QUENCHING AND MORPHOLOGICAL TRANSFORMATIONS

Physics of Groups Conference @ IAP

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EFFECT OF THE *ENVIRONMENT*

Star-formation quenching via:

- Ram-pressure stripping
  - cold gas
  - hot gas halo
- Winds and "overconsumption"
- Truncation of gas inflow from cosmic web

Morphological transformations via:

- "Harassment"
- Tidal interactions with cluster
- (Mergers?)

Orbits and timescales may help disentangle these effects

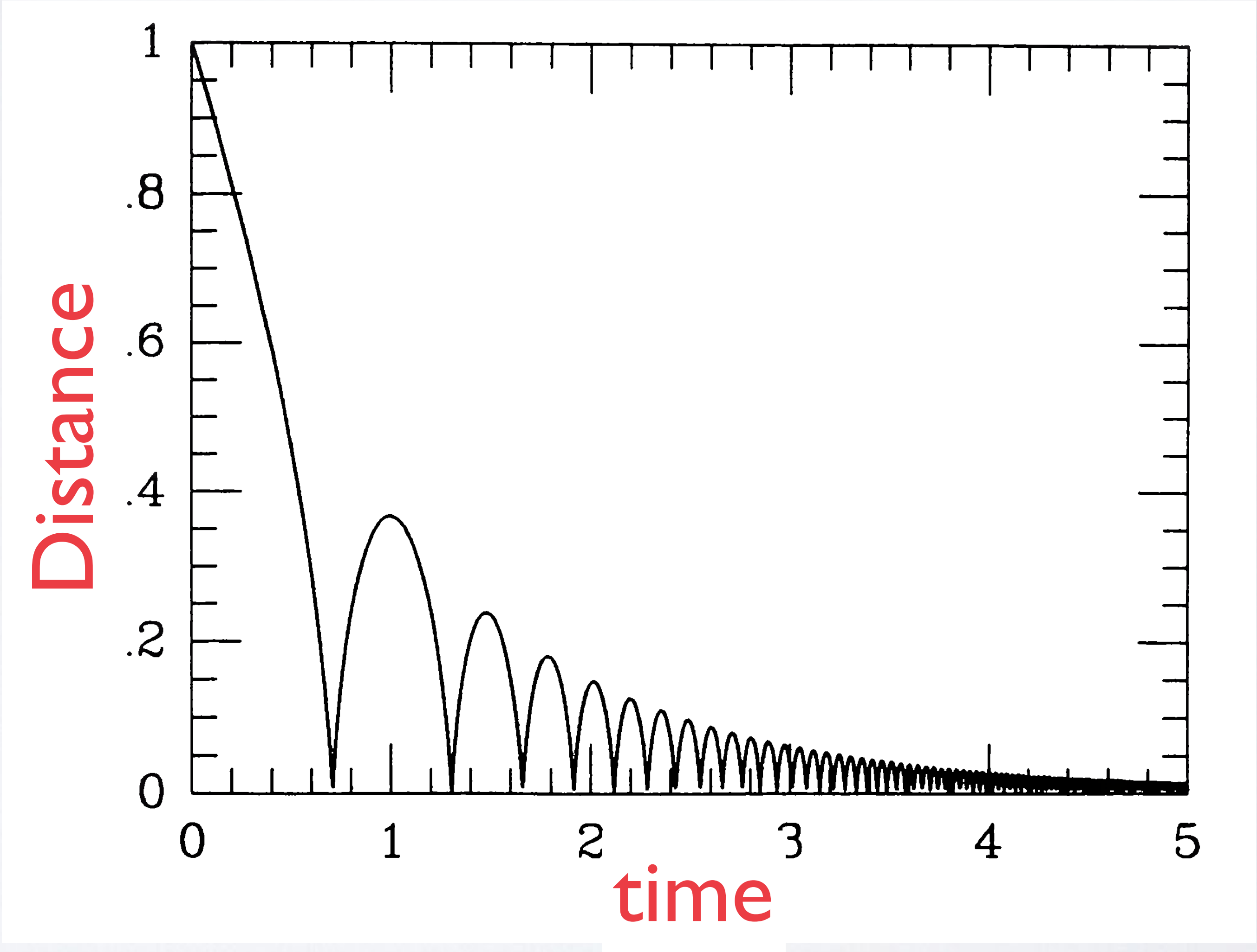
APPROACH

Use location in projected-phase space (PPS) as a clock

c.f. Gill, Knebe & Gibson 05, Mahajan, Mamon & Raychaudhury 11, Muzzin+14

- Compare data in PPS - R_{proj} and V_{los} - with N-body orbits
- PPS range includes infalling pre-processed galaxies and groups to be compared with post-processed gals observed at the same time
- Build simple models in which quenching or transformation occurs some delay time after infall
- Fit all galaxy populations simultaneously now:
  - (different from e.g. Wetzel et al. approach)
  - Allows us to isolate the effects of infall into most massive structure

