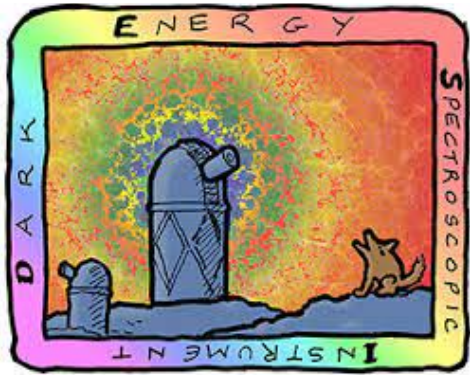
Dark Energy Spectroscopic Instrument

Survey Science Group Workshop
High1, 29-31 Jan 2024

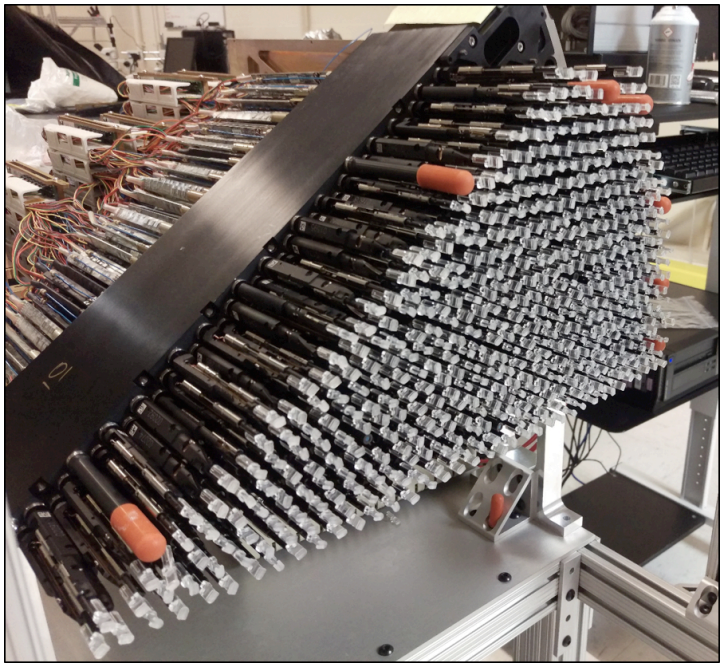
Arman Shafieloo
KASI/UST



Korea Astronomy and Space Science Institute

The Instrument





Mayall 4-meter Telescope @ Kitt Peak, Arizona
(14,000 deg2 ~ 1/3 of the nightsky)

Started 2020 - 2025

Stage IV DE experiment:
Factor x3 improvement FoM ($\sigma_{w_0}, \sigma_{w_a}$)
w.r.t Stage III (eBOSS, DES, etc)

