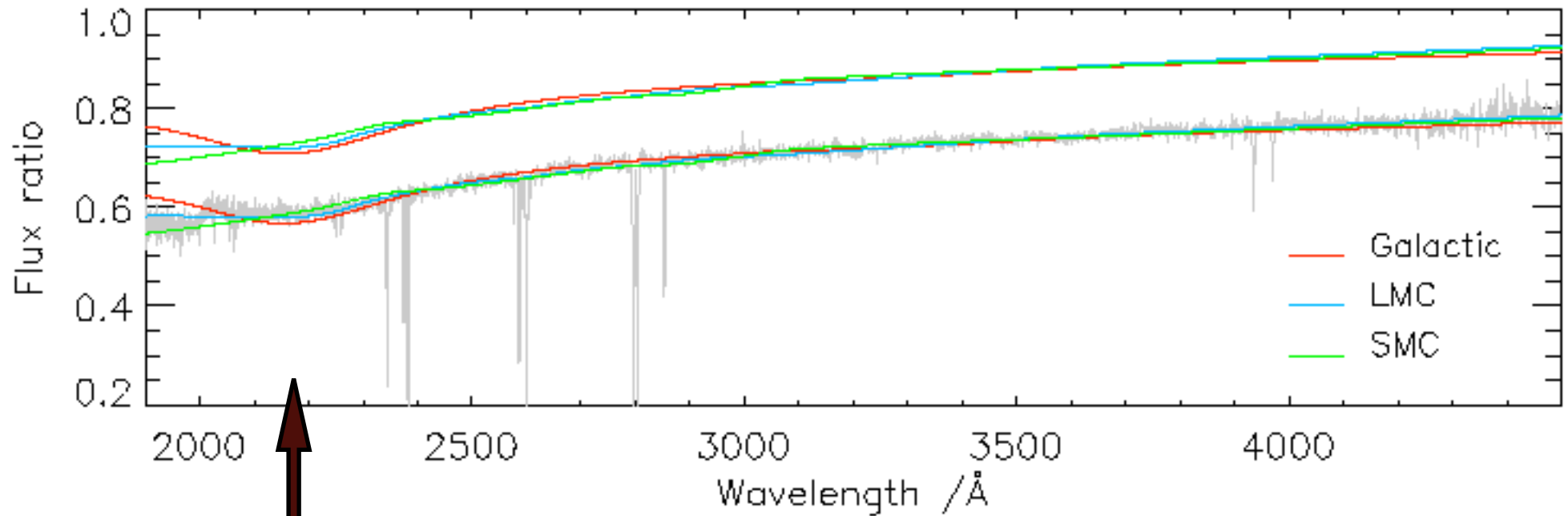


Improving SFH indicators

Vivienne Wild
MPA-Garching

Previously: PhD at IoA Cambridge
(Galaxy biasing in 2dFGRS, OH sky residuals in SDSS,
Dust in CaII H&K QSO absorption line systems)

Dust in CaII absorbers



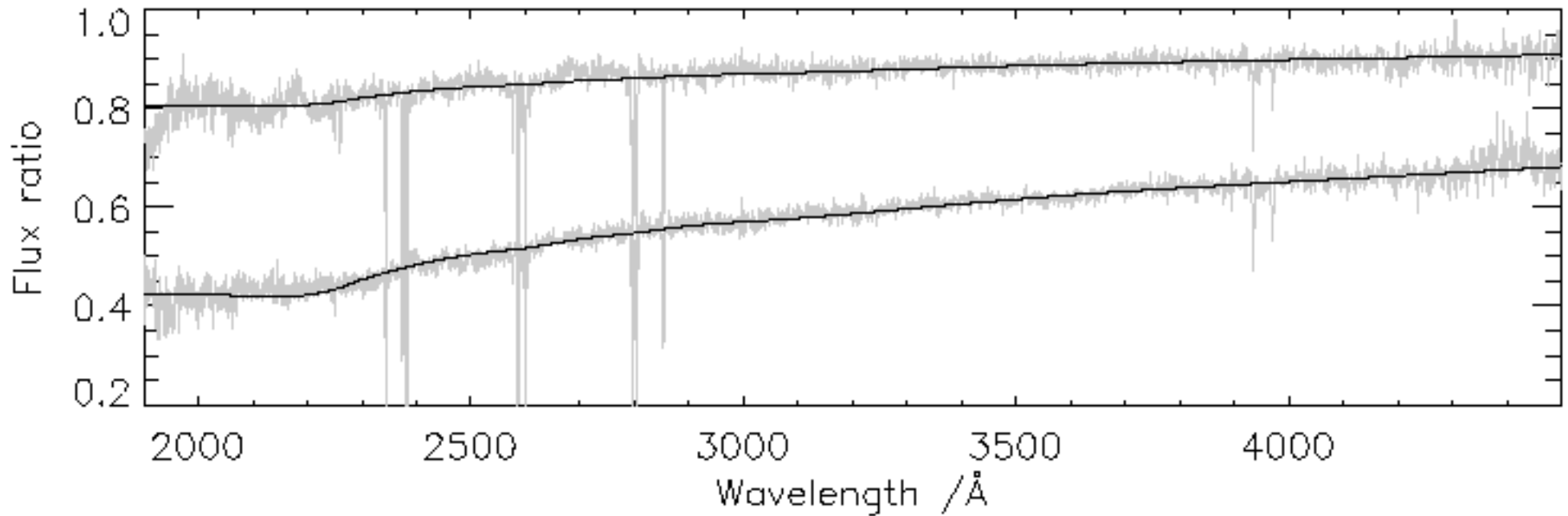
Dust
bump??

$E(B-V) \sim 0.06$ (LMC)

37 quasar spectra with intervening CaII(H+K) absorption
combined after division of each spectrum by high S/N control

Wild & Hewett 2005b; Wild, Hewett & Pettini 2006

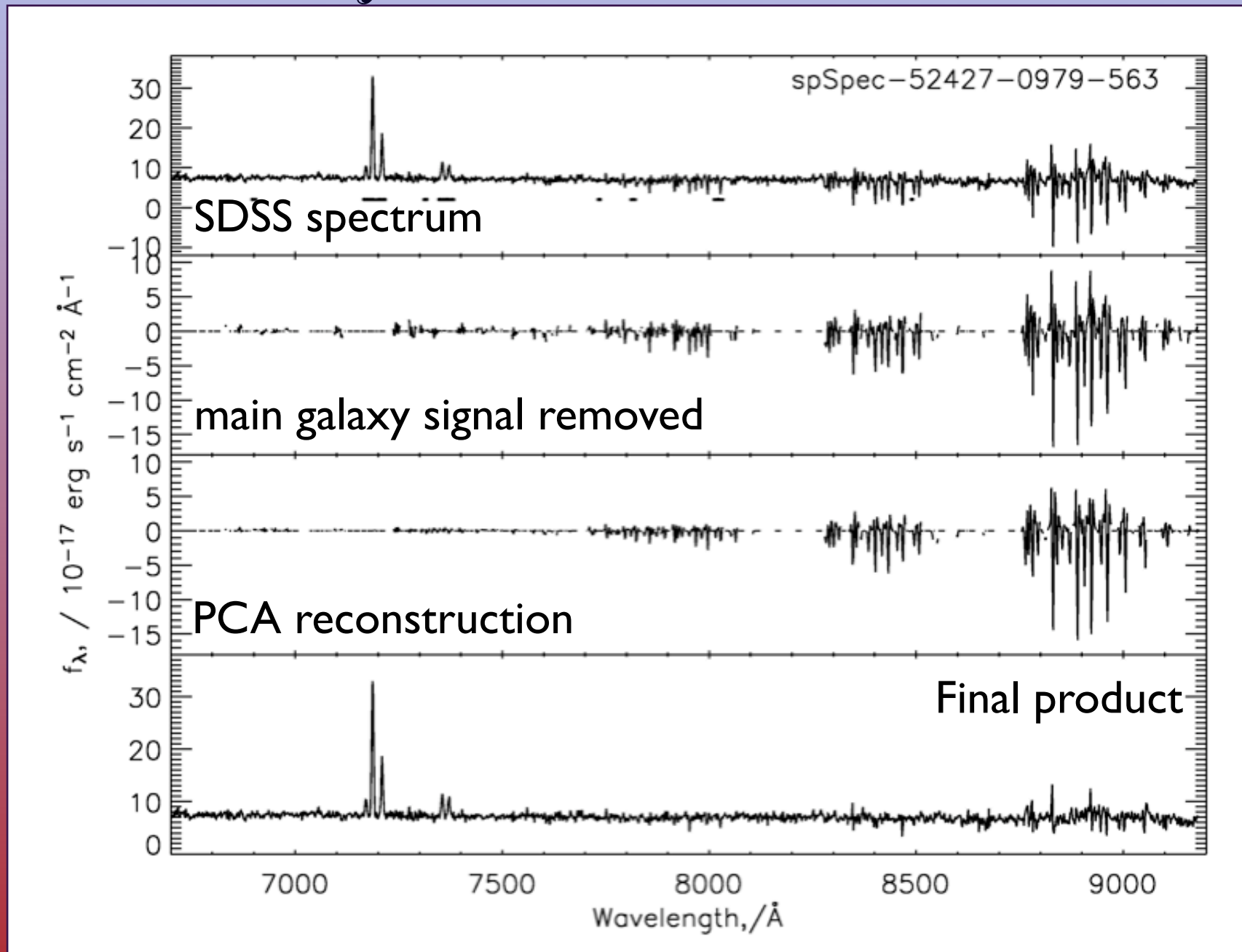
Composite spectra: split by EW



$E(B-V) \sim 0.10, 0.02$ (LMC)

