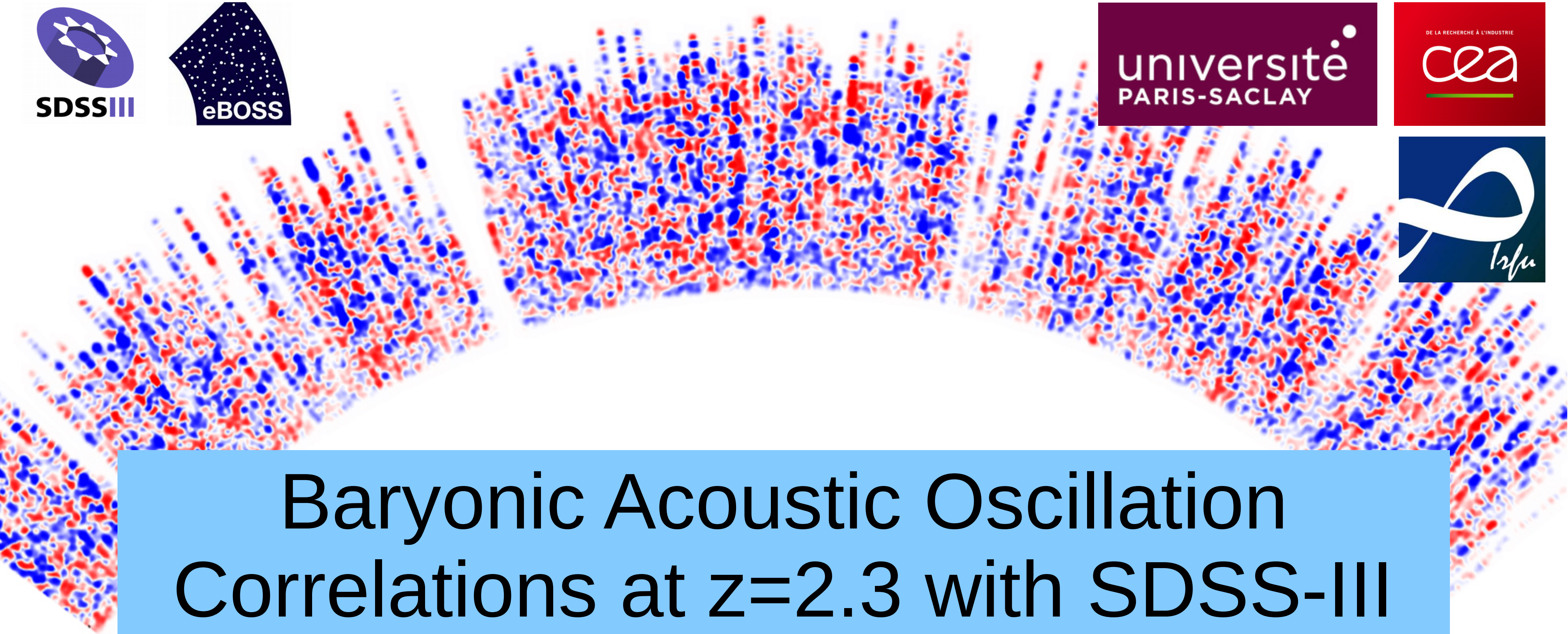
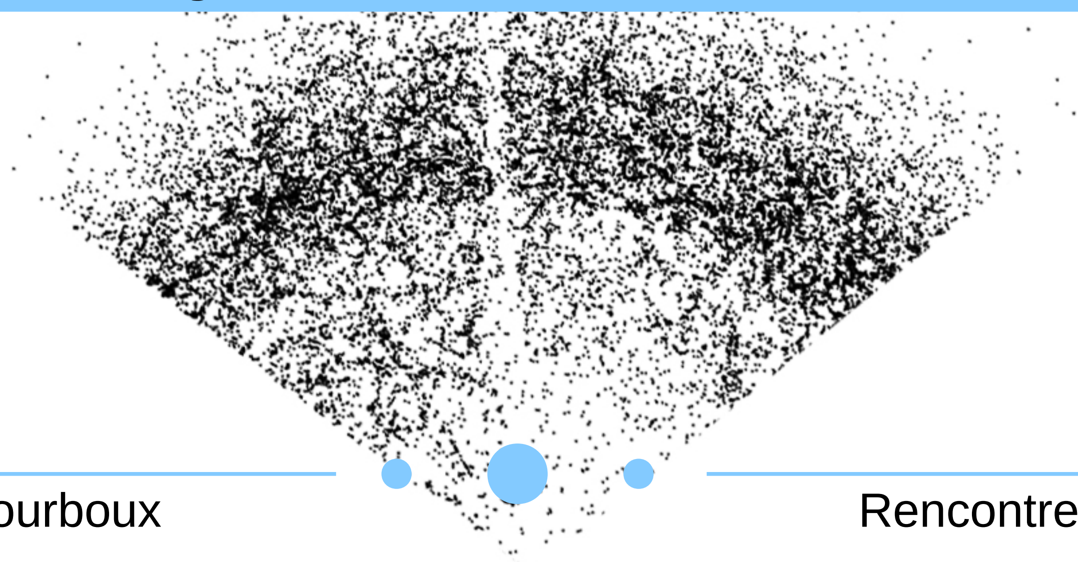


Baryonic Acoustic Oscillation Correlations at z=2.3 with SDSS-III Lyman-α Forests



Hélion du Mas des Bourboux

Rencontres de Blois 2016

→ introduction to BAO and BOSS

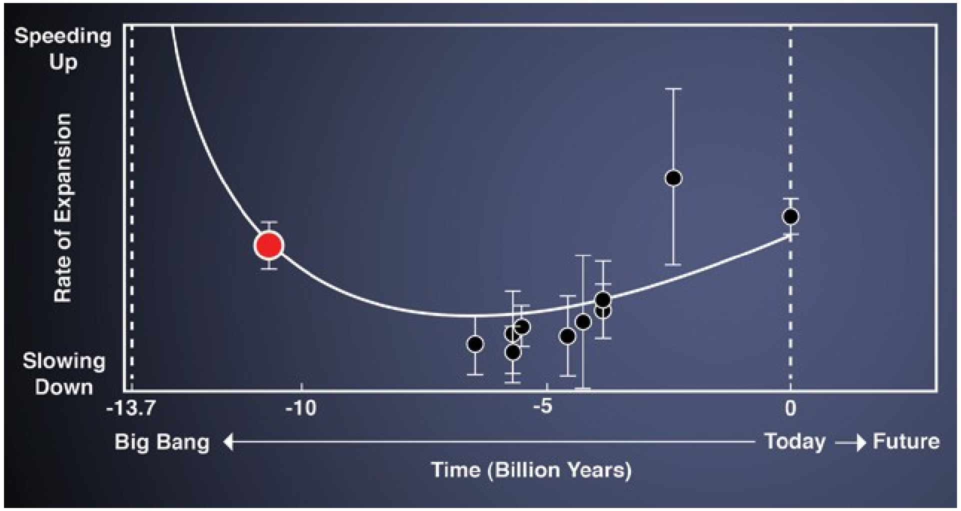
→ Lyman-α BAO

BAO

(Baryonic Acoustic Oscillations)

BAO

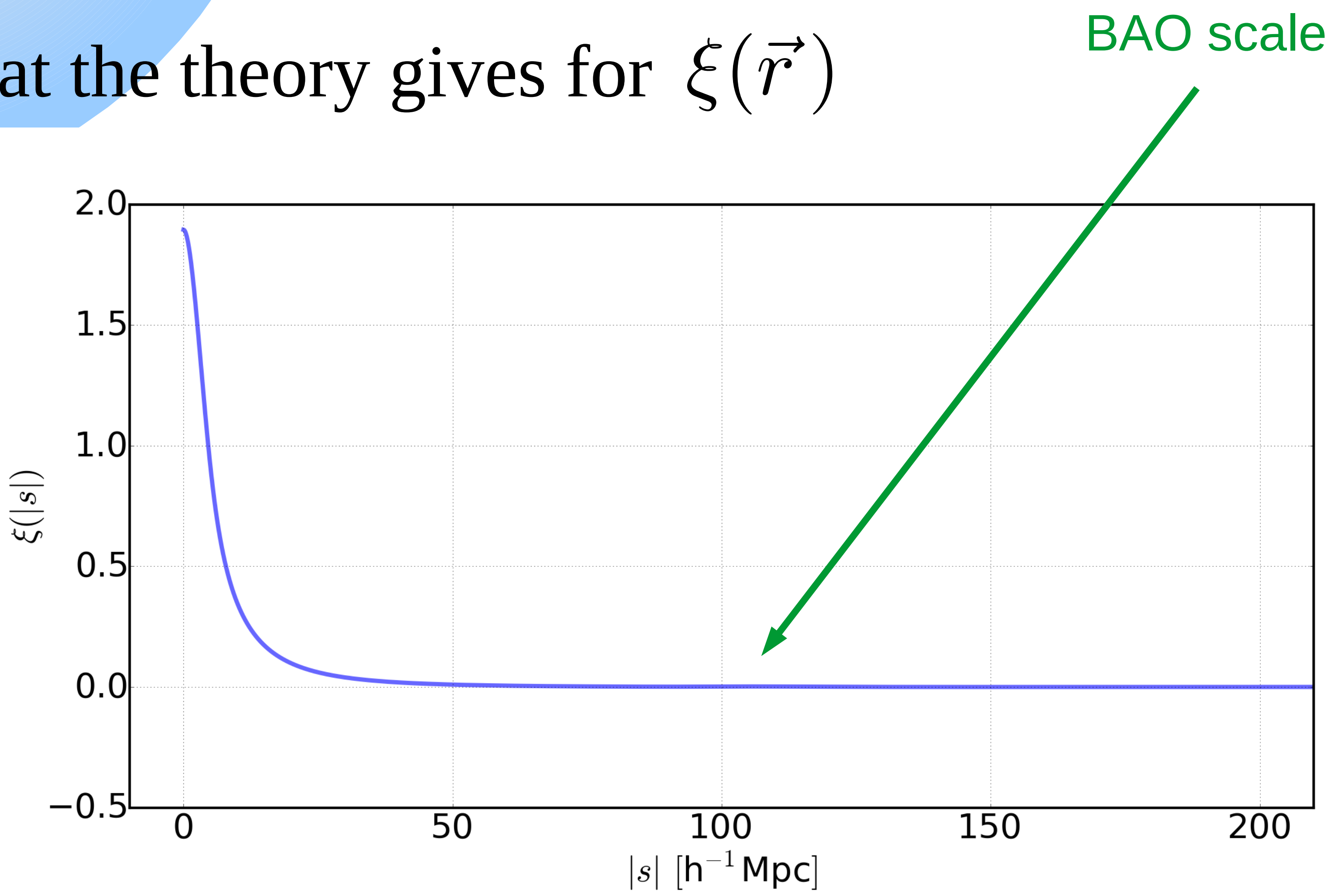
To understand what is Dark Energy we need to measure distances at different redshifts



