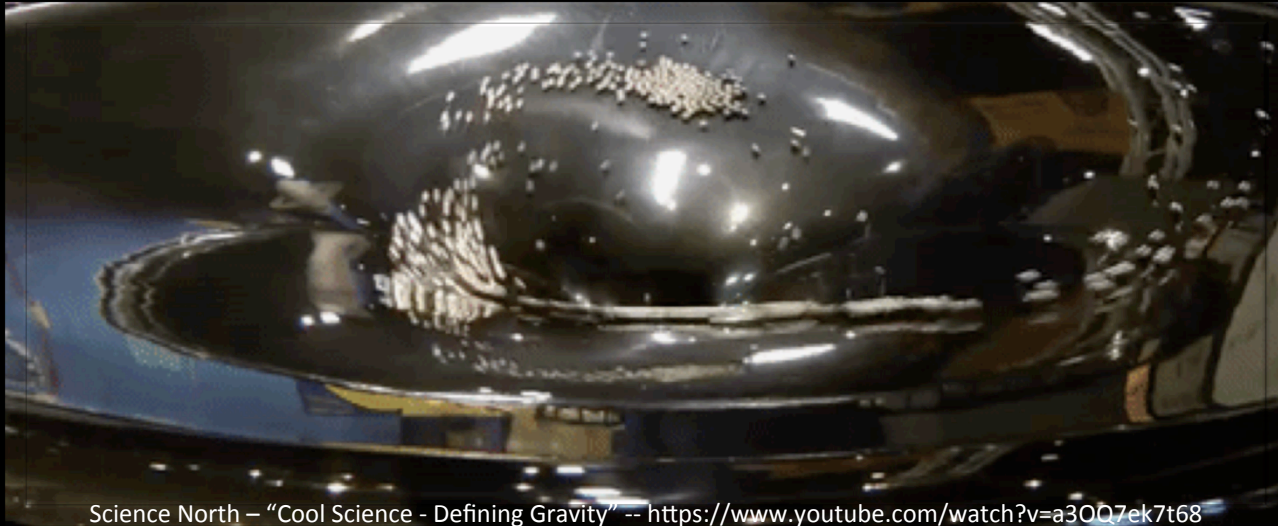


Cosmology with Velocity Dispersions



Caroline Caldwell

Ian McCarthy, Ivan Baldry, Joop Schaye, Simeon Bird, Chris Collins

L03

Lambda CDM

Velocity Dispersions are directly measured and avoid mass biases. Good independent test of results!

New simulations with neutrinos + velocity dispersion based $n(z)$ can distinguish effects of neutrinos!

Abundance of clusters, $n(z)$, is a good probe of underlying cosmology.

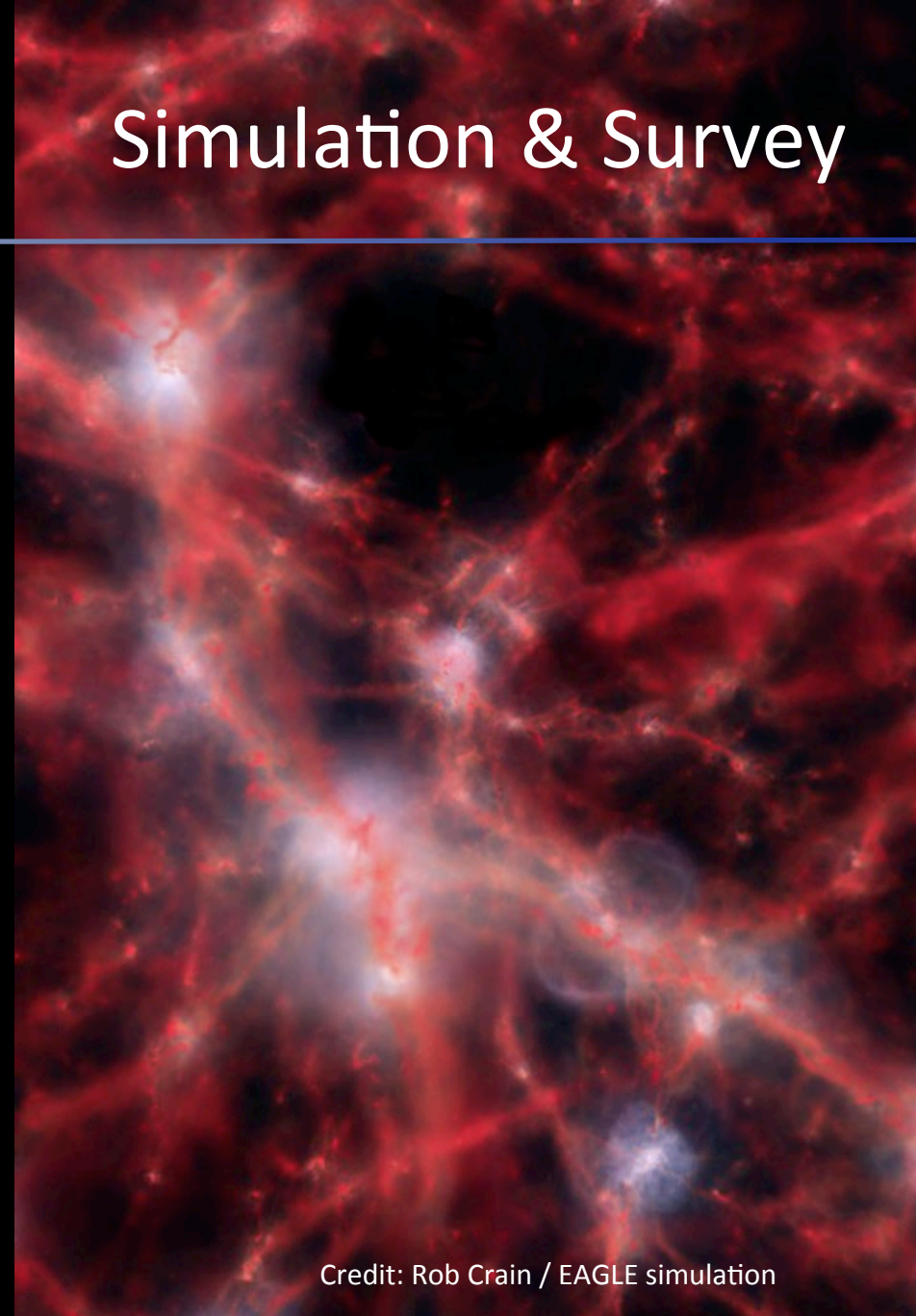
*However, there is **tension** between abundances from **models** based on CMB measurements and **observations** of cluster abundances (number counts). e.g. Planck paper 20, (2013)*

