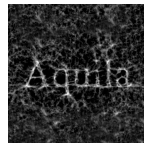


FAST REALISTIC, DIFFERENTIABLE, MOCK HALO GENERATION

FOR WIDE-FIELD GALAXY SURVEYS

Simon Ding, PhD @ Institut d'Astrophysique de Paris

supervised by Guilhem Lavaux & Jens Jasche



Want: Bayesian field-level inference of the IC of our universe

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Need: Forward model containing all the physics

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→ Model for going from ICs to some observables

MY WORK

Mapping between dark matter density to halo count fields

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Mapping between **dark matter density** to halo count fields

MY WORK

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Mapping between dark matter density to halo count fields

$$\delta_m(x) \rightarrow n(M|\delta_m(x))$$

MY WORK

Mapping between dark matter density to halo count fields

$$\delta_m(x) \rightarrow n(M|\delta_m(x))$$

Halo bias model

HALO BIAS IS COMPLEX

- Linear models only valid on large scales
- Phase-space halo finders very costly
- Need differentiability



Broken
bias
model



Machine
Learning

NPE MODEL

MAIN DESIGN IDEAS:

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- Take into account non-local information

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- Take into account non-local information
- Model linear **and** non-linear behaviour

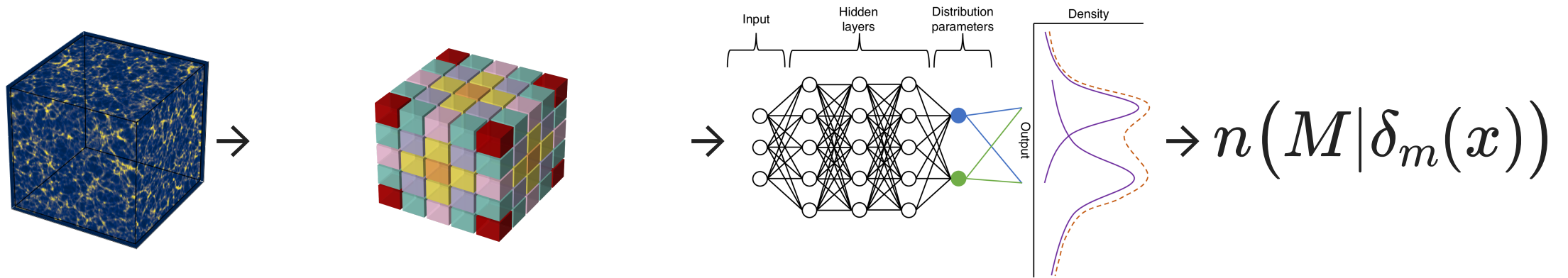
MAIN DESIGN IDEAS:

- Take into account non-local information
- Model linear **and** non-linear behaviour
 - Make use of isotropy

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- Take into account non-local information
- Model linear **and** non-linear behaviour
 - Make use of isotropy
- Generative process with stochasticity

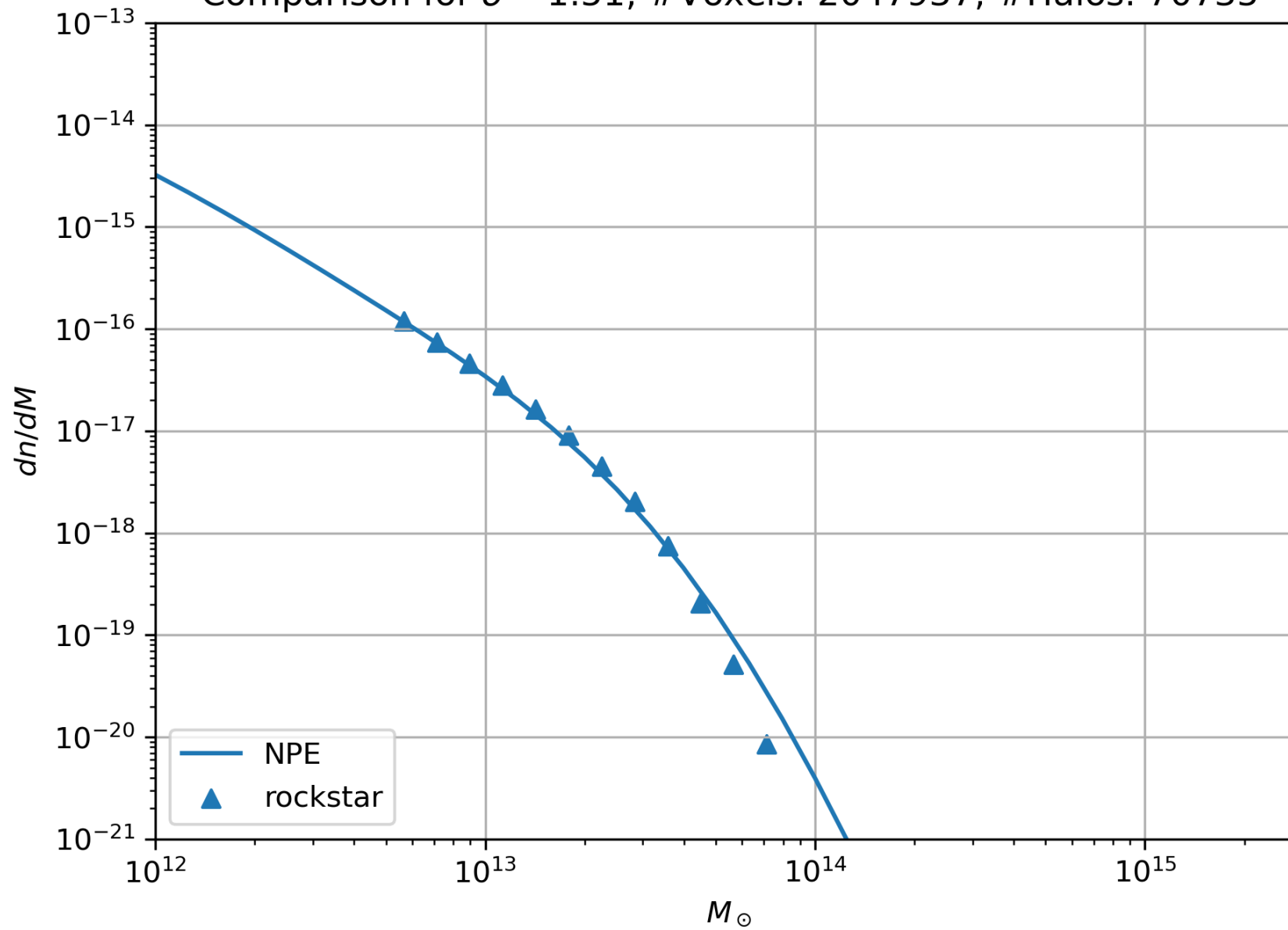
LIKELIHOOD ASSUMPTION



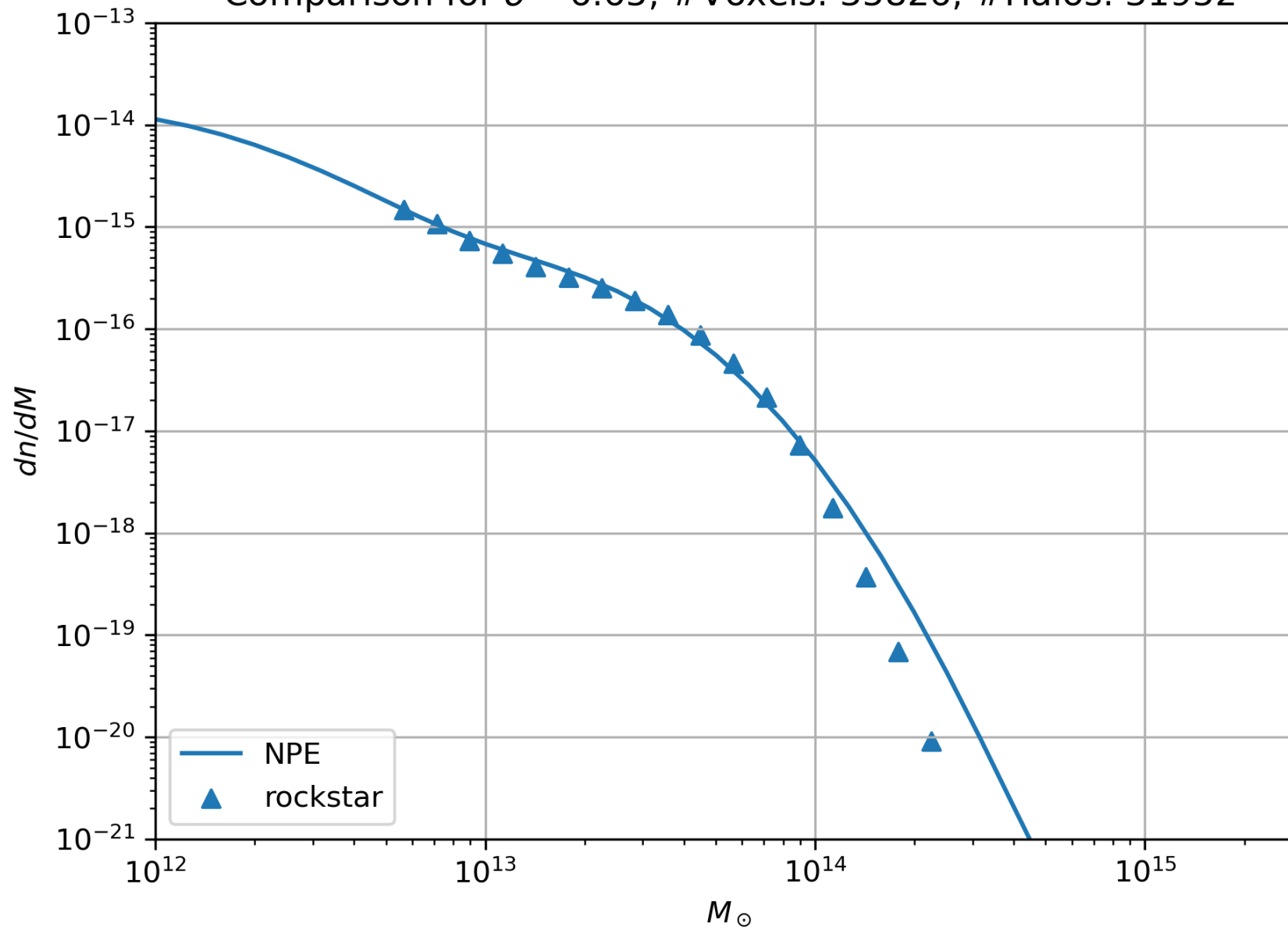
Convolve $\rightarrow \psi(x) \rightarrow$ Transform $\rightarrow P(M | \delta_m) \rightarrow$ Sample

