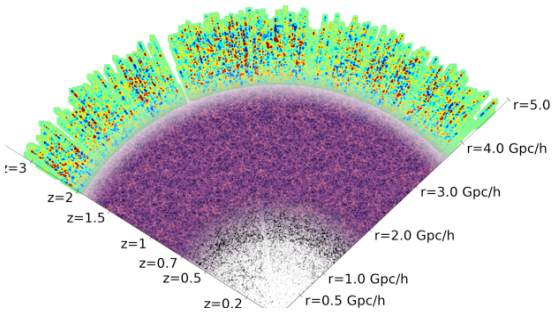
DESI Dark Energy Spectroscopic Instrument

The Dark Energy Spectroscopic Instrument (DESI) will conduct a world-leading redshift survey, making a three-dimensional map of the universe reaching to redshift 3.5 over more than 1/3 of the sky. Using 35 million galaxies and quasars observed from the Kitt Peak National Observatory Mayall telescope, DESI will make precise measurements of the expansion history of the Universe and use the growth of cosmological structure to study the properties of gravity, neutrinos, and the inflationary epoch in the early Universe.

Through its large and well-characterized survey, the DESI survey will provide a rich tool for cosmology. DESI will make exquisite measurements of the cosmic distance scale and the impact of dark energy using the baryon acoustic oscillations imprinted in the distribution of galaxies, quasars, and the Lyman-α forest. Dark energy and dark matter will be further studied using measurements of peculiar velocities and galaxy clustering. The DESI survey will probe these cosmological effects over a wide range of redshifts, from the clustering of intergalactic hydrogen at redshift 3 to large galaxy samples at intermediate redshift to dense samples of low-redshift galaxies. In addition the study of dark energy, DESI will allow investigations into the evolution of the intergalactic medium, the origin of black holes, the astrophysics of stellar evolution, the structure of the Milky Way, and the mass/energy/chemical cycles within galaxies.

The Survey

DESI aims to study a very large volume of the Universe by targeting specific classes of objects (luminous red galaxies, emission line galaxies, and quasars) for which one can most easily measure redshifts. Over its five-year survey, DESI will map 25 million galaxies and quasars out to redshift 3.5 over 14,000 deg^2 of sky. It will also measure redshifts for 10 million additional bright (r<19.5) galaxies to create a dense map of the low-redshift Universe.



The Instrument

DESI is constructing a new 5000-fiber multi-object spectrograph for the Mayall 4-m telescope at Kitt Peak in Arizona. A new wide-field corrector will provide an 8 square degree field-of-view at prime focus. Optical fibers will feed 10 triple-arm high-throughput spectrographs, simultaneously covering 360–980 nm and reaching spectral resolution R = 4000 in the infrared. The fibers will be rapidly positioned by individual actuators, allowing a rapid cadence of observations. When completed in 2019, DESI will be the world's most powerful wide-field optical spectrograph for wide-field galaxy surveys.

The DESI Collaboration

DESI is managed by the Lawrence Berkeley National Laboratory for the U.S. Department of Energy, and involves more than 200 collaborators from ~40 US and International Institutions. The DESI Project is led by Project Director Michael Levi and Project Scientists Brenna Flaugher and David Schlegel. The DESI Collaboration is led by Spokespersons Daniel Eisenstein and Risa Wechsler, and the chairs of ten science working groups.

Imaging Survey

The DESI Collaboration has begun a new imaging survey to support DESI target selection. We will image 14,000 square degrees in the g, r and z bands, to depths of g =24.7, r = 23.9, z = 23.0. This will be combined with WISE infrared photometry for the selection of DESI targets. This program started in Fall 2014 with the three-year public DECam Legacy Survey; catalogs and reduced data will be made available on regular intervals beginning in Spring 2015.

