# The projected correlation function of MD07

Stefanie Phleps
with Lihwai Lin, Sébastien Foucaud, Jean Coupon,
Chin-Wei Chen and Hung-Yu Jian

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MAX-PLANCK-GESELLSCHAFT

MPE

Work in progress!!

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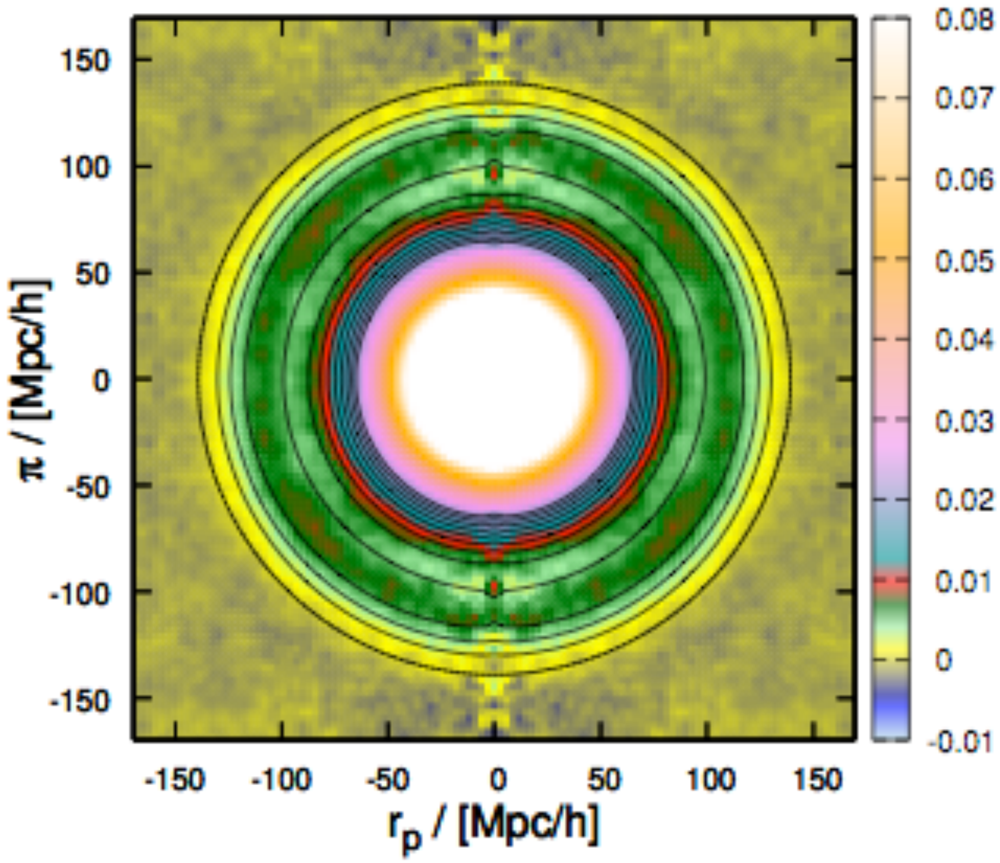
# Outline

- Why projected correlation functions?
- The data
  - sample selection
  - subsamples:
    - luminosity
    - colour
    - age
    - SFR
    - SSFR
- The projected correlation functions
- (Preliminary) results
- Future plans
  - include MD04
  - better randoms
  - fit with HOD model in order to determine halo masses for different subsamples

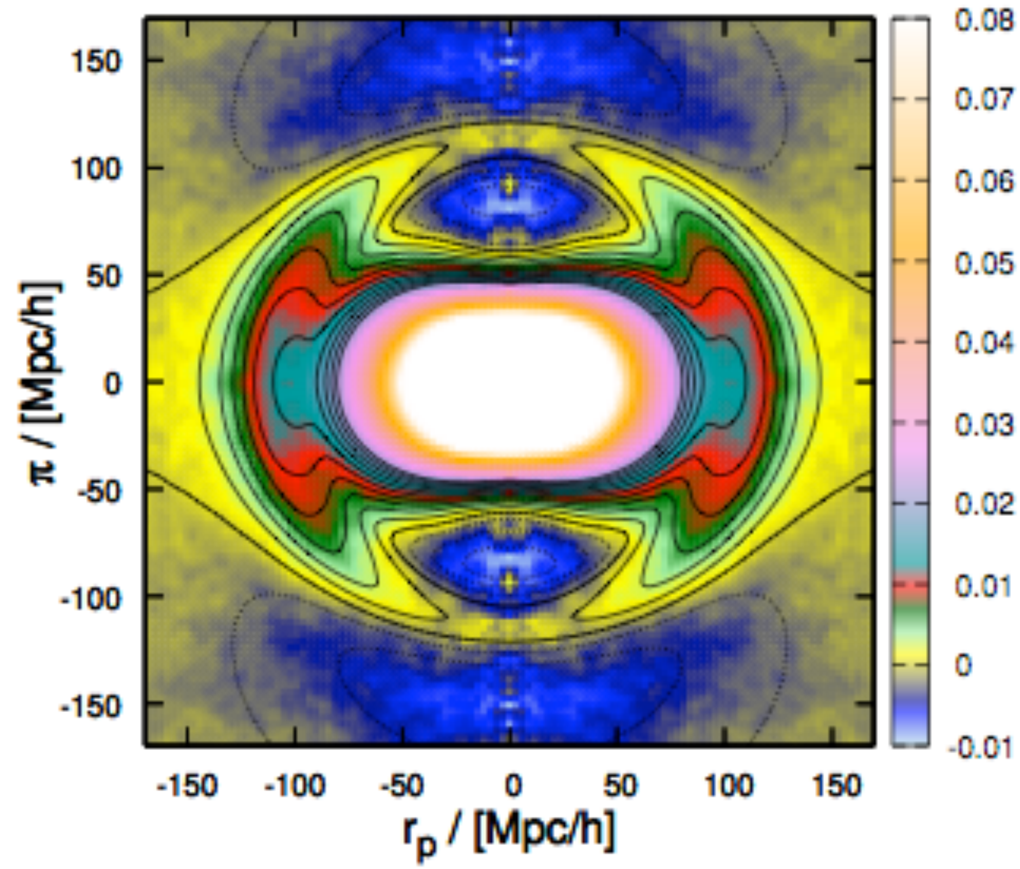
# Why the projected correlation function?

- We want to quantify galaxy clustering by means of correlation functions
- redshift errors influence the signal we measure
- we can split the correlation function into directions along the line of sight ($\pi$) and perpendicular to it ($r_p$)
- the result is the anisotropic correlation function $\xi(r_p,\pi)$
- then the direction perpendicular to the line of sight is (almost) unaffected, while the other one is distorted
- we can integrate along the line of sight, and take the influence of the redshift errors into account
- the result is the projected correlation function $w(r_p)$
- it makes use of the redshift information which is there, but minimizes the distortions

# The influence of redshift errors on the anisotropic correlation function




Real space




Redshift space

ξ(rp,π) calculated from the L-BASICC simulations
From Schlagenhaufer, Phleps & Sánchez 2012

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ξ(rp,π) calculated from the L-BASICC simulations
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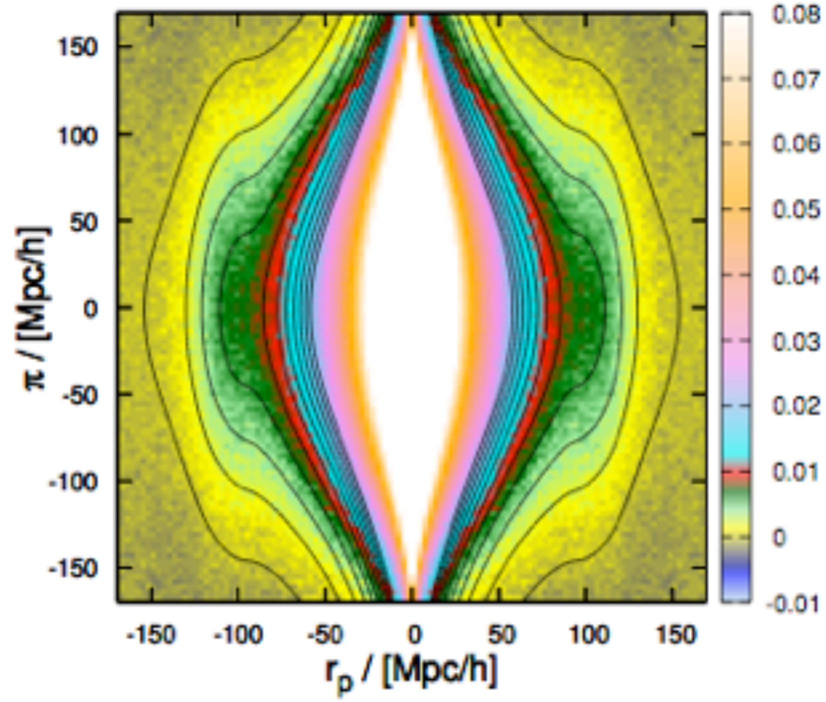
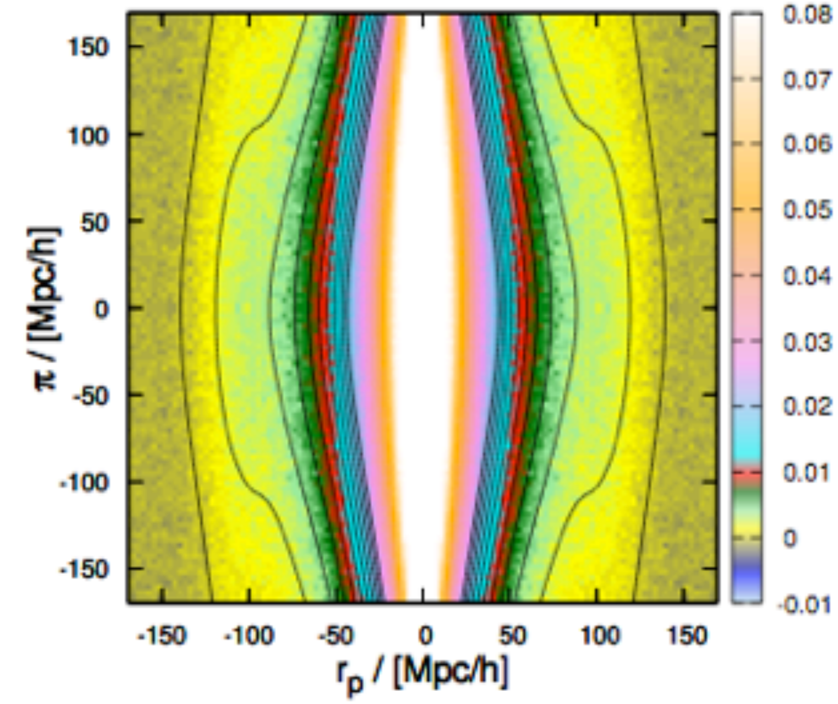
$\sigma_Z$=0.015

