Gas flows in galaxies: mergers and bars

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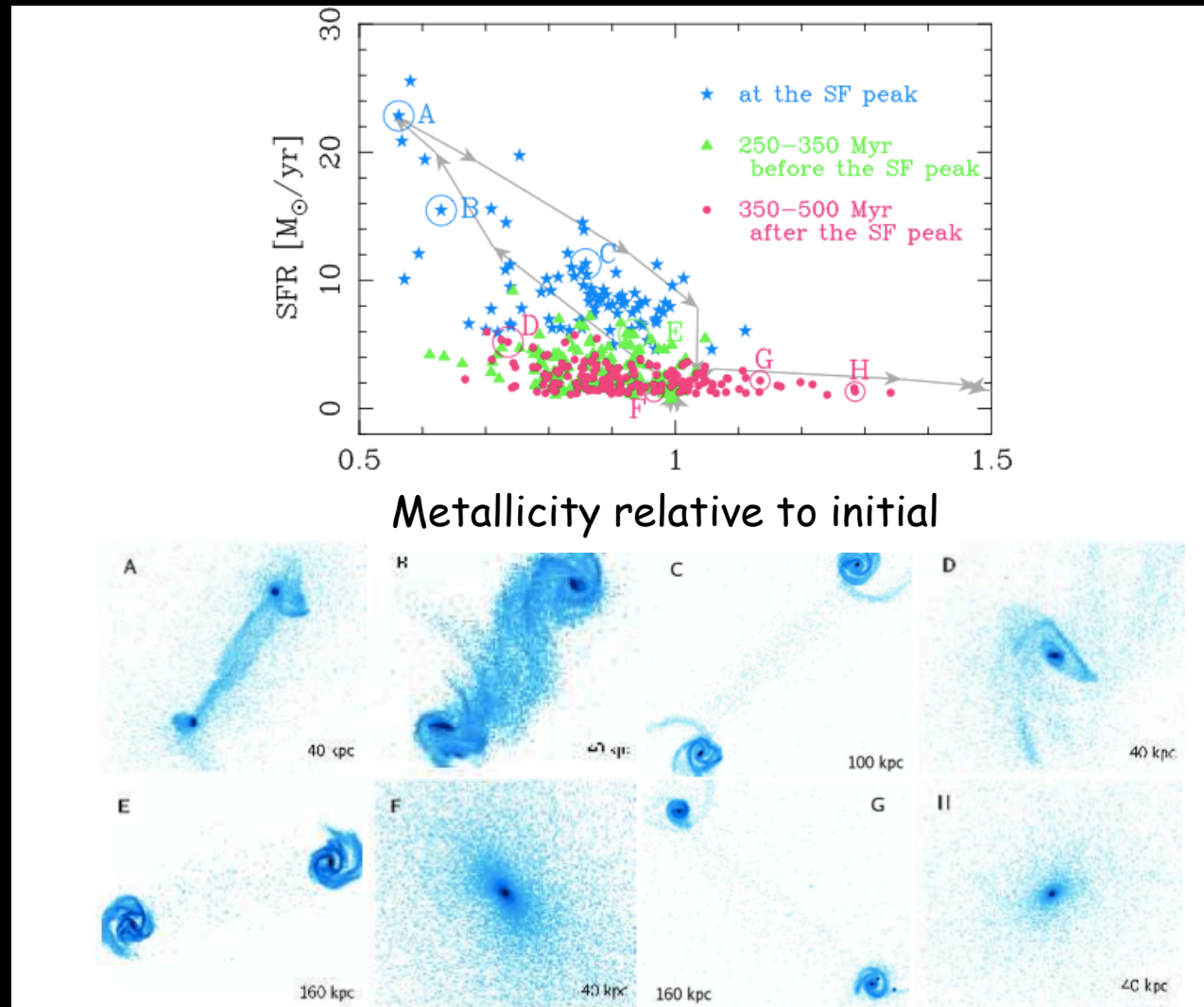Two main mechanisms for gas inflow to galactic centre to trigger star formation.

Galaxy-galaxy mergers
(e.g. the mice)

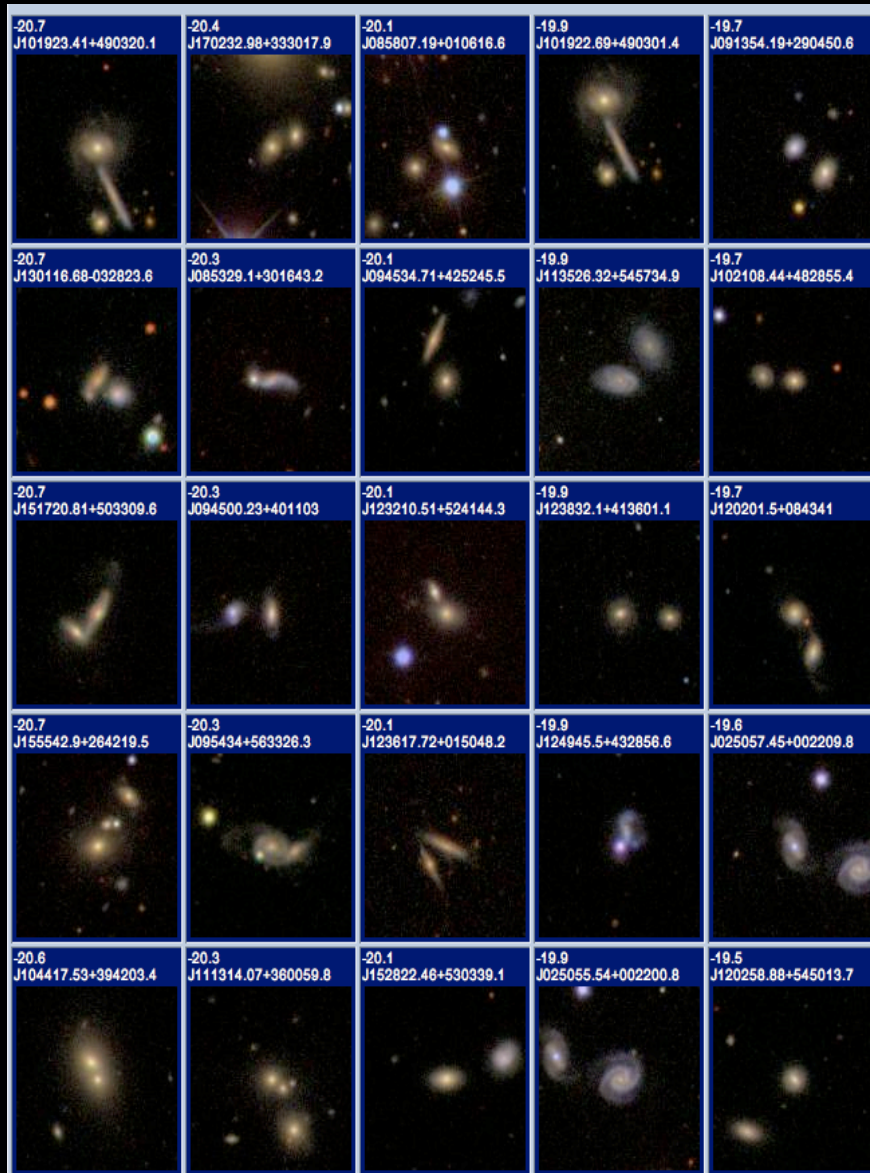Galaxy bars
(e.g. NGC 1300)

Signatures of gas flows

Montuori et al (2010)

Metal-poor gas flows to galaxy centre and triggers star formation.
Star formation is preceded by dilution of metallicity in galaxy centre
before eventual enrichment.

