COLA
COmoving Lagrangian Acceleration

Albert Izard
Supervisors: Pablo Fosalba, Martin Crocce

ICE IEEC CSIC

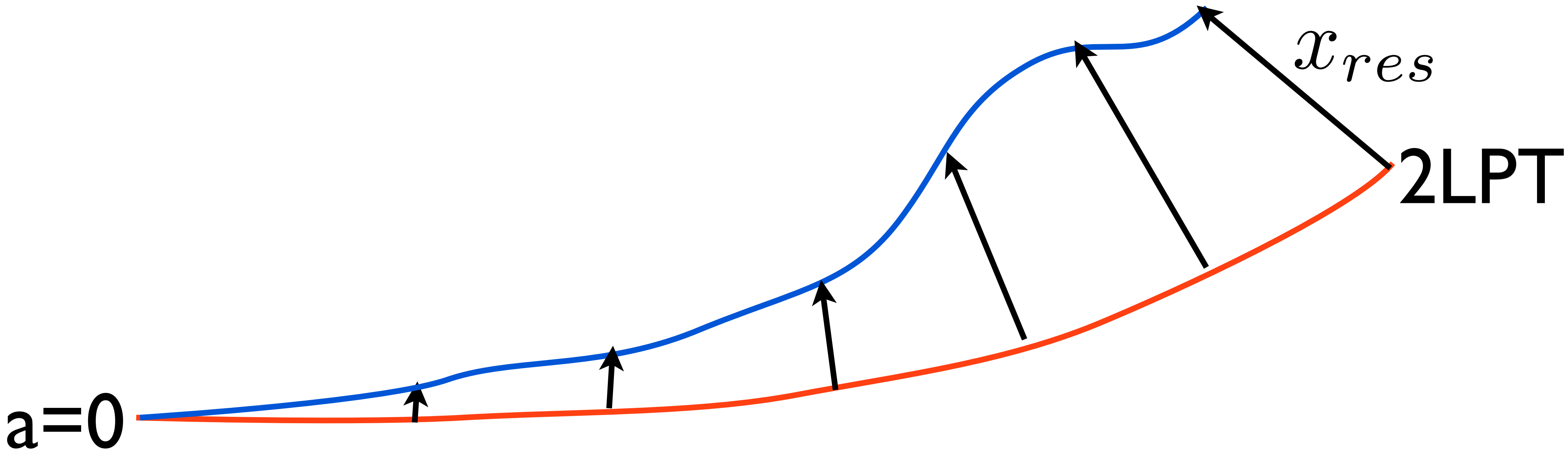
Solving large scale structure in ten easy steps with COLA (Tassev, Zaldarriaga, Eisenstein, 2013)

- COLA = theory (LPT) + numerical simulation (N-body)
- Dark matter particles
- Set up IC (2LPTic, Scoccimarro 1998; Crocce, Pueblas, Scoccimarro 2006).
- Evolve particles according to the 2LPT trajectories + residual displacement evaluated by the N-body solver.
- Find halos (FoF).

Equation of motion $$\partial_t^2 x = -\nabla\Phi$$

$$x_{res} \equiv x - x_{LPT}$$

Rewrite it $$\partial_t^2 x_{res} = -\nabla\Phi - \partial_t^2 x_{LPT}$$



Displacement vector

$x = q + s \qquad s_{res} \equiv s - D_1 s_1 - D_2 s_2$

Equation of motion

$$T^2[s_{res}] = -\frac{3}{2}\Omega_M a \partial_x \partial_x^{-2} \delta(x,a) - T^2[D_1]s_1 - T^2[D_2]s_2$$

Time operators
Drift and Kick

$$D(a_i, a_f): \; x(a_i) \to x(a_f)$$

$$K(a_i, a_f): \; v(a_i) \to v(a_f)$$

$$L_{\pm}(a): \; v(a) \to v(a) \pm (T[D_1](a)s_1 + T[D_2](a)s_2)$$

$$L_+(a_{n+1}) \left(\prod^n K(a_{i+\frac{1}{2}}, a_{i+1}) D(a_i, a_{i+1}) K(a_i, a_{i+\frac{1}{2}}) \right) L_-(a_0)$$