RESULTS

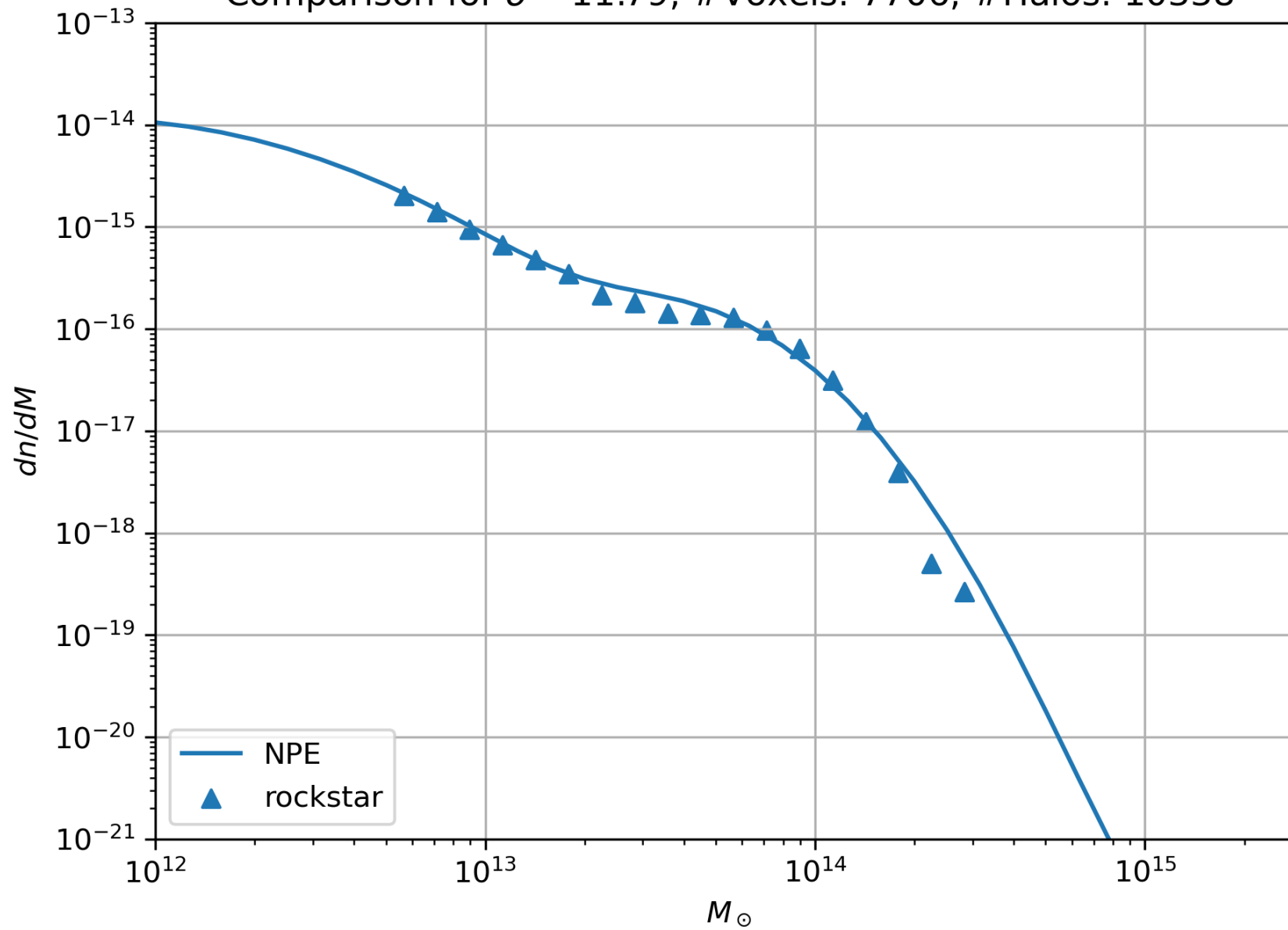
Comparison for $\delta = 1.51$; #Voxels: 2047937; #Halos: 70735



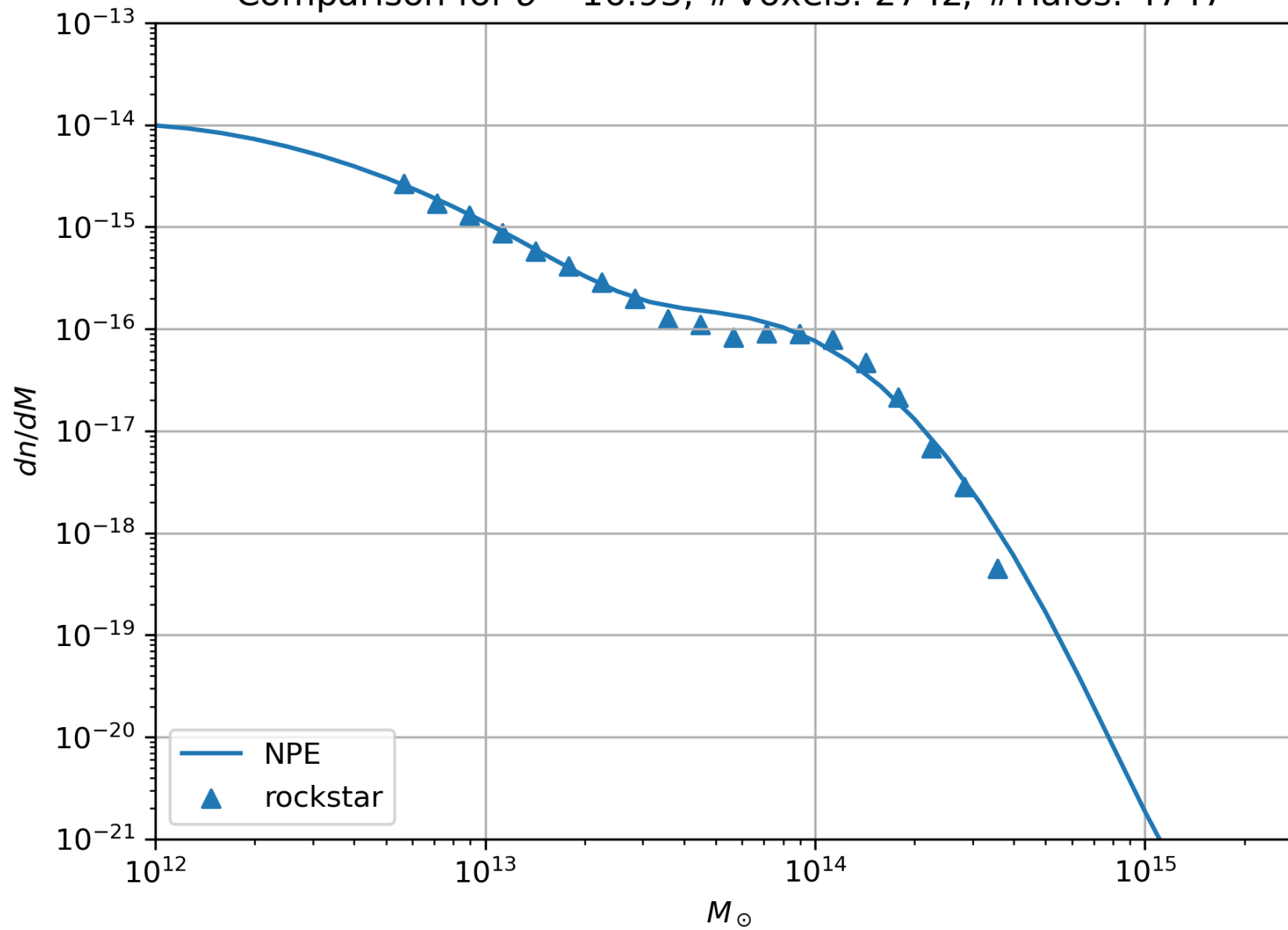
Comparison for $\delta = 6.65$; #Voxels: 35826; #Halos: 31952



