



Quenching Cluster Galaxies in the Cosmic Middle Ages

Symposium Summary

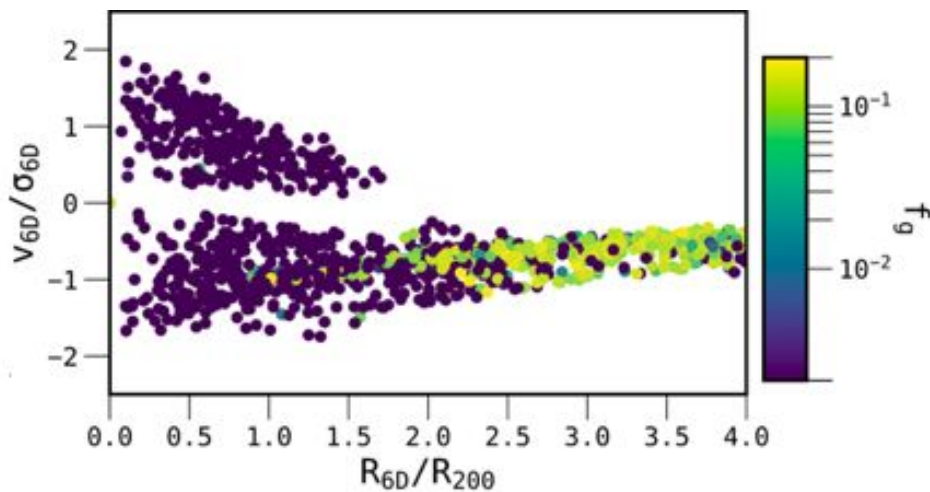
From Observations to Theory

Four broad themes

- 1.) **Where** does environment act?
- 2.) How are cluster galaxies **quenched** and what are other effects of ram-pressure stripping?
- 3.) What is the impact of the cluster environment on **galaxy size/morphology**?
- 4.) Which **other properties** are affected - e.g. galaxy kinematics and spin?

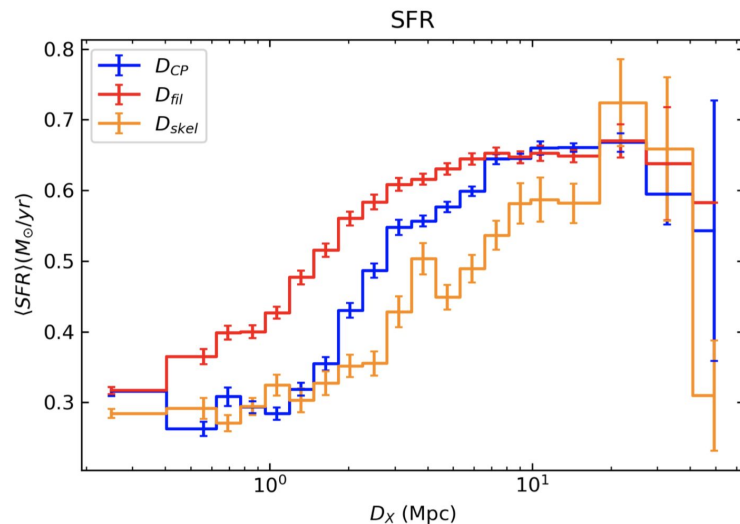
Theme 1: Where does environment act?

