MOSDEF: Measurements of Balmer Decrements and the Dust Attenuation Curve at High Redshift

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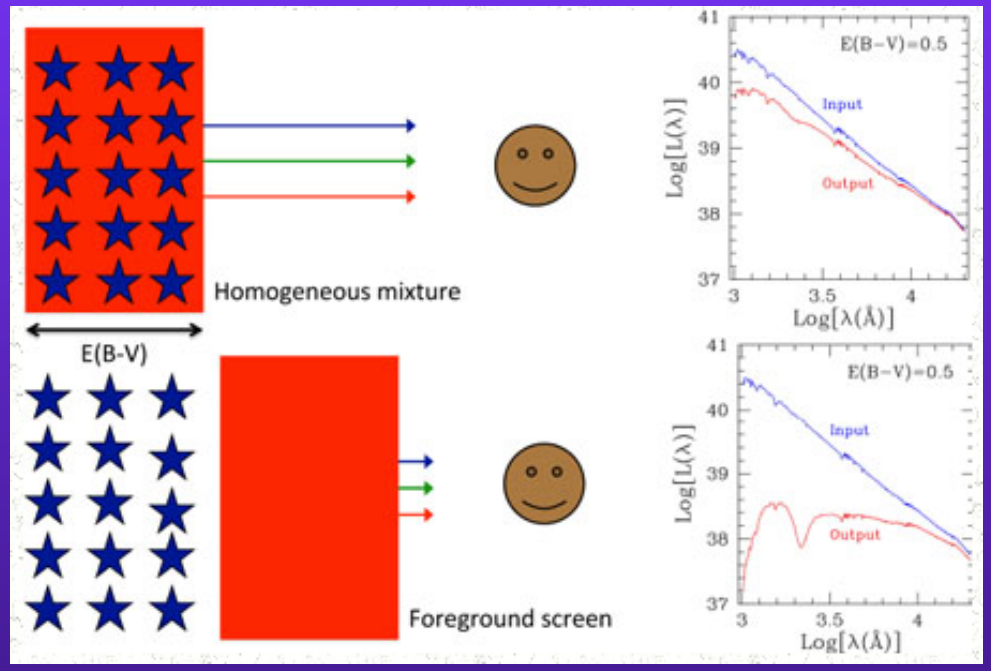
SEDs of High-z Galaxies: Lessons Learned and Open Questions,
Sesto, Italy, 28 January 2015

Importance of the Dust "Curve" for High-z Galaxies



Important input to SED fitting

Needed to infer dust-corrected SFRs

Encodes info on the dust/stars geometry

Proxies for Dust at High-z

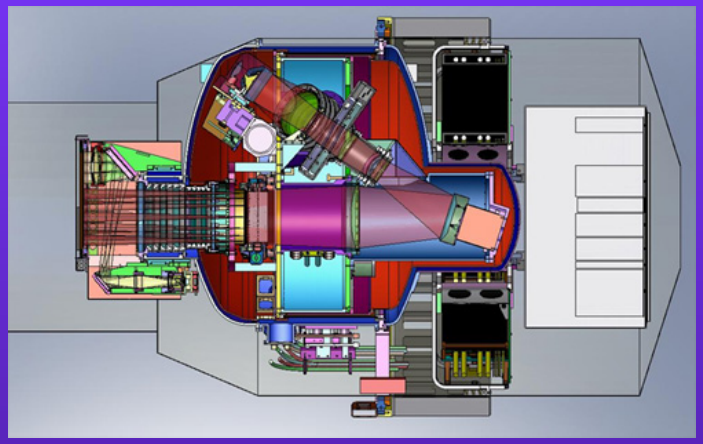
• UV Slope: sensitive to age, metallicity, and star-formation history; measurement can be complicated by presence of 2175 Å absorption feature

• Far-IR Measurements: only available for more luminous and dusty galaxies

➔ need tracers that are less sensitive to stellar population parameters (age and star-formation history), probe star formation on short timescales, and can be measured for individual typical star-forming galaxies at high redshift

BALMER DECREMENTS

MOSFIRE Deep Evolution Field (MOSDEF) Survey



-Conducted using MOSFIRE on Keck
- MOS near-IR spectroscopy covering important nebular emission lines at 1.4<z<3.8

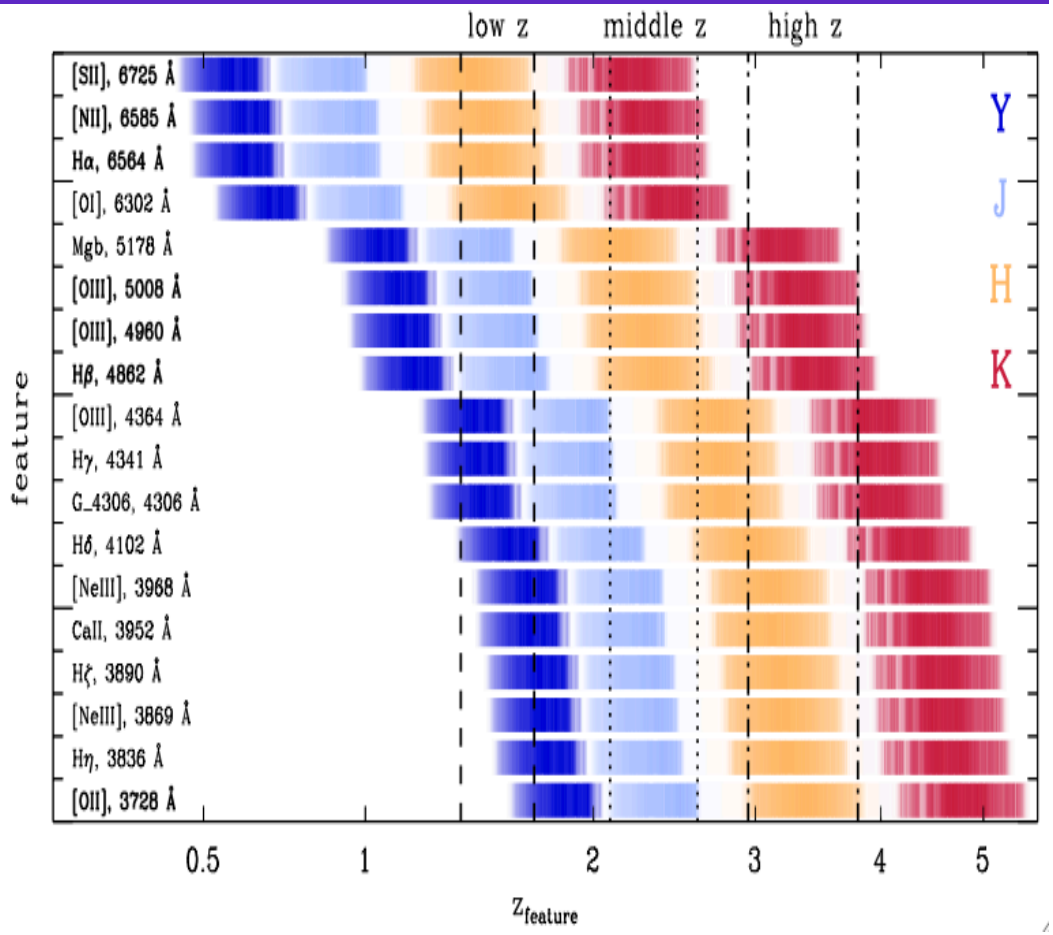
Transformative survey (Kriek+14):

(1) H band-selected rest-optical spectroscopy covering strongest em/abs features with high resolution to characterize gaseous/ stellar contents of galaxies

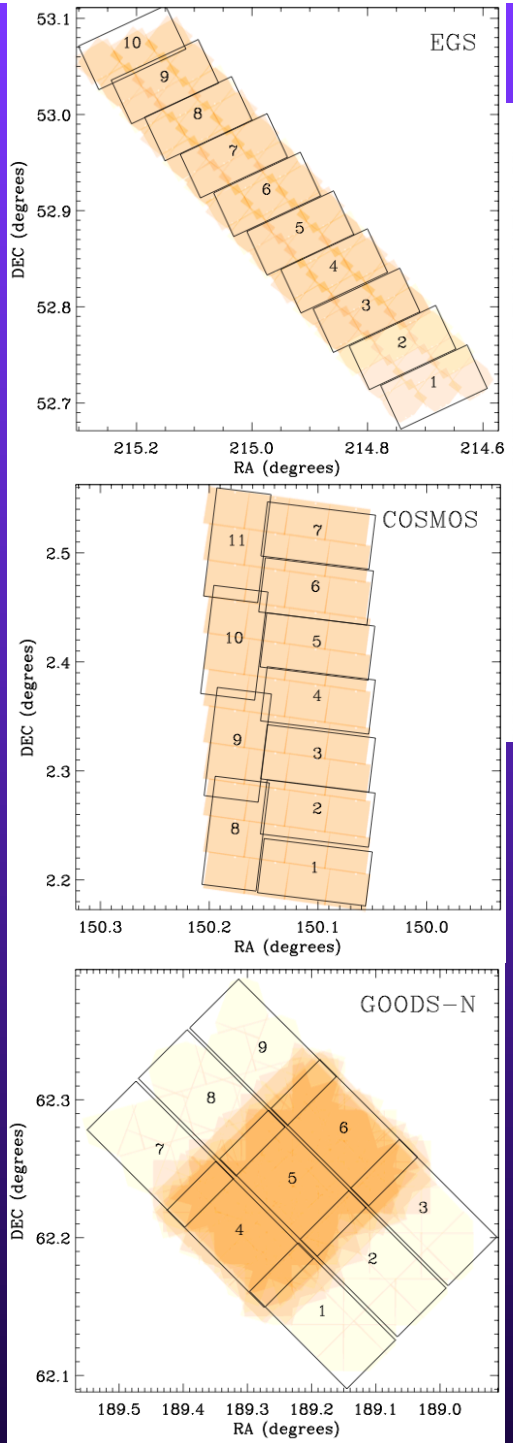
(2) large sample of objects (~1500) spanning full range of galaxy properties

