

Anisotropic satellite galaxy quenching modulated by supermassive black hole activity

Martín-Navarro et al. 2021

Yanhan Guo
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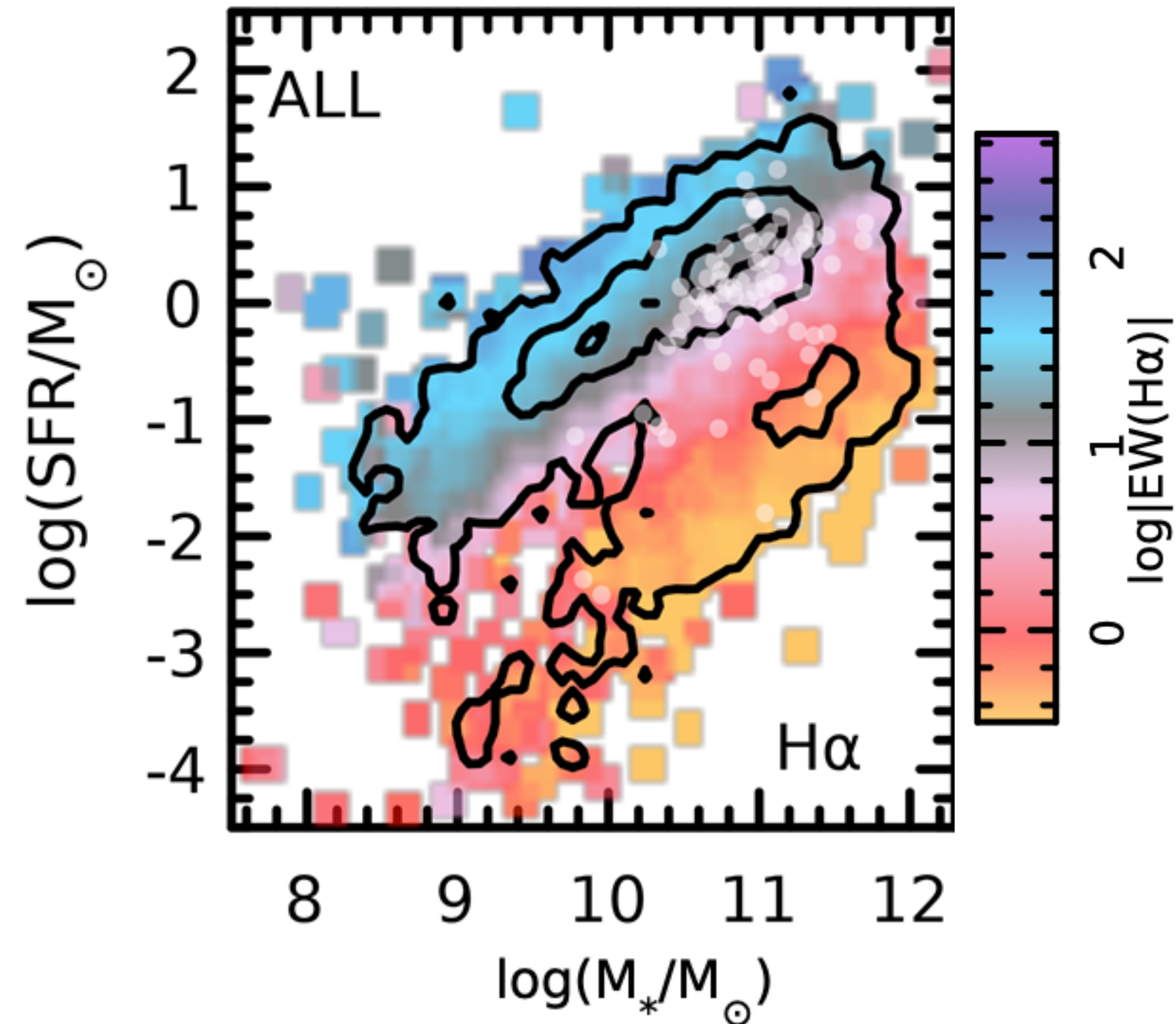
Outline

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- Methods and results
- Summary

Background

Star formation and galaxy quenching

- Star formation rate(SFR): the rate at which stars are formed in given regions, measured in units of solar masses per year
- Galaxies present a clear bimodality regarding their SFR
- Galaxy quenching: the process by which star formation ceases in galaxies



Background

Possible processes that quench satellite galaxies

- Tidal forces from the host halo
- Frequent high speed encounters with neighboring galaxies
- Ram pressure from the hot gas in the host halo
- High orbital velocity of the satellite
- ...

Take home message

- Quiescent satellites are relatively less frequent along the minor axis of their central galaxies, both in observation and simulation
- The observed signal results from the ejective nature of black hole feedback in massive halos, which is supported by TNG.

