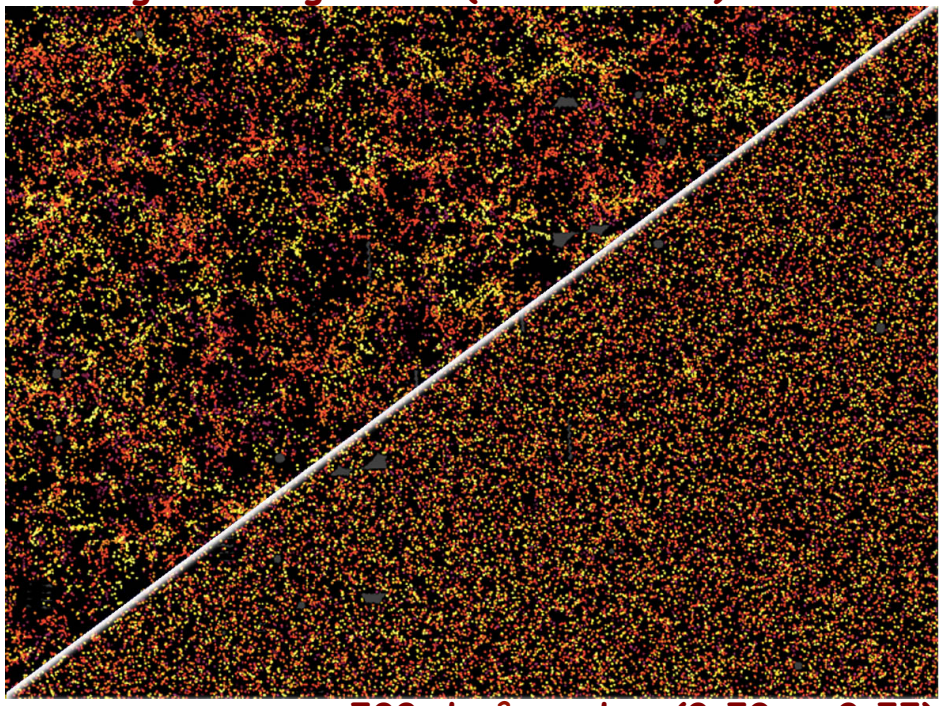
Cosmology with eBOSS and DESI

N. Palanque-Delabrouille, CEA-Saclay (IRFU)

500 deg^2 BOSS galaxies (0.50<z<0.55)

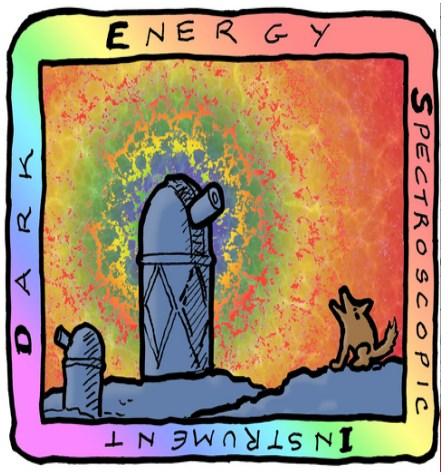


500 deg^2 random (0.50<z<0.55)

BOSS, eBOSS, DESI: a clustering saga

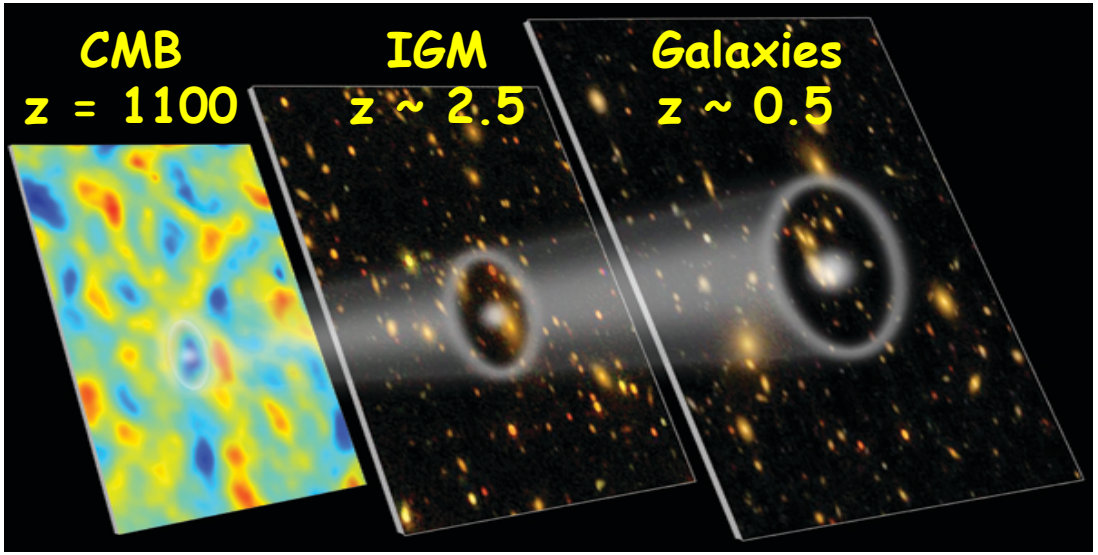
- → BAO (dark energy)
- → RSD (gravity)
- → Free-streaming cut-offs (Σm_ν, WDM)

SDSS



DESI

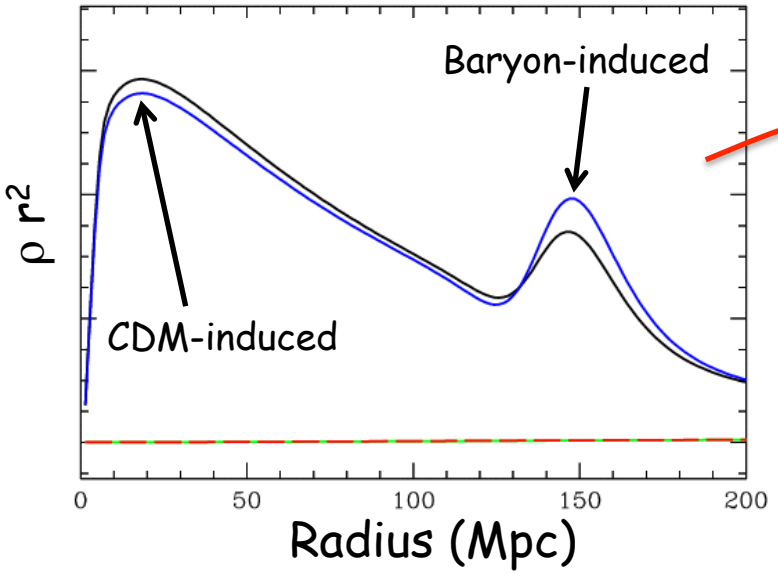
Baryon Acoustic Oscillations (BAO)

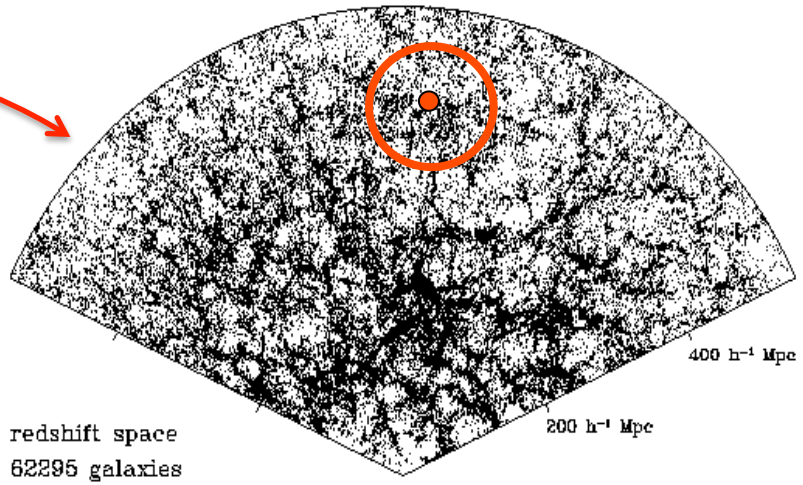


Propagation of baryon-photon overdensity wave in plasma

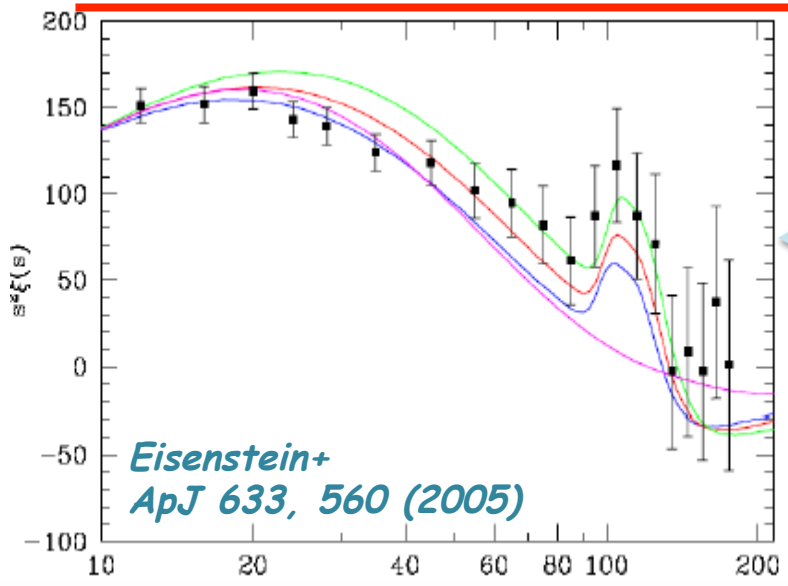
Wave frozen at recombination, at comoving r_s ~ 150 Mpc

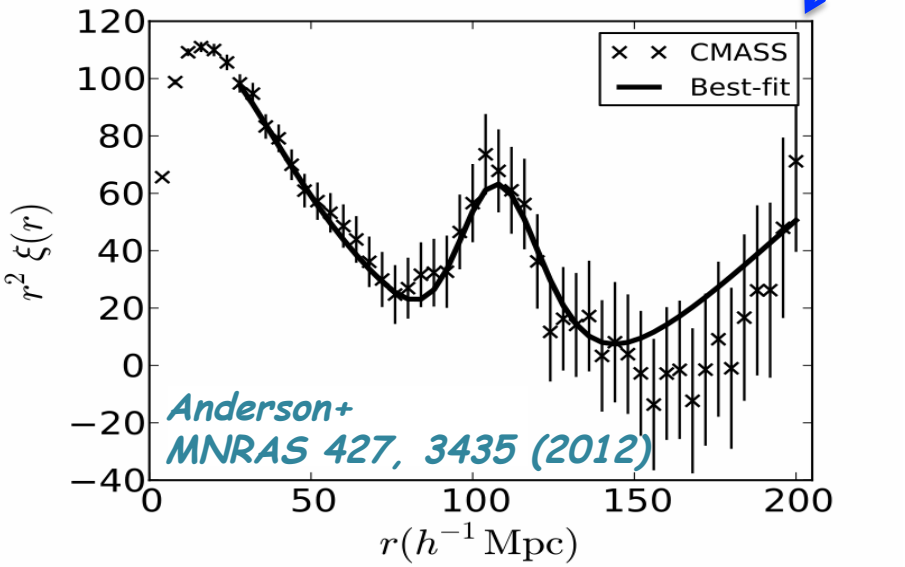
Standard ruler in LSS
A preferred 3D scale





Baryon Acoustic Oscillations (BAO)





Observations

2005: First detection of BAO peak
2012: 5σ confirmation by BOSS
2014: First 3D measurements of BAO

Baryon Acoustic Oscillations (BAO)

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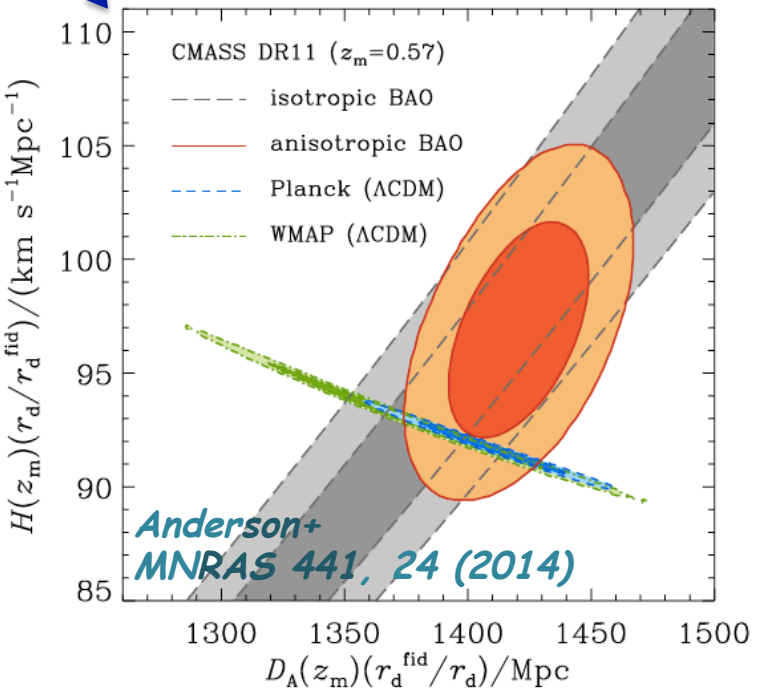


Transverse direction

$\Delta\theta = r_s / [(1+z)\, D_A(z)]$

$\Rightarrow$ Angular distance $D_A(z)$

as SNIa: $D_L(z) = (1+z)^2\, D_A(z)$

Radial direction (along line of sight)