BAOs measure the expansion rate and angular diameter distance at a given redshift

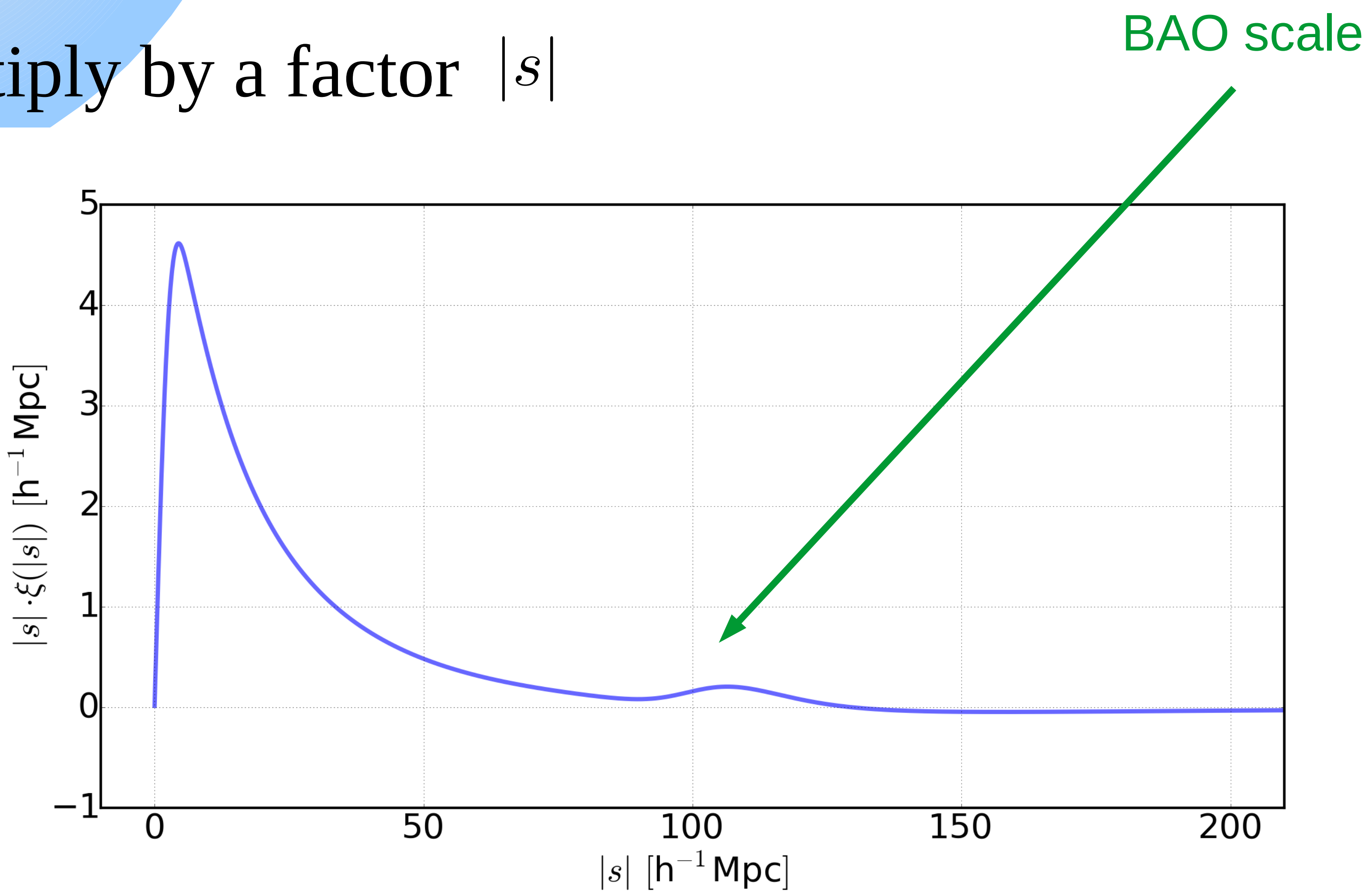
Measuring the BAO scale

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



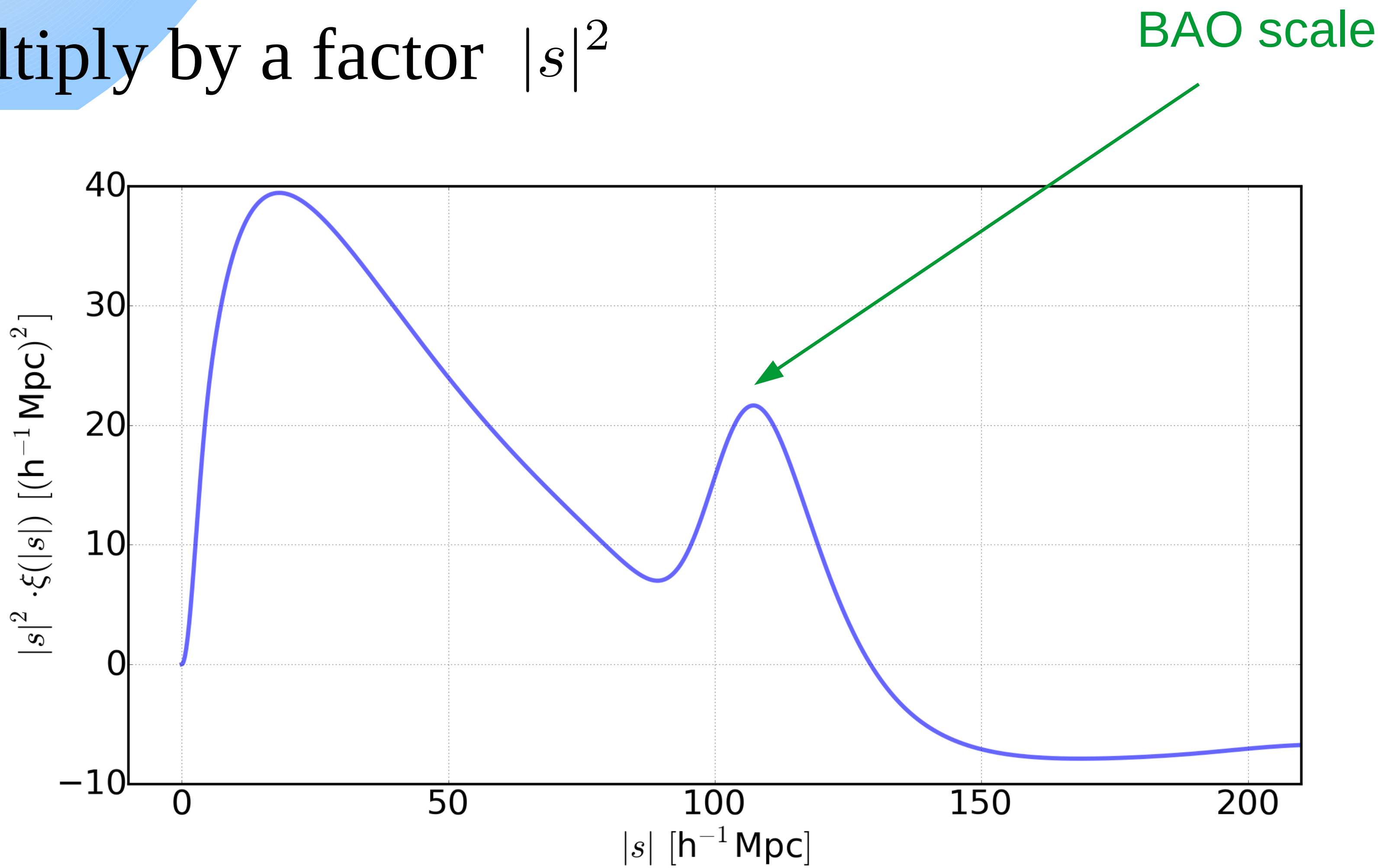
Measuring the BAO scale

Multiply by a factor $|s|$



Measuring the BAO scale

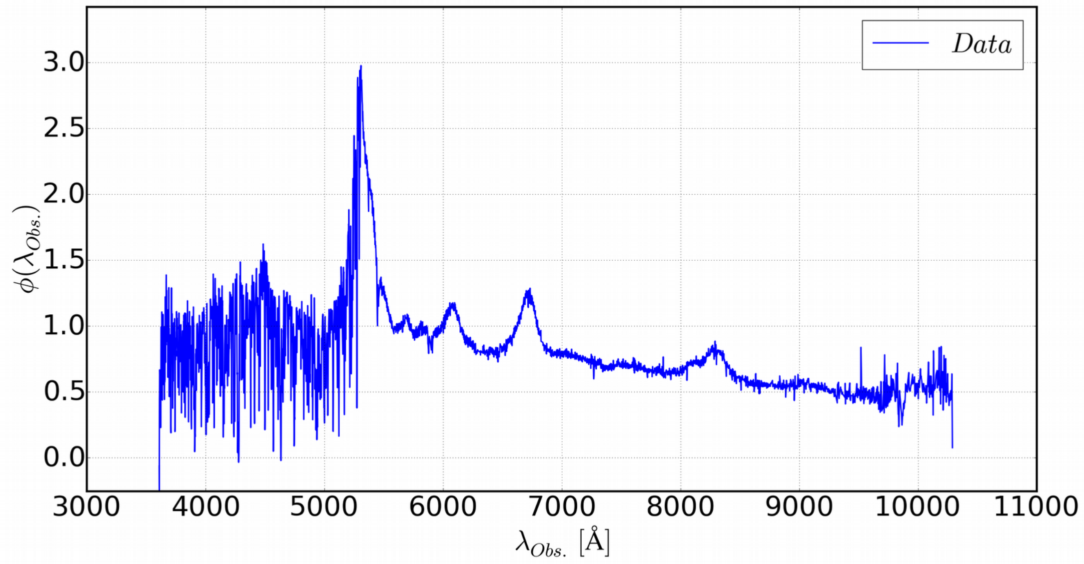
Multiply by a factor $|s|^2$



Measuring the BAO scale

Quasar

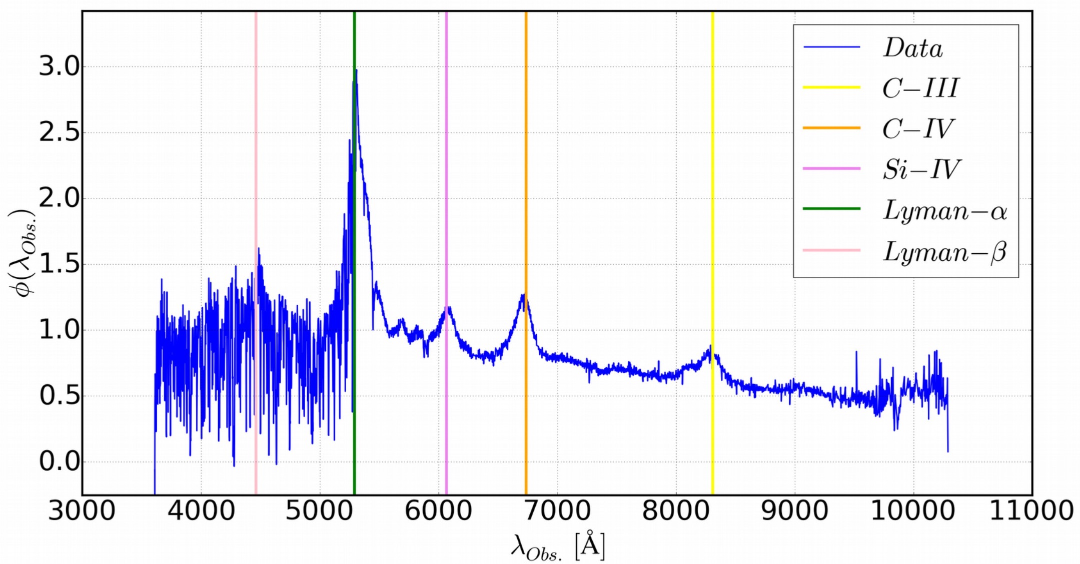
Quasar flux originates from the surrounding of a super-massive black hole



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

Quasar

Get redshift from emission lines

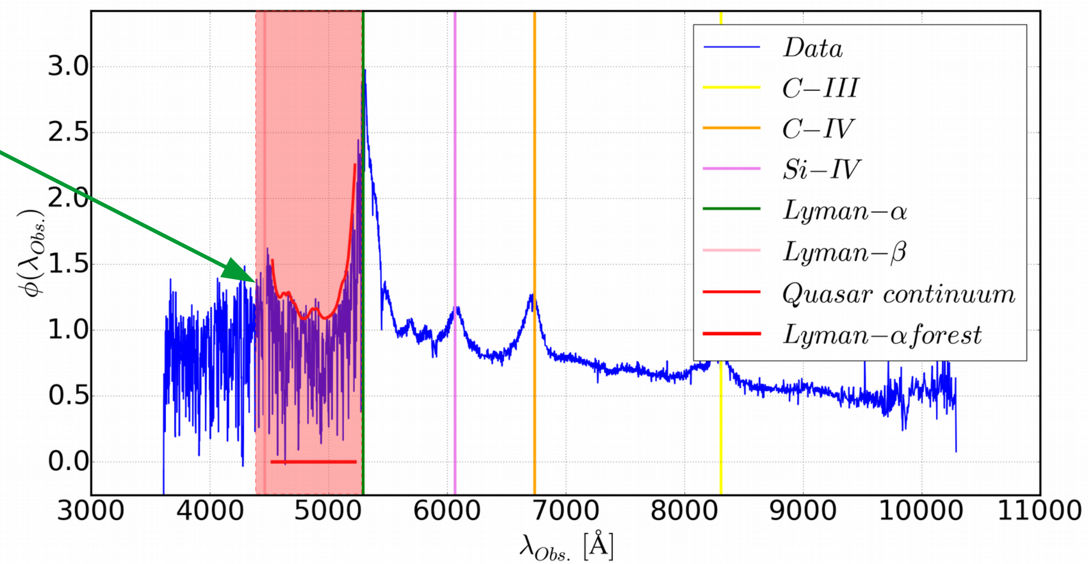


A Quasar is a boolean matter density tracer

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

Lyman-α forest

Matter density fluctuation

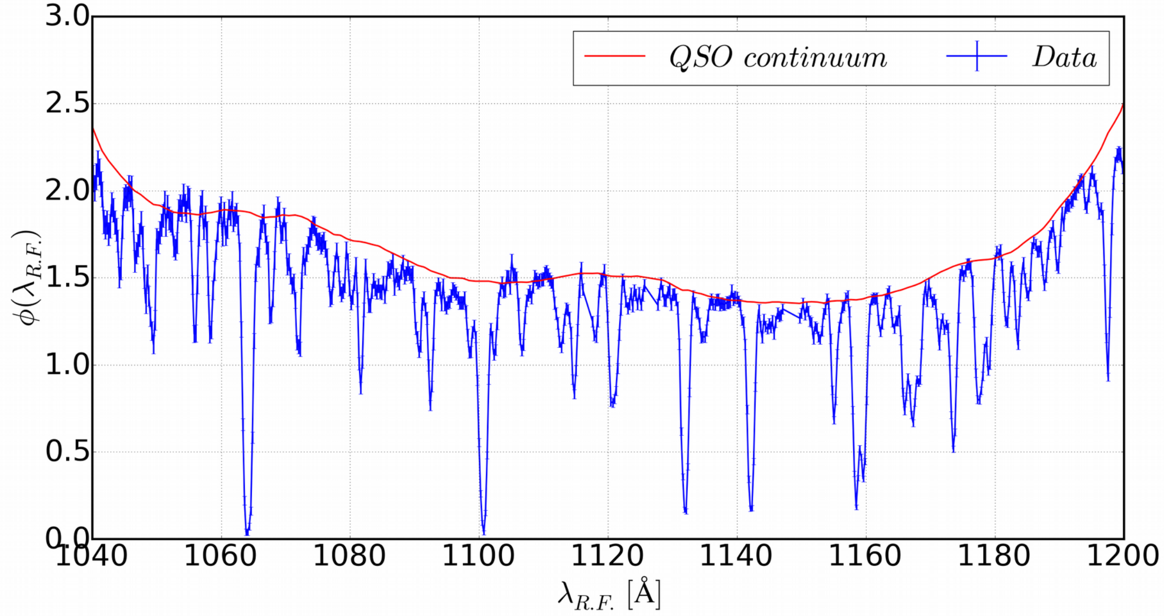
Normalized Data + correction

$$\delta_{\alpha,i} = \frac{f_{\alpha,i}}{C_{\alpha}(\lambda_{R.F.}).\bar{F}(\lambda_{Obs.})} - 1$$

