

Combining observations with data

We will discuss the basics of:

- ★ Generating a composite model SED
- ★ Generating an observed SED
- ★ Photometric redshifts
- ★ SFH parametrisation
- ★ Different fitting techniques (exercise)

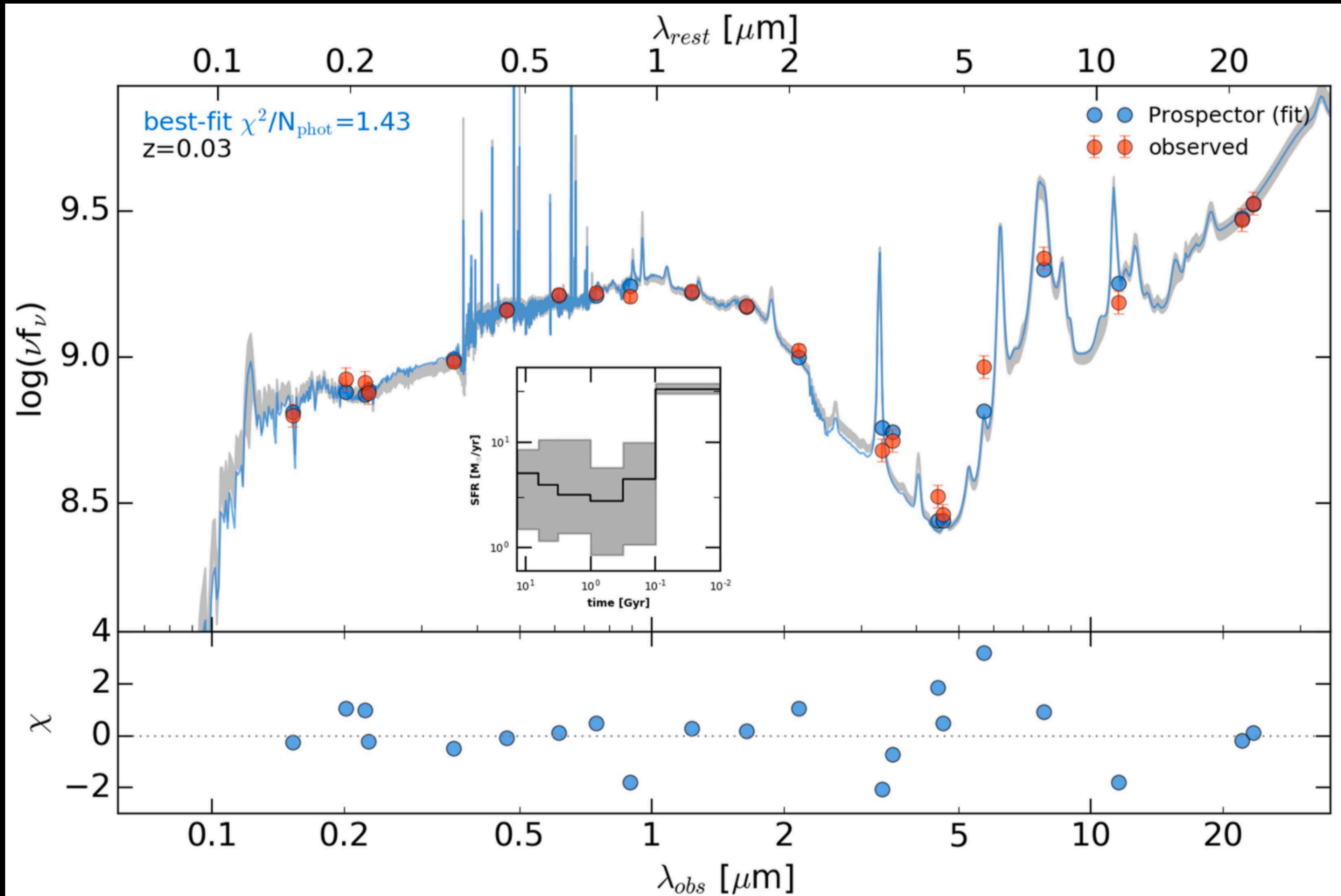


