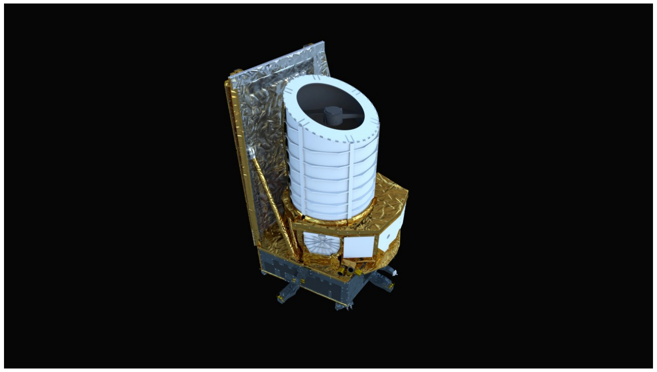
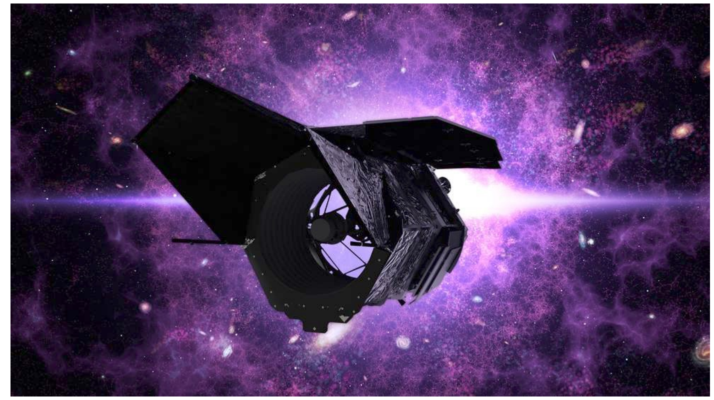


Euclid – artist rendition
Expected launch: ~2023

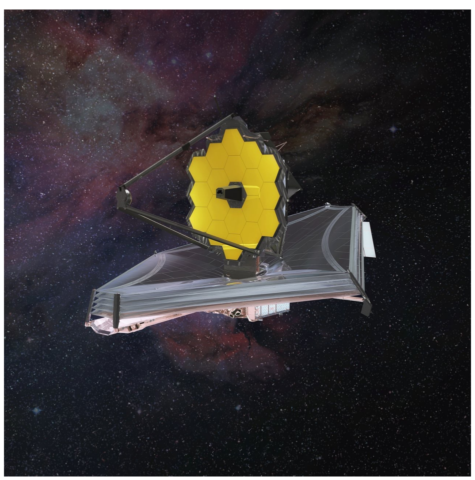


Nancy Grace Roman Space Telescope – artist rendition
Expected launch: ~mid 2020's

Linking Dust Attenuation to Dust Emission

Daniela Calzetti
University of Massachusetts, Amherst

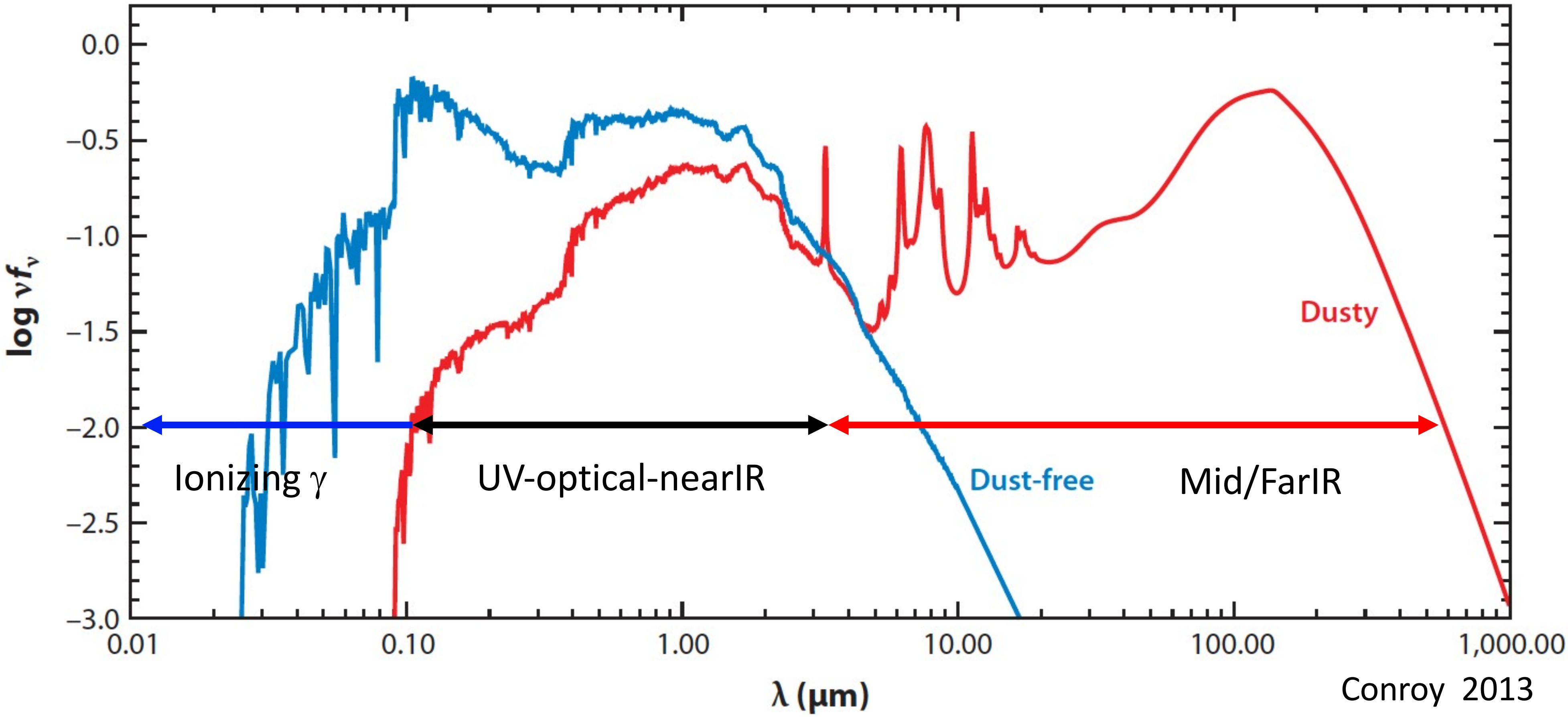
JWST – artist rendition
Launched! December 25th, 2021



1934 dust storm
(Sci News, Oct 17, 2014)

Our Galactic Ecosystem:
Opportunities and Diagnostics in the Infrared and Beyond
Lake Arrowhead, March 1st, 2022.

