Marked correlation function for Modified gravity test

Yi ZHENG (郑逸)

Korea Institute of Advanced Study (KIAS)

CINY workshop, Sep. 07 2017, YITP

Logic

- Modified gravity to explain cosmic acceleration.
- Meet the stringent constrain of GR in solar system — screening mechanism
- High density regions — screened; low density regions —unscreened — MG signal
- Normal correlation function — dominated by galaxy pairs in high density regions — modulate the density field, upweight low density regions to improve the S/N
- Low density regions — higher shot noise — where is the ‘sweet’ point?
- Linking observations to theory

Logic

- Modified gravity to explain cosmic acceleration.
- Meet the stringent constrain of GR in solar system — screening mechanism
- High density regions — screened; low density regions —unscreened — MG signal
- Normal correlation function — dominated by galaxy pairs in high density regions — modulate the density field, upweight low density regions to improve the S/N
- Low density regions — higher shot noise — where is the ‘sweet’ point?
- Linking observations to theory

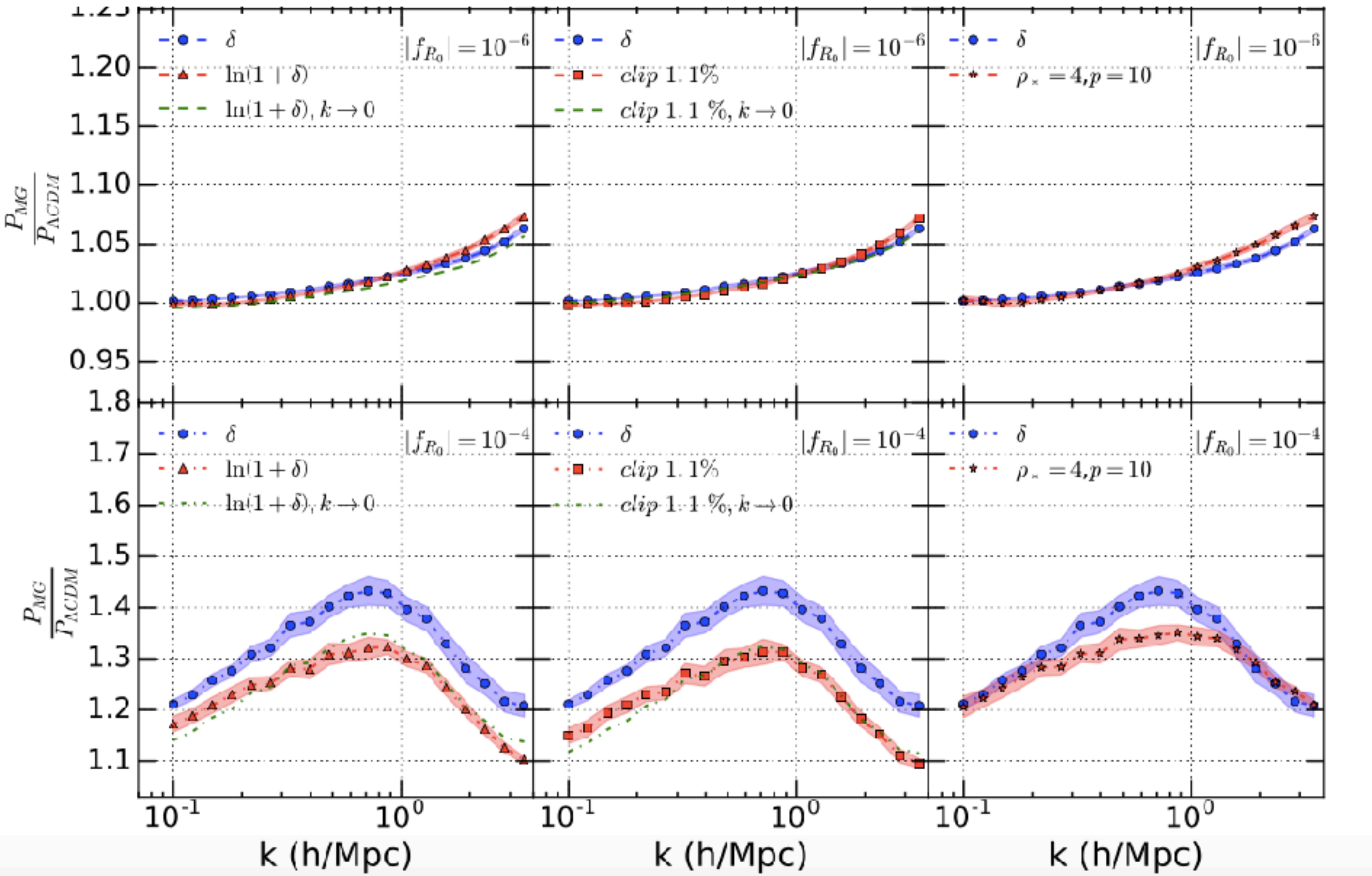
Ways modulating the density field

- 1. Logarithmic transformation $$\delta' = \ln(\delta + 1)$$
- 2. Clipped transformation $$\delta' = \delta_c = \begin{cases} \delta & \text{if } \delta < \delta_0 \\ \delta_0 & \text{if } \delta > \delta_0. \end{cases}$$
- 3. Marked transformation $$\delta' = m(\delta) = \left(\frac{\rho_* + 1}{\rho_* + \rho_m}\right)^p = \left(\frac{\rho_* + 1}{\rho_* + \bar{\rho}_m(\delta + 1)}\right)^p$$

1708.05652, 1704.02960, 1107.5169, 1609.08632

Dark matter test, e.g. f(R)

