The stellar mass assembly process of star forming galaxies in galaxy formation models

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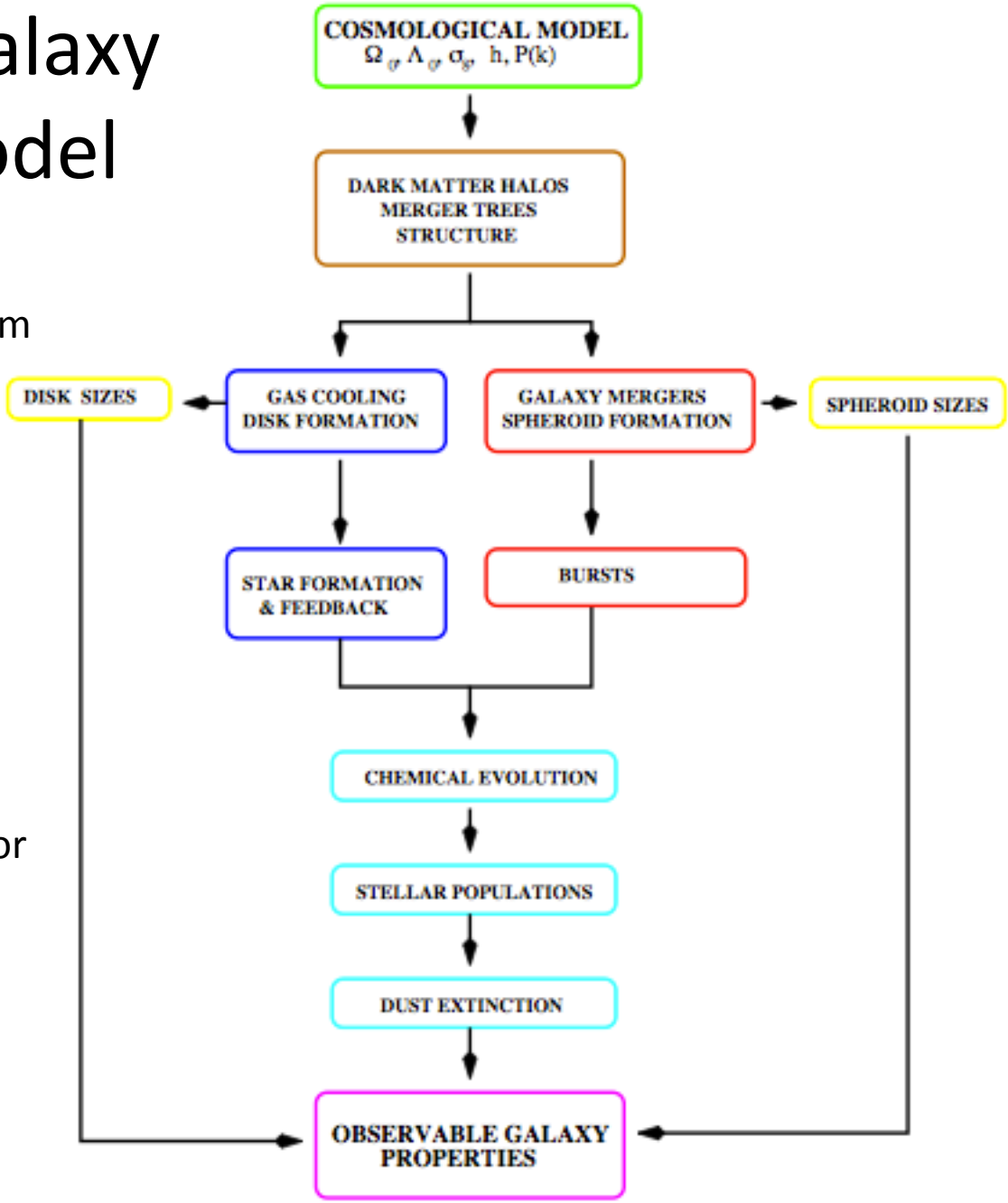
Outline

- The Galform galaxy formation model
- The star formation-stellar mass sequence
  - Evolution is different between models/data
- Star formation histories of star forming galaxies
- Connecting stellar and halo mass assembly
  - Where does the model go wrong?

