Exploring big data efficiently with the Astro Data Lab science platform

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NSF's NOIRLab

Tutorial at ADASS XXXIII, November 2023, Tucson/AZ

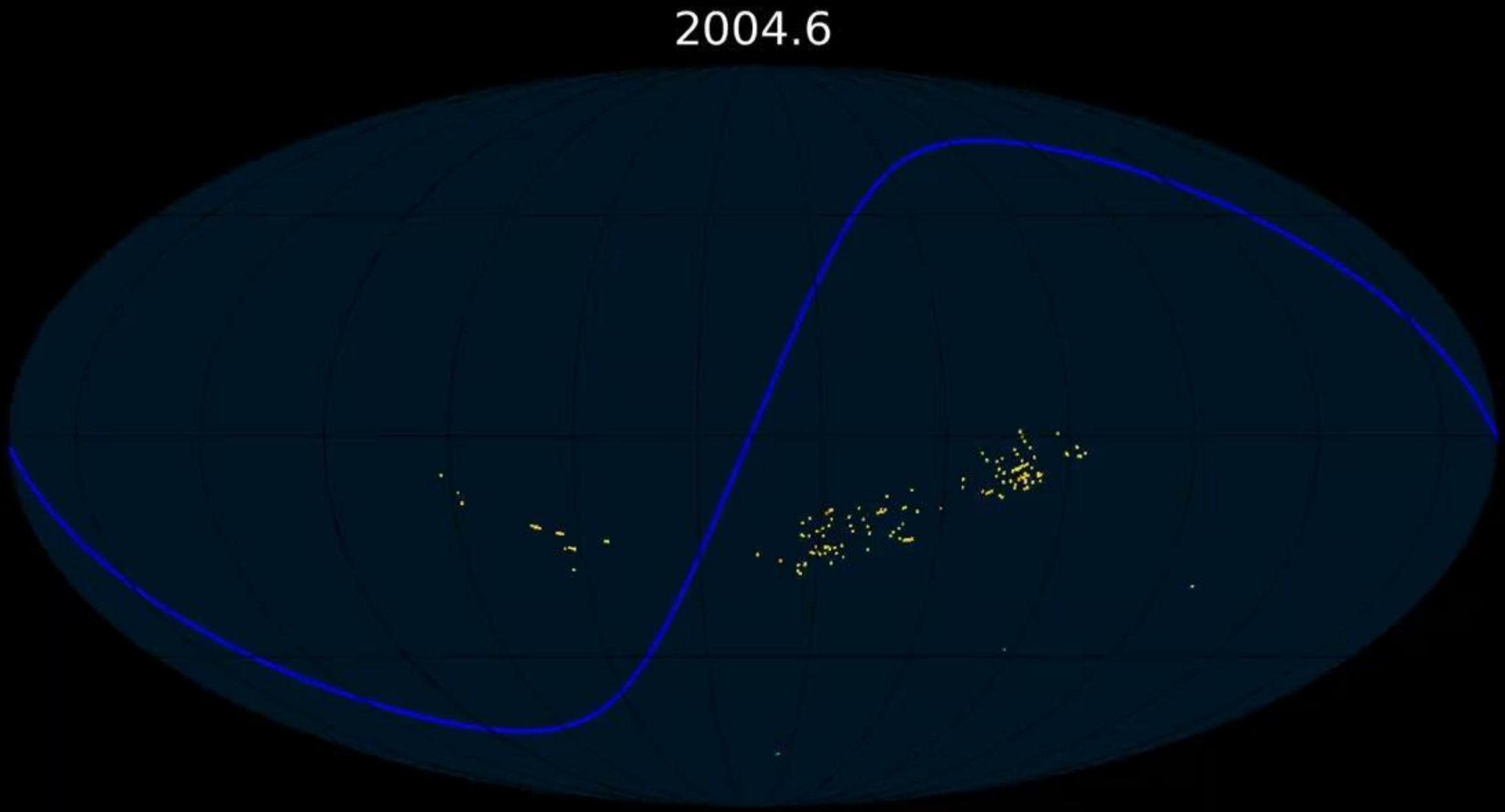
Introduction to the Astro Data Lab science platform