Data sample

Observation sample: SDSS DR 10

- 124,165 satellites and 29,631 galaxy groups and clusters

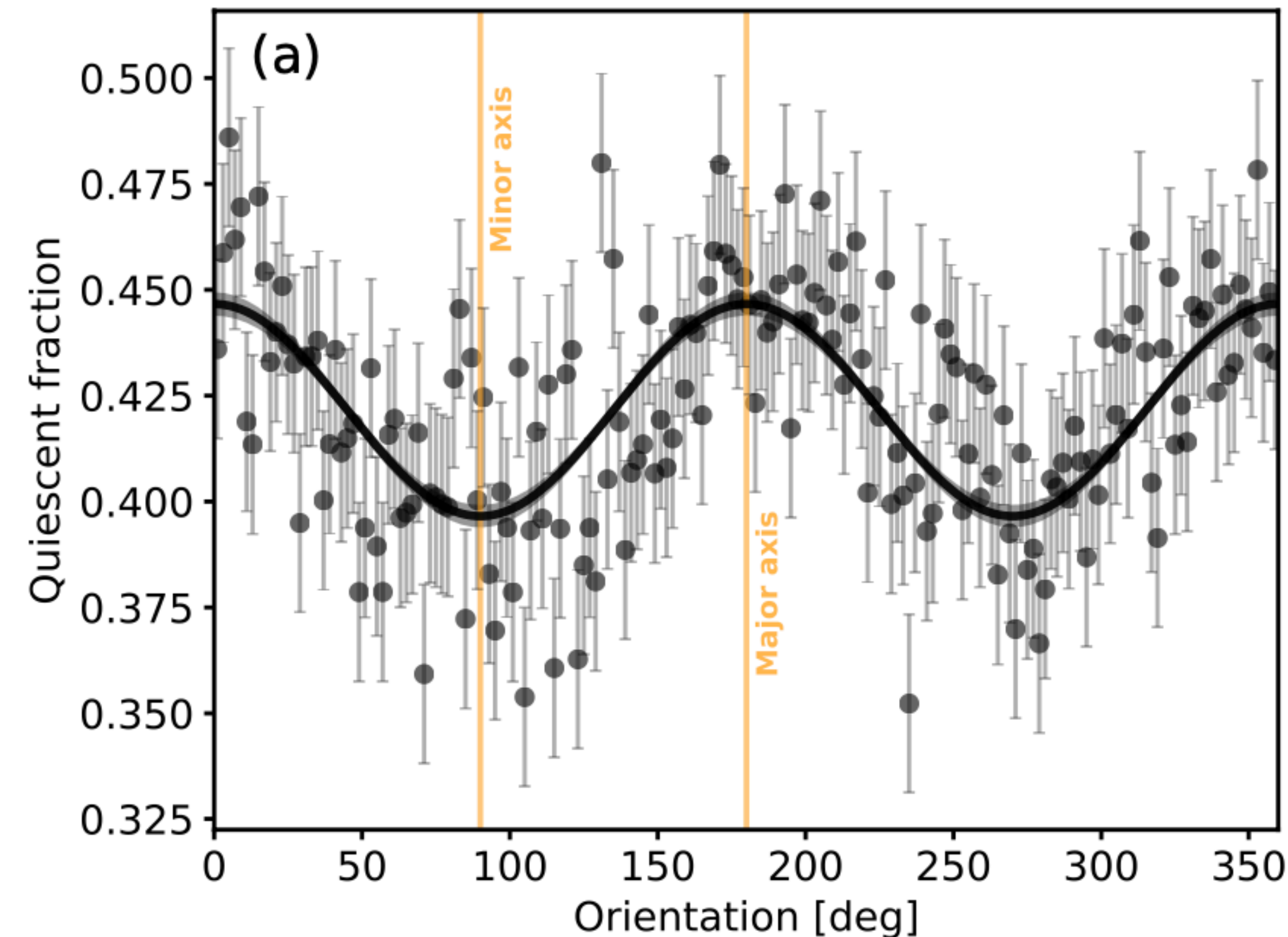
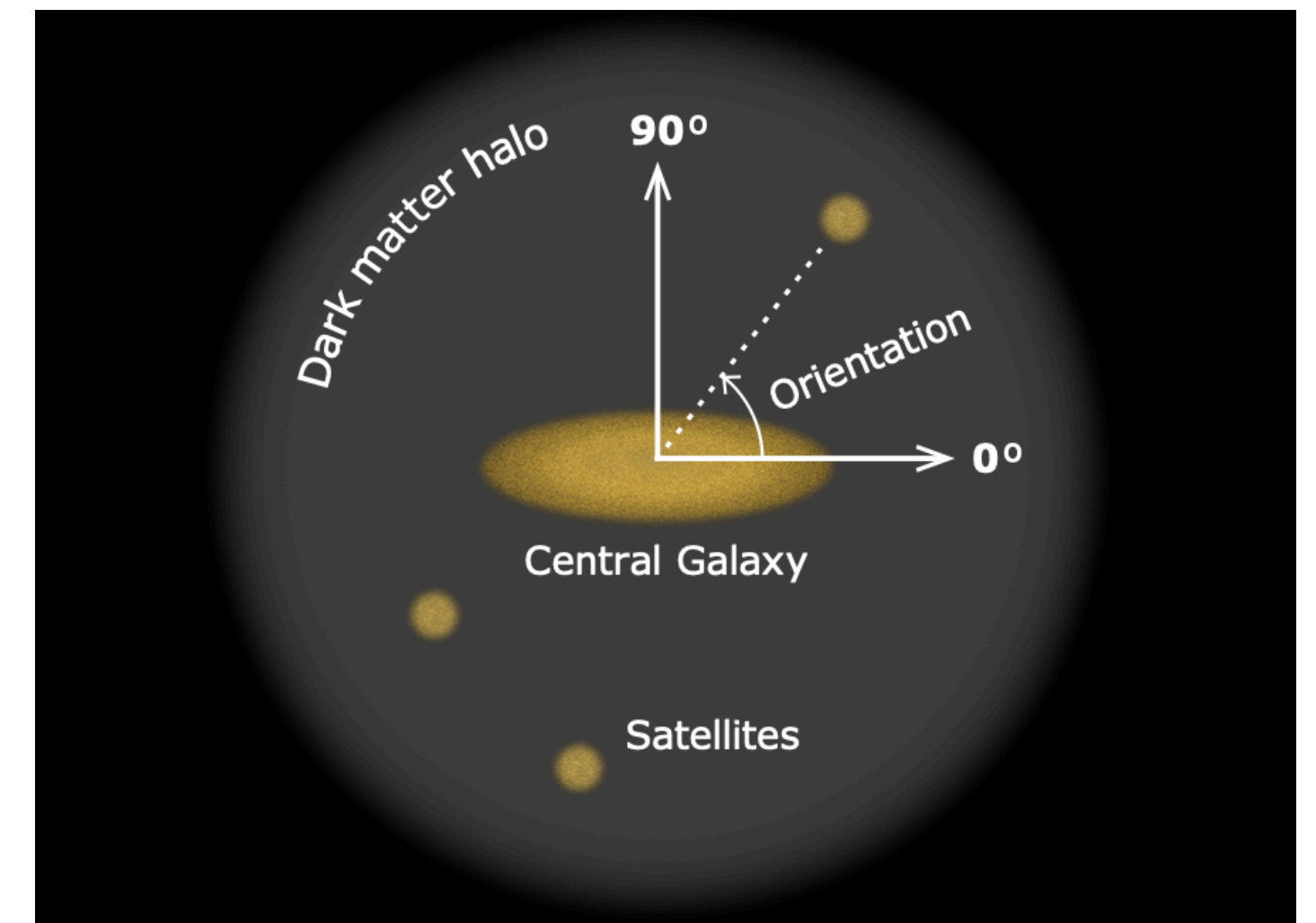
Simulation data: TNG100

