The Dark Energy Spectroscopic Instrument (DESI)

Benedict Bahr-Kalus, Korea Astronomy and Space Science Institute (KASI)
On behalf of the DESI Collaboration

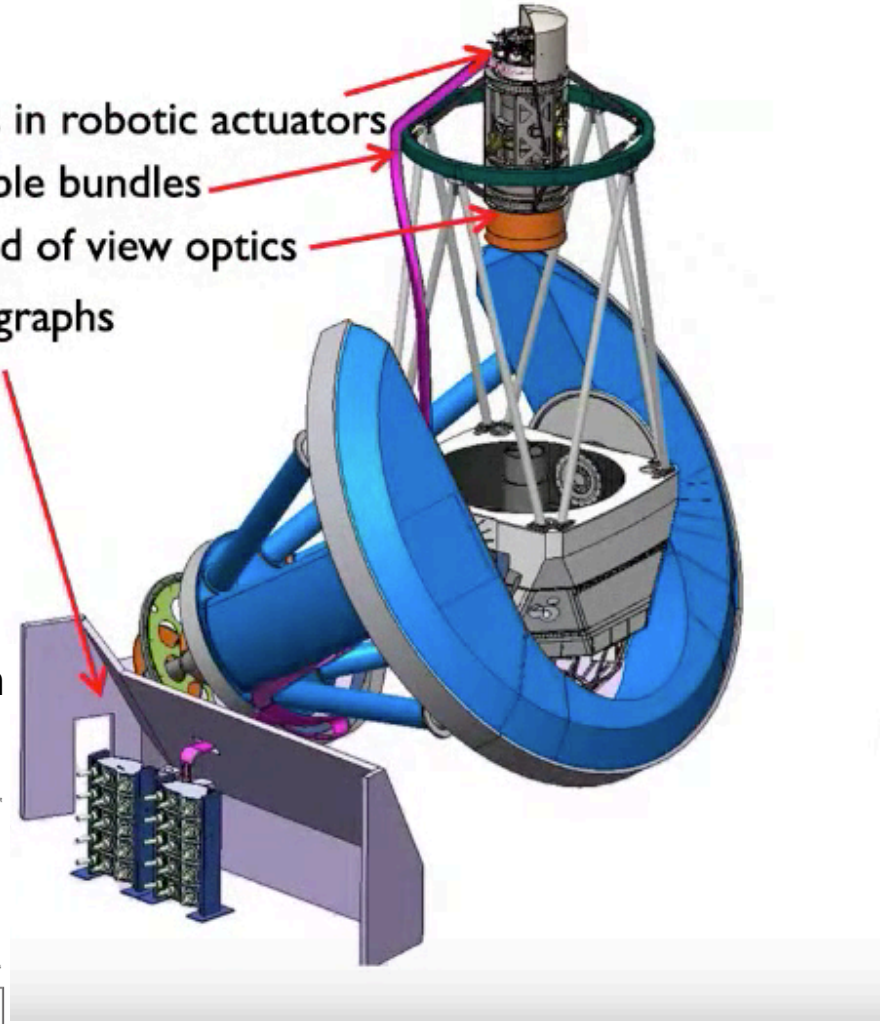
Survey Science Group Workshop 2023
High1 Resort, Korea

DARK ENERGY SPECTROSCOPIC INSTRUMENT

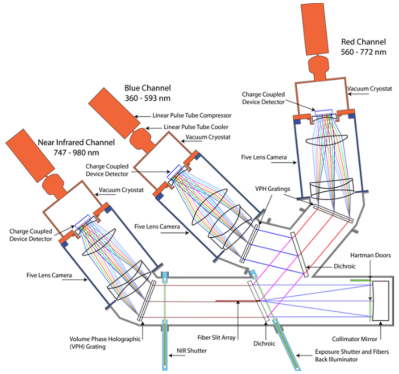
U.S. Departmer

The Dark Energy Spectroscopic Instrument

- 5000 fibers in robotic actuators
- 10 fiber cable bundles
- 3.2 deg. field of view optics
- 10 spectrographs



3 cameras/spectrograph



Credit: Claire Lamman

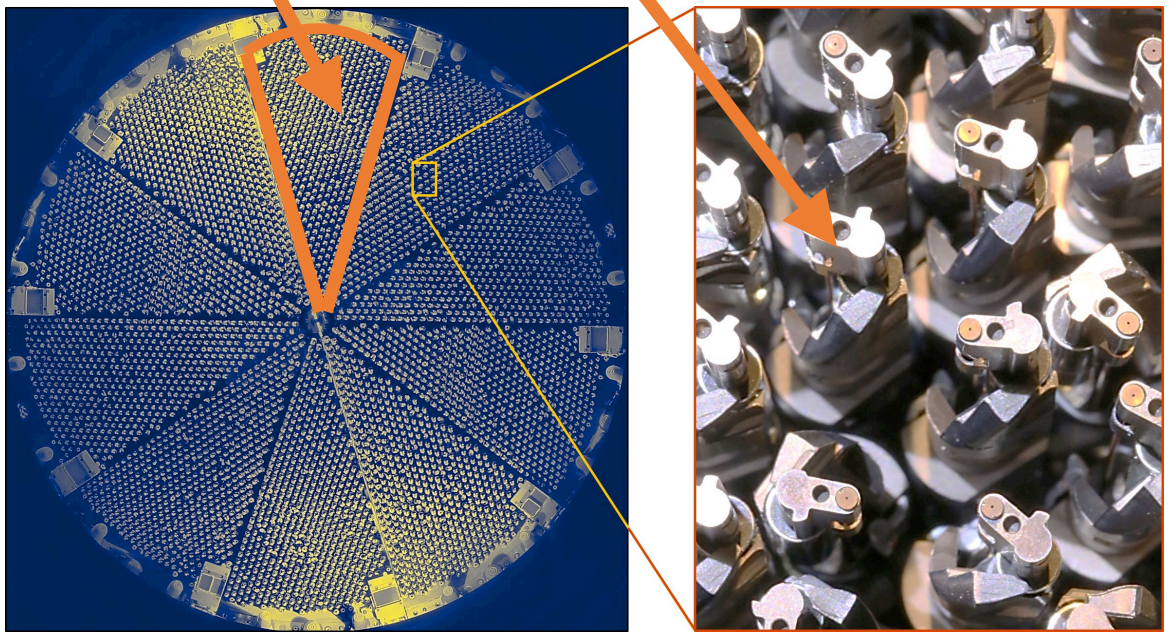
- 5000k fibers
- 10 spectrographs
- 38 times full moon area of the sky
- Order of magnitude larger than (e)BOSS

DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science

The Dark Energy Spectroscopic Instrument

10 petals, 500 positioners each



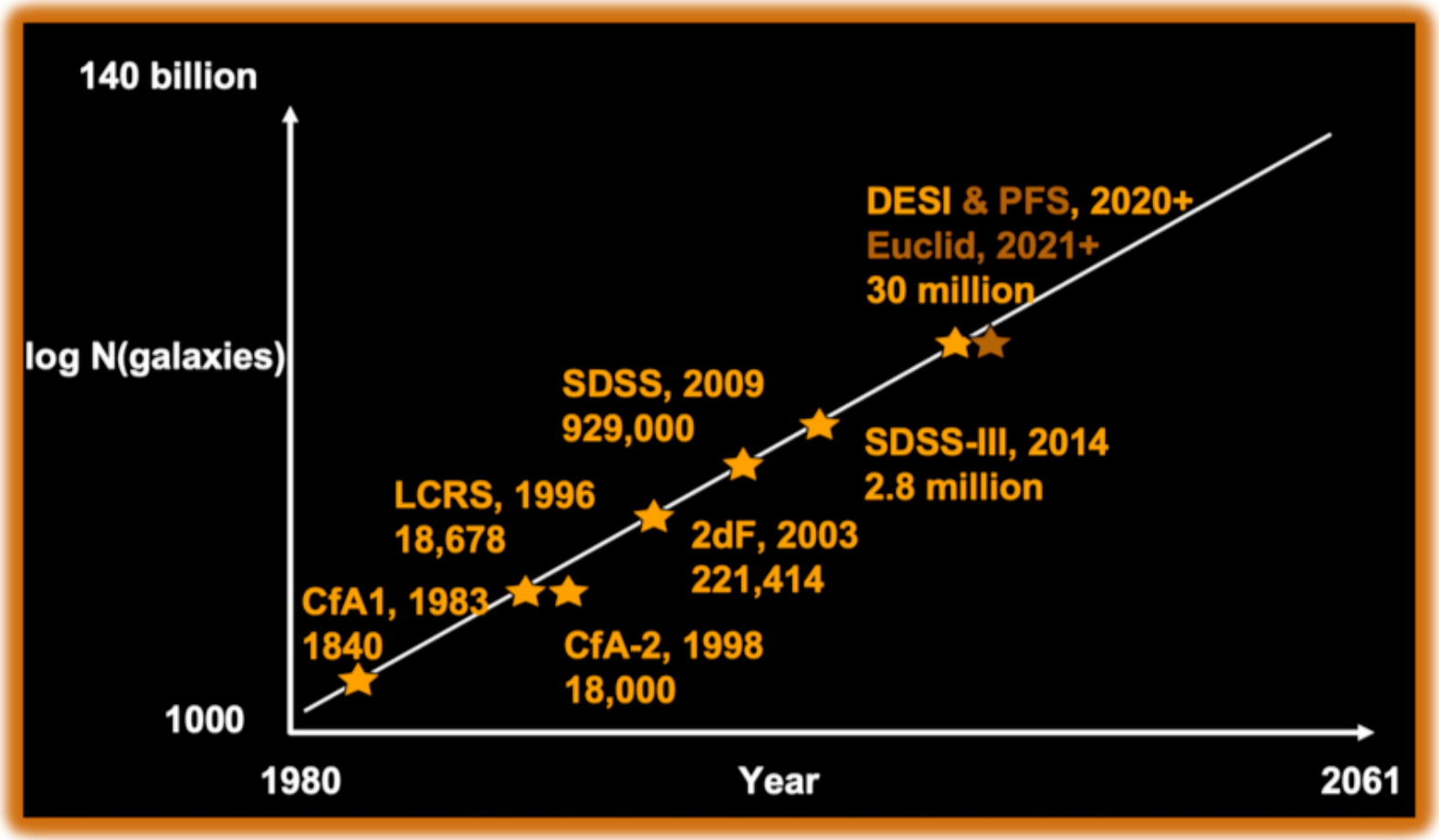
Located at the Mayall 4-meter telescope
Kit Peak Arizona (US)

DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science

3D Galaxy Maps

Number of galaxies observed by spectroscopic redshift surveys



DARK ENERGY SPECTROSCOPIC INSTRUMENT

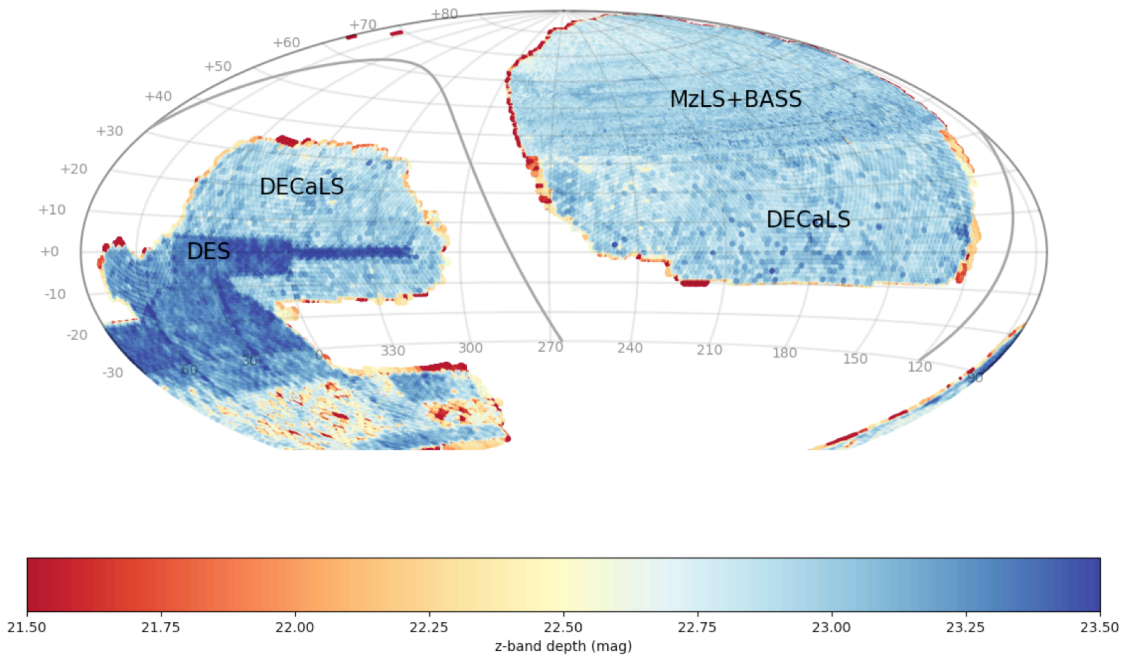
U.S. Department of Energy Office of Science

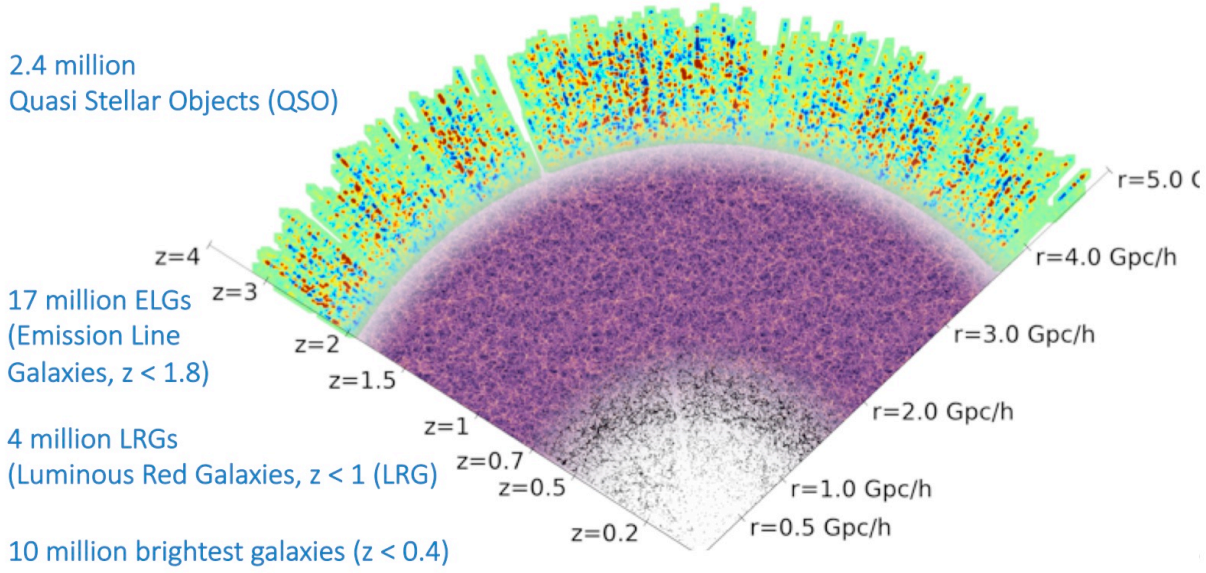
The Dark Energy Spectroscopic Instrument

DESI figures:

