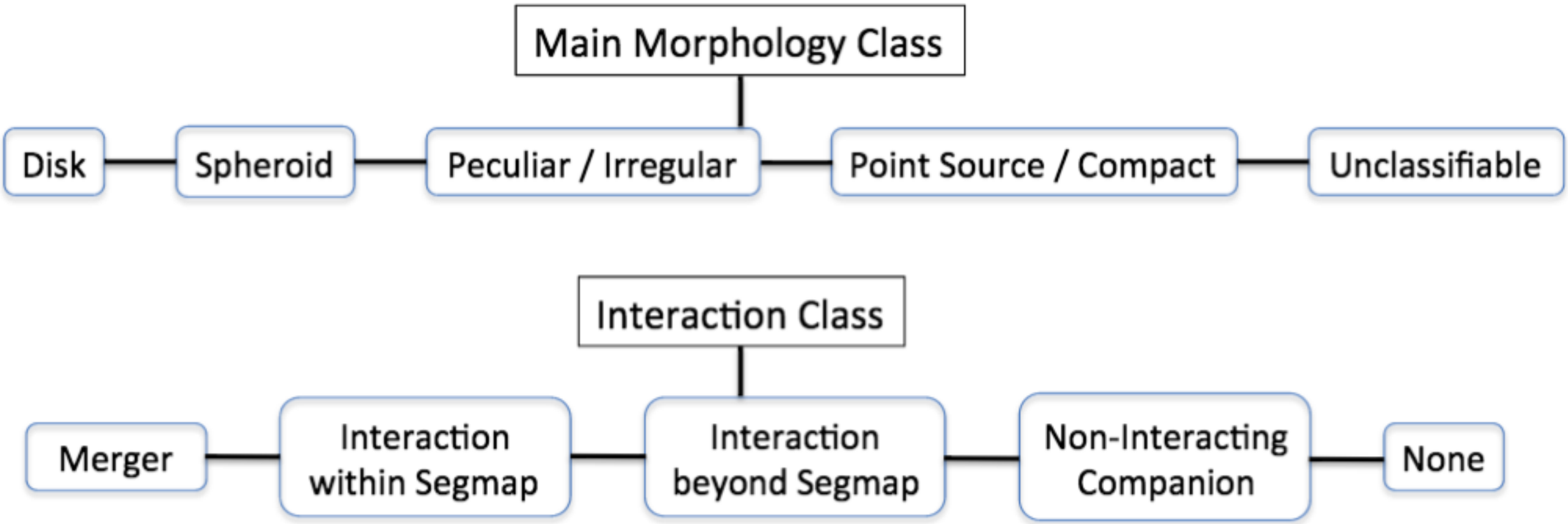
A morphology catalog for SHARDS

M. Huertas-Company

Mei, Shankar, Barro, Pérez-González, Bernardi, Daddi, Cabrera…+ CANDELS morphology team

Huertas-Company+15a,b

CANDELS visual classification tree



Kartaltepe+14

— Classification of galaxies in GOODS-S with **H<24.5**

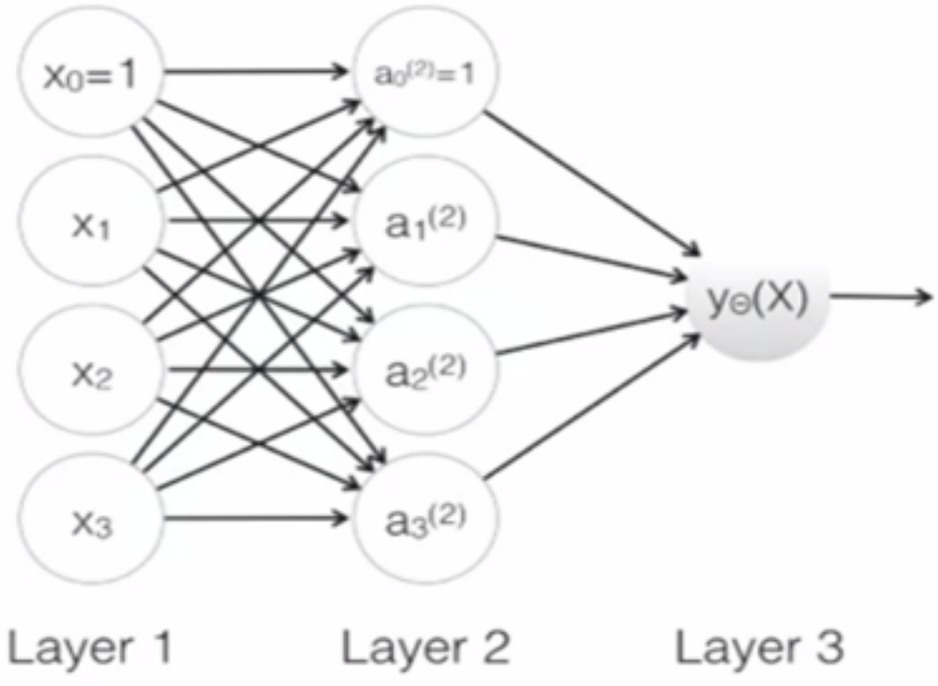
— Each galaxy is classified by 3-5 experts

— Fractions for ~8000 galaxy in GDS

— Classification done in F160 (+F125,F105)

Deep convolutional neural networks

- **Hubel & Wiesel 1962 + LeCun 1998**
- Mimic the human brain
- Learn non-linear features (from pixels!) using hidden layers
- Very expensive in computing time
  - GPUs…
- Very popular, used by *all* the technology giants (Google, Microsoft)



- 99.2% accuracy

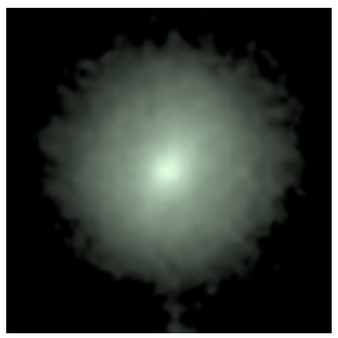
- 94.3 % accuracy

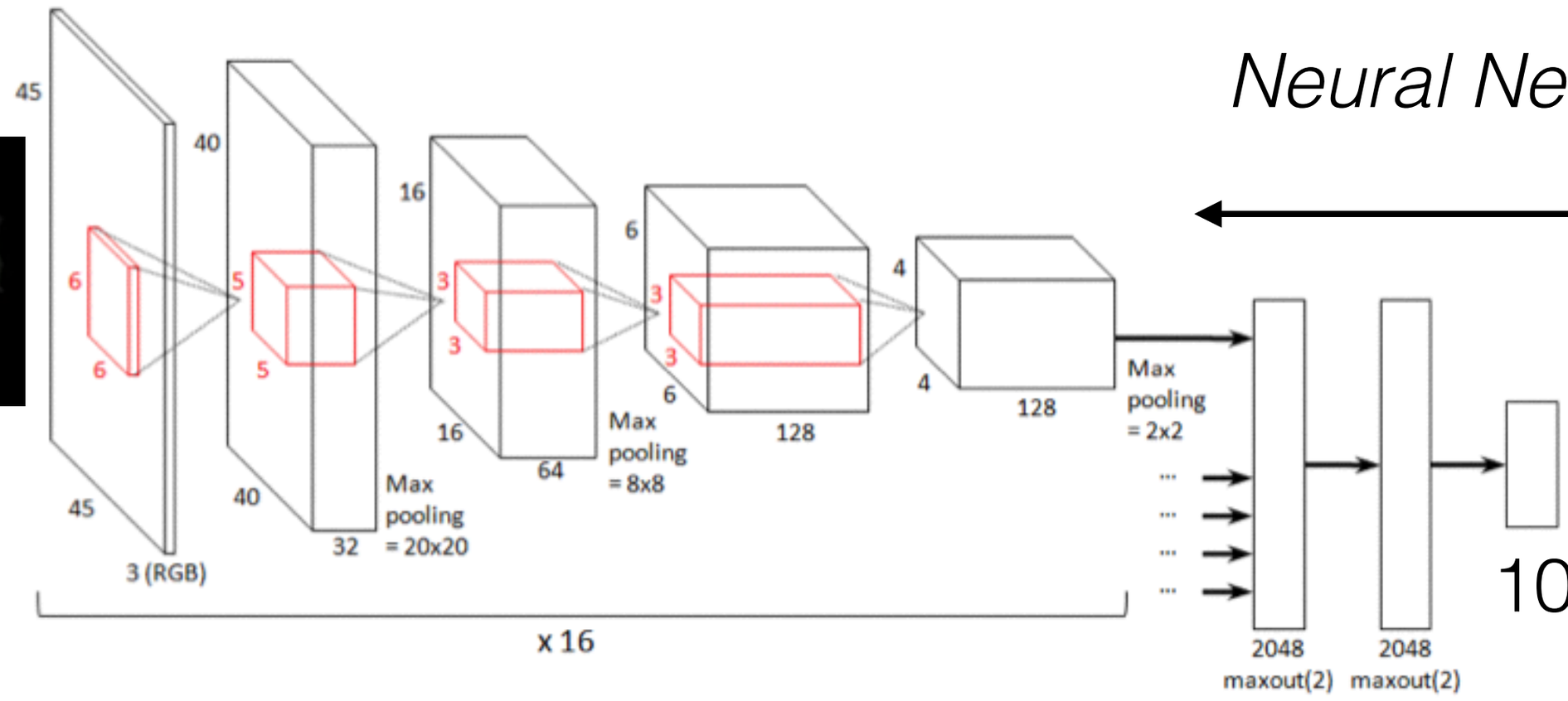
CONVNET for CANDELS

- **TRAIN**: ~50.000 redundant galaxies in GDS (~10 days)
- **CLASSIFY**: GDN, COSMOS, UDS, GDS, EGS (~8h/field)

