"Update on determinations of galaxy physical parameters

from multi-λ observations"

S. Charlot - SHARDS Meeting, Madrid, 21 June 2013

Context

- **Different types of multi-λ observations from which to constrain galaxy physical parameters**

- **Point on standard approaches to interpret galaxy SEDs**

- **New framework**
    - ➔ relative merits of different types of (photometric/spectroscopic) observations to retrieve galaxy physical parameters
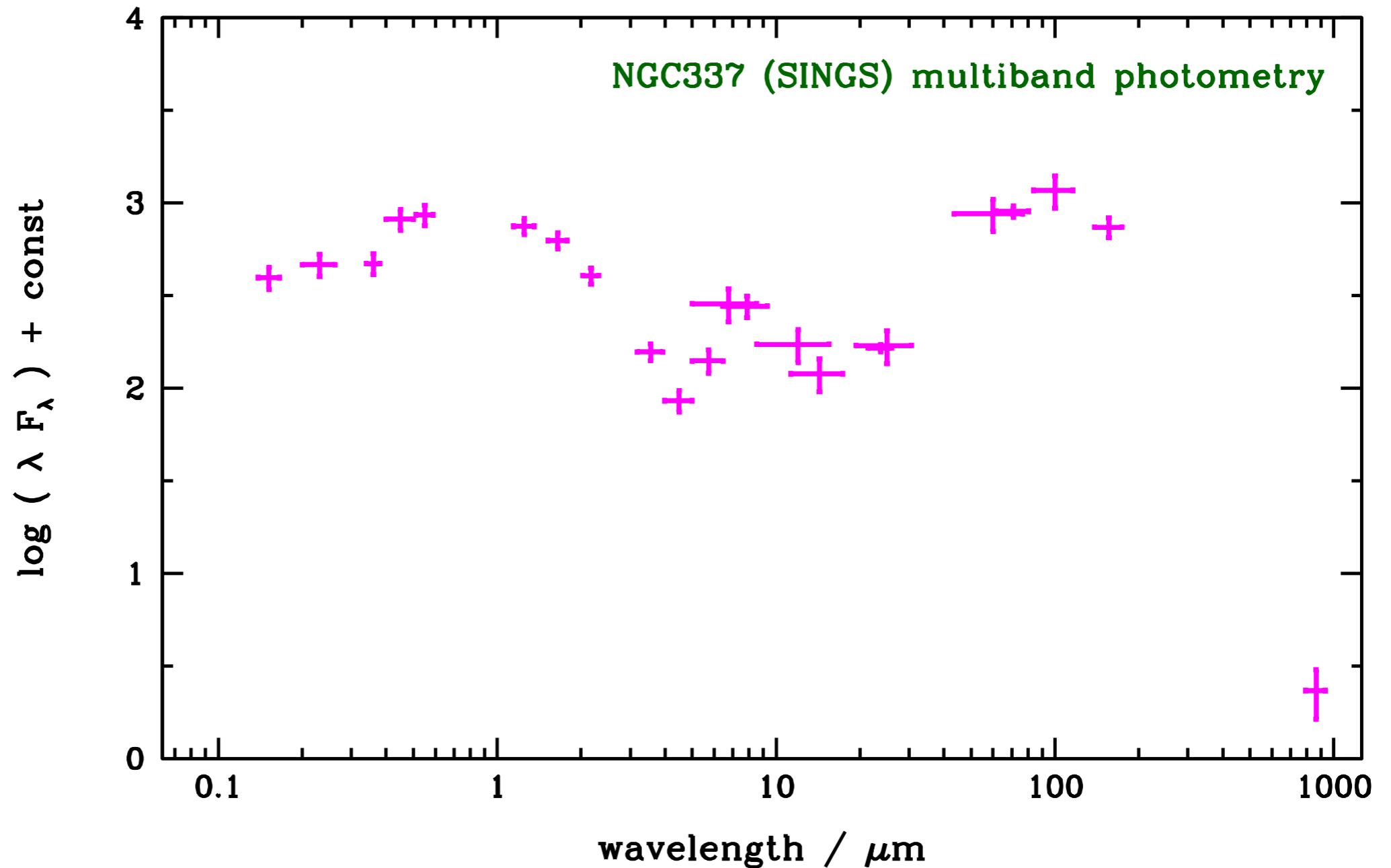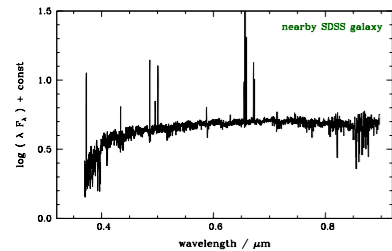   - ➔ low-resolution spectroscopy