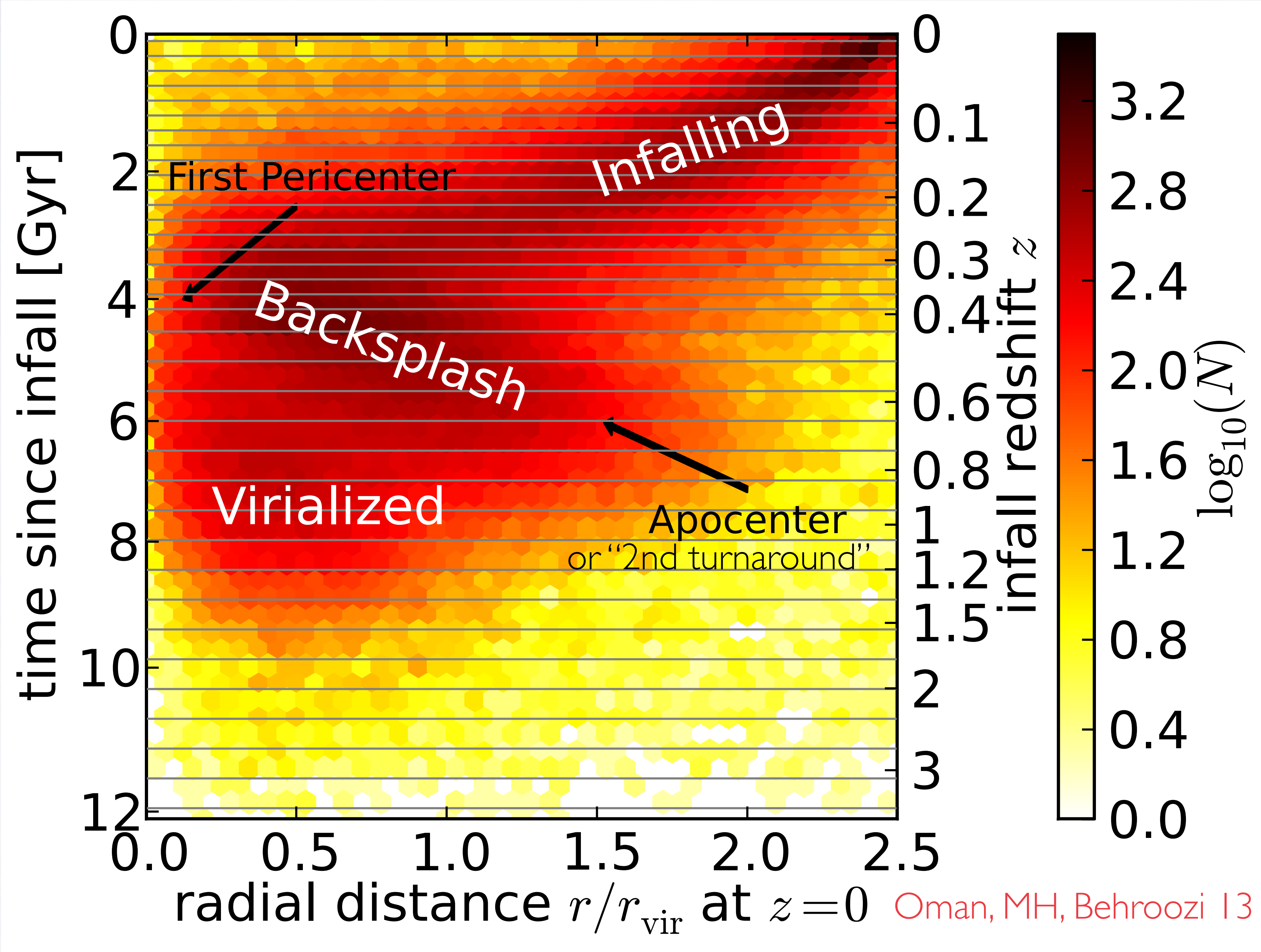
N-BODY SUBHALO ORBIT LIBRARIES



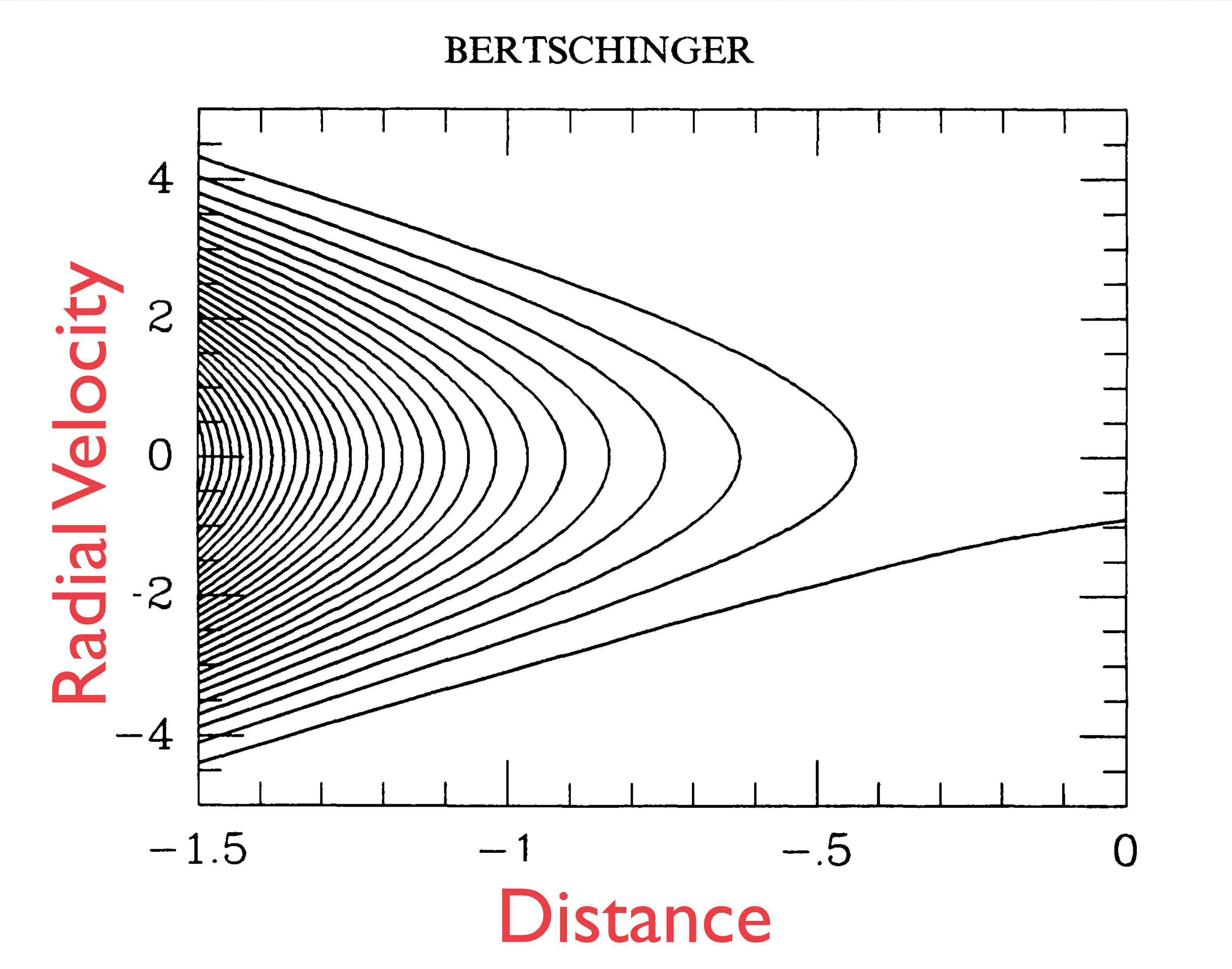
Bertschinger 1985

N-BODY SUBHALO ORBIT LIBRARIES

- Note t=0 means 2.5 r_{vir}
- $M_{host} > 10^{14}$
- $M_{sat} > 10^{11.9}$
- MultiDark N-body



ORBIT LIBRARIES IN PHASE SPACE



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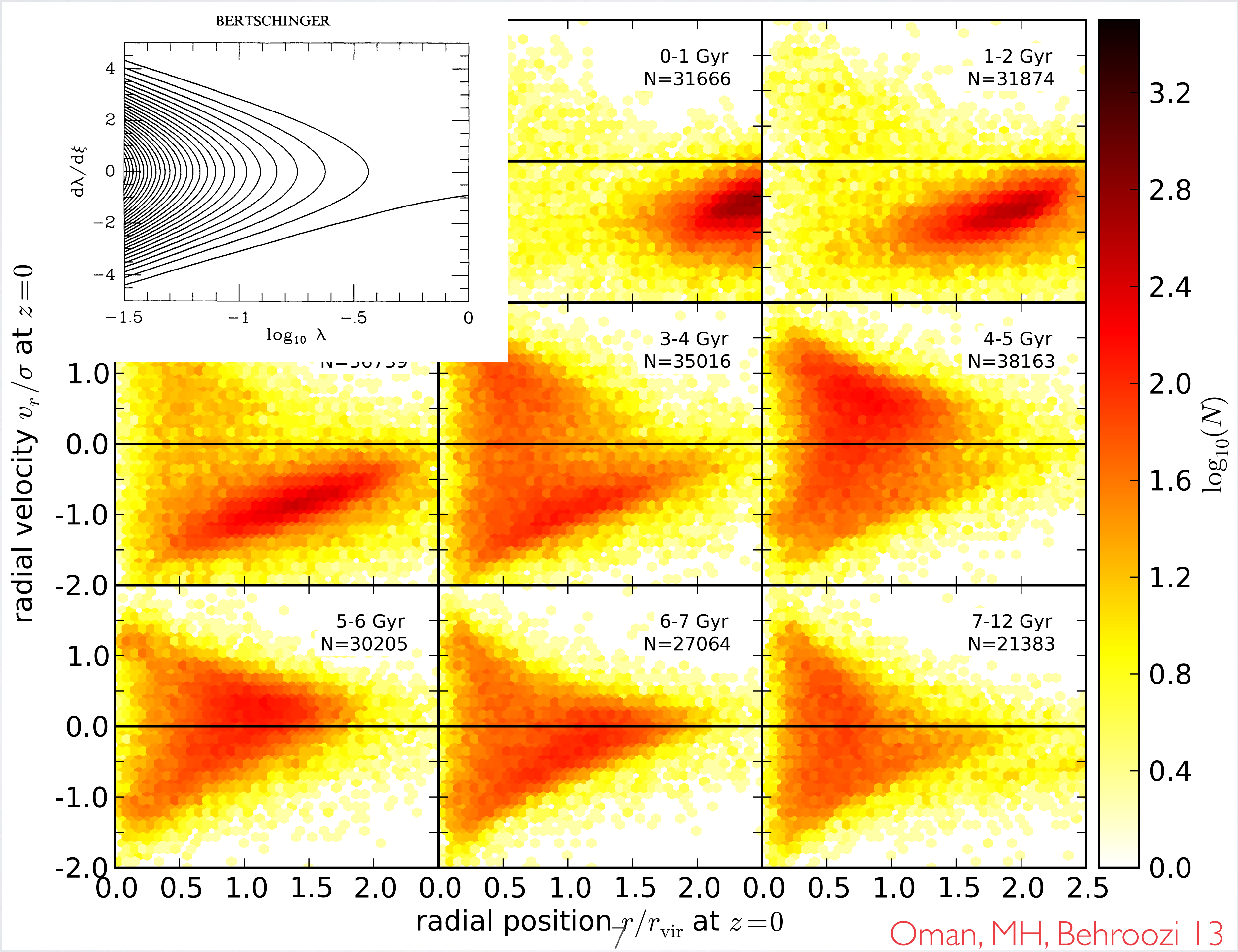
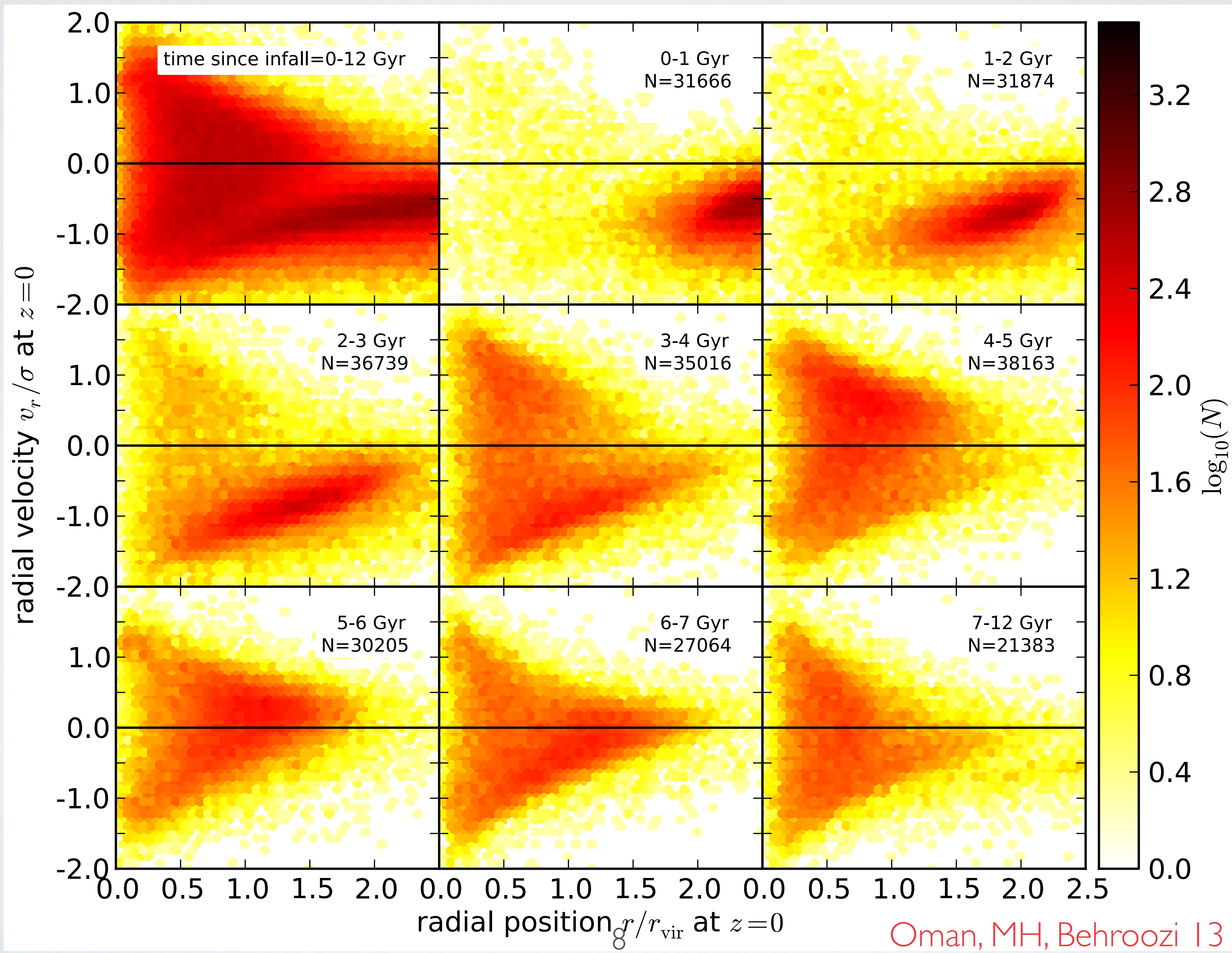