$\Delta z = r_s\, H(z) / c$

$\Rightarrow$ Hubble parameter H(z)

Sloan Digital Sky Survey

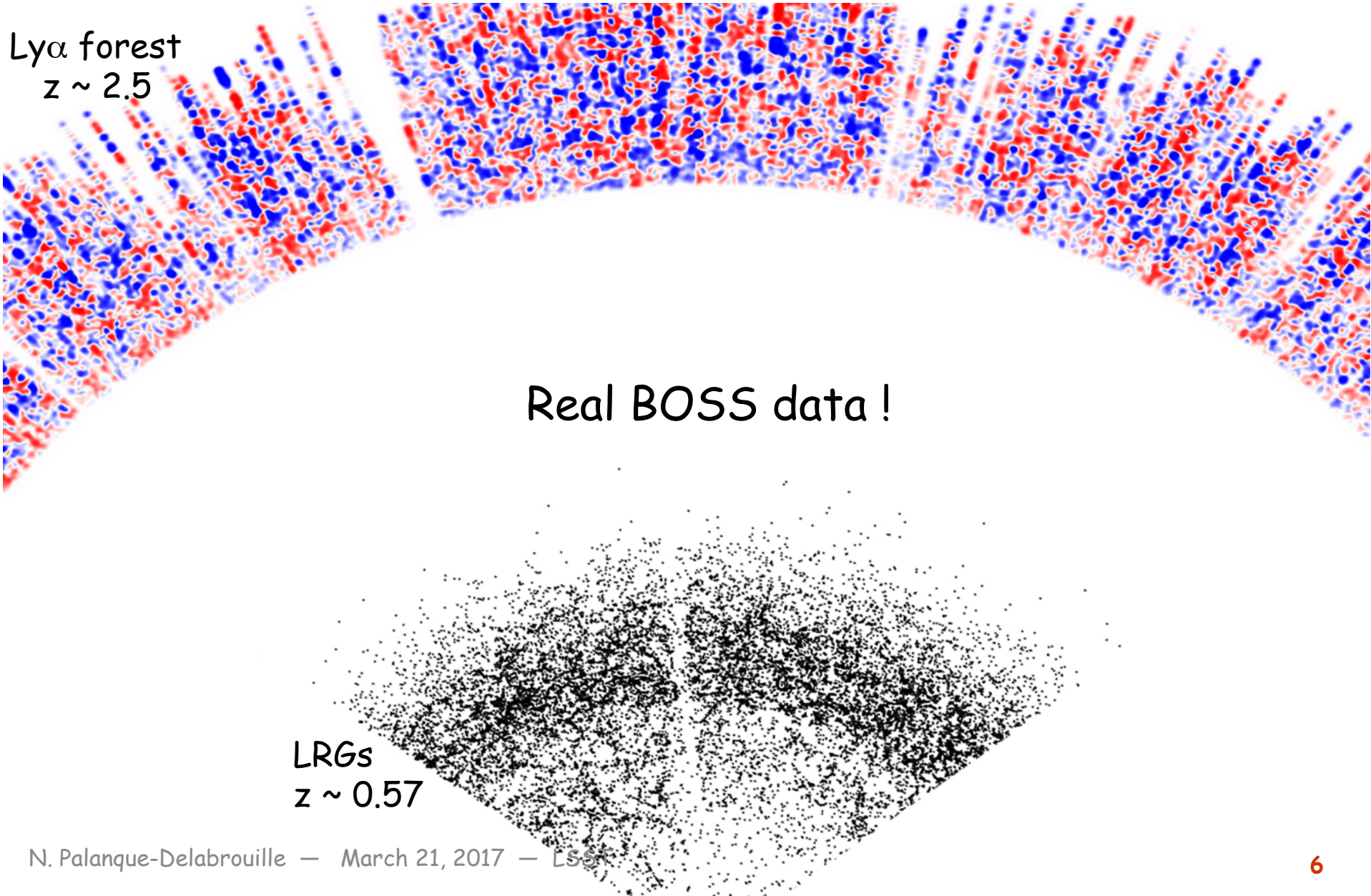
- 2.5m telescope (New Mexico)
- 7 500 deg^2 eBOSS
  10 000 deg^2 BOSS
- 1000 fibers

BOSS 2009-2014
eBOSS 2014-2020

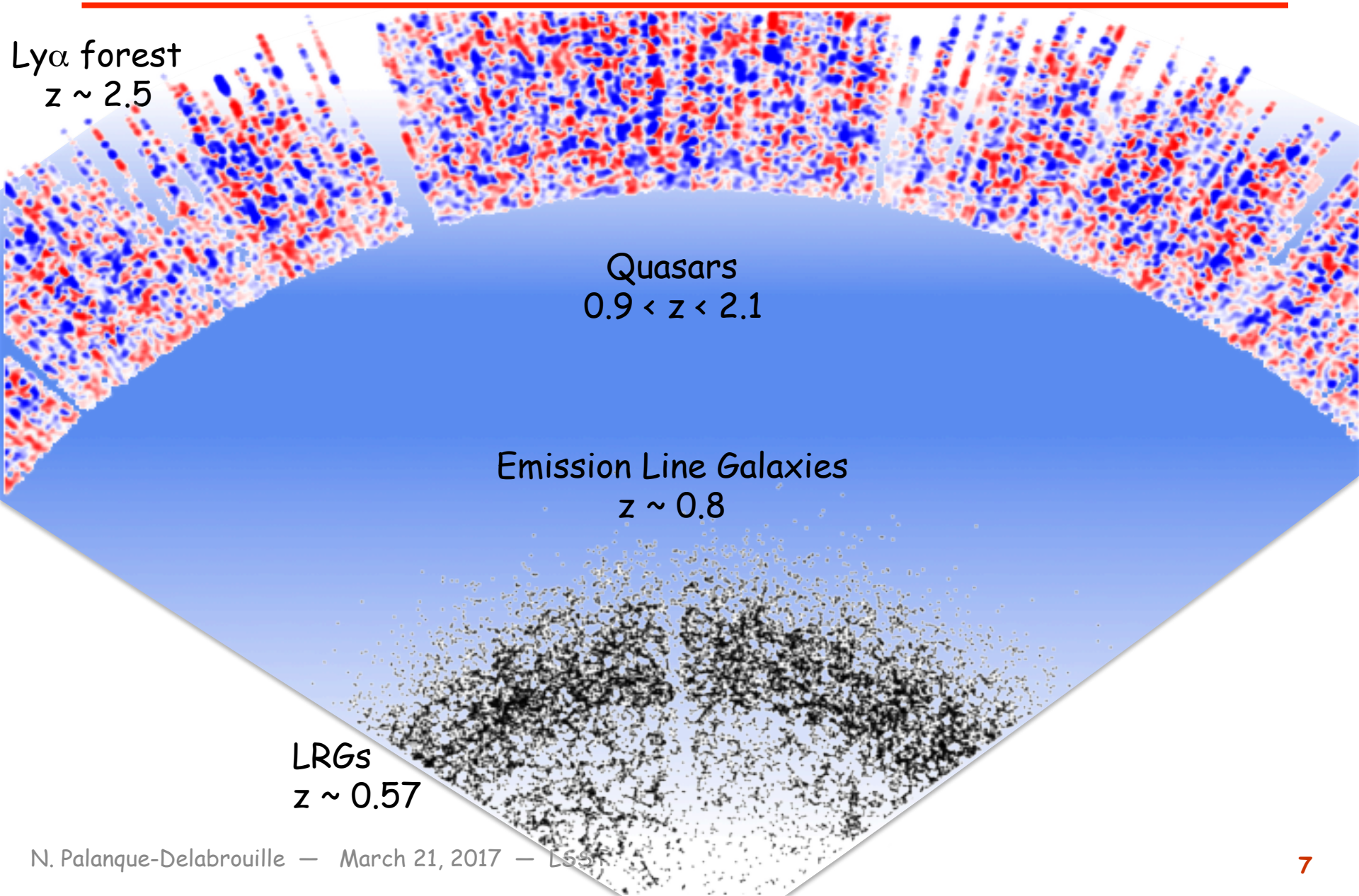
Latest results & predictions

- BAO
- RSD
- Lya and neutrinos (active M_ν or sterile ν)

Baryon Acoustic Oscillations (BAO)

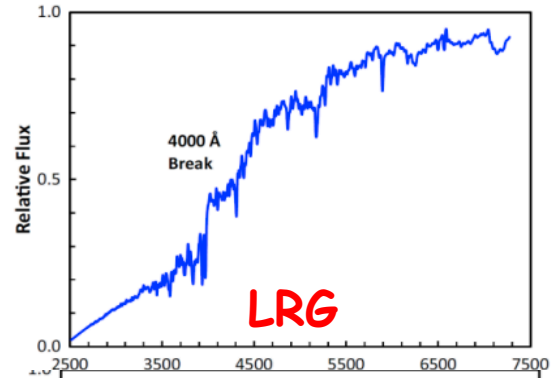


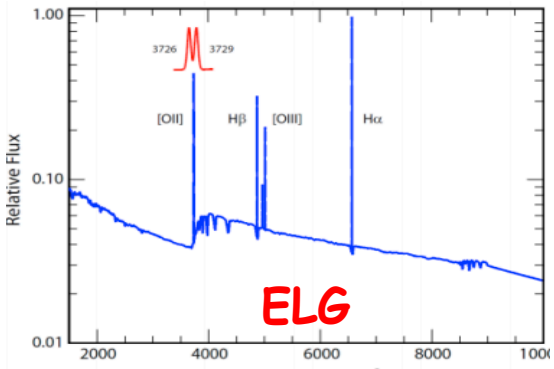
Baryon Acoustic Oscillations (BAO)

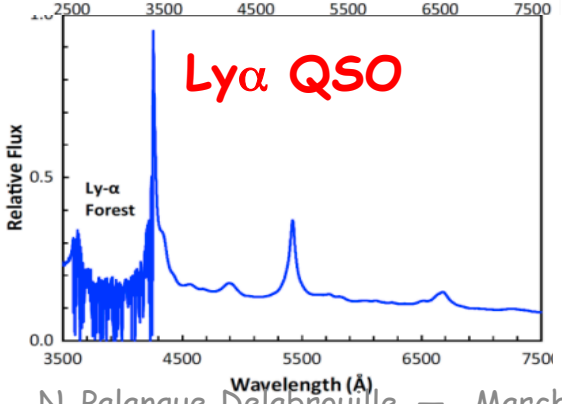


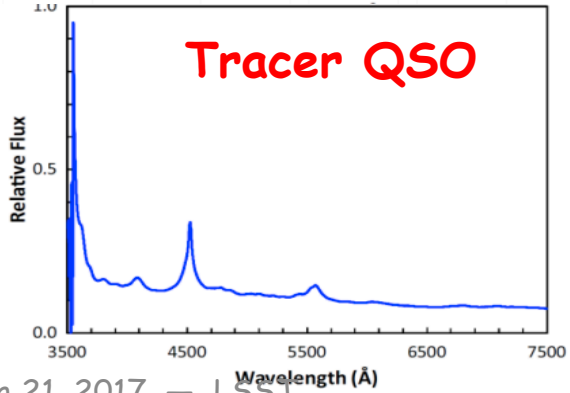
eBOSS overview

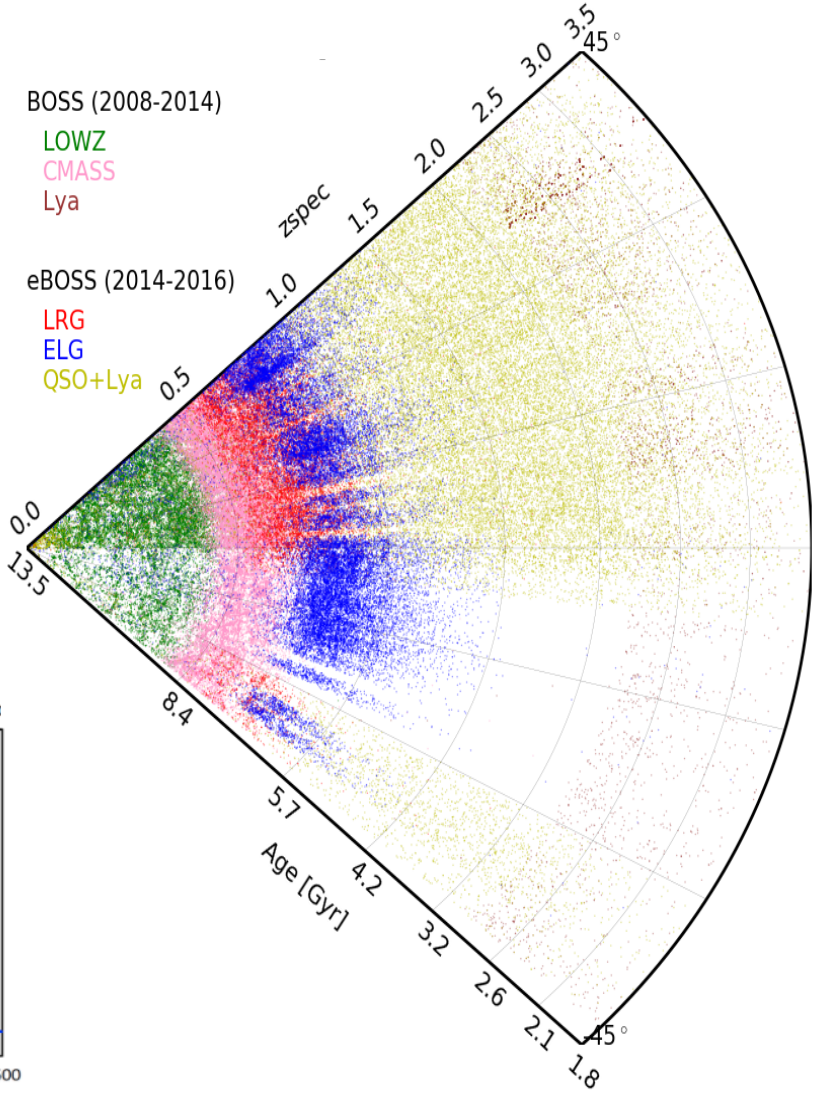
	BOSS		eBOSS	
LRG	1.2 10^6	z ~ 0.57	+ 250 10^3	z ~ 0.72
ELG		—	195 10^3	z ~ 0.87
Quasars		—	500 10^3	0.9 - 2.1
Lyα	180 10^3	z > 2.1	+ 60 10^3	z > 2.1



