

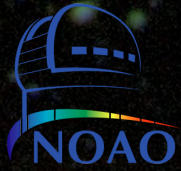


# The DECam Legacy Survey: A Progress Report

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

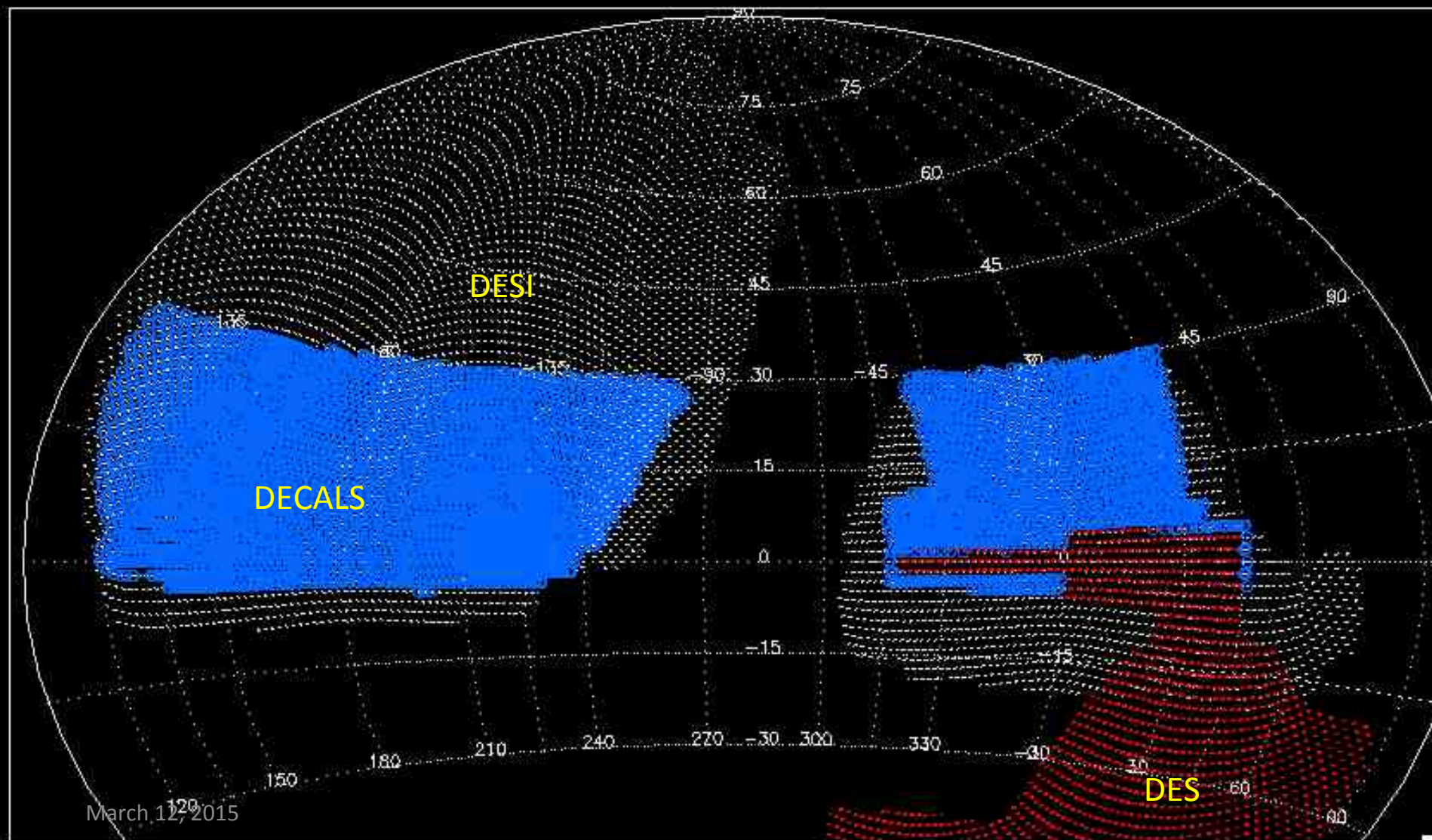
- P.I.s : David Schlegel and Arjun Dey
- CoIs: Bob Blum – Mark Dickinson – Doug Finkbeiner – David James – **Dustin Lang** – Michael Levi – David Monet – **John Moustakas** – Adam Myers – Brian Nord – Peter Nugent – **Anna Patej** – Nic Ross – Eduardo Rozo – Greg Rudnick – Eli Rykoff – Eddie Schlafly – **Casey Stark** – **Frank Valdes** – Alistair Walker – **Benjamin Weaver**
- *Many more! Full list at <https://desi.lbl.gov/trac/wiki/PublicPages/DecamLegacy/Participants>*





# DECaLS footprint

IDL 0







# DECaLS: Goals

- Image the SDSS footprint visible from CTIO
  - $\sim 6700$  sqdeg at DEC  $< +30$  deg
  - 3 bands : g, r, z
  - $\sim 1$ -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)

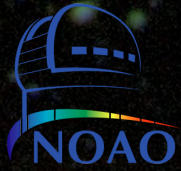




# DECaLS: Science

- *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.)

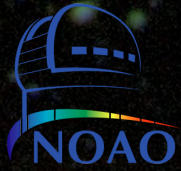




# DECaLS: Reductions

- 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

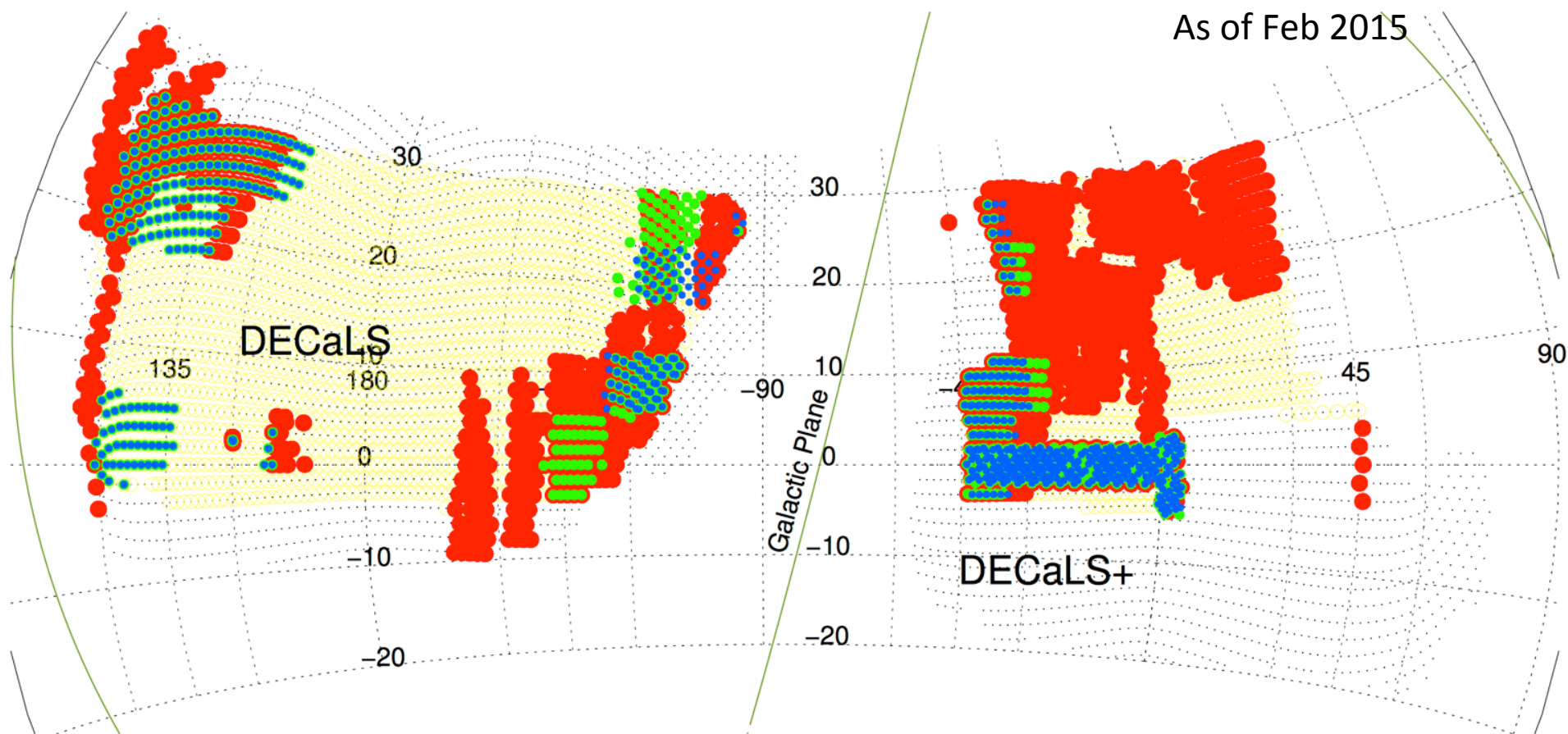
- Community pipeline processing
  - Astrometry against PS1
  - Use only single frames (not projected/stacked)
- Photometric zero points
  - Calibration of 7" diameter aperture photometry against PS1 color-corrected mags
- Tractor Catalogs (**Dustin Lang**)
  - Forward modeling of individual data frames
  - Inference-based model of the sky
    - *i.e., not a Source Extractor catalog*