Oman, MH, Behroozi 13

ORBIT LIBRARIES IN PHASE SPACE



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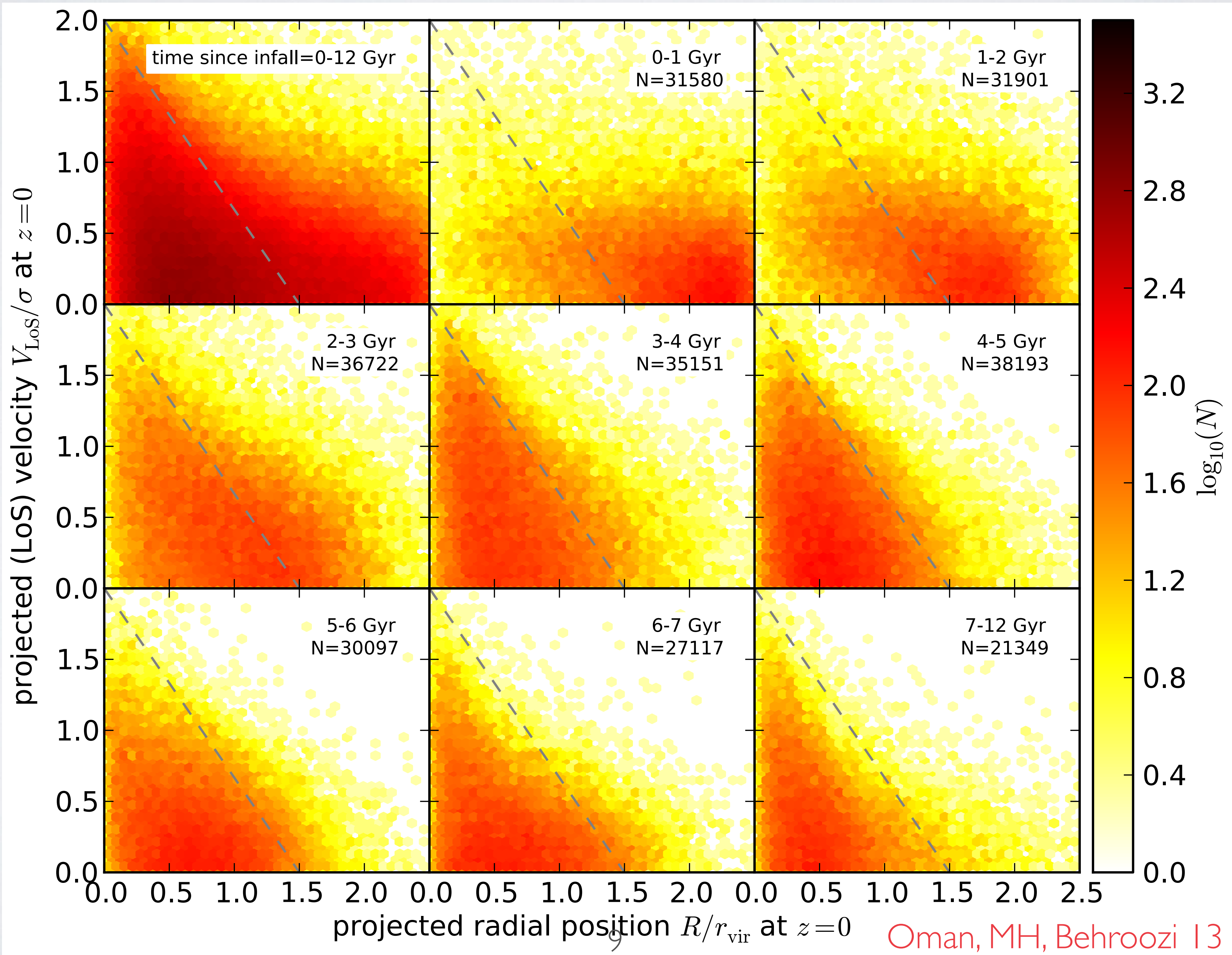
ORBIT LIBRARIES IN **PROJECTED** PHASE SPACE



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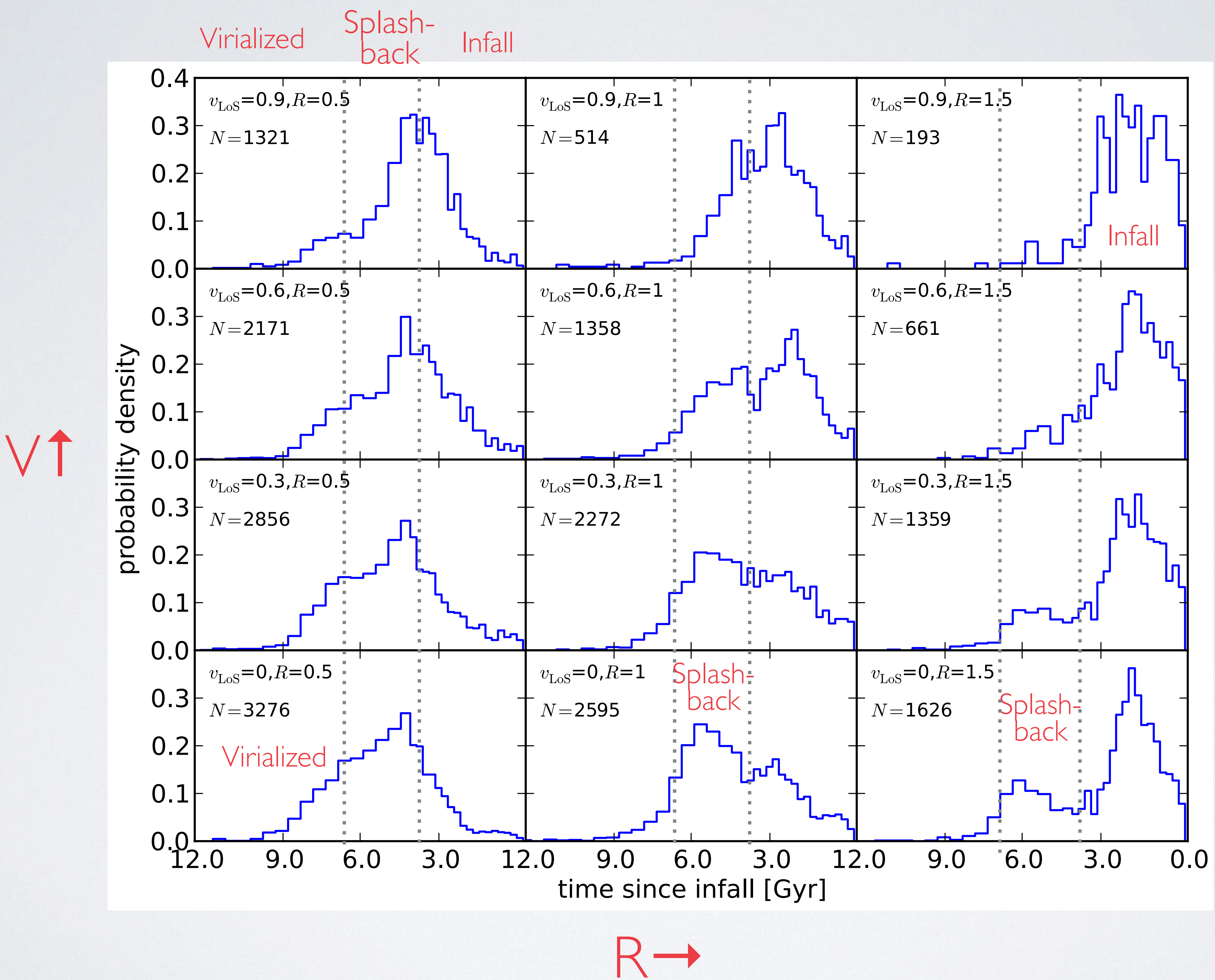
INFALL PDFS IN PHASE SPACE



