



Science & Discovery *with the* **NOAO Data Lab**

Stéphanie Juneau (NOAO)
on behalf of the DL team



National Optical Astronomy Observatory

Cerro Tololo Inter-American Observatory
Kitt Peak National Observatory
Community Science and Data Center





Current team:

Mike Fitzpatrick, Lead Developer

Leah Fulmer, Contributing Developer

Wendy Huang, Software Engineer

Stephanie Juneau, Project Scientist

David Nidever, Data Scientist

Robert Nikutta, Data Scientist

Pat Norris, Test Engineer

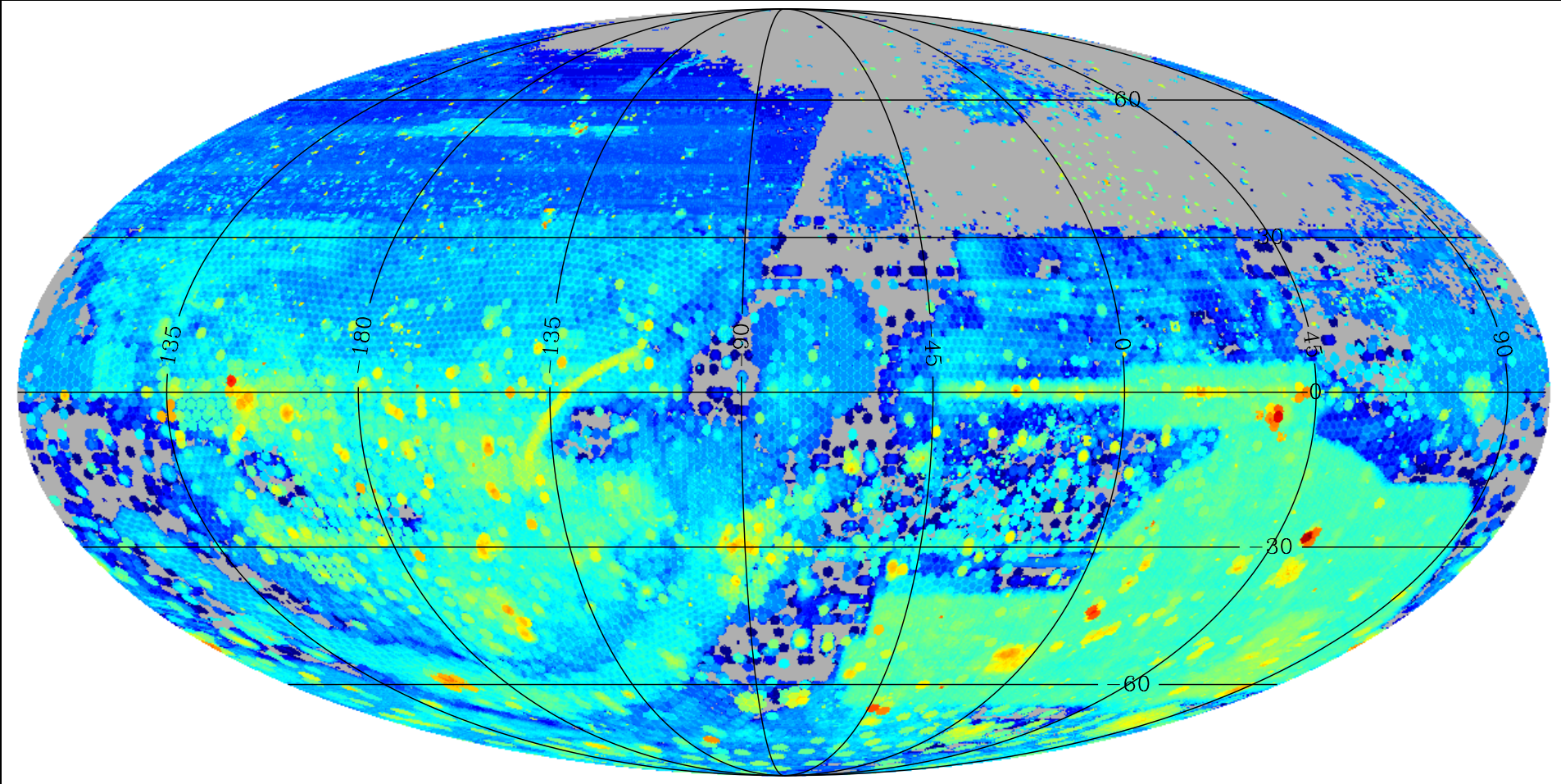
Knut Olsen, Team Leader

Steve Ridgway, Scientist

Adam Scott, Database Architect

Pete Wargo, System Administrator





Goal

Efficient exploration and analysis of large datasets with an emphasis on NOAO wide-field 4-m telescopes

Approach

- High-value catalogs from NOAO and external sources (e.g. SDSS, GAIA) and NOAO-based images linked to catalog objects
- Data discovery
- Developing intuition through interaction with selected catalog and image set of known objects
- Automation of analysis to aid discovery of unknown objects

Large Catalogs – TB-scale databases

Pixel Data – images & spectra in NOAO Science Archive

Virtual Storage – 1 TB per user to minimize data transfer

Visualization – data exploration

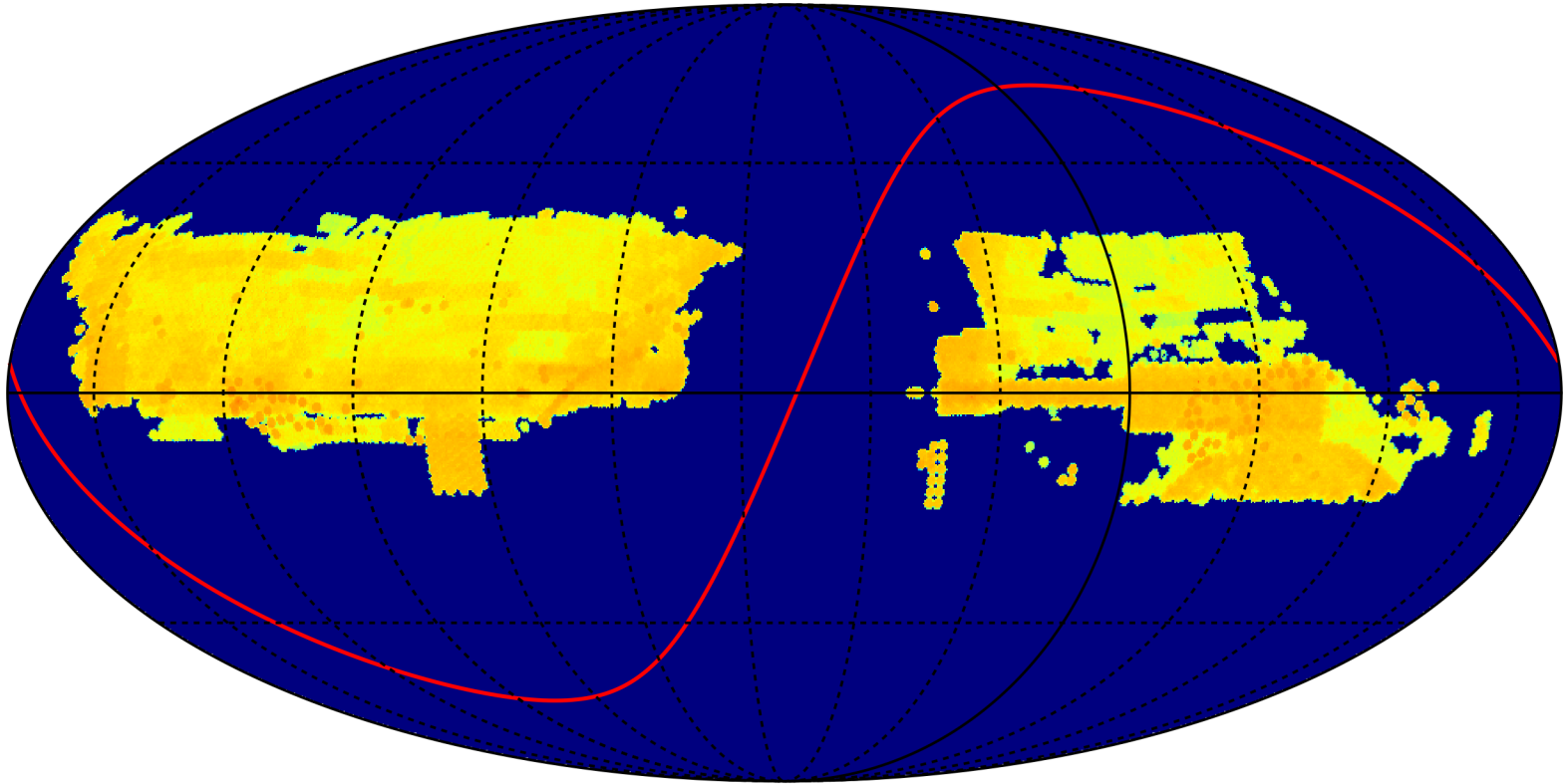
Compute Processing – workflows run close to the data

++ Access to published datasets, data publication,
exportable workflows, distributable software

Data Lab 1.0 released in June 2017 (AAS)

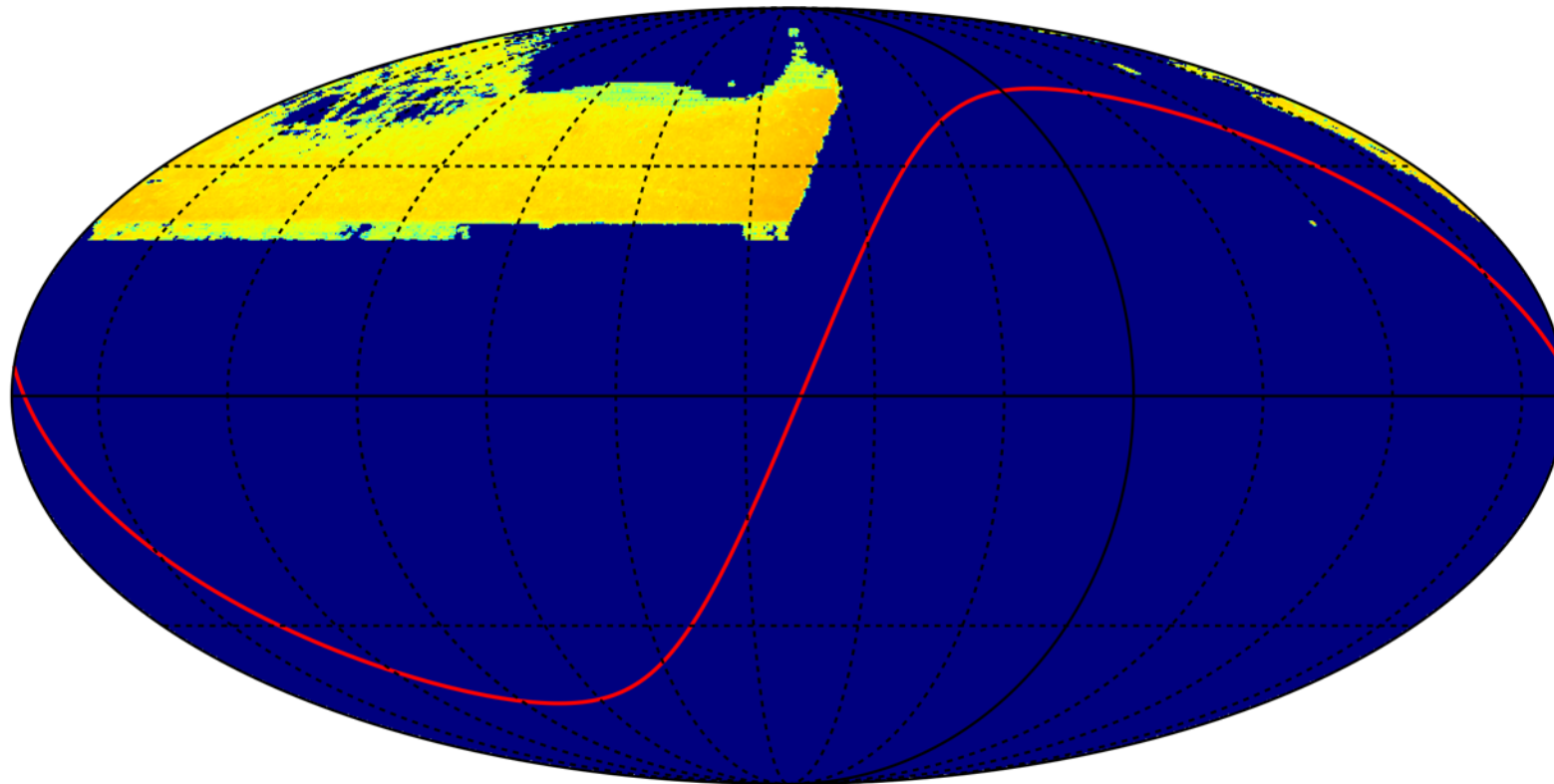
Data Lab 2.0 to be released in June 2018