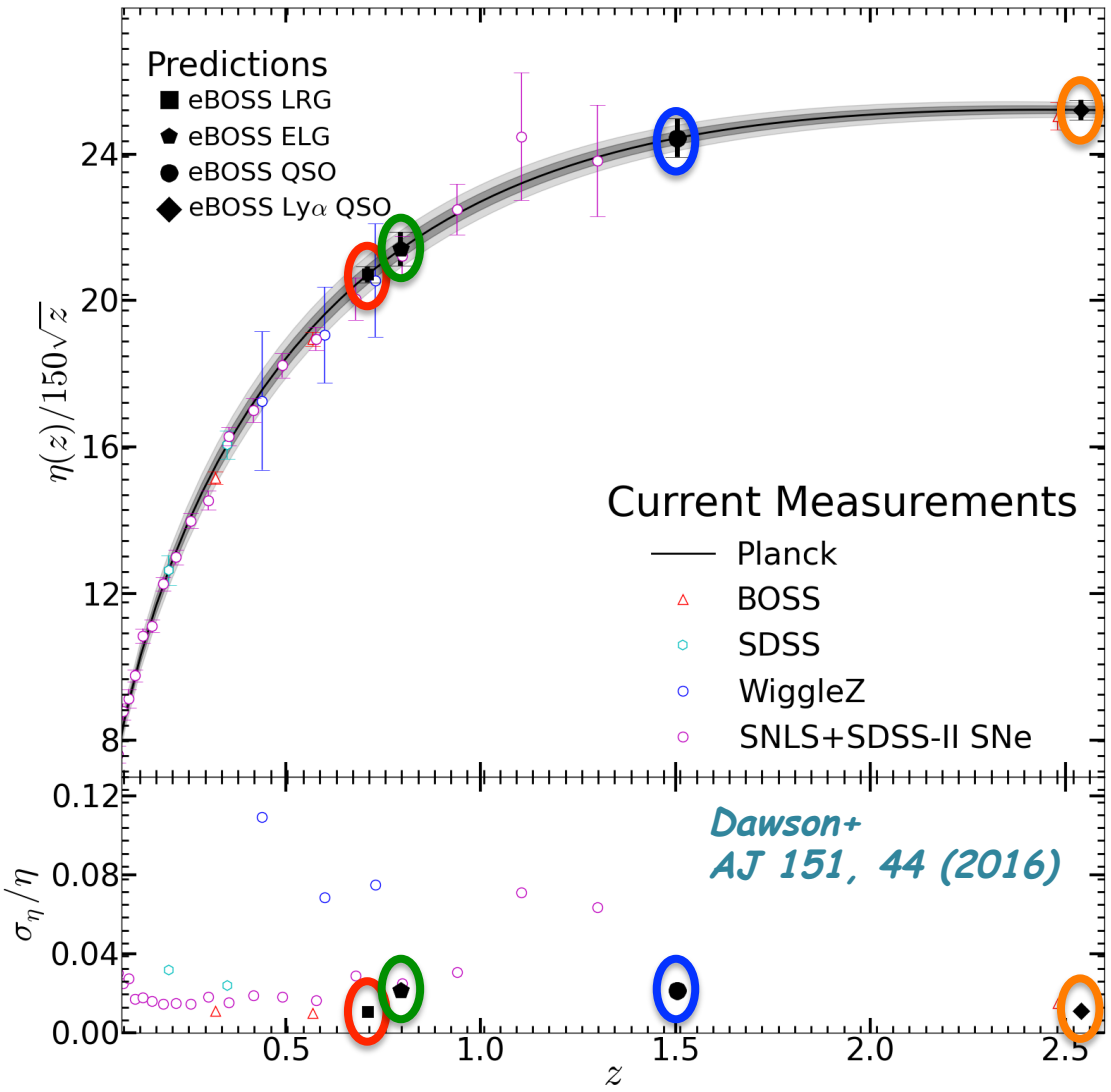








eBOSS overview - BAO

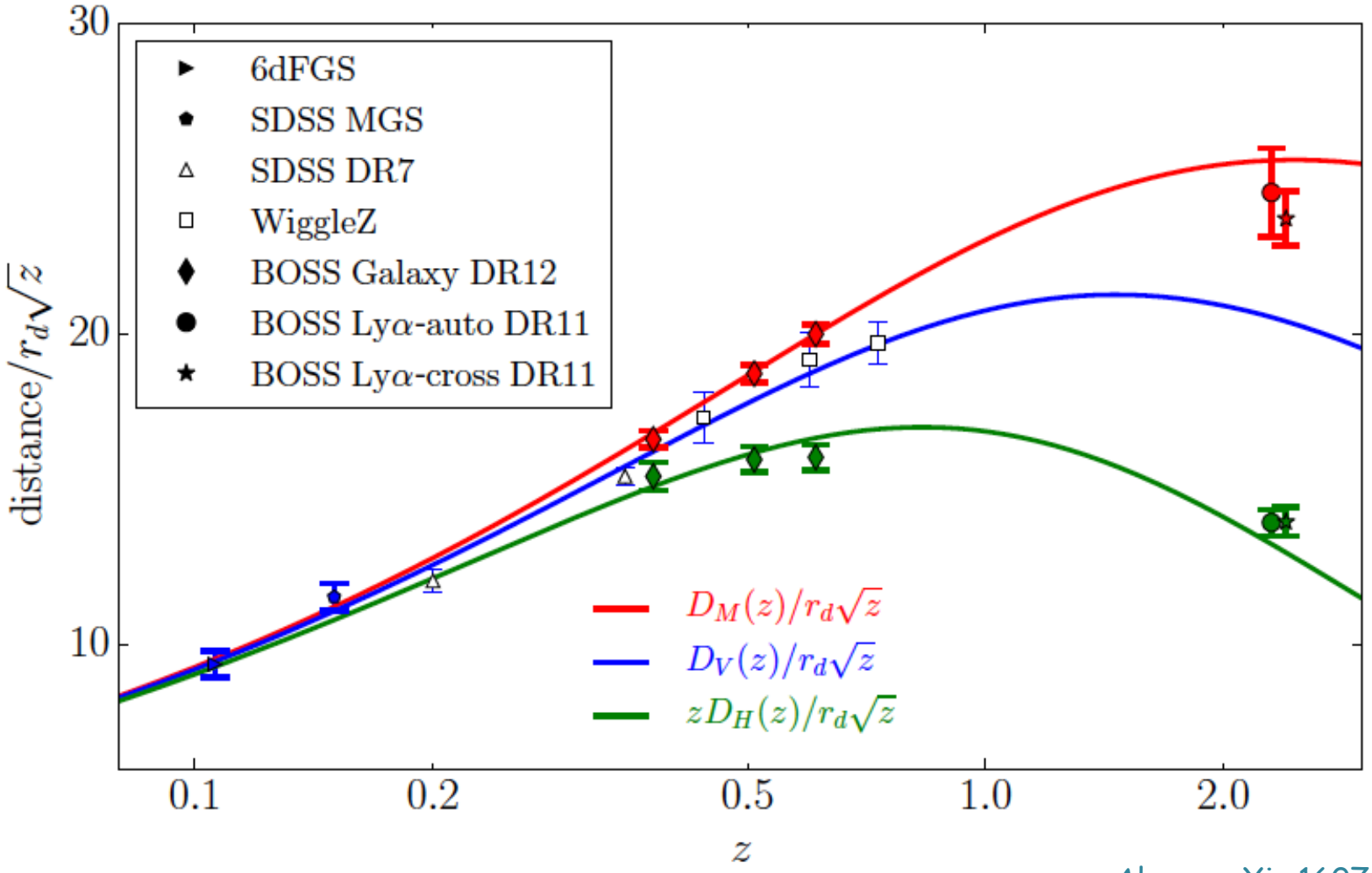


Expect 1-2% distance precision on all tracers

LRG: 0.8%
ELG: 2.0%
QSO: 1.2%

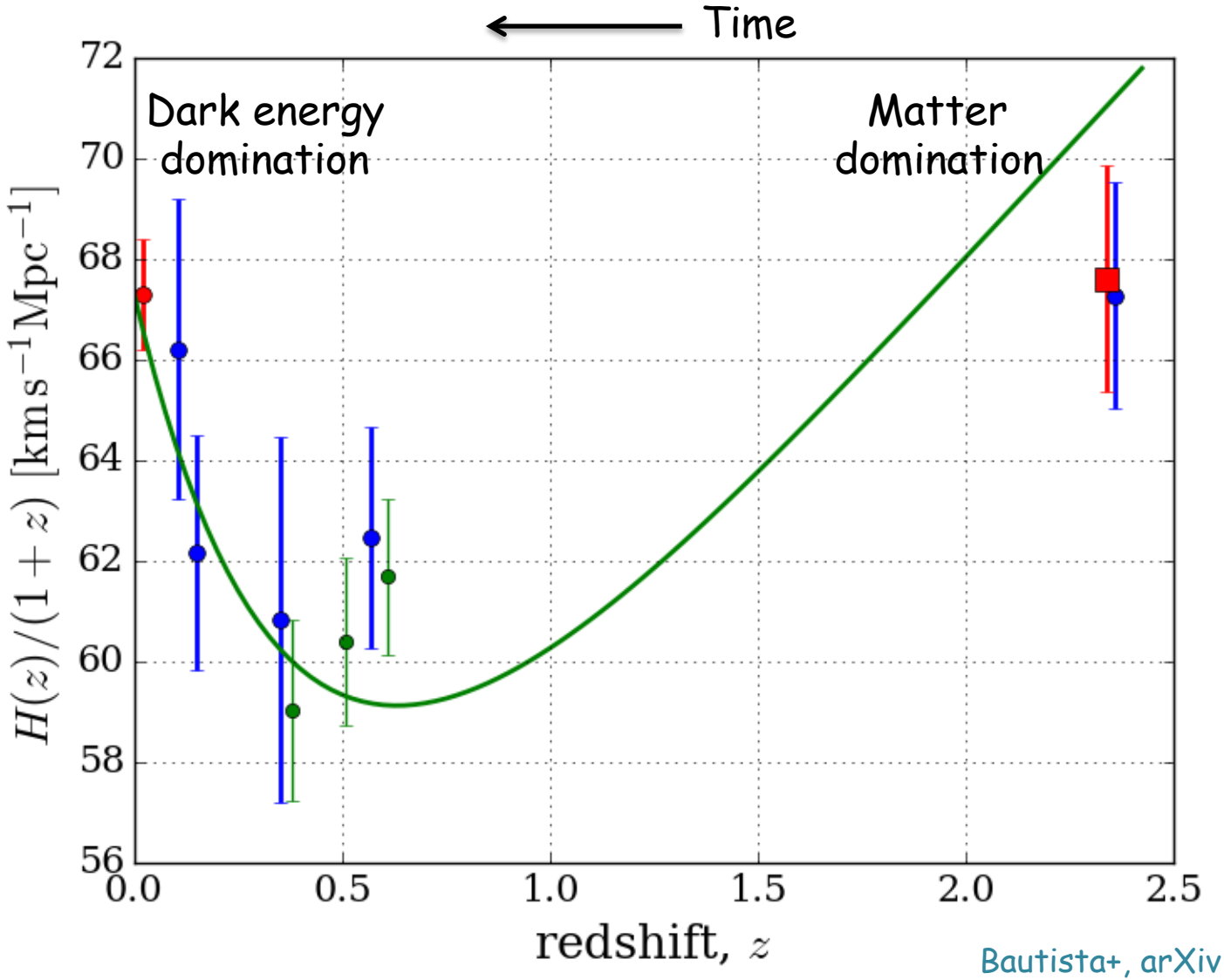
Lyα:
1.4% on H(z)
1.7% on $d_A(z)$

Latest results – BAO (BOSS DR12)



