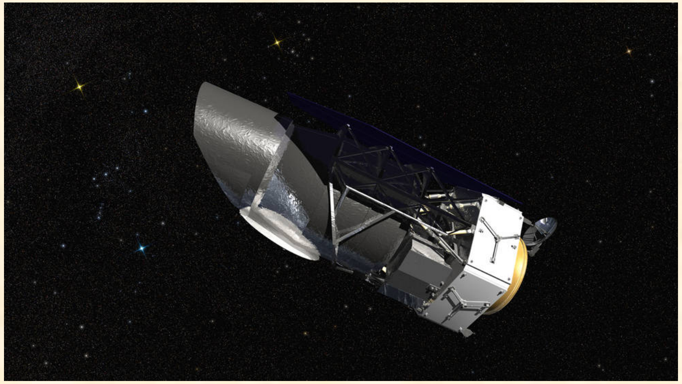


Prospects for Galaxy Clusters and AGN with WFIRST

Gillian Wilson (UC Riverside)

+

Ian Dell'Antonio, Mark Lacy, Douglas Clowe, Megan Donahue, Ranga Ram Chary, Marc Postman, Gus Evrard, Priya Natarajan, Jane Rigby, Elena Pierpaoli, Keiichi Umetsu, Tod Lauer, Massimo Meneghetti, Michael Cooper

Features of Clusters

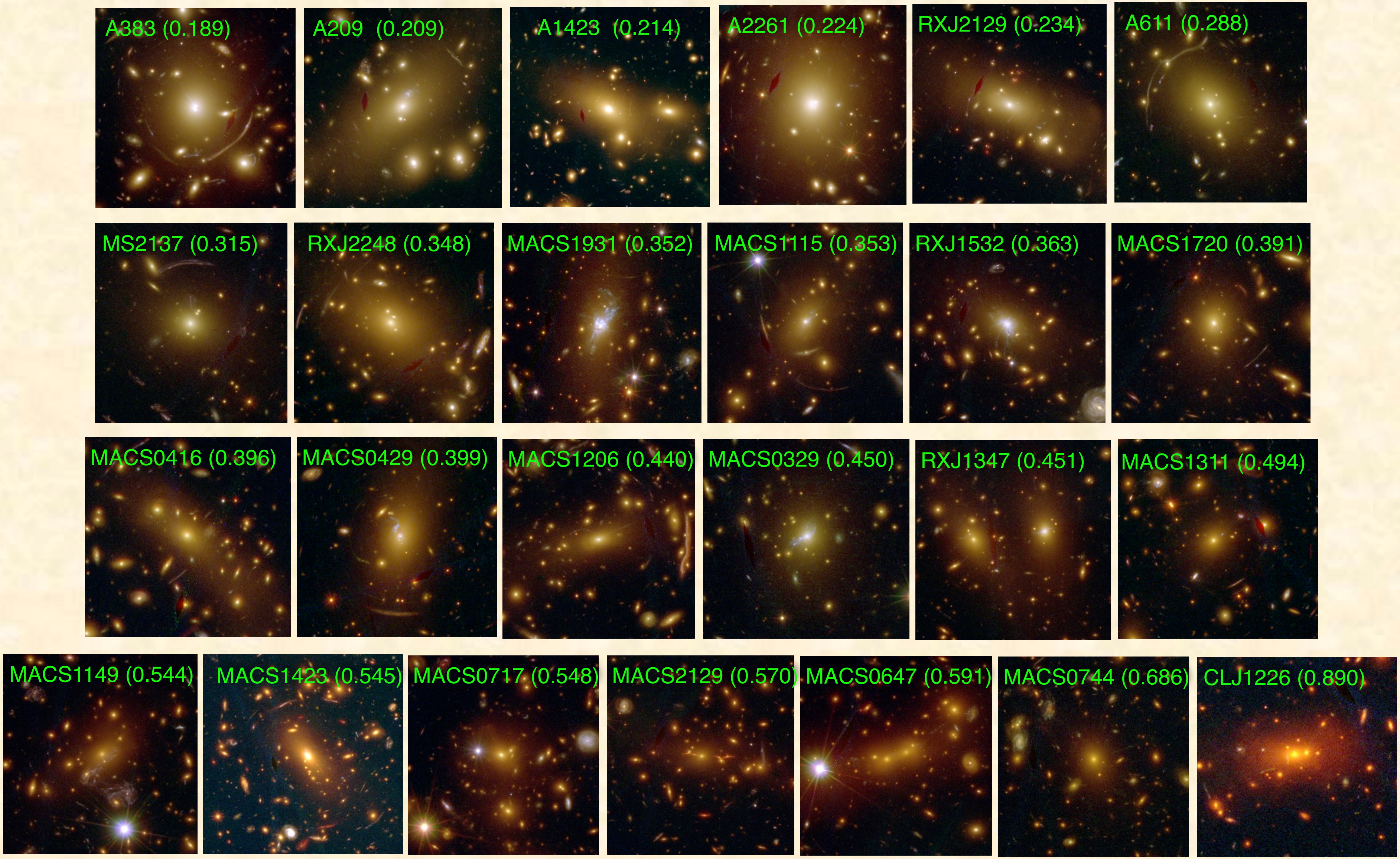
Bullet Cluster
Clowe+04

- Nearly representative census of matter (gas, stars, dark matter) within ~10 Mpc scales
- Host the most massive galaxies and supermassive black holes
- Natural laboratories for studying high-density galaxy environments (100s-1000s)

