Improving Galaxy Cluster Cosmology with Spectroscopic Followup of DES

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with significant input from
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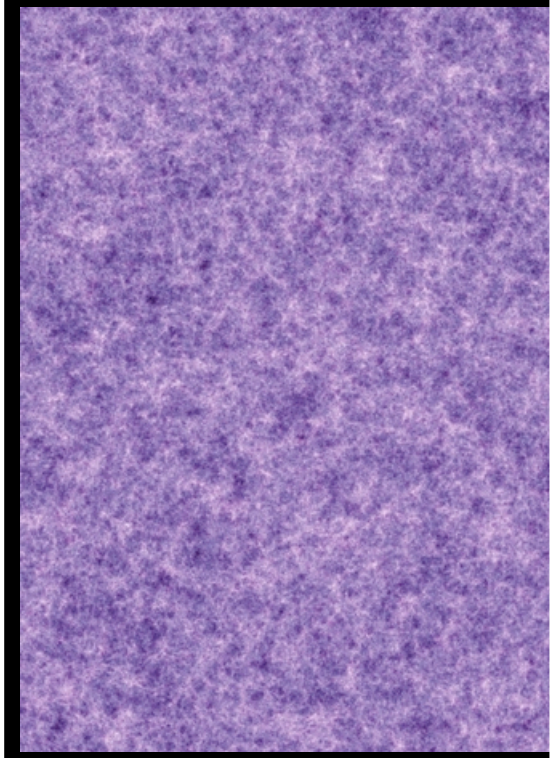
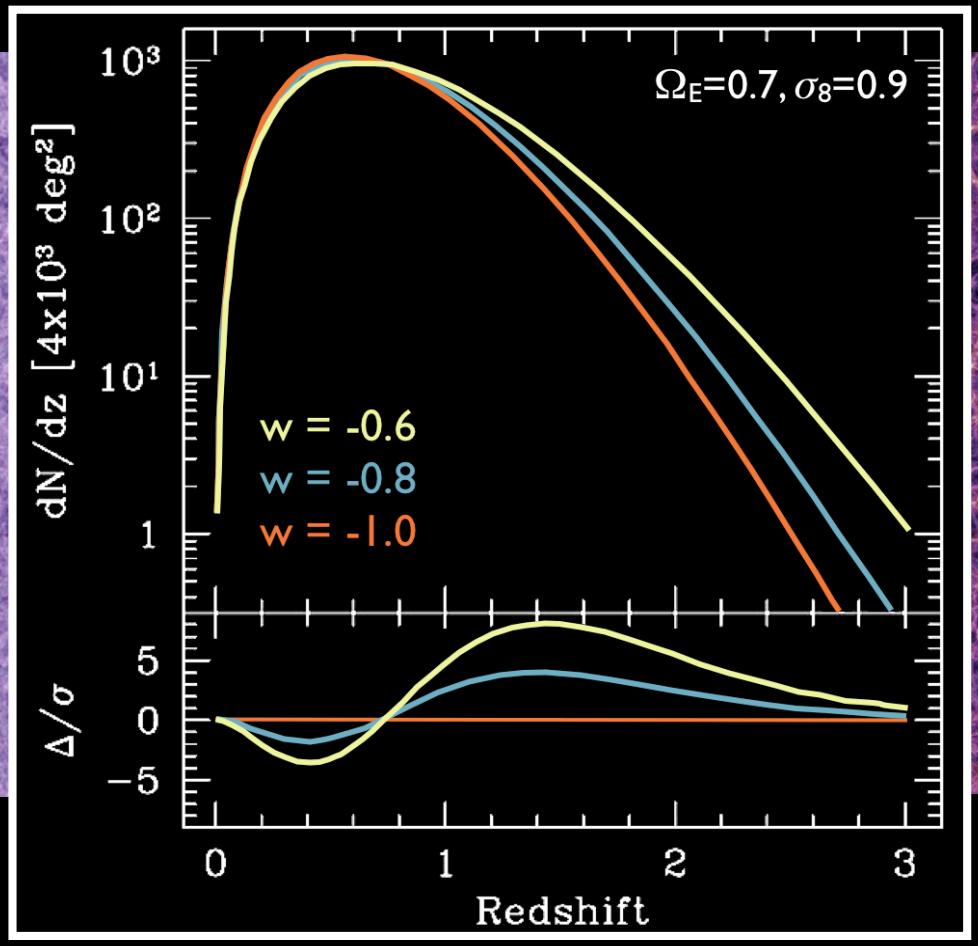
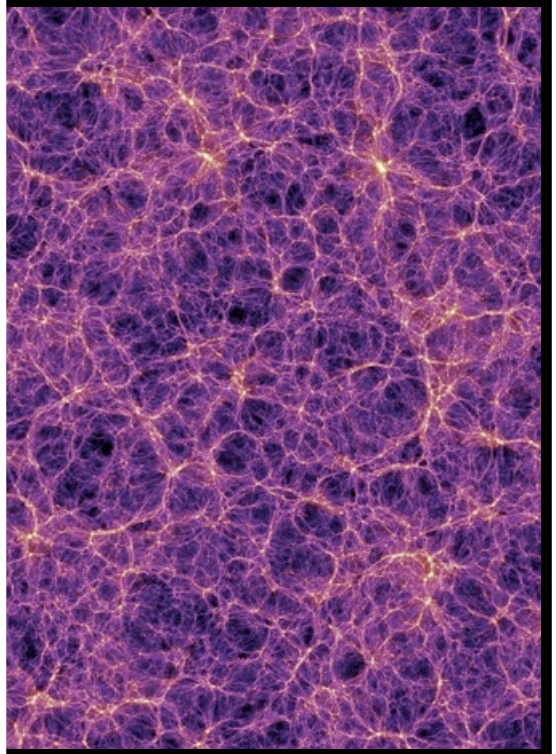
Cluster Abundance & Cosmology

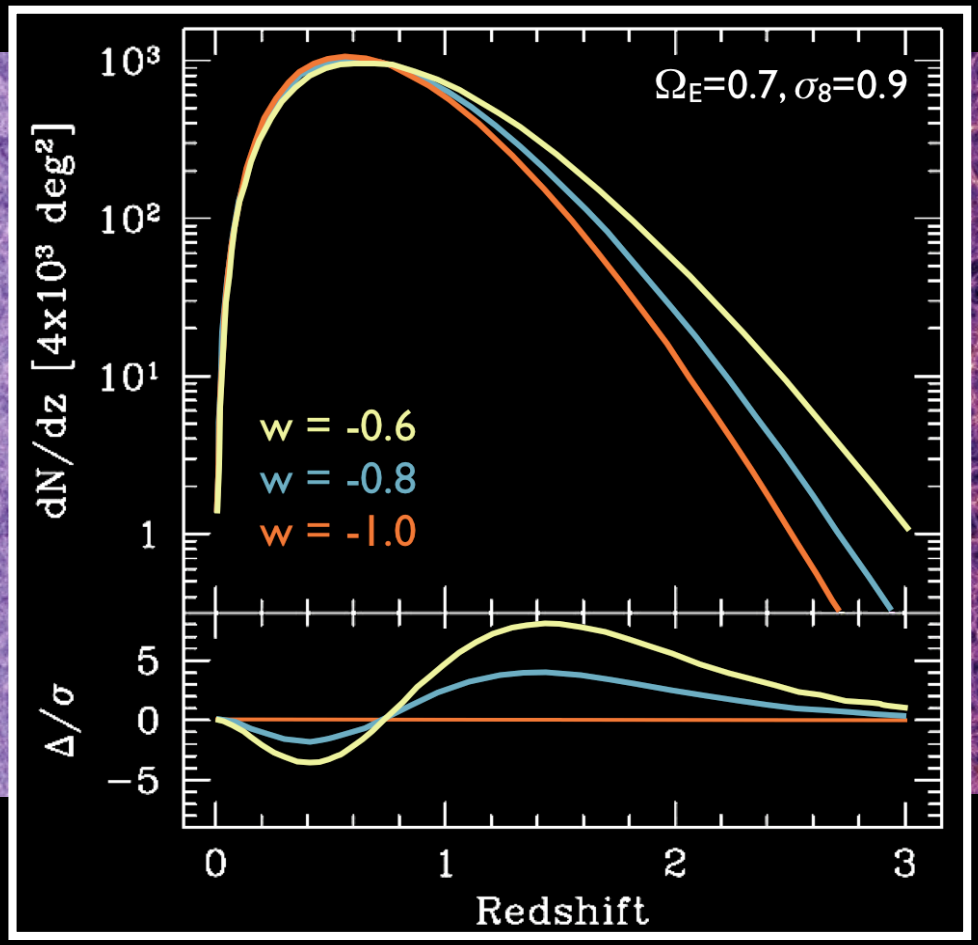






$$\frac{dN}{dz d\Omega} = \frac{d^2V}{dz d\Omega}\, n(z) = \frac{c}{H(z)}\, D_A^2 (1+z)^2 \int_0^\infty f(M,z) \frac{dn(z)}{dM}\, dM$$

