Relative merits of different types of multi-wavelength observations to constrain galaxy physical parameters

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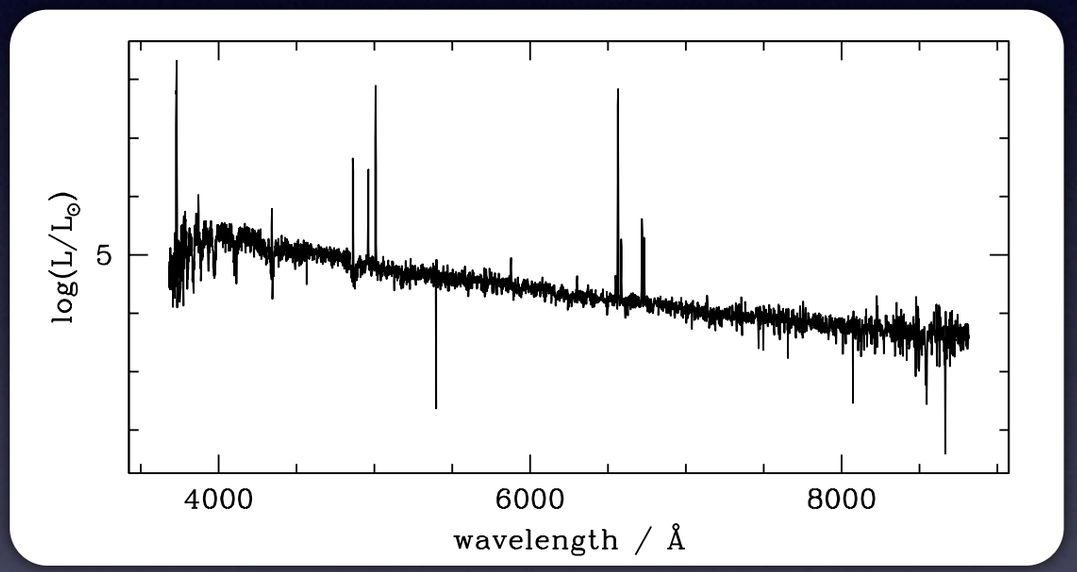
Outline

- Motivation
- Modeling approach
- Example of constraints on galaxy physical parameters
- Assess relative merits of different types of observations to constrain some main parameters
- Current and future applications (e.g. UV emission of high-redshift galaxies)

Motivation

characterize physical properties of galaxies from their light

- observations at different cosmic epochs
- using different types of multi-wavelength observations



- stellar mass
- SF history
- metallicity
- .....

quantify the accuracy to which physical parameters can be extracted from various photometric and spectroscopic observations