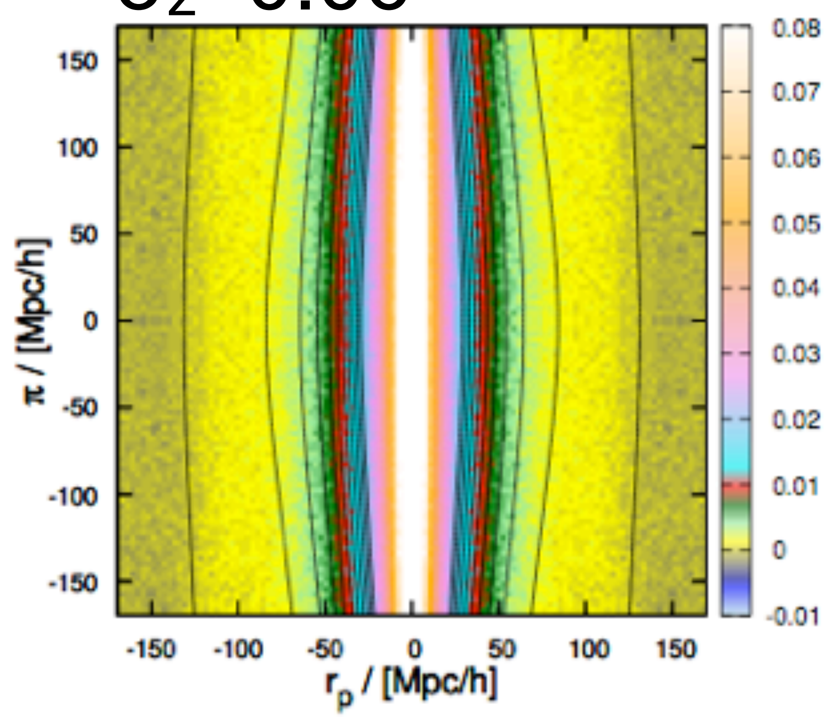



$\sigma_Z$=0.03

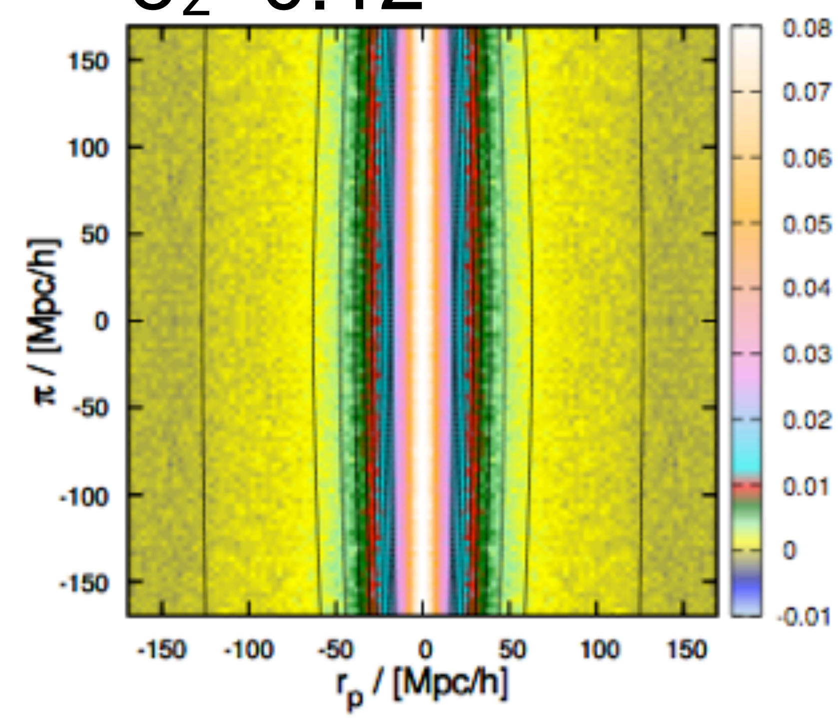



We are at $\sigma_Z \approx 0.05$

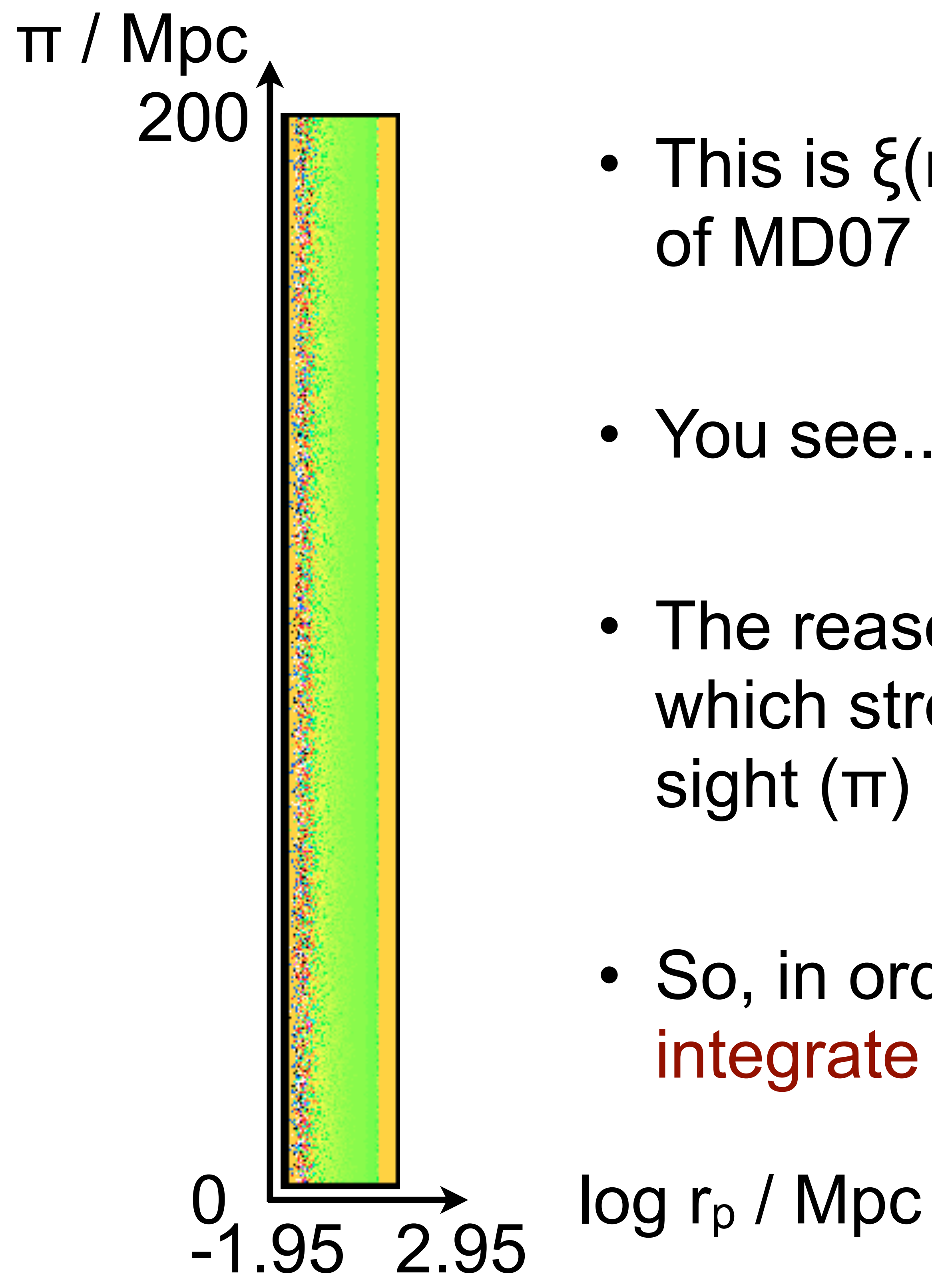
$\sigma_Z$=0.06




$\sigma_Z$=0.12



# The anisotropic correlation function $\xi(rp,\pi)$



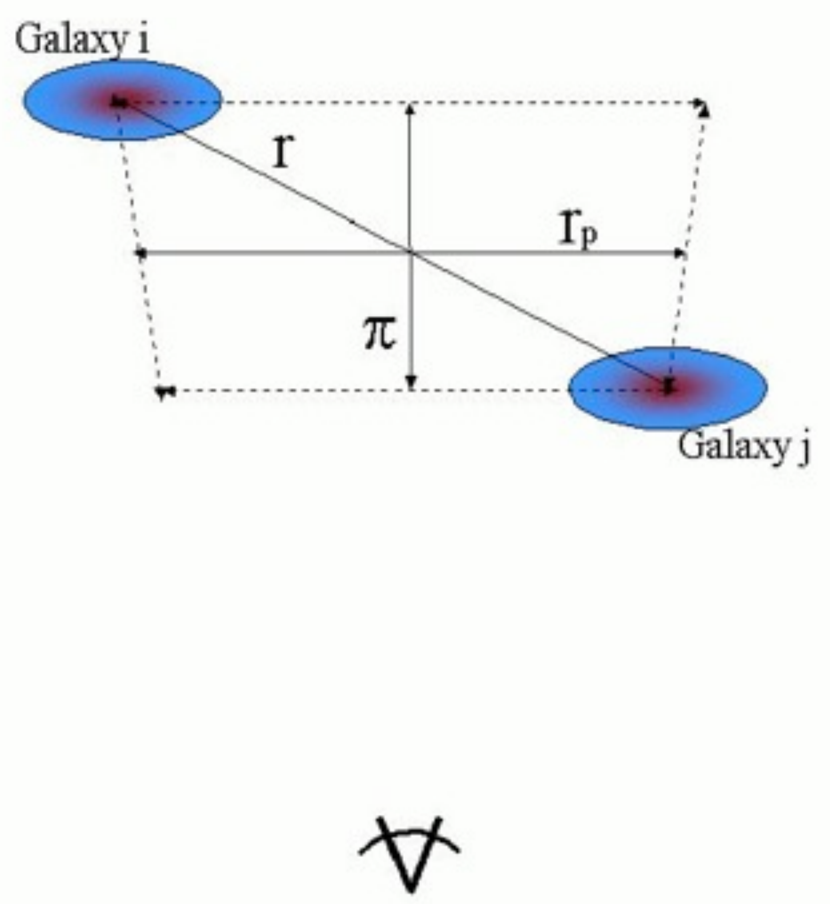

- This is $\xi(r_p,\pi)$ for a volume limited sample of MD07 galaxies with $0.4 \leq z \leq 0.6$
- You see... not very much.
- The reason are the large redshift errors, which stretch the signal along the line of sight ($\pi$)
- So, in order to enhance the signal, we integrate along $\pi$

# The projected correlation function

- The distortions along the line of sight distort the measurement of the two-point correlation function
- This can be overcome by calculating the projected correlation function $w(r_p)$:

$$w(r_p) = 2\int_0^\infty \xi\left[\left(r_p^2 + \pi^2\right)^{1/2}\right] d\pi$$

$$= 2\int_{r_p}^\infty \xi(r)\left(r^2 - r_p^2\right)^{-1/2} dr$$




- Can be deprojected by simple coordinate transform!

# The projected correlation function

If $\xi(r) = \left(\frac{r}{r_0}\right)^{-\gamma}$ then the integral can be evaluated, and

$$w(r_p) = C r_0^{\gamma} r_p^{1-\gamma}$$

with $$C = \sqrt{\pi}\,\frac{\Gamma((\gamma-1)/2)}{\Gamma(\gamma/2)}$$

So by calculating $w(r_p)$ one can recover the parameters of the 3d-correlation function

# The data: PS1 MD07

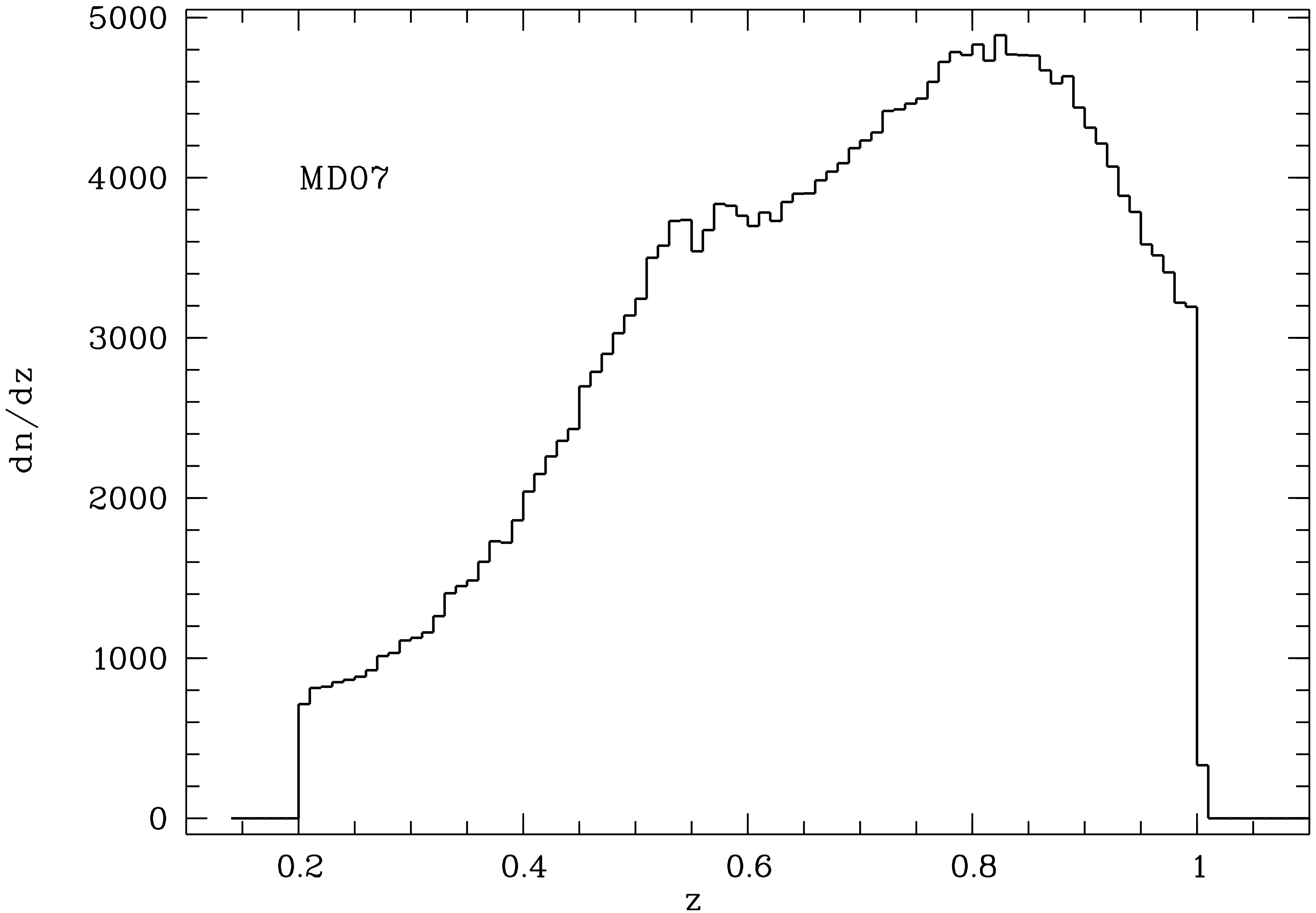
- Courtesy of Lihwai (for details please ask her!)
- EAZY redshifts and physical parameters
- based on non-psfmatched images
- extinction corrected and corrected for the zeropoint offsets including both
  - calibrations against the SDSS stars
  - adjustment from the template offset during the photoz fitting procedure
- mag is defined as the Mag_iso adjusted with the aperture correction found in the i-band (mag_auto - mag_iso). This applies to all ugrizy
- Stellar mass and SFR are still preliminary

# Sample selection

- class_star ≤ 0.5
- chi_p ≤ 100
- 18 ≤ i ≤ 24.5
- $M_R$ ≤ -18.75 (to make it volume limited up to z=1)
- Apply mask (courtesy of Sébastien and using *venice* by Jean)
- 259940 galaxies between 0.2 ≤ z ≤ 1.0

- Divide into four z bins:
  - 0.2 ≤ z ≤ 0.4
  - 0.4 ≤ z ≤ 0.6
  - 0.6 ≤ z ≤ 0.8
  - 0.8 ≤ z ≤ 1.0

# Redshift distribution



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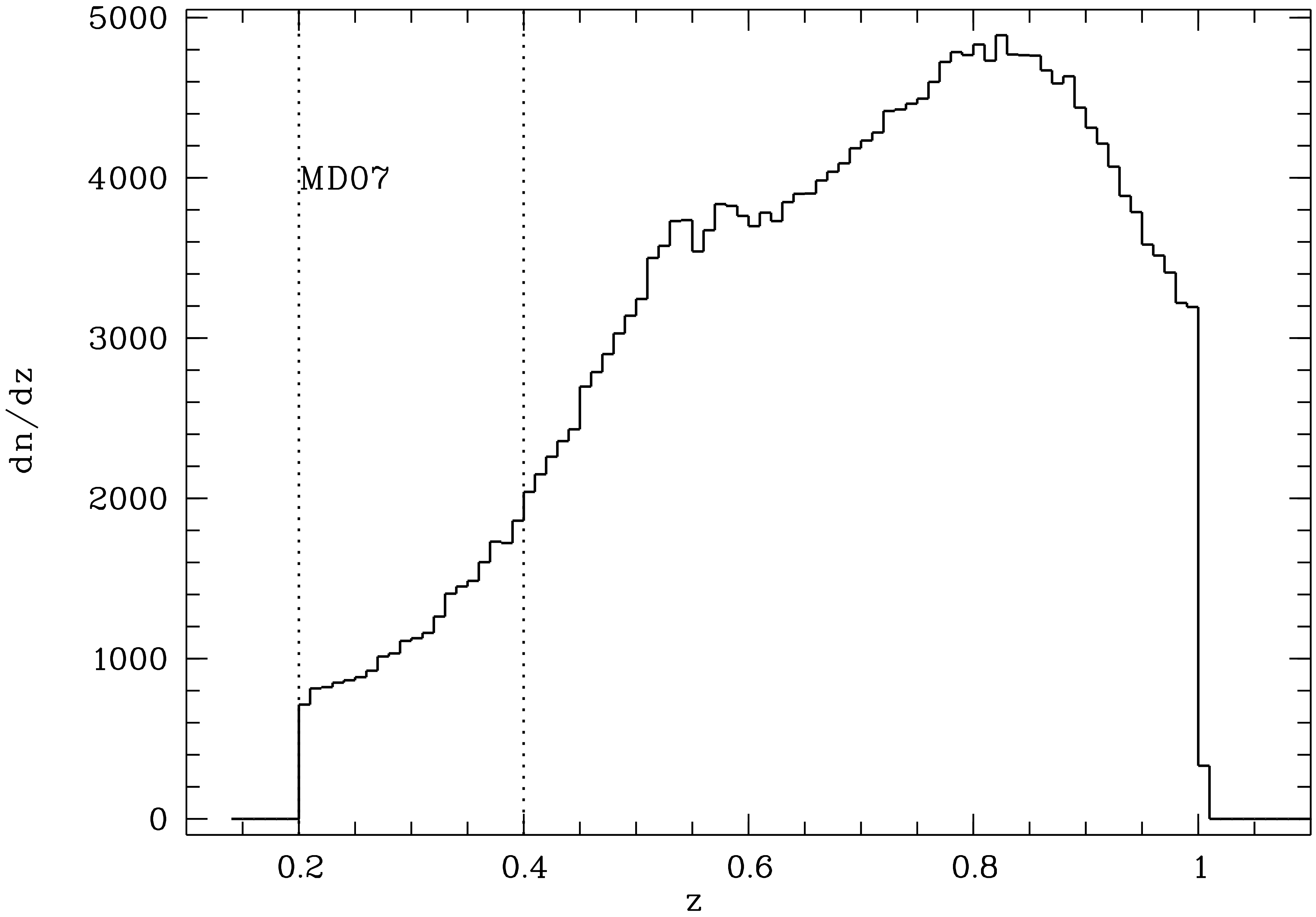

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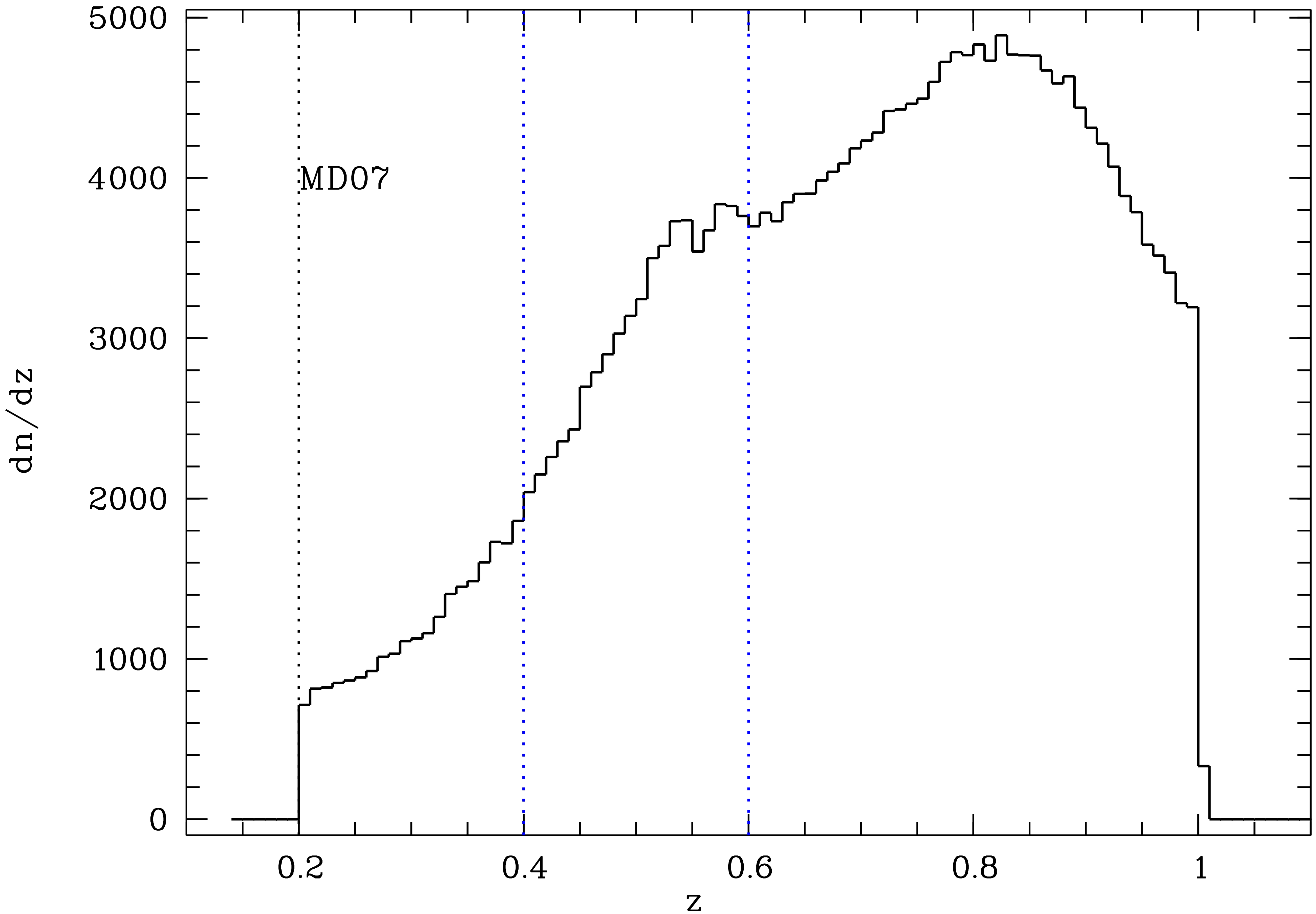