- **25M dark time objects**
- **16M Bright galaxies**

DESI will explore a x30 larger map over a x10 larger volume than SDSS

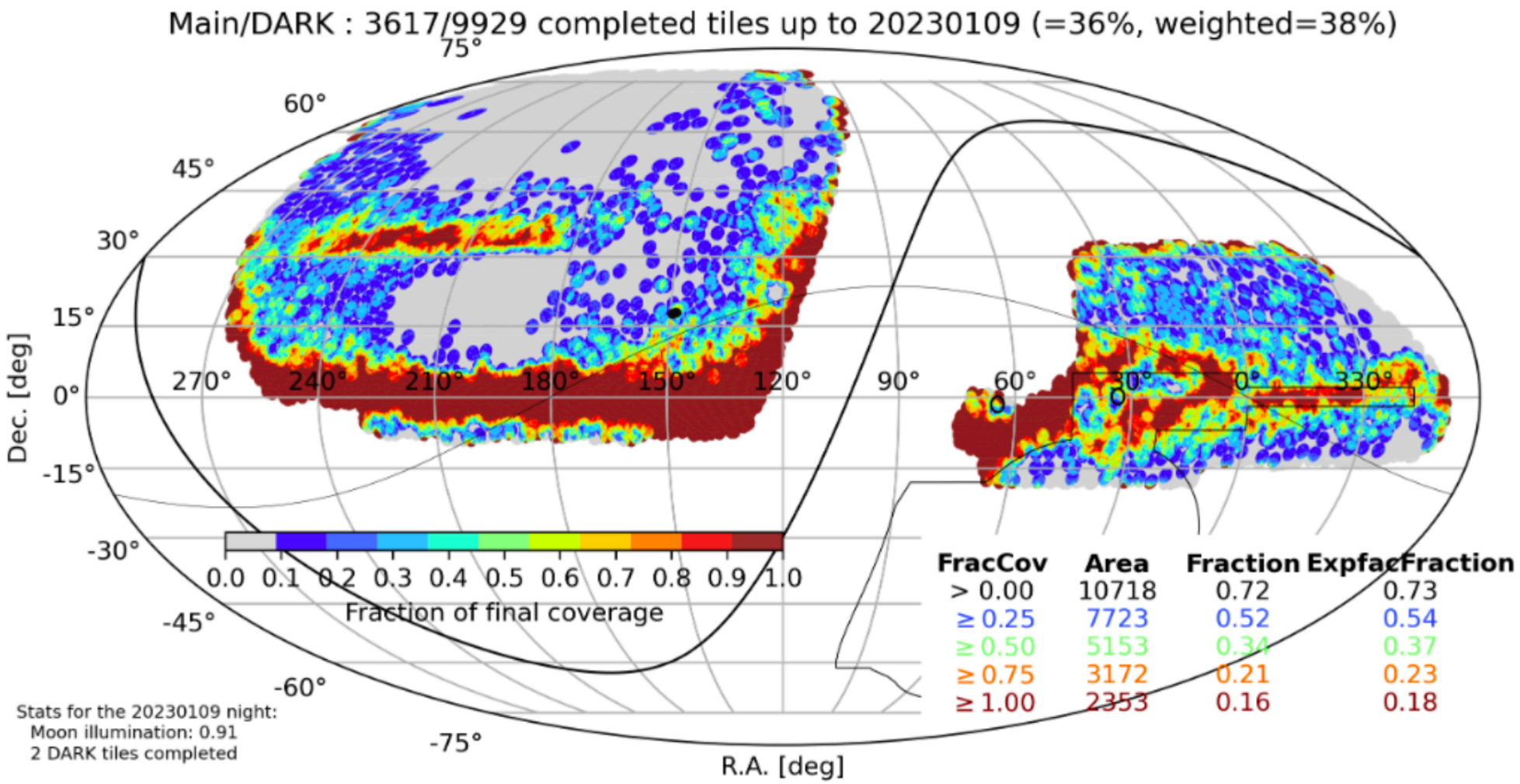




Galaxy type	Redshift range	Bands used	Targets per deg^2	Exposures per deg^2	Good z's per deg^2	Baseline sample
LRG	0.4–1.0	$g,r,z,W1$	480	610	430	6.0 M
ELG	0.6–1.6	g,r,z	2400	1870	1220	17.1 M
QSO (tracers)	< 2.1	$g,r,z,W1,W2$	170	170	120	1.7 M
QSO (Ly-α)	> 2.1	$g,r,z,W1,W2$	90	250	50	0.7 M
Total in dark time			**3140**	**2900**	**1820**	**25.5 M**
BGS	0.05–0.4	r	800	740	710	9.9 M
BGS–Faint	0.05–0.4	r	600	460	430	6.0 M
MWS	0.0	g,r (Gaia μ)	800+	720	720	10.1 M
Total in bright time			**2200+**	**1920**	**1860**	**26.0 M**

The Dark Energy Spectroscopic Instrument

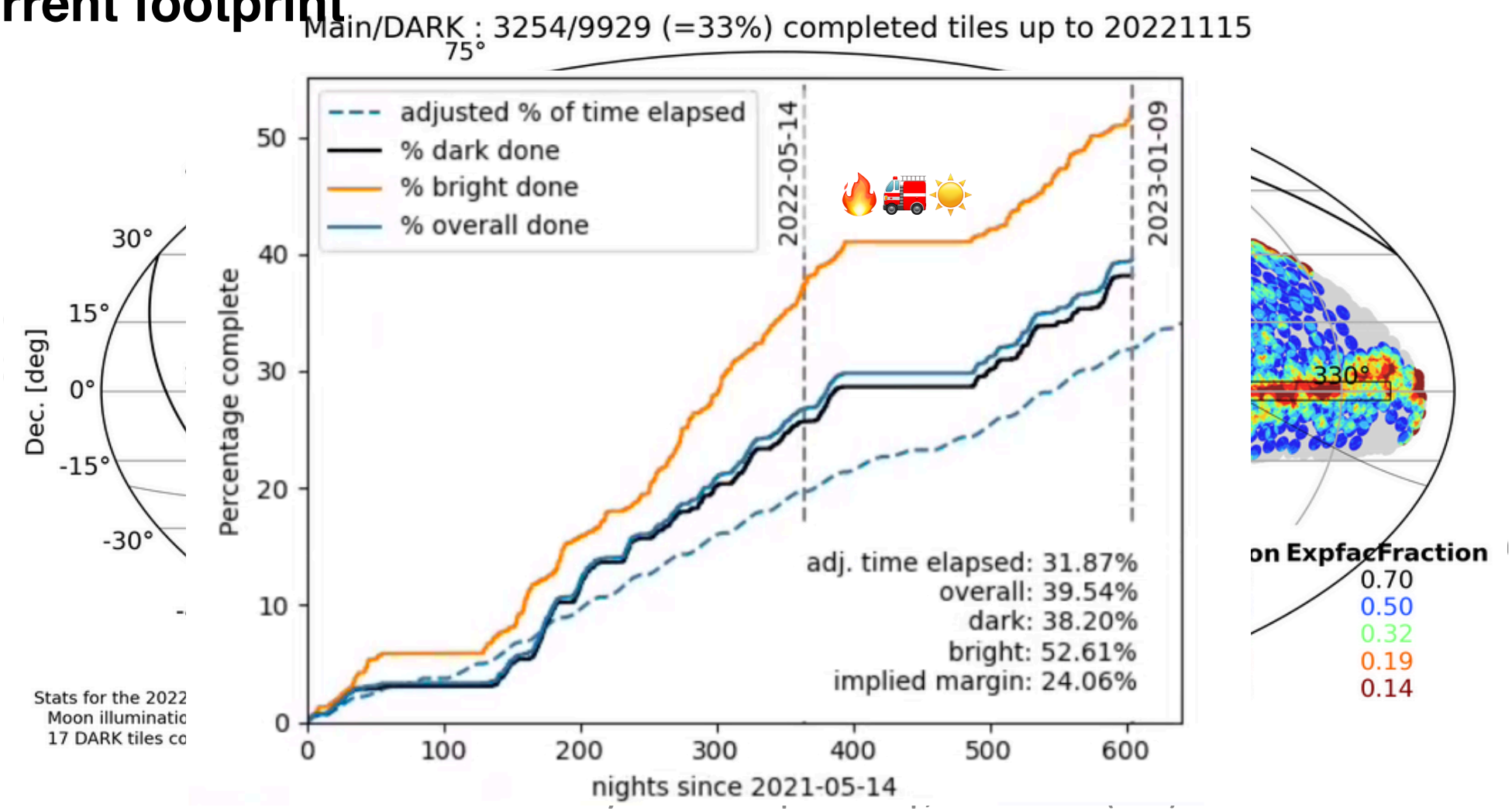
DESI cu



FracCov	Area	Fraction	ExpfacFraction
> 0.00	10718	0.72	0.73
≥ 0.25	7723	0.52	0.54
≥ 0.50	5153	0.34	0.37
≥ 0.75	3172	0.21	0.23
≥ 1.00	2353	0.16	0.18