QSO physics

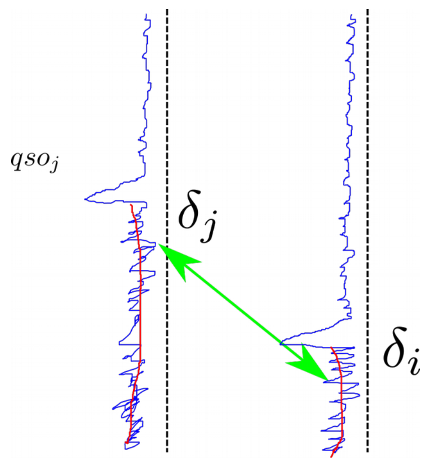
Sky + cosmology physics

$$z_{\alpha,i} = \frac{\lambda_{Obs.,i}}{1215.67} - 1$$

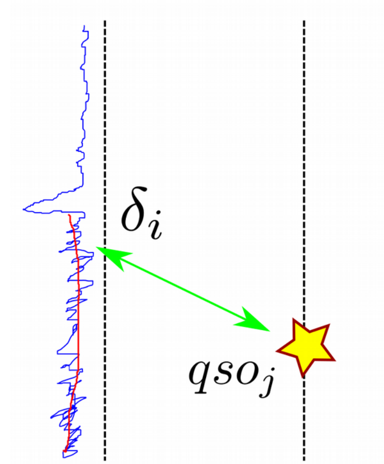


Two matter density tracers

- We have two matter density tracers:
  - Quasars
  - Lyman-α forest
- We can estimate two different correlation functions



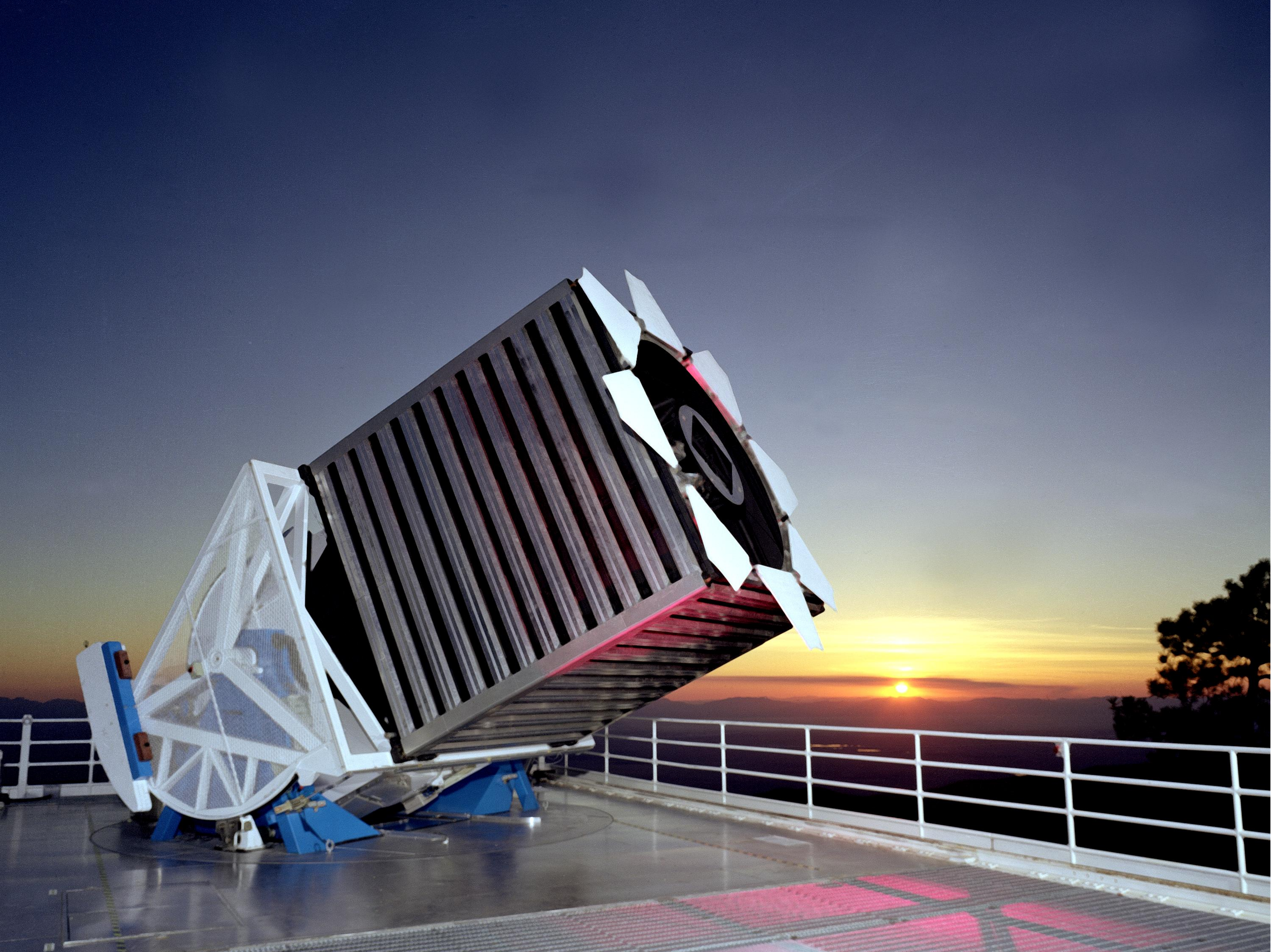
Lyman-α auto-correlation



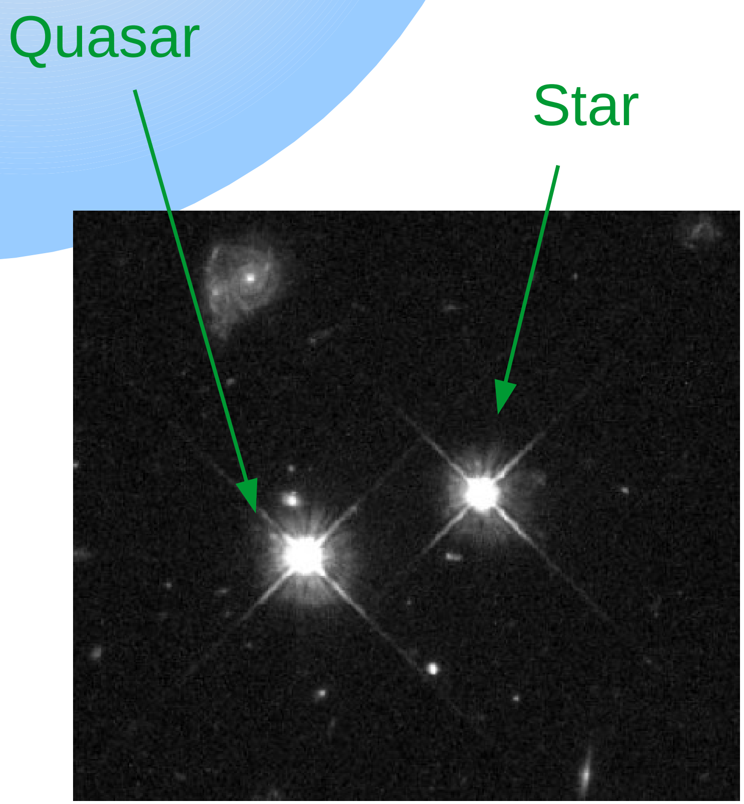
Lyman-α – QSO cross-correlation

BOSS

(Baryon Oscillation Spectroscopic Survey)



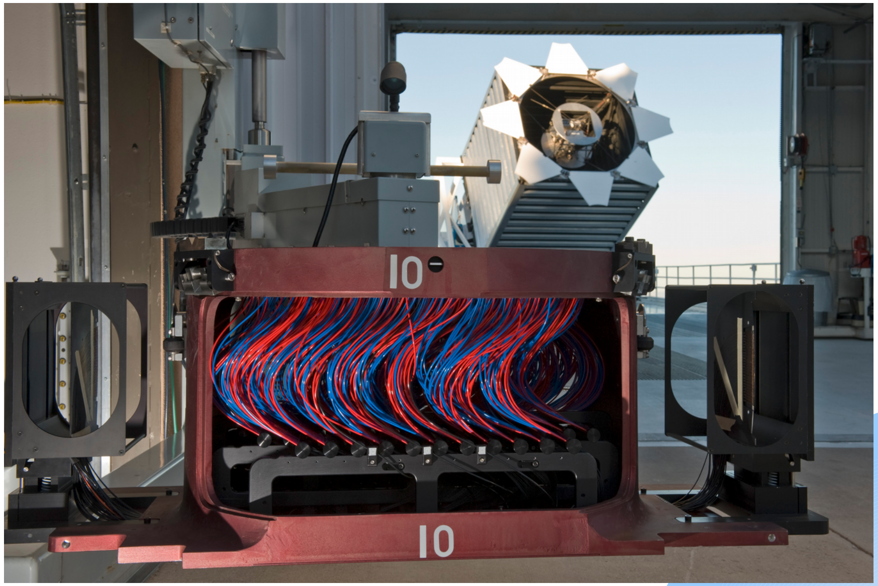
From Photometry to Spectroscopy



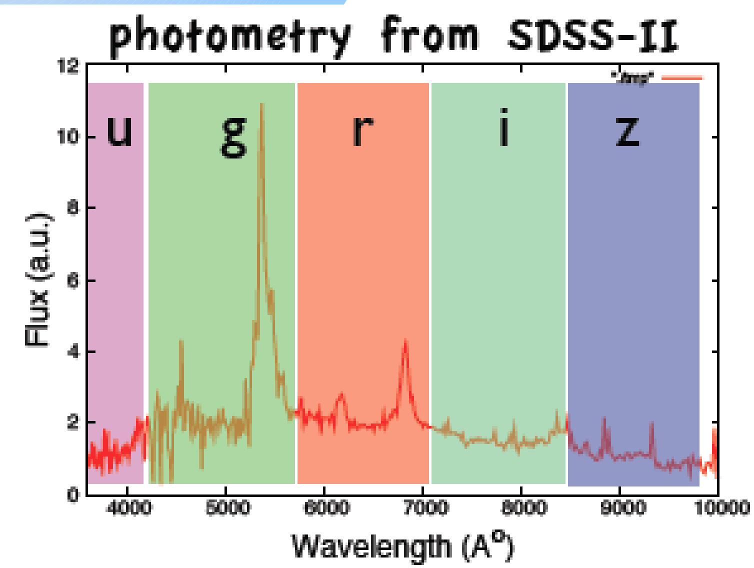
List of targets from photometry sent to the BOSS spectrograph.

