The NOAO Science Archive

Mark Dickinson
for NOAO Science Data Management

NSA ≠ NSA

NOAO Science Archive

NSA ≠ NSA

NOAO Science Archive

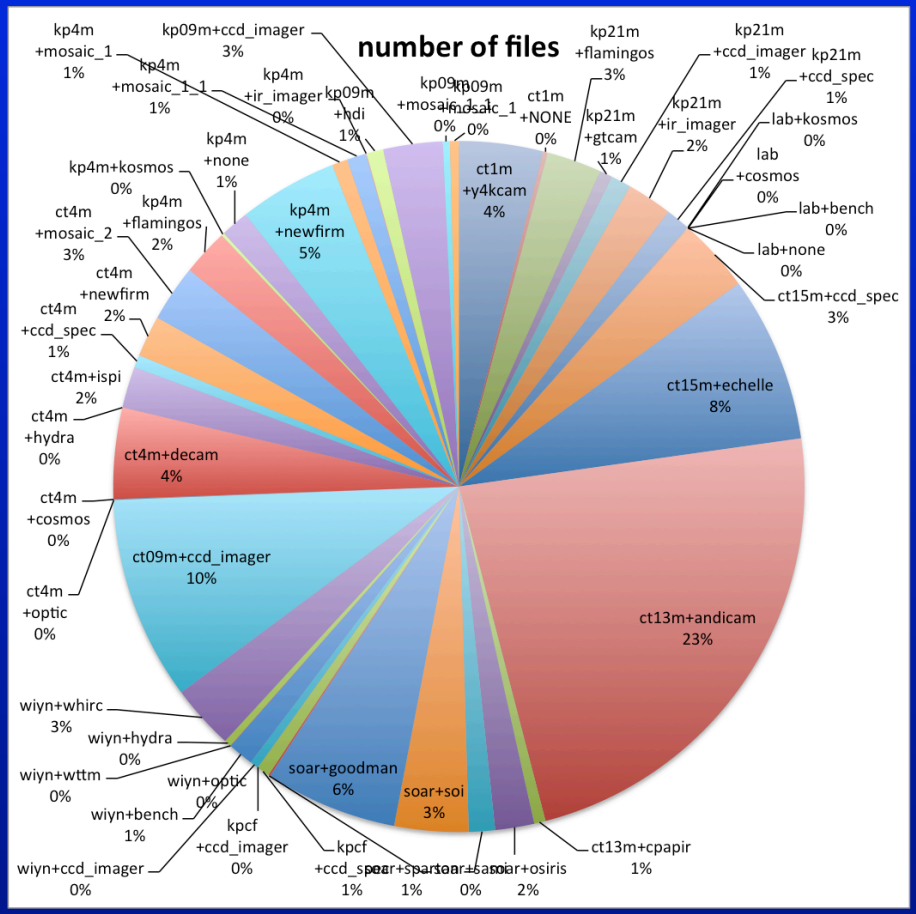
NOAO Science Archive

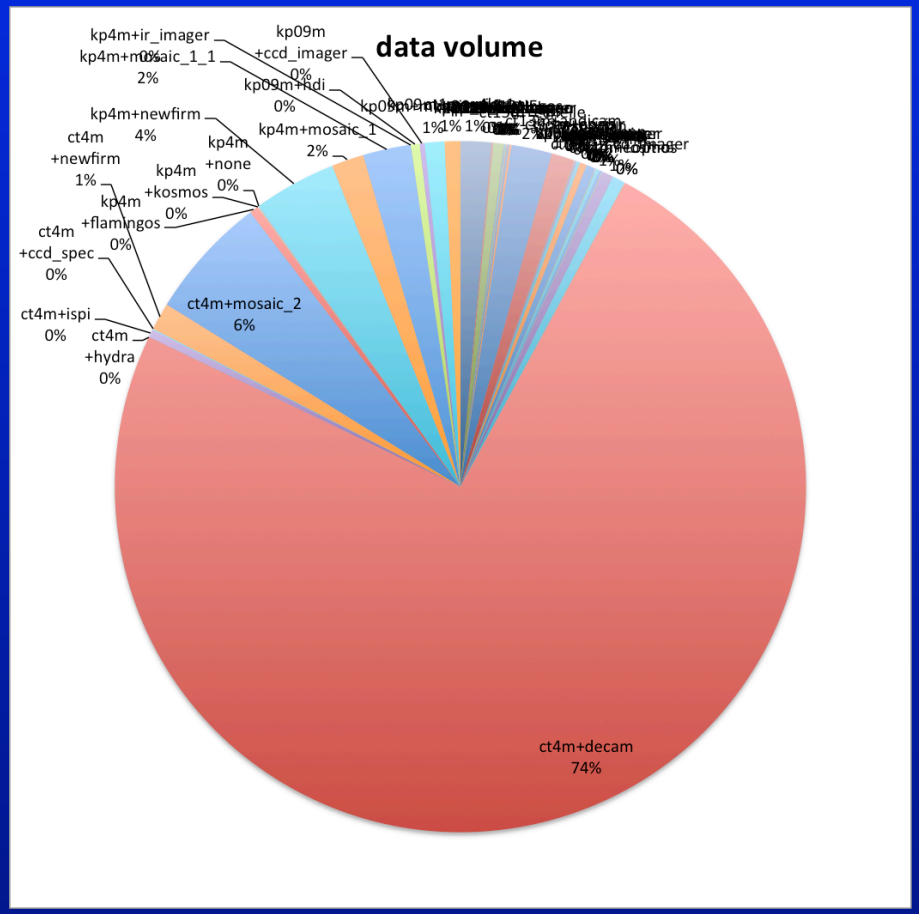
- Raw data from:
  - 11 telescopes (KPNO, CTIO, SOAR, WIYN)
  - 48 telescope+instrument combinations
- Data from 2004B to the present
  - Earlier raw data are stored on tape
- Three geographically dispersed copies of raw data
- Pipeline-reduced data from NOAO wide-field imagers:
  - Mosaic (1, 1.1, 2, at KPNO 4m+0.9m and CTIO 4m)
  - NEWFIRM (KPNO 4m + CTIO 4m)
  - DECam (CTIO 4m)
- Delivered, reduced survey data products
  - Older survey data currently in separate (older) Survey Archive
  - New DECam survey data (including DES) go into main Science Archive

NOAO Science Archive - Data Holdings

6,661,685 raw files (184.7 TB, compressed)
2,773,750 reduced files (149.6 TB, compressed)

Raw data by telescope + instrument:





Current DECam data holdings

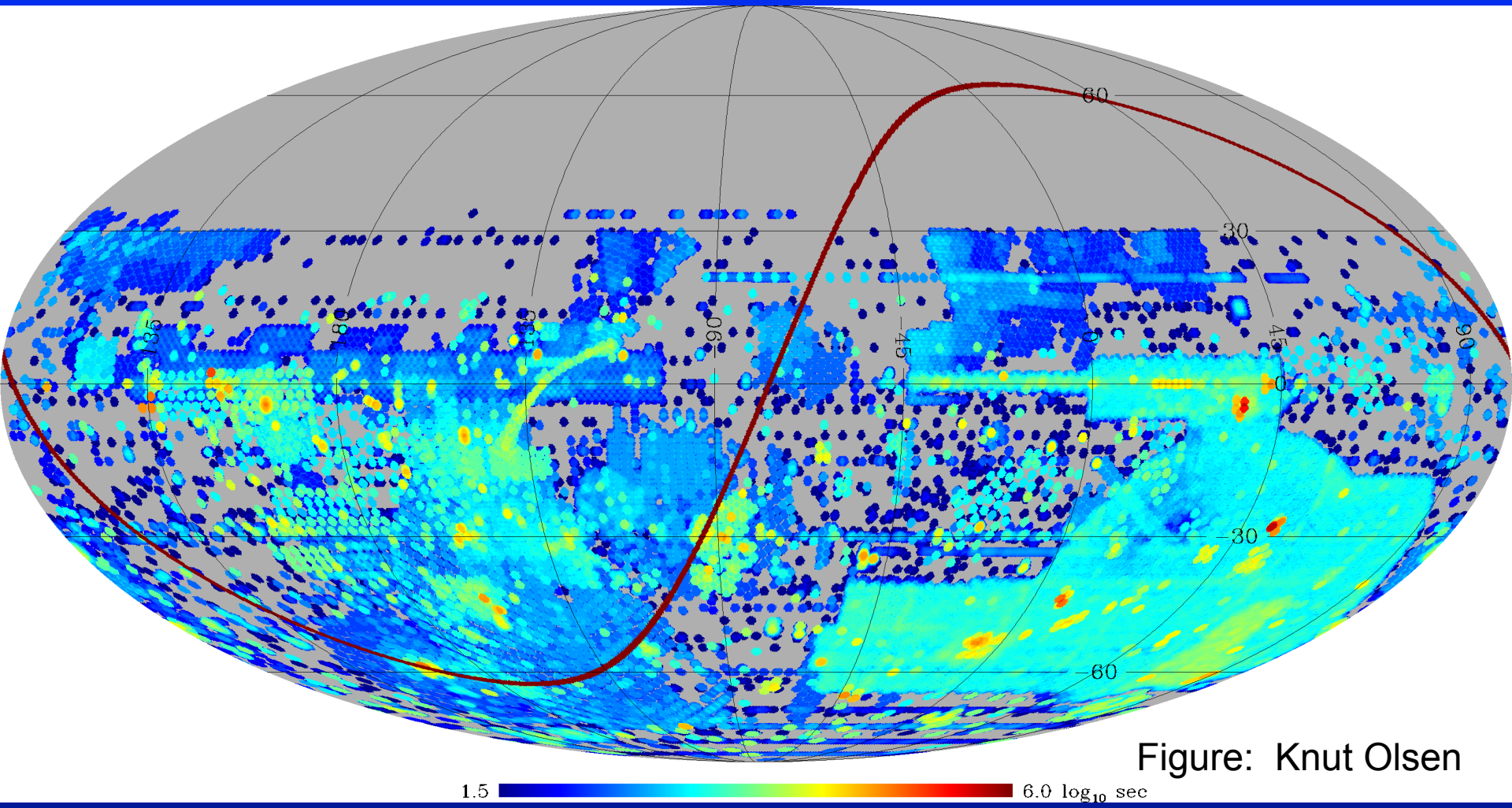


Figure: Knut Olsen

Incoming wide-field survey data

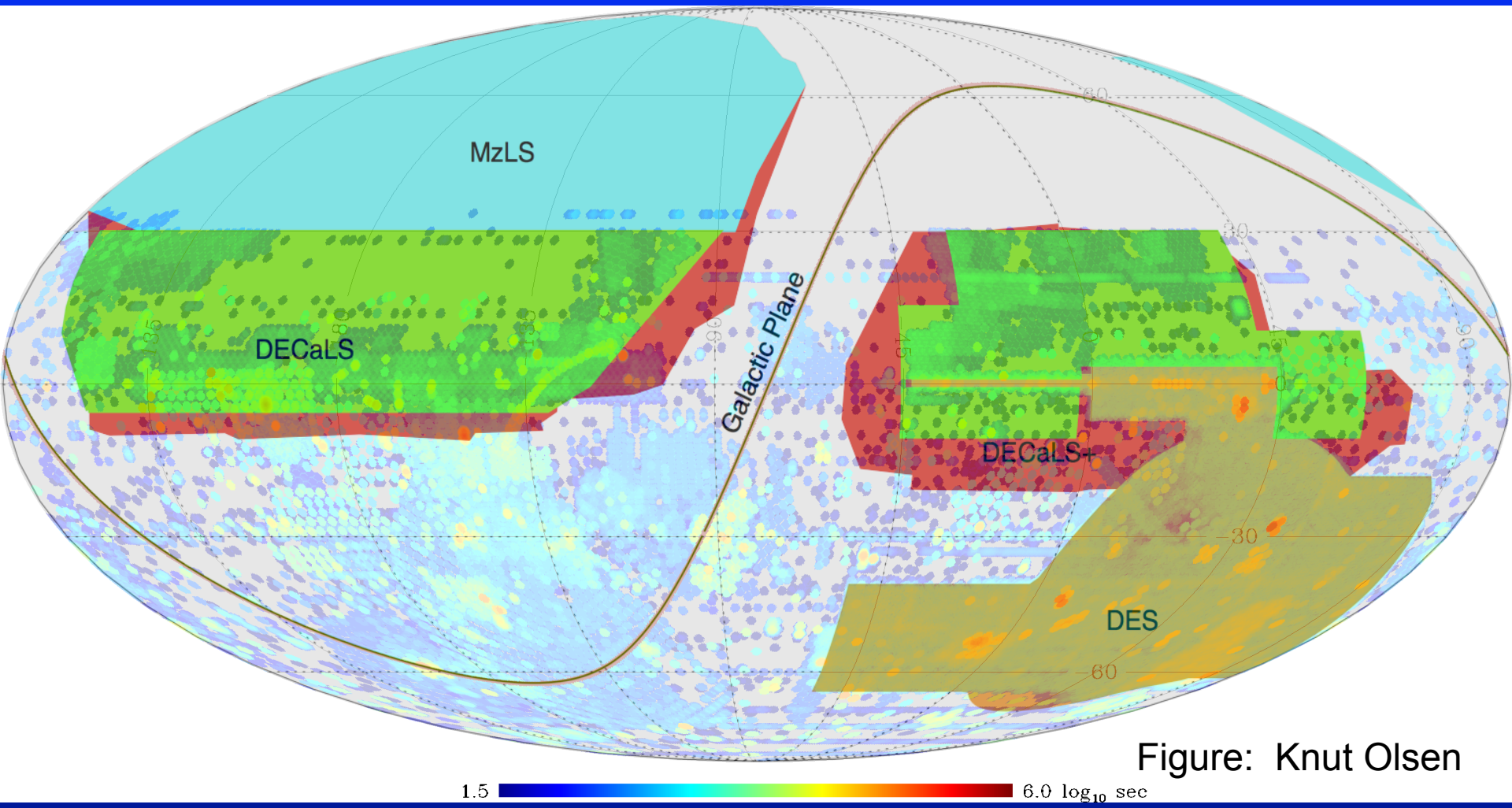


Figure: Knut Olsen

Mining the NOAO Archive

Rapidly growing hoard of NOAO wide-field imaging is a rich trove.

NOAO Archive is transitioning from being mainly a storage & distribution service (PI-oriented) to a data resource (archival users).

Beasts of the Southern Wild. Discovery of a large number of Ultra Faint satellites in the vicinity of the Magellanic Clouds

Sergey E. Koposov, Vasily Belokurov, Gabriel Torrealba, N. Wyn Evans

(Submitted on 6 Mar 2015 (v1), last revised 10 Mar 2015 (this version, v2))

We have used the publicly released Dark Energy Survey data to hunt for new satellites of the Milky Way in the Southern hemisphere. Our search yielded a large number of promising candidates. In this paper, we announce the discovery of 9 new unambiguous ultra-faint objects, whose authenticity can be established with the DES data alone. Based on the morphological properties, three of the new satellites are dwarf galaxies, one of which is located at the very outskirts of the Milky Way, at a distance of 380 kpc. The remaining 6 objects have sizes and luminosities comparable to the Segue 1 satellite and can not be classified straightforwardly without follow-up spectroscopic observations. The satellites we have discovered cluster around the LMC and the SMC. We show that such spatial distribution is unlikely under the assumption of isotropy, and, therefore, conclude that at least some of the new satellites must have been associated with the Magellanic Clouds in the past.

Eight New Milky Way Companions Discovered in First-Year Dark Energy Survey Data

The DES Collaboration, K. Bechtol, A. Drlica-Wagner, E. Balbinot, A. Pieres, J. D. Simon, B. Yanny, B. Santiago, R. H. Wechsler, J. Frieman, A. R. Walker, P. Williams, E. Rozo, E. S. Rykoff, A. Queiroz, E. Luque, A. Benoit-Levy, R. A. Bernstein, D. Tucker, I. Sevilla, R. A. Gruendl, L. N. da Costa, A. Fausti