

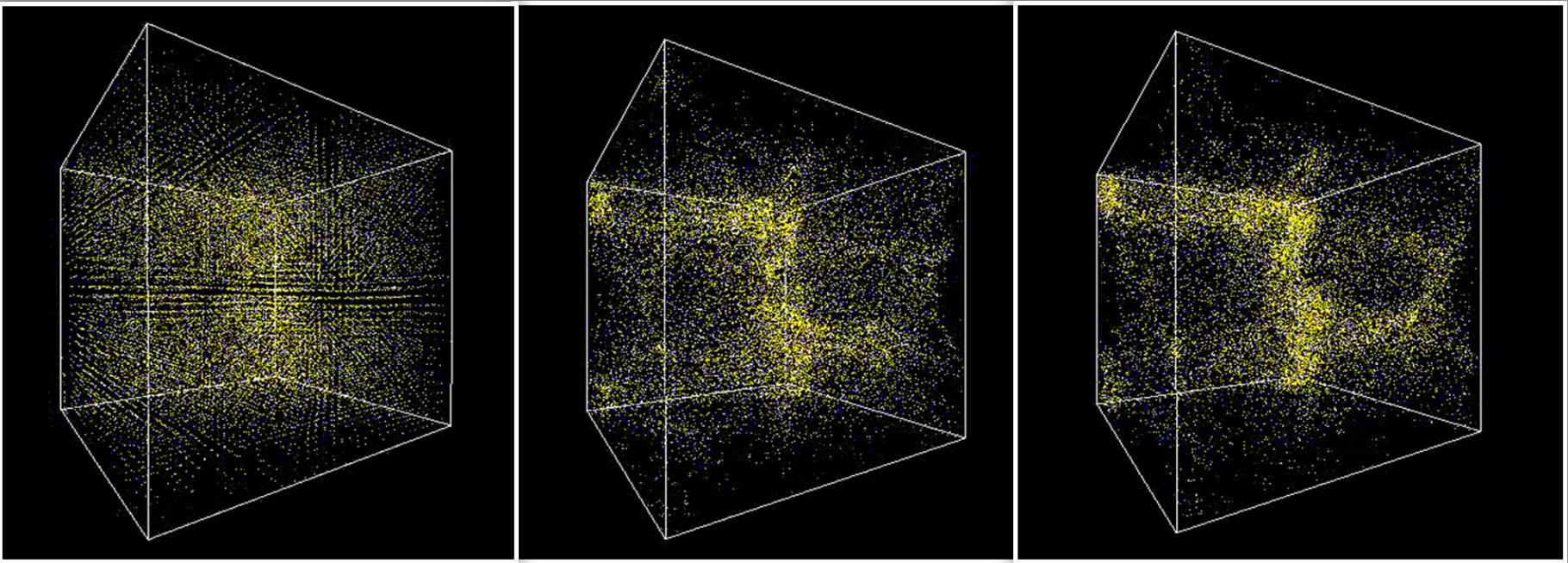
# Creating Galactic Merger Trees Using D3

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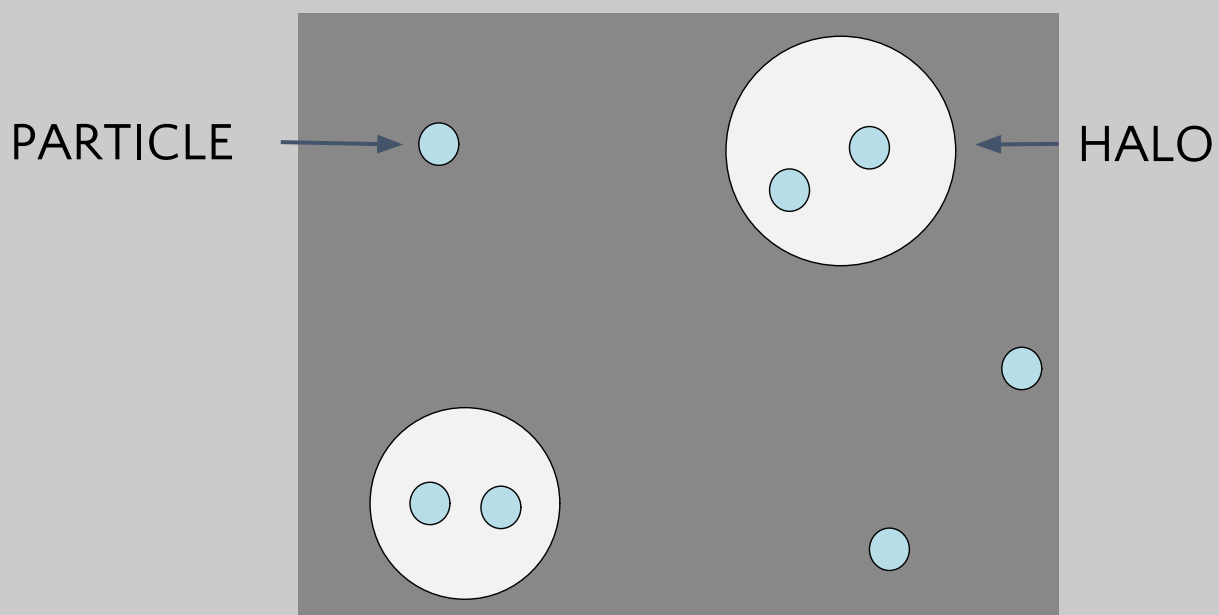
## Problem

