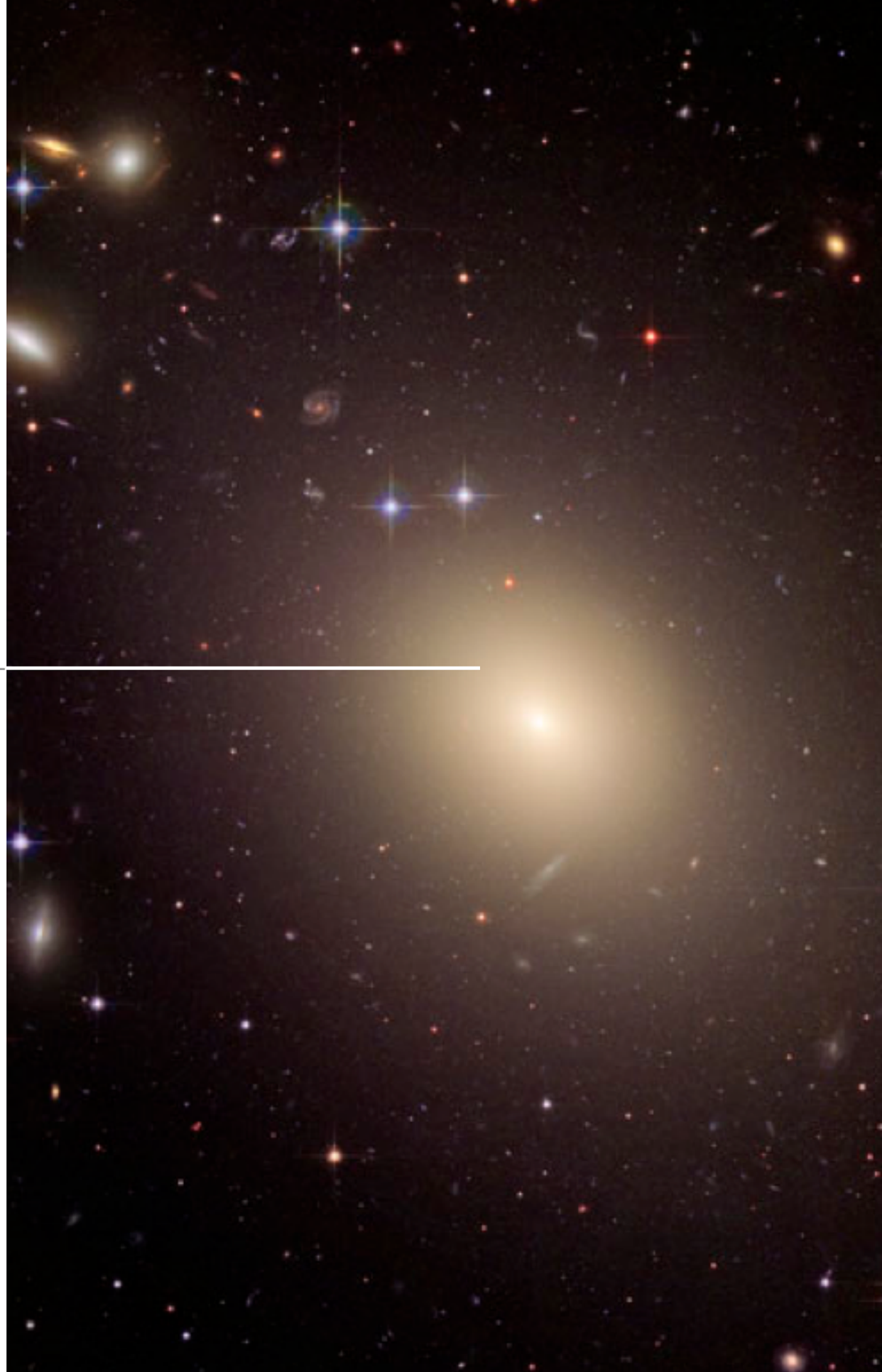
The assembly history of galaxies and their environment

Rita Tojeiro
University of St. Andrews

with **Lizzie Eardley**, John Peacock, Catherine Heymans (IfA, Edinburgh)

on **GAMA** data.



Outline

- Background and motivation:
  - the expectations and observations of halo assembly times - assembly bias;
  - simulations and observations.
- This work:
  - tools and data: geometric environment, VESPA and GAMA;
  - some estimators, plots and preliminary words.
- On-going and future work.

Halo assembly bias

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- Theoretical models of the halo-galaxy relationship assume that *galaxy populations in DM halos depend* ***only*** *on halo mass.*

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  - very successful at describing the clustering of galaxies of different luminosity, colour or environment.

- However, simulations shows that the clustering of DM halos depends not only on their mass but also - often in a complex way - on their *assembly history.* I.e. halos of the same mass cluster differently according to how long ago they assembled their mass: **assembly bias**.

Simulations and observations

Simulations and observations

- Halo assembly bias detected in simulations [Gao, Springel & White 2005; Wechsler et al. 2006; Gao & White 2007; Croton, Gao & White 2007; Li, Mo & Gao 2008], usually by studying clustering strength as a function of halo assembly time at fixed halo mass.

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- Results are less clear in data. Using galaxy clustering amplitude some have found evidence on galaxy properties that is consistent with assembly bias [e.g. Yang, Mo & van den Bosh 2006, Wang et al. 2008, 2013], but using different techniques others have not [e.g. Blanton & Berlind 2007; Tinker et al. 2008].

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- Recently Zentner et al. 2014, for example, showed that ignoring halo assembly bias results in a systematic bias of the inferred galaxy-halo relationship from clustering in simulations.

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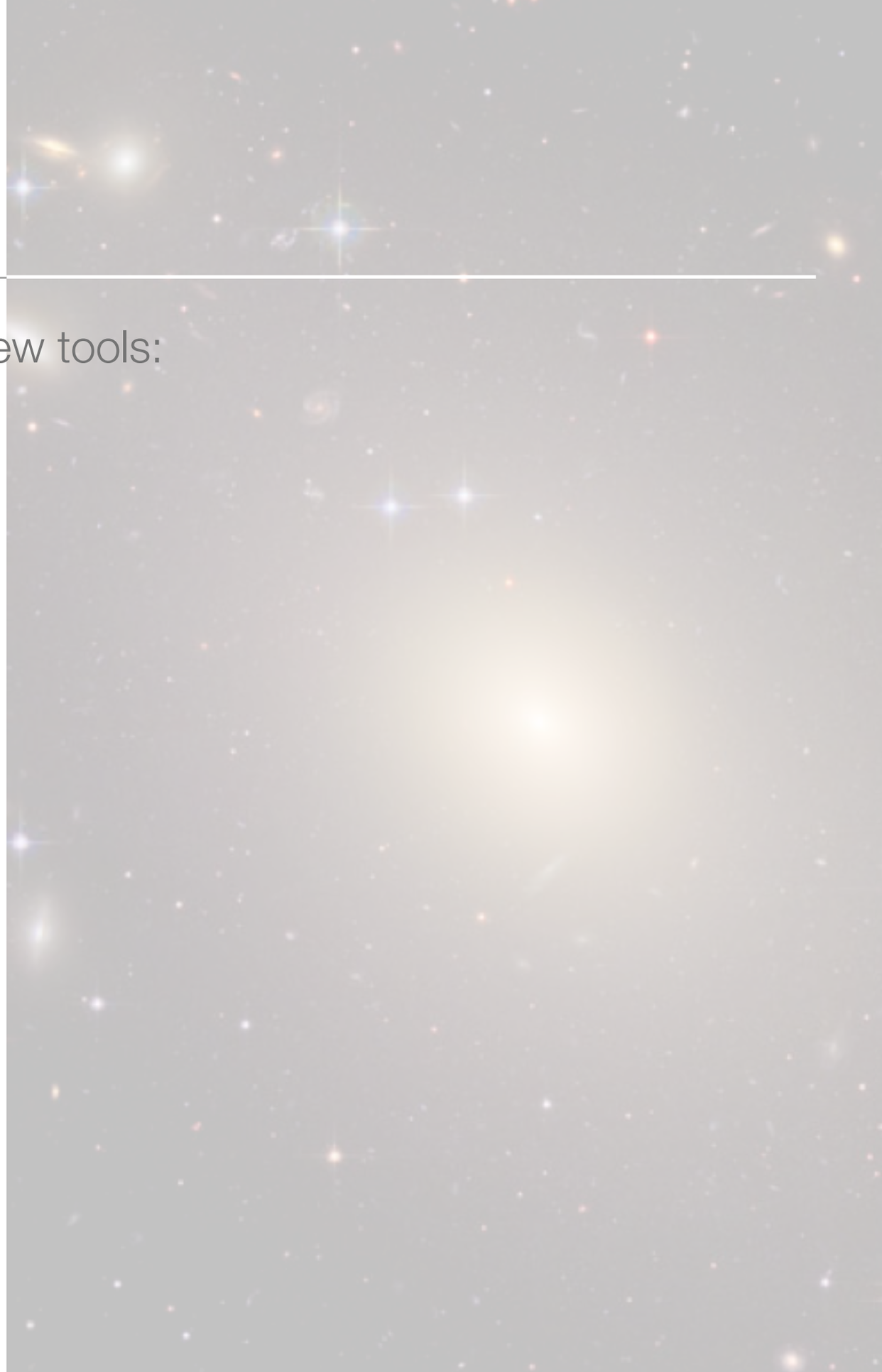
- We want to explore this issue using two new tools:



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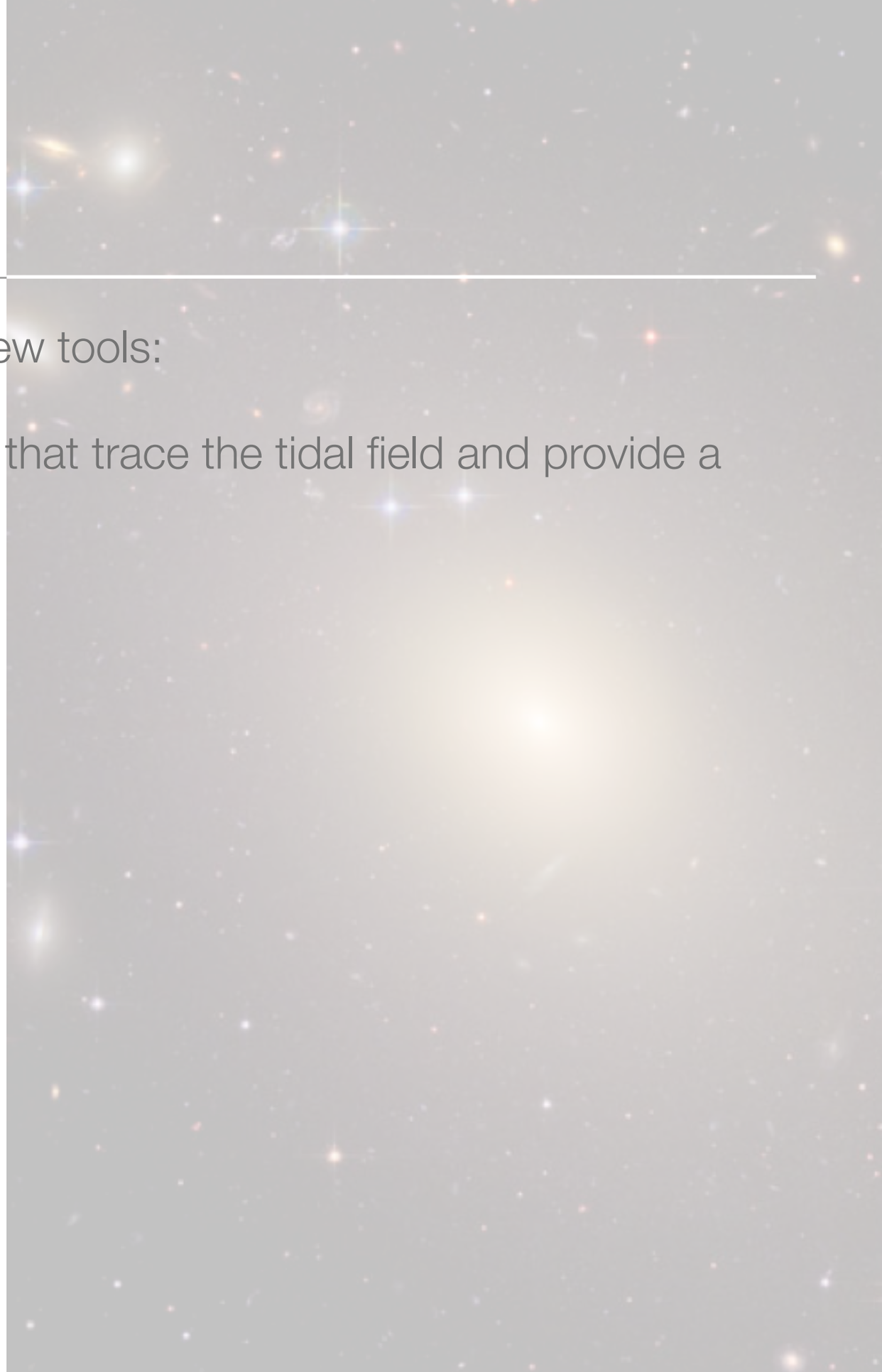