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SDSS QUENCHED FRACTION

SDSS data stacks:

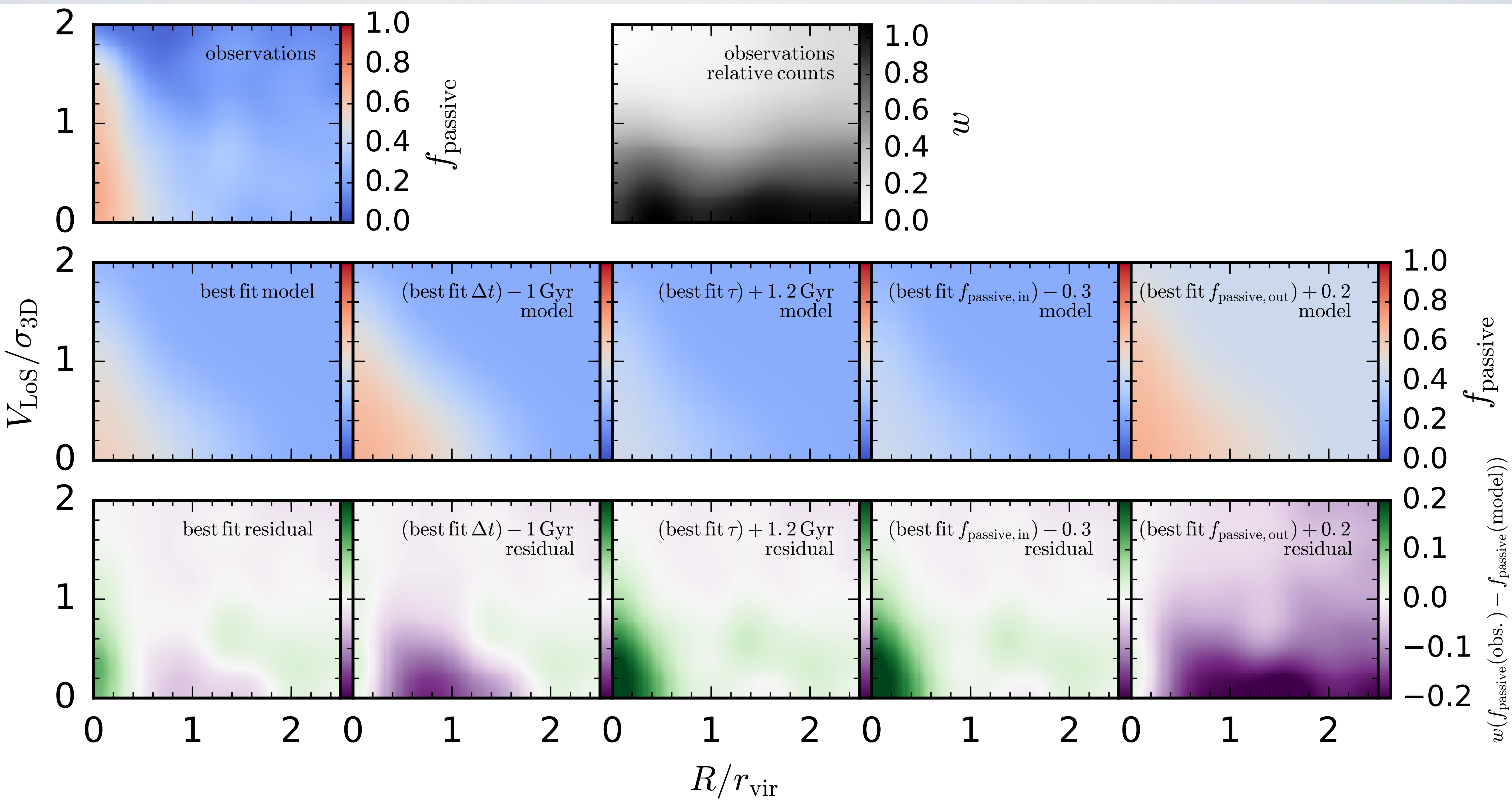
- 625 von der Linden clusters: $M \sim 10^{14}$-10^{15}
- 500,000 satellites
- sSFR from Brinchmann/Mendel
    - Split into passive and active
- Plot passive fraction in PPS

Fit parameters:

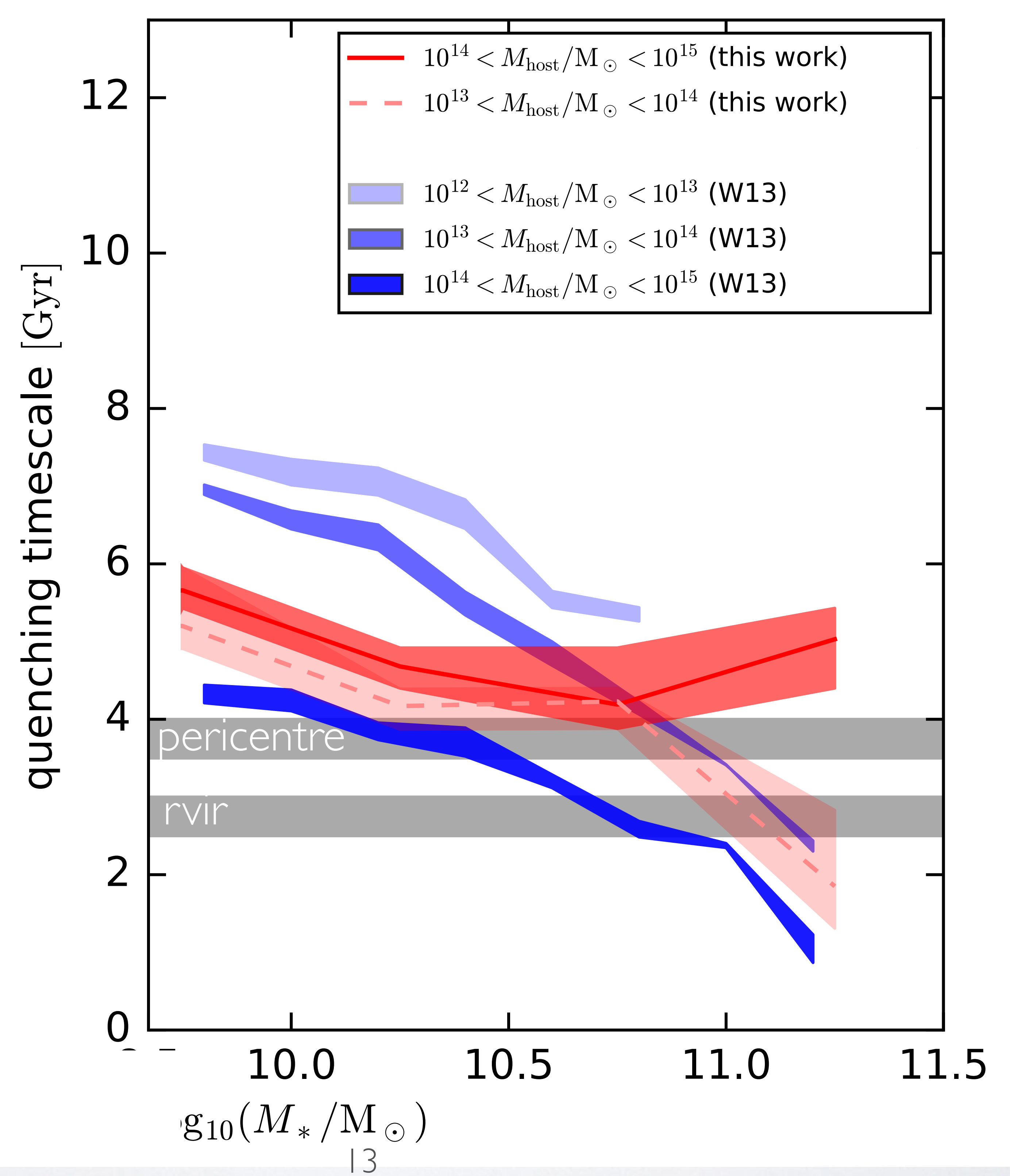
- quenching delay time
- g-g spread in delay time (small)
- passive fraction after quenching (100%)