From light to physical parameters
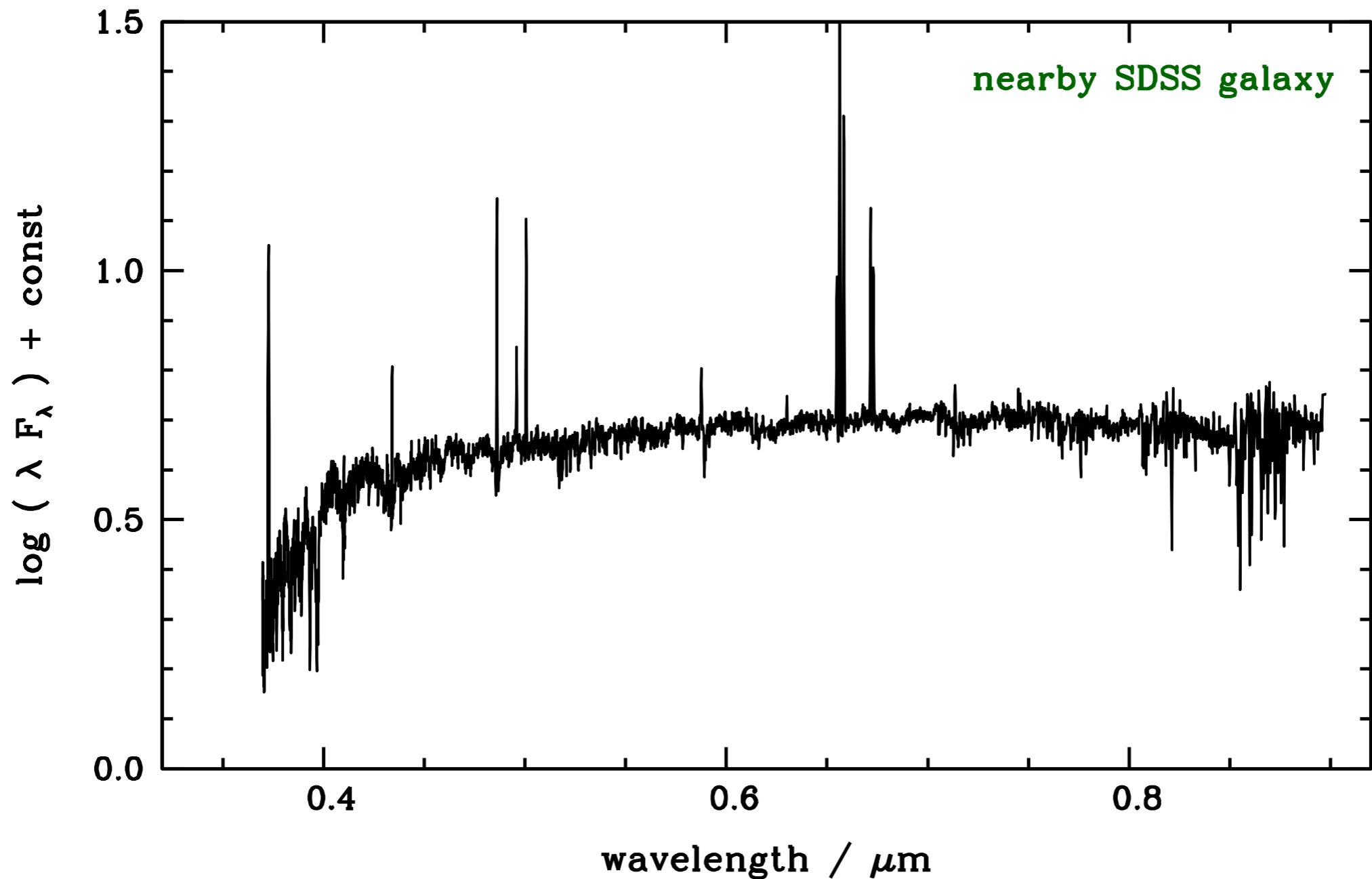
Different types of observed galaxy spectral energy distributions...

From light to physical parameters

Different types of observed galaxy spectral energy distributions...

