Parametrising Star Formation Histories

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Introduction

- Increasingly rich data sets consisting of large samples of galaxies with multi-wavelength photometry open up several avenues:
  - Evolutionary studies shift from luminosity and colour to more physical M_* (stellar mass) and M'_* (SFR).
  - Median ages of stellar populations.
  - Other aspects of galaxy evolution - e.g. importance of bursts, correlations with gas phase metallicity, dust extinction etc.
  - Photo-z estimation requires model of intrinsic galaxy colour.

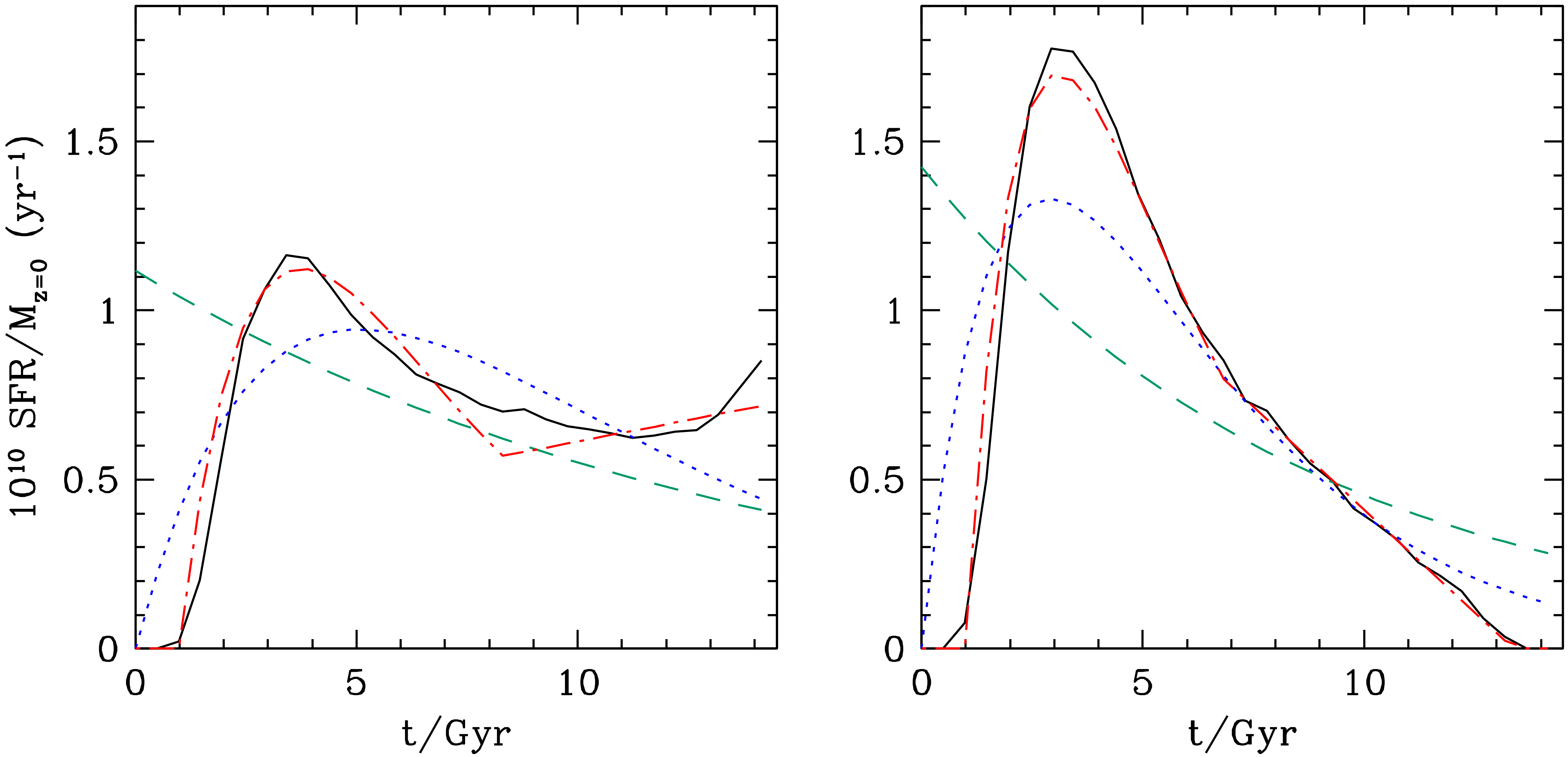
Parametrising Star Formation Histories

- KEY STEP - fitting parametrised SFH to observed SEDs.
    - Tau Model (SFR = $Ce^{-t/tau}$) most commonly used
    - Extended Tau Model (SFR = $Cte^{-t/tau}$) has also been advocated
- We examine SFHs of galaxies in SPH simulation
    - What functional forms are necessary?
    - Are these models adequate?
    - What level of complexity is required?