Feature learning

Neural Network



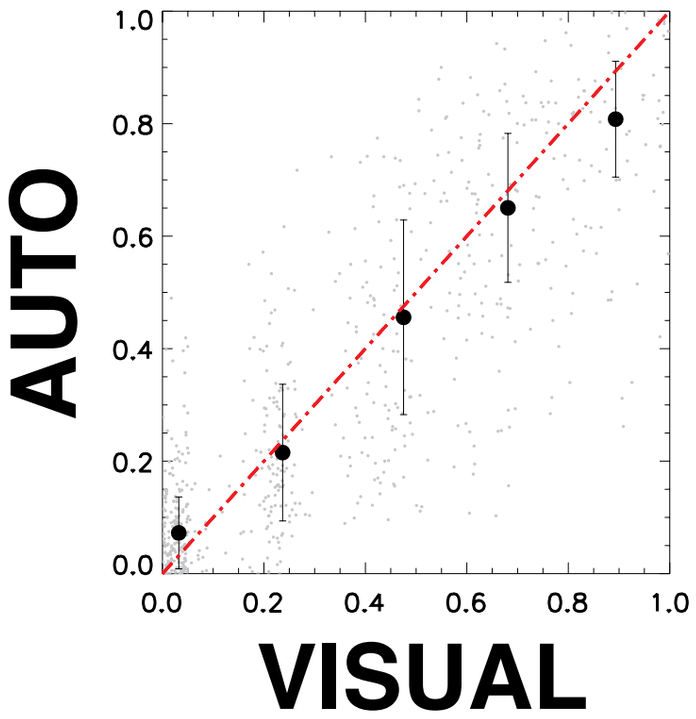


Dielman+14, MHC+15a

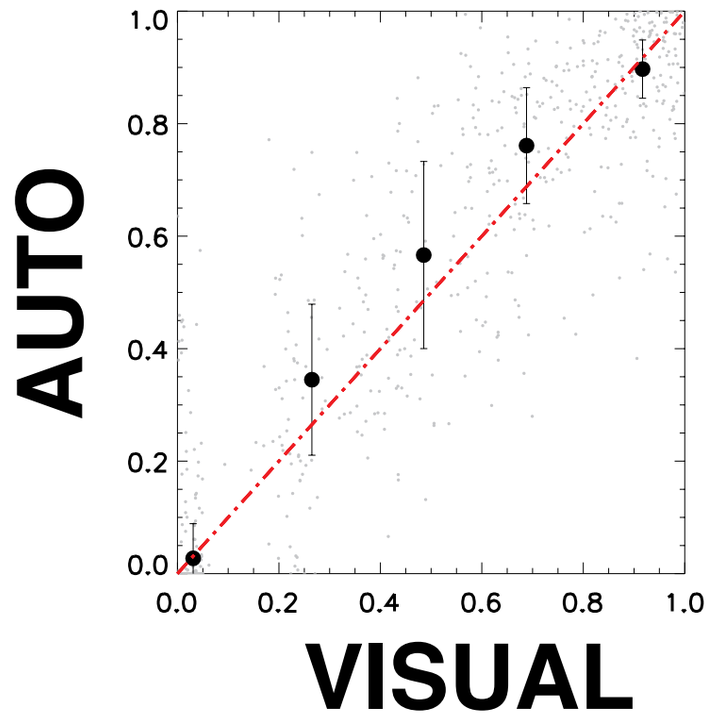
INPUT: *RGB JPEG GDS snapshots*

OUTPUT: *10 probs.*

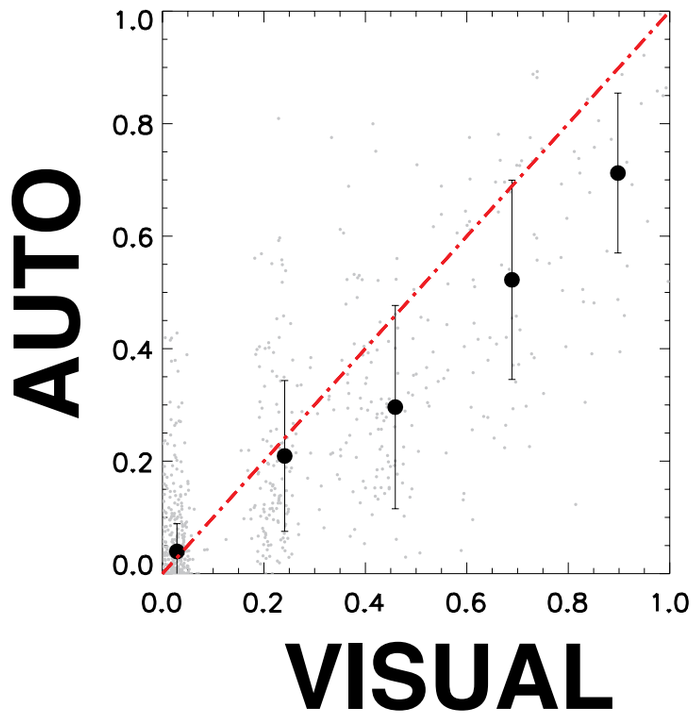
SPH



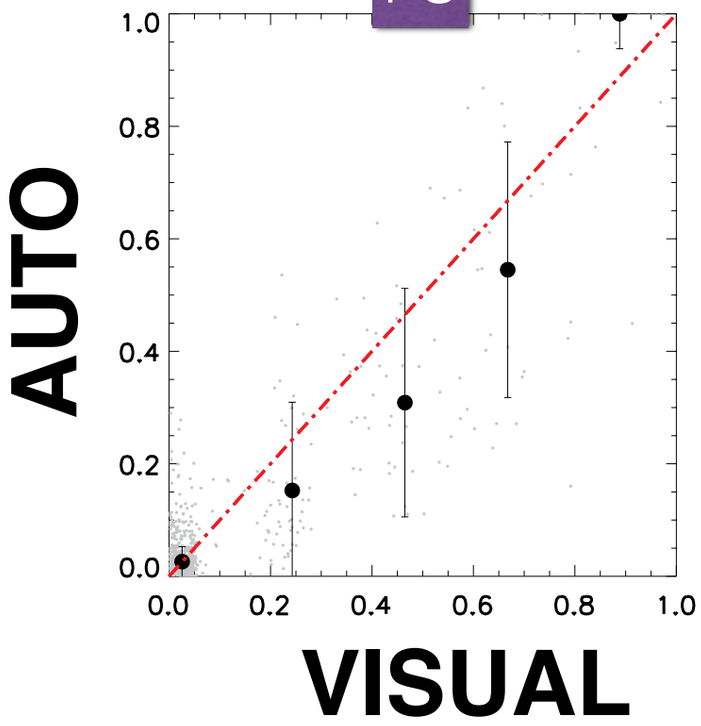
DISKS



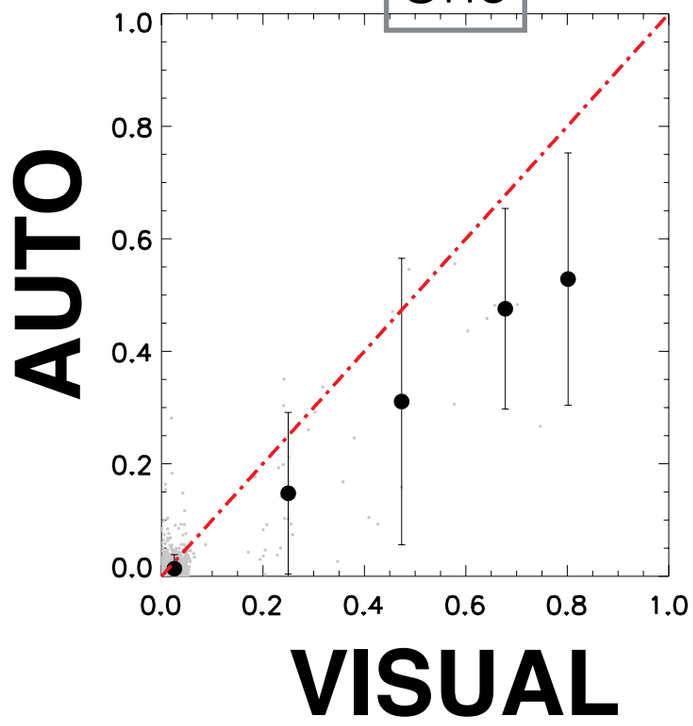
IRR



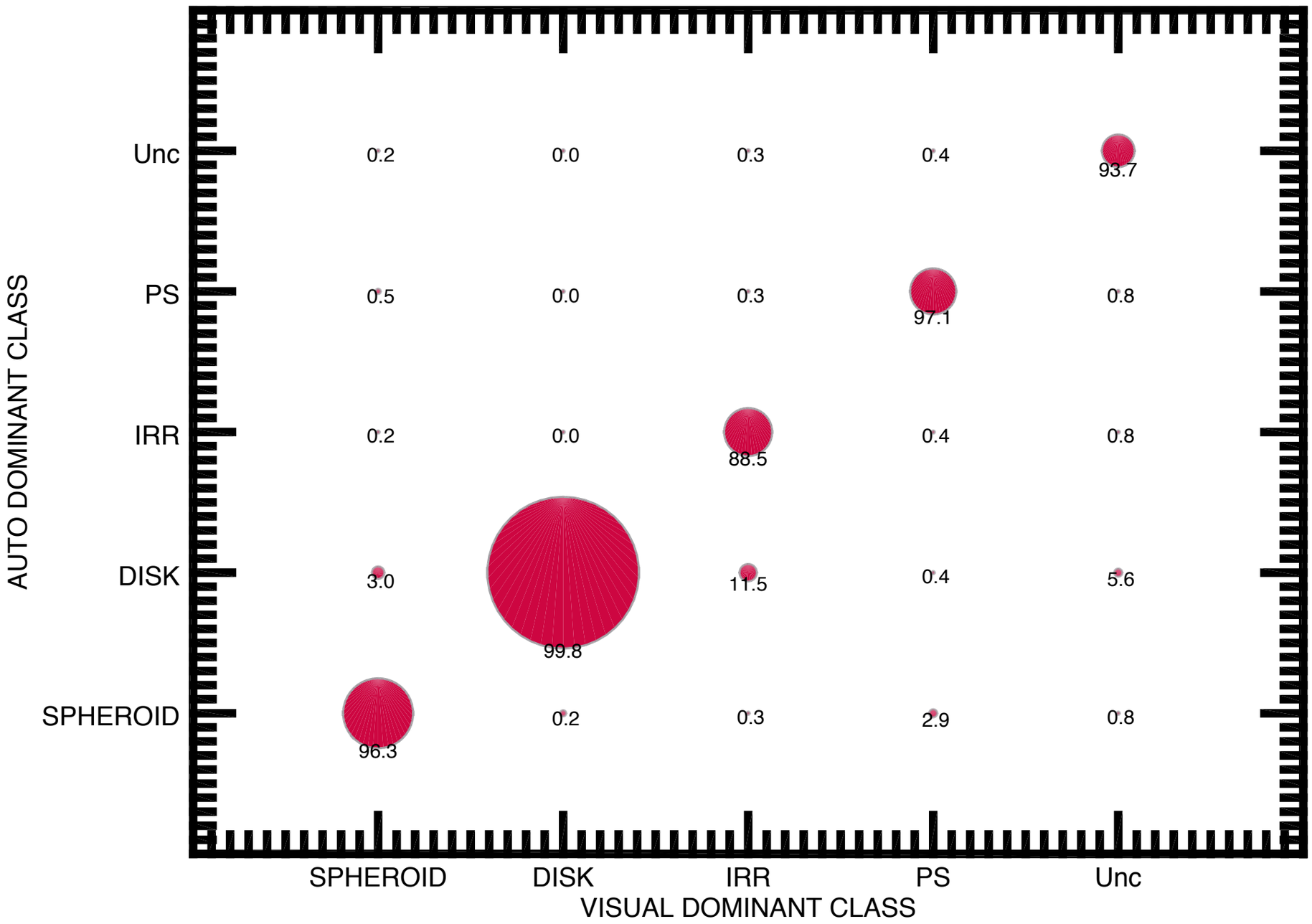
PS



Unc



MHC+15a

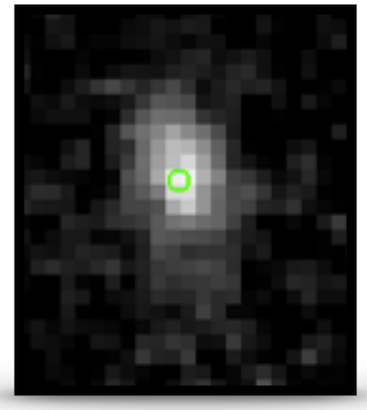

Unc
PS
IRR
DISK
SPHEROID
0.2
0.0
0.3
0.4
93.7
0.5
0.0
0.3
97.1
0.8
0.2
0.0
88.5
0.4
0.8
3.0
99.8
11.5
0.4
5.6
0.2
0.3
2.9
0.8
96.3
AUTO DOMINANT CLASS
SPHEROID
DISK
IRR
PS
Unc
VISUAL DOMINANT CLASS

