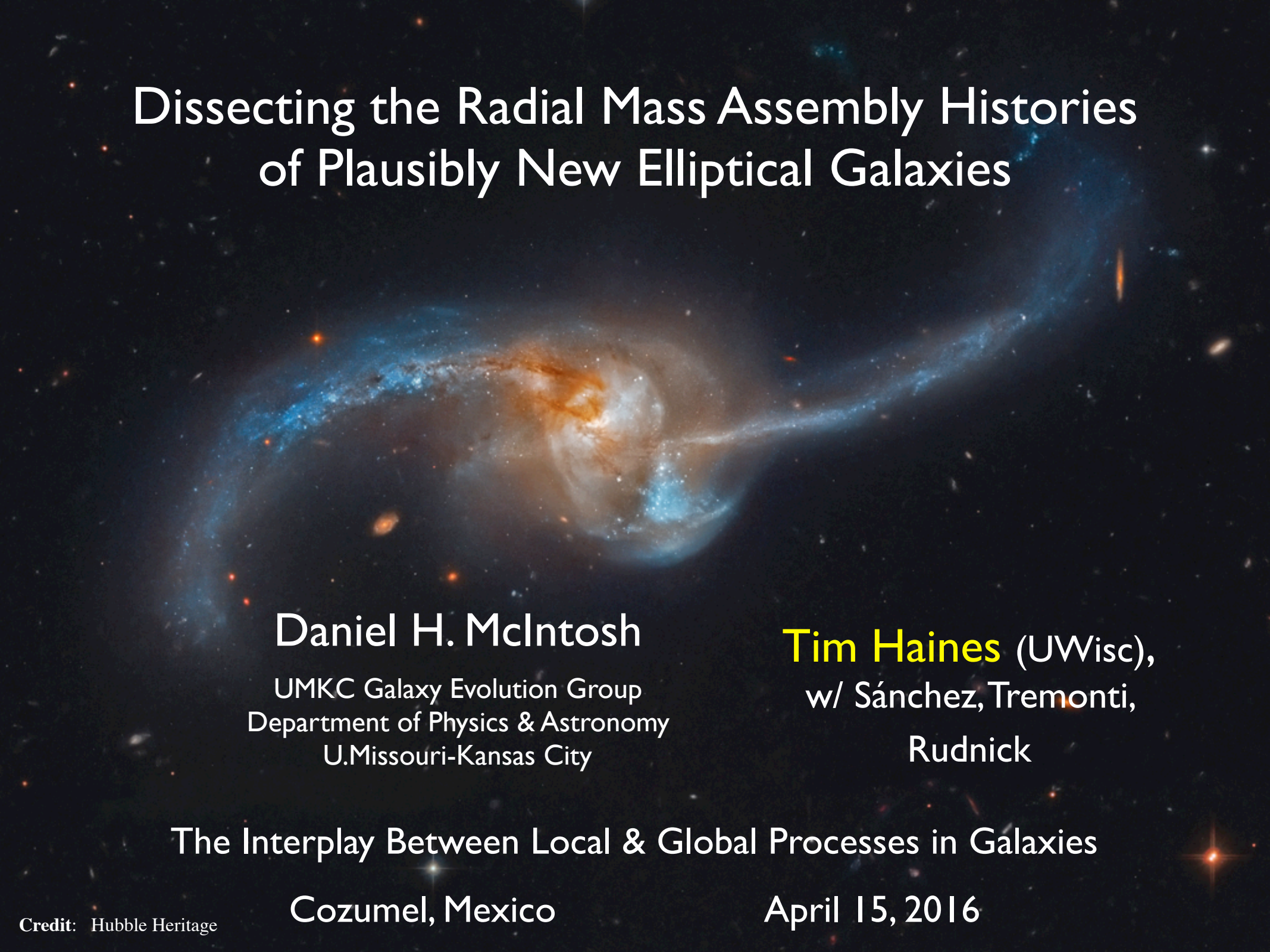
Dissecting the Radial Mass Assembly Histories of Plausibly New Elliptical Galaxies



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Tim Haines (UWisc),
w/ Sánchez, Tremonti,
Rudnick

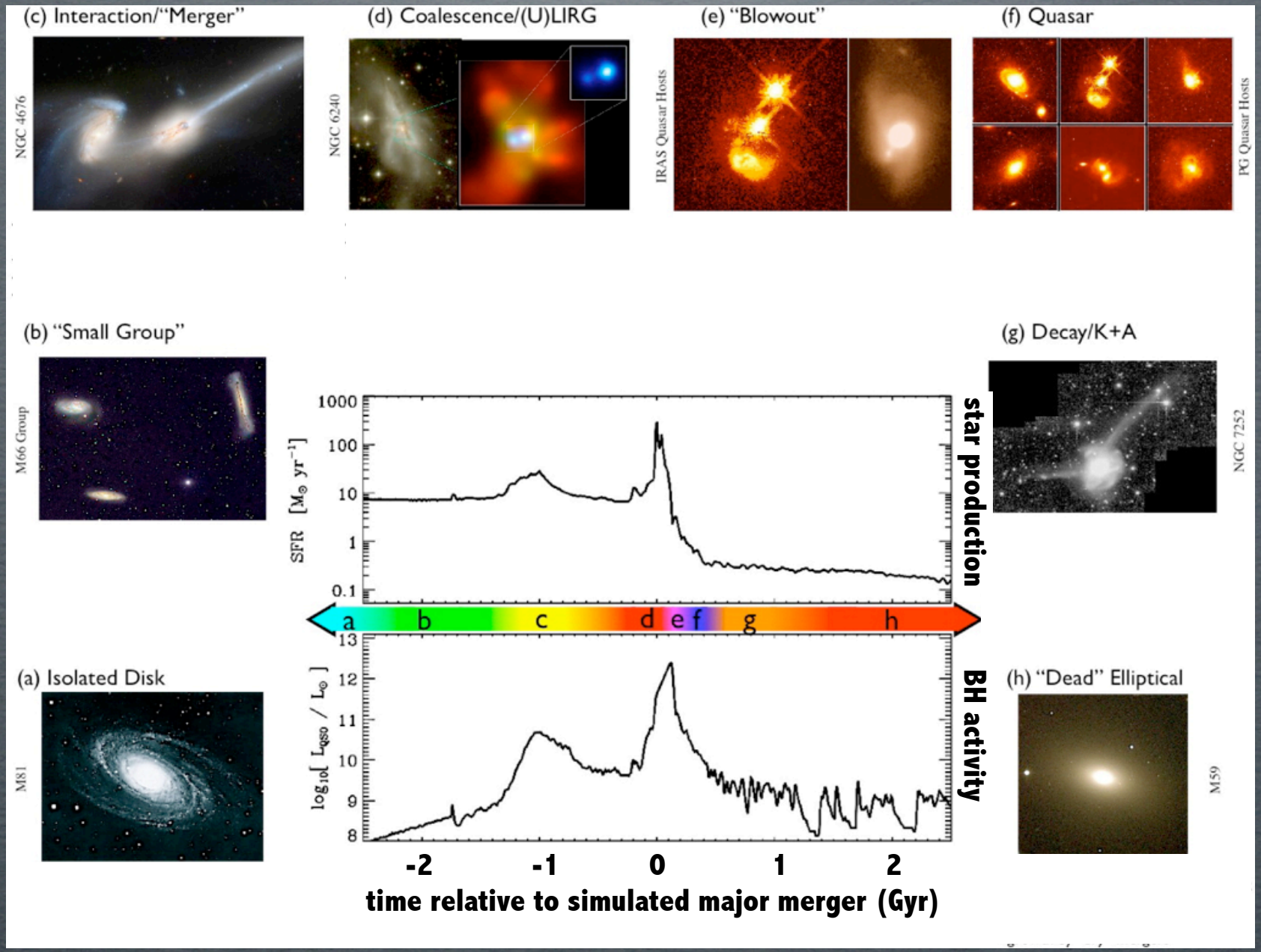
The Interplay Between Local & Global Processes in Galaxies

Cozumel, Mexico April 15, 2016

Credit: Hubble Heritage

Test: dissipative merger formation of new elliptical

Schematic outline of phases of the modern merger hypothesis (from Hopkins+08a).



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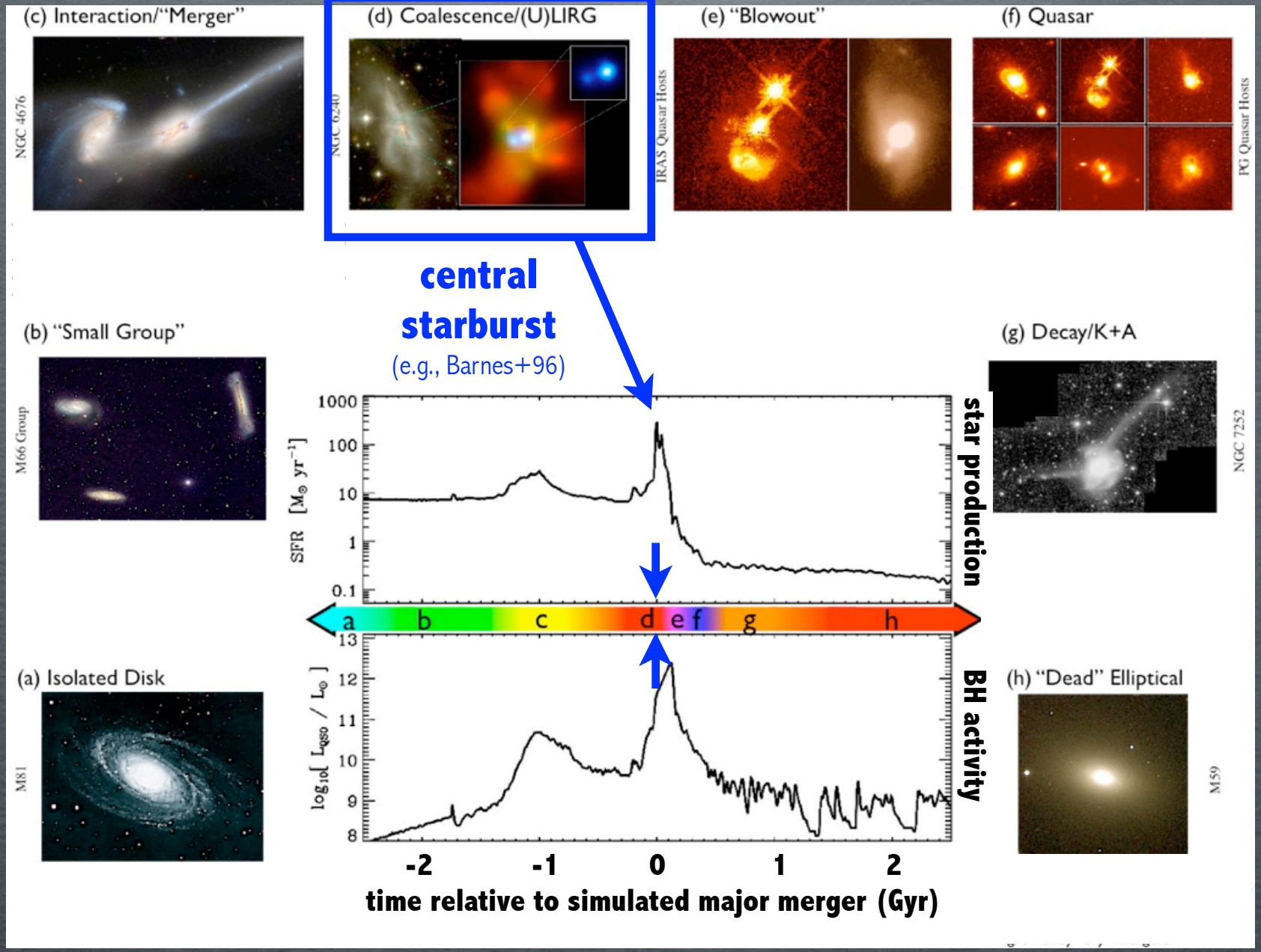

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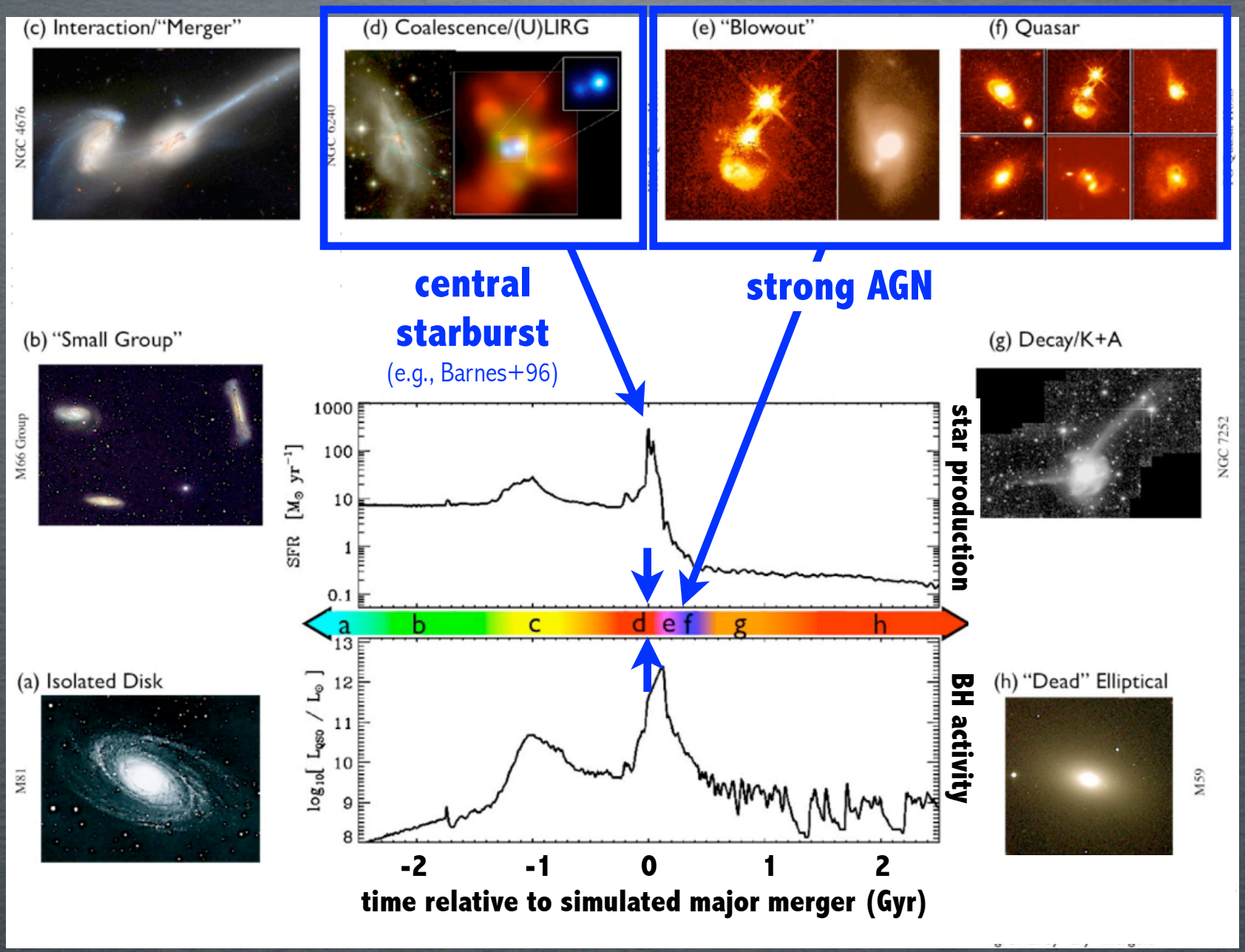

