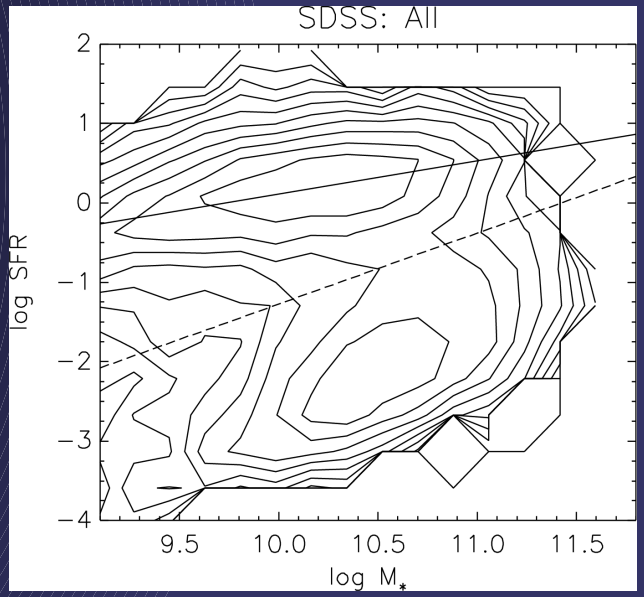
Quenching as a Function of Environment and Mass

Joanna Woo

Avishai Dekel, Sandy Faber, David Koo, Kai Noeske, and other members of the AEGIS team

Introduction



- The SFR Sequence (slope and zero point) does not depend on environment
- The fraction of quenched galaxies does depend on environment
- How does quenching depend on environment?
- Two measures of environment: galaxy number density and halo mass
- Here we explore the relations between environment and halo mass and how they relate to the quenching of galaxies from 0<z<1

Data

- SDSS:
- SFR: derived from GALEX UV (Salim 09)
- M_*: derived from SED fits (Kauffmann 03)
- Env. density $\log(1+\delta_3)$: 3rd nearest neighbour (Cooper 07)
- M_h: abundance matching (Yang 04; group catalog)
- Centrals, satellites = brightest group member, not brightest

- AEGIS:
- SFR: IR+UV, Hβ, OII, GALEX UV
- M_*: from K-band luminosity (Bundy 06)
- Env: $\log(1+\delta_3)$: 3rd nearest neighbour (Cooper 05)
- M_h: abundance matching (this work) using Gerke (05) group catalog
- Centrals, satellites = brightest group member, not brightest

δ_3 and M_h

- Density measures based on the distance to the Nth nearest neighbour are intrinsically bimodal
  - If your galaxy is in a halo with less than N members, the Nth neighbour is in another halo
    - δ_N will be small
  - If your galaxy is in a halo with more than N members, the Nth neighbour will lie in the same halo
    - δ_N will be about 200 above the mean density (prediction of non-linear spherical collapse of DM halo in ΛCDM; number density roughly follows mass density)

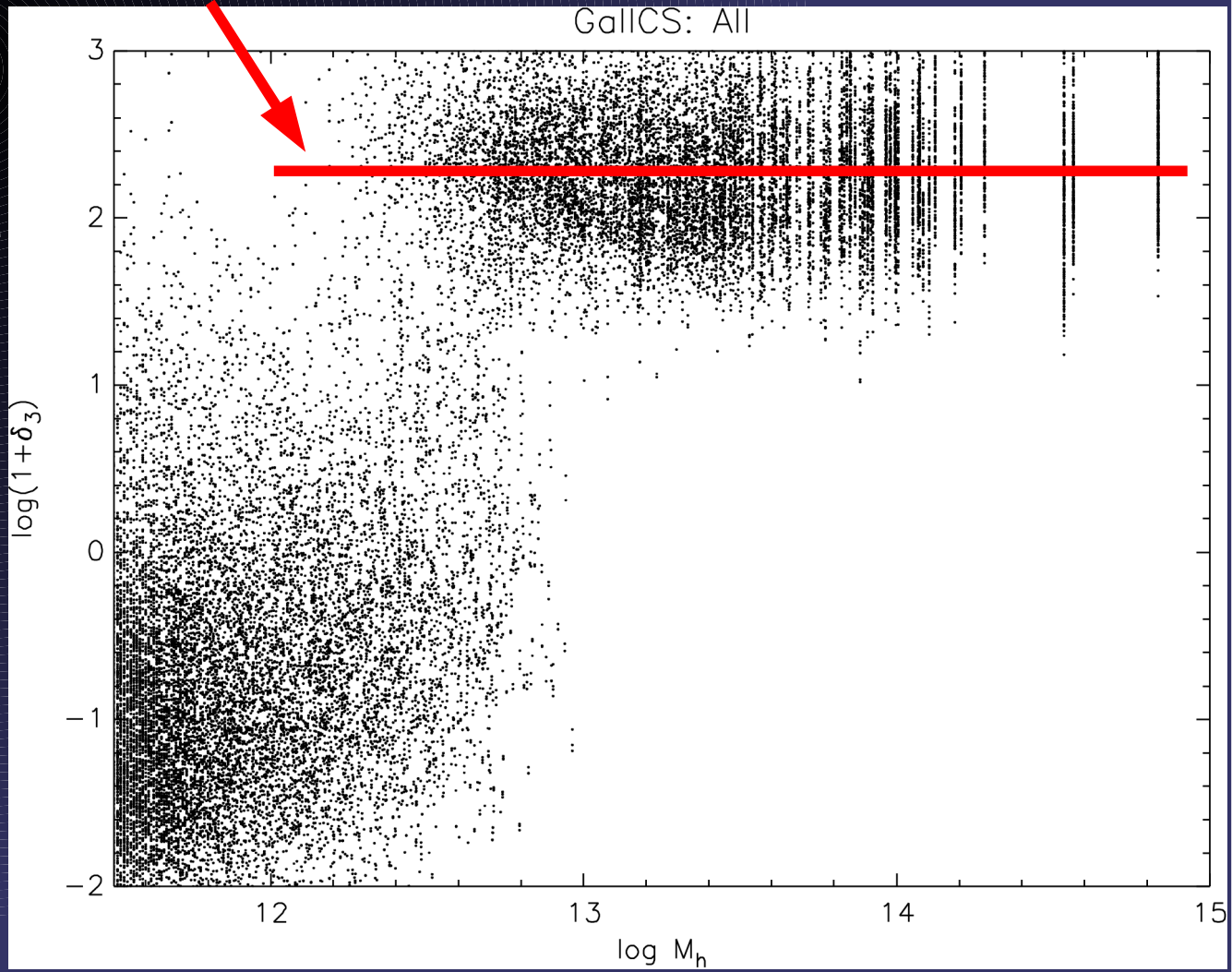
δ_3 and M_h

~200 above the median

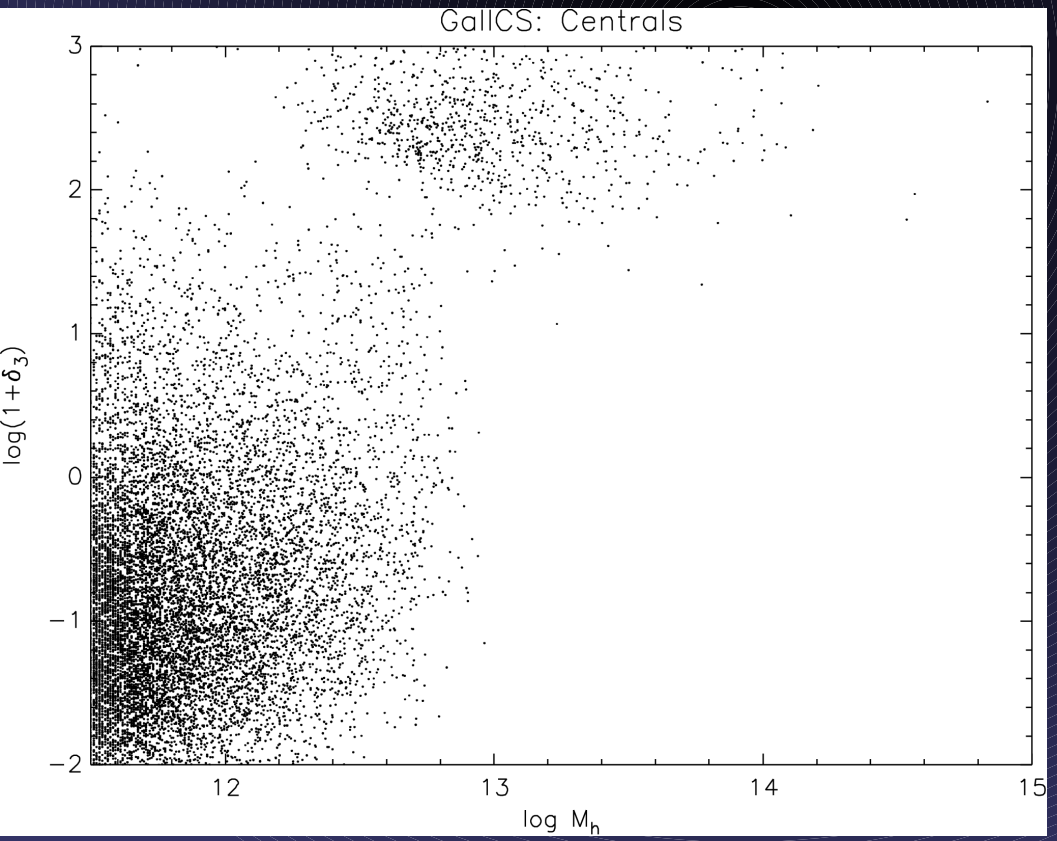
GalICS SAM (Hatton et al 2003)