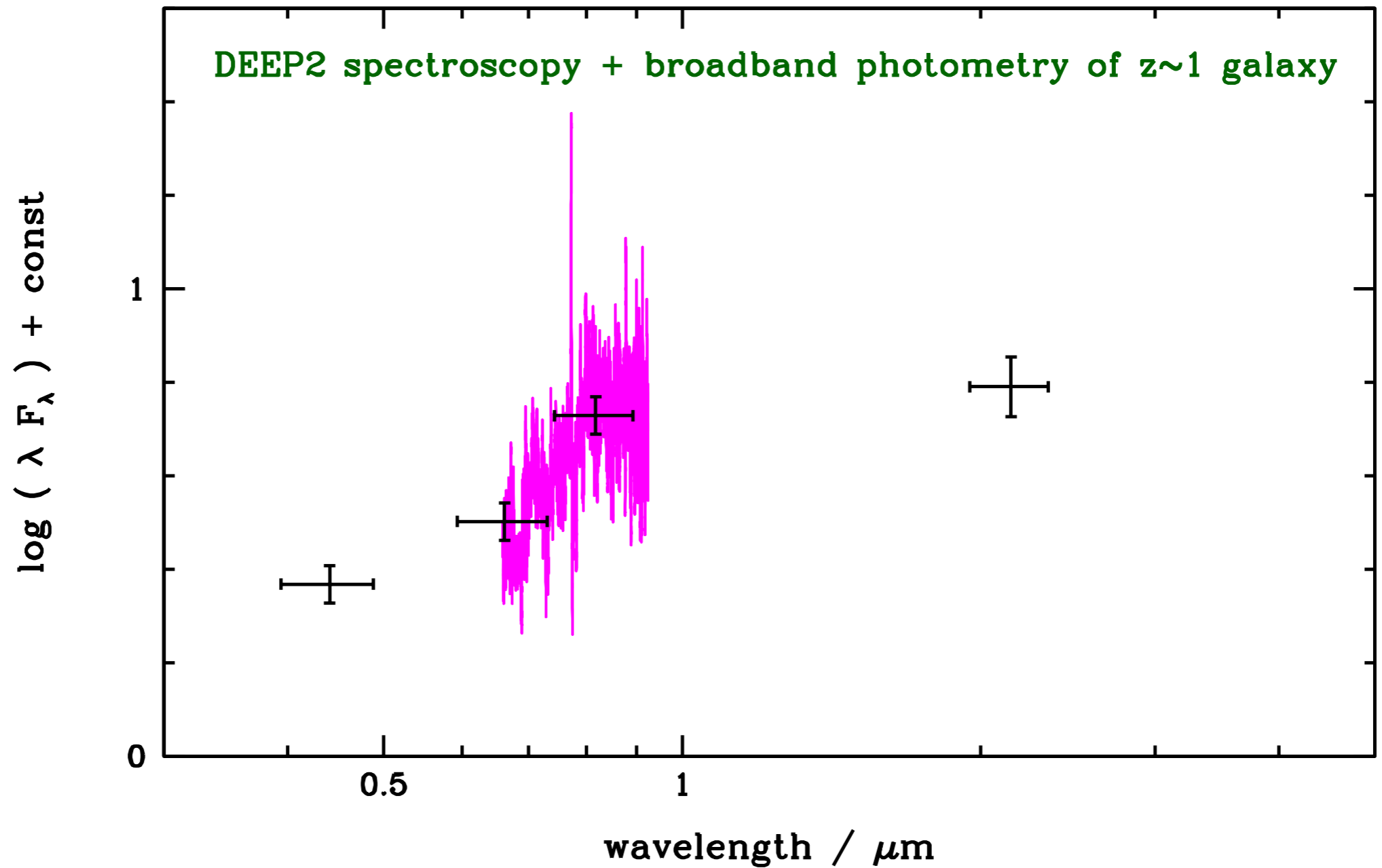

NGC337 (SINGS) multiband photometry

From light to physical parameters

Different types of observed galaxy spectral energy distributions...

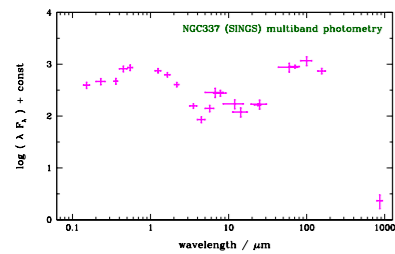DEEP2 spectroscopy + broadband photometry of z~1 galaxy

From light to physical parameters

Different types of observed galaxy spectral energy distributions...

grism spectroscopy (z~2 galaxy from 3D−HST)

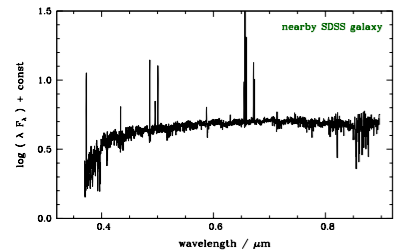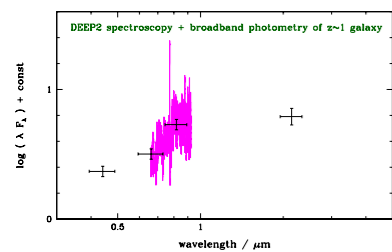log (λ F$_\lambda$) + const

wavelength / μm
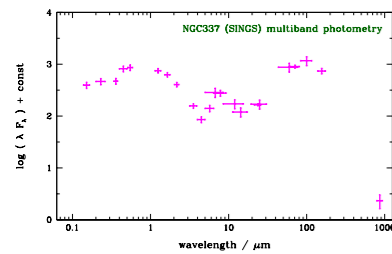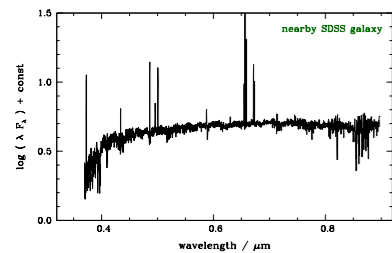
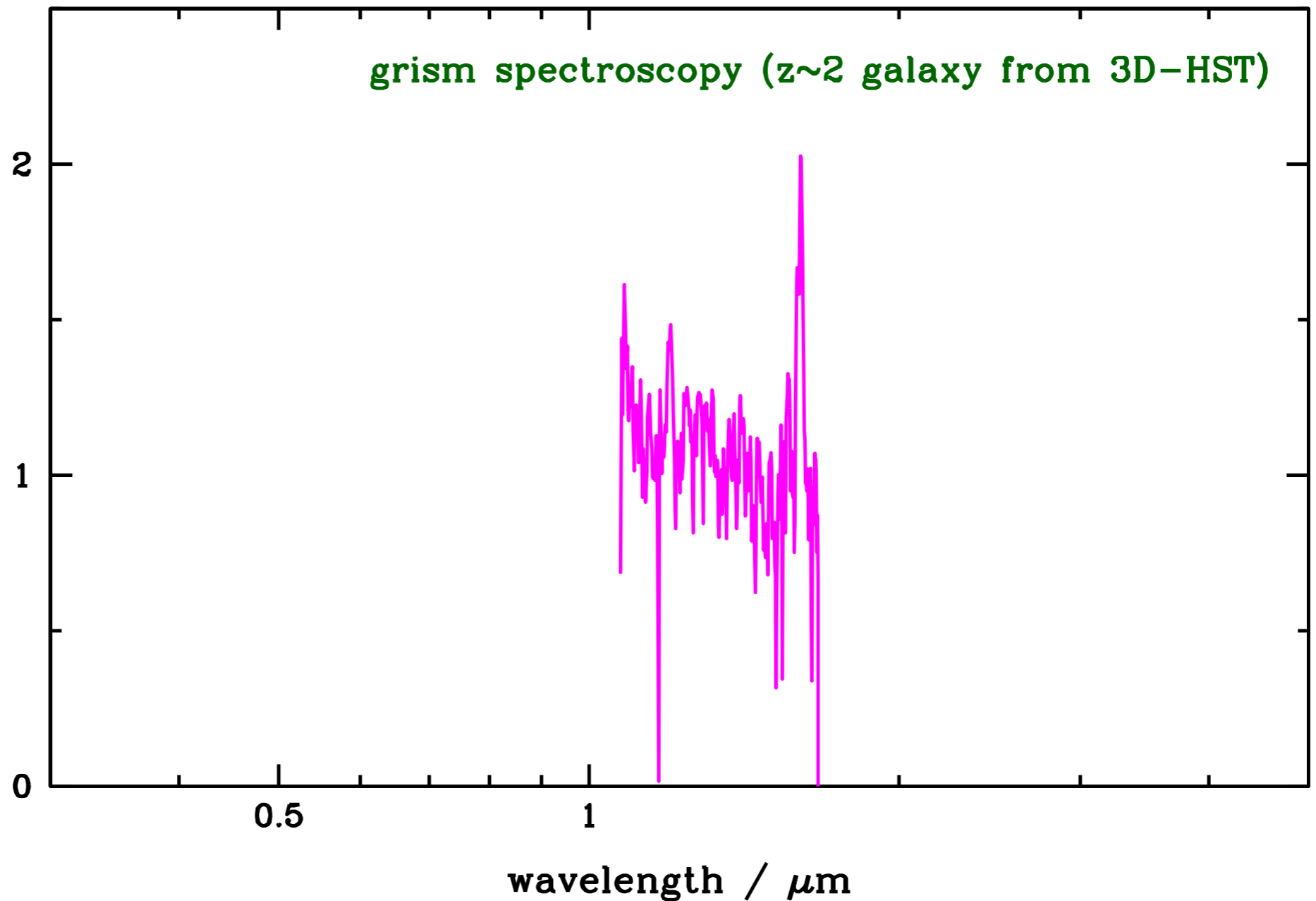# From light to physical parameters

