

Masses, Star Formation Histories of Cluster Red Sequence Galaxies and the Tilt of the Fundamental Plane

Mike Hudson
U. Waterloo

- Steve Allanson (Waterloo) [Allanson et al 09, astro-ph/0906.3288](#)
- Russell Smith (Durham)
- Coma/Hectospec team, esp. Ron Marzke



Ages, Metallicities & α -Enhancements from Spectra

- **Measure Lick indices**
(typically $H\beta$, $H\gamma$, $H\delta$, several Fe lines, Mgb)
- **Compare with α -enhanced models**
e.g. Thomas/Maraston et al, Schiavon.
- **...yields (“luminosity-weighted”) ages, metallicity, α -enhancement**

Cluster Samples

- Red and emission-free but not morphologically-selected.
- *Large dynamic range in mass*
- Shapley
 - 340 galaxies in 3 rich clusters from deep 8hr AAOmega.
Smith et al. 07 MNRAS 381 1035; Smith et al. 09b submitted
- Coma Cluster Survey
 - Deep Hectospec of 90 dwarfs.
Smith et al. 08 MNRAS 386L 96; Smith et al. MNRAS 392, 1265

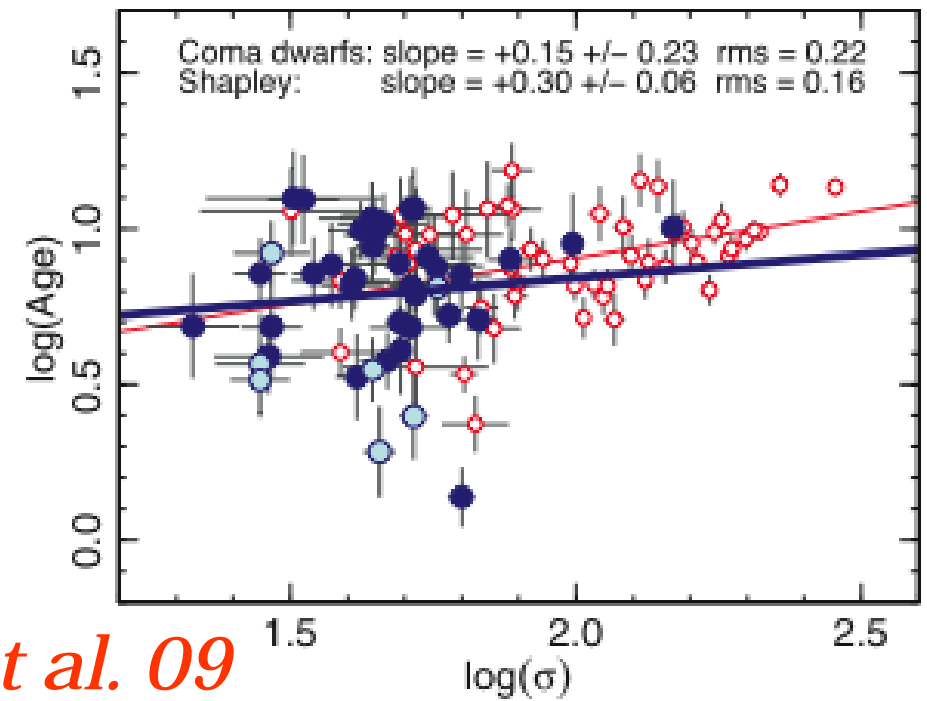
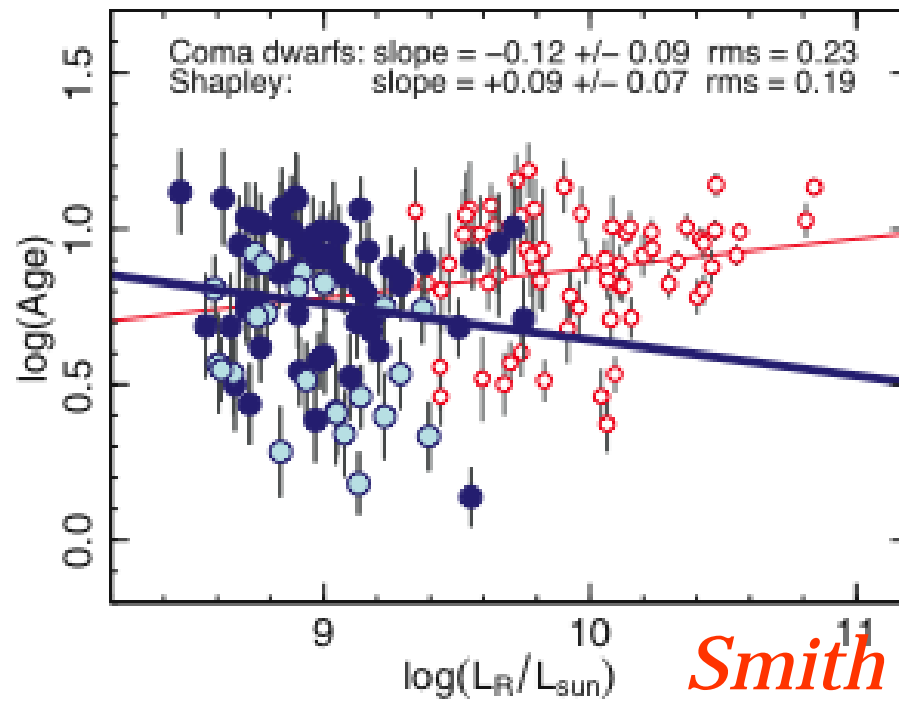
The “Driving Parameter” of Stellar Populations

Velocity dispersion, σ , is the driving scaling parameter, with little residual dependence on stellar mass.

