PhotoZ : Fit of Stellar Population Synthesis models on Spectral Data

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Outline

- Goal : Synthesis of galaxy SED spectra relevant for PhotoZ SED template fitting (to infer galaxy redshift from photometry) namely at higher redshift than done previously
- How : Fit SED model from Stellar Population Synthesis SPS code on data:
  - Started from Fors2 spectroscopic data (visible range)
  - Complemented by photometric data (GALEX, KIDS, VISTA) to extend wavelength range

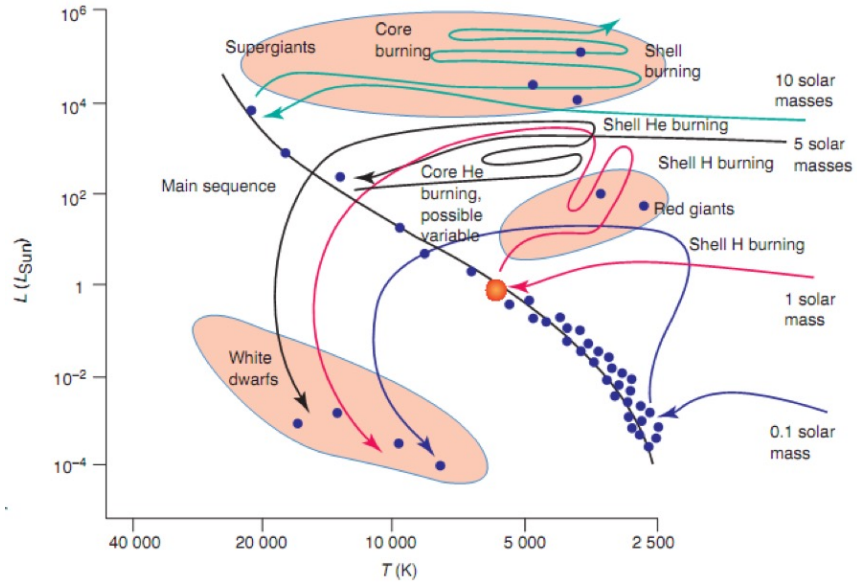
Choose DSPS a parametrical model of galaxy SED

  - Phenomenological parameters encoding the Star-Formation-Rate (SFR)

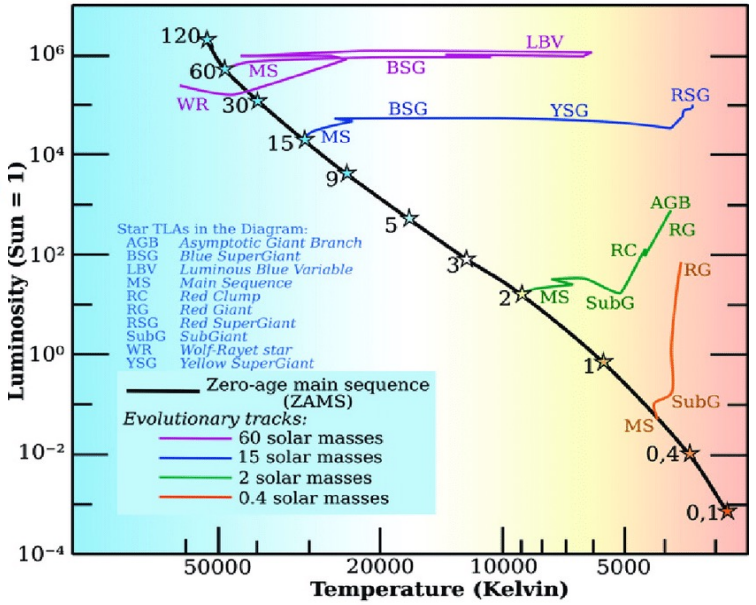
- The technical part of this work:
  - Fitting procedures
- The analysis part of this work are the results:
  - Fitted SED templates on each Fors2 spectrum
  - Comparison with Eric Nuss SED Templates obtained from StarLight model
- Perspectives
  - Better understanding of SPS parameters controlling the shape of SED namely UV part
  - Improve PZ-SED-T-fitting → Joseph Chevalier's presentation for his PhD thesis

What are Stellar population synthesis SPS codes like FSPS

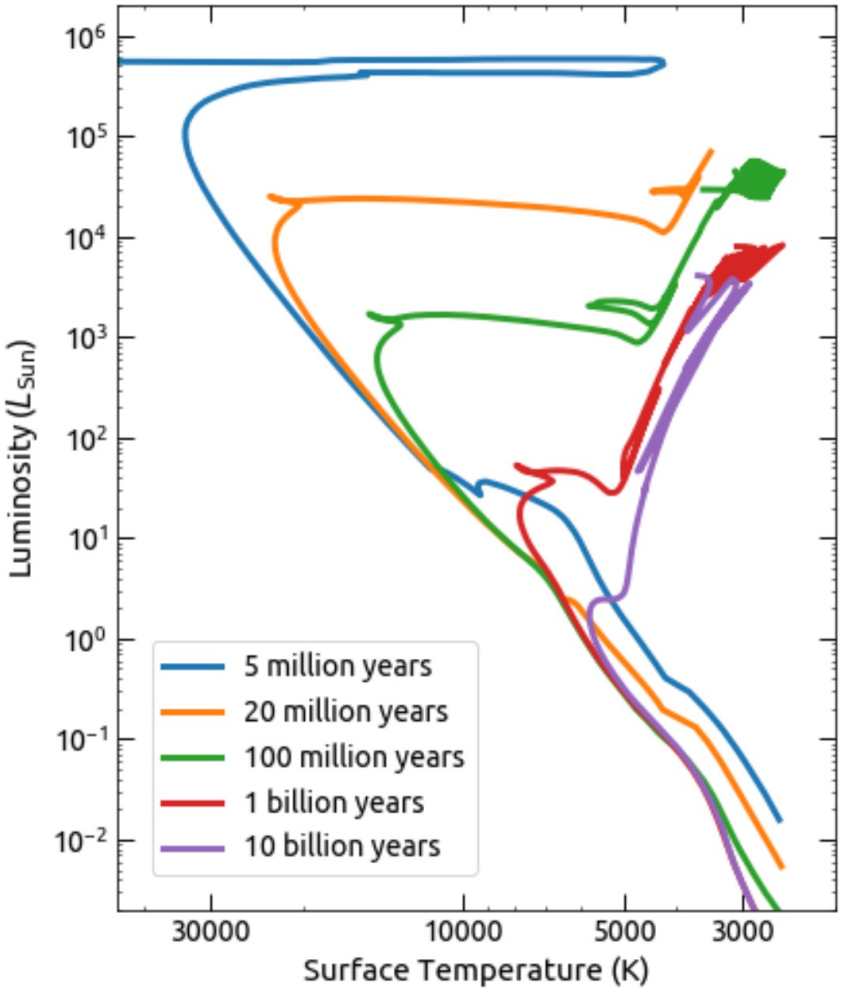
a) Star Trajectory on HR diagram
- dynamical evolution depending on mass