# DECaLS Coverage

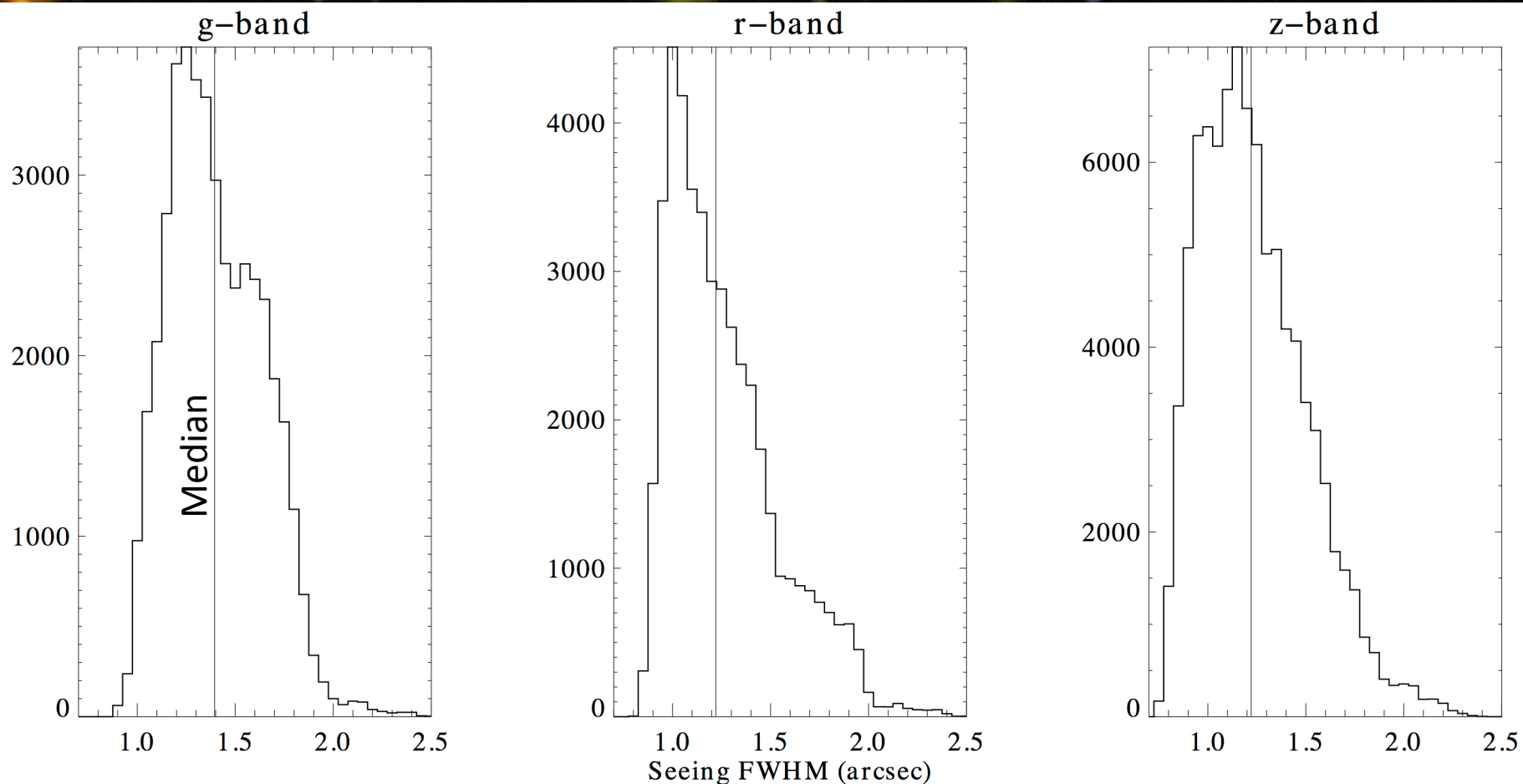
Almost all data + catalogs in DR1 (~next week!)