- 8,552 satellites and 880 halos
- previous works have shown that the IllustrisTNG galaxy population is in good agreement with SDSS results

Methods and results

Anisotropic distribution of quiescent satellite galaxies in SDSS

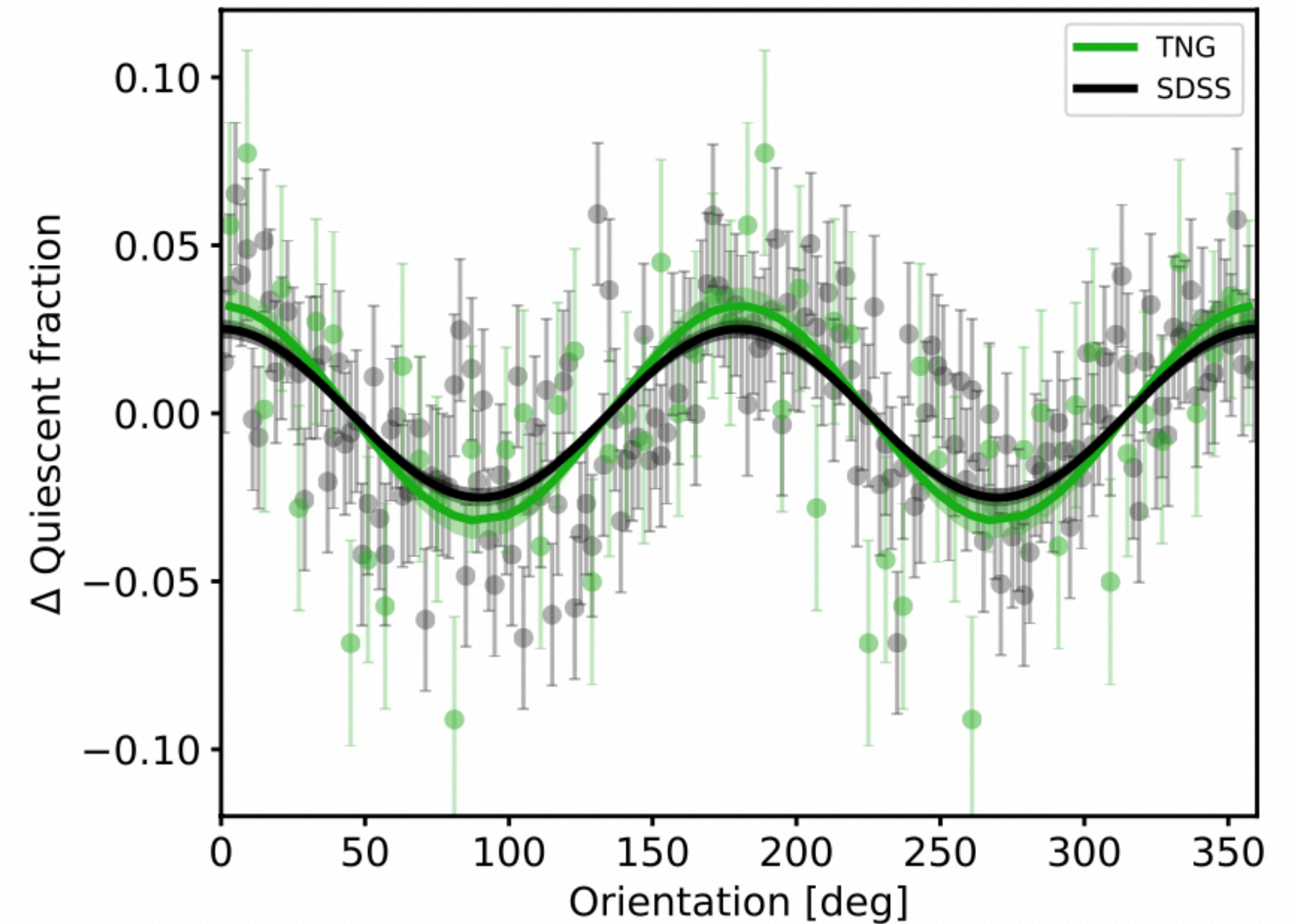
- The position angle of the central's major axis is from the SDSS imaging pipeline
- It is evident that the fraction of quiescent satellites is maximal along the major axis of the central galaxy and minimal along the minor axis
- The observed signal is fitted by a cosine function with an amplitude of 0.025 ± 0.001 on top of a 0.421 ± 0.001 average quiescent fraction.



Methods and results

Anisotropic distribution of quiescent satellite galaxies in TNG

- The signal in TNG can be modeled by a cosine function with an amplitude of 0.032 ± 0.004
- The average quiescent fraction of both datasets is subtracted in the figure.