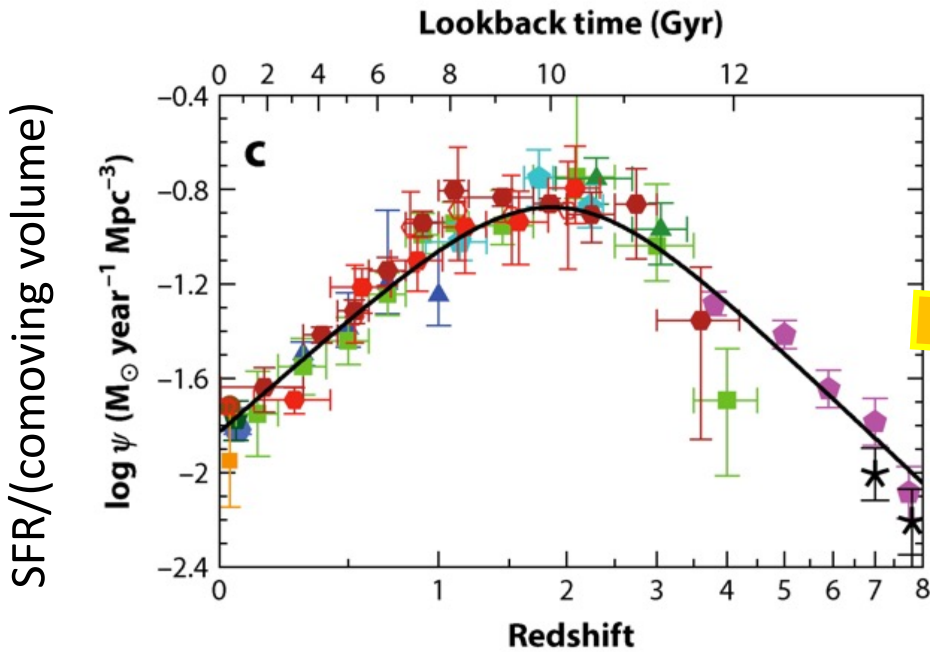
The Effects of Dust on Stellar Populations' SEDs



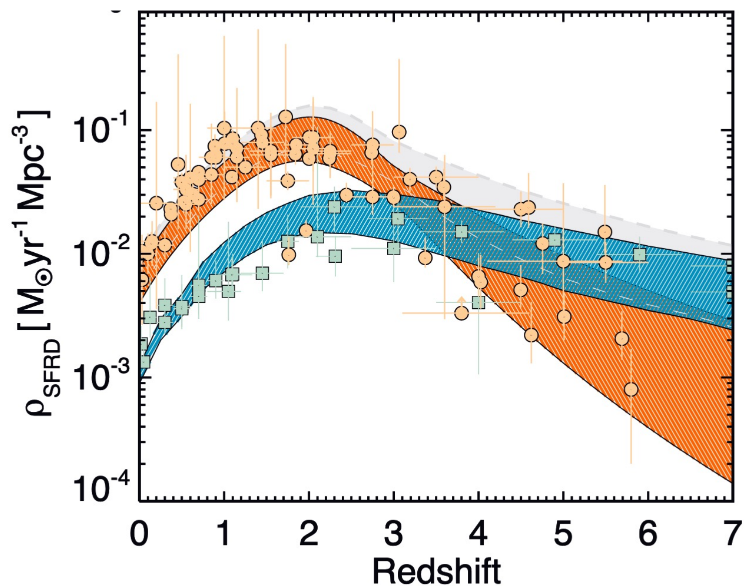
Conroy 2013

- Dust is ~1% of ISM mass of galaxies. Disproportionate impact.
- Dust absorbs (dims) and reddens (selectively dims) light from stellar populations at UV/optical/nearIR wavelengths; energy re-emitted in the mid/farIR/millimeter/radio.
- Can alter/impact morphology, sizes/shapes, and colors