Gas removal on cluster outskirts during first infall
- Meghan Gray



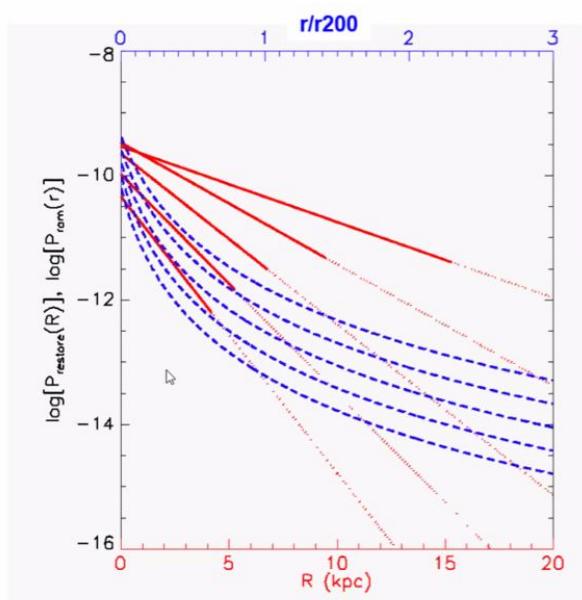
Arthur+19

Star formation quenched closer to clusters,
but also filaments - Nicola Malavasi

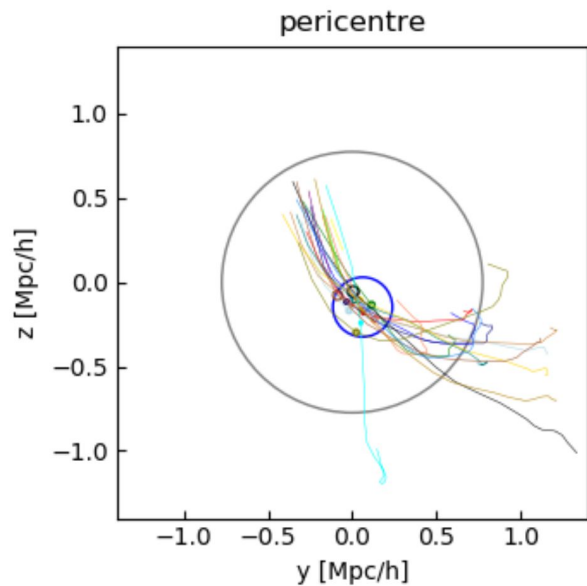


Theme 1: Where does environment act?

Expect large variation in radius at which (cold gas) stripping kicks in, dependent on cluster and galaxy mass - Ian McCarthy



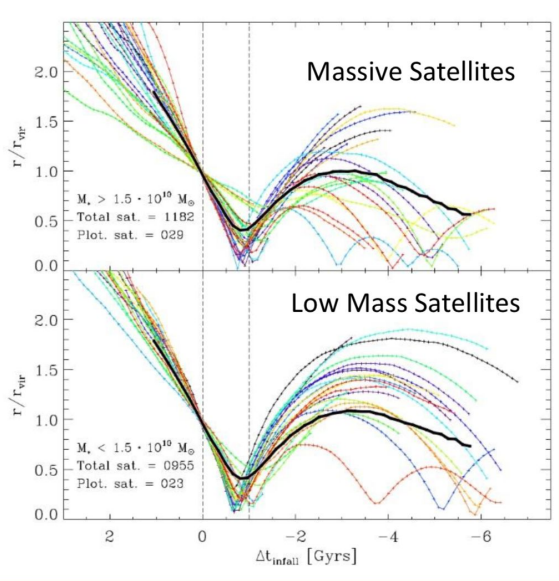
Groups dissociated around first pericentre - Nelvy Choque-Challapa