b) Variety of Star types
- star spectral model libraries



c) Stellar Isochrones



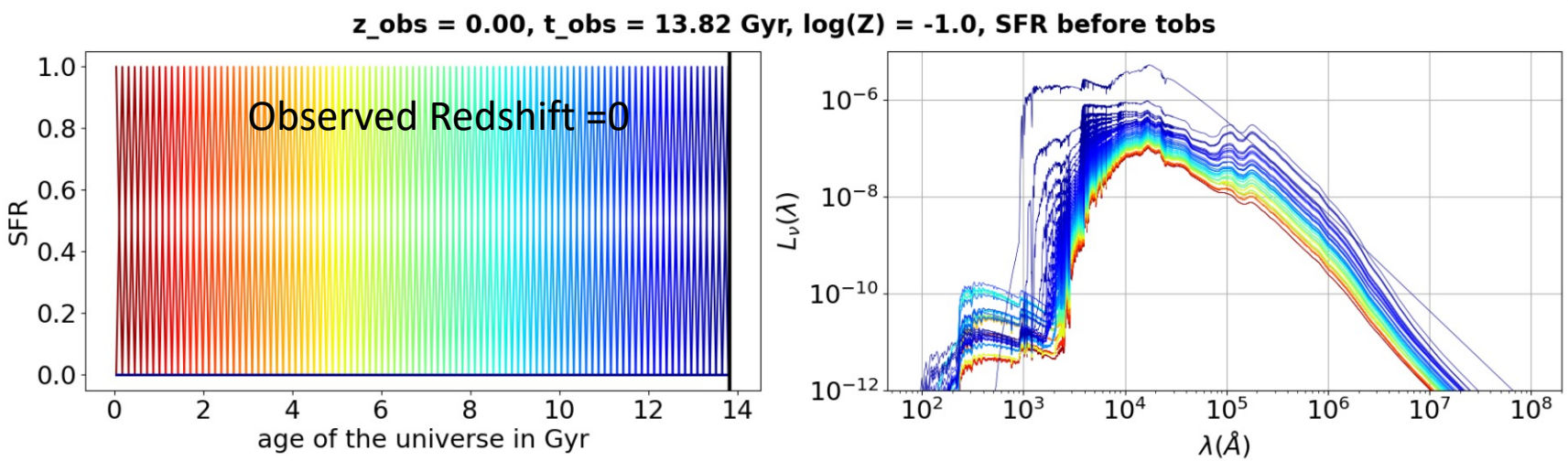
(Wikipedia)

Astrophysical model of galaxy stars evolutions

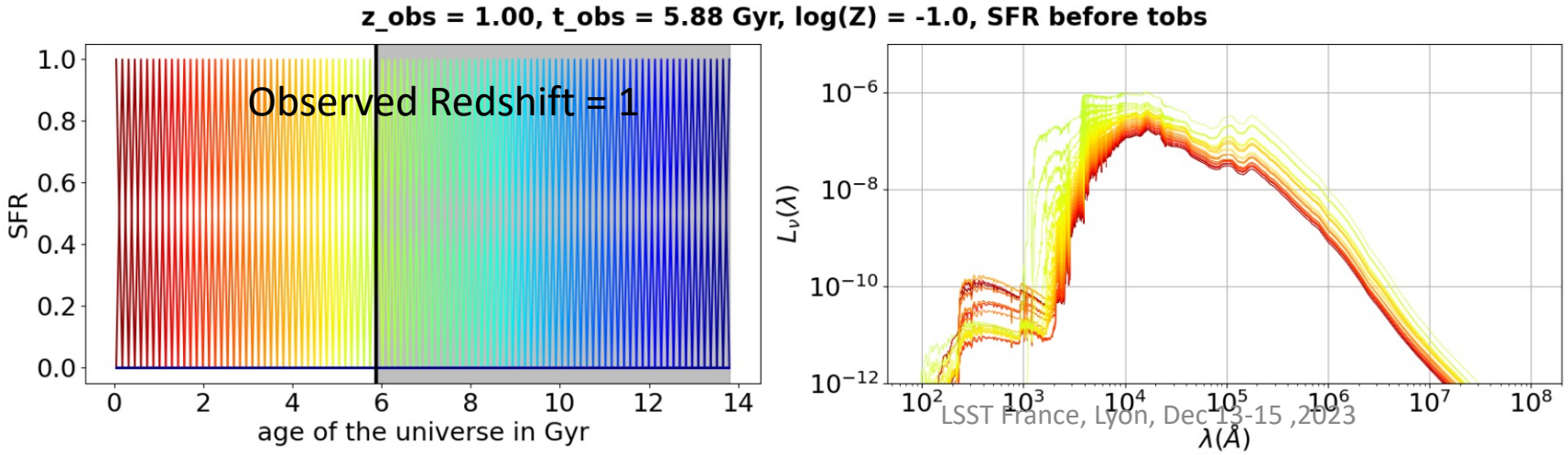
Predicted galaxy spectrum from isochrones

- Versus age of the universe when the star population birth (color)
- The observation time (give by the redshift)

From dsps



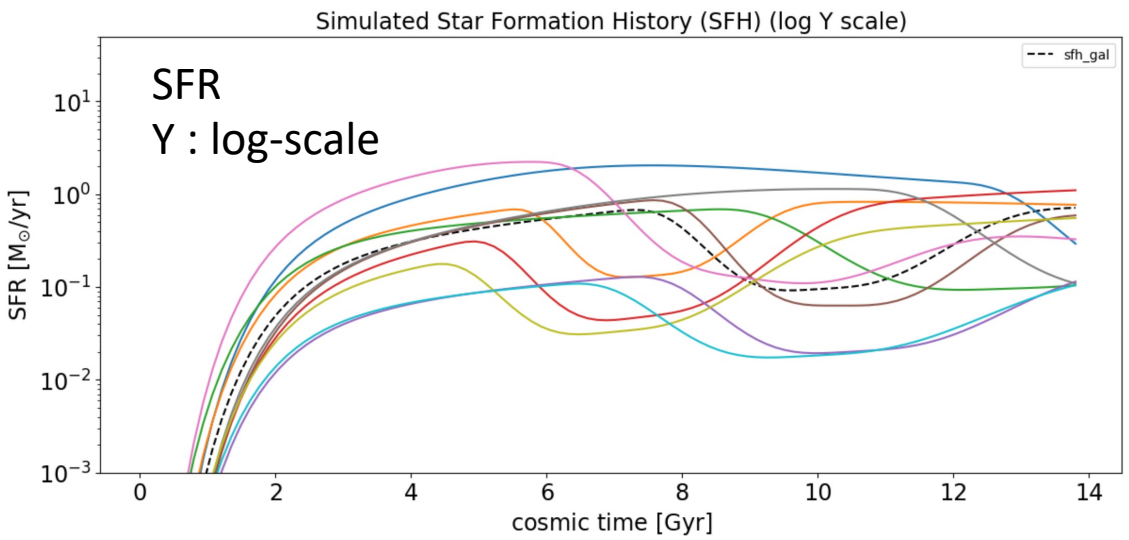
The younger the population the brighter and the bluer the SED is

