

Quasar-Lyman α Forest Cross-Correlation from BOSS survey: Baryon Acoustic Oscillations

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Few details on me

- Name: Hélión du Mas des Bourboux
- From: France / Dordogne



Few details on me

- Formation:



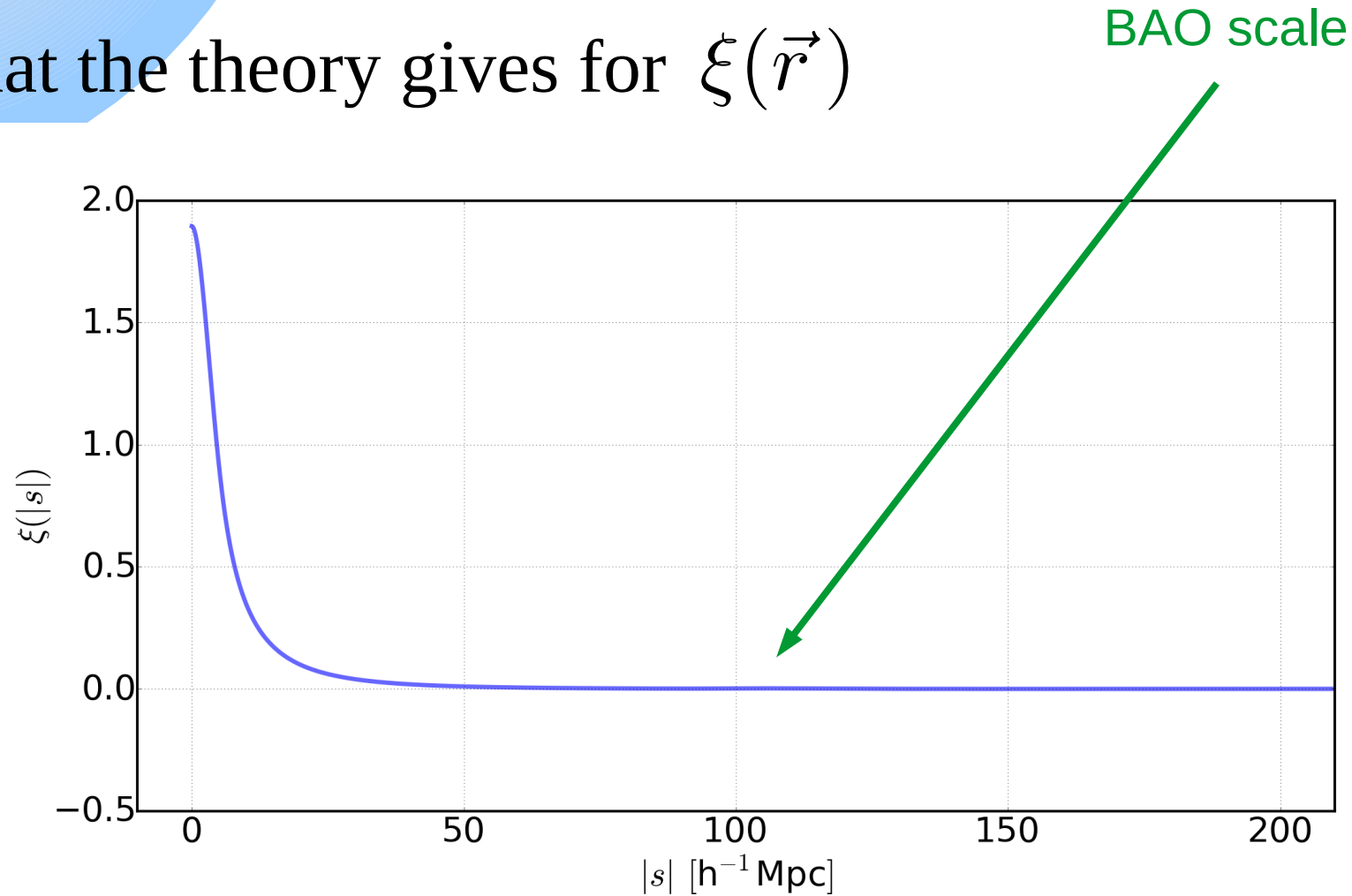
- Contact: found the thesis from the web and the NPAC website
- Motivation:
 - Because it is fun to do fundamental research, even for only 3 years.
 - With this team and this subject because the feeling was good
 - It was dealing with real data.

Outline

- Introduction to BAO cross-correlation
- Matter density tracers
- Results
- Simulations and data comparison

