High redshift BAO from BOSS and eBOSS

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

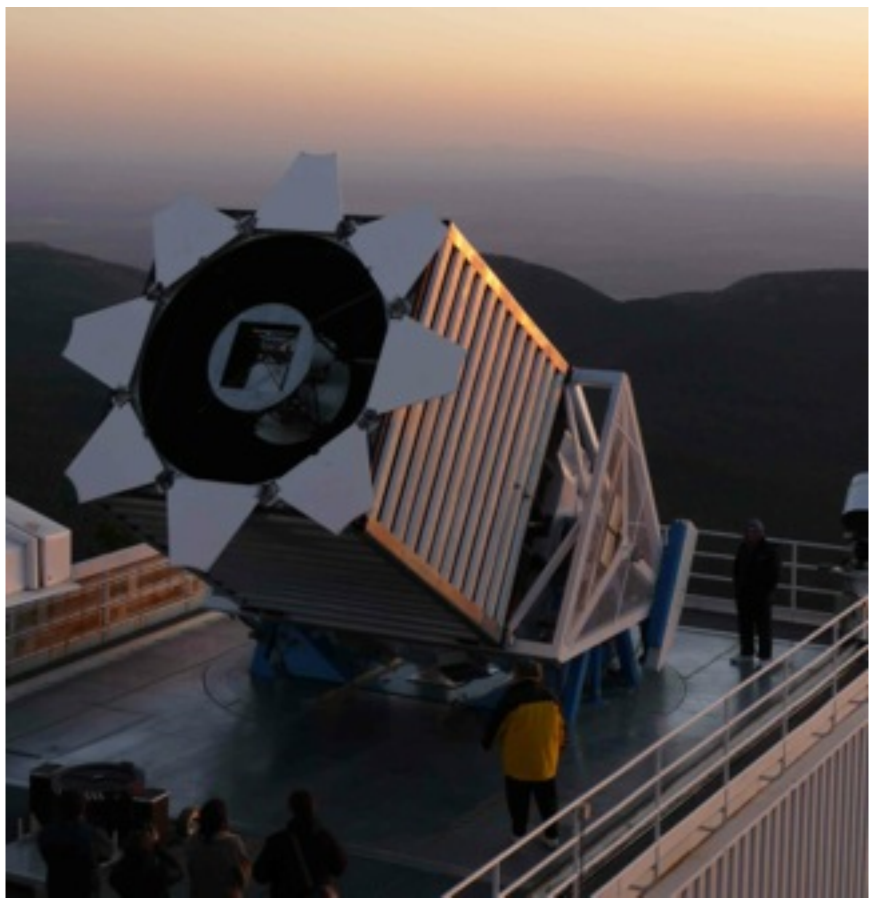
EPFL - LABORATOIRE D'ASTROPHYSIQUE

Questions I want to address

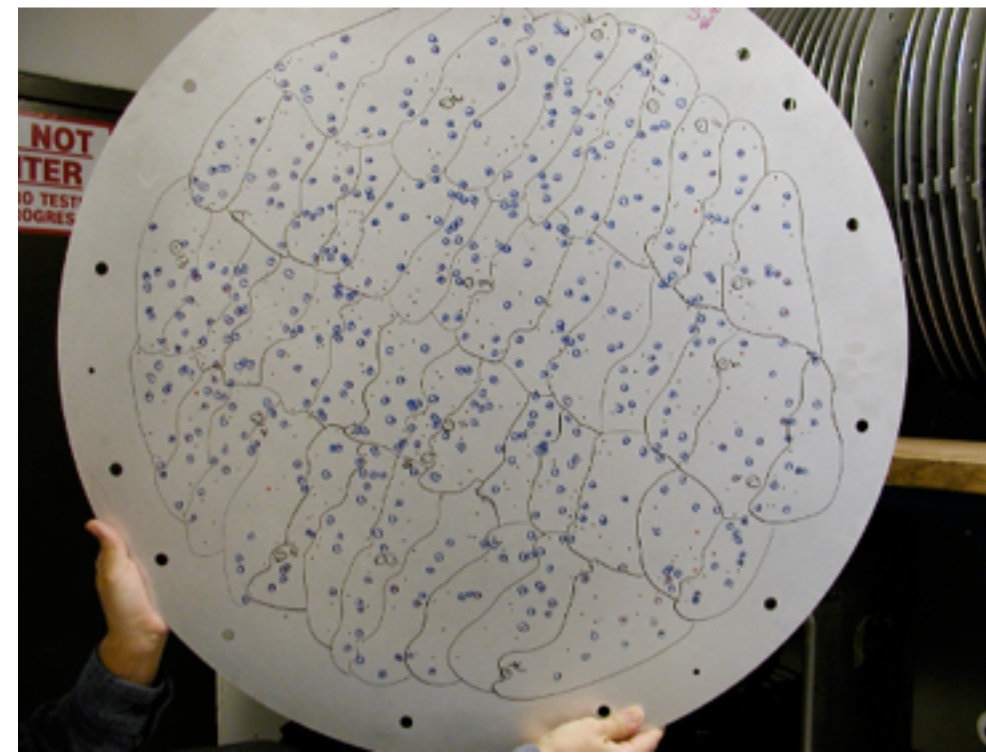
- How did we measure BAO using Lyman-alpha forests in BOSS?
- What are the resulting constraints on cosmological models?

- How are we going to improve those constraints using Emission Line Galaxies (ELGs) in eBOSS?

BOSS maps the Universe to observe the BAO

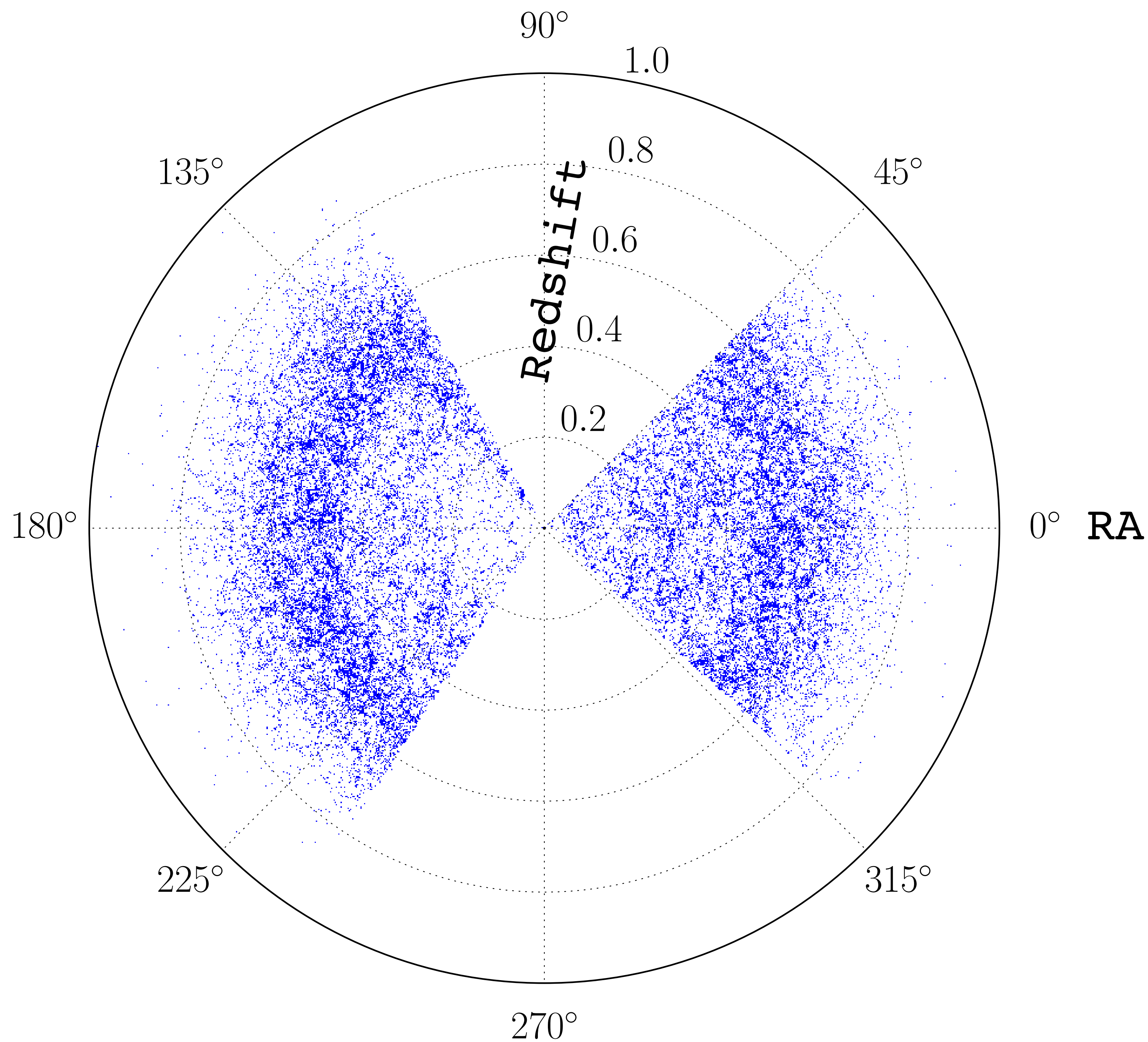


SDSSIII



- The Baryon Oscillation Spectroscopic Survey (BOSS) has acquired:
  - 1.5M galaxies (0.15< z <0.7)
  - 160k quasars (2.1< z <4.5)

BAO are observed statistically in the correlation function of galaxies



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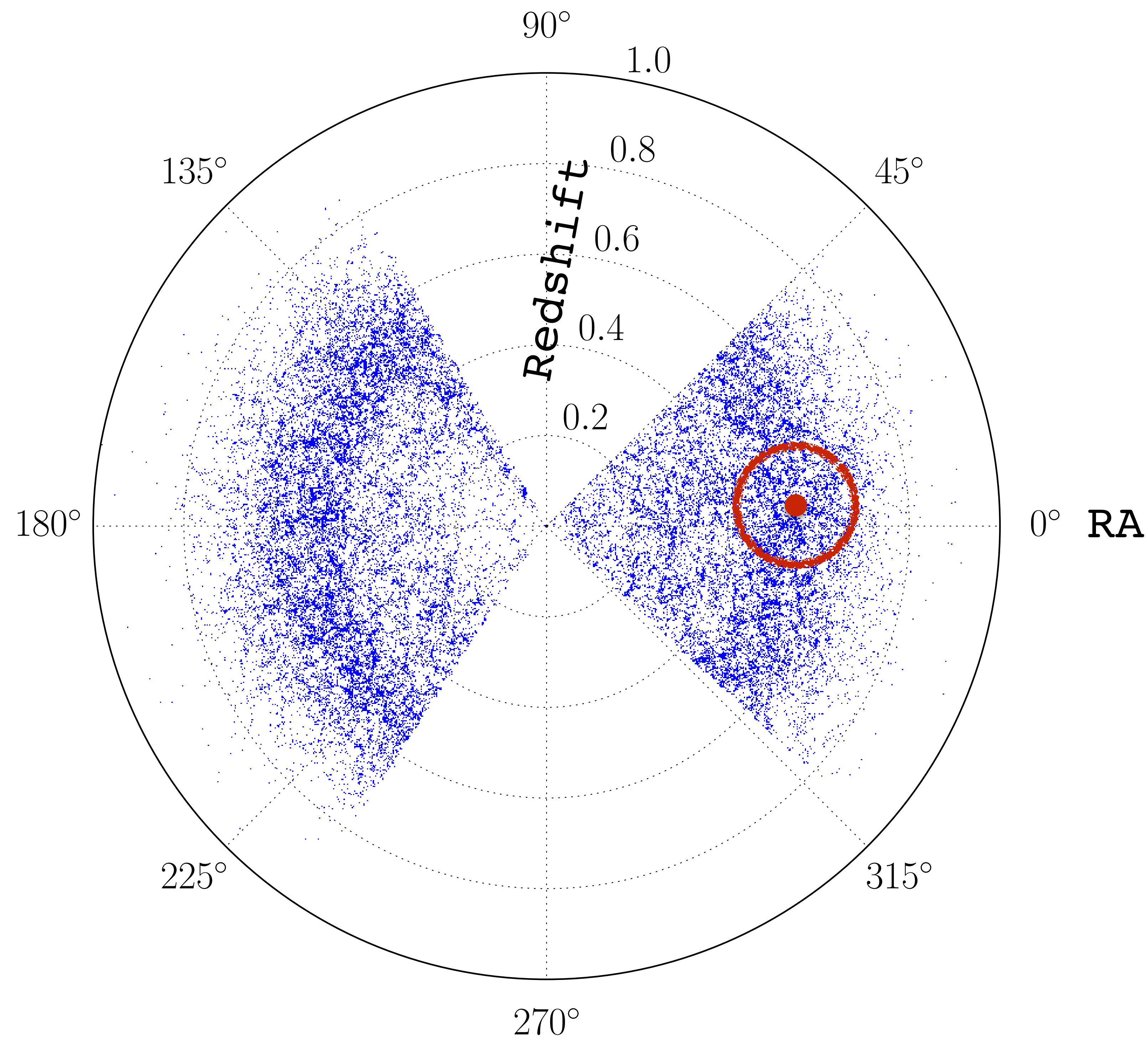

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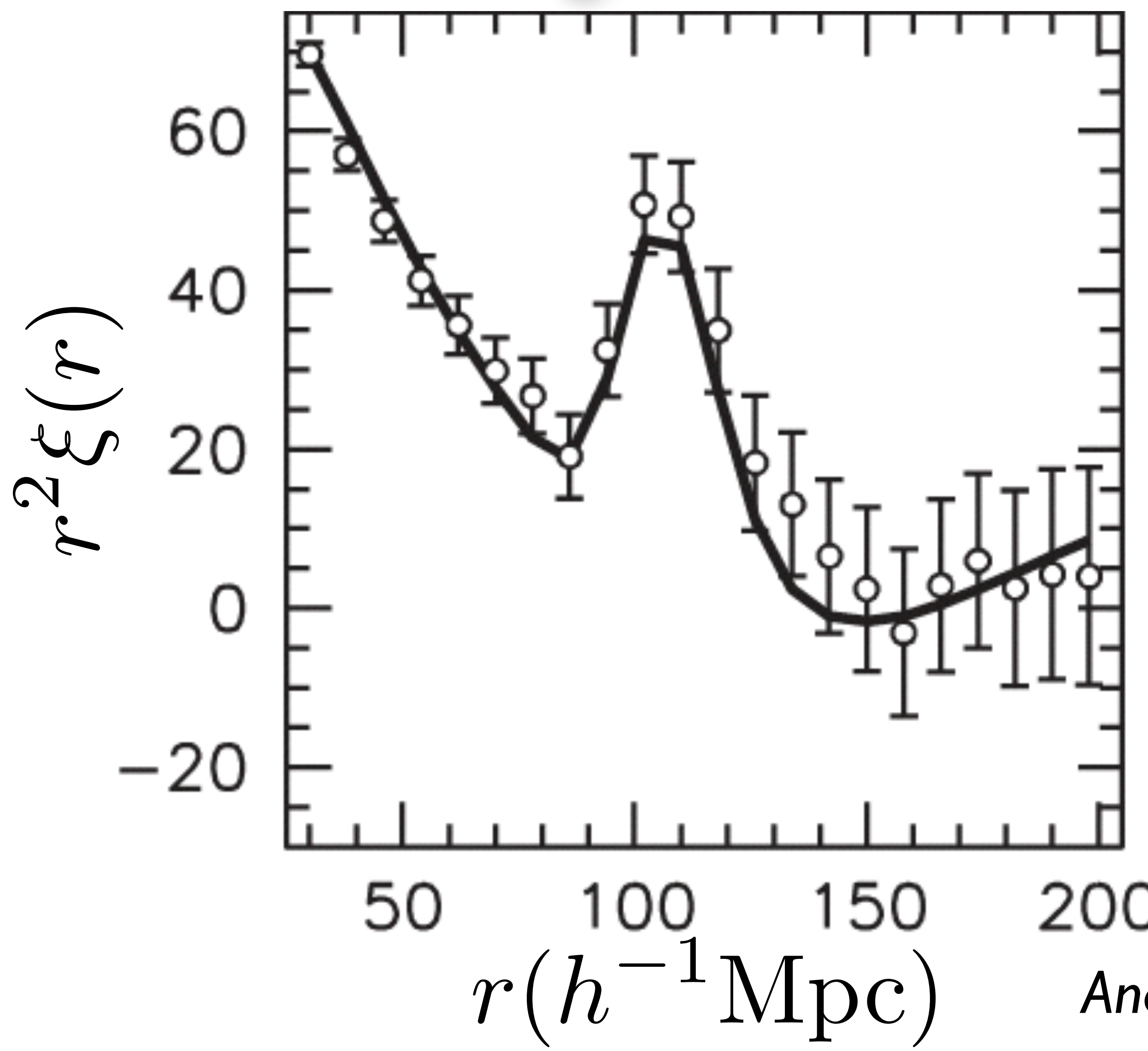

Anderson et al. (2014)

- Correlation function at z = 0.57
  obtained using 690,000 galaxies over 8500 deg^2.