DECaLS DR3

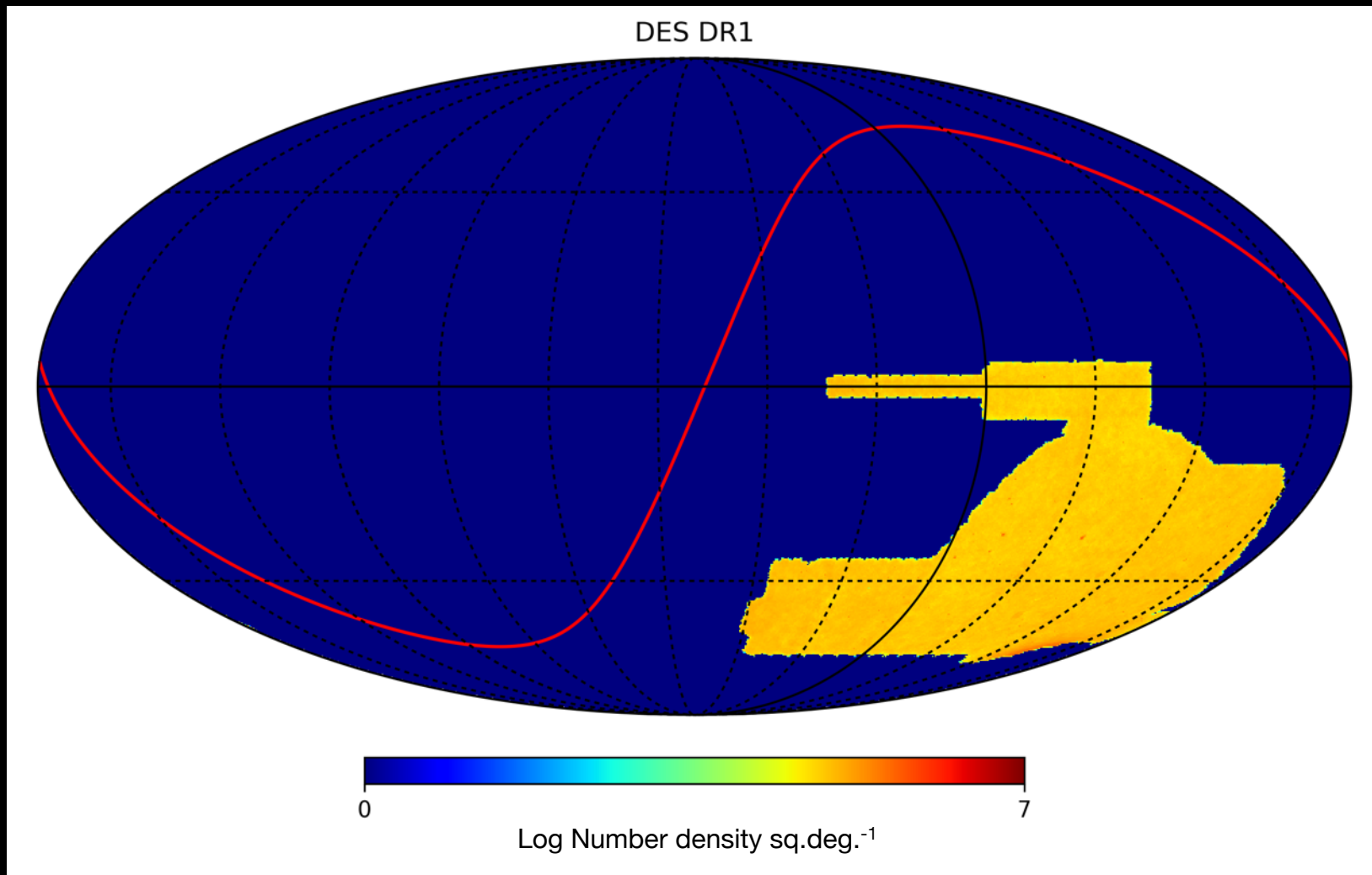


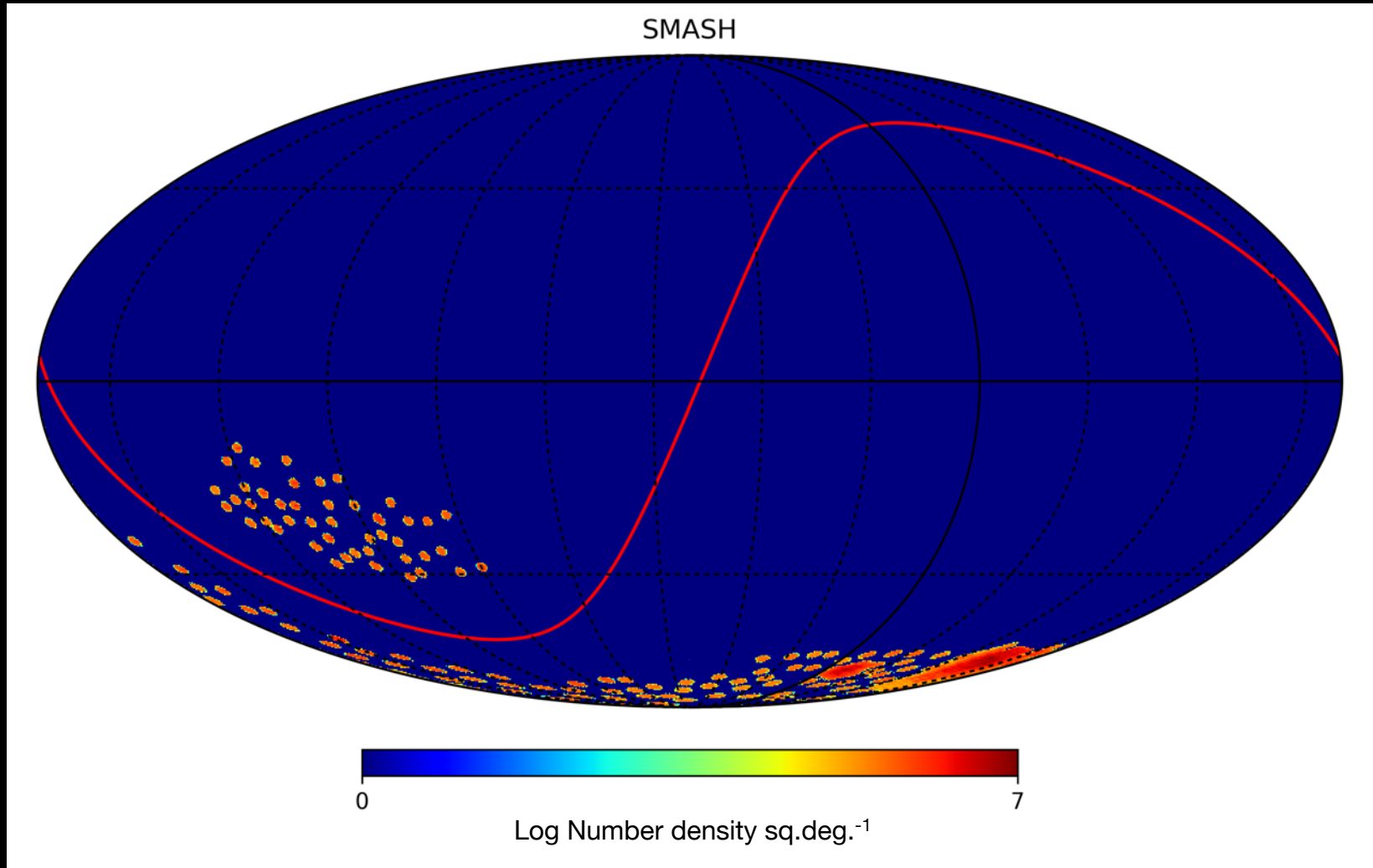
Log Number density sq.deg.⁻¹

DECaLS DR4

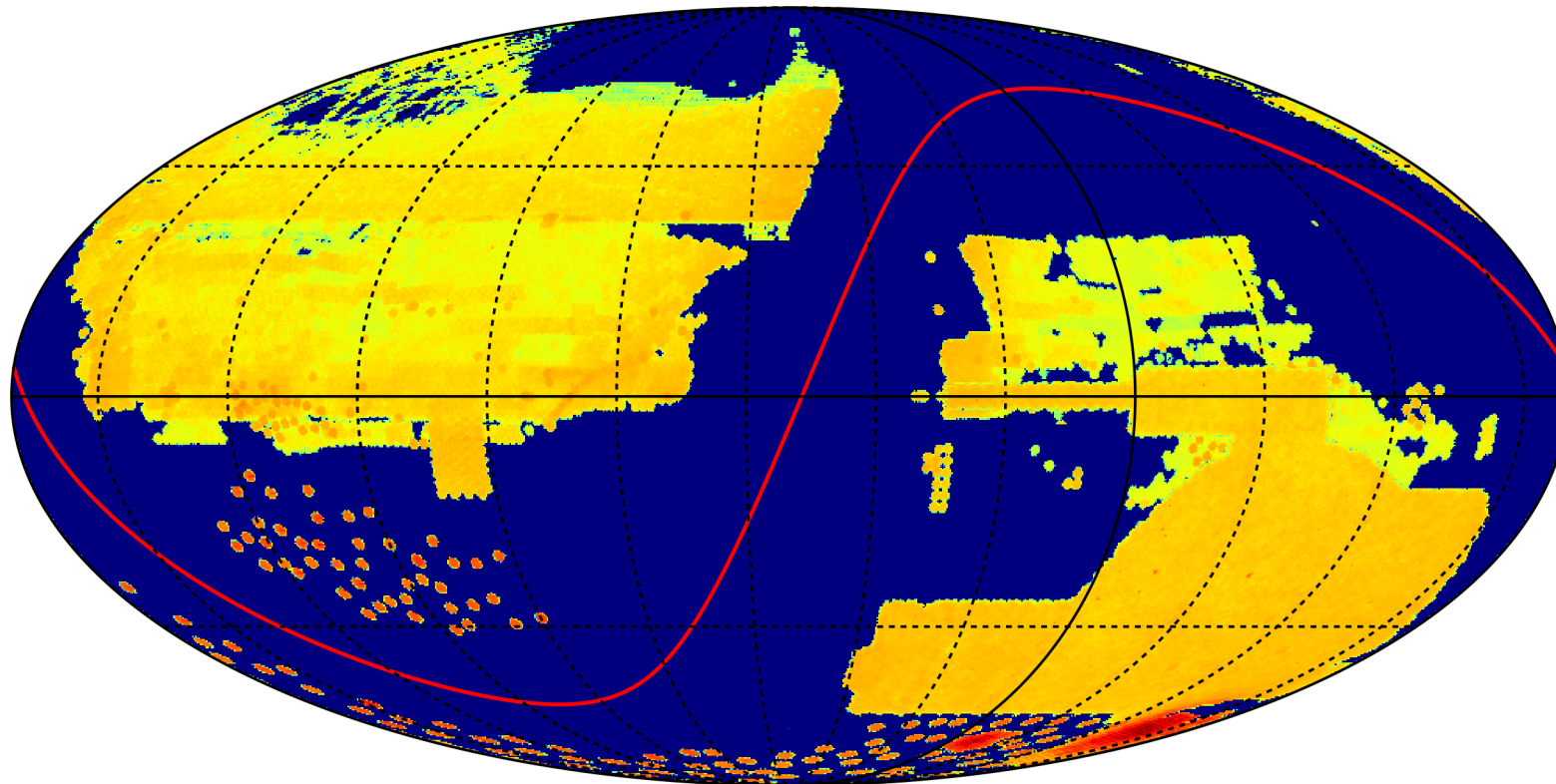


Log Number density sq.deg.⁻¹

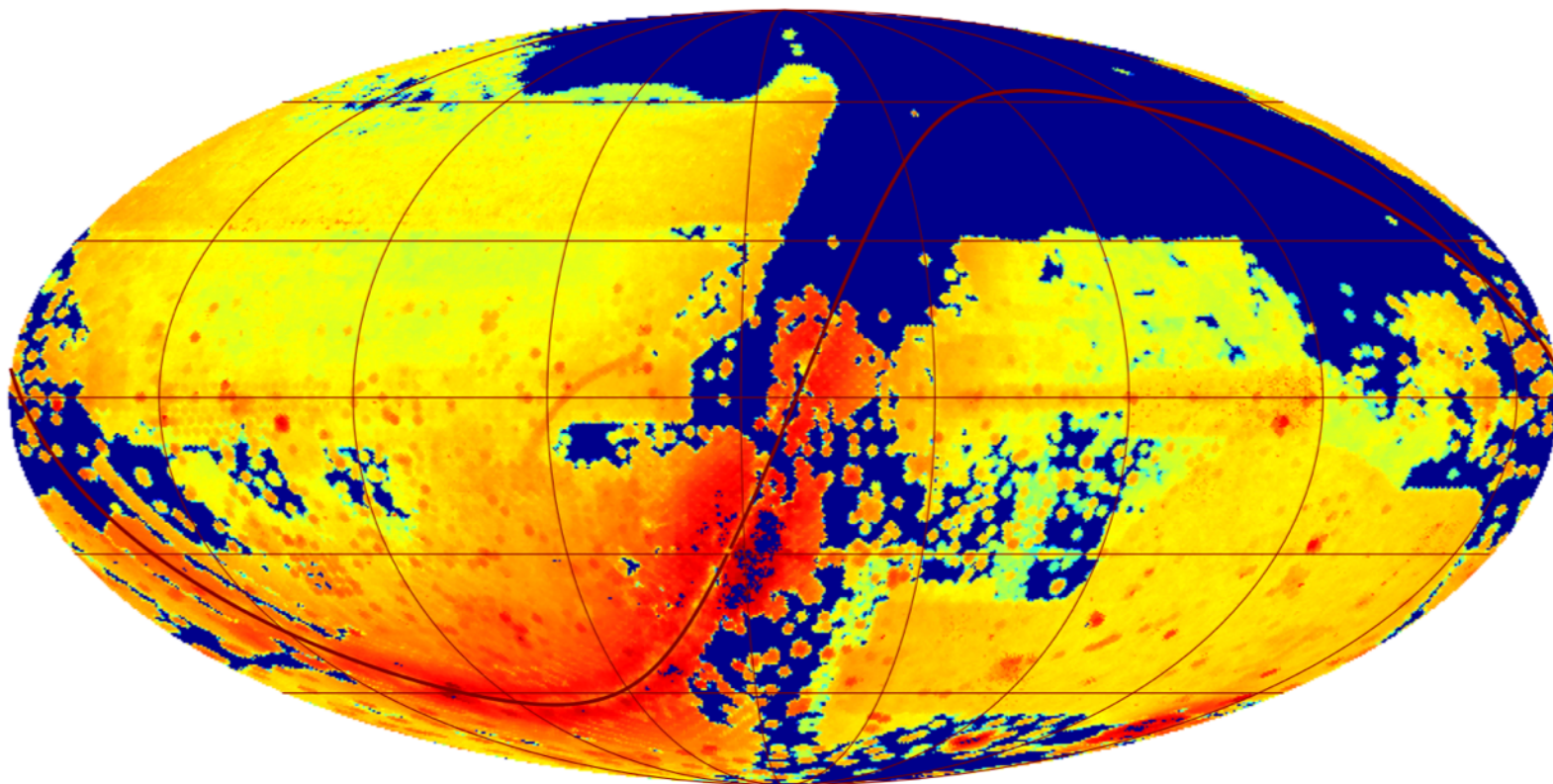




Data Lab catalogs



Log Number density sq.deg.⁻¹



-0.1  6.6

Log Number density sq.deg.⁻¹

~500 TB (February 2017) of on-target imaging data ($t_{\text{exp}} > 30\text{s}$)
currently from:

Dark Energy Survey

Legacy Surveys for DESI Targeting

Community DECam and Mosaic programs and surveys

Hundreds of TB more coming

Total holdings at PB scale

Large catalogs, e.g.:

Dark Energy Survey – 7 TB

Complete DESI Targeting Survey – ~5 TB

Community programs and surveys – up to several TB each

Summary of Current Functions

Function	Method
Sky exploration	Image discovery tool Catalog overlay tool
Authentication	Web interface datalab command Python authClient, DL interface
Catalog query	Web interface datalab command line (CLI) Python queryClient, DL interface TOPCAT
Image query	Simple Image Access (SIA) service
Query result storage	myDB Virtual storage space
File transfer	datalab command and Virtual storage space
Analysis	Jupyter notebook server

NOAO Facilities Featured Surveys:

DESI imaging Legacy Survey (LS): ~860 million objects in DR4+5

SMASH: ~100 million objects in DR1

DES: ~400 million objects in DR1

DECaPS: ~2 billion objects

NOAO All-Sky Source Catalog (NSC): ~2.9 billion objects

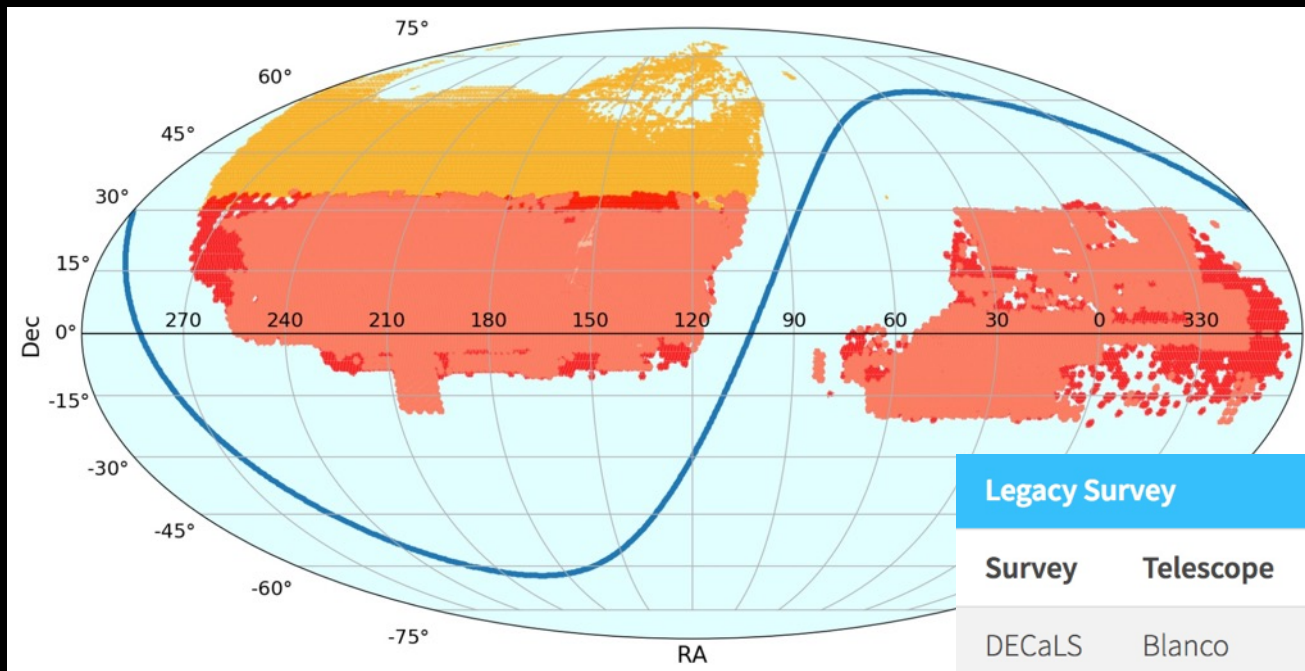
Additional Surveys:

select tables from **SDSS/BOSS** DR13 & DR14, **GAIA** DR1, DES SVA1, the **Allen NEO** catalog, and **USNO-A2/B**, *skinny* Pan-STARRS DR1, etc.

DESI Imaging Legacy Surveys (LS)

datalab.noao.edu/decals/lis.php

High-quality *g,r,z* imaging over 14,000 square degrees to select targets for DESI
 Also available for astronomy community to explore and make discoveries!



Sky coverage for:
 DR3 (pink); DR5 (red); DR4 (orange)

Legacy Survey			
Survey	Telescope	Band	Area
DECaLS	Blanco	<i>g, r, z</i>	9500 sq. deg
MzLS	Mayall	<i>z</i>	5000 sq. deg
BASS	Bok	<i>g, r</i>	5000 sq. deg
AllWISE	WISE	W1, W2, W3, W4	14000 sq. deg

Example Science case: Star/Galaxy Separation

Use colors and object shape to distinguish between stars, galaxies & QSOs

See full notebook:

http://datalab.noao.edu/notebooks/web/ScienceExamples/StarGalQSOSeparation/StarGalQsoLSDR3_20180104.html

```
In [1]: __author__ = 'Stephanie Juneau, NOAO Data Lab Team'
__version__ = '20180104' # yyyyymmdd
__datasets__ = ['ls_dr3']
```

Star/Galaxy/QSO Classification in the DESI Imaging Legacy Surveys

by Stéphanie Juneau, Robert Nikutta, Knut Olsen and the NOAO Data Lab Team

In this notebook, we investigate the optical and infrared colors of astronomical sources detected in the DECam Legacy Survey (DECaLS). The third data release of this imaging survey comprises ~400 millions stars, galaxies and quasars (or QSOs: Quasi-Stellar Objects).

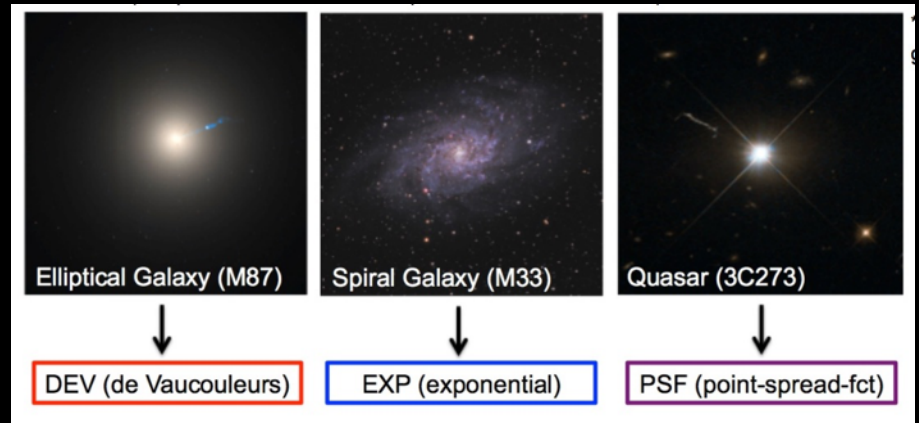
NOAO Data Lab products and services used here:

- the Legacy Survey (LS) DR3 database
- Jupyter Notebook Server
- Query Manager
- Image cutout tool similar to Data Lab SIA

Below, we query the database, compute colors, plot a few color combinations, and take into account the source "type" as defined from the light profile shape in order to differentiate between object classes.

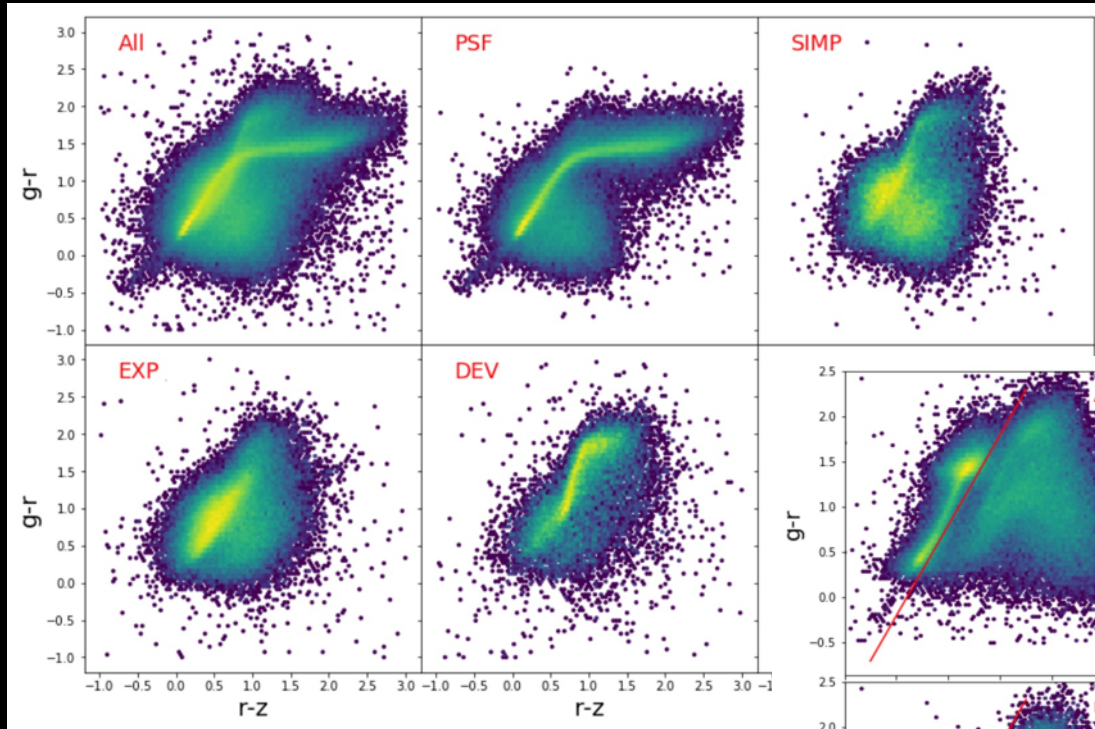
Table of contents

- [0. Disclaimer & attribution](#)
- [1. Introduction](#)
- [2. Imports & setup](#)
- [3. Authentication](#)
- [4. Query DECaLS Tractor Photometry Catalog](#)



DESI Imaging Legacy Surveys (LS)

Star/Galaxy Separation (Cont'd)

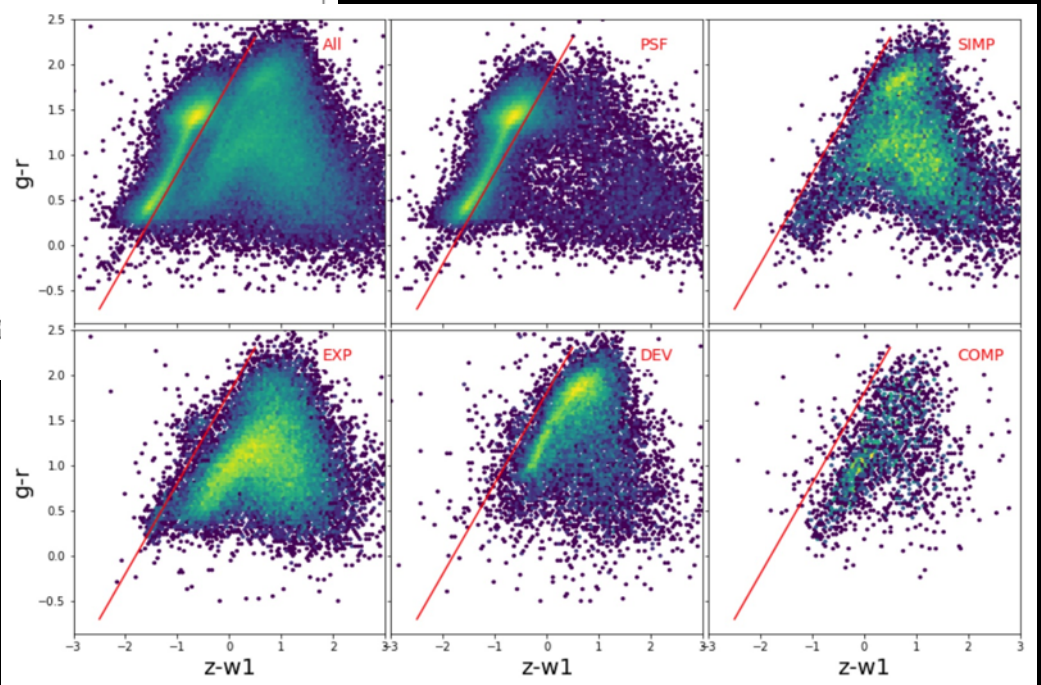


Color-color plots:

(left) $g-r$ vs. $r-z$

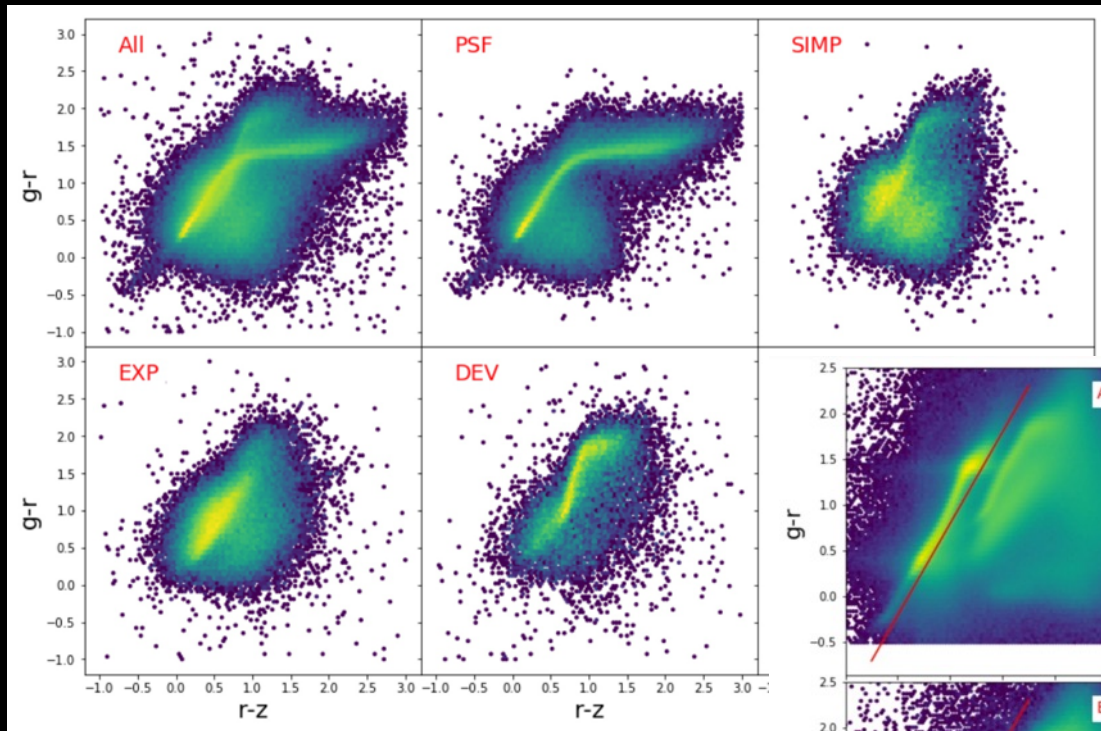
(bottom) $g-r$ vs. $z-W1$

[with infrared WISE 1 at 3.4 μm]



DESI Imaging Legacy Surveys (LS)

Star/Galaxy Separation (Cont'd)

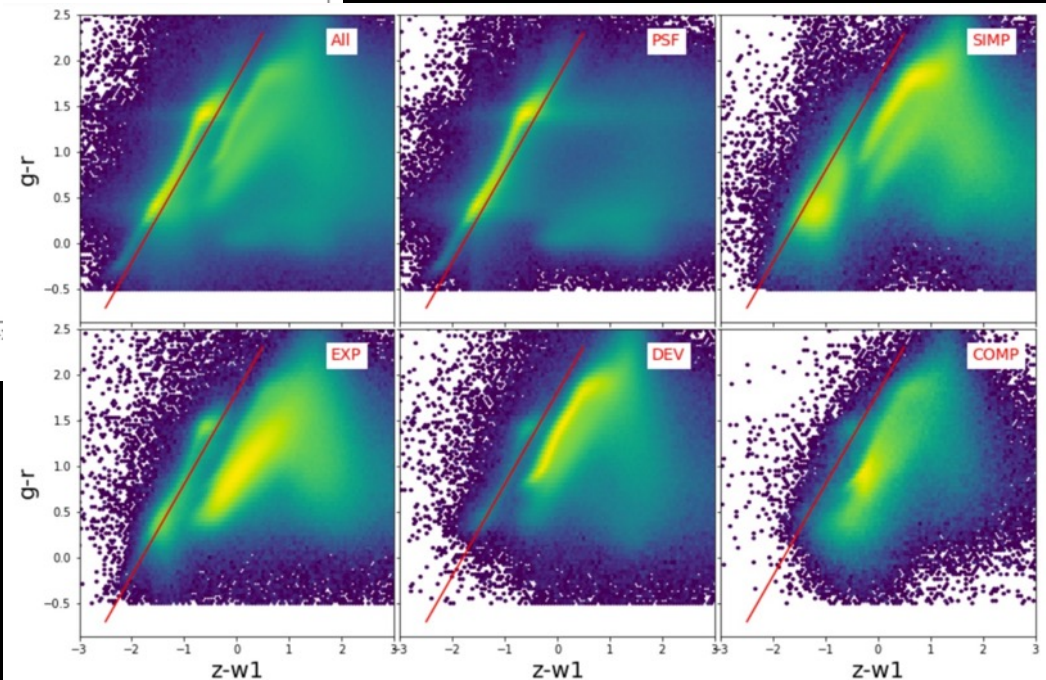


Color-color plots:

(left) $g-r$ vs. $r-z$

(bottom) $g-r$ vs. $z-W1$

[with infrared WISE 1 at 3.4 μm]





Dark Energy Survey (DES)

datalab.noao.edu/desdr1/index.php

DR1 available since January 10, 2018!

