

DESI and BAO

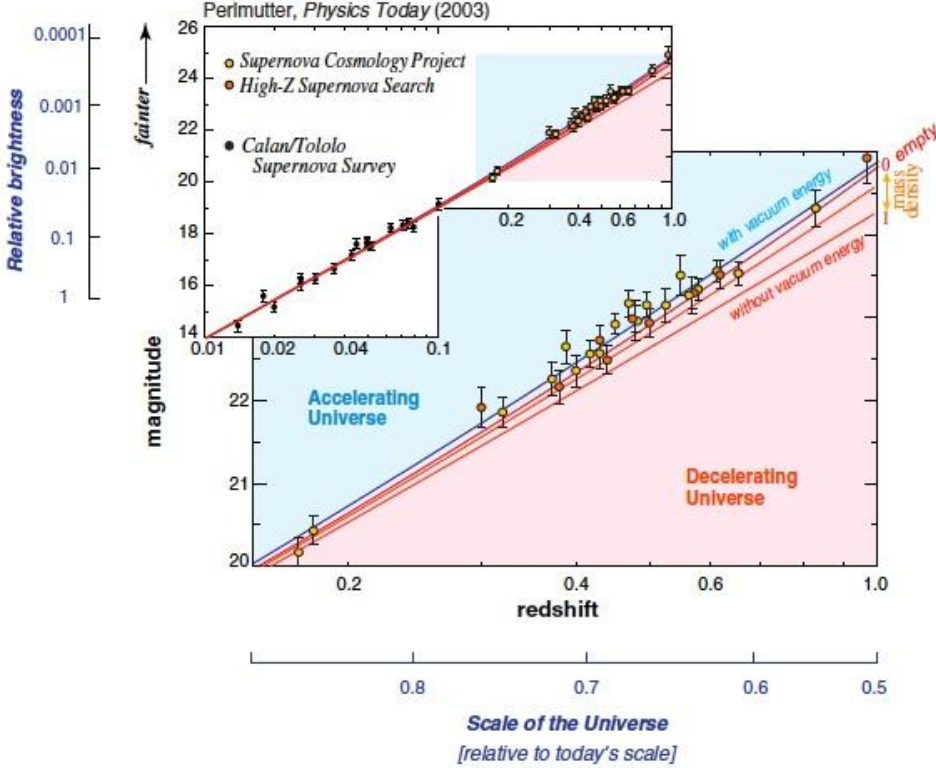
Paul Martini

go.osu.edu/desi5682



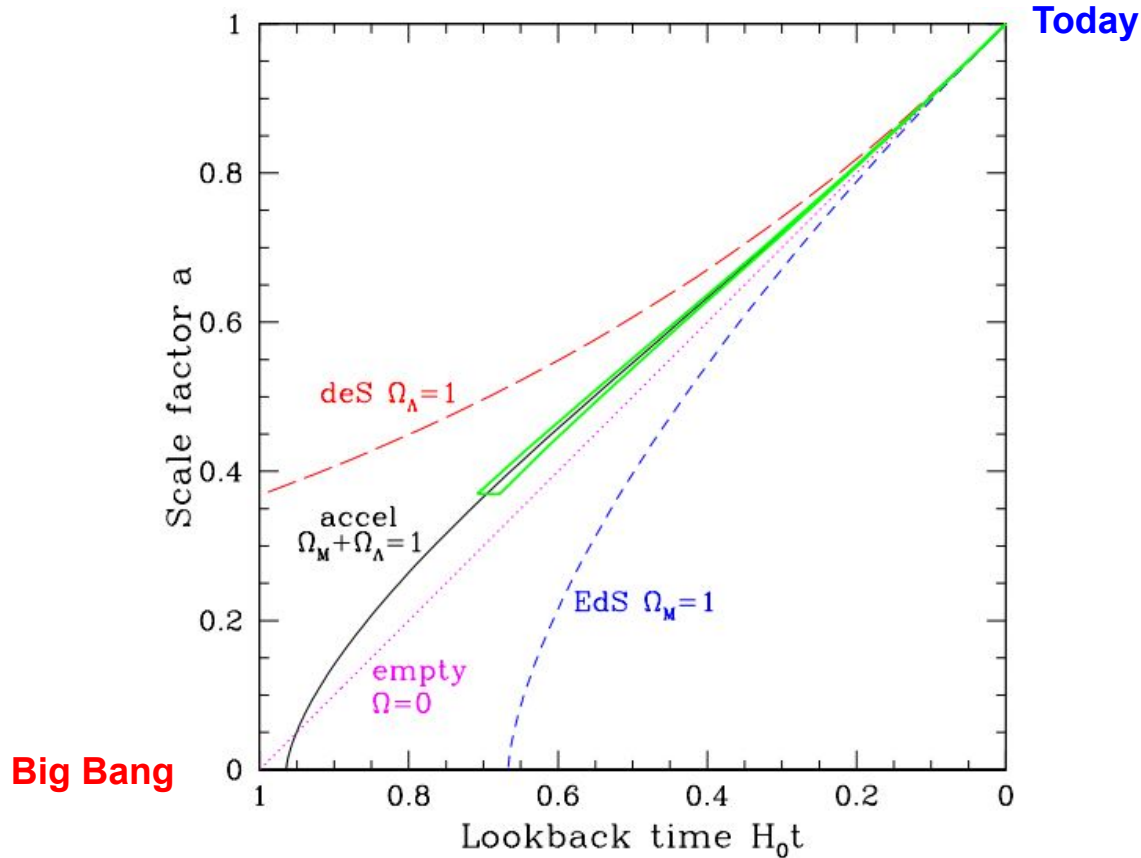
Early Evidence for the Accelerating Universe

Type Ia Supernovae



$$H(a) \equiv \frac{\dot{a}}{a} = H_0 \sqrt{(\Omega_c + \Omega_b)a^{-3} + \Omega_{\text{rad}}a^{-4} + \Omega_k a^{-2} + \Omega_{DE}a^{-3(1+w)}}$$

