Using simulated quasar catalogs for the BAO in lyman-α analysis of eBOSS and DESI

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LPNHE
PARIS

SDSS

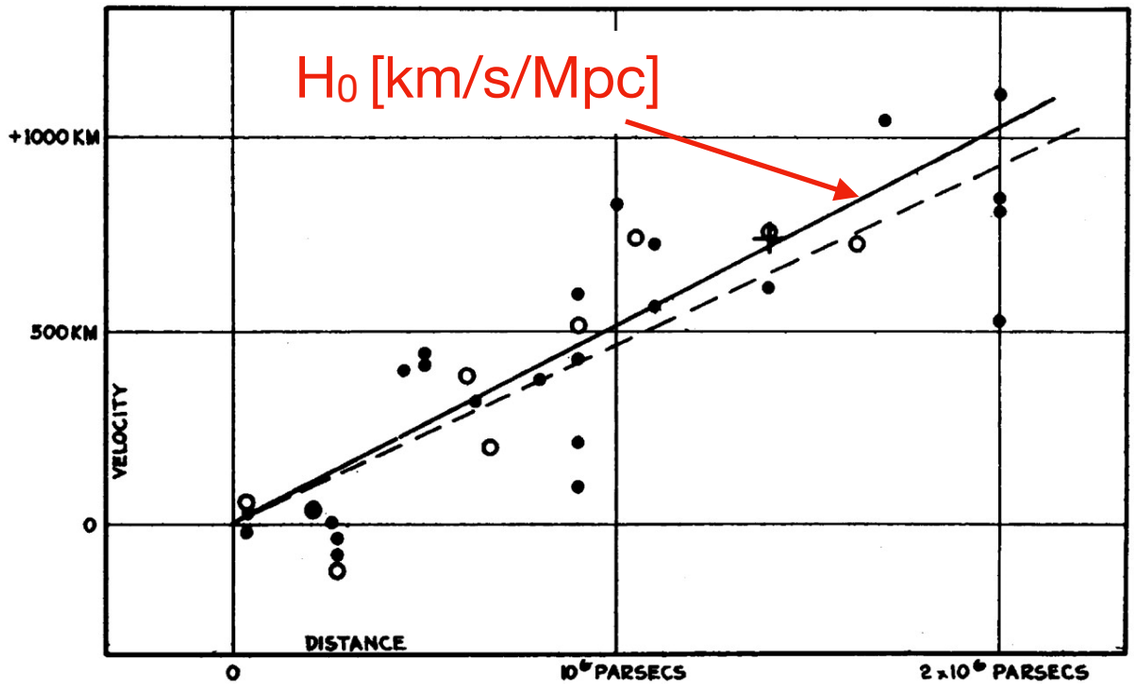
eBOSS

Dark energy and the accelerated expansion of the universe

First measurements

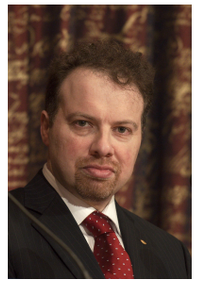
200g of dark energy sugar

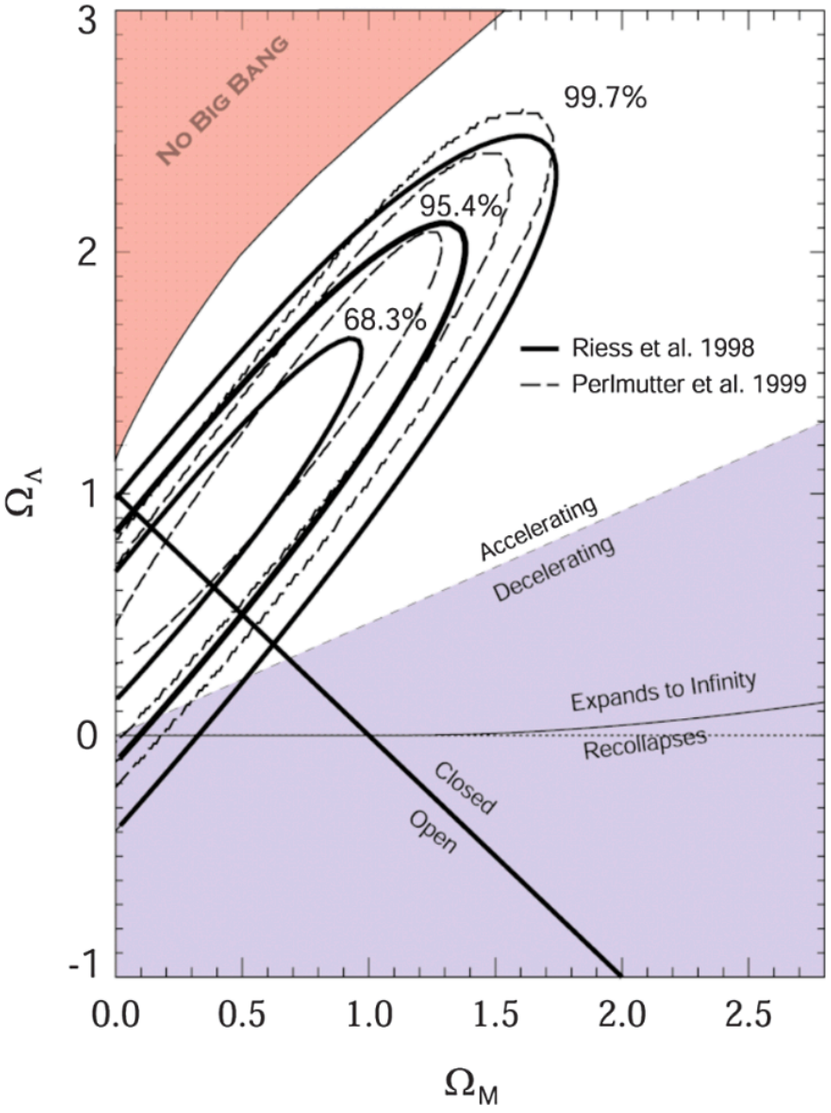
- 1929 - expansion of the universe: Galaxies



Original Hubble diagram

- 1998 - accelerated expansion: type Ia supernovae

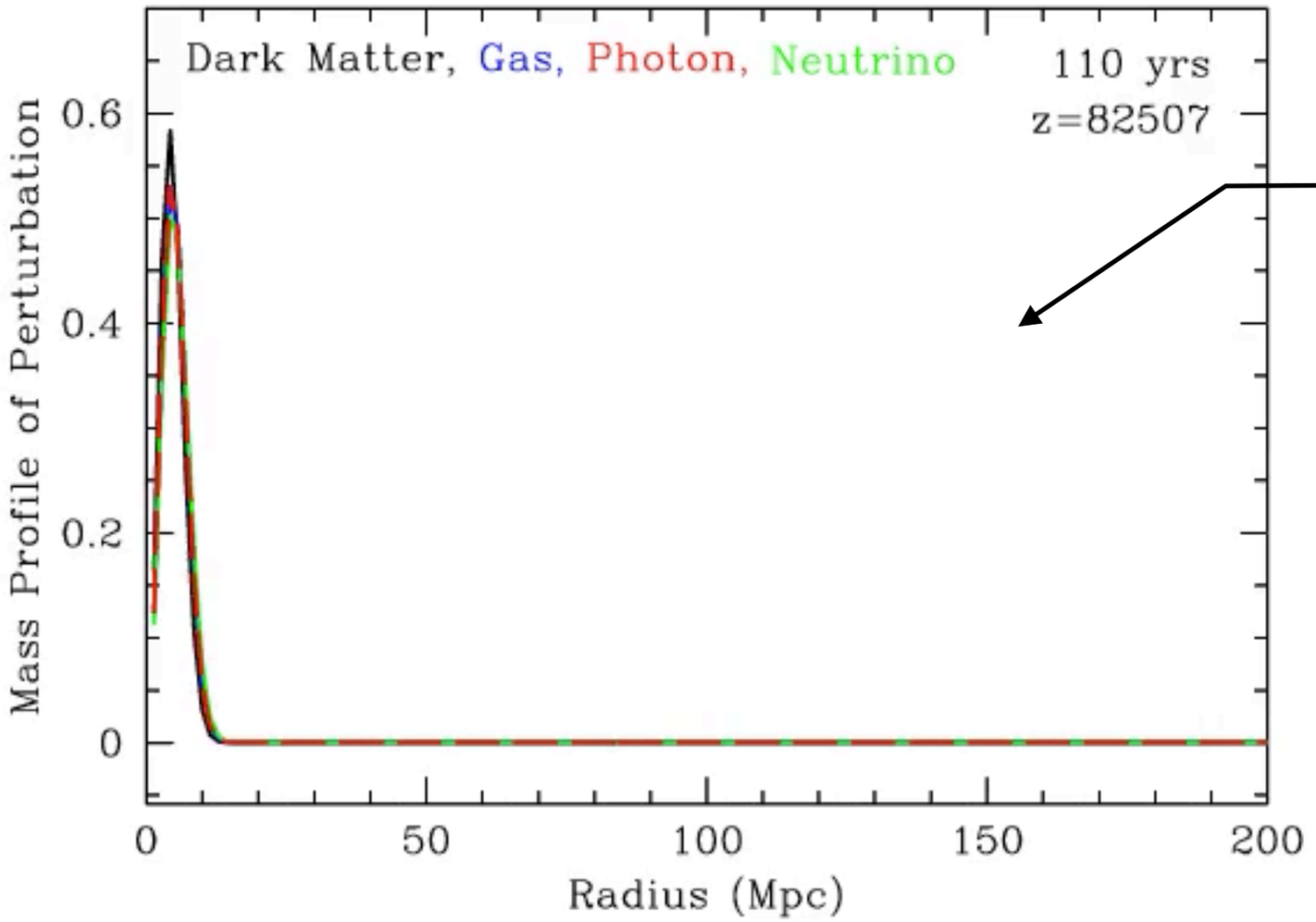




Proceedings of the National Academy of Sciences Jan 2004, 101 (1) 8-13; DOI: 10.1073/pnas.2536799100

Schmidt, Brian P: Nobel Lecture: Accelerating expansion of the Universe through observations of distant supernovae

Baryon Acoustic Oscillation (BAO)



BAO peak

Standard ruler

200g salted butter plasma

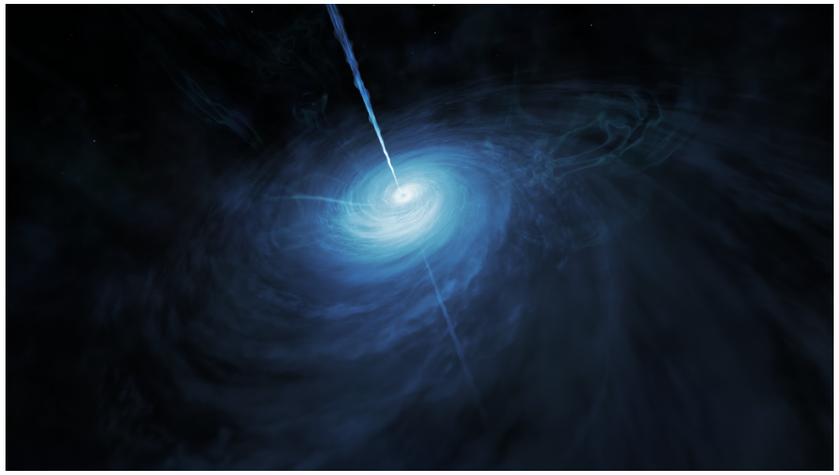
$$z = \frac{\lambda_{obs}}{\lambda_{rf}} - 1$$