CaII absorbers split into two samples by CaII EW, combined after division of each spectrum by high S/N control

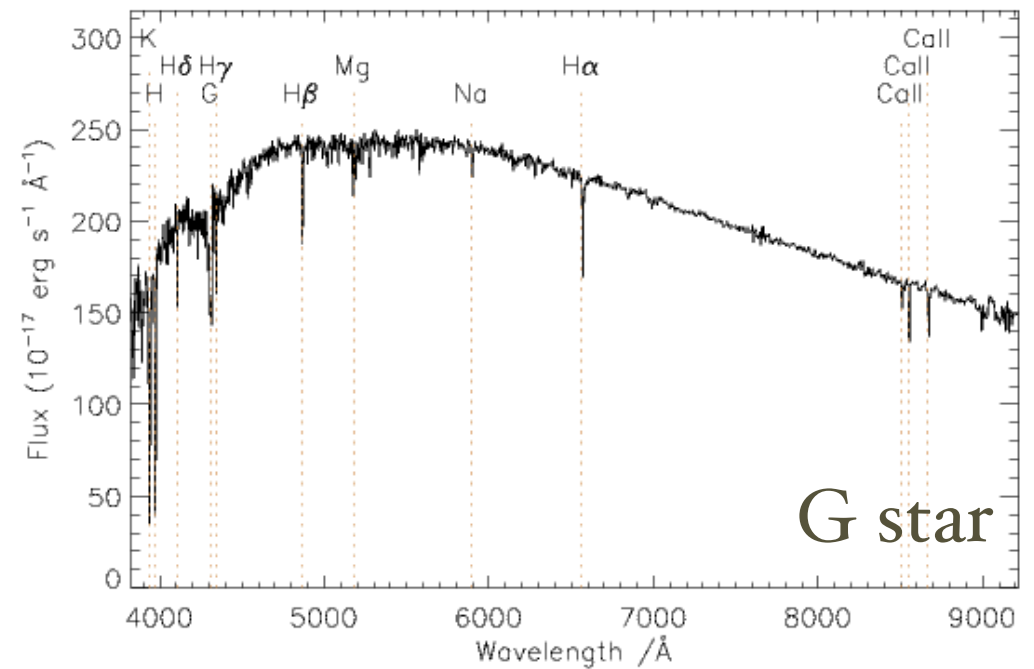
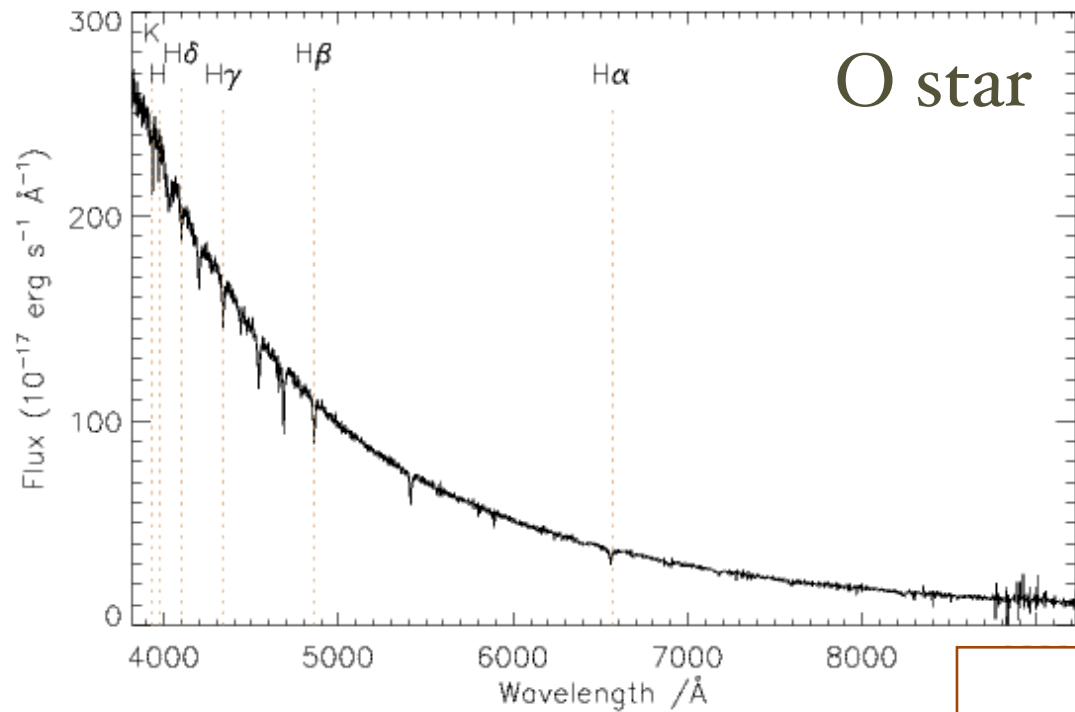
PCA sky-residual subtraction



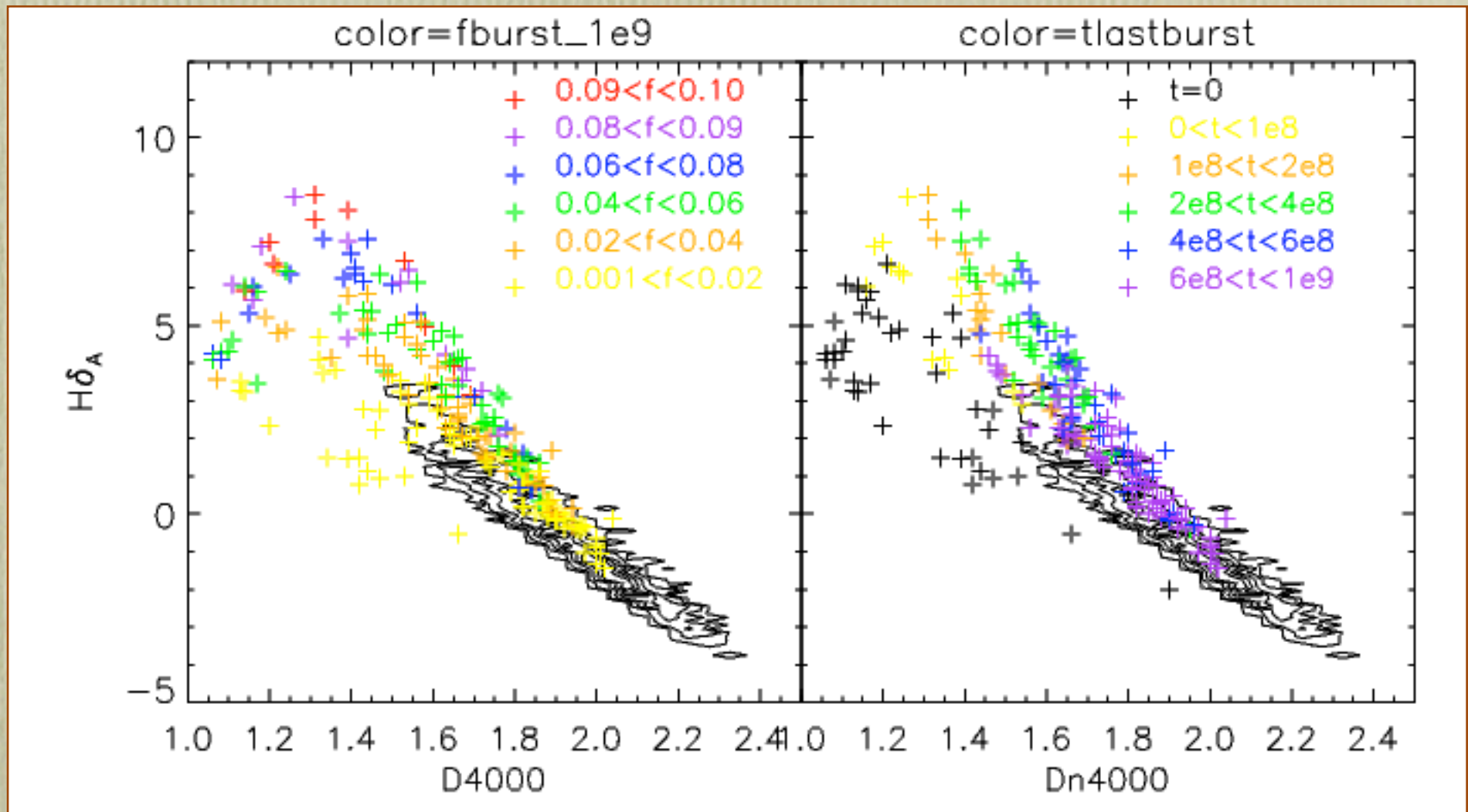
Understanding star formation in galaxies