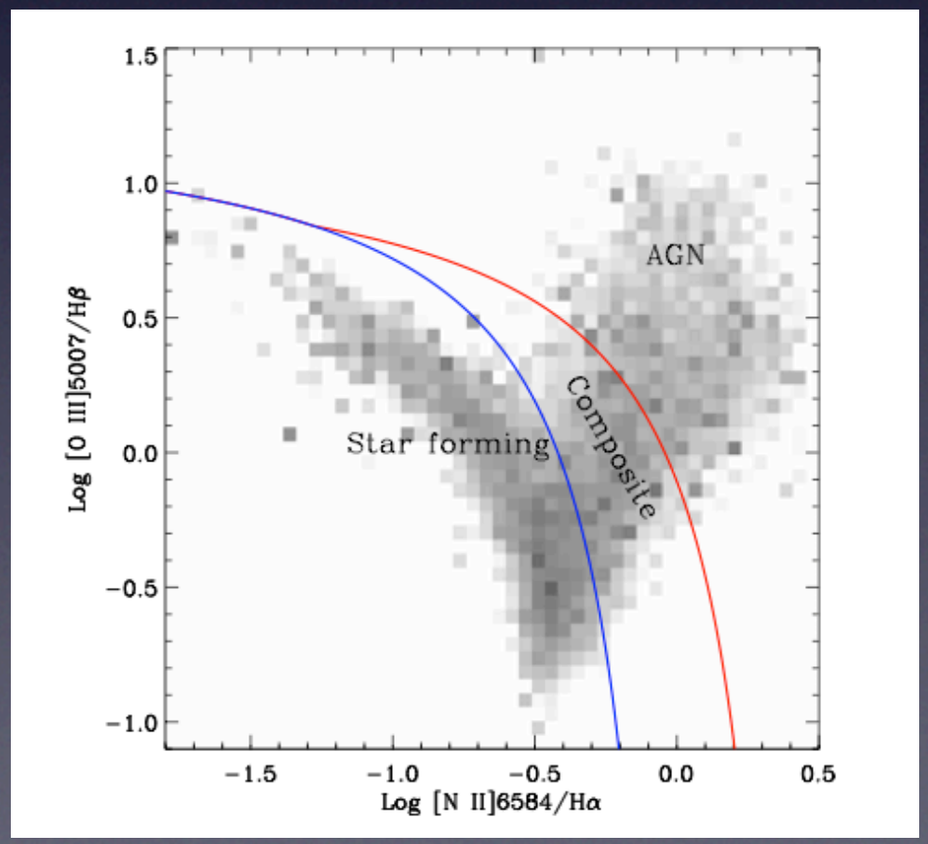
Modeling

required to relate observables to physical parameters

build library of galaxy spectra which reproduce a wide range of observables

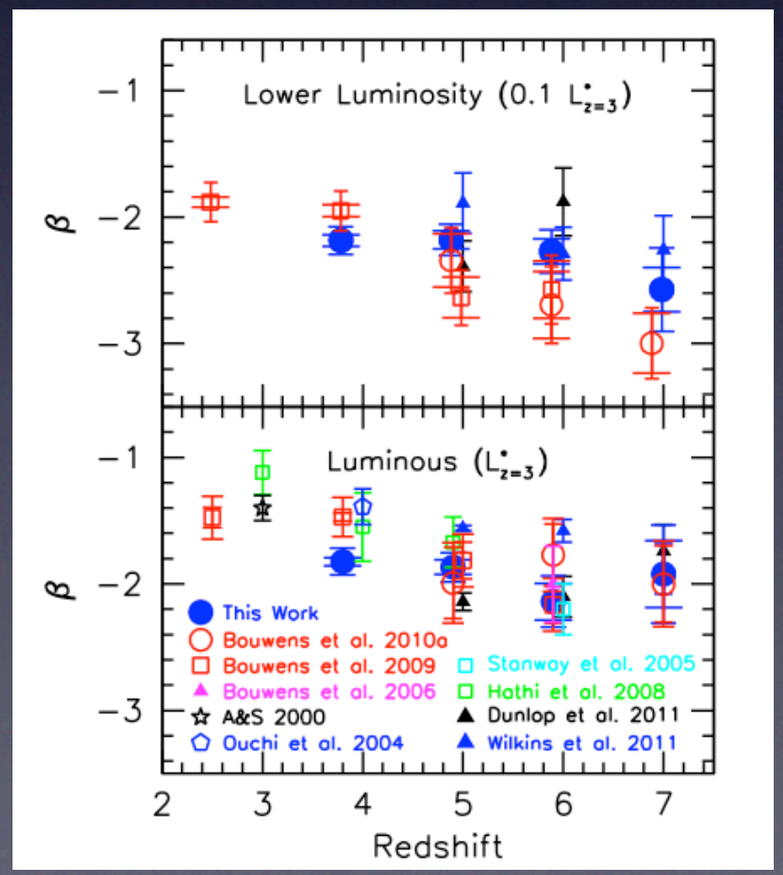
optical properties of local galaxies (SDSS)

Brinchmann et al. (2004)



UV properties of high-redshift galaxies (HST)

Bouwens et al. (2011)



Modeling

required to relate observables to physical parameters

build library of galaxy spectra which reproduce
a wide range of observables

Appeal to state-of-the-art models to include:

- physically motivated SF and chemical enrichment histories (from simulations)
- latest progress in the spectral modeling of stellar populations
- contamination of stellar emission by nebular emission
- recent prescriptions for attenuation by dust

(comprehensive range of parameters to account for models uncertainties)