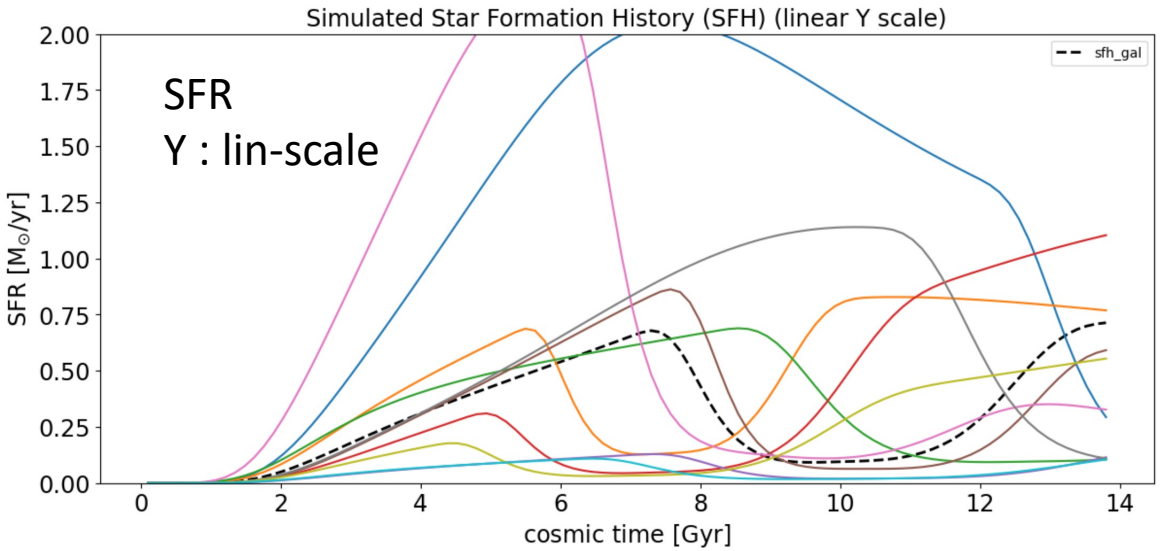


Conversely the older, the dimmer and the redder

The key for SPS modelisation is Star formation history

- Simulate 10 SFH around an average one
- 13 physically motivated shape parameters (from hydrodynamic cosmological simulations)
  - Dark matter halo formation : 4 MAH parameters ($M_0, \tau_c, \alpha_{early}, \alpha_{late}$)
  - Baryon conversion efficiency : 5 MS parameters (*lgmcrit, lgy_at_mcrit, indx_lo, indx_hi, tau_de*)
  - Quenching parameters : 4 Q parameters (*lg_qt, qlglgdt, lg_drop, lg_rejuv*)





Example of SFR which can be generated by DSPS

Attenuation curves in DSPS with 3 parameters

$$F_{\rm att}(\lambda) = 10^{-0.4A_\lambda}$$

$$A_\lambda = \frac{A_V}{4.05} \cdot k_\lambda$$

$$k_\lambda = k_0(\lambda) \cdot \left(\frac{\lambda}{\lambda_V}\right)^{\delta} + D_\lambda$$

$\lambda_V = 5500$Å;

Plaw slope: $\delta : 0, -0.25, -0.5$

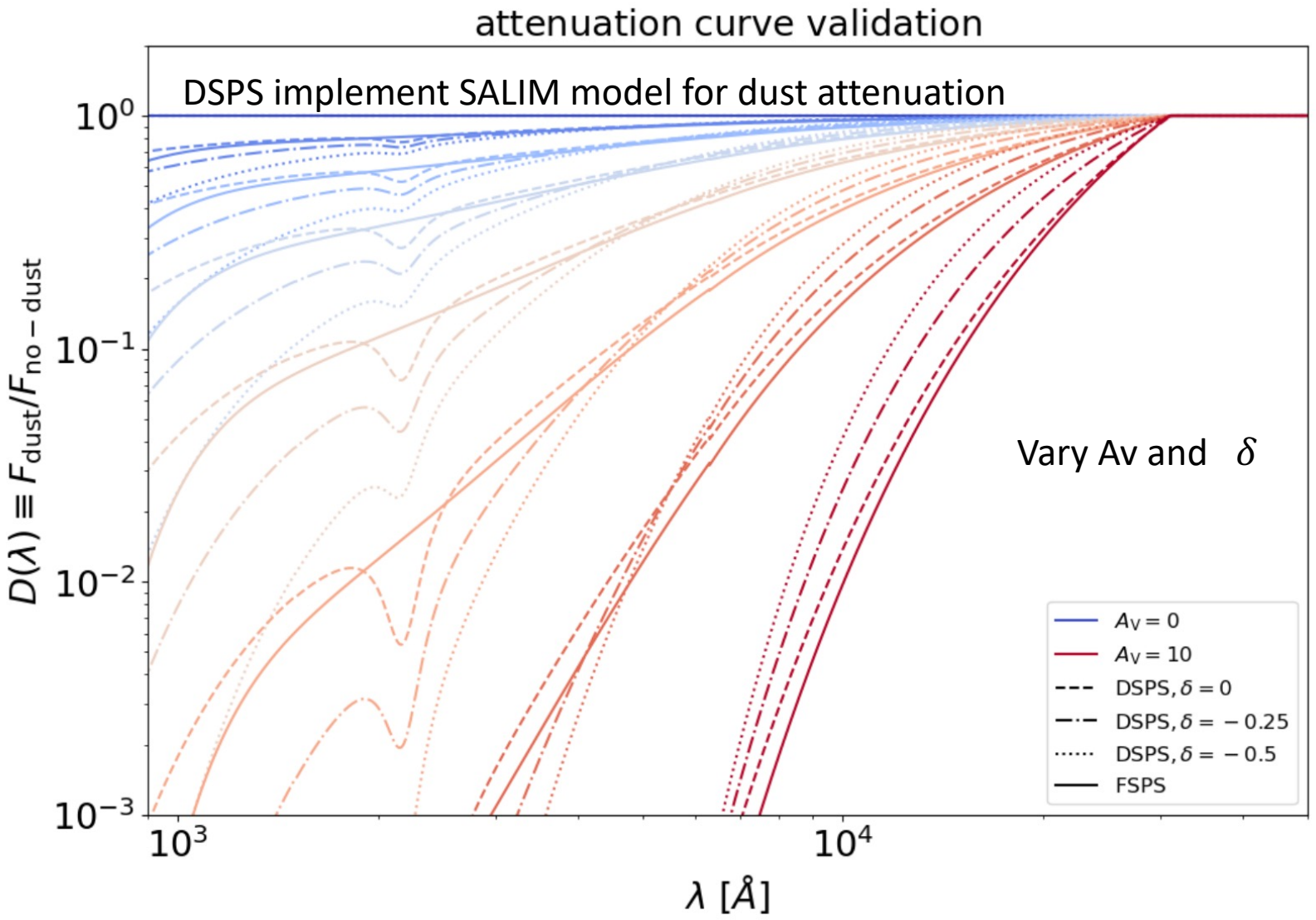
Analytical expressions for $k(\lambda)$

$\lambda > 1500\ Angstrom \rightarrow Calzetti\ law$
$\lambda < 1500\ Angstrom \rightarrow Leitherer\ law$

UV bump at $\lambda = 2175$ A

$$D_\lambda \equiv \frac{E_b(\lambda\Delta\lambda)^2}{\left(\lambda^2 - \lambda_b^2\right)^2 + (\lambda\Delta\lambda)^2},$$

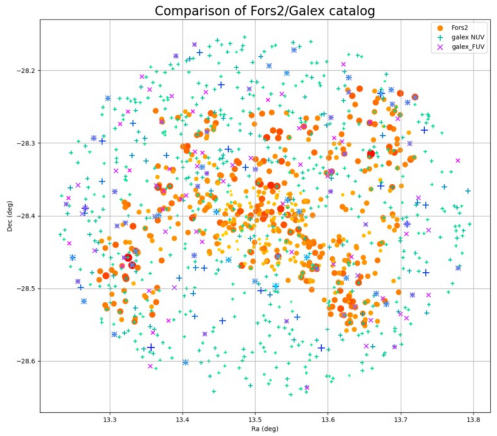
Need to fit Av, δ *and UV bump*



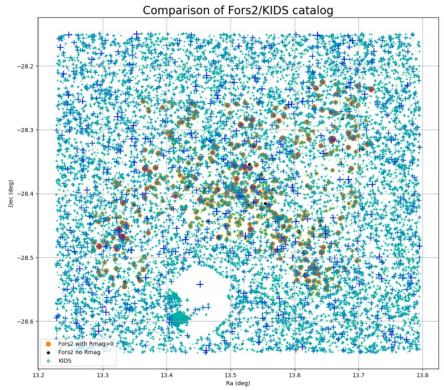
Redo Spectral stellar population synthesis from Fors2