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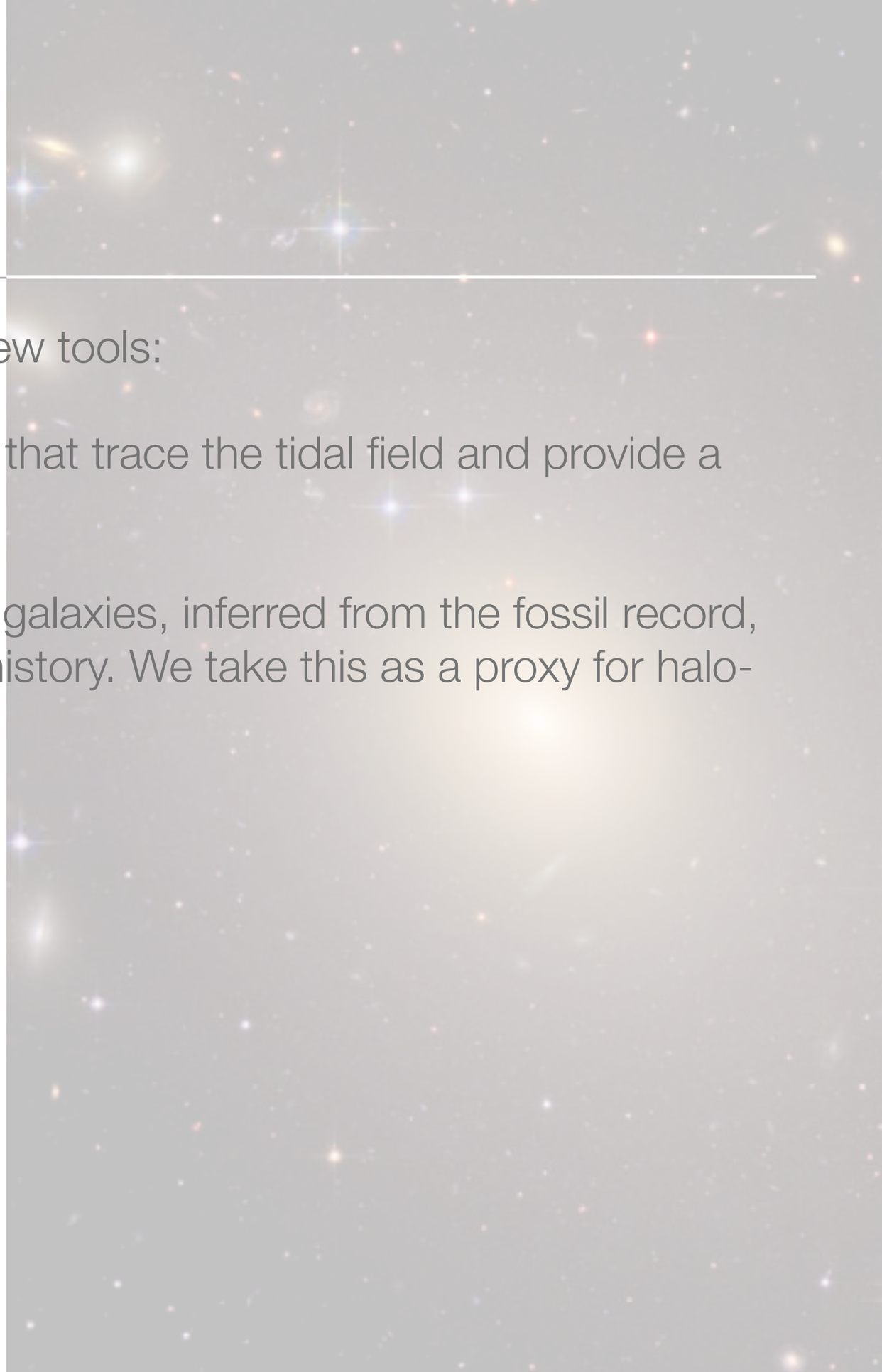
  - The detailed star-formation histories of galaxies, inferred from the fossil record, that trace their stellar-mass assembly history. We take this as a proxy for halo-assembly history.



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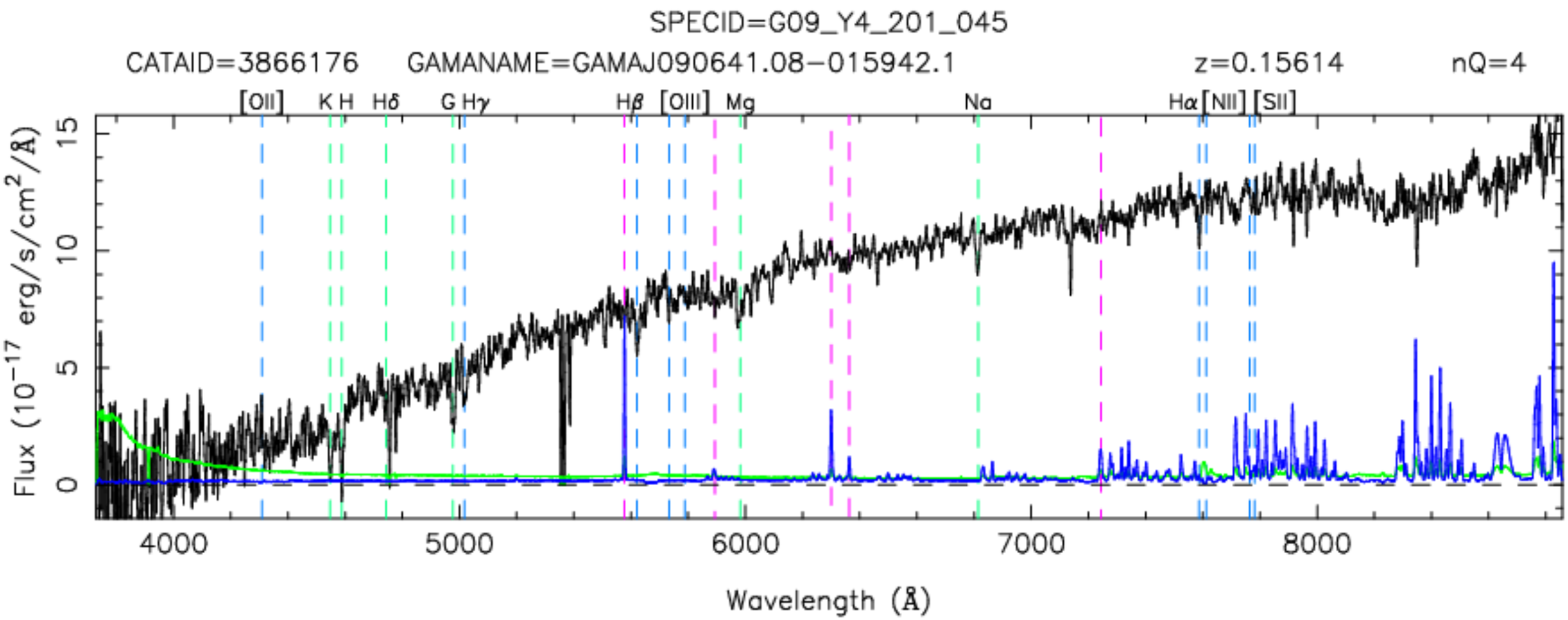
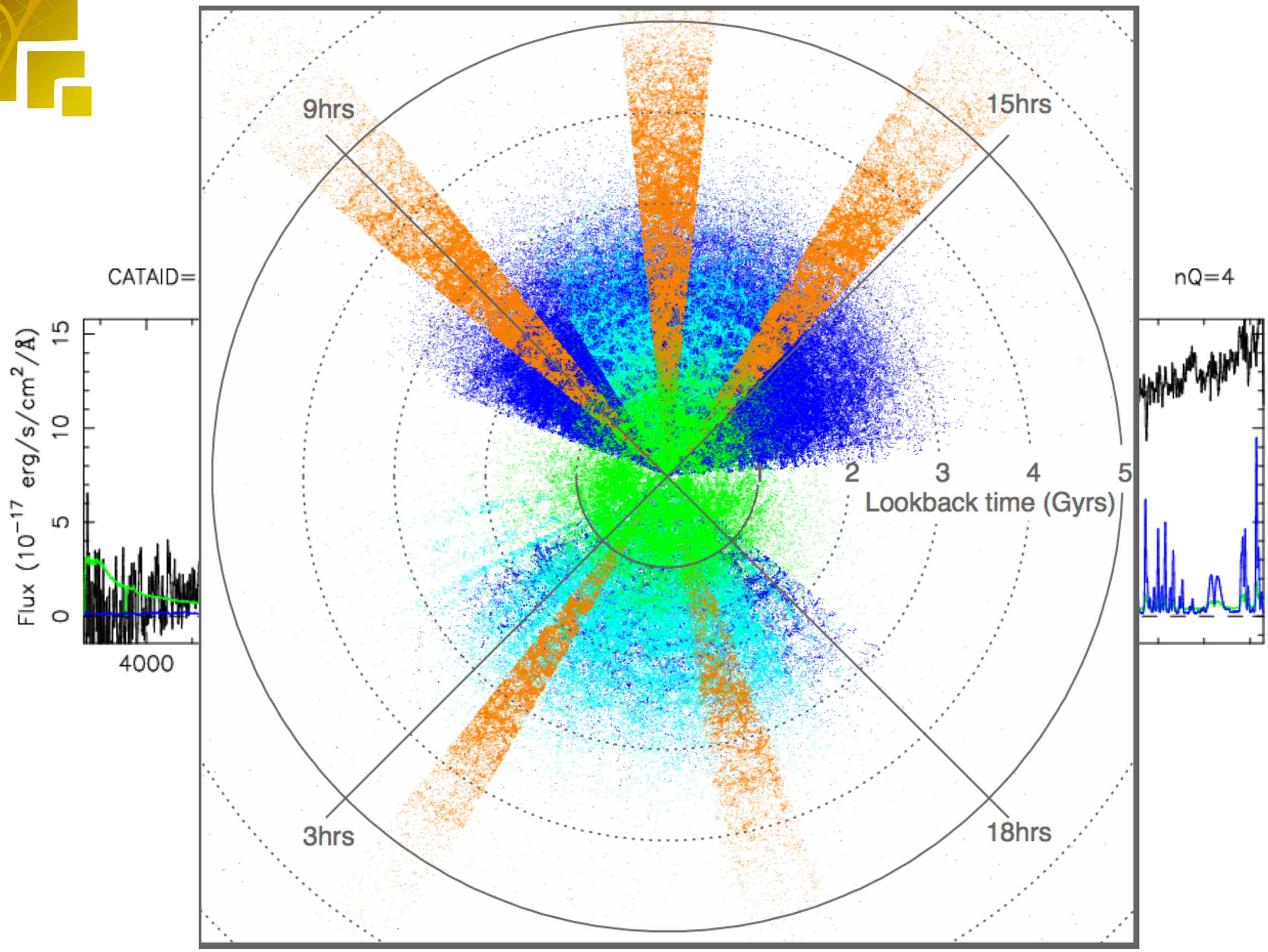
- *Ultimately, we look for a better way to re-parametrise halo-galaxy relation models.*

