THE TRIGGERING OF Z~1 OBSCURED AGN IN MERGING SYSTEMS:

AN UNPRECEDENTED VIEW FROM THE HYPER SUPRIME-CAMERA SURVEY

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& the HSC Survey Collaboration

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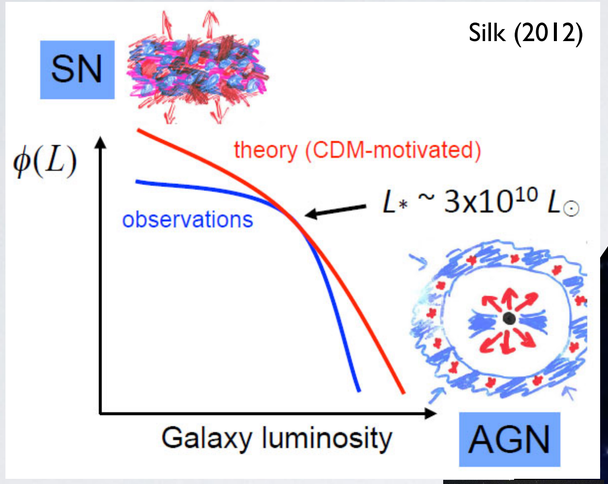
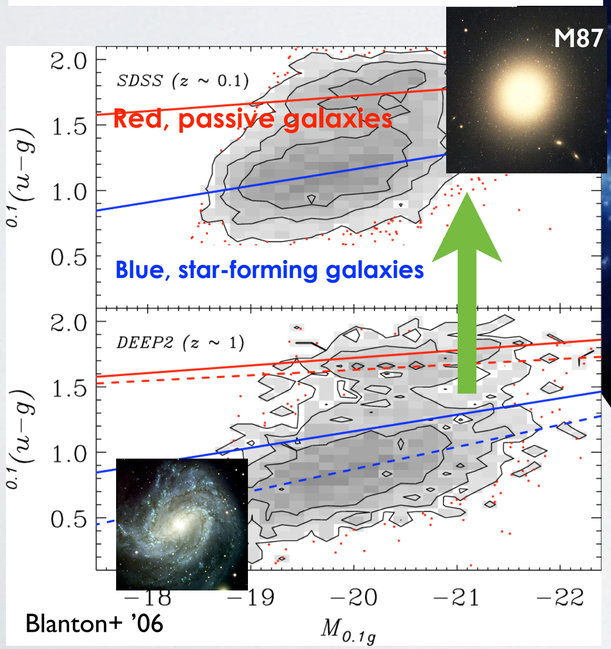
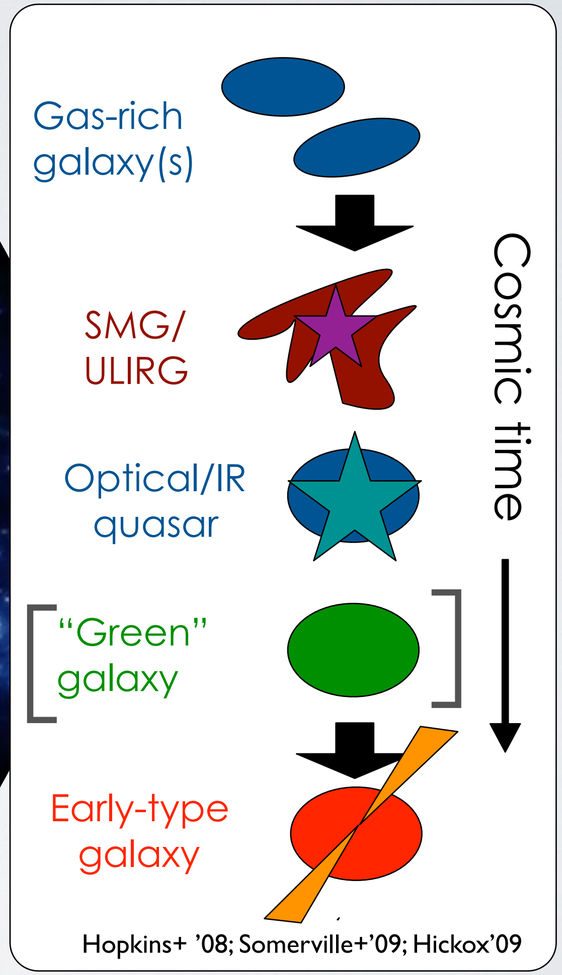
FORMATION OF STRUCTURE & THE SUPPRESSION OF STAR-FORMATION

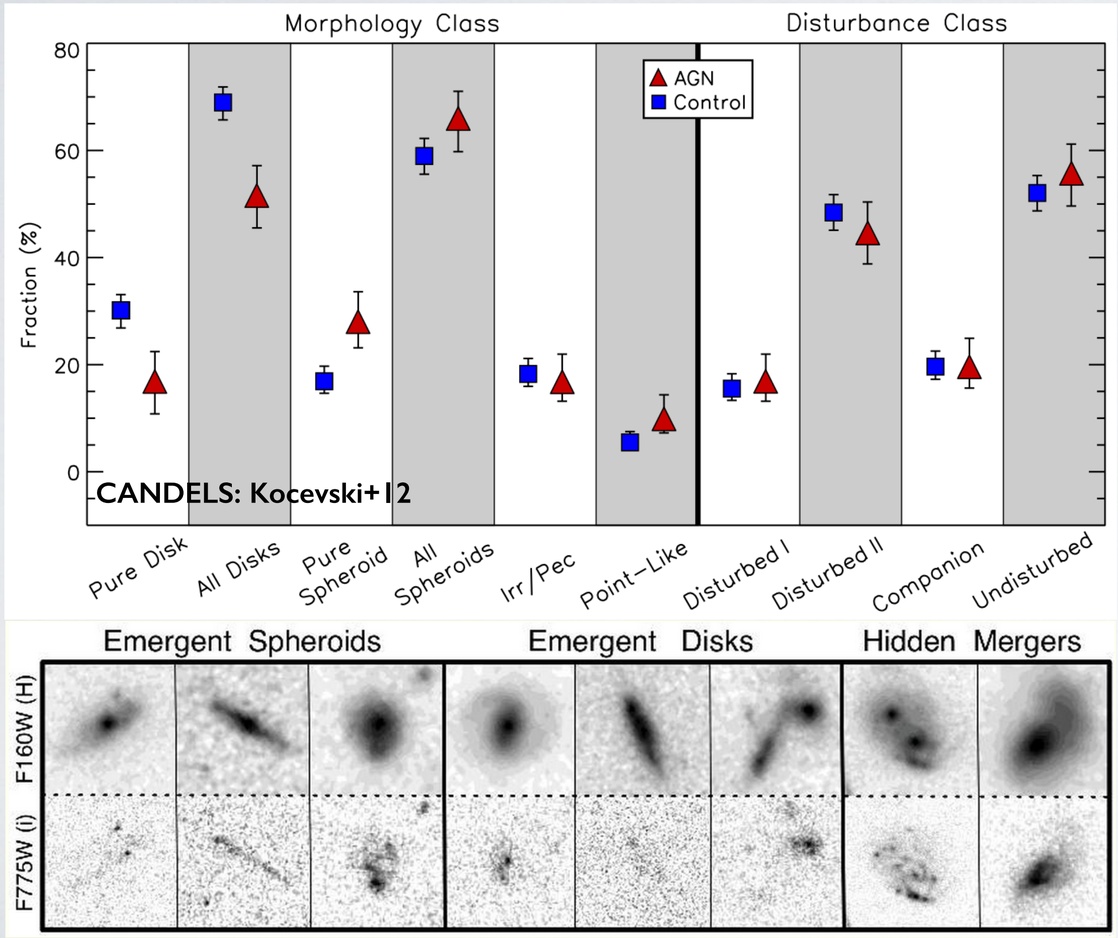






IMPORTANCE OF MERGERS IN AGN/GALAXY CO-EVOLUTION ??????

Low L_{AGN}



e.g., Cisternas et al. 2011; Schawinski et al. 2011; Triester et al. 2012; Kocevski et al. 2012; Villforth et al. 2014; Fan et al. 2014; Rosario et al. 2015 etc.

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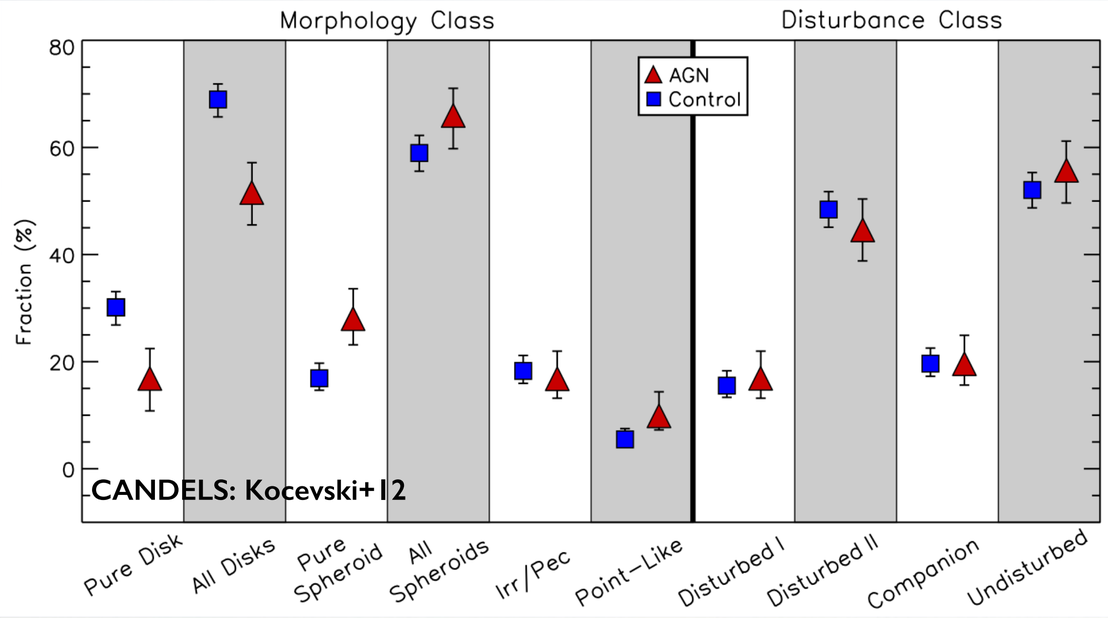

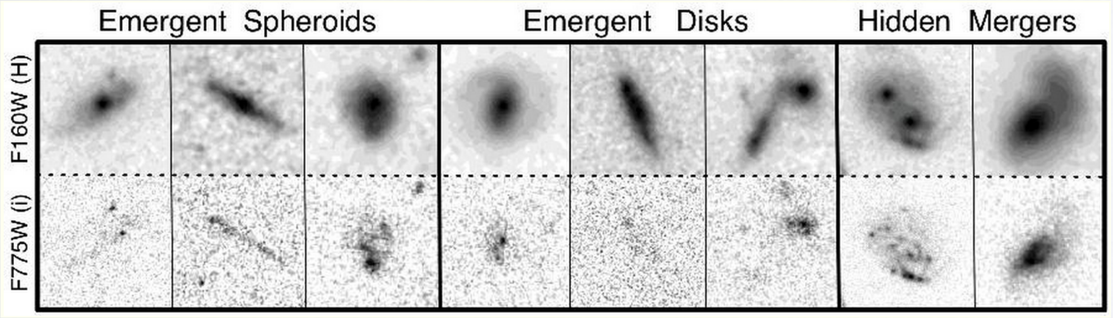

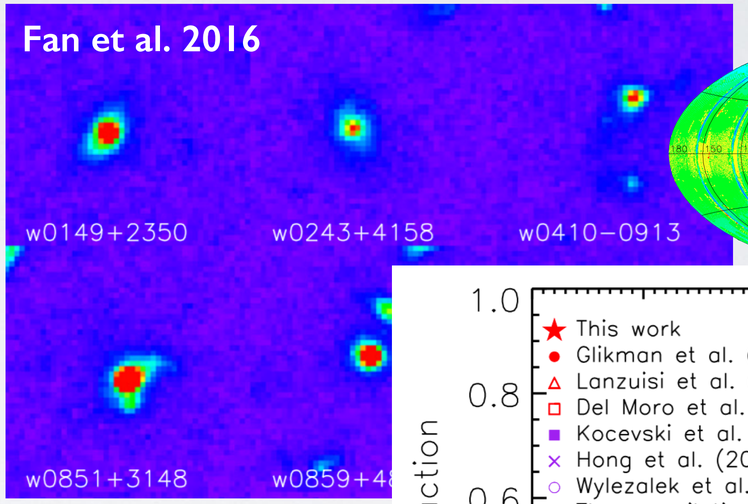

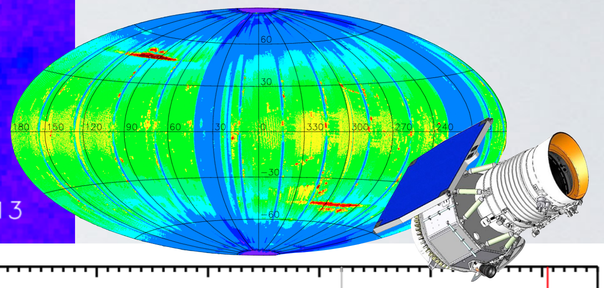

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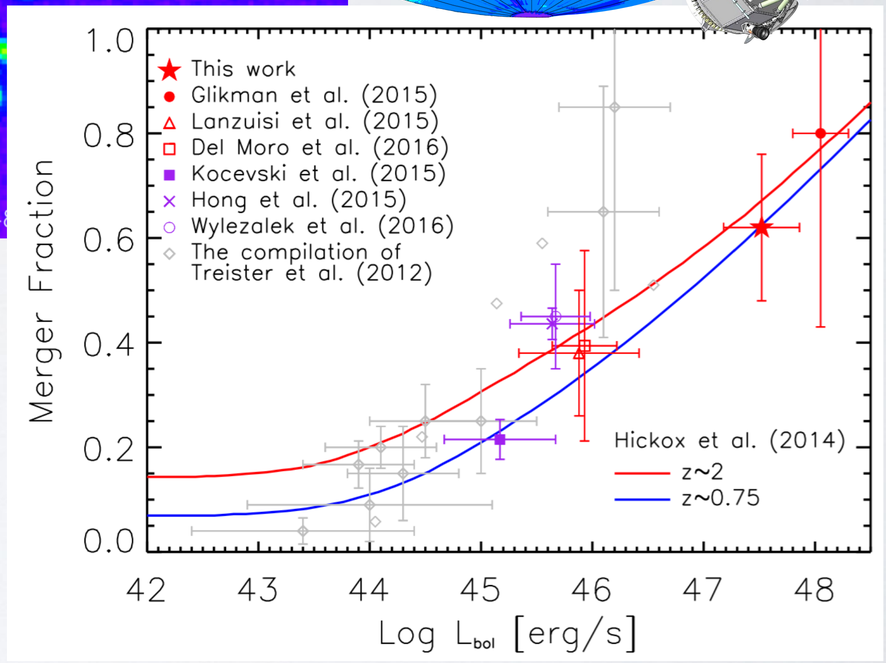

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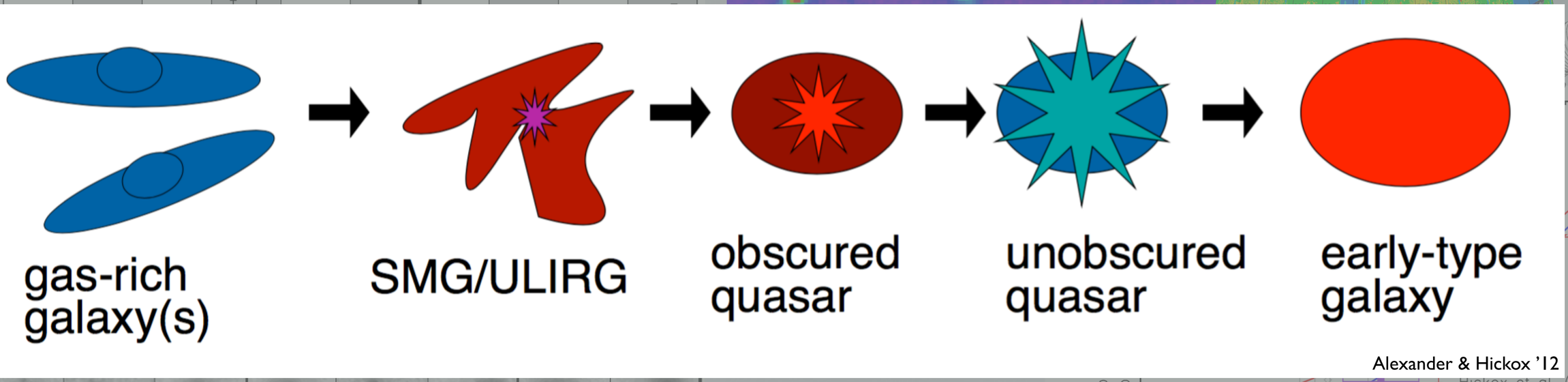
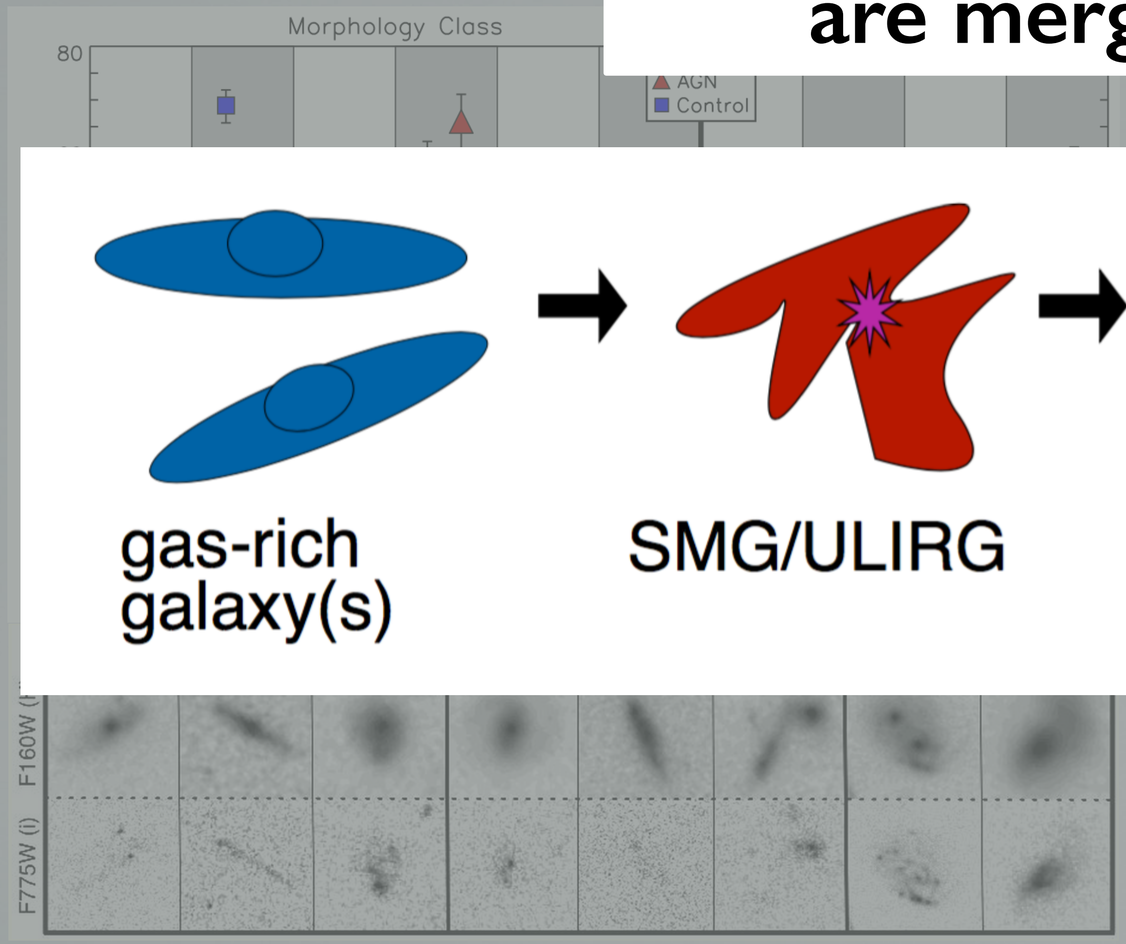
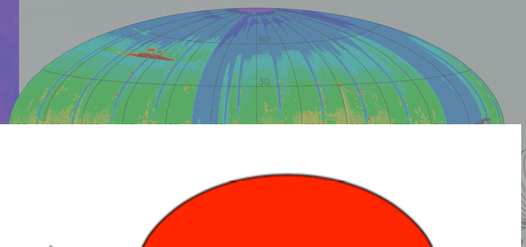
IMPORTANCE OF MERGERS IN AGN/GALAXY CO-EVOLUTION ?????

