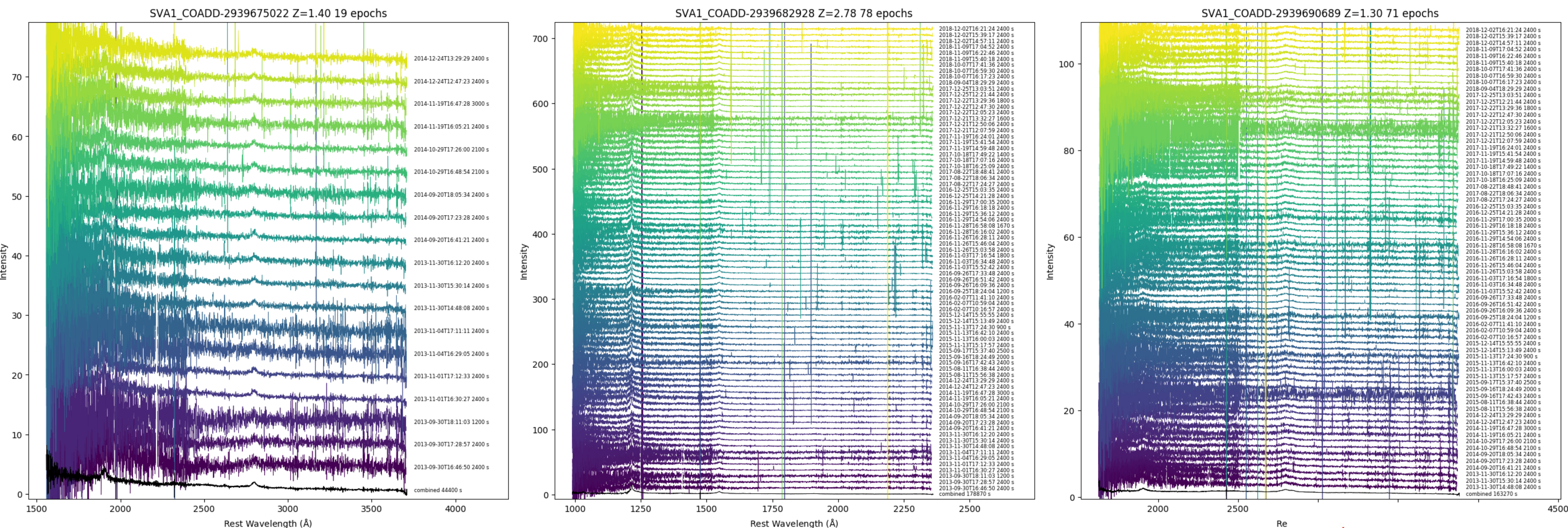
Data Central's Virtual Observatory Services



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MACQUARIE University

data central

VO services allow direct and programmatic/scriptable access (e.g. using Python) to data hosted by Data Central