Neto, M. A. G. Maia, T. Abbott, S. Allam, R. Armstrong, A. H. Bauer, G. M. Bernstein, E. Bertin, D. Brooks, E. Buckley-Geer, D. L. Burke, A. Carnero Rosell, F. J. Castander, C. B. D'Andrea, D. L. DePoy, S. Desai, H. T. Diehl, T. F. Eifler, J. Estrada, A. E. Evrard, E. Fernandez, D. A. Finley, B. Flaugher, E. Gaztanaga, D. Gerdes, L. Girardi, M. Gladders, D. Gruen, G. Gutierrez, J. Hao, K. Honscheid, B. Jain, D. James, S. Kent, R. Kron, K. Kuehn, N. Kuropatkin, O. Lahav, T. S. Li, et al. (32 additional authors not shown)

(Submitted on 9 Mar 2015)

We report the discovery of eight new Milky Way companions in ~1,800 deg^2 of optical imaging data collected during the first year of the Dark Energy Survey (DES). Each system is identified as a statistically significant over-density of individual stars consistent with the expected isochrone and luminosity function of an old and metal-poor stellar population. The objects span a wide range of absolute magnitudes (M_V from -2.2 mag to -7.4 mag), physical sizes (10 pc to 170 pc), and heliocentric distances (30 kpc to 330 kpc). Based on the low surface brightnesses, large physical sizes, and/or large Galactocentric distances of these objects, several are likely to be new ultra-faint satellite galaxies of the Milky Way and/or Magellanic Clouds. We introduce a likelihood-based algorithm to search for and characterize stellar over-densities, as well as identify stars with high satellite membership probabilities. We also present completeness estimates for detecting ultra-faint galaxies of varying luminosities, sizes, and heliocentric distances in the first-year DES data.

Raw DECam data in Archive
(as of today)

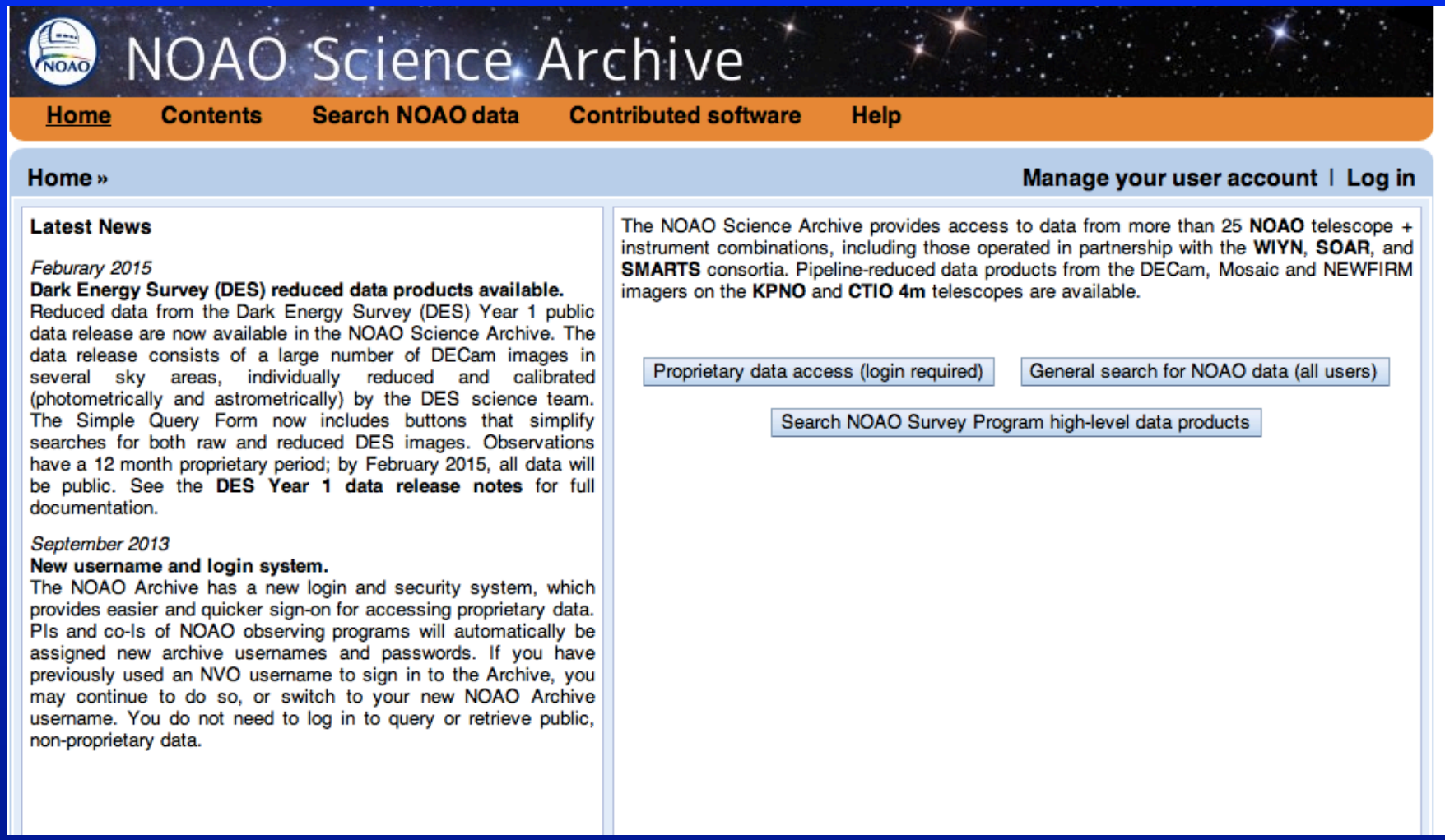
- 273,886 raw DECam files (139.5 TB)
  - DECam already makes up 75% of the total raw data volume in the Archive
  - *As many DECam exposures taken since December 2012 as with the CTIO+KPNO Mosaic cameras combined since 2004B !!*
  - 192,258 public (as of today) (70%)
  - 173,446 “object” exposures (62%; the rest are calibration, etc.)
  - 75,931 exposures come from DES (28%)
    - 51,816 DES frames are public (68% of total DES)

