Cosmology with Velocity Dispersions

Science North – “Cool Science - Defining Gravity” -- https://www.youtube.com/watch?v=a3OQ7ek7t68

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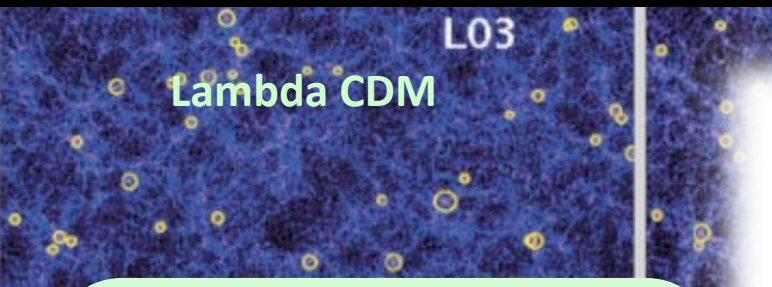


Abundance of clusters, n(z), is a good probe of underlying cosmology.

*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)*

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!

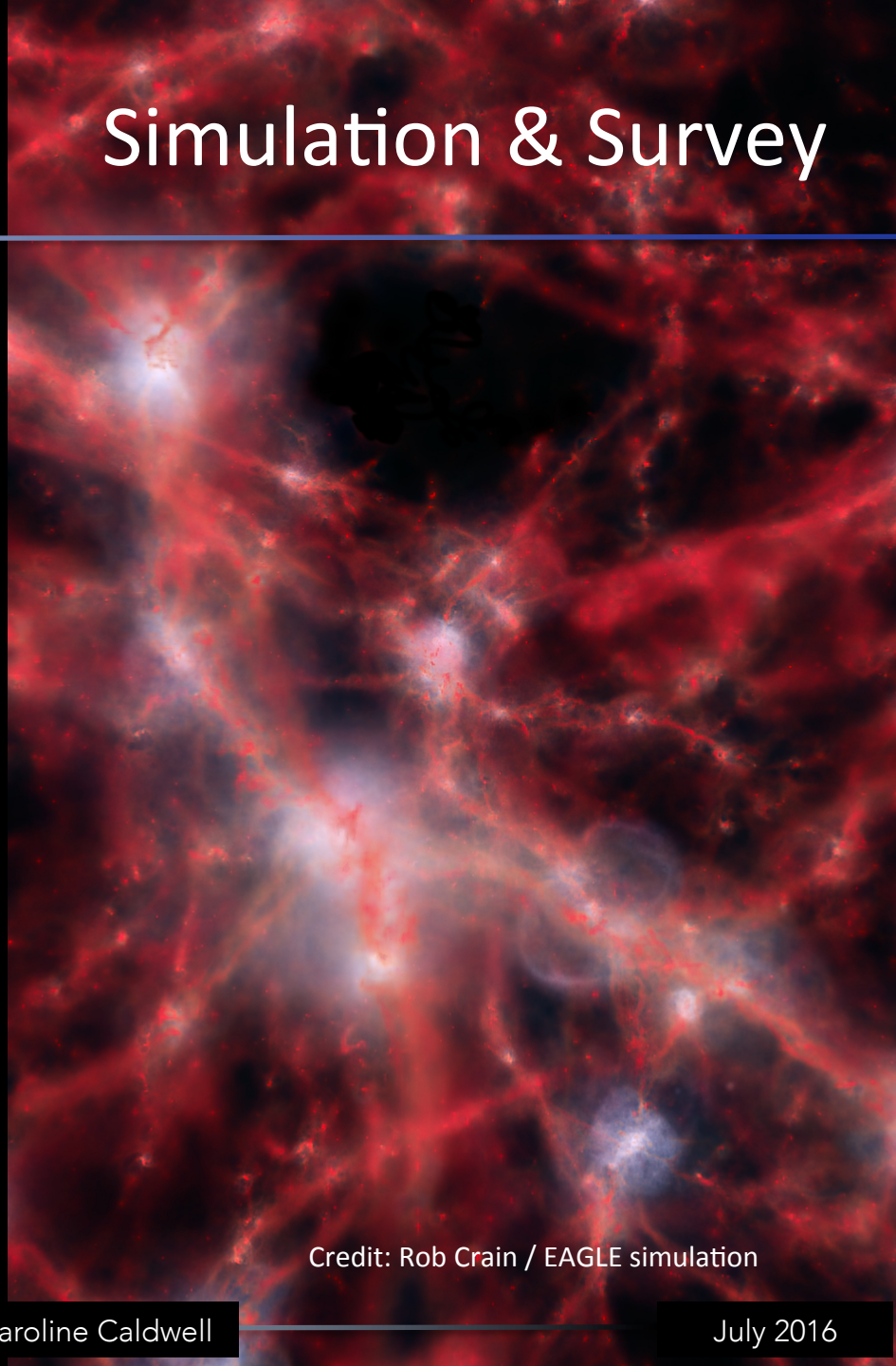
Potential causes of discrepancy:

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

Simulation & Survey

BAHAMAS:
BAryons and HAloes of MAssive Systems

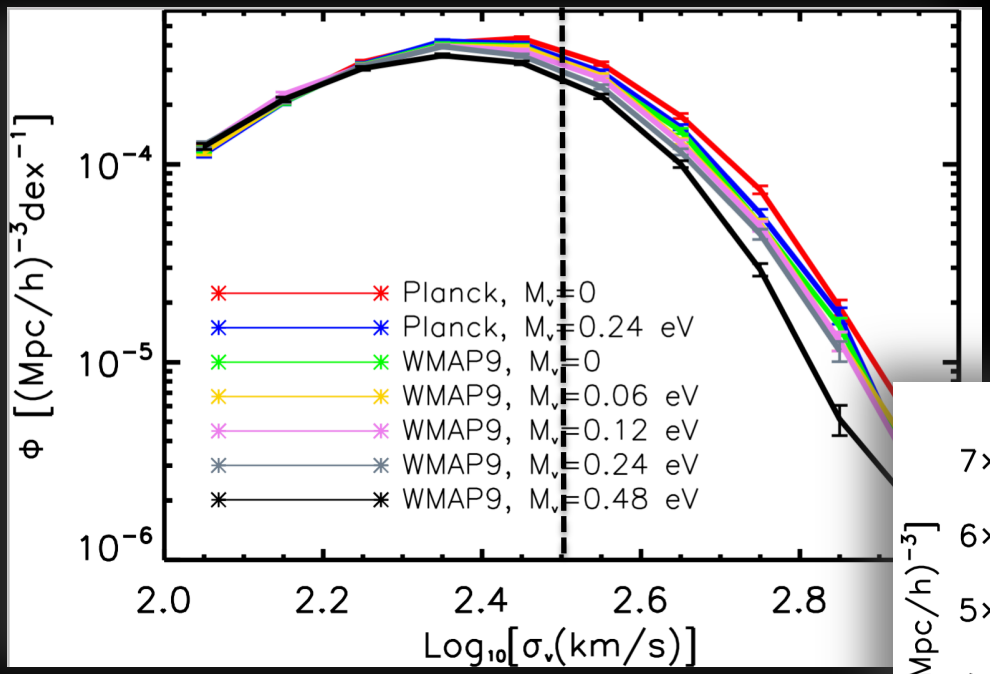
- Large box (400 Mpc/h, 1024^3 particles)
- Planck, WMAP9, and cosmologies +neutrinos
- Calibrated to match f_{gas}-M properties and galaxy stellar mass function
- Matches X-ray and SZ scaling relations and others.
- Details: McCarthy et al, 2016