Different types of observed galaxy spectral energy distributions...
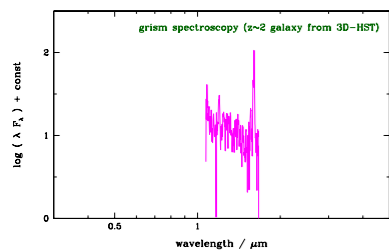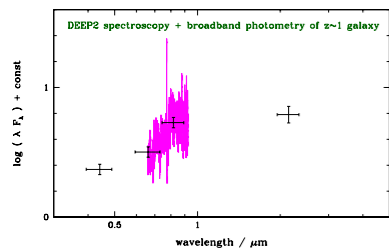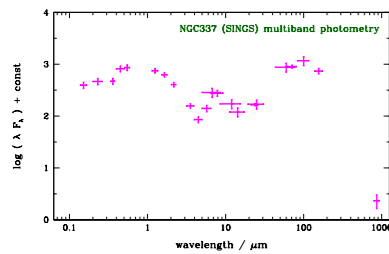
Require versatile models to
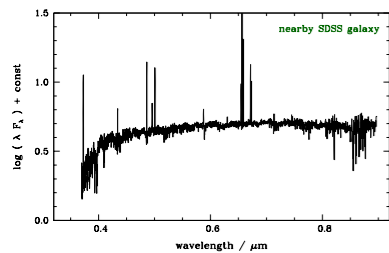
➔ interpret various types of galaxy spectral energy distributions

➔ assess relative merits of different types of observations to constrain galaxy physical parameters (help plan for future observations)

Standard approaches to interpret galaxy SEDs

- **Interpret (often separately) contributions by stars, gas and dust**
  - ➜ stellar optical and near-infrared emission (ages, metallicities, mass)
  - ➜ nebular emission lines (interstellar parameters, SFR)
  - ➜ ultraviolet and infrared emission (dust, SFR)

- **Also, several sophisticated algorithms to recover star formation (and chemical enrichment) histories from optical SEDs**
  - ➜ e.g. **MOPED** (Heavens et al. 2000); **STARLIGHT** (Cid Fernandes et al. 2005); **STECKMAP** (Ocvirk et al. 2006); **VESPA** (Tojeiro et al. 2007); **GOSSIP** (Franzetti et al. 2008); **GalMC** (Acquaviva et al. 2011)

- **These algorithms generally require high signal-to-noise ratio and neglect contribution by nebular emission to optical light**
  - ➜ affects interpretation of stellar absorption lines (potentially contaminated by emission), especially at low spectral resolution

New approach to interpret galaxy SEDs

New approach based on combination of different types of models
(Pacifici, SC, Blaizot & Brinchmann 2012)

➜ Star formation and chemical enrichment histories from the semi-analytic post-treatment of cosmological simulations (Millennium + GALICS: SFHs rescaled and extended not be limited to model predictions; also GASOLINE SPH)

➜ Latest progress in spectral modeling of stellar populations (GALAXEV)

➜ Nebular (continuum+line) emission (CLOUDY)

➜ Recent prescriptions for attenuation by dust (2-component model + uncertainties linked to optical properties and spatial distribution of the dust and orientation effects; Chevallard et al. 2013)

comprehensive ranges of models parameters

New approach to interpret galaxy SEDs

Star formation rate

ψ ($M_\odot$/yr)

Metallicity of star-forming gas

Z ($Z_\odot$)

look-back time (Gyr)

