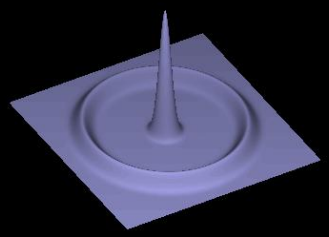
SDSS/eBOSS (2014-2019)

4MOST/Cosmology (2022-2027)

A. Raichoor (EPFL)

- **Main goals**
  - Universe expansion with BAO

BAO



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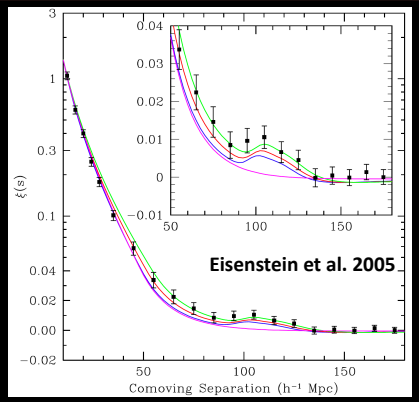
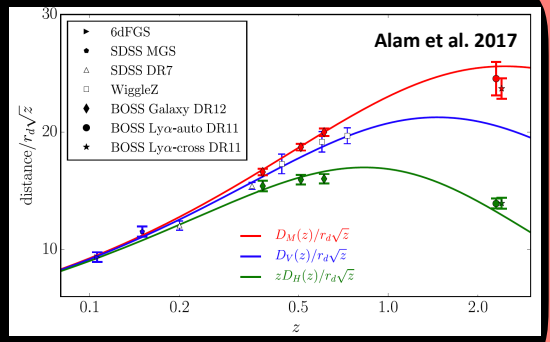
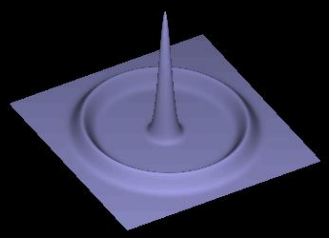




SDSS: Cosmology with LSS

- **Main goals**
  - Universe expansion with BAO
  - Growth of structures and Test of General Relativity with RSD

BAO



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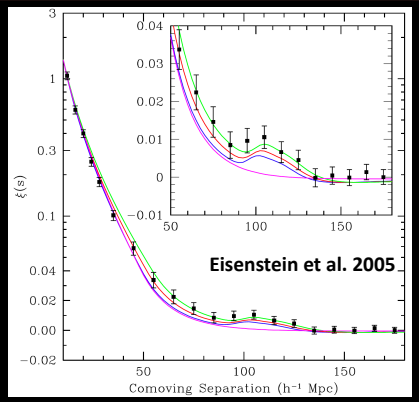
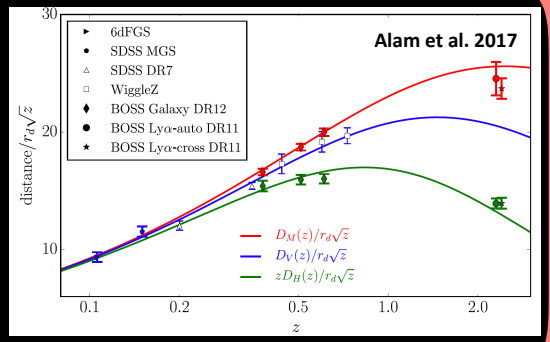
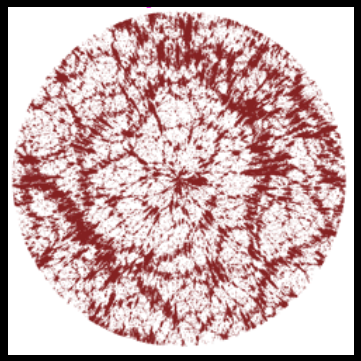
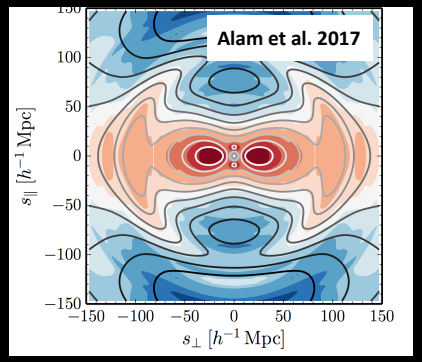
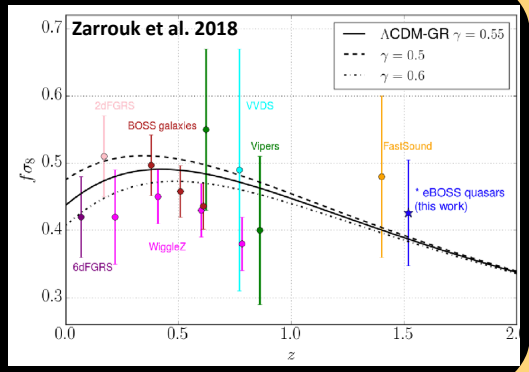




