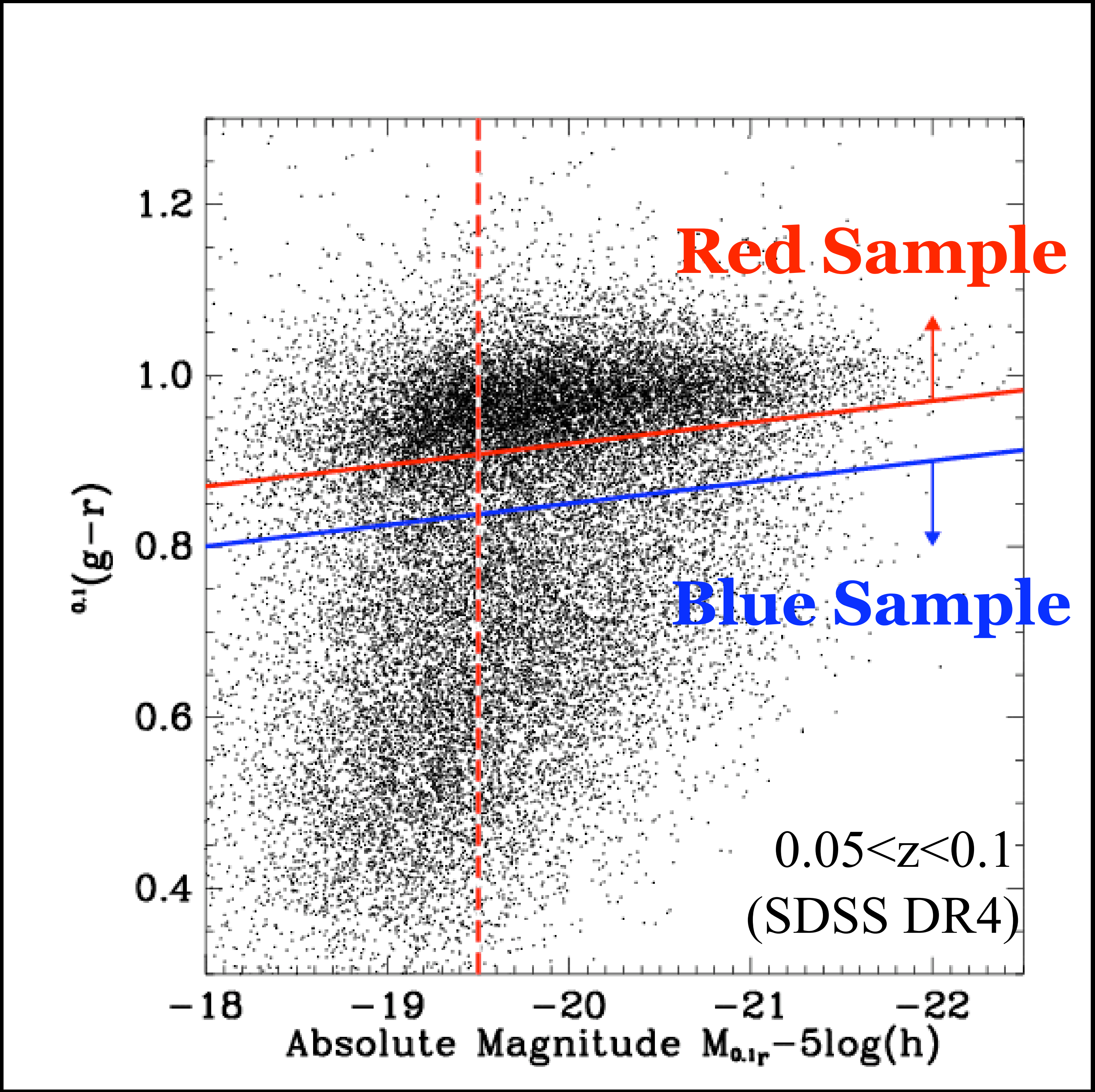
Prevalence of AGN in Red-Sequence and Post-starburst Galaxies

Renbin Yan
UC Berkeley

and
the DEEP2 Team

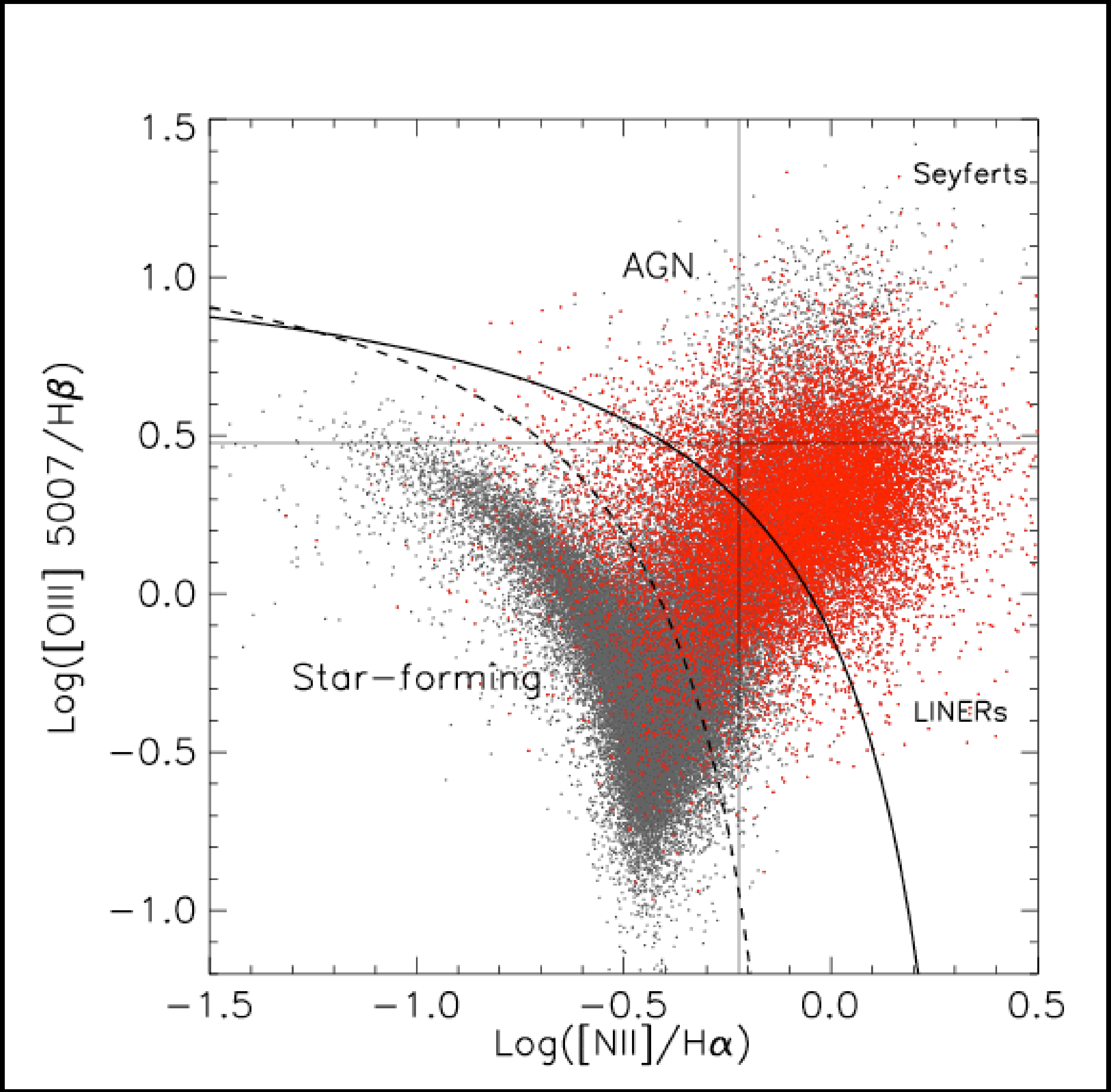
The Origin of the Bi-modality



The Question:

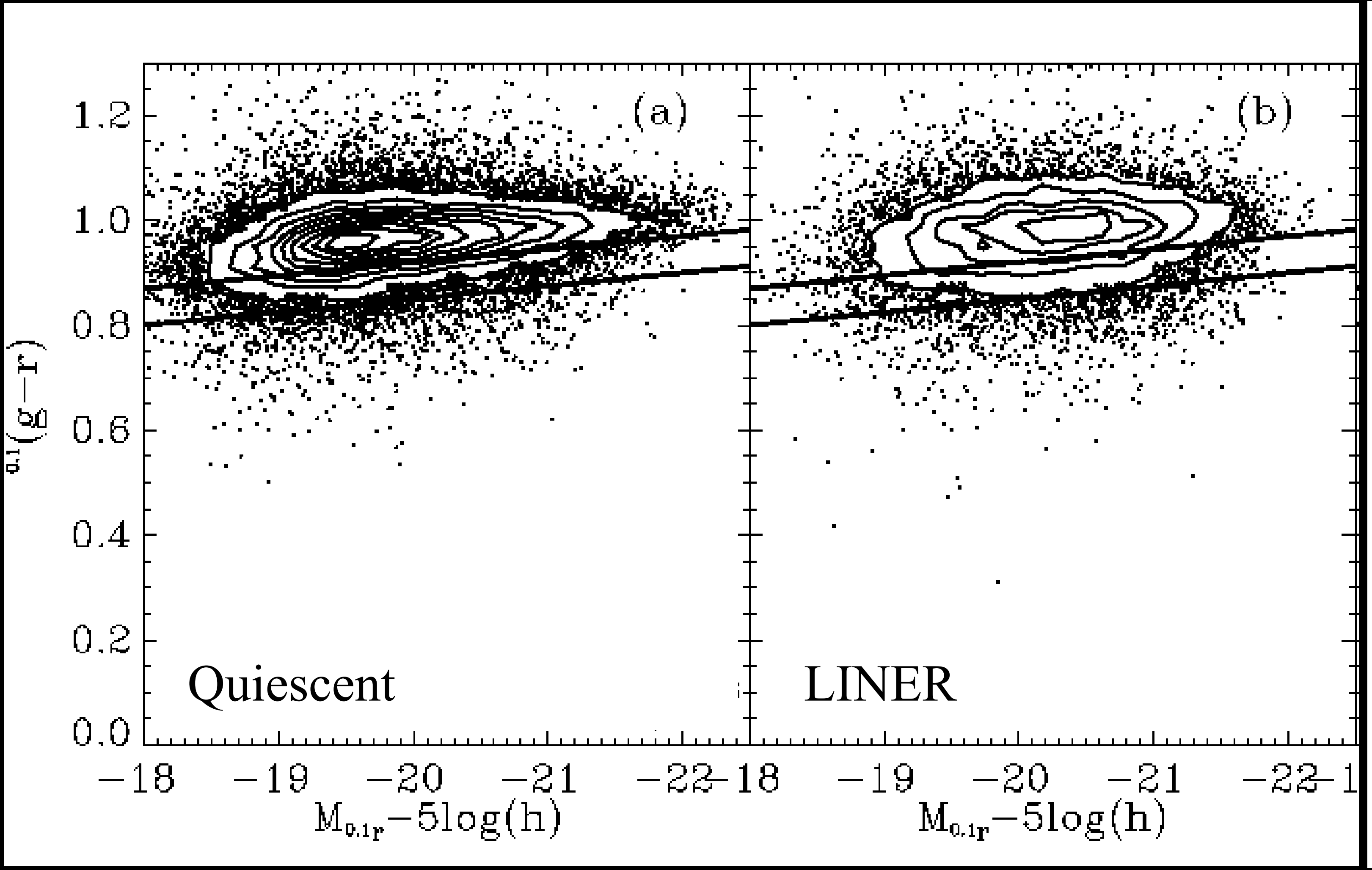
What mechanism quenches the star formation in red galaxies and keeps them quenched?

