Strong orientation dependence of surface mass density profiles of dark haloes at large scales

Statistical challenges for large-scale structure in the era of LSST
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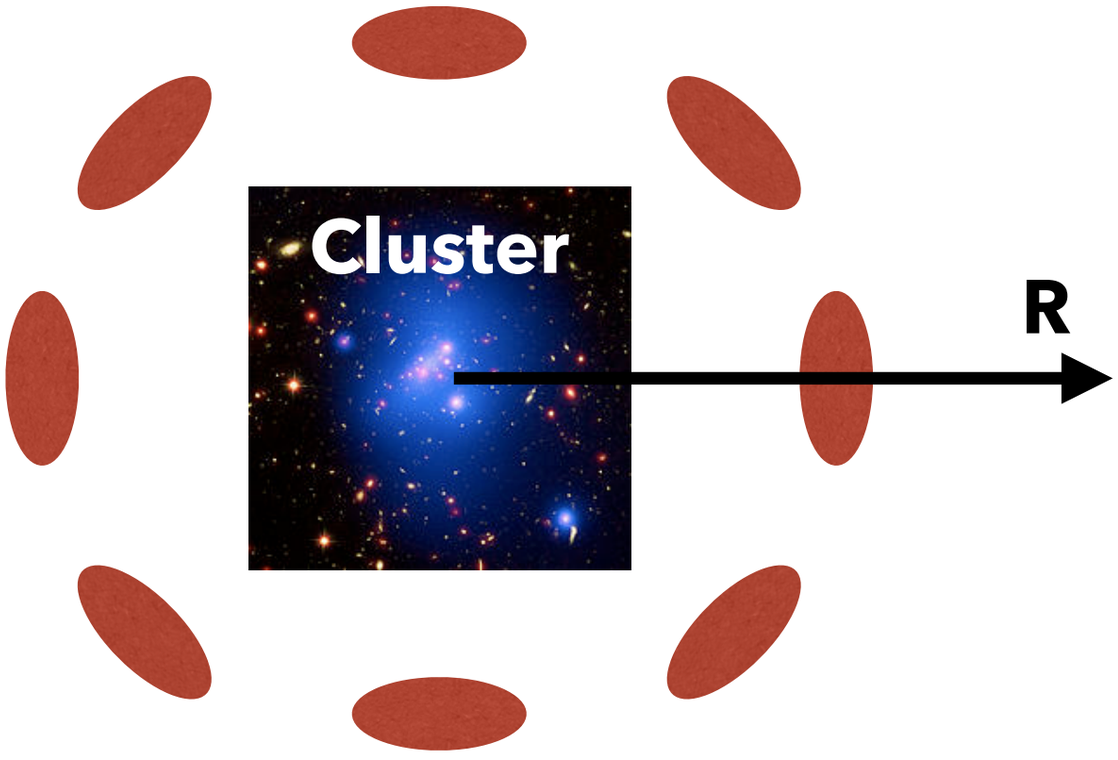
MNRAS in press (arXiv: 1712.00094)

