Fast Mocks in the Very Large Survey Era with the Peak Patch Approach

George Stein

Collaborators

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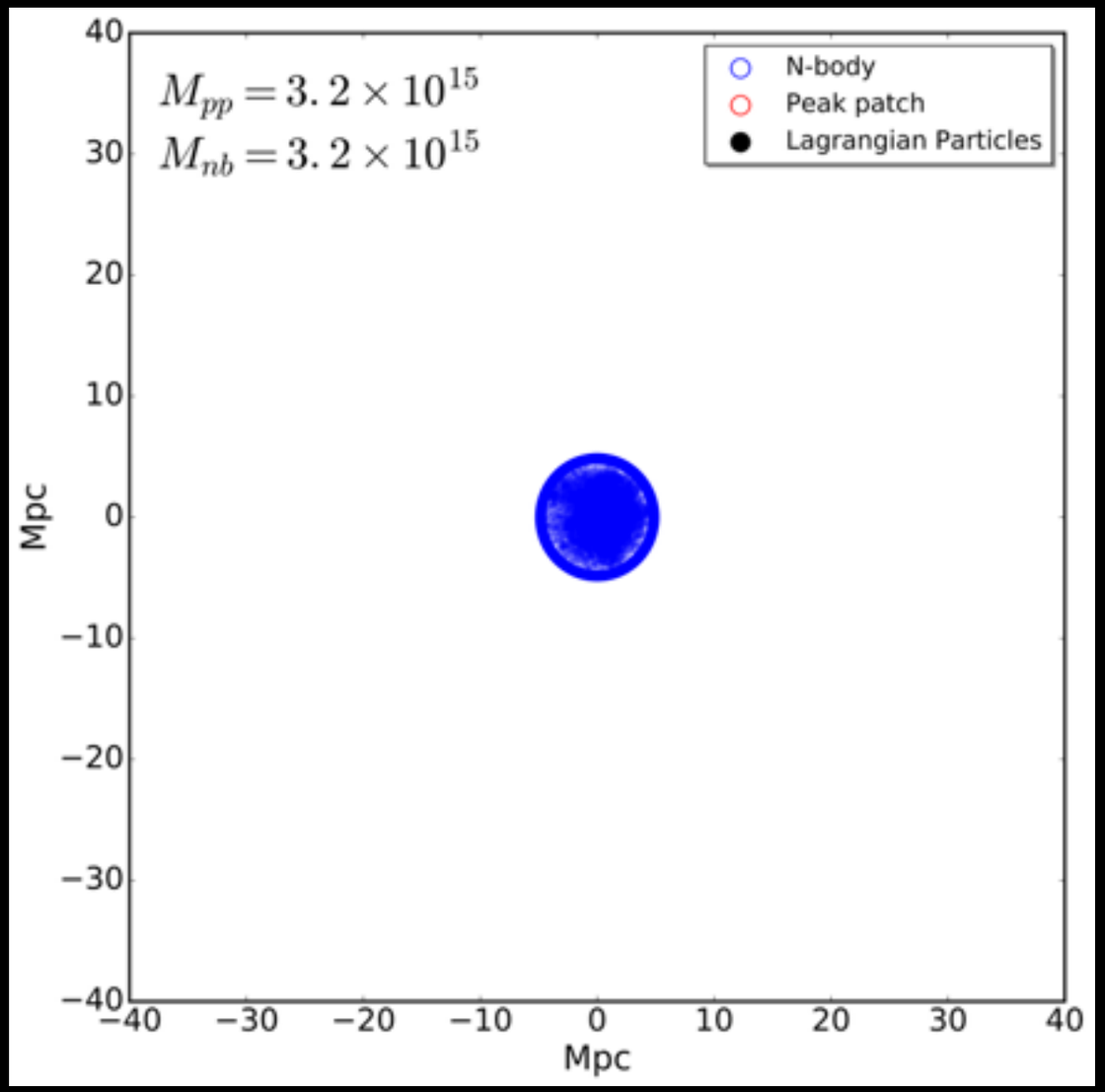
Nick Battaglia, Anita Bahmanyar

Mocking Heaven Motivation

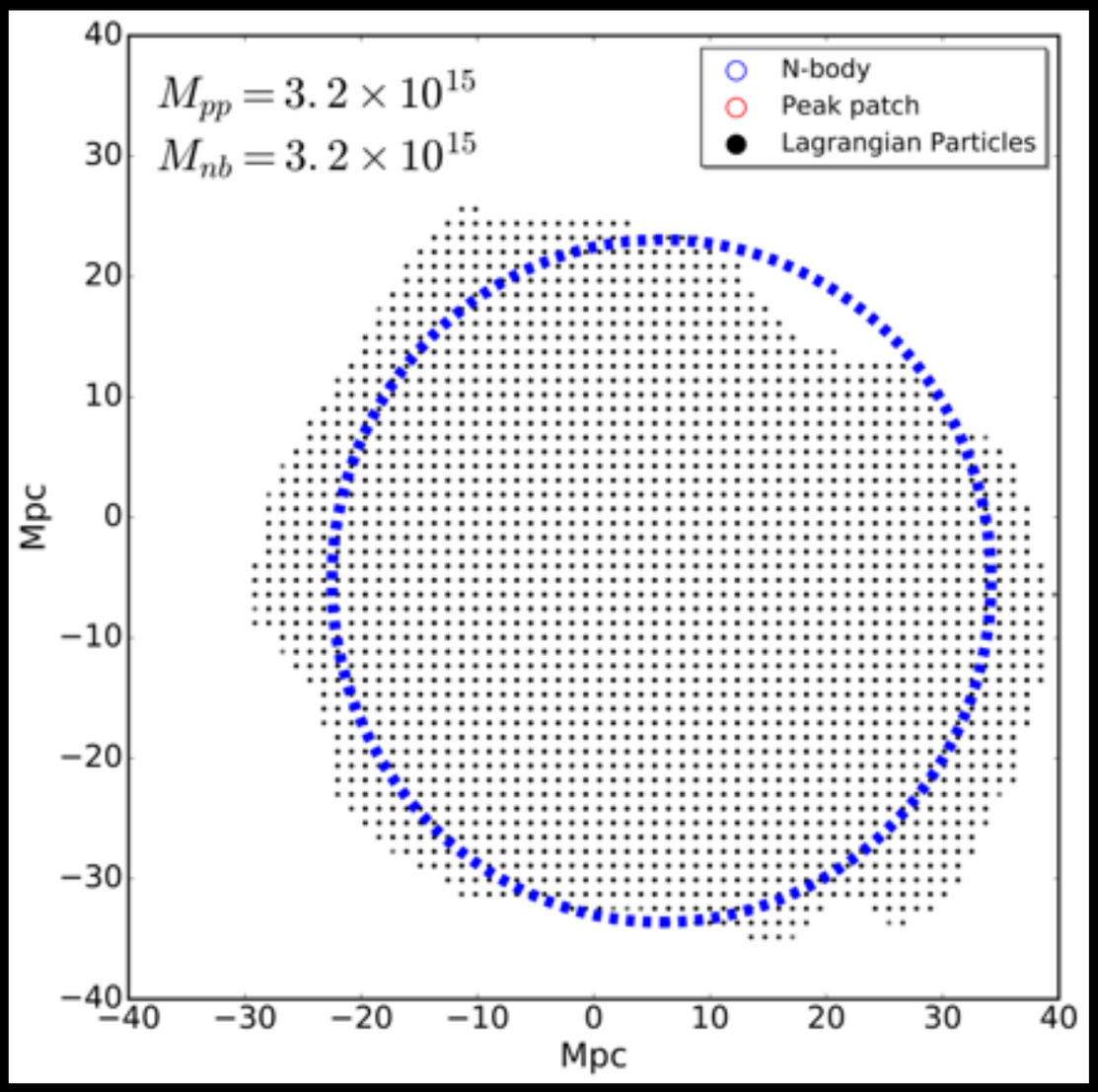
- Future surveys will cover extremely large volumes of the universe. eg. Euclid, LSST, CHIME, etc…
    - clustering measurements require an estimate of their covariance matrix for reliable cosmological constraints
- Determine impact of various systematic effects
- Pipeline Analysis