The Dark Energy Spectroscopic Instrument

DESI current footprint

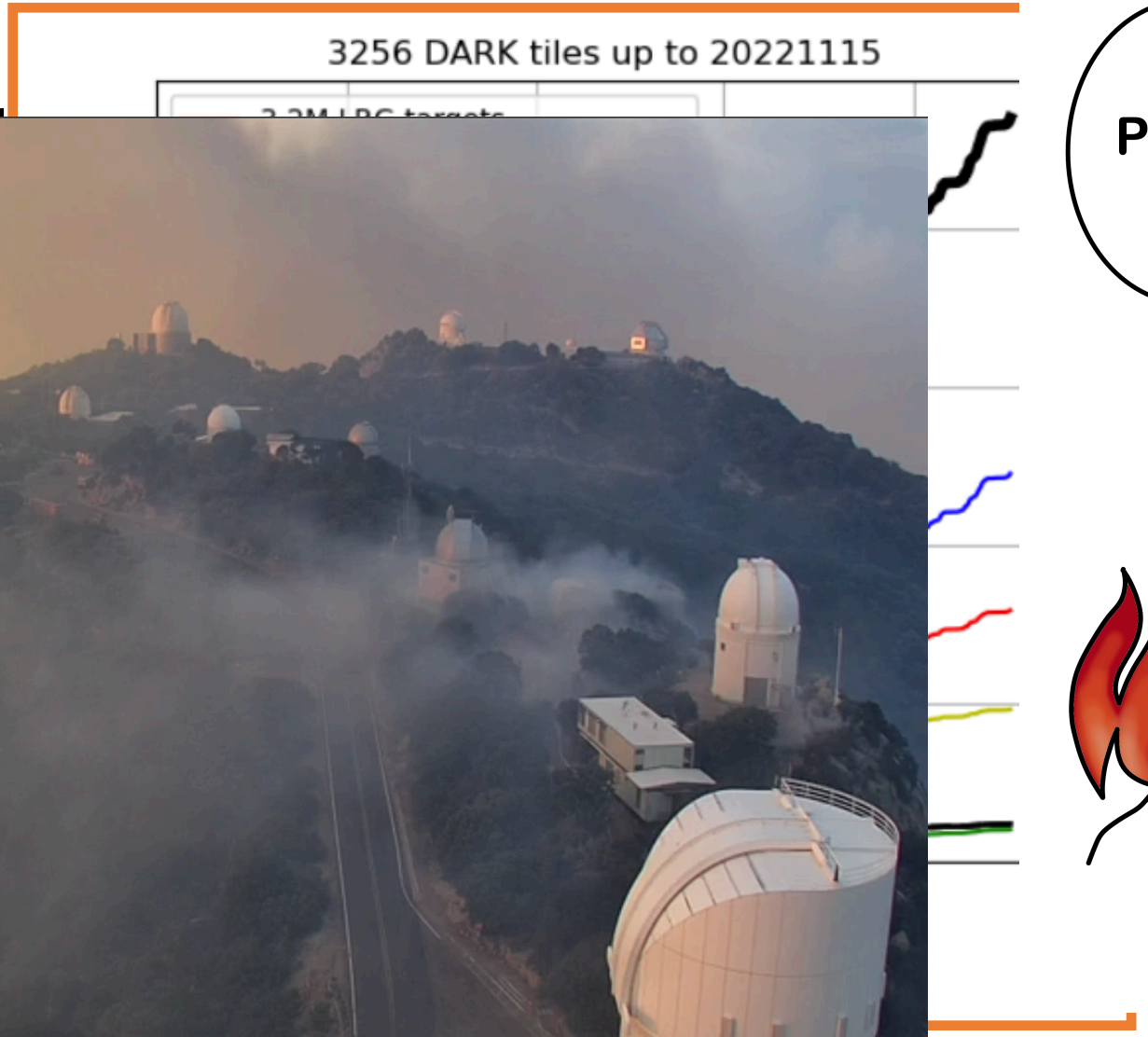


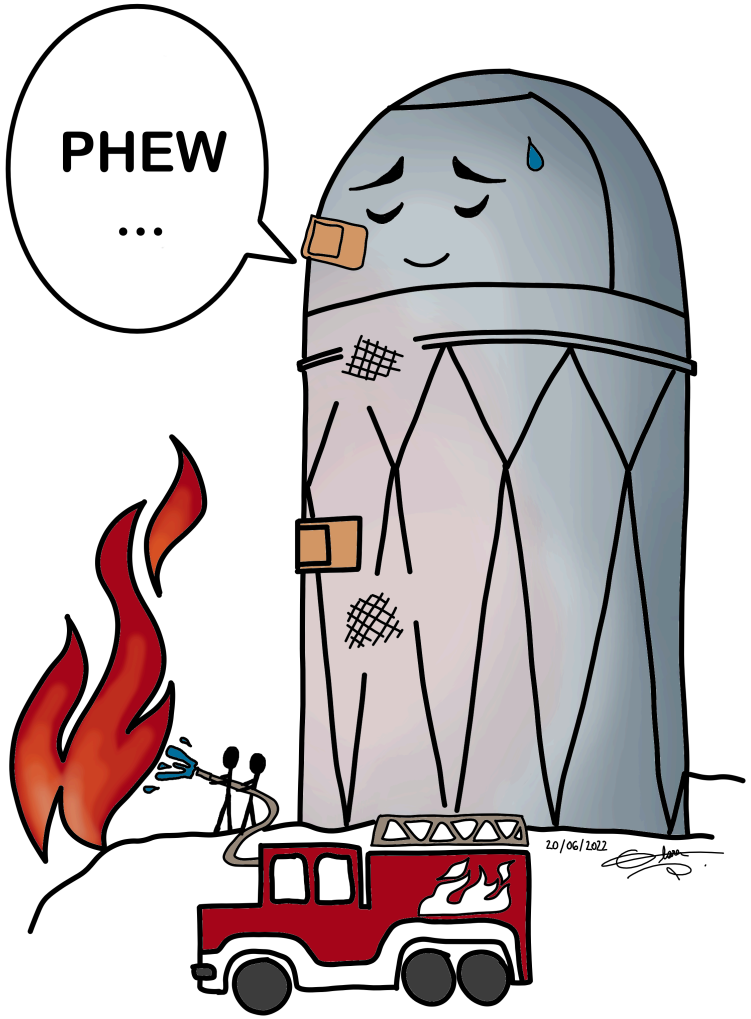
DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science

The Dark Energy Spectroscopic Instrument

DESI current footpr





(credit: Clara Delabrouille)