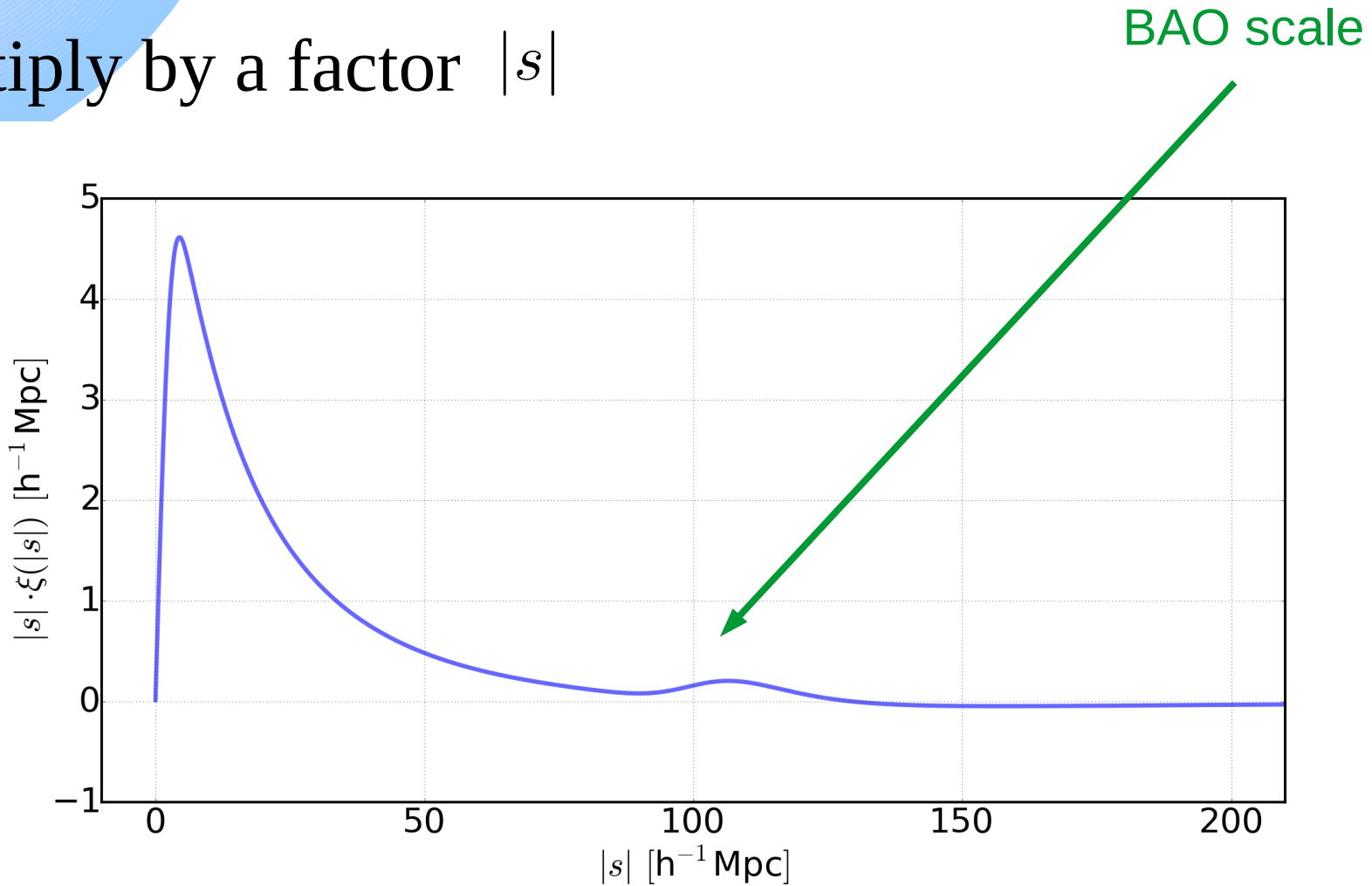
Preface

What the theory gives for $\xi(\vec{r})$



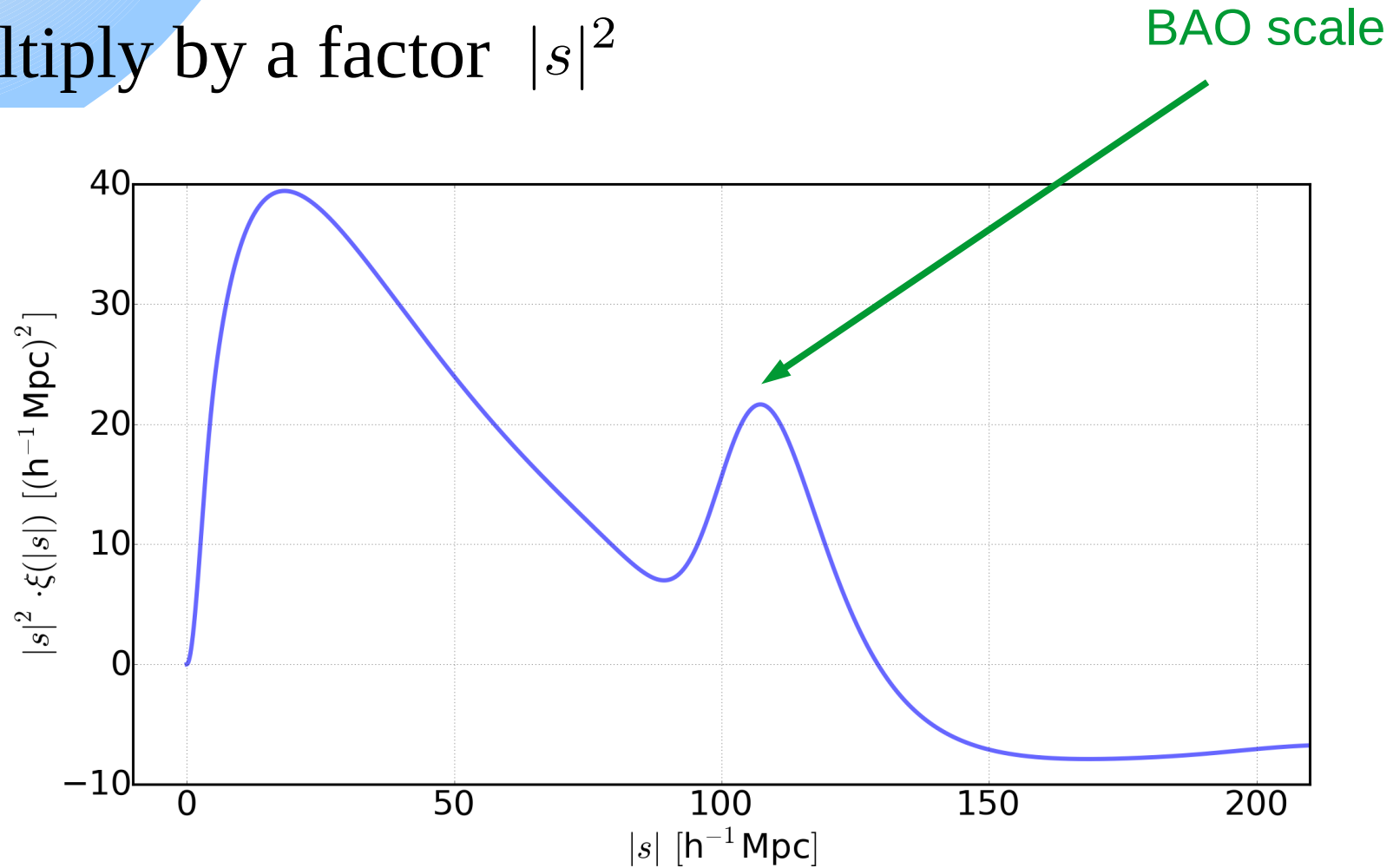
Preface

Multiply by a factor $|s|$



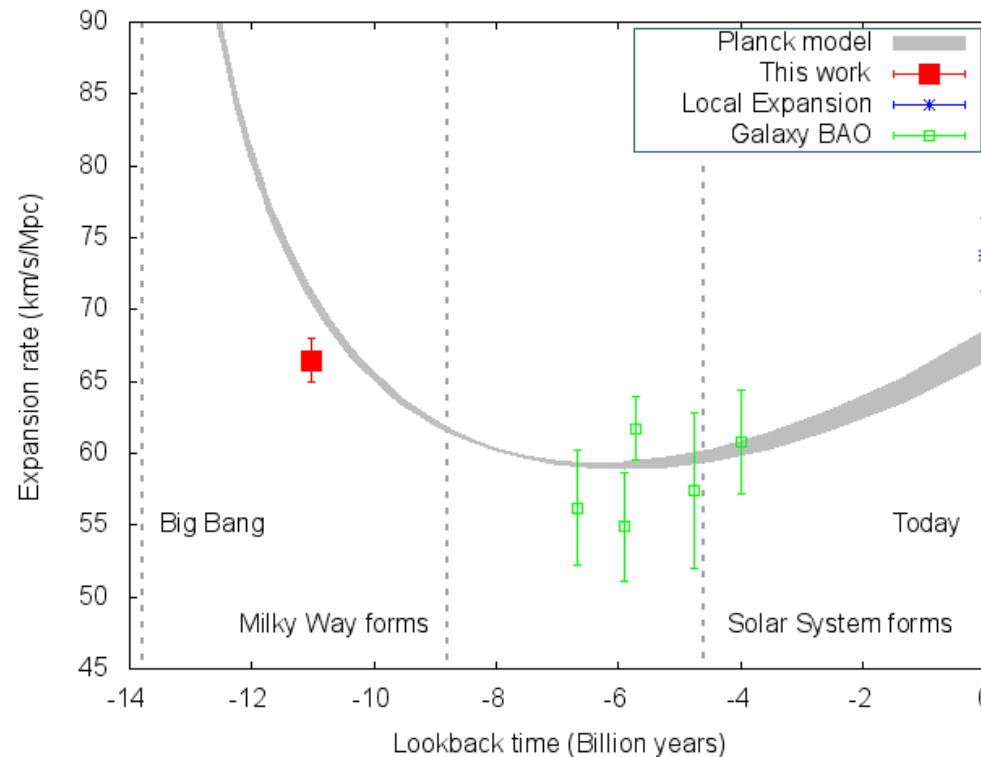
Preface

Multiply by a factor $|s|^2$

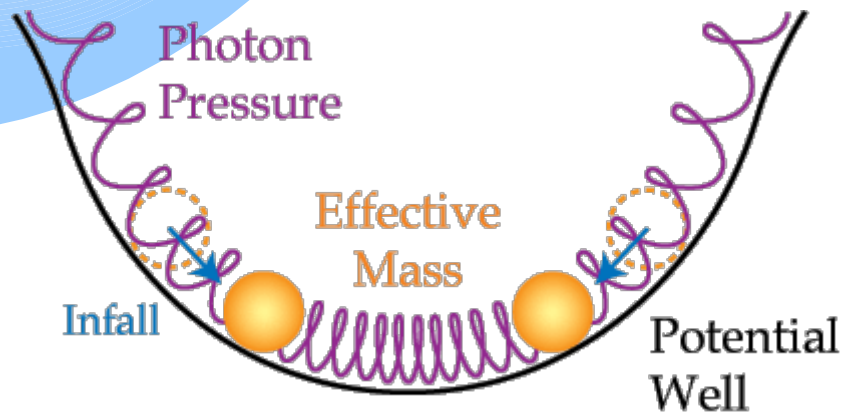


Modern Cosmology

- Modern Cosmology model Λ CDM is very robust
- But uses two unknown components: DE and DM

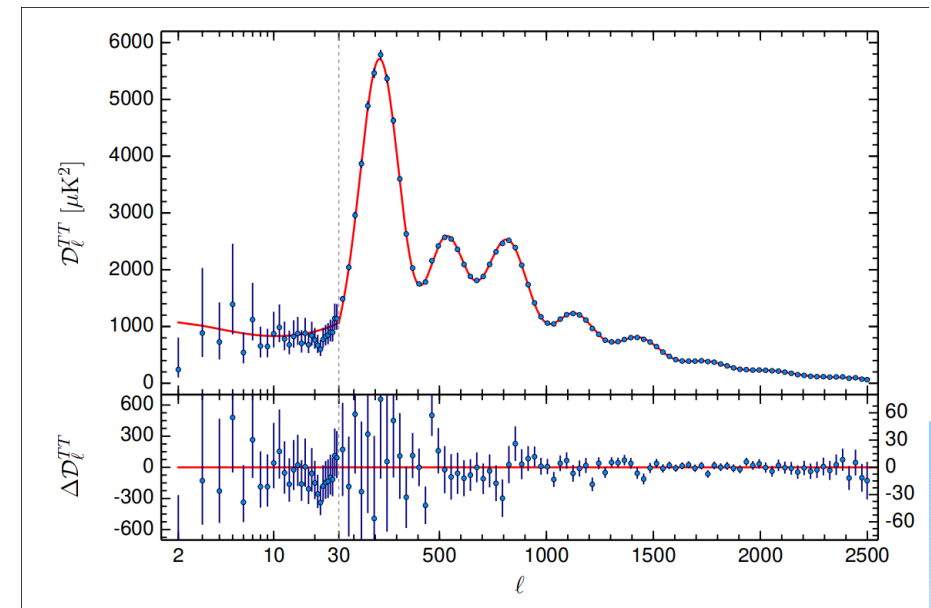


BAO and Cosmology



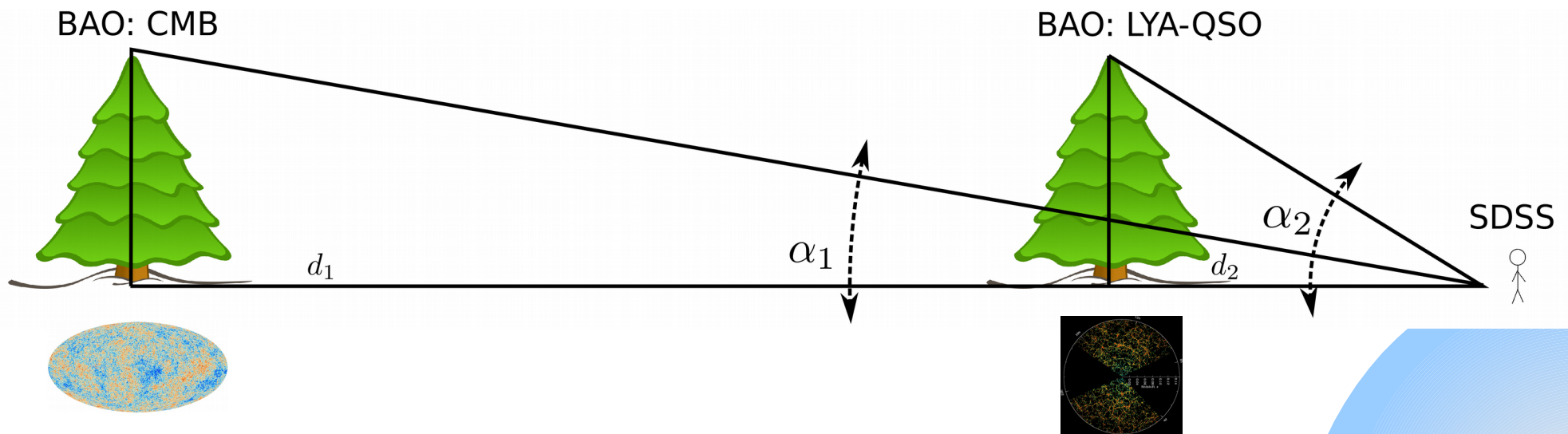
Detected in the CMB matter power spectrum.