State-of-the-art modeling

A

SF and chemical enrichment histories

+

B

- stellar emission
- nebular emission
- dust attenuation

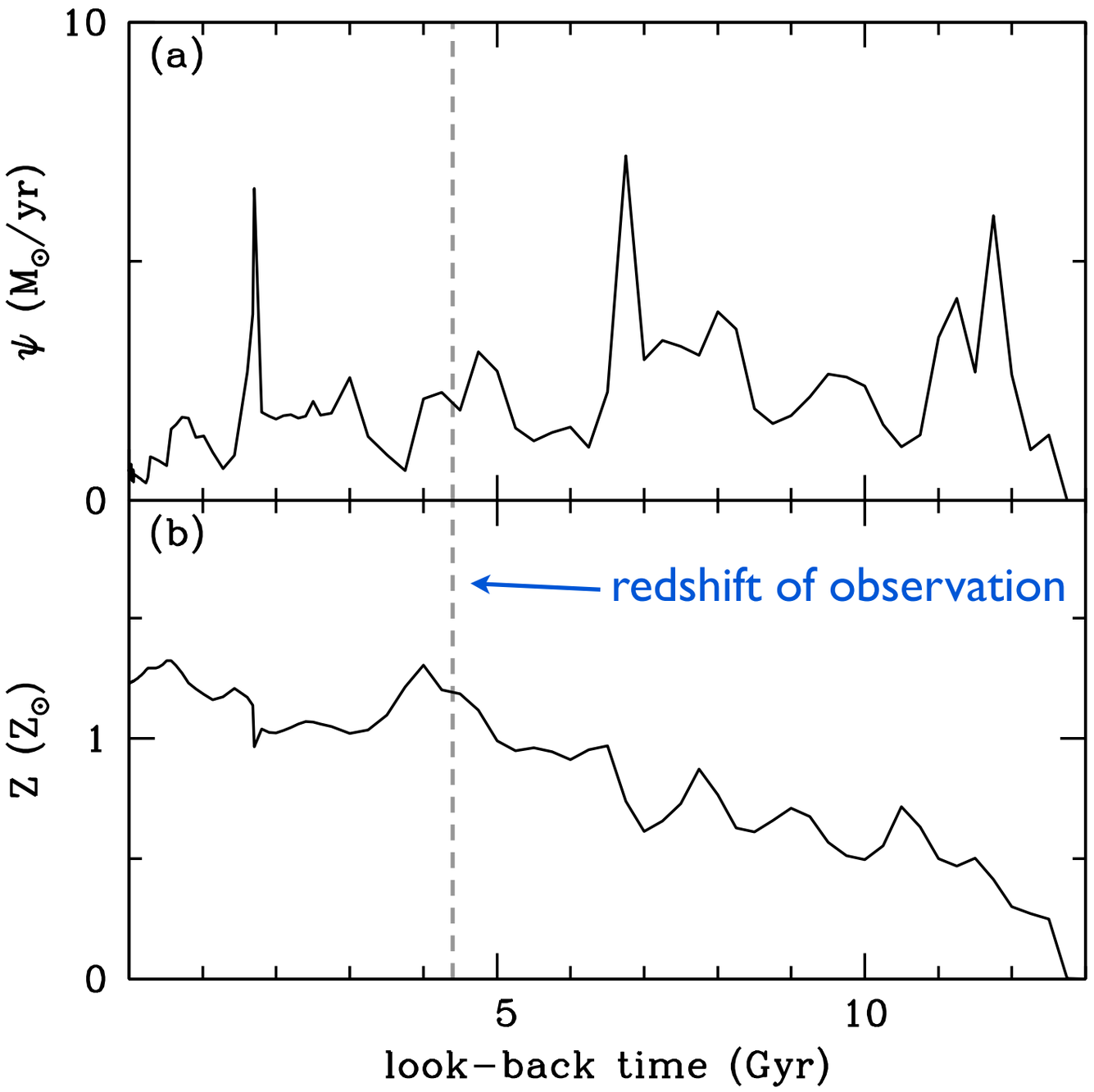
=

C

galaxy spectra

used to estimate physical parameters from multi-wavelength observations

Library of SF and chemical enrichment histories



semi-analytic post-processing of the Millennium Simulation

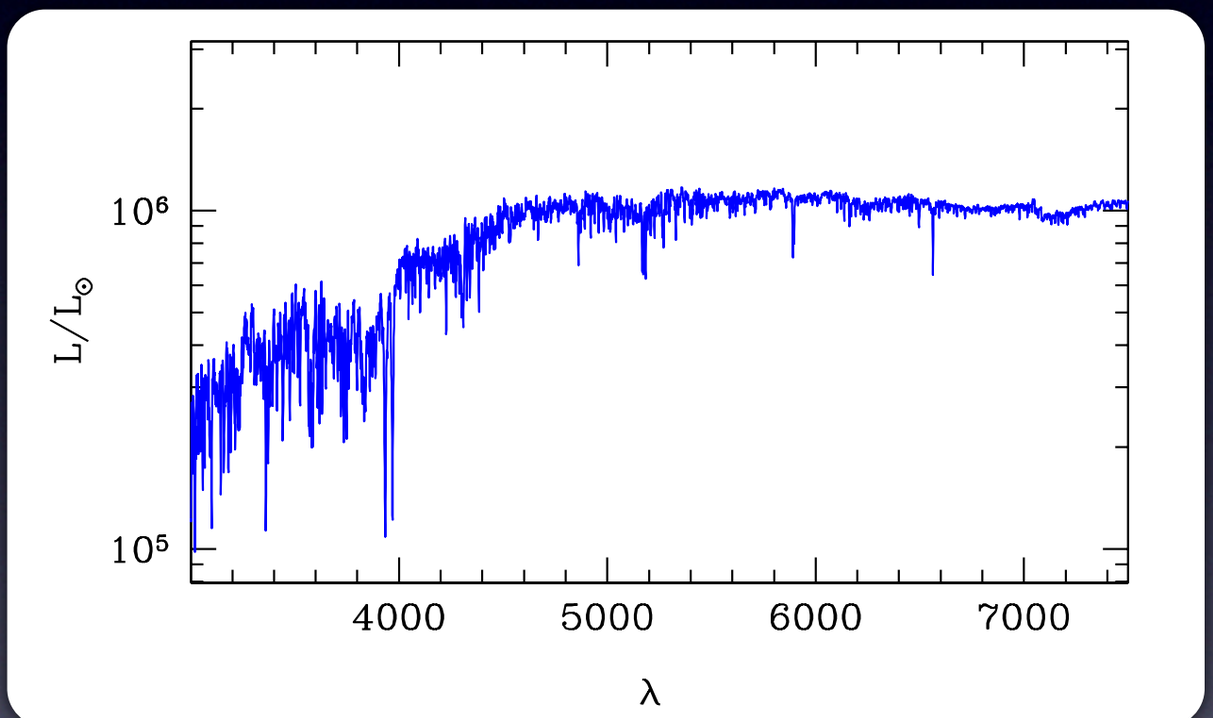
Springel et al. (2005)
De Lucia & Blaizot (2007)

draw 5,000,000 model galaxies in wide ranges of evolutionary stages

A

Galaxy spectral modeling

1. stellar component Galaxev code (Charlot & Bruzual in preparation)
2. nebular emission
3. dust attenuation