- Use more recent stellar population synthesis codes (sps)
- Combine spectroscopy with photometry

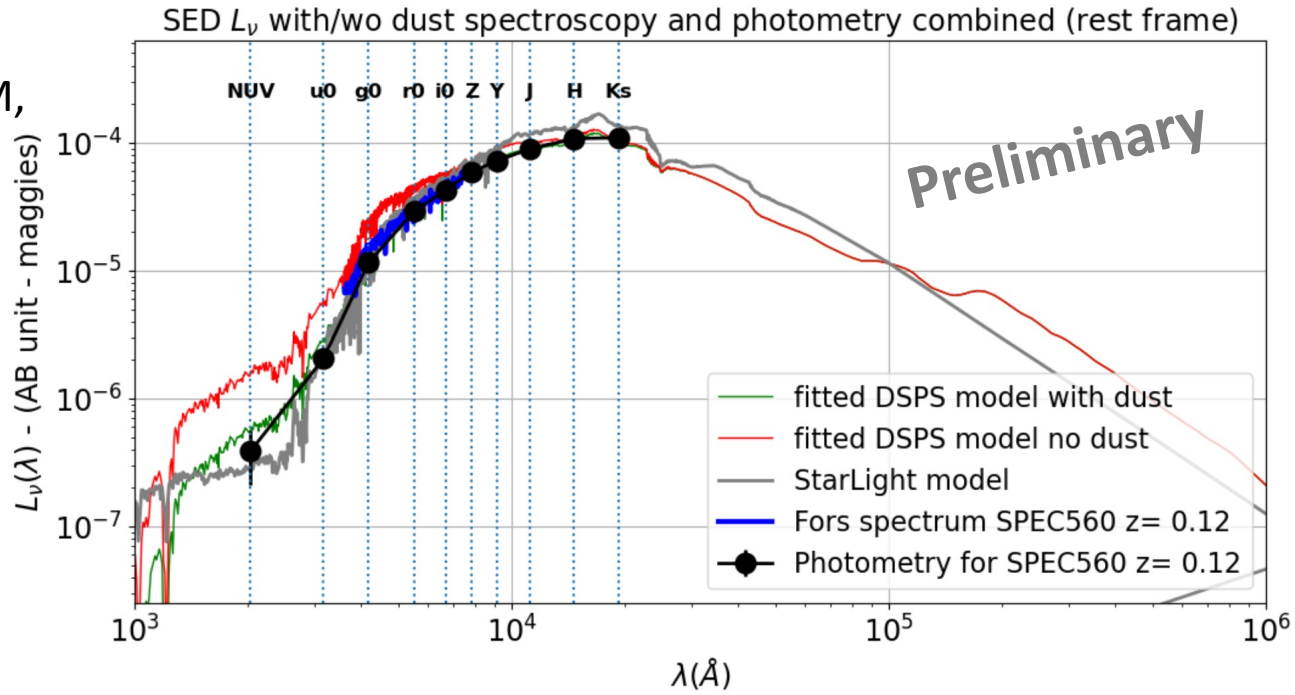
GALEX AIS Survey FUV, NUV



KIDS : OMEGACAM, VIRCAM, u,g,r,i,z,y,J,H,Ks

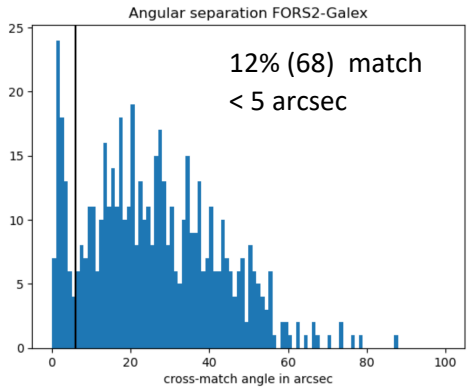


Example of FORS2 / Photometry SED fitting

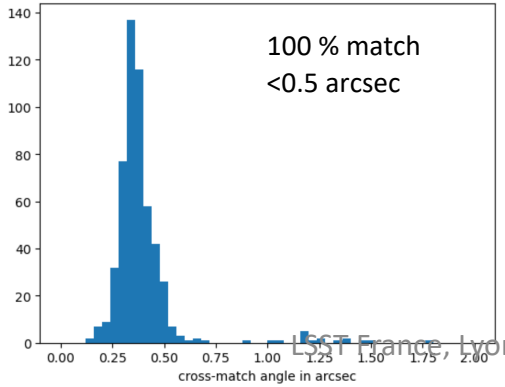


Angular correlation Fors2 / Photometric catalogs

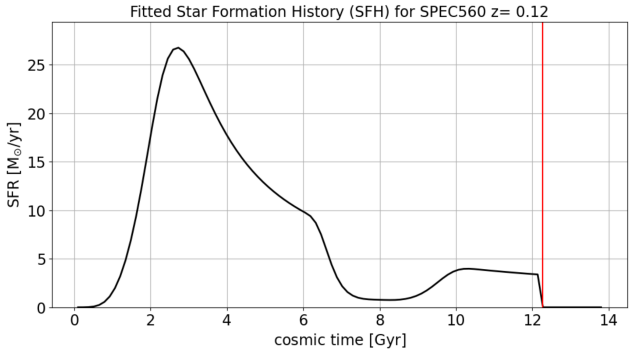
Fors2- GALEX



Fors2- KIDS

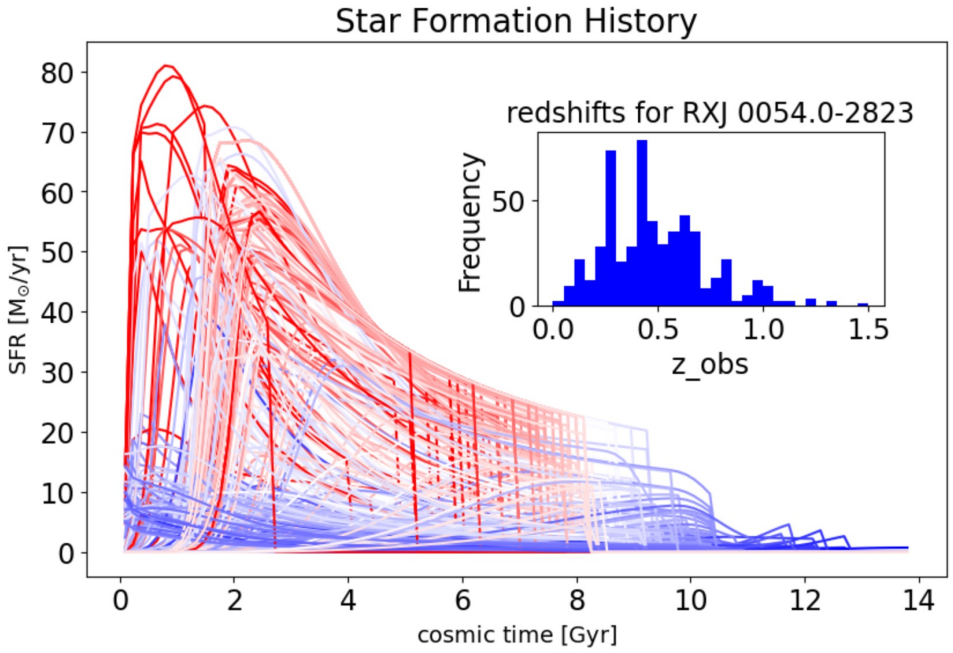