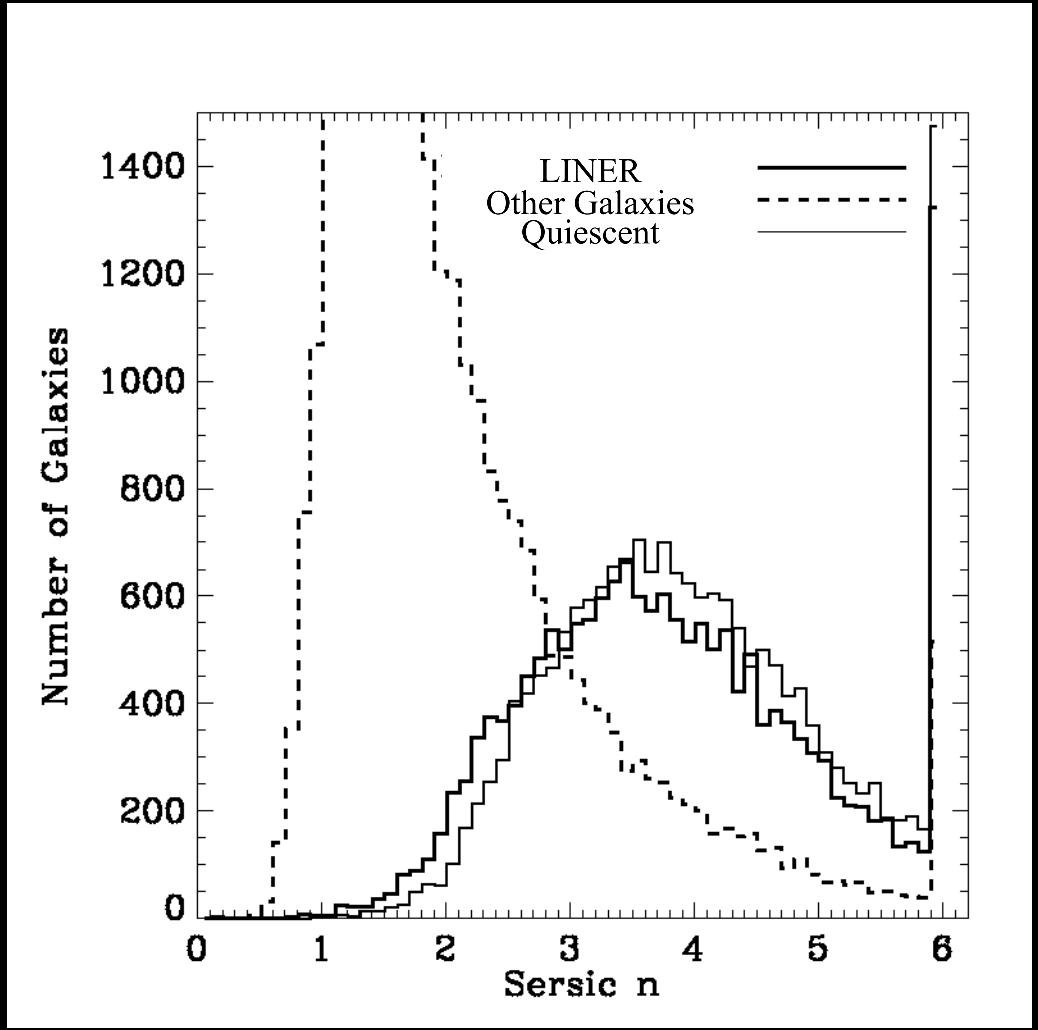
Origin of Line Emission in Red Galaxies



Quiescent (w/o detectable emission)	48%
LINER	29-40%
Seyferts & Transition Objects	6-17%
Dusty Star-forming	6%

LINERs vs. Quiescent Galaxies





LINER galaxies have the same color-magnitude-concentration distribution as quiescent galaxies.

The LINER/Quiescent Sequence

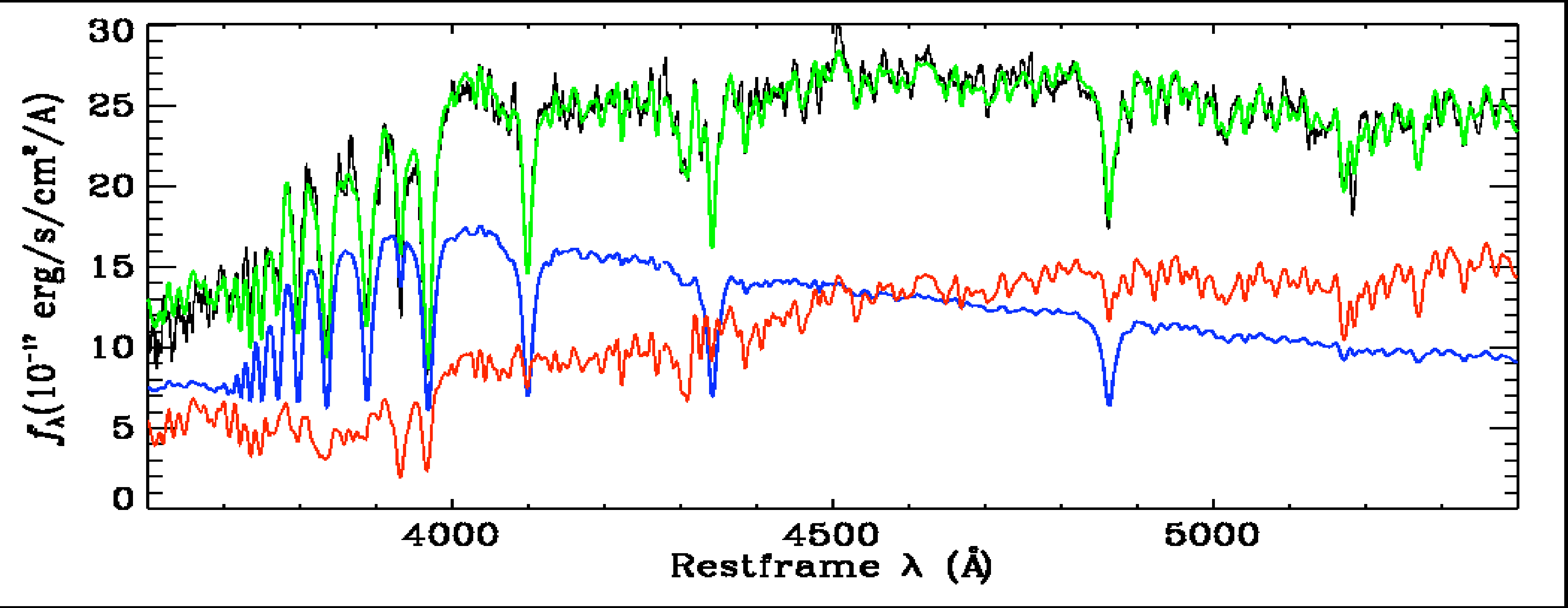
- LINERs occupy the same color-magnitude-concentration space as quiescent galaxies do. The combination of the two population defines a uniform red sequence.
- With spectral dating, it is found that galaxies with stronger LINER line emission has a younger stellar age. (Graves et al. 2006, in prep)
- The emerging scenario is that LINER might be fading with time. Is AGN activity even stronger in galaxies that have just been quenched?

Post-starburst Galaxies (aka K+A or E+A)

