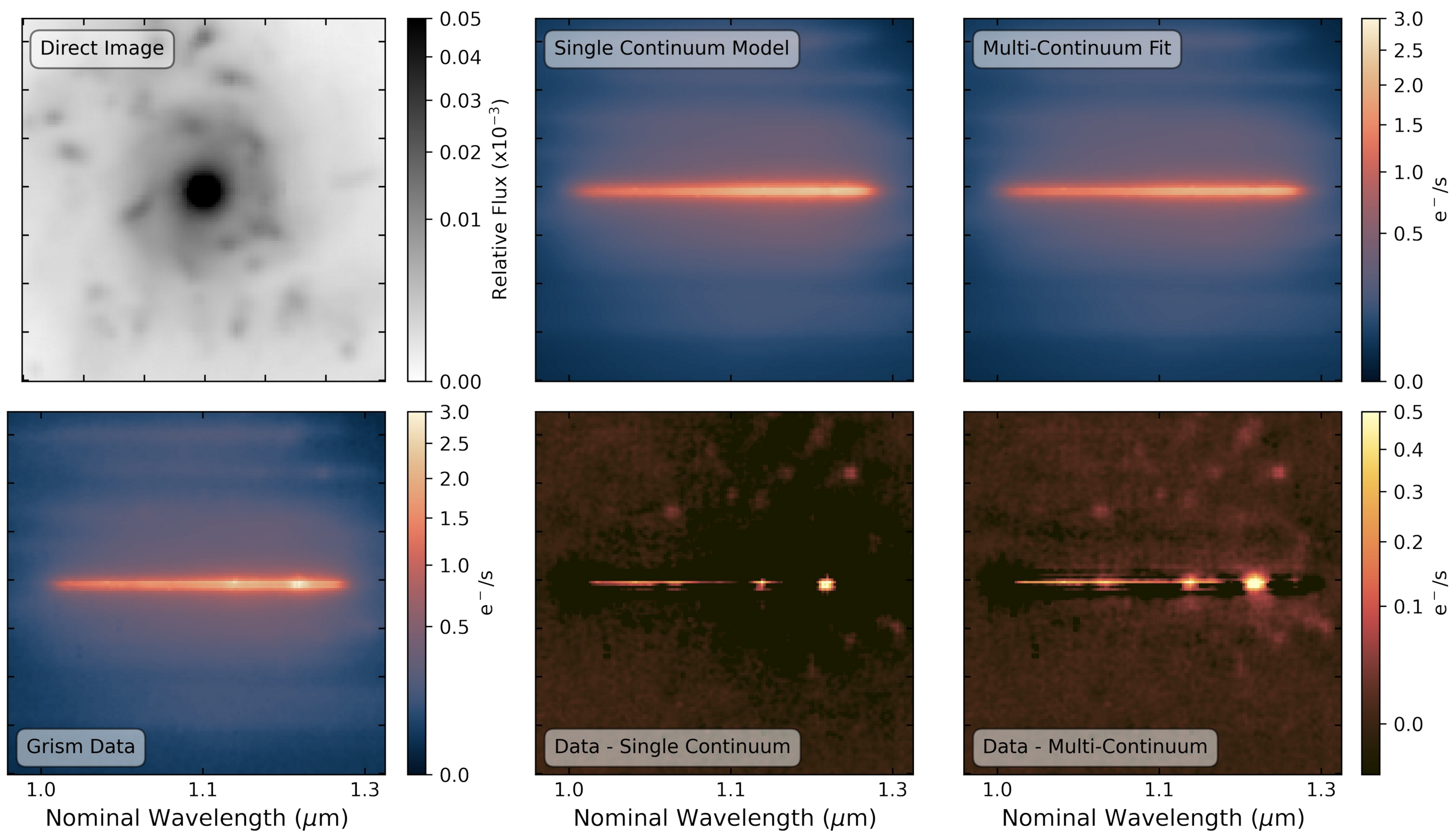
Unveiling Concurrent Physical Processes on a Cluster Galaxy at z=0.3 Using JWST

