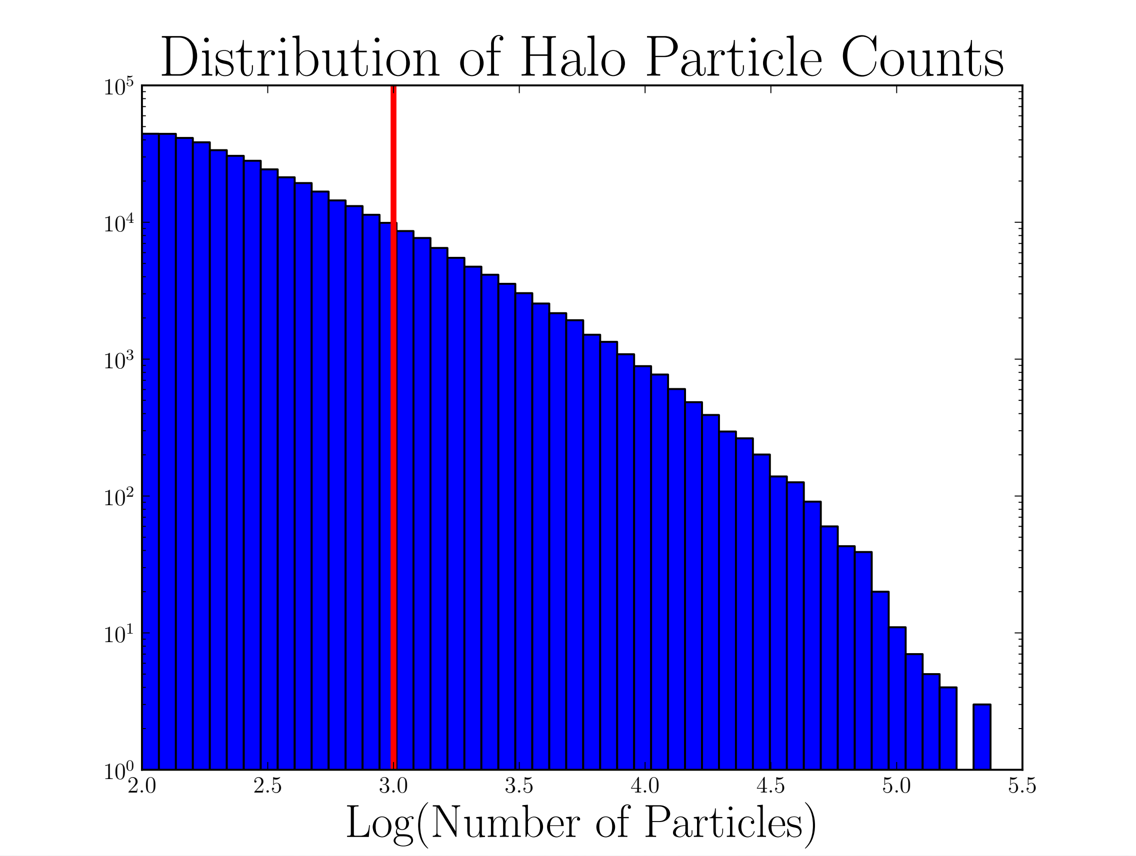
RESEARCH UPDATE II

10-620 | Independent Study: Research | Andrea Klein

THE DATA

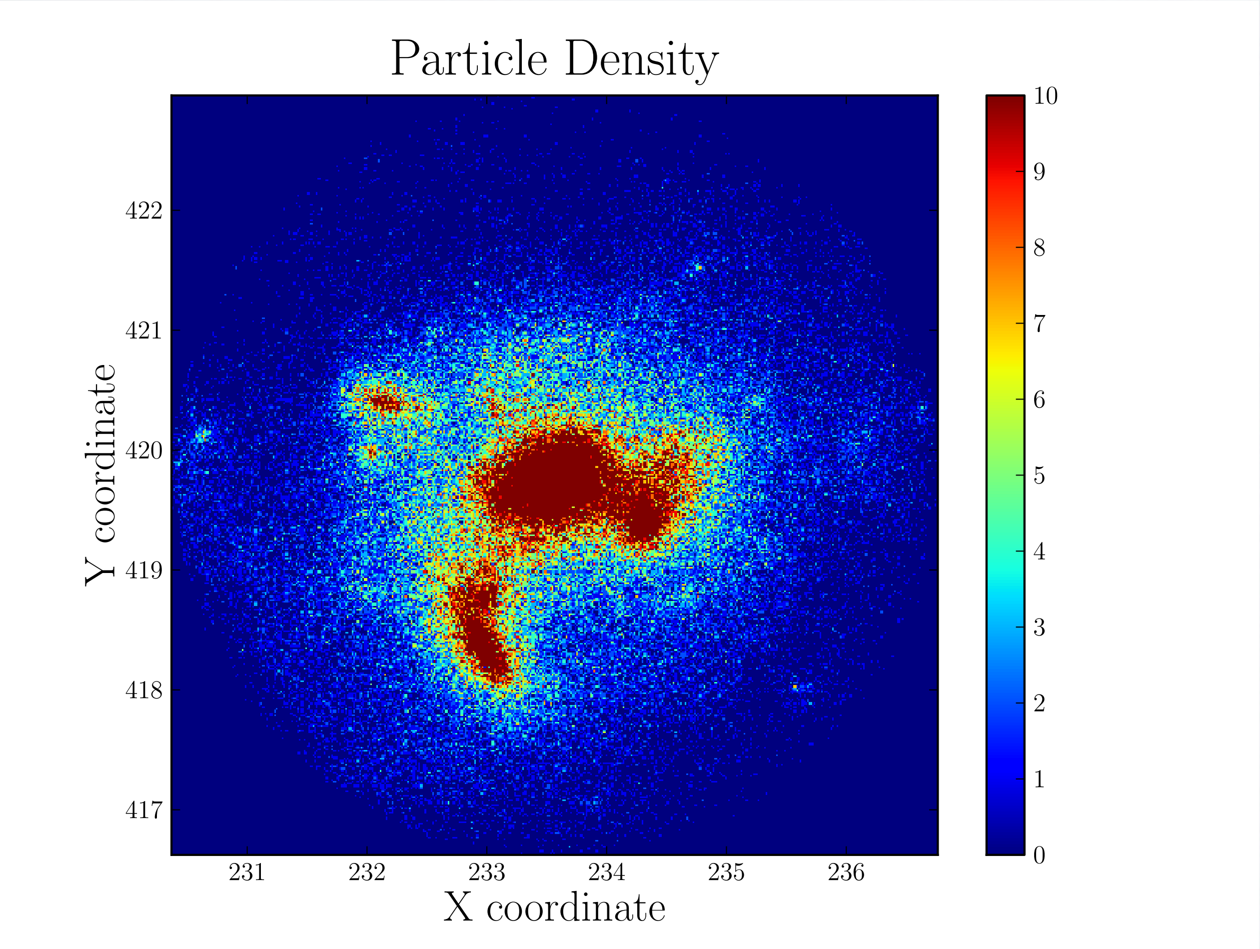
- I now have (fully parsed) particle and halo data from Hy. Each particle is labeled with its corresponding halo ID. In total, there are 449,969 halos and 333,796,680 particles.