Oman & MH 2016

DATA AND MODEL

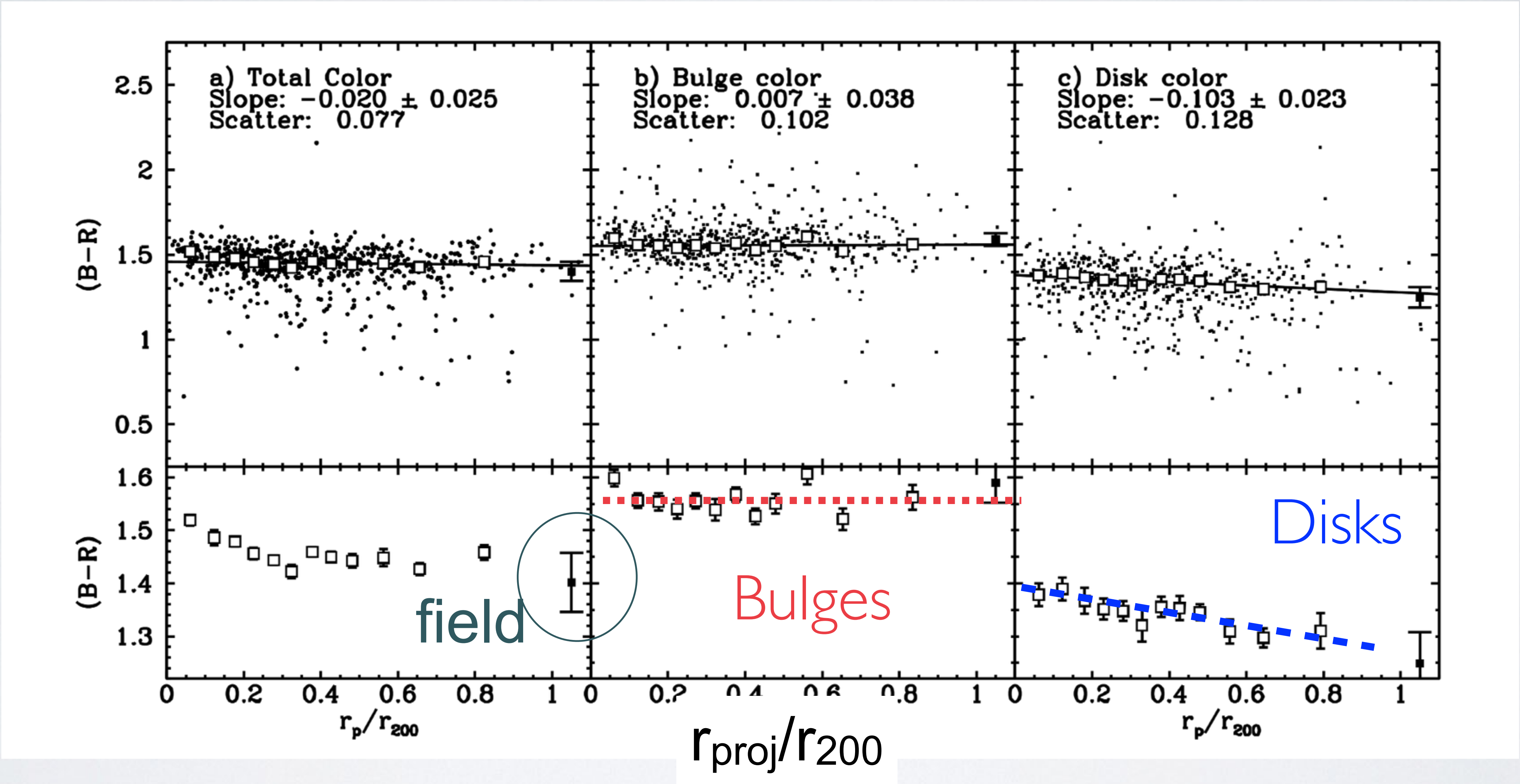


QUENCHING TIMESCALE



Oman & MH 2016

COLOURS OF BULGES AND DISKS IN CLUSTERS



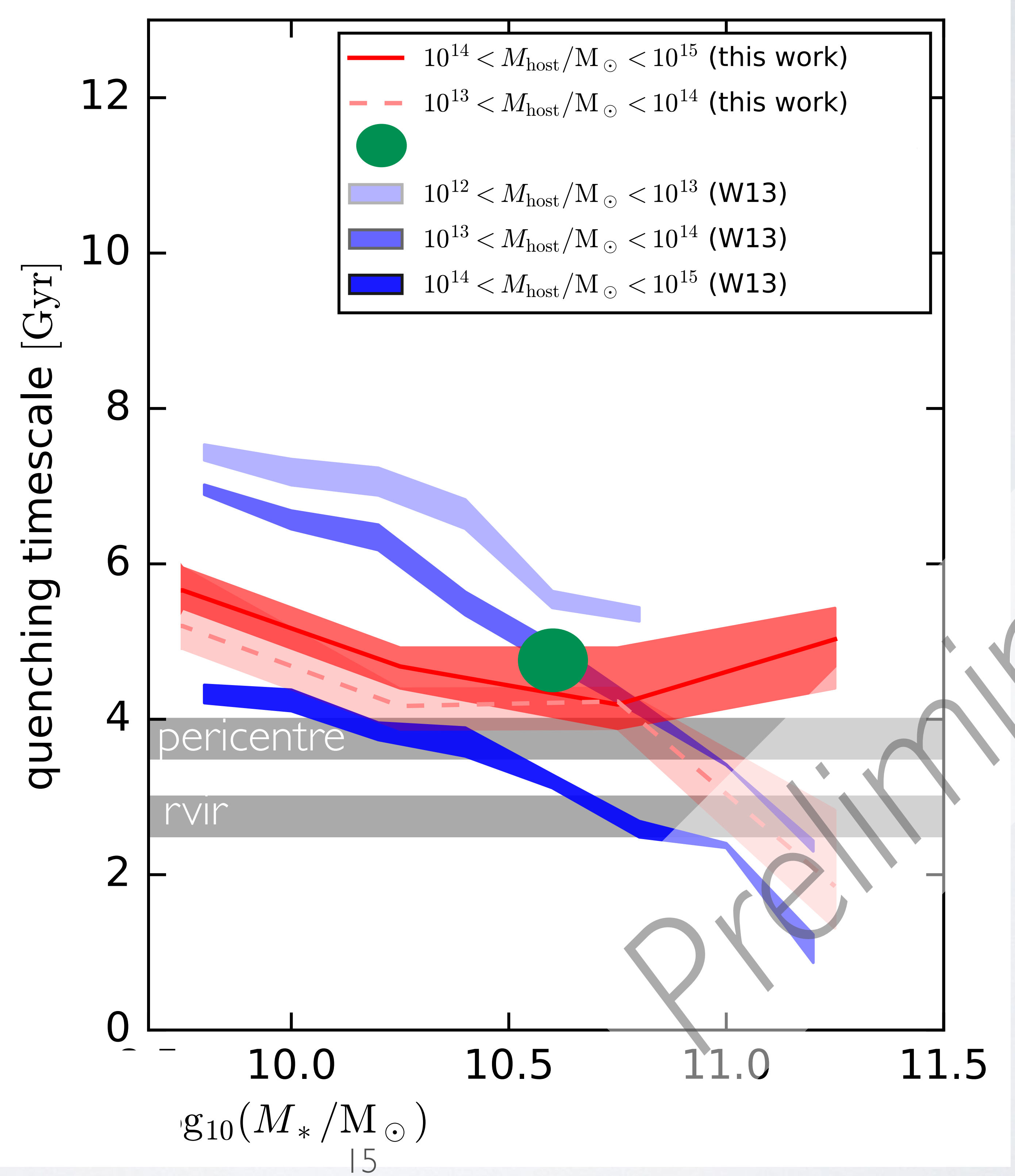
Bulges red, but colours show *no cluster-centric dependence*
Disks bluer, show a strong cluster-centric effect