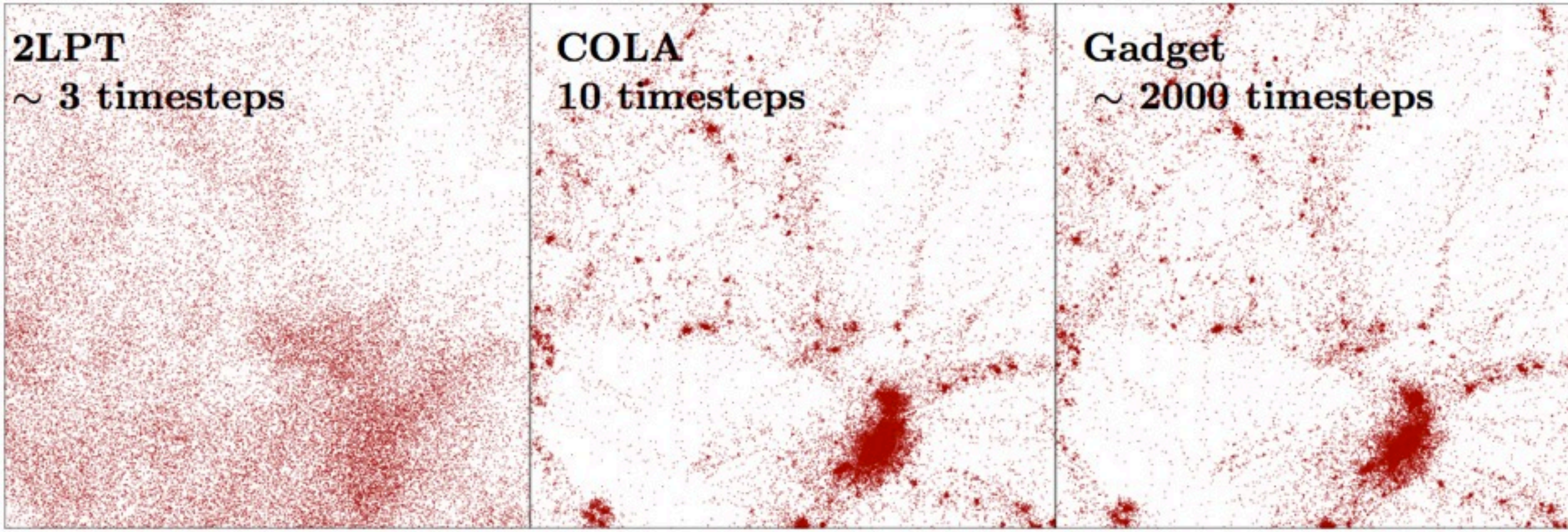
- N-body solver. Particle-Mesh code (PM).

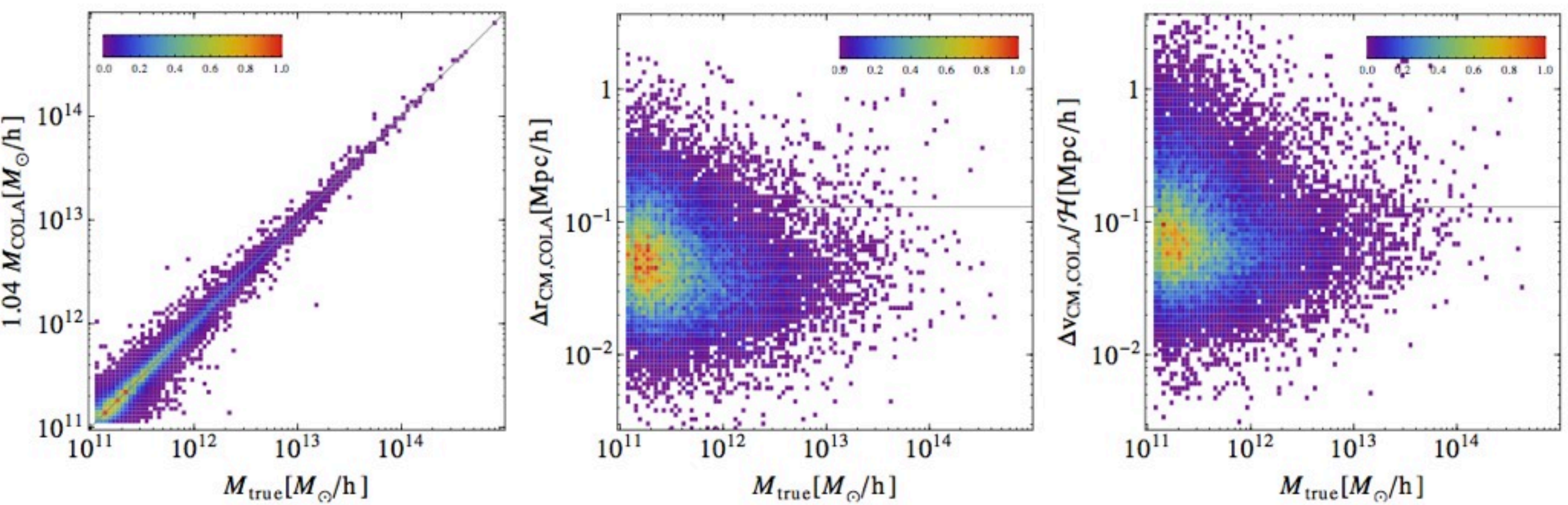
- Force mesh 3 times finer that the mean particle distance, giving a force softening scale that still resolves halos with few tens of particles.

