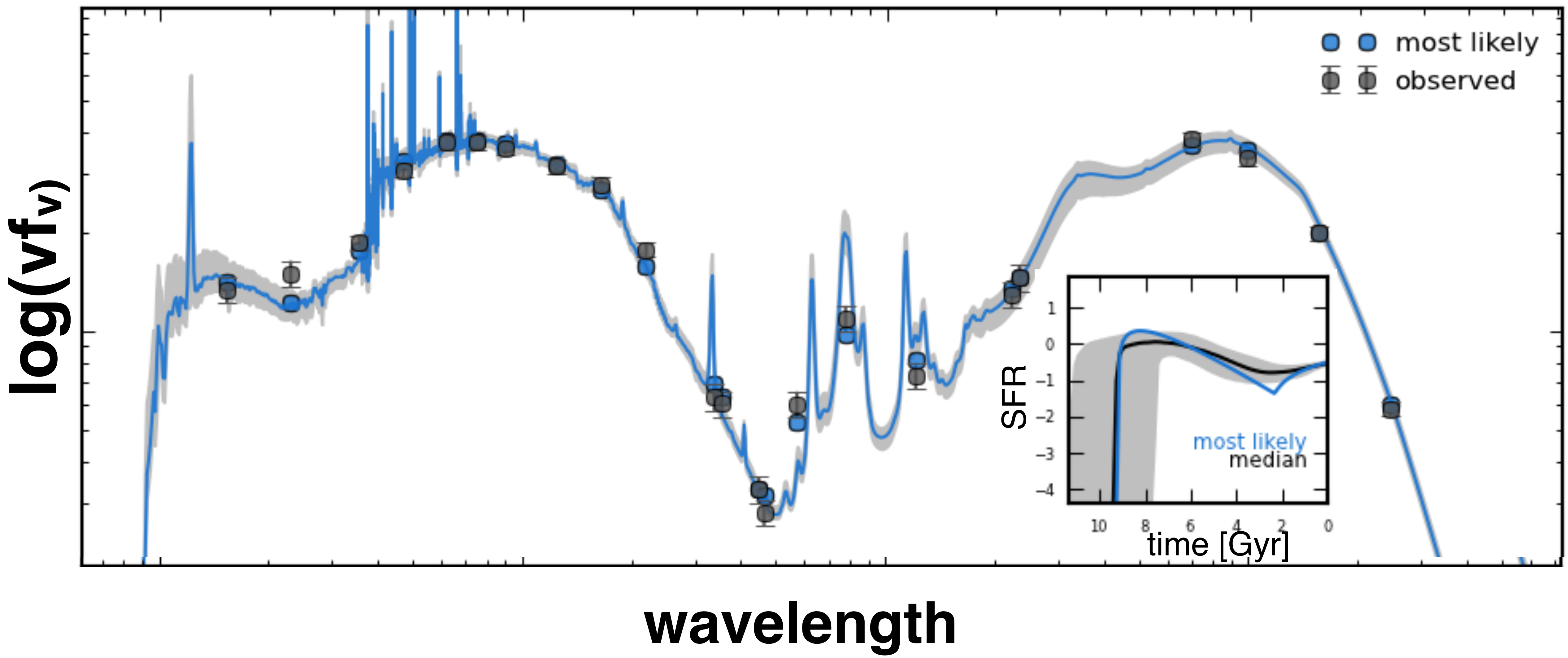
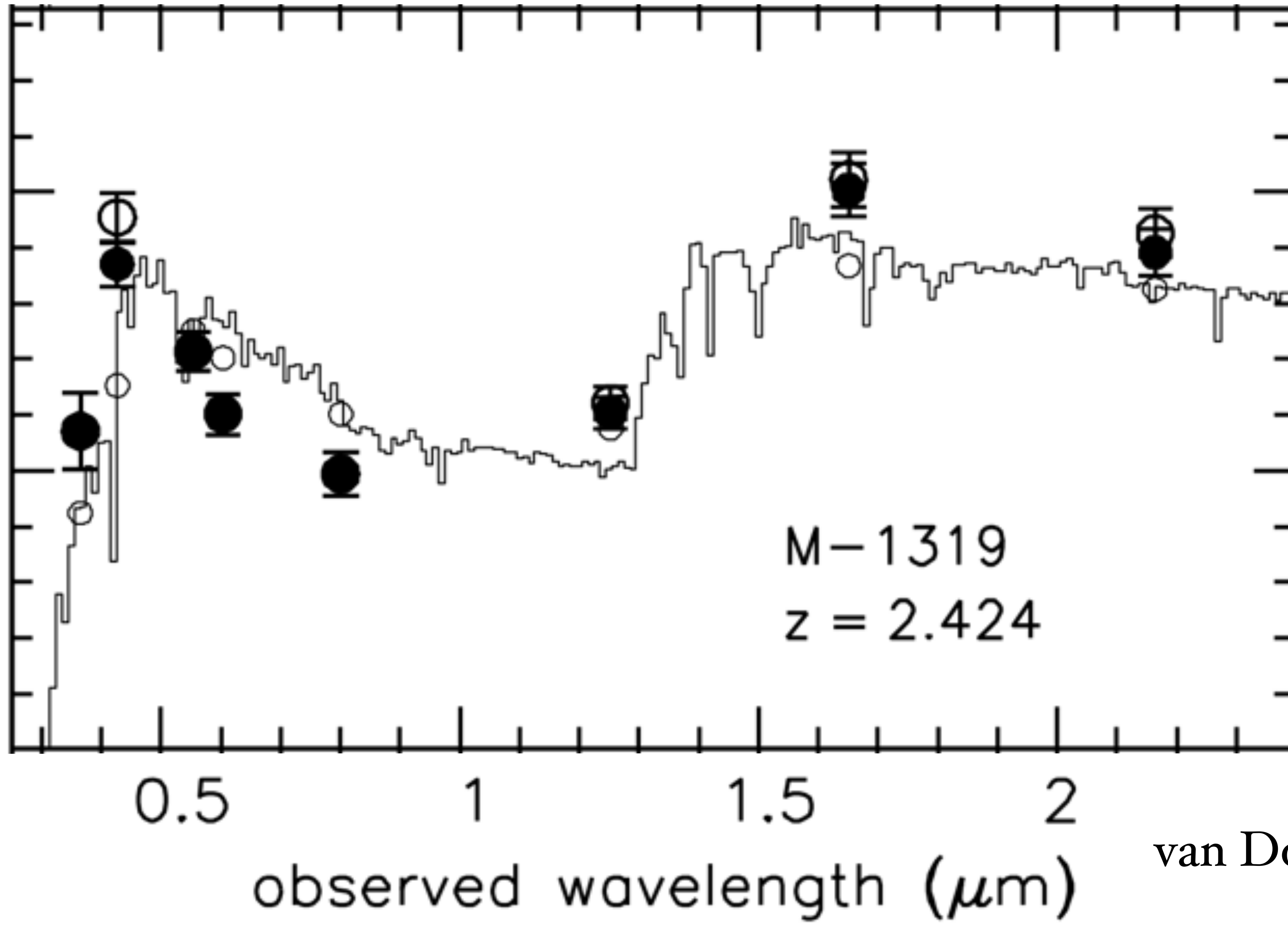
Extracting Accurate Physical Parameters From Broadband Photometry With a New Generation of SED Models



