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HALOGEN

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PREMISE

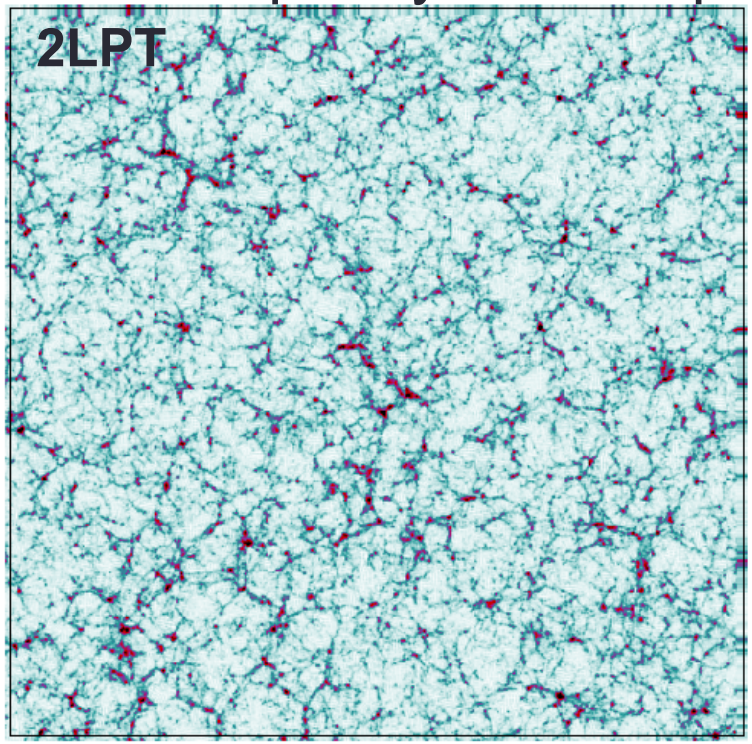
- Completely statistical reconstruction of halo catalogue.
- Primarily fit:
  - Number density
  - Halo mass function
  - 2-point correlation function (2PCF)
- Philosophy of “do the dumbest thing, and improve if necessary”.
- `HALOgen` is in relatively early development
- In terms of comparison, most similar to QPM.

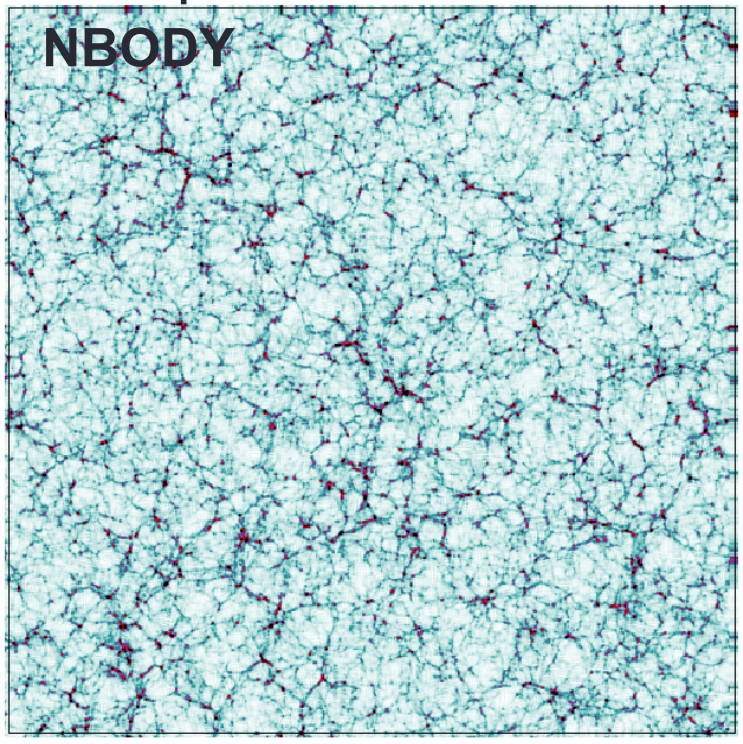
OUTLINE OF METHOD

1. Use 2LPT to achieve a fast realization of the large-scale density field. [Very Easy: Someone Else Wrote It]
2. Generate halo masses using statistical inverse CDF method with analytic fitting functions. [Easy]
3. Place halos onto 2LPT “scaffolding” to fit the 2PCF. [Hard]