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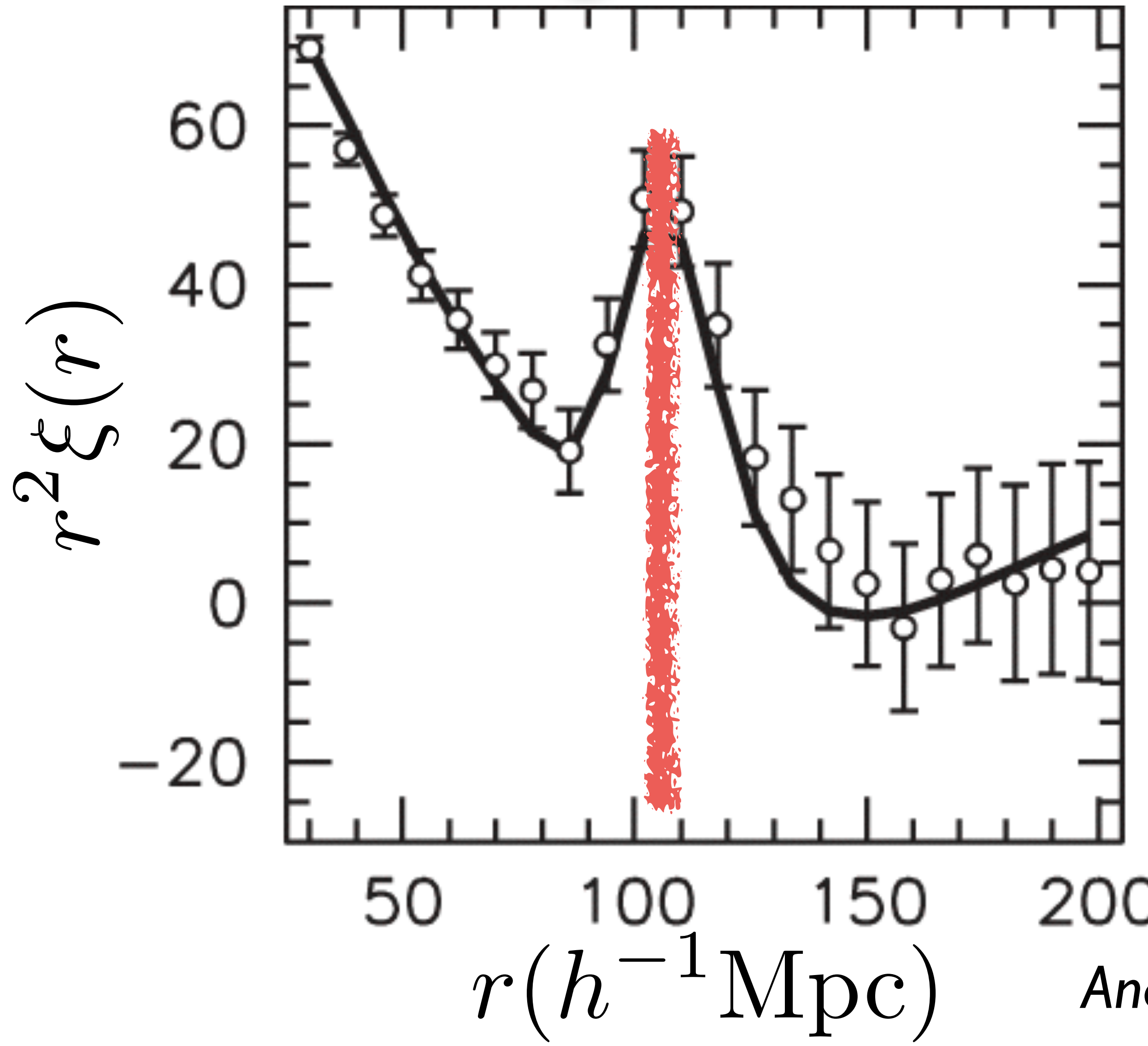

BAO peak
105 Mpc.h^{-1}

Anderson et al. (2014)

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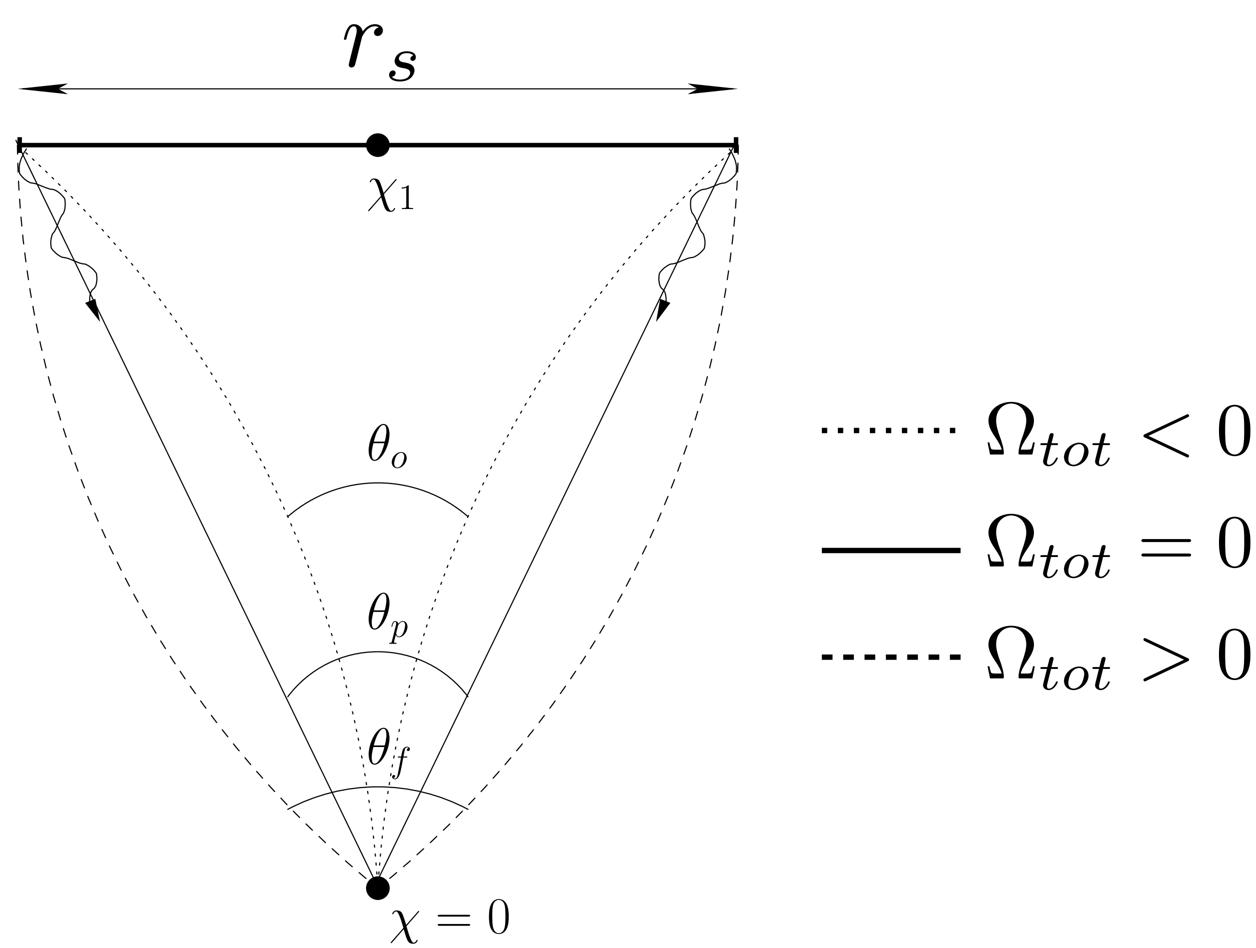
BAO can be used as a standard ruler



- Observed transversally to the line of sight, it constrains an angle:

$$\theta = \frac{r_s}{(1+z)\,D_A(z)}$$

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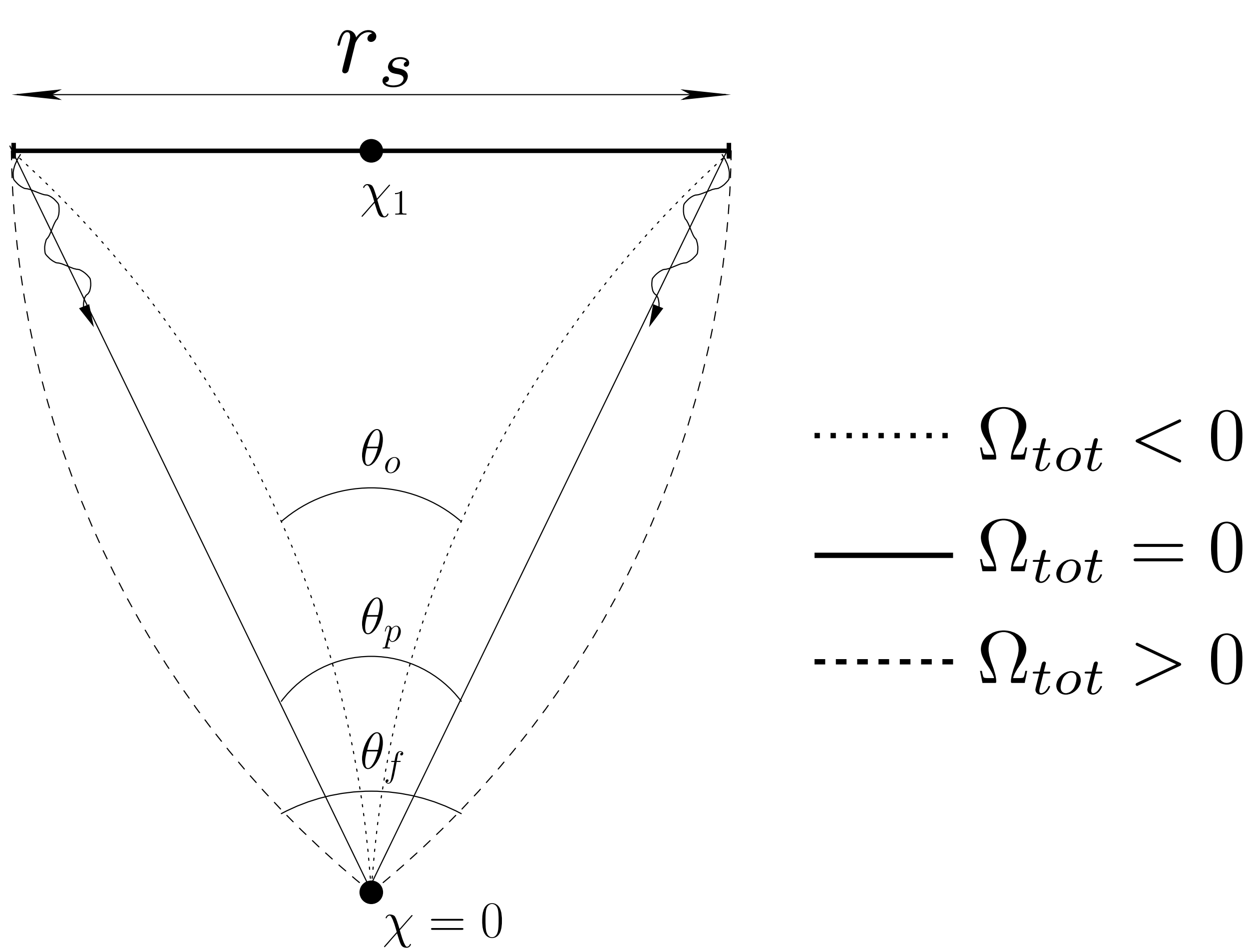

- Observed transversally to the line of sight, it constrains an angle:

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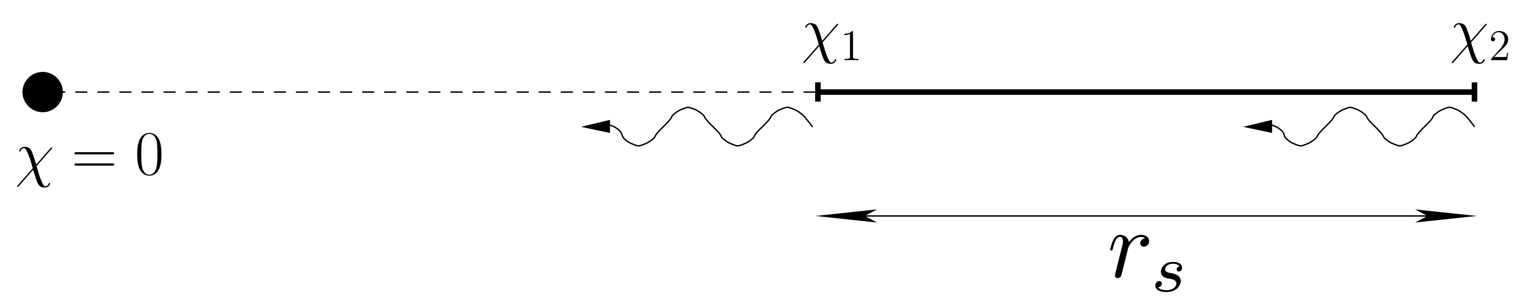
Depend on the parameters of your model

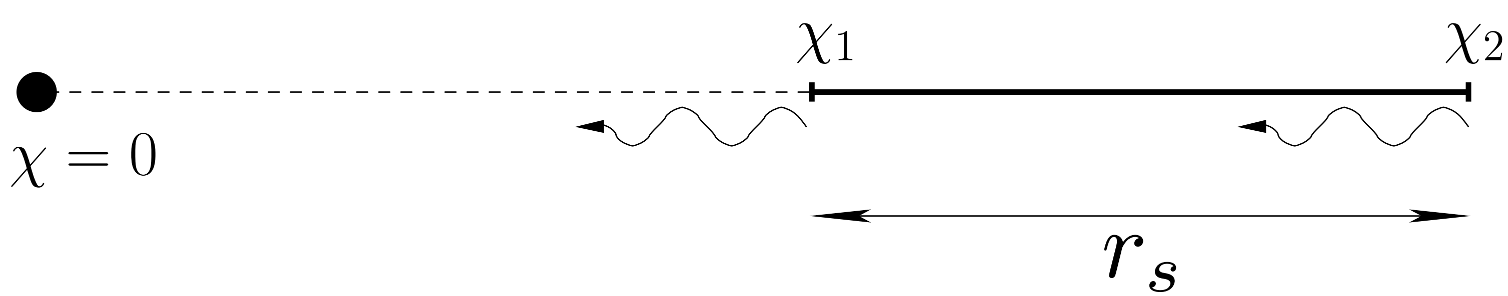
BAO can be used as a standard ruler



- Observed along the line of sight, it constrains a difference in redshift:

$$\Delta z = \frac{r_s H(z)}{c}$$

BAO can be used as a standard ruler



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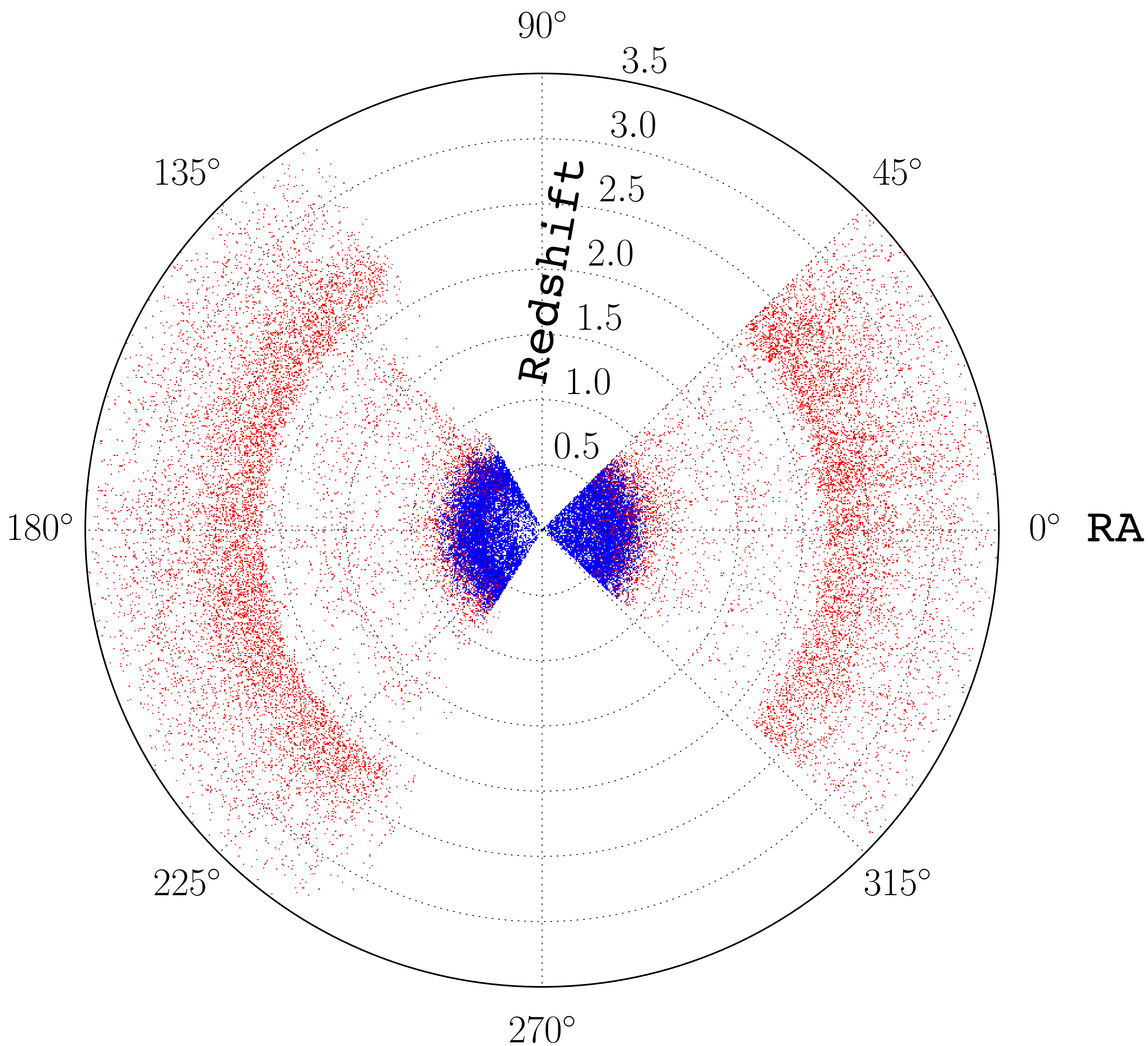
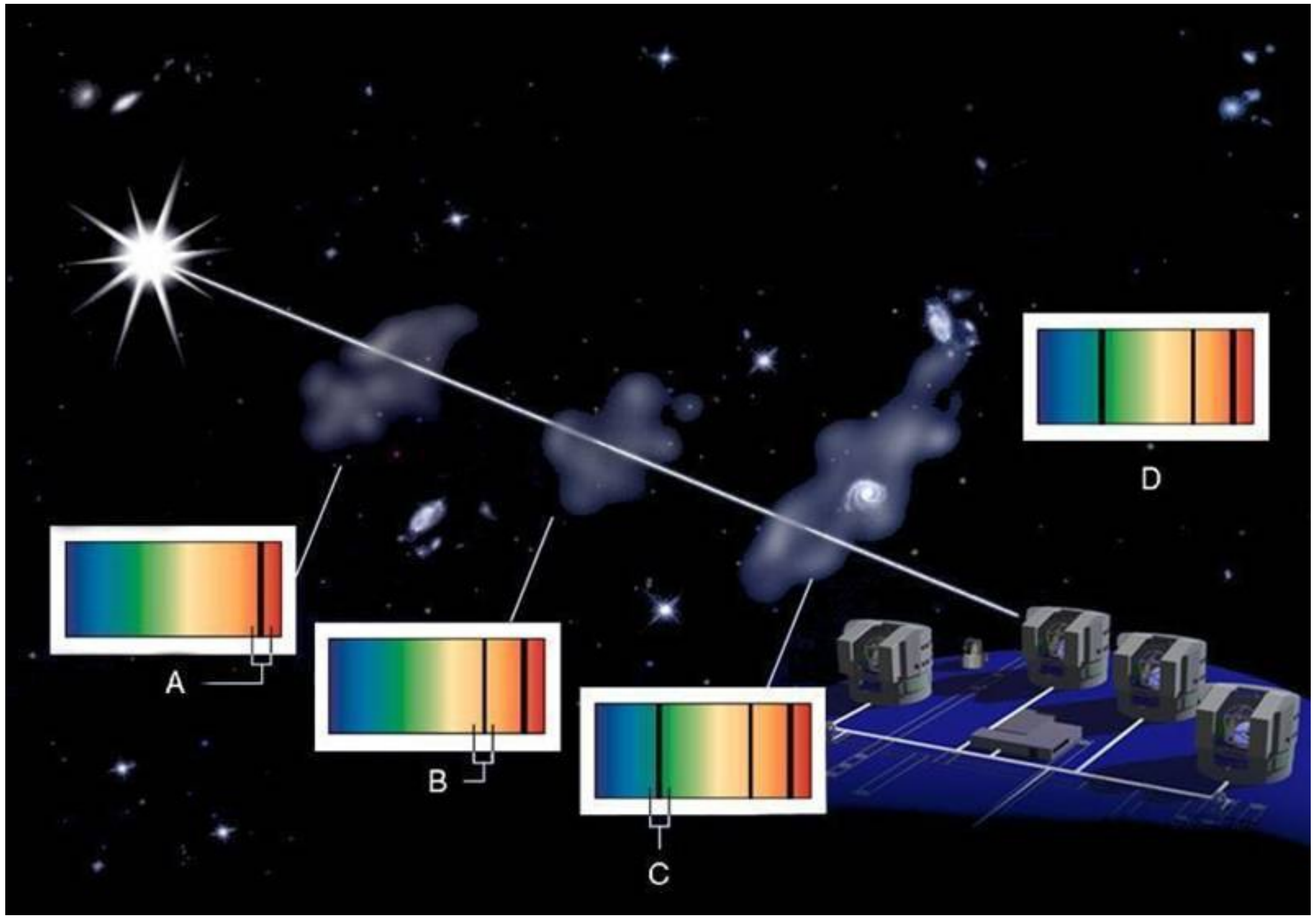
Depends on the parameters of your model

Quasars can be observed at much higher redshift than galaxies

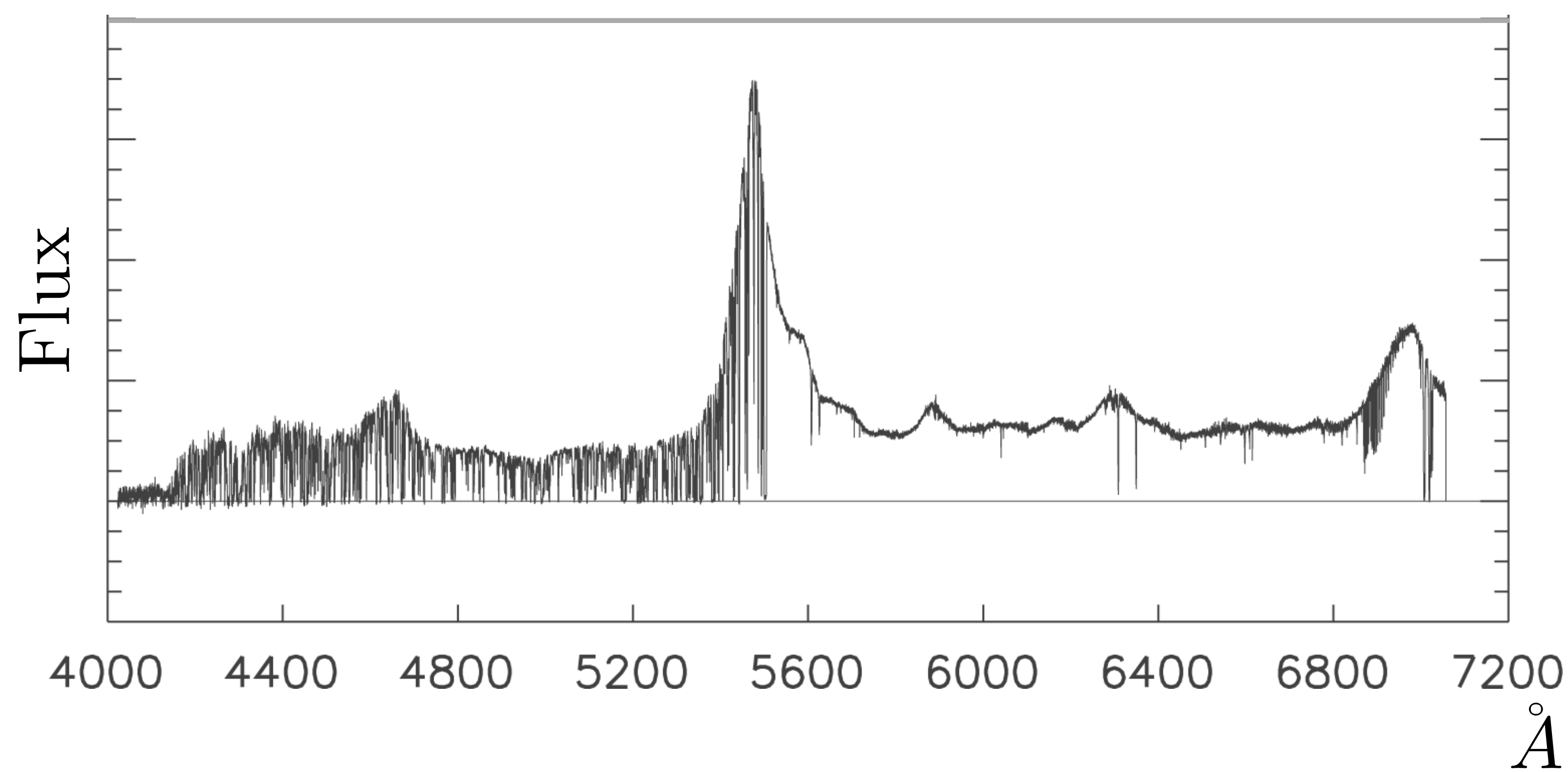


The light of quasars is absorbed during is travel toward us

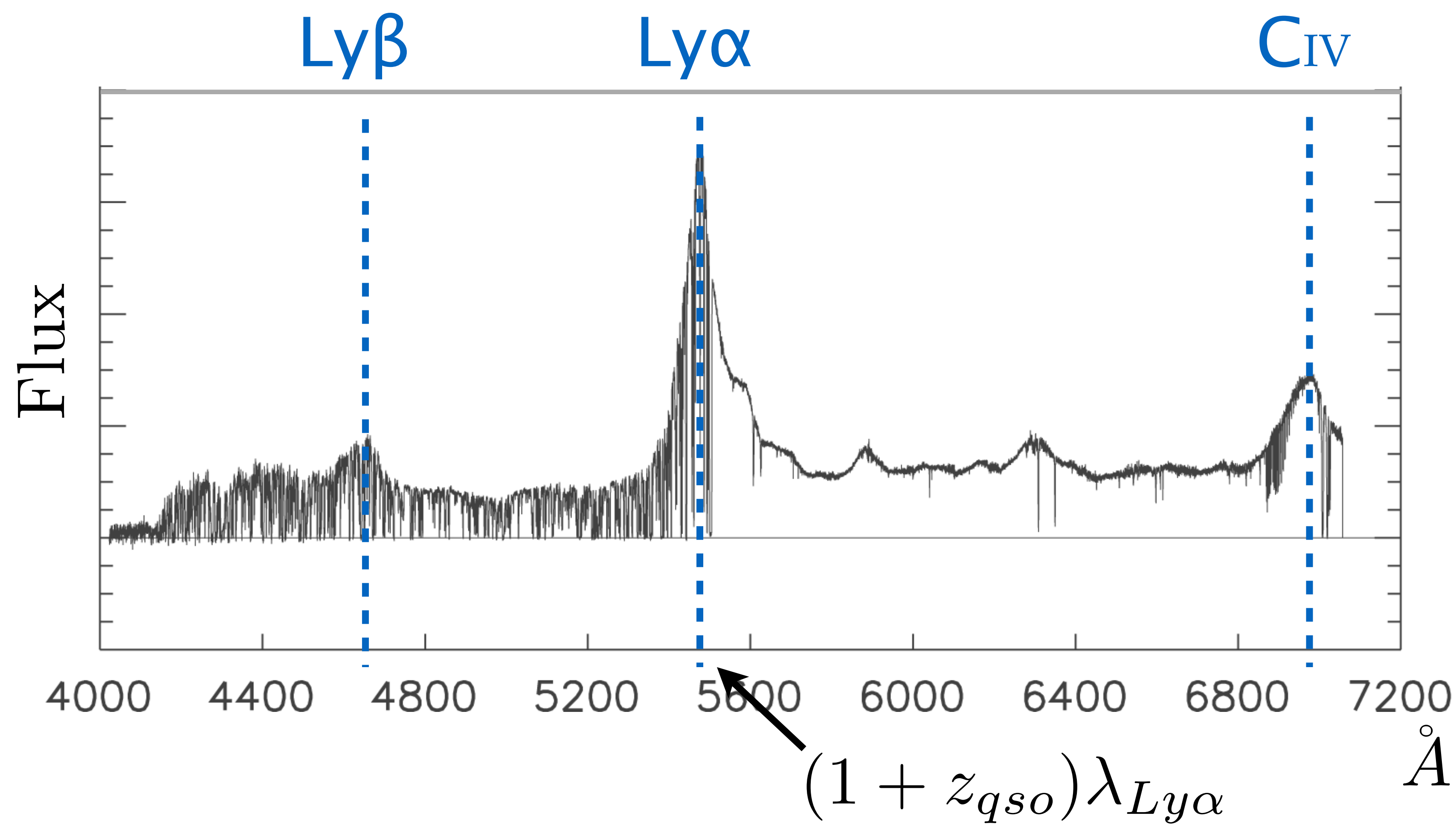


- Quasars are used as background light sources
- Neutral hydrogen creates absorption lines in their spectra

High z quasar spectra tell us about the HI density along their line of sight



High z quasar spectra tell us about the HI density along their line of sight



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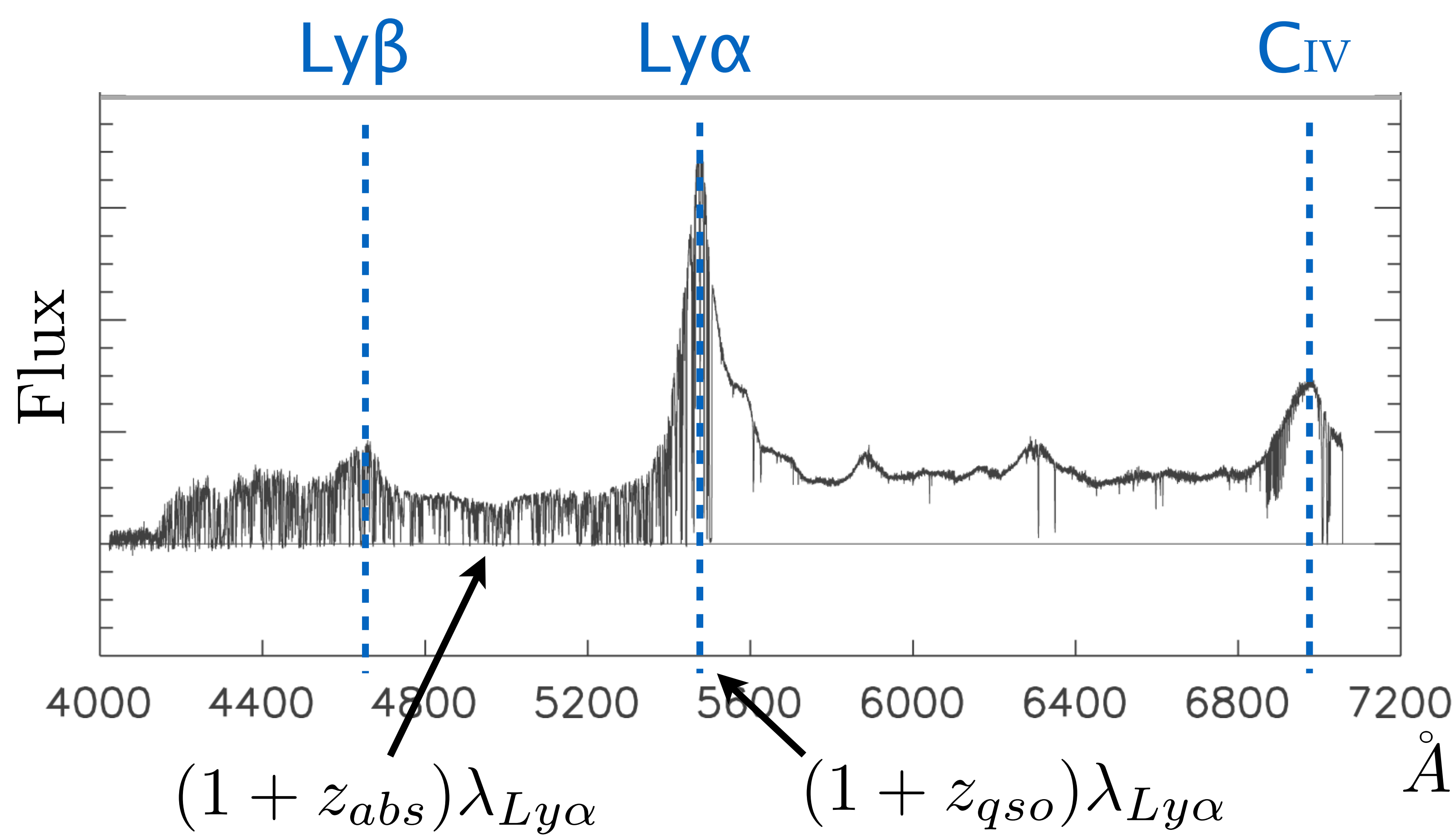