Potential causes of discrepancy:

- Systematic mass biases
- Something is wrong with the standard model (neutrinos?)

BAHAMAS: BAryons and HAloes of MAssive Systems

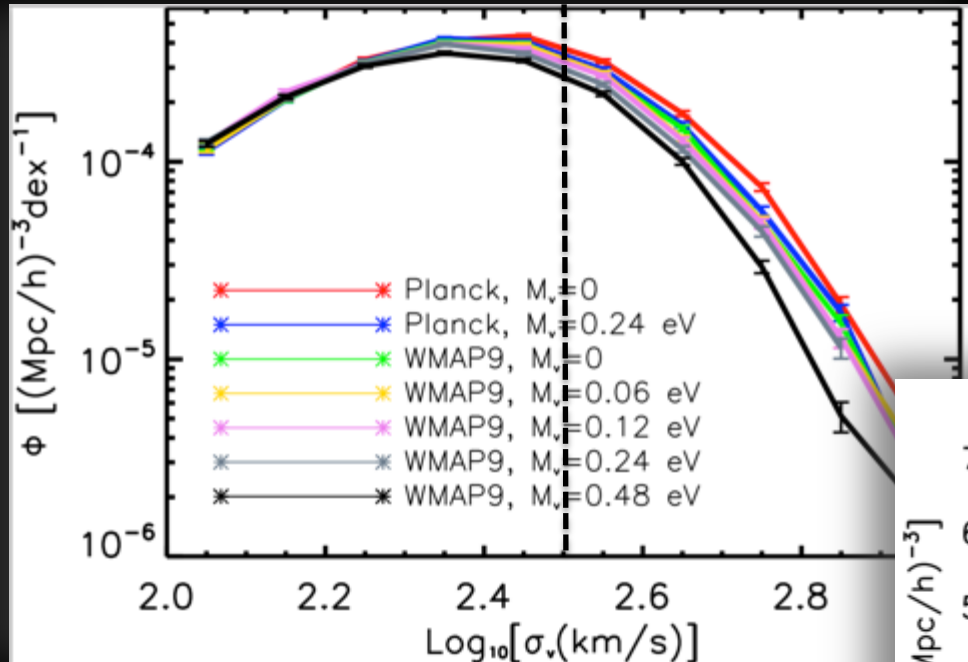
- Large box (400 Mpc/h, 1024^3 particles)
- Planck, WMAP9, and cosmologies +neutrinos
- Calibrated to match $f_{\text{gas}}\text{-}M$ properties and galaxy stellar mass function
- Matches X-ray and SZ scaling relations and others.
- Details: McCarthy et al, 2016



