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Visual Exploration of Multifaceted Halo Data Sets

Introduction

- Halos in cosmological simulations often have many properties
- Exploration of halos in high dimensional data space is non-trivial
- We present a visualization framework that assists users to explore halos of interest

Task Characterization

- Visualize multi-faceted halo properties
- Facilitate exploration of halos of interest
- Enable easy query specification
- Support responsive and flexible interactions

System Design

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PCP View

- Visualize multiple facets

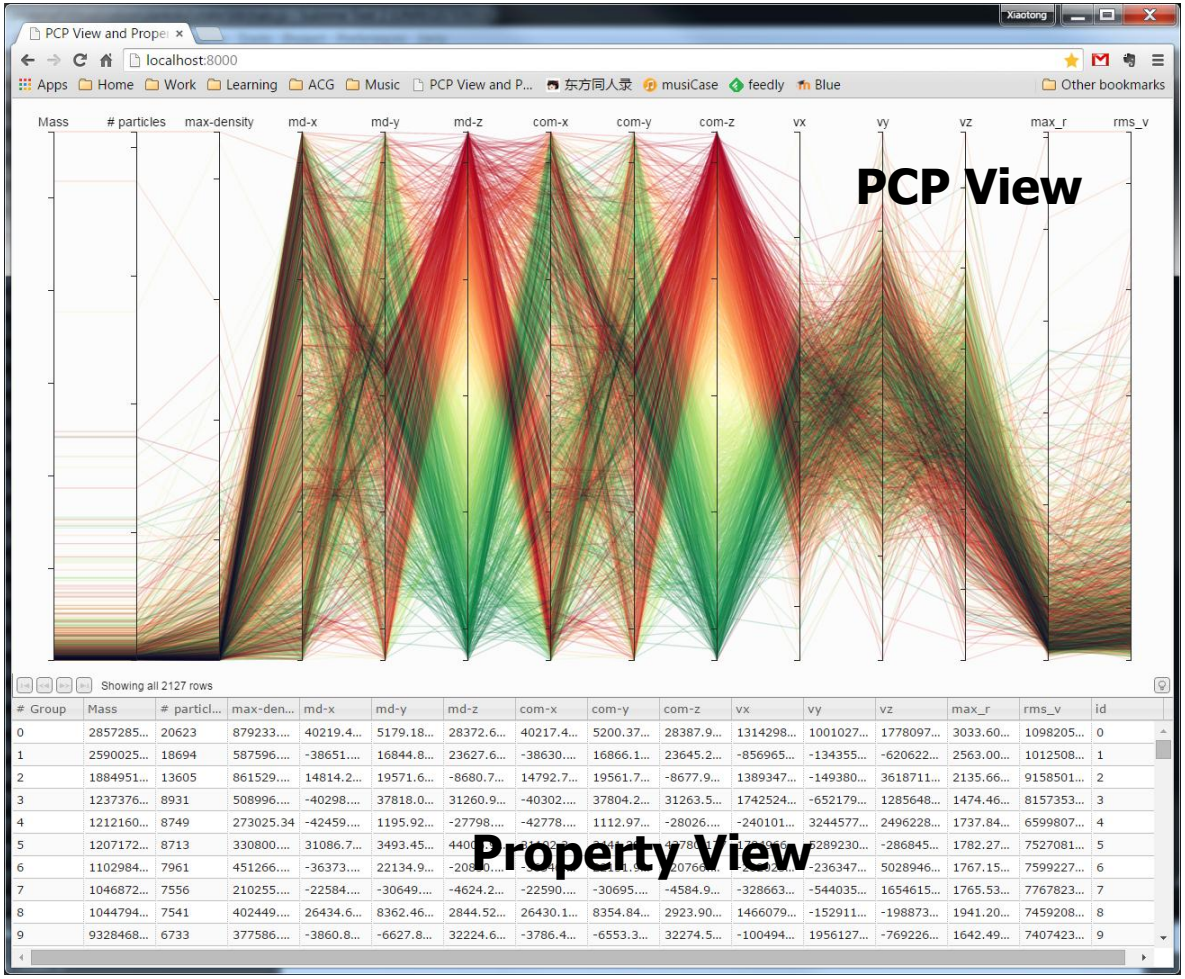
Property View