Oscillations of the baryon-photon plasma in potential well.



BAO and Cosmology

- A way to understand the nature of DE and DM is to know their density evolution
- Baryonic Acoustic Oscillations allow to do so

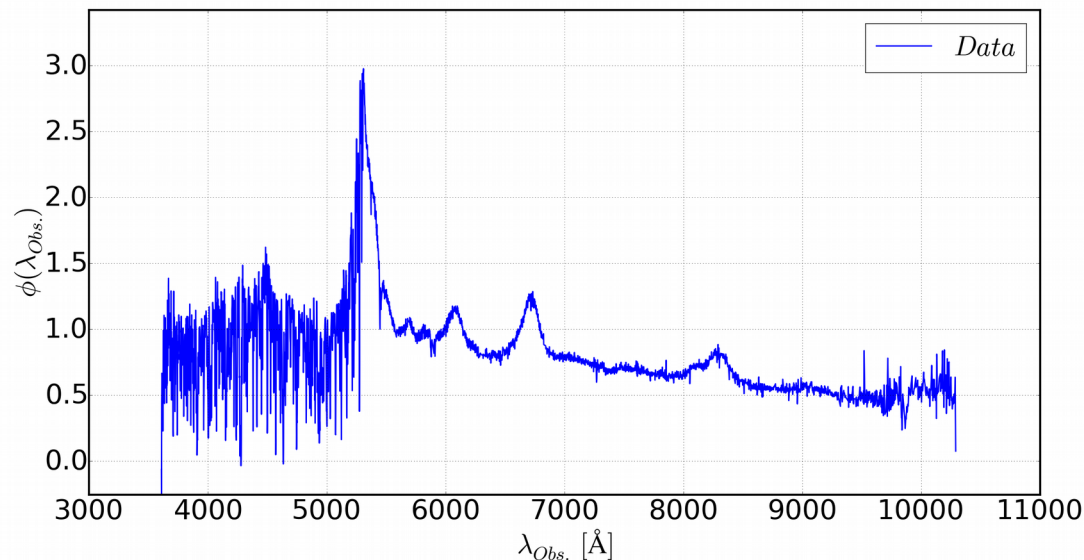


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Quasar

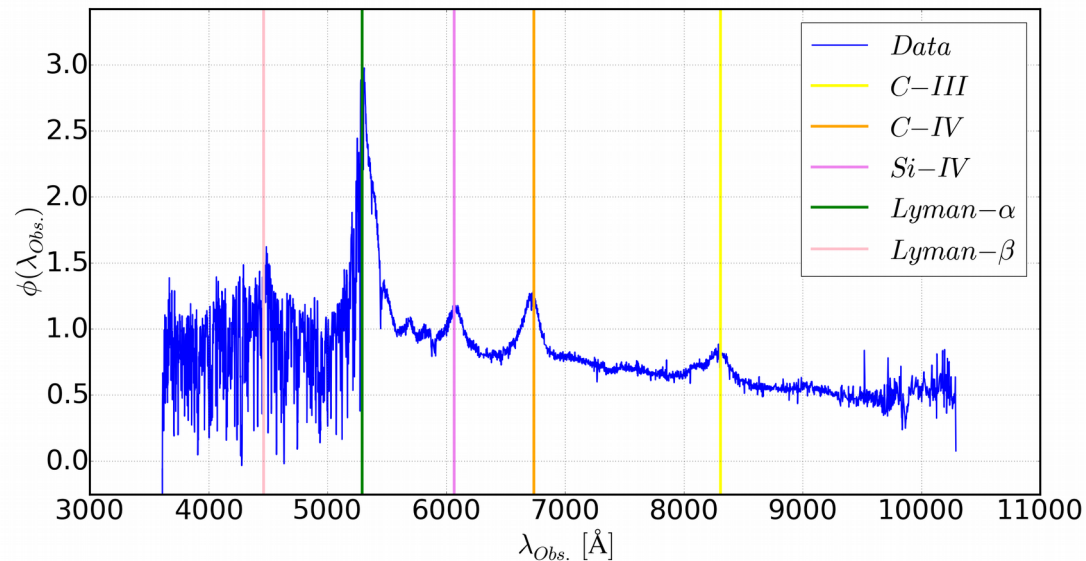
Quasar flux originates from the surrounding of a super-massive black hole



Spectrum of a BOSS Quasar at redshift $z = 3.35$, the Universe was only 2 billion years old

Quasar

Get redshift from emission lines

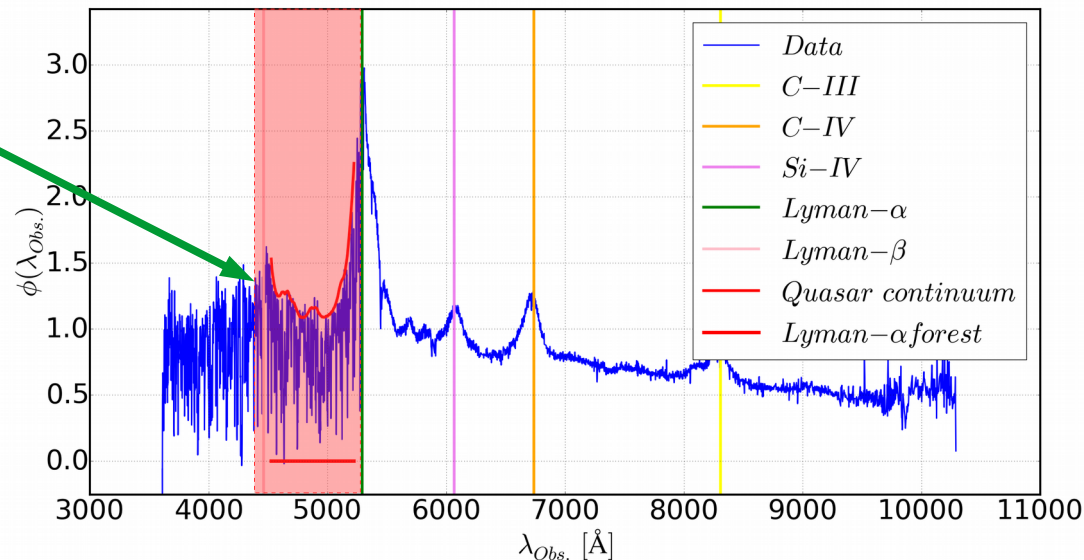


A Quasar is a boolean matter density tracer

Lyman- α forest

Absorption lines from Hydrogen continuum in the Intergalactic Medium (IGM)

Lyman- α forest



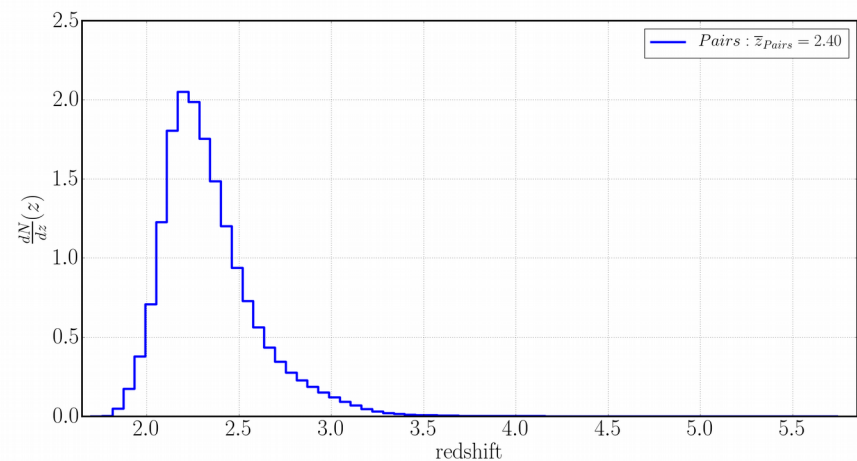
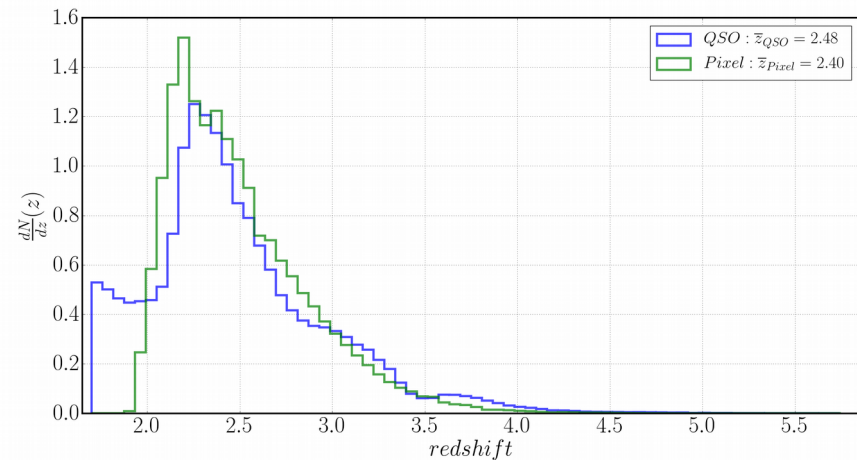
A Lyman- α pixel gives a continuous matter density tracer

Two matter density tracers

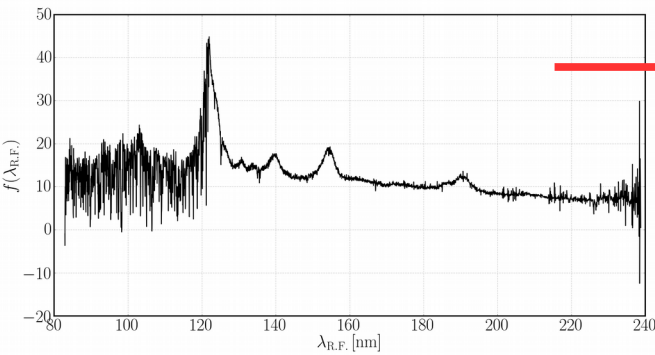
Quasar: $\delta_{qso}(\vec{x}) = \begin{cases} 0 \\ 1 \end{cases}$