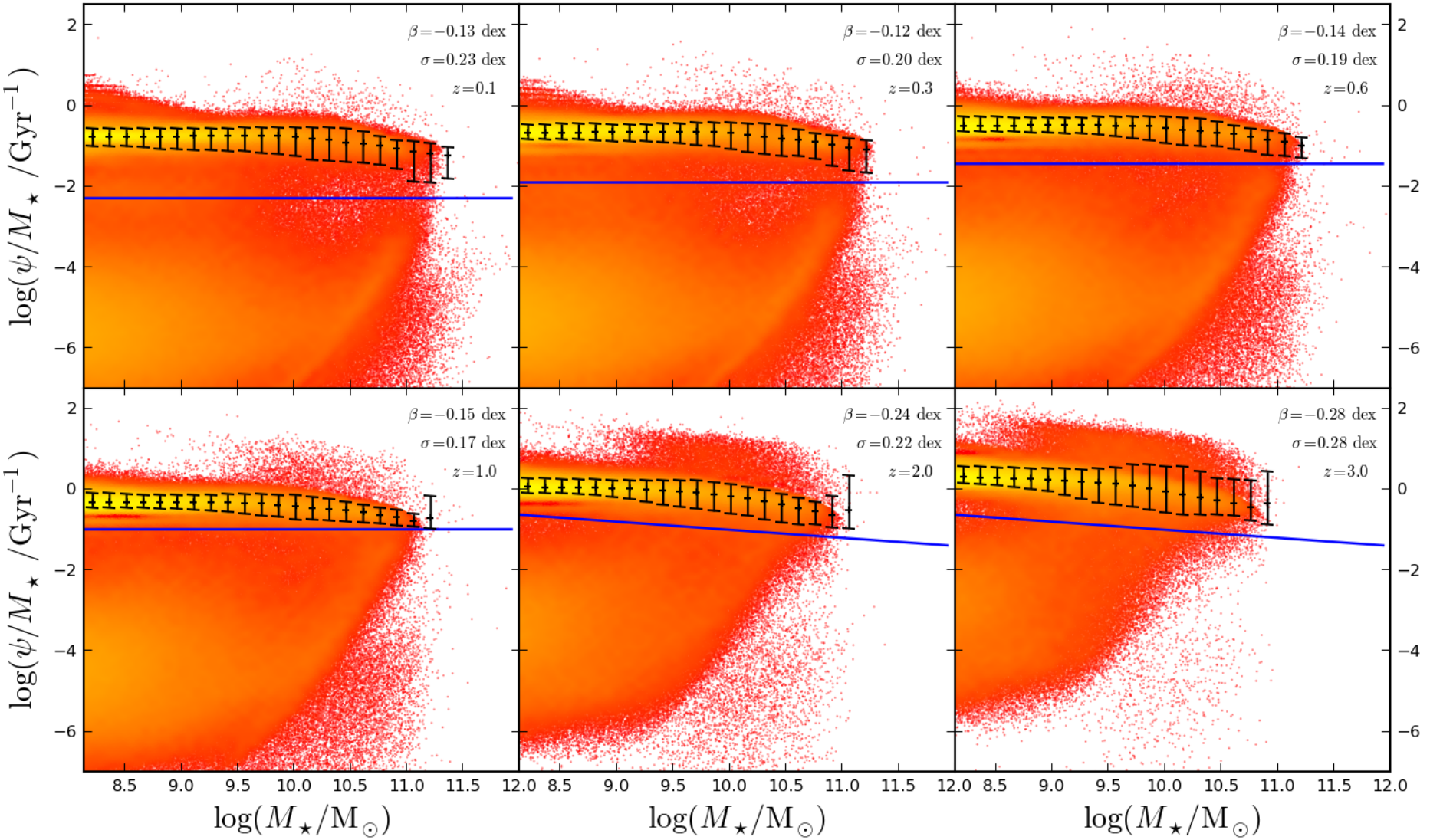
The Galform galaxy formation model

- Dark matter halo merger trees from nbody/extended Press-Schecter
- Assumed density profiles for halo,disk,bulge
- Predict cooling rate
- Empirical star formation law
- Phenomenological prescriptions for supernova feedback and gas reincorporation
- AGN feedback/environmental processes



The star formation sequence

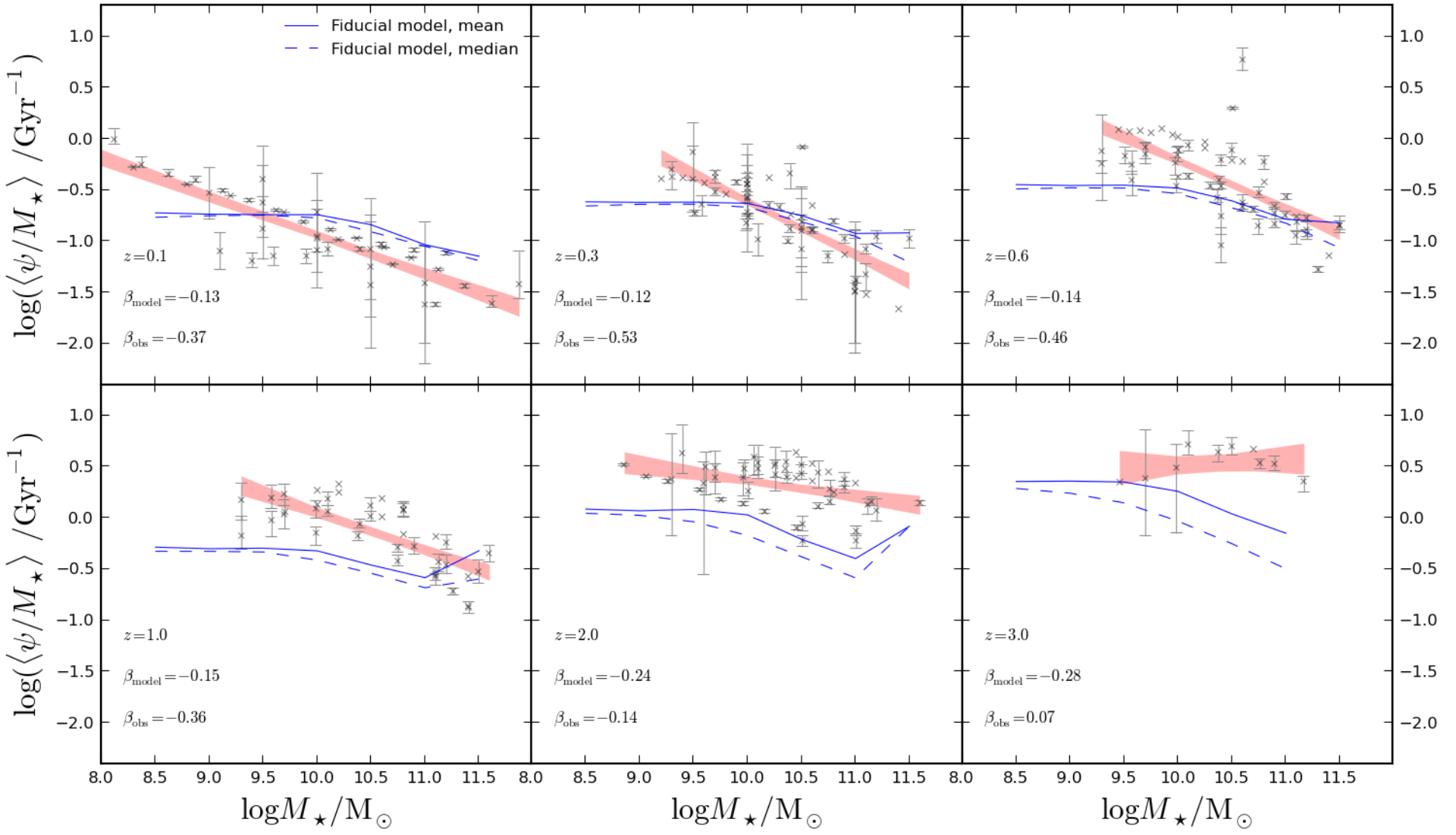
$$sSFR \equiv \psi / M_{stars} \propto M_{stars}^{\beta}$$



