The DECam Legacy Survey: A Progress Report

Arjun Dey
NOAO
Outline

• DECaLS
• DESI and its imaging surveys

Summary

• DECam is fabulous – thank you!
• CP works well
• DR1 next week (I hope!) – use the data!
DECaLS: DECam Legacy Survey

- P.I.s: David Schlegel and Arjun Dey


- Many more! Full list at https://desi.lbl.gov/trac/wiki/PublicPages/DecamLegacy/Participants
DECaLS: Goals

• Image the SDSS footprint visible from CTIO
  – ∼ 6700 sqdeg at DEC < +30 deg
  – 3 bands: g, r, z
  – ∼ 1-2 mag deeper than SDSS

• Public data and catalogs on rapid timescale:
  – Began observing Aug 2015
  – No proprietary period
  – DR1 on March 18, 2015 (next week)
DECaLS: Science

- Overlap with SDSS spectroscopy & imaging enables a slew of astrophysical investigations:
  - Cosmic evolution of
    - Halo gas
    - Clusters
    - Galaxy/QSO clustering
    - Galaxies/AGN/QSOs
  - Milky Way and its environs
    - Proper motion studies; dwarf galaxies; streams; ...
  - Identification of rare objects (multiwavelength sources, etc.)
DECaLS: Reductions

- Reductions use NOAO Community Pipeline
  - Stage 1: NOAO/DECam community pipeline produces reduced/calibrated images and variance/BP/weight masks (done at NOAO/Tucson). Delivered to LBNL/Nersc
  - Stage 2: Photometric and astrometric calibration verified/tweaked using PS1 data (done at NERSC)
  - Stage 3: Bricks and catalogs (Tractor & SE) generated (done at NERSC).
  - Final products (images and catalogs) delivered to collaboration and served by NERSC and NOAO

- QA and Analyses
  - In progress (Needs team to get more involved)
DECaLS: Reductions

- Community pipeline processing
  - Astrometry against PS1
  - Use only single frames (not projected/stacked)

- Photometric zero points
  - Calibration of 7” diameter aperture photometry against PS1 color-corrected mags

- Tractor Catalogs (Dustin Lang)
  - Forward modeling of individual data frames
  - Inference-based model of the sky
    - *i.e., not a Source Extractor catalog*
DECaLS Coverage
Almost all data + catalogs in DR1 (~next week!)

As of Feb 2015

DECaLS

DECaLS+

March 12, 2015

DECam Community Science Workshop

Arijun Dey
DECaLS Seeing Distribution

Median

- g-band
- r-band
- z-band

March 12, 2015

DECam Community Science Workshop

Arjun Dey
DECaLS is on the DECam System

Calibration against PS1

- Color terms constructed for g/r/z bands
- PS1 mags transformed to DECam system
- Detect stars on DECam + match to PS1 + compare 7” dia ap photometry to PS1 color-corrected mags

March 12, 2015

DECam Community Science Workshop

Arjun Dey

Doug Finkbeiner & Eddie Schlafly
DECaLS is on the DECam System

Color corrections between PS1 and DECam

\[(g-i) = g_{\text{PS}} - i_{\text{PS}}\]

\[\text{Mag}_{\text{DECam}} = \text{mag}_{\text{PS}} - C_1(g-i) - C_2(g-i)^2 - C_3(g-i)^3\]

Coefficients:

\[g : [-0.04709, -0.00084, 0.00340]\]
\[r : [0.09939, -0.04509, 0.01488]\]
\[z : [0.13404, -0.06591, 0.01695]\]

measured using stars in the color range 0.4 < \((g-i)\) < 2.7
Astrometric and Photometric Offsets

From systematic effects,
Astrometric range <10 mas
Photometric range <20 mmag
=> Can do better!
First look at photometric uniformity
(4 months ago...)

Eli Rykoff
DECaLS Single Image Depths

g-band

r-band

z-band

5σ Point Source Depth (apdia = 1.35 x FWHM)
Need dark skies – even for z
And we don’t like the moon – even for z-band

**NOAO schedulers and directors:** please take note
DECaLS: Bricks & Cats

http://legacysurvey.org/

5-sigma point source depth: g=24.7, r=24, z=23
~1-2 mag deeper than SDSS/PS1 + better image quality
DECaLS Data Releases

• **No proprietary period** on image data
  – Raw and CP reduced data available as soon as they appear in NOAO Science Archive – typically a few days after observing
• DRs with catalogs roughly 6 months after data are taken (*DR1 next week* – hopefully!)
• Catalogs matched to SDSS + WISE
• Following DRs on 6 month timescale
• All code on github
• If you want to help us – join us!

*Philosophy: Usage => Success*
DECaLS TBD

- Better masking of particle events, satellite trails, bleeds, etc. in single epoch data
- Implement better astrometric matching in Tractor
- Implement better psf models in Tractor — account for B/F and pixel size variations
- Constrain fits using SED templates?
- Individual epoch photometry
- Database access tools
DECaLS and you

• grz coverage over 6200 sq deg in 2 yrs
  – With other projects, 14k sq deg by 2019A
• 10 year baseline for astrometry
• Public project ⇒ you have access to the data and catalogs
• Please use it for your science
  “usage = success”
**Protoclusters at High-Redshift**

Dey, K.S. Lee, et al. 2015
Evolution of Fe/Mg with $z$

- JHU-SDSS DR7 QSO Absorption Line Catalog with $\sim$34,000 MgII absorbers
- Weak trend of $W$(FeII)/$W$(MgII) with redshift
- Can be explained by global SF history + SN rates + outflows
- ... but relationship to halos+galaxies not yet understood
  => DECaLS!

Dey et al. 2015

LADFIT: $y = 0.338 - 0.044(1+z)$
LINFIT: $y = (0.341, -0.012) + (-0.045/0.005)(1+z)$
LADFIT: $y = 0.325 - 0.053(1+z)$
LINFIT: $y = (0.317, -0.008) + (-0.049/0.004)(1+z)$

Fit range: $0.55 < z < 1.90$
Total sample: 31727
The sky is the limit!

- High-z QSOs
- Luminous LBGs
- Blobs in space!
- Galactic structure
- Clustering studies
- Dwarf galaxies
- Proper motions
- Galaxy evolution

March 12, 2015
DECam Community Science Workshop
Arijun Dey
DECaLS will provide targets for DESI

- 23 million ELGs
- 2 million QSOs
- 4 million LRGs

Redshifts for...

Courtesy Anze Slosar

March 12, 2015
DECam Community Science Workshop
Dark Energy Spectroscopic Instrument

*Nearly 40,000 spectra per night!!*

Mayall telescope at KPNO + New top end for DESI

- 3 deg dia FoV
- 5000 fibers

- Ten 3-arm spectrographs
- 380nm – 1μm
- R~5000

*Sub-percent constraints on cosmological parameters!*

March 12, 2015
DECam Community Science Workshop
Arjun Dey
DESI Pre-Imaging Surveys

1. **DECaLS (NOAO+LBNL)**
   - Dec $< +30$, NGP+SGP within SDSS
   - In progress; EDR done; DR1 on March 18, 2015

2. **MOSAIC z-band survey (NOAO)**
   - Dec $> +30$, NGP
   - Begins 2016A

3. **BASS g,r-band survey (China+UA)**
   - Dec $> +30$, NGP
   - In progress

4. **DECam southern extension**
   - Dec $< +30$, NGP+SGP outside SDSS and DES
   - No plan yet

All surveys need help with observing and science!
DECaLS vs DESI vs DES footprint
The DESI Imaging Surveys

Also: see poster by K. Olsen!
Thank you!