Researchers from the UW Astronomy Department are investigating the formation and characteristics of galaxies through time from the beginning of the universe. Specifically, they study the merging behavior between galaxies across time. This project was motivated by their need for an interactive tool to facilitate their exploration without the need of building queries for the backend database.

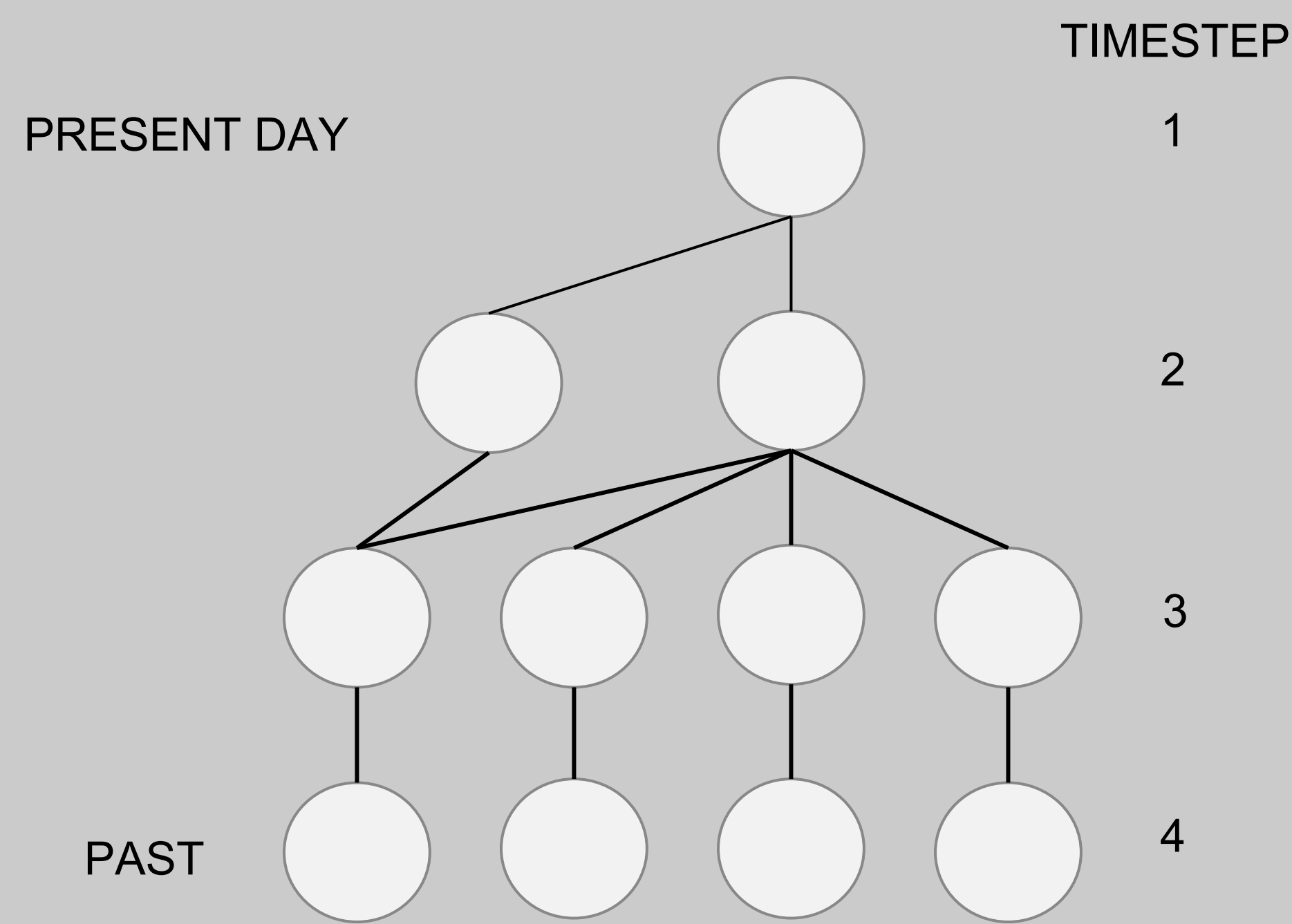
1) Astronomers simulate the evolution of the universe through particle interactions at distinct timesteps