Lyman- α forest pixel:

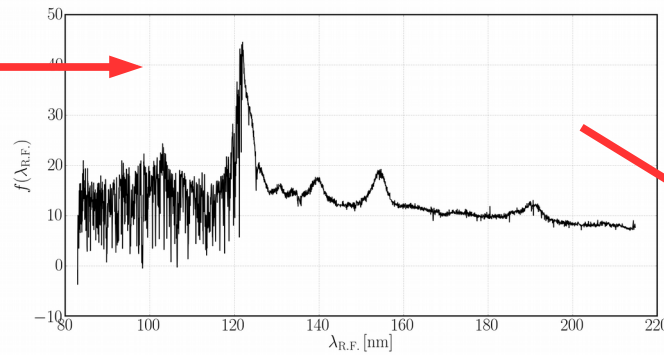
$$\delta_{Ly\alpha}(\vec{x}) = \delta_{\alpha}$$



Extract data

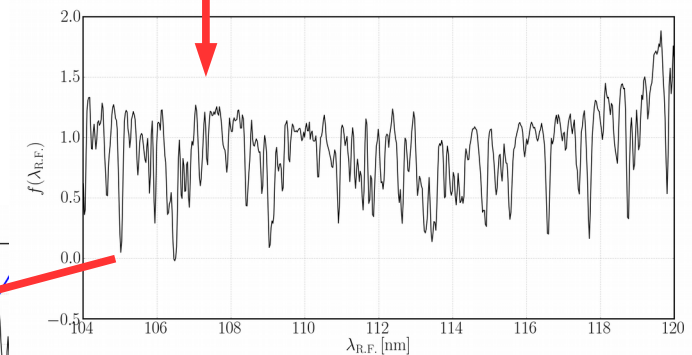
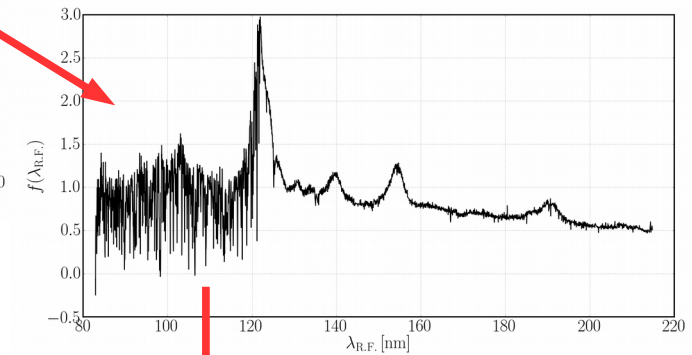


Data



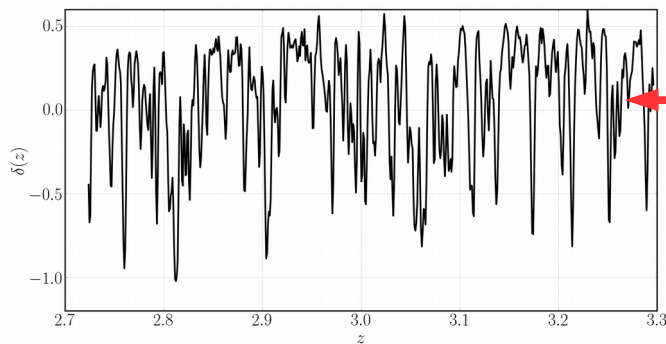
Veto lines and correct from sky and remove CCD boundaries

Normalize spectrum

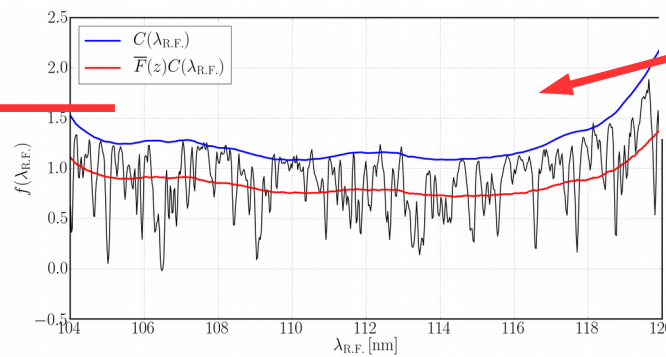


Get only Ly α forest

Matter fluctuation estimator



Fit forest

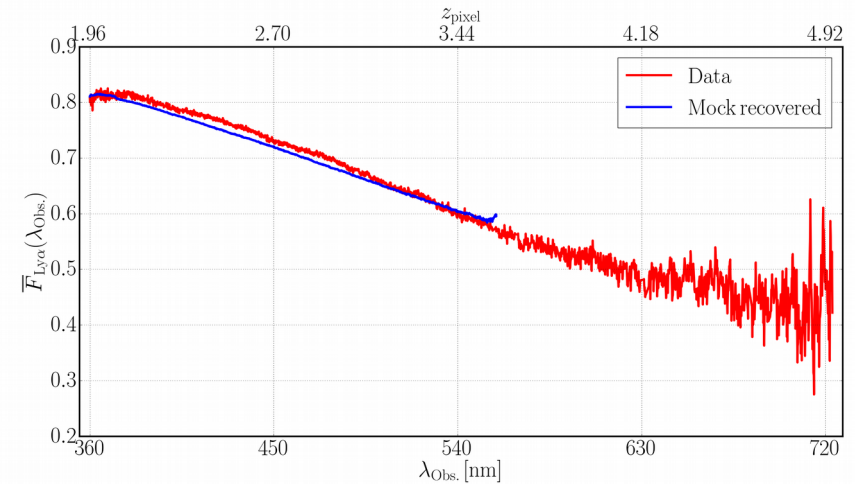
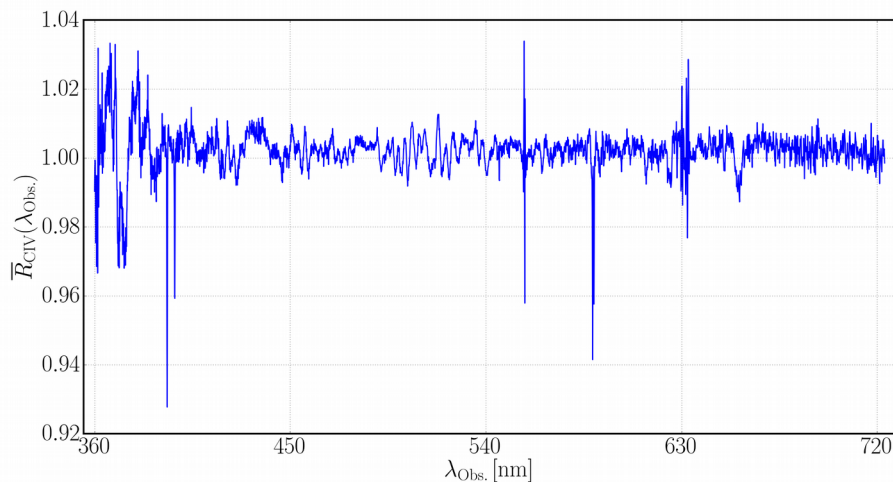


Extract data

Remove effect of the sky and star calibration:

- Light goes through atmosphere and Milky Way
- Flux is calibrated using stars

→ Estimate the correction and veto lines

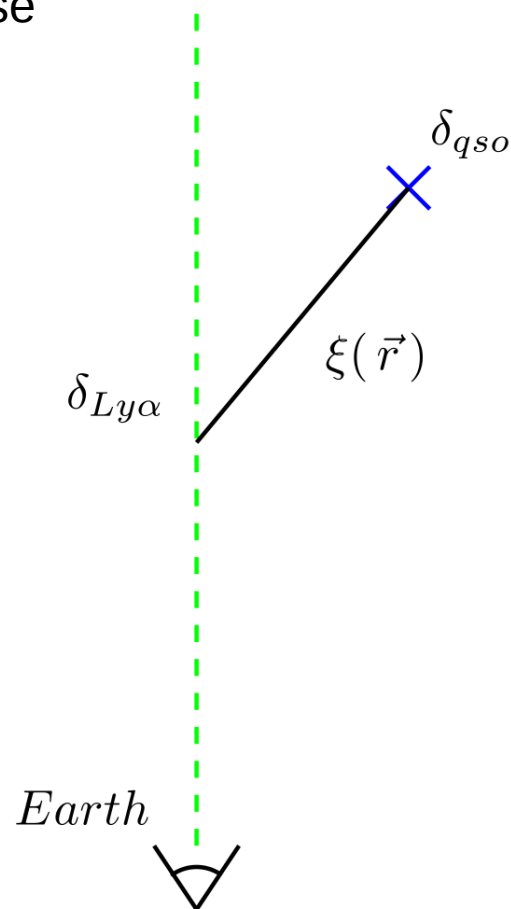


Calculation of the cross-correlation

1 if the distance between the qso and the pixel is in bin A, 0 else

$$\xi_A^{qf} = \frac{\sum_k^{N_{QSO}} \sum_i^{N_{pixel}} \theta_A^{ki} w_i \delta_i}{\sum_k^{N_{QSO}} \sum_i^{N_{pixel}} \theta_A^{ki} w_i}$$