N-body

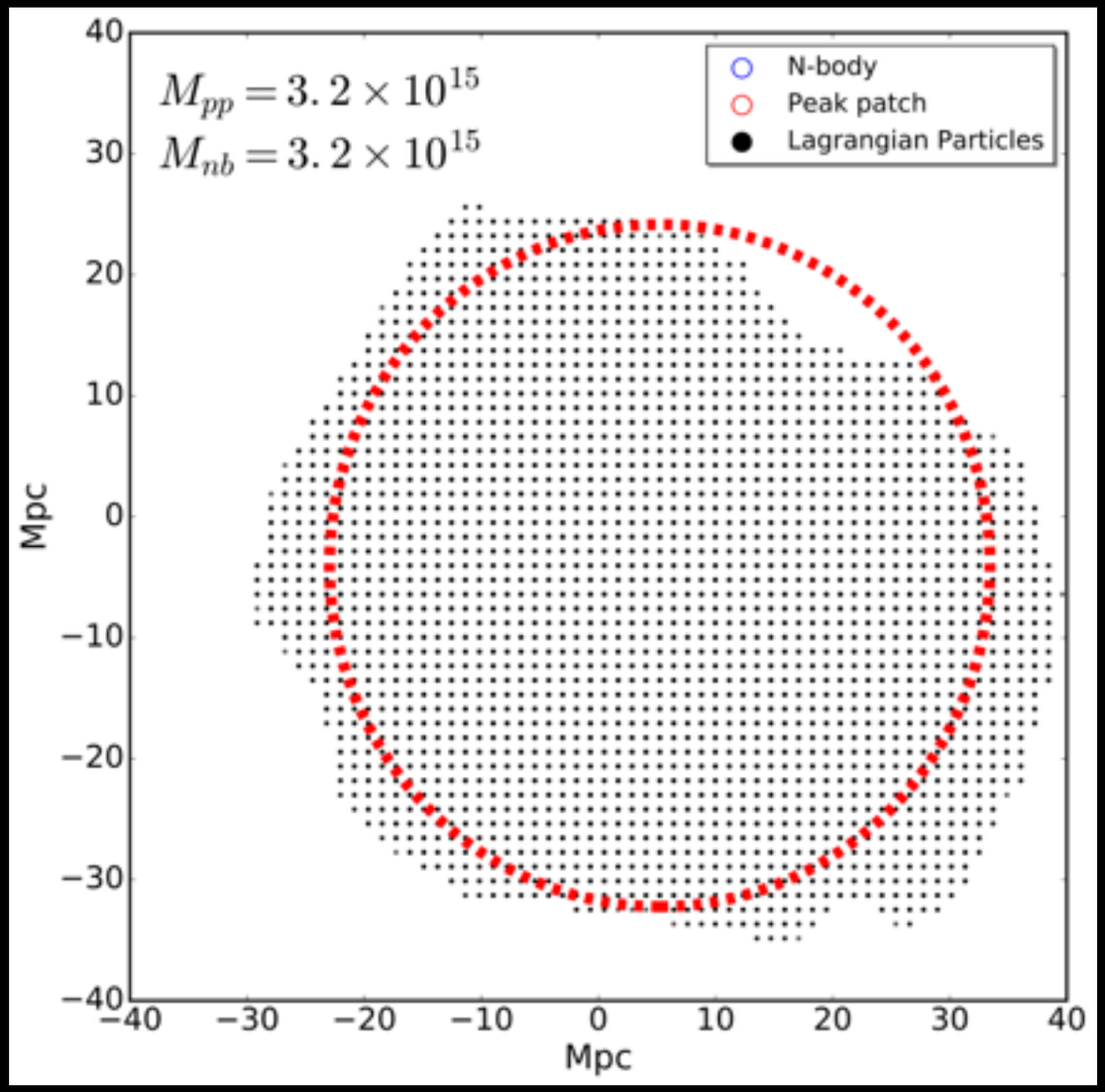
Eulerian



Lagrangian



Peak-Patch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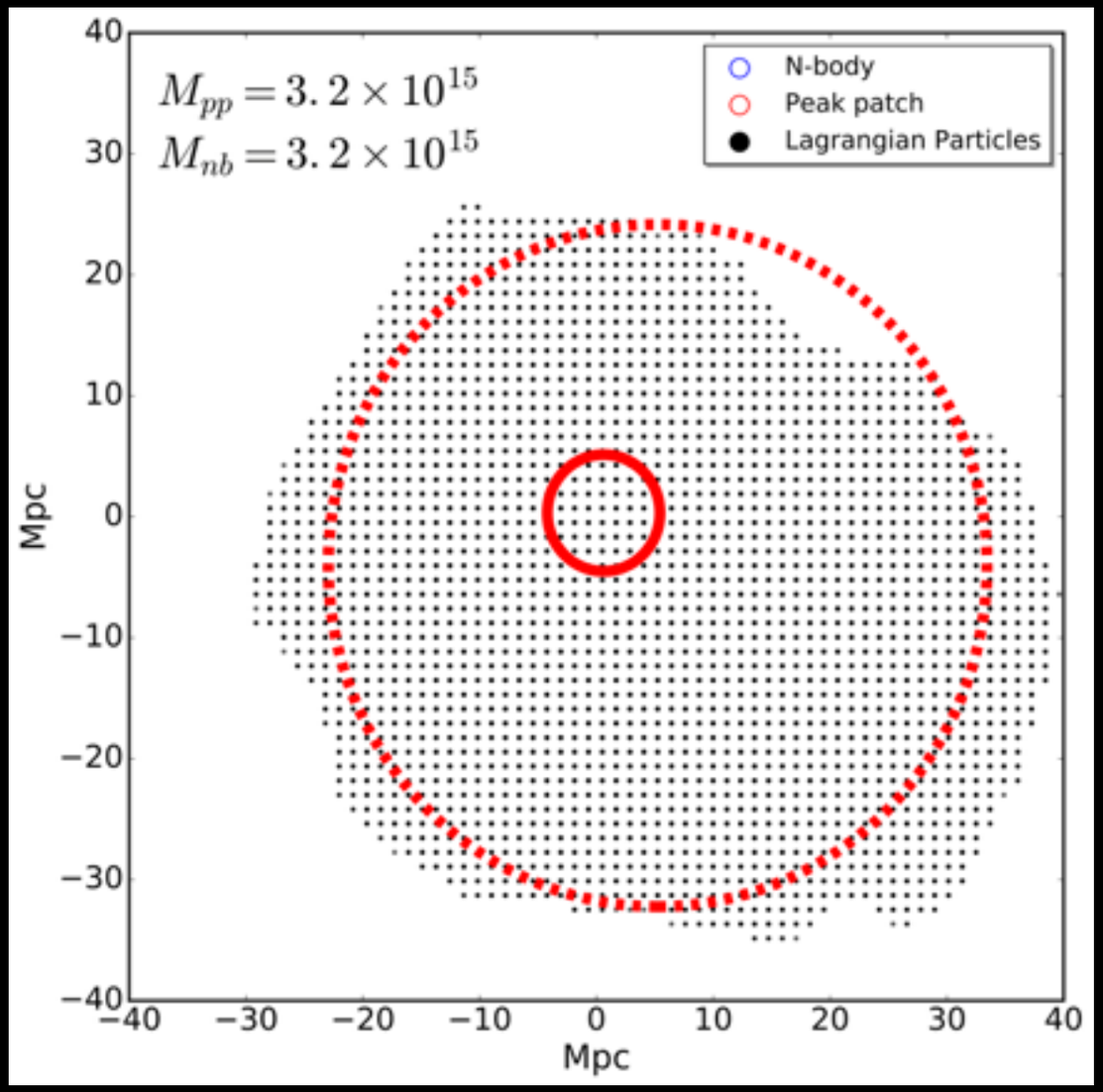
$M_{nb} = 3.2 \times 10^{15}$
N-body
Peak patch
Lagrangian Particles
Mpc
Mpc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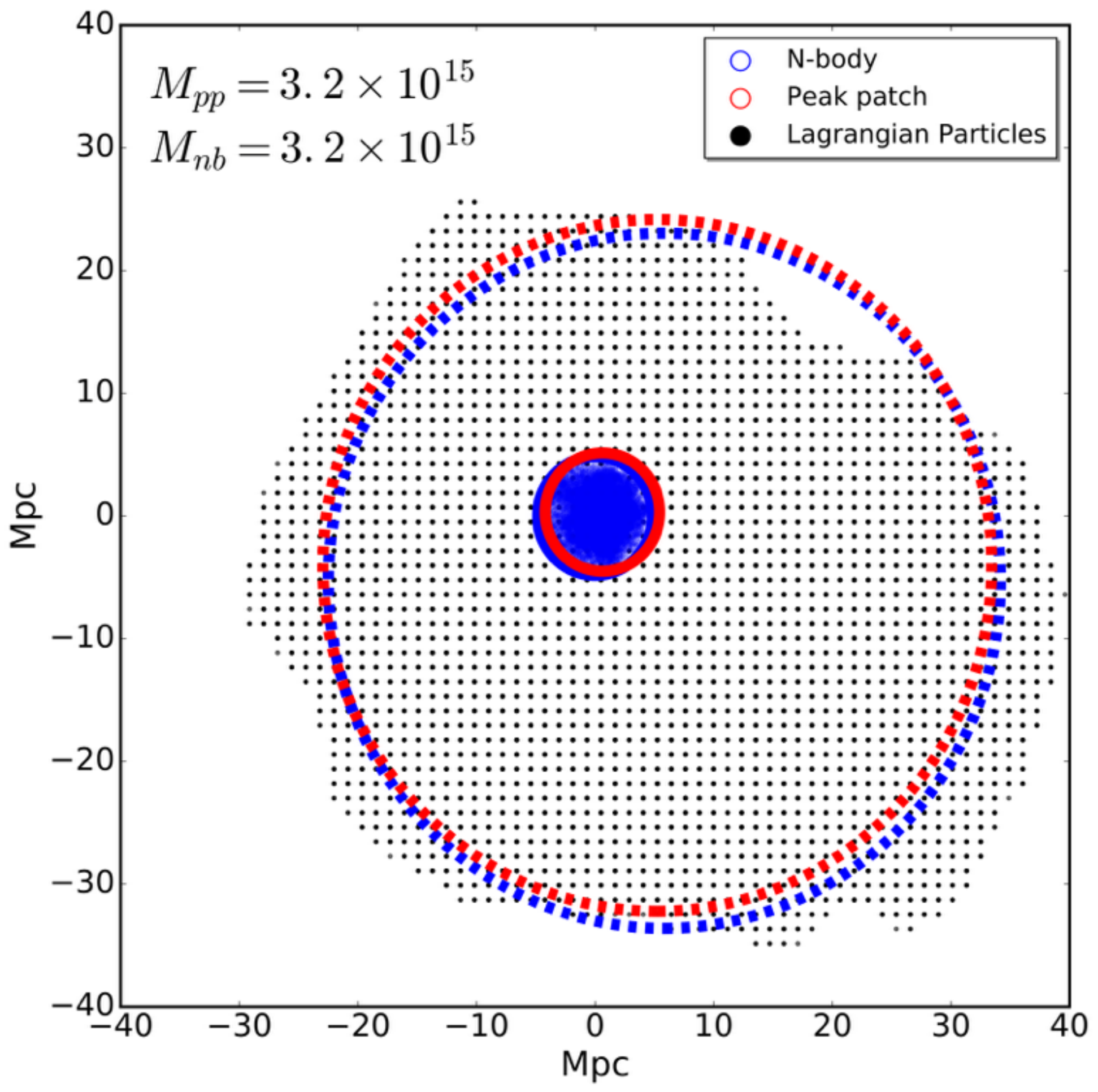
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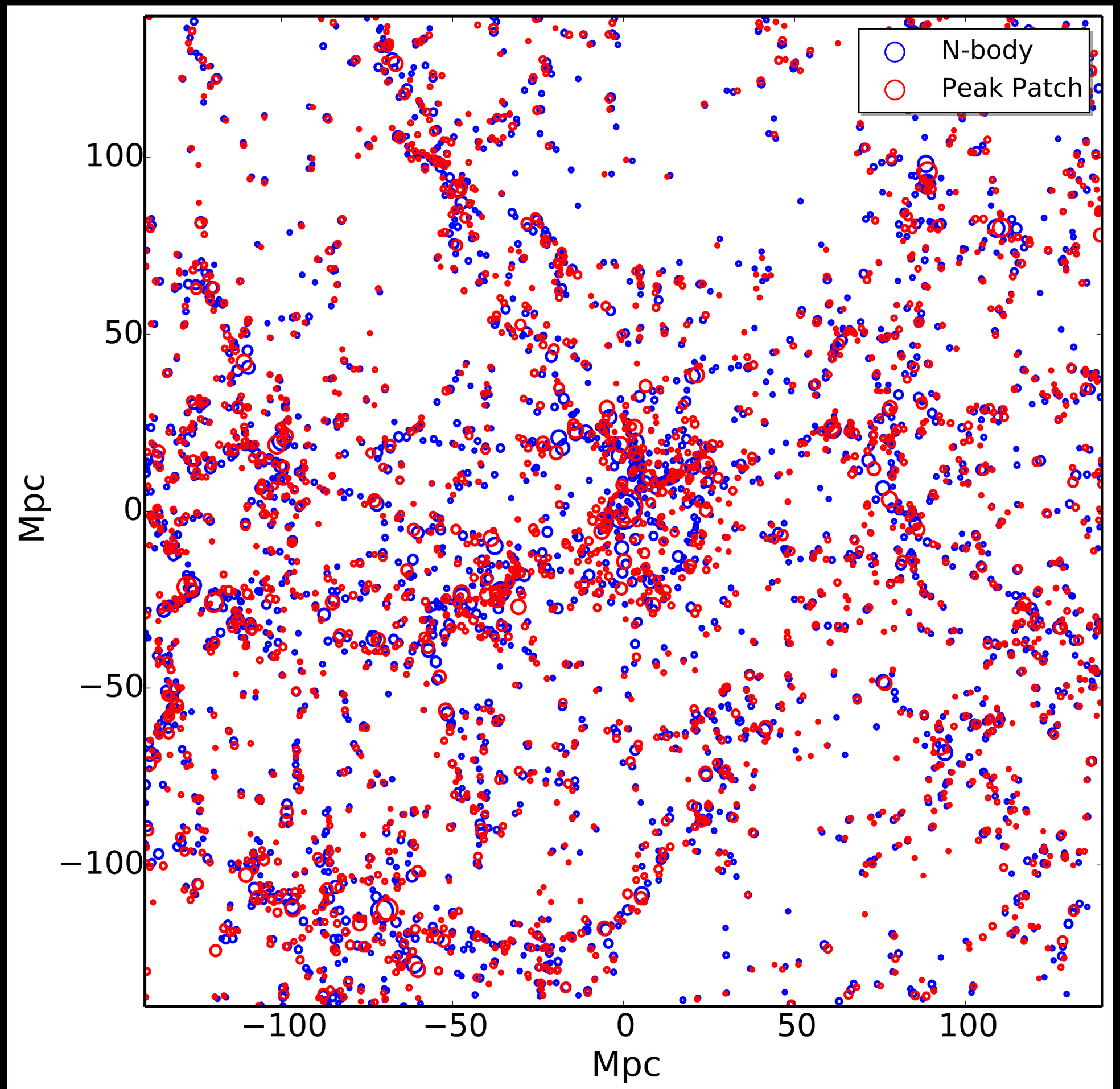
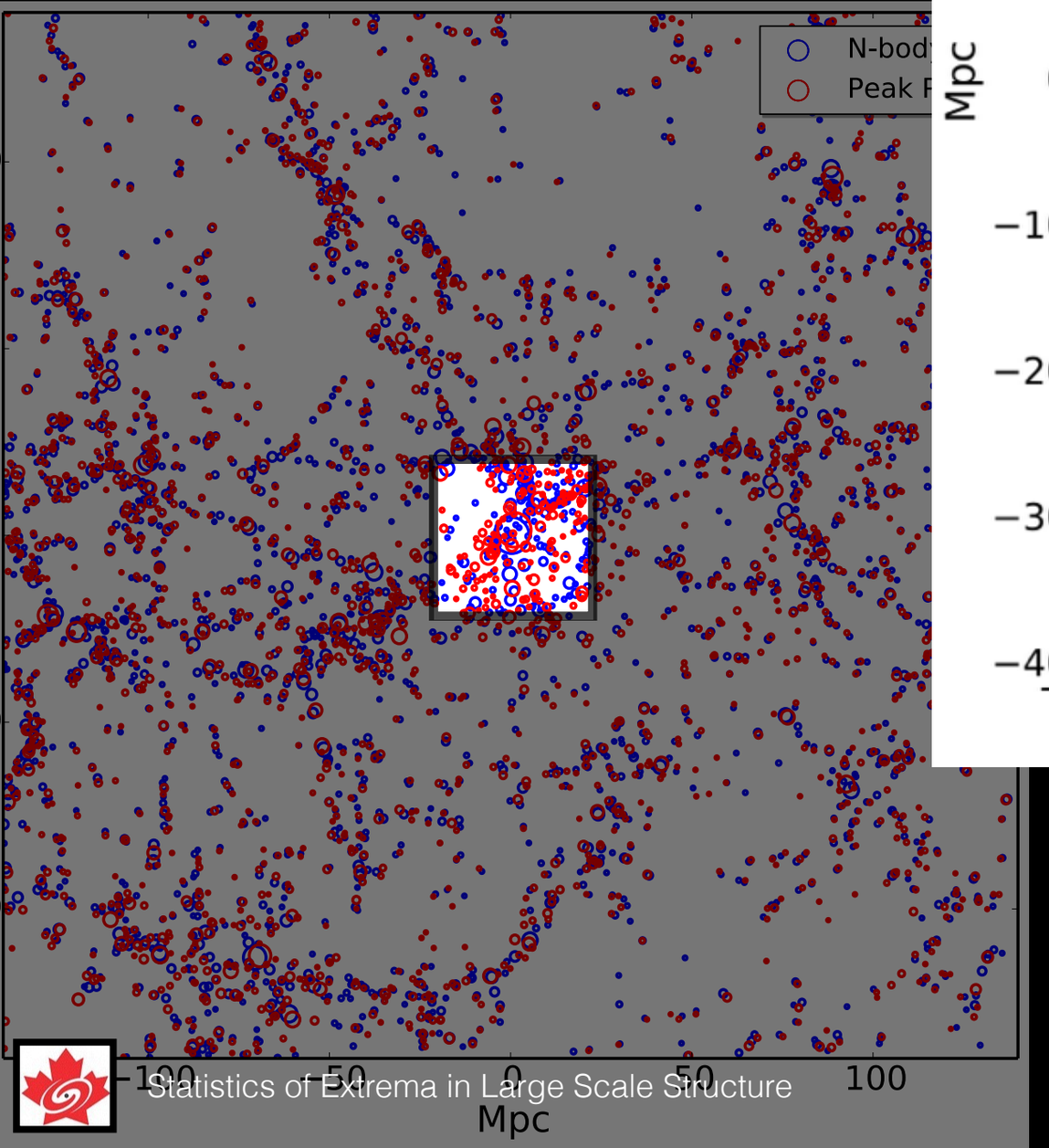
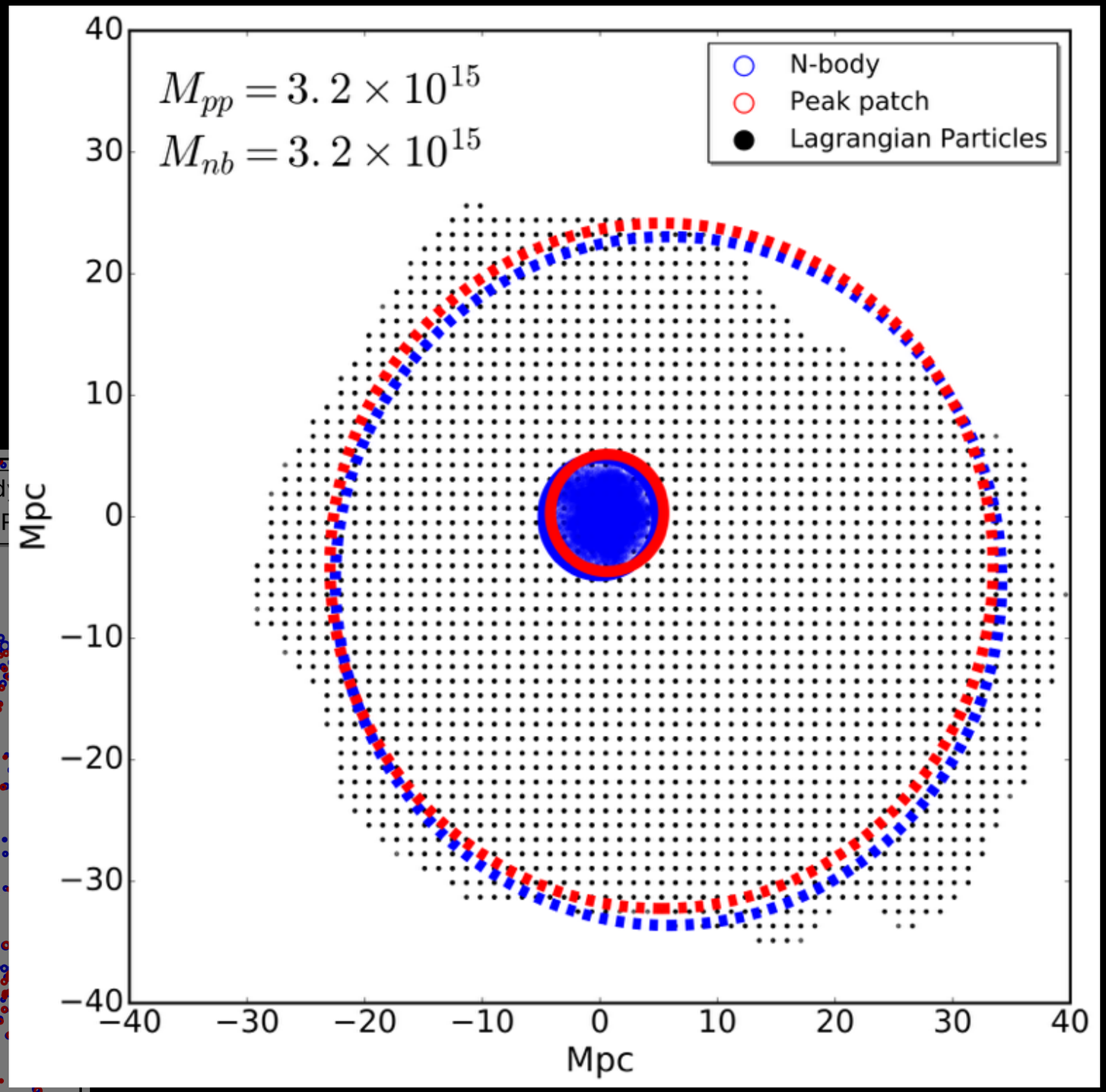
$M_{nb} = 3.2 \times 10^{15}$
N-body
Peak patch
Lagrangian Particles
40
30
20
10
0
−10
−20
−30
−40
Mpc
−40
−30
−20
−10
0
10
20
30
40
Mpc