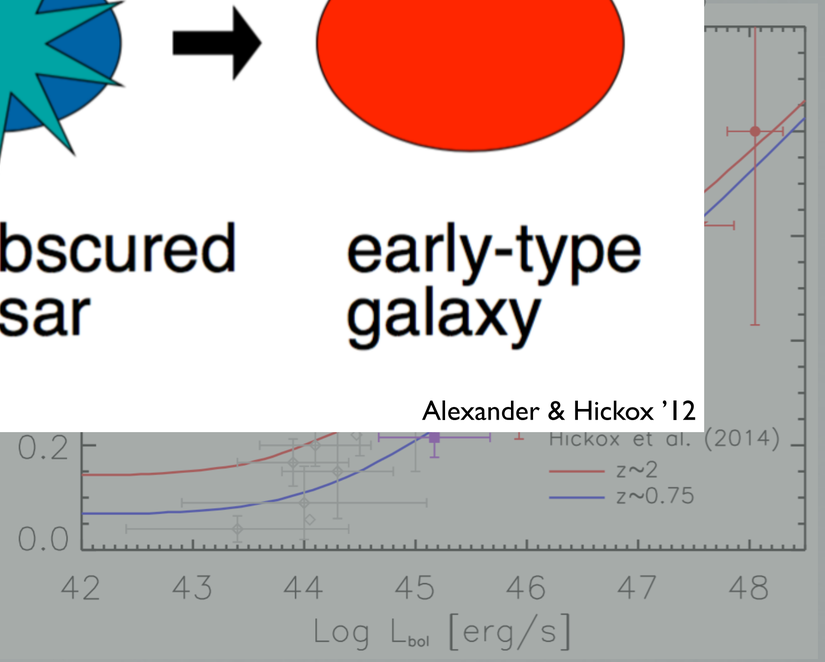
At higher AGN luminosities, are mergers the key?



Alexander & Hickox '12







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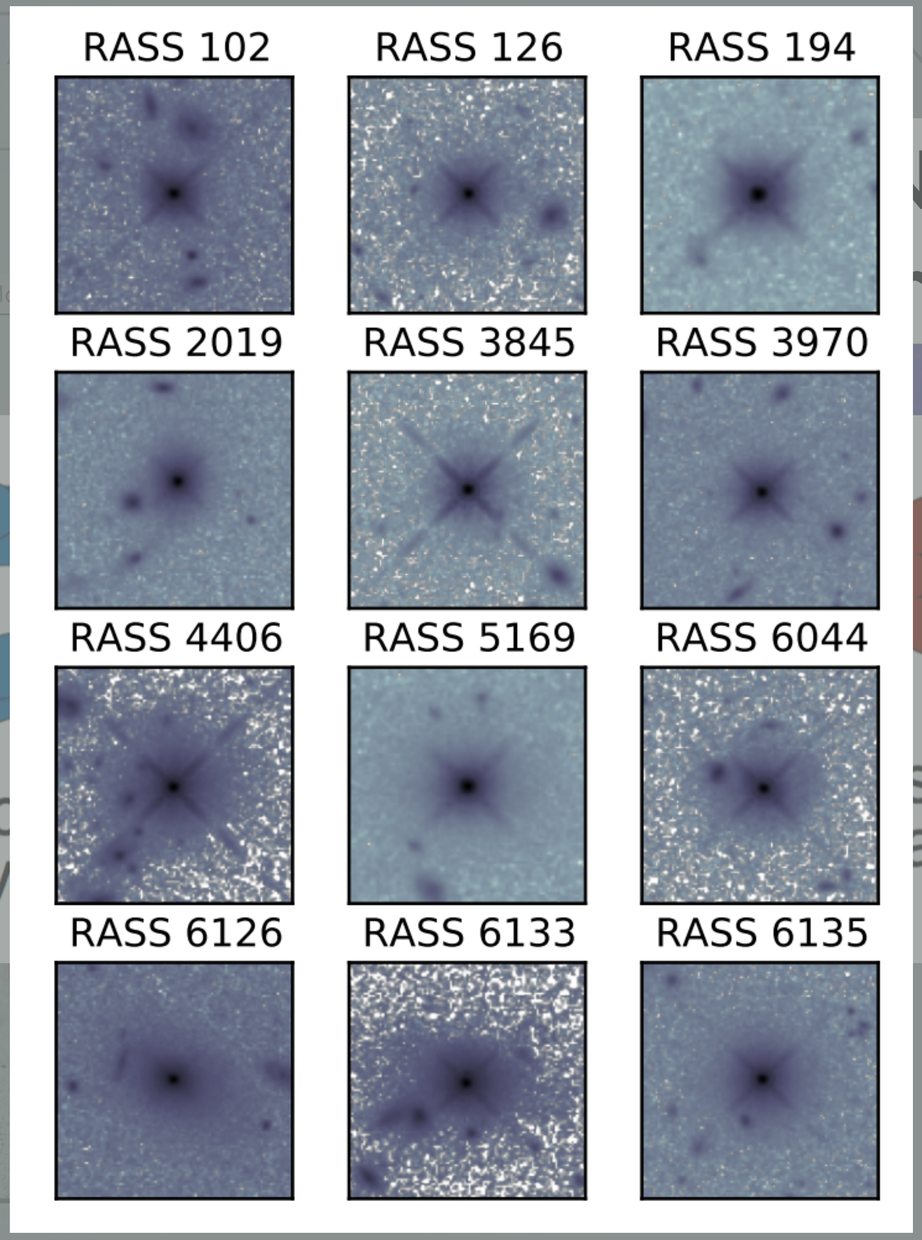

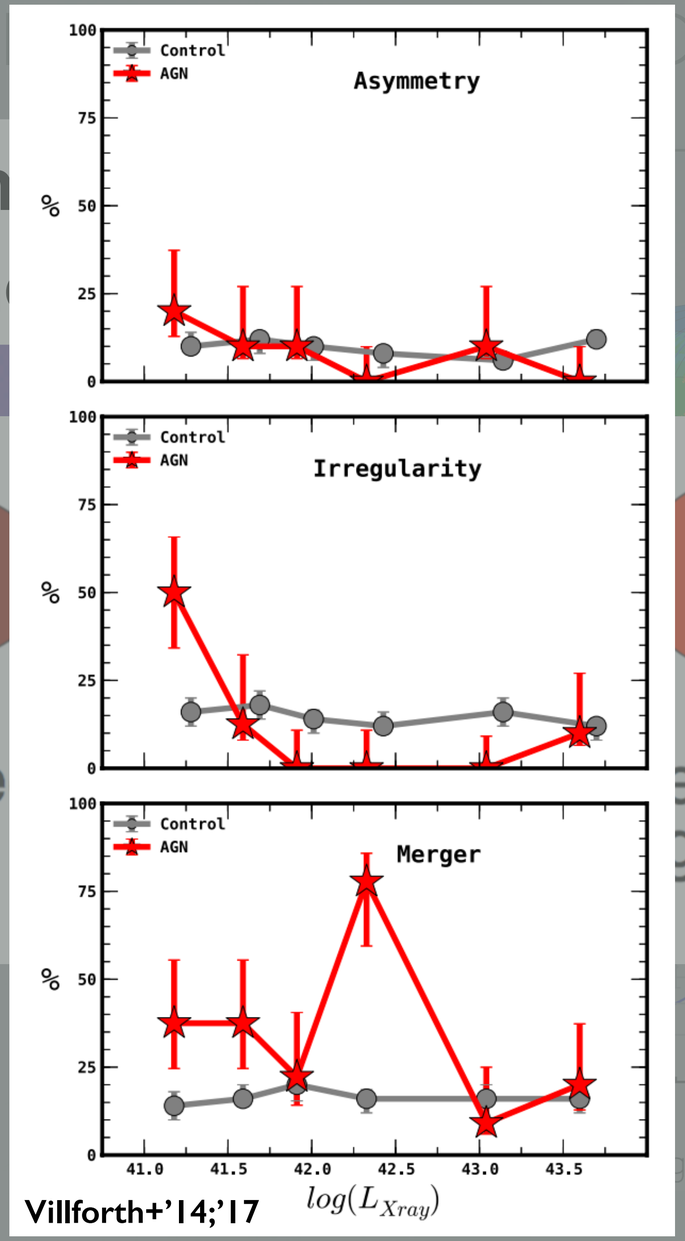

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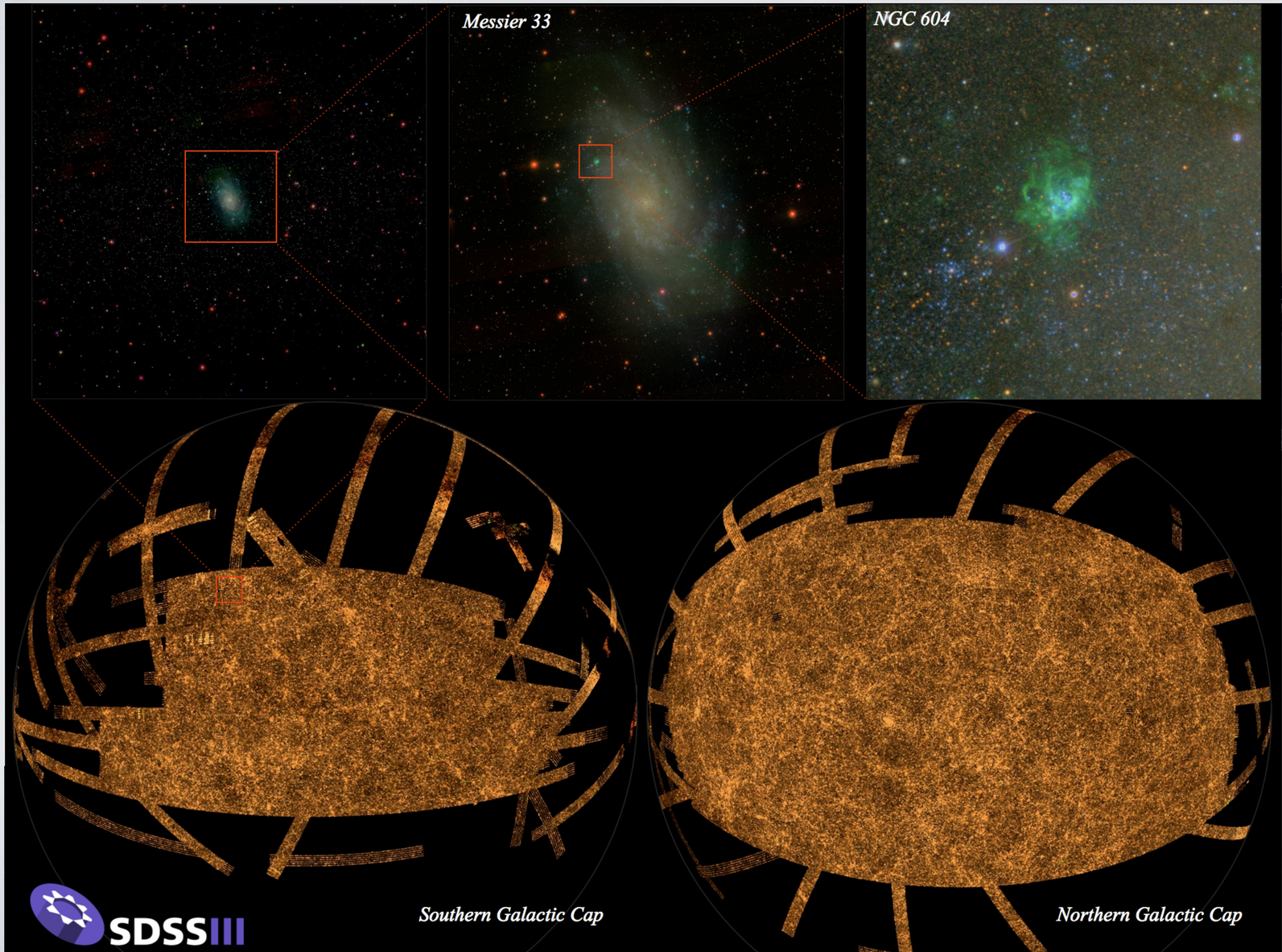
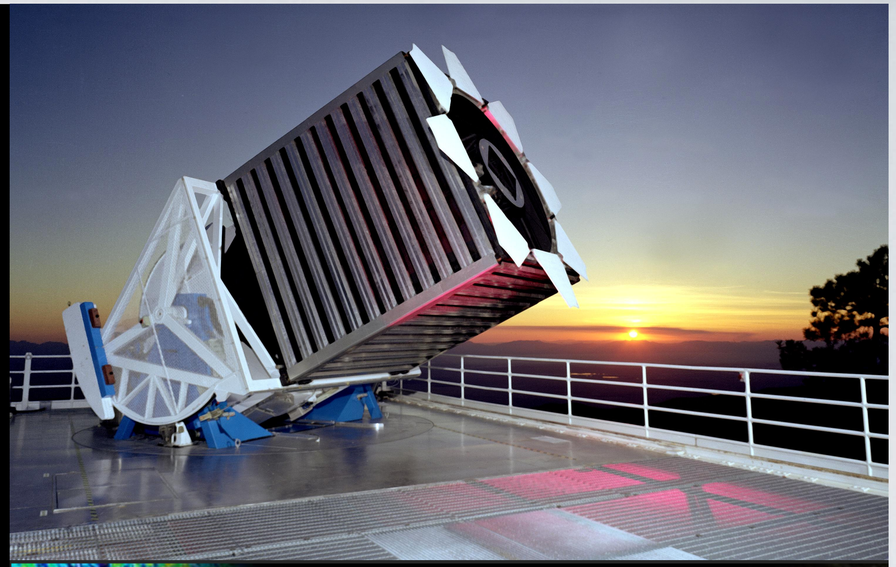
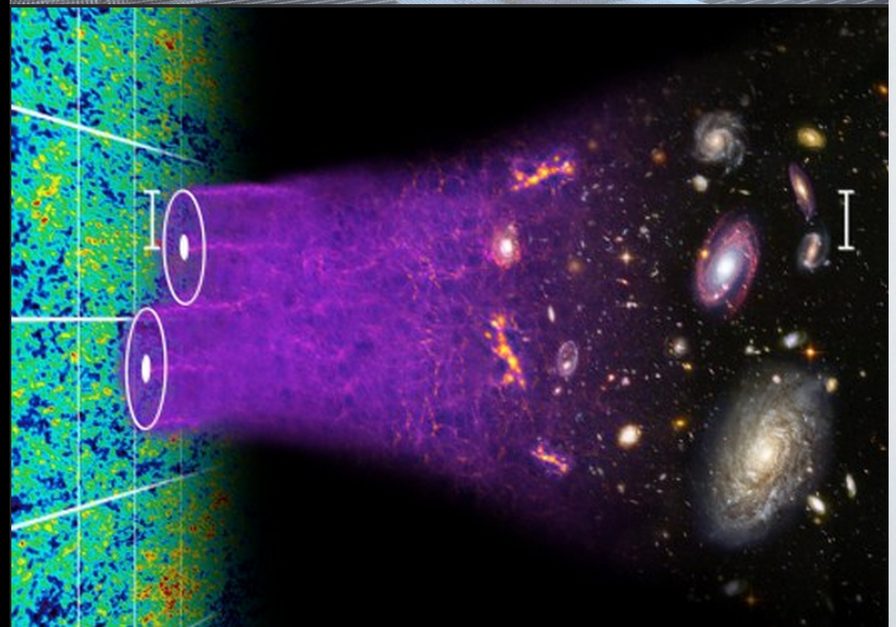
SDSS: GALAXY/MERGER AGN DEMOGRAPHICS IN THE PRESENT DAY







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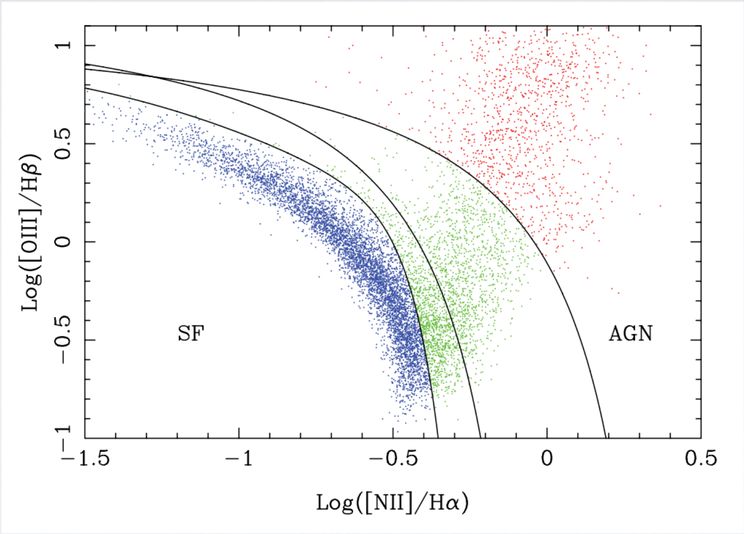

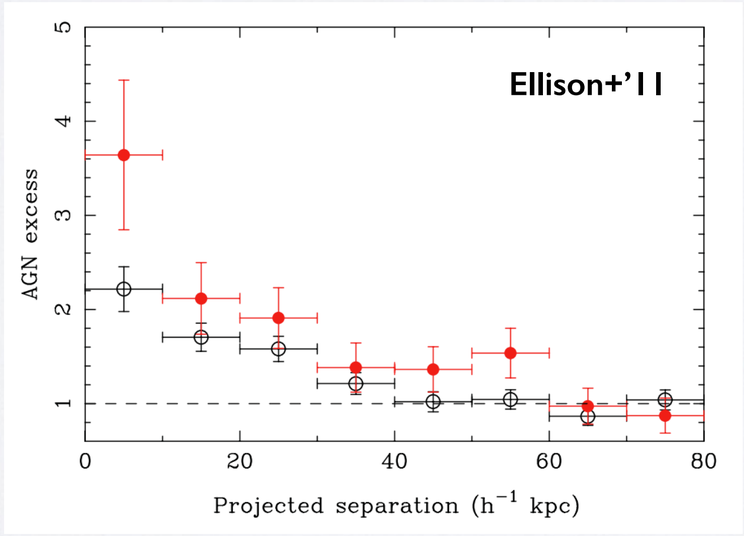

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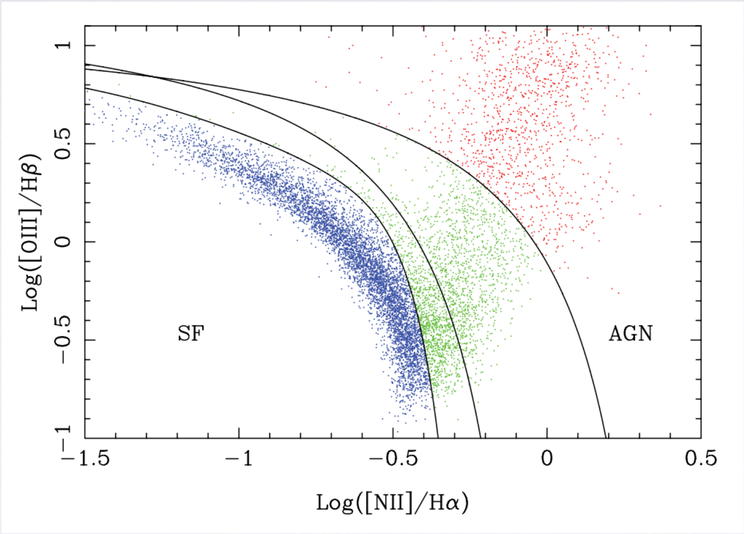
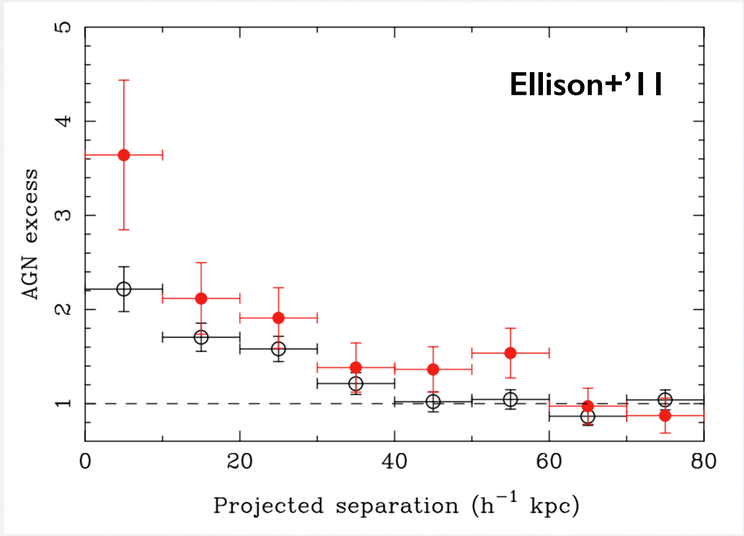
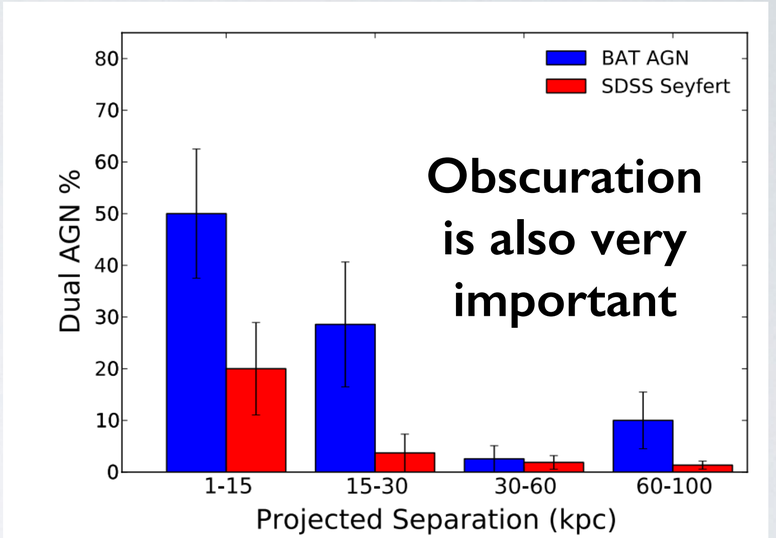
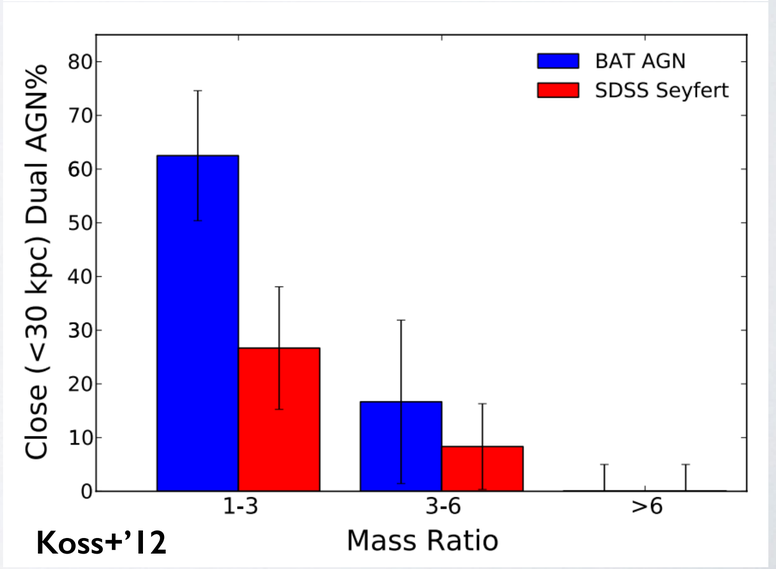
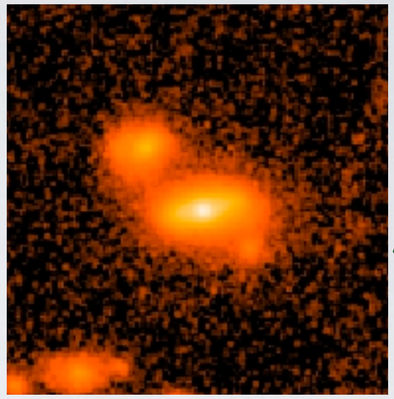






