Northwestern | CIERA CENTER FOR INTERDISCIPLINARY EXPLORATION AND RESEARCH IN ASTROPHYSICS | Argonne NATIONAL LABORATORY

Modeling galaxies in extreme-scale cosmology simulations

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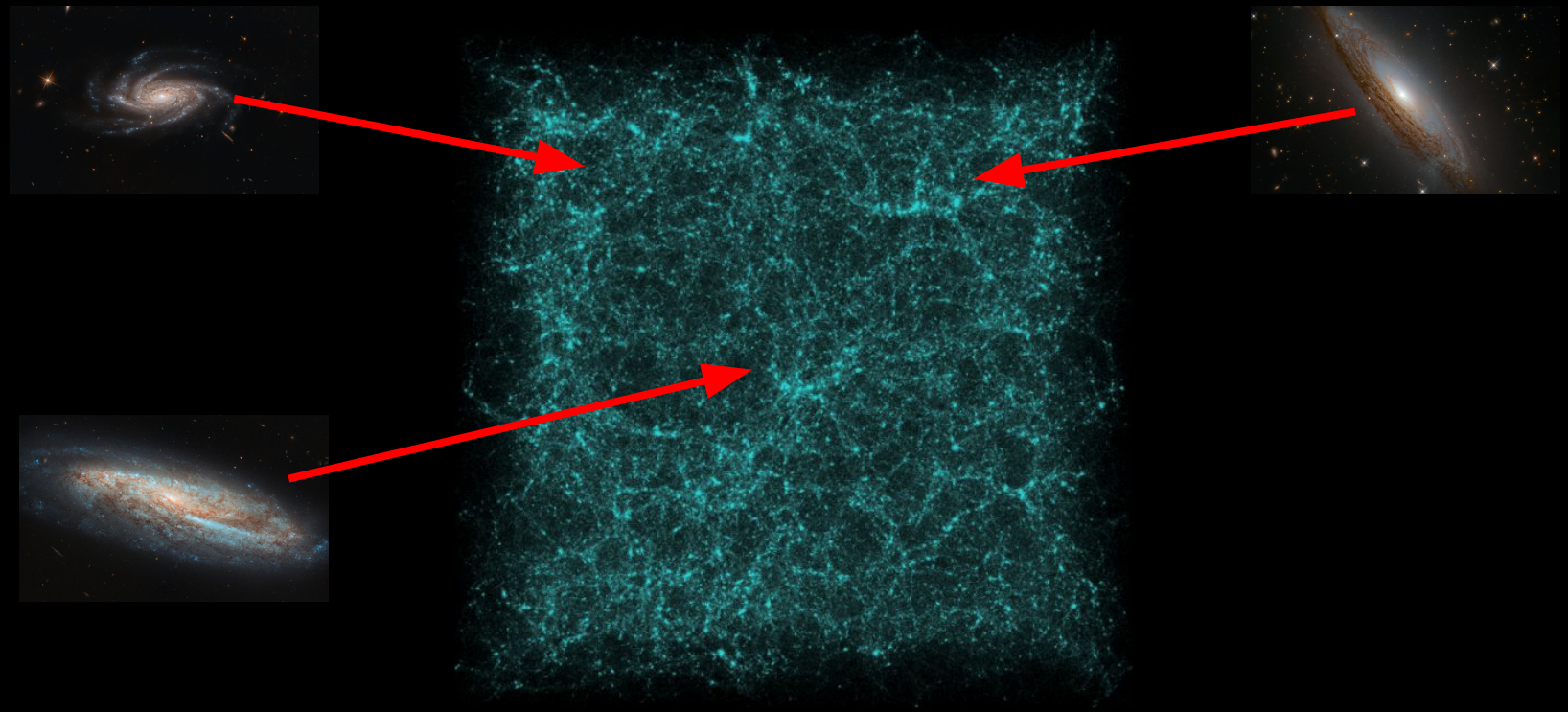
arXiv:2012.09262 Sultan, I., Frontiere, N., Habib, S., Heitmann, K., Kovacs, E., Larsen, P., Rangel, E. 2021