N-body
Peak Patch
100
50
0
−50
−100
Mpc
−100
−50
0
50
100
Mpc


N-bod
Peak P
−100
−50
0
50
100
Mpc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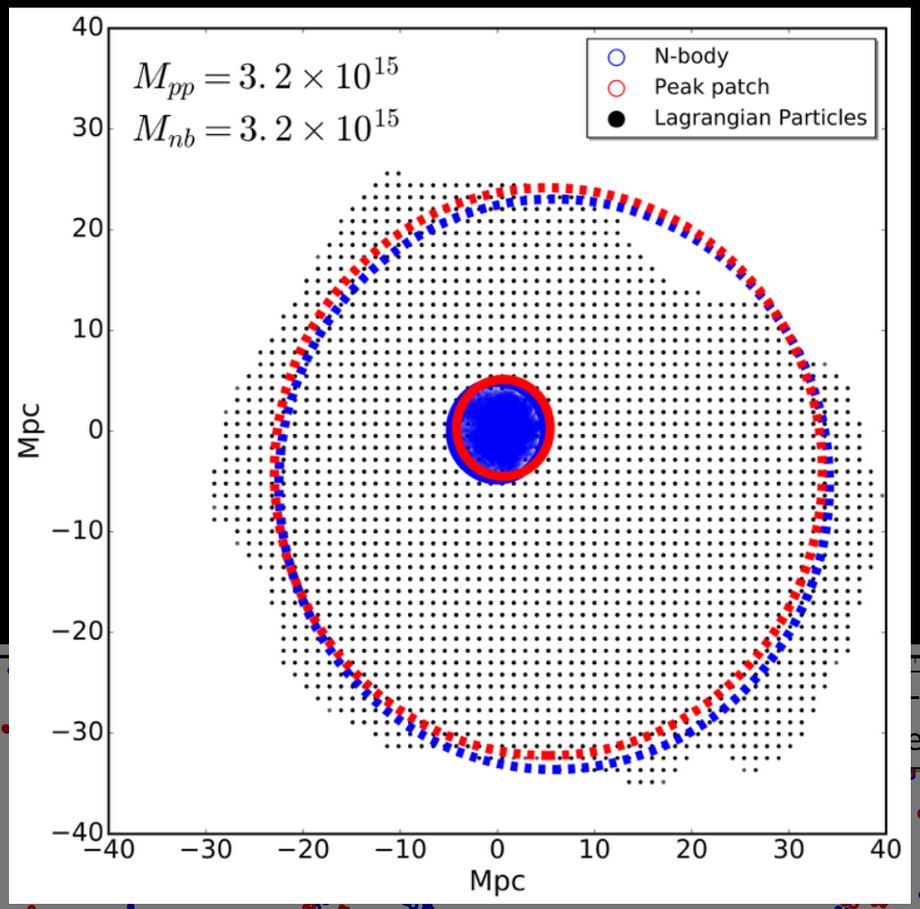
20
30
40
Mpc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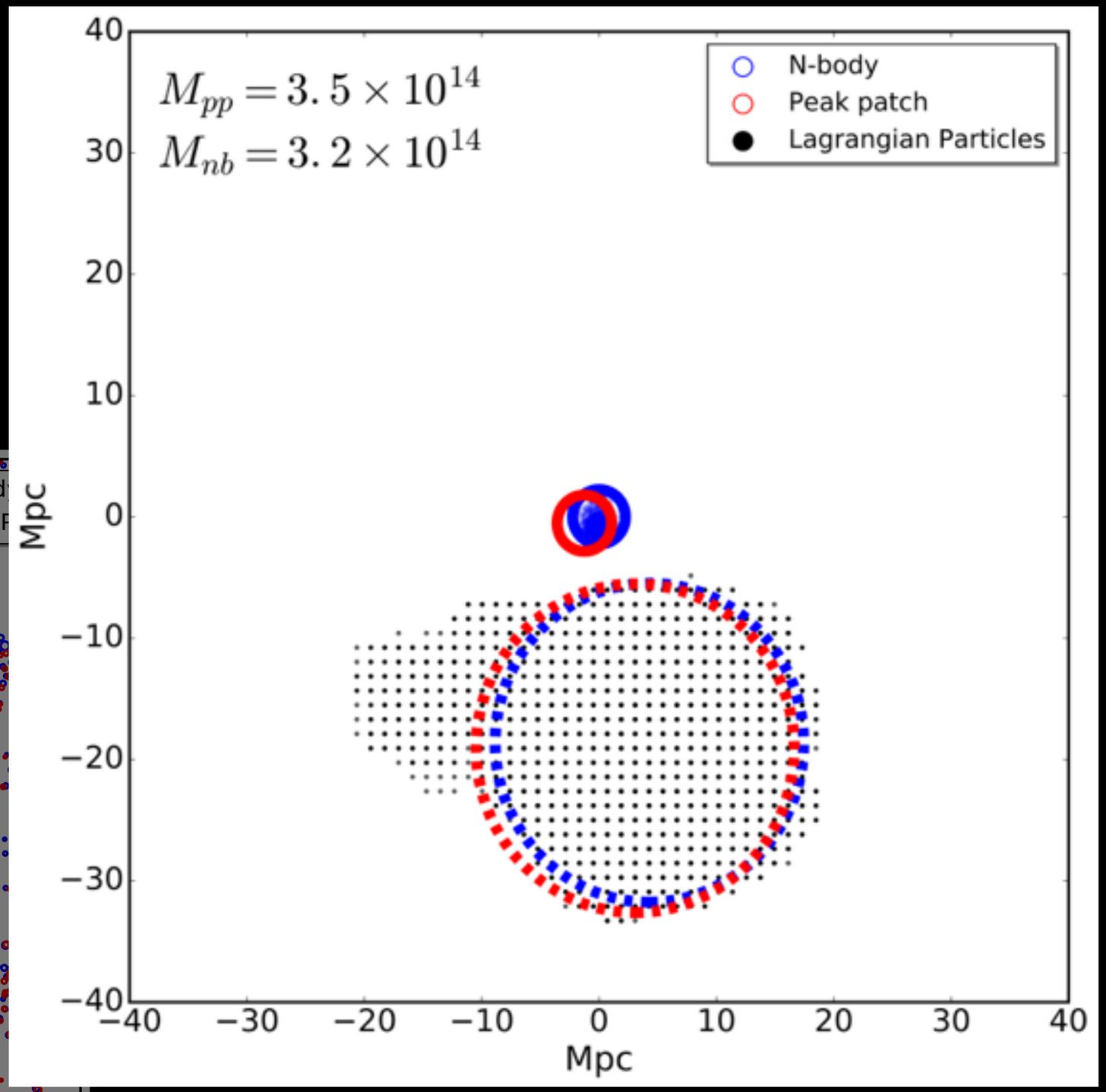
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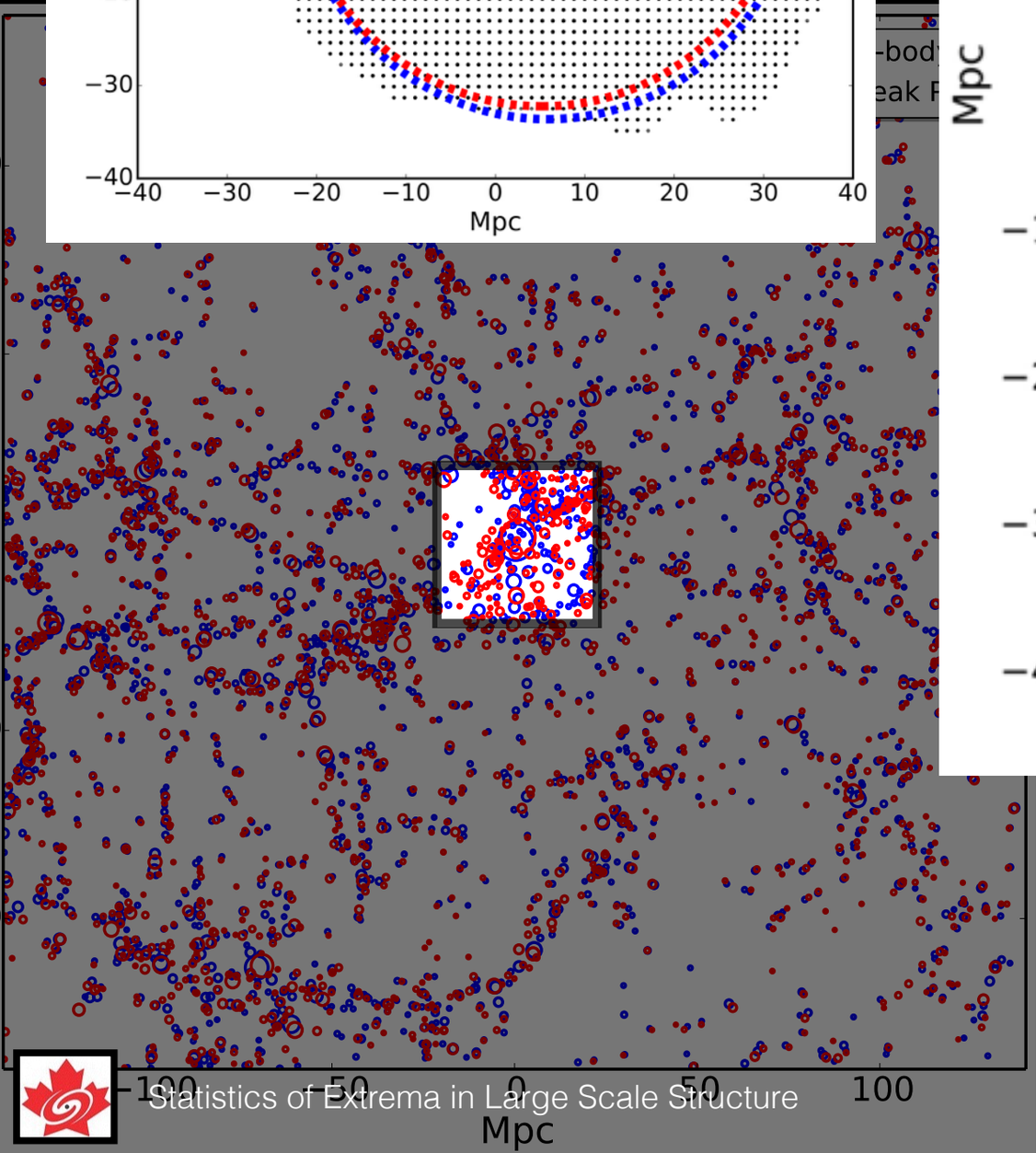
N-body
Peak patch
Lagrangian Particles
Mpc
Mpc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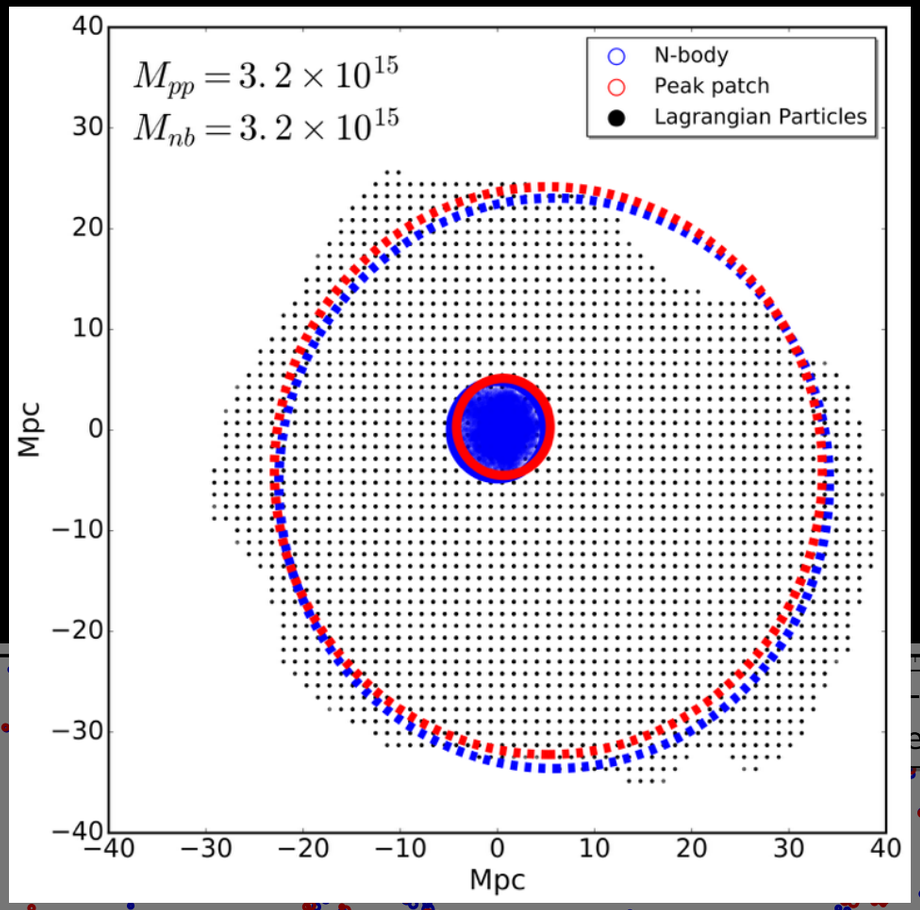
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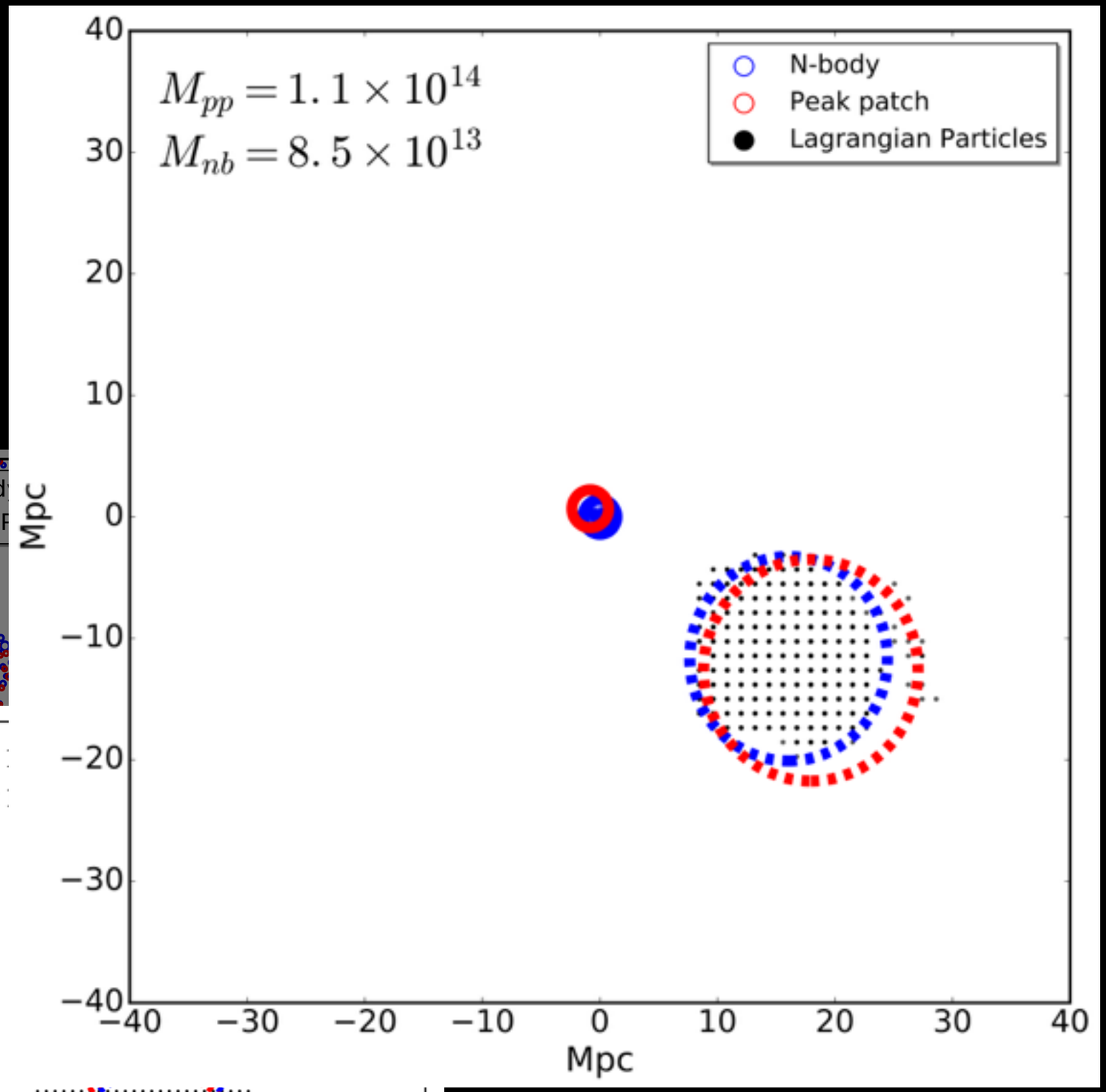
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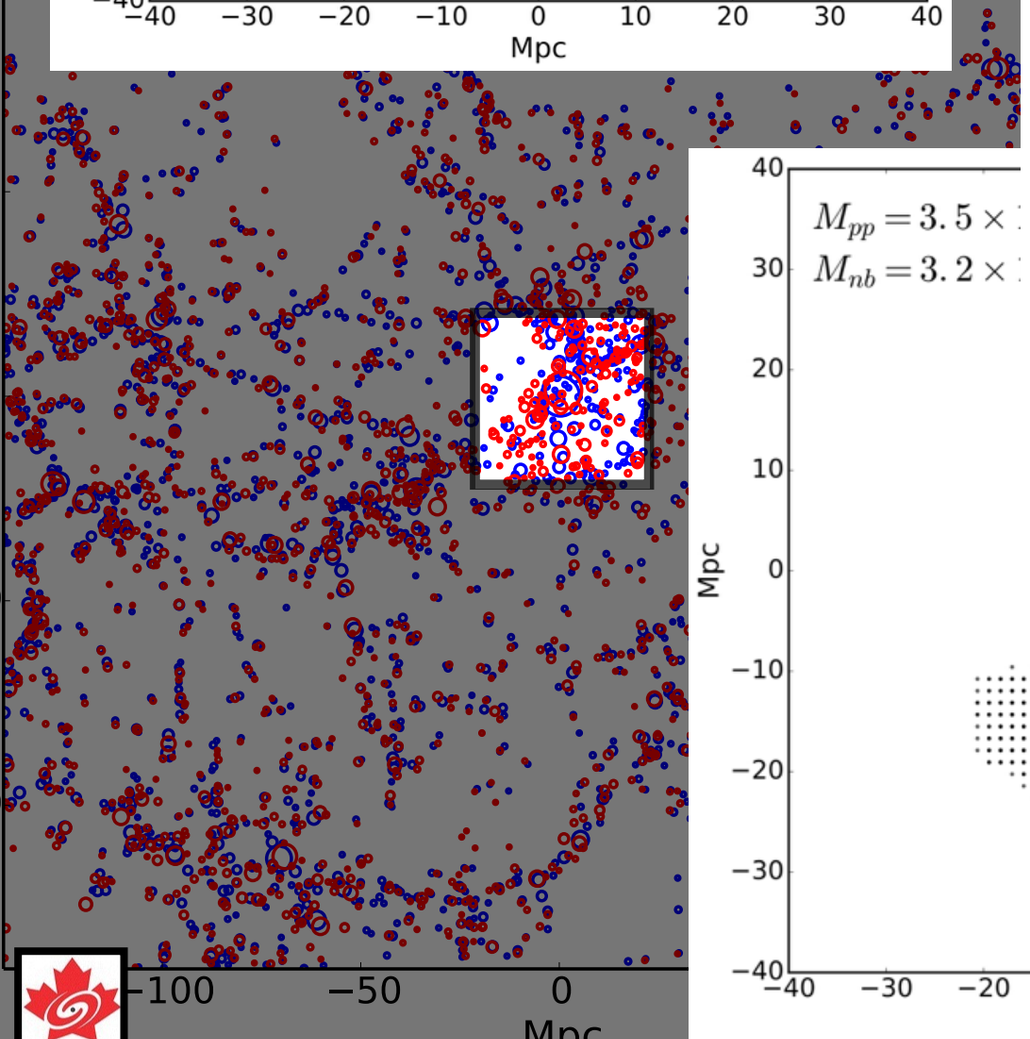
N-body
Peak patch
Lagrangian Particles
Mpc
Mpc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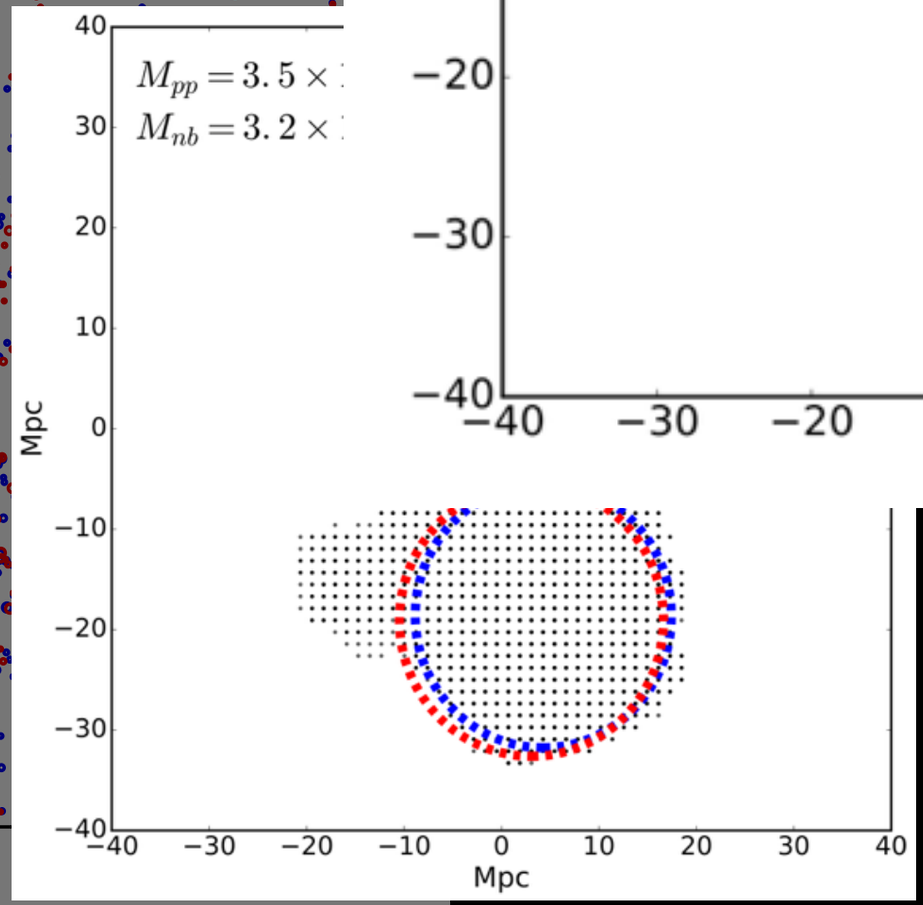
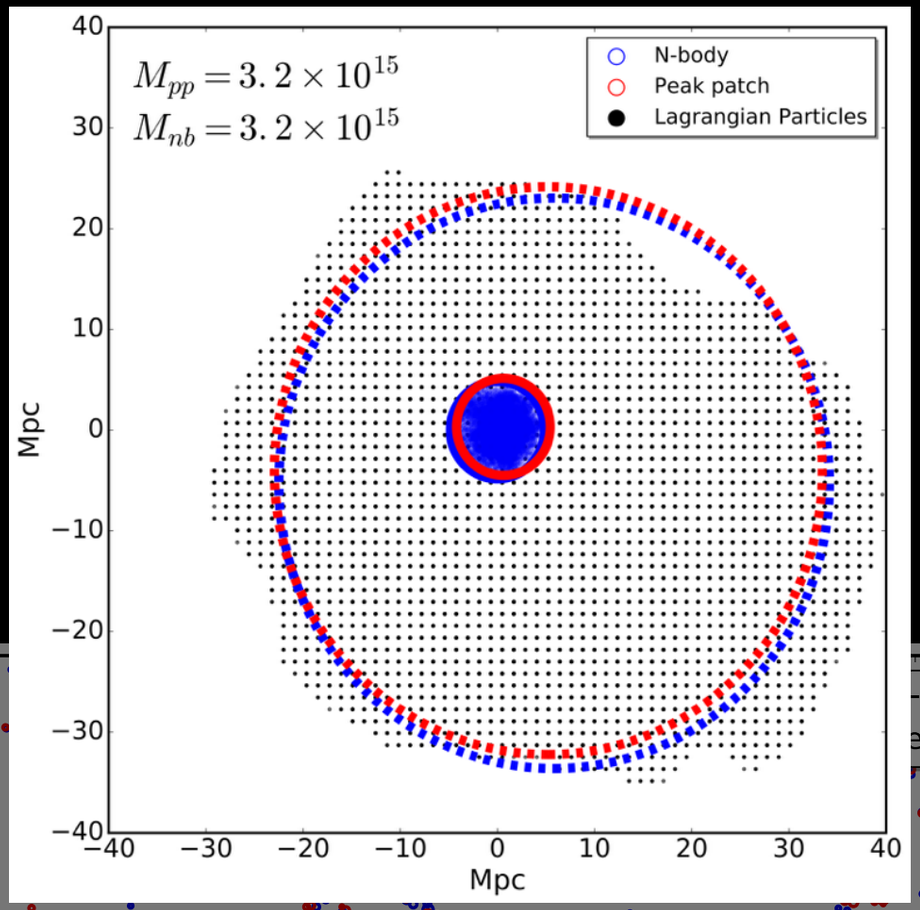