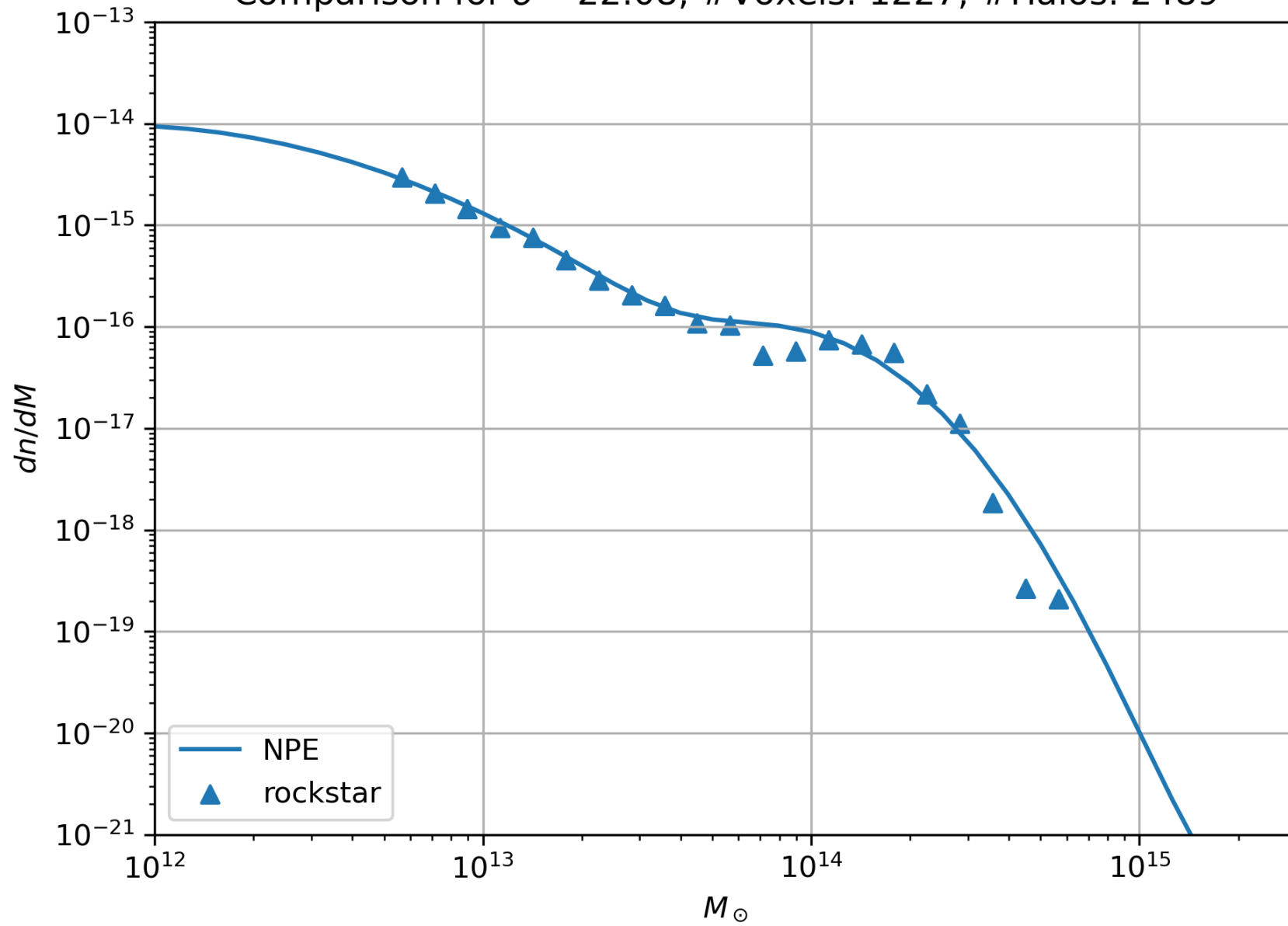
Comparison for $\delta = 11.79$; #Voxels: 7706; #Halos: 10338



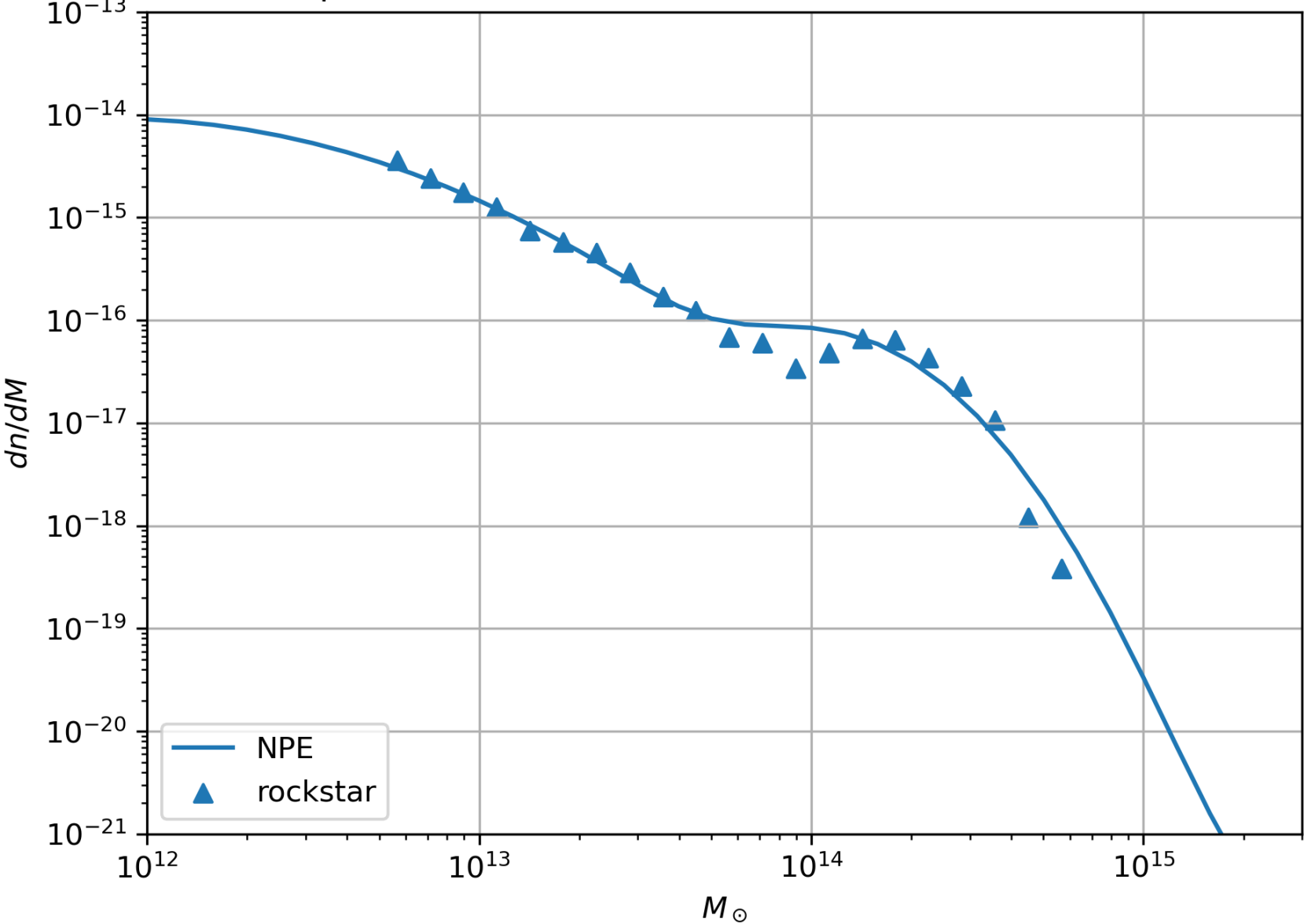
Comparison for $\delta = 16.93$; #Voxels: 2742; #Halos: 4747



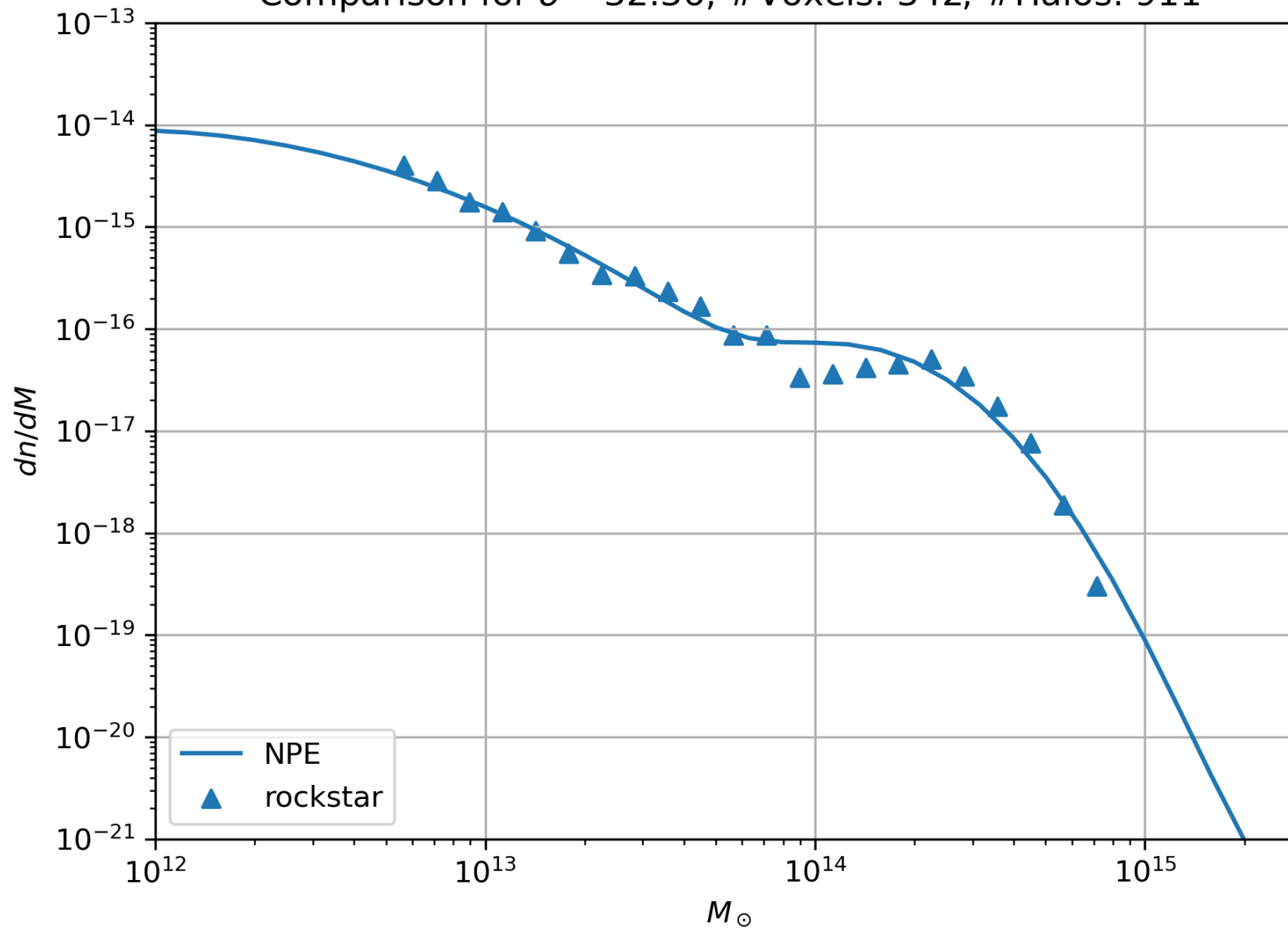
Comparison for $\delta = 22.08$; #Voxels: 1227; #Halos: 2489