- Sloan Digital Sky Survey (SDSS)
- 2.5-m wide-angle optical telescope

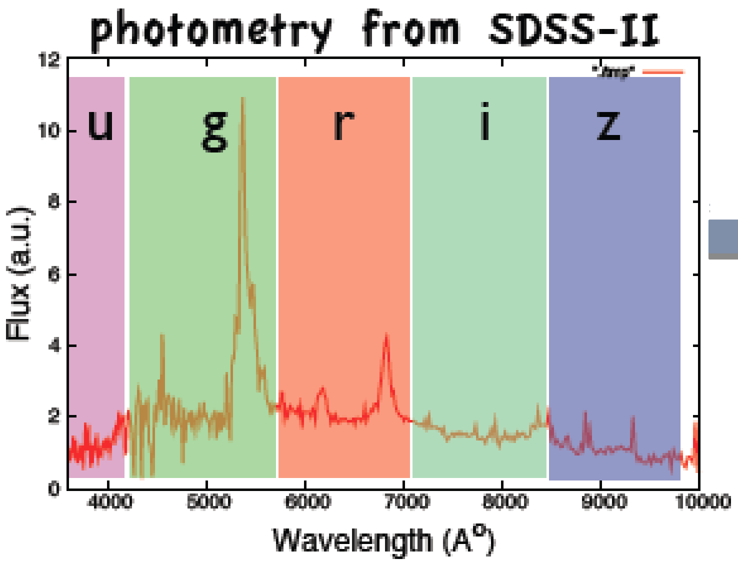
- Spectroscopy with the Baryonic Oscillation Spectroscopic Survey (BOSS)
- 1000 fibers
- Run: 2009-2014



From Photometry to Spectroscopy



From Photometry to Spectroscopy

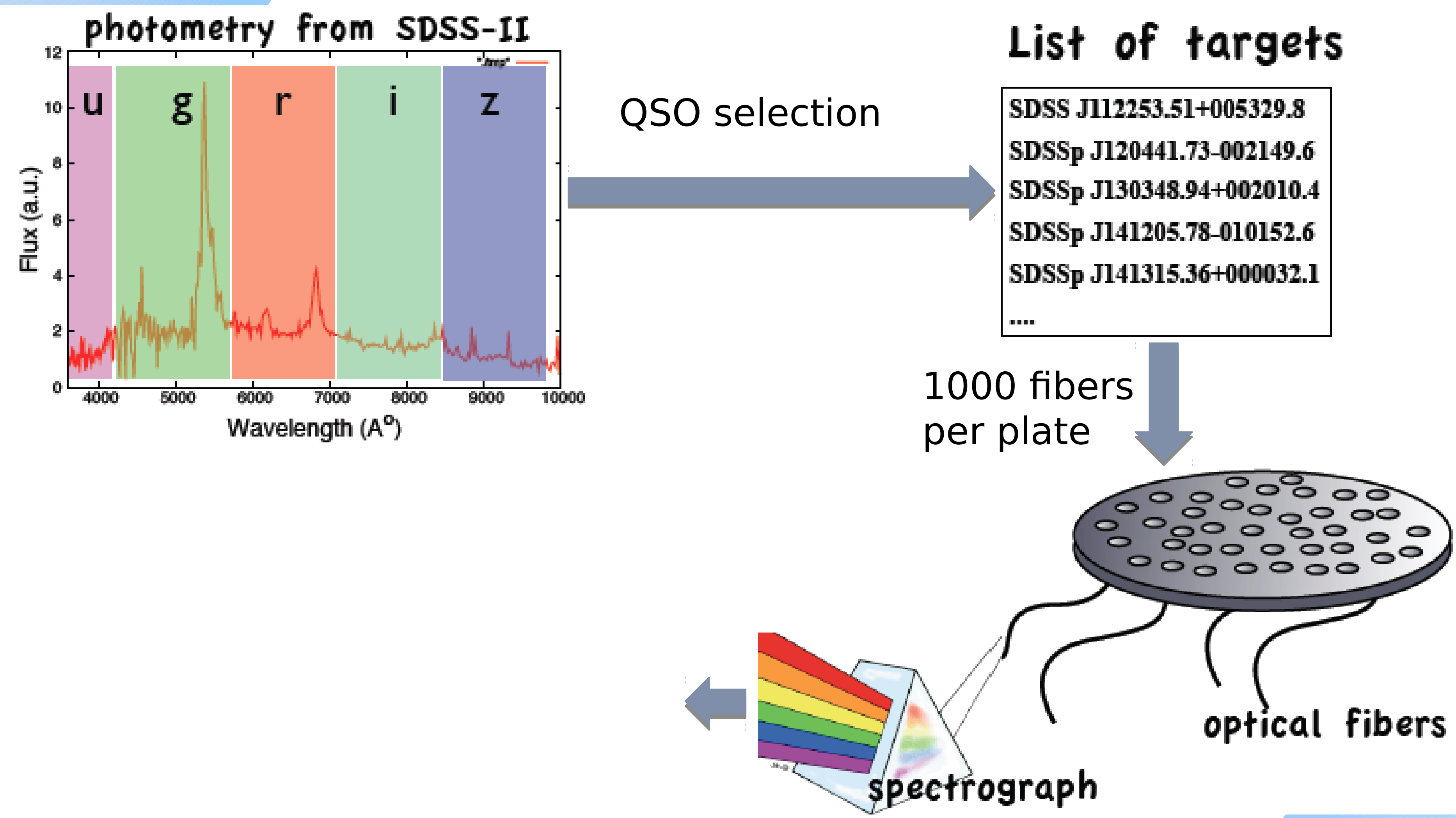


QSO selection

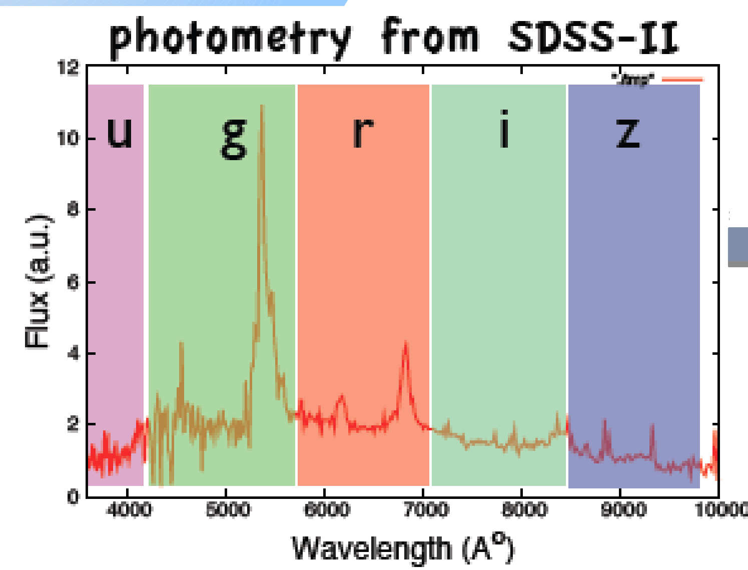
List of targets

SDSS J112253.51+005329.8
SDSSp J120441.73-002149.6
SDSSp J130348.94+002010.4
SDSSp J141205.78-010152.6
SDSSp J141315.36+000032.1
....

