Star Formation Quenching in Post-Mergers

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INTRODUCTION

Galaxies show a bimodality between blue, star-forming spirals and red, quiescent ellipticals, driven by star formation quenching. Kalinova et al. (2021) show quenching leaves complex signatures in the Interstellar Medium (ISM). Mergers leave a unique ISM imprint compared to secular starbursts (Thorp et al. 2024); we test if quenching shows a similar signature, using QueStNA (QUEnching STages and Nuclear Activity, Kalinova et al. (2021)) on post-mergers for the first time.

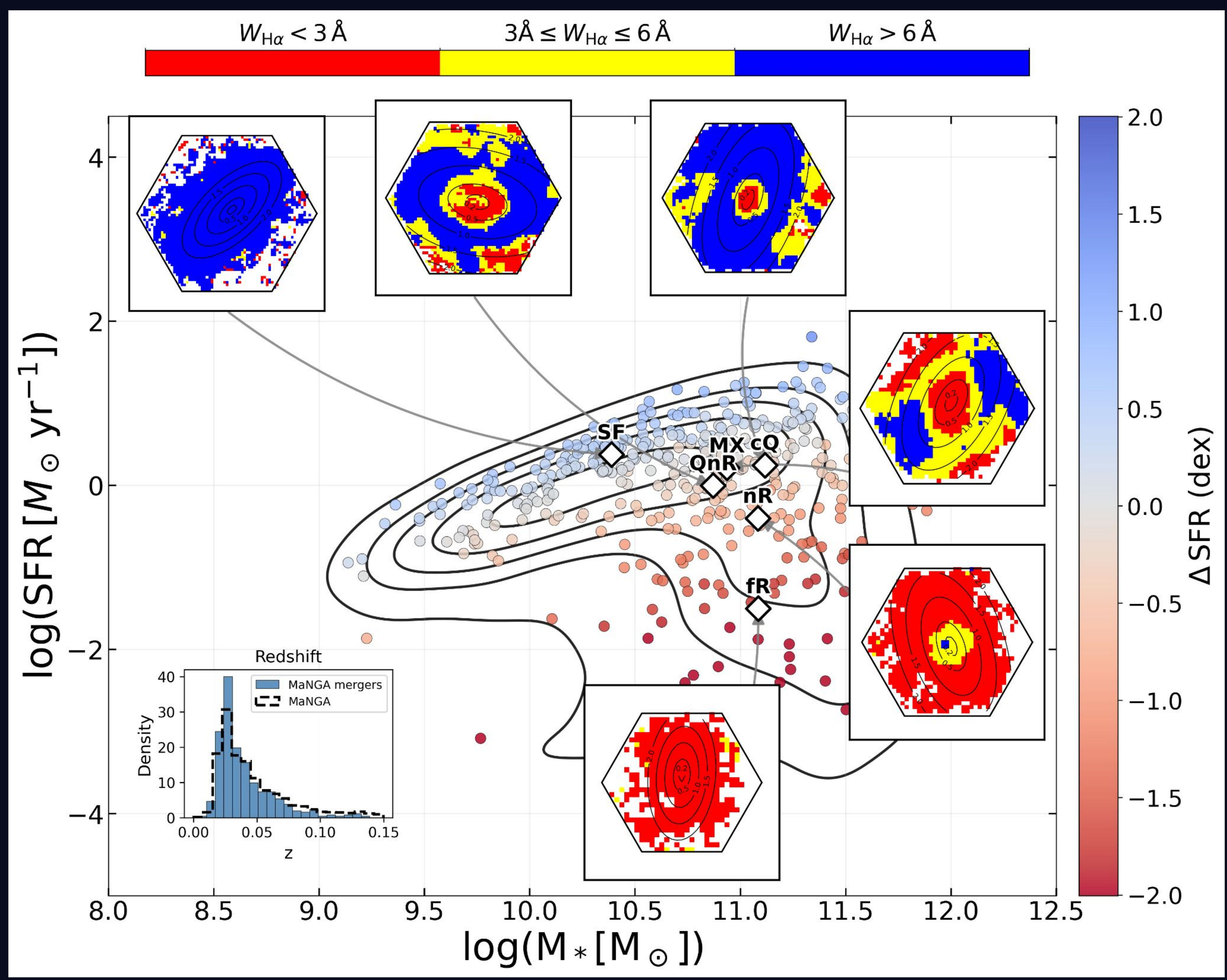

Figure 1: Star formation main sequence for the post-merger galaxies, coloured by ΔSFR, contour map show the entire MaNGA sample. Hα equivalent width maps show the six quenching stages (QS), defined by the fraction of star-forming (blue), mixed (yellow), and retired (red) spaxels. White diamonds show the median value per QS. Different QS stages trace galaxy's evolution off the main sequence and into the quenched population.