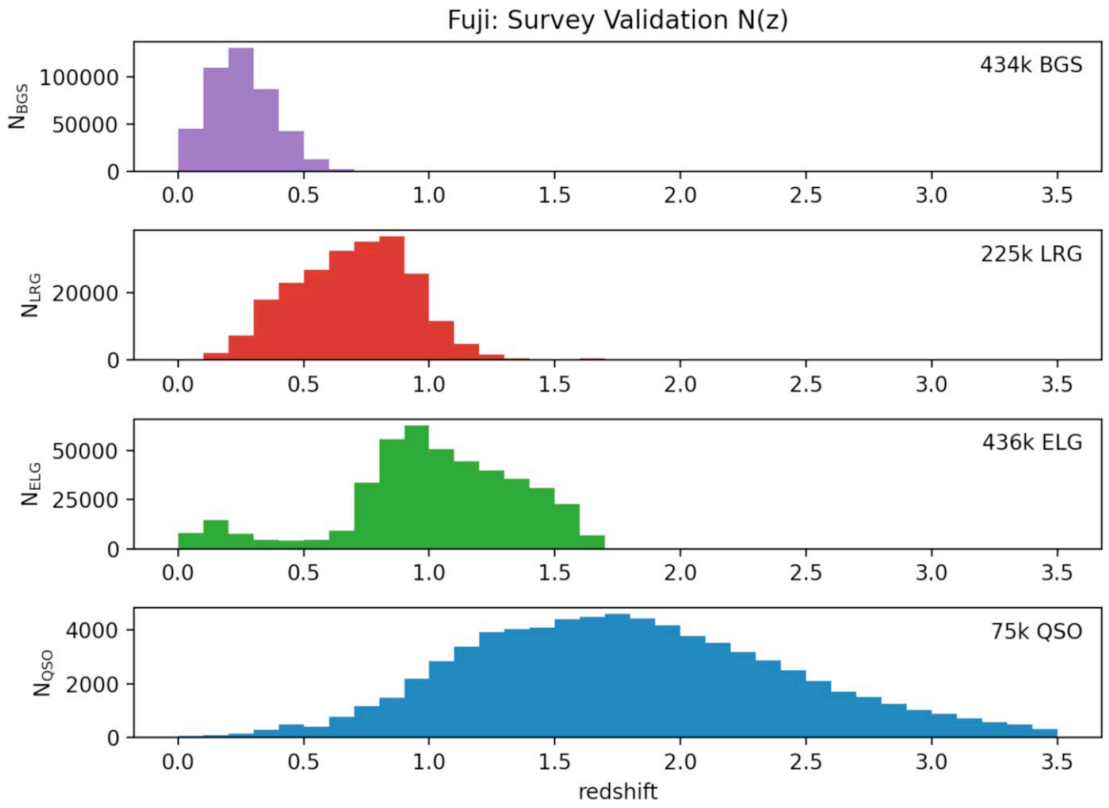
DARK ENERGY SPECTROSCOPIC INSTRUMENT

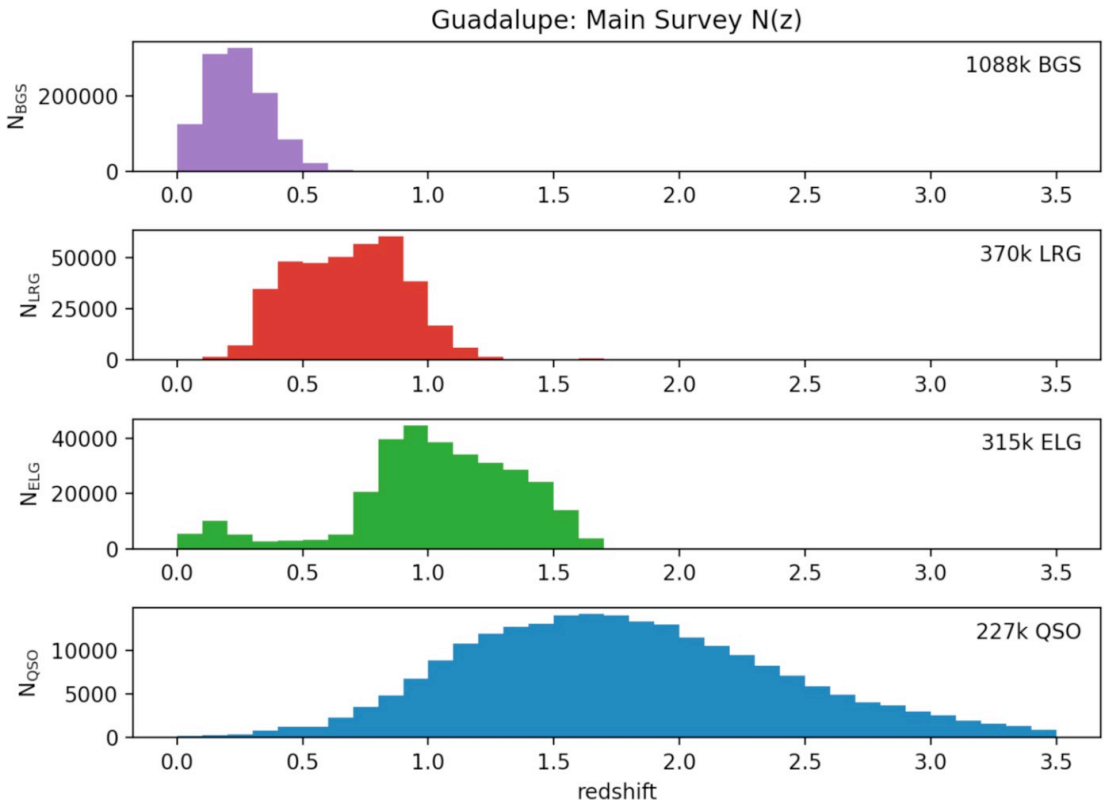
U.S. Department of Energy Office of Science

The Dark Energy Spectroscopic Instrument

Early Data Release

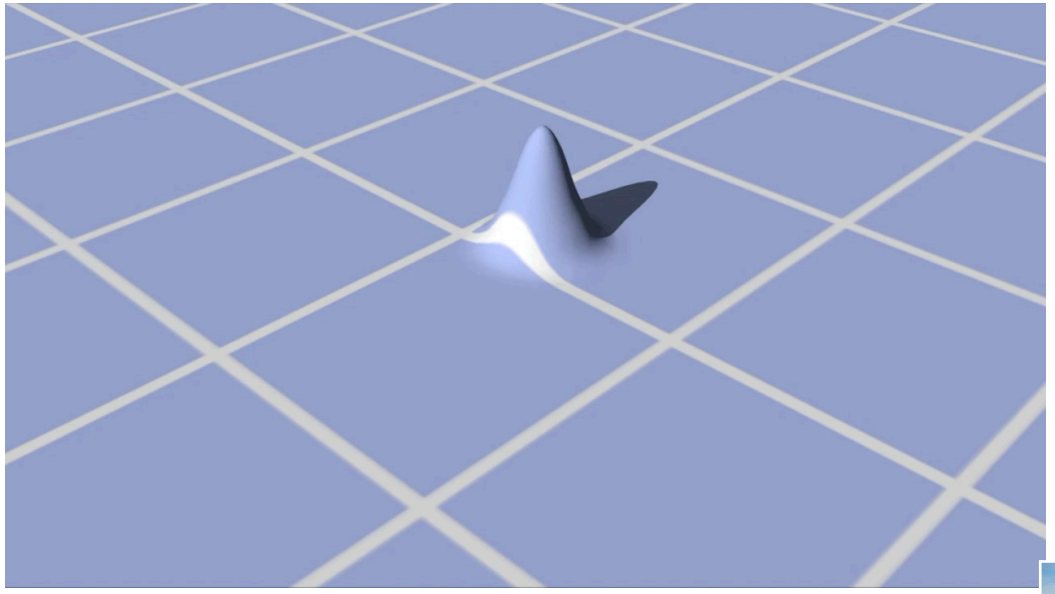
- EDR: 2 months of main survey data (05/22 - 07/22) + SV (> 05/21)
- Over 2 million redshifts including BGS, LRG, ELG and QSO