Valogiannis&Rachel, 1708.05652



$$SNR = \sqrt{\sum_{i,j}^{N_{bins}} \bar{P}(k_i) C_{ij}^{-1} \bar{P}(k_j)},$$

$$\text{SNR boost} = \frac{\text{SNR}(\delta')}{\text{SNR}(\delta)}$$

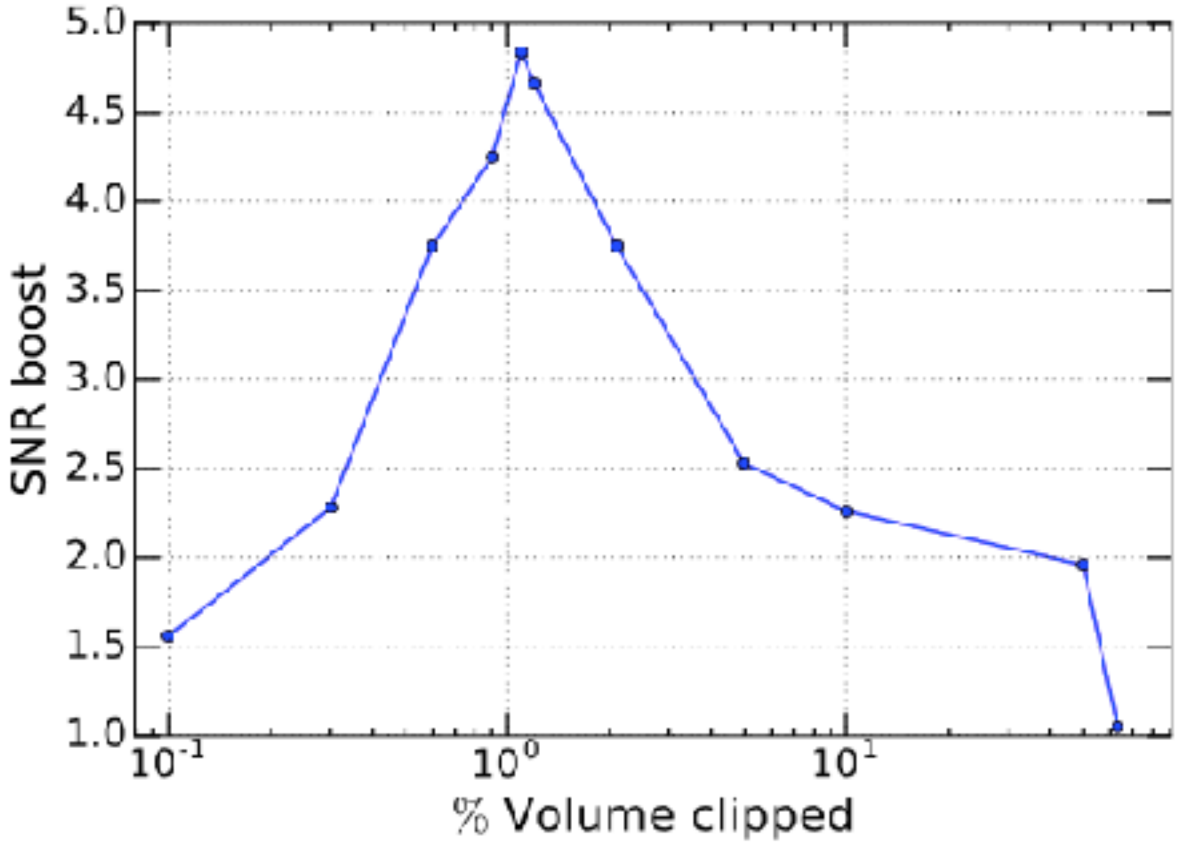


FIG. 2: The variation of the signal-to-noise ratio (SNR) boost, defined in (17), for the clipped ΛCDM density transformation relative to the normal density distribution, as a function of the clipping threshold, shown as the % of the simulation volume that is clipped (i.e. has $\delta > \delta_0$).