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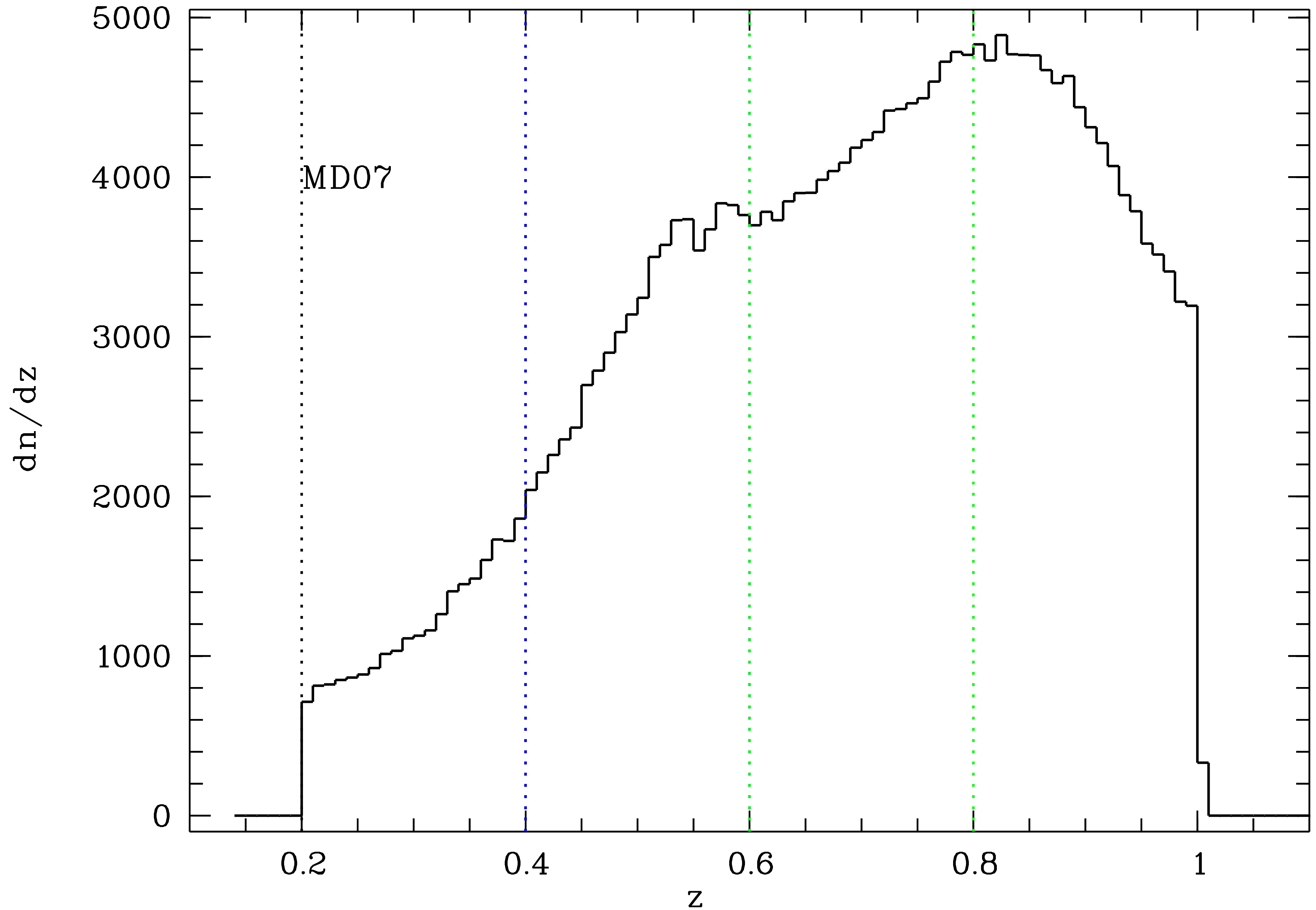

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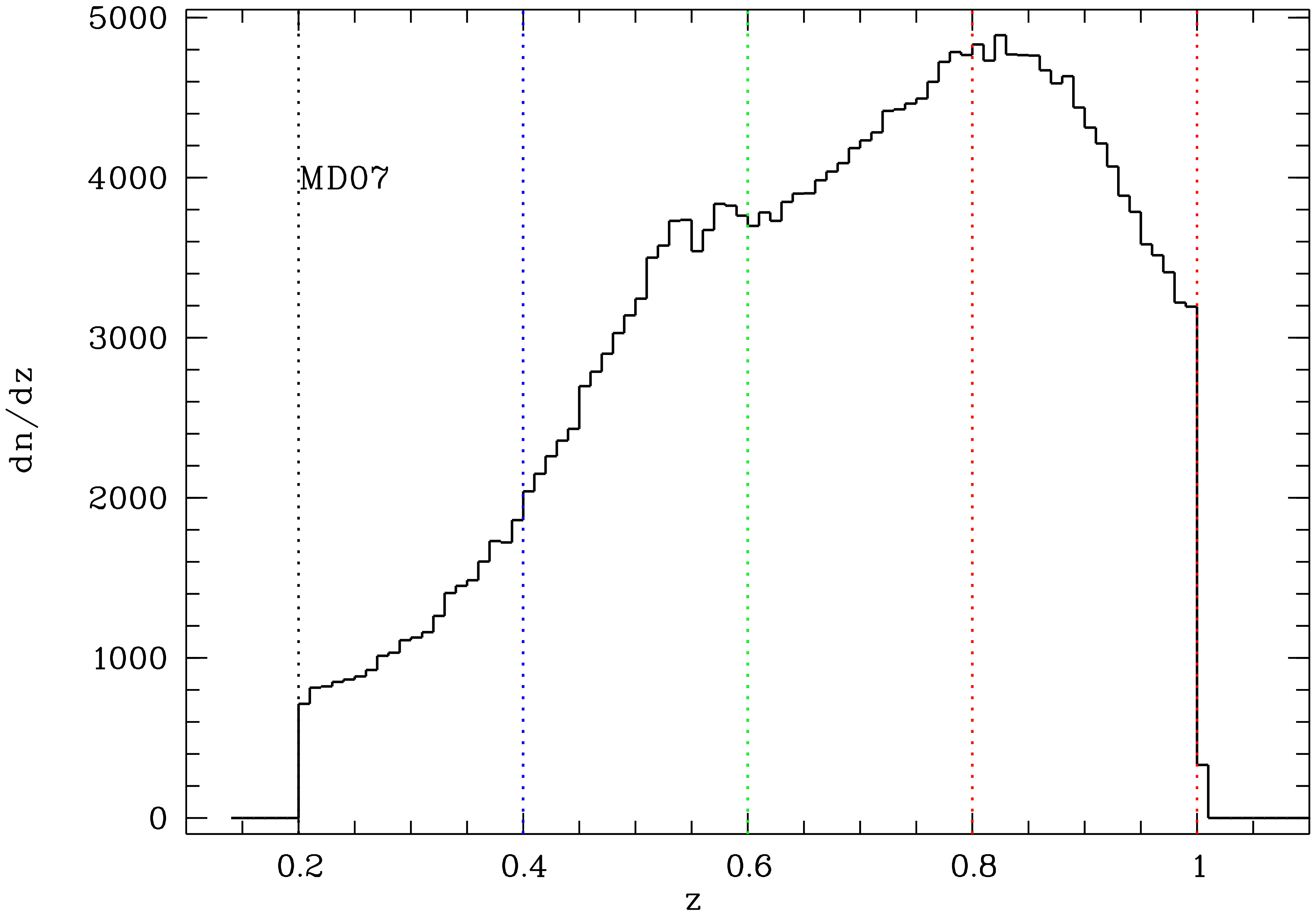
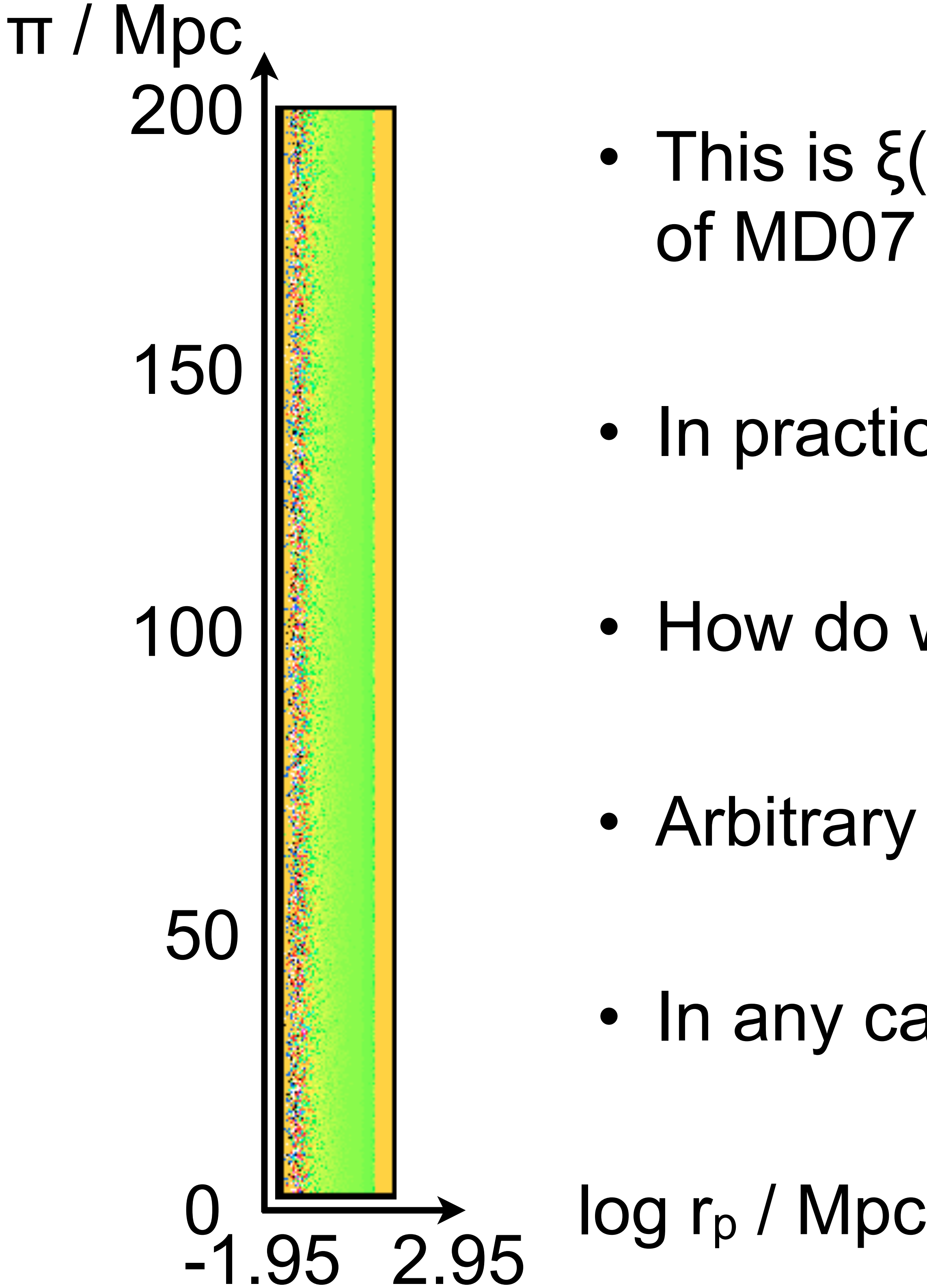


# The anisotropic correlation function ξ(rp,π)




- This is $\xi(r_p,\pi)$ for a volume limited sample of MD07 galaxies with $0.4 \leq z \leq 0.6$
- In practice impossible to integrate out to ∞
- How do we choose the integration limits?
- Arbitrary to some degree...
- In any case not larger than the redshift bin

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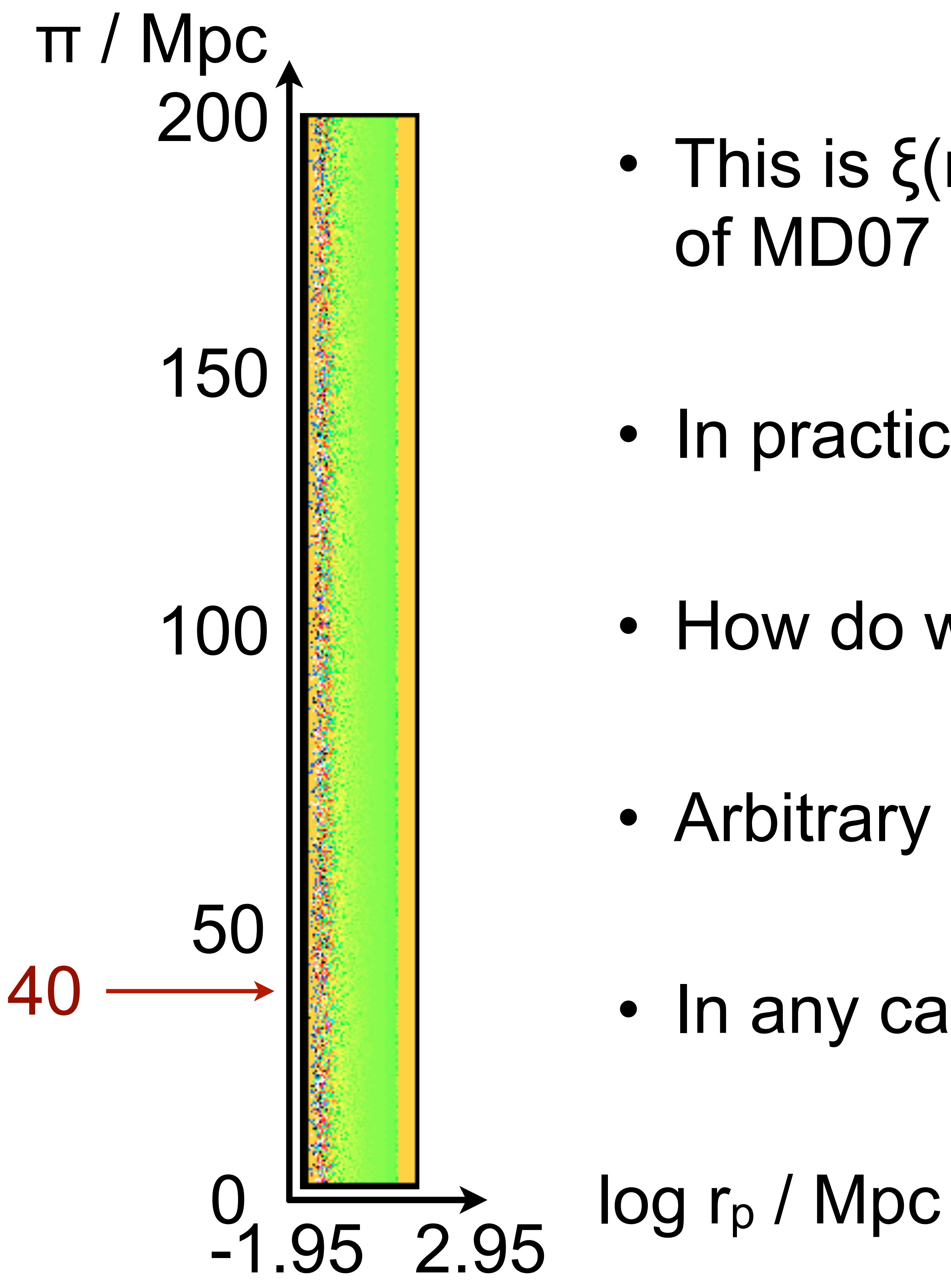


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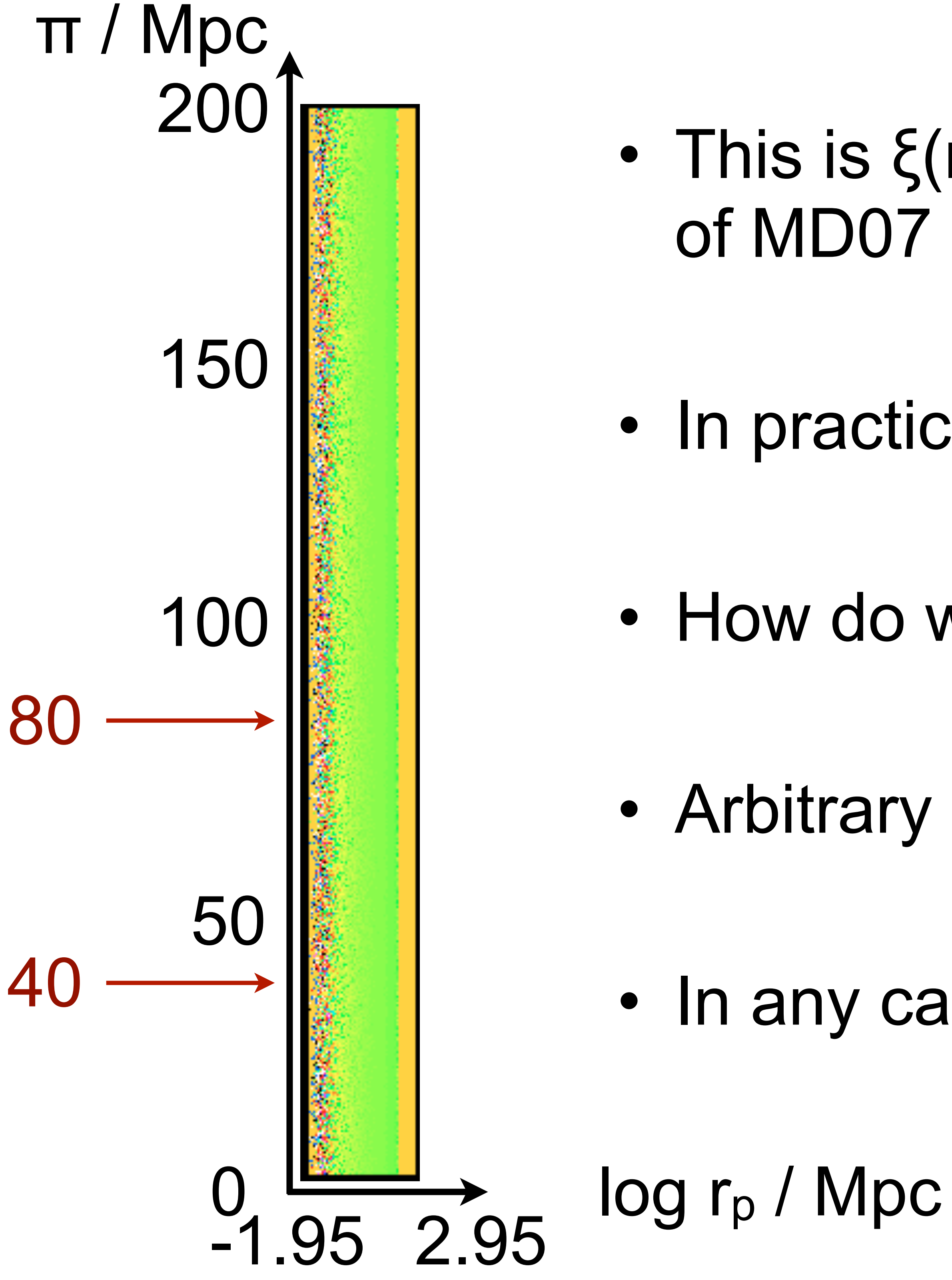