MHC+15a

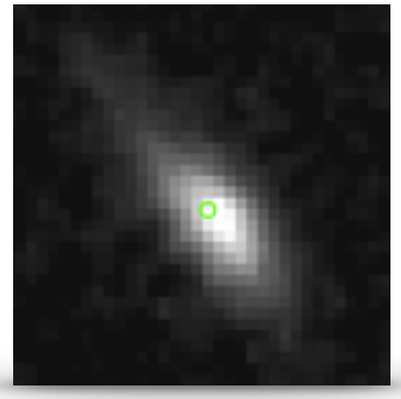
Catastrophic “errors”

fsph_v > 0.7 and fsph_a < 0.3 or fsph_v < 0.3 and fsph_a < 0.7

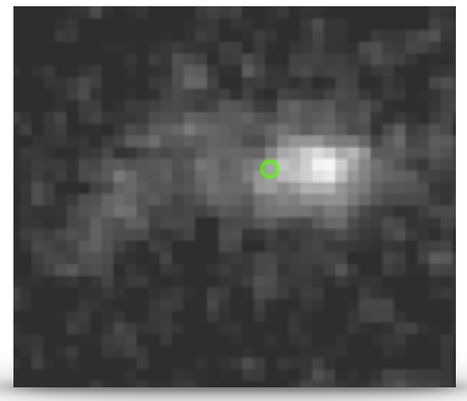
~15/8000=0.2%



fsph=0.82 / 0.25
fdisk = 0.5 / 0.76
firr = 0.0 / 0.22



fsph=0.8 / 0.25
fdisk = 0.75 / 0.95
firr = 0.0 / 0.0

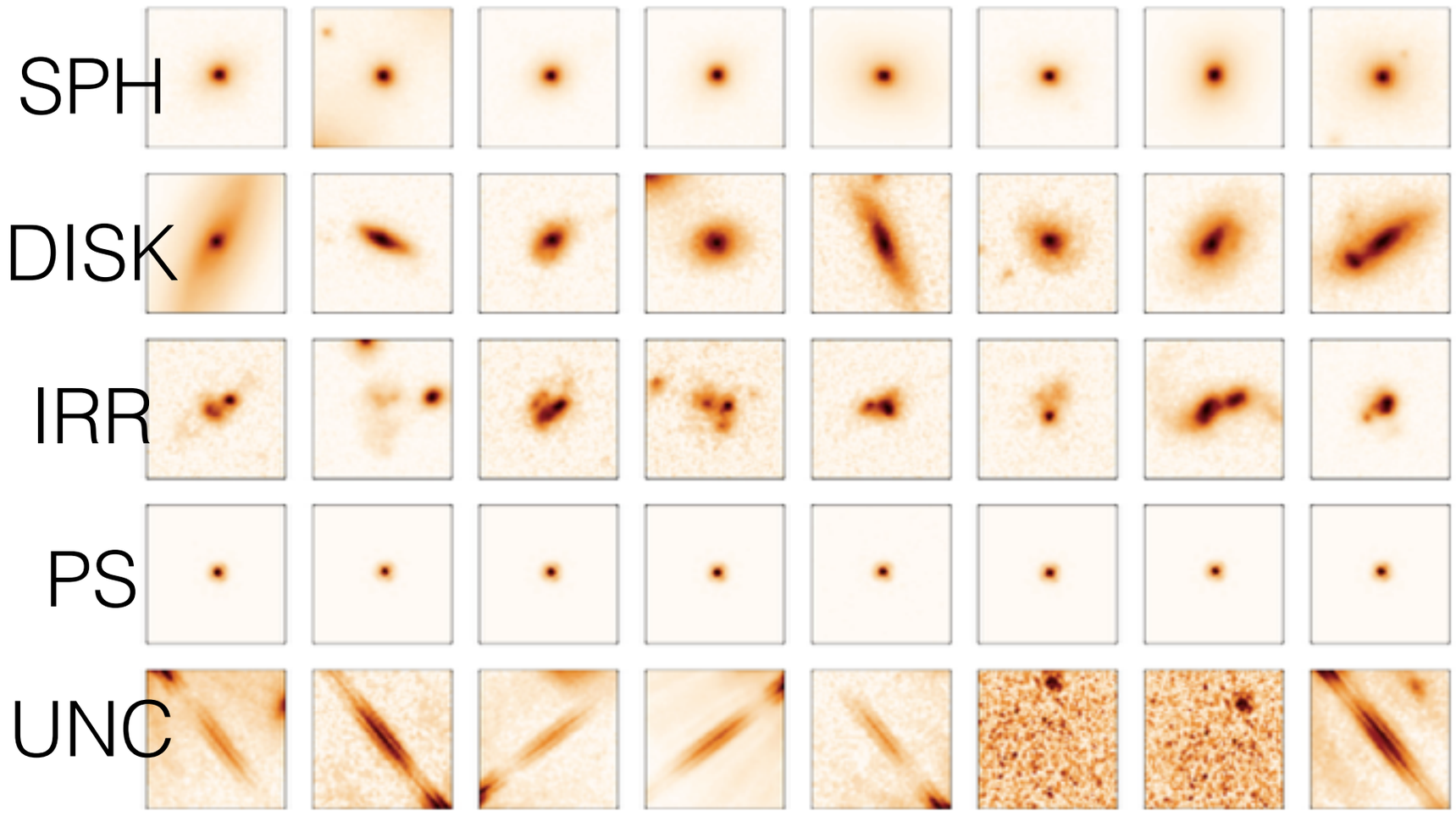


fsph=0.76 / 0.11
fdisk = 0.6 / 0.66
firr = 0.39 / 0.53

VISUAL / AUTO

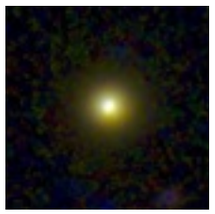
Catalog available in Rainbow

- ~ **50.000** galaxies in **5 CANDELS fields** (GDN, GDS, COSMOS, UDS, EGS) *X 3 filters X 3 rotations*
- 10 probabilities (fractions for each galaxy)
- **H < 24.5**
- **<z>= 1.25**
- Optical rest-frame morphology at 1<z<3
- ~80% complete at Mstar>10^10 Msol

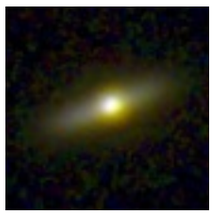


MHC+15a

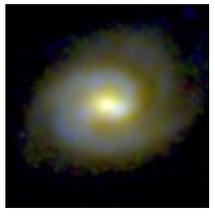
Use it for your science!