Credit: Rob Crain / EAGLE simulation

BAHAMAS results

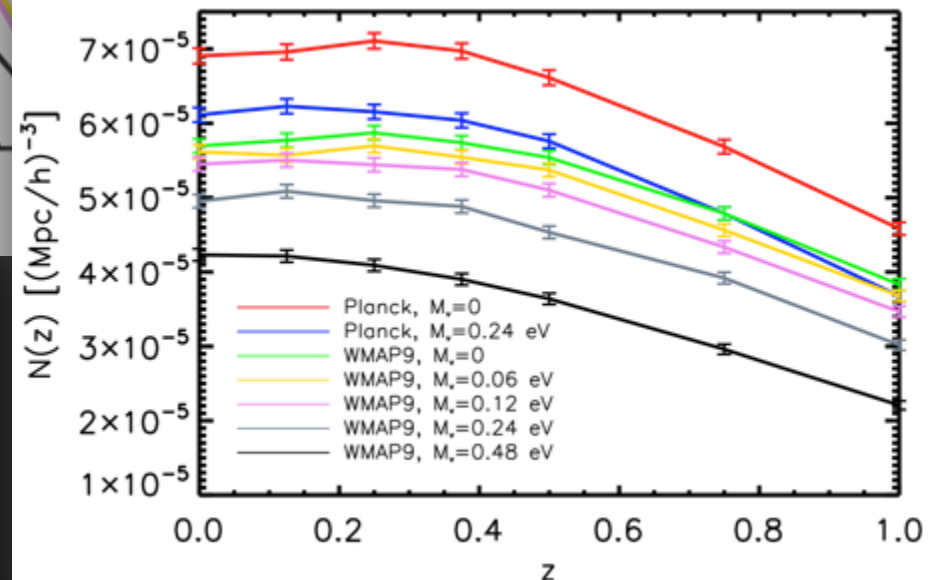
The Velocity Dispersion function



Galaxy groups:

- At least 4 members
- $M_{200m} > 10^{10} M_{\text{sun}}$

Number of Groups $> 300 \text{ km/s}$

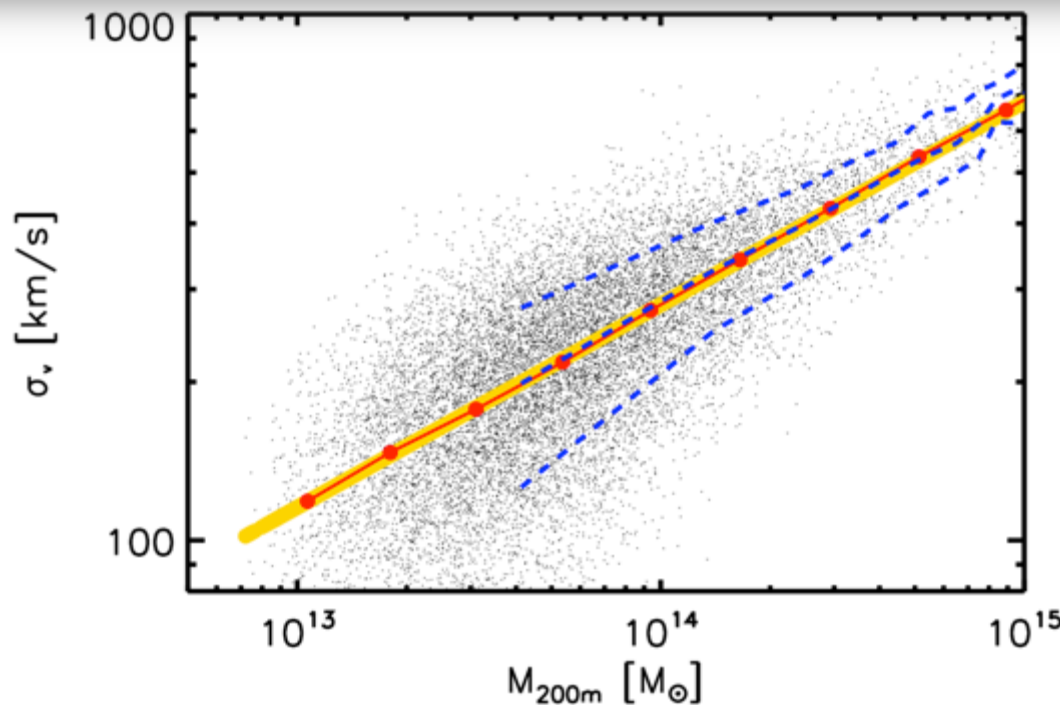


Model the VDF

Mass Function \rightarrow Mean sigma-M powerlaw \rightarrow scatter = “Model” velocity dispersions