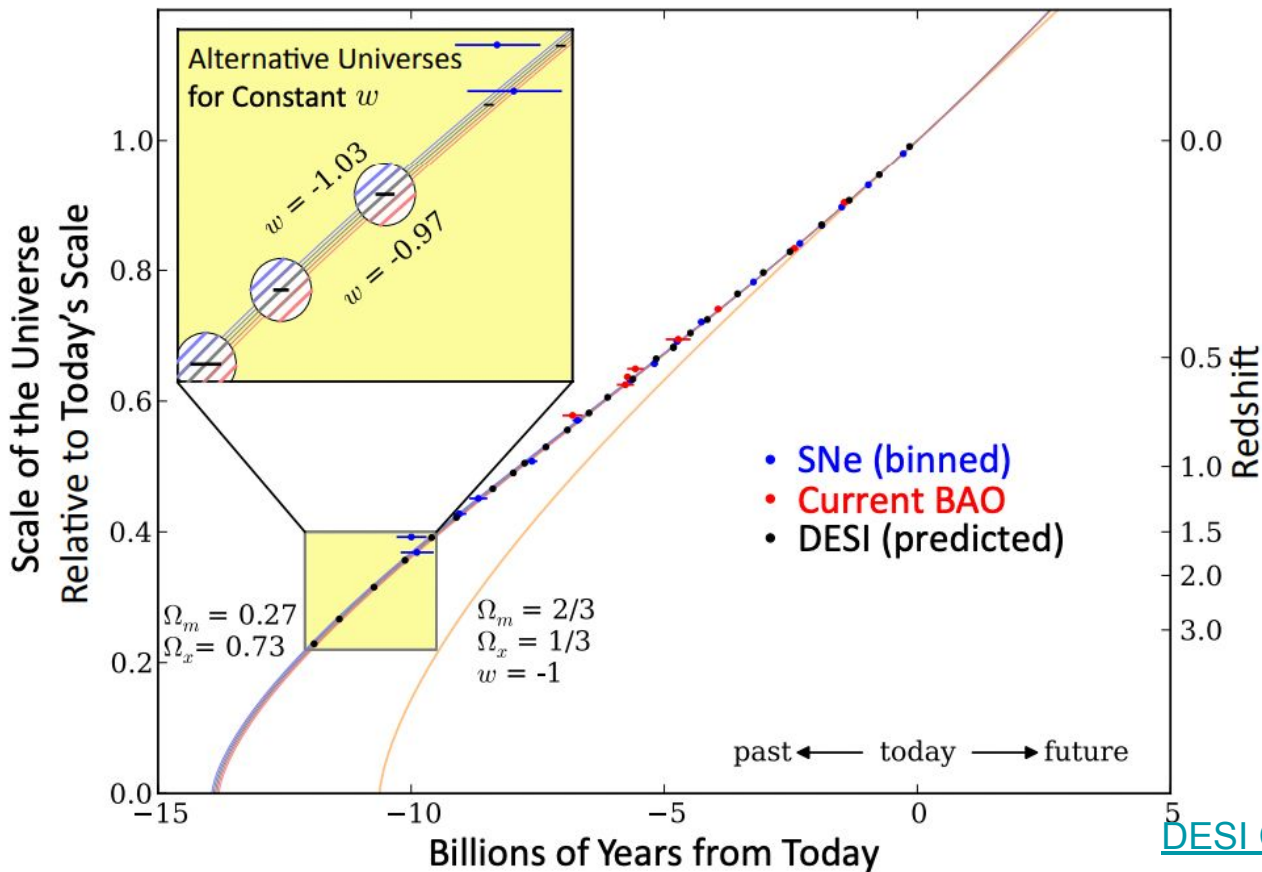
Parameter Dependence



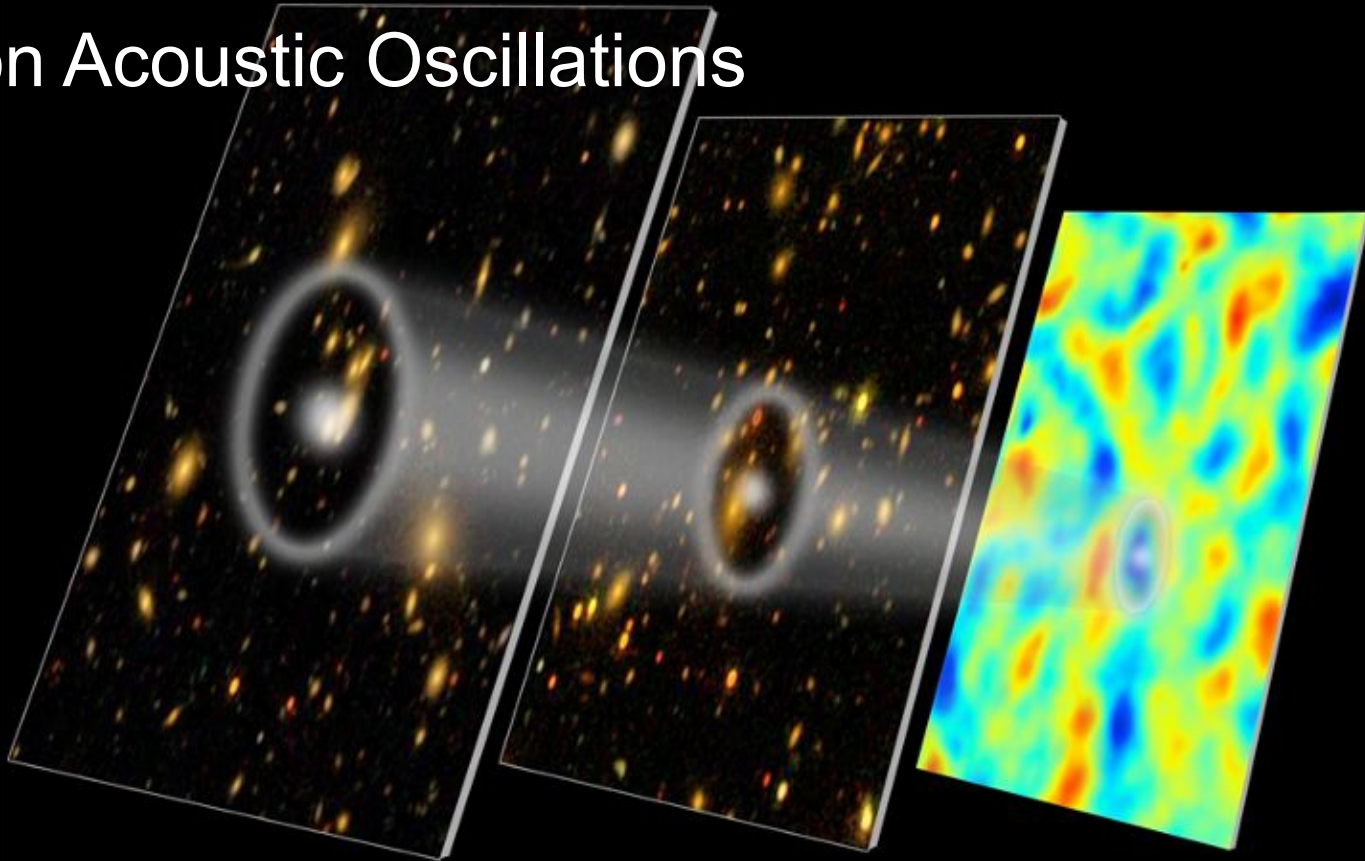
Forecast for DESI

Friedmann equation

$$H(a) \equiv \frac{\dot{a}}{a} = H_0 \sqrt{(\Omega_c + \Omega_b)a^{-3} + \Omega_{\text{rad}}a^{-4} + \Omega_k a^{-2} + \Omega_{DE}a^{-3(1+w)}}$$



