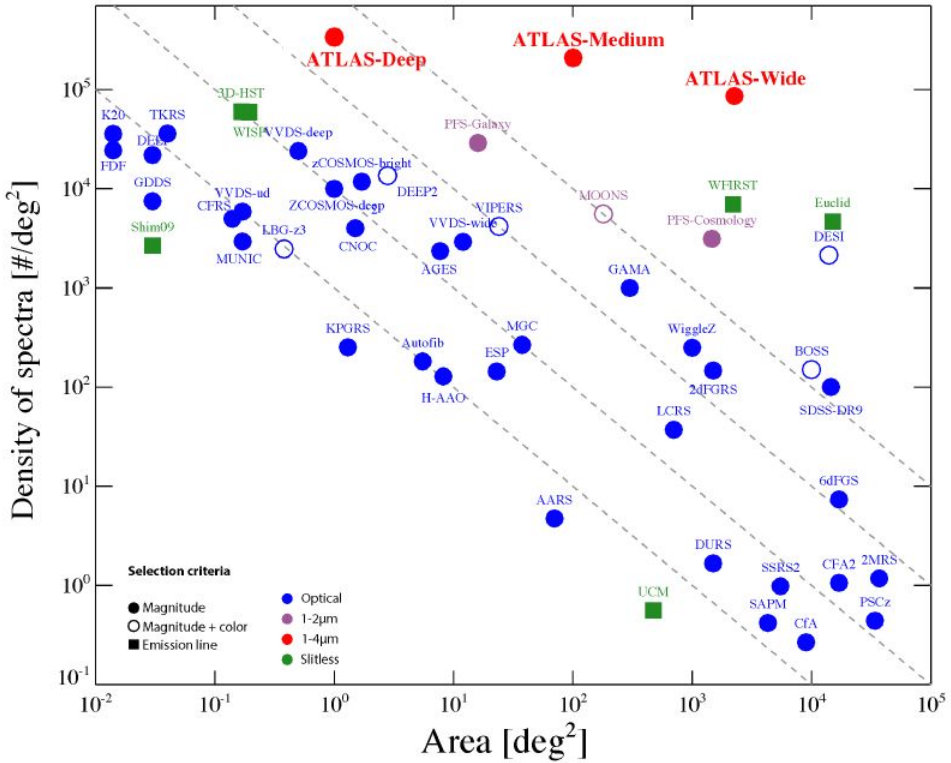
Higher Order Statistics with ATLAS

Lado Samushia - Kansas State University

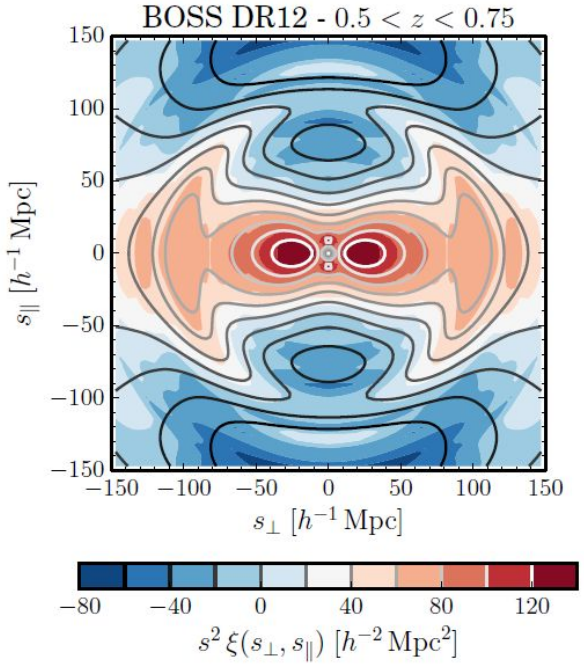
Cosmology with ATLAS



For cosmology we need large Volume and high number density. Multiple tracers in the same volume is a great plus.

ATLAS is great for cosmology!