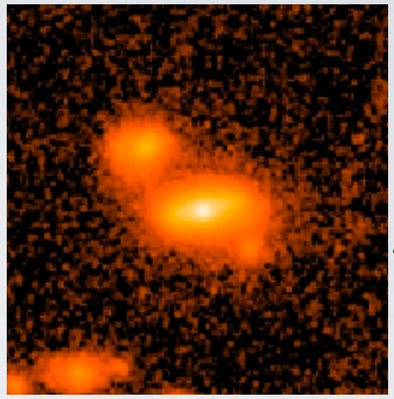


Nearby:



Distant:

Nearby:

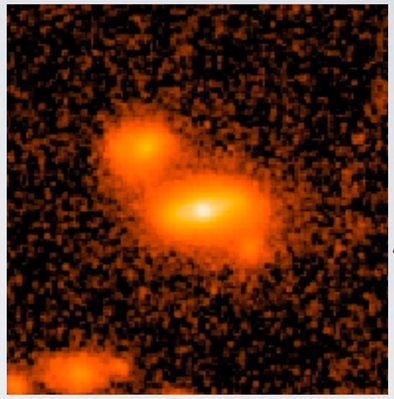


Distant:

- large sample with high-quality imaging
- a time averaged picture of AGN accretion

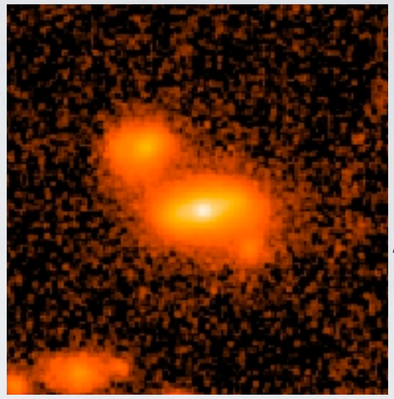
Nearby:

- large sample with high-quality imaging
- a time averaged picture of AGN accretion



Distant:

- large volume
- high luminosities
- observe (possible) evolution



Nearby:

Distant:

- large sample with high-quality imaging
- a time averaged picture of AGN accretion

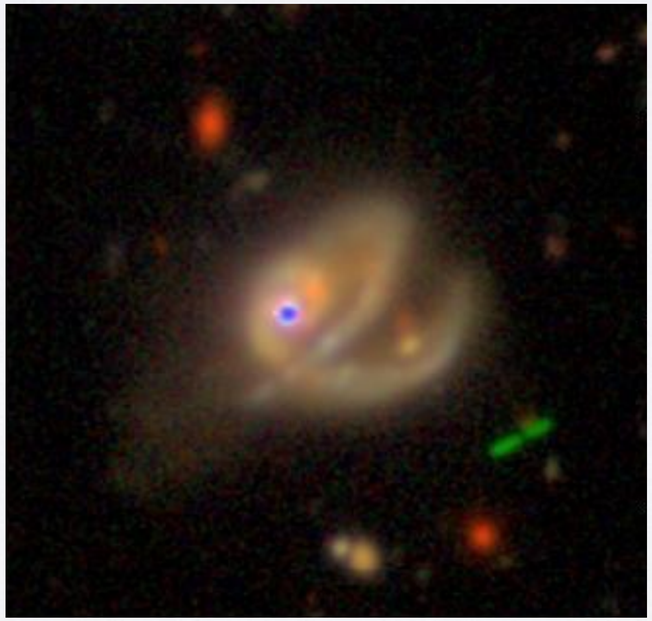
Require deep, high-quality wide-format imaging

- large volume
- high luminosities
- observe (possible) evolution

HSC

Nearby:

- large sample with high-quality imaging
- a time averaged picture of AGN accretion



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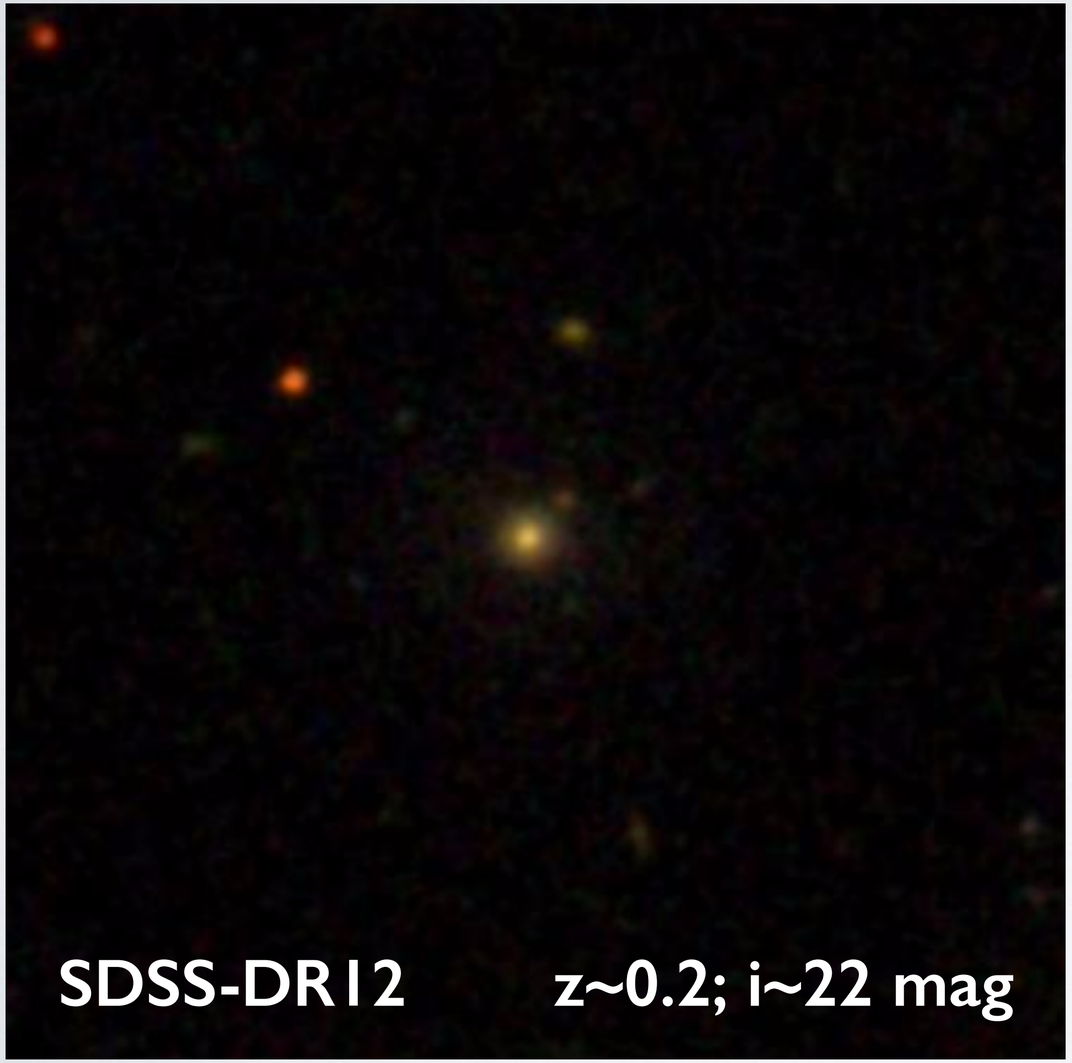
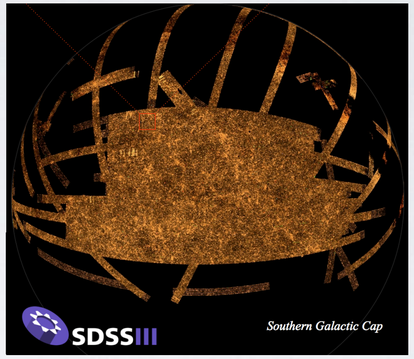
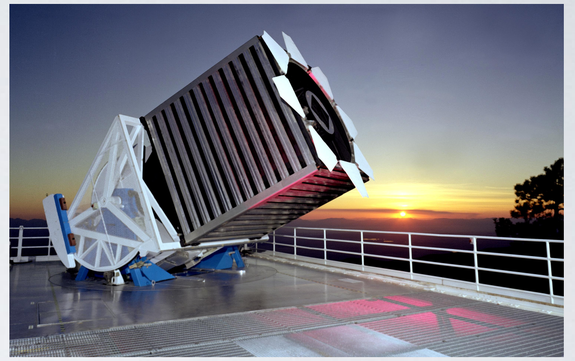
EXTENDING MORPHOLOGIES TO Z~1 IN WIDE-FIELD OPTICAL SURVEYS







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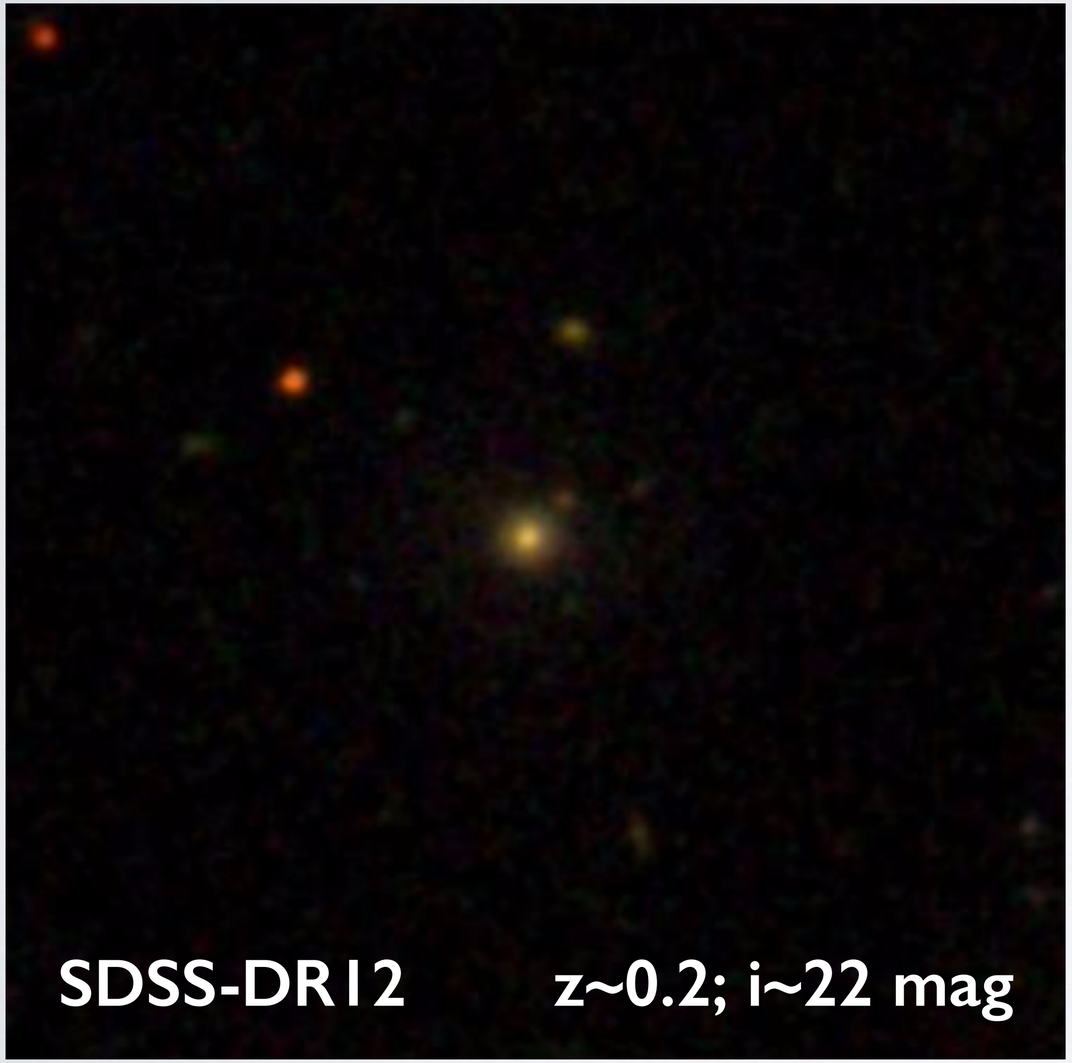
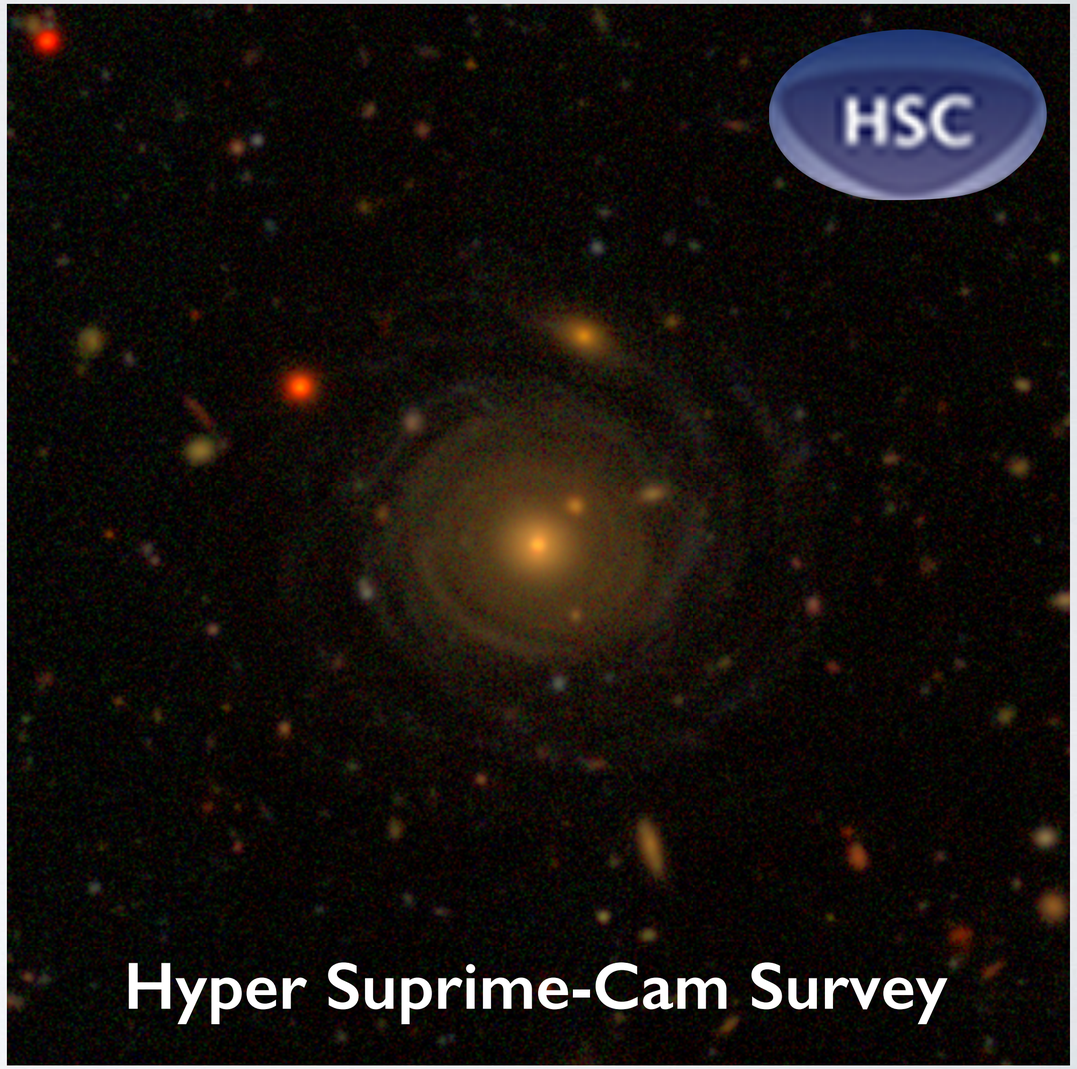
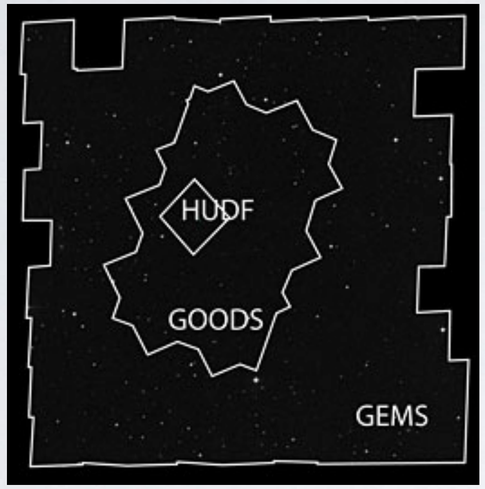
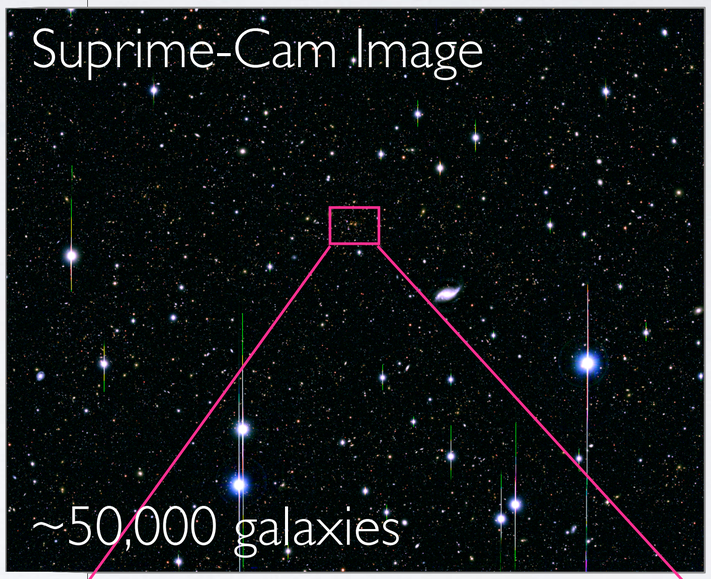