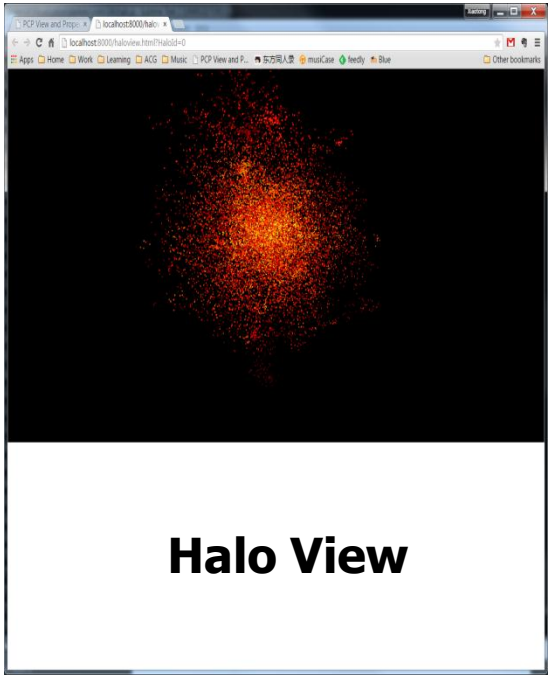
- Display specific values

Halo View

- Visualize particles of a halo

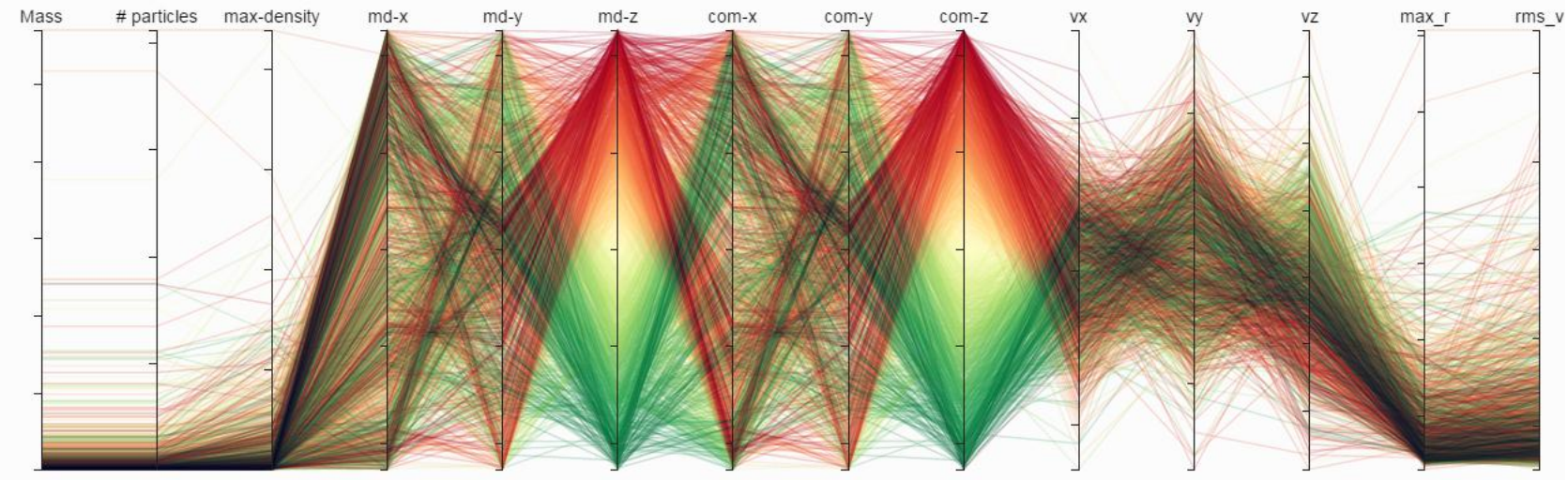
System Overview





PCP View

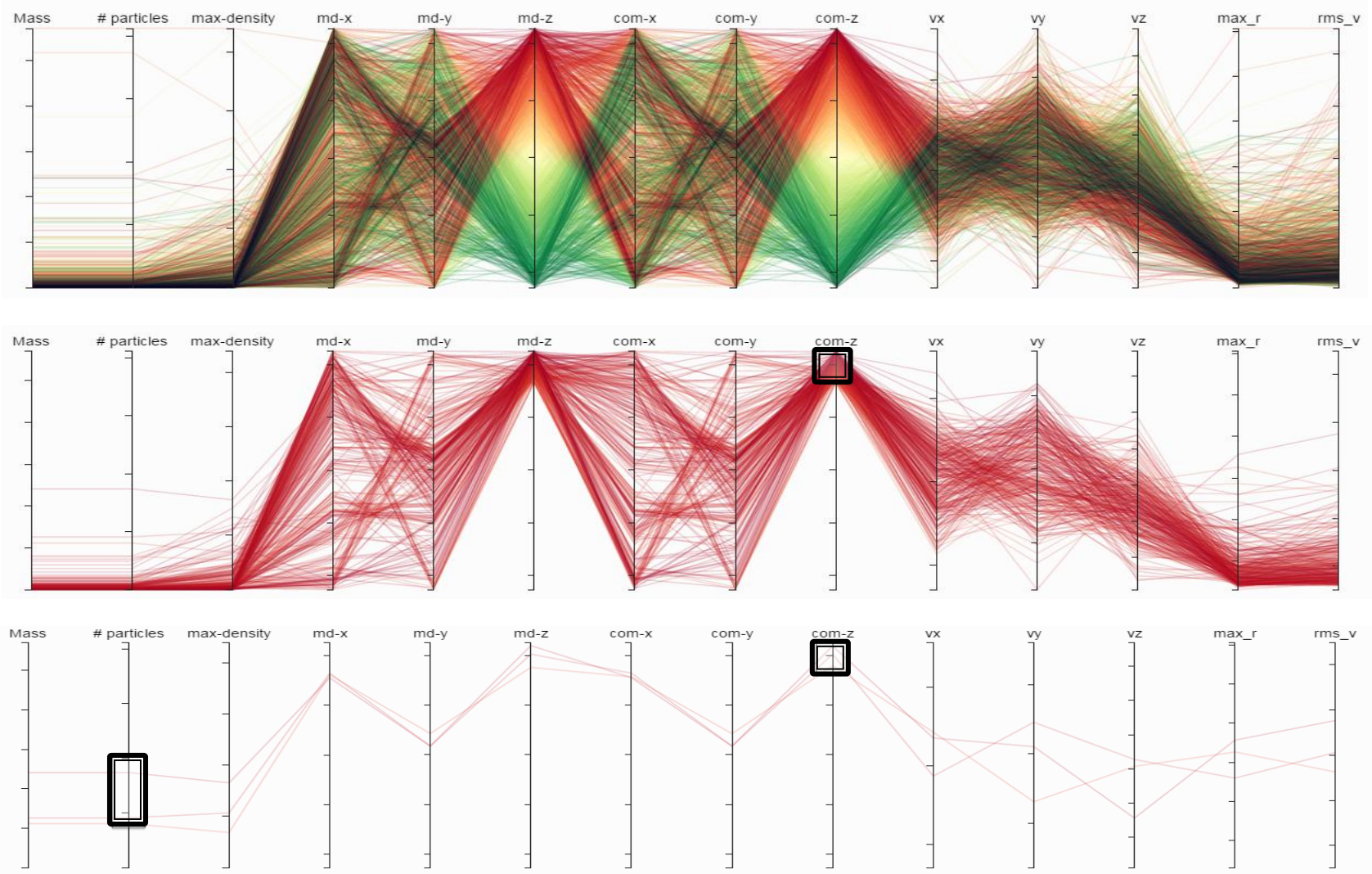
- Parallel Coordinates Plot
  - dimension axes: property facets
  - a halo in multiple-dimensional space as a polyline



