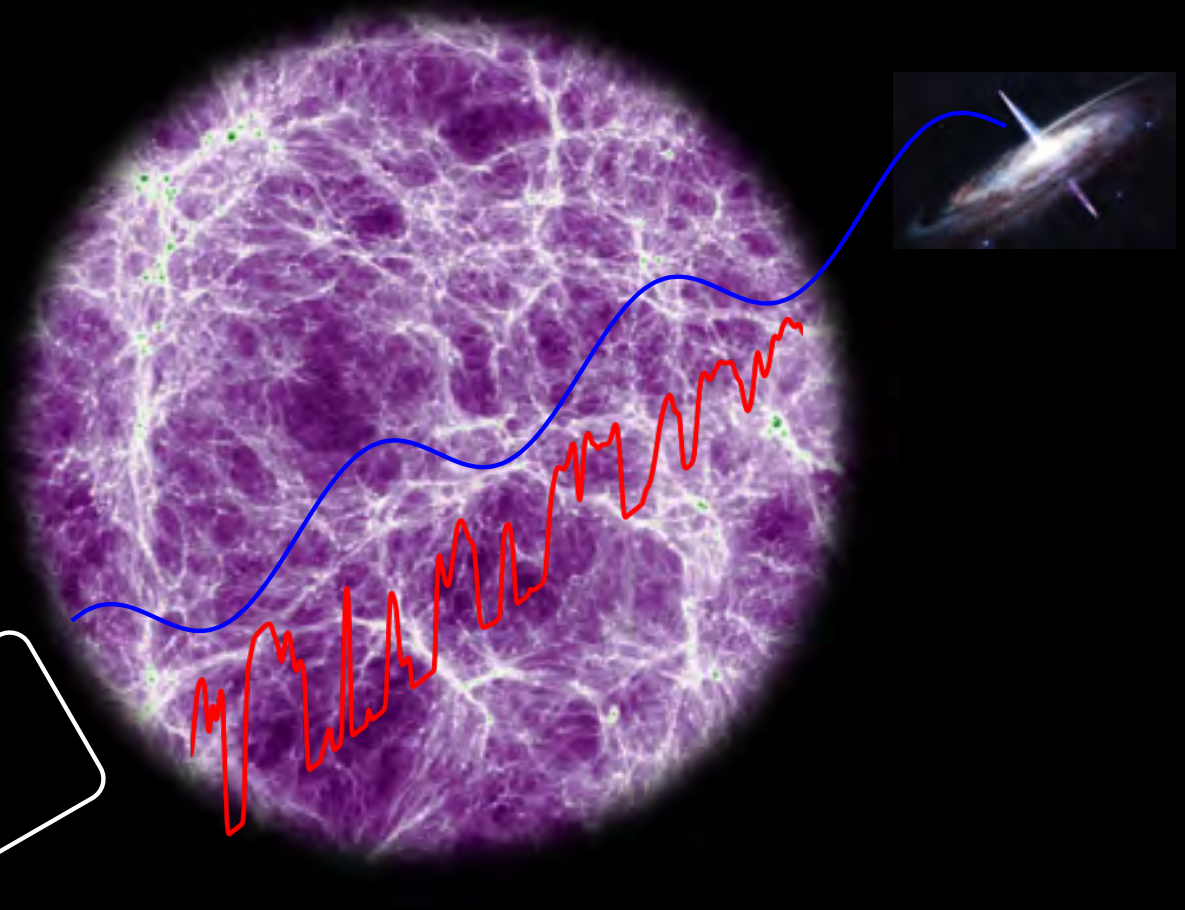
Cosmology with Lyman-α forest

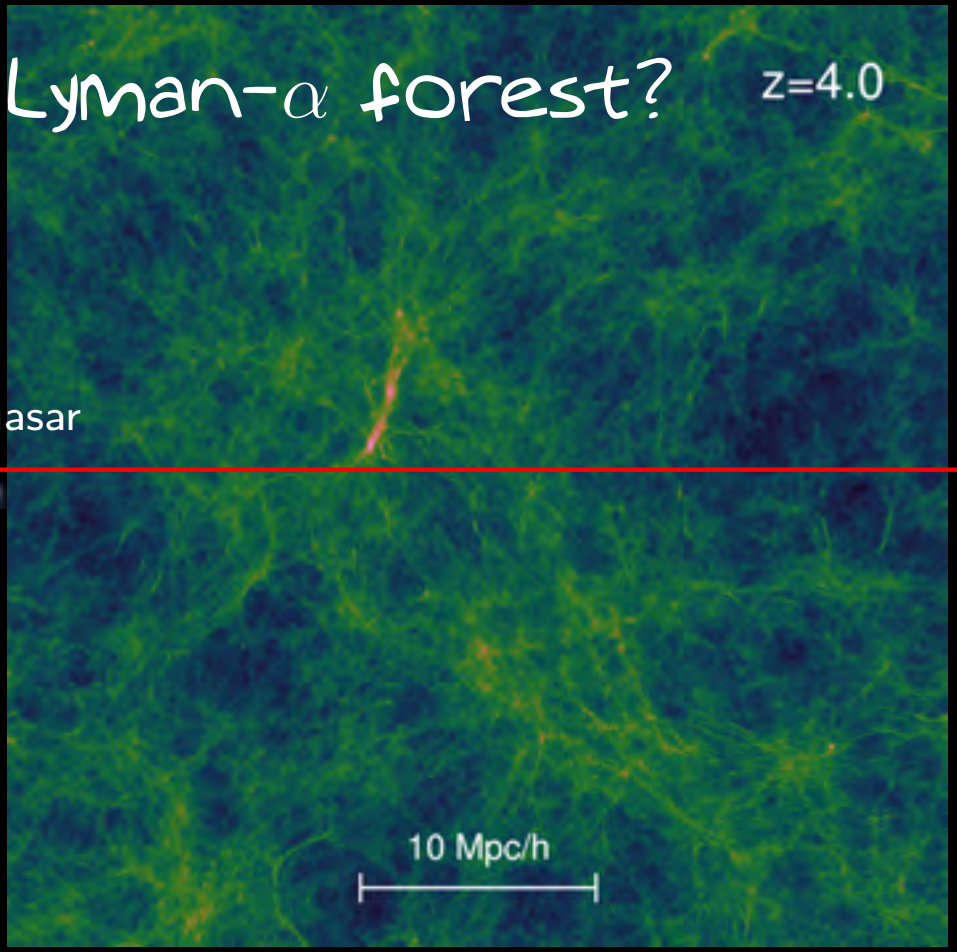


Vid Iršič
@ KICC

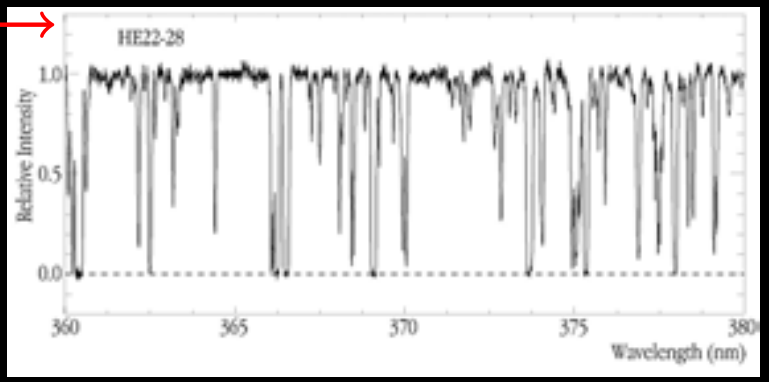
Kavli Science Day