Eisenstein et al. 2007

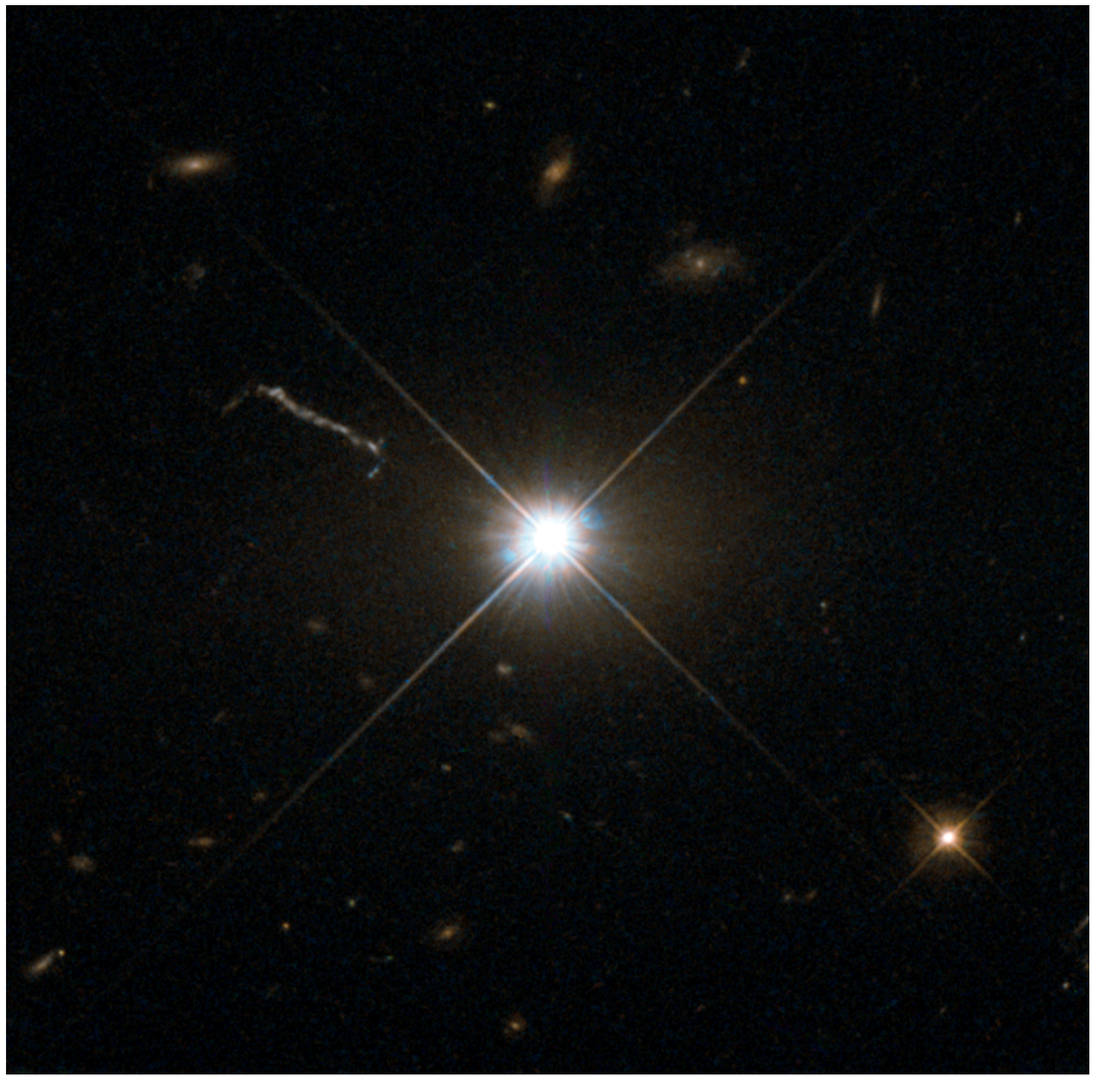
Quasars

Very Luminous Active Galactic Nuclei (AGN)

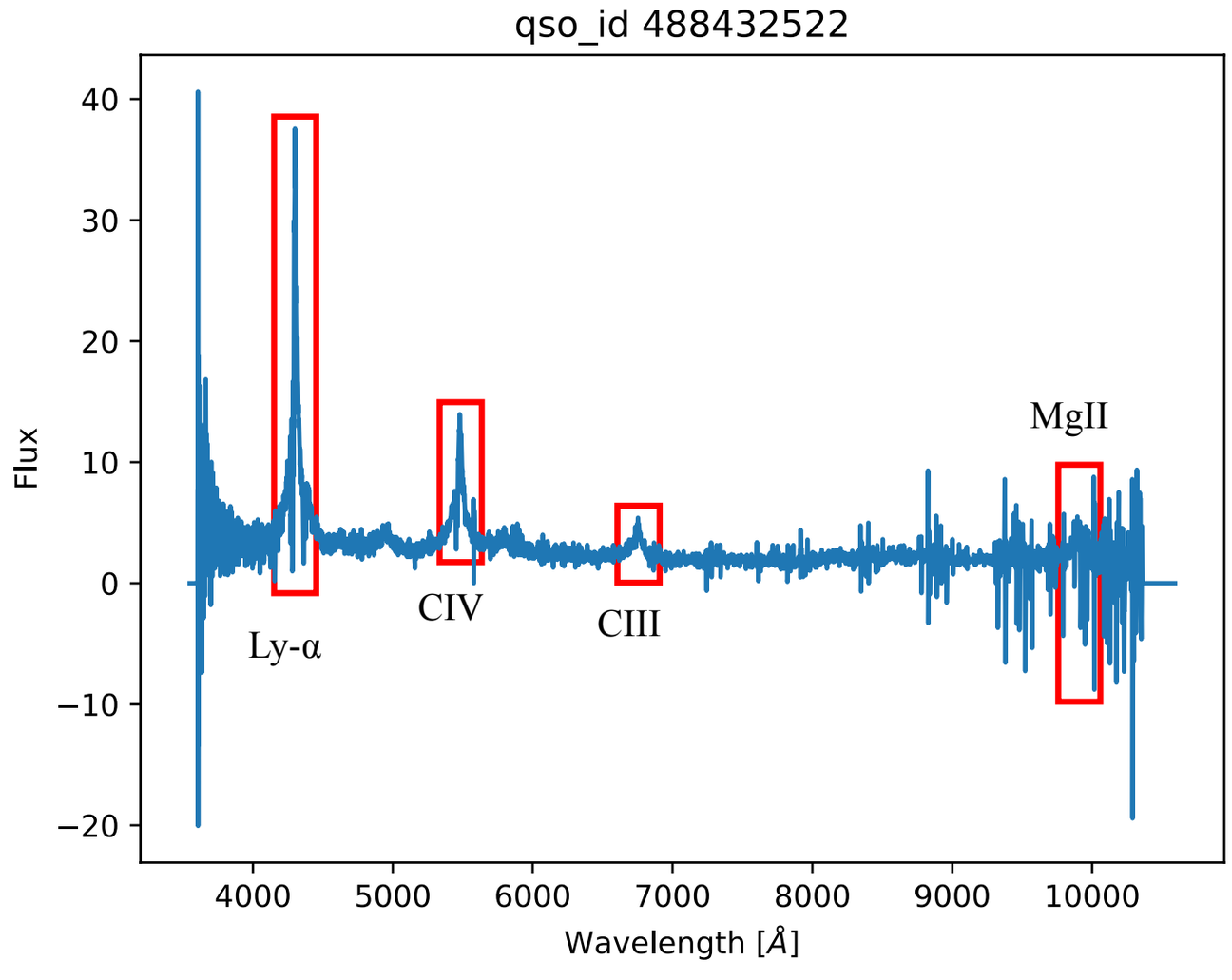
Gaseous accretion disk



ESA/Hubble: artist's impression



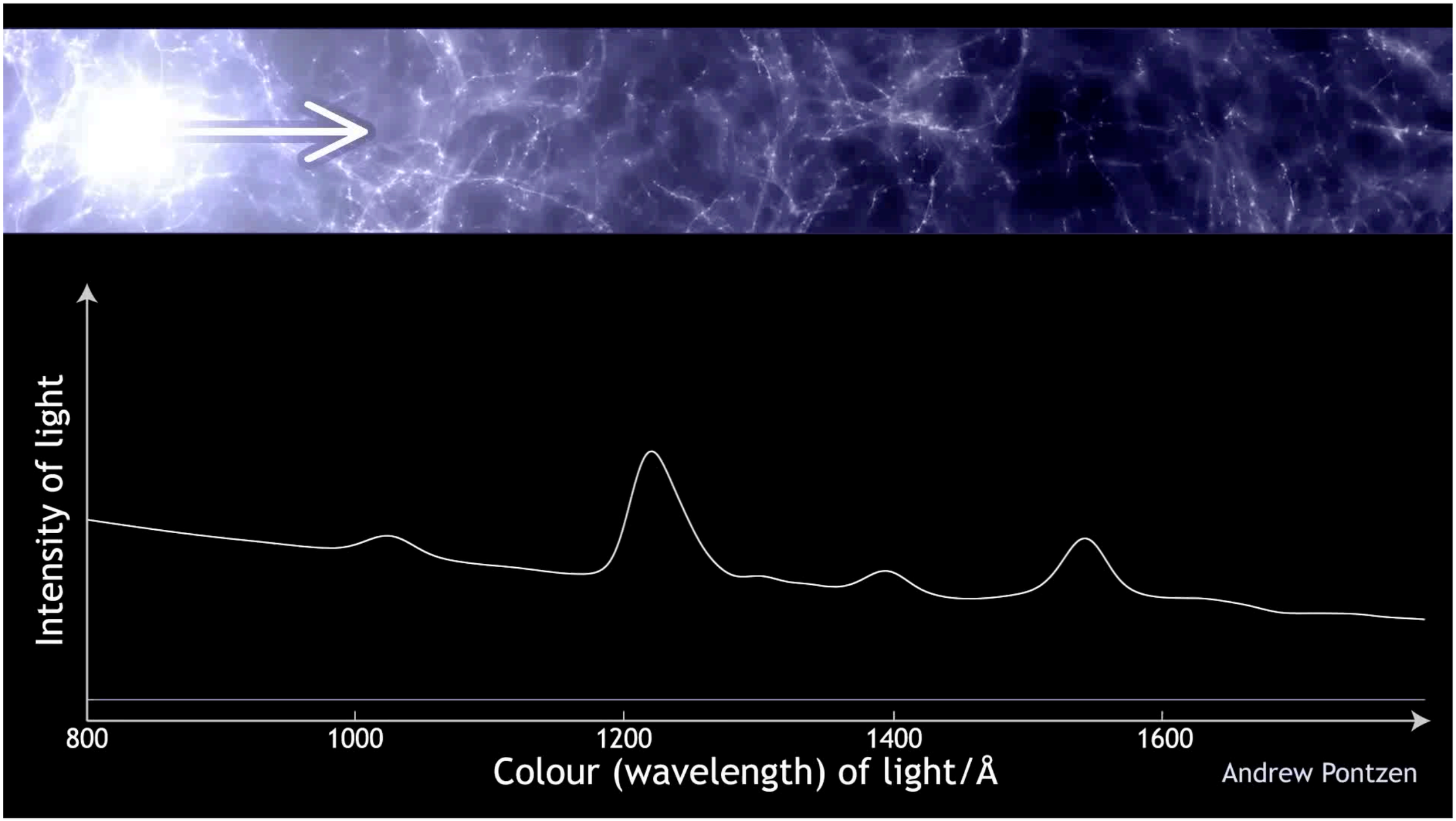
ESA/Hubble: Best image of bright quasar 3C 273