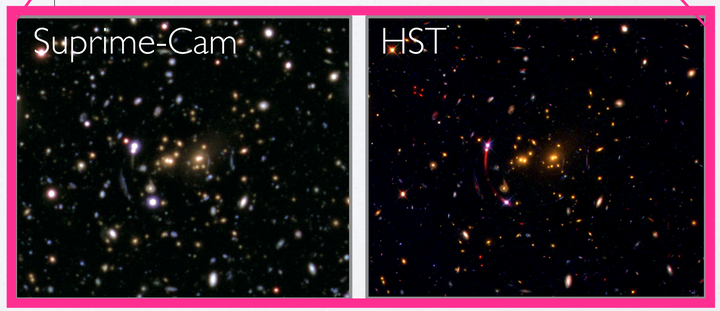


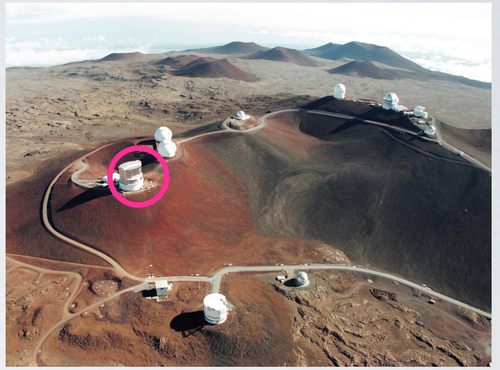
SUBARU & THE PRIME-FOCUS INSTRUMENT

Subaru Telescope: wide field of view & excellent image quality





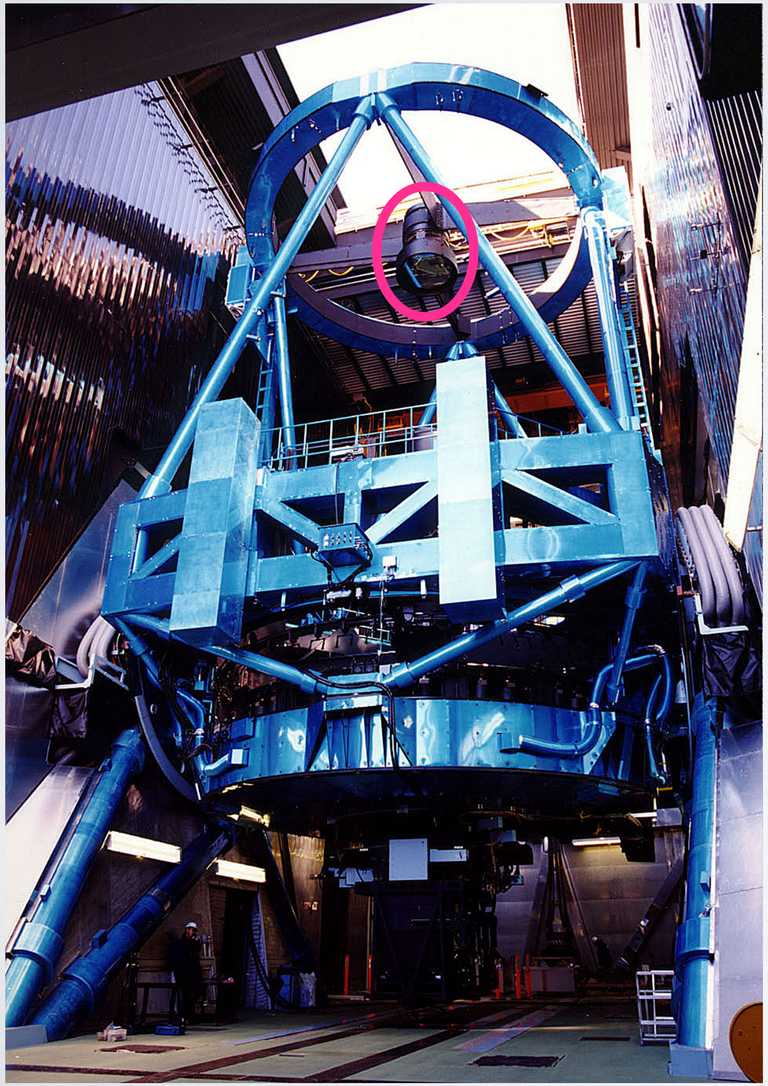




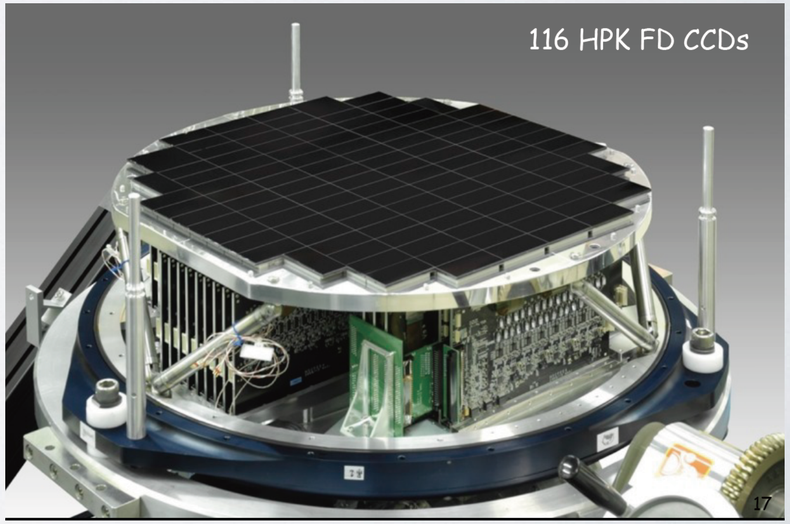
What makes for a good cosmological survey?

- **Fast, Wide, Deep & Sharp**

UPGRADE: HYPER SUPRIME-CAMERA



- world's largest camera
- 3m high
- weigh 3 ton
- 116 CCDs
- ~0.9B pixels



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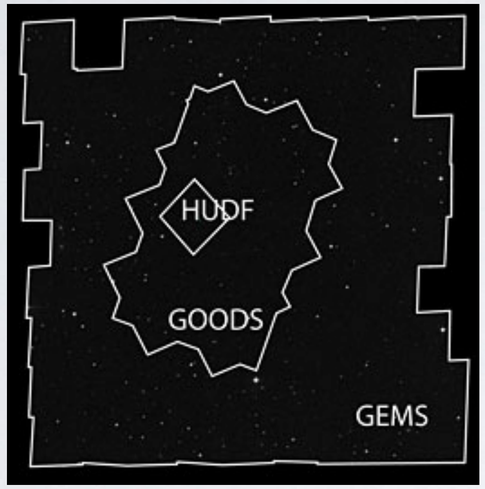

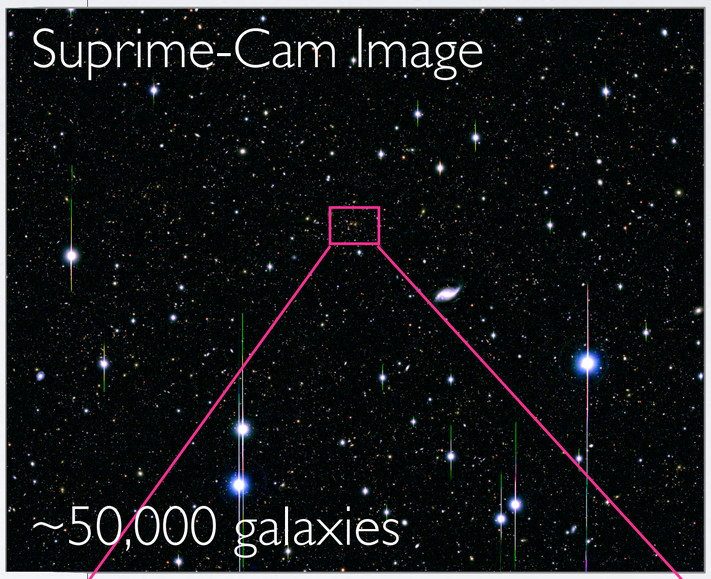

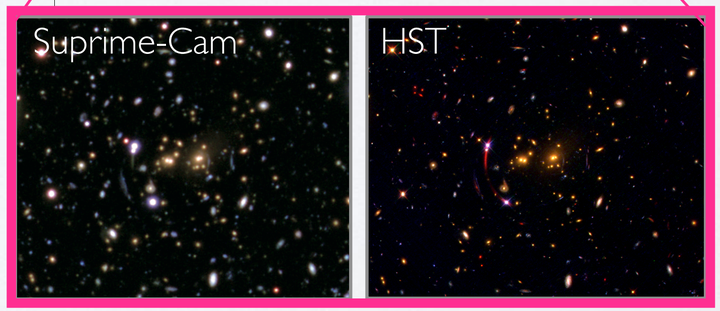

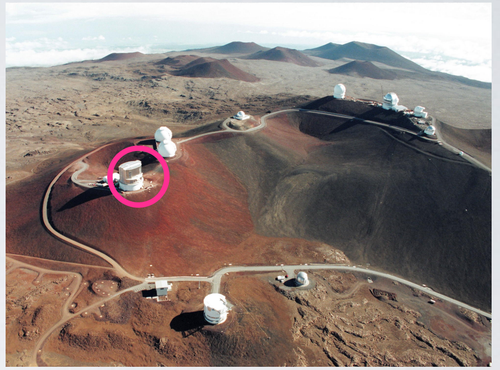

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SUBARU & THE PF

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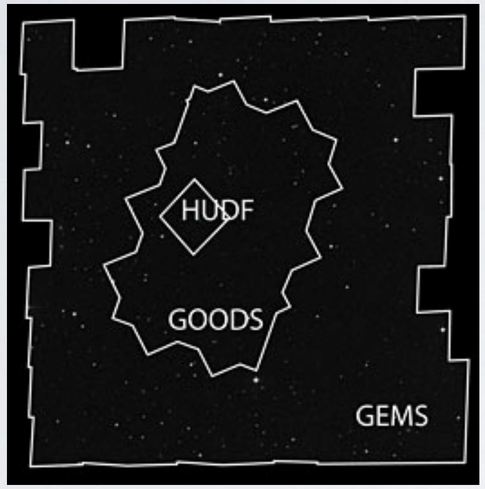

HSC : FOV ~1.8 deg^2

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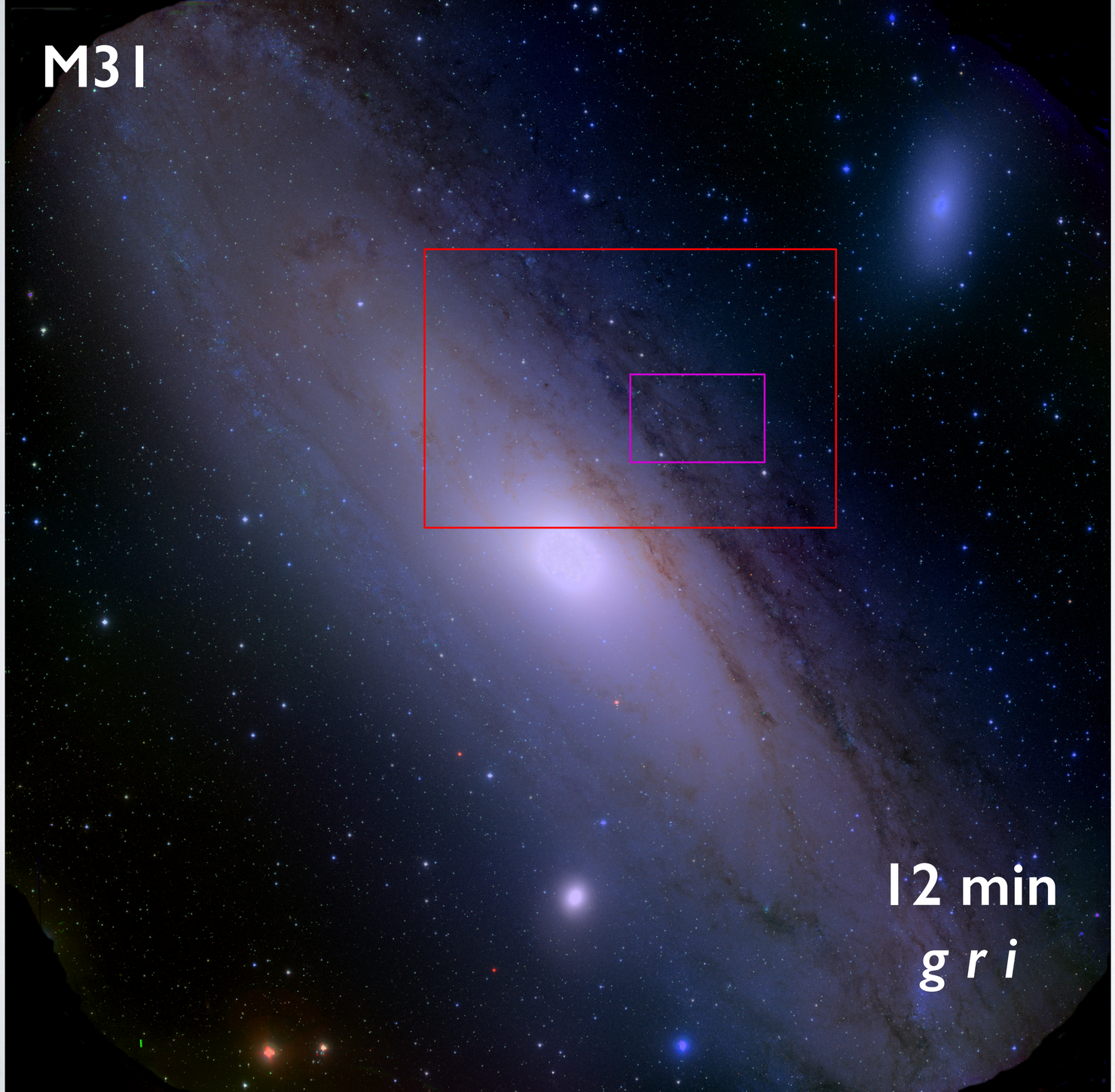
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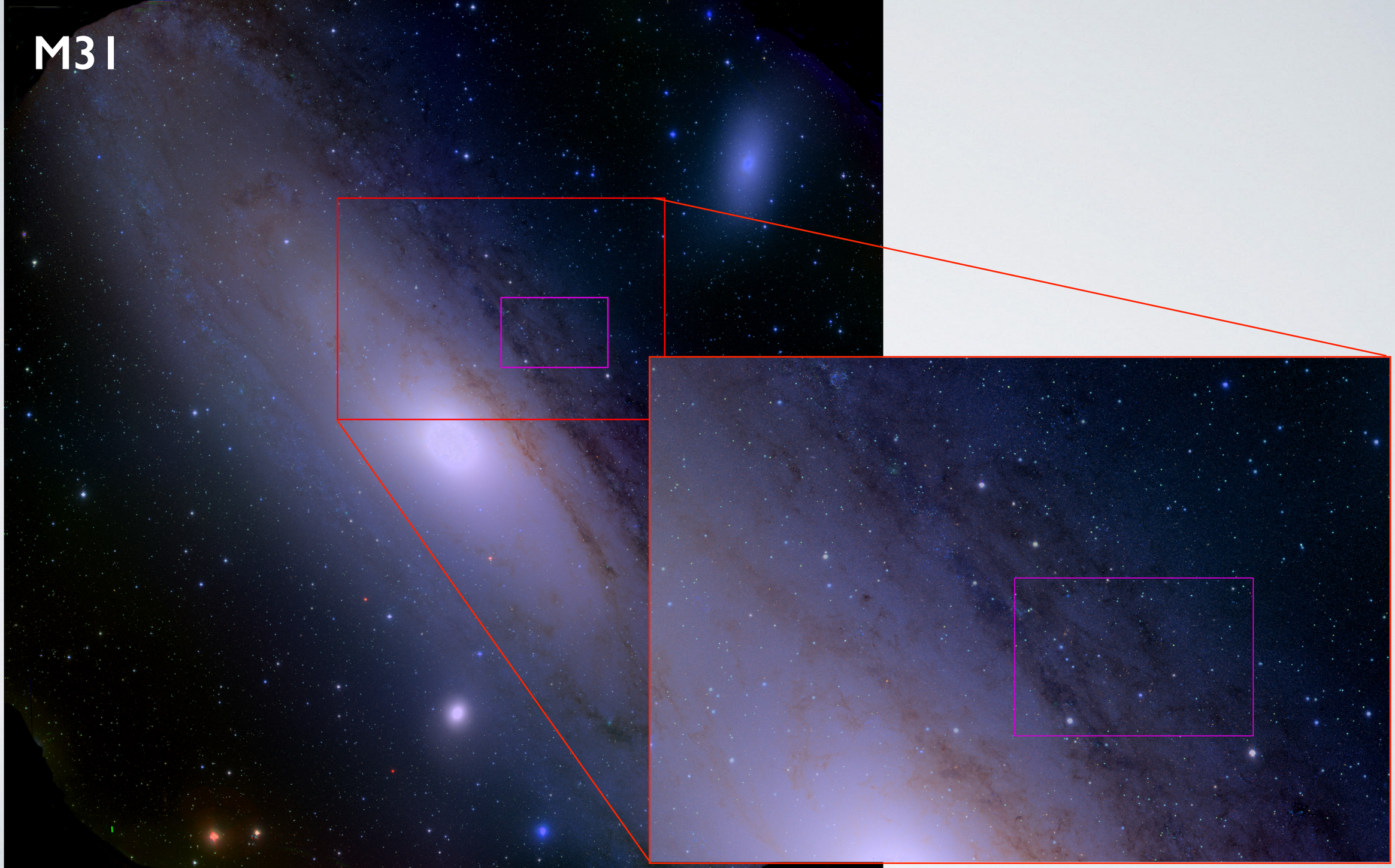
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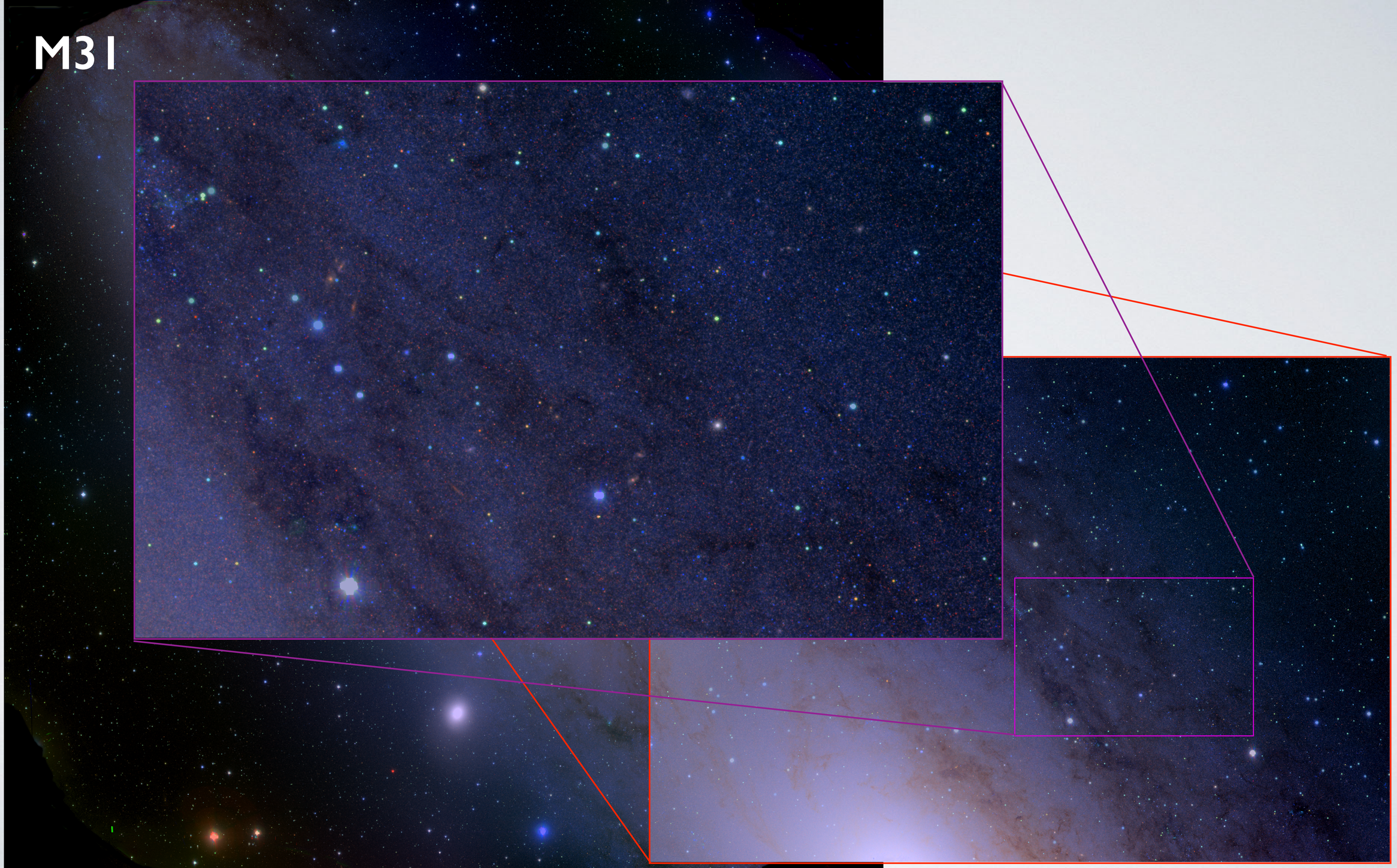
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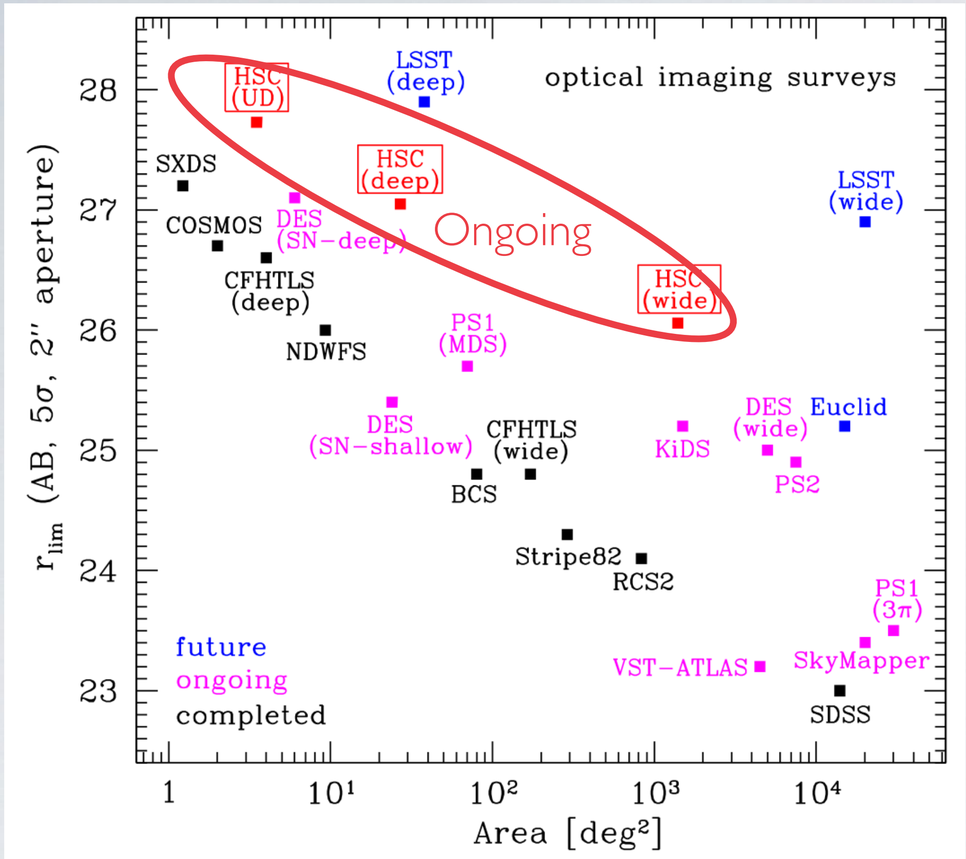
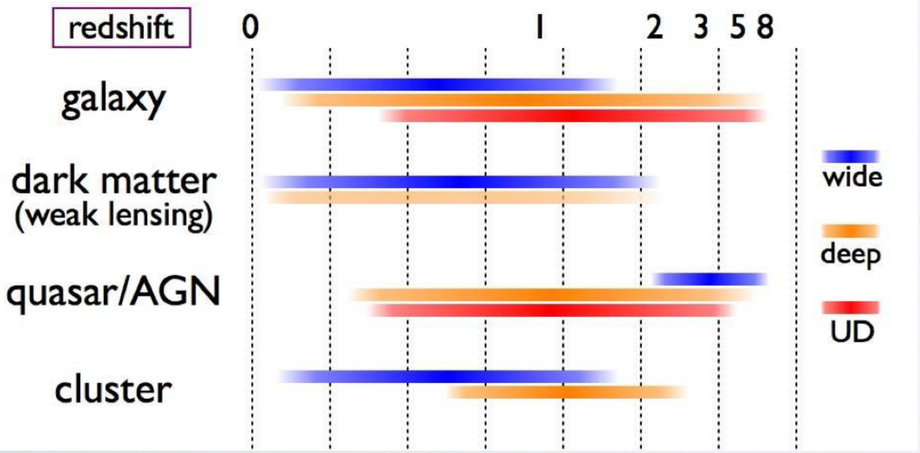
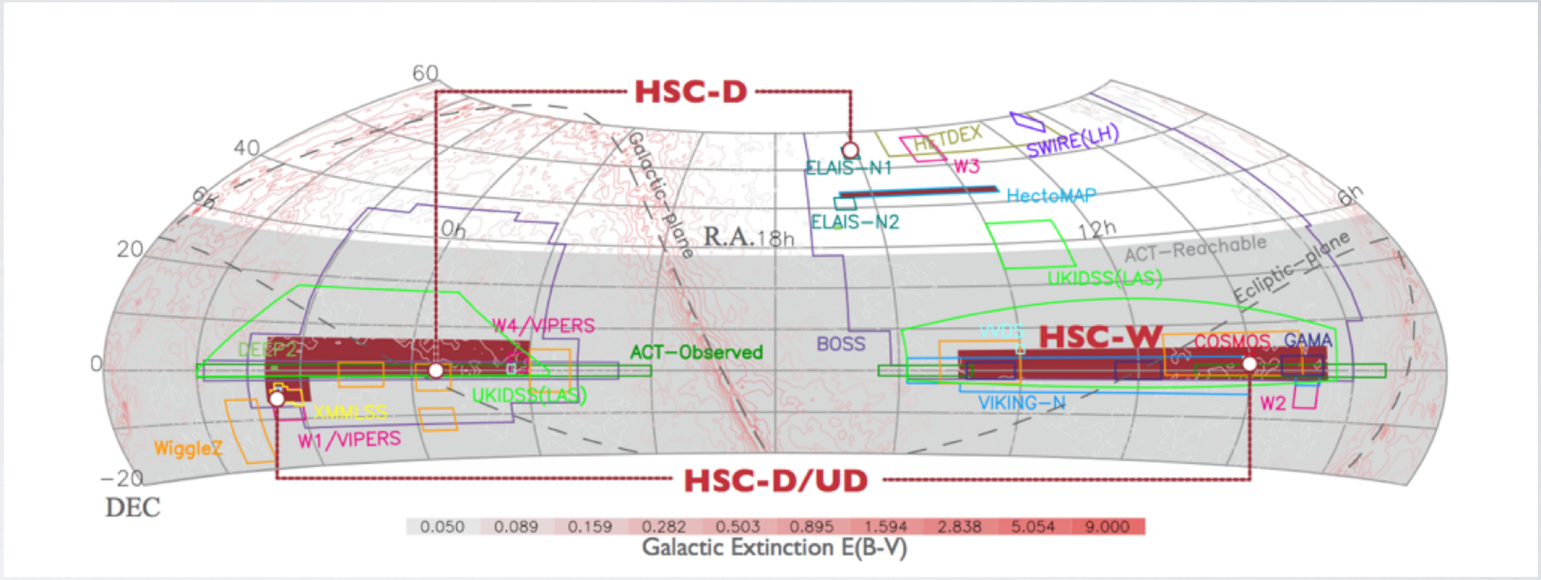