Mpc
Mpc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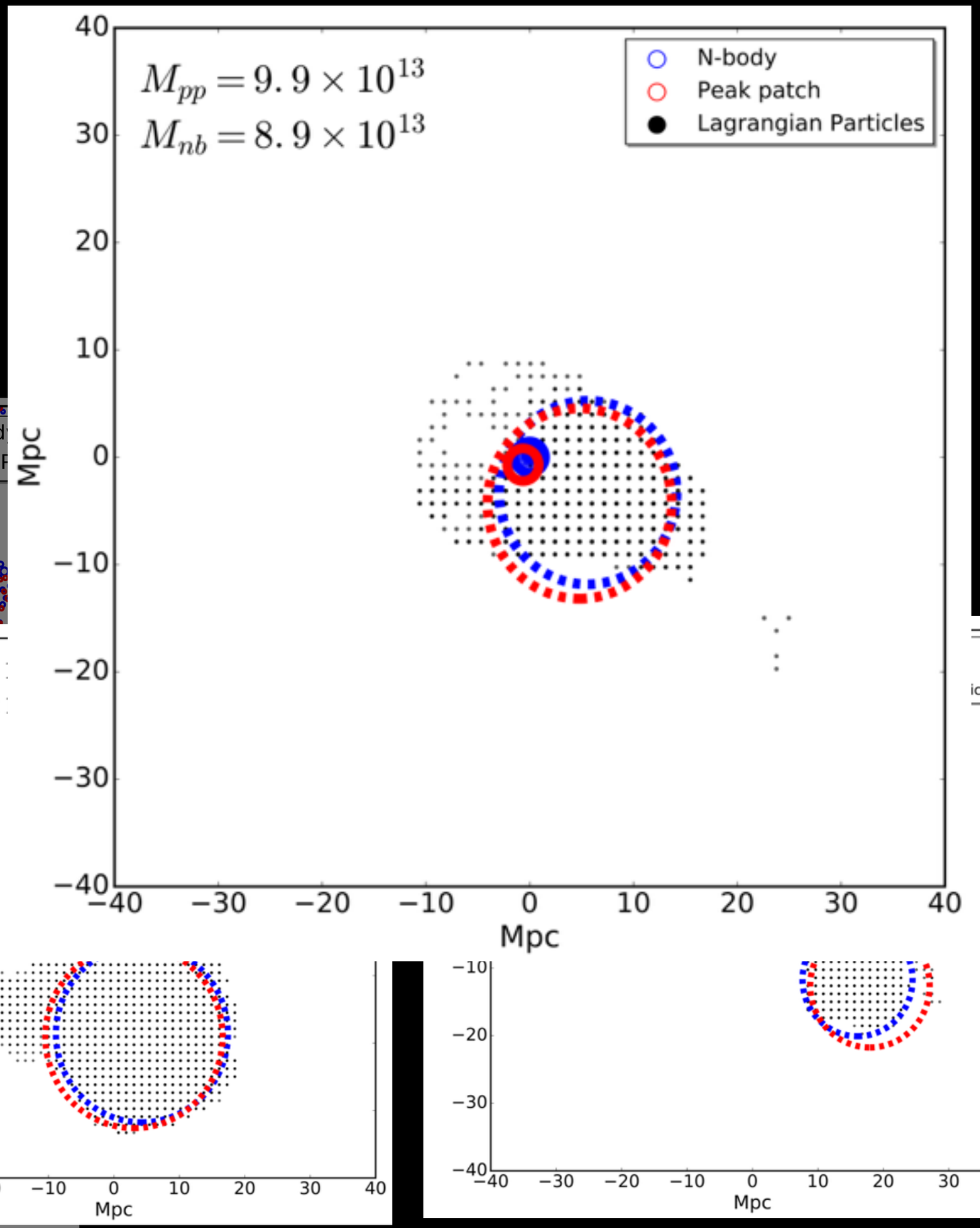
Mpc
Mpc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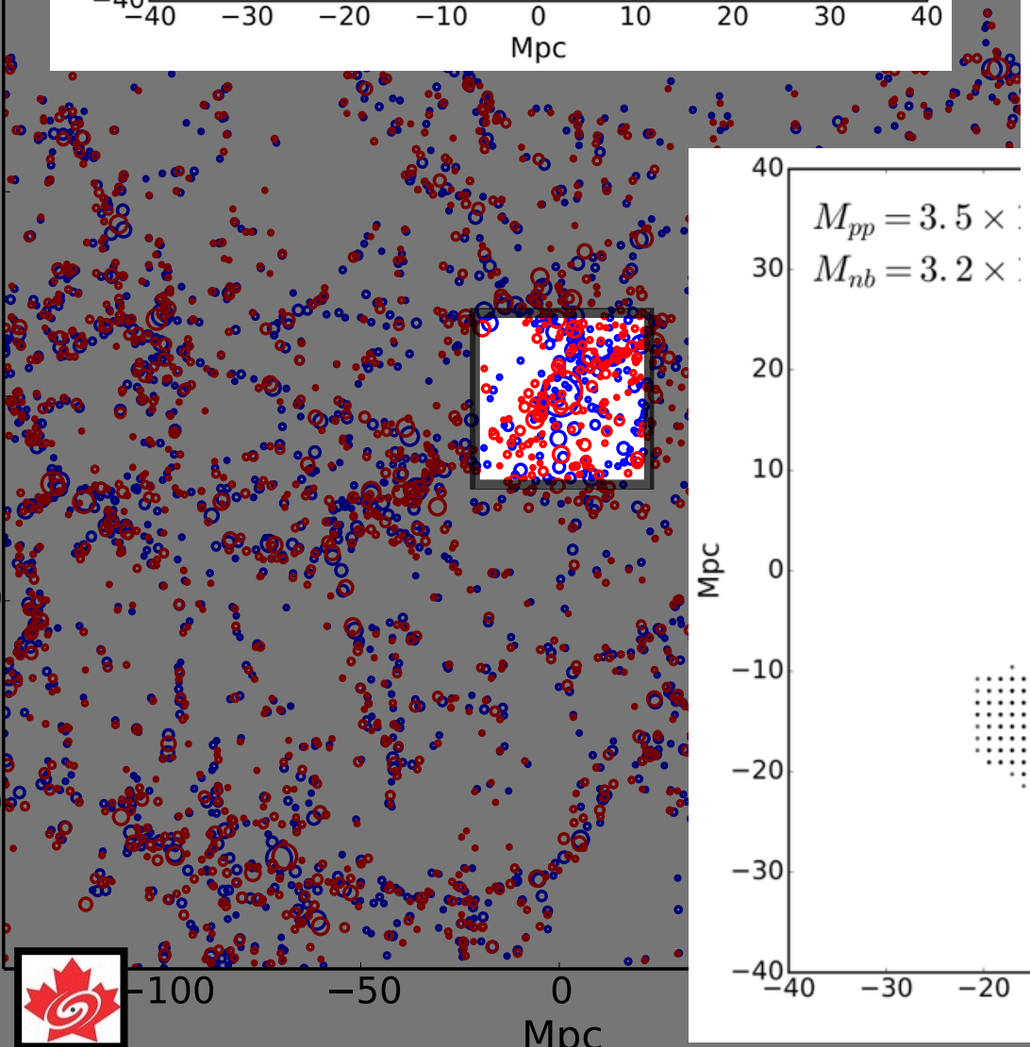
N-body
Peak patch
Lagrangian Particles
Mpc
Mpc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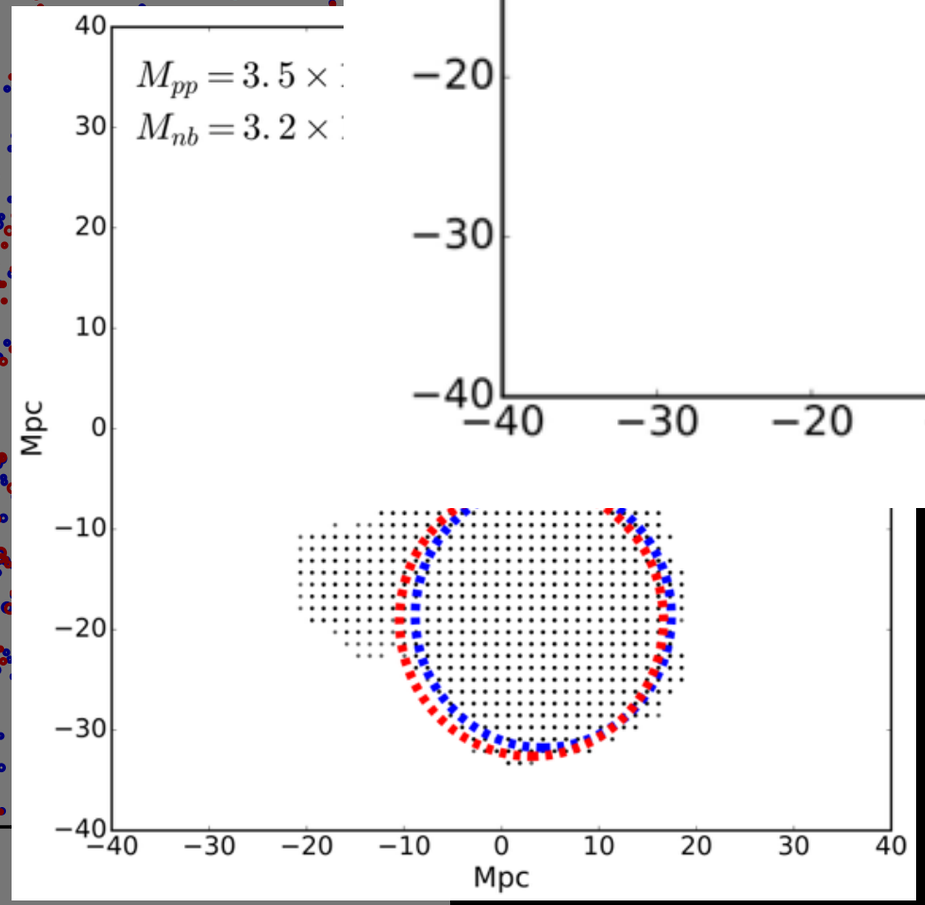
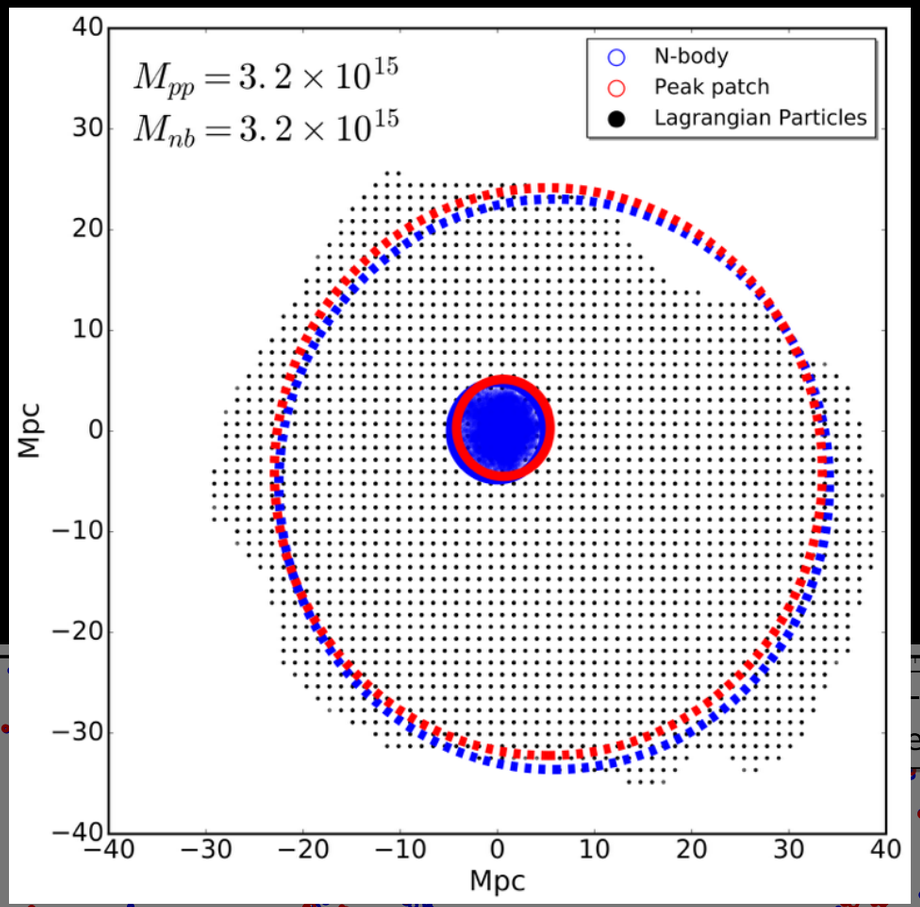

Mpc
Mpc

Mpc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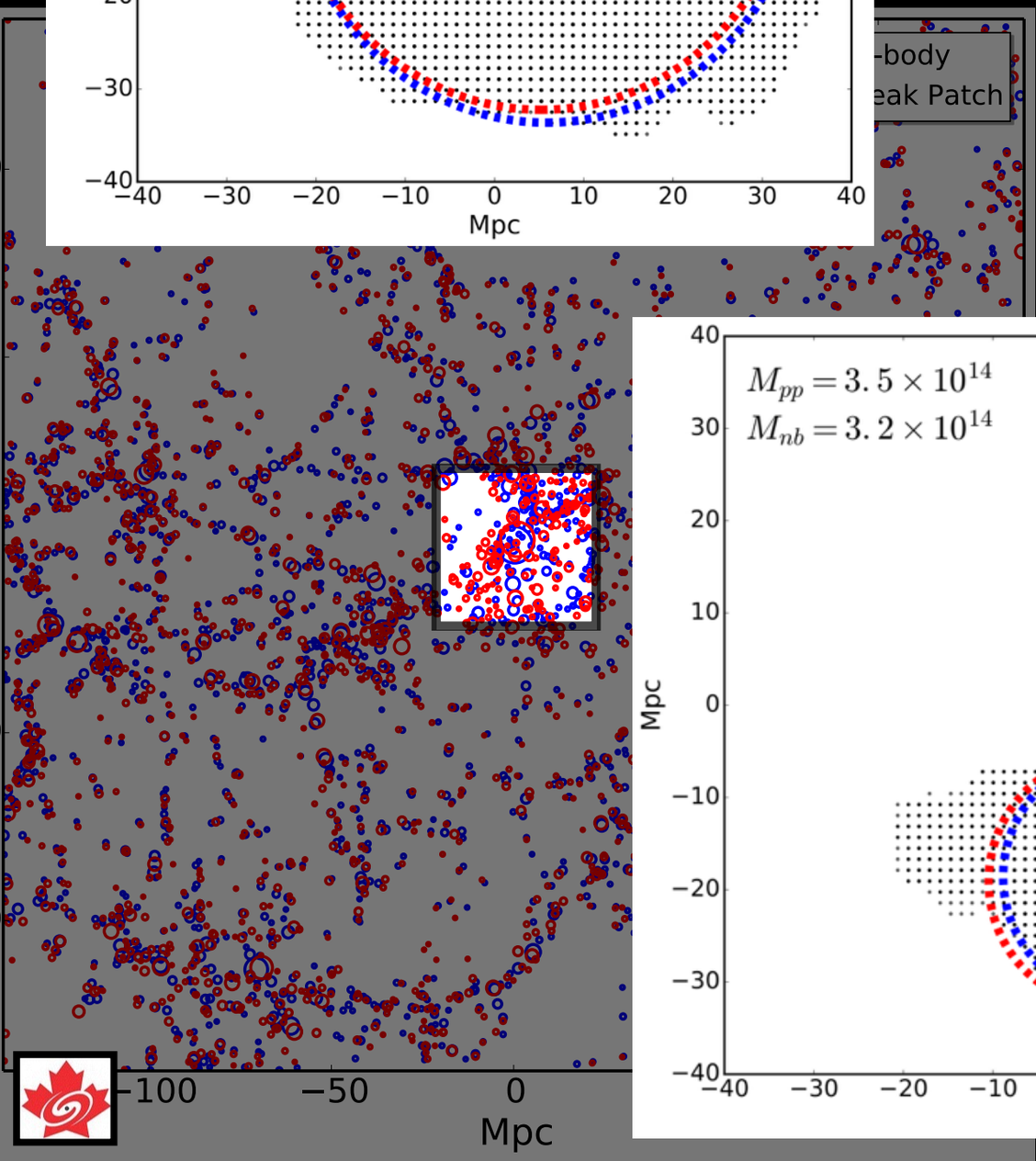
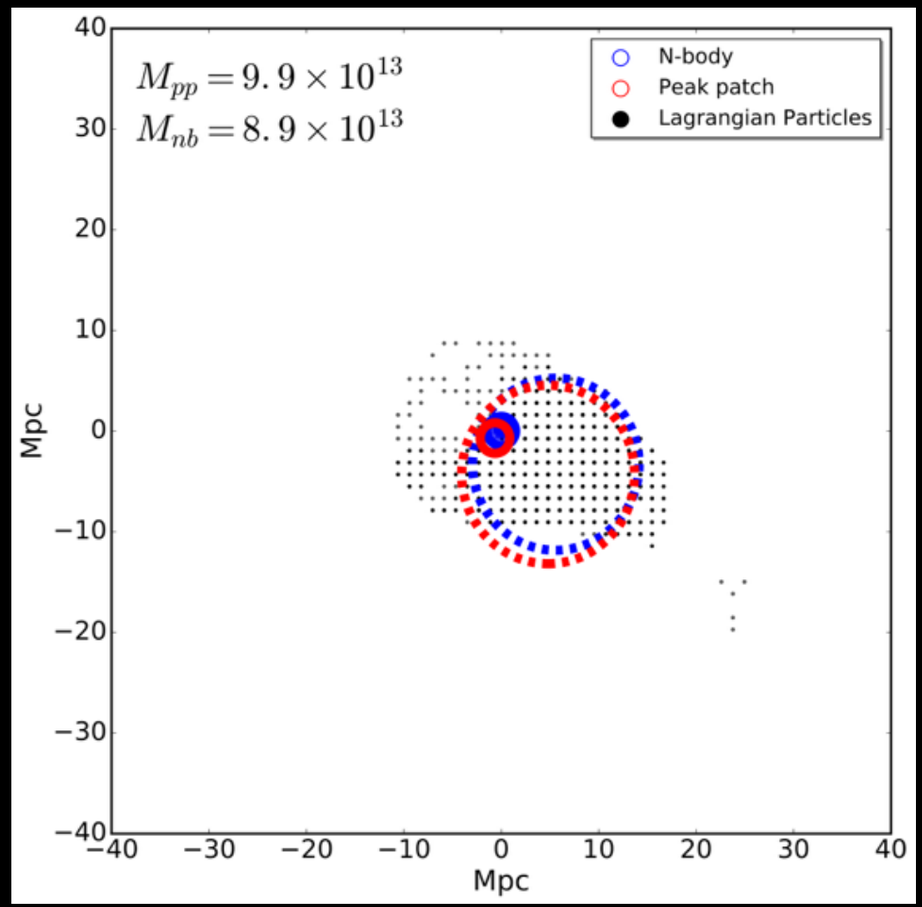
Mpc
Mpc