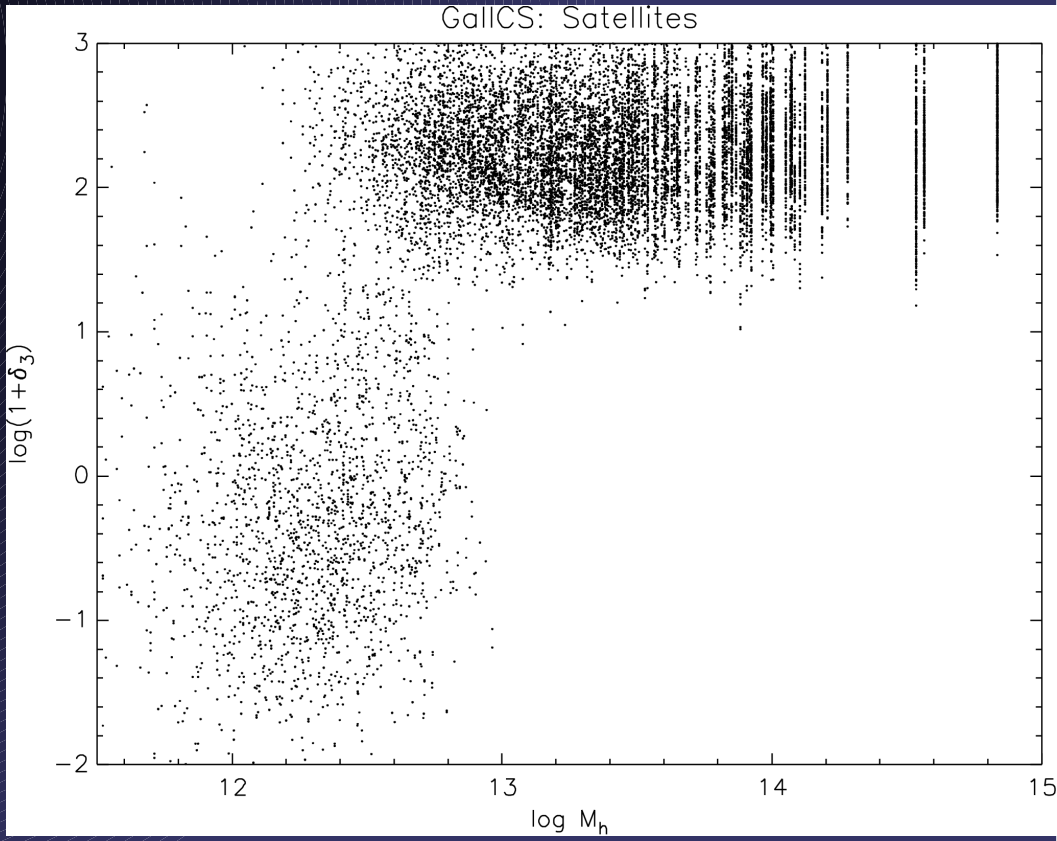
log(1+δ_3) calculation: Elad Zinger
- exact calculation, 3D distance to nearest neighbour

Two populations:
- galaxies in halos with < 4 members
- galaxies in halos with > 4 members



Centrals and Satellites





Satellites mostly occupy areas of higher number density, higher halo mass
Centrals mostly occupy areas of lower number density, lower halo mass

Lesson to be learned: Satellites and centrals must be treated differently in studies of environment

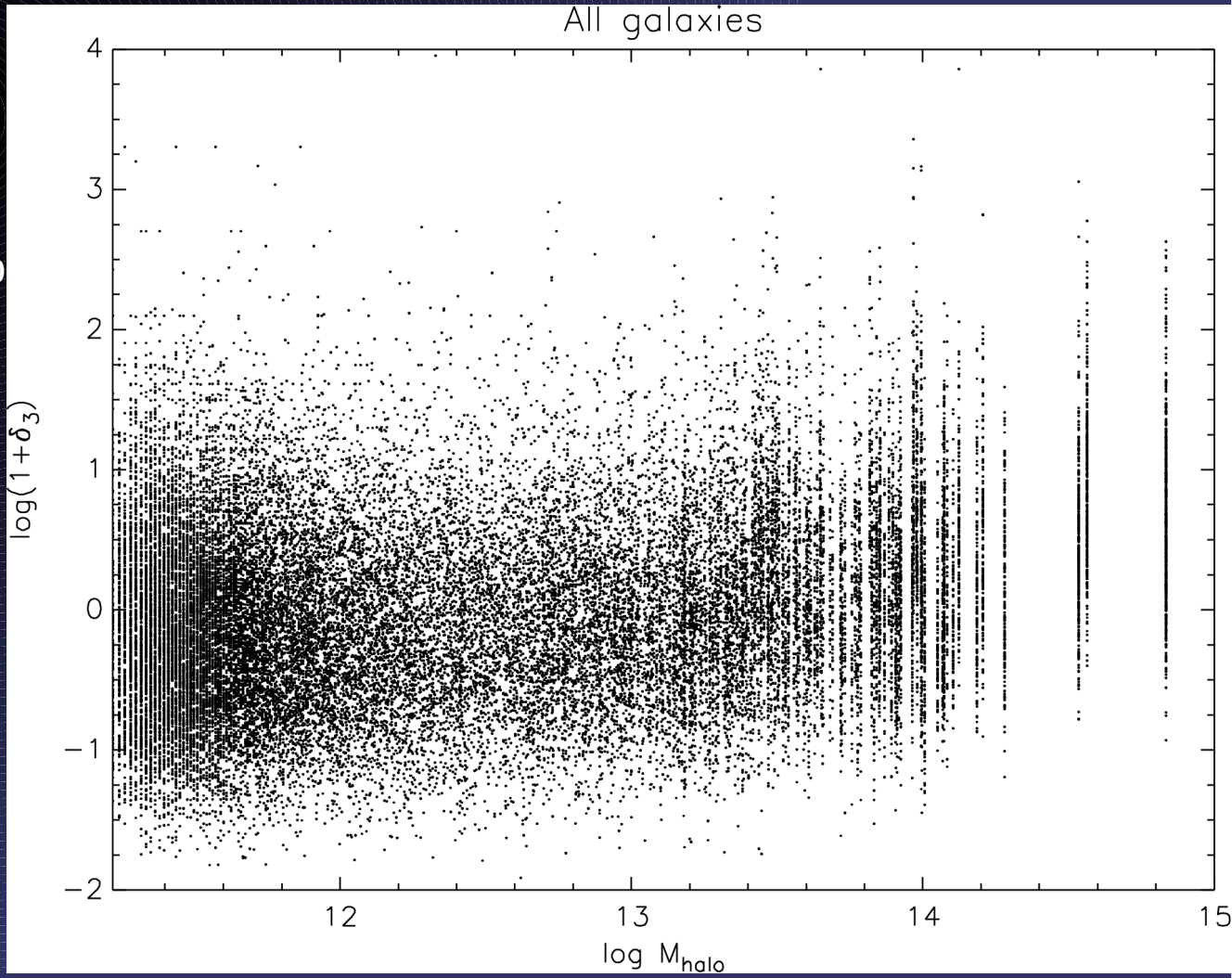
δ_3 and M_h

$\log(1+\delta_3)$ now more like observations:

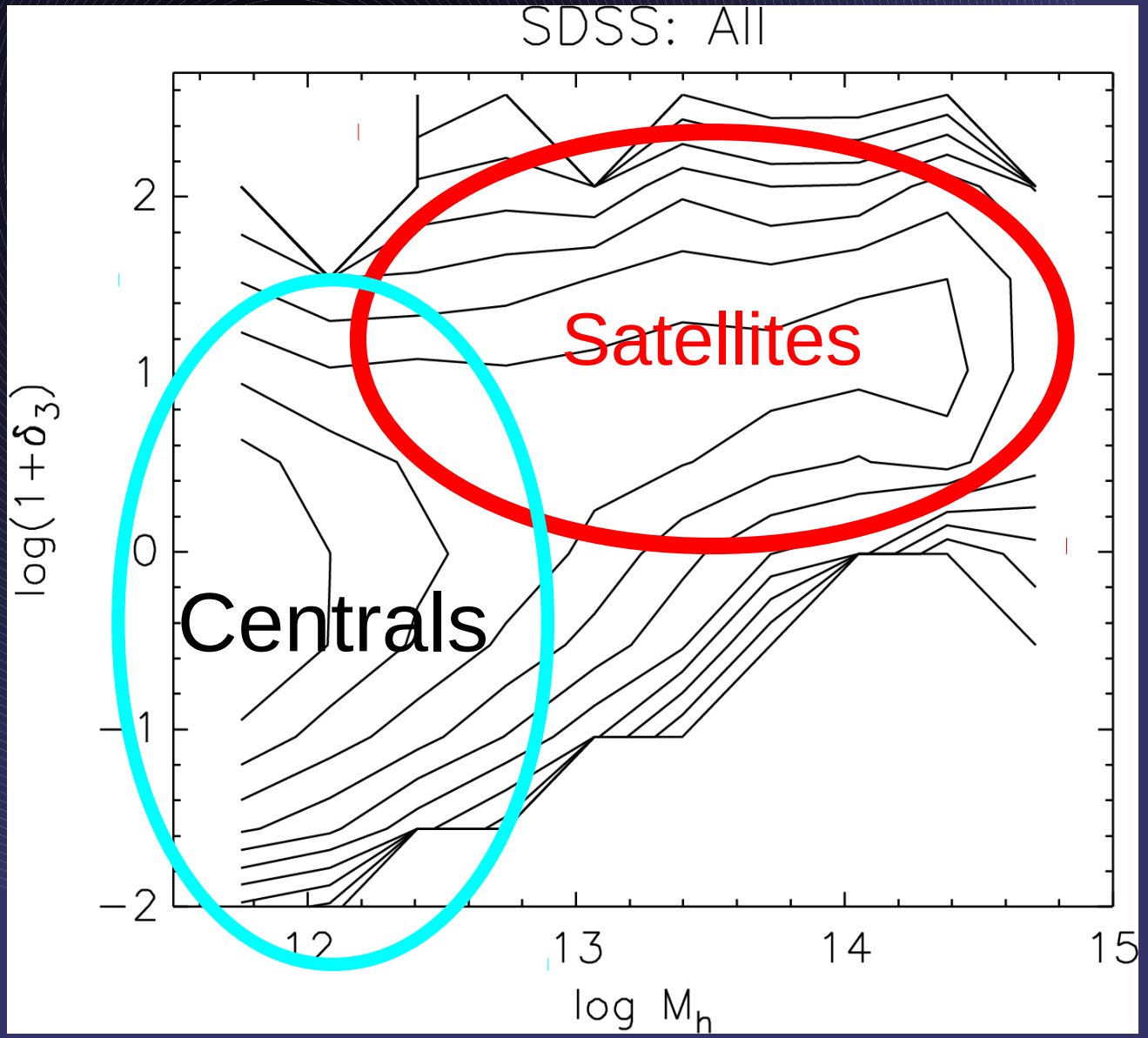
- based on projected distance to 3rd nearest neighbour, with z-window of about 500 km/s

The effect of using projected distances: smears the bimodal distribution

(still to be done: play with the z-window to find an optimal size)

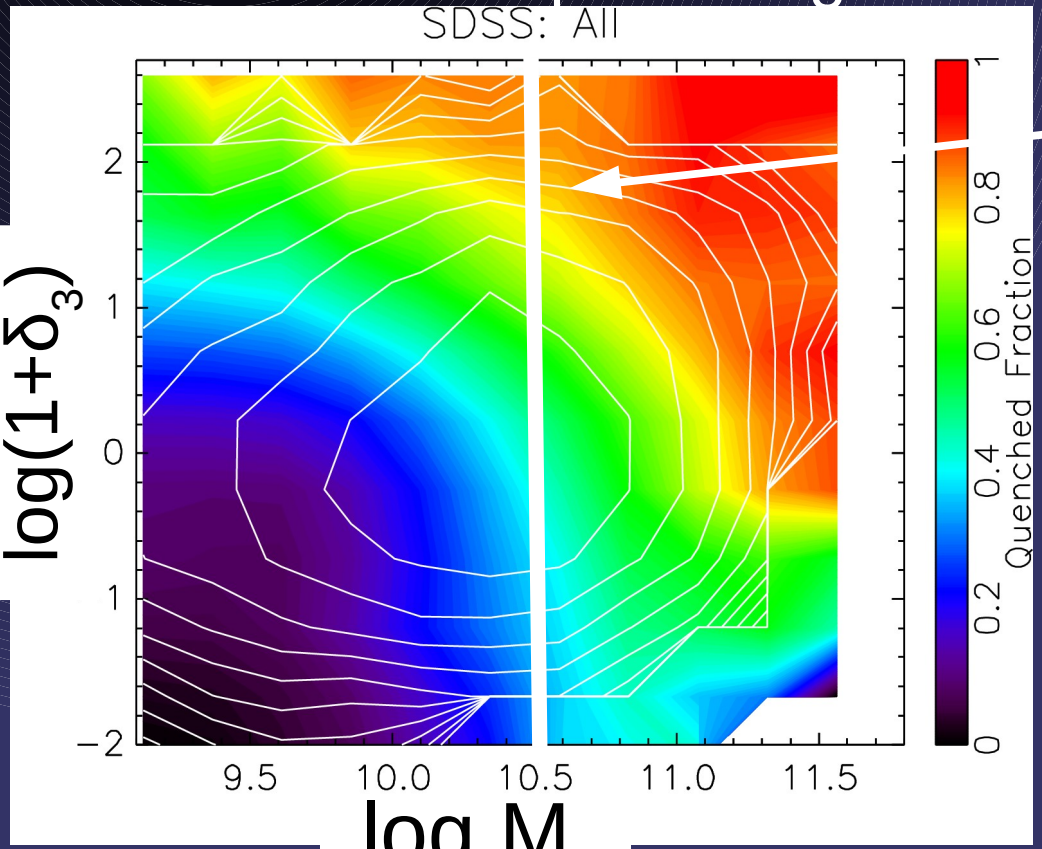


The Real Universe: SDSS



Quenching, Satellites and Halo M_h as a function of δ_3 and M_*: SDSS

- The red fraction of galaxies is known to correlate with both environment density and stellar mass (eg. Kauffmann et al 2004, Cooper et al 2007, Peng et al. 2010)
- Two manifestations of halo quenching?



Approx. where log M_h ~ 12, the scale for virial shock heating

Satellite quenching

SDSS

Quenching of centrals due to virial shock heating in big enough halos

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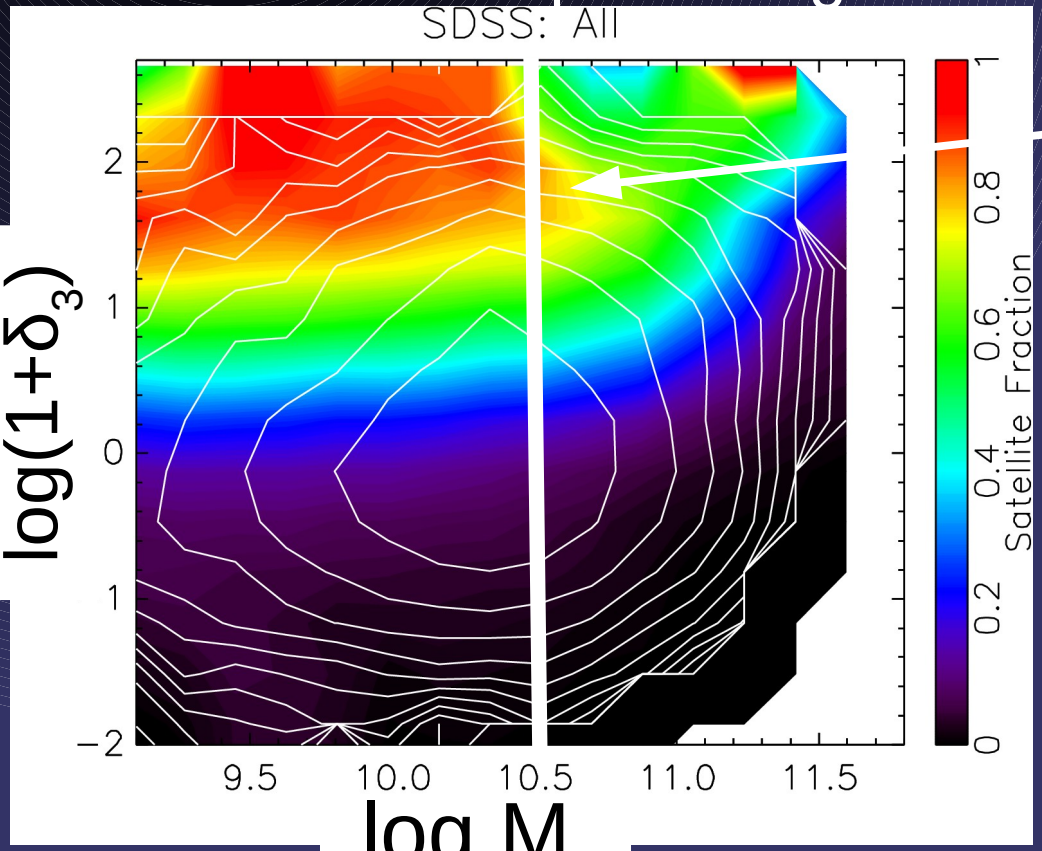