2) At each timestep, cluster particles into halos (galaxies)



3) Determine when halos merge together to create merger trees of present day galaxies



4) **Problem:** Want to visually inspect and analyse these tree structures, but there is no existing tool that facilitates this exploratory process

## Motivation

With an interactive visualization of these merger trees, astronomers will be able to better analyze and research the creation of our universe.

### Challenges:

- The clustering algorithm that assigns particles to halos is not always correct and sometimes results in faulty merges, so the data needs to be cleaned
- Trees have hundreds of nodes, so the visualization must allow features to be highlighted and hidden
- Each halo has many properties, so it must balance the amount of data shown with the effectiveness of the visualization
- Must allow for intuitive transitioning to facilitate navigation through a tree
- Develop a similarity metric to allow for tree comparison

## Approach

### Data Processing

Halos are stored in a local SQL Server database. We run an iterative query to compute all links between halos in sequential timesteps.

Generated Files:

- **Nodes**
  - Properties for each Halo
    - mass, luminosity, total particle count, total dark particle count
- **Edge information:**
  - Information on the links between halos
    - number of shared particles

We use these files during the visualization to build each tree using D3's tree layout.

### Visualization Interactions

#### Tree Structure

- Bounded zooming and dragging of the tree

#### Nodes

- Single click on a node to collapse children
- Display tooltips
- Size nodes by mass, color based on whether it is a progenitor (halo contributing the most particles)