Peter J. Watson (peter.watson@inaf.it), Benedetta Vulcani, and the GLASS-JWST Collaboration

Motivations

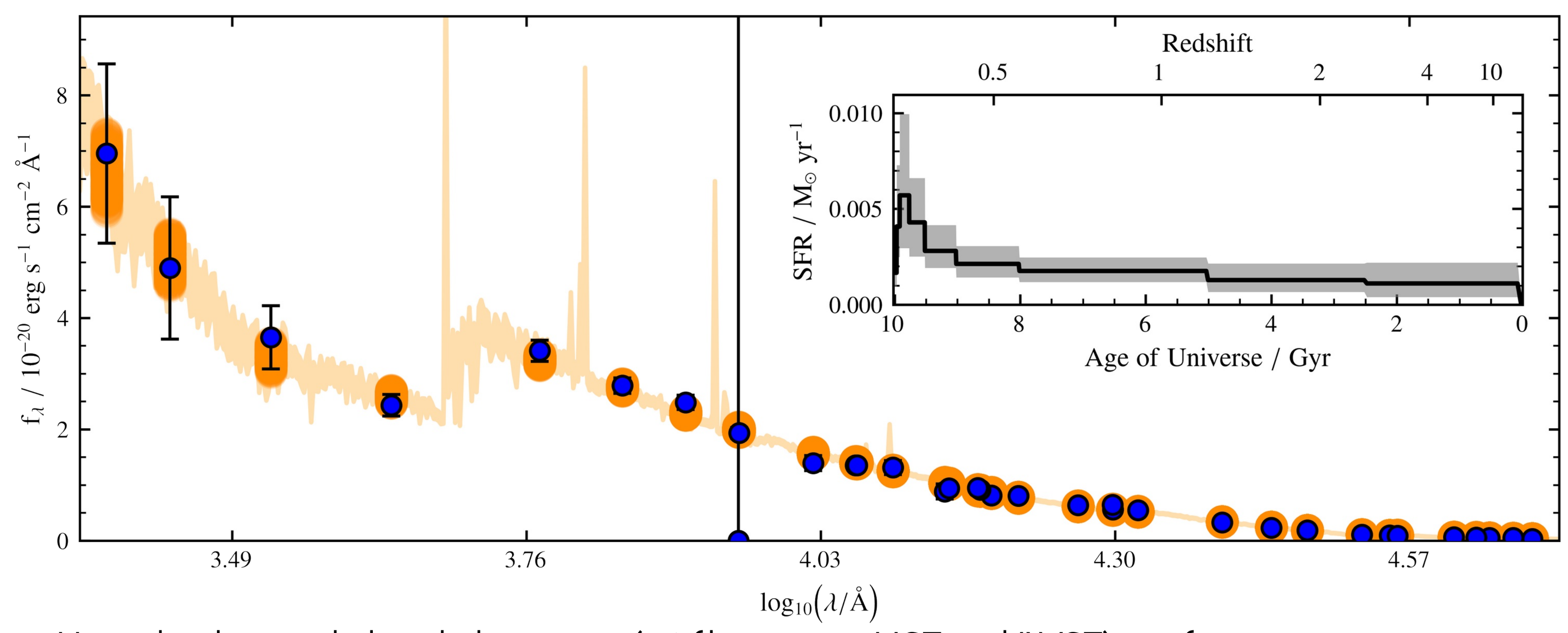
- Large observing programs with JWST-NIRISS have often focussed on more compact, high-z sources
- We aim to use these observations to investigate the cluster environment, particularly ram-pressure stripped (RPS) galaxies, also known as "jellyfish" galaxies
- Whilst there is considerable research into the optical and radio properties of these galaxies (e.g. the GASP collaboration), their near-IR emission remains almost entirely unexplored
- We focus on a candidate RPS galaxy in Abell 2744:
  - F0083 (Owers+12) – a Type I Seyfert galaxy, with a potential unwinding spiral arm and dispersed star-forming clumps
- JWST-NIRISS data were sourced from the GLASS-JWST (Treu+22) observations, HST and JWST-NIRCam data from the UNCOVER and MegaScience data releases (Suess+24)