1. Mean Mass – velocity dispersion power law.

$$\langle \sigma_v \rangle (z=0) = 280.5 \pm 1.0 \text{ km/s} \left(\frac{M_{200m}}{10^{14} M_\odot} \right)^{0.385 \pm 0.003}$$



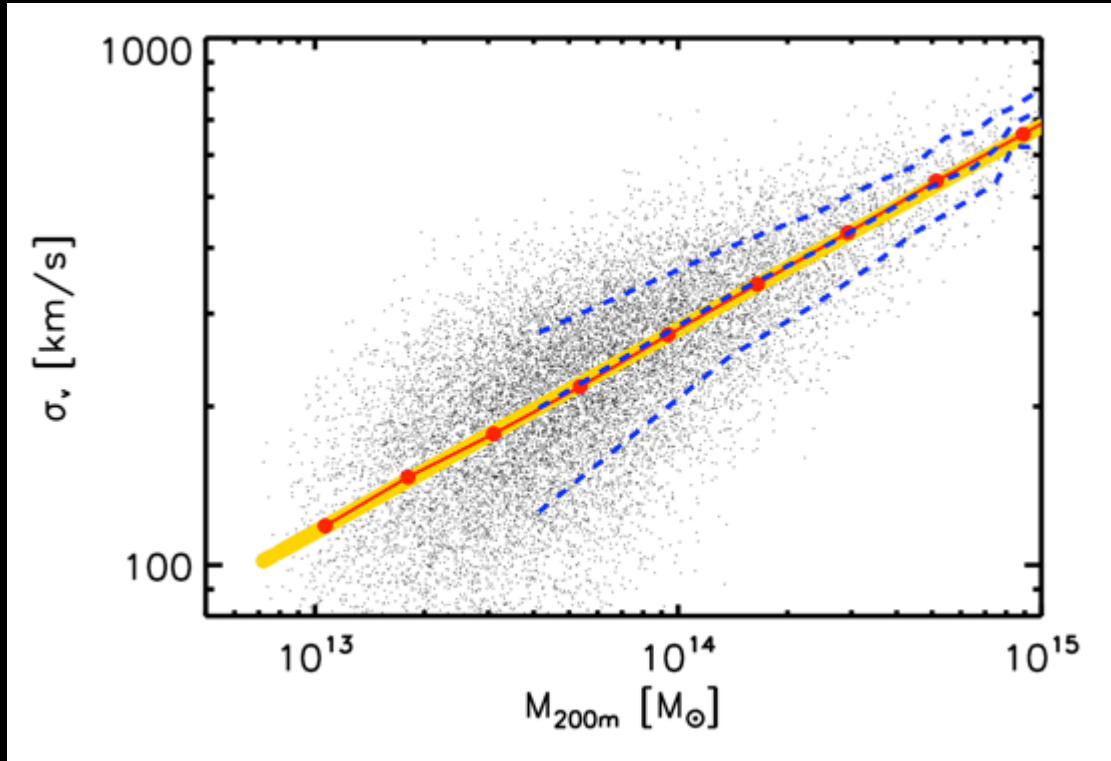
Black scatter points =
Planck data from
simulation