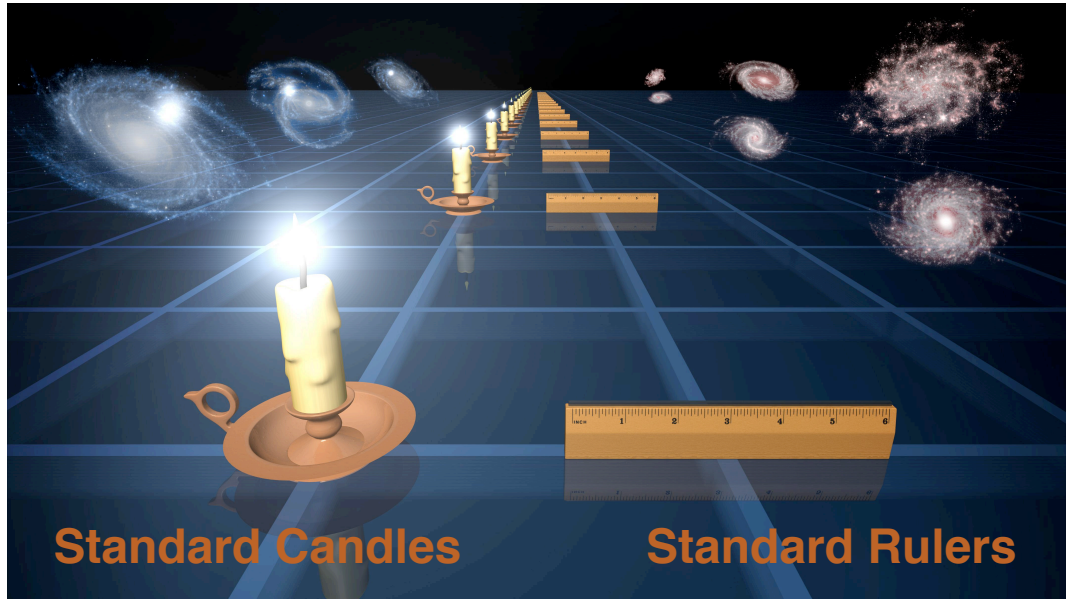


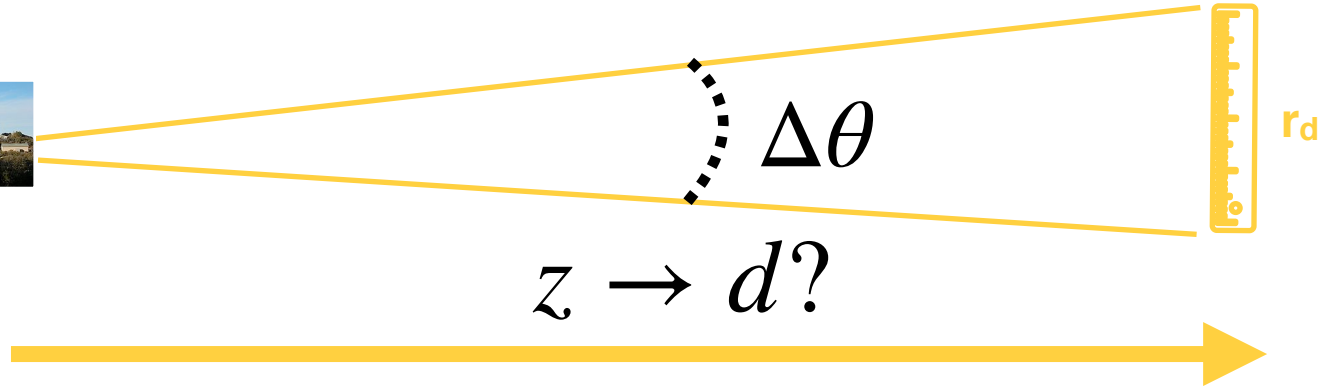
Cosmology with DESI: Baryon Acoustic Oscillations

BAO as a standard ruler



Credit: CAASTRO



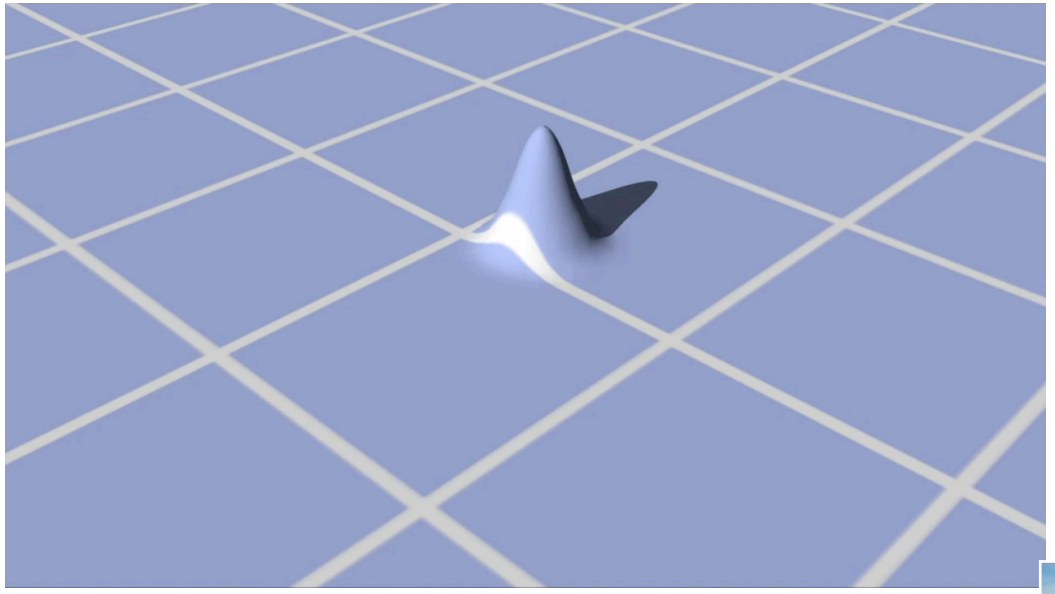


$$\Delta\theta = r_{\rm d}/d_{\rm A}(z)$$

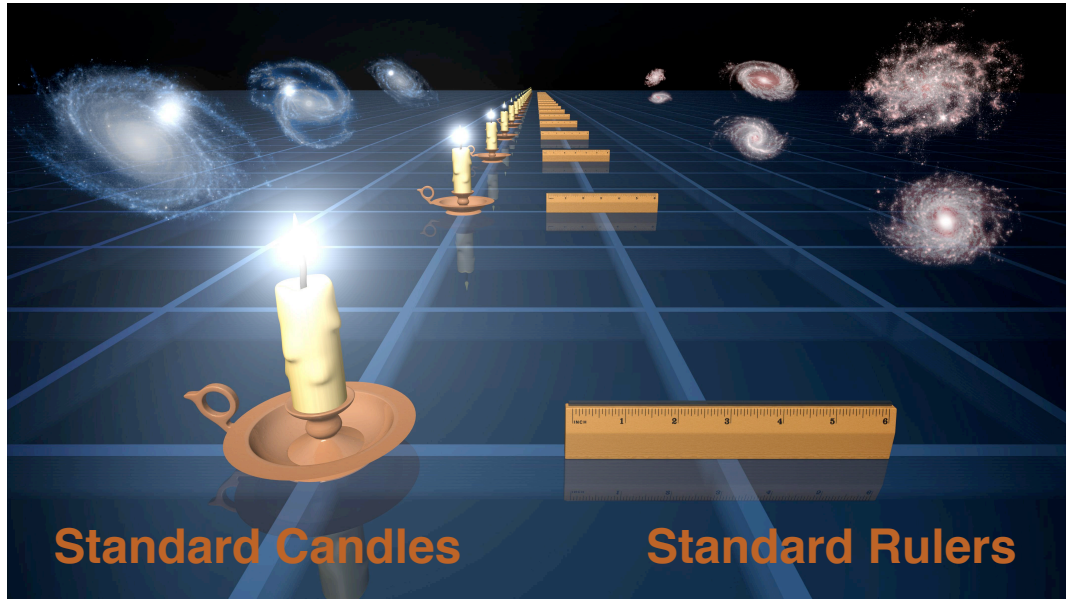
$$d_{\rm A}(z) = \int_0^z \frac{{\rm d}z'}{H(z', H_0, \Omega_{\rm M})}$$

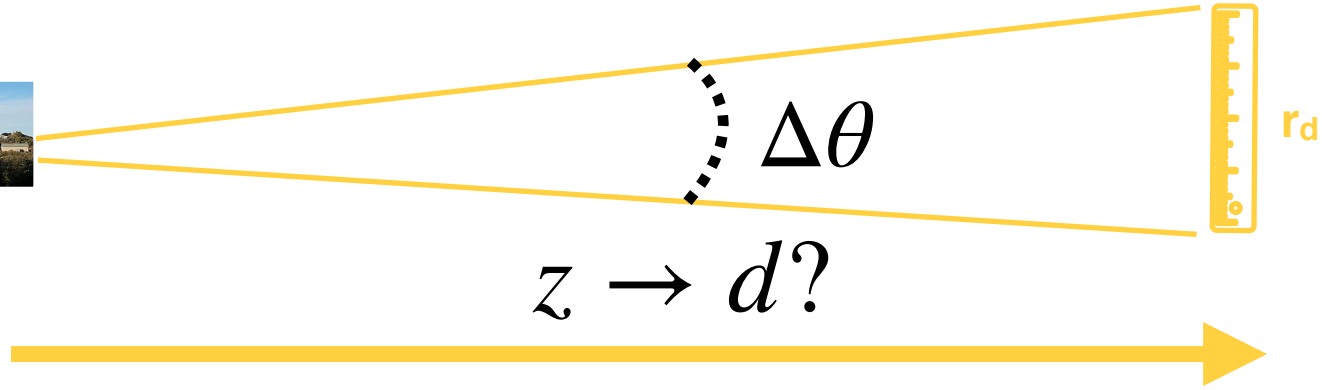
Cosmology with DESI: Baryon Acoustic Oscillations