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What is SED fitting?

- The attempt to analyse a galaxy SED and derive one or several physical properties simultaneously from fitting models to the observed SED.

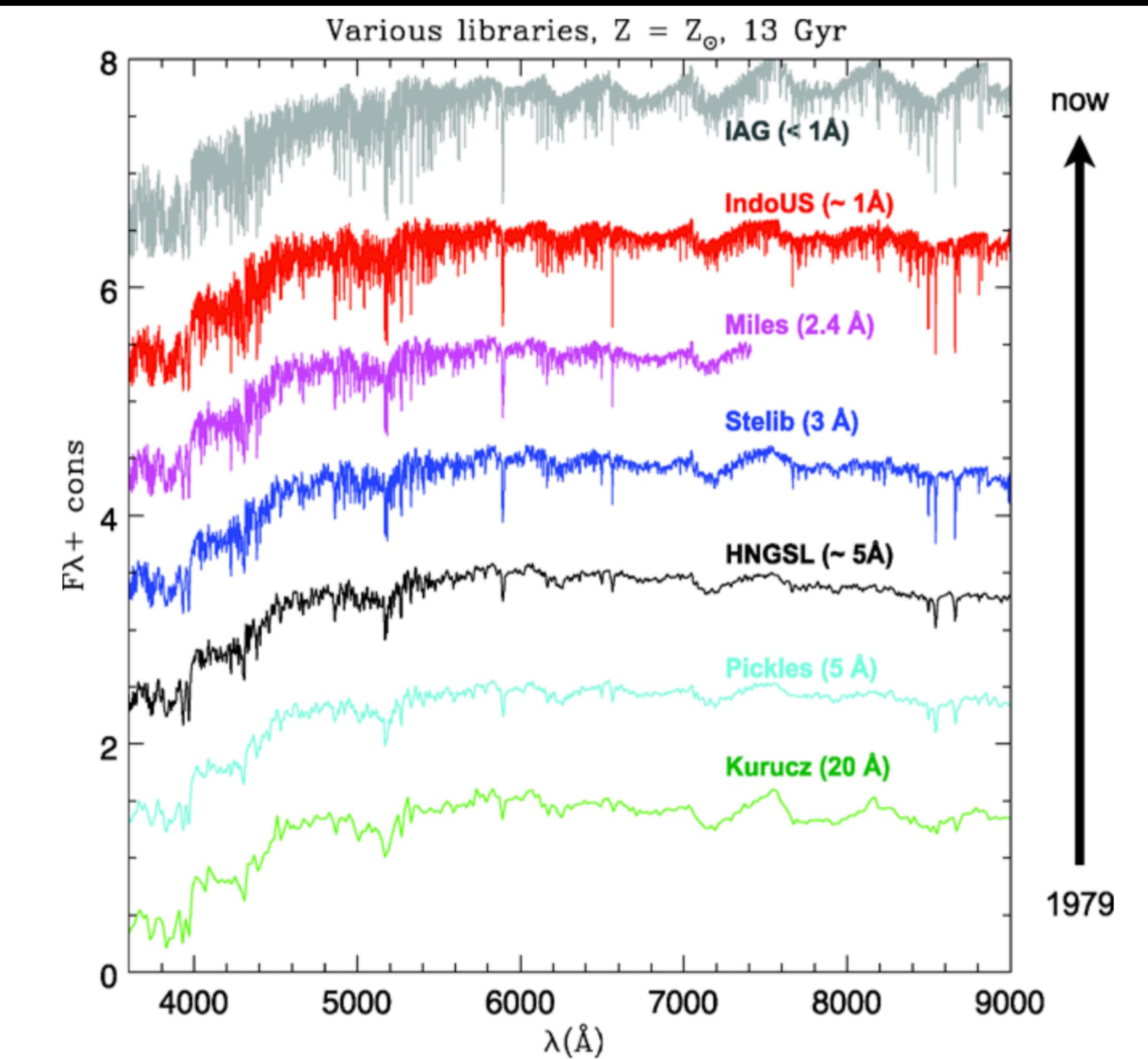
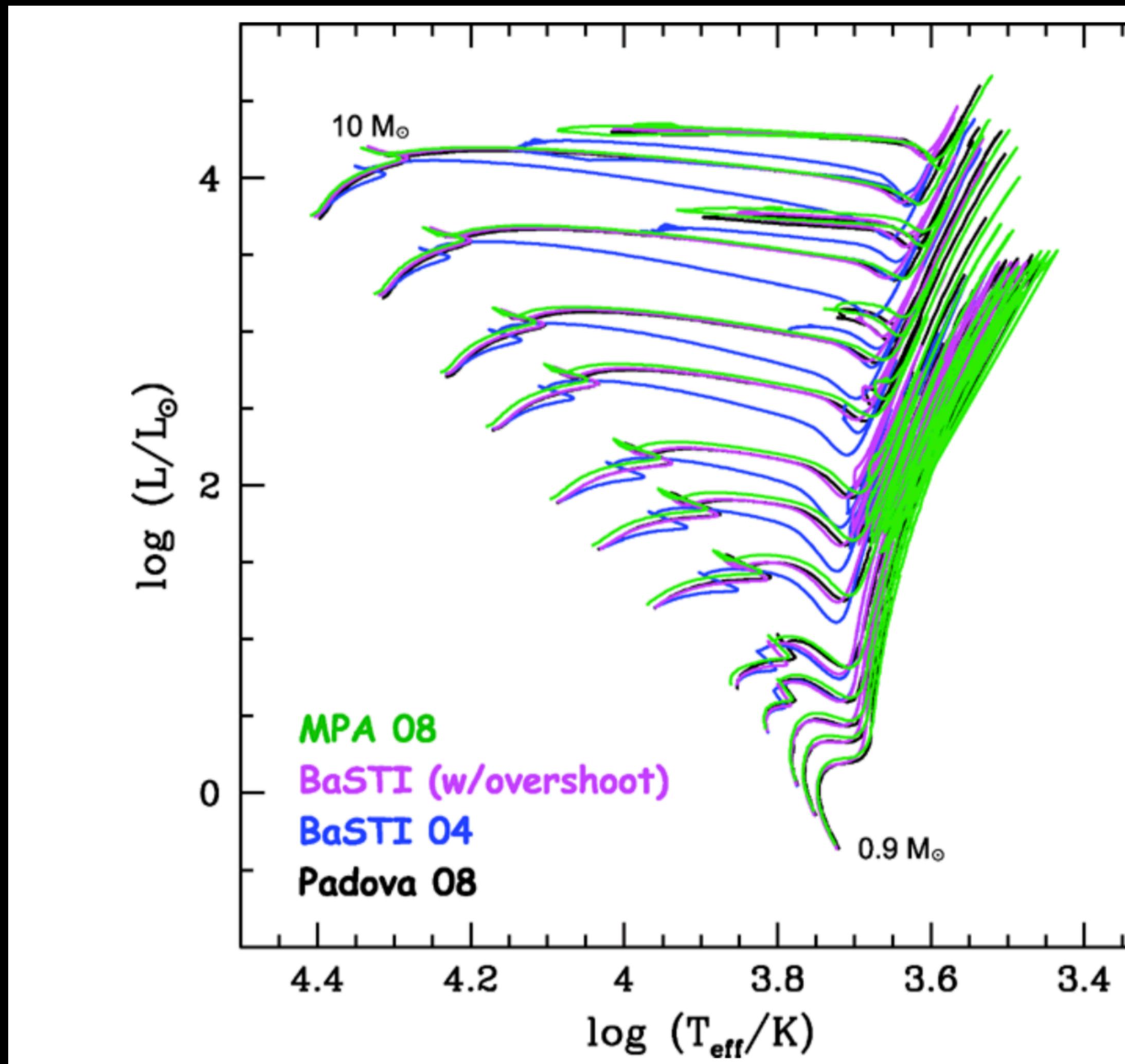