- Major goal of extra galactic astronomy
 - AGN/star formation connection...
- Optical spectra → range of possible diagnostics
 - Balmer absorption lines e.g H δ
 - Shape/colour e.g. 4000Å break strength (D4000)
 - Emission lines e.g. H α , OII, OIII
 - Metal lines
- H δ and D4000 are both useful indicators of age of stellar populations
 - e.g. Kauffmann et al. 2003
 - But.... SNR of H δ poor at high z and in lower quality spectra

| | Main Sequence Lifetime | Spectral features | |
|--------|------------------------|--|--|
| O star | $\sim 10^6$ | Steep UV continuum He absorption | Strong UV continuum excites nebular emission lines |
| B star | $\sim 10^7$ | Some Balmer (HI) absorption | |
| A star | $\sim 5 \times 10^8$ | Strong Balmer lines and Balmer break Ca H&K lines | A trend with temperature within A stars: T↓ Ca↑ break ↓ |
| G star | $\sim 8 \times 10^9$ | Strong metal lines Balmer series weak Strong 4000Å break | |

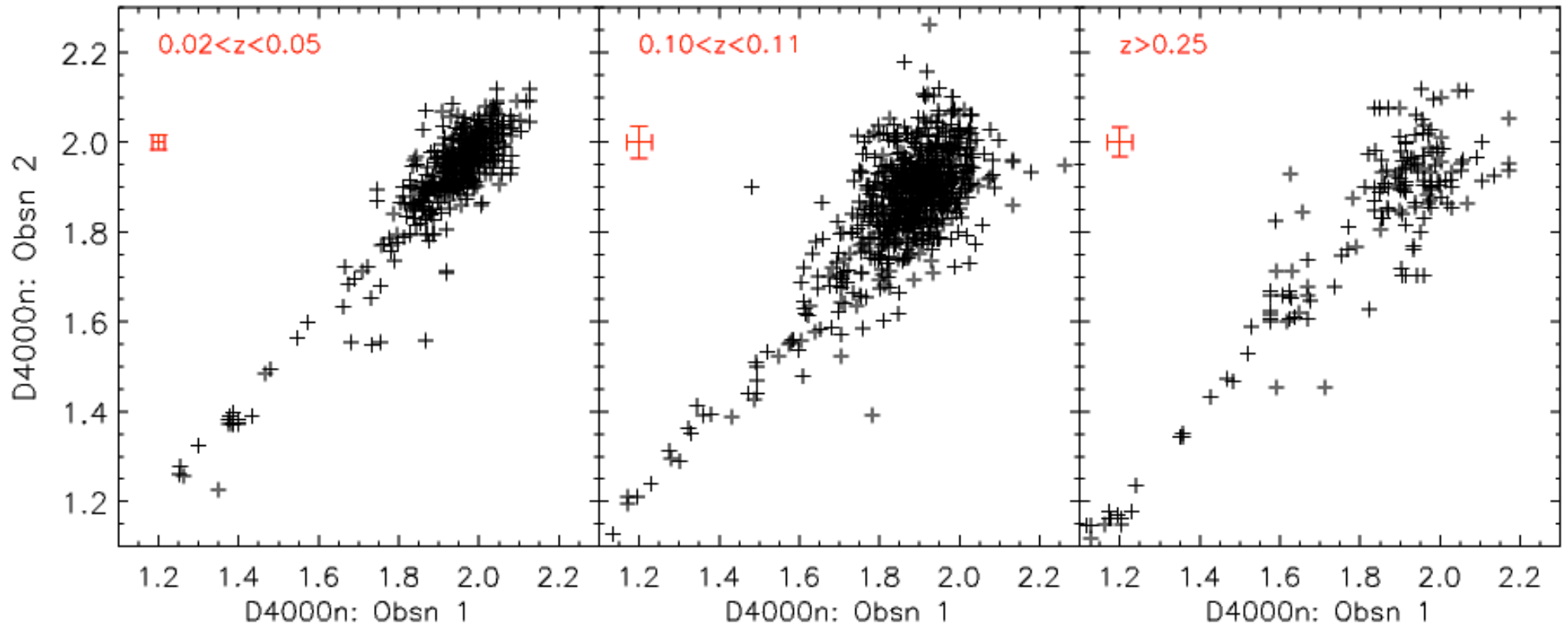


In theory....



BCo3; Stochastic burst catalogue; 'ellipticals' with less than 10% of their stars formed in bursts in the last 2×10^9 years

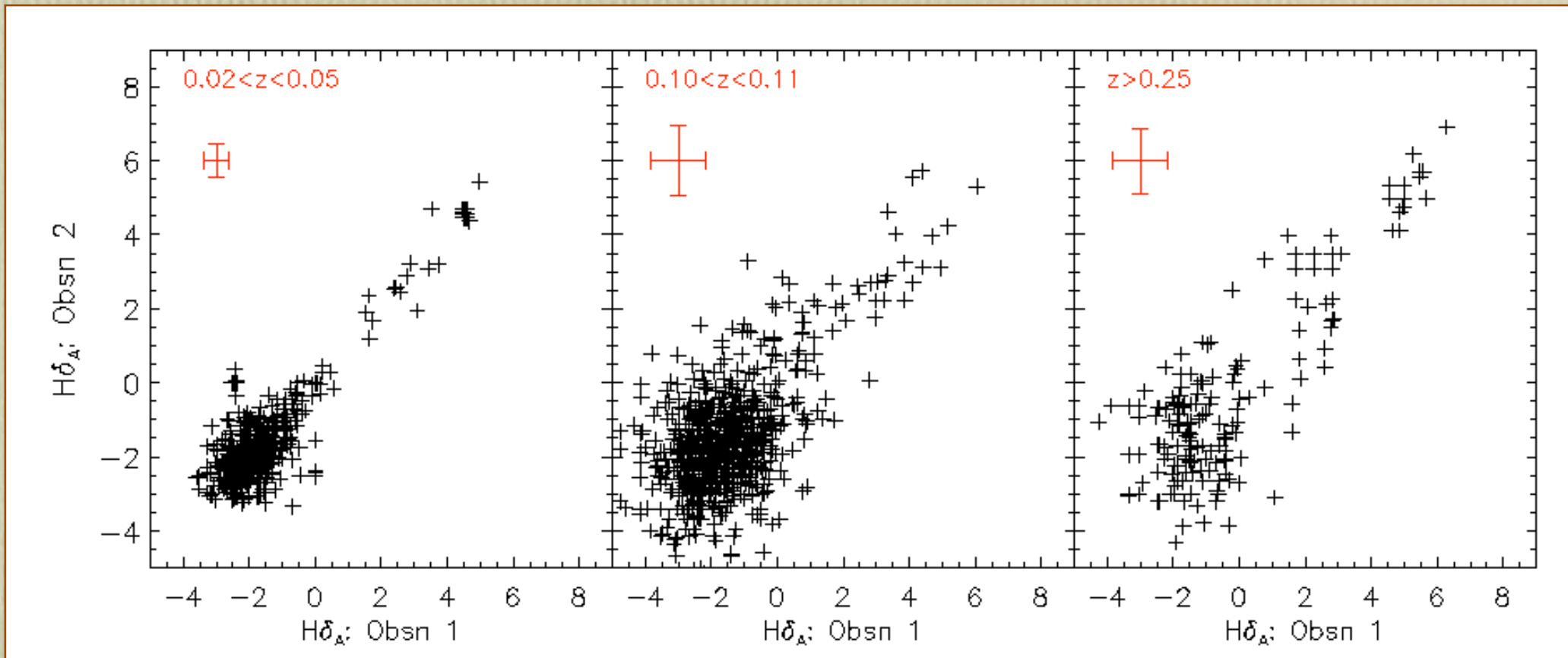
In reality....