RSD

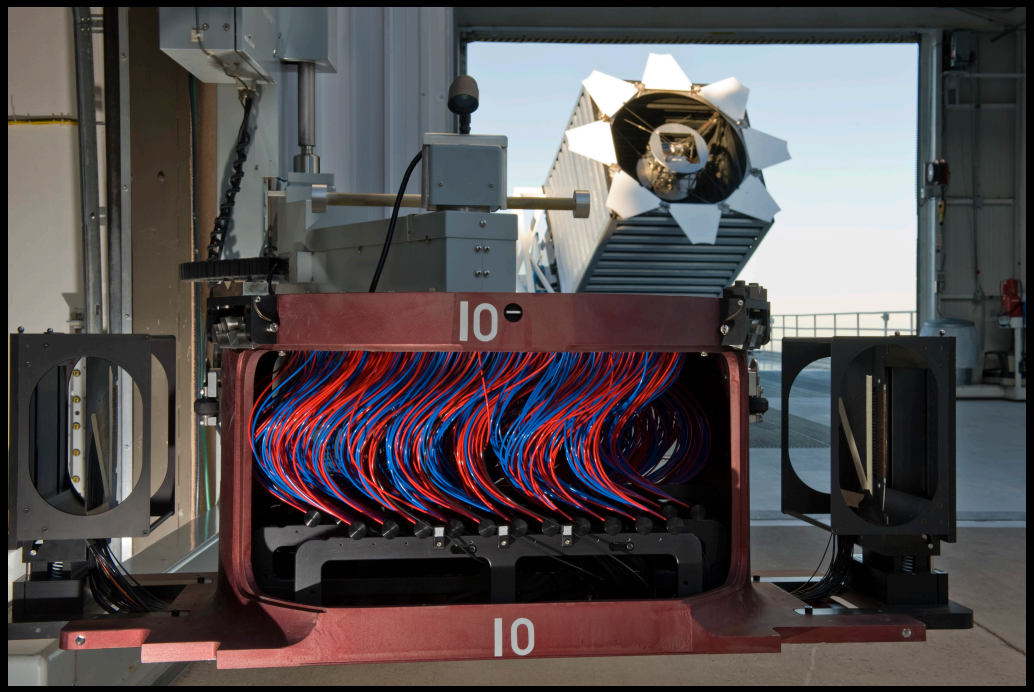






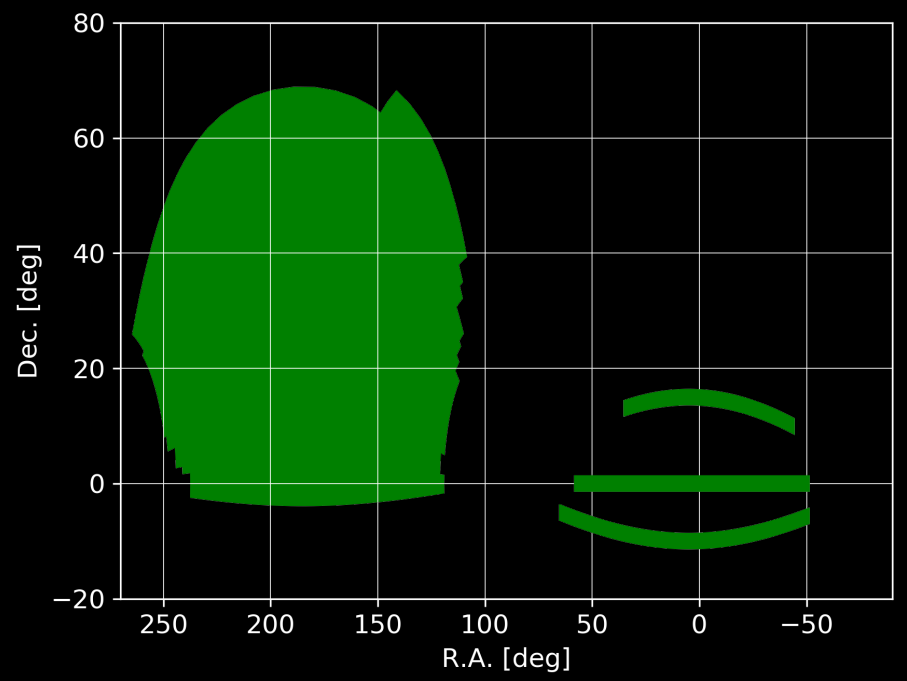
SDSS: telescope

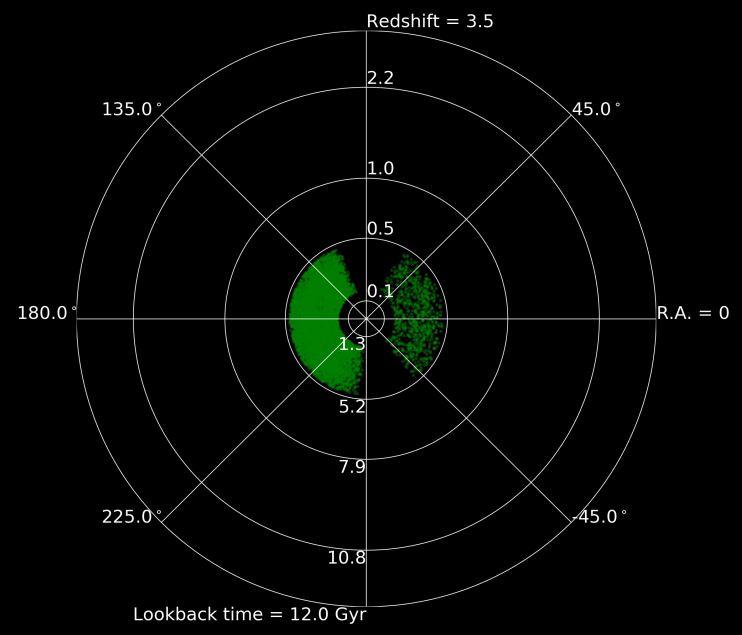
- **SDSS telescope**
  - 2.5-metres, field-of-view of 7 deg^2
  - SDSS spectrograph (2000-2008): 640 fibres
  - BOSS spectrograph (2008-): 1000 fibres



SDSS: LSS surveys

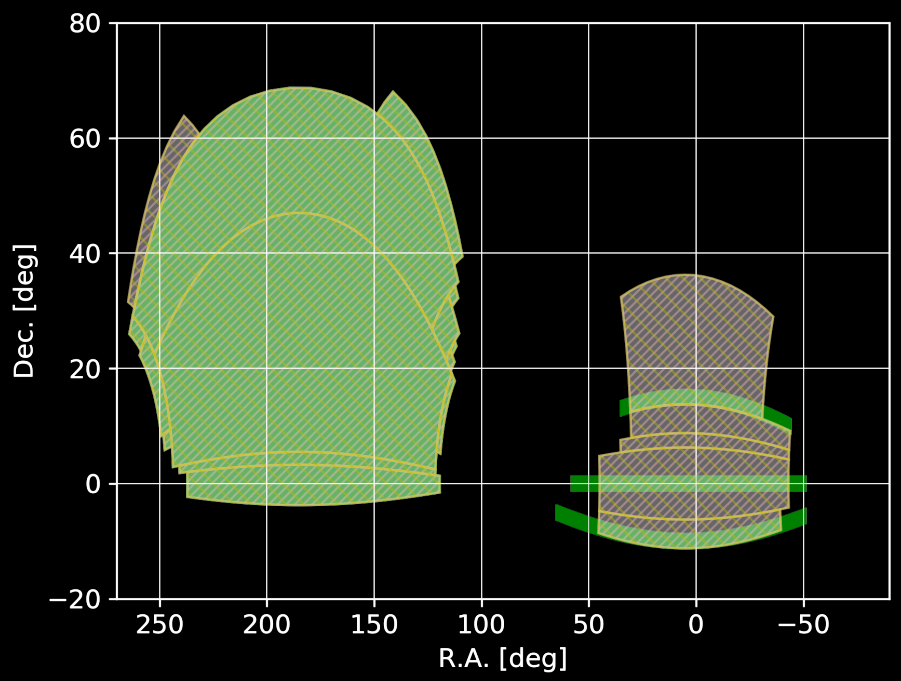
- **SDSS-LRG sample (2000-2008)**
  - 100k LRG at z~0.35
  - 2005: co-first BAO measurement with 45k LRG (5% precision), along with 2dF