~5000 Fiber Positioners

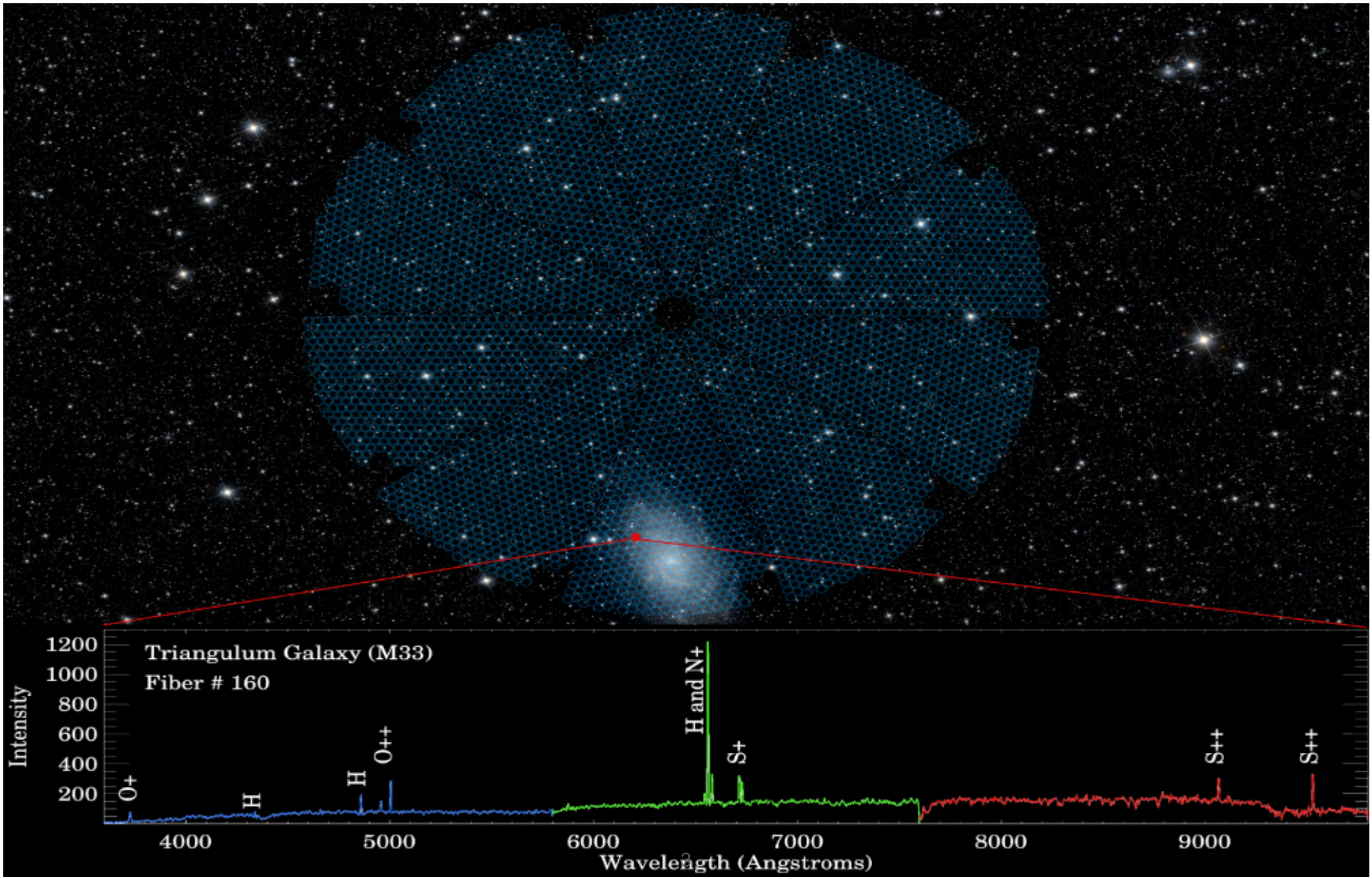
Using 10 Spectrographs:

- 35 Million galaxies
- 2.4 Million Quasars

Redshift Targets & Distributions:

- $0 < z < 0.4$ Brightest Galaxies (~10M)
- $0.4 < z < 1.0$ Luminous Red Galaxies (~6M)
- 3. $0.6 < z < 1.6$ Emission Line Galaxies (~17M)
- $1.0 < z < 2.1$ QSO (~2.4 M)
- $z > 2.1$ LyA