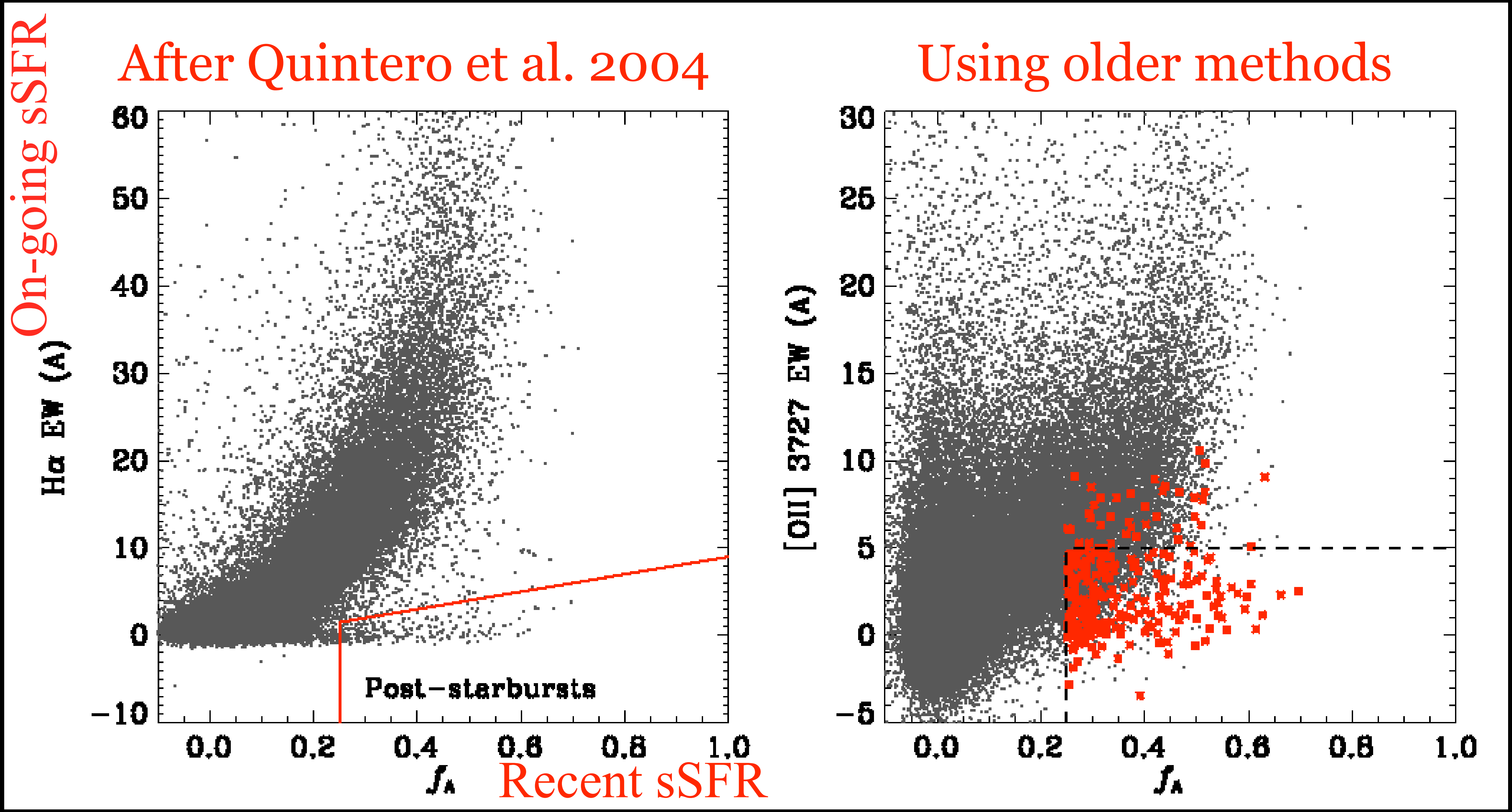
- Discovery

  First identifed by Dressler & Gunn 1983

- Definition
  - No ongoing star formation --- Lack of Emission lines
  - Recent star formation (within 1Gyr) --- Strong Balmer Absorption lines