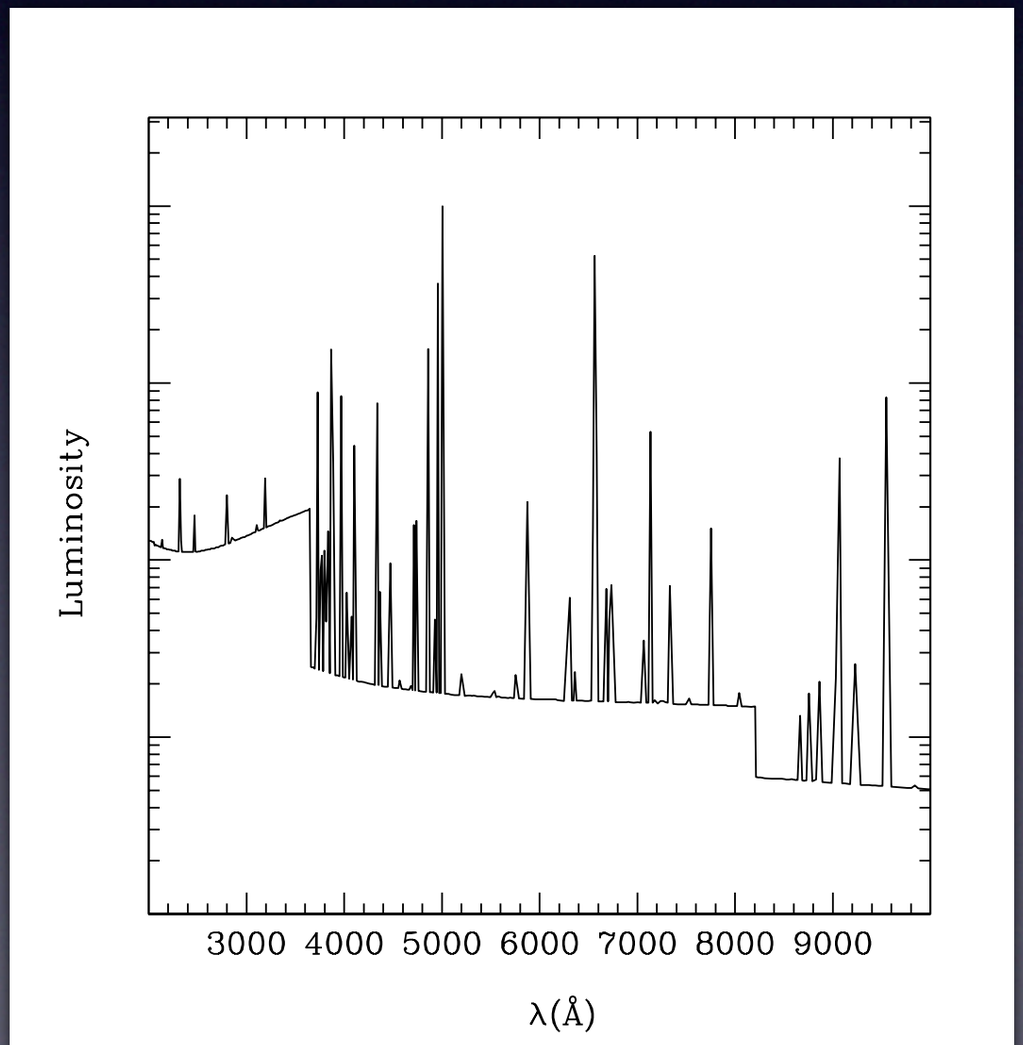


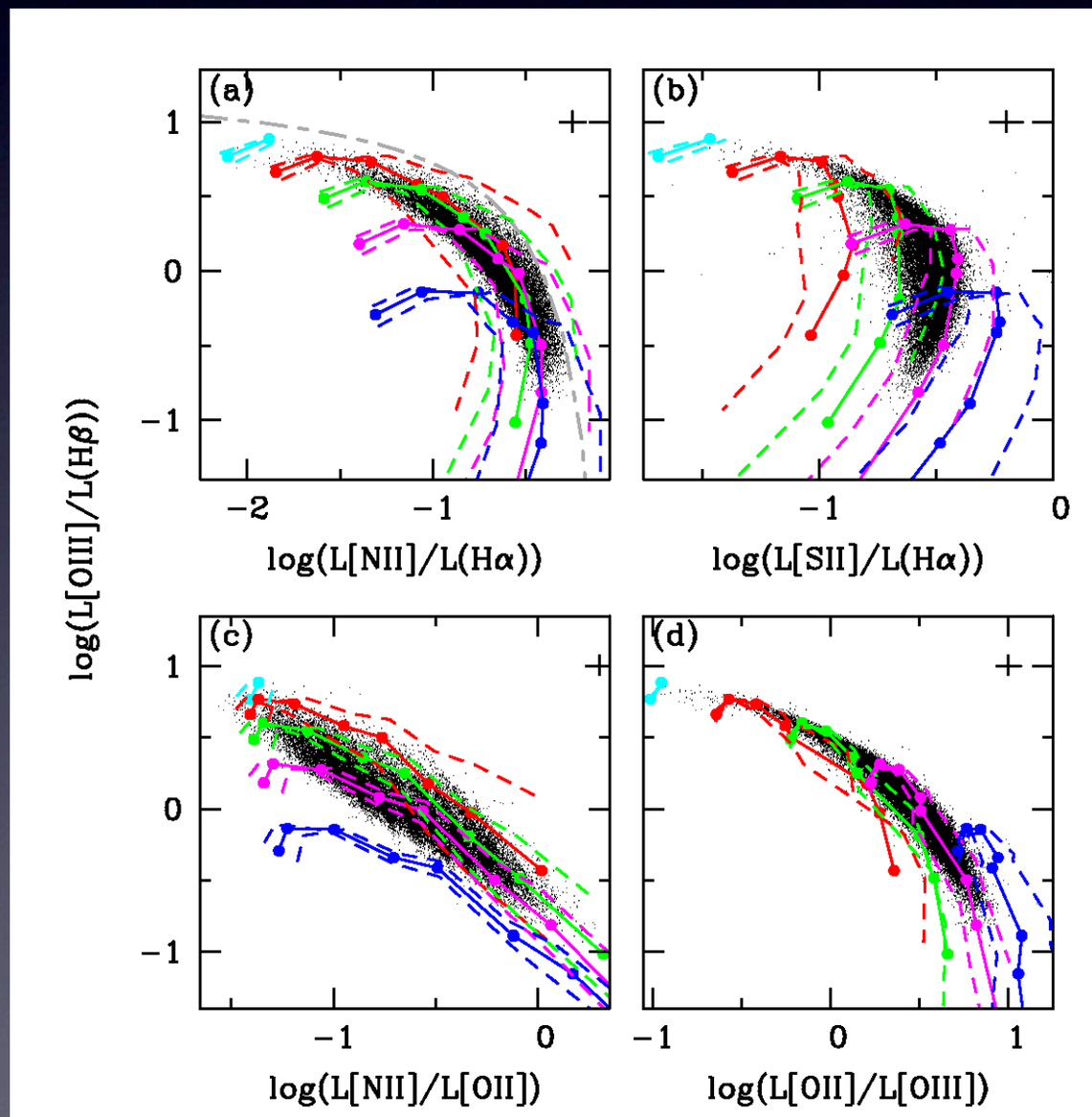
TP-AGB stars
high-resolution rest-frame UV

B

Galaxy spectral modeling

1. stellar component
2. nebular emission Galaxev + CLOUDY (Charlot & Longhetti 2001)
3. dust attenuation