Why fit SEDs?

- Different physical processes occurring in galaxies all leave their imprint on the global and detailed shape of the spectrum, each dominating at different wavelengths.
- So detailed analysis of the shape of an observed SED can be used to fully infer details about galaxies.

Generating composite SEDs

- First a set of composite SEDs are required, generally produced using SSPs using theoretical or observed stellar libraries.



Other parameters required

- ISM gas: atomic form crucial to reprocess $\lambda < 912\text{\AA}$ photons into strong UV, optical, IR emission lines.
 - ★ General assumption in photoionisation is that all such photons are absorbed within the Strömgren sphere and is re-emitted in the hydrogen recombination lines.
- ISM dust: attenuates shorter wavelengths and re-emits absorbed energy at higher wavelengths.
 - ★ Some codes are now able to combine the stellar and dust emission together. e.g., FSPPS, MAGPHYS
 - ★ However, large uncertainties may be present over on how dust attenuation, dust-to-metal ratios, re-radiation, and differential emission from birth-cloud and diffuse dust components.

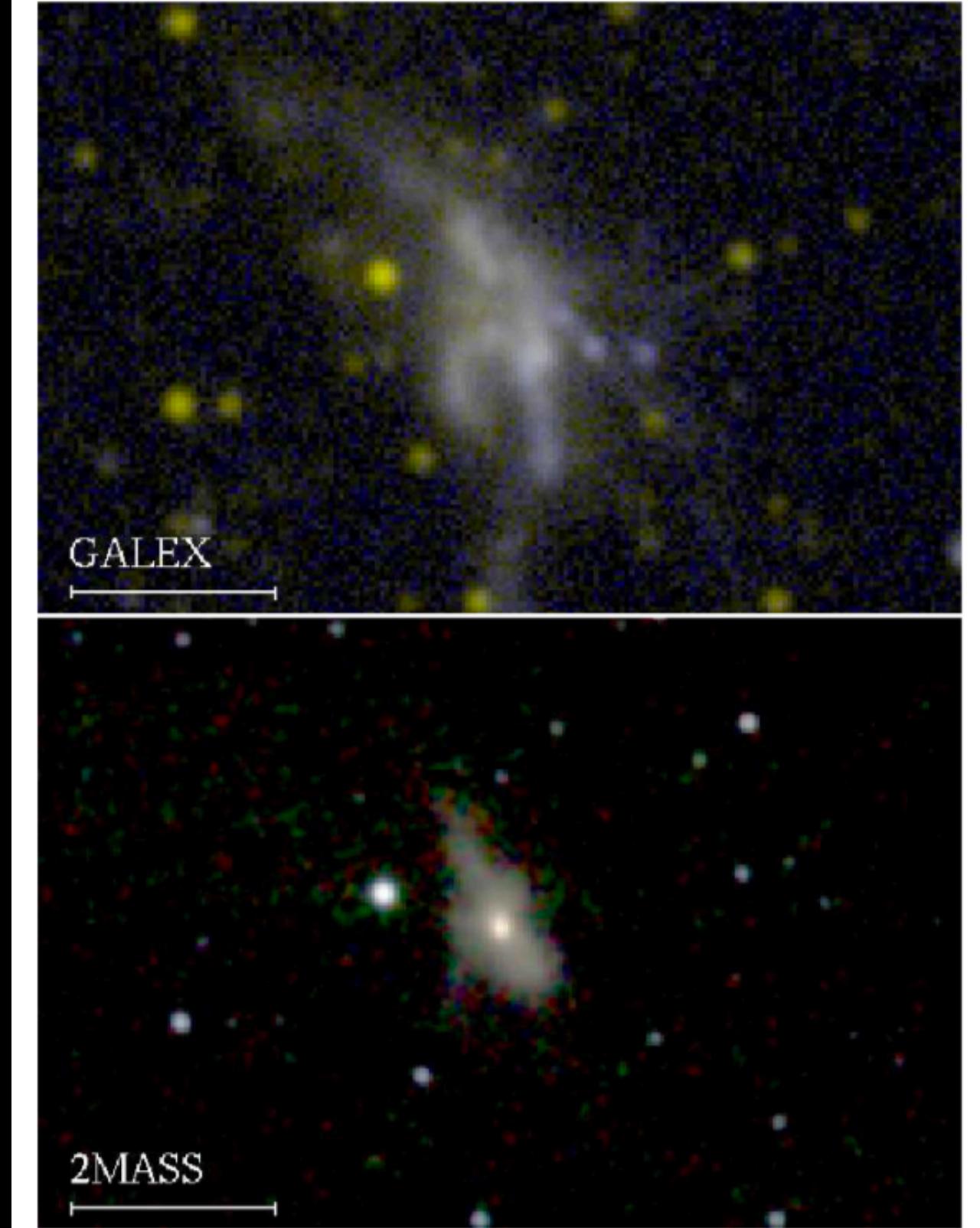
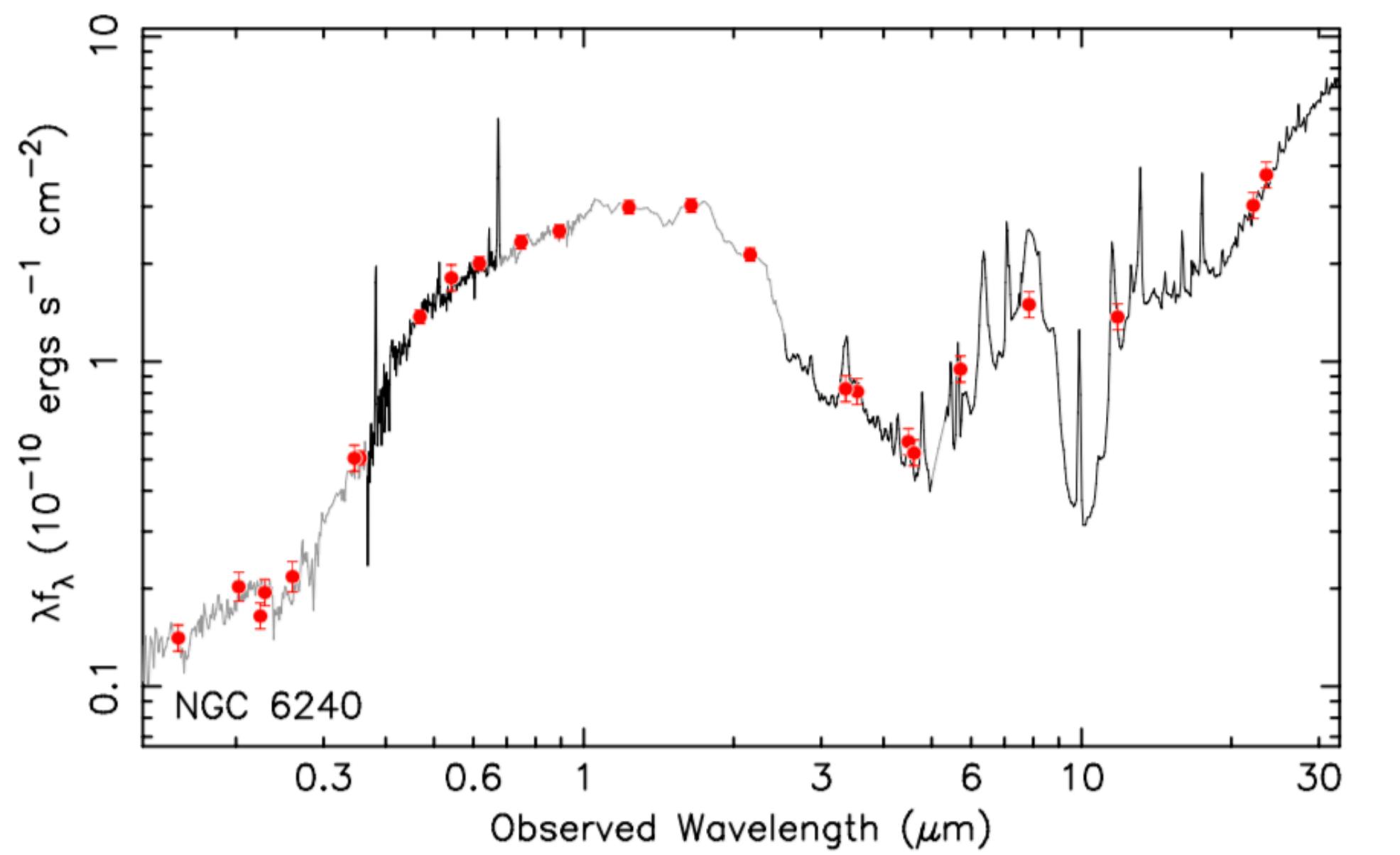
Simplified galaxy evolution

- Three main things to consider when making purely theoretical SEDs:
 - ★ Chemical evolution: metallicity, infall rates, and dust pollution rates are used to workout the ISM properties, which are then combined with the SSPs.
 - ★ Models involving the whole galaxy: based on hydrodynamic and N-body codes and considers star formation from gas and feedback processes.
 - ★ Cosmological models: use outputs from DM simulations to approximate galaxy formation within dark matter haloes (e.g. gas cooling, star formation, AGN fuelling, feedback) to consider effects of mergers, gas content and metallicity to determine the spectra of the galaxy.