SPH Simulation

- Smoothed Particle Hydrodynamics (SPH) simulation using GADGET.
- 50 h^{-1}Mpc box with 288^3 (~ 24 million) particles.
- Wind feedback.
- No AGN feedback.
- Post-processing prescription to quench star formation in massive galaxies and produce more realistic stellar mass function (match Bell et al., 2003).
- Use FSPS (Conroy, Gunn & White 2009) to compute luminosity and colour.

SFH Models Compared



- Simple tau models ($e^{-t/tau}$) do not describe SFHs adequately.
- $te^{-t/tau}$ does better but fails to capture late time behavior - “too red” for blue galaxies and “too blue” for red galaxies.
- Need delayed start time.
- Need additional linear component to describe late time behavior.

Testing SFH Models - Part I

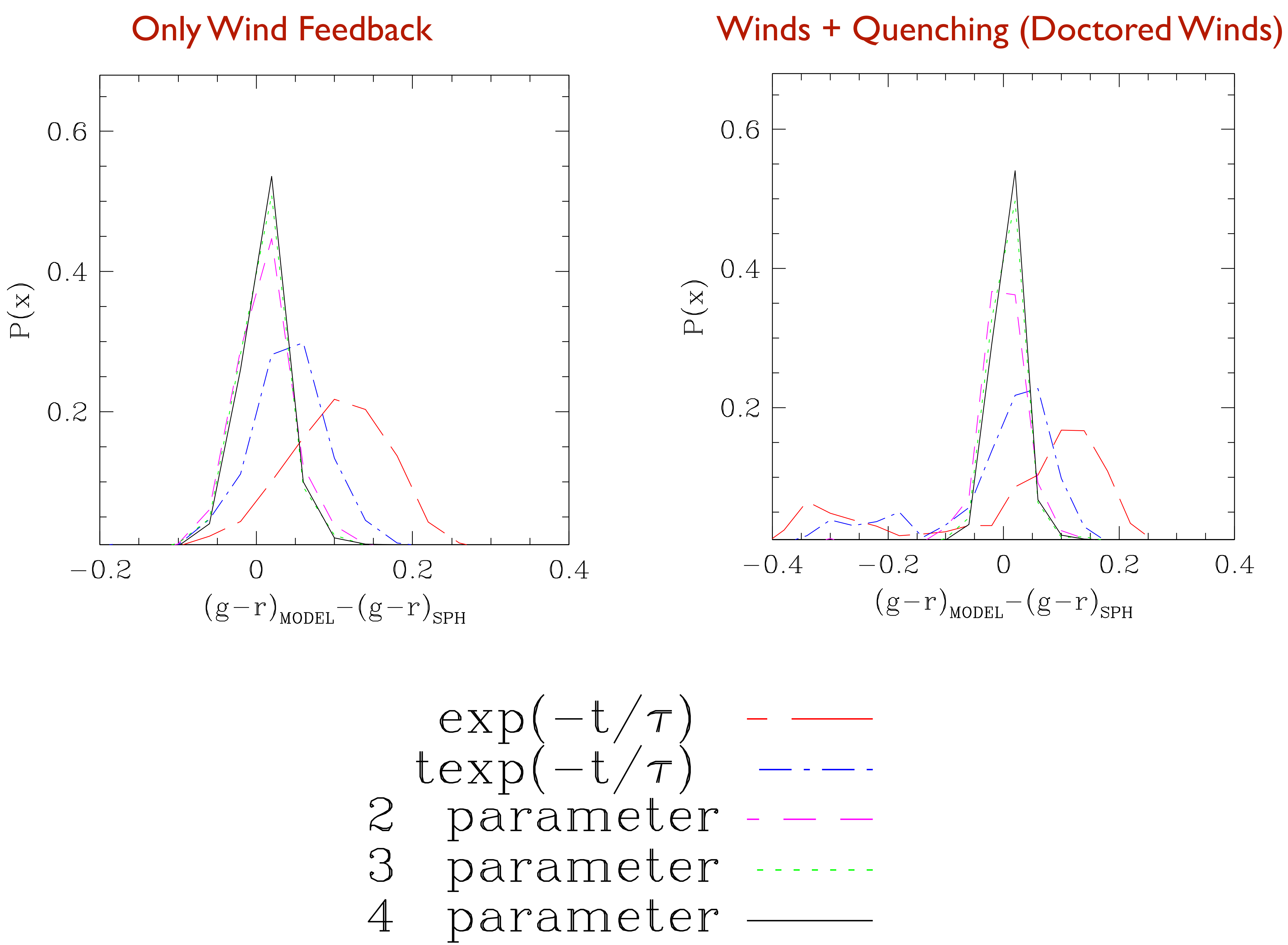
➡ Consider Tau model ($e^{-t/tau}$), Extended tau model ($te^{-t/tau}$) and our 4 parameter model:

$$\mathrm{SFR(t) = A(t - t_0)e^{-(t-t_0)/\tau}} \qquad \mathrm{(t < t_{trans})}$$

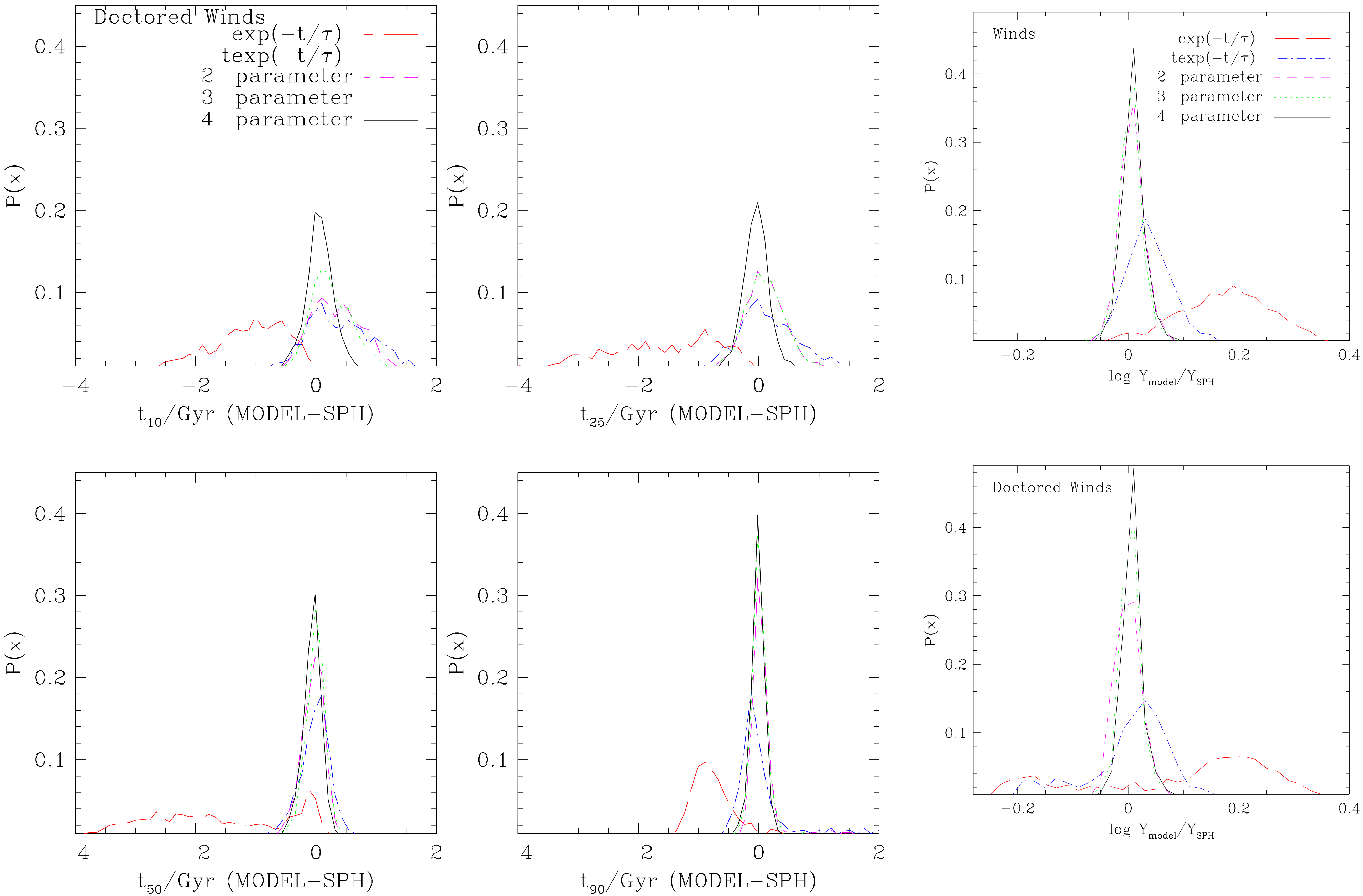
$$\mathrm{SFR(t) = SFR(t_{trans}) + tan(\theta)(t - t_{trans})} \qquad \mathrm{(t > t_{trans})}$$