-body
eak Patch
−100
−50
0
Mpc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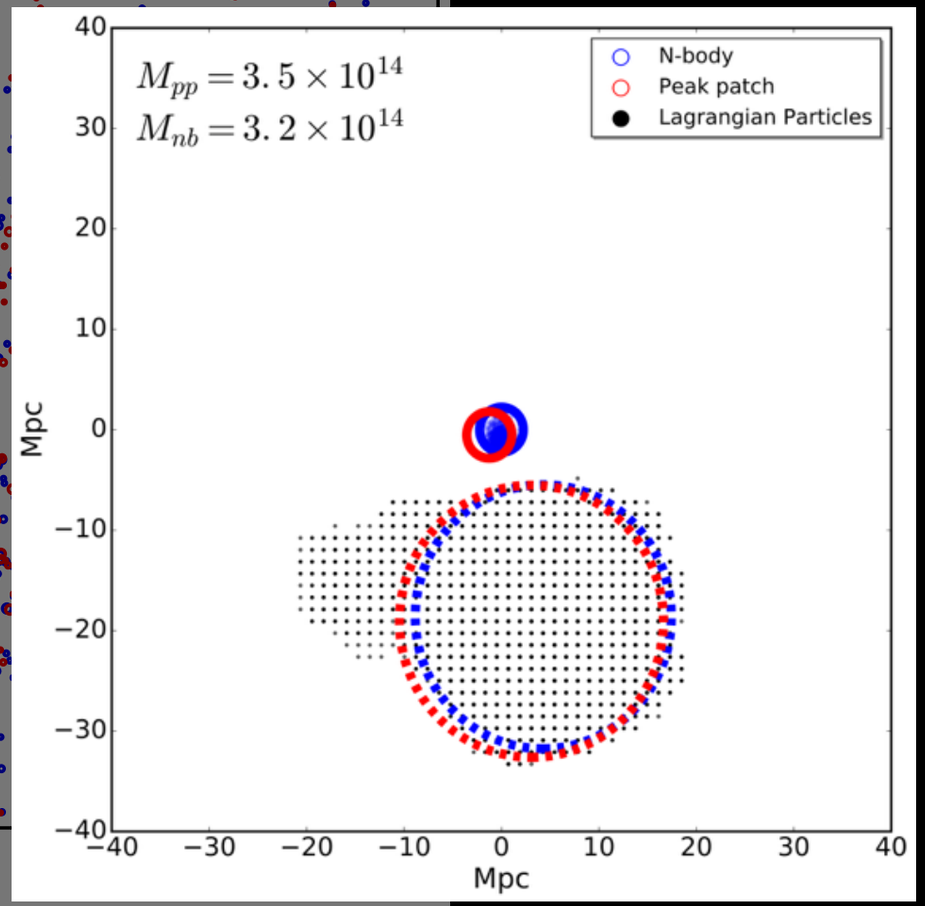
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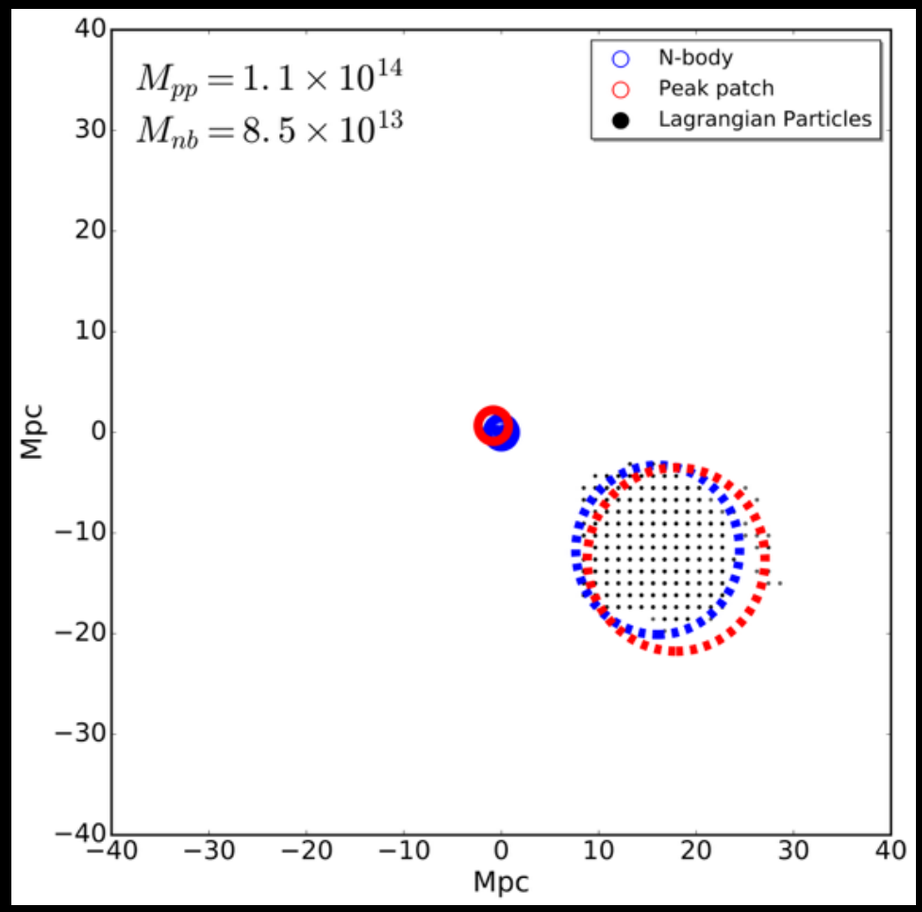
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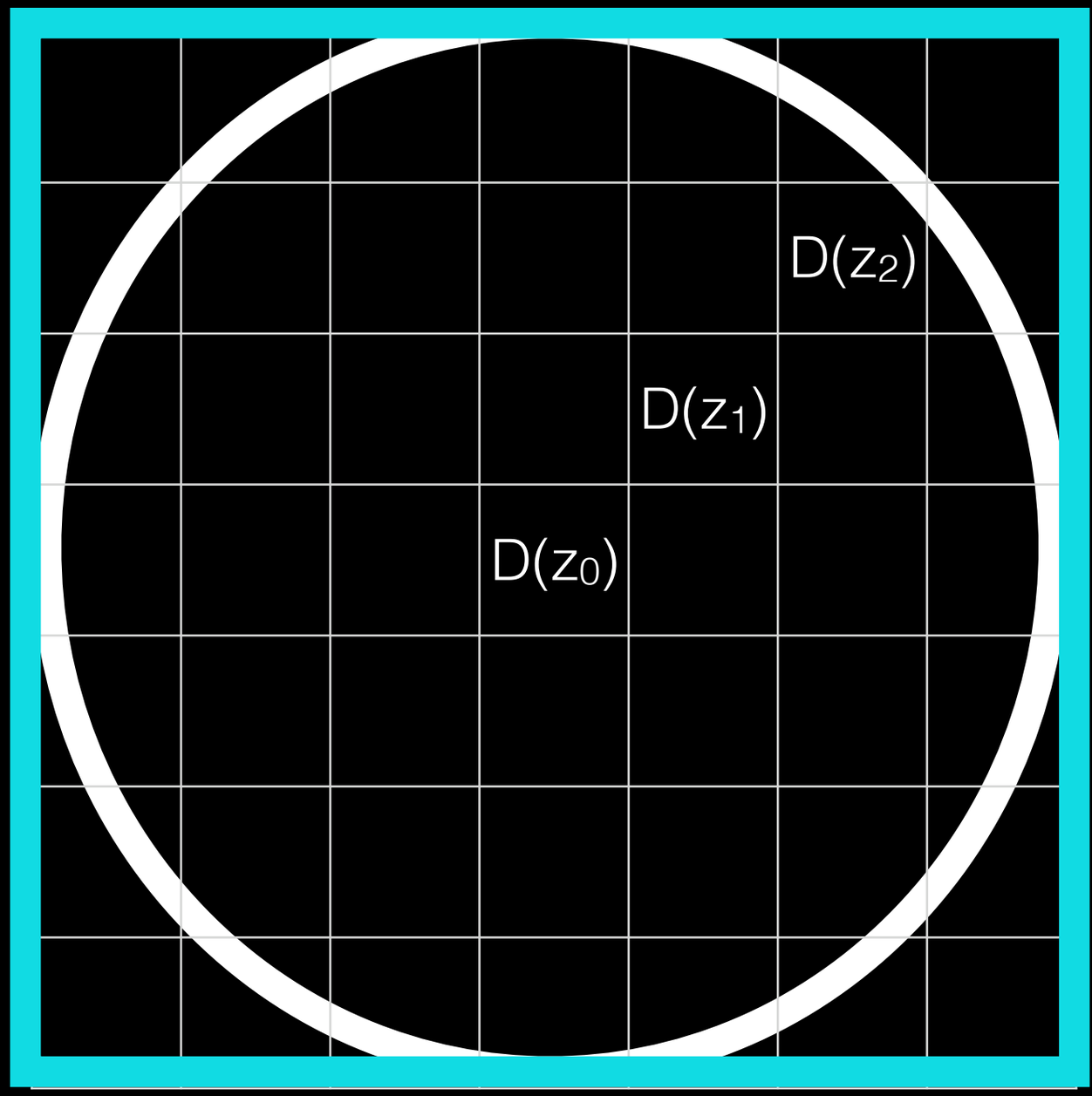
Mpc

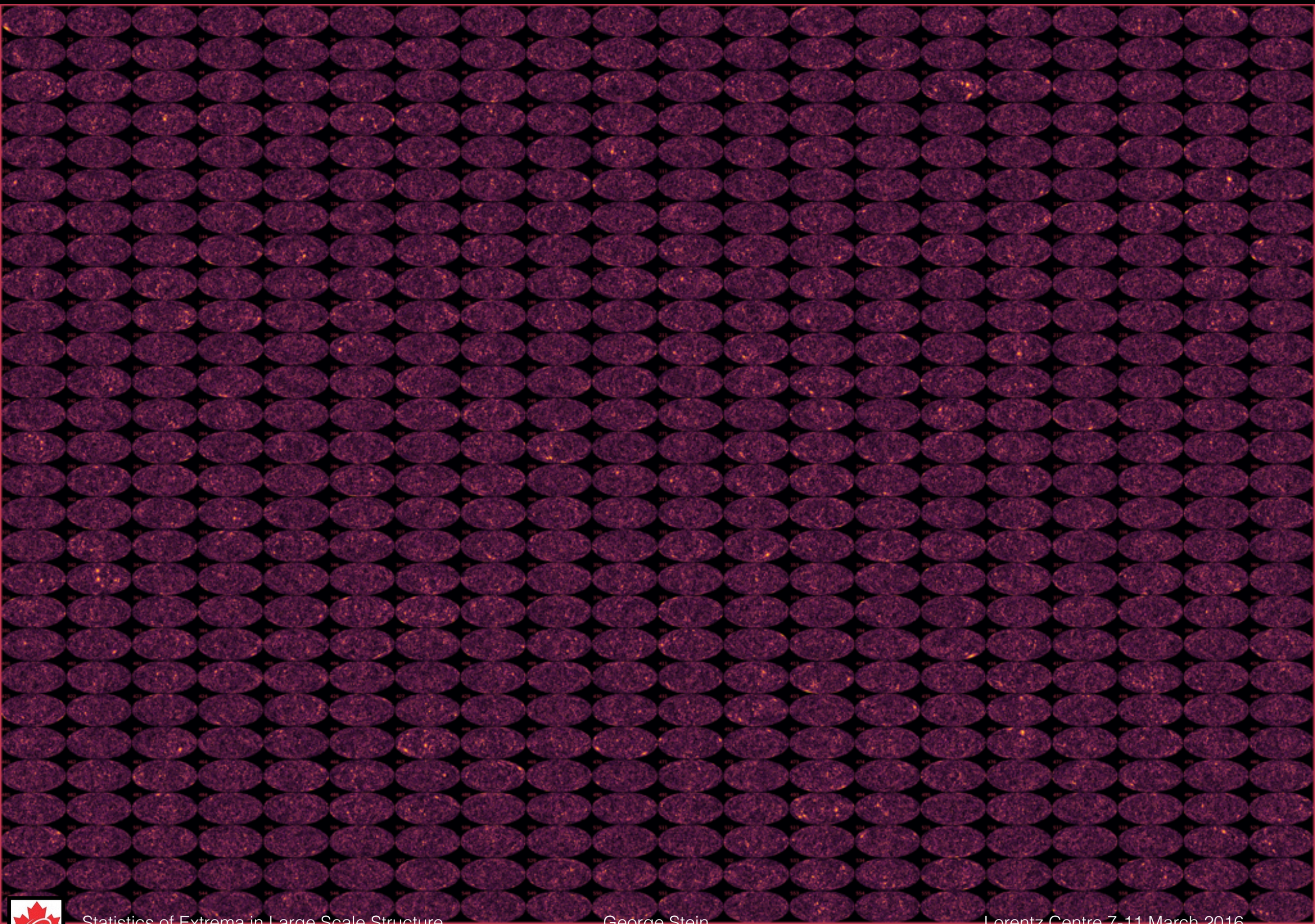
On the fly Light Cones

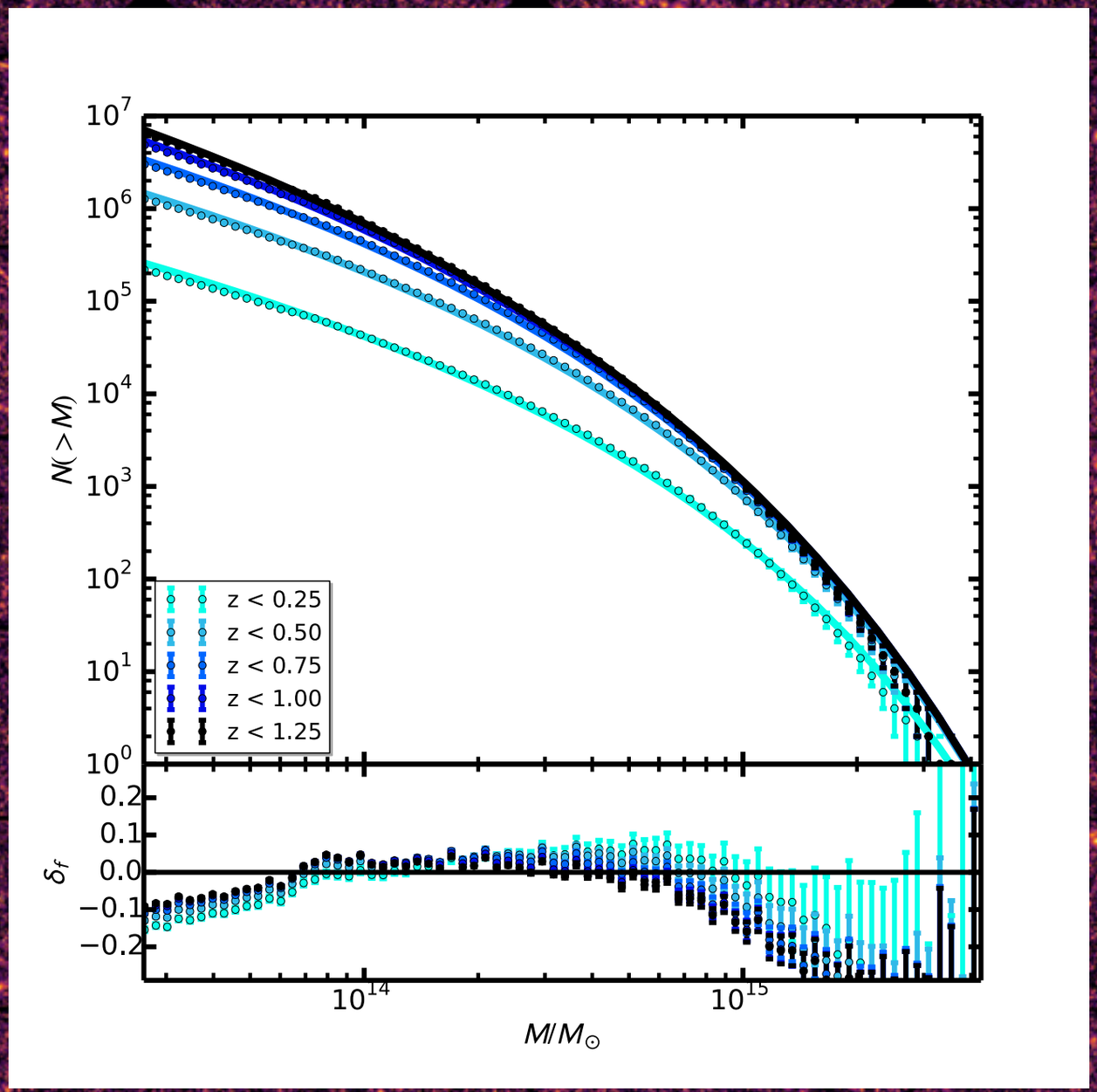
- Scale ICs by linear growth factor
- Calculate Ellipsoidal collapse at z_{pk}
- Save Halo