Standard Analysis of Galaxy Surveys

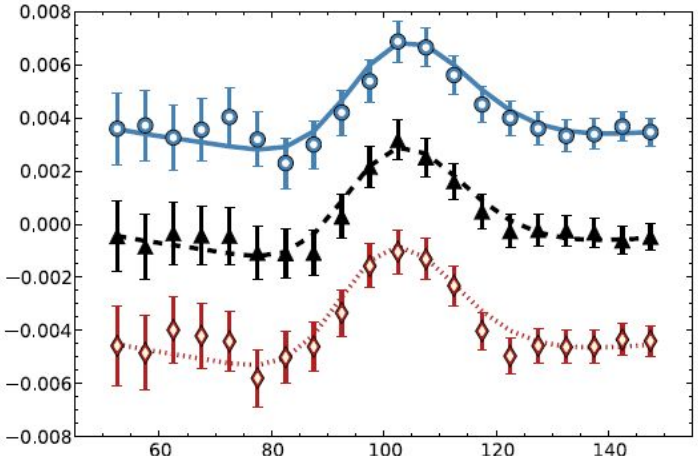


BOSS DR12

Measure 2-point statistics on linear/semi-linear scales.

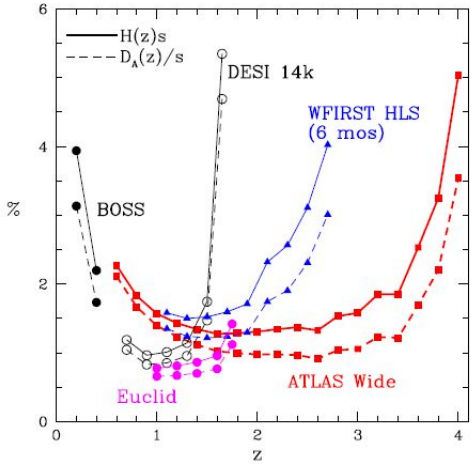
Detect BAO peak, Measure RSD/AP from anisotropy.

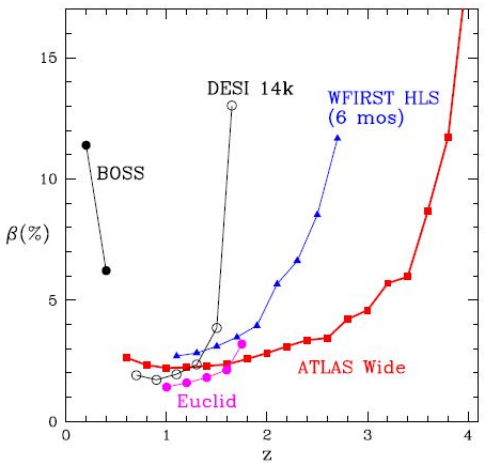
Most contribution to FOM comes from distortions not the shape



Galaxy Surveys Pre-Atlas

- We managed to make 1% BAO measurements (and 5% RSD measurements) with BOSS
- DESI/Euclid will push these to multiple sub-percent (~ 1 percent measurements)
- By the time ATLAS gets data we will have well-tested BAO/RSD pipelines that have been validated at that precision.