- Fit each model to SFH of an SPH galaxy.
- Compute colours, M/L, median age of best-fit model of each type.
- Compare these to colour, M/L, median age of SPH galaxy whose SFH has been fit.

Testing SFH Models - Part I



Testing SFH Models - Part I



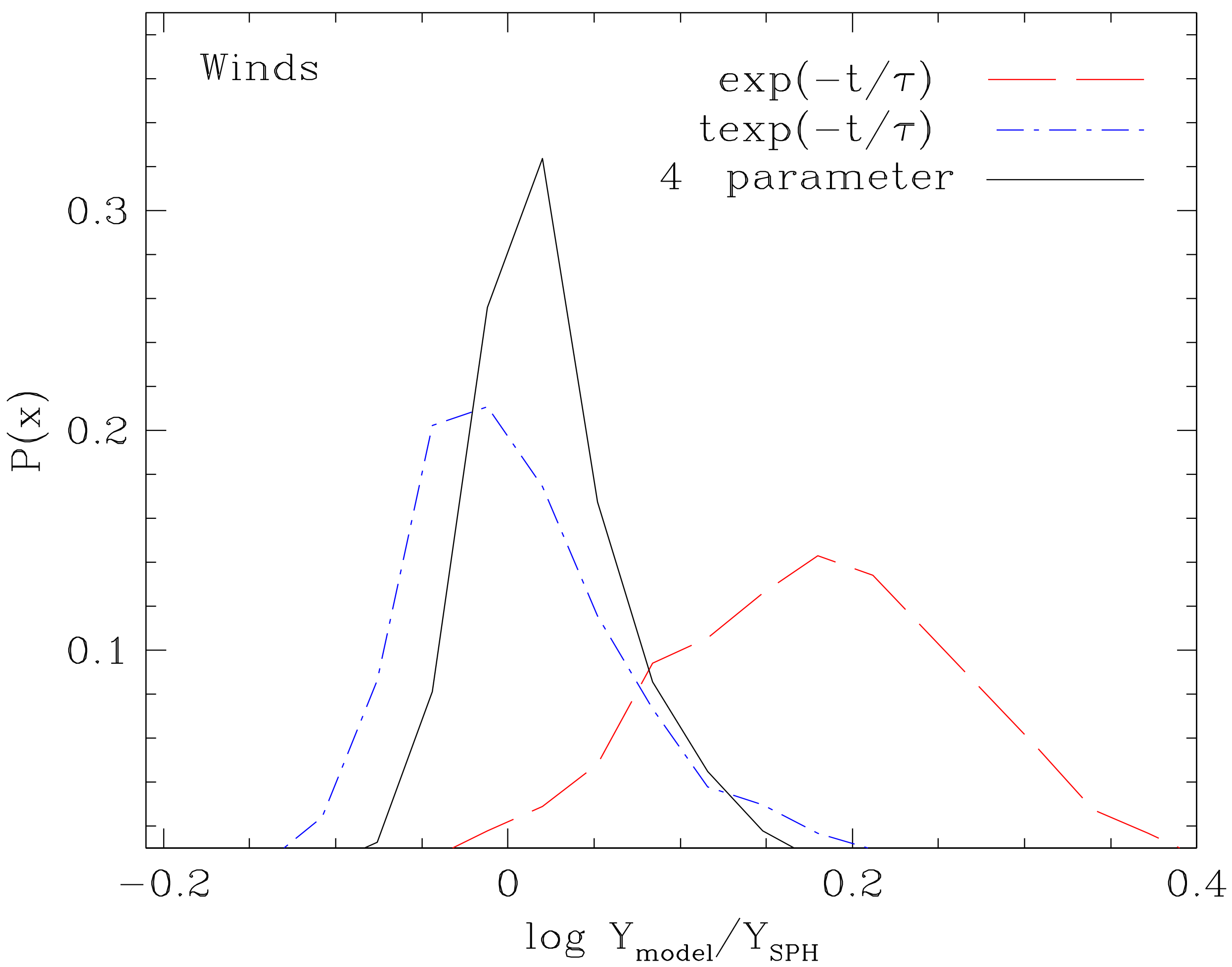
Testing SFH Models - Part II

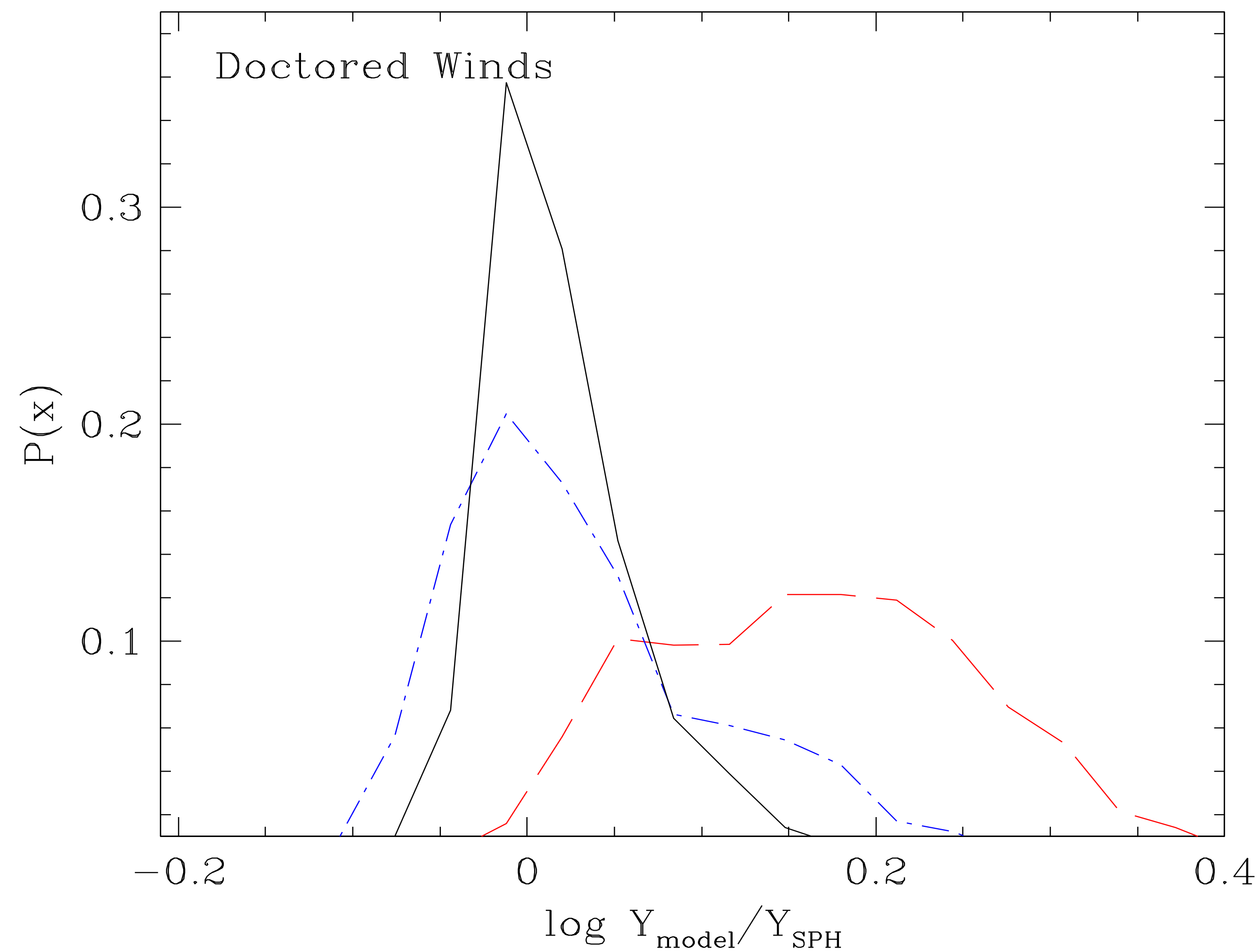
- In reality we do not know SFH and must fit SFH models to colours!