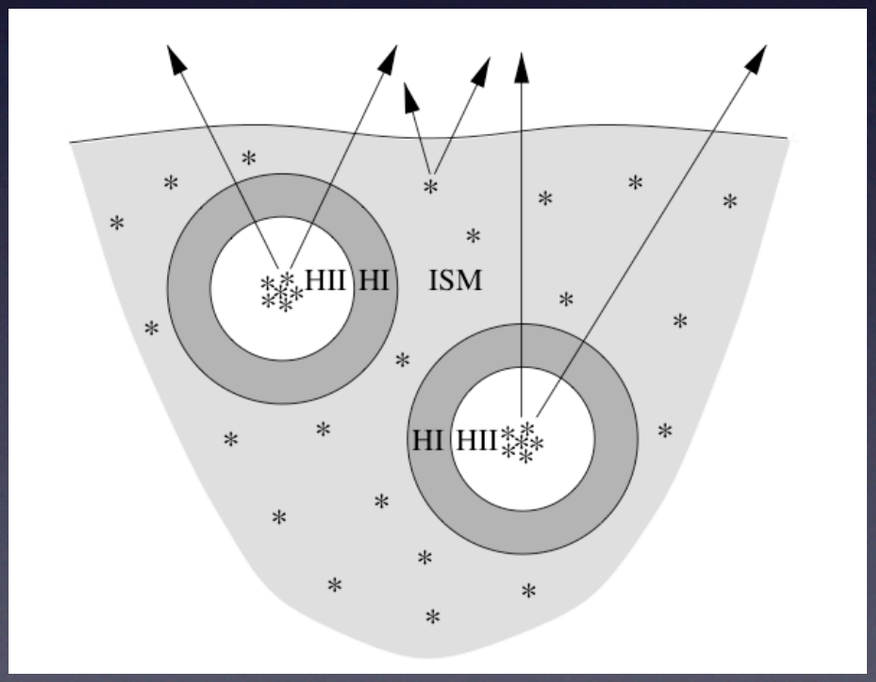




B

Galaxy spectral modeling

1. stellar component
2. nebular emission
3. dust attenuation 2-component model (Charlot & Fall 2000)



include uncertainties in:

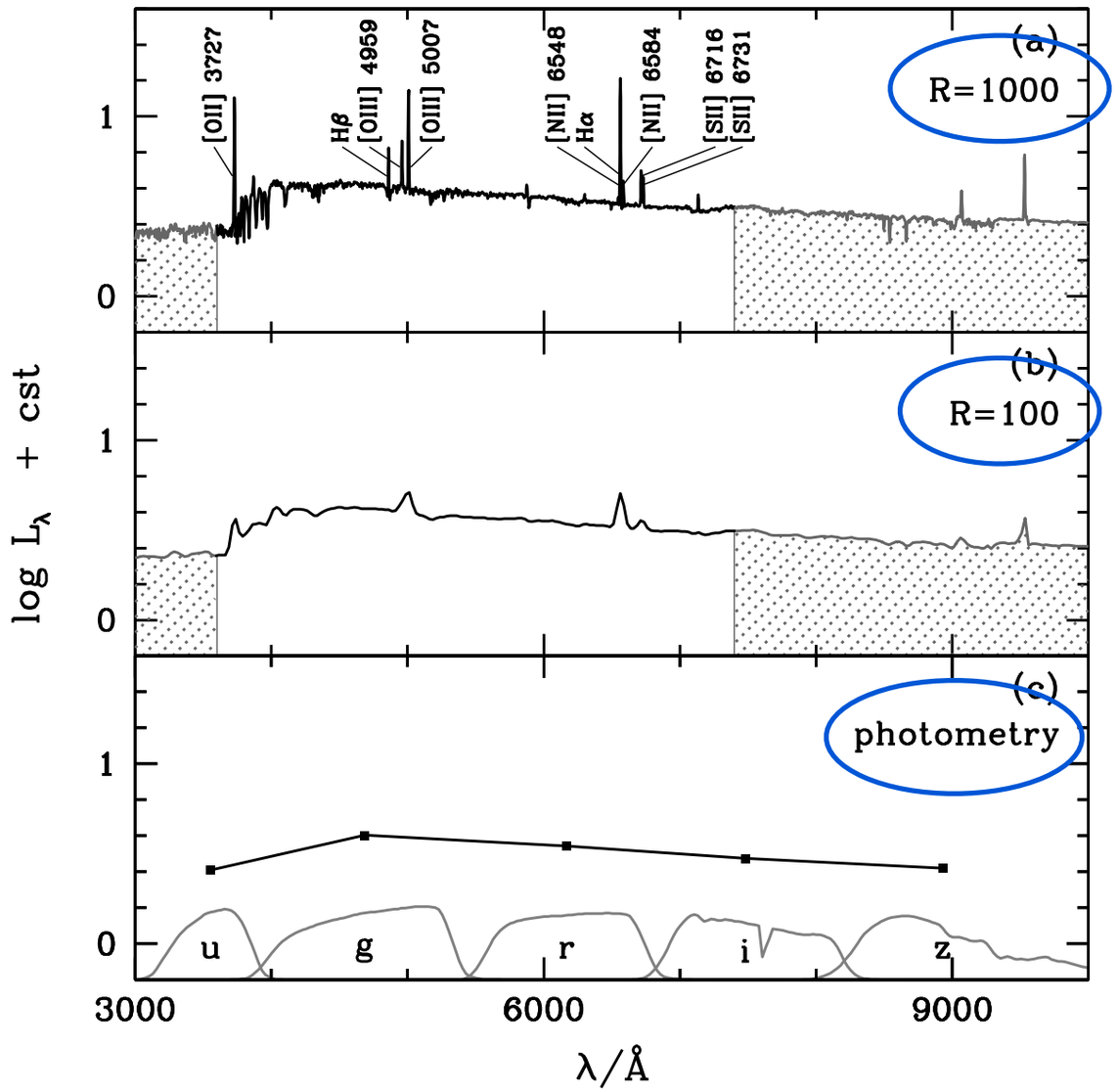
- optical properties
- spatial distribution
- galaxy orientation (Chevallard et al. in preparation)

by considering ranges of:

- relative proportions of dust in giant molecular clouds and diffuse ISM
- slopes of the attenuation curve in diffuse ISM