Quenching Stage Distribution

Case	SF	QnR	cQ	MX	nR	fR
Post-Mergers	$55.9 \pm 0.3\%$	$2.7 \pm 0.3\%$	$3.0 \pm 0.8\%$	$8.4 \pm 4.9\%$	$15.3 \pm 4.9\%$	$3.5 \pm 0.0\%$
Controls	$42.9 \pm 0.3\%$	$1.5 \pm 0.1\%$	$7.2 \pm 0.2\%$	$7.0 \pm 3.6\%$	$23.2 \pm 2.8\%$	$11.3 \pm 0.1\%$

Table 1. Quenching stage (QS) distribution for post-mergers and controls. Post-mergers overpopulate the SF stage and underpopulate the fR stage relative to controls, while the intermediate stages are similarly populated within uncertainties. Errors are estimated from the fraction of galaxies whose classification differs between 1σ vs. 3σ Hα-EW maps. In general, compared to iEDGE (Colombo et al. (2025)), the SF, cQ, and fR classes are similar. MaNGA has more nR than MX and QnR, likely due it probing higher redshifts and more quenched populations.

Star Formation Radial Profiles

SF: Star formation (SF) is boosted near the center for post-mergers, likely from merger-driven gas inflow. Central SF boost matches Thorp et al. 2024. Beyond 0.5 Re, post-mergers and controls show a smoothed decline in SFR.

QnR: Post-mergers are more efficiently quenched around 0.5 Re and beyond, likely because these galaxies are further along the quenching process, or because merger-driven tidal forces enhance quenching once central gas is consumed.

cQ: The two populations look similar out to large radii before diverging: controls show rising star formation at larger radii, while post-mergers stay quenched. This suggests post-mergers can quench the entire disk more rapidly.

MX: Post-mergers and controls are similar except in the center, where AGN activity in post-mergers suppresses star formation. MX post-mergers host 17.7% more AGN than SF post-mergers; AGN and non-AGN profiles are otherwise similar in both samples.

nR: Post-mergers are more quenched in the disk but show relatively higher star formation in the outer regions and center compared to controls.

fR: Limited spaxel coverage prohibits any robust results about the star formation distribution at this stage.

References

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METHODS

Data: We use integral field spectroscopy from MaNGA (Mapping Nearby Galaxies at Apache Point Observatory), covering 3622–10354 Å at R ~ 2000, for galaxies at 0.01 < z < 0.15, containing 10,070 galaxies in MaNGA DR17 (Bundy et al. 2015, Abdurro'uf et al. 2022). Spatially resolved properties (Σ*, Σ_{SFR}, BPT fluxes) come from Pipe3d (Sánchez et al. 2016a,b), with global M* and SFR from its value-added catalog (Lacerda et al. 2022; Sánchez et al. 2022). Inclination corrected deprojected radius (Re) come from the NSA catalog. Post-mergers taken from Thorp et al. (2024).

Sample: Our sample consists of 367 post-merger galaxies matched with 5,229 isolated control galaxies from MaNGA DR17, matched in redshift z(± 0.2 dex), global stellar mass M*(± 0.2 dex), ΔSFR(± 0.2 dex), and matched in quenching stage (QS).

Classification: Following Kalinova et al. (2021), we classify galaxies using Hα equivalent width (Hα-EW) maps into six quenching stages — star-forming (SF), quiescent-nuclear ring (QnR), centrally quenched (cQ), mixed (MX), nearly retired (nR), and fully retired (fR) — using an automated and visual classification (Figure 1).

Radial Profiles: We construct star formation radial profiles using $\Delta\Sigma_{SFR}$, calculated by matching spaxels in stellar mass surface density (Σ*), global stellar mass (M*), and deprojected radius, following Thorp et al. (2022), who compute Σ_{SFR} from Hα and D4000. A $\Delta\Sigma_{SFR}$ map is shown in Figure 2. For each quenching stage we generate a median profile to analyse the enhancement and suppression of star formation as a function of deprojected radius.