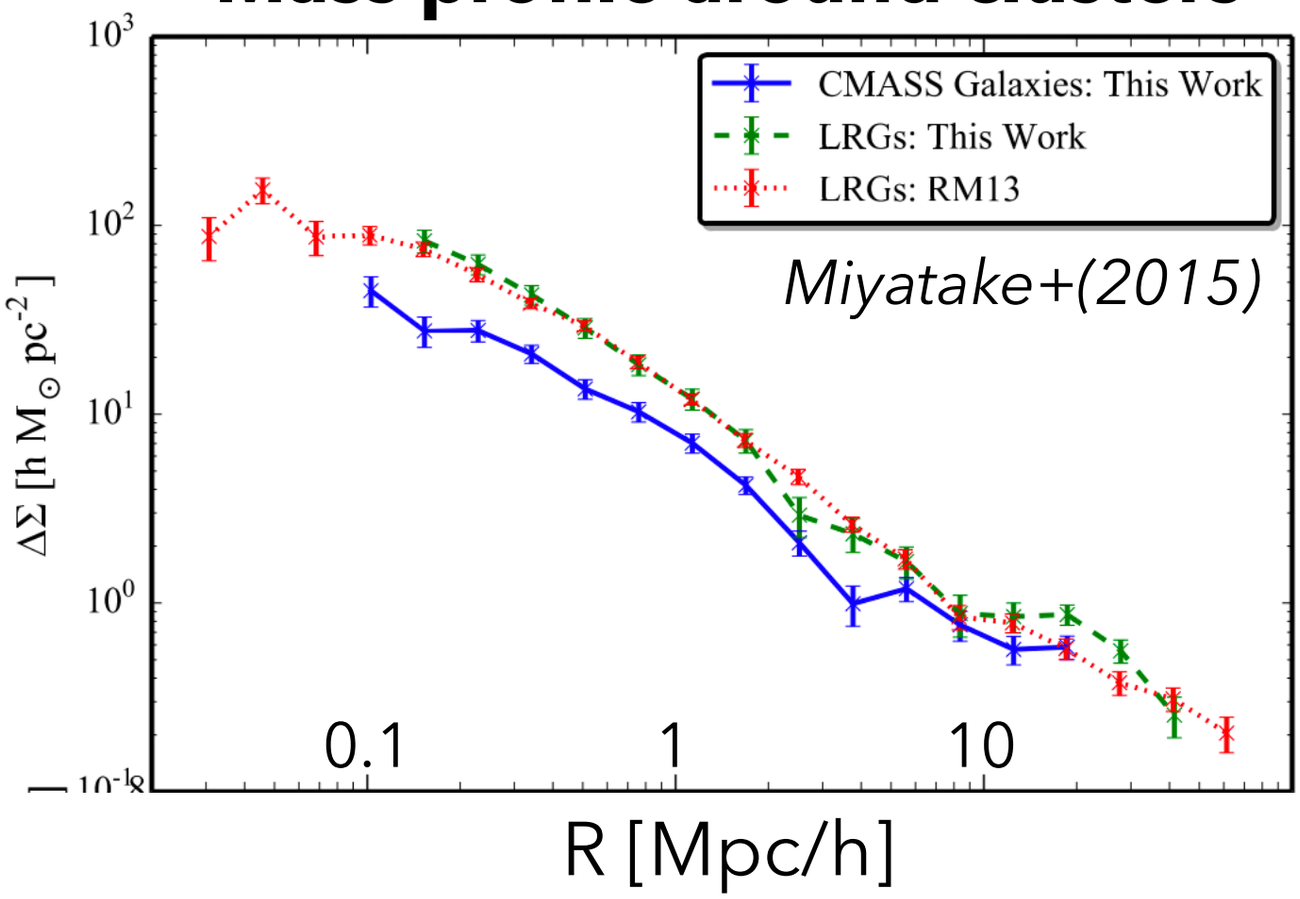
Galaxy-Galaxy Lensing

✦Galaxy-galaxy lensing (stacked lensing)

$$\gamma_t = \frac{\Delta\Sigma(R)}{\Sigma_{\rm cr}} = \frac{\bar{\Sigma}(<R) - \Sigma(R)}{\Sigma_{\rm cr}}$$



Mass profile around clusters



Stacked lensing profile reflects the mass density profile
which consists of **matter in dark halo itself** and **gravitational clustering**.

➡One of important probes which probe
the structure of dark halos and cosmology.