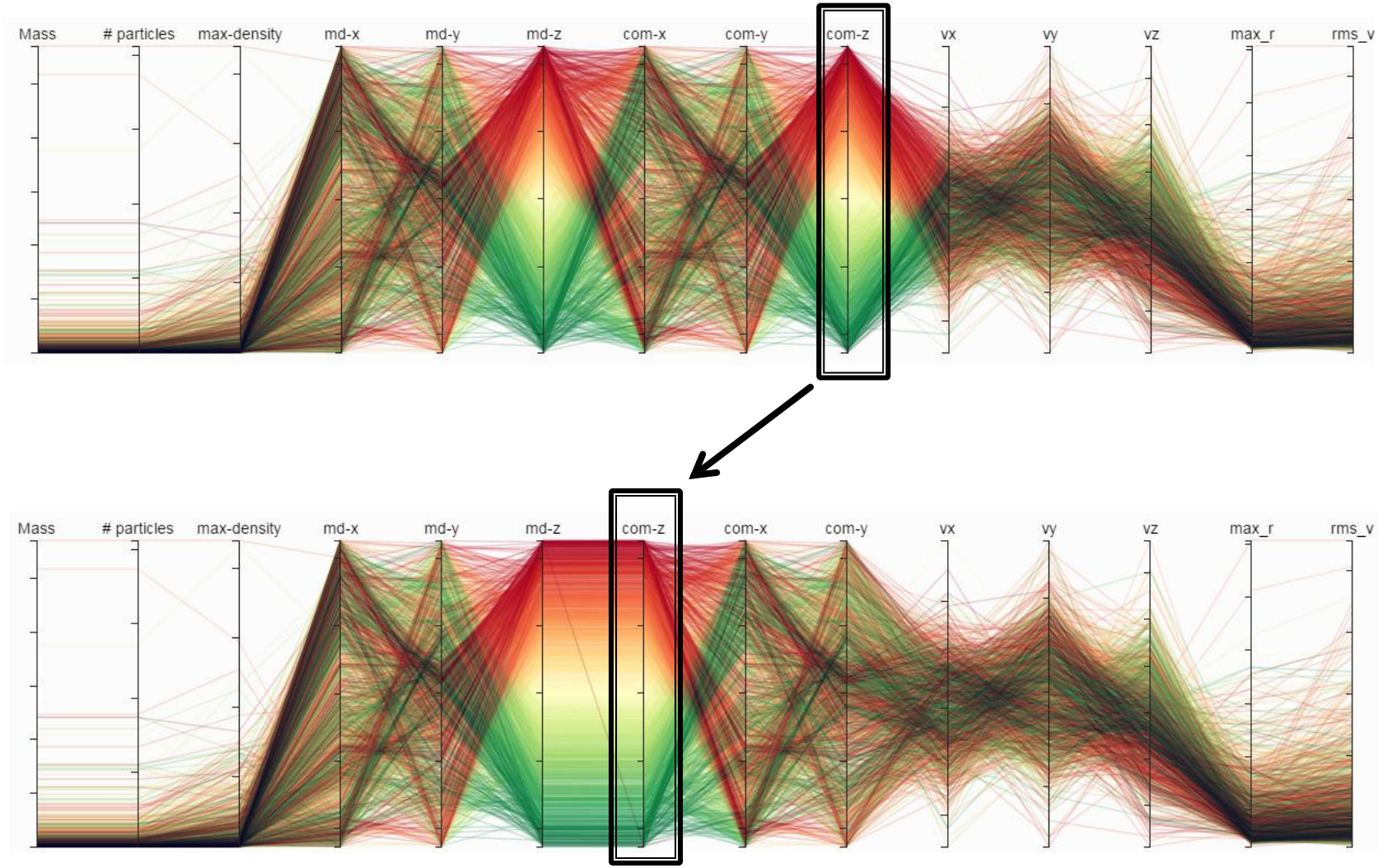
Interactions and Rendering

- Brushing and linking
- Axis reordering
- Progressive rendering

Brushing and Linking



Axis Reordering



Progressive Rendering

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- Put all the polylines in a queue
- Render a subset of polylines per frame
- Build up the final image progressively

Property View

- Dynamic table
  - showing specific property values of halos
  - columns: properties
  - rows: halos