MH, Stevenson et al '10

SDSS QUENCHED FRACTION

Quenching times from disk colours

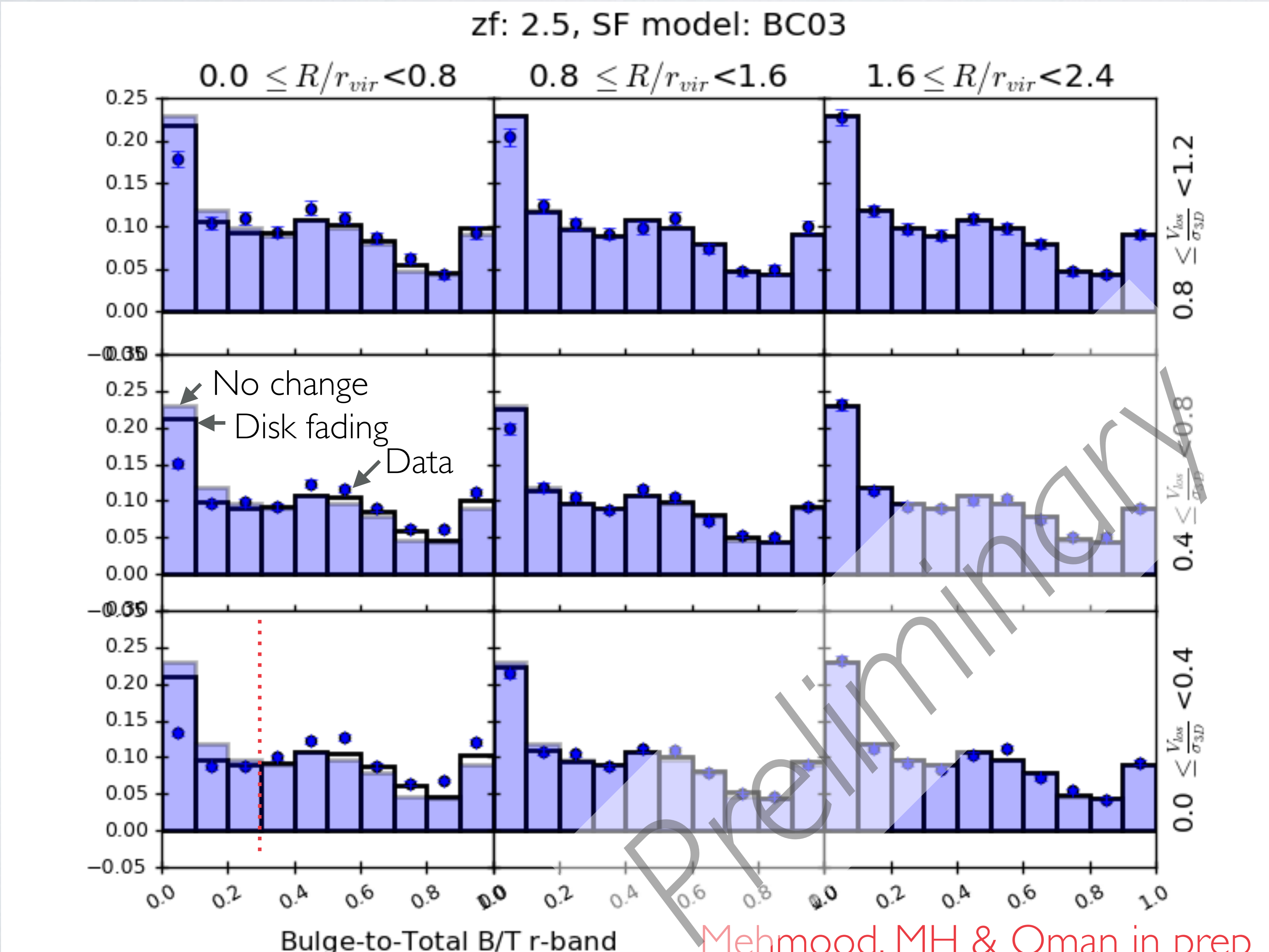
Mehmood, MH & Oman in prep



MORPHOLOGICAL TRANSFORMATIONS

- If disk fades due to quenching, then B/T increases
- This fading-induced shift in B/T might be interpreted as a morphological change.
- Our model allows for disk fading and measures *additional* morphological changes

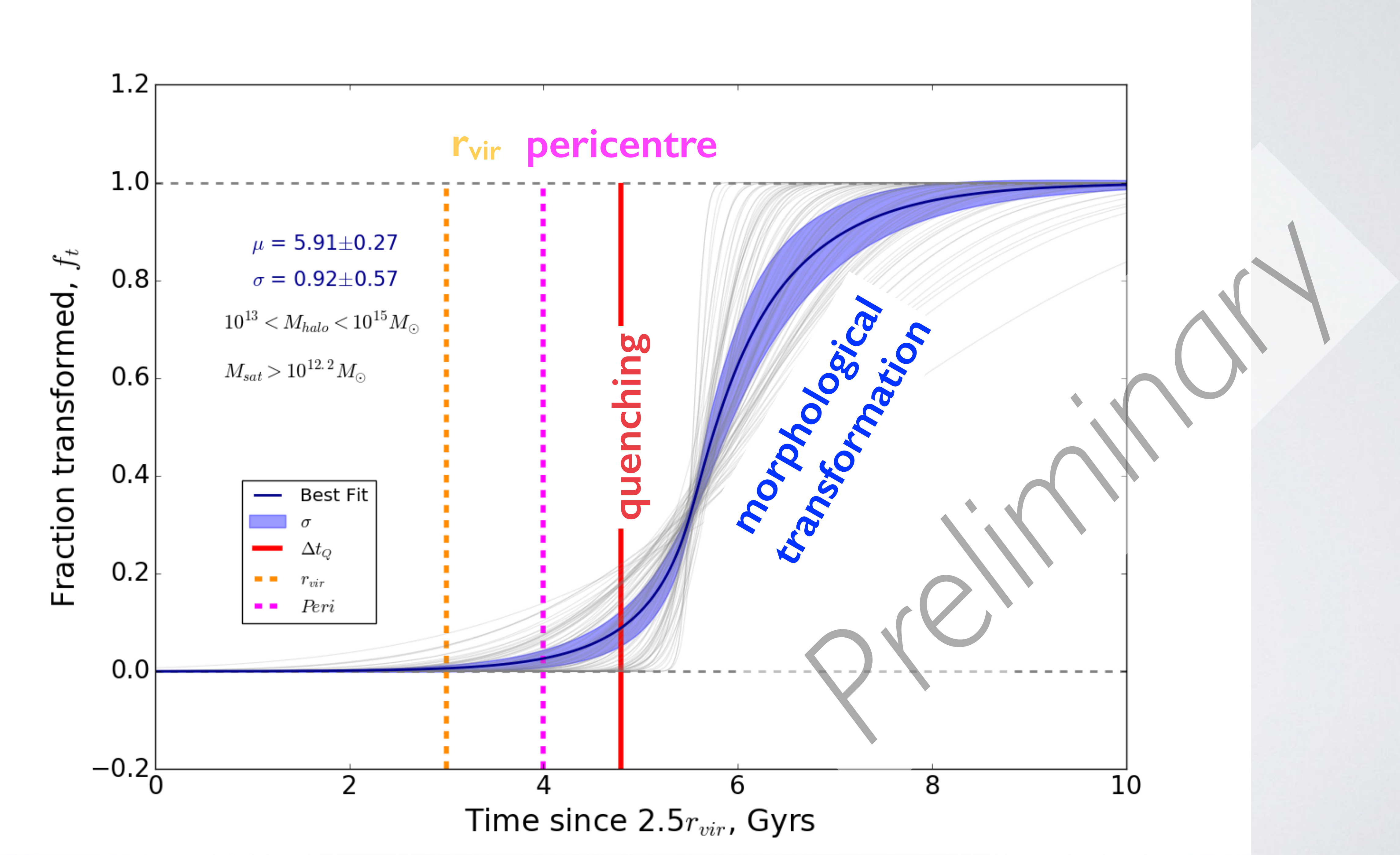
MORPHOLOGICAL TRANSFORMATIONS



Mehmood, MH & Oman in prep

Data in virialized region have a *small* excess of bulge-dominated and a deficit of disk-dominated galaxies

MORPHOLOGICAL TRANSFORMATIONS



Mehmood, MH & Oman in prep

FUTURE

- Other parameter ranges / environments
  - Satellite mass: lower mass systems more sensitive to environment
  - Host mass: groups (e.g. Yang)
- Use more physical variables (than “time since infall”)
  - distance of pericentre
  - maximum ram pressure
- Combine with weak lensing to measure tidal stripping of DM subhalos in PPS
  - CFIS + SDSS/DESI