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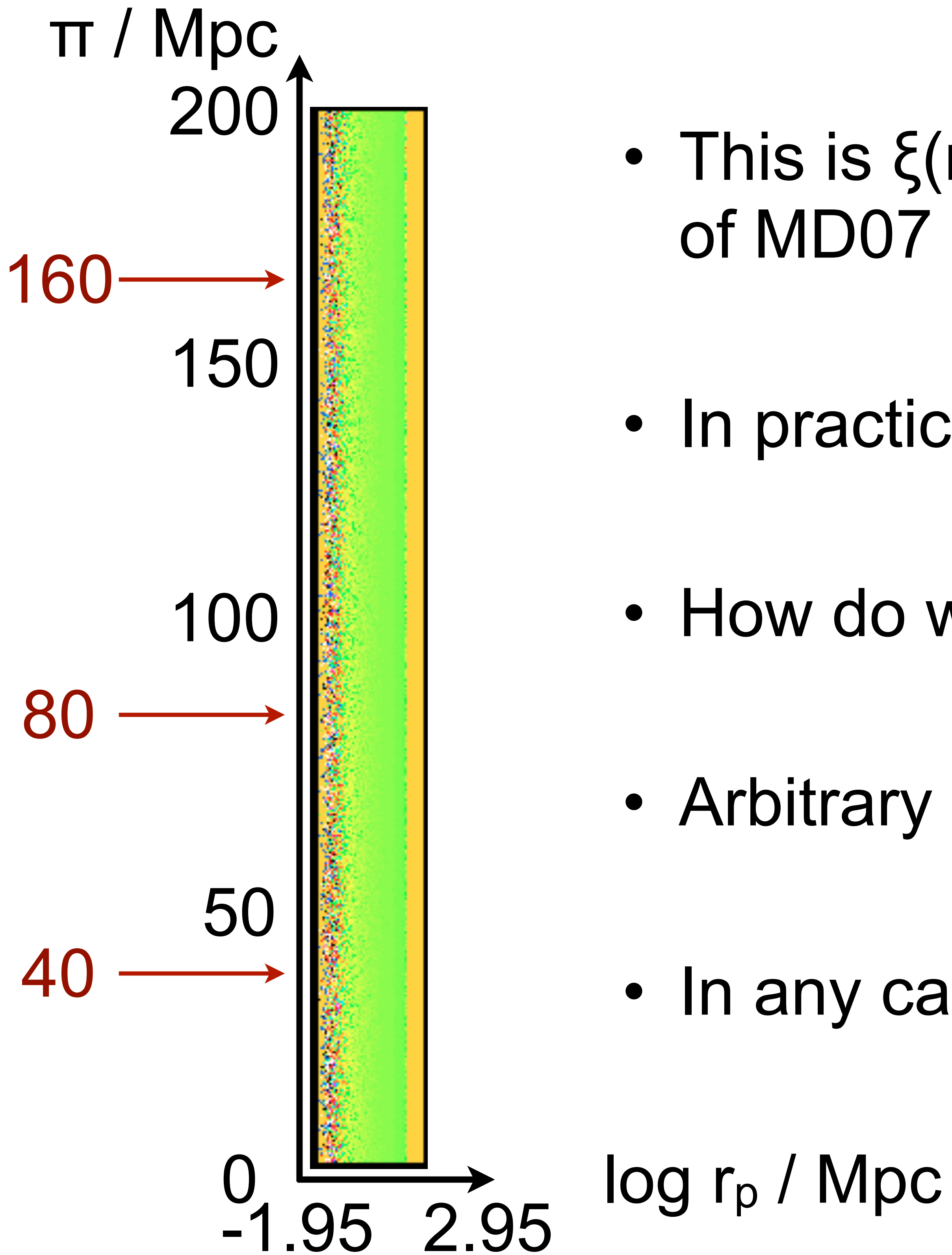


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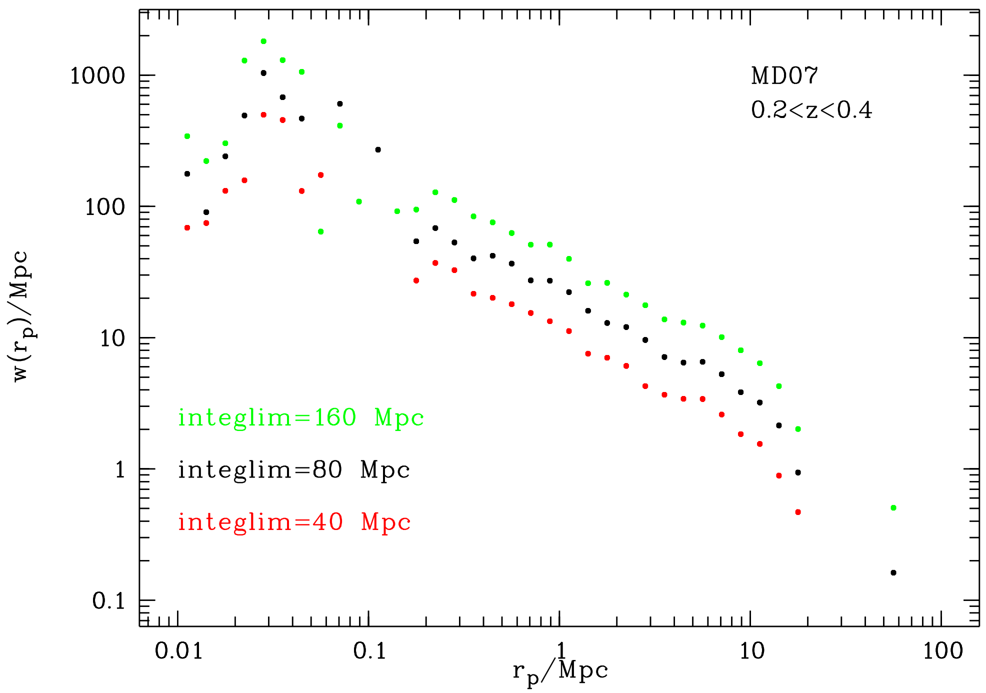
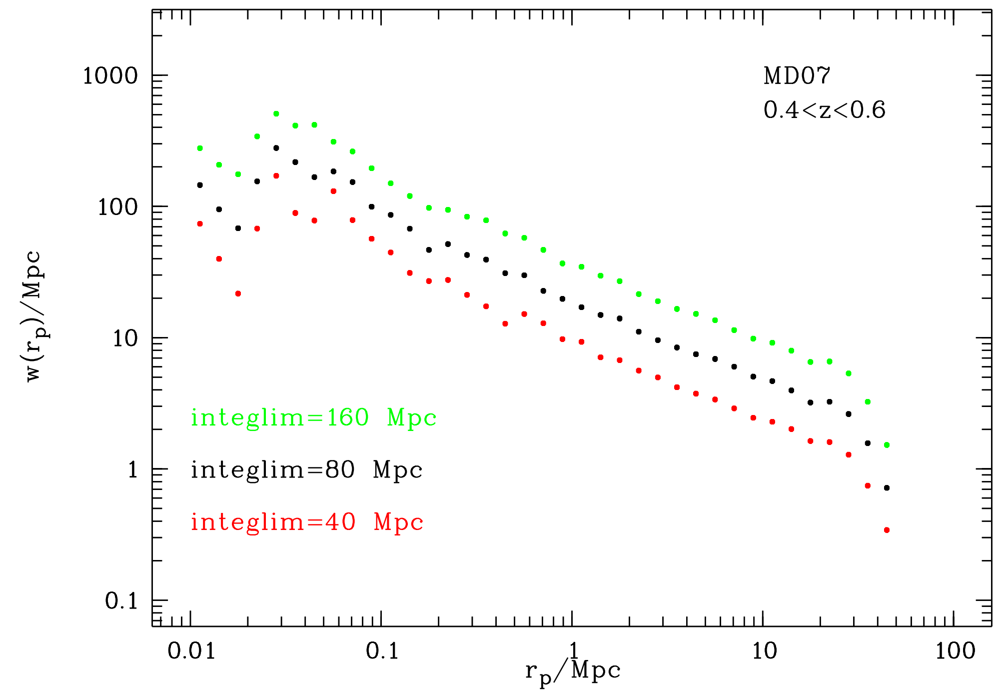
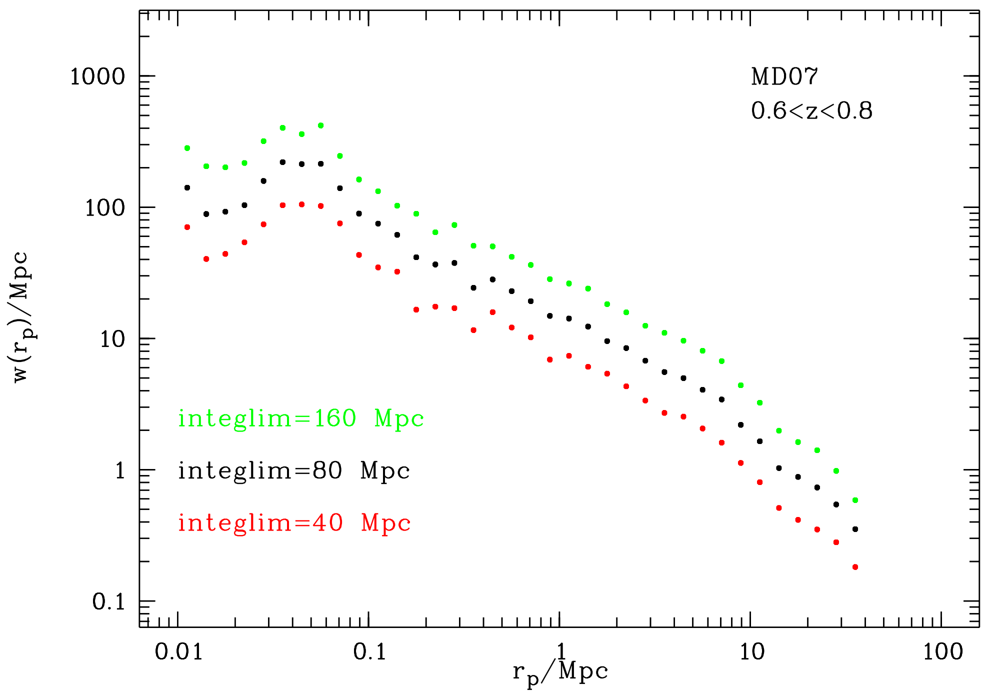
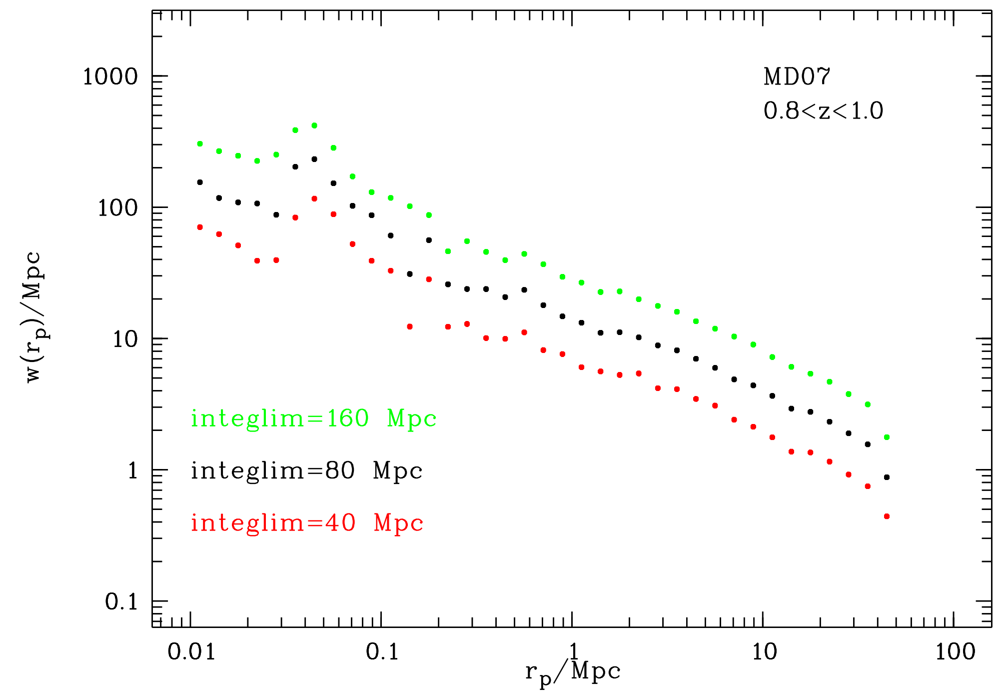
# Results: Different integration limits



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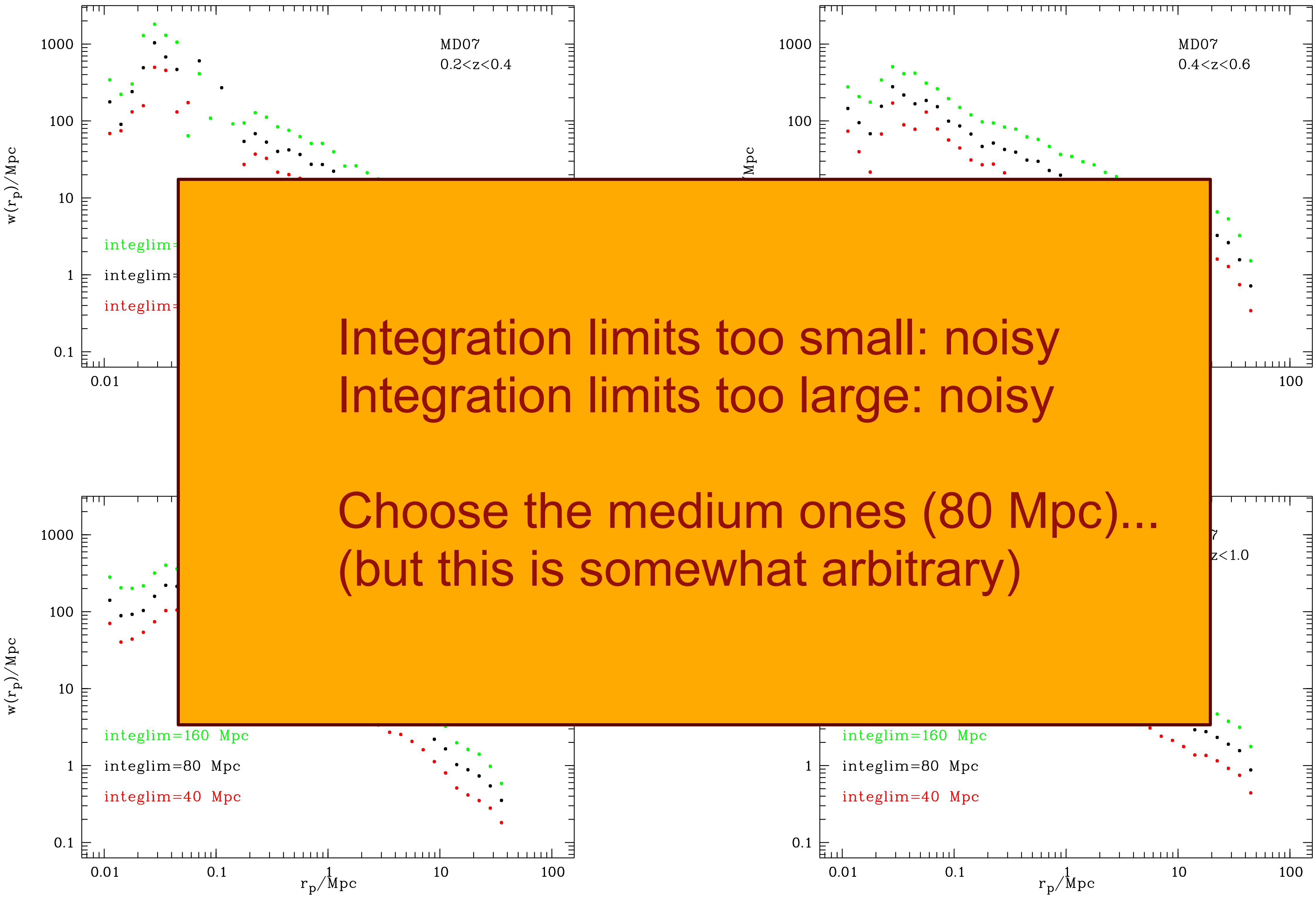
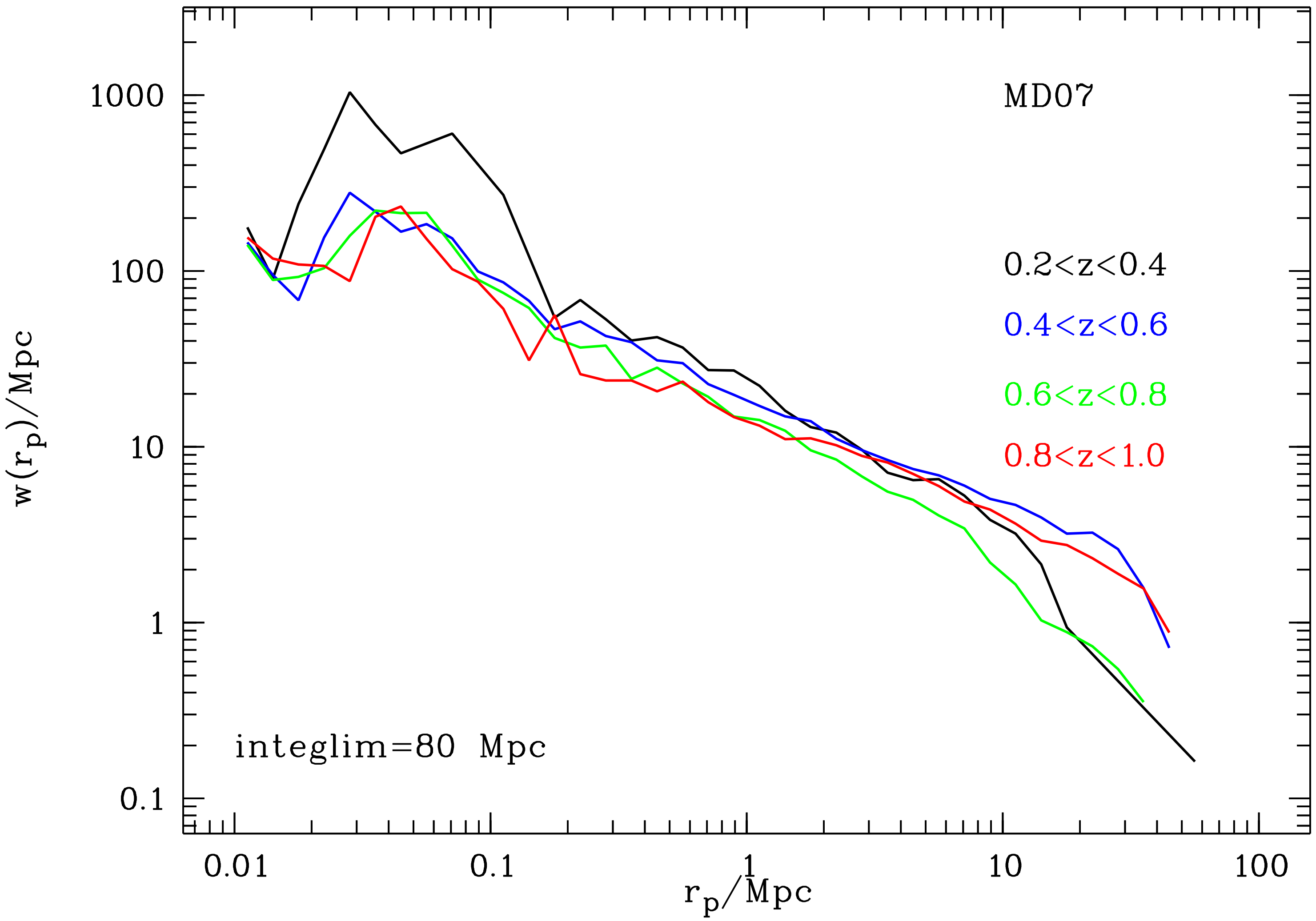