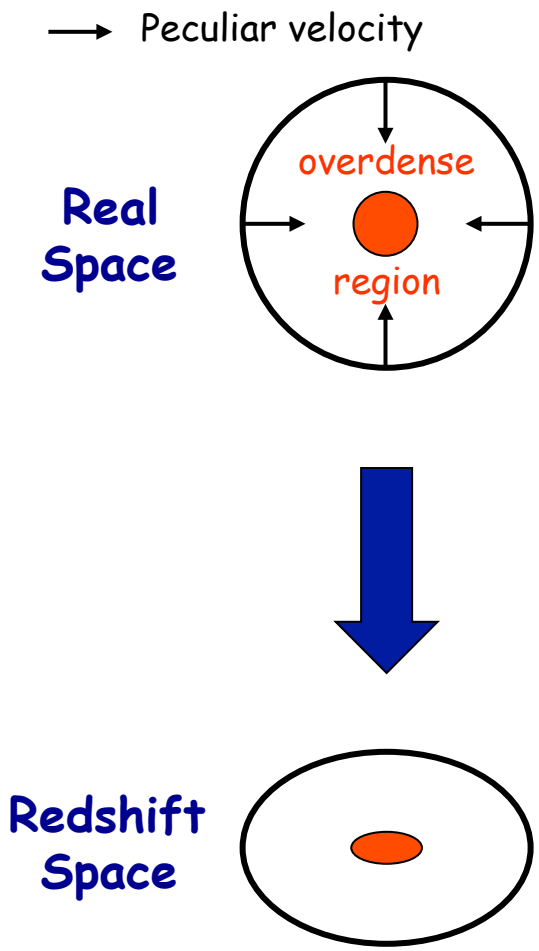
Alam+ arXiv:1607.03155

Latest results – BAO (BOSS DR12)



Bautista+, arXiv:1702.00176

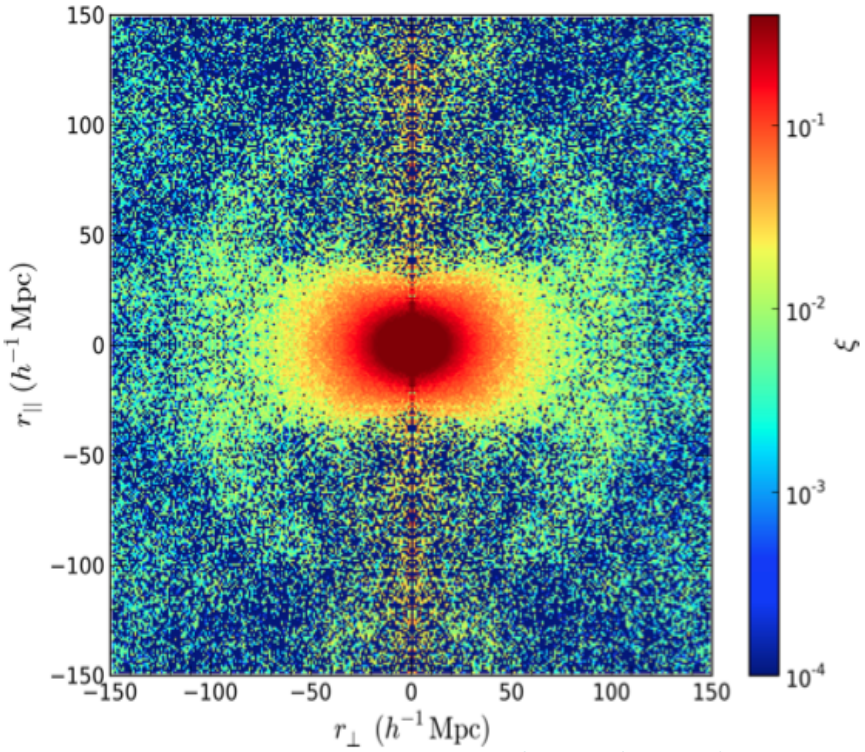
eBOSS overview - RSD



Measure of gravitational growth

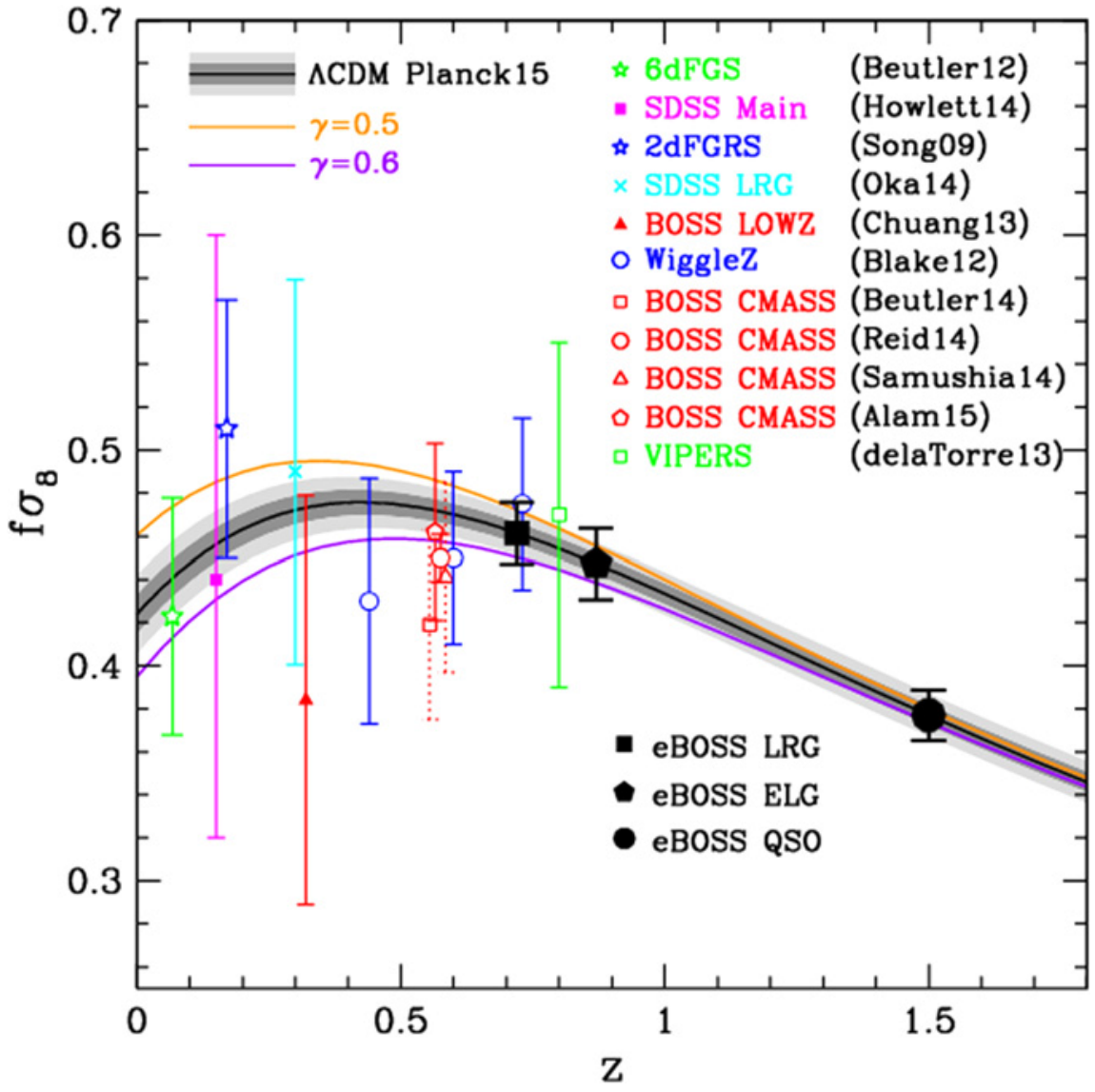
$$P_F(k) = b_F^2 \times \left[1 + \beta \cos(\theta)^2\right]^2 \times P_L(k)$$

$$\beta \rightarrow f\sigma_8$$



Samushia+ (2014)

eBOSS overview - RSD



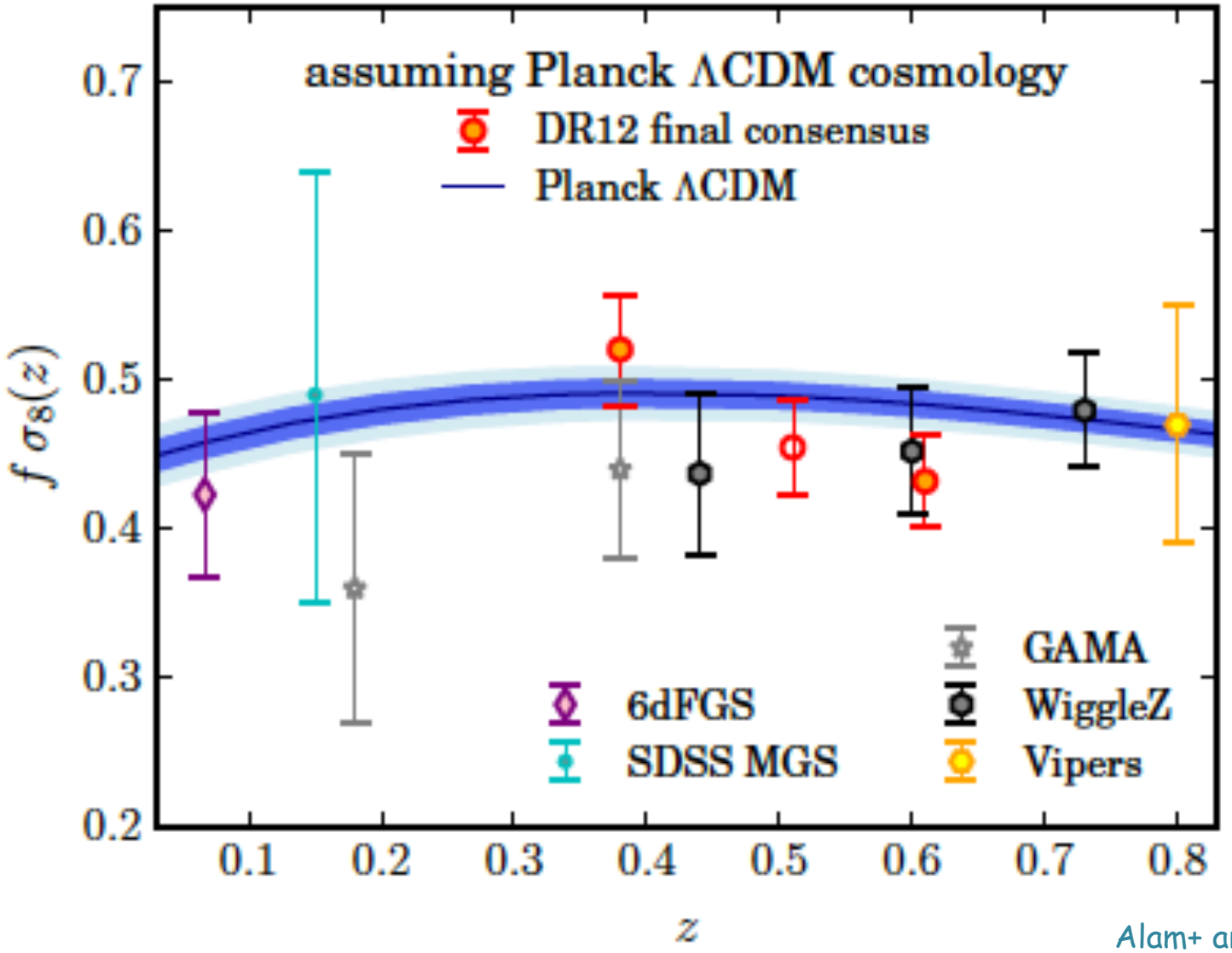
Expect 2.6-3.8% precision

on f σ_8

for all tracers

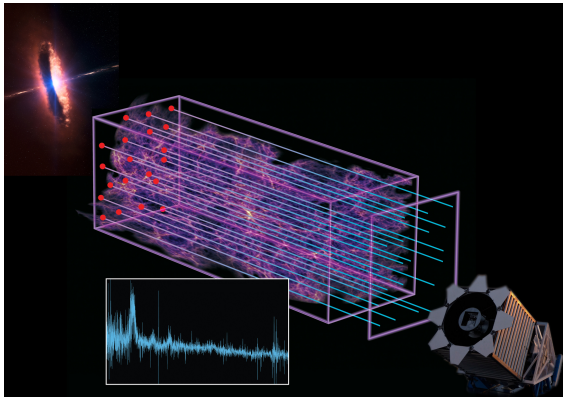
Dawson+
AJ 151, 44 (2016)

Latest results – RSD (BOSS DR12)