# DECaLS Seeing Distribution

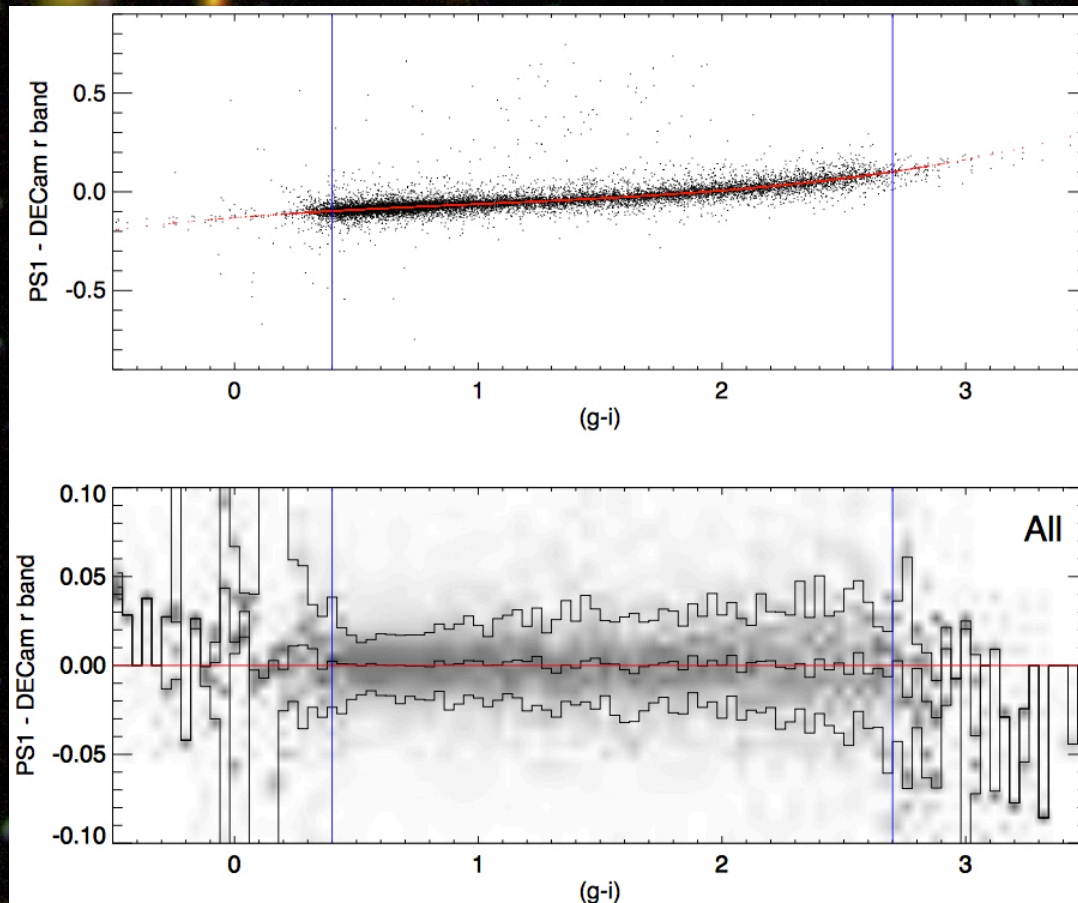




# DECaLS is on the DECam System

## 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



Doug Finkbeiner & Eddie Schlafly



# DECaLS is on the DECam System

## Color corrections between PS1 and DECam

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

$$\text{Mag\_DECAM} = \text{mag\_PS} - C_1 * (g-i) - C_2 * (g-i)^2 - C_3 * (g-i)^3$$

Coefficients:

$$g : [-0.04709, -0.00084, 0.00340]$$

$$r : [0.09939, -0.04509, 0.01488]$$

$$z : [0.13404, -0.06591, 0.01695]$$

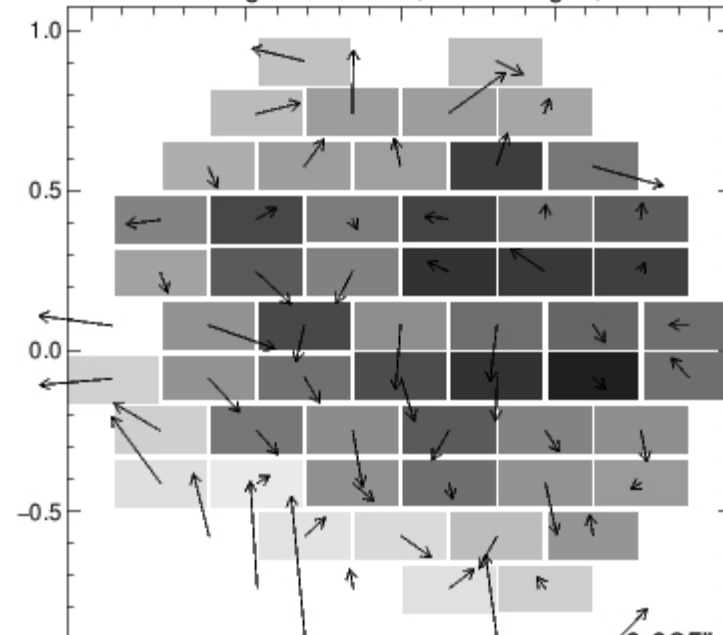
measured using stars in the color range  $0.4 < (g-i) < 2.7$



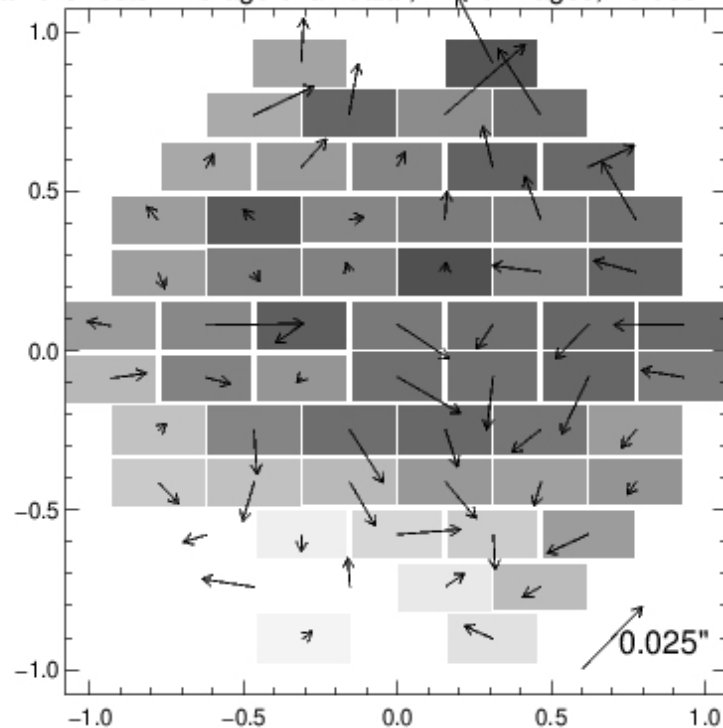
# Astrometric and Photometric Offsets

From systematic effects,  
Astrometric range  $< 10$  mas  
Photometric range  $< 20$  mmag  
 $\Rightarrow$  Can do better!

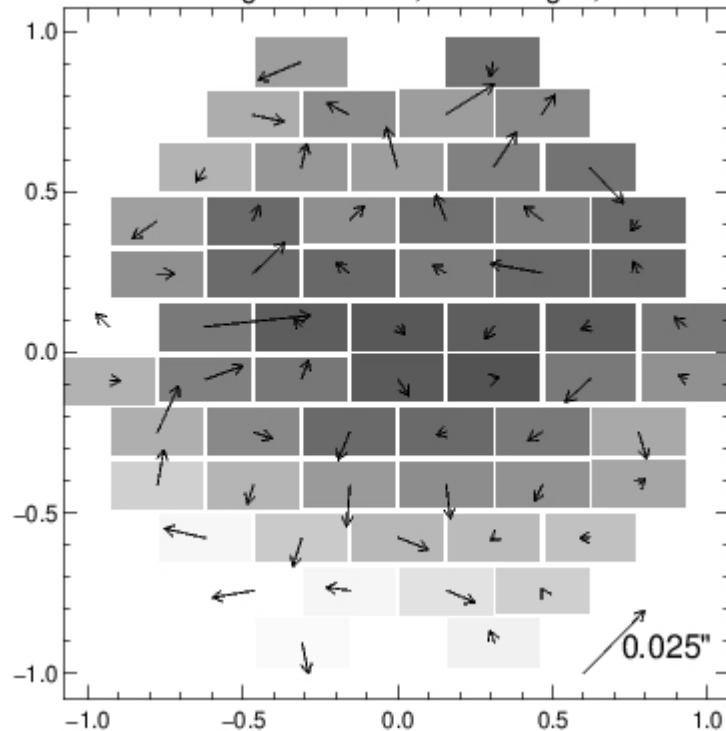
Relative Offsets: Average of all data ; 453 images;  $-0.008 < \Delta m_0 < 0.023$



Relative Offsets: Average of all data ; 1440 images;  $-0.005 < \Delta m_0 < 0.012$