[OII] 3727

Hβ
[OIII] 4959
[OIII] 5007

[NII] 6548
Hα
[NII] 6584
[SII] 6716
[SII] 6731

R=1000

R=100

log L$_\lambda$ + cst

photometry

u   g   r   i   z

λ/Å
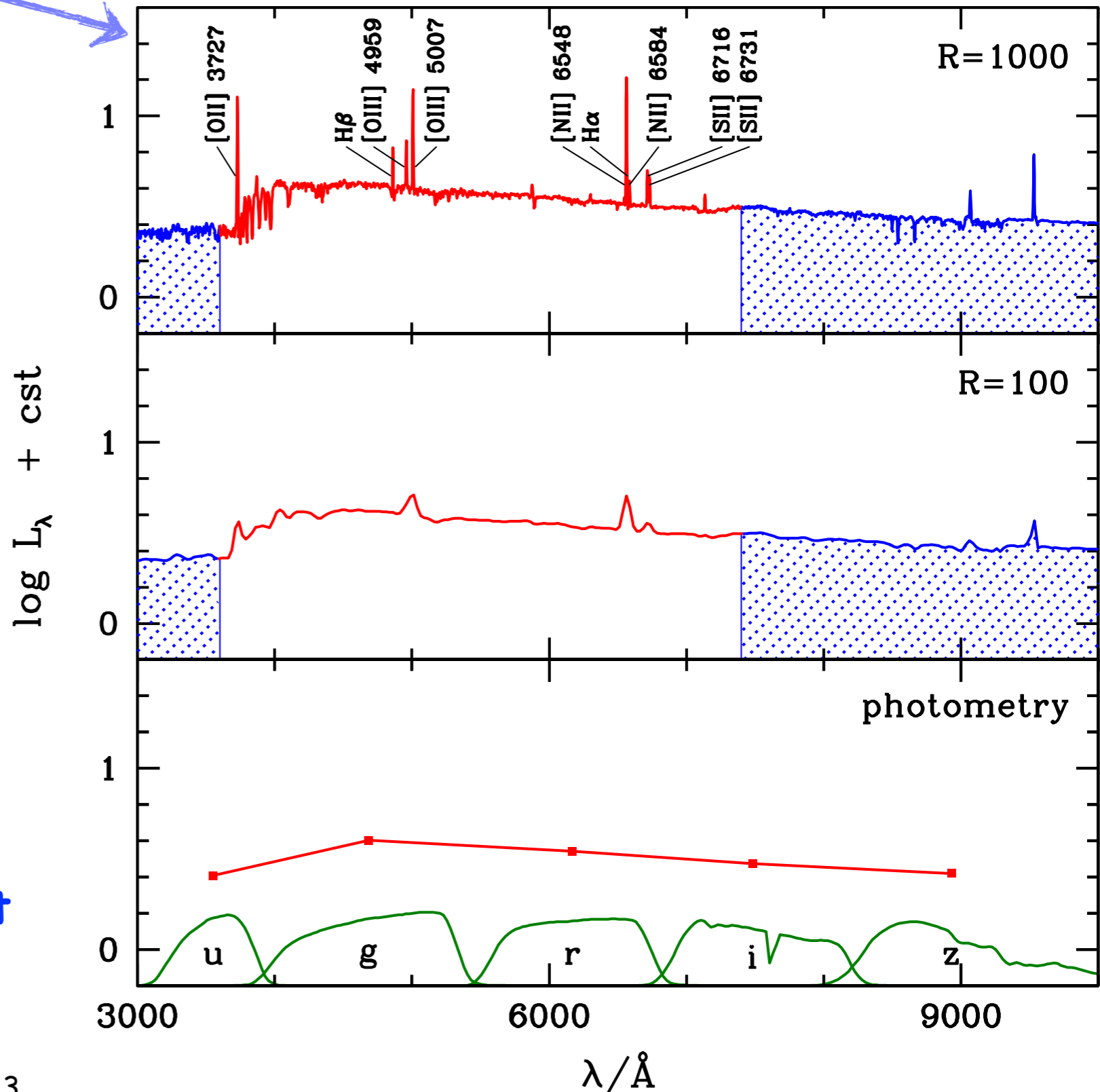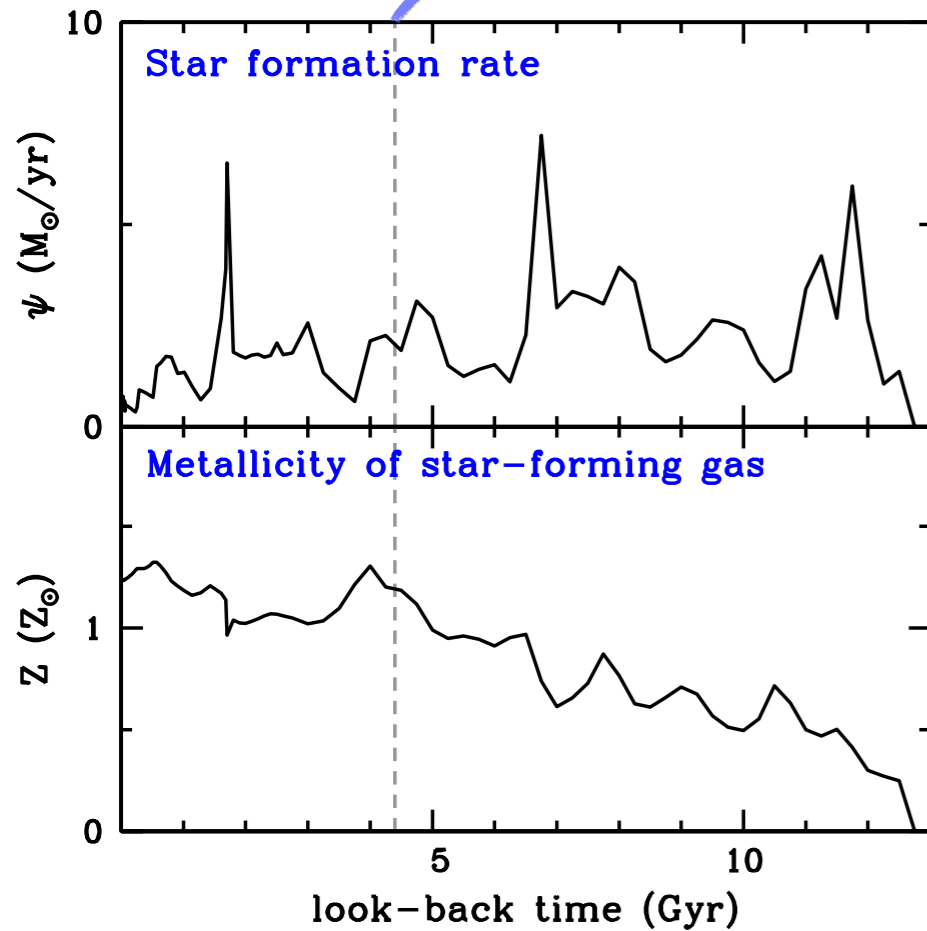
5 million model galaxies in wide ranges of evolutionary stages

SED can be **viewed in different ways** (maximum resolving power R= $\lambda/\Delta\lambda$ ~ 4000)

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New approach to interpret galaxy SEDs

Can assess retrievability of physical parameters as a function of R and S/N

→ produce **pseudo-observations** by adding noise to model spectra

→ likelihood distributions of physical parameters through comparisons with models in library (Bayesian approach)