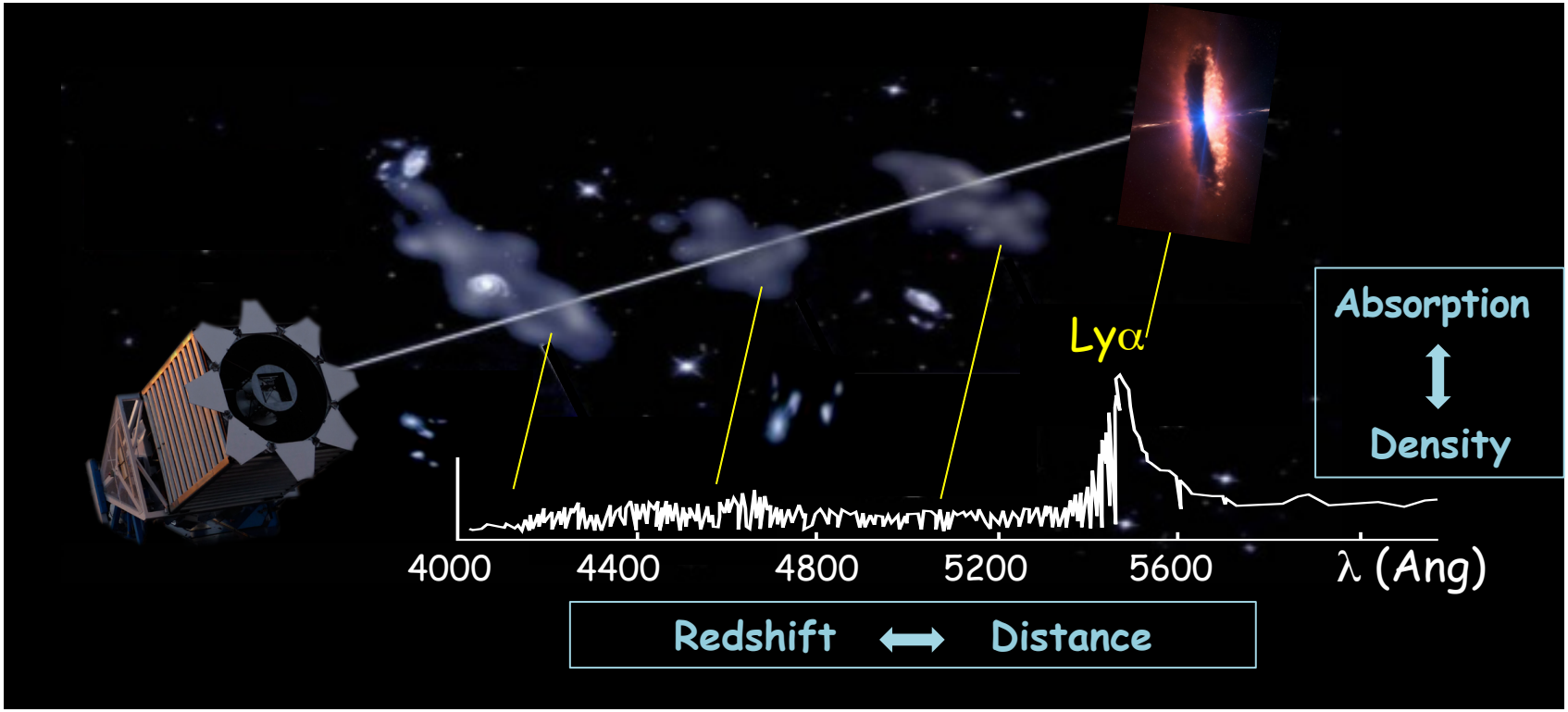


Alam+ arXiv:1607.03155

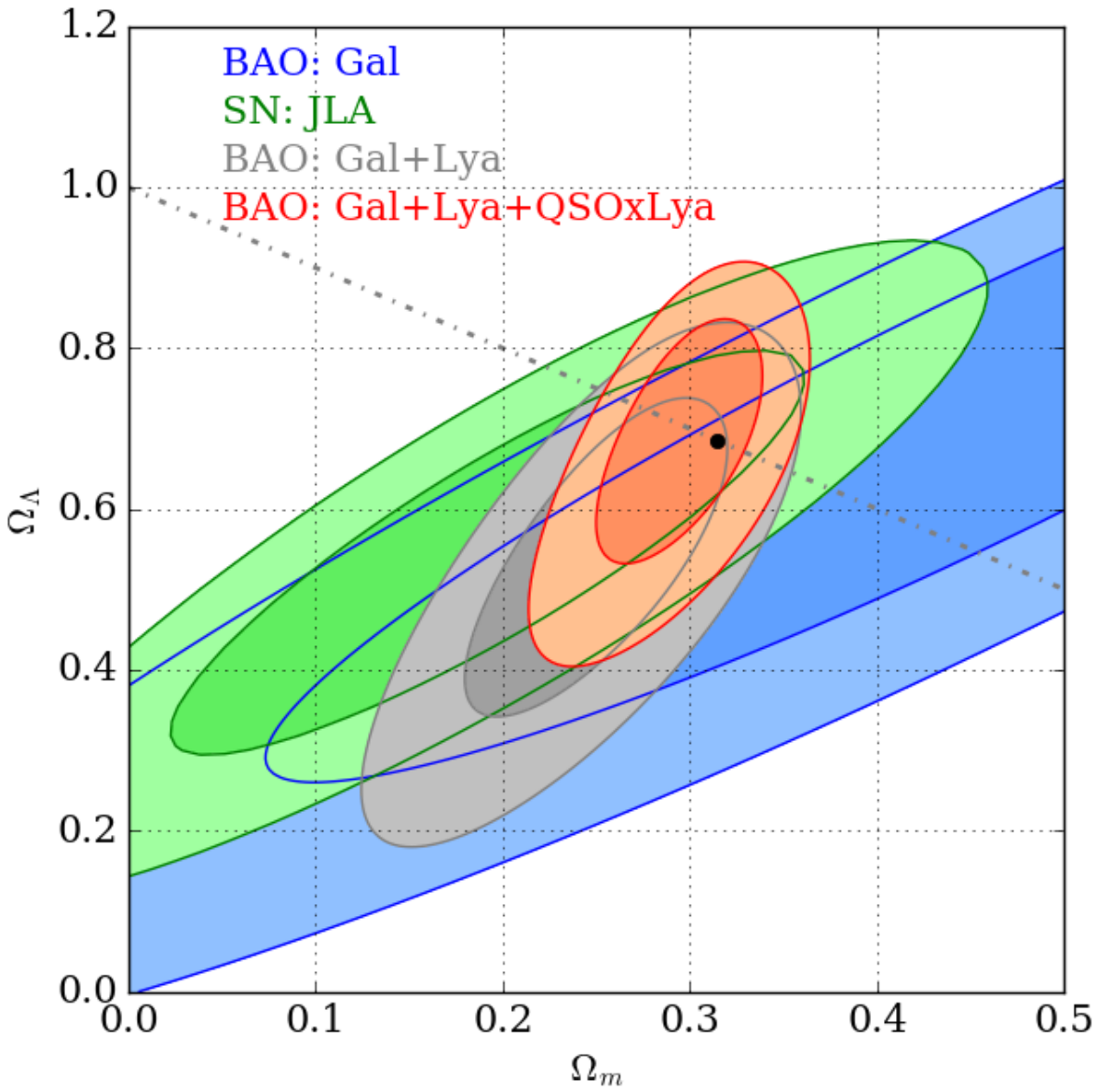
Lyman-α overview



- Quasars visible to high redshift (>5)
- Absorption by neutral H (IGM) along line-of-sight
- IGM probes matter density
- Matter distribution on small scales (ν, ν_s)



Lyman-α overview



Spatial flatness

independently

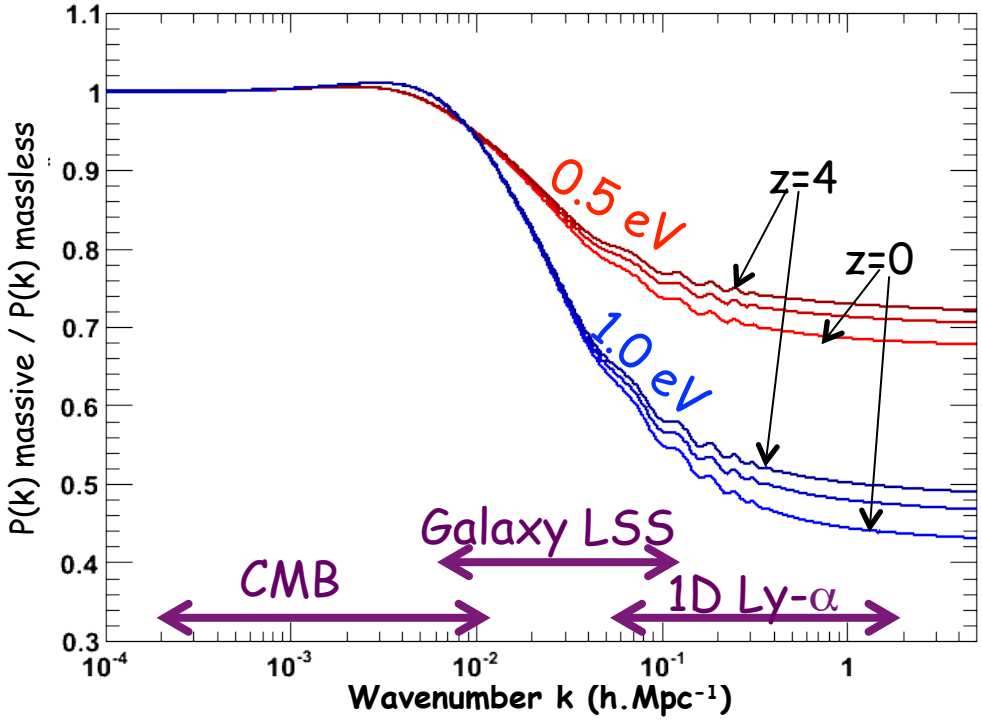
of CMB

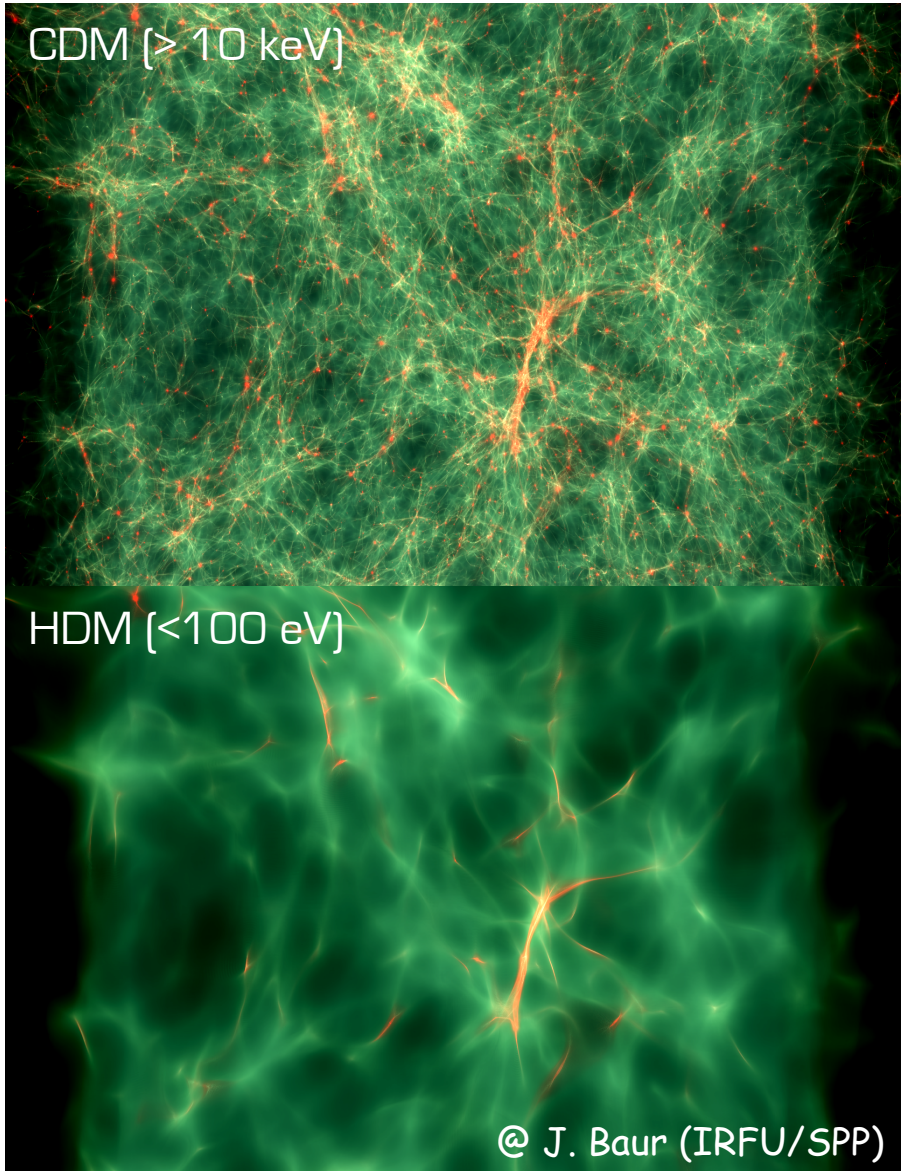
Lyα & Mν

Neutrinos have mass but m_ν is small

→ ν's are relativistic during most of history of Universe

→ ν's free stream and slow-down clustering

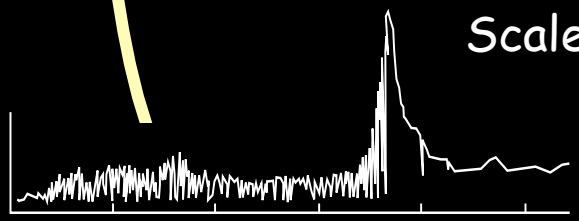




Latest results - Lyα & Mν (BOSS DR9)

Spatial correlation of absorption features (power spectrum)