2LPT SCAFFOLDING

- Very fast.
- Large scales (>4Mpc/h) essentially correct.
- Damped power on small scales, especially at late times.
- Used to quickly localize placement positions for halos.



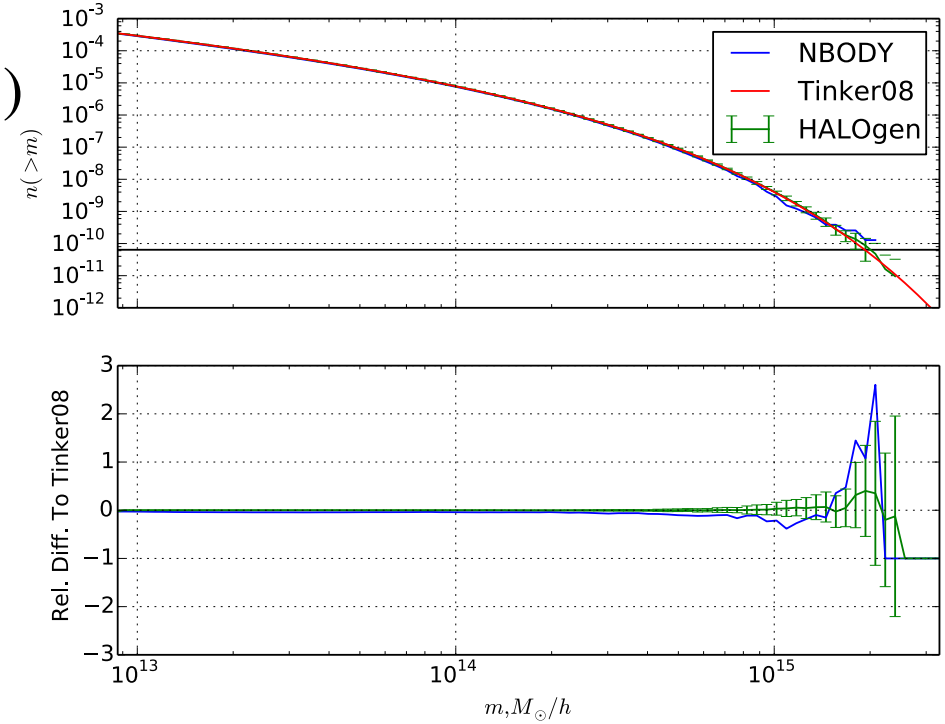


GENERATING THE HMF

- Assume analytic fit for $n(>m)$
- Then $n(>M_{h,\min}) = \bar{n}_h \Rightarrow M_{h,\min}$
- And $N_h = \bar{n}_h L^3$
- Use Inverse-CDF to get N_h samples from the CDF