DES DR1 Summary	
Area covered	5000 deg ²
Bands	<i>grizY</i>
Depth (10 σ , <i>grizY</i>)	24.45, 24.3, 23.5, 22.90, 21.70 mag
Seeing (<i>grizY</i>)	~1 arcsec
Number of objects	399,263,026

Data Lab one of three access points, others are NCSA
DESaccess and LInEA Science Server

Data Lab release includes crossmatch tables, a table of
neighboring objects with 30 arcsec, otherwise identical





DES Data Management

Home

Releases ▾

SVA1 Gold ▾

DR1 ▾

Overview ▾

Products ▾

Data Access ▾

DR1 FAQ

DR1 Release Team

Get Help

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DR1 Data Access

If you'd like to access the images and catalogs from DES DR1, please use the complementary set of tools created by a collaborative effort between NCSA, NOAO, and LineA. These tools allow the users to access, obtain, visualize, and explore DES DR1 products.

When using DES data and/or DES access tools please consider the notes in the [Acknowledgement](#) page.

Click on the logos below to start exploring DES data tools. Follow the links below to learn more about each tool and their functionalities.



[NCSA DESaccess](#)



[NOAO DataLab](#)



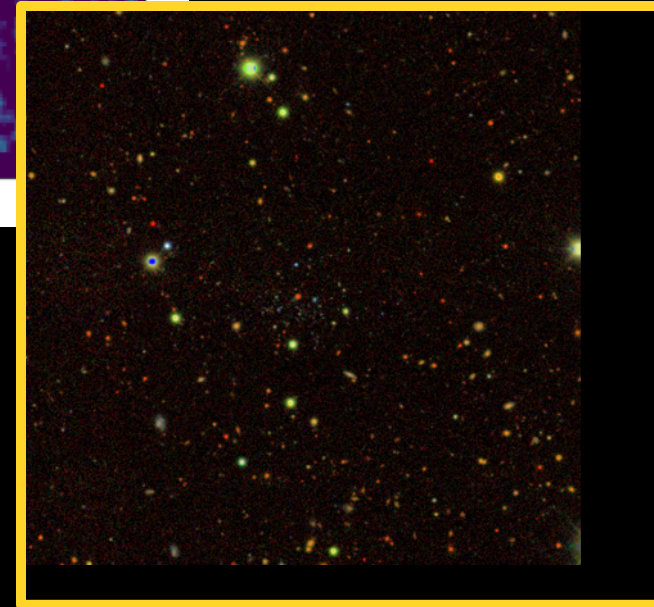
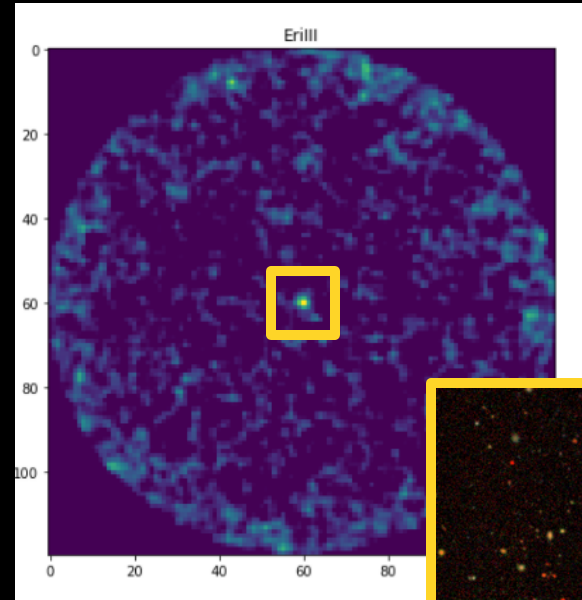
[DES-BRAZIL
LineA Science Server](#)

<https://des.ncsa.illinois.edu/releases/dr1/dr1-access>

Example Science case:

Rediscovering a Milky Way
dwarf galaxy

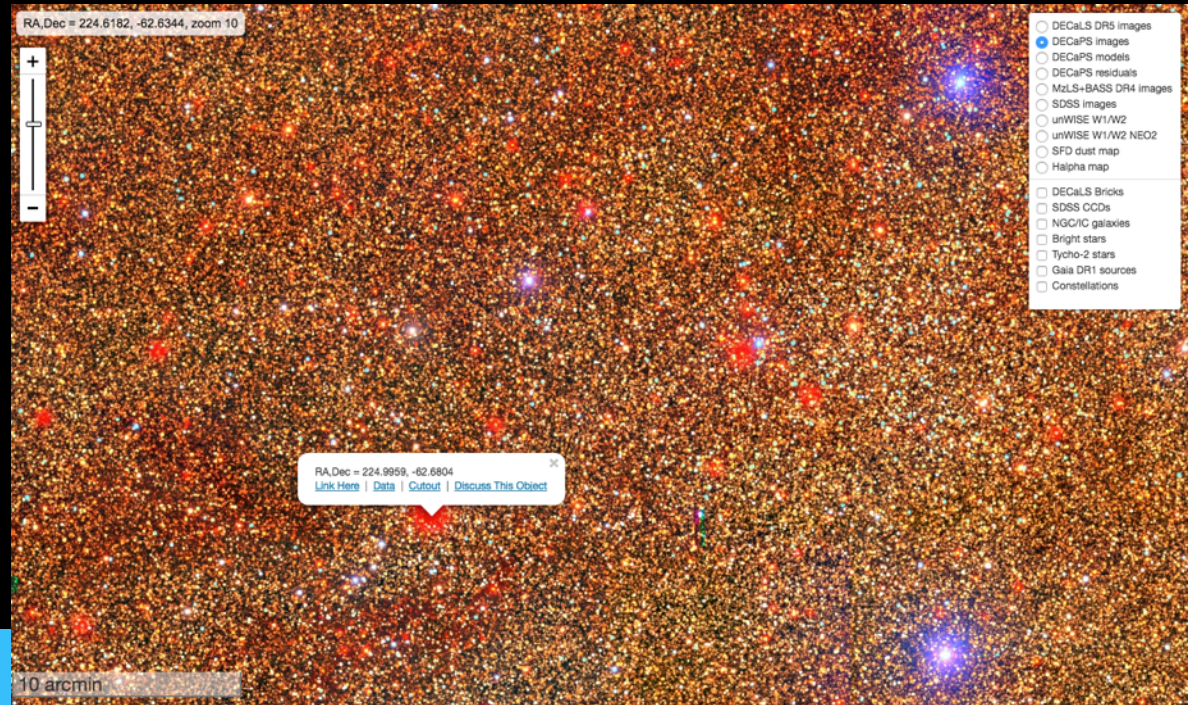
Verifying with an image
cutout



See full notebook:

http://datalab.noao.edu/desdr1/analysis/DwarfGalaxyDESDR1_20171101.html

- Released in 2017
(decaps.skymaps.info;
Schlafly et al 2017)
- Object table served at Data Lab since January 2018
- Measurement table (single-epoch) available soon!



DECaPS Summary Table

Area covered	~1000 deg ²
Bands	<i>grizY</i>
Depth (5σ , <i>grizY</i>)	23.7, 22.8, 22.2, 21.8, 21.0 mag
Number of objects	~2,000,000,000

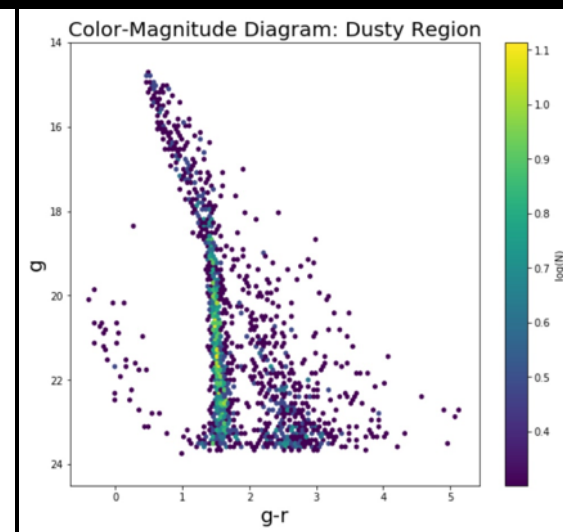
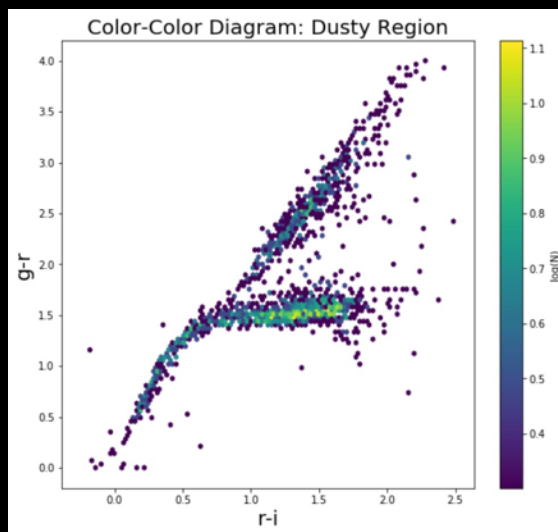
Example Science case:

Galactic substructure

Plot stellar populations on color-color & color-magnitude diagrams

See full notebook:

http://datalab.noao.edu/notebooks/web/ScienceExamples/GalacticStructure/GalacticStructureDECaPS_20180111.html





NOAO Source Catalog (NSC)

datalab.noao.edu/nscdr1/index.php

Data: **1 Petabyte** (uncompressed)

Images: **~255,000**

Sky Coverage: **~30,000 deg²**

Number of measurements: **~34 billion**

Number of objects: **~2.9 billion**

Astrometric accuracy: **~2 mas**

Photometric precision: **~1-2%**

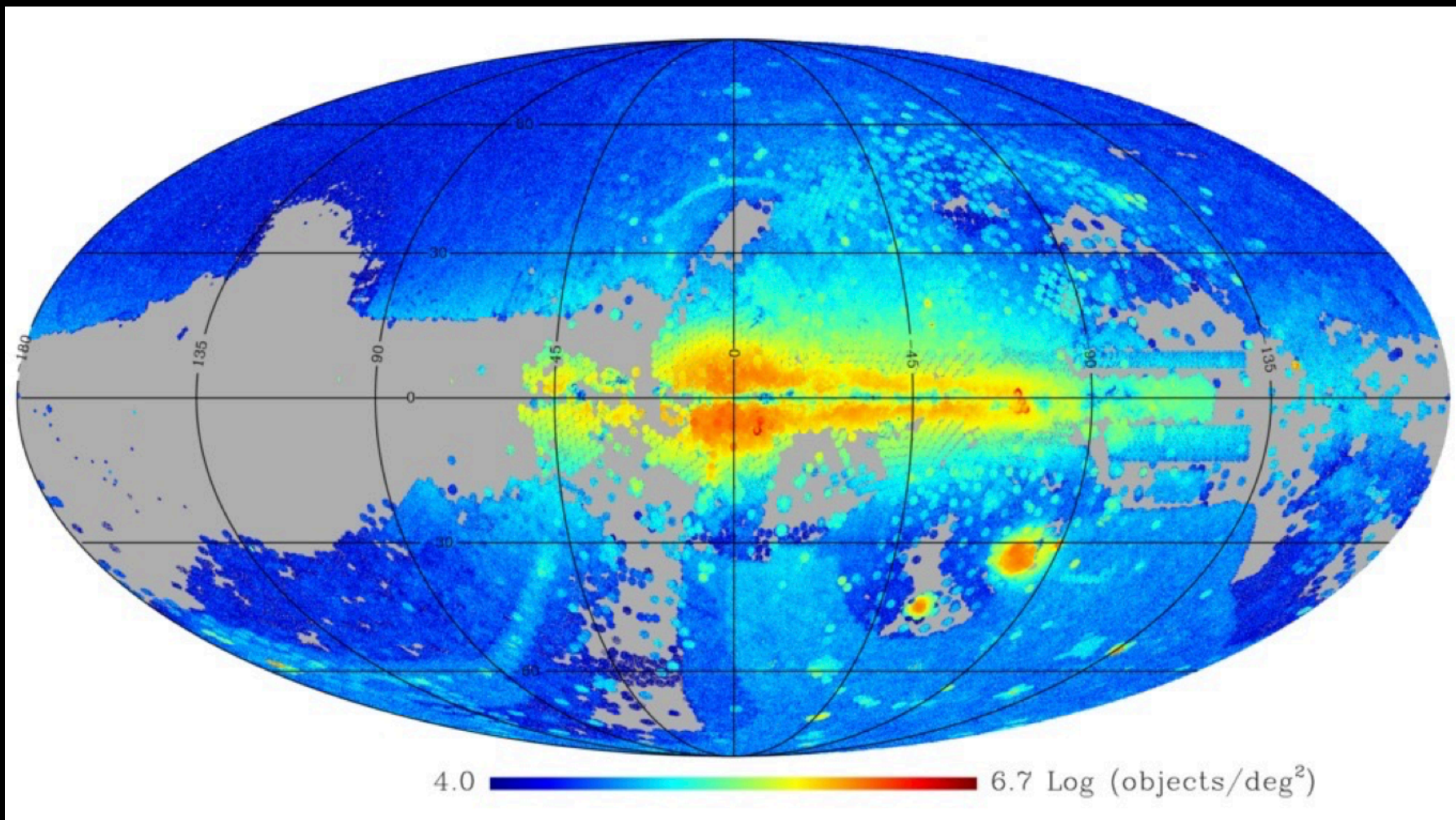
Depth: **~23rd mag** (u, g, r, i, z, Y, VR)