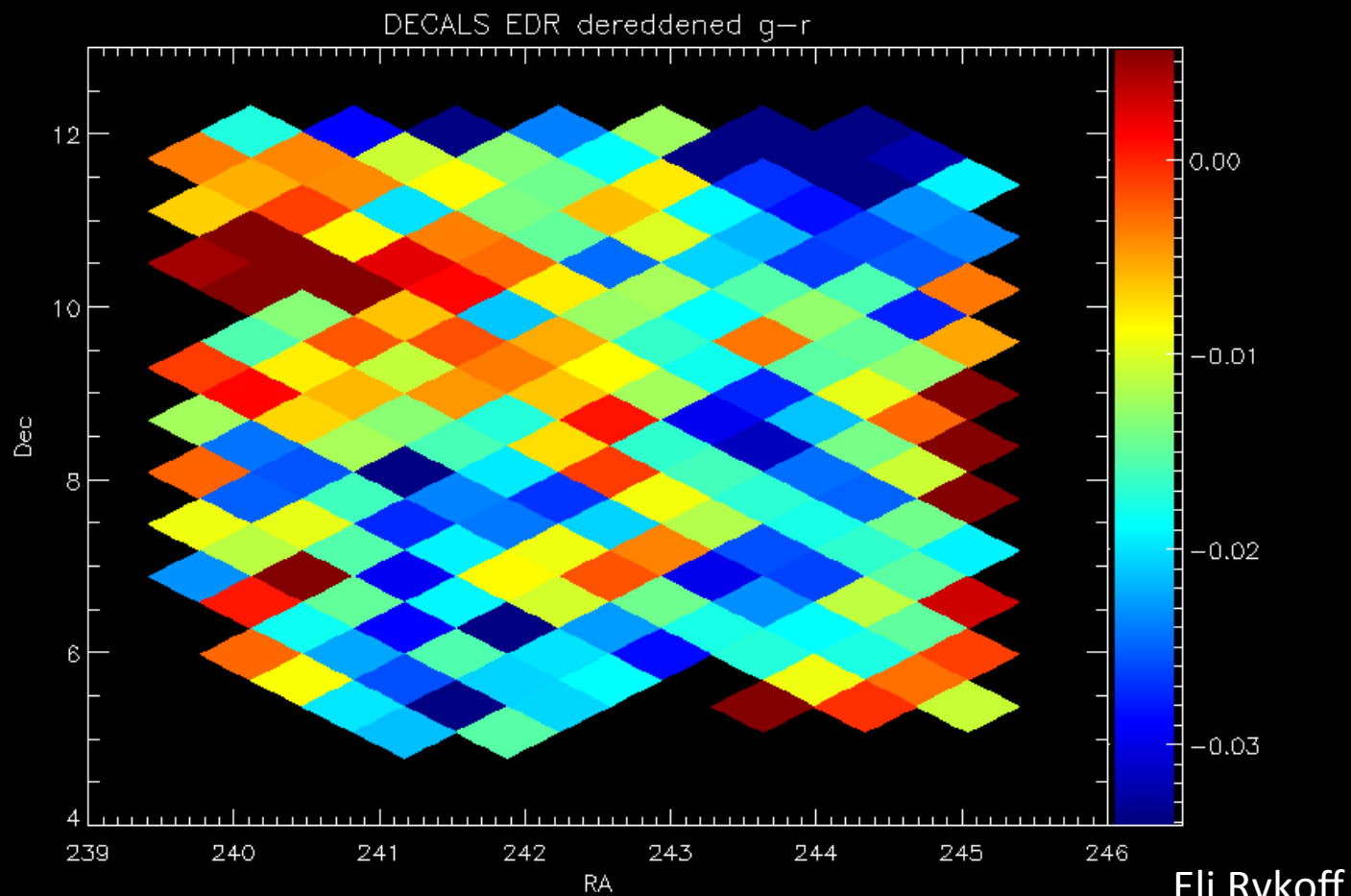


Relative Offsets: Average of all data ; 571 images;  $-0.005 < \Delta m_0 < 0.021$