SDSS DR4 duplicate observations; $\sigma_v > 155 \text{ km/s}$; median SNR > 10

Tremonti et al. 2004 - SDSS MPA catalogue at <http://www.mpa-garching.mpg.de/SDSS/>

In reality....

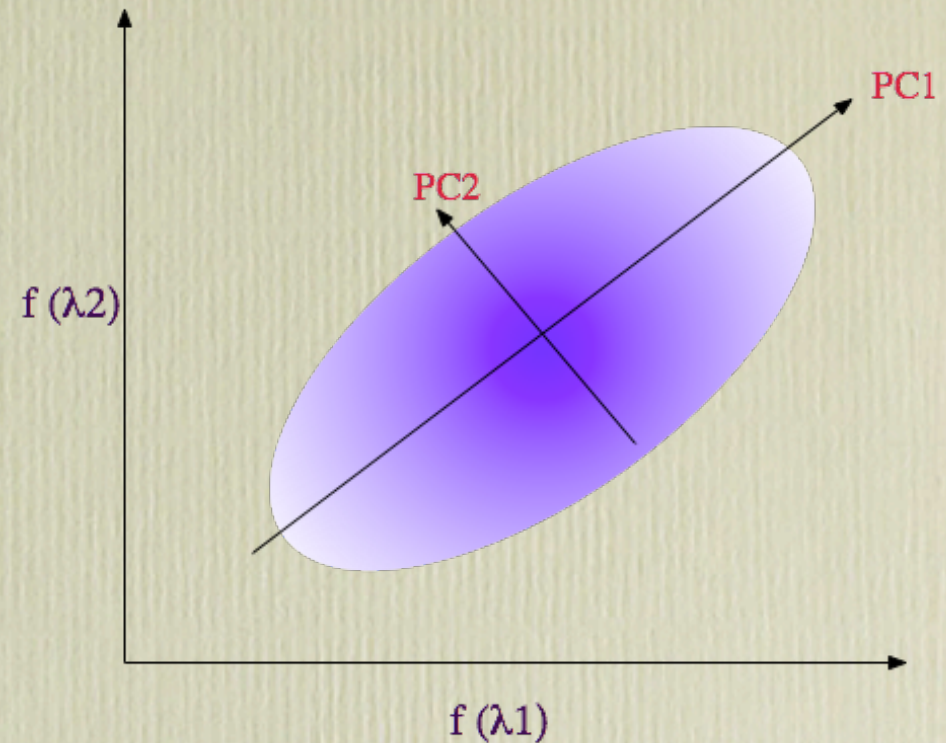


SDSS DR₄ duplicate observations; $\sigma_v > 155 \text{ km/s}$; median SNR > 10

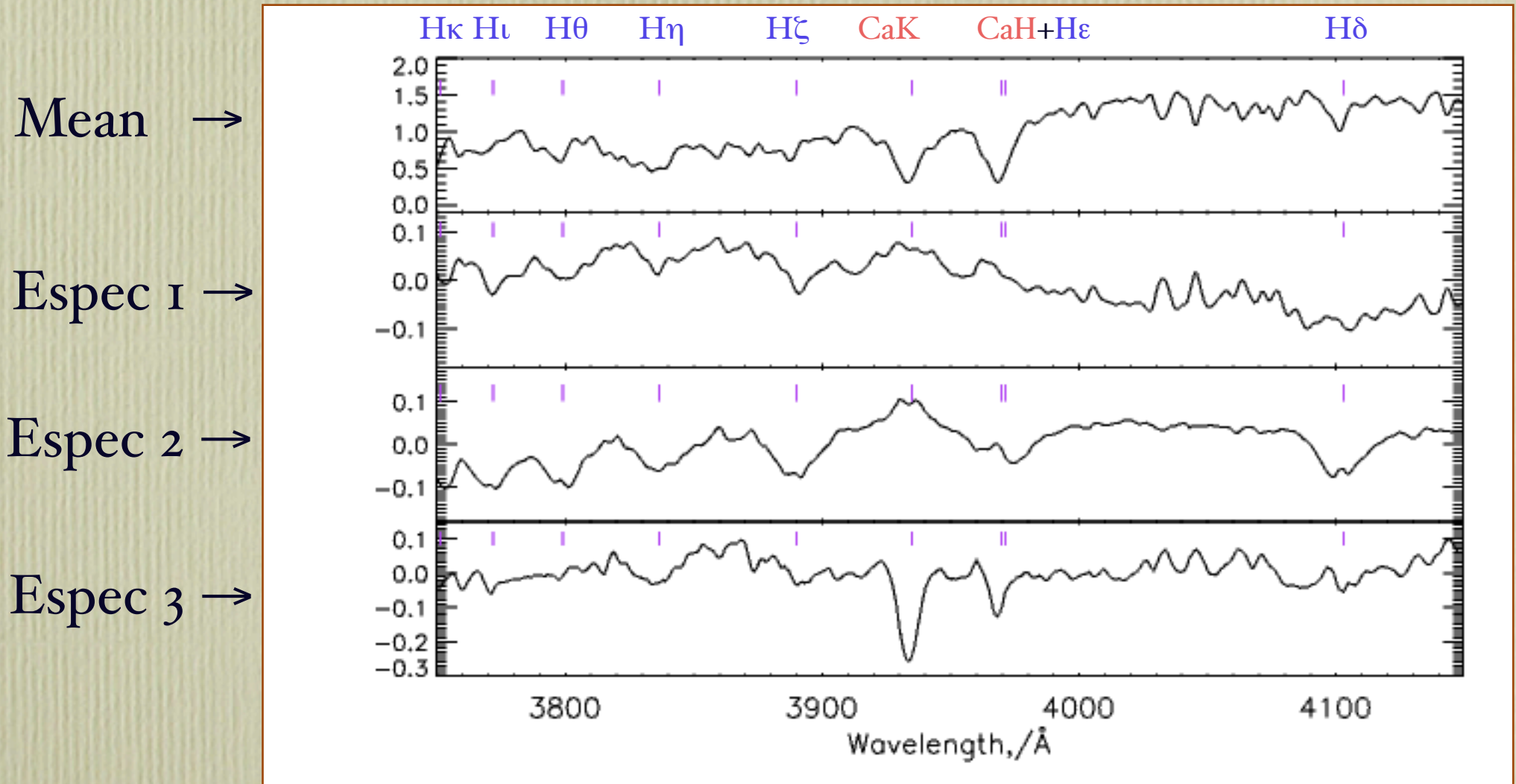
Tremonti et al. 2004 - SDSS MPA catalogue at <http://www.mpa-garching.mpg.de/SDSS/>

PCA: Using the whole spectrum

- Lines of greatest variance in a data matrix
 - N pixels \rightarrow N dimensional array
 - Each spectrum is 1 point in N -d space
 - principal components = eigenvectors of the covariance matrix of the data array
 - Commonly used in data compression, spectral classification....
- Knows nothing about physics
- Picks out correlations across the entire wavelength range
 - Should allow an increase in SNR over measures such as $H\delta$ and $D4000$.



The “Eigenspectra”



BCO₃; Stochastic burst catalogue (Salim et al. 2005); ‘ellipticals’ with less than 10% of their stars formed in bursts in the last 2×10^9 years

