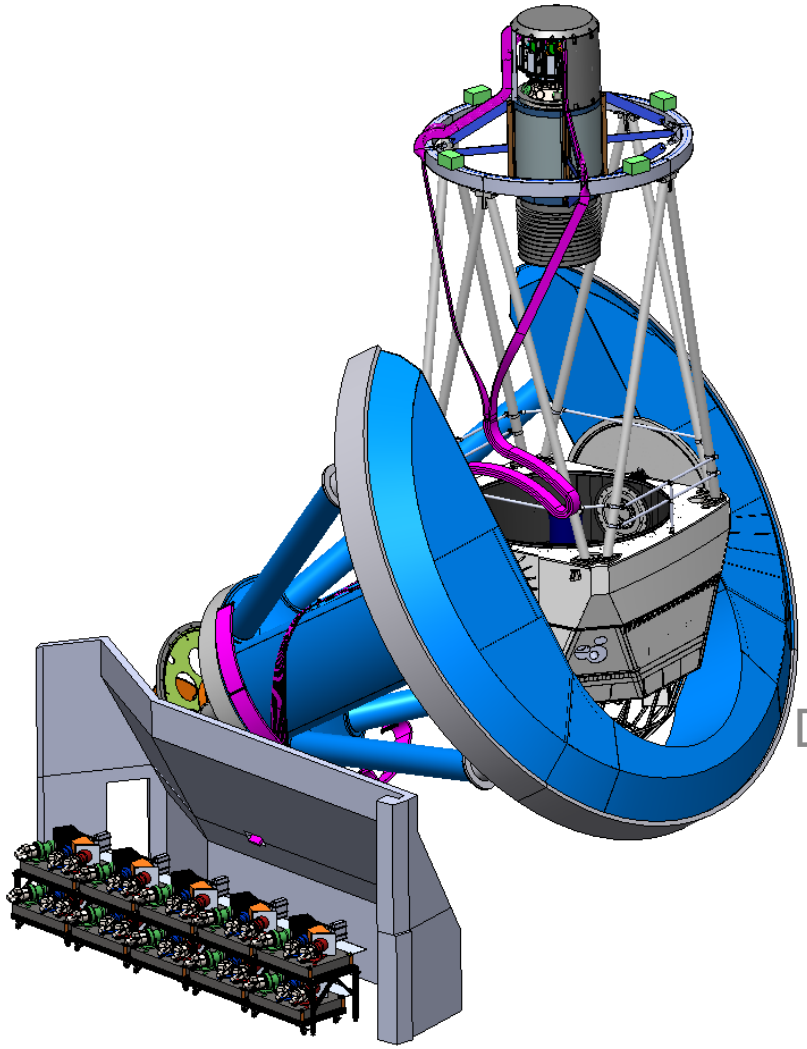


DESI Project Overview

Peter Nugent(LBNL)
Department Head for Computational Science
Lawrence Berkeley National Laboratory

DESI Scientific Experiment Goals

Using the DESI Instrument fabricated by the project…

- We will observe 14,000 deg^2 of the night sky
- Will study the distribution of ~ 35M distant galaxies (correlations between them)
- The DESI Science Goals echo the CD-0 and P5 recommendations: precision measurement of dark energy, while making important contributions to the physics of inflation and neutrinos
- The Science Requirements Document (SRD) flows these science goals to the instrument requirements
- We use a rigorous Systems Engineering approach to tie the science to the requirements for the experiment

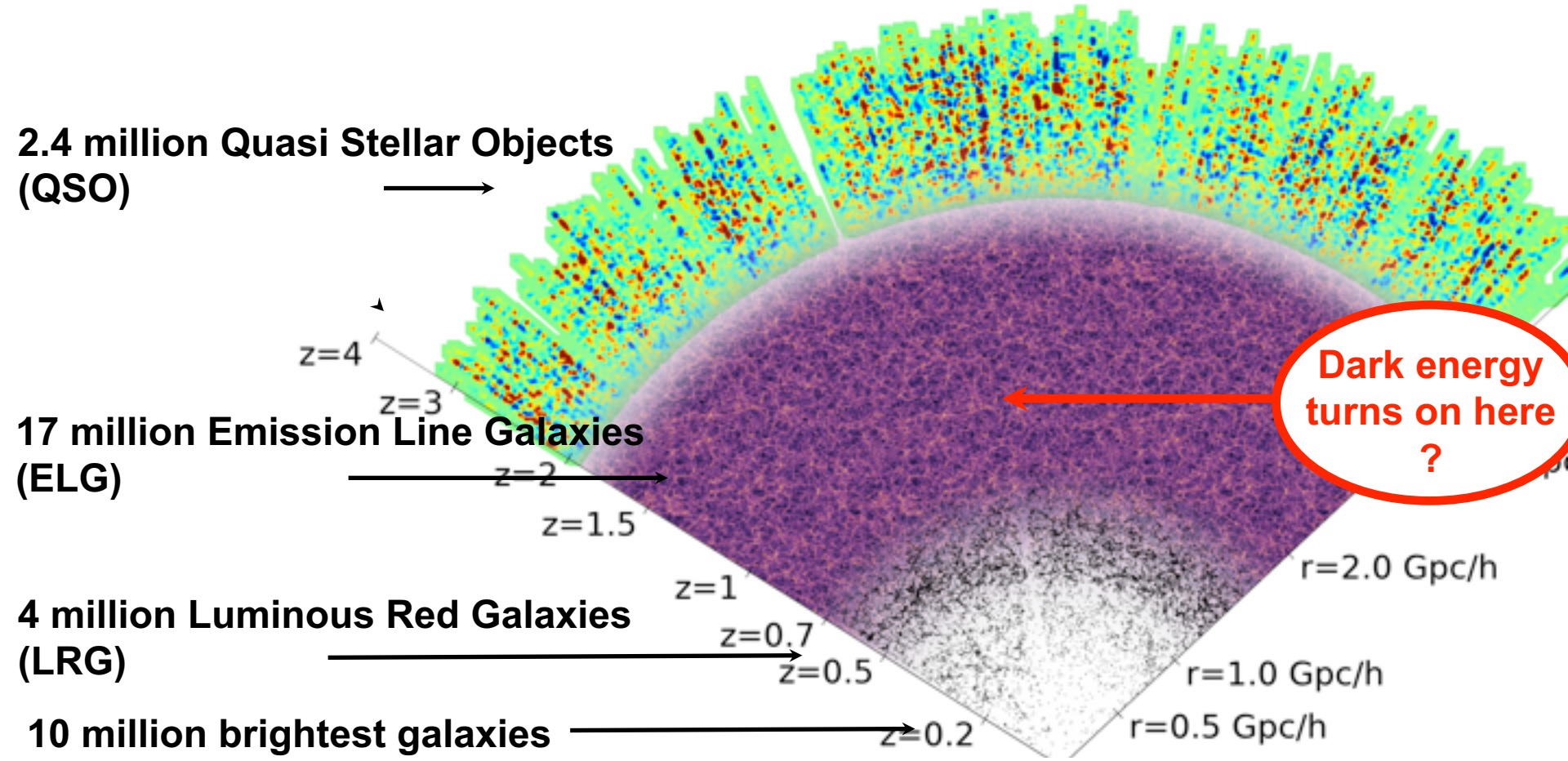
CD-0 Mission Need Statement defines the DESI science goals