Joel Leja

(Yale University —> Harvard University)

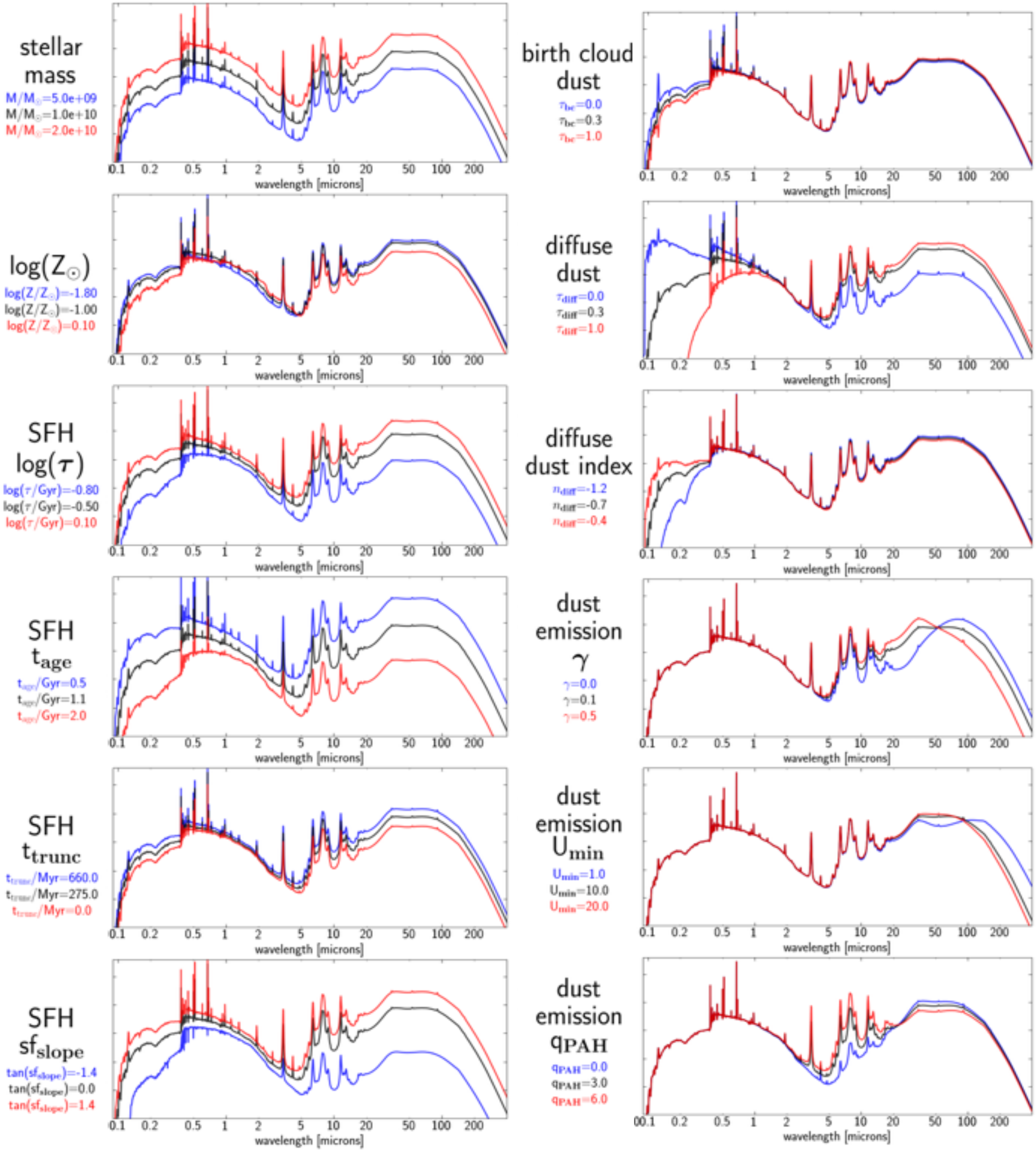
with Benjamin Johnson, Charlie Conroy, and Pieter van Dokkum



van Dokkum et al. 2004

Id	$\log \tau$ yr	A_V mag	$\log \mathrm{SFR}$ $M_\odot\,\mathrm{yr}^{-1}$	$\log M_*$ $M_\odot$
M–1319	$9.4^{+0}_{-0.3}$	$1.3^{+0.1}_{-0.1}$	$2.39^{+0.09}_{-0.04}$	$11.68^{+0.08}_{-0.08}$

Simple SED models can result in **misleading error bars** and **biased parameters**