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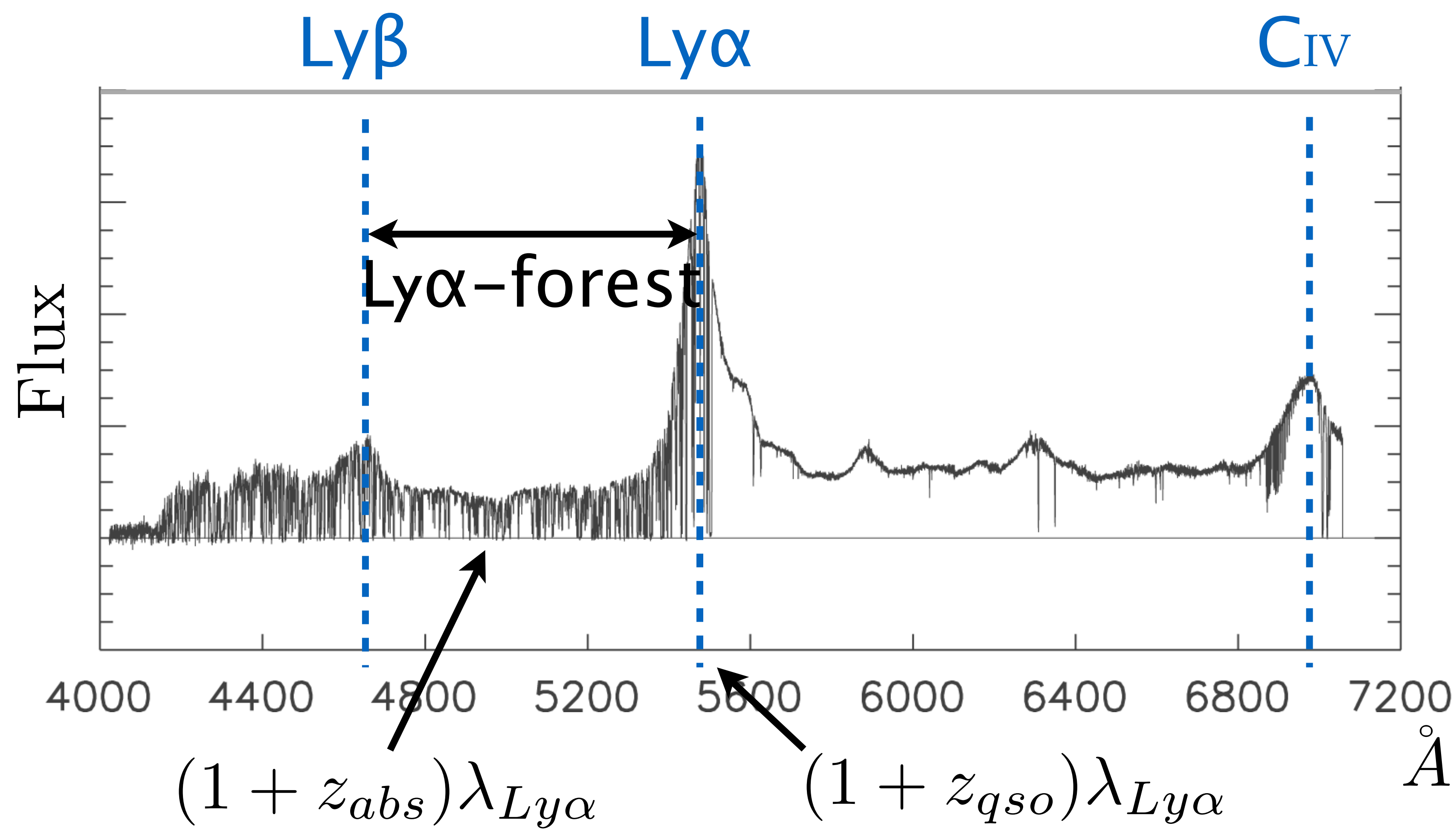

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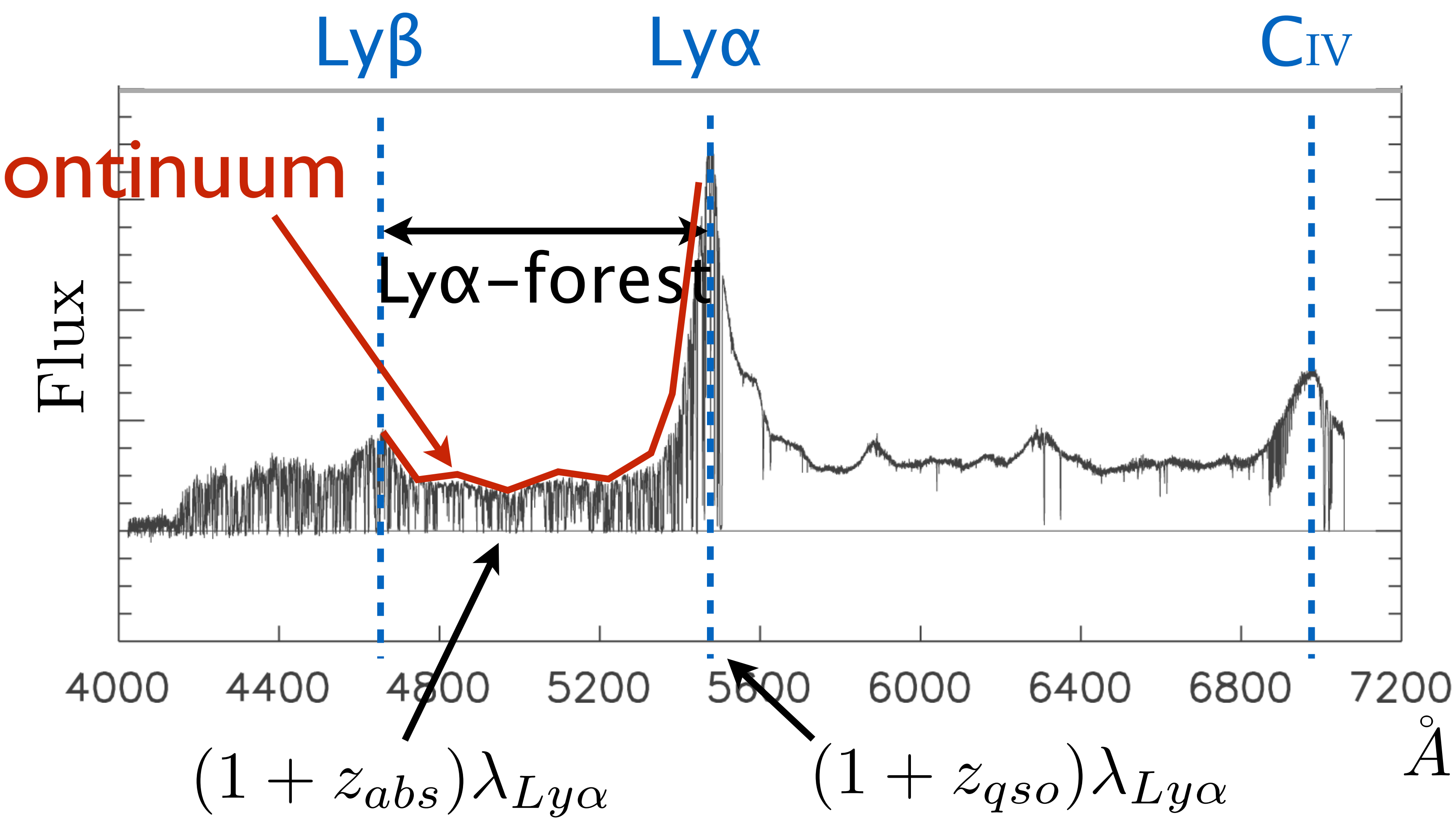


- Transmitted flux fraction :

$$F(\lambda_{obs}) = \frac{Flux}{Continuum} = e^{-\tau}$$

- Optical depth :

$$\tau(\lambda_{obs}) \propto n_{\mathrm{HI}}(z_{abs})$$

Compute the correlation function of the Lyman-alpha forest

- Define a delta field:

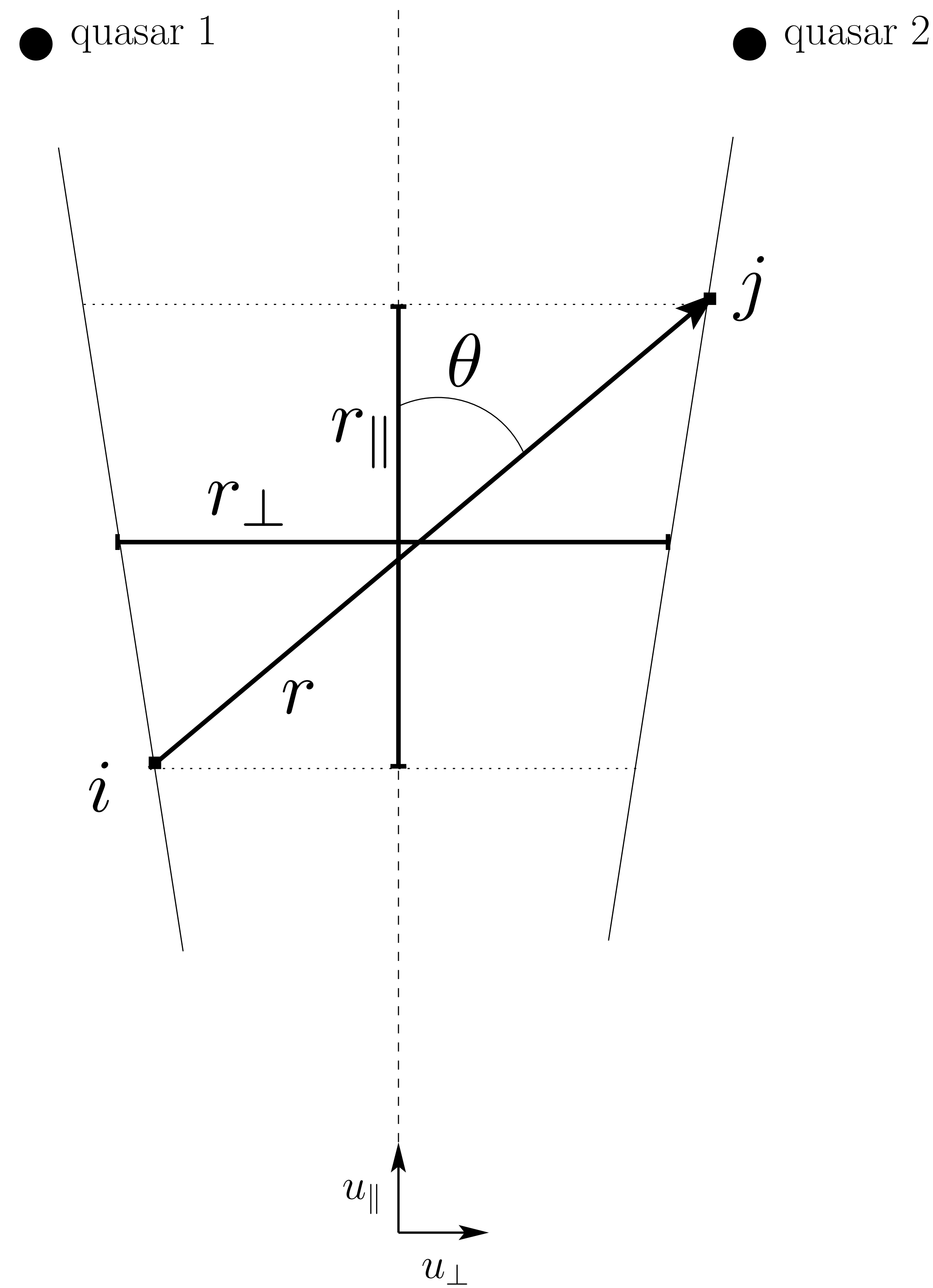
$$\delta_f(\lambda_{rq}, \lambda_{obs}) = \frac{f(\lambda_{obs})}{Cont(\lambda_{rq})\bar{F}(\lambda_{obs})} - 1$$

- Use a trivial estimator:

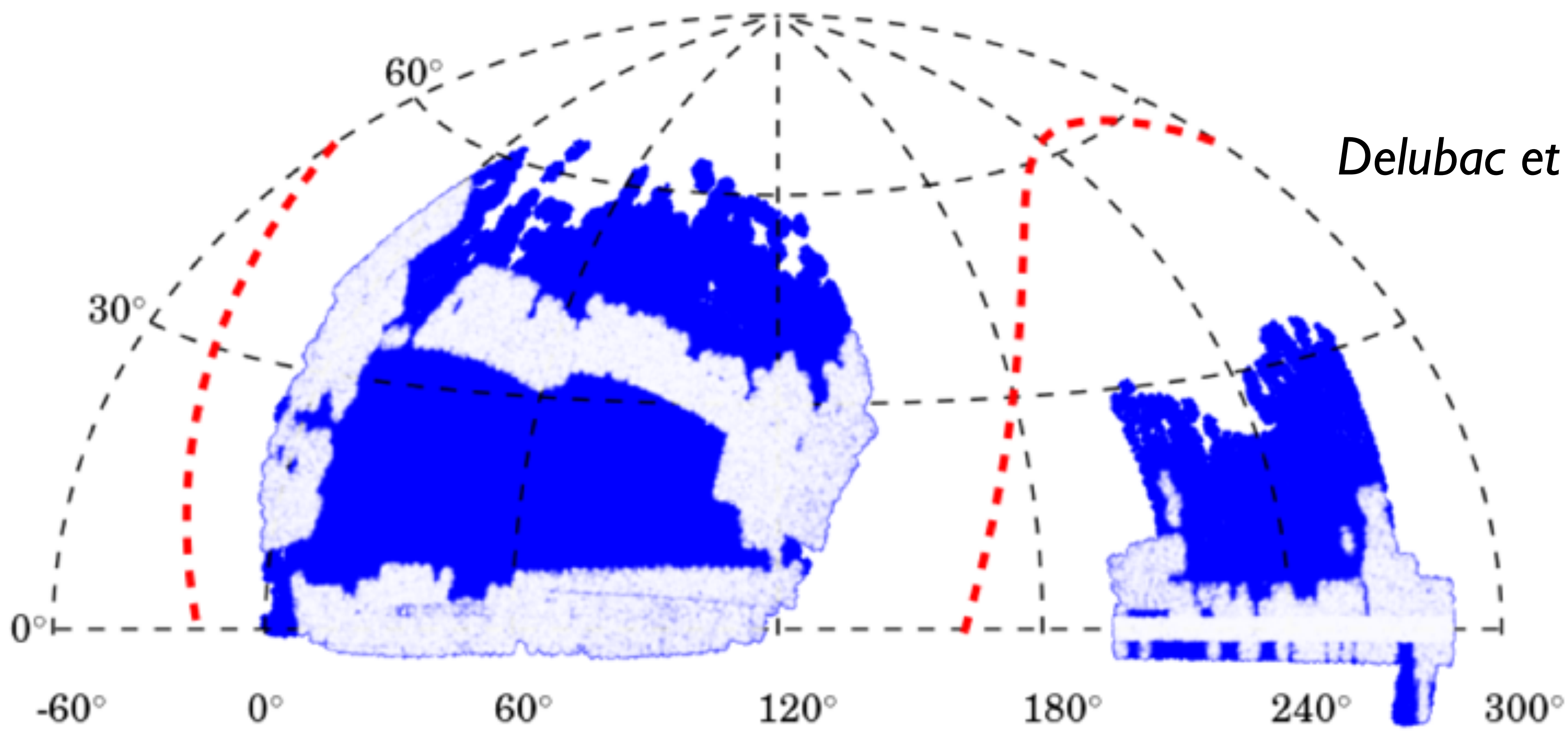
$$\hat{\xi}_A = \frac{\sum_{i,j \in A} w_i w_j \delta_i \delta_j}{\sum_{i,j \in A} w_i w_j}$$

