Halo Abundance Matching for eBOSS Galaxies

Jiaxi Yu

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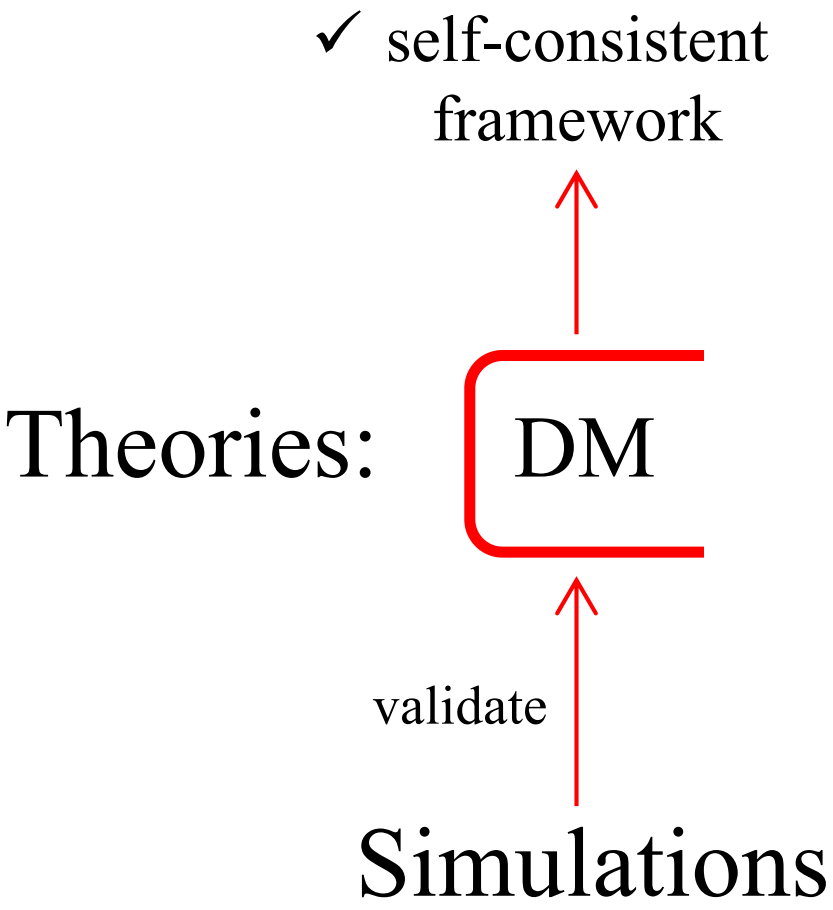
Background:

Study the Universe:

- **Theories : the framework - LCDM**
- **Observations :** in the redshift space
- **Simulations :** in the real space

Why do we need HAM?



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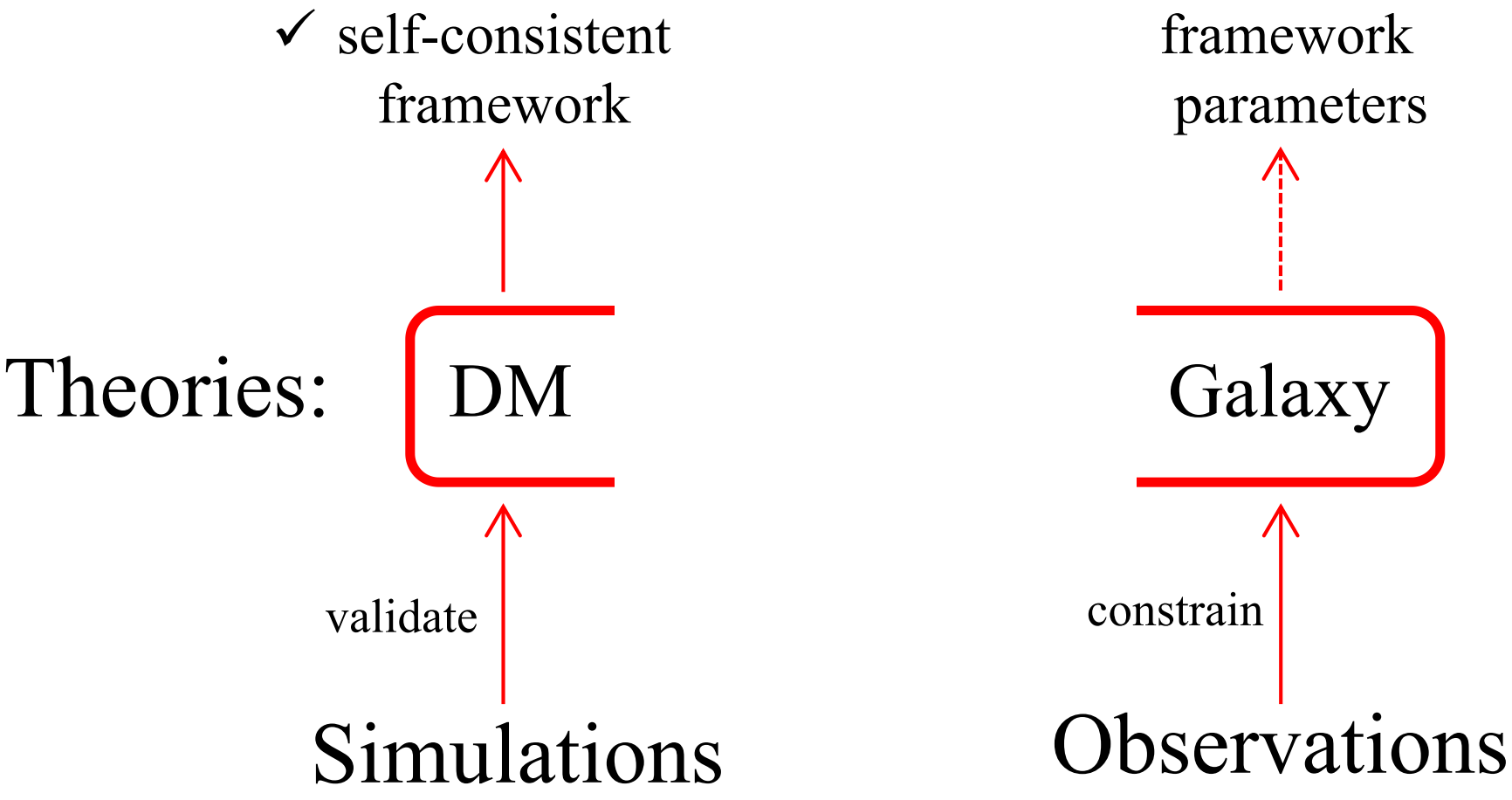