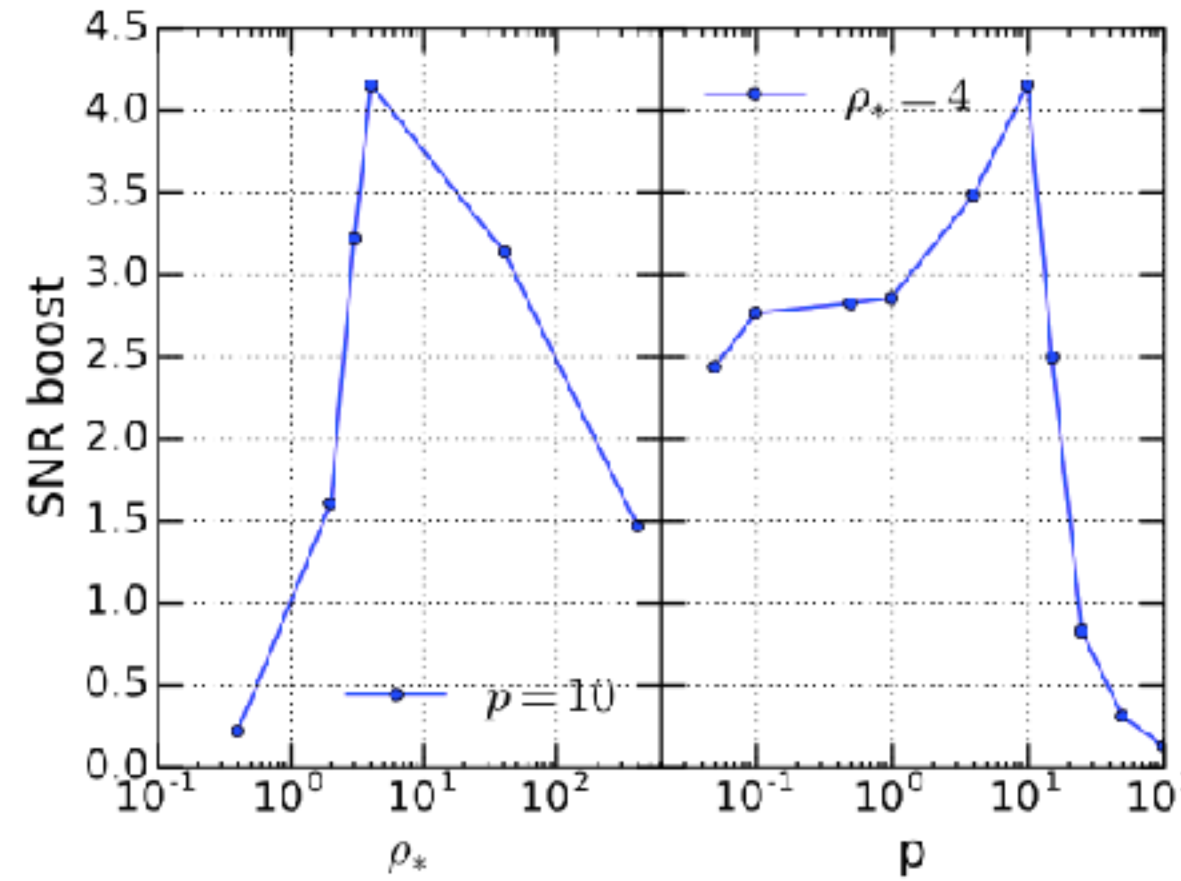
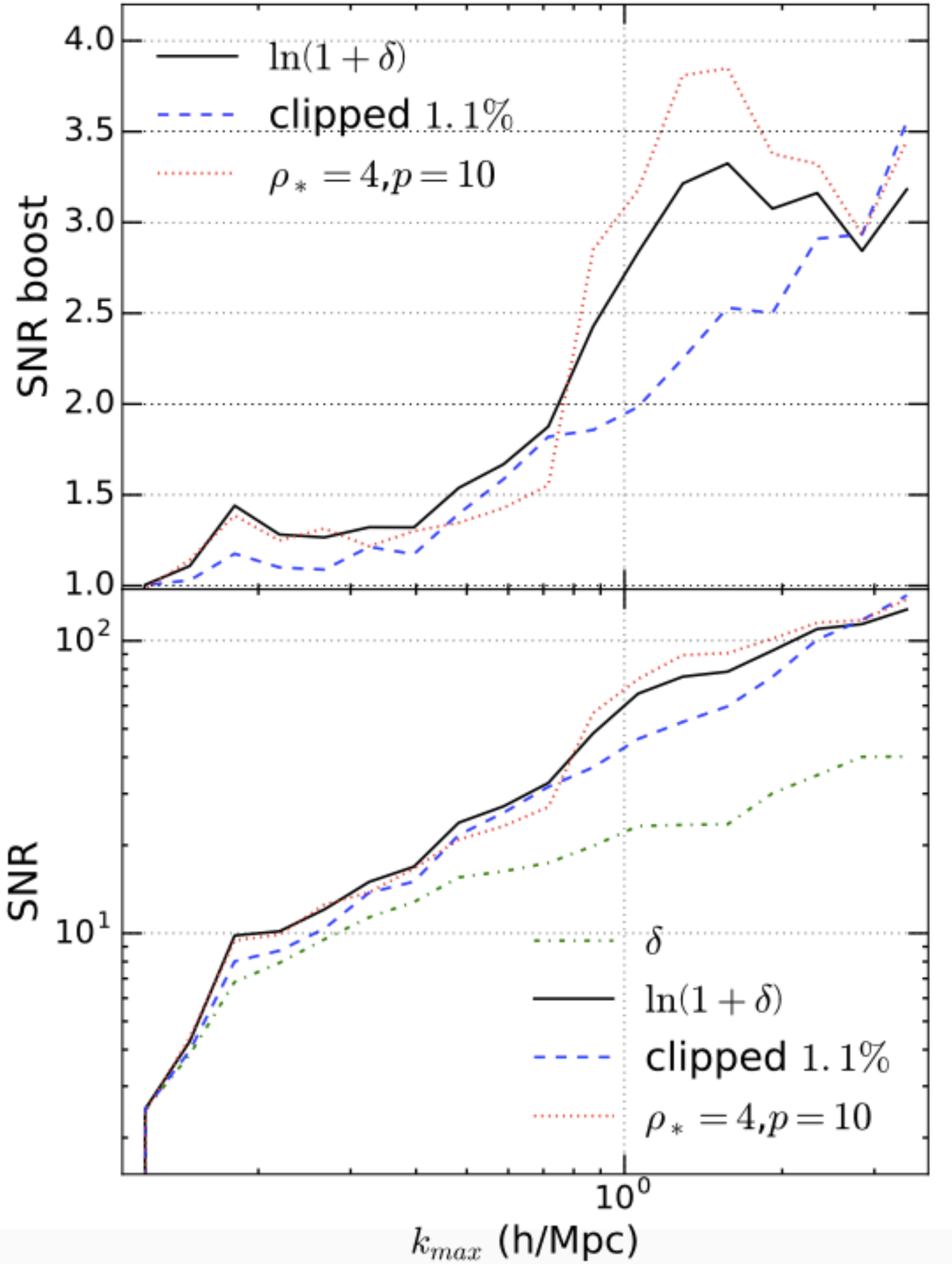


FIG. 3: The variation of the signal-to-noise ratio (SNR) boost, defined in (17), for the marked transformation in a ΛCDM scenario, as a function of [left] ρ_*, with fixed $p = 10$, and [right] p, with fixed $\rho_* = 4$.