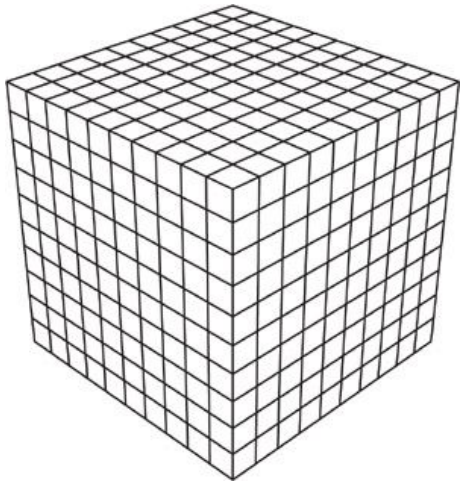


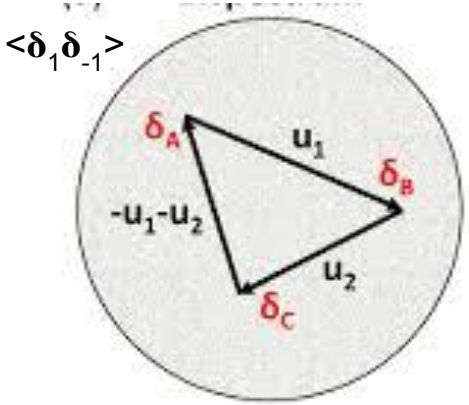
Non-Standard Analyses

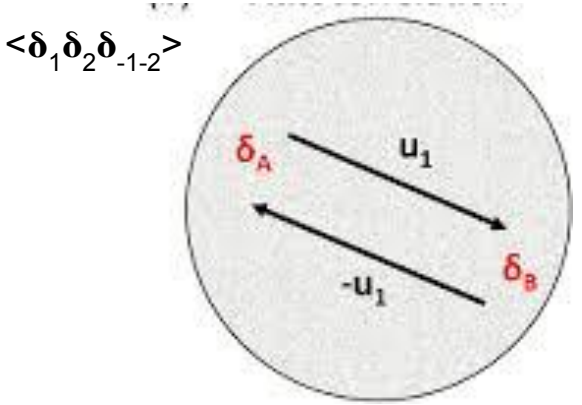
- Multitracer BAO/RSD
- WL + spectroscopy
- WL + clustering
- SN
- Clusters
- **Higher order statistics**

Bispectrum

- Power spectrum – square of the amplitude at each lattice point. Function of a vector **k**. Two independent numbers (k, μ)
- Bispectrum – product of three lattice points forming a closed triangle. Function of three vectors $\mathbf{k_1}$, $\mathbf{k_2}$, $\mathbf{k_3}$. Five independent numbers (k_1, k_2, k_3, $\boldsymbol{\vartheta}$, ϕ)