Cluster Abundance & Cosmology



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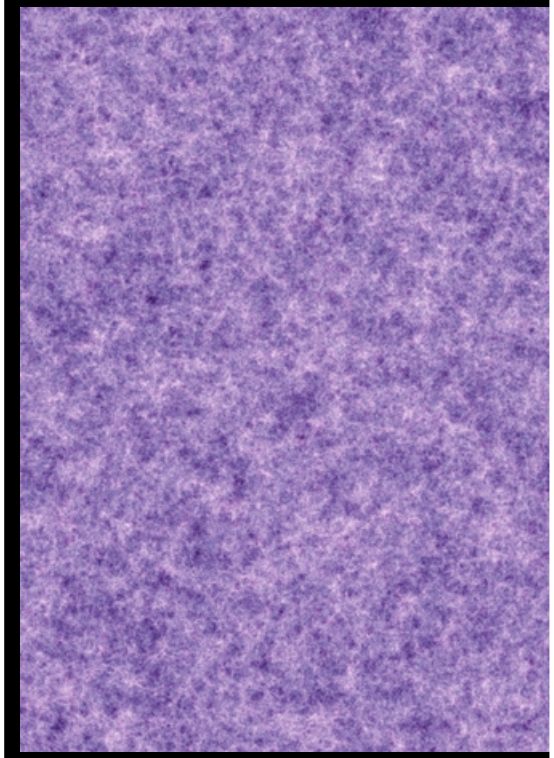
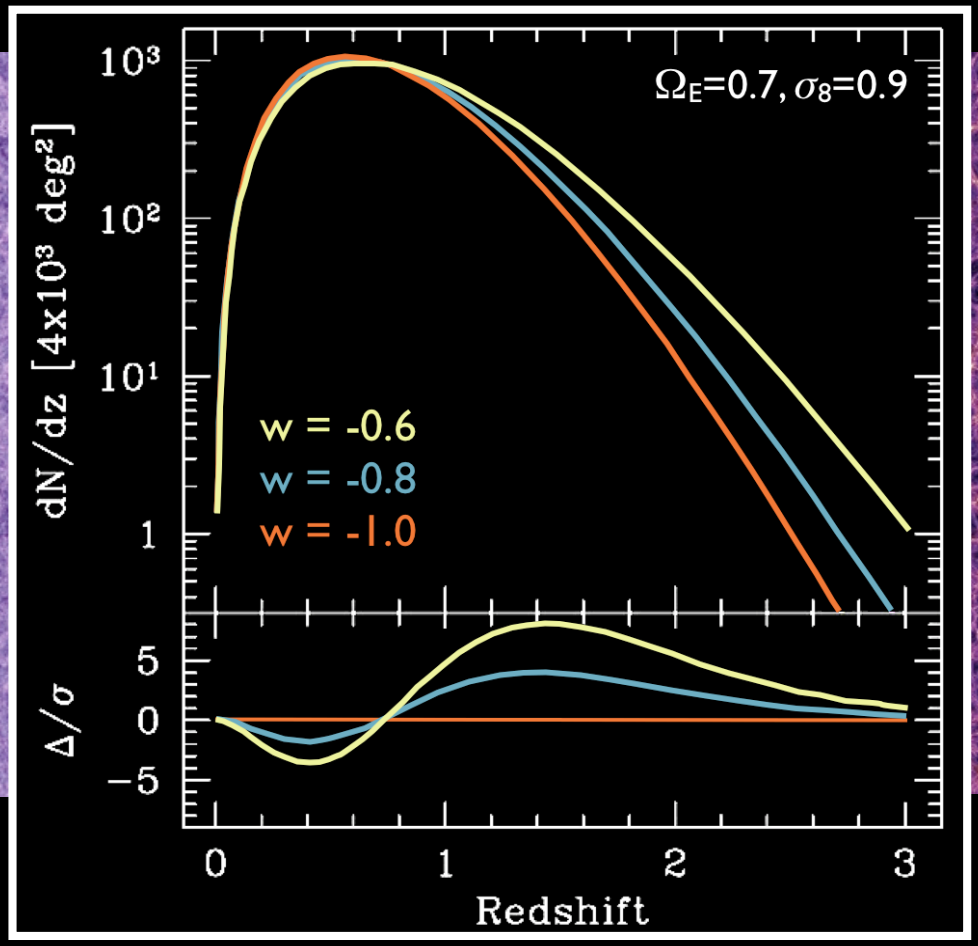
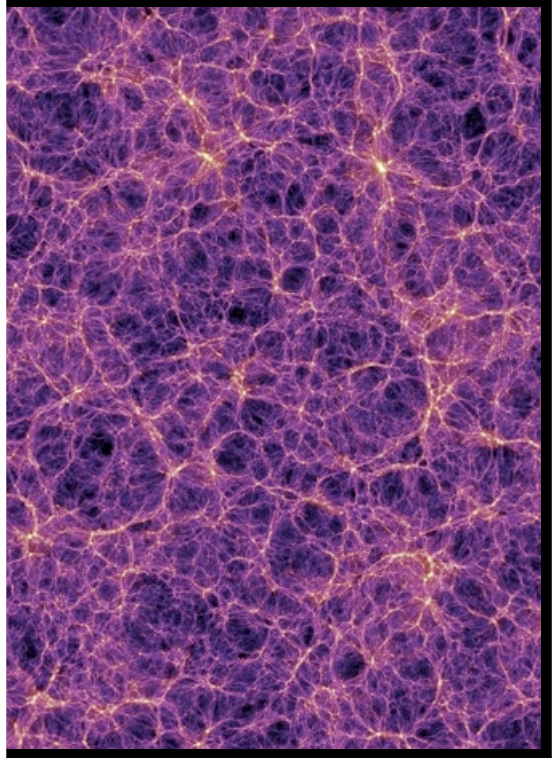
geometry abundance