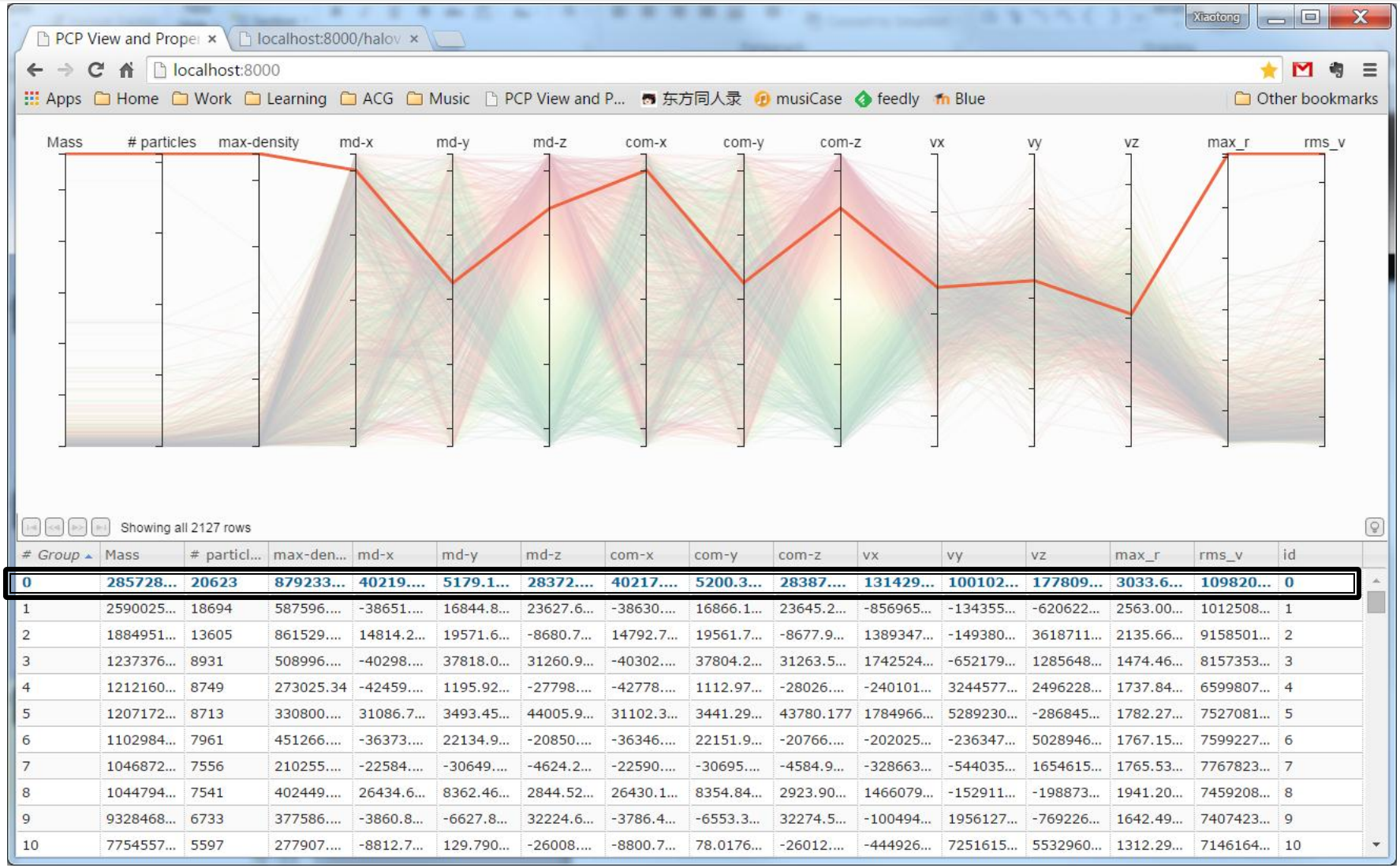
Showing all 2127 rows

# Group	Mass	# particl...	max-den...	md-x	md-y	md-z	com-x	com-y	com-z	vx	vy	vz	max_r	rms_v	id
0	2857285...	20623	879233....	40219.4...	5179.18...	28372.6...	40217.4...	5200.37...	28387.9...	1314298...	1001027...	1778097...	3033.60...	1098205...	0
1	2590025...	18694	587596....	-38651....	16844.8...	23627.6...	-38630....	16866.1...	23645.2...	-856965...	-134355...	-620622...	2563.00...	1012508...	1
2	1884951...	13605	861529....	14814.2...	19571.6...	-8680.7...	14792.7...	19561.7...	-8677.9...	1389347...	-149380...	3618711...	2135.66...	9158501...	2
3	1237376...	8931	508996....	-40298....	37818.0...	31260.9...	-40302....	37804.2...	31263.5...	1742524...	-652179...	1285648...	1474.46...	8157353...	3
4	1212160...	8749	273025.34	-42459....	1195.92...	-27798....	-42778....	1112.97...	-28026....	-240101...	3244577...	2496228...	1737.84...	6599807...	4
5	1207172...	8713	330800....	31086.7...	3493.45...	44005.9...	31102.3...	3441.29...	43780.177	1784966...	5289230...	-286845...	1782.27...	7527081...	5
6	1102984...	7961	451266....	-36373....	22134.9...	-20850....	-36346....	22151.9...	-20766....	-202025...	-236347...	5028946...	1767.15...	7599227...	6
7	1046872...	7556	210255....	-22584....	-30649....	-4624.2...	-22590....	-30695....	-4584.9...	-328663...	-544035...	1654615...	1765.53...	7767823...	7
8	1044794...	7541	402449....	26434.6...	8362.46...	2844.52...	26430.1...	8354.84...	2923.90...	1466079...	-152911...	-198873...	1941.20...	7459208...	8
9	9328468...	6733	377586....	-3860.8...	-6627.8...	32224.6...	-3786.4...	-6553.3...	32274.5...	-100494...	1956127...	-769226...	1642.49...	7407423...	9
10	7754557...	5597	277907....	-8812.7...	129.790...	-26008....	-8800.7...	78.0176...	-26012....	-444926...	7251615...	5532960...	1312.29...	7146164...	10

Dynamic Table

- Dimension-oriented sorting
- Linking with the PCP view
  - Highlight a specific halo in the PCP view
  - Zoom into a subset of halos for exploration
- Linking with the Halo view