Galaxy pairs

DR7 full pairs sample:
Projected separation <80 kpc
ΔV <10,000 km/s
Mass ratio 0.1 - 10

Yields: 22,777 galaxies in pairs (often use a subset with ΔV<500 km/s for mergers).

Construct control samples that are matched in mass and redshift, typically 10 control galaxies per pair.
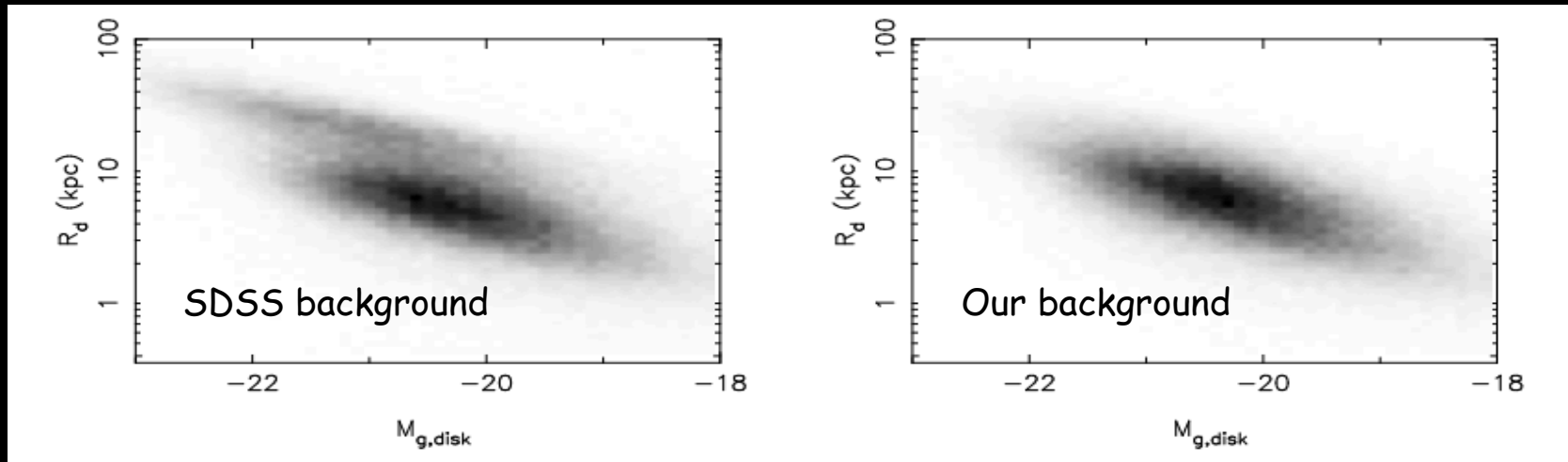
Photometry of close pairs

Several improvements made to SDSS photometry, which has problems in crowded environments:
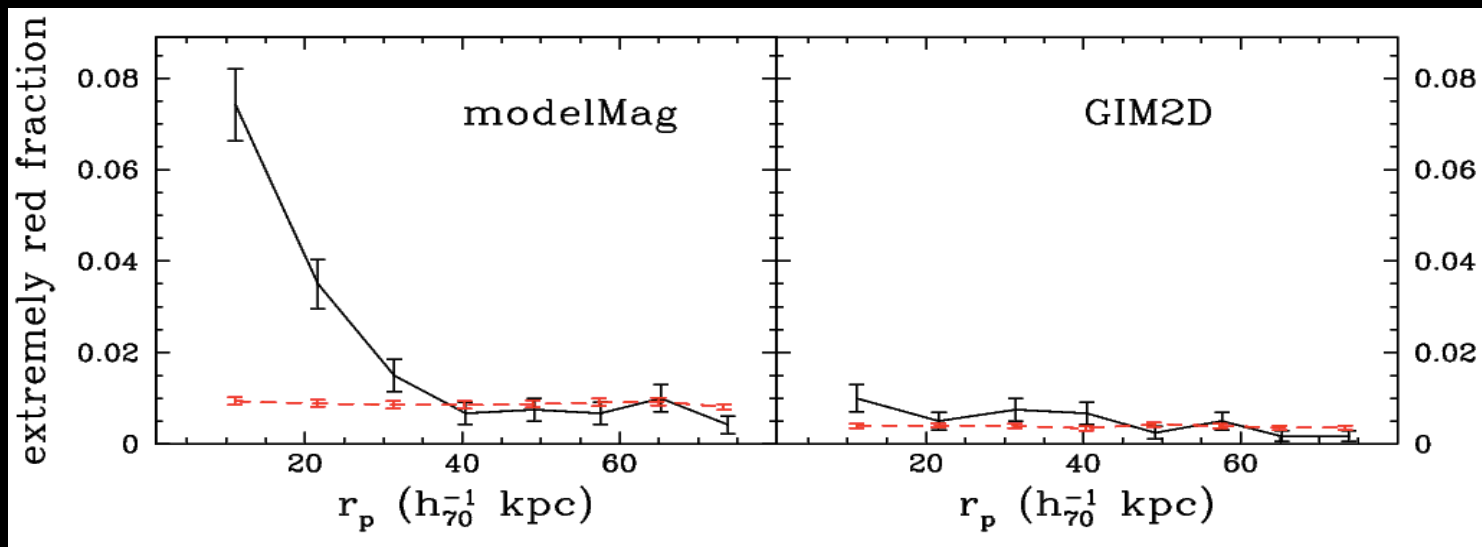
- Sextractor deblending
- Local sky determination
- Simultaneous r+g fits

Public catalog available: Simard et al. (2011)