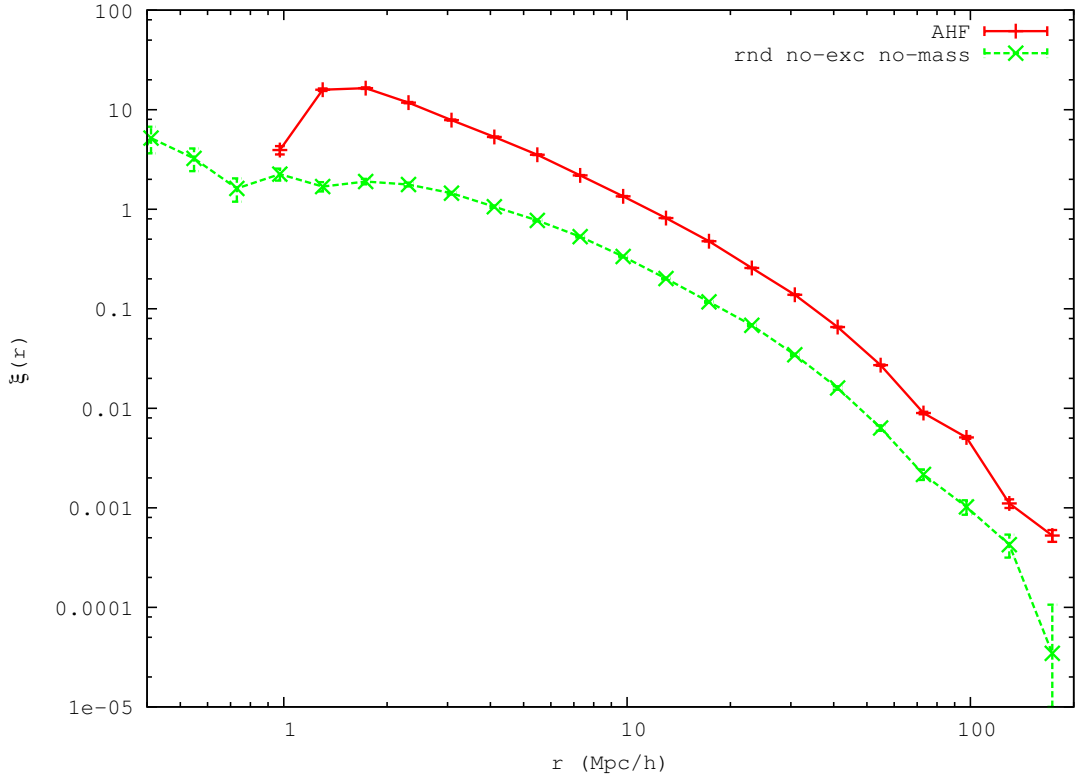
$$X \sim \frac{n(>m)}{n(>M_{h,\min})}, X \in (M_{h,\min}, 10^{17})$$

- Similar to QPM.
- Error determined by:
  - Error in fitting function (~10%)
  - Poisson Noise (controlled by *L*)



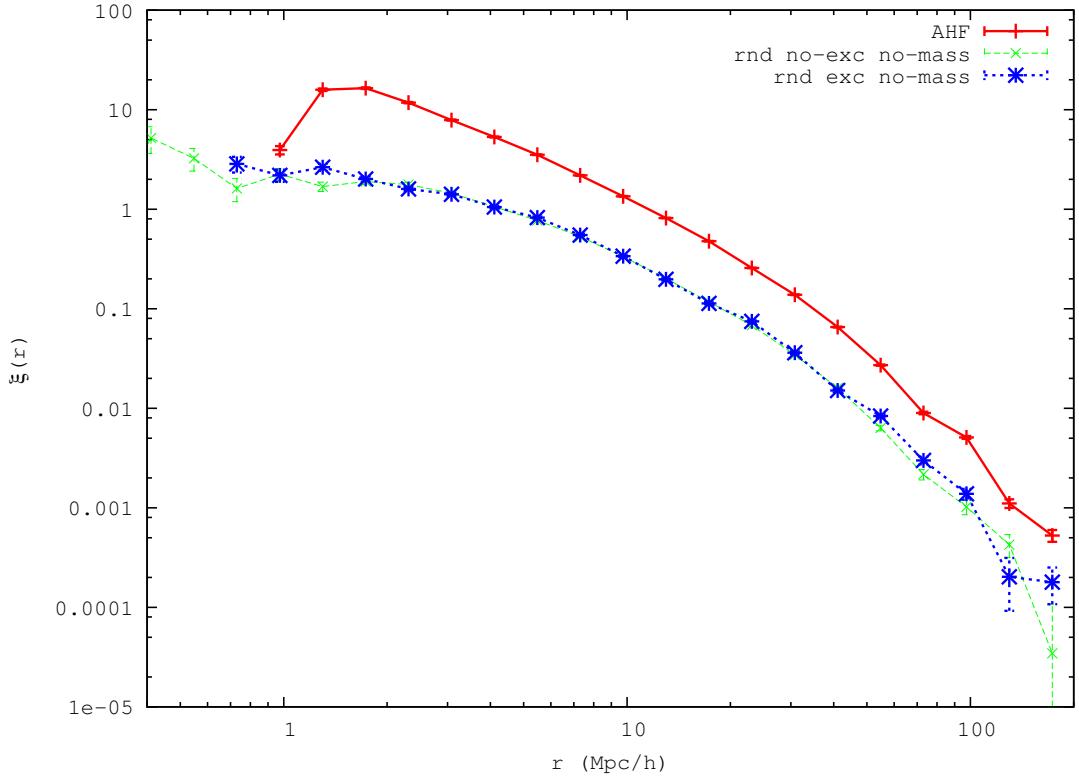
PLACING THE HALOS (la parte difícil)