Nidever et al (2018): arxiv1801.01885

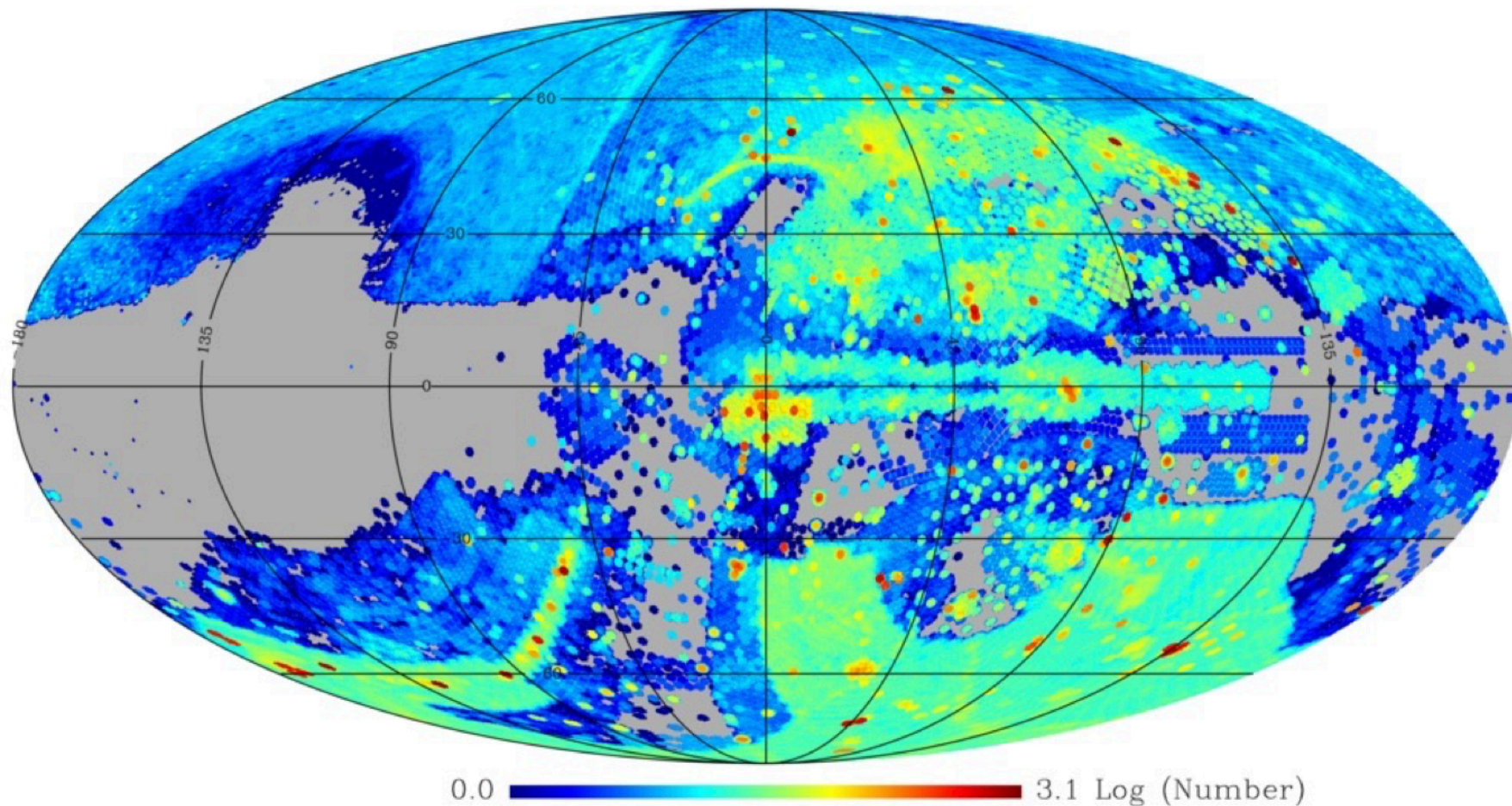


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Number of Exposures





NOAO Source Catalog (NSC)

datalab.noao.edu/nscdr1/index.php

Example Science cases:

dwarf galaxies, streams

variable stars, AGN, solar system objects

Future Releases:

Time-series: **100+ epochs for 200 million objects**

PSF photometry on individual and stacked images

Forced photometry on individual images

Real-time updates as data become public



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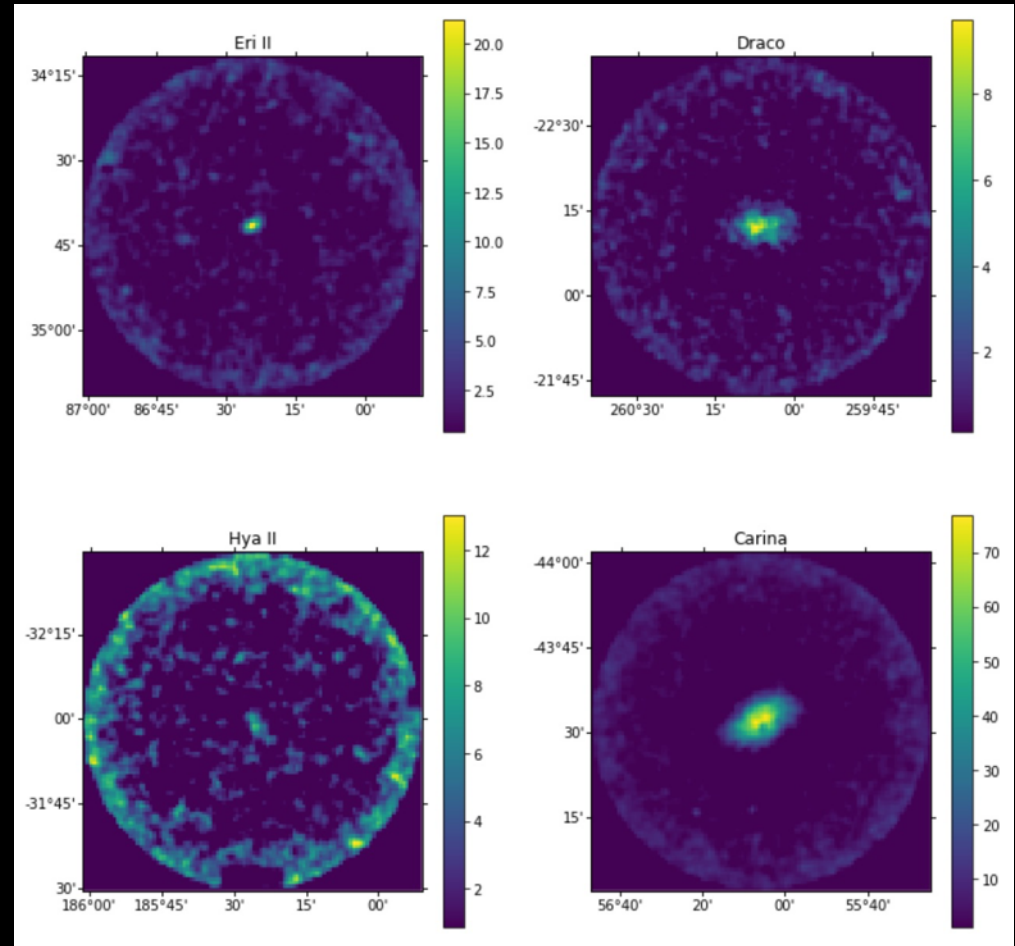


Example Science case: dwarf galaxies

Plot stellar density and
convolve with a spatial filter

See full notebook:

http://datalab.noao.edu/notebooks/web/ScienceExamples/DwarfGalaxies/DwarfGalaxiesInNscDr1_20180105.html



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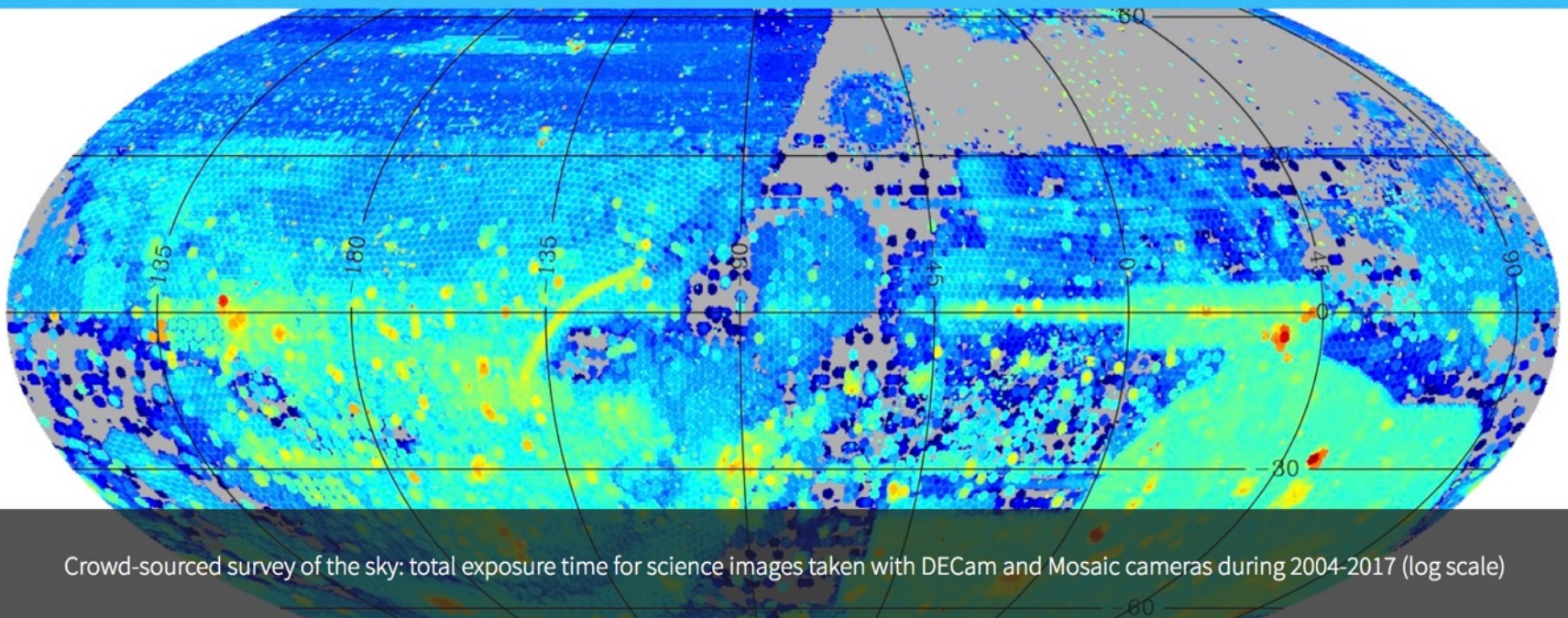
[Quick Start](#)

[Tools](#)

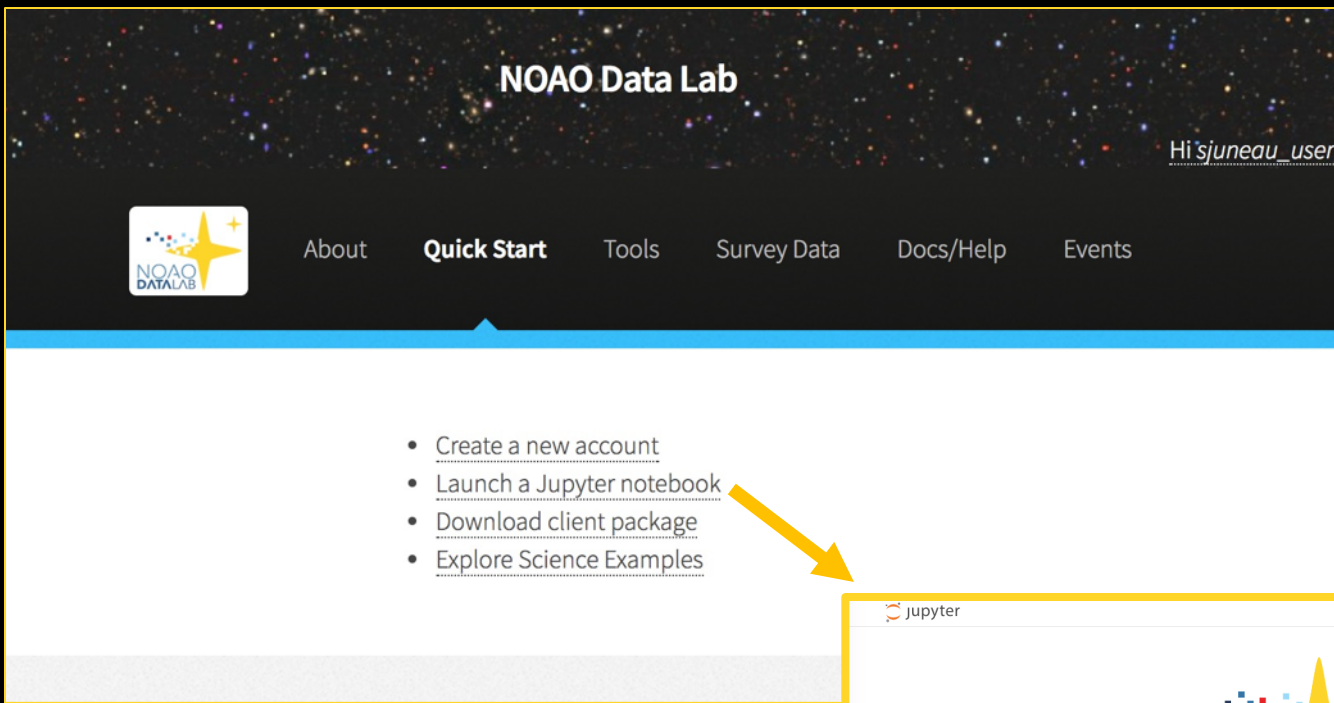
[Survey Data](#)

[Docs/Help](#)

[Events](#)



Crowd-sourced survey of the sky: total exposure time for science images taken with DECam and Mosaic cameras during 2004-2017 (log scale)