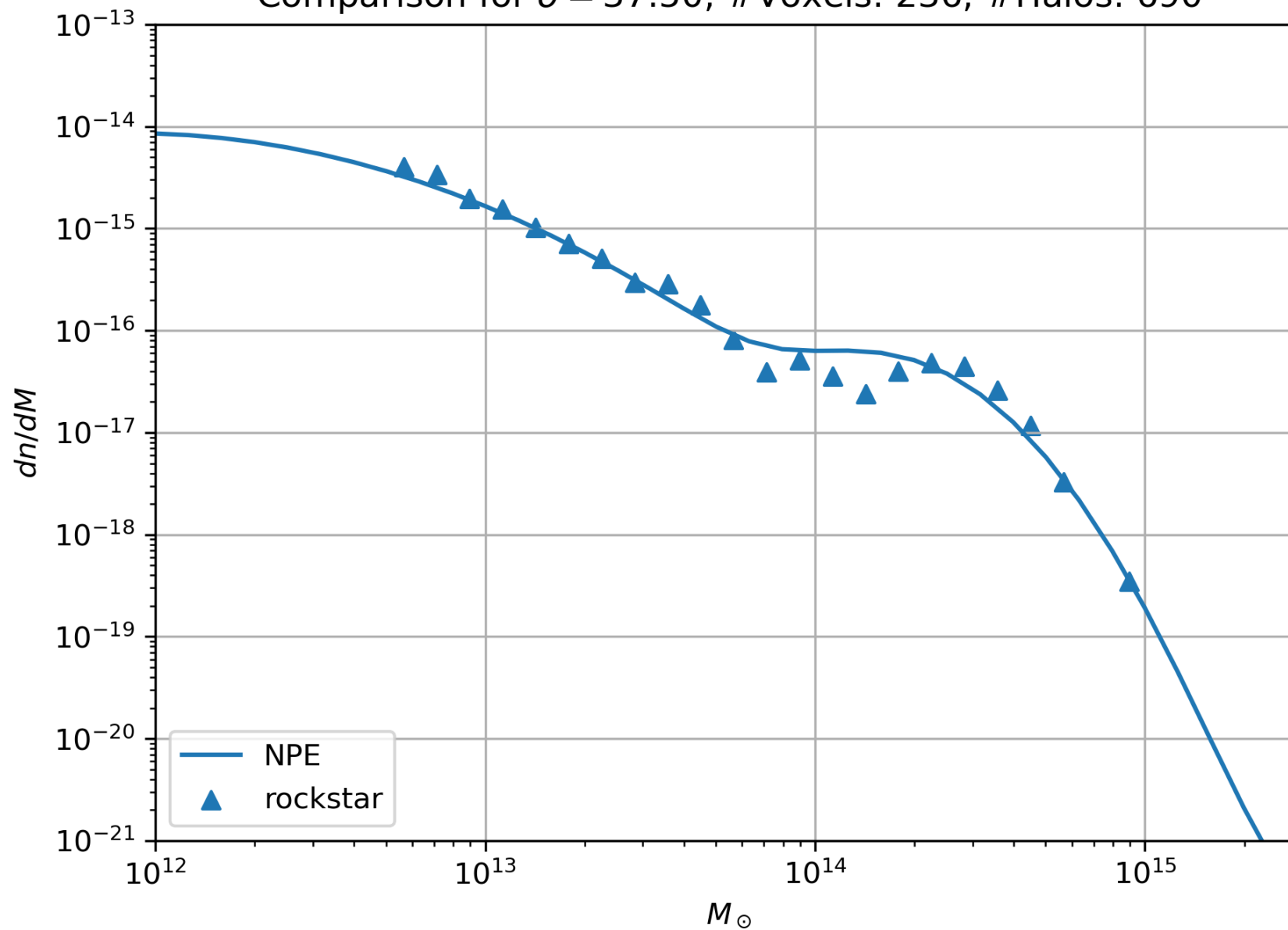
Comparison for $\delta = 27.22$; #Voxels: 676; #Halos: 1634



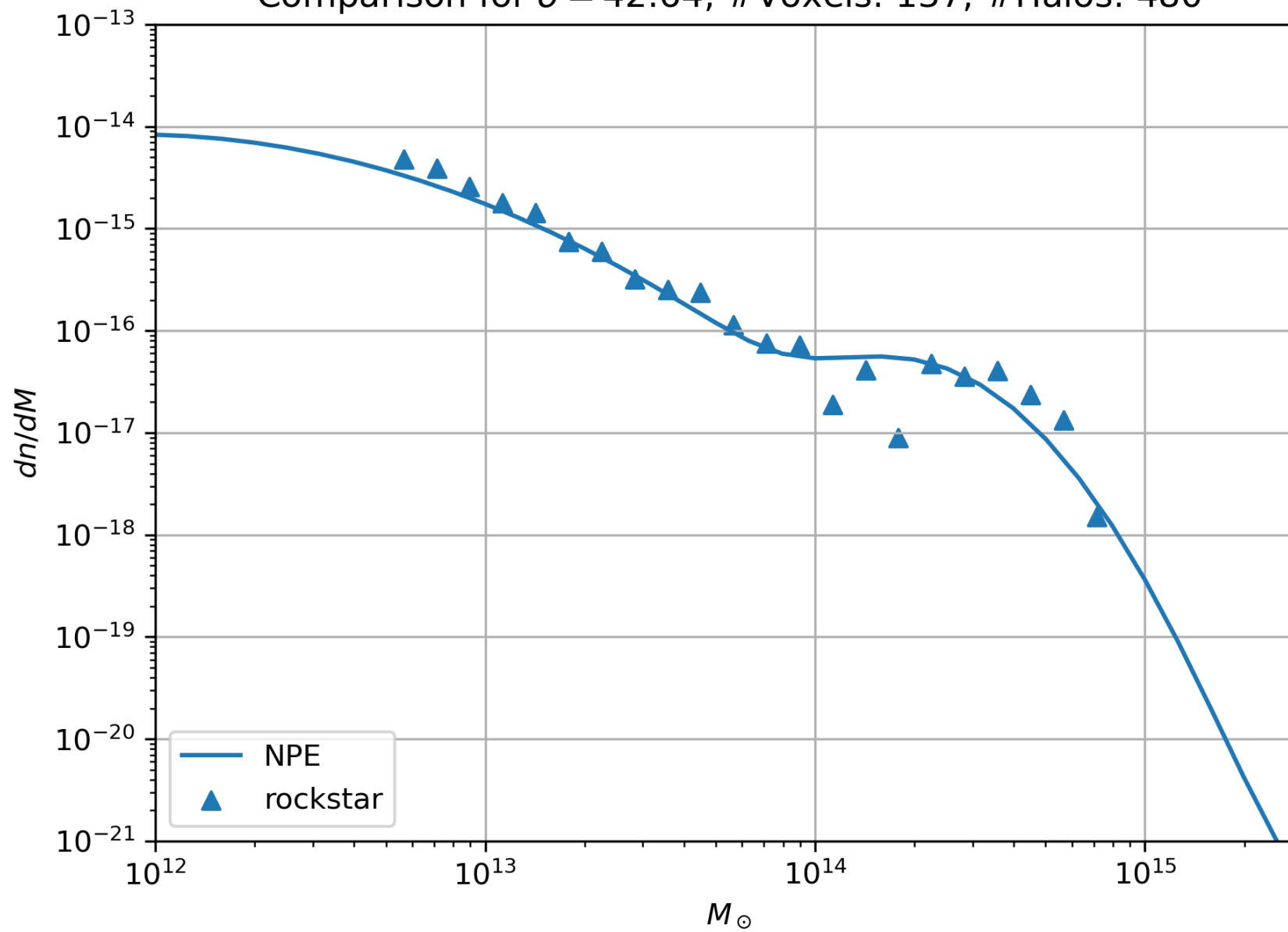
Comparison for $\delta = 32.36$; #Voxels: 342; #Halos: 911