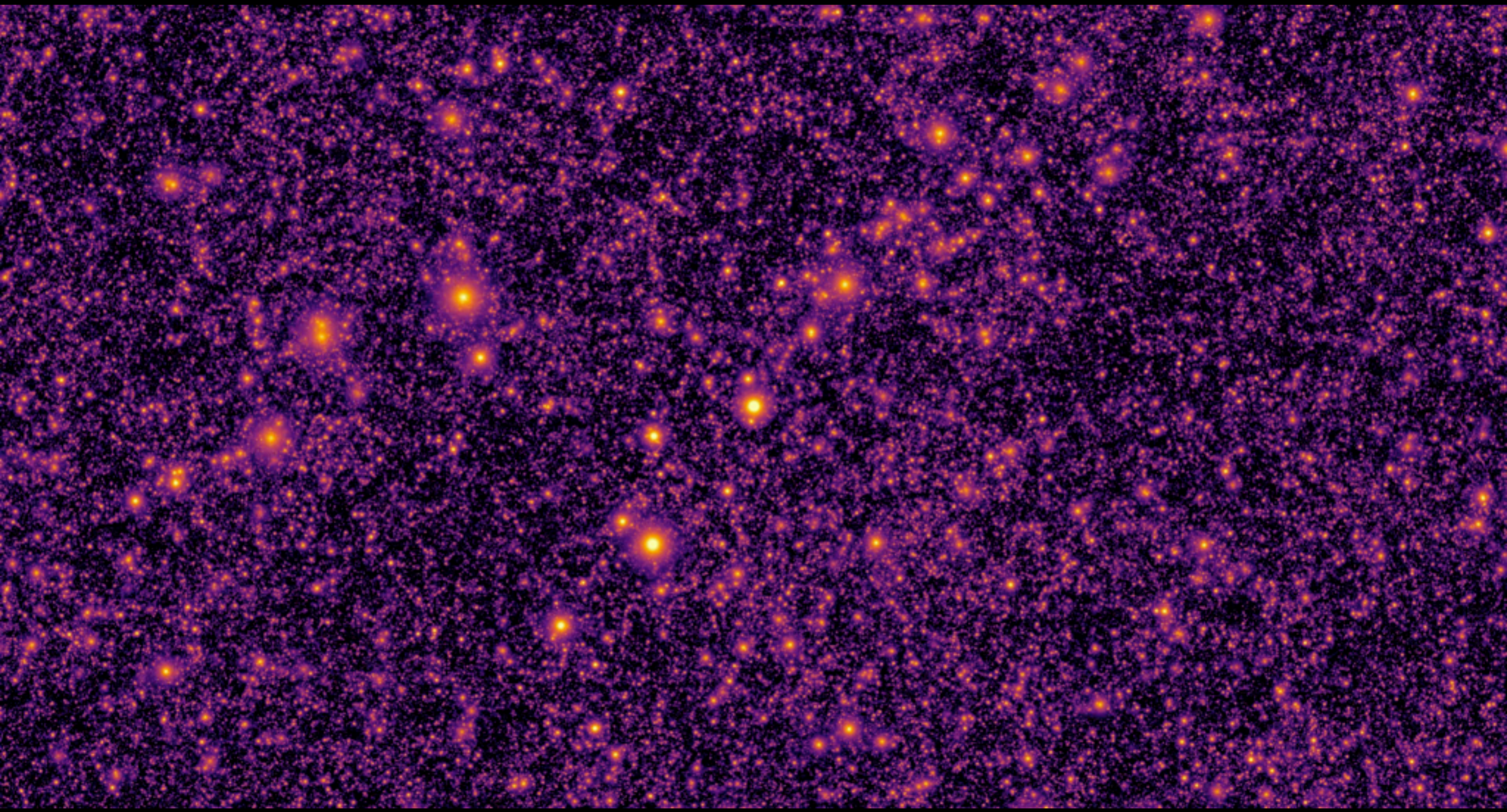


Peak Patch Full Sky Maps

8Gpc Box, 4096^3 cells
t~10 minutes on 1024 cores
~60 million halos
Complete to z <1.25, M > 2.6 x 10^{13} M_{sun}
~560 maps




10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
$N(>M)$
z < 0.25
z < 0.50
z < 0.75
z < 1.00
z < 1.25
0.2
0.1
0.0
−0.1
−0.2
δ_f
10^{14}
10^{15}
$M/M_\odot$



Halo Population

1.) Point Sources

Optical

- Manera et al. 2012

CIB

- Shang et al. 2012

Intensities

- HI, CO, C_2

2.) Extended Sources

tSZ

- BBPS 2011

kSZ

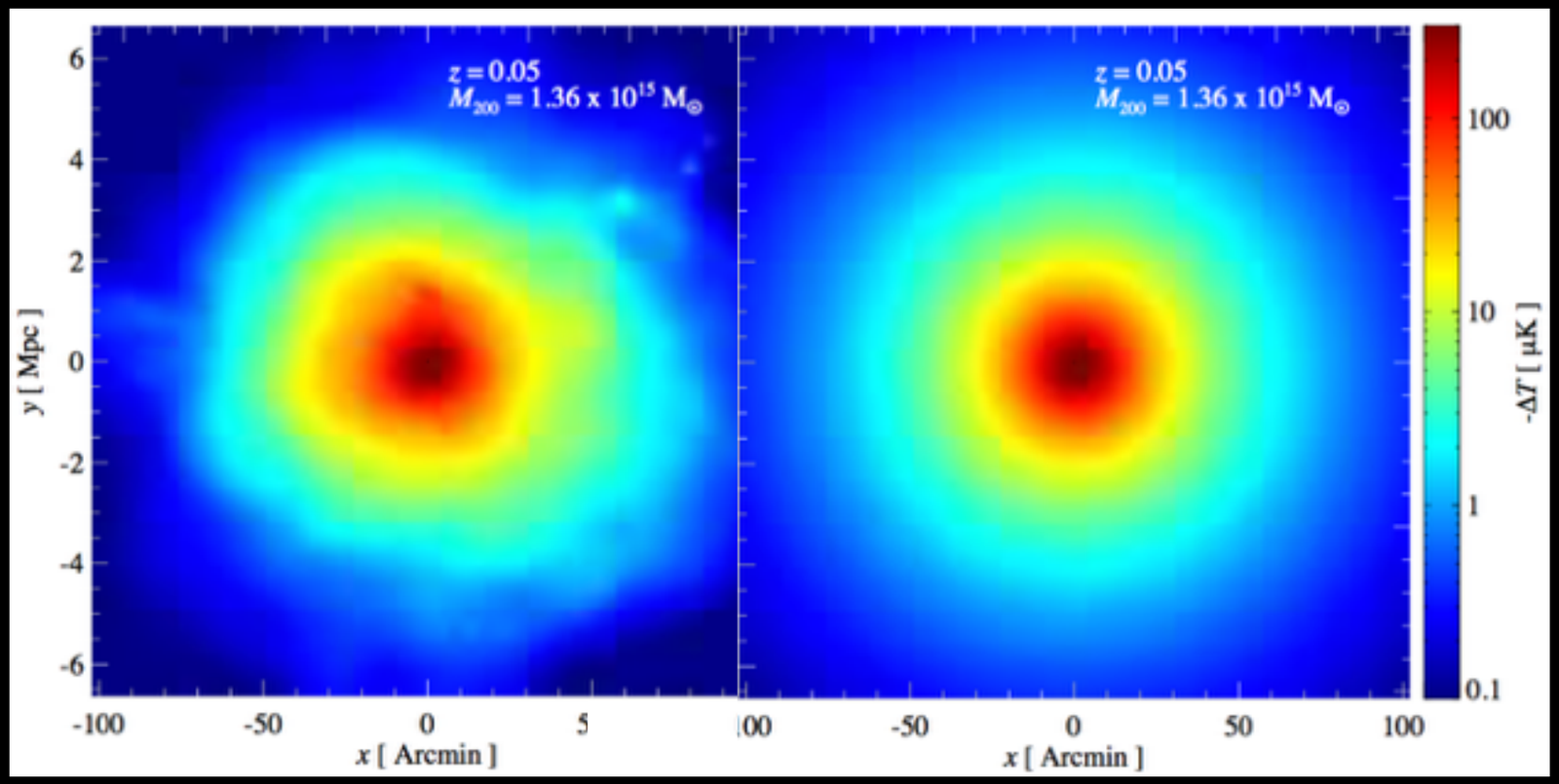
- BBPS 2011

Empirical Pressure & Gas Density Profiles

Battaglia, Bond, Pfrommer, Sievers (2011)

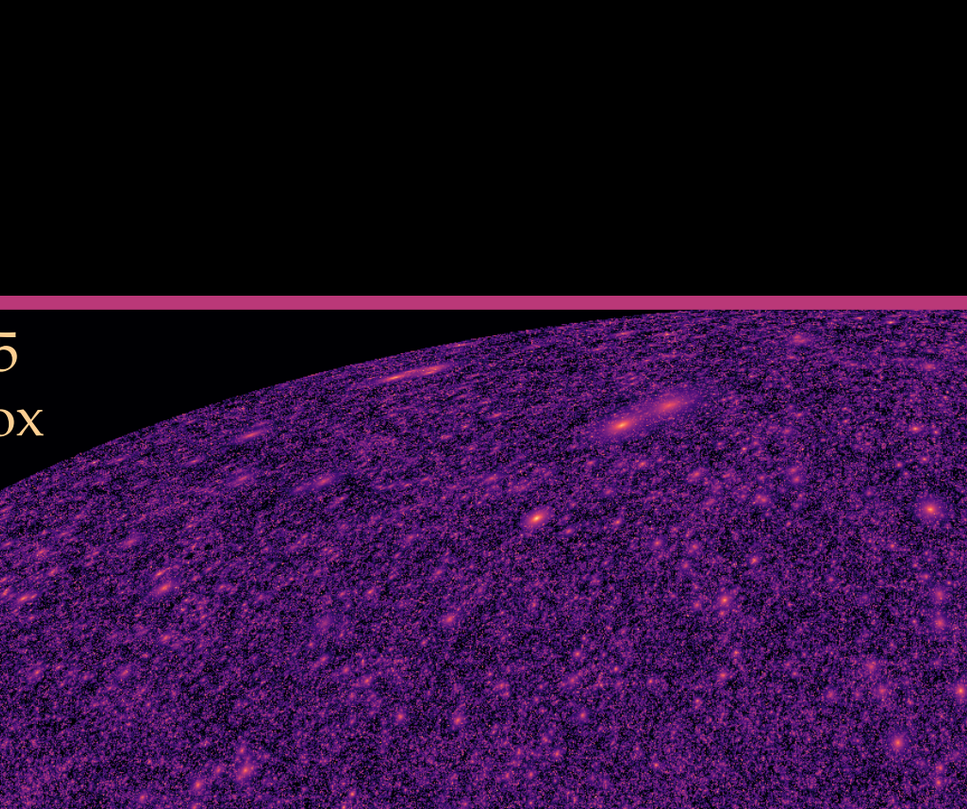
Suite of hydrodynamical TreePM-SPH simulations that include:

- radiative cooling
- star formation
- supernova feedback
- energetic feedback from AGN



$0.00 < z < 1.25$
8Gpc, 4096^3 Box
$N = 6.5 \times 10^6$

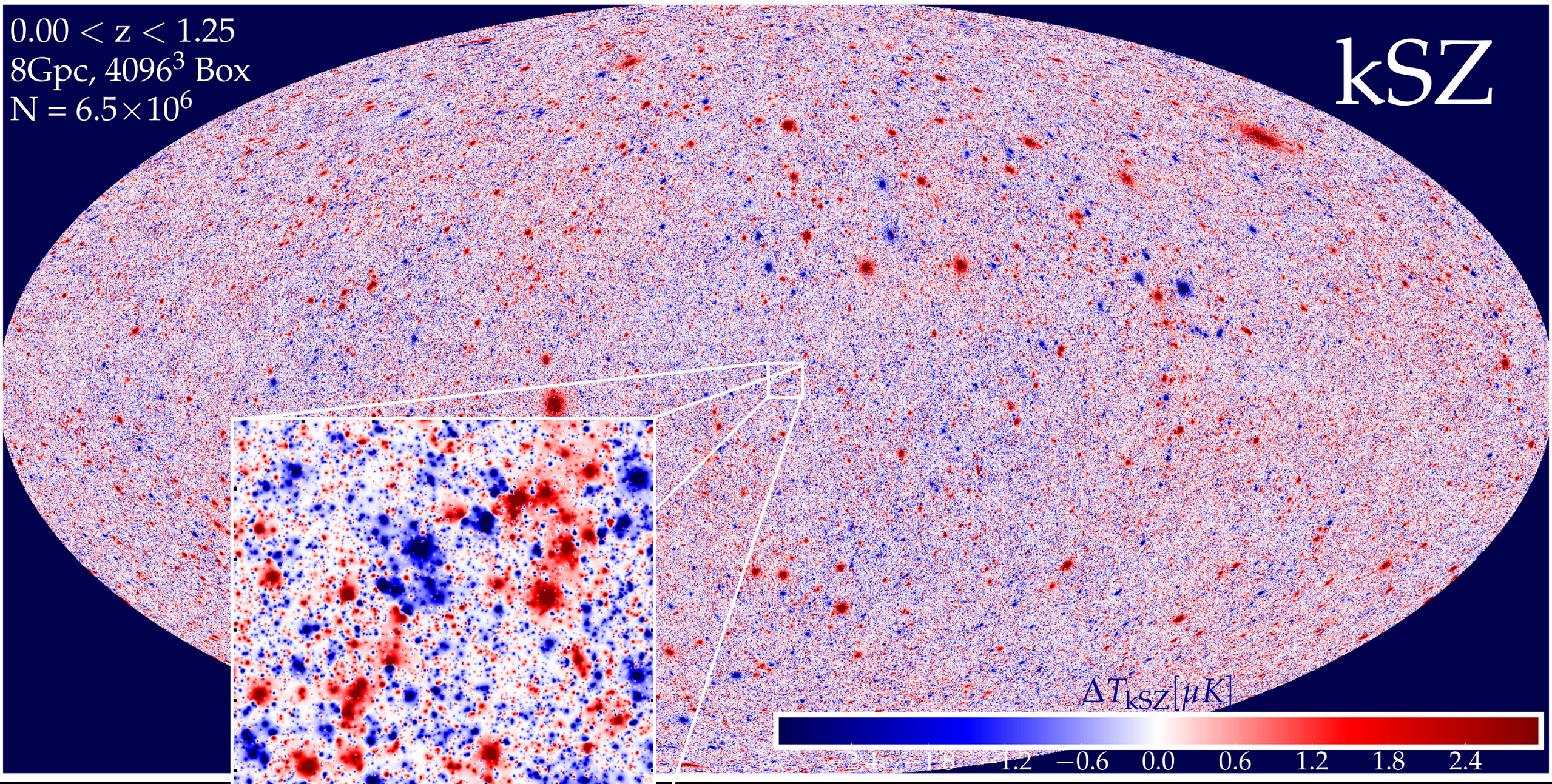
tSZ



6 deg

log Compton-y

−7.5 −7.0 −6.5 −6.0 −5.5 −5.0 −4.5 −4.0

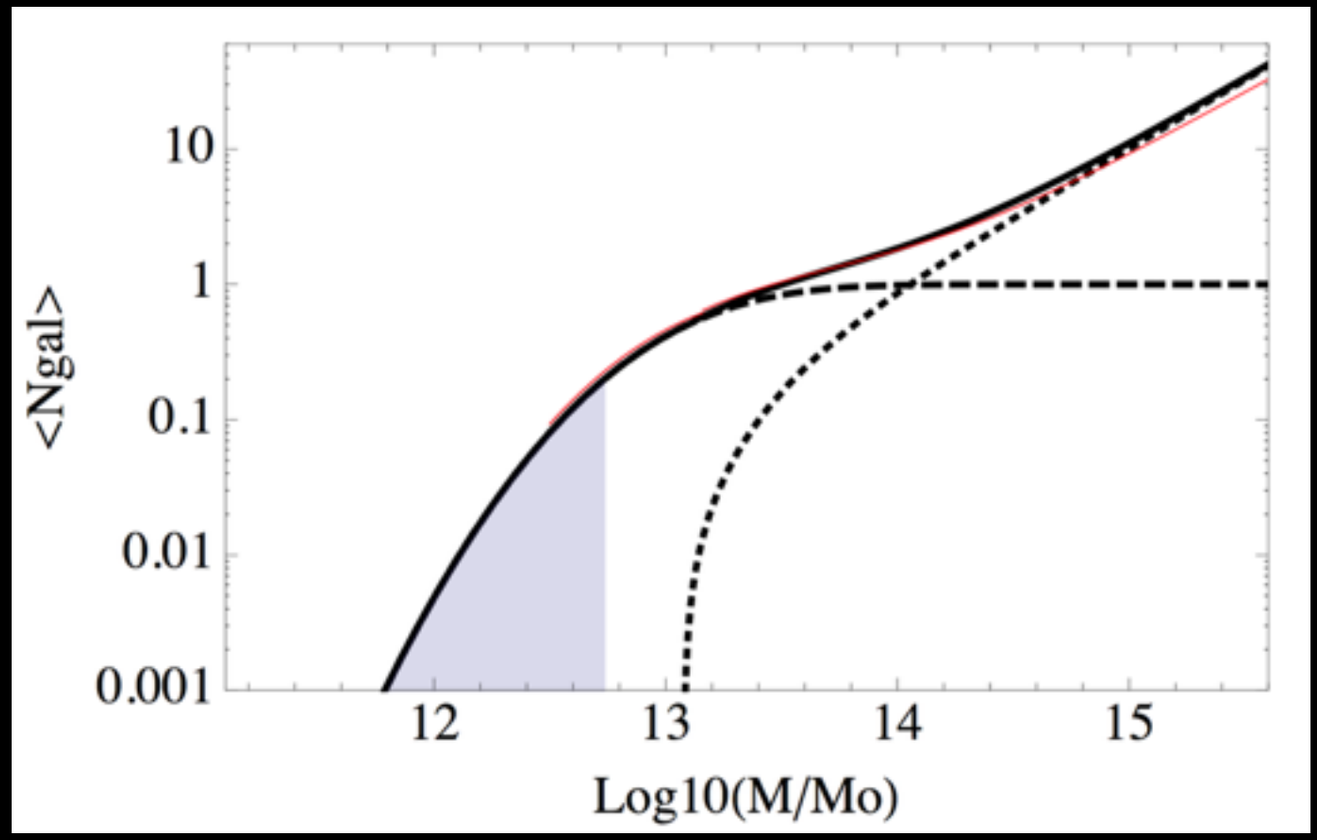

$0.00 < z < 1.25$
8Gpc, 4096^3 Box
$N = 6.5 \times 10^6$
kSZ
$\Delta T_{kSZ}[\mu K]$
−1.2
−0.6
0.0
0.6
1.2
1.8
2.4
6 deg

