Connecting catalogs to image pixels with the Astro Data Archive

Knut Olsen (NOIRLab/CSDC)
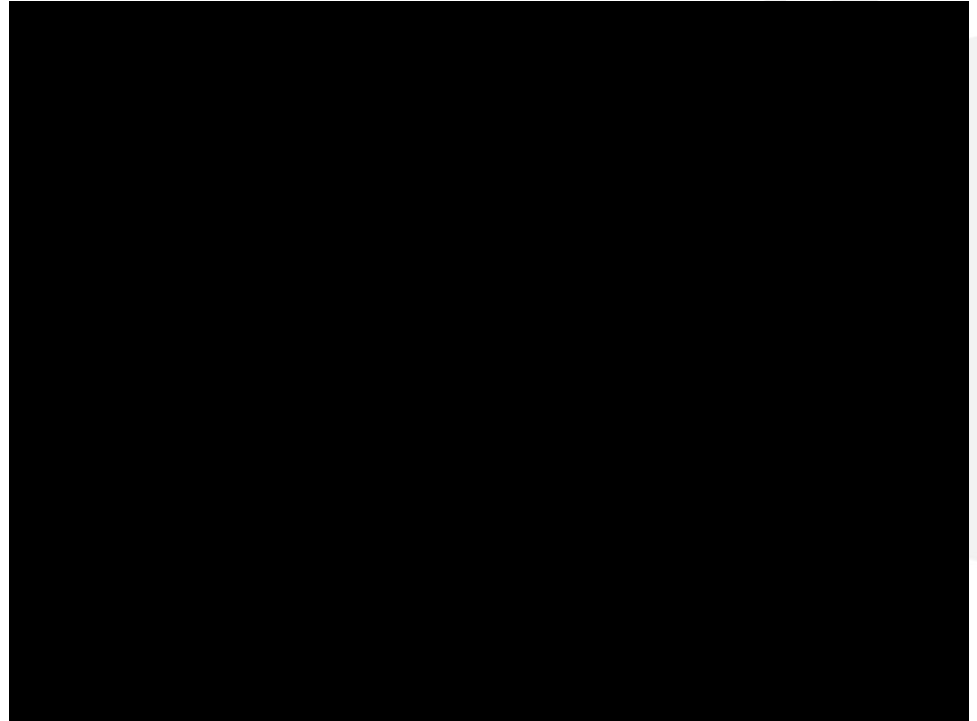## *on behalf of Sean McManus, Steve Pothier, and Pete Peterson*