Improved Continuum Subtraction



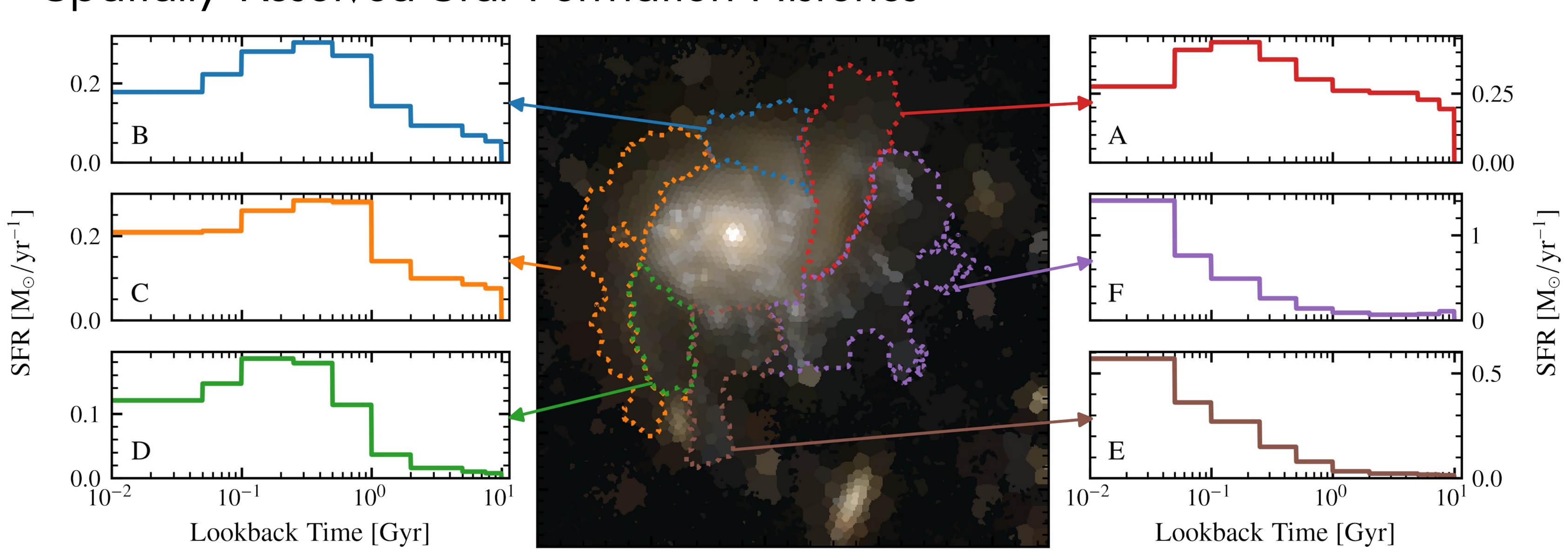
- The absolute residuals between continuum models is quite small – on the order of <10%
- However, this can make a big difference when extracting faint emission!
- In the case of F0083, a single continuum model over-weights the central (AGN) component
- This is poorly fit by the current set of models, and consequently the surrounding components are over-subtracted
- Simultaneously fitting multiple continuum models improves the fit considerably – whilst the central region is still imperfect, the faint [SIII] doublet is clearly visible

Fitting Non-Parametric SFHs Using Photometry



- Using the deep multi-band photometry (34 filters across HST and JWST), we fit non-parametric star-formation histories (SFHs) using Bagpipes (Carnall+18)
- We perform this in both an integrated manner, to determine nearby objects at different redshifts, and a spatially-resolved manner
- For the latter method, we derive convolution kernels to match PSFs in all filters, and adapt the weighted Voronoi binning method (Cappellari+03, Diehl+06) to ensure a consistent S/N in all bins