- Construct mock "observations" of galaxies in our simulation
  - Compute colours using SPS code in SDSS bands.
  - Assume errors of 0.02 magnitudes.
- Fit each type of model to these colours.
- Extract model M/L, median age, SFR and compare to M/L, median age, SFR of galaxy in simulation.

- How well can each type of model recover the M/L, SFR and median age of a galaxy given mutil-wavelength photometry?

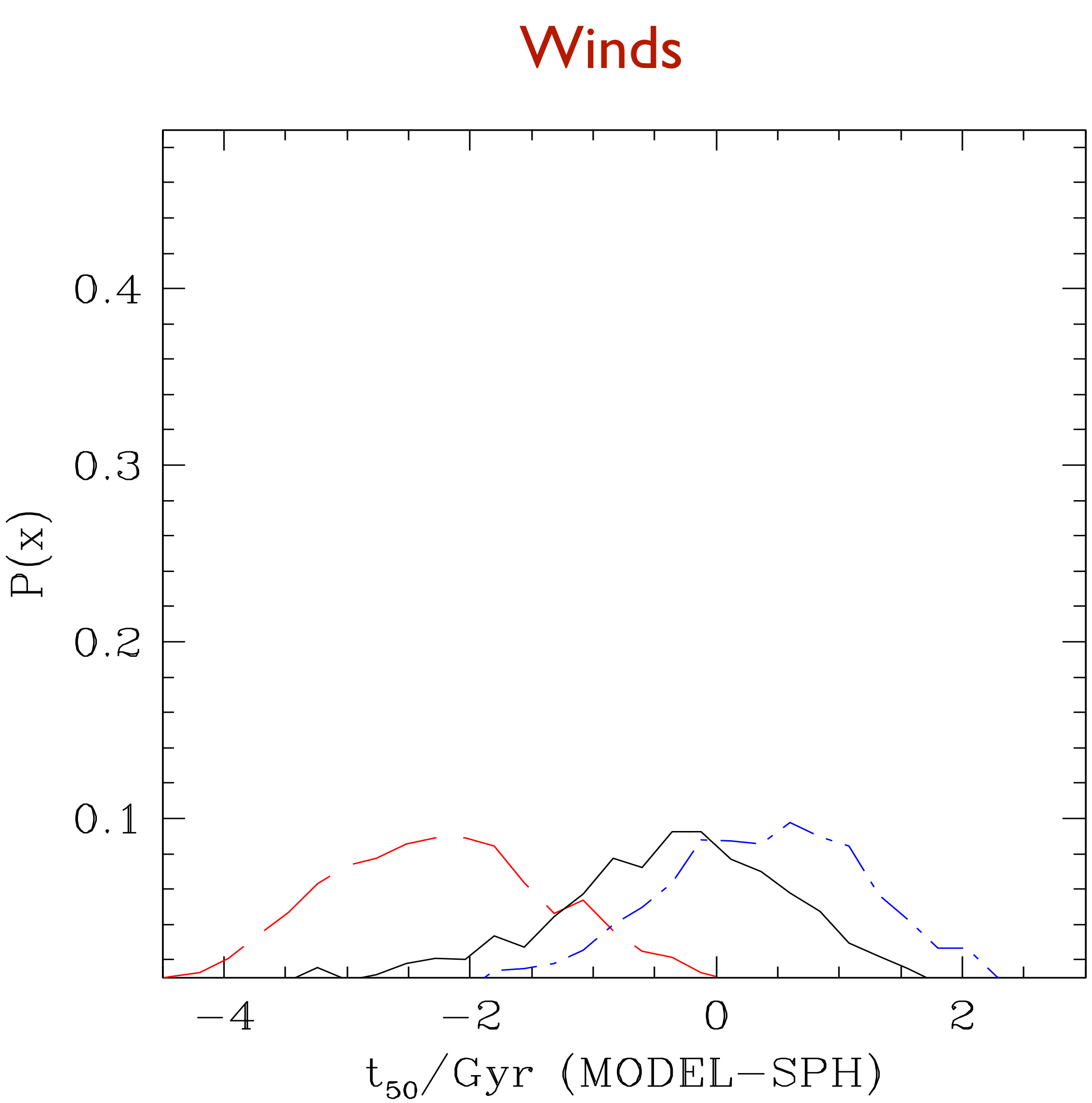
Mass to Light Ratio

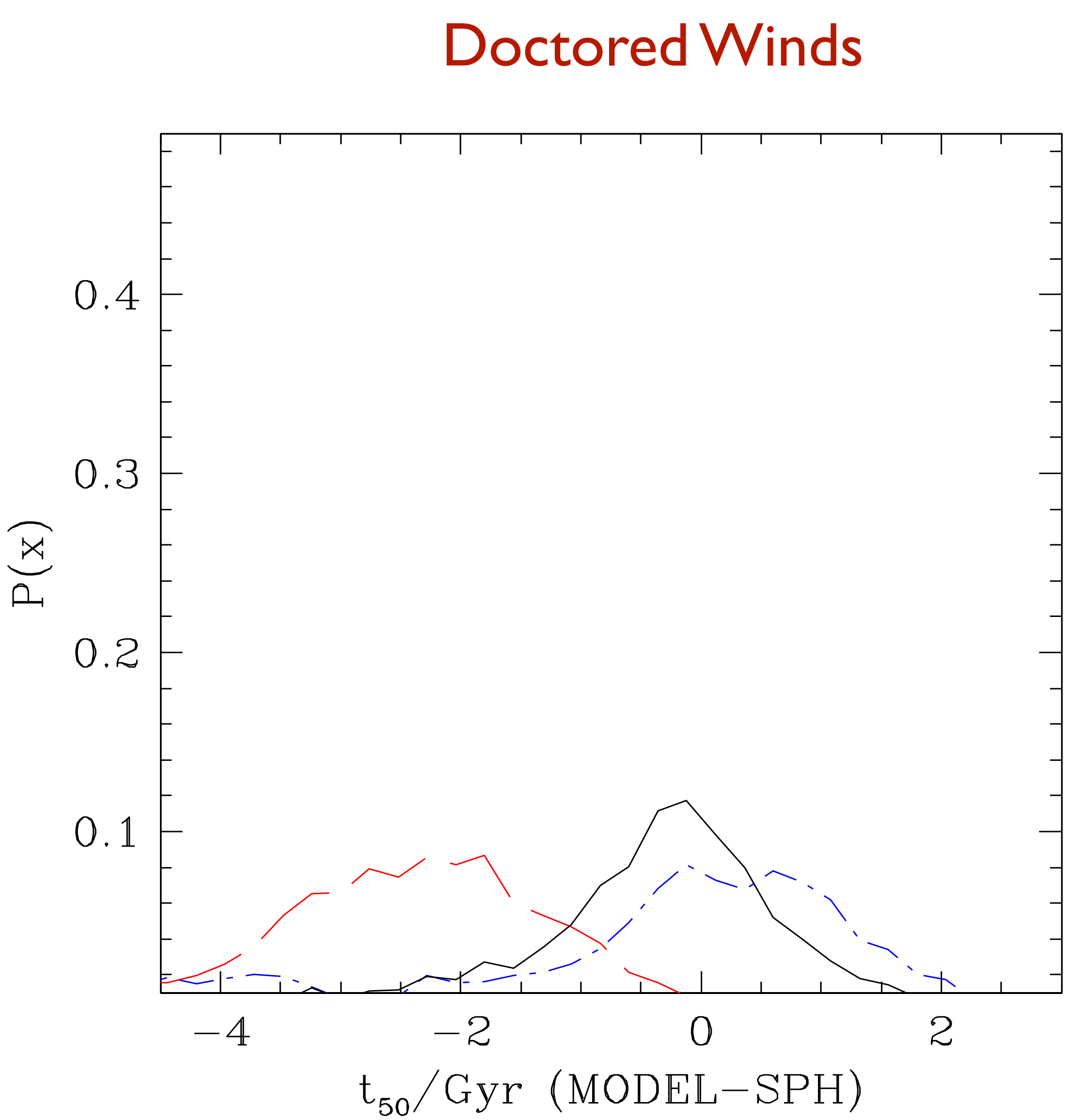




- Tau model overestimates M/L by factor of ~1.5
- 4 parameter model gets M/L within 10% for 68% of galaxies