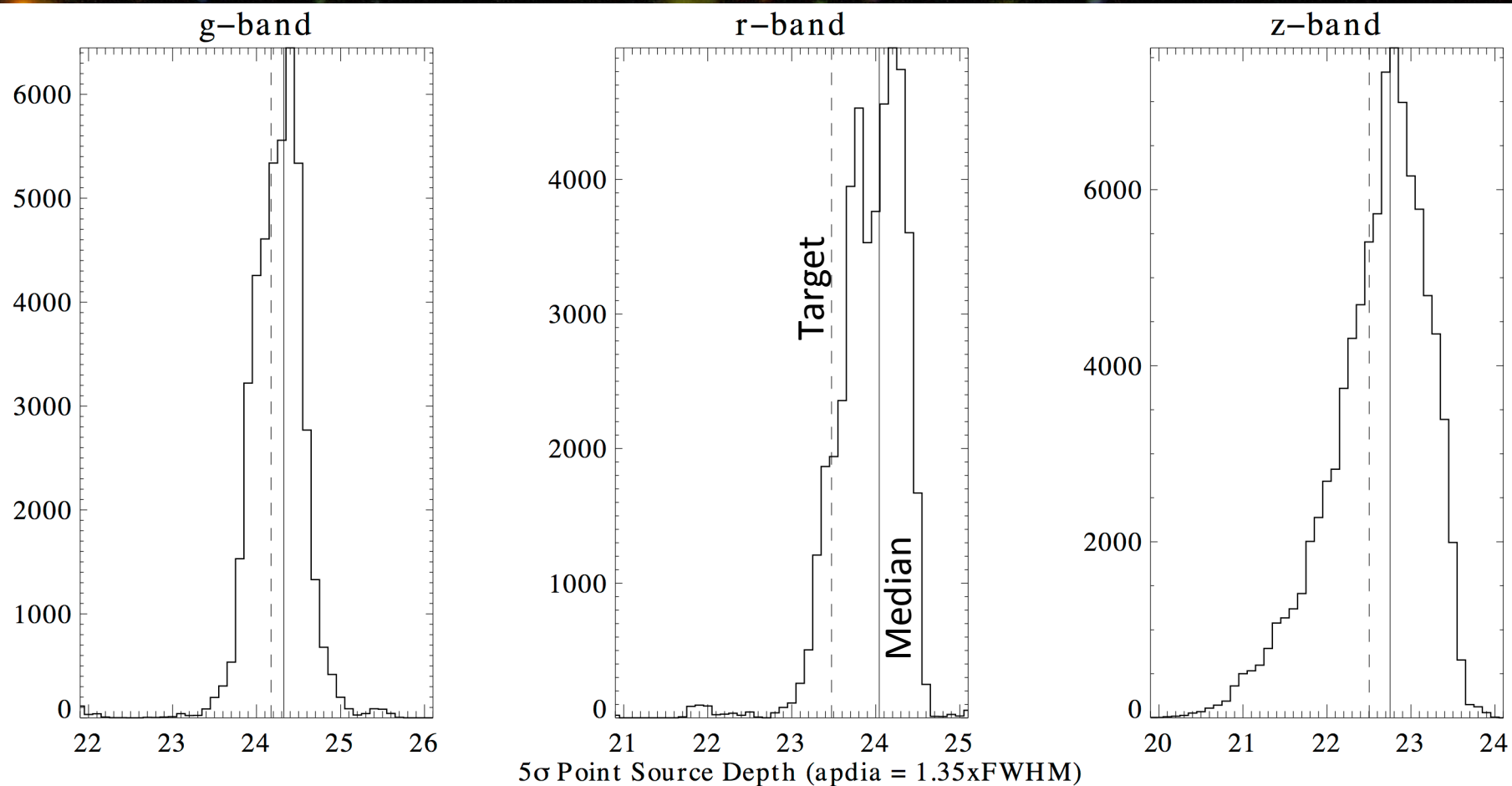


# First look at photometric uniformity (4 months ago...)



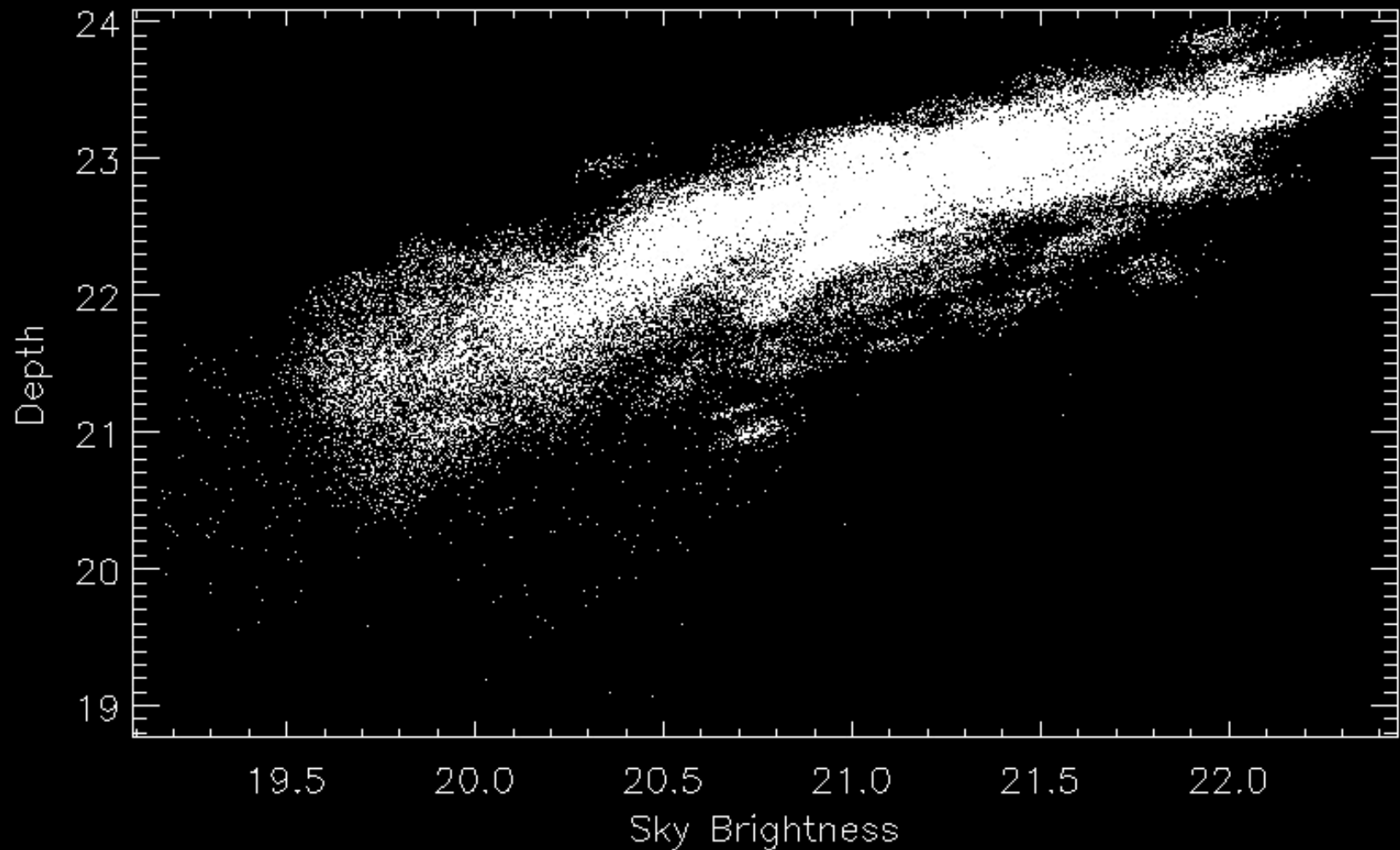


# DECaLS Single Image Depths





# Need dark skies – even for $z$

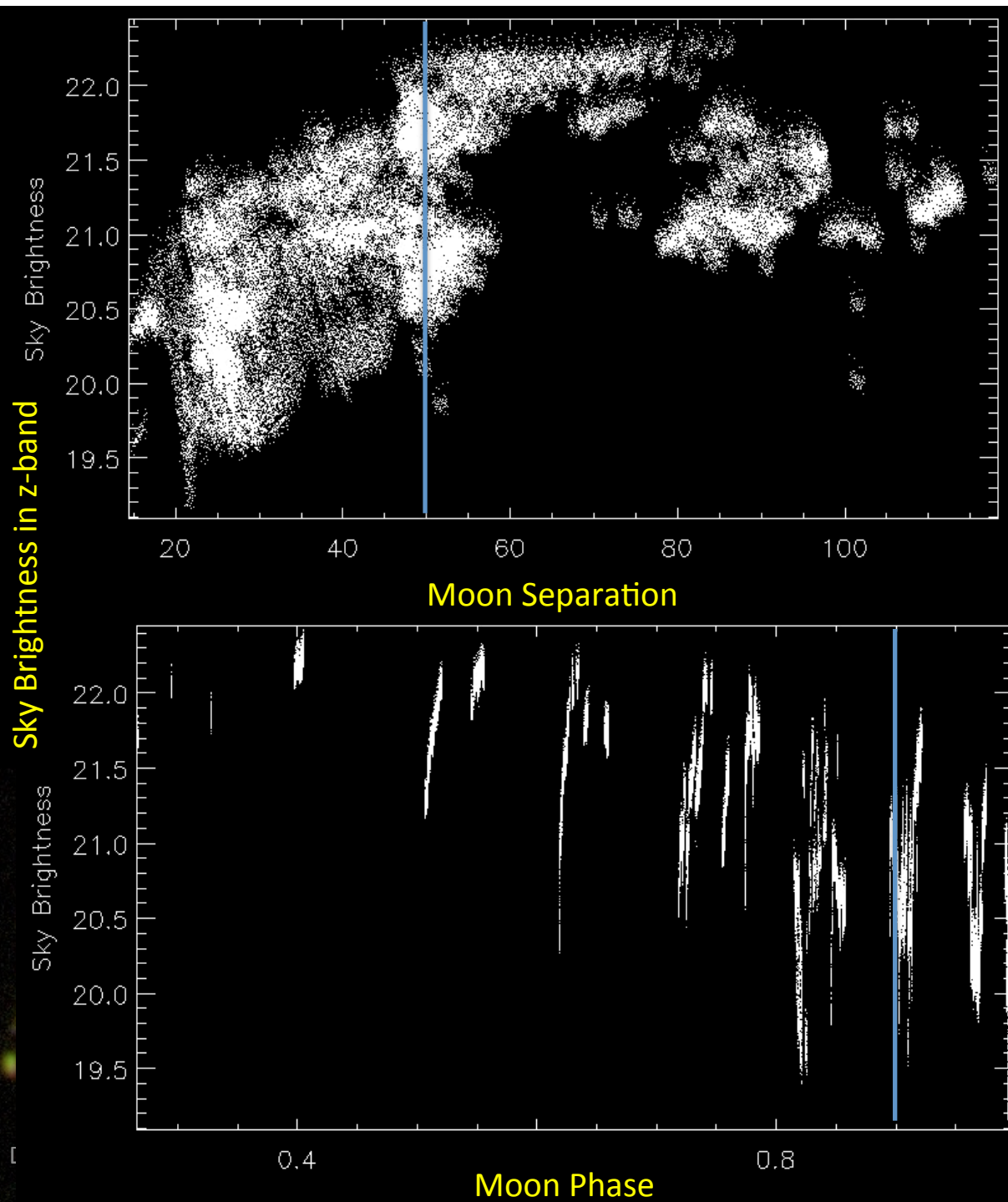




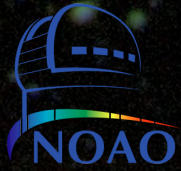
And we don't like  
the moon – even for  
z-band