Why WFIRST will ***Revolutionize*** Cluster Science:
1) Resolution

- Higher resolution than LSST/Euclid

The CLASH HST Gallery



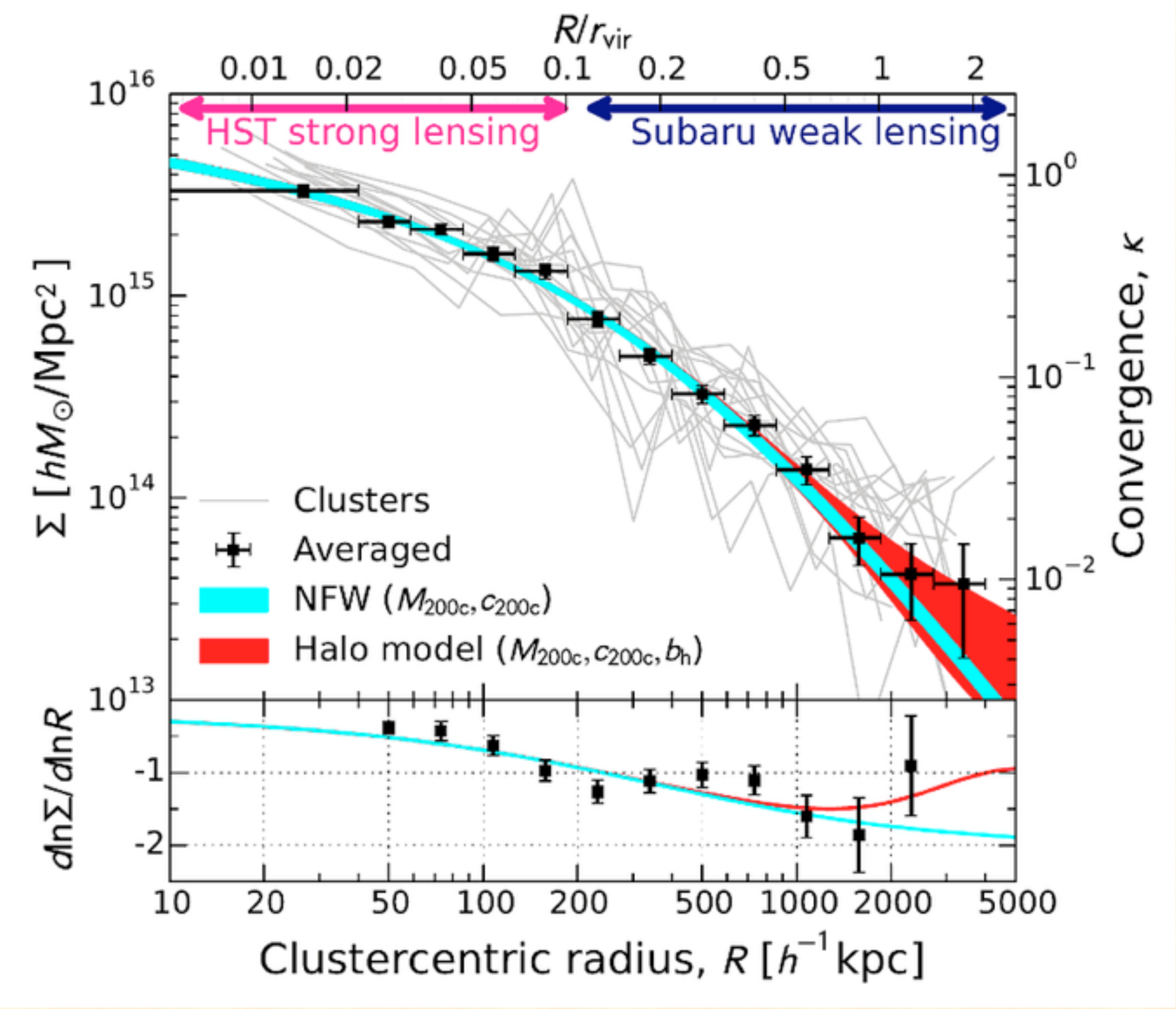
25 clusters at $0.2 < z < 0.9$

Postman+12

Why WFIRST will ***Revolutionize*** Cluster Science: 2) Large FOV

- Higher resolution than LSST/Euclid
- Larger field of view than HST/JWST

CLASH Ensemble Mass Profile



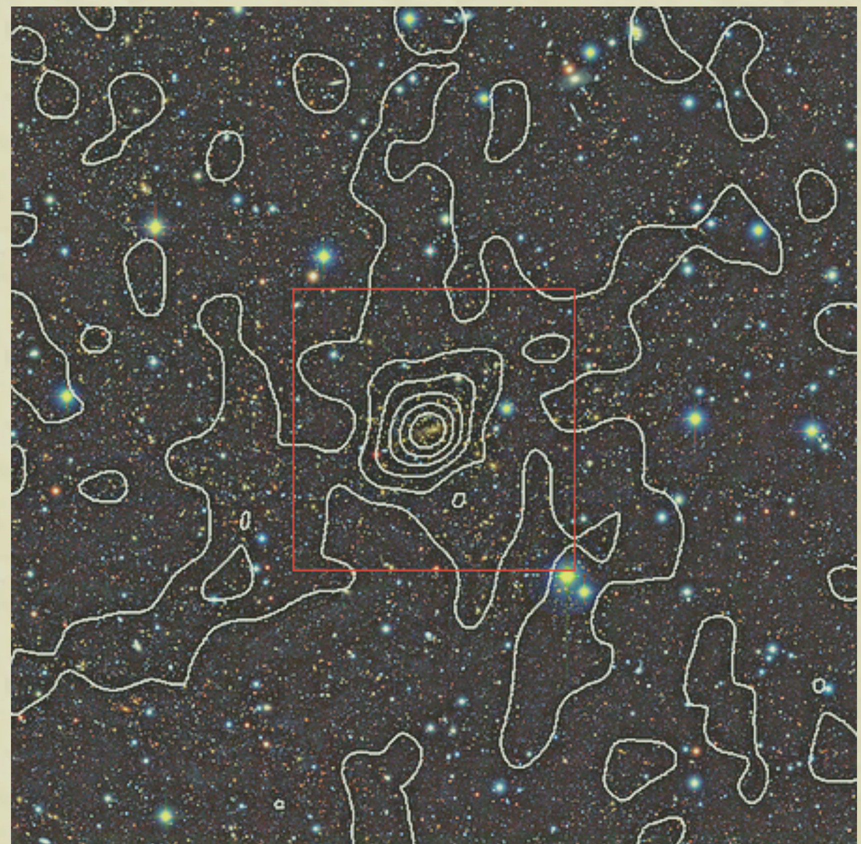
Umetsu+15

At z < 0.5, HST and JWST don't give you virial radius in single pointing

