rijksuniversiteit groningen

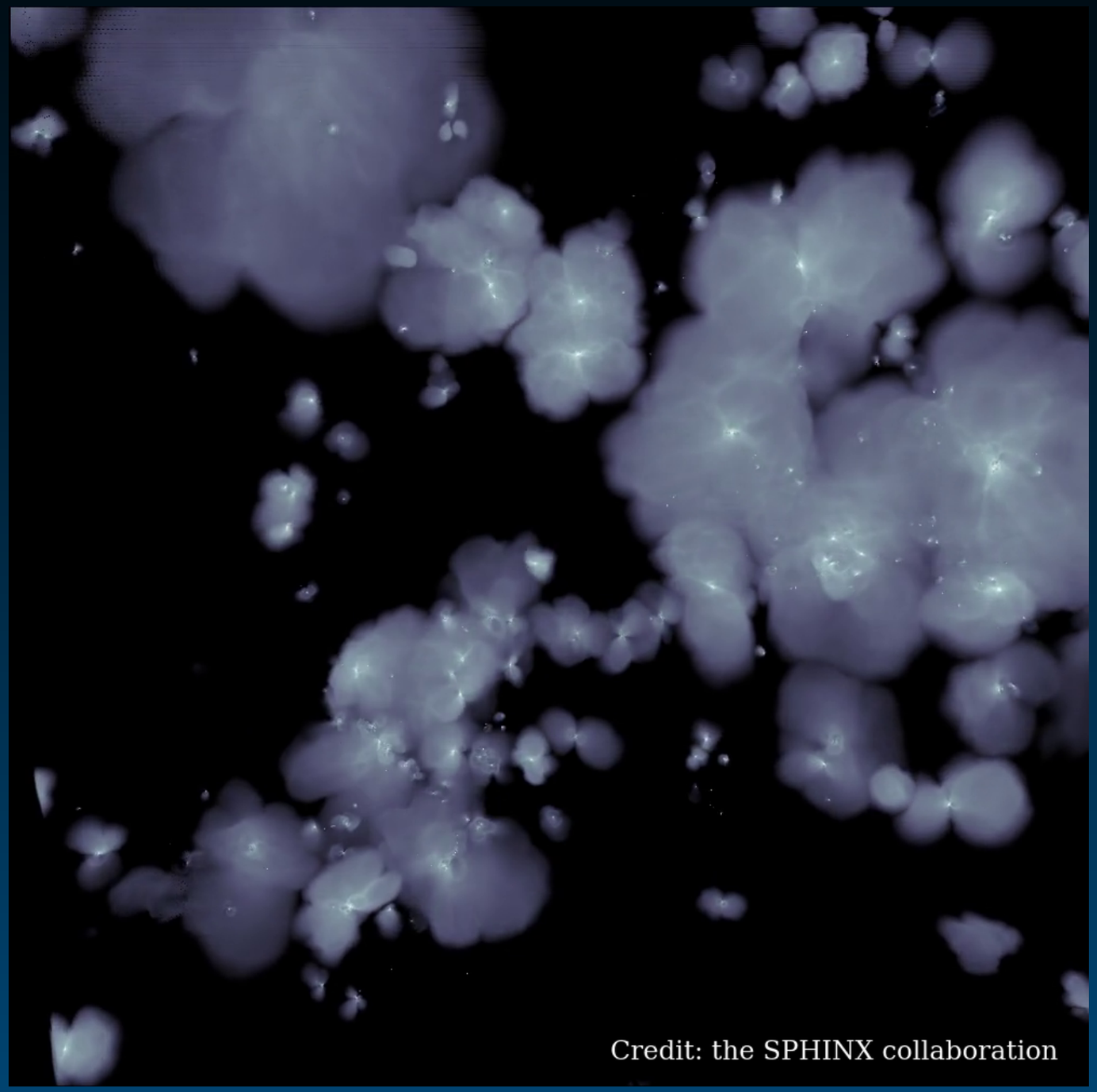
ODIN

Escape of Lyman radiation from galactic labyrinths
9th April 2025

Probing the escape of ionising photons: ISM absorption lines and dust attenuation in SPHINX20

Valentin Mauerhofer

The epoch of reionisation

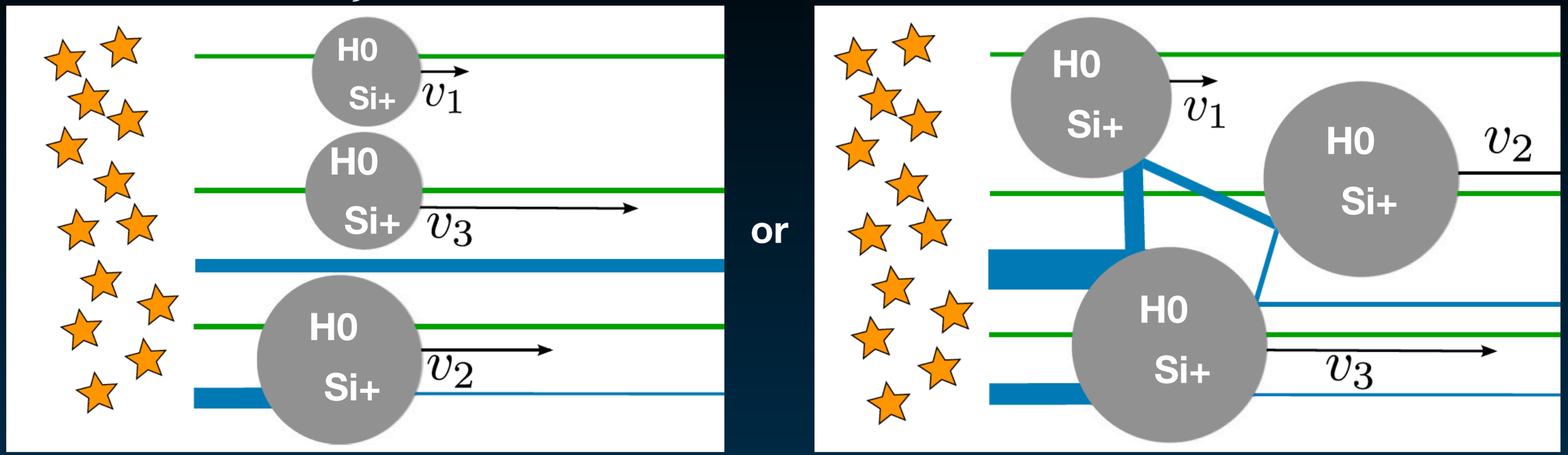


$$\text{Ionising emissivity} = \rho_{\text{UV}} \times \xi_{\text{ion}} \times f_{\text{esc}}$$

Escape fraction of ionising photons: Crucial to identify the sources of Reionisation

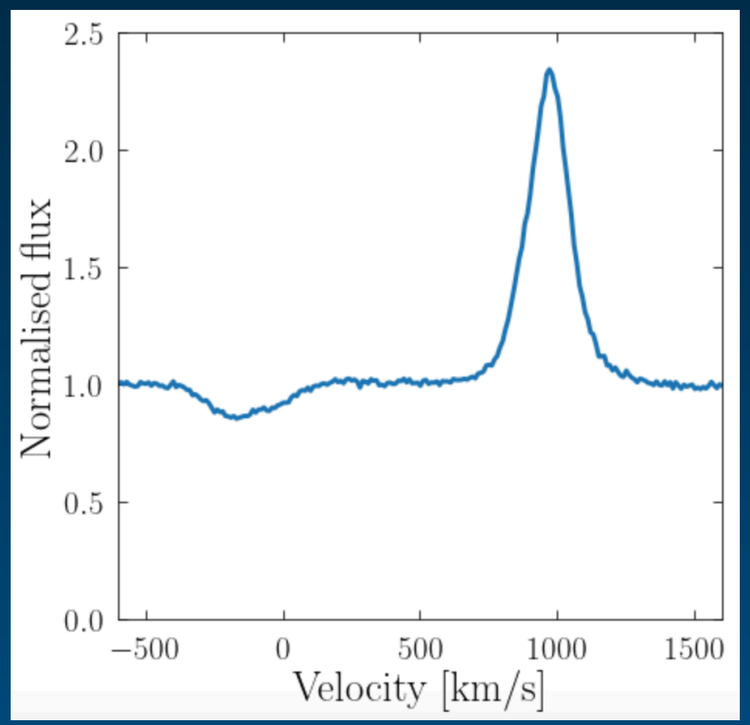
Lyman continuum escape and metallic UV absorption lines