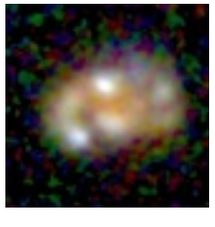
***Pure* SPHEROIDS**



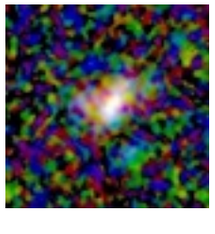
BULGE + DISK



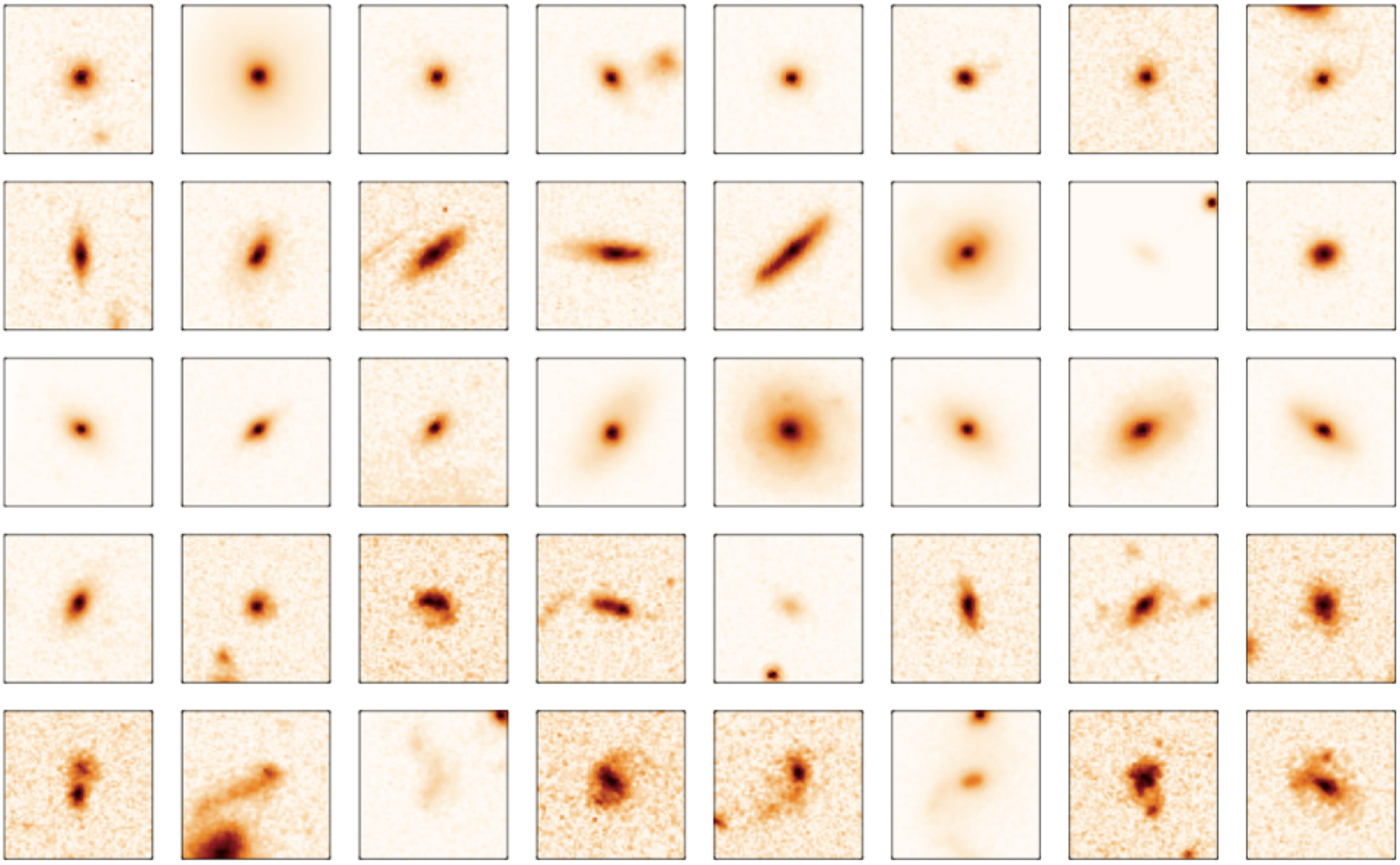
***Regular* DISKS**



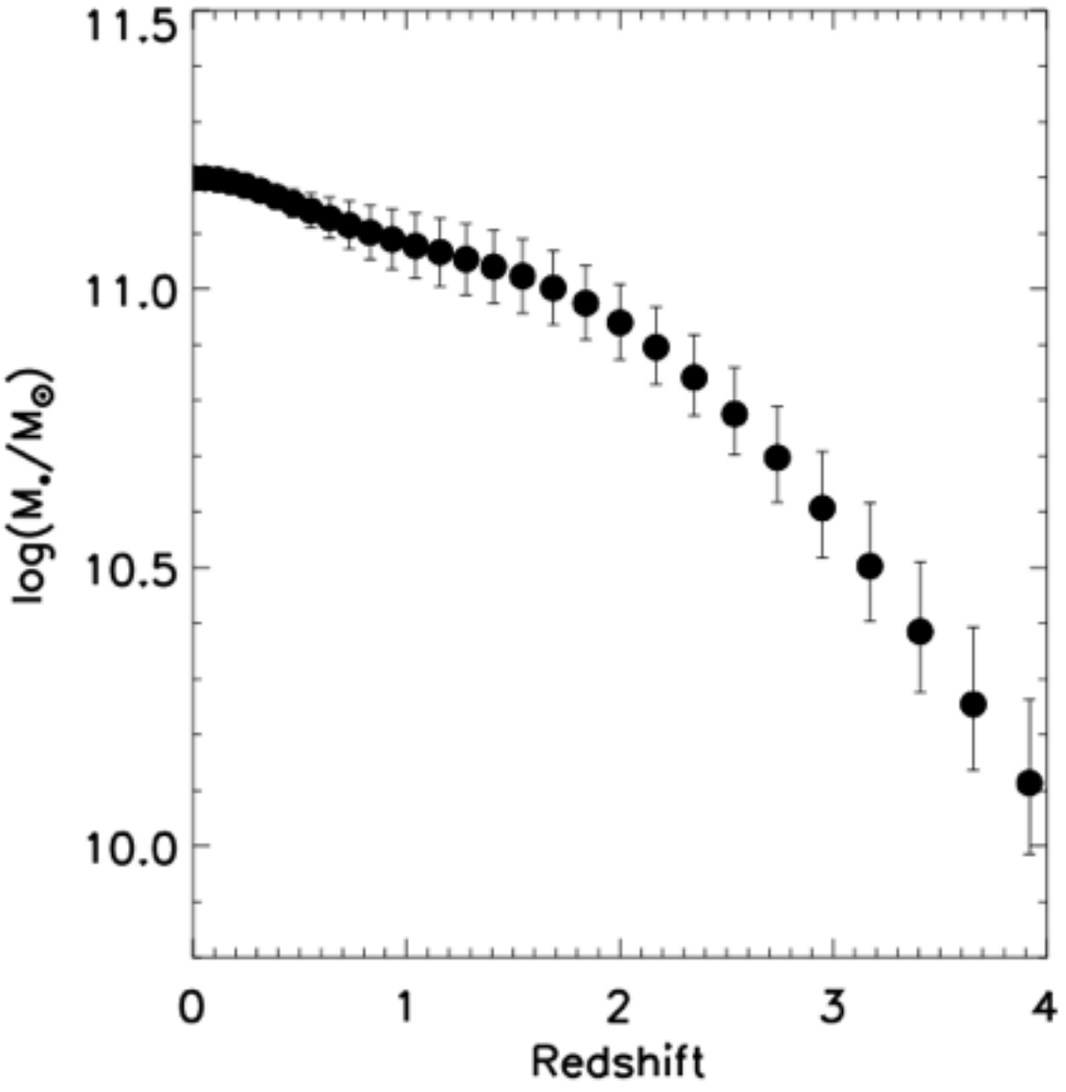
Irr*egular* DISKS



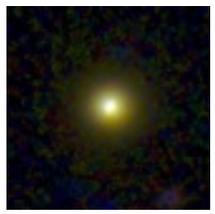
Irr*egulars*



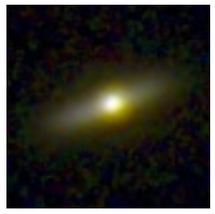
Selection along the progenitors



Detailed morphologies

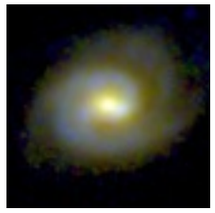


***Pure* SPHEROIDS**



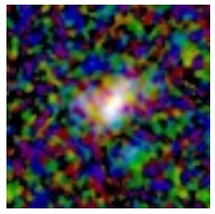
BULGE + DISK

+

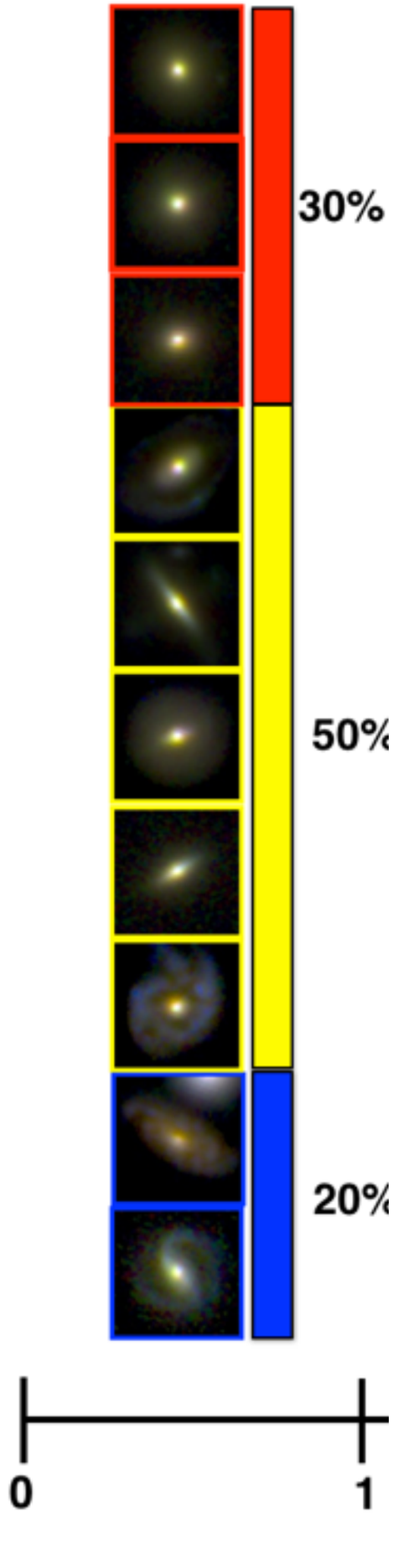


***Regular* DISKS**

Irr*egular* DISKS



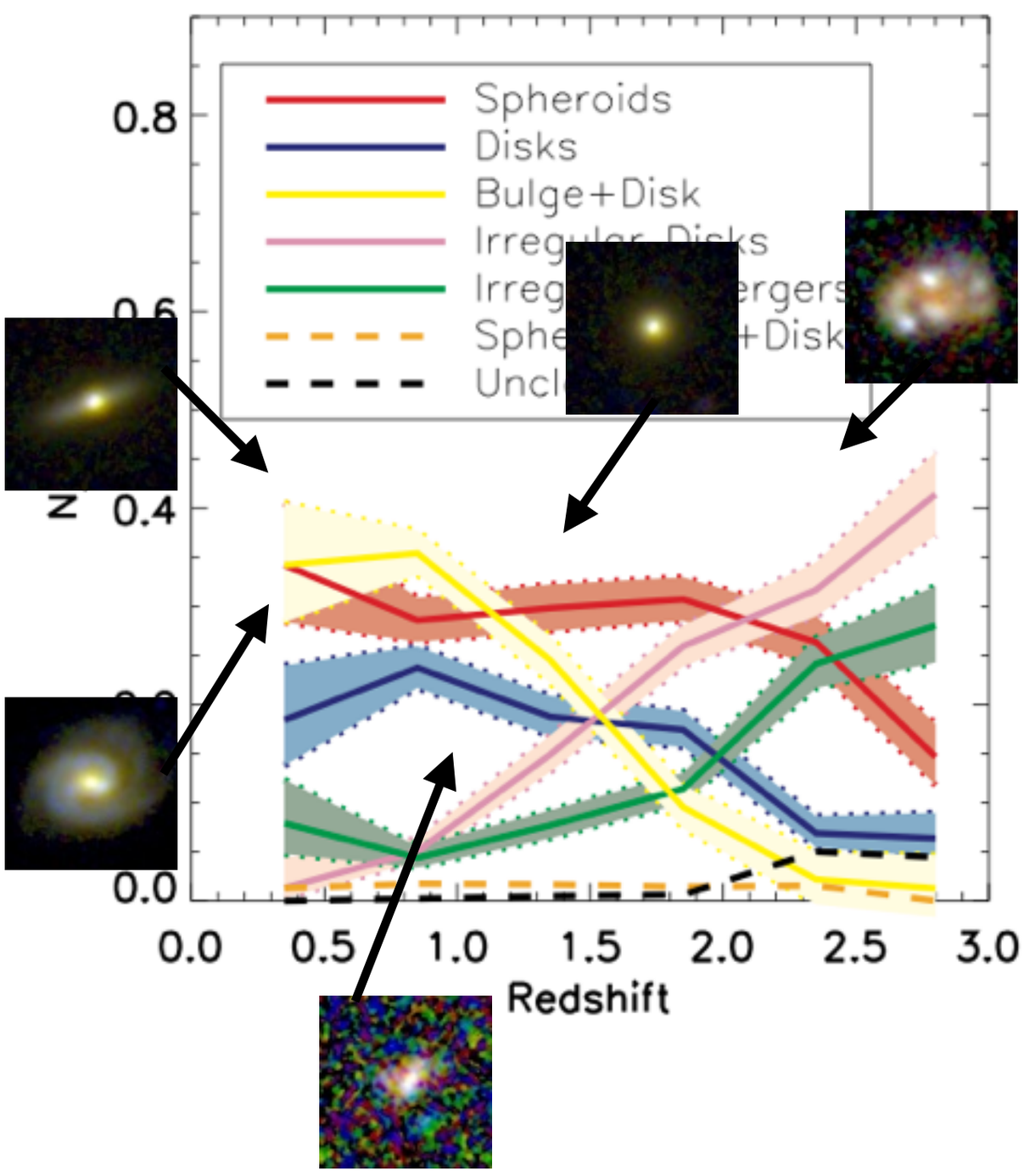
Irr*egulars*

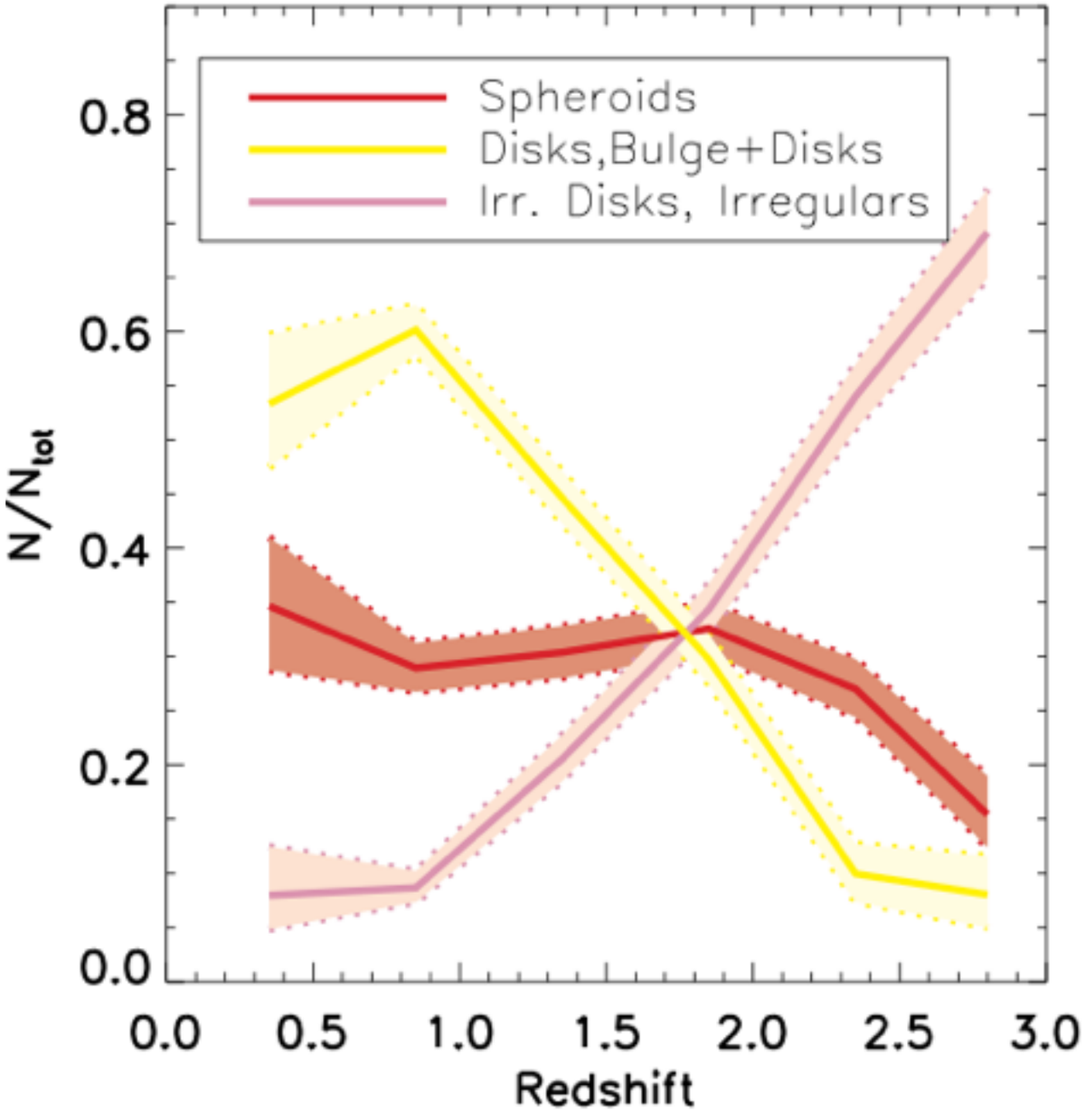


A constant fraction of “pure bulges”