Sep 30, 2021

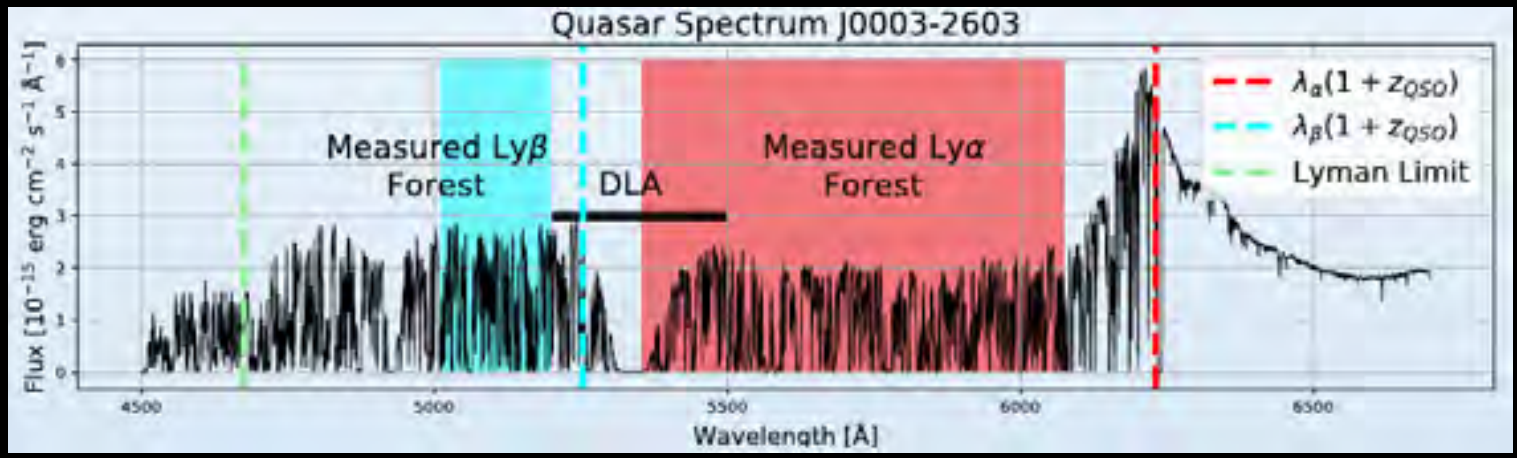
Lyman-α forest?



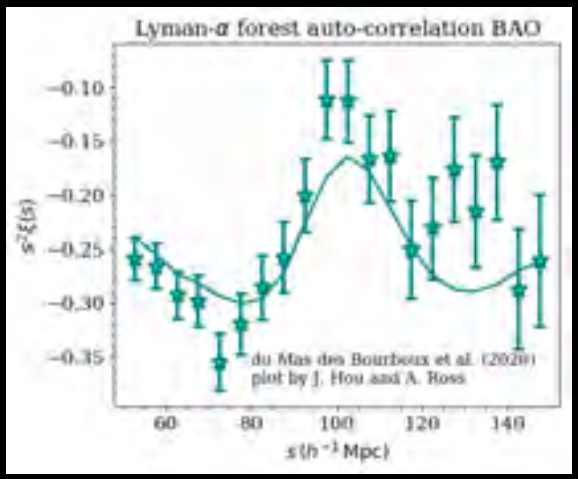
Scattering of the electron: $n = 1 \rightarrow n = 2$
Hydrogen transition (Lyman-α)