WFIRST wide-field imaging will allow HST-level PSF and galaxy densities over ~degree scales

Subaru FOV

WFIRST FOV



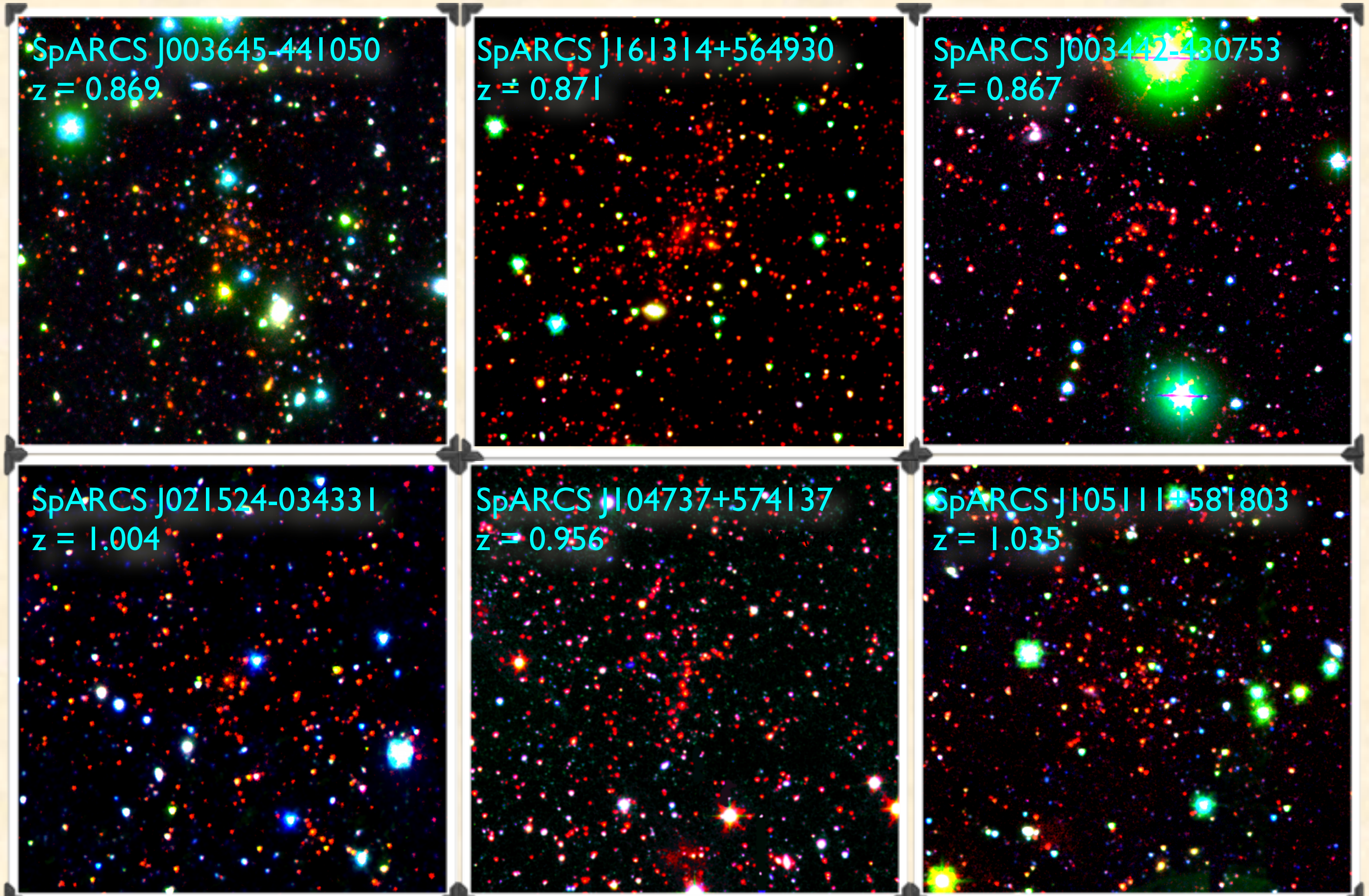
MACSJ1206.2-0847 z=0.44 Umetsu+12

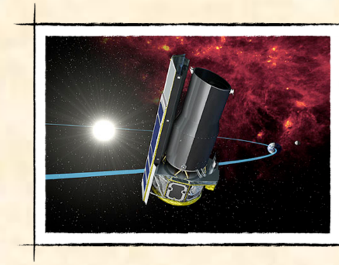
Why WFIRST will ***Revolutionize*** Cluster Science: 2) Large FOV

- HLS will return CLASH-depth for 40,000 clusters extending far beyond virial radius
- GO Program could do Frontier Field-depth for >100 clusters