Red = mean sigma in
bins of Mass

Yellow = fit to red points

Blue = mean and 1-
sigma distribution of
scatter points

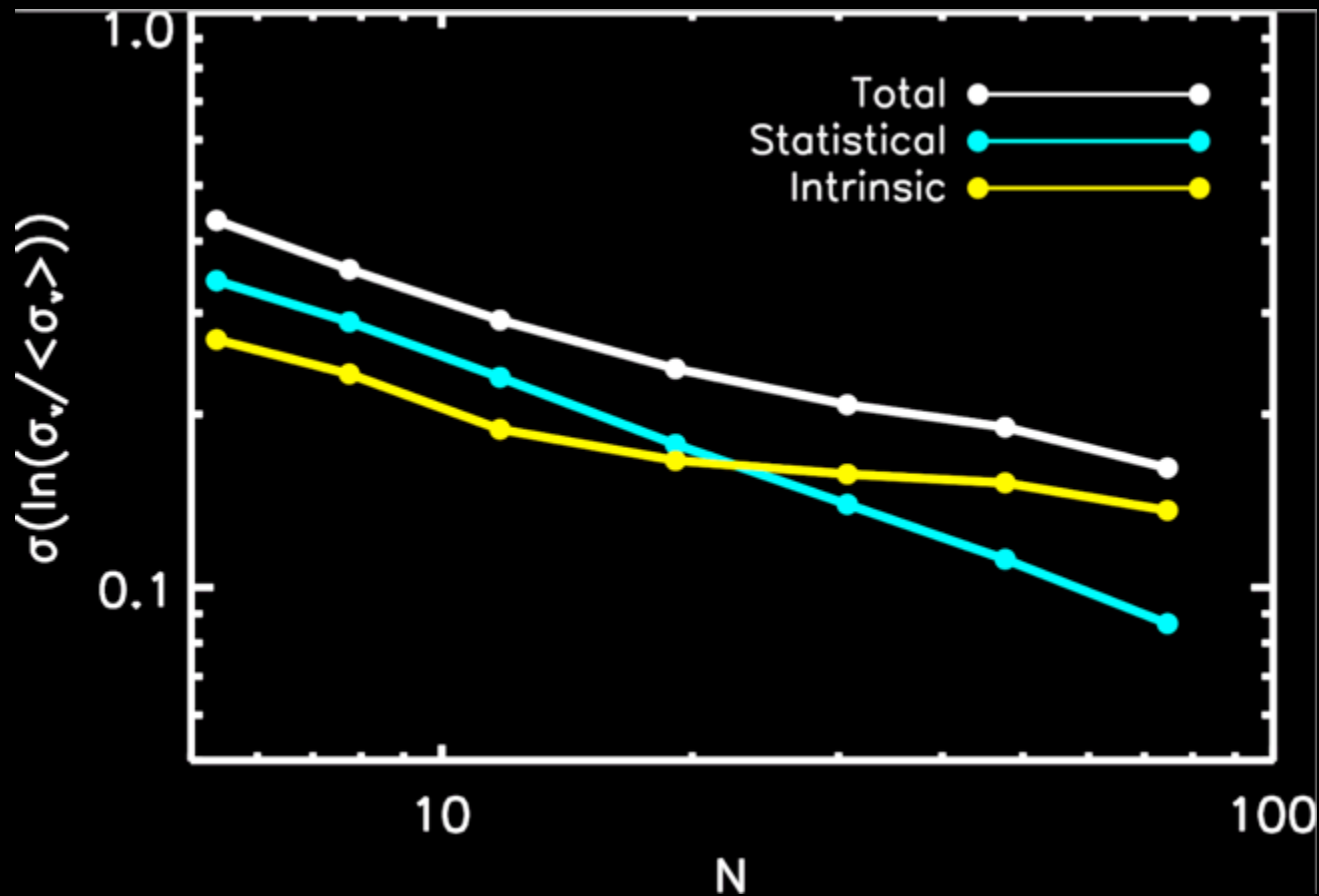
Scatter



1. Divide velocity dispersions by the power-law.