Highlighting a Specific Halo



# Group	Mass	# particl...	max-den...	md-x	md-y	md-z	com-x	com-y	com-z	vx	vy	vz	max_r	rms_v	id
0	**285728...**	**20623**	**879233...**	**40219....**	**5179.1...**	**28372....**	**40217....**	**5200.3...**	**28387....**	**131429...**	**100102...**	**177809...**	**3033.6...**	**109820...**	**0**
1	2590025...	18694	587596....	-38651....	16844.8...	23627.6...	-38630....	16866.1...	23645.2...	-856965...	-134355...	-620622...	2563.00...	1012508...	1
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3	1237376...	8931	508996....	-40298....	37818.0...	31260.9...	-40302....	37804.2...	31263.5...	1742524...	-652179...	1285648...	1474.46...	8157353...	3
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7	1046872...	7556	210255....	-22584....	-30649....	-4624.2...	-22590....	-30695....	-4584.9...	-328663...	-544035...	1654615...	1765.53...	7767823...	7
8	1044794...	7541	402449....	26434.6...	8362.46...	2844.52...	26430.1...	8354.84...	2923.90...	1466079...	-152911...	-198873...	1941.20...	7459208...	8
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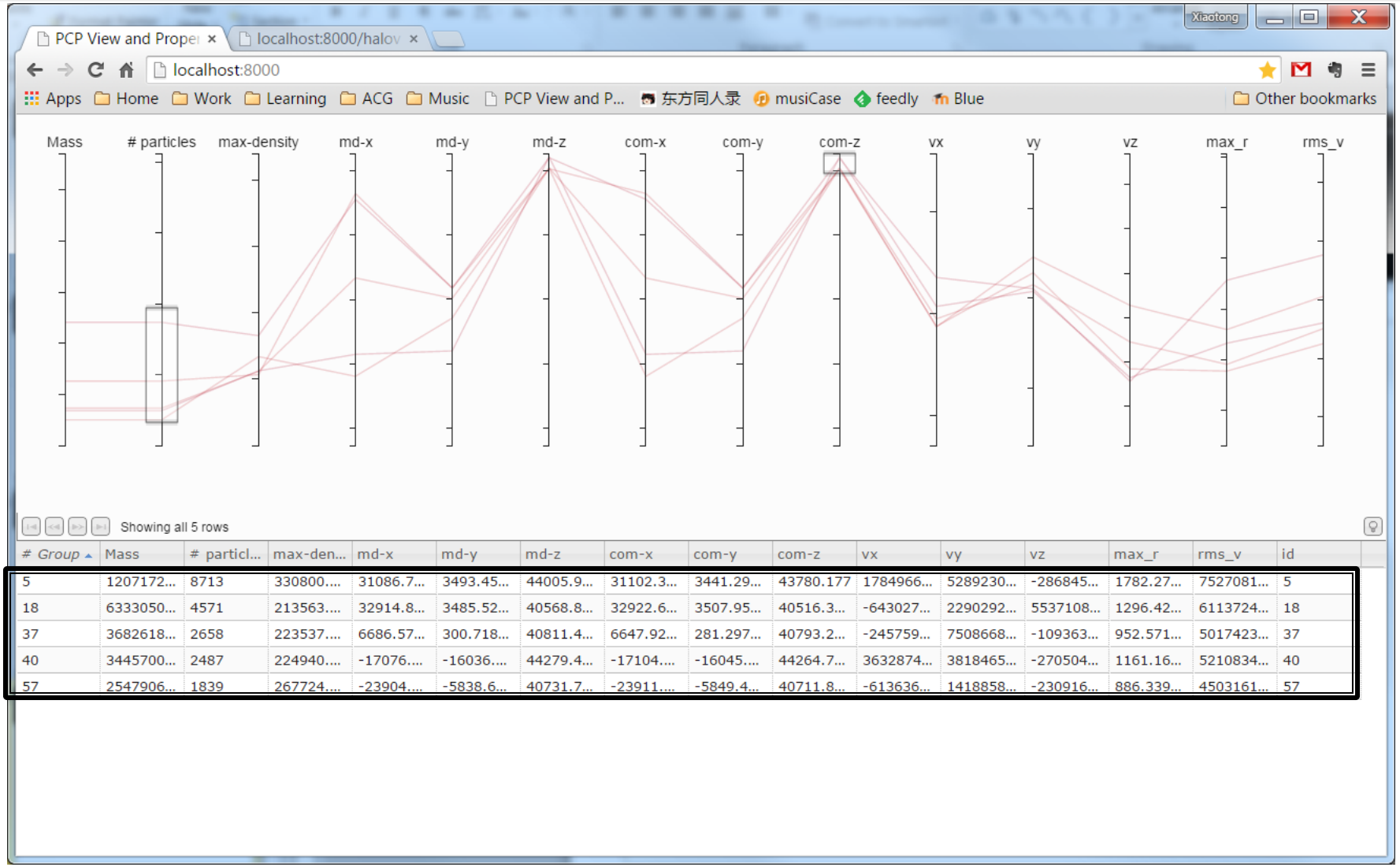
10	7754557...	5597	277907....	-8812.7...	129.790...	-26008....	-8800.7...	78.0176...	-26012....	-444926...	7251615...	5532960...	1312.29...	7146164...	10