The Astro Data Lab

Mission

Efficient exploration and analysis of large astronomy datasets with an emphasis on NOIRLab wide-field 4-meter telescopes

datalab.noirlab.edu

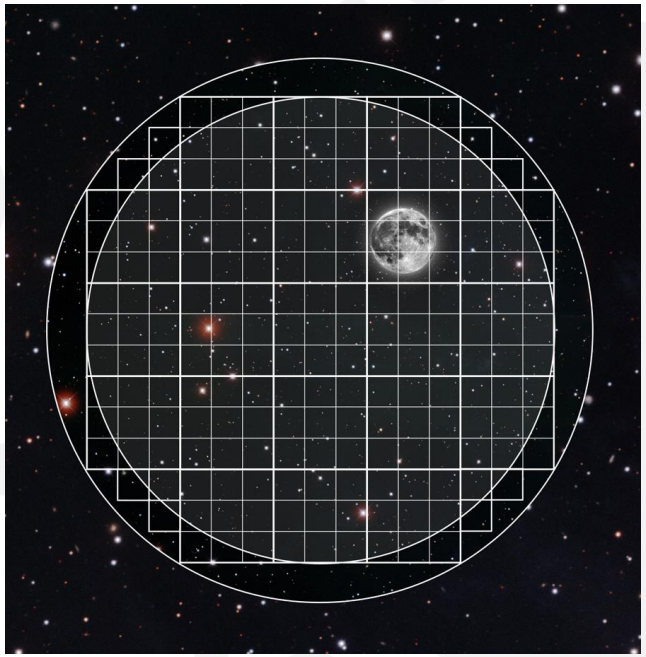


Total exposure time on NOIRLab 4-m class telescopes

Wide-field cameras & data avalanche

Dark Energy Camera
570 Mpix

Rubin Camera
3200 Mpix

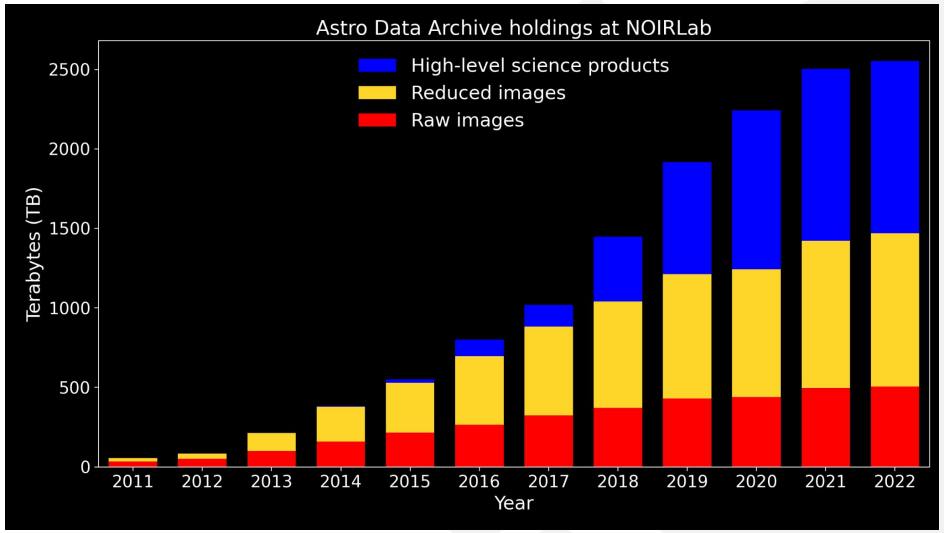


Rubin Camera
40x Moon area

Astro Data Lab Science Platform

Pre-installed software/tools/tutorials co-located with data

- Web services (website)
- JupyterLab (notebook) server
- Large variety of Python packages



Rich variety & volume of data

- Images (2.5 PB)
- Catalogs (175 TB) in databases
- Spectra (40+ M) from ground-based & space-based observatories

Astronomers/students can

- Create a user account, log on
- Use our services for their *entire* analysis (directly from their browser or install a command-line package)