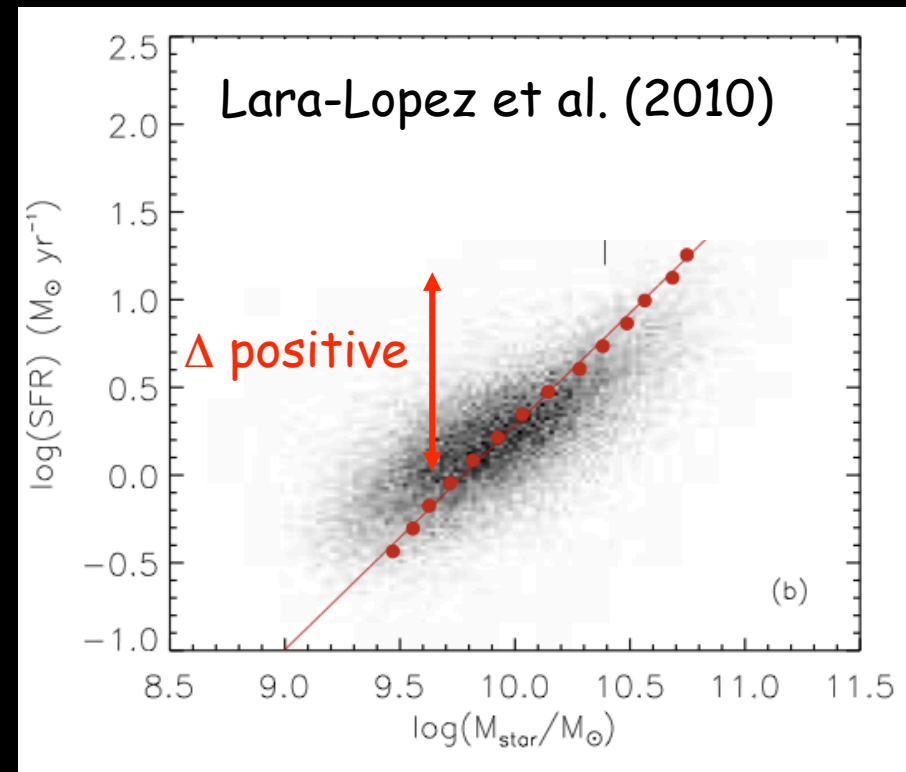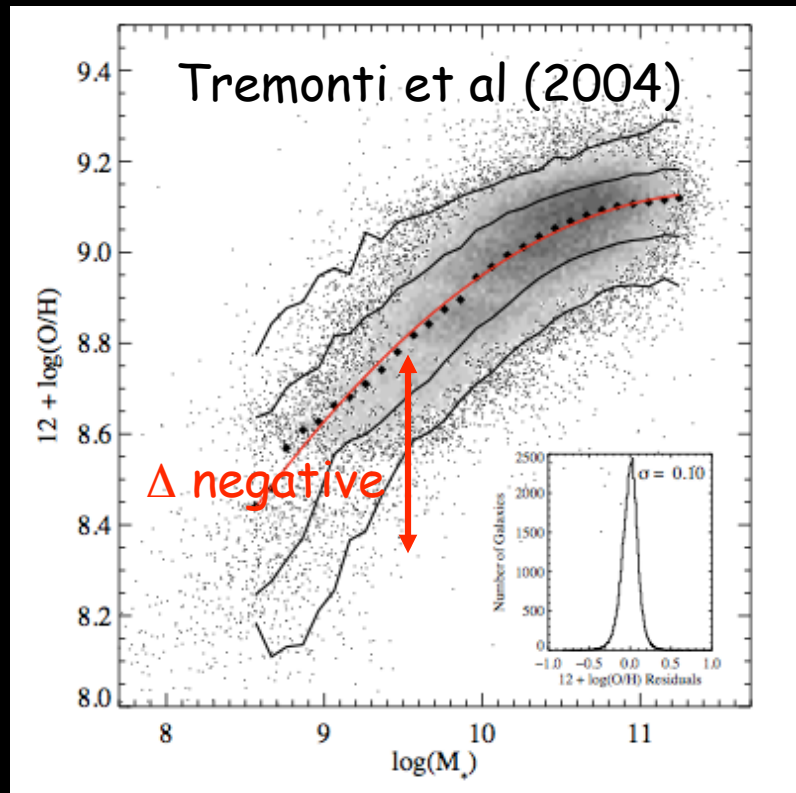# Poor background determination can lead to extended disks:

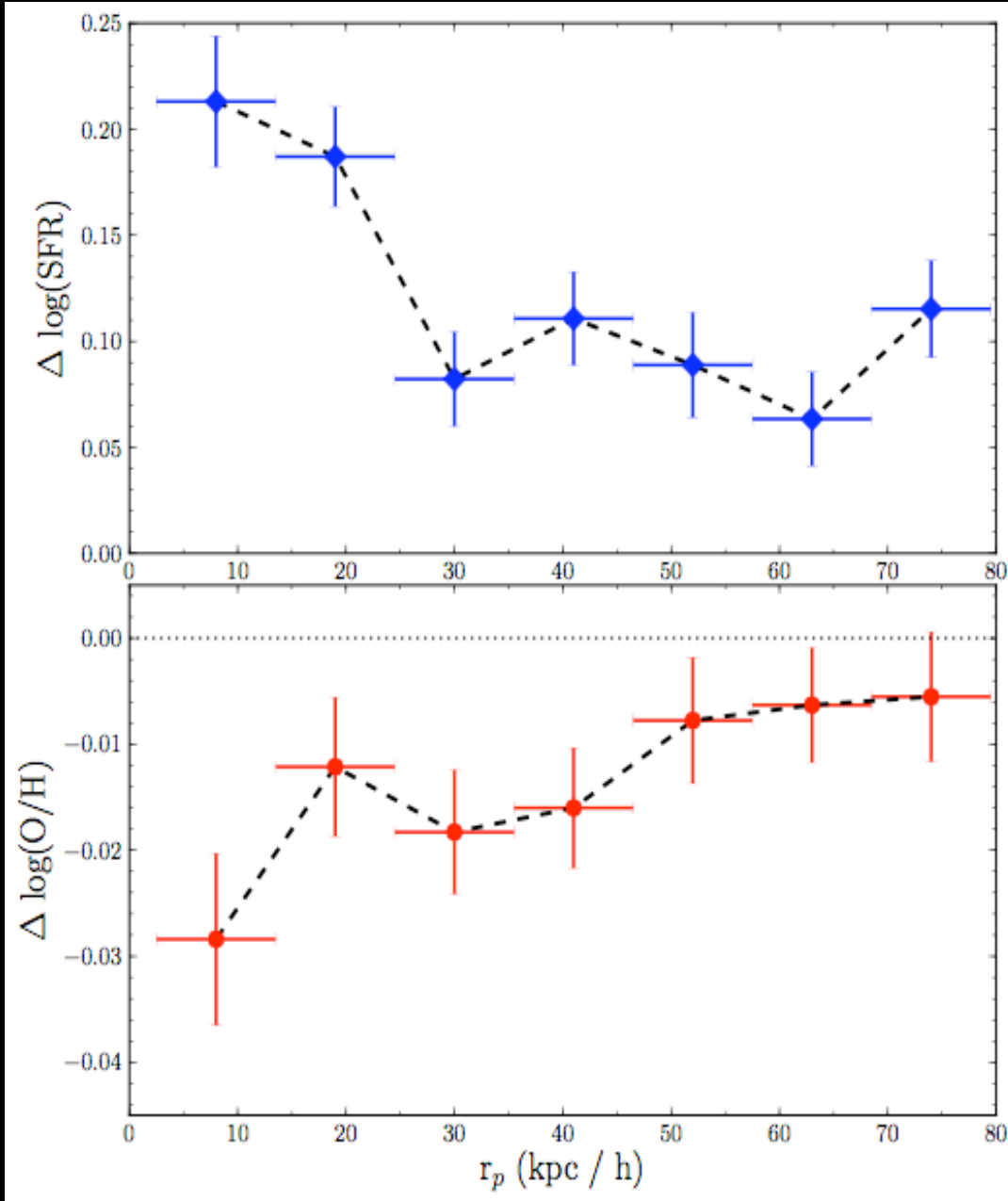# Poor object definition leads to spuriously red colours:

Full SDSS data release of 1.12 million galaxies: Simard et al. (2011)

Quantify SFR and metallicity enhancements by looking for offsets from the mass-SFR and mass-metallicity relations of control galaxies.
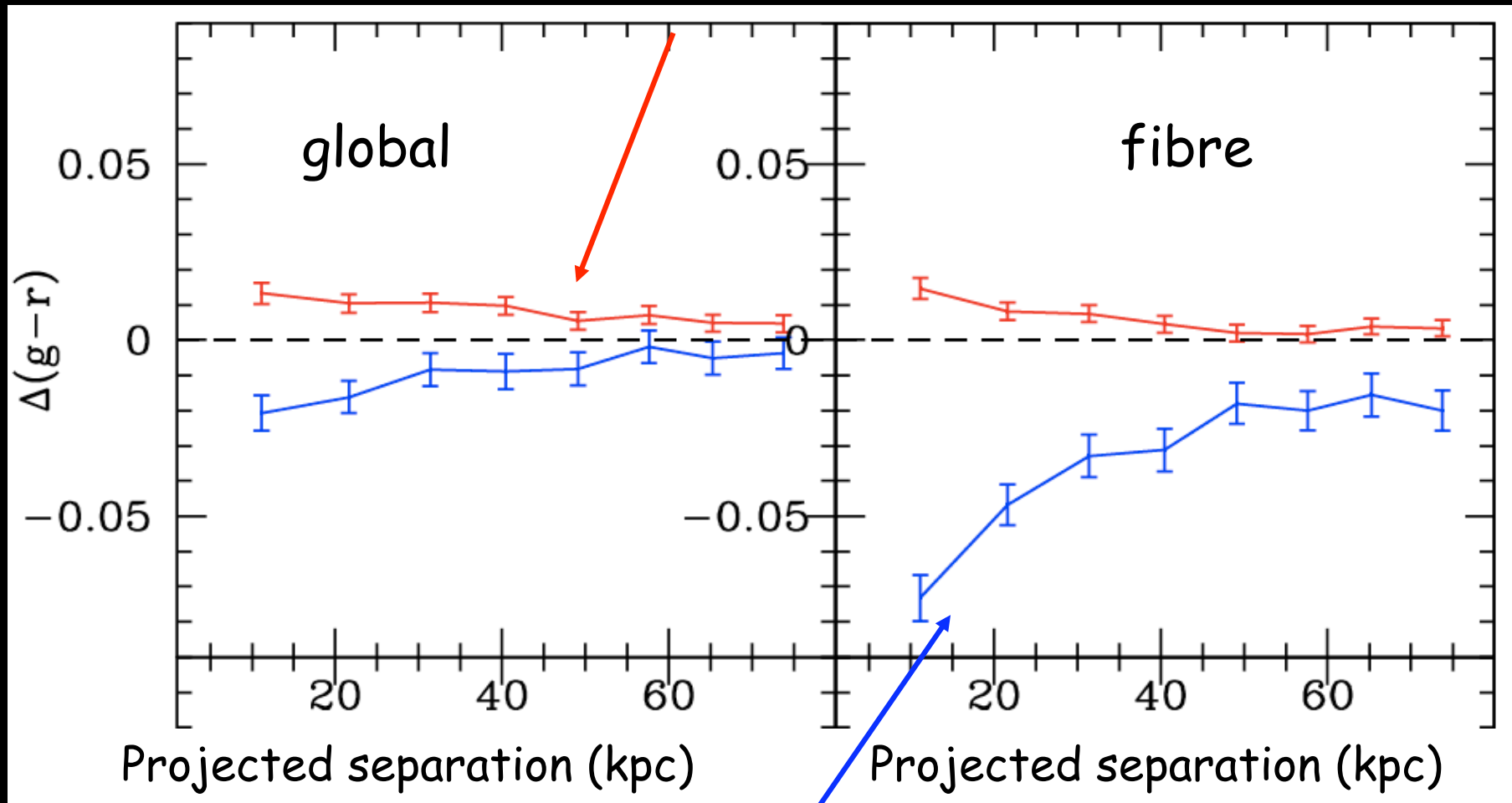