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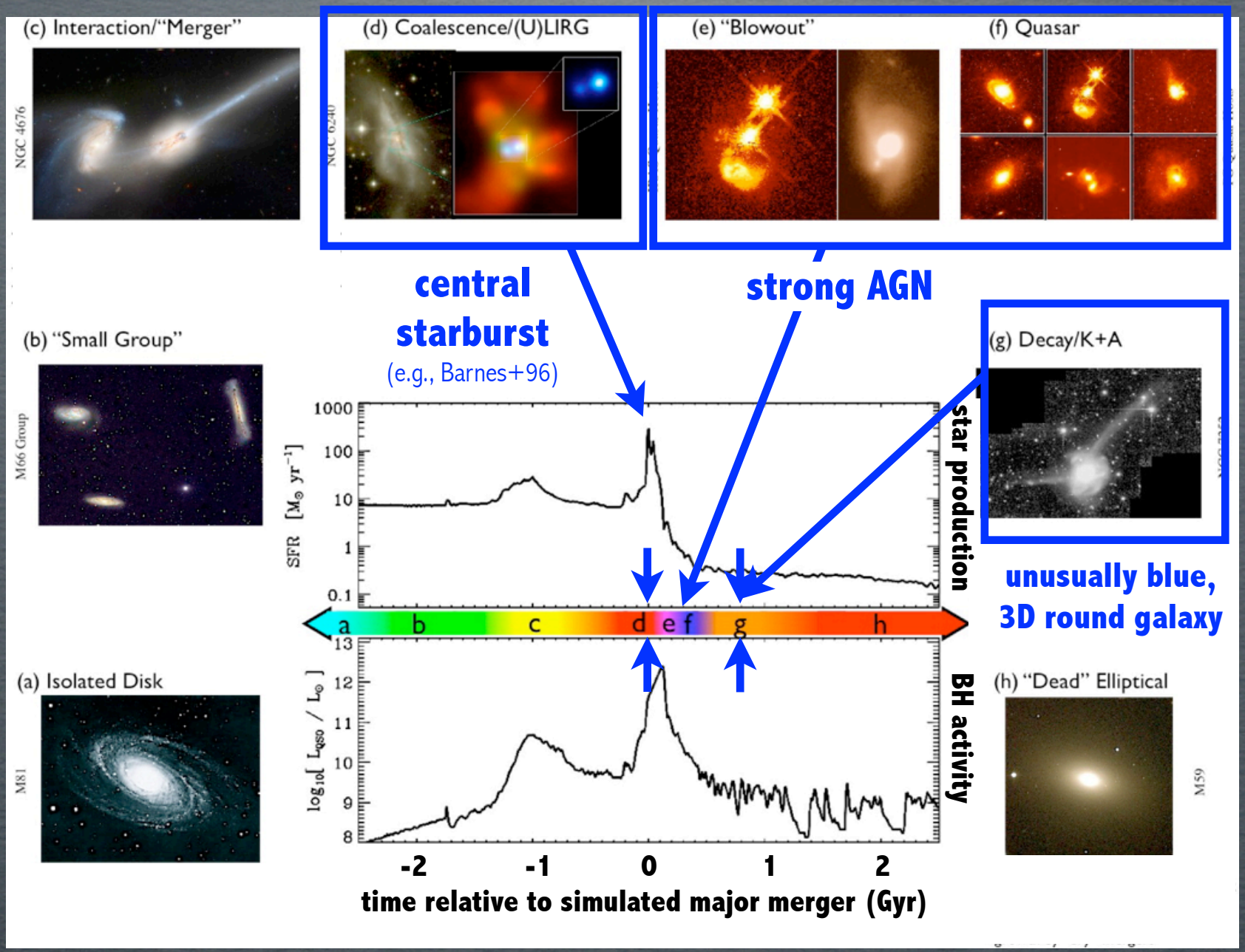

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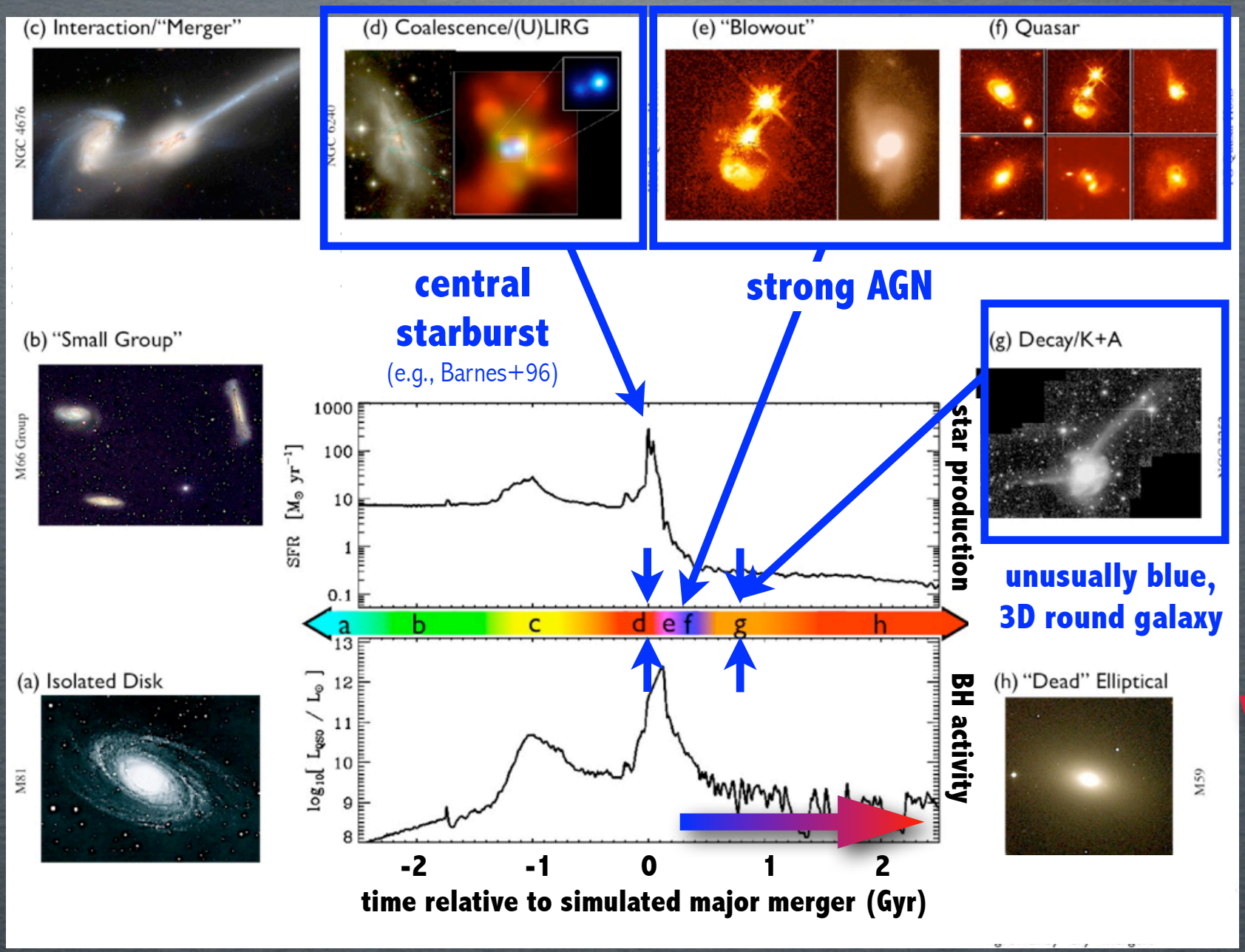

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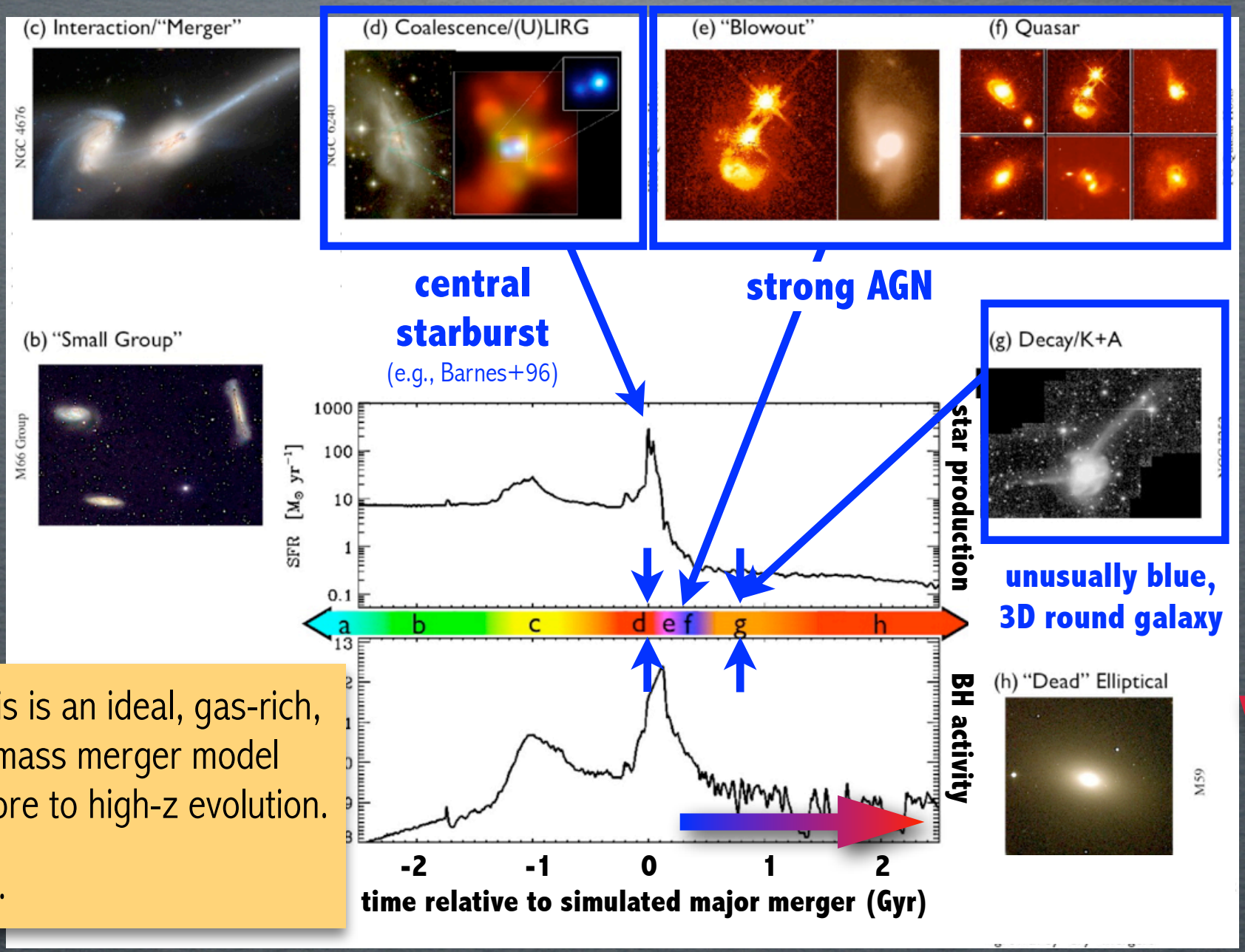


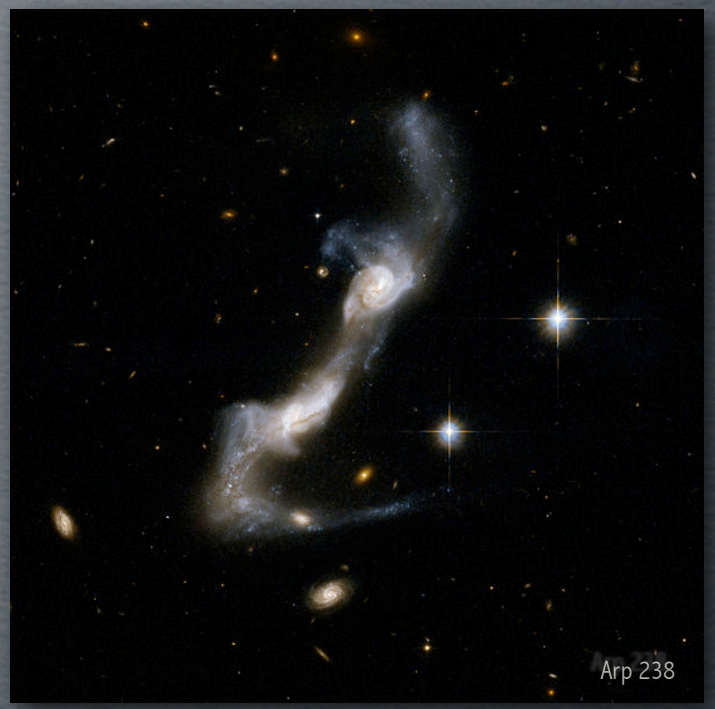
Yes, this is an ideal, gas-rich, equal-mass merger model tied more to high-z evolution.

But . . .

Motivation: study "pet objects" to understand key processes

- these major mergers occur today, but how identify recent remnants, or recent ULIRGs?
  - 10x more common than PSBs (e.g., Darg+10 vs. Goto+07)
  - typ. ~bimodal mass (most PSBs logM<10 Msun)

"Major" Merging = the gravitational interaction of two ~equal-mass galaxies and the subsequent coalescence and production of one larger galaxy.



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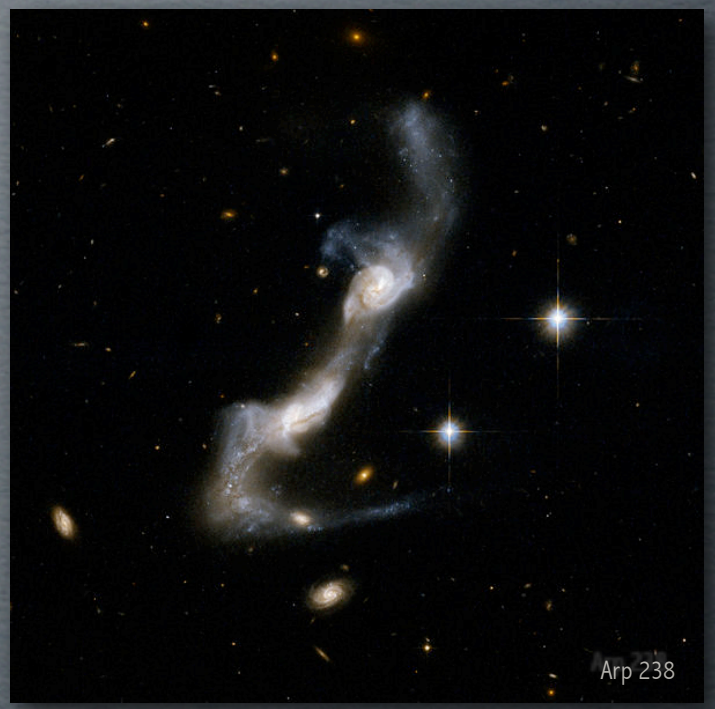

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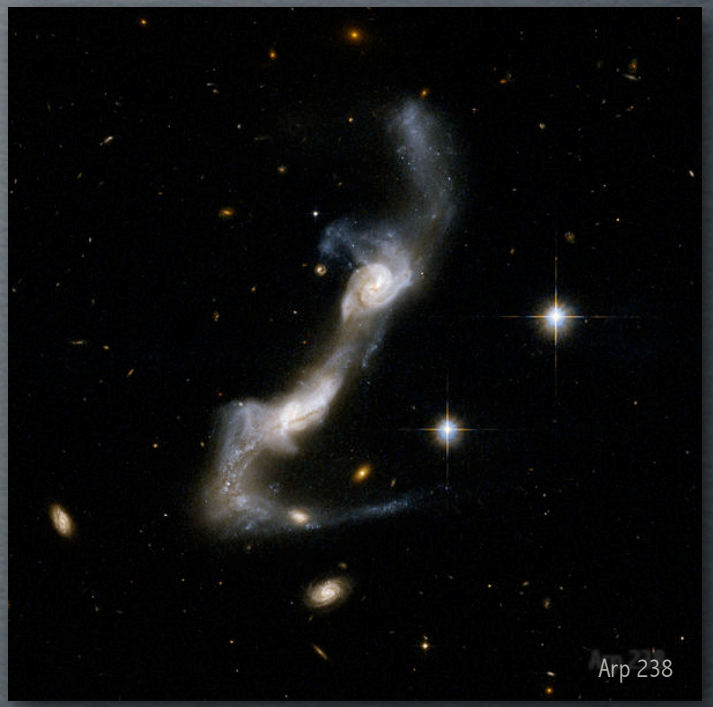
- mergers tied to a number of key evolutionary processes
  - AGN triggering (Springel+05, Ellison+13, Satyapal+14)
  - SF triggering (Renaud+14, Combes & others talks ...)
  - morpho transformation, quenching & galaxy bimodality (e.g., blue-into-red: Bundy+06, Faber+07, Hopkins+08)