The Instrument

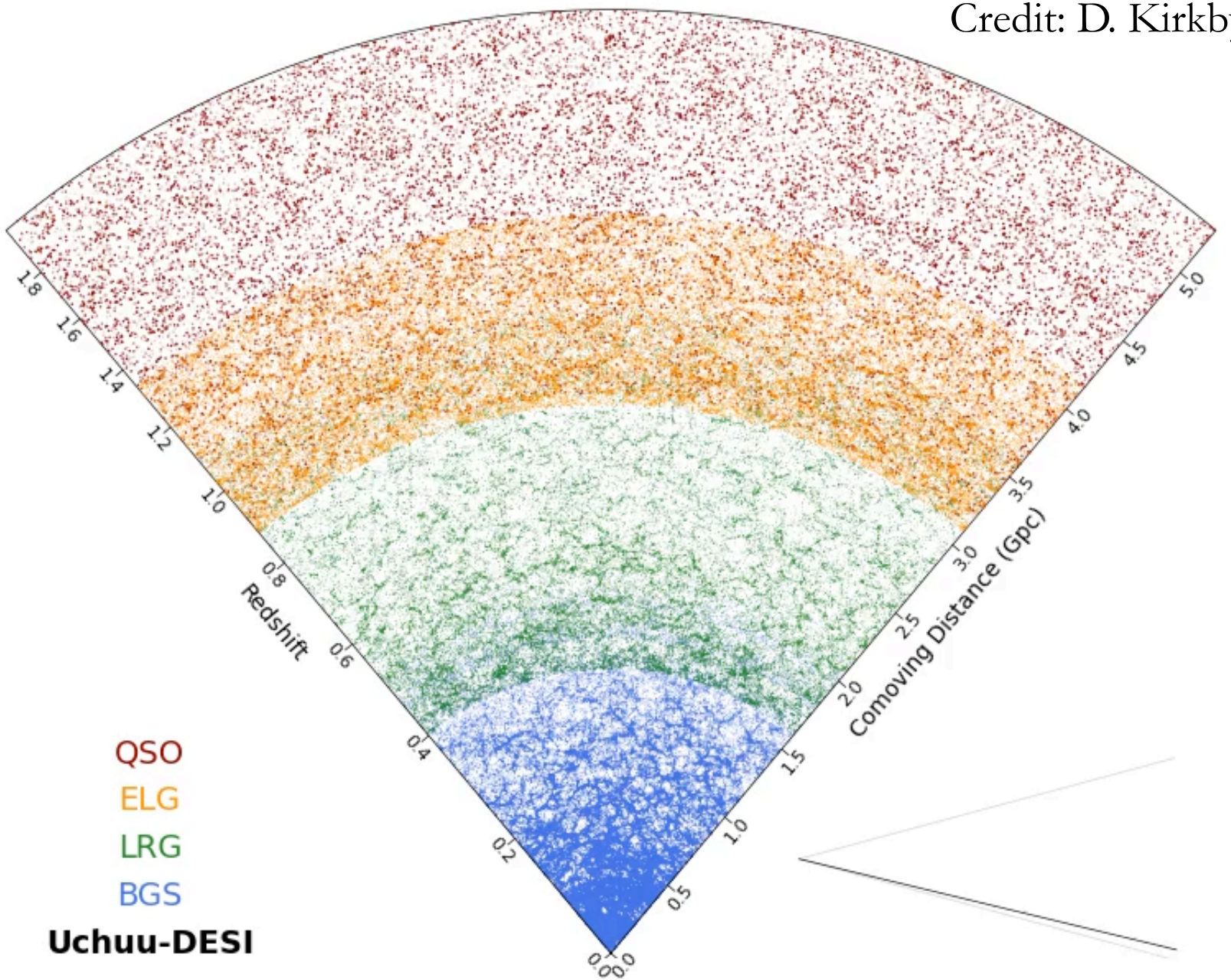


The Collaboration

Large international collaboration

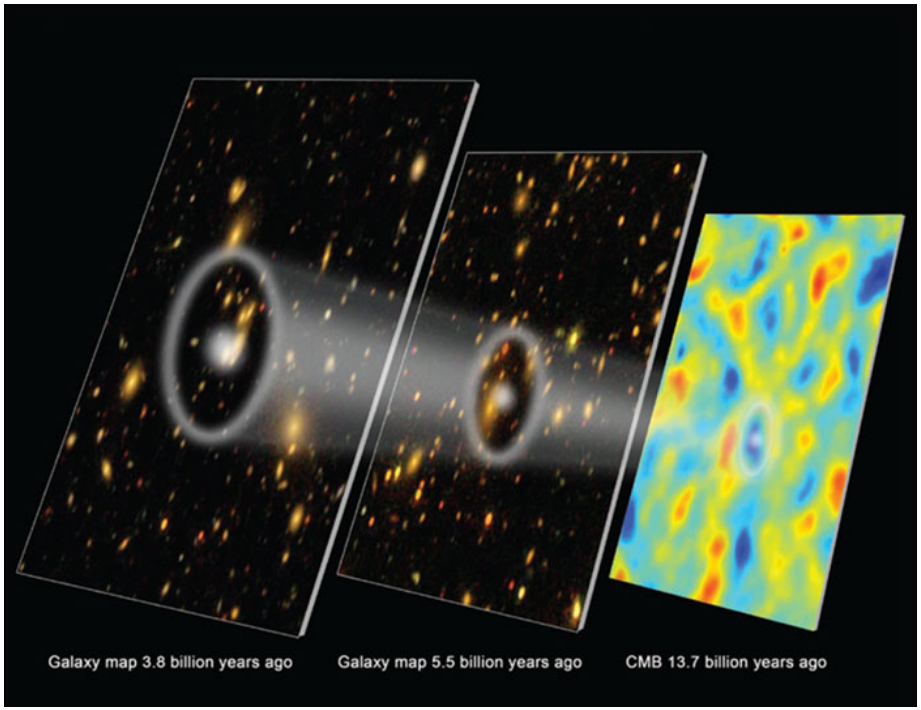
- Funded by US. Department of Energy.
- Budget: 80~90 million USD
- 74 institutions including 46 non-US (Australia, Brazil, Canada, Chile, China, France, Korea, Mexico, Spain, Switzerland, UK)
- >700 DESI members
- **Targeting a key problem in theoretical physics and physical cosmology**