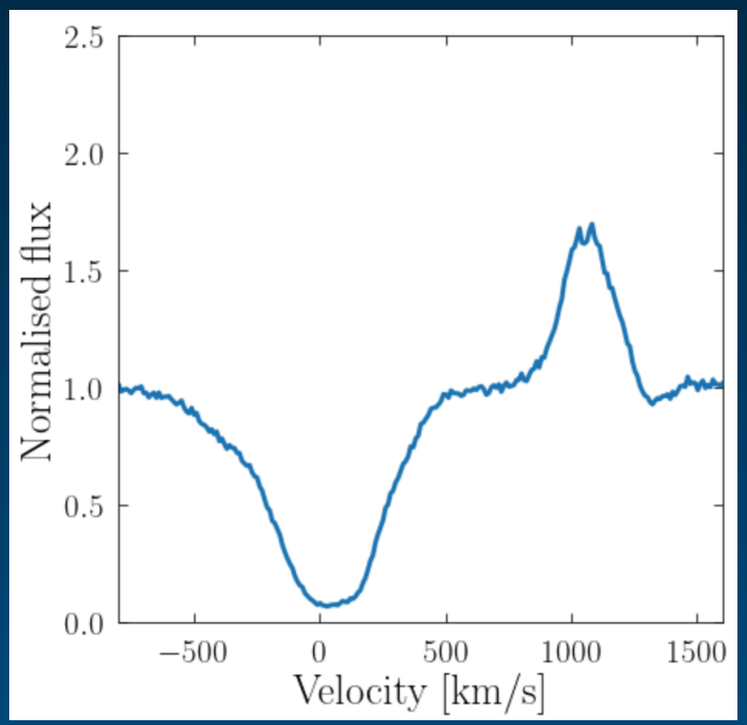
Rivera-Thorsen+15



SiII 1526

weak line
~
rather high fesc





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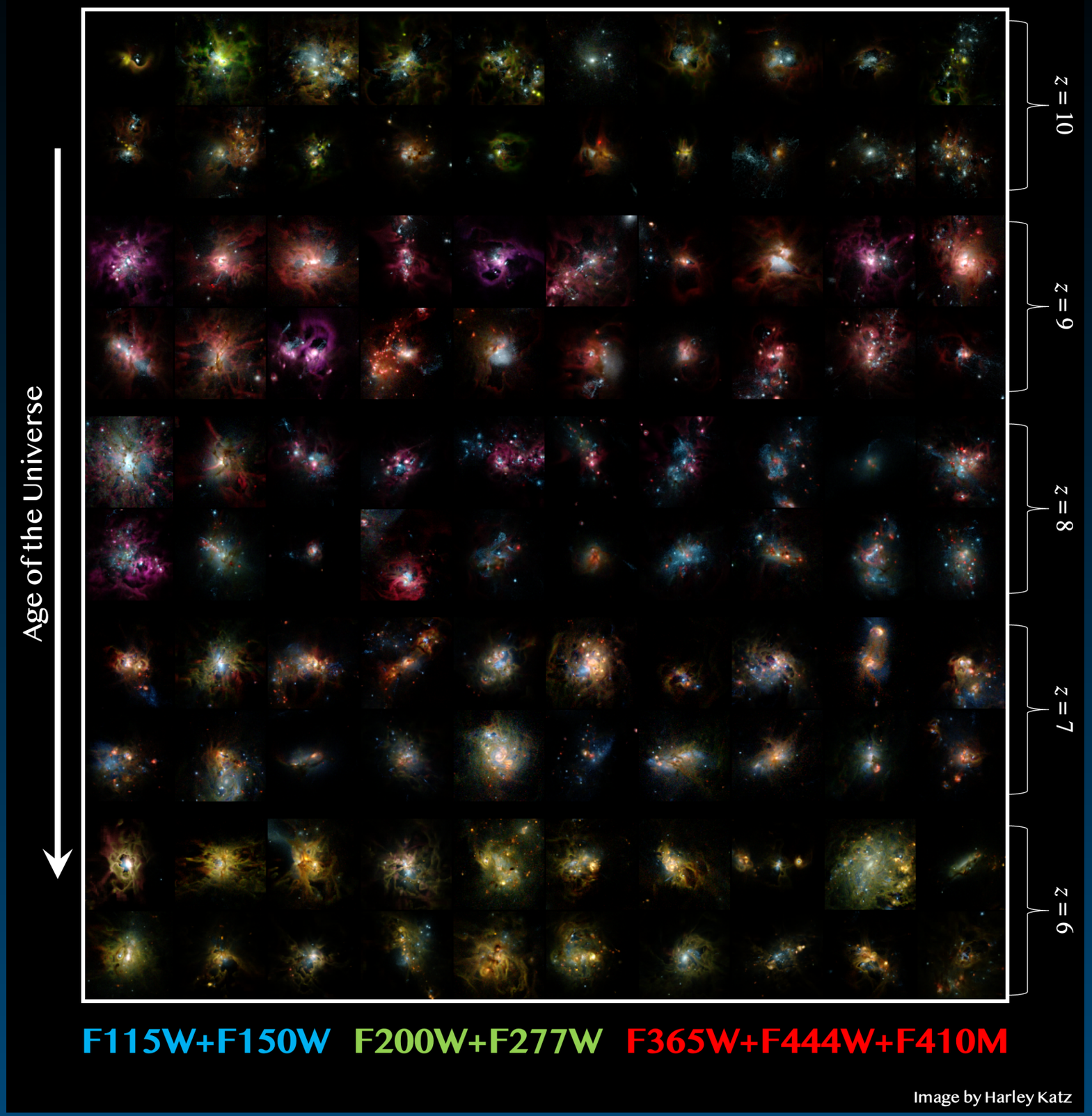
The Galaxies that Reionized the Universe



Public data release of SPHINX20 galaxy properties: emission lines, stellar and nebular continuum, etc.

1380 star-forming galaxies, ranging from z=4.6 to z=10, mock observations in 10 viewing angles.