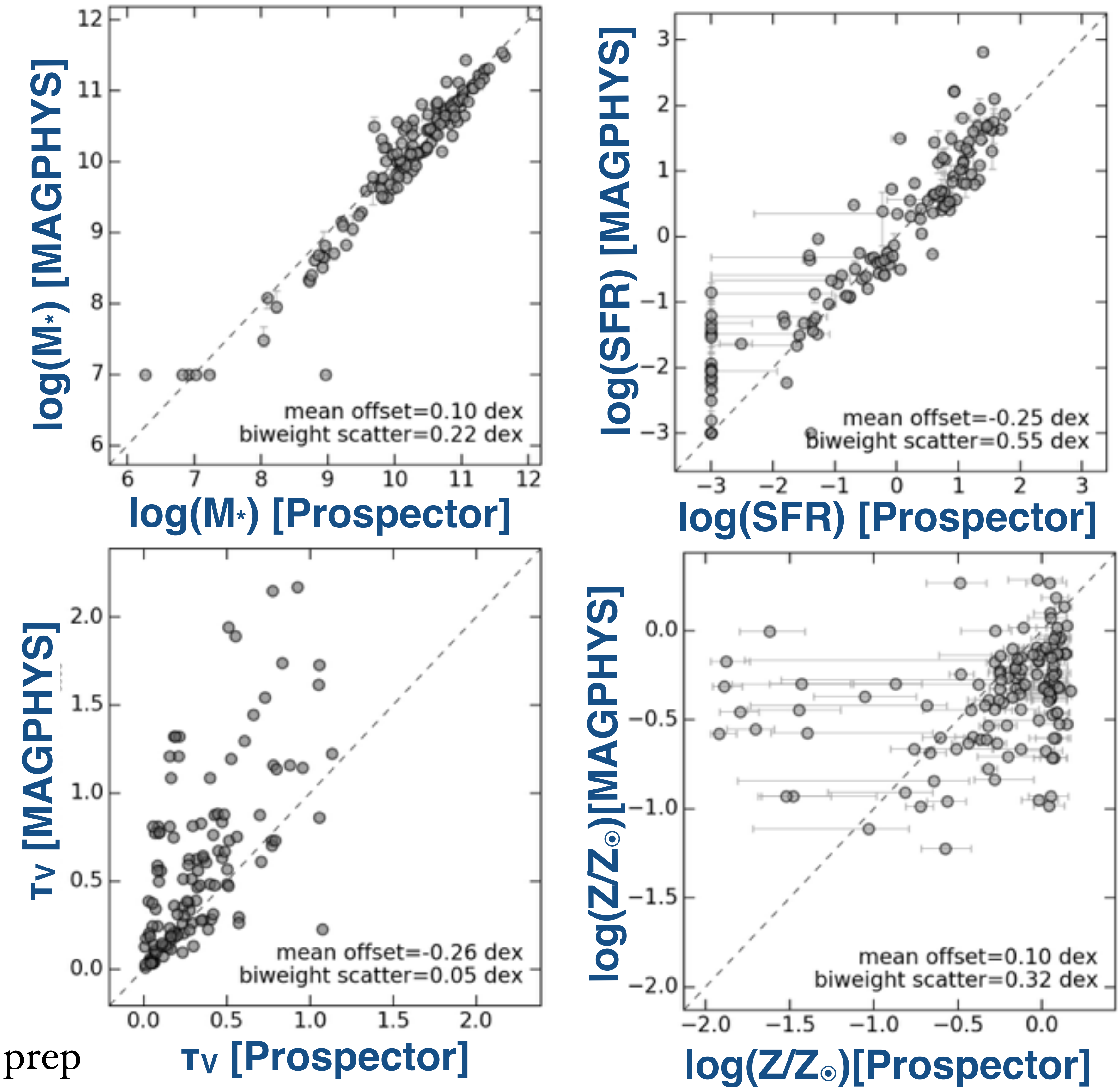
Galaxies are **complex**

Many parameters control the observed SED

Highly degenerate problem when fitting broadband photometry

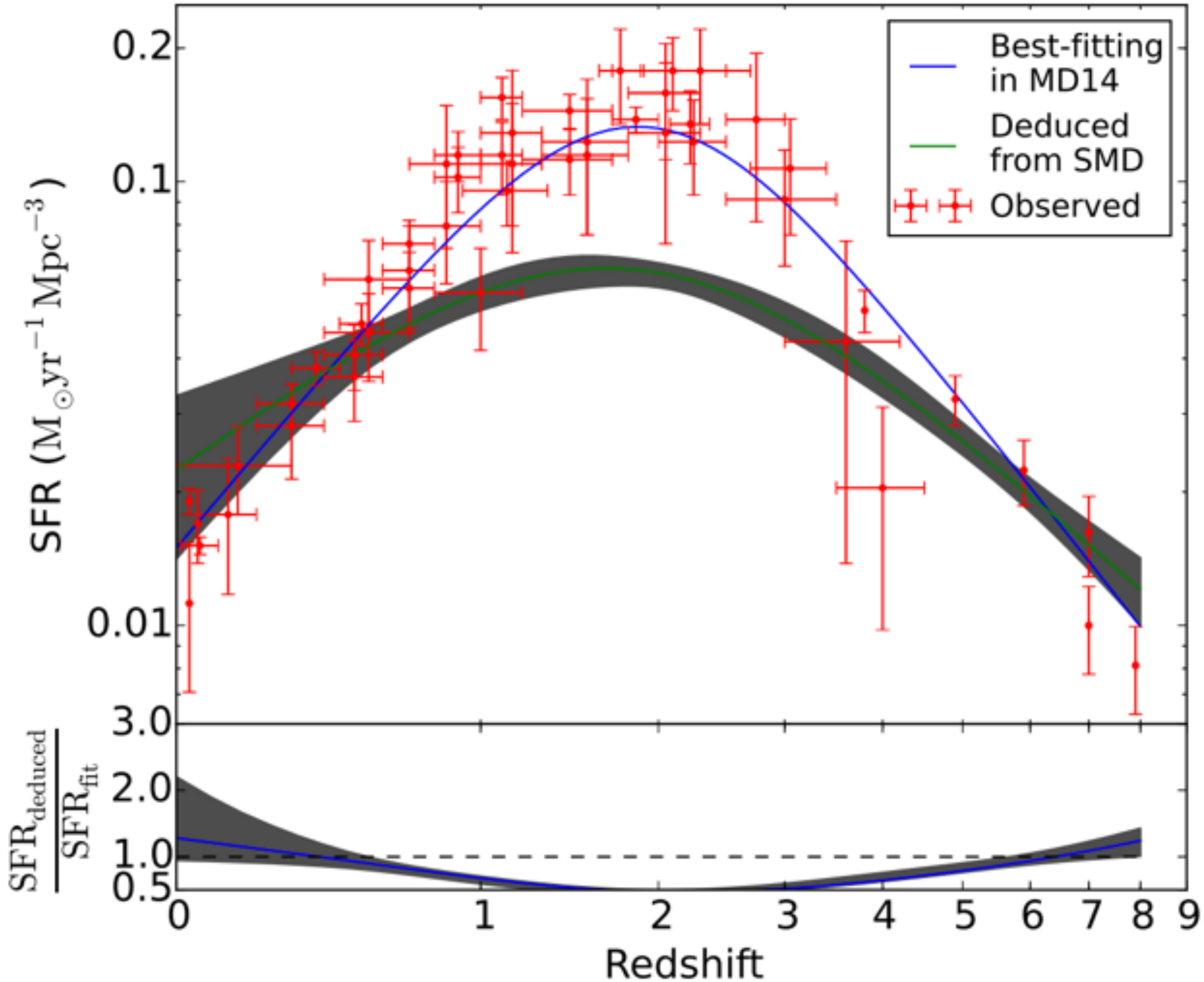
Leja et al. 2016 in prep

Two fitters with **reasonable** but **different** implementations can produce **drastically different** galaxy properties



Leja et al. 2016 in prep

in addition to model-to-model scatter, mass and SFR estimates **systematically disagree** by ~2x!



Yu & Wang 2016

It is **not yet possible** for models to fully match both the observed SFRs and the observed stellar mass function!

also see Leja+14, Madau+14, Genel+14, Tomczak+15, Davé+16, and many others...!