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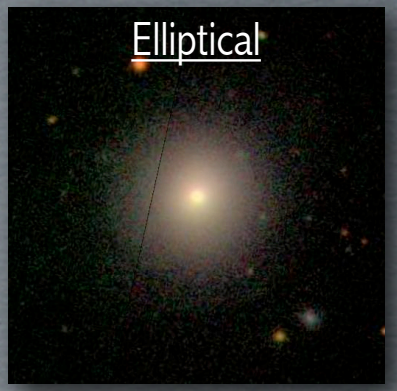
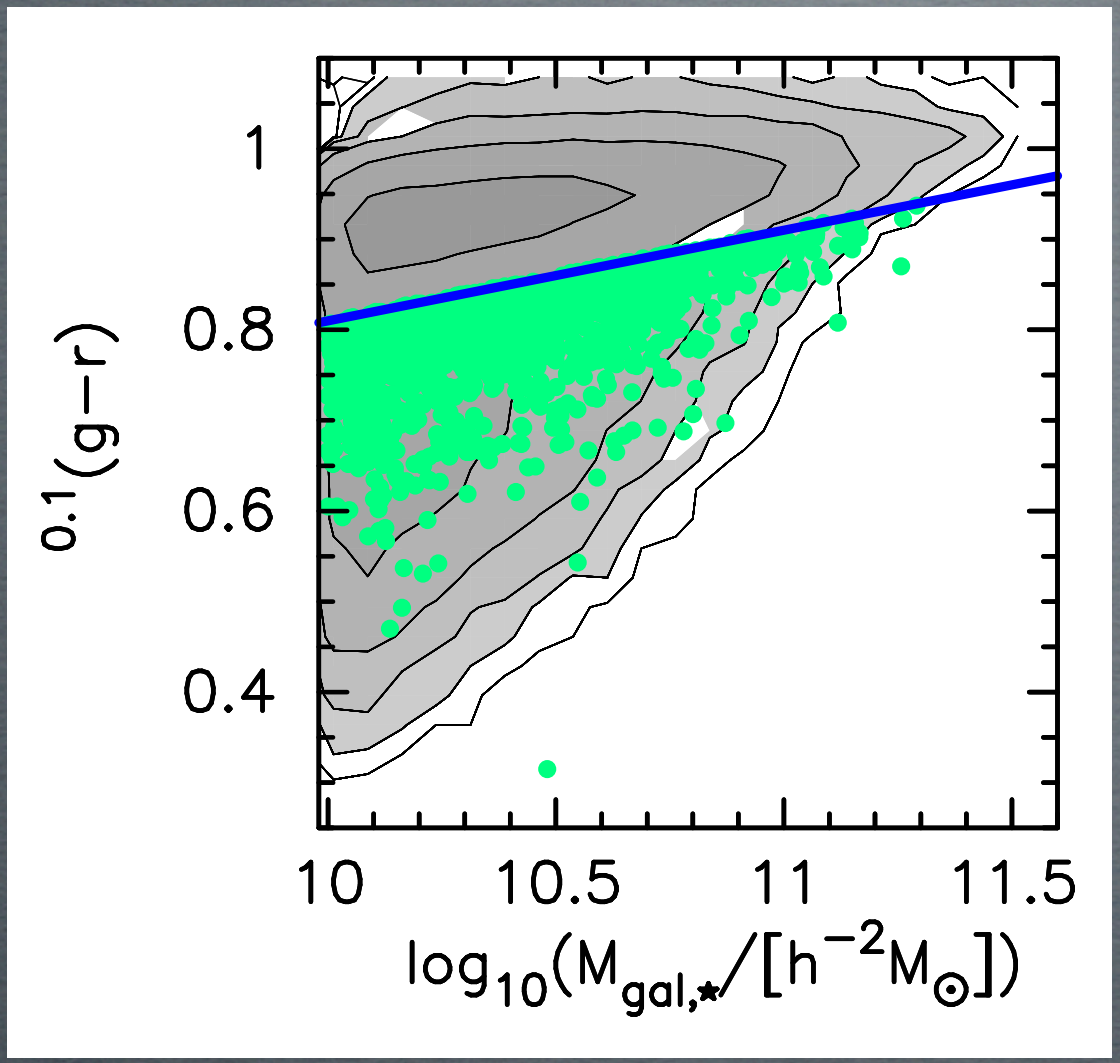
Experiment: search for young cores in plausible new ellipticals





64,000 high-mass, z<0.08 galaxies (McIntosh+14)

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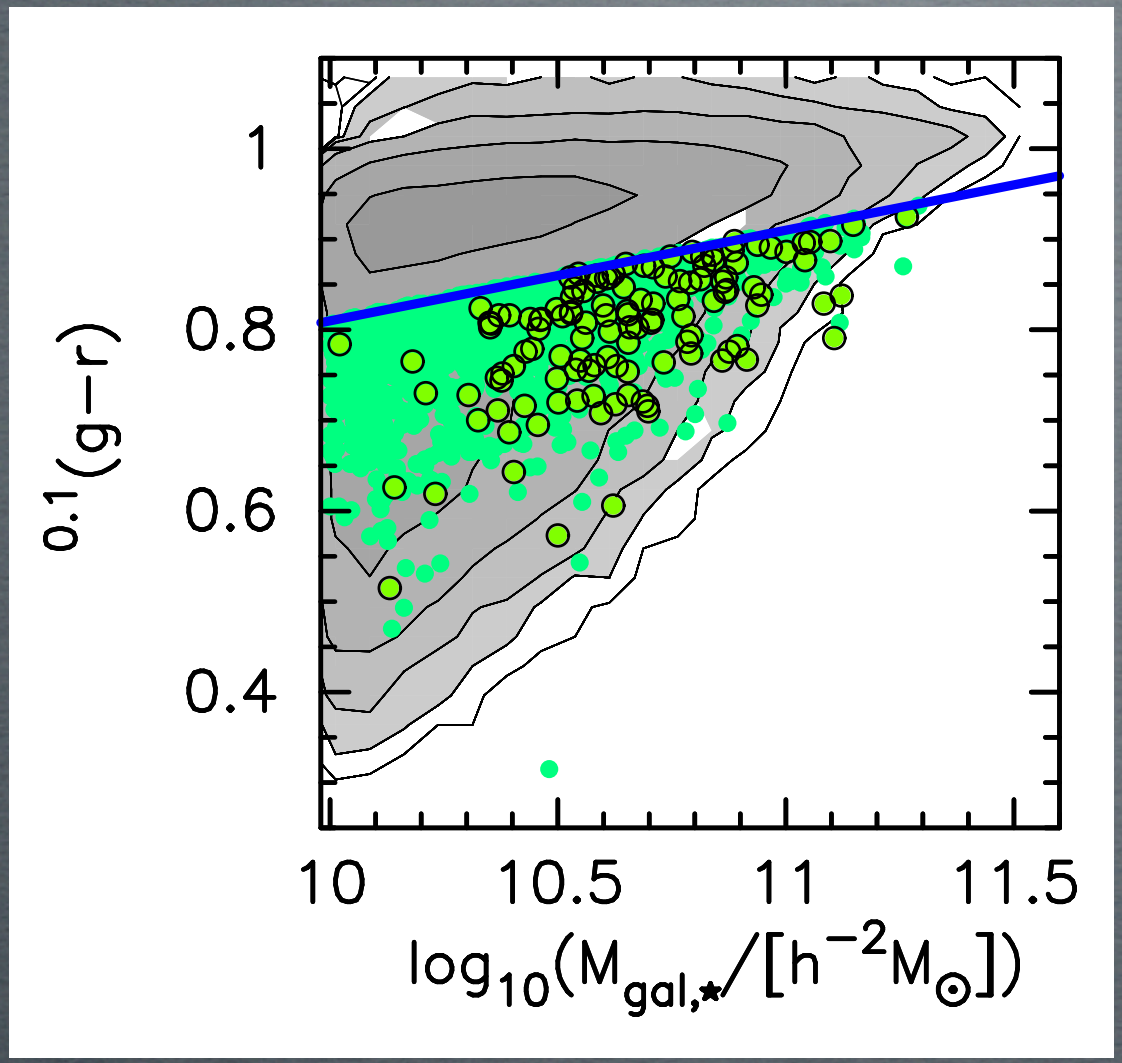

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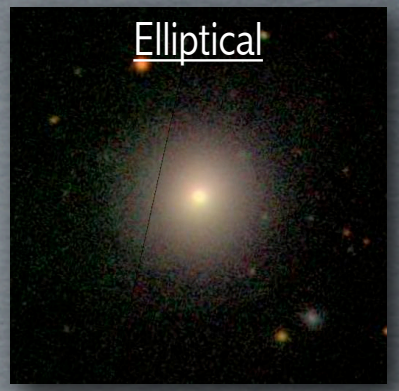

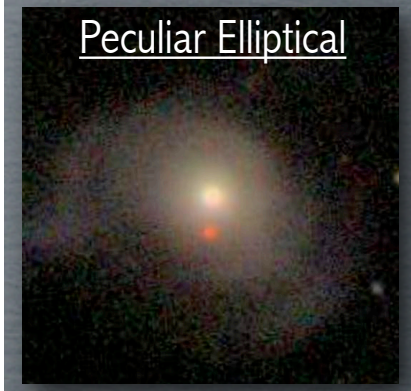

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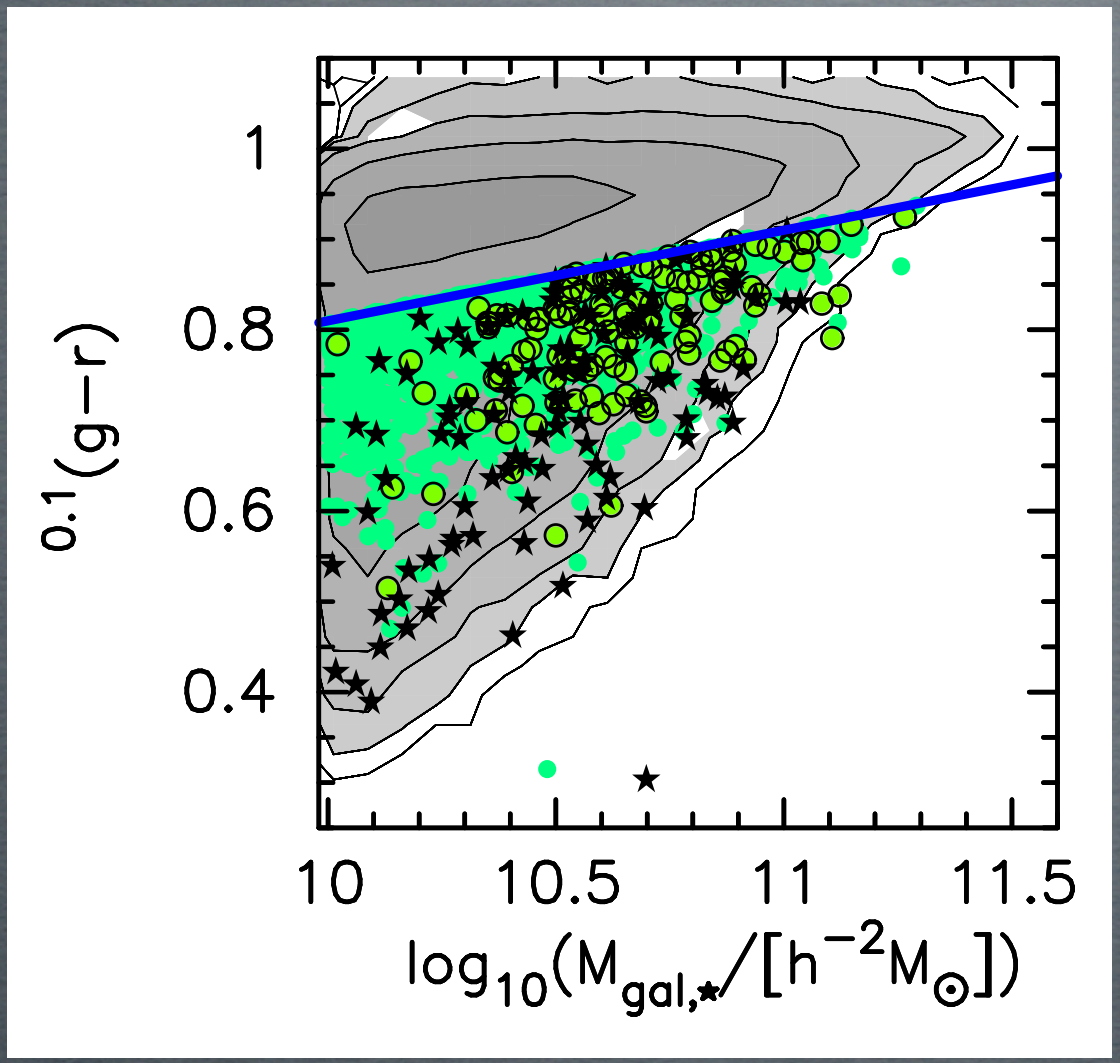

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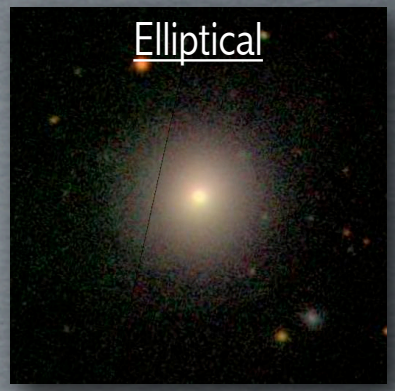
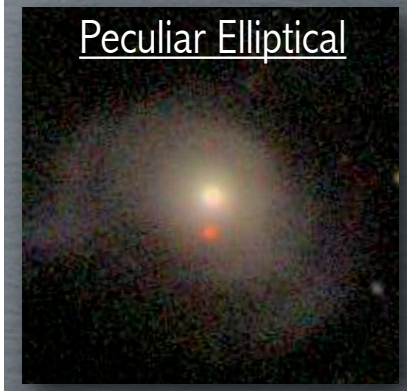
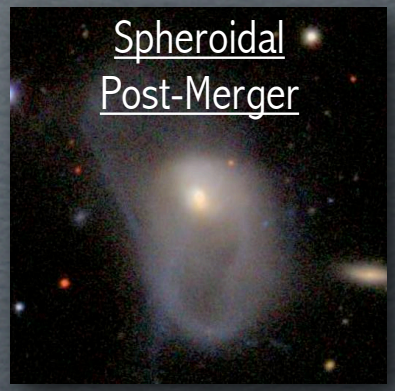