Integration limits too small: noisy
Integration limits too large: noisy

Choose the medium ones (80 Mpc)...
(but this is somewhat arbitrary)

# Results: Different redshift bins




Amplitude seem not to grow significantly with decreasing redshift as expected

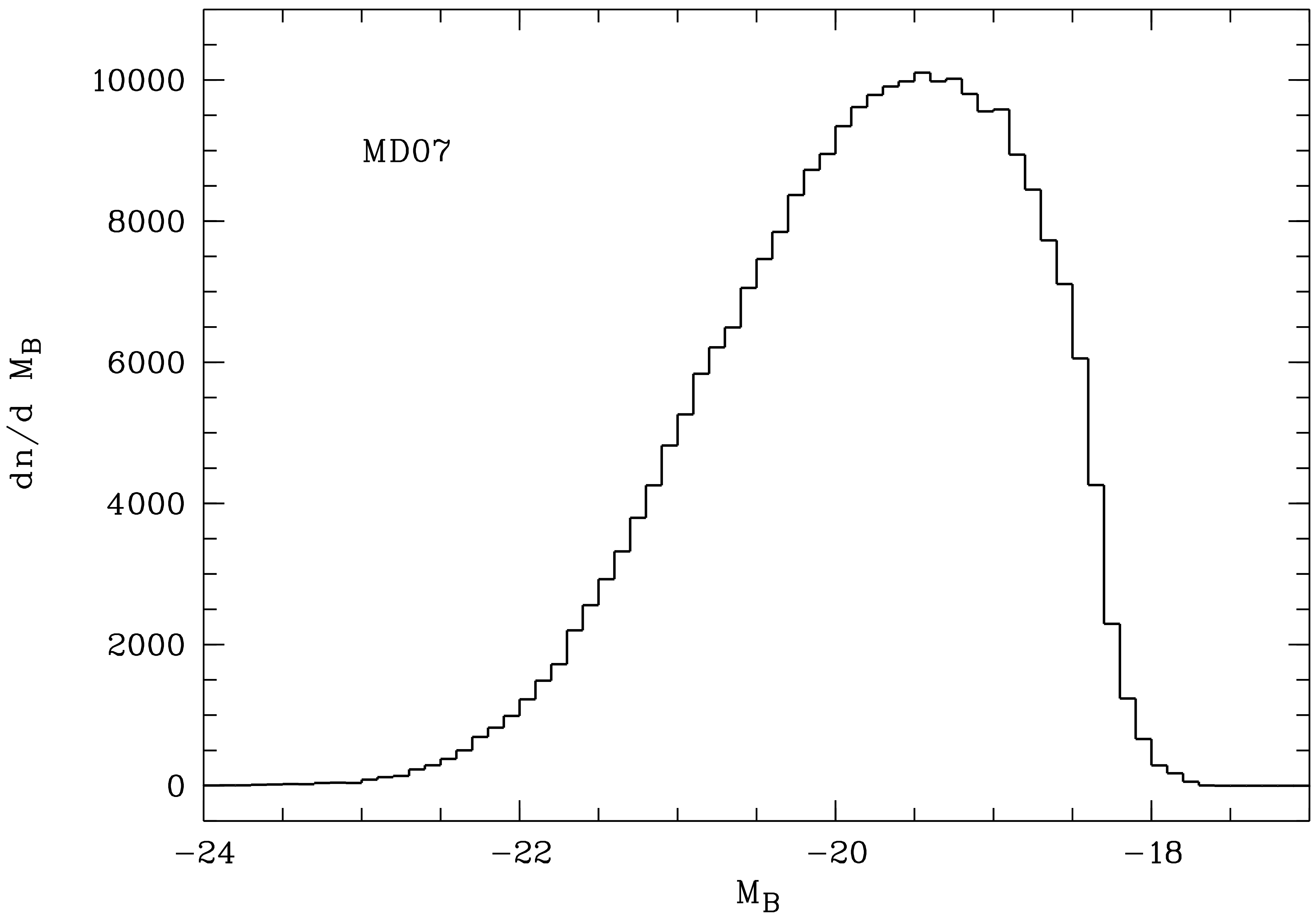
but measured amplitude depends on redshift accuracy which depends on redshift and galaxy type

(different population mix at different redshifts!)

# Subsamples

- In each of the four redshift bins compute correlation functions for the following subsamples such that the division is roughly in the mean of the distribution (except for colour, where the distribution is bimodal):
  - bright and faint galaxies (bright means $M_B$<-19.75)
  - red and blue galaxies (red means u-r > 1.9)
  - old and young galaxies (old means log age > 8.5)
  - low and high stellar mass galaxies (massive means log M > 9.5)
  - high and low SFR (high SFR means log SFR > -0.5)
  - high and low SSFR (high SSFR means log SSFR > -10.)

# Distribution of $M_B$



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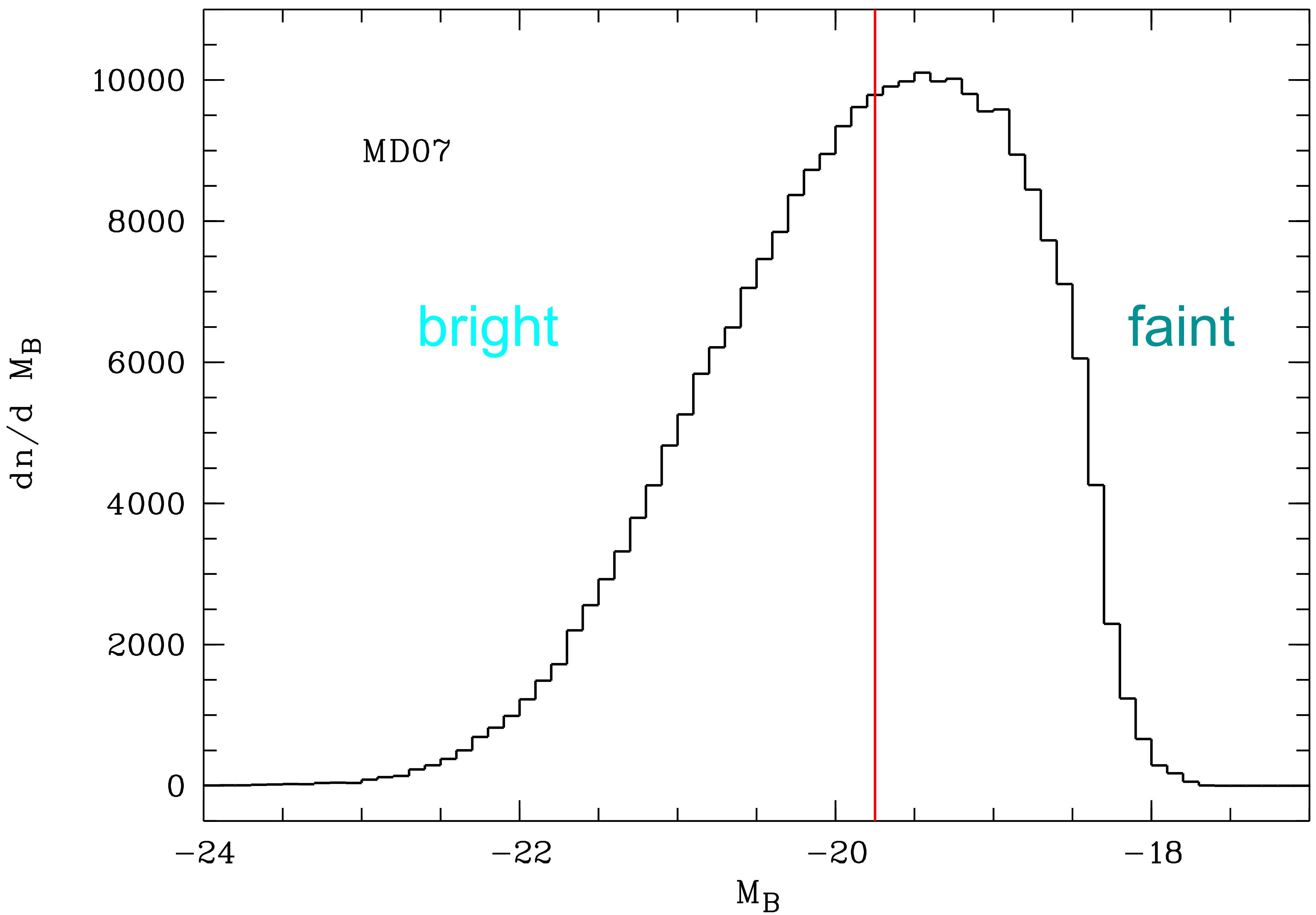
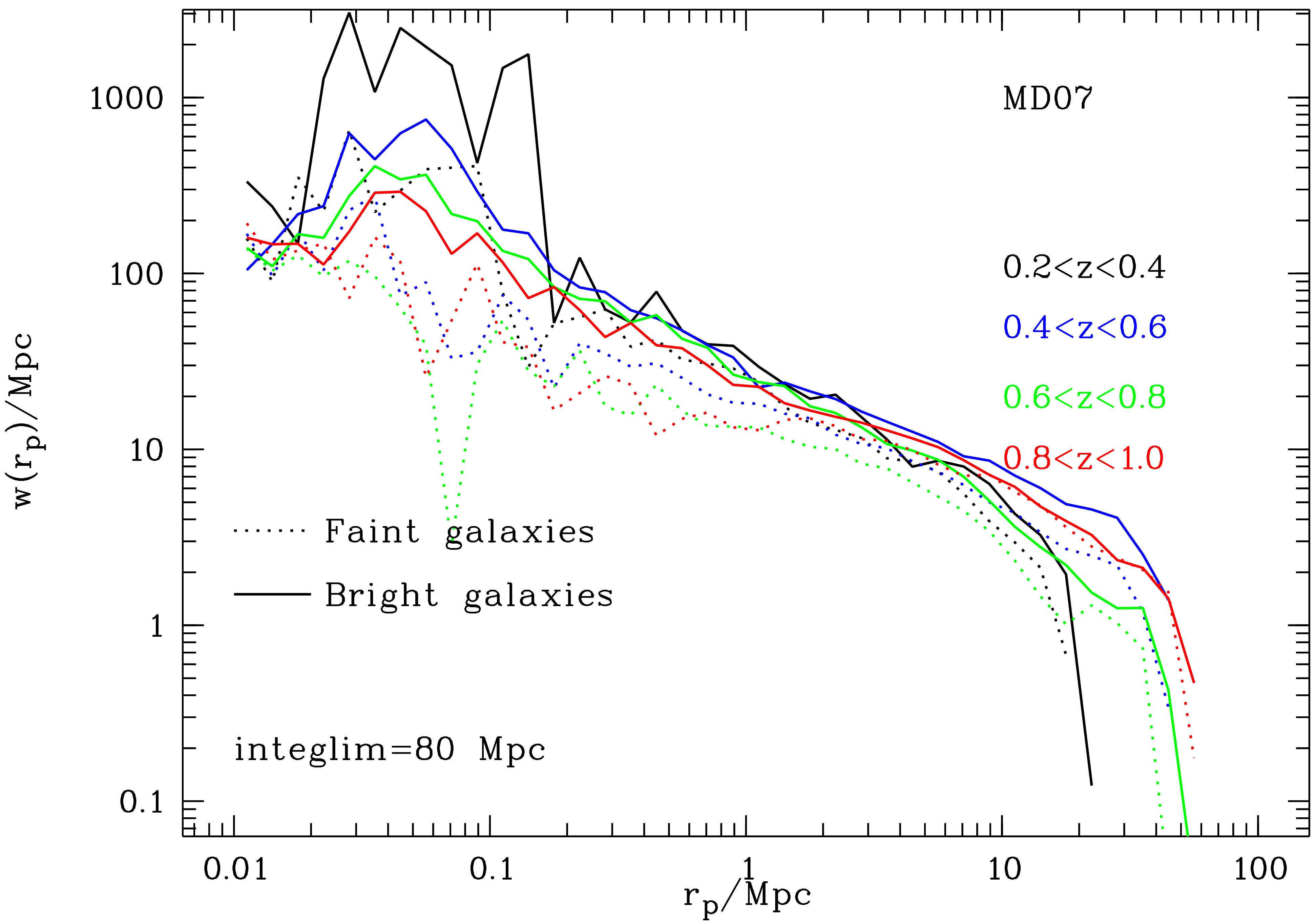
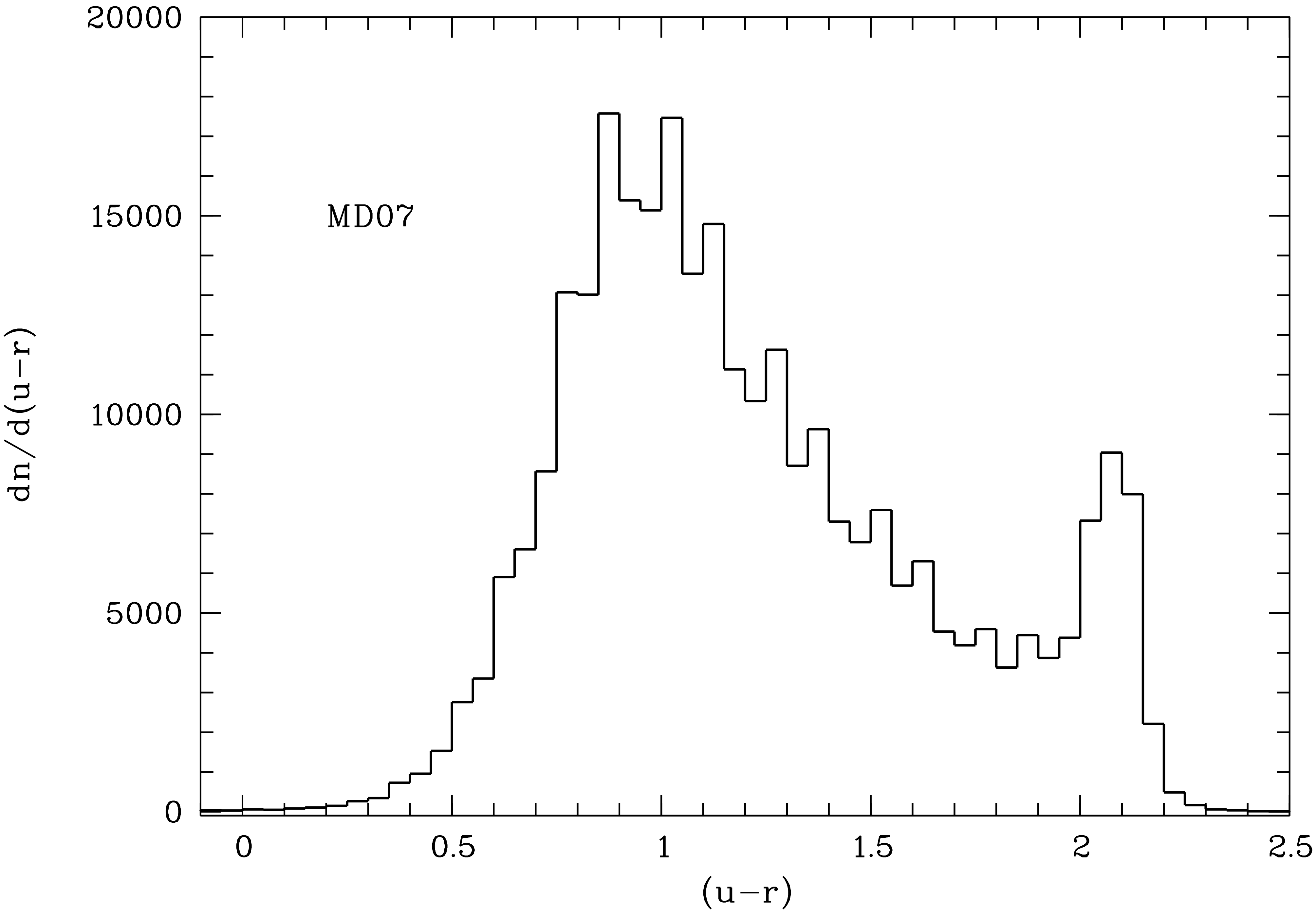