The GAlaxy and Mass Assembly Survey

- A multi-wavelength, spectroscopic survey of the low redshift Universe ($z < 0.5$).
- Fibre spectroscopy using AAT/2dF+AAOmega
- Area: ~290 deg^2 split over 5 regions
- Main sample: ~300k galaxies to $r < 19.8$ mag
- $\langle z \rangle \sim 0.27$
- $R = 1300$, $370 < \lambda < 880$ nm


SPECID=G09_Y4_201_045
CATAID=3866176
GAMANAME=GAMAJ090641.08−015942.1
z=0.15614
nQ=4
[OII]
K H
Hδ
G Hγ
Hβ
[OIII]
Mg
Na
Hα
[NII]
[SII]
Flux (10^{-17} erg/s/cm^2/Å)
0
5
10
15
4000
5000
6000
7000
8000
Wavelength (Å)


9hrs
15hrs
3hrs
18hrs
2
3
4
5
Lookback time (Gyrs)
CATAID=
nQ=4
Flux (10^{-17} erg/s/cm^2/Å)
15
10
5
0
4000

Re-scaling GAMA spectra (Lizzie's work)

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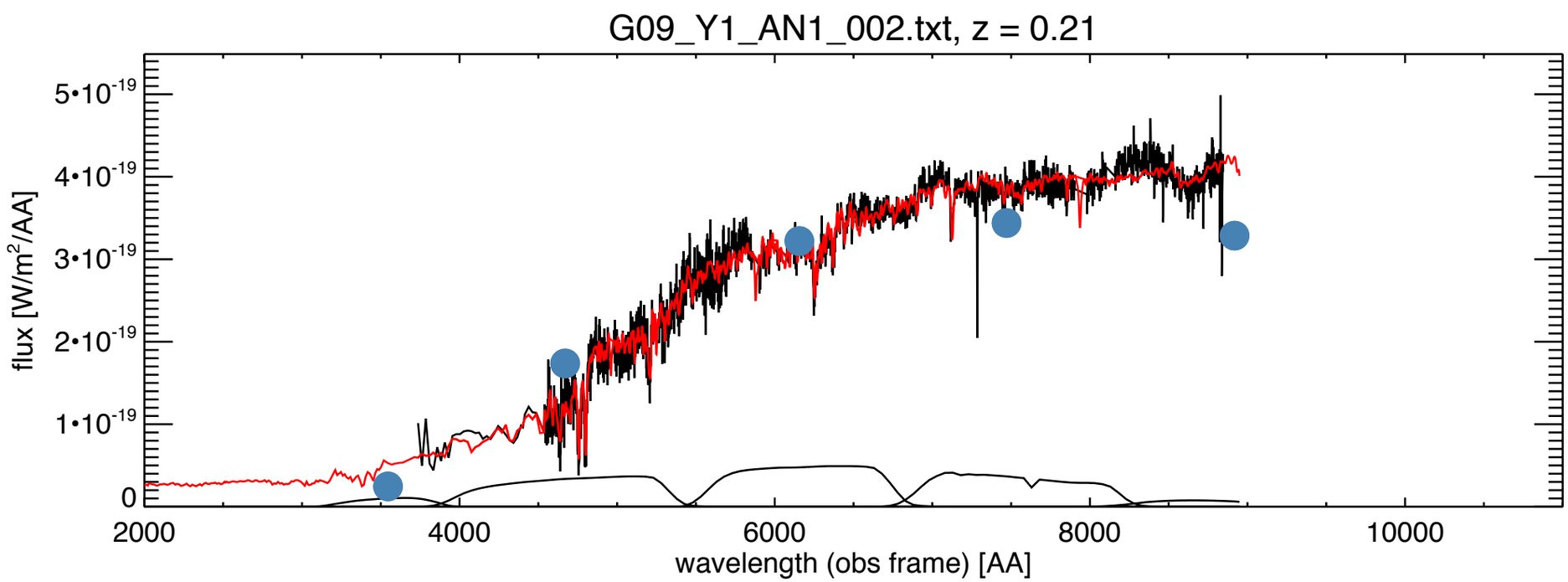
- GAMA spectra suffer from problematic spectrophotometric calibration.
  - We have rescaled the spectra to the optical SDSS photometry using a linear interpolation in the optical bands.
  - Tests show positive effect: we recover more physical solutions, better agreement with independent measurements (e.g. stellar masses) and scaled spectra populate PCA parameter space as they should.

R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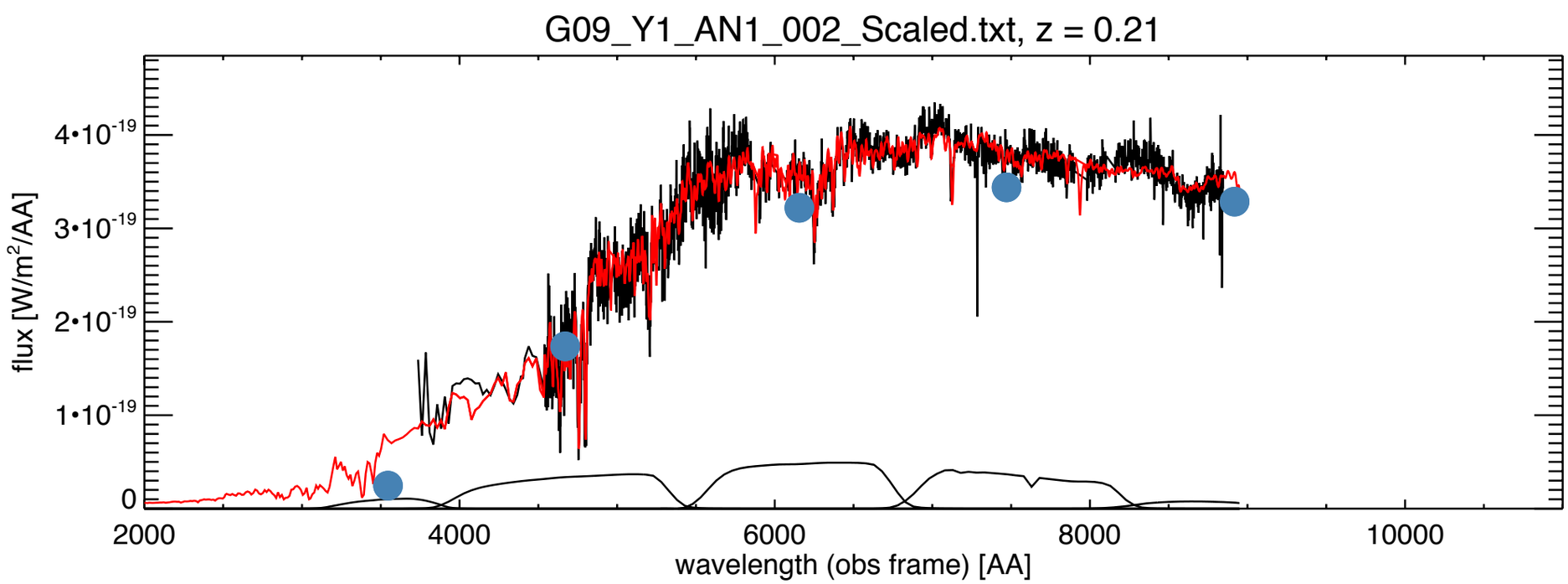
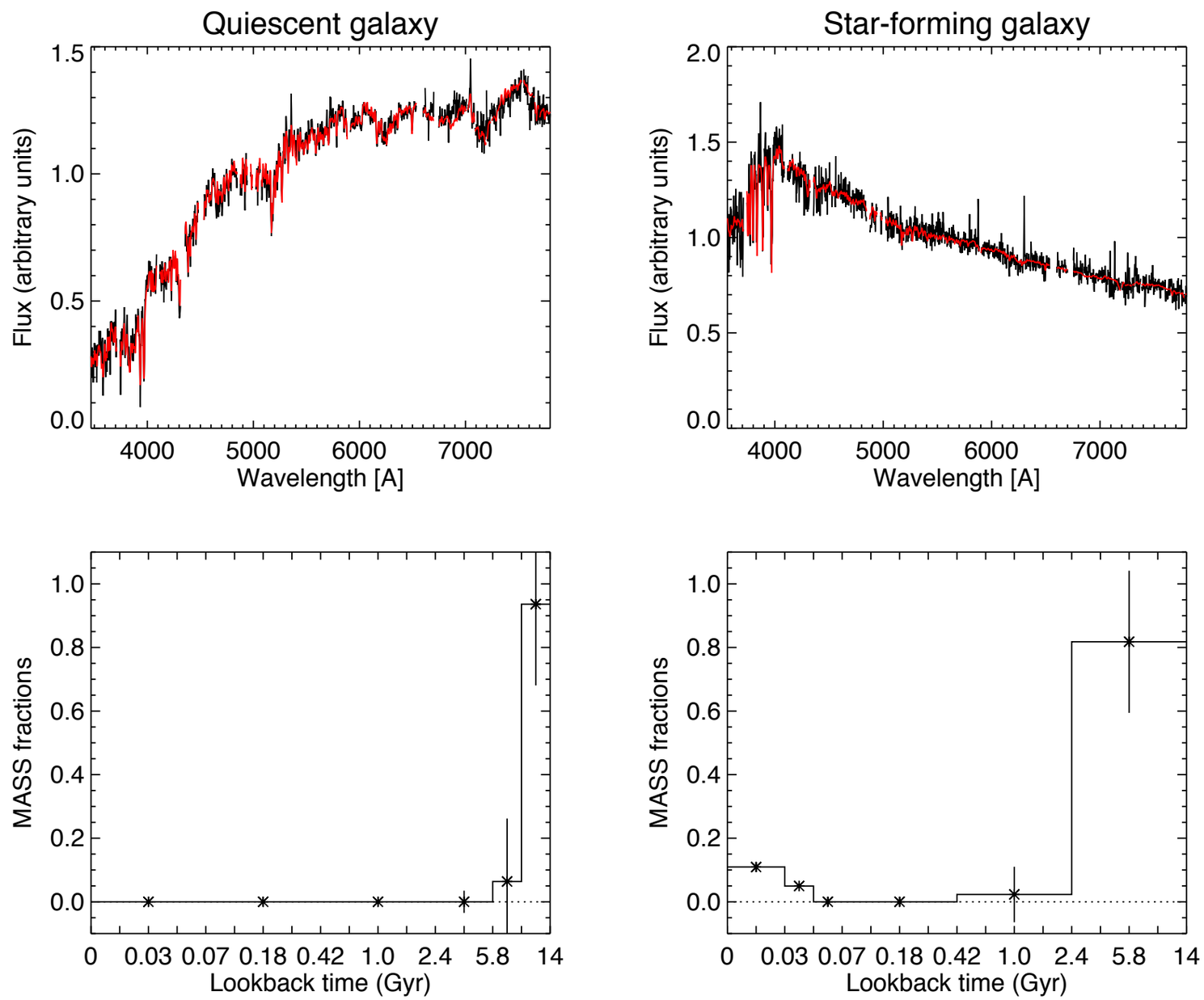
flux [W/m²/AA]
5•10⁻¹⁹
4•10⁻¹⁹
3•10⁻¹⁹
2•10⁻¹⁹
1•10⁻¹⁹
0
2000
4000
6000
8000
10000
wavelength (obs frame) [AA]