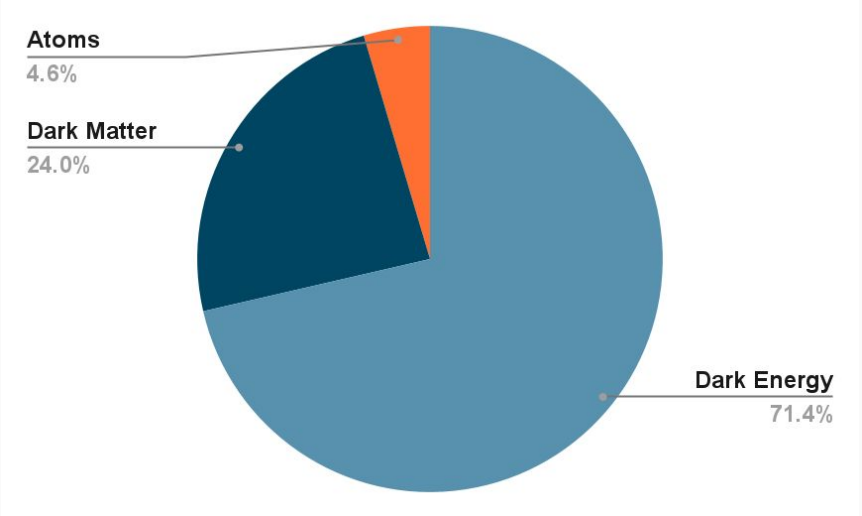
DSI Research/Networking session
July 14, 2021