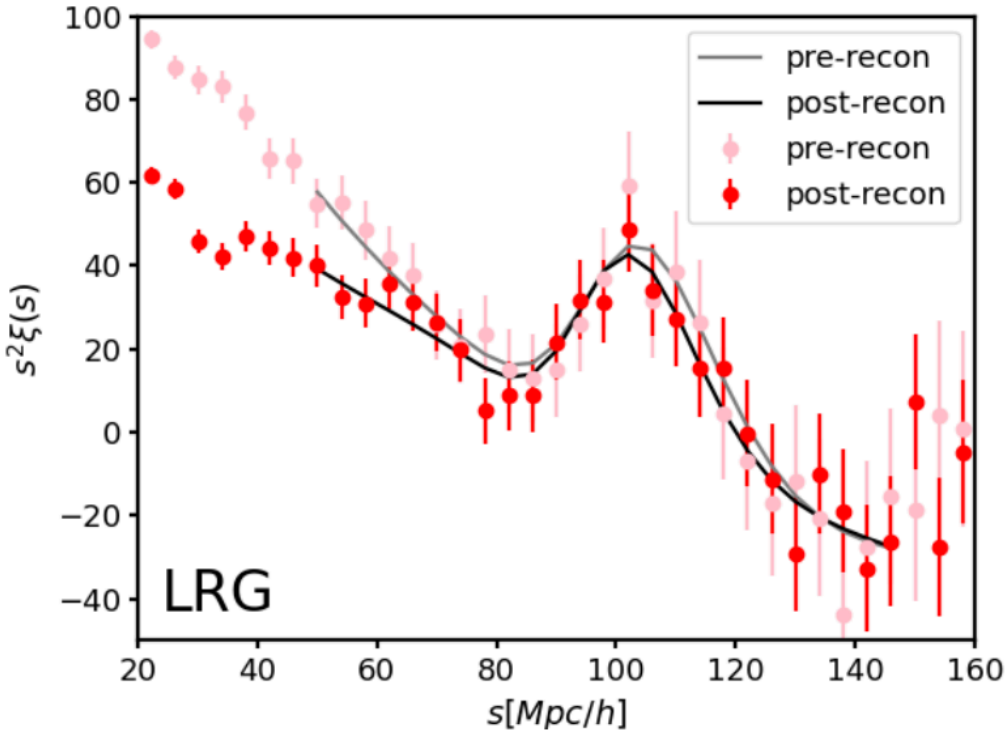
Credit: D. Kirkby



Baryon Acoustic Oscillation

Standard Ruler imprinted in the LSS



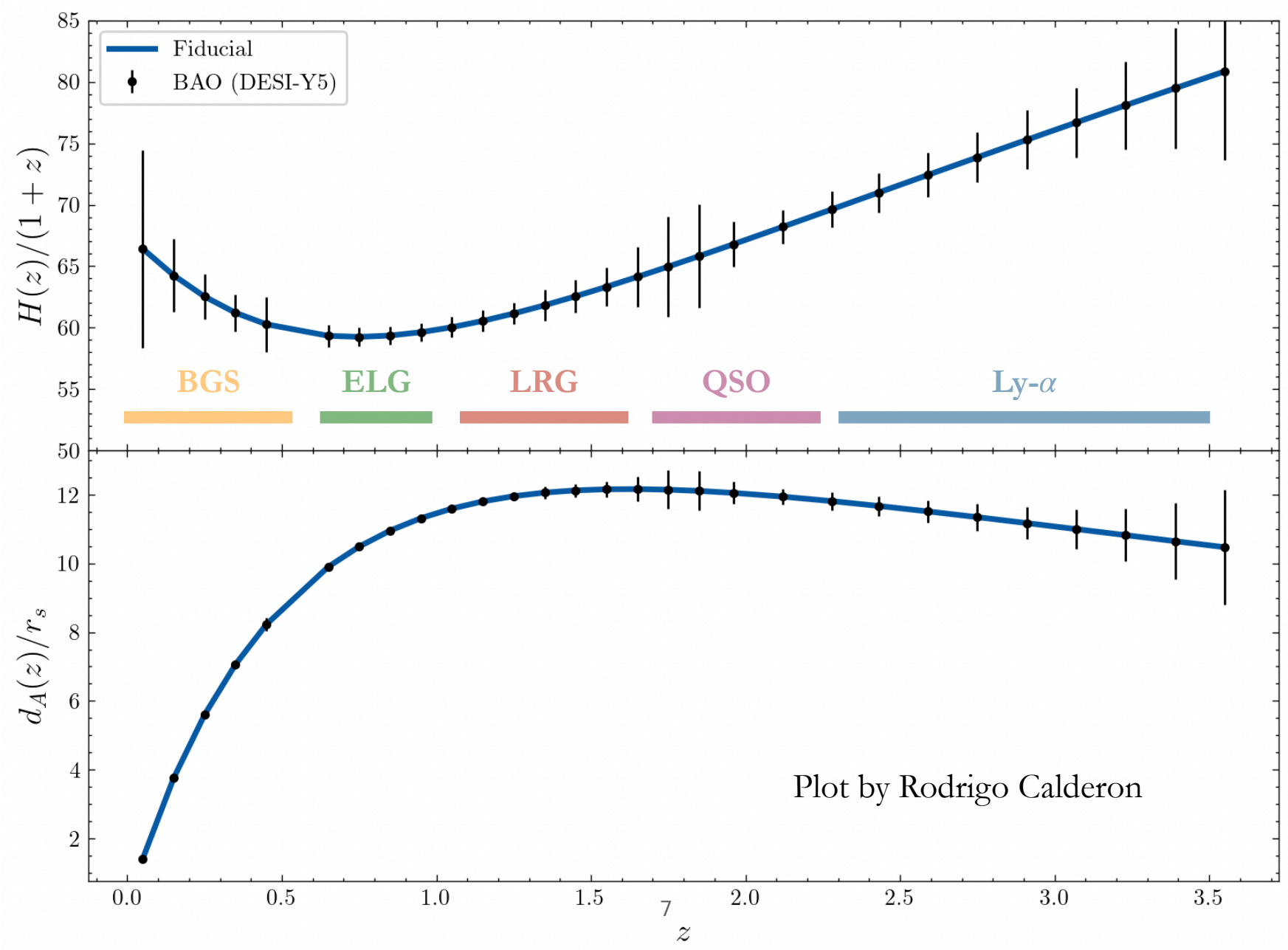


J. Moon et al. (2023) - First Detection of the BAO Signal from Early DESI Data

Significance of the detection (with percent level of observation) comparable to that of eBOSS