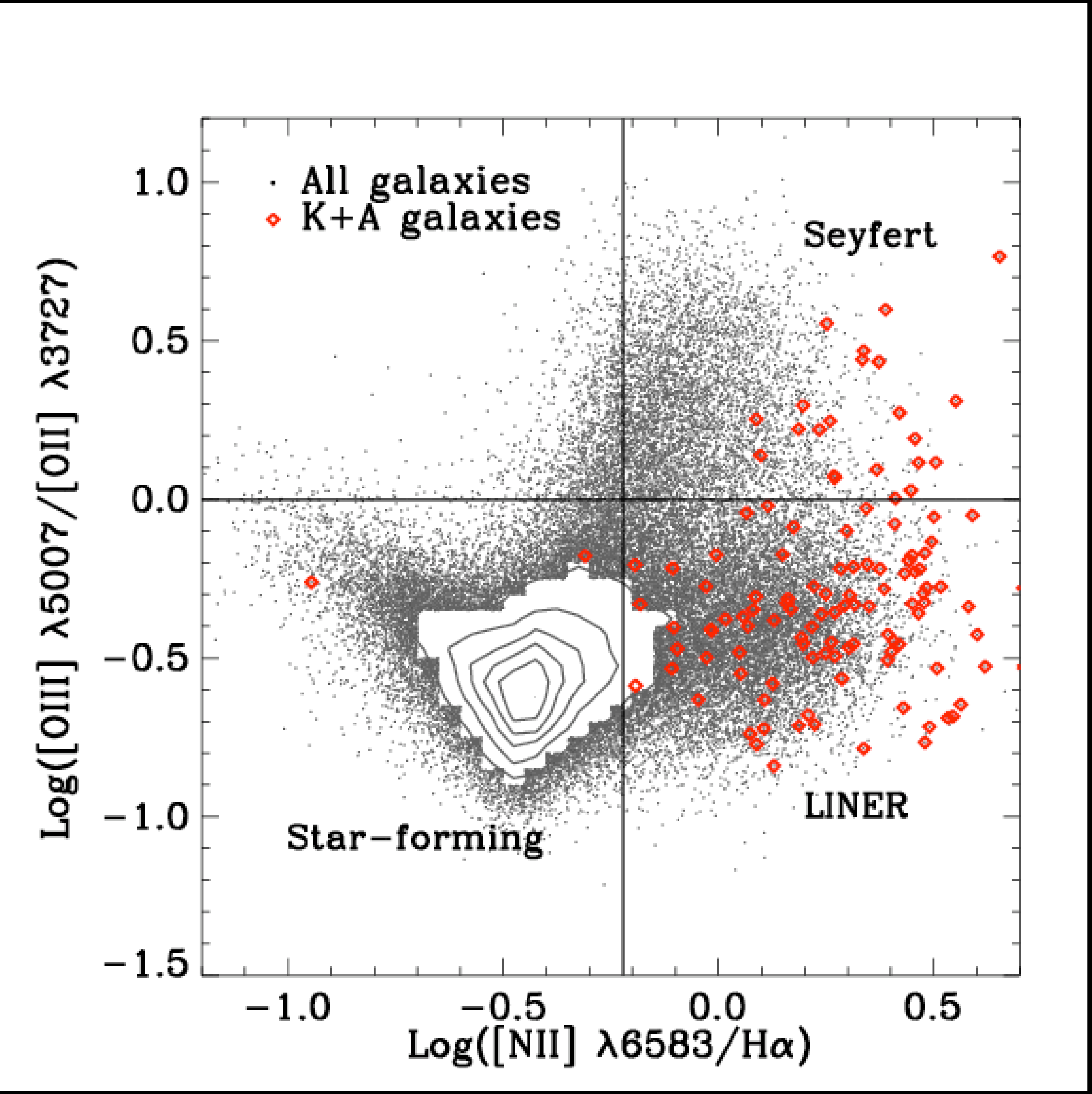


Selections of Post-Starbursts



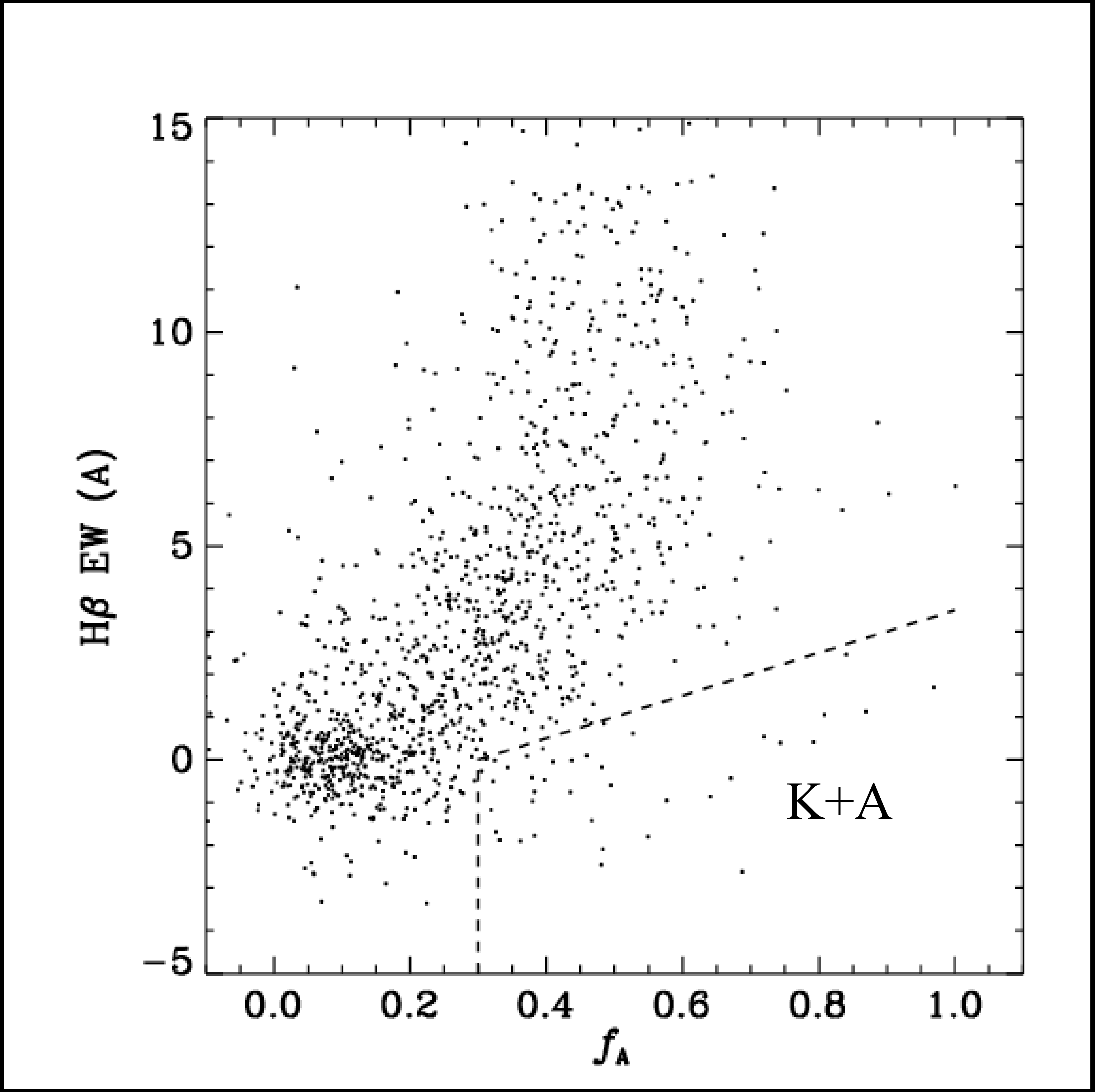
Using SDSS galaxy sample, Quintero et al. 2004 first pointed out that post-starburst galaxies stand out as a separate population in Hα EW vs. f_A plot. But they do not stand out separately in [OII] EW (Yan et al. 2006)!

AGN/LINER-like emission in K+As



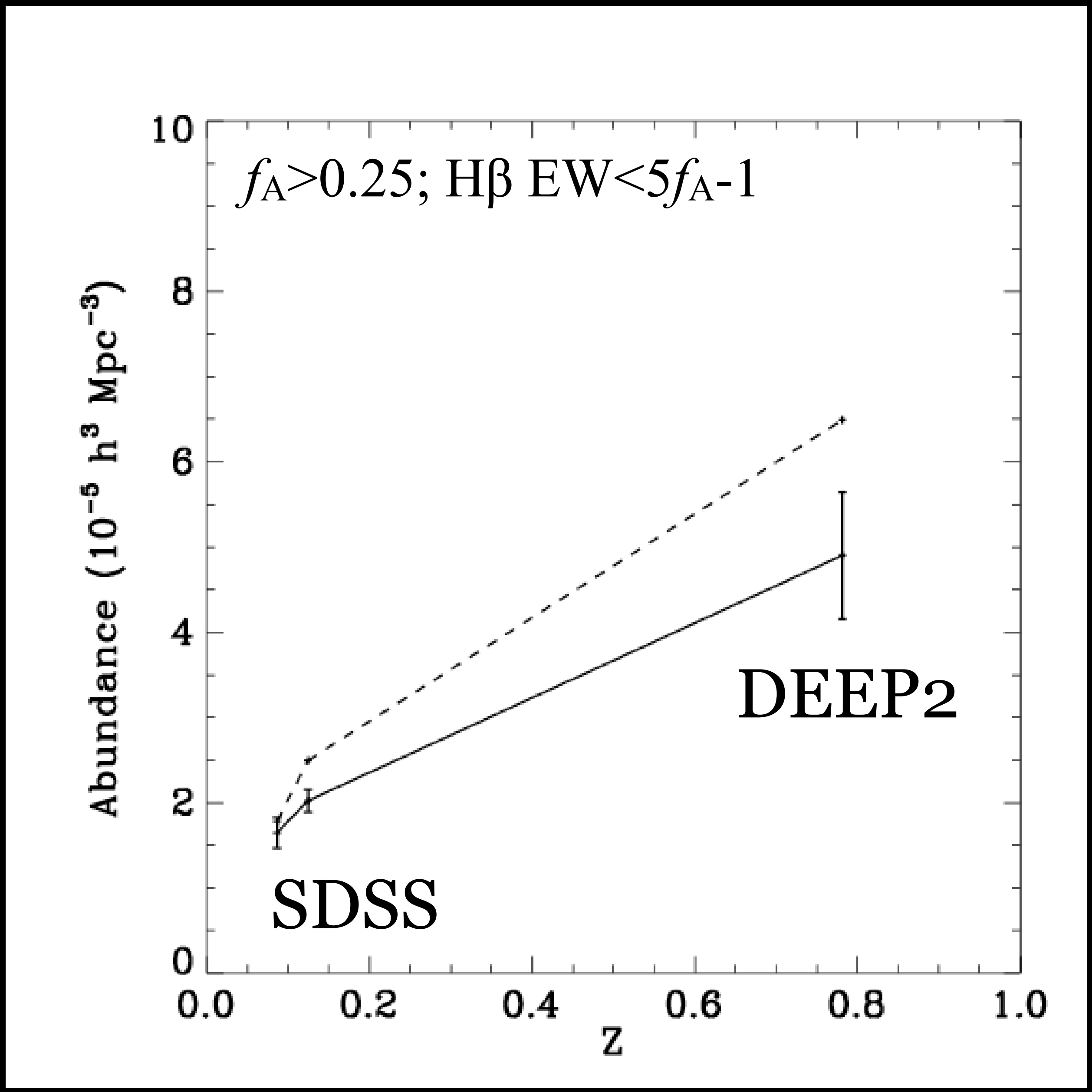
78% of post-starburst have detectable AGN emission
vs.
46% in Red Sequence Galaxies