Valogiannis&Rachel, 1708.05652



Valogiannis&Rachel, 1708.05652

$$SNR = \sqrt{\sum_{i,j}^{N_{bins}} \bar{P}(k_i) C_{ij}^{-1} \bar{P}(k_j)},$$

$$\text{SNR boost} = \frac{\text{SNR}(\delta')}{\text{SNR}(\delta)}$$

Mock galaxy test, e.g. f(R) and normal-branch DGP

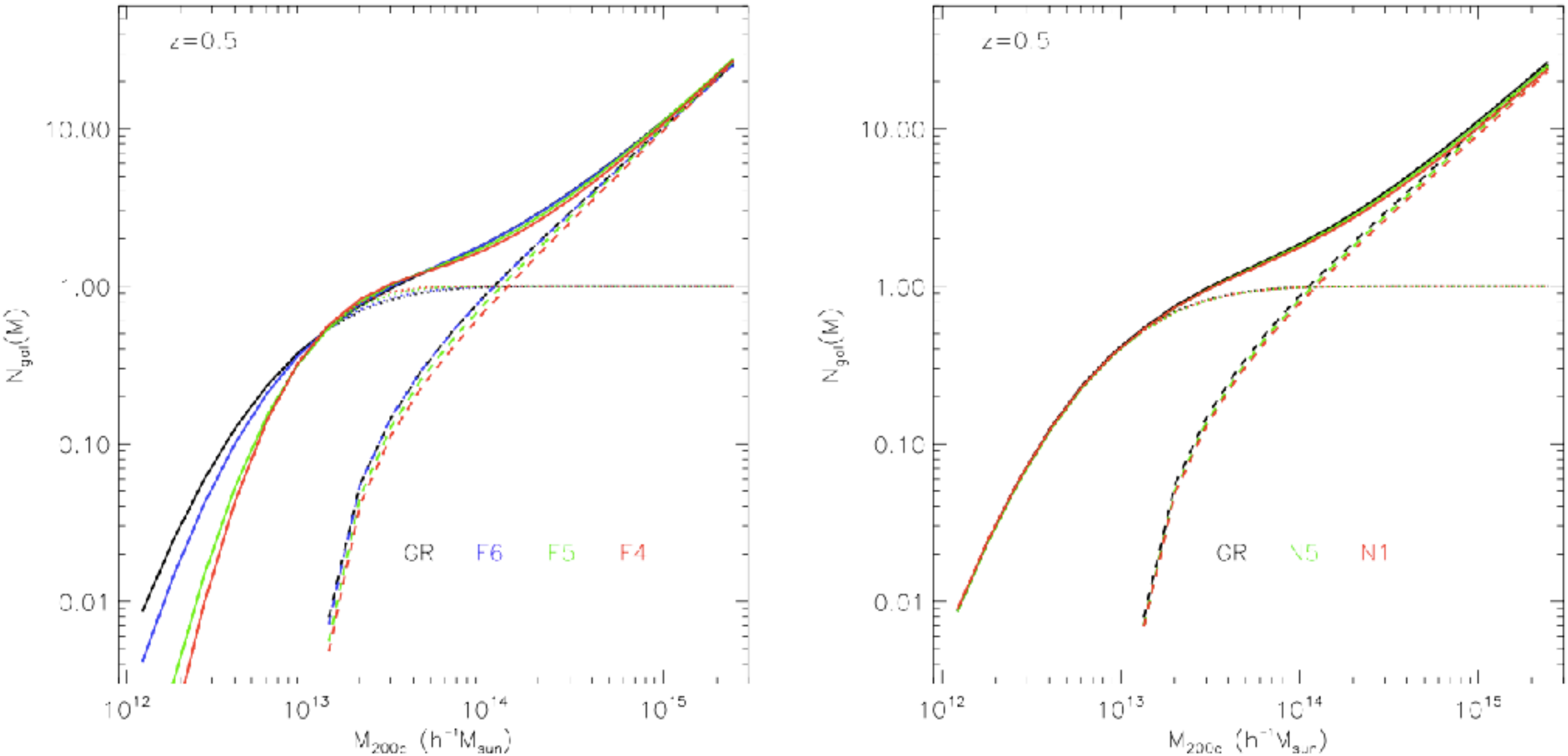
```
------
Models
------

GR        LCDM w/o massive neutrinos in WMAP-9 cosmology (see below)
F6        Hi-Sawicki f(R) with n=1 and f_R0=-1E-6                    (weak   deviation from GR)
F5        Hi-Sawicki f(R) with n=1 and f_R0=-1E-5                    (medium deviation from GR)
F4        Hi-Sawicki f(R) with n=1 and f_R0=-1E-4                    (strong deviation from GR)
N5        normal-branch Dvali-Gabadadze-Poratti model with r_c*H0=0.5 (medium deviation from GR)
N1        normal-branch Dvali-Gabadadze-Poratti model with r_c*H0=0.1 (strong deviation from GR)
```

```
------------------------
Cosmological parameters
------------------------

Cosmology        WMAP9
Omega_b          0.046
Omega_cdm        0.235
Omega_m          0.281
Omega_L          0.719
h                0.697
n_s              0.971
sigma_8          0.820
```