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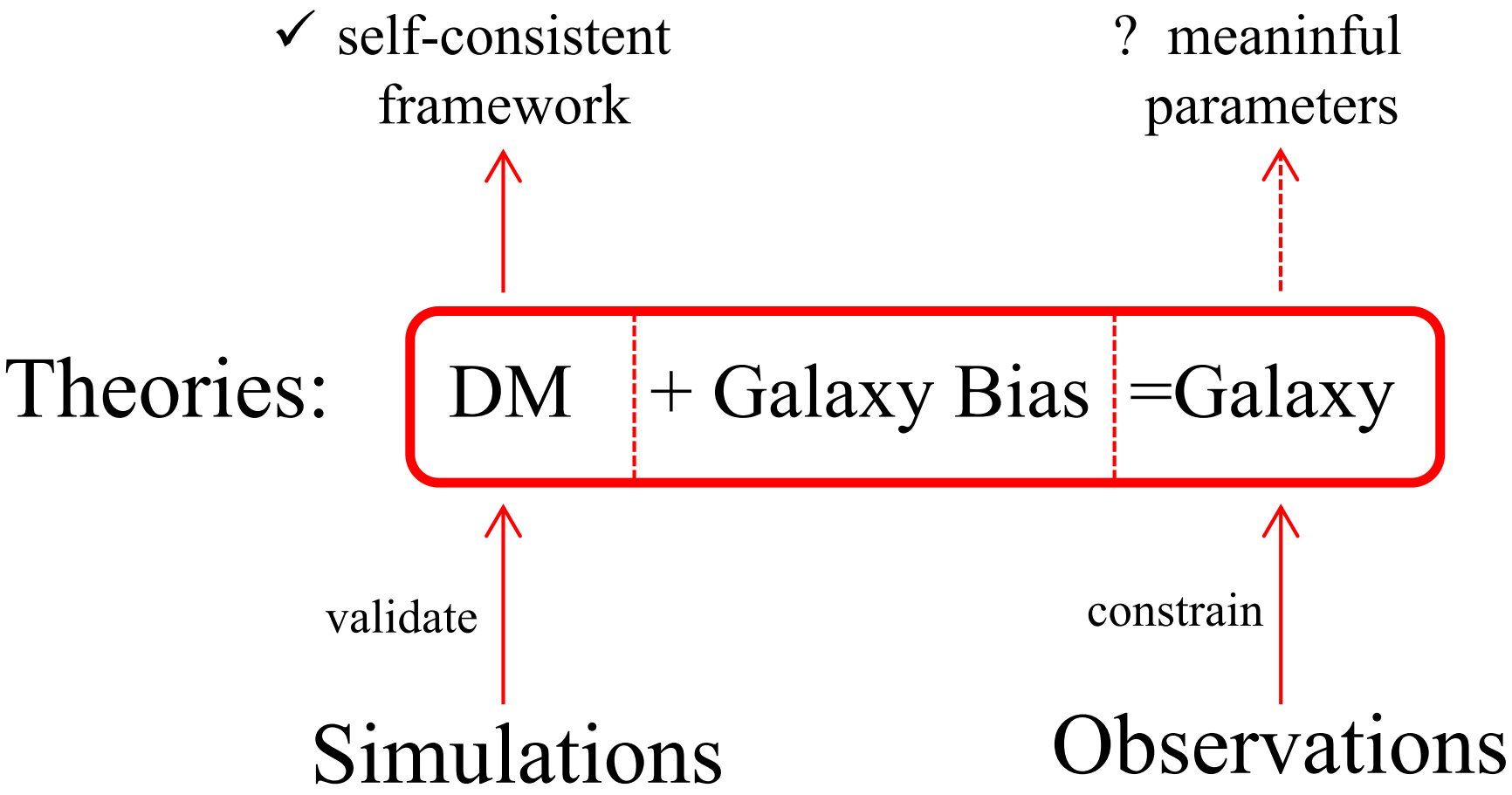

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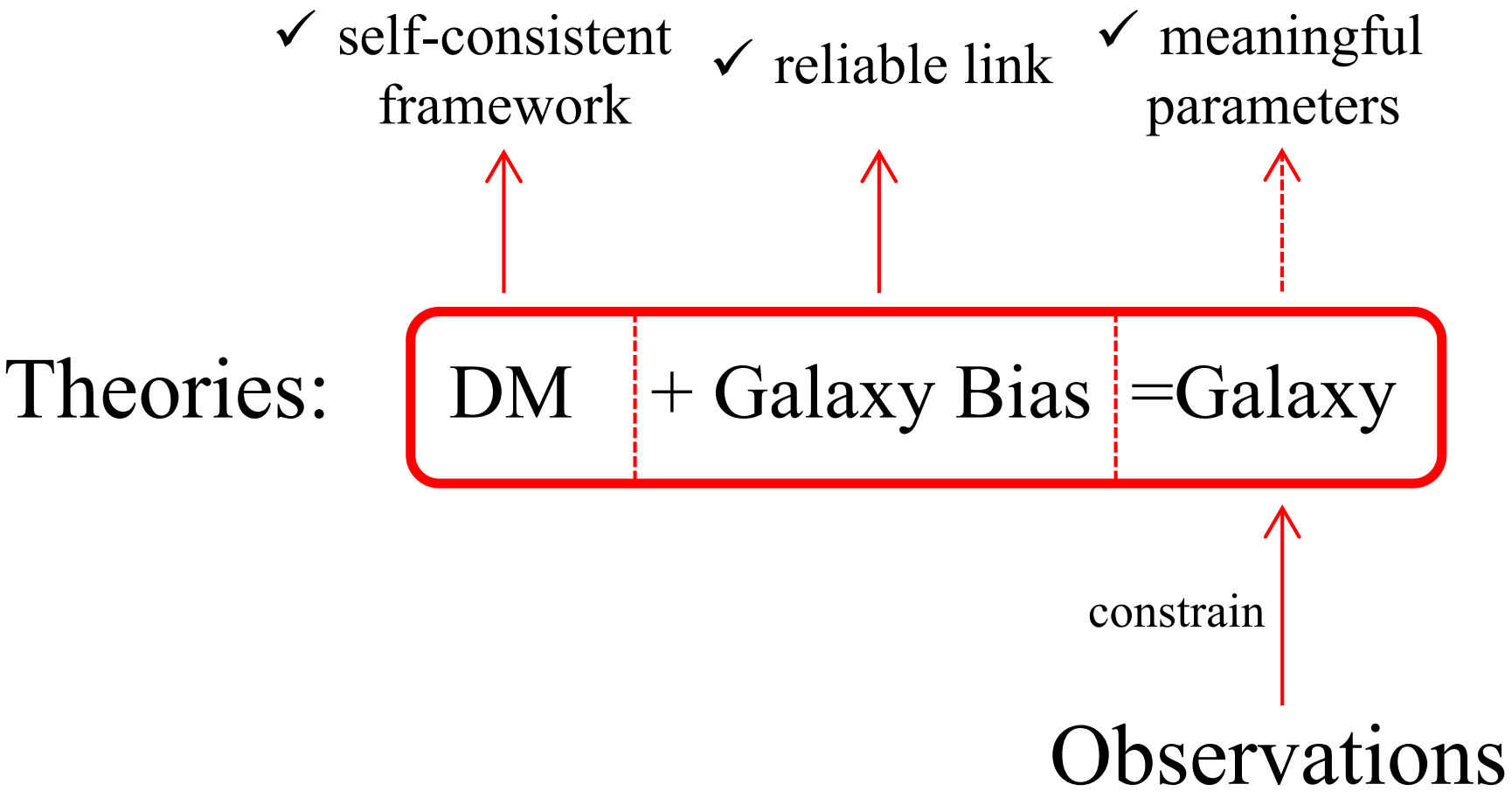