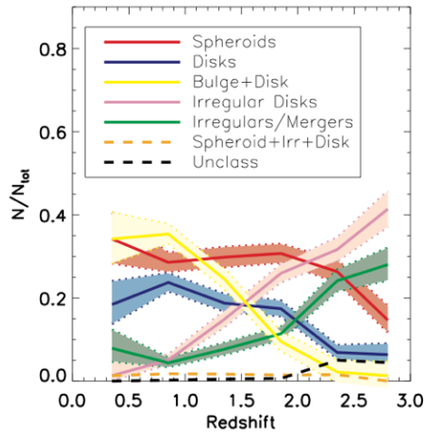
~70% of progenitors of massive galaxies at z~3 were irregular

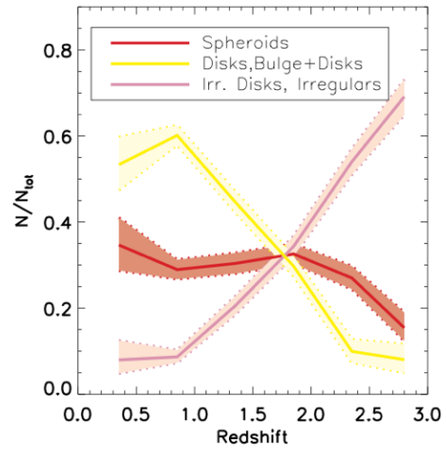
MHC+15b


Spheroids
Disks
Bulge+Disk
Irregular Disks
Irreg ergers
Sphe +Disk
Uncl
N/N_tot
0.0
0.2
0.4
0.6
0.8
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Redshift

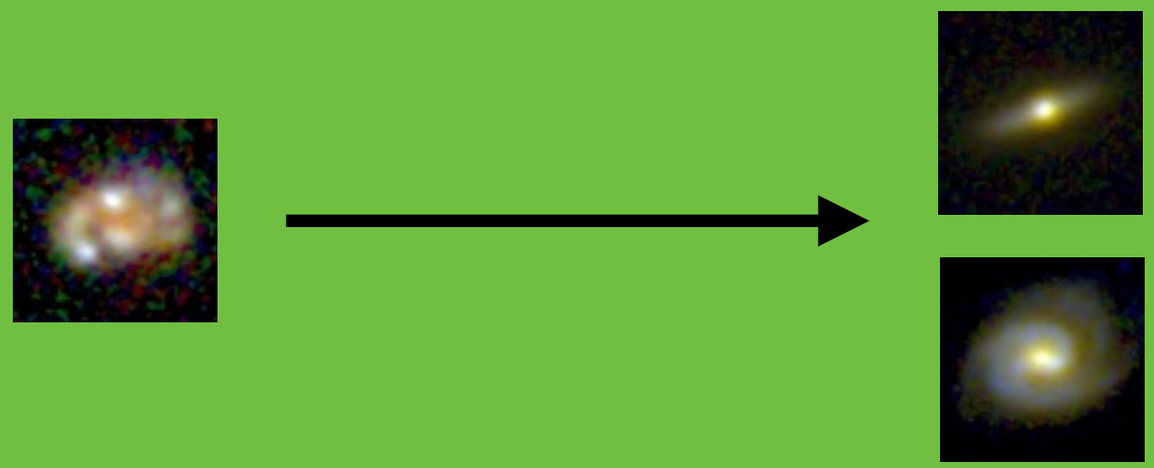

Spheroids
Disks,Bulge+Disks
Irr. Disks, Irregulars
N/N_tot
0.0
0.2
0.4
0.6
0.8
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Redshift

MHC+15b



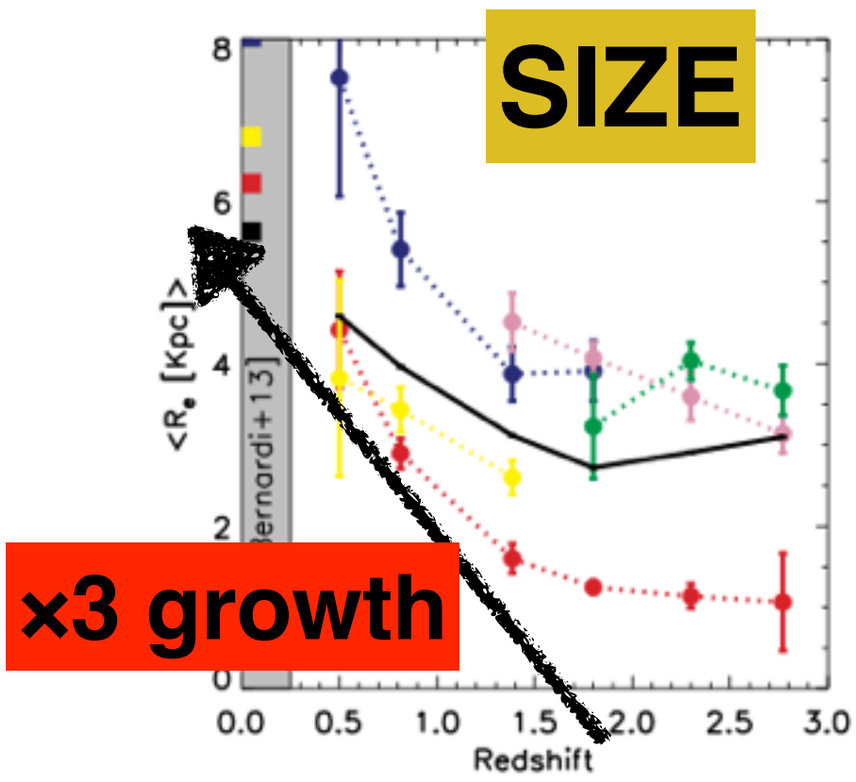


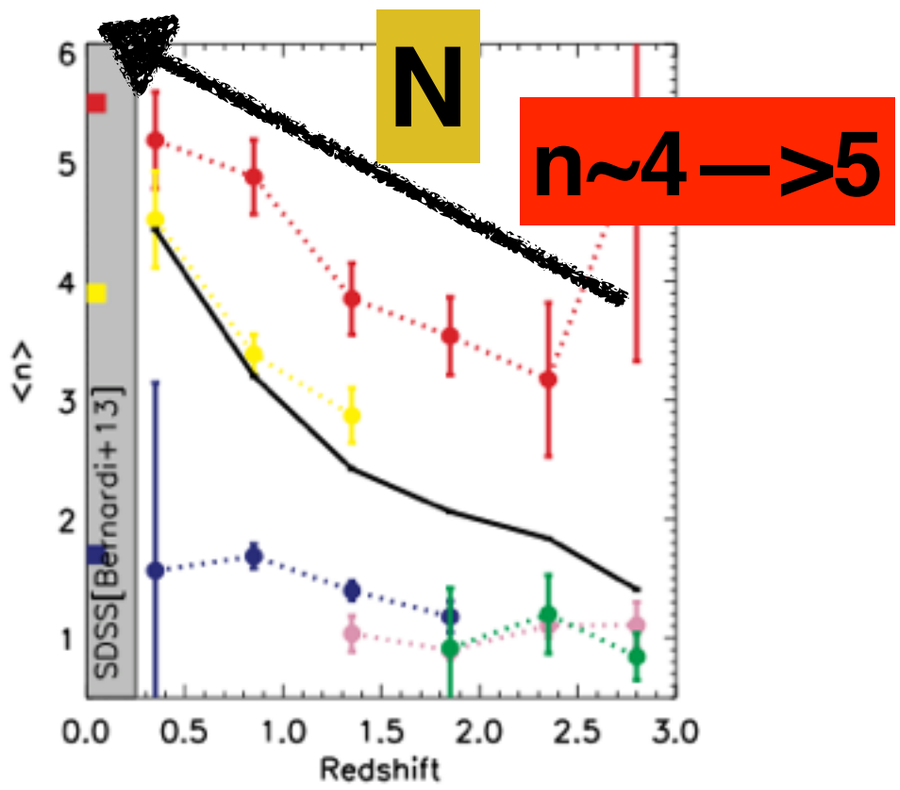
1. **“A clumpy track” (slow)**: A morphological transformation at z>1 from clumpy/irregular disky galaxies to regular disk +bulge systems