Spatially-Resolved Star Formation Histories

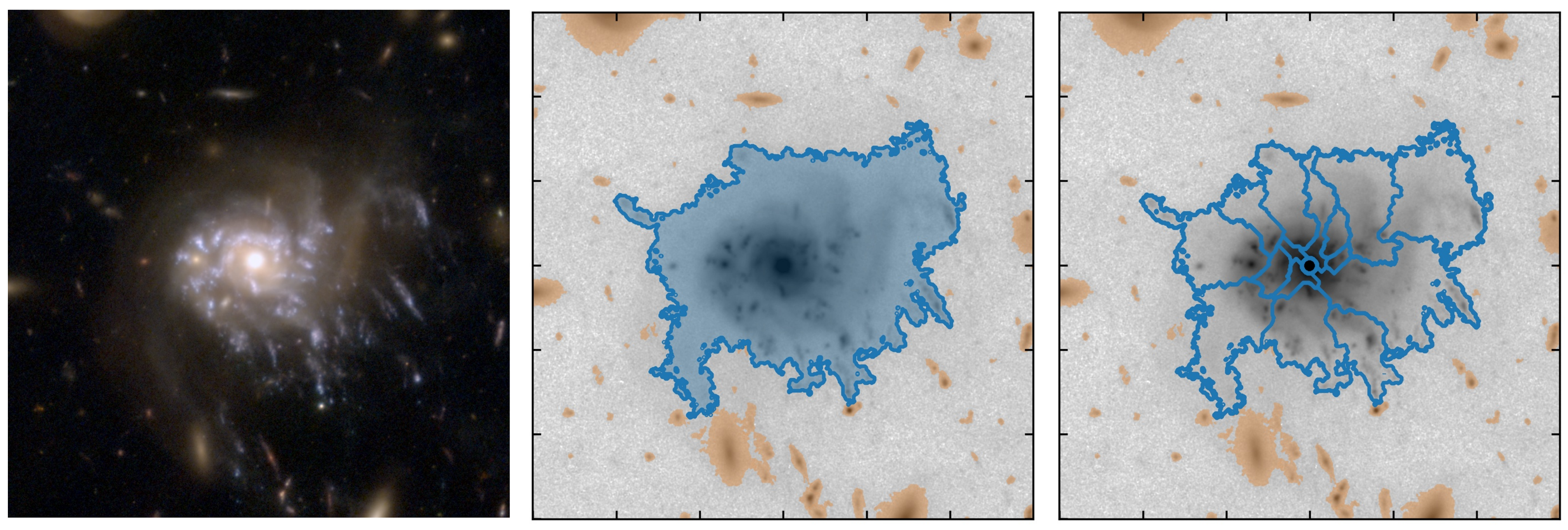


- There is a considerable difference between SFHs of the outer regions of this galaxy – from the oldest (A), to the youngest (E and F)
- We see a progression in mass-weighted ages anti-clockwise (along the visible arm/tidal tail), with B, C, and D all showing enhanced SFRs, peaking between 0.1-1 Gyr previously
- In contrast, E and F show increasing SFRs towards the present epoch, consistent with extremely young mass-weighted ages and high specific SFRs

Conclusions

- Through WFSS from NIRISS, and photometry from HST and NIRCAM, we derive spatially-resolved star formation histories for F0083, using generalised methods that can be applied elsewhere
- We show that this galaxy is highly likely to have been affected by two distinct physical mechanisms within the last 1 Gyr, and hope to follow this up with dedicated spectroscopic observations in future