Impact of Dust on Interpreting Galaxy Evolution



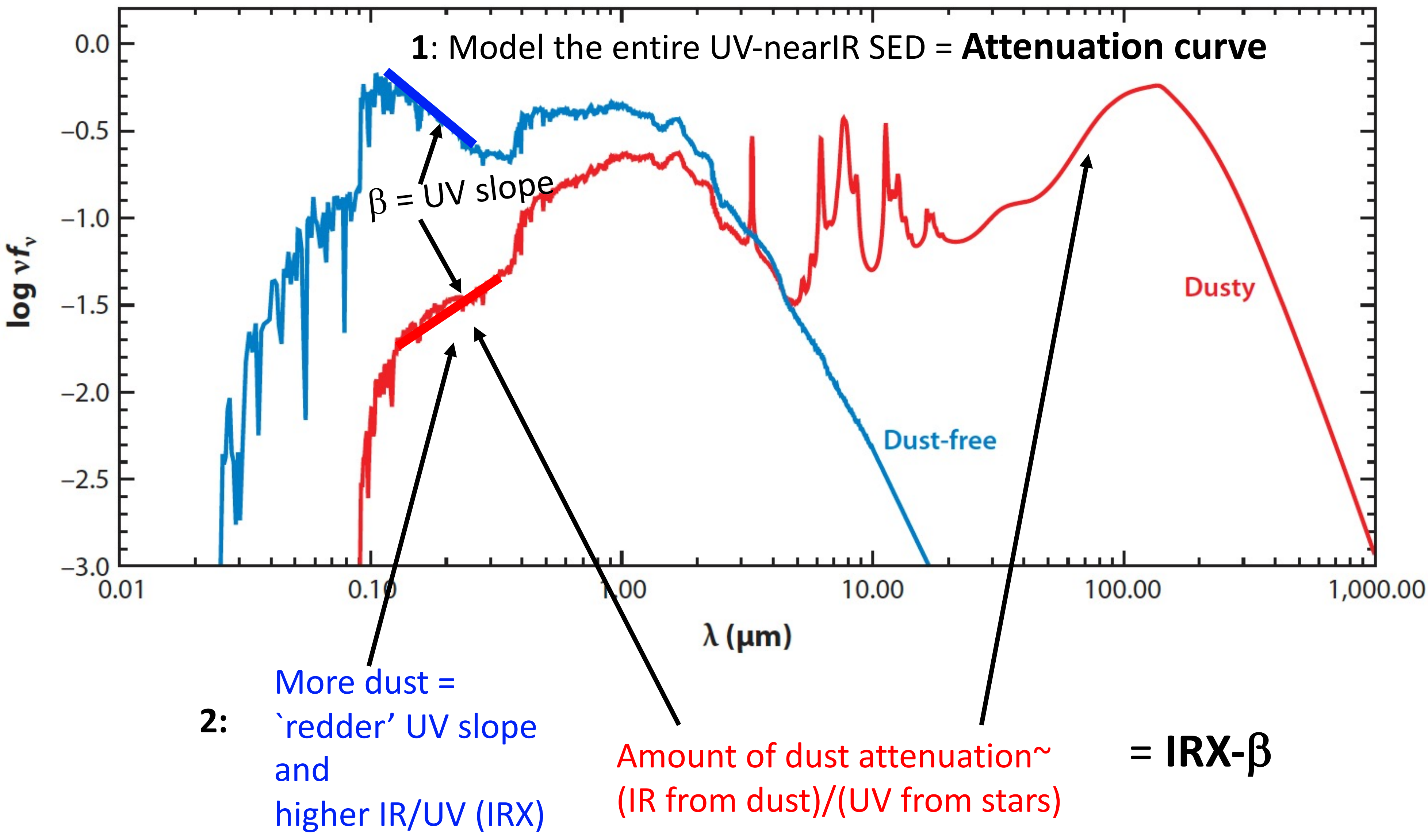
Madau & Dickinson 2014



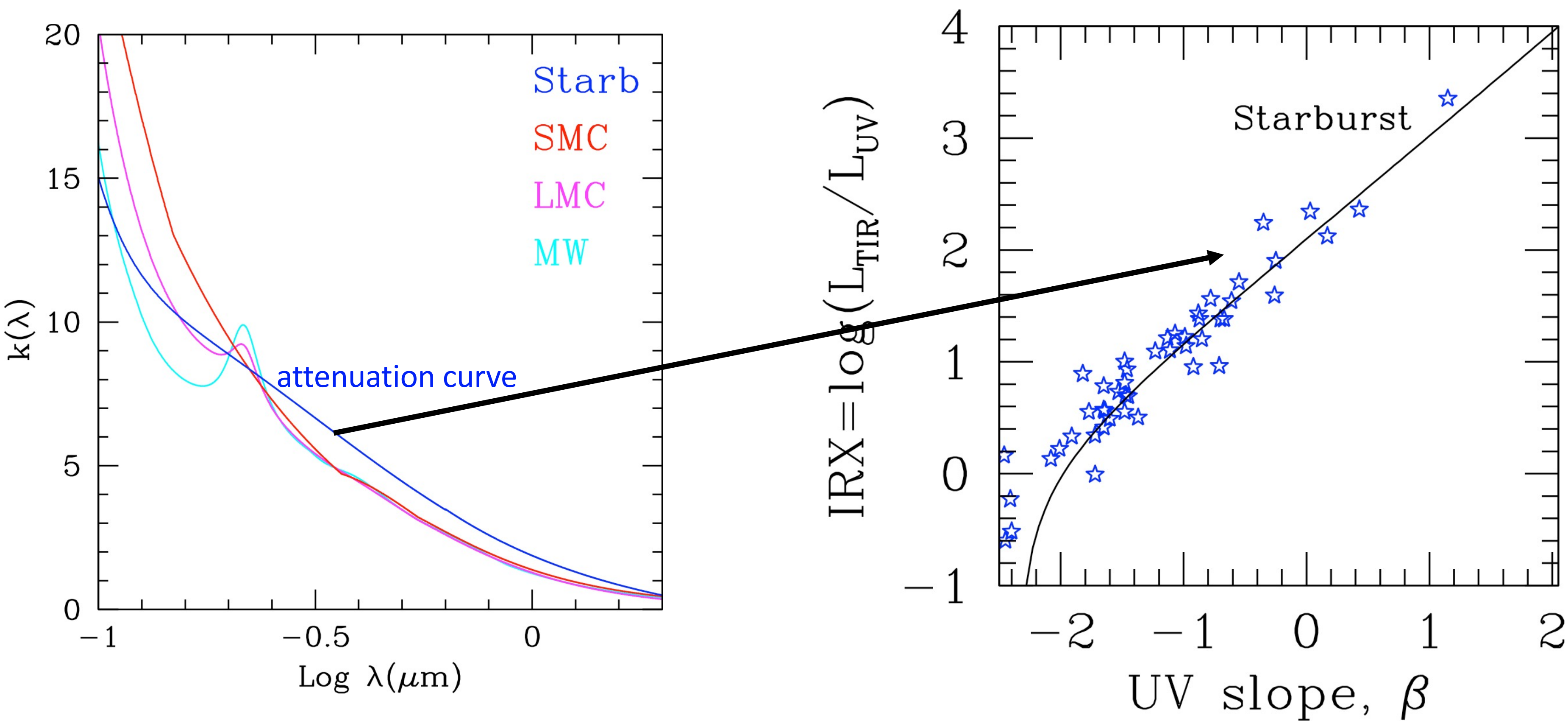
Zavala+2021

- Dusty galaxies become increasingly more prominent at high redshift, with a peak z~2
    - due to higher gas content than at low z, and higher metallicity than at higher z.
- Impact: 2-10x on SFR measurements; 1.2-3x on stellar mass estimates.
- Upcoming large surveys of galaxies with UV-nearIR SEDs (LSST, Roman, Euclid, JWST) will not benefit from matching rest-frame FIR measurements