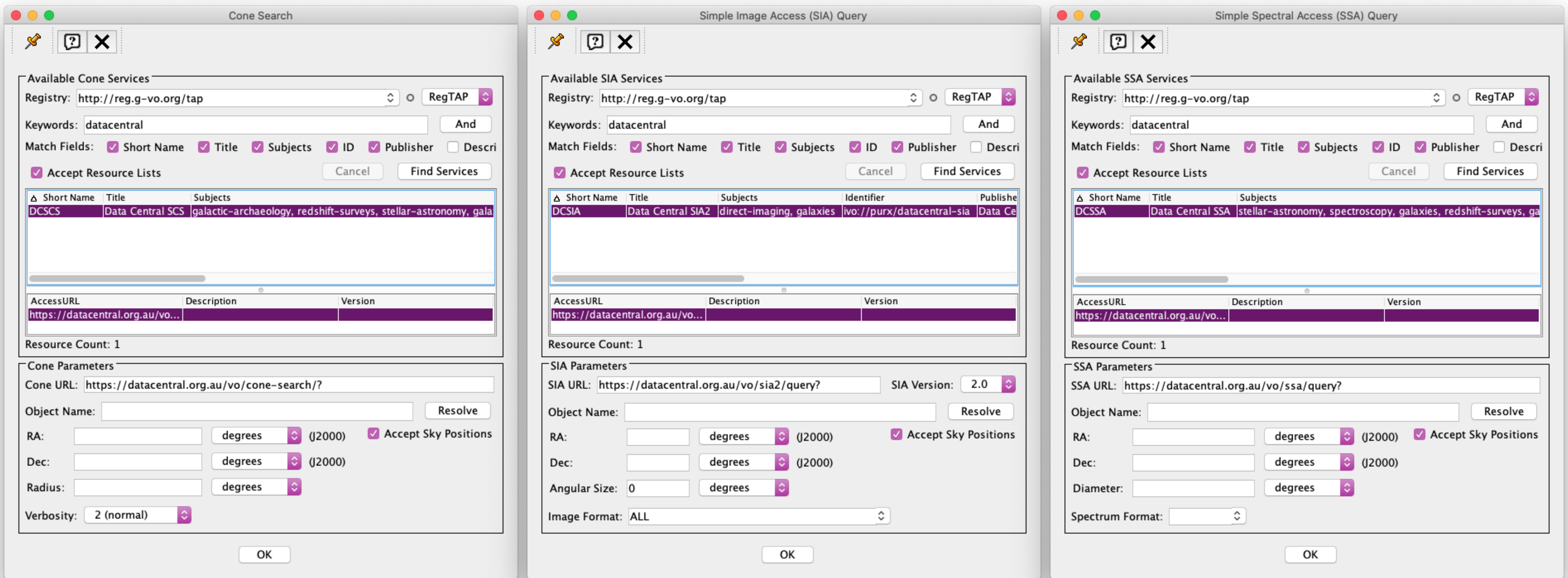
VO services offer a convenient, standardised interface for data access

Available services

- **SCS (Simple Cone Search)**
  - Basic cone search of Data Central hosted catalogues
- **SIA2 (Simple Image Access)**
  - Cutout service for Data Central imaging data (version 2.0 of SIA specifications)
- **SSA (Simple Spectral Access)**
  - Search and download Data Central spectra (excluding IFU spectra)
- **TAP (Table Access Protocol)**
  - Query Data Central catalogues using **ADQL** (will be updated in near future)
- **Data Aggregation Service (DAS)**
  - Makes extensive use of VO services, combining all above and more (but not a VO service)

Access details: https://docs.datacentral.org.au/reference/services/vo/
Example code: https://docs.datacentral.org.au/help-center/examples/general-virtual-observatory-examples/

SCS, SIA and SSA: discoverable via IVOA registry



Once catalogues, images or spectra ingested by Data Central, users querying IVOA registry can find your data

SkyMapper VO services

- **SCS (Simple Cone Search)**
- **SIA (Simple Image Access)**
- **TAP (Table Access Protocol)**
- **See Marc White talk on Thursday**

SCS

Simple Cone Search

The Data Central SCS service runs at https://datacentral.org.au/vo/cone-search/, and searches though all the data releases hosted by Data Central. There is some example code within the pyvo docs which shows how to access data via SCS in Python. The following code can be used as a starting point to experiment with the Data Central SCS:

```
>>> from astropy.coordinates import SkyCoord
>>> import astropy.units as u
>>> import pyvo
>>> scs_table = pyvo.dal.conesearch(
...     "https://datacentral.org.au/vo/cone-search/",
...     SkyCoord(ra='130.6178d', dec='-0.271607d'),
...     radius=60 * u.arcsec
... )
>>> scs_table
<bound method DALResults.fieldname_with_utype of <Table length=6>
 RA ICRS    DEC ICRS   Source Name Dataset        Distance          DC ID
   deg         deg                                   deg
 float32     float32      object     object          object          object
--------- ----------- ----------- -------- --------------------- ------
130.61781 -0.27160797      202627 GAMA DR2 1.231963786451914e-05 169748
130.61035  -0.2747296      202628 GAMA DR2  0.008076649105768092 169750
130.62766 -0.27284884      202691 GAMA DR2  0.009930320903546022 169865
 130.6172   -0.283532      202636 GAMA DR2  0.011939943386627126 169763
 130.6044  -0.2628667      202647 GAMA DR2   0.01599290493049995 169785
130.61838  -0.2880986      202637 GAMA DR2   0.01650187238502076 169765>
>>> scs_table.status
('OK', 'Successful Response')
```