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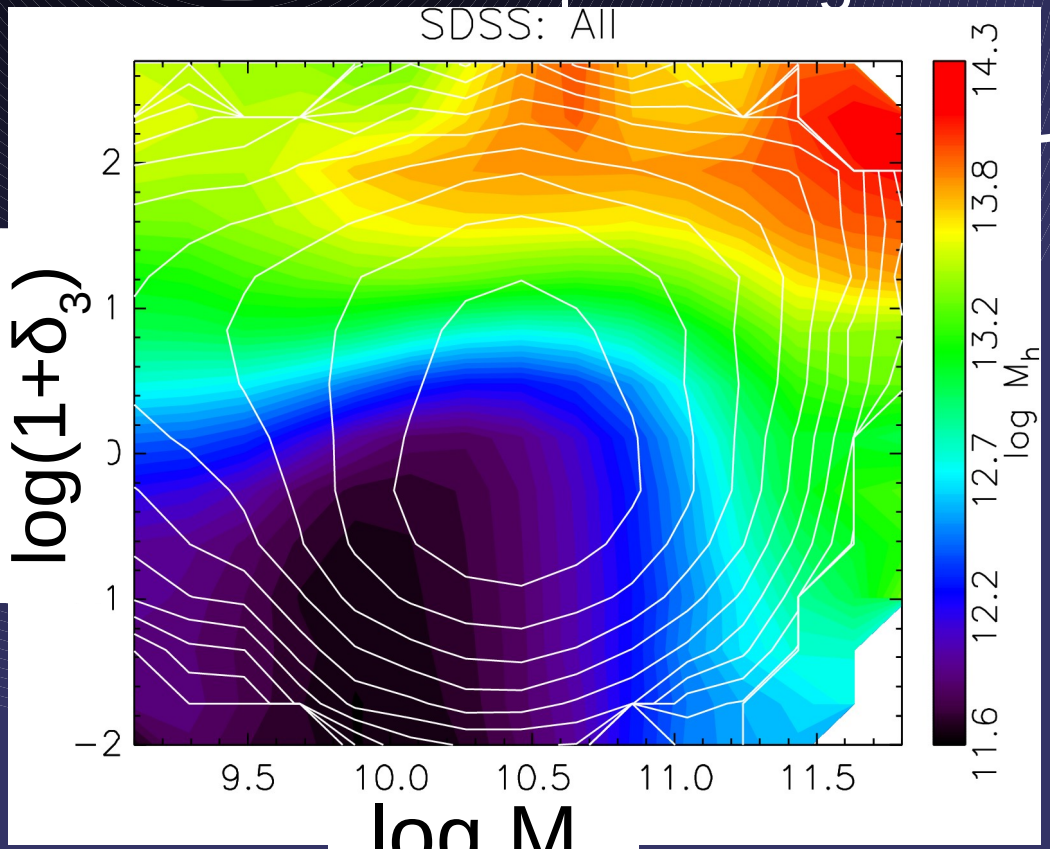

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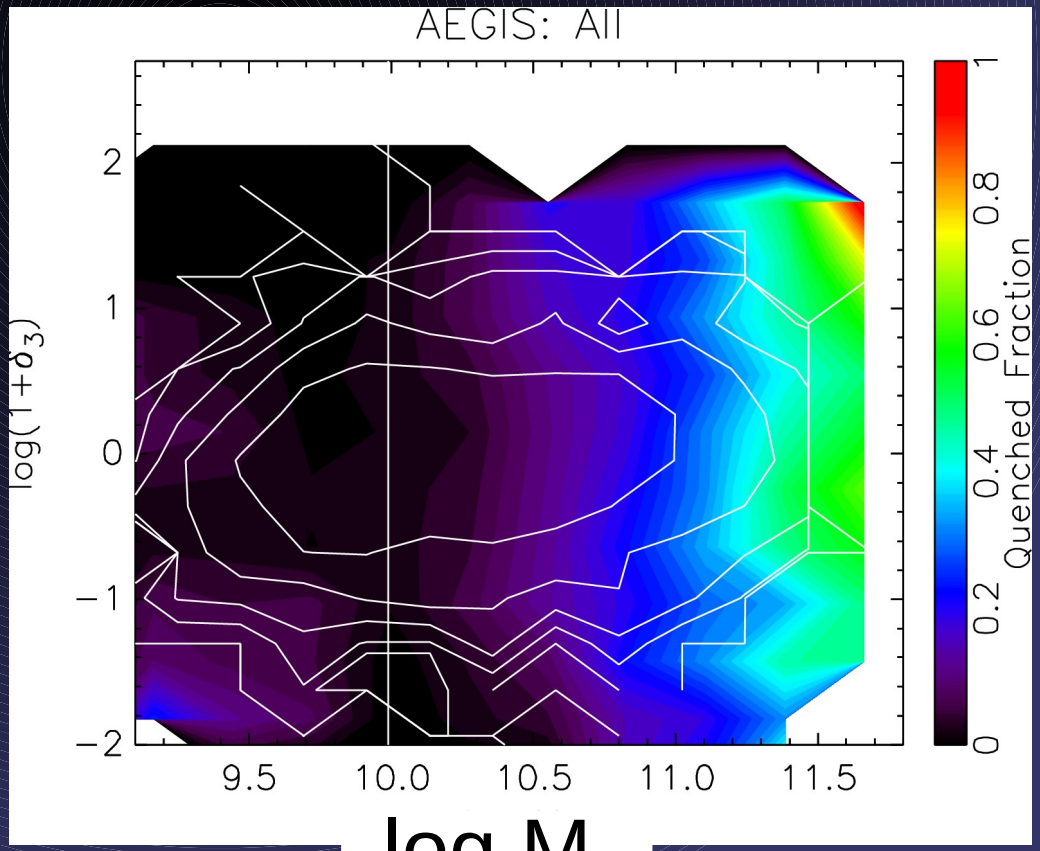
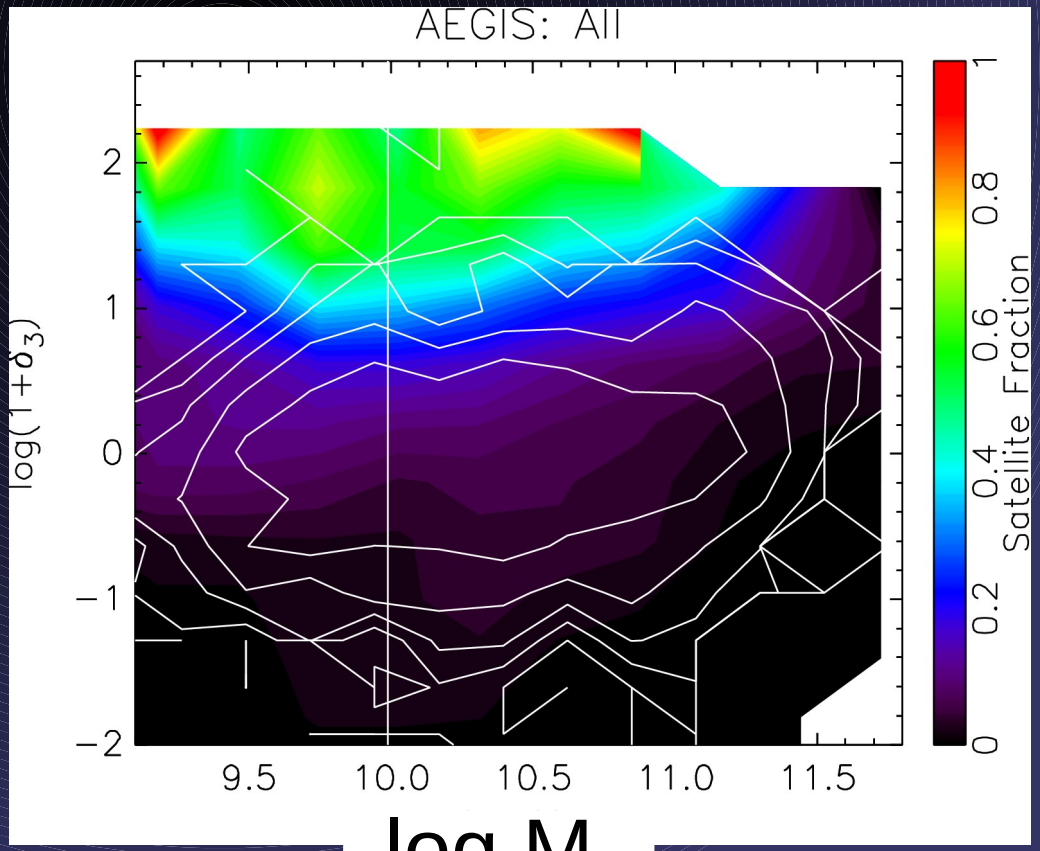
Quenching, Satellites and Halo M_h as a function of δ_3 and M_*: AEGIS