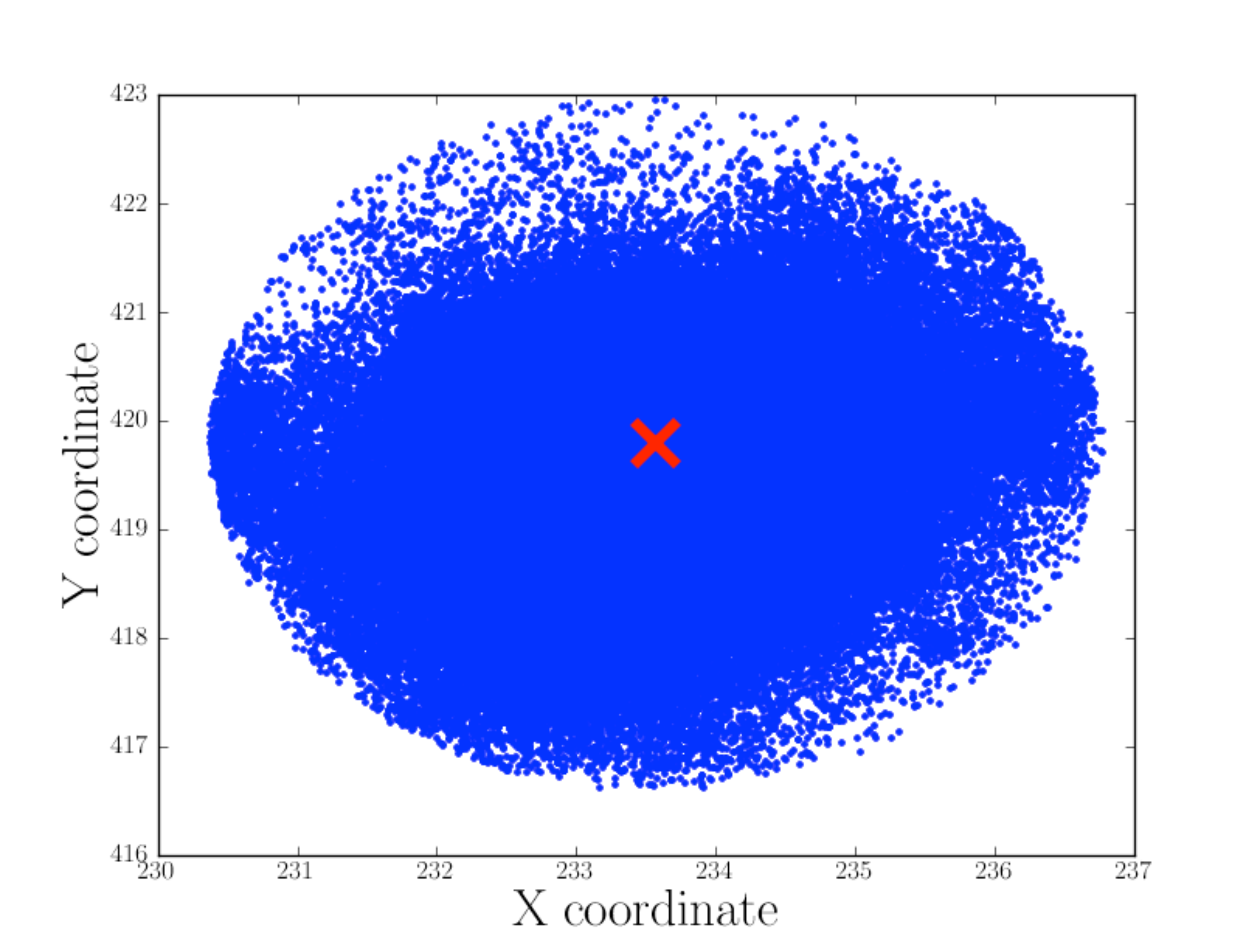
- I don't expect the internal velocity distributions to be well-resolved in halos with fewer than ~1,000 particles. Applying this cut leaves me with 60,351 halos - with particle-summed masses from 10^12.7 to 10^15.0 Msun - and 225,069,021 particles. As you can see in the histogram below, I exclude a lot of particles (all those to the left of the red line at 10^3), but the resulting dataset is still huge.