Another example: https://datacentral.org.au/vo/cone-search/?RA=217.45103&DEC=0.28289&SR=0.03

TAP

TAP HOME PAGE

- Data Central TAP Service -

Service description

An IVOA-compliant query tool

Available resources

- async
- tables
- capabilities
- availability
- sync

ADQL query

Query:

```
SELECT *
FROM TAP_SCHEMA.tables;
```

Execution mode: ○ Asynchronous/Batch ◉ Synchronous

Format: votable

☐ **Result limit:** -1 rows *(0 to get only metadata ; a value < 0 means 'default value')*

☐ **Duration limit:** -1 seconds *(a value ≤ 0 means 'default value')*

Execute!

Page generated by TAPLibrary v2.0

Holds a few older tables

TAP will be updated in near future

To be powered by Data Central cluster

Newer TAP version supports user table uploads for cross matching

Please use: https://datacentral.org.au/services/query/ for now (or API access)

SSA: Access to millions of AAT and UKST spectra

2dFGRS
The 2dF Galaxy Redshift Survey
Final Data Release | Schema | Docs

6dFGS
The 6dF Galaxy Survey
Final Data Release | Schema | Docs

DEVILS
The Deep Extragalactic VIsible Legacy Survey
Data Release 0 | Schema | Docs

GALAH
GALactic Archaeology with Hermes
Data Release 3 | Schema | Docs
Data Release 2 | Schema | Docs
Data Release 1 | Schema | Docs

GAMA
Galaxy And Mass Assembly Survey
Panchromatic Data Release | Schema | Docs
Data Release 2 | Schema | Docs

DR4 coming soon

Available from SSA service

OzDES
The Australian Dark Energy Survey (OzDES)
Data Release 2 | Schema | Docs
Data Release 1 | Schema | Docs

RAVE
The Radial Velocity Experiment
Data Release 5 | Schema | Docs

S7
S7
Data Release 2 | Schema | Docs

SAMI
The SAMI Galaxy Survey
Data Release 3 | Schema | Docs
Data Release 2 | Schema | Docs
Data Release 1 | Schema | Docs

WiggleZ
The WiggleZ Dark Energy Survey
Final Data Release | Schema | Docs

SSA Links

- Endpoint: https://datacentral.org.au/vo/ssa/query
- Main doc page: https://docs.datacentral.org.au/reference/services/simple-spectral-access-ssa-service/
- Several Python examples: https://docs.datacentral.org.au/help-center/examples/simple-spectral-access-ssa-examples/
- Specutils loaders: https://github.com/astropy/specutils/tree/main/specutils/io/default_loaders

SSA Workflow

The intended workflow of the SSA service is as follows:

1. The user supplies an HTTP GET query to the query interface URL.
2. A query is performed using the query parameters, producing a list of available spectra.
3. If the POS parameter is specified (i.e. a cone search), the results are ordered in increasing distance from the position
4. A VOTABLE with the query results is returned with each row containing an **access_url** link.
5. The **access_url** is a Datalink-enabled service that returns a spectrum (on request) for each result.

In many cases, the spectrum from **access_url** is actually a simplified 1D spectrum that is extracted from an original multi-extension file.

The original file may be retrieved using the url in the **full_data_url** column of the VOTABLE output.

Many different parameters may be supplied: see https://docs.datacentral.org.au/reference/services/simple-spectral-access-ssa-service/ for a full list

Example query: Stacked ozdes spectra covering 3000A (at rest)

TOPCAT(5): Table Browser

Table Browser for 5: query?COLLECTION=ozdes_dr2&DPSUBTYPE=combined&BA...