G09_Y1_AN1_002_Scaled.txt, z = 0.21
flux [W/m²/AA]
4•10⁻¹⁹
3•10⁻¹⁹
2•10⁻¹⁹
1•10⁻¹⁹
0
2000
4000
6000
8000
10000
wavelength (obs frame) [AA]

ra

The fossil record of galaxies using VESPA

[Tojeiro et al. 2007, 2009]



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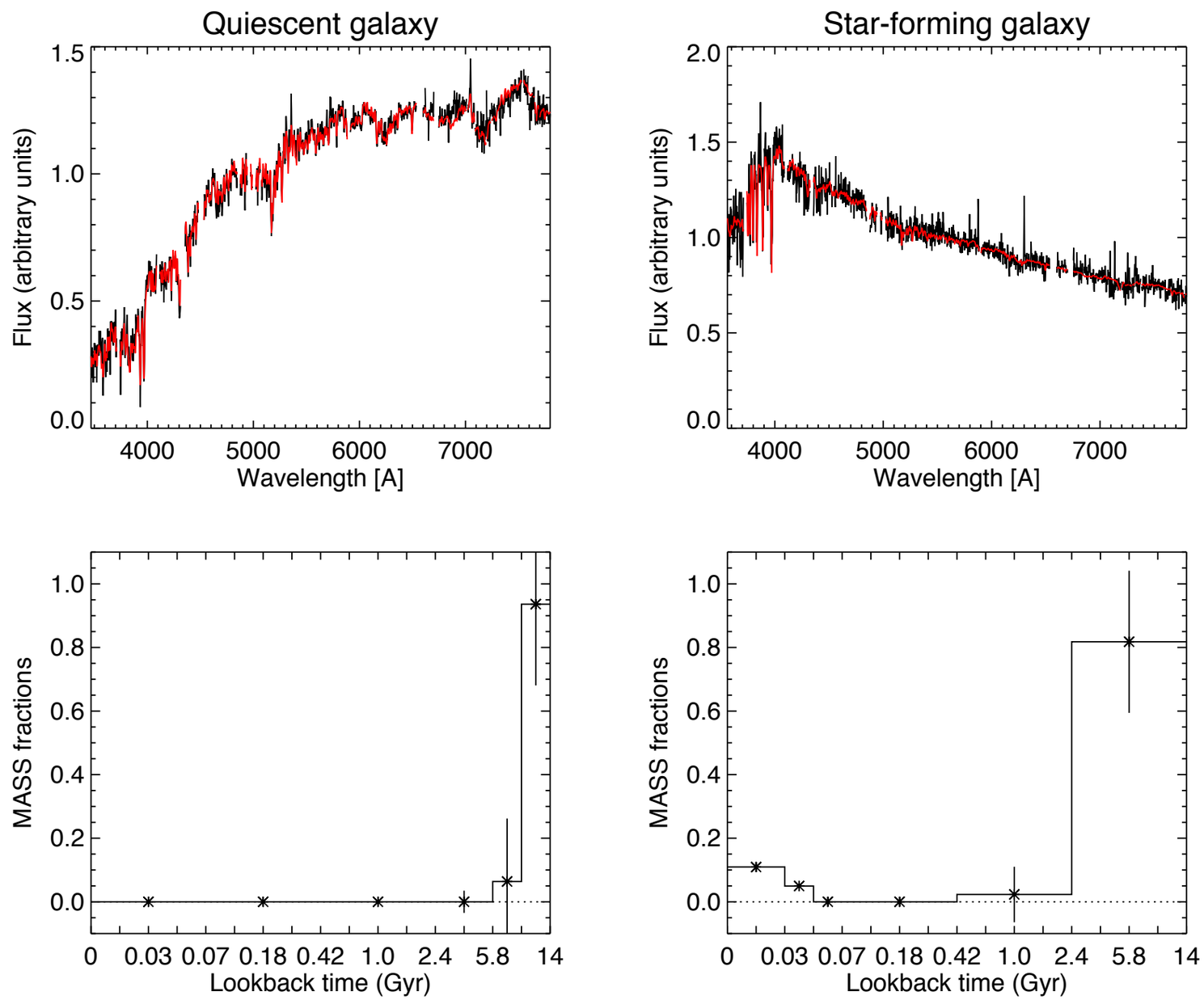


We can reconstruct the **star-formation history** of a galaxy from the fossil record.

Estimators of stellar-mass assembly time

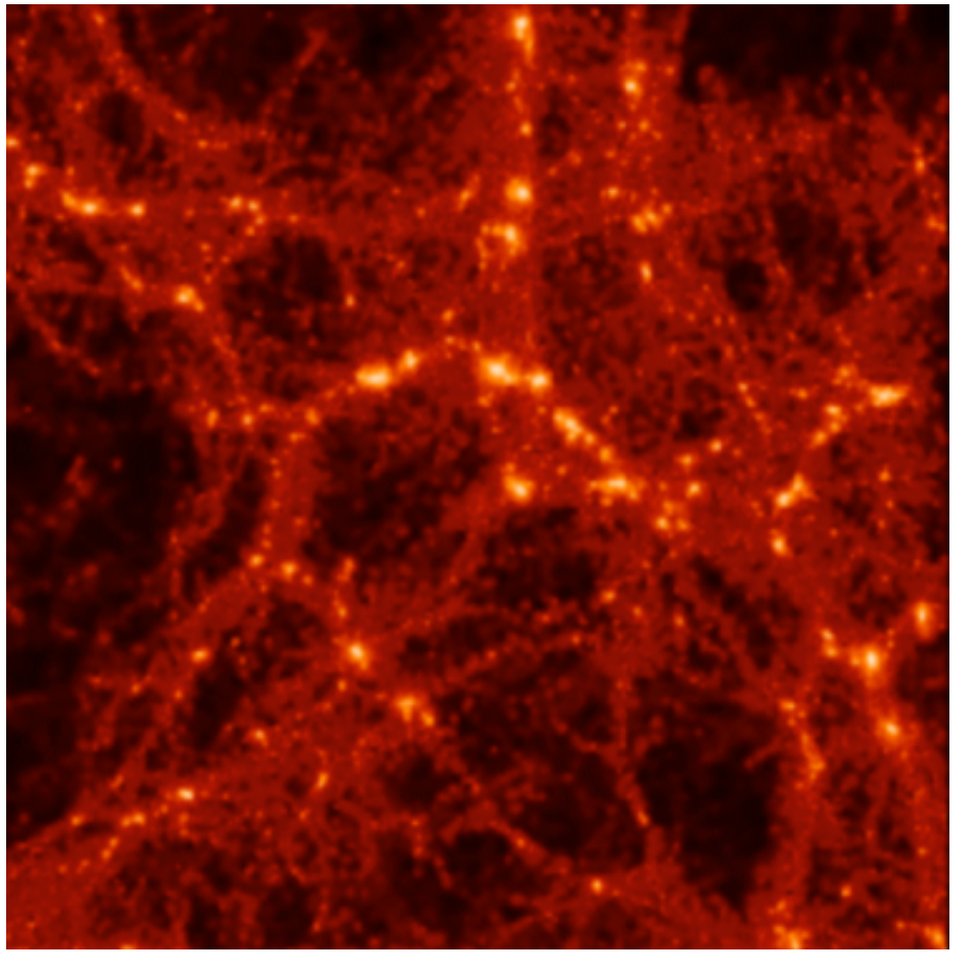
(a) $t_{0.85}$ - time in Gyrs at which 85% of stellar mass had assembled.

(b) Mass-weighted age in Gyrs.

(c) fraction of young stars (age < 275 Myrs).

-> each computed from the full SFH from each galaxy.

Environment classifications (more of Lizzie's work)



- VOIDS
- SHEETS
- FILAMENTS
- KNOTS

Tidal Tensor Prescription:

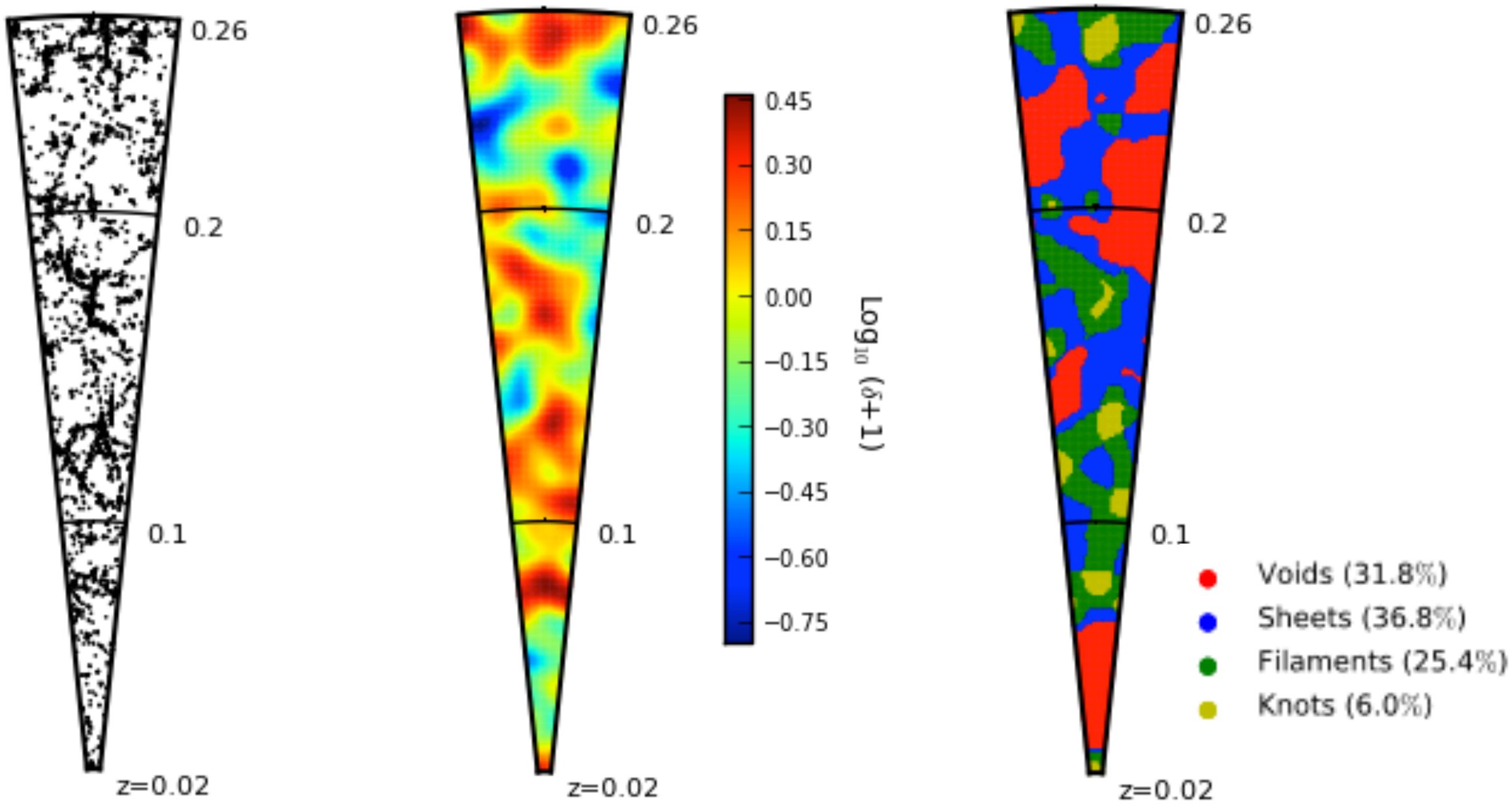
$$T_{ij} = \frac{\partial^2 \phi}{\partial q_i \partial q_j}$$

Second derivative of gravitational potential indicates whether point is near a potential minima or potential maxima.