Δ O/H = log O/H - log O/H$_{predict}$

Δ SFR = log SFR - log SFR$_{predict}$

SFR increases and metallicity decreases in close pairs and remains offset from the field even out to 80 kpc (Scudder et al. in prep).
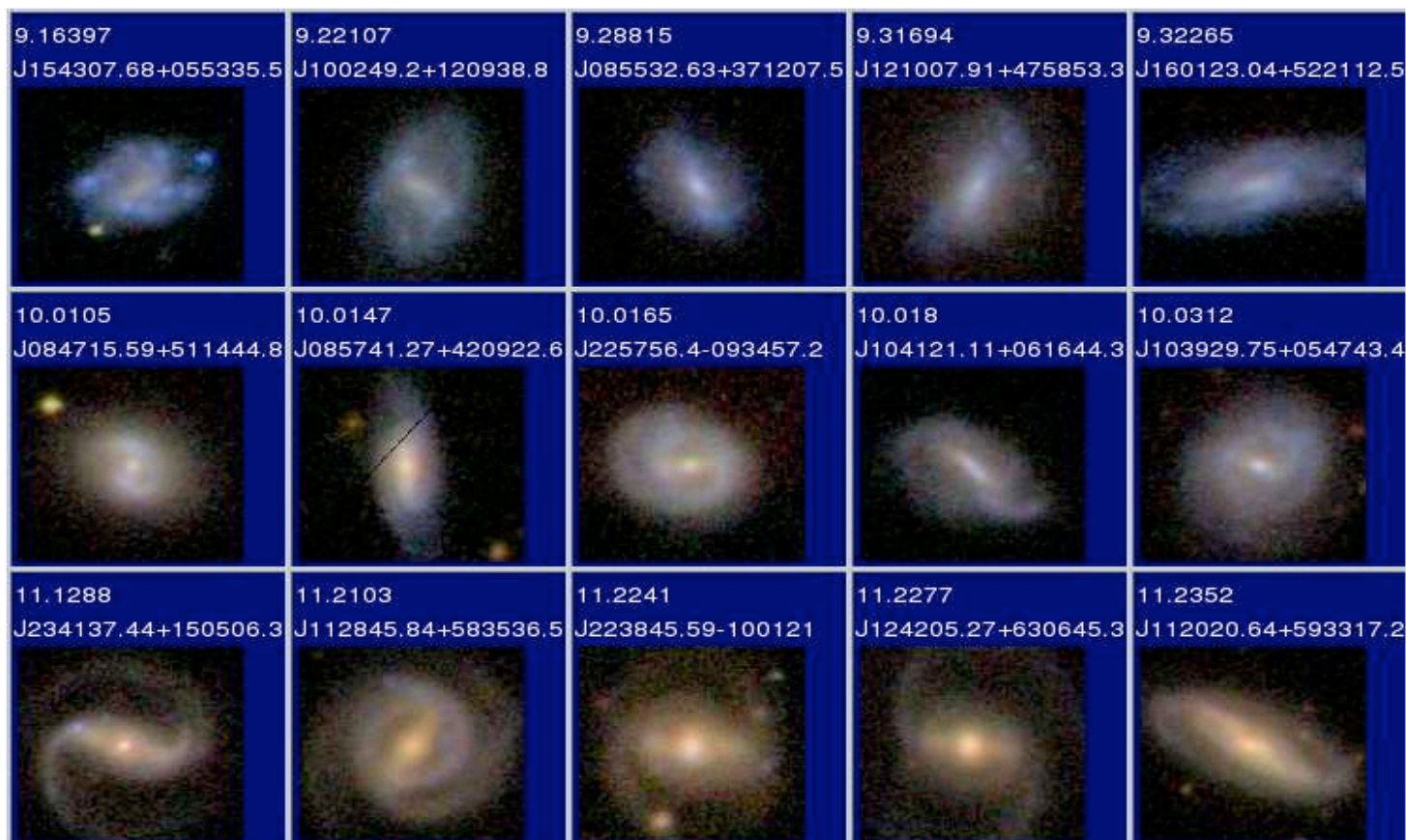
SFR enhancement depends on mass ratio (Ellison et al. 2008) and environment (Ellison et al. 2010).

Red pairs slightly redder than control, likely due to environment.
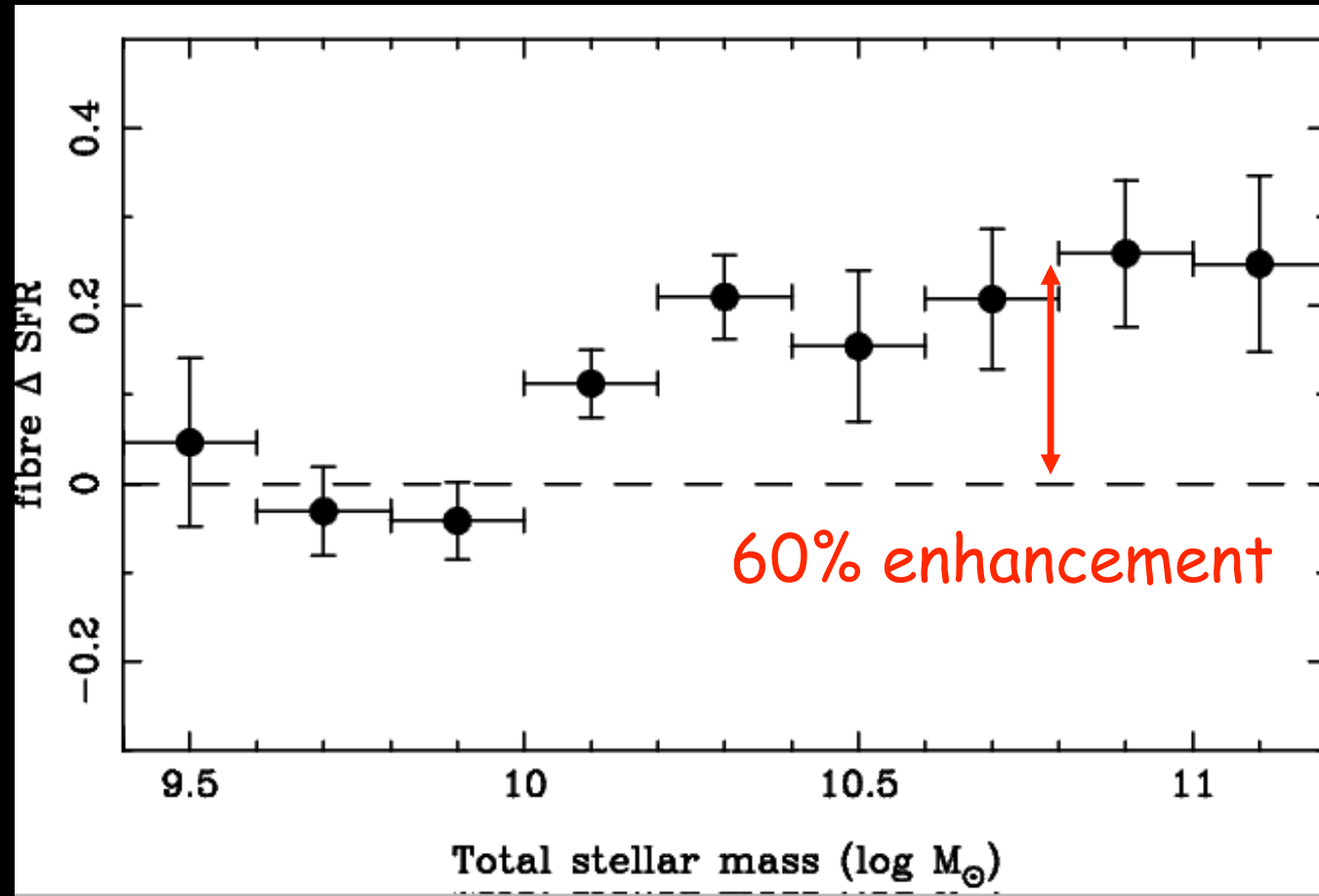

Blue galaxies get bluer than their controls at small separations, dominated by changes in their central regions: star formation is nuclear.   Patton et al. (2011)