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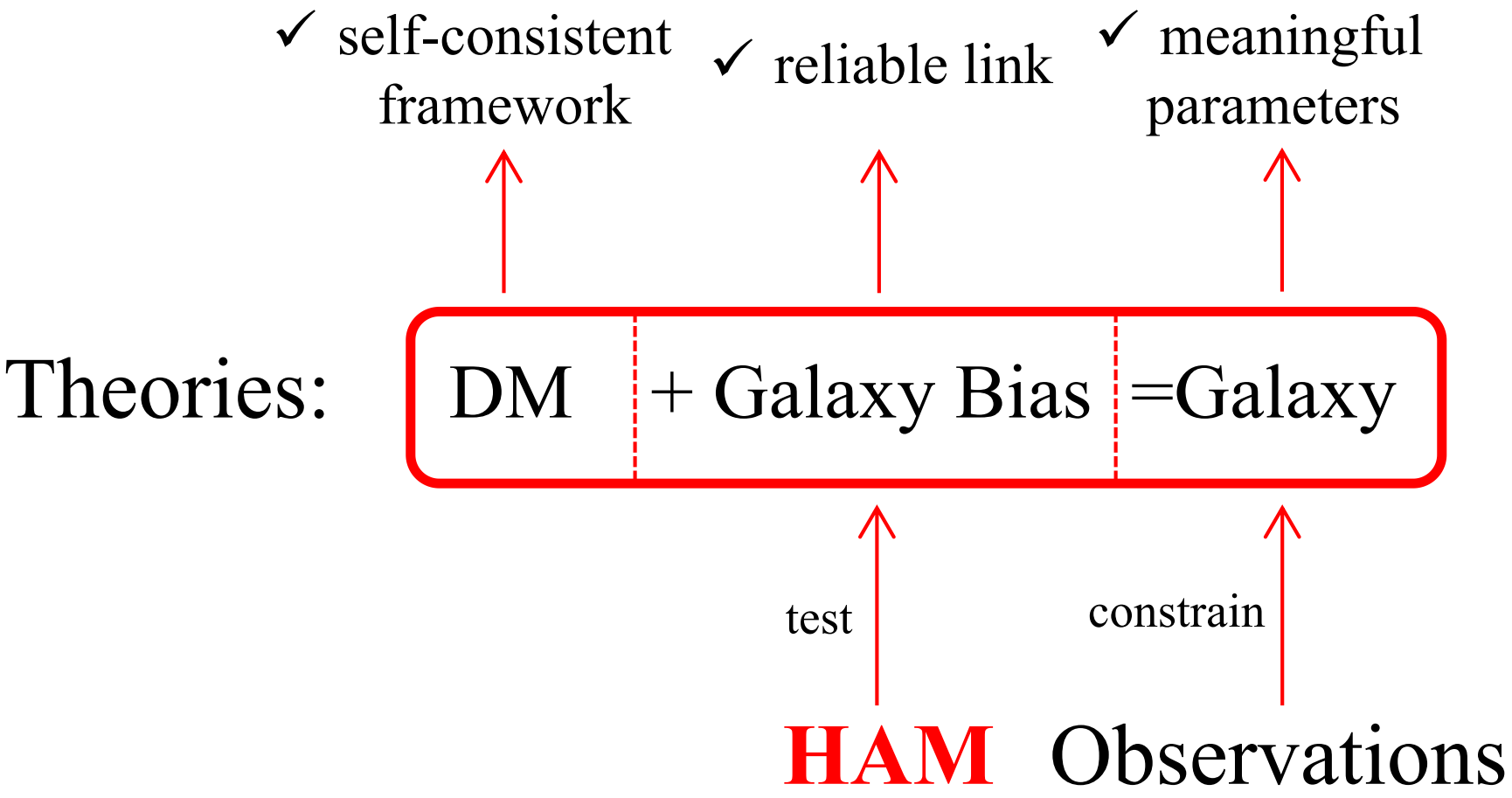


What is Halo Abundance Matching?

- A method to test the galaxy bias models
- By investigating galaxy distribution in DM halos

density contrast: $\delta(\boldsymbol{x}) = \dfrac{\rho(\boldsymbol{x}) - \bar{\rho}(\boldsymbol{x})}{\bar{\rho}(\boldsymbol{x})}$

correlation function: $\xi(\boldsymbol{s}) = < \delta(\boldsymbol{x})\delta(\boldsymbol{x}-\boldsymbol{s}) >$

linear galaxy bias: $b = \dfrac{\delta_{gal}(\boldsymbol{x})}{\delta_{DM}(\boldsymbol{x})} \Rightarrow b^2 = \dfrac{\xi_{gal}(\boldsymbol{s})}{\xi_{DM}(\boldsymbol{s})}$

What is Halo Abundance Matching?