Eigenvalues of T_{ij} determine geometrical nature of each point in space.

Number of positive eigenvalues corresponds to the dimension of the stable manifold.

Application to GAMA (still Lizzie's work)



a) Galaxies

b) Smoothed density contrast

$\sigma_s = 10h^{-1}\mathrm{Mpc}$

c) Environments

$\lambda_{th} = 0.1$

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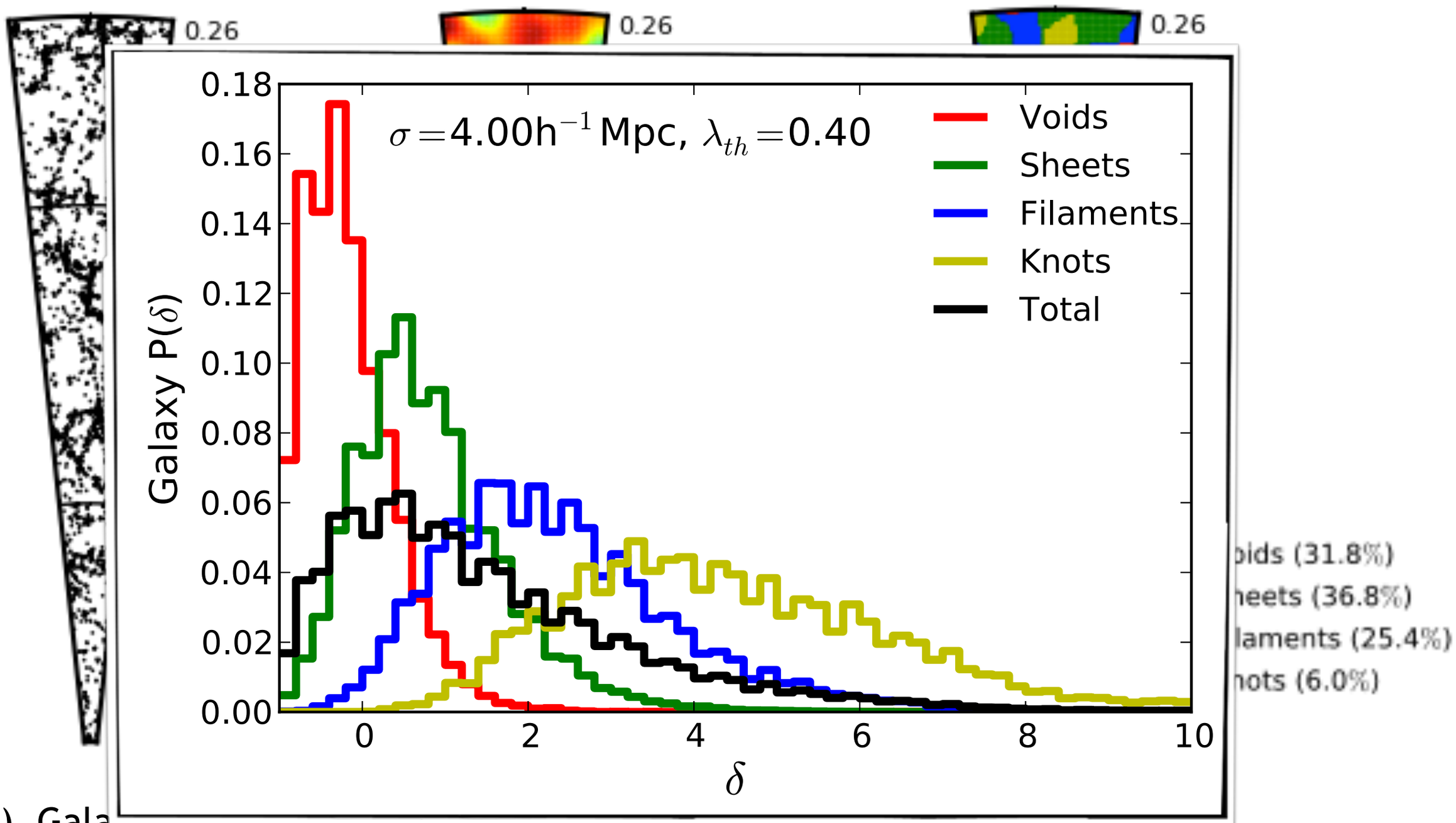