- Step 0 (the “dumbest” idea): Random placement.
- Fast; Roughly correct shape.
- Wrong amplitude; halos can overlap arbitrarily.



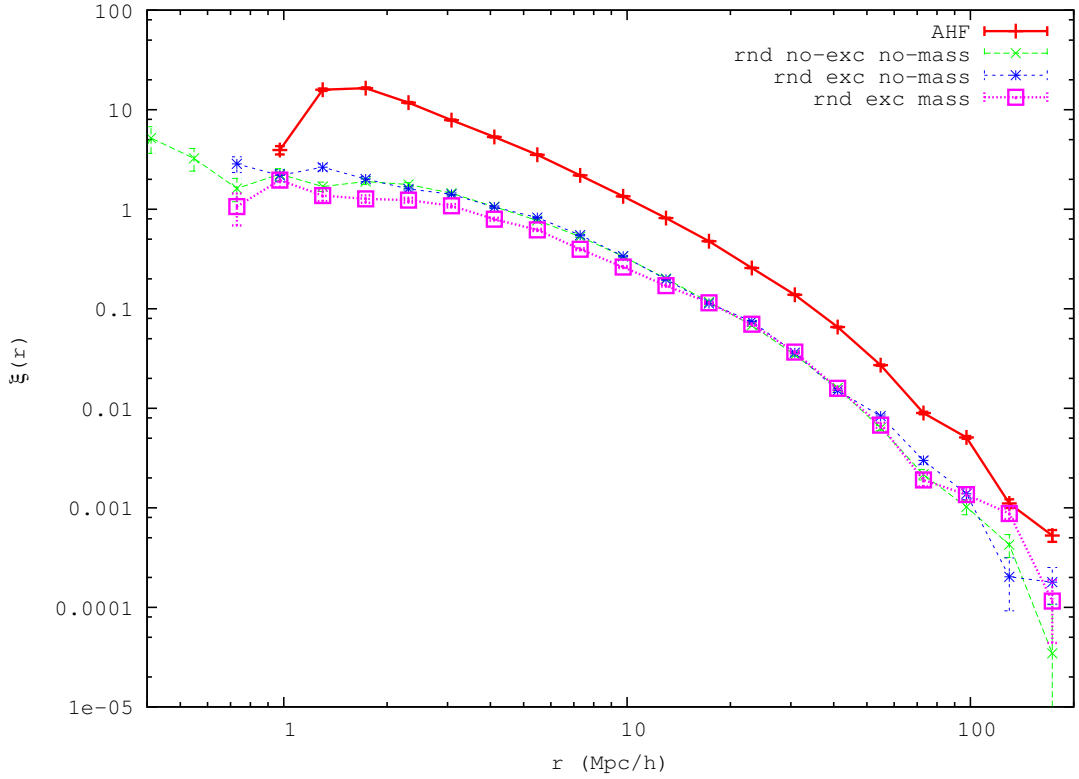
PLACING THE HALOS (cont'd)

- Step 1: Halo exclusion
- Better small-scale cut-off.
- Slightly slower; amplitude still wrong.