2. Bin residuals by mass
3. Fit log normal curve
4. Width of curve = width of scatter around powerlaw

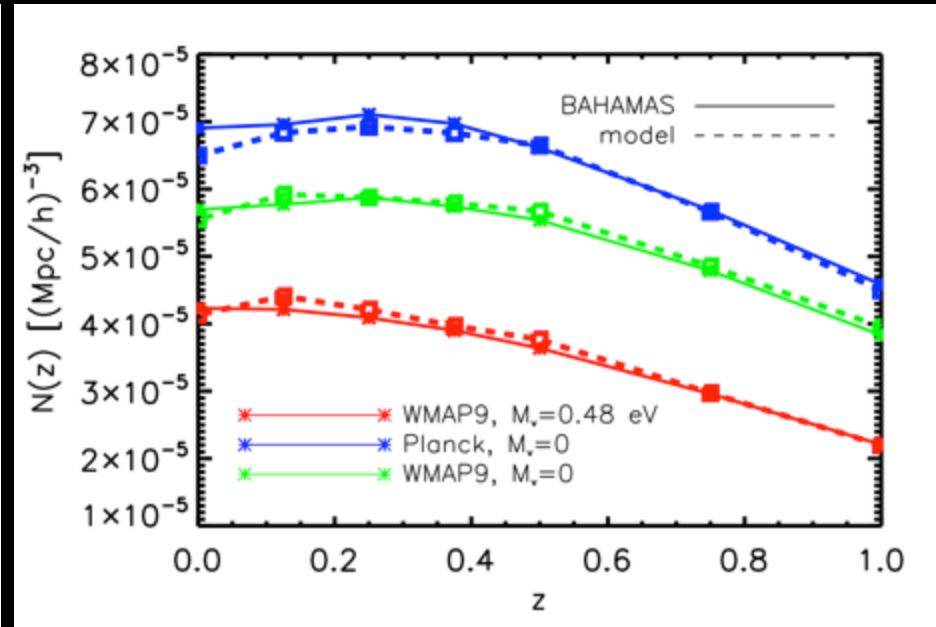
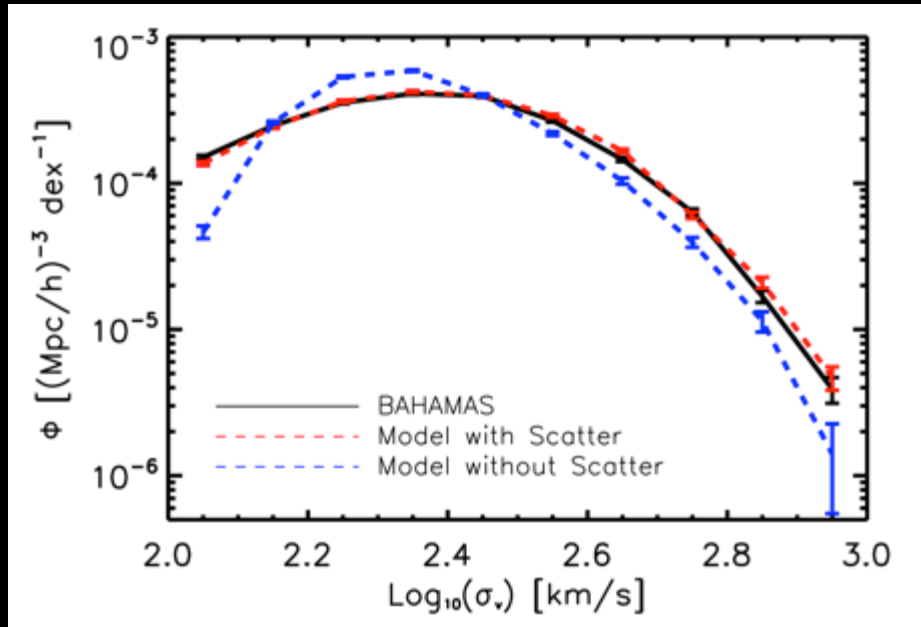
Scatter