- Use a fiducial cosmology:

$$(\Omega_m, \Omega_\Lambda) = (0.27, 0.73)$$



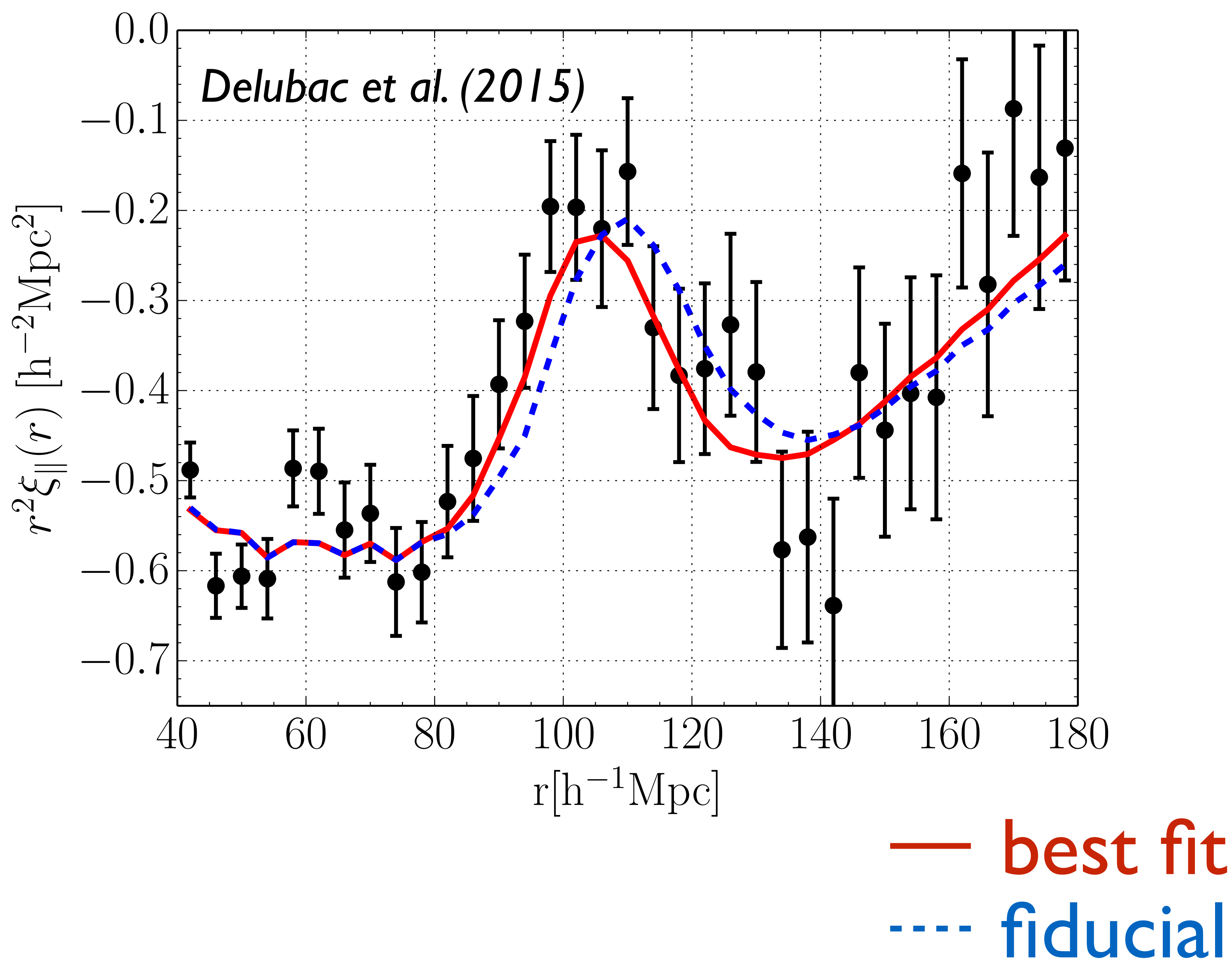
Used BOSS DR11 quasars sample



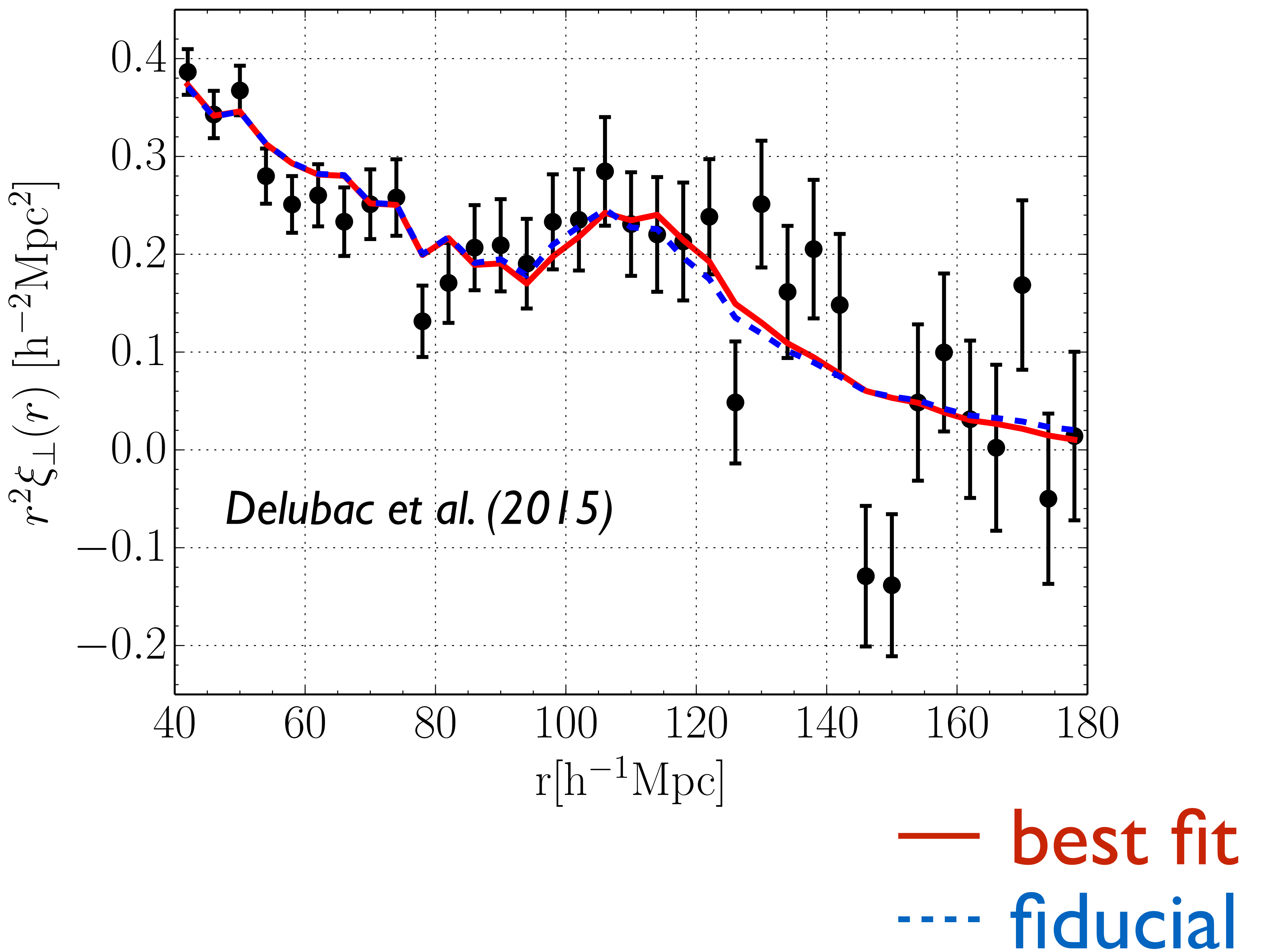
Delubac et al. (2015)

- Analysis uses ~140,000 quasars with $2.1 < z < 3.5$ over 9,000 deg^2

Have a 5 sigma detection of the BAO peak



High redshift space distortion makes the peak bigger in the line of sight



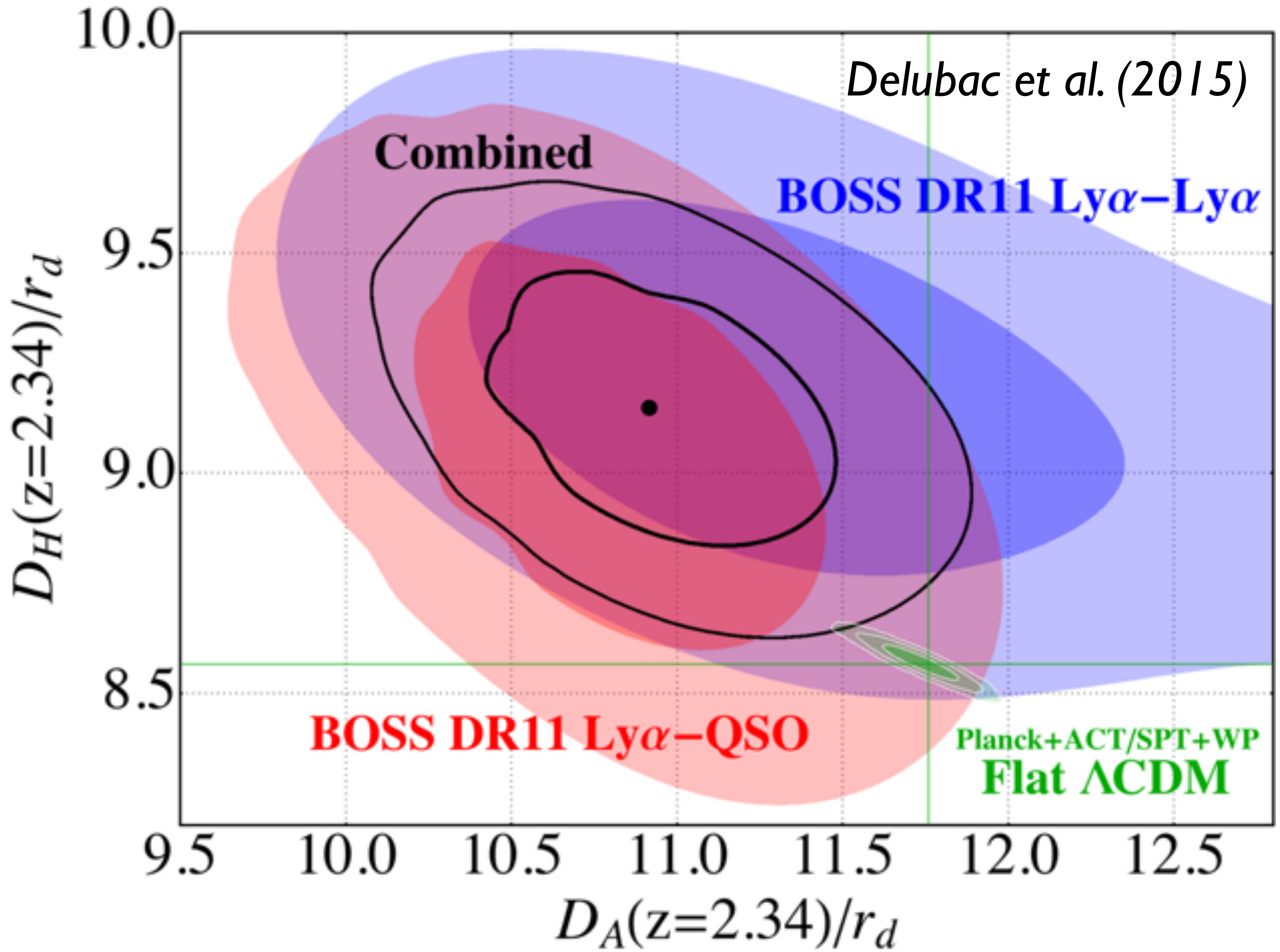
No evidence for systematic effects at the level of statistical uncertainties

- Systematics that have been considered so far include:
  - Analysis pipeline
  - bias in the fit
  - Metal contaminations
  - Residuals in sky subtraction
  - wavelength dependent flux bias
  - Correlated noise in pixels
  - …

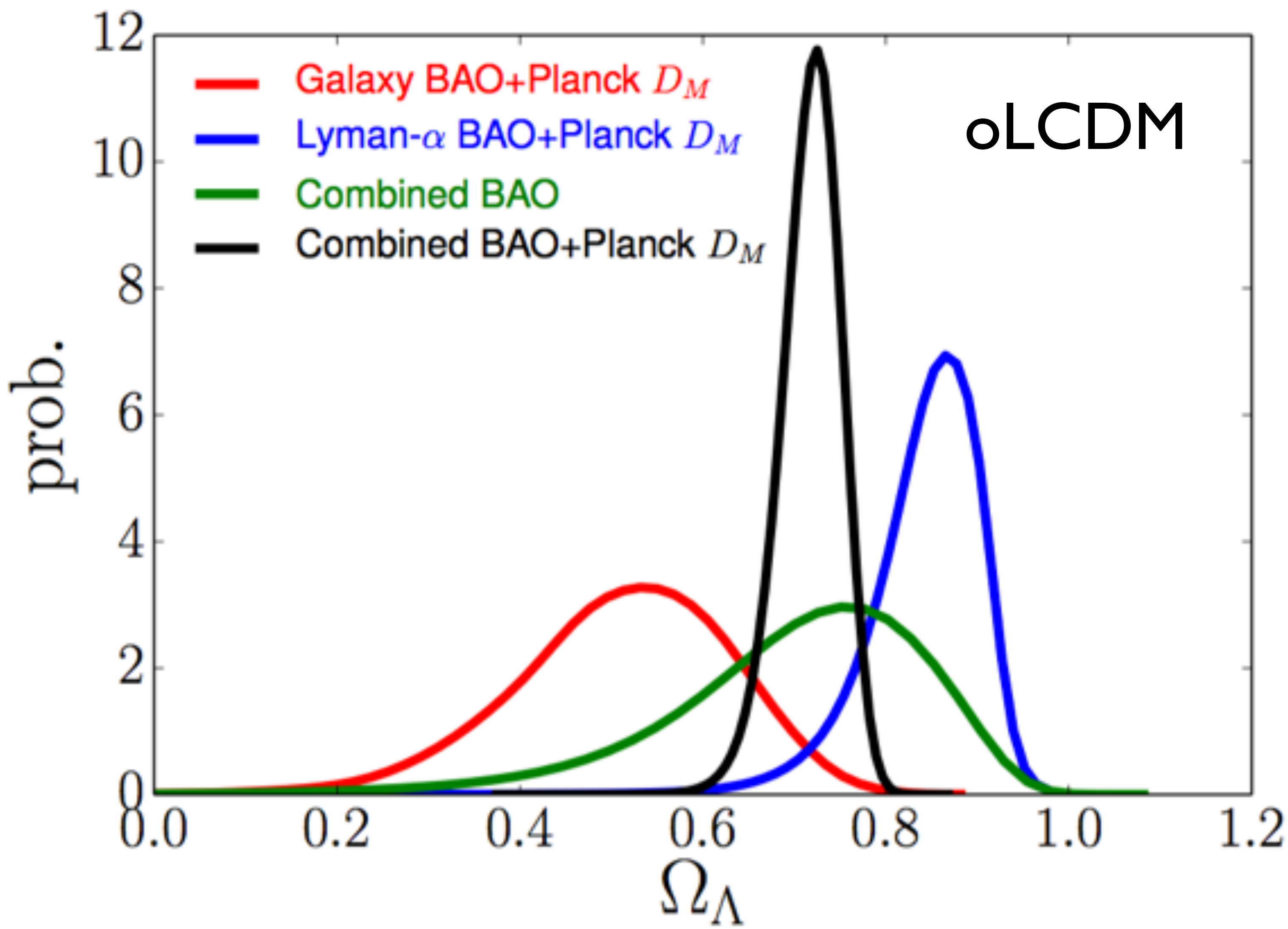
Mocks

BOSS Pipeline

Obtain model independent constraints on D_A/r_s and D_H/r_s



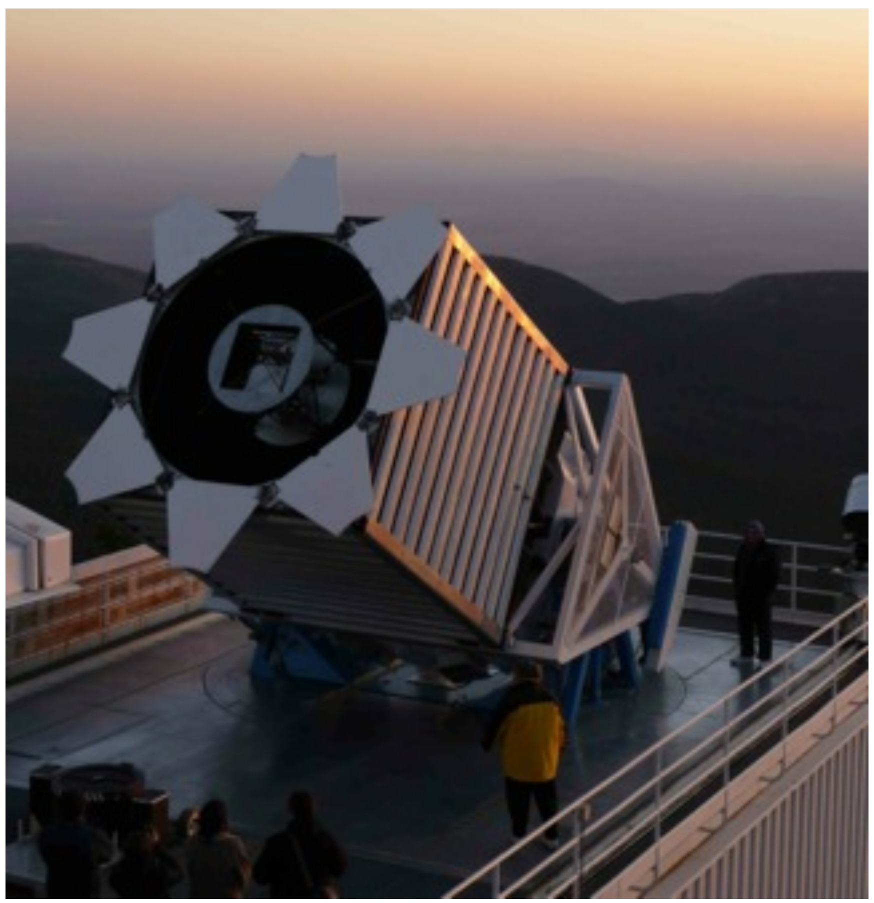
Numerous cosmological implications including detection of Dark Energy by BAO only

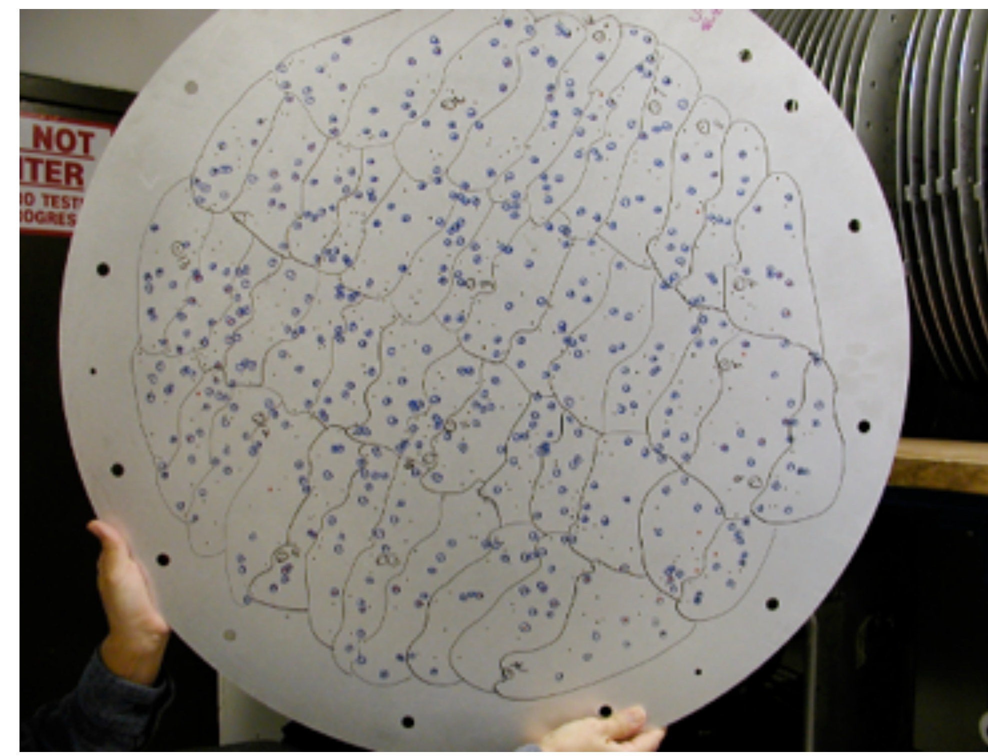


Aubourg et al. (2015)

- Purely geometric constraints. Lambda detected form BAO alone at more than 3 sig.