Lyman-alpha (Ly-α) forest

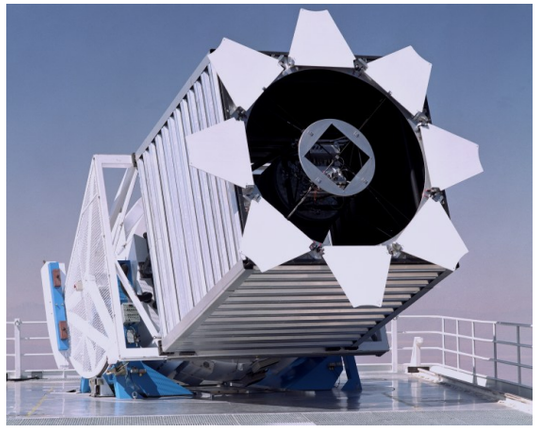
250g of Neutral H clouds flour

neutral H clouds on the line of sight (LOS) which absorb part of light from quasars -> ly-a forest

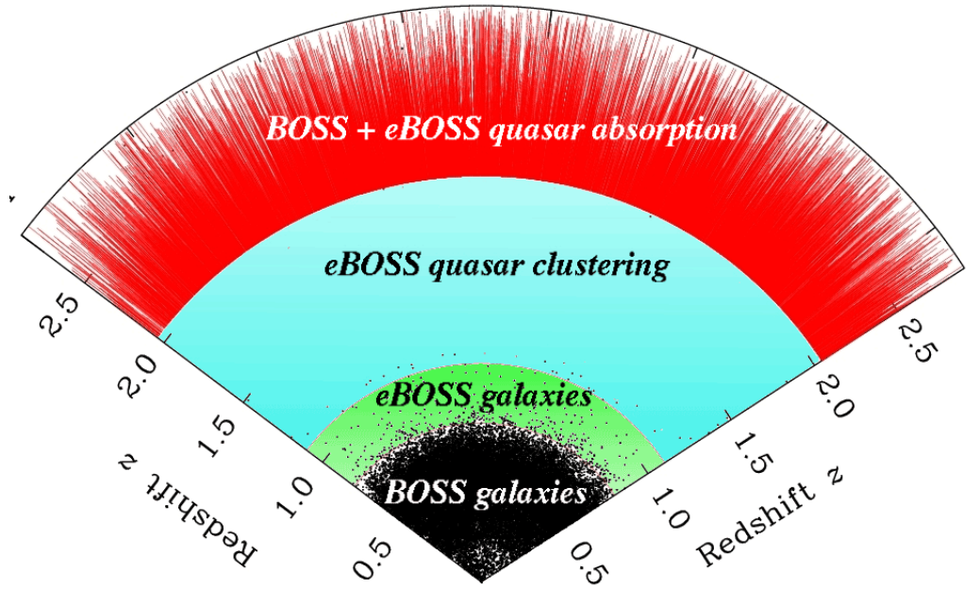


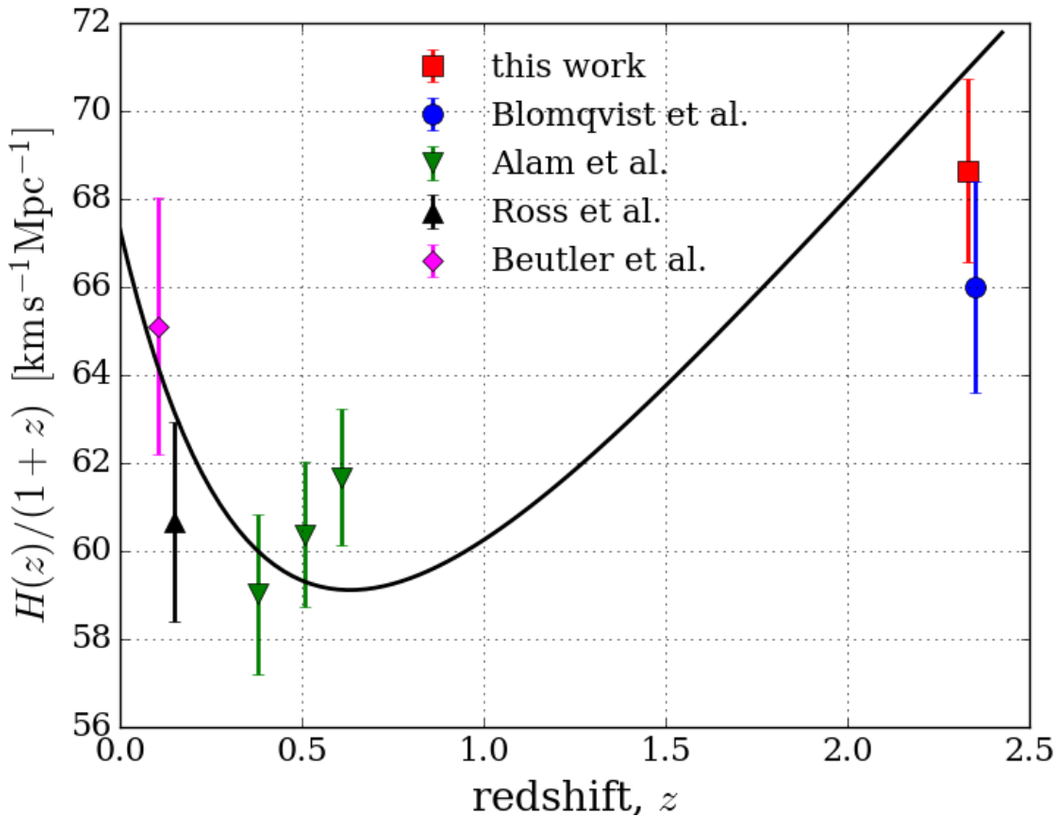
eBOSS - extended Baryon Oscillation Spectroscopic Survey

Sloan Digital Sky Survey - NM, USA



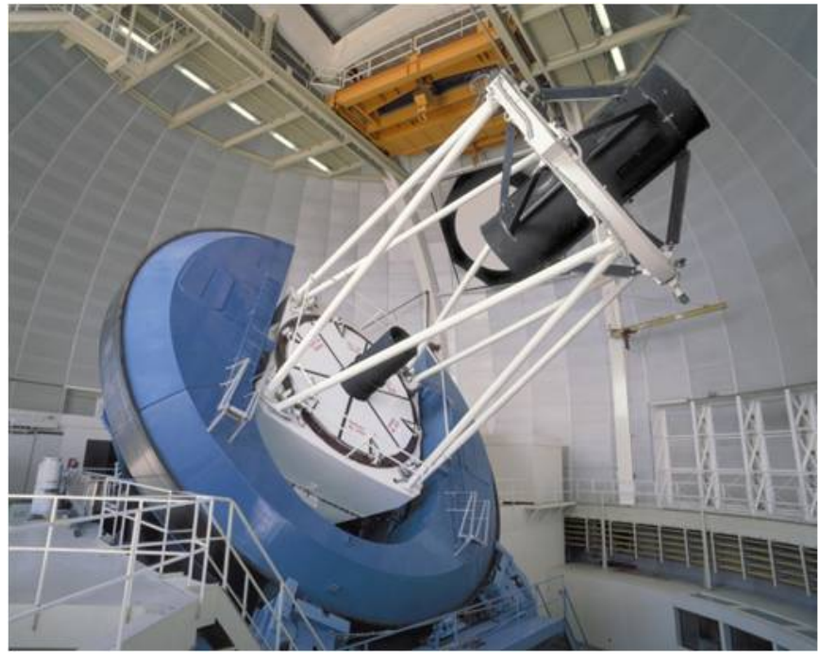
- 2.5 m telescope
  - eBOSS: 200k + quasars in 2019
- $0.5 < z < 3$
- 3D map of ⅓ of sky





de Sainte Agathe et al. 2019

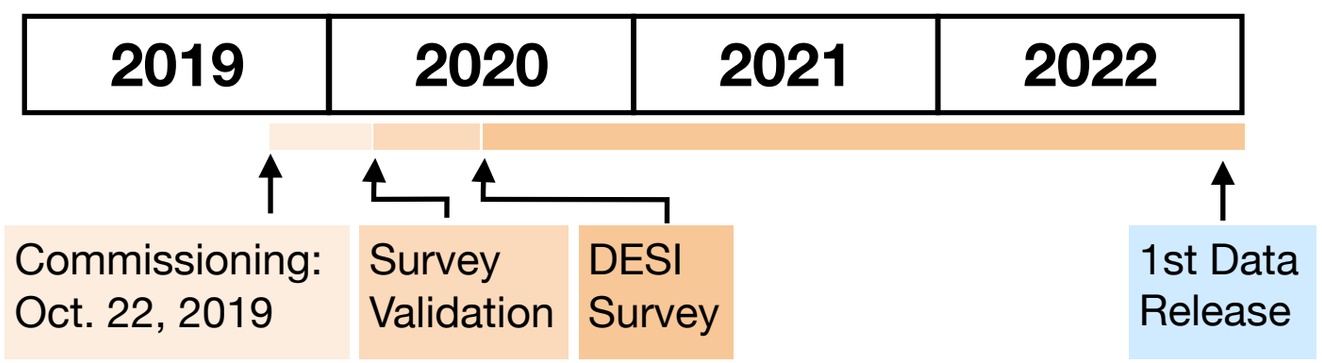
DESI - Dark Energy Spectroscopic Instrument

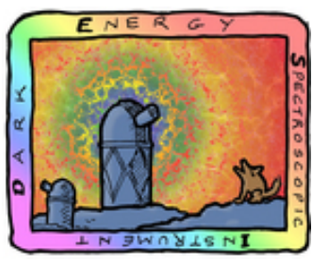


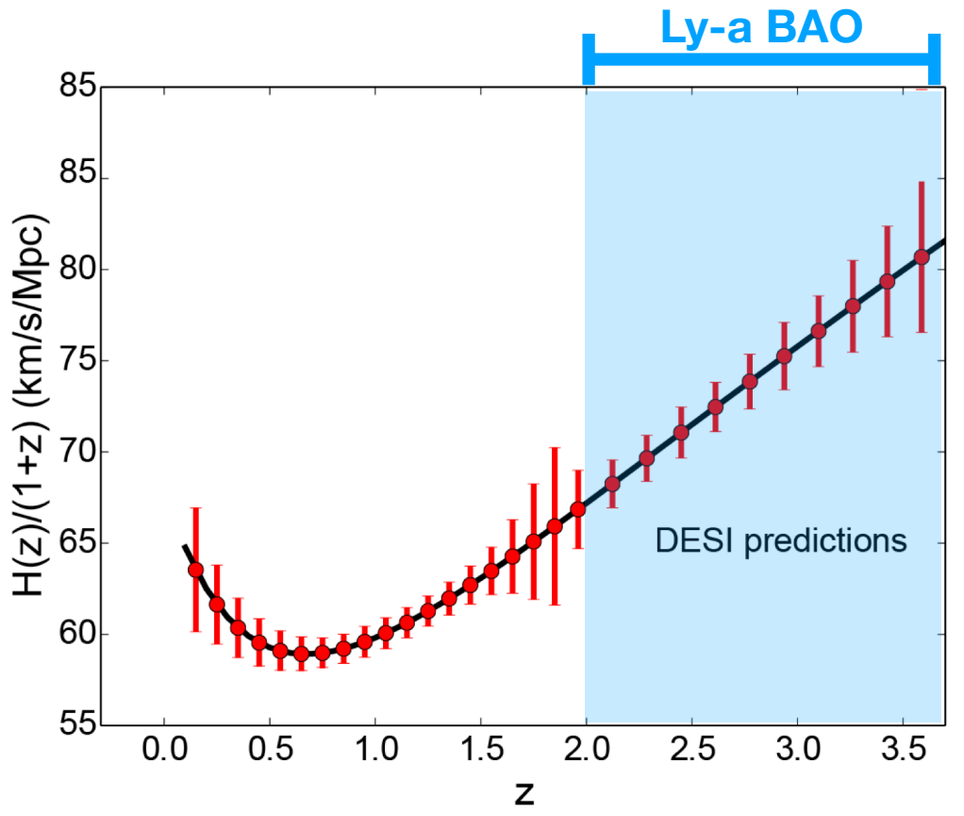
Kitt Peak National Observatory - Az, USA