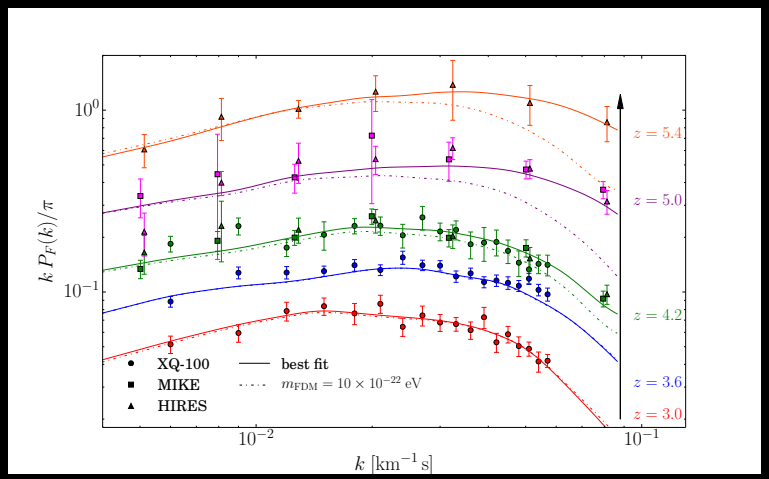


Absorption in Quasar spectra along the line of sight

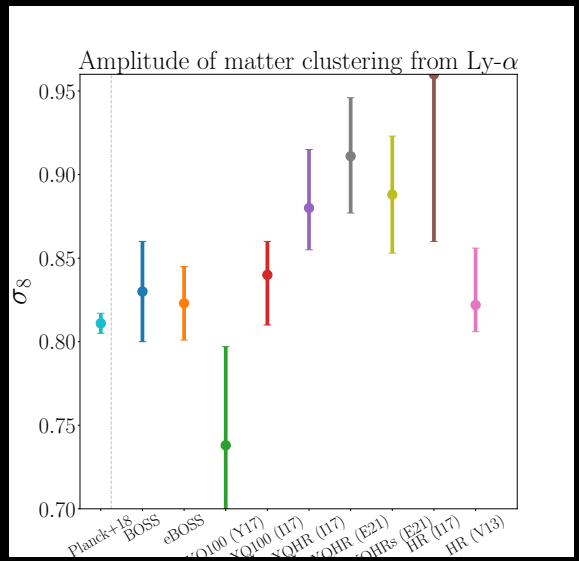


Current Status

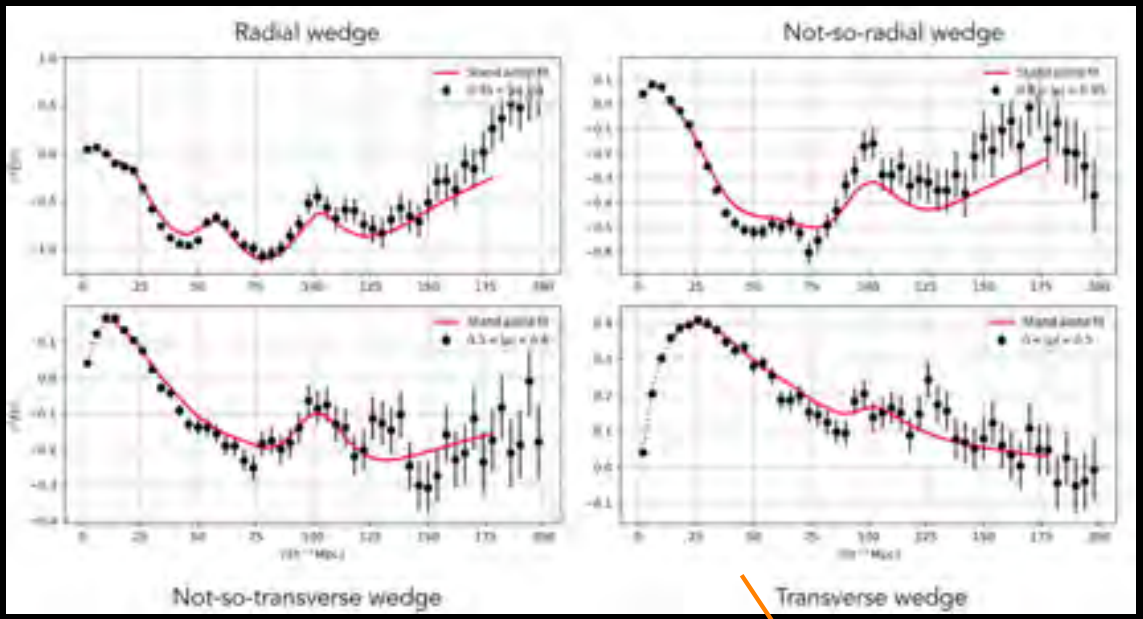




100 Mpc/h — 10 Mpc/h — 1 Mpc/h — 100 kpc/h



Large-scales (> 10 Mpc/h)



du Mas de Bourboux et al. 2020 (eBOSS)

BAO → Full-Shape

Expansion history

Amplitude (σ_8) and growth ($f\sigma_8$)