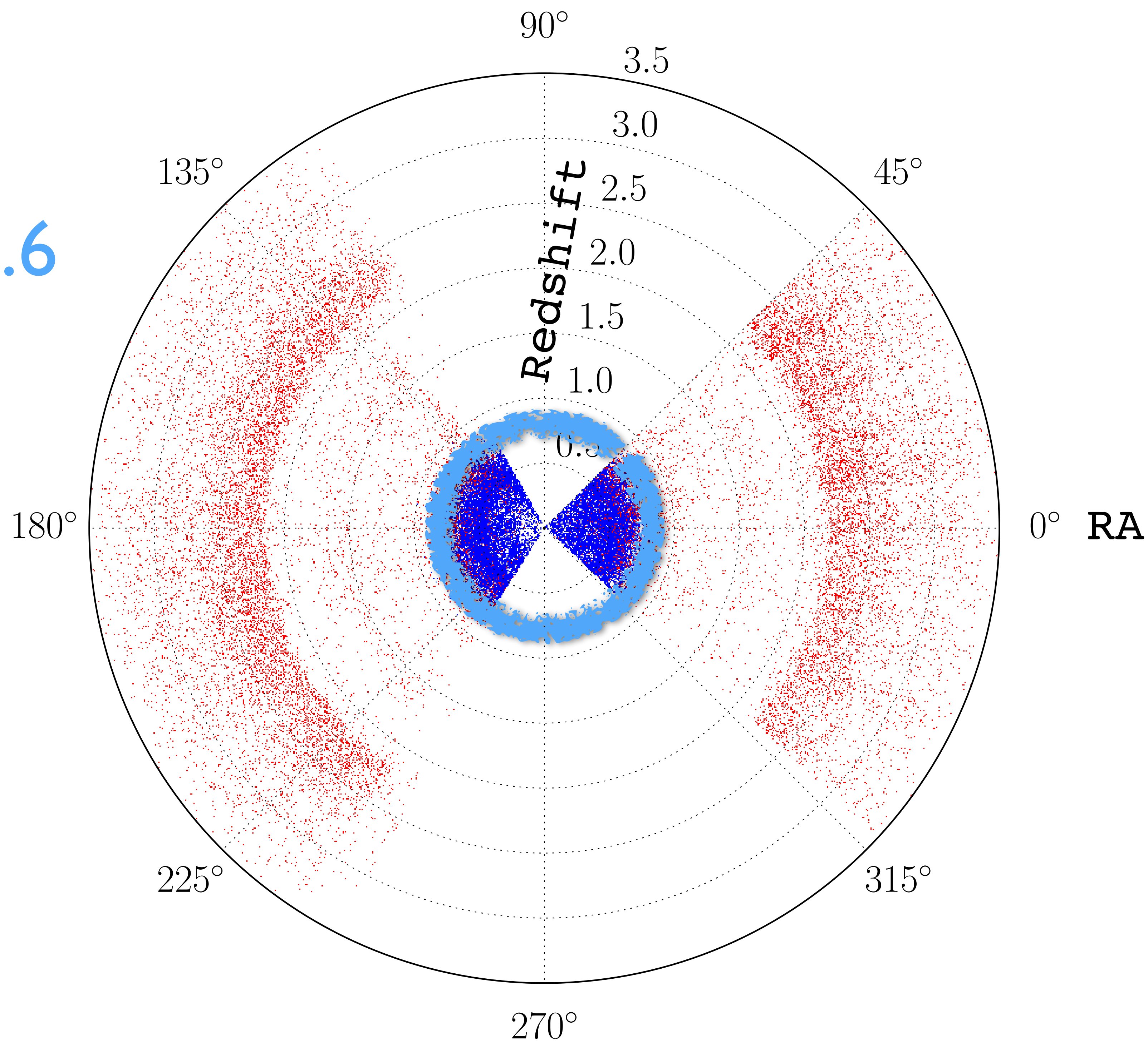
eBOSS maps the Universe to observe the BAO





eBOSS will use 4 different tracers to improve BOSS constraints

LRGs at z>0.6



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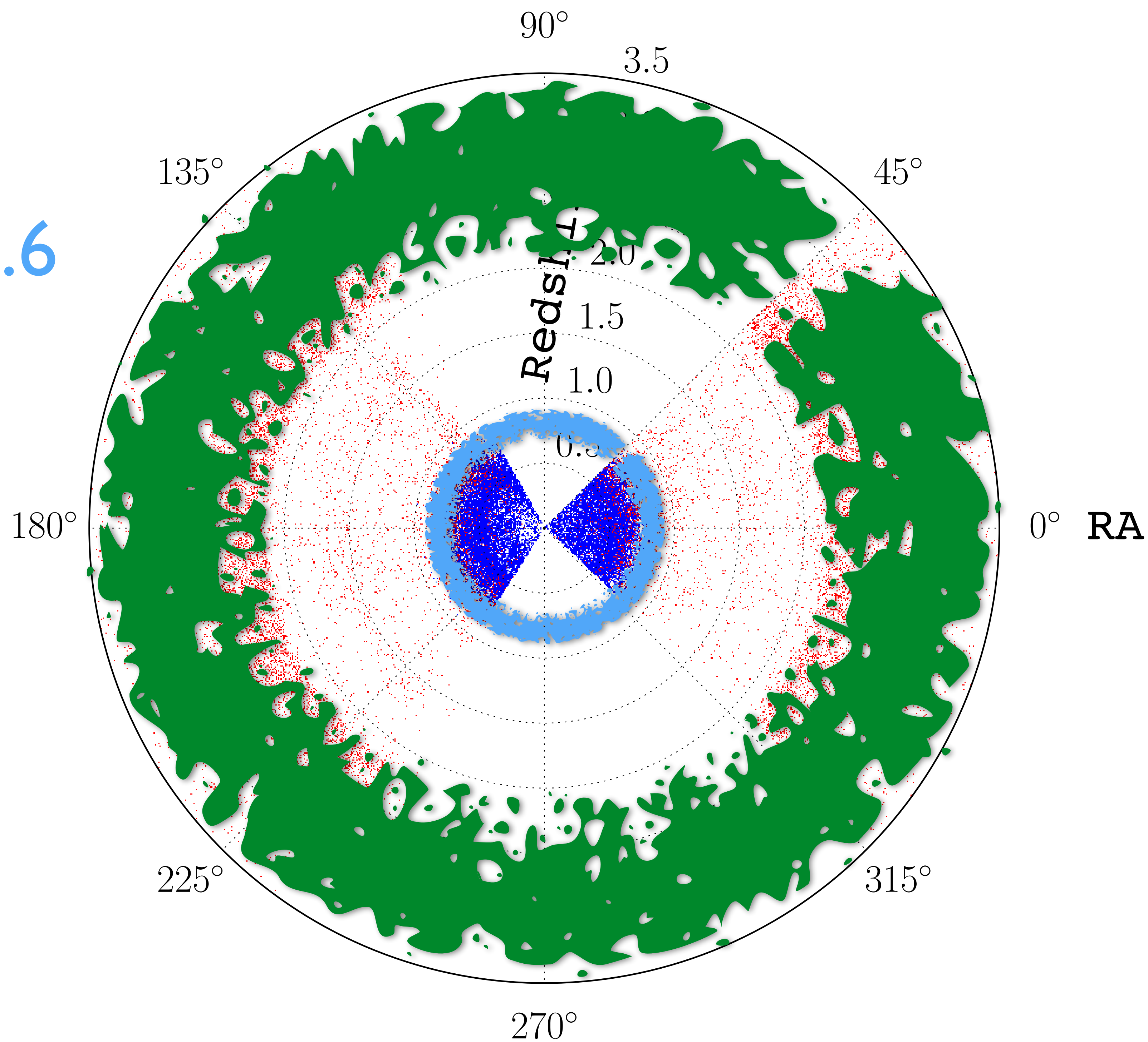

Lyman-alpha quasars at z>2.1

eBOSS will use 4 different tracers to improve BOSS constraints

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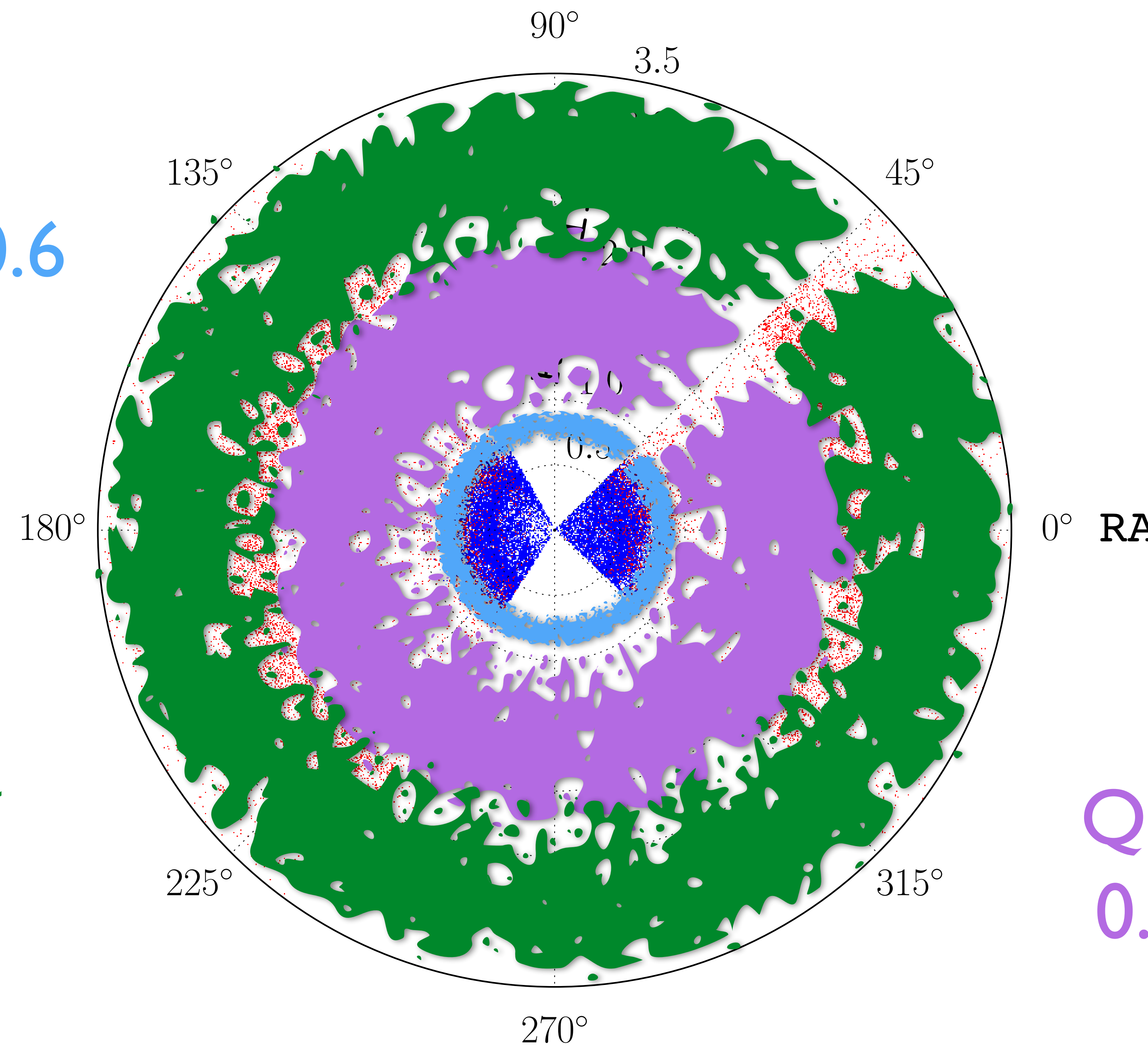
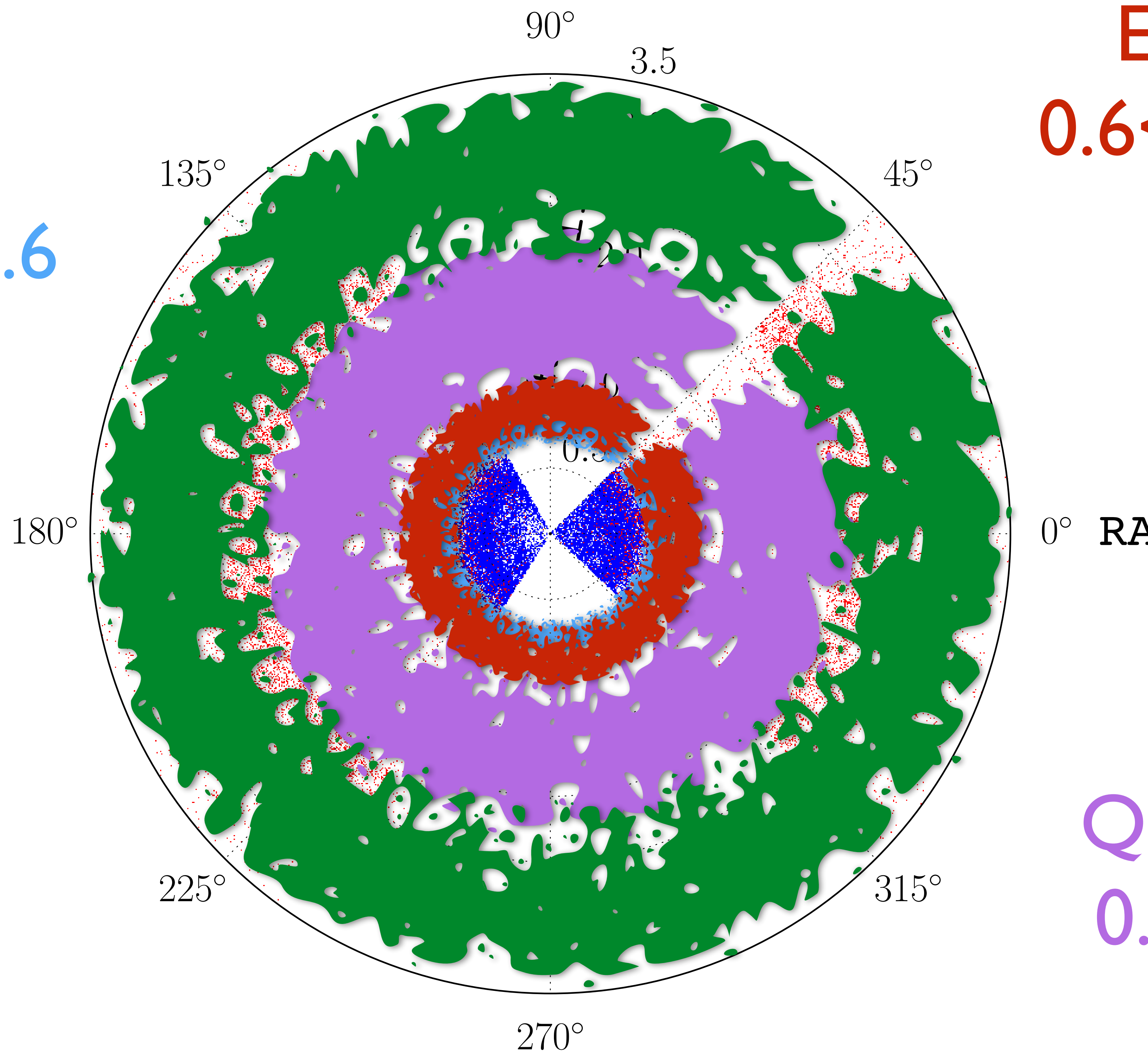