Scatter Decomposition:



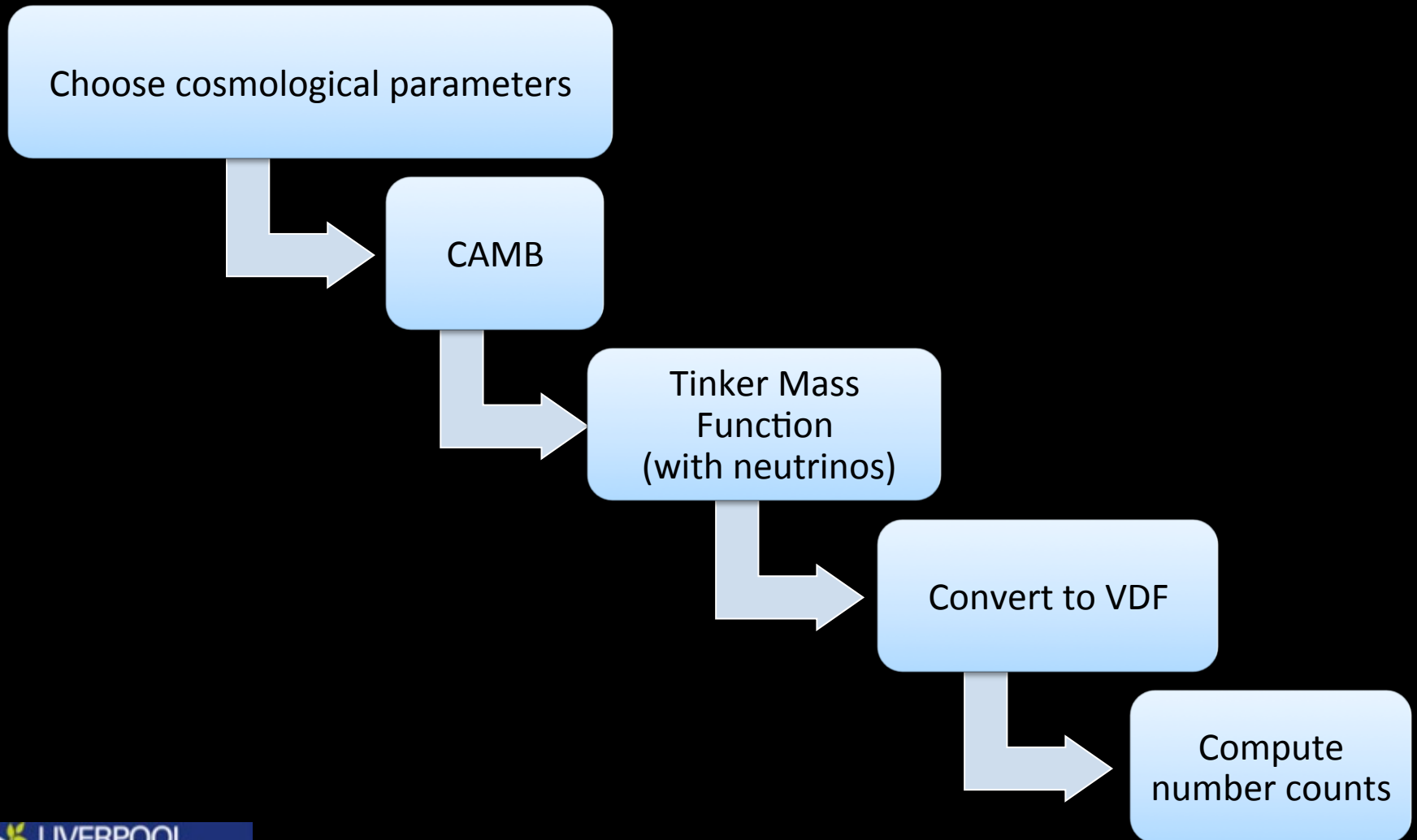
Parametric Model vs. BAHAMAS

Mass Function \rightarrow Mean sigma-M powerlaw \rightarrow scatter = “Model” velocity dispersions



VDF and $dN(z)$ can be modeled to high precision!

Creating the $\Omega_m \sigma_8$ grid



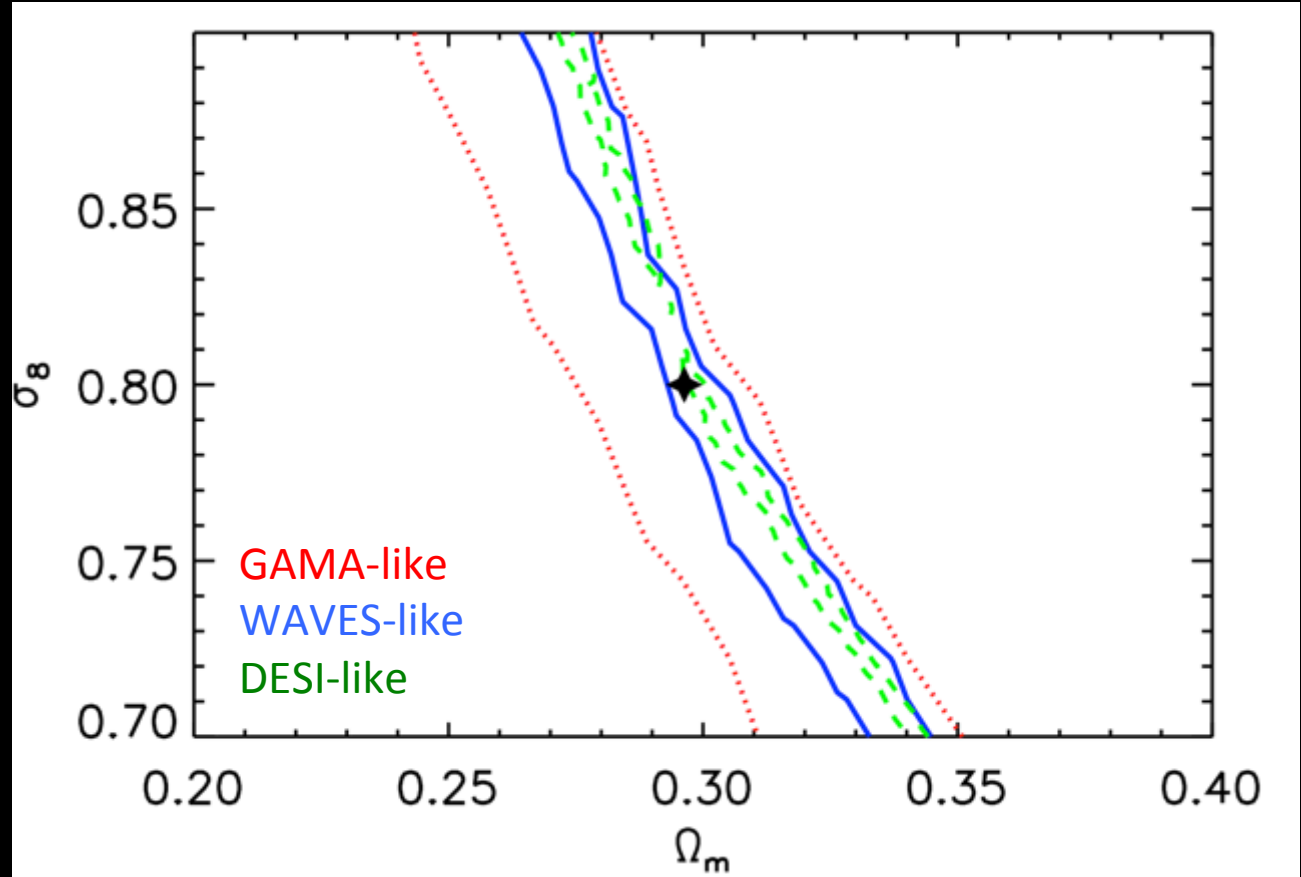
Constraining Power of Future Surveys

Using simulated data only:

1-sigma χ^2
intervals for
three survey
volumes.