- Mission Need Statement:
  - *1. Determine as well as possible whether the accelerating expansion is consistent with a cosmological constant.*
  - *2. Measure as well as possible any time evolution of the dark energy.*
  - *3. Search for a possible failure of general relativity through comparison of the effect of dark energy on cosmic expansion with the effect of dark energy on the growth of cosmological structures like galaxies or galaxy clusters.*

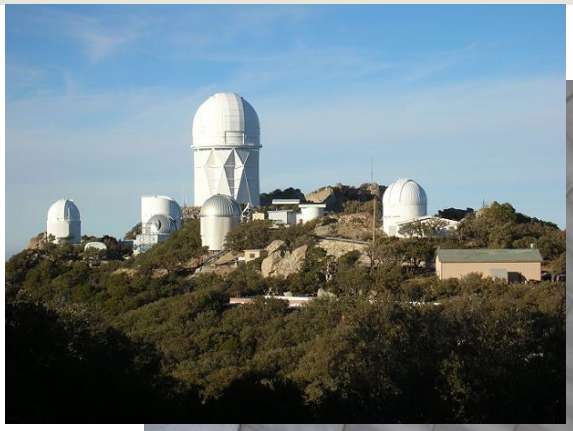
- Will use Baryon Acoustic Oscillation (BAO) & Redshift Space Distortion (RSD) techniques
- BAO gives us a ruler in the sky and enables us to measure the expansion of the Universe
- RSD allows us to measure the pull of gravity and check General Relativity

DESI will be the largest spectroscopic survey for dark energy. Each spectrum measures a galaxy redshift.