BAO as a standard ruler



Credit: CAASTRO



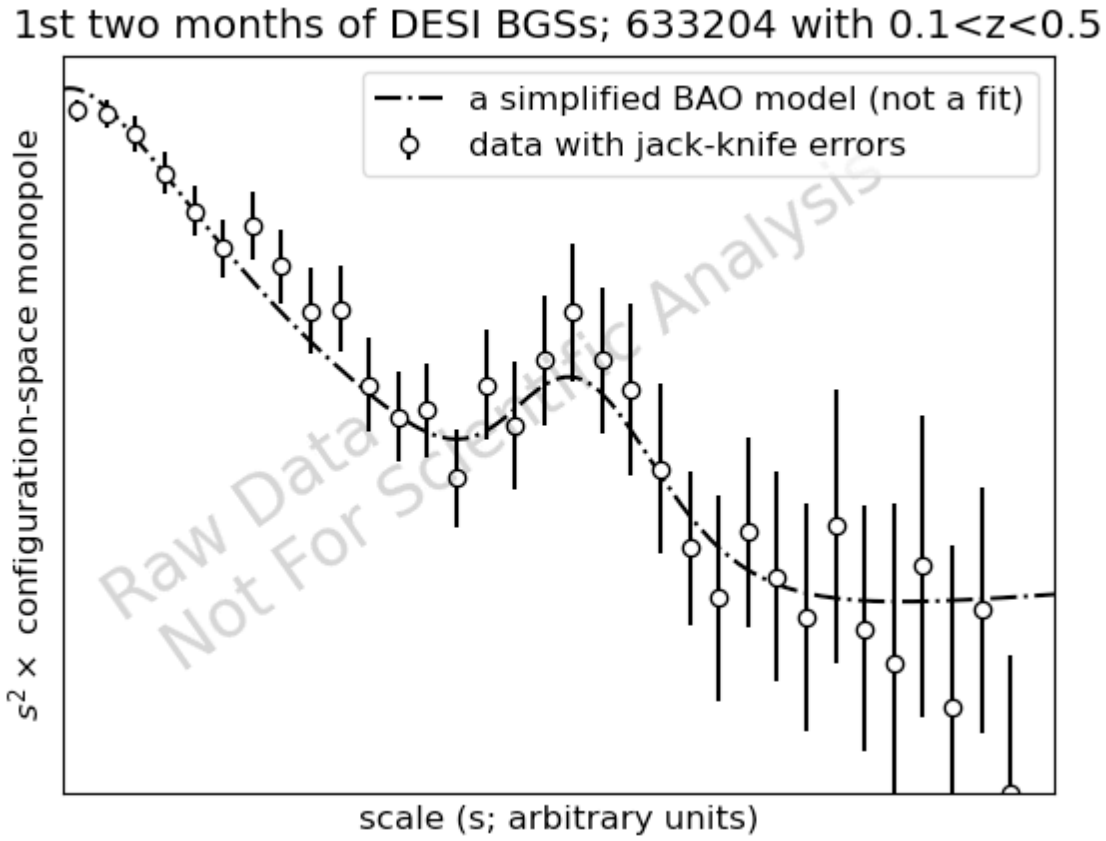


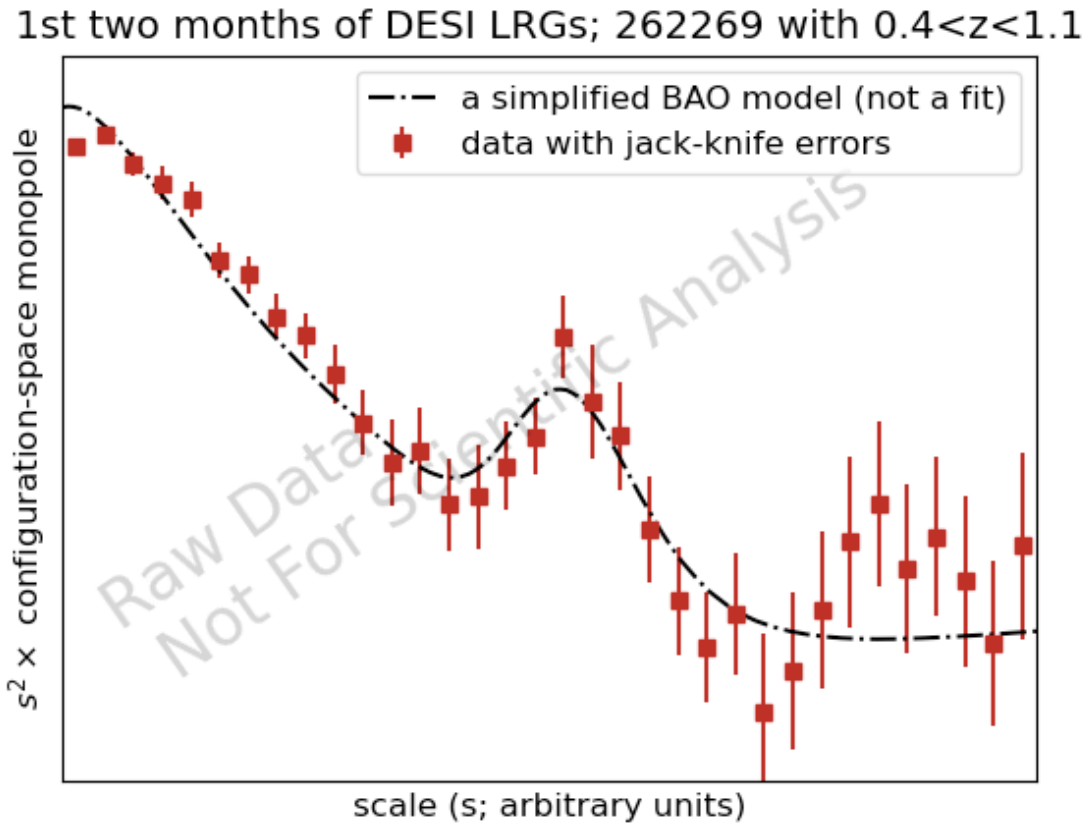
$$\Delta\theta = r_{\rm d}/d_{\rm A}(z)$$

$$d_{\rm A}(z) = \int_0^z \frac{{\rm d}z'}{H(z', H_0, \Omega_{\rm M})}$$

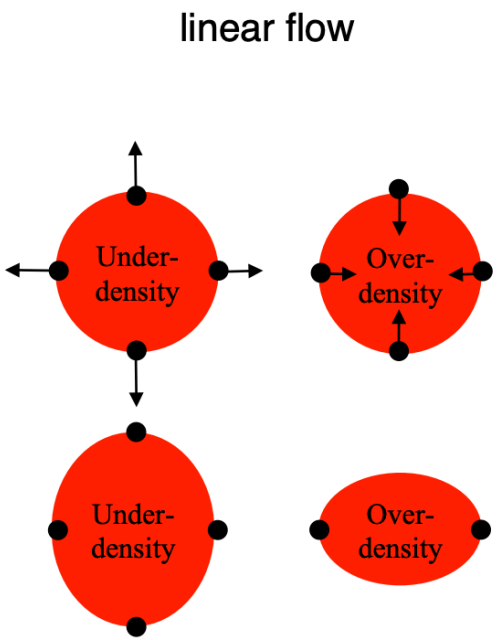
Cosmology with DESI: BAO

Early Data Release (2 months of data)



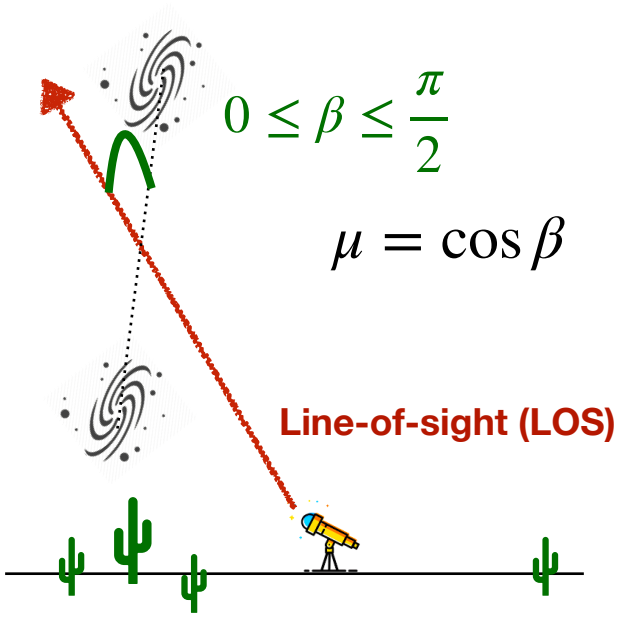


Cosmology with DESI: Redshift Space Distortions



Power is enhanced on large-scales

(credit: Will Percival)