Halo Asphericity and Cluster Finding

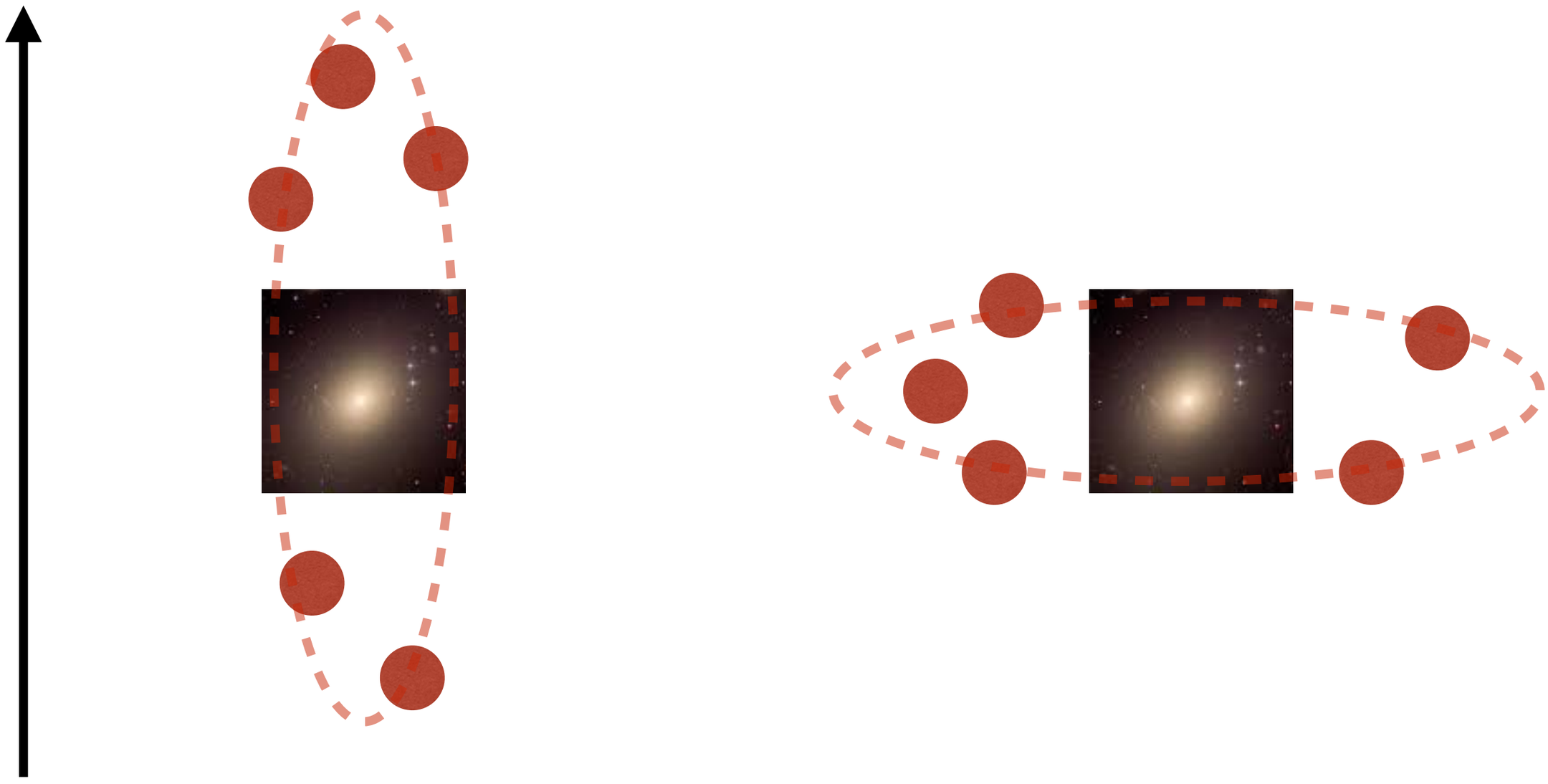
✦Previous studies (e.g., Jing & Suto, 2002) show that dark halos are not spherical, rather **triaxial**.

Clusters finding algorithms are based on optical survey data.