hard part

Cluster Abundance & Cosmology







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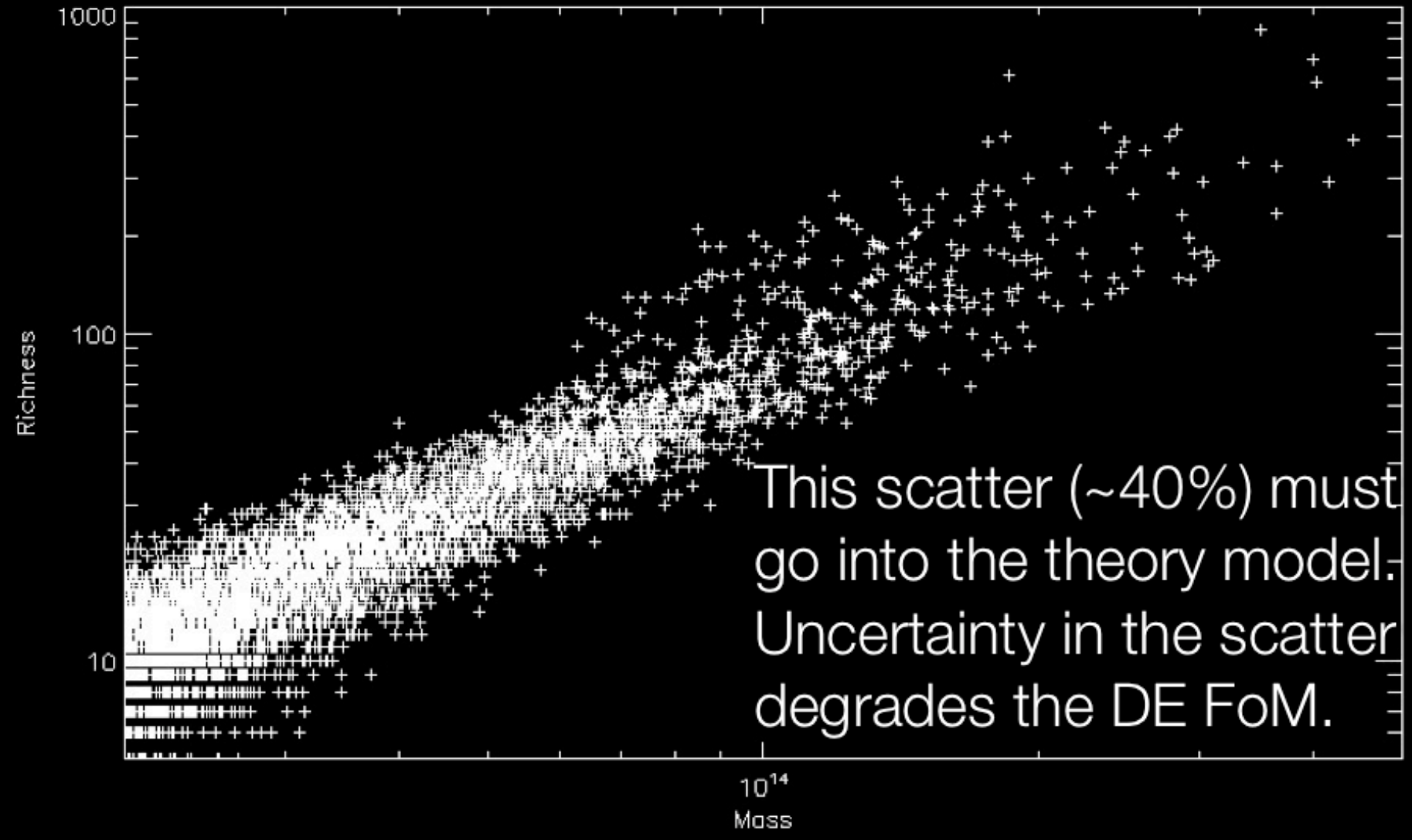
find clusters

estimate mass

determine redshift

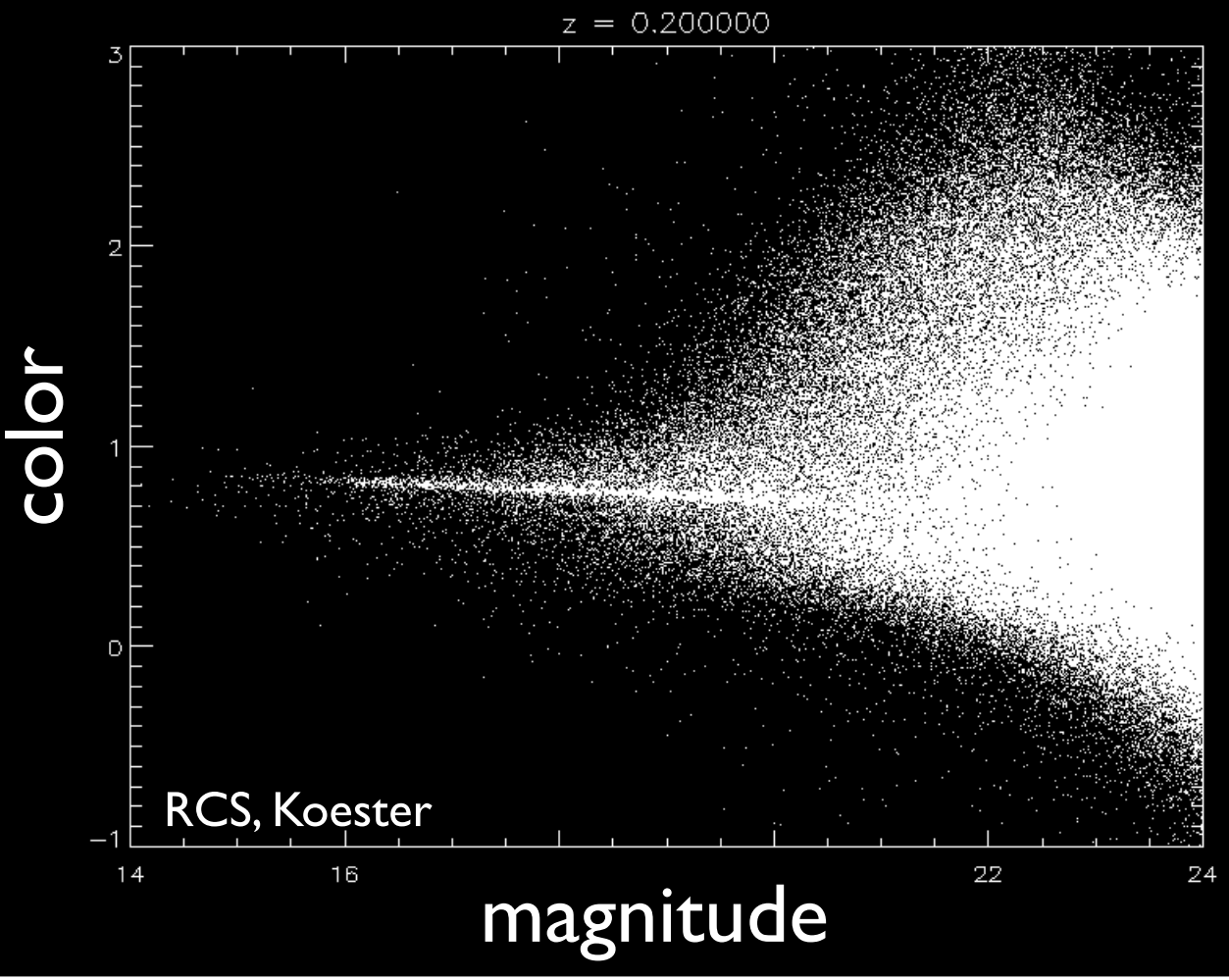
Intrinsic Uncertainty in the Mass-Richness Relationship



Location/Richness Optimization

For cluster finding, richness optimization & photometric redshift calibration: need the (evolving) color distribution of cluster members as a function of redshift