Crowd Sourcing the Sky

- Astro Data Archive inception in 2004
- Imaging data covers >80% of sky
- Billions of astronomical objects in associated catalogs
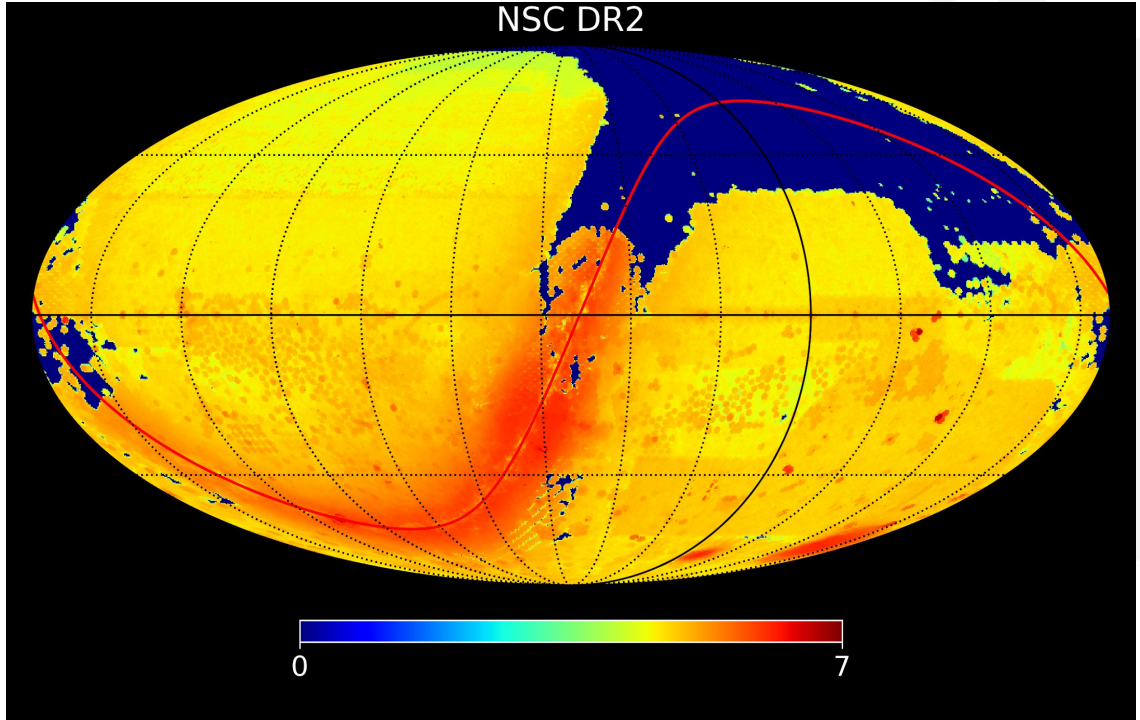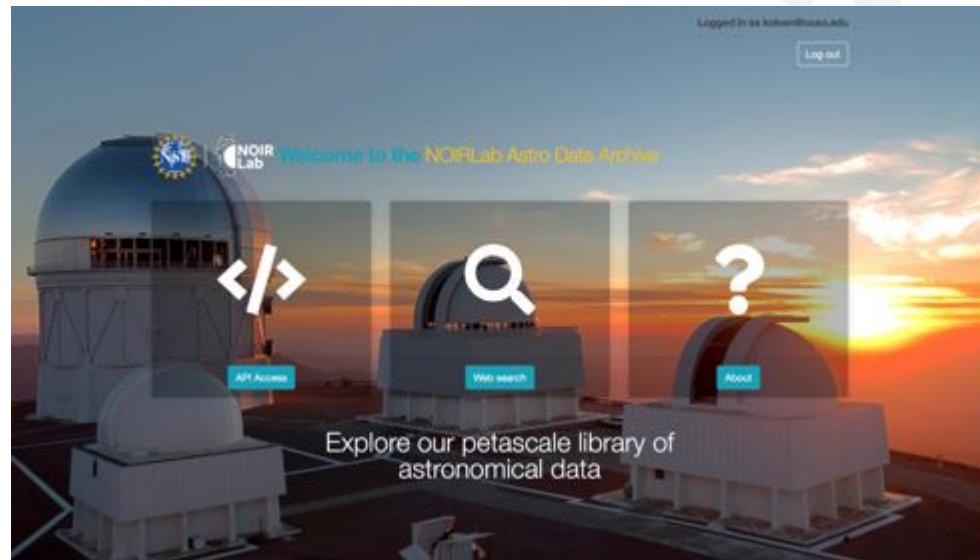
Animated Sky Coverage Map:
https://www.youtube.com/watch?v=IbRWdOqWrEk

From images to catalogs

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

NSC DR2

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astroarchive.noirlab.edu

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

Fast exploration

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Advanced search capabilities

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

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
```

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

```python
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",
            "CENRA1",
            "CENDEC1",
            "COR1RA1",
            "COR2RA1",
            "COR3RA1",
            "COR4RA1",
            "COR1DEC1",
            "COR2DEC1",
            "COR3DEC1",
            "COR4DEC1",
            "FWHM",
            "AVSKY",
        ],
        "search" : [
            ["fitsfile__caldat", startdate.isoformat(), enddate.is
            ["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)
```
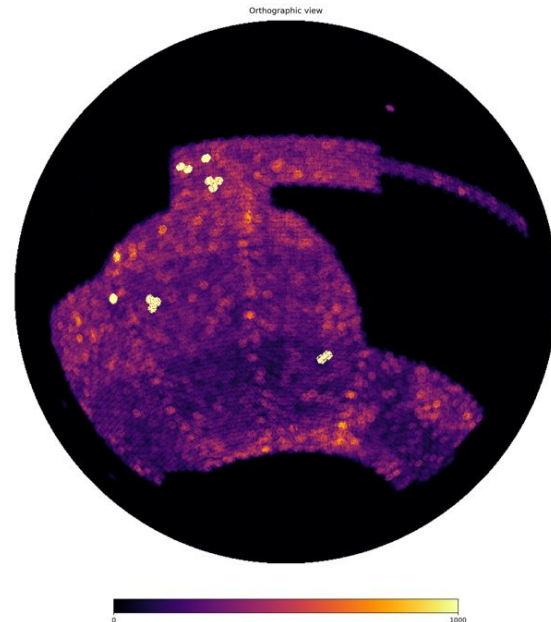

Orthographic view

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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)

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