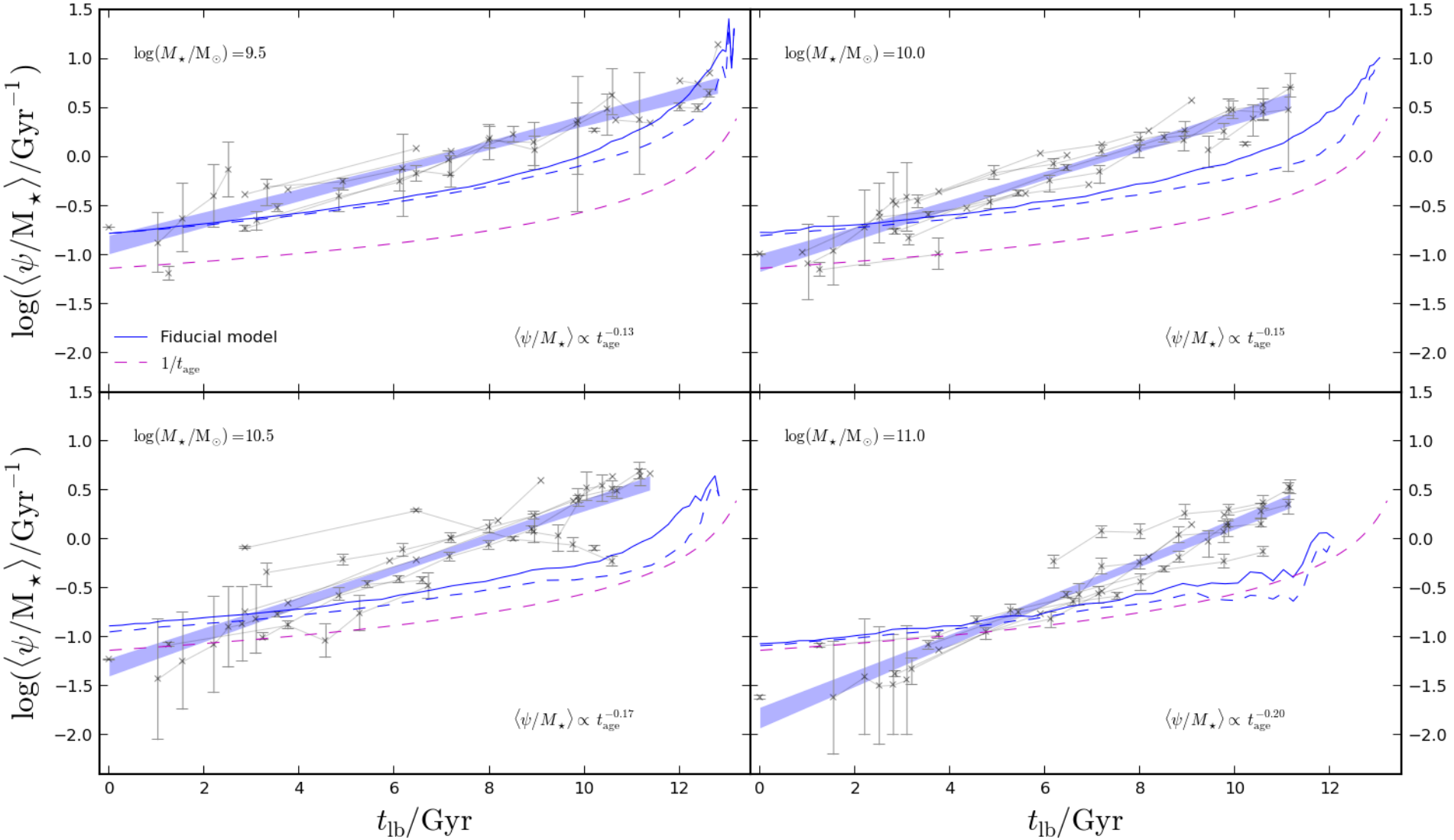
The star forming sequence in observations

- SFR can only be estimated reliably for actively star forming objects
- This makes it difficult to disentangle passive and actively star forming galaxies.
  - Trade off between sensitivity and the fraction of passive galaxies as a function of redshift
- Separation is usually performed using rest frame colour diagnostics