$\mathrm{SFR} \geq 0.3 \mathrm{M}_{\odot}\,\mathrm{yr}^{-1}$

Katz et al. 2023

From simulation to mock observations

- Using the Monte-Carlo code **RASCAS** Michel-Dansac+20

From simulation to mock observations

- Using the Monte-Carlo code **RASCAS** Michel-Dansac+20

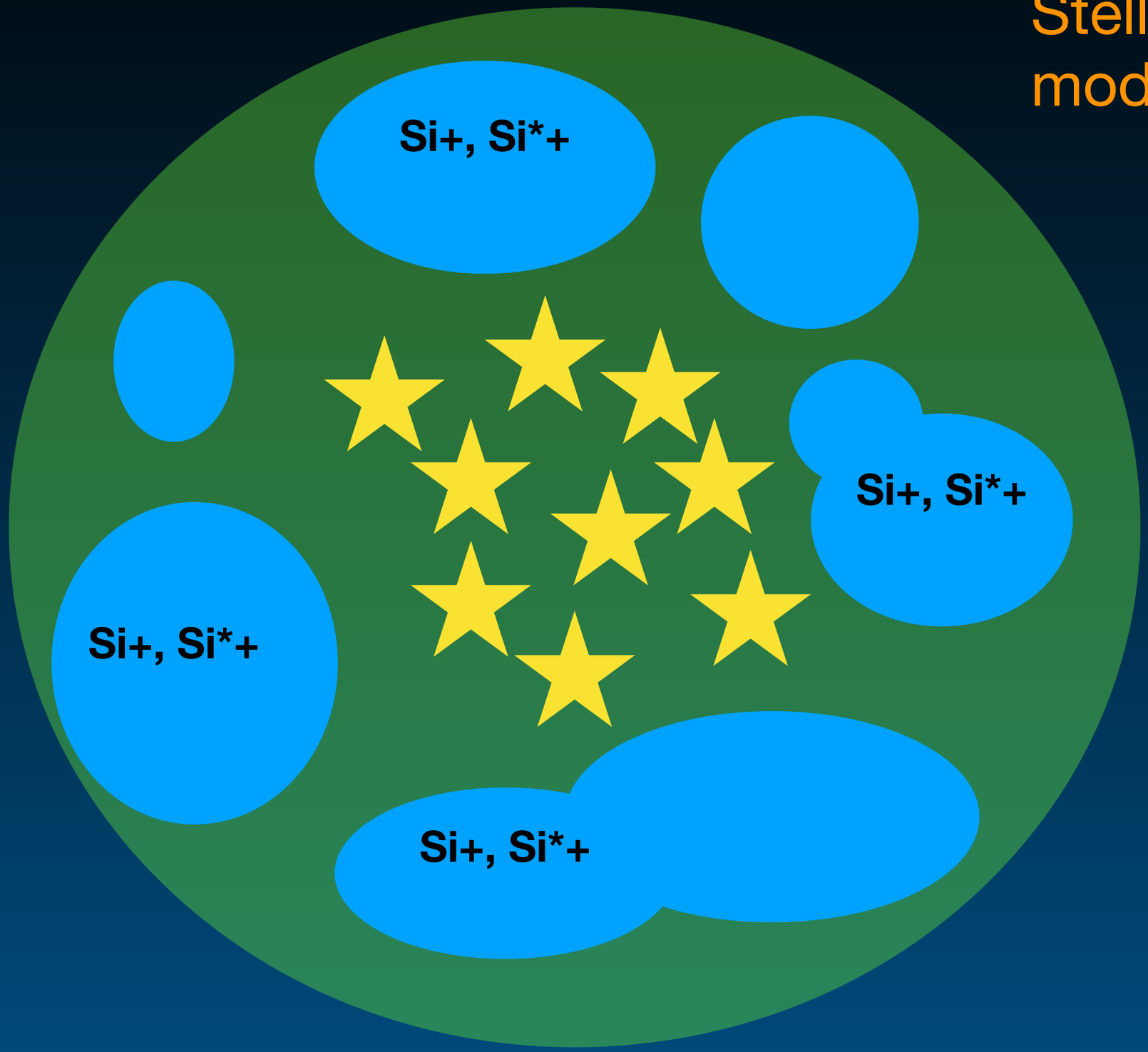
Stellar continuum
modelled with BPASS

From simulation to mock observations

- Using the Monte-Carlo code **RASCAS** Michel-Dansac+20

Stellar continuum modelled with BPASS

Computation of ion densities



From simulation to mock observations

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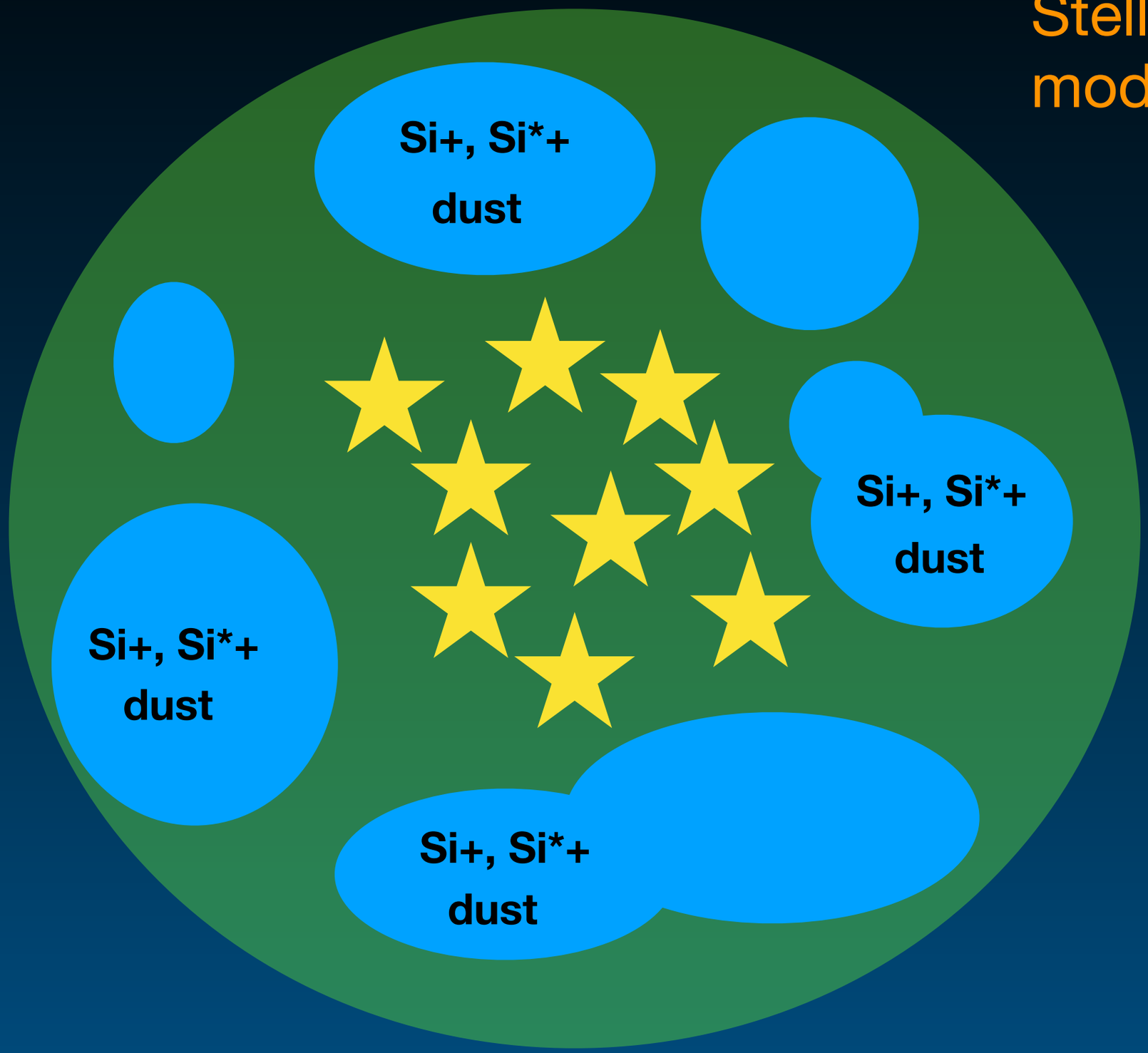