B

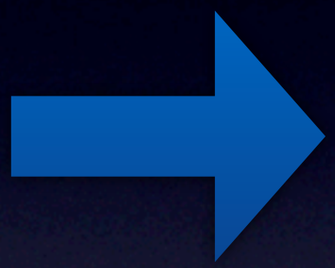
Galaxy spectral modeling



use these models to generate SEDs of 5 millions galaxies in the library

Estimates of physical parameters

Mimic any type of observation by convolving model SED with instrument responses

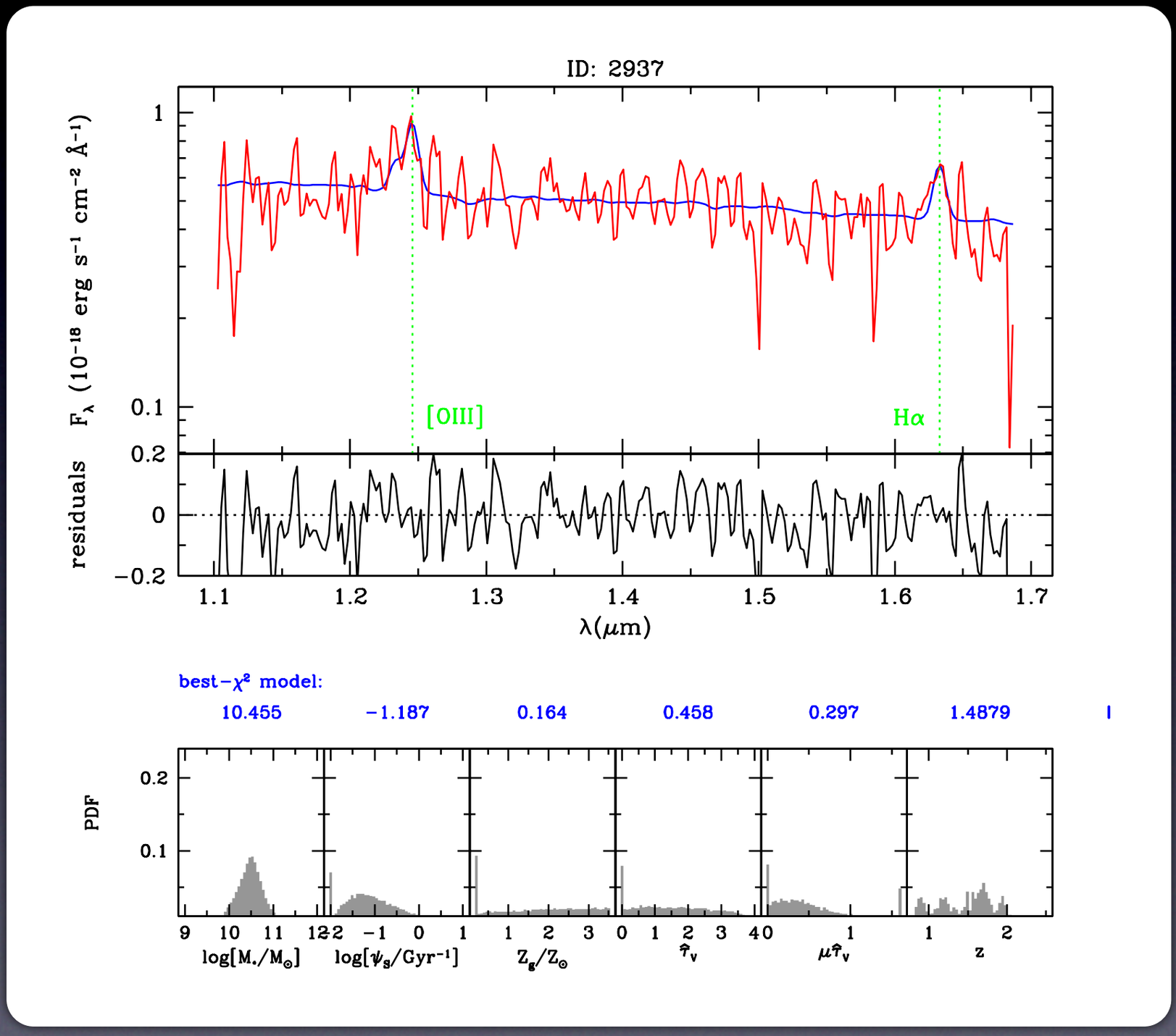


estimate physical parameters of observed galaxies by comparison with every model in library (Bayesian)

- broad-band photometry
- emission-line luminosity
- emission-line equivalent width
- absorption features
- entire spectrum at different resolutions

Originality: stellar continuum and nebular emission fitted simultaneously

Example of parameter estimates

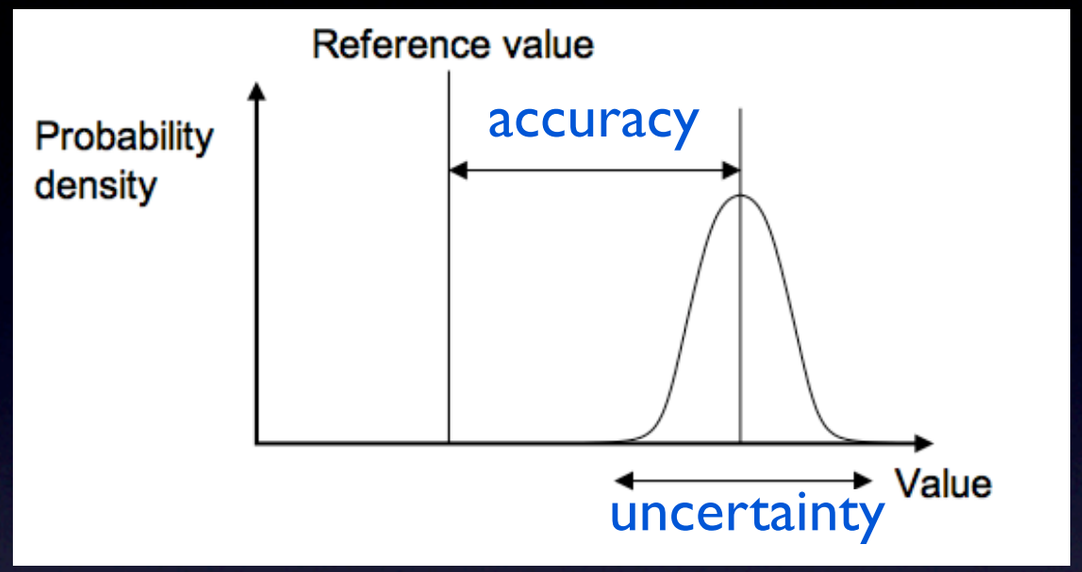


Elisabete da Cunha (MPIA), **Hans-Walter Rix** (MPIA), **3D-HST** data

Accuracy in these estimates

Pacifici et al. (submitted)

goal: assess accuracy and uncertainty to which physical parameters can be estimated