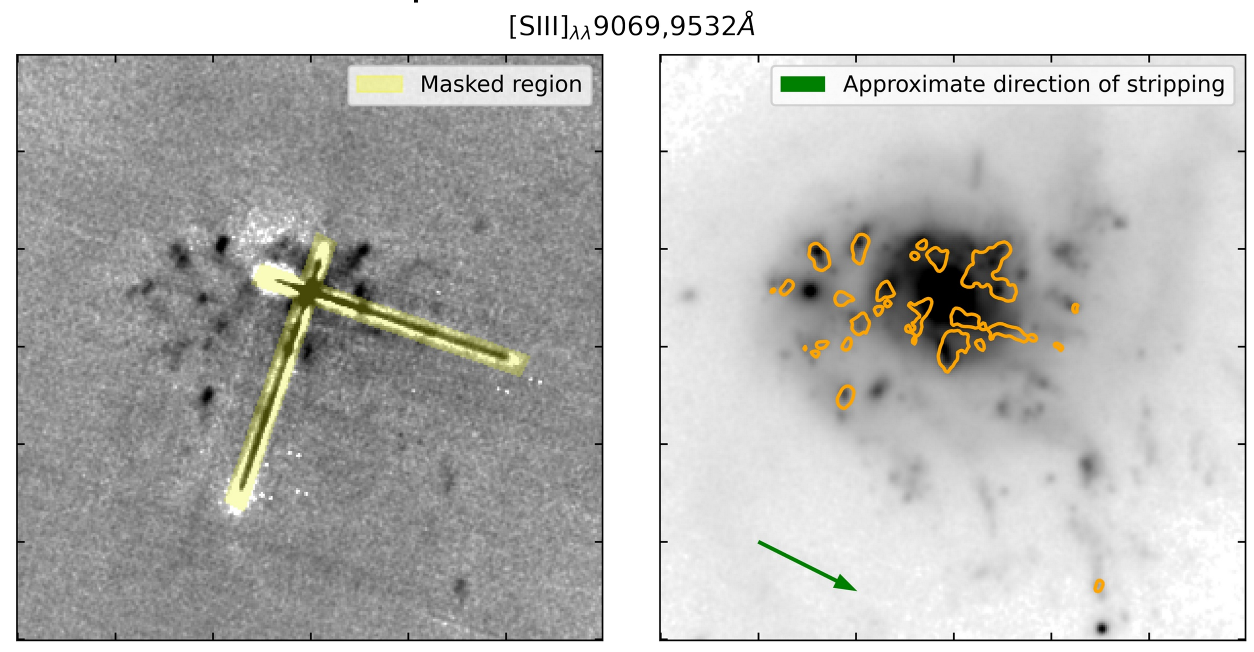
F0083 – A Case Study



HST+JWST (0.4-2μm), re-processed by PJW | Original segmentation map | RPS galaxy re-segmented using watershed algorithm