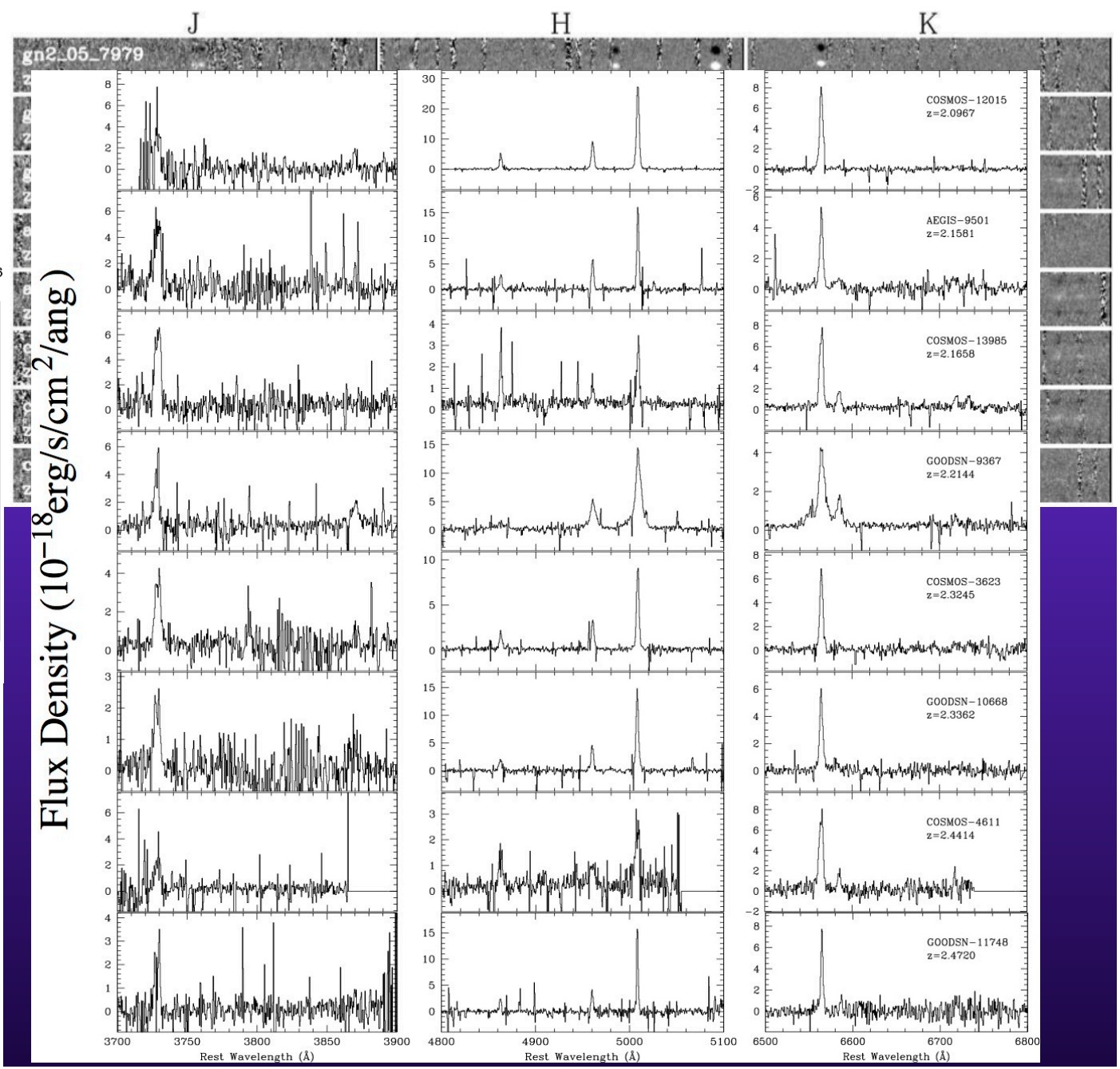
(3) multiple redshifts to enable evolutionary studies

Kriek et al. (2015)