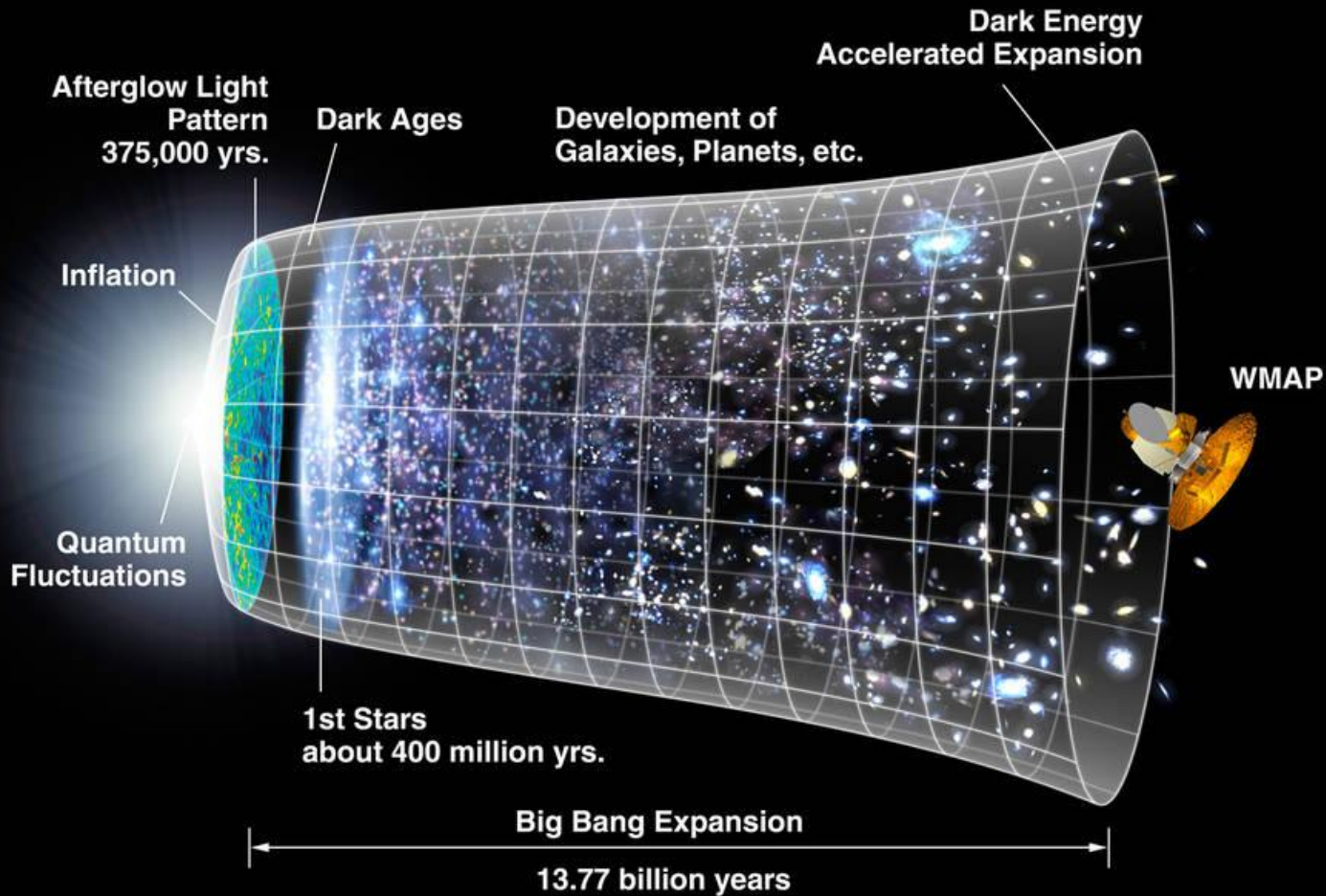
Baryon Acoustic Oscillations



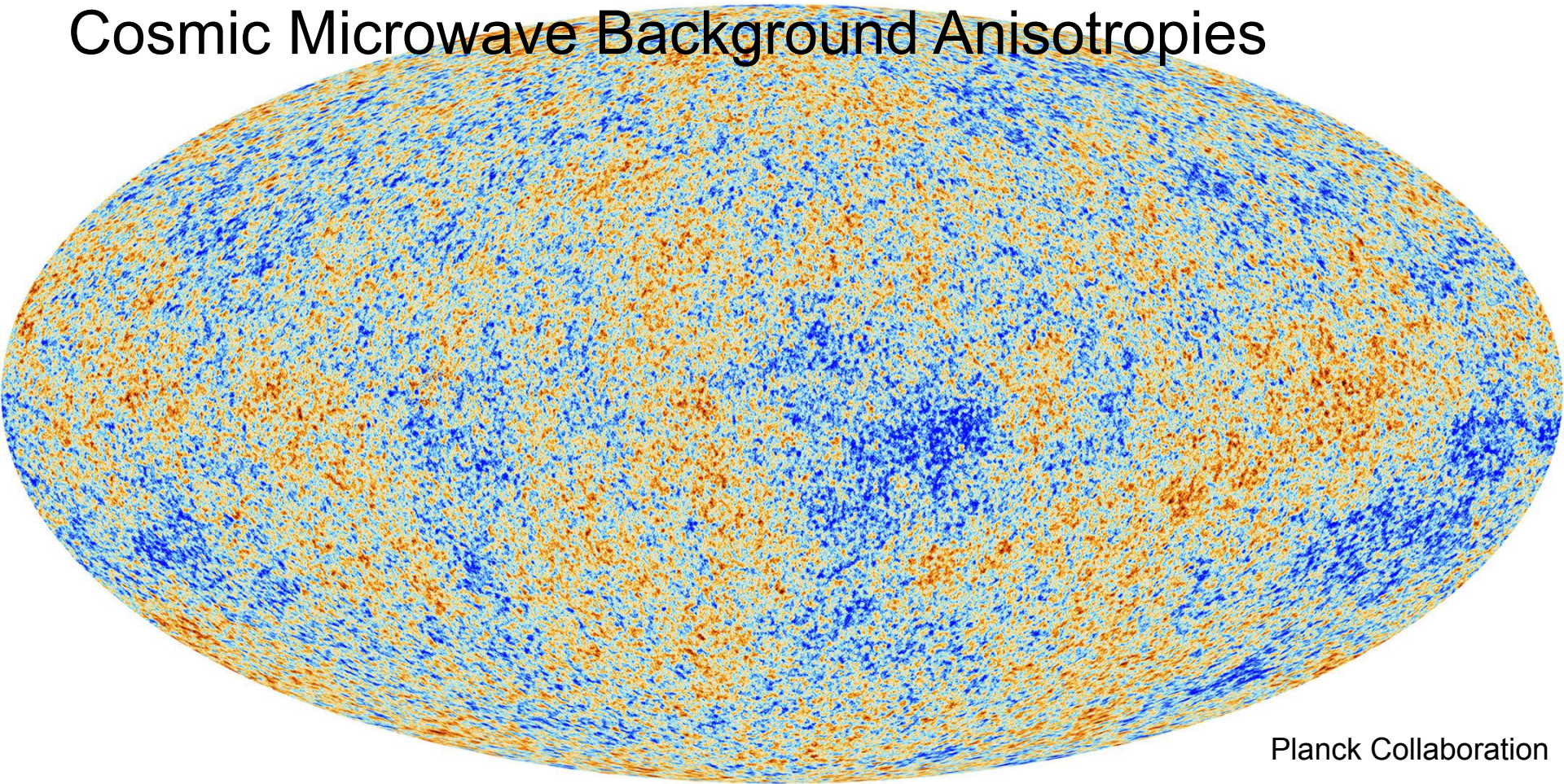
Galaxy map 3.8 billion years ago

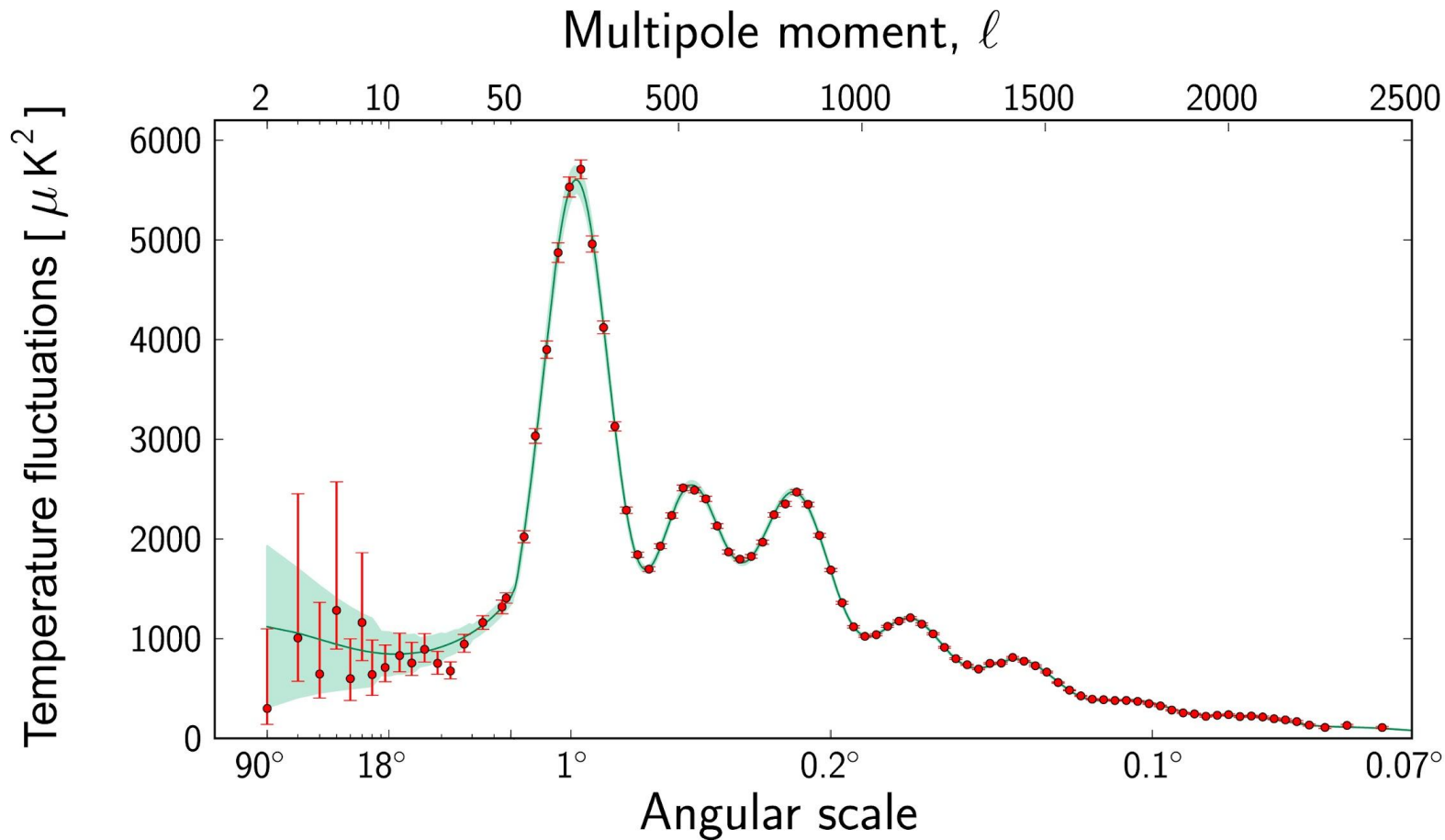
Galaxy map 5.5 billion years ago

CMB 13.7 billion years ago

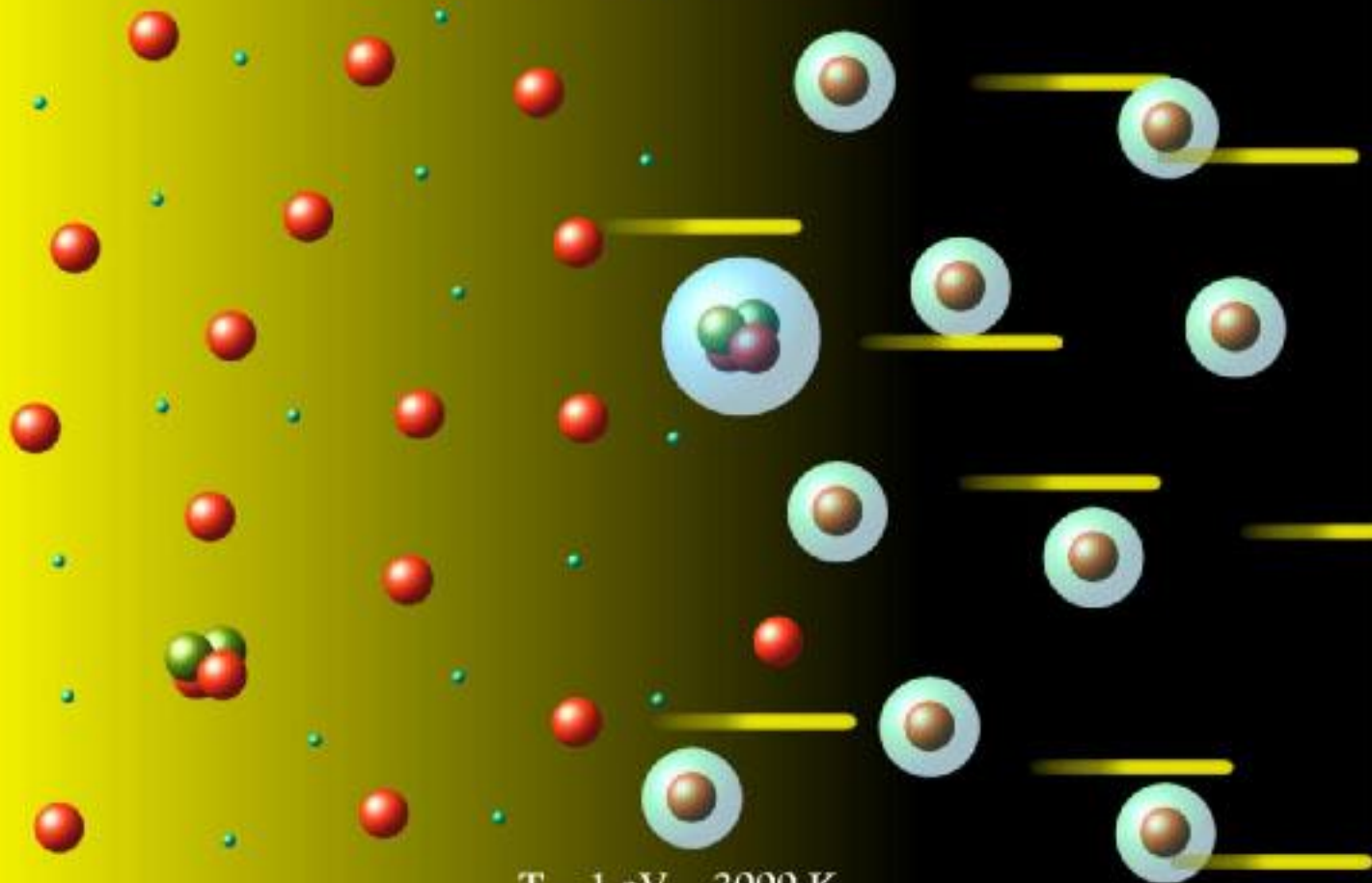


Cosmic Microwave Background Anisotropies





Recombination



10 eV

$T \sim 1 \text{ eV} \sim 3000 \text{ K}$

0.1 eV

Kinney (2002)

Early Acoustic Waves

Before recombination

- Universe is ionized
- Photons provide pressure and restoring force
- Perturbations oscillate as acoustic waves

After recombination

- Universe is neutral
- Photons can travel freely
- Perturbations grow by gravitational instability

Sound Waves

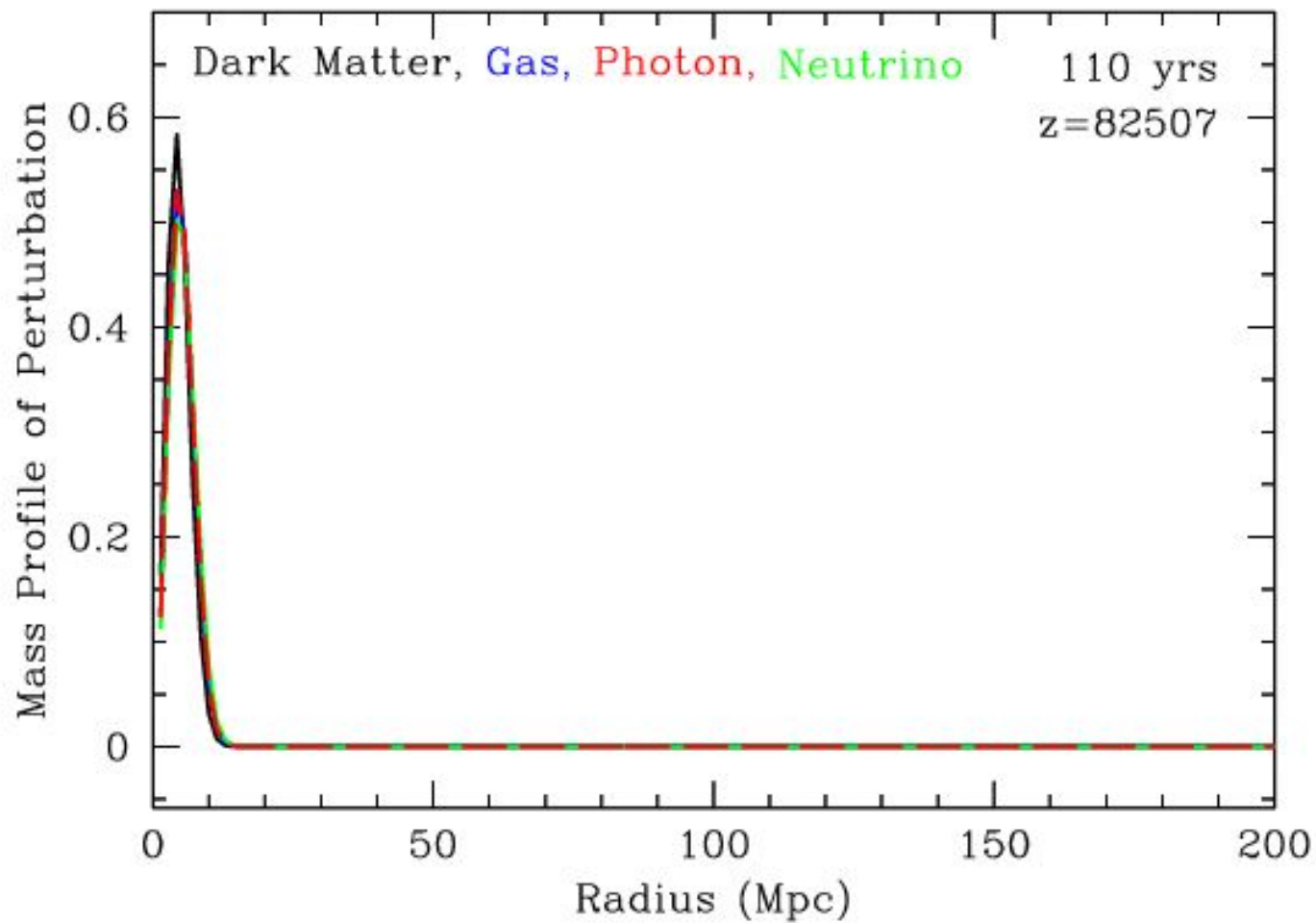
Every initial overdensity (dark matter & gas) is overpressured and launches a spherical sound wave