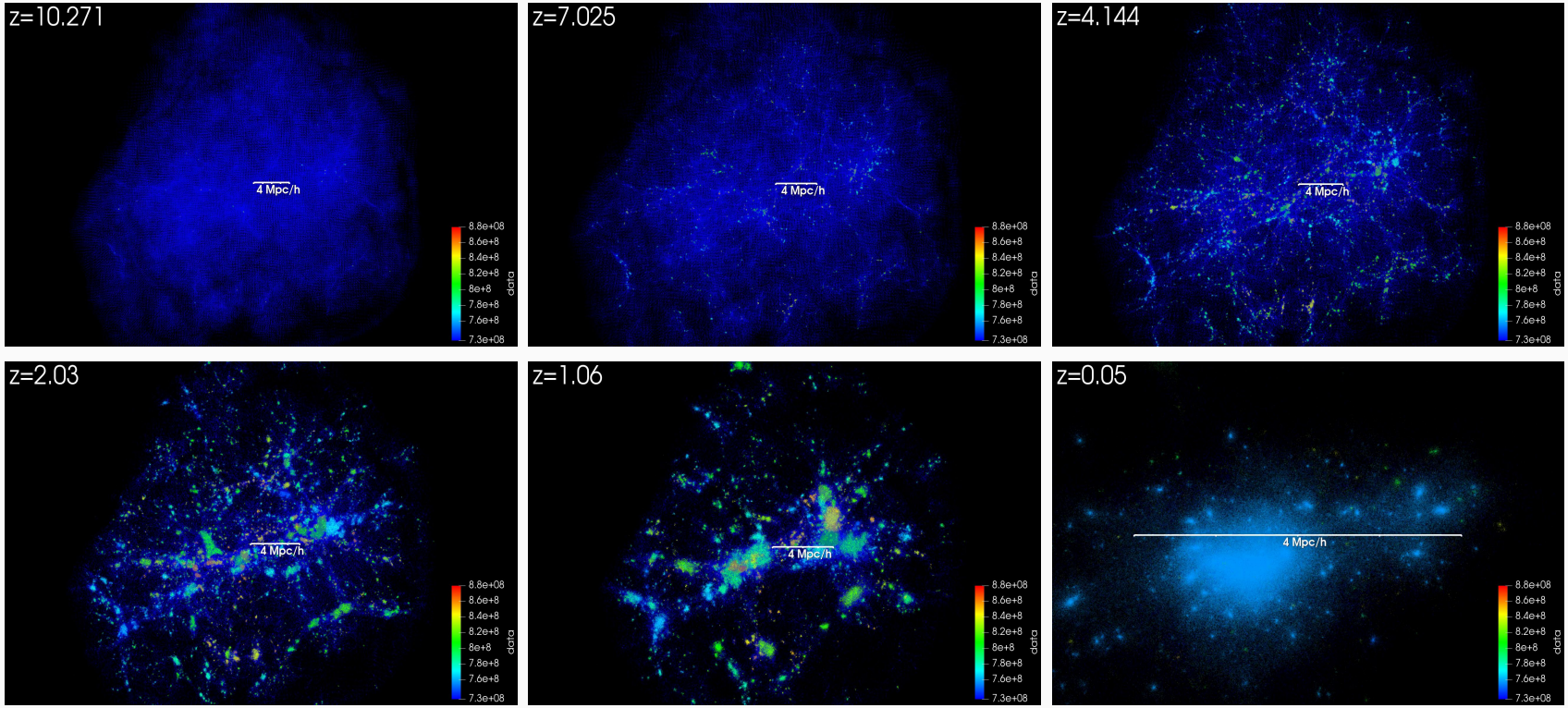
Galaxy images: ESA/Hubble & NASA

Extreme-scale gravity only simulations

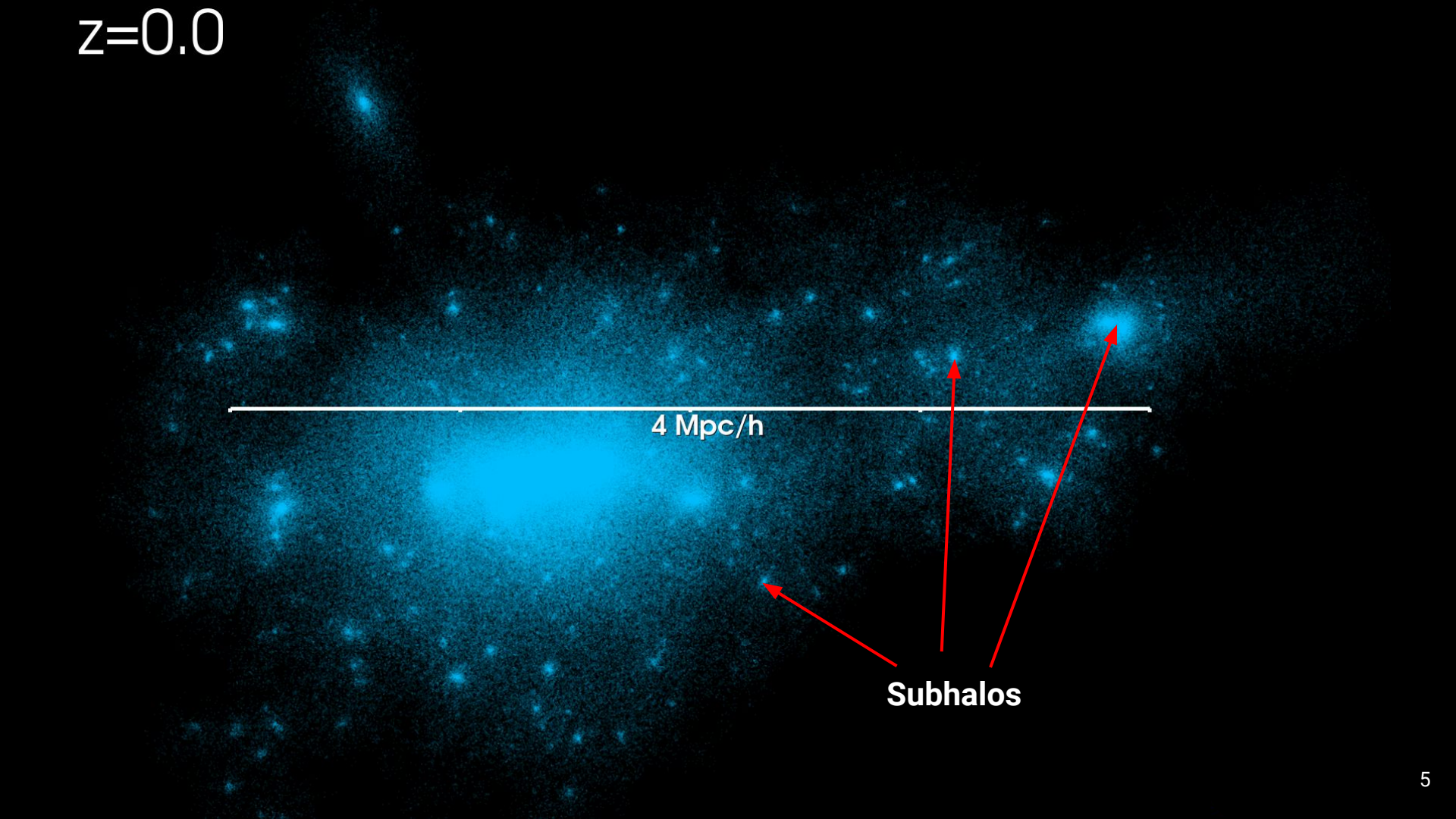
- Dark matter simulations
- Last Journey Simulation
  - over 1 trillion particles in a (16 billion light years)^3 volume