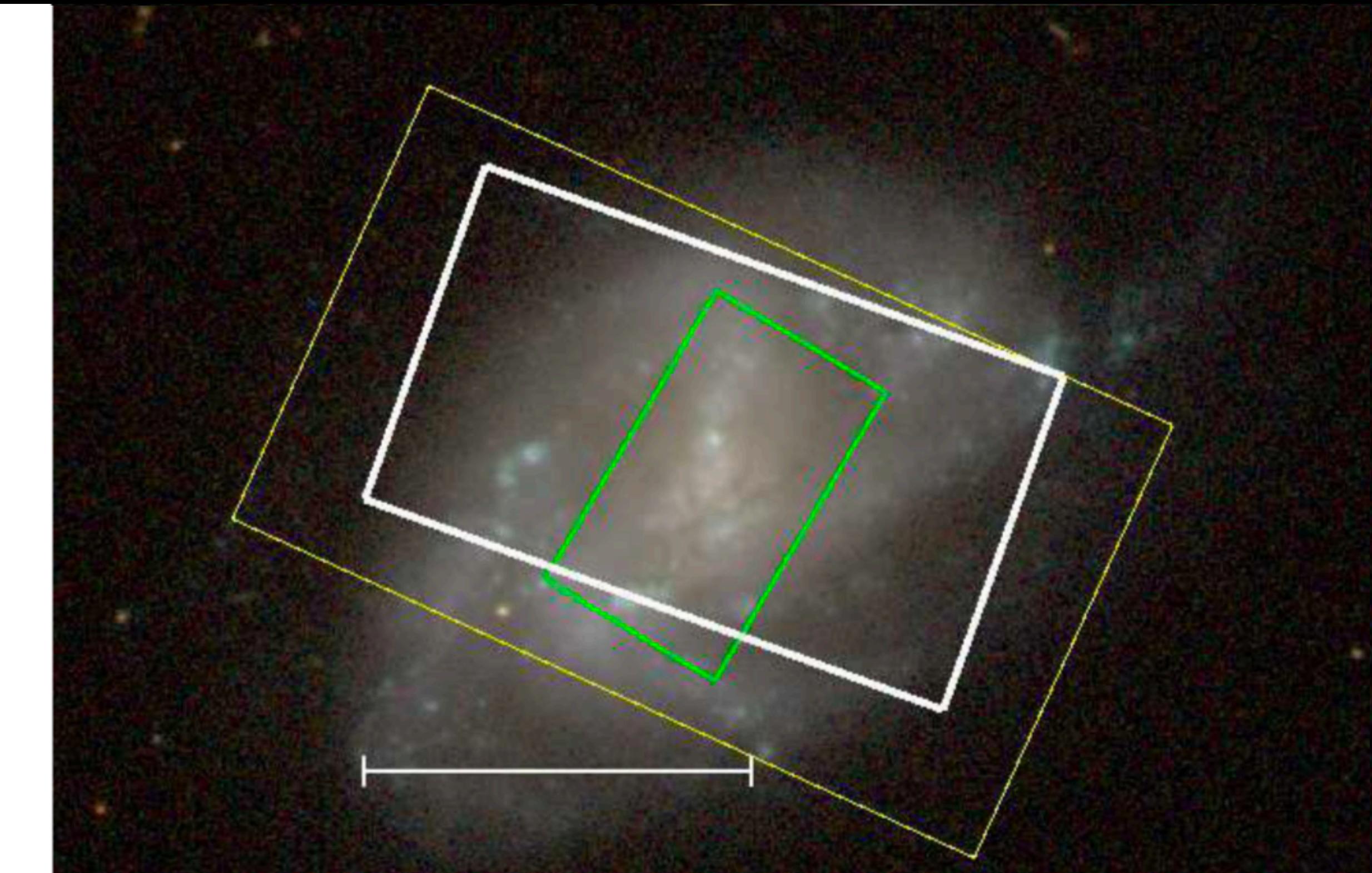
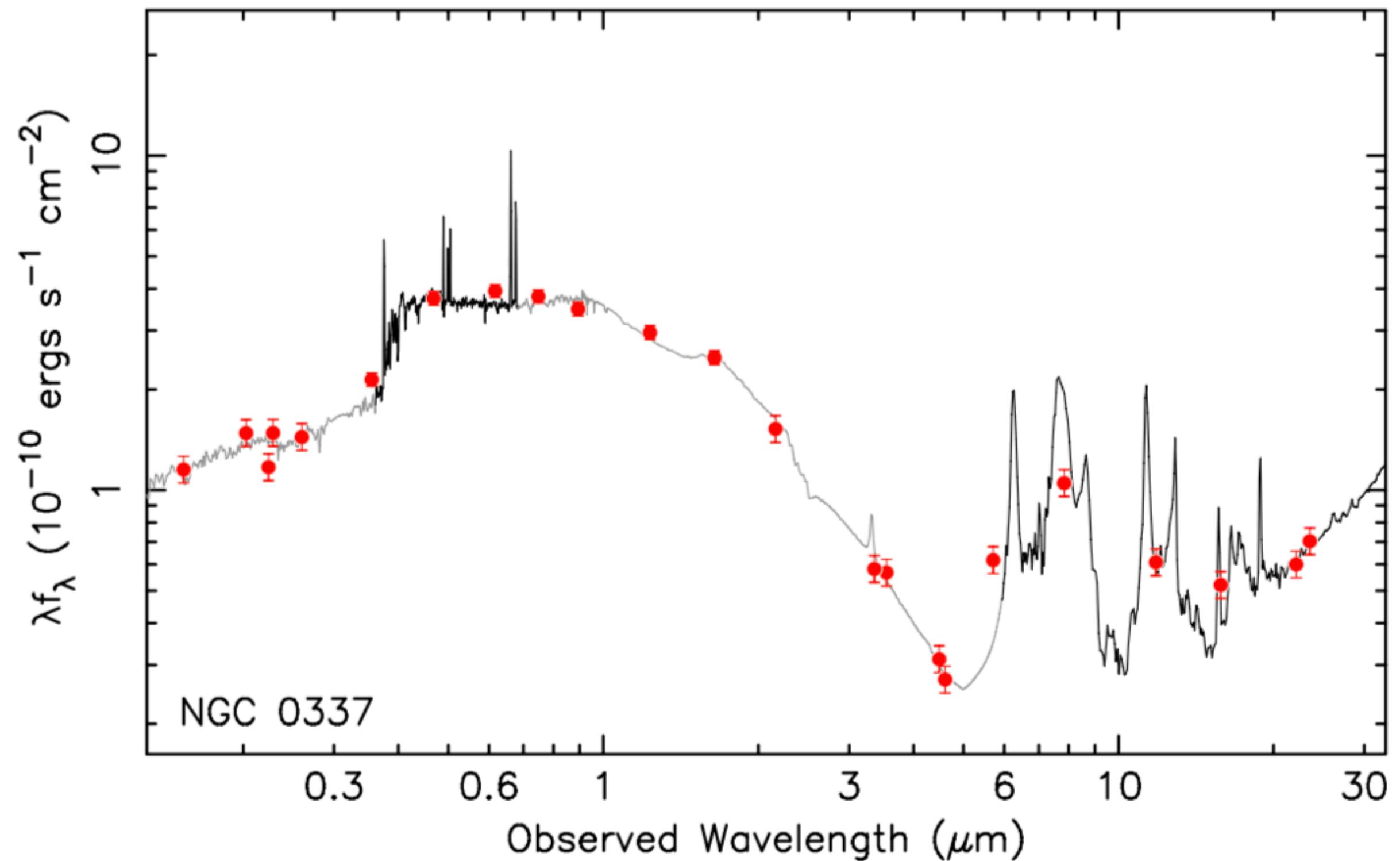
Observed galaxy SEDs

- Part from theoretical models, observations made on singular galaxies in a large wavelength range can be used to produce an observed galaxy SED.
- Things to keep note:
 - ★ Spectral response curve and resolution
 - ★ Spatial resolution, aperture bias, and matching.