The projection affects the probability that the clusters are found.

Likely to be found

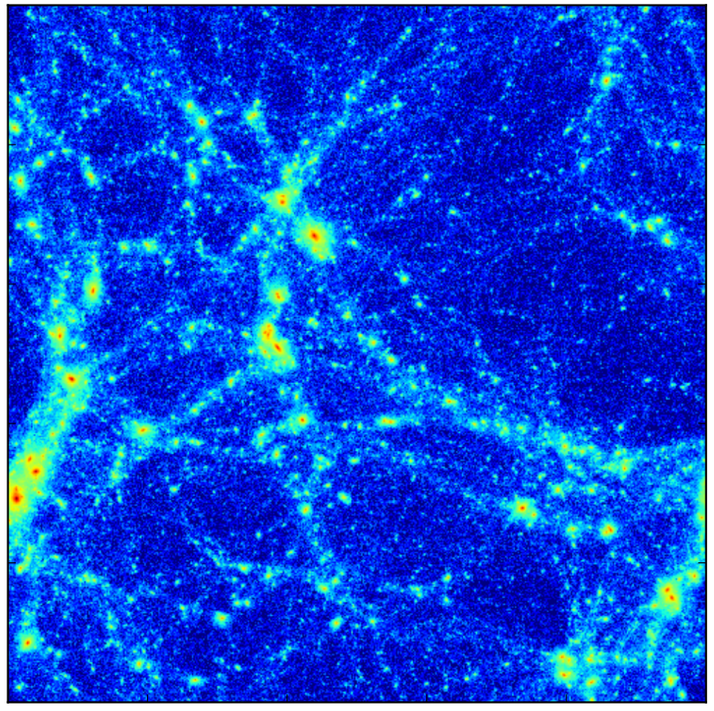
Less likely



N-body Simulations

✦**N-body simulations: Mock observations**

A large suite of N-body simulations
for Dark Emulator project (Nishimichi+, in prep.).