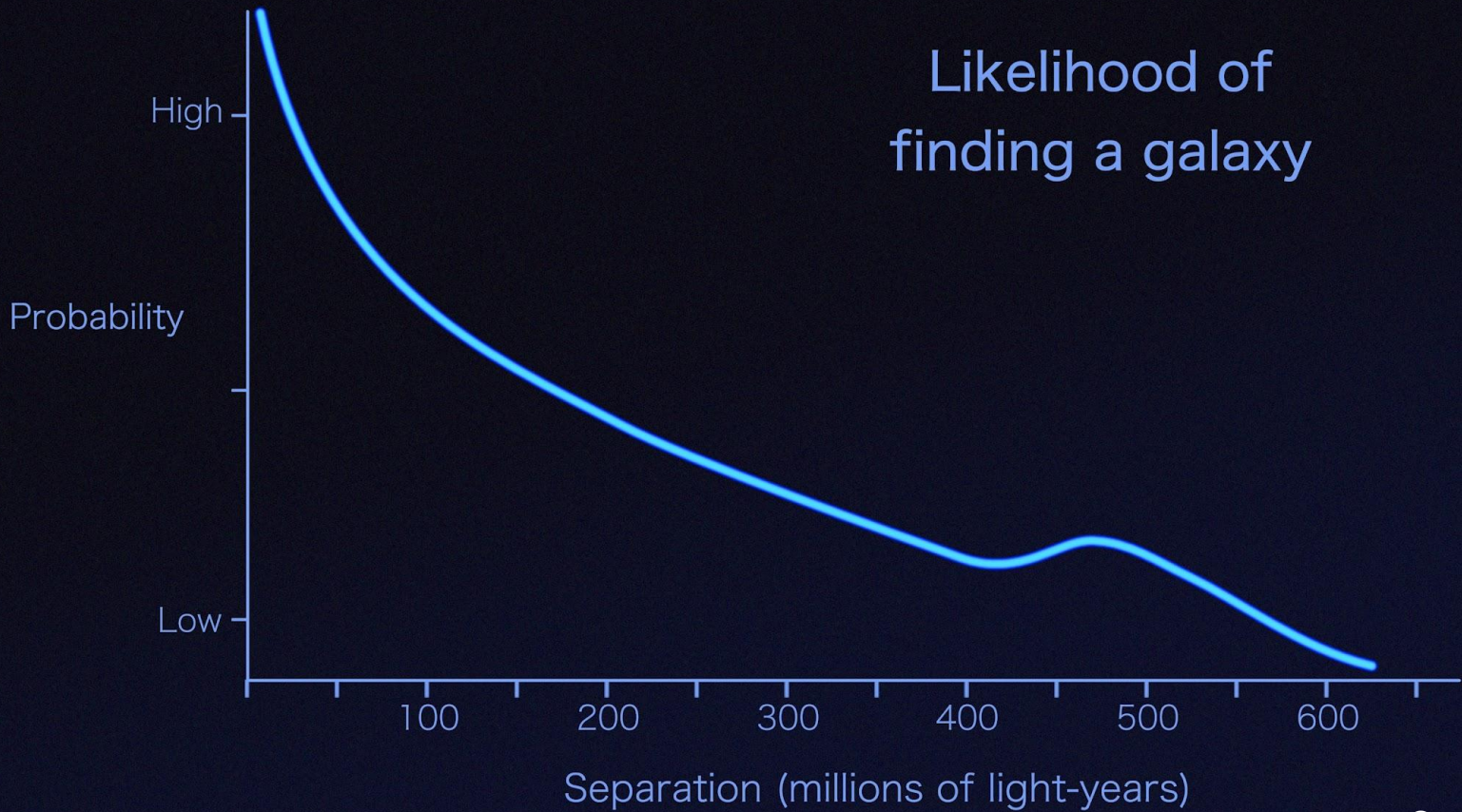
The wave travels outwards at about 60% of the speed of light

After recombination, the photons decouple, so the photon pressure is lost and the wave stalls

The decoupled photons are visible as the CMB

The overdensities seed the formation of galaxies with a preferred separation of 150 Mpc (500 Mly)



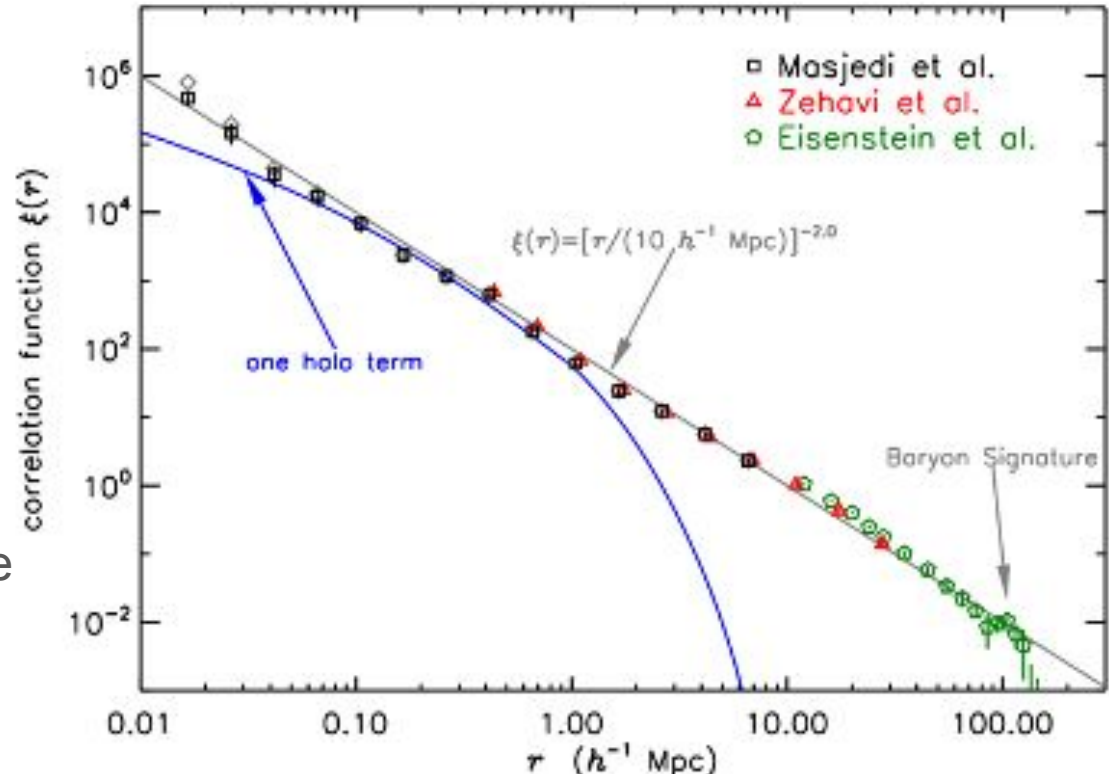


Large Scale Structure

Probability of observing galaxy 2
at distance r from galaxy 1

$$dP_{12}(r) = n^2 [1 + \xi_{12}(r)] dV_1 dV_2$$

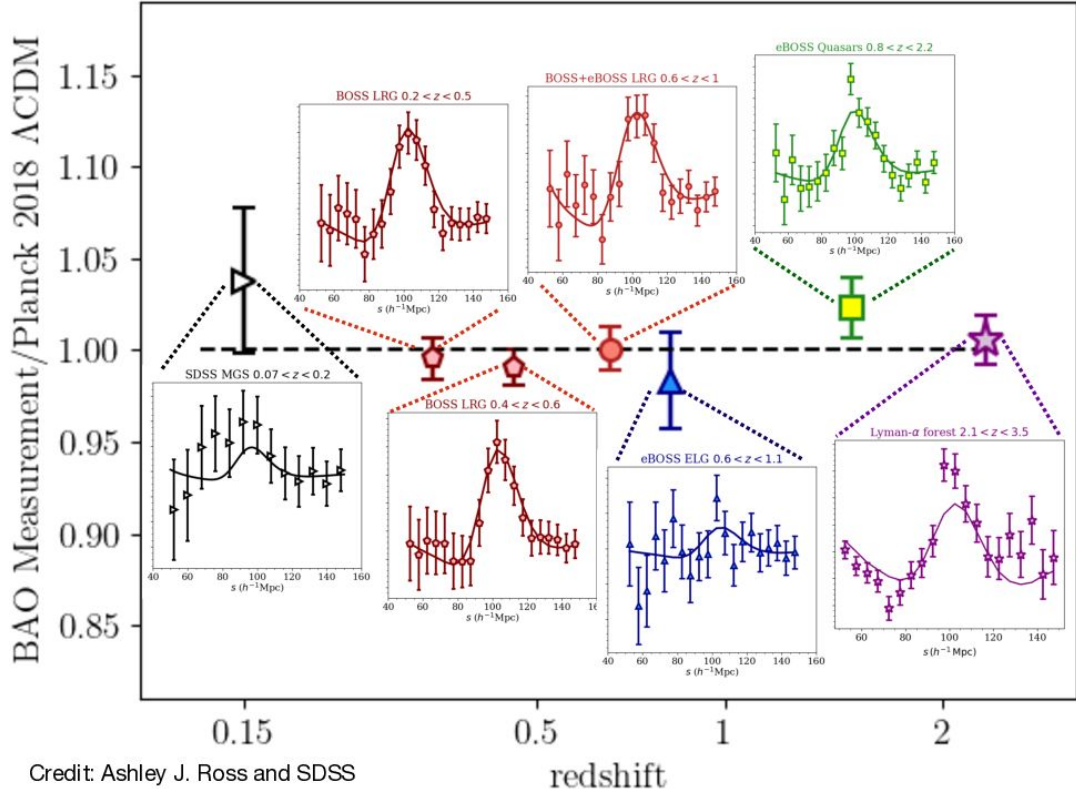
Measure in both the comoving
direction (along the line of sight)
and angular separate (transverse
to the line of sight)



Credit: Masjedi et al. (2005)