- Select halos that can host a galaxy so that:
- Selected halos (i.e., galaxies) match empirical distribution
- Galaxy correlation functions match the observation

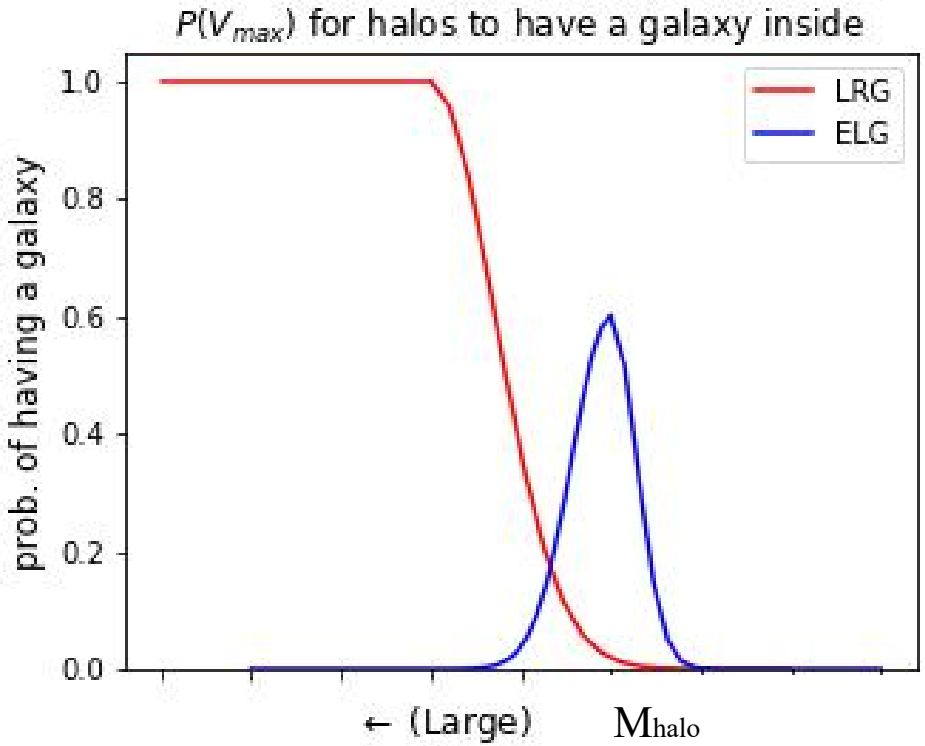
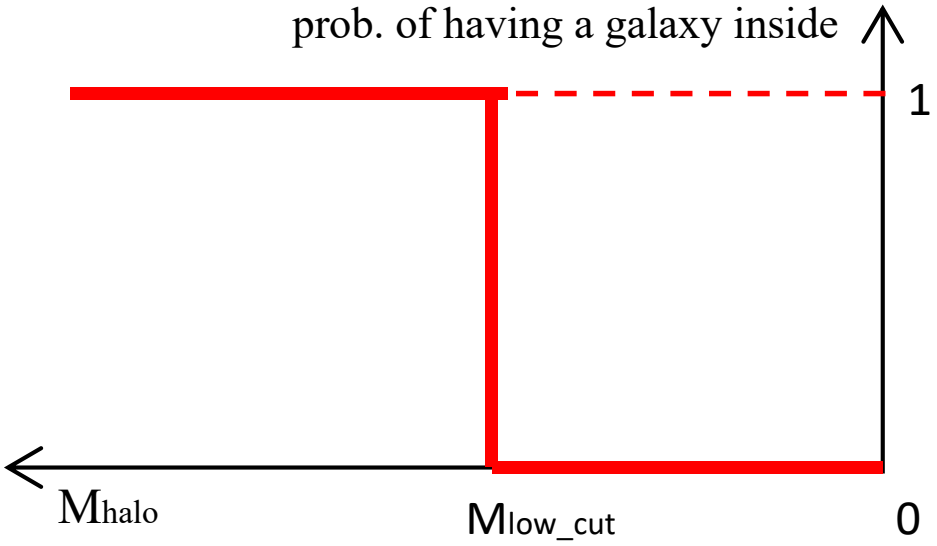


Fig 1. Galaxy P.D.F. for halos

How to use HAM?



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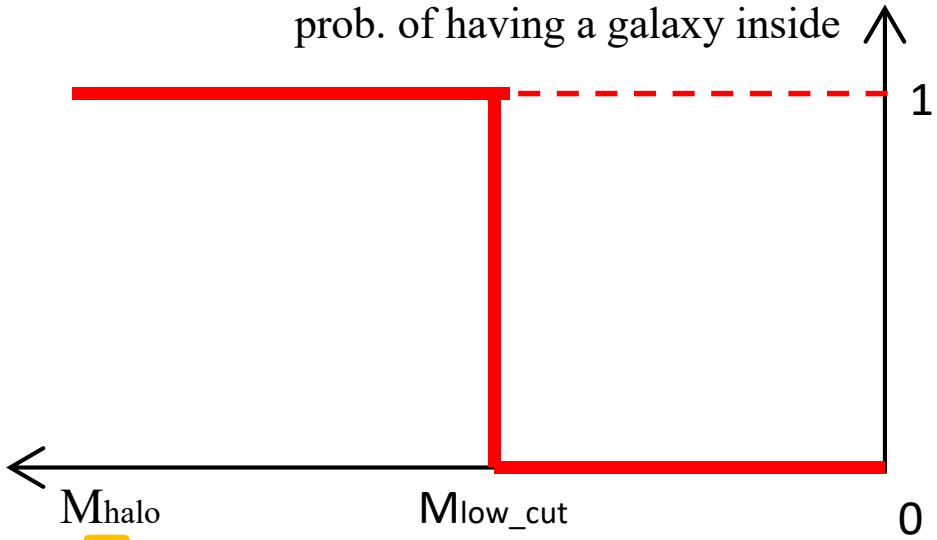
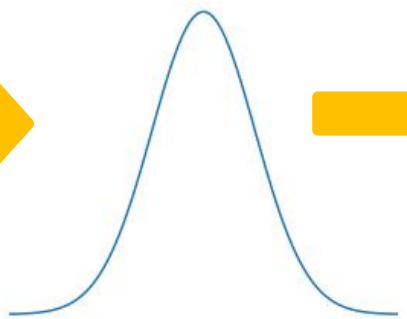
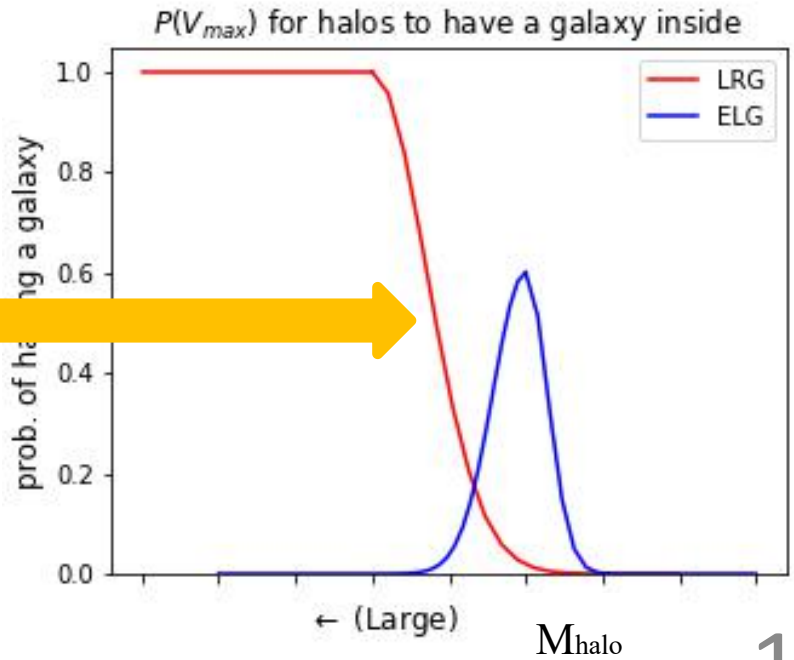