- Do few timesteps: ~10. Enough to recover halo statistics.

- Speed-up of two orders of magnitude wrt full N-body.

Tassev, Zaldarriaga, Eisenstein, 2013



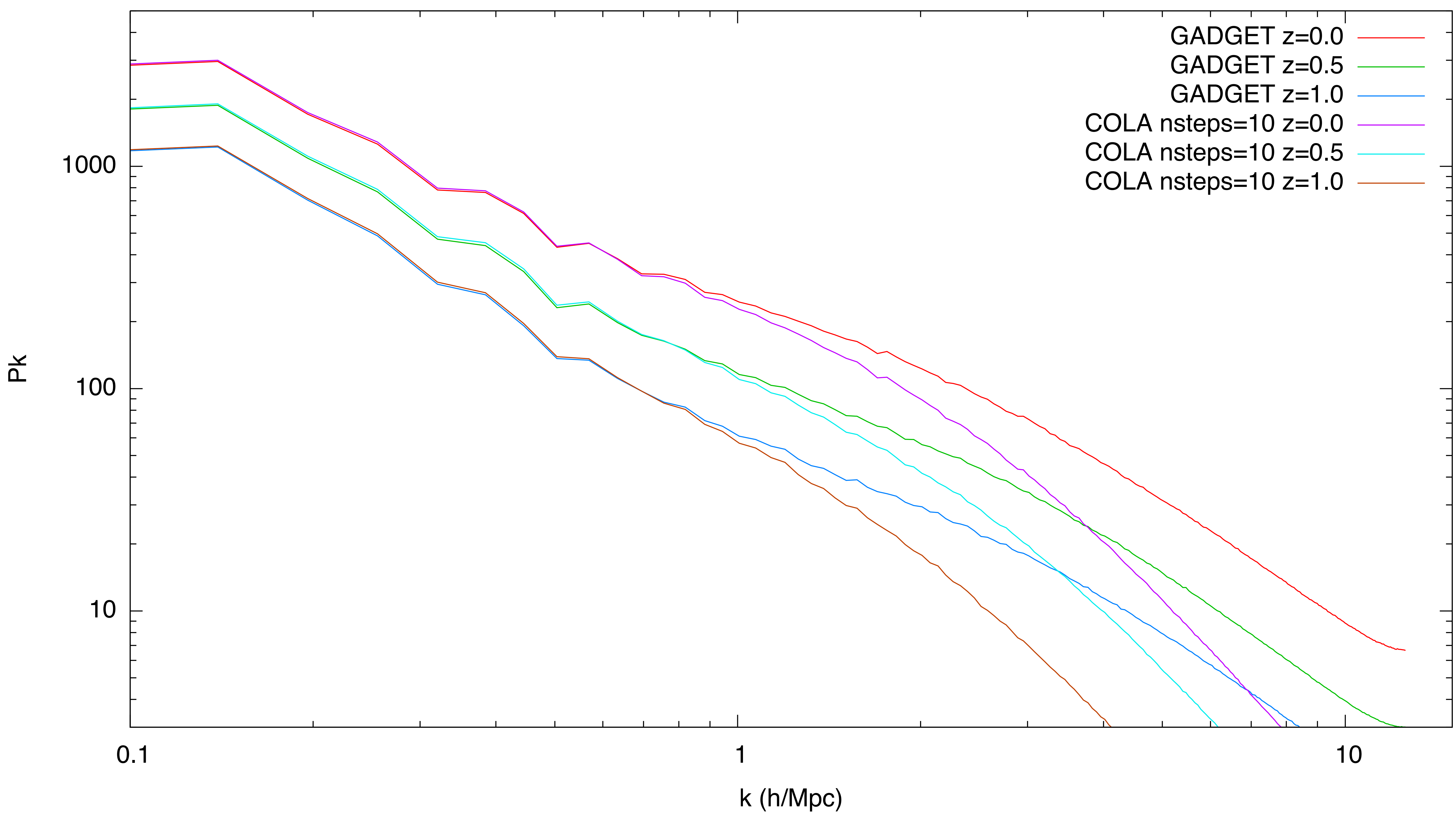


Parallel COLA

• Parallel version by Jun Koda for WiggleZ mocks (Kazin et al 2014). MPI + OpenMP parallelization. It Includes:

- 2LPT gaussian initial conditions
- COLA method parallelized
- FoF on the fly

COLA_N256_L100_nsteps10 vs LGADGET_N256_L100



- PROS

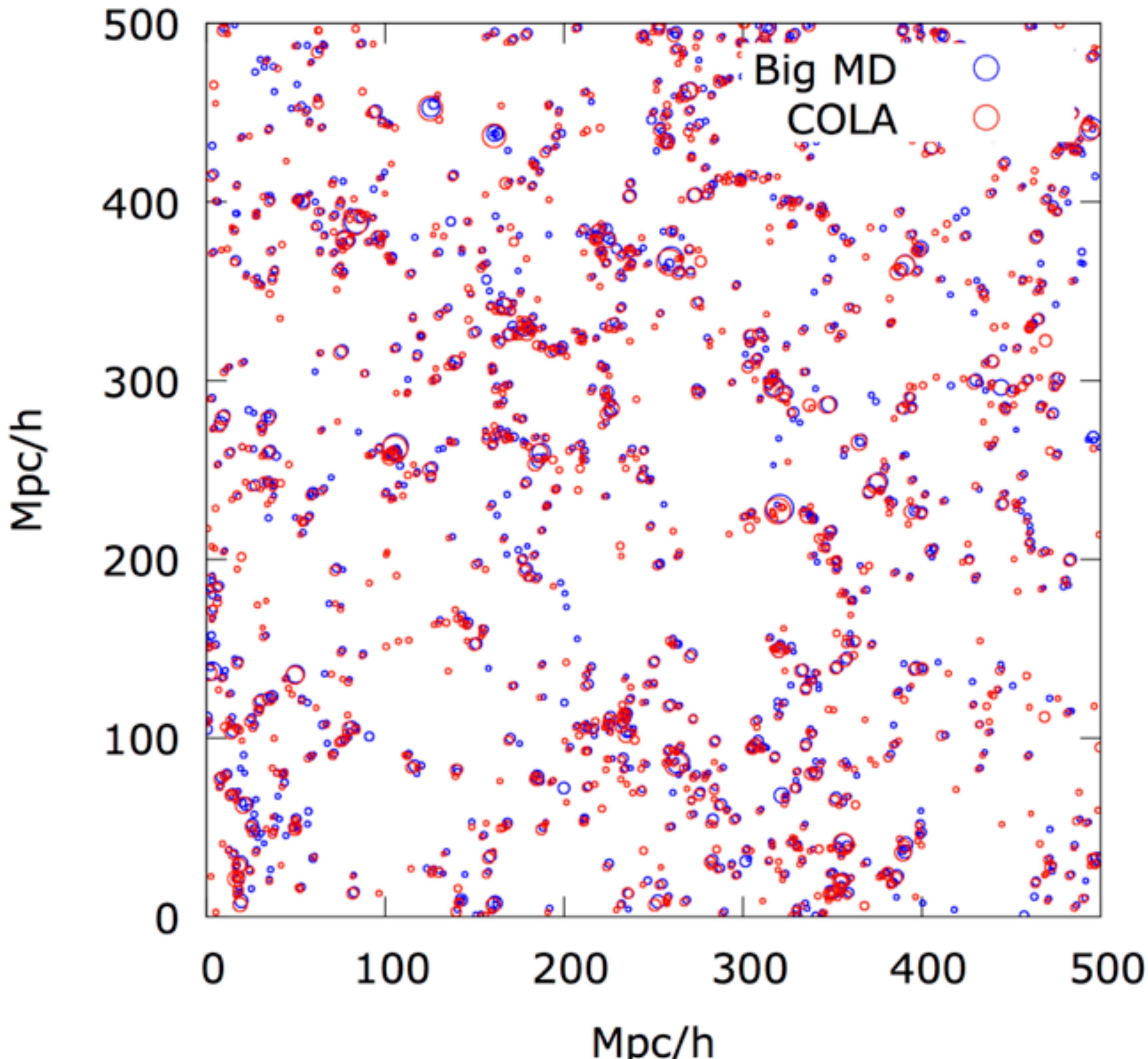
- Large scale dynamics is exact.
- Accuracy at small scales controled by the number of timesteps.
- Very fast: only 10 timesteps compared to thousands of N-body
- Dark matter field available.
- FoF on the fly.

- CONS

- Large amount of memory needed for the force mesh.

nIFTy mocks

• Using white noise file to fix random initial phases. Still work in progress: large scale structure seems to reproduce BigMD simulation but the mass function is bad (missing >30% of objects)



nIFTy mocks

• Available:
- 2 runs with the small box (1 Gpc/h, N=512^3, mp=6.35e11)
- 1 run with the big box (2.5 Gpc/h, N=1280^3, mp=6.35e11), random initial conditions
- Hopefully during this week: fix the white noise problem to have the same phases

• For the larger run:
- 3 hours (to z=0 wt FoF) x 64 procs ~ 200 cpu hours
- 550 Gb, ~300 bytes/particle

THANK YOU!