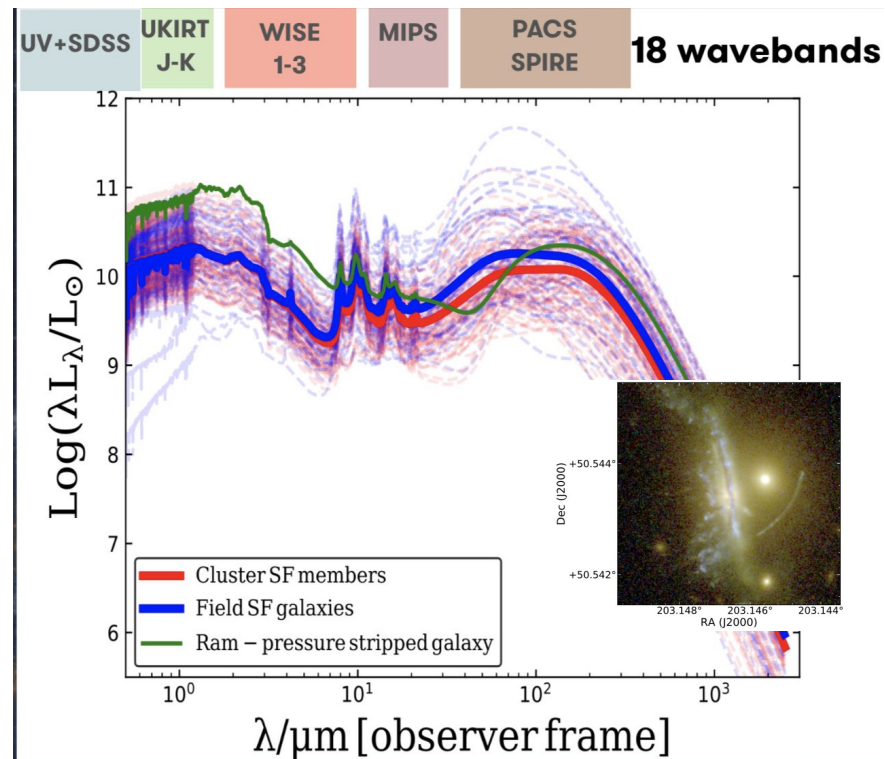
Theme 2: Quenching in clusters

Dust as tracer of environmental impact in galaxies undergoing ram pressure stripping - Matteo Bianconi

Influence of orbits on quenching: radial vs. tangential - Rhea-Silvia Remus

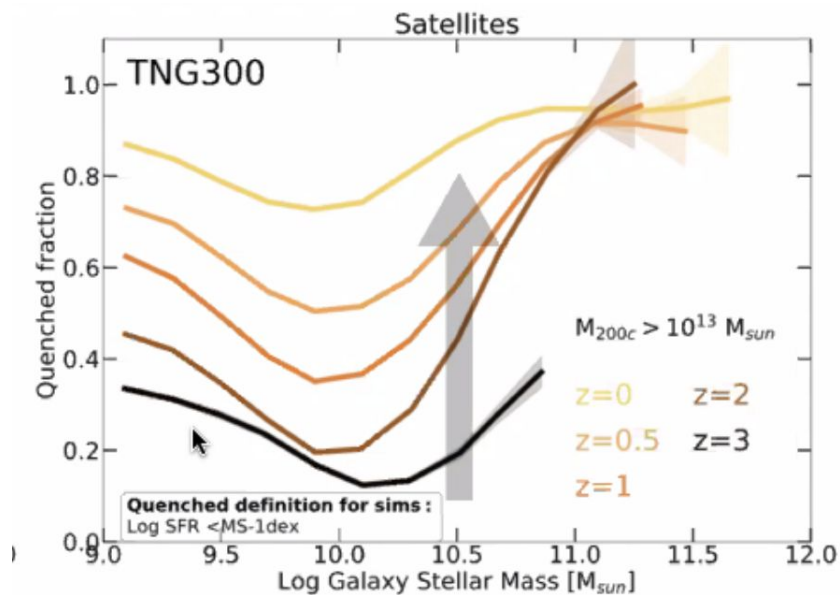


Lotz+19

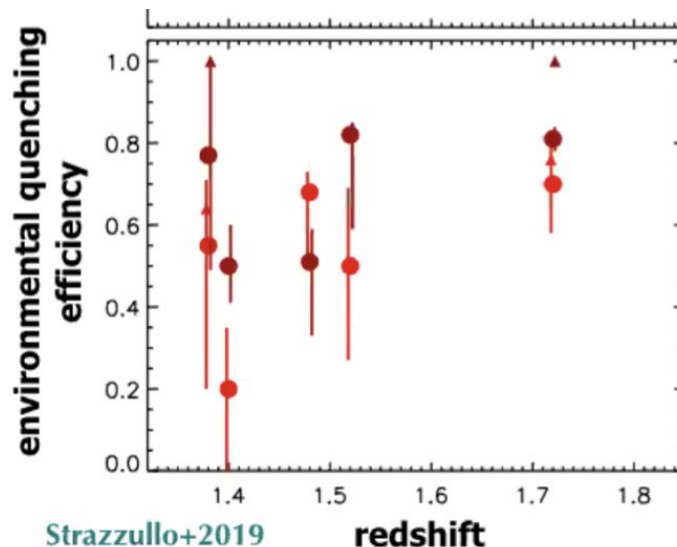


Theme 2: Quenching in clusters

Martina Donnari: satellite quenching increases with time (TNG simulations)