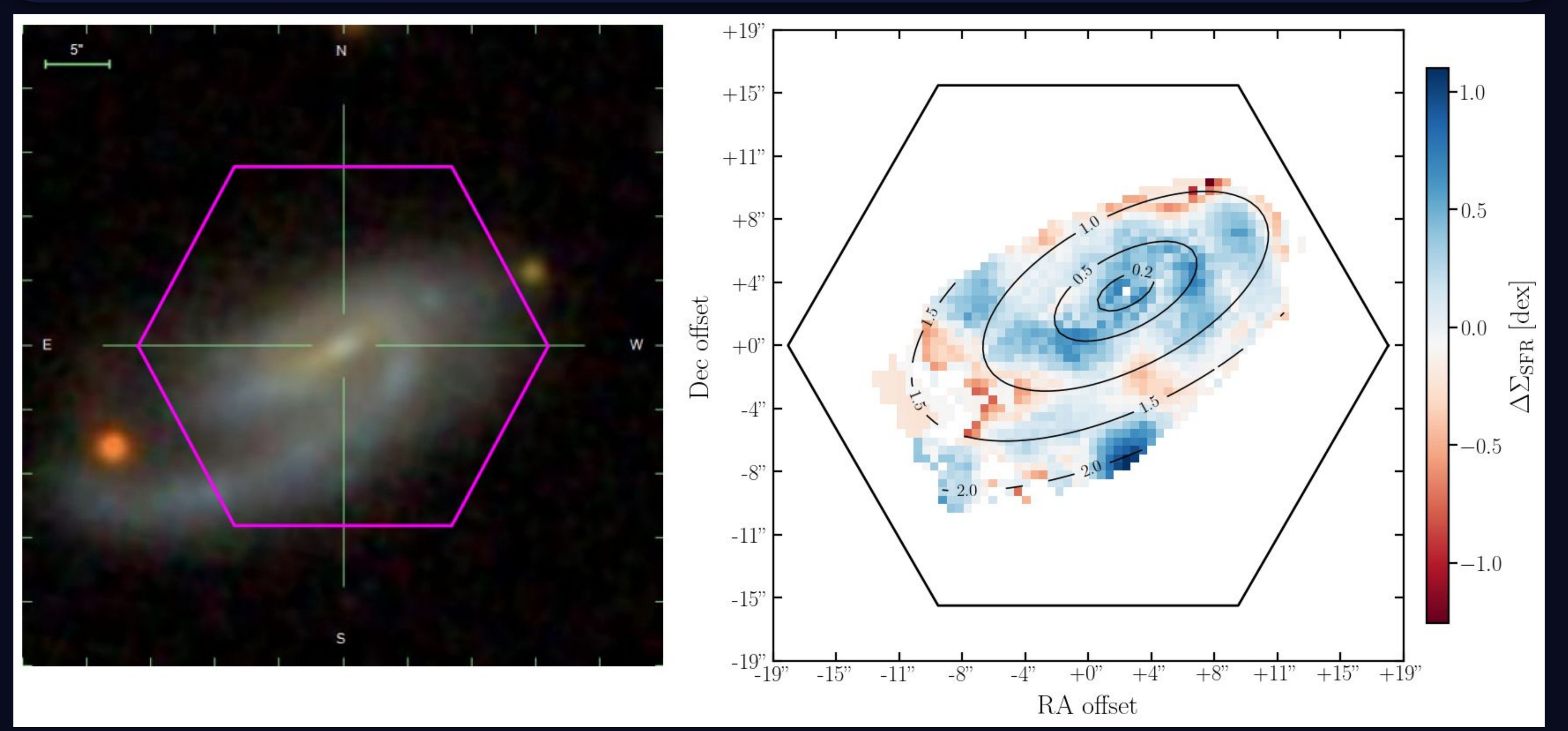

Figure 2: SDSS gri image (left) and $\Delta\Sigma_{SFR}$ map (right) of an example post-merger galaxy (manga-plateifu:10509-12701). Hexagon in both figures represents the IFU. Blue regions show enhanced star formation near the center; red regions show suppression in the outskirts, relative to matched controls.