Optical HOD

- Calibrated to reproduce the clustering measurements on scales between 30 and 80 h^{-1}Mpc

- Satellites laid down according to excluded poisson on top of NFW profile

Manera et al. 2012



$0.00 < z < 1.25$
8Gpc, 4096^3 Box
$N = 9.9 \times 10^6$

Optical

6 deg

CIB HOD

Shang et al. 2012

L-M relation

$$L_{(1+z)\nu}(m,z) = L_0 \Phi(z) \Sigma(m) \Theta[(1+z)\nu]$$

SED shape

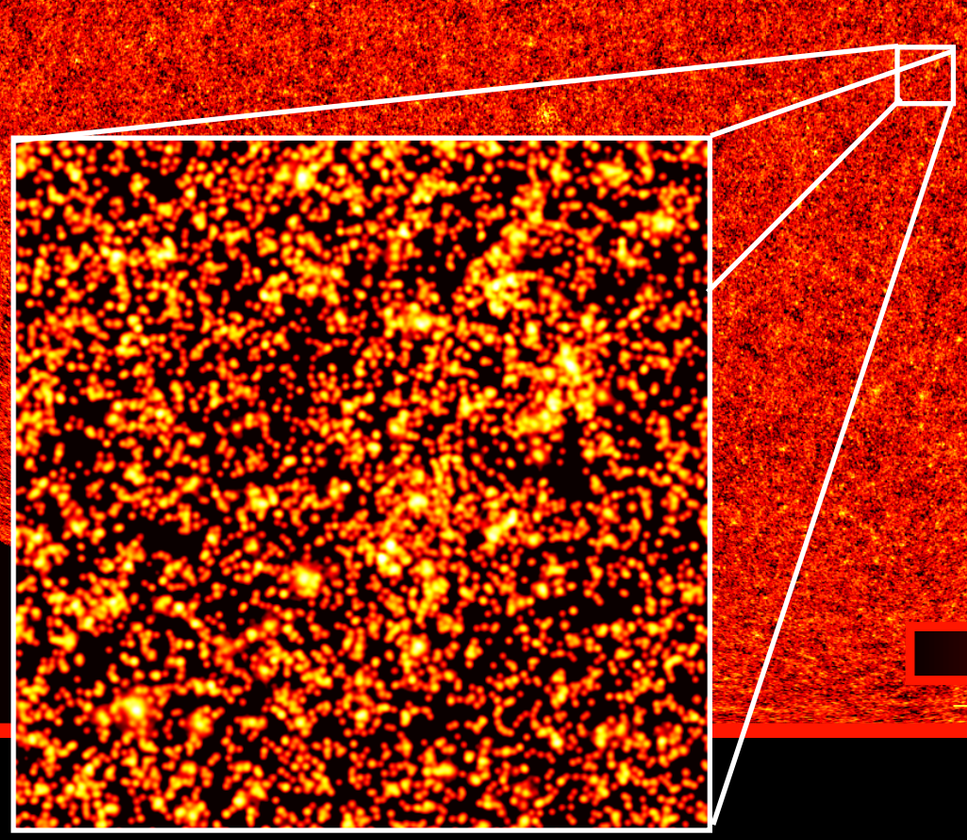
$$N_{\rm cen} = \begin{cases} 0 & M < M_{\rm min} \\ 1 & M \geq M_{\rm min} \end{cases}$$

$$N_{\rm sat} = \left(\frac{M}{M_{\rm sat}} \right)^{\alpha}$$

- Satellites laid down according to excluded poisson on top of NFW profile

$0.00 < z < 1.25$
8Gpc, 4096^3 Box
$N = 232 \times 10^6$

CIB

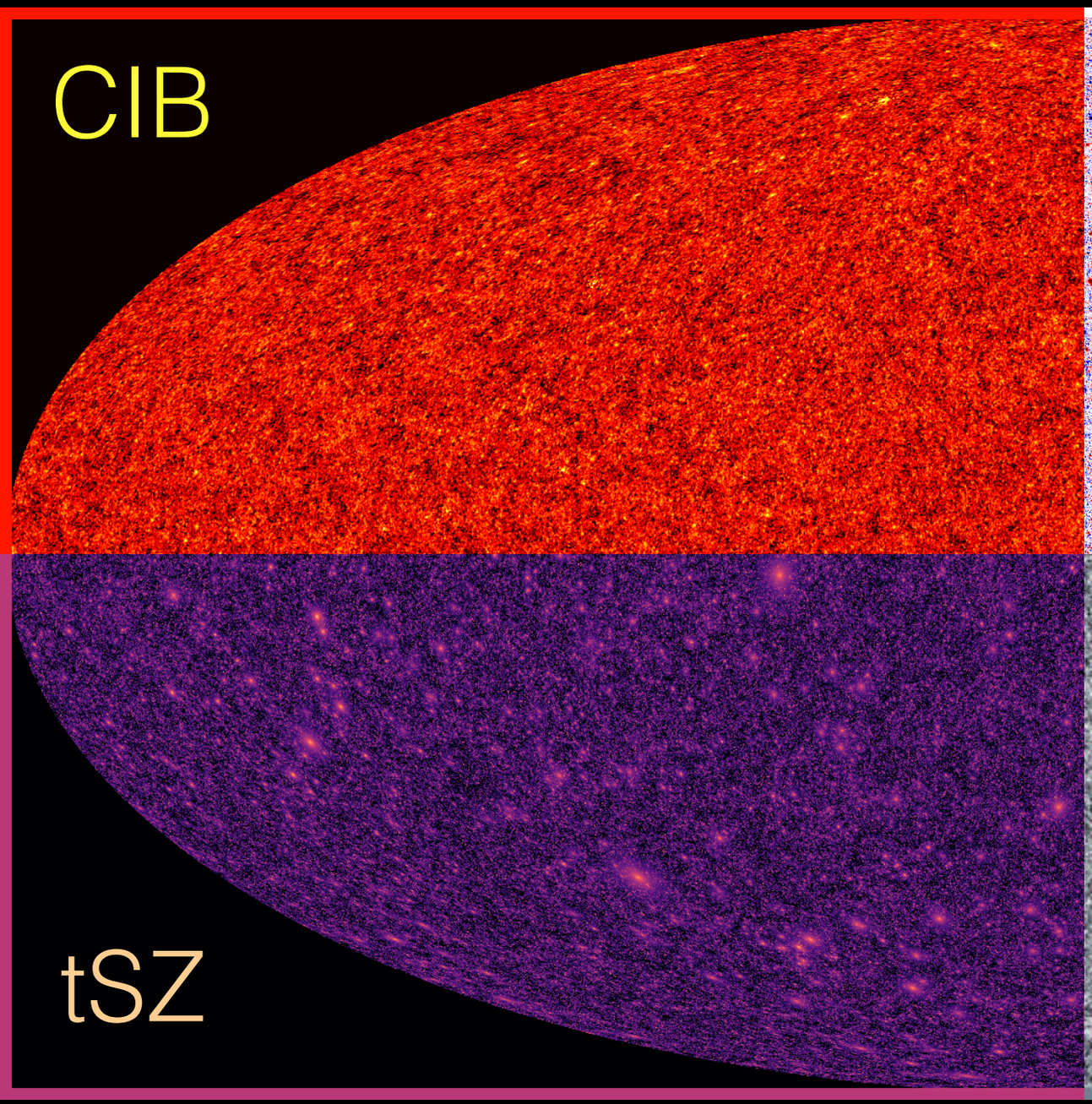


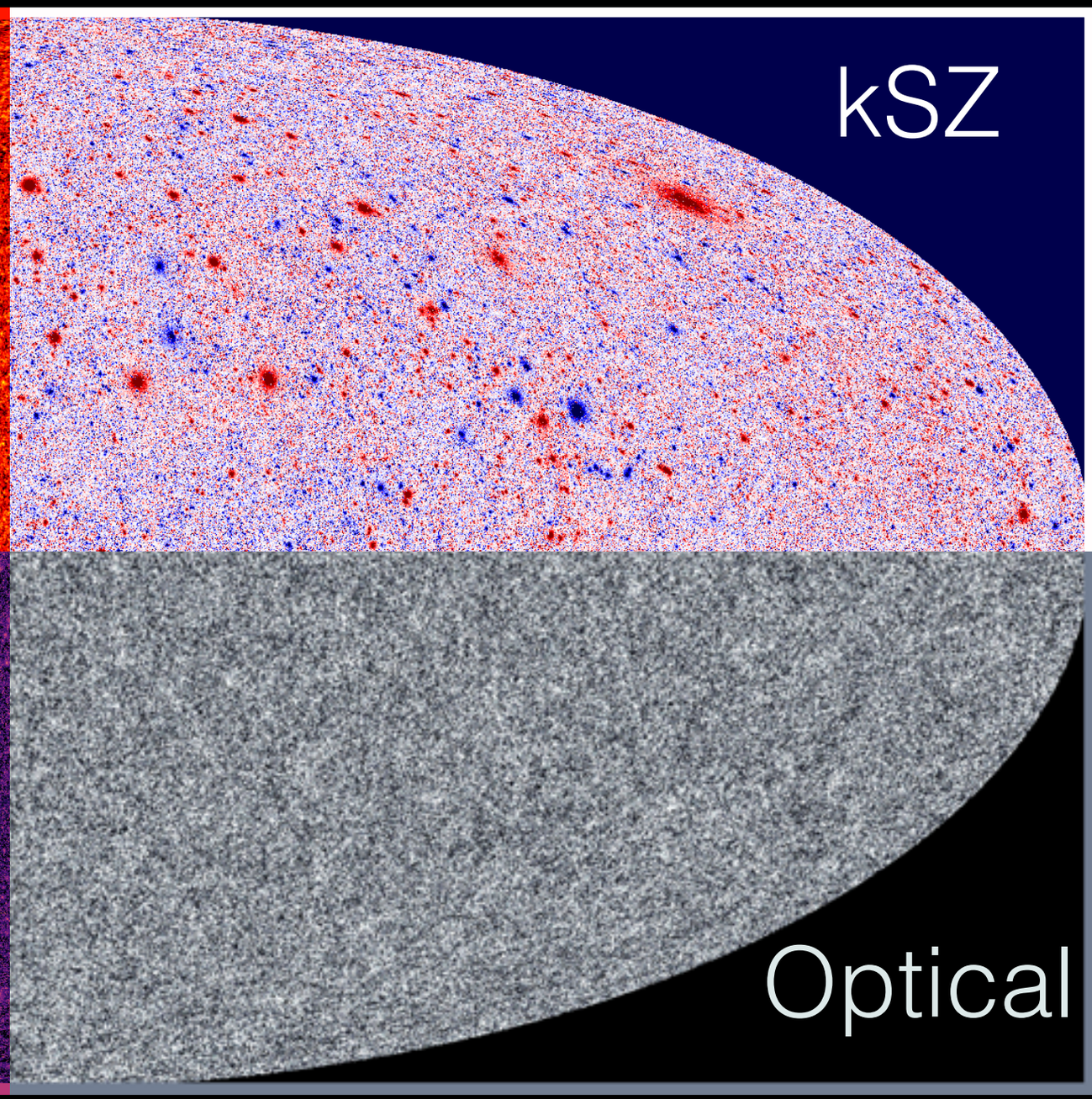
6 deg

log MJy/sr

−3.4 −3.2 −3.0 −2.8 −2.6 −2.4 −2.2

Peak Patch Full Sky Model



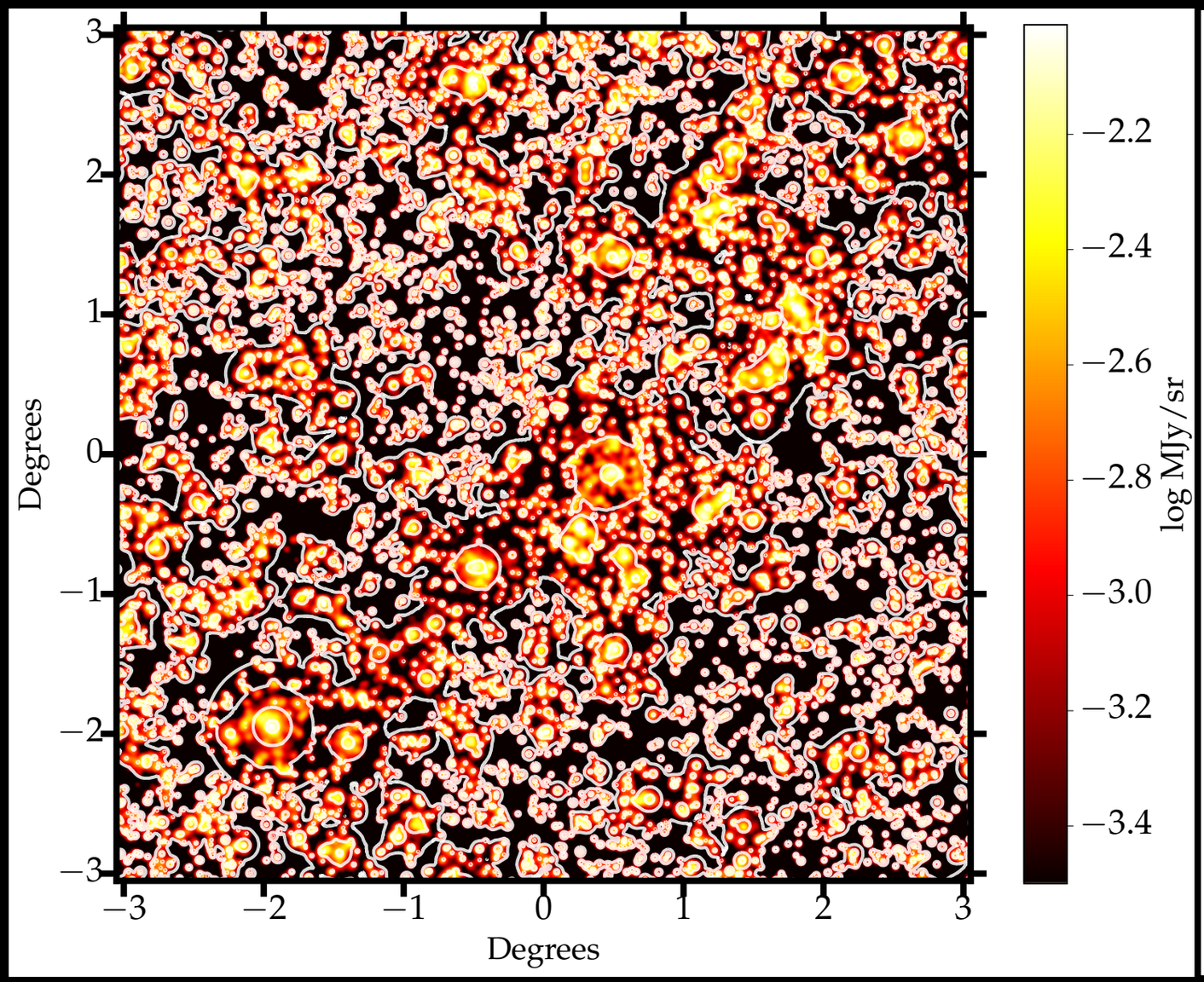


Multi-tracers

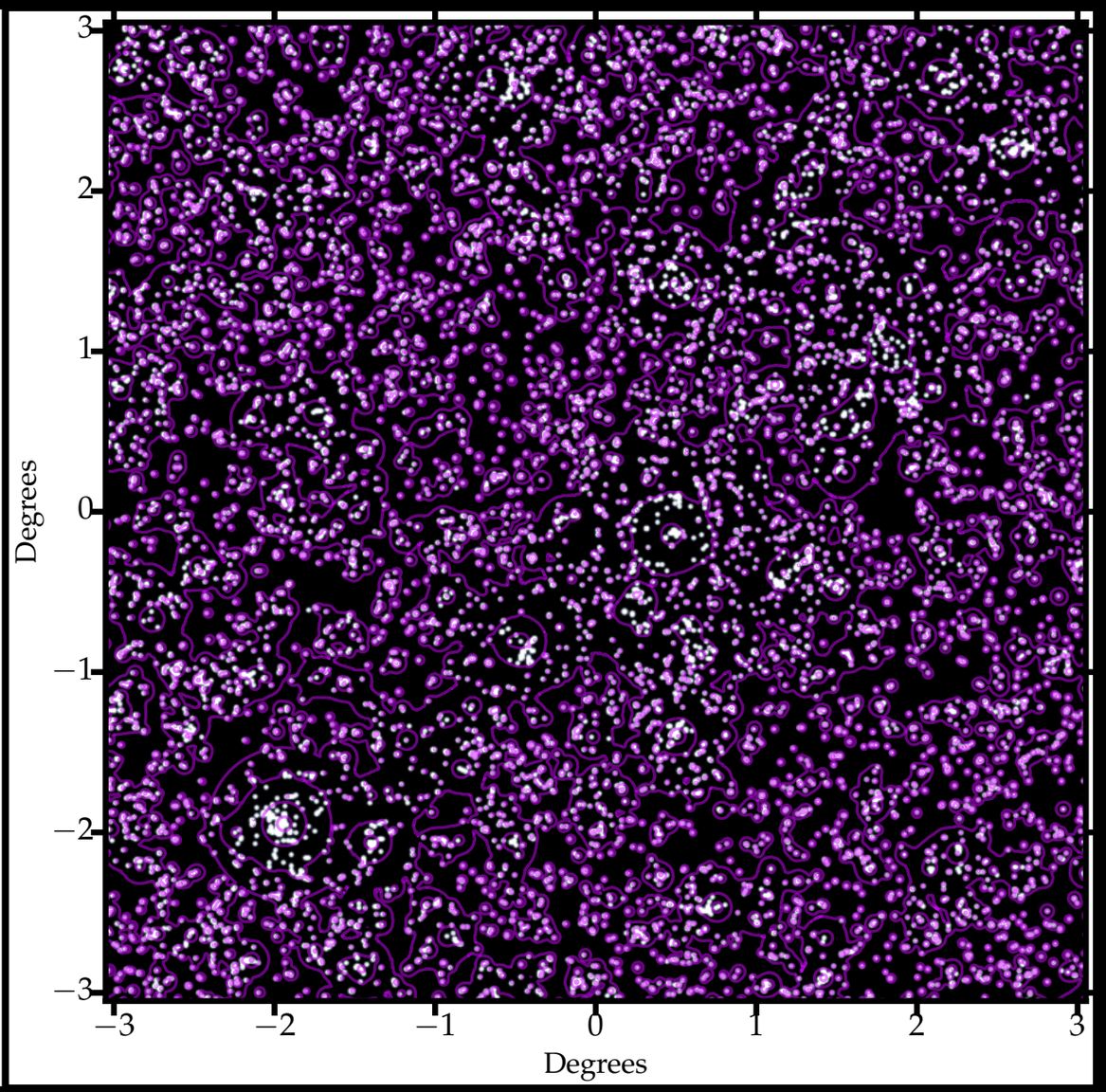
- Many galaxy and halo observables are correlated.