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

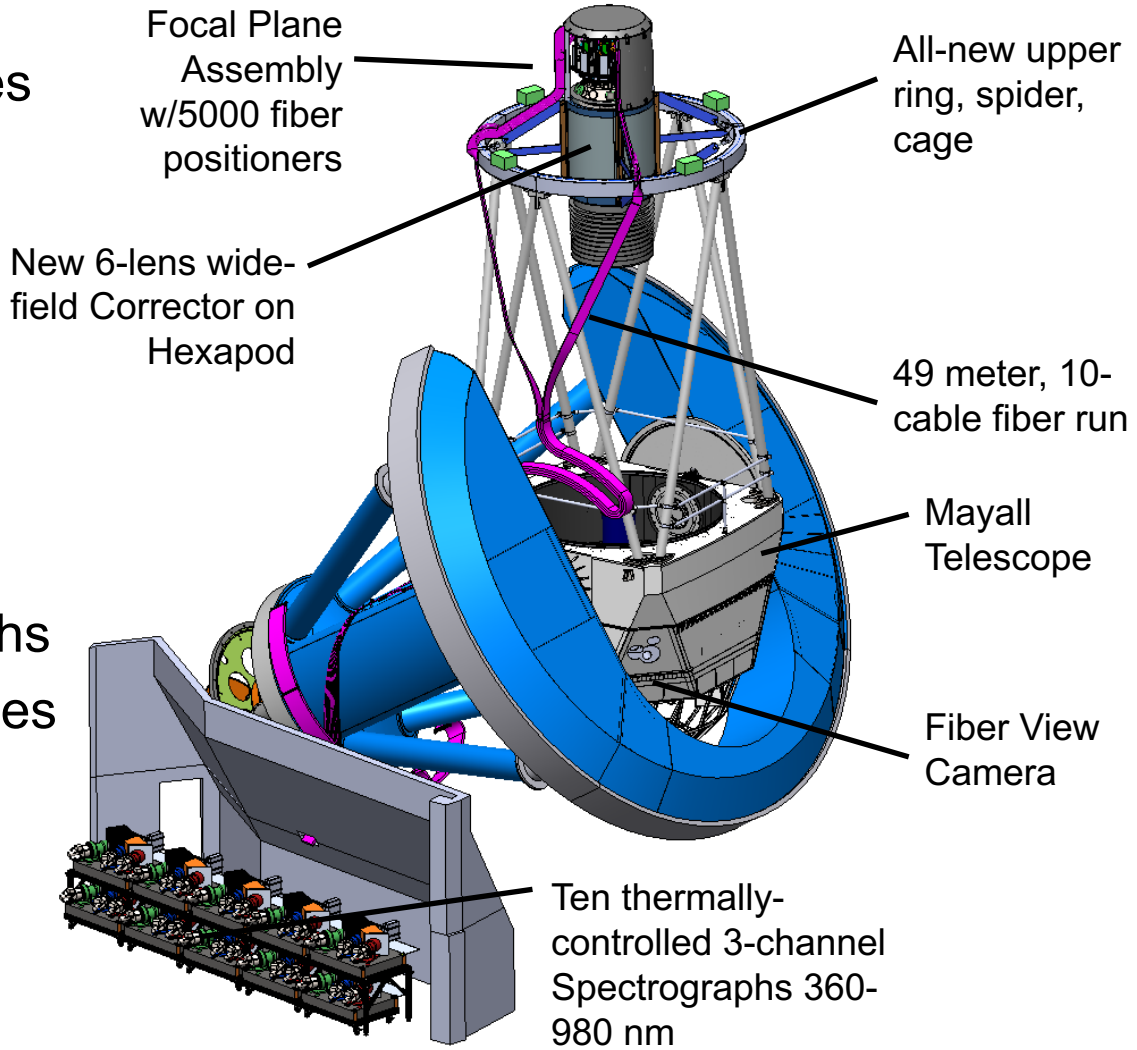


DESI is being installed at the Mayall 4-m Telescope at Kitt Peak, Arizona



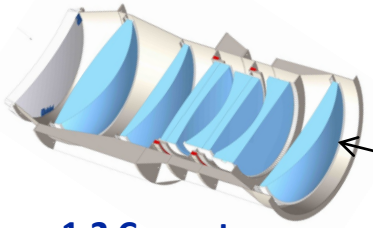
DESI Overview

- DESI is a Fiber-fed multi-object spectrograph. It uses robotic control to position a fiber optic strand onto the location of a known galaxy
- 5000 robotically positioned optical fibers on the focal plane
- New 8 sq.deg. FOV
- Ten 3-channel spectrographs
- Spectra of 35 million galaxies and quasars over 14,000 deg^2 in five years



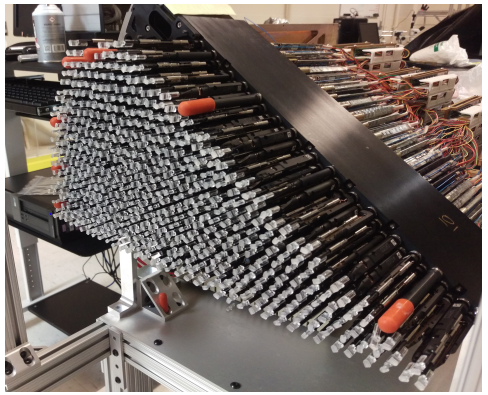
Hardware Elements: following the path of a photon

Light bounces off the primary, then…

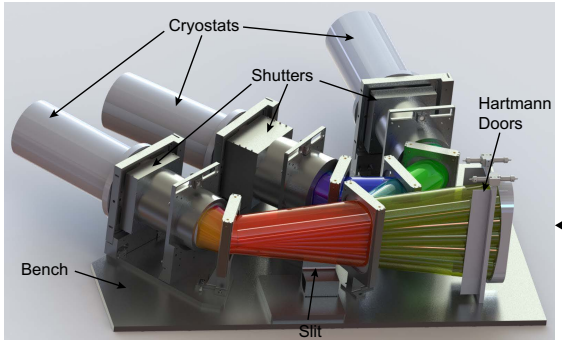


1.2 Corrector

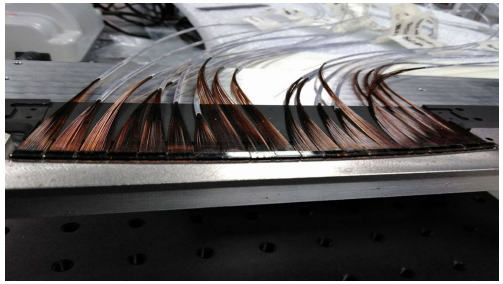
1.3 Cage & Barrel



1.4 Focal Plate



1.6 Spectrograph



1.5 Fiber System

Top-end removal

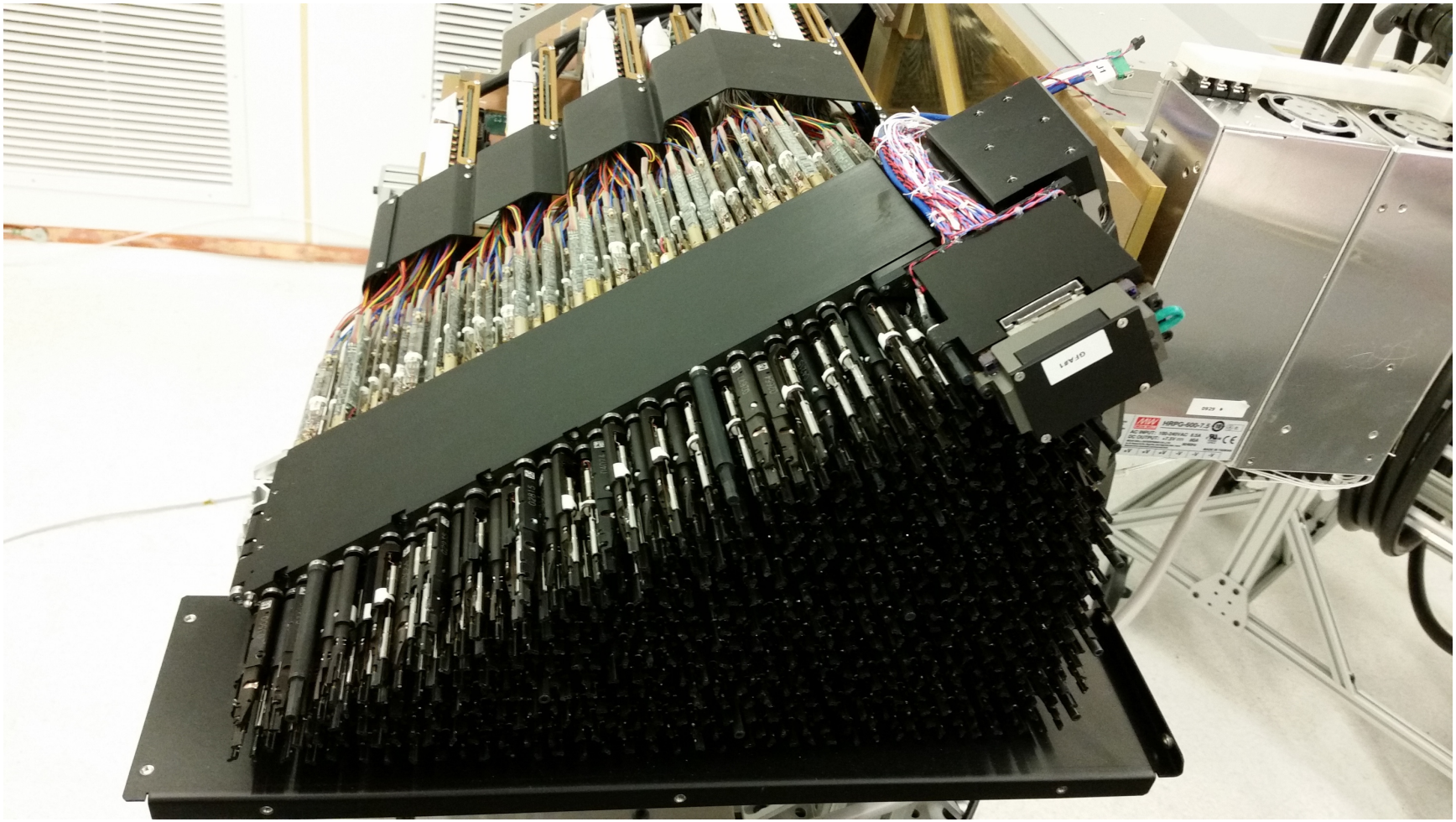
With help of a very large crane….