# The correlation functions




Bright galaxies are slightly more strongly clustered than faint galaxies

# Distribution of (u-r)



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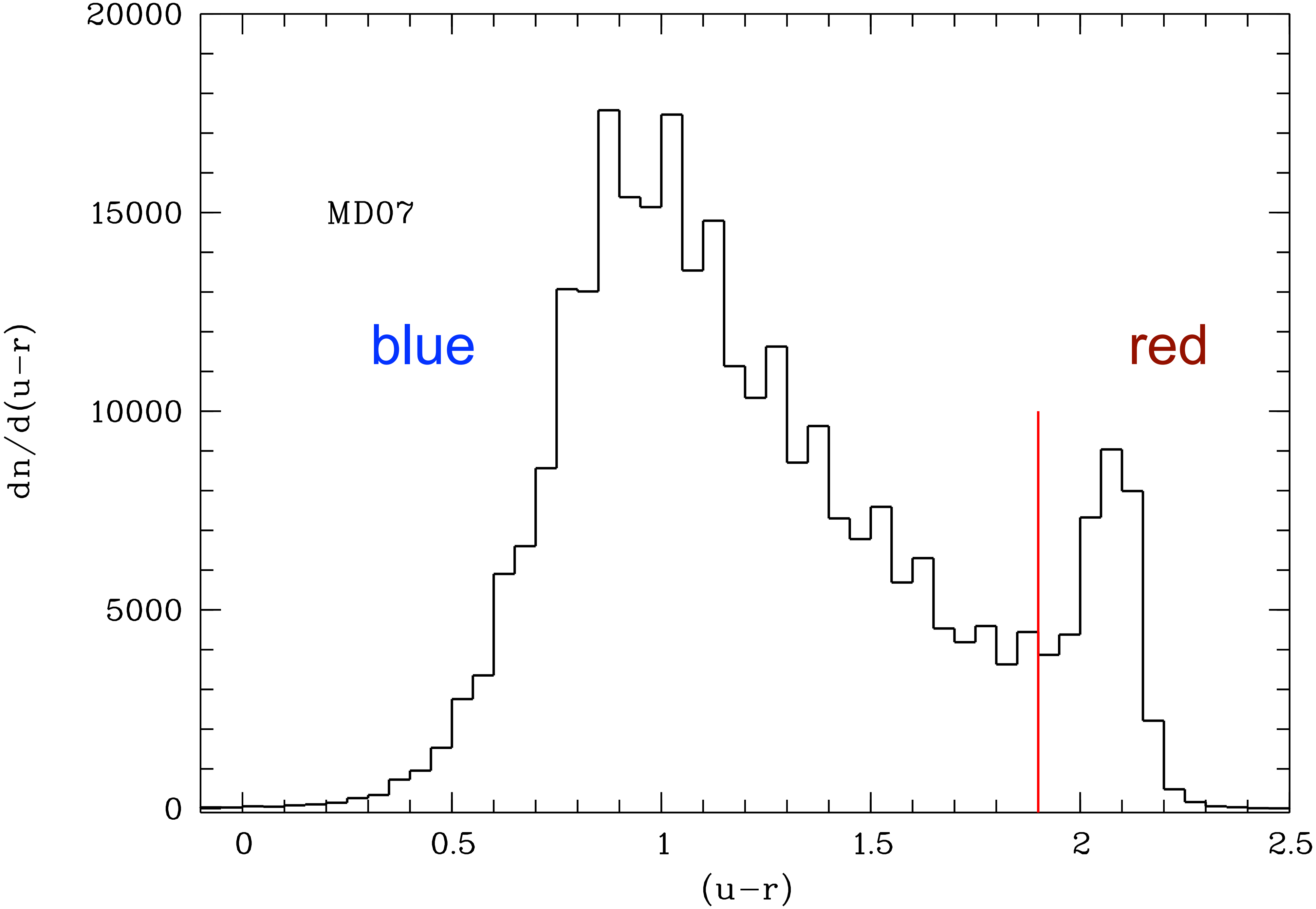
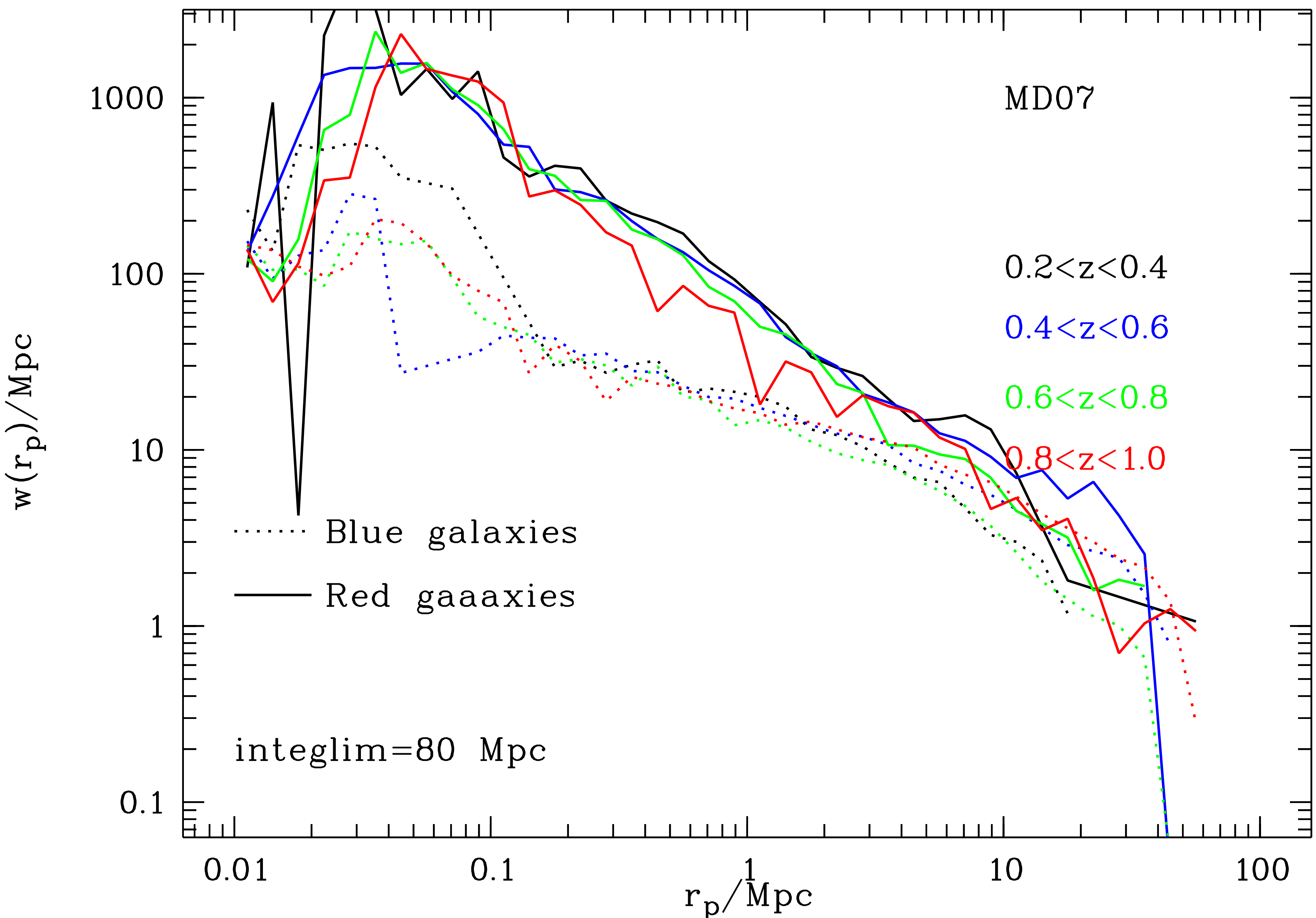
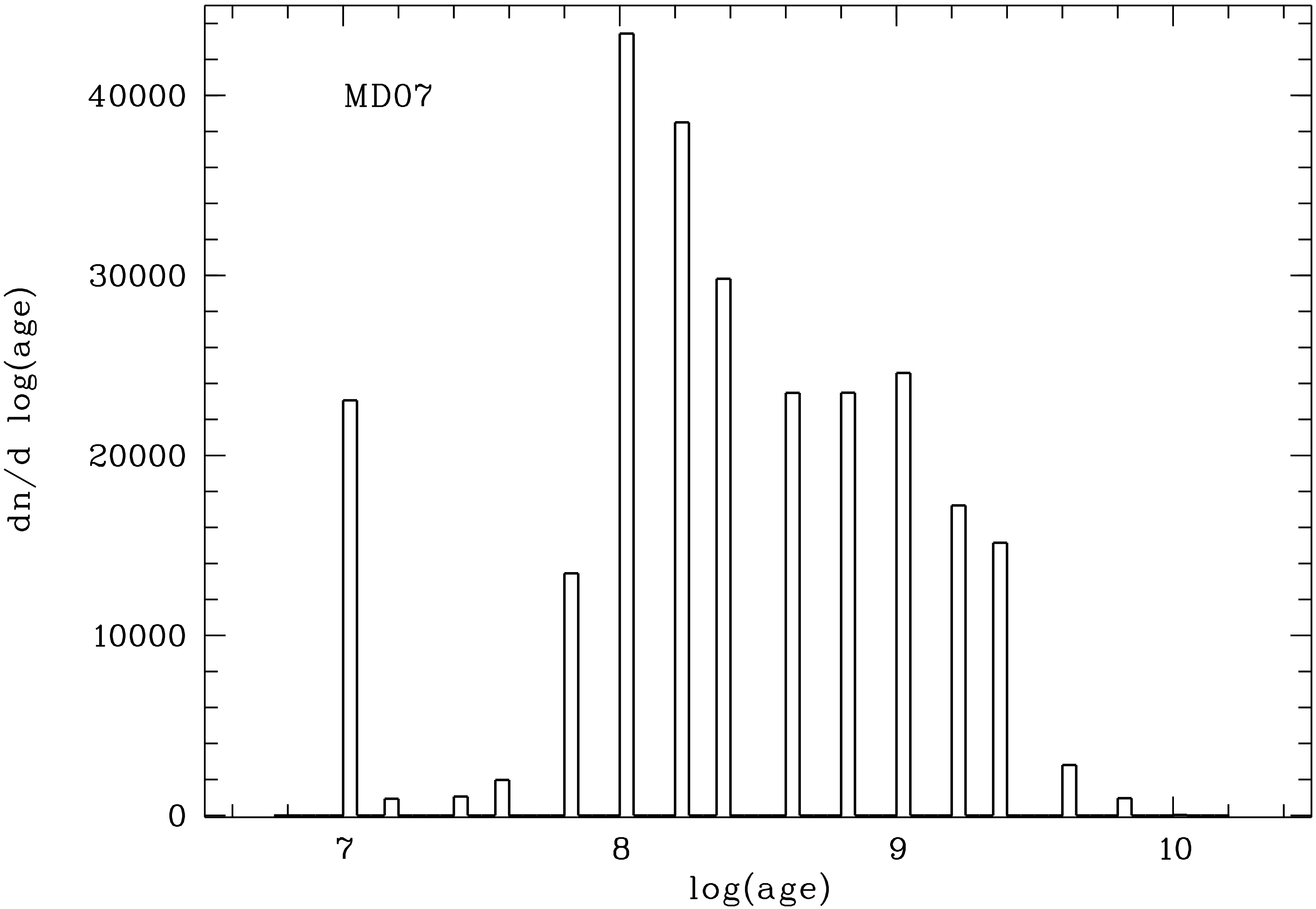


# The correlation functions




Red galaxies are much more strongly clustered than blue galaxies, in particular on small scales (slope of correlation function is steeper) - this is exactly as expected (qualitatively)

# Distribution of log age



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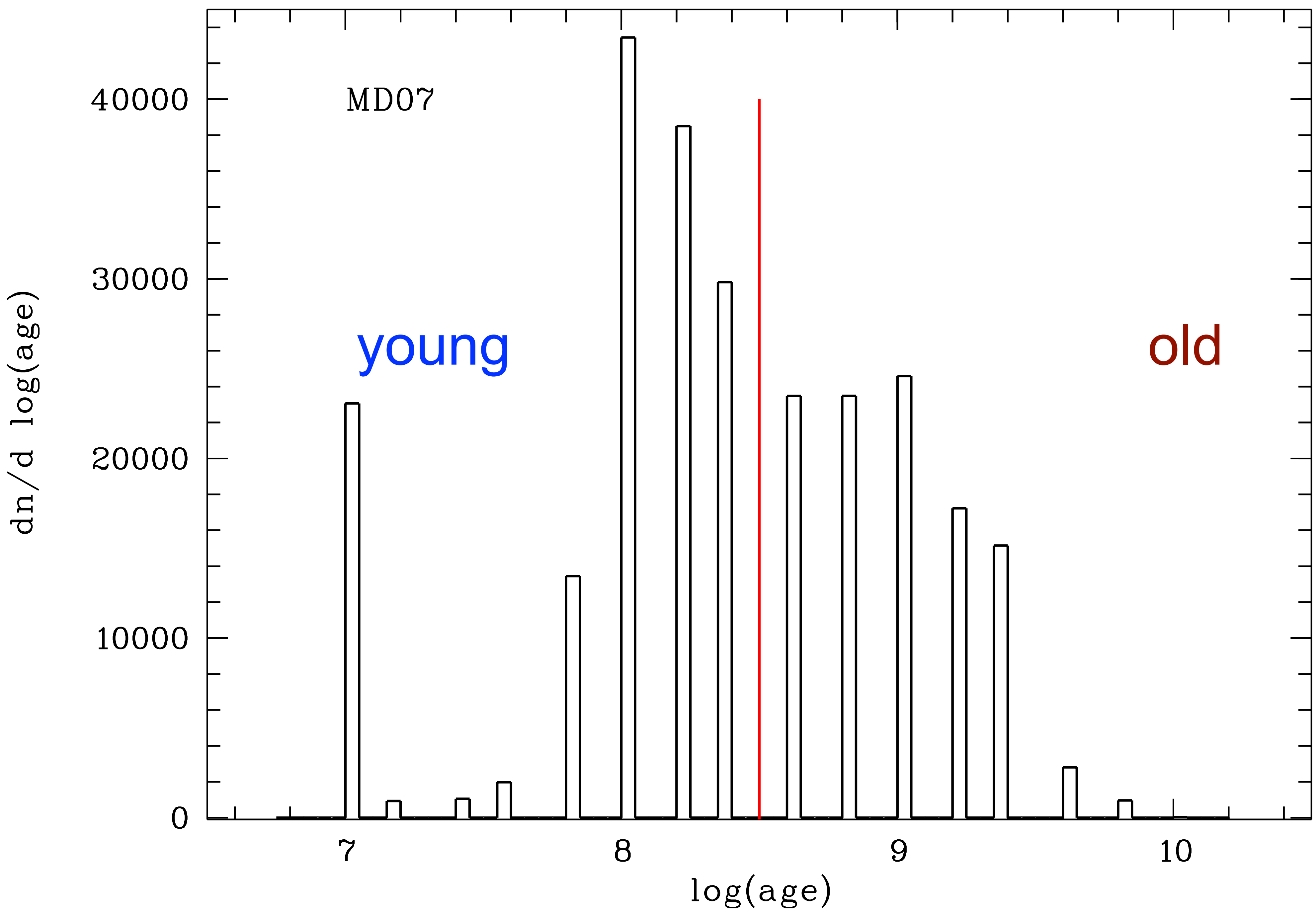
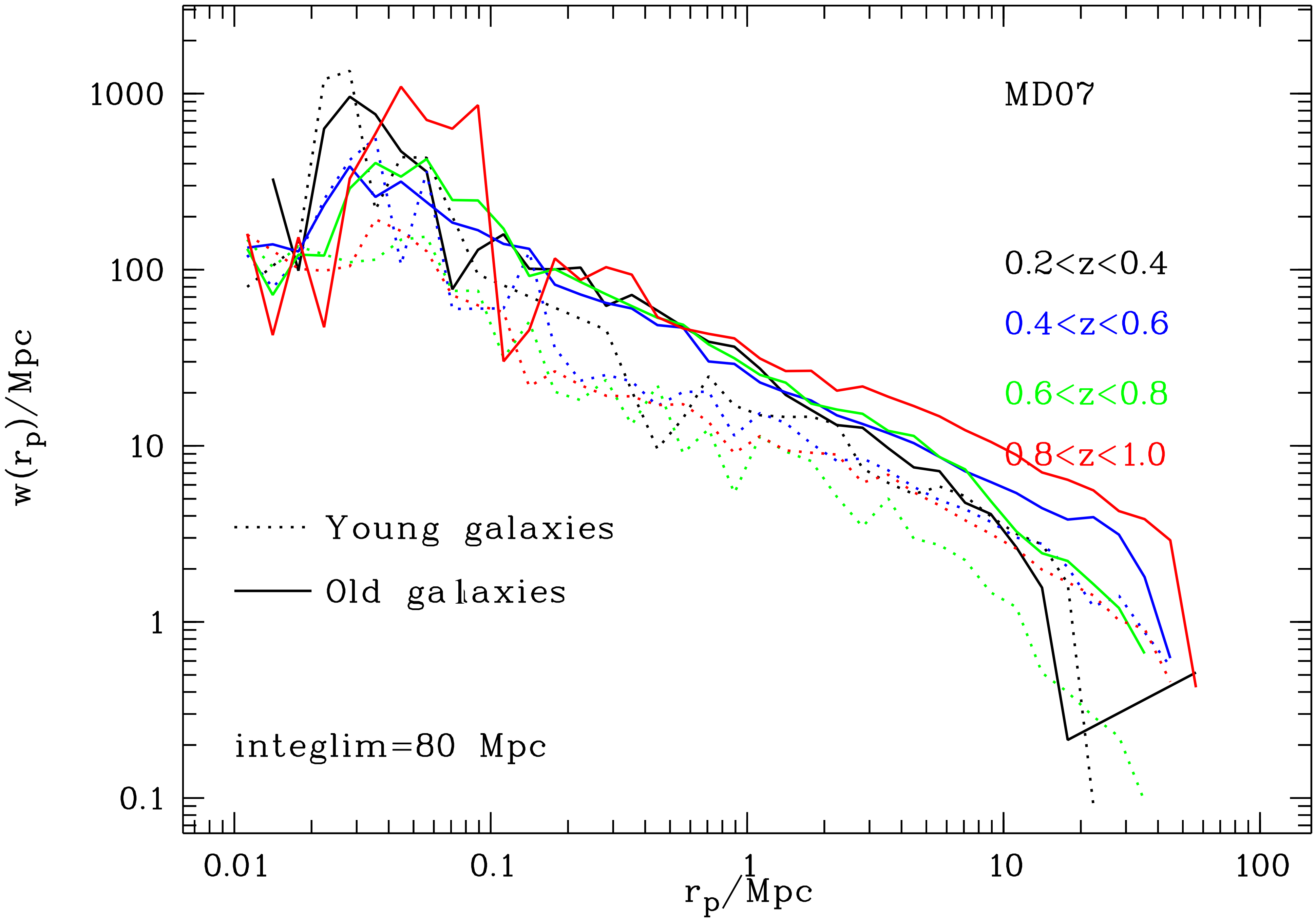
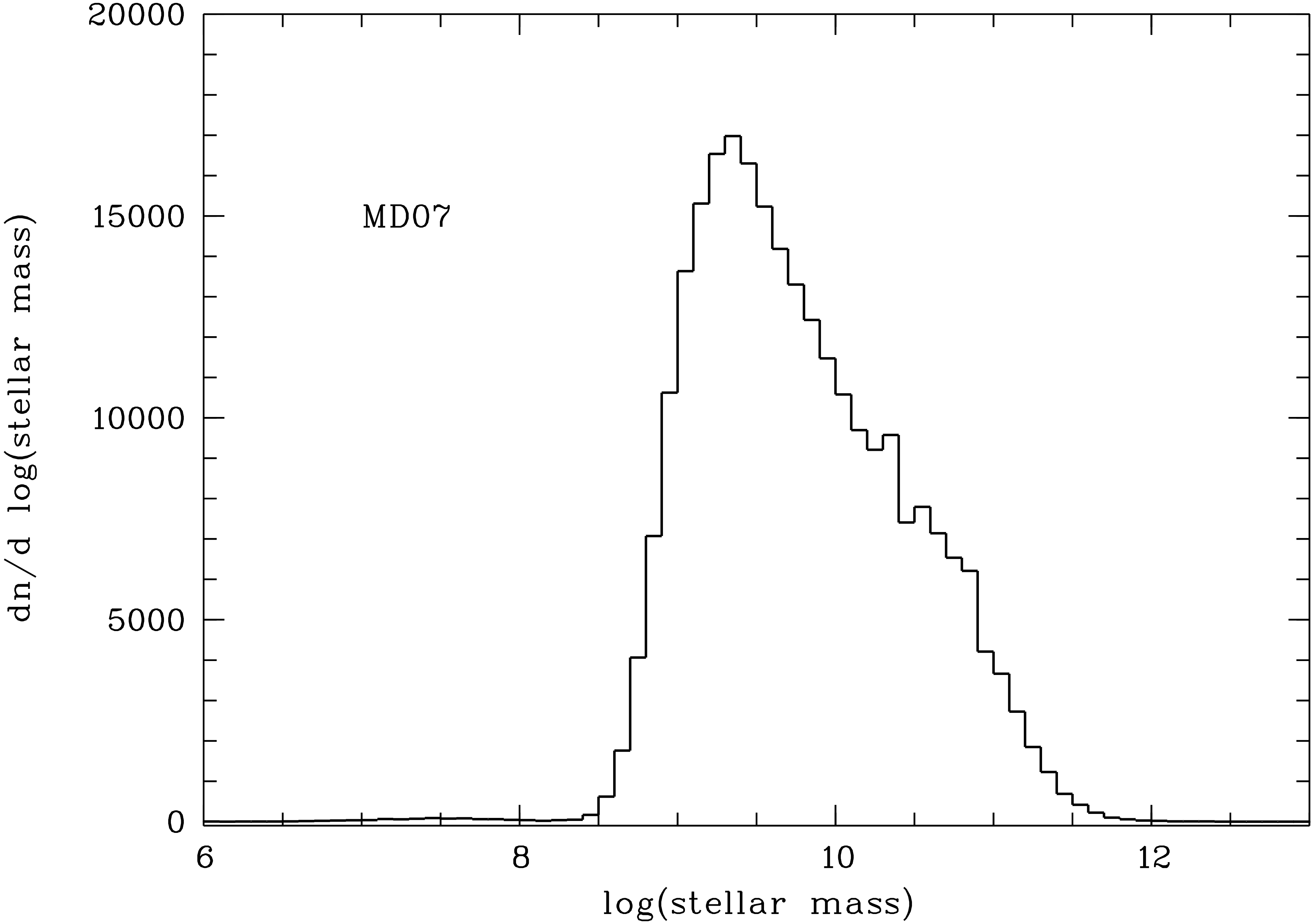