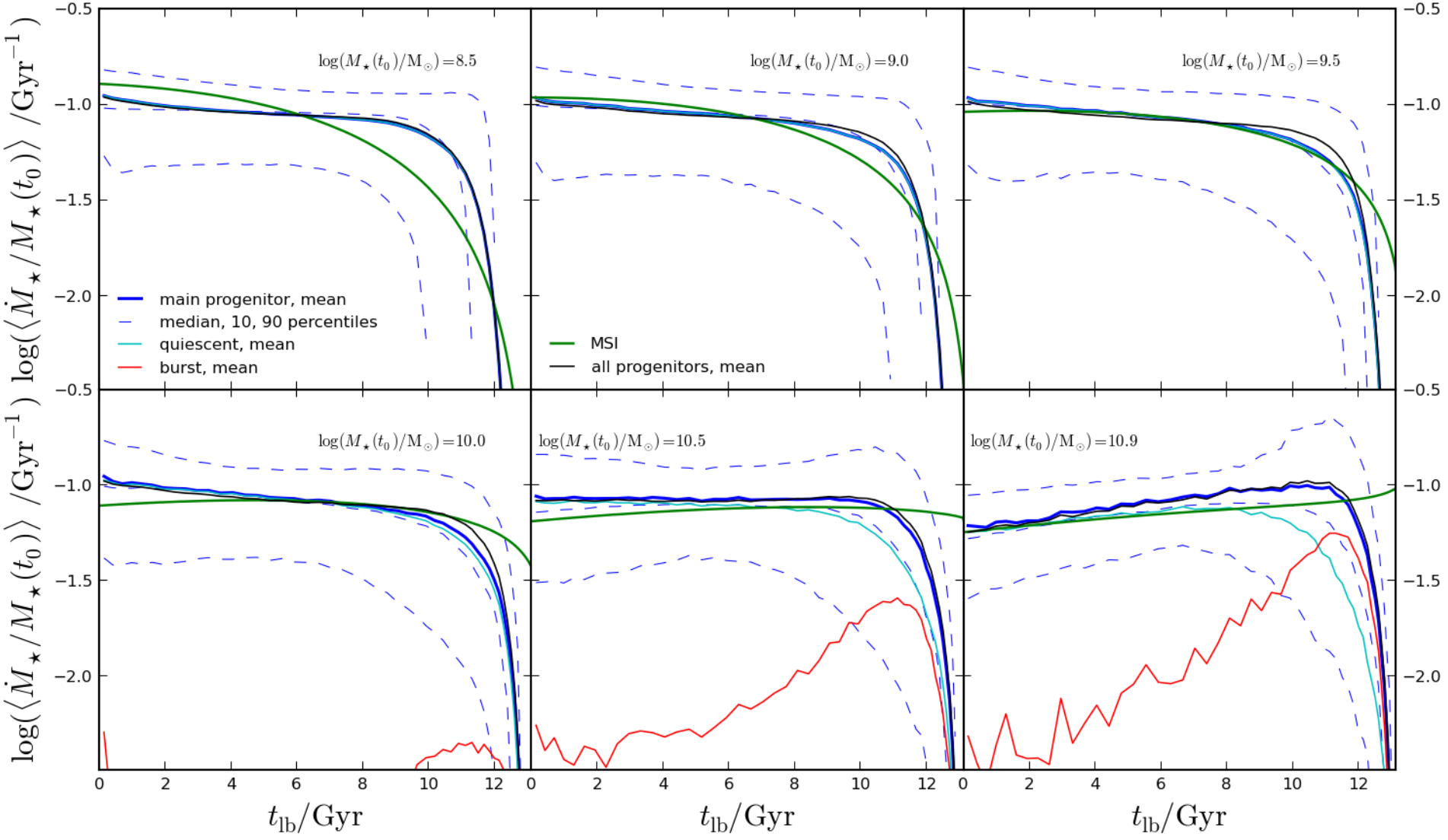
Comparison with observational data, star forming galaxies only