The Effects of Dust: What can be Measured



Two tools: the attenuation curve and the IRX – β relation

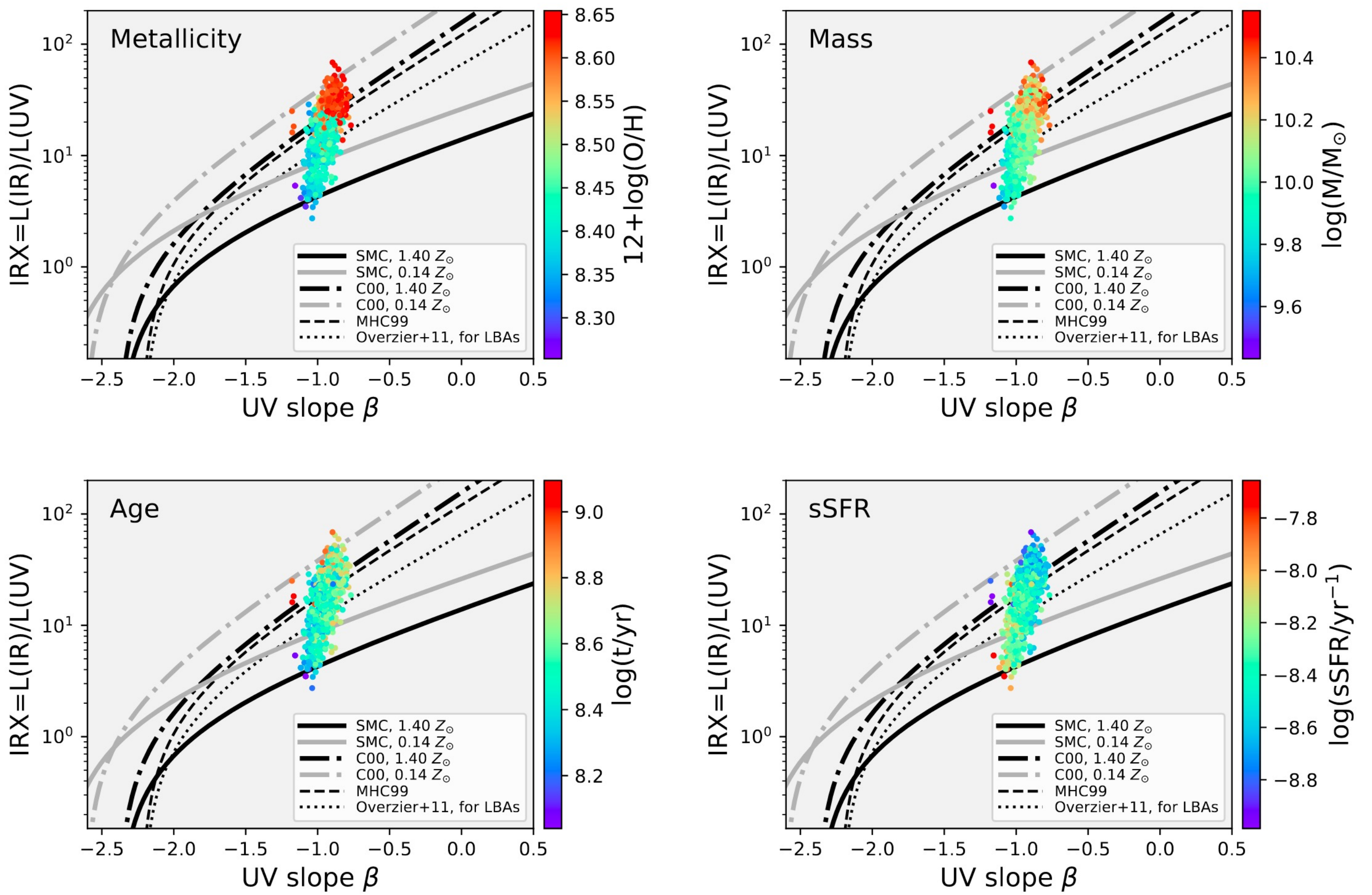


The two are connected: the attenuation curve applied to the UV-to-nearIR SED needs to reproduce the IRX-β relation.

Local starbursts mark a clear **sequence in the IRX-β plane.**

C+1994,1995,2000, Meurer+1999

Metallicity plays a role

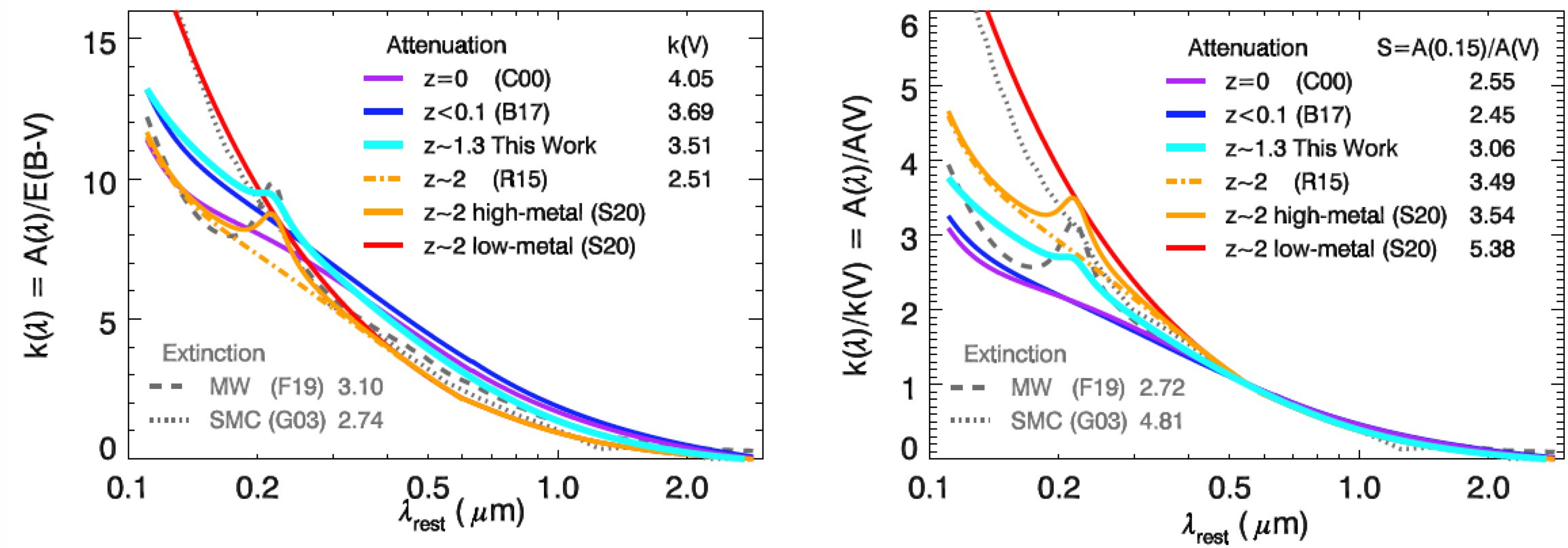


Shivaei+2020

At z~2, metal-rich star-forming galaxies tend to follow the canonical IRX-β relation, while metal-poor (12+log(O/H)<8.5) galaxies require steeper relations.