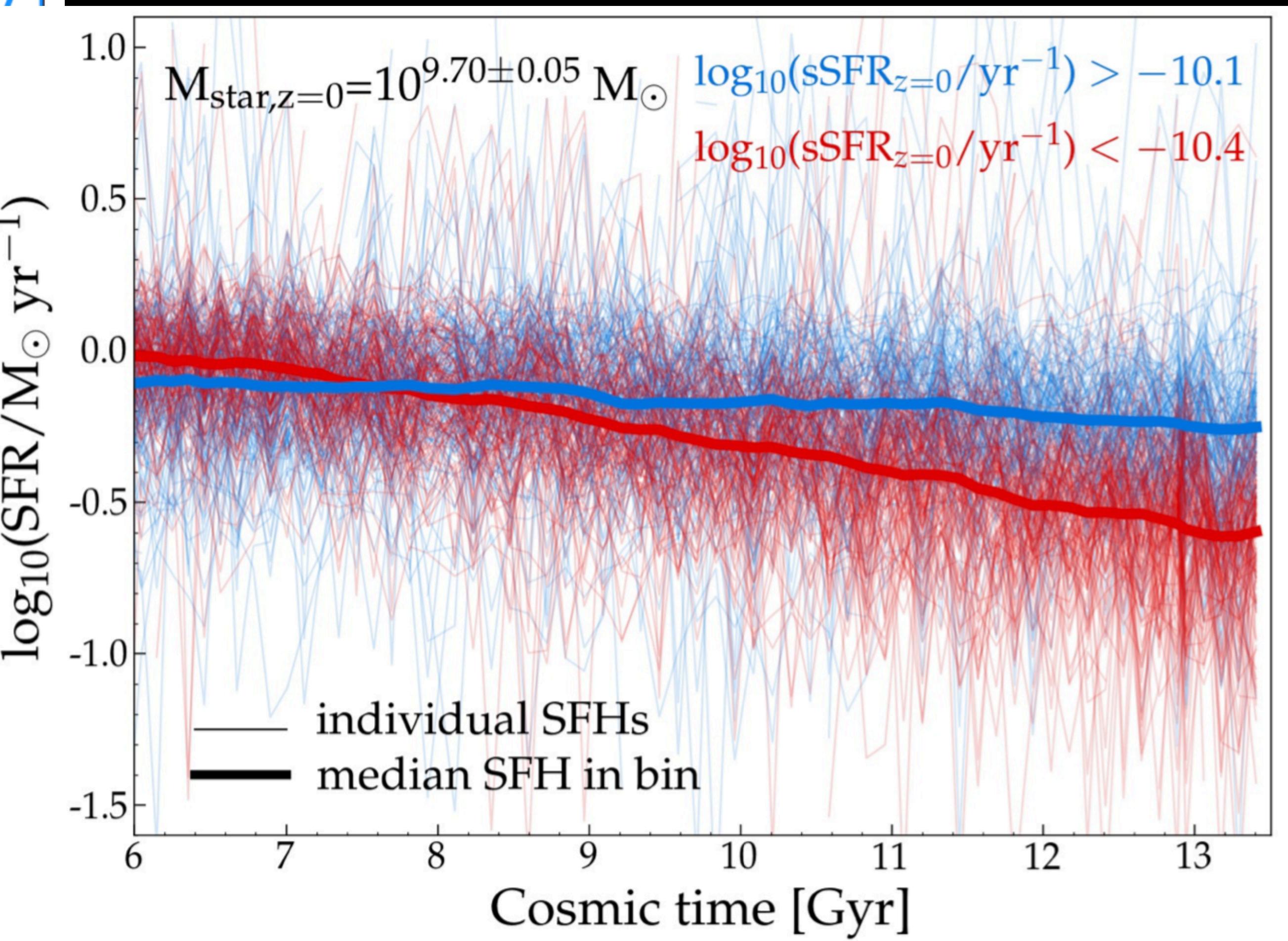
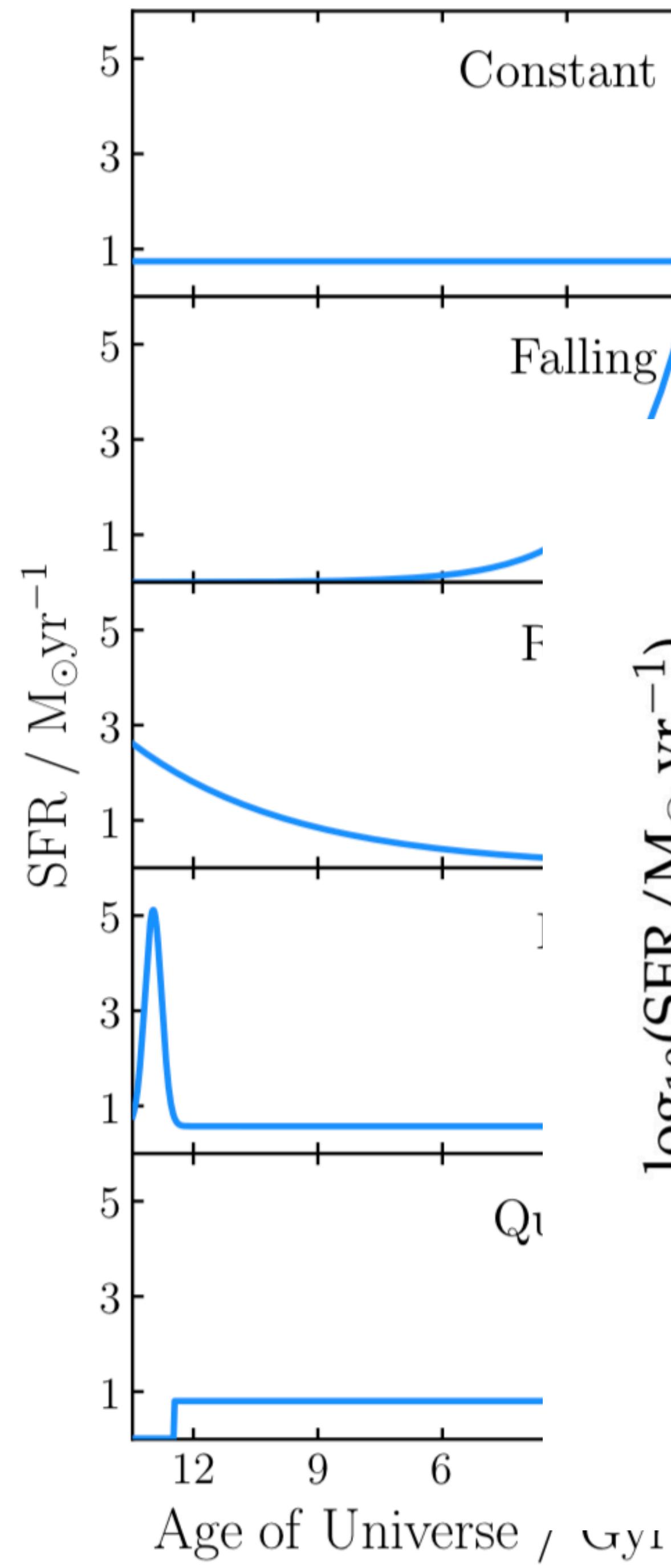
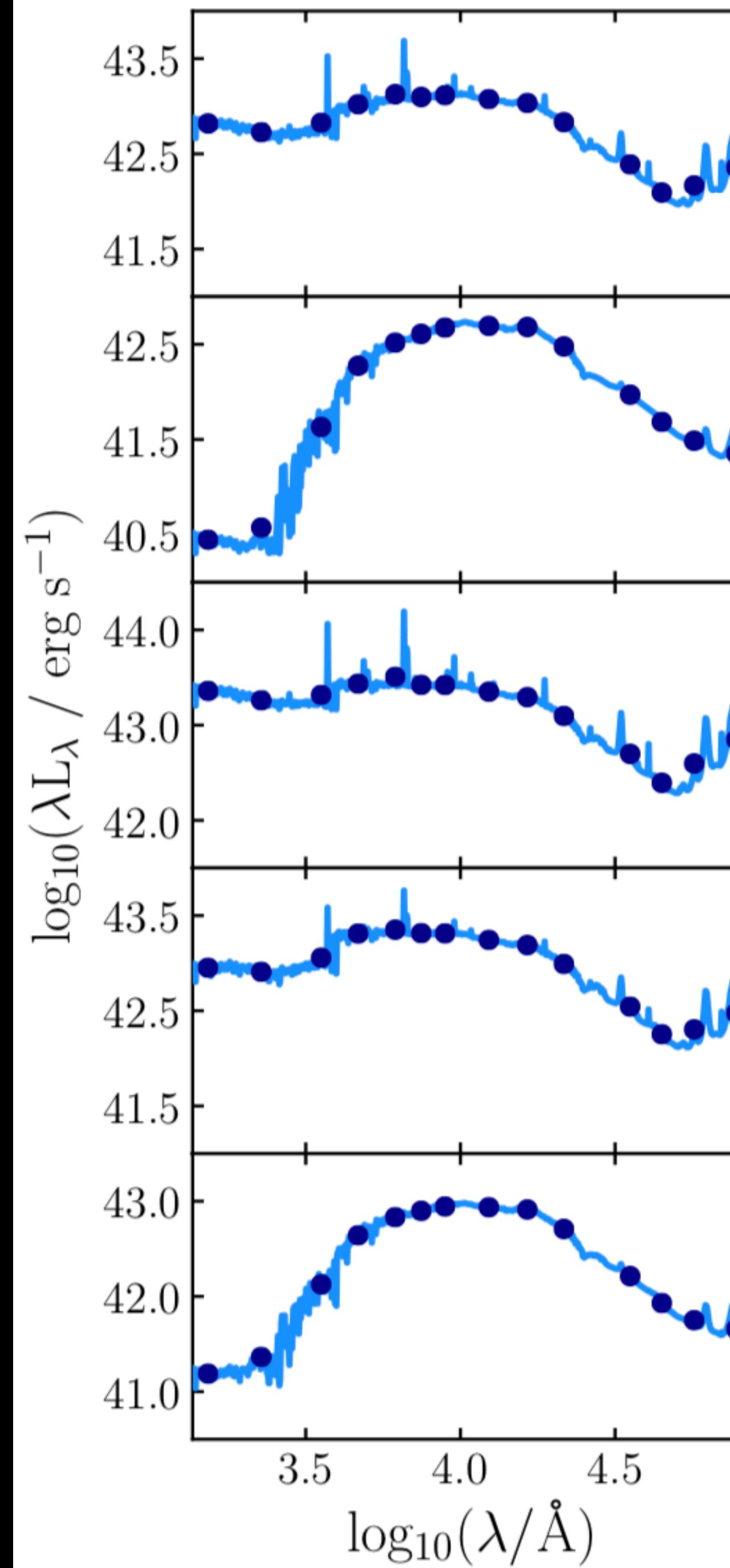
Observed galaxy SEDs