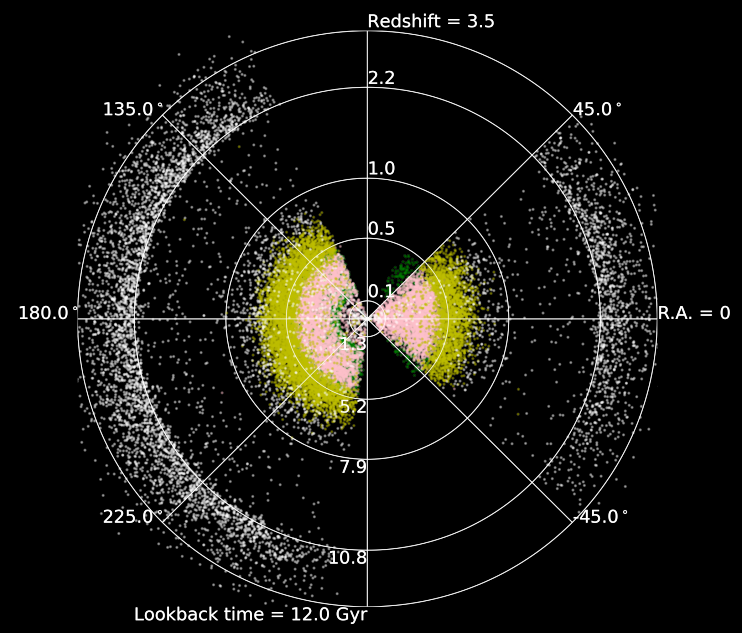




SDSS: LSS surveys

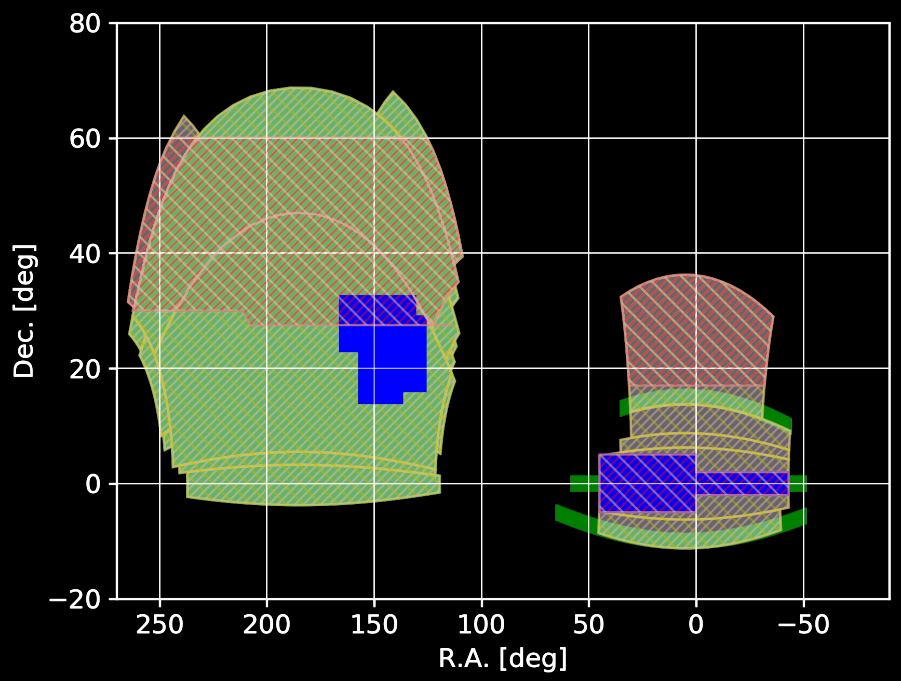
- **SDSS-BOSS sample (2008-2014)**
  - massive observation of LRG + new tracer (Lyα)
  - 1.5M spectra over 10k deg^2
  - two tracers: 1.2M LRG at z~0.3,0.6 and 0.2M Lyα at z~2.3
  - BAO: 1-2% precision on distance measurement
  - RSD: 8% precision on $f \cdot \sigma_8$ measurement

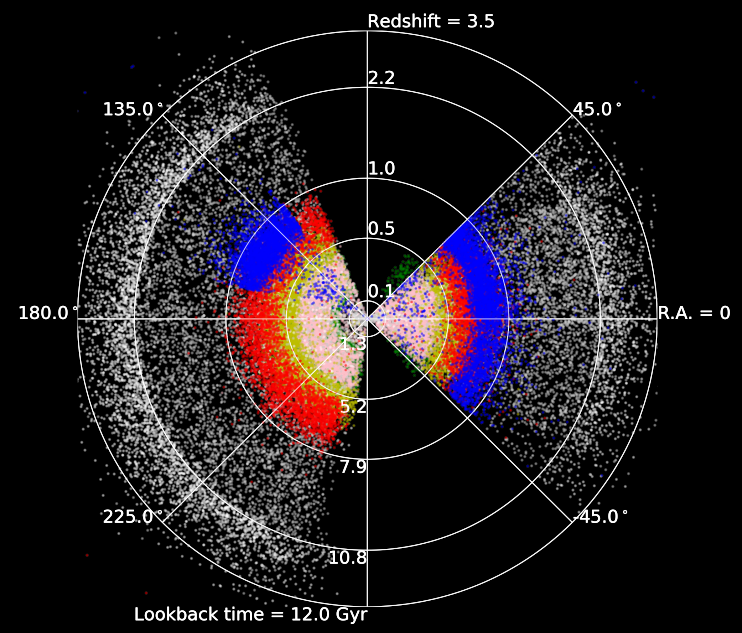




SDSS: LSS surveys

- **SDSS-eBOSS sample (2014-2019)**
  - extension of BOSS to 0.6<z<2.1 + new tracer (ELG)
  - 1M spectra over 8k deg^2
  - three tracers: LRG (0.6<z<1.0), ELG (0.6<z<1.1), QSO+Lyα (z>0.9)
  - Results with **partial** sample (DR14):
    - BAO: 3%-4% precision on distance measurement (LRG, QSO)
    - RSD: 18% precision on $f \cdot \sigma_8$ measurement (QSO)