*NOAO schedulers  
and directors:  
please take note*

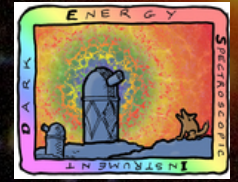
March 12, 2015



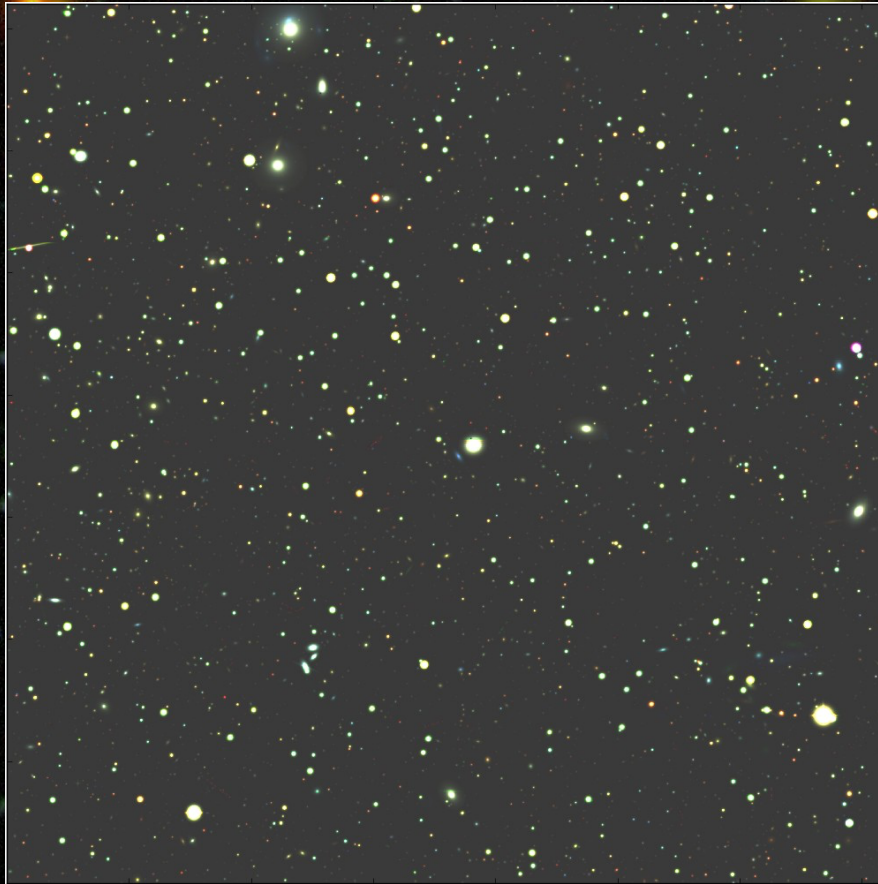




# DECaLS: Bricks & Cats



<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”