AEGIS (0.7<z<1): we're seeing mostly centrals; the gradient of the quenched fraction is in the M_* direction

Quenching, Satellites and Halo M_h as a function of δ_3 and M_*: AEGIS



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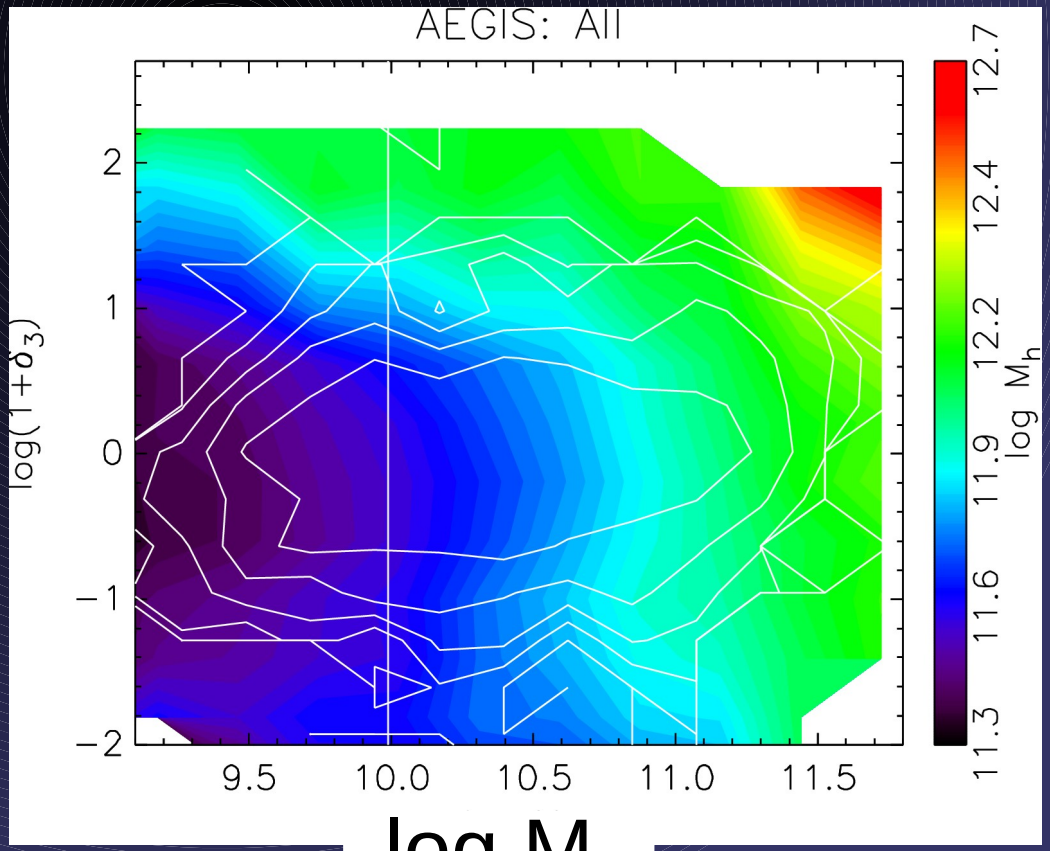

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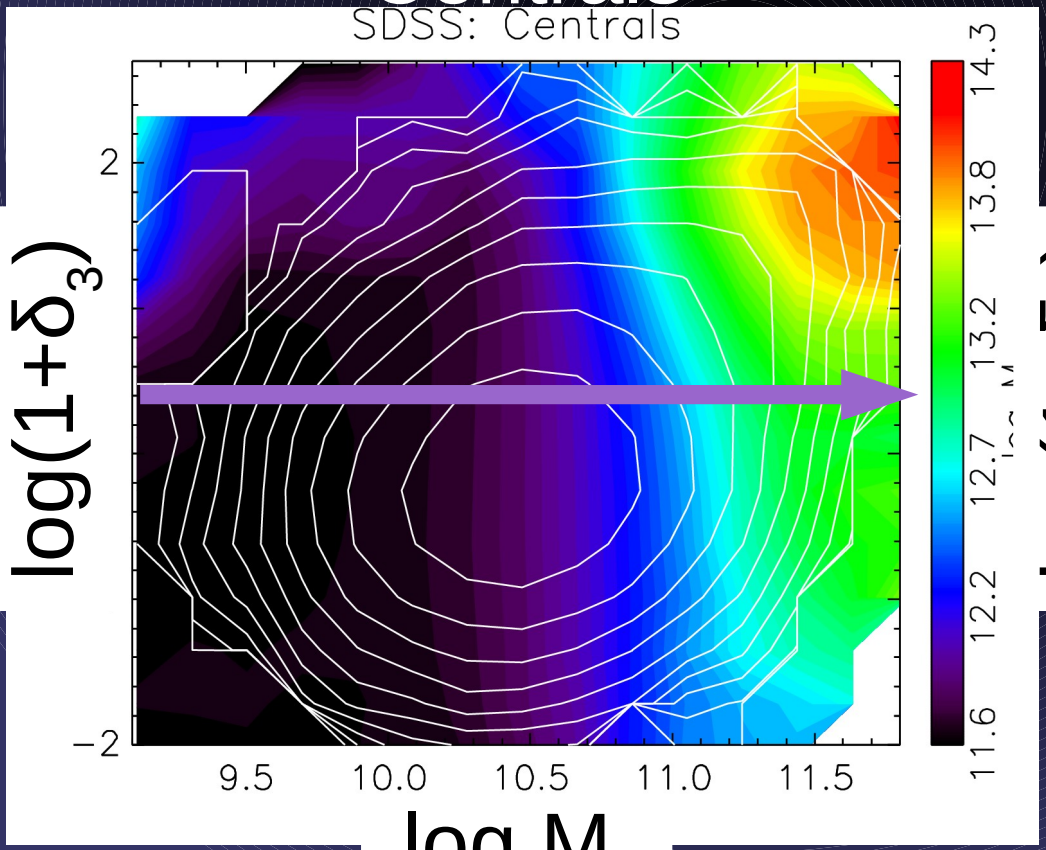
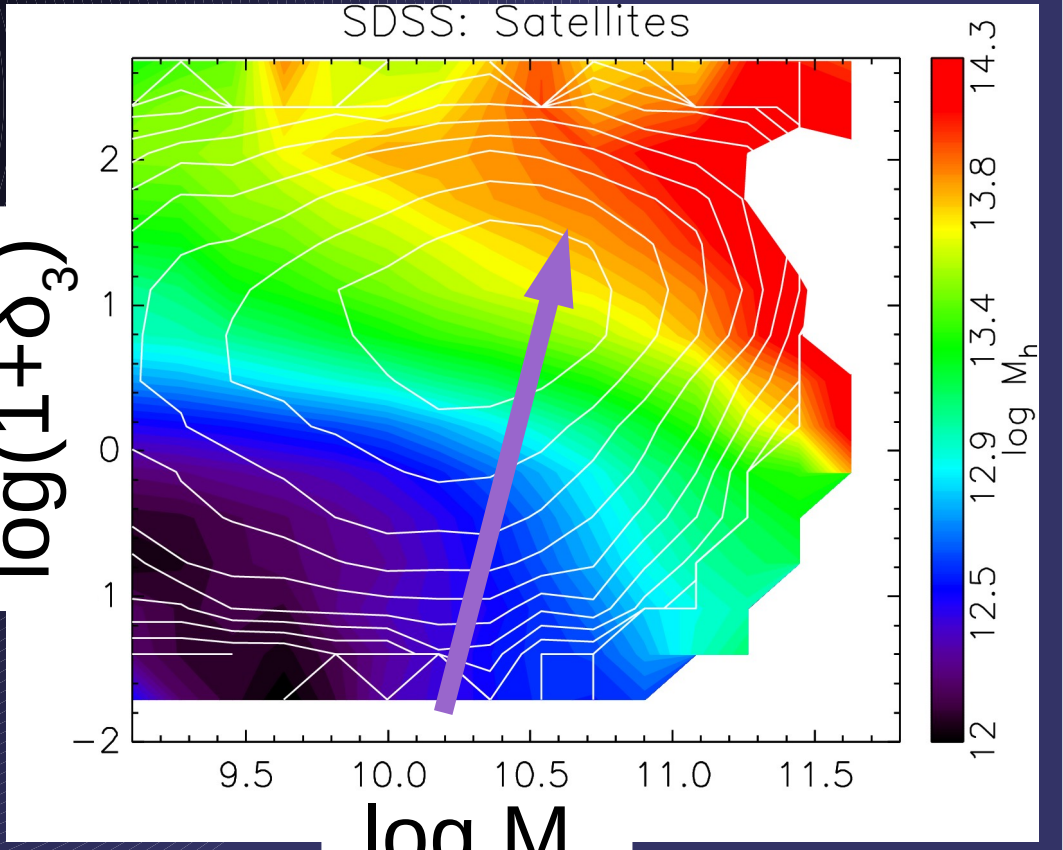
Halo M_h as a function of δ_3 and M_*