1) User logs in to Data Lab



2) Launch Jupyter Notebook server



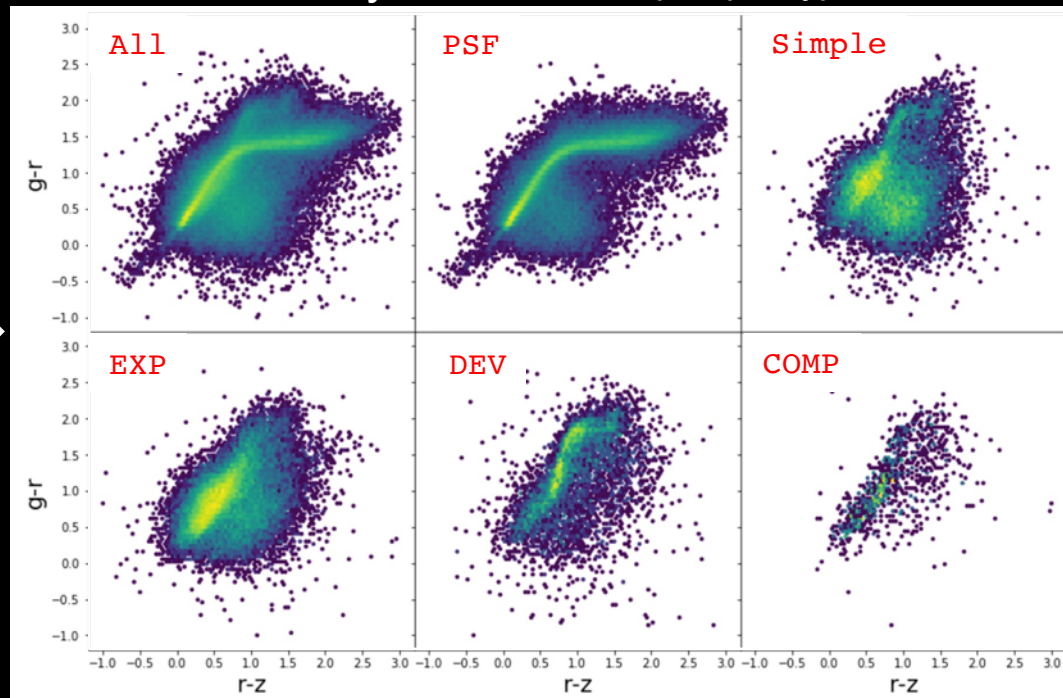
Query to database: magnitudes and object shape (type)

```

query = """
SELECT dered_mag_g as gmag, dered_mag_r as rmag,
       dered_mag_z as zmag,
       dered_mag_w1 as w1mag, dered_mag_w2 as w2mag, type,
       snr_g, snr_r, snr_z, ra, dec
FROM ls_dr3.tractor_primary
WHERE (snr_g>3 and snr_r>3 and snr_z>3)
LIMIT 200000"""

# dered_mag_g,r,z = AB mag in DECam g,r,z bands corrected
#                  for Galactic reddening
# dered_mag_w1,w2 = AB magnitudes in WISE bands W1 & W2
#                  corrected for Galactic reddening
# type            = object type (PSF, SIMP, EXP, DEV, COMP)
# snr_g,r,z       = signal-to-noise ratios (S/N) in g,r,z bands
# ra,dec          = celestial coordinates
#
# WHERE: requirement that S/N>3 in each DECaLS band
# LIMIT: returns 200,000 rows that satisfy the query
    
```

Analysis: color-color plot per type



Example Workflow

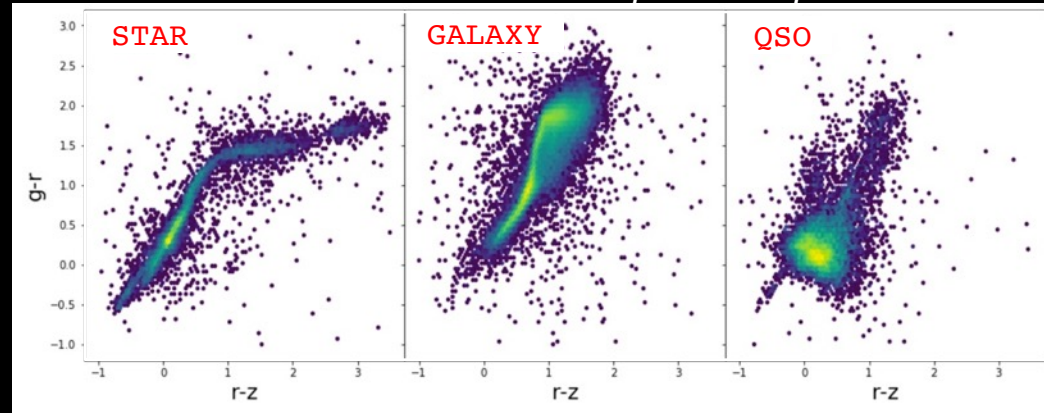
Machine-Learning:

Confusion matrix (spectroscopic training set)

GALAXY	0.982	0.008	0.001
QSO	0.087	0.878	0.035
STAR	0.018	0.012	0.97
	GALAXY	QSO	STAR

Joint query:

cross-match with SDSS spectroscopic class



Using the NOAA Data Lab

data.noaa.gov

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About

[Quick Start](#)

[Tools](#)

[Survey Data](#)

[Docs/Help](#)

[Events](#)

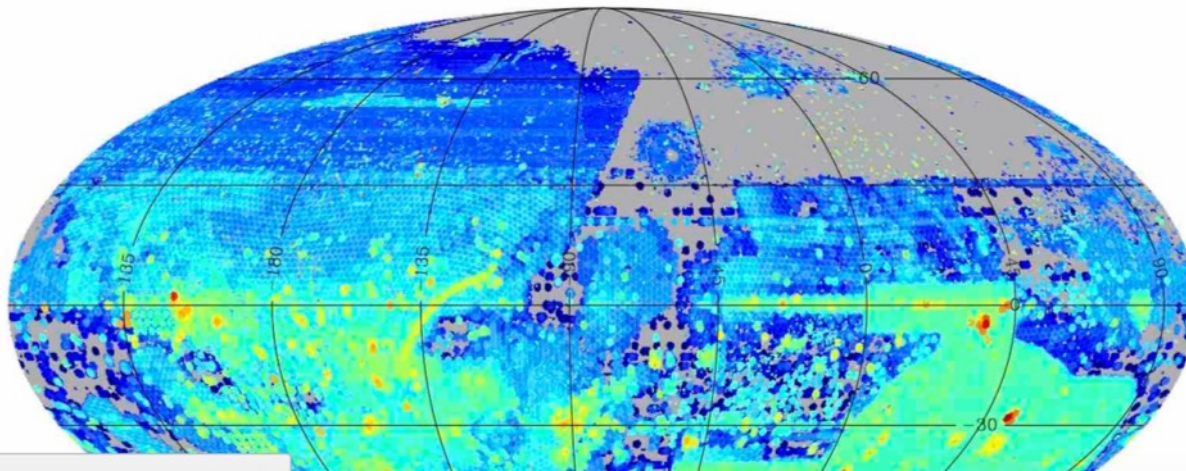
People

Data Lab Publications

Acknowledgements

Disclaimers

About the NOAA Data Lab



Using the NOAO Data Lab

datalab.noao.edu

The screenshot shows the NOAO Data Lab website. At the top, the text "NOAO Data Lab" is centered, with "Login | Sign up" on the right. Below this is a navigation bar with the NOAO Data Lab logo and links for "About", "Quick Start", "Tools", "Survey Data", "Docs/Help", and "Events". The "Quick Start" menu is open, showing options: "Create a new account", "Launch a Jupyter notebook", "Download client package", and "Explore Science Examples". Below the menu is a list of links: "Launch a Jupyter notebook", "Download client package", and "Explore Science Examples". At the bottom, there are logos for NOAO, AURA, and NSF, along with GitHub and Twitter icons. A paragraph of text describes the lab's development by NOAO, AURA, and NSF. At the bottom, contact information is provided: "For further information, contact datalab@noao.edu."

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Launch a Jupyter notebook
Download client package
Explore Science Examples

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NOAO AURA NSF

The NOAO Data Lab is being developed by the [National Optical Astronomy Observatory](#), the national center for ground-based nighttime astronomy in the United States operated by the [Association of Universities for Research in Astronomy \(AURA\)](#) under cooperative agreement with the [National Science Foundation](#).


For further information, contact datalab@noao.edu.

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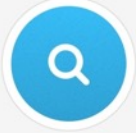
datalab.noao.edu

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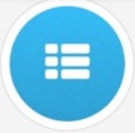
 [About](#) [Quick Start](#) **Tools** [Survey Data](#) [Docs/Help](#) [Events](#)

- Discovery Tools
- Query Interface
- Analysis Tools



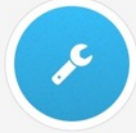
Discovery Tools

Launch our Image Discovery or Catalog Discovery Tools



Query Interface

Query our catalog database and view and store the results



Analysis Tools

Links to client software and our Jupyter notebook server

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About

[Quick Start](#)

[Tools](#)

[Survey Data](#)

[Docs/Help](#)

[Events](#)

DECaPS

DES

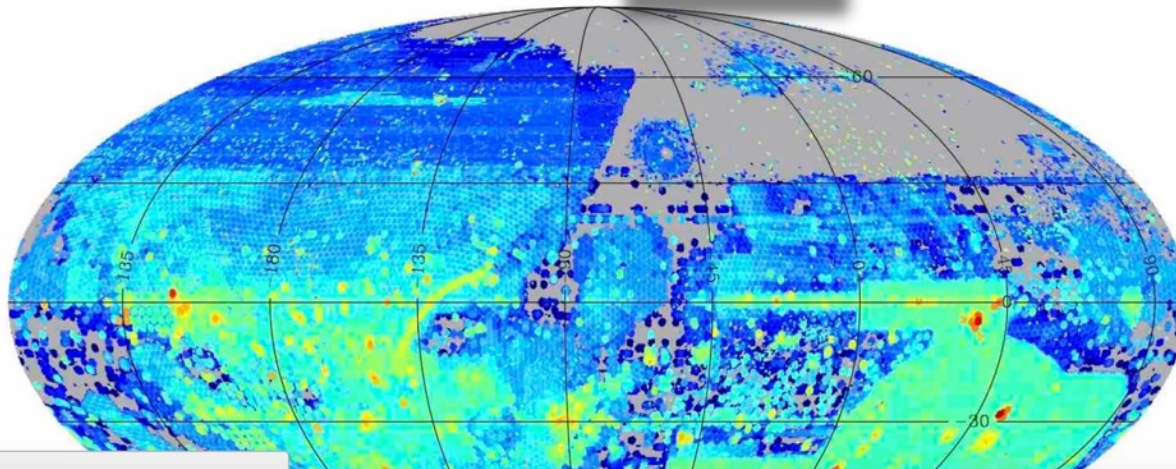
Legacy Survey

NOAO Source Catalog

SMASH

Other

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datalab.noao.edu/survey.php

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[About](#)

[Quick Start](#)

[Tools](#)

[Survey Data](#)

[Docs/Help](#)

[Events](#)

[Helpdesk](#)

[User manual](#)

[API documentation](#)

Documentation and Help

- [Helpdesk](#)
- [User manual](#)
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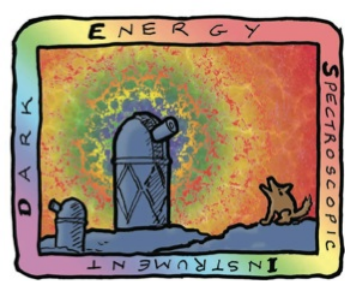
For further information, contact datalab@noao.edu.

DESI (Dark Energy Spectroscopic Instrument) Survey

Future releases of current datasets

“Skinny” versions of PanSTARRS, GAIA, LSST, etc.

Data Publication Service (could be your dataset!)

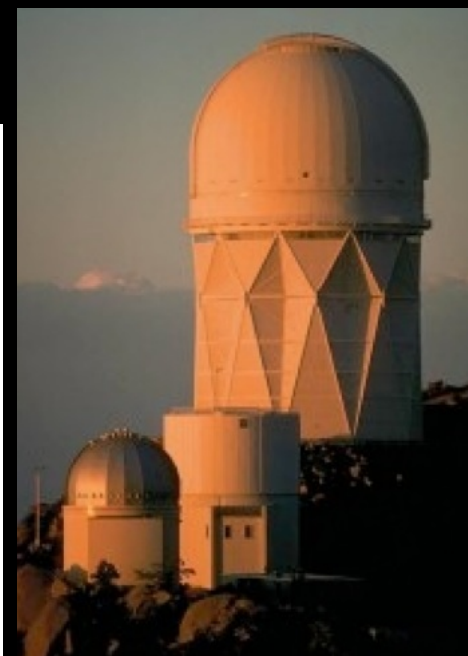


DESIGN

Dark Energy Spectroscopic Instrument

- 14,000 square degrees
- 30 million spectra of galaxies and quasars!
- 10 million spectra of stars
- Commissioning in 2018 (survey 2019-2024)

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	---



Mayall 4m
Kitt Peak, AZ

Host DESI imaging Legacy Surveys (DECaLS, BASS/MzLS)

→ Databases (ls_dr3, ls_dr4, ls_dr5)

→ Images in NOAO Science Archive (raw + processed)

now!

Host a copy of DESI targets

→ Database for final, public set of targets

Host DESI redshifts

→ Database for public releases of redshift catalogs

→ Tools for spectra visualization/analysis

future

Create example Notebooks & workflows

Users can work with all data products

Easy access to data for entire astronomy community

→ Databases: Tables, Images, Spectra

User-friendly yet powerful analysis tools

→ Quick start analysis

→ Automated & sophisticated workflows

Data Publication Service

→ User contributed datasets

Interactive interface with advanced visualization

→ connected exploration & analysis, drag-and-drop workflow

Data Lab software package

→ widely distributed, user-contributed developments

Machine-Learning algorithms

→ Running in background on all the datasets

Education & Public Outreach

→ Astronomy/Data Science activities for classrooms

→ Art/Science Collaborations

Citizen-science projects

Combining increasingly larger datasets including multi-wavelength cross-analysis & combining with simulations/simulated data

Interface between different Data Centers

- different technologies
- different data models and/or formats
- cannot always have co-located data (e.g., full LSST)

Balancing public (astro/cosmo community) and private (survey team) needs for data access and analysis tools



Try it out and get in touch!