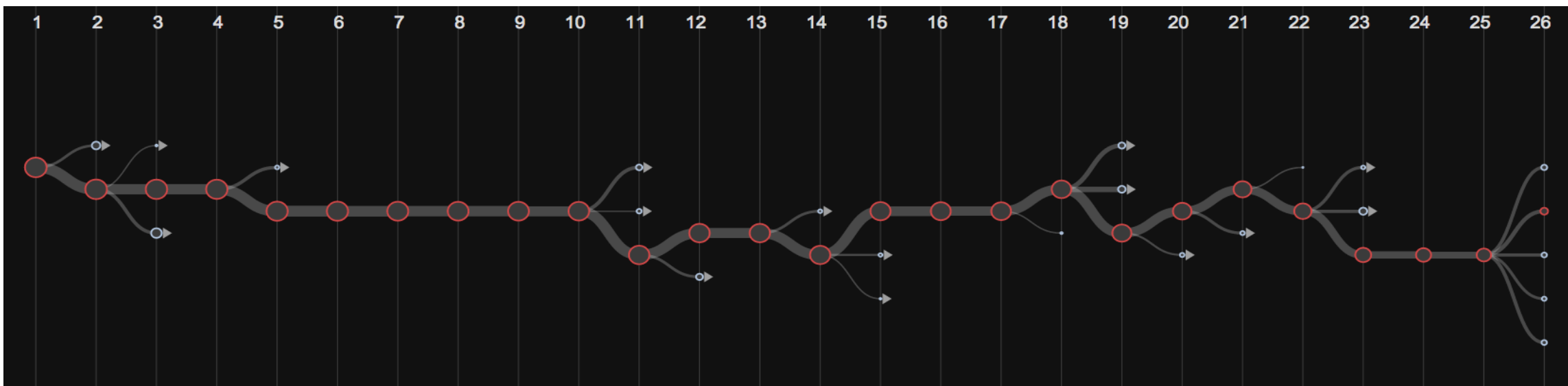
#### Edges

- Thickness determined by the number of particles shared between two halos

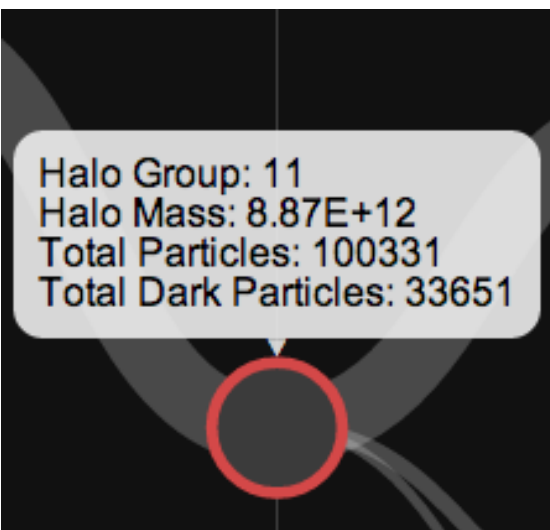
#### Filters

- Brushing and highlighting of nodes based on mass and number of particles per halo