Disagreement in the evolution between models/data



Stellar mass assembly of star forming galaxies in Galform

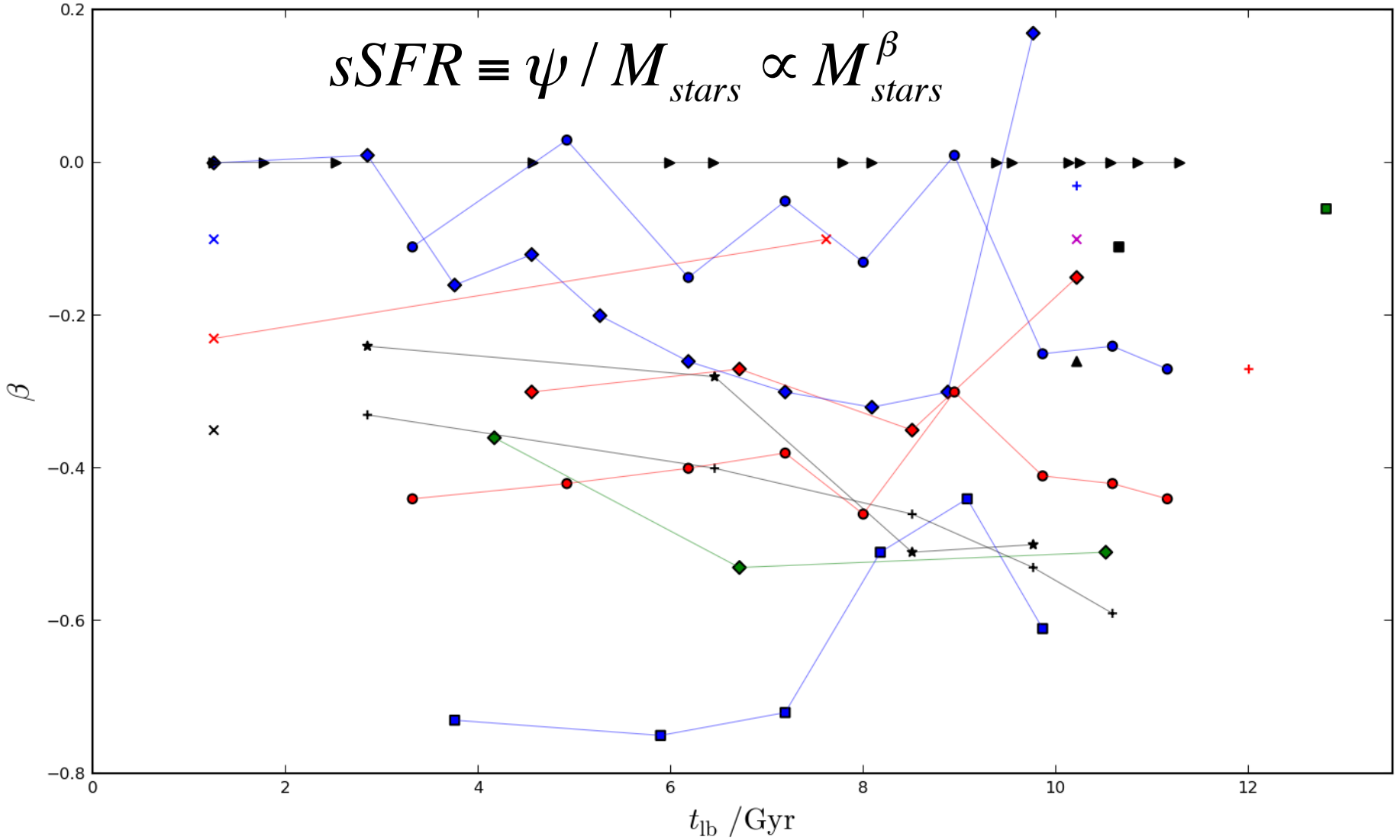


Main Sequence Integration (MSI)

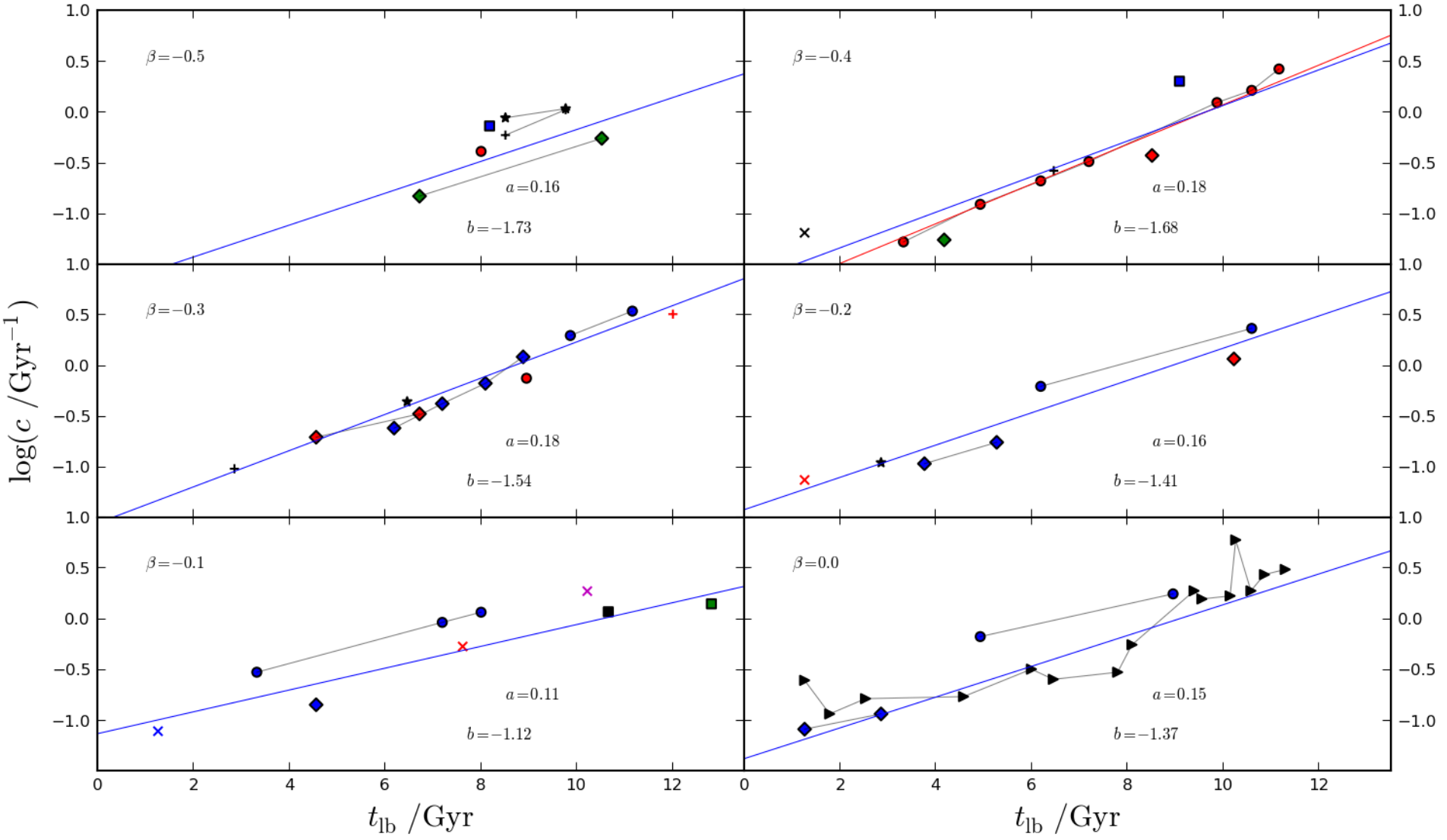
- Assume that a galaxy on the star forming sequence at z=0 has always been on the sequence
- Assume that the contribution from galaxy mergers to stellar mass assembly is small
- Integrate backwards from z=0 to predict the average SFH of star forming galaxies of a given stellar mass at z=0