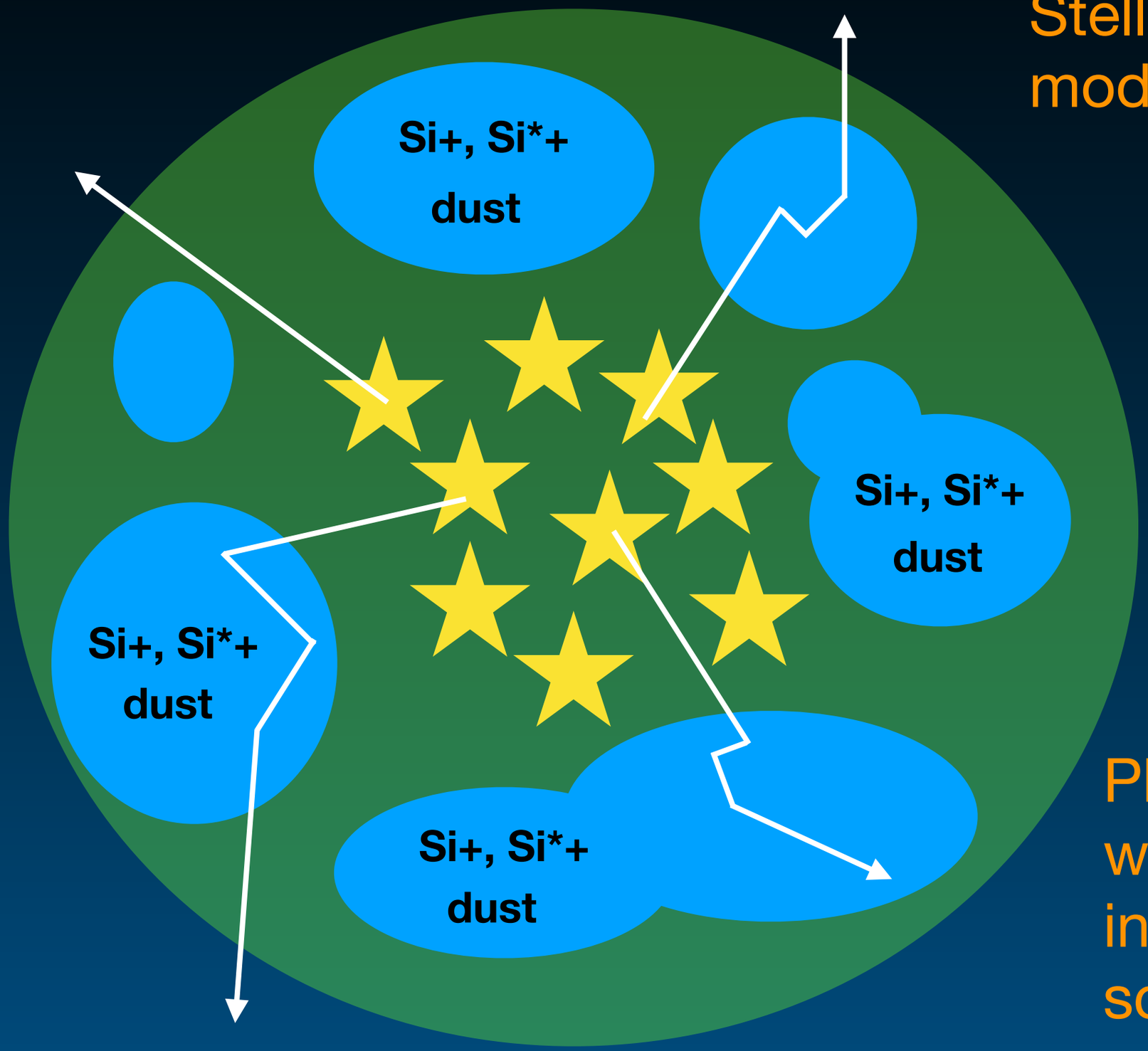
Stellar continuum modelled with BPASS

Computation of ion densities

Dust modelling

From simulation to mock observations

- Using the Monte-Carlo code **RASCAS** Michel-Dansac+20



Stellar continuum modelled with BPASS

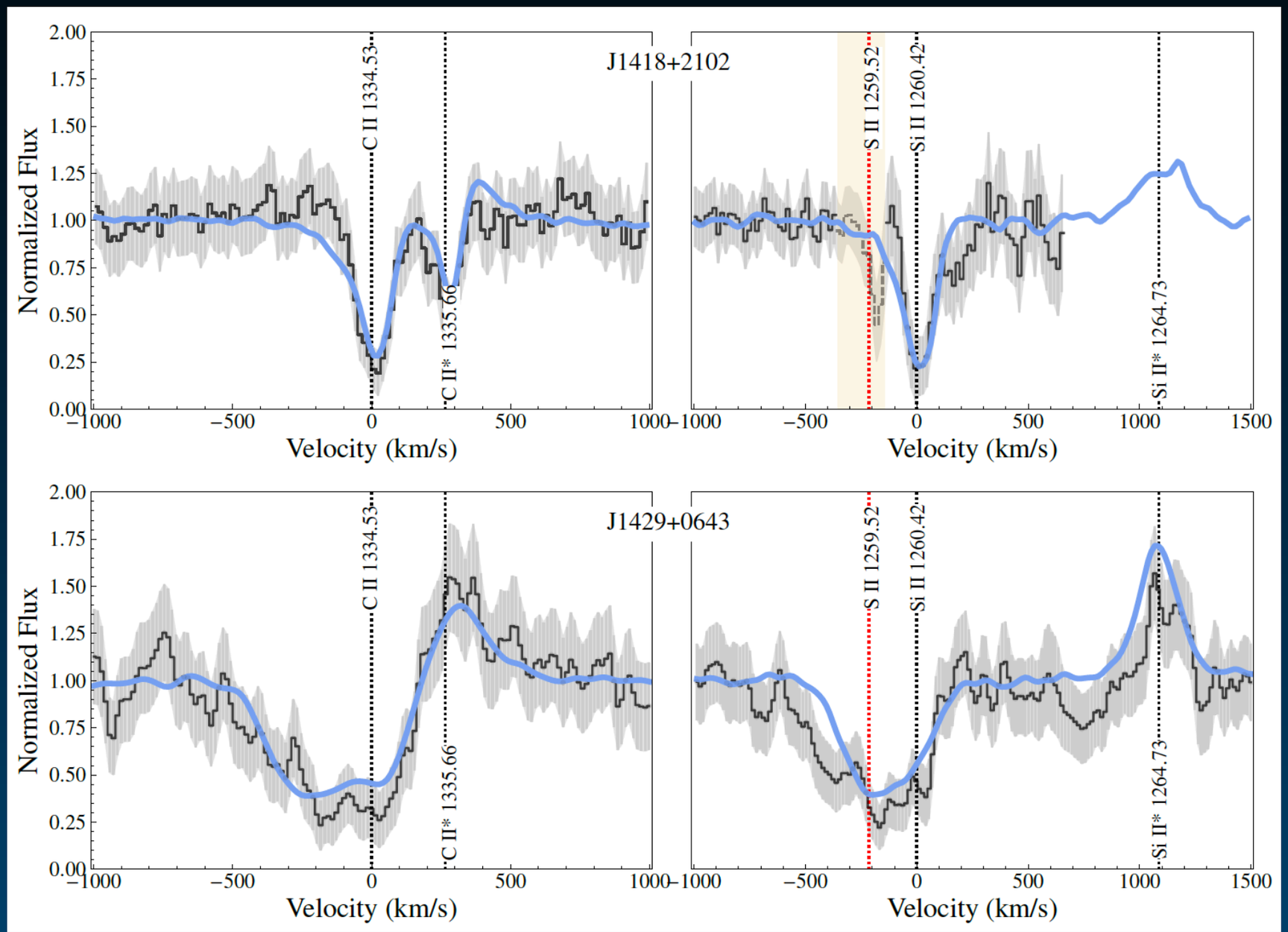
Computation of ion densities

Dust modelling

Photons transferred with **RASCAS,** including resonant scattering

Are the mock absorption lines realistic?

Gazagnes et al. 2023



Comparison with low-z analogs of high-z galaxies: the CLASSY sample (Berg+22). Compact, low metallicity star-forming galaxies

~90% of CLASSY galaxy absorption lines are well reproduced by a single z~3 simulated galaxy with Mstar ~ 10^9

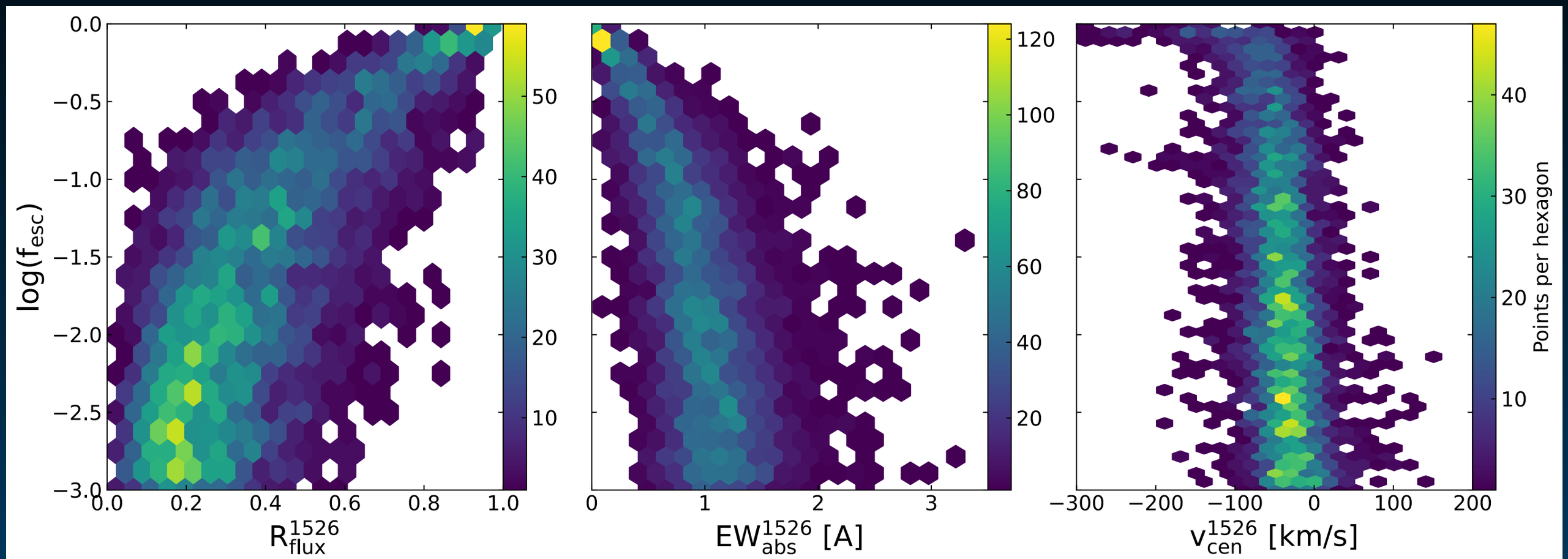
Can we infer escape fractions of ionising photons from absorption lines?

No good correlation between f_esc and simple line properties

residual flux == line depth

equivalent width == line area

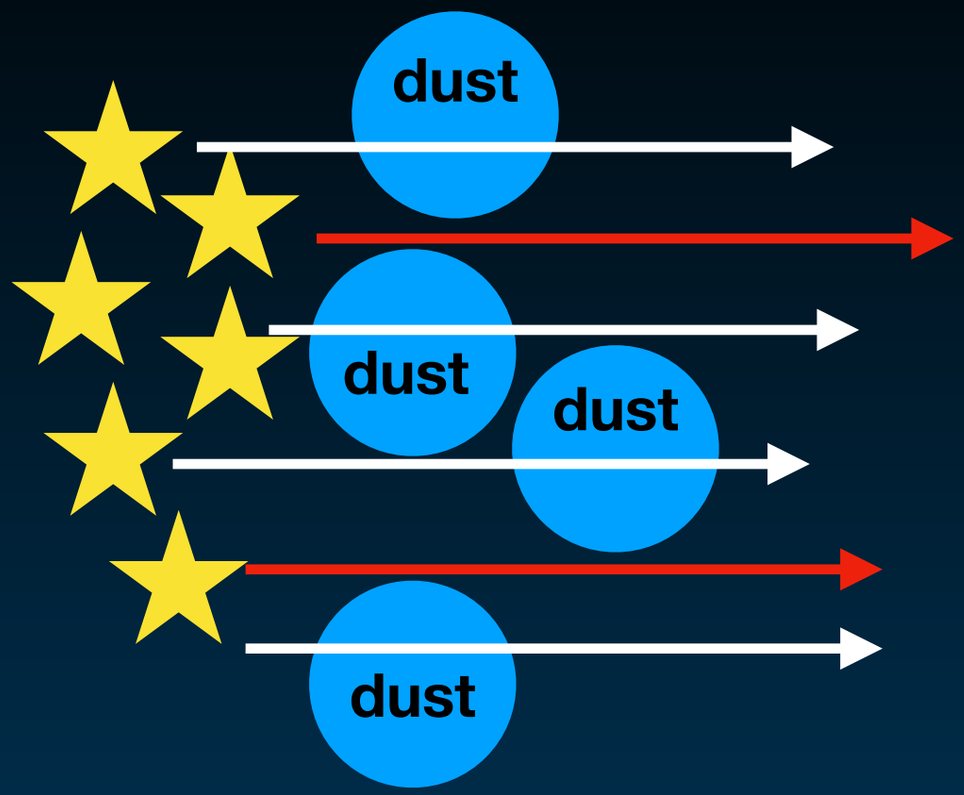
v_cen == line shift



Very weak (or absent) absorption lines indicate high escape, but otherwise no solid prediction of the escape fraction.

Applying a dust correction to the residual flux

Reddy+16
Steidel+18
Gazagnes+18
Chisholm+18



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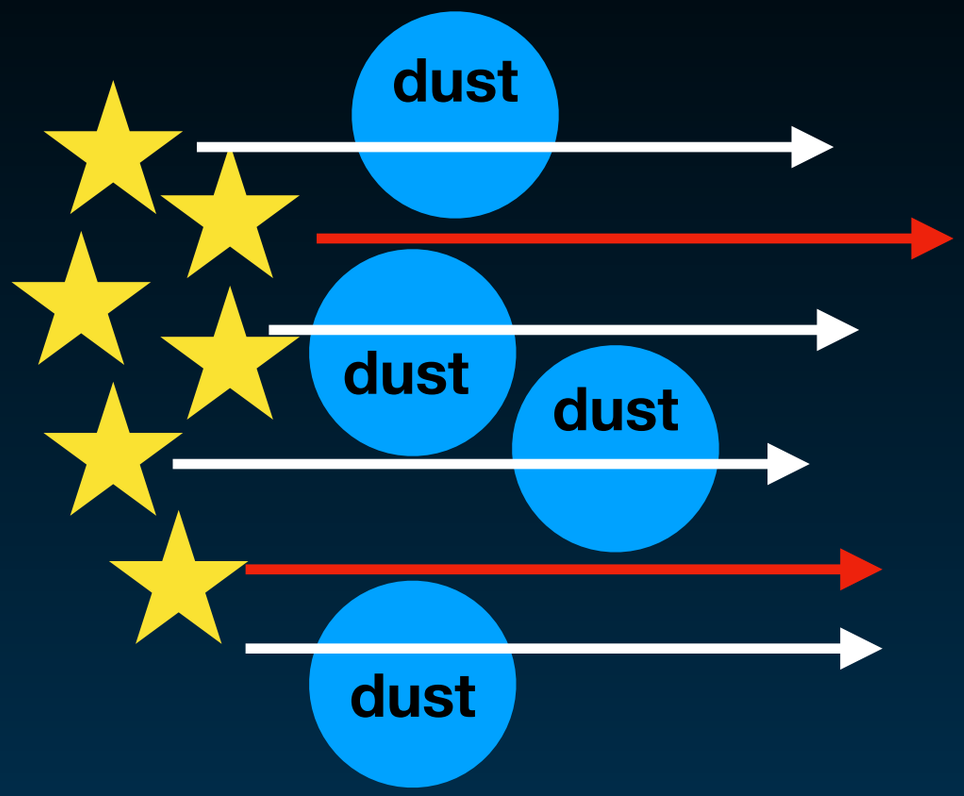