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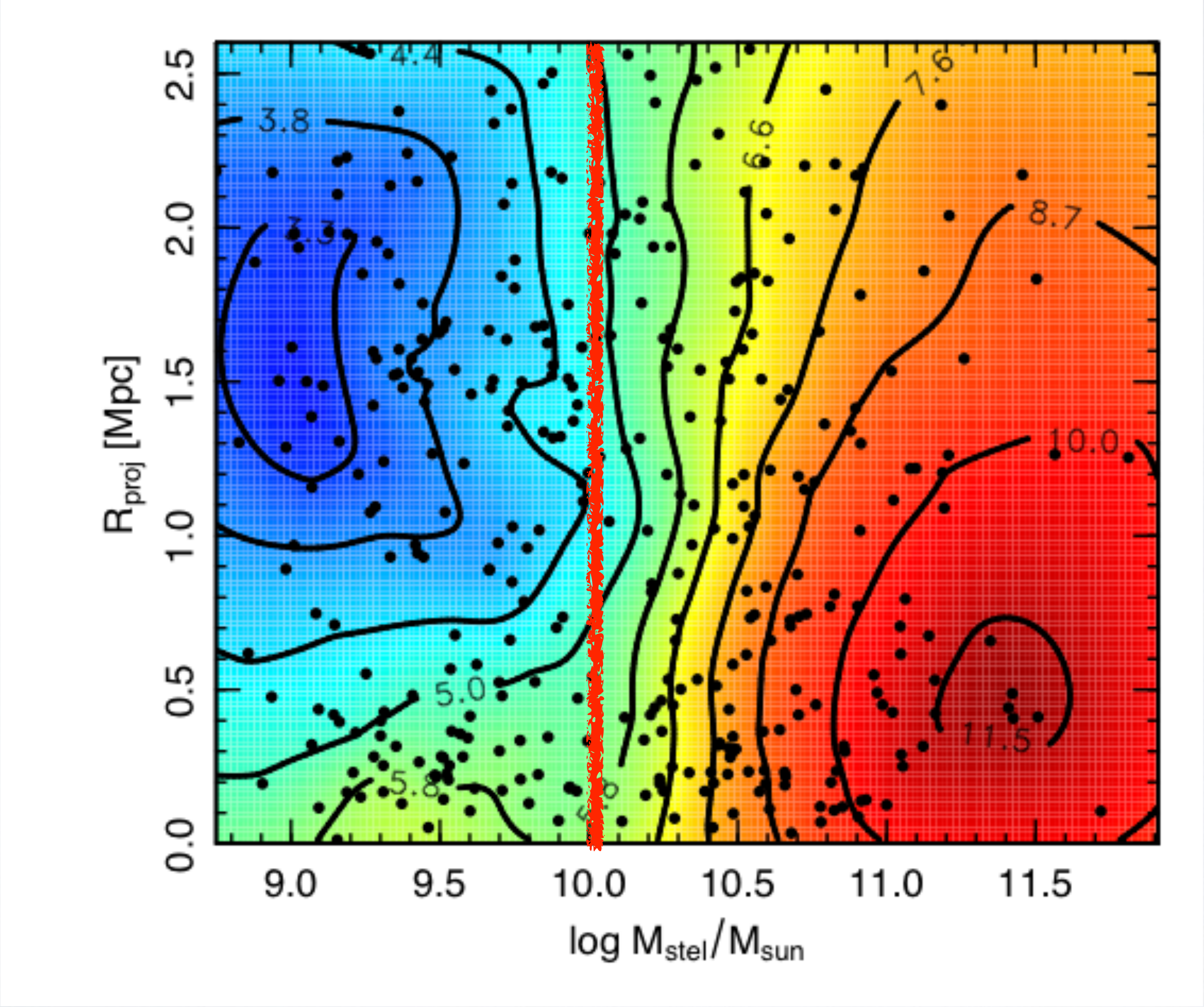
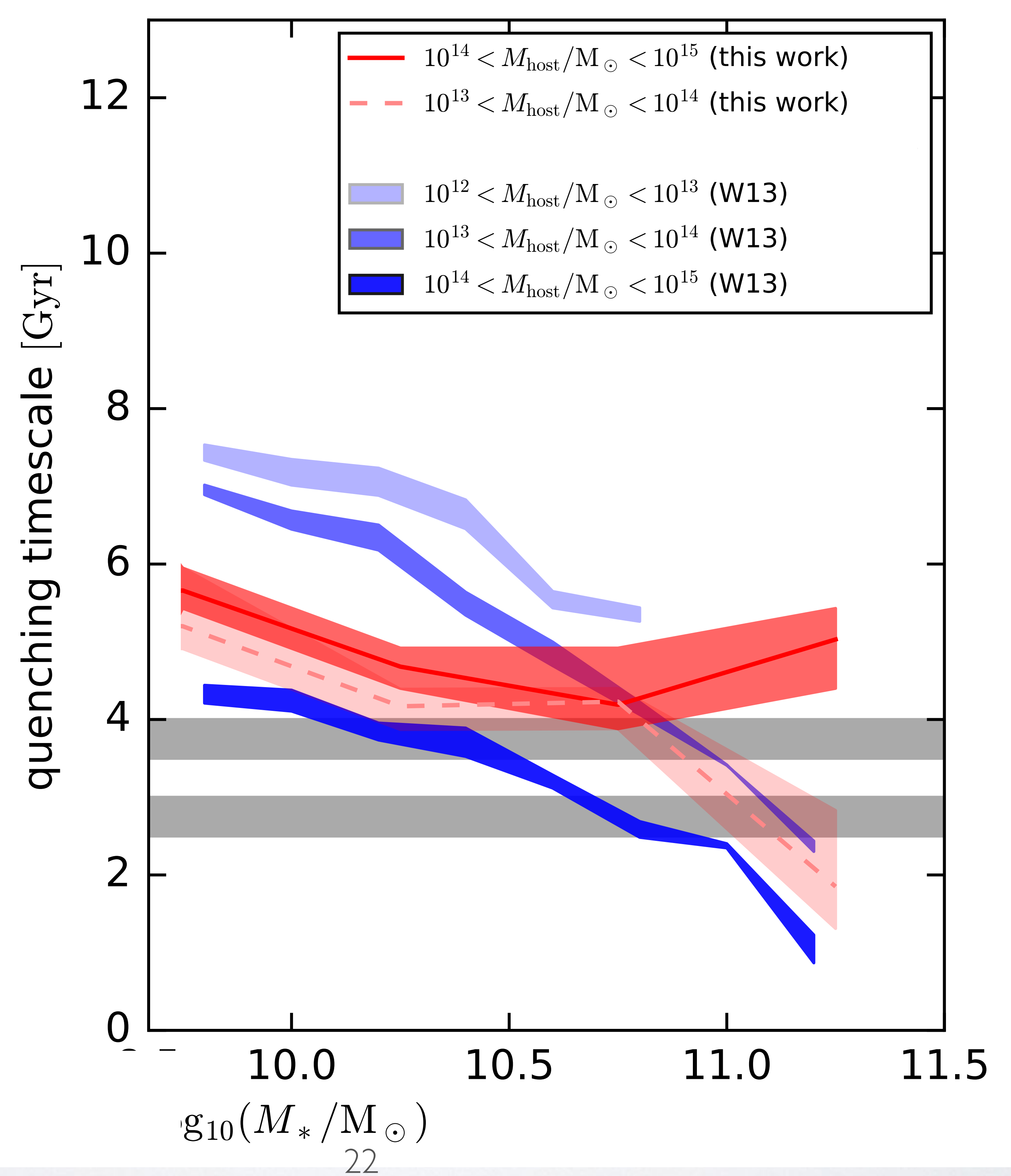
AGES OF RED GALAXIES AS A FUNCTION OF MASS AND R_{PROJ}