Methods and results

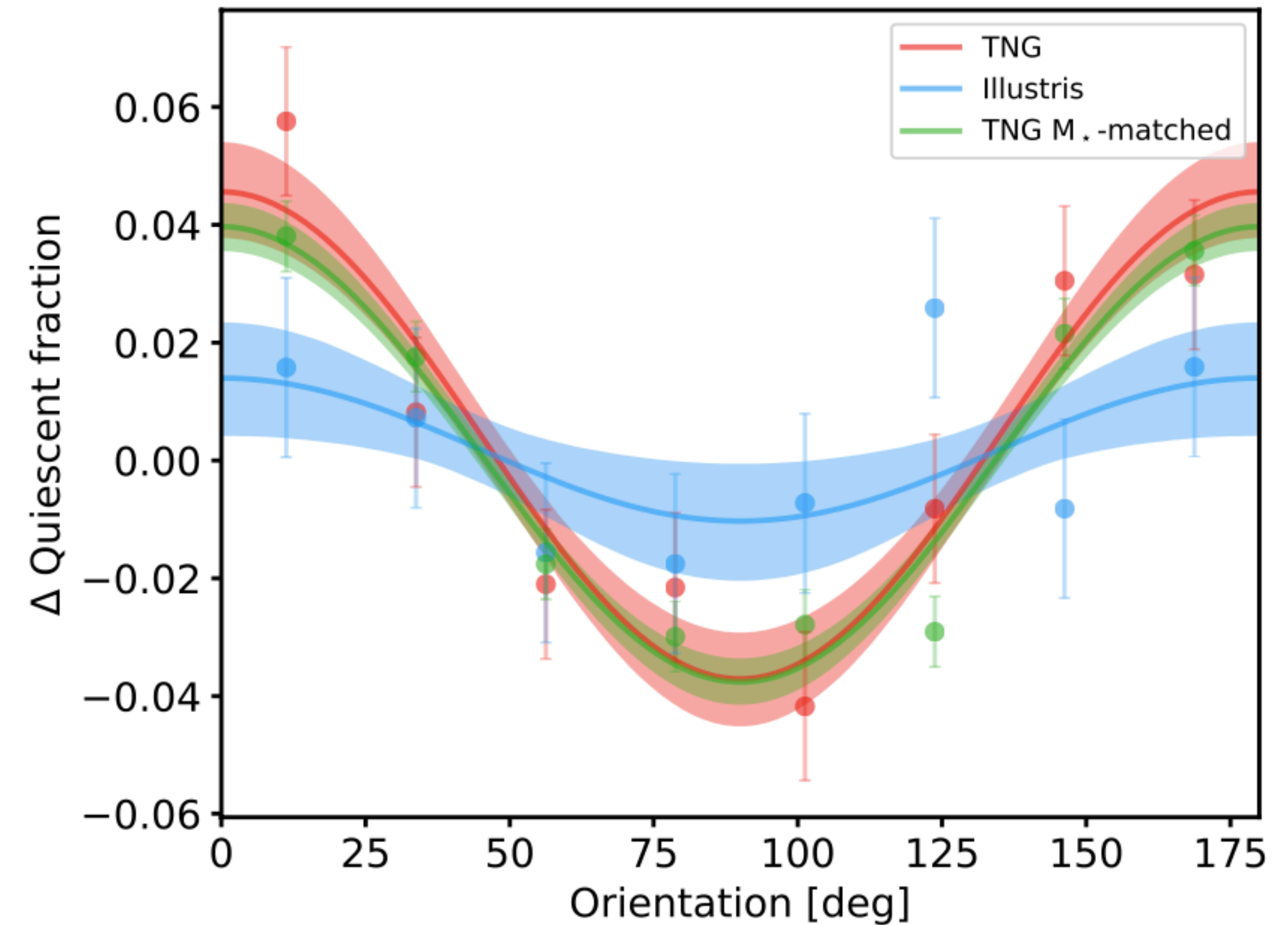
Possible origin of the anisotropic distribution

- the manifestation of a large-scale structure phenomenon, i.e. satellites have quenched before falling into the halos they reside currently
- The result of a (host) halo phenomenon, i.e. the interaction between satellite galaxies and their host halo