Pipeline-reduced DECam data in Archive
(as of today)

- 782,929 reduced DECam data files
  - *Note:* CP produces several reduced files for each raw exposure
  - 387,456 reduced public (49%)
- Reduced single-frame "object" images:
  (PROCTYPE = InstCal, PRODTYPE = image)
  - 129,188 exposures
    - 12,027 are delivered products from DES-Y1 (9%; all public)
    - 117,161 from CP (90%)
      - 58,253 CP public (50%)
- Reduced coadds:
  (PROCTYPE = Stacked, PRODTYPE = image)
  - 16,415 stacks
    - 8,304 public (51%)

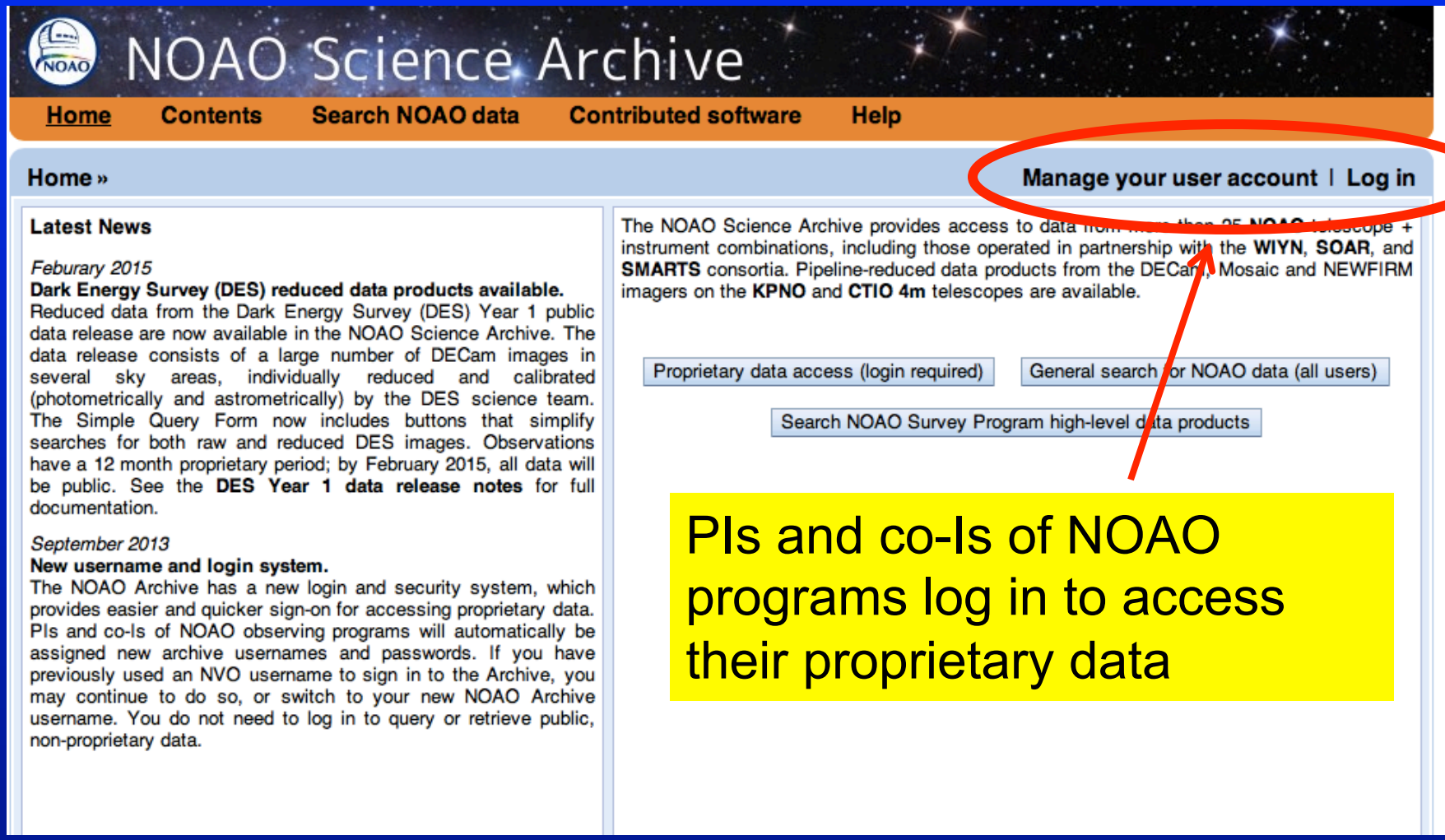
NOAO Science Archive

http://portal-nvo.noao.edu



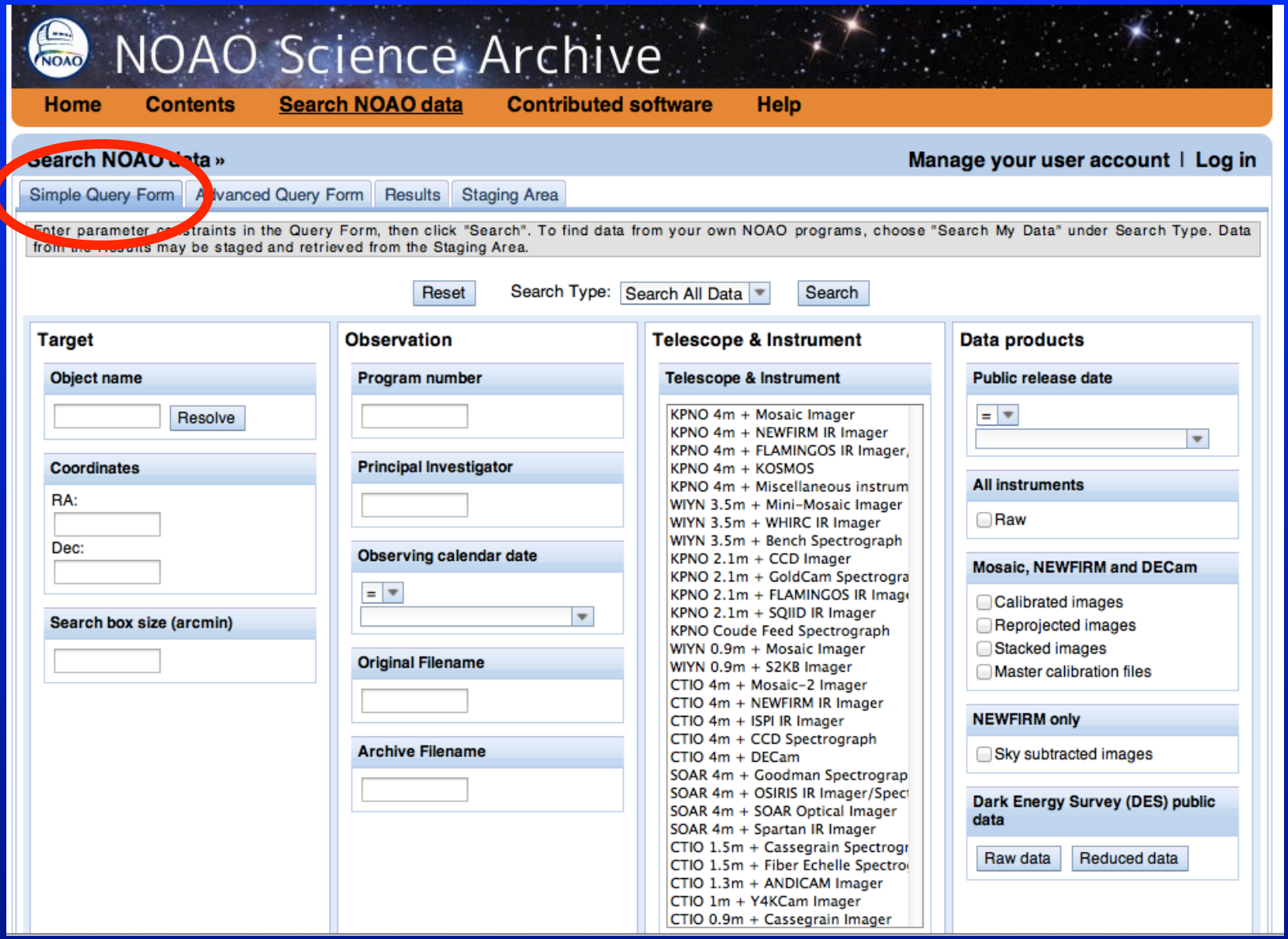
NOAO Science Archive

http://portal-nvo.noao.edu

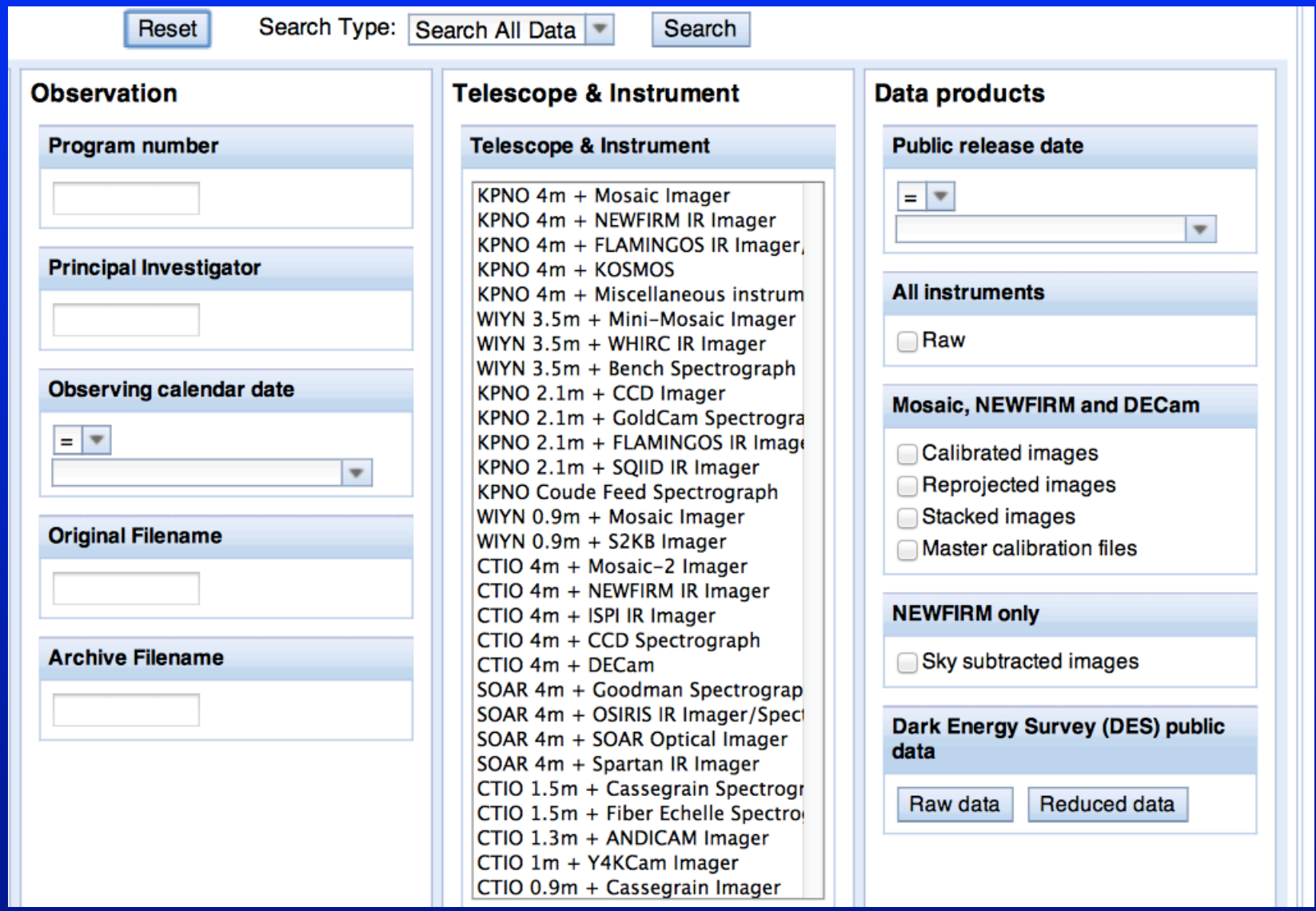


PIs and co-Is of NOAO programs log in to access their proprietary data

Simple Query Form



Simple Query Form



Simple Query Form

Reset | Search Type: Search All Data | Search

Observation

Program number

DES

Principal Investigator

Observing calendar date

=

Original Filename

Archive Filename

Telescope & Instrument

Telescope & Instrument

KPNO 4m + Mosaic Imager
KPNO 4m + NEWFIRM IR Imager
KPNO 4m + FLAMINGOS IR Imager
KPNO 4m + KOSMOS
KPNO 4m + Miscellaneous instrum
WIYN 3.5m + Mini-Mosaic Imager
WIYN 3.5m + WHIRC IR Imager
WIYN 3.5m + Bench Spectrograph
KPNO 2.1m + CCD Imager
KPNO 2.1m + GoldCam Spectrogra
KPNO 2.1m + FLAMINGOS IR Image
KPNO 2.1m + SQIID IR Imager
KPNO Coude Feed Spectrograph
WIYN 0.9m + Mosaic Imager
WIYN 0.9m + S2KB Imager
CTIO 4m + Mosaic-2 Imager
CTIO 4m + NEWFIRM IR Imager
CTIO 4m + ISPI IR Imager
CTIO 4m + CCD Spectrograph
CTIO 4m + DECam
SOAR 4m + Goodman Spectrograp
SOAR 4m + OSIRIS IR Imager/Spect
SOAR 4m + SOAR Optical Imager
SOAR 4m + Spartan IR Imager
CTIO 1.5m + Cassegrain Spectrogr
CTIO 1.5m + Fiber Echelle Spectro
CTIO 1.3m + ANDICAM Imager
CTIO 1m + Y4KCam Imager
CTIO 0.9m + Cassegrain Imager

Data products

Public release date

<=

2015-03-11

All instruments

- [ ] Raw

Mosaic, NEWFIRM and DECam

- [x] Calibrated images
- [ ] Reprojected images
- [ ] Stacked images
- [ ] Master calibration files