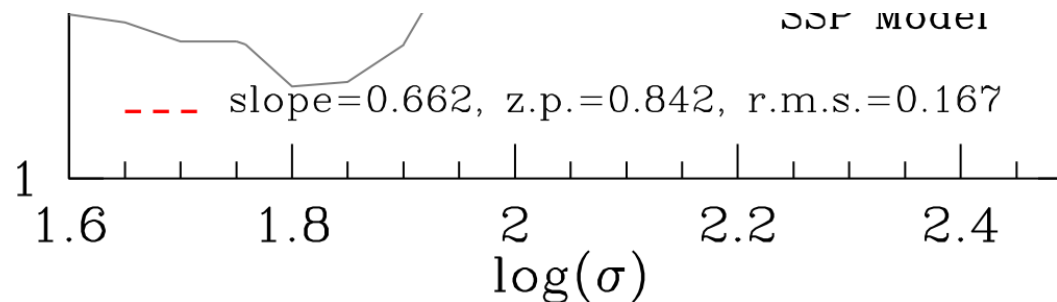
Smith, Lucey, MH 09, submitted

See also Graves & Faber 09

The End of Downsizing?

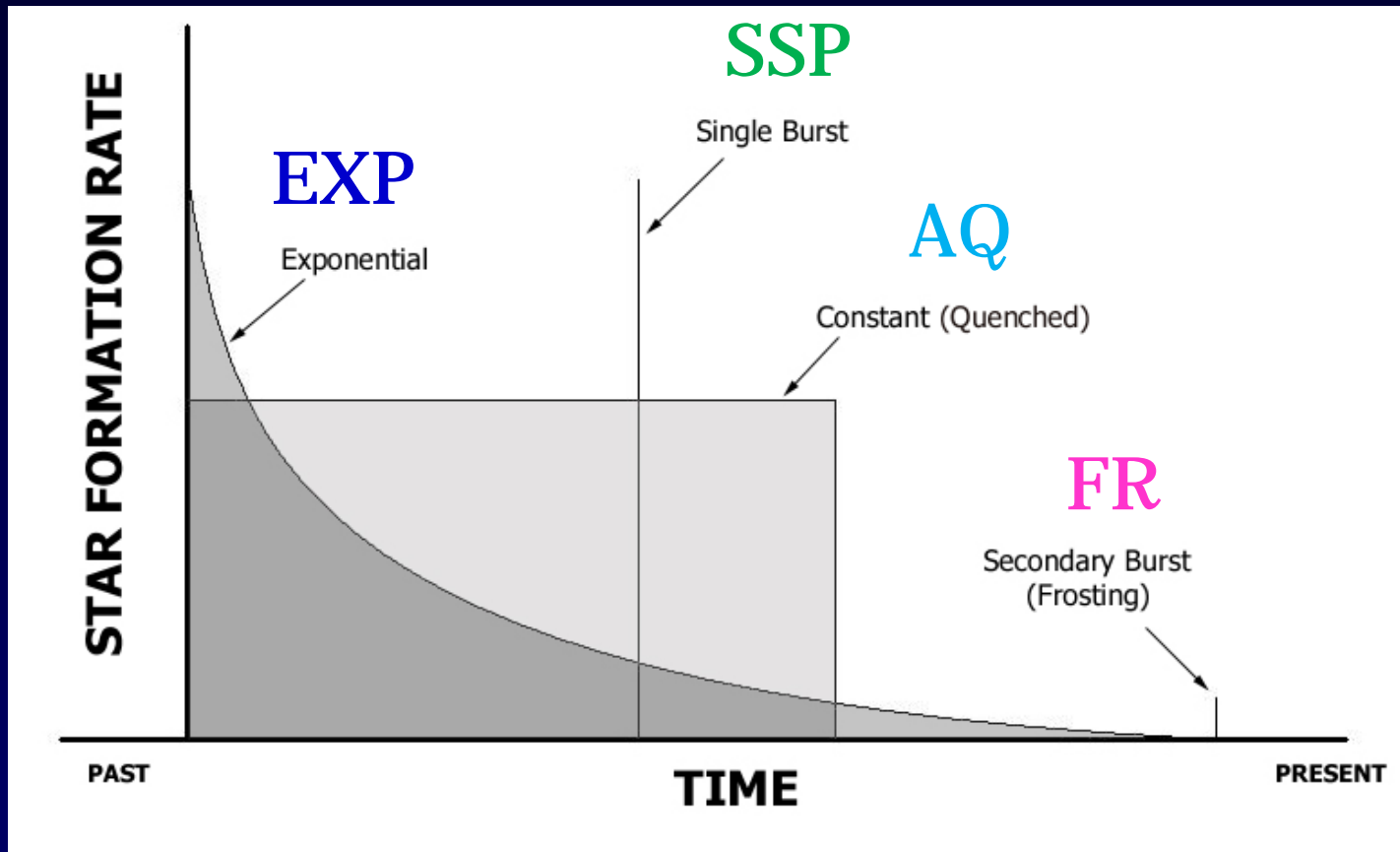


Smith et al. 09



Ages from Balmer Lines

... are *luminosity-weighted* ages. Could be



Very hard to distinguish these possibilities with spectra

Frosting disfavoured

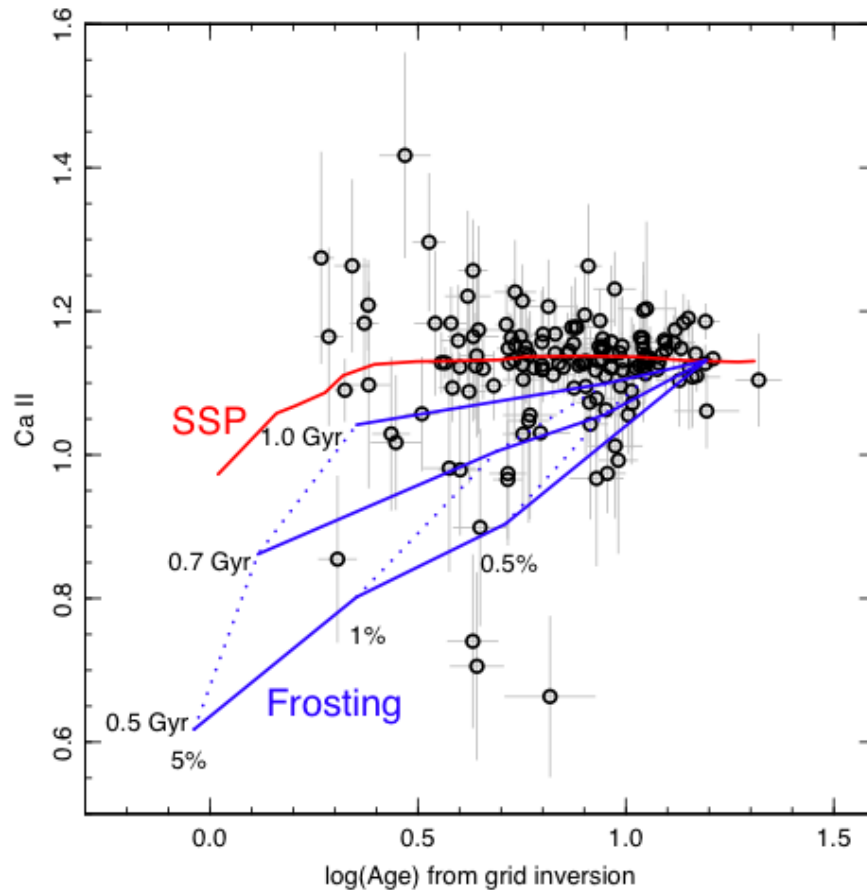


Figure 6. The Rose Ca II index for galaxies with errors smaller than 0.15, compared to the SSP-equivalent age. The grid indicates the expected behaviour for frosting by secondary bursts of age 1.0, 0.7 and 0.5 Gyr (solid lines top to bottom), and mass-fractions 5, 1 and 0.5 per cent (dotted lines, left to right), with the remaining mass in a 13 Gyr base population. The upper track shows predictions for SSPs, demonstrating the stability of Ca II for ages >1 Gyr. Although a few galaxies fall in the region of the frosted models, *on average* the SSP-equivalent ages of young galaxies are not driven by secondary bursts in the past Gyr.

Rose CaII index disfavours <1 Gyr “frosting” as the explanation for most young *cluster* RSGs.

(In contrast to field from e.g. UV?)