Best measurement circa 2020

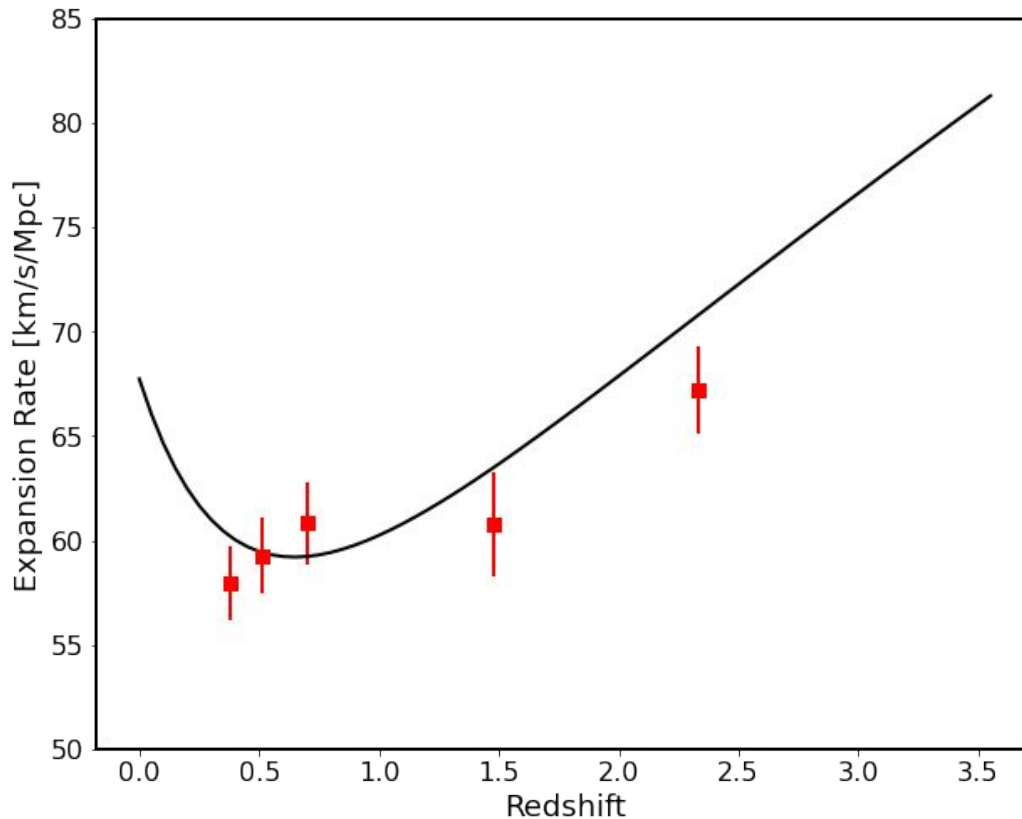
SDSS BAO Distance Ladder



About 3M galaxies and quasars

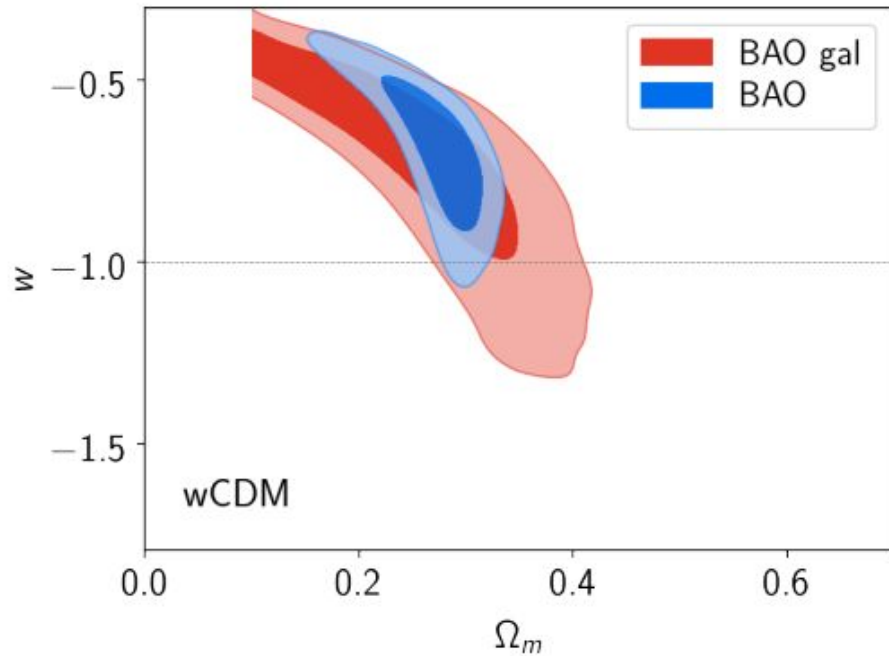
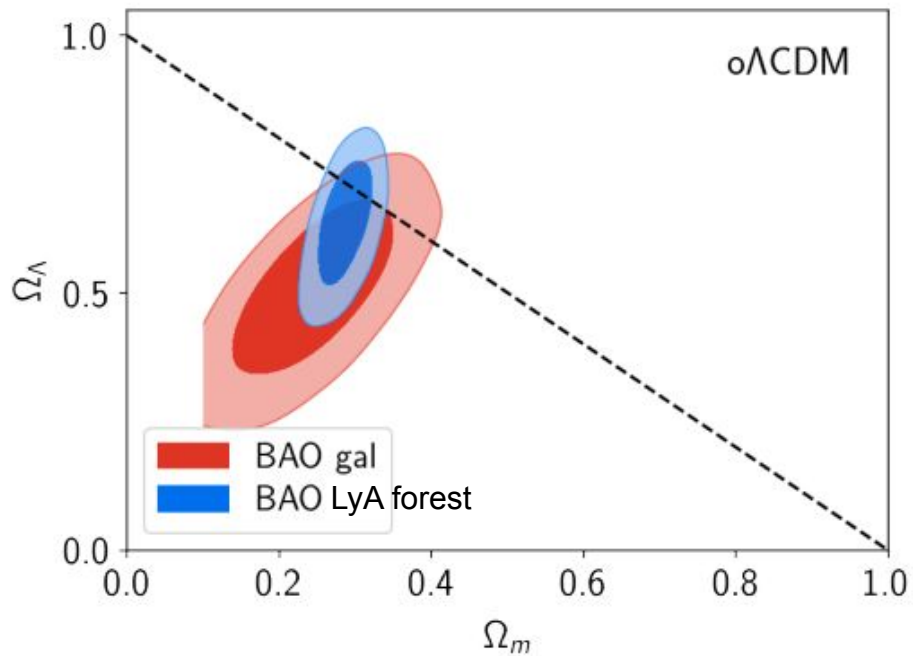
Credit: Ashley J. Ross and SDSS