Additional Regularity/Systematic Trends?

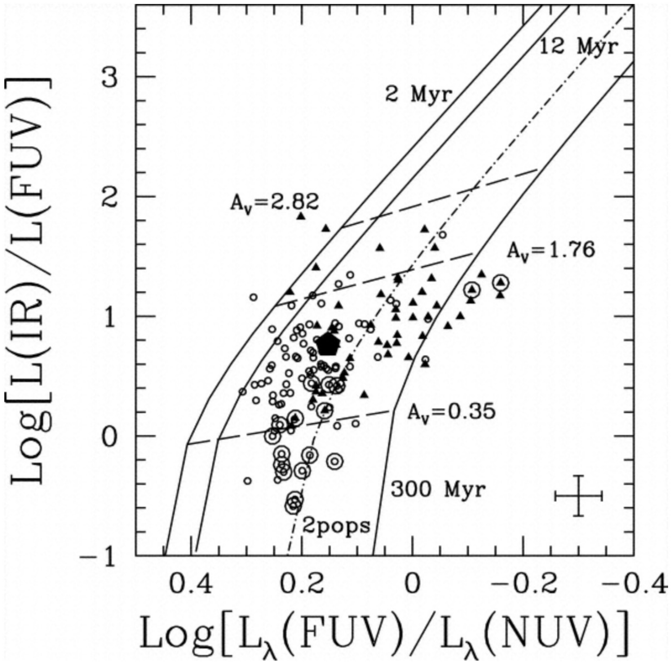
Battisti+2022, subm.



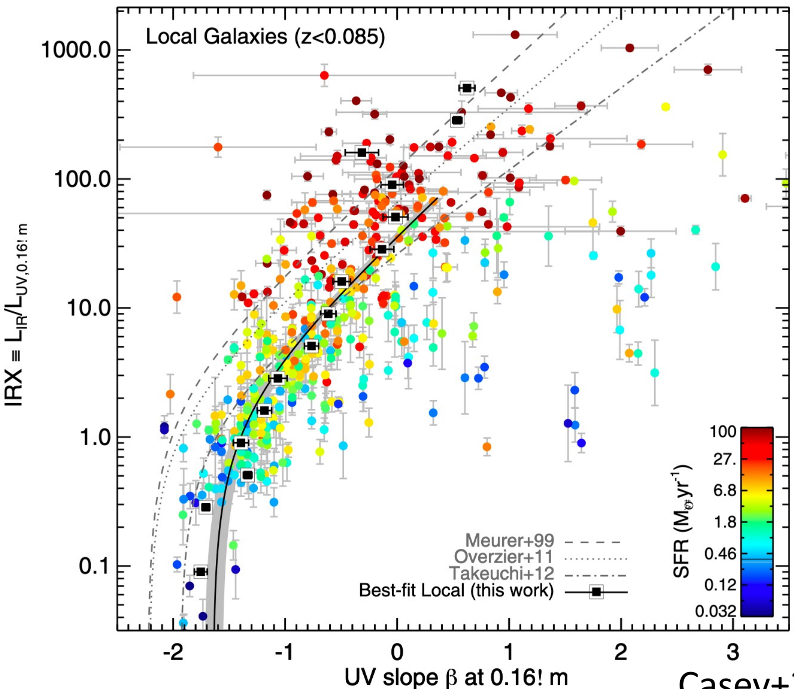
There appears to be a trend with redshift: the higher the redshift, the steeper the UV raise of the attenuation curve, plus the 2175 Å bump begins to become more prominent.

Based on multi-band photometry and spectroscopy: local starbursts, SDSS (z~0), WISP survey (z~1.2), 3D-HST survey (z~1.3), MOSDEF survey (z~2).

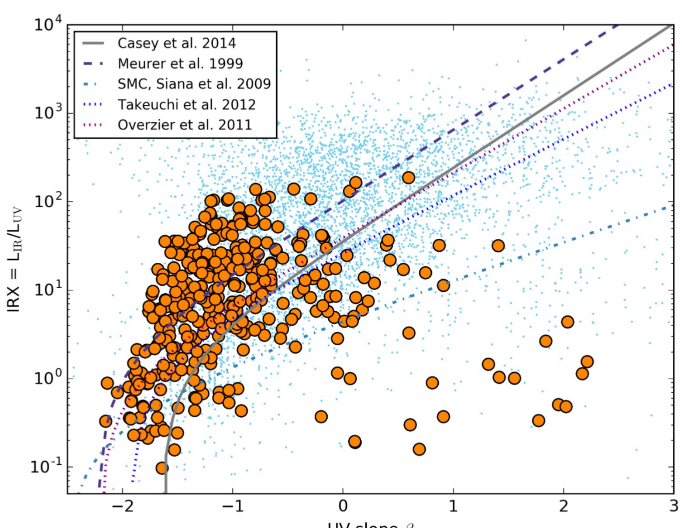
The Complexity of SFHs Likely Plays a Role



C+2005, models



Casey+2014, fit



Narayanan+2018, simulations; see, also, Liang+2020.

Use of multiple stellar populations in models helps explain the scatter in the IRX-β plane.

Roughly degenerate with changes in the extinction curve (except for `zero' point).

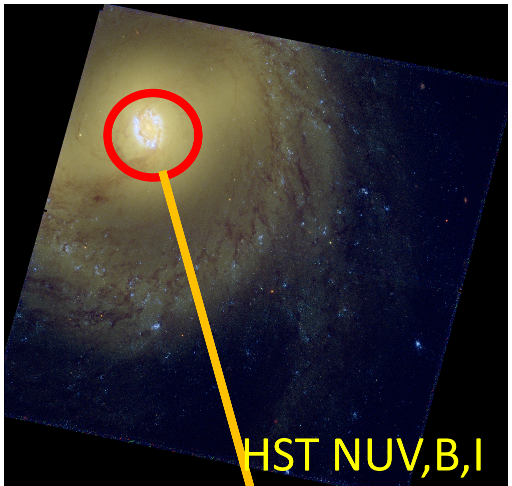
However, correlation does not prove causation. How do we prove it?