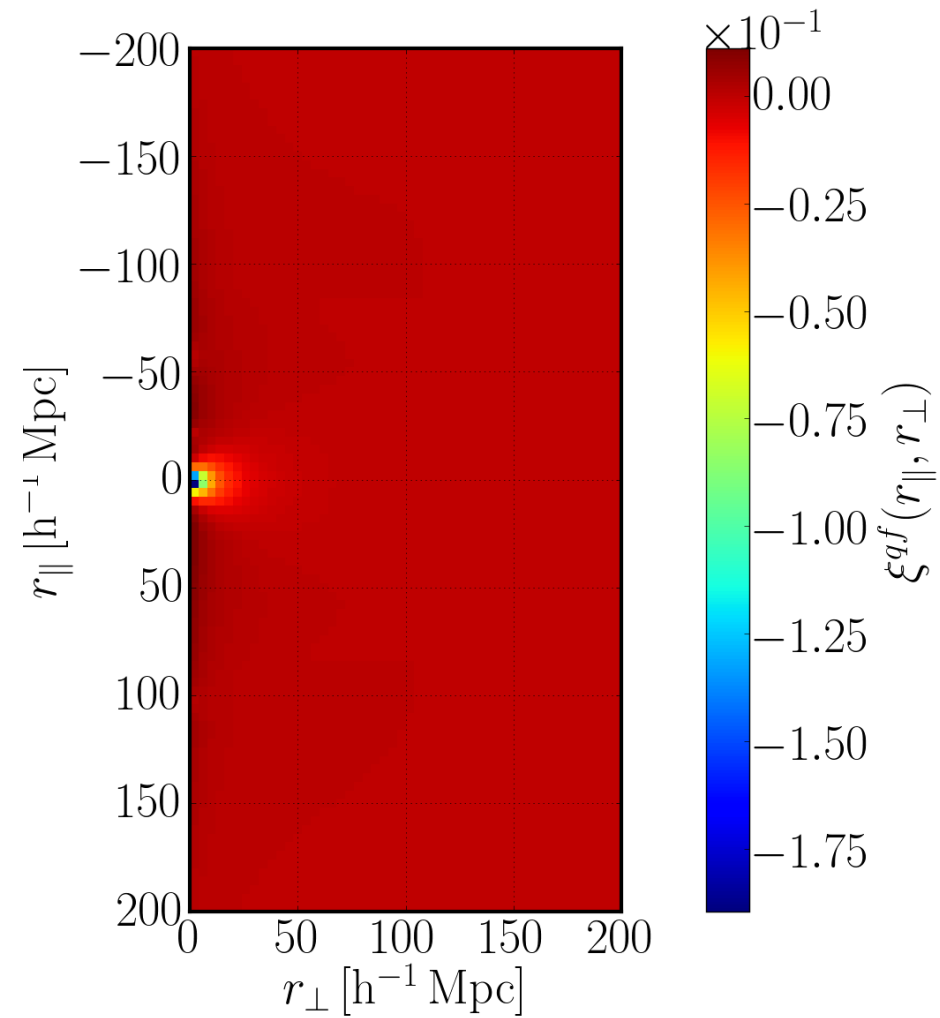
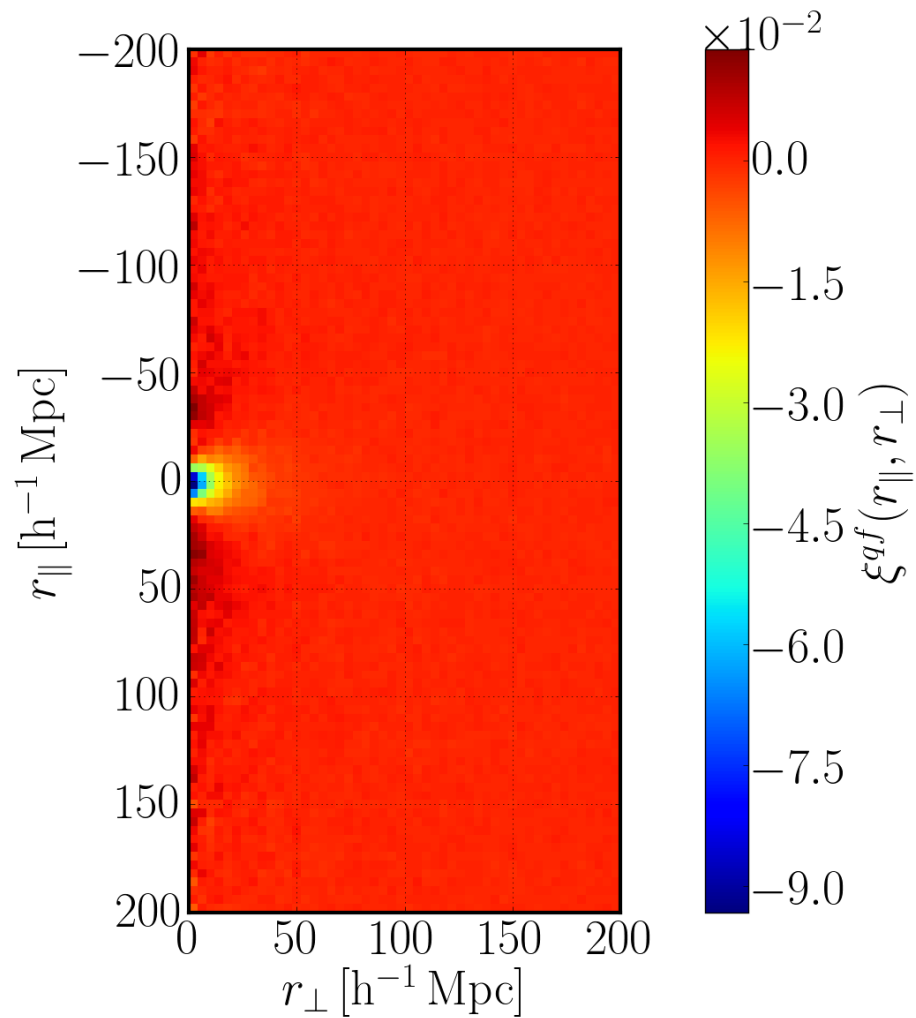
A: one bin



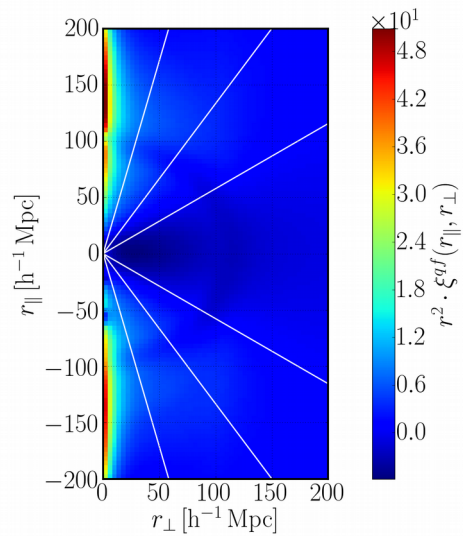
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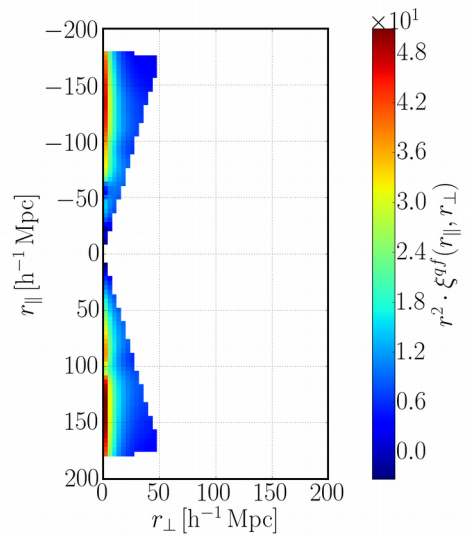
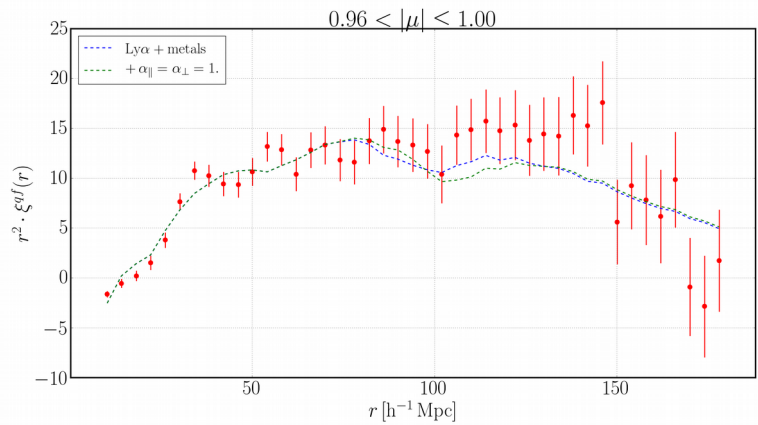
Results