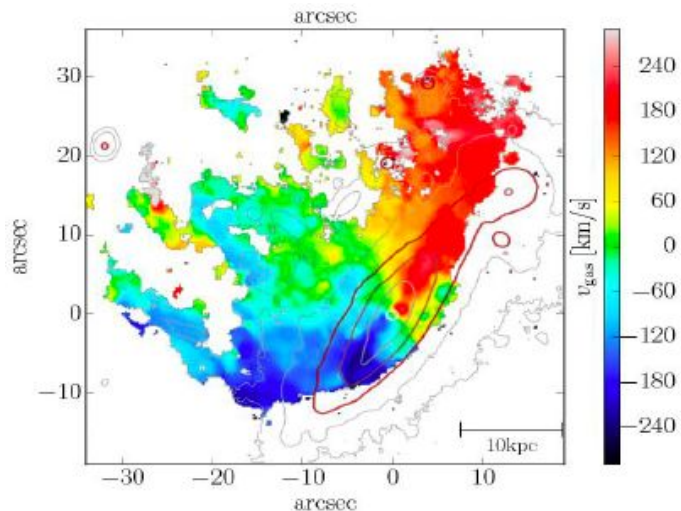


Veronica Strazzullo: quenching observed in massive clusters already at $z > 1$



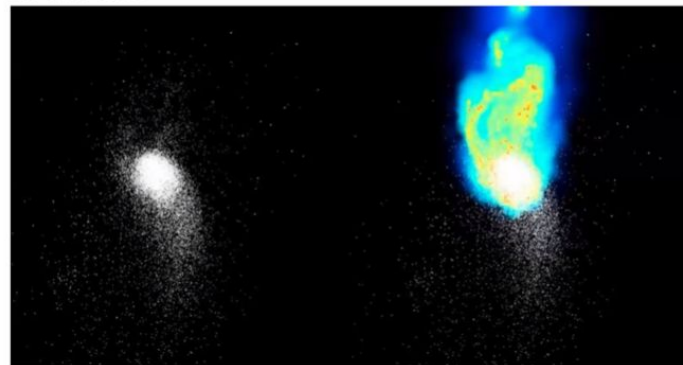
Theme 2: Quenching in clusters

Systematic observations of ram pressure stripping from e.g. GASP - Marco Gullieuszik



Gullieuszik+ 2017

Simulations predict gas + stellar tails in opposite directions, as observed in Fornax cluster - Michele Mastroiello

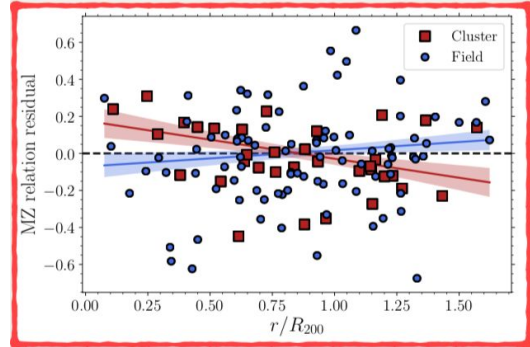
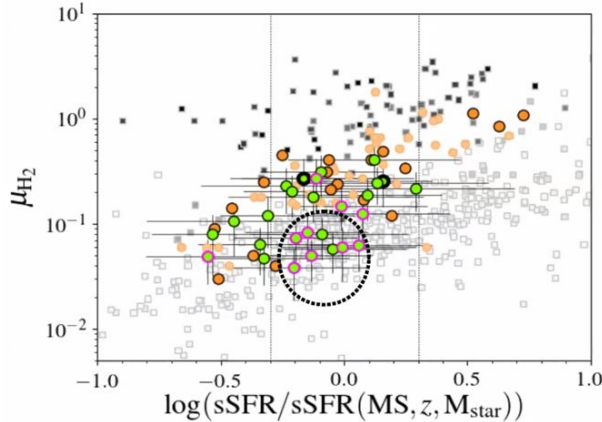


