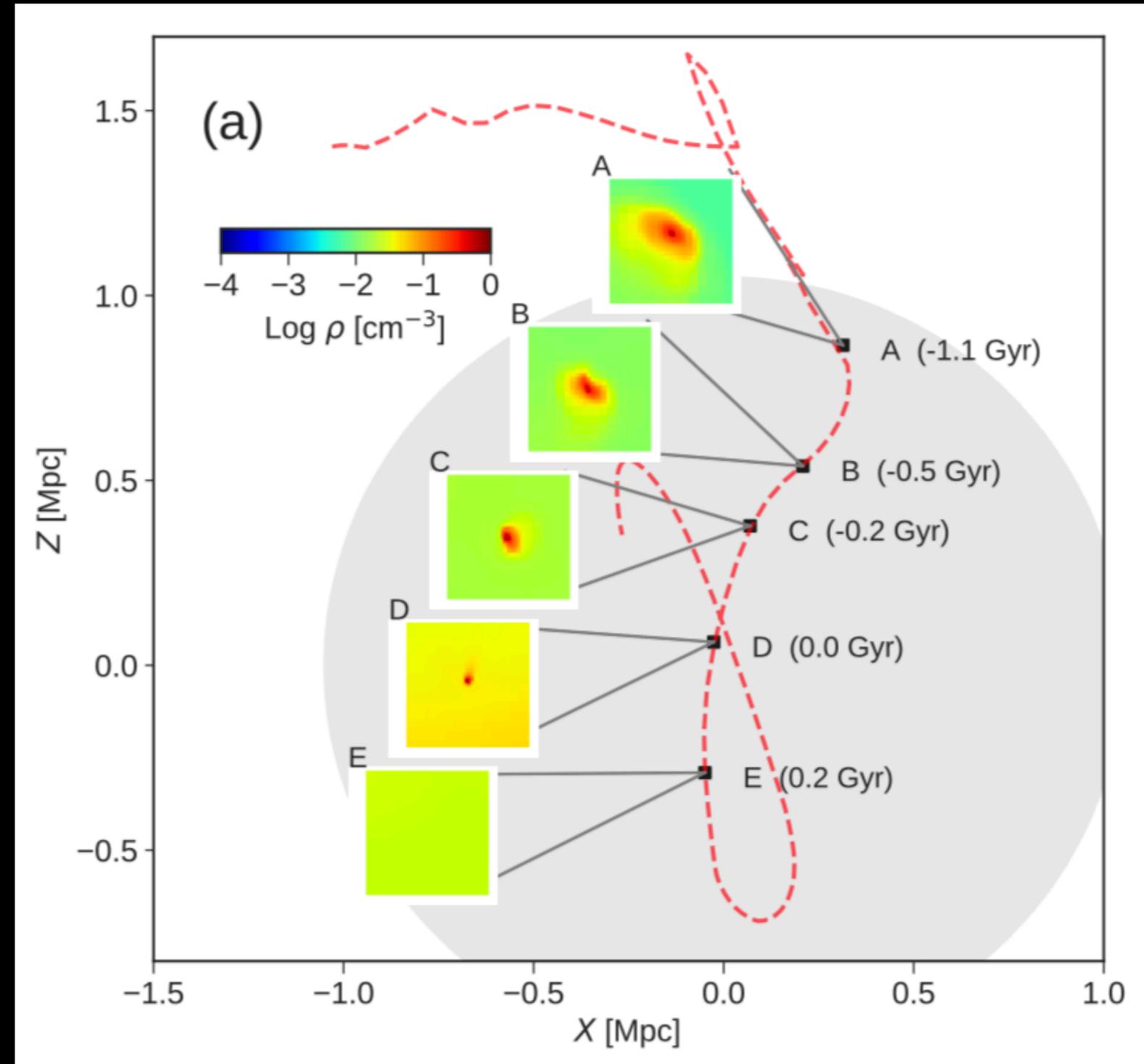
YZiCS galaxies

Green dots: Stars

Contours: cold gas

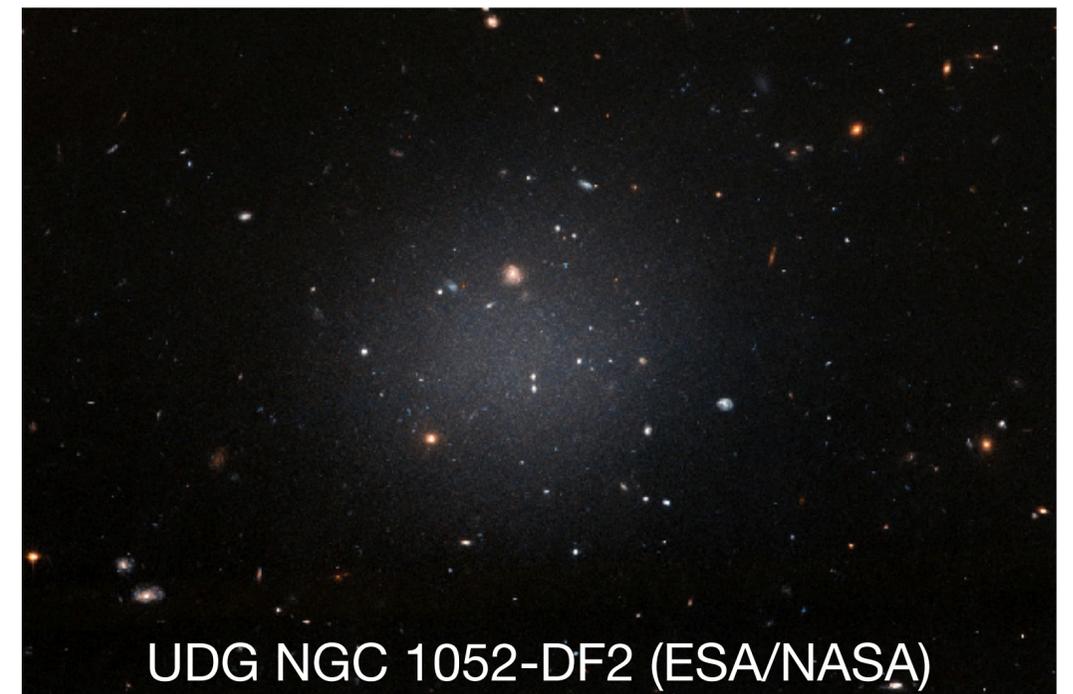