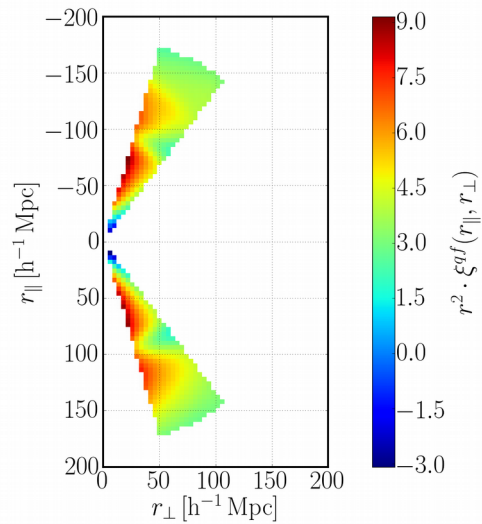
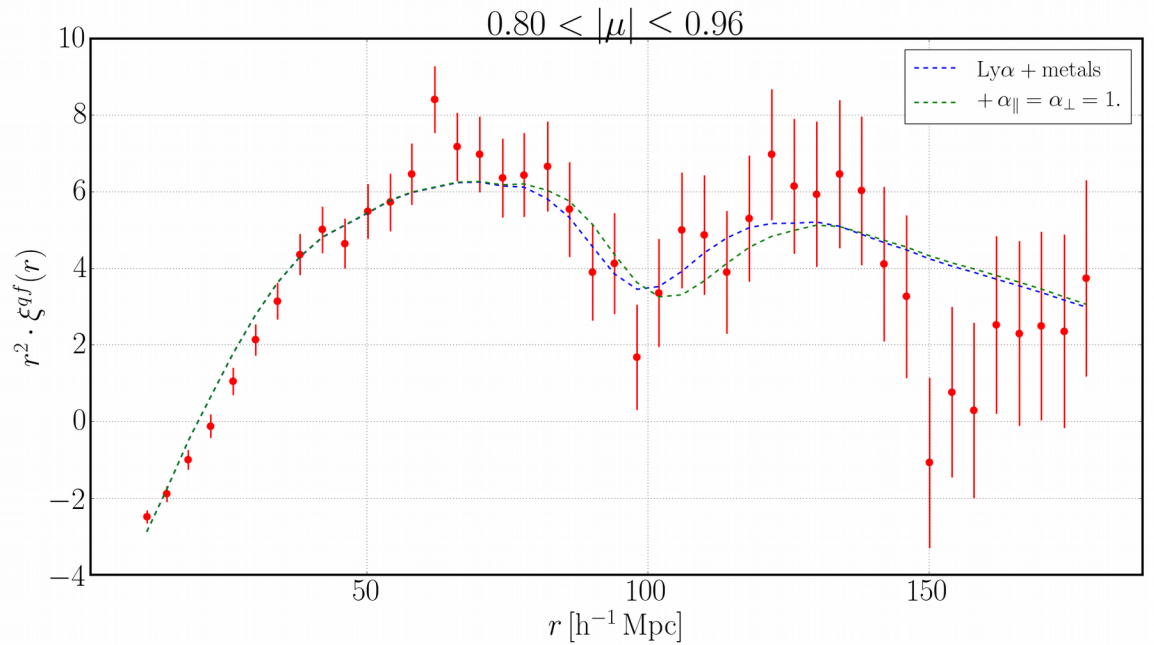
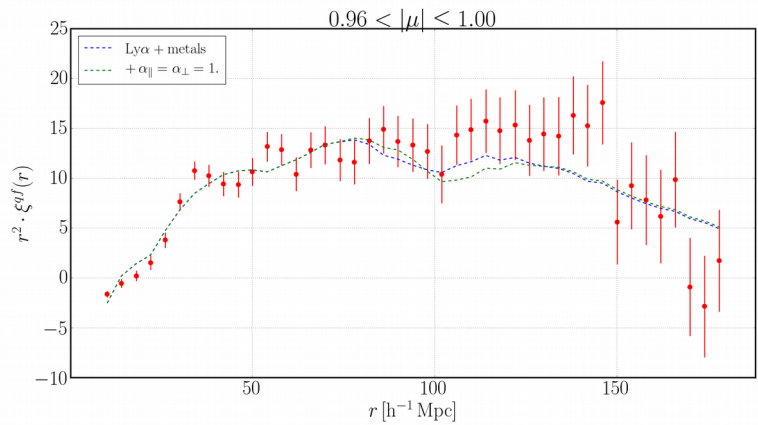
Results



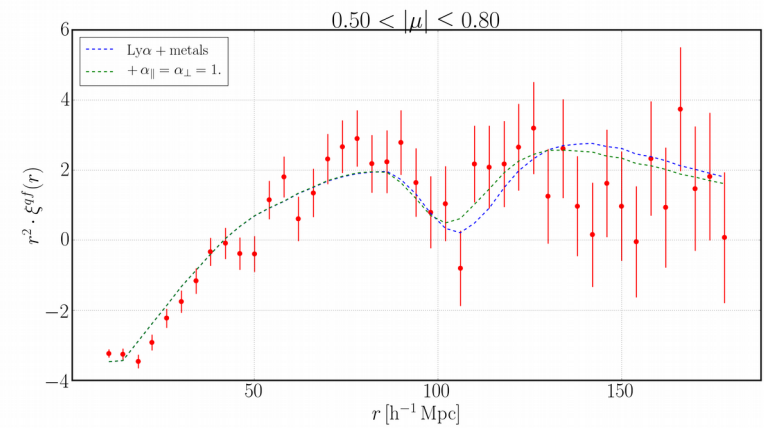
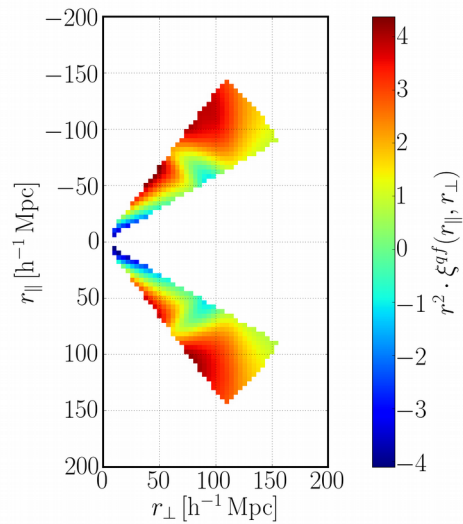
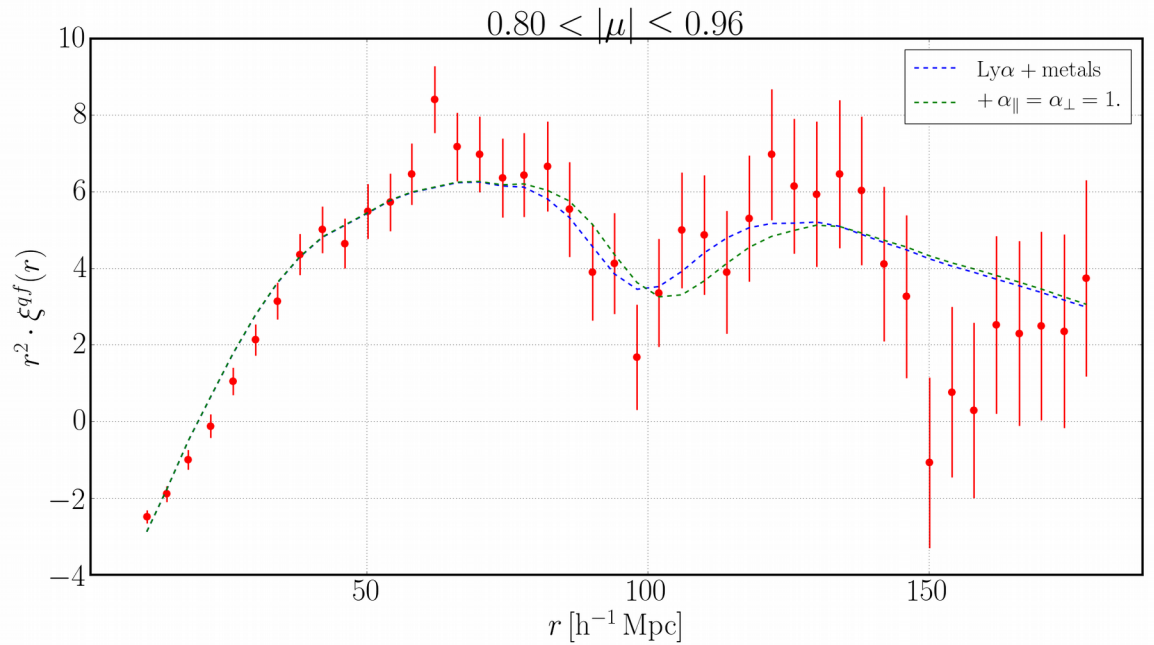
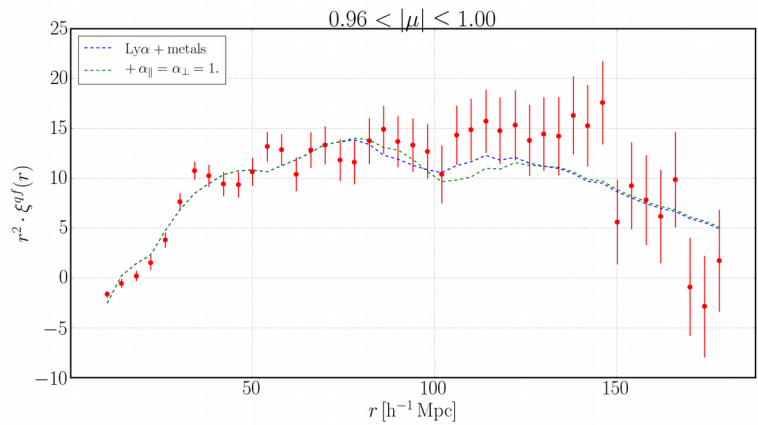
Results