From Photometry to Spectroscopy



From Photometry to Spectroscopy



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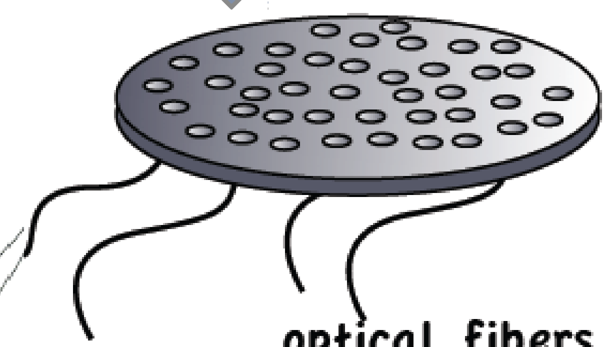
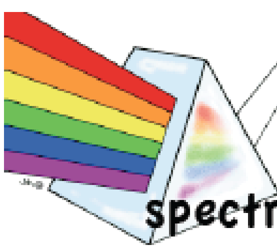
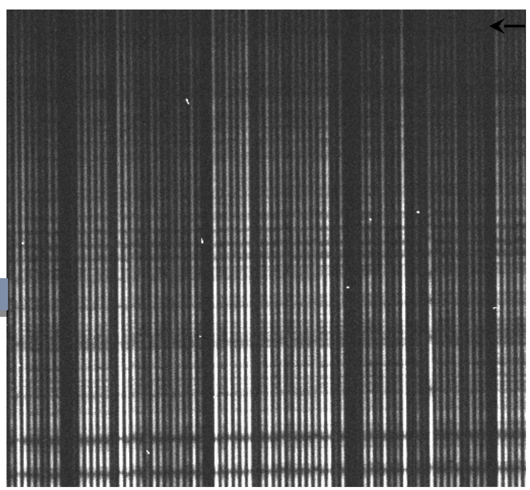
SDSSp J141315.36+000032.1
....