- 4 m Mayall telescope
- 2.5 million quasars to be observed
- $0.5 < z < 3.5$
- 3D map of ⅓ of sky

Timeline:



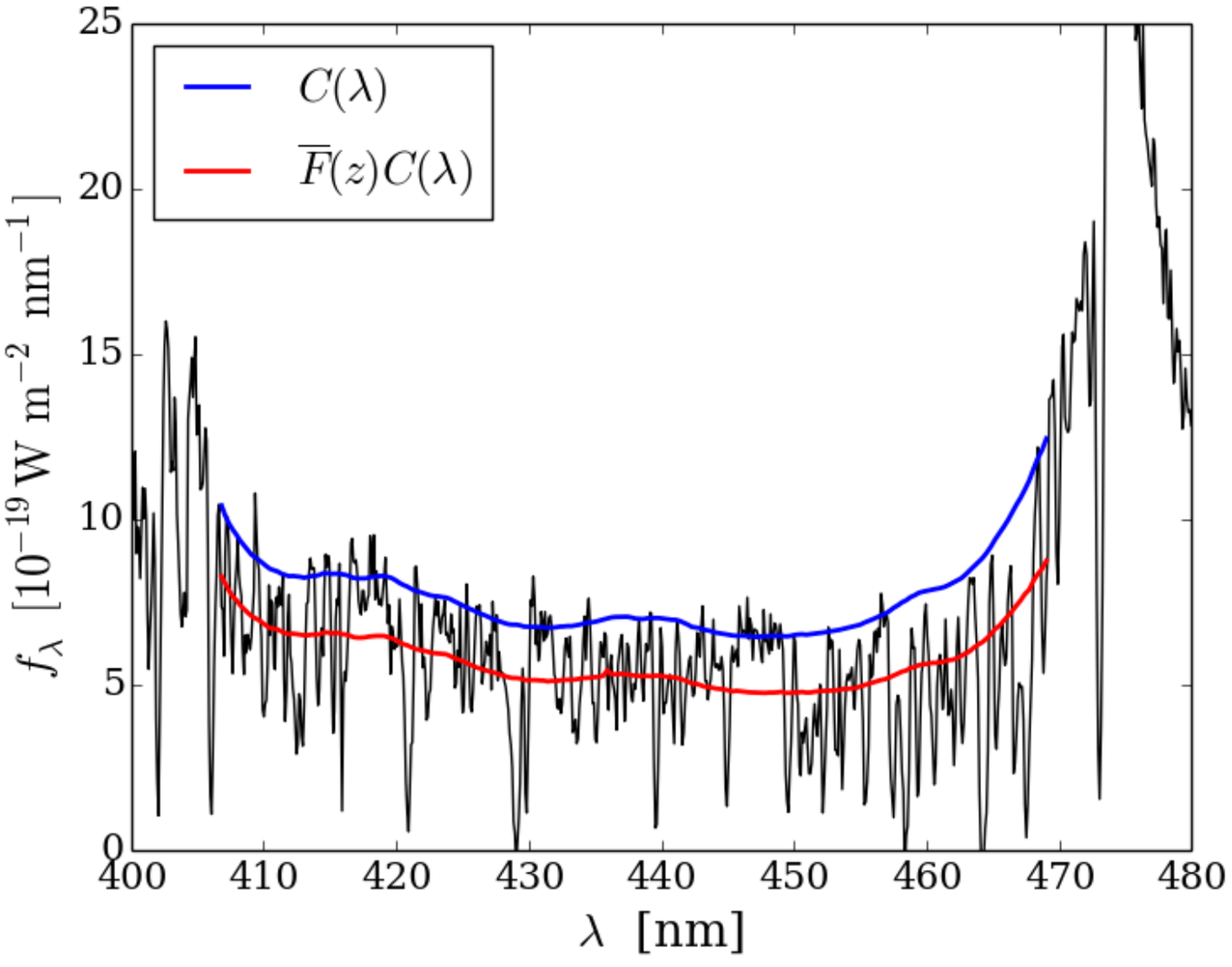




Measuring the ly-a auto-correlation function:

Absorption field δ

In the lyman-α region:



Bautista et al. 2017

absorption field

flux

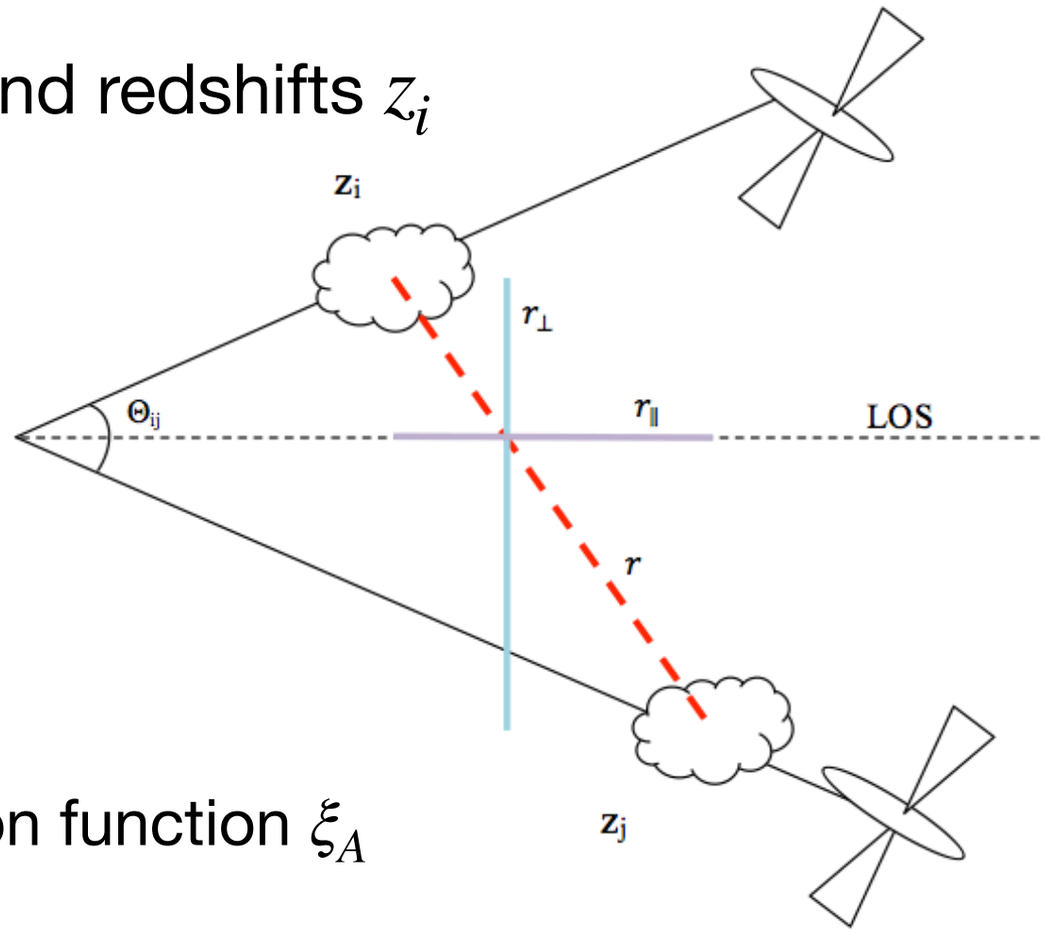
$$\delta_q(\lambda) = \frac{f_q(\lambda)}{C_q(\lambda)\bar{F}(z)} - 1$$

unabsorbed flux or continuum

mean transmitted flux fraction

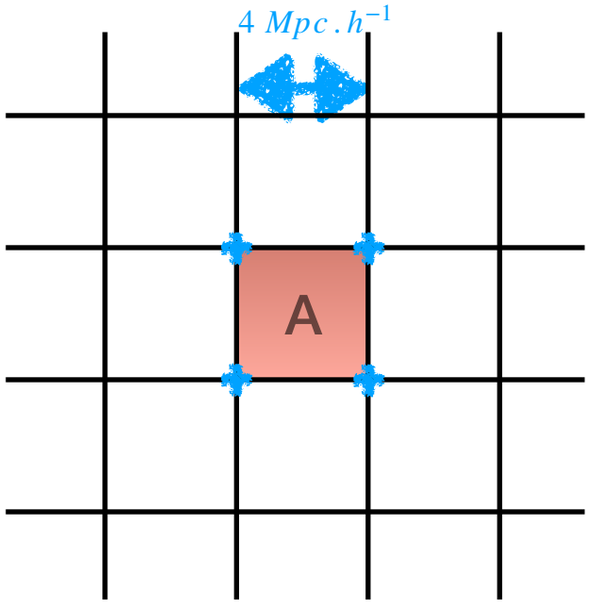
Measuring the ly-a auto-correlation function:

Angular separations θ_{ij} and redshifts z_i



$\theta,\ z \longrightarrow$ distances

Cosmology dependent: Planck 2016



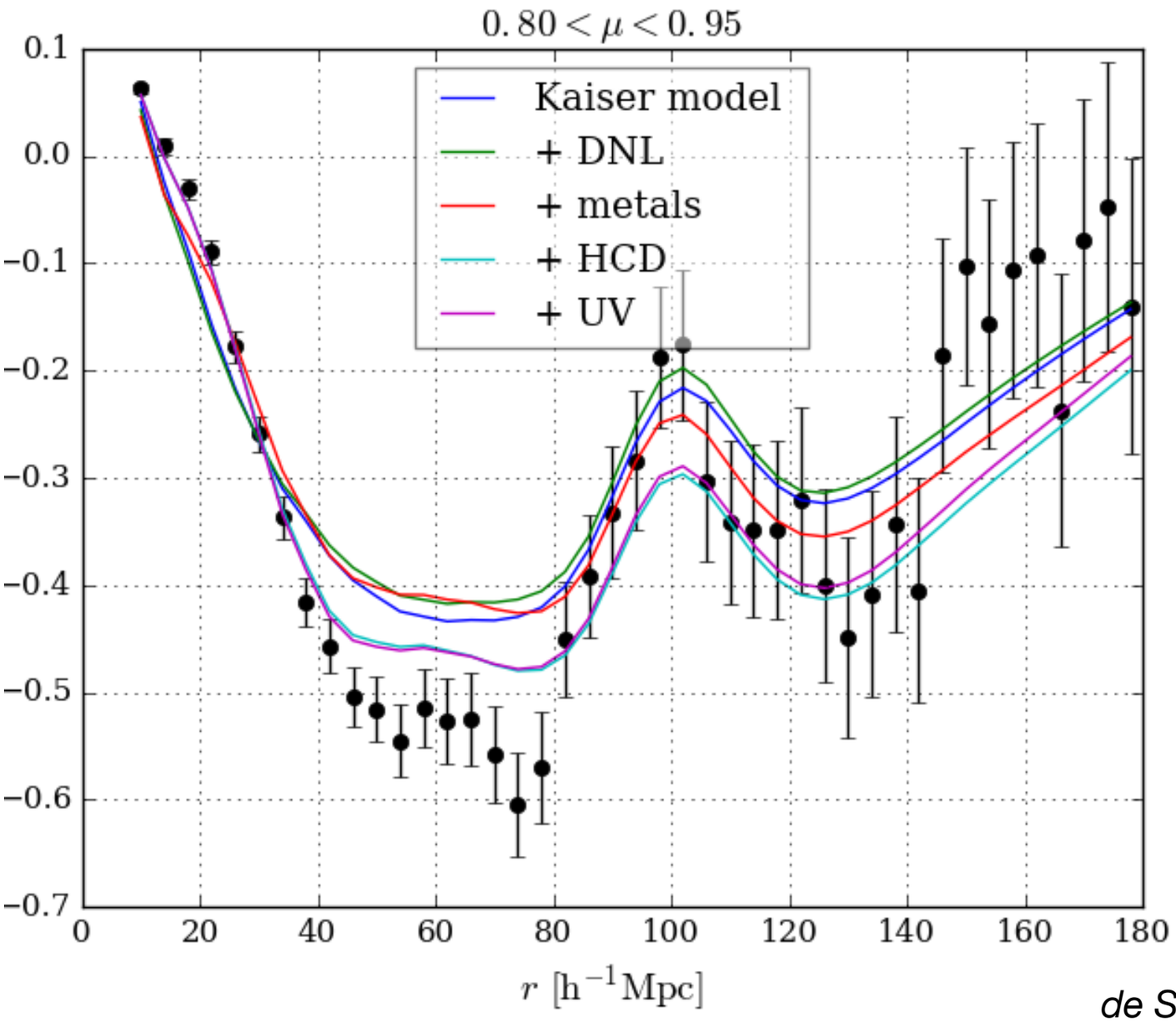
Calculating the correlation function ξ_A

$$\xi_A = < \delta(x) > < \delta(x + r) >$$

Measuring the ly-a auto-correlation function:

Model

Decompose: $\xi_A = \xi_{smooth} + \xi_{peak}$



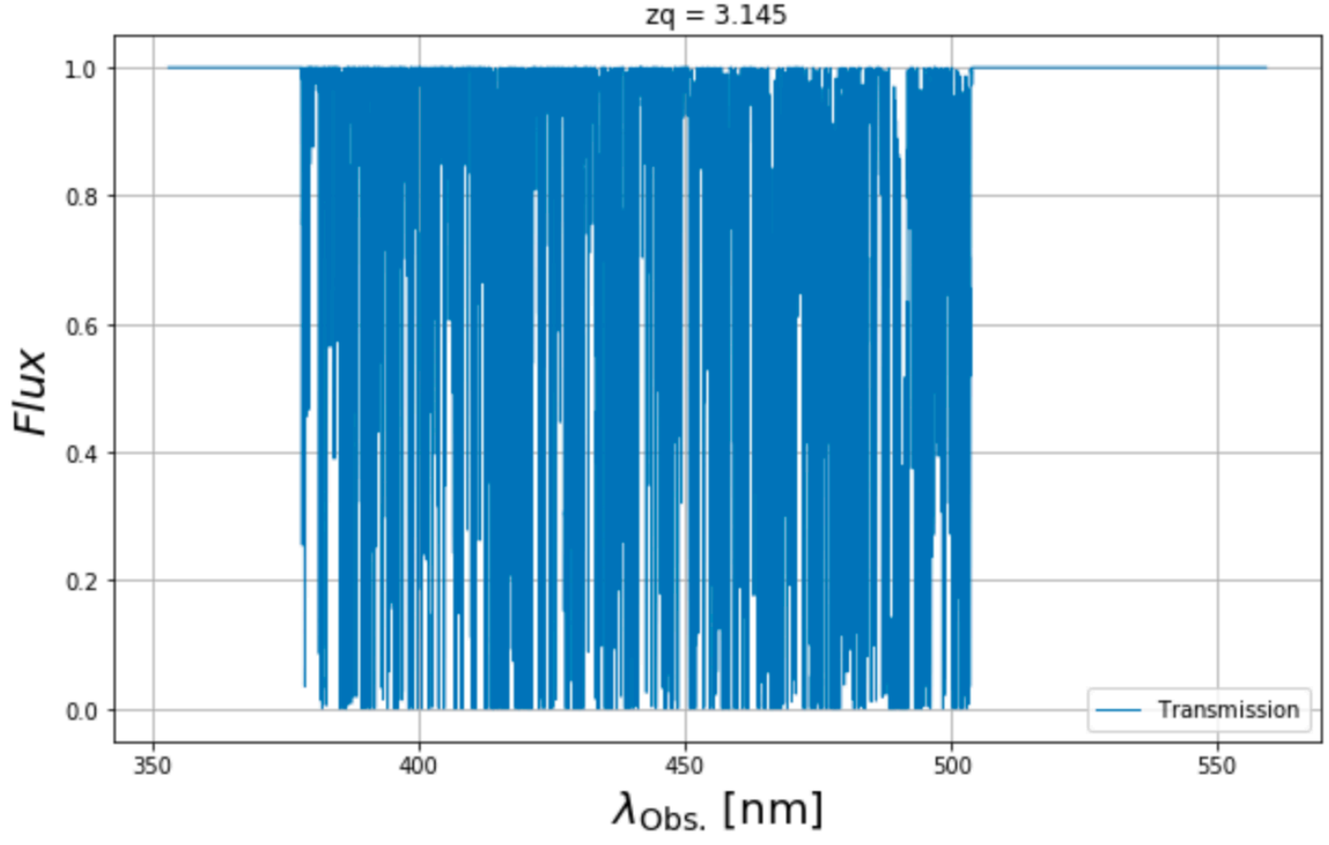
de Sainte Agathe et al. 2019

Simulations - Mocks

Concept

2 different sets developed by teams in Saclay and London

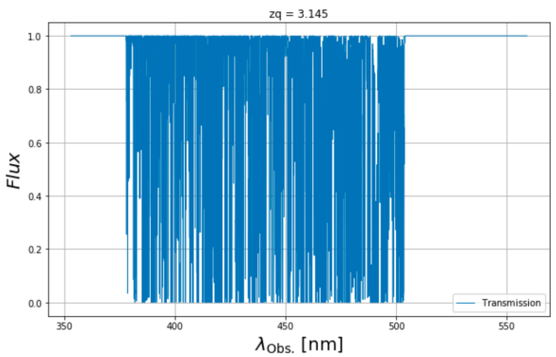
- Focus on Saclay mocks
  - Random gaussian fields δ_k tuned for correct ξ_{1D} and ξ_{3D}



Transmission field example

Analysis of the Mocks

Transmission files

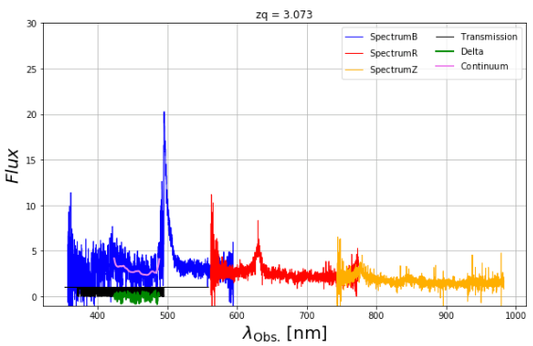


Mocks

Cooked mocks

eboss-0.*

Spectra



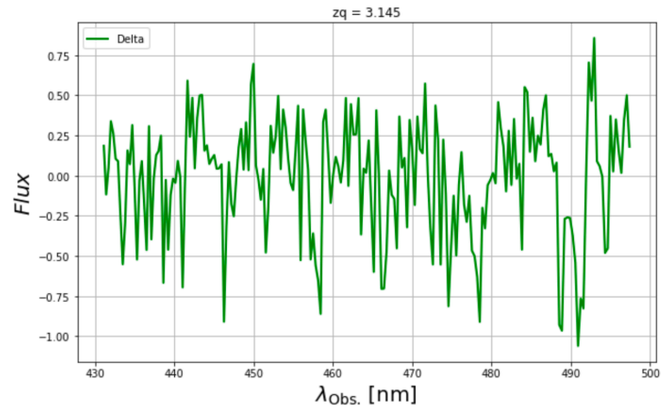
Continuum + noise: 0

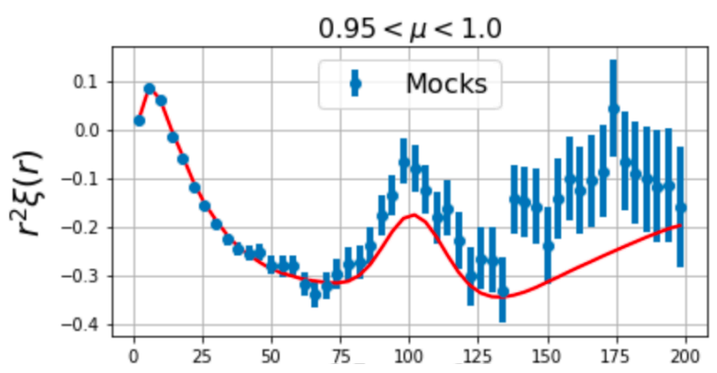
(+metals: 1)

(+DLAs: 2)