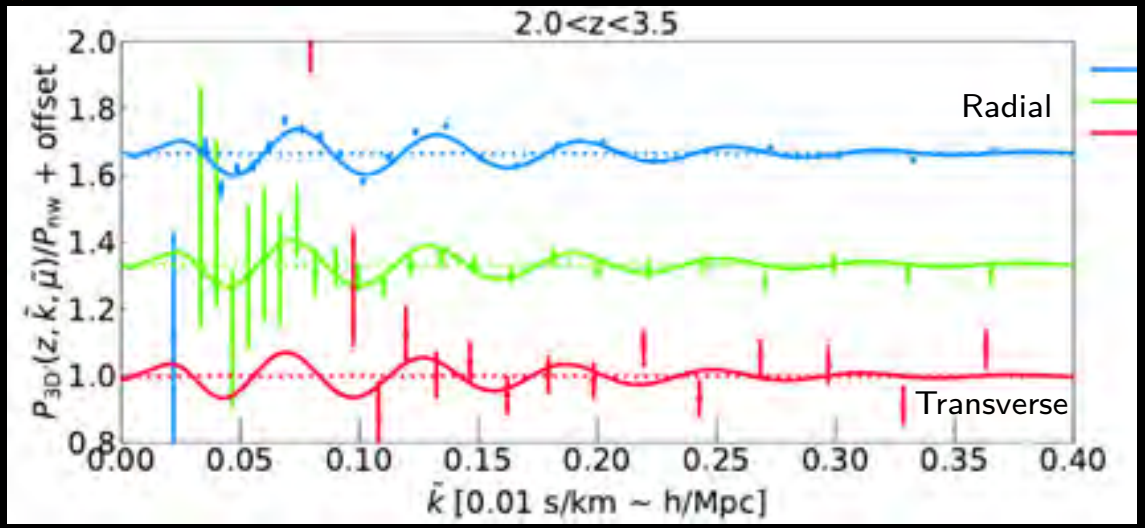
DESI survey

Roger de Belsunce, Vl, George Efstathiou

Challenges:

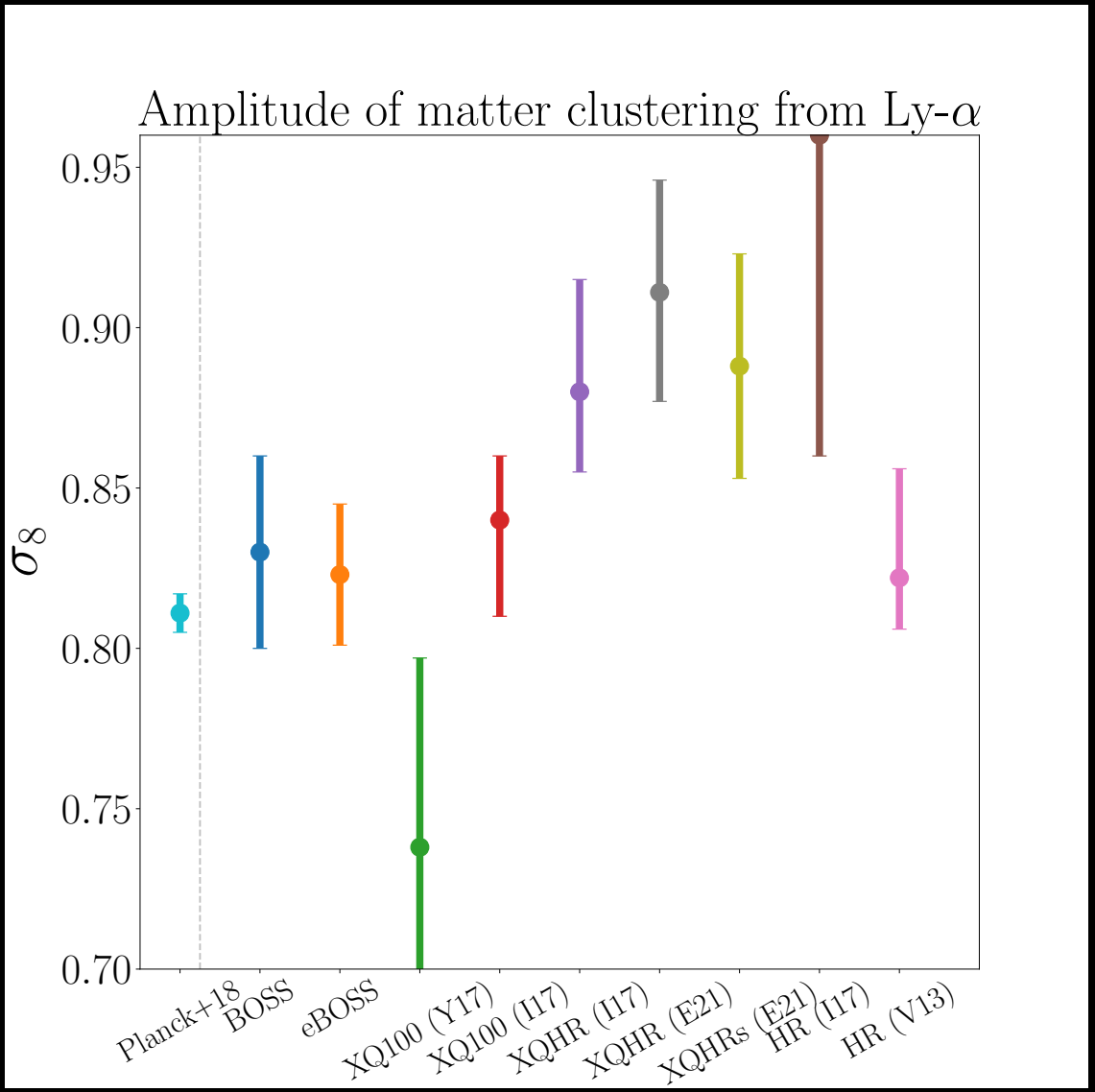
- Quasar Continuum
- Correlated noise
- Metal absorbers

Clustering amplitude at the peak of SF?