Spectra are essential for determining membership probability model

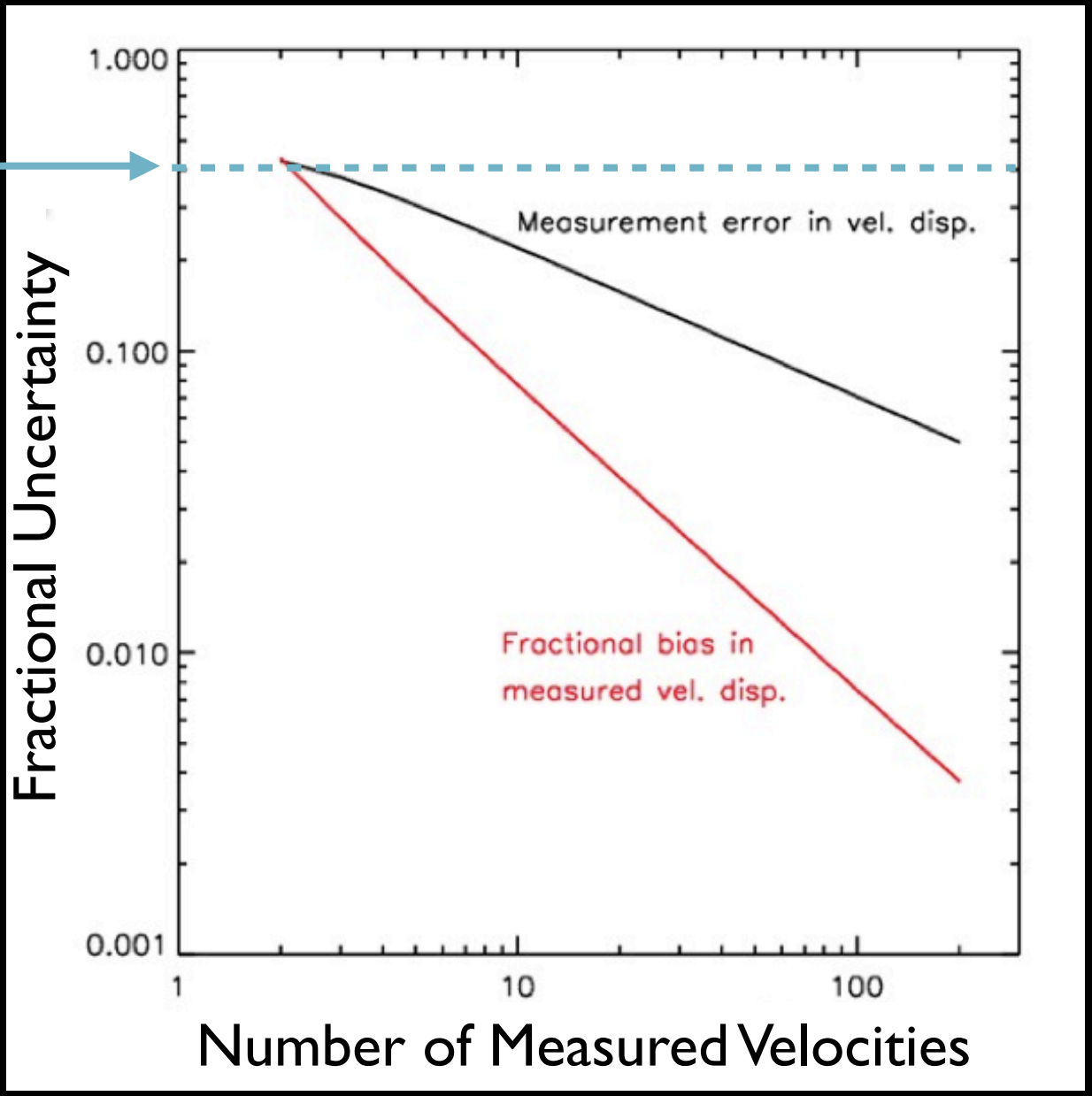


Velocity Dispersion as A Mass Proxy

How Many Spectra Are Needed?

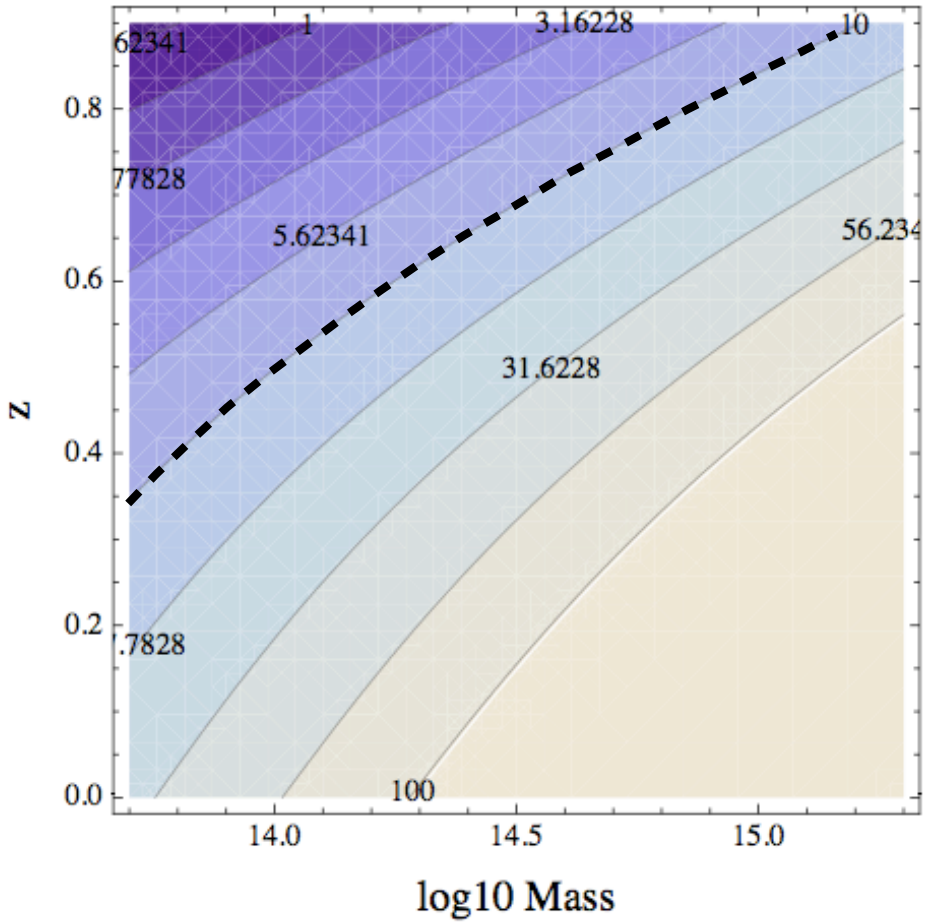
intrinsic mass-richness scatter

Small-number statistics dominate the error budget unless have at minimum ~10 velocities per cluster