WBS 1.3 Corrector Mechanical Support System is complete (FNAL deliverable)

Cage and Ring being delivered to the Mayall telescope building

Assembled to go on the top-end of the telescope

WBS 1.4 Completed Production Petal with Guider, eight of ten are finished

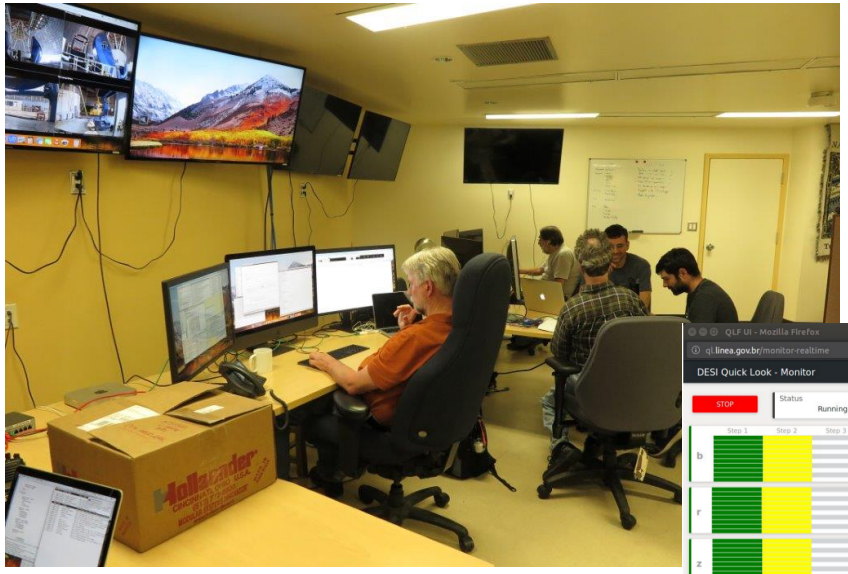


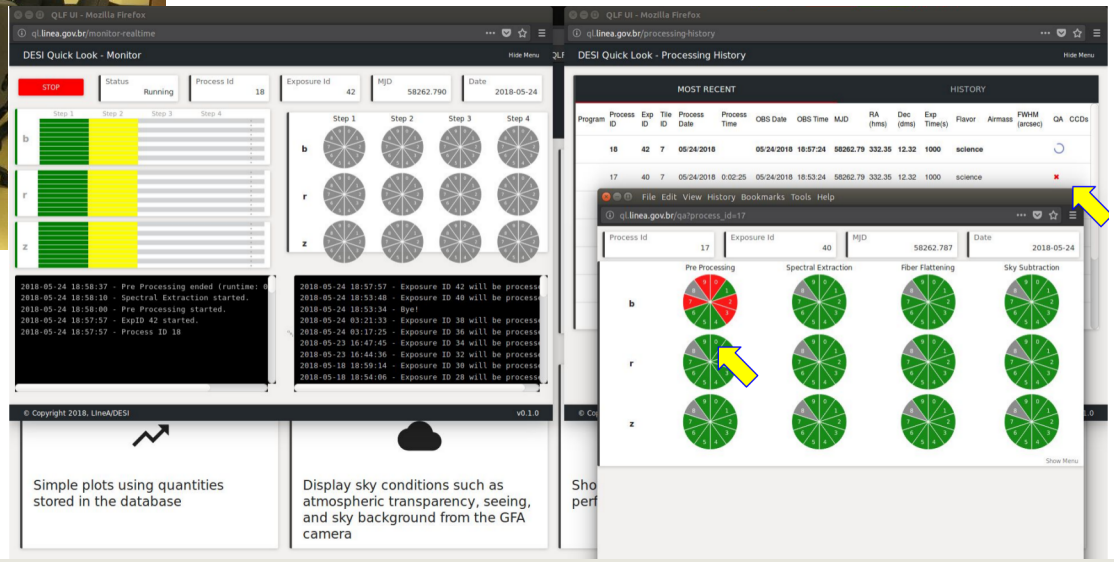
WBS 1.6 Spectrograph System

First of ten spectrographs delivered to Kitt Peak

WBS 1.7 Instrument Control System is completed

- New control room constructed
- Mock Observing Run at Kitt Peak
- All deliverables received and accepted