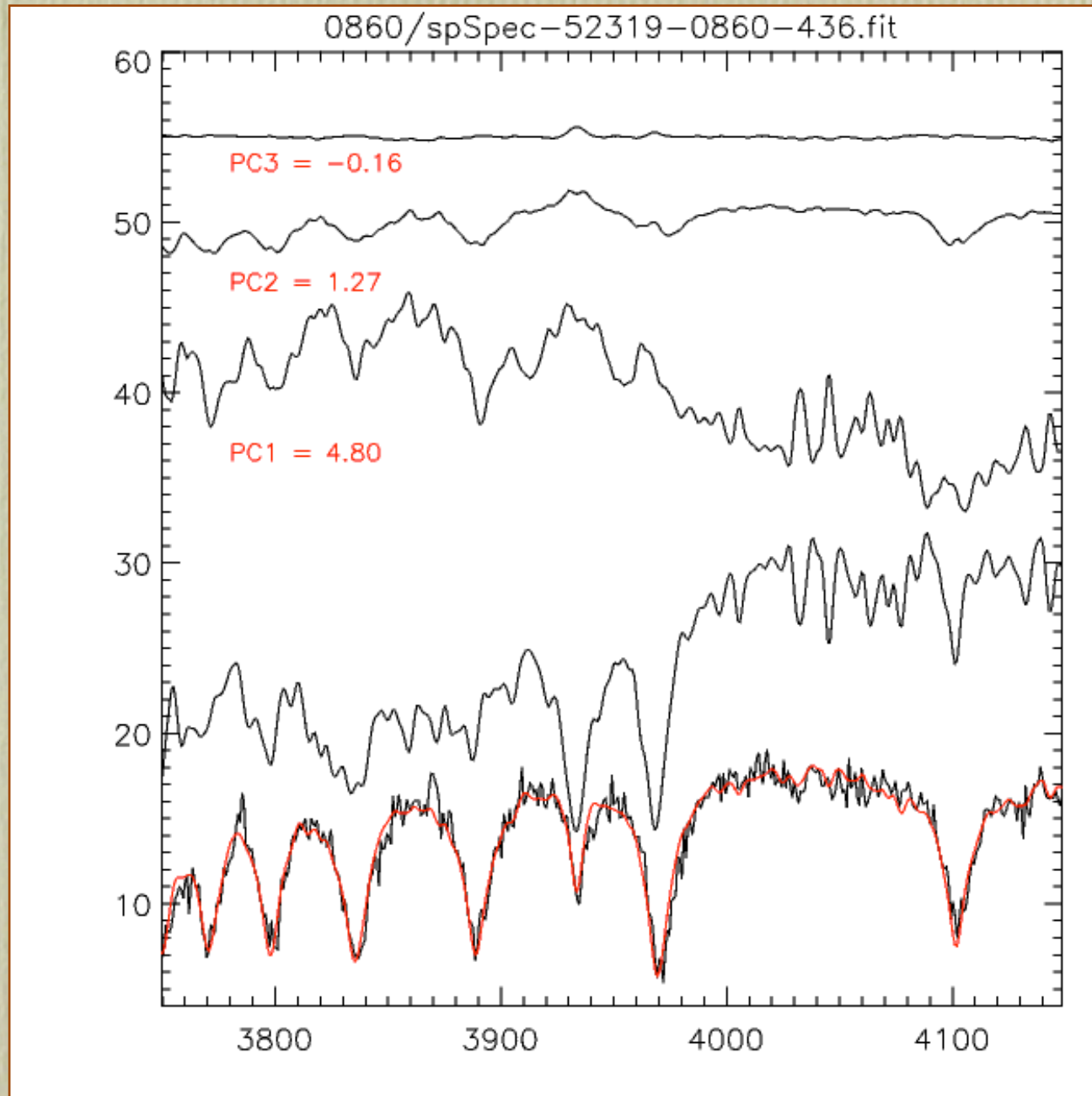
Building stellar populations I

Espec 3 →
+
Espec 2 →
+
Espec 1 →

+

Mean →

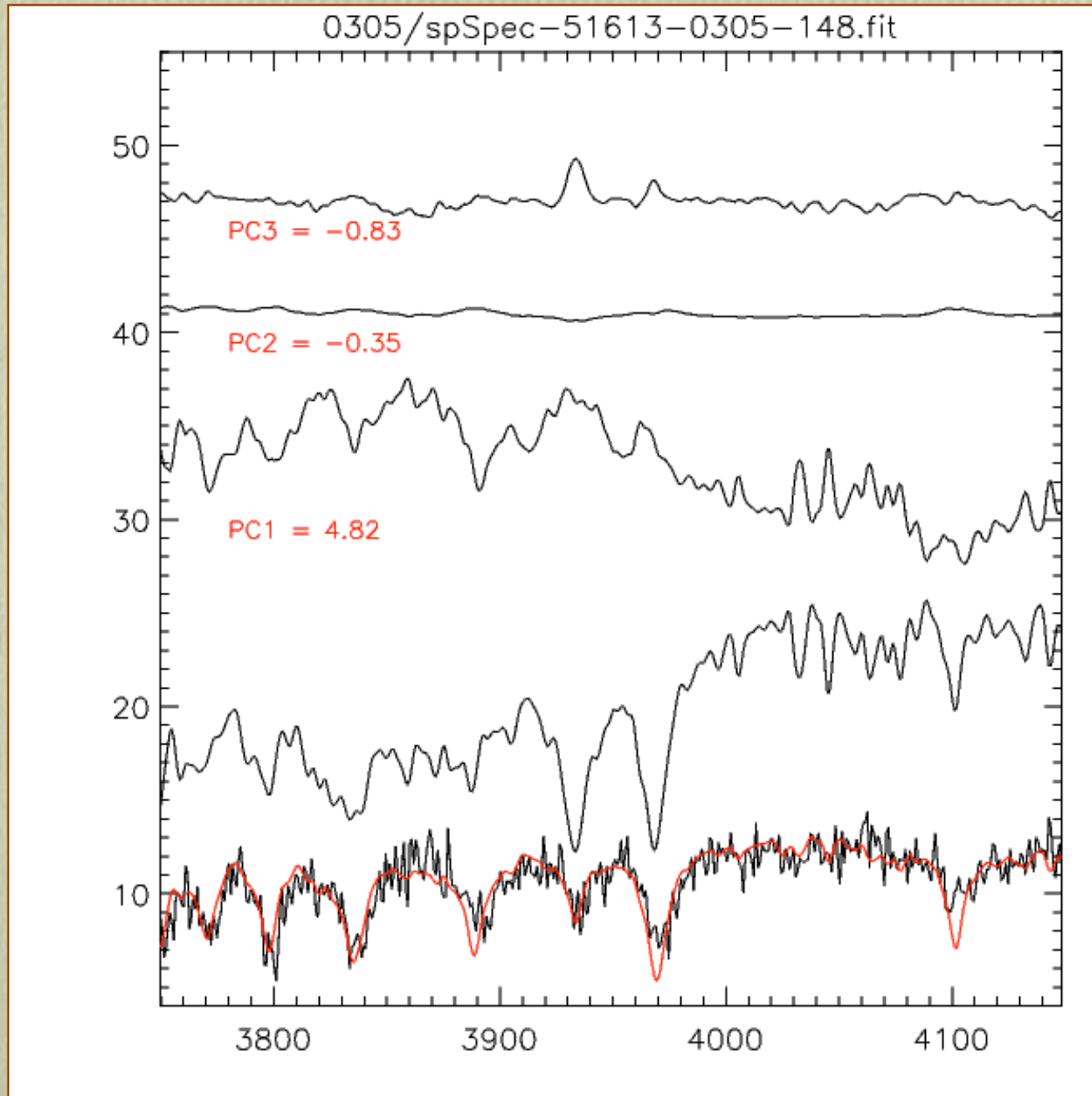
=
Galaxy →
PCA
reconstruction



These are
all offset!!