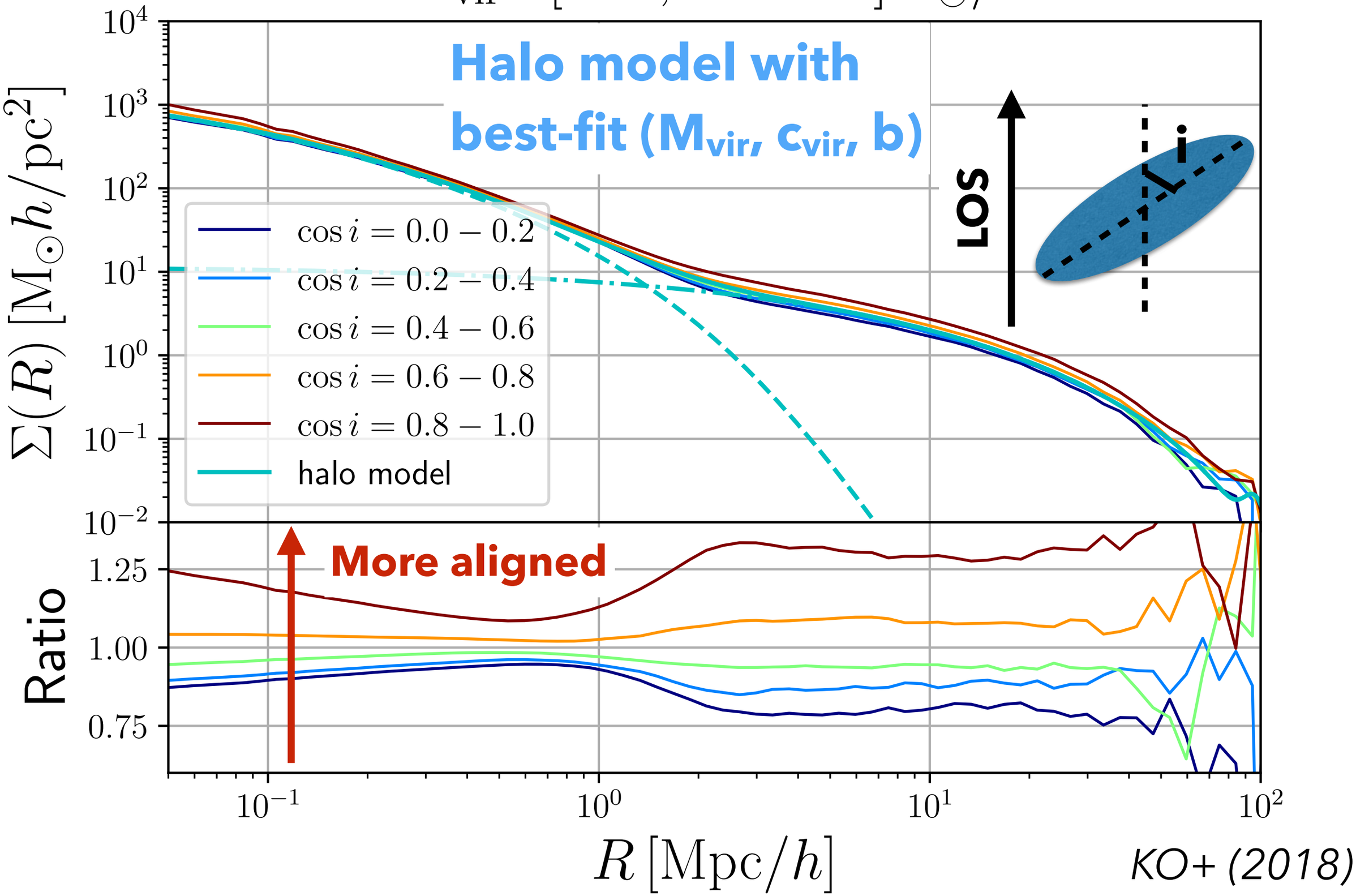
Tree-PM code: L-Gadget-2 (Springel, 2005)
Cosmology: Planck 2015
Box size: $(1\ \mathrm{Gpc}/h)^3$ x 24 realizations
Halos: based on Rockstar (Behroozi+, 2012)
We select halos > $10^{14}\ M_{\mathrm{sun}}/h$.

✦For each halo, we compute a reduced iterative momentum tensor (Bett, 2012).
Hereafter, we use **the direction of the major axis as the indicator of halo shape.**

$$\mathcal{M}_{ij}^{(k)} = \sum_{p=1}^{N} m_{\mathrm{particle}} \frac{R_{p,i}^{(k)} R_{p,j}^{(k)}}{\left(\tilde{R}_p^{(k)}\right)^2},$$