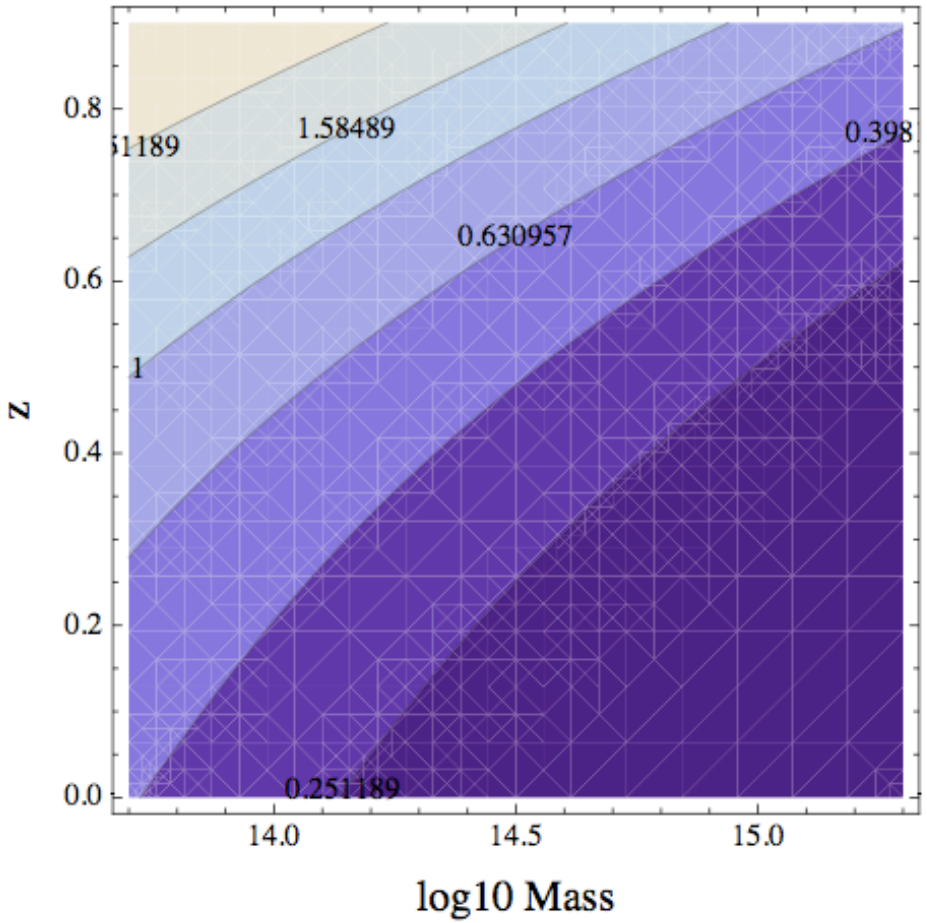


Quality of Velocity Dispersion Mass Proxy Depends on M,z

number of velocities per cluster



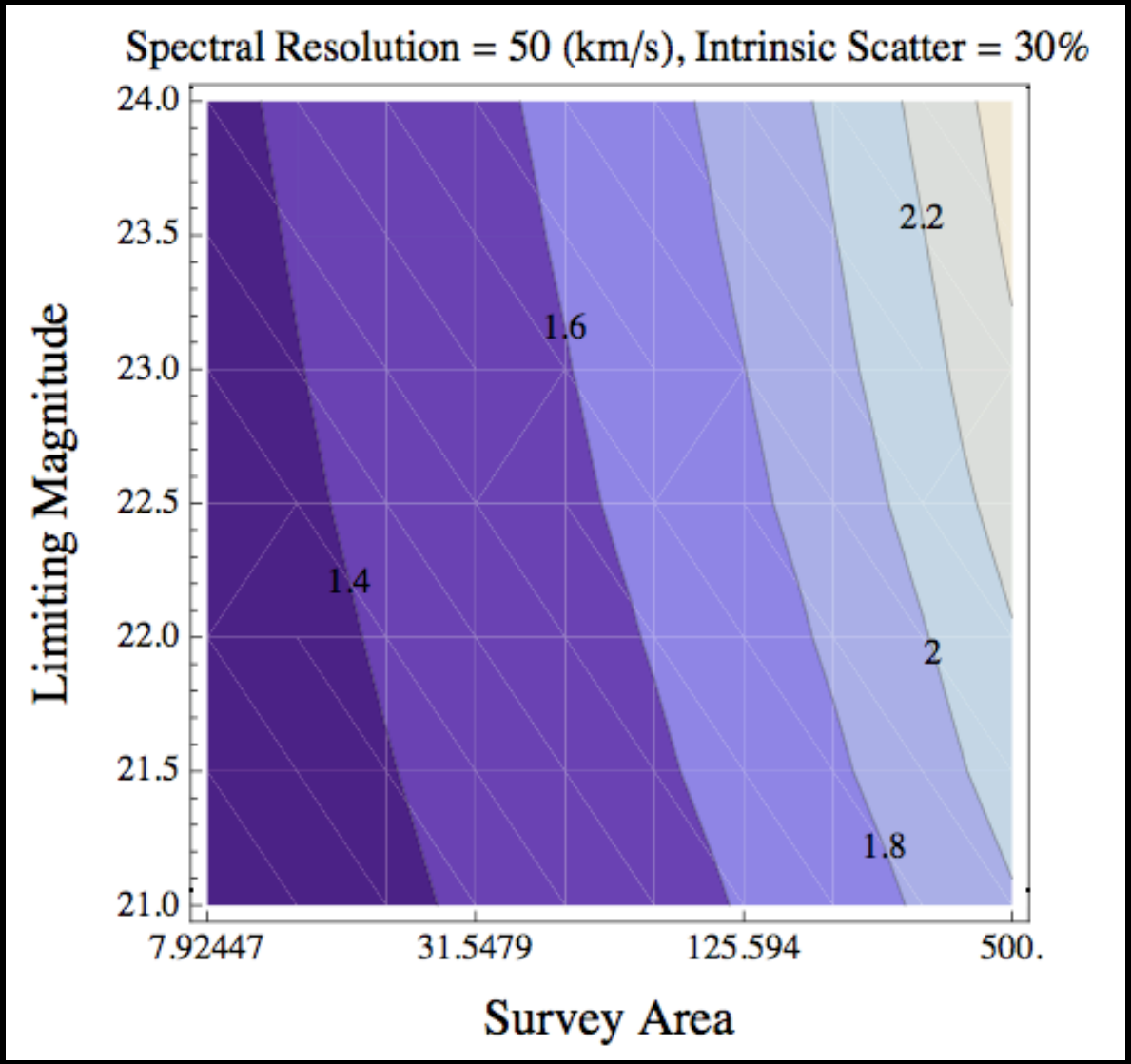
mass uncertainty (Δ logM)



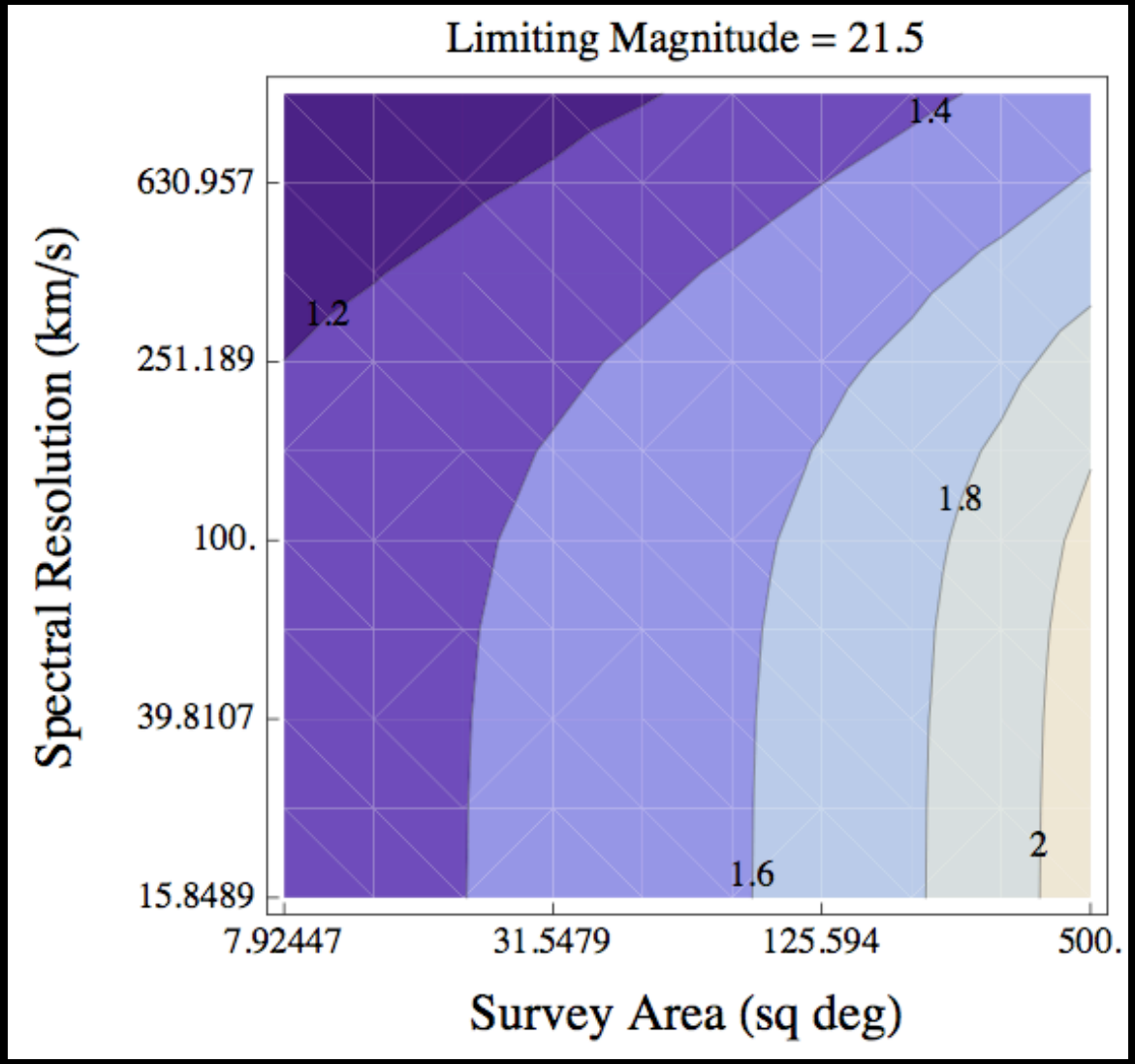
(100% completeness to fixed depth)

Impact of Depth & Area on FoM

Since it isn't necessary to get much beyond ~10 spectra/cluster, getting more area is more important than depth in the fixed-depth case.



What Spectral Resolution?