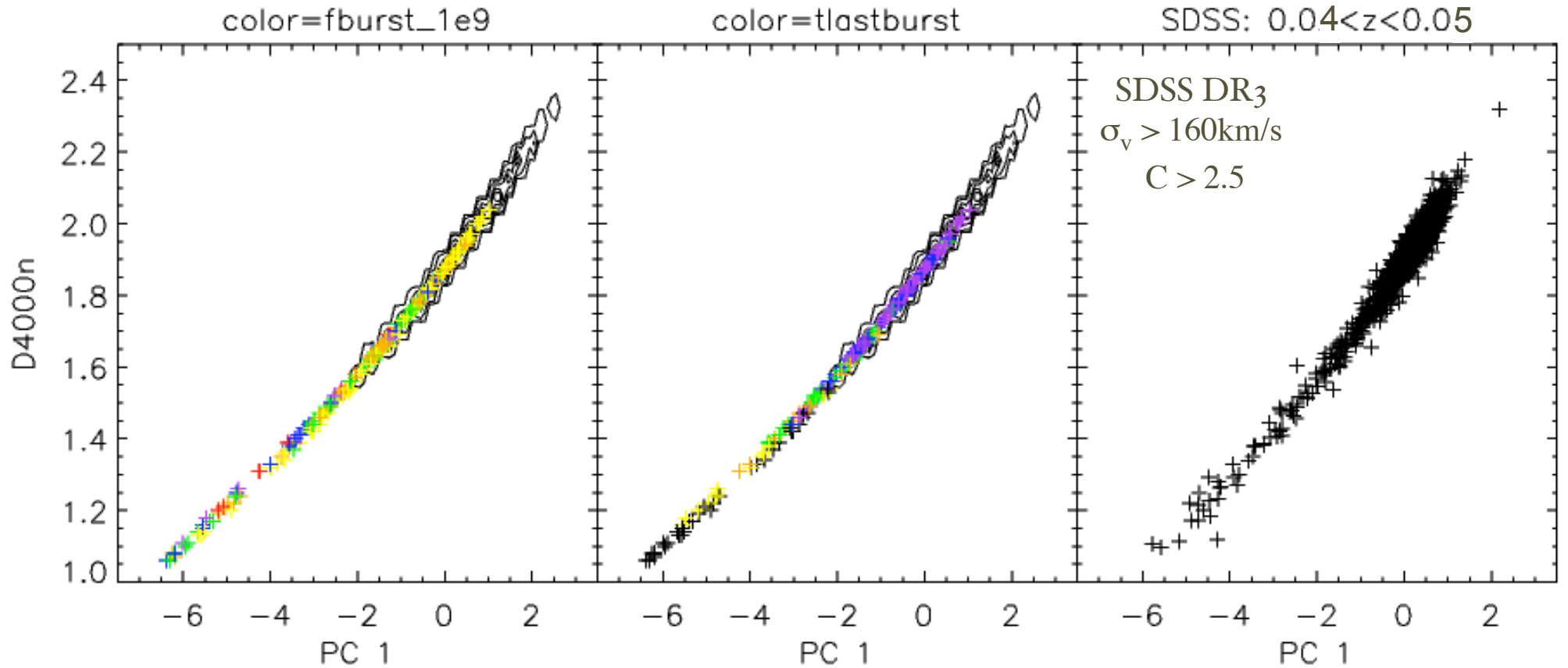
Building stellar populations II

Espec 3 →
+
Espec 2 →
+
Espec 1 →
+
Mean →
=
Galaxy →
PCA
reconstruction



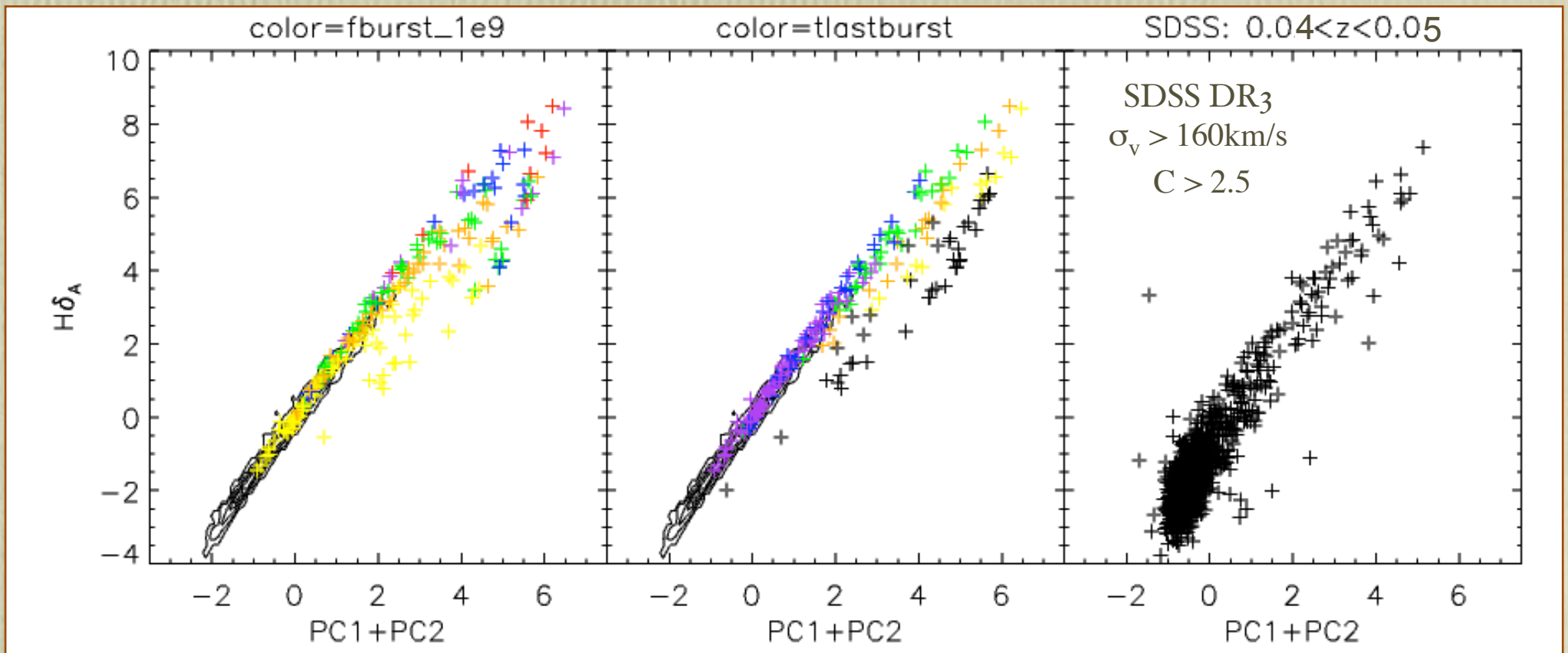
These are
all offset!!

Adding back the physics



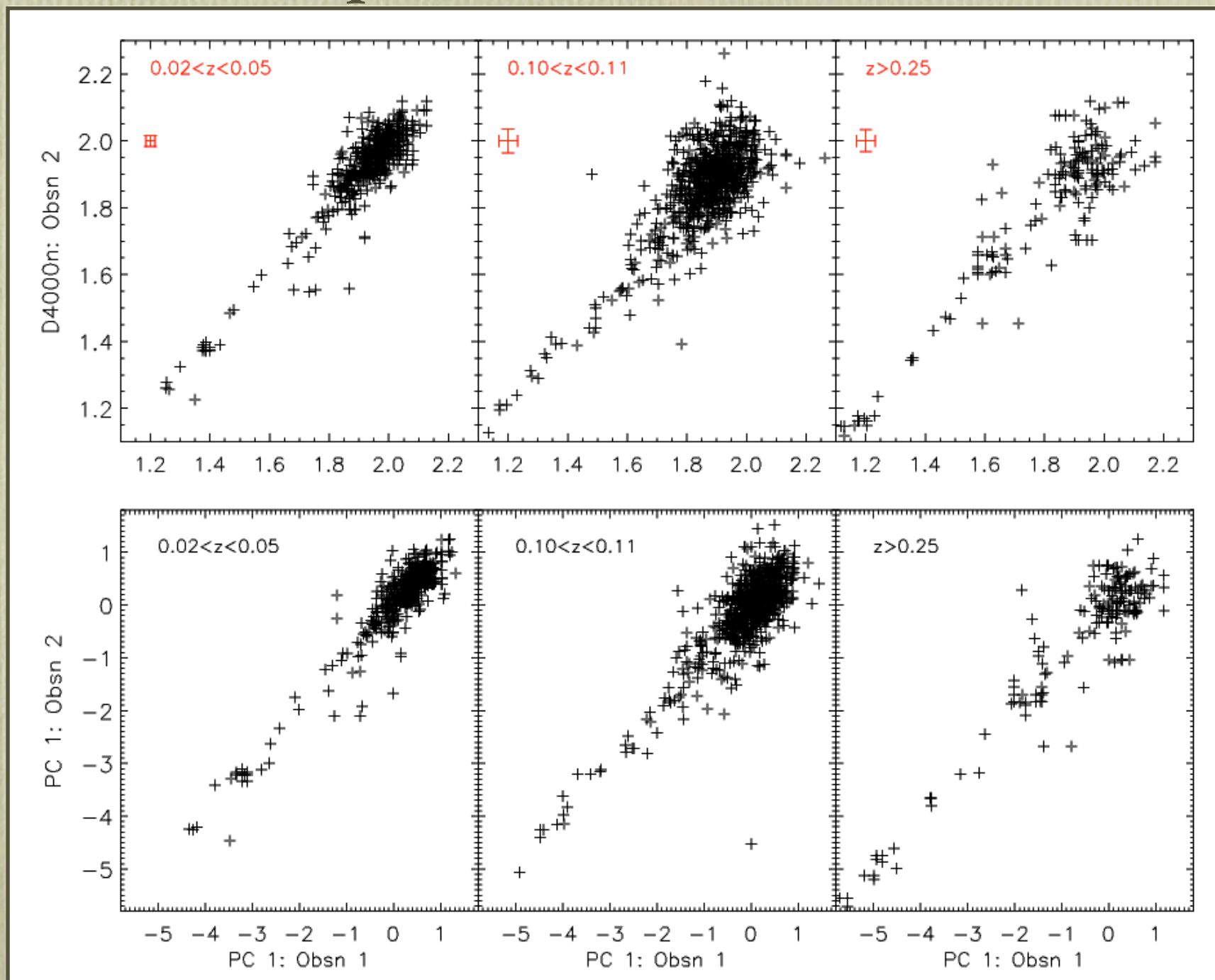
Although PCA knows nothing about physics, it chooses as Principal Components the same properties traditionally found to be useful diagnostics of changing stellar populations