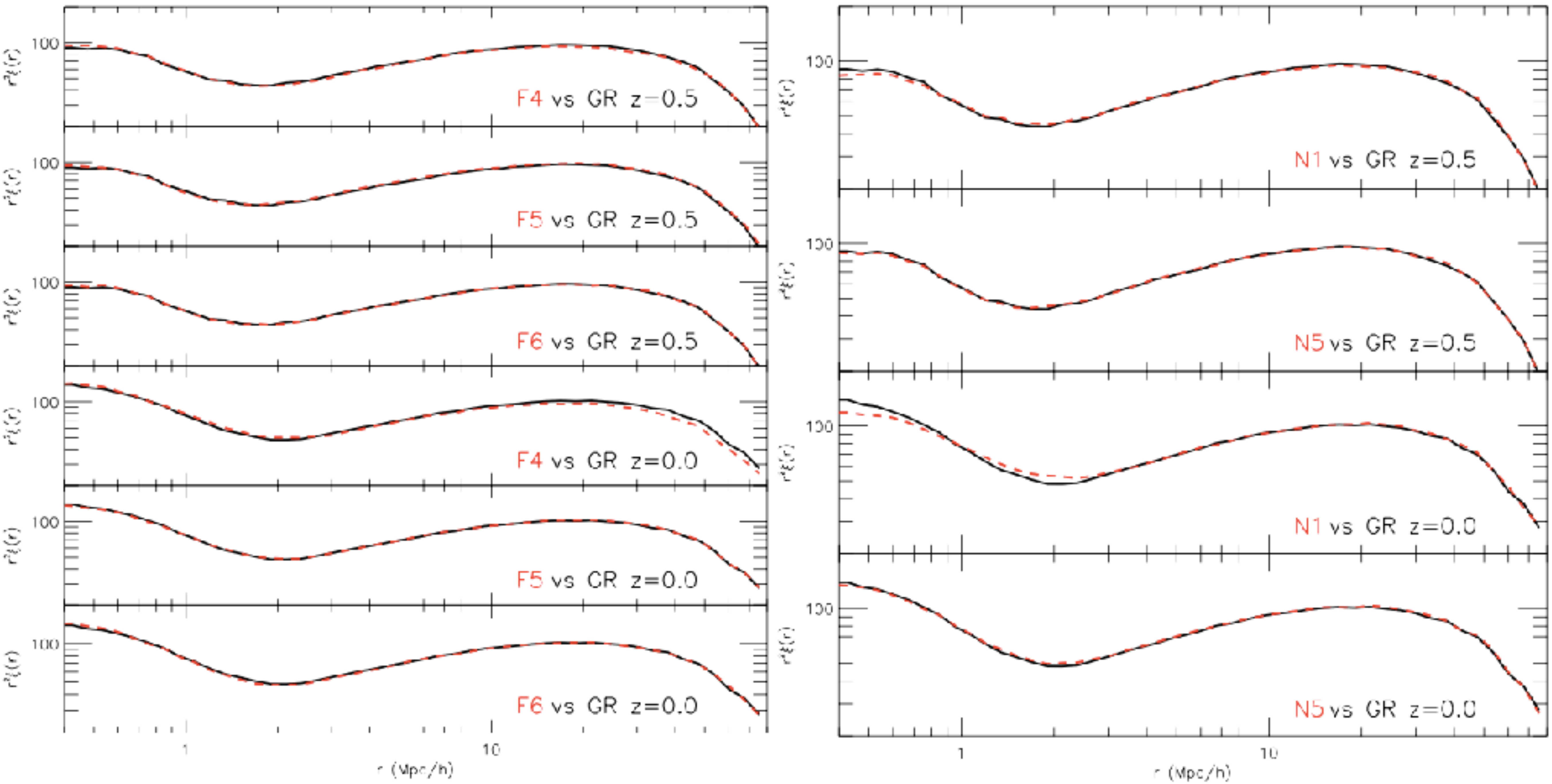
```
--------------
HOD catalogues
--------------

HOD Model taken from Eq.(16) of Manera et al., 2013, MNRAS 428, 1036 (M13),
with the following 5 HOD parameters:

1. M_min                 (for GR 13.09)
2. sigma_logM            (for GR 0.596)
3. M_0                   (for GR 13.077)
4. M_1                   (for GR 14.00)
5. alpha                 (for GR 1.0127)

of which 1 & 2 control central galaxies, while 1-5 control satellites.
```

Made by Baojiu Li

Adopted HOD paramter values for GR are given above; for modified gravity models the HOD parameters are tuned such that their predicted galaxy number density and galaxy 2-point correlation functions (in 3D real space and implicitly the projected 2-point correlatin functions) match the values in the corresponding GR HOD catalogue.



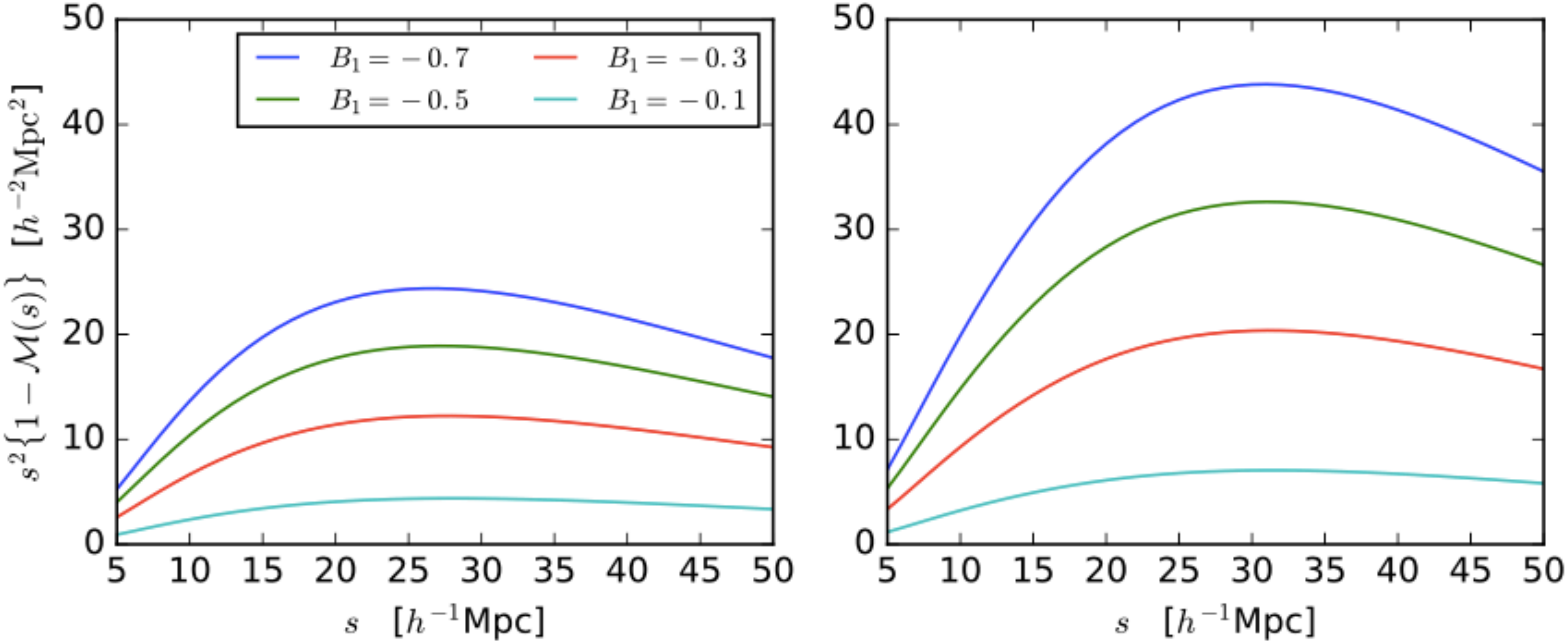
Made by Baojiu Li



Made by Baojiu Li

Marked correlation function

$$\mathcal{M}(r) \equiv \frac{1}{n(r)\bar{m}^2}\sum_{ij} m_i m_j = \frac{1+W}{1+\xi} \qquad m = \left(\frac{\rho_\star + 1}{\rho_\star + \rho_R}\right)^p$$