# The correlation functions




Old galaxies are more strongly clustered than young ones

# Distribution of log stellar mass



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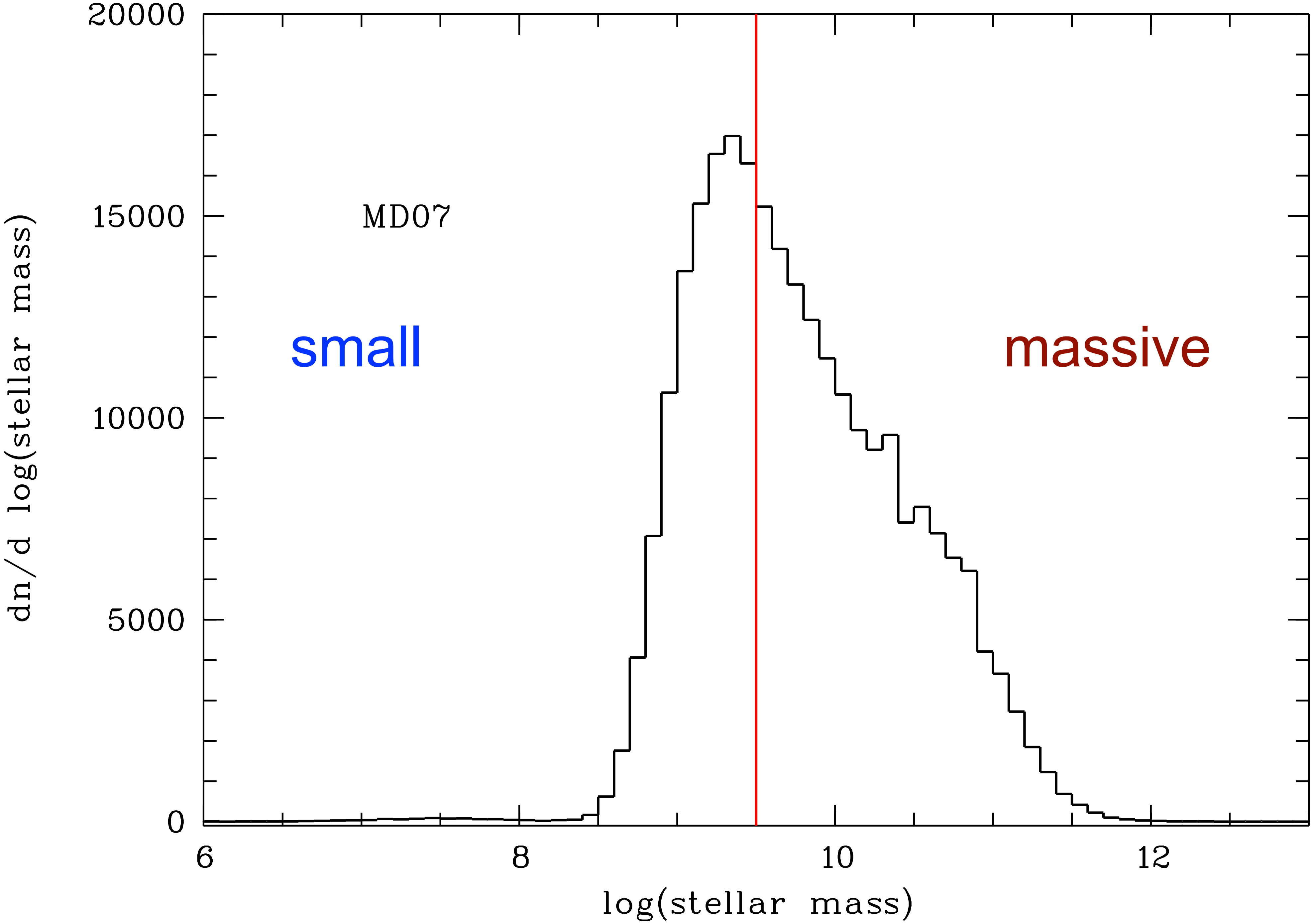
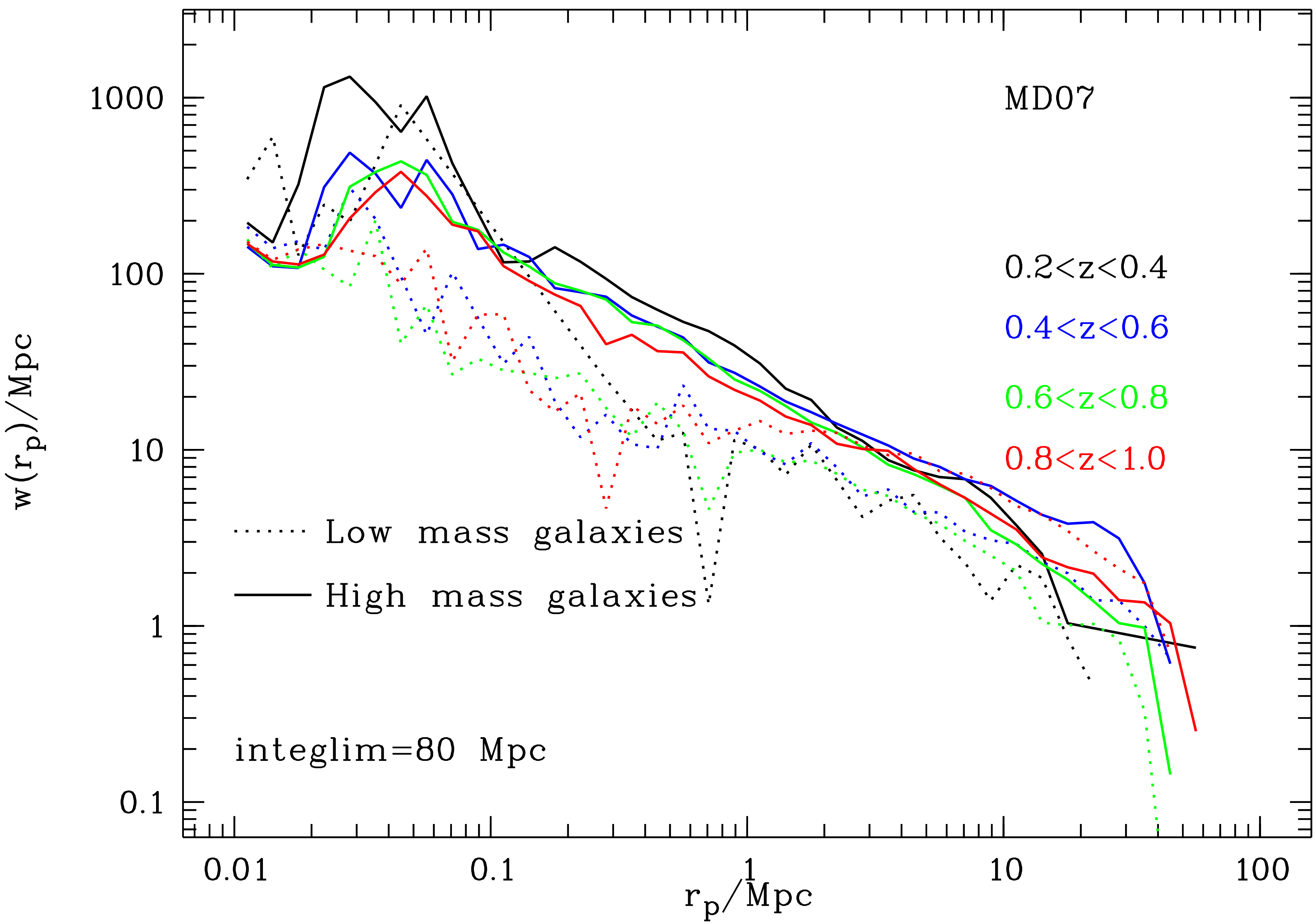
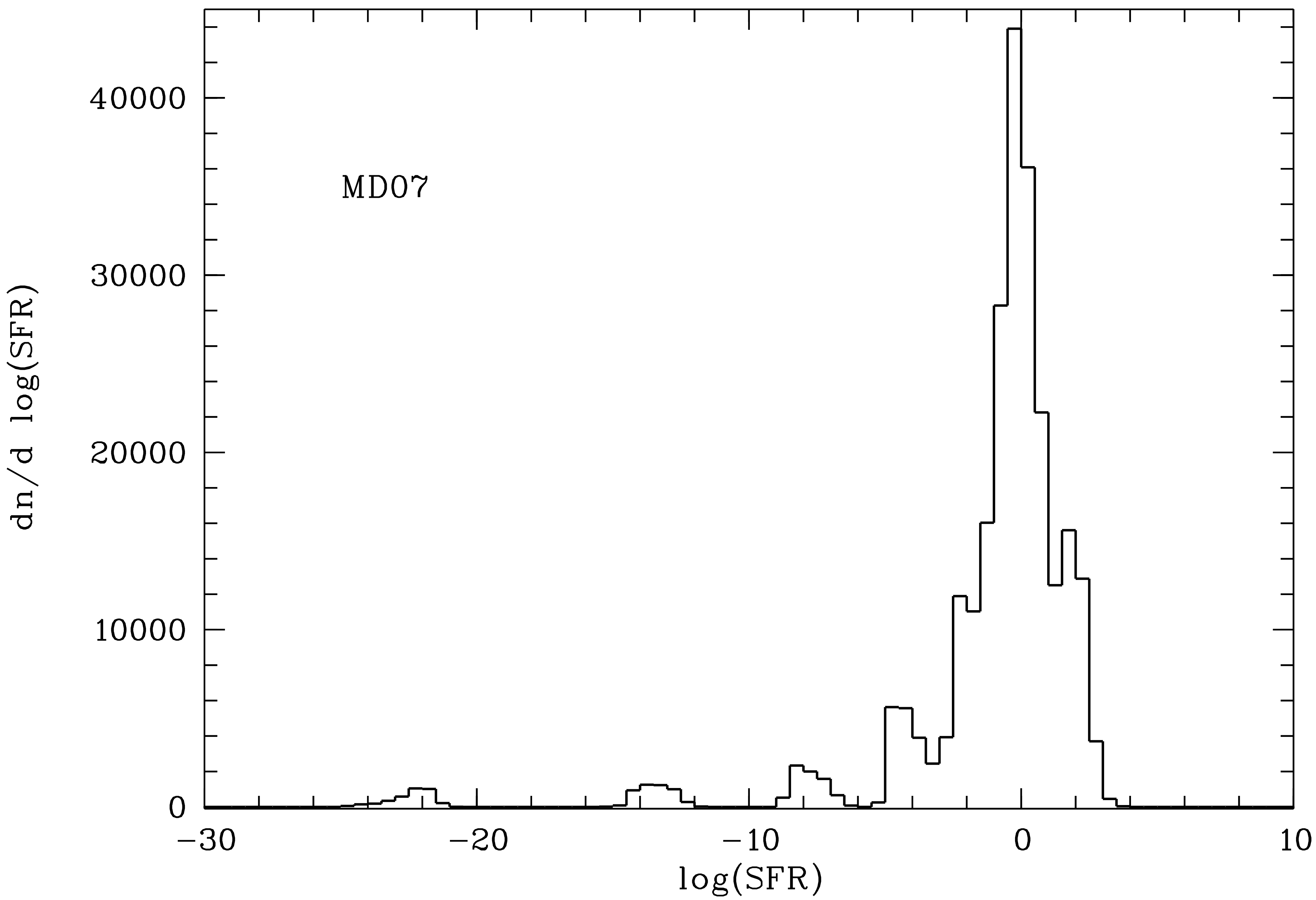


# The correlation functions




Galaxies with high stellar mass are more strongly clustered than those with small stellar mass