Methods and results

Exclude the effects of large-scale structure

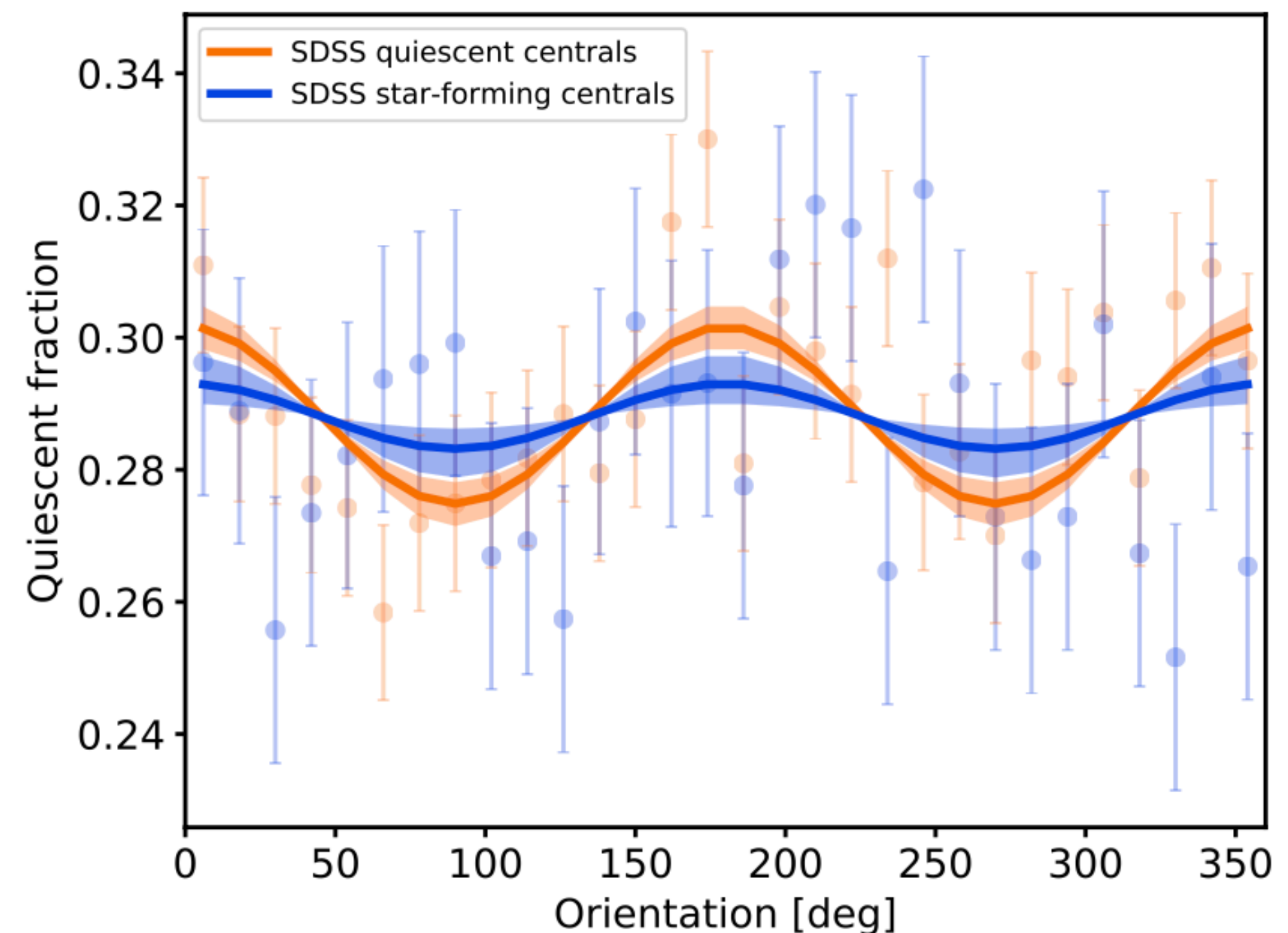
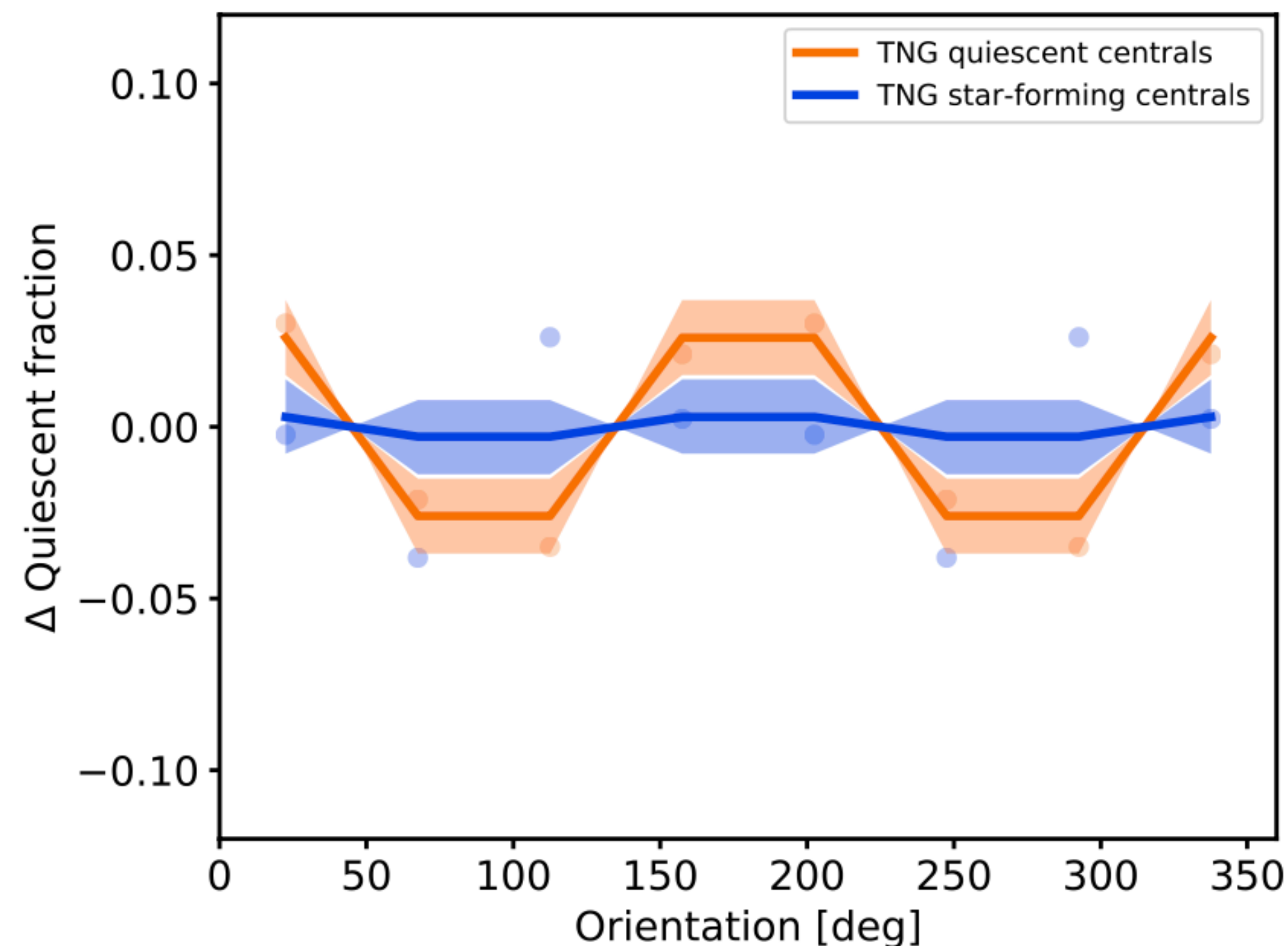
- TNG includes an improved treatment of active galactic nuclei feedback, in particular in the low accretion rate regime, while Illustris doesn't
- For the first Illustris simulation, results are actually consistent with no modulation at a $\sim 2\sigma$ level (0.013 ± 0.07)