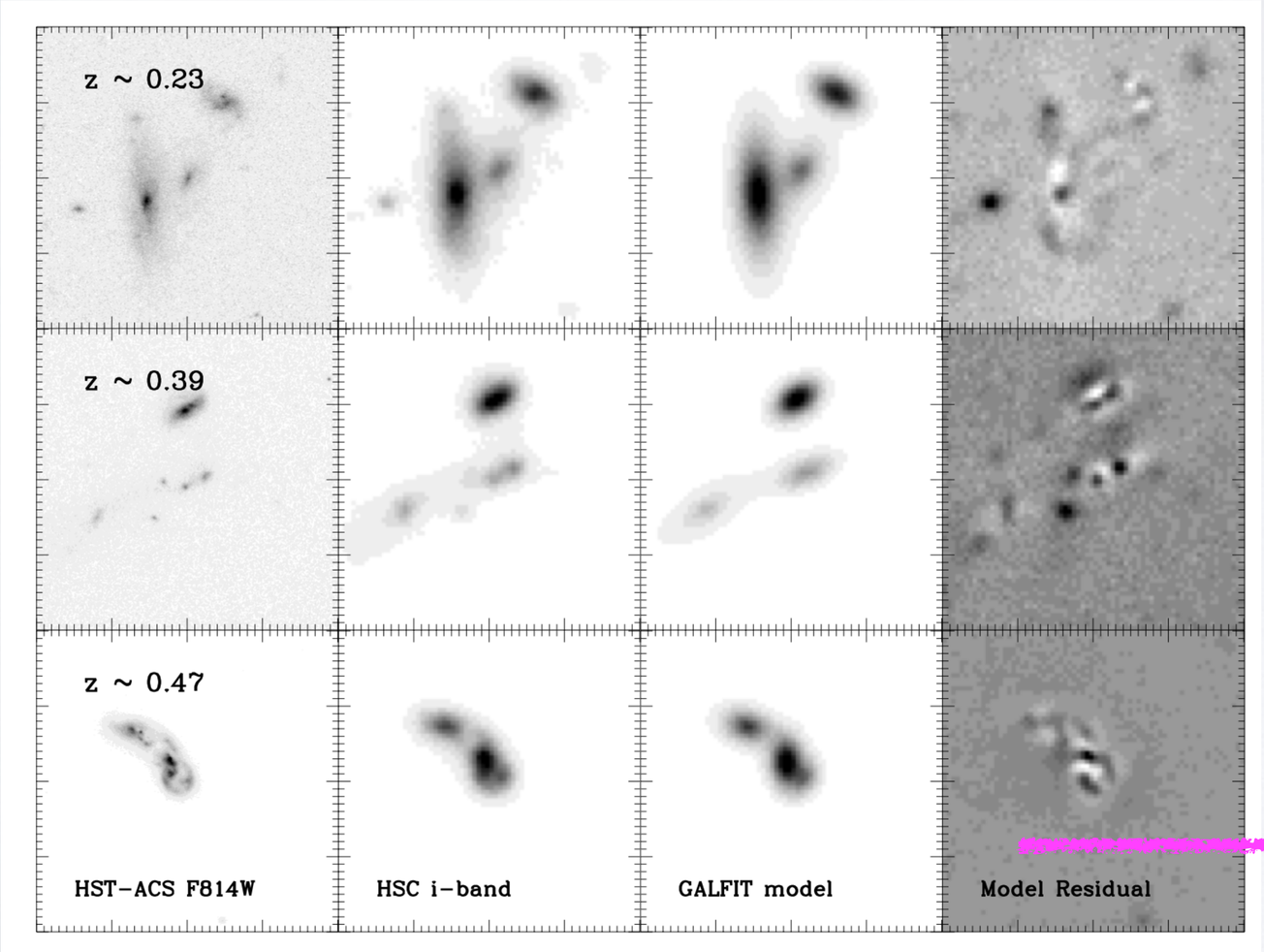
300 night survey: 5 years
~2 million sources / deg^2

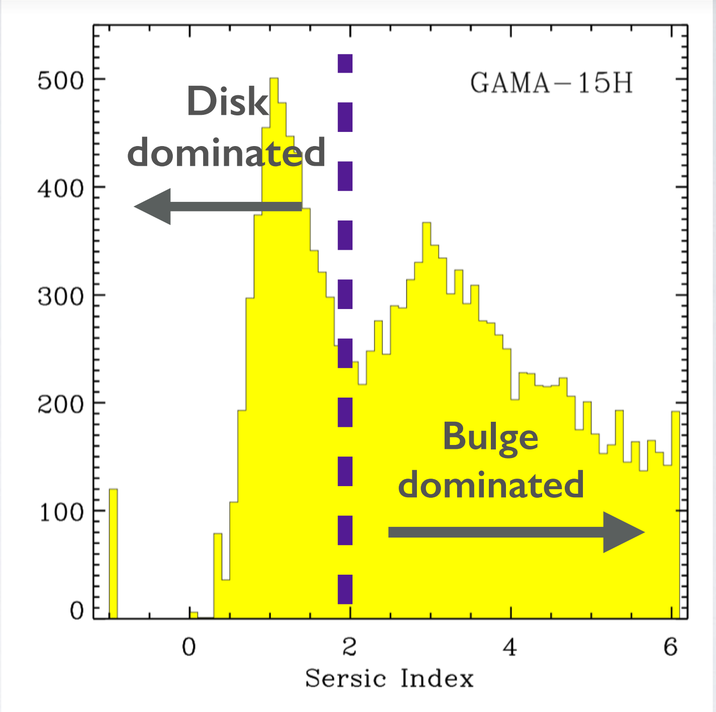
Wide: 1400 deg^2 (i=25.9, grizy) for WL cosmology
Deep: 27 deg^2 (i=26.8, grizy +NB)
Ultra Deep: 3.5 deg^2 (i=27.4, grizy + NB)

Public DR1 now available: 100 deg^2

BIG DATA PROBLEMS: AUTOMATED MORPHOLOGIES IN HSC

Validation of 2D morphologies using GALFIT analysis of HST and HSC galaxies in COSMOS & AEGIS



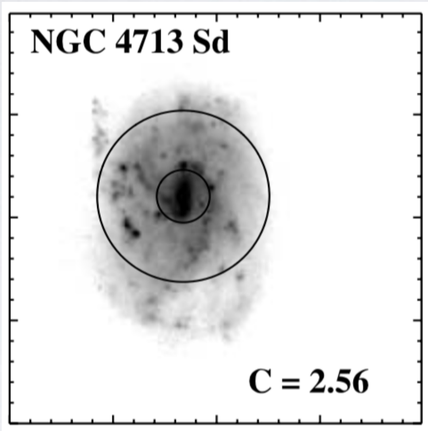


- i<22 mags in HSC-WIDE
- All spec-z selected
- ~140,000 galaxies in first ~170deg^2

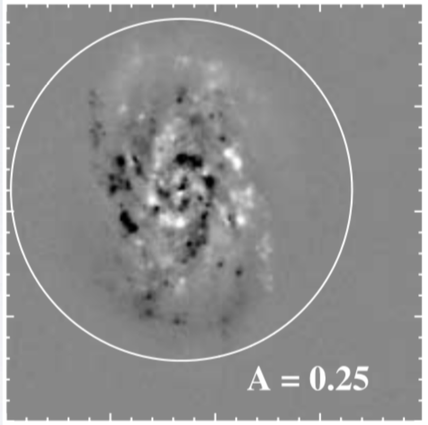
$redshift_{limit} \sim< 1$

AUTOMATED INTERACTION-STAGE CLASSIFICATIONS

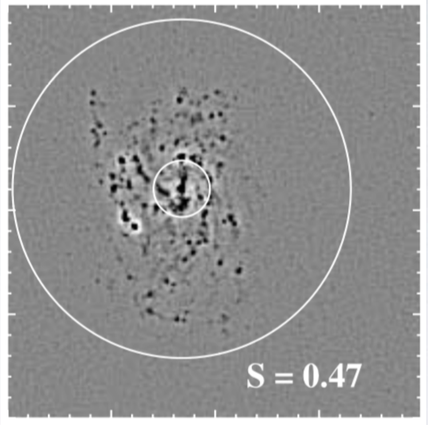
Concentration



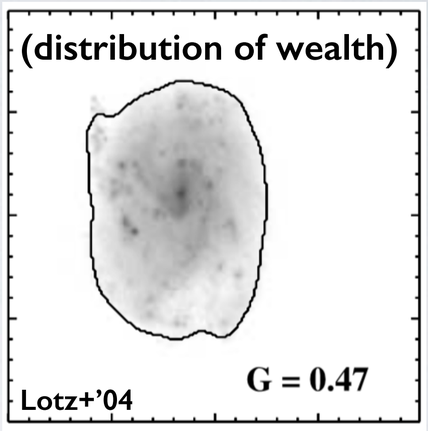
Asymmetry



Smoothness

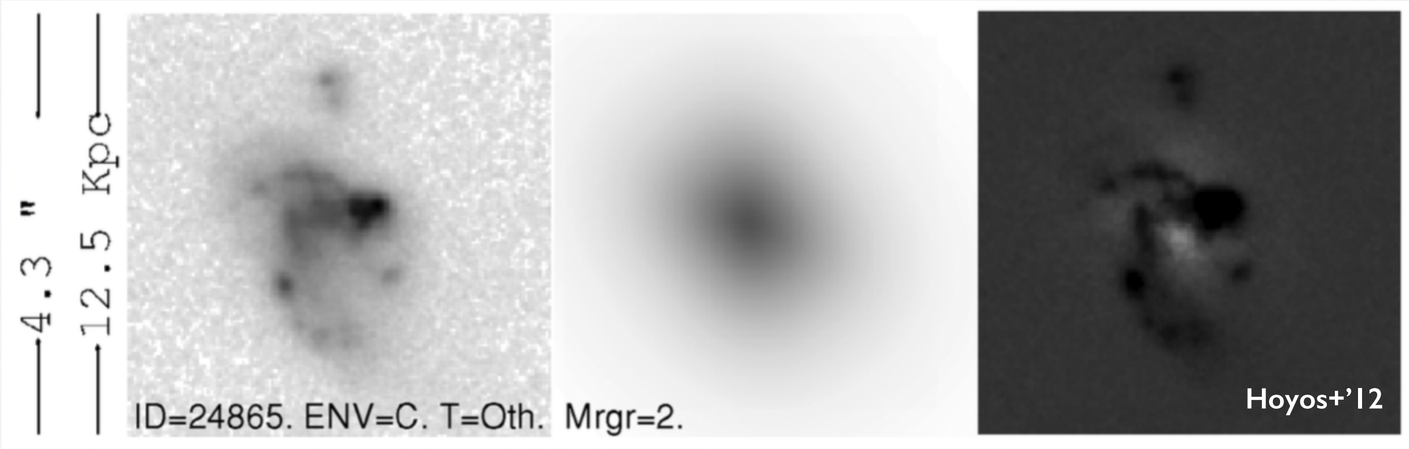


Gini

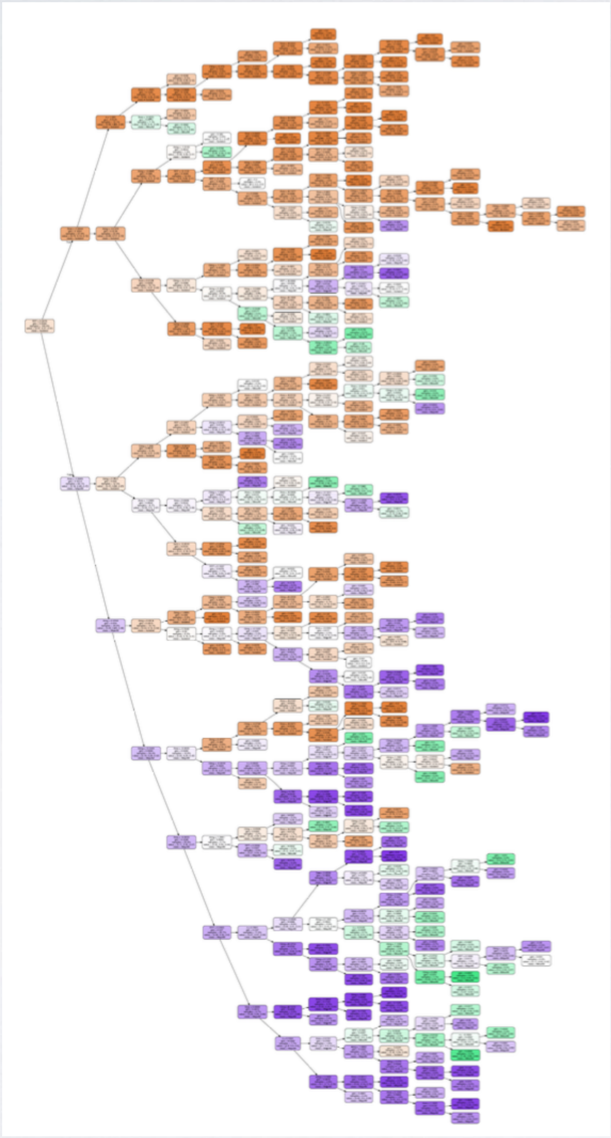


see Conselice '03; Lavery+'04; Lotz+'04; Cassata+'05; Conselice+'08; Jogee+'08,'09; Lotz+'08; Wen+'09; Hoyos+'12