Subset Exploration



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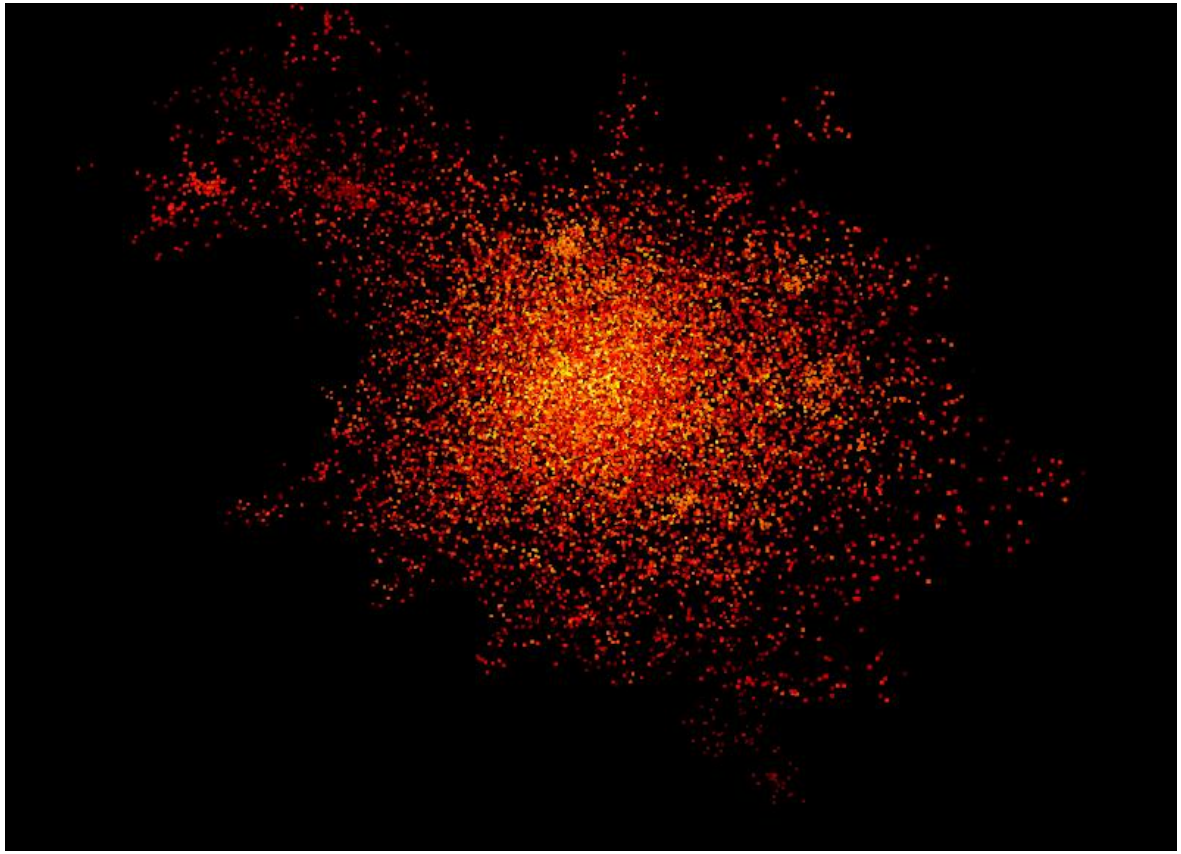
18	6333050...	4571	213563....	32914.8...	3485.52...	40568.8...	32922.6...	3507.95...	40516.3...	-643027...	2290292...	5537108...	1296.42...	6113724...	18
37	3682618...	2658	223537....	6686.57...	300.718...	40811.4...	6647.92...	281.297...	40793.2...	-245759...	7508668...	-109363...	952.571...	5017423...	37
40	3445700...	2487	224940....	-17076....	-16036....	44279.4...	-17104....	-16045....	44264.7...	3632874...	3818465...	-270504...	1161.16...	5210834...	40
57	2547906...	1839	267724....	-23904....	-5838.6...	40731.7...	-23911....	-5849.4...	40711.8...	-613636...	1418858...	-230916...	886.339...	4503161...	57