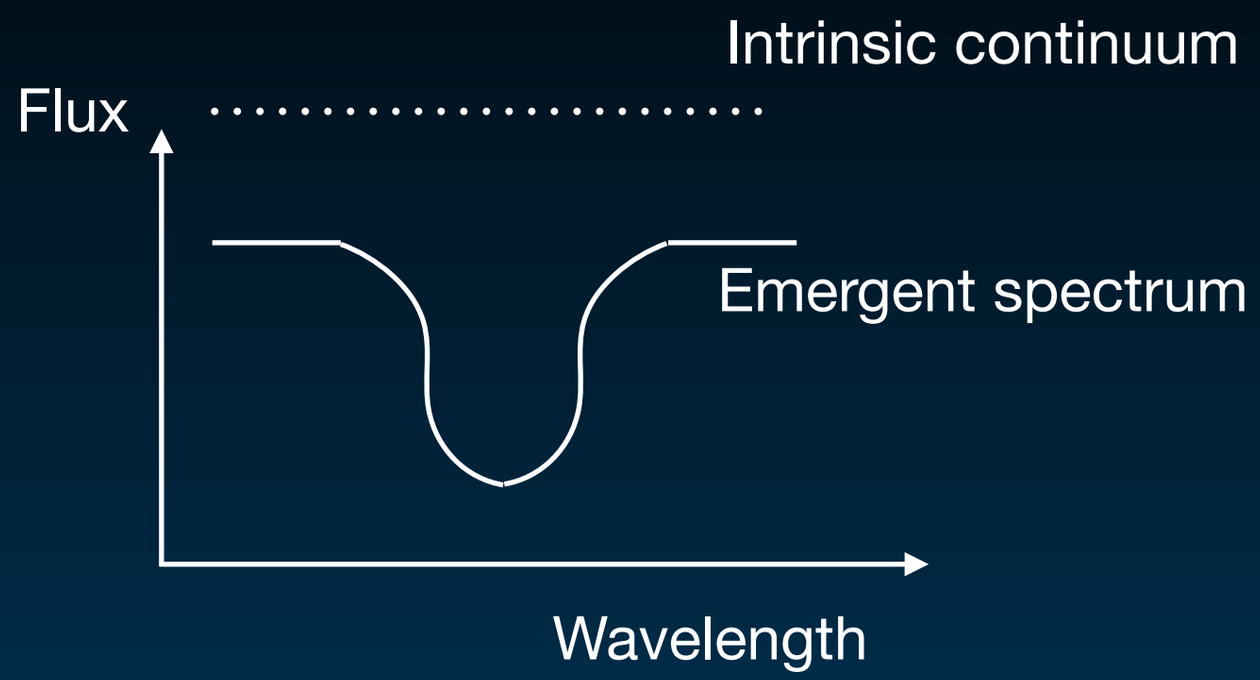

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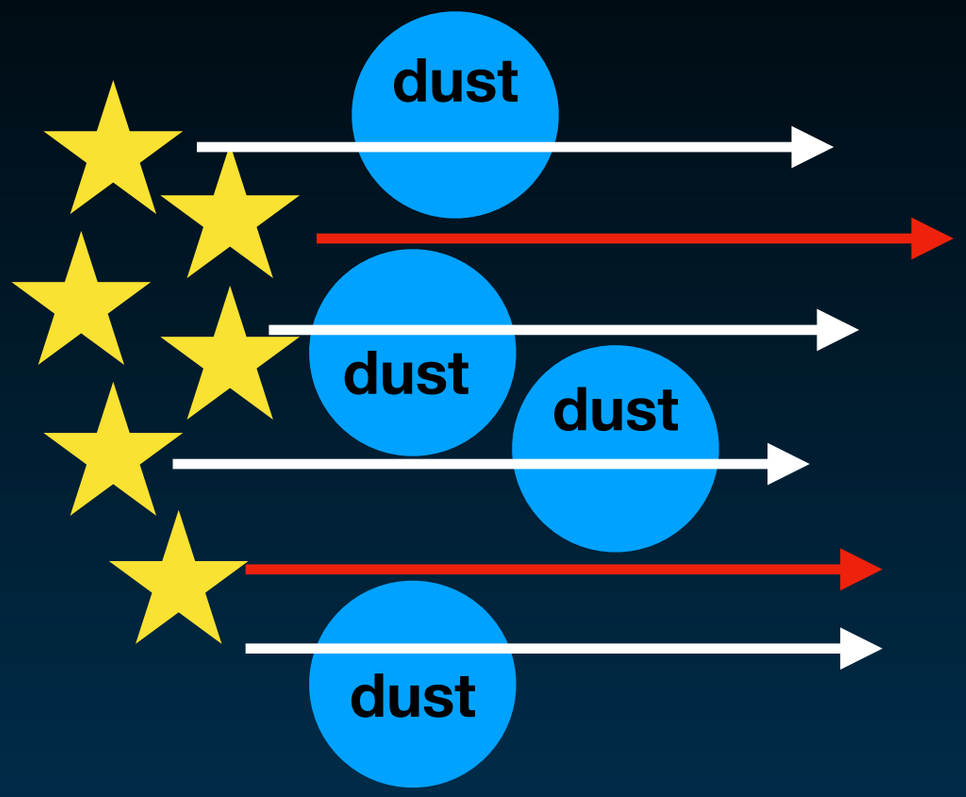
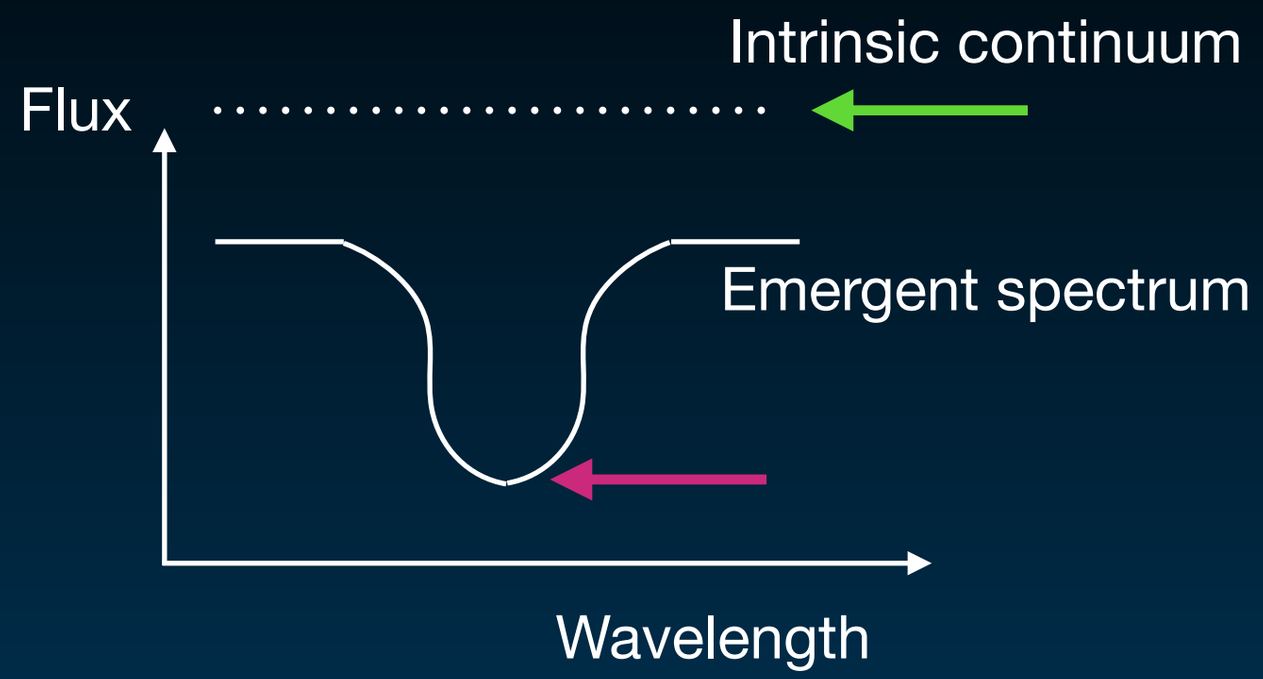