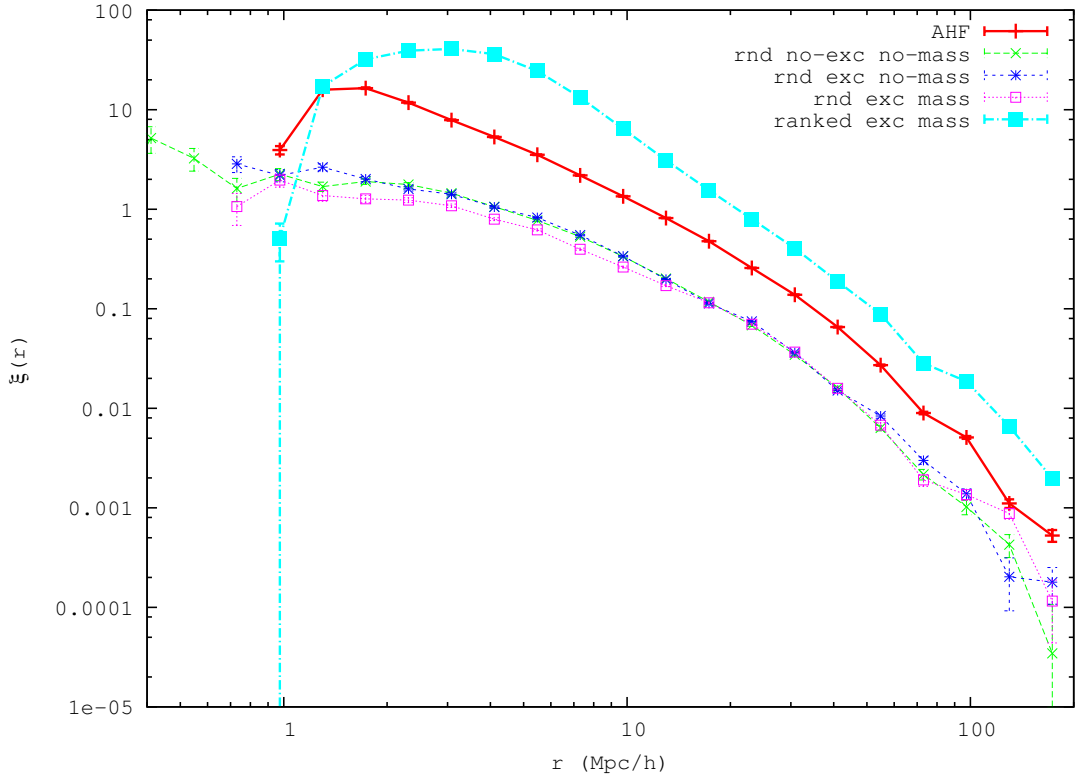
PLACING THE HALOS (cont'd)

- Step 2: Mass conservation.
- Less small-scale structure (better shape)
- More conceptually involved; Slightly slower; Amplitude *still* wrong.