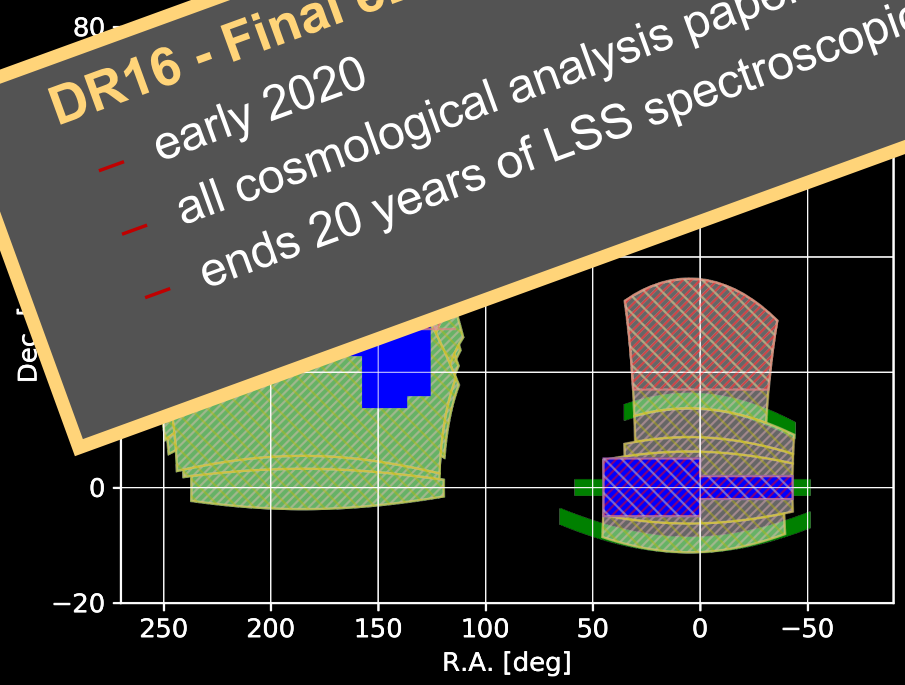


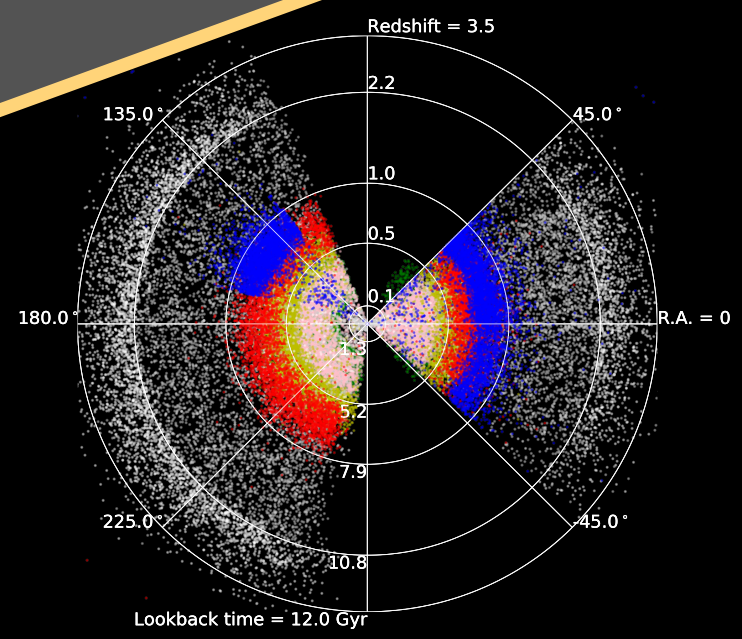


SDSS: LSS surveys

- **SDSS-eBOSS sample (2014-2019)**
  - extension of BOSS to 0.6<z<2.1 + new tracer (ELG)
  - 1M spectra over 8k deg^2
  - three tracers: LRG (0.6<z<1.0), ELG (0.6<z<1.1)
  - Results with **partial** sample (DR14):
    - BAO: 3%-4% precision on
    - RSD: 18% precision

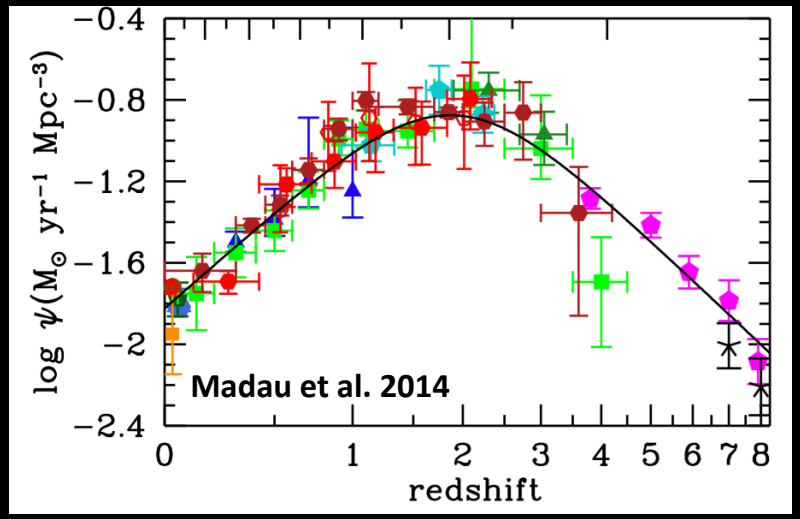
- **DR16 - Final eBOSS release**
  - early 2020
  - all cosmological analysis papers and catalogues to be released then
  - ends 20 years of LSS spectroscopic observations at SDSS