Telescope	Bands	Area
Blanco	g, r, z	9500 sq. deg
Mayall	z	5000 sq. deg
Bok	g, r	5000 sq. deg
WISE	W1, W2	14000 sq. deg

DESI Dark Time Survey

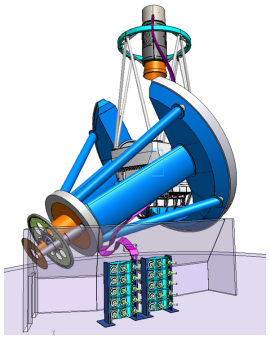
In dark time, the DESI Collaboration will conduct its primary survey of faint galaxies and quasars. This will use luminous red galaxies to z=1 and higher-redshift emission-line galaxies and quasars to probe a large cosmological volume with adequate number density to map the large-scale structure and its acoustic peak. The survey will provide a measurement of the distance scale that is accurate to better than 0.3% from $0 < z < 2$, a measurement of the Hubble parameter with redshift to better than 1% from $2 < z < 4$, and a measurement of the growth factor to a few percent to $z = 1.5$. Combined with CMB data, it will also provide a measurement of the sum of neutrino masses to 0.02 eV rms.

Bright Galaxy Survey

The DESI Collaboration will pursue a large survey of bright galaxies when the moon is too bright or conditions are otherwise unsuitable to observe dark time survey galaxies. We anticipate a survey of at least 10 million galaxies, a nearly complete survey of galaxies brighter than $r < 19.5$ over at least 14000 sq. degrees. The increase in area, volume, and sampling density over previous surveys will make this the reference low-redshift galaxy sample for the future. The Bright Galaxy Survey will allow precision tests of dark energy and gravity using redshift space distortions and baryon acoustic oscillations, provide a catalog of host redshifts for low-redshift supernovae and LIGO events, and supply a rich sample for studies of galaxy and cluster evolution.

Milky Way Survey

Interleaved with the Bright Galaxy Survey, DESI will conduct a survey of bright stellar targets in the Milky Way. These spectra will yield radial velocities, atmospheric parameters, and chemistry information for 10 million stars to V~18, a large increase over current stellar surveys. These quantities will allow investigation of how baryons settled into the Milky Way's dark matter halo. The combination of DESI stellar spectra with the astrometric and photometric data from the all-sky ESA Gaia mission will provide a comprehensive probe of the mass, stellar populations, and assembly history of the Milky Way to regions of the Galaxy beyond the reach of other surveys.



Object Class	Number of Spectra	Redshift Range
bright galaxies, $r < 19.5$	10 million	$0 < z < 0.4$
luminous red galaxies (LRGs)	4.2 million	$0.4 < z < 1.0$
emission line galaxies (ELGs)	18 million	$0.6 < z < 1.6$
quasars (QSOs)	2.4 million	$0.5 < z < 3.5$
Milky Way stars	10 million	---

DESI Collaborating Institutions

DESI has received funding from the U.S. Department of Energy, the Gordon and Betty Moore Foundation, the Heising-Simons Foundation, the Science and Technologies Facilities Council of the United Kingdom, and from Member Institutions: Aix-Marseille Univ.; Argonne National Laboratory; Australian Astronomical Observatory; Brookhaven National Laboratory; Carnegie Mellon Univ.; CEA/IRFU Saclay; Centro de Investigacion y de Estudios Avanzados del IPN; Cornell Univ.; Durham Univ.; Ecole Polytechnique Federal Lausanne; ETH Zurich; Fermi National Accelerator Laboratory; Harvard Univ.; Instituto de Fisica, UNAM, Mexico; Kansas State Univ.; Korean Astronomy and Space Science Institute; Korea Institute for Advanced Study; Lawrence Berkeley National Laboratory; National Optical Astronomy Observatory; New York Univ.; Observatory Nacional, Brazil; The Ohio State Univ.; Queensland Univ.; Siena College; SLAC National Accelerator Laboratory; Southern Methodist Univ.; Swinburne Univ.; Universidad de los Andes; Univ. of Arizona; Univ. of Barcelona; Univ. of California, Berkeley; Univ. of California, Irvine; Univ. of California, Santa Cruz; Univ. College, London; Univ. of Edinburgh; Univ. of Kansas; Univ. of Madrid; University of Michigan; Universidad Nacional Autonoma de Mexico; Univ. of Pittsburgh; Univ. of Portsmouth; Univ. of Toronto; Univ. of Utah; Yale Univ.

Interested in learning more about DESI? Visit http://desi.lbl.gov, or contact Director Michael Levi (levi@lbl.gov) and/or Spokespersons Daniel Eisenstein (deisenstein@cfa.harvard.edu) & Risa Wechsler (rwechsler@stanford.edu).