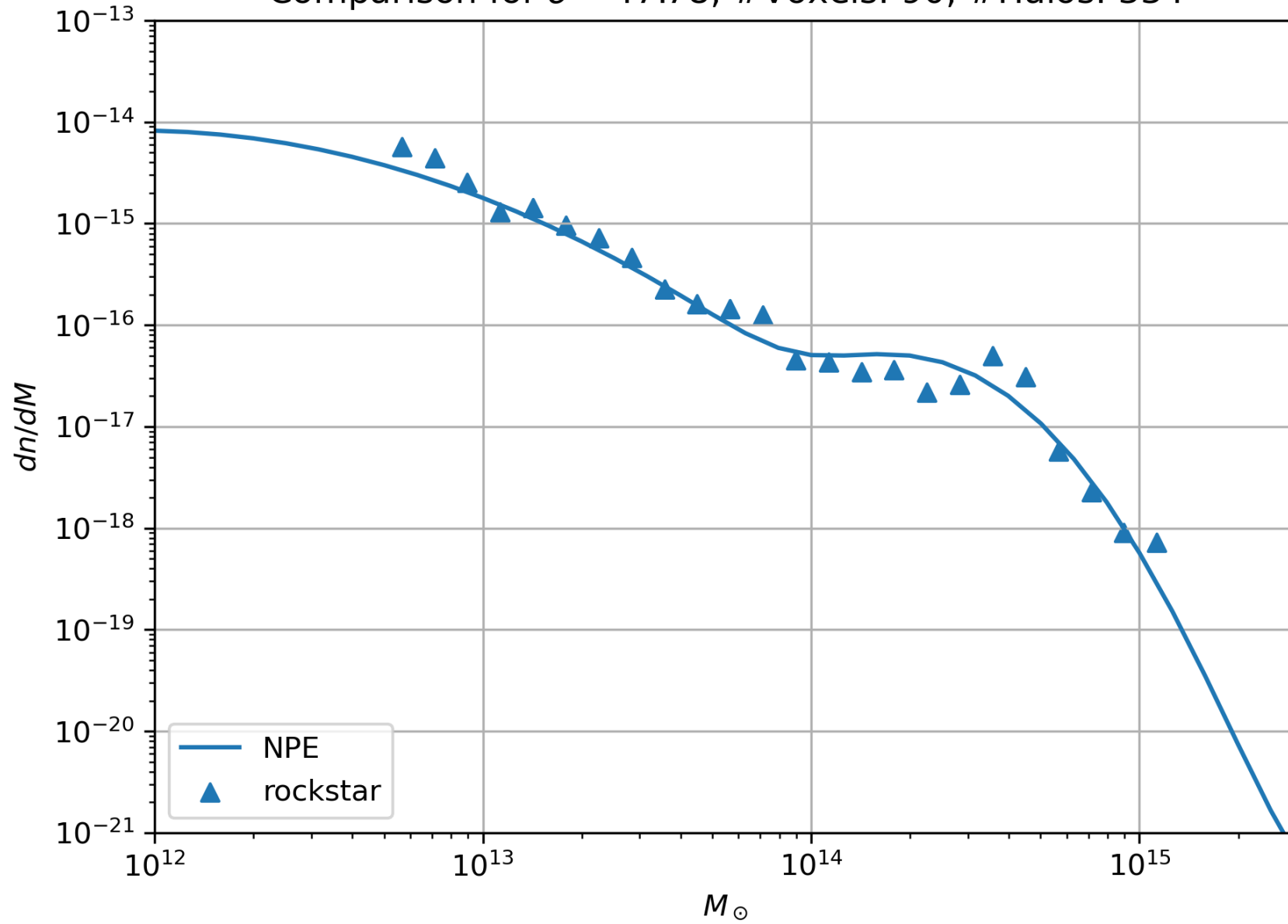
Comparison for $\delta = 37.50$; #Voxels: 236; #Halos: 690



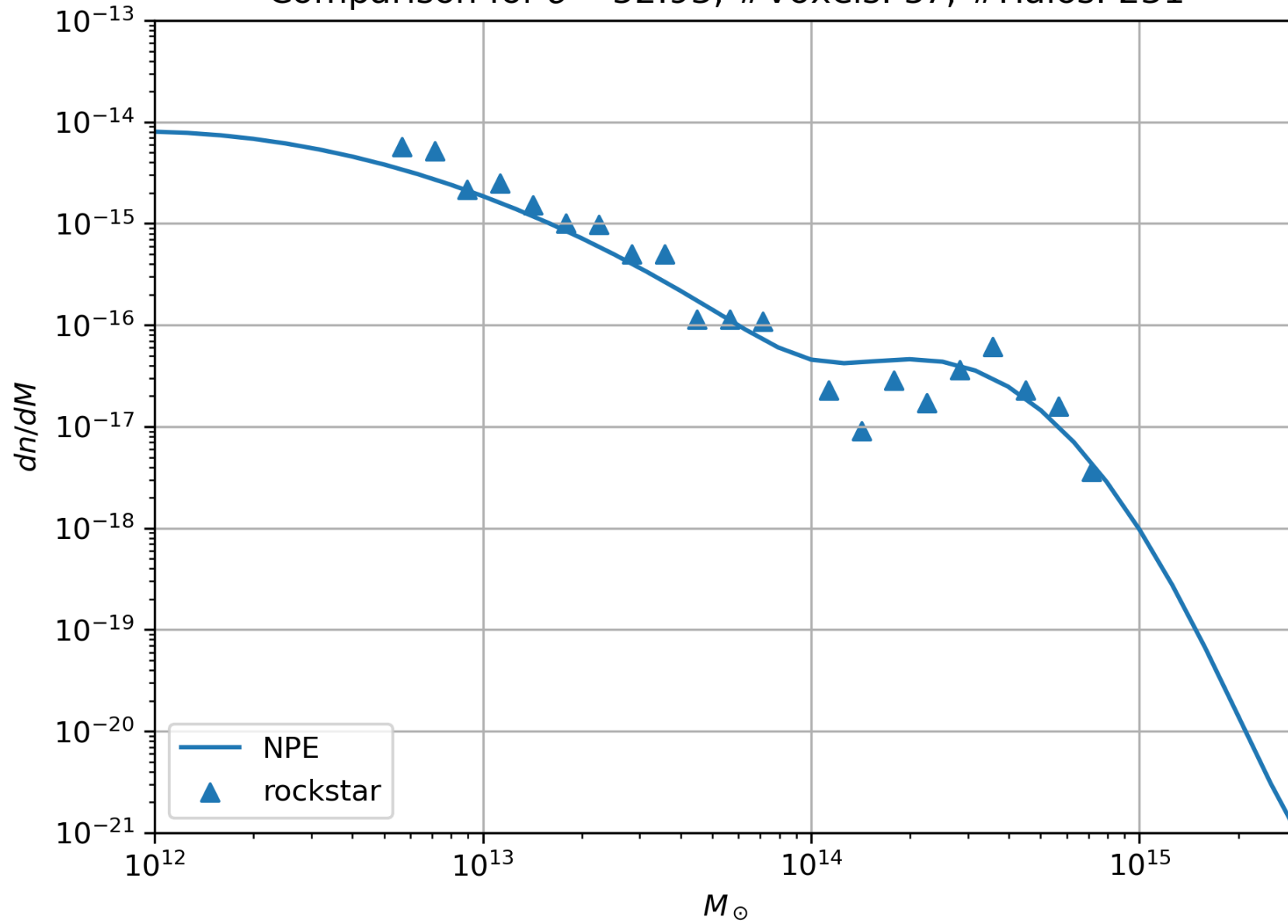
Comparison for $\delta = 42.64$; #Voxels: 137; #Halos: 480



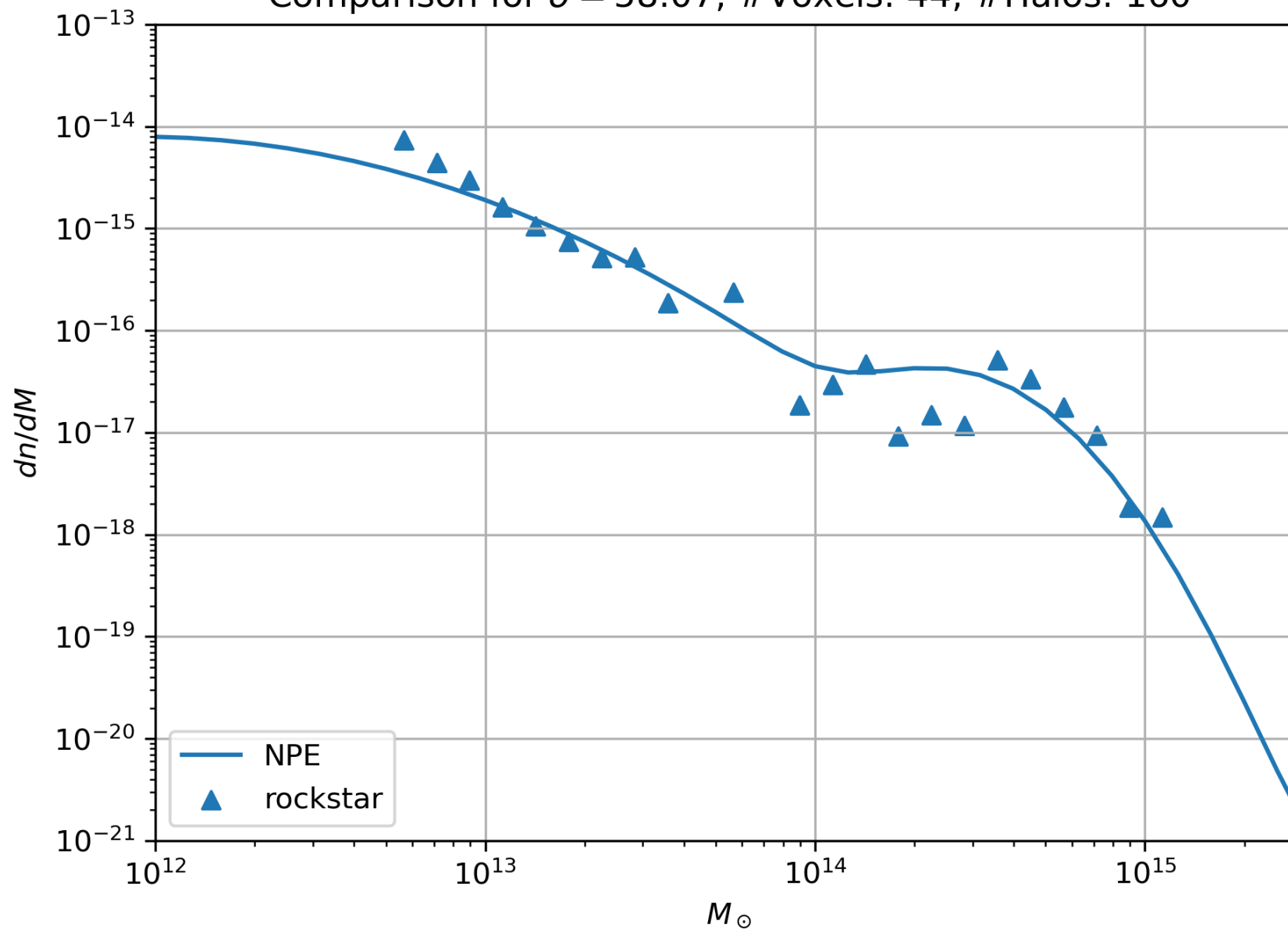
Comparison for $\delta = 47.78$; #Voxels: 90; #Halos: 334