Font-Ribera et al. 2017 (BOSS mock data)

Intermediate-scales ($1 - 10$ Mpc/h)



Amplitude – $P_L(k_p, z_p)$
and shape – $d \ln P_L / d \ln k (k_p, z_p)$
of matter clustering

Possible issues:

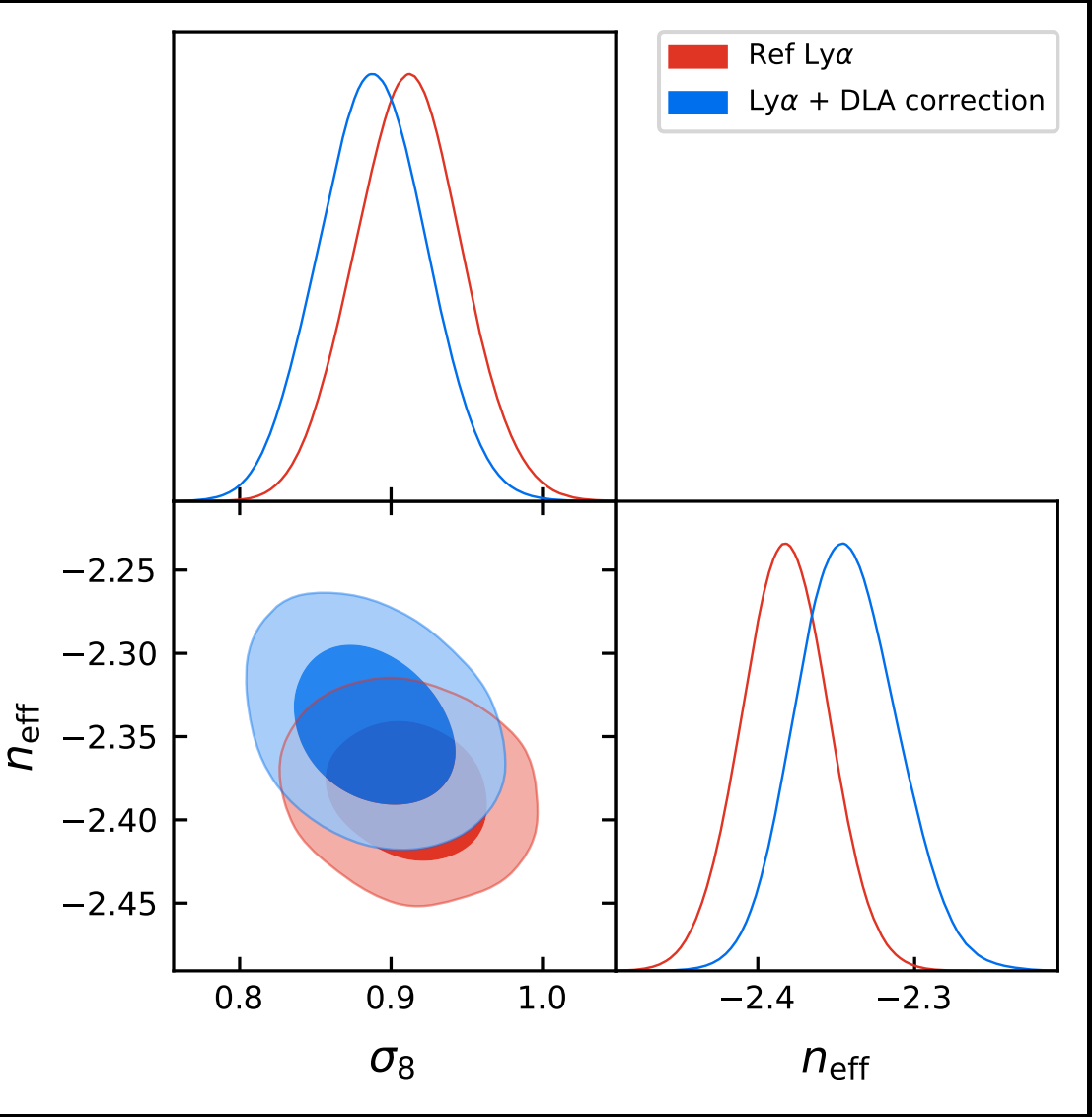
- High-column density
- UVB fluctuations

Cosmology $\longleftrightarrow$ IGM physics

Determine sum of neutrino masses?

Matteo Esposito, Vl, Matteo Viel

Intermediate-scales ($1 - 10$ Mpc/h)



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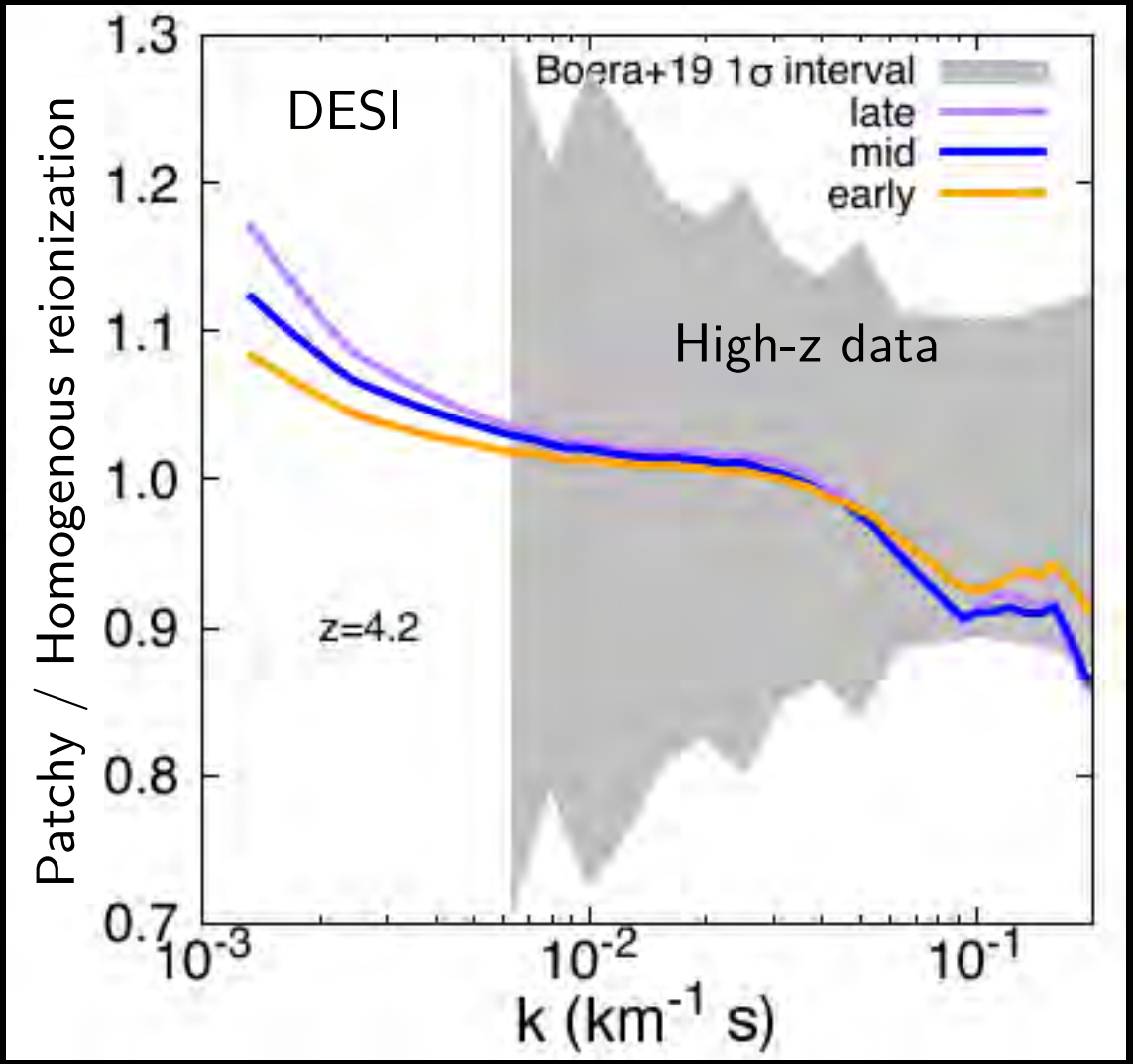
Cosmology $\longleftrightarrow$ IGM physics