Stellar Population Age

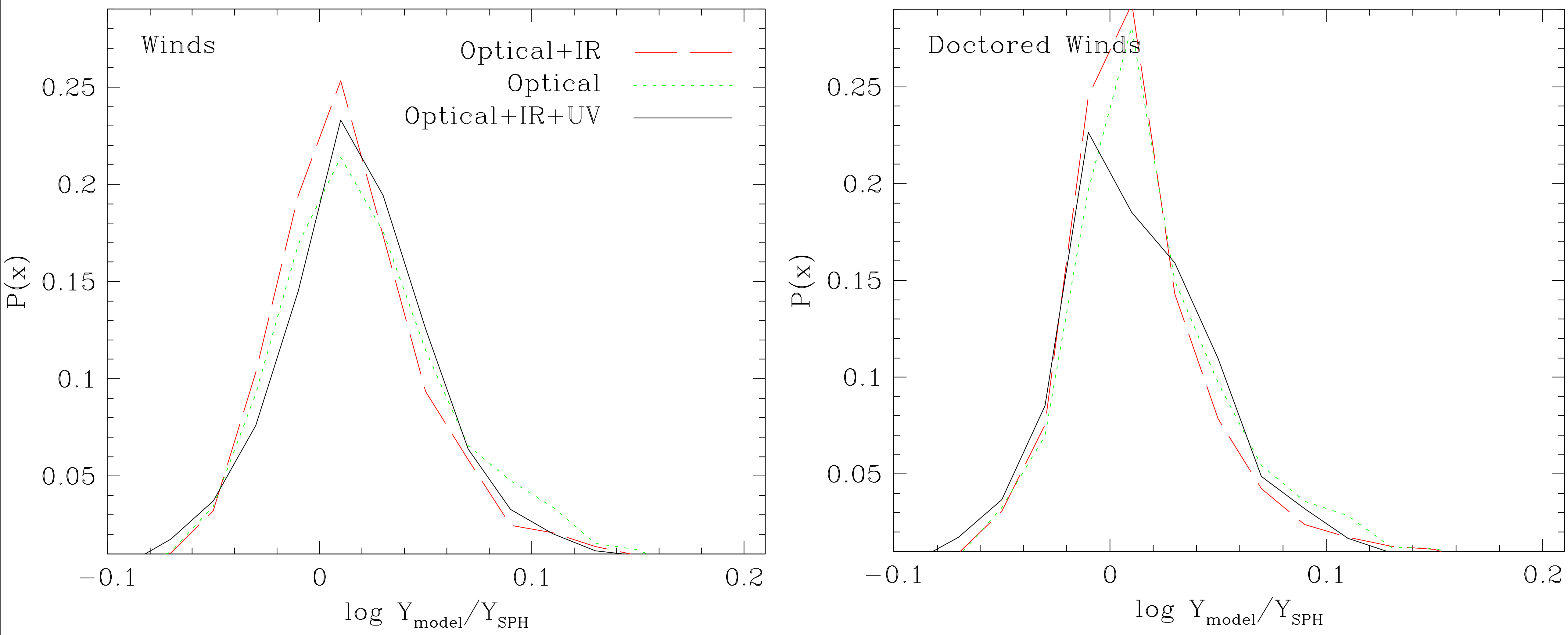




- Tau model overestimates stellar population age by ~2-3 Gyr
- 4 parameter model gets M/L within 1Gyr for 68% of galaxies

Effect of UV and IR Colours

- Compute GALEX NUV & FUV and 2MASS J,H & K colours and fit to those too



- Adding UV and IR does not seem to improve things
- BUT very likely to help break degeneracies with dust, metallicity and determination of photo-z

Conclusions

- We examine SFHs of galaxies in SPH simulation.
- What model SFHs should be fit to observed SEDs?
- Commonly Used Tau Model ($e^{-t/tau}$) does not adequately describe the SFHs of galaxies in SPH simulation.
- It introduces significant biases in estimates of physical parameters such as M/L, median age, SFR.
- Extended tau model ($te^{-t/tau}$) is a substantial improvement.
- We advocate extended tau up to a transition time followed by linear with variable slope - 4 parameter model (start time, tau, transition time, slope of linear component) of which start time and transition time can be fixed for relatively small cost.