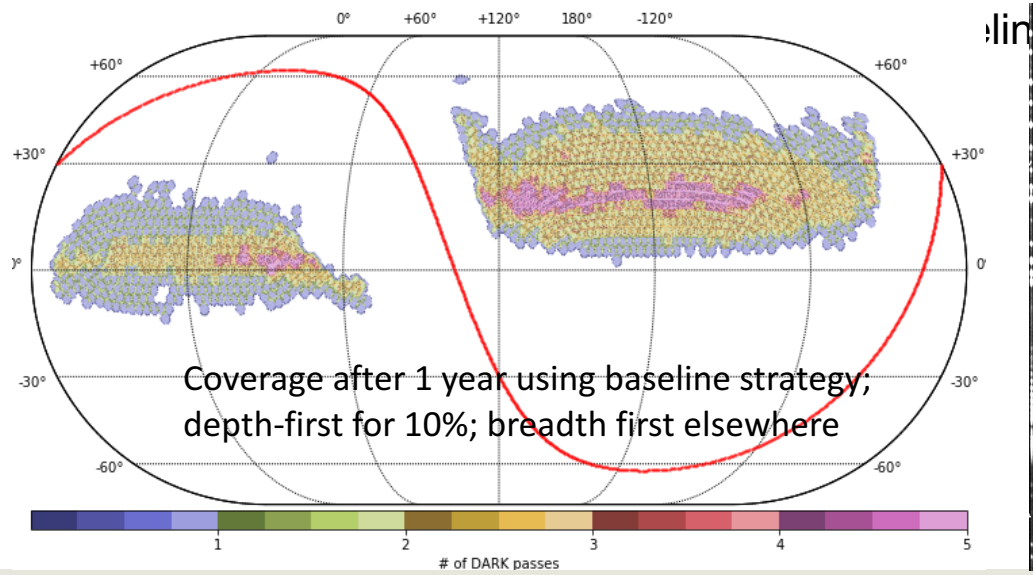




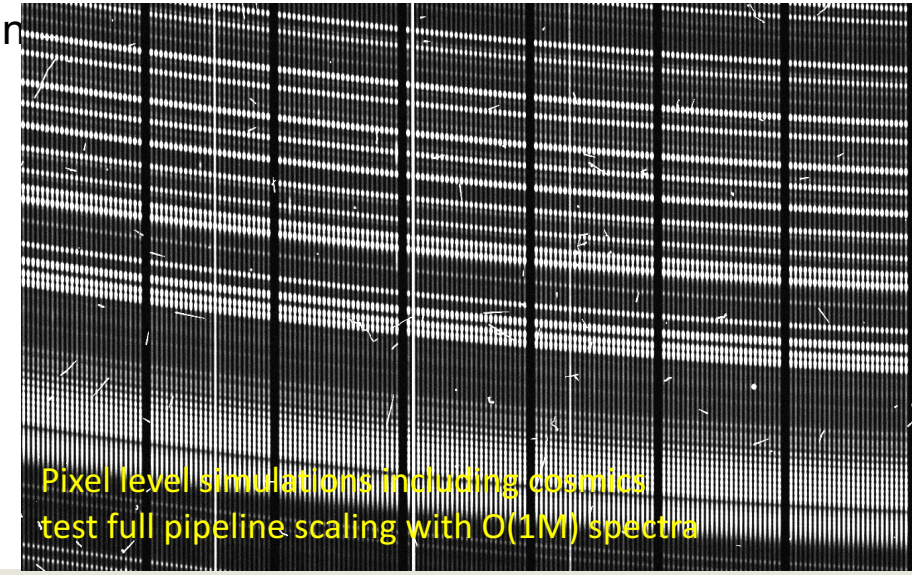
WBS 1.8 Data Systems is completed

WBS 1.8 Data Systems

- All deliverables received and accepted
- Spectroscopic data reduction pipeline
  - Refined algorithms using EM spectrograph data, e/BOSS data, pixel-level sims
  - Testing performance and scaling at NERSC, routinely processing ~1M spectra
- Data challenges at multiple levels of fidelity / completeness
  - Full 5 year survey operations simulations
  - Spectra simulations + calibrations + redshifts for ~5M spectra

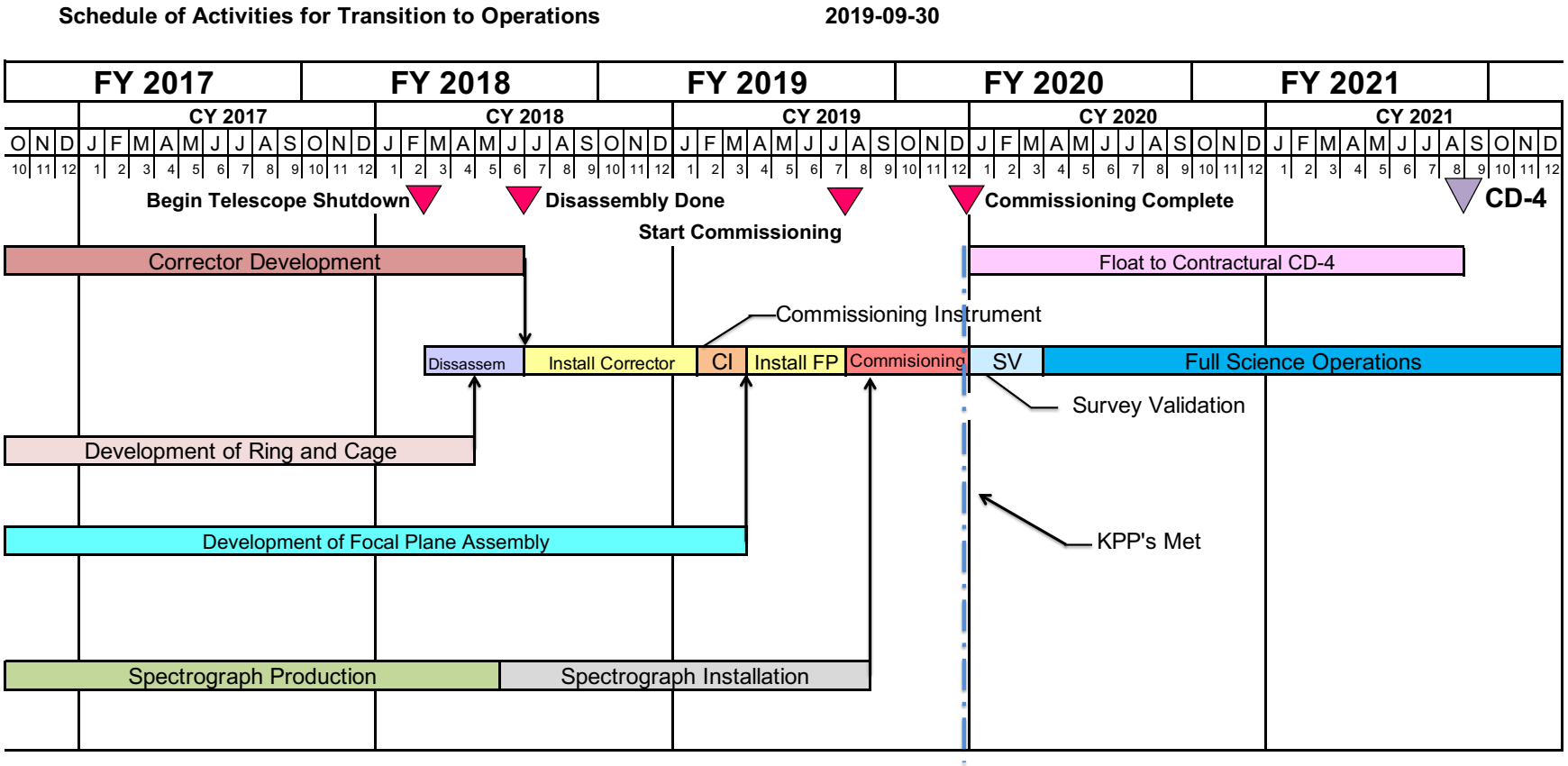


Coverage after 1 year using baseline strategy; depth-first for 10%; breadth first elsewhere