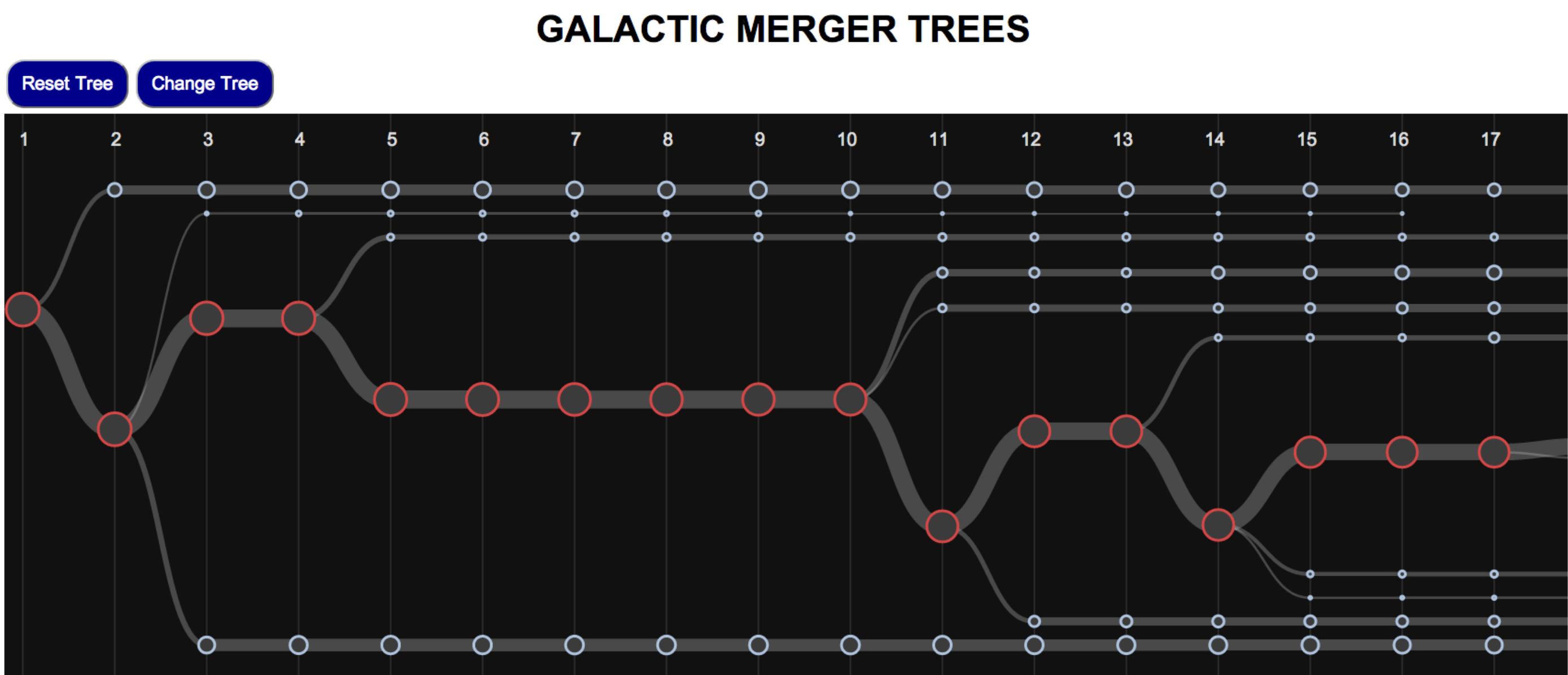
## Results



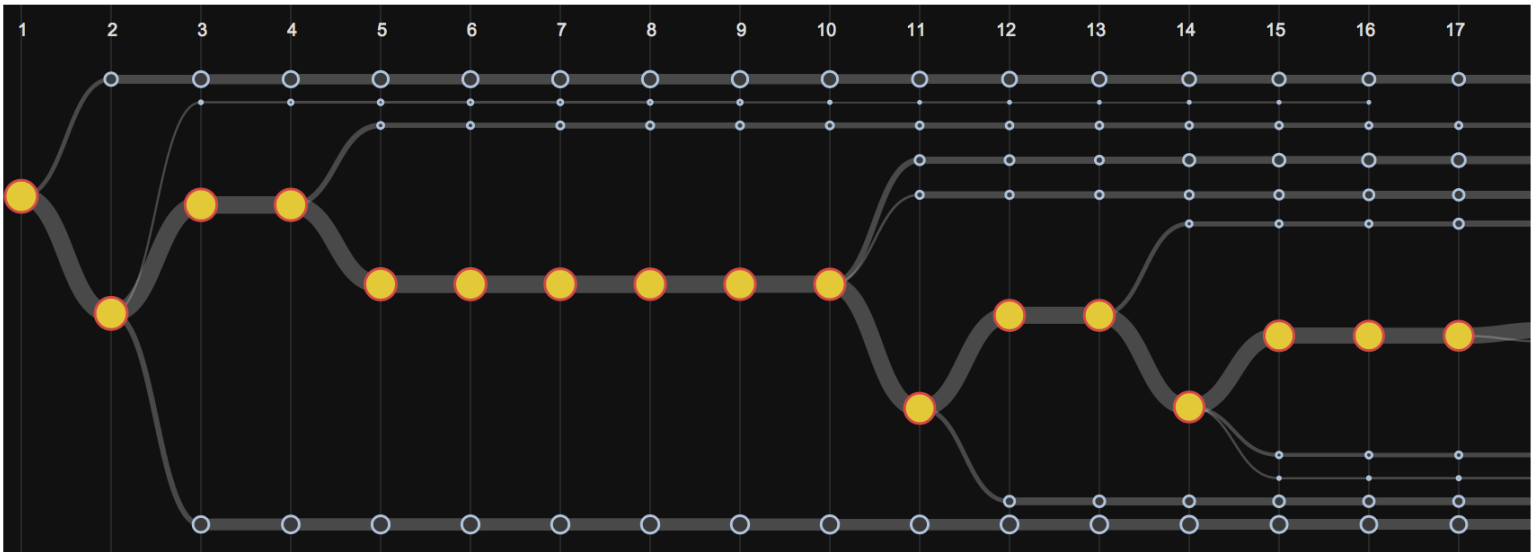
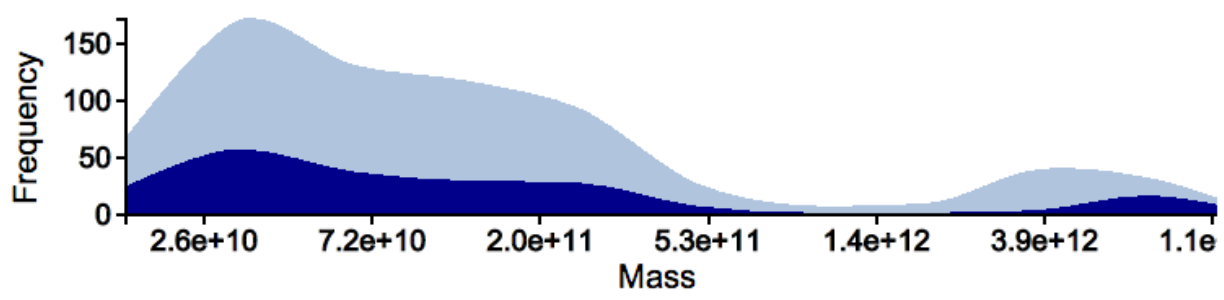
Collapse children through node click