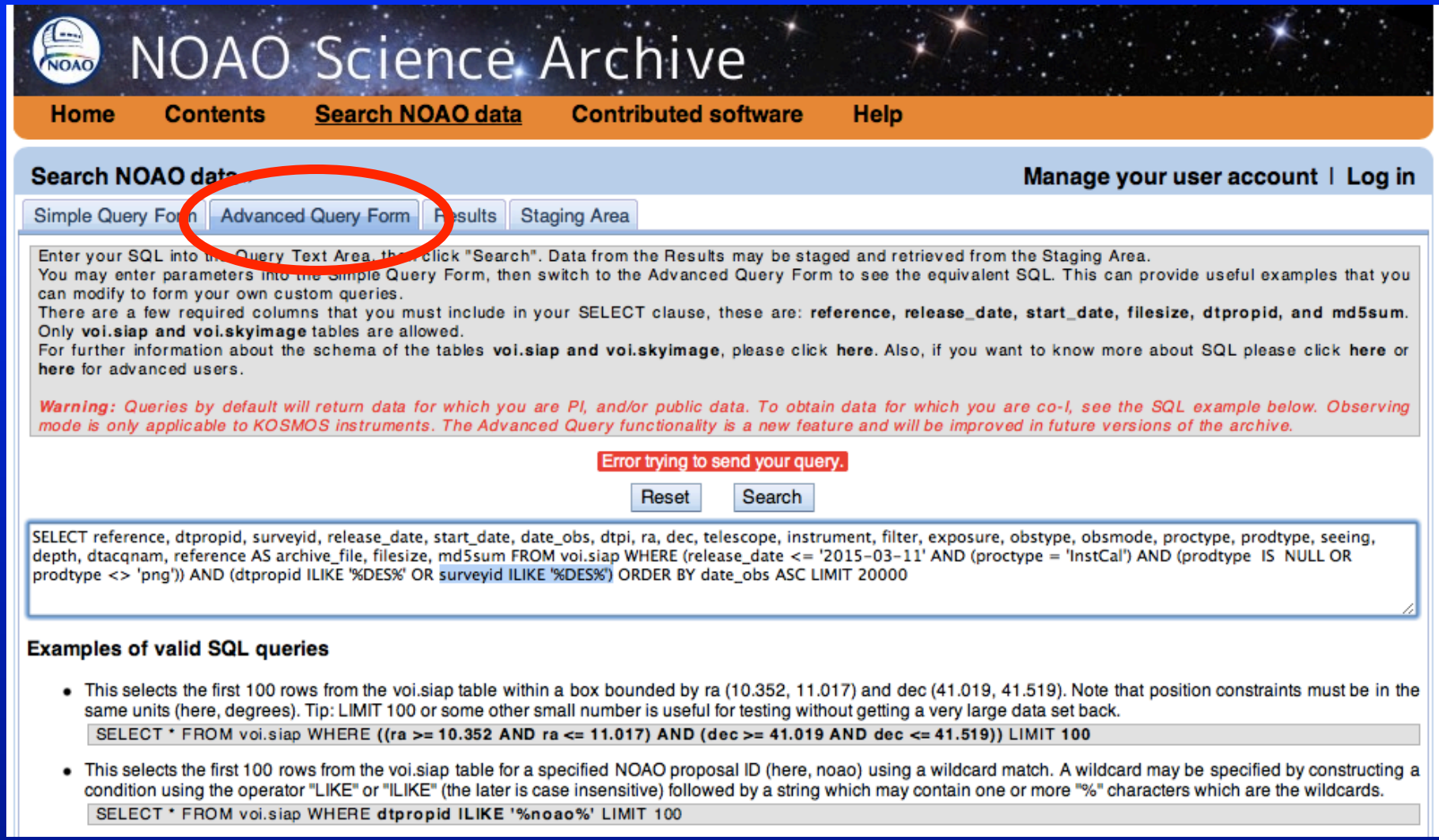
NEWFIRM only

- [ ] Sky subtracted images

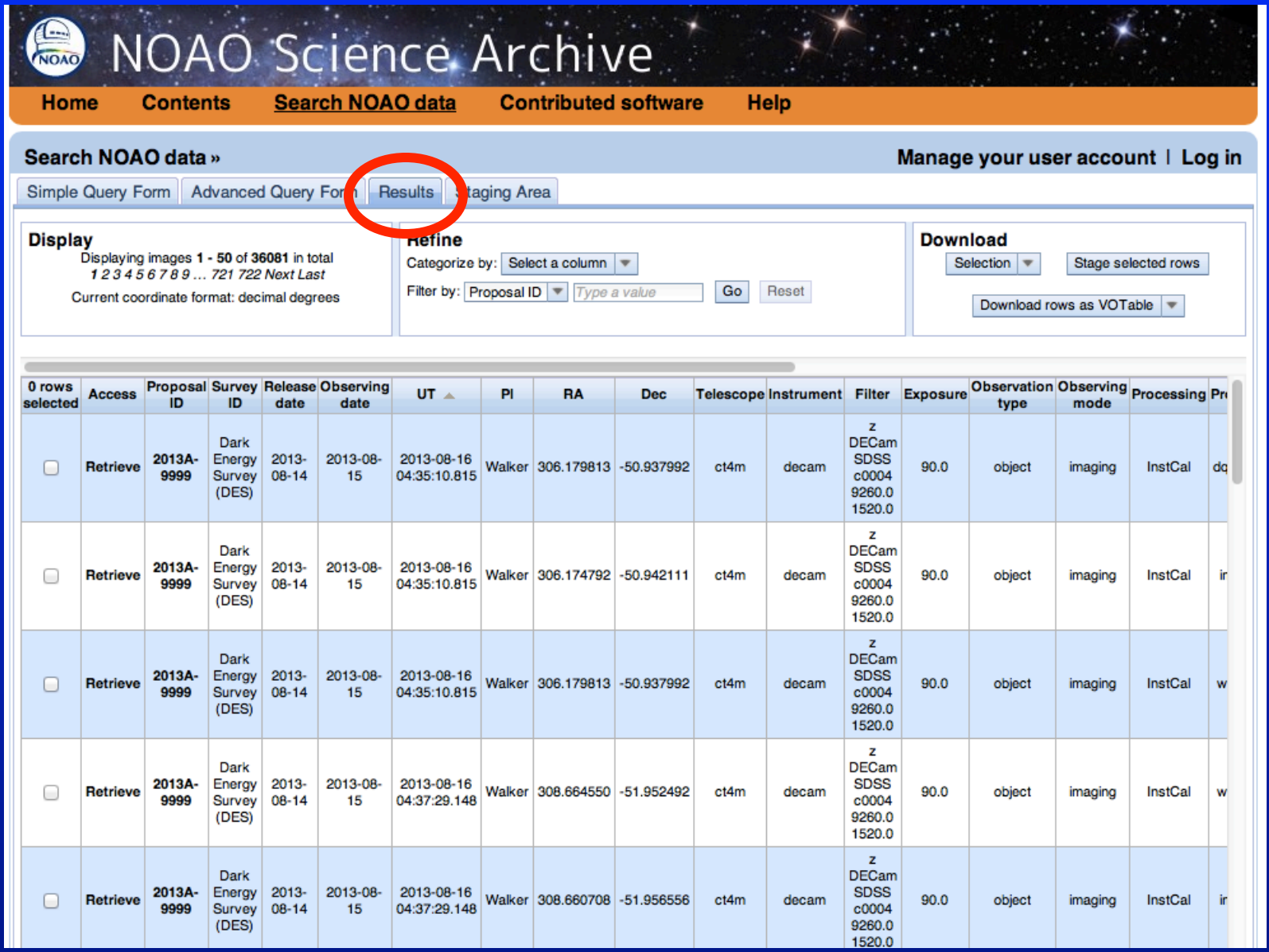
Dark Energy Survey (DES) public data

Raw data | Reduced data

Advanced Query Form



Search Results



NOAO Science Archive

Home | Contents | Search NOAO data | Contributed software | Help

Search NOAO data »

Manage your user account | Log in

Simple Query Form | Advanced Query Form | Results | Staging Area

Display

Displaying images **1 - 50** of **36081** in total

1 2 3 4 5 6 7 8 9 ... 721 722 Next Last

Current coordinate format: decimal degrees

Refine

Categorize by: Select a column

Filter by: Proposal ID | Type a value | Go | Reset

Download

Selection | Stage selected rows

Download rows as VOTable

0 rows selected	Access	Proposal ID	Survey ID	Release date	Observing date	UT	PI	RA	Dec	Telescope	Instrument	Filter	Exposure	Observation type	Observing mode	Processing	Pr
☐	Retrieve	2013A-9999	Dark Energy Survey (DES)	2013-08-14	2013-08-15	2013-08-16 04:35:10.815	Walker	306.179813	-50.937992	ct4m	decam	z DECam SDSS c0004 9260.0 1520.0	90.0	object	imaging	InstCal	dq
☐	Retrieve	2013A-9999	Dark Energy Survey (DES)	2013-08-14	2013-08-15	2013-08-16 04:35:10.815	Walker	306.174792	-50.942111	ct4m	decam	z DECam SDSS c0004 9260.0 1520.0	90.0	object	imaging	InstCal	ir
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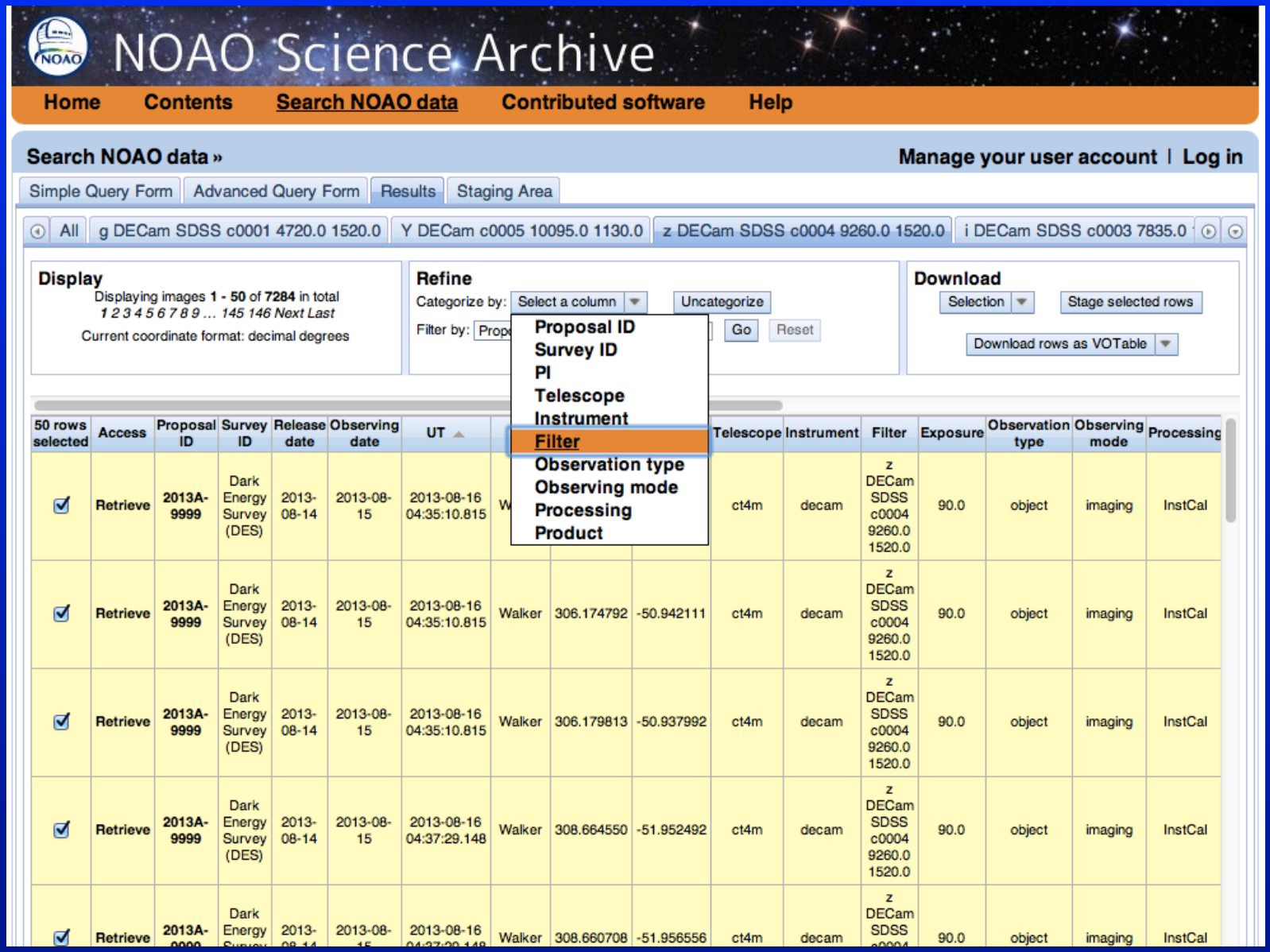
☐	Retrieve	2013A-9999	Dark Energy Survey (DES)	2013-08-14	2013-08-15	2013-08-16 04:37:29.148	Walker	308.664550	-51.952492	ct4m	decam	z DECam SDSS c0004 9260.0 1520.0	90.0	object	imaging	InstCal	w
☐	Retrieve	2013A-9999	Dark Energy Survey (DES)	2013-08-14	2013-08-15	2013-08-16 04:37:29.148	Walker	308.660708	-51.956556	ct4m	decam	z DECam SDSS c0004 9260.0 1520.0	90.0	object	imaging	InstCal	ir