Scattering with





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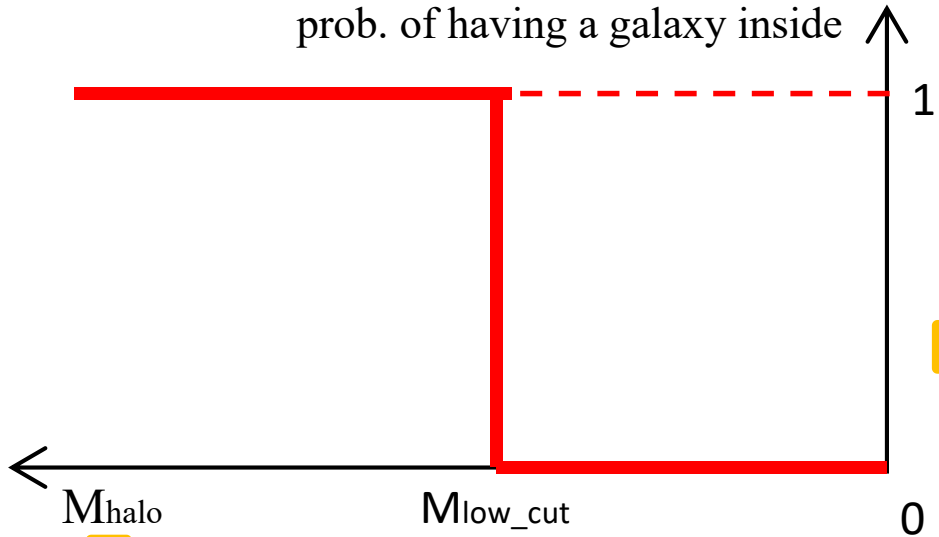
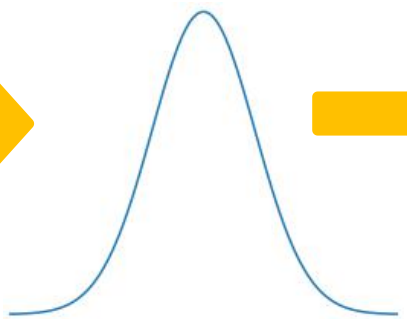
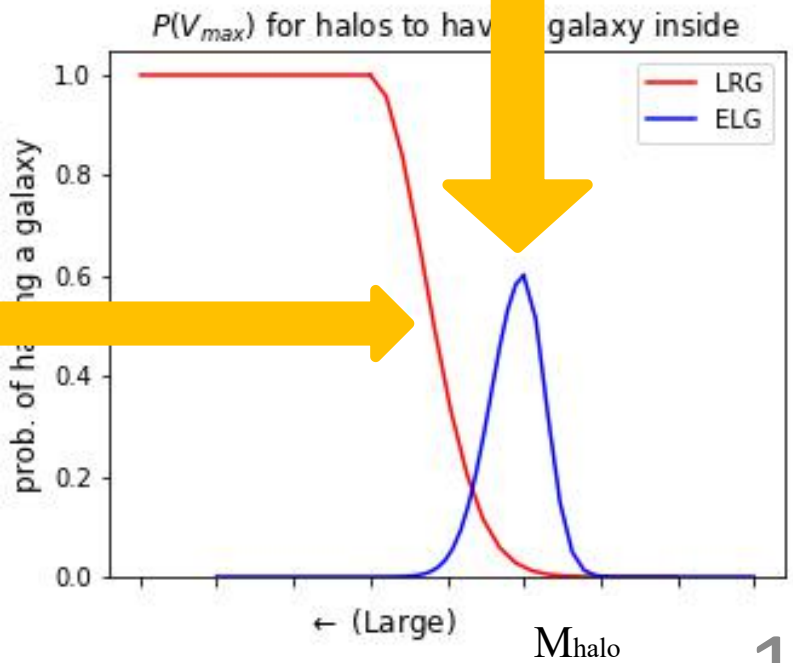


Scattering & M_{high_cut}

Scattering with





Progress:

Thesis topic:

- Test the galaxy bias models with HAM

The specific question:

- How do galaxies distribute in DM haloes?

Solutions:

- ✓ Select halos to assign galaxies (HAM)
- ✓ Fit the galaxy $\xi_l(r)$ to observations to get bias models (test)

Progress:

✓ the Redshift Space Distortion effect (fitting in the redshift space)

