



# Connecting catalogs to image pixels with the Astro Data Archive

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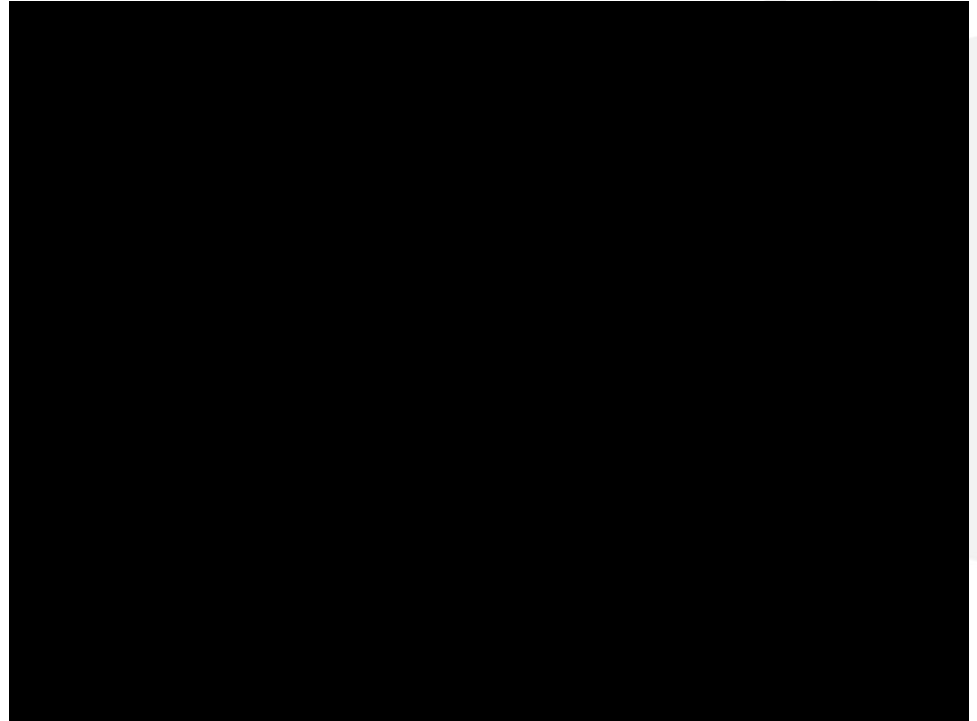
# Crowd Sourcing the Sky



- Astro Data Archive inception in 2004
- Imaging data covers >80% of sky
- Billions of astronomical objects in associated catalogs

Animated Sky Coverage Map:

<https://www.youtube.com/watch?v=IbRWdOqWrEk>

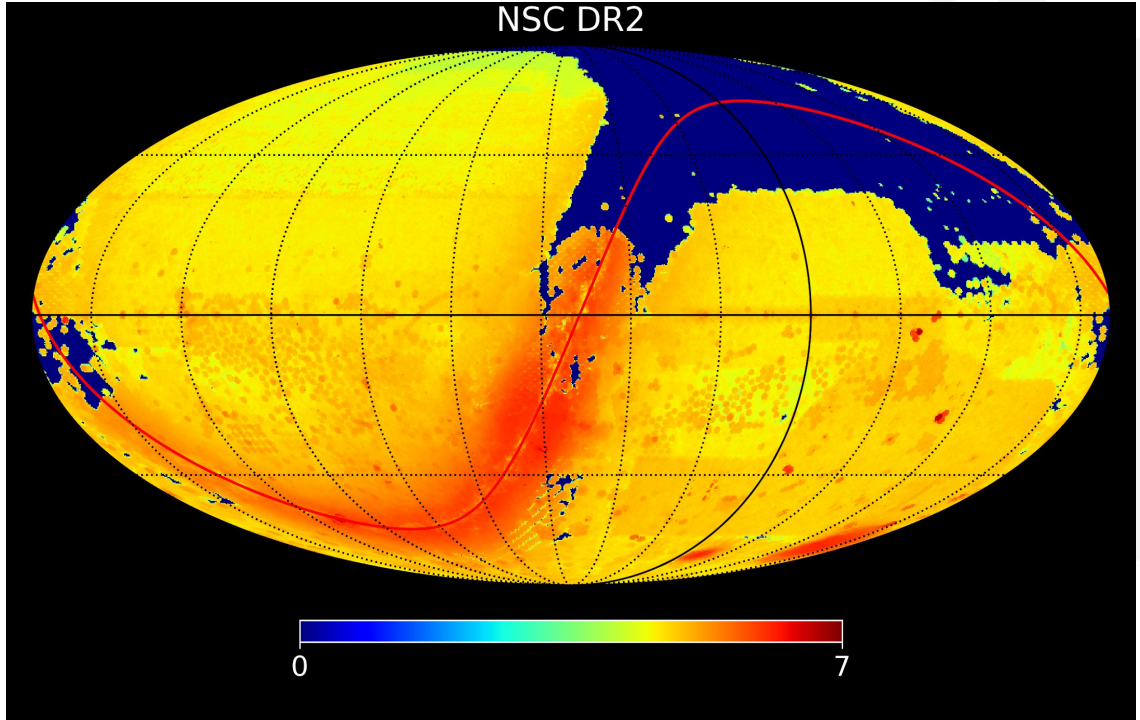




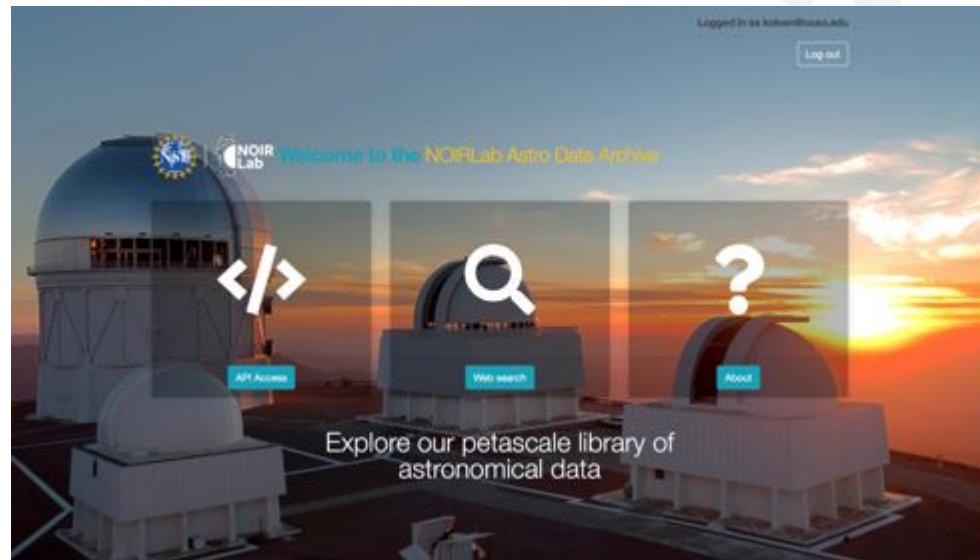
# From images to catalogs



- NOIRLab Source Catalog DR2 (Nidever et al. 2020)
- 3.9 billion objects
- 68 billion measurements



- Petascale pixel data archive
- Web and API queries
- Astroquery module
- Jupyter notebook examples





# Fast exploration



Raw and reduced data from NOIRLab telescopes and instruments

Search within collections: All Holdings

Search

Toggle Code View | Clear Search

15715733 Records found

Search Form Results Stage/Download

Change Columns / Fields Display

1 to 100 Page 1

Download tabular results

Stage selected files Stage ALL results

Target Search via coordinates

Object Name (Used to find RA, Dec values) RA Dec Radius

An astro-object i.e. m31 0.0 0.0 0.1

(in decimal degrees)

Get Coordinates Enter Position List

Image & Telescope / Instrument Search an image processing and specific telescope and instrument

Filter Observation Type

Select option Select option

Process Type Telescope & Instrument

Select option Select option

\* Calibrated, Aperiodized, Staked, Master calibration, Image files are for Mosaic, NEWFIRM and DECam.