Lyman-alpha quasars at z>2.1

Quasars at 0.9<z<2.2

eBOSS will use 4 different tracers to improve BOSS constraints



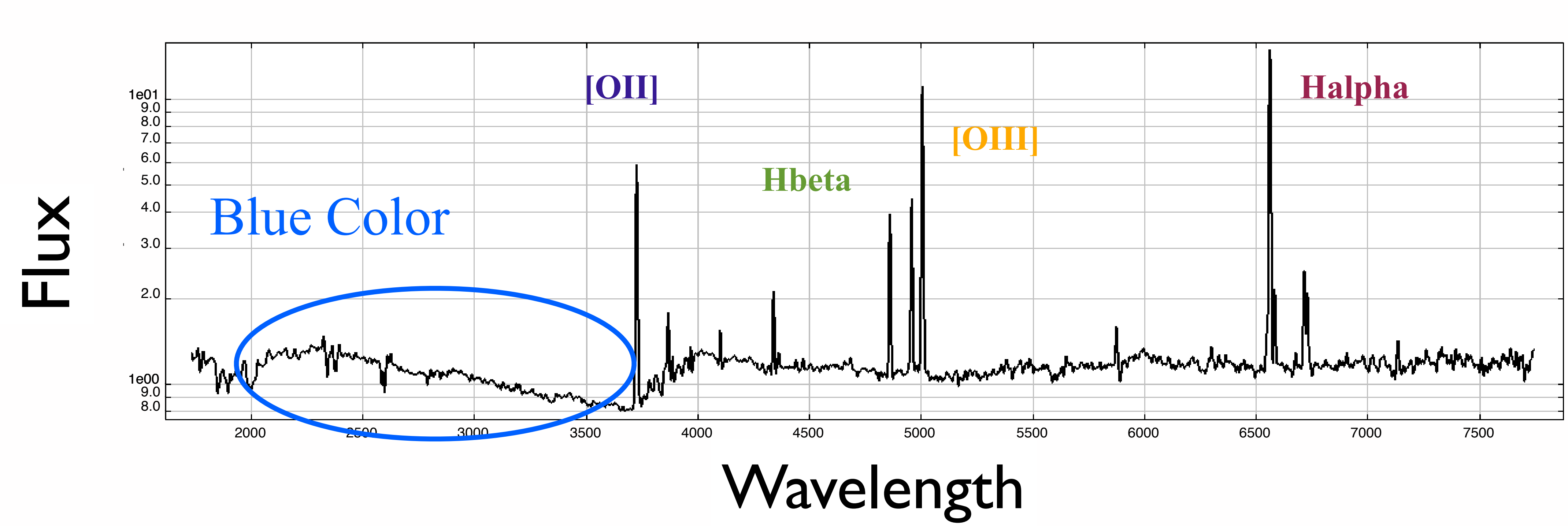
ELGs
0.6<z<1.0

LRGs at z>0.6

Lyman-alpha
quasars
at z>2.1

Quasars at
0.9<z<2.2

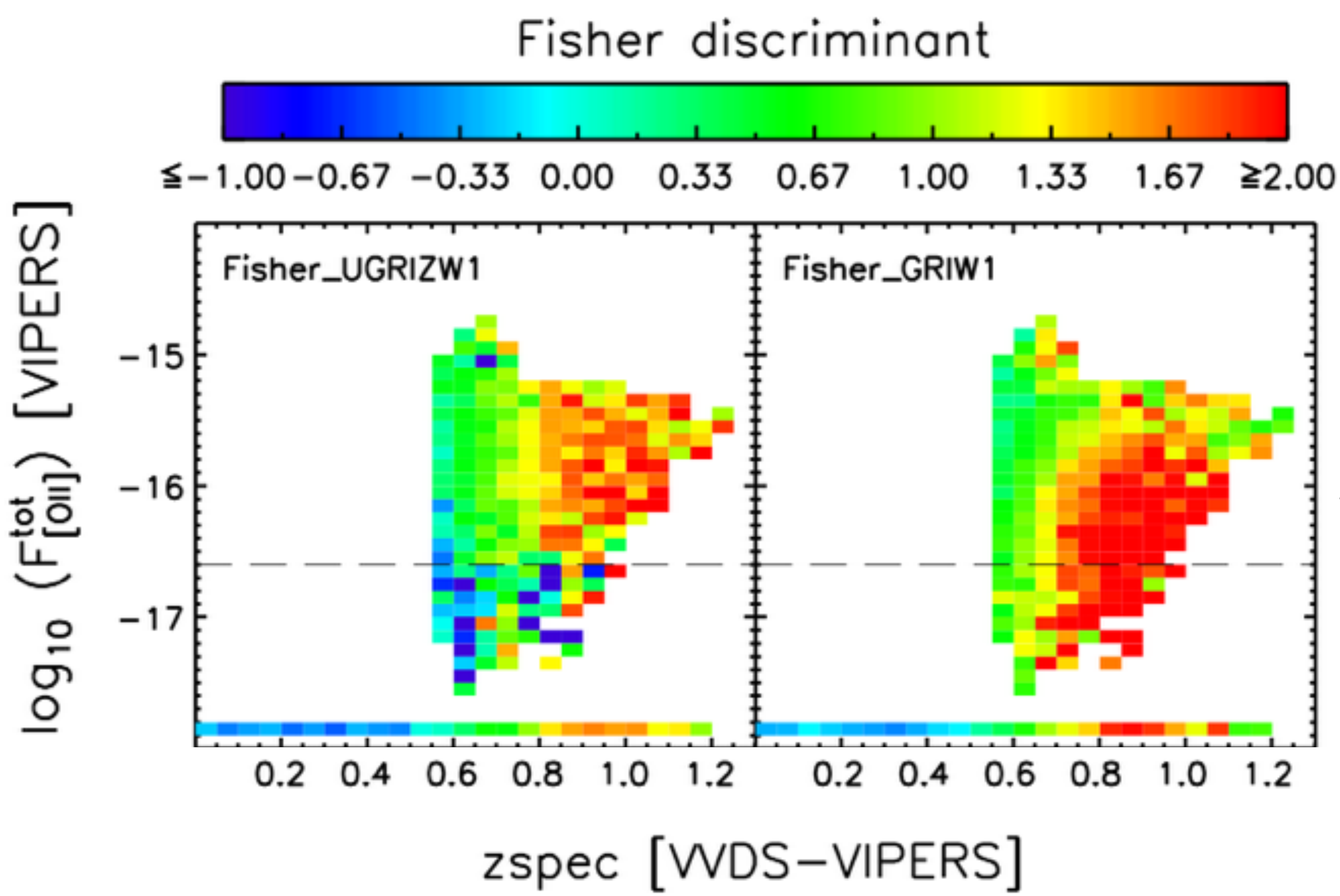
ELGs will be the main tracer for DESI, Euclid, PSF, 4MOST…



- For z>0.8 the massive population of galaxies is dominated by star forming galaxies.
- ELG spectra display strong emission lines allowing secure estimation of their redshift in short exposure time.

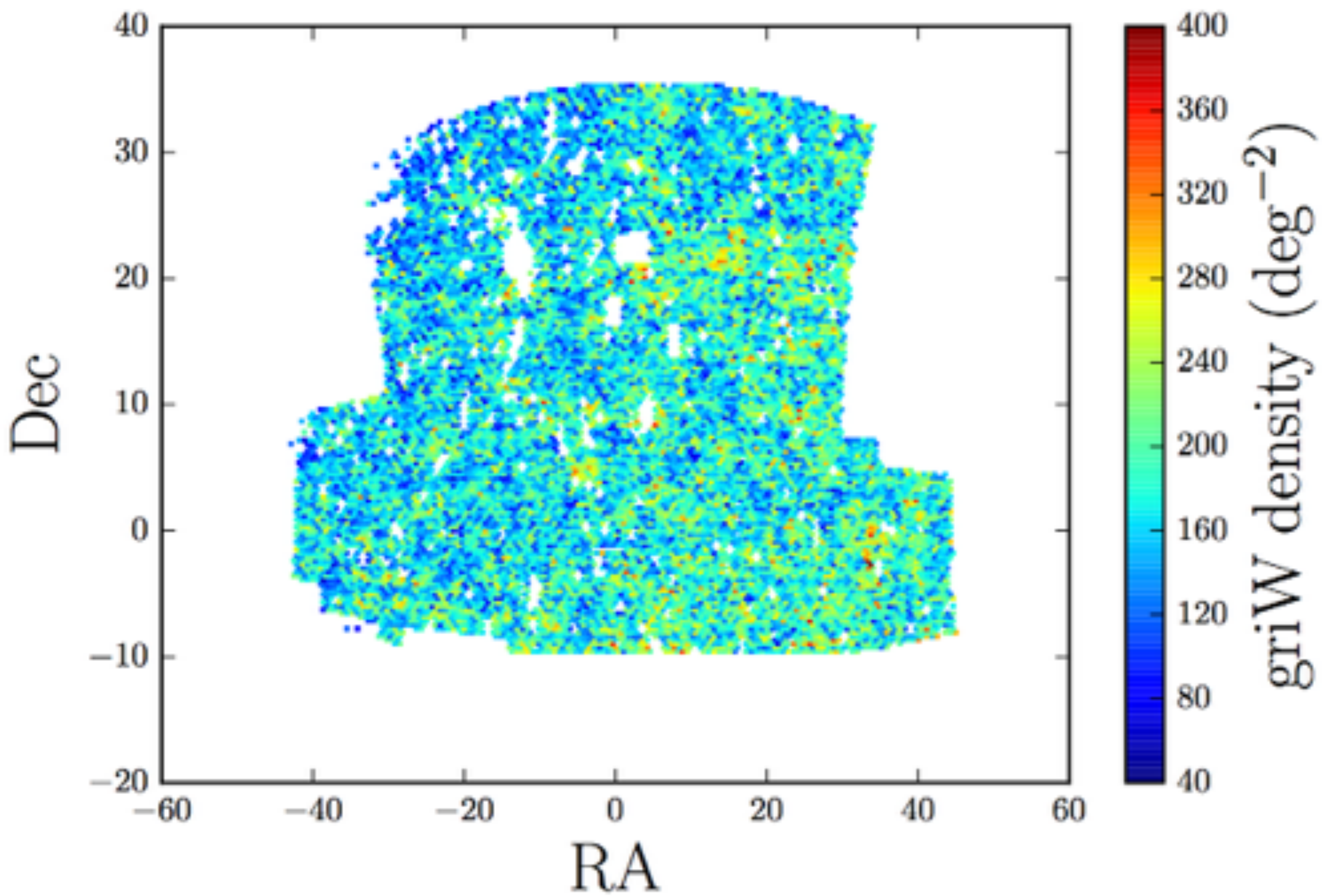
Propose an ELG selection using a Fisher discriminant

$$X_{FI} = \alpha_0 + \alpha_{ur} \times (u - r) + \alpha_{gr} \times (g - r) + \alpha_{ri} \times (r - i) + \alpha_{rz} \times (r - z) + \alpha_{rW1} \times (r - W1)$$

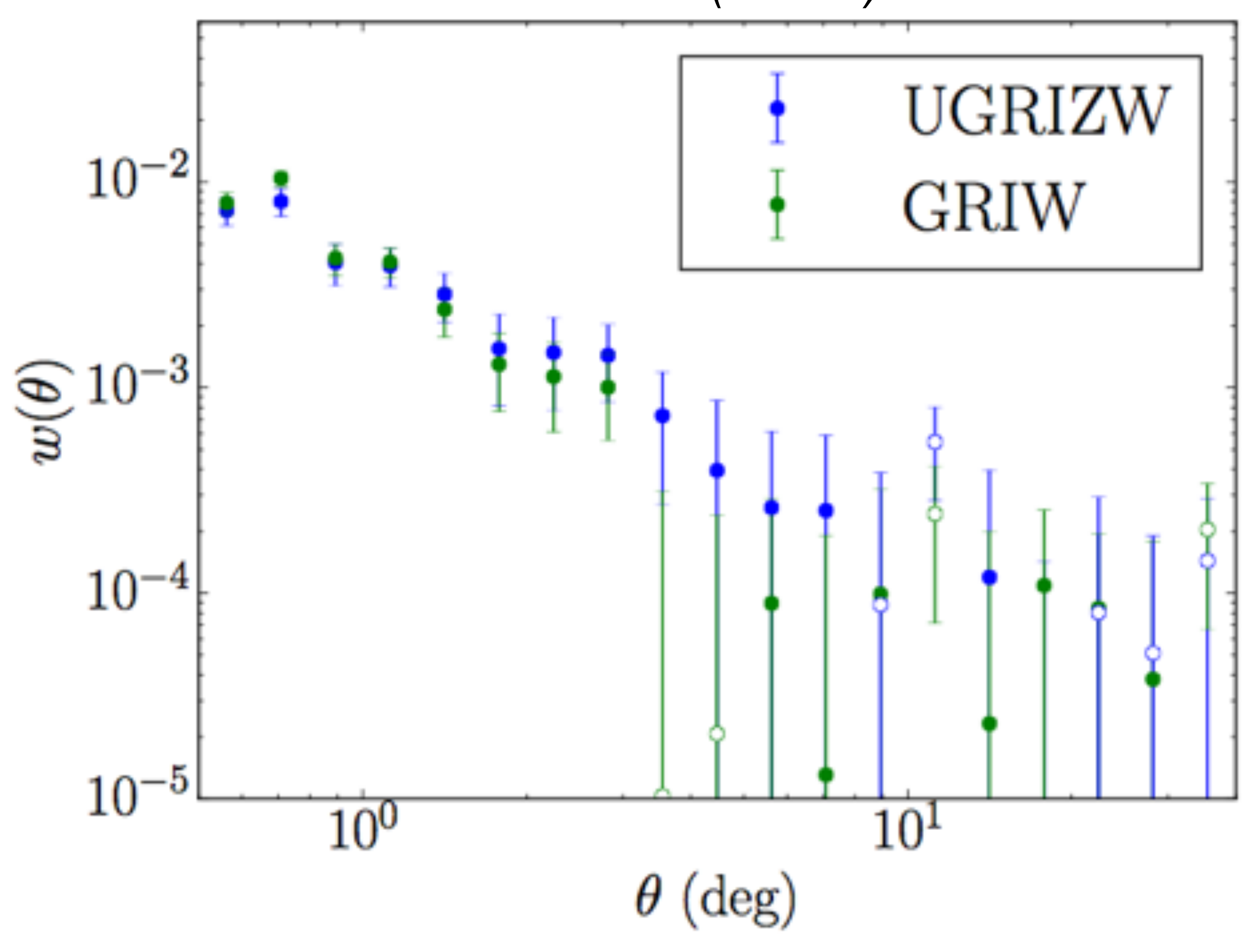


Raichoor, Comparat, Delubac et al. (2015)

Catalog of ELGs publicly available soon!