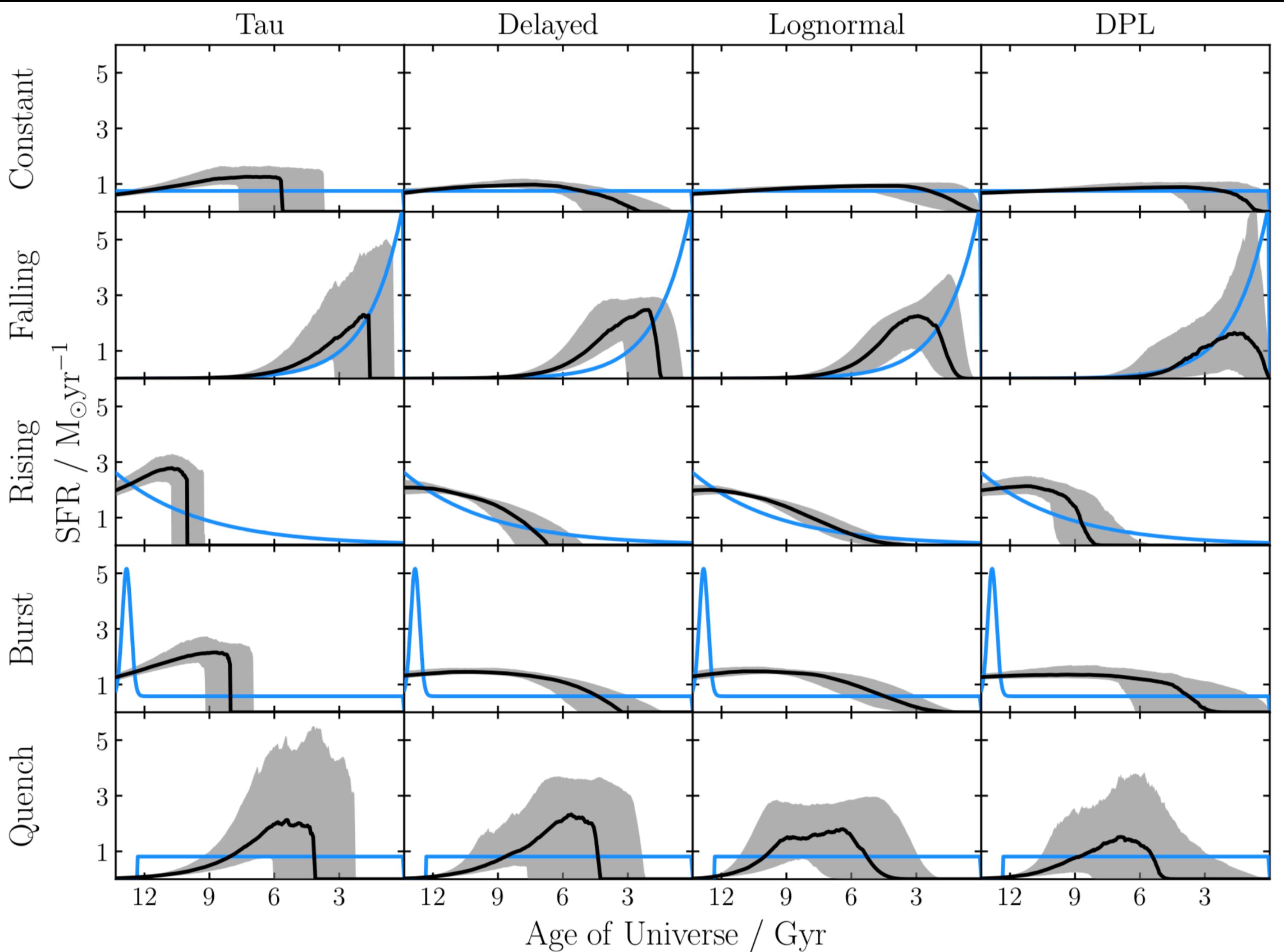
Observed galaxy SEDs



SFH parameterisations



SFH parameterisations



- It is not easy to reproduce the input SFH parametrisation

Fitting techniques used by different fitting techniques

- Spectral indices
- PCA
- Spectral fitting by inversion
- Bayesian

Read Section 4 in Walcher et al., 2011 <https://ui.adsabs.harvard.edu/#abs/2011Ap&SS.331....1W/abstract>

Typically inferred properties

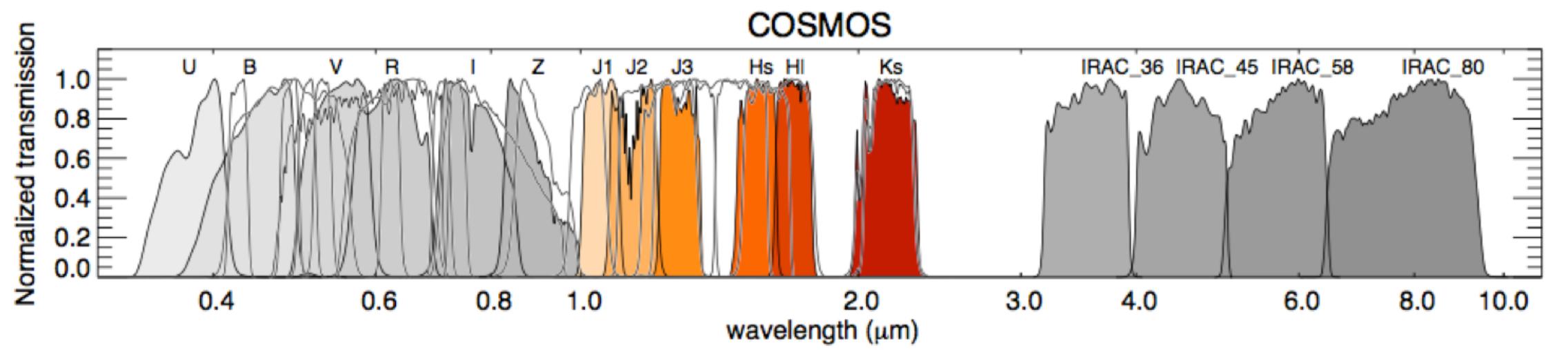
- ★ Photometric redshifts
- ★ Stellar mass
- ★ SFR and SFH
- ★ Dust extinction
- ★ Metallicity
- ★ Age

Note: Derived properties may suffer from strong degeneracies, therefore need to take values with a grain of salt.

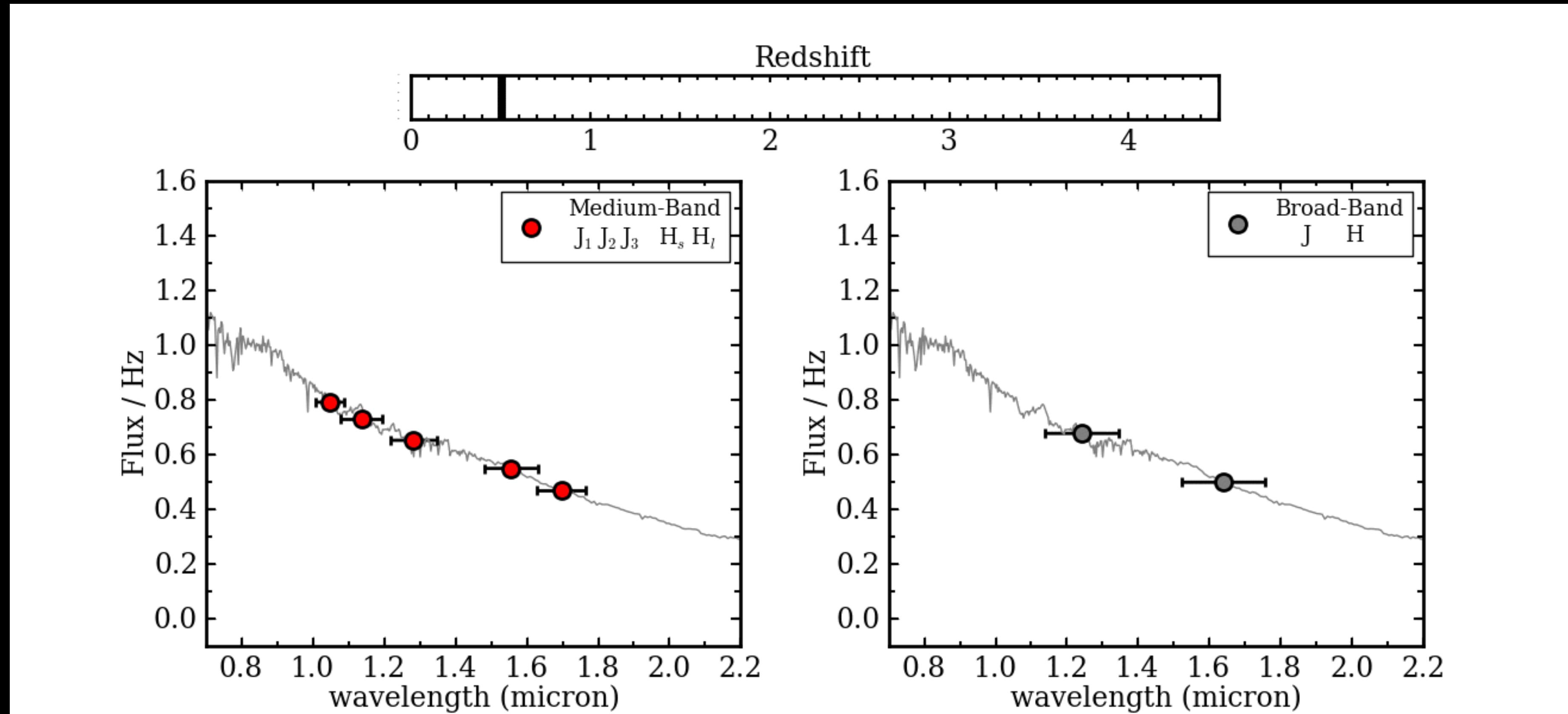
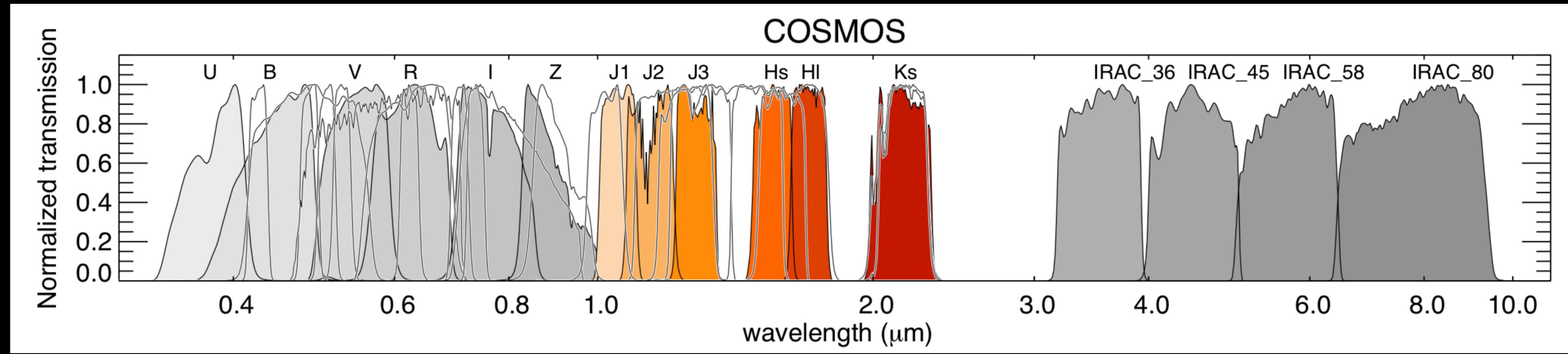
ZFOURGE