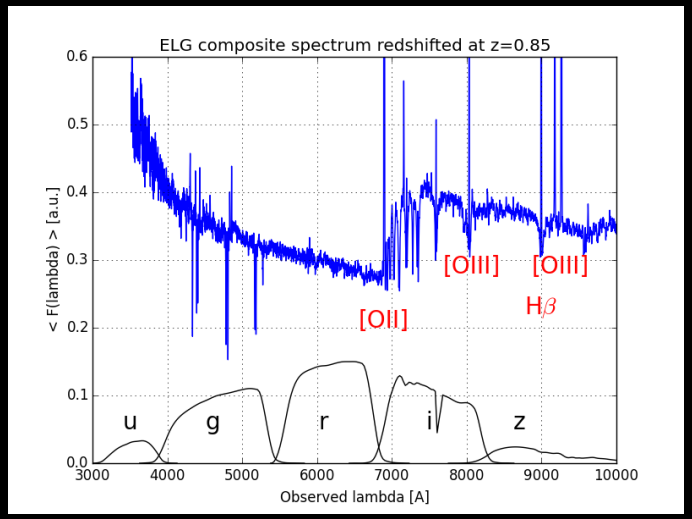




- **Why ELGs (Emission Line Galaxies)?**
  - abundant at redshift ~1-2
  - emission lines ([O_{II}] 3727 A) permits quick z_{spec} measurement
  - key for future BAO surveys (DESI, *Euclid*, PFS)

- **How to select ELGs at z~0.9?**
  - star-forming → « blue » cut in g-r
  - Balmer break → « red » cut in r-z
  - [O_{II}] flux correlates with g-mag → « bright » cut in g-mag

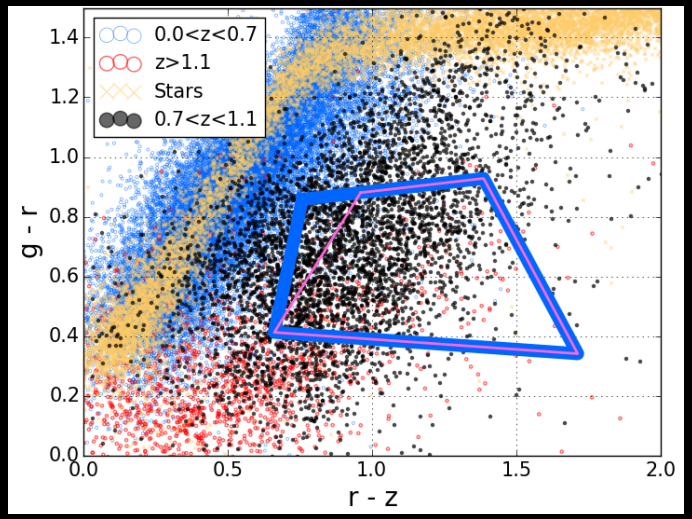


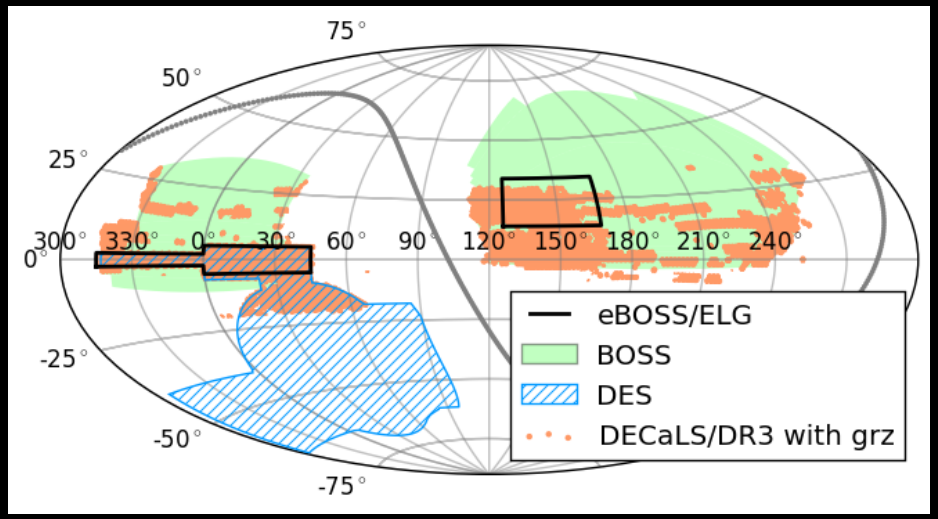


eBOSS/ELG: Target Selection

- **Cuts**
  - 21.8 < g < 22.8 + grz-box
  - 270k targets over 2 x 600 deg^2 regions
  - density ~230 deg^{-2}

- **DECaLS imaging**
  - TS done in Spring-Fall 2016: DECaLS/DR3 (preliminary DESI imaging)
  - already ~2mag deeper than SDSS imaging