	s_ra	s_dec	s_fov	s_region	s_resol...	s_seeing	s_xel1	s_xel2	t_min	t_max	t_midpoint	t_exptime	t_resolution	t_xel	em_min	em_m
112	53.80087	-28.14061	0.00058				5000	1	58044.68413	58134.56093	58089.62253	39060.	1787.	20	3.732848E-7	8.
288	7.72879	-44.01419	0.00058				5000	1	57986.55377	58109.49582	58048.0248	44000.	2526.	18	3.732848E-7	8.
296	8.29046	-42.336	0.00058				5000	1	57986.55377	58109.49582	58048.0248	44000.	2526.	18	3.732848E-7	8.
274	10.66308	-43.99392	0.00058				5000	1	57989.59194	58110.50096	58050.04645	37500.	2077.	16	3.732848E-7	8.
284	9.11129	-42.49069	0.00058				5000	1	57986.55377	58073.53171	58030.04274	39200.	2526.	16	3.732848E-7	8.
315	41.13071	-0.42019	0.00058				5000	1	57749.50389	58112.50372	57931.0038	39400.	2526.	16	3.732848E-7	8.
326	9.74713	-43.54606	0.00058				5000	1	57986.61942	58049.47068	58018.04505	37500.	2077.	16	3.732848E-7	8.
197	53.39821	-27.68031	0.00058				5000	1	58073.63486	58133.53343	58103.58414	28520.	1787.	15	3.732848E-7	8.
344	53.67967	-28.35333	0.00058				5000	1	58044.68413	58132.58653	58088.63533	27540.	1926.	15	3.732848E-7	8.
147	52.79796	-27.96439	0.00058				5000	1	58048.69586	58131.49648	58090.09617	26240.	1926.	14	3.732848E-7	8.
289	7.46483	-44.0015	0.00058				5000	1	57986.55377	58048.52578	58017.53977	34400.	2526.	14	3.732848E-7	8.
300	6.73637	-43.00969	0.00058				5000	1	57986.55377	58048.52578	58017.53977	34400.	2526.	14	3.732848E-7	8.
312	40.63946	-0.55322	0.00058				5000	1	57989.71875	58112.50372	58051.11123	34600.	2526.	14	3.732848E-7	8.
307	36.11758	-5.40208	0.00058				5000	1	57747.43691	58049.57897	57898.50794	31200.	2526.	13	3.732848E-7	8.
142	52.58396	-27.97539	0.00058				5000	1	58048.69586	58134.48051	58091.58818	22340.	1926.5	12	3.732848E-7	8.
305	43.48192	0.07783	0.00058				5000	1	57748.51052	58111.5106	57930.01056	28200.	2526.	12	3.732848E-7	8.
311	42.77408	-0.81392	0.00058				5000	1	57987.66569	58111.5106	58049.58815	28200.	2526.	12	3.732848E-7	8.
394	7.609	-43.21925	0.00058				5000	1	56595.40075	56626.51269	56610.95672	28800.	2526.	12	3.732848E-7	8.
396	8.02671	-43.15989	0.00058				5000	1	56595.40075	56626.51269	56610.95672	28800.	2526.	12	3.732848E-7	8.
397	7.6855	-43.13178	0.00058				5000	1	56595.40075	56626.51269	56610.95672	28800.	2526.	12	3.732848E-7	8.
404	9.09508	-42.79983	0.00058				5000	1	56595.40075	56626.51269	56610.95672	28800.	2526.	12	3.732848E-7	8.
303	40.86929	-1.28503	0.00058				5000	1	57749.50389	58049.67405	57899.58897	27000.	2526.	11	3.732848E-7	8.
167	52.57033	-27.87525	0.00058				5000	1	58043.64036	58113.57874	58078.60955	17100.	1867.	10	3.732848E-7	8.
271	10.34388	-43.66853	0.00058				5000	1	57986.61942	57990.65169	57988.63556	24000.	2526.5	10	3.732848E-7	8.
275	9.64808	-44.95853	0.00058				5000	1	57986.61942	57990.65169	57988.63556	24000.	2526.5	10	3.732848E-7	8.
276	9.41987	-44.90375	0.00058				5000	1	57986.61942	57990.65169	57988.63556	24000.	2526.5	10	3.732848E-7	8.
277	9.45475	-44.62961	0.00058				5000	1	57986.61942	57990.65169	57988.63556	24000.	2526.5	10	3.732848E-7	8.
301	43.42562	0.71103	0.00058				5000	1	58044.59154	58111.5106	58078.05107	23400.	2526.	10	3.732848E-7	8.
354	52.34625	-28.06944	0.00058				5000	1	58043.64036	58137.52973	58090.58505	18900.	1326.	10	3.732848E-7	8.
365	55.07746	-29.46194	0.00058				5000	1	56565.69919	56626.70444	56596.20182	22800.	1926.	10	3.732848E-7	8.
371	55.1185	-29.484	0.00058				5000	1	56565.69919	56626.70444	56596.20182	22800.	1926.	10	3.732848E-7	8.
382	52.45342	-28.5785	0.00058				5000	1	56595.59559	56625.60888	56610.60223	22442.	2526.	10	3.732848E-7	8.
384	52.65763	-27.30853	0.00058				5000	1	56595.59559	56625.60888	56610.60223	22442.	2526.	10	3.732848E-7	8.
283	9.03154	-42.67536	0.00058				5000	1	57986.55377	57990.58576	57988.56977	21600.	2526.5	9	3.732848E-7	8.
286	8.38996	-43.24717	0.00058				5000	1	57986.55377	57990.58576	57988.56977	21600.	2526.5	9	3.732848E-7	8.
290	7.80558	-43.90442	0.00058				5000	1	57986.55377	57990.58576	57988.56977	21600.	2526.5	9	3.732848E-7	8.
291	7.69567	-43.91022	0.00058				5000	1	57986.55377	57990.58576	57988.56977	21600.	2526.5	9	3.732848E-7	8.
299	7.88296	-42.19158	0.00058				5000	1	57986.55377	57990.58576	57988.56977	21600.	2526.5	9	3.732848E-7	8.
306	41.399	-0.217	0.00058				5000	1	57989.71875	58049.67405	58019.6964	22200.	2526.	9	3.732848E-7	8.
308	42.58967	-0.27406	0.00058				5000	1	57748.51052	58048.68755	57898.59903	21600.	2526.	9	3.732848E-7	8.