Centrals



Gradient of halo mass is mostly in the M_* direction

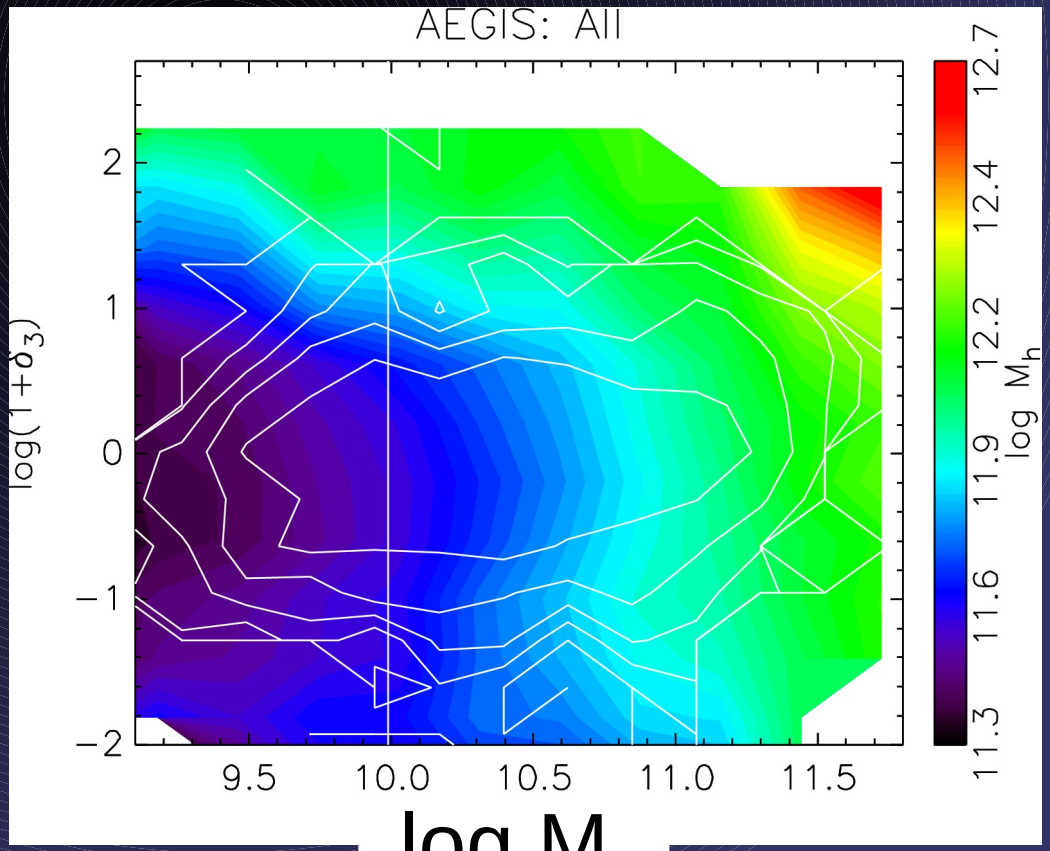
Satellites



Gradient of the halo mass is mostly in the δ_3 direction

SDSS

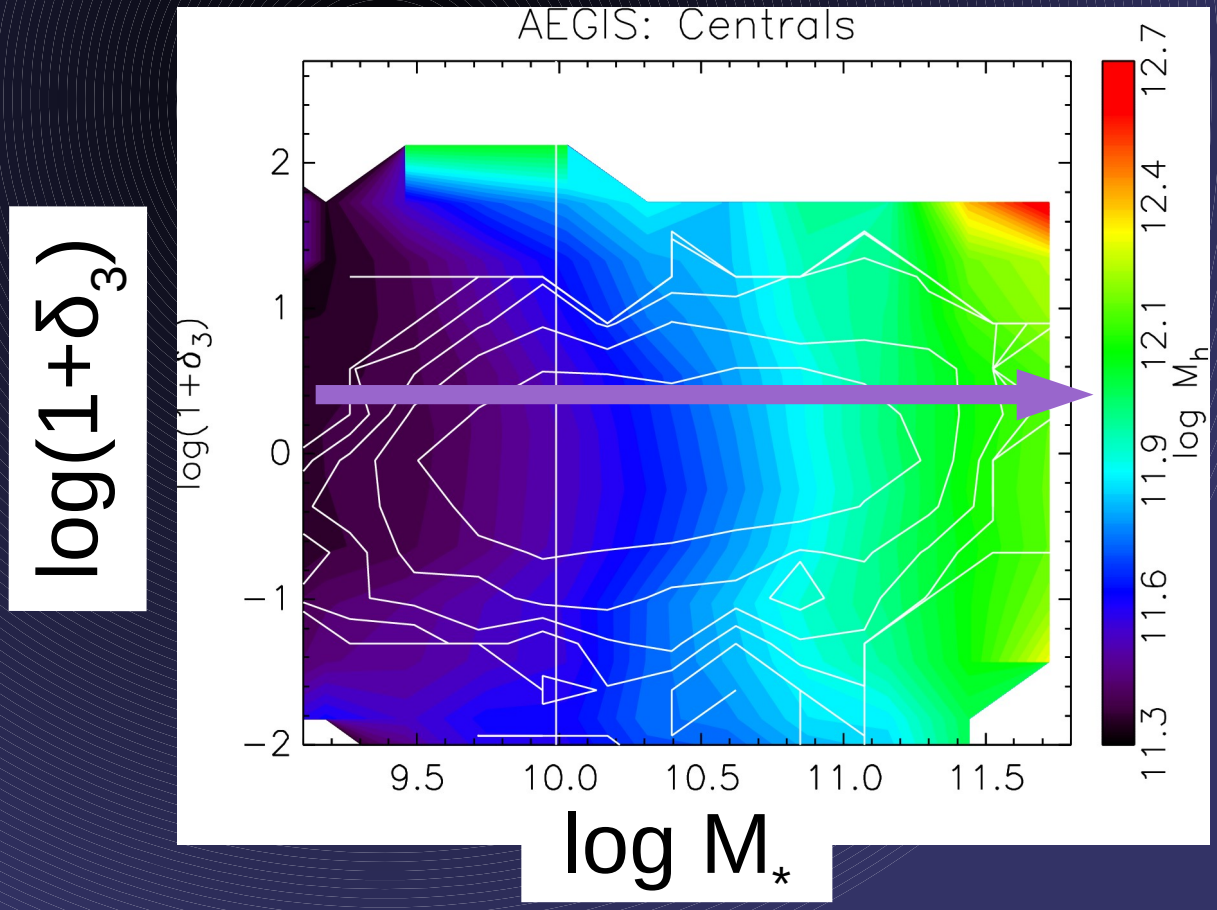
Halo M_h as a function of δ_3 and M_*



All

AEGIS

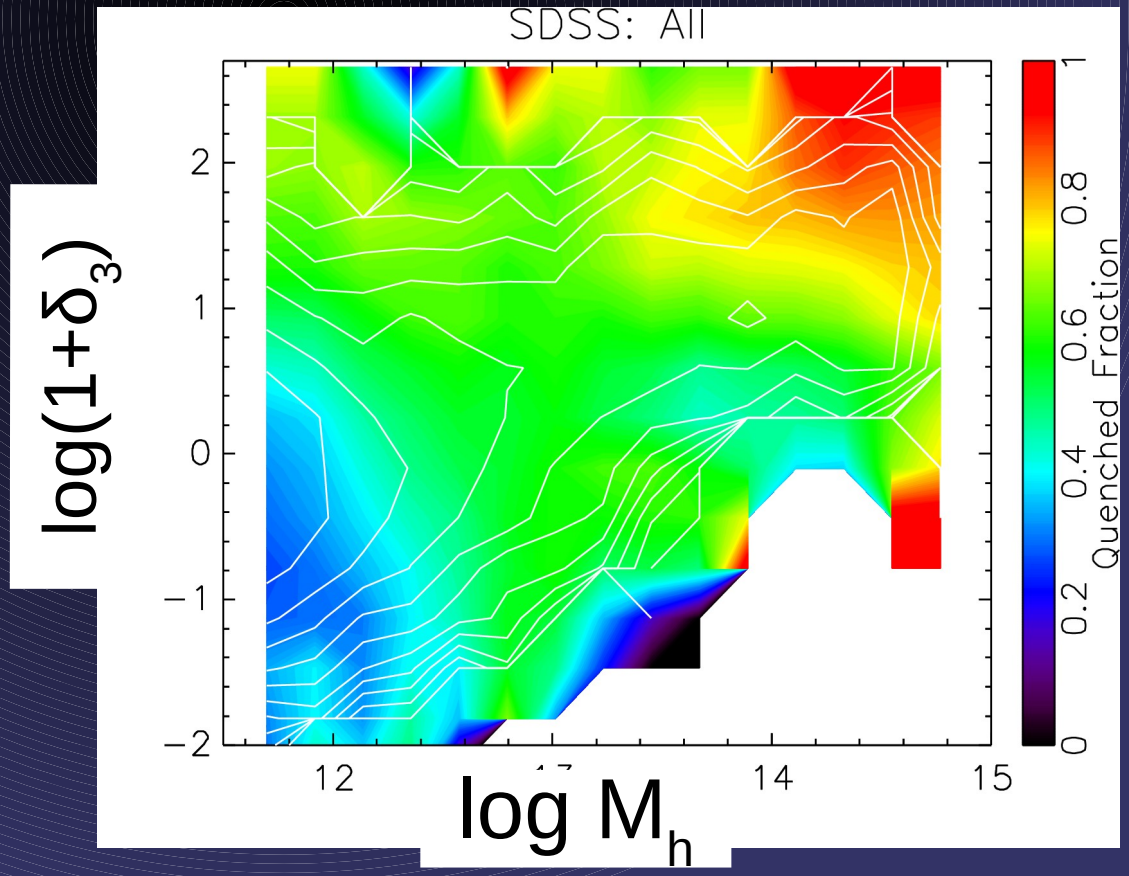
Halo M_h as a function of δ_3 and M_*



Centrals

AEGIS: Gradient of halo mass is in the M_* direction for centrals

Quenching as a function of δ_3 , M_h