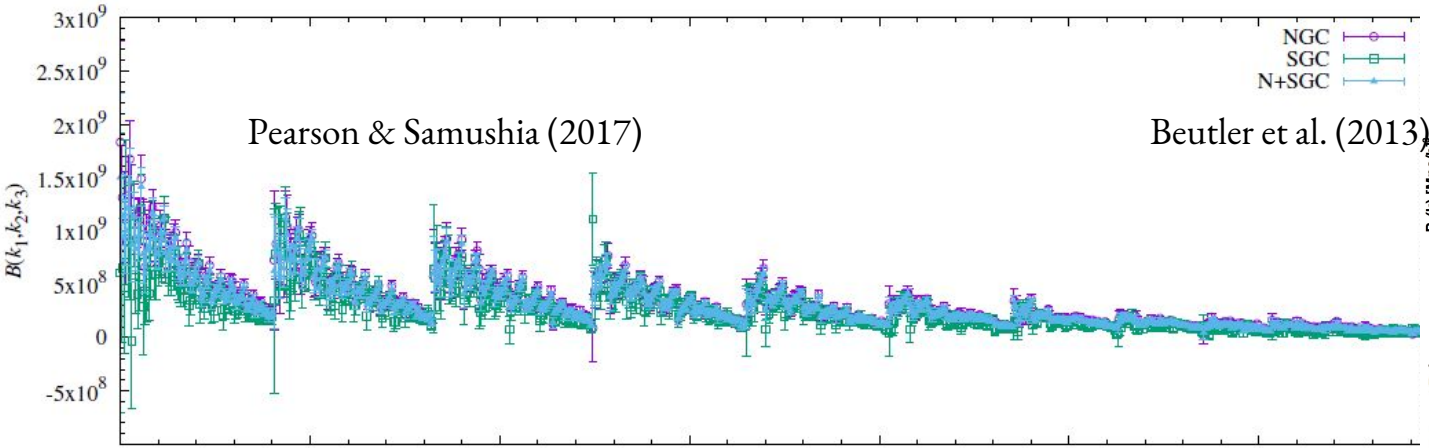


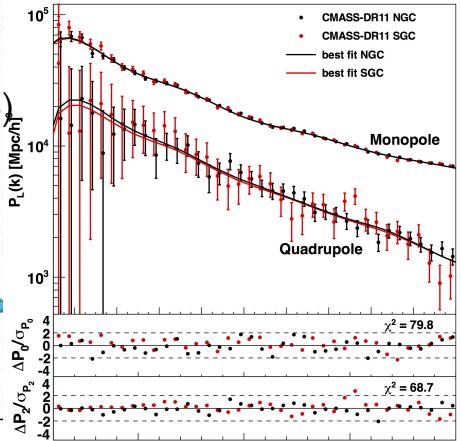




Cosmology from Bispectrum

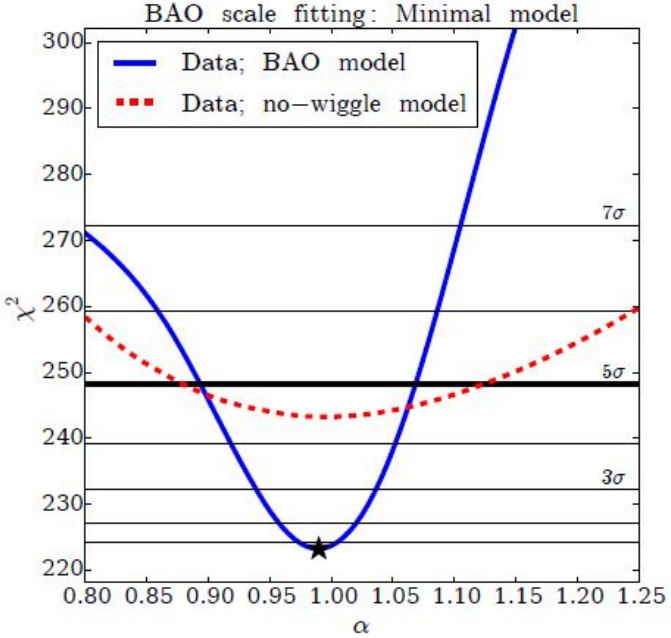
- As a measurement B(k,k,k) is independent from P(k)
- It's expectation value is zero for Gaussian fields
- But non-zero even if f_nl = 0 because of nonlinear bias and gravitational evolution.
- While B(k,k,k) shape does not contain that much additional information compared to P(k), the distortions. B(k,k,k) in some cases do contain quite a lot of extra information

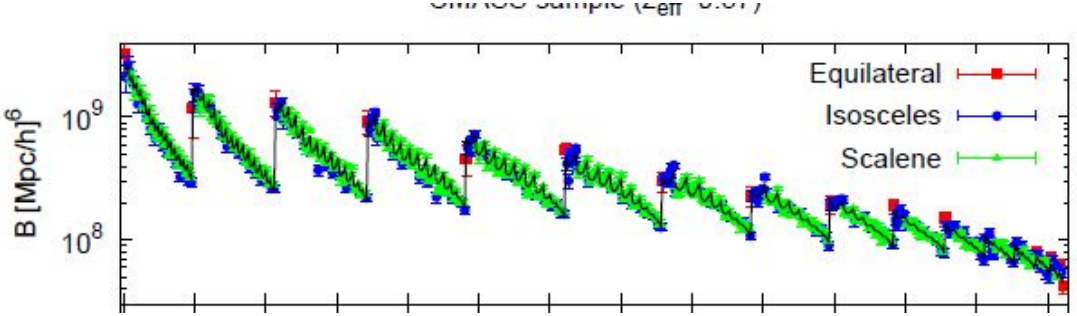




Existing Bispectrum Analyses (BOSS DR12)

Slepian et al. (2016)

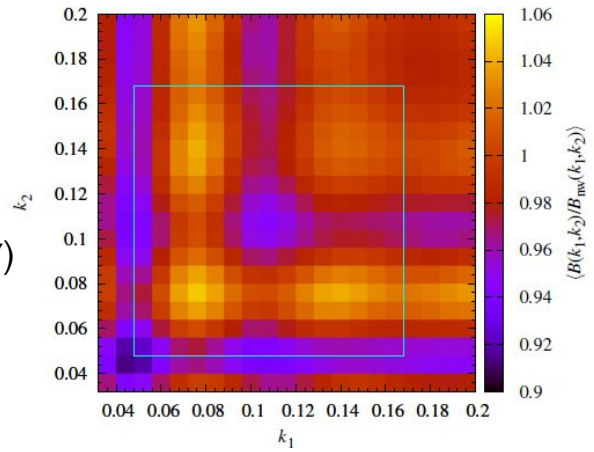




Gil-Marin et al. (2016)