Low barrier of entry to powerful tools

Access to big data

Open & inclusive Community oriented

Some datasets hosted at DL

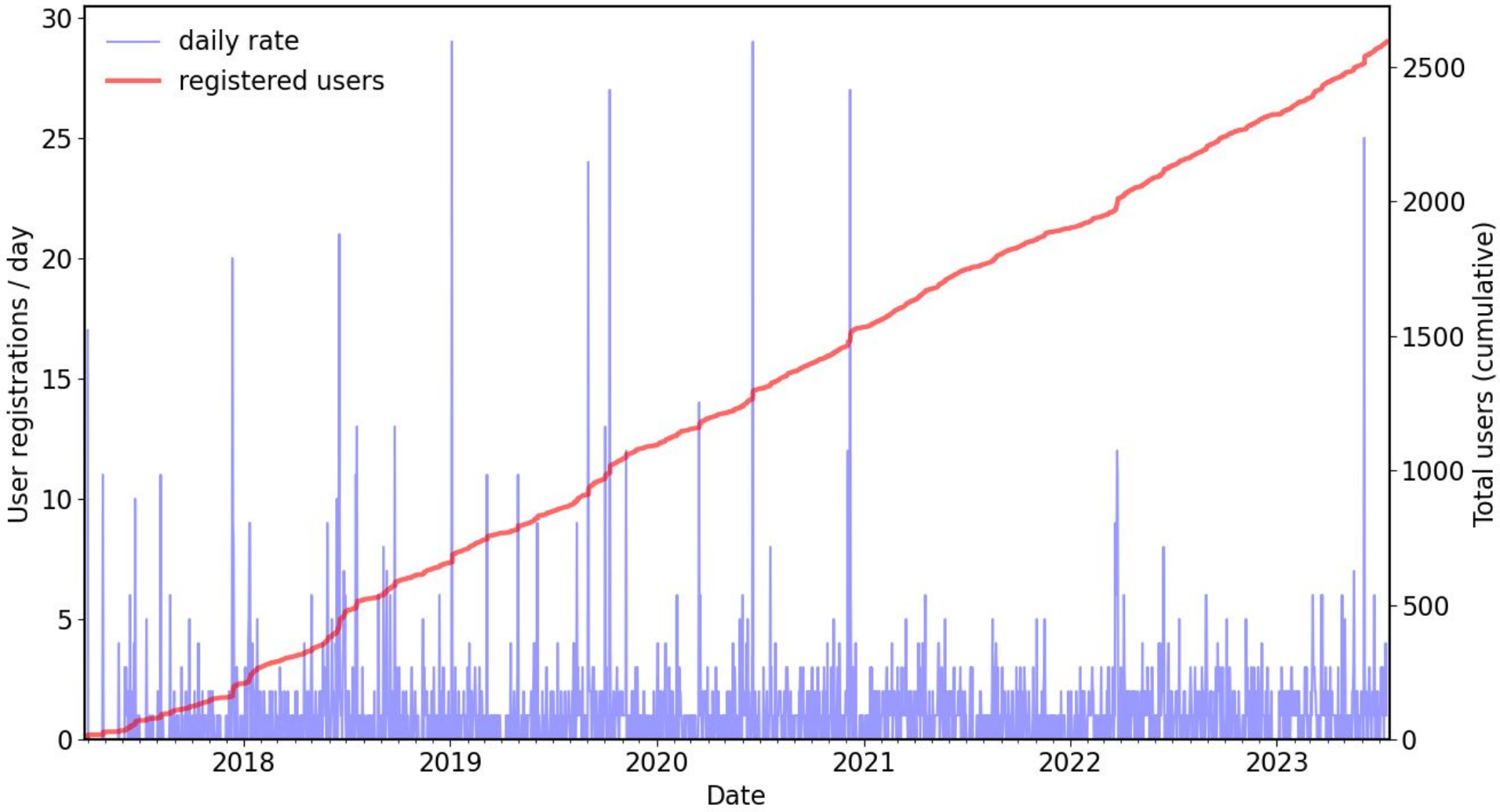
Dataset	Number of objects or measurements	Notes
DES DR 1 & 2	691M objects in DR 2	photometry
DECaLS DR 3 through 10	3.14B objects in DR 10	photometry, targeting for DESI
NOIRLab Source Catalog DR 1 & 2	3.9B objects, 68B measurements in DR 2	homogeneous reduction across 3 cameras
SMASH DR 1 & 2, DELVE DR 1 & 2	2.5B objects in DELVE DR 2	photometry
PHAT v2	117M objects	Andromeda
DESI EDR, SPARCL (metadata)	2M spectra in DESI EDR	spectroscopy
Gaia DR 1, 2, EDR3, 3	1.8B objects in DR 3	astrometry
AllWISE, unWISE, CatWISE2020	2.2B objects in unWISE	IR
VHS DR 5	1.4B objects	photometry (S hemisphere)
UKIDSS DR 11+	1.2B objects	photometry (N hemisphere)
Buzzard DR 1, LSST SIM DR 2	12.6B objects in LSST SIM DR 2	simulated datasets