Best measurement circa 2020

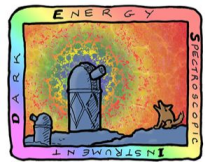


About 3M galaxies
and quasars

Dark Matter and Energy circa 2020

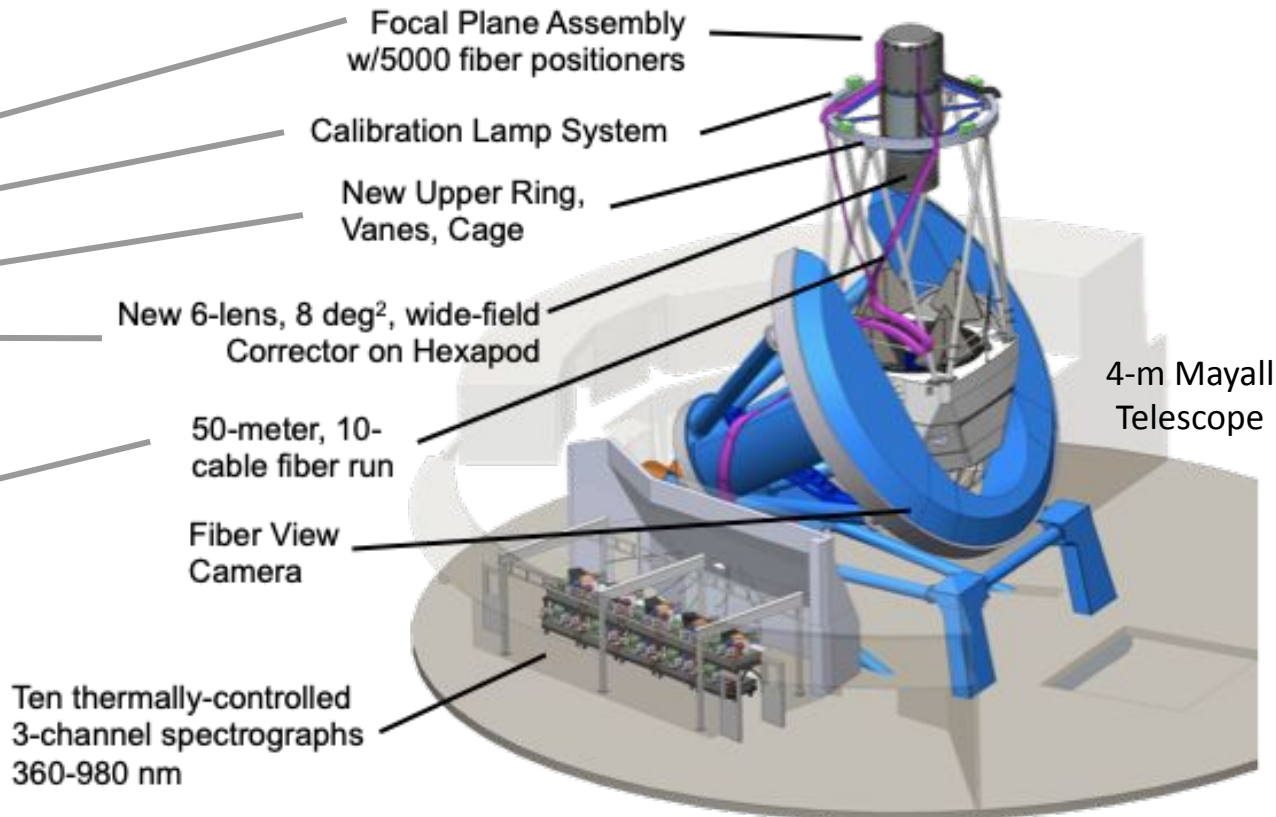


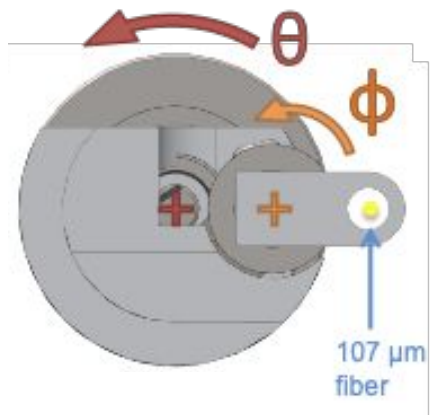




DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science





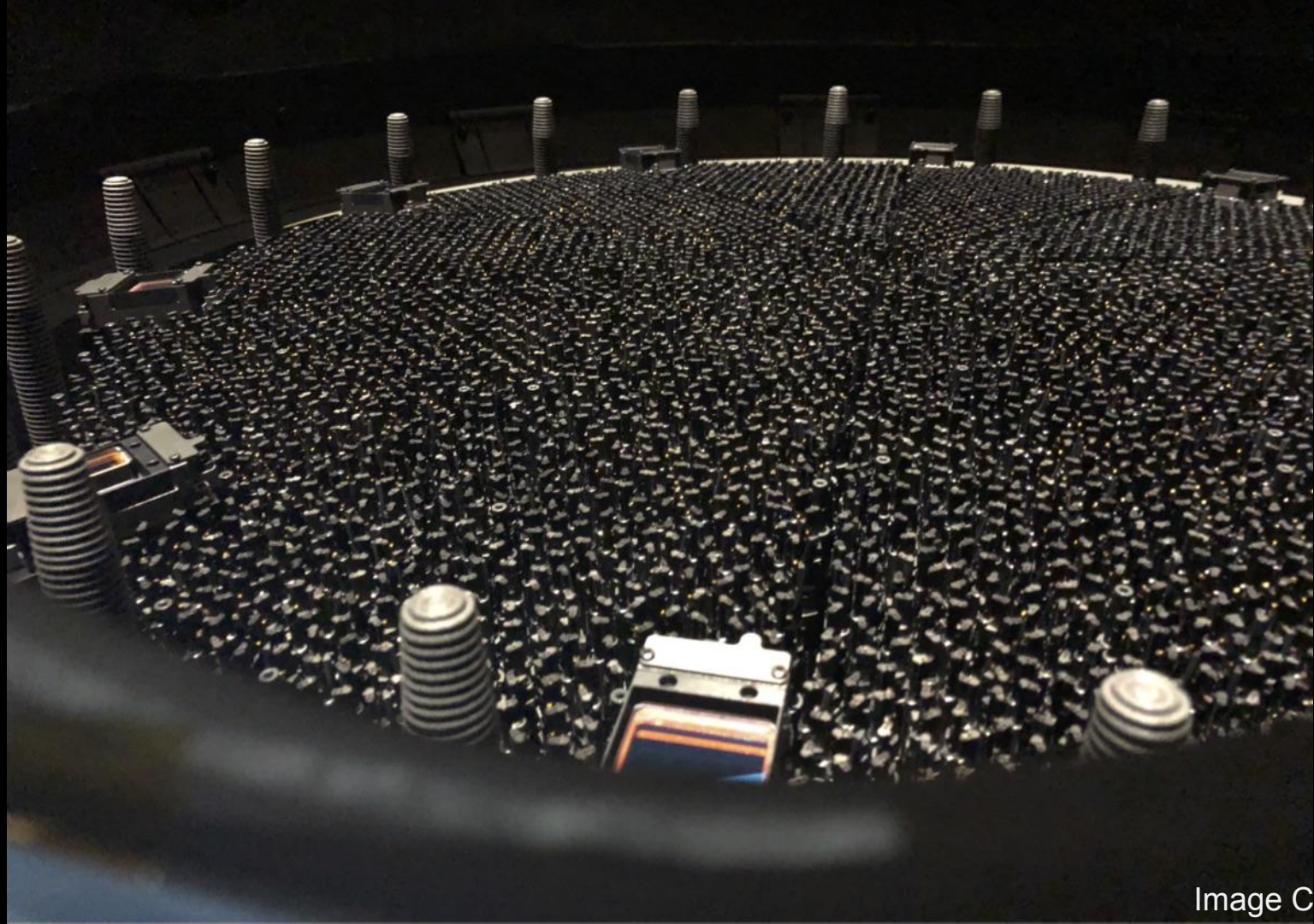


Image Credit: DESI



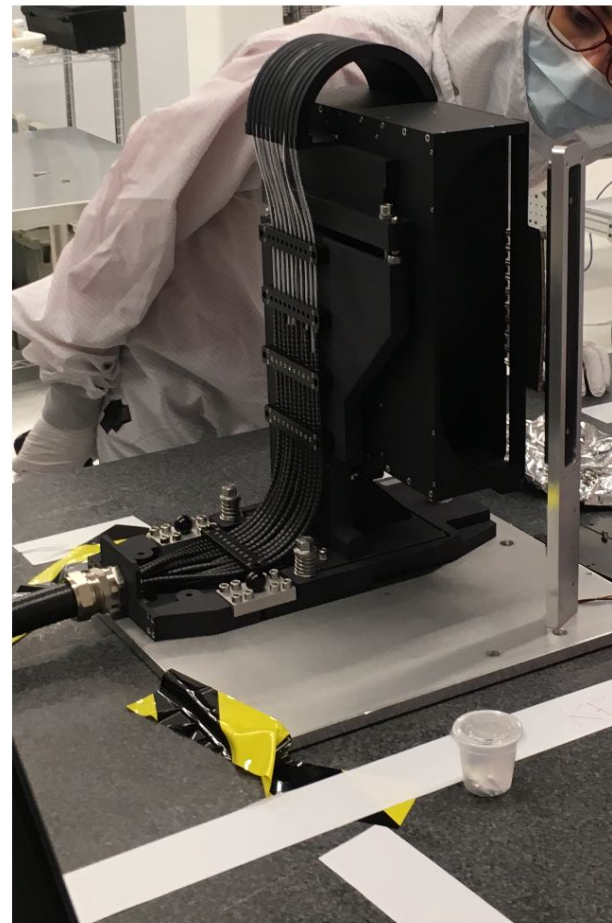
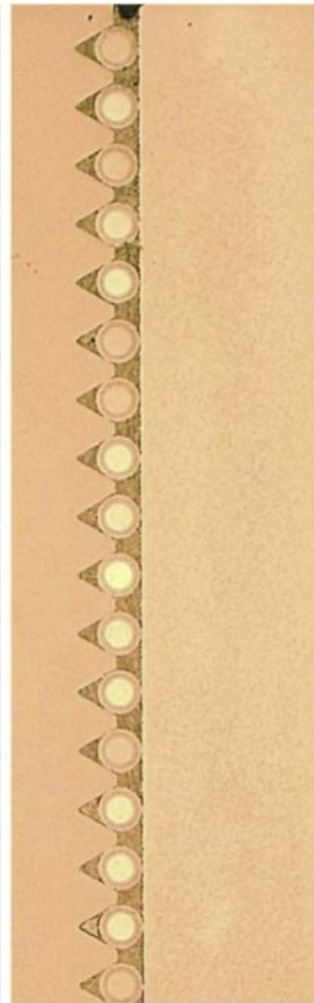