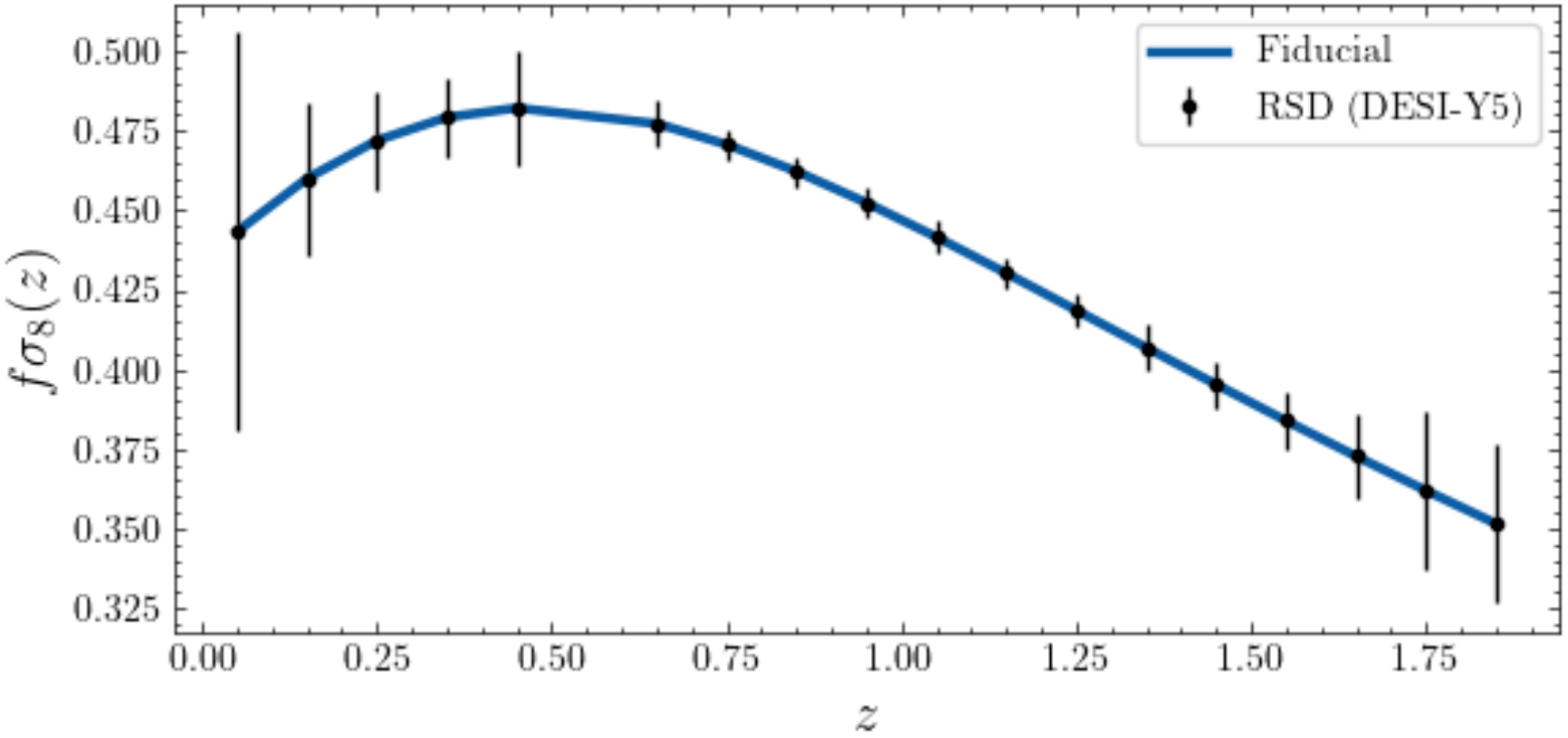
Baryon Acoustic Oscillation

Probing the Expansion History



Redshift Space Distortions

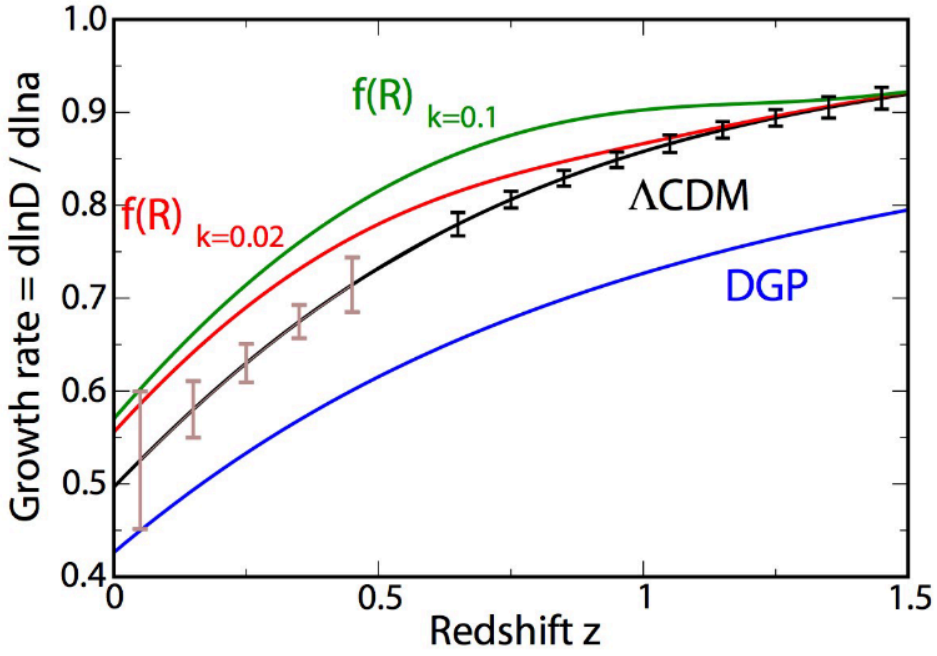
Probing the nature of dark energy/gravity on large-scales