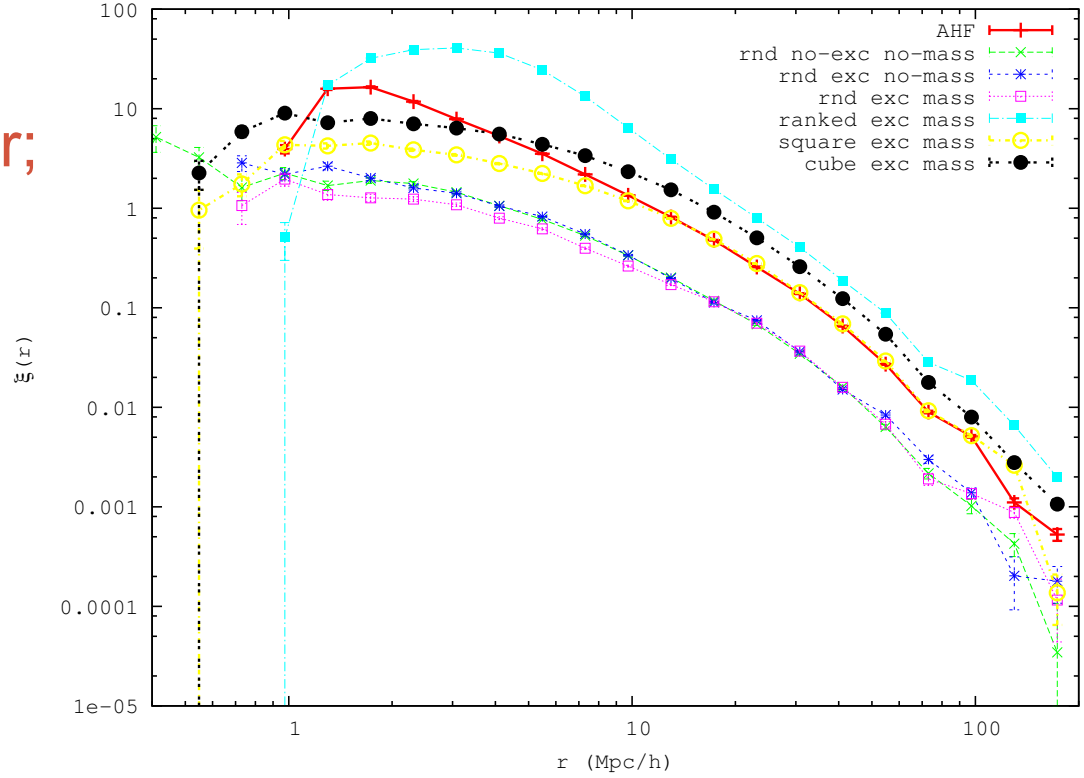
PLACING THE HALOS (cont'd)

- An Idea: Ranked-ordered placement
- Slightly faster
- Over-predicts correlations; inflexible



PLACING THE HALOS (cont'd)