Search Results



50 rows selected	Access	Proposal ID	Survey ID	Release date	Observing date	UT				Telescope	Instrument	Filter	Exposure	Observation type	Observing mode	Processing
☑	Retrieve	2013A-9999	Dark Energy Survey (DES)	2013-08-14	2013-08-15	2013-08-16 04:35:10.815	W			ct4m	decam	z DECam SDSS c0004 9260.0 1520.0	90.0	object	imaging	InstCal
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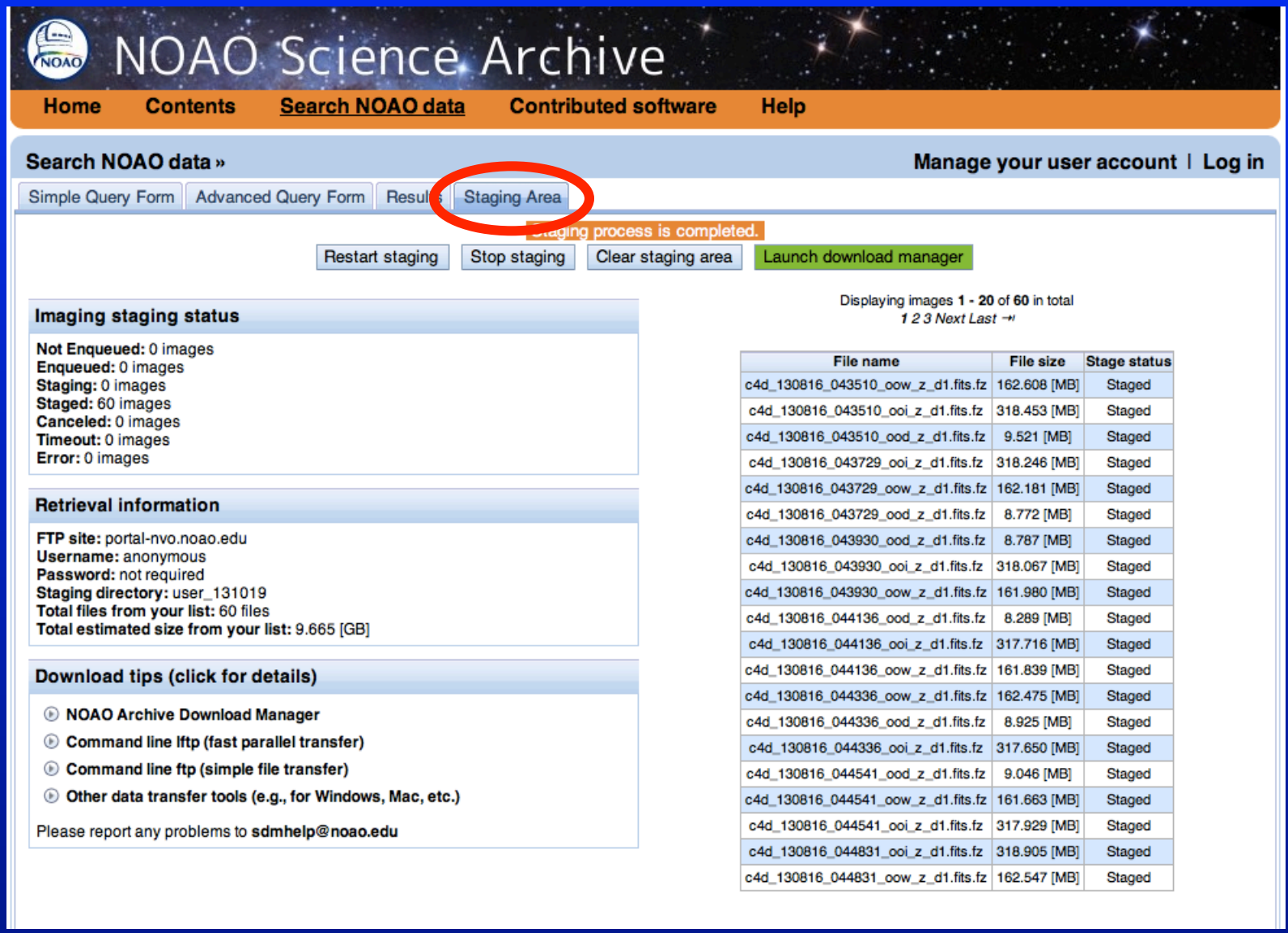
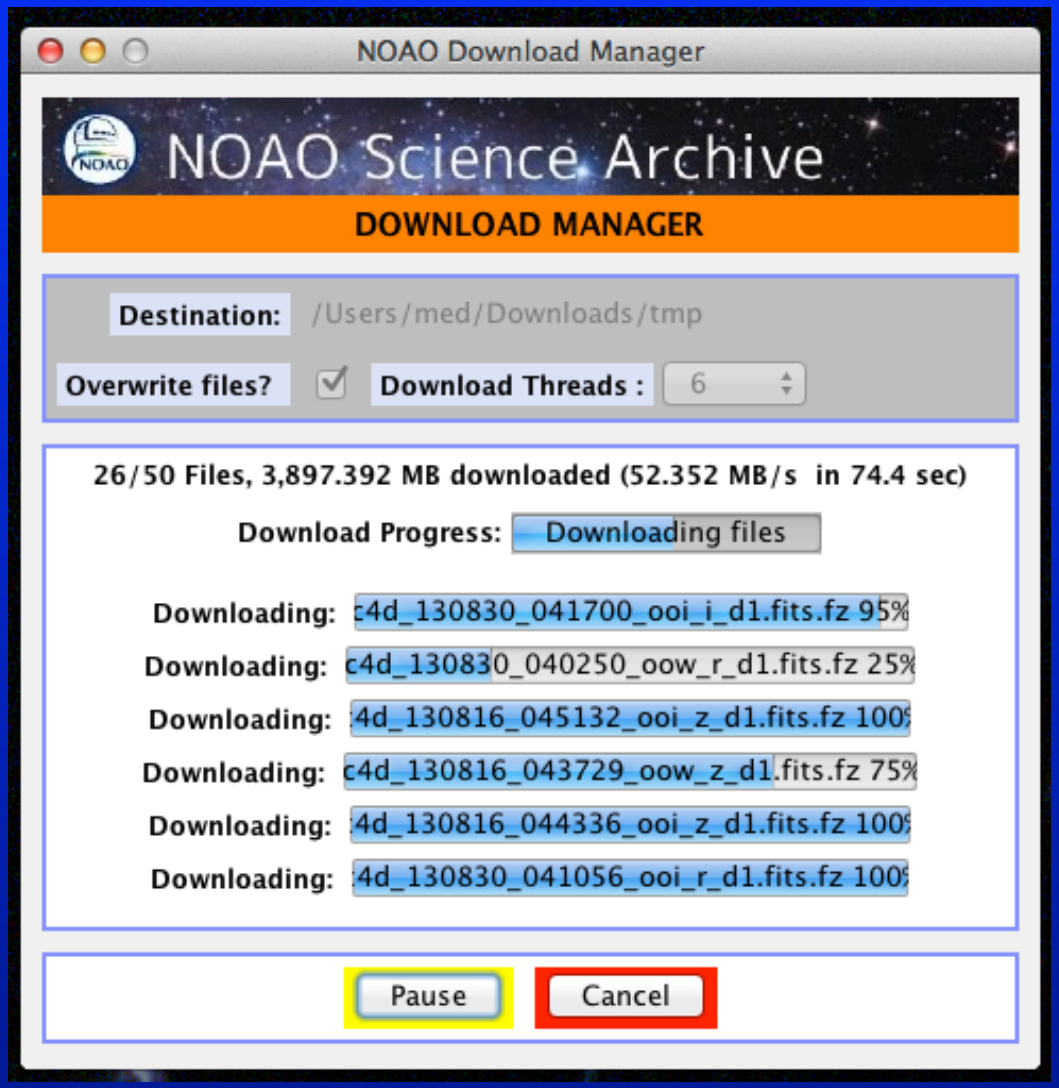
Staging Area



Download Manager

- Fast parallel transfer
- Easy restart if needed

Next release will automatically pull files from mass storage in North or South depending on user location.



Help and Documentation

NOAO Science Archive: Tutorials

Return To Portal | Search and Retrieve NOAO Data | PI & Co-I Data Access | Data compression | Archive file names

Search and Retrieve NOAO Data

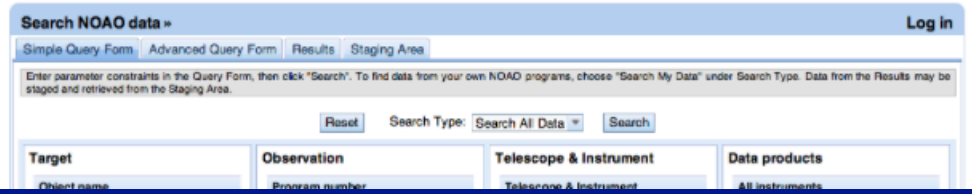
The ***Query page*** lets you search for data in the NOAO Science Archive. The Archive holds data from many different combinations of telescopes and instruments, including the NOAO facilities at **KPNO** and **CTIO**, and NOAO data from consortium facilities such as **WIYN**, **SOAR** and **SMARTS**. All raw data from these telescopes and instruments are archived, as well as pipeline-reduced data products from the DECam, Mosaic and NEWFIRM imagers on the NOAO 4m telescopes. Principal Investigators and authorized co-investigators of NOAO observing programs who have registered with the NOAO Archive can retrieve their proprietary data using the Query form. Any user (registered or not) can search for and retrieve non-proprietary data as well.

The process of finding and accessing NOAO data follows several basic steps:

- **Searching for data using the query form**
  - **Search for data from your own NOAO observing programs**
  - **Search for any data in the NOAO Archive**
  - **Search form parameters**
- **Search results**
  - **Sorting, filtering, and categorizing search results**
  - **Selecting data for retrieval**
- **Staging data for ftp retrieval**
  - **The Staging Area**
  - **Retrieving your data**
  - **Problems with staging data**
  - **Cleaning up your ftp staging area**
- **Retrieving data directly from the Archive using cURL**
- **Working with your downloaded data**
  - **Data compression**
  - **Archive filenames and renaming**