Why WFIRST will ***Revolutionize*** Cluster Science: 3) Can Discover Clusters at z > 1

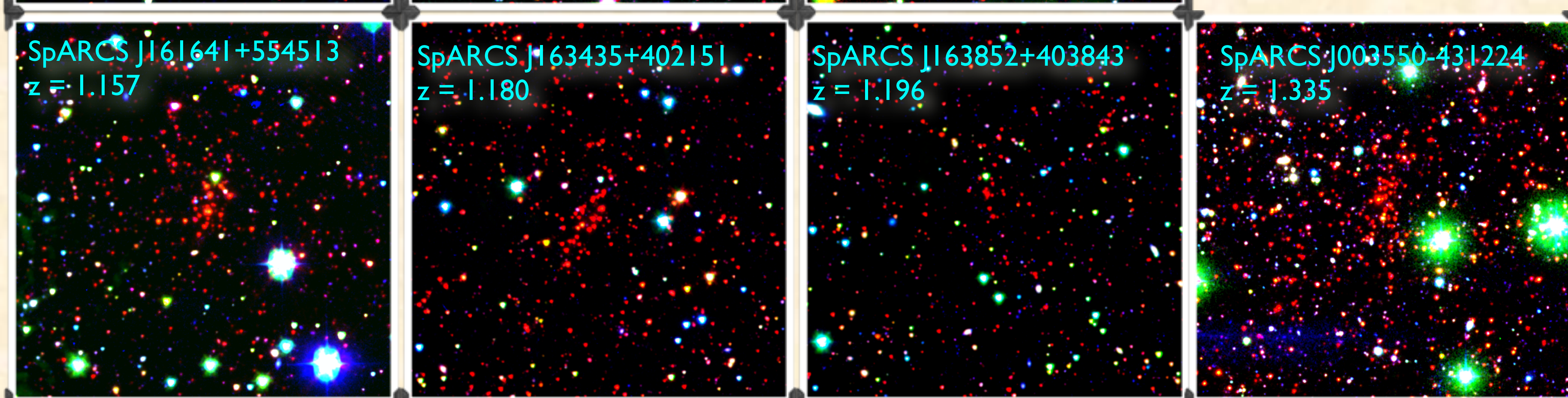
- Higher resolution than LSST/Euclid
- Larger field of view than HST/JWST
- Low sky background in space





Ten clusters at z~1 from Spitzer SpARCS near-IR selected survey

Wilson+09, Muzzin +09



Why WFIRST will ***Revolutionize*** Cluster Science: 3) Can Discover Clusters at z > 1

- Higher resolution than LSST/Euclid
- Larger field of view than HST/JWST
- Low sky background in space
- Higher z than LSST/Euclid

Why WFIRST will ***Revolutionize*** Cluster Science: 4) Will Discover 40,000 Clusters at z > 1 => Cluster Cosmology "for free"

- Higher resolution than LSST/Euclid
- Larger field of view than HST/JWST
- Low sky background in space
- Higher z than LSST/Euclid
- Cluster mass evolution at z > 1

Considerations for Cluster (& AGN) Science with WFIRST

- HLS choice of fields: optimal overlap with other surveys e.g., LSST, Euclid, eRosita, SZ, spectroscopy
- Filter choices
- Observation strategies: dithers, depth
- Revisit strategies: Optimal number and type of pointed observations towards the most massive (and therefore rare) systems.
- Much work needed: simulators, lensing experts, and survey experience required

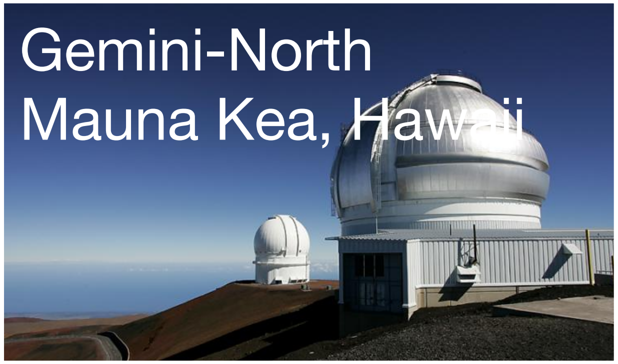
Why WFIRST will ***Revolutionize*** Cluster Science: 5) Will Discover 40,000 Clusters at z > 1 => Galaxy Evolution as a Function of Environment

- Higher resolution than LSST/Euclid
- Larger field of view than HST/JWST
- Low sky background in space
- Higher z than LSST/Euclid
- Cluster mass evolution at z > 1
- Stellar mass at z > 1

The GCLASS Survey (PIs Wilson/Yee)
25 night Gemini spectroscopic program

- z ~1 clusters from Spitzer SpARCS survey
- 500 members total amongst 10 clusters