Combination of RPS and strangulation required in model to match central surface brightness + H α /R-band sizes - Sam Vaughan

Theme 2: Quenching in clusters

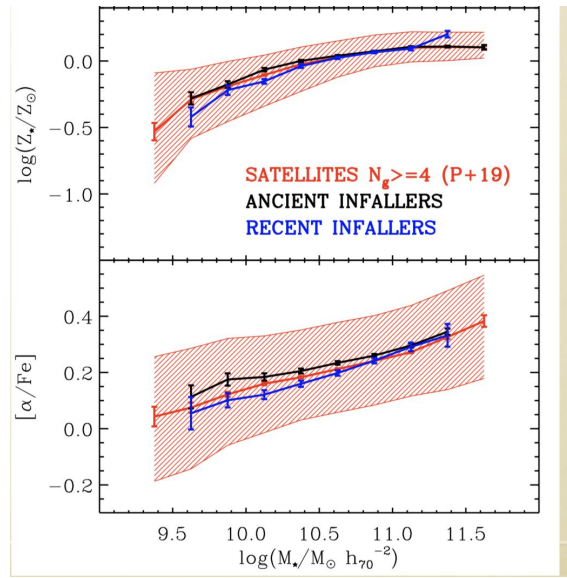
Molecular gas content (and metallicity) affected **before** star formation rate. Many gas-depleted galaxies still on star-forming main sequence

Damien Spérone-Longin



Sam Vaughan

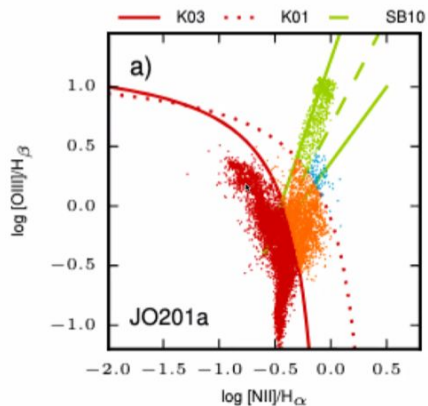
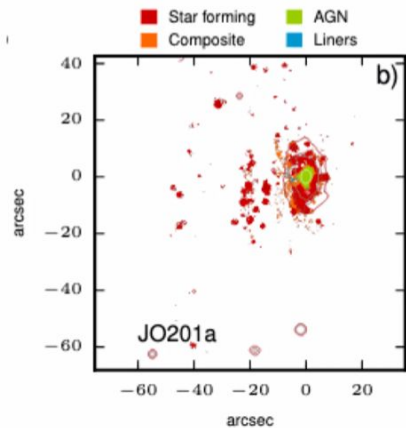
ancient infallers are older, metal-rich and more α -enhanced than recent infallers



“Nature” versus “Nurture” debate

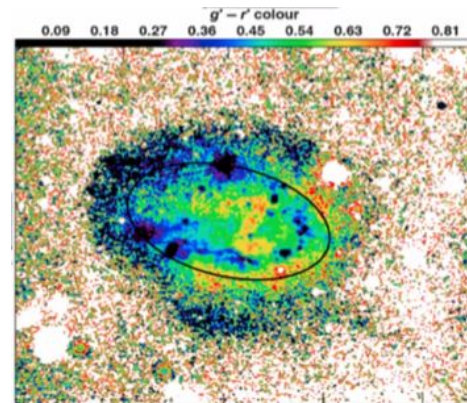
Theme 2: Quenching in clusters

Ram pressure stripping also linked to **enhanced** AGN activity - Sean McGee



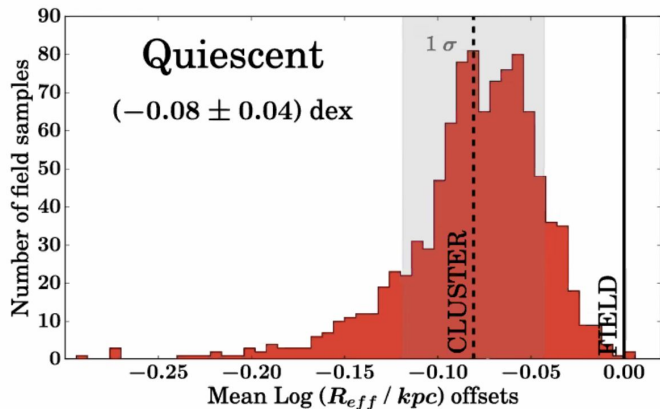
(Poggianti et al. 2017)