HALO 1: A CLOSER LOOK

Pictured are two views of the most massive halo in the X-Y plane: a density plot (left), and a scatter plot with the halo center indicated with a red **X** (right):





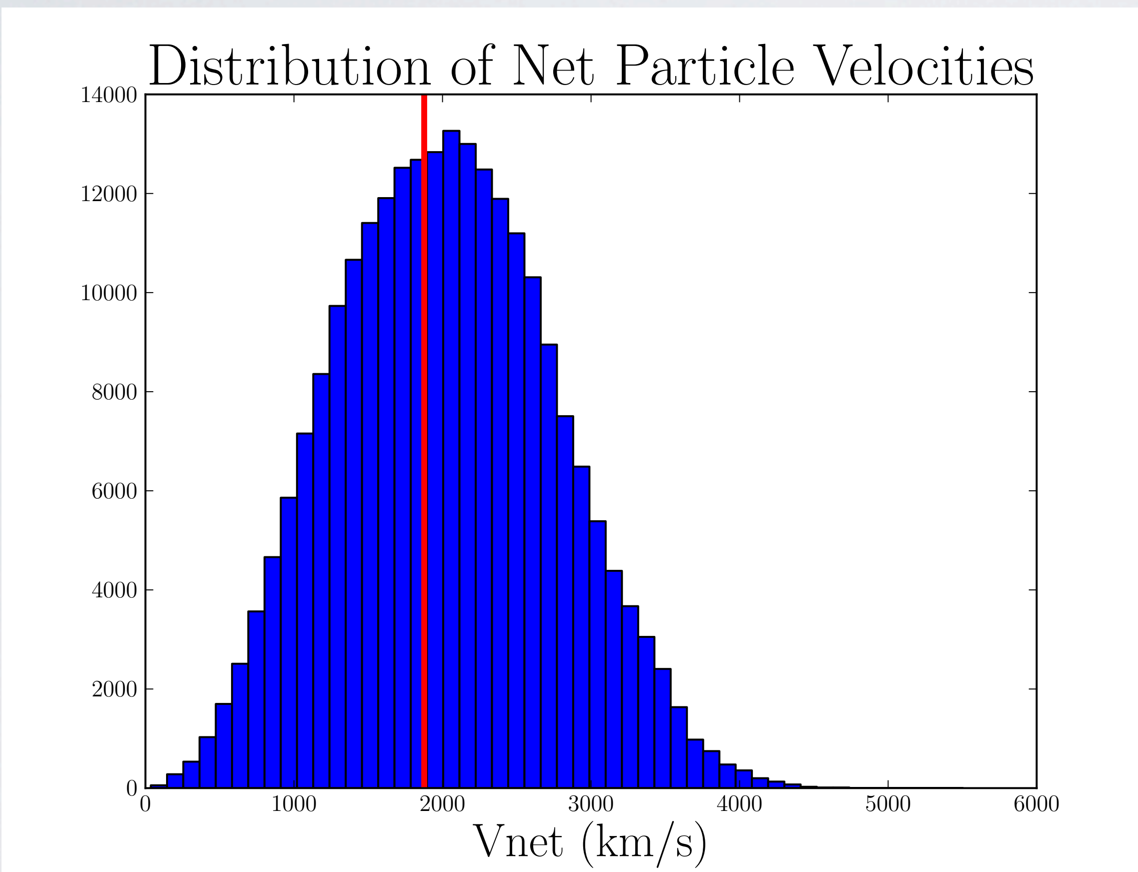
Note that halo 1 appears to be undergoing a merger, which may contribute to some unexpected features in the velocity distribution (see next few slides).