Image Credit: DESI



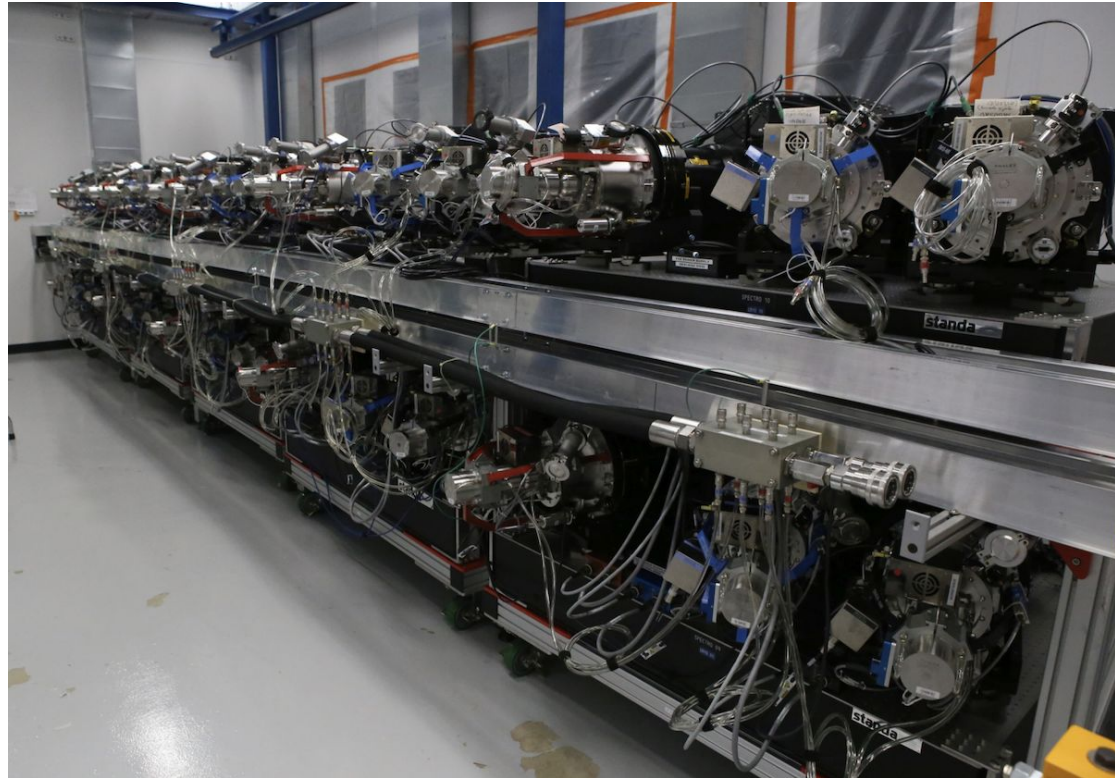
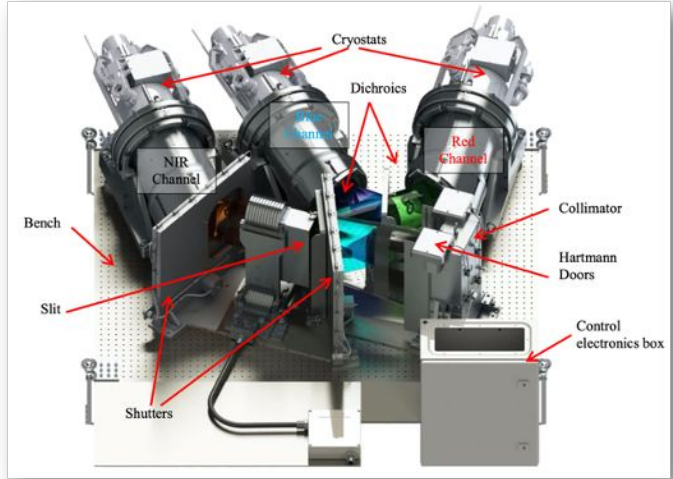
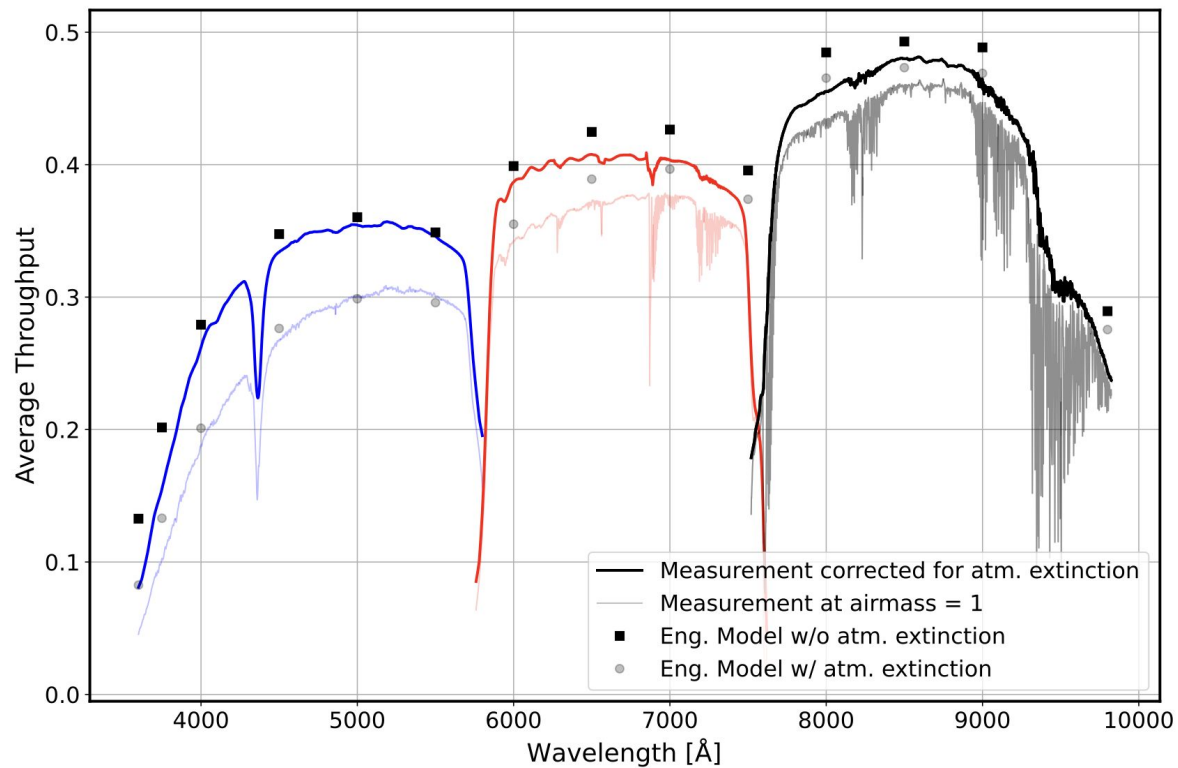
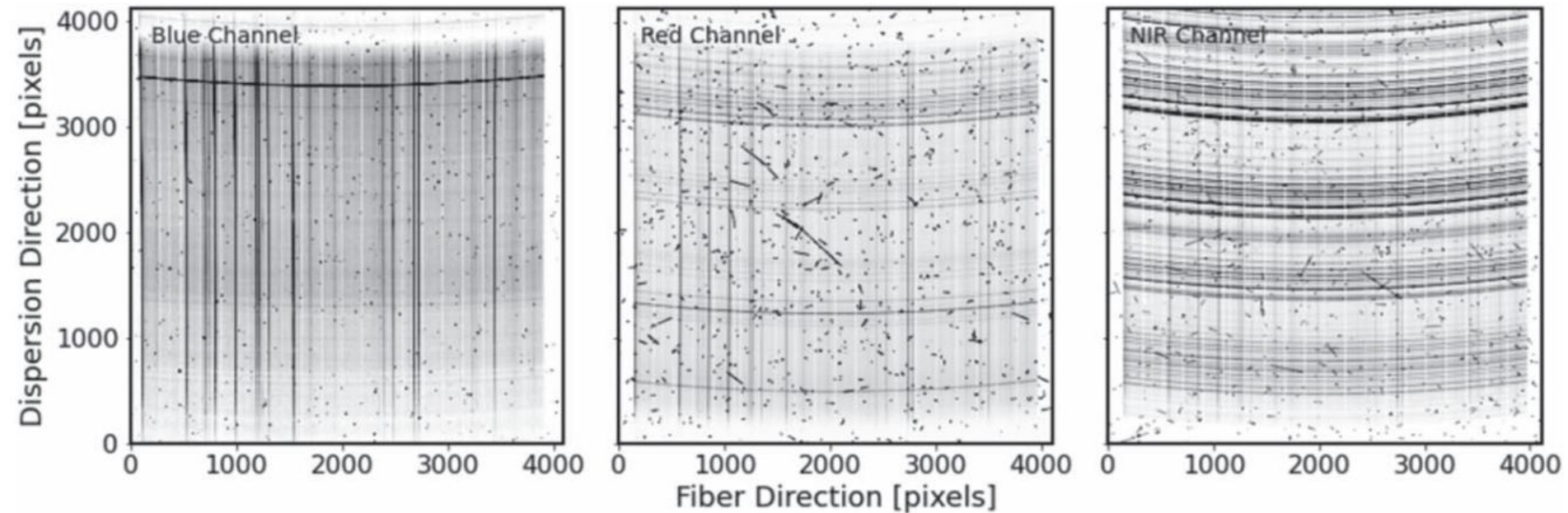


Image Credit: DESI

Superbly sensitive



Raw data from one spectrograph



Example of our beautiful data

Target selection from Imaging Survey



Credit: C. Poppett

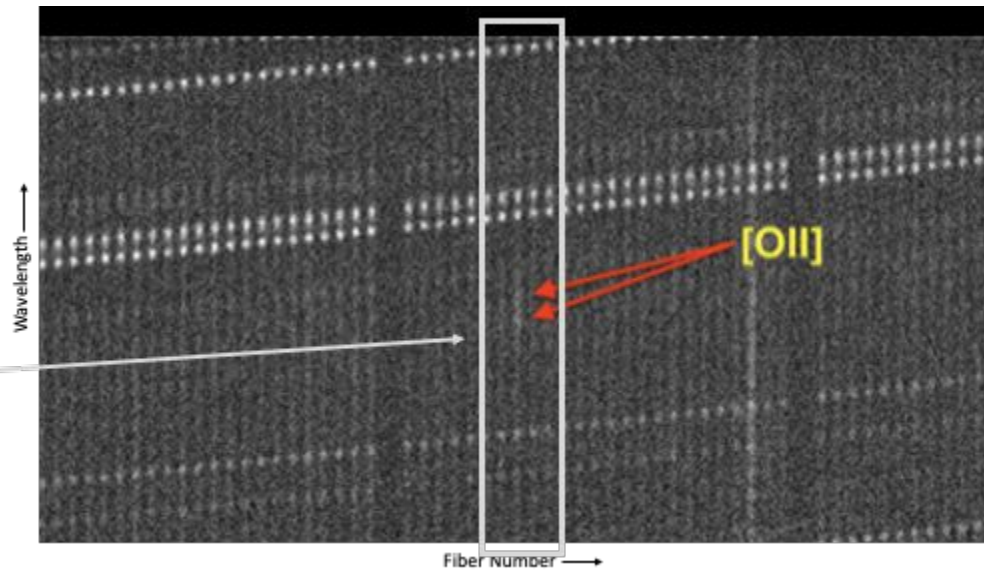
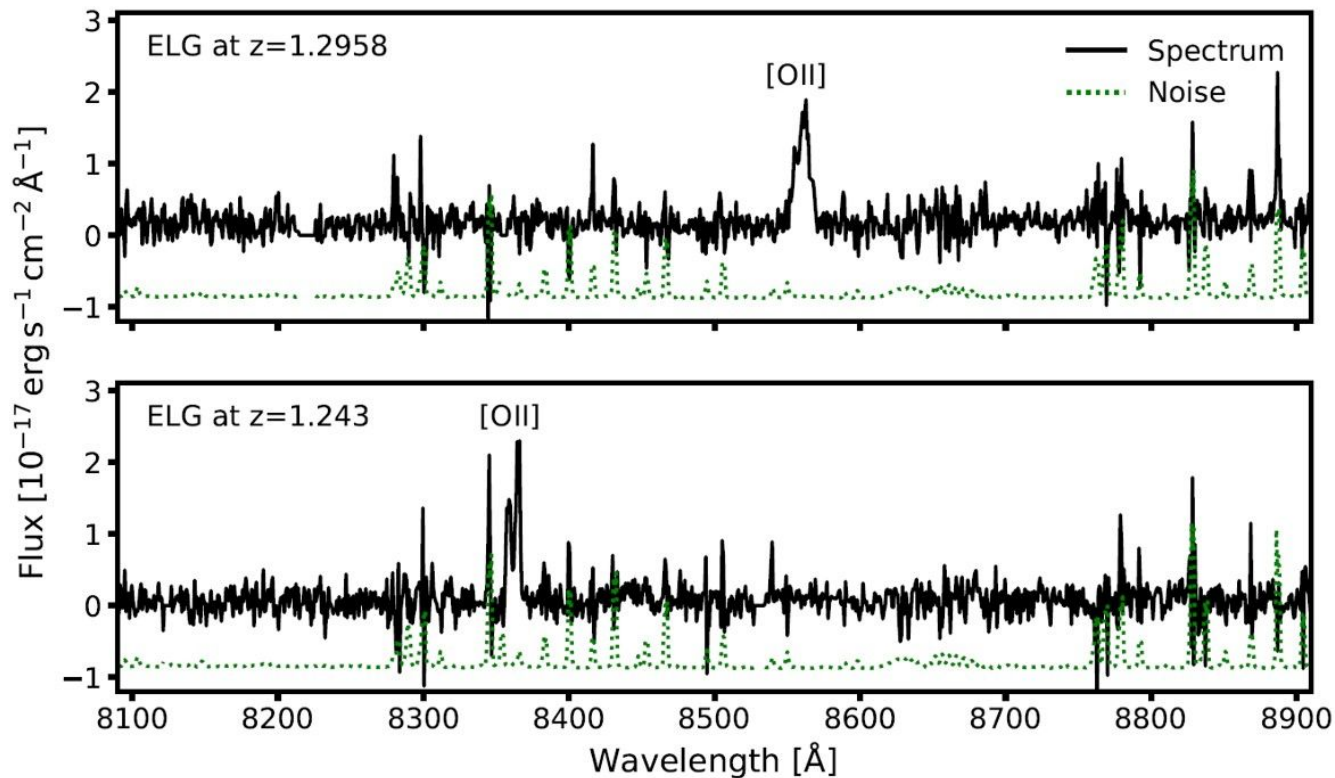
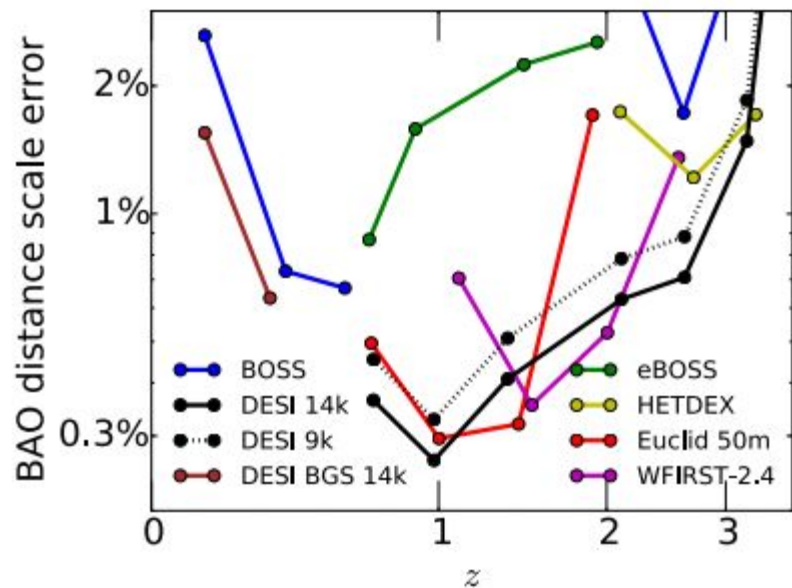
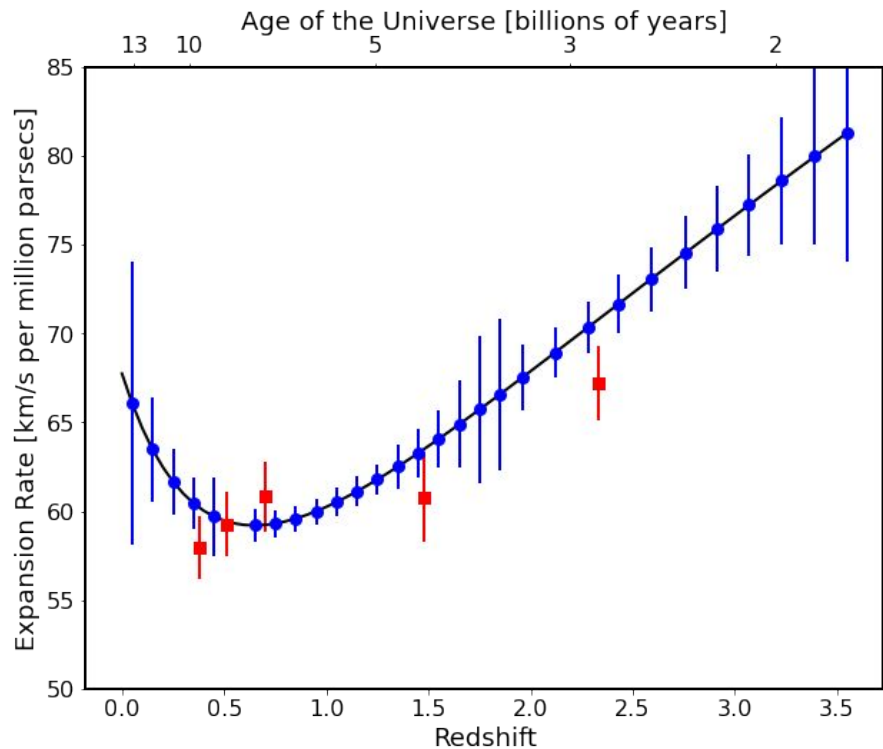