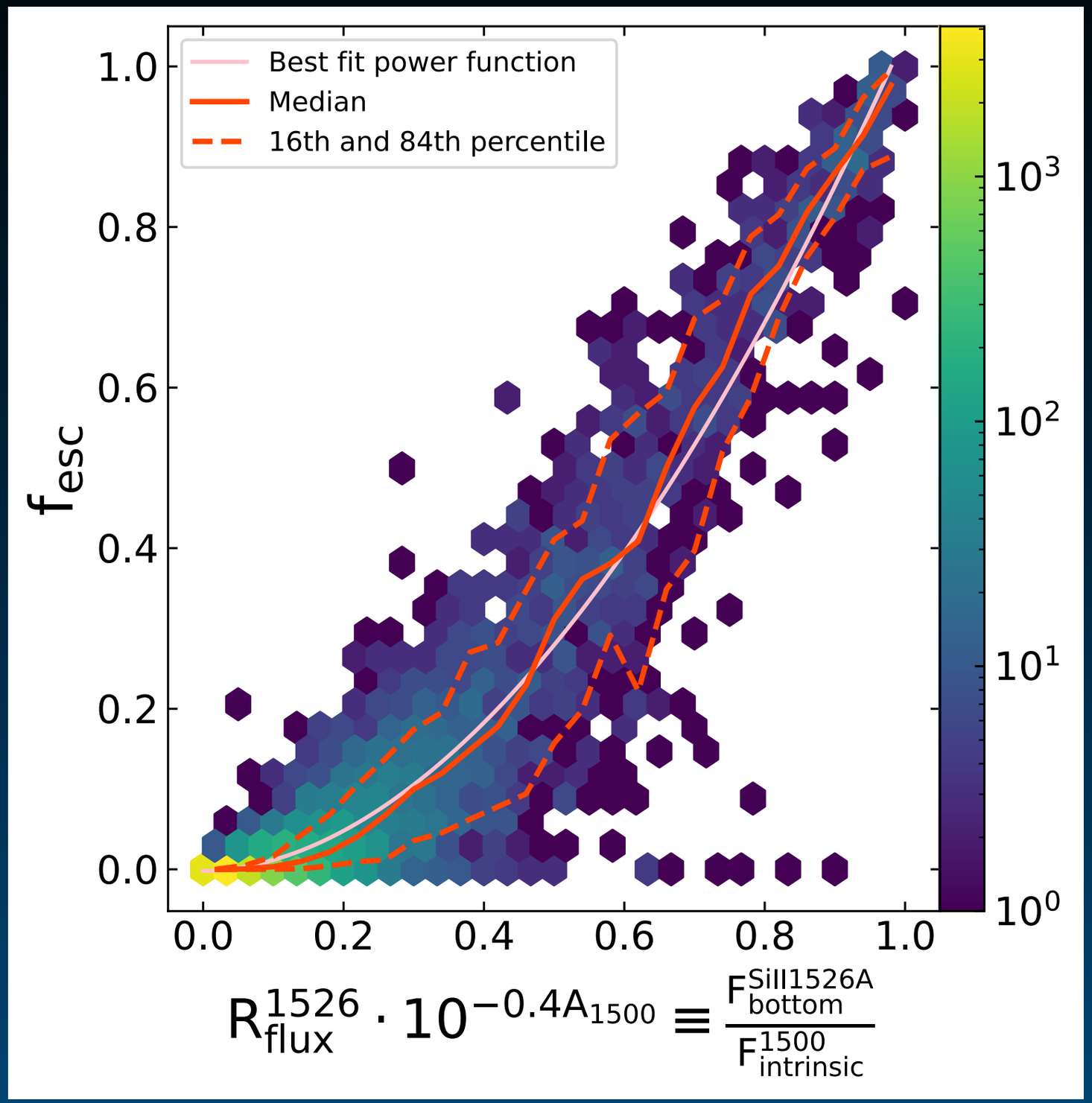


In this “dusty picket-fence model”, the escape fraction of ionising photons is equal to the escape fraction of line photons, which is:

$$= \frac{\text{flux at the bottom of the line}}{\text{flux of the intrinsic continuum}}$$

= “dust-corrected residual flux”

Dust corrected residual flux correlates strongly with f_esc

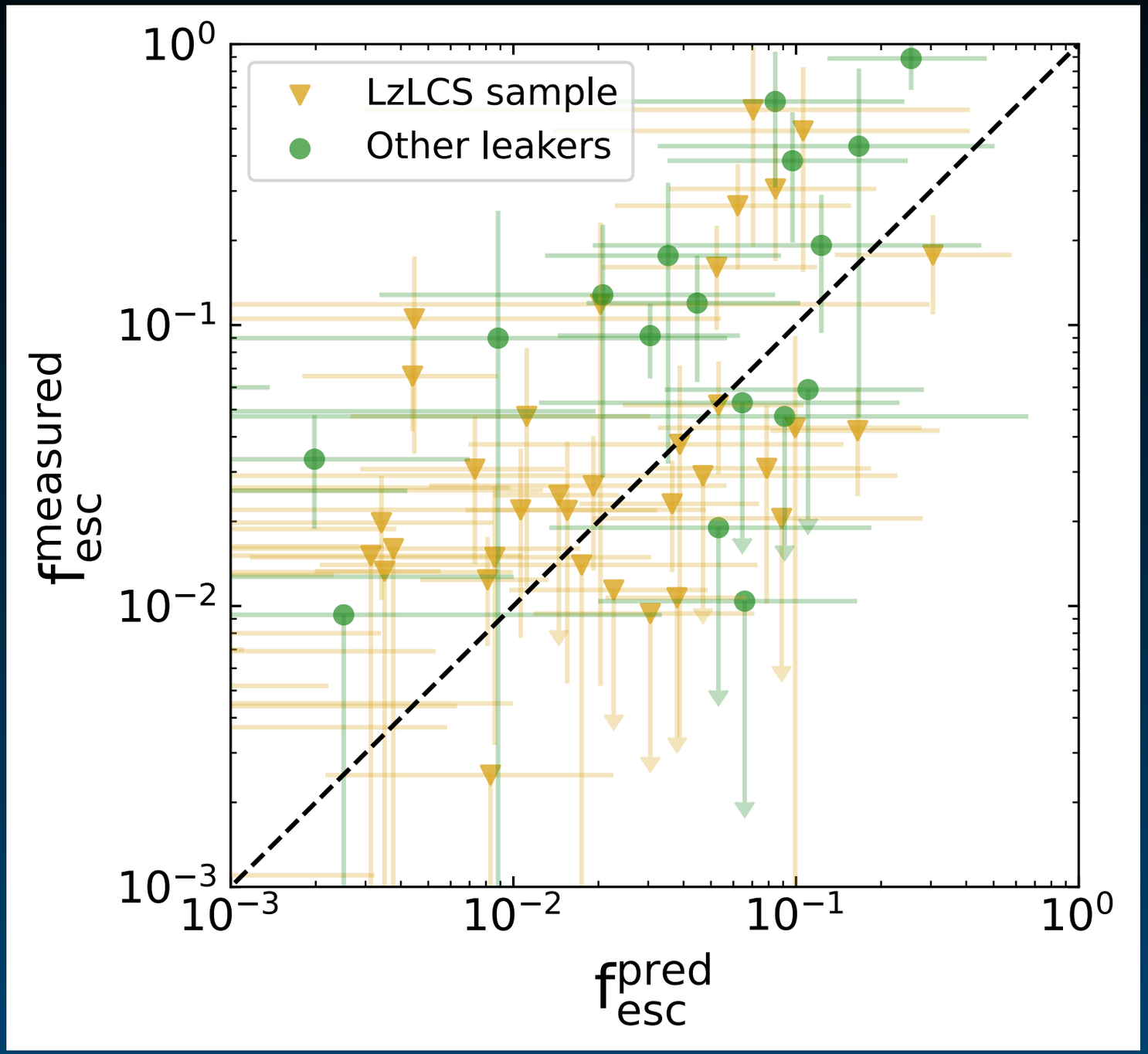


- We find this approximate relation:

$$f_{esc} \approx 1.04 \left(R^{1526}_{flux} \cdot 10^{-0.4A_{1500}}\right)^{1.887} - 0.002$$

- Mean error of this prediction of the escape fraction: 0.015
- For galaxies with significant escape, the mean error is 0.046
- We find a better prediction with SiII 1526A than with SiII 1260A