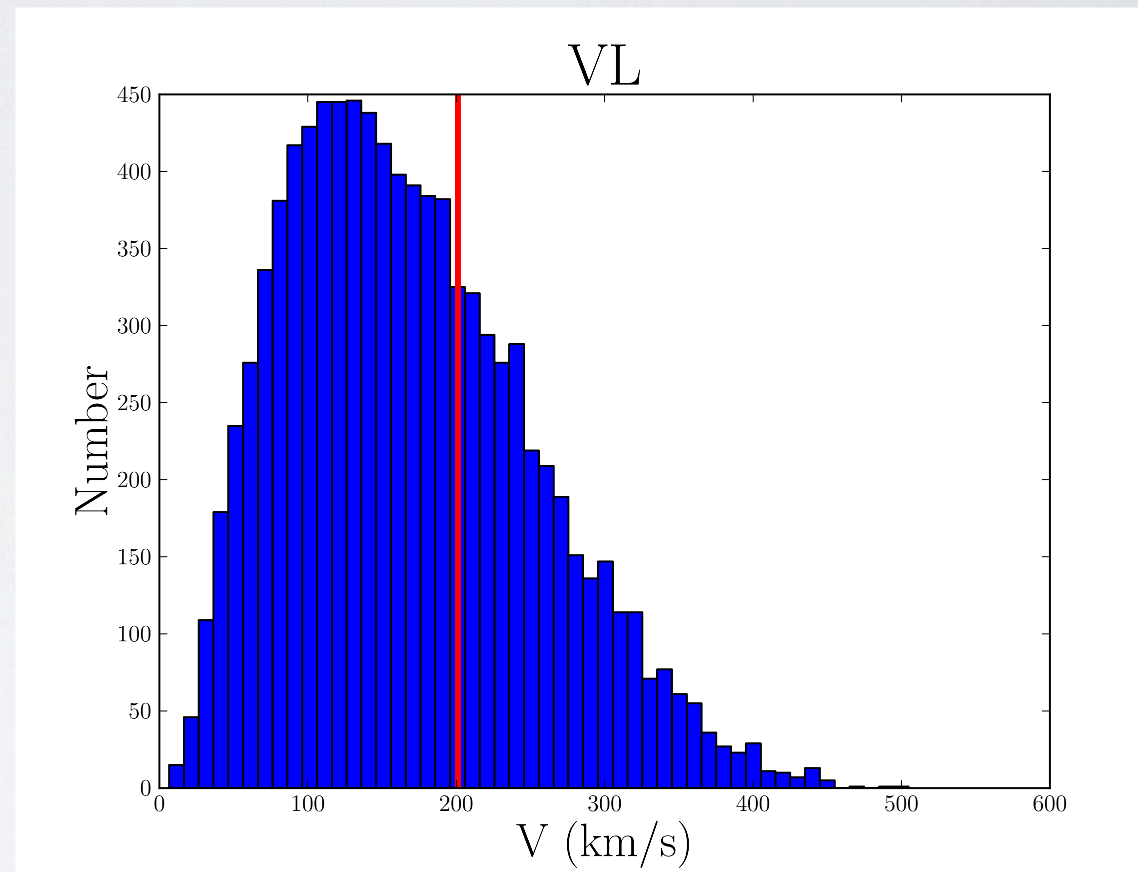
HALO 1: A CLOSER LOOK

- This halo contains **236,103 particles** (number of particles with halo label = halo's N200a)
- Sum of particle masses: **1.062 e 15 Msun** (a Milky Way-size simulation, such as Via Lactea II, has a mass of about 10^12 Msun)
- Several other ways to measure halo mass are included in the halo data. For comparison, the listed masses are:
  - M200a = 2.06 e 15 Msun
  - M500a = 1.79 e 15 Msun
  - M200c = 1.52 e 15 Msun
  - M500c = 8.01 e 14 Msun

HALO 1: A CLOSER LOOK

Selected particle velocity plots (with Via Lactea II subhalos at right for comparison):



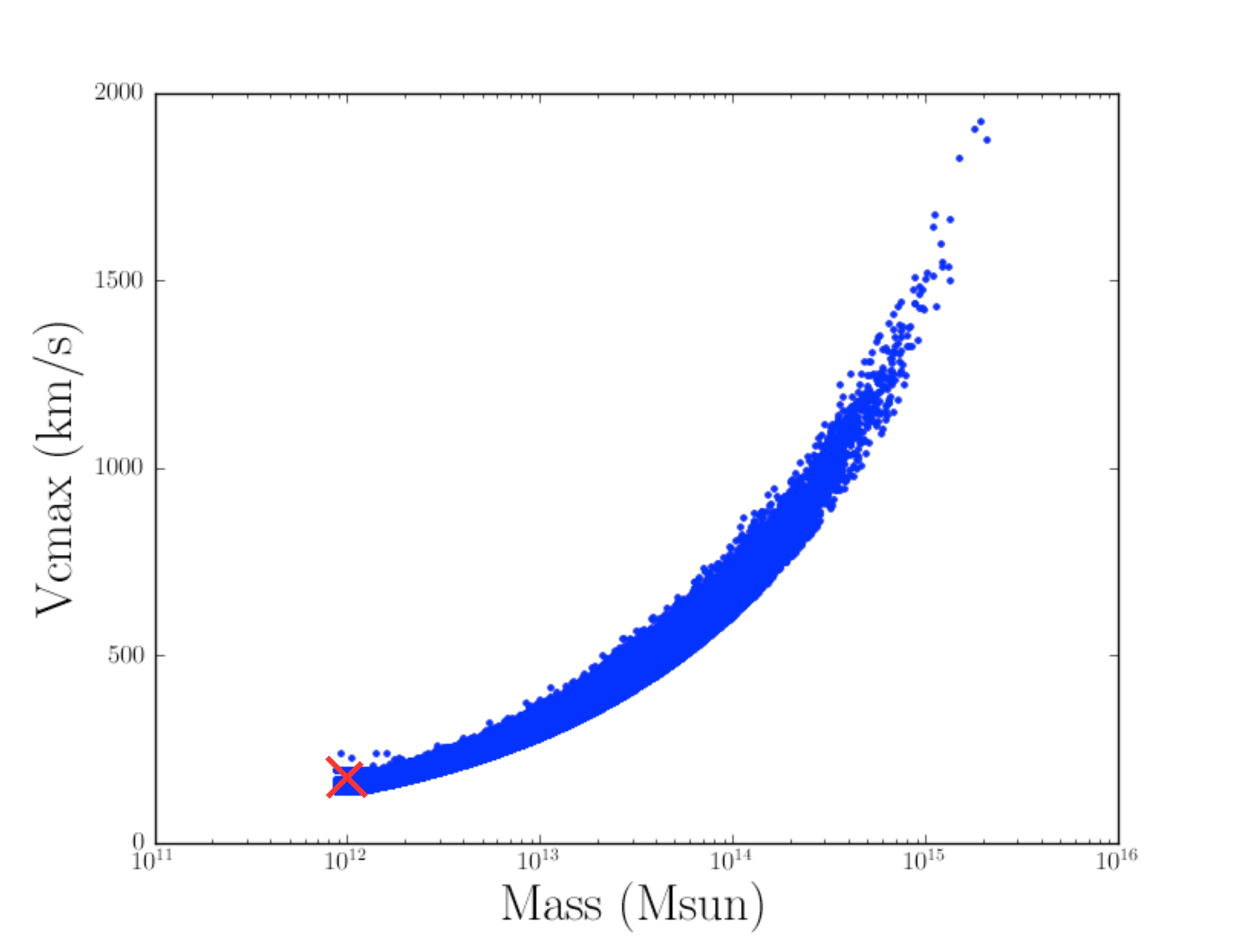


Vmax (vcmax) indicated with red line.