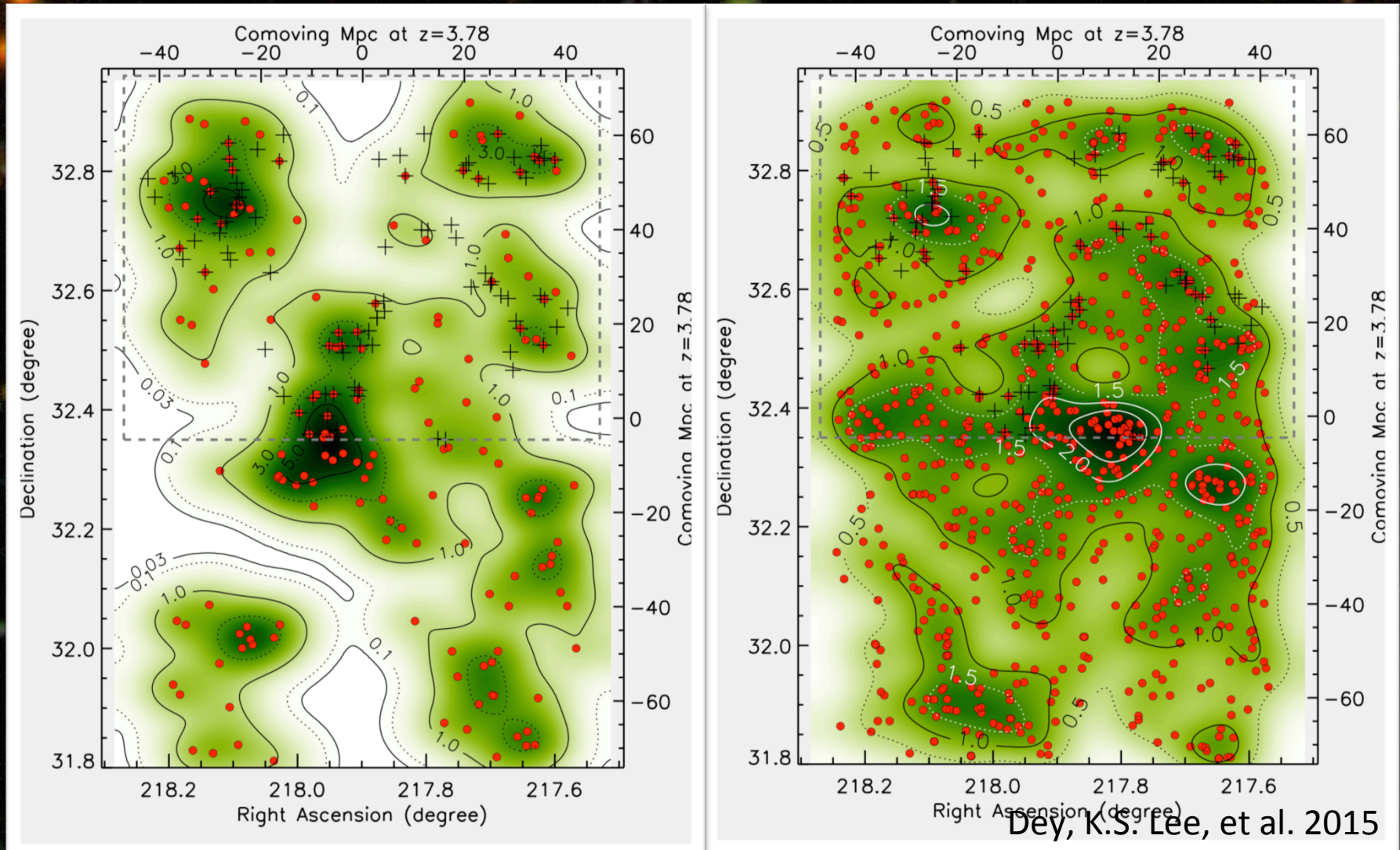


Thing 1

# Protoclusters at High-Redshift

LAEs

LBGs



March 12, 2015

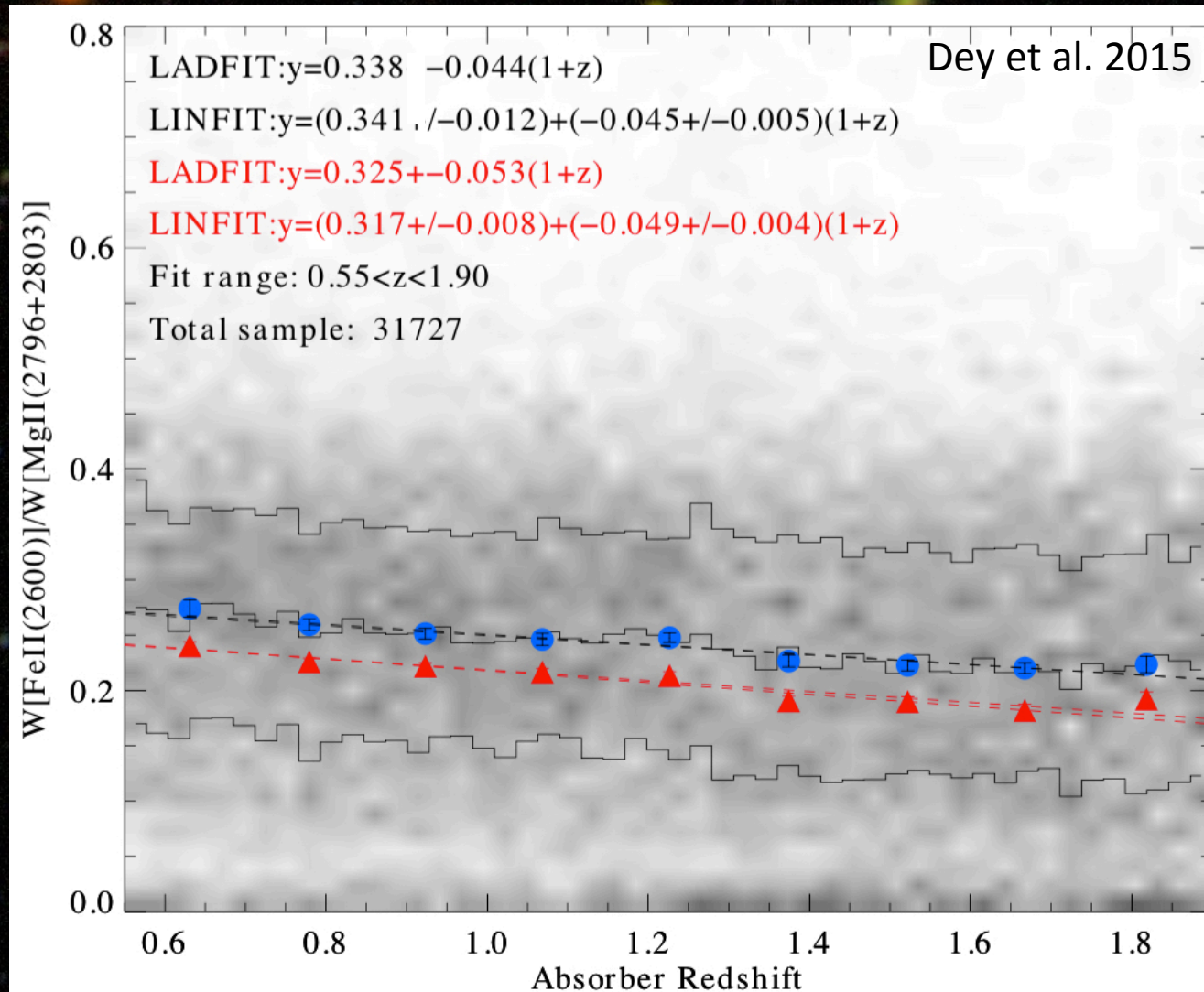
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Arjun Dey



## Thing 2

# Evolution of Fe/Mg with $z$



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



# The sky is the limit!

High-z QSOs

Luminous LBGs

Blobs in space!

Proper motions

Galactic structure

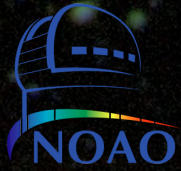
Your project here

Galaxy evolution

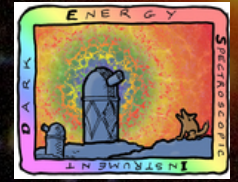
Clustering studies

Dwarf galaxies

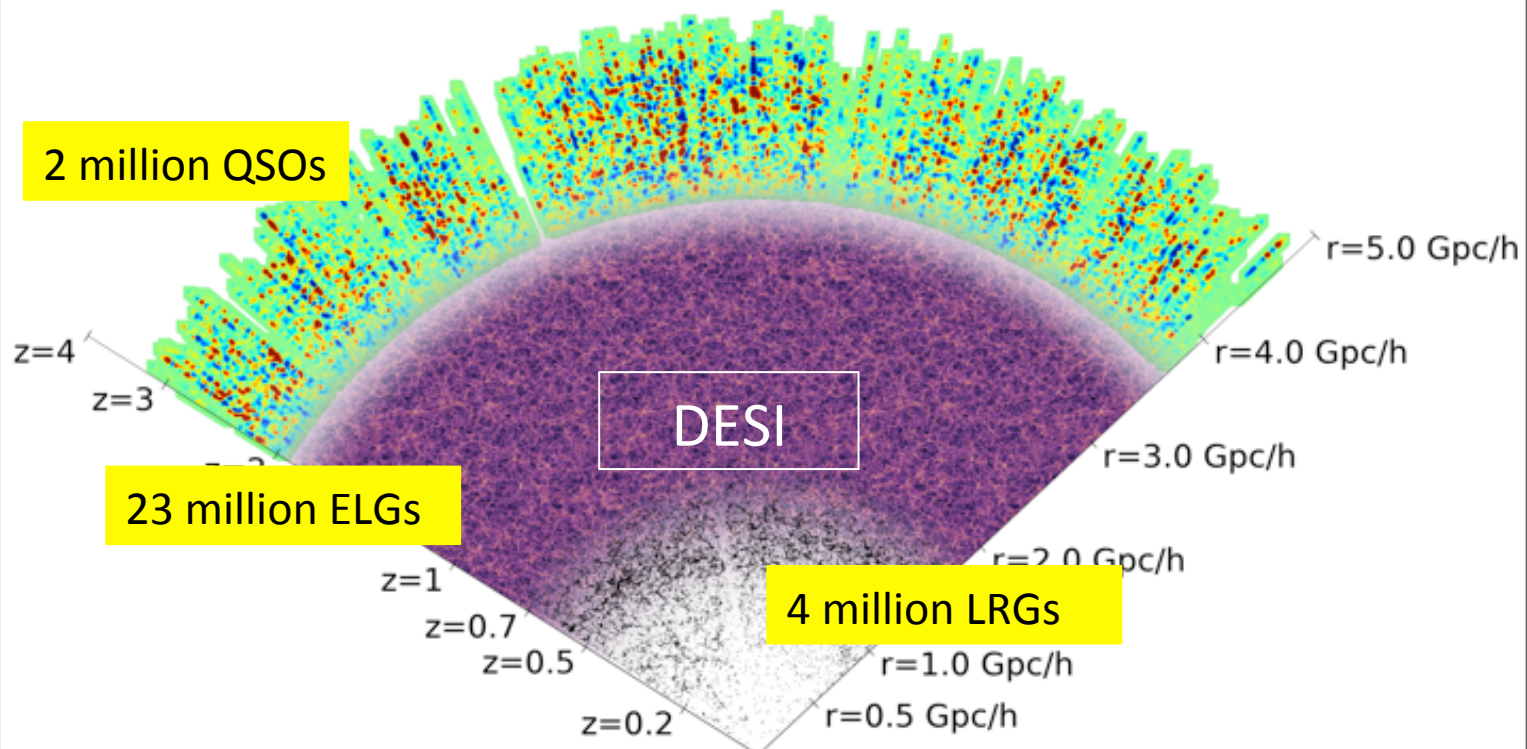




# DECaLS will provide targets for DESI



Redshifts for ...