Inference Framework

Prospector, maintained by Ben Johnson

- **On-the-fly** stellar population generation allows flexibility + high dimensionality
- **Bayesian statistics** with transparent + easily customizable priors
- **MCMC ensemble sampling** with the emcee python package
- **fits photometry + spectroscopy** with flexible noise modeling
- **see poster #18** for more information

Stellar Population Synthesis

FSPS, maintained by Charlie Conroy

- performs **fast, accurate, state-of-the-art** stellar population synthesis

Leja et al. in prep Model

11 parameters + normalization

Stars

SFH (4 parameters)
flexible, allows for bursts and quenching (Simha+14)

Stellar Metallicity (1 parameter)
metallicity distribution function

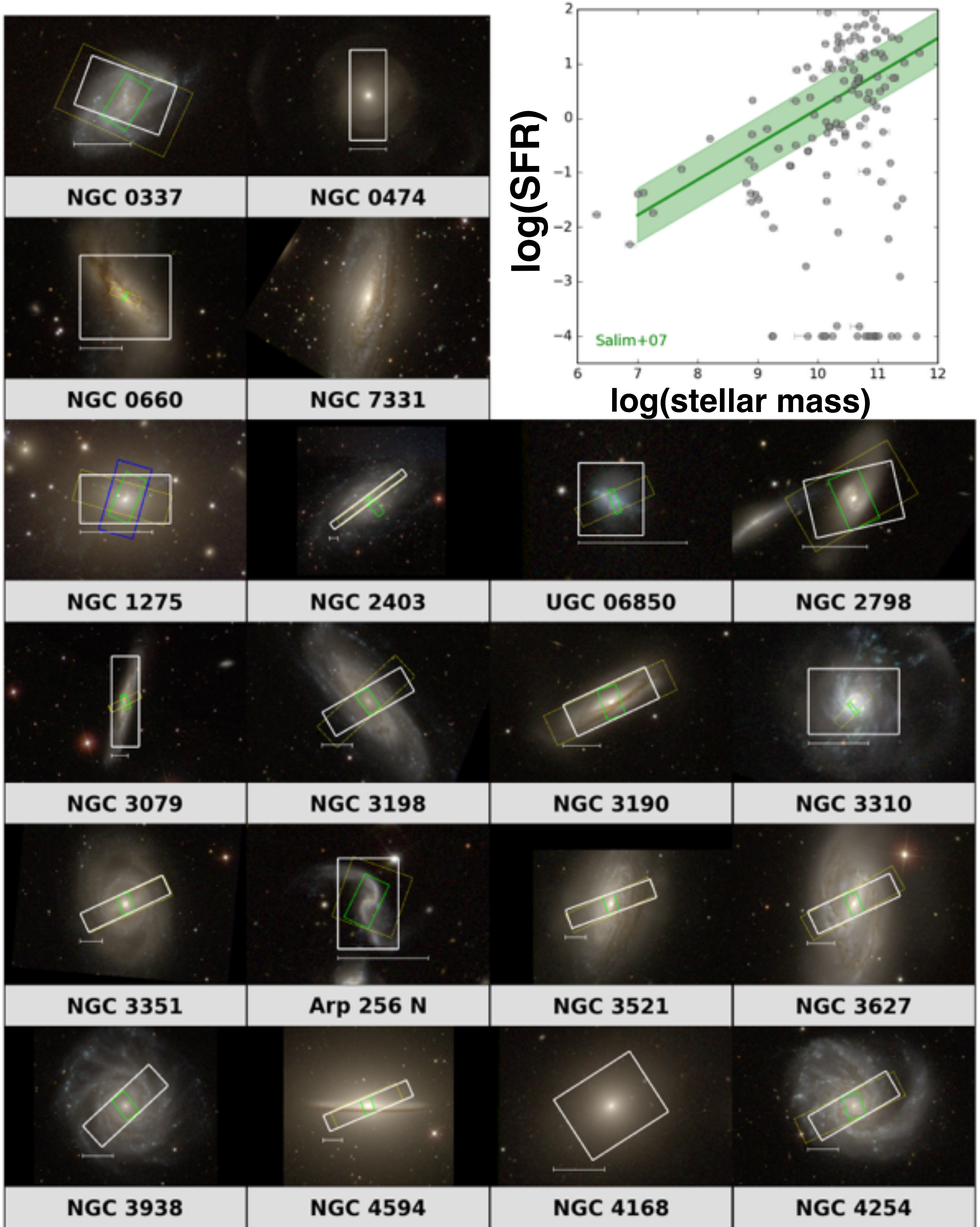
Dust

Attenuation (3 parameters)
two-component Charlot & Fall model with variable attenuation curve

Emission (3 parameters)
Draine & Li (2007) model and circumstellar dust

Gas

CLOUDY grids (0 parameters)
nebular line and continuum emission



Test Sample

- **129 z=0 galaxies** from Brown et al. 2014.
- **GALEX to *Spitzer* 24 µm** broadband imaging, +subsample have Herschel imaging
- **Optical spectroscopy**, aperture-matched to photometry
- **Eclectic mix** of stellar masses, sSFRs, and galaxy morphologies.