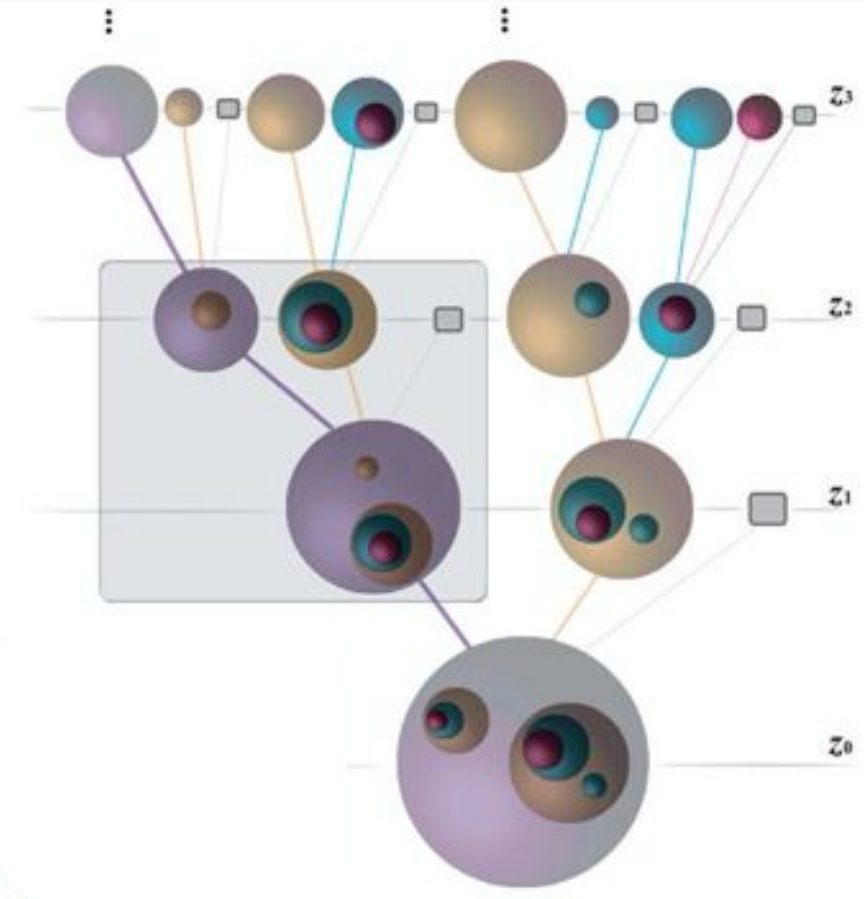
WMAP-9 (NASA)