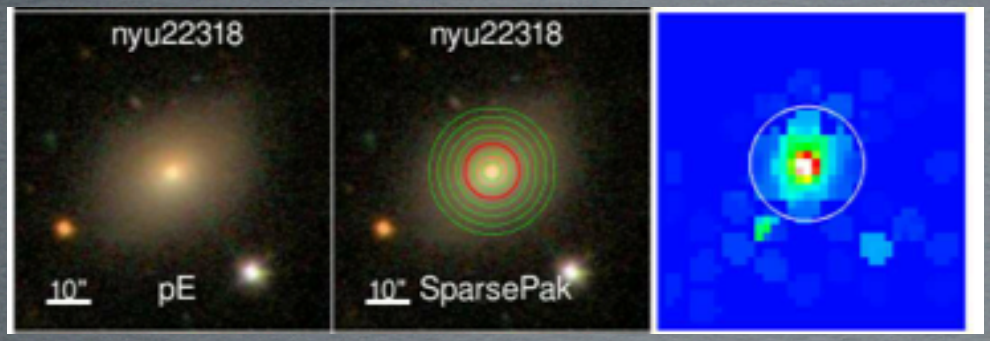


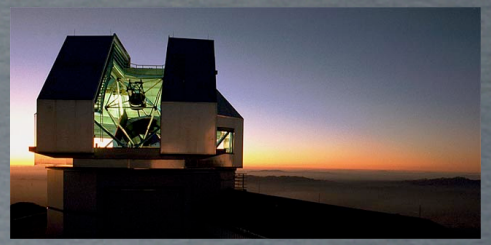


plausible qualitative time sequence since merging

Selection: 12 with z<0.03 sampling these morphs

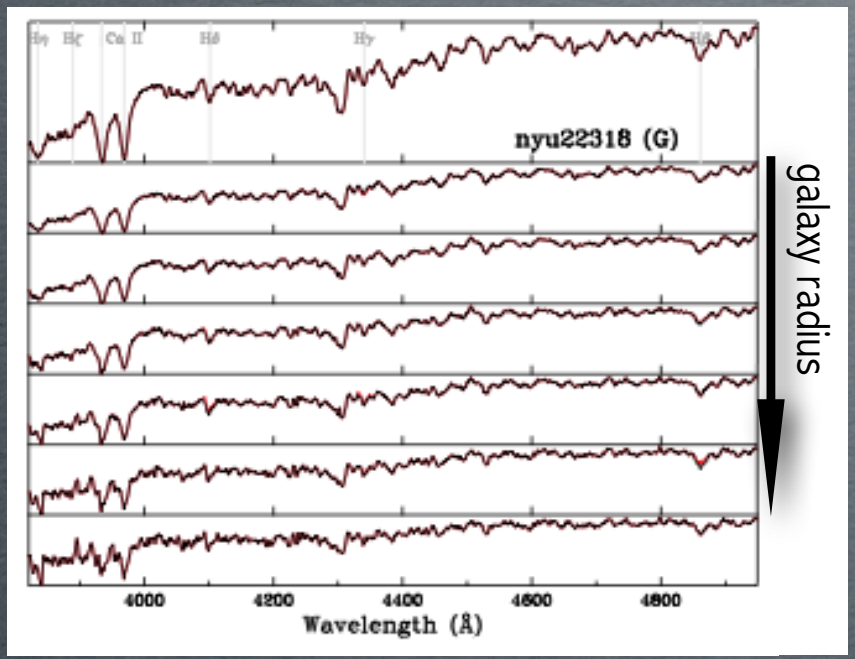
Method: dissect radial SFHs to probe mass assembly

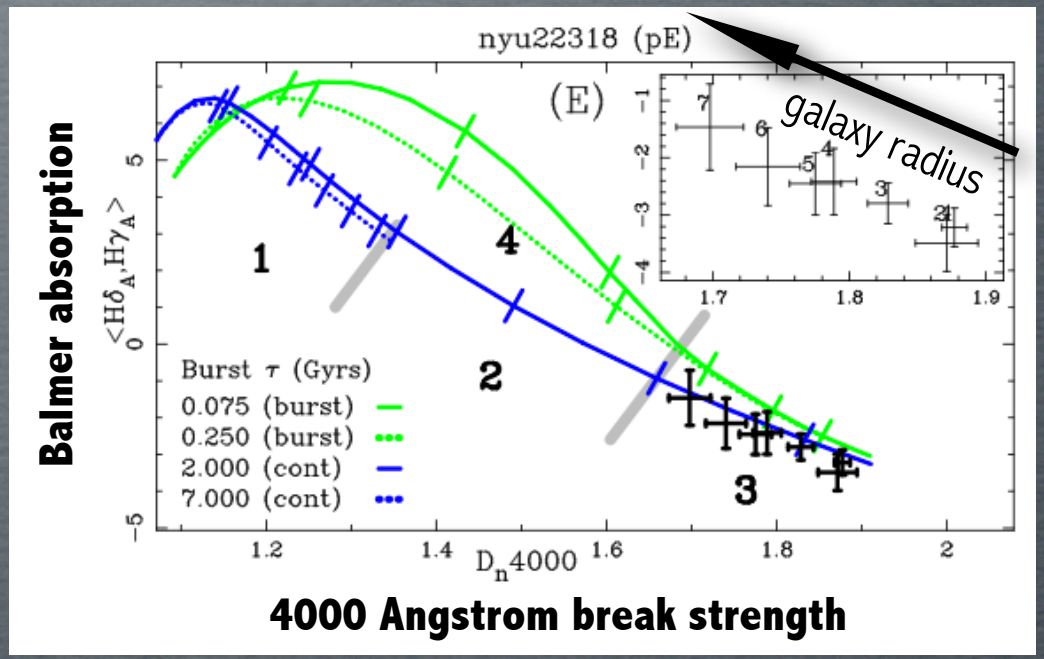




3.5-meter WIYN + SparsePak
3.5-meter CAHA + PMAS/PPAK

Track 2 important stellar age indicators from core to several R_{50}





Haines, DHM et al. 2015

Method: dissect radial SFHs to probe mass assembly

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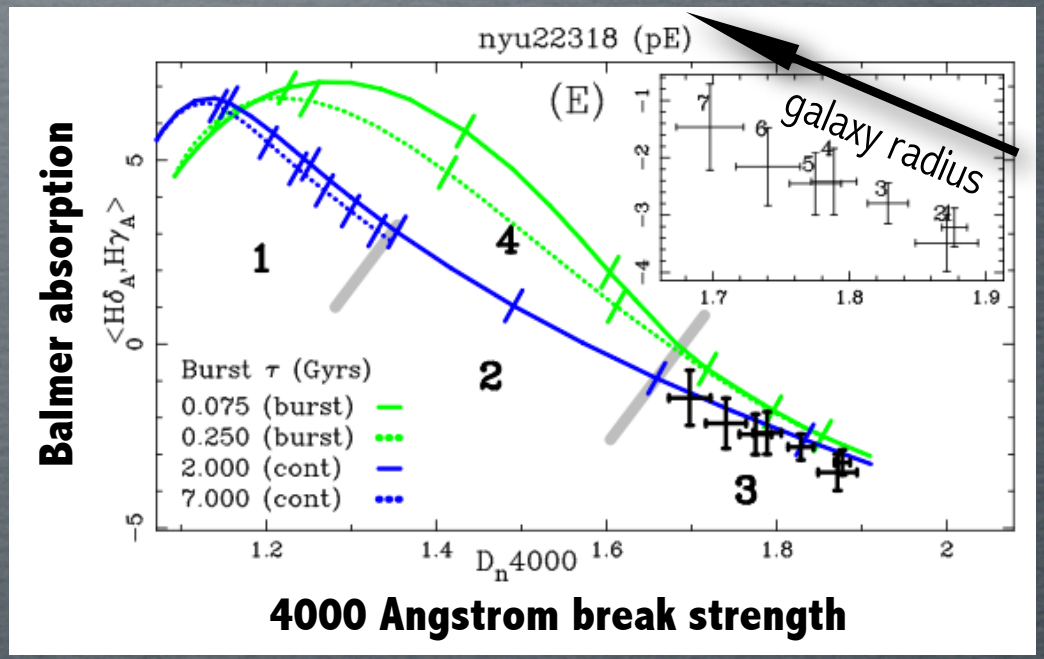
Qualitatively distinguish several different SFHs following Kauffmann+03



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Suite of model indices spanning many SFHs

SEDs from impro code (Moustakas+13) convolved with
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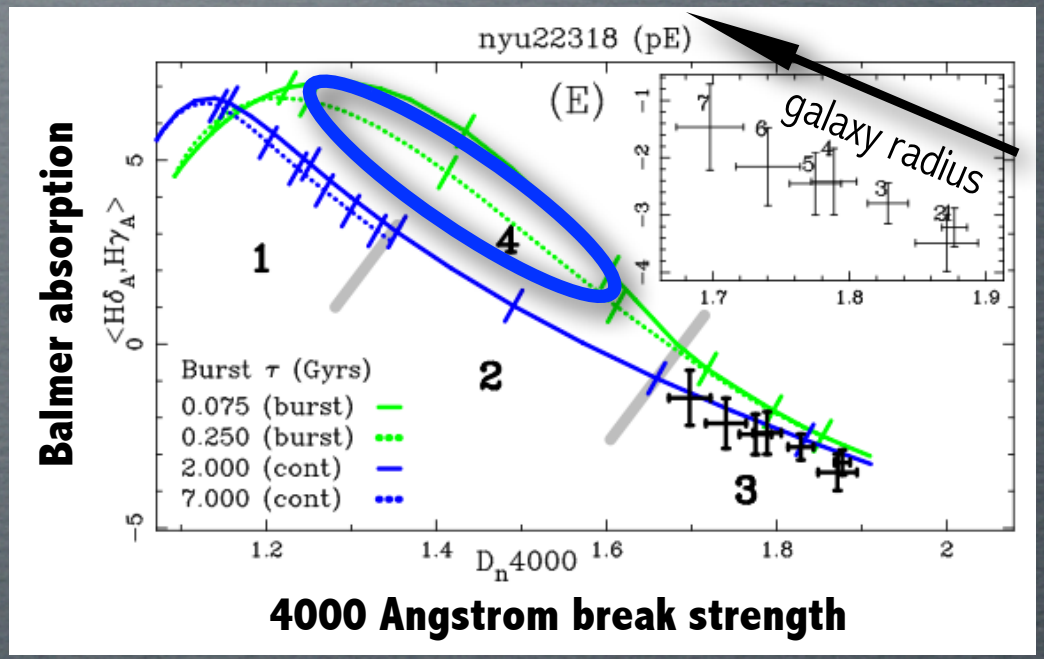

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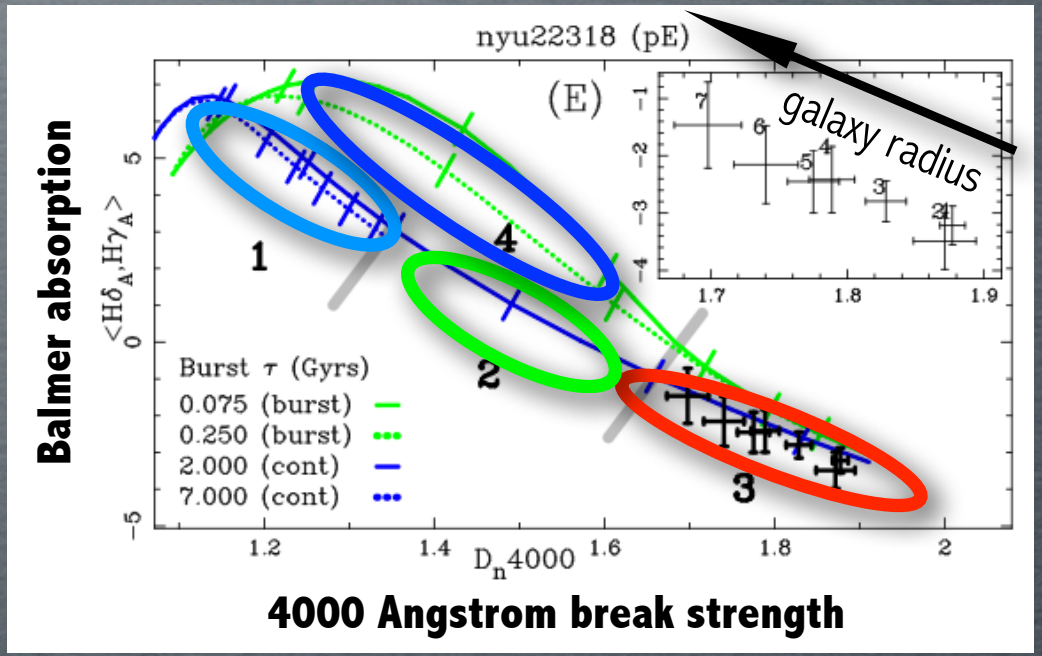
>15%, <1Gyr burst

star-forming

middle-aged, weakly star-forming

red-n-dead



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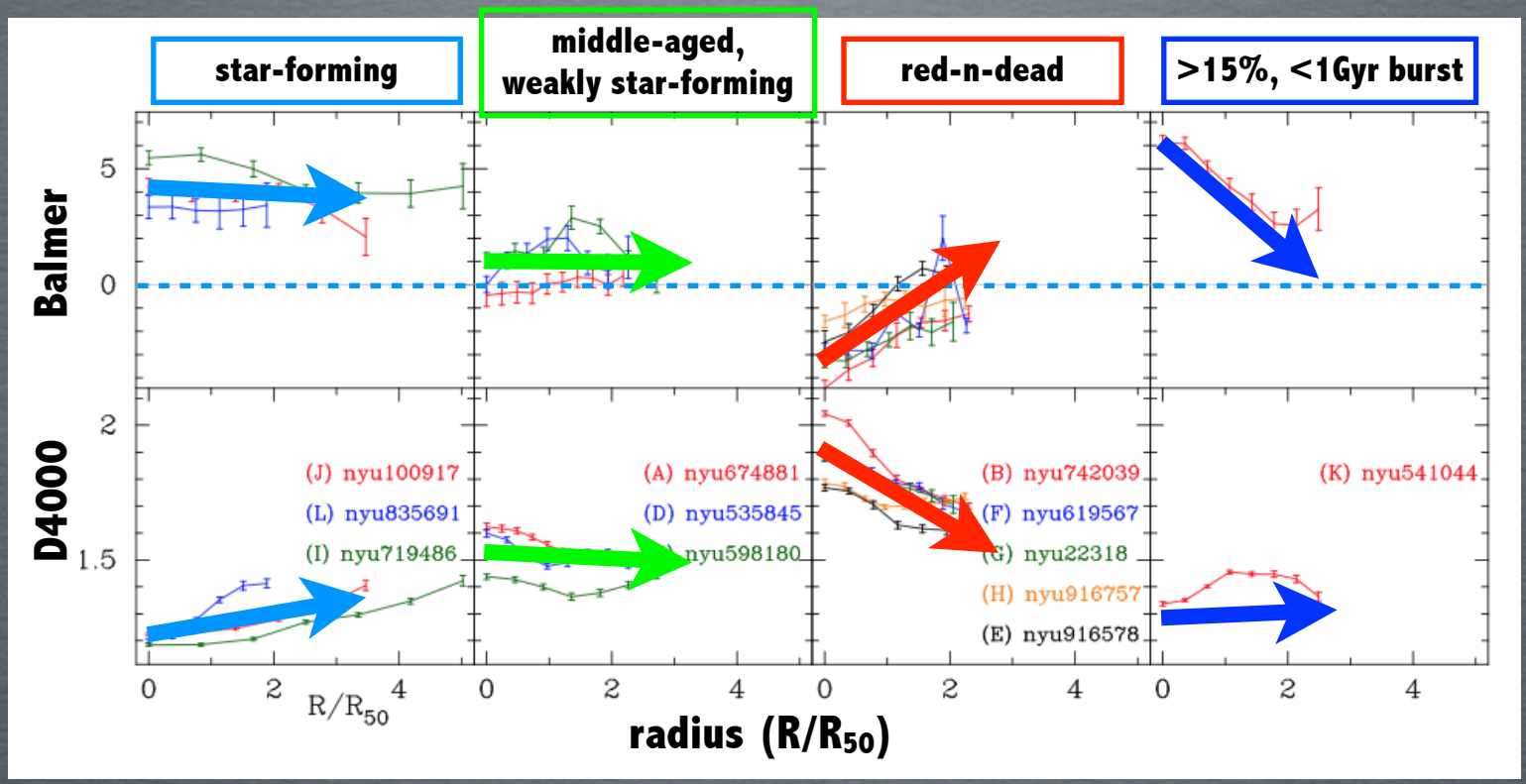
Different SFHs Have Different Radial Behavior