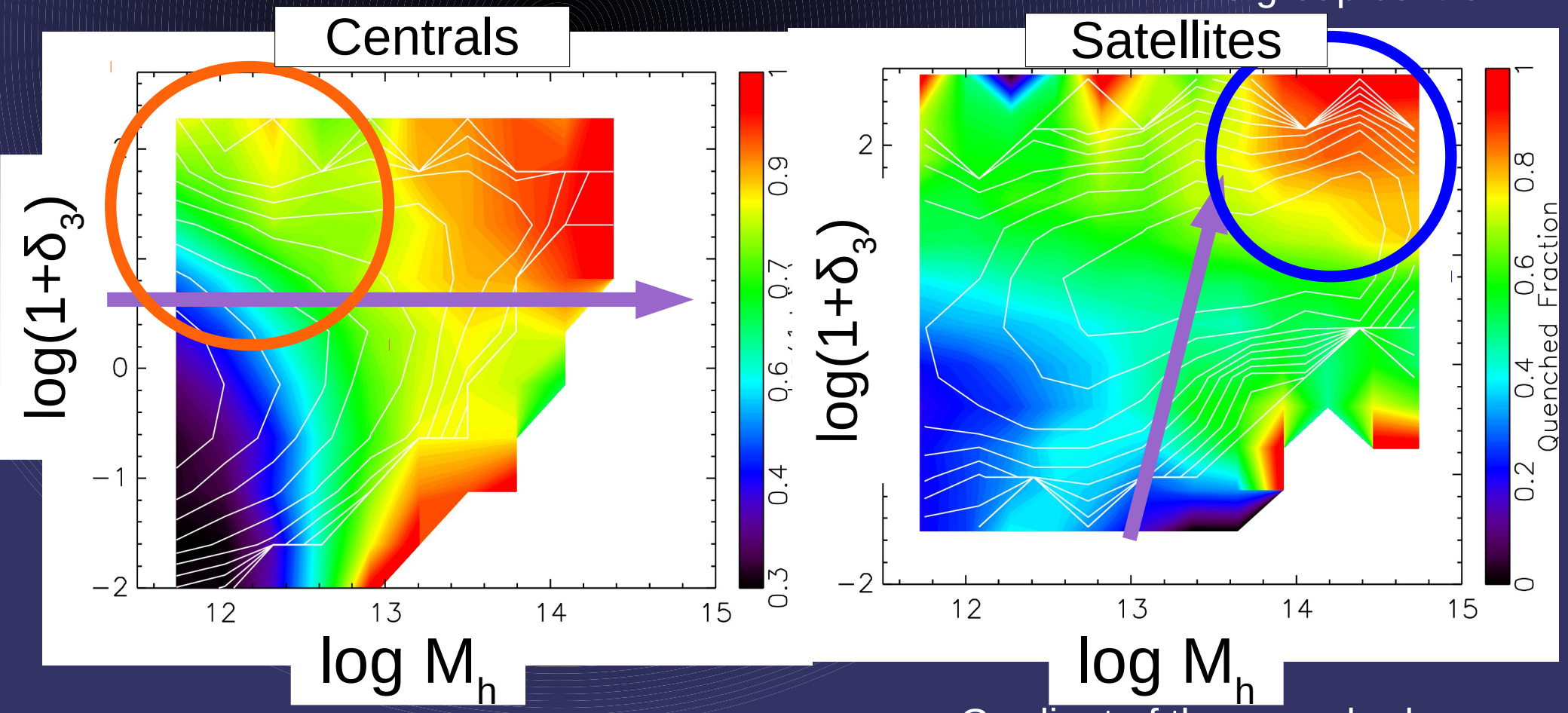


SDSS

Quenching as a function of δ_3 , M_h

Merger induced virial shock?

Satellites closer to the group centre



Gradient of the quenched fraction is mostly in the M_h direction

SDSS

Gradient of the quenched fraction is mostly in the δ_3 direction

Quenching as a function of δ_3 , M_h

Merger induced virial shock?

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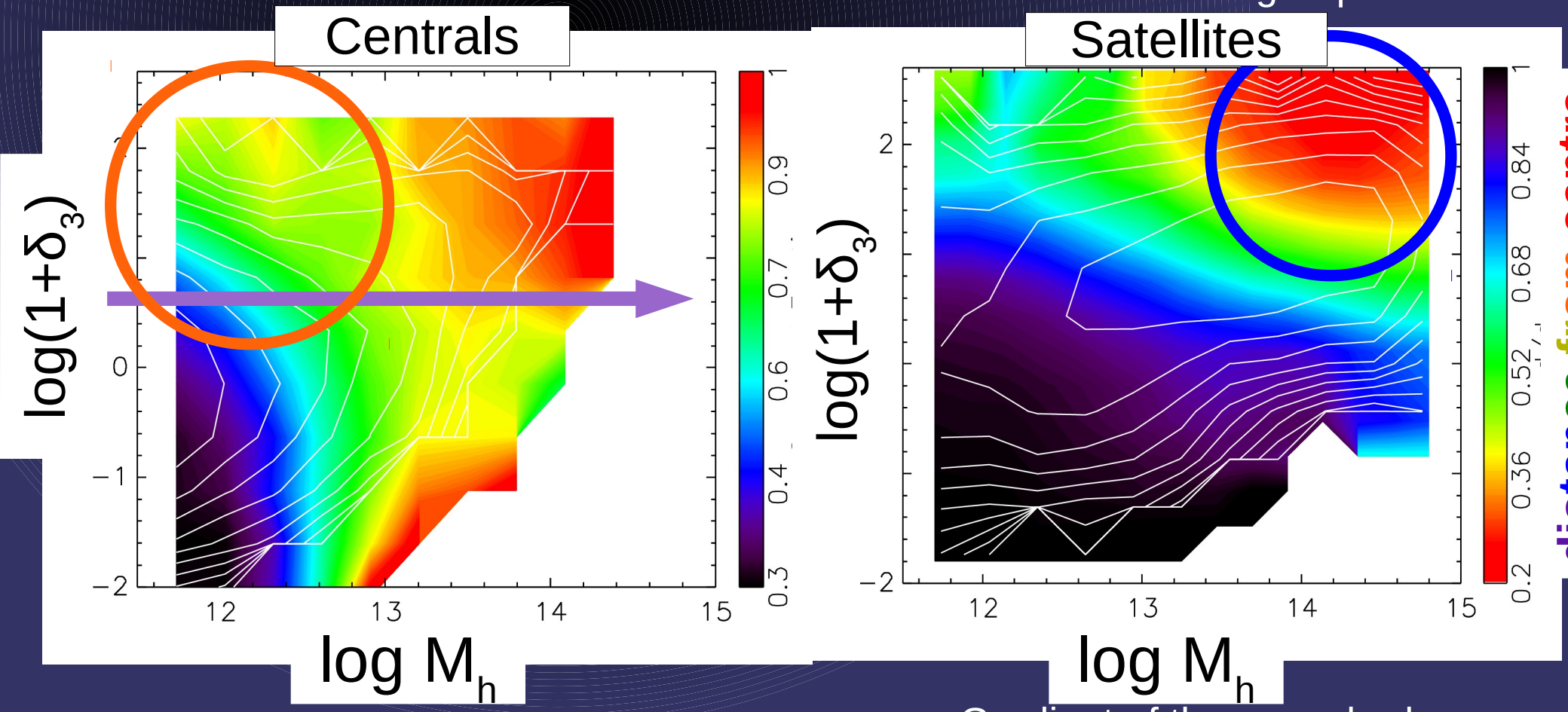