Name[a]	z_{spec}	RA[b] J2000	DEC[b] J2000	σ_v^c [km/s]	M_{200}^d [10^{14} $M_\odot$]	R_{200}^d [Mpc]	Spec-z Members
SpARCS-0034	0.867	00:34:42.06	-43:07:53.41	700^{+90}_{-150}	$2.4^{+1.0}_{-1.2}$	$0.9^{+0.1}_{-0.2}$	45
SpARCS-0035	1.335	00:35:49.70	-43:12:24.20	780^{+80}_{-120}	$2.5^{+0.9}_{-1.0}$	$0.8^{+0.1}_{-0.1}$	20
SpARCS-0036	0.869	00:36:45.03	-44:10:49.91	750^{+80}_{-90}	$2.9^{+1.0}_{-0.9}$	$1.0^{+0.1}_{-0.1}$	47
SpARCS-0215	1.004	02:15:24.00	-03:43:32.15	640^{+120}_{-130}	$1.7^{+1.1}_{-0.8}$	$0.8^{+0.2}_{-0.2}$	48
SpARCS-1047	0.956	10:47:33.43	57:41:13.30	660^{+70}_{-120}	$1.9^{+0.7}_{-0.9}$	$0.8^{+0.1}_{-0.2}$	31
SpARCS-1051	1.035	10:51:11.21	58:18:03.17	500^{+40}_{-100}	$0.8^{+0.2}_{-0.4}$	$0.6^{+0.1}_{-0.1}$	34
SpARCS-1613	0.871	16:13:14.63	56:49:29.95	1350^{+100}_{-100}	$16.9^{+4.0}_{-3.5}$	$1.8^{+0.1}_{-0.1}$	92
SpARCS-1616	1.156	16:16:41.32	55:45:12.44	680^{+80}_{-110}	$1.9^{+0.7}_{-0.8}$	$0.8^{+0.1}_{-0.1}$	46
SpARCS-1634	1.177	16:34:38.22	40:20:58.36	790^{+60}_{-110}	$2.9^{+0.7}_{-1.0}$	$0.9^{+0.1}_{-0.1}$	50
SpARCS-1638	1.196	16:38:51.64	40:38:42.91	480^{+50}_{-100}	$0.6^{+0.2}_{-0.3}$	$0.5^{+0.1}_{-0.1}$	44



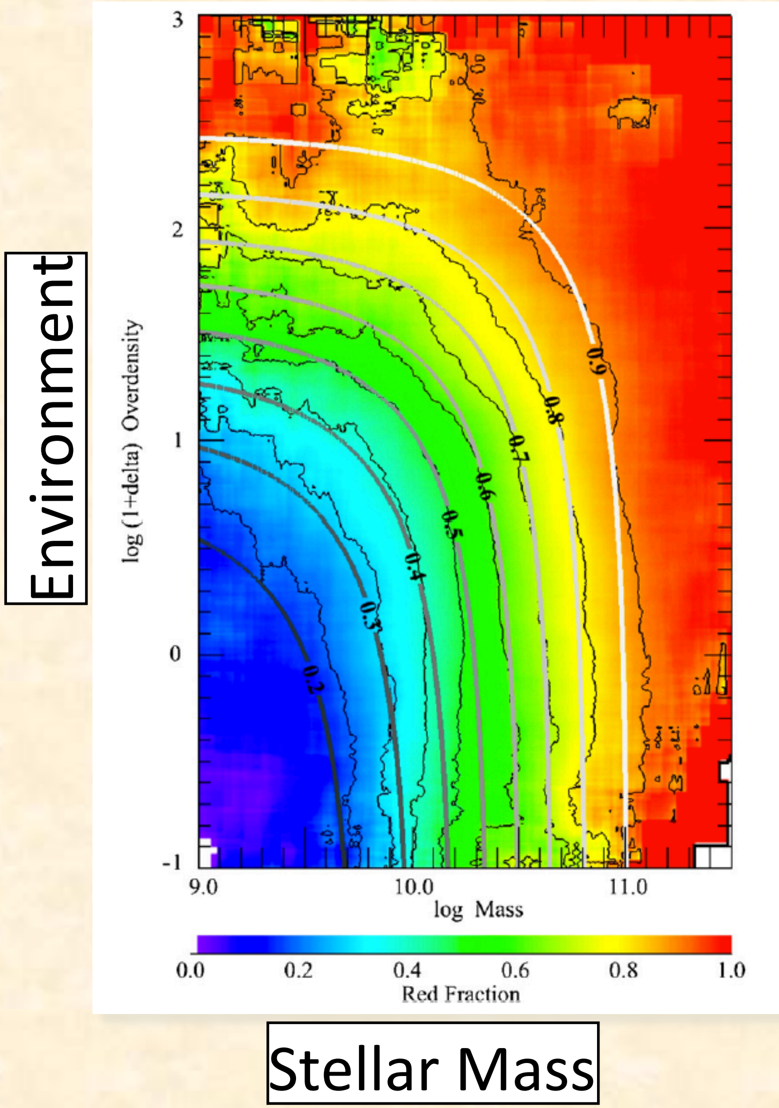
van der Burg+14

Also Muzzin+09; Wilson+09; Demarco+10; Muzzin+12; Lidman+12,13; Noble+13,16; van der Burg+13; Foltz+15; Balogh+16