Barred galaxies

311 visually selected bars with z<0.1, g<16 from DR4 spectroscopic sample (Nair & Abraham 2010).
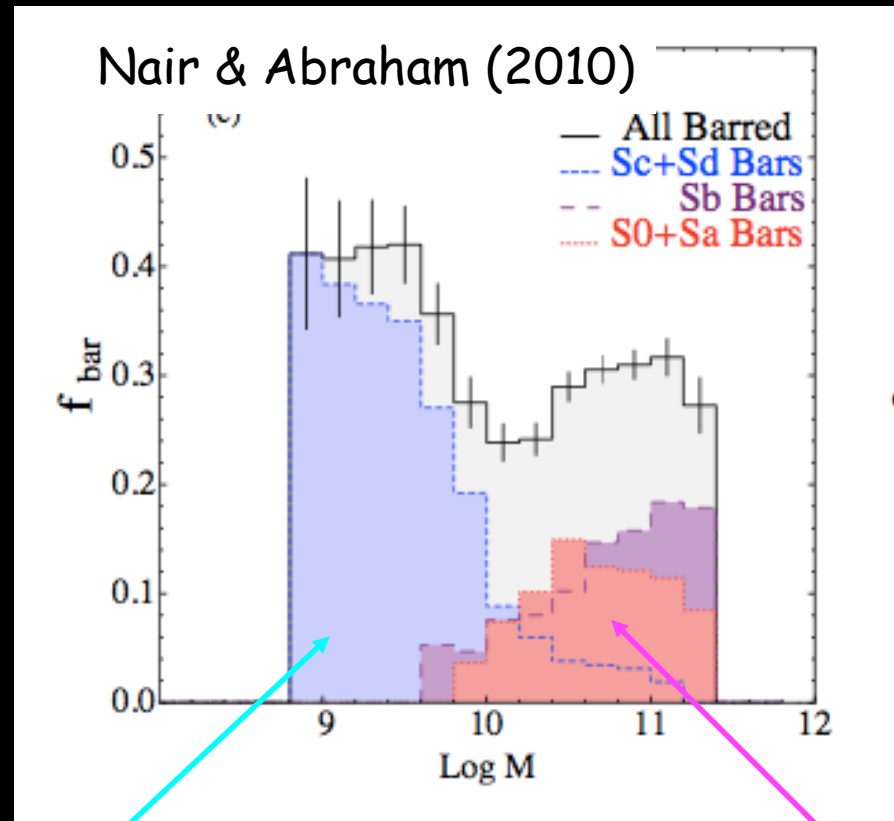
Star formation rates in bars

60% enhancement

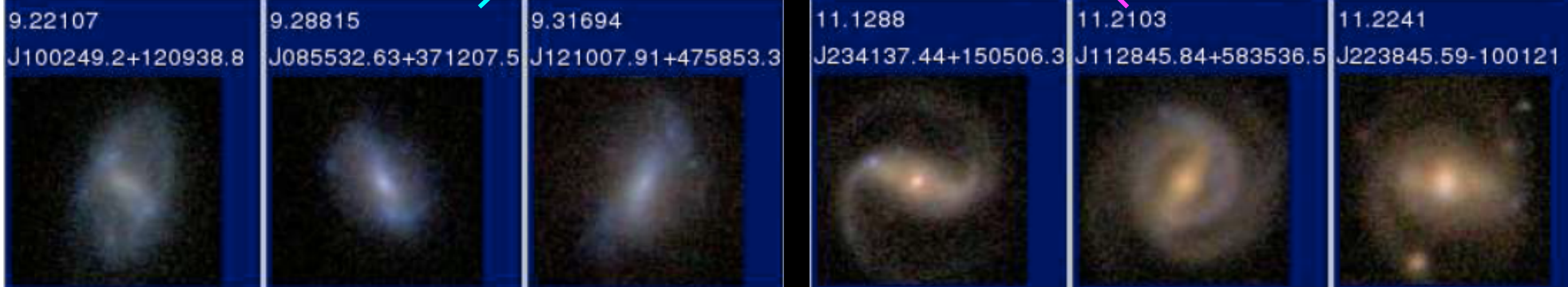60% enhancement in fibre SFR in barred galaxies with Log M > 10 M$_{sun}$.

Ellison et al. (2011)

Mass of 10^{10} M_{sun} corresponds to morphological transition

Low mass bars are mostly late-types (Sc and Sd)

High mass bars are mostly late-types (SO-Sb)

Nair & Abraham (2010)

All Barred
Sc+Sd Bars
Sb Bars
S0+Sa Bars

f_{bar}

0.5
0.4
0.3
0.2
0.1
0.0

9   10   11   12

Log M

9.22107
J100249.2+120938.8

9.28815
J085532.63+371207.5

9.31694
J121007.91+475853.3

11.1288
J234137.44+150506.3

11.2103
J112845.84+583536.5

11.2241
J223845.59-100121

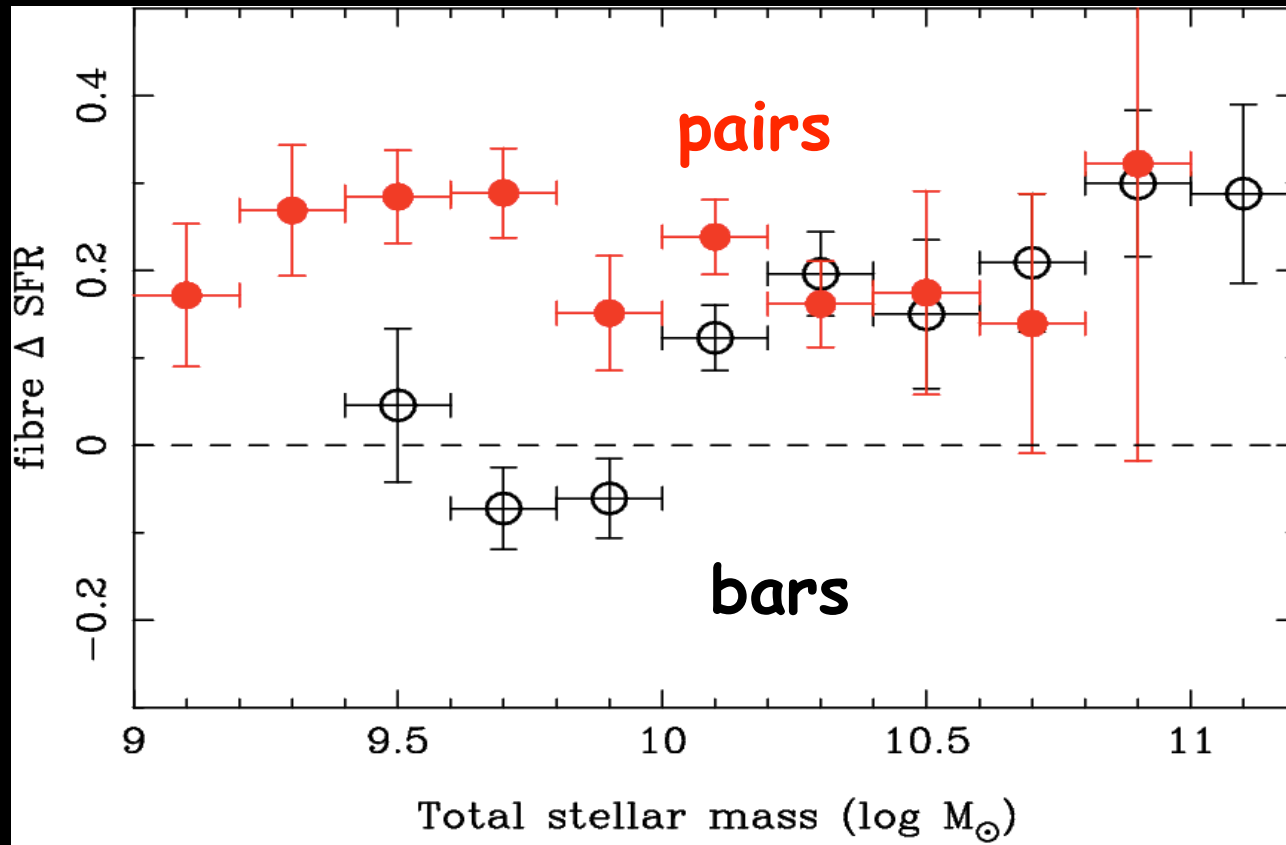# Metallicities in barred galaxies

0.06 dex enhancement

Barred galaxies more metal-rich at all masses. Bars sufficiently long lived to show enrichment, even after SF.