Leja et al. 2016 in prep

Model H_α compared to observed H_α

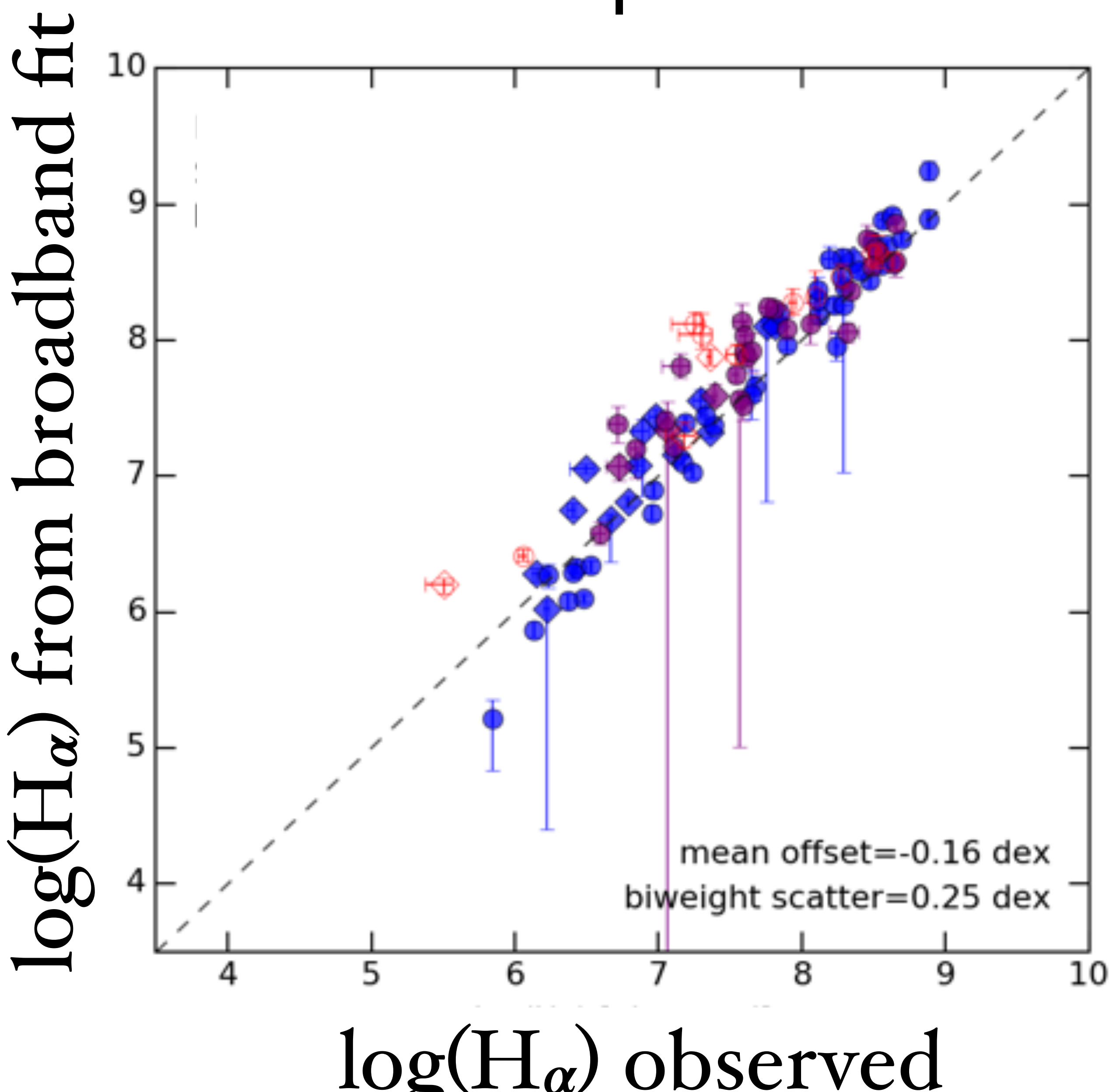
calculated from the Kennicutt+98 conversion between H_α and SFR