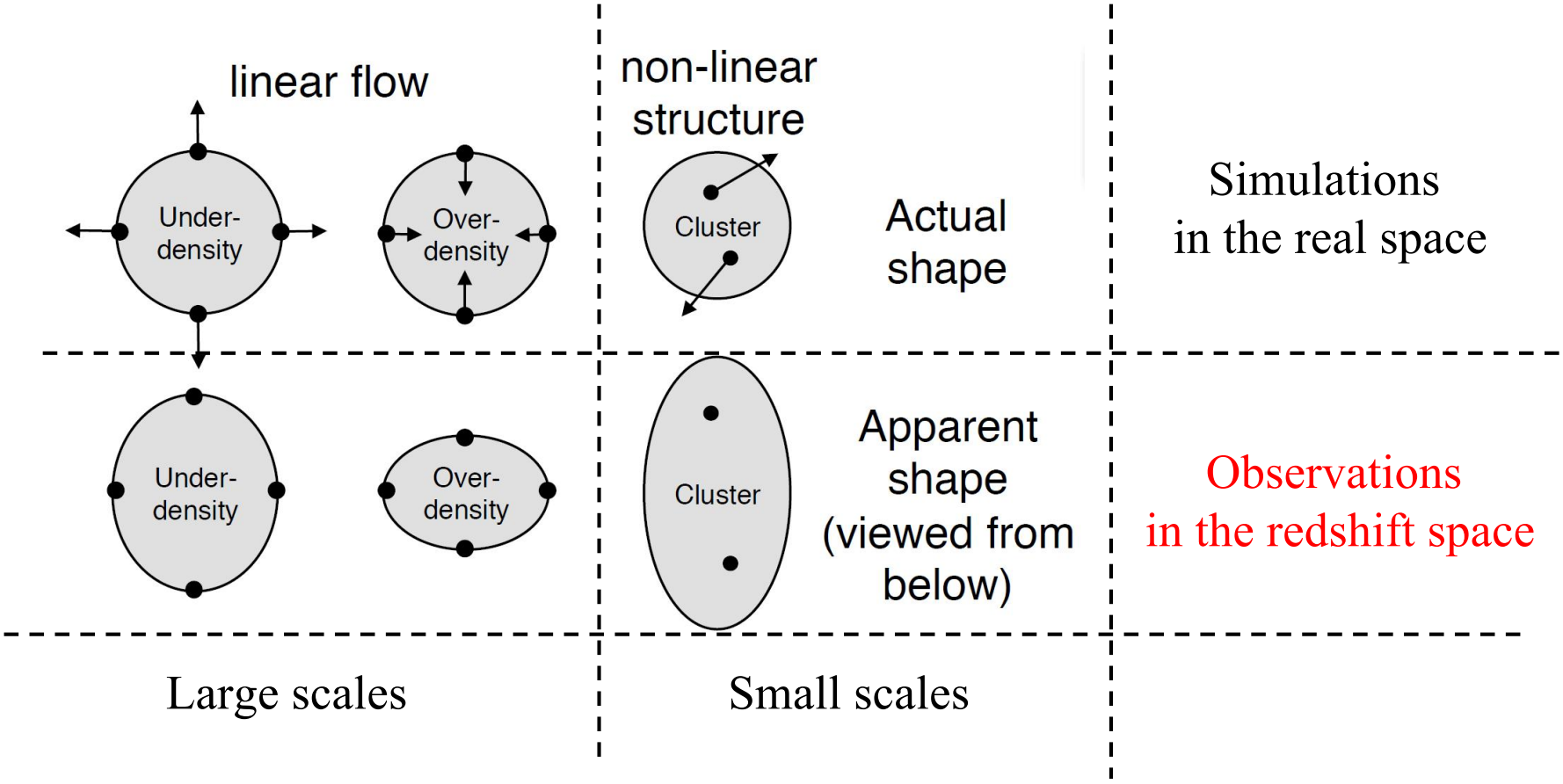


Fig 2. The Redshift Space Distortion effects (diagrams from Jean-Paul's AstroIV slides)

Progress:

✓ the Redshift Space Distortion effect (fitting in the redshift space)

$$\xi_l(r,\mu) = a_0 P_0(\mu) + a_2 P_2(\mu) + a_4 P_4(\mu) + \ldots$$ ($P_n(\mu)$ is the Legendre polynomials)

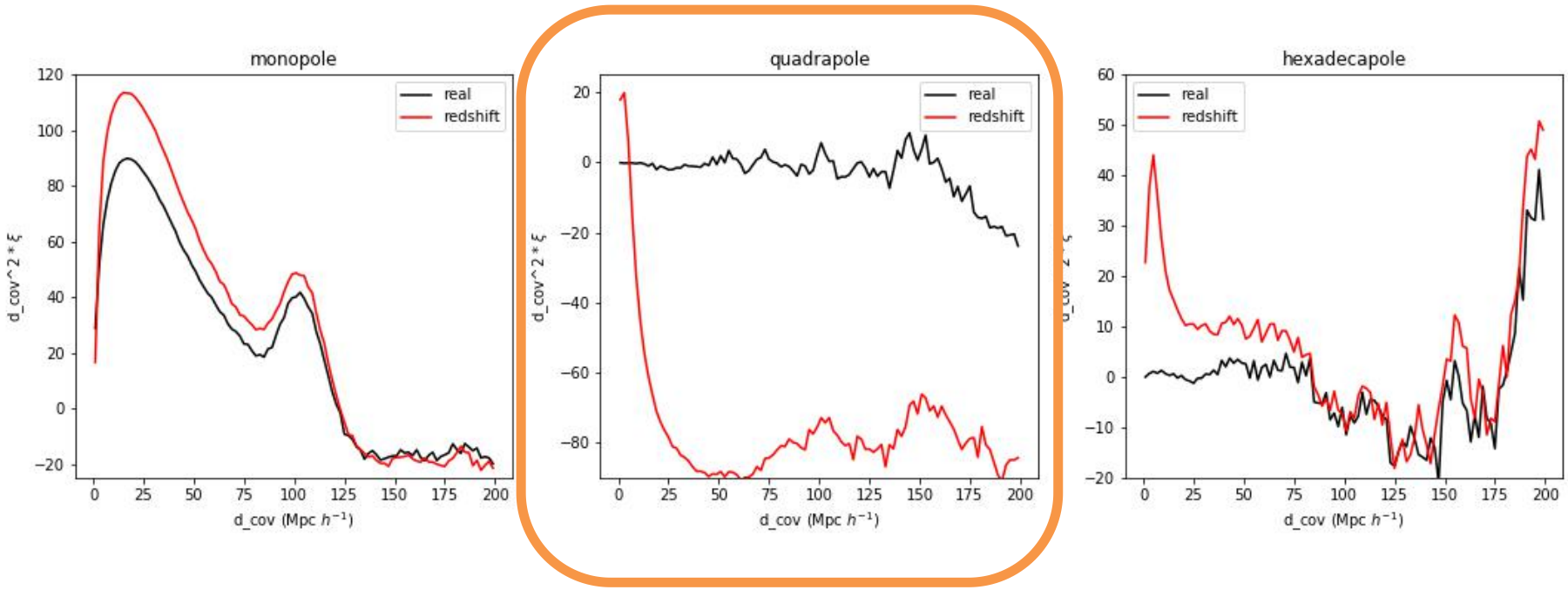


Fig 3. The correlation function multipoles of DM halo simulations in the real space (black) and in the redshift space (red)

Progress:

- ✓ Redshift Space Distortion effect
- ✓ Parameters' effects on $\xi_l(r)$ and galaxy distributions

$$a_0 = a_0(b^2, b) \qquad a_2 = a_2(b)$$

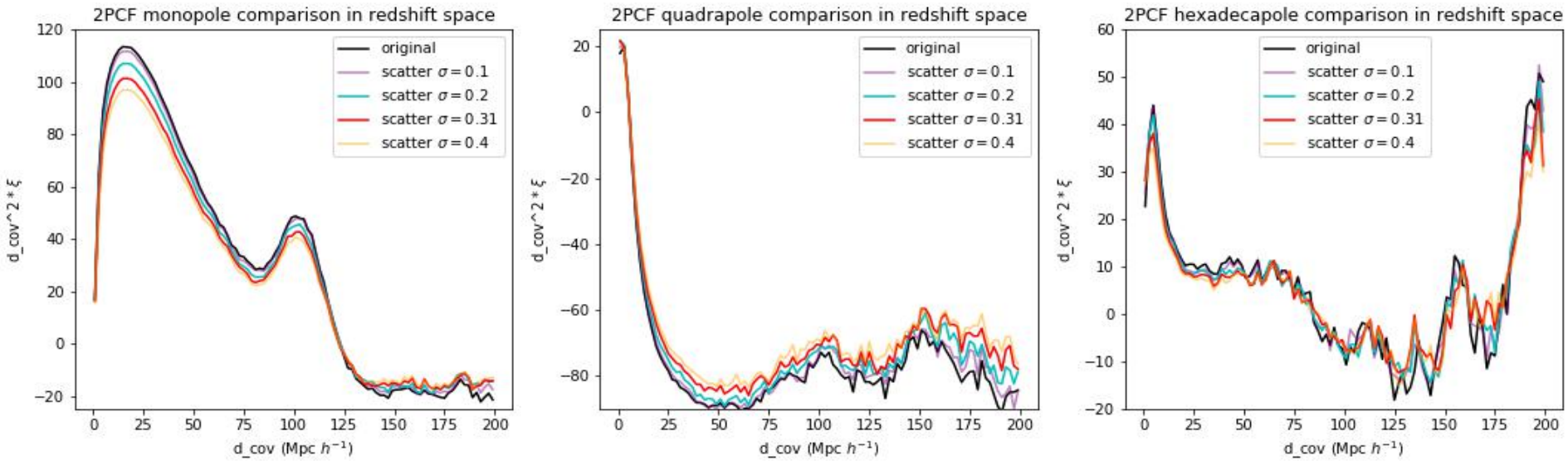


Fig 4. The correlation function multipoles for different scattering parameters

Progress:

- ✓ Redshift Space Distortion effect
- ✓ Parameters' effects on $\xi_l(r)$ and galaxy distributions

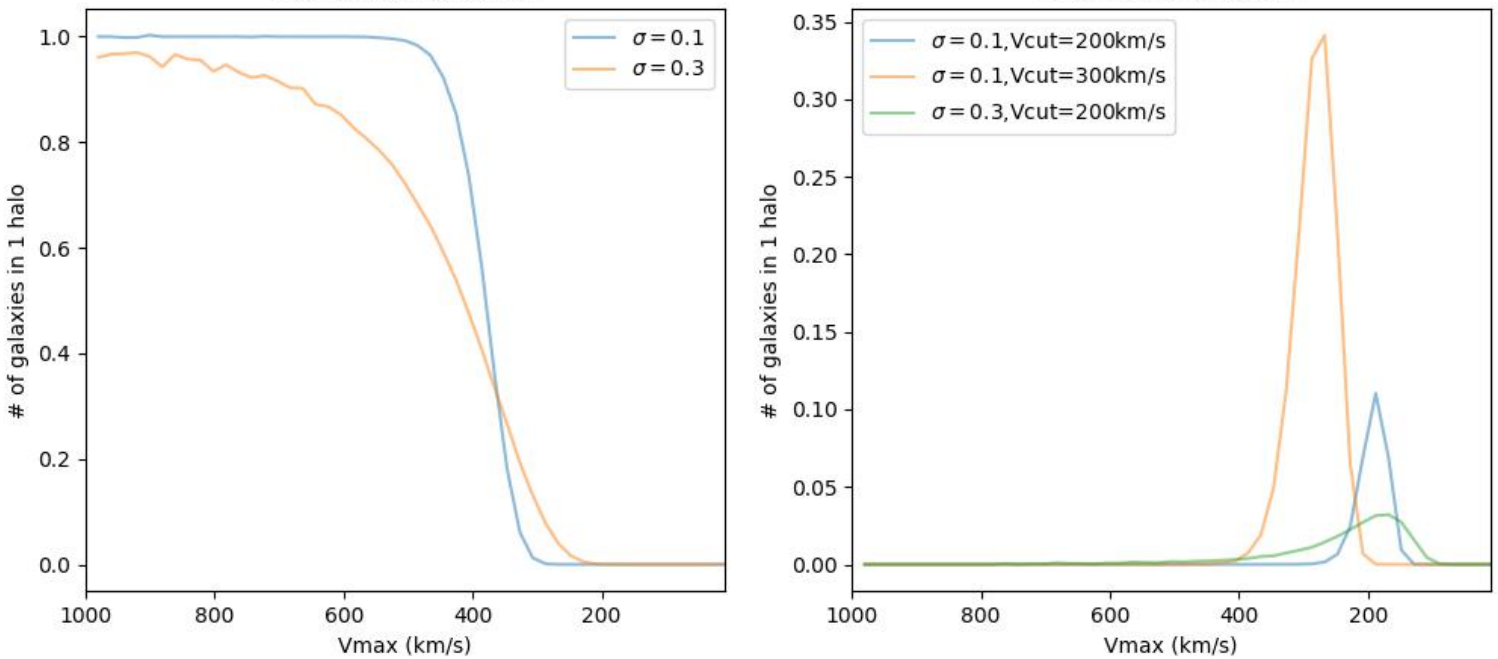


Fig 5. The galaxy P.D.F for different model parameters

Progress:

- ✓ Redshift Space Distortion effect
- ✓ Parameters' effects on $\xi_l(r)$ and galaxy distributions
- ✓ χ^2 minimisation for mono+quadru -poles
  - ✓ scripts
  - ✓ statistical instability of HAM in $\xi_l(r)$