Lee-Waddell+18



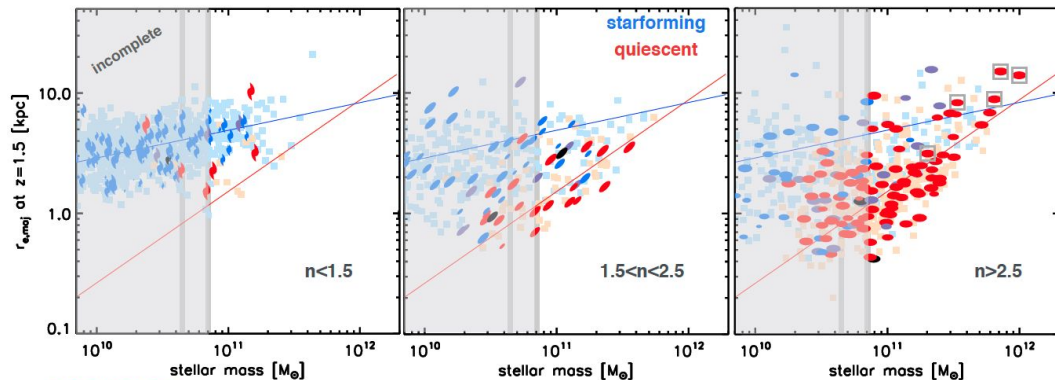
Younger/bluer stars on leading edge - Michele Mastropietro

Theme 3: Impact of environment on size/morphology



Quiescent cluster galaxies are **~20% smaller** than quiescent field galaxies (at fixed M_*).

Jasleen Matharu



all clusters
(scaled to $z=1.5$)

Strazzullo+ in prep.

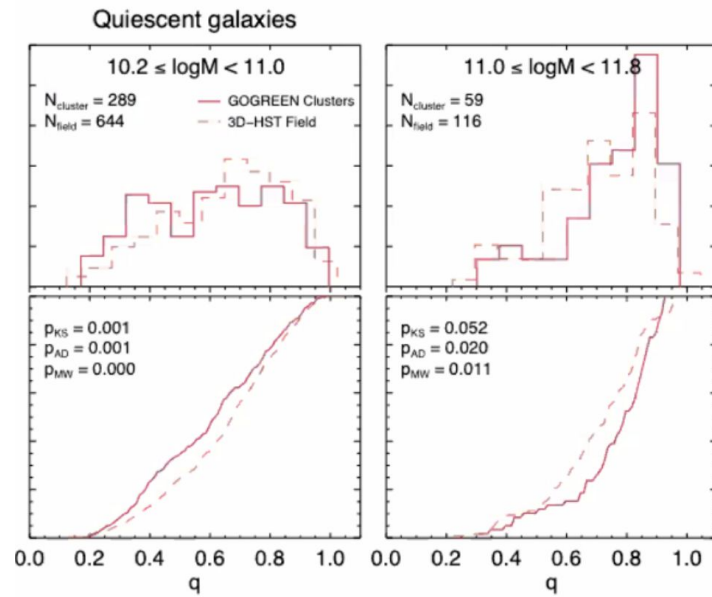
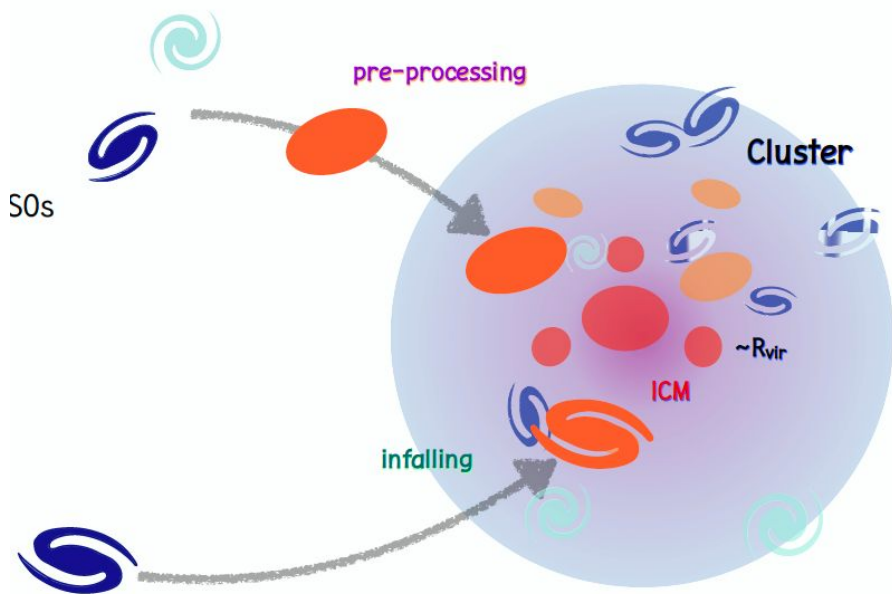
Sérsic index transforms alongside quenching, size evolution follows later - Veronica Strazzullo