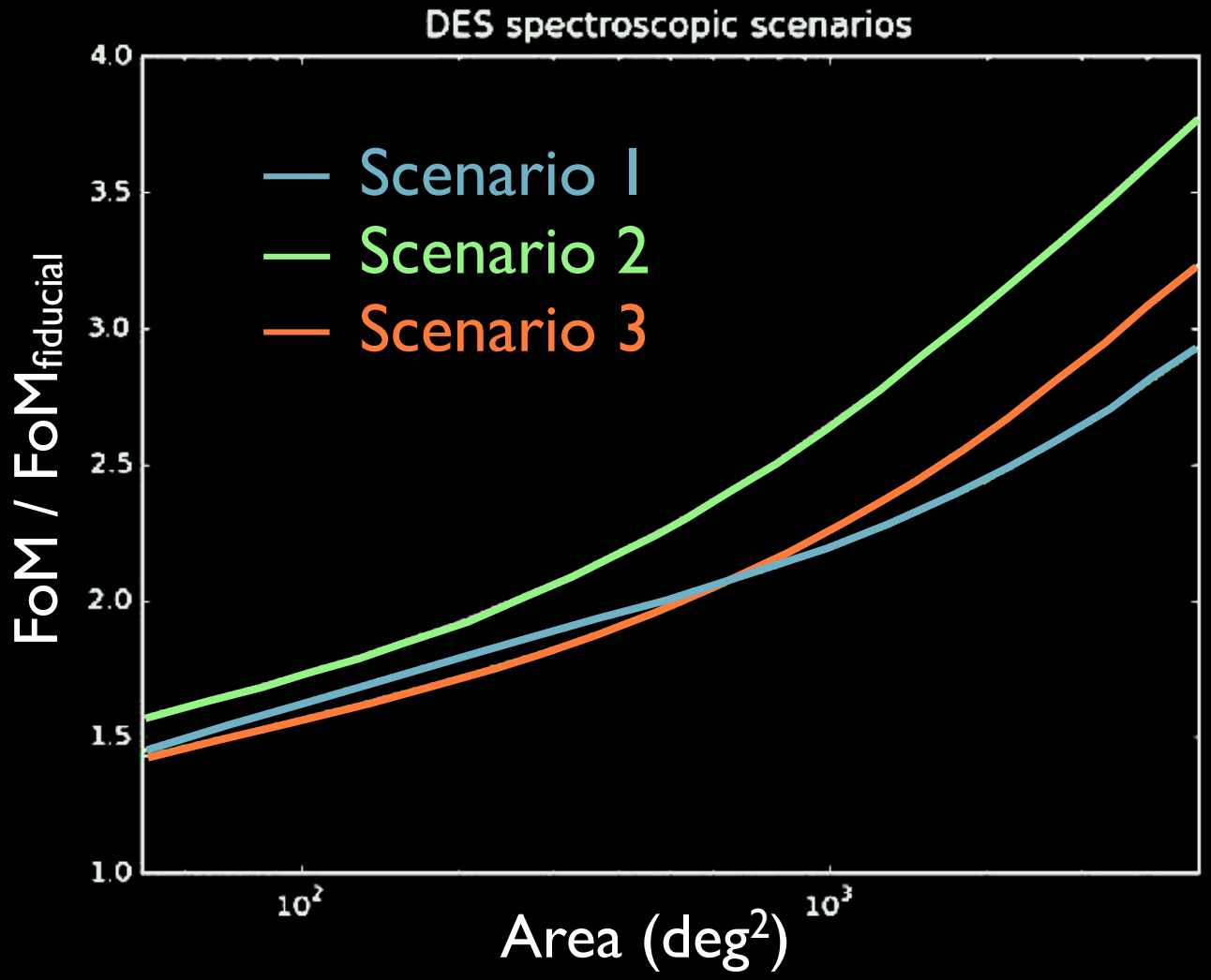
For FoM improvement, no strong need to do better than ~100 km/s

Three Scenarios Considered

The DES Science Committee requested consideration of the following spectroscopic followup programs:

- Scenario 1: 100% completeness to r=21 with 80 km/s redshift accuracy
- Scenario 2: 100% completeness to r=21 + 50% completeness to r=22.5 with 80 km/s redshift accuracy
- Scenario 3: 100% completeness to r=22 with 300 km/s redshift accuracy

Figure of Merit Improvement



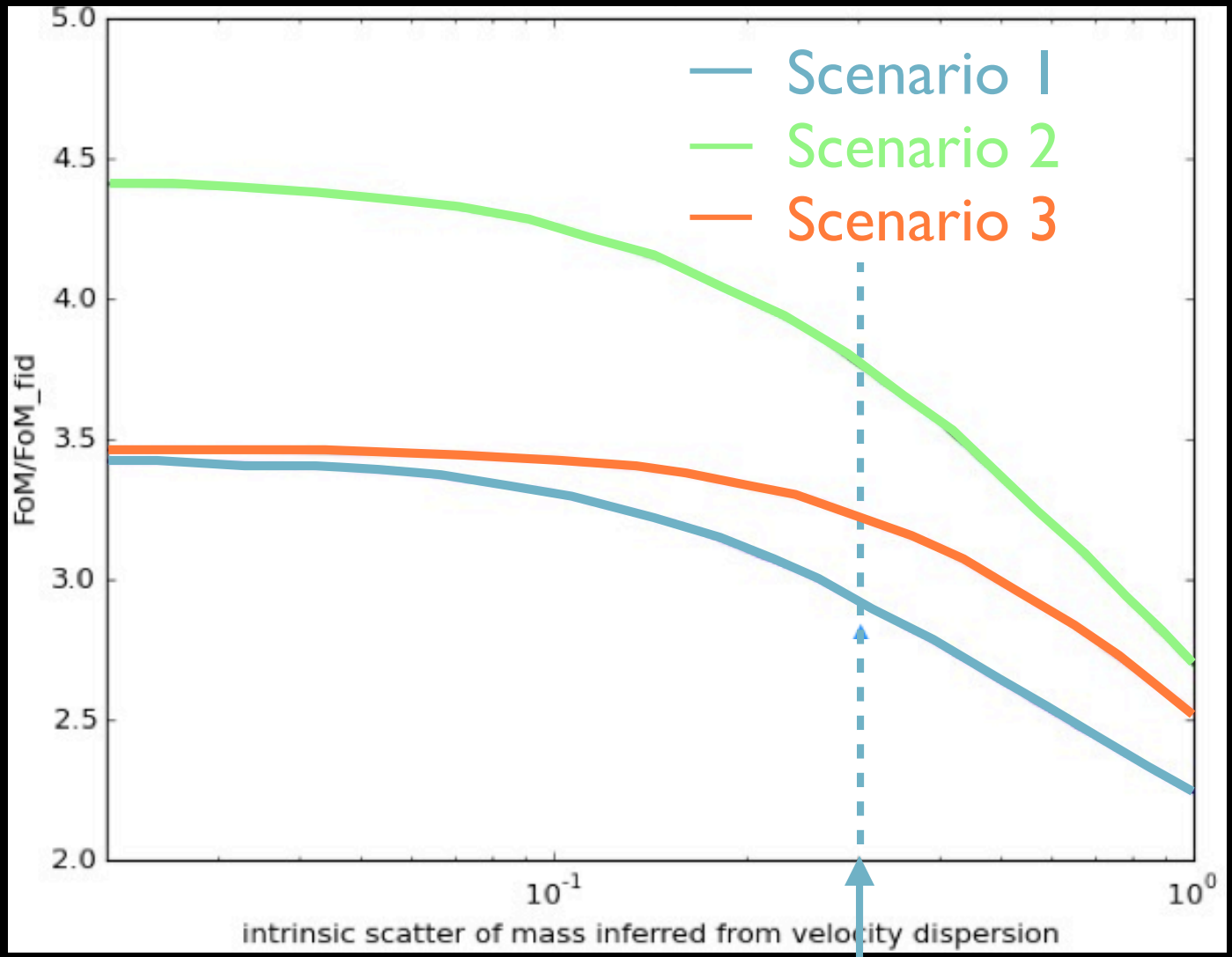
FOM$_{fiducial}$ from DES clusters with self-calibration