Pixel level simulations including cosmics
test full pipeline scaling with O(1M) spectra

Transition to Operations Schedule

Activities for transitioning from design and fabrication of the instrument to reaching full science operations at the Mayall telescope



Status on imaging

Pre-imaging over 14,000 sq. deg required for target selection

Three optical surveys

- **North** (*5k deg²*) **BASS** gr — 95% completed
  MzLS z — 100% completed
- **South** (*9k deg²*) **DECaLS** grz — 97% completed

One infrared survey

- **All Sky WISE** (NASA satellite)
  W_1 W_2 — 125% completed

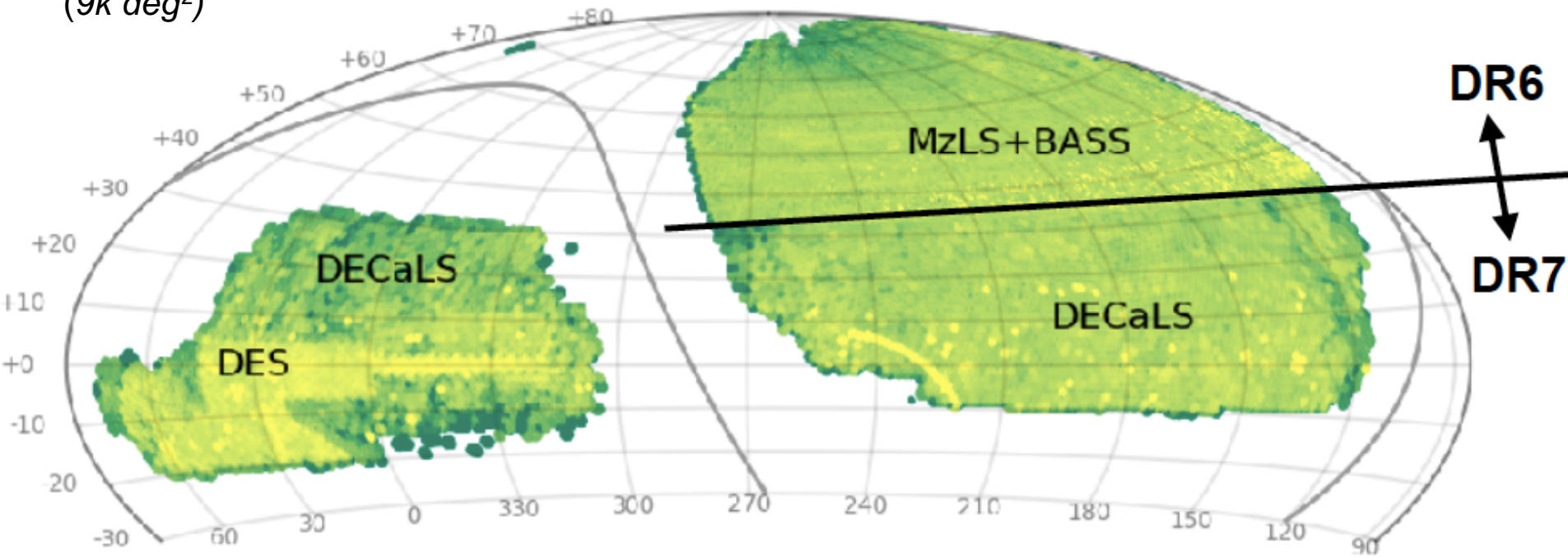
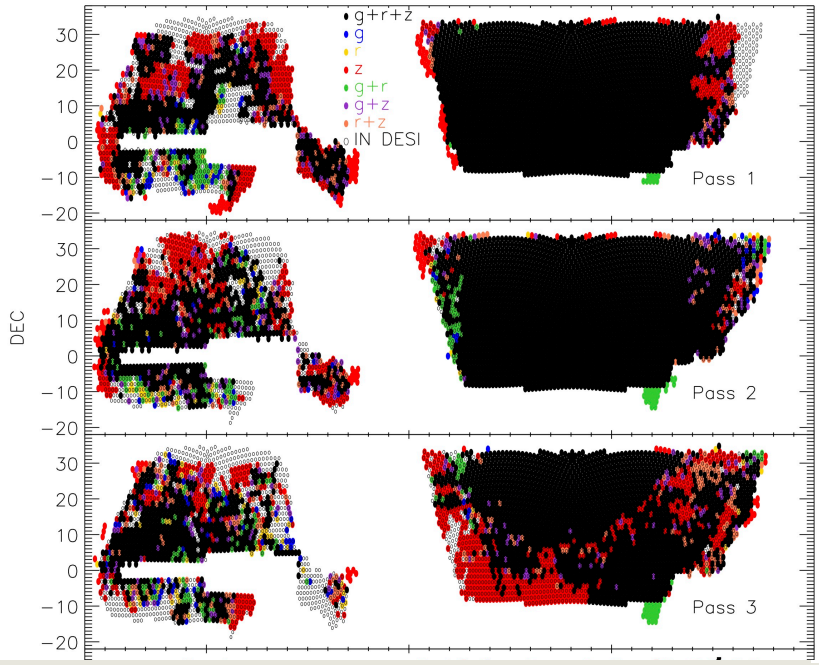