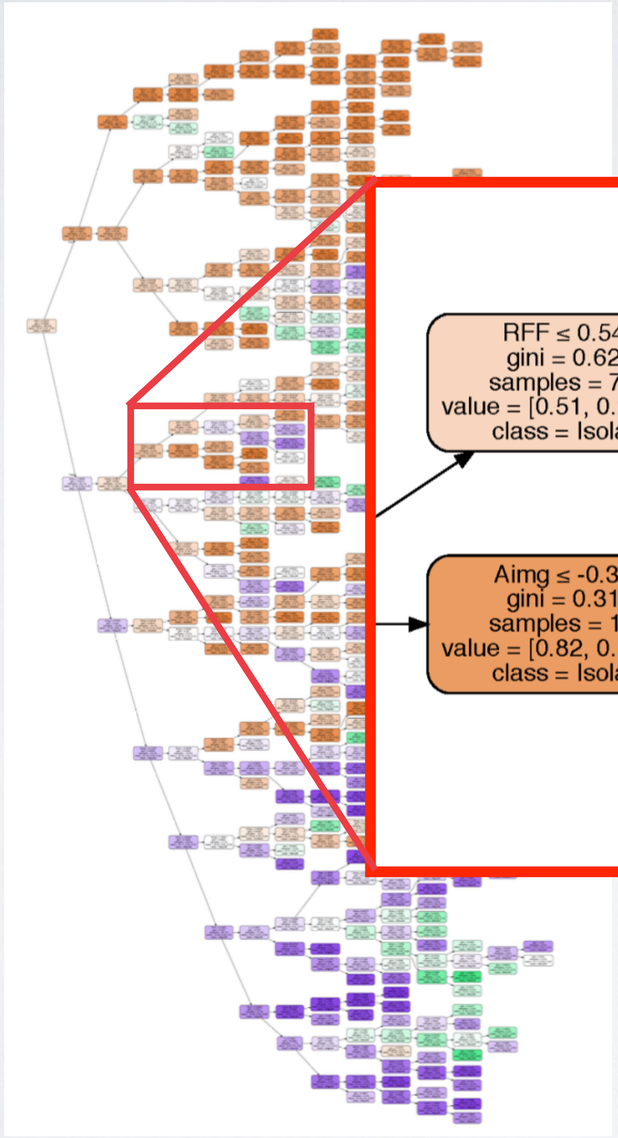
Residual Flux Fluctuations

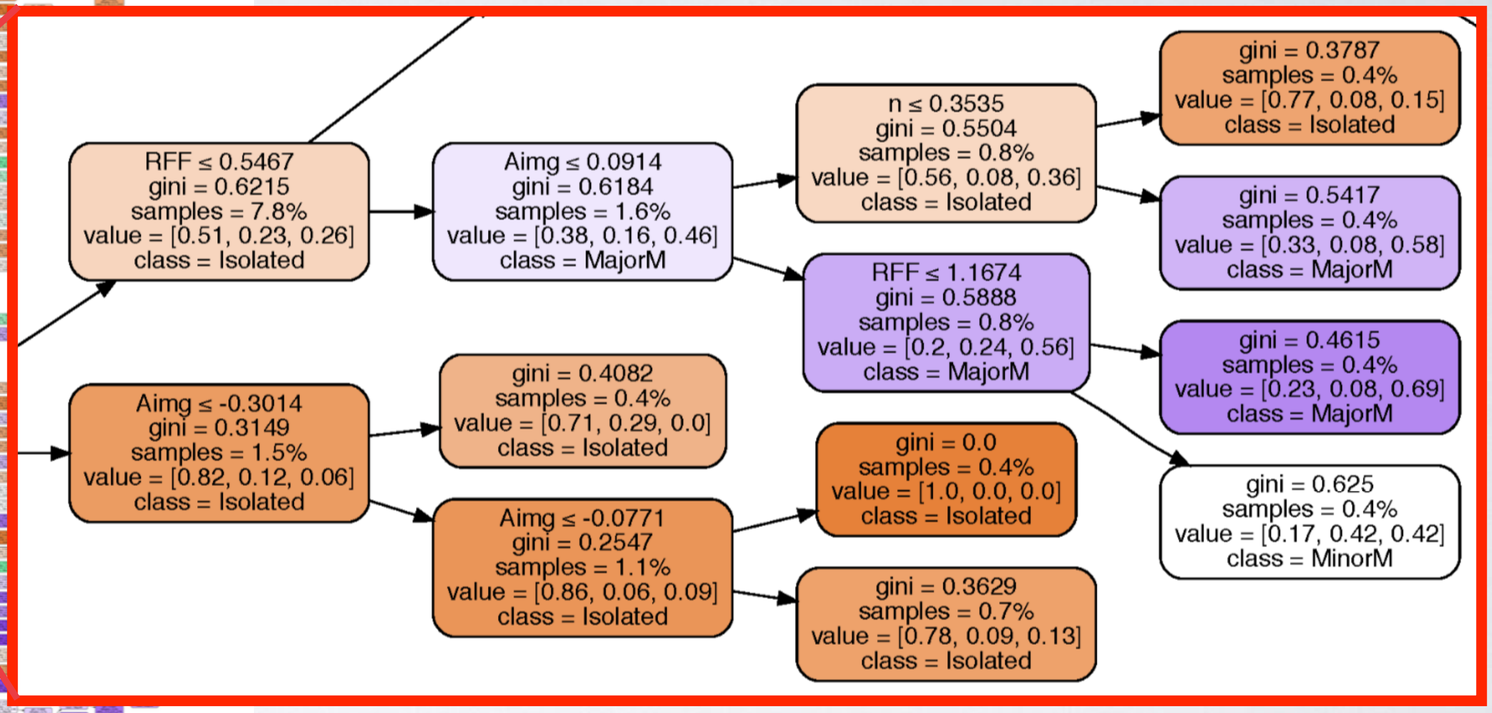


PLANTING (DECISION-)TREES & GROWING (RANDOM-)FORESTS

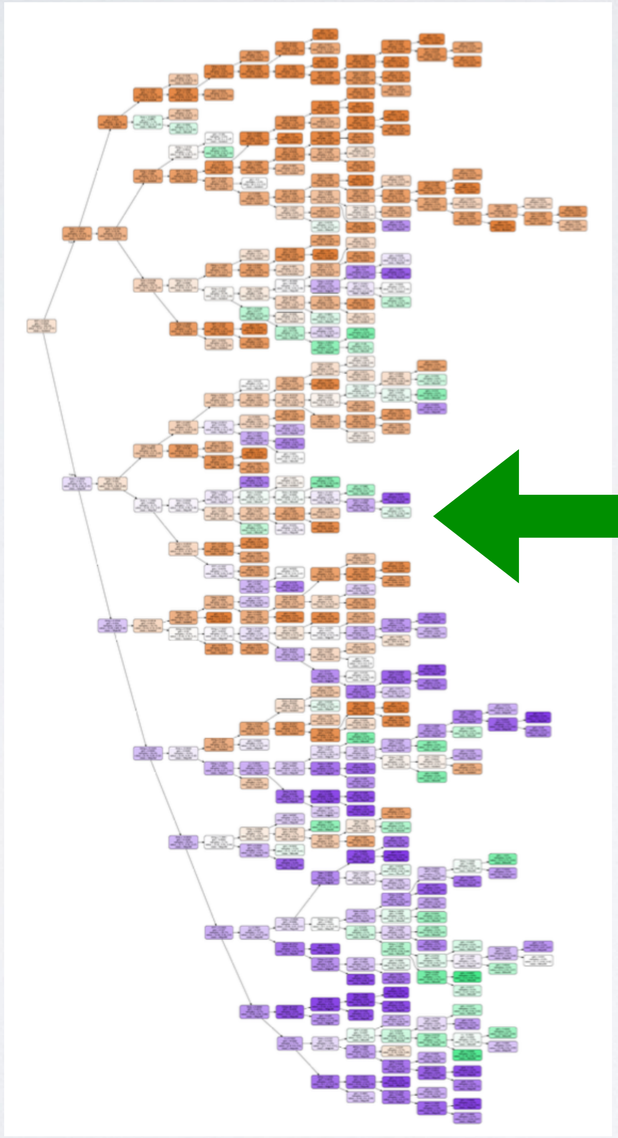


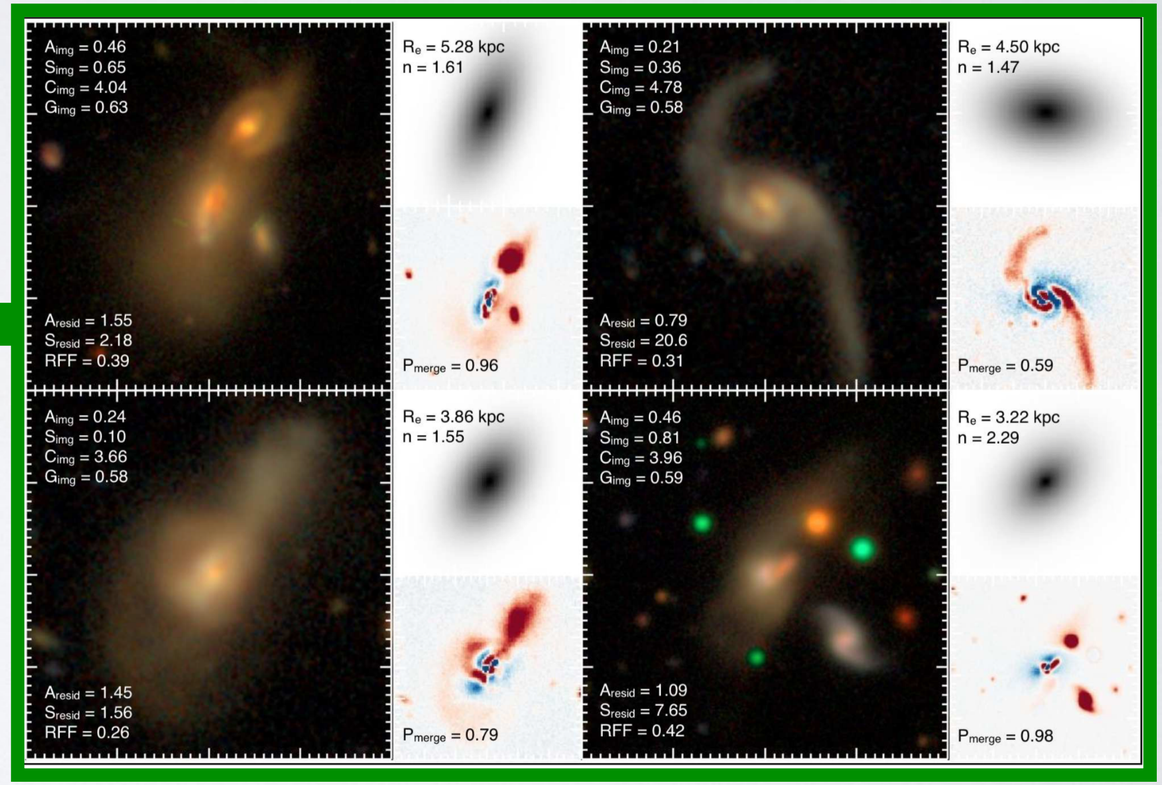
PLANTING (DECISION-)TREES & GROWING (RANDOM-)FORESTS



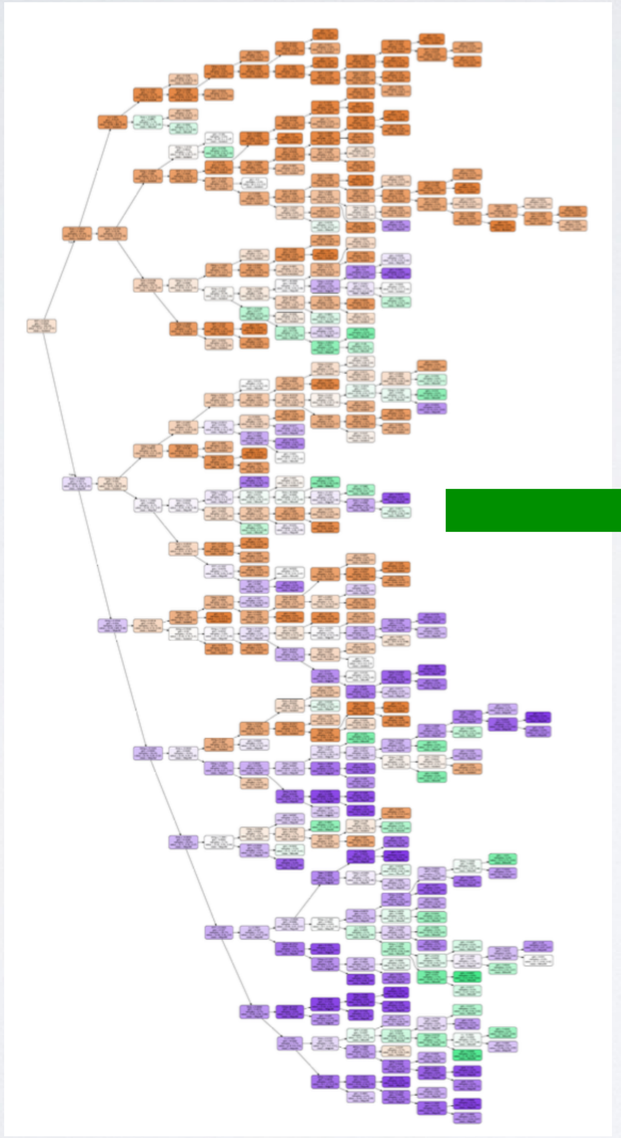


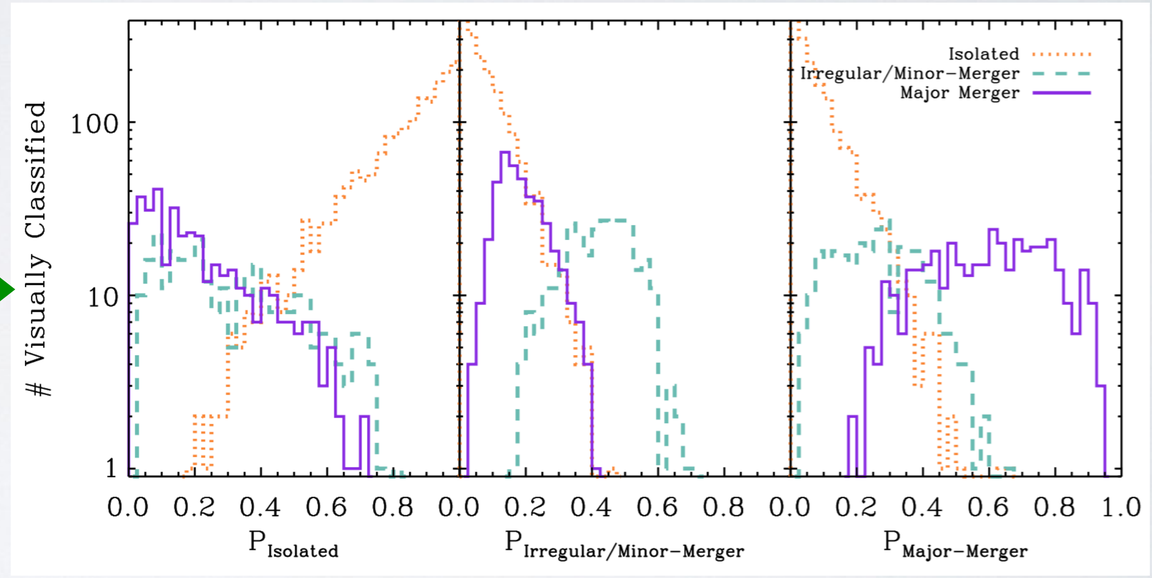
PLANTING (DECISION-)TREES & GROWING (RANDOM-)FORESTS

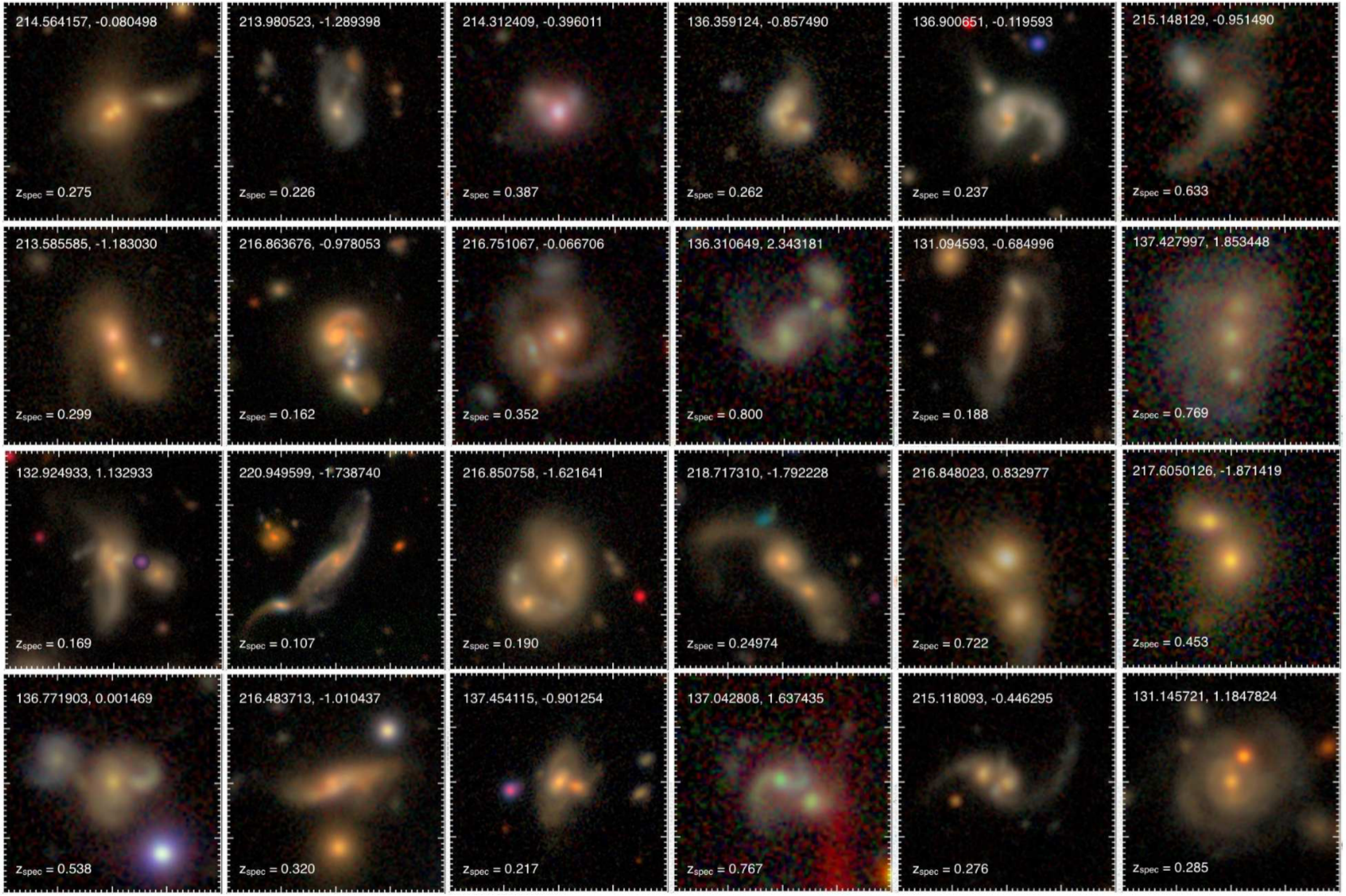


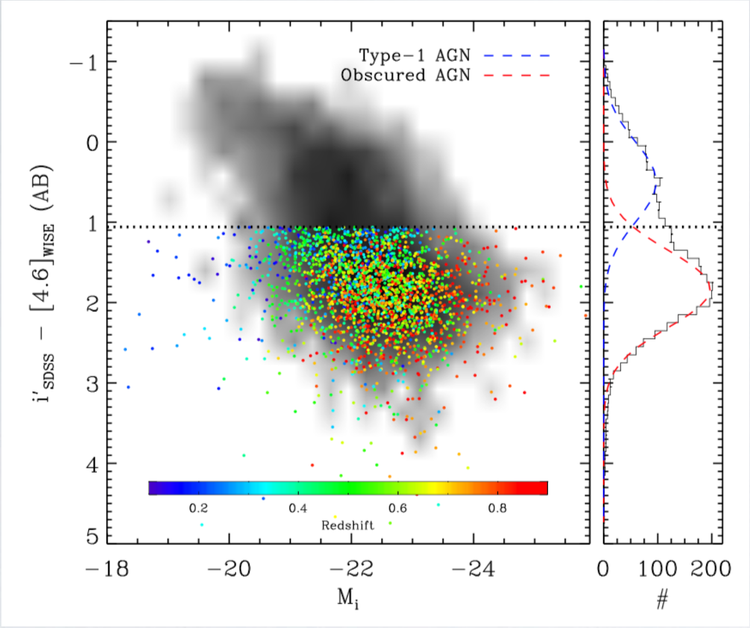


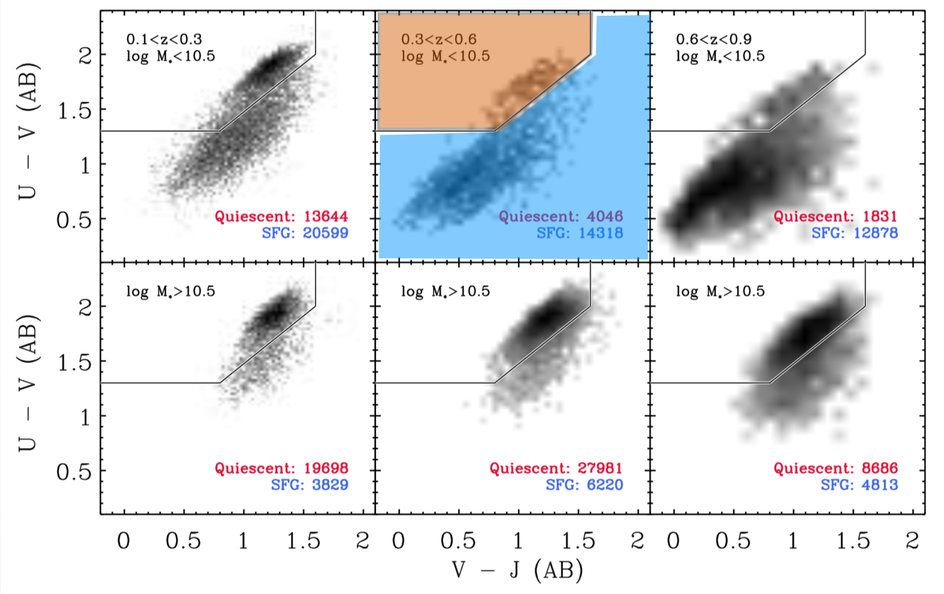
PLANTING (DECISION-)TREES & GROWING (RANDOM-)FORESTS

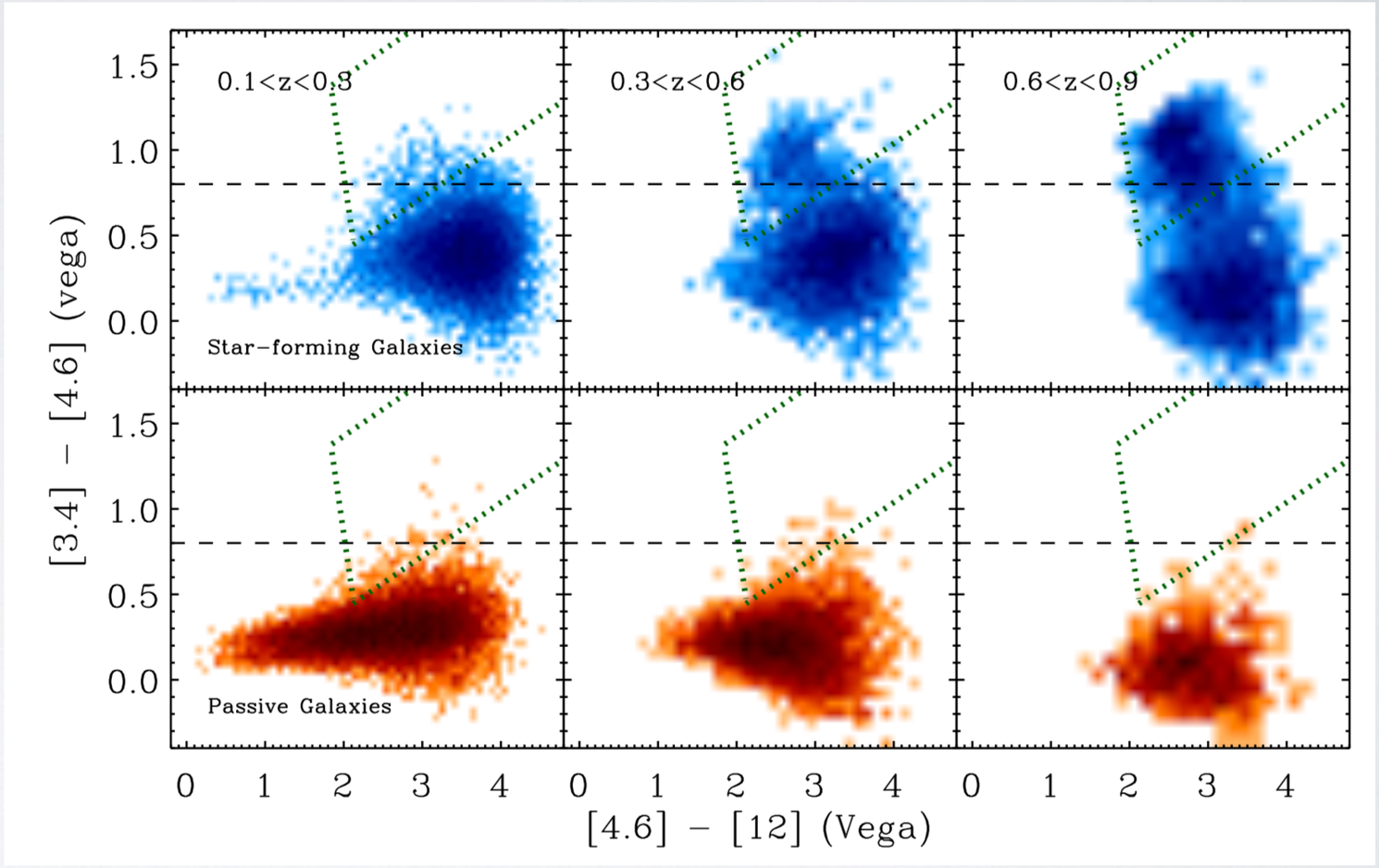


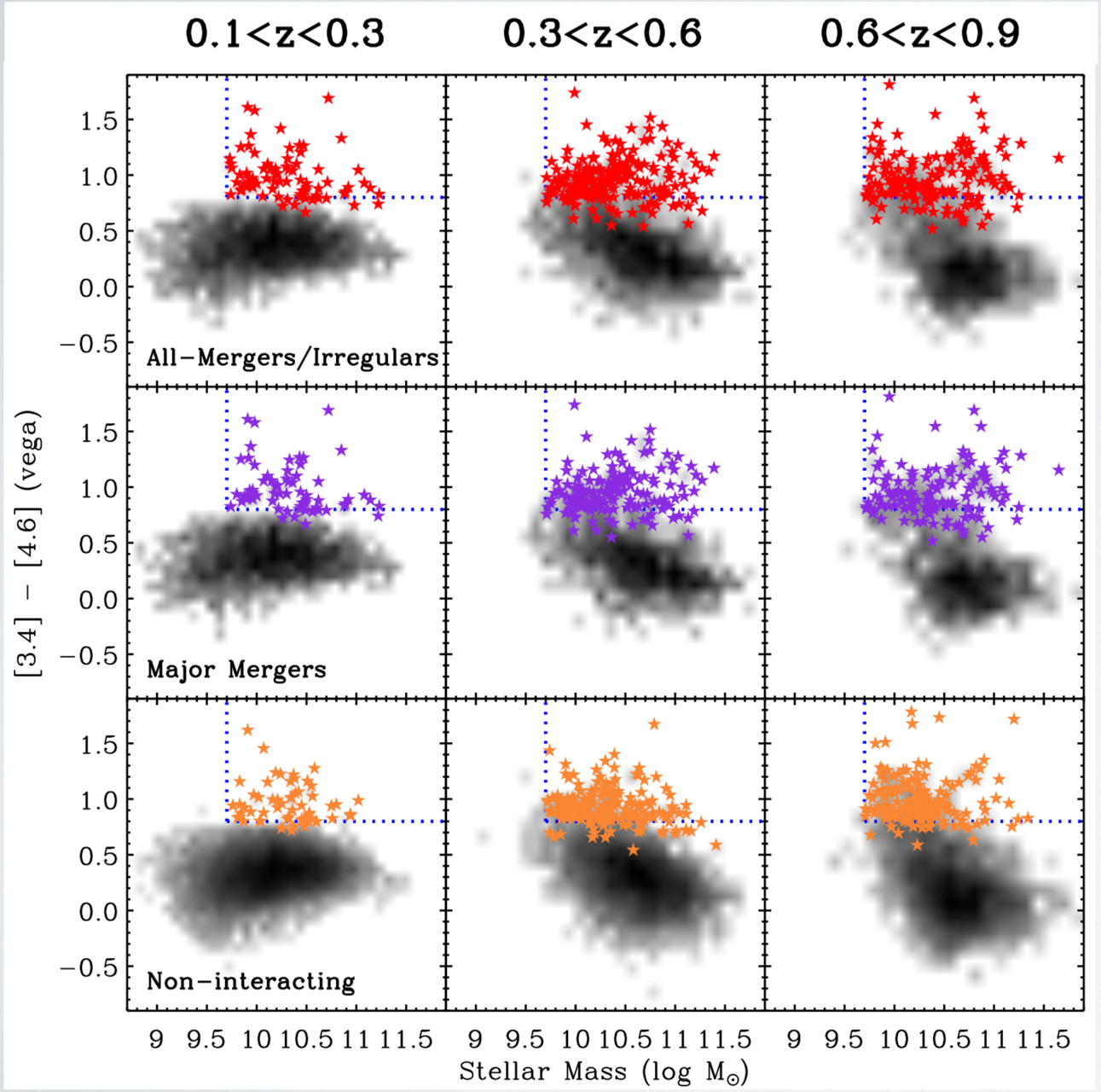


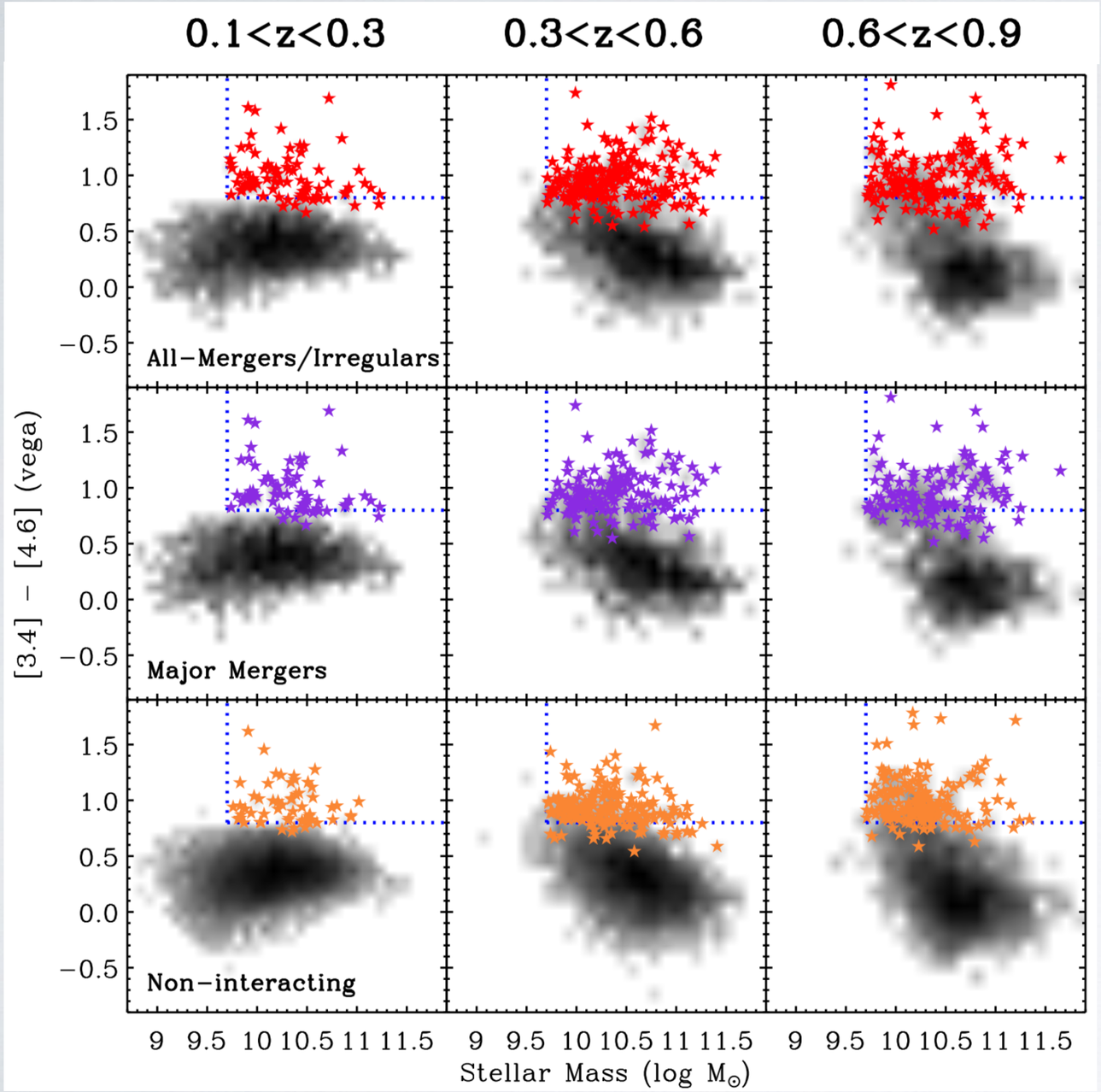

214.564157, -0.080498
z_{spec} = 0.275
213.980523, -1.289398
z_{spec} = 0.226
214.312409, -0.396011
z_{spec} = 0.387
136.359124, -0.857490
z_{spec} = 0.262
136.900651, -0.119593
z_{spec} = 0.237
215.148129, -0.951490
z_{spec} = 0.633
213.585585, -1.183030
z_{spec} = 0.299
216.863676, -0.978053
z_{spec} = 0.162
216.751067, -0.066706
z_{spec} = 0.352
136.310649, 2.343181
z_{spec} = 0.800
131.094593, -0.684996
z_{spec} = 0.188
137.427997, 1.853448