Halos: dense regions of dark matter within which galaxies form


z=0.0
4 Mpc/h
Subhalos

Halos: hierarchically formed



time

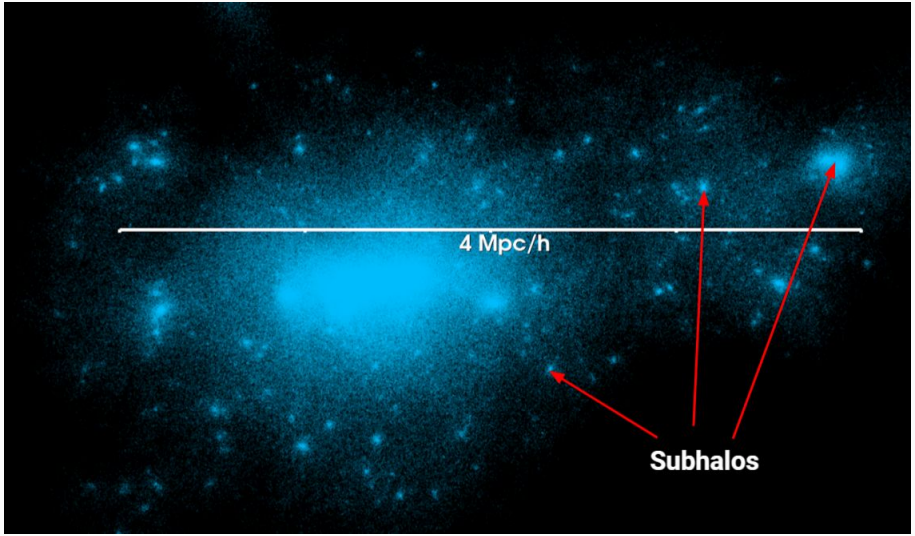
Jiang & van den Bosch 2016

Modeling galaxies

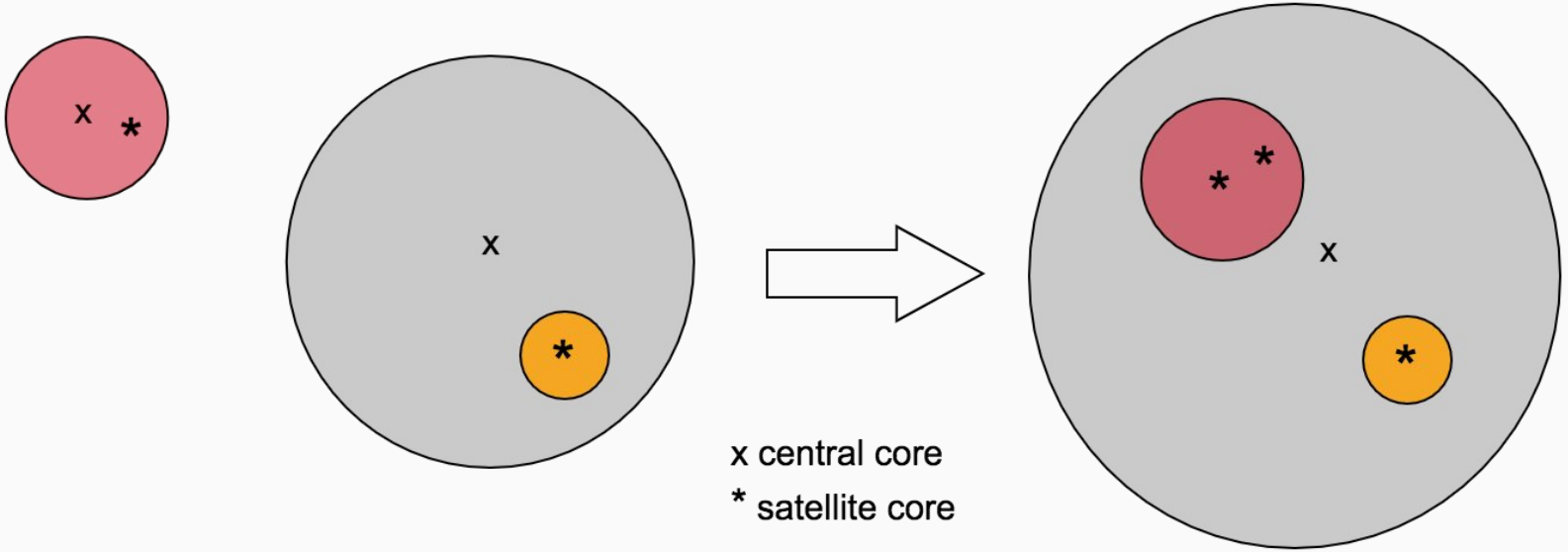
To add galaxies, we need to know **each subhalo's**:

1. Location
2. Mass
3. Merger tree (which halos is it descended from?)

- Traditional method: Subhalo Finding
  - Very computationally expensive



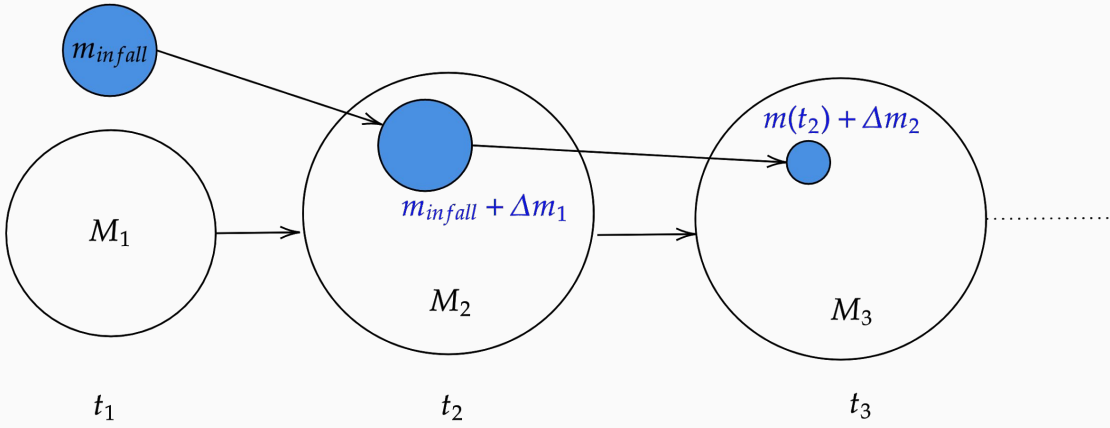
Core-tracking

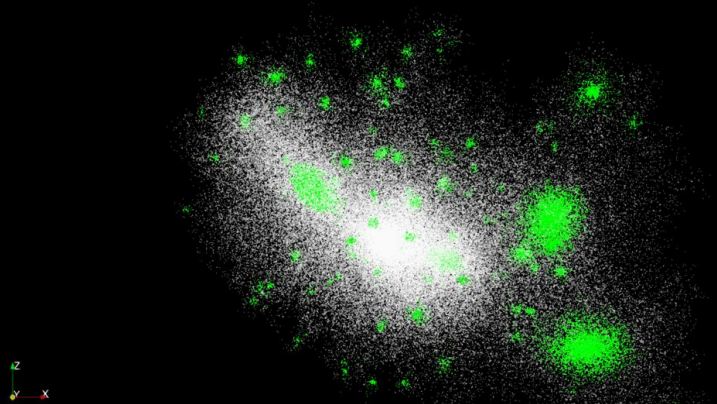


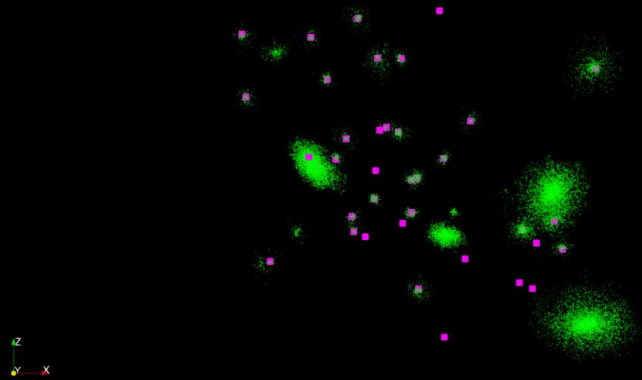
Mass loss model

$$\dot{m} = -A\frac{m}{\tau_{\rm dyn}}\left(\frac{m}{M}\right)^{\zeta}$$

van den Bosch+ 2005, Jiang & van den Bosch 2016







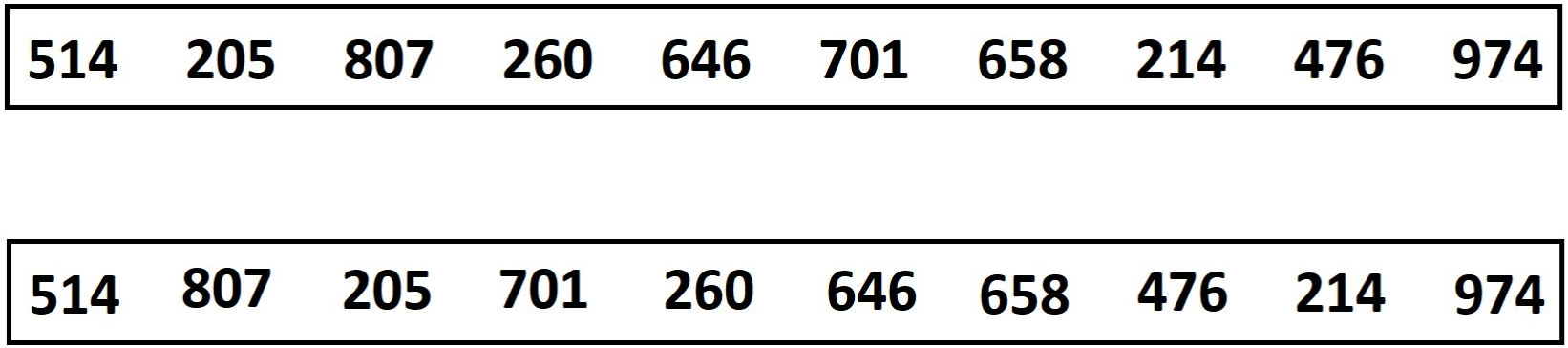
ParaView

FIREFLY

https://ageller.github.io/Firefly

Data Science challenge:
Applying the mass model to much larger simulations