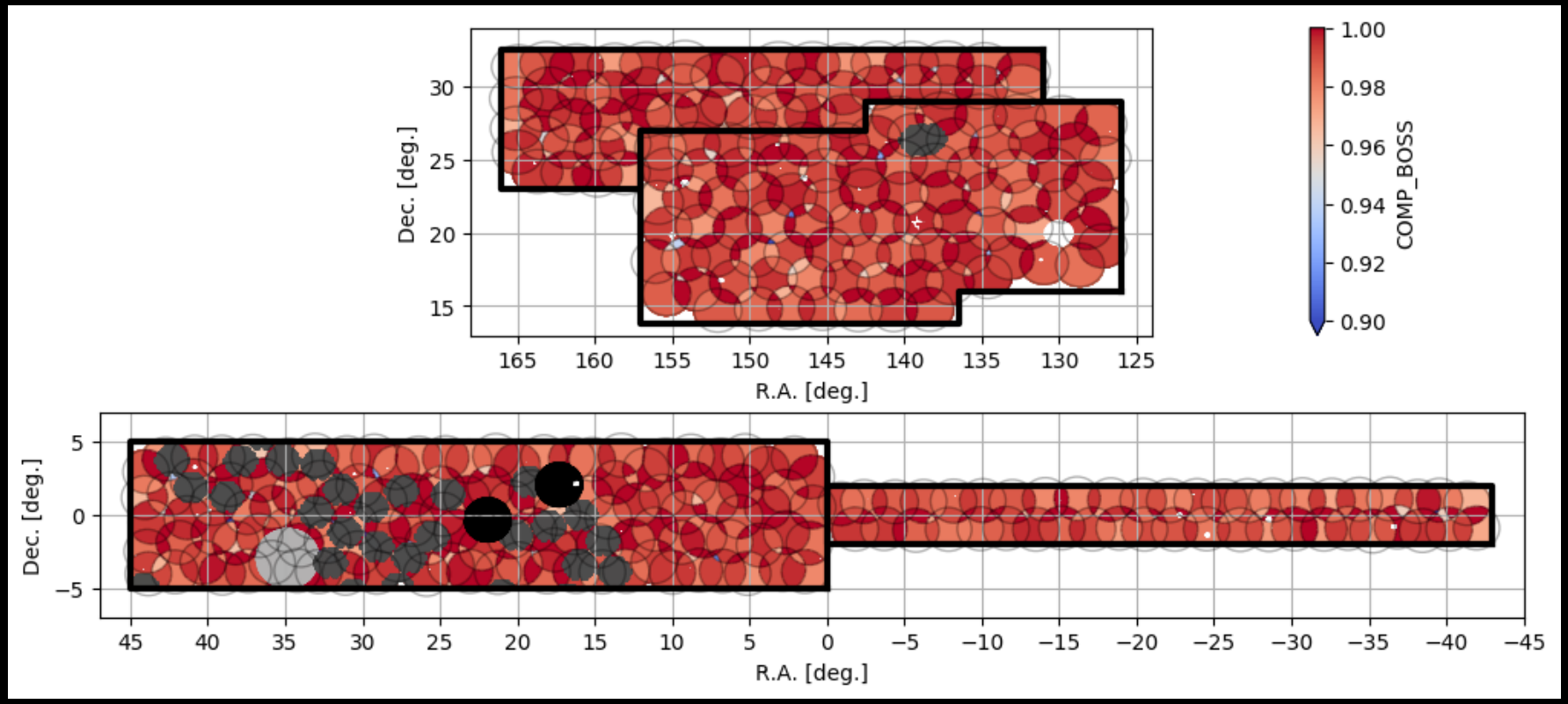




Raichoor et al. 2017

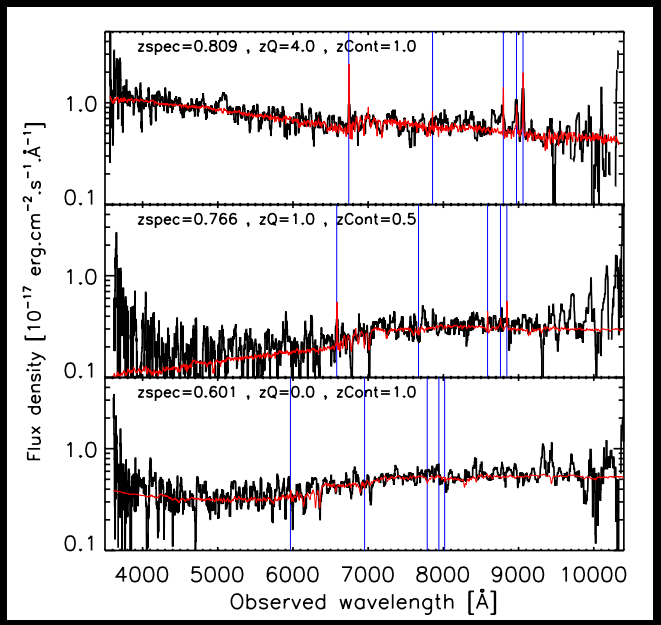
eBOSS/ELG: observations

- **255k spectra**
  - 2016, Sep. to 2018, Mar.
  - 305 plates, ~850 ELGs per plate
  - typically 45min-1h exposure time for NGC/SGC

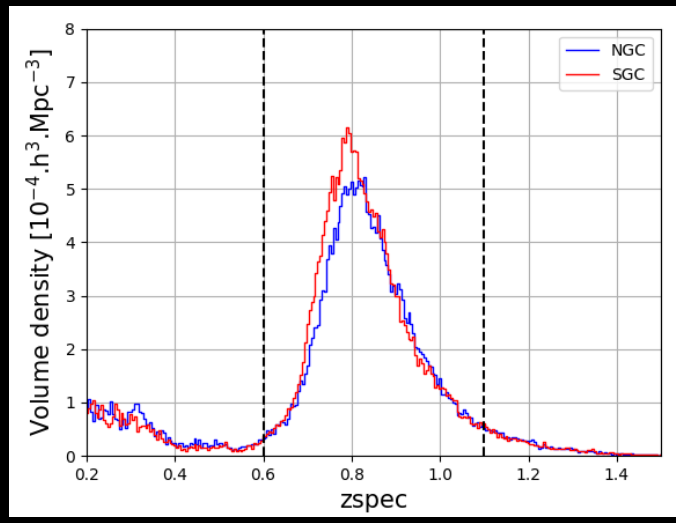


eBOSS/ELG: z_{spec} measurement

- **ELG spectra**
  - low SN, [O_{II}] doublet not resolved (resolution~1600)
  - use DESI redshift fitter, not anymore BOSS redshift fitter
  - catastrophic redshifts quantified with visual inspections + duplicate observations



	idlspec1d (BOSS)	redrock (DESI)
reliable zspec	83.0 %	89.6 %
reliable 0.6<zspec<1.1	74.0 %	79.9 %
catastrophic 0.6<zspec<1.1	0.5 %	0.4 %

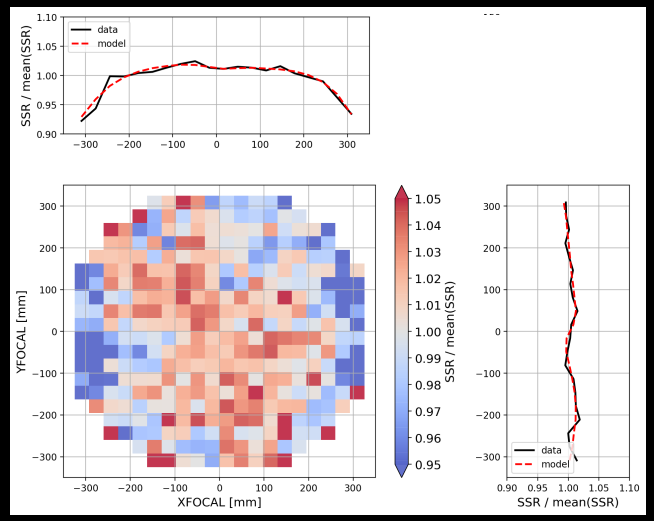


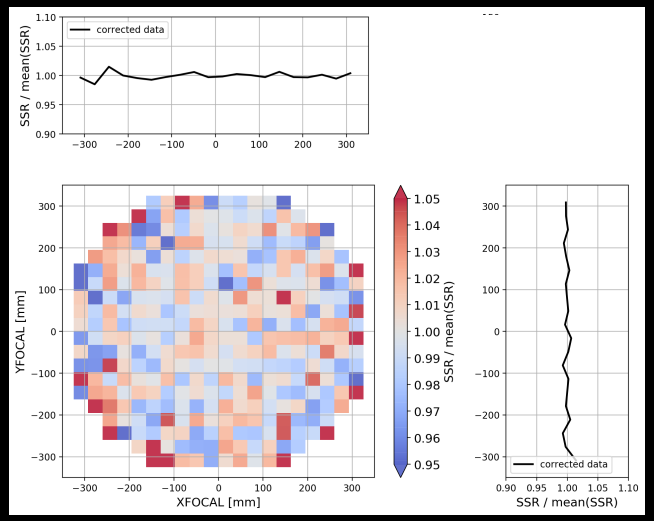
Raichoor et al. 2017

eBOSS/ELG: LSS catalogues

- **LSS catalogues**
  - weights to correct for:
    - redshift failures (~10%)
    - close pairs
    - tiling completeness
    - imaging systematics
  - n(z) dependence on imaging depth included in the randoms