- Scenario 1: 100% completeness to r=21 with 80 km/s redshift accuracy
- Scenario 2: 100% completeness to r=21 + 50% completeness to r=22.5 with 80 km/s redshift accuracy
- Scenario 3: 100% completeness to r=22 with 300 km/s redshift accuracy

HOWEVER

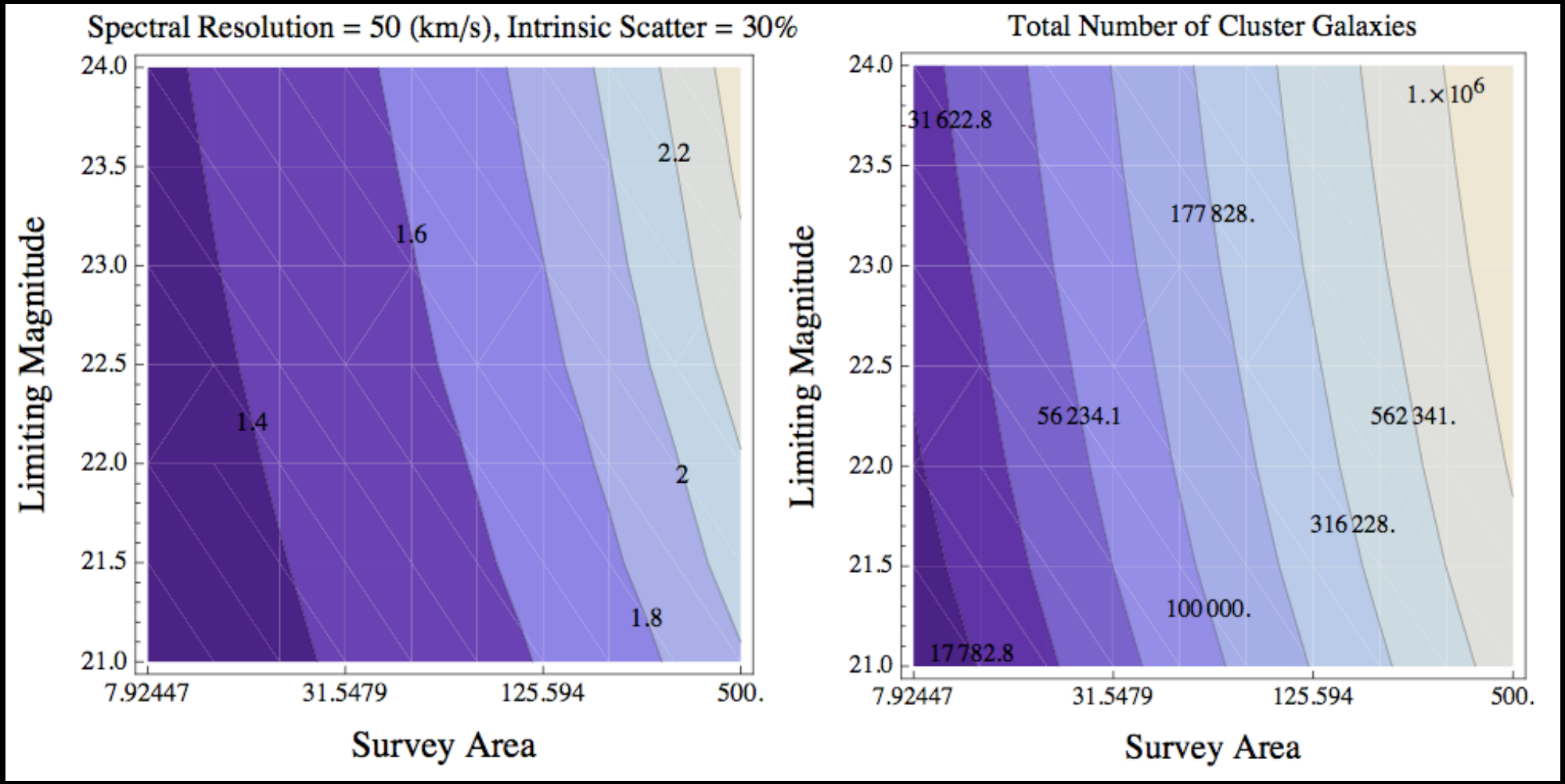
Impact of Intrinsic Scatter on FoM

FoM improvement degrades if the mass-richness scatter is larger: need a robust optical mass proxy over wide range of mass and redshift



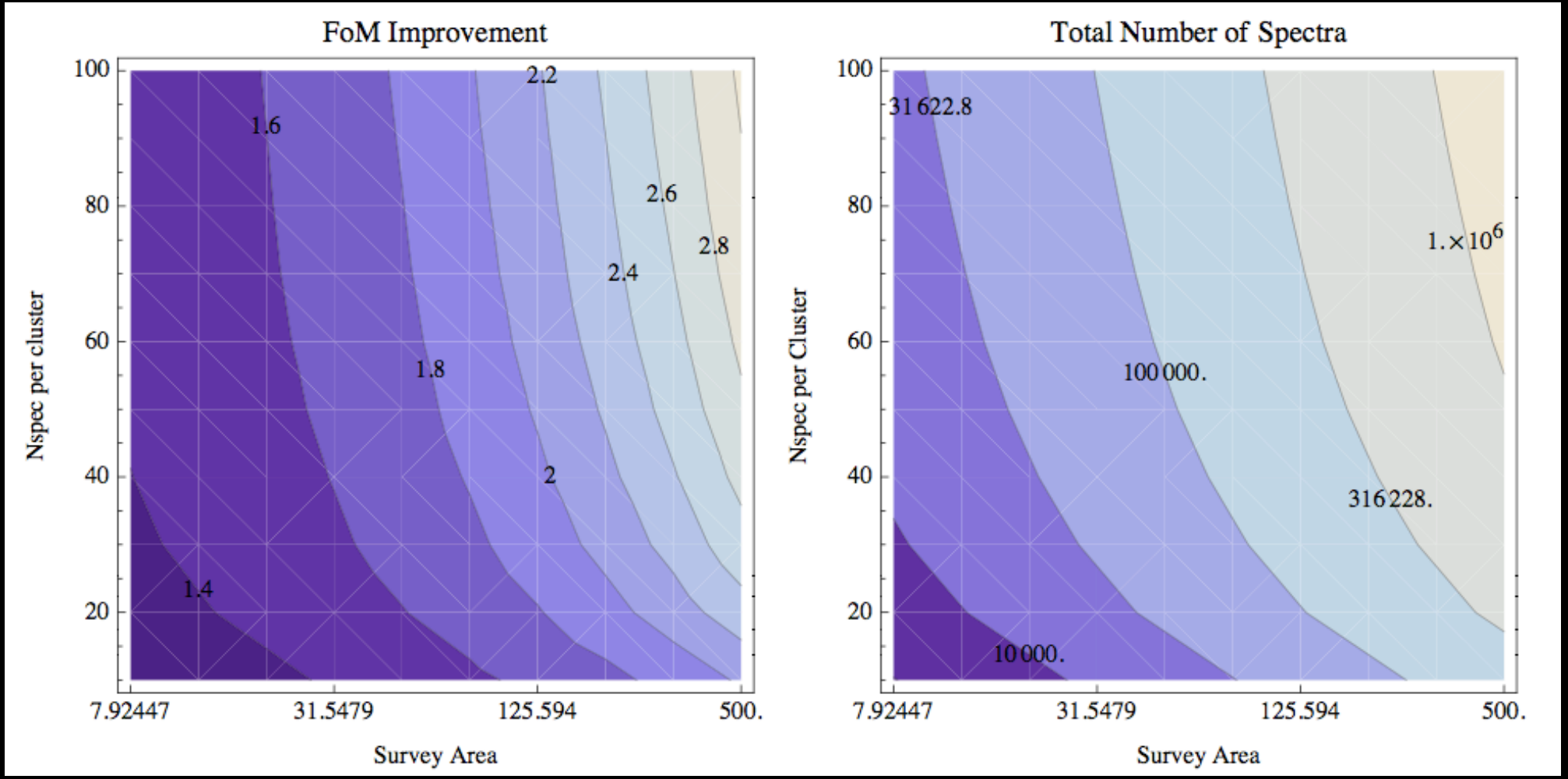
Lots of Targets!