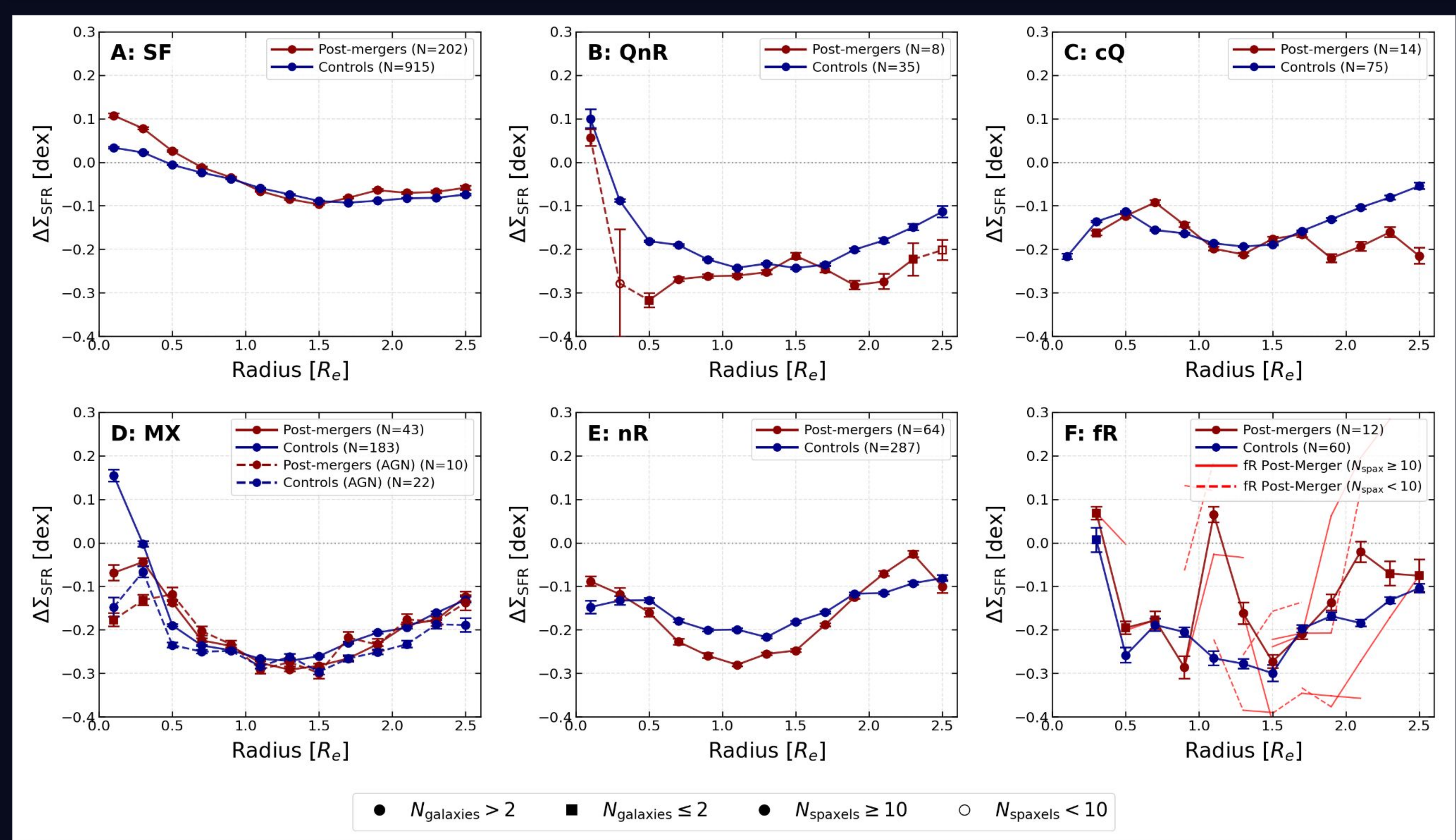

Figure 3. Median $\Delta\Sigma_{SFR}$ radial profiles for post-mergers (red) and controls (blue) across the quenching stages (A–F). Filled/open markers and circles/squares indicate spaxel and galaxy sample sizes, respectively (see legend). Error bars are error on the mean.

Colombo et al. (2025) link inside-out quenching to declining star formation efficiency (SFE), not just gas loss. Our results suggest regions of low $\Delta\Sigma_{SFR}$ in intermediate quenching stages could imply even lower SFEs in the post-merger sample, though resolved gas studies are needed to confirm this.

Takeaway: Post-mergers overpopulate the SF stage and underpopulate the fR stage, suggesting mergers boost star formation and delay full retirement. Once matched by quenching stage, post-mergers have remarkably similar $\Delta\Sigma_{SFR}$ profiles to controls, except in some regions (QnR, cQ, nR) that show uniquely efficient quenching.

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