tests **model dust attenuation** and **model SFR**

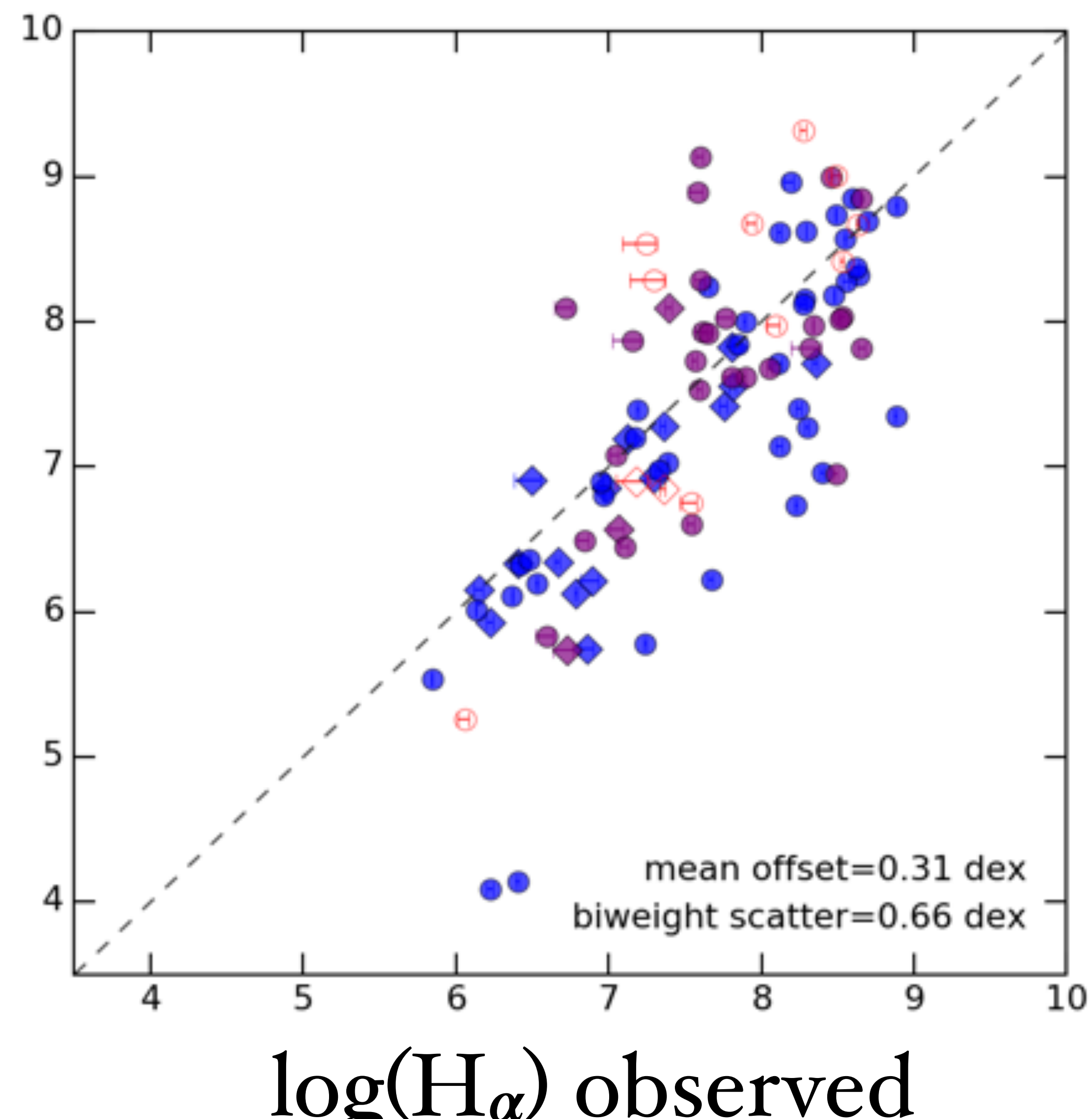
legend

star-forming
composite
AGN

Prospector



public version of MAGPHYS



Leja et al. 2016 in prep

Model H_α compared to observed H_α

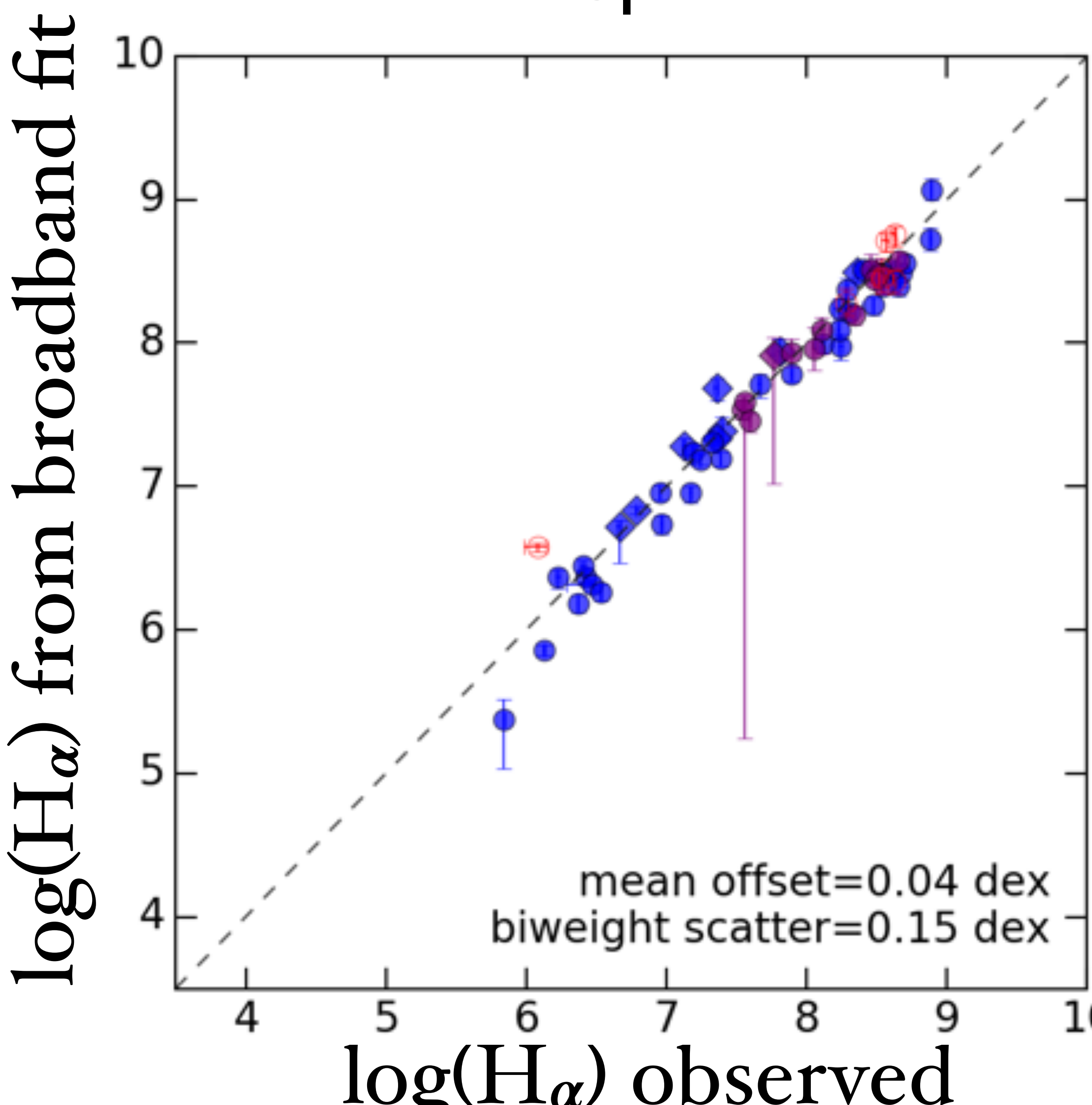
using built-in CLOUDY H_α flux

legend

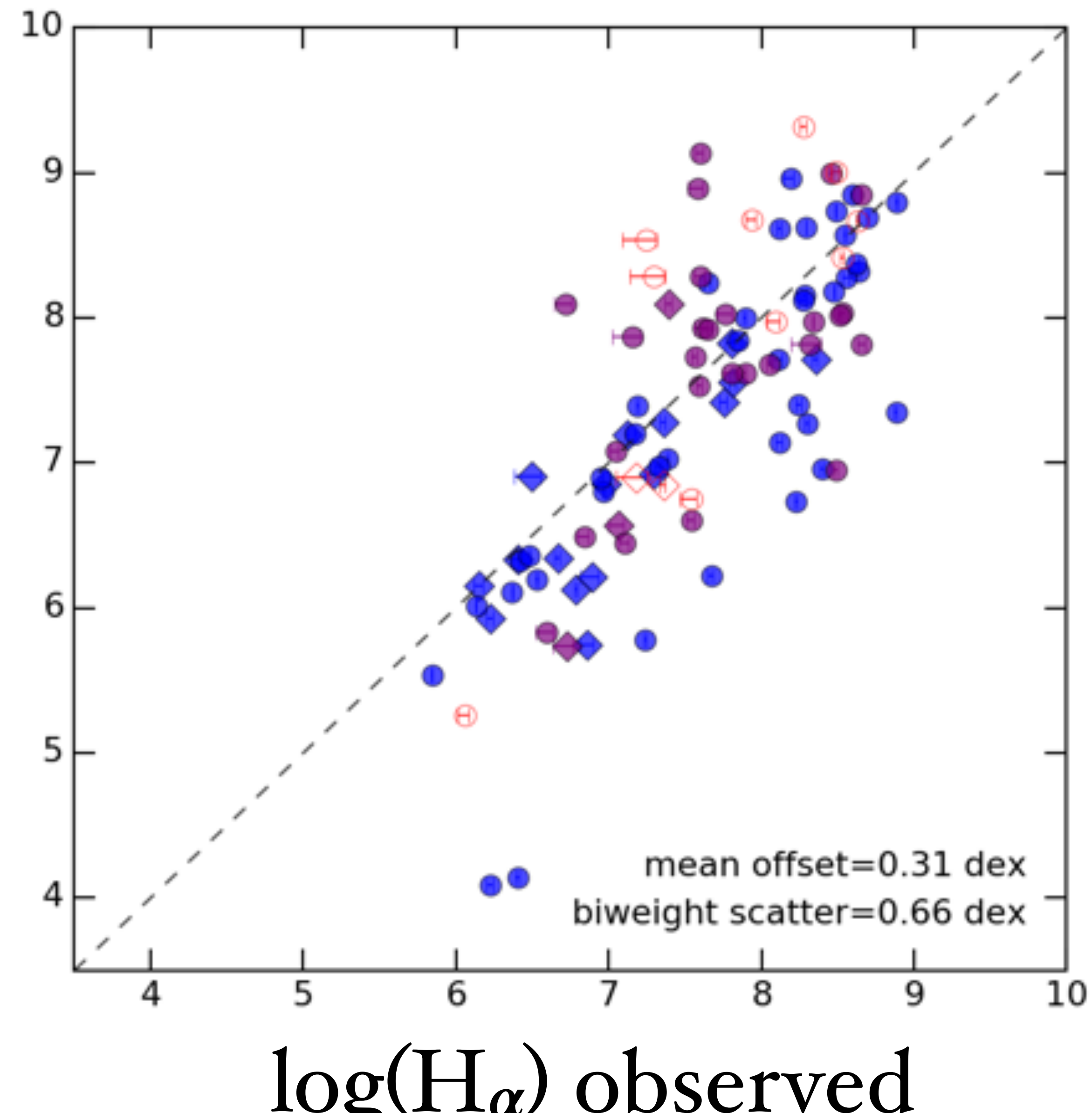
star-forming
composite
AGN

integrates ionizing UV flux from model, adding information about **stellar metallicity**