- **LSS analysis**
  - radial integral constrain
  - nulling angular modes to remove unknown remaining systematics

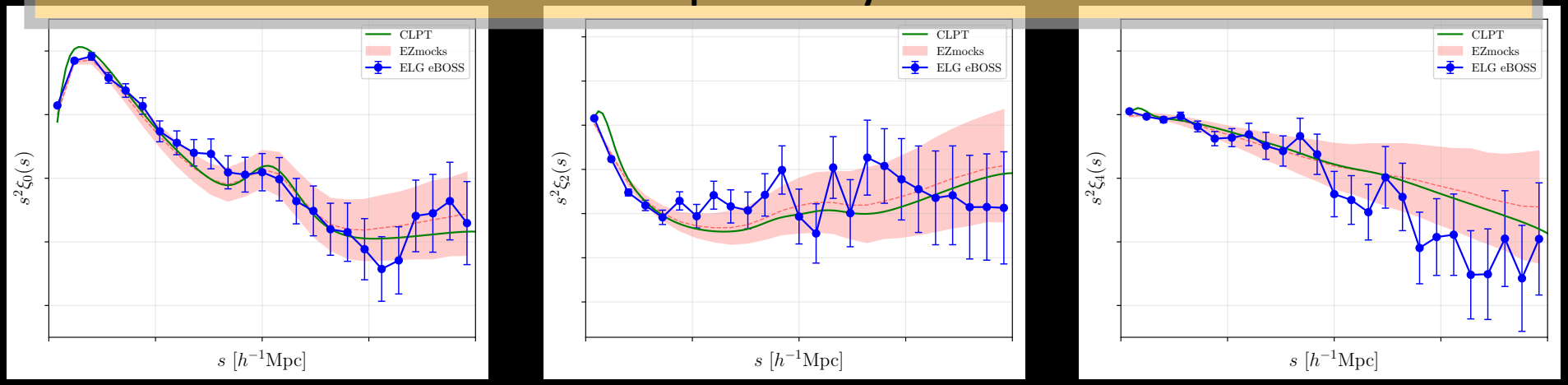




eBOSS/ELG: BAO and RSD results

- **RSD: analysis validated on mocks**
- **Data, mocks, and model in agreement**
- **Results coming soon**
  - LSS catalogues + isotropic BAO (Raichoor et al.)
  - RSD in configuration space (Tamone et al.)
  - RSD in Fourier space (de Mattia et al.)
  - BAO precision ~3%
  - $f \cdot \sigma_8$ precision ~20% , $(\alpha_{\parallel}, \alpha_{\perp})$ precision ~6%

preliminary

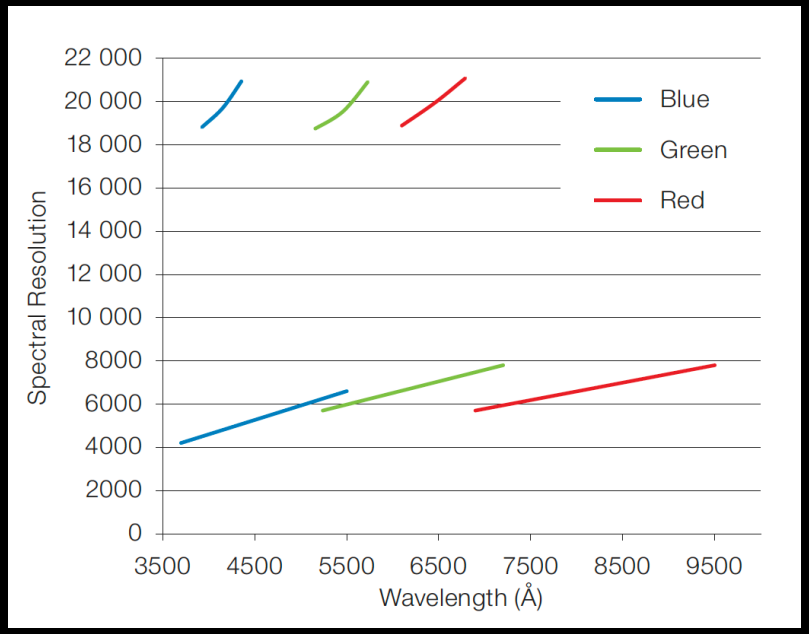


Credits: A. Tamone

4MOST: overview

- **Instrument**
  - ESO, 4m VISTA telescope at Paranal
  - large field of view (4.2 deg^2)
  - 2436 fibres (1 R~20,000 spectrograph ; 2 R~6500 spectrographs)

- **Consortium survey (2022-2027)**
  - 70% of observation time during the first 5 years of operation
  - broad range of science