Web: datalab.noao.edu

Email: datalab@noao.edu

GitHub: <https://github.com/noao-datalab>

Twitter: [@NOAODataLab](https://twitter.com/NOAODataLab)



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Community Science and Data Center



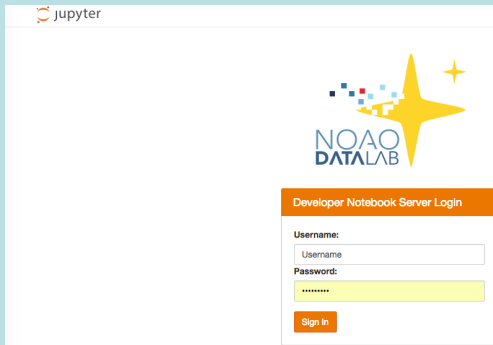
Extra Slides: Data Lab Info & Tutorial



Example: Detecting a faint dwarf galaxy

User logs in to Data Lab

1



Launches Jupyter Notebook

Queries database for blue stellar objects in SMASH DR1 Field

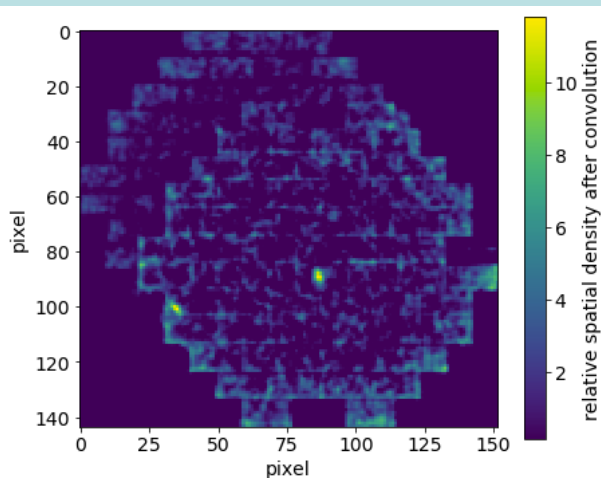
2

```
field = 169 # SMASH field number to query
depth = 1 # depth (=no short exposures please)

# Create the query string; SQL keyword capitalized for clarity
query_template = \
"""SELECT ra,dec,gmag,rmag,imag FROM smash_dr1.object
WHERE fieldid = '%d' AND
depthflag > %d AND
abs(sharp) < 0.5 AND
gmag BETWEEN 9 AND 25 AND
(gmag-rmag) BETWEEN -0.4 AND 0.4"""

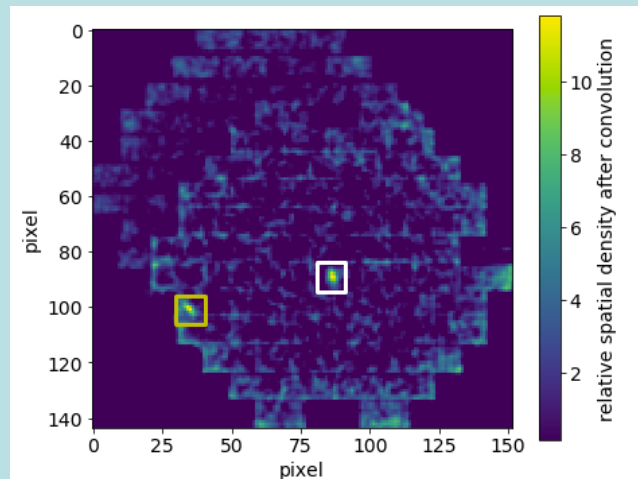
query = query_template % (field, depth)
```

Applies filter to spatial distribution



3

Runs automatic peak detection



4

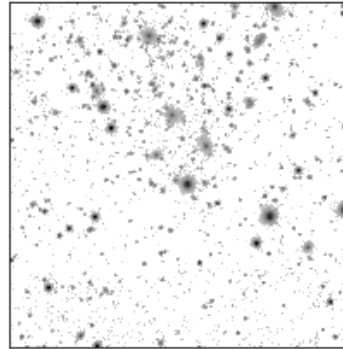
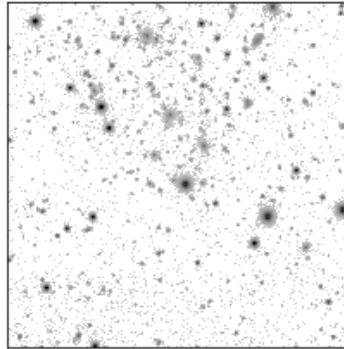
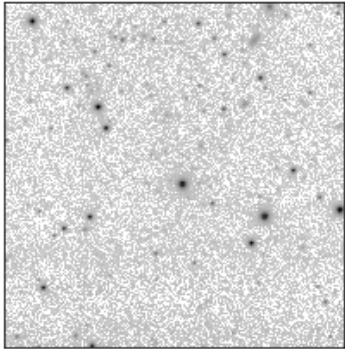
Queries peak locations for image cutouts

5

g band

r band

i band



Stores all results in virtual storage...

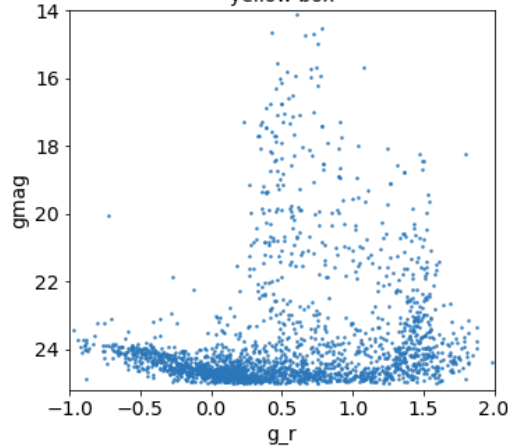
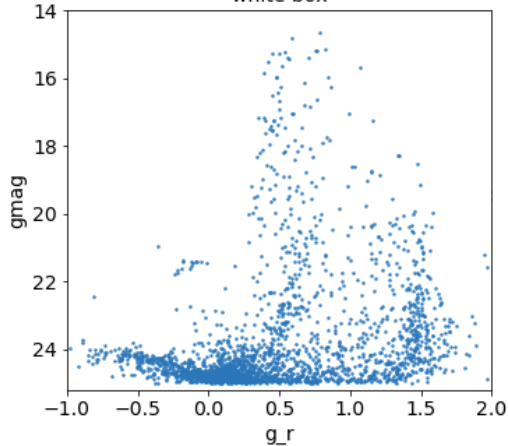
7

...and repeat!

Queries peak locations for full photometry

white box

yellow box

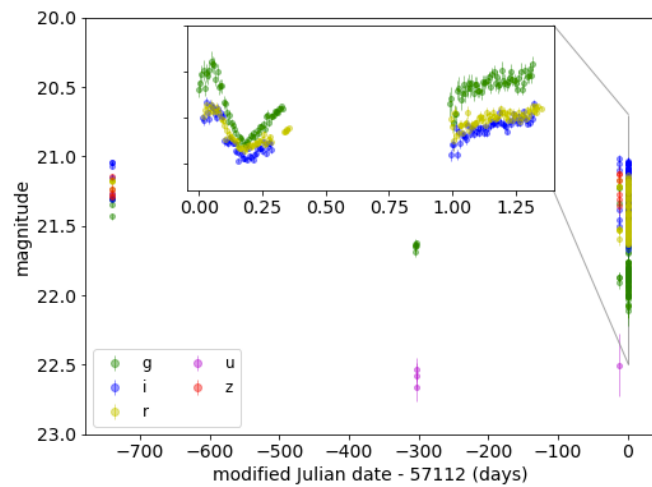


6

Example: Detecting variables

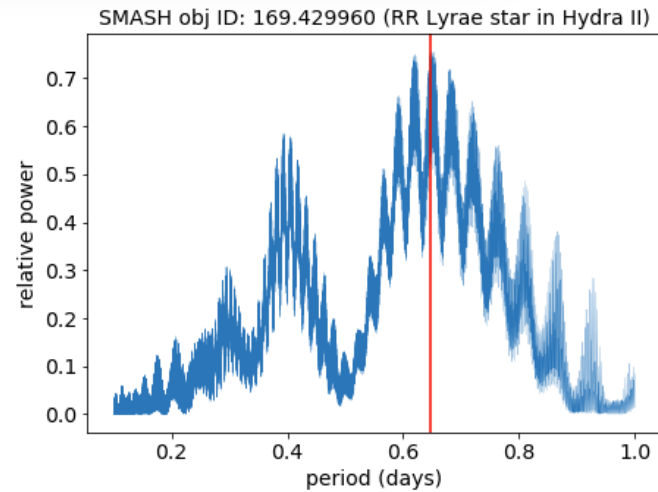
Retrieve light curve of candidate Hydra II variable

1



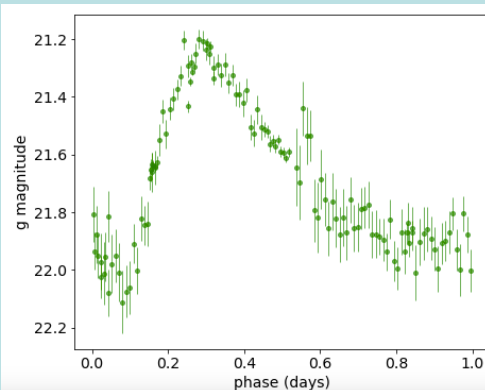
Apply Lomb-Scargle

2



Fold light curve

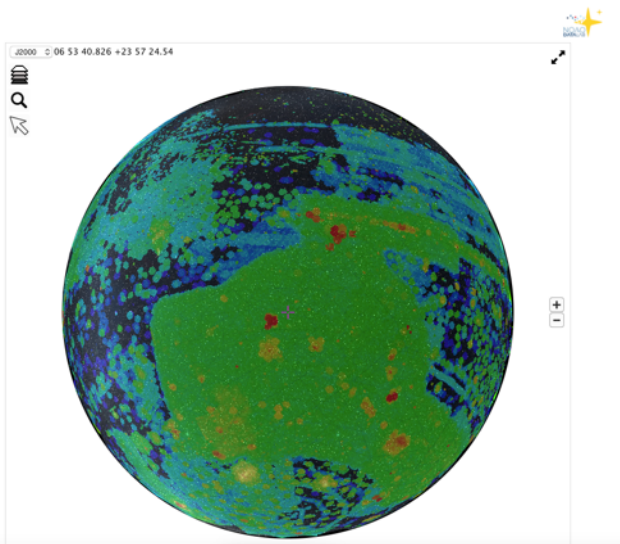
3



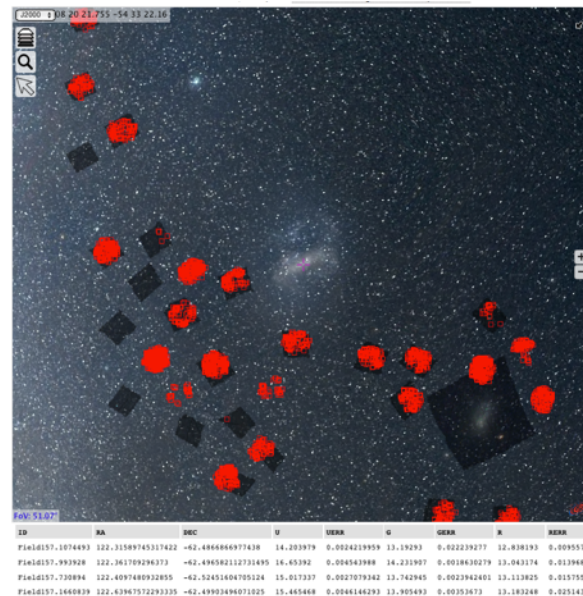
Identify more variables through statistical techniques!

4

Images

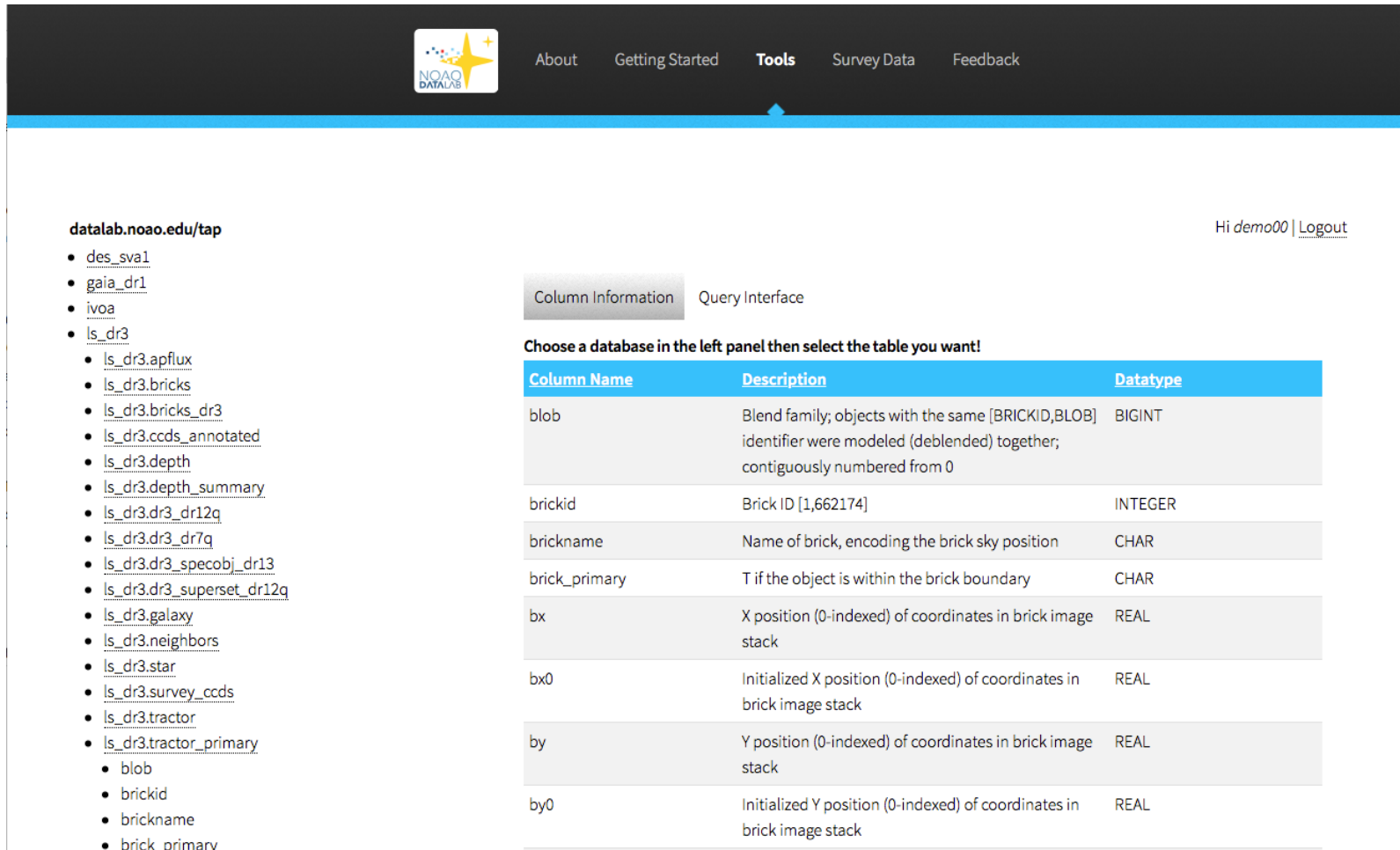


Catalogs



Querying the catalogs

- Through the Data Lab website:



The screenshot shows the NOAO DataLab website interface. At the top, there is a navigation bar with the NOAO DataLab logo and links for "About", "Getting Started", "Tools", "Survey Data", and "Feedback". The "Tools" link is highlighted with a blue arrow. Below the navigation bar, the main content area is divided into two panels. The left panel, titled "datalab.noao.edu/tap", lists various databases and tables, including "des_sva1", "gaia_dr1", "ivoa", "ls_dr3", and several sub-tables under "ls_dr3" such as "ls_dr3.apflux", "ls_dr3.bricks", "ls_dr3.bricks_dr3", "ls_dr3.ccds_annotated", "ls_dr3.depth", "ls_dr3.depth_summary", "ls_dr3.dr3_dr12q", "ls_dr3.dr3_dr7q", "ls_dr3.dr3_specobj_dr13", "ls_dr3.dr3_superset_dr12q", "ls_dr3.galaxy", "ls_dr3.neighbors", "ls_dr3.star", "ls_dr3.survey_ccds", "ls_dr3.tractor", and "ls_dr3.tractor_primary". The right panel, titled "Column Information" and "Query Interface", displays a table of column information for a selected database. The table has three columns: "Column Name", "Description", and "Datatype". The table lists columns such as "blob", "brickid", "brickname", "brick_primary", "bx", "bx0", "by", and "by0", each with a detailed description and a data type (BIGINT, INTEGER, CHAR, REAL).