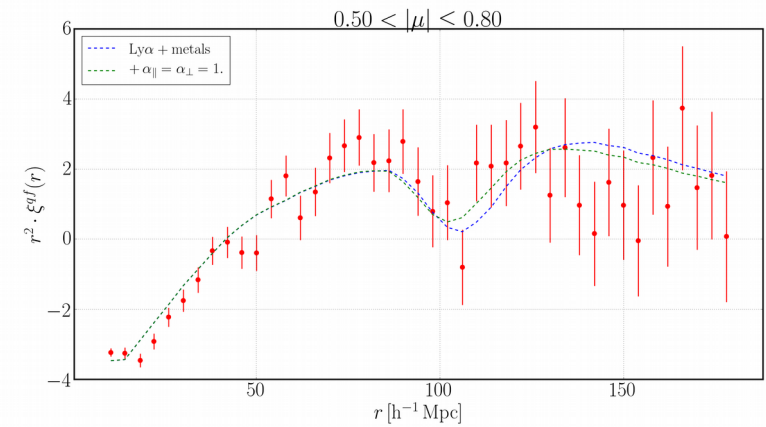
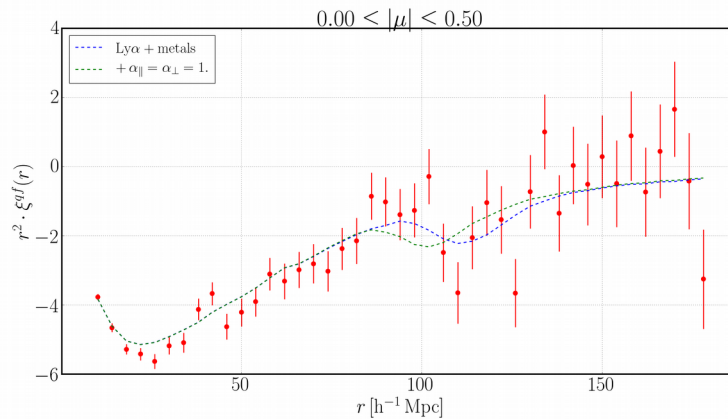
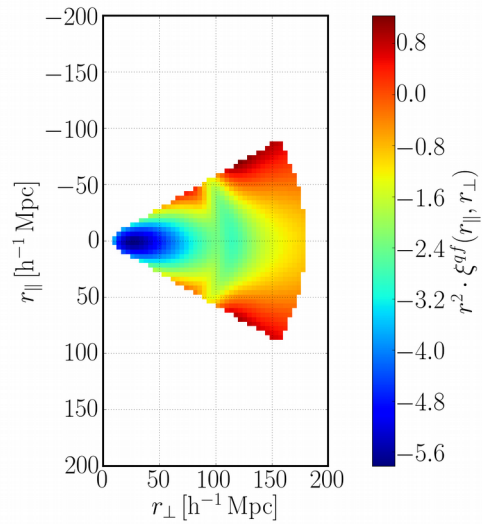
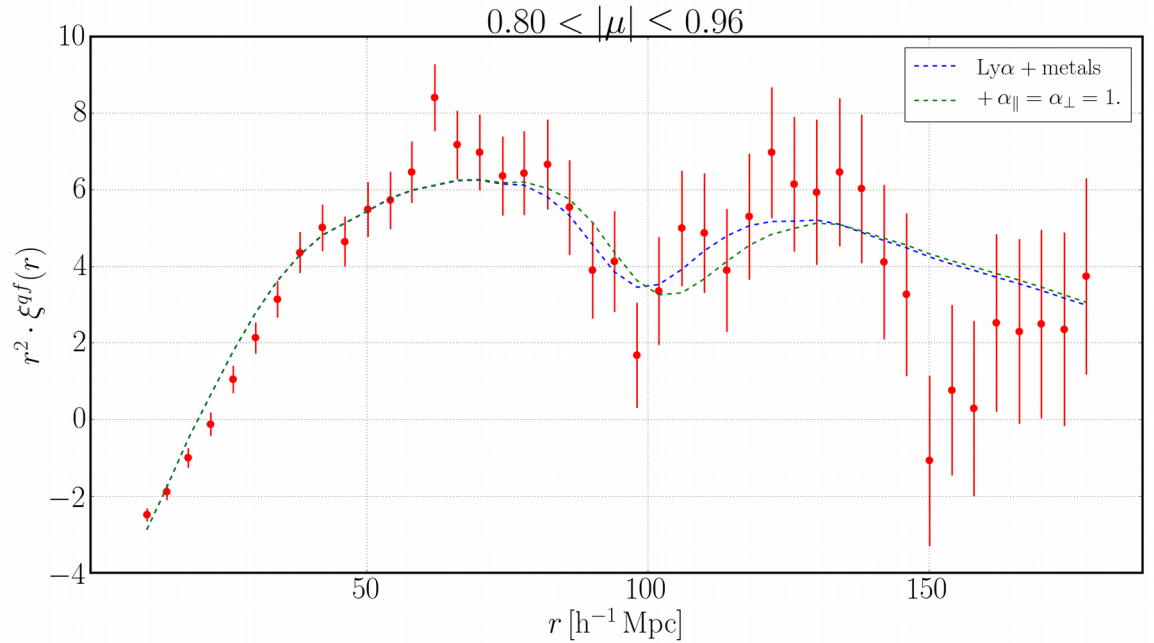
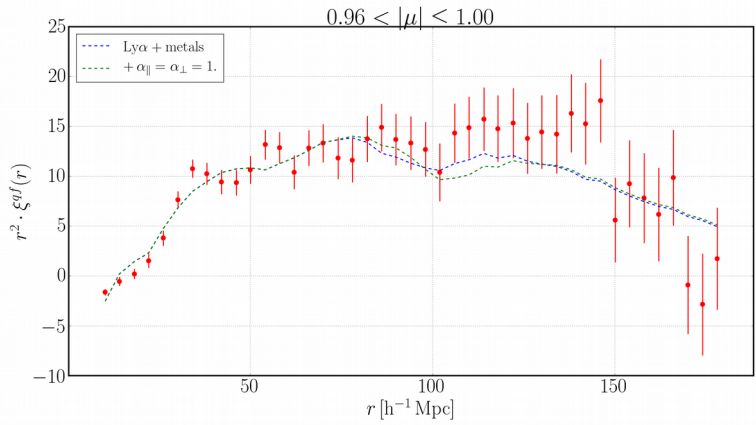
Results



Results



Results



Results

- We get two parameters telling us how far we are from the Planck2014 cosmology.
- When these parameters are one, we have the same cosmology.

$$\alpha_{\parallel} = 1.075^{+0.028}_{-0.034} (sys < 0.008)$$

$$\alpha_{\perp} = 0.892^{+0.045}_{-0.032} (sys < 0.008)$$

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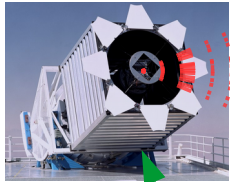
Simulations

- In order to study the robustness of the correlation function:
 - Signal extraction
 - Covariance matrix
 - Bias in measures
 - Error bars of the measures