z_{spec} = 0.769
132.924933, 1.132933
z_{spec} = 0.169
220.949599, -1.738740
z_{spec} = 0.107
216.850758, -1.621641
z_{spec} = 0.190
218.717310, -1.792228
z_{spec} = 0.24974
216.848023, 0.832977
z_{spec} = 0.722
217.6050126, -1.871419
z_{spec} = 0.453
136.771903, 0.001469
z_{spec} = 0.538
216.483713, -1.010437
z_{spec} = 0.320
137.454115, -0.901254
z_{spec} = 0.217
137.042808, 1.637435
z_{spec} = 0.767
215.118093, -0.446295
z_{spec} = 0.276
131.145721, 1.1847824
z_{spec} = 0.285

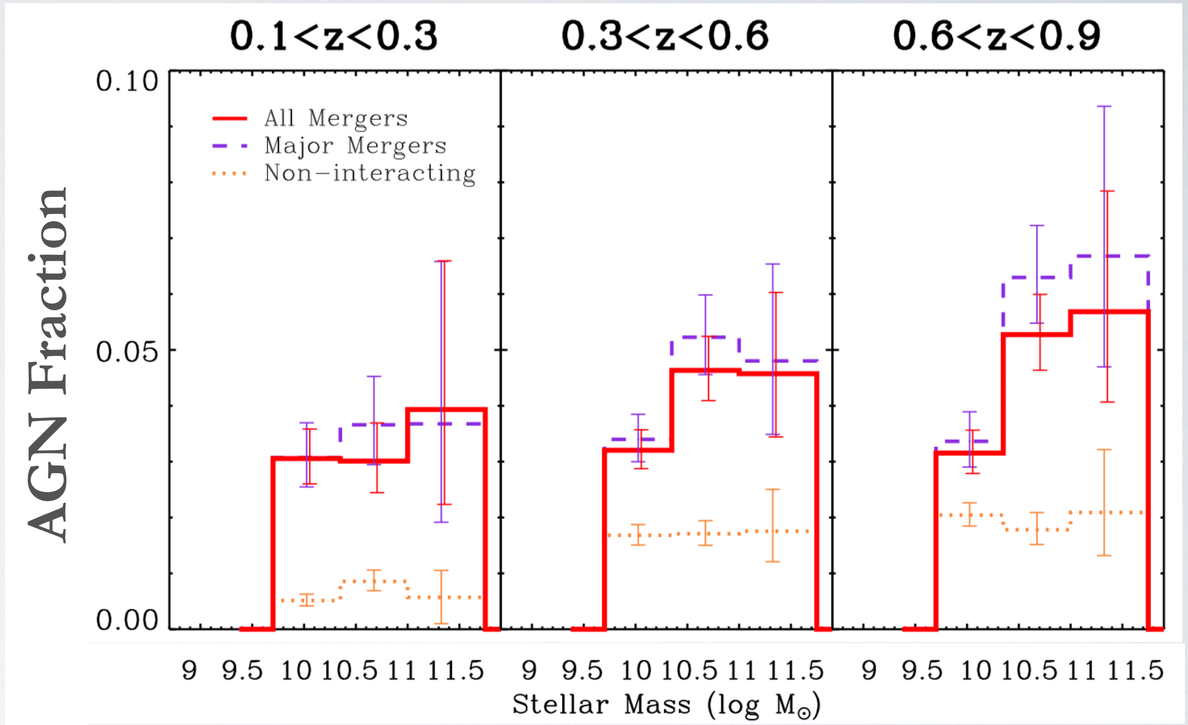

Type−1 AGN
Obscured AGN
Redshift
$i'_{SDSS} - [4.6]_{WISE}$ (AB)
M_i
#


0.1<z<0.3
log M*<10.5
0.3<z<0.6
log M*<10.5
0.6<z<0.9
log M*<10.5
log M*>10.5
log M*>10.5
log M*>10.5
Quiescent: 13644
SFG: 20599
Quiescent: 4046
SFG: 14318
Quiescent: 1831
SFG: 12878
Quiescent: 19698
SFG: 3829
Quiescent: 27981
SFG: 6220
Quiescent: 8686
SFG: 4813
U − V (AB)
V − J (AB)


0.1<z<0.3
0.3<z<0.6
0.6<z<0.9
Star−forming Galaxies
Passive Galaxies
[3.4] − [4.6] (vega)
[4.6] − [12] (Vega)

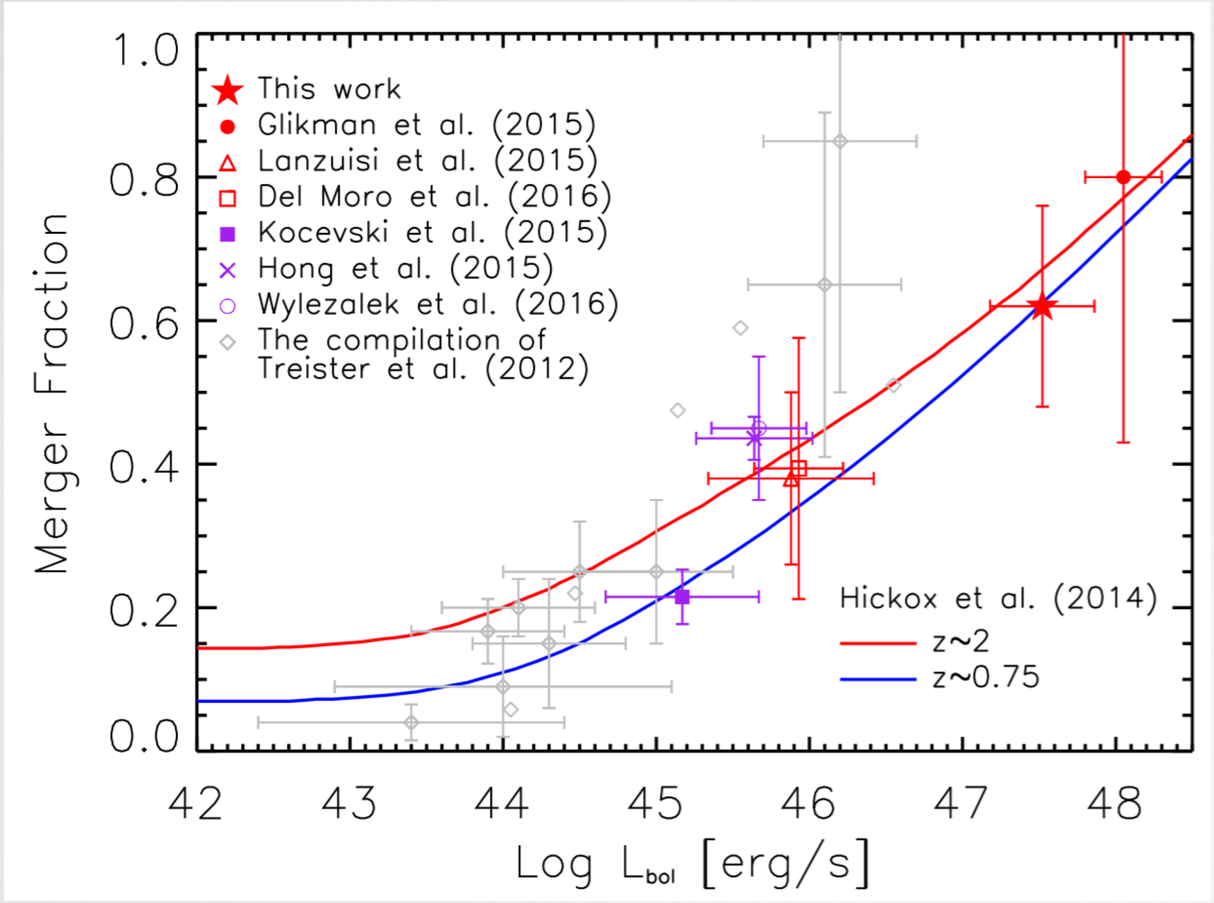

0.1<z<0.3
0.3<z<0.6
0.6<z<0.9
All−Mergers/Irregulars
Major Mergers
Non−interacting
[3.4] − [4.6] (vega)
Stellar Mass (log M⊙)
1.5
1.0
0.5
0.0
−0.5
9
9.5
10
10.5
11
11.5