Image validation WG chair: E. Gaztanaga

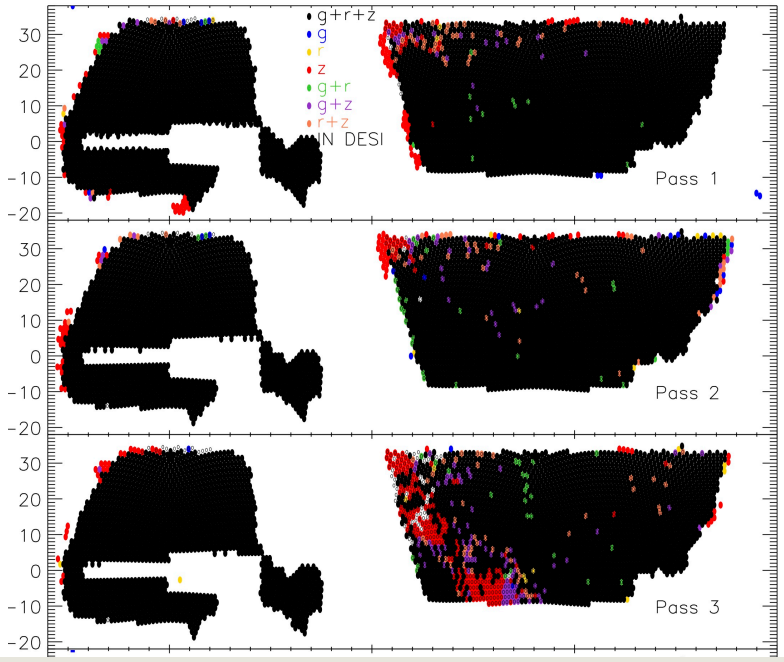
Imaging Survey Progress

- DECam imaging in the SGC has largely been completed in 2018B.
  - Thanks to major support from NOAO!
- This retires a substantial survey risk, i.e., what to observe in the fall.
- There is time remaining until Feb 2019 to finish DECaLS and BASS, but we are well above the threshold of a viable survey.

March 18, 2018



November 11, 2018



Status on imaging

- Robust data reduction through custom software *Tractor*
- All data made public via releases every six months
  - DR1 May 2015 DECaLS through DeC 2014 + WISE 1yr
  - …
  - DR6 Feb 2018 BASS+MzLS through Jul 2017 + WISE 4yrs
  - DR7 Jul 2018 DECaLS through Mar 2018 + WISE 5yrs (final)
  - **DR8** Jan 2019 DECaLS through Jun 2018 + BASS final + MzLS final

    → **Imaging for Survey Validation**
  - **DR9** Jun 2019 DECaLS final, BASS, MzL

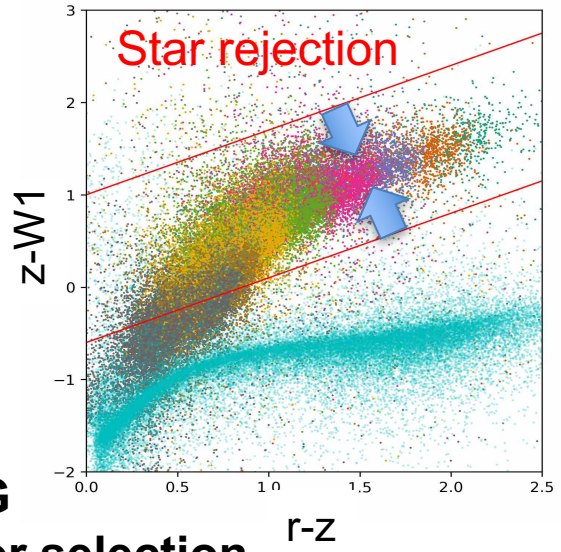
    → **Final imaging data release for DESI TS**
- Superb public image viewer to inspect the data and link to catalogs
  - http://www.legacysurvey.org/viewer
- Overview paper of imaging surveys submitted to ApJ (*Dey et al., arXiv:1804.08657, 153 authors*)

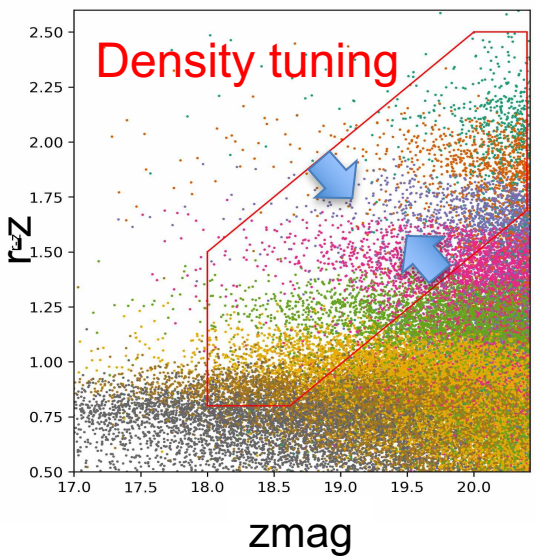
Target selection

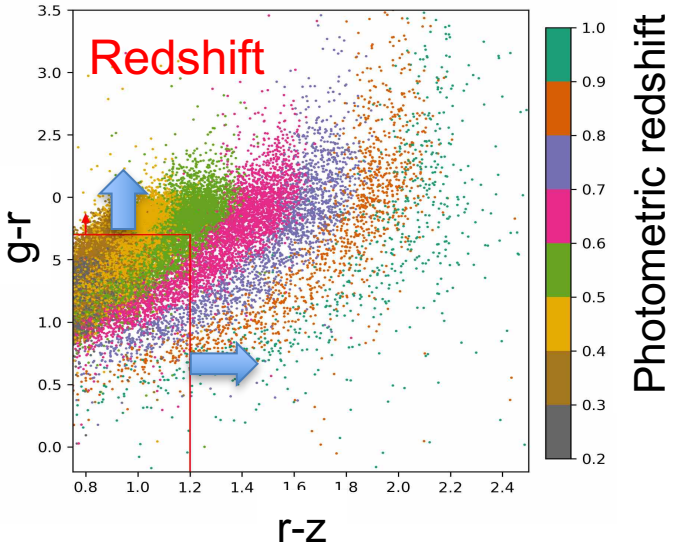
Galaxy type	Redshift range	Bands used	Targets per deg^2	Exposures per deg^2	Good z's per deg^2	Baseline sample
LRG	0.4–1.0	g,r,z,$W1$	480	610	430	6.0 M
ELG	0.6–1.6	g,r,z	2400	1870	1220	17.1 M
QSO (tracers)	< 2.1	g,r,z,$W1$,$W2$	170	170	120	1.7 M
QSO (Ly-α)	> 2.1	g,r,z,$W1$,$W2$	90	240	50	0.7 M
Total in dark time			**3140**	**2890**	**1820**	**25.5 M**
BGS	0.05–0.4	r	800+	740	710	9.9 M
MWS	0.0	g,r (Gaia μ)	800+	720	720	10.1 M
Total in bright time			**1600+**	**1460**	**1430**	**20.0 M**