- Top Categories from results
- Up to 30 category results shown
- Telescopes
    - ct4m 9877172
    - ct13m 2836918
    - kp4m 2198587
    - soar 1346809
    - ct15m 1094479
    - cd05m 88109
    - wjw 41929
    - kp21m 46403
    - kp06m 330911
    - ct1m 317819
    - bok22m 285585
  - Instruments
  - Proposal
  - Principal Investigator
  - Observations Per Year

Selected	Telescope	Instrument	Program number	Observation type	Proc type	RA	Dec	Filter	Exposure
<input type="checkbox"/>	ct4m	mosaic_2	2011A-0477	object	instcal	185.537417	-72.227306	ha H-alpha c6009	180
<input type="checkbox"/>	ct4m	flamingos	2013B-0395	object	raw	40.388125	28.049889	H	
<input type="checkbox"/>	ct4m	decam	2015A-0618	object	resampled	349.135708	-53.424528	r DECam SDSS c0002 6415.0 1480.0	405
<input type="checkbox"/>	ct4m	newfirm	2013B-0236	object	instcal	20.075500	-0.774111	Ks	60
<input type="checkbox"/>	ct4m	decam	2017A-0398	object	instcal	228.207958	-33.447222	r DECam SDSS c0002 6415.0 1480.0	376
<input type="checkbox"/>	soar	goodman	2014B-0602	object	raw	272.292733	-25.916138	<NO FILTER>	
<input type="checkbox"/>	ct4m	decam	2013B-0325	object	instcal	281.003042	-29.865889	g DECam SDSS c0001 4720.0 1520.0	60
<input type="checkbox"/>	ct13m	andicam	smarts	object	raw	153.401833	-45.075889		40.04
<input type="checkbox"/>	ct4m	decam	2012B-0001	object	instcal	341.725625	-58.463944	i DECam SDSS c0003 7835.0 1470.0	90
<input type="checkbox"/>	ct4m	decam	2016B-0301	object	resampled	100.376125	-50.961278	Y DECam c0005 10095.0 1130.0	150
<input type="checkbox"/>	ct4m	decam	2018A-0913	object	skysub	202.662875	-2.558250	i DECam SDSS c0003 7835.0 1470.0	35
<input type="checkbox"/>	soar	goodman	2013B-0270	object	raw	68.950517	6.565061	r-SDSS	
<input type="checkbox"/>	kp4m	newfirm	2013B-0236	object	instcal	23.748833	0.582750	Ks	60
<input type="checkbox"/>	ct4m	decam	2019A-0915	object	raw	289.655117	-22.204170	i DECam SDSS c0003 7835.0 1470.0	30
<input type="checkbox"/>	ct13m	andicam	smarts	object	raw	343.528250	-17.577194		20.05
<input type="checkbox"/>	kp4m	newfirm	2012B-0540	object	instcal	12.544250	42.616944	JX	30
<input type="checkbox"/>	ct4m	decam	2012B-0001	object	instcal	10.860000	-42.129250	i DECam SDSS c0003 7835.0 1470.0	90
<input type="checkbox"/>	ct13m	andicam	smarts	flat	raw	0.478583	21.709972		26.03
<input type="checkbox"/>	ct15m	echelle	smarts	calibration	raw	133.420458	-30.119278		2



Discovering Our Universe Together



# Advanced search capabilities



- API with interactive documentation
- Use to access and search any field in file headers

The screenshot shows the NOIR Lab Astro Data Archive website. At the top, there is a navigation bar with 'Search', 'Documents', 'Help', and 'Logout' buttons. Below this, there are two promotional cards: one for 'The Astropy Project' with a 'NOIRLab astroquery module.' button, and another for 'Jupyter' with an 'Experiment with our API!' button. The main content area features a 'REST API v1' section with a description, version information (3.2), and links to 'Release Notes' and 'Contact the developer'. Below the API section, there is a 'Schemes' dropdown menu set to 'HTTPS' and a 'Filter by tag' input field. At the bottom, there is a search bar with the text 'adv\_search' and a dropdown arrow.



# API image retrieval

```
Out[13]: 'https://astroarchive.noirlab.edu/api/retrieve/84289f753e3155b55955b7d4ffeb7c4b/?hdus=35'
```

Unique identifier

```
In [14]: hdu = fits.open(onehduurl)
         hdu.info()
```

```
Filename: /home/pothiers/.astropy/cache/download/url/c4a811d78e3043fd7c834c396c565ff5/contents
```

No.	Name	Ver	Type	Cards	Dimensions	Format
0	PRIMARY	1	PrimaryHDU	251	()	
1	N4	1	CompImageHDU	127	(2046, 4094)	float32

*\*required field.*

ra dec (optional)  
204.17582498817

Alert RA and DEC  
in decimal degrees:

Survey:

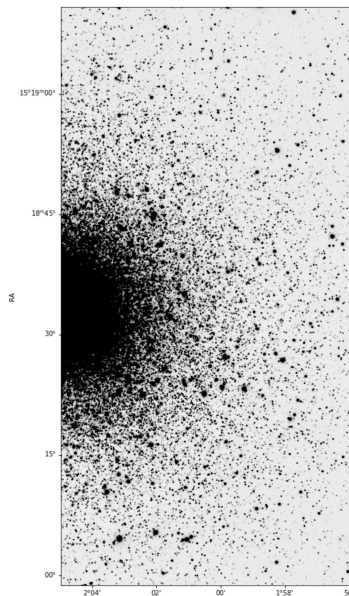
Size:

Filter:  All  G  B  I  Z  Y

(RA:229.1758, DEC:2.498817, (Undefined)) 1222 images found.

Thumbnail	Instrument_name	obs_bandpass	exptime	proctype	date_obs	original_filename	All	None
	DECam	z	120	image	Raw	2018-08-08T23:14:47.042283	c4d_180808_231447_ori.fits	<input type="checkbox"/>
	DECam	z	120	image	SkySub	2018-08-08T23:14:47.042283	c4d_180808_231447_csk_z_v1.fits	<input type="checkbox"/>

In Data Lab:



# Making a DES exposure map

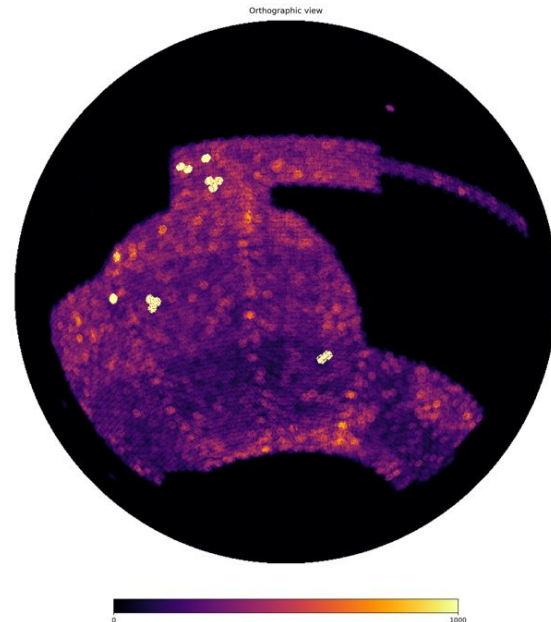
Map of effective exposure time depends on atmospheric transparency, PSF FWHM, sky brightness, and commanded exposure time

This metadata is available at detector level for every image

```

startdate = datetime.date(2011,9,2)
td = datetime.timedelta(days=365*2)
bins = 5
for i in range(bins):
    enddate = startdate+td
    jj = {
        "outfields" : [
            "fitsfile",
            "hdu_idx",
            "fitsfile_archive_filename",
            "fitsfile_exposure",
            "fitsfile_ifilter",
            "CENRAL",
            "CENDECI",
            "COR1RAL",
            "COR2RAL",
            "COR3RAL",
            "COR4RAL",
            "COR1DECI",
            "COR2DECI",
            "COR3DECI",
            "COR4DECI",
            "FWHM",
            "AVSKY",
        ],
        "search" : [
            ["fitsfile_caldat", startdate.isoformat(), enddate.isoformat()],
            ["fitsfile_instrument", "decam"],
            ["fitsfile_proc_type", "instcal"],
            ["fitsfile_prod_type", "image"],
            ["fitsfile_obs_type", "object"],
            ["fitsfile_proposal", "2012B-0001"],
            ["fitsfile_ifilter", "r DECam", "contains"]
        ]
    }
    startdate = enddate + datetime.timedelta(days=1)

df2 = None # Pandas DataFrame
apiurl=f'{adsurl}/hasearch/?limit=5000000'
#apiurl=f'{adsurl}/hasearch/?limit=50000'
response = requests.post(apiurl,json=jj)
    
```







# Summary



- Astro Data Archive puts a Petabyte+ of pixel data and metadata in your hands
- Is the source of billions of catalog objects and measurements
- Come to NOIRLab Data Services Splinter Session on **Thursday at 4:10 PM** to see Astro Data Archive and other NOIRLab services as an integrated scientific workflow:
  - DES depth map (Astro Data Archive)
  - Discovery of dwarfs and streams in DES catalog data (Astro Data Lab)
  - Discovery of associated variables and transients (ANTARES)
  - Scheduling a followup observation with Gemini (AEON)