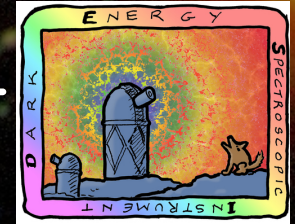
*Courtesy Anze Slosar*





# Dark Energy Spectroscopic Instrument

*Nearly 40,000 spectra per night!!*



Mayall telescope at KPNO + New top end for DESI



- Ten 3-arm spectrographs
- 380nm – 1 $\mu$ m
- R~5000

- 3 deg dia FoV
- 5000 fibers

*Sub-percent constraints on cosmological parameters!*

March 12, 2015

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# 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

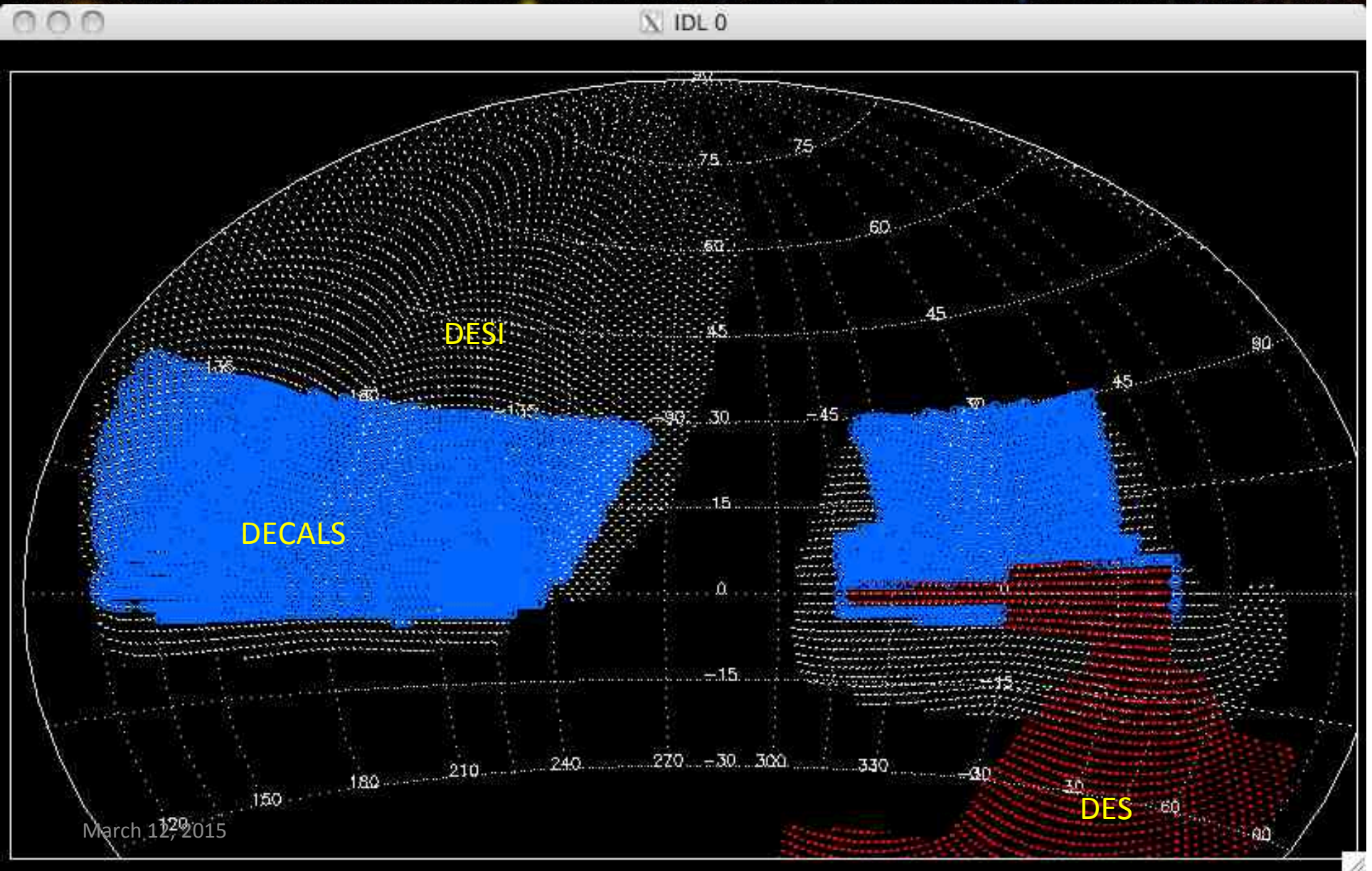
## 4. DECam southern extension

- Dec  $< +30$ , NGP+SGP outside SDSS and DES
- No plan yet

*All surveys need help  
with observing and  
science!*



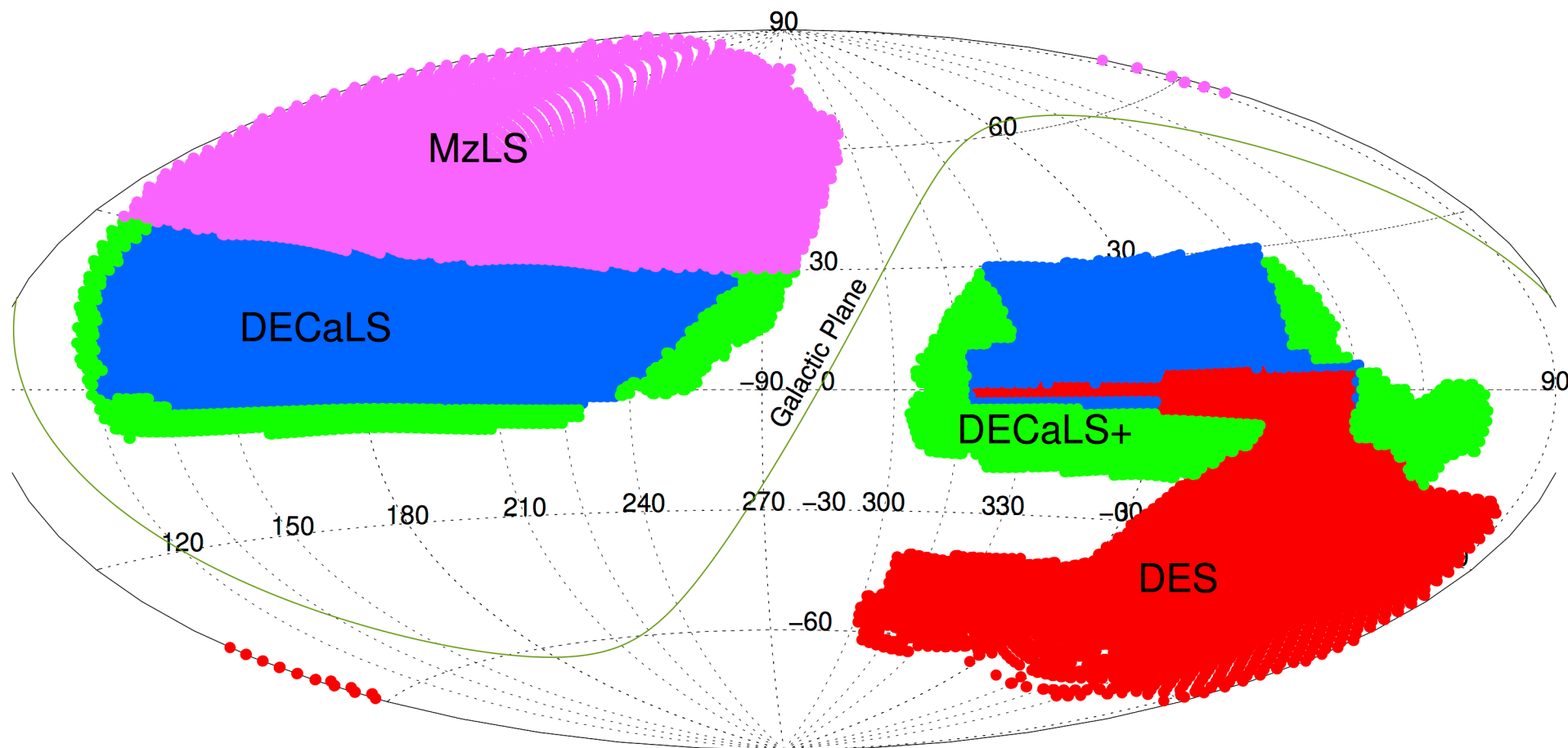
# DECaLS vs DESI vs DES footprint





# The DESI Imaging Surveys

Also: see poster by K. Olsen !







Thank you!