- Design & evaluation of algorithms by target selection working group
- Implementation on imaging data on project (*desitarget* package)
- Status:
  - Algorithms are converging, LRG, QSO tracers & BGS reaching FDR goals
  - Currently on 2nd generation algorithms (machine-learning methods) for QSO Lyα (working) and ELGs (being optimized & tested via pilot surveys)
- The BGS is currently proposed to consist of a bright high priority sample to an r-band magnitude limit r ~ 19.5, with a fainter low priority sample to r ~ 20.

Target selection

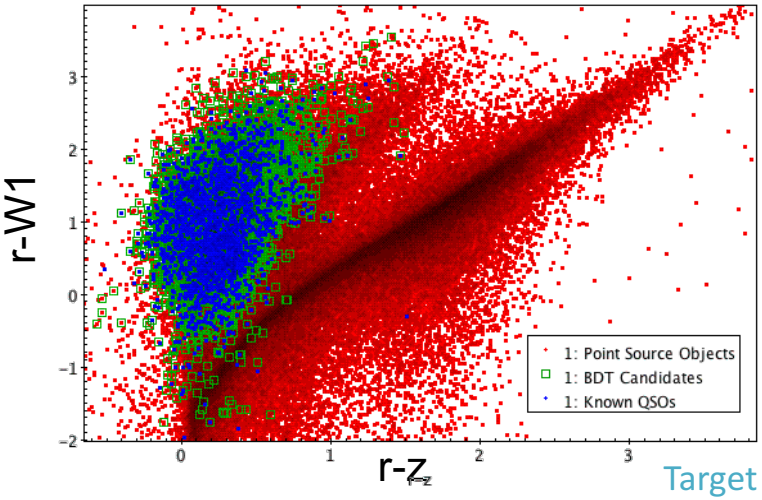






LRG
color selection

QSO
random forest
selection



Point sources
Known QSOs
Random Forest selection

Target selection WG chairs: Ch. Yèche & A. Raichoor

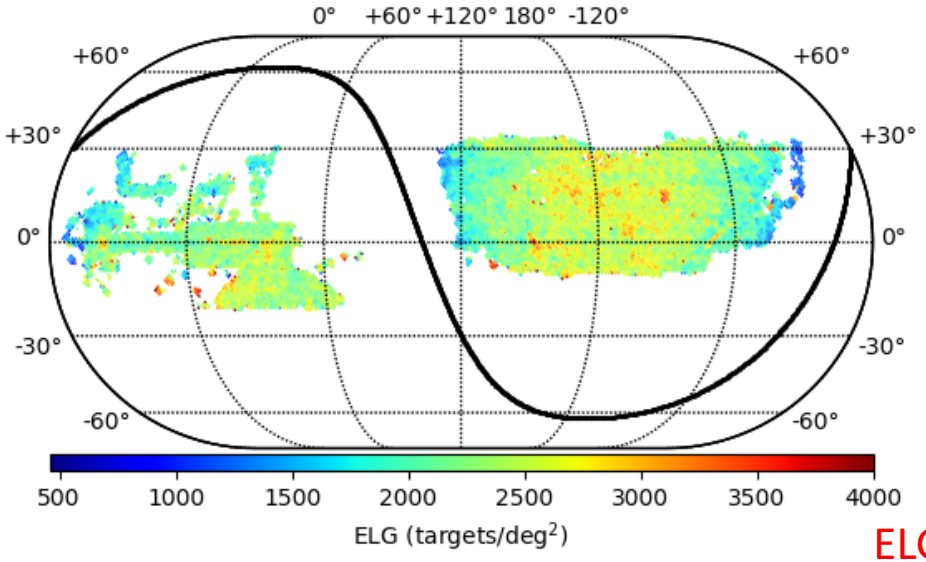
Target selection

DESI-3349

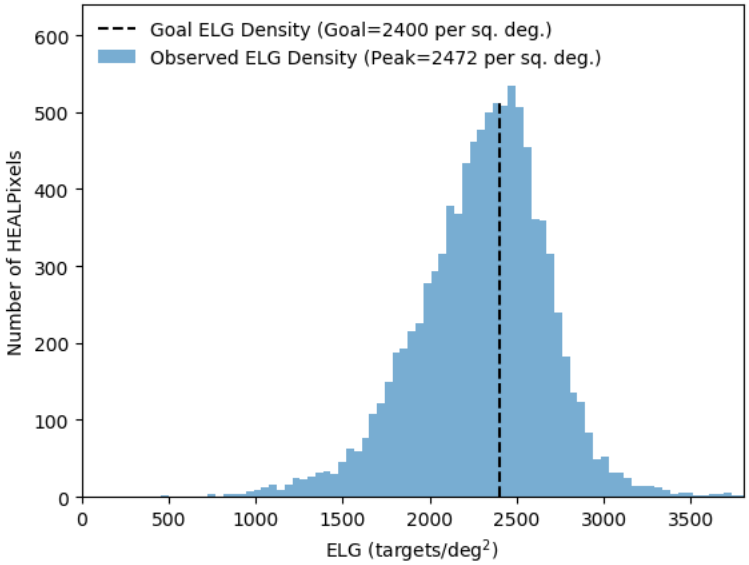
AlsoBO3.3 Bailey/Guy

- Separate optimization for North and South
  to best accommodate different depth & bands of photometric surveys
- Optimization retuned with each imaging data release

- Target selection code ~1 hr for all 35 M targets on NERSC
- Automatic QA plots



ELG DR5



Target selection project lead: Adam Myers