NOIRLab telescopes

external

simulated

Growing user community

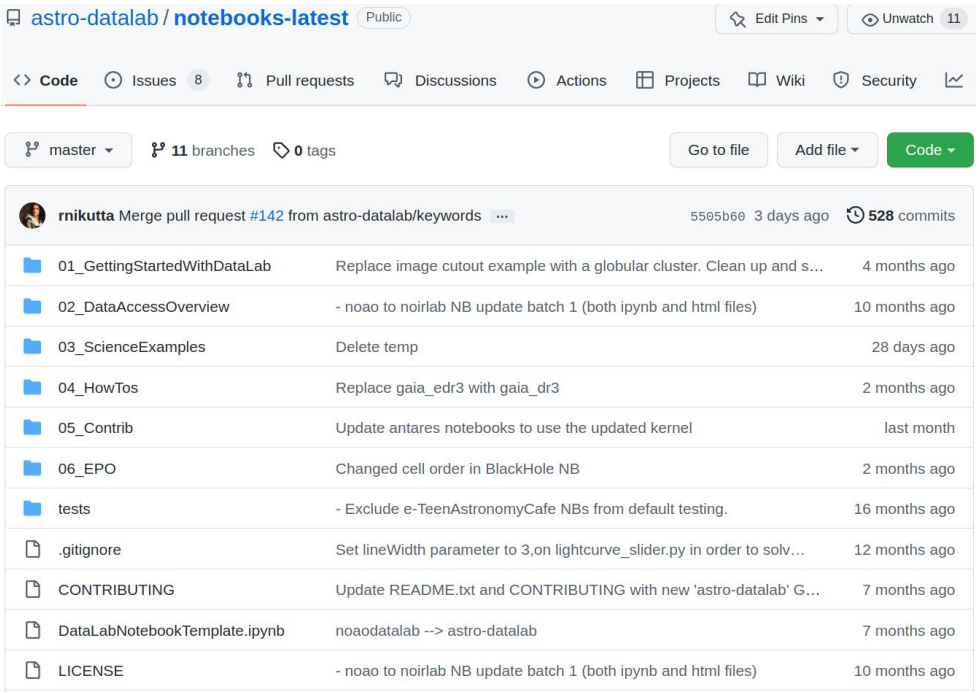


As of June 14, 2023

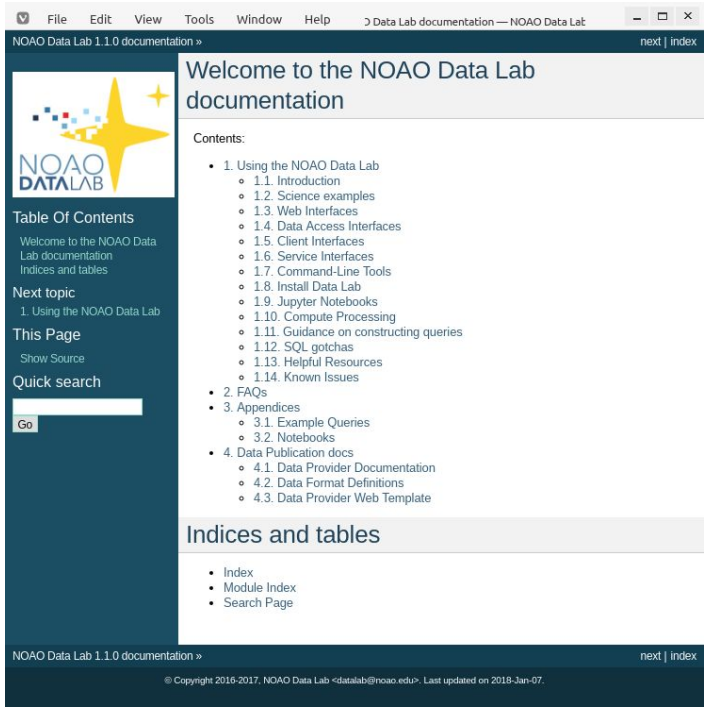
Data services & tools

Action	Modes	Notes
Authentication	web, client/API, cmdline	log on to access user-specific functions
Sky exploration	Aladdin Lite	
Catalog query	web form, client/API, cmdline	SQL/ADQL, sync/async
Cross-matching	web, client/API, cmdline	Also hosting fast pre-crossmatched tables