Halo View

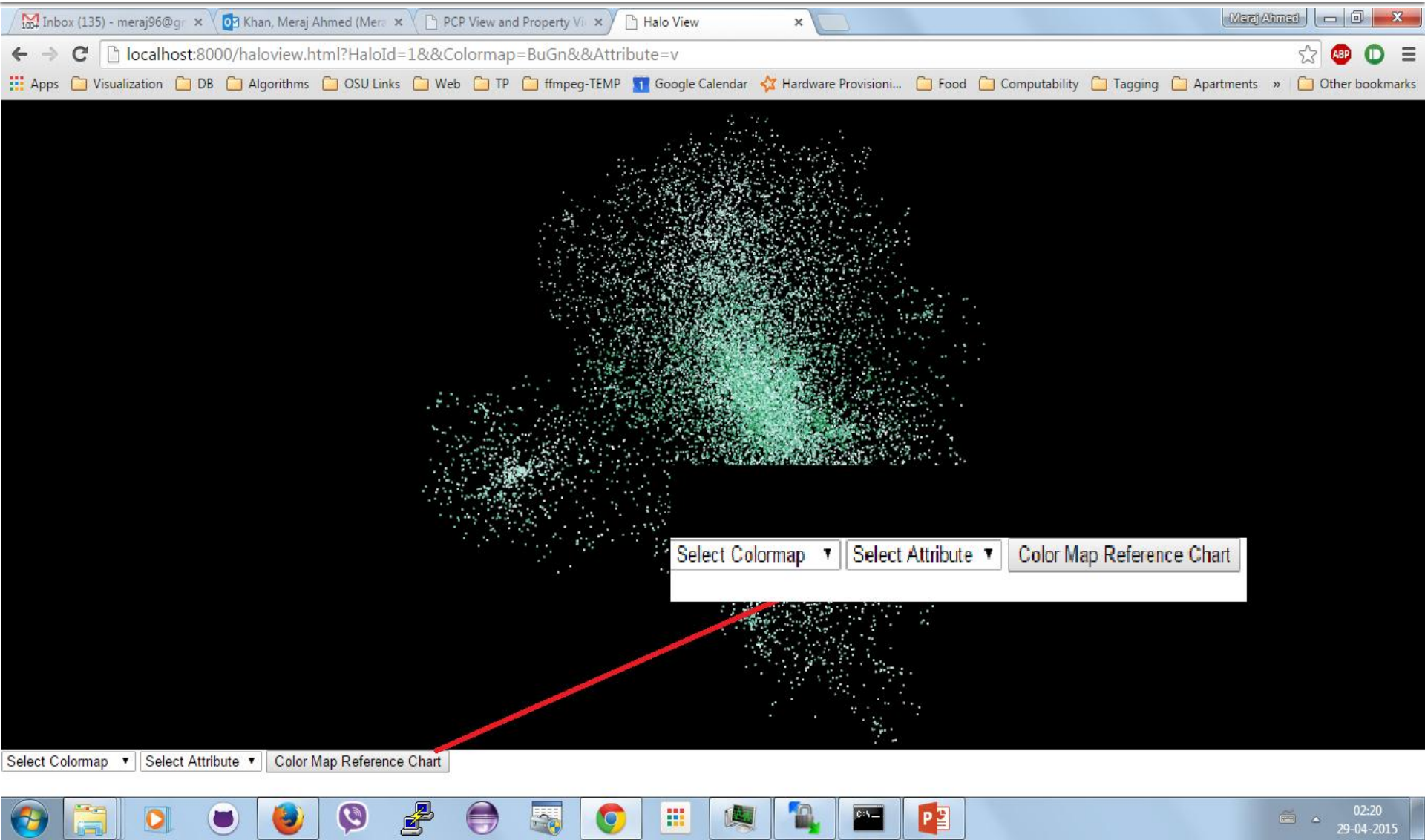
- Particle rendering of the selected halo



Supported Interactions

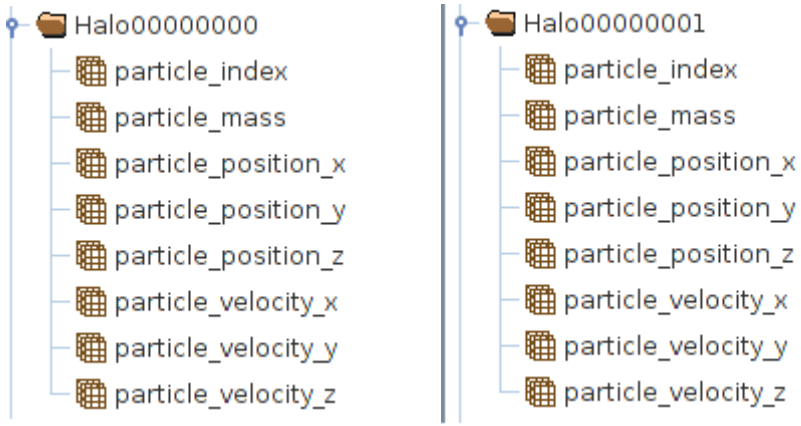
- Choose coloring attribute
- Choose colormap
- Rotate to examine the Halo Structure from different angles
- Move camera away or towards the viewing plane to get a better understanding of the Halo outline

Supported Interactions



Halo Particles

- Particle information for all the halos dumped in an hdf5 file.
- Hdf5 file structure for particle information.



Particle Coloring

- Particles can be colored based on one of the following attribute choices.
  - Velocity
  - Density of Particles
- A set of matplotlib provided sequential colormaps to choose from.

Particle Velocity

- Calculated as magnitude of particle velocity.

$$v = \sqrt{(v_x^2 + v_y^2 + v_z^2)}$$

- Value is a specific property of each particle fetched from the hdf5 file.

Density of Particles

- Gaussian Kernel Density Estimation

- Value is dependent on density of particles in the region and not a property of the particle

Discussion

- Most halos have relatively few particles
- The mass of a halo is positively correlated to the number of particles
- The maximum density particle more or less represents the center of mass for the halo

Implementation

- **Yt.py** is used to read and process the raw particle data in SDF format
- **h5py** is used for analyzing halo particle dump.
- **D3.js** is used to create the interactive PCP view and the Property view
- **WebGL** is used to render the particles in the halo view

Future Work

- Dynamically changing point cloud with resampling to support zooming in and out for Halo View.
- Explore Halo Substructures.
- Explore Halo evolution over time.
- To combine with other groups for VIS'15 contest submission

Question?

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