Note that the particle velocities in Halo 1 are ~10X greater than the subhalo velocities in VLII (see next slide). Vcmax is unexpectedly low relative to the mean particle velocity in Hy's halo.

HALO 1: A CLOSER LOOK

Selected particle velocity plots (with Via Lactea II subhalos at right for comparison):

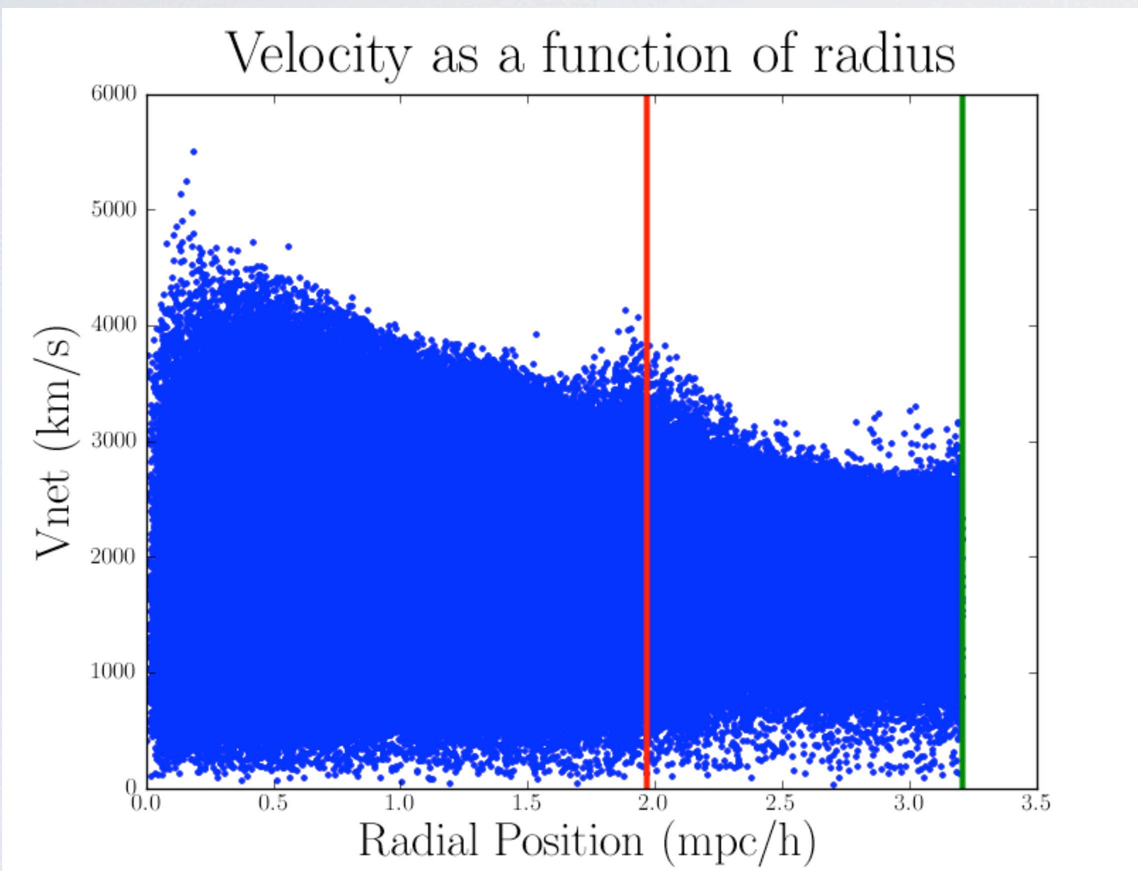


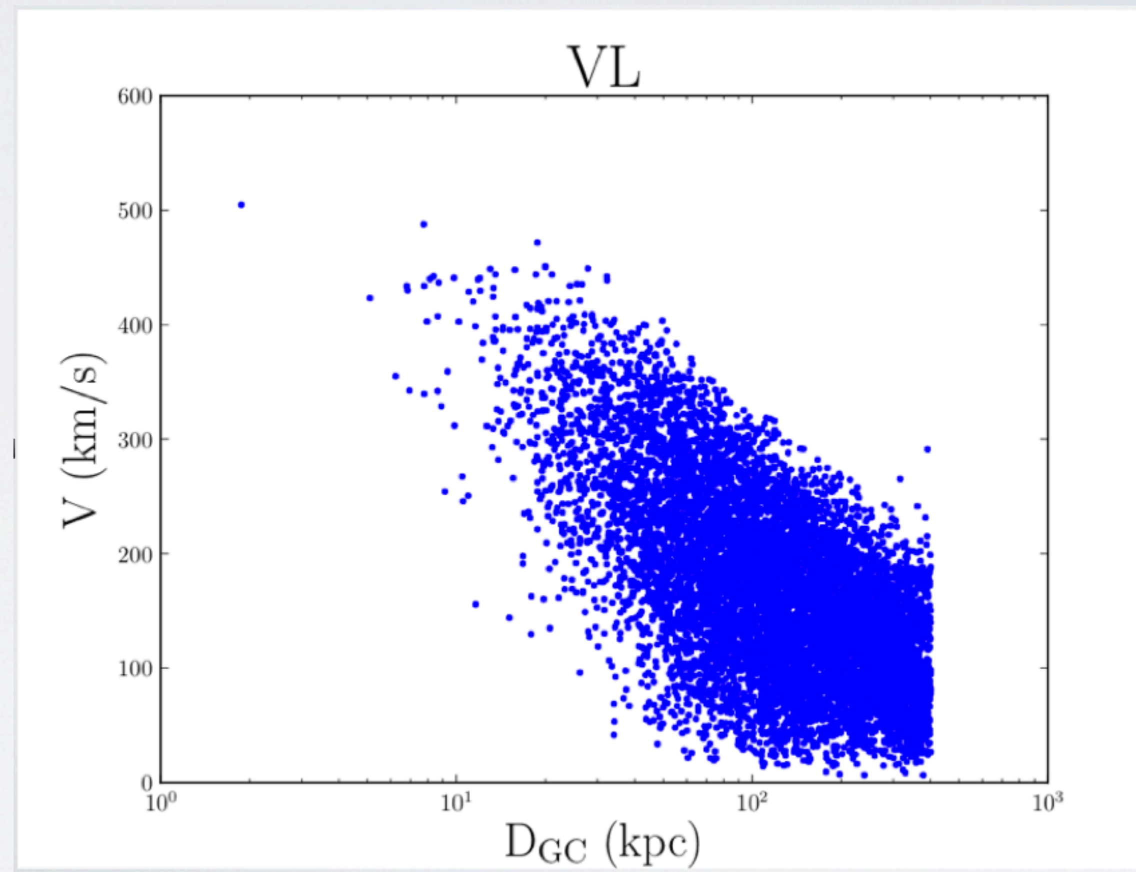
Via Lactea II indicated with red **X** (mass ~ 10^12; vmax ~ 200).