Theme 3: Impact of environment on size/morphology

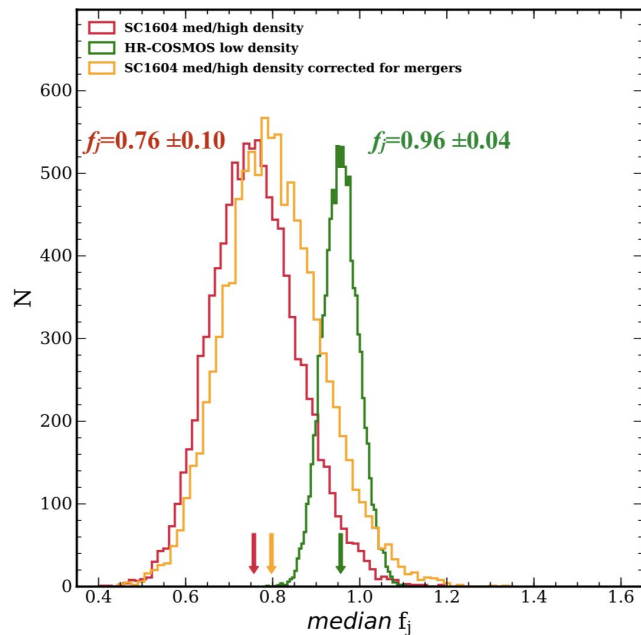
But, Mina Pak:

Suggesting observational constraint in timescales between SF quenching and morphological transformation (~ 5 Gyrs)

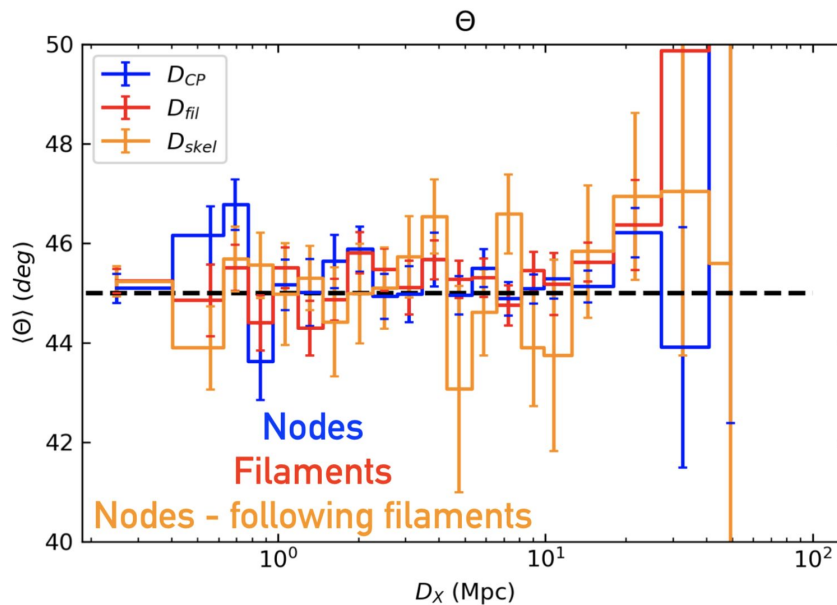
Intermediate- and high mass quiescent galaxies show (small) difference in axis ratios - Jeffrey Chan