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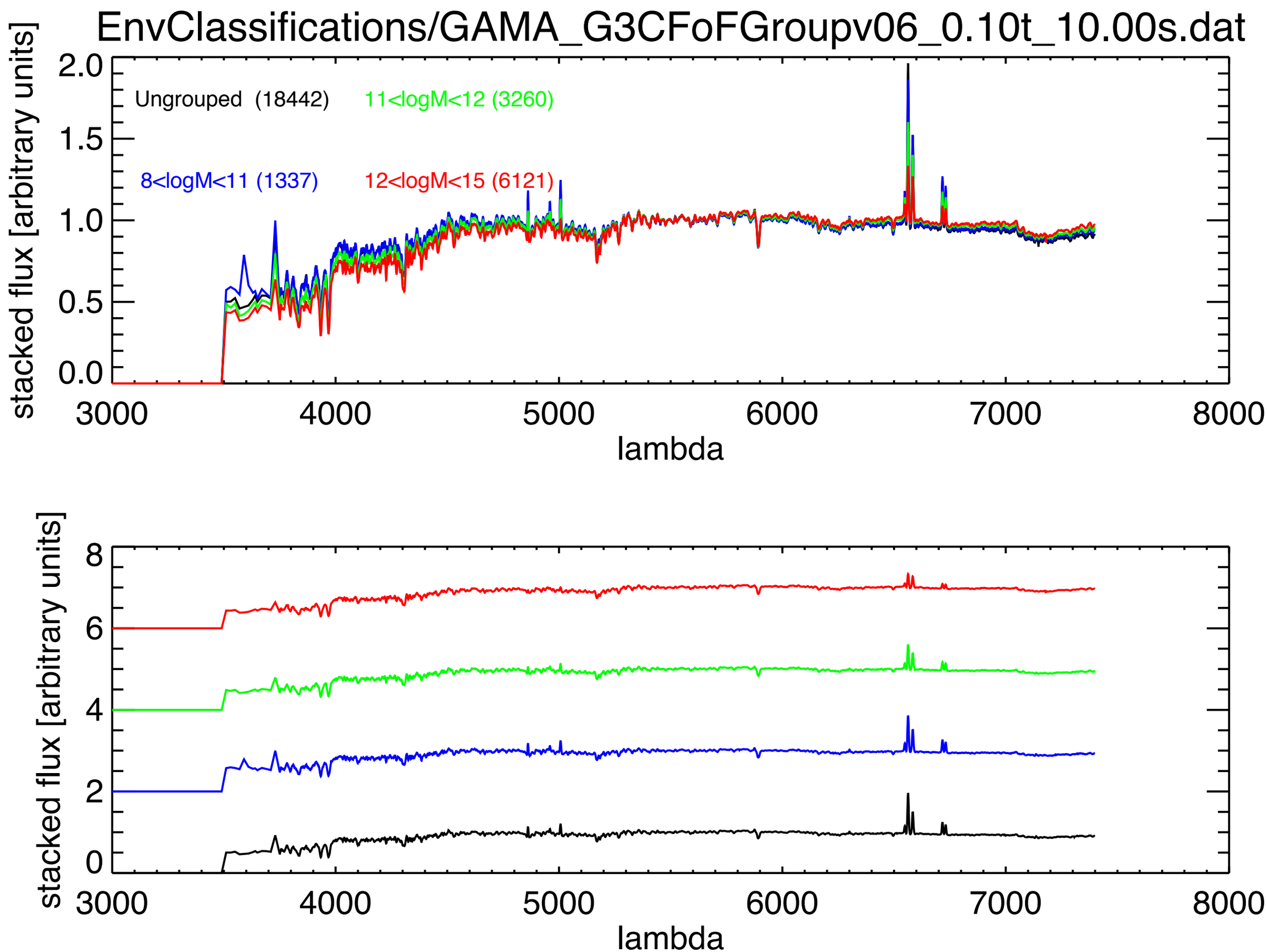
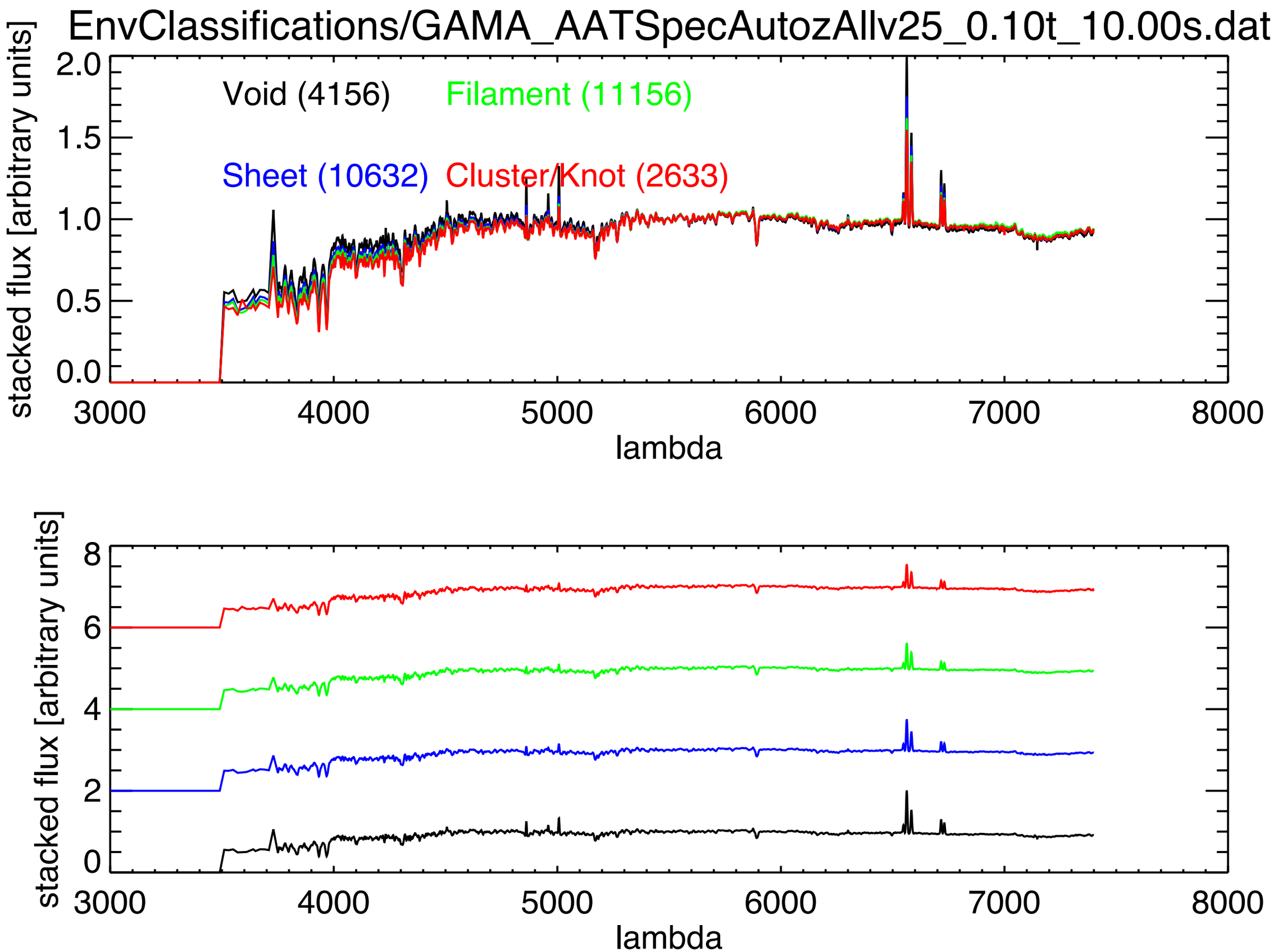
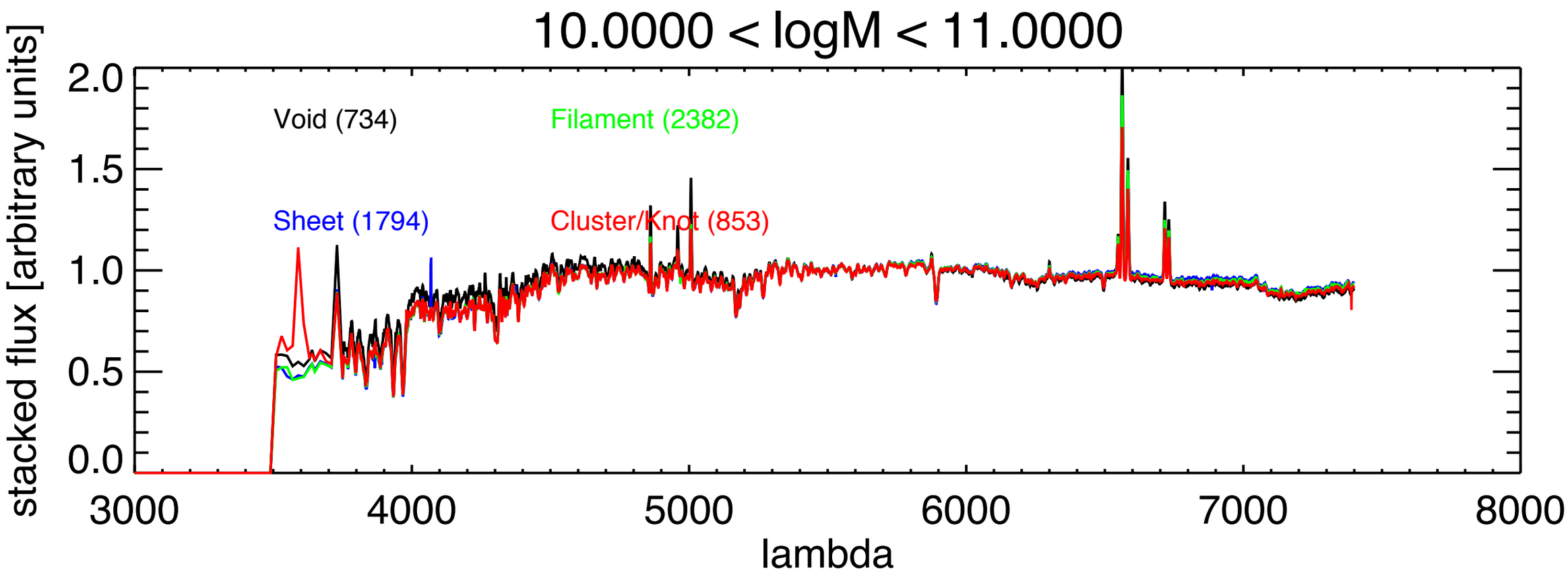
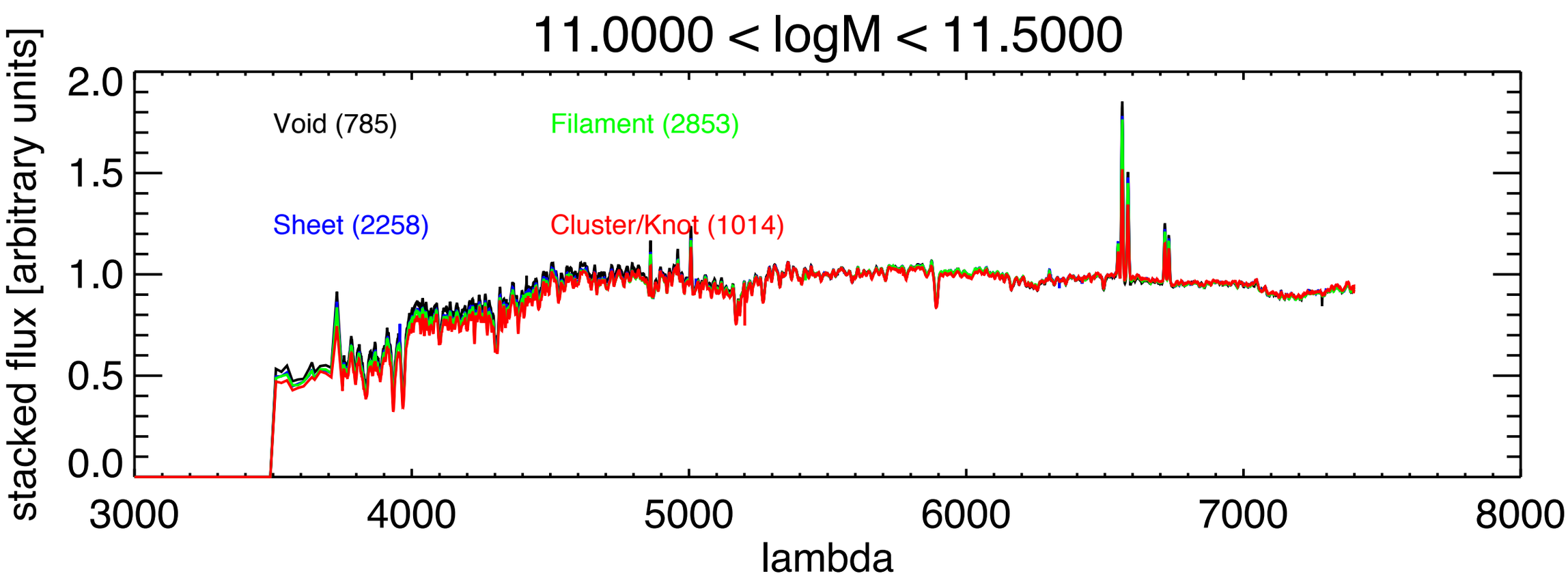
Stacked spectra

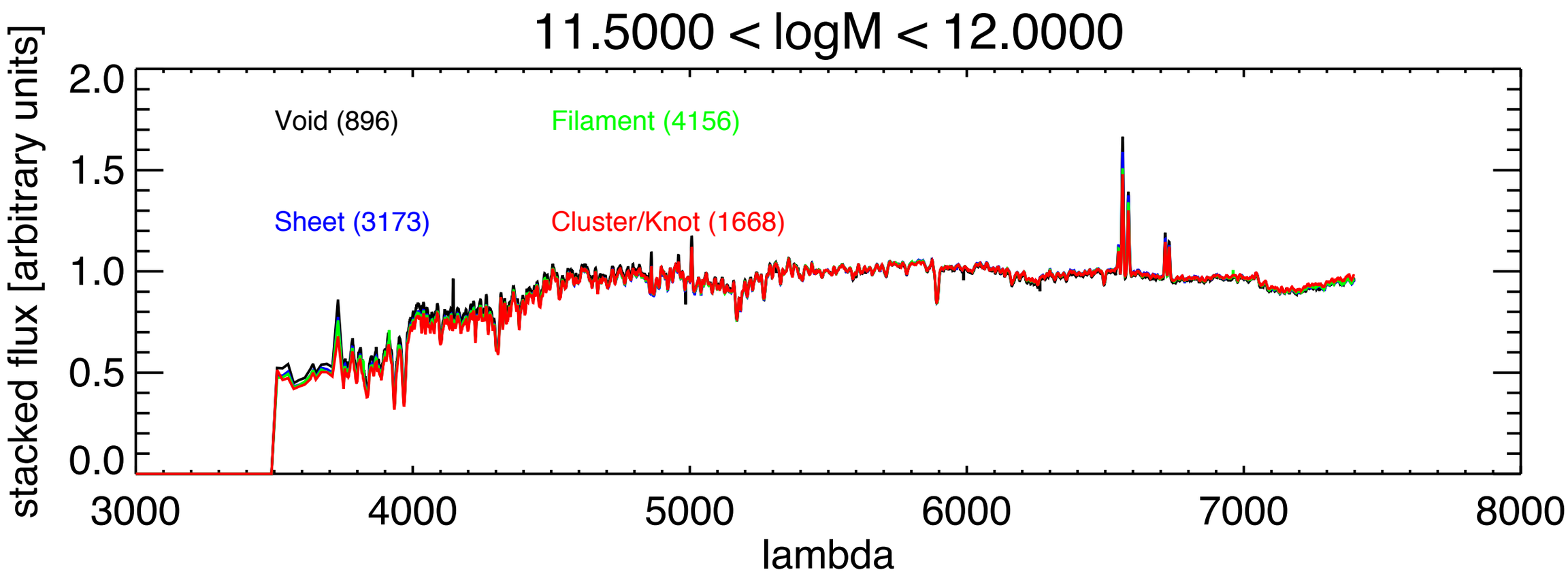
- Geometric environment classifications from Lizzie Eardley.
- Group masses from G^3Cv1 group catalogue from Robotham et al. 2011