Gradient of the quenched fraction is mostly in the M_h direction

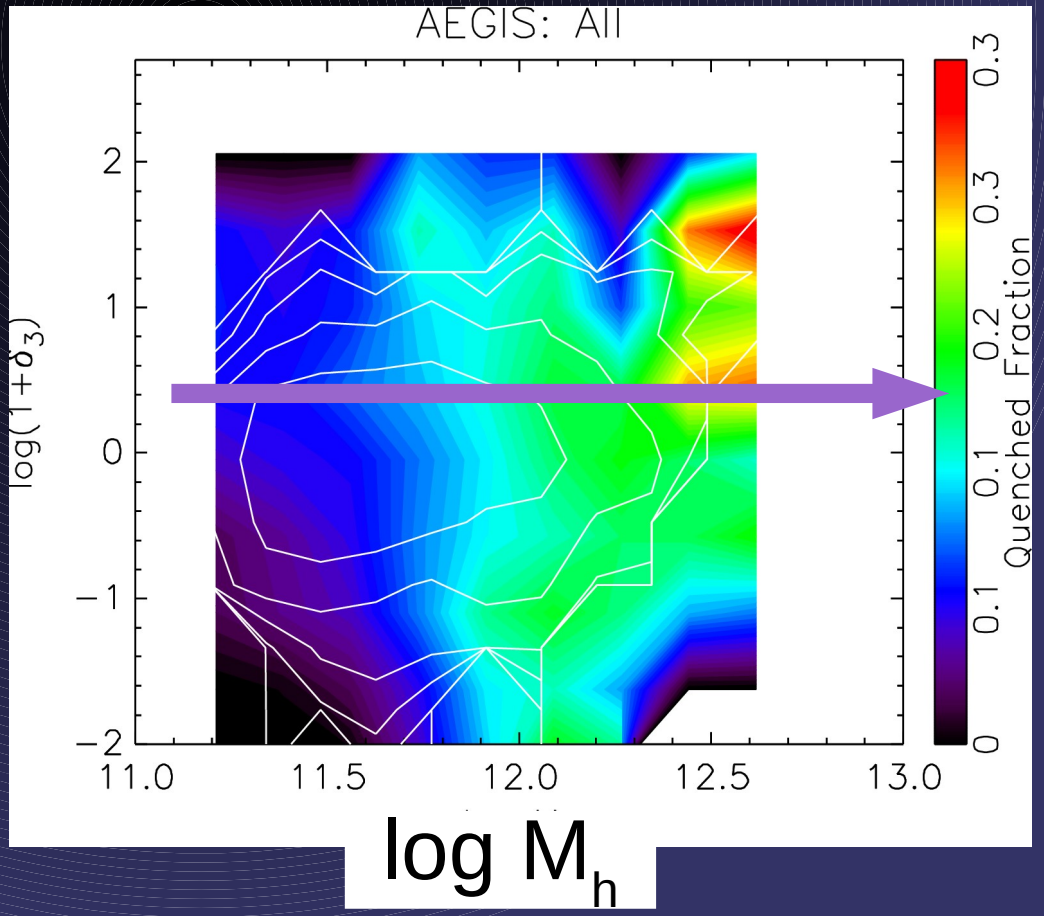
SDSS

Gradient of the quenched fraction is mostly in the δ_3 direction

Quenching as a function of δ_3 , M_h

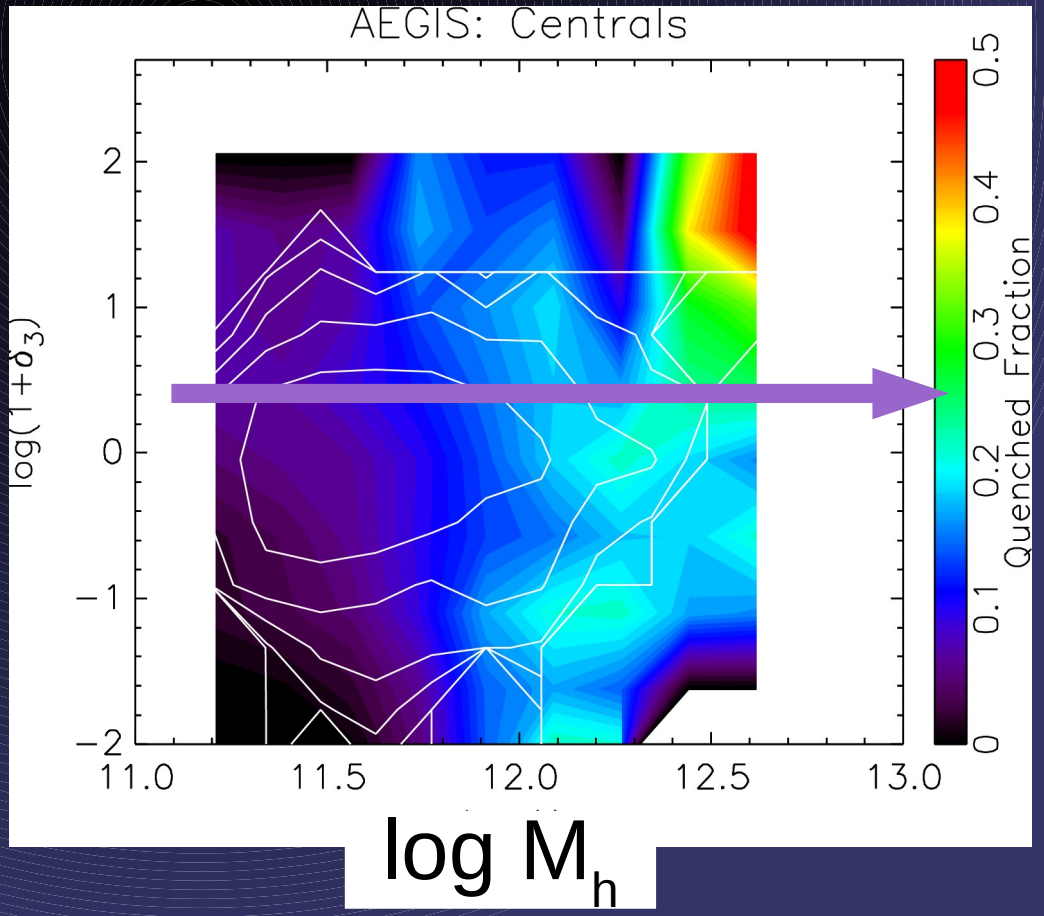
All

$\log(1+\delta_3)$



AEGIS: mostly centrals, gradient of quenched fraction is in the M_h direction

Quenching as a function of δ_3 , M_h



Centrals

$\log(1+\delta_3)$

AEGIS: mostly centrals, gradient of quenched fraction is in the M_h direction

Conclusions

- The quenched fraction of galaxies correlates with:
  - halo mass (and stellar mass) for centrals (true for z~0 and z~1)
  - environment density (proximity to group centre) for satellites
- Interpretation:
  - centrals are quenched in big halos due to virial shock heating
  - satellites are quenched when they enter areas of high number density, ie big halos whose gas is already heated