Simulation vs Halo Model

$M_{\rm vir}$: $[10^{14}, 5\times10^{14}]{\rm M}_\odot/h$



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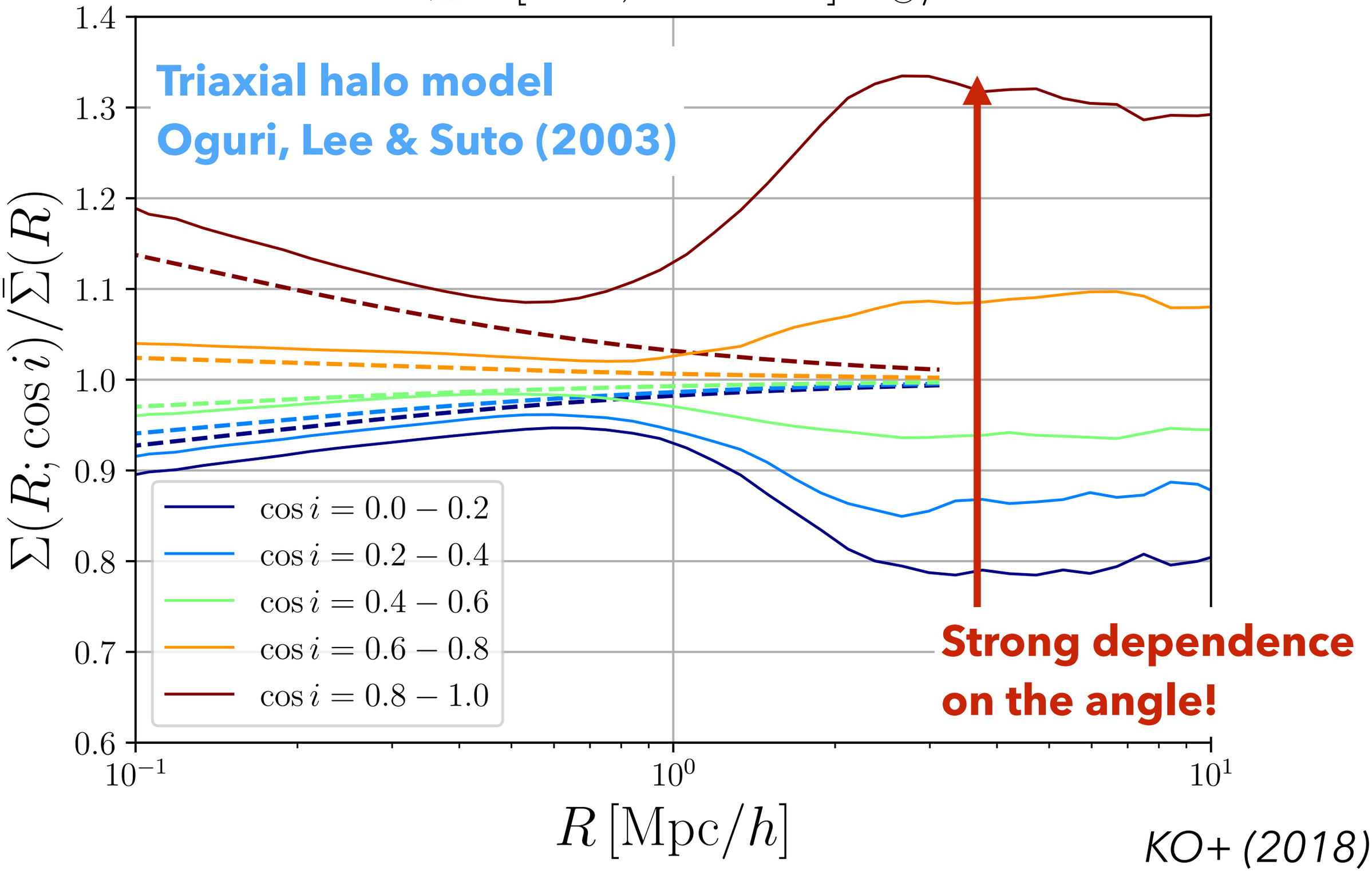
Triaxial Halo Model



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Fitting with Halo Model

✦Fitting

From surface mass density, we fit virial mass, bias, concentration parameter.