Quenching

Two Ways to Kill a Galaxy

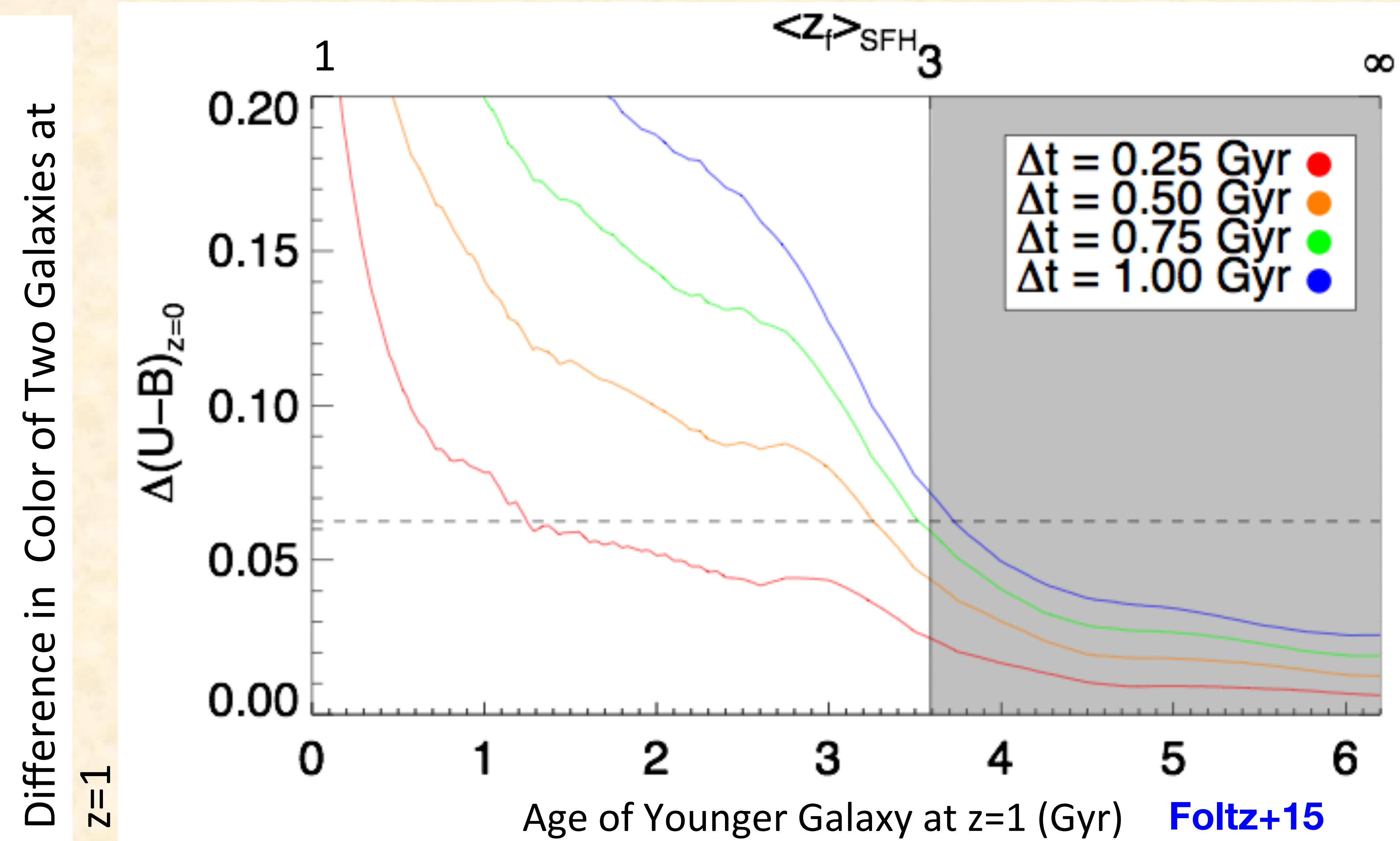
z = 0 (SDSS)



Fraction of quenched galaxies is correlated with stellar mass BUT ALSO with environment

Peng+2010

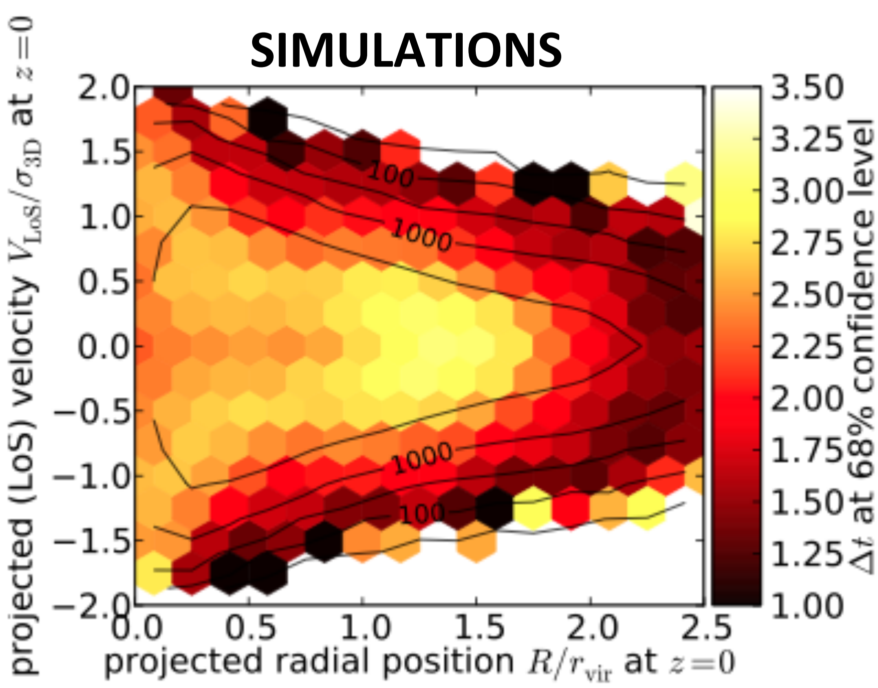
Scatter in RS Color constrains Formation Redshift to z > 3



WFIRST will extend this analysis to **higher redshift and with *thousands* of clusters**