Vcmax is a decent order of magnitude characterization of the average velocity within each halo. Note that Hy's vcmax vs. mass relation is consistent with VL-II.

HALO 1: A CLOSER LOOK

Selected particle velocity plots (with Via Lactea II subhalos at right for comparison):



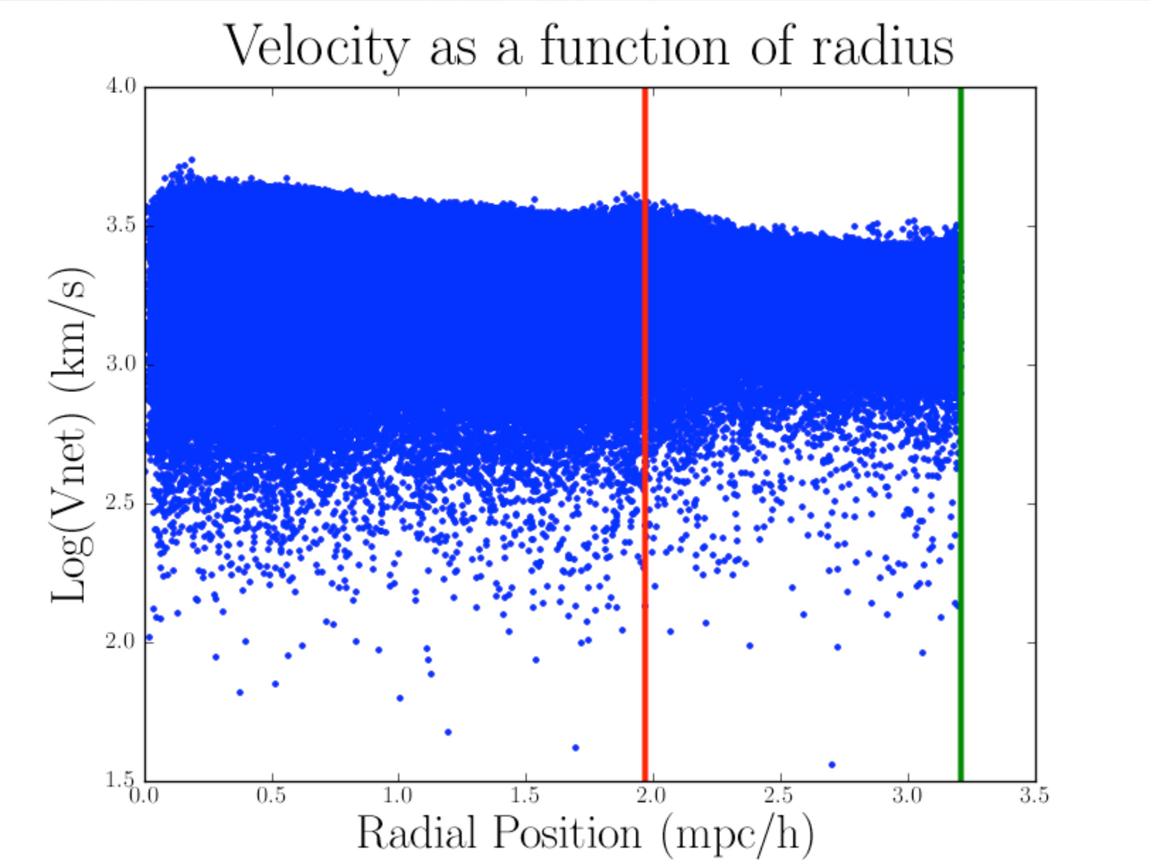


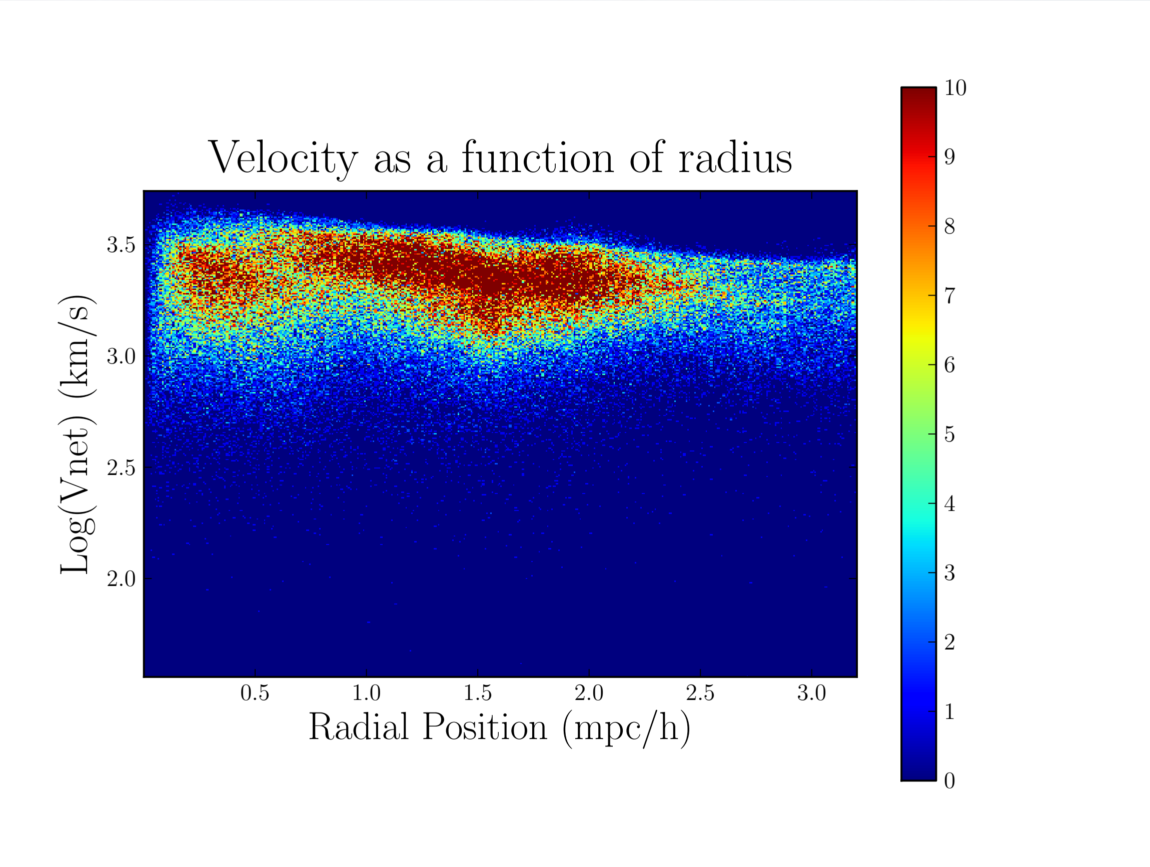
In left plot, rcmax is indicated in red, and R200a is indicated in green.
For VLII, Rmax ~ 57 kpc and Rvir ~ 402 kpc.
Apologies for different x-axes.

Note that the distribution in Halo 1 is much less strongly correlated with radius. The scatter is quite large, due partly to saturation (see density plot on next slide) and possibly exacerbated by two-body relaxation (Hy is concerned he may have set the gravitational softening to be too low) and/or the merger.

HALO 1: A CLOSER LOOK

Selected particle velocity plots (with Via Lactea II subhalos at right for comparison):