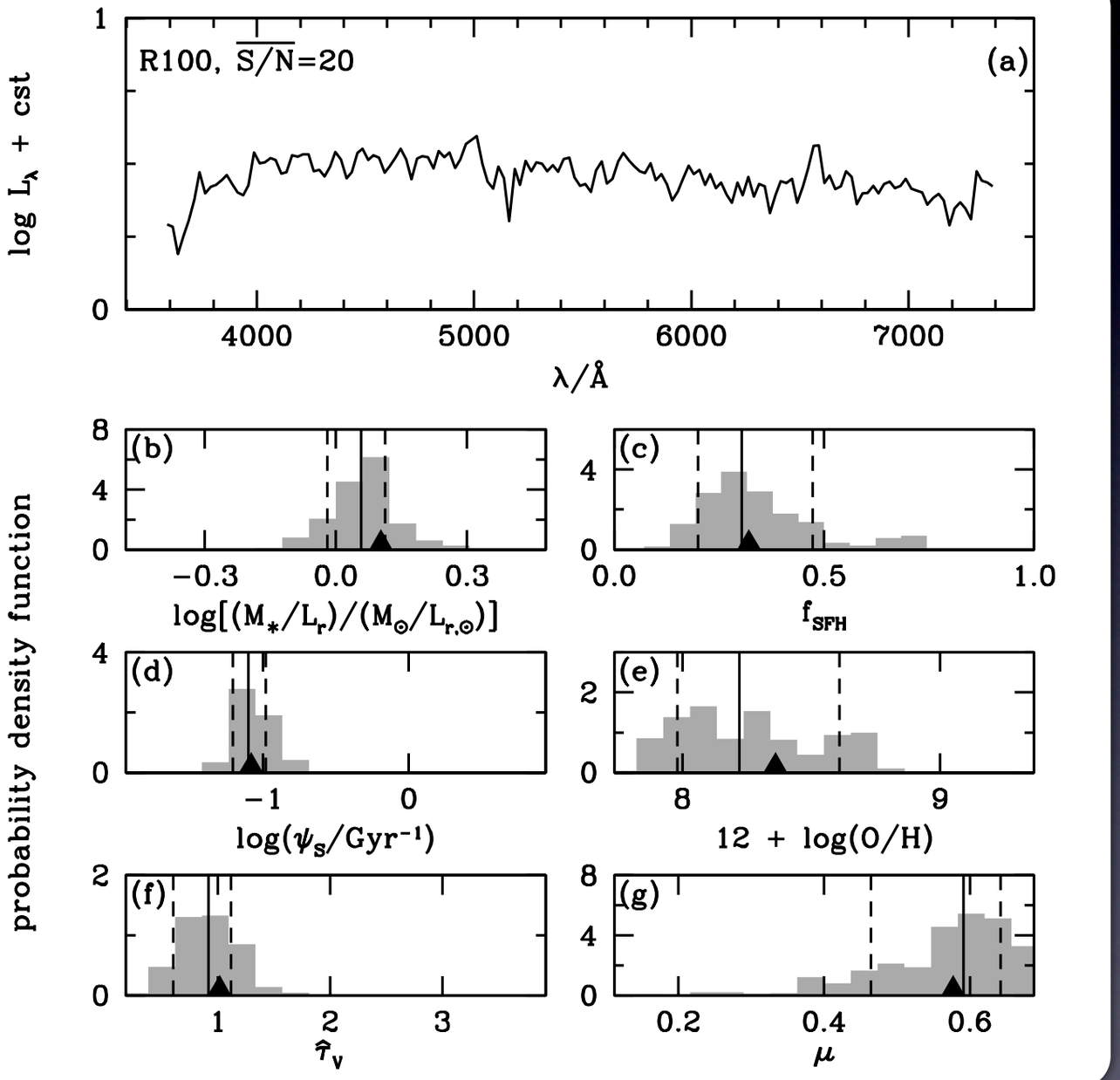
physical parameters of observed galaxies cannot be known a priori

require model galaxies with known parameters

simulate observations by adding **noise** to state-of-the-art models

(assume models are good approximations of true galaxies)

Example of parameter retrieval



SPECTRAL FIT

rest-frame optical spectrum
S/N~20, R=100

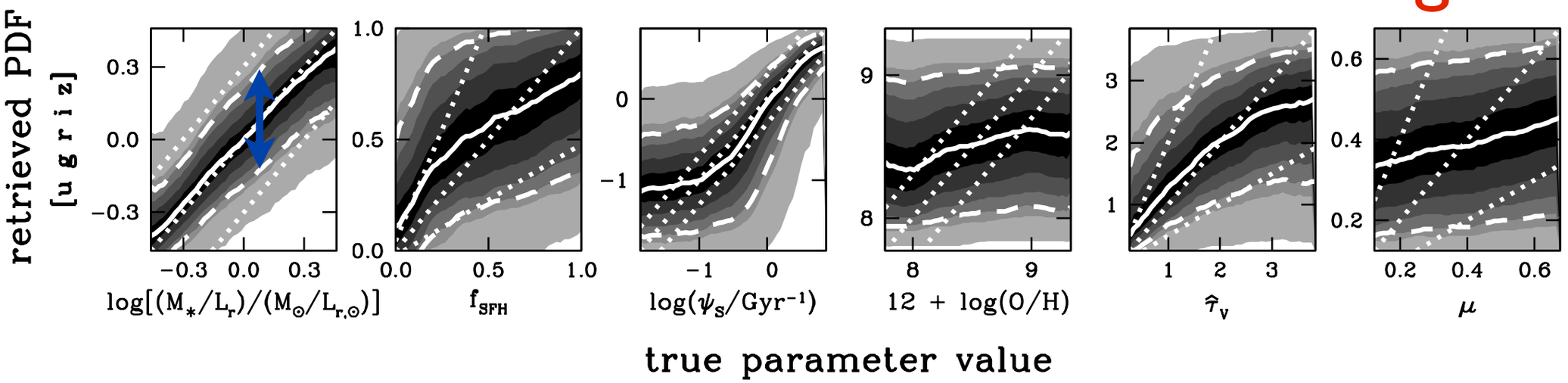
- mass-to-light ratio
- fraction of stellar mass formed in the last 2.5 Gyr
- specific SFR
- gas-phase oxygen abundance
- dust attenuation optical depth
- fraction dust in the ISM