Performing MSI on observational data

- Large uncertainty on the power law slope

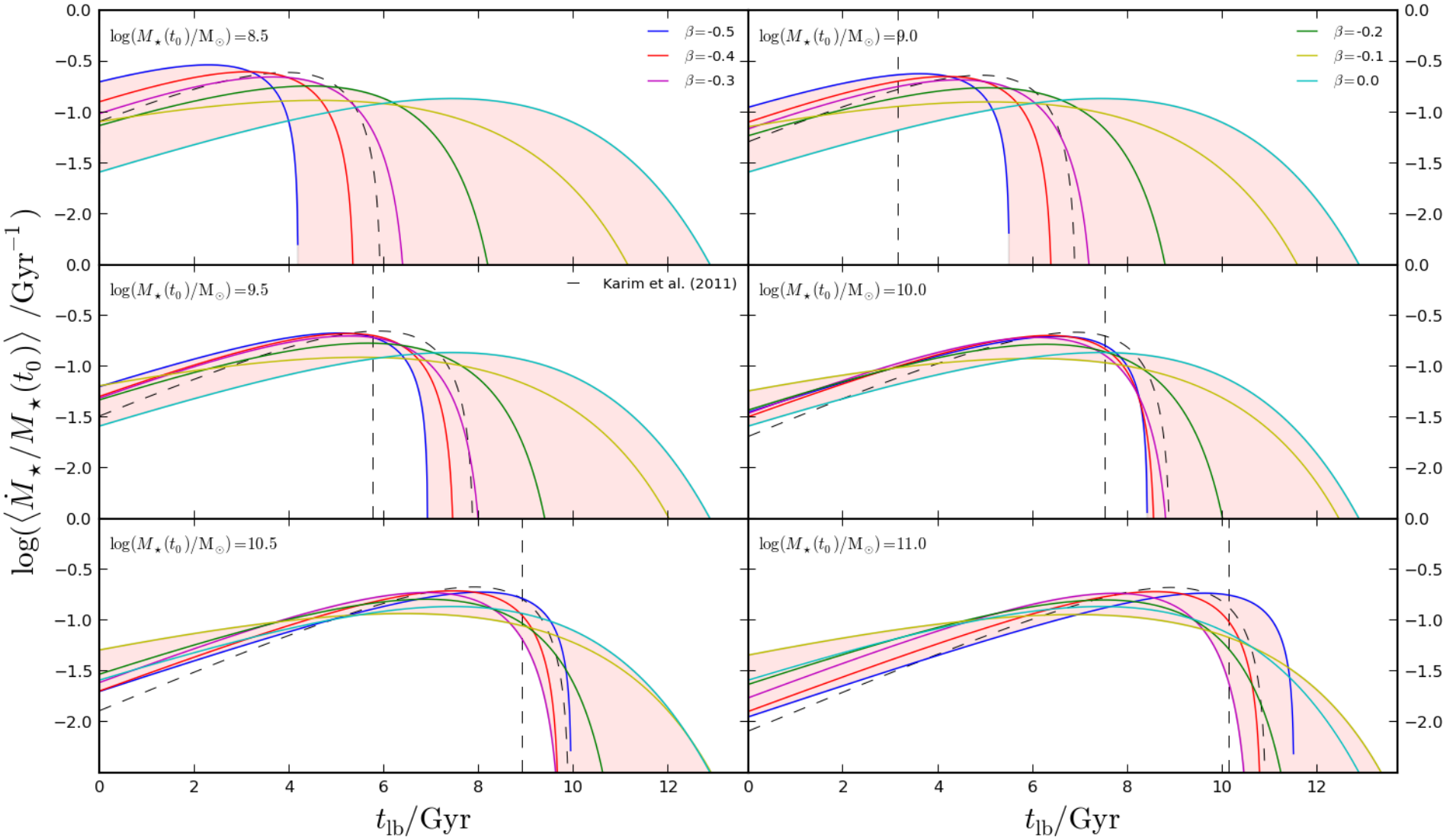


- Better consensus on the evolution in the normalisation

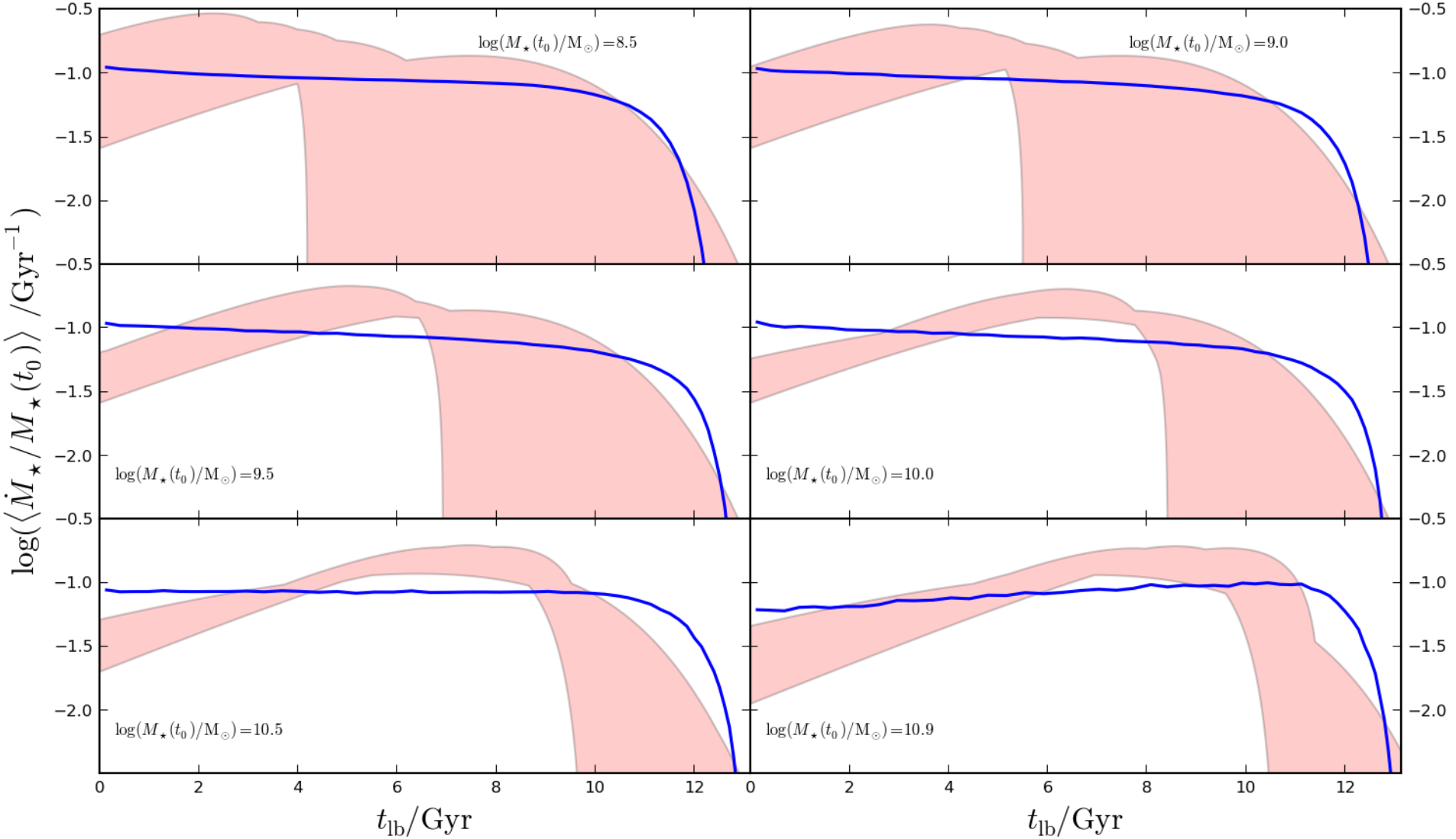