Quickquasars

Deltas





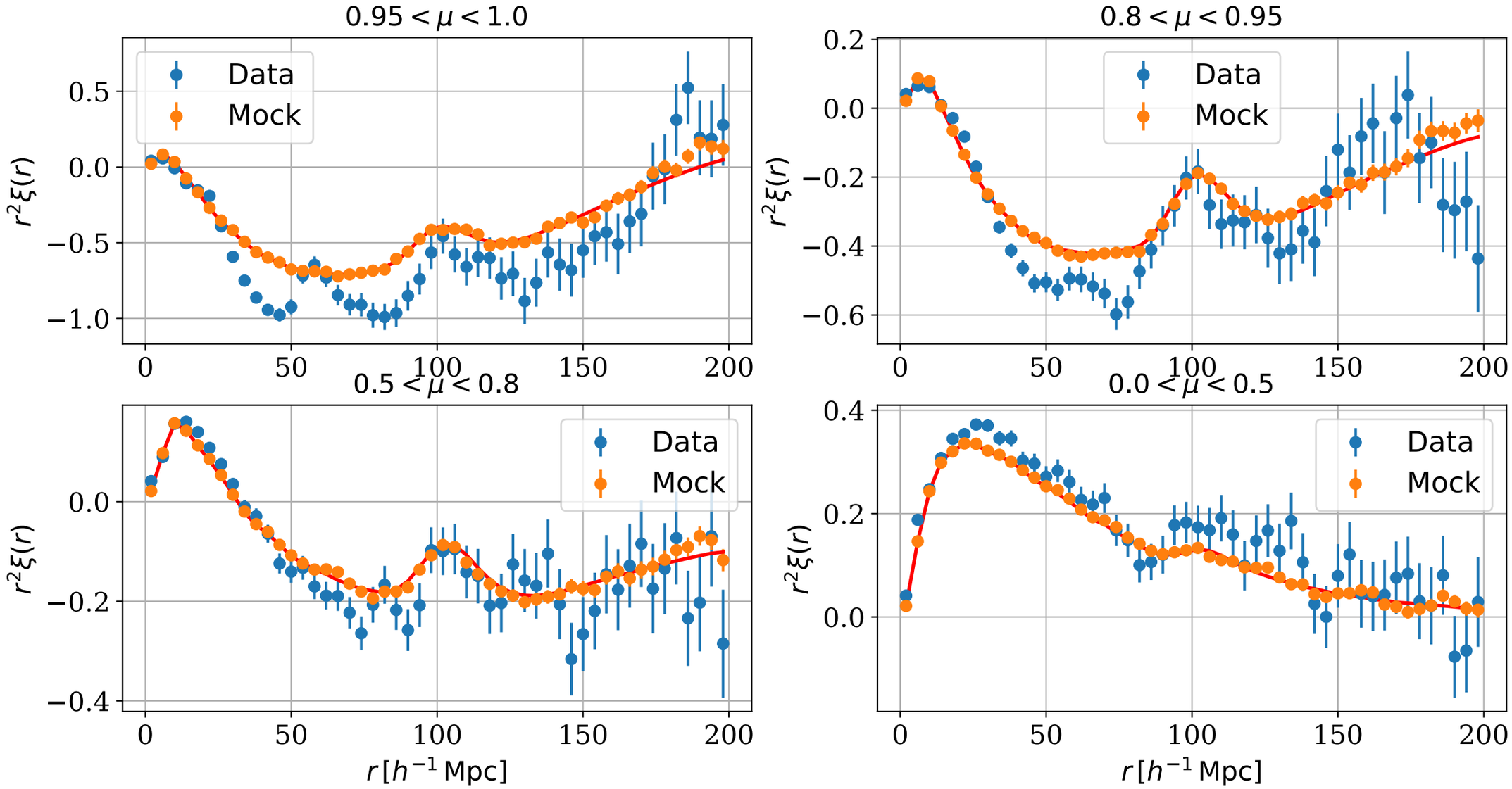
Correlation functions

Picca

BAO analysis on mocks

Divide the sky in 4 wedges of angle $\mu = \dfrac{r_{\parallel}}{r}$

Along the LOS



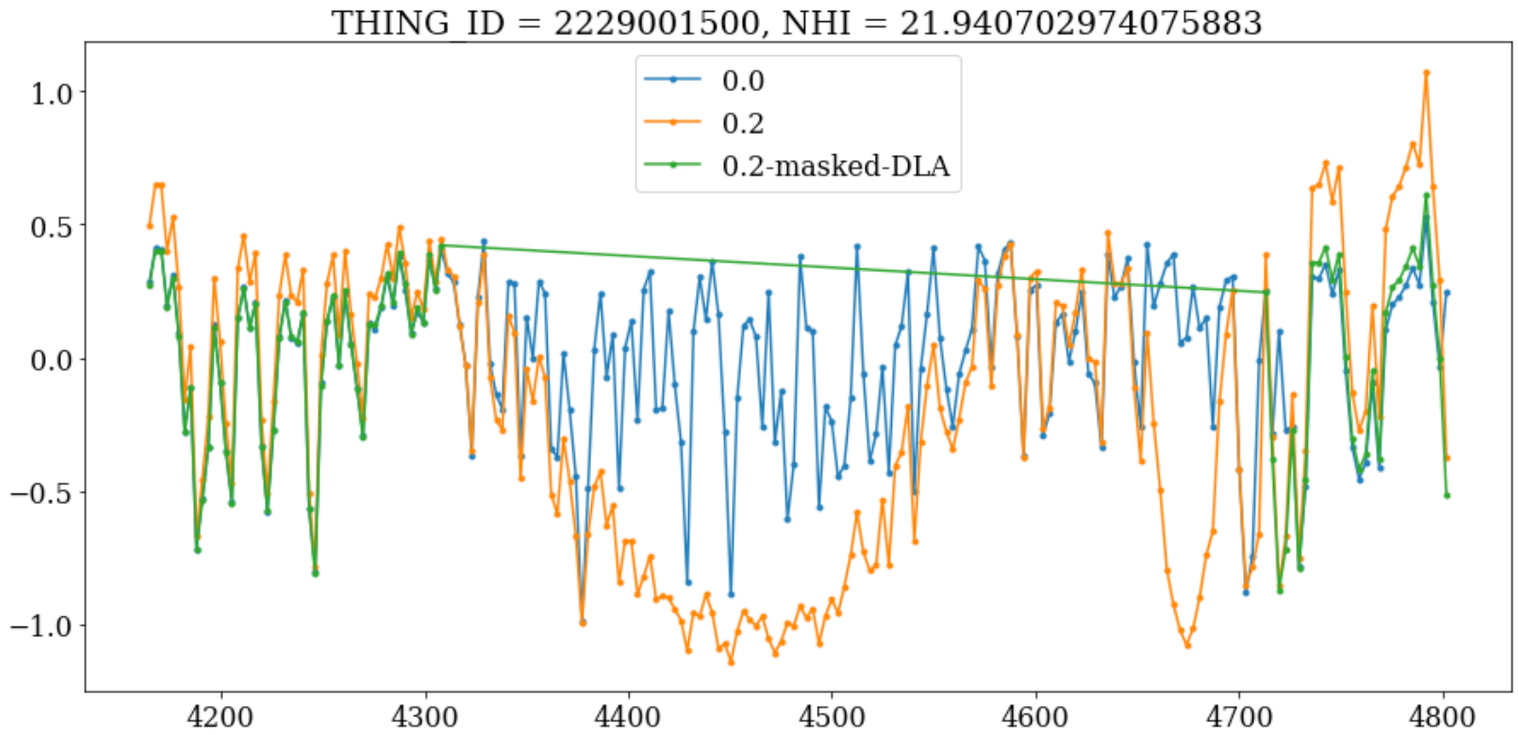
Across the LOS

Auto-correlation function

Damped Ly-a absorbers (DLAs)

Regions along the LOS of the quasar with high concentration of neutral hydrogen gas i.e. $n_{HI} \geq 2.10^{20}\ atoms/cm^2$

- Skew estimation of δ field for specific wavelength
- Run finder algorithm to find and mask DLAs in the forest