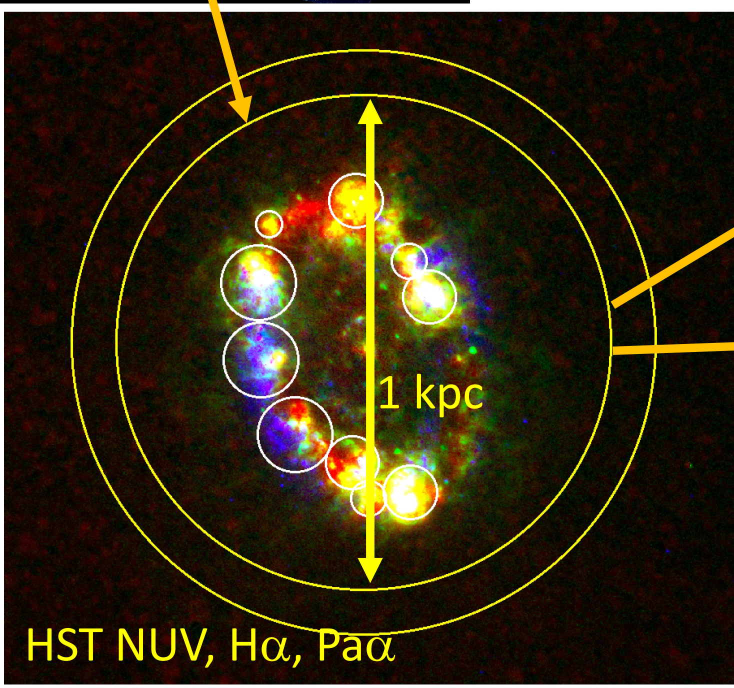
(see, also, Wijesinghe+2011)

Disentangling Star Formation History from Attenuation

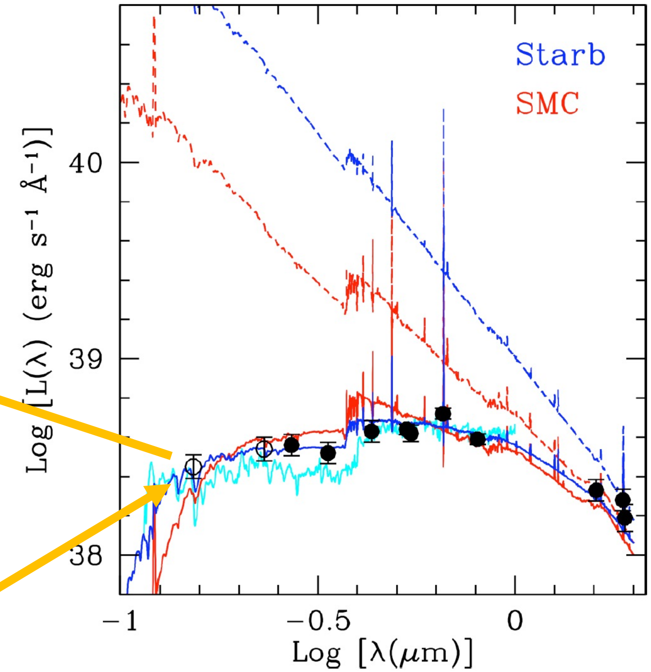
C+2021

NGC3351

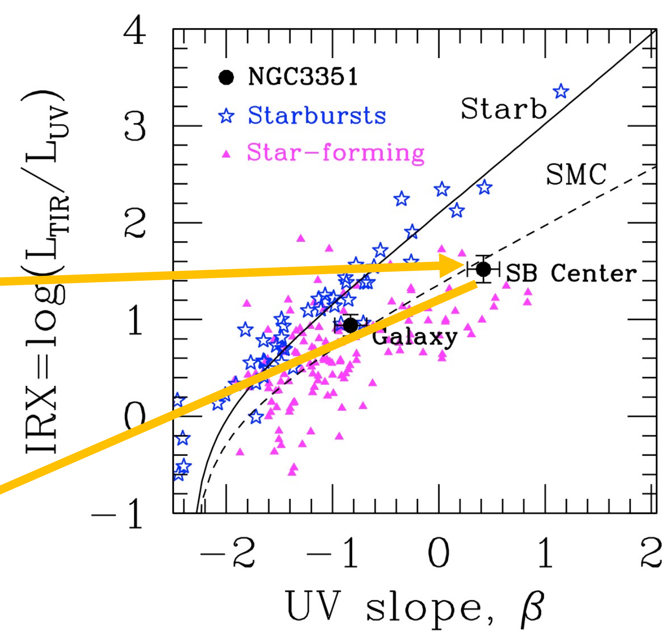




The UV-to-nearIR SED of the central region supports a starburst attenuation curve (blue line)