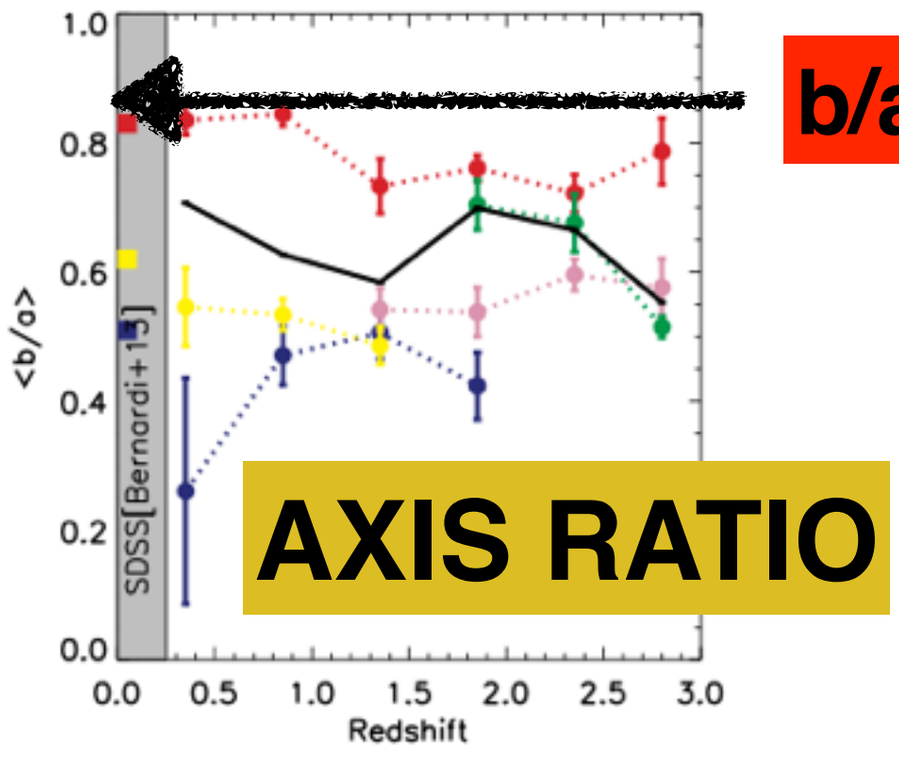
2. **“A nugget track” (fast):** Bulges rapidly formed at z>2.5