Credit: Rob Crain / EAGLE simulation

BAHAMAS results

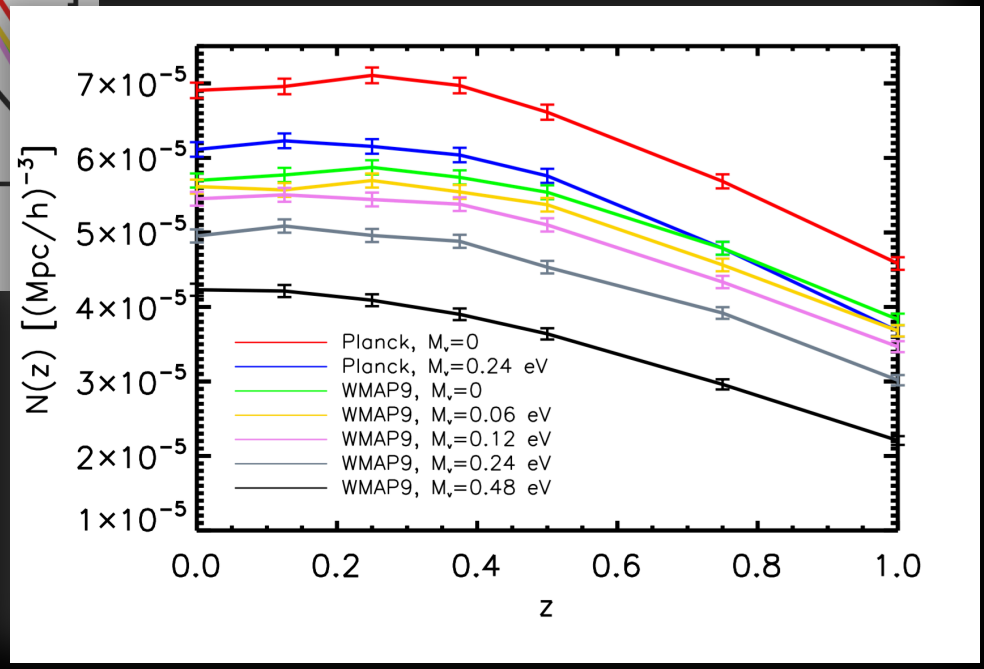
The Velocity Dispersion function



Galaxy groups:

- At least 4 members
- M200m > 10^{10} M sun

Number of Groups > 300 km/s

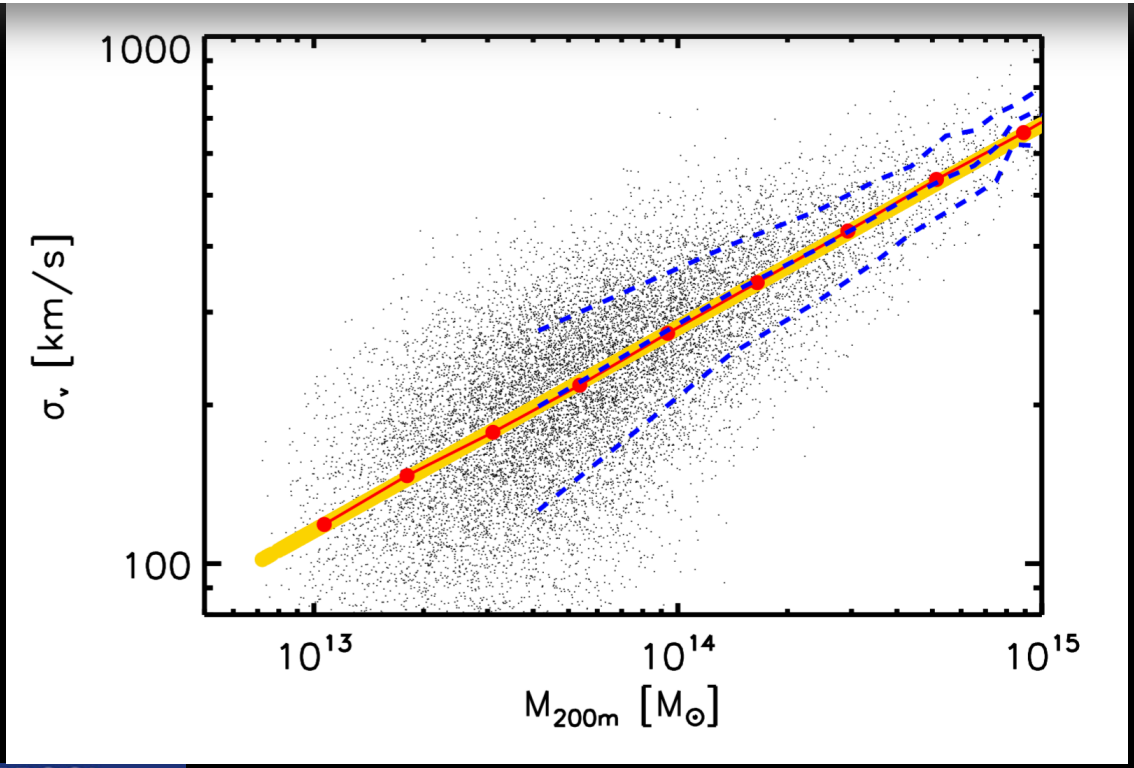


Model the VDF

Mass Function -> Mean sigma-M powerlaw -> scatter = "Model" velocity dispersions

1. Mean Mass – velocity dispersion power law.

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



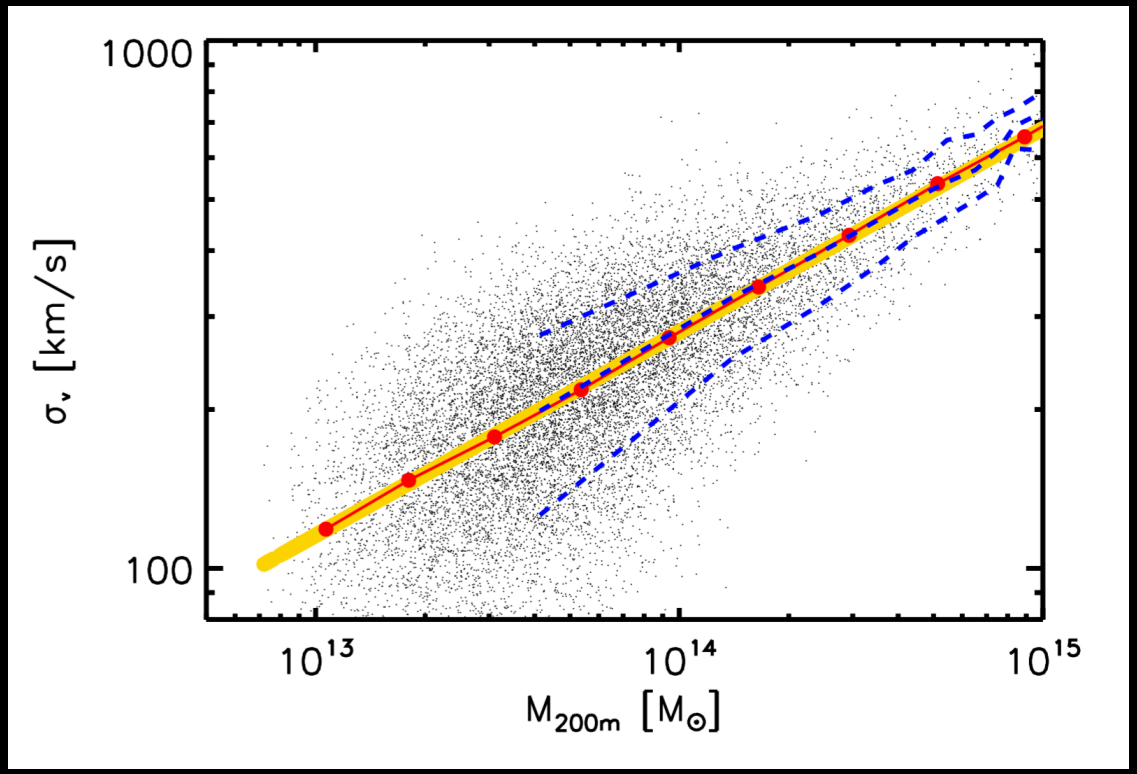
Black scatter points = Planck data from simulation