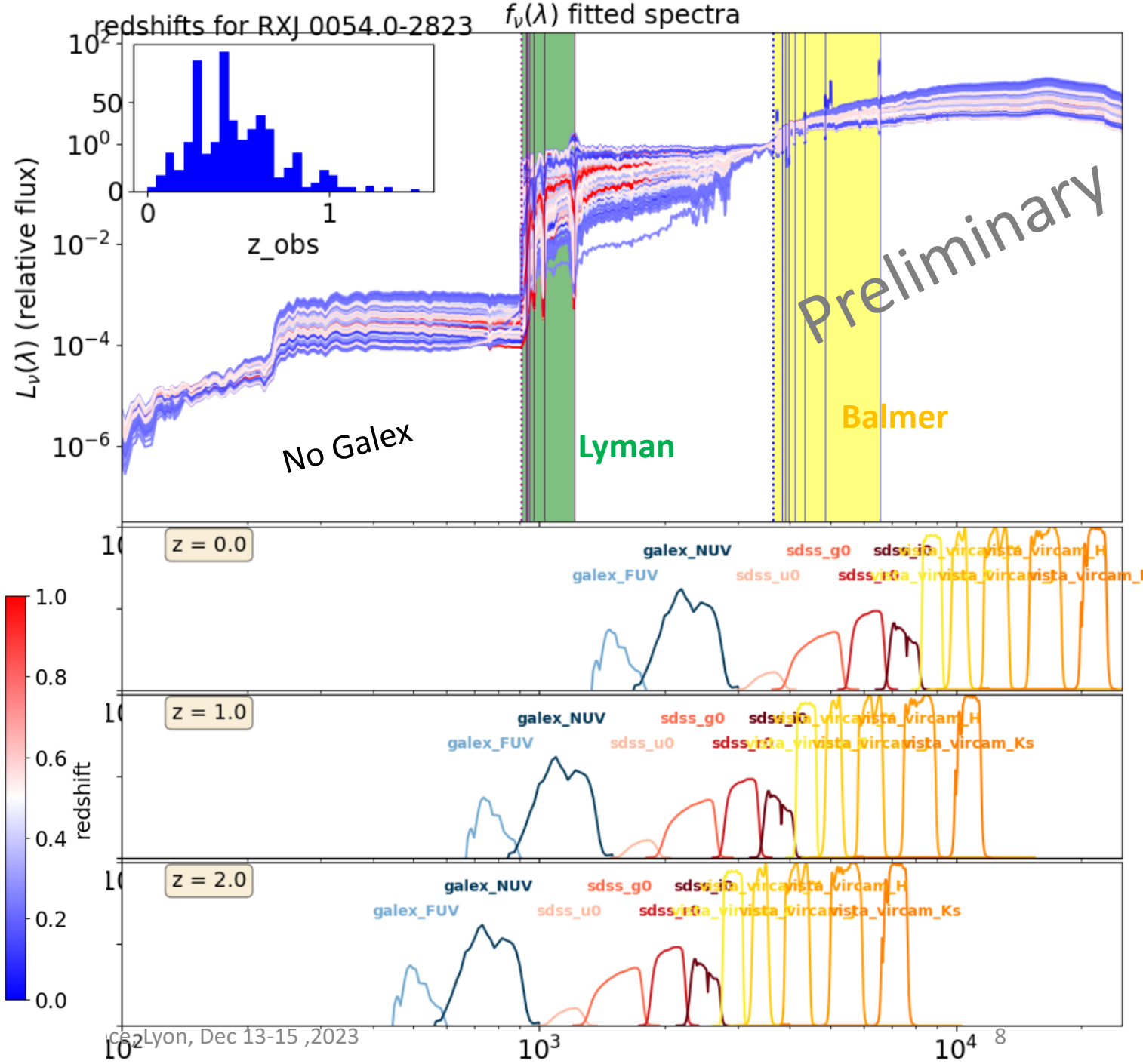
Fitted Star formation history



Preliminary results on DSPS SED fits

- full wavelength range spectra with dust removed
- Star Formation History

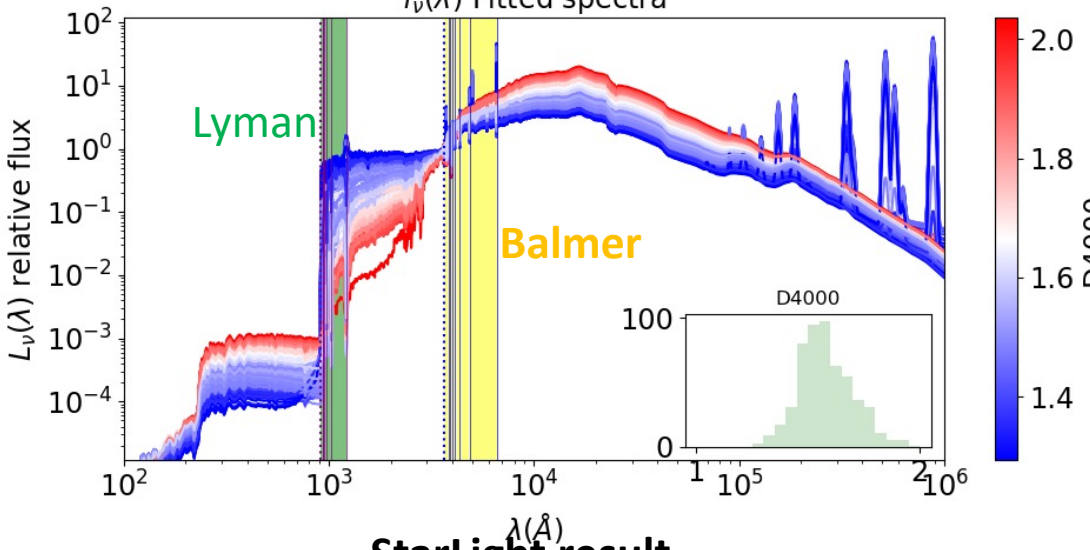




Comparison of dust free SEDs generate with DSPS fits wrt to Starlight fits

Preliminary

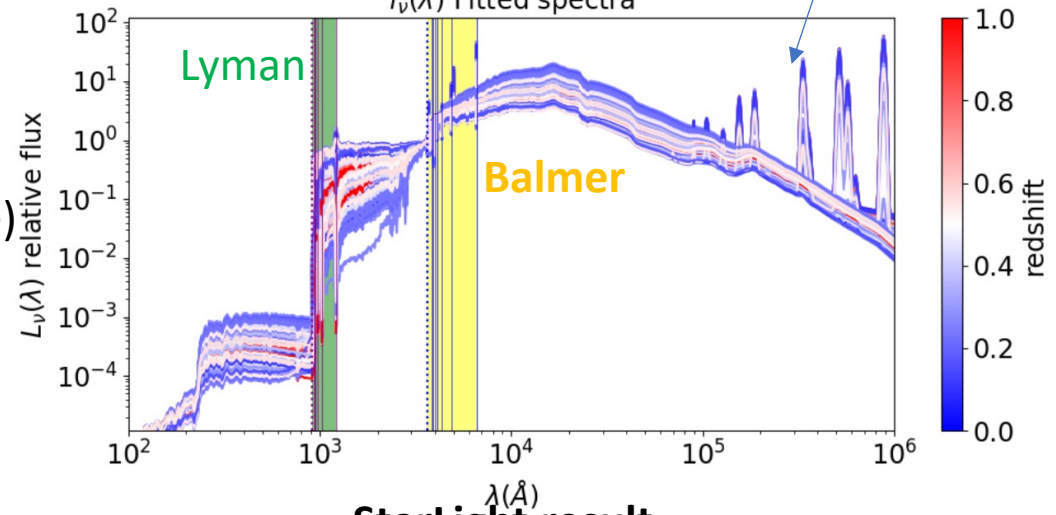
Our result with DSPS



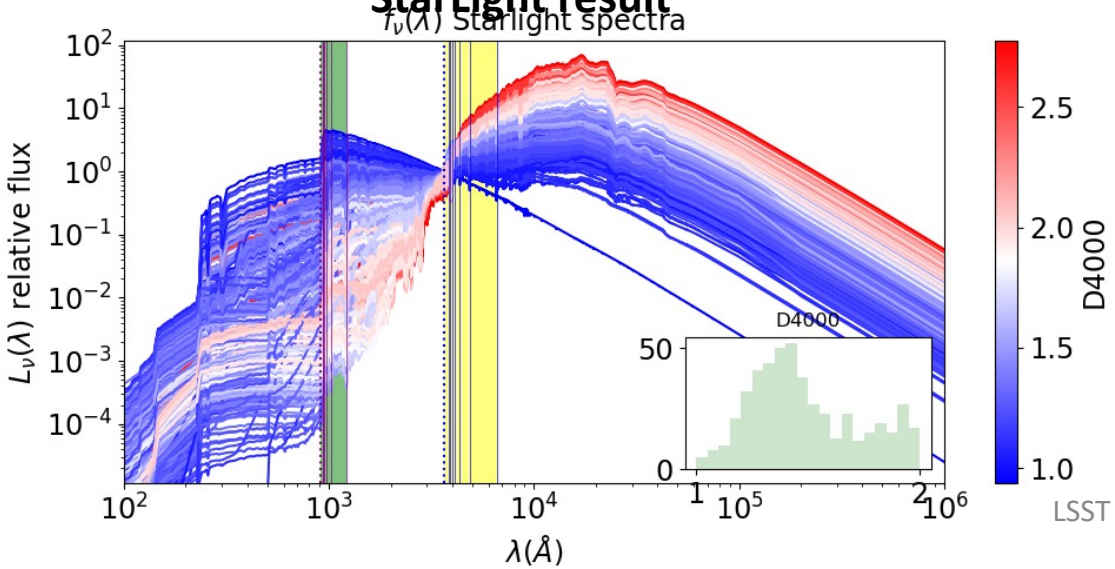
Color indexed by « color» -D4000 parameter (ratio flux red/blue)