Structure



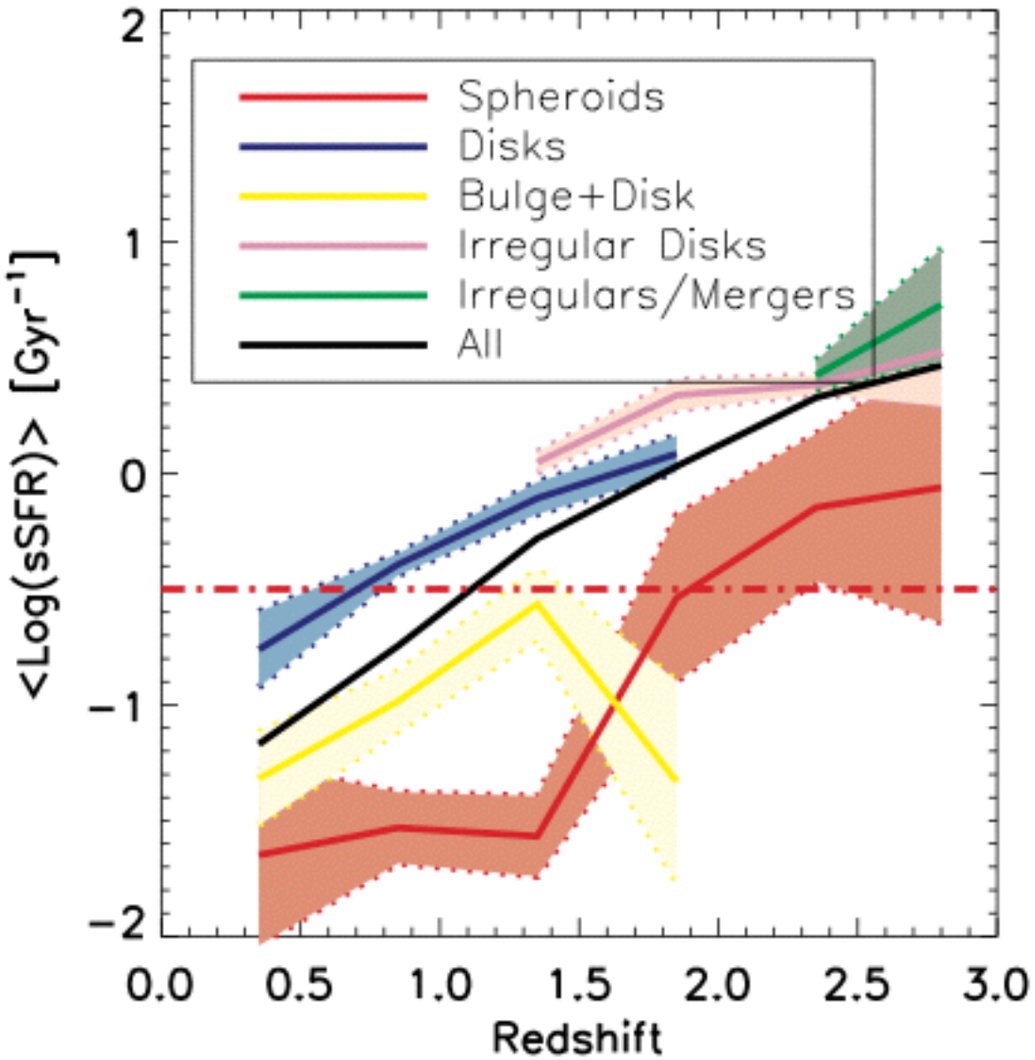


— ALL

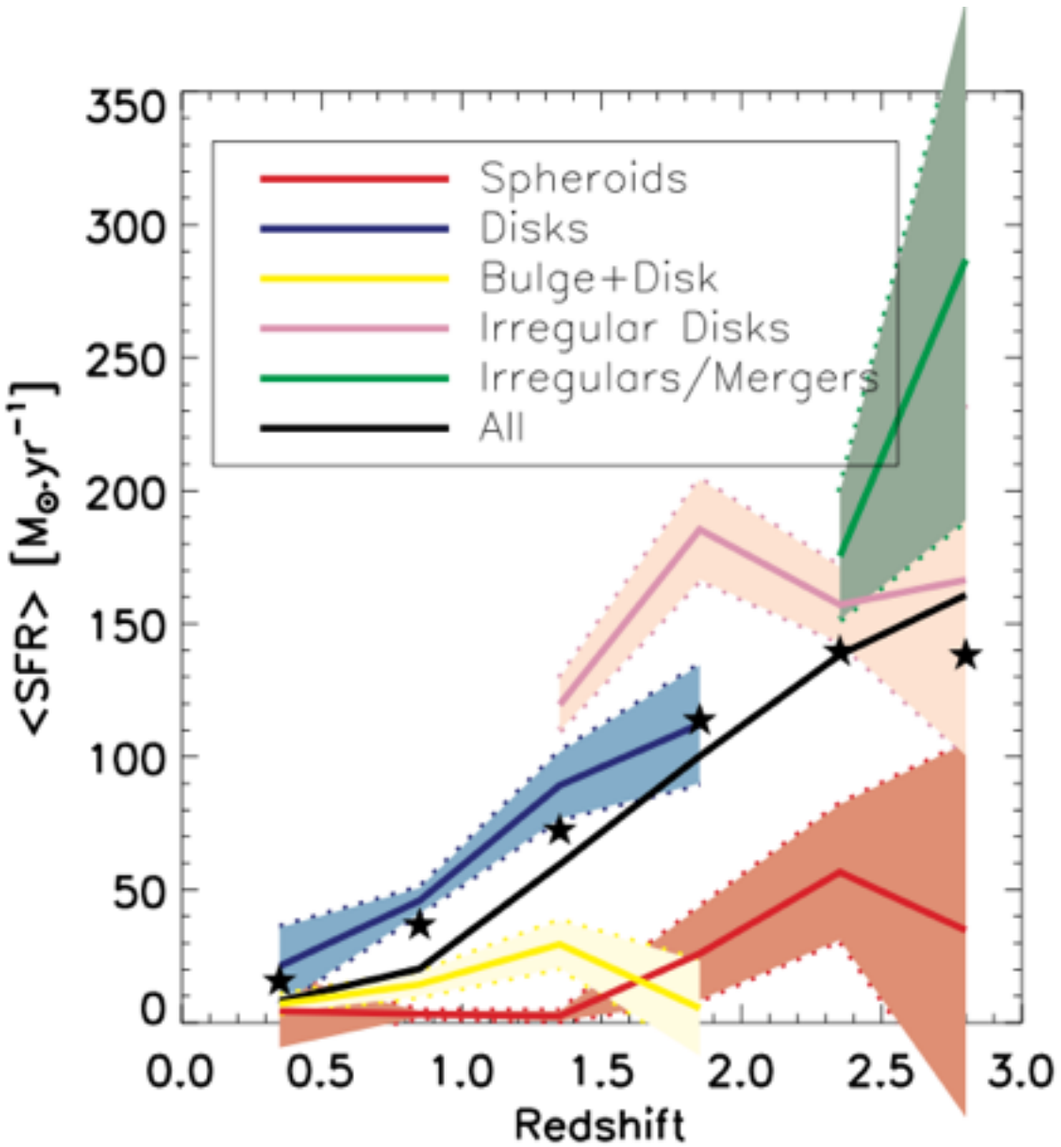


MHC+15b

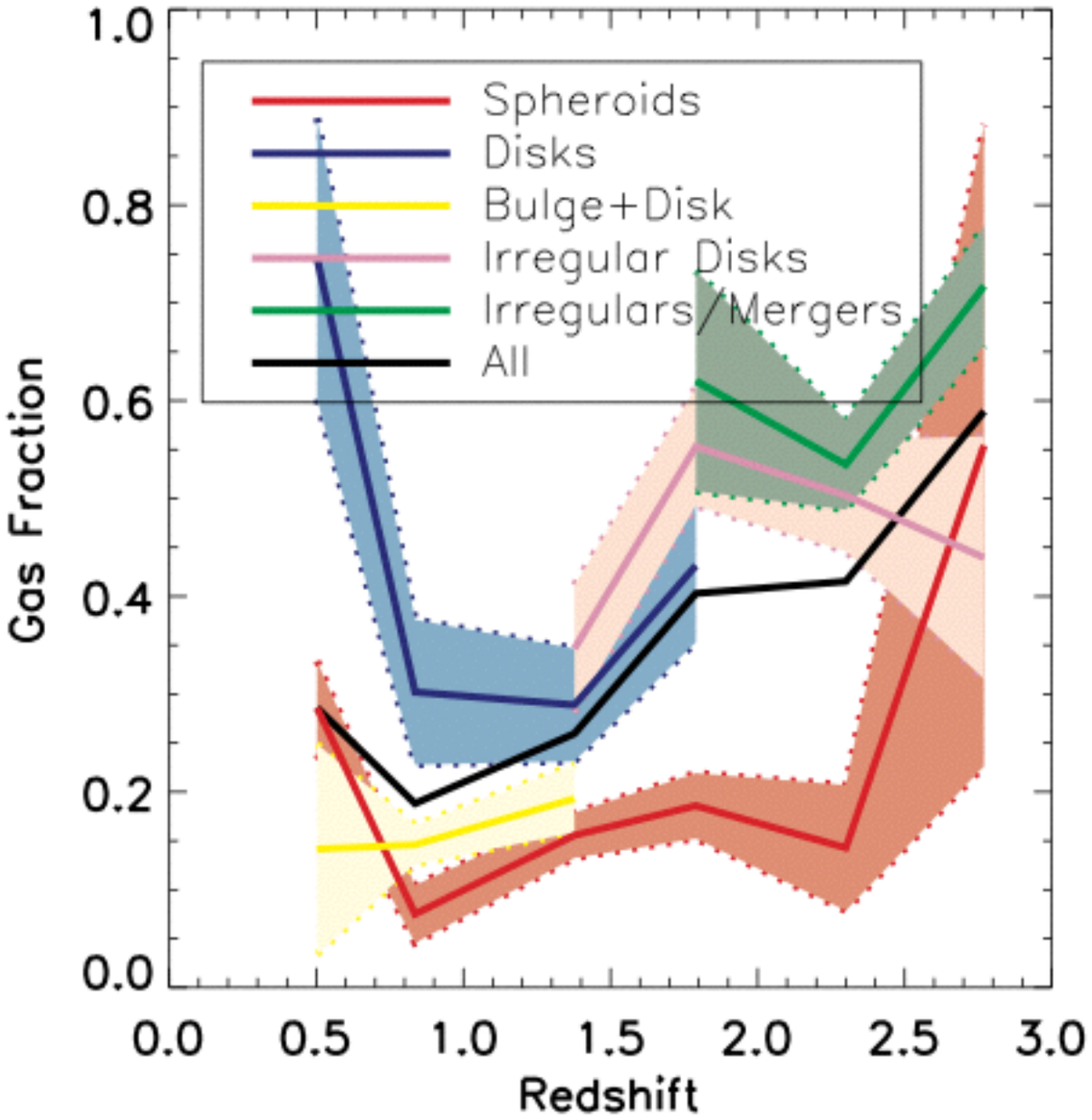
Star-formation histories

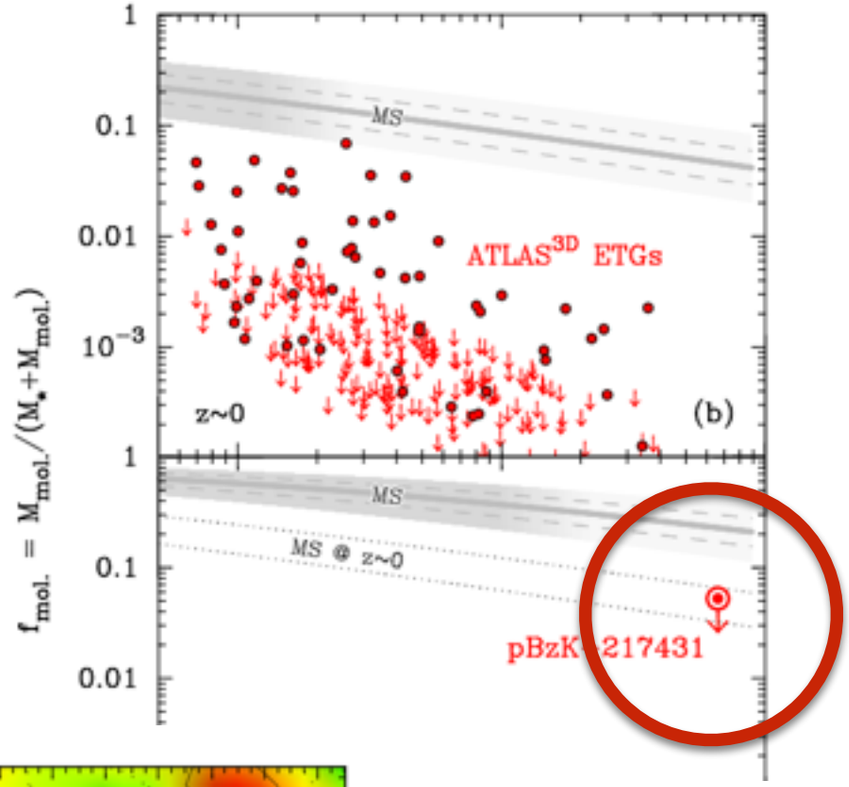


sSFR

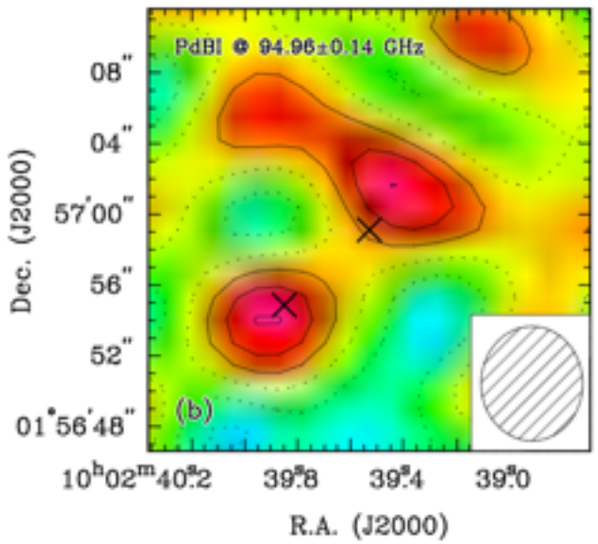


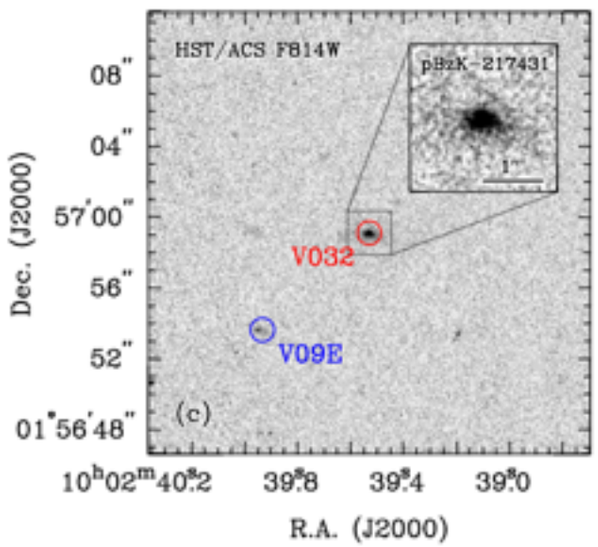
(Inferred) Gas fraction





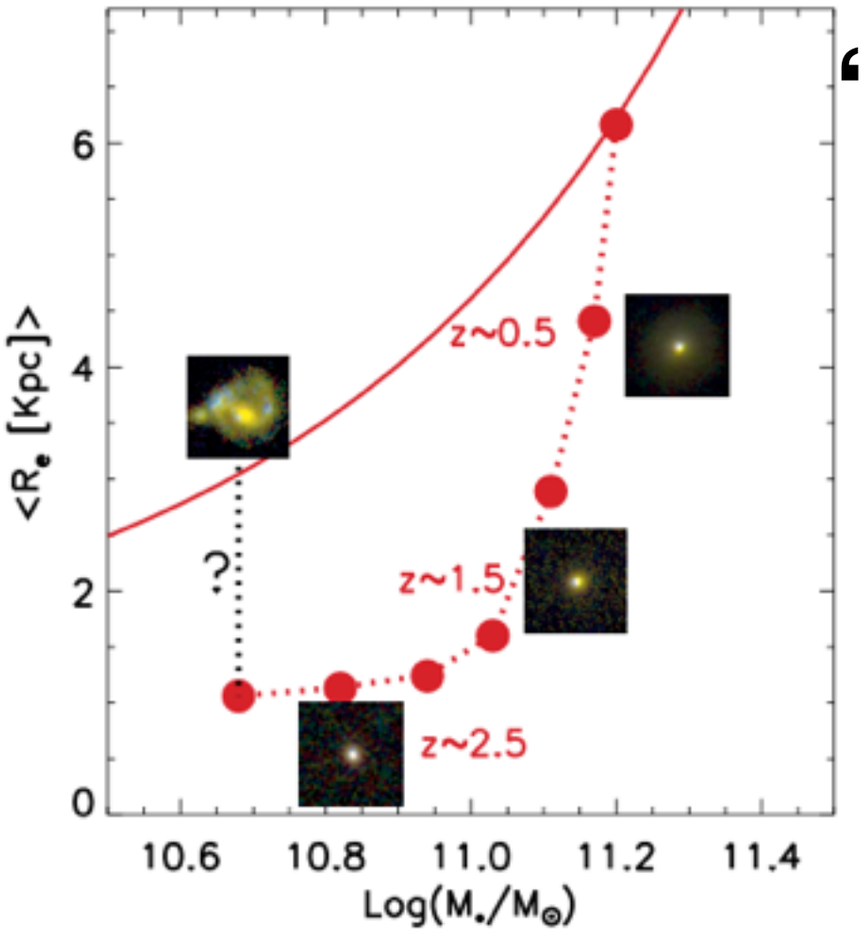
~5%fgas

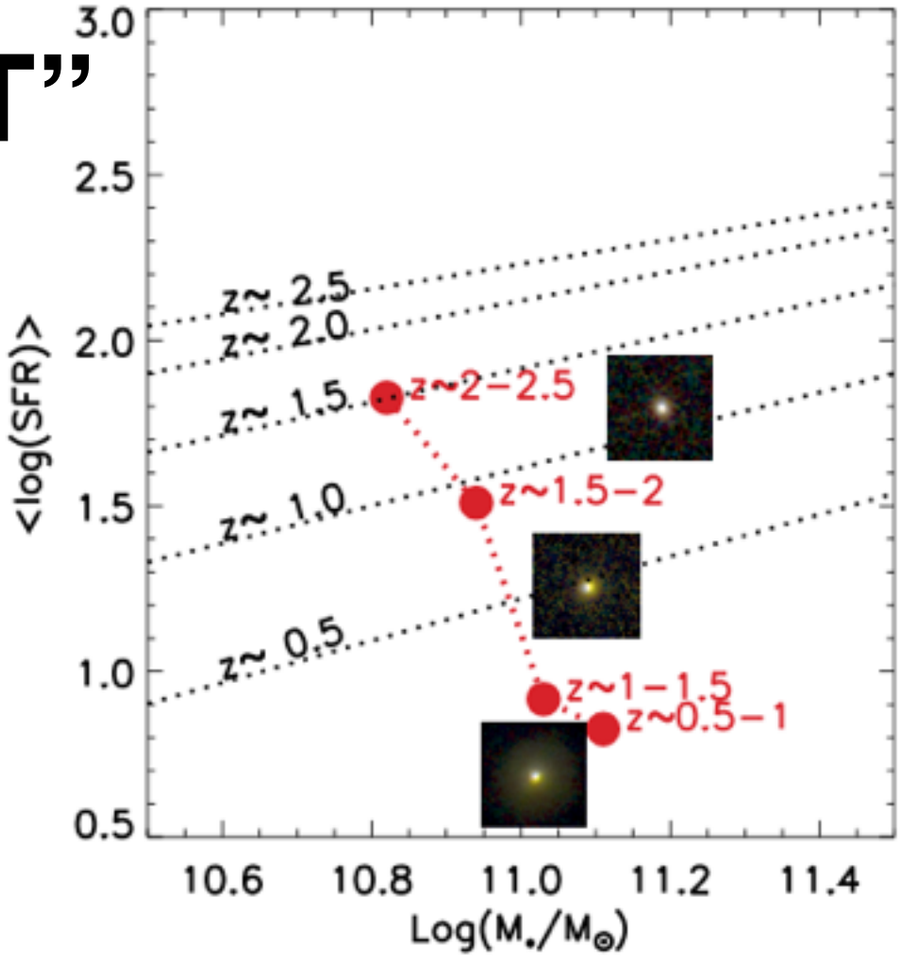




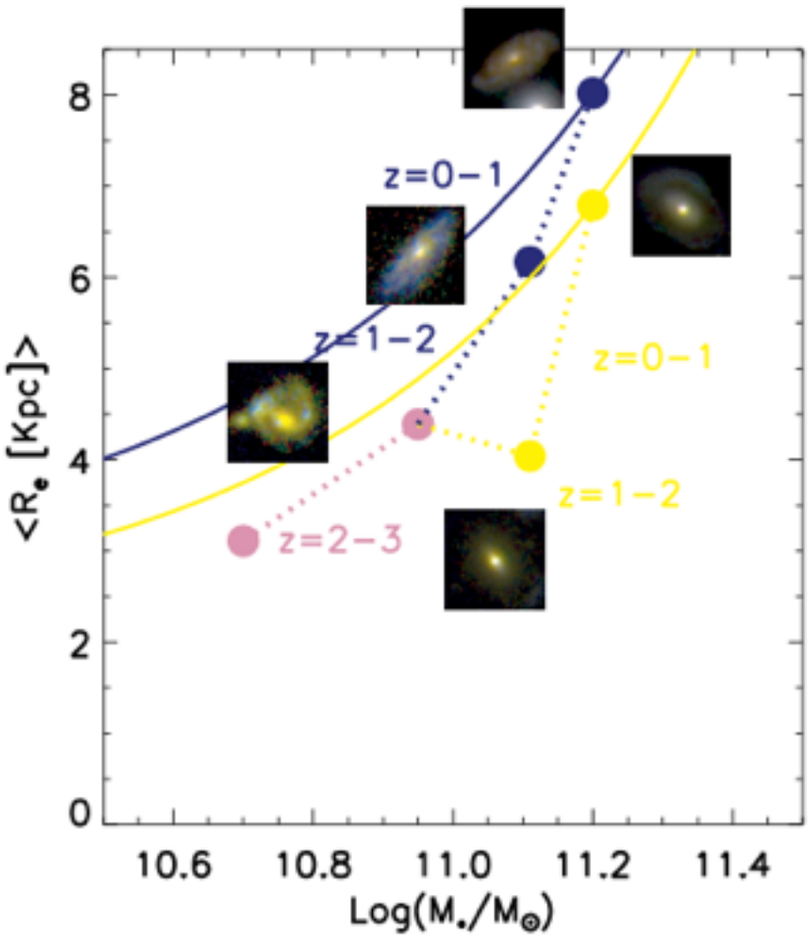
Sargent+15

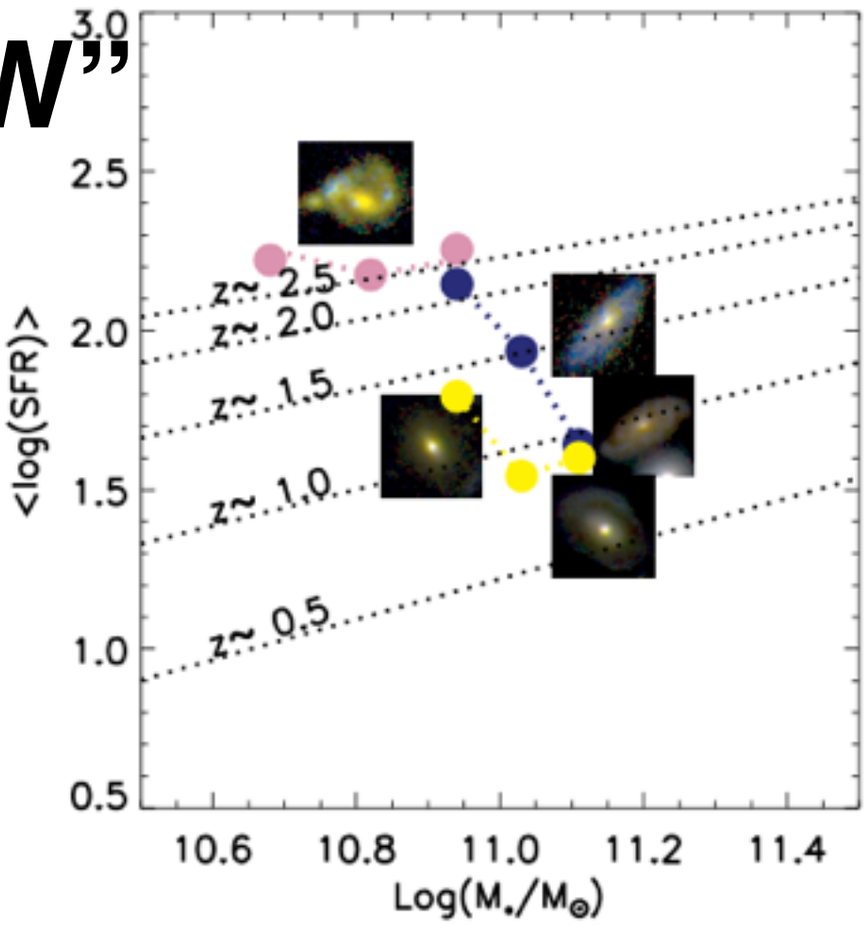
“FAST”


z~0.5
z~1.5
z~2.5
?