→ accounts for contamination of stellar absorption lines by nebular emission (even at low R)
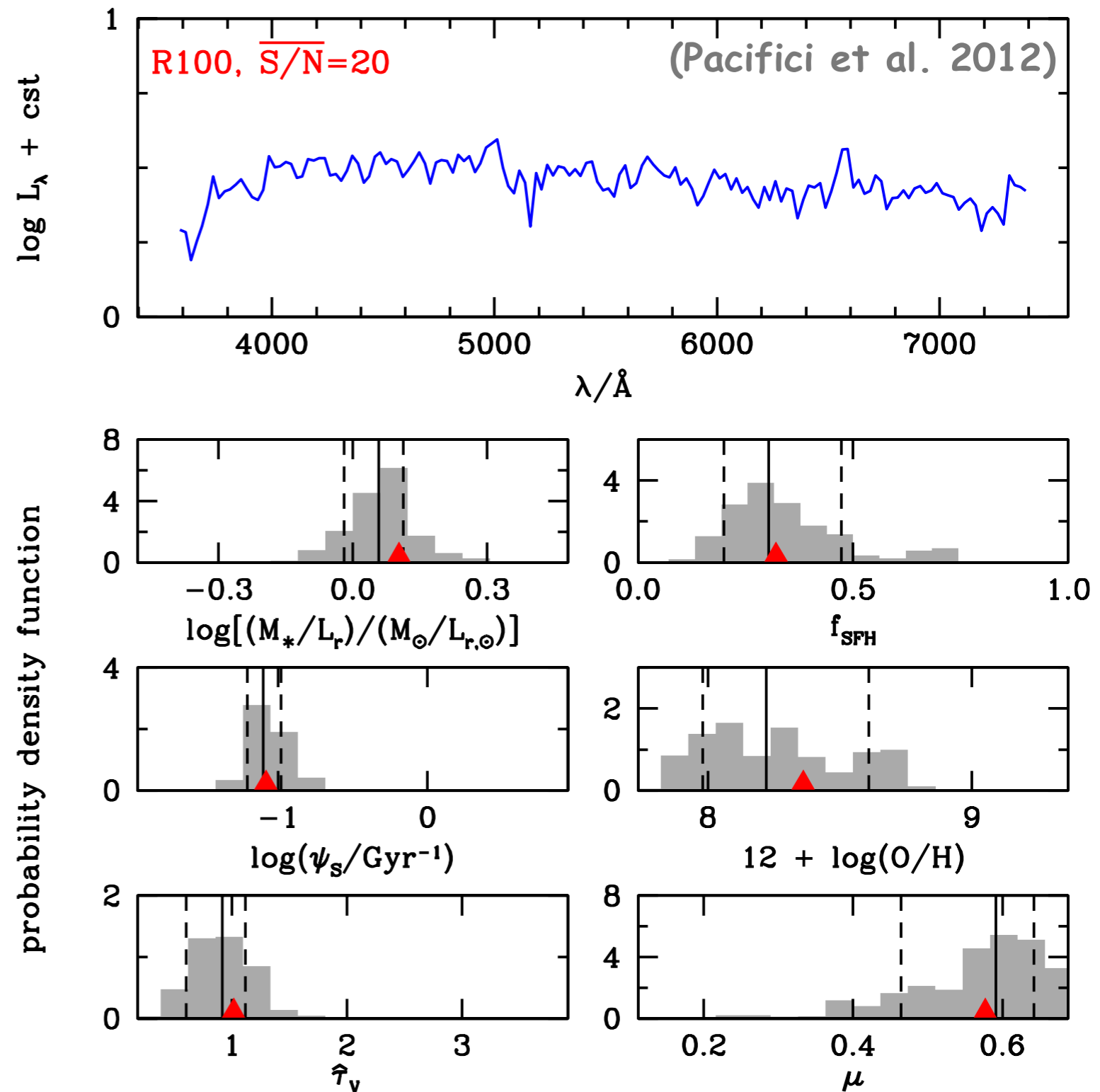
R100, $\overline{S/N}$=20

(Pacifici et al. 2012)

log L_λ + cst

$\lambda/\text{Å}$

probability density function

$\log[(M_*/L_r)/(M_\odot/L_{r,\odot})]$

f_{SFH}

$\log(\psi_s/\text{Gyr}^{-1})$

$12 + \log(O/H)$

$\hat{\tau}_V$

μ

New approach to interpret galaxy SEDs

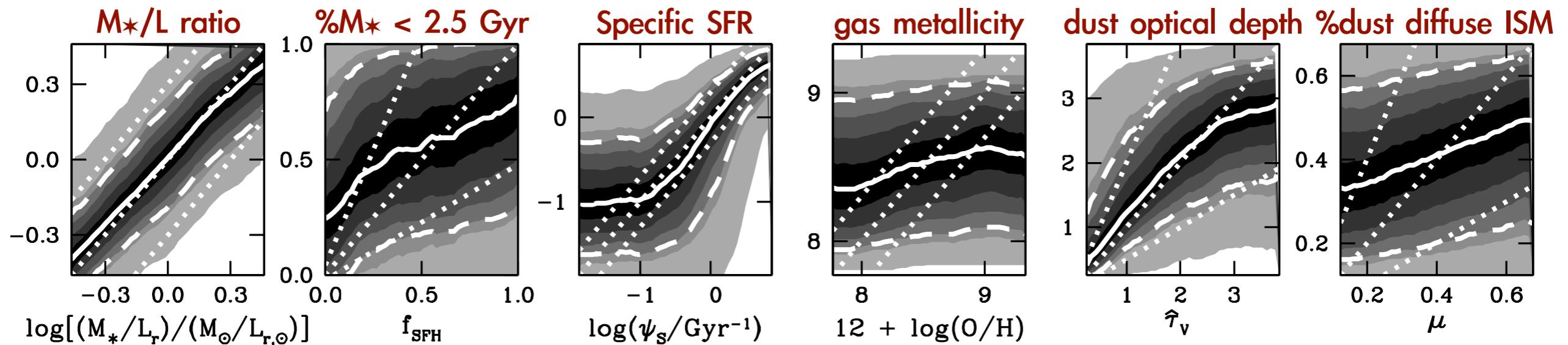**Global results for 10,000 pseudo-observed galaxies (wide range of true parameters)**