Pearson & Samushia (2017)

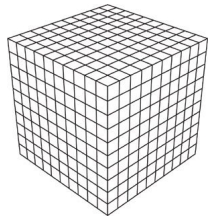
(2% BAO)



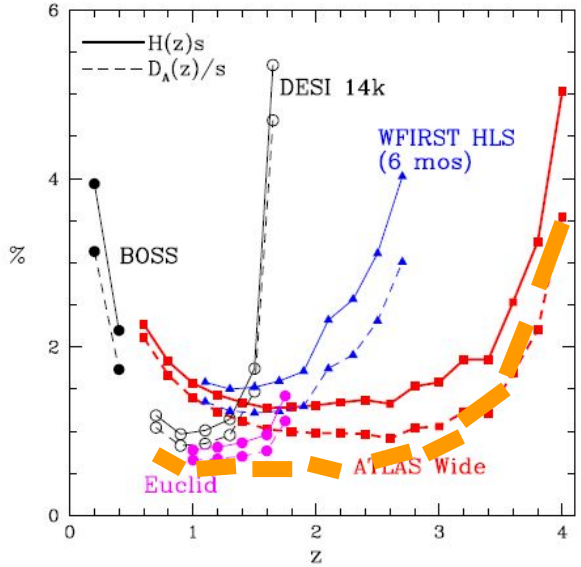
Can Bispectrum be Competitive?

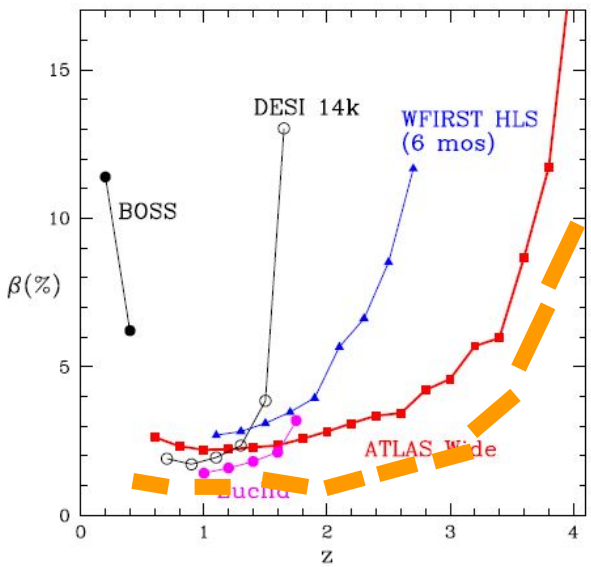
- Shot noise scales like $\mathbf{1/n}$ for P(k) and $\mathbf{1/n^2}$ for B(k,k,k)
- Number of pairs scales as $\mathbf{k^3_{max}}$ for P(k), number of triangles scales as $\mathbf{k^6_{max}}$ for B(k,k,k)
- For competitive B(k,k,k) constraints we need high density and ability to push to higher wavenumbers

- Let's be ambitious and see what would happen if we were able to analyse the full shape up to k_max = 0.25. Measuring BAO/RSD exactly like we do for the power spectrum.



ATLAS Bispectrum Predictions





On paper, ATLAS Bispectrum (thick orange line) outperforms ATLAS standard/DESI/Euclid.

Can we pull off systematics free sub-percent modeling of bispectrum up to k ~ 0.25 Mpc/h?

Summary

- For dense surveys, information form bispectrum on linear/semi-linear scales can significantly enhance cosmological constraints form standard (2pt analysis)
- ATLAS wide will be ideal for this type of analysis
- The main hurdle is our ability to model higher order statistics to required accuracy
- At high redshifts, where everything becomes more linear, this may be doable