Red = mean sigma in bins of Mass

Yellow = fit to red points

Blue = mean and 1-sigma distribution of scatter points

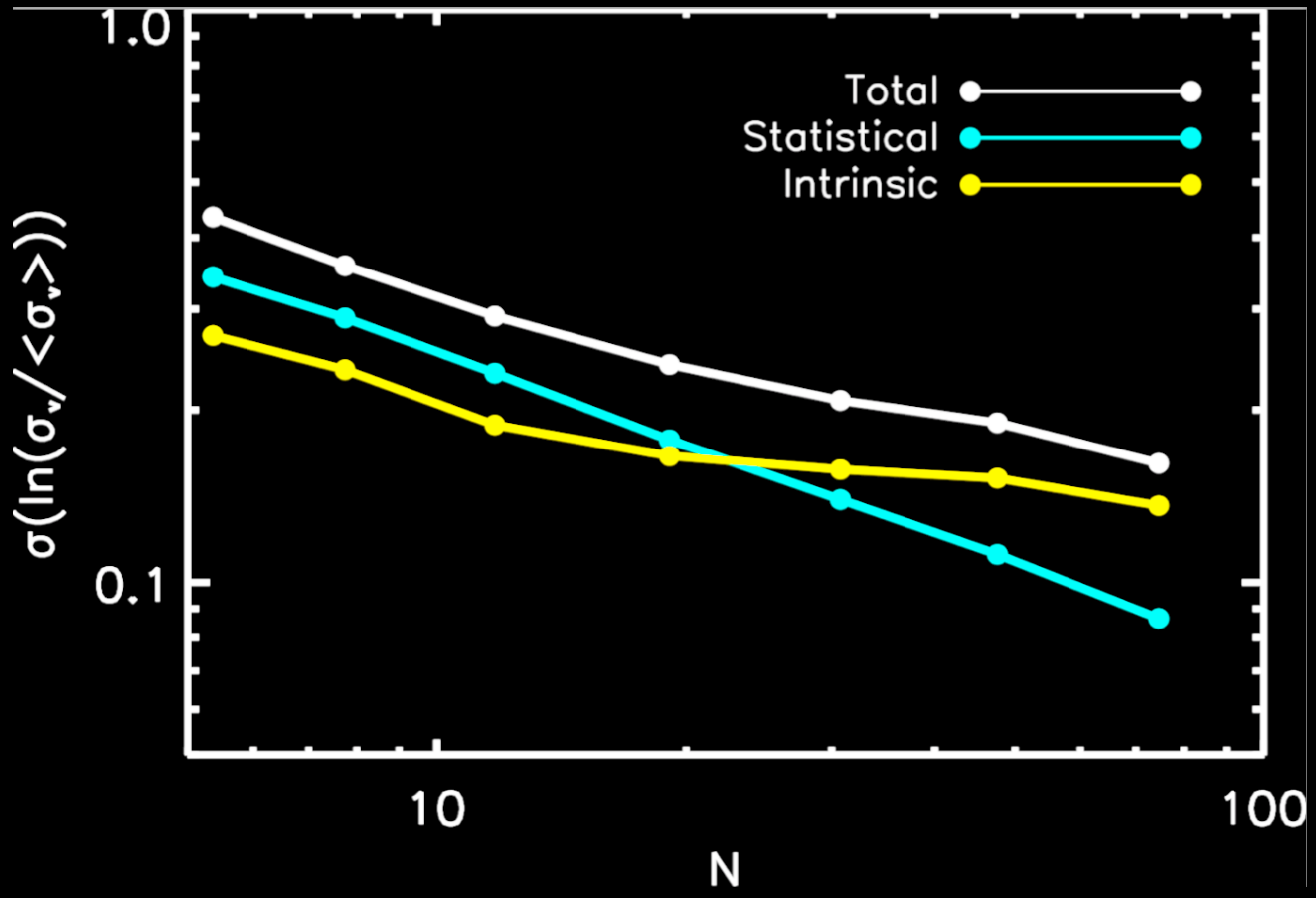
Scatter



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

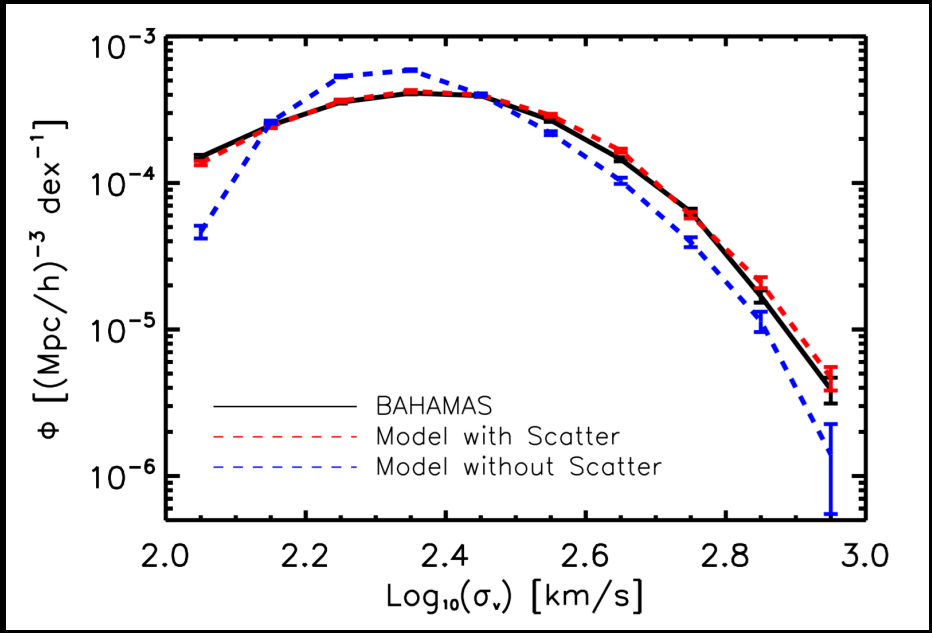