MOSDEF Fields/Spectra

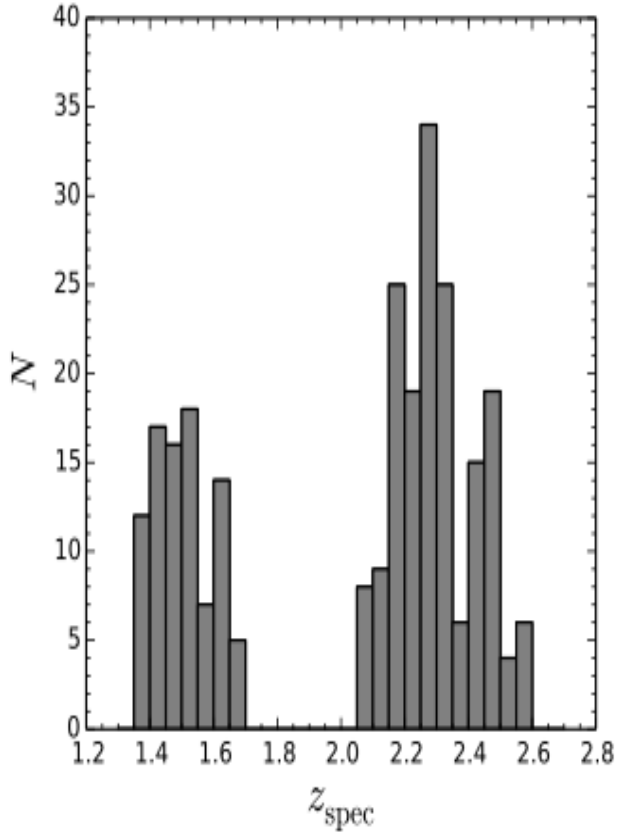


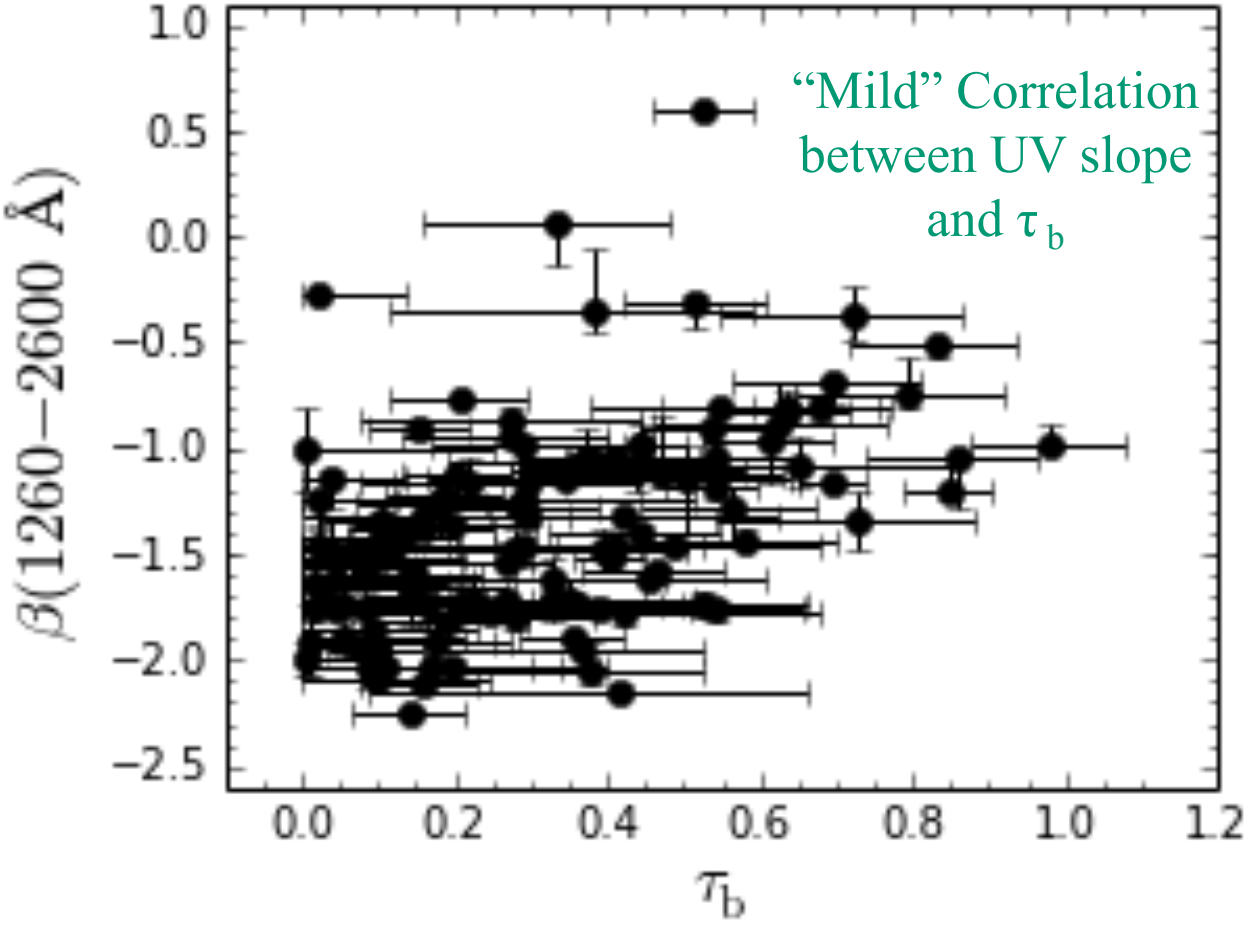


Balmer Decrement Measurements

$$\tau_b \equiv \ln\left(\frac{H\alpha/H\beta}{2.86}\right)$$

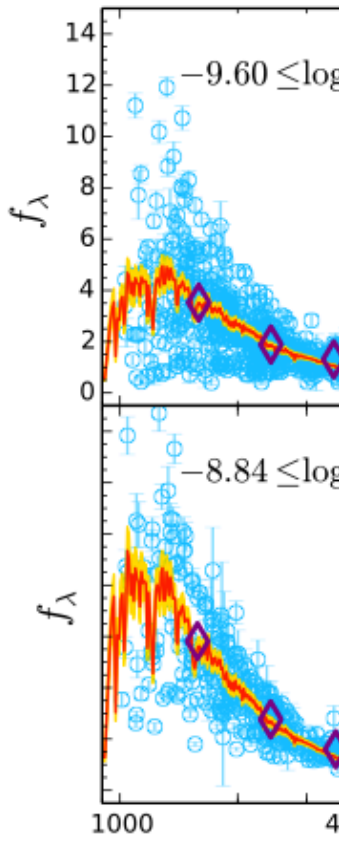
224 star-forming galaxies
at z_{spec} = 1.36 – 2.59