1000 fibers per plate



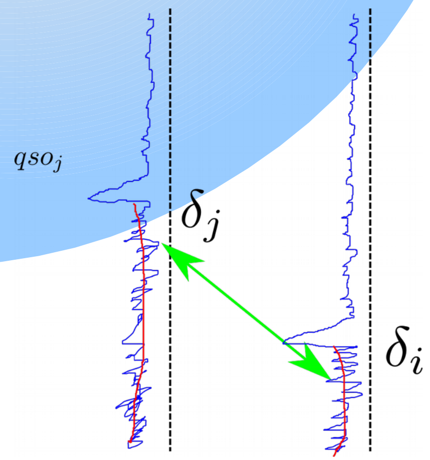


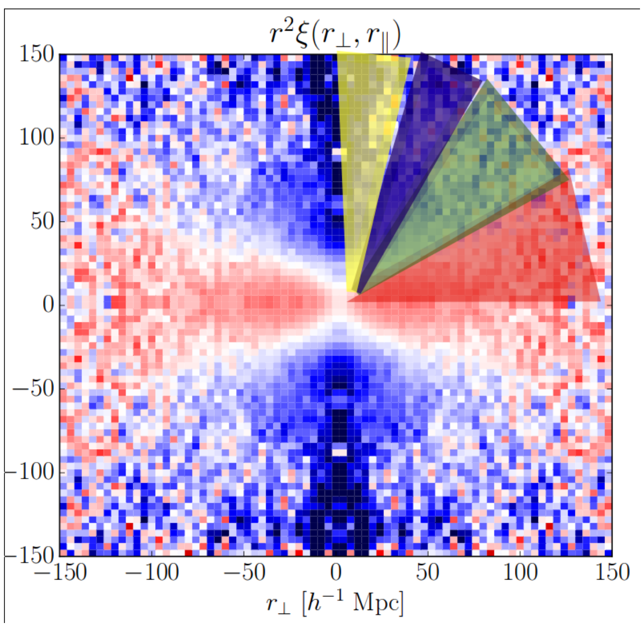


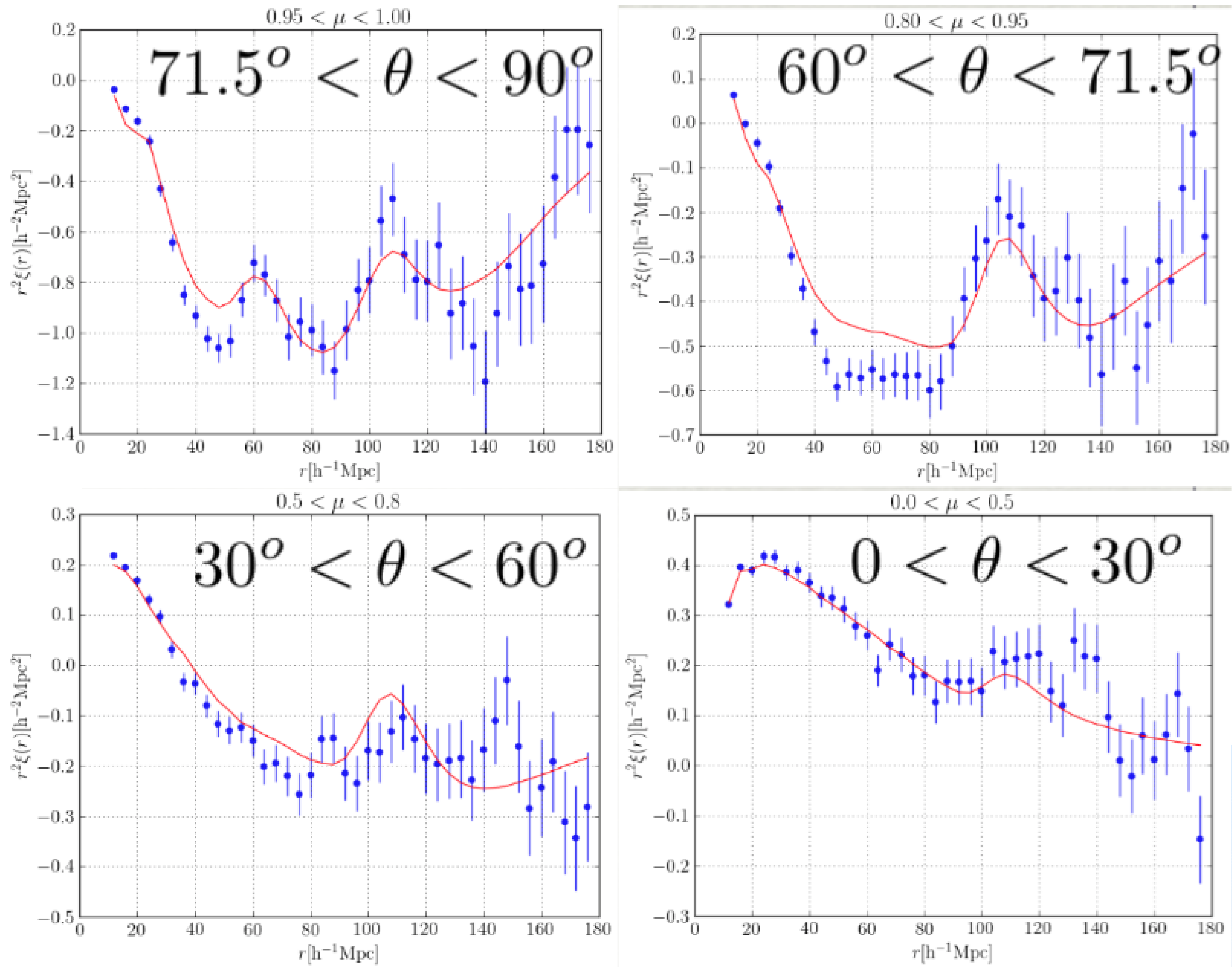
Redshifts

Lyα BAO Results

Auto-correlation



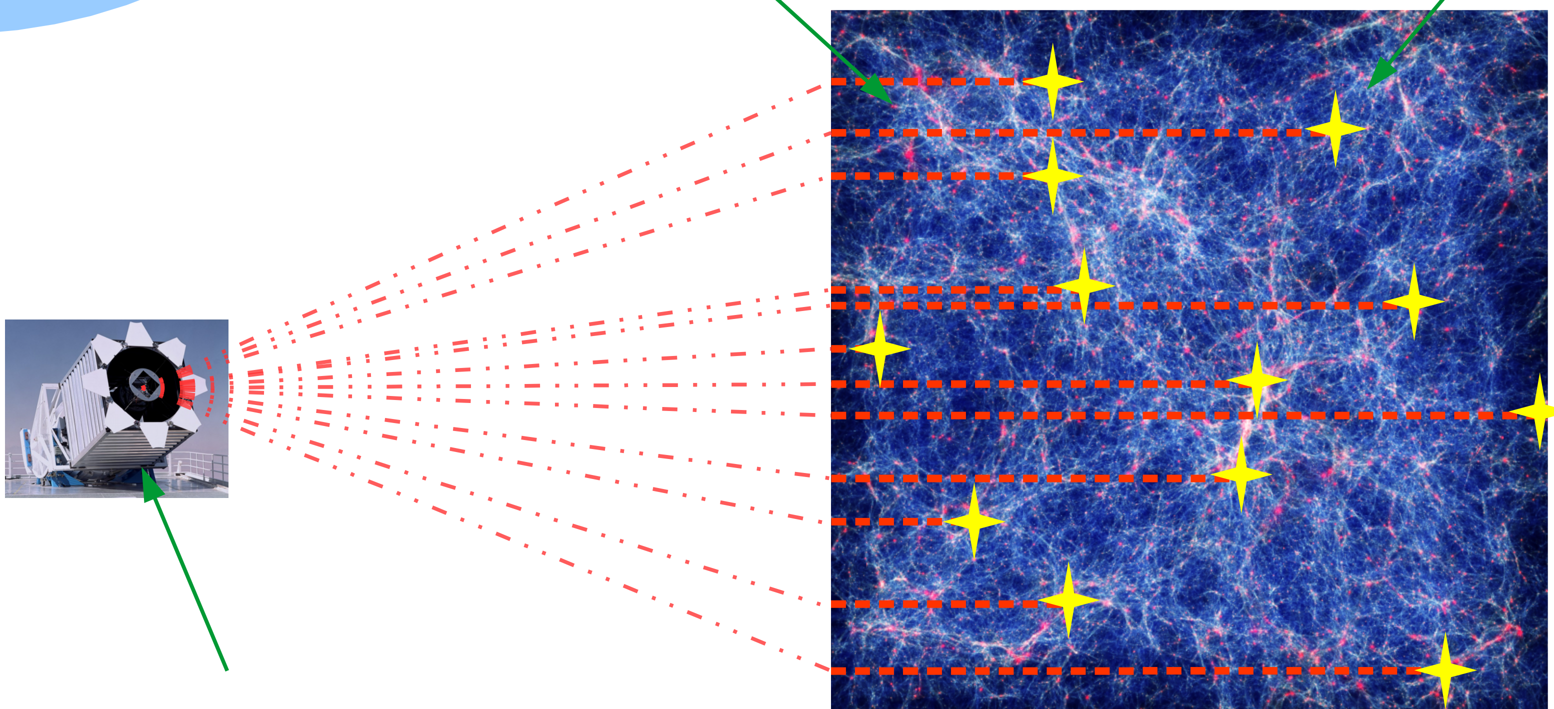




Gaussian Random Field Simulations

Lyα forest along the line-of-sight

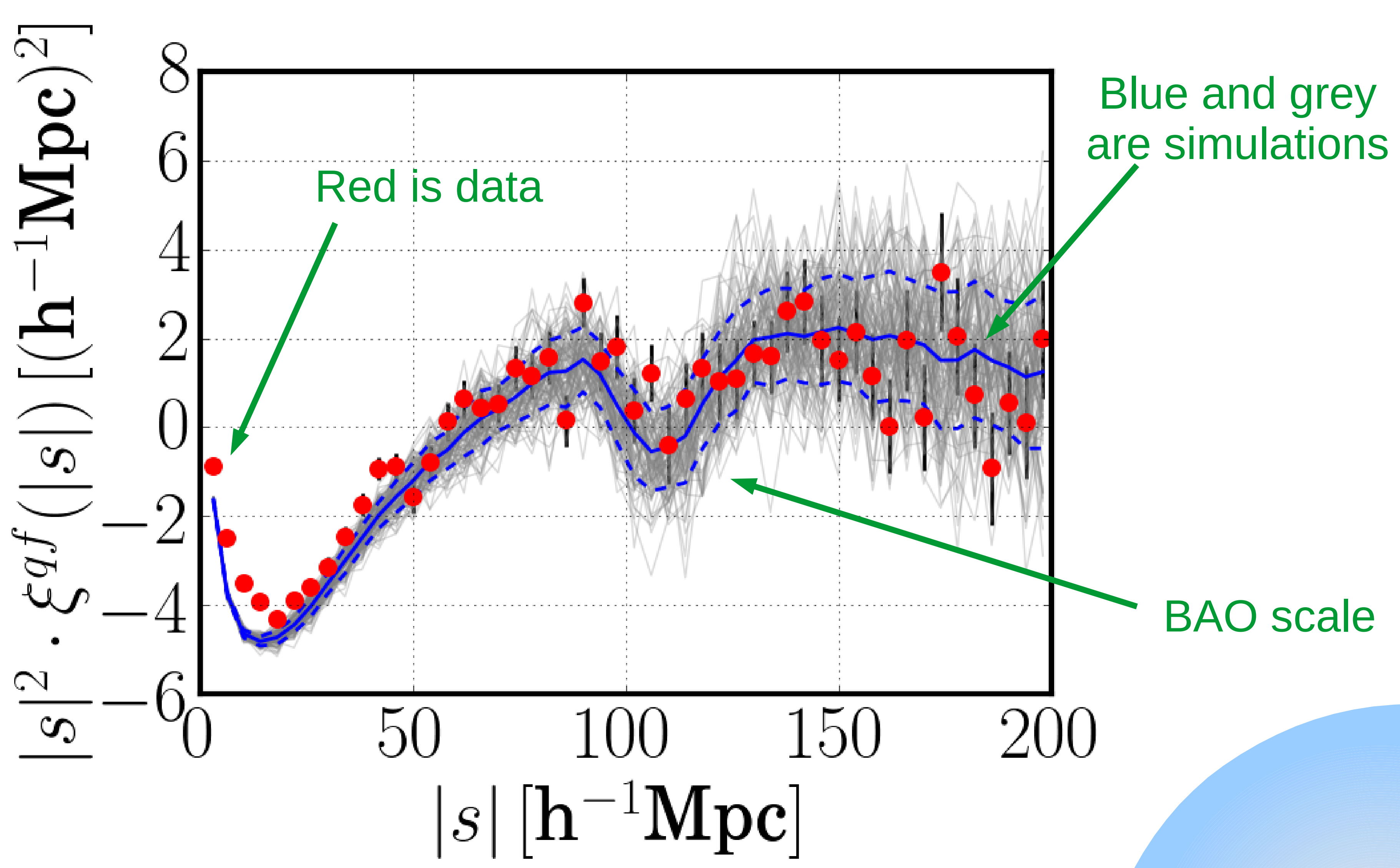
QSO set on big Over-density



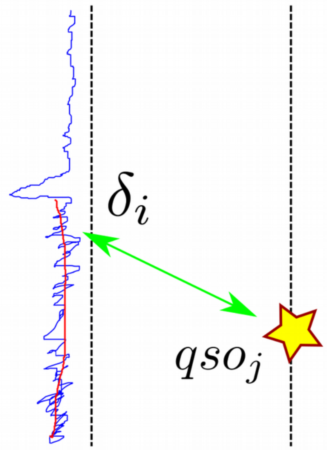
Apply telescope properties

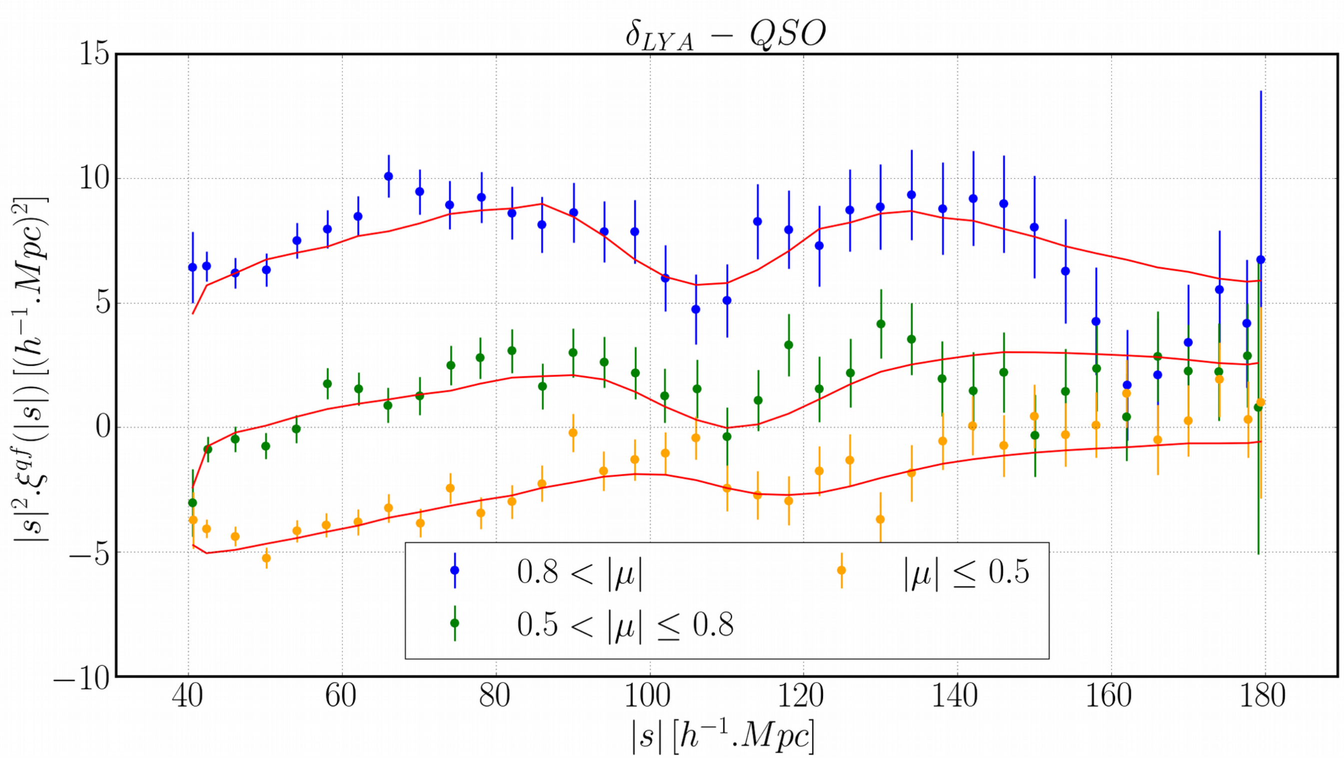
IGM image provided by Julien Baur

Gaussian Random Field Simulations



Cross-correlation





BAO Results

Radial BAO

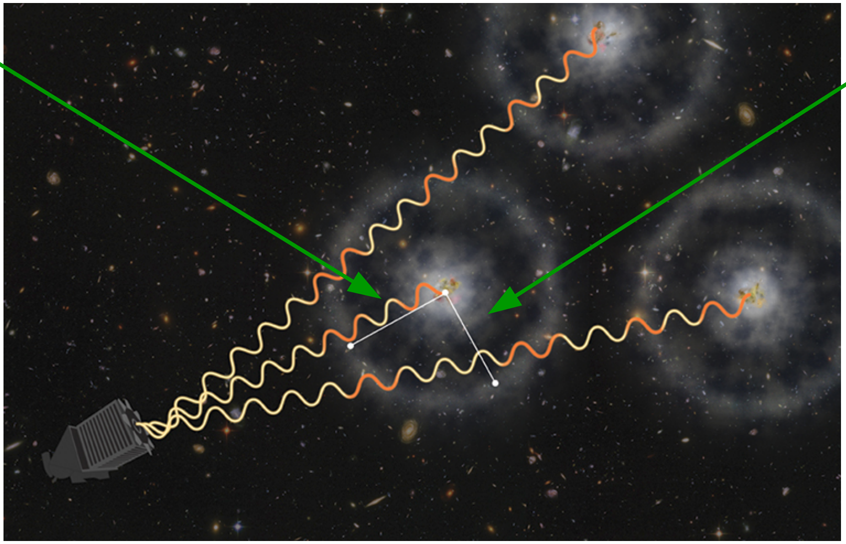