Scatter

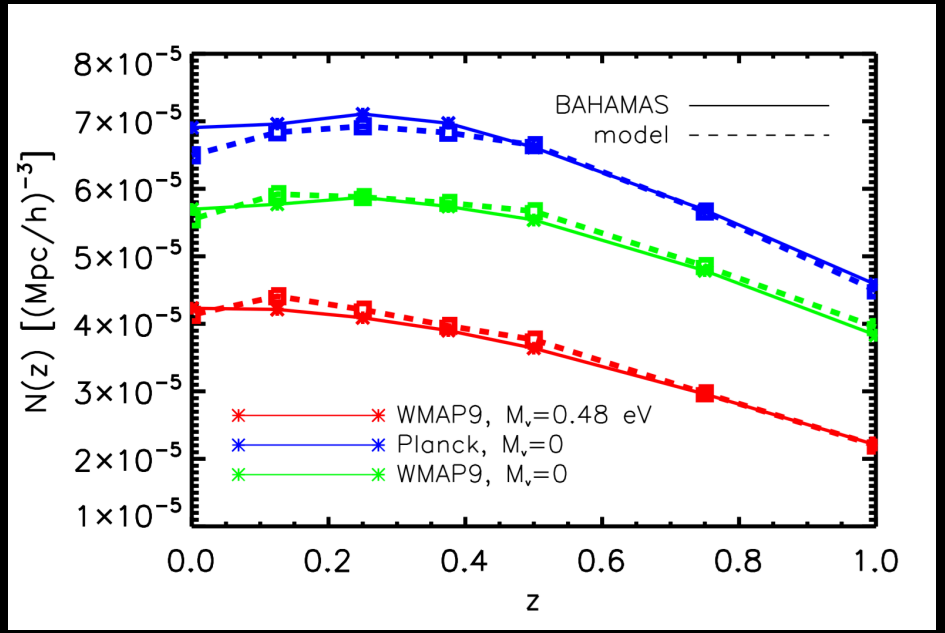
Scatter Decomposition:



Parametric Model vs. BAHAMAS

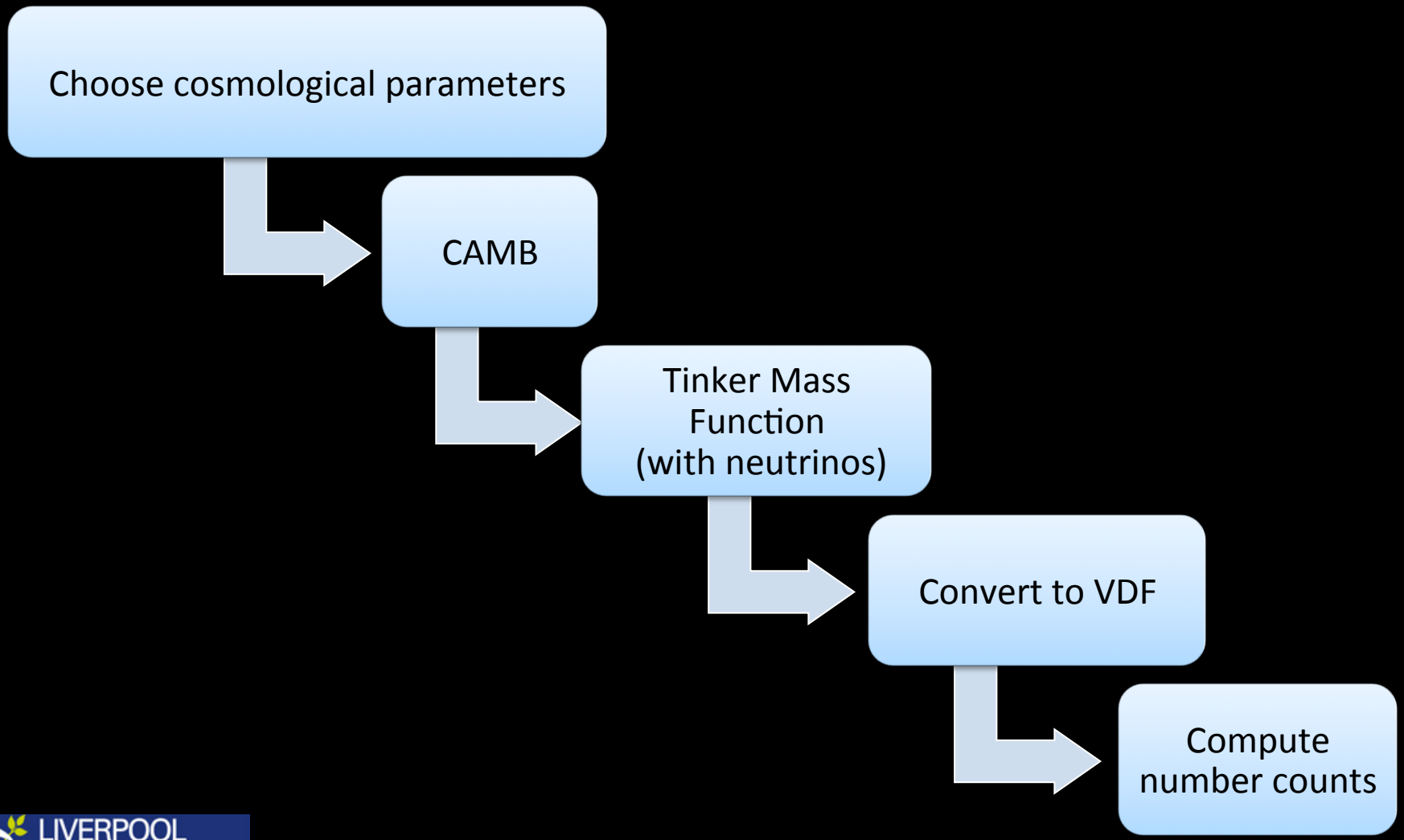
Mass Function -> Mean sigma-M powerlaw -> scatter = “Model” velocity dispersions