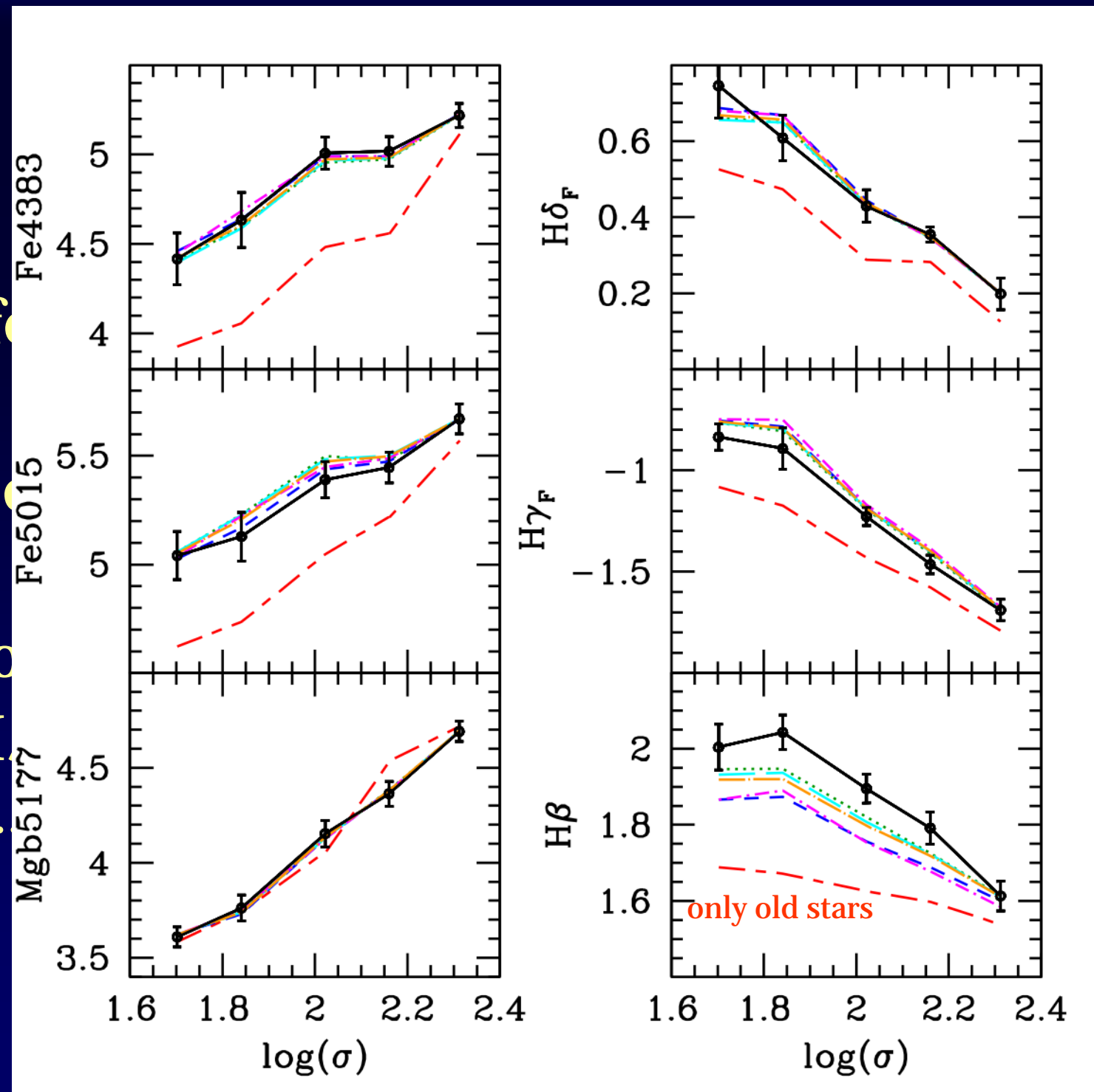
Smith, Lucey, MH 2007

diff

Pre

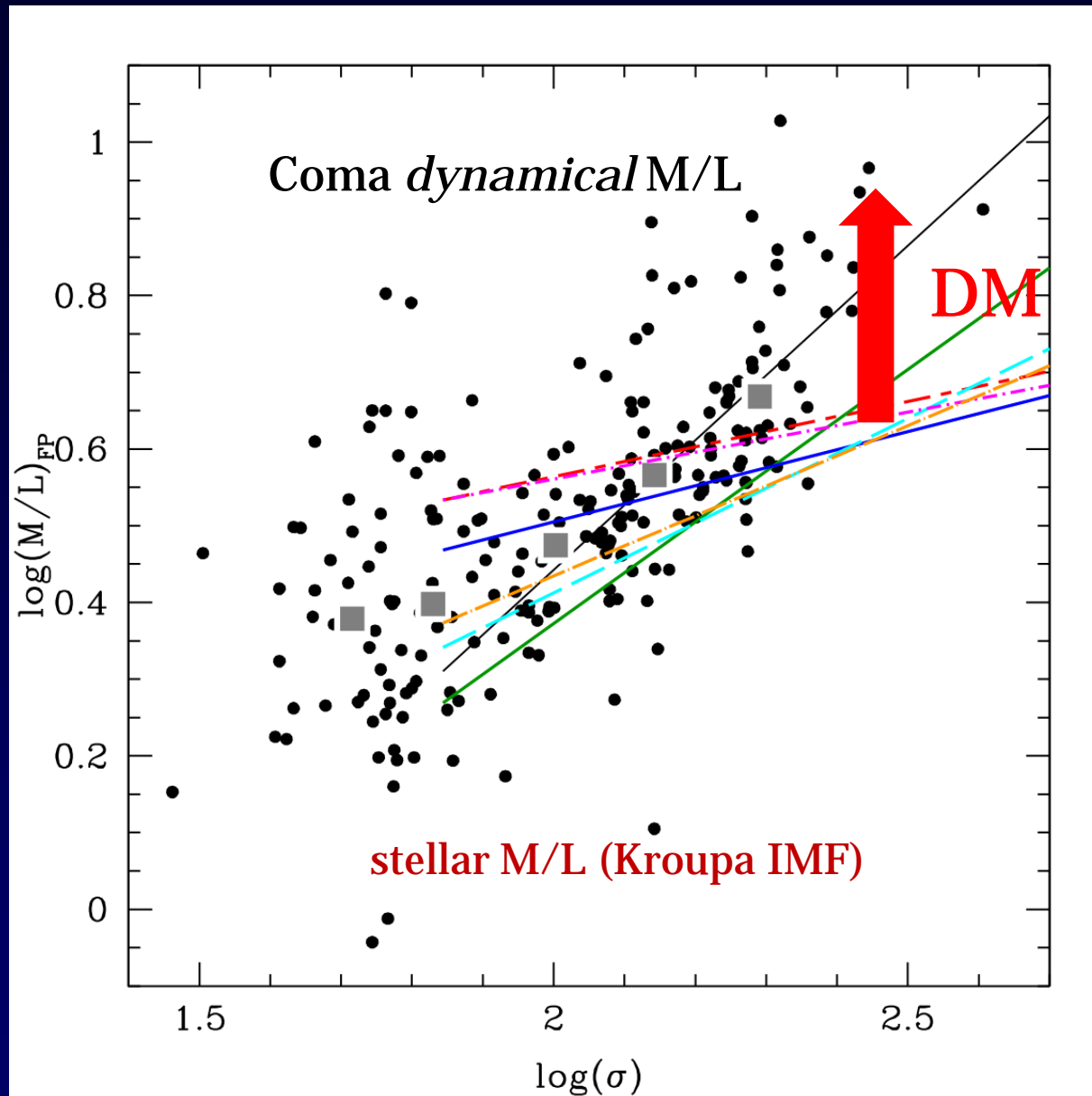
• Co

• M



th

Dark Matter and the Tilt of the FP



M/L =

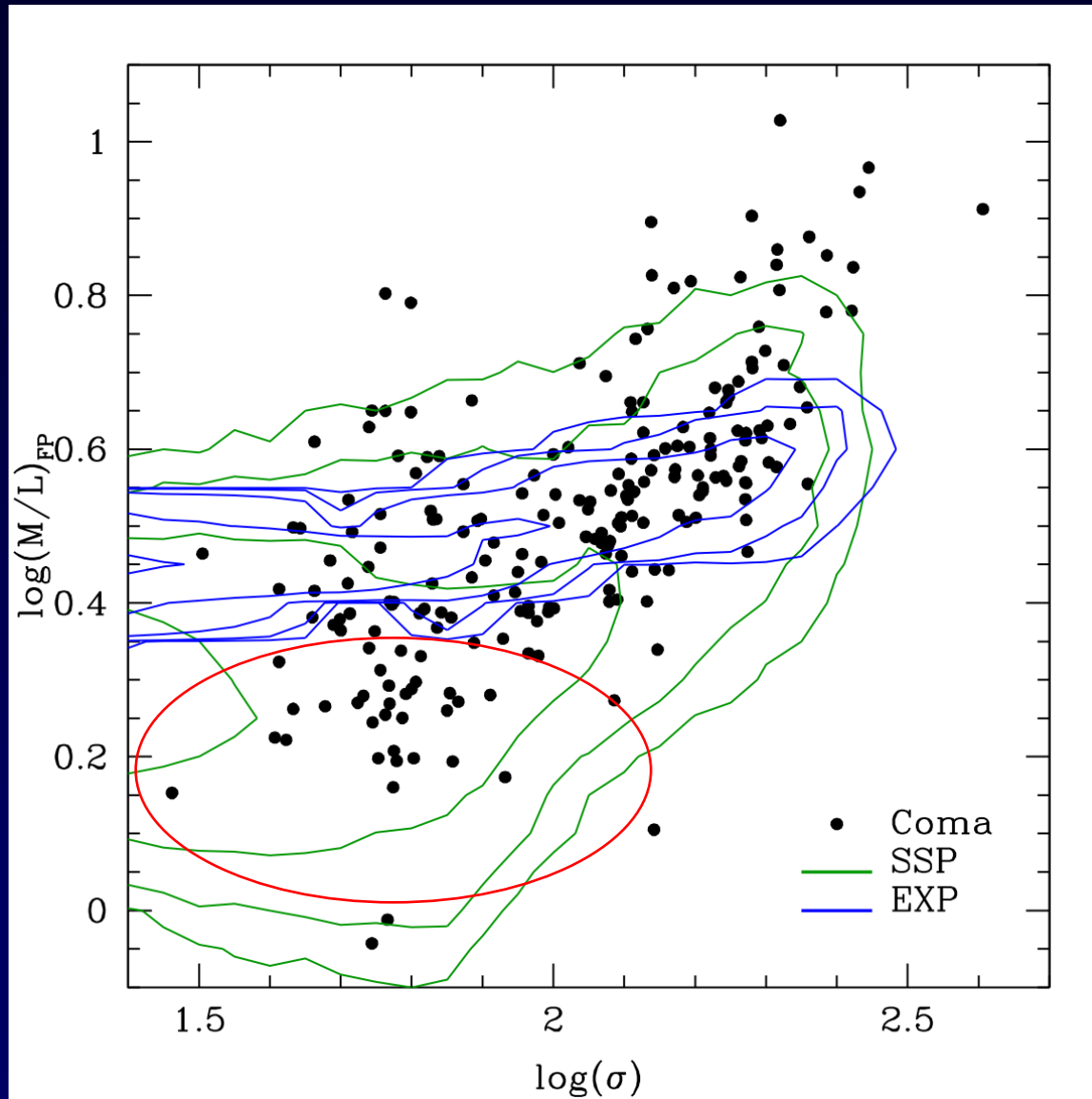
$$5 \sigma^2 r_{\text{eff}} / L G$$

Frosting,
Exponential SFR:
 $M_*/L > M_{\text{dyn}}/L$

Quenched: OK
Young SSP: OK

Allanson, MH,
Smith & Lucey 2009

Age as the source of FP tilt and scatter



OK for points to be above contours: add DM

EXP models can't reproduce low dynamical M/L

Notice how the *shape* of SSP stellar M/L matches the shape of the distribution of dynamical M/L measurements

Dark Matter and the Tilt of the FP

Bell and de Jong popularized the exponential star formation history in their study of *spiral* galaxy M/L ...