Also, send email to:
sdmhelp@noao.edu

The Search Form

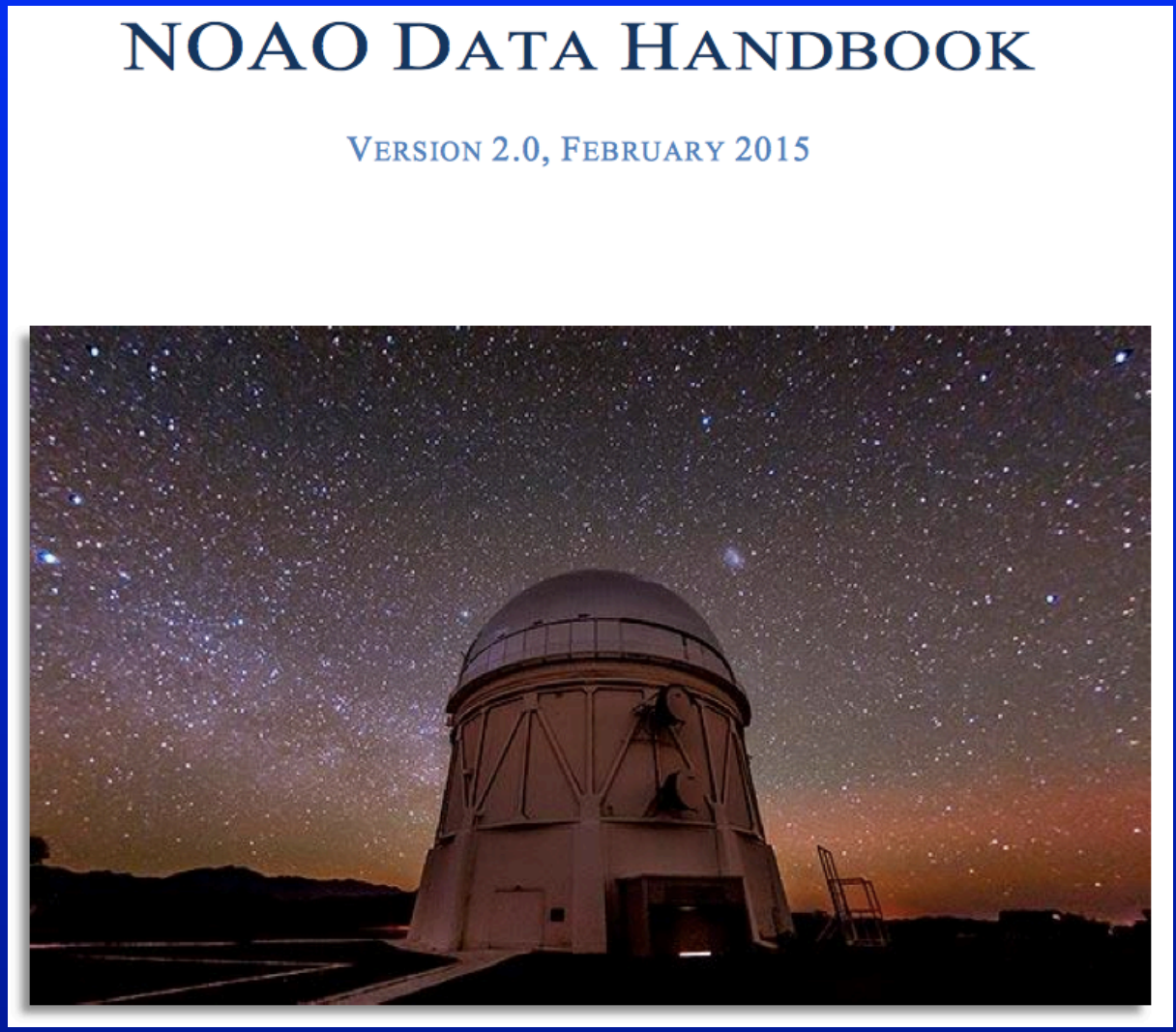


- At top left (under **Search NOAO data**), there are four tabs marked **Query Form**, **Advanced Query Form**, **Results**, and **Staging Area**. These let you switch back and forth between the search form (or the advanced query form), the search results, and the place where you will stage selected data for ftp retrieval.

NOAO Data Handbook

Newly revised!
R. Shaw, editor

- Intro to NOAO data and archives
- Mosaic cameras
- NEWFIRM
- **DECam**



Archive Usage

- Download statistics for CY2014 (approximate):
  - 717,000 files downloaded
  - 76 TB downloaded
  - average of 150 FTP users per month

What's next for the NOAO Archive?

- Features in upcoming archive releases:
  - Larger staging volumes (up to 250,000 files)
  - Better performance
- New survey data:
  - DECam Legacy Survey (DECaLS) DR1 – this month!
  - Other DECam data from NOAO Survey Programs
  - Eventually: migrate pre-DECam surveys from old (obsolete) Survey Archive to NOAO Science Archive
- Behind the scenes:
  - Major overhaul of 3rd-party software systems & infrastructure
- On my long-term wish-list:
  - Uniform reprocessing of all Mosaic, NEWFIRM and DECam data

Big images lead to big catalogs

- NOAO imaging data is growing to ~petabyte scale:
  - Dark Energy Survey
  - DECaLS and DESI Targeting Survey
  - Community DECam programs and surveys
- NOAO Science Archive serves images, not catalogs
- But…Large catalogs are coming:
  - Dark Energy Survey – 45 TB
  - DESI Targeting Survey – ~5 TB
  - Community programs and surveys – up to several TB each

The NOAO Data Lab

Enable efficient exploration and analysis of the large datasets being generated by instruments on NOAO wide-field 4-m telescopes:

- Science with large catalogs
- Easy interplay between catalog objects & associated image data
- Combine services into custom workflows to derive scientific results from catalogs + pixels
- Collaboration tools for distributed research teams working on large data sets

The Data Lab team (so far):

- Project scientist: Knut Olsen
- System architect & lead developer: Mike Fitzpatrick
- In the trenches: Matthew Graham, Ken Mighell, Betty Stobie, Pat Norris, Stephen Ridgway

The Data Lab in a Nutshell

Large Catalogs – Data Lab will serve TB-scale databases

Pixel Data – Data Lab will connect users to images and spectra in NOAO Science Archive

Virtual Storage – Minimizes data transfer

Visualization – Data Lab will enable data exploration

Compute Processing – Data Lab will allow workflows to run close to the data

Additional features – Access to published datasets and external data services, data publication, exportable workflows, distributable software

NOAO Data Lab

- Data Lab will benefit from and build off existing tools and systems where possible
  - SDSS CasJobs, MAST, IRSA, CANFAR, NERSC, VAO, community-led projects

- Timeline:
  - Conceptual design review next week!
  - Science demonstration at AAS January 2016
    - Functional prototypes of various subsystems
  - First public release in January 2017

Discussion session

Friday, 10:45 – 11:45

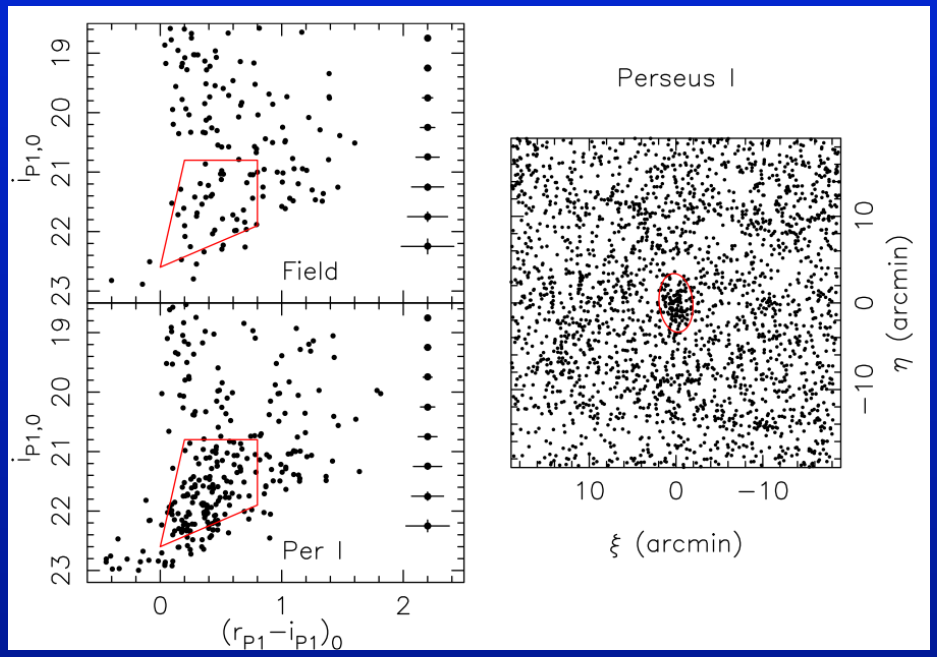
Round-table discussion 7b: NOAO Science Archive

- What is good?
- What should the NOAO Archive be doing better?
- What isn't the NOAO Archive doing at all?

Extra slides

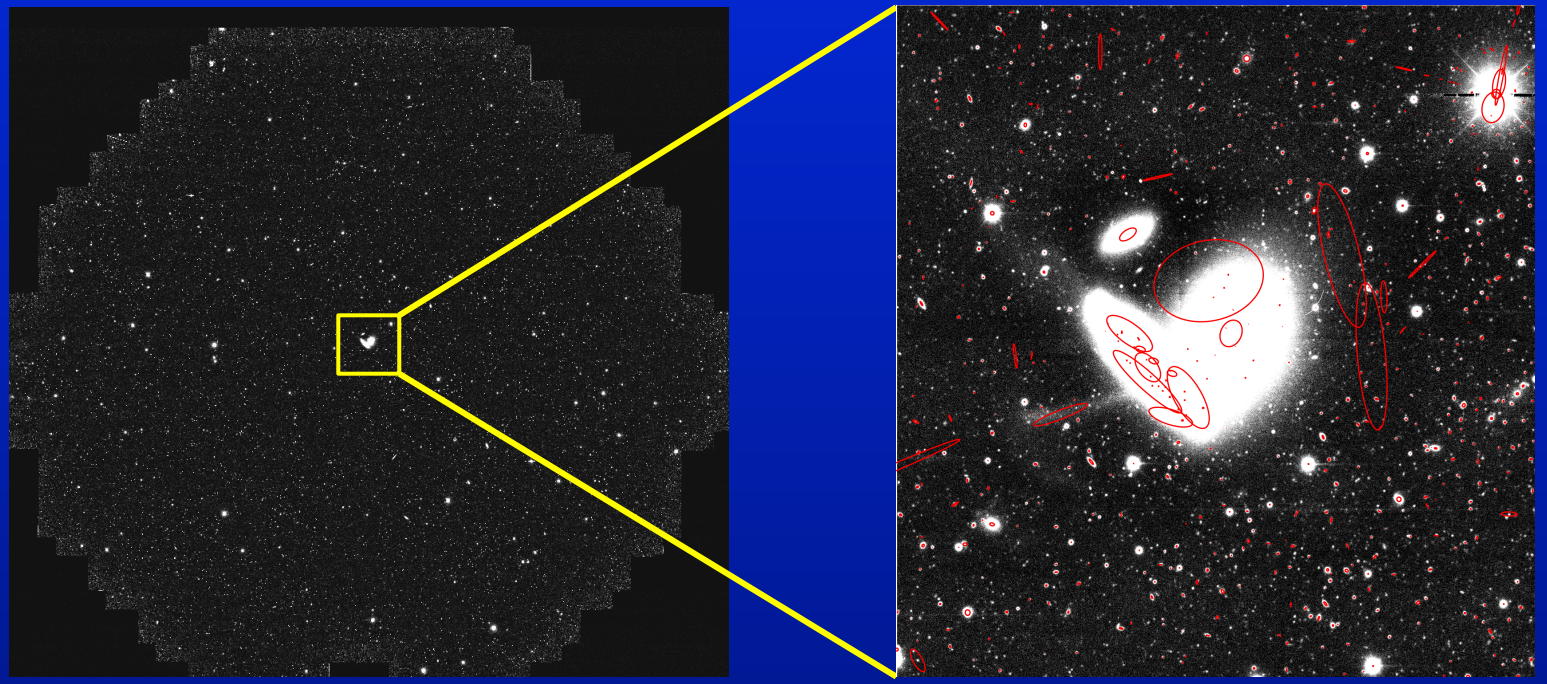
Scientific Approaches Using the Data Lab

- Catalog science
  - Example: search for Galactic substructure through photometric selection of candidate populations
  - Data Lab will provide access to large catalog databases, query interface, personal storage, and visualization capability



Scientific Approaches Using the Data Lab

- Exploration
  - Example: selection of a sample of large galaxies from a catalog, retrieving image cutouts, overlaying with catalog measurements
  - Data Lab will provide a fast image cutout service, visualization capability, cross-match service