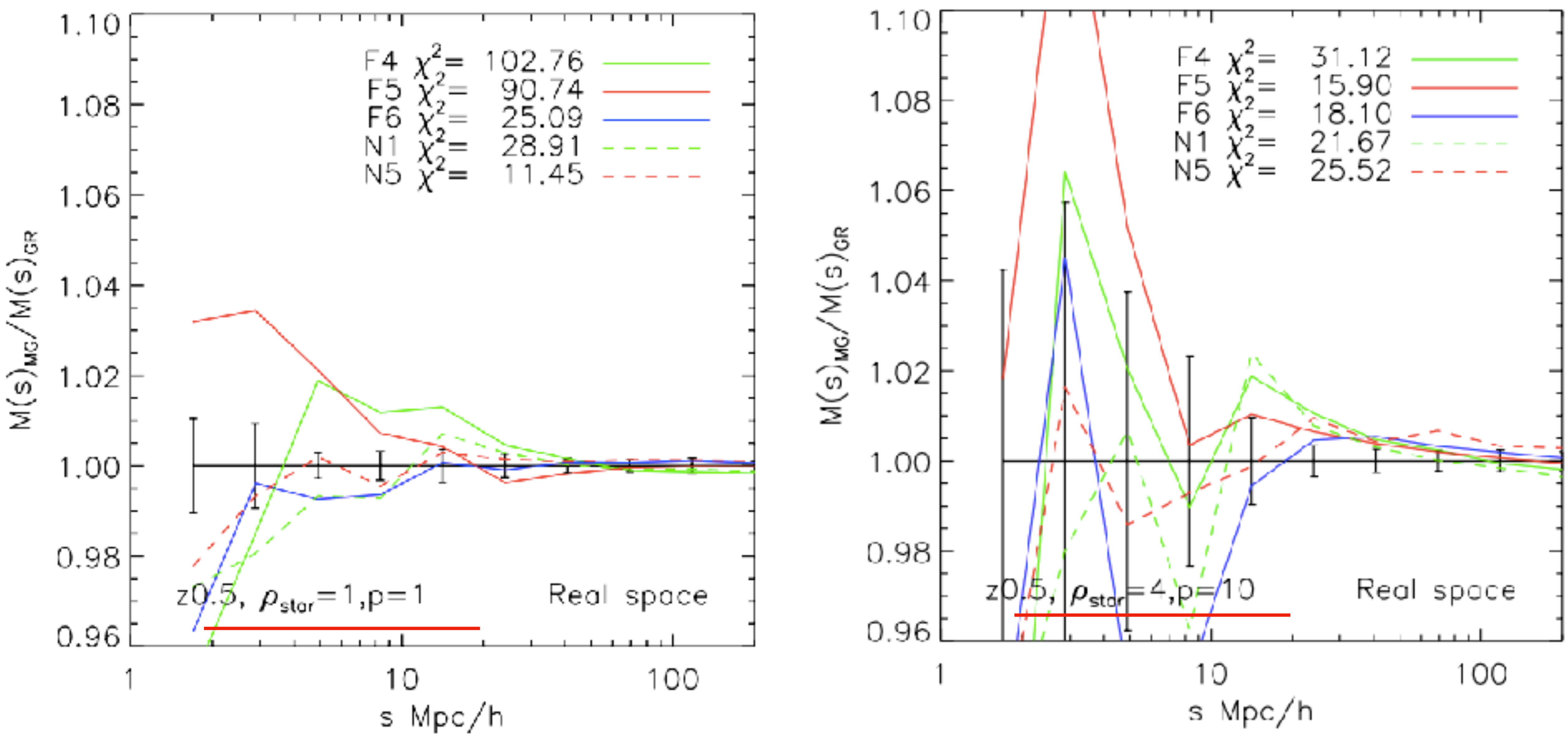


Martin White, 1609.08632

We use spline kernel interpolation to calculate \rho_R, nearest 20 particles

$$\rho_R = \sum_{1}^{20} W(r_i, h), \qquad W(r,h) = \frac{8}{\pi h^3} \begin{cases} 1 - 6\left(\frac{r}{h}\right)^2 + 6\left(\frac{r}{h}\right)^3, & 0 \le \frac{r}{h} \le \frac{1}{2}, \\ 2\left(1 - \frac{r}{h}\right)^3, & \frac{1}{2} < \frac{r}{h} \le 1, \\ 0, & \frac{r}{h} > 1. \end{cases} \qquad m = \left(\frac{\rho_\star + 1}{\rho_\star + \rho_R}\right)^p$$