... much previous work on the tilt of the FP has *assumed* exponential/bursty star formation history for red galaxies

Kauffmann et al. 03, Galazzi et al. 05, Padmanabhan et al. 04, Bernardi et al. 09, Tortora et al. 09, Grillo et al. 09, etc.

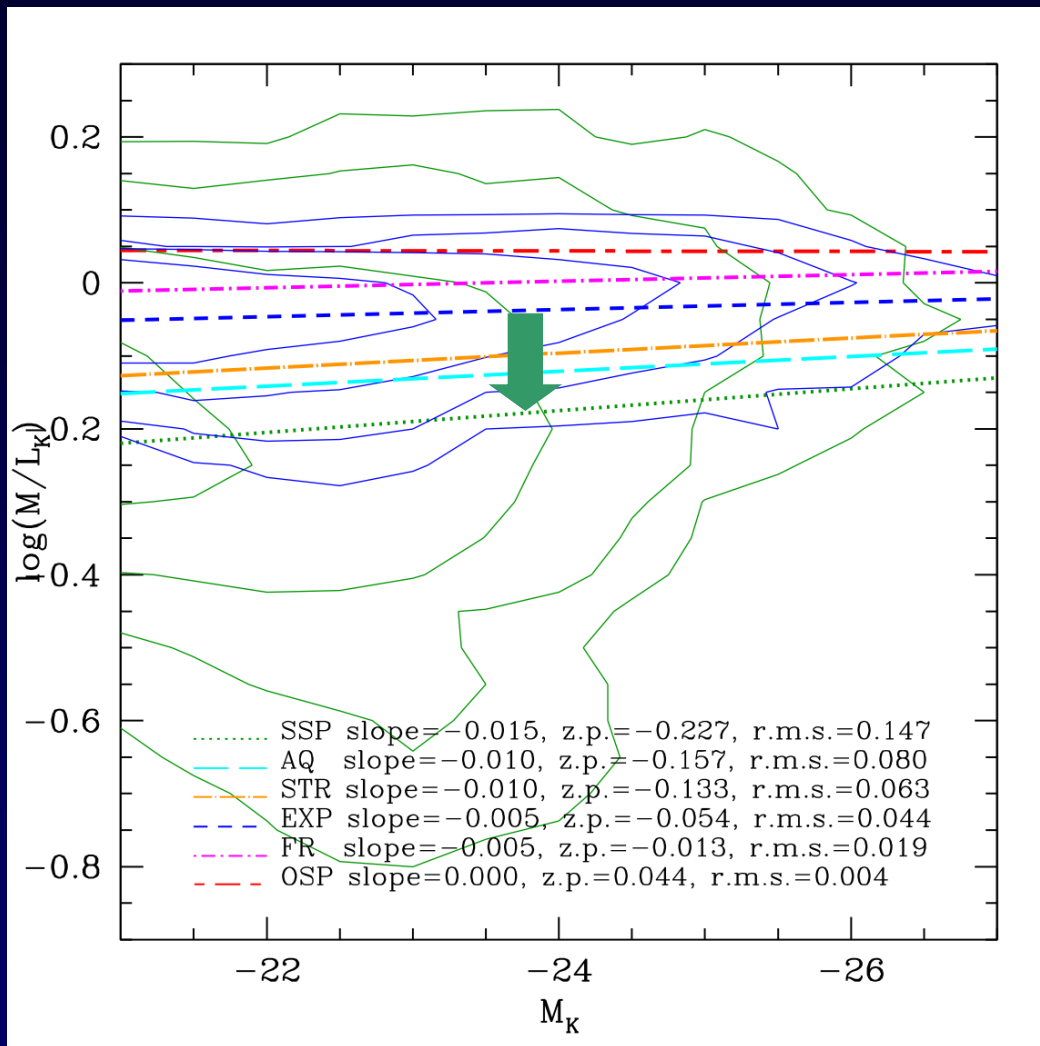
... FP tilt depends on assumed *star formation history*:

SSP : tilt is *all* due to stellar pops

AQ : 2/3 of tilt is stellar pops

(If EXP were correct, then tilt would be due mostly to DM)