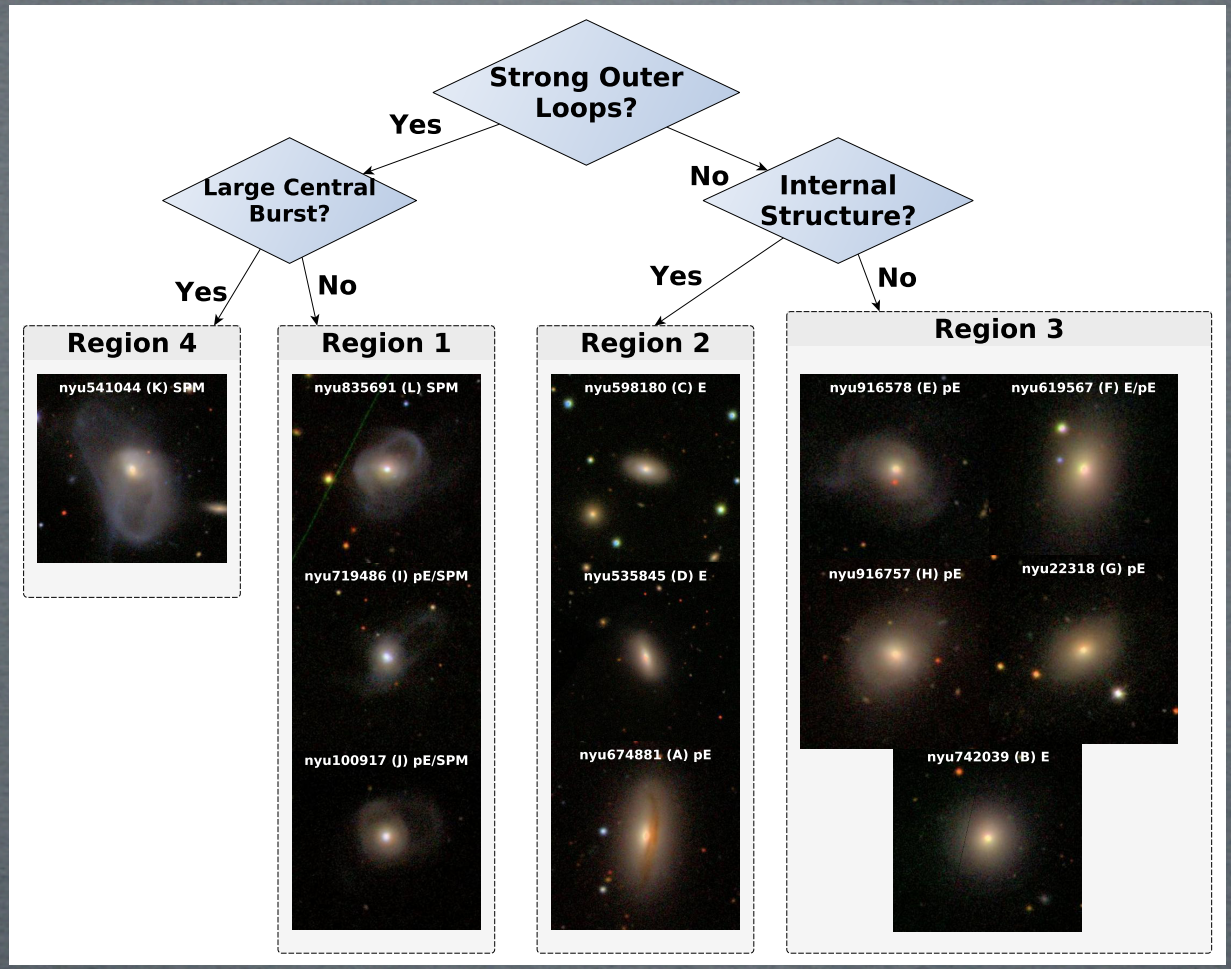
Organized by region in which most of indices are found:



Haines, DHM et al. 2015

~5% young stars at all radii	uneven "frosting" of young stars	very old stars in center	recent central starburst

Radial SFHs Associated with Specific Tidal Features



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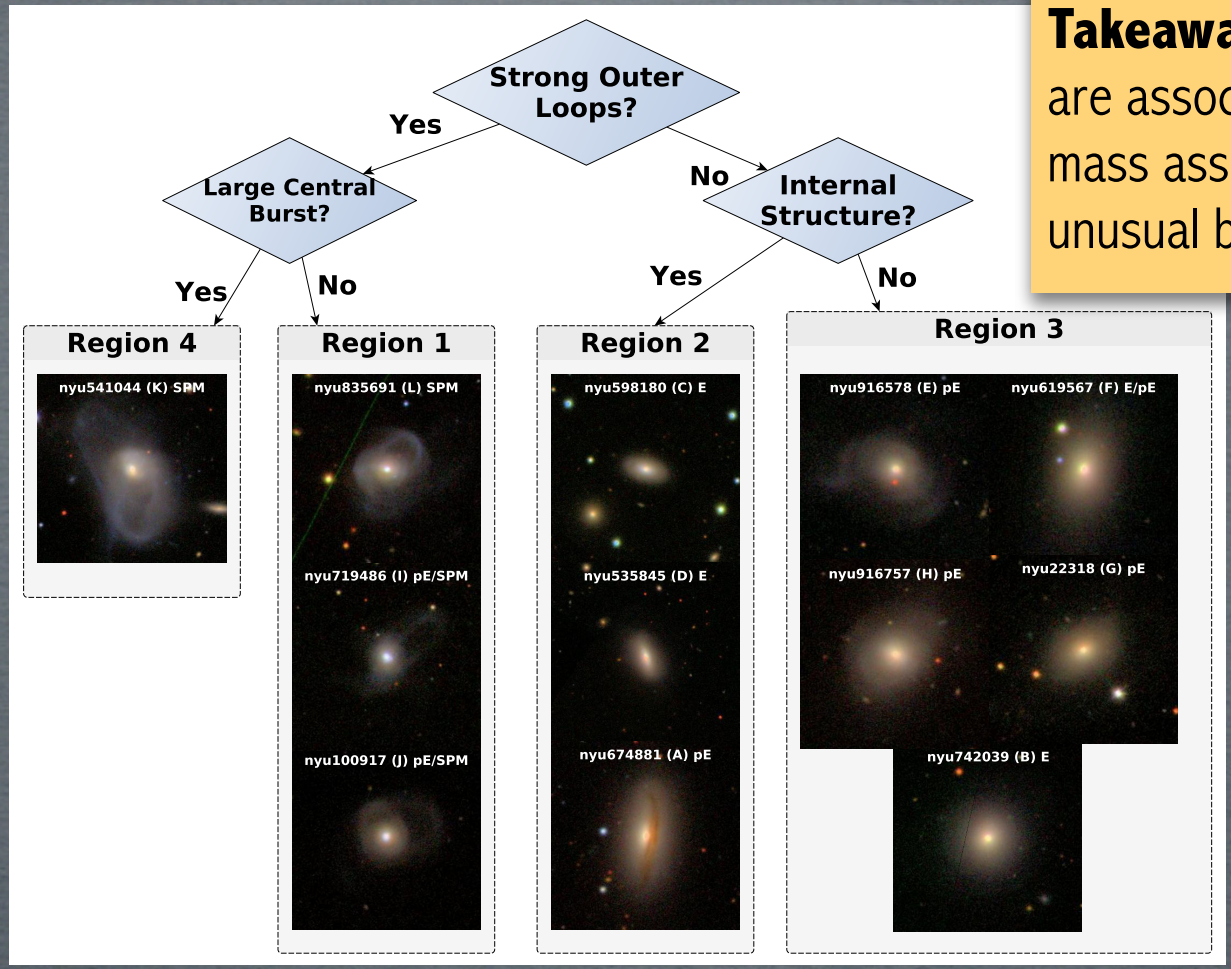
Radial SFHs Associated with Specific Tidal Features

Takeaway 1: tidal features are associated with <u>different</u> mass assembly processes in unusual blue ETGs



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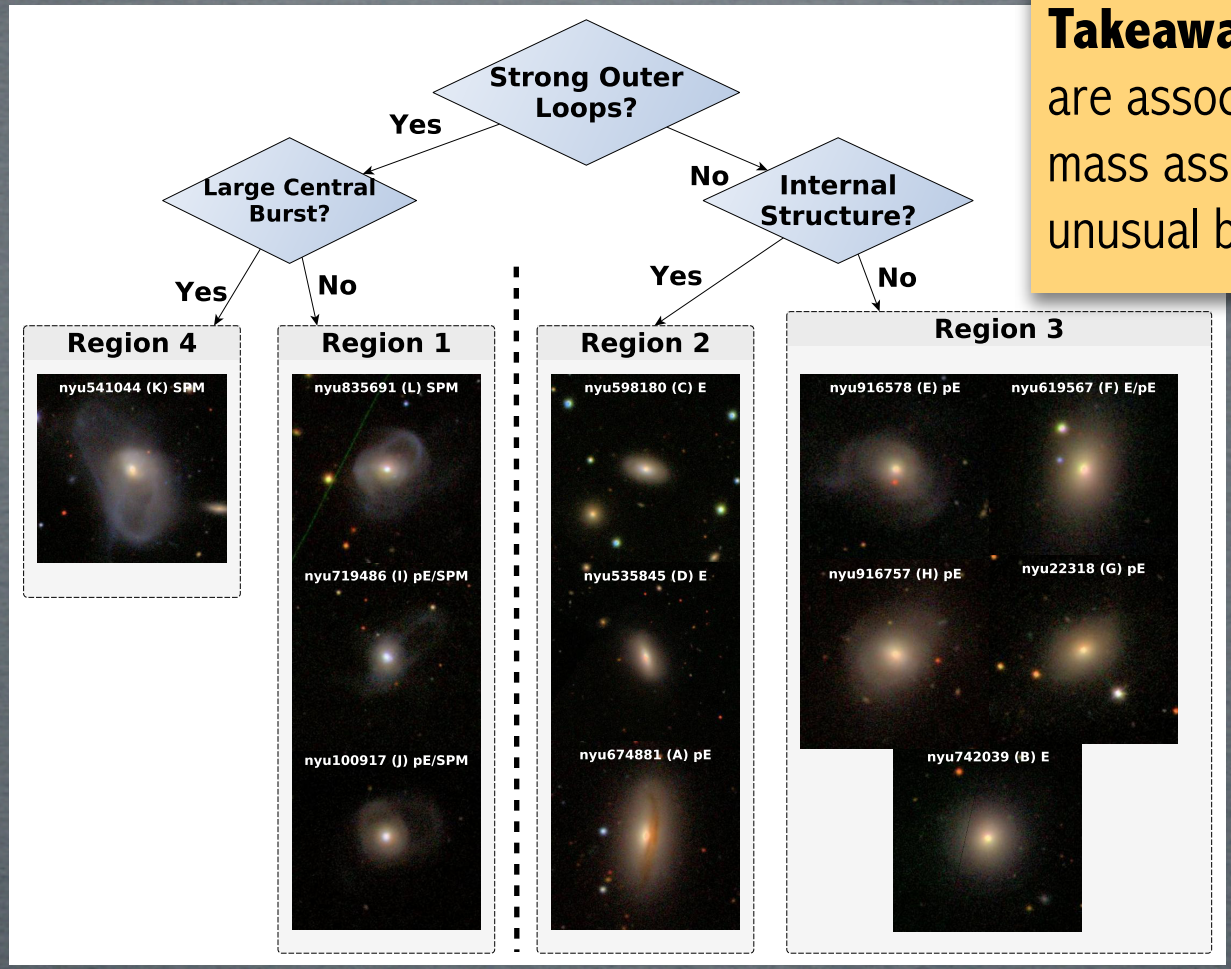

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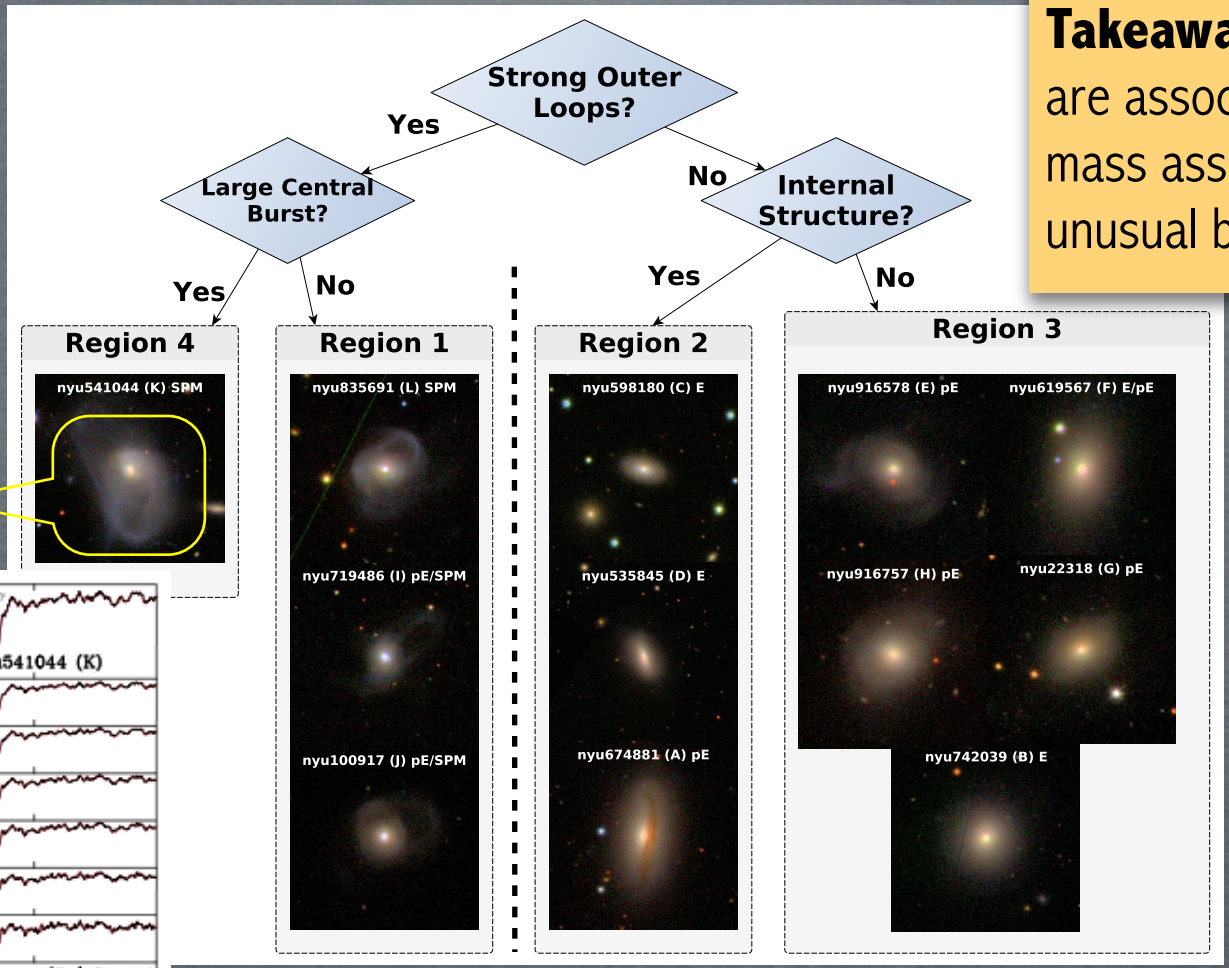
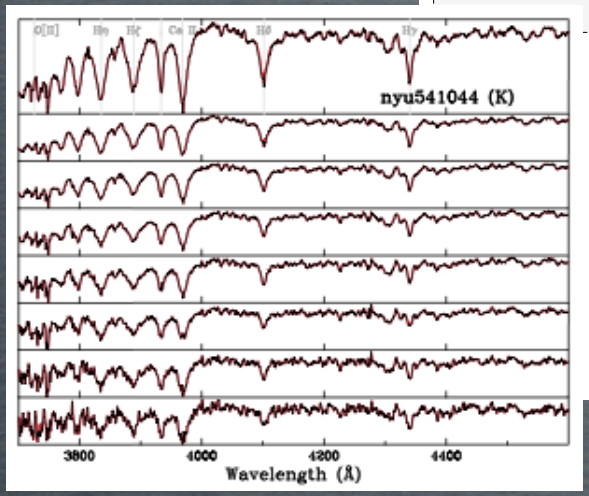