$$\alpha_{\parallel} = \frac{D_H(\overline{z})/r_d}{[D_H(\overline{z})/r_d]_{fid}}$$

Hubble scale factor

Transverse BAO

$$\alpha_{\perp} = \frac{D_A(\overline{z})/r_d}{[D_A(\overline{z})/r_d]_{fid}}$$

Angular size



BAO Results

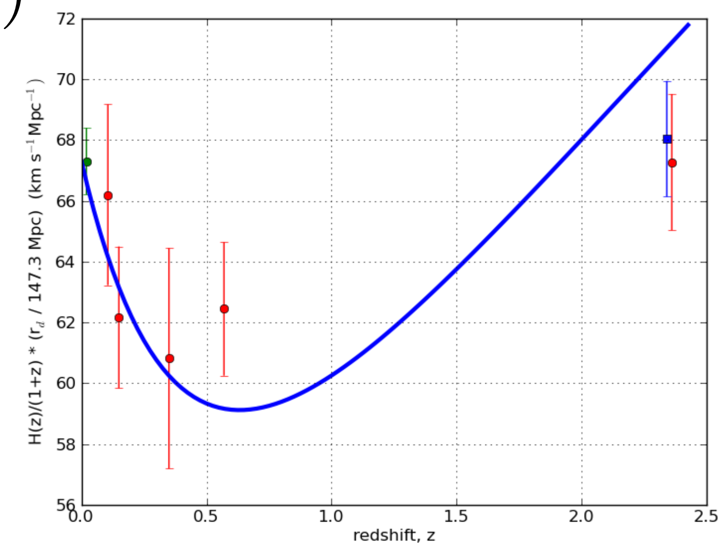
- Auto-correlation DR12: (JB++ in prep.)

$$\chi^2/dof = 1630.43/(1589-10)$$
$$\alpha_{\parallel} = 1.028 \pm 0.028$$
$$\alpha_{\perp} = 0.983 \pm 0.048$$

- Cross-correlation DR12: (HdMdB++ in prep.)

$$\chi^2/dof = 3115.24/(3030-14)$$
$$\alpha_{\parallel} = 1.045 \pm 0.032$$
$$\alpha_{\perp} = 0.913 \pm 0.038$$

Preliminary