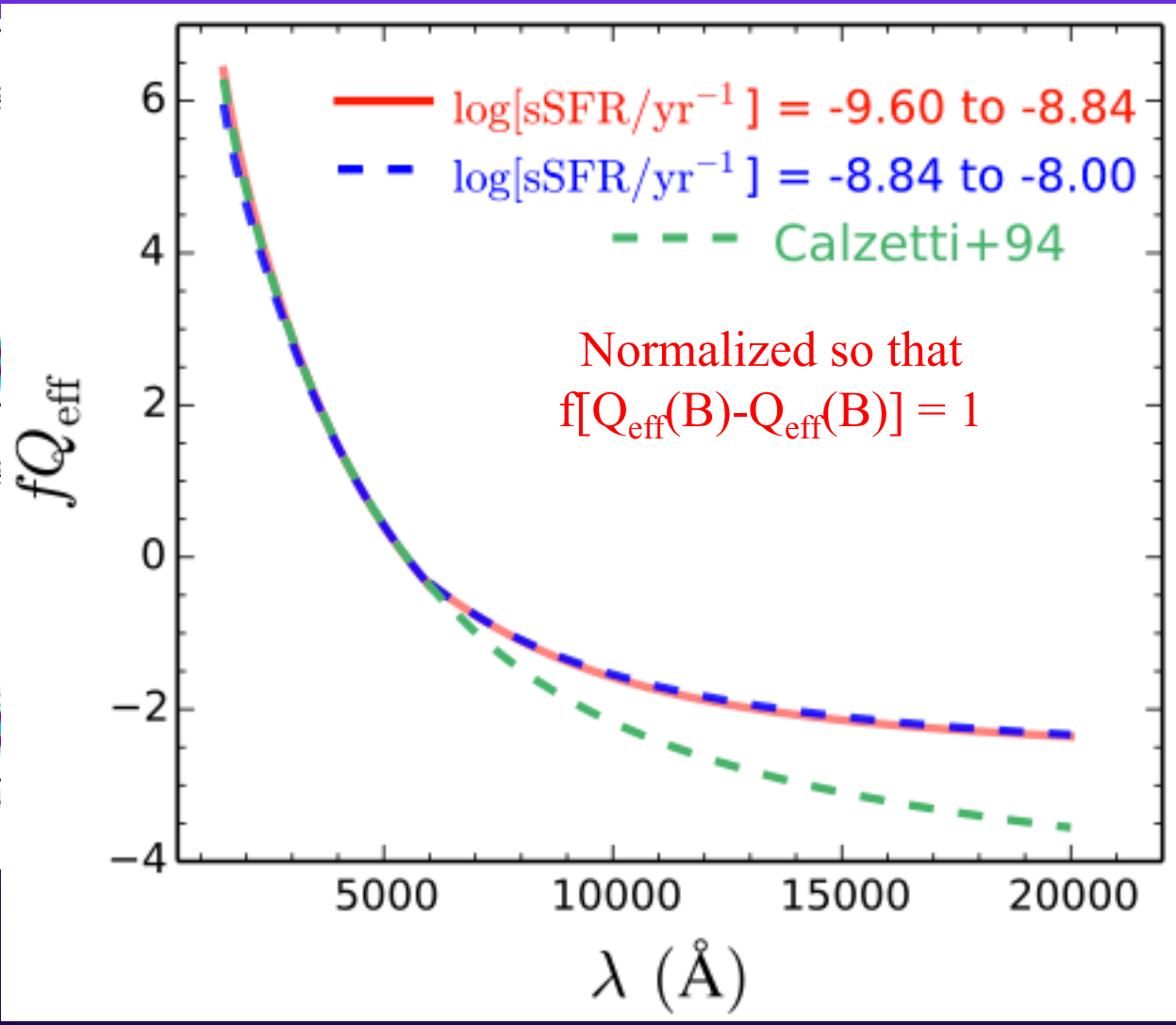


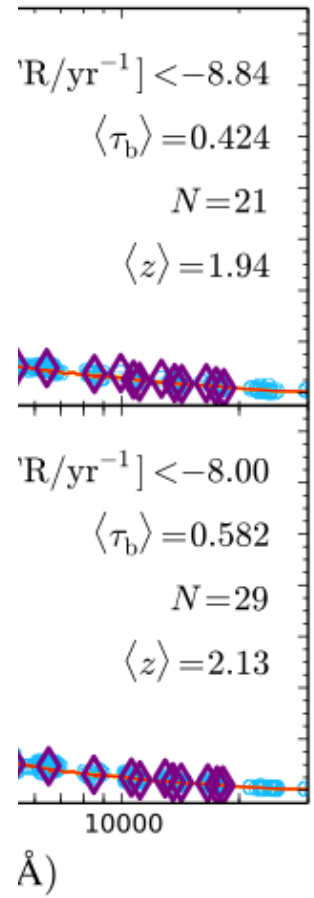


Calculating the Attenuation Curve…

Ratios of Composites

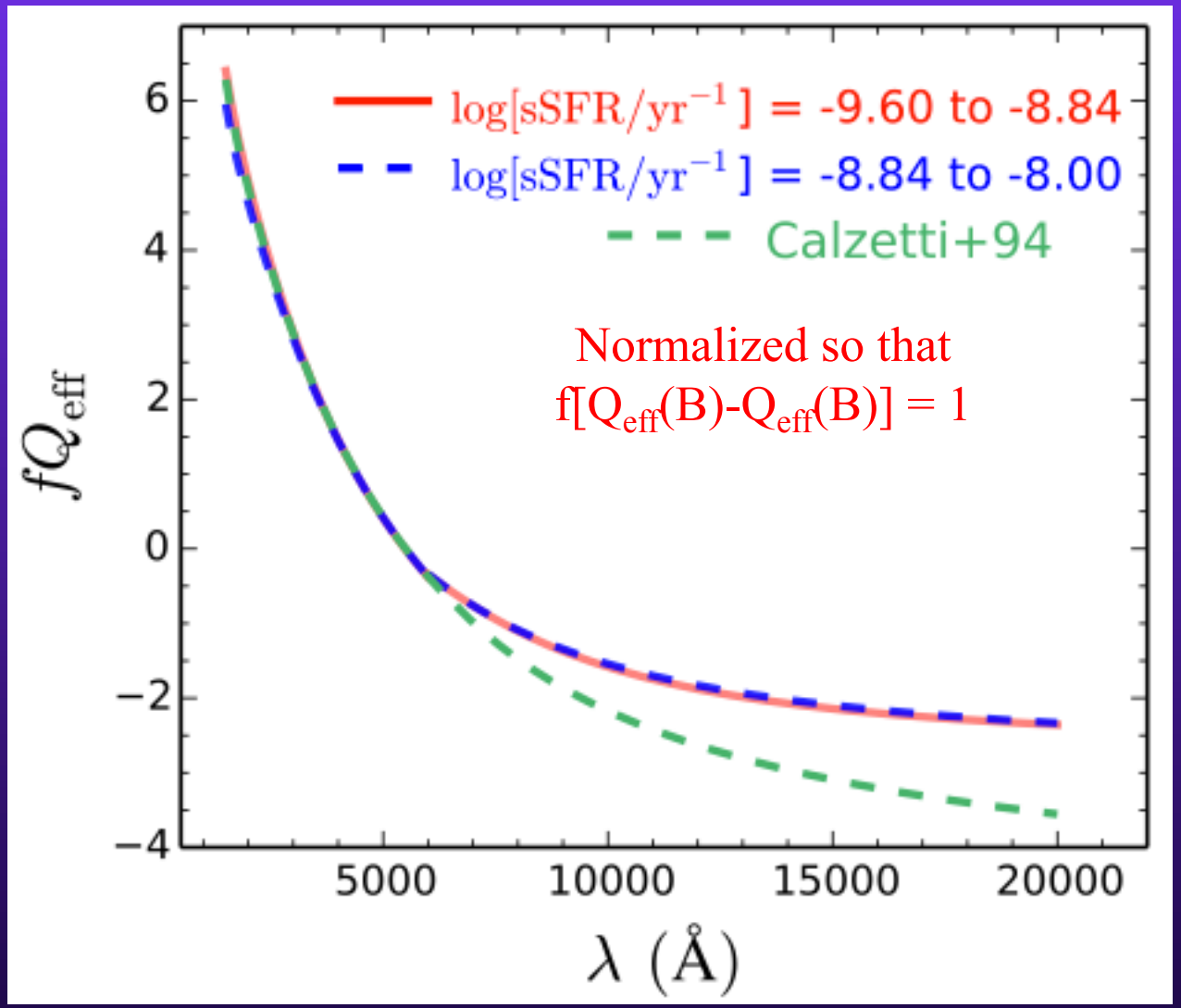






Calculating the Attenuation Curve…

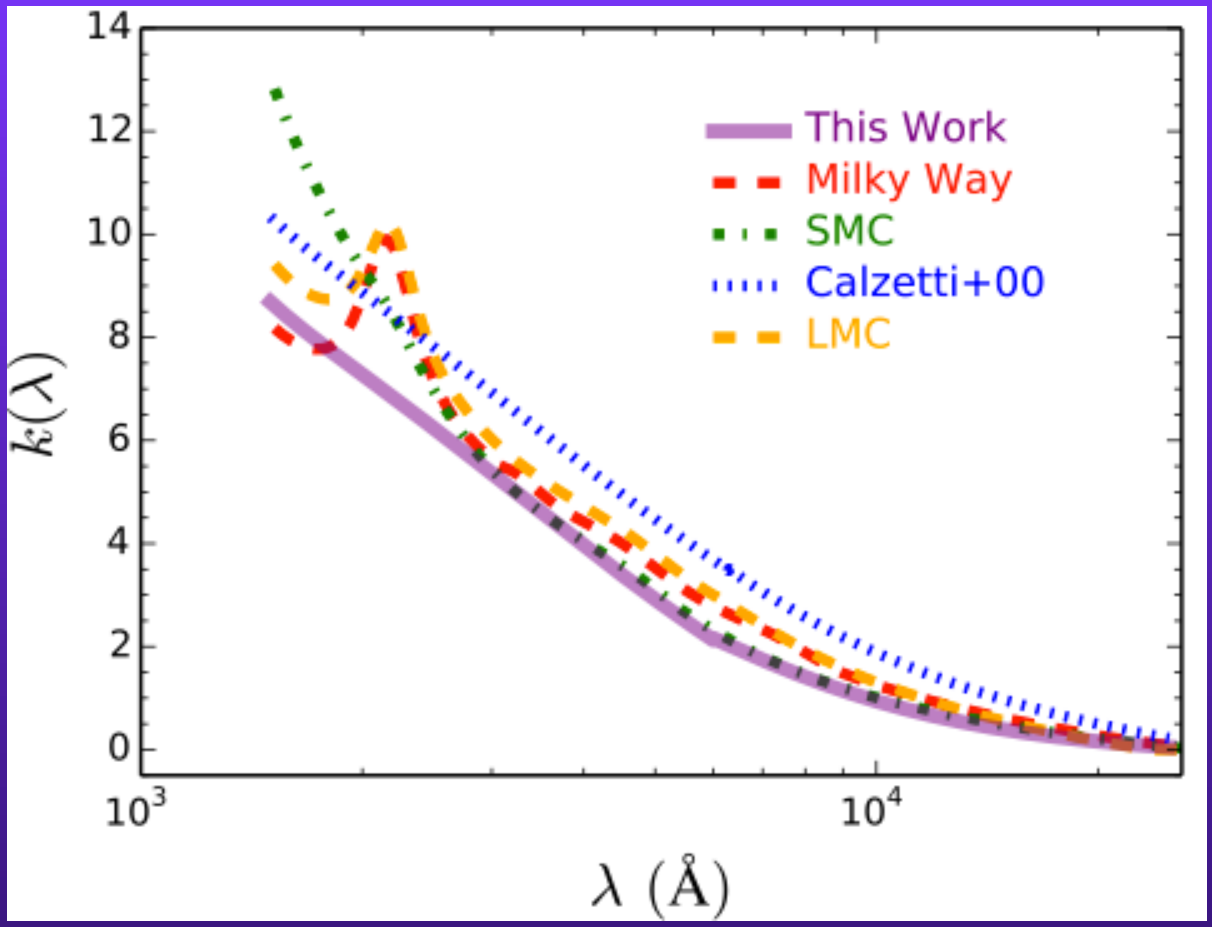
Normalization (R_V)



Renormalized so that $fQ_{eff}(\lambda \rightarrow 2.85\ \mu m)=0$

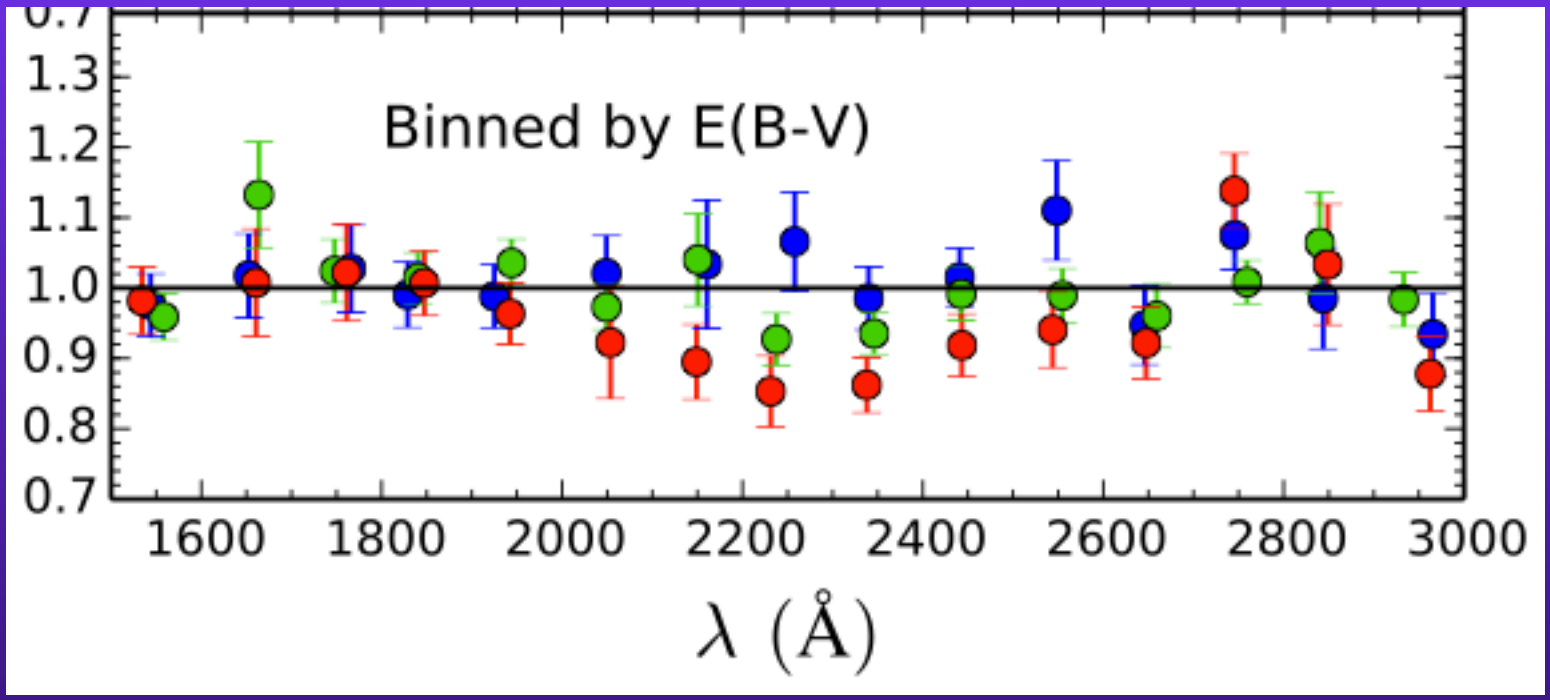
Systematic uncertainties of $\Delta R_V \approx 0.4$