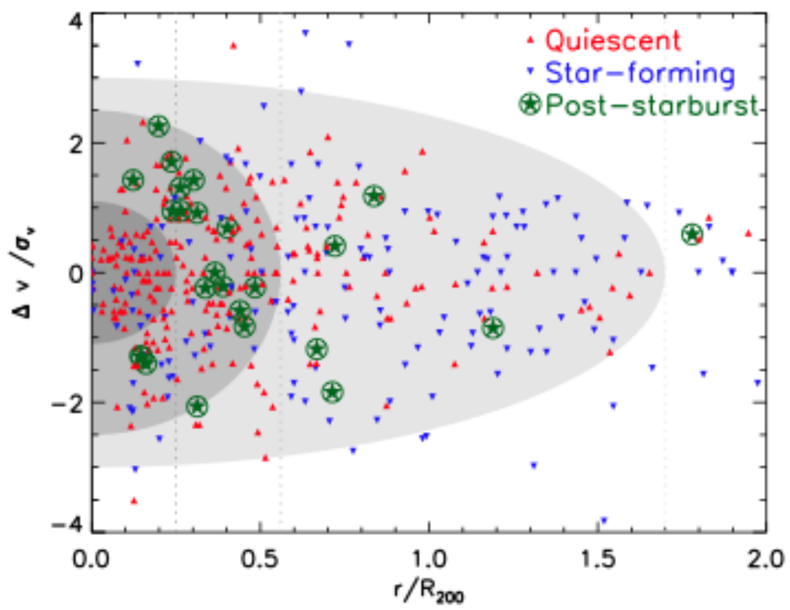
Phase Space Analysis: Constraining the Quenching Timescale and Mechanism

SIMULATIONS



Oman+14

OBSERVATIONS



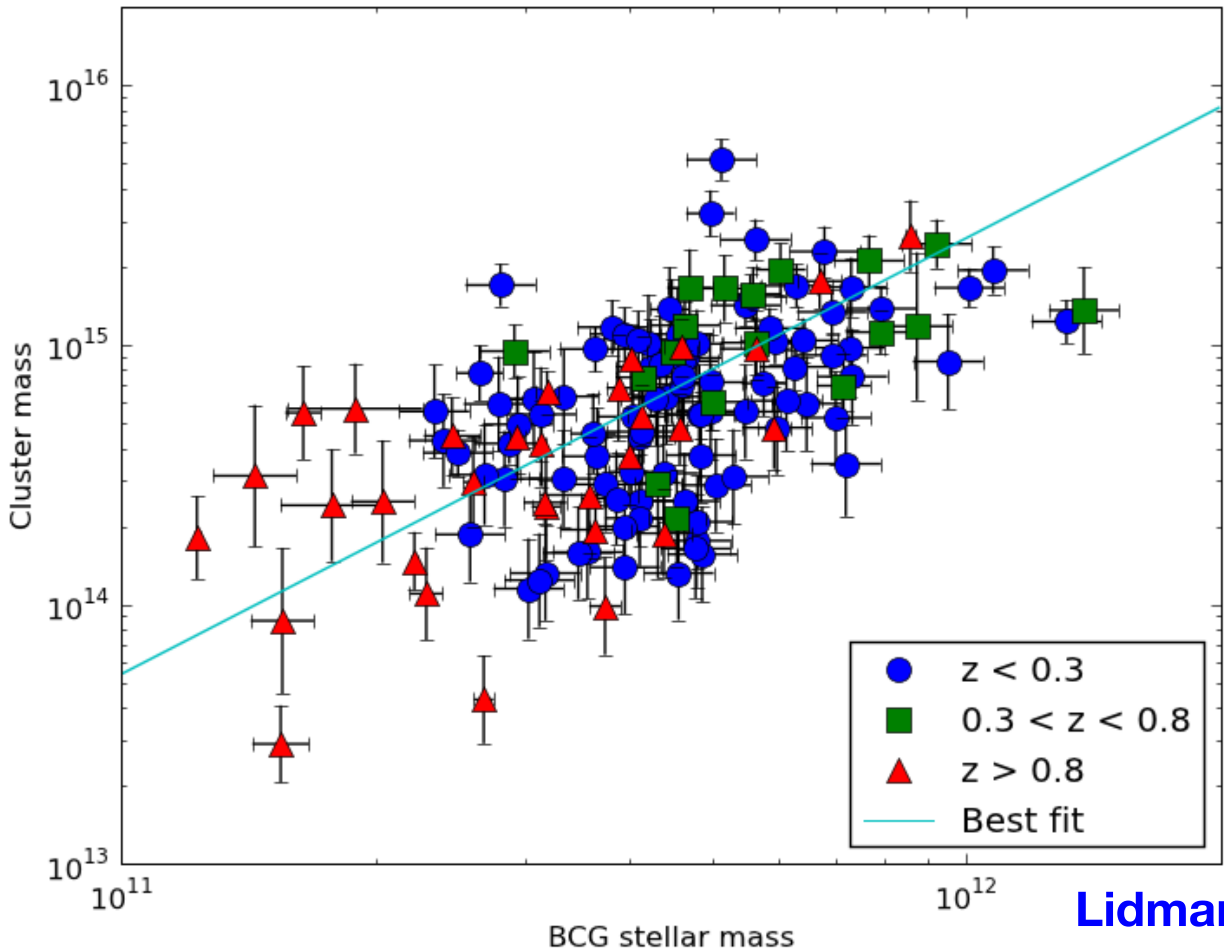
Muzzin+14

see also Noble+13; Balogh 16

Comparison of location of 25 post-starburst galaxies with simulations suggests quenching is due to either hot halo gas stripping “strangulation” or cold gas stripping “ram pressure stripping”