Example of DLAs in 1 mock quasar

10g of yeast DLAs

DLA finder: performances

Found = $\Delta z \leq 0.006$

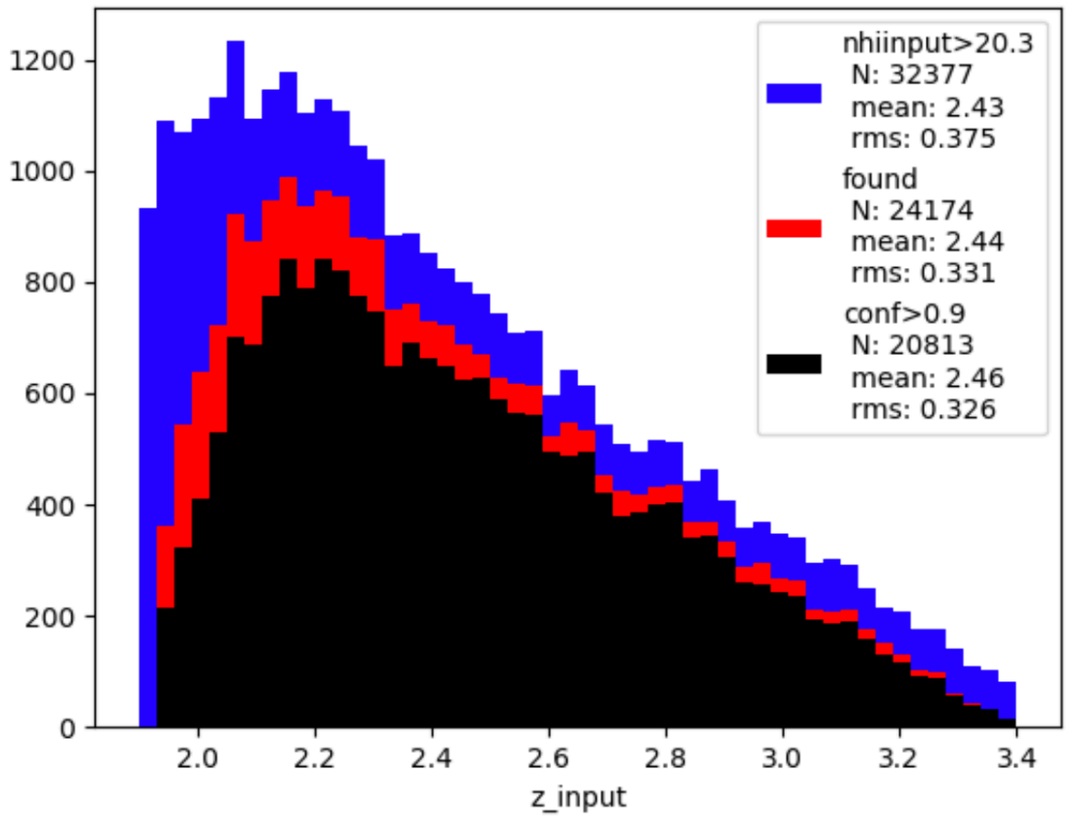
Efficiency: how many DLAs are found

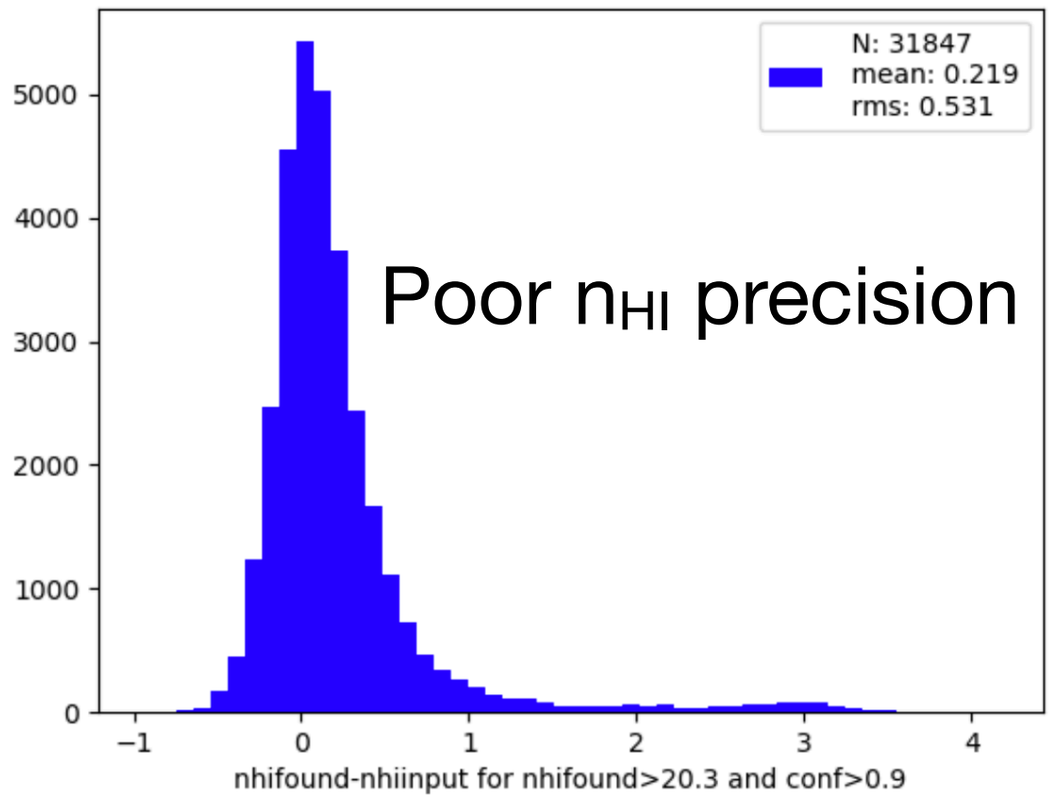
- 60%

Purity: if a DLA is found, does it exist

- 90%

Distribution of DLAs with z

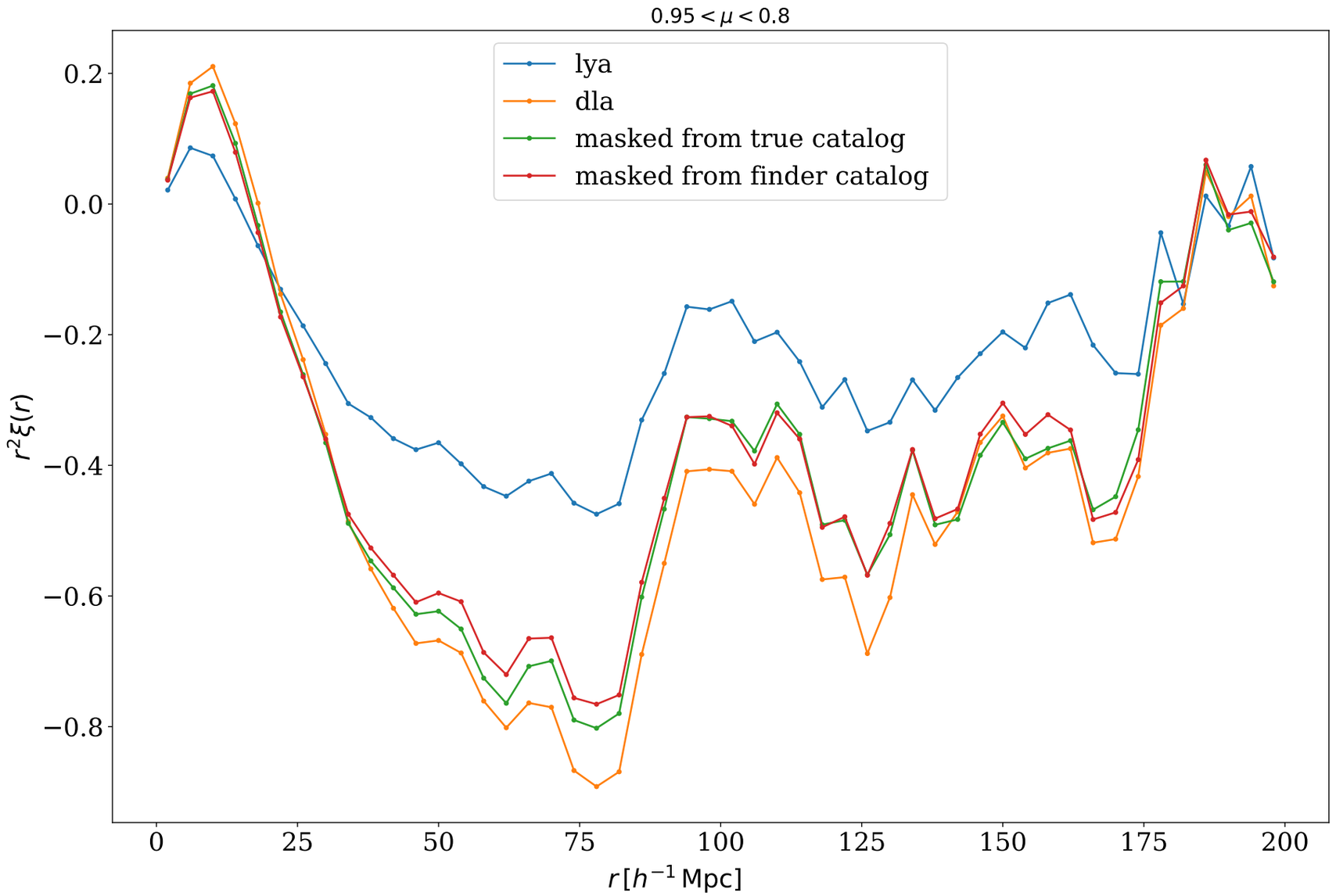




Plots by Jim Rich

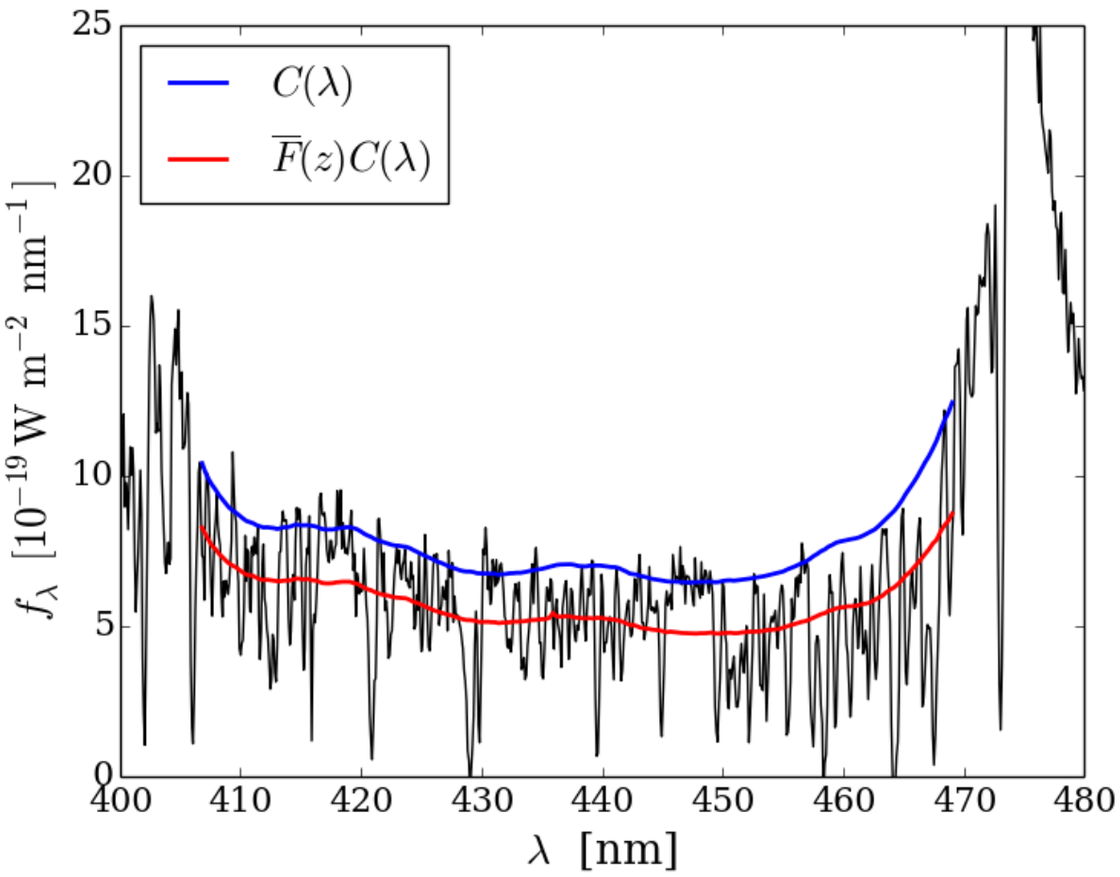
Damped Ly-a absorbers (DLAs)

Effects on the correlation function



Continuum estimation

$$\delta_q(\lambda) = \frac{f_q(\lambda)}{C_q(\lambda)\bar{F}(z)} - 1$$



Bautista et al. 2017

No way of knowing TRUE continuum

- needs to be estimated

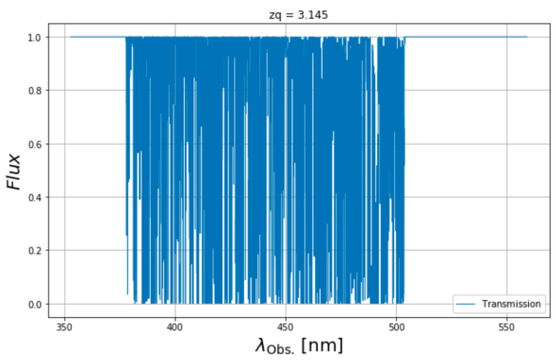
$$C_q(\lambda) = C(\lambda_{RF})\ (a_q + b_q log(\lambda))$$

Introduces additional correlation

- distortion matrix

Analysis of the Mocks

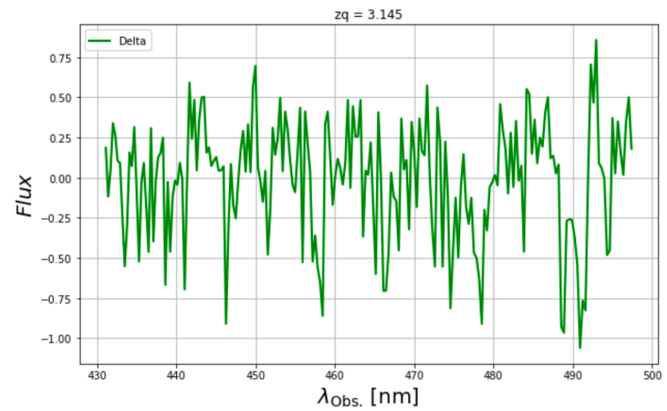
Transmission files



eboss-raw

raw mocks

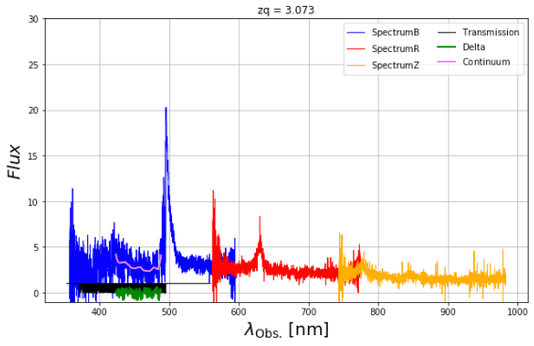
Deltas



Cooked mocks

eboss-0.*

Spectra



Continuum + noise: 0

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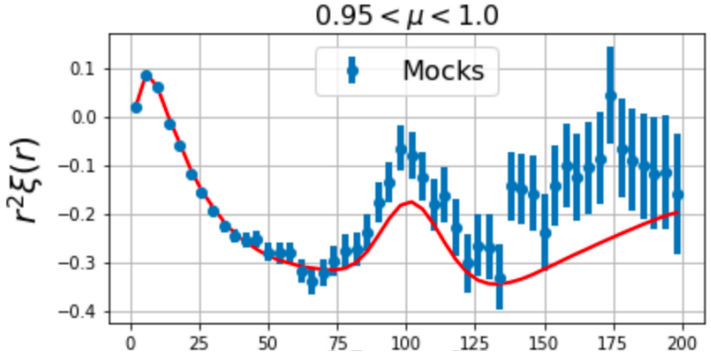