<Re [Kpc]>
Log(M*/M⊙)


z~2.5
z~2.0
z~1.5
z~1.0
z~0.5
z~2–2.5
z~1.5–2
z~1–1.5
z~0.5–1
<log(SFR)>
Log(M*/M⊙)

“SLOW”


z=0–1
z=1–2
z=2–3
z=0–1
z=1–2
<Re [Kpc]>
Log(M*/M⊙)


z~2.5
z~2.0
z~1.5
z~1.0
z~0.5
<log(SFR)>
Log(M*/M⊙)

Testing these tracks with SHARDS (see Paola's talk tomorrow)

HST imaging in GDN (7 filters)

multi-lambda B/D dec.

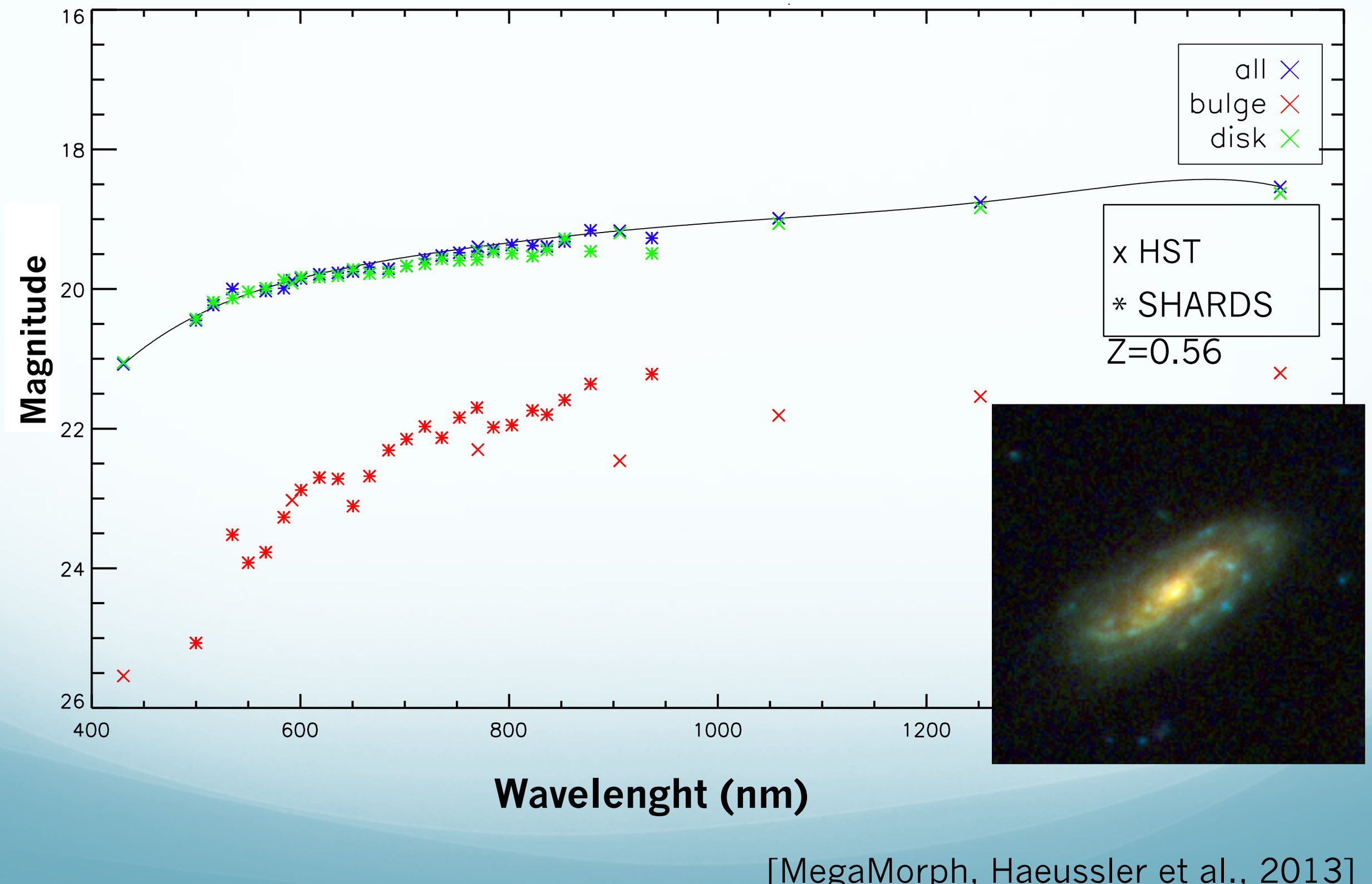
Bulge+Disk structural parameters as a function of wavelength

SHARDS

+

Accurate stellar populations of disks and bulges

CANDELS+SHARDS data



[MegaMorph, Haeussler et al., 2013]