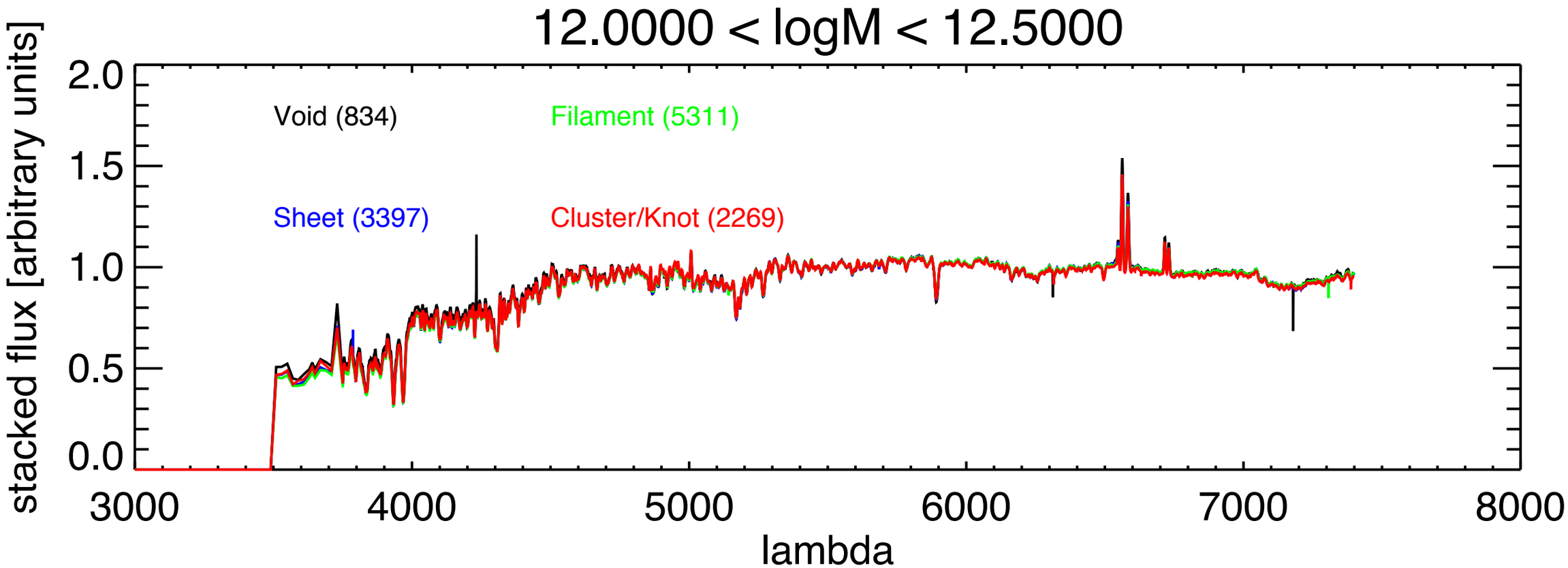

EnvClassifications/GAMA_G3CFoFGroupv06_0.10t_10.00s.dat
Ungrouped (18442)
11<logM<12 (3260)
8<logM<11 (1337)
12<logM<15 (6121)
stacked flux [arbitrary units]
lambda
2.0
1.5
1.0
0.5
0.0
3000
4000
5000
6000
7000
8000
stacked flux [arbitrary units]
lambda
8
6
4
2
0
3000
4000
5000
6000
7000
8000


EnvClassifications/GAMA_AATSpecAutozAllv25_0.10t_10.00s.dat
Void (4156)
Filament (11156)
Sheet (10632)
Cluster/Knot (2633)
stacked flux [arbitrary units]
2.0
1.5
1.0
0.5
0.0
3000
4000
5000
6000
7000
8000
lambda
stacked flux [arbitrary units]
8
6
4
2
0
3000
4000
5000
6000
7000
8000
lambda


10.0000 < logM < 11.0000
stacked flux [arbitrary units]
lambda
Void (734)
Filament (2382)
Sheet (1794)
Cluster/Knot (853)
2.0
1.5
1.0
0.5
0.0
3000
4000
5000
6000
7000
8000


11.0000 < logM < 11.5000
stacked flux [arbitrary units]
lambda
Void (785)
Filament (2853)
Sheet (2258)
Cluster/Knot (1014)
2.0
1.5
1.0
0.5
0.0
3000
4000
5000
6000
7000
8000


11.5000 < logM < 12.0000
Void (896)
Filament (4156)
Sheet (3173)
Cluster/Knot (1668)
stacked flux [arbitrary units]
2.0
1.5
1.0
0.5
0.0
3000
4000
5000
6000
7000
8000
lambda


12.0000 < logM < 12.5000
Void (834)
Filament (5311)
Sheet (3397)
Cluster/Knot (2269)
stacked flux [arbitrary units]
2.0
1.5
1.0
0.5
0.0
3000
4000
5000
6000
7000
8000
lambda