Inferred stellar mass assembly histories

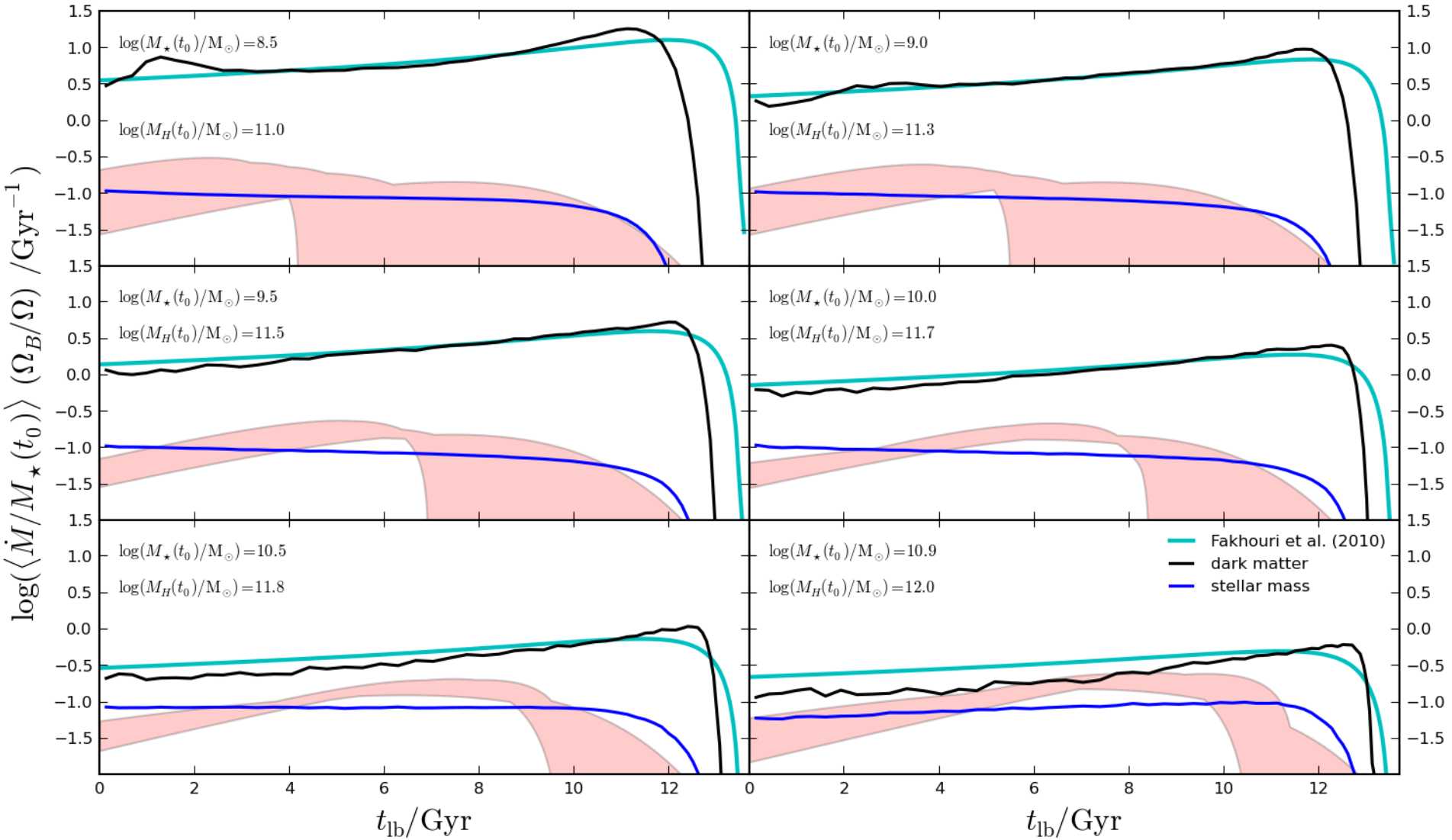
$$sSFR \equiv \psi / M_{stars} \propto M_{stars}^{\beta}$$



MSI/model comparison



Connecting to haloes



Why does the model fail?