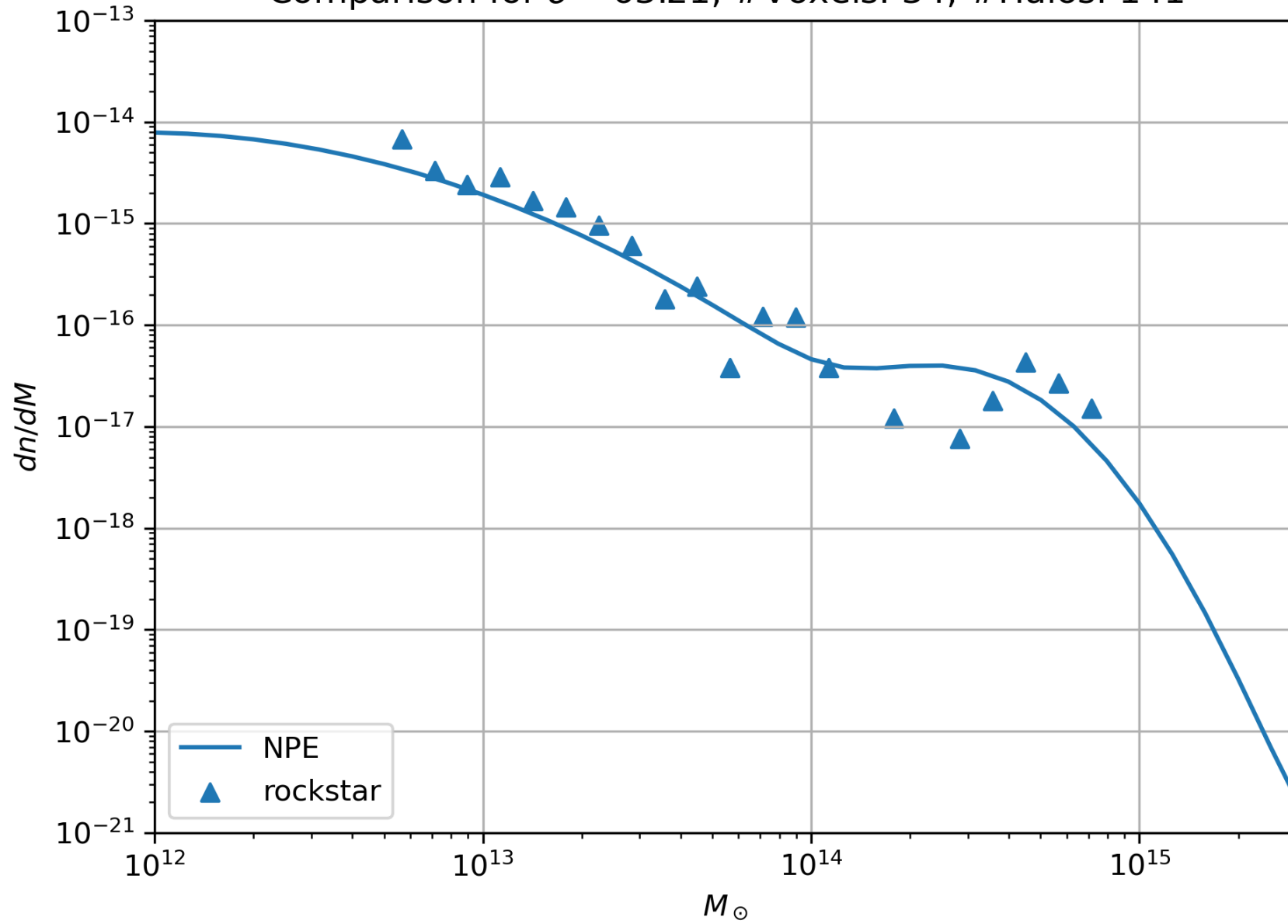
Comparison for $\delta = 52.93$; #Voxels: 57; #Halos: 231



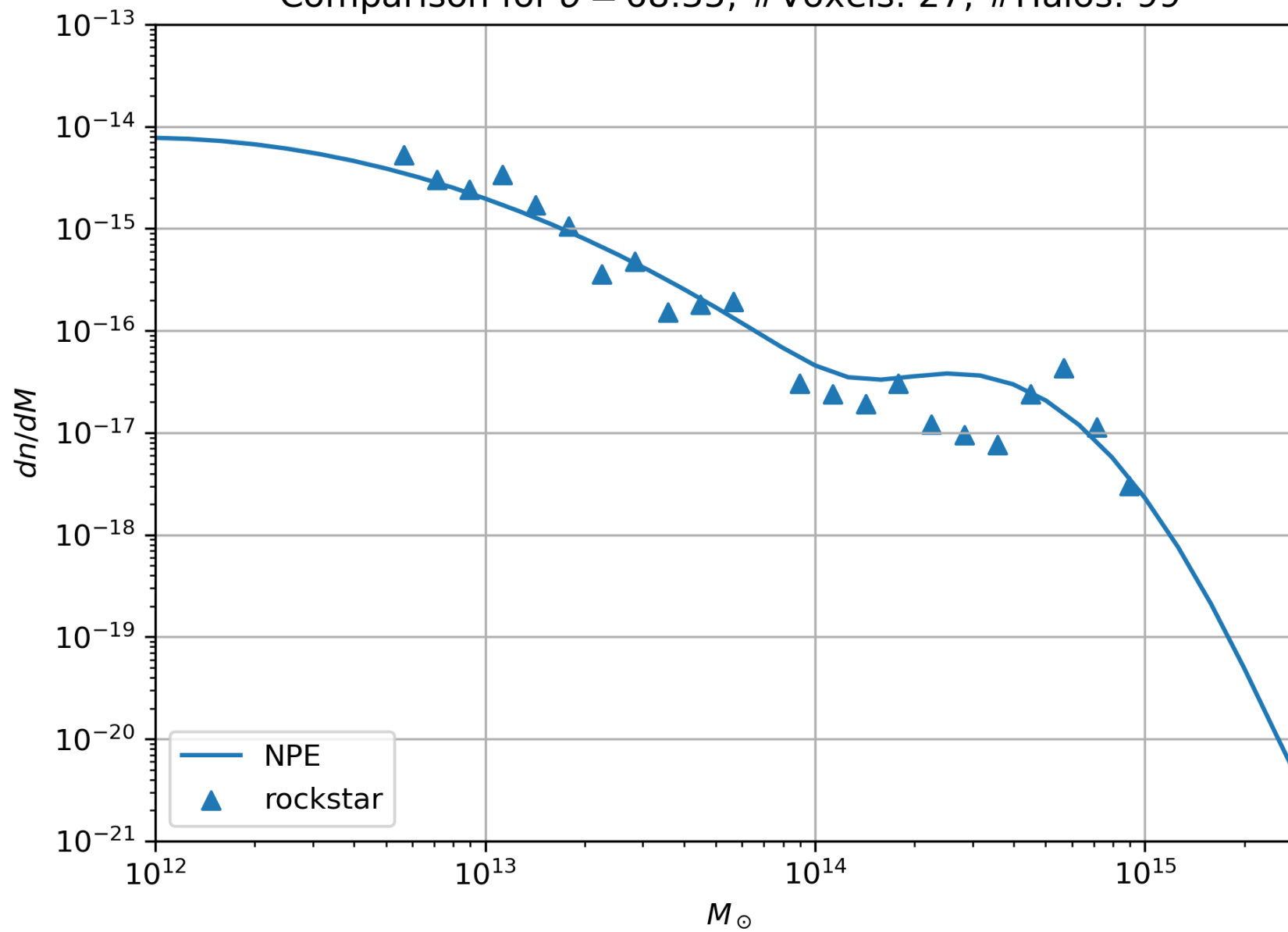
Comparison for $\delta = 58.07$; #Voxels: 44; #Halos: 160