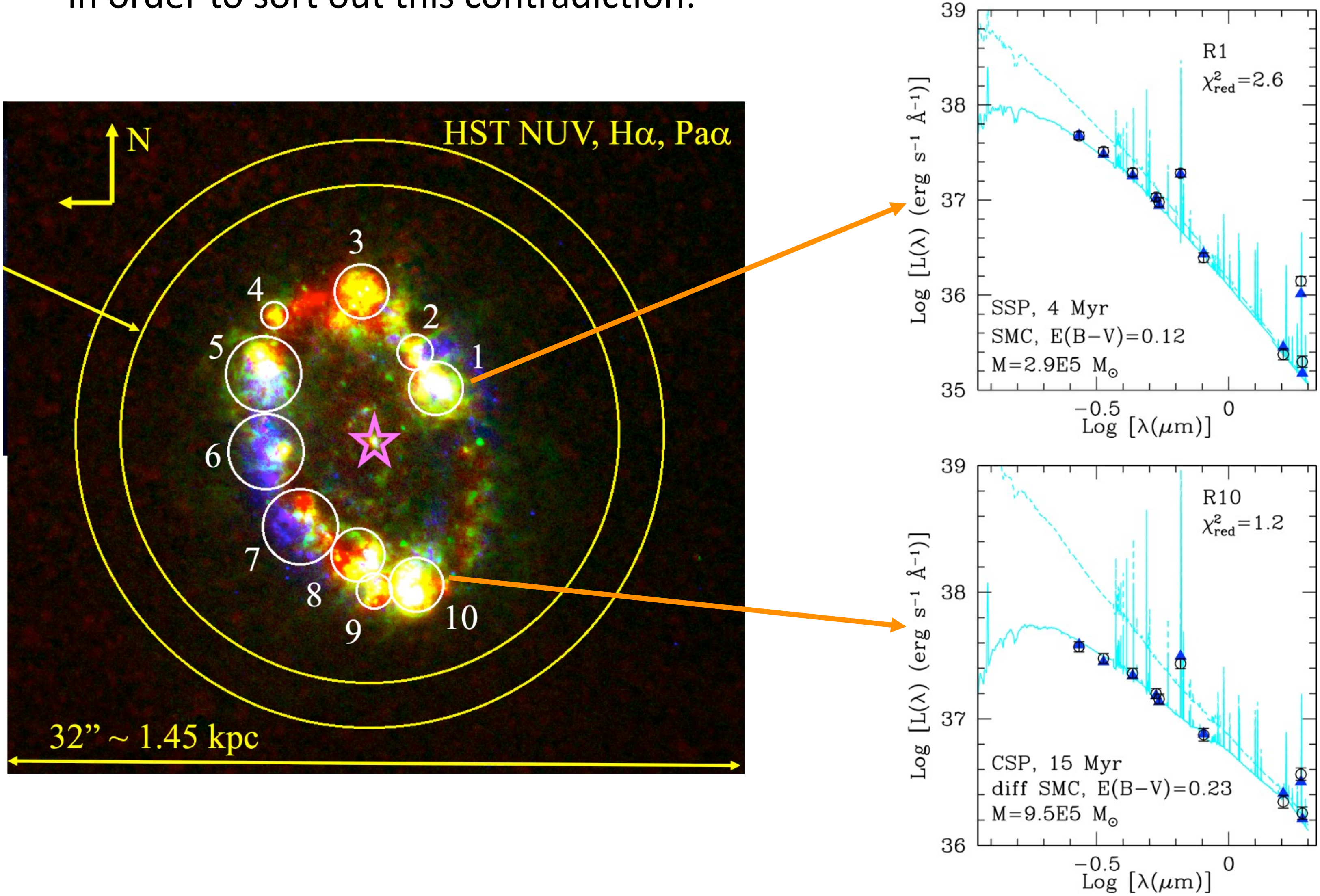


The IRX-beta better agrees with SMC extinction

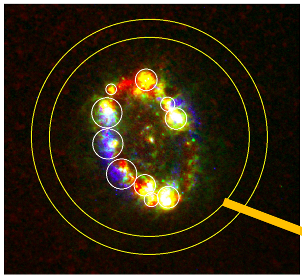


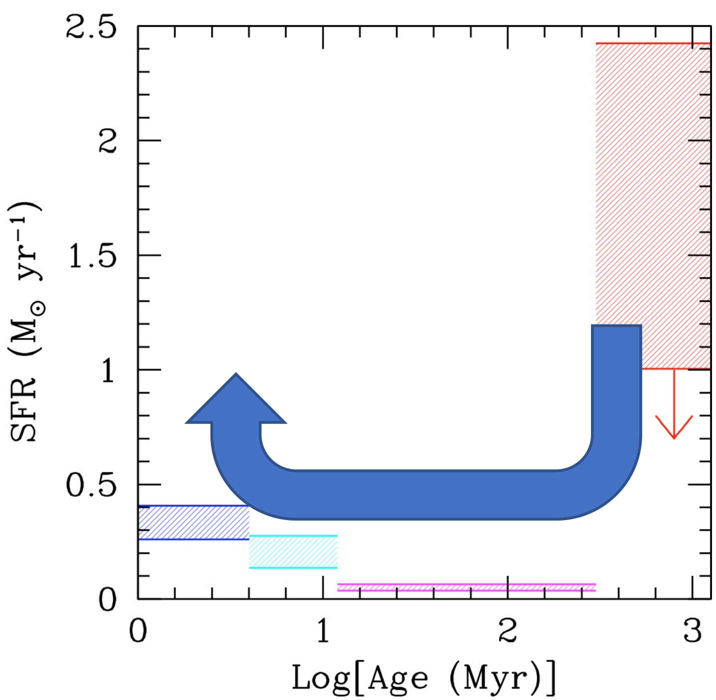
Disentangling Star Formation History/Attenuation