Scales ~ 1 to 100 Mpc



ν

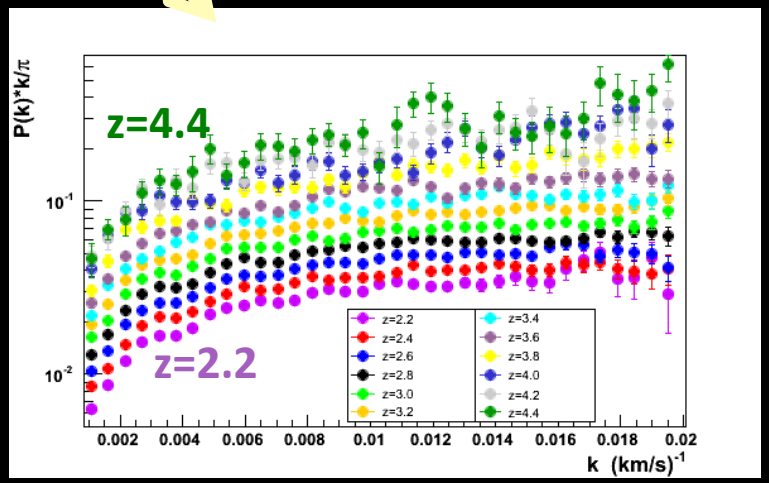
ν_s

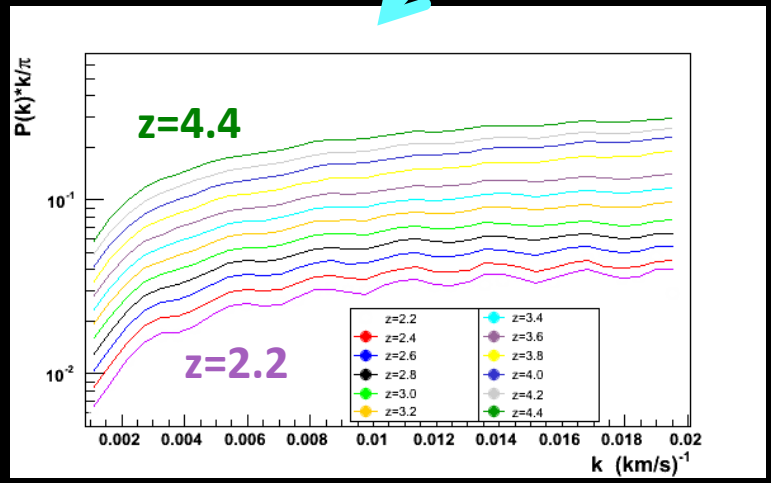
Borde+ JCAP 7 5 (2014)

Rossi+ A&A 567 79 (2014)

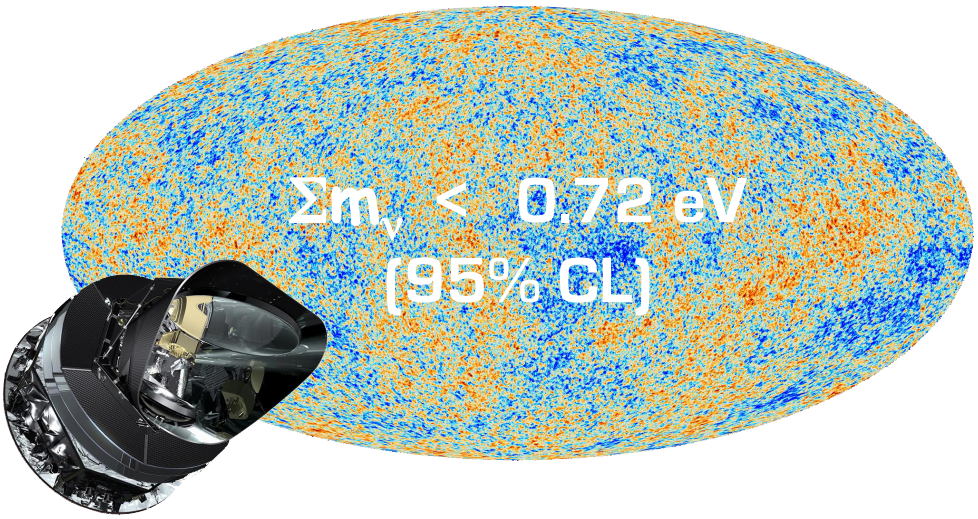
Data - PD+ A&A 559 85 (2013)

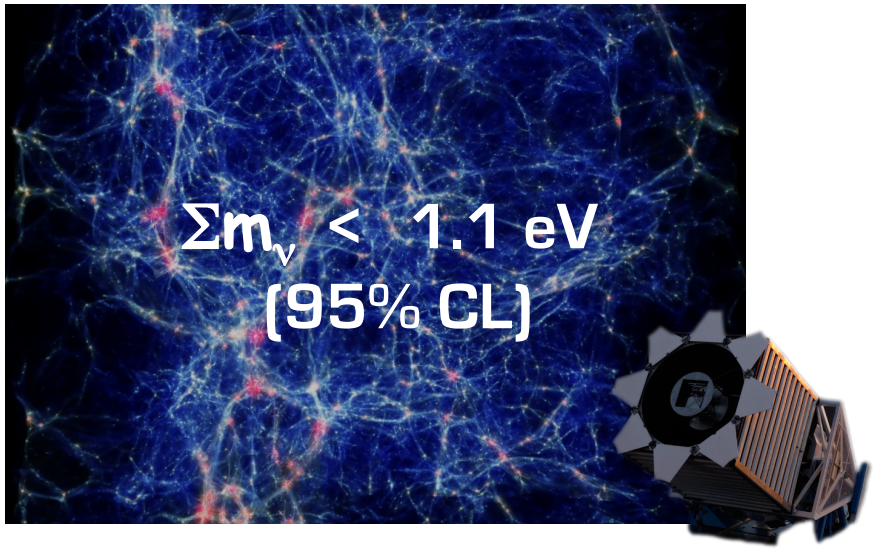
Simulations



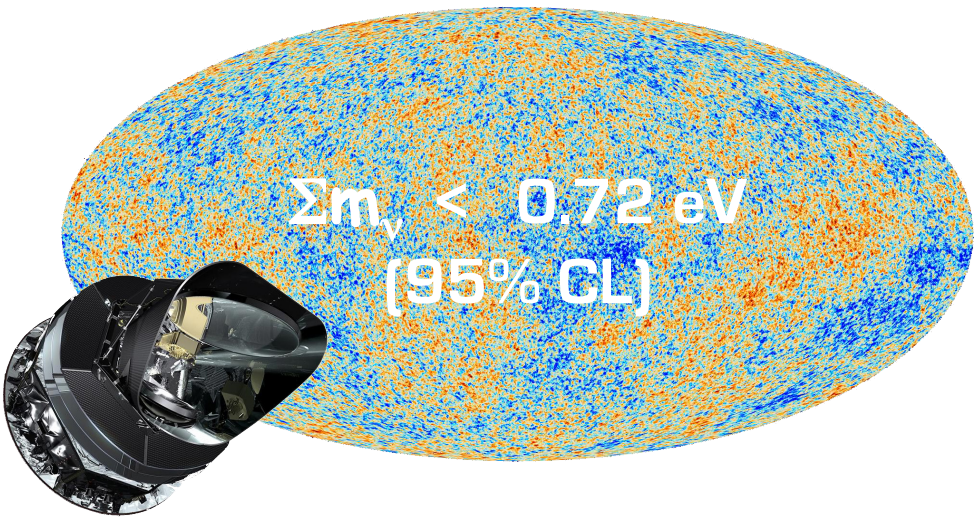


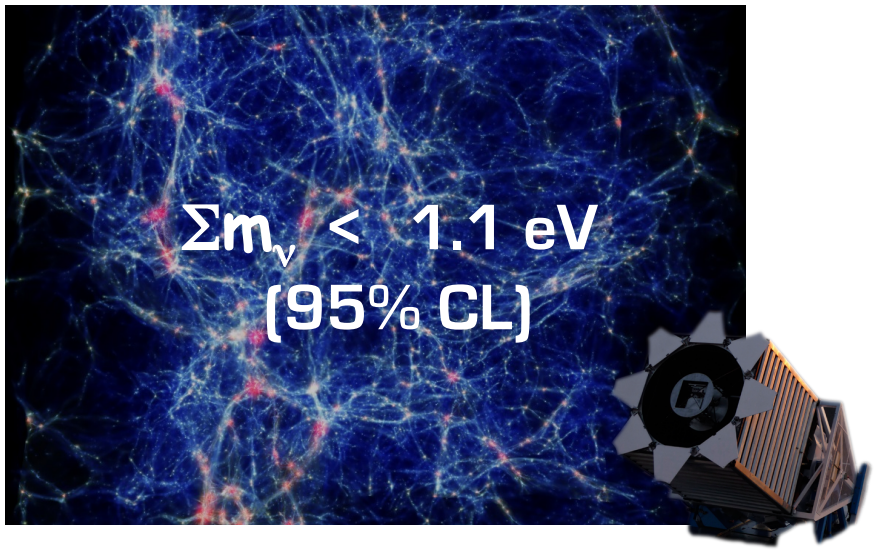
Latest results - Lyα & Mν (BOSS DR9)

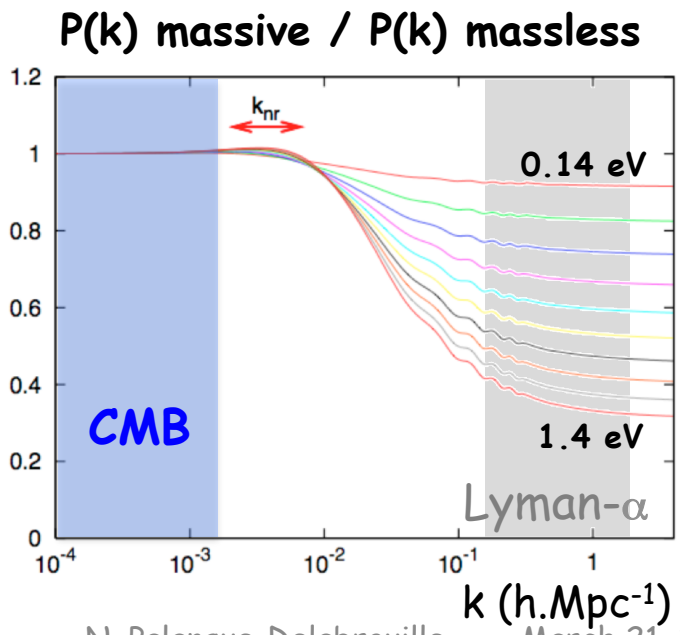


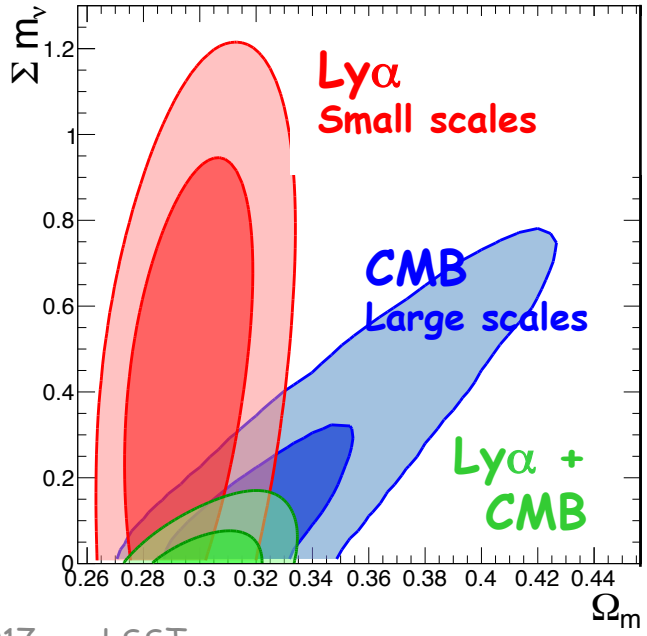


Latest results - Lyα & Mν (BOSS DR9)





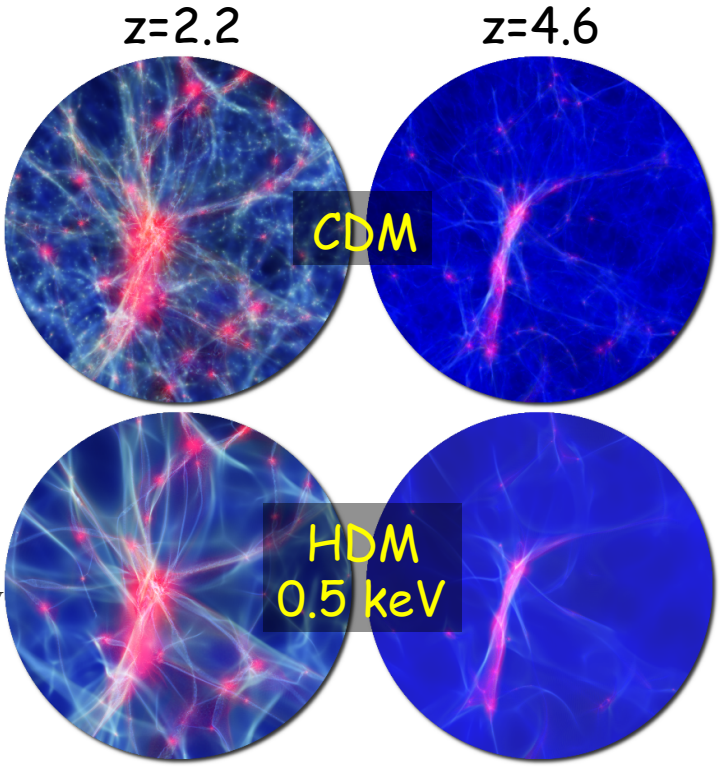


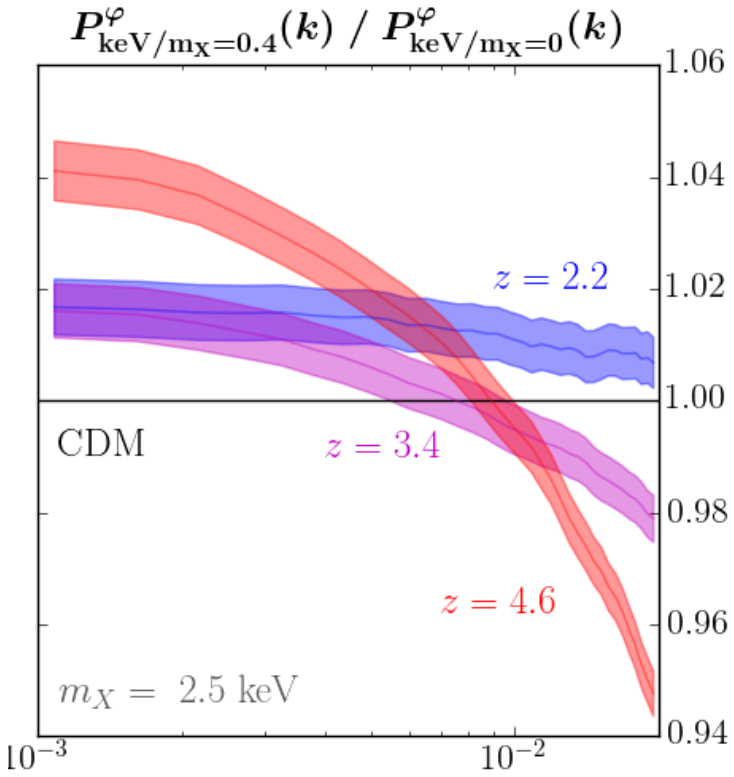


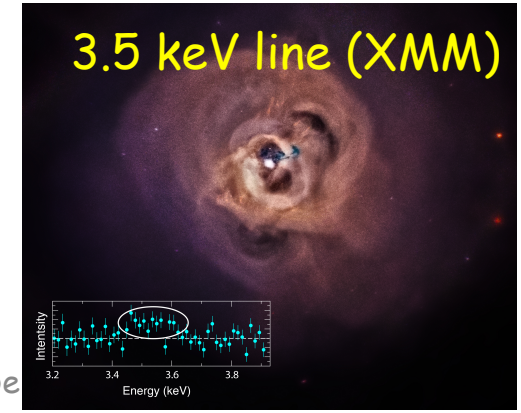
$\Sigma m_\nu < 0.12$ eV

PD+ JCAP 11 11 (2015)