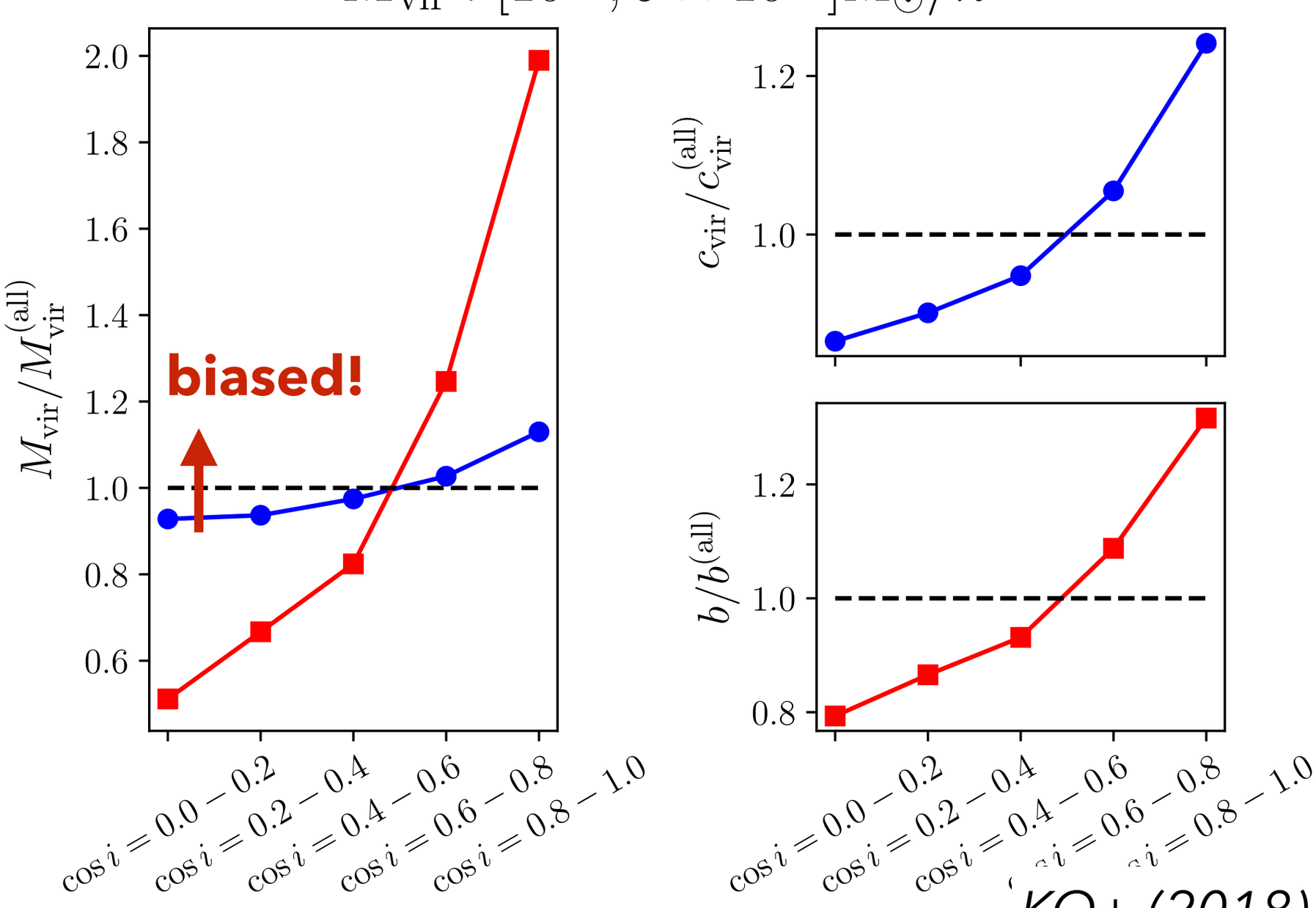
$$\chi^2 = \sum_i \frac{[\Sigma^{\rm sim}(R_i;\cos i) - \Sigma^{\rm model}(R_i; M_{\rm vir}, c_{\rm vir}, b)]^2}{\sigma_\Sigma^2(R_i)},$$

✦Parameter bias

According to the viewing angle, estimated properties are biased up to ~20%.

✦2-halo mass (red)

We can convert estimated bias to halo mass (Tinker+, 2010).



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Summary

- Stacked lensing is one of important probes into the structure of dark halos and cosmology.

- We carried out a mock observation with N-body simulations. We selected halo samples according to their major axis direction.

- We fit the results from simulations with the halo model, and estimate halo properties, i.e., mass, concentration, and bias.