Fourstar Galaxy Evolution Survey

- Multi-wavelength survey of the universe
- Uses narrow band imaging to constrain photometric redshifts
- 45 nights on Magellan: FourStar
- 3 HST legacy fields: COSMOS, CDFS and UDS of $11' \times 11'$ FOV



Photometric redshifts



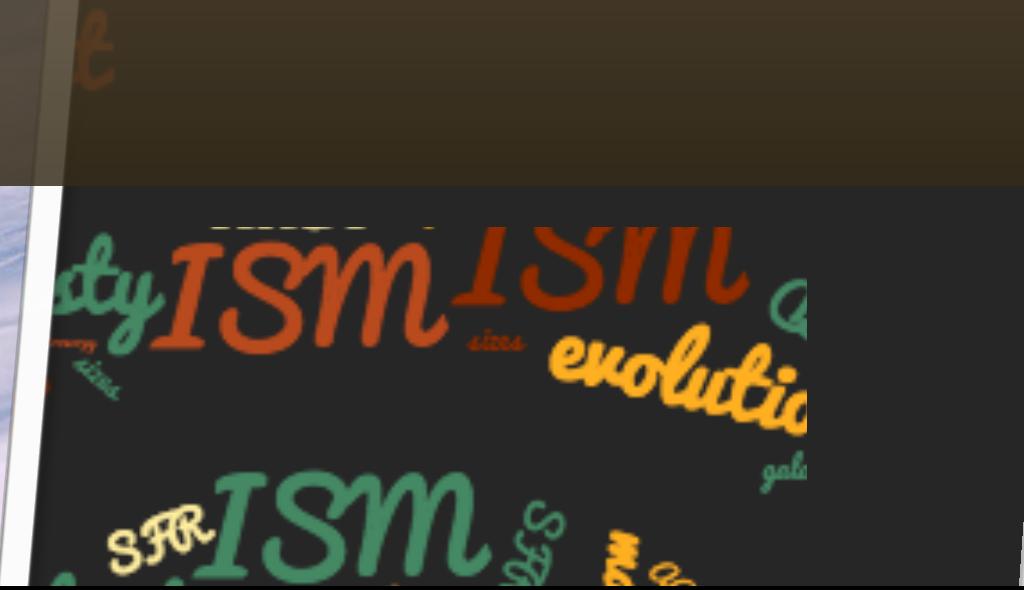
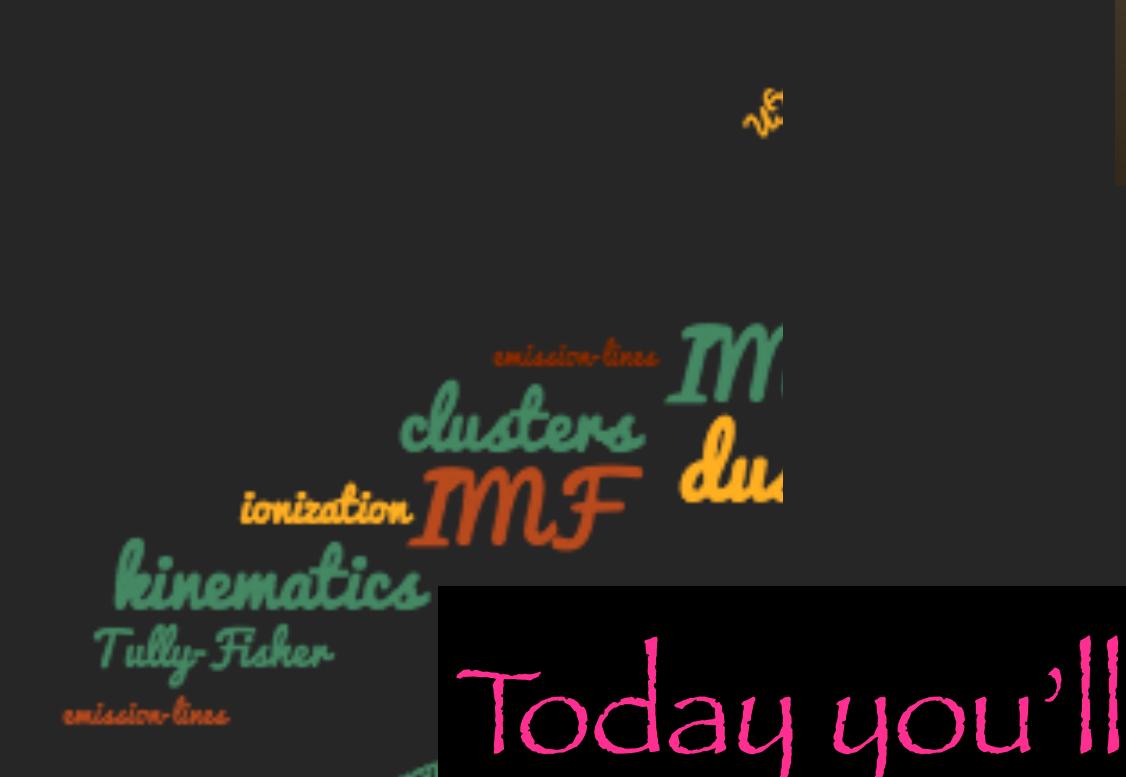
Subaru