Dust grains, PAC and silicates

Our result with DSPS

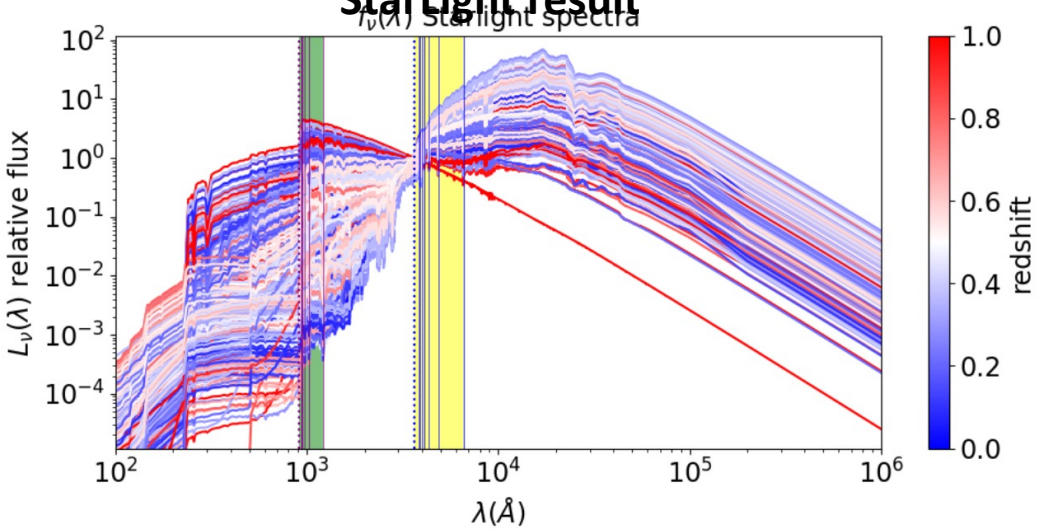


StarLight result



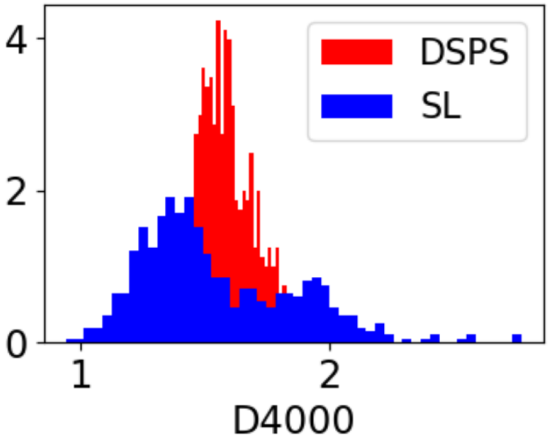
Color indexed by redshift

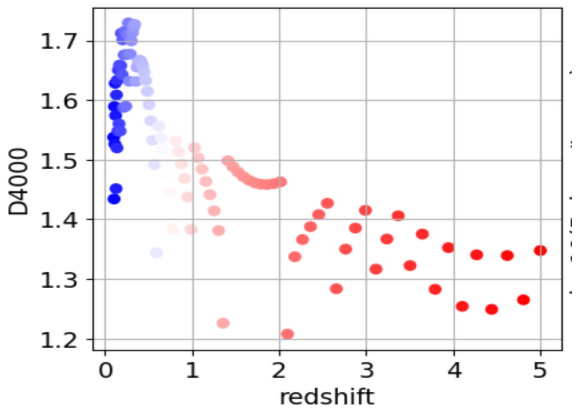
StarLight result



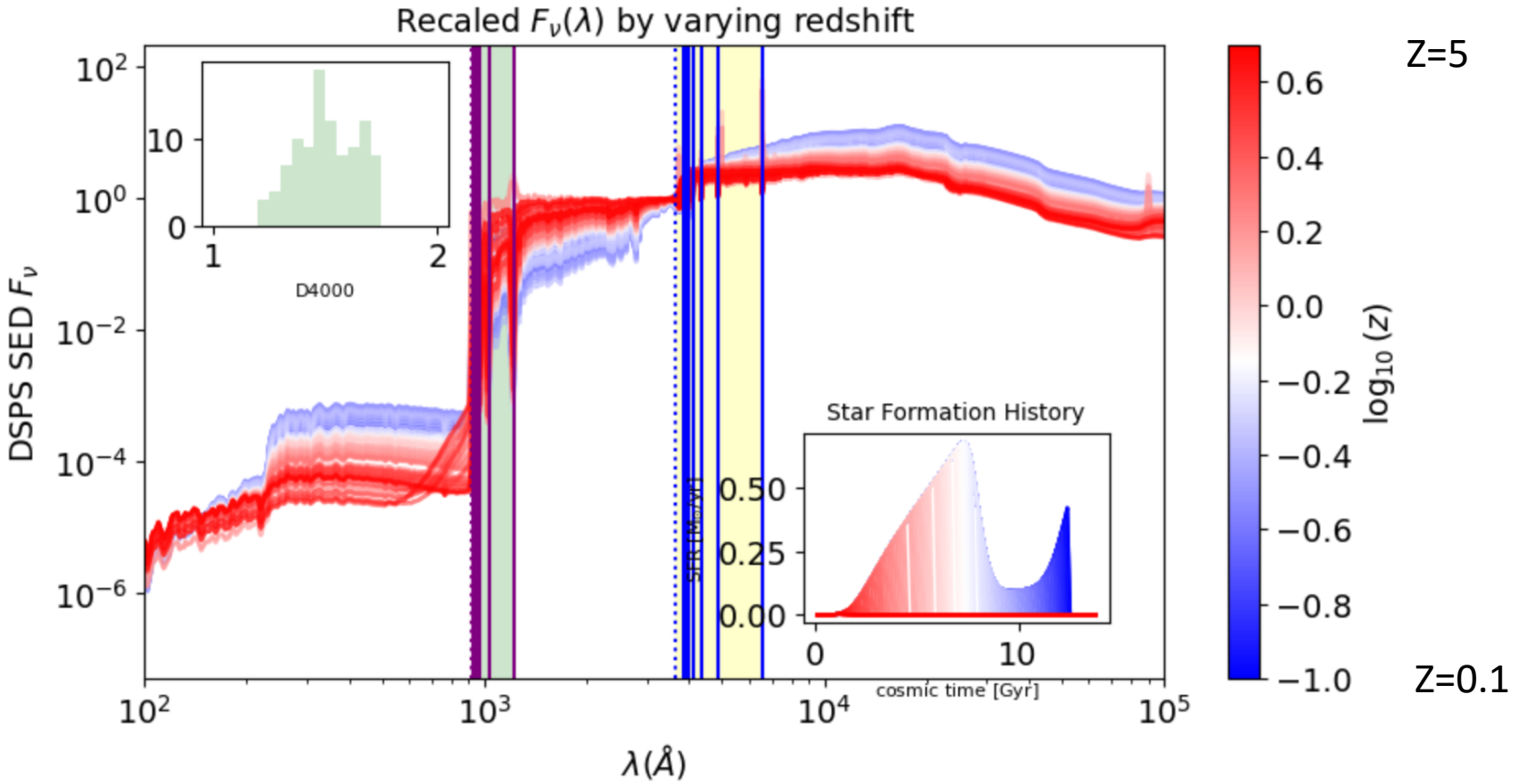
Which parameter in SFR impacts color