Query results to..	client, VOSpace, MyDB	Format conversions on the fly
Spectro access	client/API	SPARCL
Remote user file storage	client/API, cmdline	VOSpace
Remote user DB	client/API, cmdline	MyDB
Image search & cutout	client/API, web	SIA
Analysis (with all of Python)	web, local	Jupyter notebook server

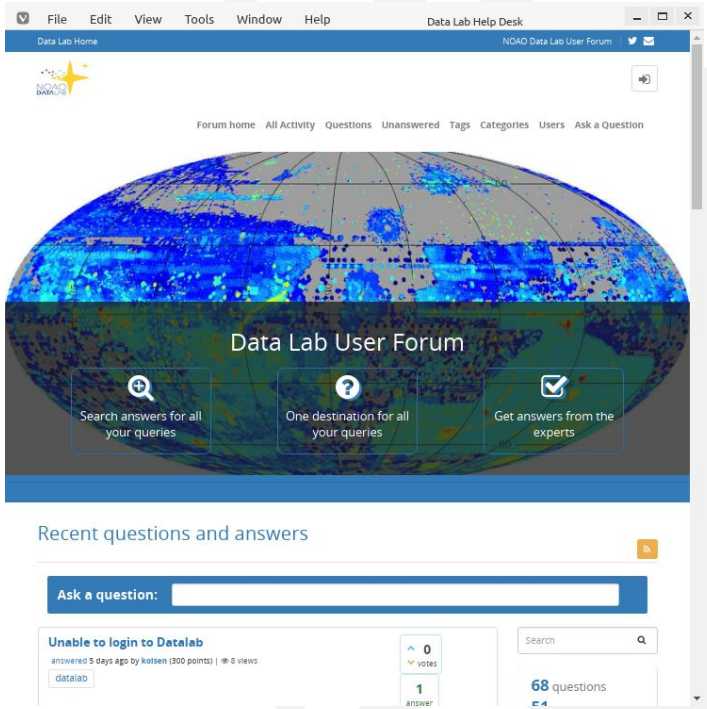
Learning & Documentation



Curated Jupyter notebook collection
Intros, How-Tos, Science Cases, EPO, Contributed…