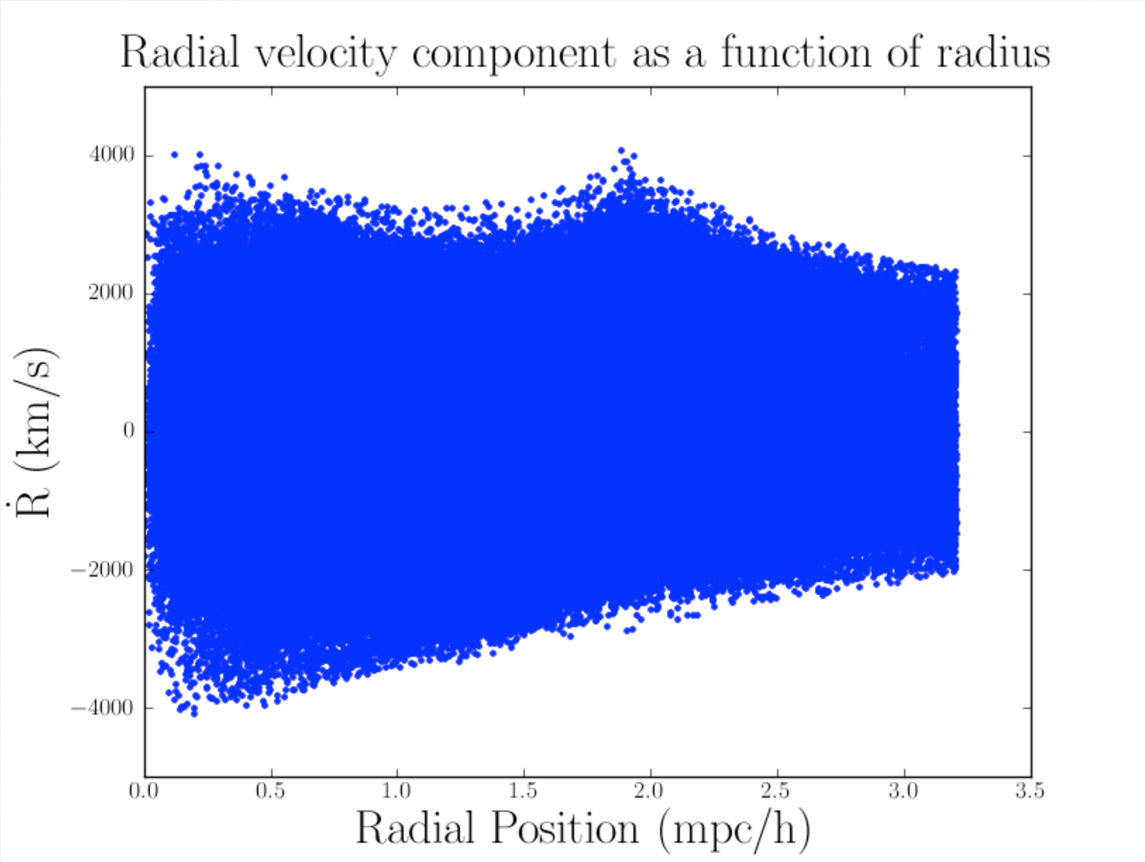


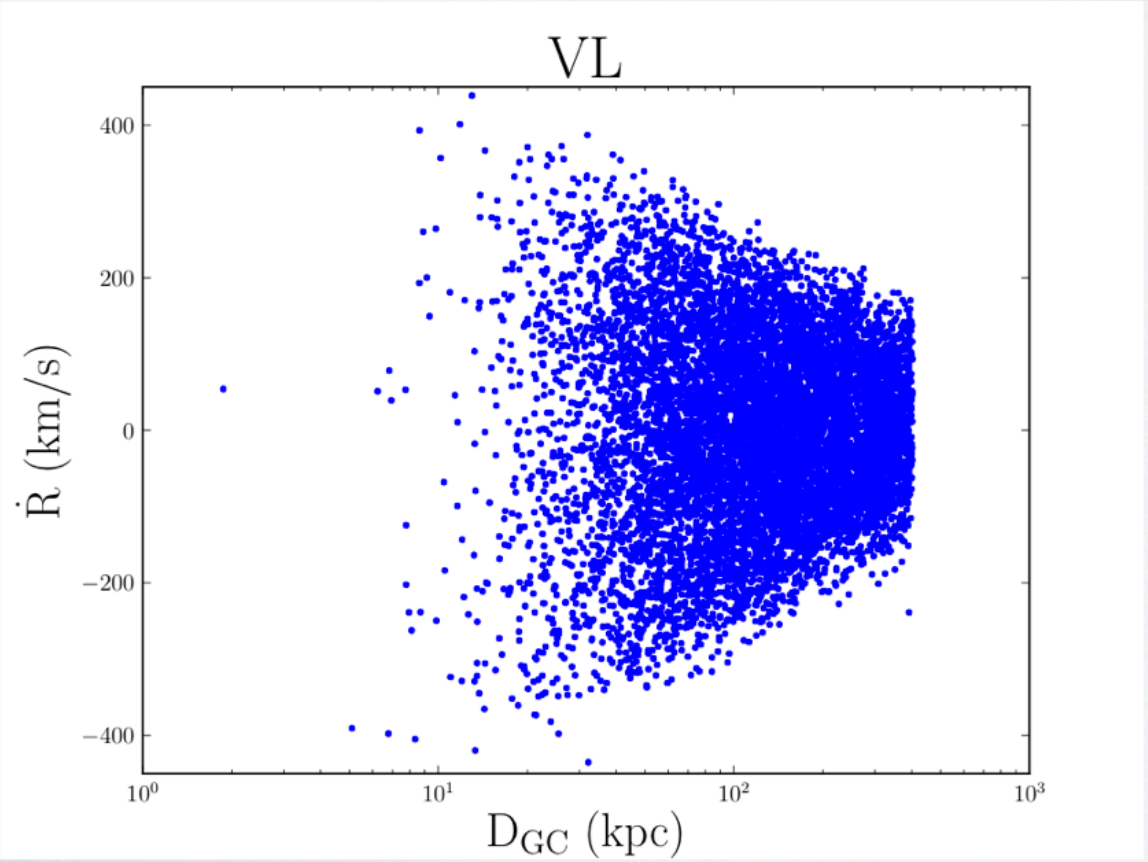
In left plot, rcmax is indicated in red, and R200a is indicated in green.
For VLII, Rmax ~ 57 kpc and Rvir ~ 402 kpc.
Apologies for different x-axes.

Density vs. scatter plots of Halo 1's particle velocity distribution (now in semilogy)

HALO 1: A CLOSER LOOK

Selected particle velocity plots (with Via Lactea II subhalos at right for comparison):





Apologies for different x-axes.

A different view: just the radial velocity component.

NOW FOR SOME SVR

- The basic idea of the project is to try to learn a function of the following form using Support Vector Regression (SVR):
  - [<parent halo parameters>, position] -> velocity
- This can be done separately for each velocity component, with some tweaking to the input parameters. To start with, I'll be using the following information:
  - [<Mass, vcmax, Mcmax, Rcmax>, (radial position)/Rvir] -> |V_R| (norm of radial velocity)
- Note that I've chosen to "normalize" the radial location of each particle relative to the virial radius. (Indeed, ultimately, all the values should be mapped to ranges from 0-1.) The input is meant to characterize the shape/scale of the parent halo, as well as the particle's "role" within it.
- Note also that all particle velocities are being considered relative to the halo center.

NOW FOR SOME SVR

- Data selection:
  - Each particle constitutes a training vector. Recall that ~200 million particles pass my initial cuts, which is too many to simply pass to an SVR classifier.
  - Consequently, I propose to train on a reasonably-sized subset of the particle catalog.
  - If I select particles uniformly at random from the catalog, I will select more from the heavier halos, which may bias the results in some way. (Subsequent discussion with the group suggests this may not be a strong effect.)
  - Consequently, I propose to **fix the number of particles I consider from each halo**. The particles will be selected uniformly at random within the corresponding halo. (Possible follow-up: select them uniformly in log-space by radius.) I'll probably start with 1 or 10 particles per halo, then scale up as far as I can.

PRELIMINARY RESULTS

- In progress... check back soon!