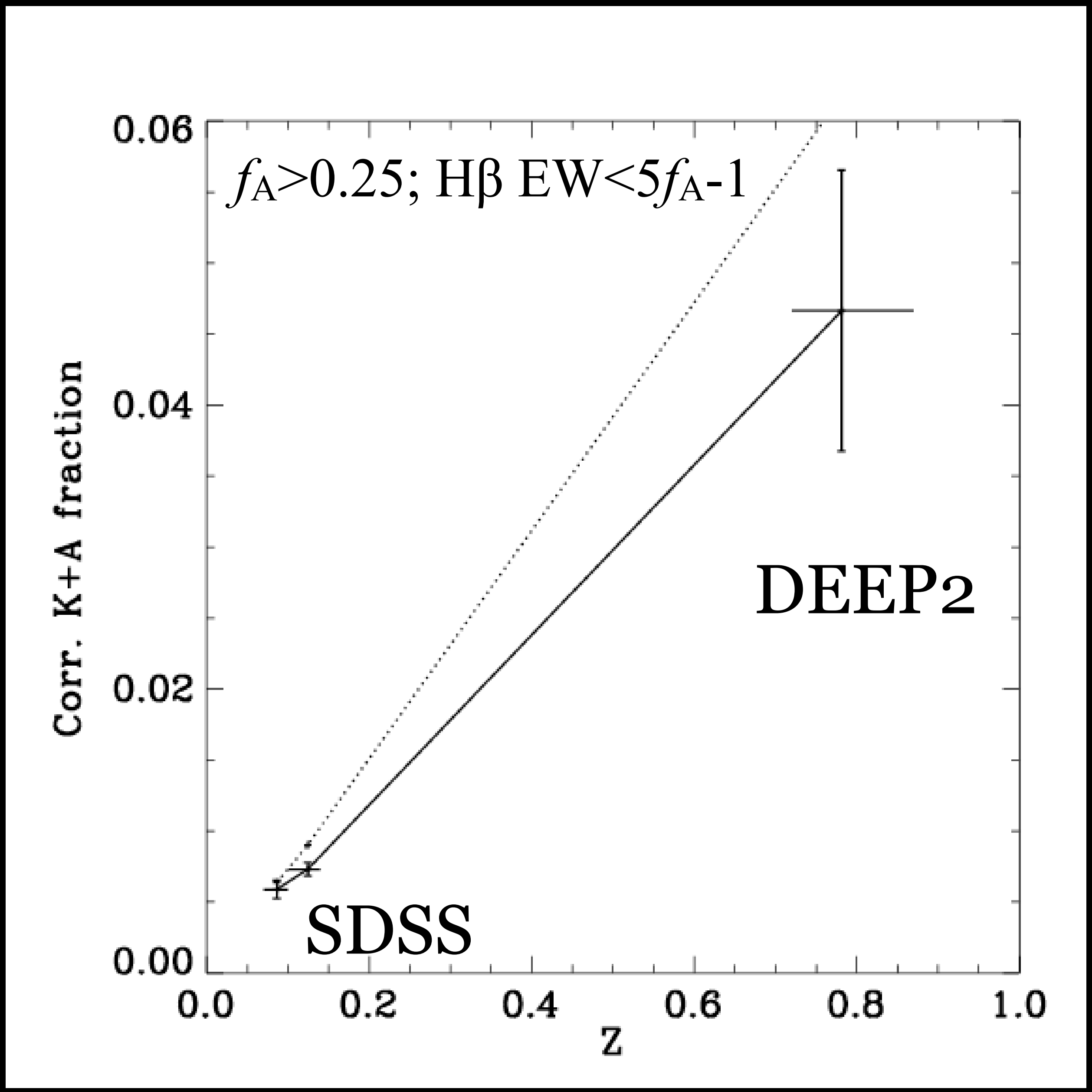
Finding K+A galaxies in DEEP2 at z>0.7



- Using Hβ in place of Hα
- This limits the sample to 0.68 < z < 0.88
- Require $M_B<-20.8$ to ensure high s/n and low contamination rate.

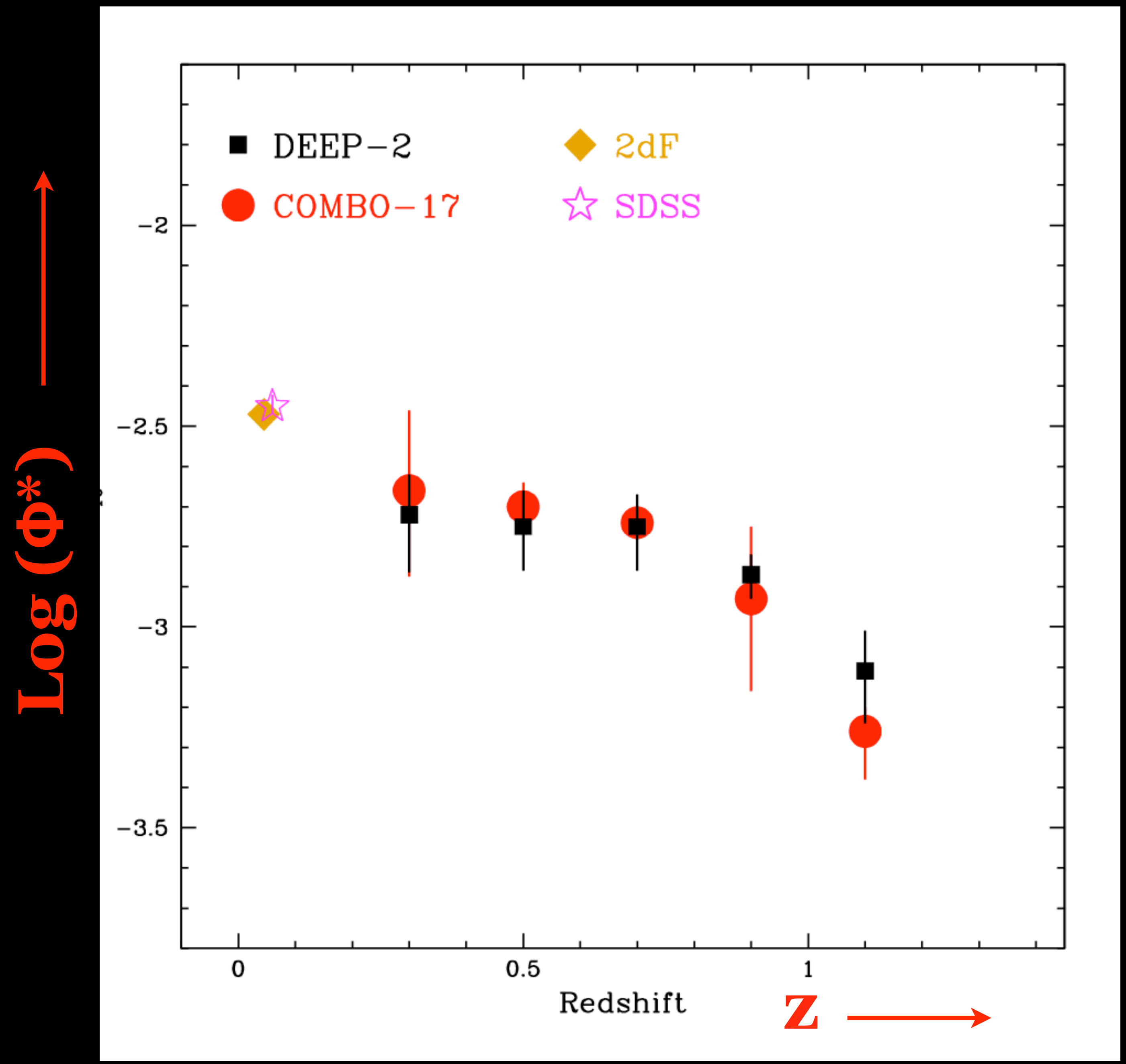
Abundance evolution





The abundance of K+A galaxies brighter than $1.4L_B^*$ increases significantly with redshift. K+A fraction $\propto (1+z)^{4.1+/-0.4}$ (Yan et al. in prep)