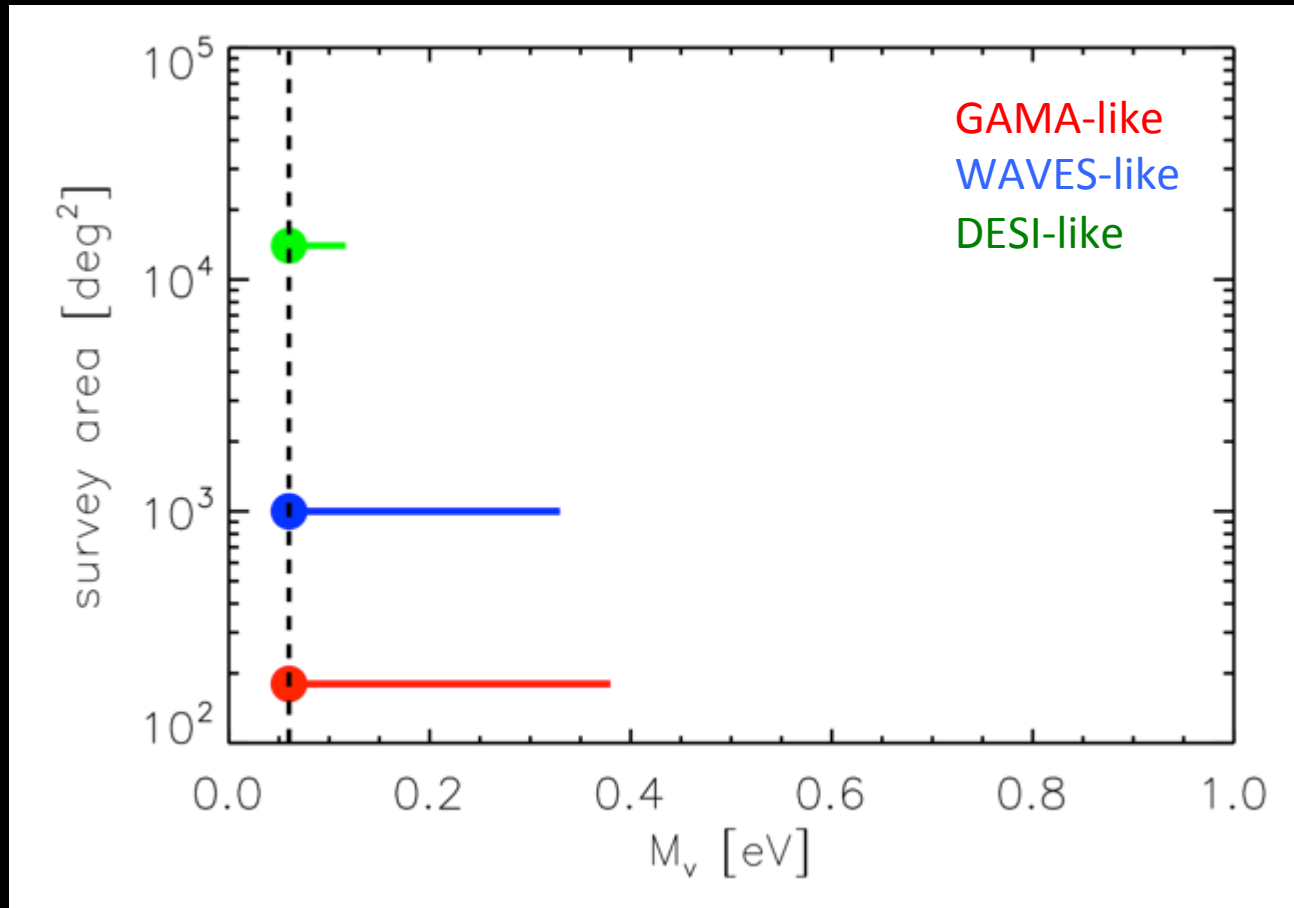
σ_8 = normalization
of power
spectrum

Ω_m = density of
matter



Constraining Power of Future Surveys

Using simulated data only:



Summary

- Velocity dispersions can be used for group number counts
 - Directly observable – alternative to mass
- Demonstrated that neutrinos can reduce abundances of massive groups
- Successfully modeled the VDF
- Estimated confidence intervals for Ω_m and σ_8 and neutrino mass

arXiv:1602.00611

Future:

- Use data from GAMA survey to obtain real confidence intervals