Latest results - Lyα & ν_s (BOSS DR9)







Ly-α from SDSS/BOSS

$\Rightarrow m_{WDM} > 4.1$ keV (95% CL)

$m_{sterile} > 24.4$ keV (95% CL)

Baur+ JCAP 8 12 (2016)

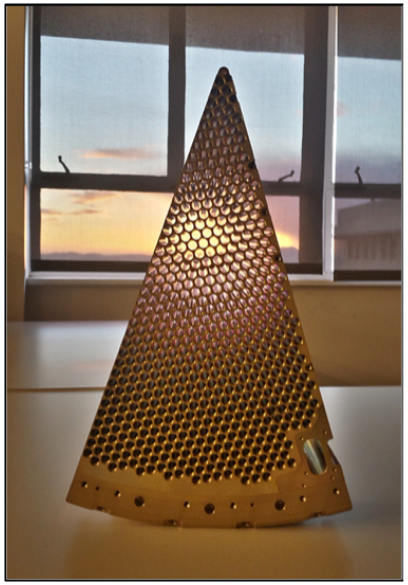
DESI (2019 - 2024)

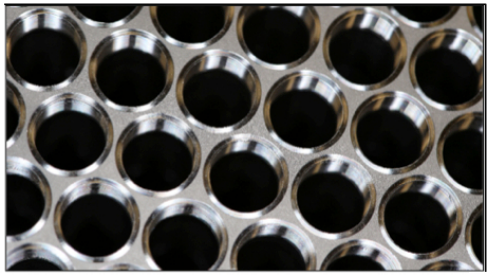
- 4m telescope (Arizona)
- 14 000 deg^2 survey
  20 million spectra
  $0 < z < 5$
- 5000 fibers (robot positioner)

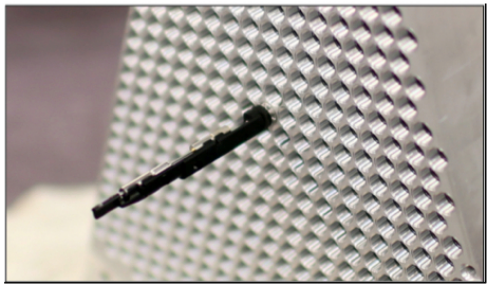
Courtesy of David Harvey, University of Arizona

DESI overview

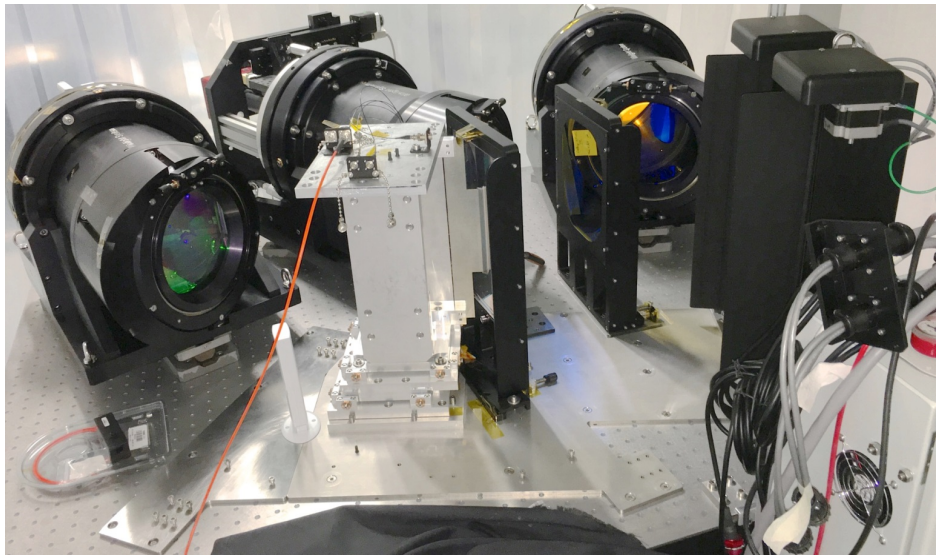
Petal (1/10 focal plane) and 1st fiber positioner

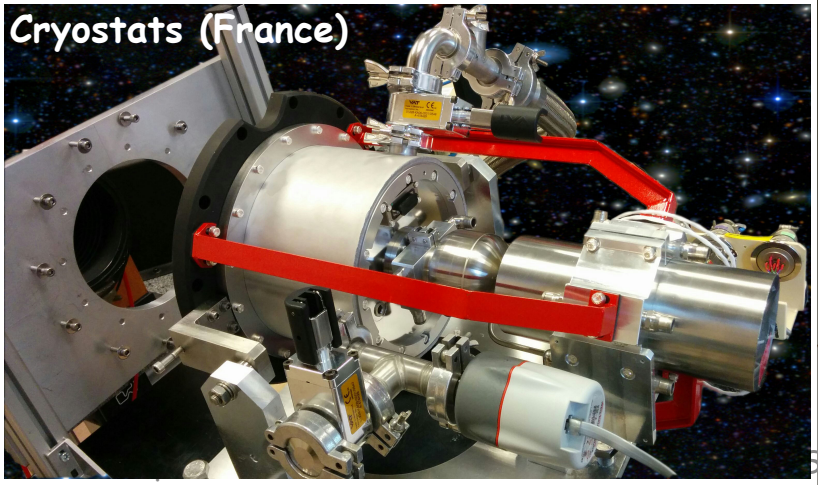


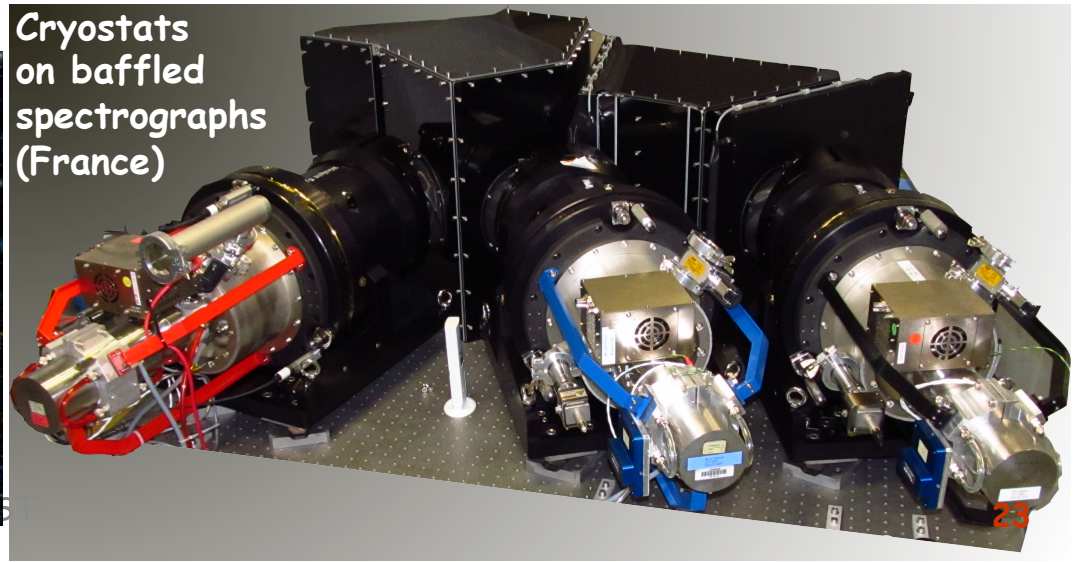




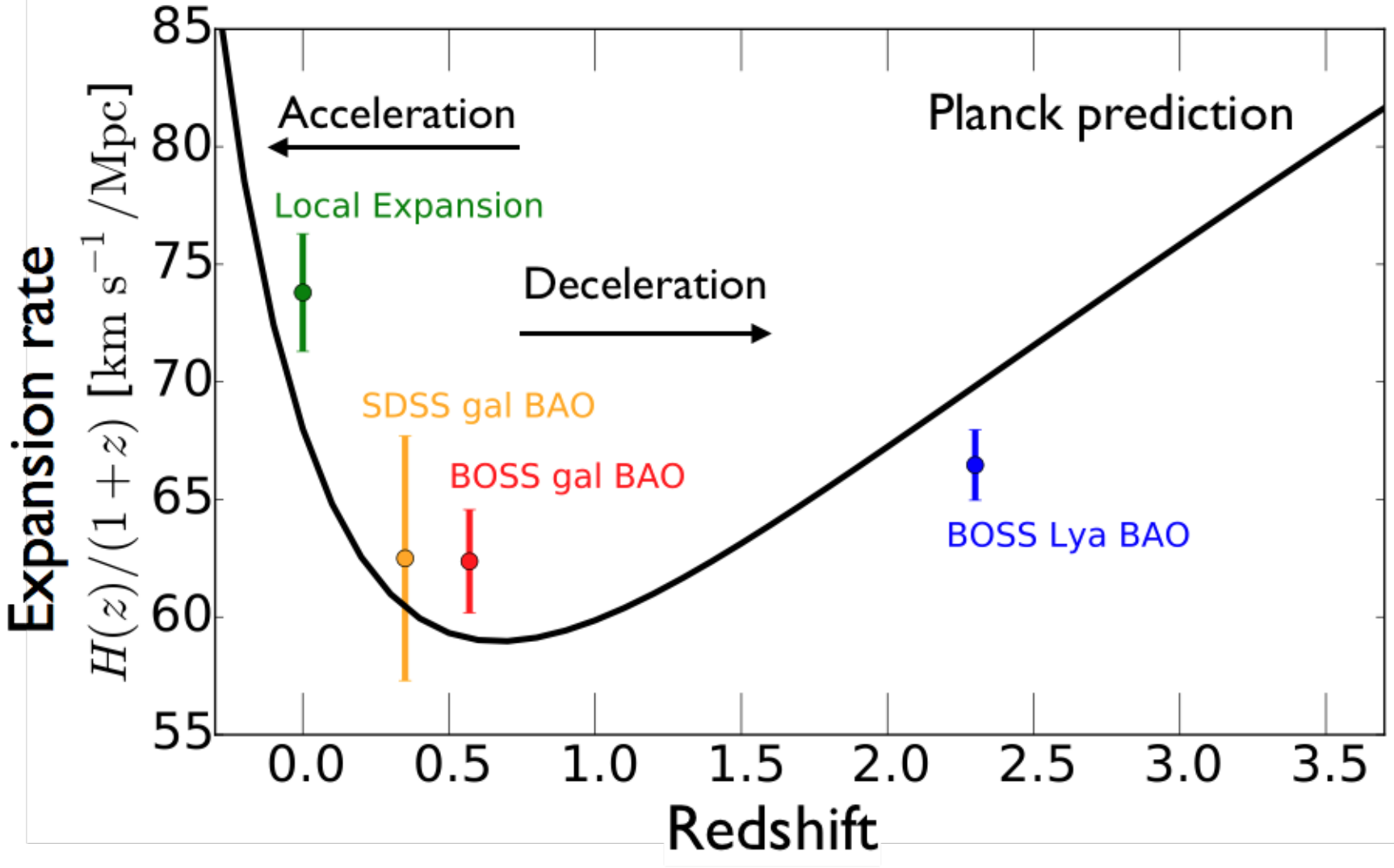
Spectrographs (France)