Plot by Rodrigo Calderon

Redshift Space Distortions

Probing the nature of dark energy/gravity on large-scales

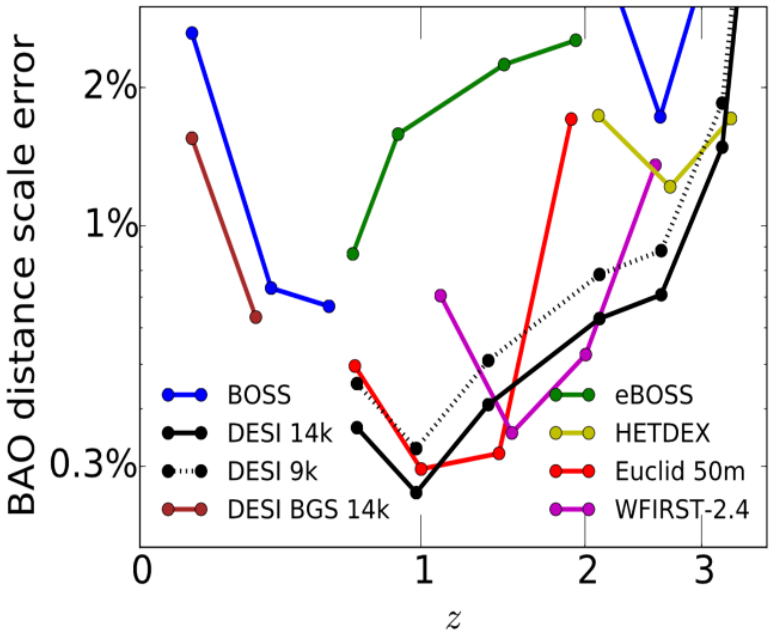


Aghamousa et al, 2016

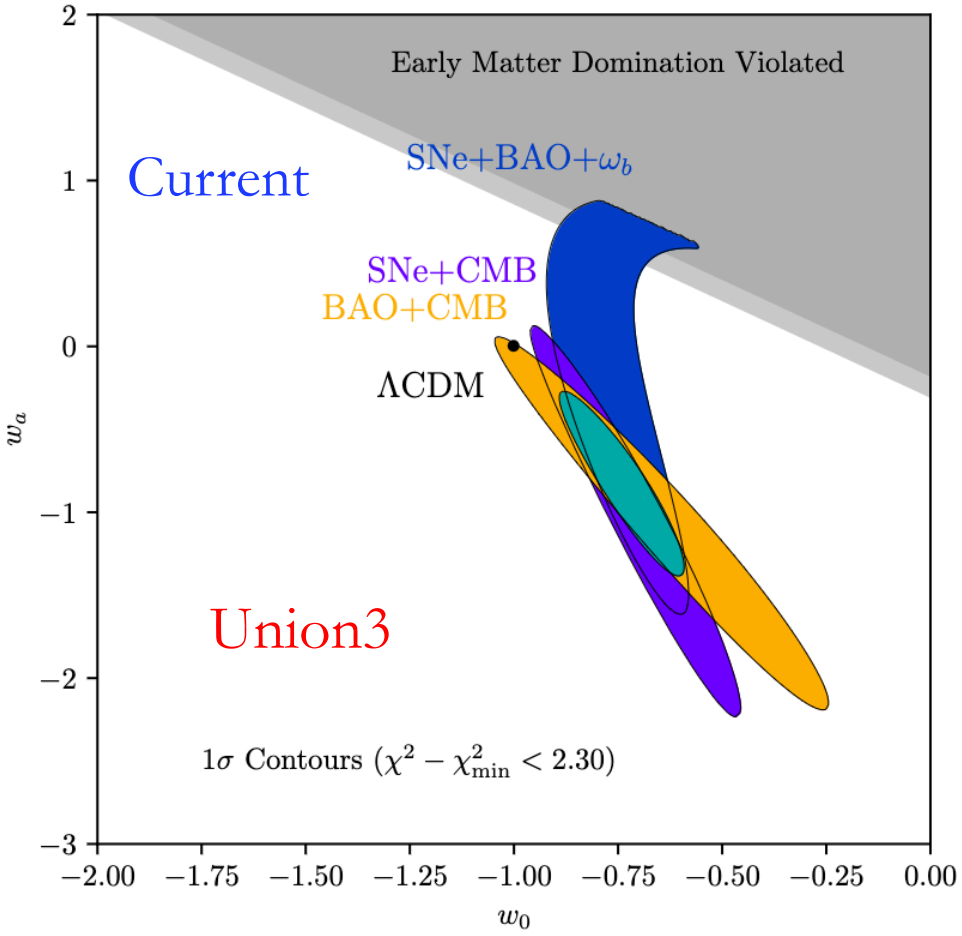
DESI goal

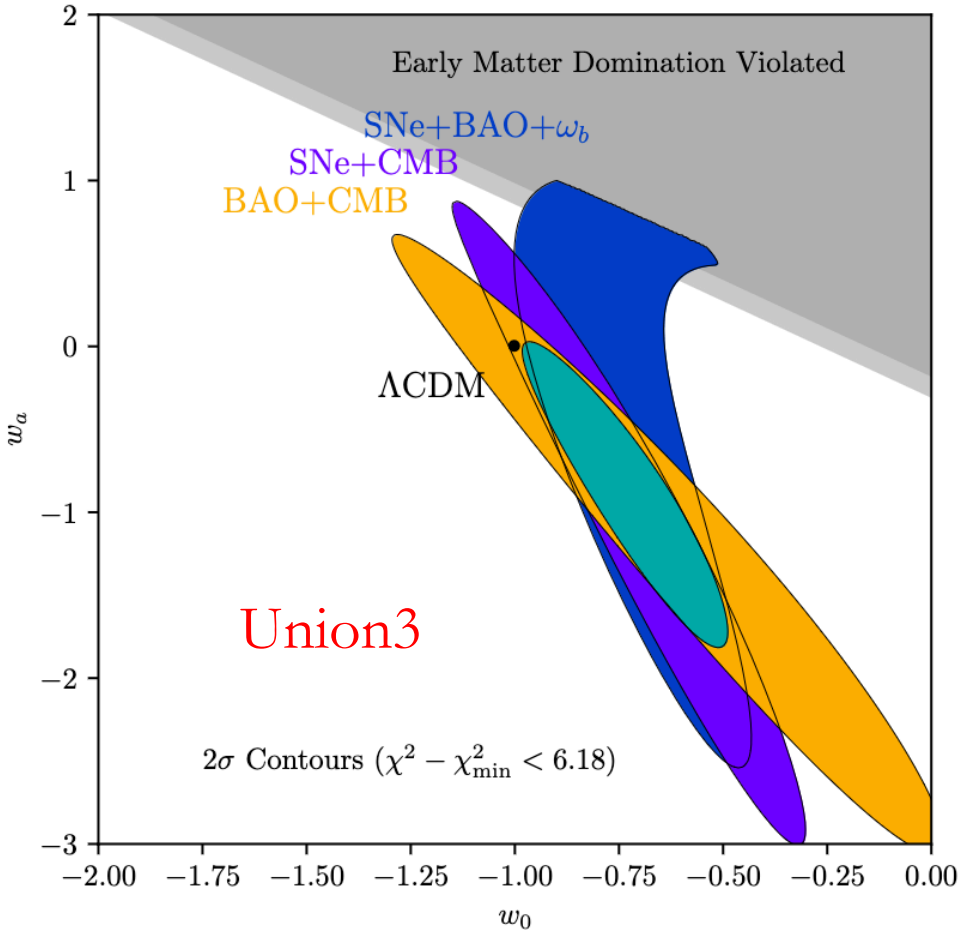
RSD

σ(f) < a few %
at 0.5<z<1.6



Current Constraints on DE





For the first time, dark energy constraining power from galaxy surveys will be better than supernova compilations

Y1 cosmology key papers are being prepared to appear in April

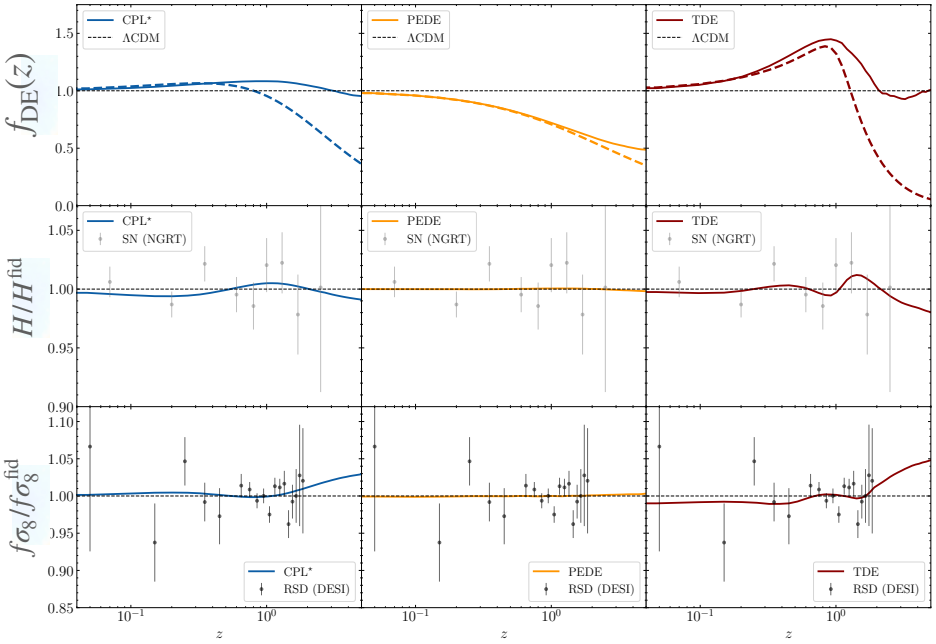
our group activity

More inclined towards the key science of DESI