Application to the LzLCS sample



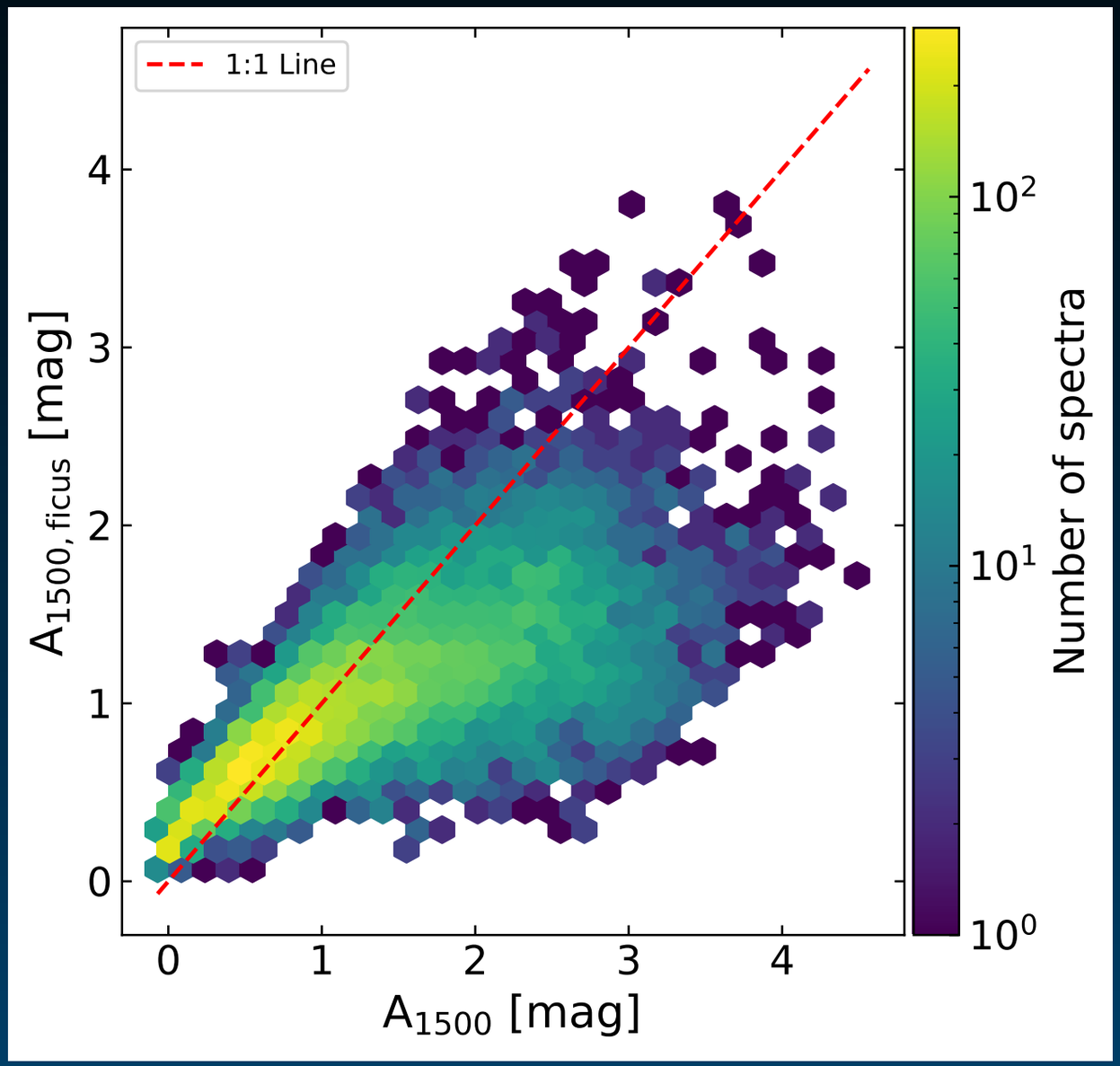
Significant discrepancies appear when applying our diagnostic to real data

Several systematic differences must be taken into account, mainly:

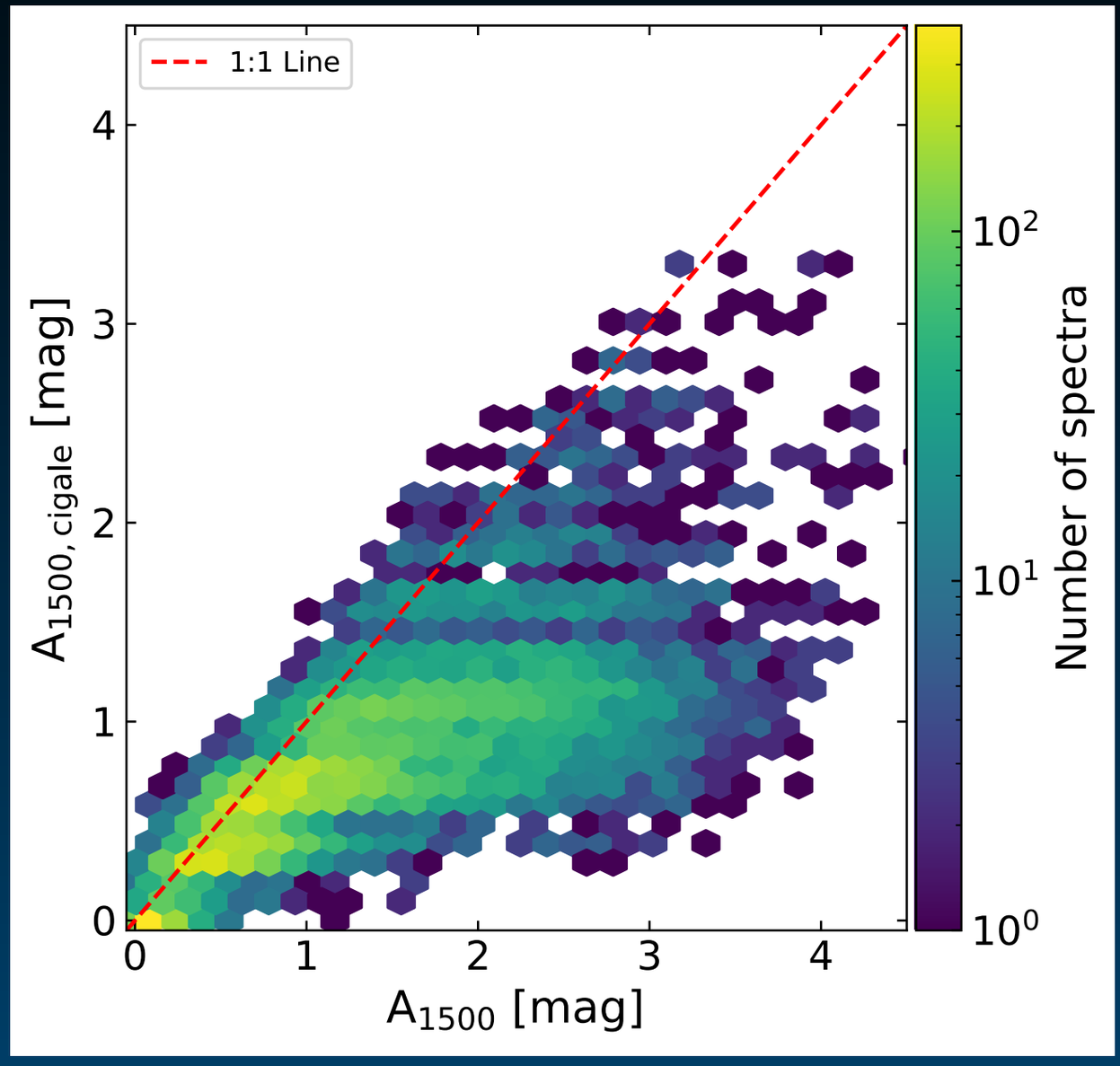
- Residual flux measurements are very sensitive to spectral resolution
- No SiII 1526 in LzLCS
- The dust attenuation cannot always be accurately recovered from spectral fitting

Biases in dust attenuation measurements

FiCUS (Saldana-Lopez et al. 2023)



CIGALE



SED-fitting methods often underestimate the extinction of dusty galaxies

Summary

- Using the radiative transfer code RASCAS, I produce realistic ISM absorption lines from the cosmological simulation SPHINX20

- The dust-corrected residual flux of SiII 1526 is a good tracer of f_esc

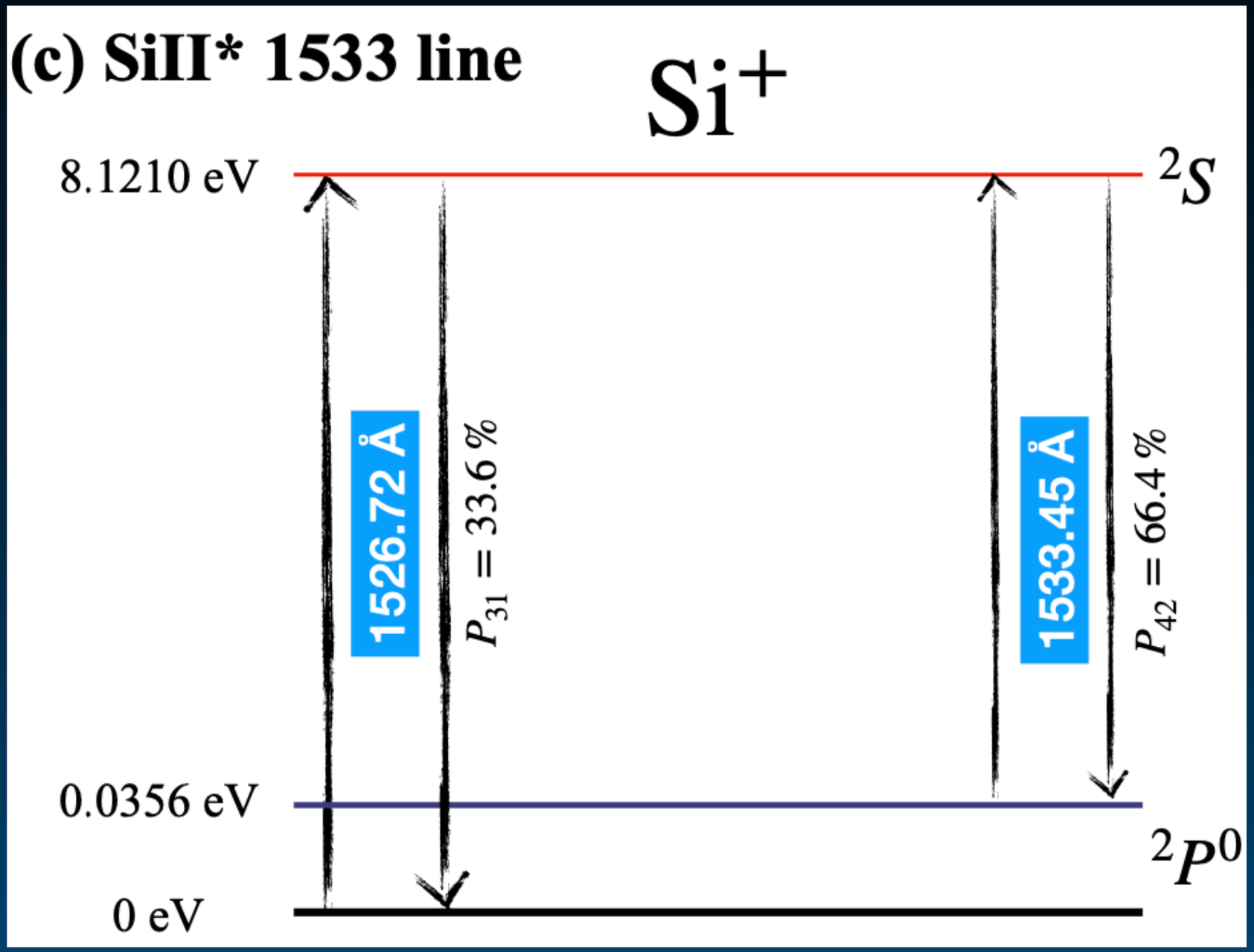
- However, the dust attenuation is difficult to infer with (UV-optical) SED-fitting