Stellar Mass Density on the RS

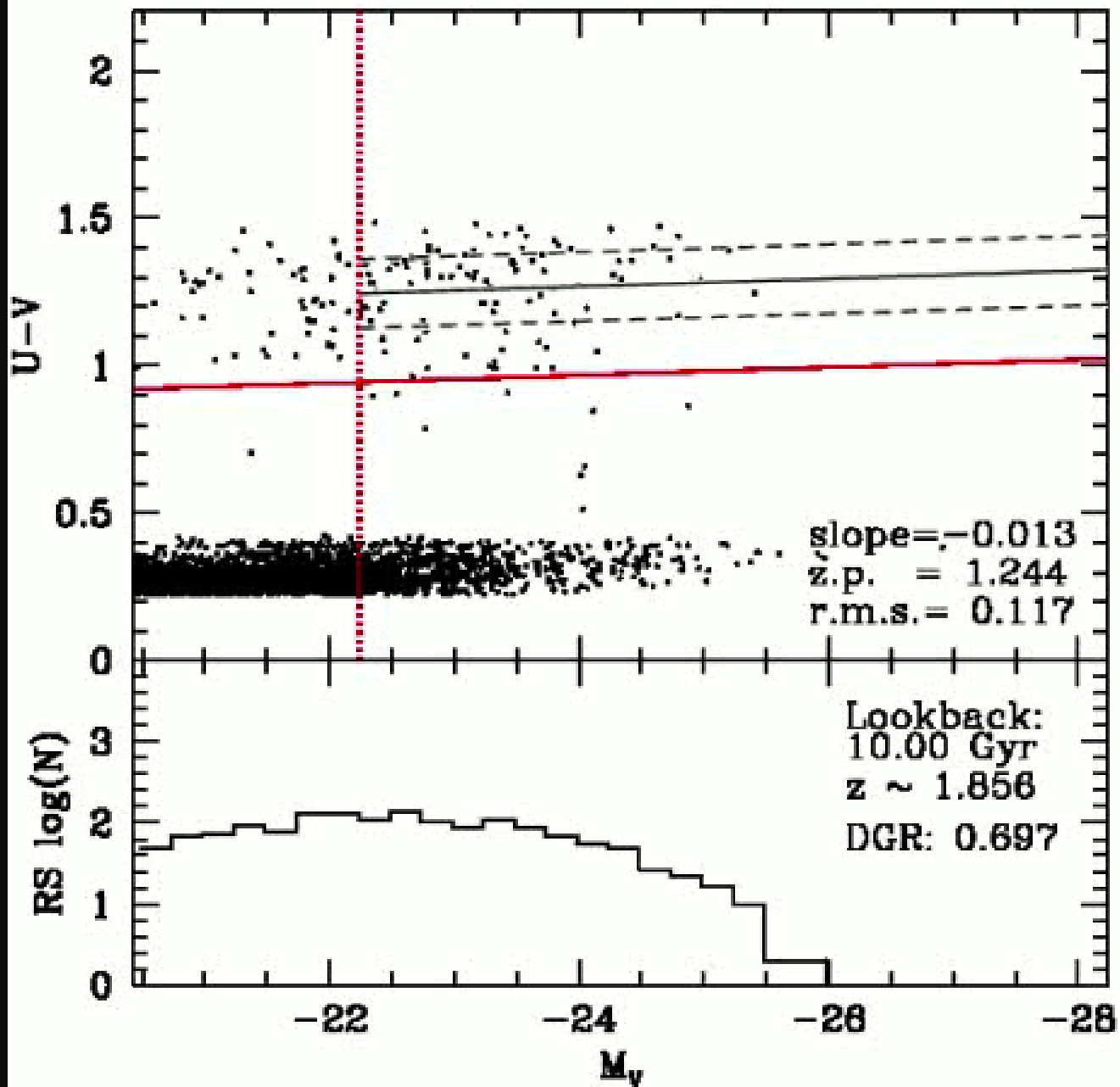


For red galaxies
stellar M/L can
be lower, even
at K, by as
much as 0.17
dex (~33%)