- D4000 : ratio flux red/flux blue
- `wl_blue = [3750.,3950.]`
- `wl_red = [4050.,4250]`



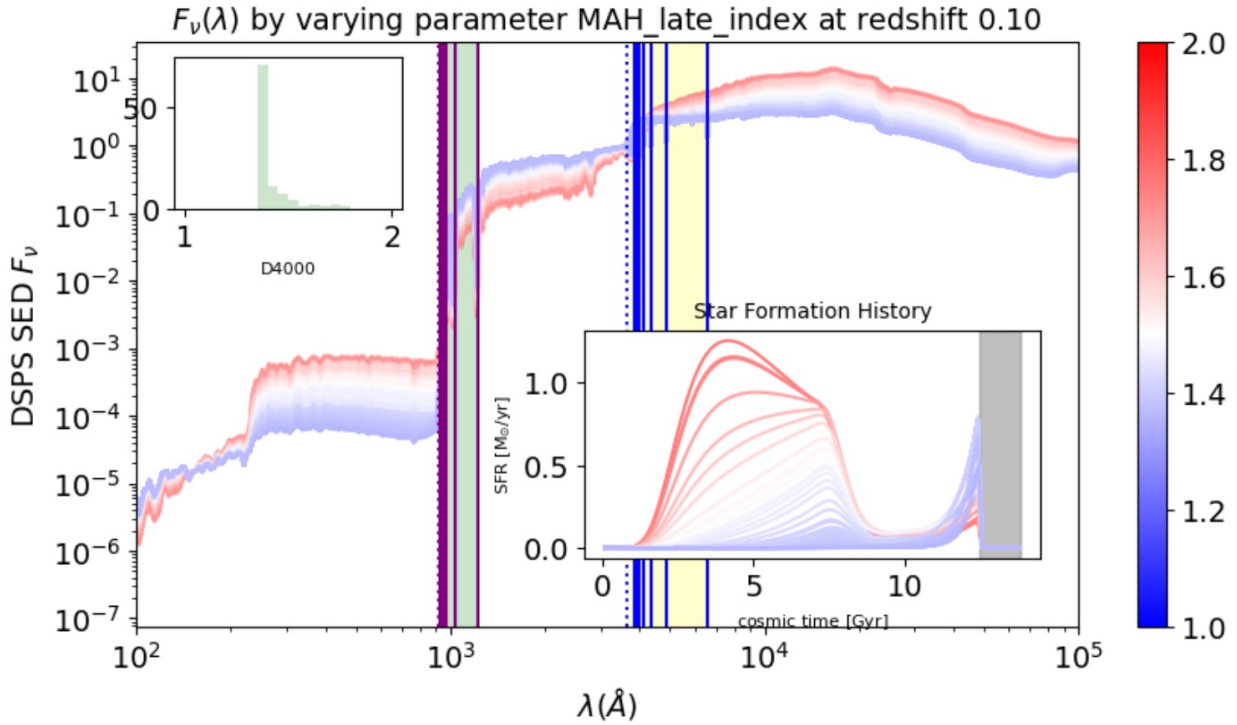


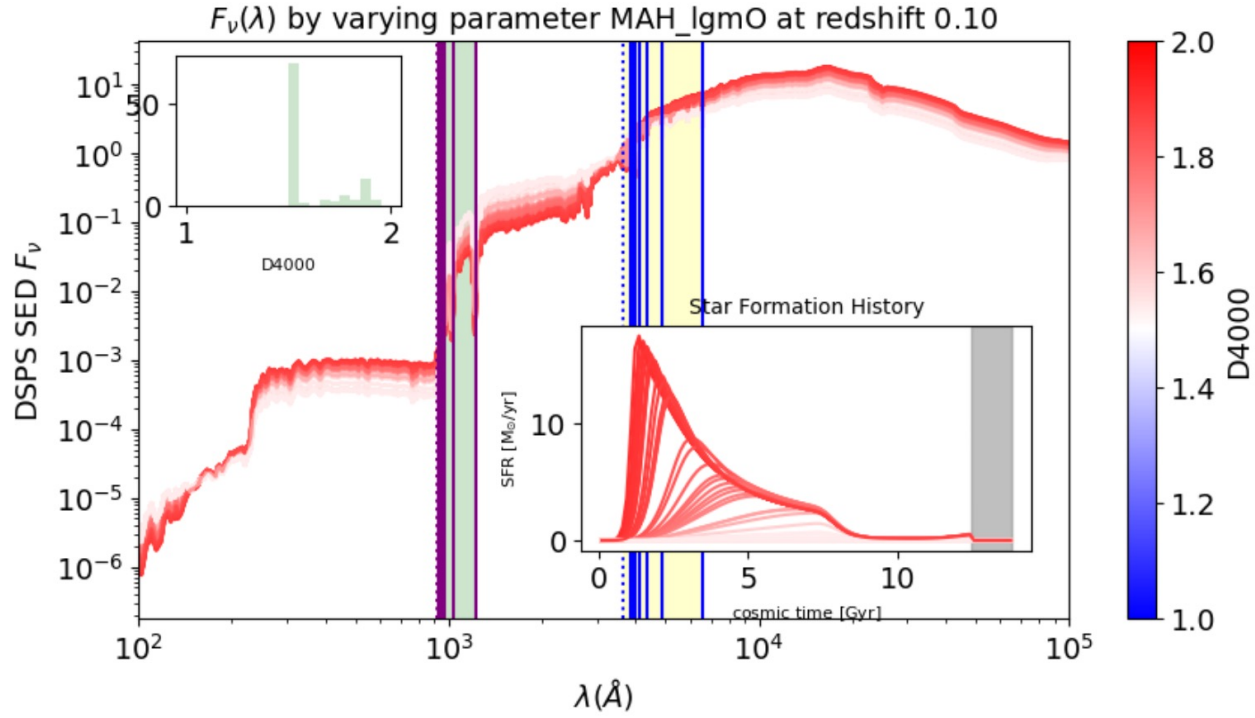
Pure simulation (not fitted on data) : select a set of SFR parameters and look at SED shape by varying the redshift