The build-up of the Red Sequence

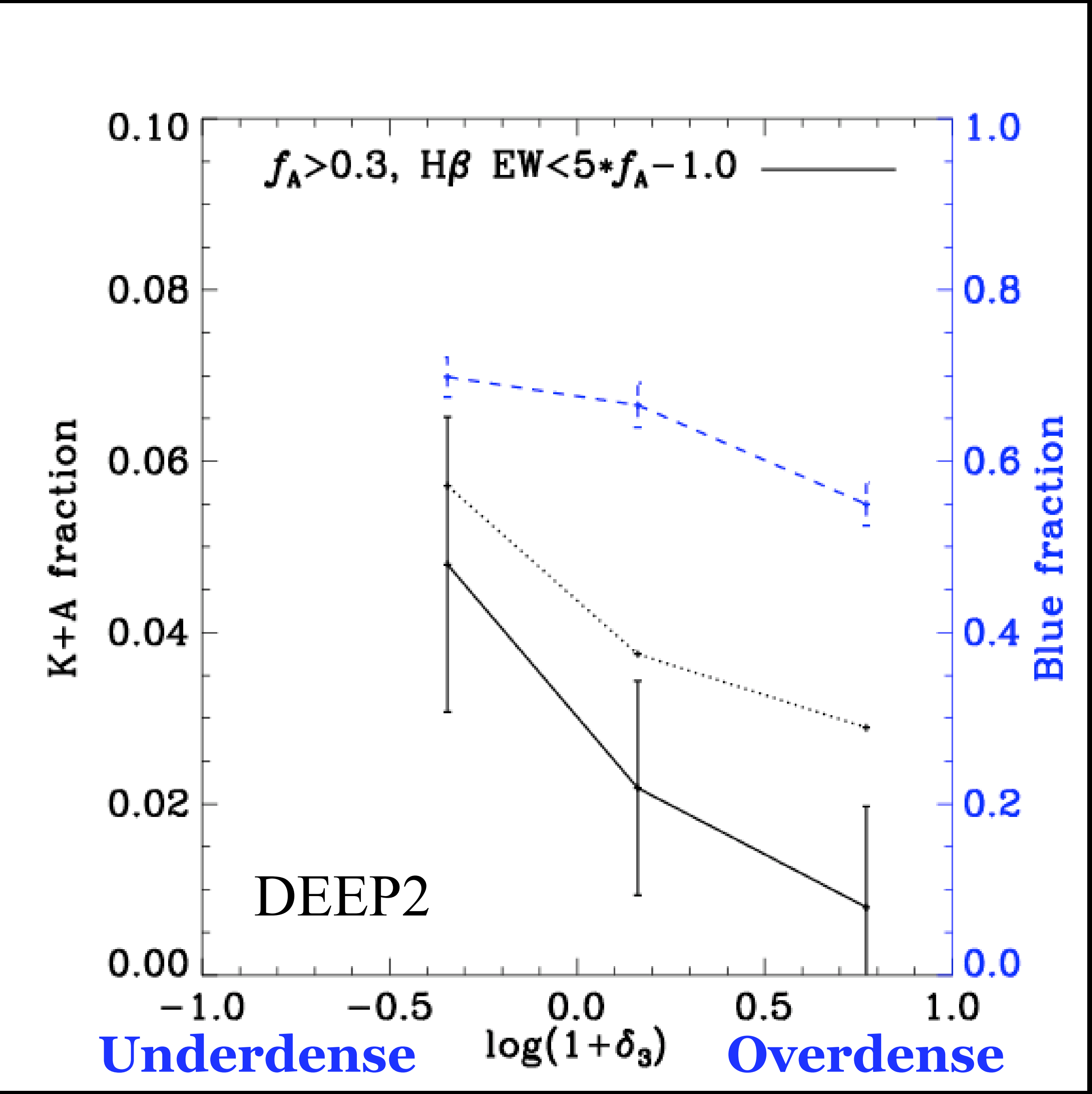


Faber et al. 2005

The total comoving abundance of L* red galaxies appears to change by 2~4x between z=1 and z=0.

Rough estimates show K+A at z~0.8 could account for 15%-30% of the growth in red sequence population, but probably not all.

Environmental dependence



(Yan et al. in prep)

K+A galaxies at z~0.8 populate similar environments as blue, star-forming galaxies (probably their progenitors). This is consistent with Hogg et al.'s result on SDSS using similar selection criteria.

Past studies with selection using [OII] and/or smaller samples have shown contradictory results between different authors (Zabludoff et al. 1996, Balogh et al. 1999, Dressler et al. 1999, Tran et al. 2004, Blake et al. 2004).