SFHs and assembly times

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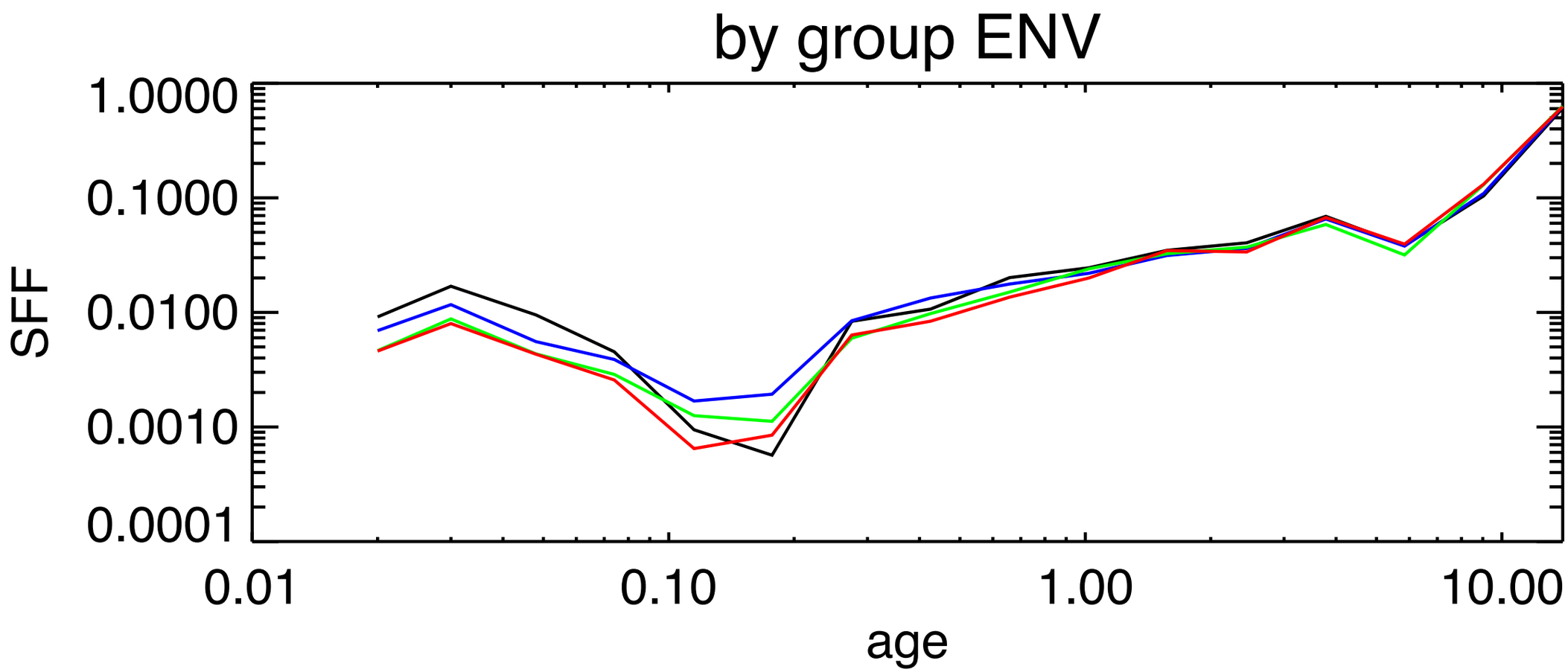
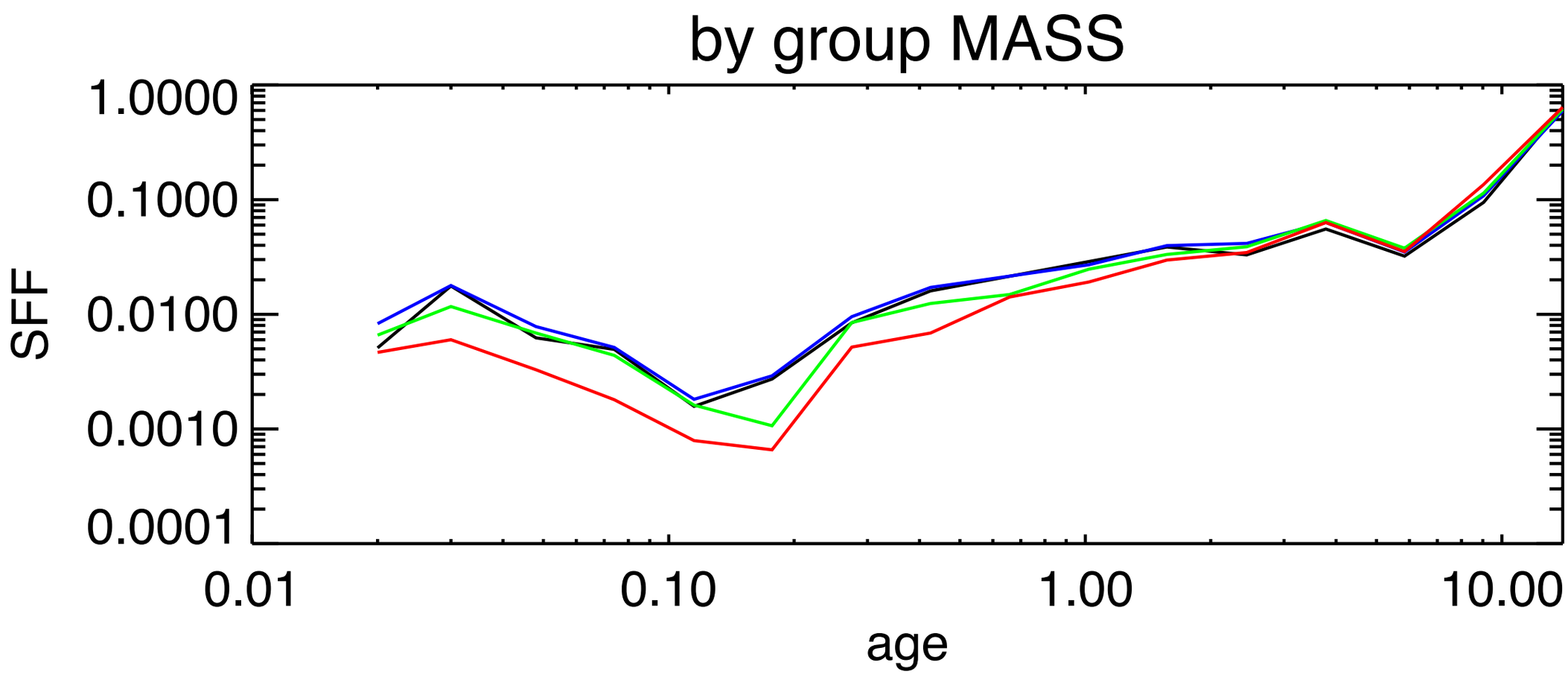
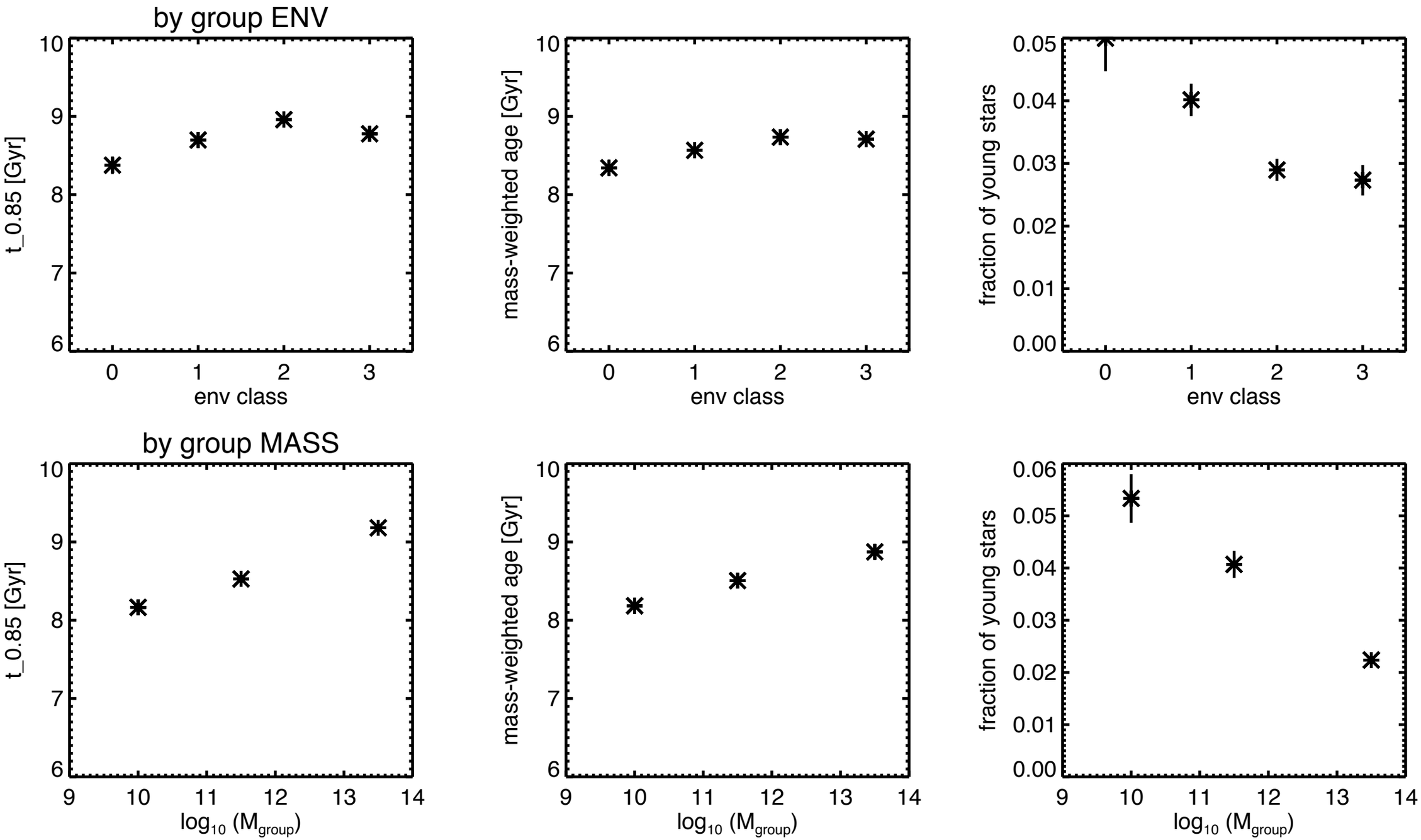
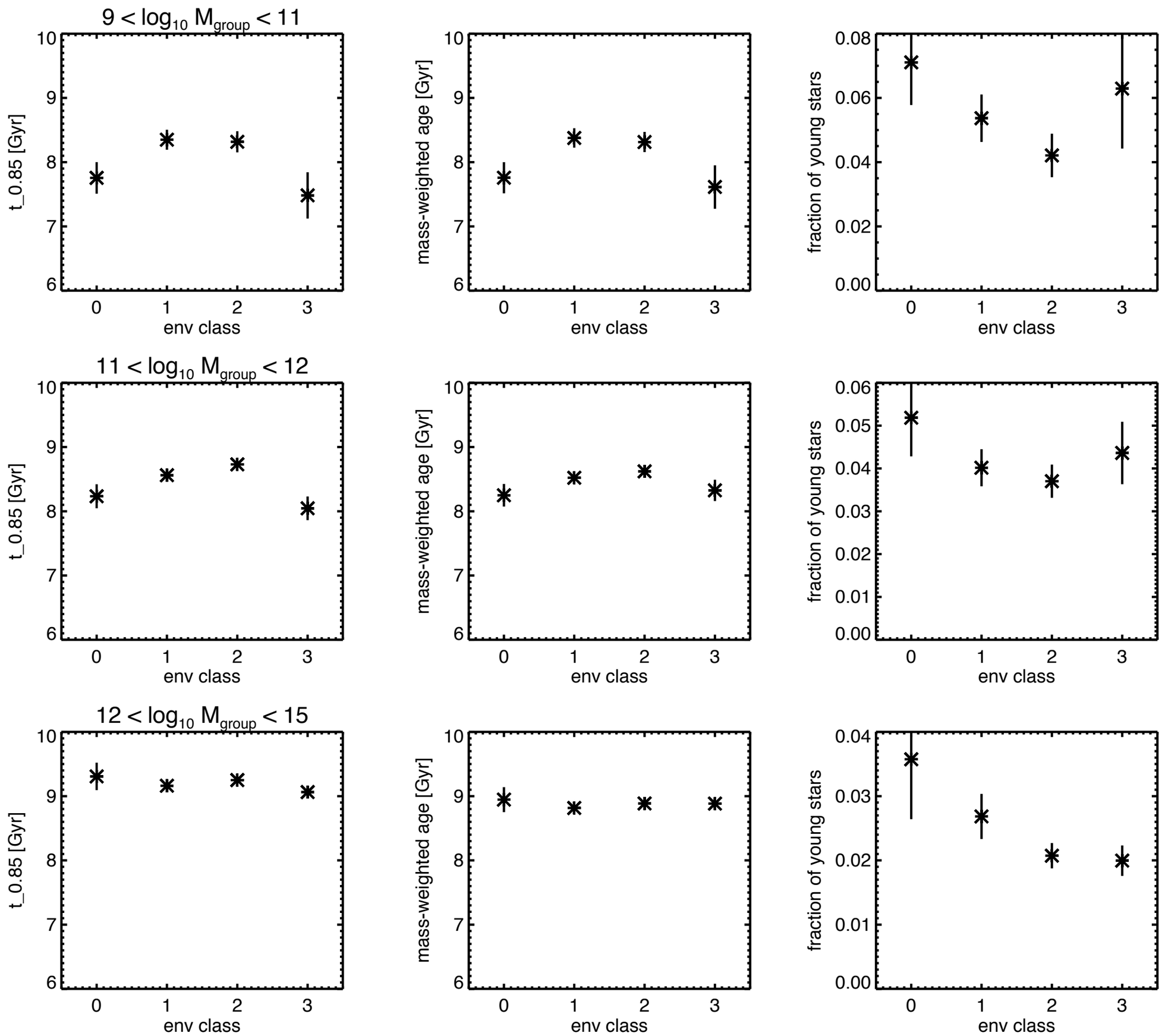
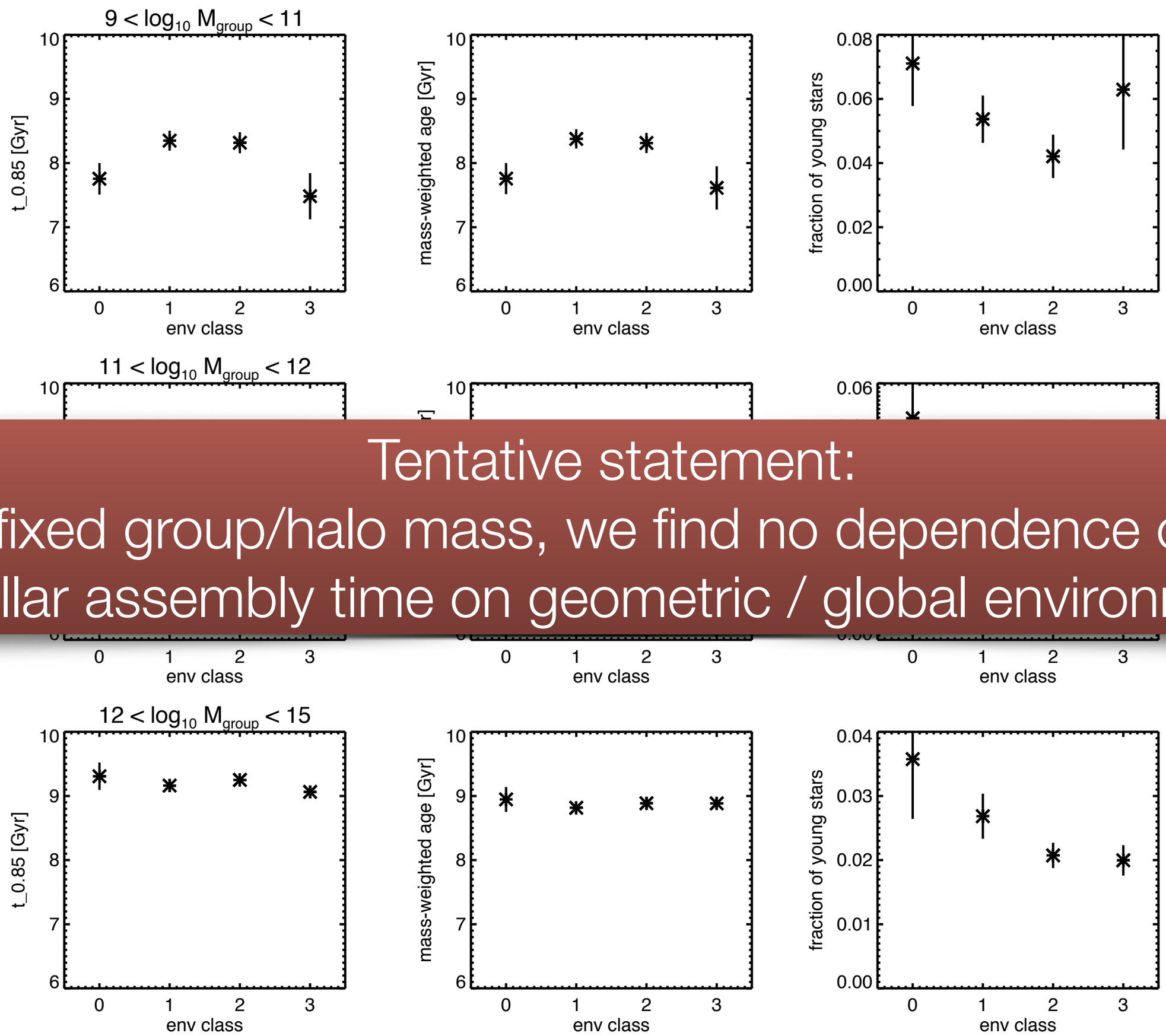
- Group masses from G^3Cv1 group catalogue from Robotham et al. 2011.
- SFHs and assembly times from VESPA.


by group ENV
1.0000
0.1000
0.0100
0.0010
0.0001
SFF
0.01
0.10
1.00
10.00
age


by group MASS
1.0000
0.1000
0.0100
0.0010
0.0001
SFF
0.01
0.10
1.00
10.00
age


by group ENV
t_0.85 [Gyr]
mass-weighted age [Gyr]
fraction of young stars
env class
by group MASS
log10 (Mgroup)


9 < log10 Mgroup < 11
11 < log10 Mgroup < 12
12 < log10 Mgroup < 15
t_0.85 [Gyr]
mass-weighted age [Gyr]
fraction of young stars
env class



Tentative statement:

at fixed group/halo mass, we find no dependence of the stellar assembly time on geometric / global environment.

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- Do our estimators trace halo assembly times?
  - Hard to imagine a scenario where they don't *to some extent*. We are sourcing suitable **simulations** with which to study this in detail.
  - Even if so, can we assign all effects of global environment on galaxy properties to assembly bias? What about super-halo interactions?

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- What about **galaxy assembly bias**? Coming next!

Thank you.

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