Examples of DSPS parameter showing a strong impact on SED color

Category of Dark Halo : Dark Halo mass and its growth

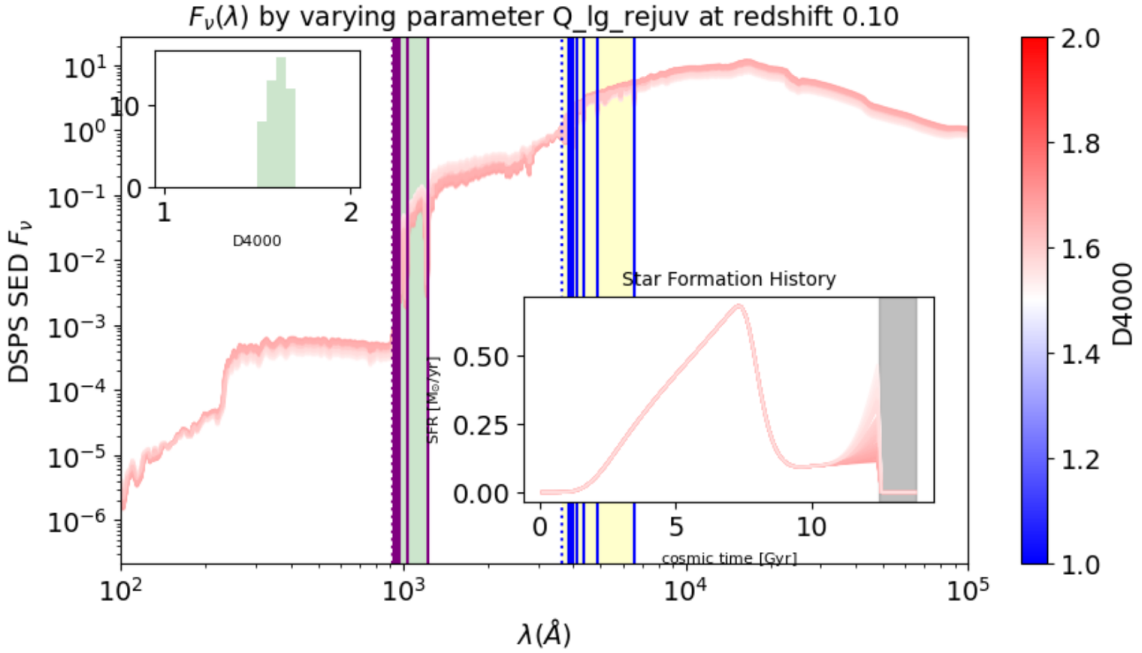


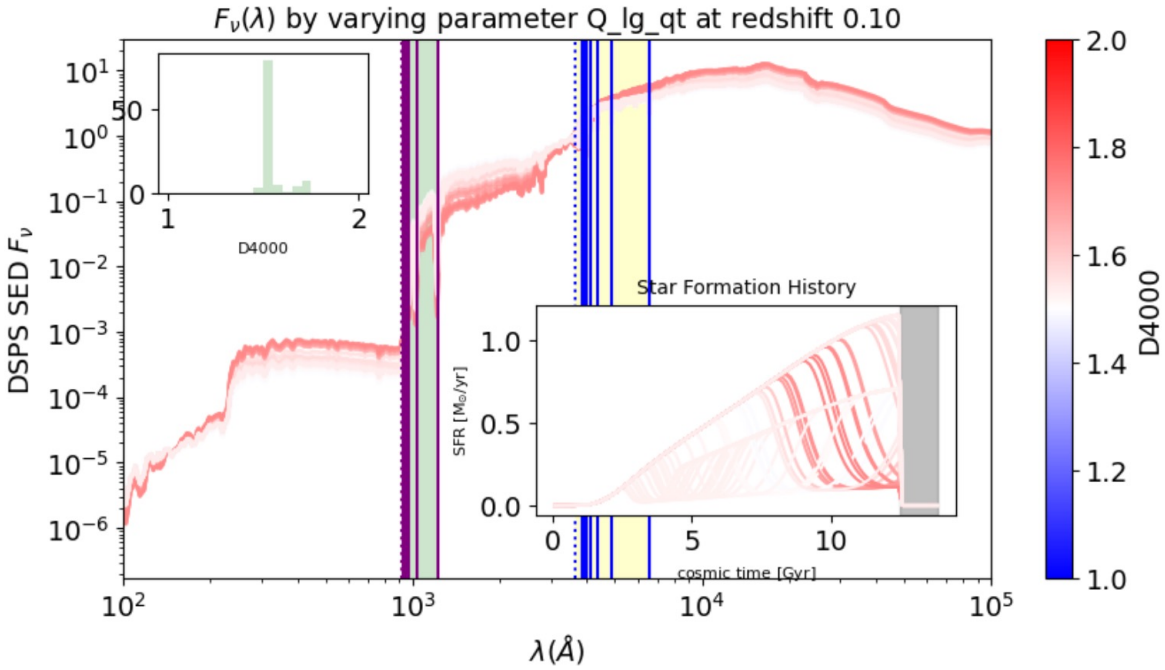


Vary a single parameter over the 10 per simulation series

Examples of DSPS parameter showing a strong impact on SED color

Category : Quenching and rejuvenation parameters





Vary a single parameter over the 10 per simulation series

Main Take away

- We have a tool to generate SED templates by fitting spectroscopic and photometric data based o DSPS-FSPS
- We extracted SED templates from Fors2-KIDS-VISTA survey
- Comparison done with StarLight previous SED templates look reasonable but have different extent in shape.
- Relationship between SED shape and redshift is not obvious → need more information
- Star Formation History plays has an impact on SED shape, which can be investigated further by manipulating DSPS parameter having physical meaning

Perspectives

- Broaden the DSPS parameter range in fits while keeping them in a physical range,
- Select cautiously those spectra having good GALEX photometry,
- Continue analysis on these data : parameters and their correlation,
- Fitting identified emission lines (Equivalent width in DSPS),
- Investigate impact of metallicity (+ ionisation parameters),
- Difference between cluster galaxy/ field galaxy, (would run cluster finding algorithm)
- Associate DSPS features to imaging features like the morphology,
- Search for other recent and deeper, broader in wavelength datasets (DESI + some photometry),
- SED template selection and validation on PZ estimation performance (part of Joseph C. thesis)
- Joseph C's dream on PZ inference : replace series of discrete SED templates, by a Bayesian model combining a continuous parameters DSPS model with appropriate priors.