Methods and results

Dependence of the signal on blackhole feedback in TNG and SDSS

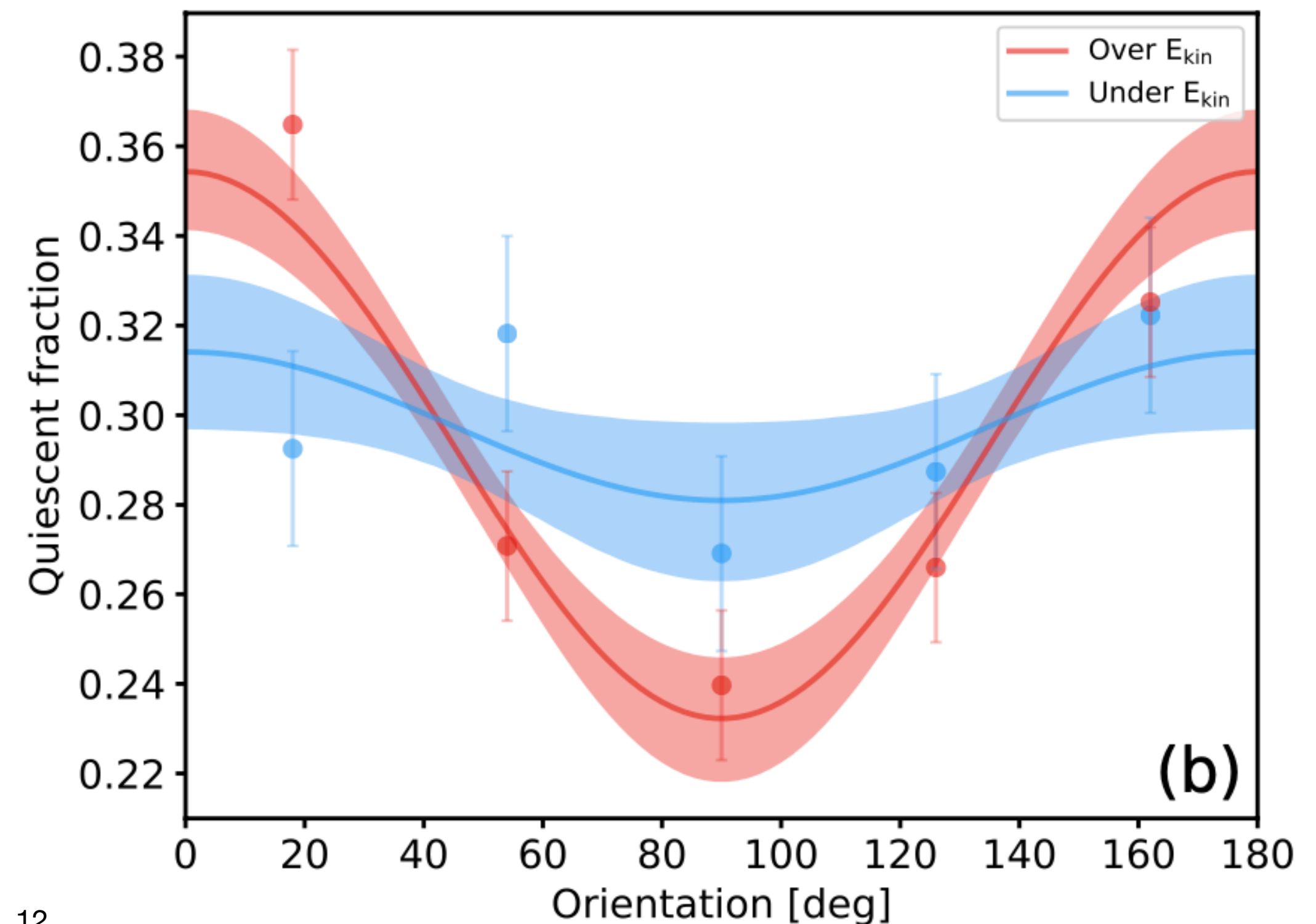
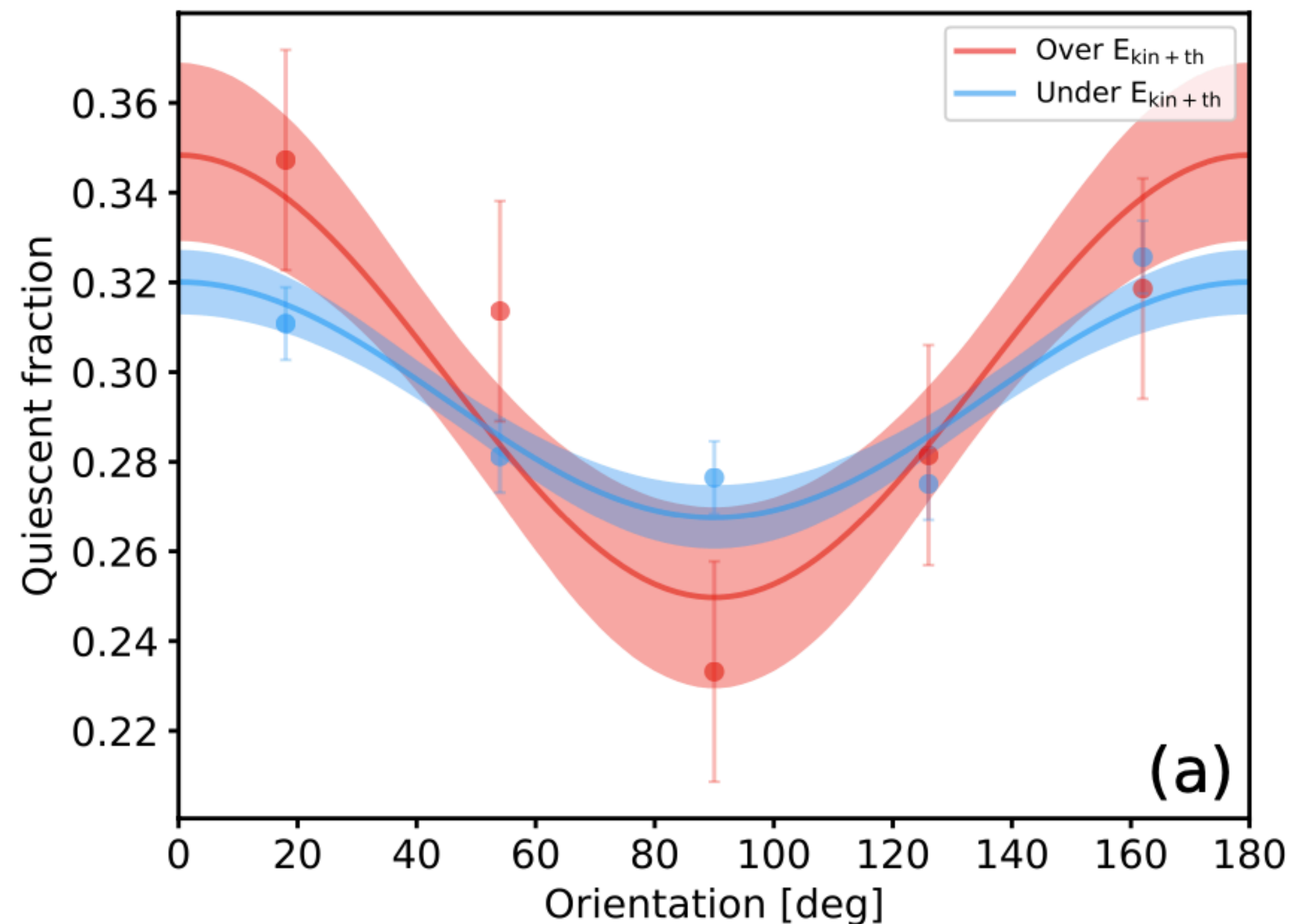
- Quiescentness in IllustrisTNG is a strong indication of an effective black hole feedback
- The modulation in the signal appears to be stronger for quiescent centrals than for star-forming ones in both TNG and SDSS