Theme 4: Impact on kinematics and spin



Lower angular momentum, plausibly related to mergers - Debora Pelliccia



Spin shows no correlation with distance from any structure type - Nicola Malavasi

Outlook - The path to better simulations

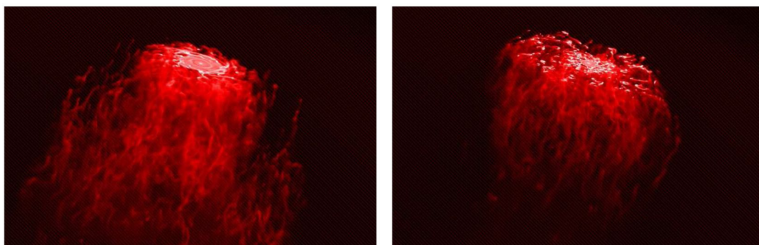
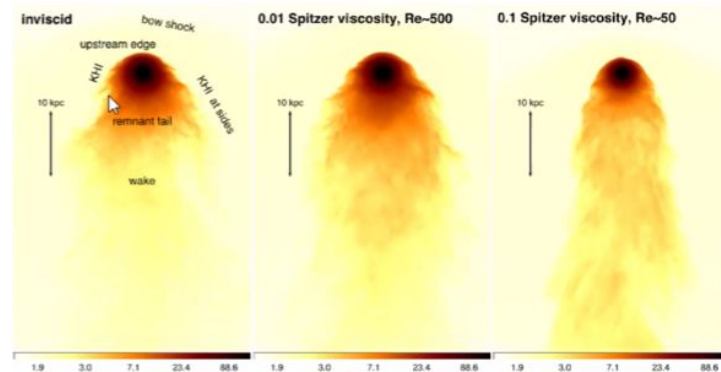
Roediger+14

Additional physical processes (e.g. photoionization, viscous stripping, anisotropic conduction) - Ian McCarthy

Higher dynamical range: trade-off between resolution and most massive haloes - Rhea-Silvia Remus

Using different physics engines to test robustness - Meghan Gray

+ Detailed comparison to observations! - Sean McGee



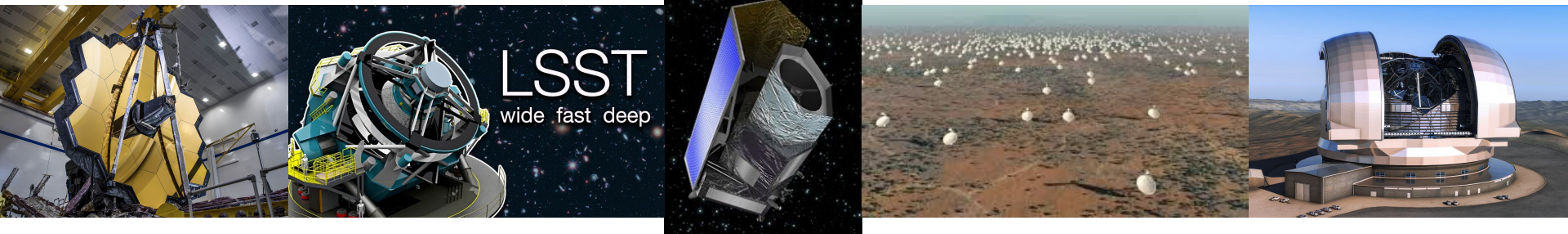
Tonnesen & Bryan (2009): ram pressure stripping affected by ISM cooling

Also: better modelling of ISM (work in progress)

Outlook - Observations

When did the “cosmic middle ages” start? Regime of proto-clusters becomes accessible

Observatories coming online: JWST, Vera Rubin/LSST, Euclid, SKA, ELT era...



Stay connected!

And... keep sharing thoughts on the Slack channel