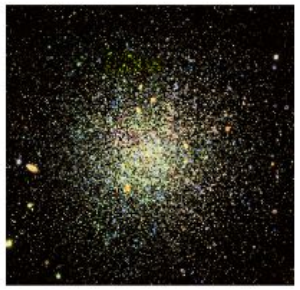
User Manual & API docs



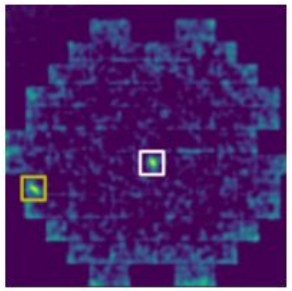
Helpdesk & FAQ

Discovery Ready Science Notebooks

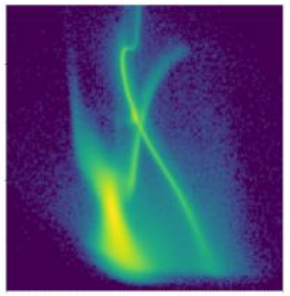
Astro Data Lab Notebook Gallery



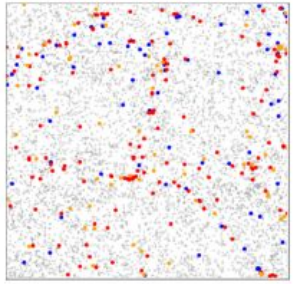
Getting Started with Data Lab
Learn the basics such as importing modules, sending a database query, and using the Simple Image Access (SIA) service to create image cutouts.



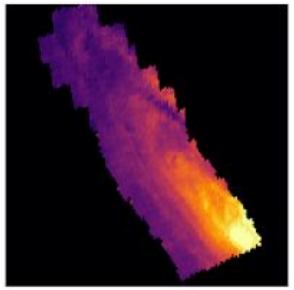
Dwarf Galaxies in the SMASH survey
Discover the ultrafaint Hydra II dwarf galaxy in the SMASH DECam survey based on spatial overdensities of blue stars with a detection algorithm.



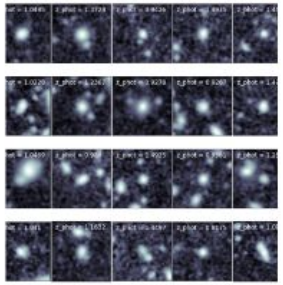
Exploring SMASH DR2
The 480 square degree SMASH DECam survey of the Magellanic Clouds and their periphery contains a wealth of objects, including this capture of the SMC with 47 Tuc in the foreground.



Large-Scale Structure of the Universe
Investigate cosmic filaments and clusters of galaxies, pan around an interactive sky viewer, combining spectroscopy and DESI pre-imaging.



Fun with PHAT
Visualize the 100 million+ stars in the Andromeda Galaxy captured by the Panchromatic Hubble Andromeda Treasury (PHAT).



Gallery of Cluster Galaxies
Use the Simple Image Access (SIA) service to retrieve images from the Gemini GOGREEN program.