$$\epsilon_{b/p} = \frac{f_b}{f_p} \times \frac{f_{b,\star}}{f_{p,\star}} \times \frac{10^{\Delta SFR_b}}{10^{\Delta SFR_p}}$$

Ratio of enhanced star formation coming from bars and pairs.

pairs

bars
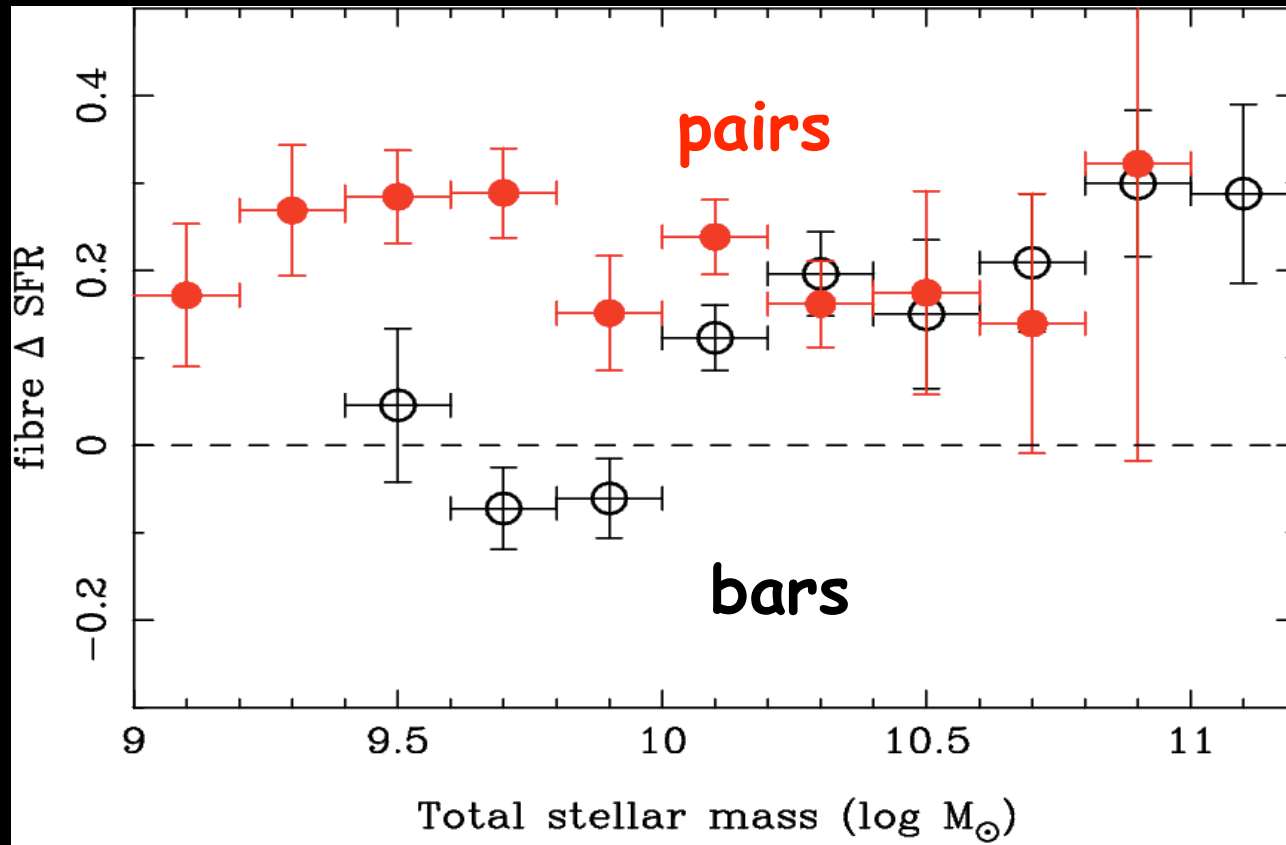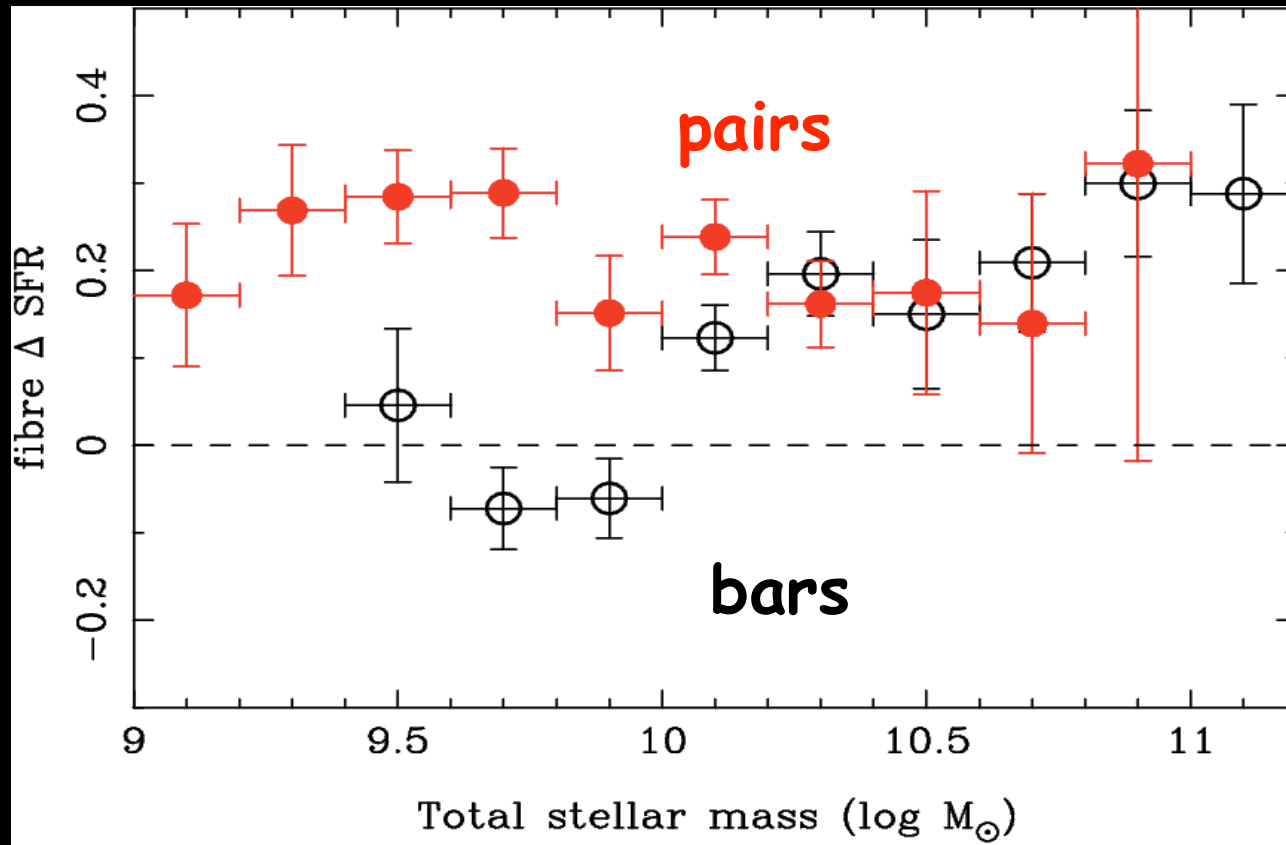
$$\epsilon_{b/p} = \frac{f_b}{f_p} \times \frac{f_{b,\star}}{f_{p,\star}} \times \frac{10^{\Delta SFR_b}}{10^{\Delta SFR_p}}$$