- **Active in Cosmological Parameter Estimation, WG.**
- Leading our internal project (DESI 282) on non-parametric reconstruction of the expansion history and properties of dark energy, test of gravity and falsification of the concordance model.
- Model independent consistency tests between various data.
- Active in time domain WG (SN classification, catalogue of strong lens systems, cross correlation with GW dark sirens)



Calderón, L'Huillier, Polarski, Shafieloo & Starobinsky - Phys. Rev. D 106 (2022) 8, 083513

Dark Energy Reconstructions

$$f_{DE}(z) \equiv \frac{\rho_{DE}(z)}{\rho_{DE,0}} \sim \mathcal{N}\left(\bar{f} = 1, K = k(\sigma_f, \ell_f)\right)$$

Mean Kernel

DESI Y5 Simulations

Summary

- Upcoming Y1 cosmology results (~Spring/Summer)
- Ahead of time ! Expected to finish the full footprint ~1 year in advance
- Forecasted precision (14,000 deg2):

  - BAO :

    $\sigma(D_V) \sim 0.3\,\%$ precision from $0 < z < 1.9$

    $\sigma(H) \sim 1\,\%$ precision at $1.9 < z < 3.7$

  - RSD:

    $\sigma(f) \sim$ a few % at $0.5 < z < 1.6$

DESI is the most powerful multi-object spectrograph on the planet.

We hope the make the next breakthrough discovery in cosmology with DESI

Sorry that I could not show any result from Y1 analysis…..