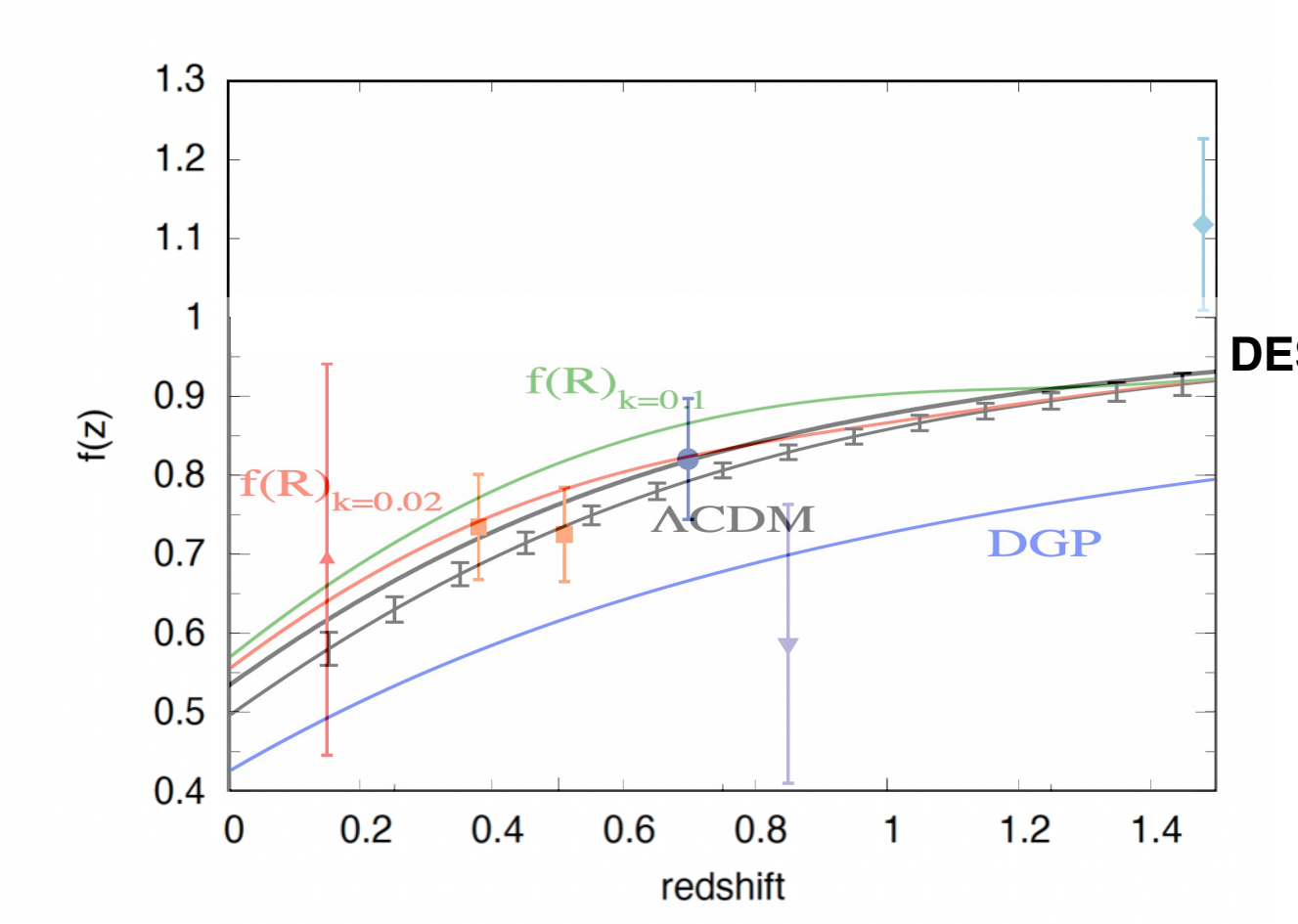
(credit: Héctor Gil-Marín)

In linear regime: $P_{\rm g}(k,\mu) = \left(b + \mu^2 f\right)^2 P_{\rm m}(k)$

For GR: $f(z) = \Omega_{\rm m}(z)^{0.557}$

Cosmology with DESI: Redshift Space Distortions

State-of-the-art Perturbation $f(z)\sigma_8(z)$ measurements



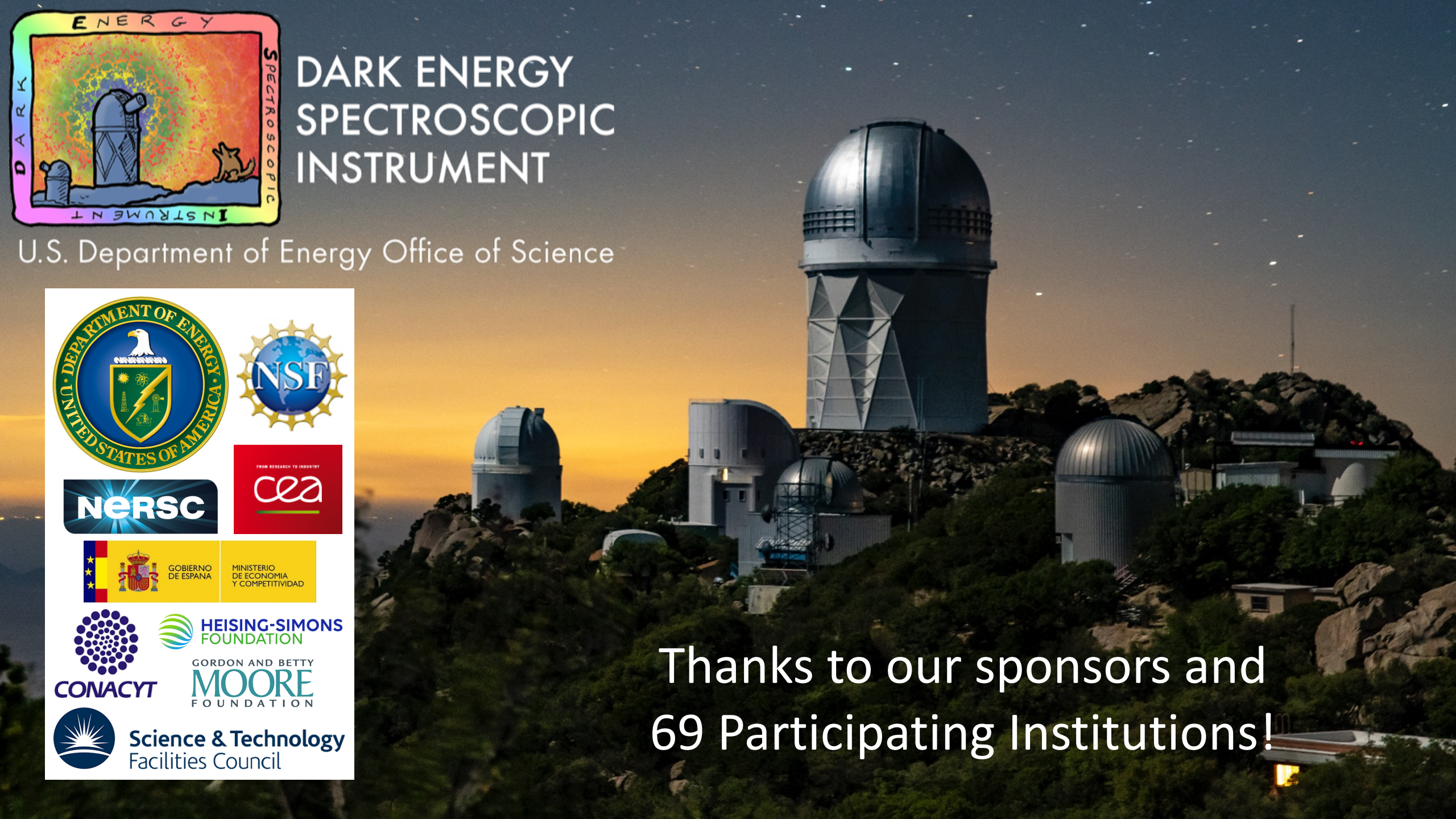
DESI forecast

Conclusions

- BAO are one of the best probes of Dark Energy effects (background effect)
- RSD offers the possibility to test GR at intergalactic scales (perturbation level)
- From 2023 DESI will deliver more precise measurements on BAO, RSD, (f_{nl}, sum of neutrino masses)
- DESI clustering measurements are “blind” for robustness and to avoid confirmation bias

DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science



Thanks to our sponsors and 69 Participating Institutions!