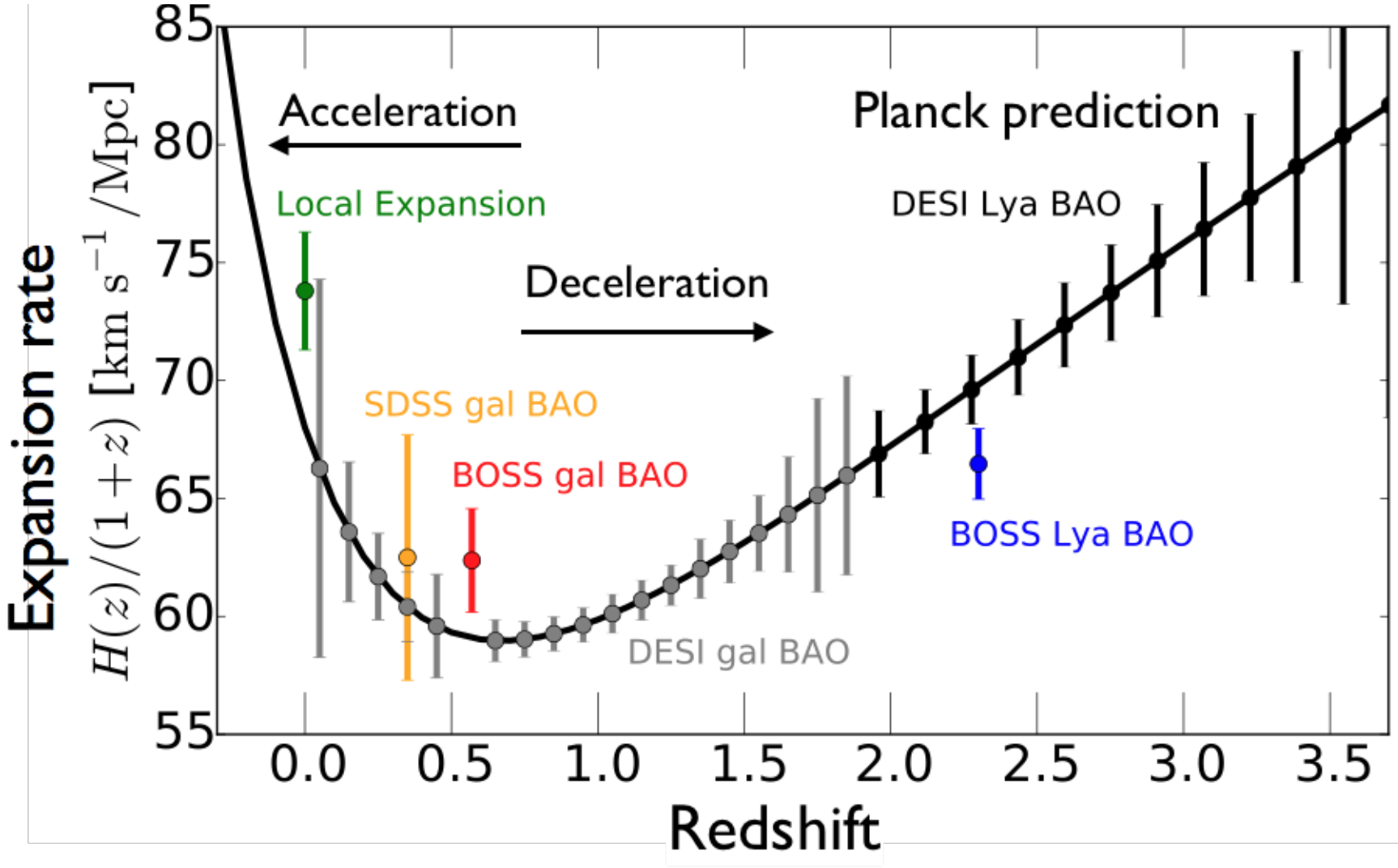




DESI overview (BAO)

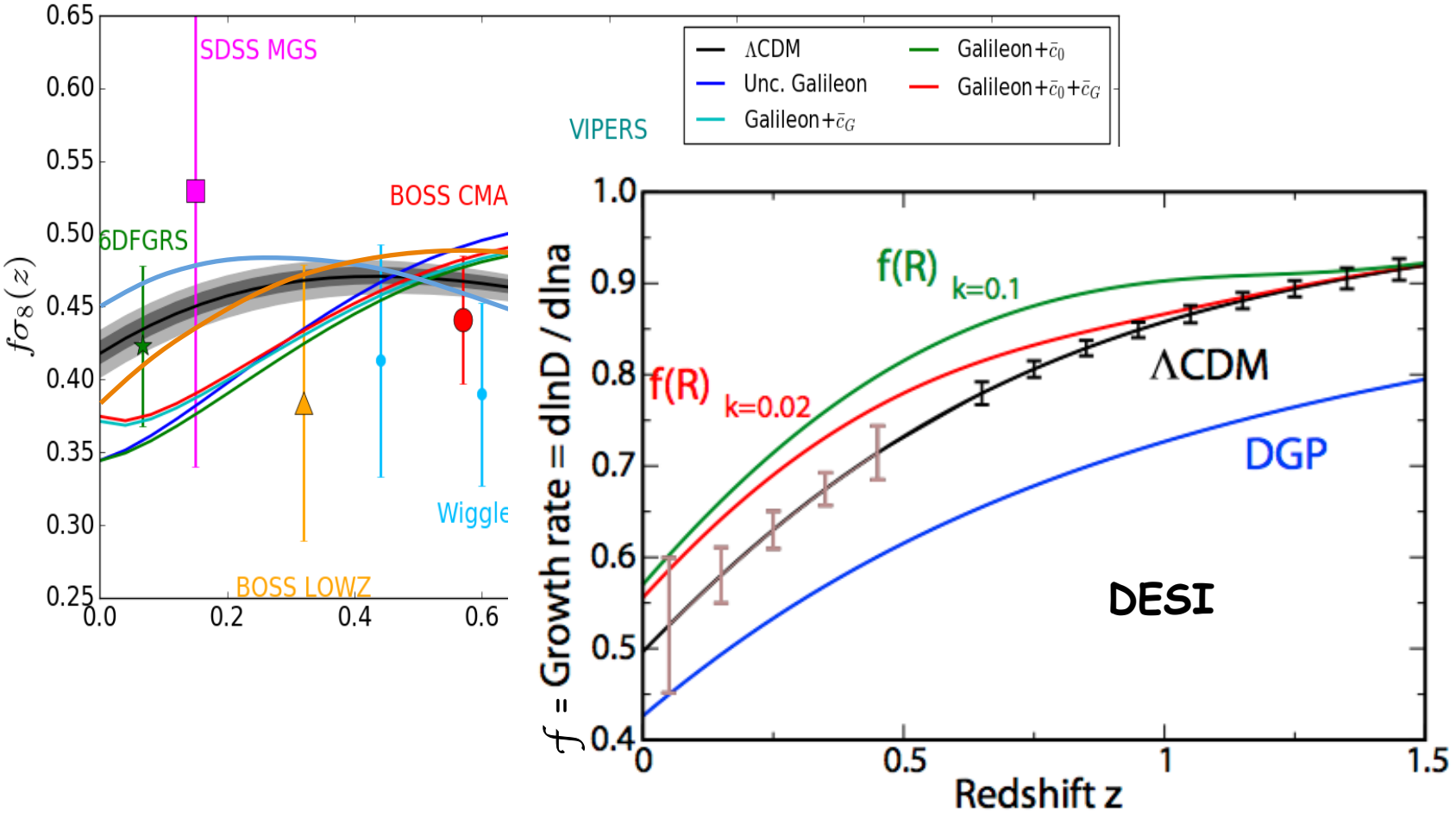


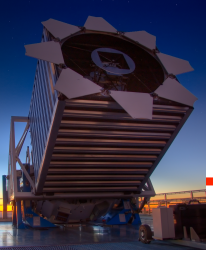
DESI overview (BAO)



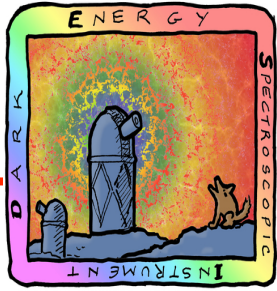
DESI projections Font-Ribera+ (2014)

DESI overview - RSD





Conclusions

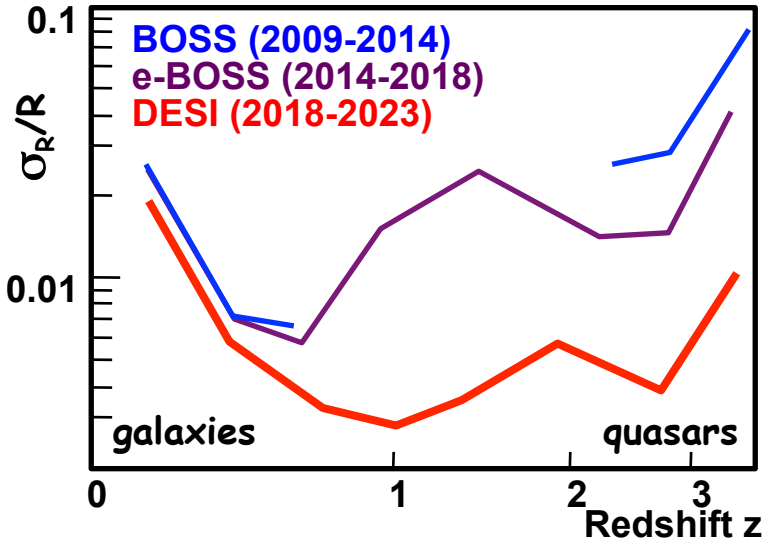


eBOSS well under way

- Percent-level constraints on H(z) & $d_A(z)$ up to z~3.5
- BAO data impose spatial flatness, independently of CMB
- Tight constraints from Lyα on
  - Neutrino masses Σm_ν < 0.12 eV (95% CL) from Lyα+CMB
  - Sterile neutrinos

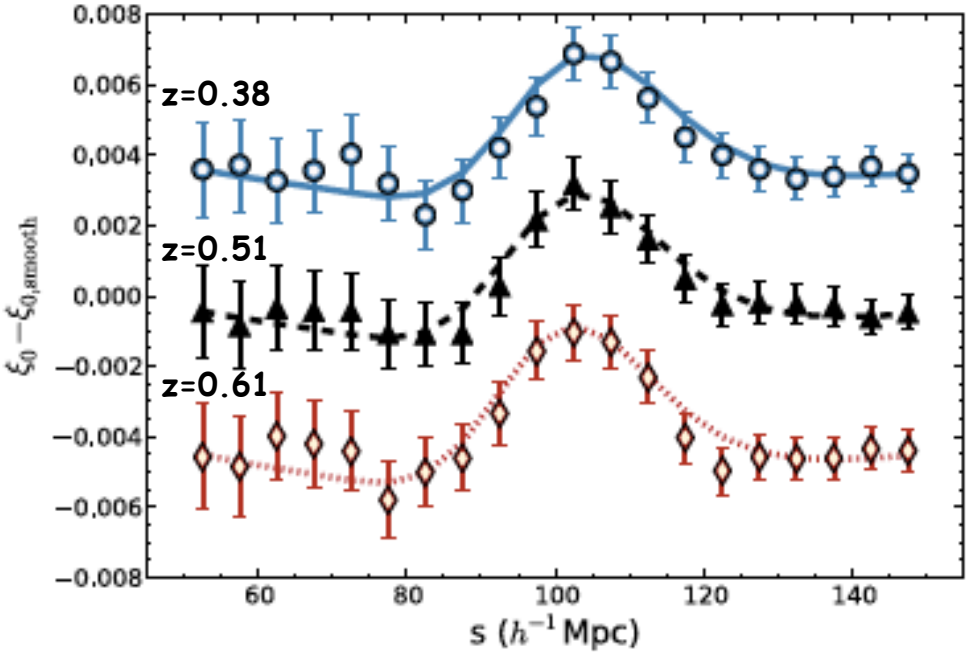
DESI coming up

- x2-10 improvement on BAO
- x5 improvement on Σm_ν
  24 meV from galaxy clustering

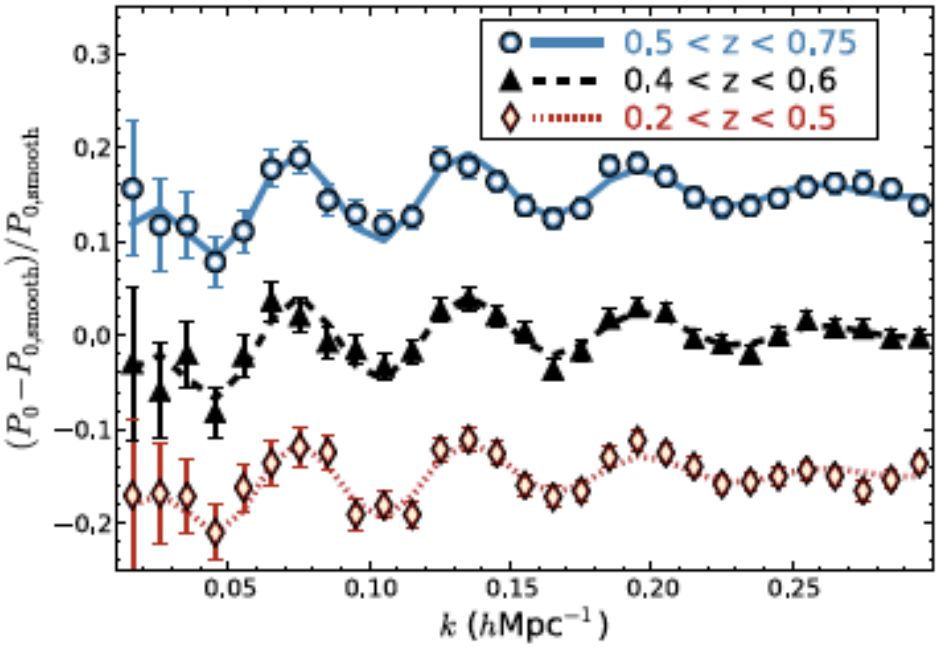


Latest results – BAO (BOSS DR12)

Not only in the correlation function



But also in the power spectrum



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