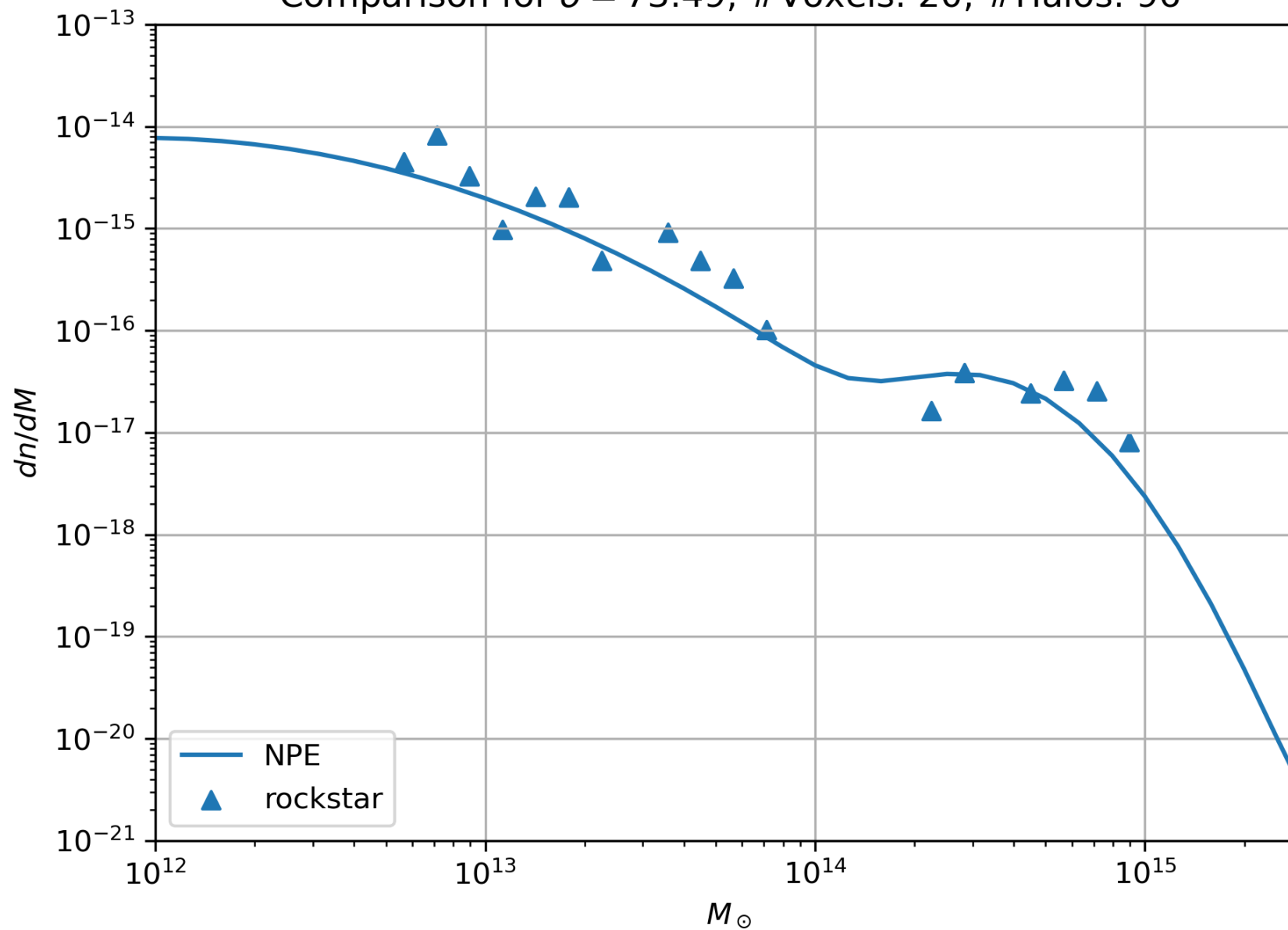
Comparison for $\delta = 63.21$; #Voxels: 34; #Halos: 141



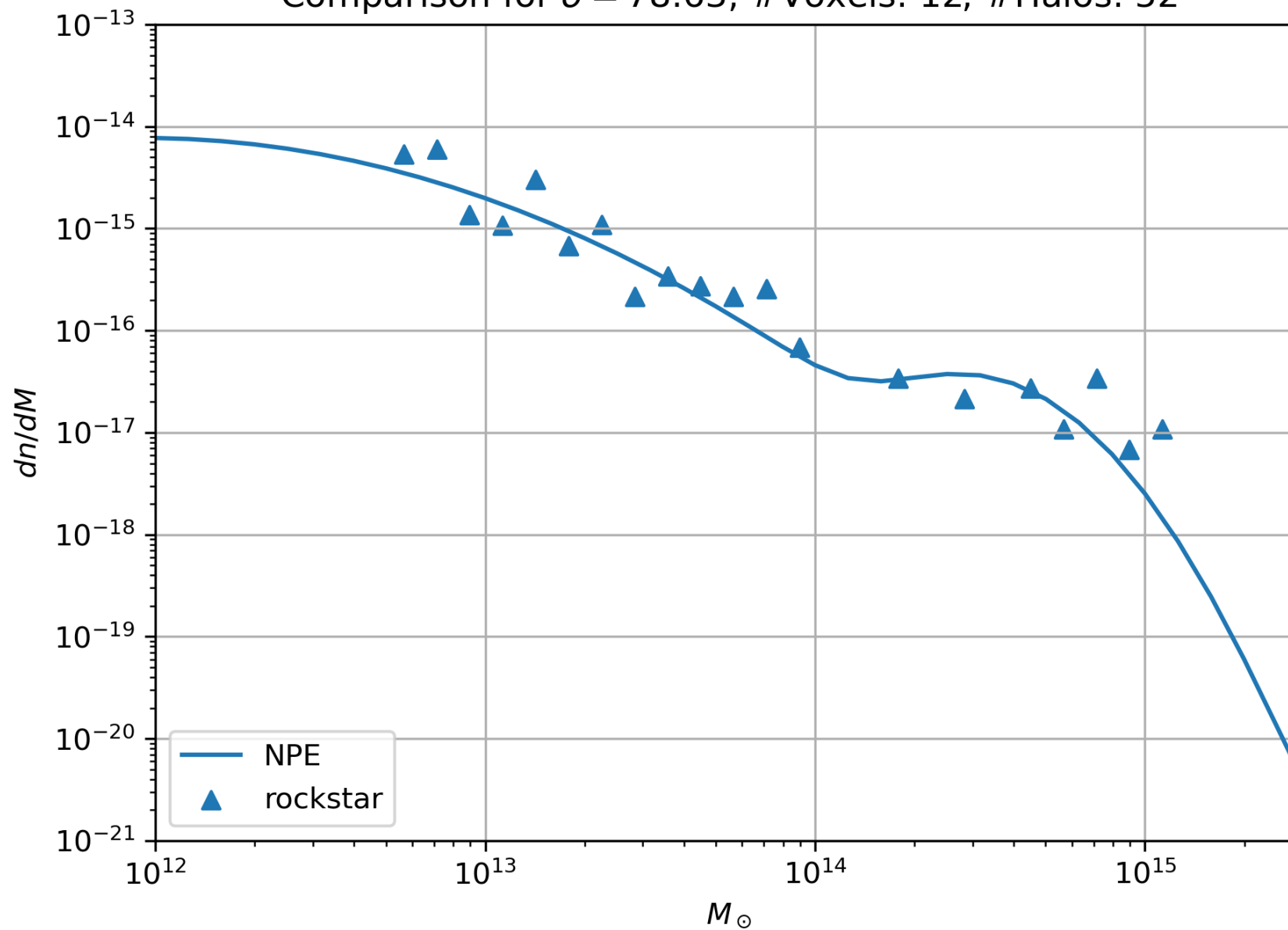
Comparison for $\delta = 68.35$; #Voxels: 27; #Halos: 99



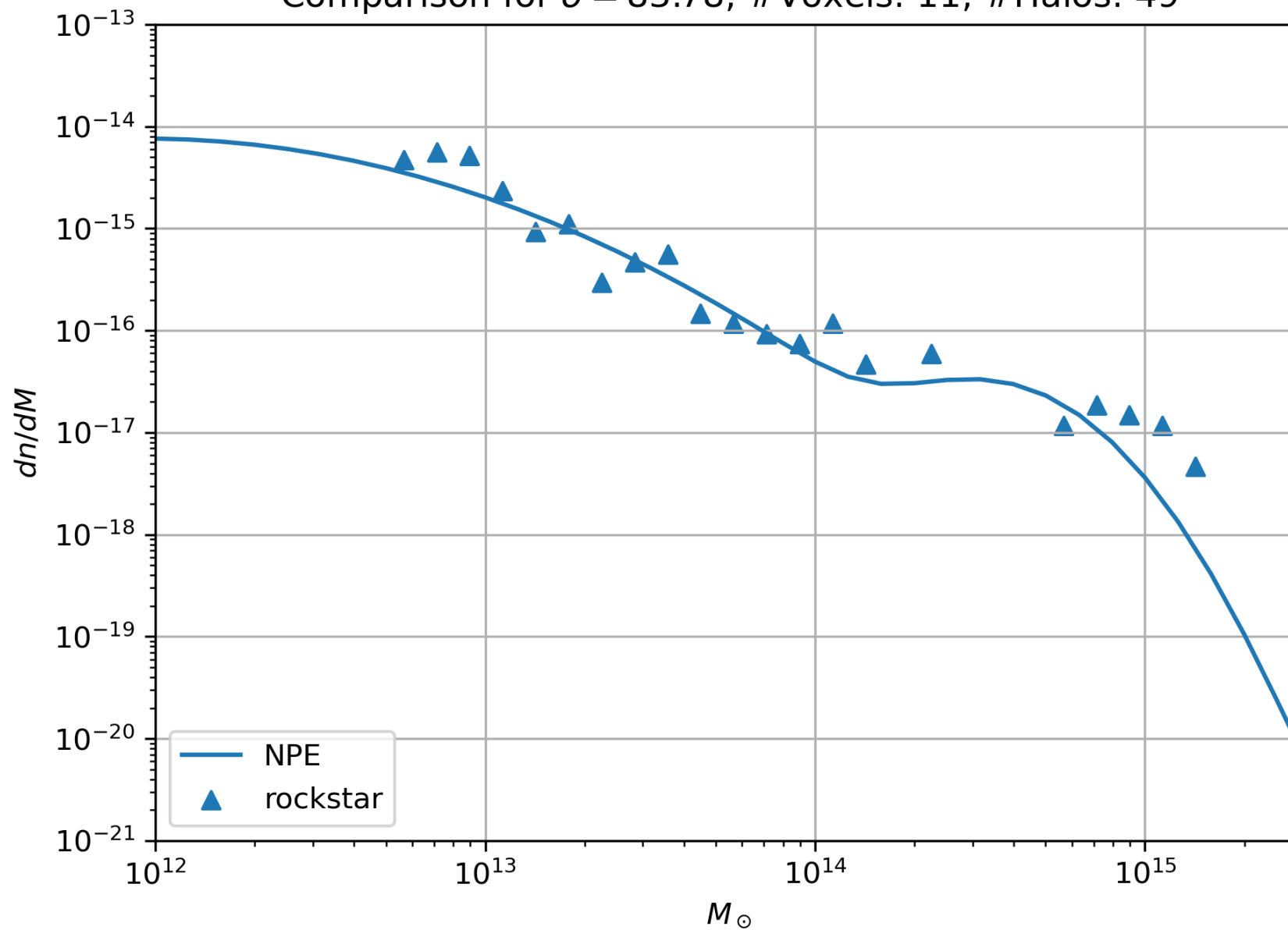
Comparison for $\delta = 73.49$; #Voxels: 20; #Halos: 96