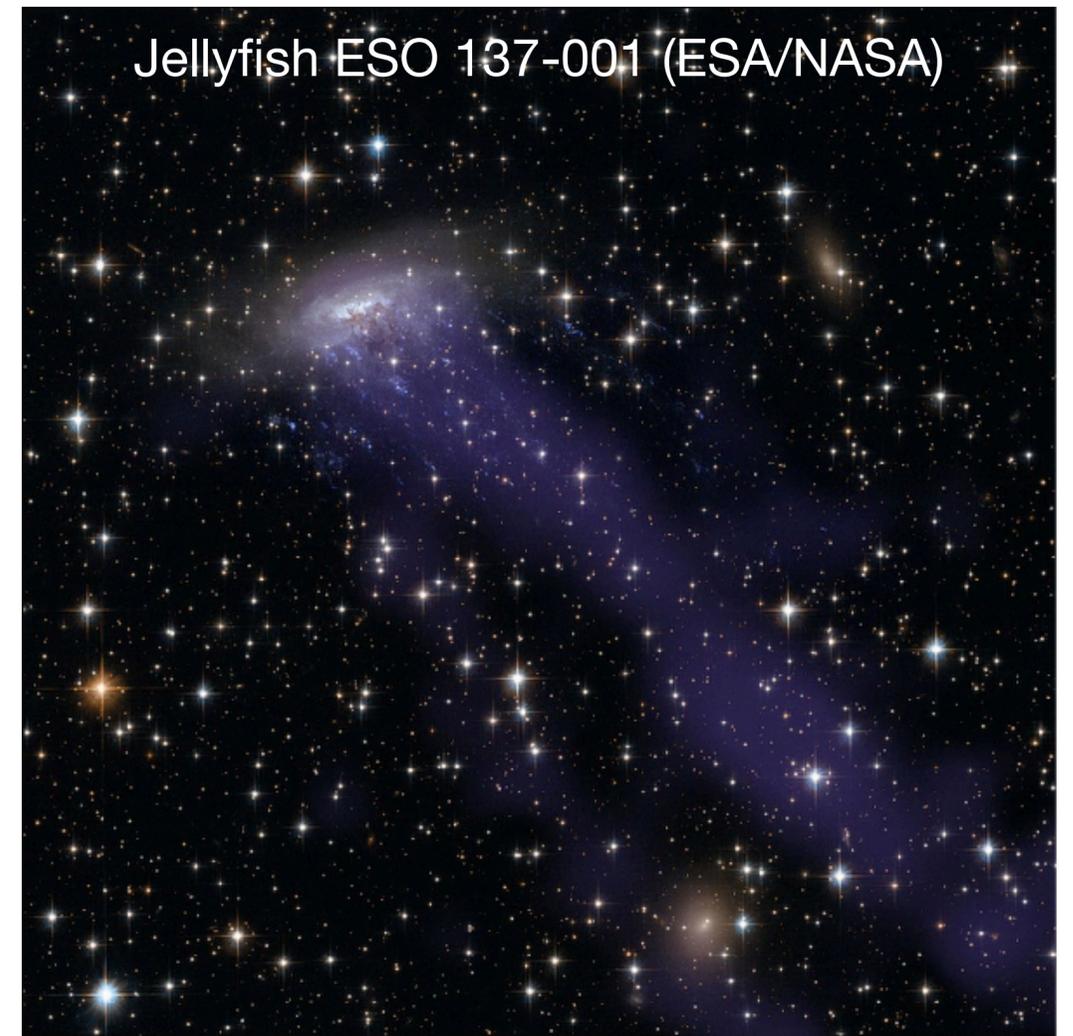
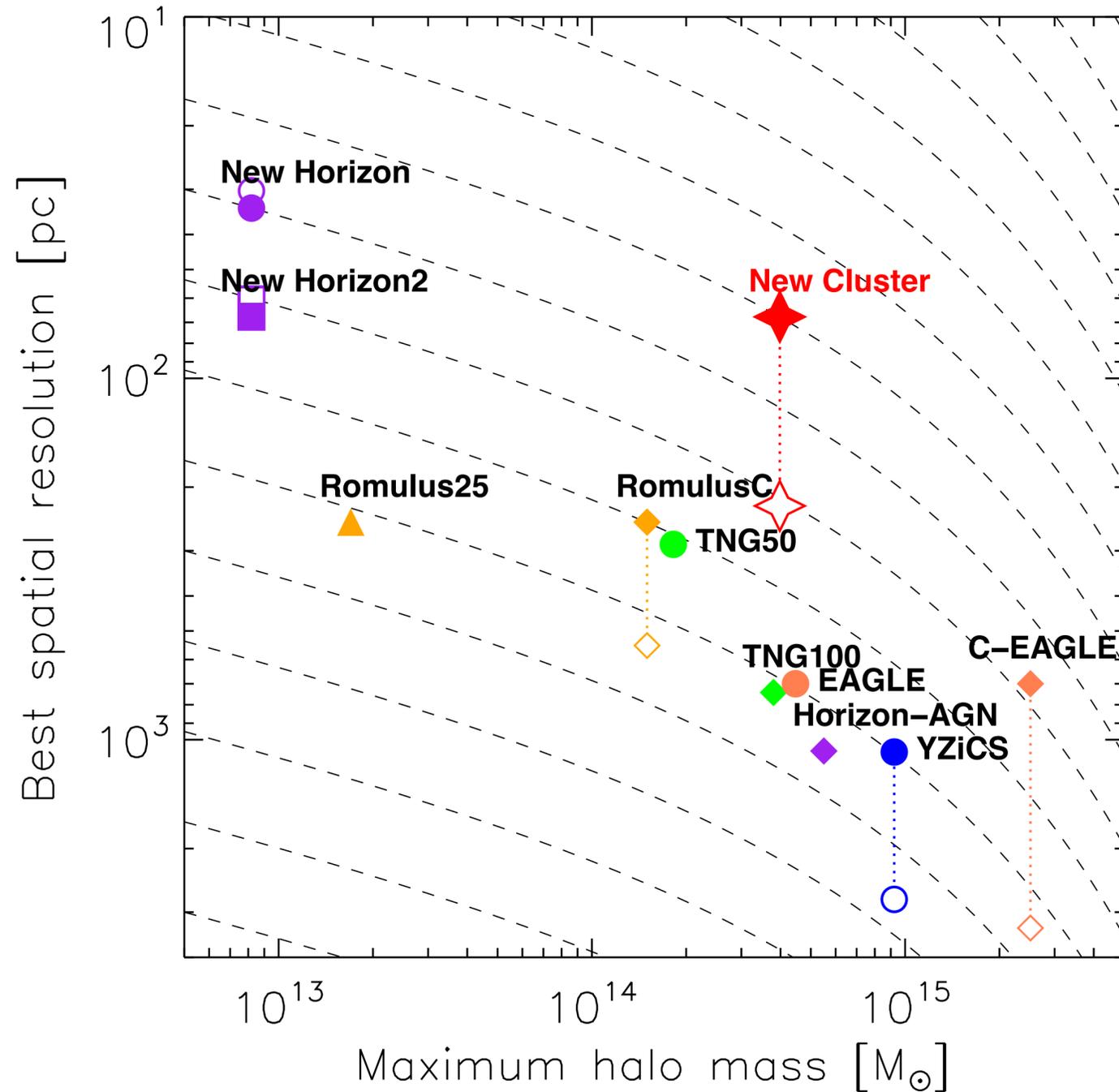


Virgo 은하단 은하 (Chung et al. 2009)



YZiCS2

Higher resolution



Prospect

NH2 to be completed (1/2022)

YZiCS2 to be continued

Ramses-yOMP

Velociraptor: halo/galaxy detection

SKIRT mocks (also, JK's mocks)