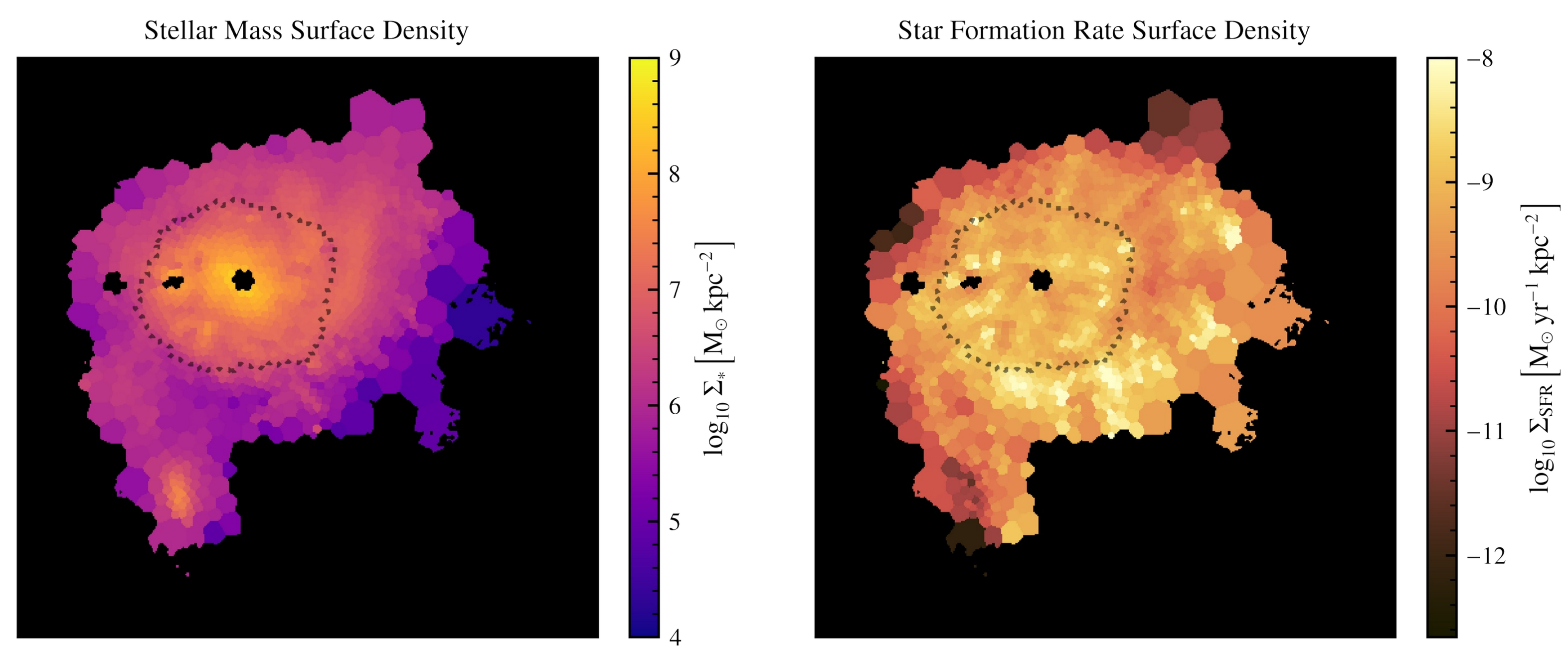
- Current methods (grizli, Brammer & Matharu+23) are very efficient for compact high-z sources
- However, we cannot assume a single simple continuum shape for extended sources (e.g. core+disk, AGN host)
- The solution is to separate individual galaxies into subcomponents, and fit each part simultaneously