Smith, R. J. et al. 2012 MNRAS, arXiv 1108.3836

QUENCHING TIMESCALE



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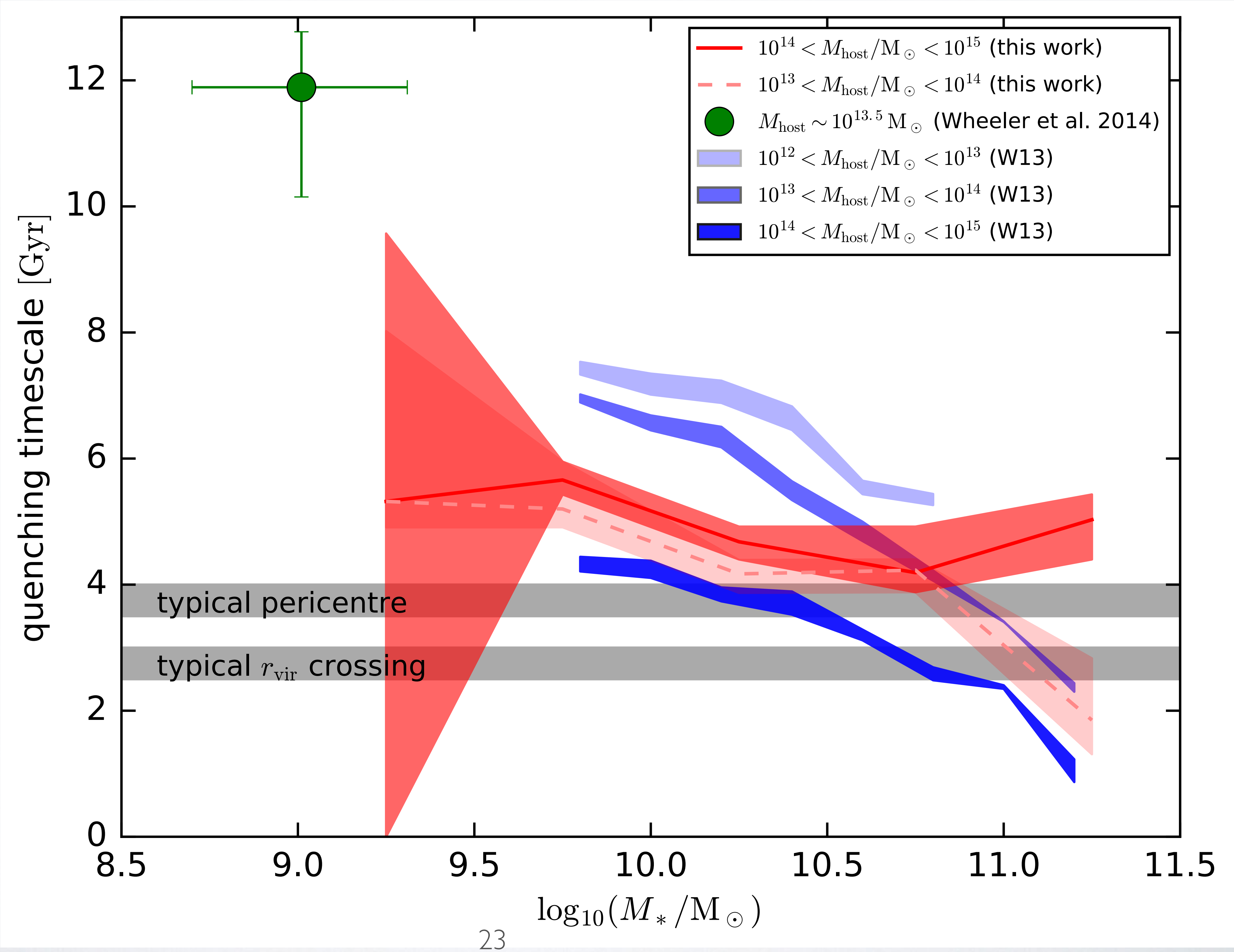

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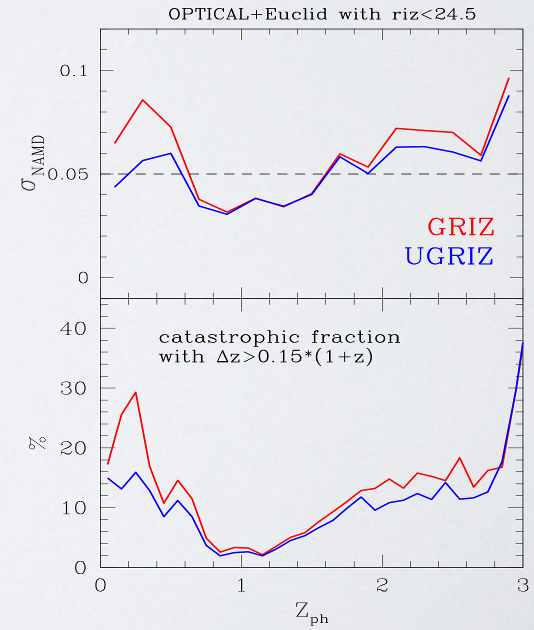
CANADA-FRANCE IMAGING SURVEY

r' band

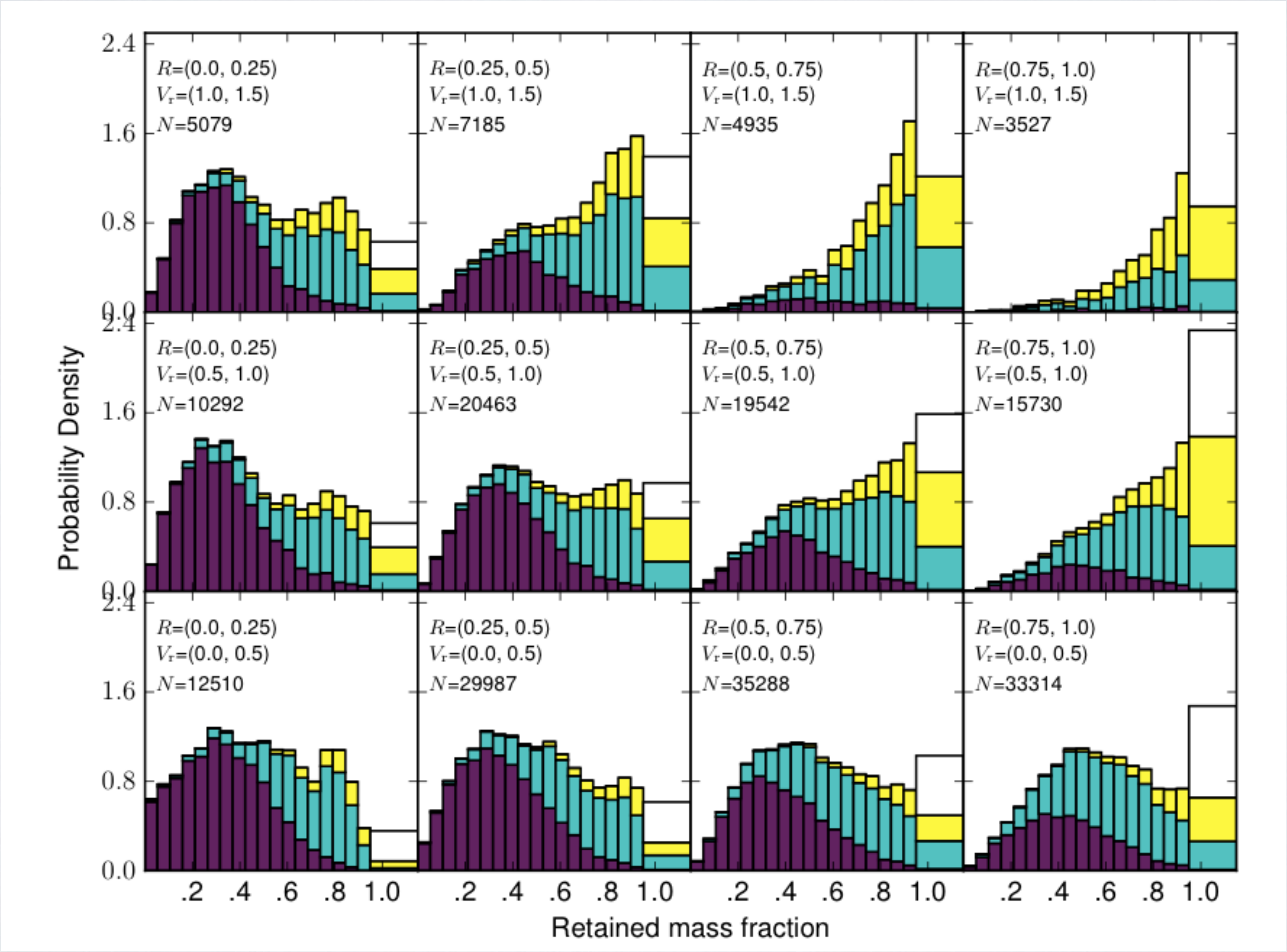
- 5,000 sq. deg
- 0.6 - 0.7 '' median seeing
- r < 24.85 (5 sigma 2'' diameter)
- Dec. > +30 covering SDSS/BOSS/DESI region lots of **spectra** (>30 m)!
  - group DM
  - satellites DM
  - LSS and filament DM
  - intrinsic alignments

u band

- 10,000 sq deg
- Science: metallicity of stars in halo
- Also photo-z with Euclid



TIDAL STRIPPING IN PPS



SUMMARY

- Galaxy disks start to quench soon (<1 Gyr) after pericentre
    - Weak dependence on satellite mass
    - No obvious dependence on host mass
    - Similar quenching timescales whether estimated by emission lines or colours of *disks*
  - Suggests ram pressure stripping
    - But then why longer times for smaller mass galaxies? Incomplete stripping?
- Morphological changes follow after the quenching by a Gyr or so (<2 Gyr after pericentre)
  - “Harassment”?
  - Still work in progress ….