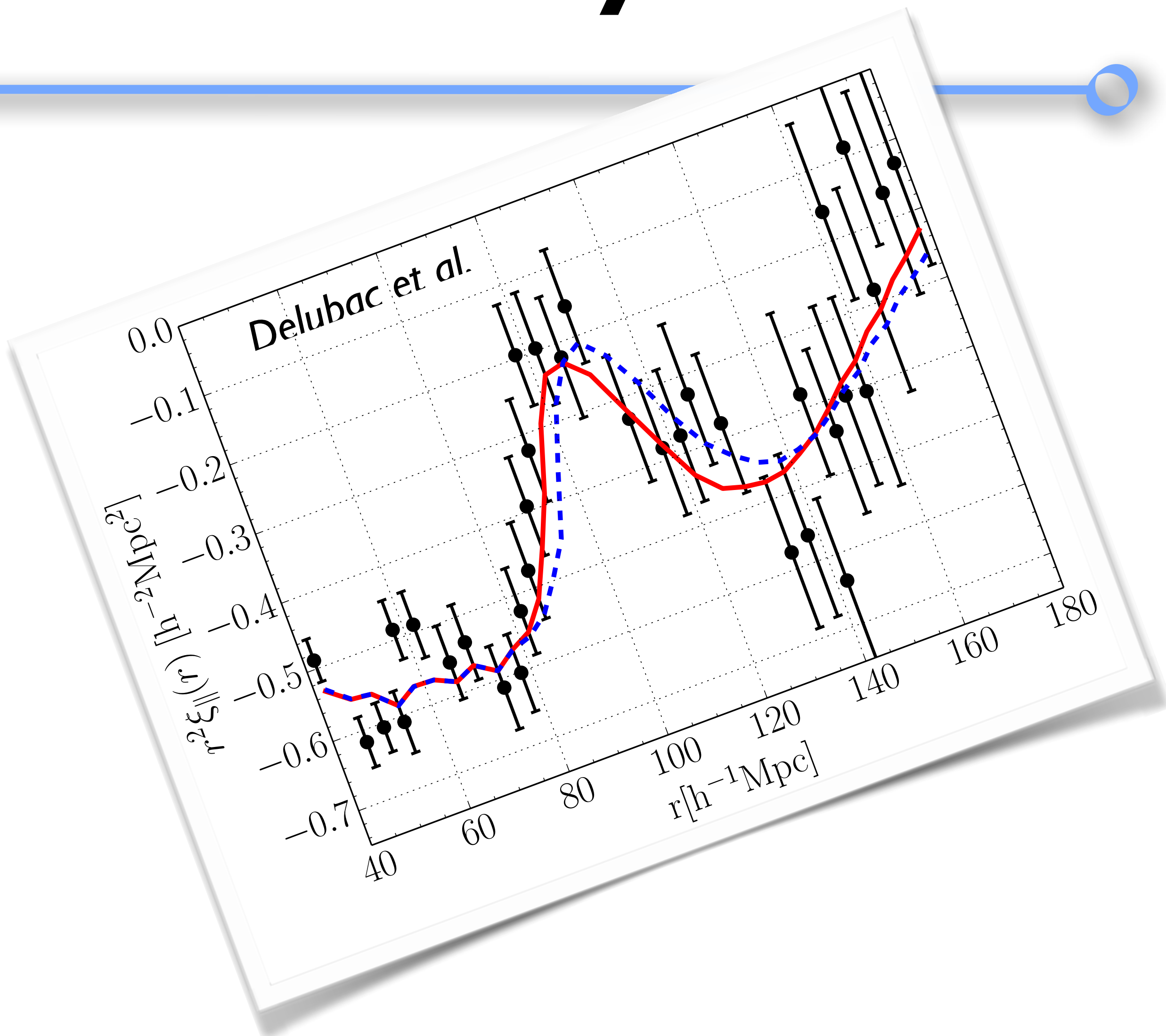


Delubac et al. (2015)



- Galaxy bias of 1.35
- Contains about 600,000 ELGs over the South Galactic Cap

Take away message



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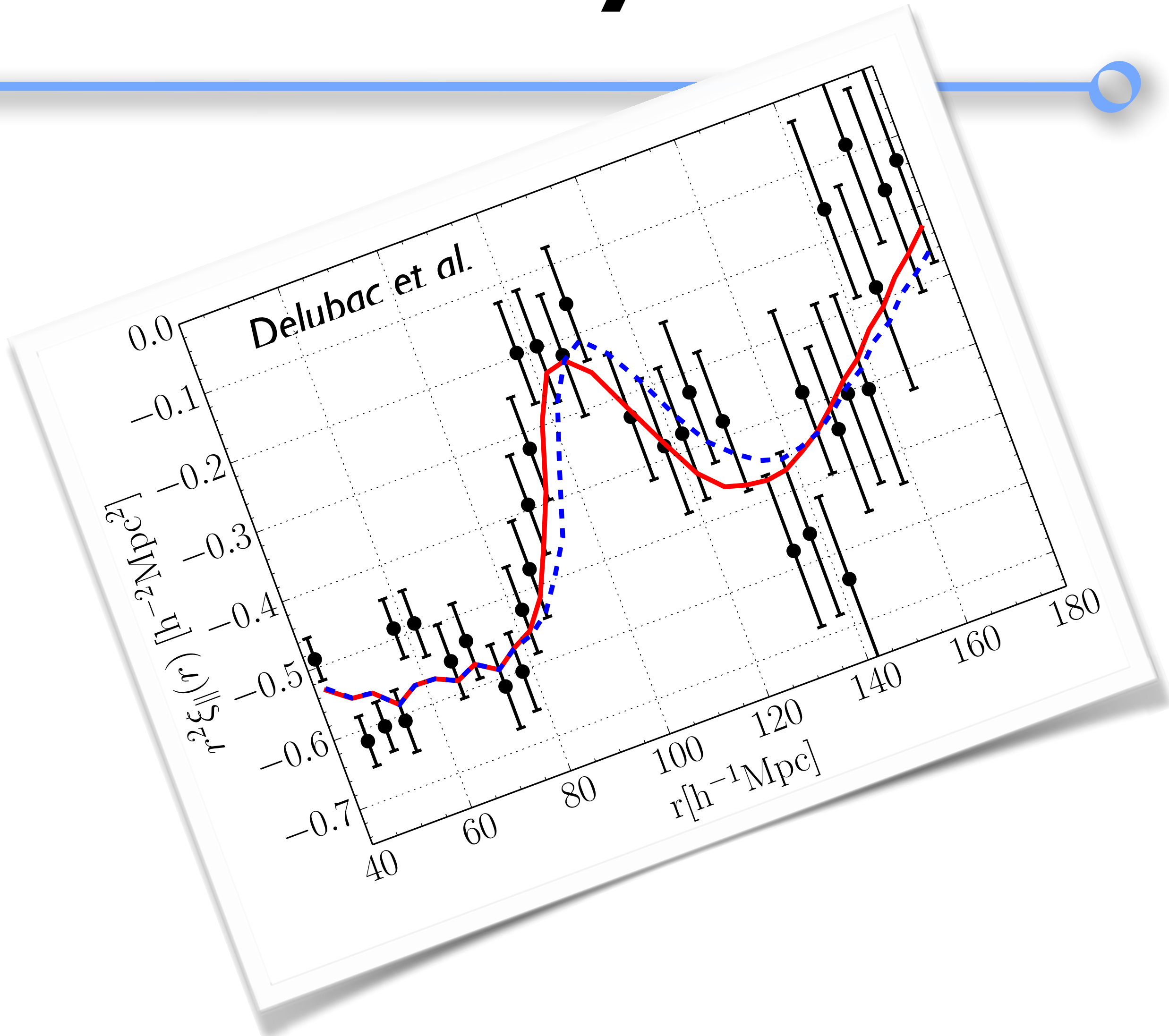

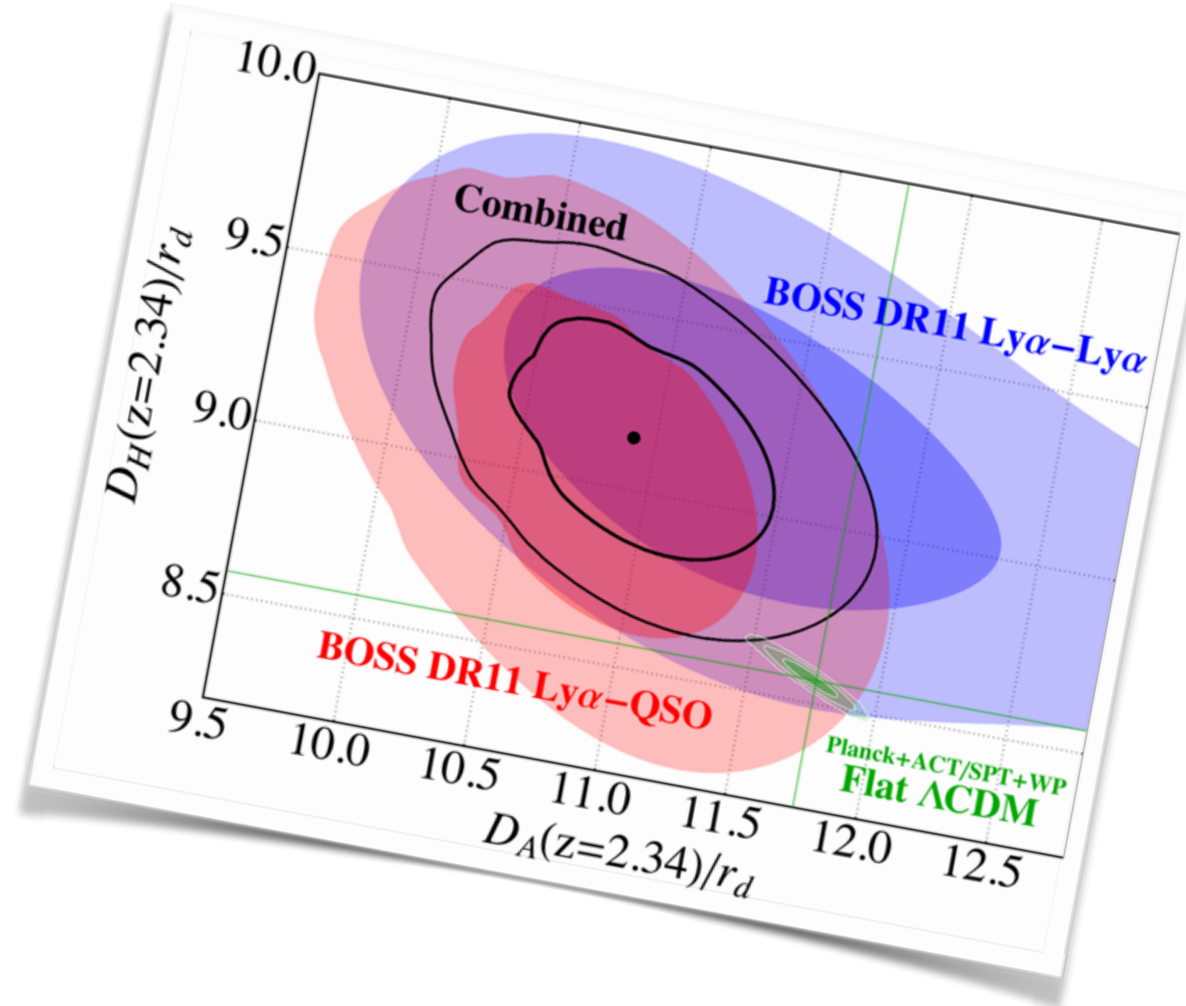

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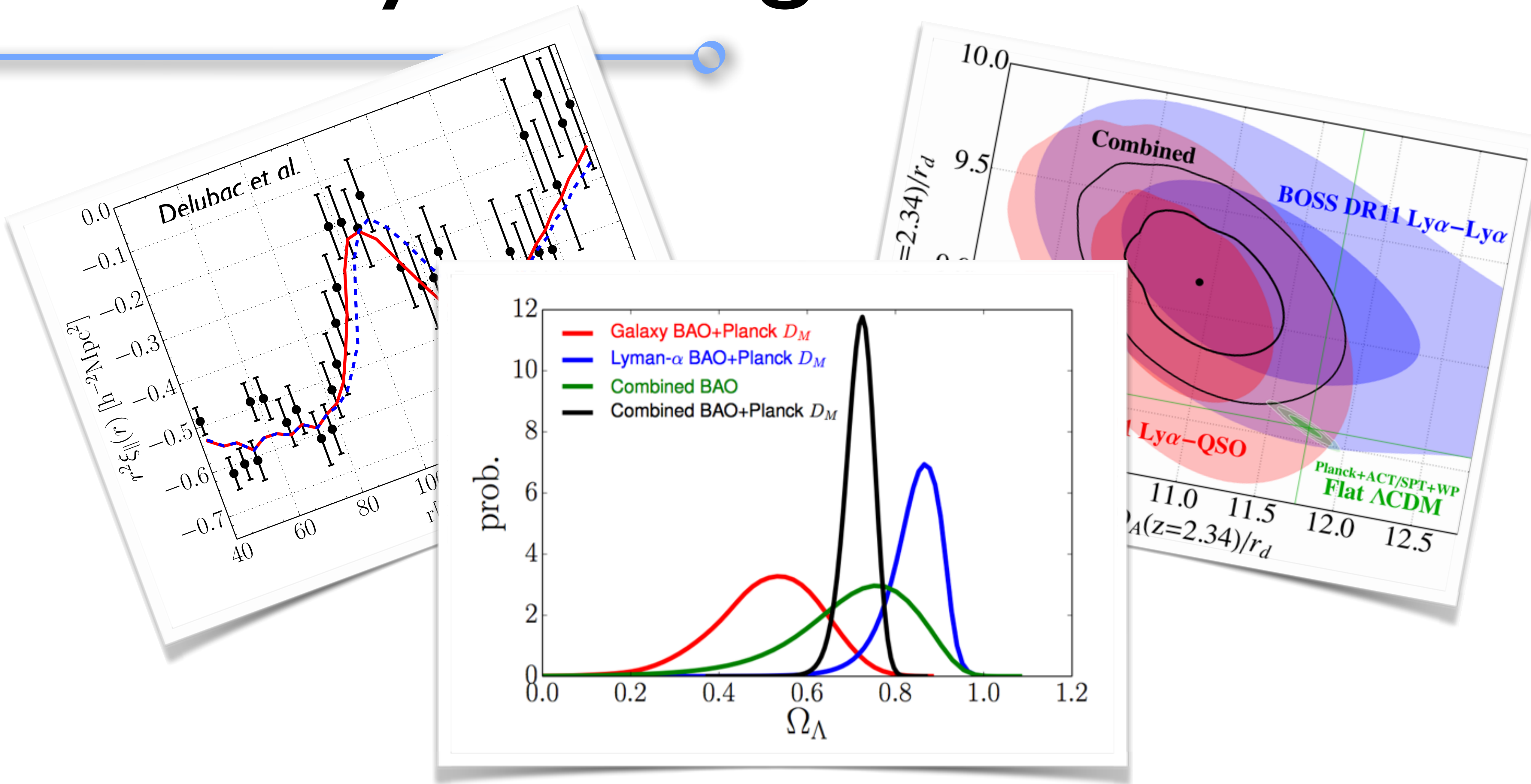

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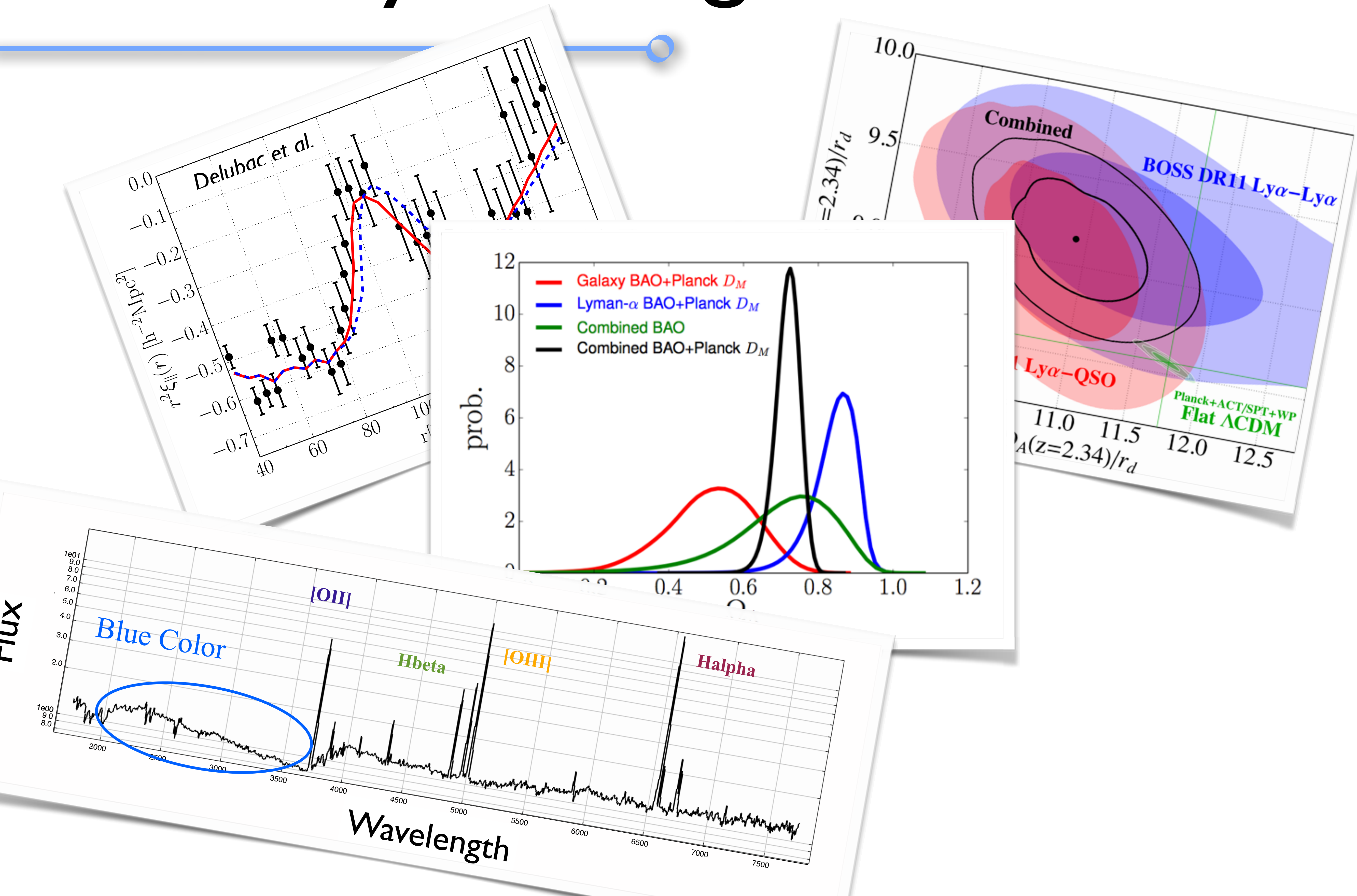

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