Parameter retrieval from different types of observations

broad-band photometry *ugriz*
S/N=30
5,000,000 models, 10,000 pseudo-observation

16% - 84% confidence interval

ugriz

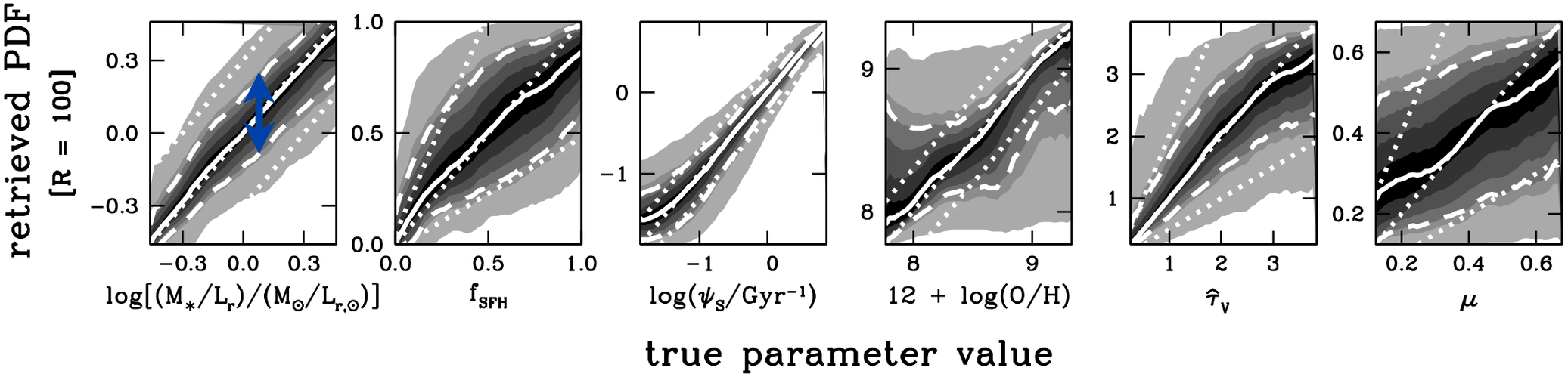


Parameter retrieval from different types of observations

spectral fit low-resolution (R=100, FWHM=50 Å)
S/N=20
5,000,000 models, 10,000 pseudo-observation

16% - 84% confidence interval

R=100

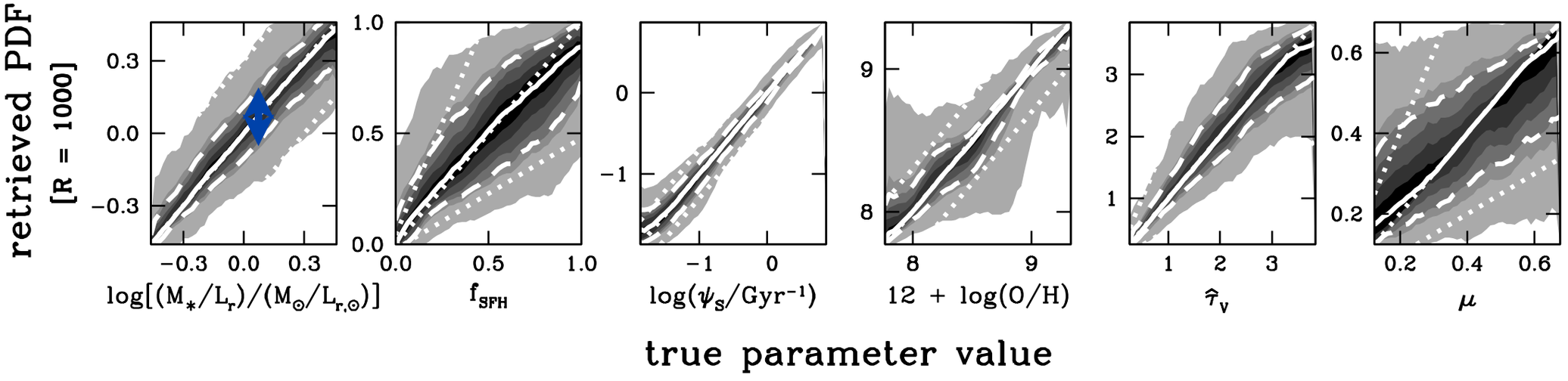


Parameter retrieval from different types of observations

spectral fit medium-resolution (R=1000, FWHM=5 Å)
S/N=20
5,000,000 models, 10,000 pseudo-observation

16% - 84% confidence interval

R=1000



Up to now...

- new approach to constrain galaxy physical parameters from combined interpretation of stellar and nebular emission
- assessed relative merits of different types of optical observations
  - presented examples of this application
- approach applicable to the analysis of any type of observation (including combination of photometric and spectroscopic data) across the wavelength range covered by spectral evolution models (e.g., 3D-HST survey)

.....

Next: rest-frame UV emission

approach extendable to the analysis of any observable within reach of the models

explore rest-frame UV in high-redshift galaxies

Appeal to:

- refined library of SF histories for z > 2 galaxies
- new, high-resolution UV stellar spectra (+ nebular emission)

Specific questions include:

- accuracy of photometric redshift determinations for different S/N
- UV slope (dependence on dust and other model parameters)
- age and metallicity from (UV) absorption-line features
- ...