# Distribution of log SFR



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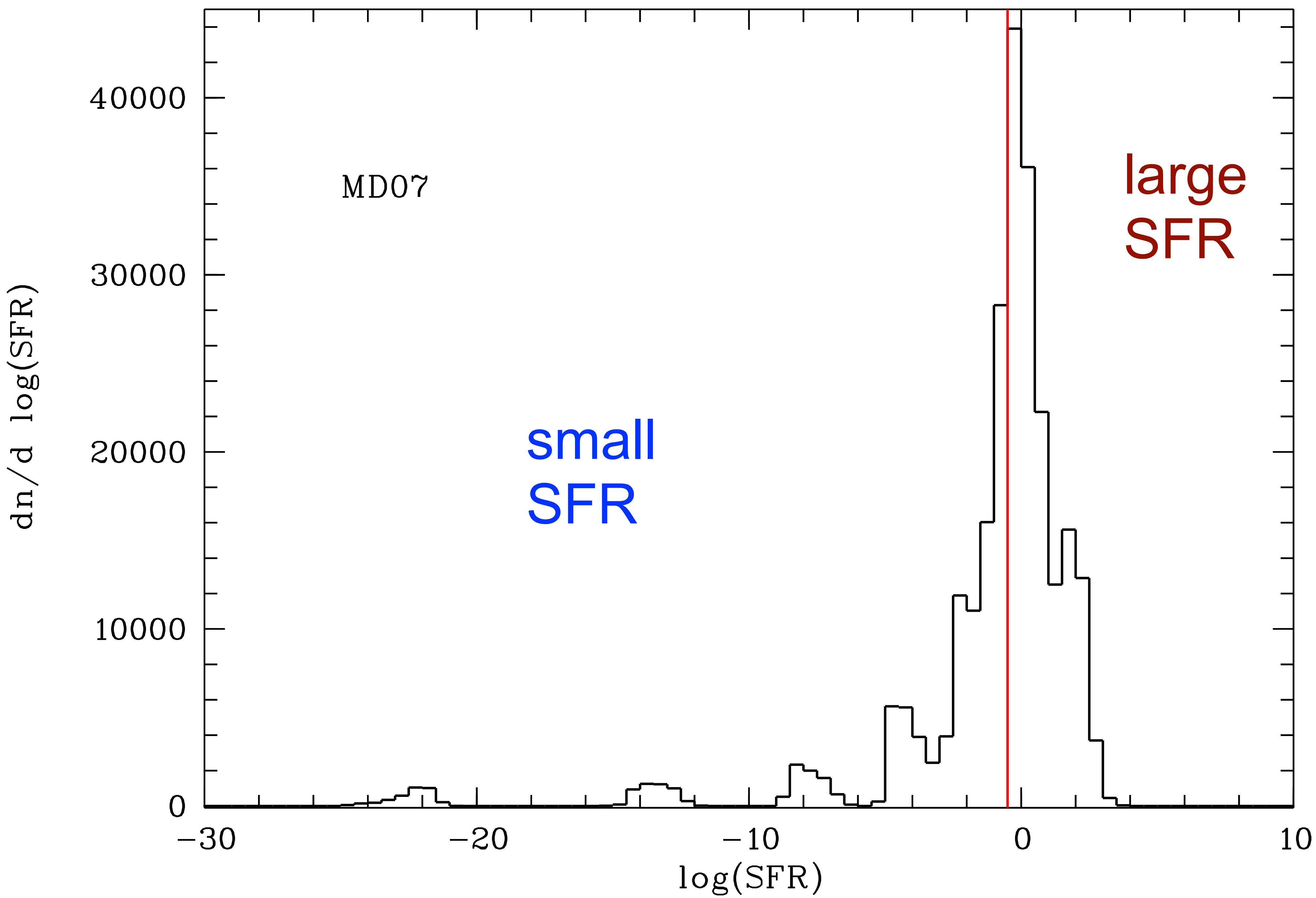
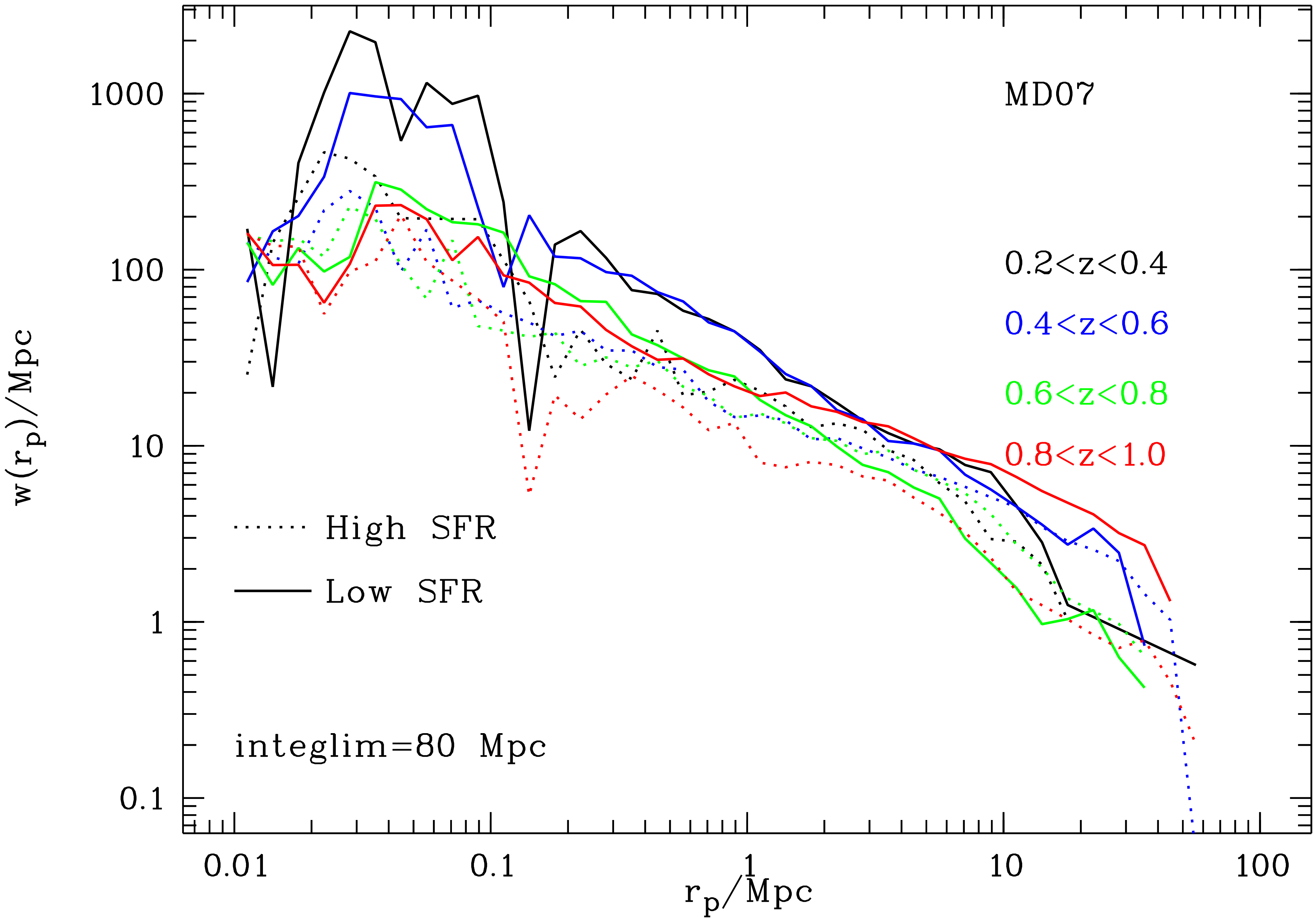
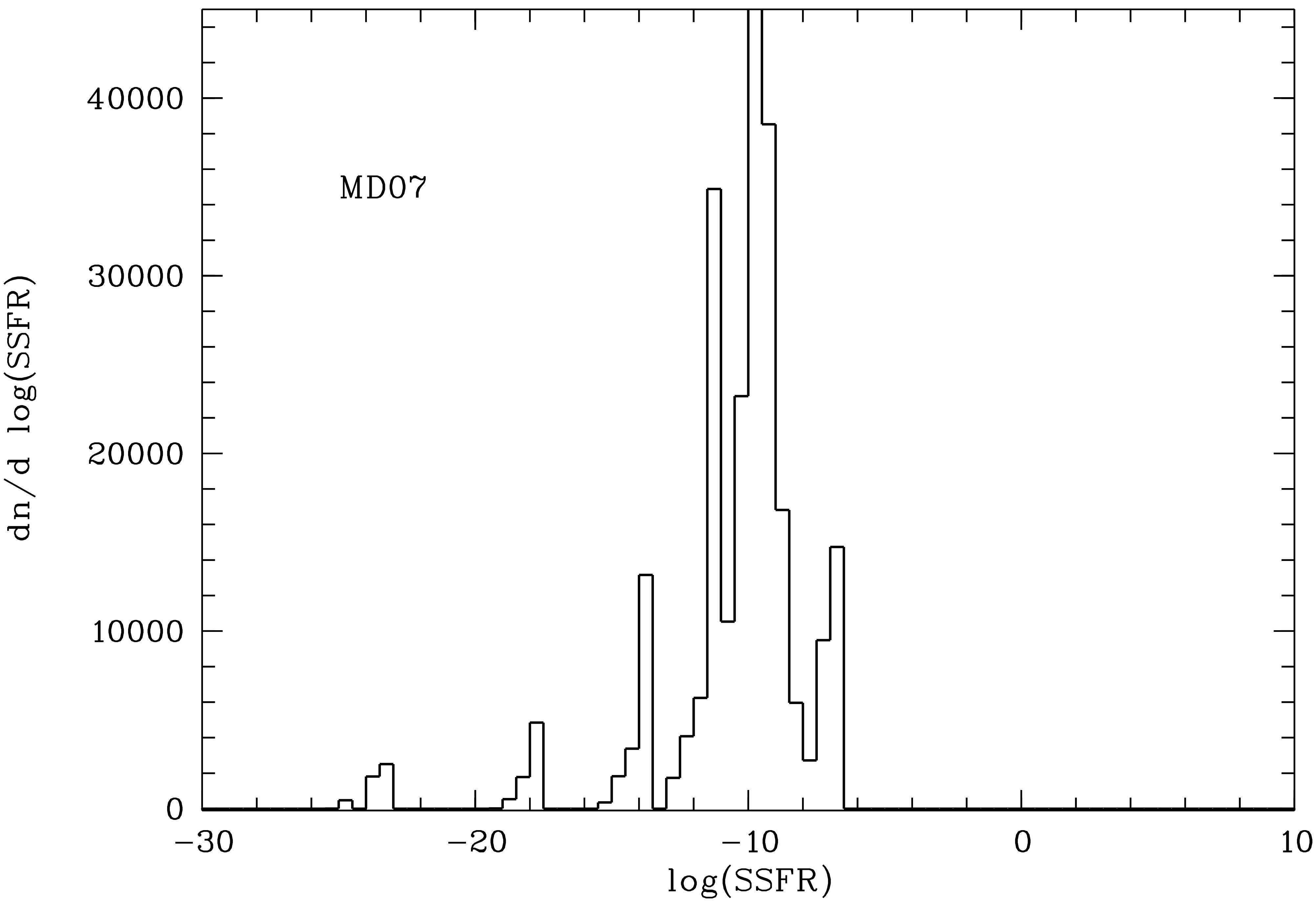


# The correlation functions



# Distribution of log SSFR



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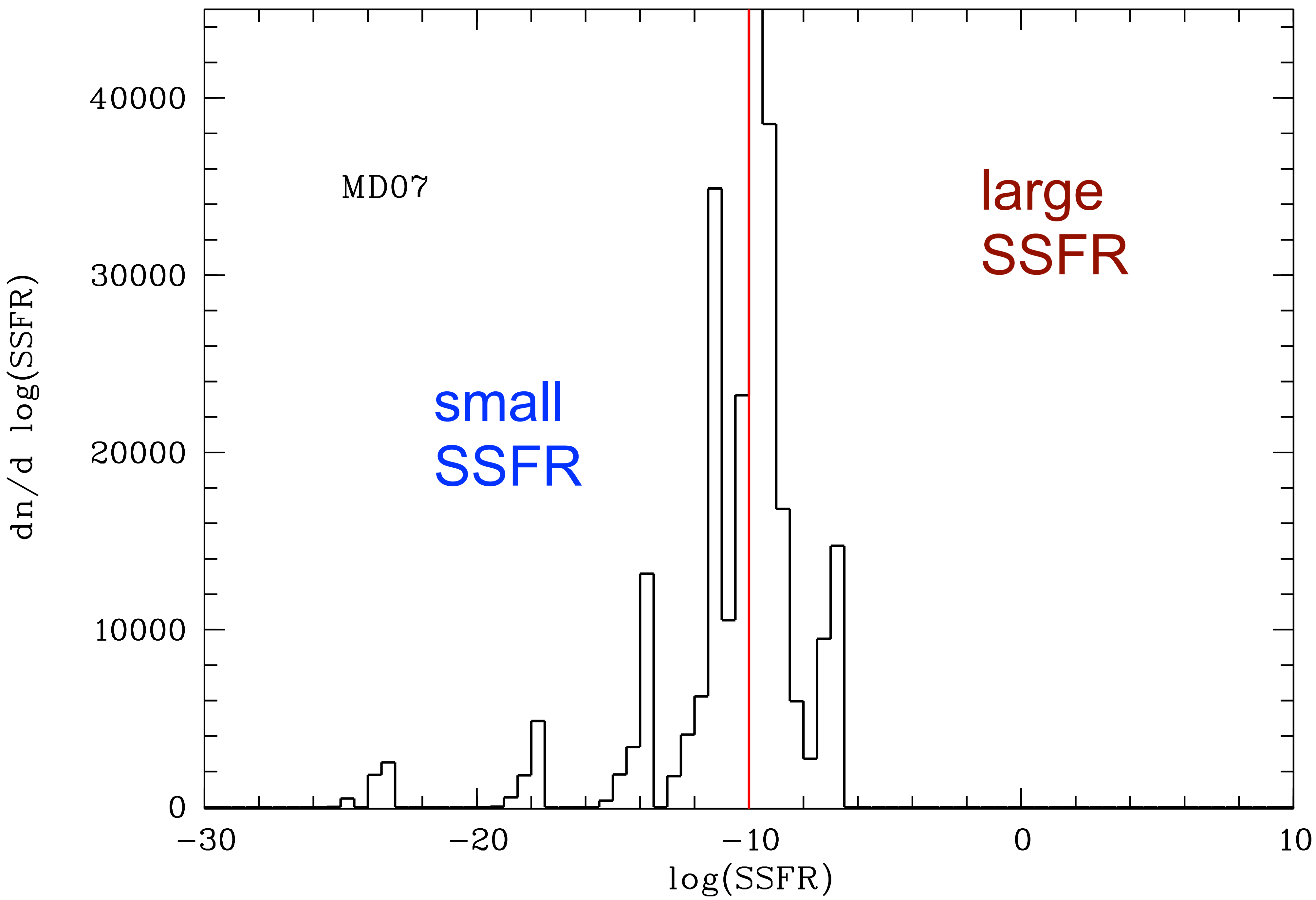

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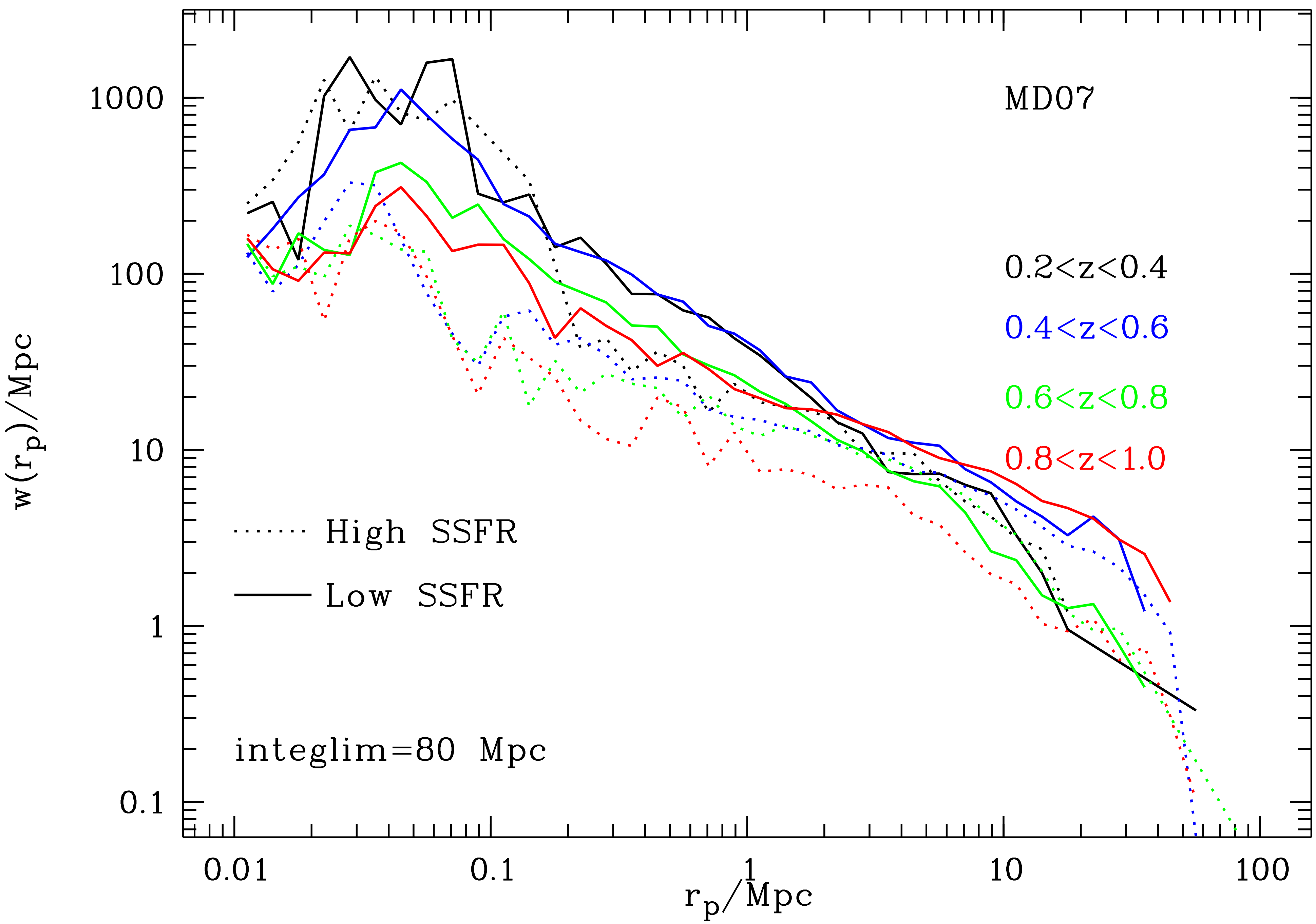

# (Preliminary) results

- Projected correlation functions behave qualitatively as they should
  - Bright is more strongly clustered than faint
  - Red is more strongly clustered than blue
  - Old is more strongly clustered than young
  - Massive is more strongly clustered than small
  - Galaxies with low (S)SFR are is more strongly clustered than those with high (S)SFR

- Amplitude does not grow much with decreasing redshift in all cases

# Future plans

- Improve redshifts and physical parameters, define clean sample
- Run everything for MD04 and eventually all other fields
- Improve random catalogue
  - Got a random distribution in the observed field with ra and dec coordinates
  - picked randomly redshifts from sample under consideration and attached them to the random points
  - This is not ideal, as it may still contain a clustering signal
  - Have to fit the observed distribution and Monte-Carlo simulate the redshifts accordingly
- Improve mask?
- Calculate errors (ideally covariance matrices) for correlation functions
- Fit HOD model and determine DM halo masses

# HOD fitting

- We intend to fit the projected correlation functions with a HOD model
- This will yield typical dark matter halo masses and satellite fractions, etc as a function of galaxy properties
- Information about HOD parameters is encoded in the shape of the correlation function
- Problem: We have to know the redshift error distribution very precisely (probably including outliers)
- because it has to be taken into account in the fit by convolving the redshift space correlation function with a pairwise redshift error distribution function
  - redshift errors change shape of anisotropic correlation function
  - choice of integration limits depends on redshift errors and has to be the same in both data and model

# Summary

- Used Taiwan MD07 data to calculate the projected correlation function of volume limited samples of galaxies in four different redshift bins
- split into
  - colour
  - luminosity
  - age
  - stellar mass
  - star formation rate
  - specific star formation rate
- Found that the preliminary results look promising
- Will fit the correlation functions with a HOD model to determine DM halo mass as a function of galaxy properties