Matteo Esposito, Vl, Matteo Viel (in prep)

Intermediate-scales ($1 - 10$ Mpc/h)



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Possible issues:

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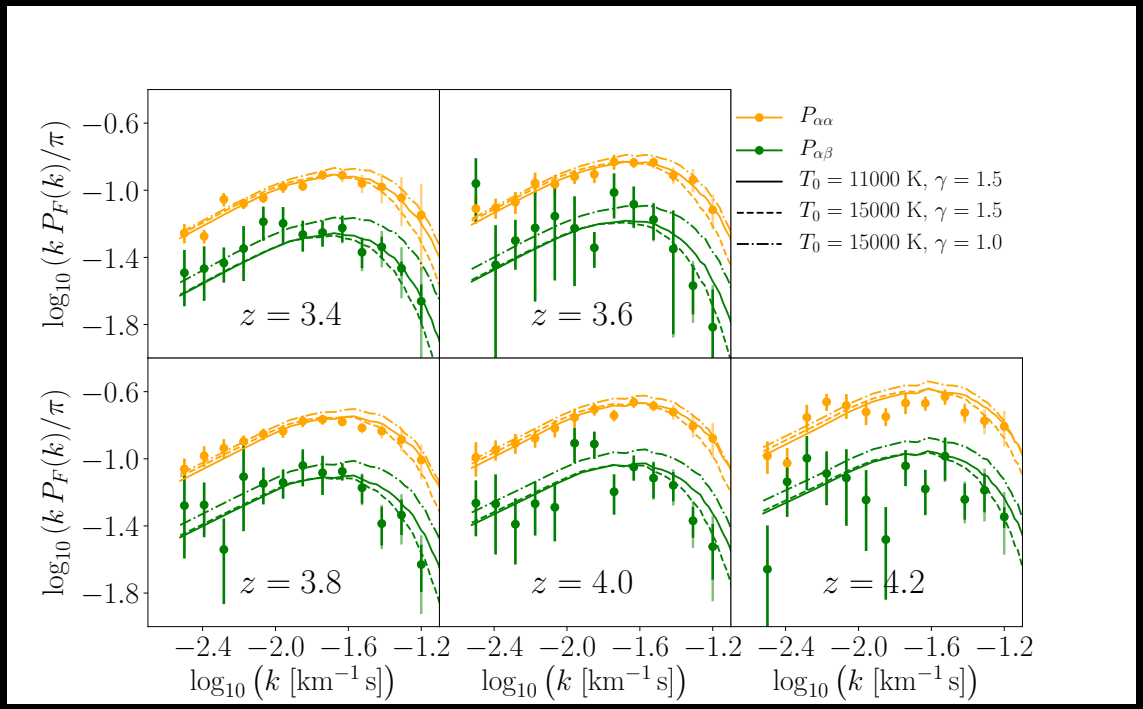
Cosmology $\longleftrightarrow$ IGM physics

Margherita Molaro, Vl, James Bolton (astro-ph/2109.06897)

Intermediate-scales ($1 - 10$ Mpc/h)



Bayu Wilson, Vl, Matthew McQuinn (astro-ph/2106.04837)

Amplitude – $P_L(k_p, z_p)$
and shape – $d\ln P_L / d\ln k(k_p, z_p)$
of matter clustering

Possible issues:

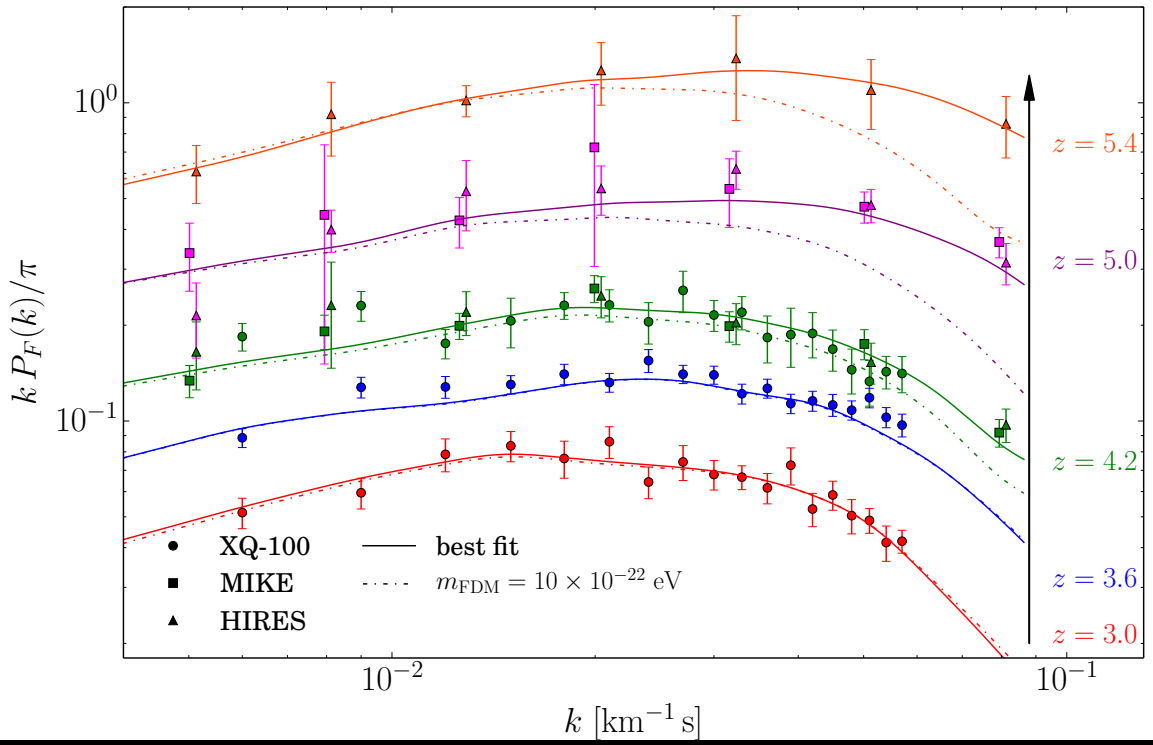
- High-column density
- UVB fluctuations

Cosmology $\longleftrightarrow$ IGM physics

- Higher order Lyman series
- Higher order statistics

Small-scales (< 1 Mpc/h)

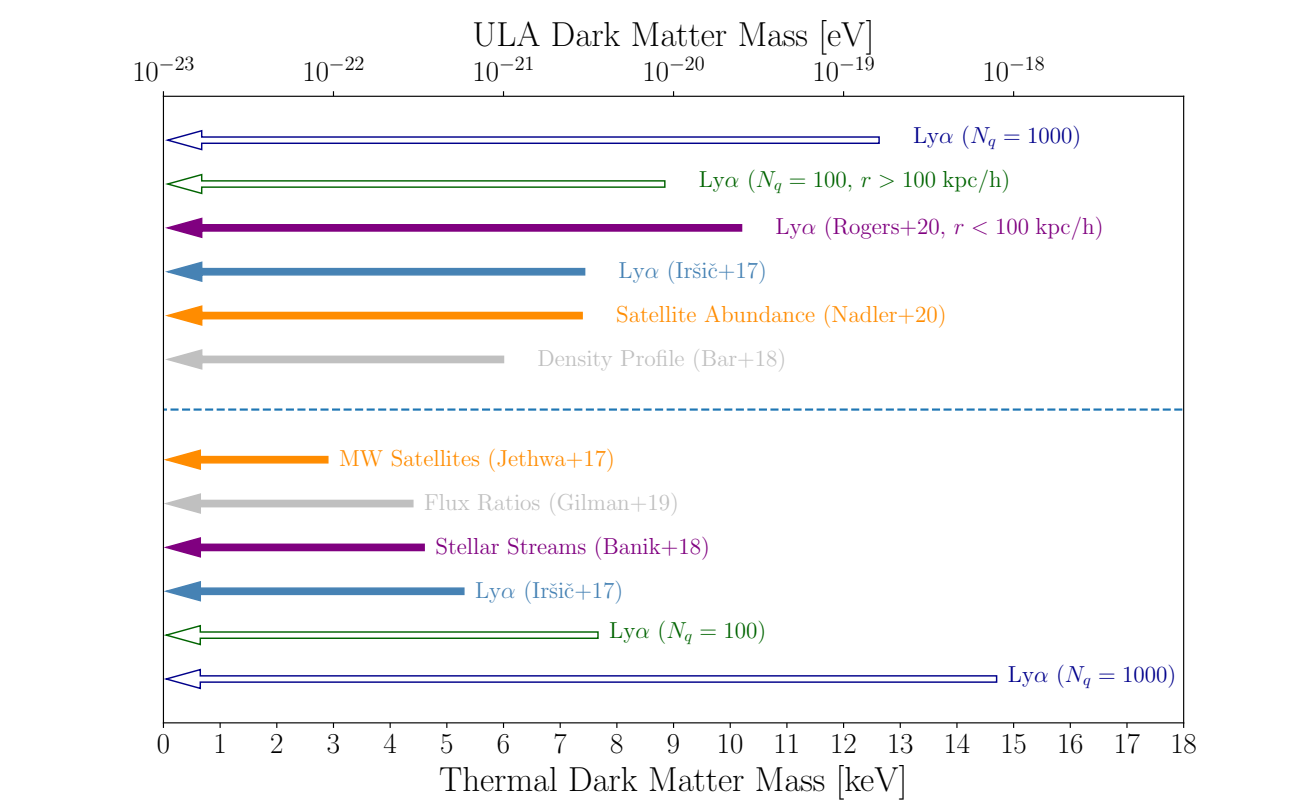
Testing Dark Matter models



- Relative suppression of small-scale clustering
- Robust constraints for variety of models

Small-scales (< 1 Mpc/h)

Testing Dark Matter models



- Relative suppression of small-scale clustering
- Robust constraints for variety of models

Can we rule out large ranges in DM particle mass?