Image Credit: DESI

Example of our beautiful data

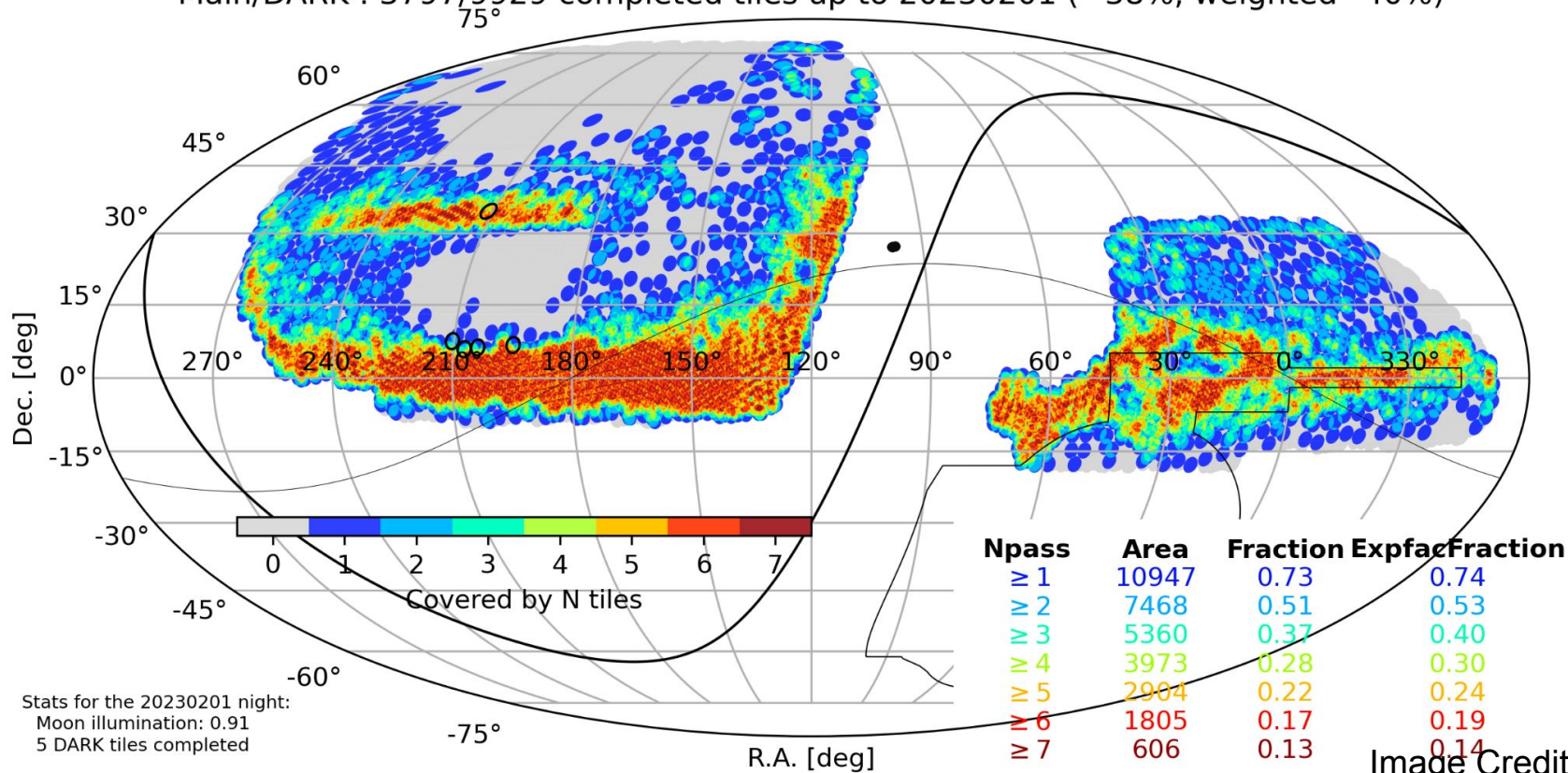


DESI Forecasts

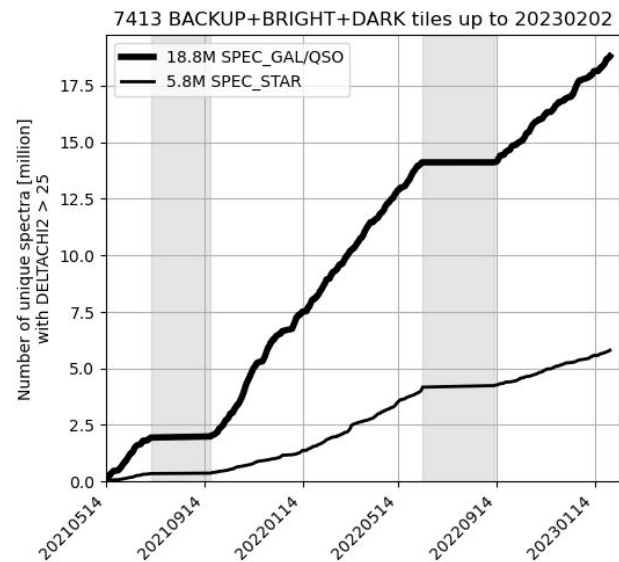
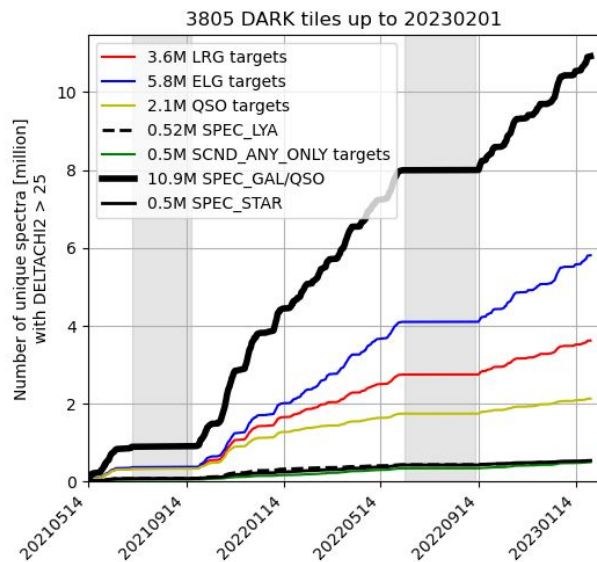
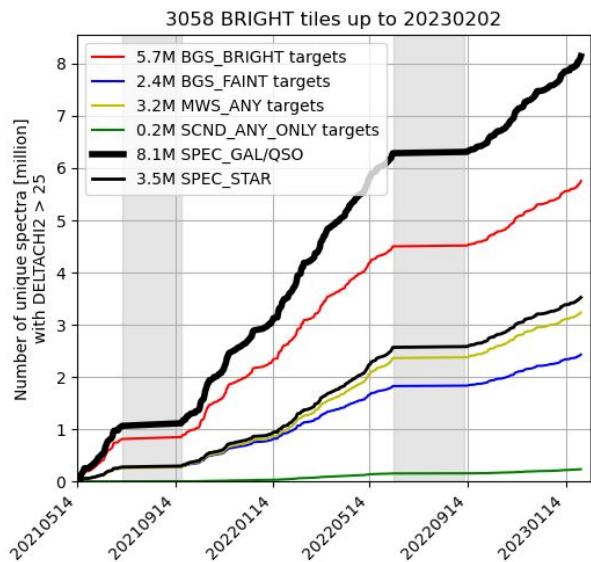


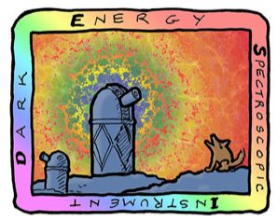
DESI Status

Main/DARK : 3797/9929 completed tiles up to 20230201 (=38%, weighted=40%)



DESI Status





DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science



GOBIERNO
DE ESPAÑA

MINISTERIO
DE ECONOMÍA
Y COMPETITIVIDAD



GORDON AND BETTY
MOORE
FOUNDATION



Science & Technology
Facilities Council



We are honored to be permitted to conduct astronomical research on Iolkam Du'ag (Kitt Peak), a mountain with particular significance to the Tohono O'odham Nation.