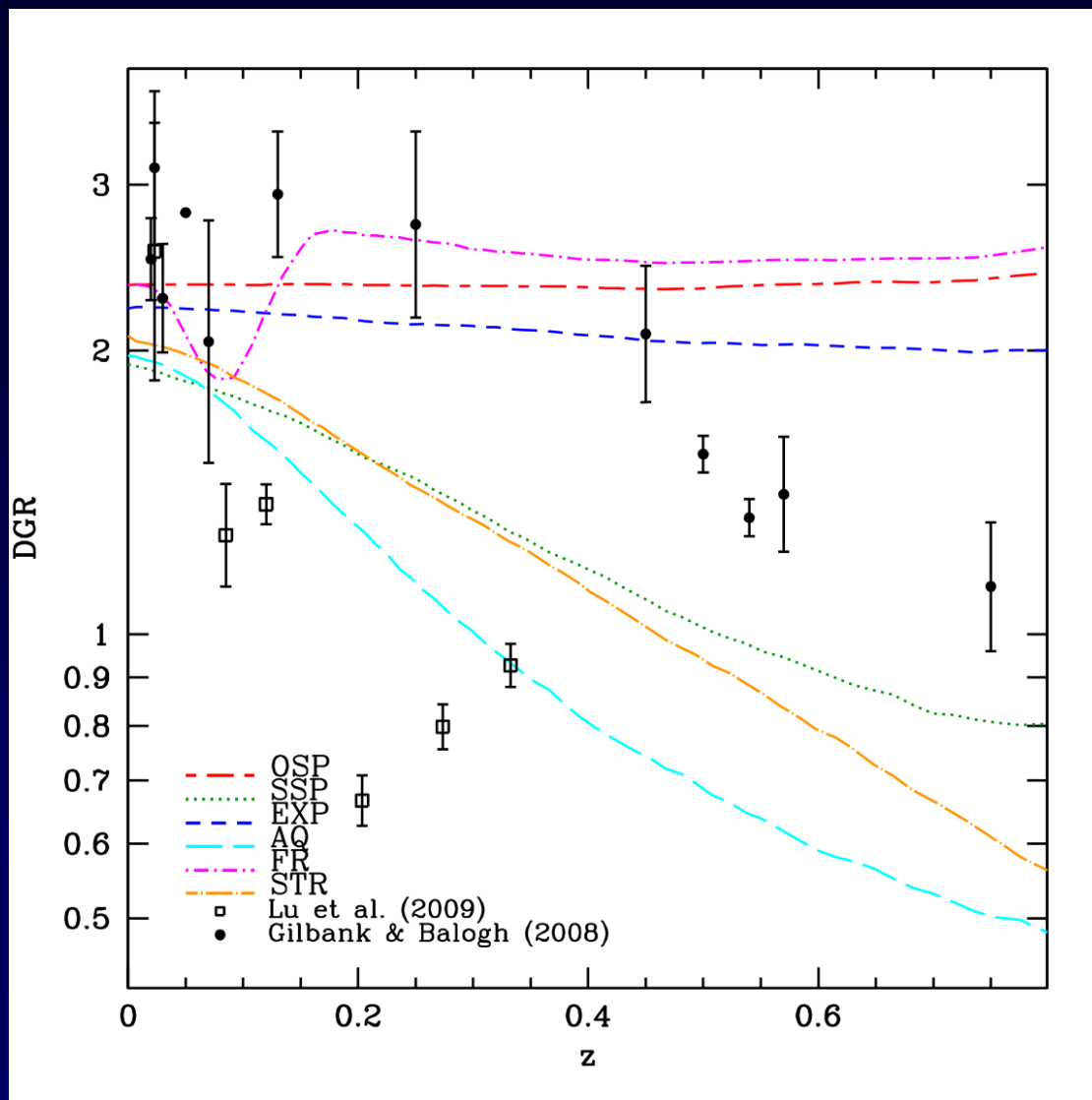
Buildup of the red sequence

If age is a strong function of mass/velocity dispersion then the red-sequence itself is built “top-down”

Buildup of the Red Sequence



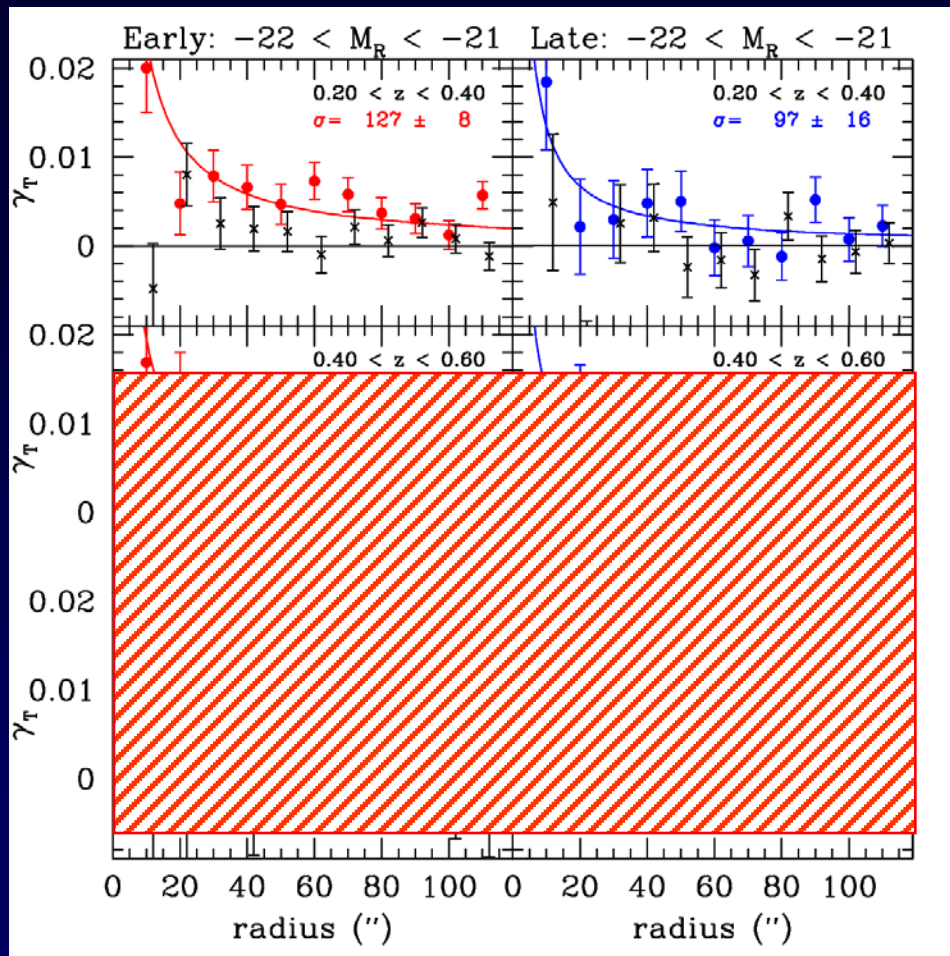
Dwarf-to-Giant Ratio as a function of redshift



**DGR
evolution
rules out
frosting,
exponential.**

**To do:
CMR slope
and scatter,
FP evolution
etc.**

CFHTLS



**~10% errors on σ
for a *single bin* in
z, type,
magnitude from
17 sq deg (10%) of
CFHTLS data...**

Watch this space

Cluster Red Sequence Galaxies

- Strong age (“downsizing”), metallicity and α -enhancements along the RSG *velocity dispersion* sequence.
- Downsizing stops at $\sigma \sim 70$ km/s.
- Exponential (and late frosting) models do not fit dynamical M/L, but SSP or Quenched models are good fits.
- Dark matter contribution to the tilt depends on SF history
- Stellar mass density reduced compared to exponential SF history

Allanson et al. 09, astro-ph/0906.3288