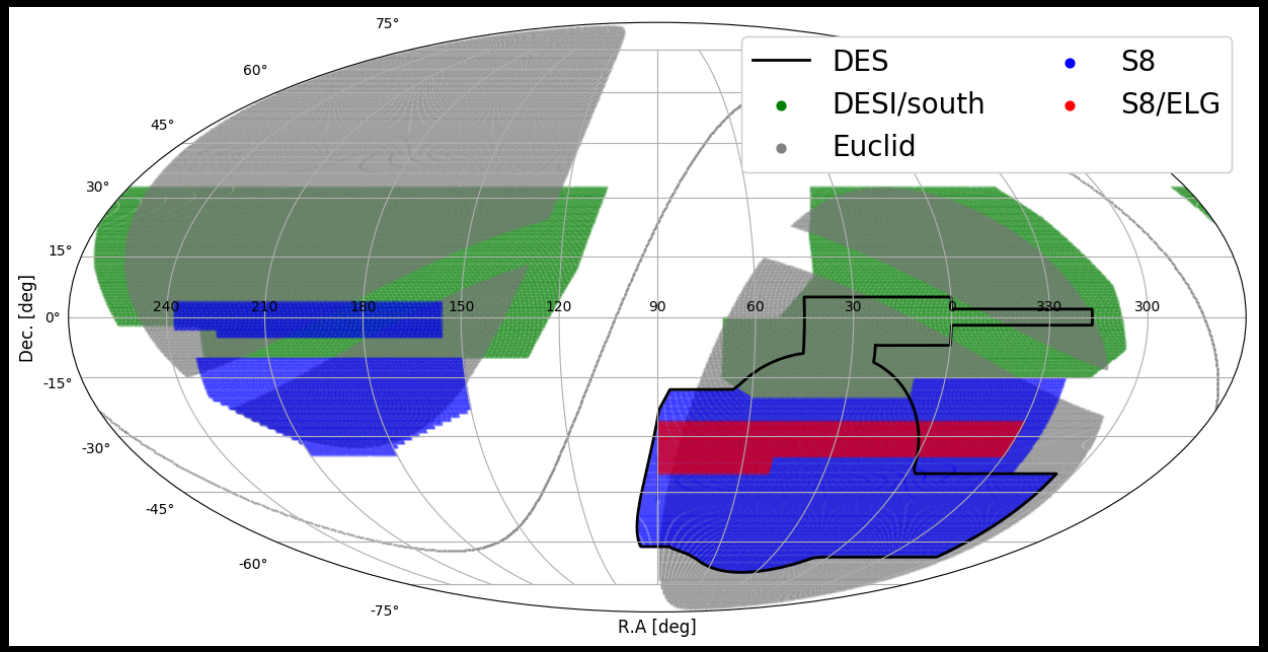
No	Survey Name
S1	Milky Way Halo LR Survey
S2	Milky Way Halo HR Survey
S3	Milky Way Disc and Bulge LR Survey (4MIDABLE LR)
S4	Milky Way Disc and Bulge HR Survey (4MIDABLE HR)
S5	Galaxy Clusters Survey
S6	AGN Survey
S7	Galaxy Evolution Survey (WAVES)
S8	Cosmology Redshift Survey
S9	Magellanic Clouds Survey (1001MC)
S10	Time-Domain Extragalactic Survey (TiDES)

de Jong et al. 2019

4MOST/S8: overview

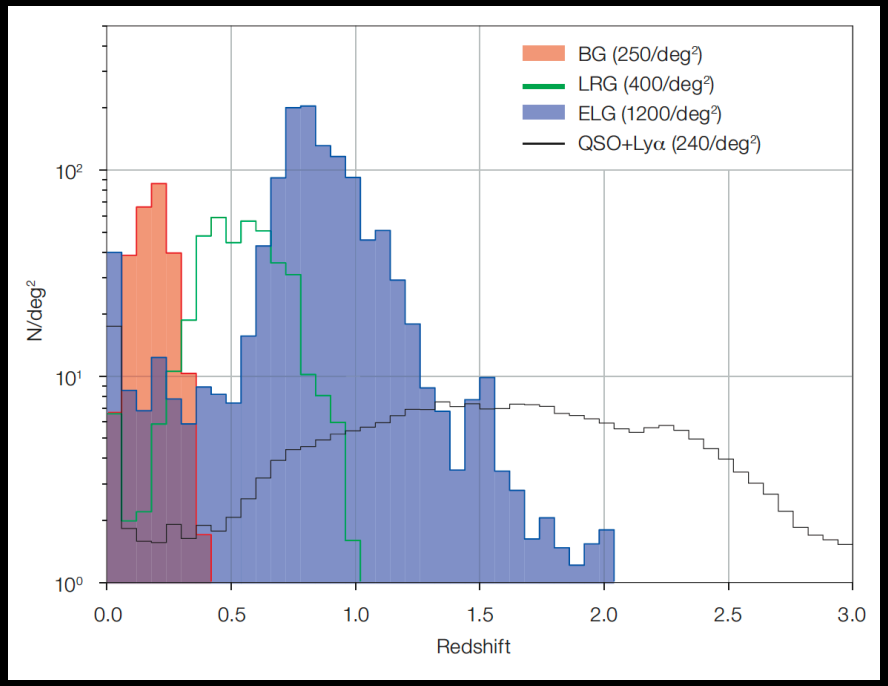
- **Science goals**
  - tests of gravitational physics (weak-lensing, RSD)
  - source redshift distributions via cross-correlation
  - synergies with CMB Stage 4 experiments
  - BAO

- **Survey properties**
  - 8 million spectra
  - 7500 deg^2
  - reference spectroscopic survey for the Southern Hemisphere (DES, KiDS, *Euclid*, LSST)



4MOST/S8: targets

Name	z	Selected (AB) magnitude range	R-band (magnitude [AB])	Sky area (deg^2)	Density (deg^2)	Colour selection	Redshift completeness	Number of targets (10^6)
BG	0.15–0.4	$16 < J < 18$	20.2 ± 0.4	7500	250	J–Ks, J–$W1$	95%	1.88
LRG	0.4–0.7	$18.0 < J < 19.5$	21.8 ± 0.7	7500	400	J–Ks, J–$W1$	75%	3.00
ELG	0.6–1.1	$21.0 < g < 23.2$	23.9 ± 0.3	1000	1200	g–r, r–i	80%	1.20
QSO	0.9–2.2	$g < 22.5$	22.2 ± 0.7	7500	190	g–i,i–$W1$,$W1$–$W2$	65%	1.43
QSO-Lyα	2.2–3.5	$r < 22.7$	22.2 ± 0.7	7500	50	g–i,i–$W1$,$W1$–$W2$	90%	0.38



Richard et al. 2019

4MOST: Community Programmes

- **Community Programmes:**
  - 30% of observing time during the first 5 years of operation
  - two types of Survey programmes (participating, non-participating)
  - 2020, Jan.: call for Letters of Intent
  - 2020 Q2: call for Proposal
  - http://www.eso.org/sci/meetings/2019/4MOST2019/VIDEO/Mainieri_Tuesday1.mp4

- **Great opportunity for the Cosmology Community! for instance:**
  - complete the S8/ELG survey over DES
  - EMU radio sources follow-up
  - DES gravitational lenses follow-up