<u>Core:</u>
recent, >15% burst
+ quenched colors



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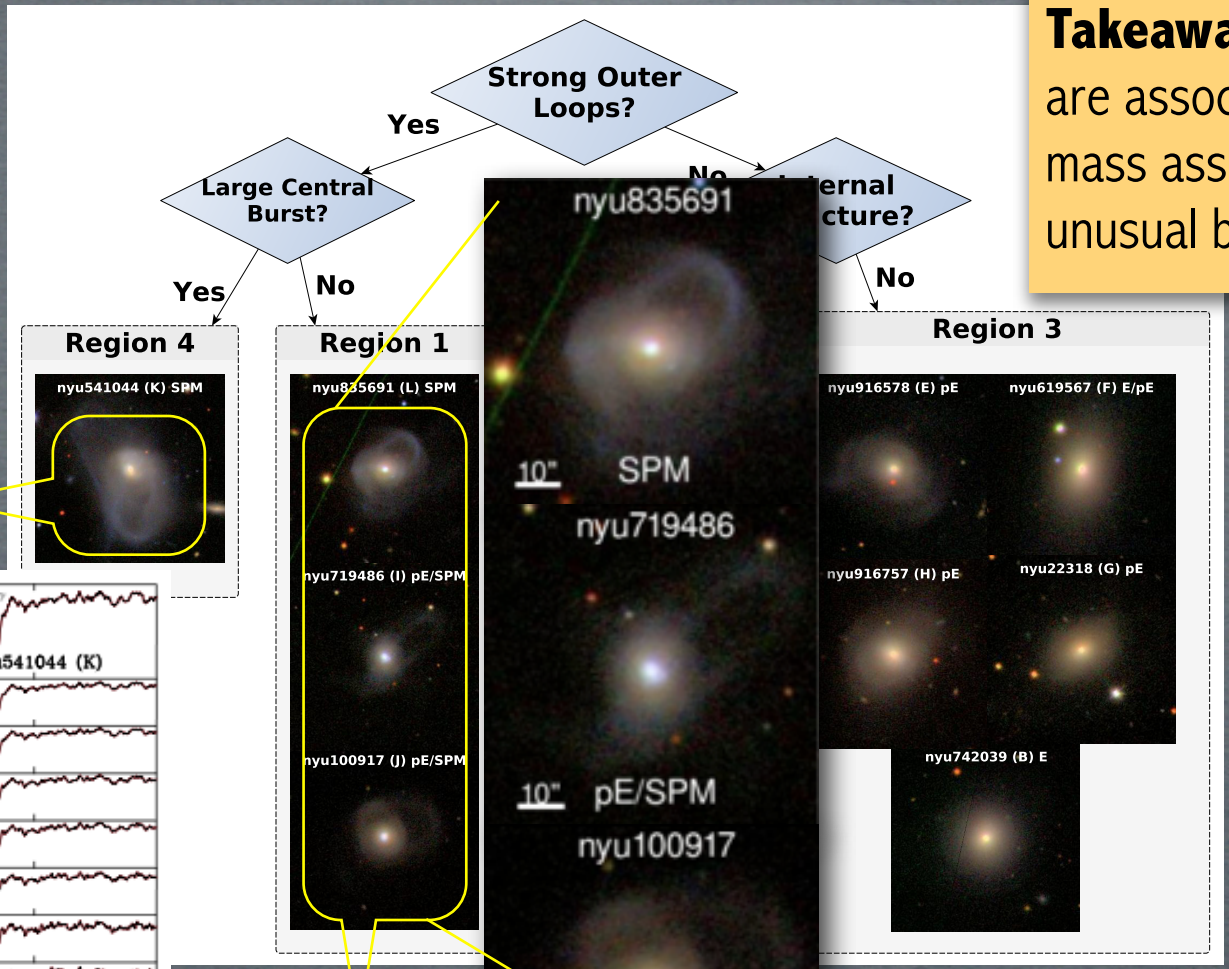

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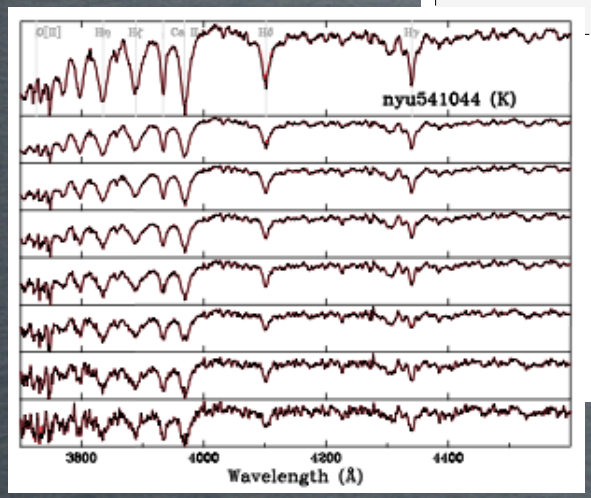

~5% central burst
+ ongoing SF colors

consistent with recent gas-rich major merging

burst characteristics depend on merger specifics
(e.g., Mihos+96, Cox+08, many more ...)

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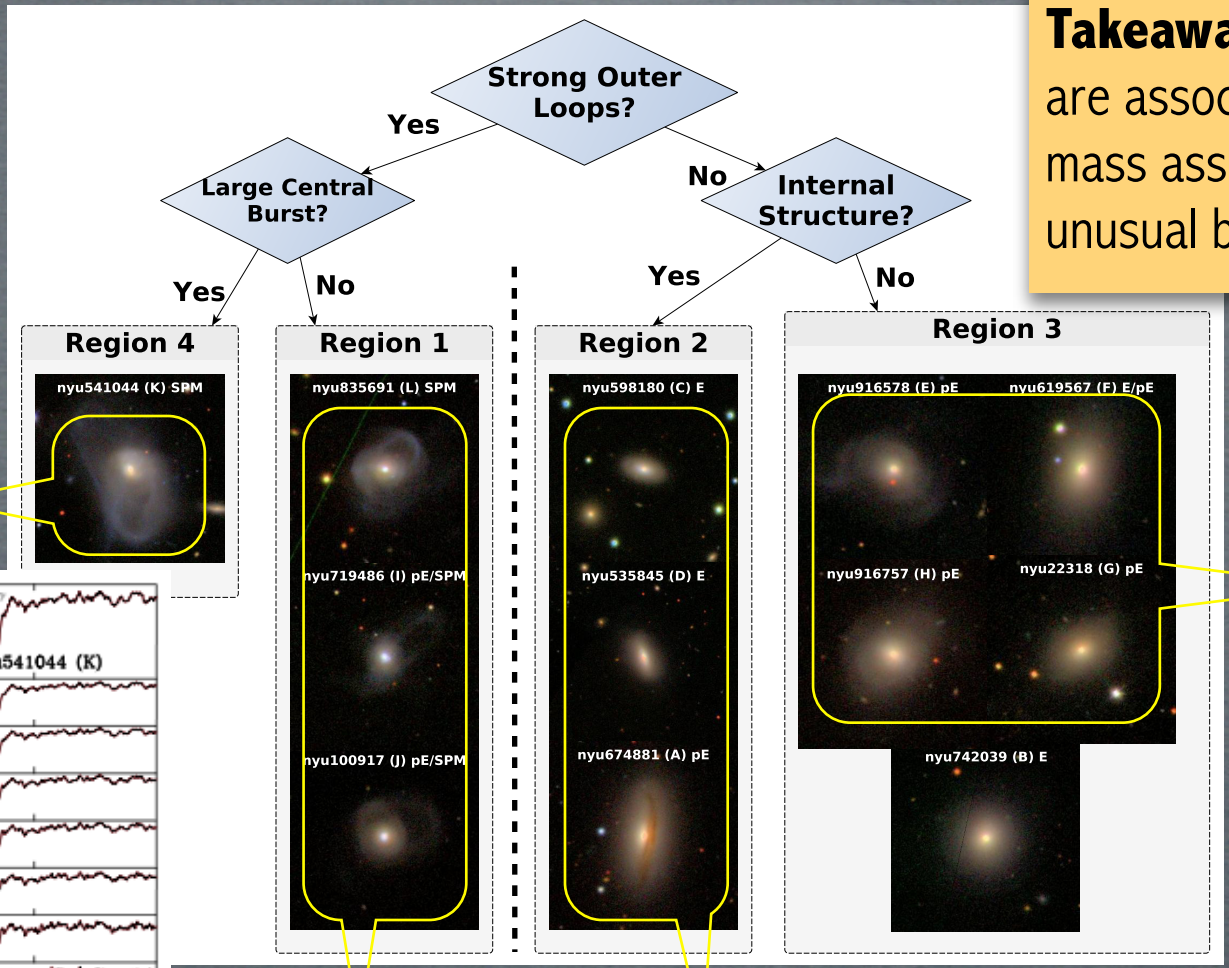

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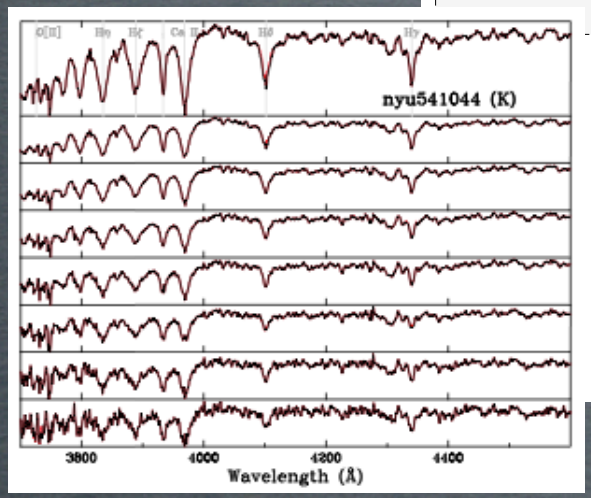

broad, diffuse outer asymmetries

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+ ongoing SF colors

inner blue ring
or dust lane

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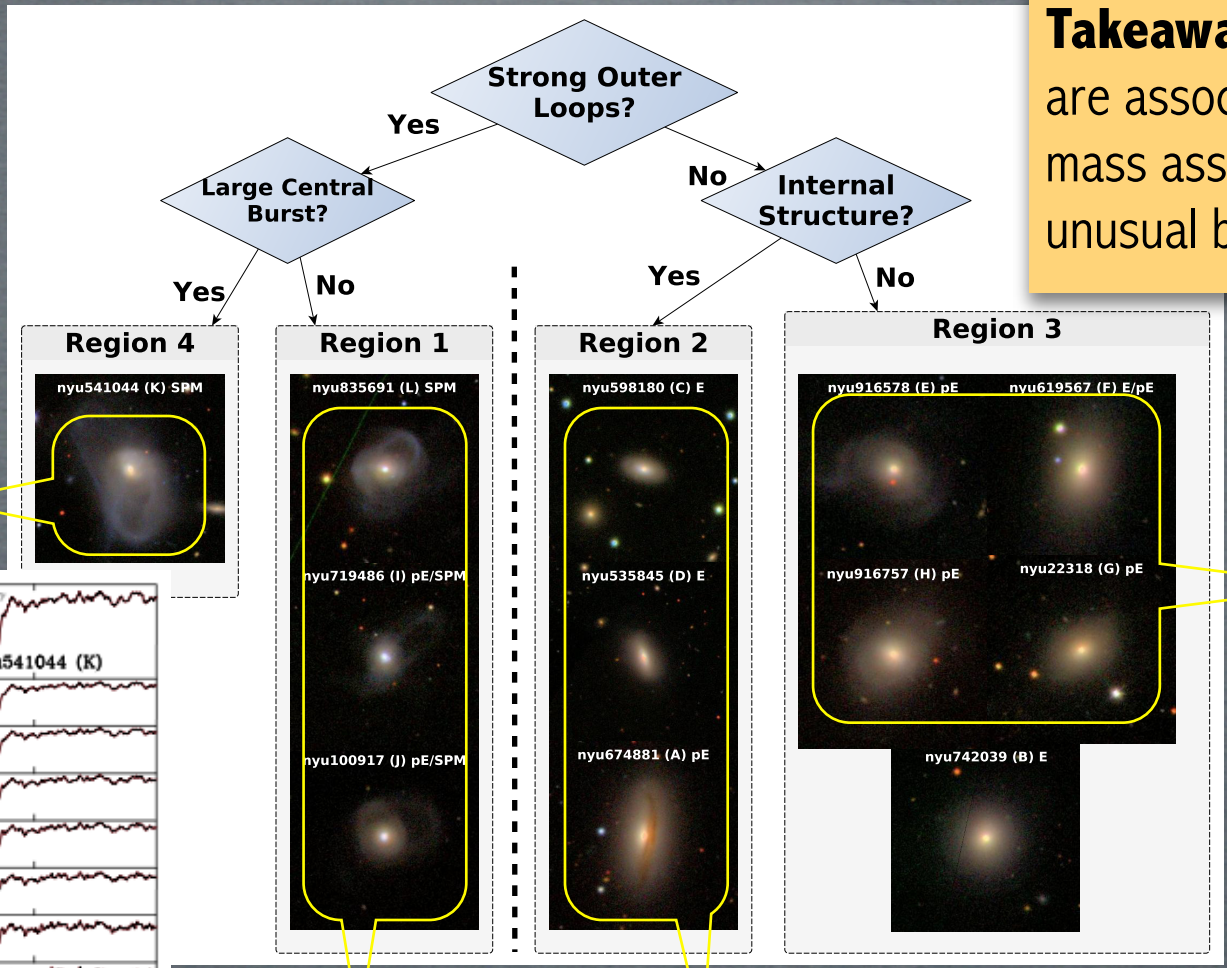

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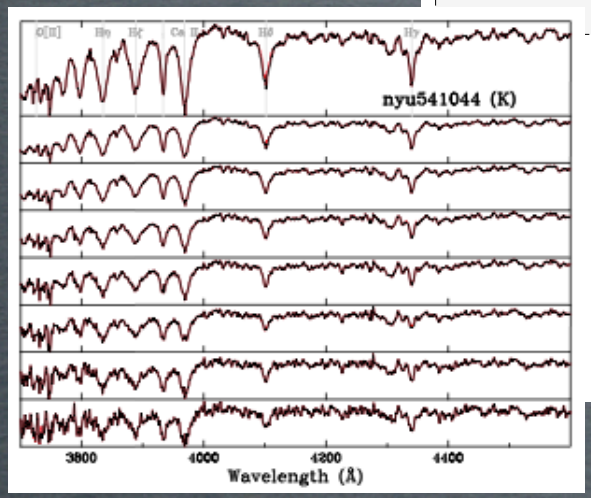


broad, diffuse outer asymmetries

radial SFHs similar to normal ellipticals

~5% central burst
+ ongoing SF colors

inner blue ring or dust lane

recent dry merger?
color errors?

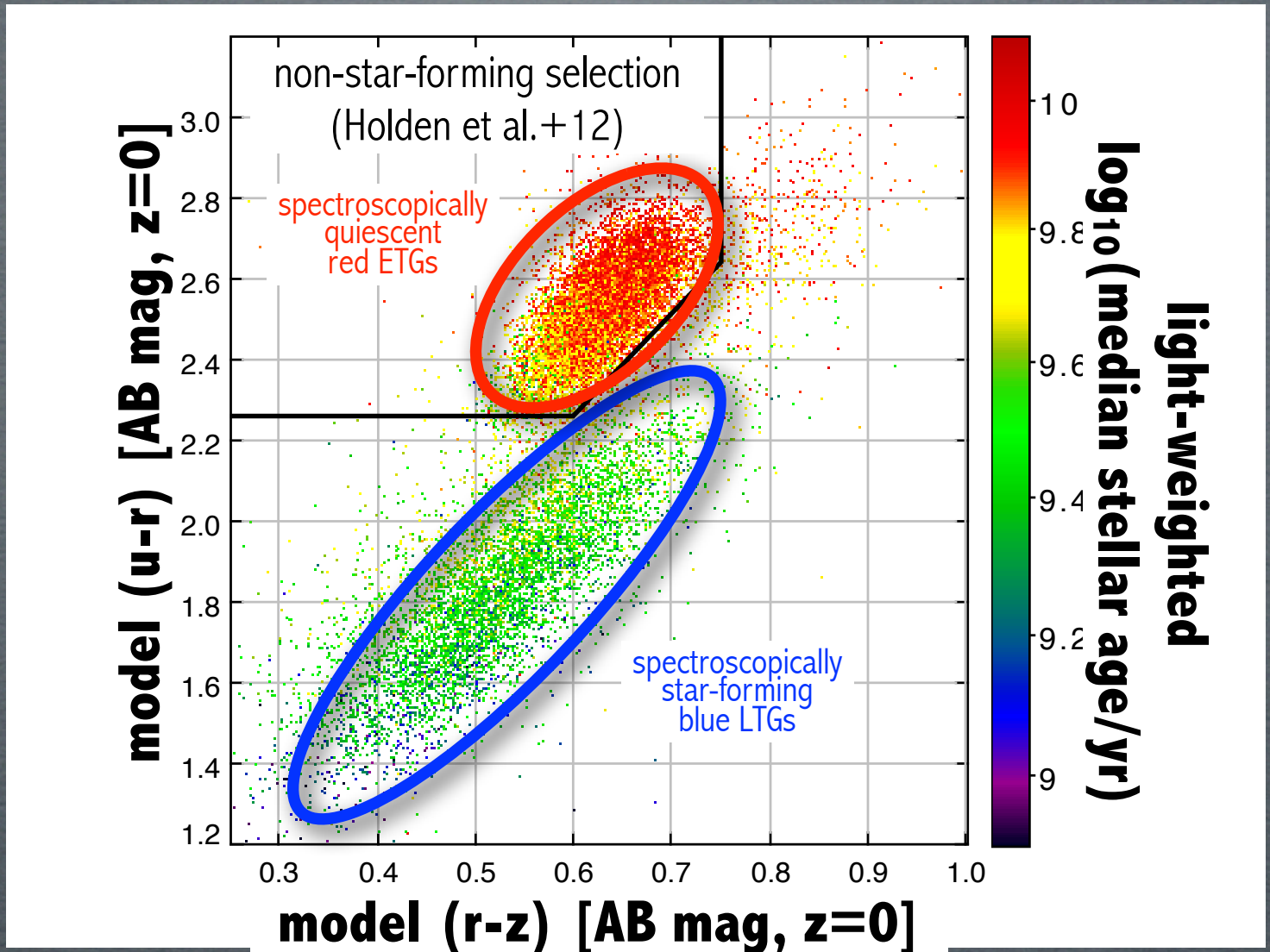
consistent with recent gas-rich major merging

burst characteristics depend on merger specifics
(e.g., Mihos+96, Cox+08, many more ...)