- CMB is correlated with galaxy surveys

CIB x tSZ



Optical x tSZ



Redshift Evolution

- Cross-correlation in each redshift slice picks out contribution from that slice
- Can infer growth of structure

tSZ

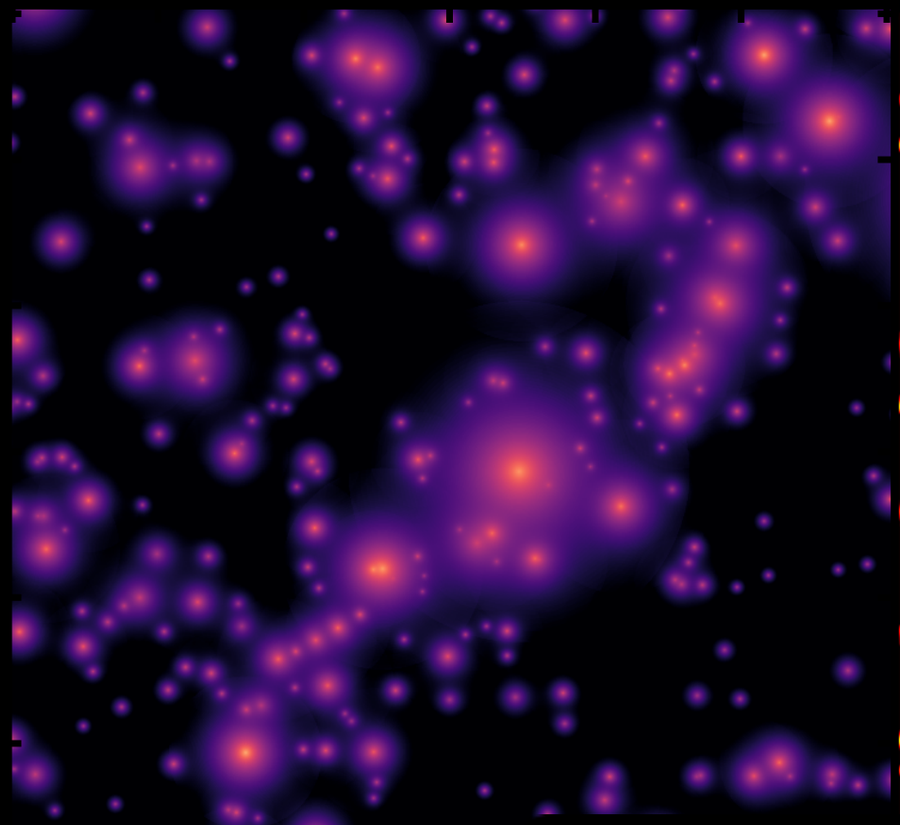
CIB

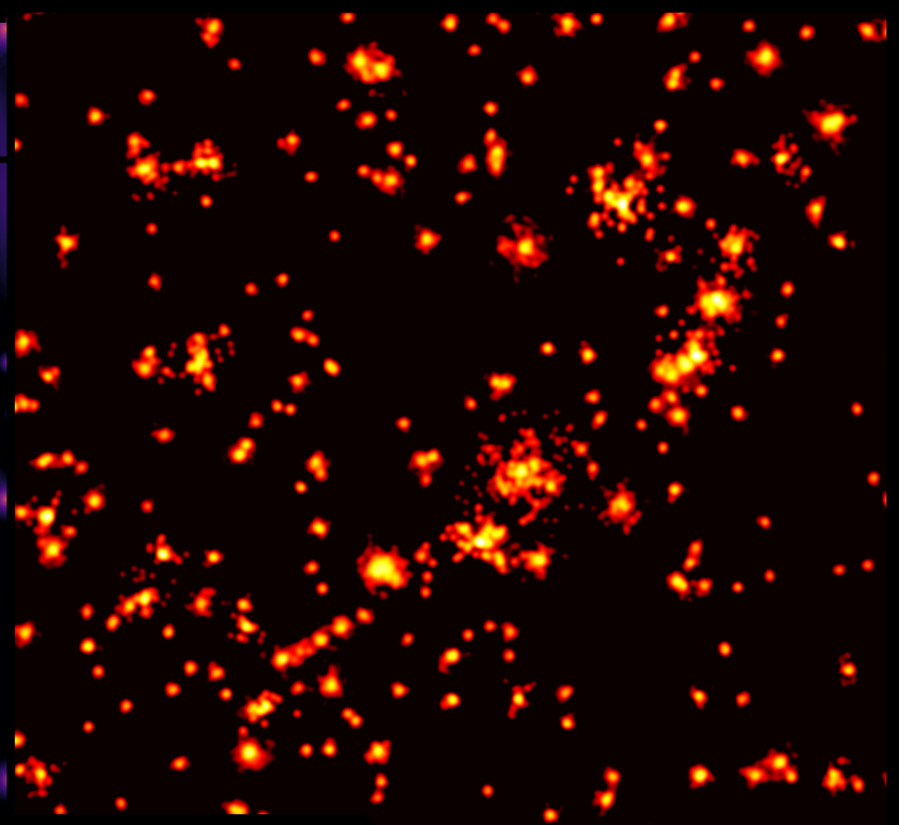
0.00 < z < 1.25

Optical

kSZ

tSZ

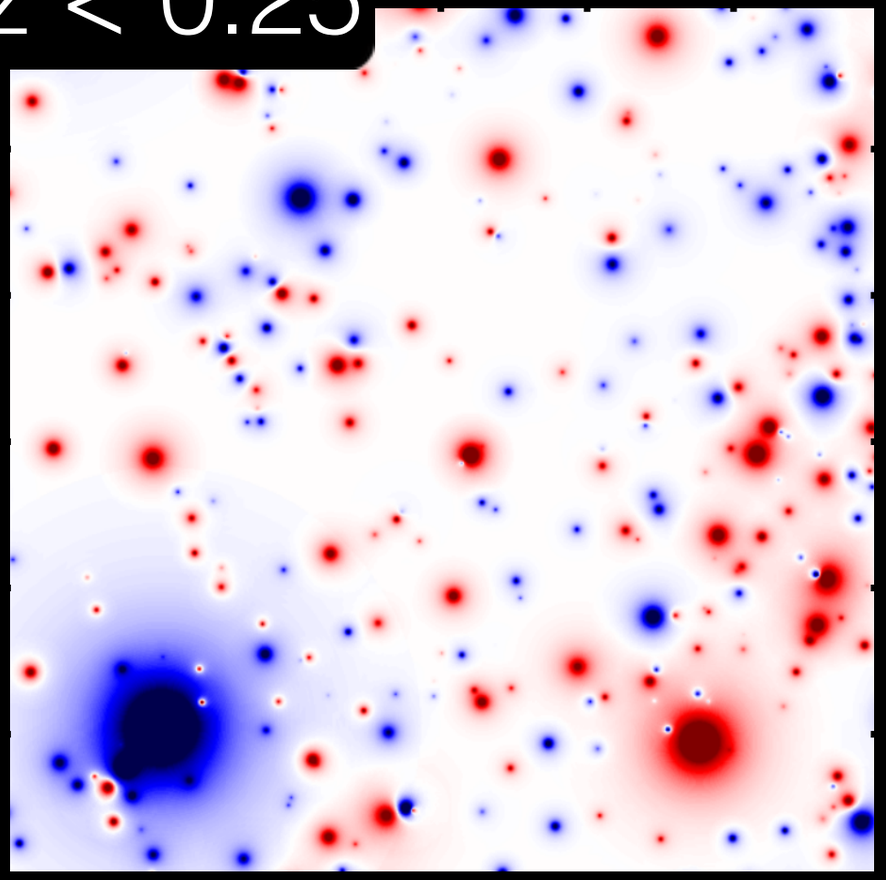




CIB

0.00 < z < 0.25

Optical



kSZ

tSZ

CIB

$0.25 < z < 0.50$

Optical

kSZ

tSZ

CIB

$0.50 < z < 0.75$

Optical

kSZ

tSZ

CIB

$0.75 < z < 1.00$

Optical

kSZ

tSZ

CIB

$1.00 < z < 1.25$

Optical

kSZ

Summary

application to Planck all-sky, Advanced ACTpol - (talk Feb. 20 Princeton ACT mtg - Battaglia, Bond)
CMB Stage 4 - (talks Mar. 7,9 Berkeley S4 - Battaglia, Bond)

- Peak Patch Monte Carlo mocks provide a wealth of cosmological information for parameter estimation, analyzing systematic effects, and testing pipelines

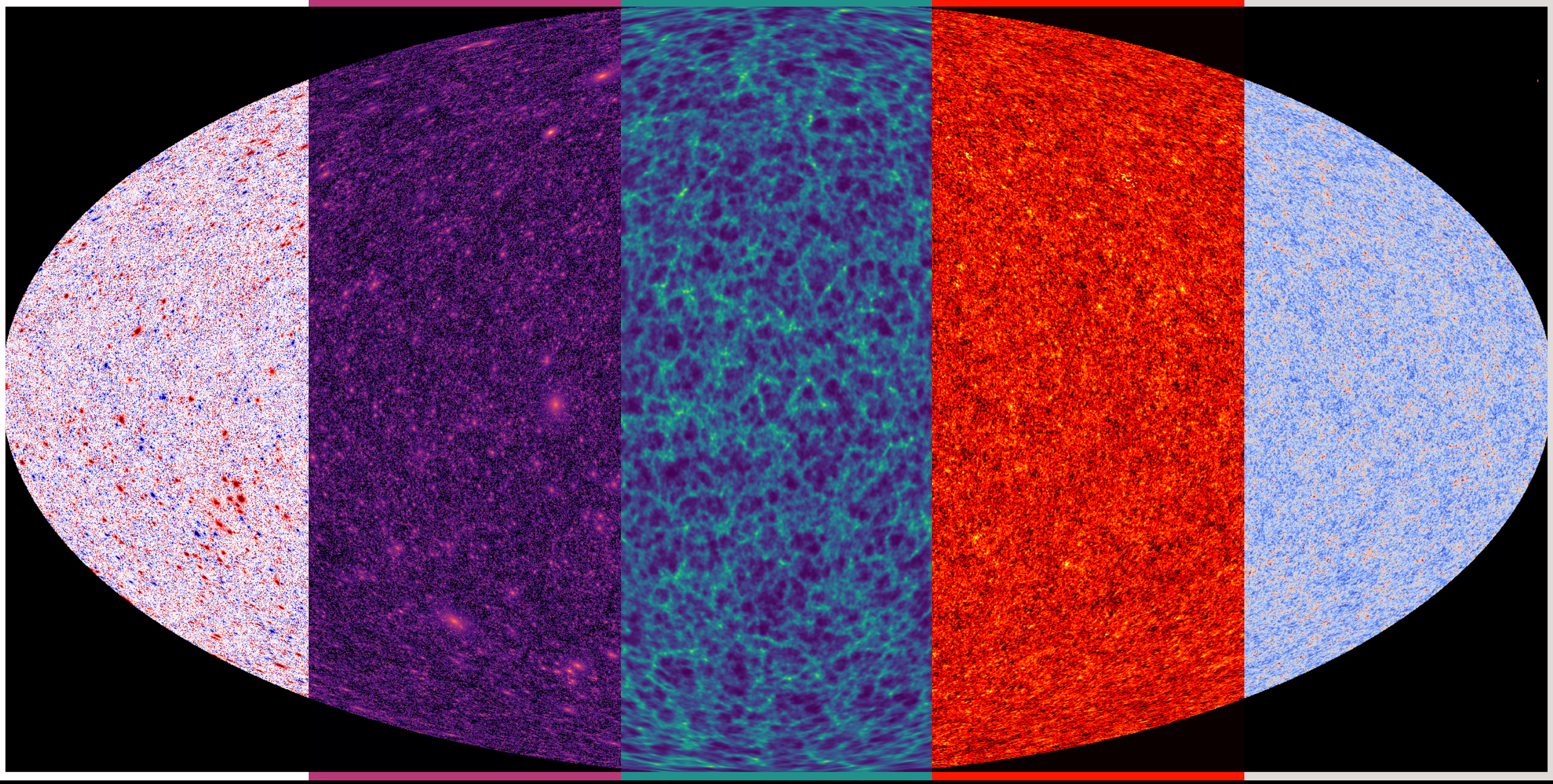
- Extremely efficient light cone simulations and halo profiles with accurate statistics

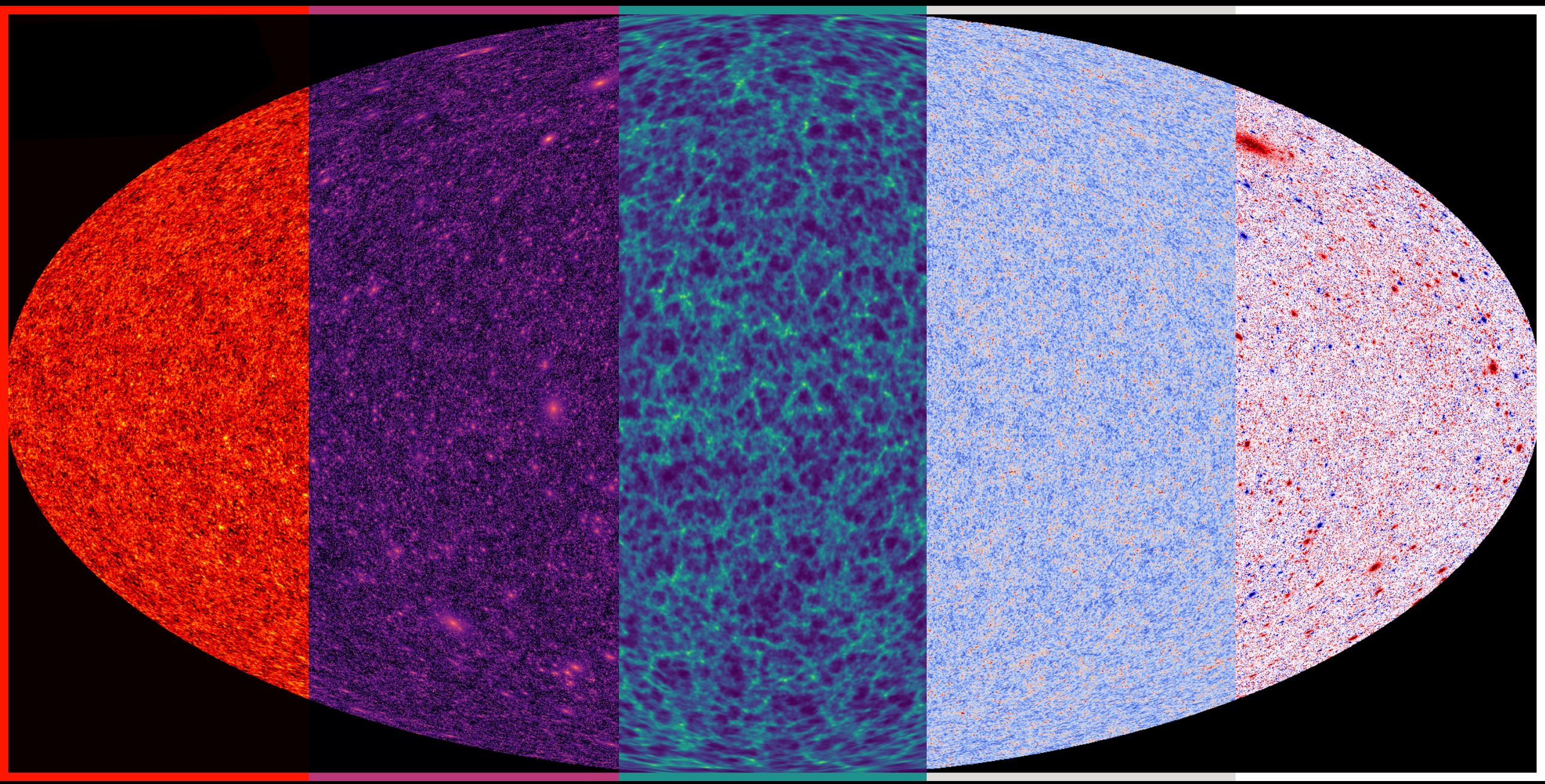
- Mocks + Mapmaking pipeline has numerous applications. tSZ, kSZ, CIB, Optical, Lensing

- Cosmic parmeters - dynamical dark energy/modifed gravity, neutrino mass, primordial NG (perturbative and intermittent), …

Peak Patch Full Sky Model

kSZ tSZ HI CIB Optical



Peak Patch Full Sky Model

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