Motivation: non-resonant sterile neutrino (3.5 keV), excluding ultra-light axions with $m_{\rm a} > 10^{-14}$ eV

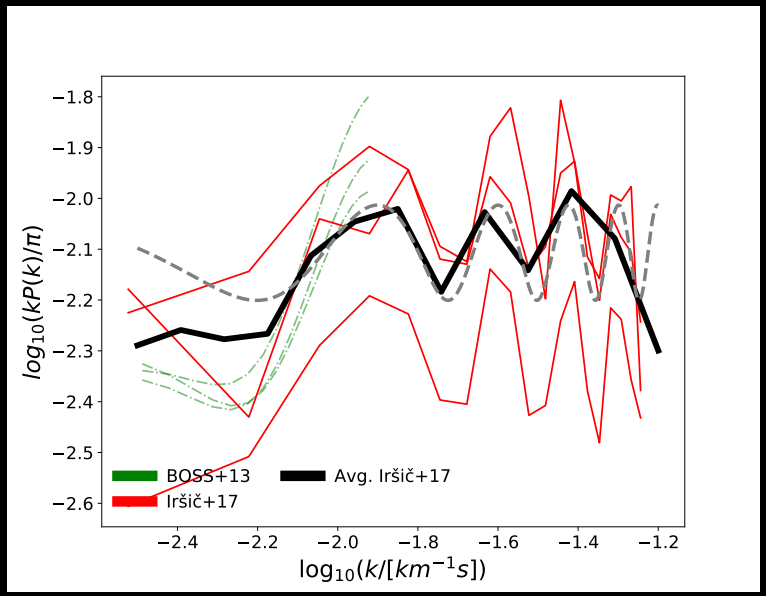
Can we distinguish between DM models?

Motivation: information on production mechanism

Small-scales (< 1 Mpc/h): Link Between Cosmology & Galaxies

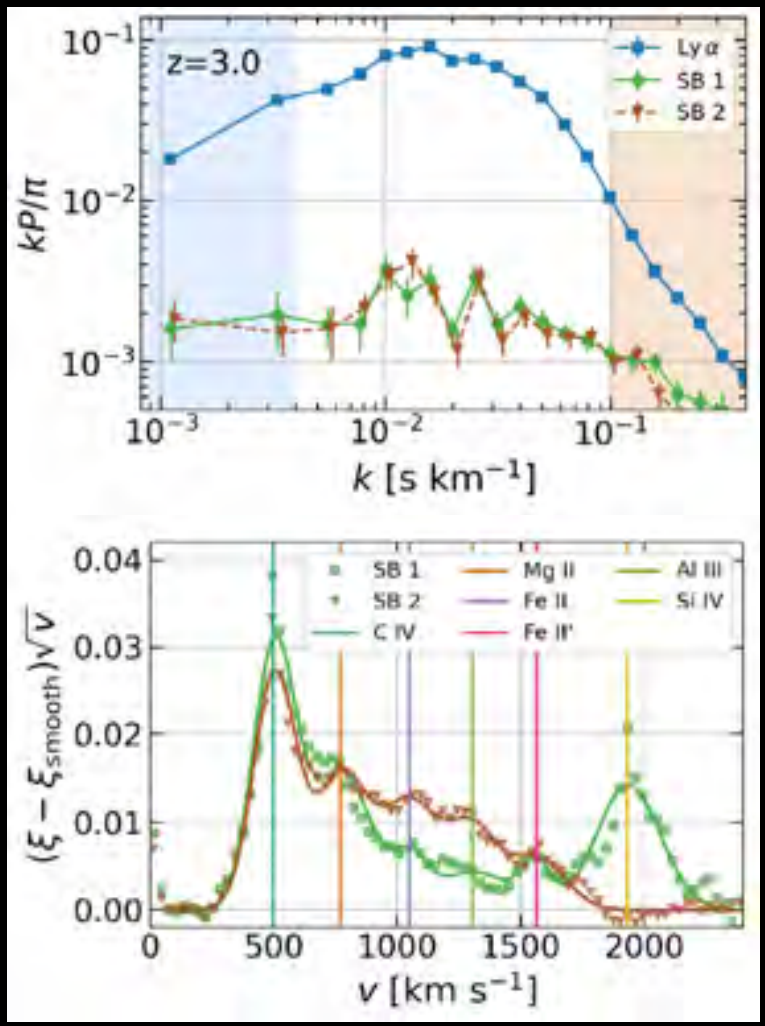
Estimated power subtracts metals: $P_{\alpha\alpha} = P_F - P_m$

Metal power P_m measured red-side of Lyα emission



Wilson,Vl+21 (astro-ph/2106.04837)

Correlations of metal doublets



Karacayli,Vl+21 (astro-ph/2108.10870)

Conclusions

- Lyman-α forest as a high-z LSS tracer
- A unique probe of the IGM (redshift range, small scales)
- Large-scales ($> 10\ \mathrm{Mpc/h}$): BAO + Full-Shape(?)
- Intermediate-scales ($1 - 10\ \mathrm{Mpc/h}$): Amplitude/Slope of matter clustering
- Small-scales ($< 1\ \mathrm{Mpc/h}$): Robust constraints on DM models
- With increasing statistical power of the data $\rightarrow$ access to CGM