➔ high-quality observations (S/N=30)

5-band ugriz photometry

averaged retrieved PDF

M∗/L ratio | %M∗ < 2.5 Gyr | Specific SFR | gas metallicity | dust optical depth | %dust diffuse ISM

$\log[(M_*/L_r)/(M_\odot/L_{r,\odot})]$ $f_{\rm SFH}$ $\log(\psi_s/{\rm Gyr}^{-1})$ $12 + \log({\rm O/H})$ $\hat{\tau}_V$ μ

true parameter value

(Pacifici et al. 2012)

New approach to interpret galaxy SEDs

Global results for 10,000 pseudo-observed galaxies (wide range of true parameters)

→ high-quality observations ($\overline{S/N}$=20)

R=100 spectroscopy (3600-7400Å)

averaged retrieved PDF

| M*/L ratio | %M* < 2.5 Gyr | Specific SFR | gas metallicity | dust optical depth | %dust diffuse ISM |

$\log[(M_*/L_r)/(M_\odot/L_{r,\odot})]$ f_{SFH} $\log(\psi_s/\mathrm{Gyr}^{-1})$ $12 + \log(O/H)$ $\hat{\tau}_V$ μ
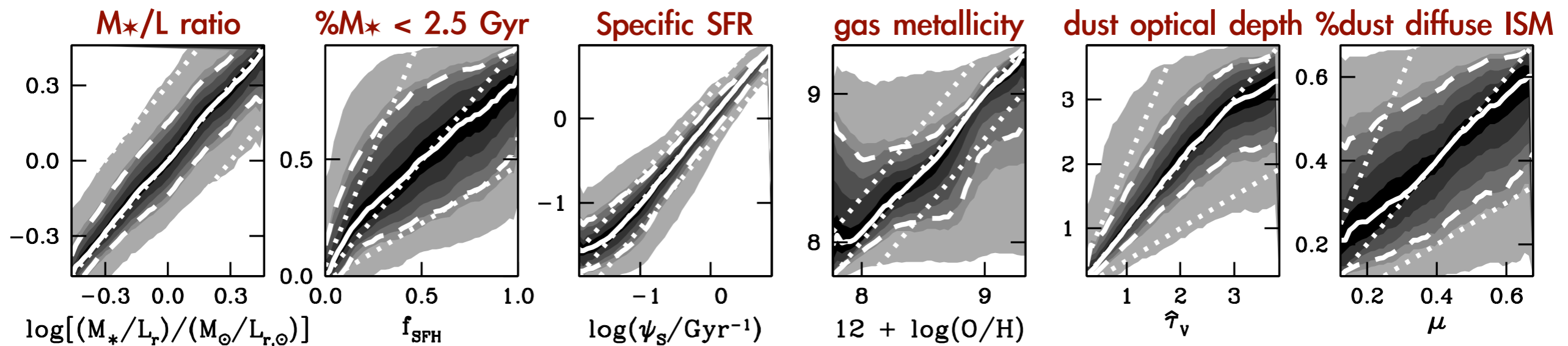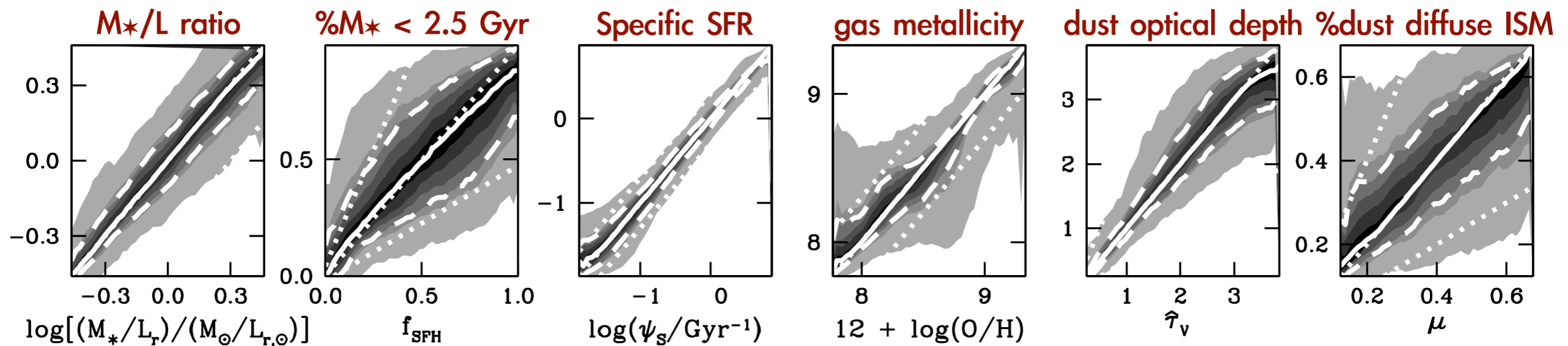
true parameter value

(Pacifici et al. 2012)

New approach to interpret galaxy SEDs

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$\log[(M_*/L_r)/(M_\odot/L_{r,\odot})]$ — f_{SFH} — $\log(\psi_S/\text{Gyr}^{-1})$ — $12 + \log(O/H)$ — $\hat{\tau}_V$ — μ

true parameter value

(Pacifici et al. 2012)

➔ extendable to the analysis of **any type of observation** (e.g. combination of photometric and spectroscopic data) across wavelength range accessible to spectral evolution models