Comparison to other common curves



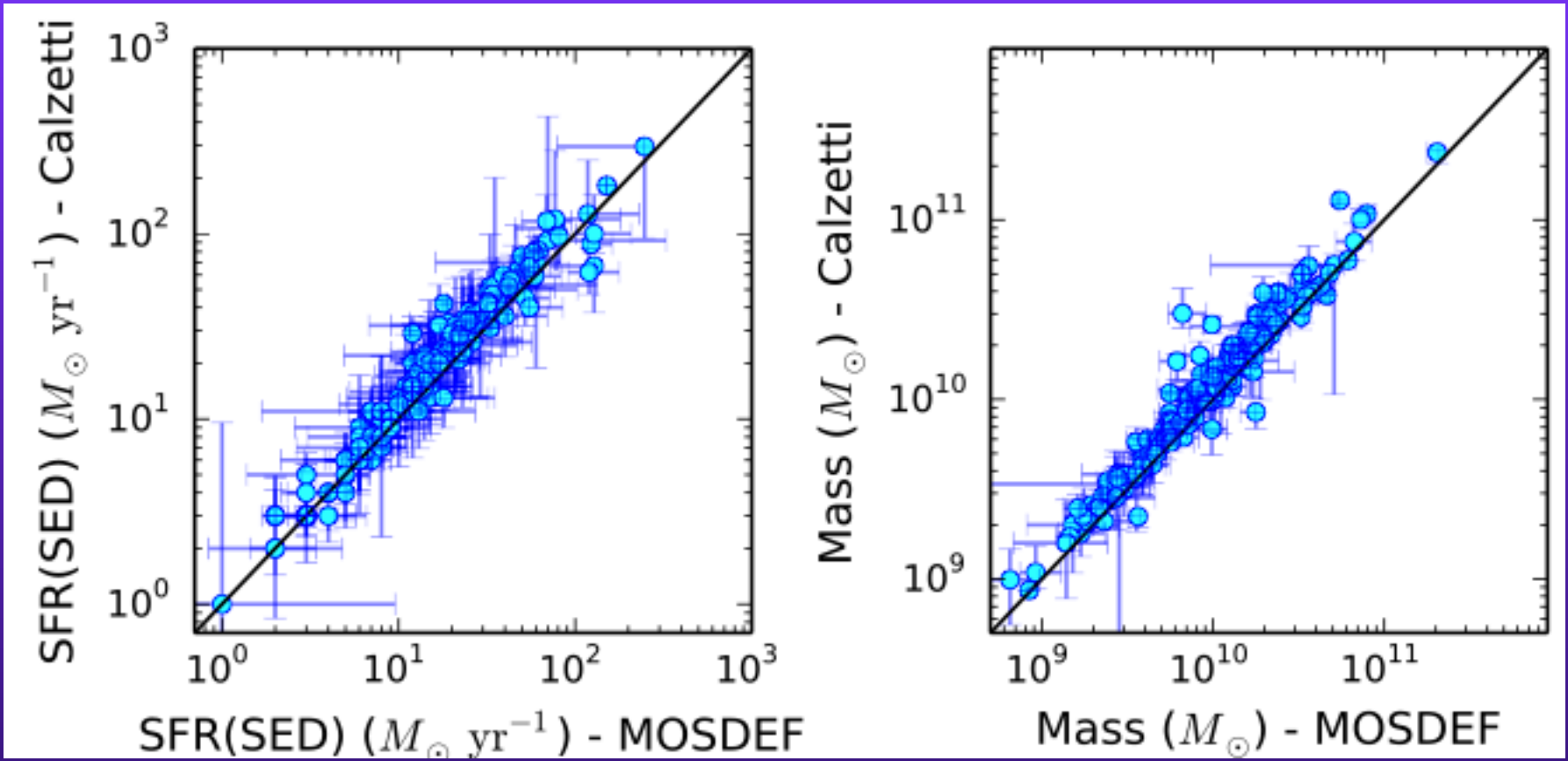
Similar in shape (and normalization) to SMC at λ>2500 Å
Similar in shape (but lower normalization) than Calzetti at λ<2500 Å

Excess UV Absorption at 2175 Å?