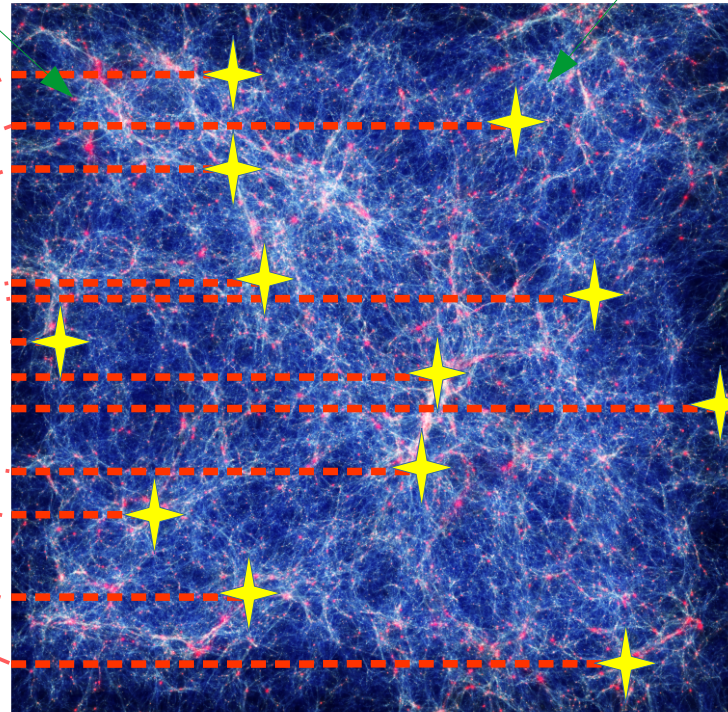
Gaussian Random Field Simulations

Ly α forest along the
line-of-sight

QSO set on big
Over-density

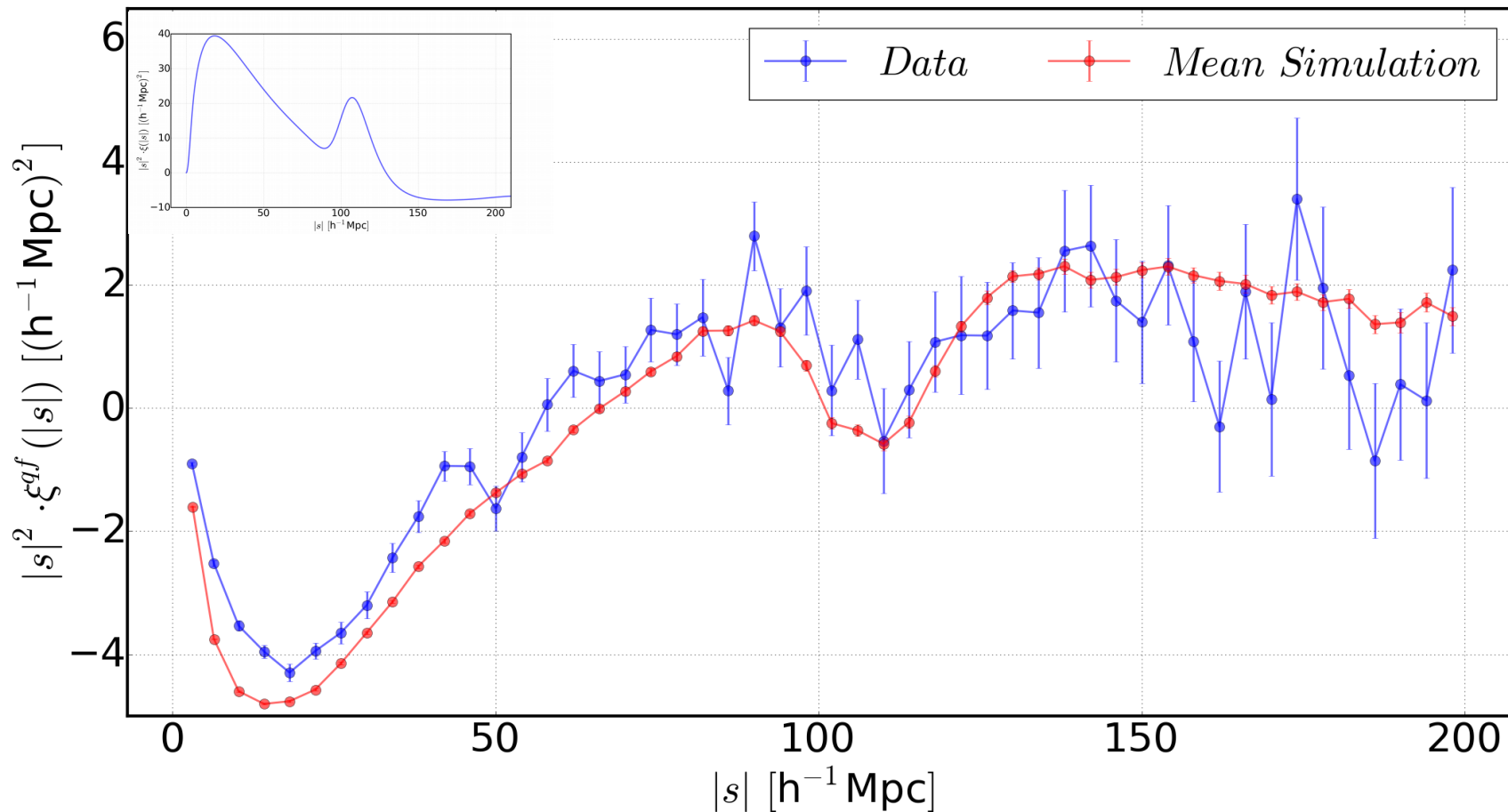


Apply telescope
properties



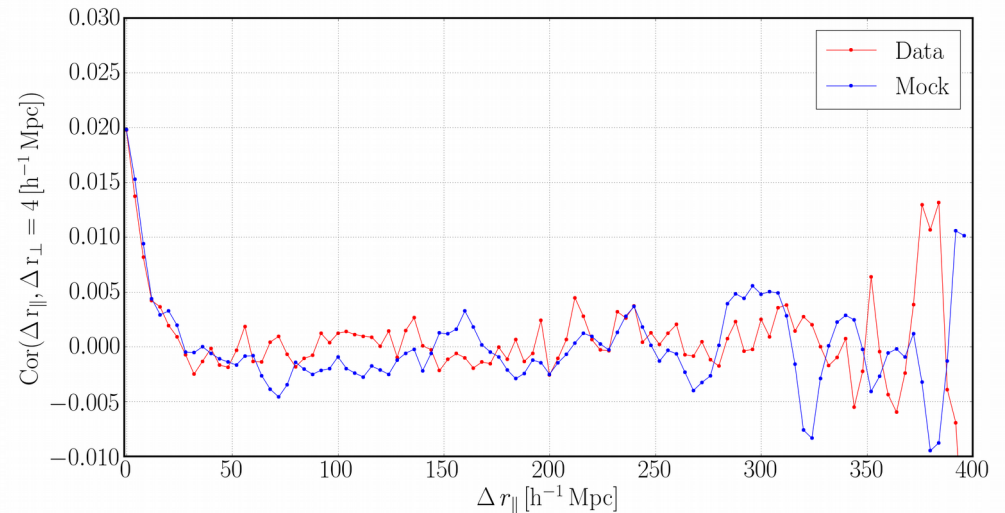
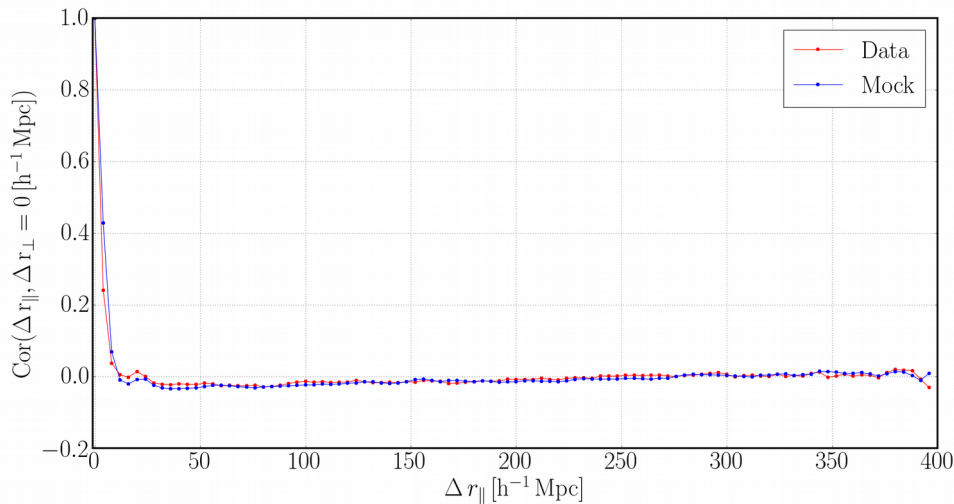
IGM image provided by Julien Baur

Simulation and data



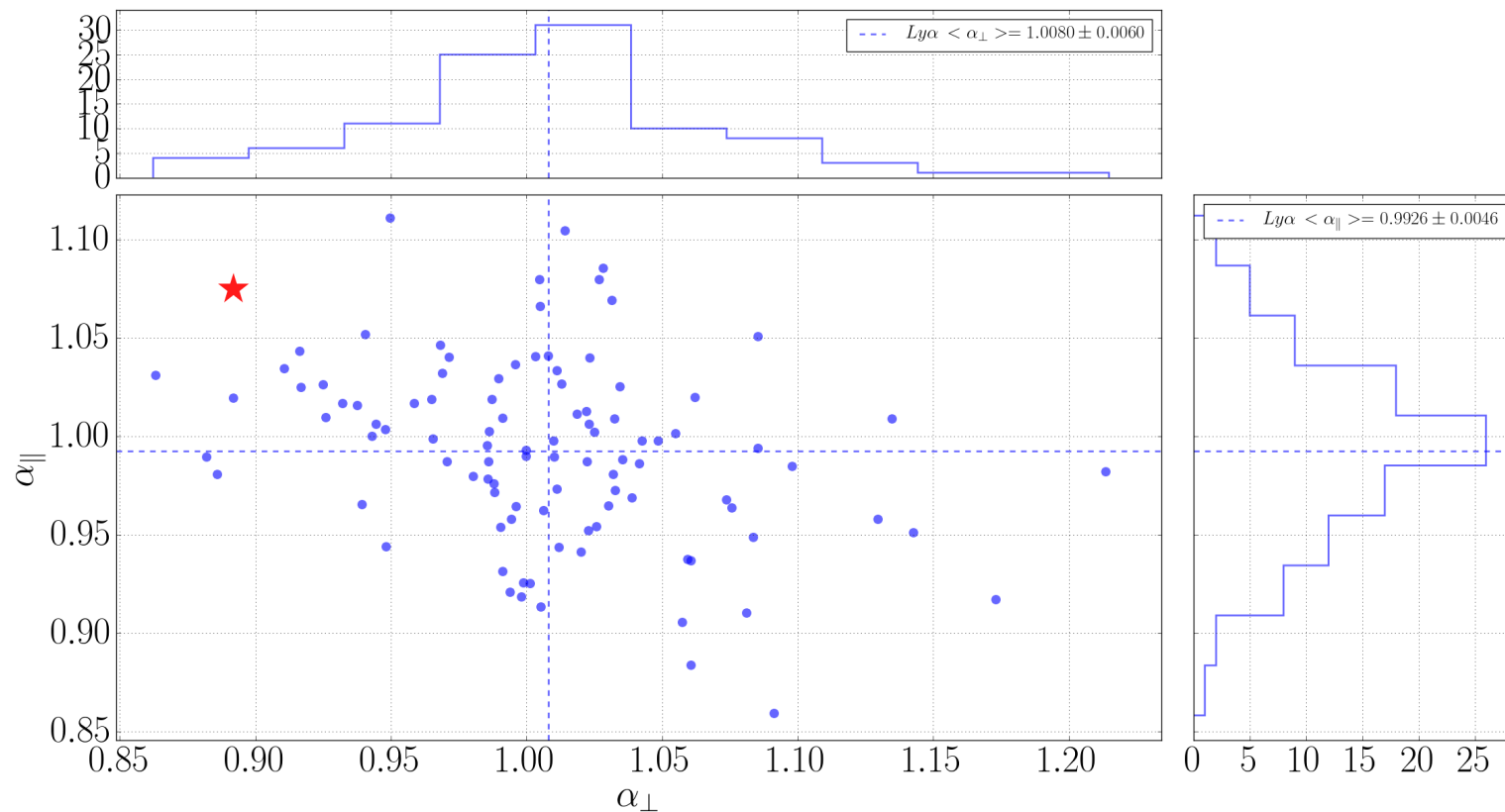
Correlation matrix

- We want to see if the method we use to estimate the correlation matrix is valid.
- Compare sub-sampling on data versus covariance of 100 simulations



Bias and errors on α

- We measure α on each simulation.

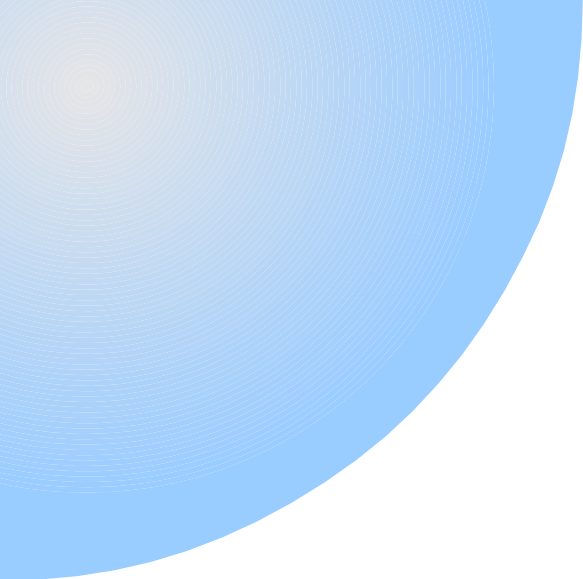


Conclusion

- BAO scale measurements give the DE and DM density evolution.
- Lyman- α forests and quasars give the furthest measures of BAO scale.
- I have developed simulations of the measure. They allow to test its robustness.

Thank you for your attention





Hélion du Mas des Bourboux



DDays