New approach to interpret galaxy SEDs

Example of application: interpret combined broadband photometry and DEEP2 spectroscopy of galaxies at redshifts out to ~1.5 (Pacifici et al. 2013a)
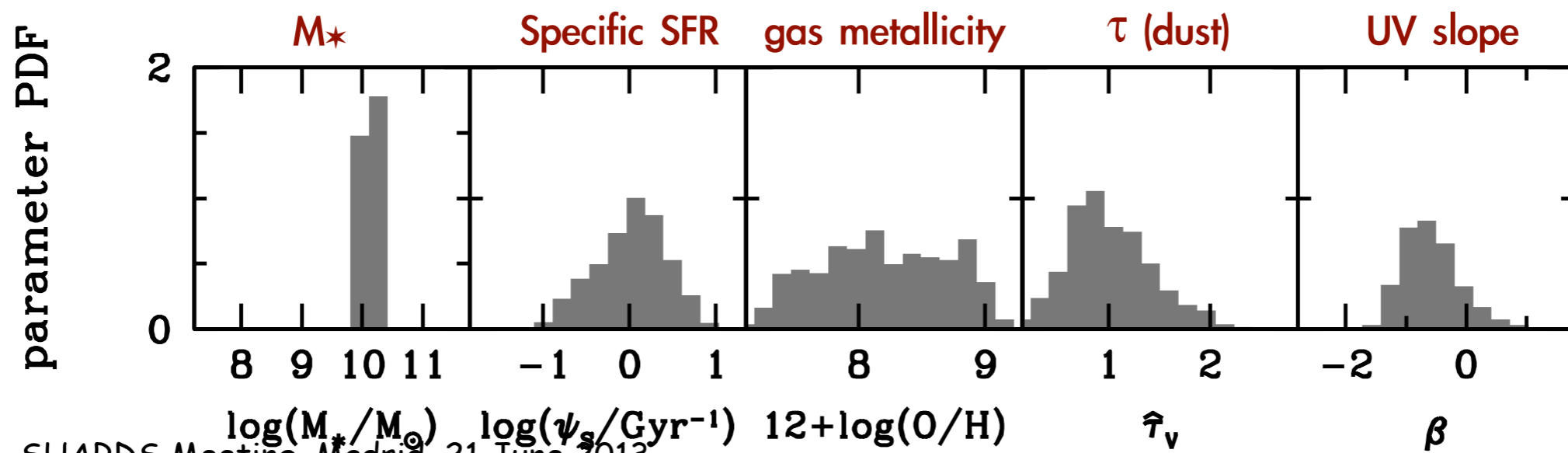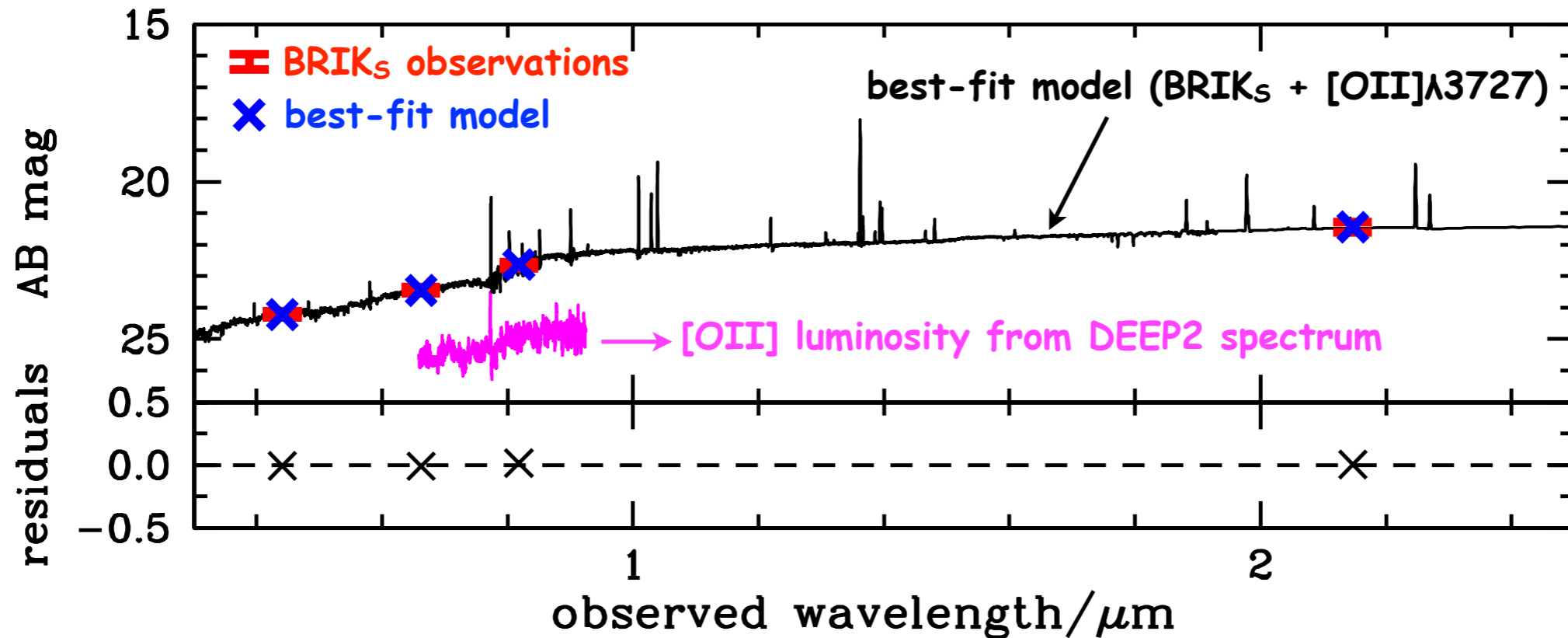
New approach to interpret galaxy SEDs

Other example: interpret infrared grism spectroscopy of z~2 galaxies from 3D-HST survey (to be combined with UV-FIR photometry from FIREWORKS)

(Pacifici et al. 2013b)