- Check-out the SPHINX20 public data release, containing many galaxy properties, emission lines, mock photometry, etc.
  Absorption lines to be added in a few weeks!

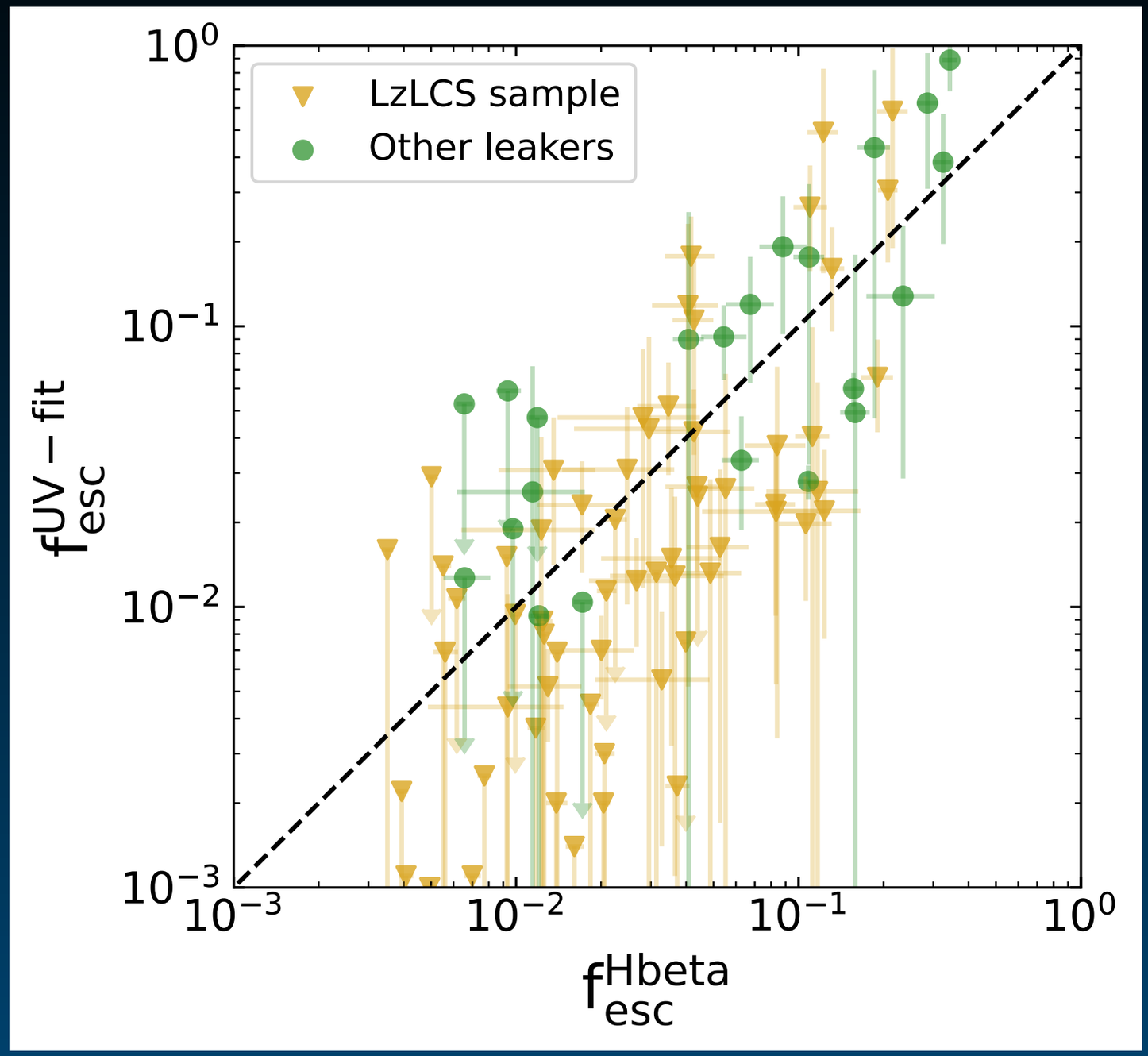
https://github.com/HarleyKatz/SPHINX-20-data **Katz et al. 2023**

Backup slides

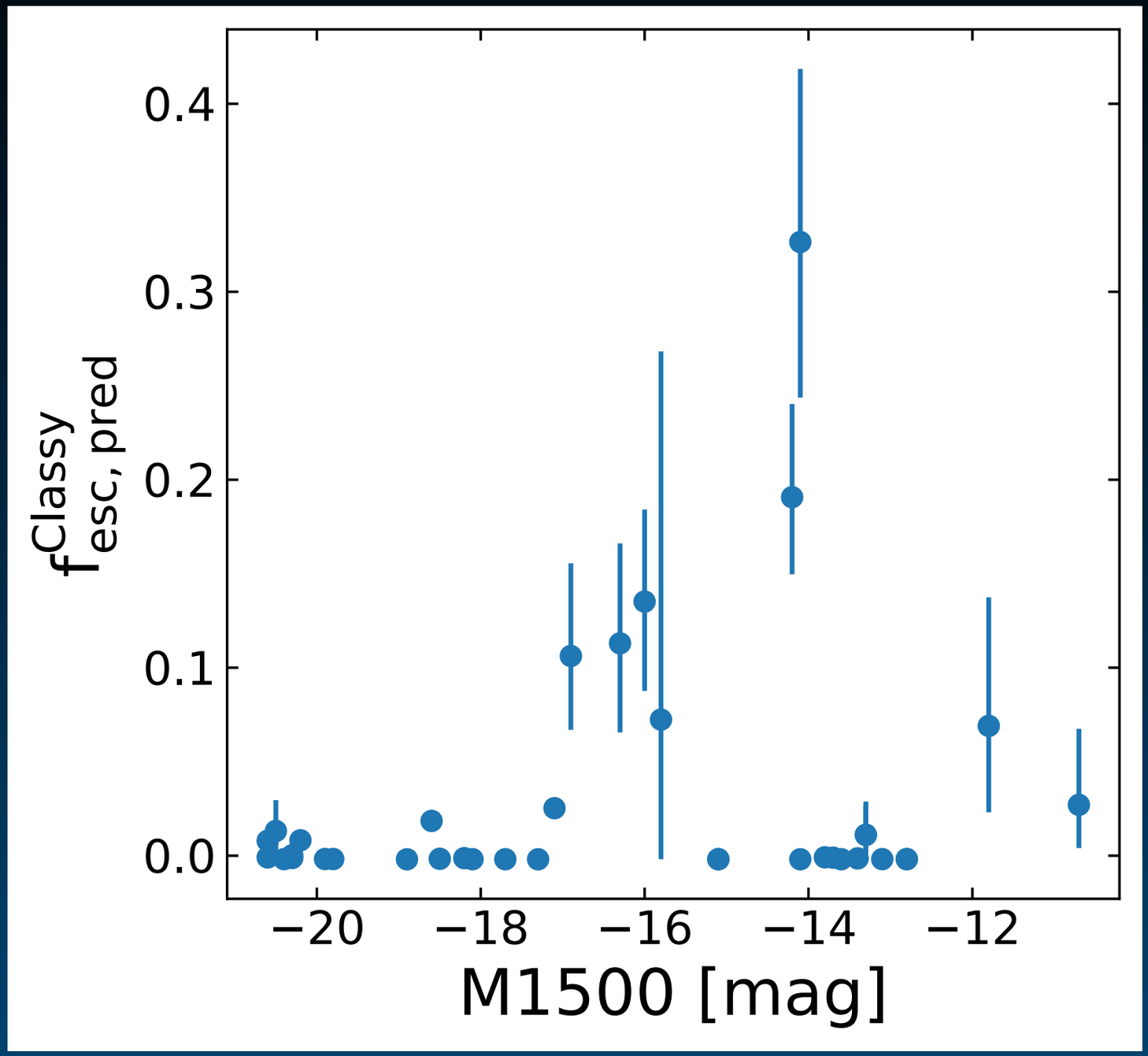
Atomic levels of Si+



LzLCS fesc comparison



f_esc predictions for the CLASSY sample



LEPHARE predictions of SPHINX20 dust attenuations