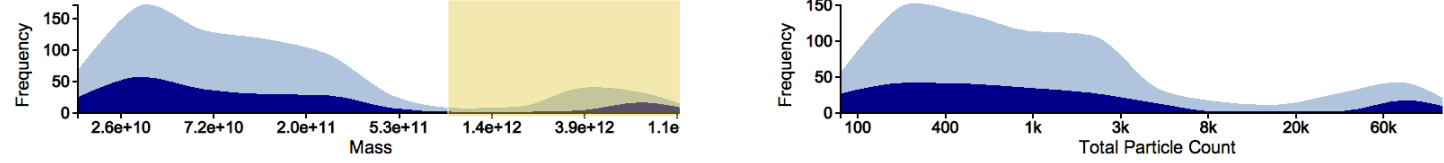
Hover over tooltip to see halo properties



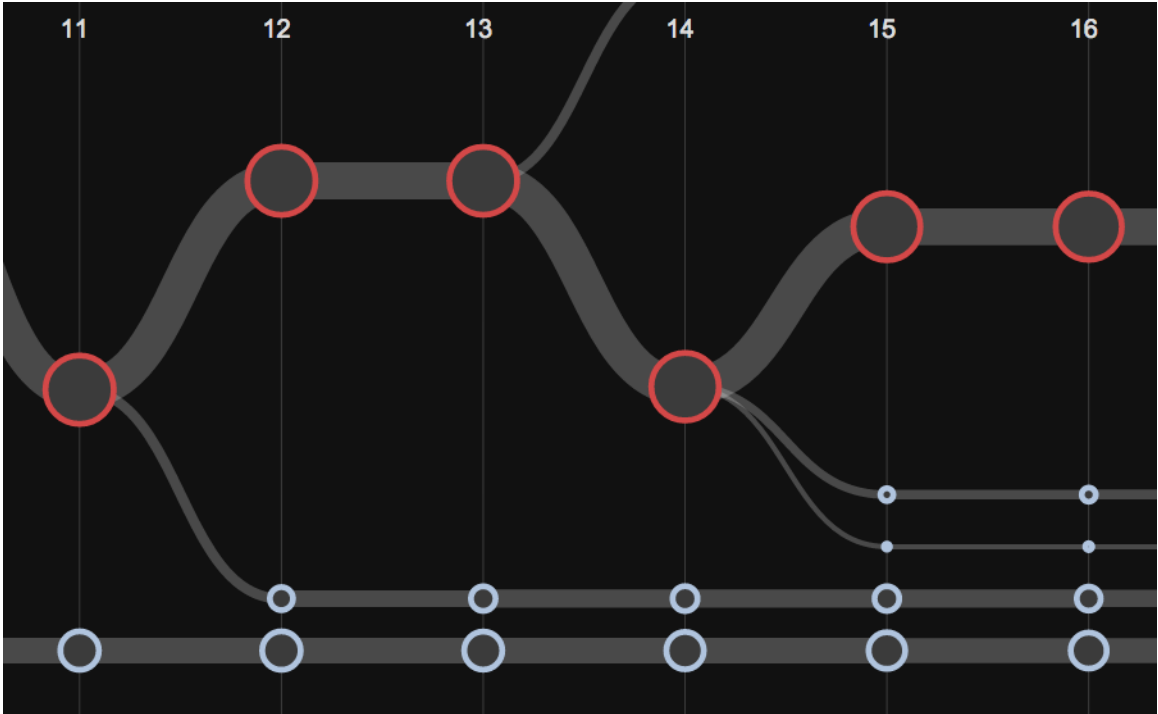
Highlights



Highlights



Highlight node through filters



Zooming in and dragging nodes

## Future Work

- Show thumbnails of all halos sorted by similarity to currently viewed halo to facilitate comparison
- Show luminosity of halo through blurred edges of nodes
- Incorporate user feature selection through check boxes
- Facilitate node selection for smaller halos