Intended for

- Training
- Education
- Research

Science cases

- Intro
- Galactic
- Extragalactic
- Time Domain

Datasets

- Images
- Catalogs
- Spectra

Introduction to SPARCL

SPARCL

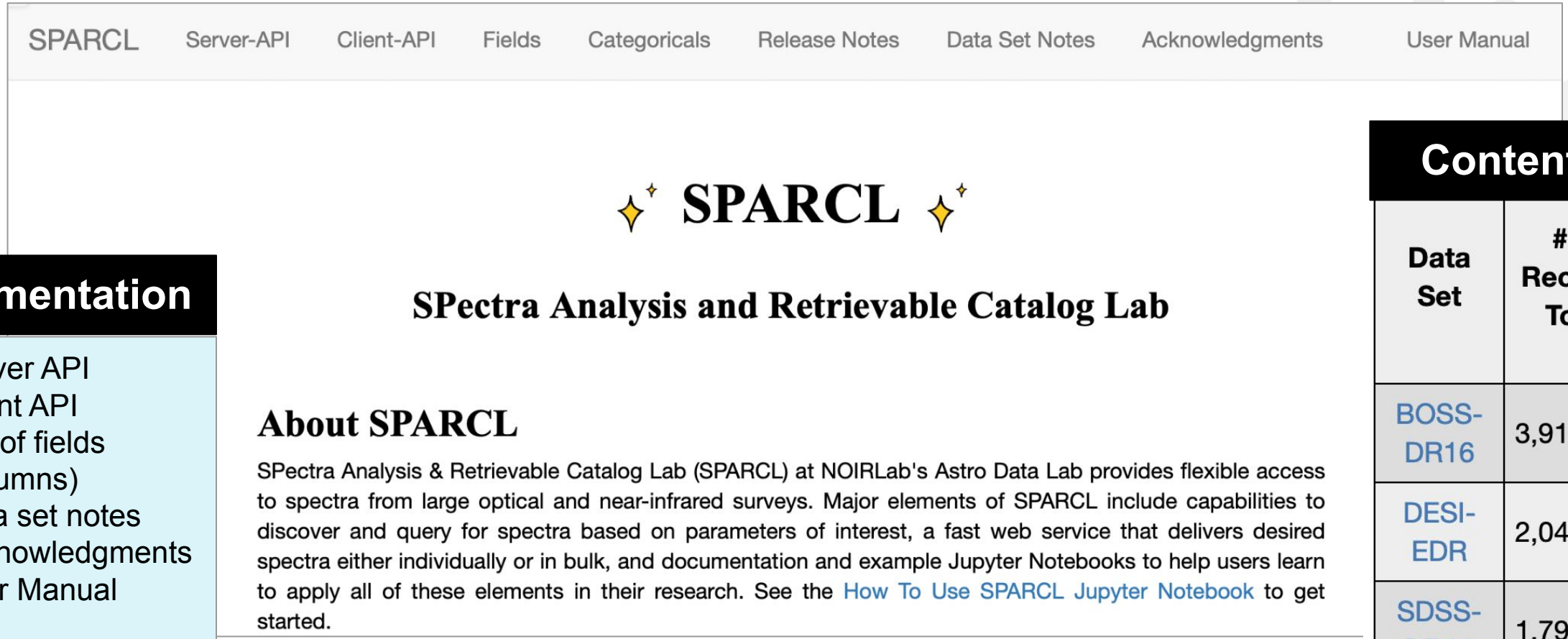
SPectra Analysis & Retrievable Catalog Lab

astrosparcl.datalab.noirlab.edu

- Spectroscopic database for large surveys/datasets
- Data Discovery
- Data Access/Retrieval
- Server can work with different clients
- Compatible with Astro Data Lab (works in JupyterLab)
- Public version: SDSS DR16 (SDSS, (e)BOSS), DESI EDR

- Future goals:
  - Add other spectroscopic datasets (streamlining the ingest process)
  - Add more advanced functionality (e.g., aligning spectra)
  - Add an *authentication* feature (e.g., proprietary access for DESI collaborators)

Website



Documentation

- Server API
- Client API
- List of fields (columns)
- Data set notes
- Acknowledgments
- User Manual

\+ How-To Notebook

Contents

Data Set	# of Records Total
BOSS-DR16	3,918,000
DESI-EDR	2,044,588
SDSS-DR16	1,798,901
TOTALS	**7,761,489**

astrosparcl.datalab.noirlab.edu

Notebook: How to use SPARCL

How to use SPARCL

MVP release of SPectra Analysis and Retrievable Catalog Lab (SPARCL)

Table of contents

- Public version for SDSS DR16 & now DESI EDR
- Fast data discovery and access to 1D spectra (retrieval for up to 20k spectra per call)

Full notebook available (Jacques et al.):
github.com/astro-datalab/notebooks-latest/blob/master/04_HowTos/SPARCL/How_to_use_SPARCL.ipynb

Contact

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#datalab-tutorial

Thank you!

Hacking together on great science with Data Lab!

Resources

Data Lab website: https://datalab.noirlab.edu

SPARCL website: https://astrosparcl.datalab.noirlab.edu

Register account: https://datalab.noirlab.edu/account/register.html

User manual: https://datalab.noirlab.edu/docs/manual

Helpdesk: https://datalab.noirlab.edu/help

Notebook server: https://cloud.datalab.noirlab.edu

Notebook collection: https://github.com/astro-datalab/notebooks-latest

Notebook gallery: [LINK]

Tutorial materials: https://github.com/astro-datalab/Tutorial-ADASS-2023

How to clone them:

```
git clone https://github.com/astro-datalab/Tutorial-ADASS-2023.git
```

Backup slides