datalab.noao.edu/tap Hi demo00 | [Logout](#)

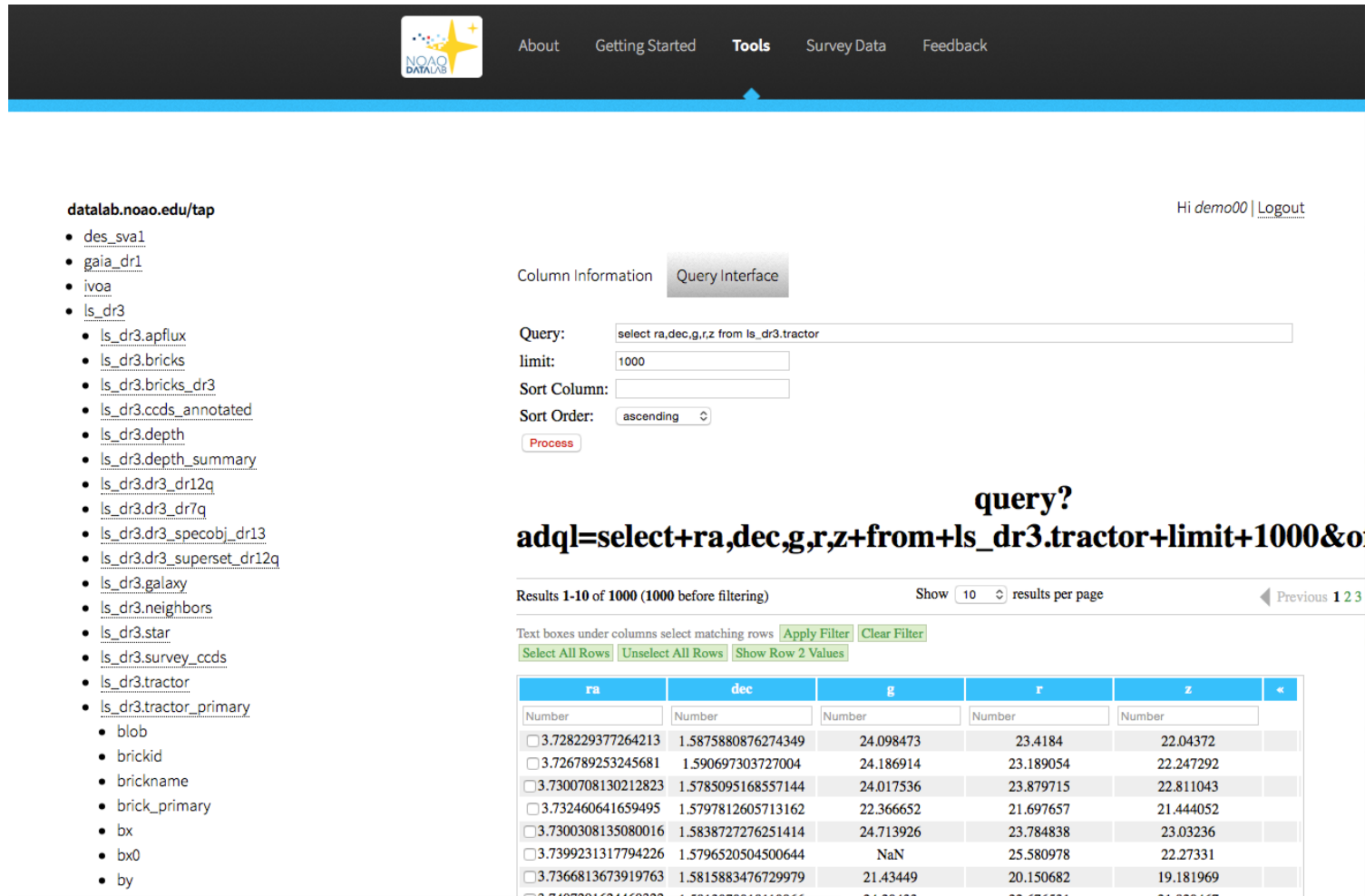
- [des_sva1](#)
- [gaia_dr1](#)
- [ivoa](#)
- [ls_dr3](#)
 - [ls_dr3.apflux](#)
 - [ls_dr3.bricks](#)
 - [ls_dr3.bricks_dr3](#)
 - [ls_dr3.ccds_annotated](#)
 - [ls_dr3.depth](#)
 - [ls_dr3.depth_summary](#)
 - [ls_dr3.dr3_dr12q](#)
 - [ls_dr3.dr3_dr7q](#)
 - [ls_dr3.dr3_specobj_dr13](#)
 - [ls_dr3.dr3_superset_dr12q](#)
 - [ls_dr3.galaxy](#)
 - [ls_dr3.neighbors](#)
 - [ls_dr3.star](#)
 - [ls_dr3.survey_ccds](#)
 - [ls_dr3.tractor](#)
 - [ls_dr3.tractor_primary](#)
 - [blob](#)
 - [brickid](#)
 - [brickname](#)
 - [brick_primary](#)

Column Information Query Interface

Choose a database in the left panel then select the table you want!

Column Name	Description	Datatype
blob	Blend family; objects with the same [BRICKID,BLOB] identifier were modeled (deblended) together; contiguously numbered from 0	BIGINT
brickid	Brick ID [1,662174]	INTEGER
brickname	Name of brick, encoding the brick sky position	CHAR
brick_primary	T if the object is within the brick boundary	CHAR
bx	X position (0-indexed) of coordinates in brick image stack	REAL
bx0	Initialized X position (0-indexed) of coordinates in brick image stack	REAL
by	Y position (0-indexed) of coordinates in brick image stack	REAL
by0	Initialized Y position (0-indexed) of coordinates in brick image stack	REAL

- Through the Data Lab website:



The screenshot shows the NOAO Data Lab website interface. At the top, there is a navigation bar with links for 'About', 'Getting Started', 'Tools', 'Survey Data', and 'Feedback'. The 'Tools' link is highlighted. Below the navigation bar, the URL 'datalab.noao.edu/tap' is displayed. On the right side, there is a user session indicator 'Hi demo00 | Logout'. A list of data catalogs is shown on the left, including 'des_sva1', 'gaia_dr1', 'ivoa', 'ls_dr3', and various sub-catalogs under 'ls_dr3'. The 'Query Interface' tab is active, showing a query form with the following fields: 'Query:' (containing 'select ra,dec,g,r,z from ls_dr3.tractor'), 'limit:' (set to 1000), 'Sort Column:', and 'Sort Order:' (set to 'ascending'). A 'Process' button is visible below the form. Below the query form, the text 'query?' and 'adql=select+ra,dec,g,r,z+from+ls_dr3.tractor+limit+1000&o' is displayed. The results section shows 'Results 1-10 of 1000 (1000 before filtering)' and 'Show 10 results per page'. There are buttons for 'Apply Filter', 'Clear Filter', 'Select All Rows', 'Unselect All Rows', and 'Show Row 2 Values'. A table of results is shown with columns for 'ra', 'dec', 'g', 'r', and 'z', each with a 'Number' input field and a checkbox. The table contains 10 rows of data.

ra	dec	g	r	z
3.728229377264213	1.5875880876274349	24.098473	23.4184	22.04372
3.726789253245681	1.590697303727004	24.186914	23.189054	22.247292
3.7300708130212823	1.5785095168557144	24.017536	23.879715	22.811043
3.732460641659495	1.5797812605713162	22.366652	21.697657	21.444052
3.7300308135080016	1.5838727276251414	24.713926	23.784838	23.03236
3.7399231317794226	1.5796520504500644	NaN	25.580978	22.27331
3.7366813673919763	1.5815883476729979	21.43449	20.150682	19.181969

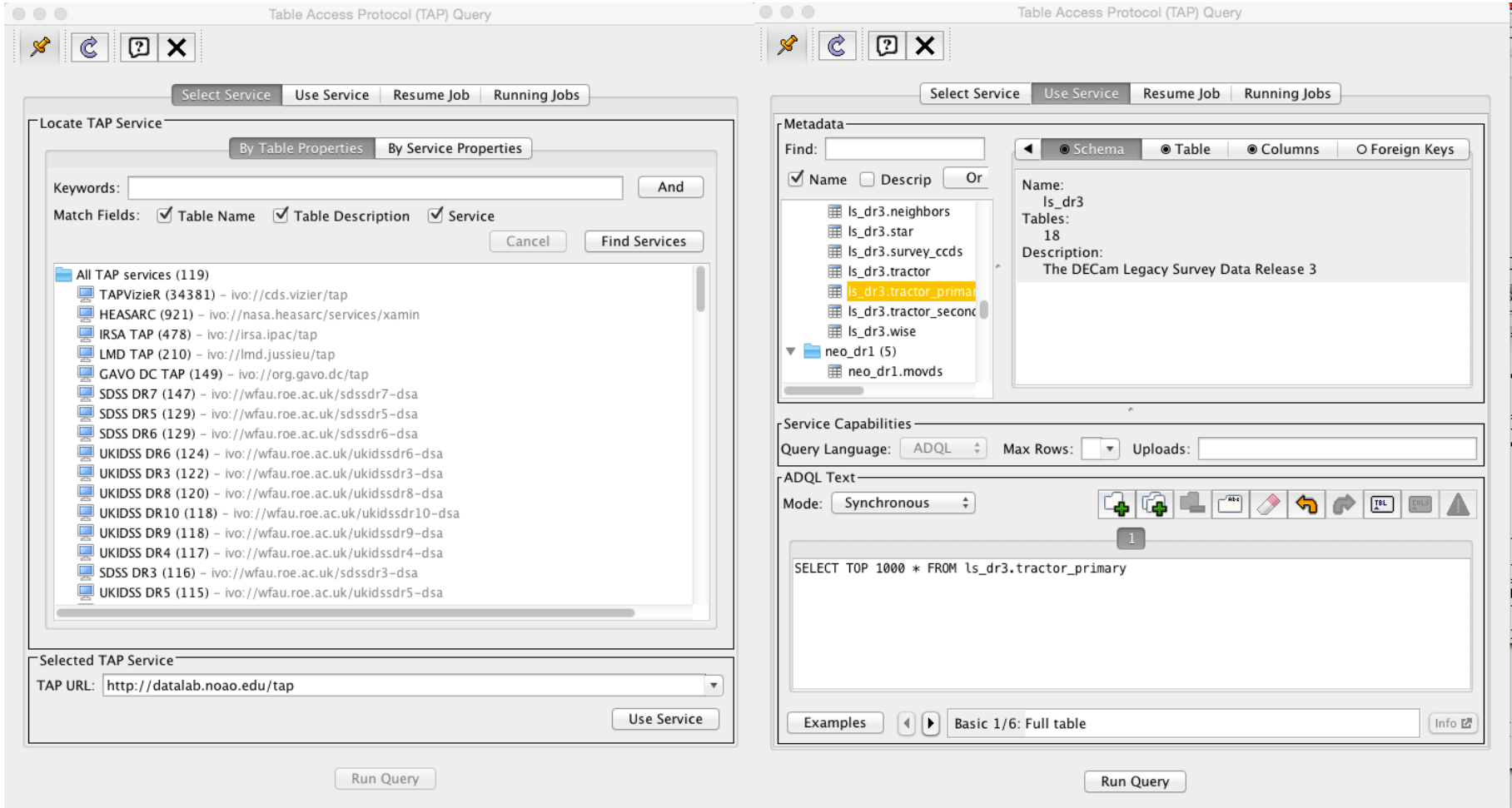
- Through the Python queryClient module:

```
In [4]: from dl import authClient, queryClient
        from getpass import getpass
        token = authClient.login(raw_input('Enter username: '),getpass('Enter password: '))
```

```
In [29]: %%time
        query="SELECT id,ra,dec,gmag,rmag FROM smash_dr1.object WHERE fieldid=169 LIMIT 100"
        try:
            response = queryClient.query(token, sql = query, fmt = 'csv')
        except Exception as e:
            print e.message
            raise
        print response[:205]
```

```
id,ra,dec,gmag,rmag
169.458572,185.342365895208,-32.1201617232873,24.8856,24.6991
169.460663,185.348188180985,-32.1200524648251,24.665,24.5361
169.1065651,185.353177442806,-32.1208638198927,25.0639,24.6239
CPU times: user 7.4 ms, sys: 956 µs, total: 8.36 ms
Wall time: 53 ms
```

- Through TOPCAT:



The image displays two screenshots of the TOPCAT (Table Access Protocol) Query interface.

Left Screenshot: Locate TAP Service

- Buttons: Select Service, Use Service, Resume Job, Running Jobs
- Locate TAP Service: By Table Properties, By Service Properties
- Keywords: [] And
- Match Fields: Table Name Table Description Service
- Cancel Find Services
- All TAP services (119)
 - TAPVizieR (34381) - ivo://cds.vizier/tap
 - HEASARC (921) - ivo://nasa.heasarc/services/xamin
 - IRSA TAP (478) - ivo://irsa.ipac/tap
 - LMD TAP (210) - ivo://lmd.jussieu/tap
 - GAVO DC TAP (149) - ivo://org.gavo.dc/tap
 - SDSS DR7 (147) - ivo://wfau.roe.ac.uk/sdssdr7-dsa
 - SDSS DR5 (129) - ivo://wfau.roe.ac.uk/sdssdr5-dsa
 - SDSS DR6 (129) - ivo://wfau.roe.ac.uk/sdssdr6-dsa
 - UKIDSS DR6 (124) - ivo://wfau.roe.ac.uk/ukidssdr6-dsa
 - UKIDSS DR3 (122) - ivo://wfau.roe.ac.uk/ukidssdr3-dsa
 - UKIDSS DR8 (120) - ivo://wfau.roe.ac.uk/ukidssdr8-dsa
 - UKIDSS DR10 (118) - ivo://wfau.roe.ac.uk/ukidssdr10-dsa
 - UKIDSS DR9 (118) - ivo://wfau.roe.ac.uk/ukidssdr9-dsa
 - UKIDSS DR4 (117) - ivo://wfau.roe.ac.uk/ukidssdr4-dsa
 - SDSS DR3 (116) - ivo://wfau.roe.ac.uk/sdssdr3-dsa
 - UKIDSS DR5 (115) - ivo://wfau.roe.ac.uk/ukidssdr5-dsa
- Selected TAP Service: TAP URL: <http://datalab.noao.edu/tap> Use Service
- Run Query

Right Screenshot: Metadata

- Buttons: Select Service, Use Service, Resume Job, Running Jobs
- Metadata: Find: []
- View: Name Descrip Or
- Table: Schema Table Columns Foreign Keys
- Name: ls_dr3
- Tables: 18
- Description: The DECam Legacy Survey Data Release 3
- Service Capabilities: Query Language: ADQL Max Rows: [] Uploads: []
- ADQL Text: Mode: Synchronous
- Query: `SELECT TOP 1000 * FROM ls_dr3.tractor_primary`
- Examples: Basic 1/6: Full table Info
- Run Query