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

Creating the Ω_m σ_8 grid



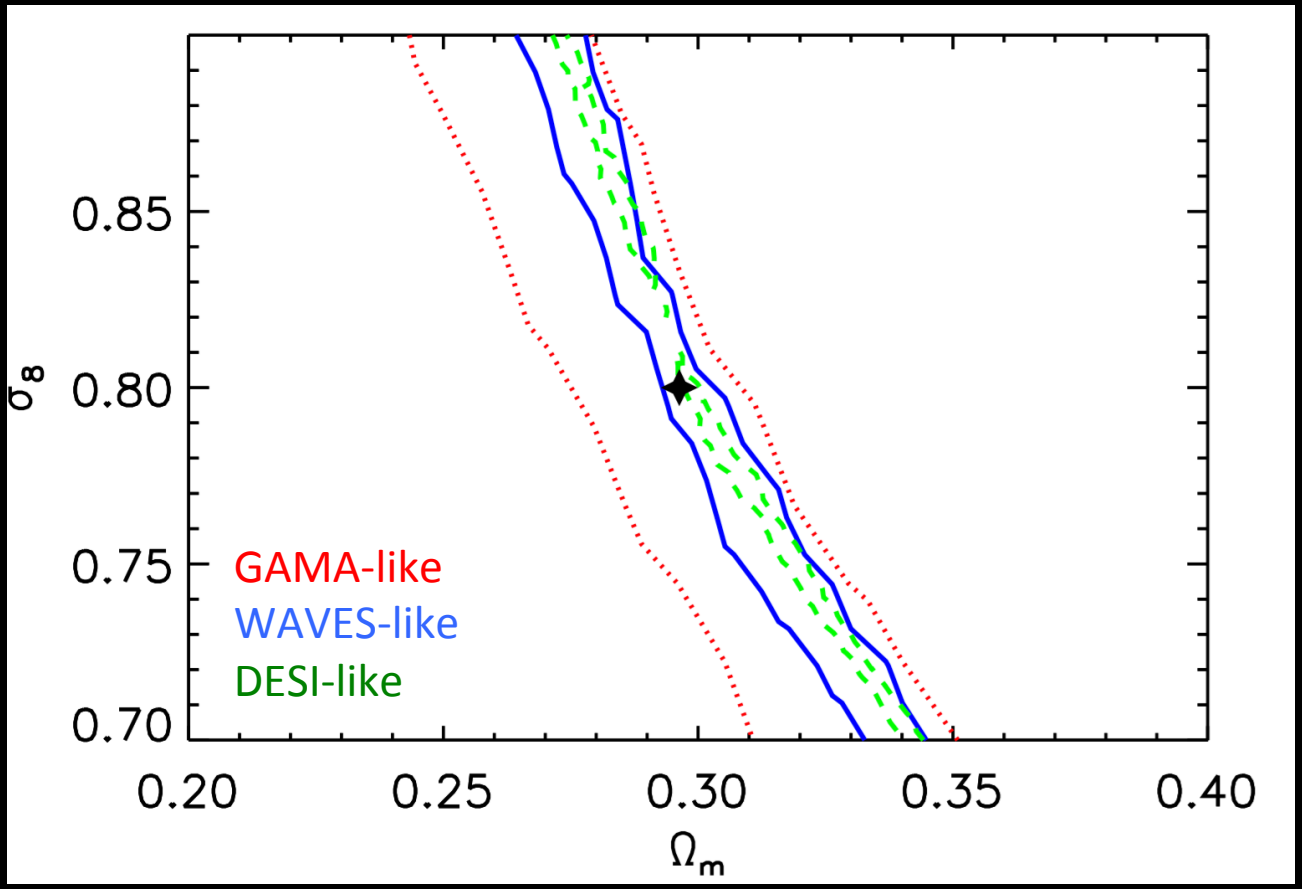
Constraining Power of Future Surveys

Using simulated data only:

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

σ_8= normalizaton of power spectrum

Ω_m=density of matter



Constraining Power of Future Surveys

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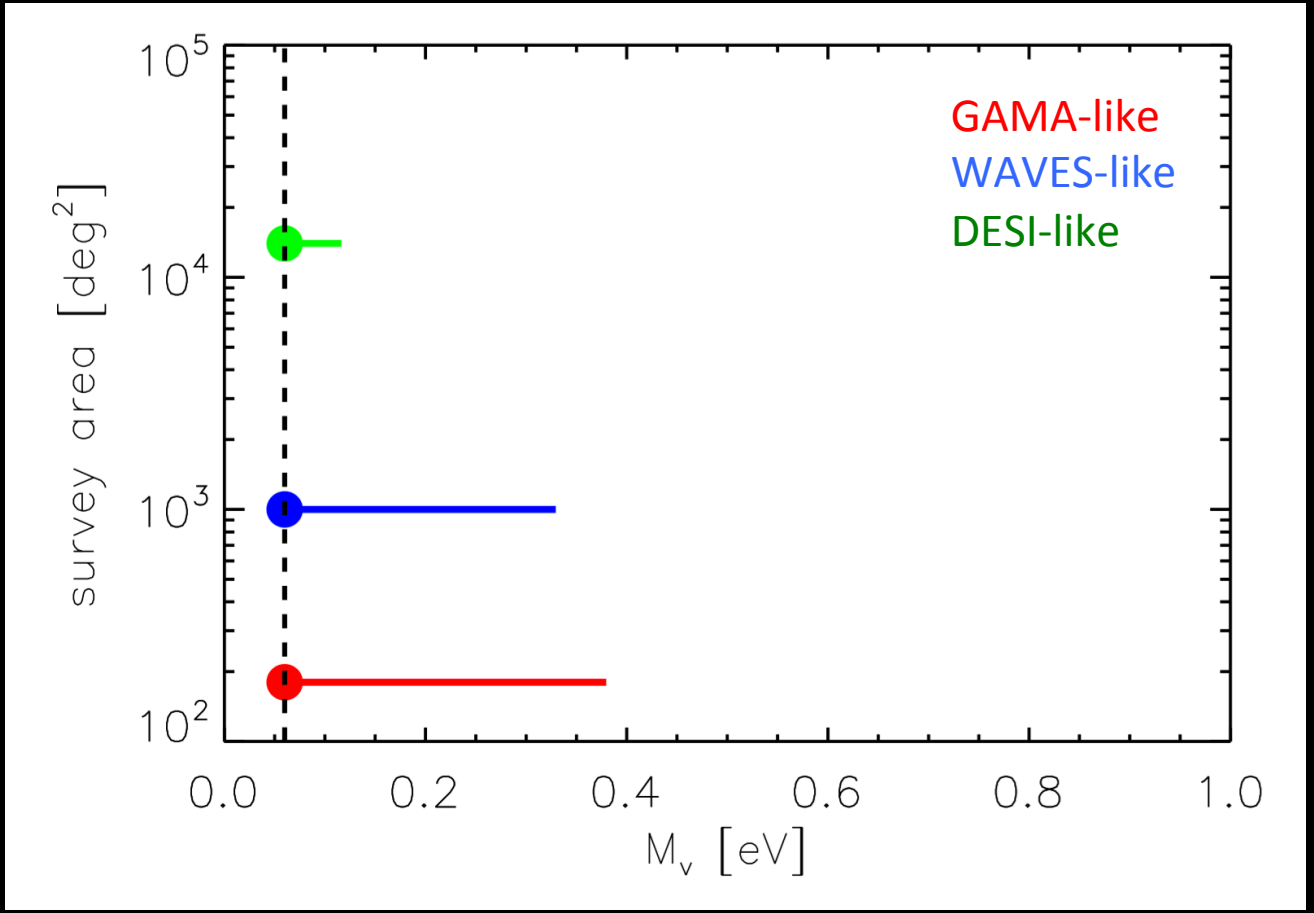

Summary

- 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