NIRISS Emission Line Maps



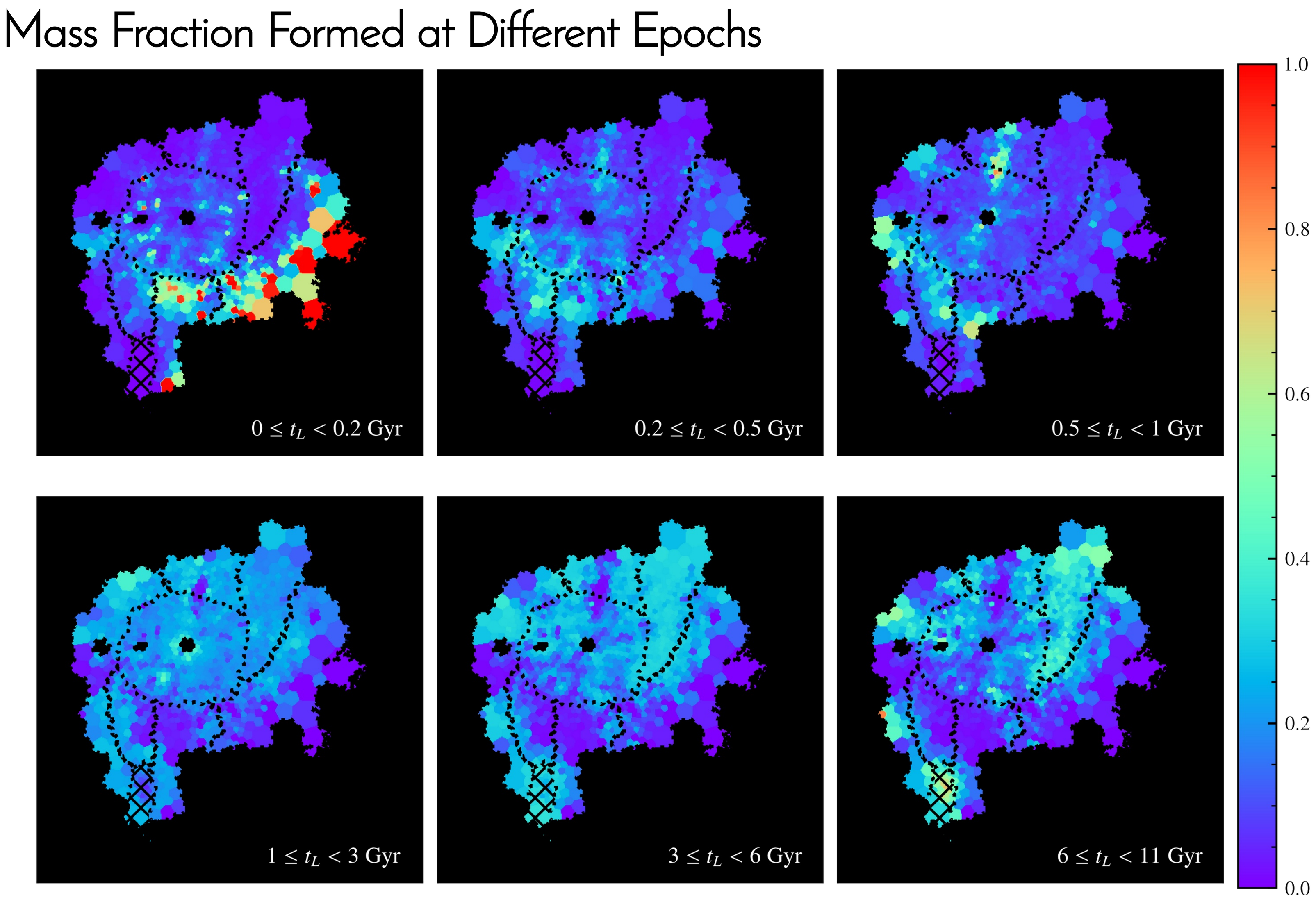
- The continuum subtraction is still not perfect, particularly for the AGN – work to improve this is ongoing
- However, we can still derive useful science – for example, here the nebular [SIII] emission is concentrated on the leading edge of the galaxy, not in the stripped tail
- These clumps are strongly coincident with the UV emission, as expected

Spatially-Resolved Star Formation Histories



- We mask out the central bins due to the AGN contribution, and also mask objects outside the cluster redshift
- Compared to the RGB imaging, the stellar mass surface density is much smoother, and we note that the
- There is a considerable difference between the approximate central stellar disk (dotted region), and the South-Western (SW) tail, with the latter displaying elevated sSFRs

Mass Fraction Formed at Different Epochs



- Despite the high current SFRs, the majority of mass in the central region formed at much earlier times
- Similarly, the early formation epoch of the arm/tidal stream (regions B and C opposite) is clearly visible
- The hatched region indicates the low-mass companion galaxy – given the dispersed old stellar component, we suggest an interaction with this led to the creation of the tidal stream in regions B and C
- This likely triggered the recent burst in star formation between 0.2-1 Gyr previously (region D)
- In the SW region (regions E and F), the majority of mass formed within the last 200 Myr – alongside the directionality of this formation, this is strongly indicative of ram-pressure stripping
- What we are seeing is very likely the combination of multiple physical processes – at least one recent interaction, with the entire system then falling into the cluster and undergoing RPS