<u>inconsistent</u> with recent gas-rich major merging

likely frosted by recent gas-rich <u>minor</u> merger

Common Morpho-Struct-Color Samples Miss Rare Objects that May Provide Best Insights into Key Evolutionary Processes



McIntosh+14

(Gallazzi+05 ages)

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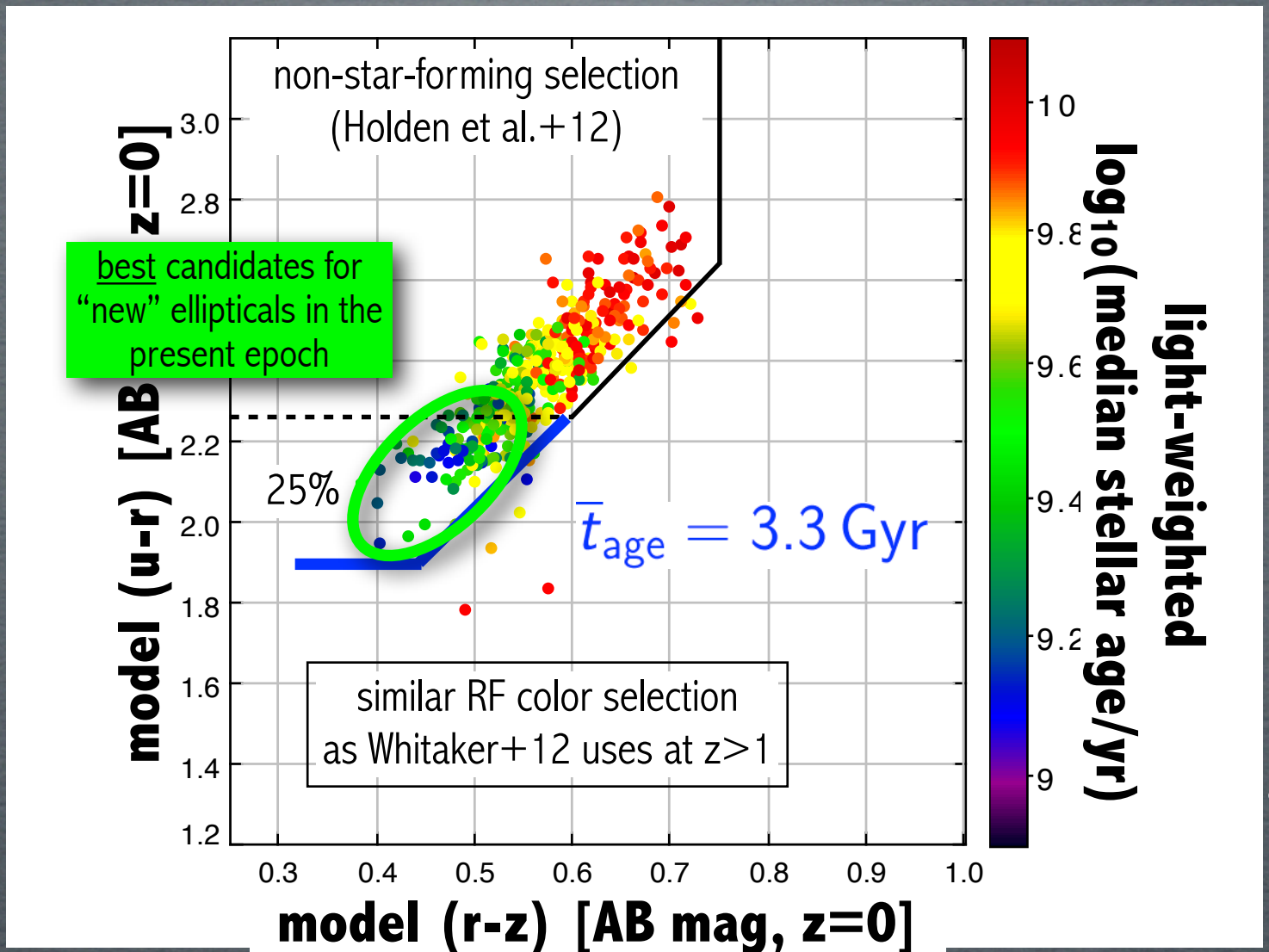
Recently Quenched Ellipticals



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Sufficient number density to explain expected red growth at late cosmic time.

$2.7–4.7 \times 10^{-5}\, h^3\, \mathrm{Mpc}^{-3}$

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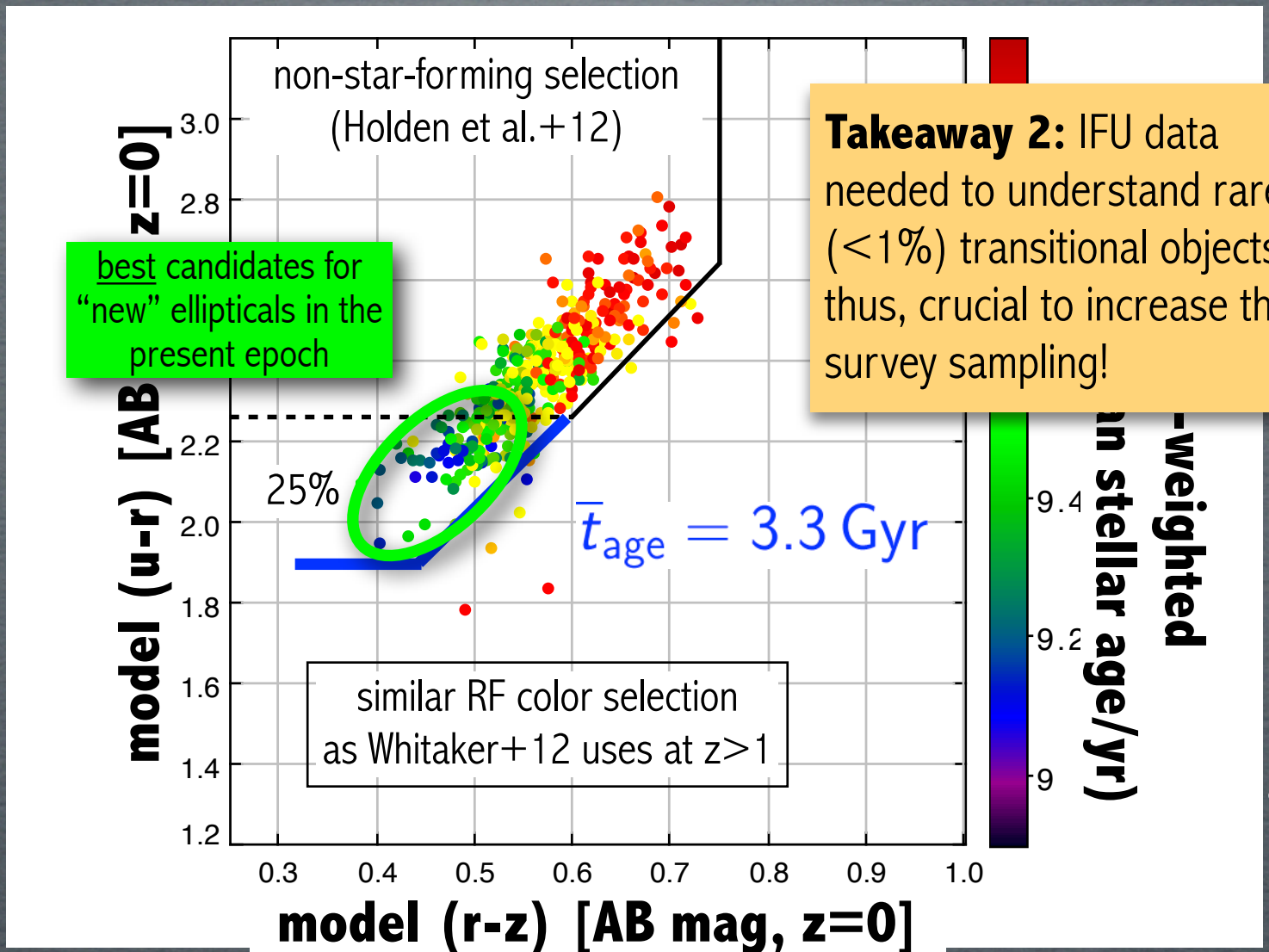


Takeaway 2: IFU data needed to understand rare (<1%) transitional objects; thus, crucial to increase their survey sampling!

Sufficient number density to explain expected red growth at late cosmic time.

$2.7–4.7 \times 10^{-5}\, h^3\, \mathrm{Mpc}^{-3}$

Summary: study "pet objects" to better understand key processes

- Unusual blue ellipticals with weak tidal signatures tend to have radial SFHs that are inconsistent* with predictions of the modern merger hypothesis.
- Highly-disturbed spheroids (with strong tidal features) are likely gaseous major mergers, but strong central starbursts are not the norm*.

*caveat: based on small # statistics

- A fraction of green-valley ellipticals are recently quenched.
- IFU data + detailed SFH and kinematic modeling are necessary to thoroughly understand the recent assembly histories of plausibly transitioning galaxies.

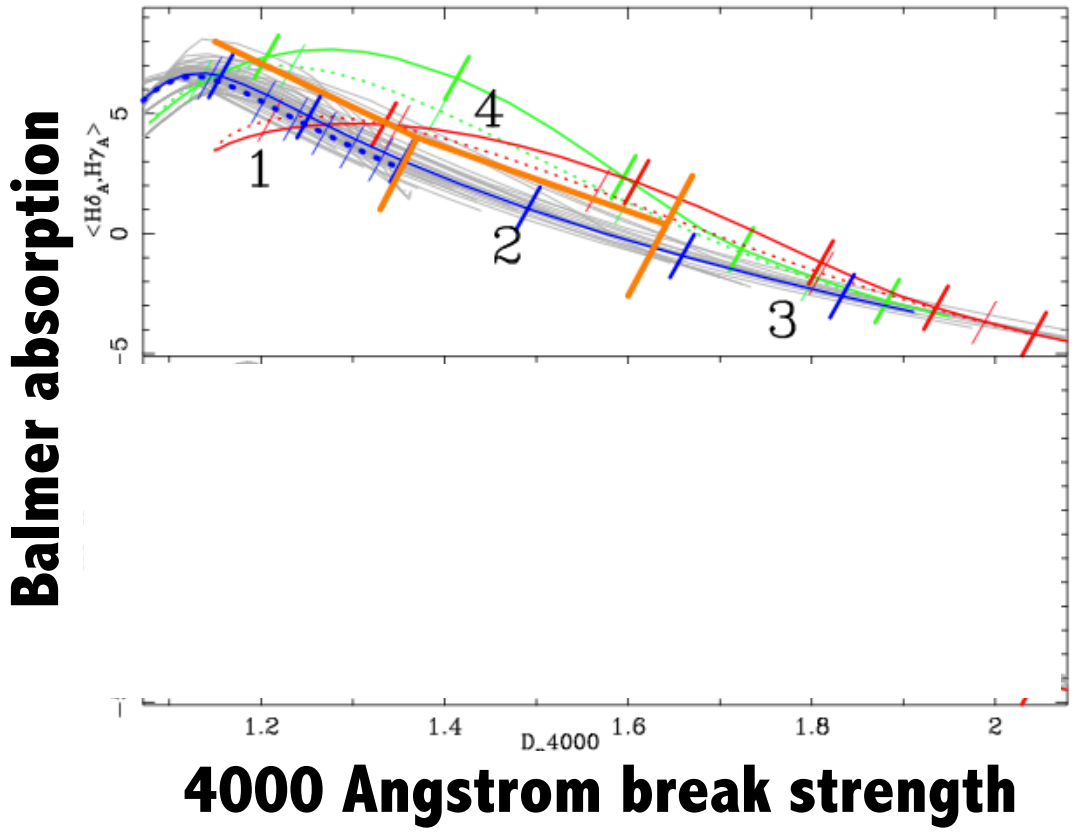
Takeaway 2: IFU data needed to understand rare (<1%) transitional objects; thus, crucial to increase their survey sampling!

Distinguishing Recent Bursts from Continuous SF

Suite of model indices spanning many SFHs

SEDs from impro code (Moustakas et al. 2013) convolved with SSP SEDs from B&C03 spanning their full metallicity range

Qualitatively distinguish several different SFHs following Kauffmann et al. 2003



continuous

$\mathrm{SFR}(t) \propto e^{-t/\tau}$

slow (long) e-folding

Region 1: typically late-type star formers

fast (short) e-folding

Region 3: typically old, quiescent early-types

Region 2: moderately old, weakly star-forming

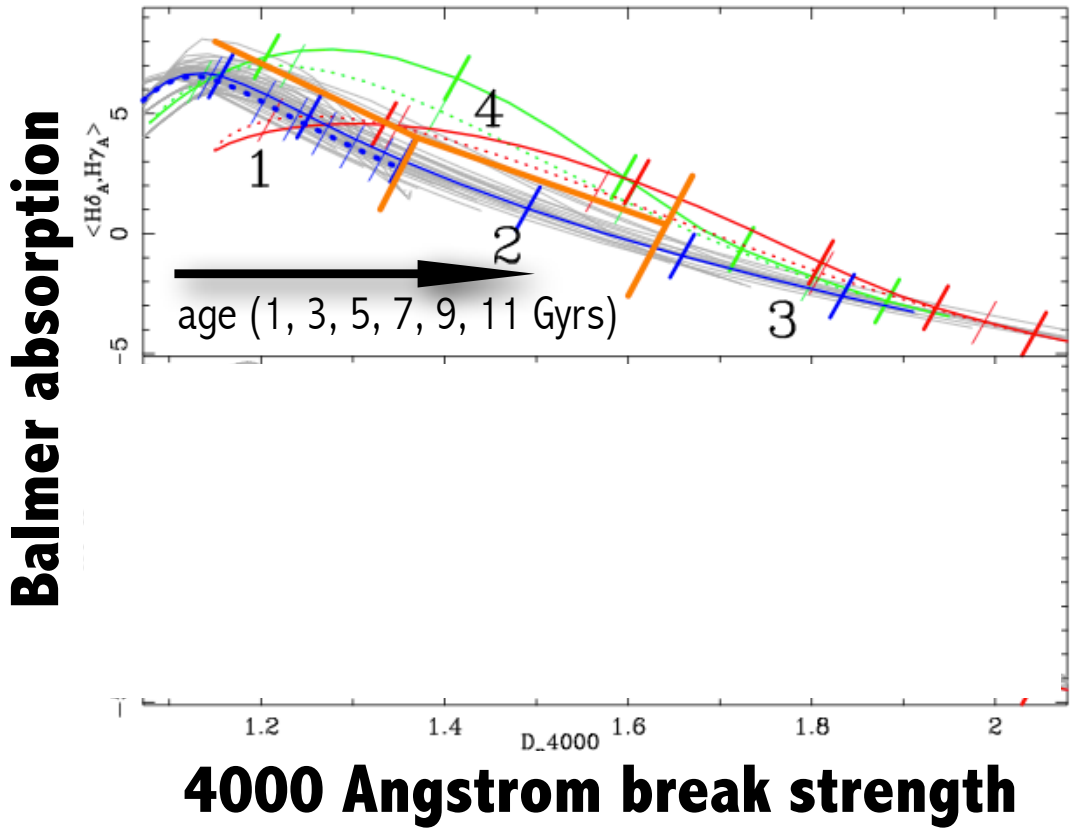
full param space of continuous SFH models