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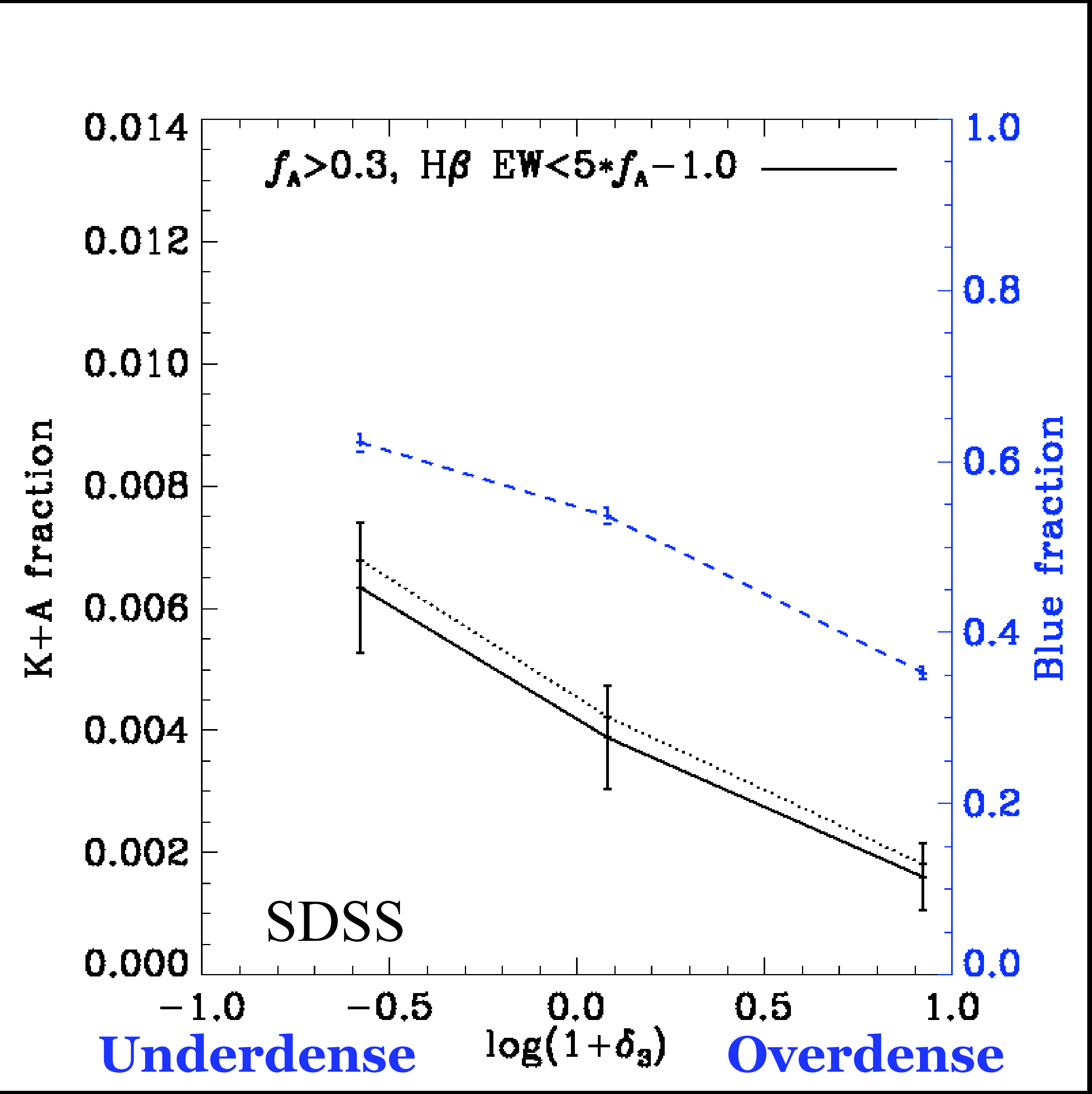

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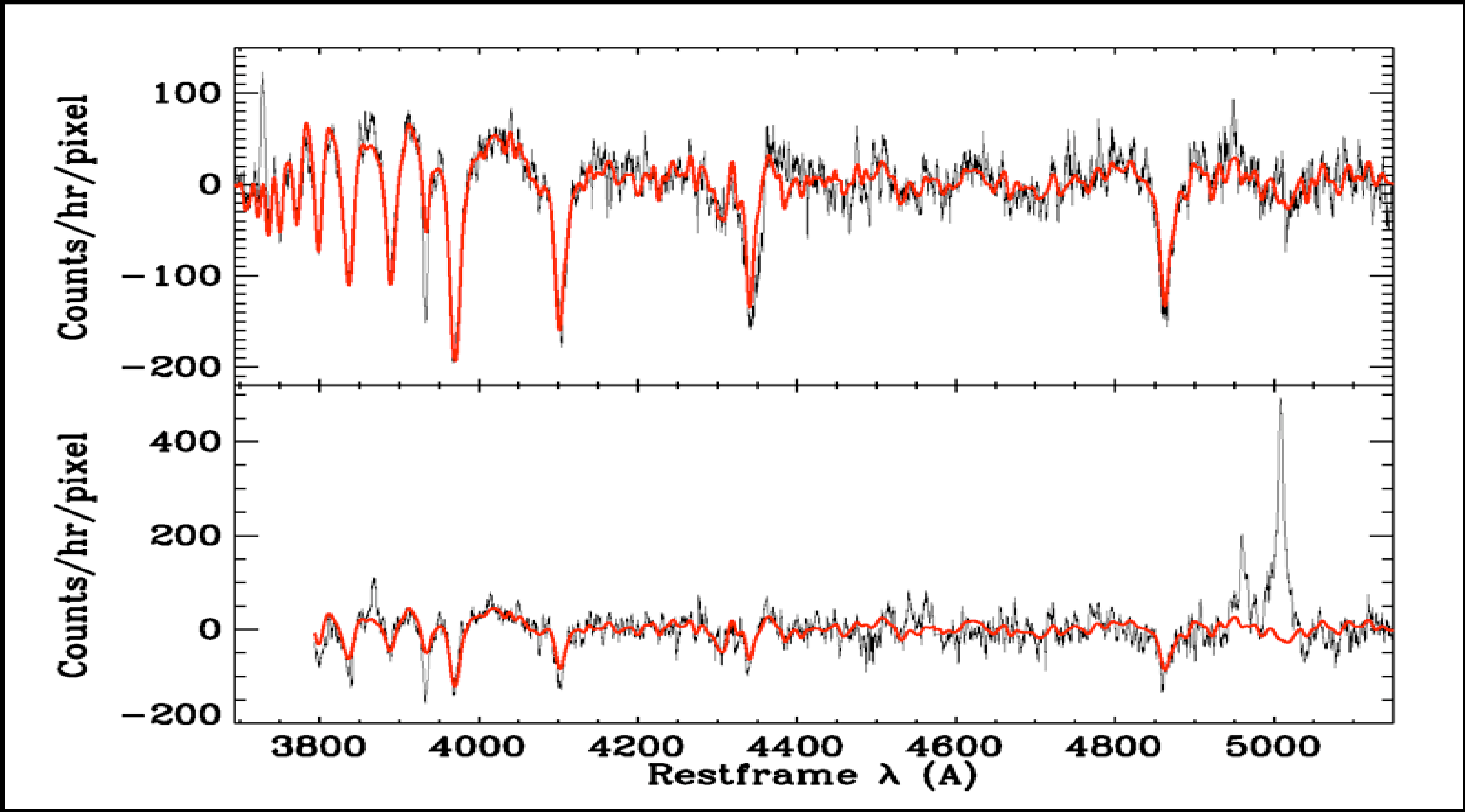
Post-starburst AGN spectra from DEEP2



Just like the local universe, ~70% of K+A galaxies at z~0.8 have [OII] and [OIII] detected. Mostly they have AGN-like line ratios. Thus these lines are NOT due to residual star formation, but probably AGN activity.

Conclusions

- 45% of red galaxies have line ratios typical of various types of AGNs. K +A galaxies have an even higher AGN frequency (73%).
- LINER-like galaxies are almost indistinguishable from quiescent galaxies in color-mag-concentration space. The combination of the two defines a uniform red sequence.
- K+A galaxies can only be distinguished from star-forming galaxies when using Hα or Hβ as the star formation indicator. K+A samples defined using [OII] will be either incomplete or heavily contaminated.
- The abundance of K+A galaxies at z~0.8 is significantly higher than that in the local universe, but not enough to account for all the growth in red galaxy population.
- K+A galaxies are NOT preferentially found in high-density environments, instead, they show similar environmental dependence as star-forming galaxies.

For more details, see Yan et al. 2006 (astro-ph/0512446)