- The efficiency of supernova feedback in modulating the process of converting gas into stars is roughly constant over most of the lifetime of a star forming galaxy.
  - Consequently, galaxy star formation histories closely trace halo assembly histories
- This appears incompatible with the star formation histories of star forming galaxies inferred using MSI.
- This behaviour is generic for the traditional implementation of feedback within Galform and other theoretical models.

Summary

- Galaxy formation models predict evolution in the sSFR of these star forming galaxies that is too slow compared to data up to z=1-2

- Integrating the sequence backwards to infer the average SFH reveals that star forming galaxies need to have a peak of star forming activity at z=1-2.

- This is not reproduced in models because either the mass loading or the gas reincorporation timescale (or both) do not evolve in the right way over the lifetime of a star forming galaxy

Where is the failure in the model

- Cooling timescales are short – irrelevant
- Disk gas depletion timescales are short when feedback is effective
- This leaves:
  - Supernova feedback
  - Gas reincorporation timescale

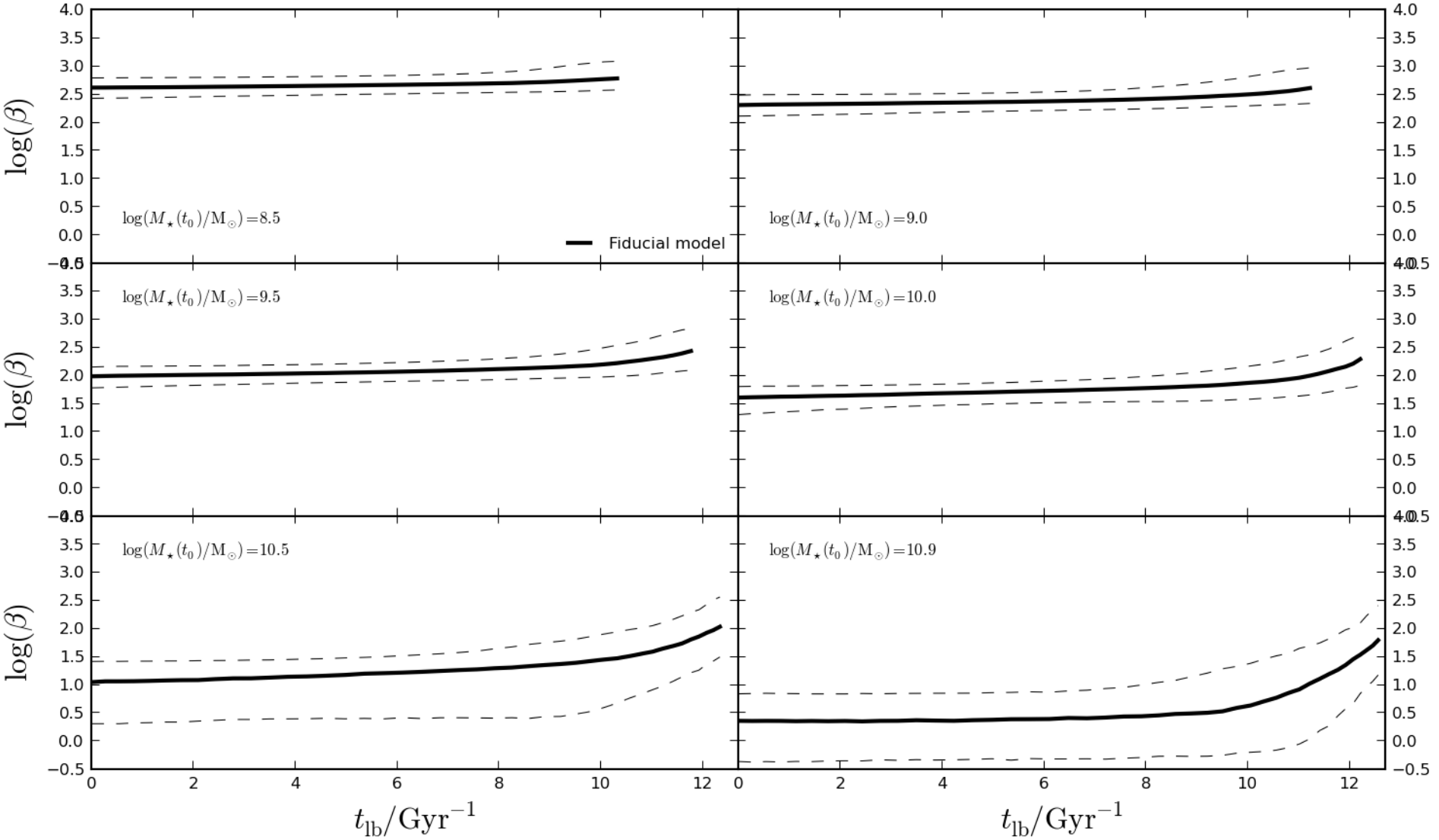
$$\beta \equiv \frac{\dot{M}_{eject}}{\dot{M}_{stars}} = \left(\frac{V_{disk}}{V_{hot}} \right)^{\alpha_{hot}}$$

$$\dot{M}_{res} = \beta \dot{M}_{stars} - \frac{\alpha_{reheat}}{t_{dyn}}$$

Where is the failure in the model

- MSI implies that you need a peak in the SFH of star forming galaxies at z=1-2
- This requires a larger inefficiency in converting accreted gas to stars at early times than is in the model currently
- This could be achieved by
  - Higher mass loading at early times in small haloes
  - Longer reincorporation timescale at early times in small haloes

Evolution in the mass loading factor



Evolution in the reincorporation timescale