- Size of core catalogs: 100 GB → 20 TB
- Split core catalog and distribute job to hundreds of parallel processes using **MPI** (Message Passing Interface)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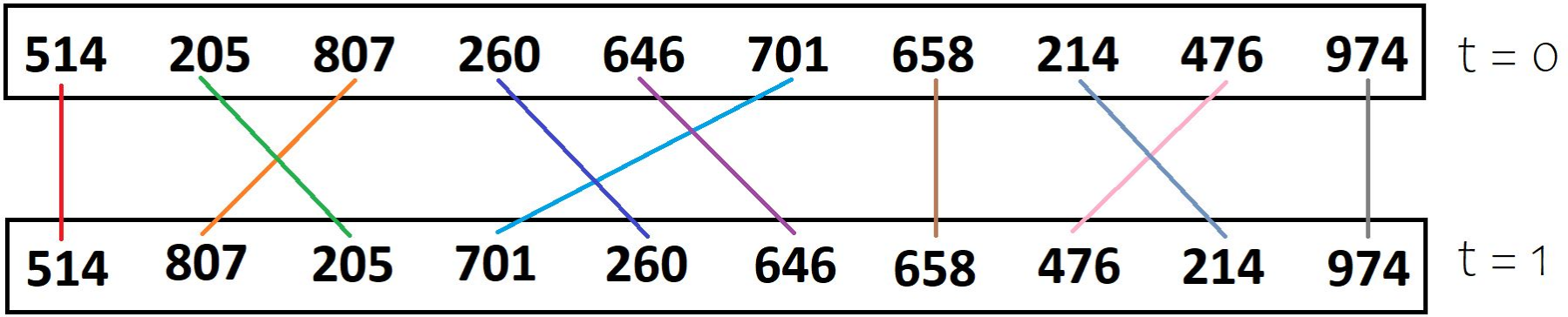
514 807 205 701 260 646 658 476 214 974
t = 1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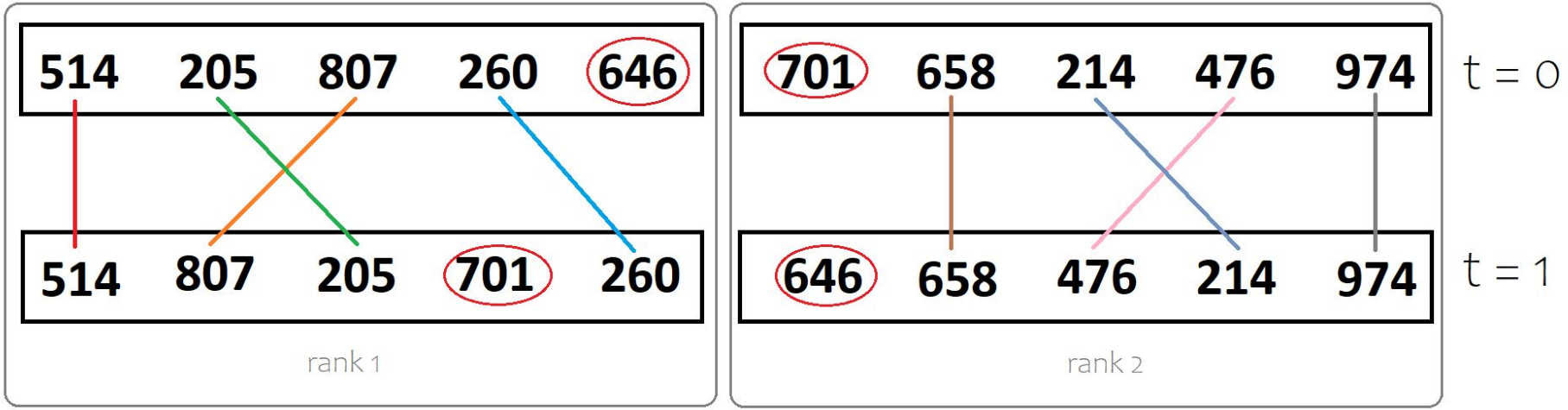
514 205 807 260 646
514 807 205 701 260
rank 1
701 658 214 476 974
646 658 476 214 974
rank 2
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t = 1

Thanks for your time!

Questions?

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