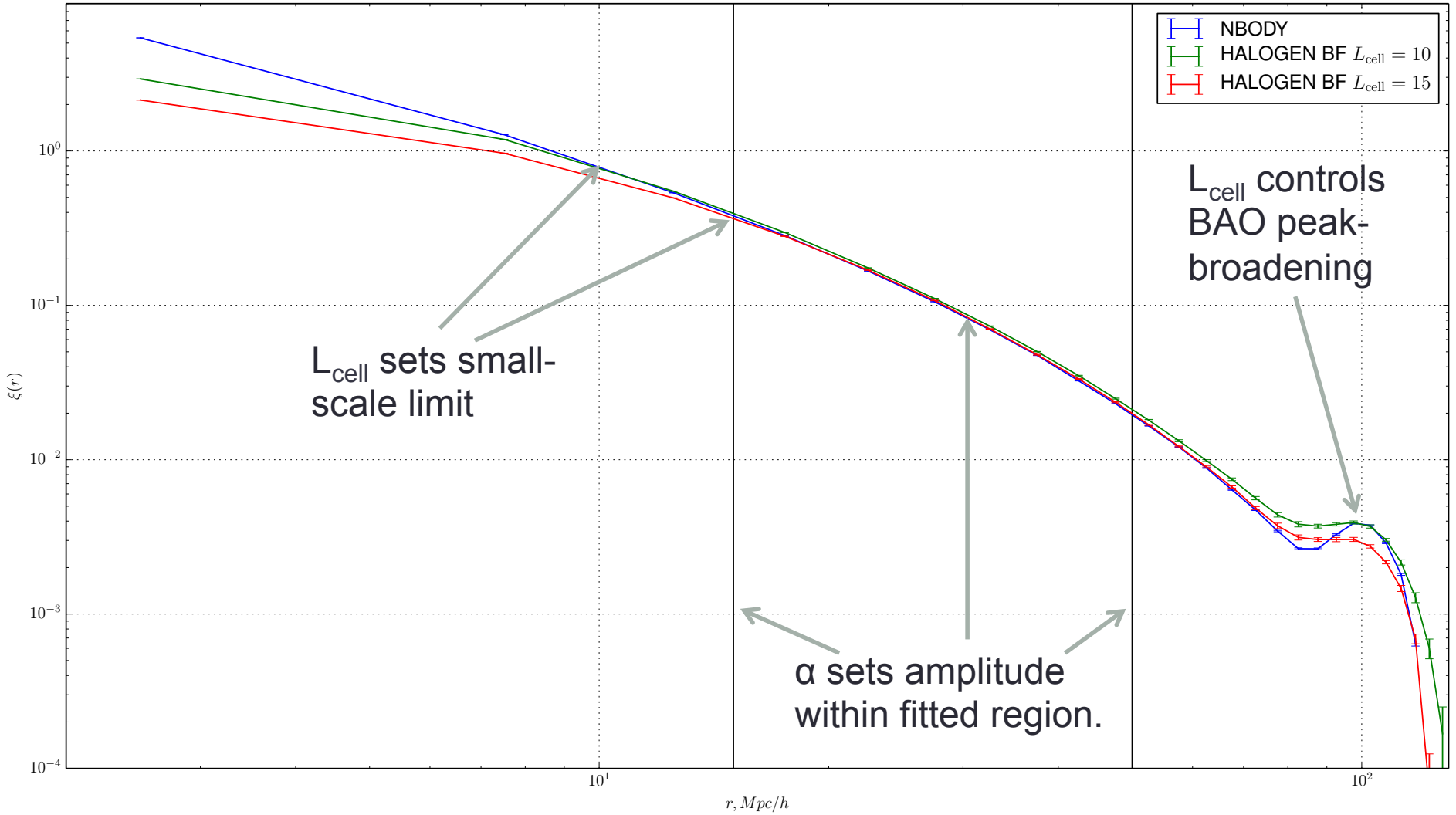
- Step 3: Control stochasticity/bias
  - Random *too stochastic* (low); Ranked *too biased* (high).
  - Parameterize amplitude with $P_i \propto f(M_i),\ i \in 1, \ldots, N_{cell}$
  - In particular, $P_i \propto M_i^{\alpha}, \quad \alpha \geq 0$
- Amplitude can be fit
- Extra parameter; slower; α has to be *fit*.



PLACING THE HALOS (cont'd)

- Step 4: Connect with bias
  - Cosmologically, $P(\rho \mid M_h) \propto f(\rho, M_h) P(\rho)$
  - So $P_i \propto f(M_i, M_h) = M_i^{\alpha(M_h)}$
  - Determine $\alpha(M_h)$ in mass bins.
- Bias function correct
- Fitting procedure takes ~400 times a single run.
  - Only run once
  - Can be run on a small box to improve performance.

HALOGEN CHARACTERISTICS



PERFORMANCE

- Performance roughly $T \propto N_{part}^3 + N_h N_{cell}^3$
- Excluding 2LPT,
  - N_h=5,500,000, N_{cell}=160 → 40min on single node with 12 cores
- Not easily scalable, because placement is order-dependent. May change.
- Fitting α is costly, but only done once
  - Use smaller box/less cells.

THANK YOU