Scaling Relations

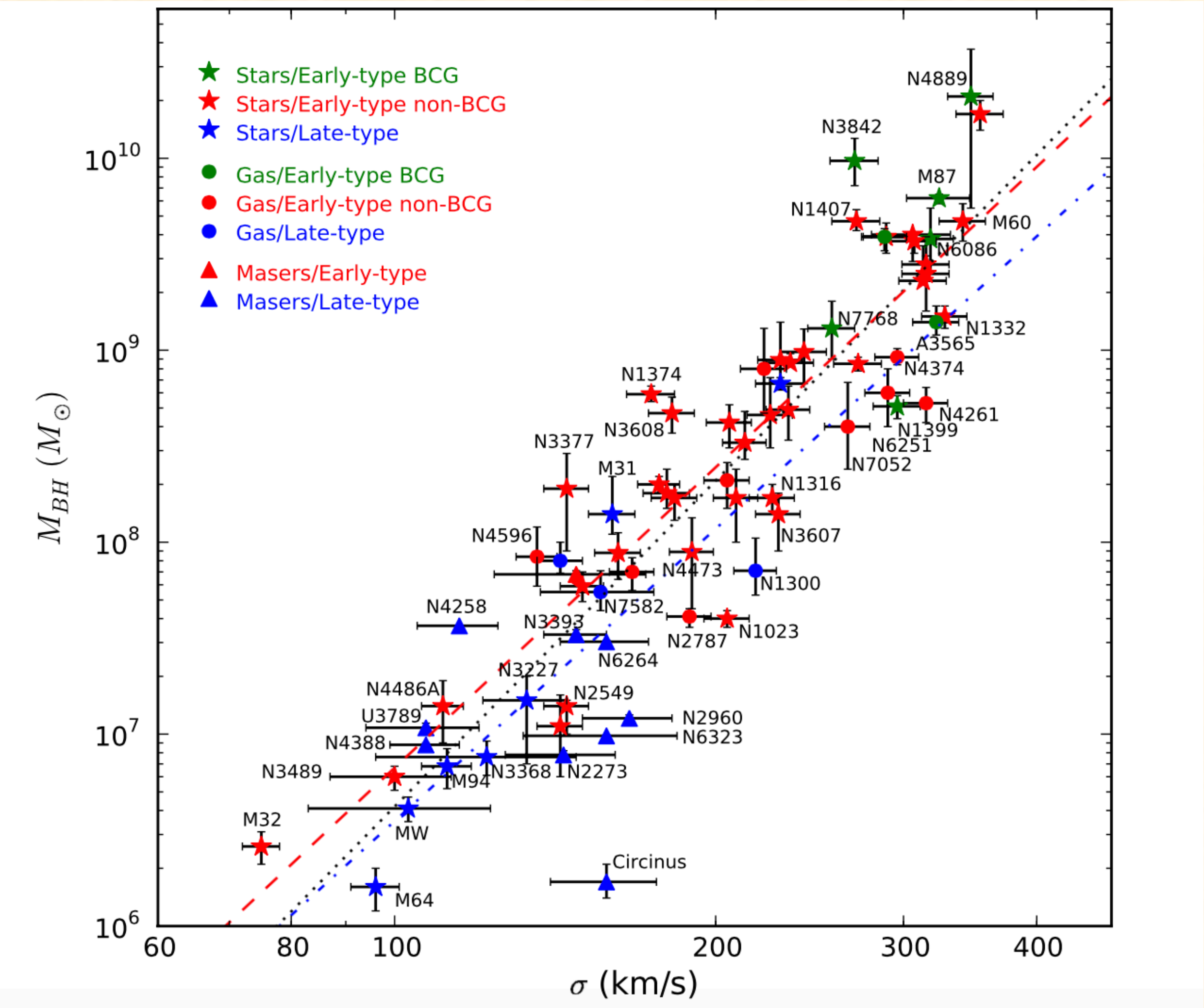
Scaling Relation between Total Mass of Cluster and Stellar Mass of Brightest Cluster Galaxy (BCG)



Lidman+12

See also van der Burg+14; Webb+15

Co-evolution of Supermassive Black Holes and their Host Galaxies



Local Universe

McConnell/Ma+13

WFIRST: Co-evolution of Supermassive Black Holes and their Host Galaxies

- HLS will discover tens of thousands of type-1 and type-2 AGN
- One or more broad lines fall continuously in WFIRST grism from z=0.06 to z=2.8
- ~50,000 type-1 AGN will have a broad line in the grism, bright enough to estimate a width and hence a black hole mass
- Stellar mass of host halo can be estimated from PSF subtraction (of AGN+quasar host galaxy)

=> M-sigma relation to z~3

- GO program could use coronograph to study host properties of brightest type-1 quasars (stellar luminosity, size etc.)

Synergy with TMT

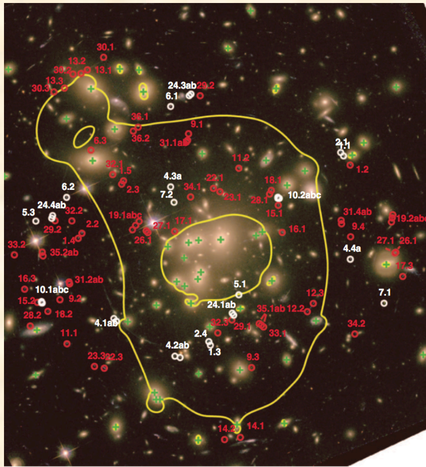
WFIRST will discover 40,000 clusters to z~3 but follow up needed

- Redshift distribution of background galaxies

WFIRST will return z for clusters but in order to obtain unbiased weak lensing cluster mass estimates, will require to determine the background redshift distribution spectroscopically

- Strong Lensing Angular Diameter Cosmography

Cosmological constraints from positions of multiple images (which depend on lens mass distribution and background redshift distribution). The 10x higher resolution of TMT will provide many additional lensed pairs (more accurate mass models) than WFIRST alone + a spectroscopic background redshift distribution



Jullo+11

Dell'Antonio, Wilson & Treu

WFIRST-TMT Science Synergy article, SDT 2015 Report