Progre

- ✓ Reds
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- ✓ χ^2 r

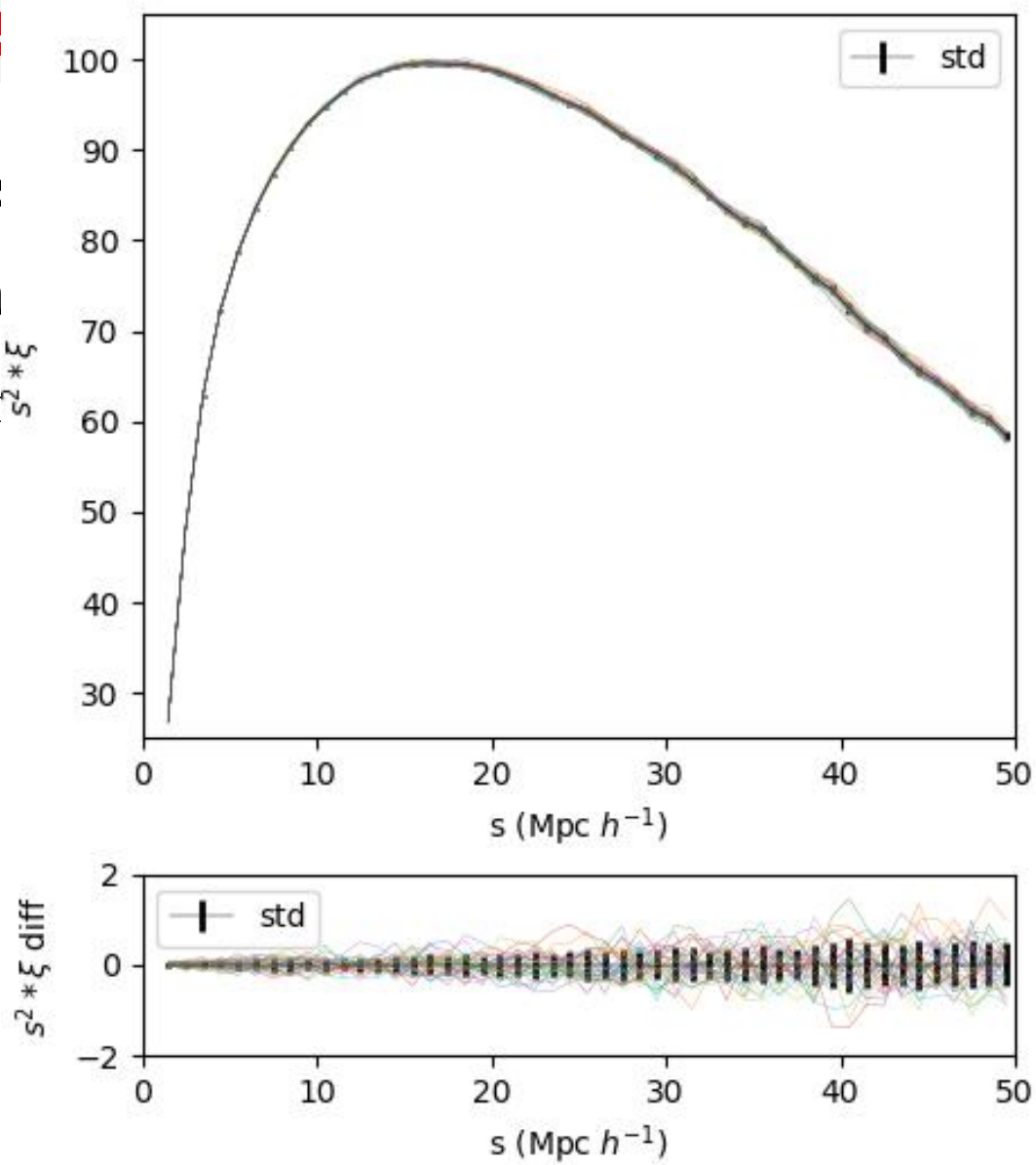

Fig 6. Correlation multipoles with the same scattering parameters but different random seeds

Progress:

- ✓ Redshift Space Distortion effect
- ✓ Parameters' effects on $\xi_l(r)$ and galaxy distributions
- ✓ χ^2 minimisation for mono+quadru -poles
  - ✓ scripts
  - ✓ statistical fluctuations of HAM in $\xi_l(r)$

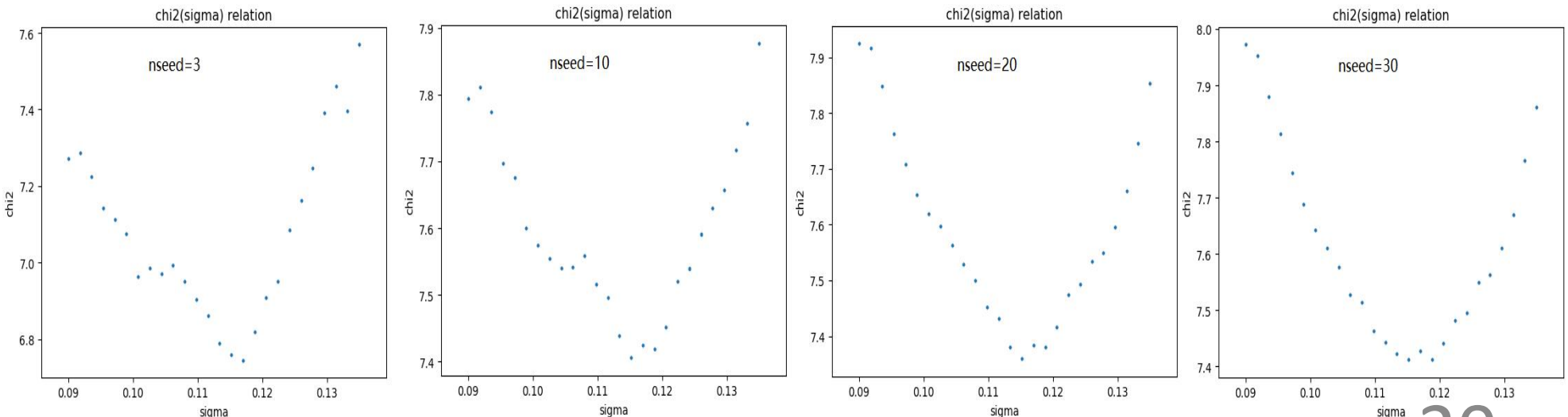

Fig 7. chi2-sigma relations with different number of random seeds being averaged

Progress:

- ✓ Redshift Space Distortion effect
- ✓ Parameters' effects on $\xi_l(r)$ and galaxy distributions
- ✓ χ^2 minimisation for mono+quadru -poles
  - ✓ scripts
  - ✓ statistical fluctuations of HAM in $\xi_l(r)$

To do:

- ➢ Remove the fluctuation completely with more seeds
- ➢ Use MCMC sampler to get reliable parameter errors

Outlook:

- ✓ Reliable LRG & ELG bias models
- ☐ Multi-tracer HAM
  - ☐ 'generate' multiple tracers simultaneously
  - ☐ difficulty: overlapped distribution function
- ☐ Cross-Correlation between tracers

Thanks!