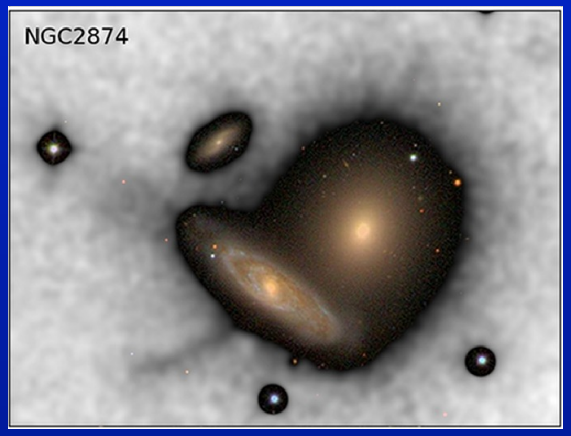


NGC 2874
Sweet et al.
DECam program

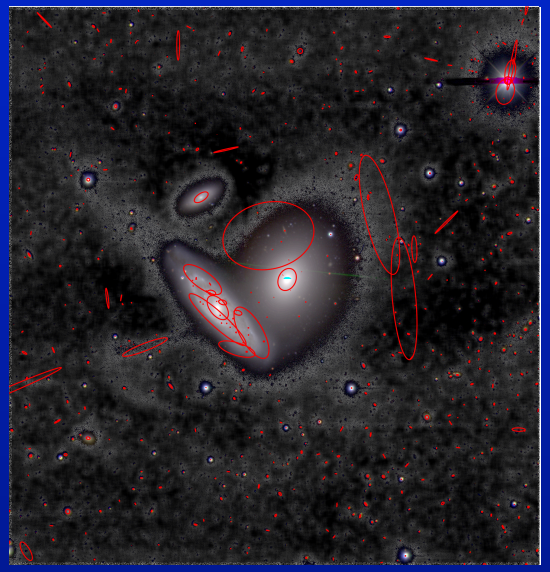
9 arcmin cutout

Scientific Approaches Using the Data Lab

- Custom workflows
  - Example: Use a large sample of galaxies to determine frequency of minor mergers, obtaining image cutouts and performing custom pixel analysis (e.g. PSF subtraction, image filtering, automated feature detection)
  - Data Lab will provide ability to string previous services into a workflow, interface to legacy software, compute service



Miskolczi et al. (2011)

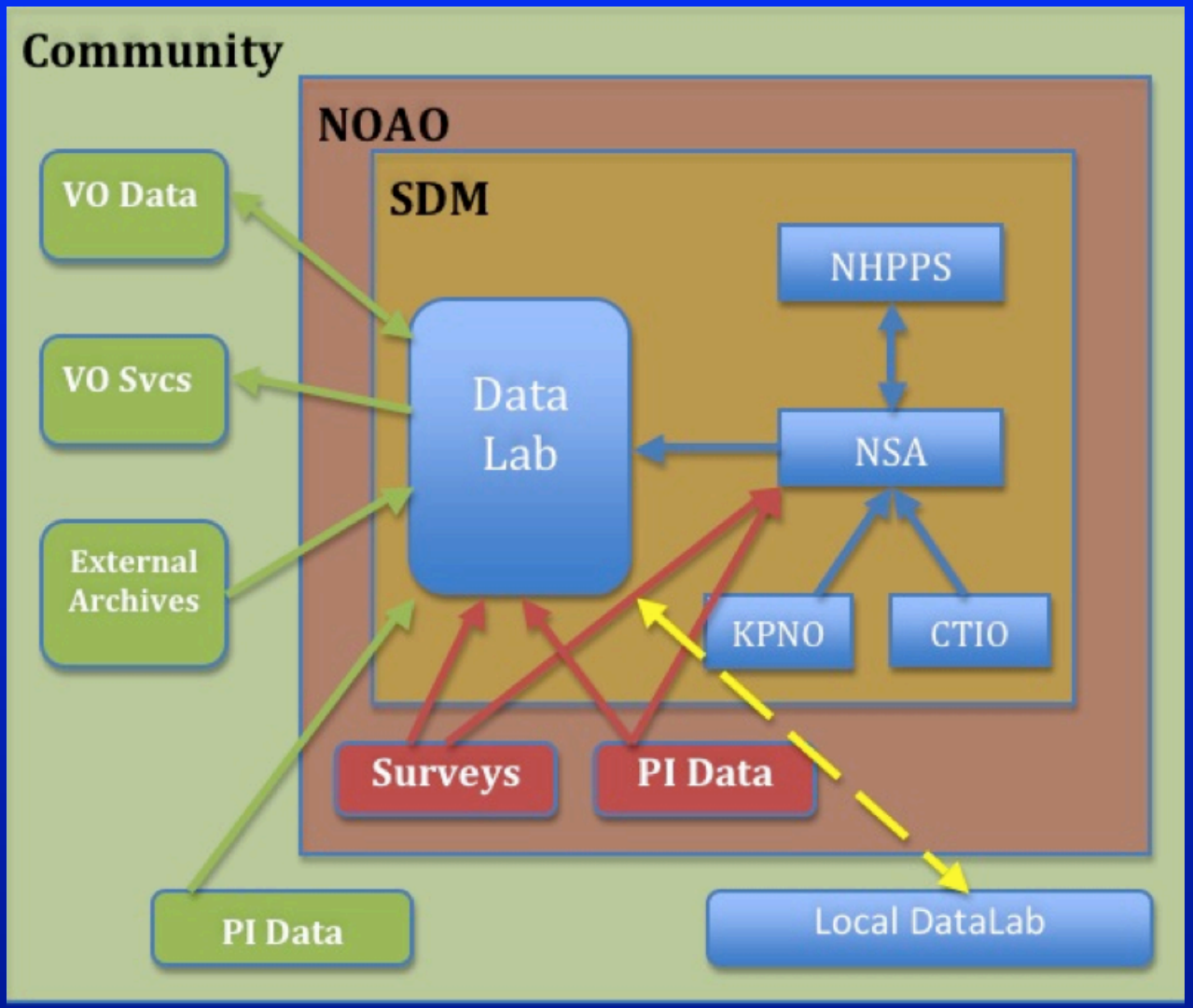


NGC 2874 Sweet et al. DECam program

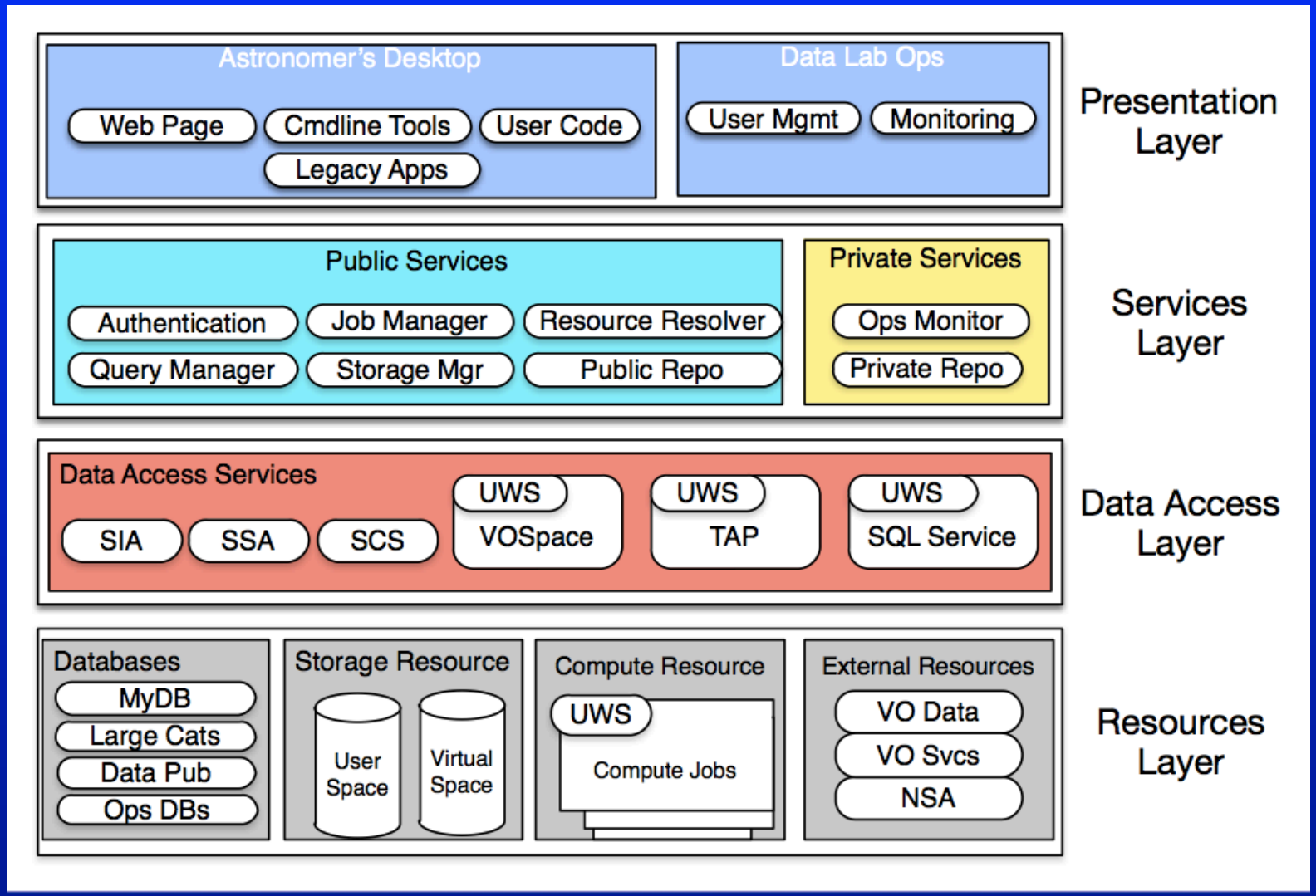
Scientific Approaches Using the Data Lab

- Collaborative research
  - Example: SMASH collaboration has 30 investigators working on many aspects of search for Magellanic Cloud populations all over the sky. Data products include reduced images and photometry from three different approaches; tasks include star/galaxy separation, foreground modeling, population detection, population analysis, and simulations, divided over different people
  - Data Lab will provide access to a shared storage space, shareable containers for software tasks, and a customizable virtual machine

Data Lab Context



Data Lab Architecture



Data Lab System Architecture

Example Flow of Use Case through System Architecture