FoM improvement ⟶ Required # Velocities

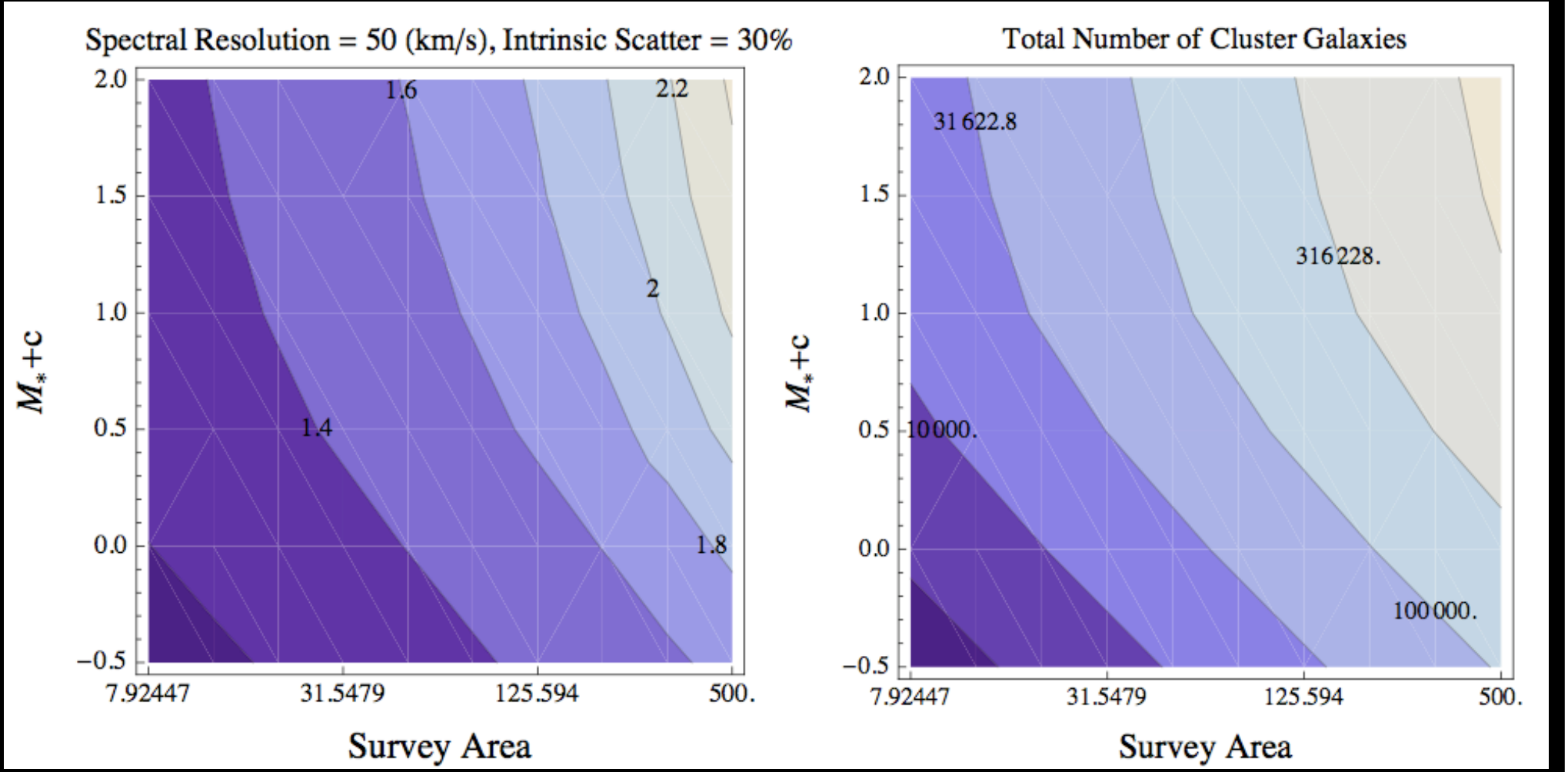


fiber density is a serious issue for cluster work

FoM Improvement: *Fixed N*



Time-Optimized: *Fixed Luminosity*



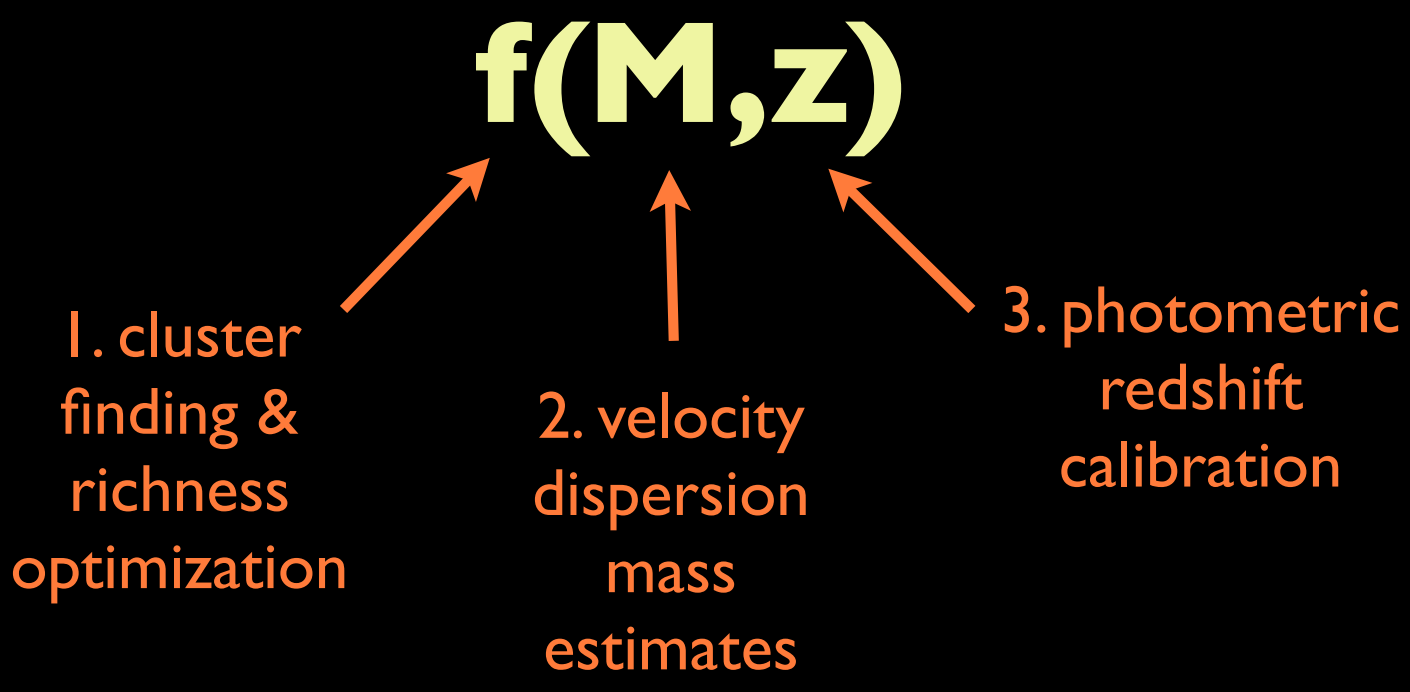
HOWEVER

Needs Consideration

- Target/fiber density
- Realistic completeness, including as f(z)
- Scatter, velocity bias as f(z)
- Have not yet incorporated WL or SZ calibration (only self-calibration). With those, the $FoM_{fiducial}$ may be higher, and thus the $FoM_{spec}/FoM_{fiducial}$ weaker.
- Need to consider optimizing for fixed telescope time, with some realistic assumptions.
- How many spectra do we need to calibrate richness & cluster photo-zs?
- Other cluster galaxy science has different demands

Summary

Spectroscopic followup has the potential to strengthen cluster cosmology in three complementary ways:



Now essential to consider some practicalities!