Methods and results

Dependence of the signal on blackhole feedback in TNG

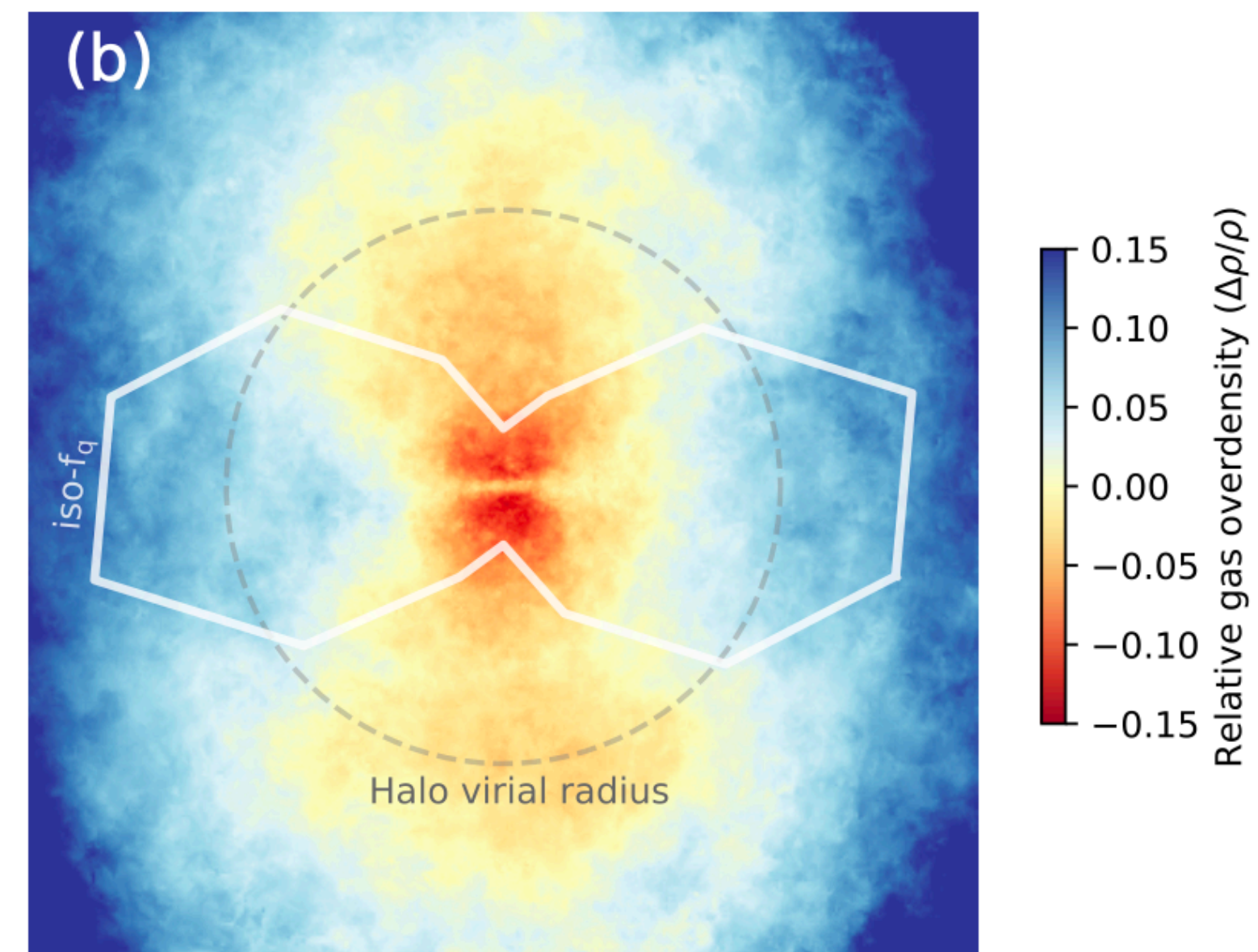
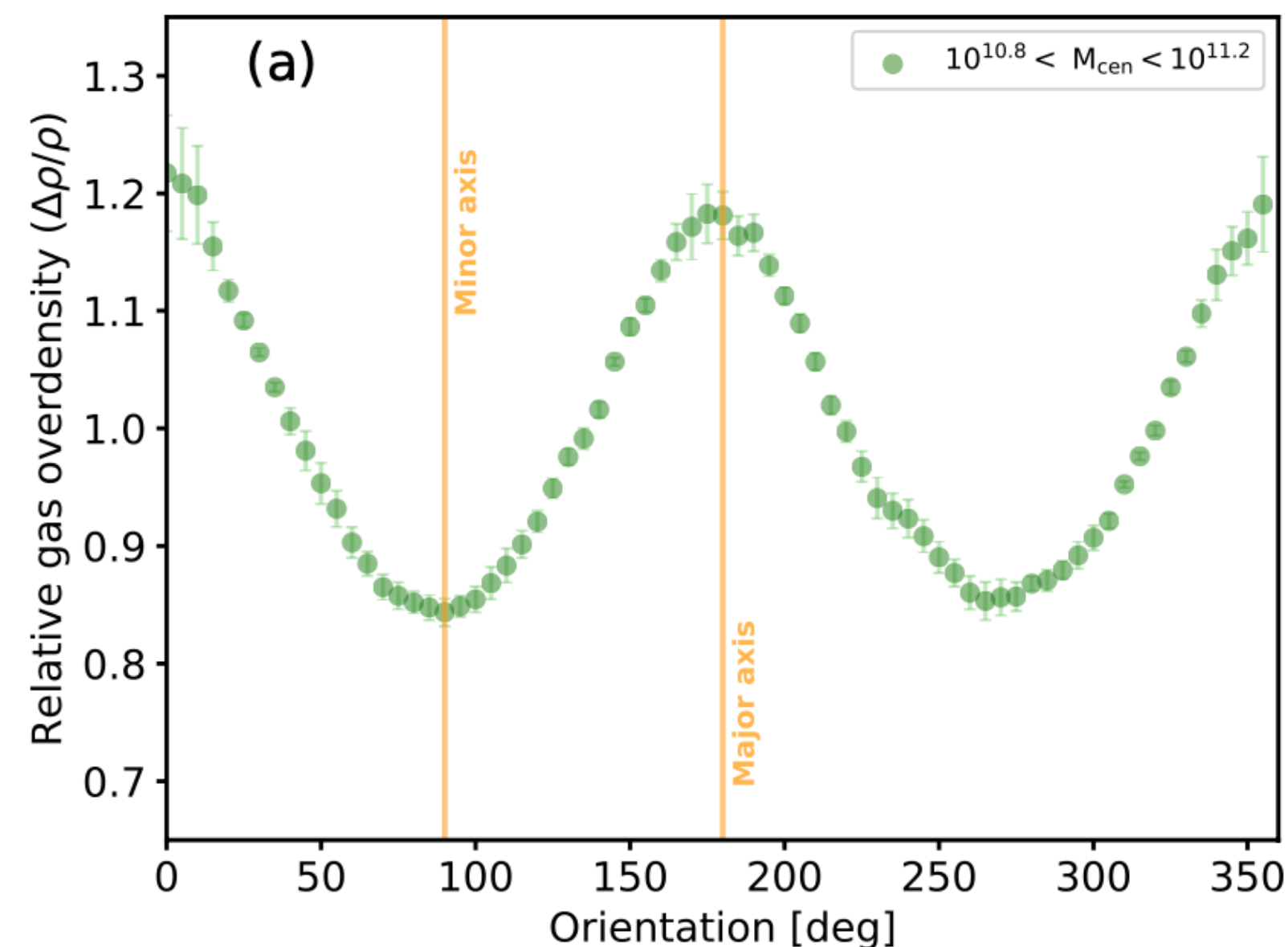
- Halos are divided into two groups: above or below the average of the energy injected by the blackhole in central galaxies
- The anisotropic signal depends on the energy emitted by the super-massive black holes



Methods and results

Anisotropic CGM density in IllustrisTNG

- The energy and mass radiated by AGN activity are expected to escape the central galaxy preferentially along the minor axis
- AGN feedback carves low-density bubbles in the CGM surrounding the central galaxy, and drives the signal



Summary

- Quiescent satellites are relatively less frequent along the minor axis of their central galaxies.
- It is the interaction between satellites and the CGM, in turn modulated by AGN activity, that drives the observed signal
- It may be the process when satellite galaxies pass through these low-density regions, such as ram pressure stripping become less efficient, increase the relative abundance of star-forming galaxies along the direction of the minor axis

Question

- Why the energy and mass radiated by AGN activity are expected to escape the central galaxy preferentially along the minor axis?
- How are the error bars estimated in those figures?
- The anisotropic signal may be weakened by the satellites not quenched in current halo?