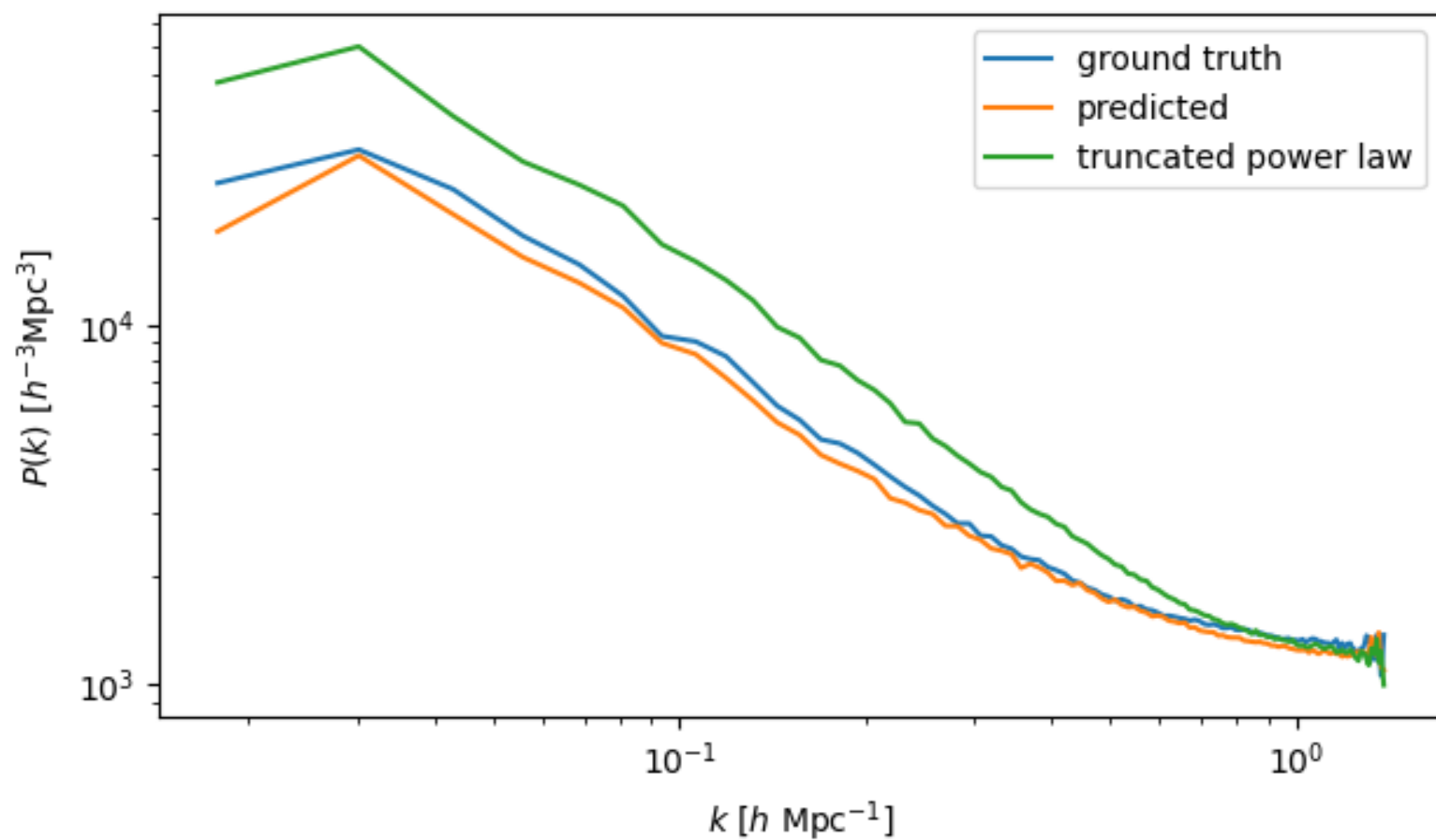
Comparison for $\delta = 78.63$; #Voxels: 12; #Halos: 52



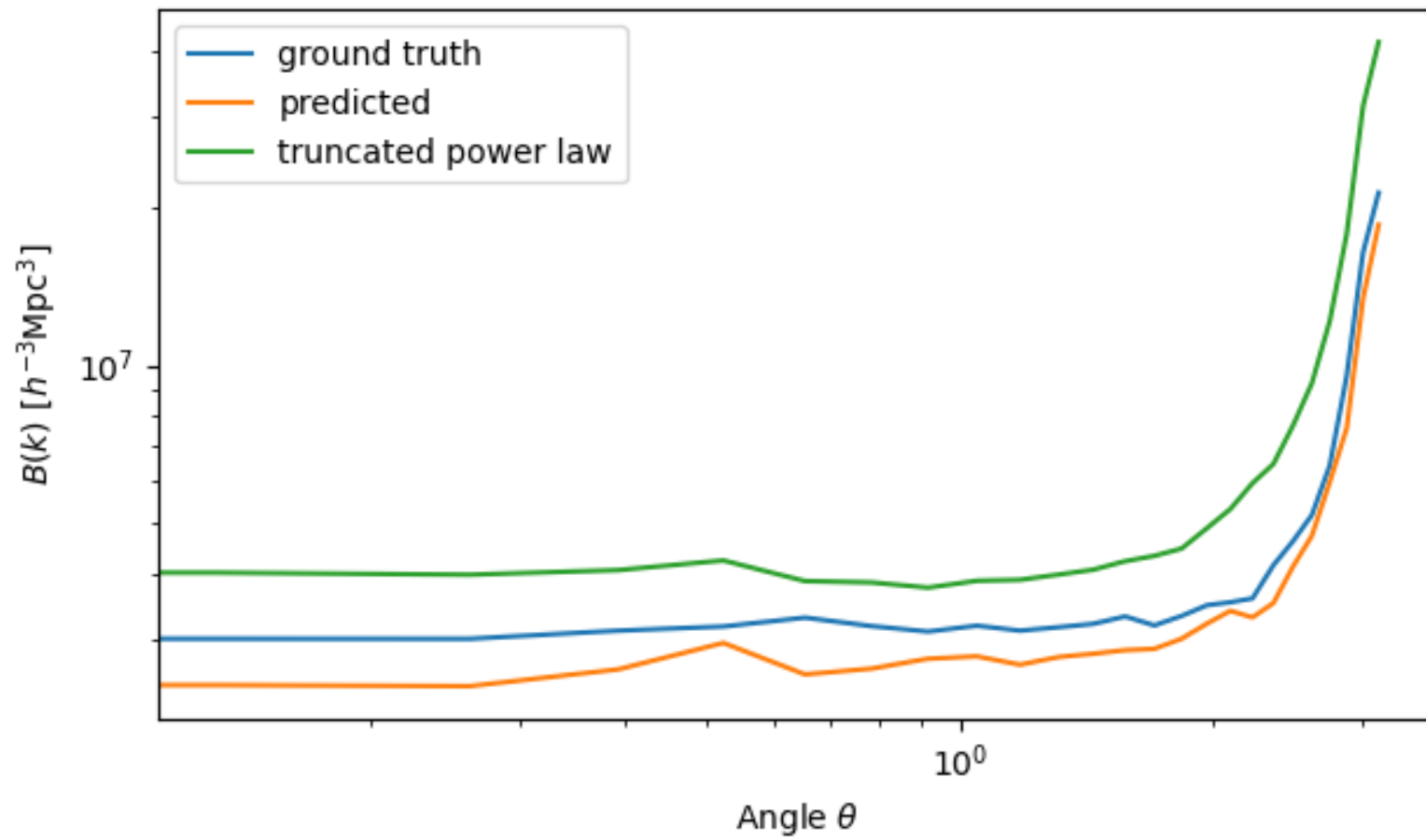
Comparison for $\delta = 83.78$; #Voxels: 11; #Halos: 49



NPE for
voxel size $3.91h^{-1}\text{Mpc}^3$ and mass bins [' $5.00\text{e}+12$ ', ' $2.81\text{e}+13$ ']



NPE for
voxel size $3.91h^{-1}\text{Mpc}^3$ and mass bins [' $5.00\text{e}+12$ ', ' $2.81\text{e}+13$ ']



SUMMARY

- Model has reduced number of weights → zero-shot learning
- Generative model that can generate realistic mocks once trained
- Kernel weights can be interpreted
- **Shameless plug:** [Bias test bench](#)
- Happy to chat in person or via simon.ding@iap.fr