Prospector



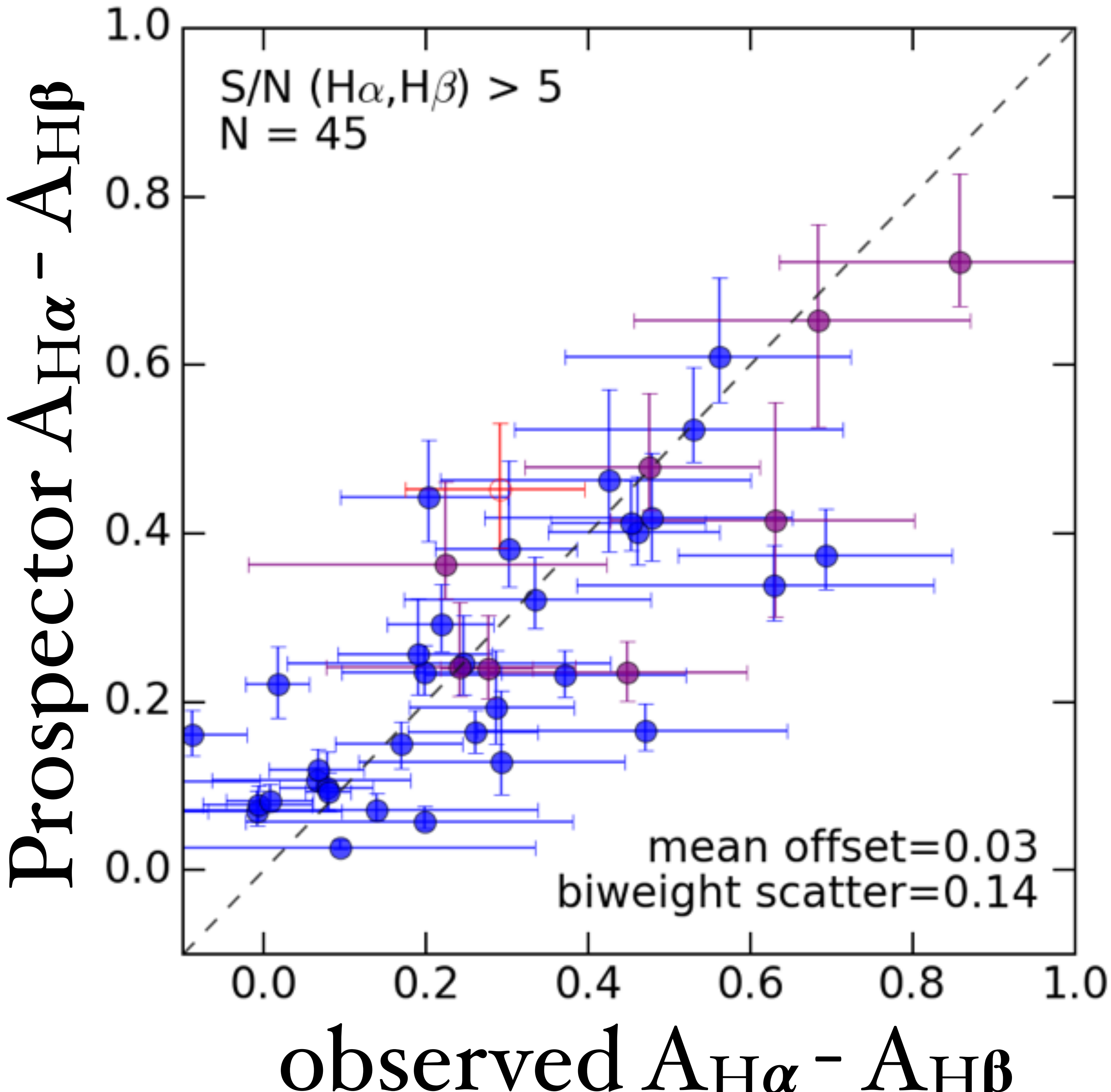
public version of MAGPHYS



Leja et al. 2016 in prep

Dust Attenuation Towards HII Regions

from the observed Balmer decrement

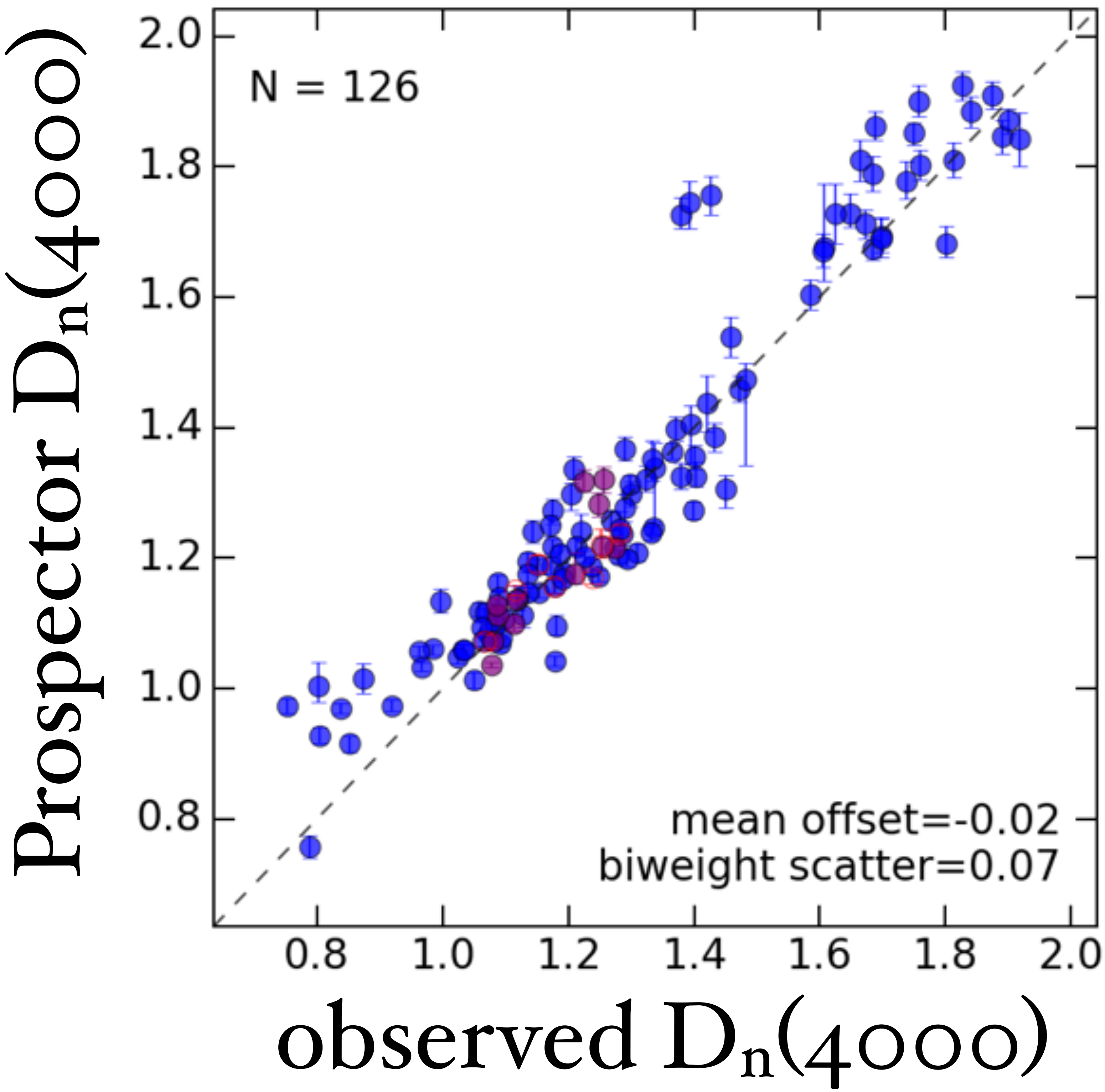


star-forming
composite
AGN

Leja et al. 2016 in prep

The $D_n(4000)$ Break

test of stellar age and metallicity

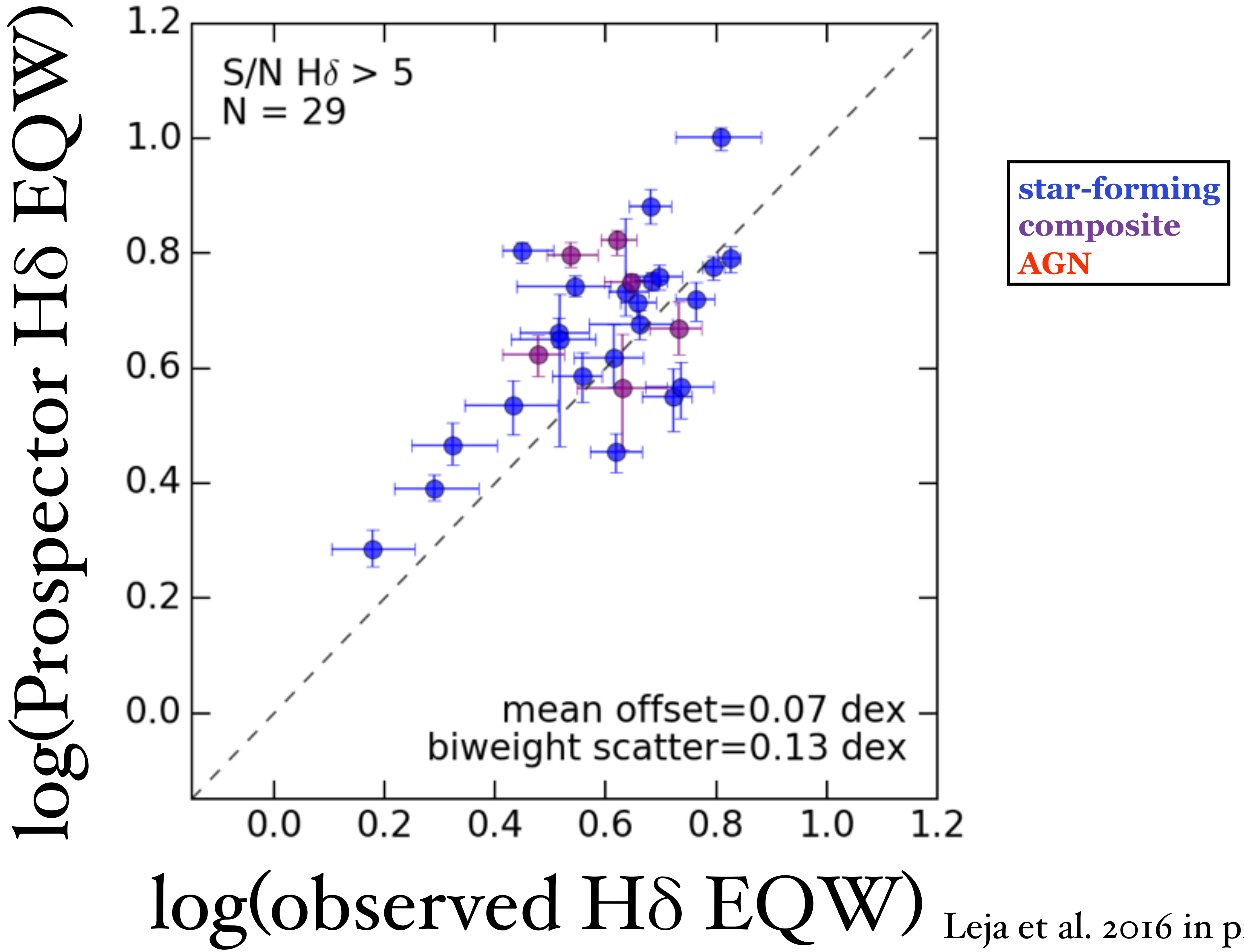


star-forming
composite
AGN

Leja et al. 2016 in prep

Hδ Absorption

test of stellar age



Leja et al. 2016 in prep

We built a galaxy SED model that fits broadband photometry to predict **H$_\alpha$ luminosities** with both **high accuracy** and **precision**

in addition to H$_\alpha$, we investigate and validate the following quantities:

- dust PAH mass fractions
- Hδ absorptions
- $D_n(4000)$
- nebular attenuation
- stellar metallicities
- dust attenuation curves

The Future

simultaneous, self-consistent derivation of **stellar masses(z)** and **star formation rates(M,z)**

— new values? new consistency?