Adding back the physics

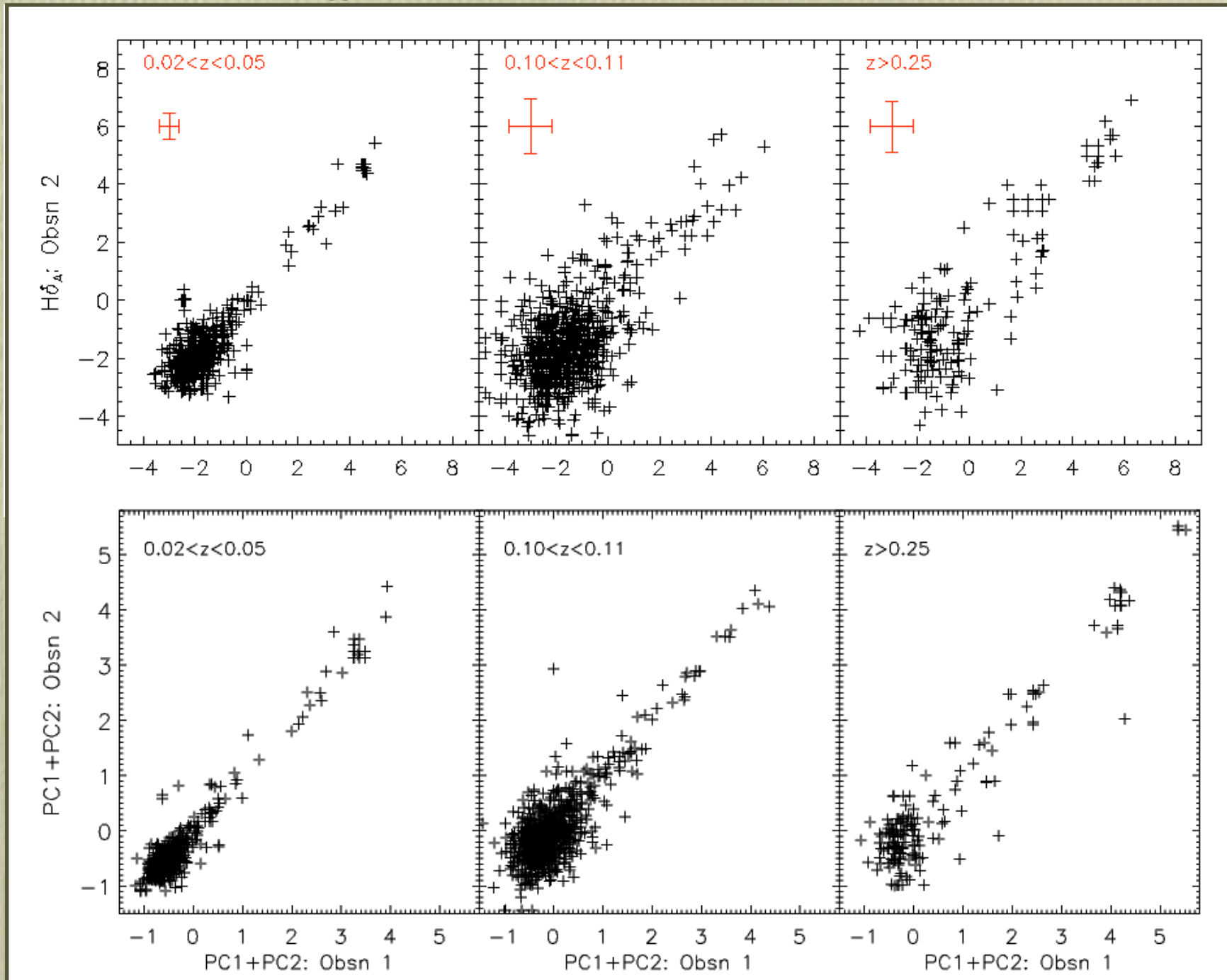


Although PCA knows nothing about physics, it chooses as Principal Components the same properties traditionally found to be useful diagnostics of changing stellar populations

Can PCA improve current SFH estimators?

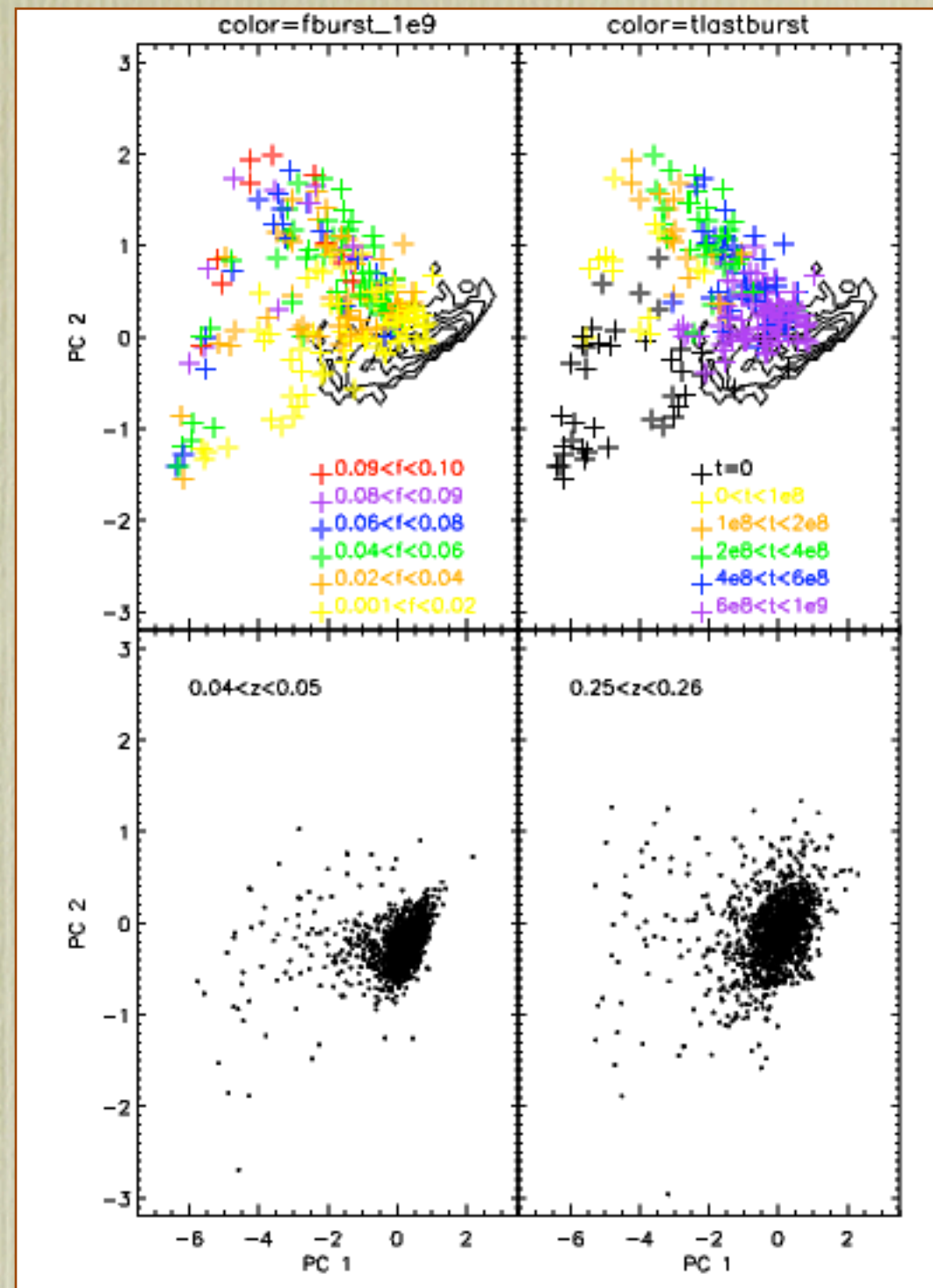


Can PCA improve current SFH estimators?