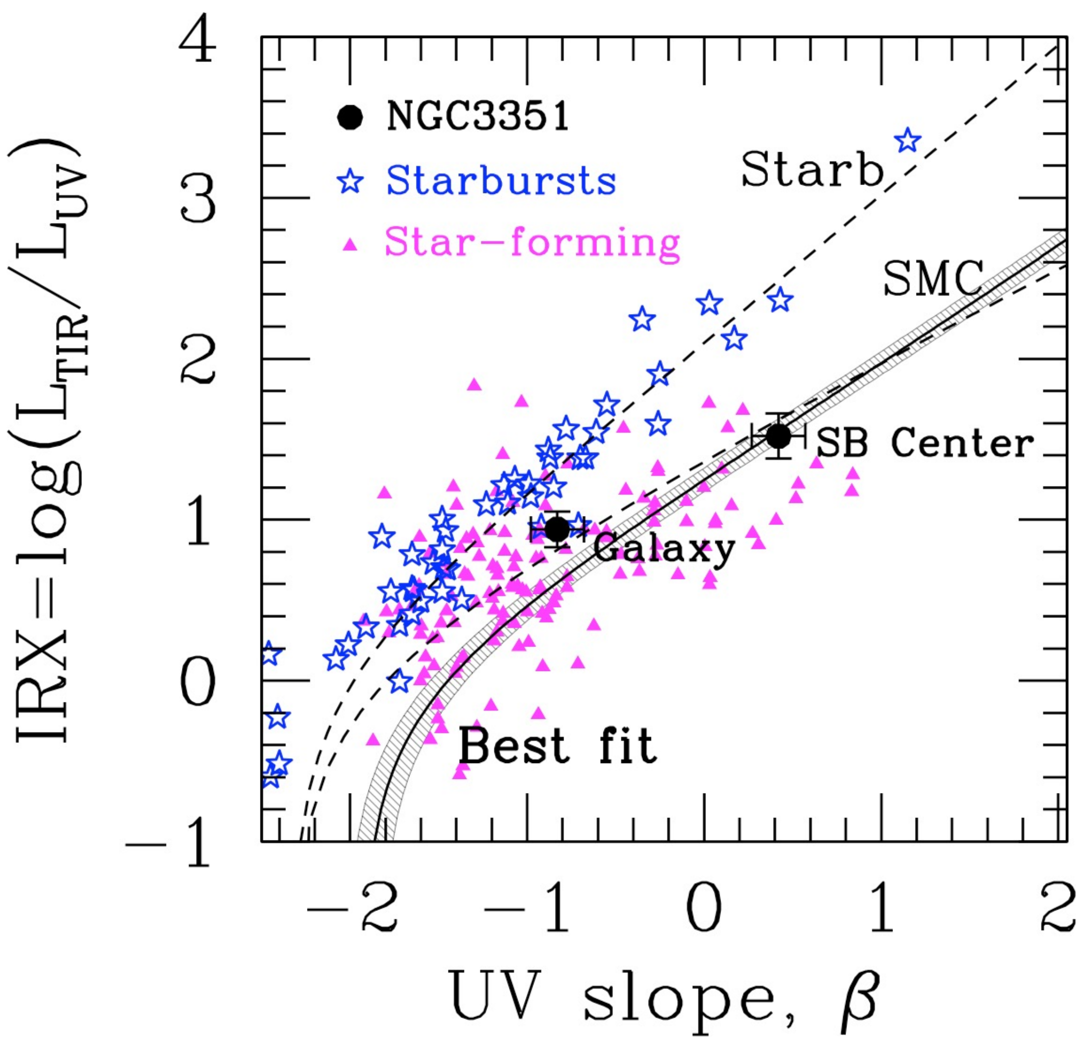
Let's determine the stellar populations and attenuation values of individual regions, in order to sort out this contradiction:



Disentangling Star Formation History/Attenuation





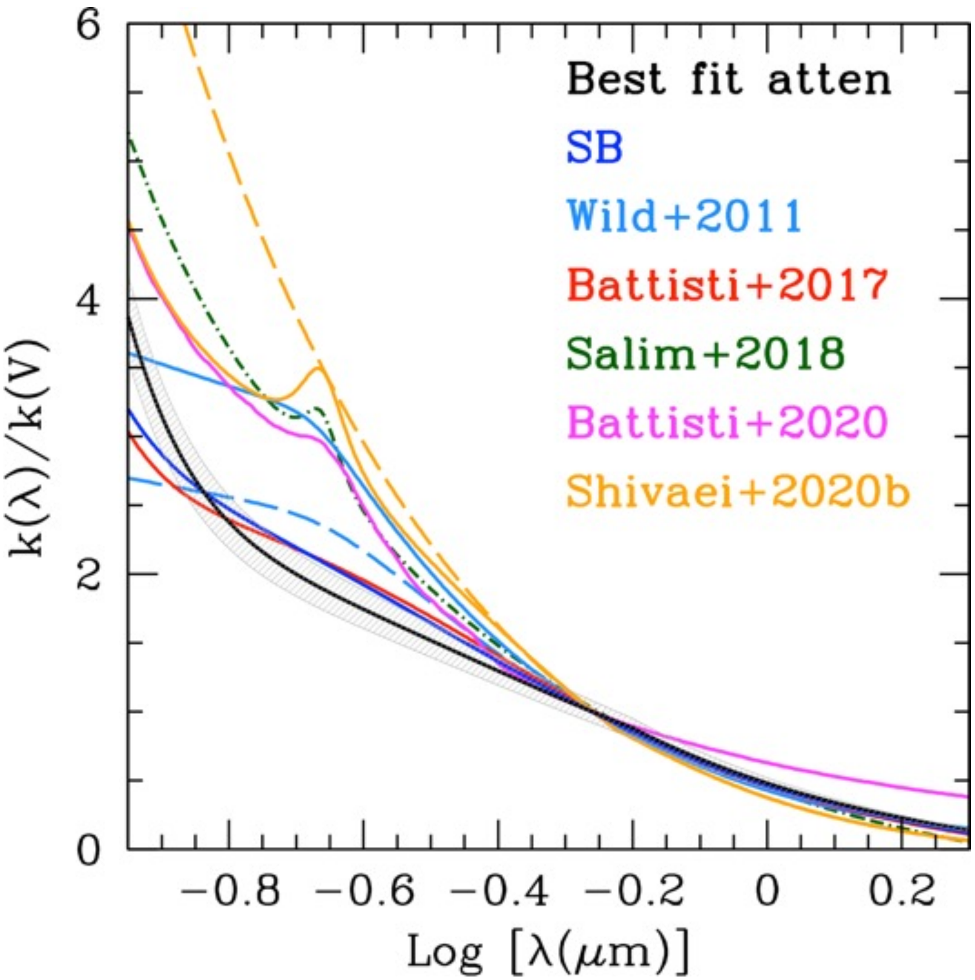


Non-monothonic SFH!

The star formation history has an outsized effect on the relation between attenuation and UV color, by determining the shape of the intrinsic UV SED.

Disentangling Star Formation History/Attenuation

What is the resulting `net' attenuation curve?



Only mildly steeper than the starburst attenuation curve.

HOWEVER, based on the location of the galaxy on the IRX-β plot, one would have guessed an attenuation curve closer to the Shivaei+2020b !!!

Compared with attenuation curves from the literature

CONCLUSIONS

- The degeneracy between the star formation history (SFH) and dust attenuation in determining **BOTH** the observed and **intrinsic** SEDs of galaxies has not been sufficiently explored, particularly for starbursts.
- Most modeling efforts of high redshift galaxy SEDs adopt monotonic SFHs, which may not be realistic in all cases. These are used to then derive attenuation curves and the properties of the galaxies.
- A detailed analysis of the nearby active galaxy NGC3351 indicates that its star formation history is the predominant effect in determining its offset from the IRX-β relation; its attenuation curve is close to a `starburst' one.
- As attenuation curves are mainly a product of geometry, we need to first understand how the stirring caused by the star formation activity affects the dust distribution in starburst galaxies. **On average**.
- More galaxies to come….