Distinguishing Recent Bursts from Continuous SF

Suite of model indices spanning many SFHs

SEDs from impro code (Moustakas et al. 2013) convolved with SSP SEDs from B&C03 spanning their full metallicity range

Qualitatively distinguish several different SFHs following Kauffmann et al. 2003



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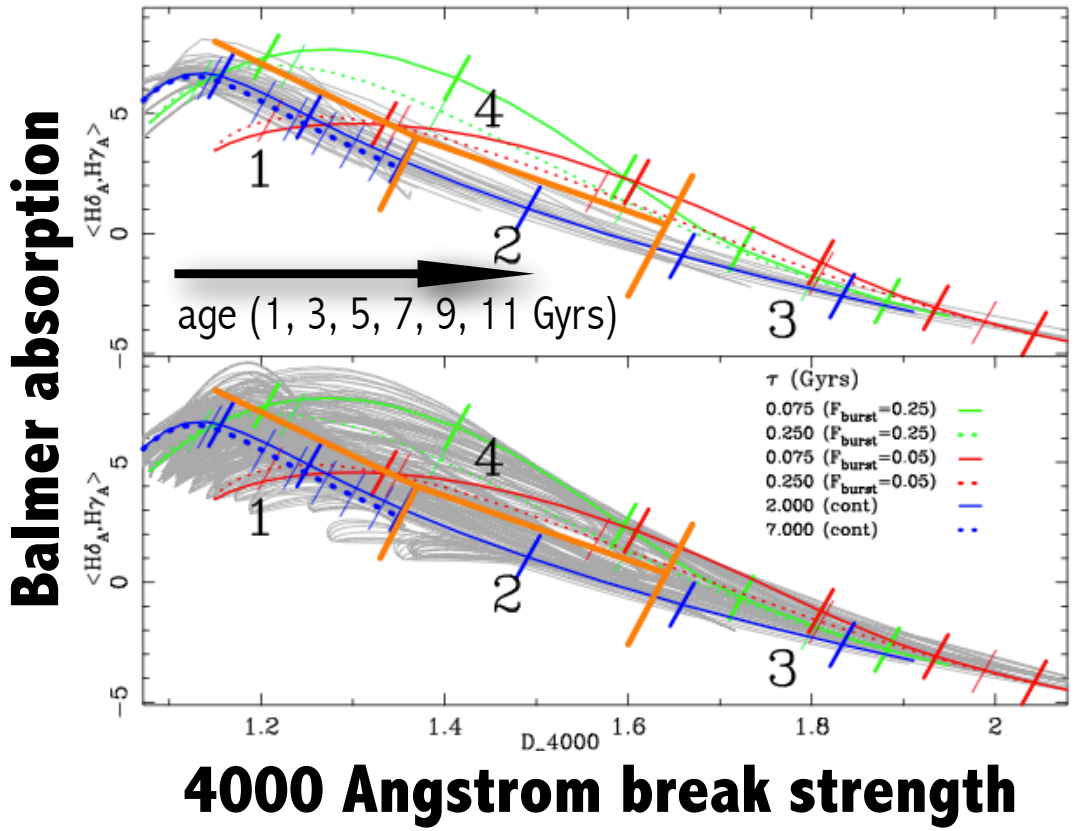

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25% on top of 12 Gyr-old SSP

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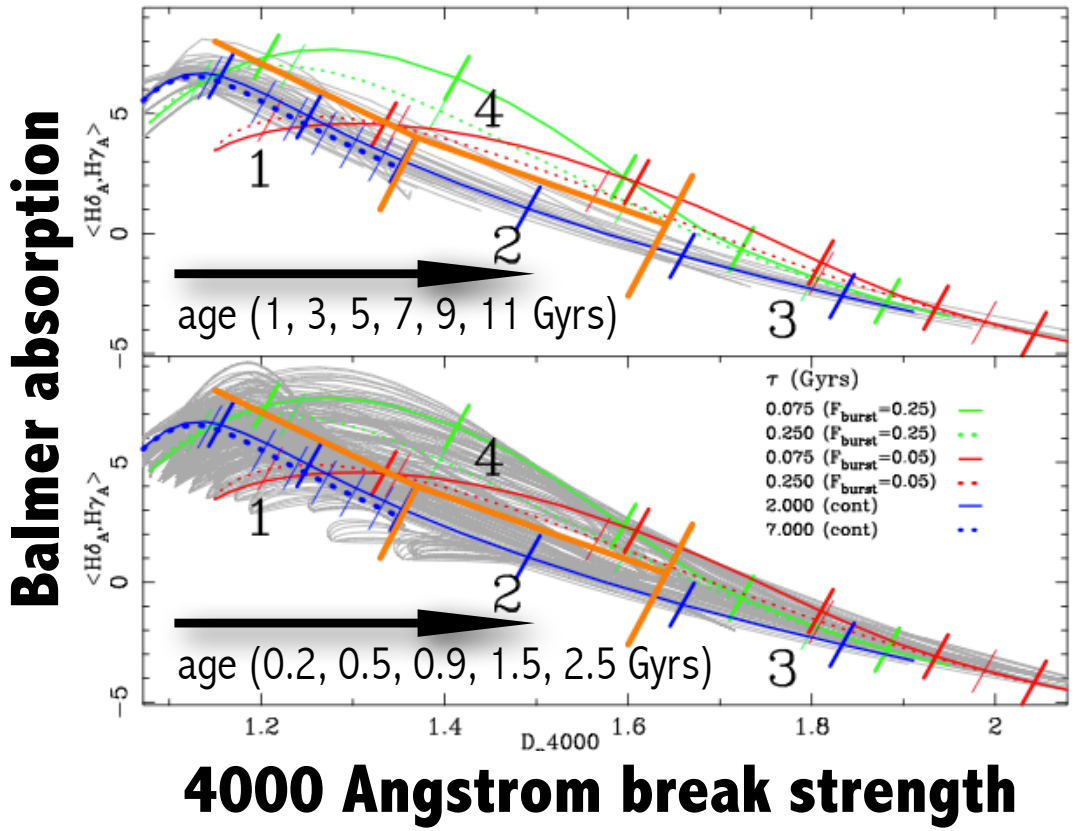

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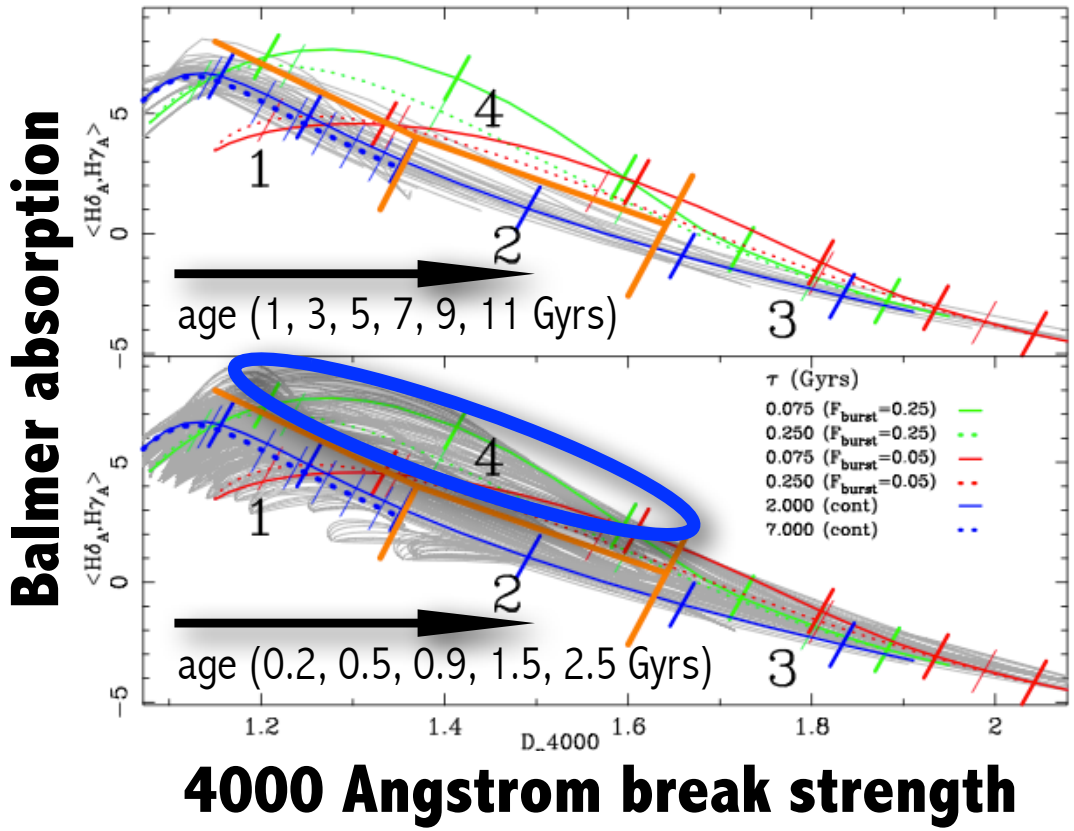

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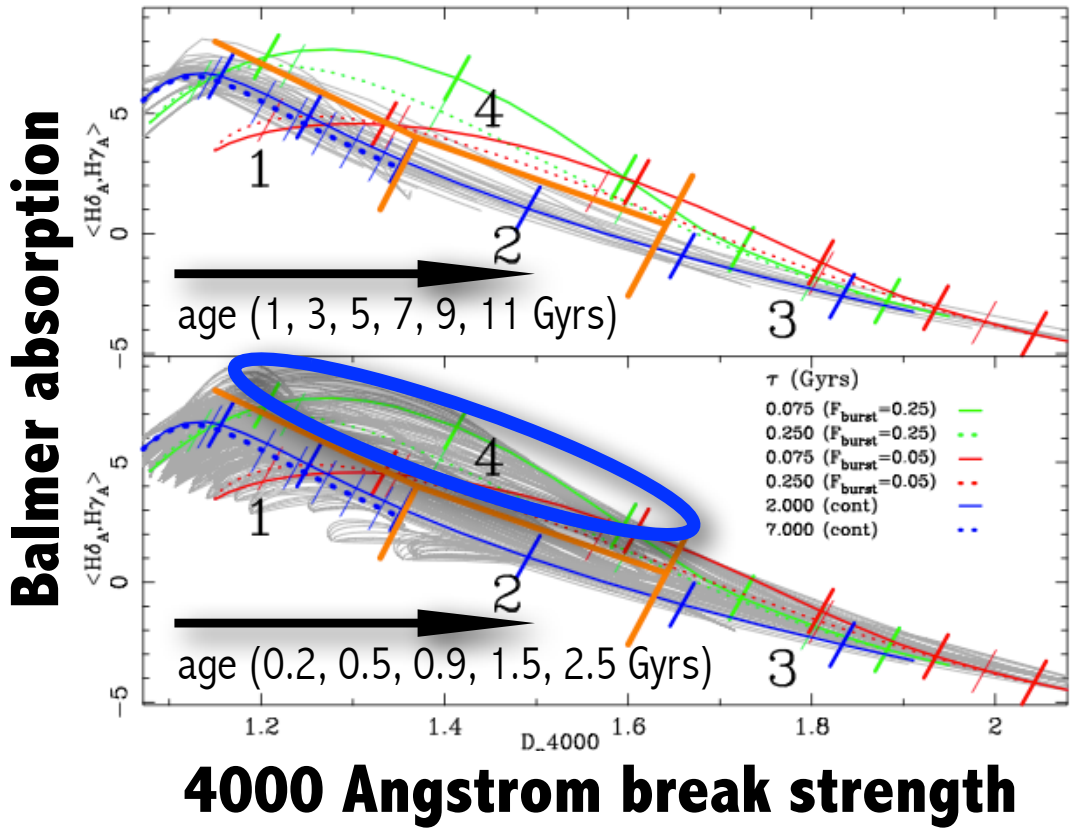

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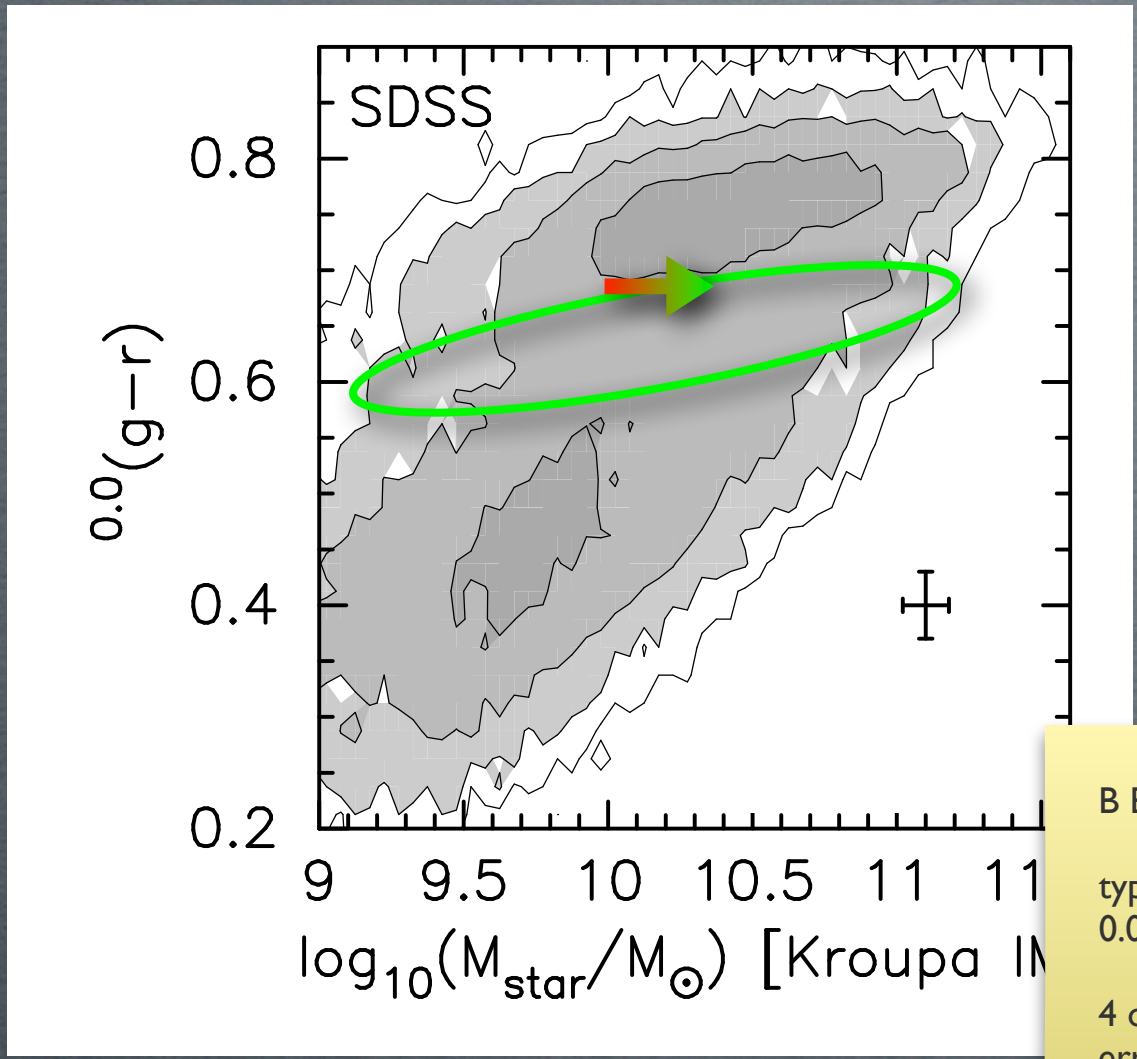
Radial indices of each galaxy in our sample are typically confined to a single region.

Red-red ("dry") merger to a green-valley object?



a dry merger (DHM et al. 2008)

would conserve color of lower-mass progenitors

B E F G H

typ g-r color error = 0.04mag

4 of 5 have g-r w/in 1sig error of blue/red selection