Marginal (3σ) significance

Implications for SFR(SED) and M*



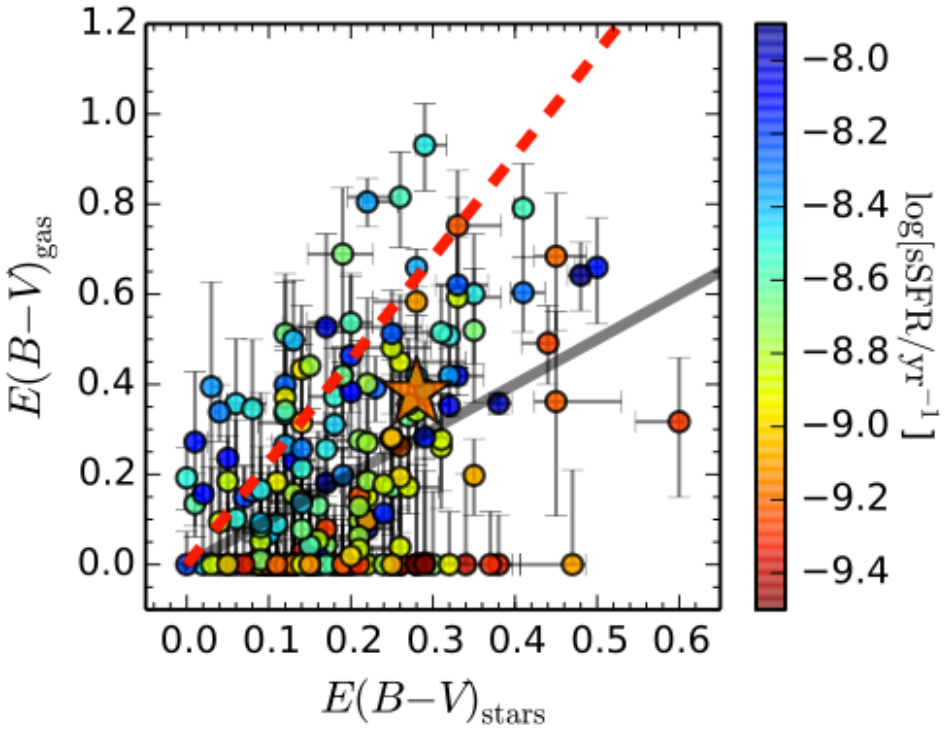
≈20% lower SFRs with new curve

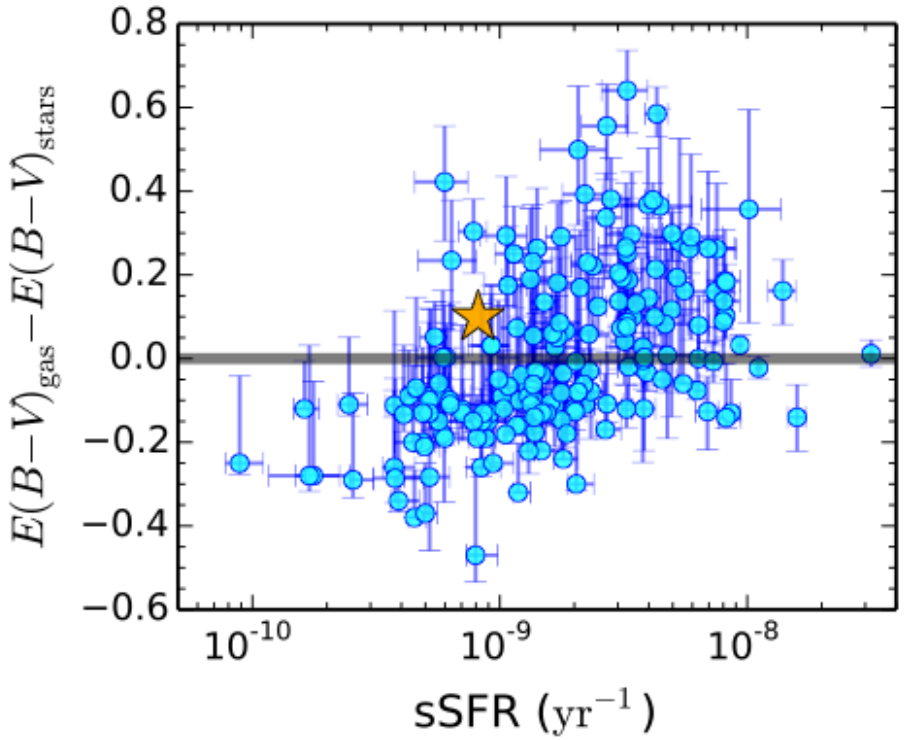
$\Delta\log(M^*/M_\odot) = 0.16$ dex

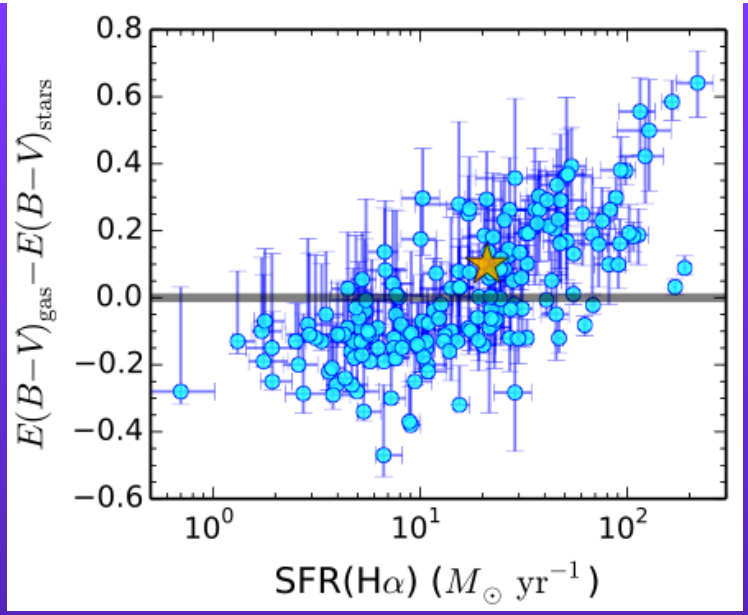
Color Excesses of the Ionized Gas vs. Stellar Continuum

$$E(B-V)_{\rm gas} = \frac{2.5}{k(\mathrm{H}\beta) - k(\mathrm{H}\alpha)} \log_{10}\left(\frac{\mathrm{H}\alpha/\mathrm{H}\beta}{2.86}\right)$$

Assumes Cardelli+89 (Galactic) extinction curve

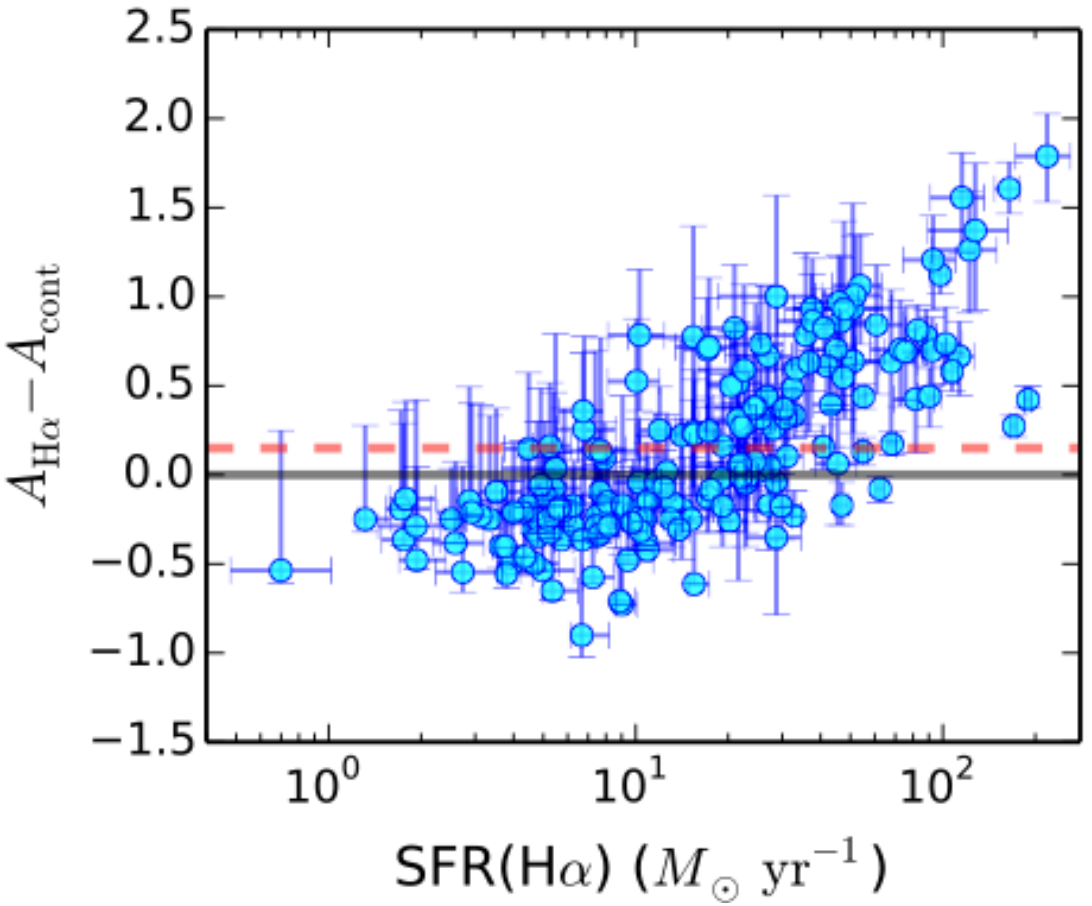






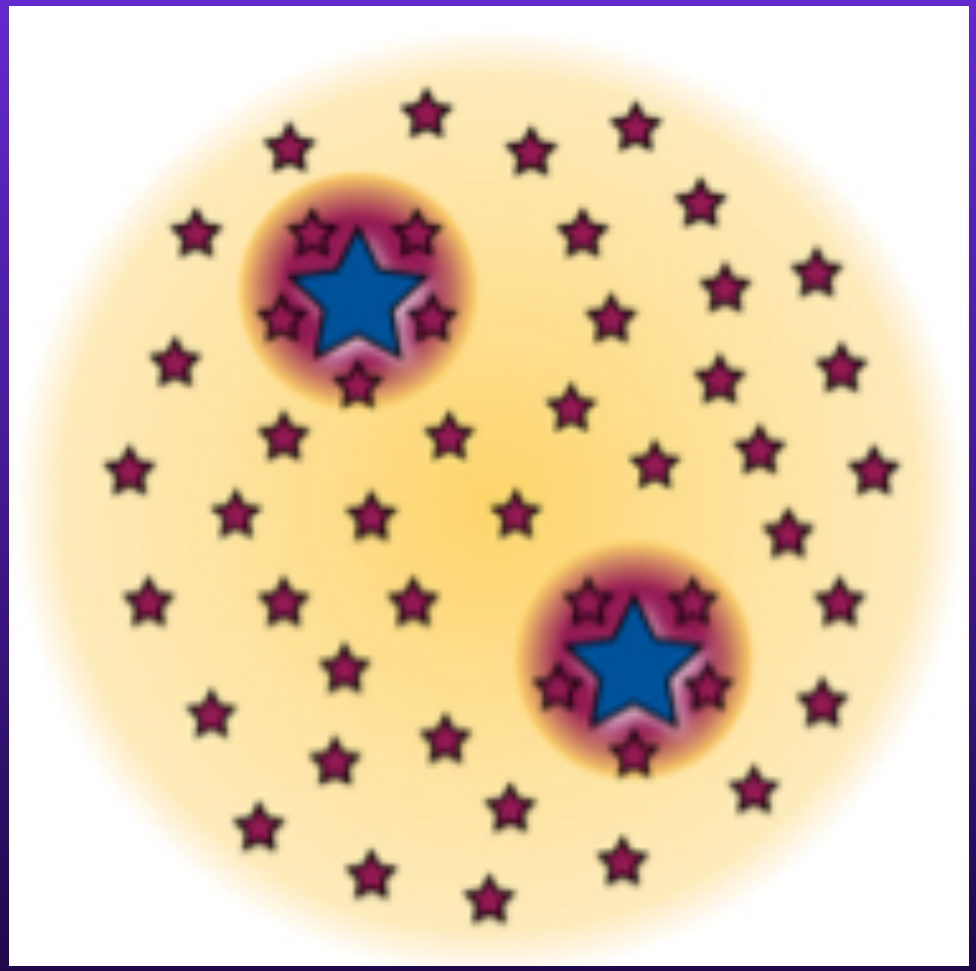
Dependence of the Difference in *Color Excess* on SFR