Ratio of bar and pair fraction in galaxy population.
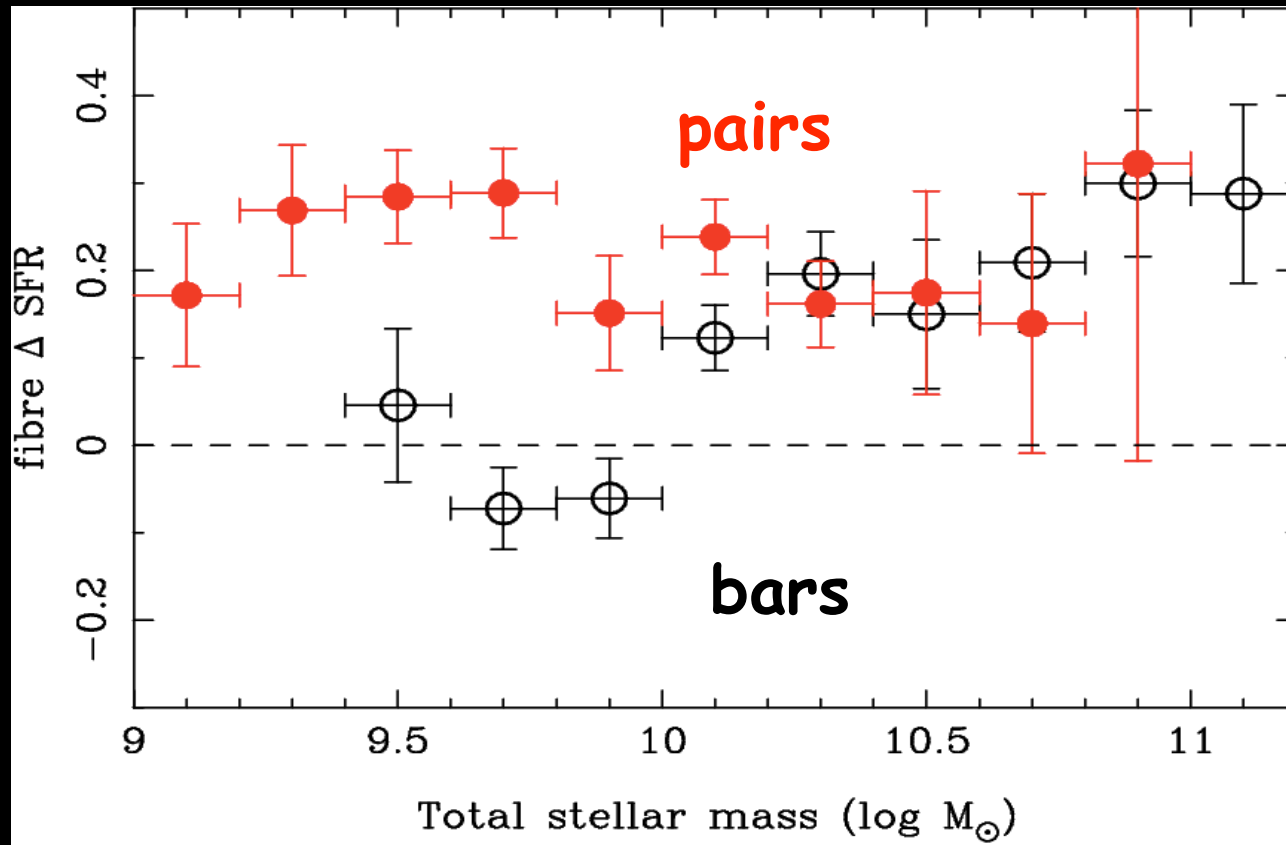
$$\epsilon_{b/p} = \frac{f_b}{f_p} \times \frac{f_{b,\star}}{f_{p,\star}} \times \frac{10^{\Delta SFR_b}}{10^{\Delta SFR_p}}$$

Ratio of bar and pair fraction in star-forming sample.

$$\epsilon_{b/p} = \frac{f_b}{f_p} \times \frac{f_{b,\star}}{f_{p,\star}} \times \boxed{\frac{10^{\Delta SFR_b}}{10^{\Delta SFR_p}}}$$

Ratio of SFR enhancements bar and pair star-forming sample (this ratio ~1).

$$\epsilon_{b/p} = \frac{f_b}{f_p} \times \frac{f_{b,\star}}{f_{p,\star}} \times \frac{10^{\Delta SFR_b}}{10^{\Delta SFR_p}}$$

$\epsilon_{b/p}$ >3, I.e. at least 3 times more central star formation comes from bars than pairs.

Ellison et al. (2011)

Summary

• Pairs of galaxies experience triggered star formation mostly in blue galaxies, star formation is central and persists out to at least 80 kpc: Ellison et al. (2008, 2010), Patton et al. (2010), Scudder et al (in prep)

• Galaxy pairs are metal-poor for their mass due to gas inflows: Ellison et al. (2008), Scudder et al. (in prep).

• Bars also show central SFR enhancements by about 60%, but only at log M > 10 where the population becomes dominated by early-type bars: Ellison et al. (2011).

• Bars have high central metallicities for their mass by ~0.06 dex: Ellison et al. (2011).

• The relatively high bar frequency means that bars contribute to at least times more central star formation than interactions.