Combination of deep observations

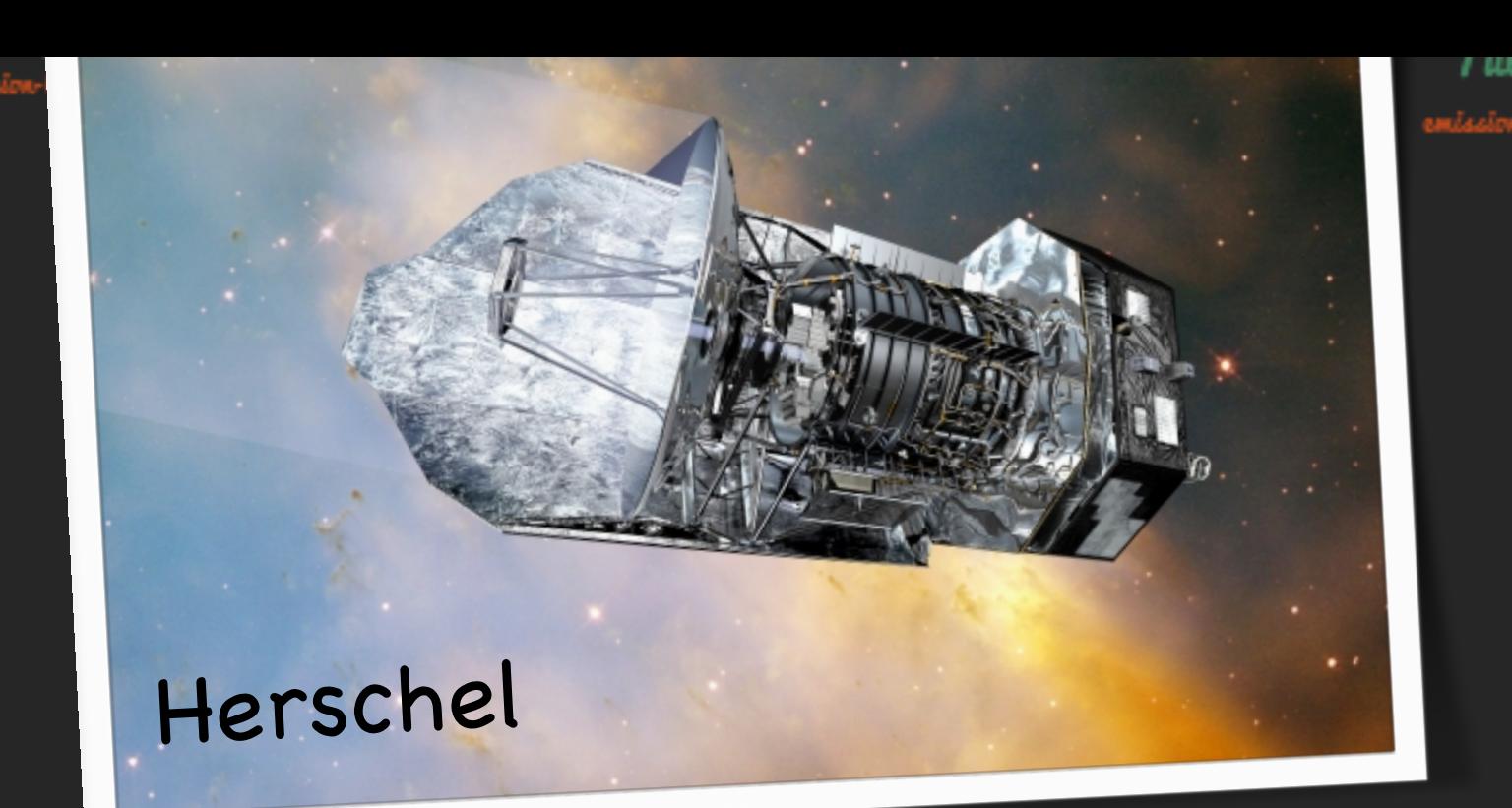
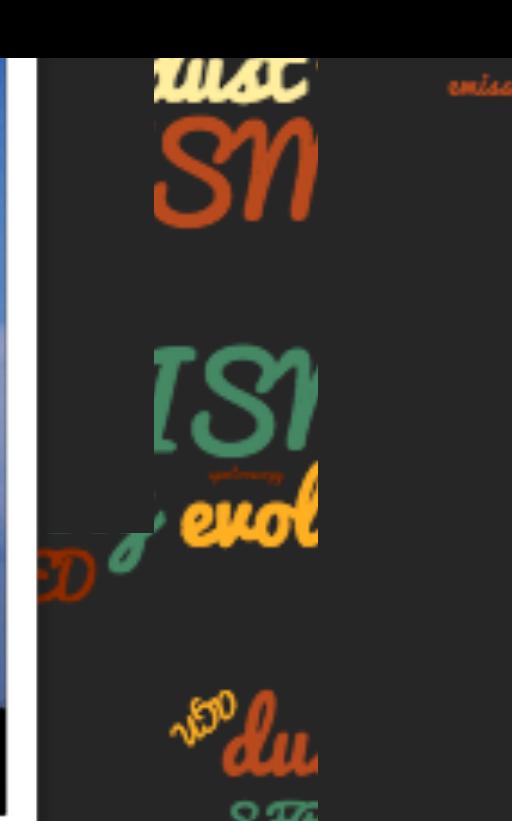
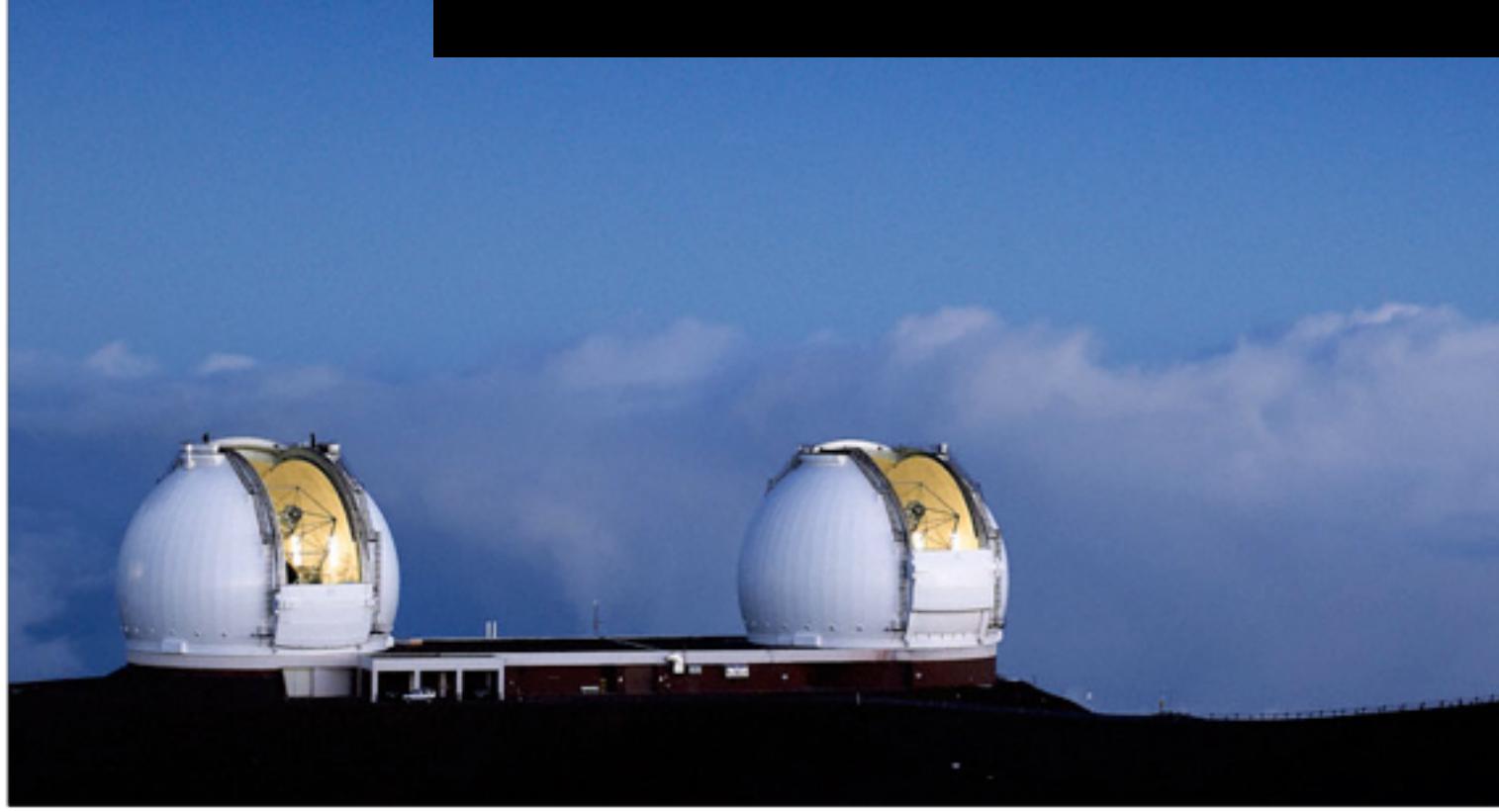


SED



Magellan

Keck



Herschel



CFHT