Dependence of the Difference in *Total Attenuation* on SFR



A Possible Physical Interpretation

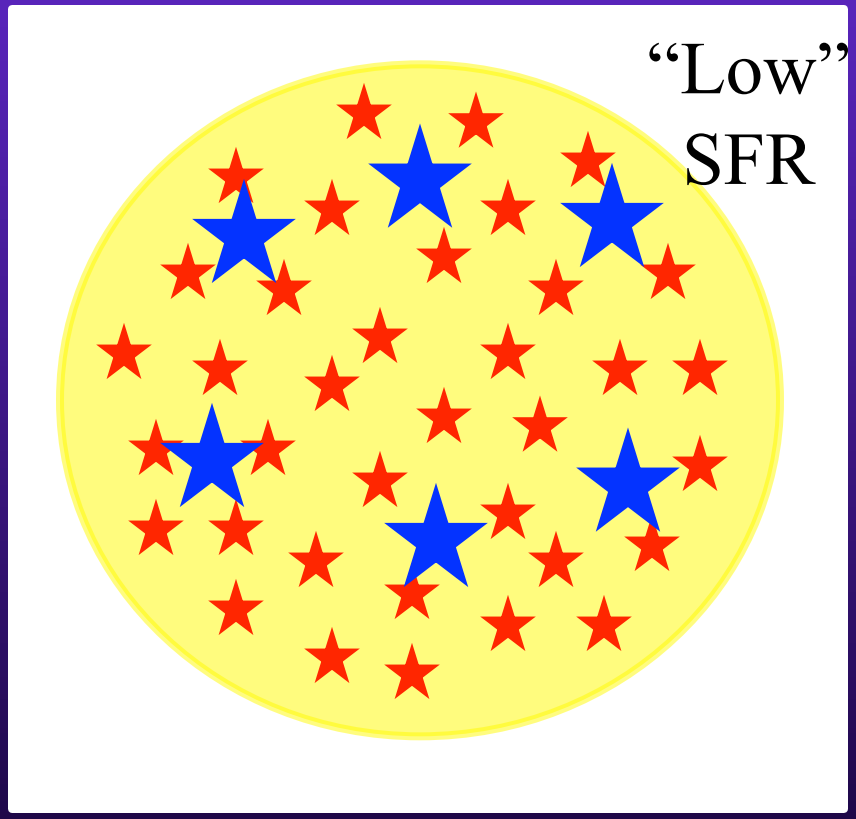
Locally…ionizing stars found in parent birth clouds

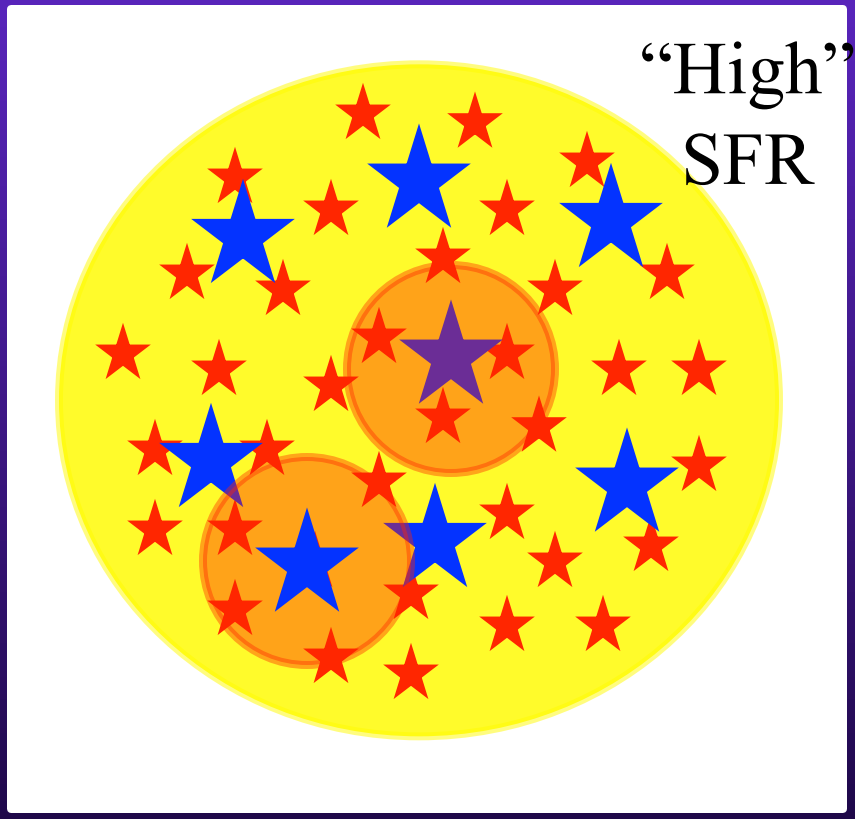


Taken from Price+13

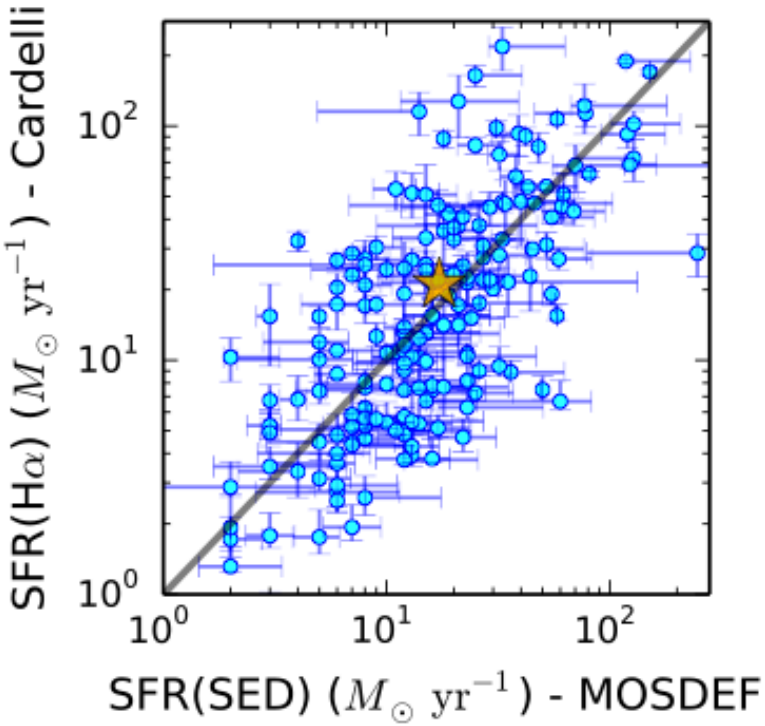
A Possible Physical Interpretation

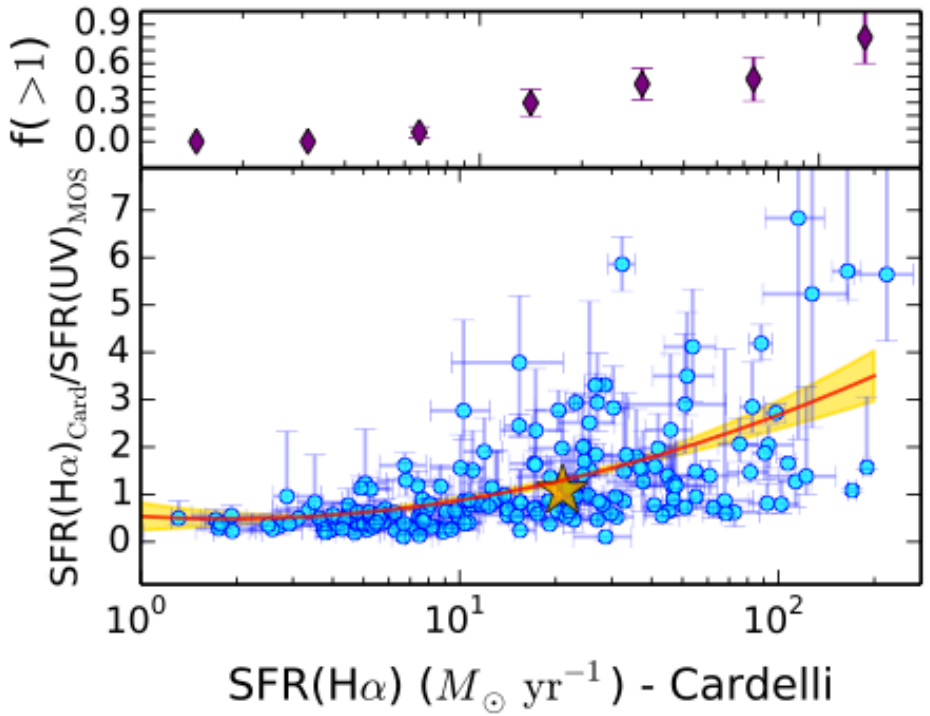
At high-z: stars of all masses are attenuated by same amount, with larger contribution of dust-enshrouded SF at higher SFRs