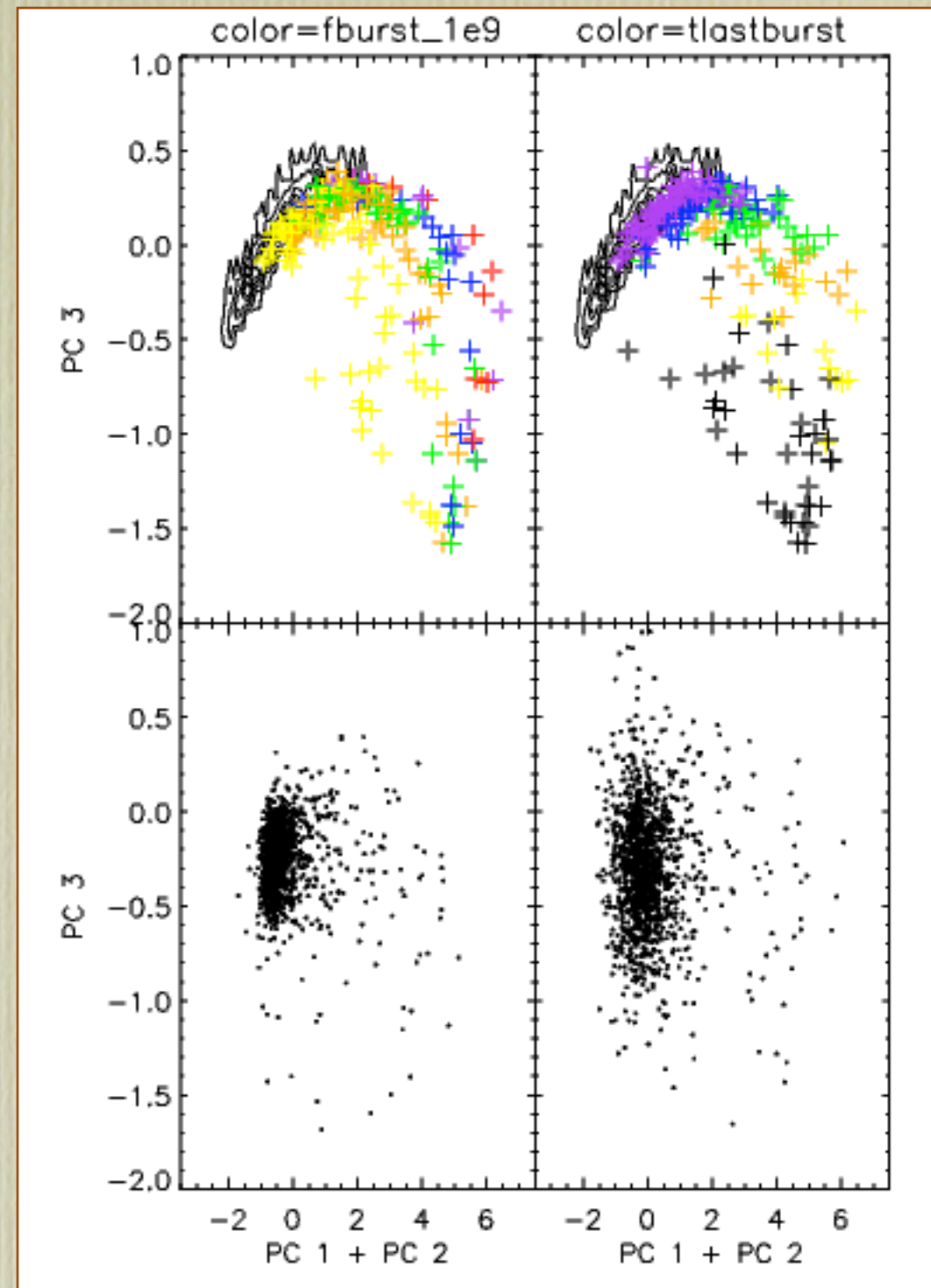
And improve on them?...

Separating
post-starbursts
from starbursts



And improve on them?...

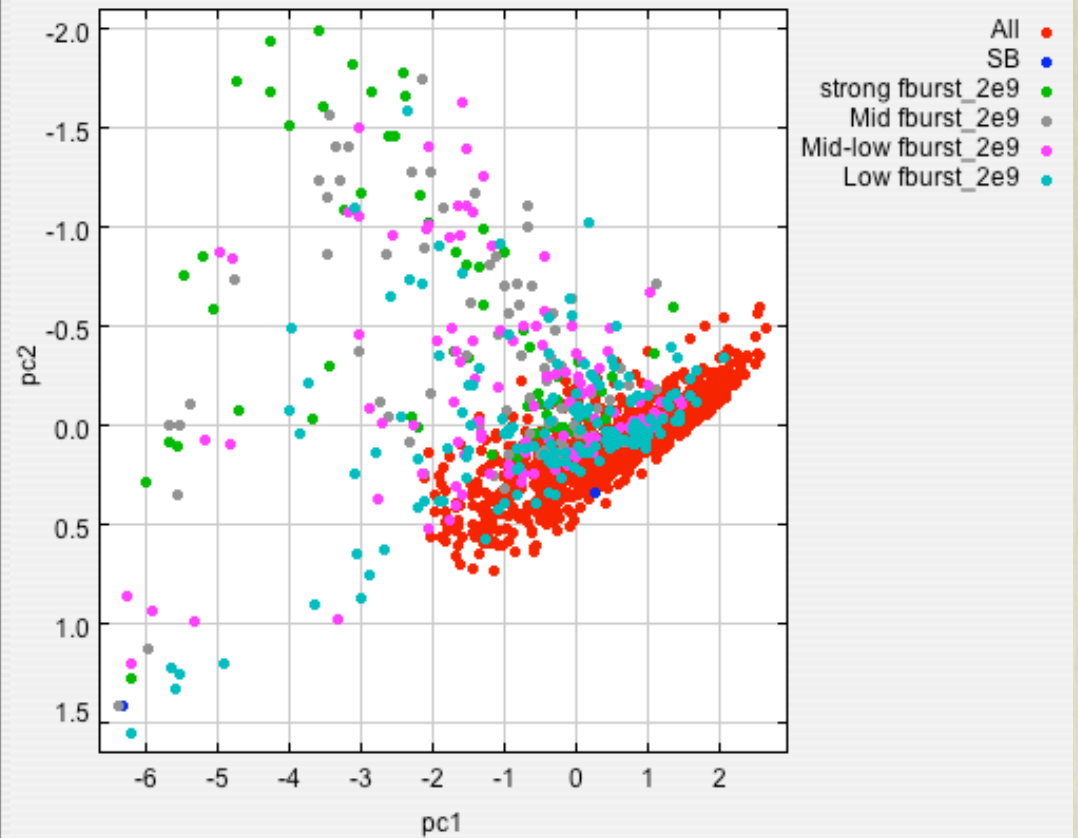
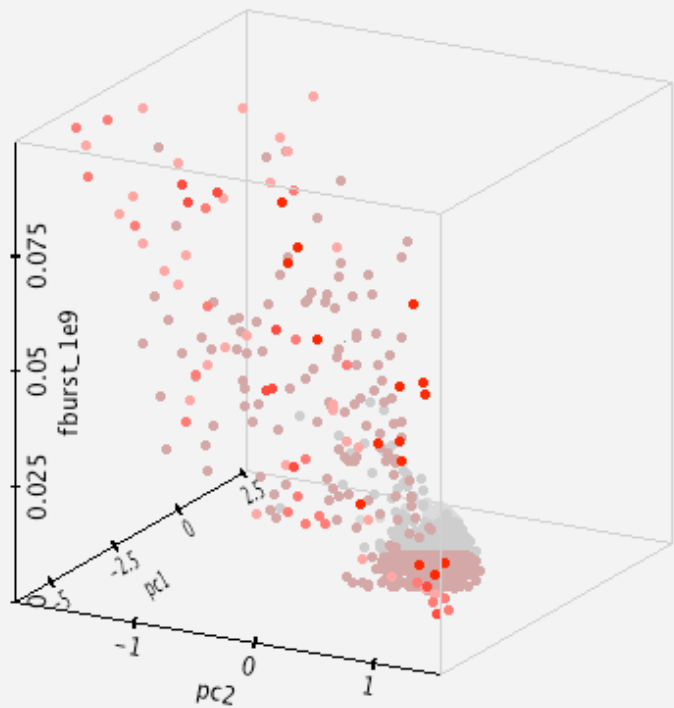
Breaking the degeneracy between time of last burst and size of burst
($t < 5 \times 10^8$ yrs)



The SDSS-MPA+DR3+ GALICS+BCo3+PCA database

- Much of this work made extensive use of the SDSS database at MPA (thanks to Gerard Lemson)
 - Quick and easy exploration of multidimensional datasets
 - No more days spent trying to read new file formats or retrieving new parameters you forgot, no storage of large datasets.
 - Simple joins between independent catalogues
 - IDL SQL wrapper (thanks to Ben Panter)
 - Write your SQL queries direct into your code
 - TOPCAT for examining, analysing, plotting tables
 - Stream SQL queries direct into this tool
- See talk by Gerard in VO session

Exploring multi-dimensional datasets



Summary

- Using the entire wavelength range available to us can increase the SNR of spectral SFR diagnostics.
 - PCA provides one way to do this. Simple correlation with known, traditional, indicators.
- Applications...
 - Starbursts in LRGs (SDSS)
 - The AGN - post starburst connection (SDSS)
 - Higher redshift spectroscopic catalogues
- Improvements...
 - Can we escape from our reliance on the model spectra?
 - Velocity dispersion and emission lines
 - Making use of PCs 1,2 and 3 to break degeneracy between time of last burst vs. fraction of stars formed in burst

Thank you.

Comments, thoughts, ideas,
suggestions welcome