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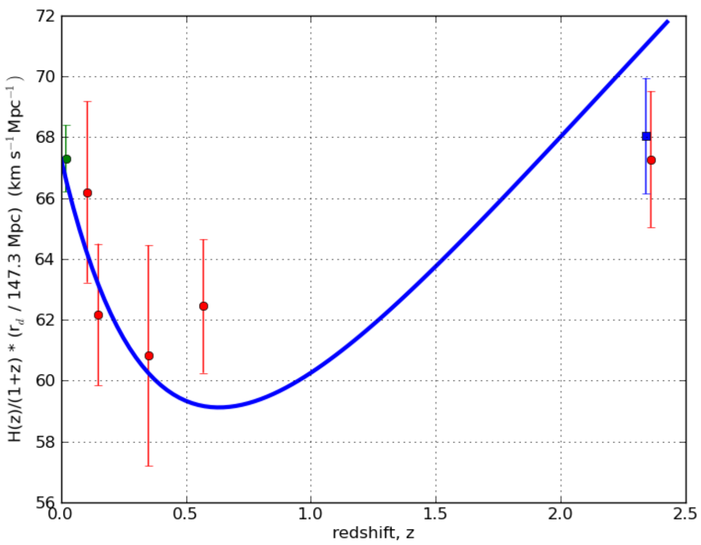


Improvements

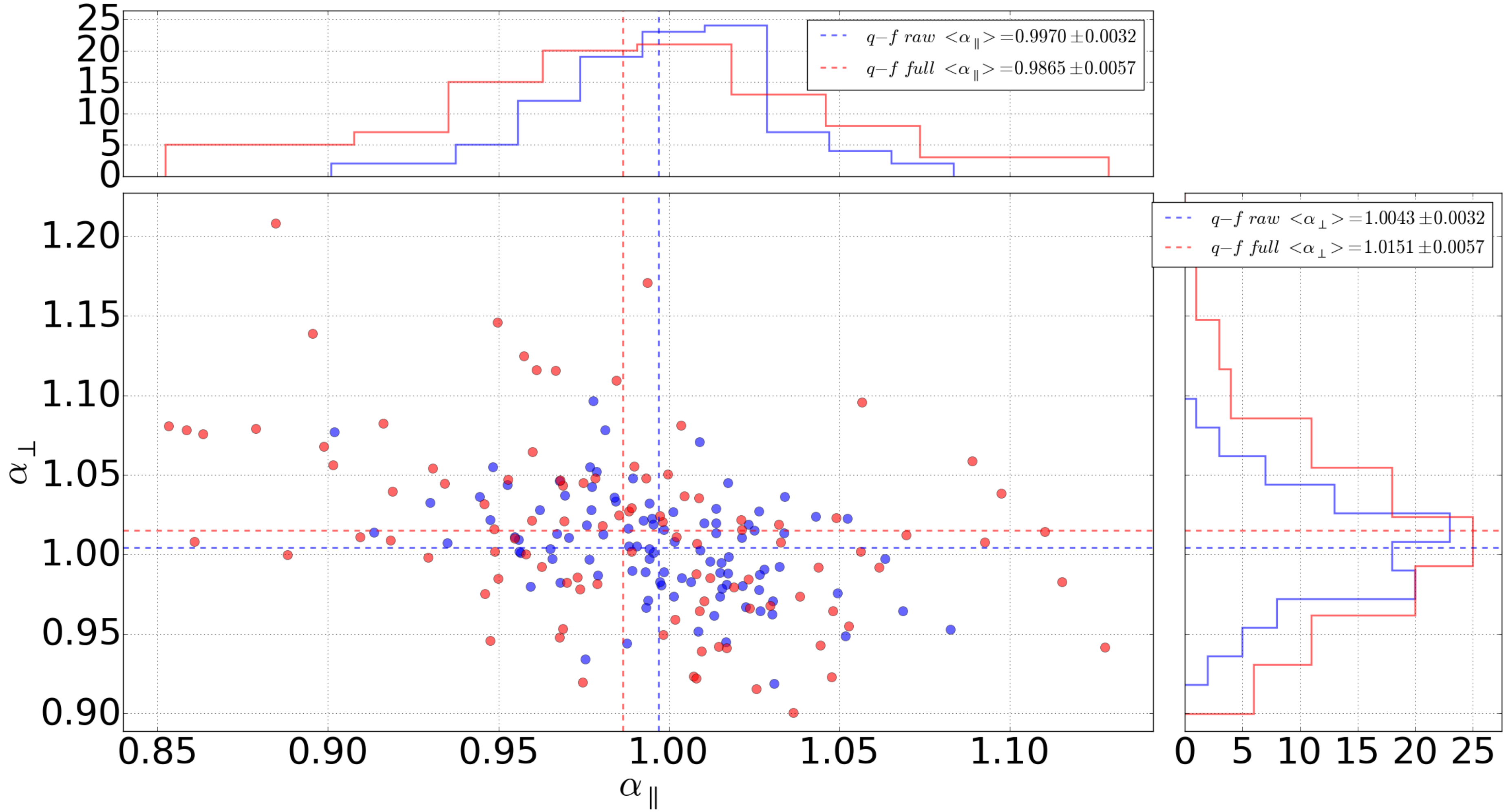
- Better model for contamination by carbon, silicon ...
- Better model for the distortion caused by continuum fitting
- Better data-reduction and calibration
- Better understanding of spurious correlations induced by instrument/data-reduction
- First simulations of the cross-correlation.

Conclusion

- A ~ 2.8 % measurement of the expansion rate at z = 2.3.
- Robust measurement against systematics
- First simulations of the cross-correlation.

BACKUP slides

Gaussian Random Field Simulations



Metal templates