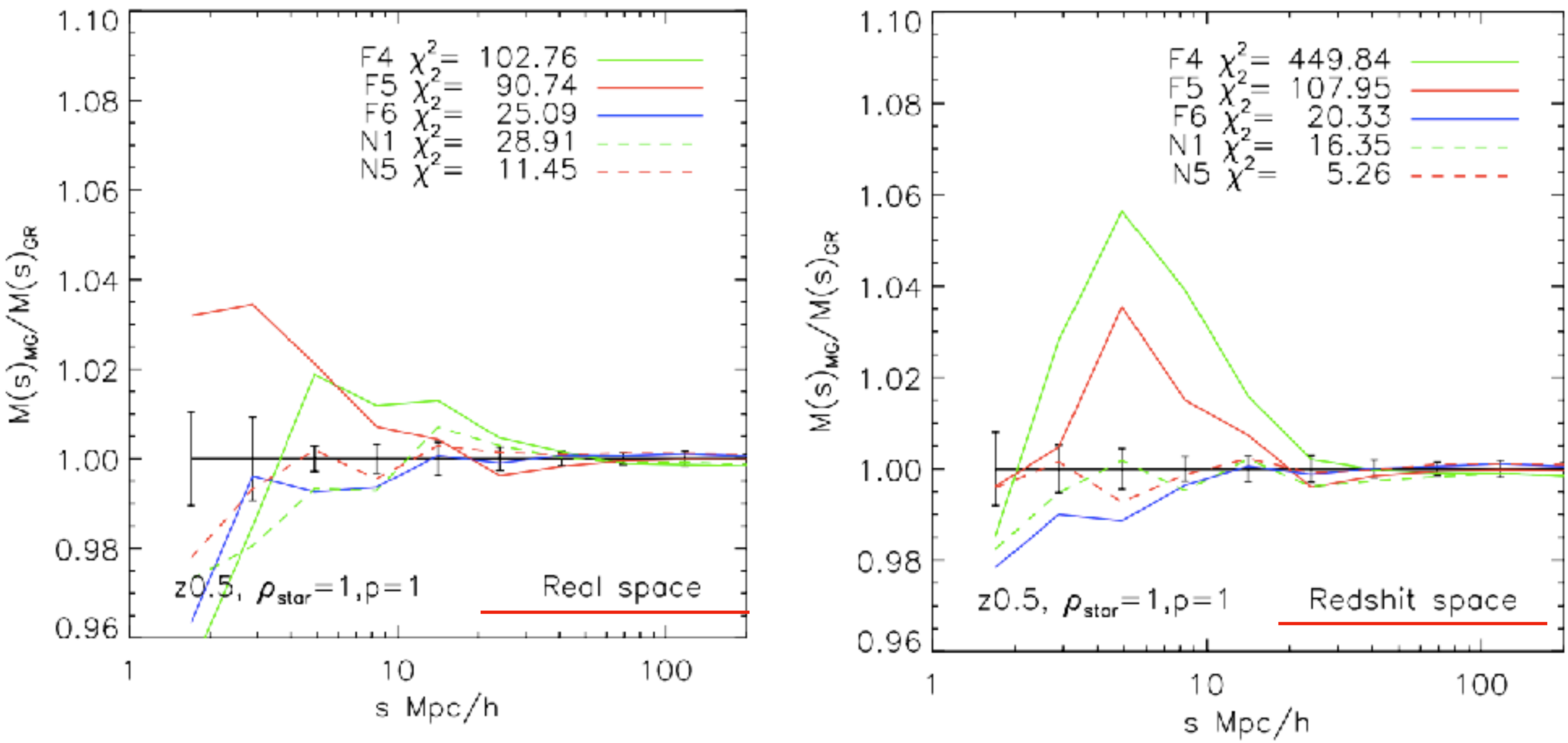
Very preliminary !



We use spline kernel interpolation to calculate \rho_R, nearest 20 particles

$$\rho_R = \sum_{1}^{20} W(r_i, h), \qquad W(r,h) = \frac{8}{\pi h^3} \begin{cases} 1 - 6\left(\frac{r}{h}\right)^2 + 6\left(\frac{r}{h}\right)^3, & 0 \le \frac{r}{h} \le \frac{1}{2}, \\ 2\left(1-\frac{r}{h}\right)^3, & \frac{1}{2} < \frac{r}{h} \le 1, \\ 0, & \frac{r}{h} > 1. \end{cases} \qquad m = \left(\frac{\rho_\star + 1}{\rho_\star + \rho_R}\right)^p$$

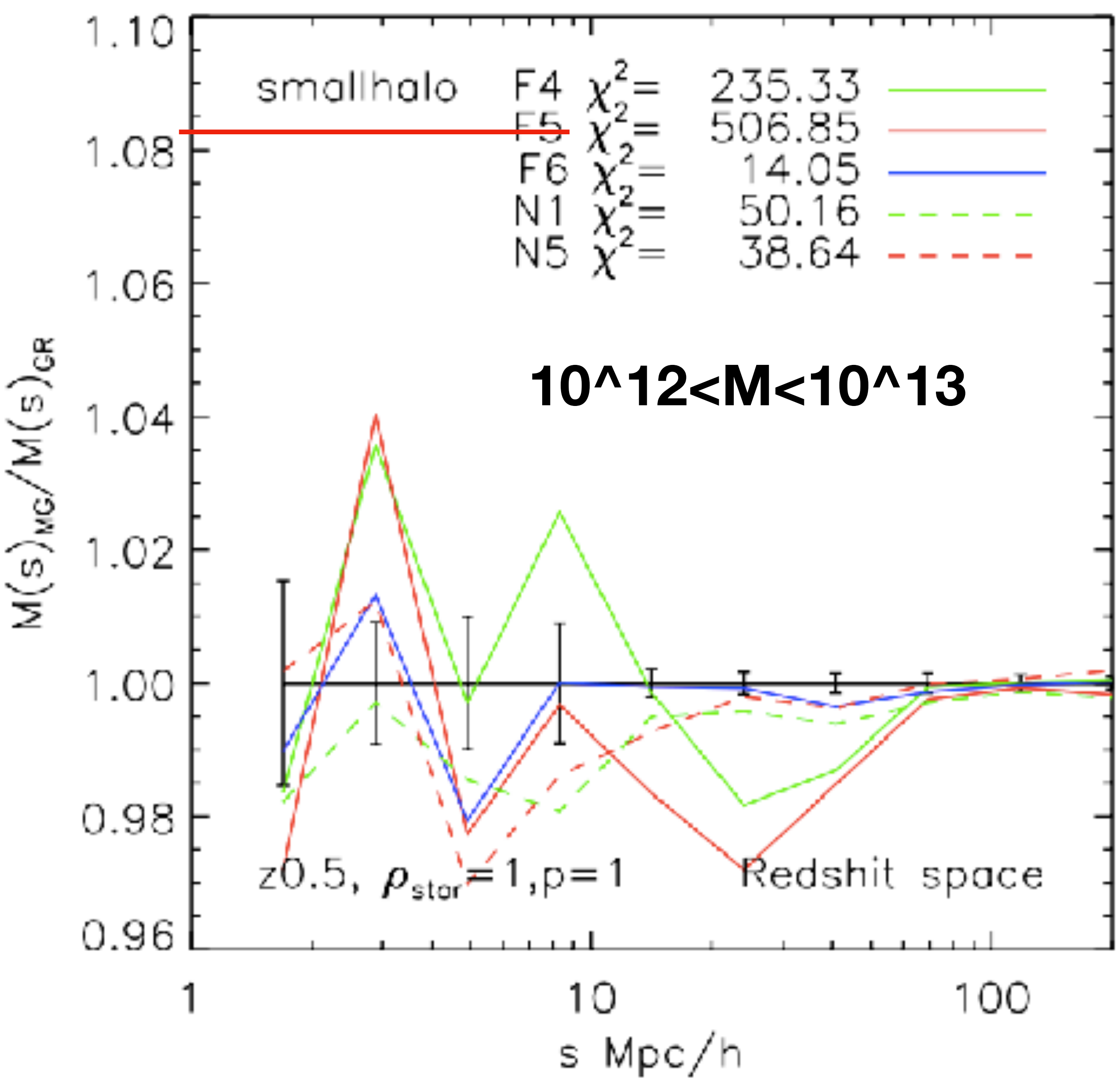
Very preliminary !