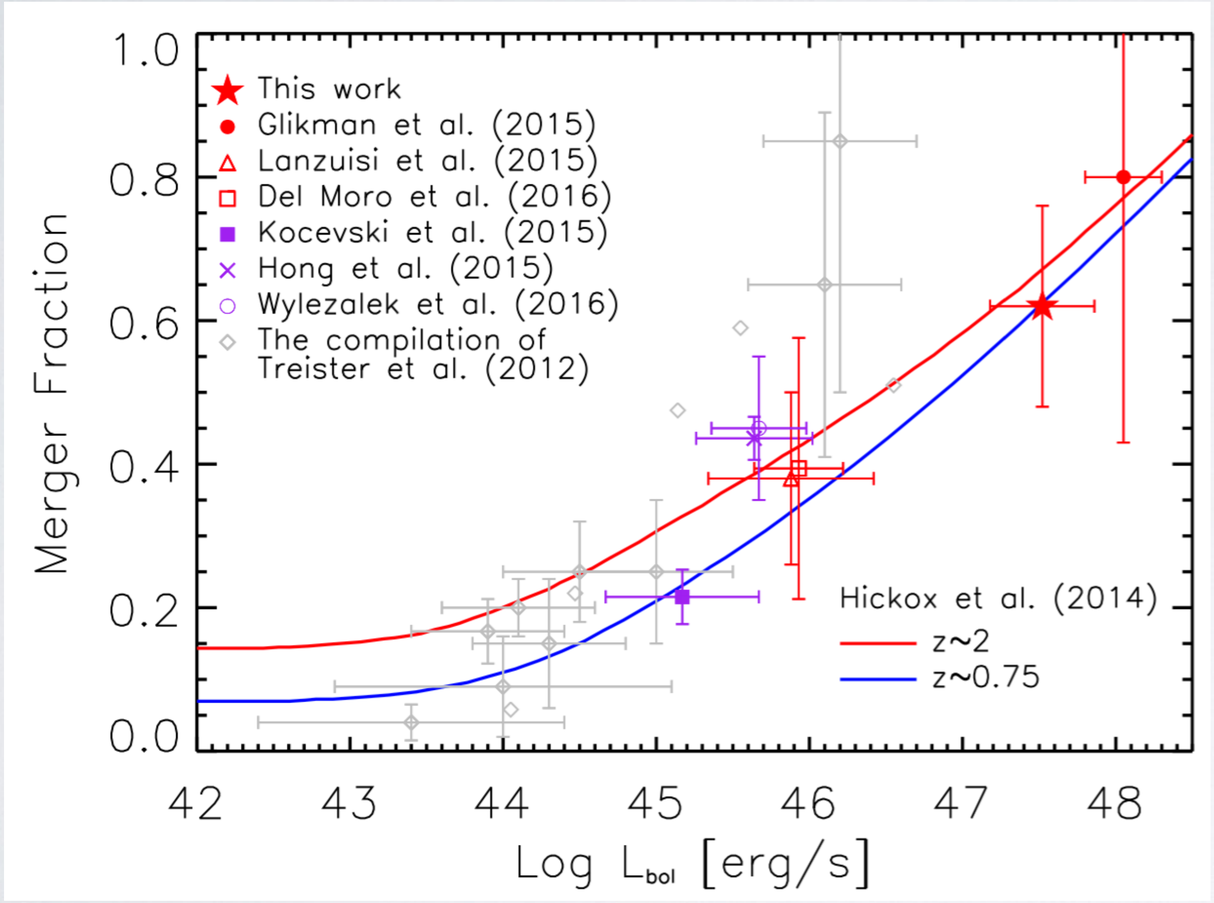


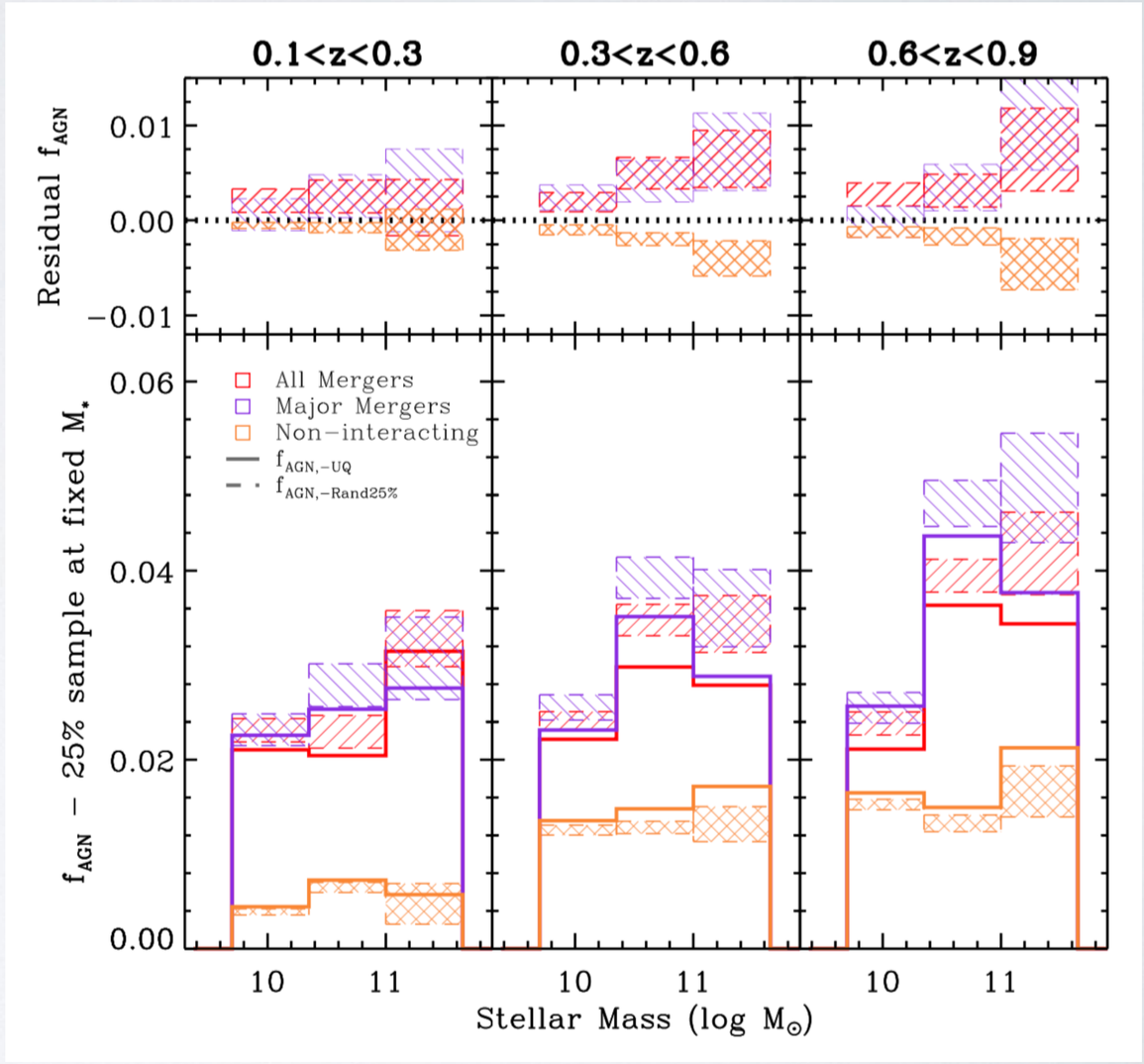
Galaxy mergers are a factor ~2–7 more likely to contain an obscured AGN with $L_{AGN} > 10^{43}$ erg/s than non-interacting galaxies

MERGING GALAXIES HOST THE MOST RAPIDLY GROWING BHS

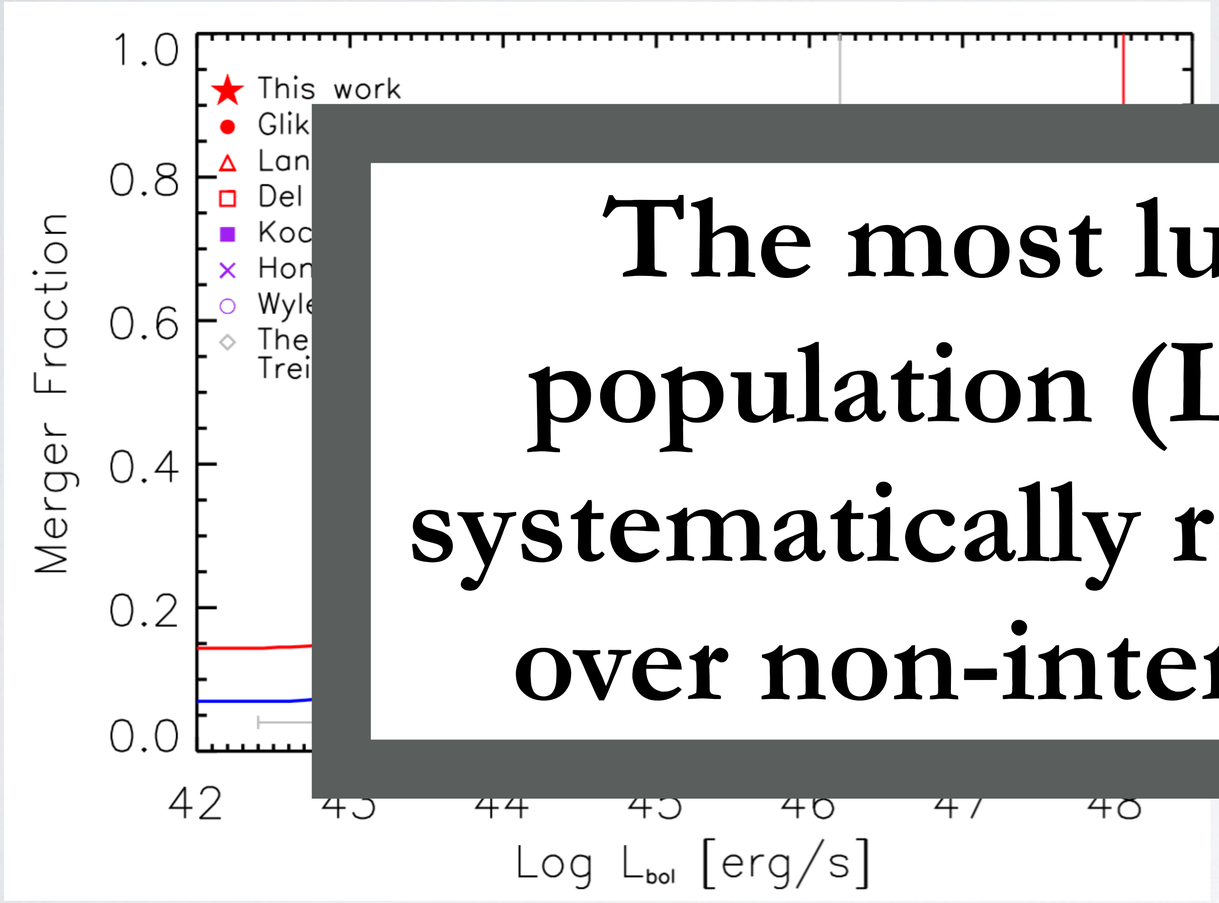


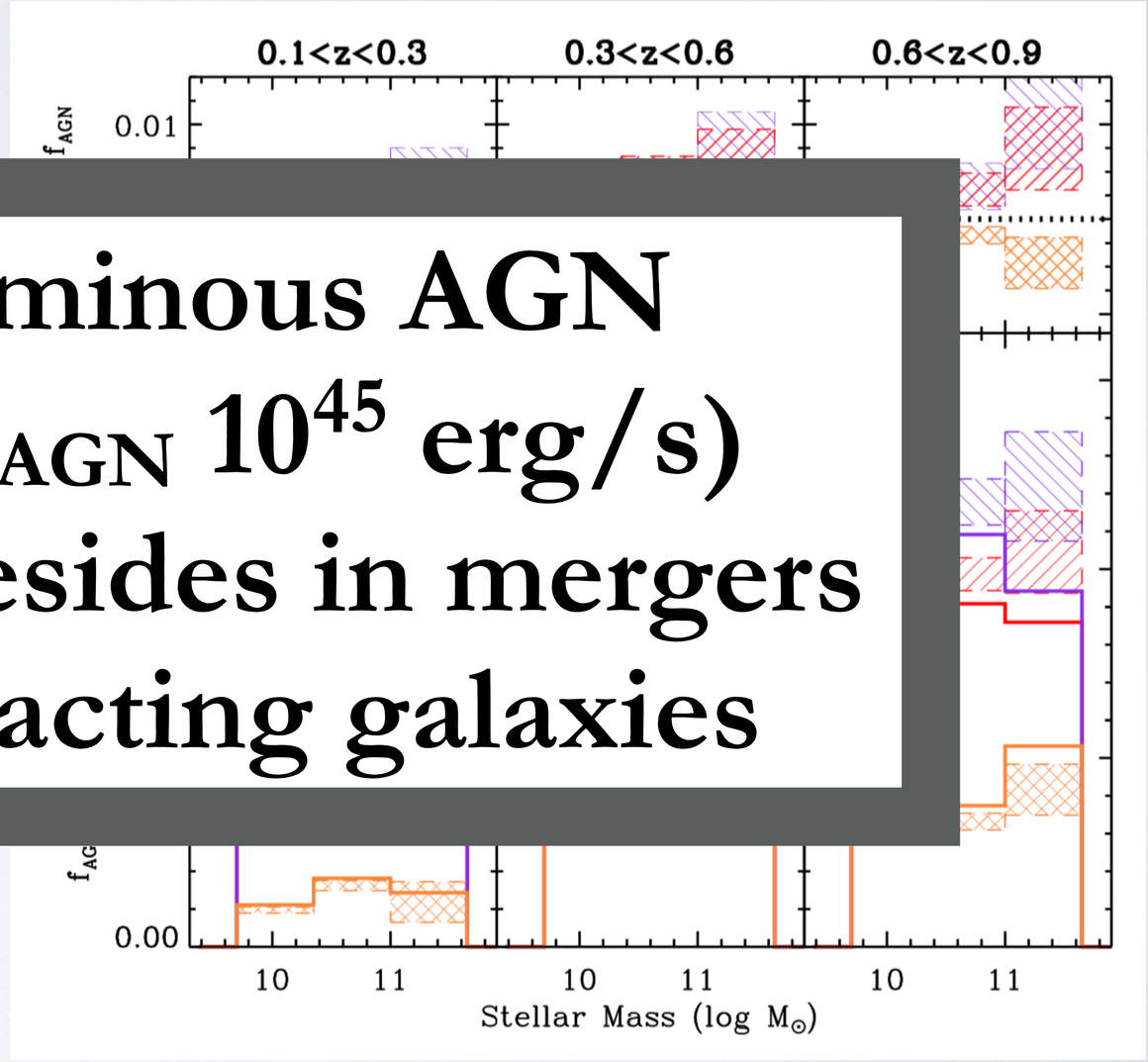
MERGING GALAXIES HOST THE MOST RAPIDLY GROWING BHS





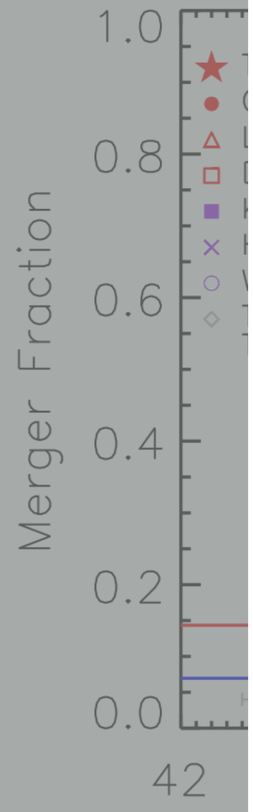
MERGING GALAXIES HOST THE MOST RAPIDLY GROWING BHS

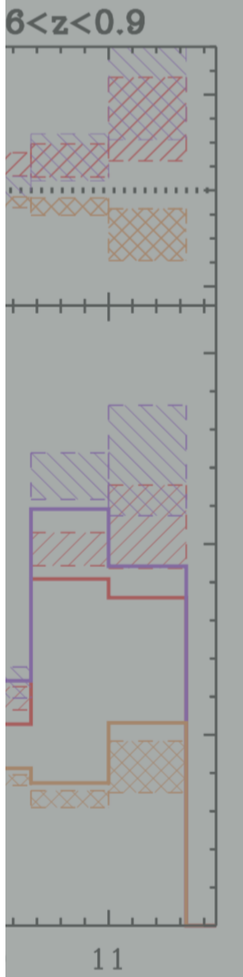




The most luminous AGN population (L_{AGN} 10^{45} erg/s) systematically resides in mergers over non-interacting galaxies

MERGI

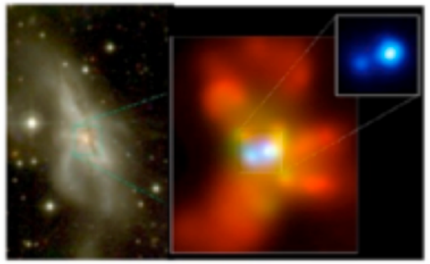




(c) Interaction/"Merger"

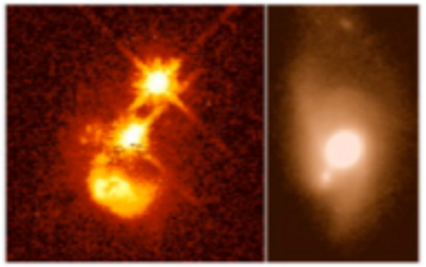
- now within one halo, galaxies interact & lose angular momentum
- SFR starts to increase
- stellar winds dominate feedback
- rarely excite QSOs (only special orbits)

(d) Coalescence/(U)LIRG



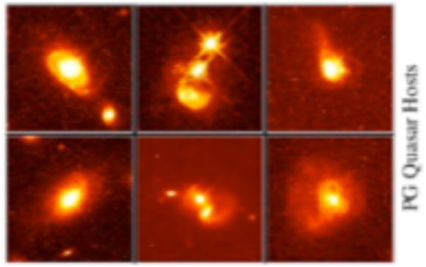
- galaxies coalesce: violent relaxation in core
- gas inflows to center: starburst & buried (X-ray) AGN
- starburst dominates luminosity/feedback, but, total stellar mass formed is small

(e) "Blowout"



- BH grows rapidly: briefly dominates luminosity/feedback
- remaining dust/gas expelled
- get reddened (but not Type II) QSO: recent/ongoing SF in host; high Eddington ratios; merger signatures still visible

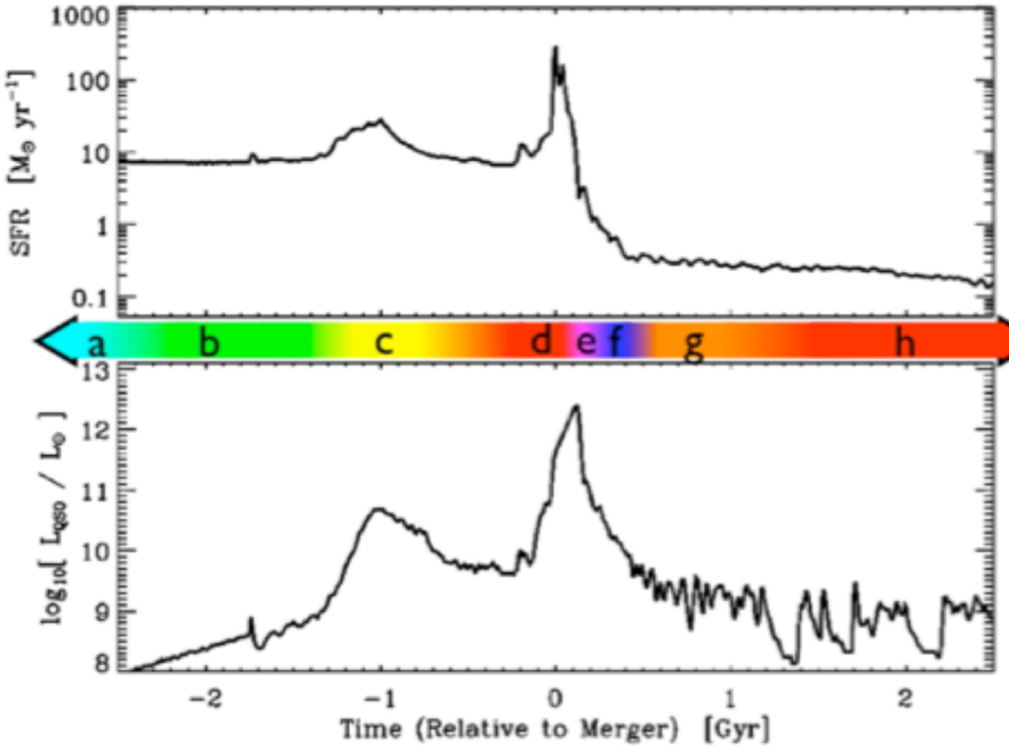
(f) Quasar



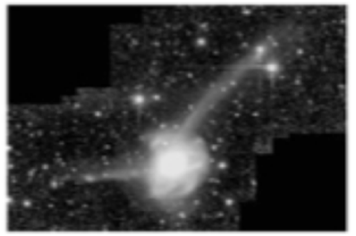
- dust removed: now a "traditional" QSO
- host morphology difficult to observe: tidal features fade rapidly
- characteristically blue/young spheroid

(b) "Small Group"

- halo accretes similar-mass companion(s)
- can occur over a wide mass range
- M_{halo} still similar to before: dynamical friction merges the subhalos efficiently



(g) Decay/K+A



- QSO luminosity fades rapidly
  - tidal features visible only with very deep observations
- remnant reddens rapidly (E+A/K+A)
- "hot halo" from feedback
  - sets up quasi-static cooling

(a) Isolated Disk

- halo & disk grow, most stars formed
- secular growth builds bars & pseudobulges
- "Seyfert" fueling (AGN with M_B>-23)
- cannot redden to the red sequence

(h) "Dead" Elliptical

- star formation terminated
- large BH/spheroid - efficient feedback
- halo grows to "large group" scales: mergers become inefficient
- growth by "dry" mergers