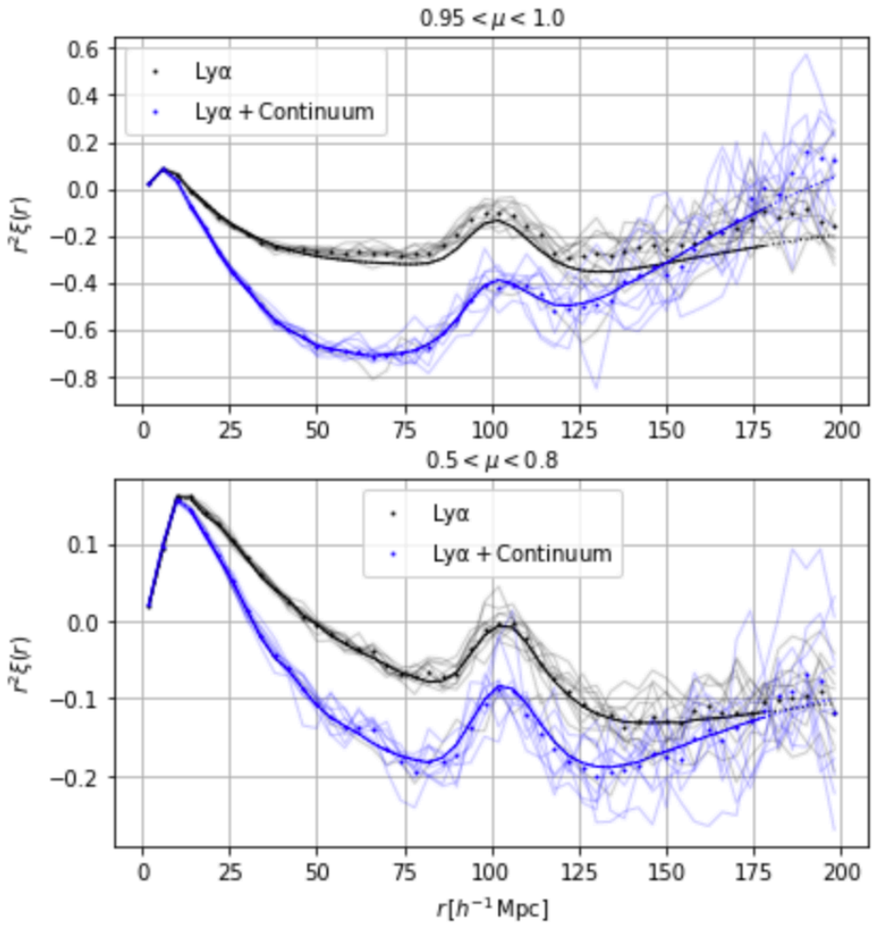
Correlation functions

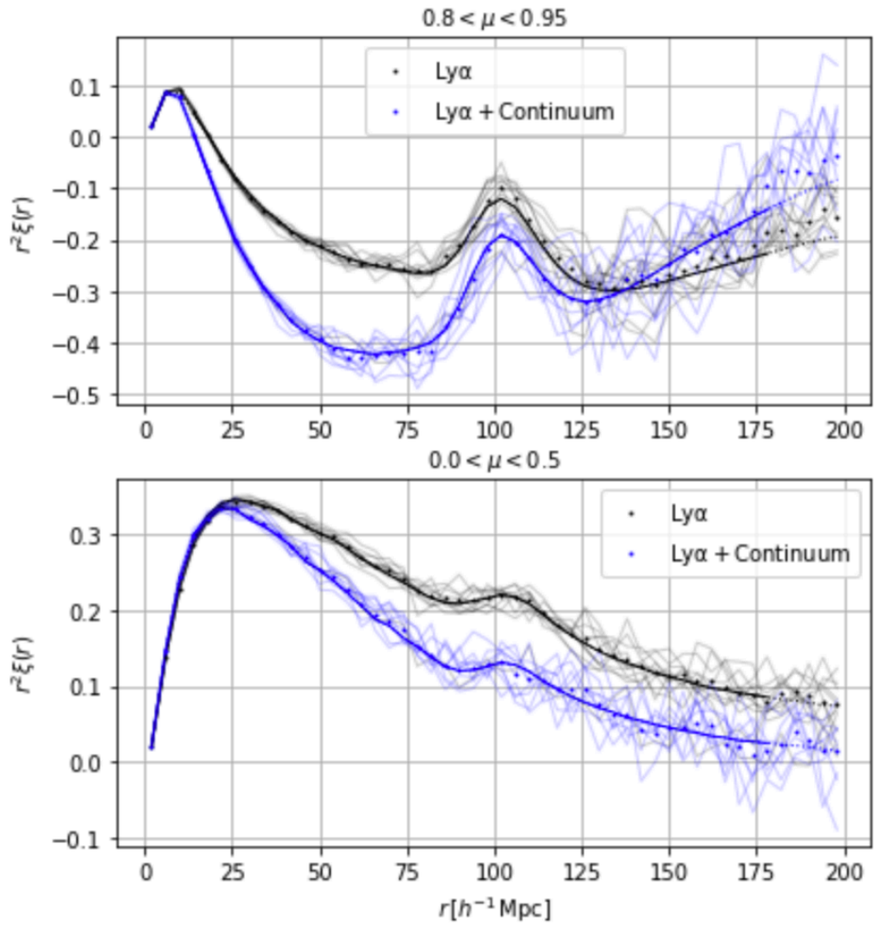
Mocks

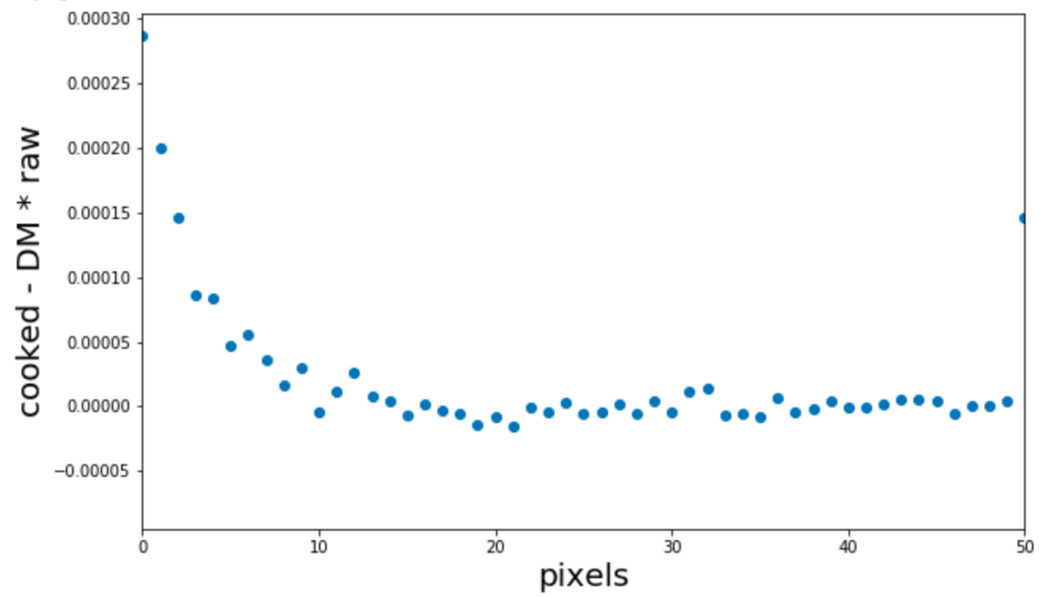
Quickquasars

Picca

Comparison between raw and cooked mocks: auto correlation



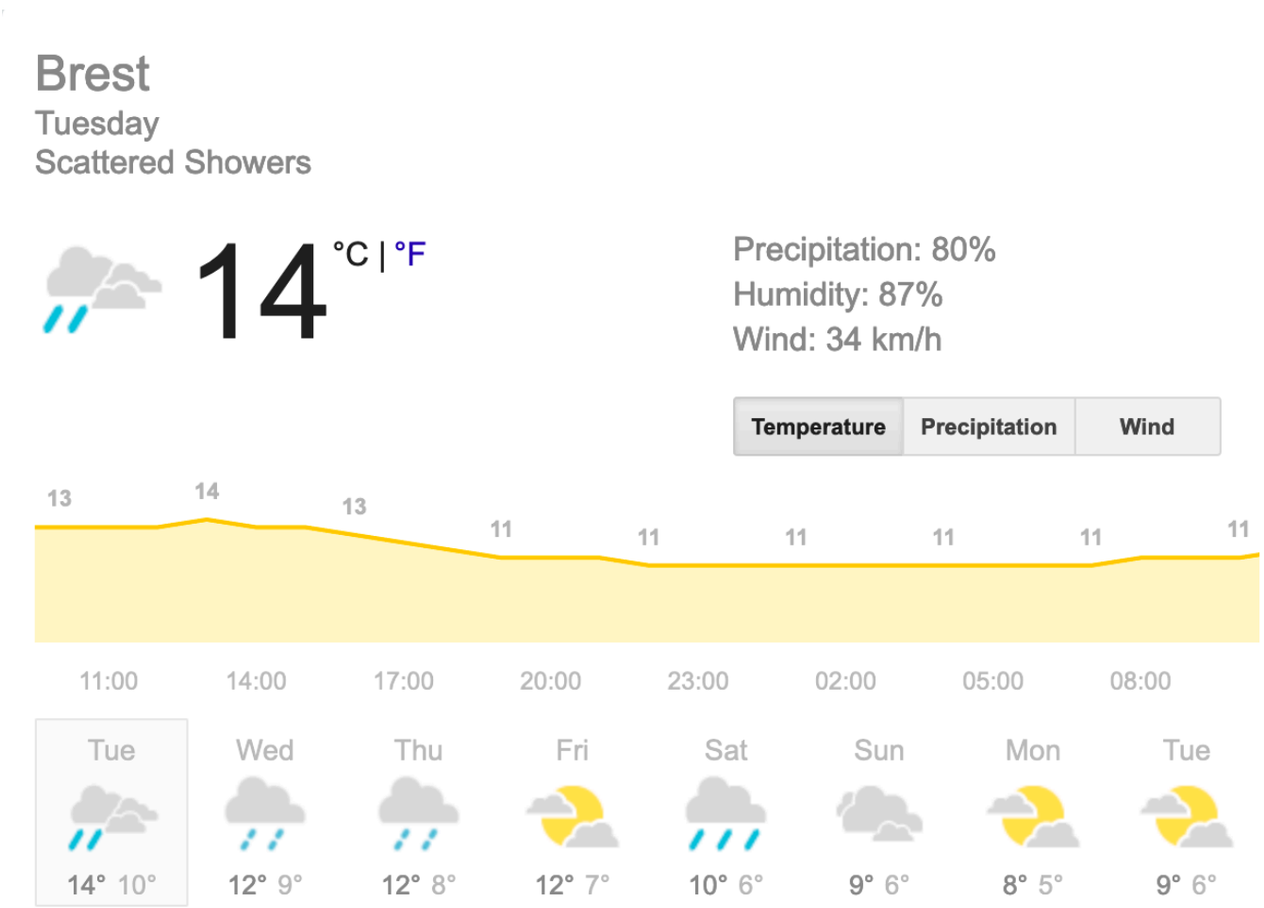




Conclusion

Mix all the ingredients together

10cl of Bretagne rain water



Thunderstorms Warning (Yellow)

Finistere

9 hours ago – Météo-France

Des phénomènes habituels dans la région mais occasionnellement et localement dangereux sont prévus, (ex ...

Conclusion

Bake at 210° for 35 minutes

Conclusion

Wash it down with some Chuchen

Thank you!