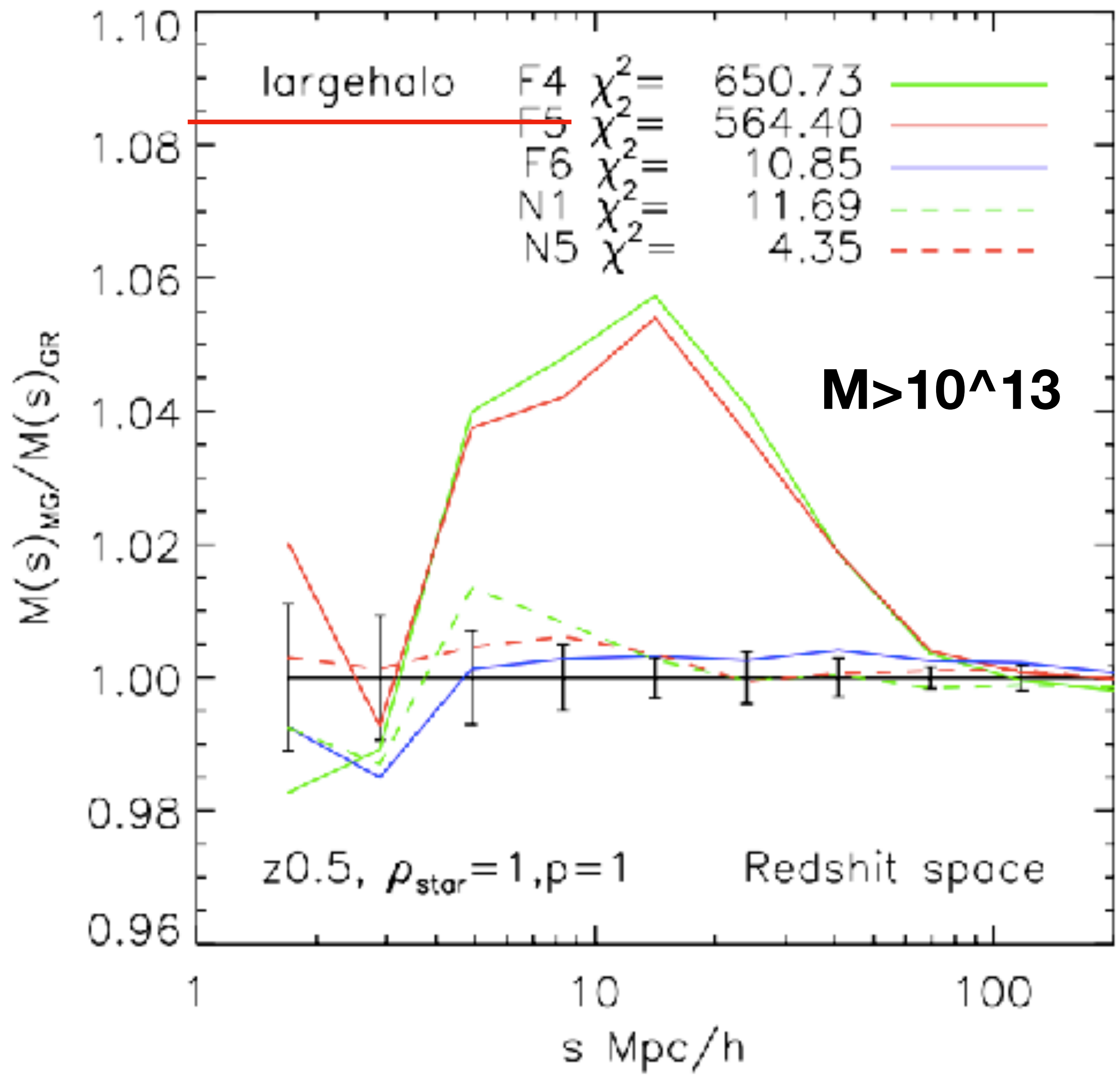


We use spline kernel interpolation to calculate \rho_R, nearest 20 particles

$$\rho_R = \sum_{1}^{20} W(r_i, h), \qquad W(r,h) = \frac{8}{\pi h^3}\begin{cases} 1 - 6\left(\frac{r}{h}\right)^2 + 6\left(\frac{r}{h}\right)^3, & 0 \le \frac{r}{h} \le \frac{1}{2}, \\ 2\left(1-\frac{r}{h}\right)^3, & \frac{1}{2} < \frac{r}{h} \le 1, \\ 0, & \frac{r}{h} > 1. \end{cases} \qquad m = \left(\frac{\rho_\star + 1}{\rho_\star + \rho_R}\right)^p$$

Very preliminary !





Discussions

- HOD galaxy mock? Sample variance.
- Fiber collision?
- Theoretical prediction? Degeneracy with halo bias?
- Multi-tracer?