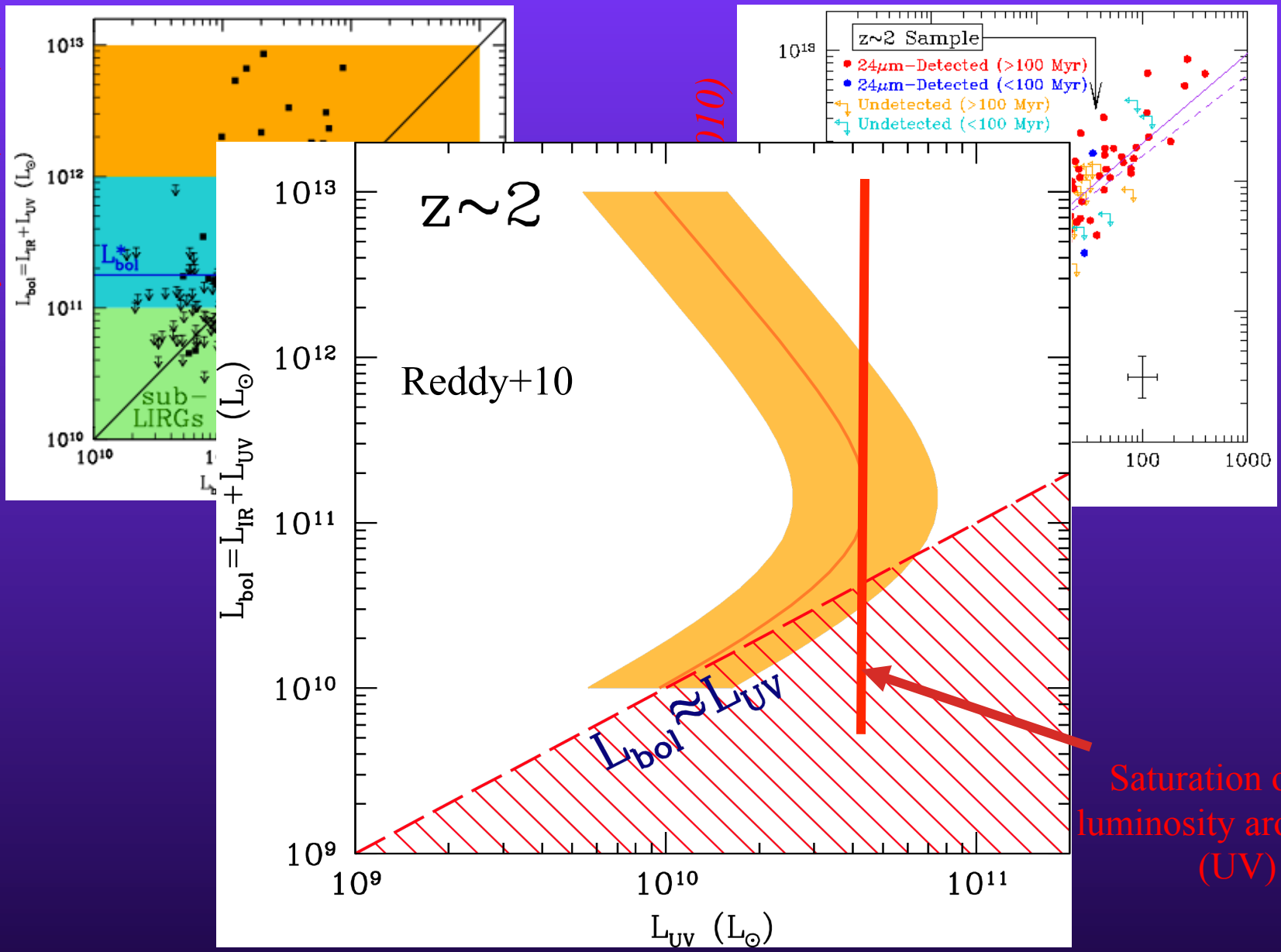
Implications for SFRs from the UV or SED-fitting



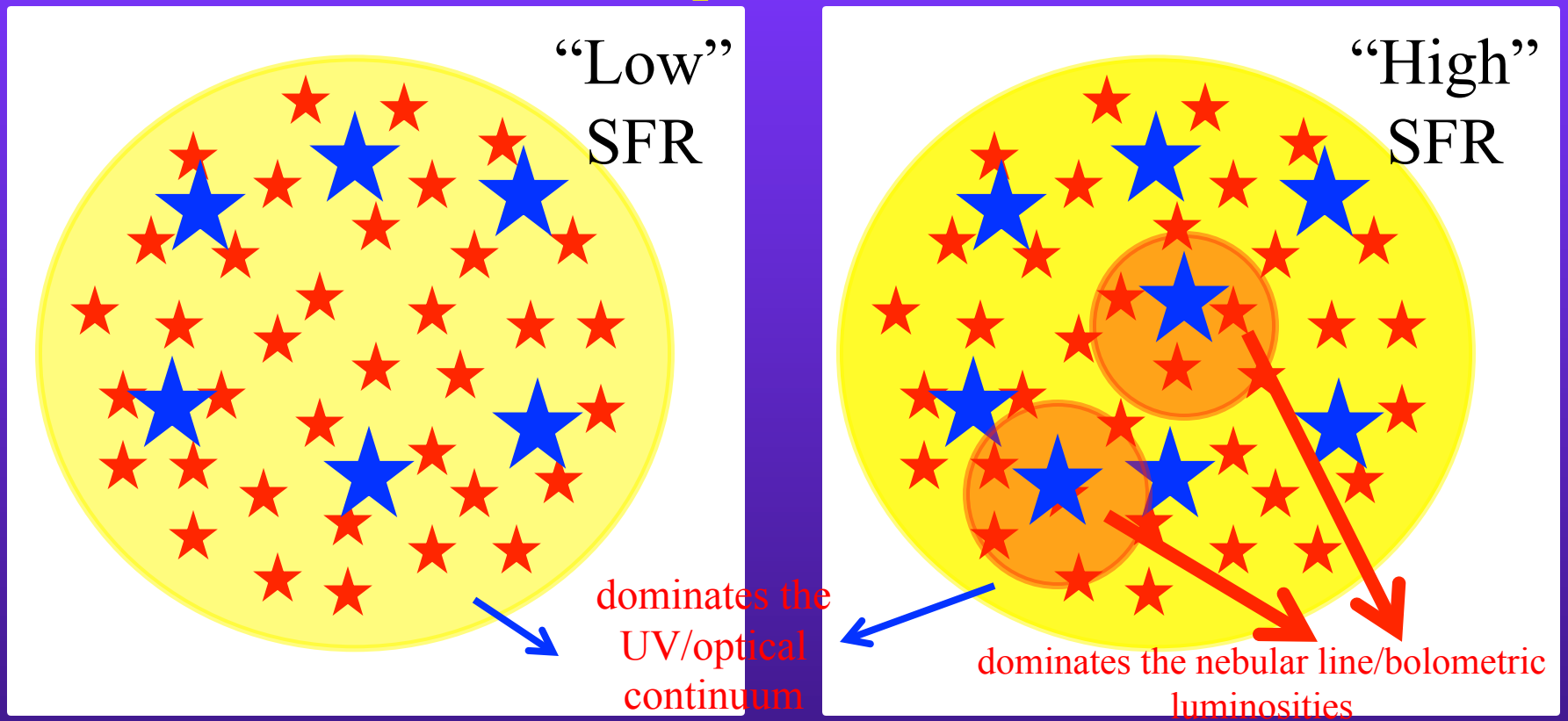


UV/SED-based SFRs *underpredict* total SFR above ≈ 20 $M_\odot$/yr

Similar "Saturation" seen with IR vs UV-based SFRs



Implications



SFR(SED) and SFR(UV) may underpredict total SFR at even "modest" levels

Appropriate attenuation curve to use for HII regions? Gray at low SFR, MW/SMC at high SFR?

Conclusions

• Large sample of Balmer decrements aids in calculating the attenuation curve *relevant for the stellar continuum*

• Attenuation curve found here is similar to SMC at longer wavelengths (λ>2500 Å), and similar in *shape,* but with different *normalization*, than Calzetti+00

• New curve implies SFR ≈20% lower, and log M* that are 0.16 dex lower, than those obtained with the Calzetti relation

• Difference in the color excess (and total attenuation) of the ionized gas and stellar continuum correlates strongly with sSFR and SFR, with higher SFR galaxies exhibiting the largest differences

• Data suggest a physical interpretation where galaxies consist of moderately reddened stellar population that dominated the UV through optical continuum, and a second, dustier population, that begins to dominate the line and bolometric luminosities at higher SFRs.