Total: 455 Visible: 455 Selected: 1

https://datacentral.org.au/vo/ssa/query?COLLECTION=ozdes_dr2&DPSUBTYPE=combined&BANDREST=3000e-10&REQUEST=queryData

Output data formats

- Datalink service **slink** that extracts spectra of interest
  - VOTable output by default, to allow for **TOPCAT/SPLAT** preview of spectra
  - Can add **&RESPONSEFORMAT=fits** to urls to return FITS format
- **Simplified 1D spectra:** Available from **access_url**
  - Accessible spectra, readable from majority of clients
  - A few essential header keywords added by Data Central
- **Original spectra:** Available from **full_data_url**
  - Survey team provided file that contains spectrum of interest
  - Often complex format, may require loaders to open **(specutils github repo)**
  - Full original header information + other spectra (sky background, variance, etc.)

FITS header keywords added by Data Central

FITS Header Keyword	Obscore Parameter
RA	s_ra
DEC	s_dec
OBJECT	target_name
SURVEY	obs_collection
Z	redshift
RV	rv
TMIN	t_min
TMAX	t_max
TMID	t_midpoint
EXPTIME	t_exptime
TXEL	t_xel
BAND	band_name
SEEING	s_seeing
WMIN	em_min (converted to Angstrom)
WMAX	em_max (converted to Angstrom)
WMID	em_midpoint (converted to Angstrom)
WMINREST	em_min_rest (converted to Angstrom)
WMAXREST	em_max_rest (converted to Angstrom)
WMIDREST	em_midpoint_rest (converted to Angstrom)
FOV	s_fov (converted to arcsec)

```
SIMPLE  =                    T / conforms to FITS standard
BITPIX  =                  -32 / array data type
NAXIS   =                    1 / number of array dimensions
NAXIS1  =                 4886
WCSAXES =                    1 / Number of coordinate axes
COMMENT This file was generated by Data Central for the Virtual Observato
COMMENT le Spectral Access (SSA) service from an original science file pr
COMMENT to us. Visit our website at https://datacentral.org.au or use our
COMMENT  download the original file.
HISTORY This file was generated at 2021-03-24T14:01:14.250658+11:00 with
HISTORY -ssa-fits' writer by the Data Central SSA service.
BUNIT   = '1e-16 erg / (A cm2 s)' / unknown
CRPIX1  =               2443.0 / Pixel coordinate of reference point
CDELT1  =       1.032775416613 / [Angstrom] Coordinate increment at refer
CUNIT1  = 'Angstrom'           / Units of coordinate increment and value
CTYPE1  = 'Wavelength'         / Coordinate type code
CRVAL1  =        7229.06640625 / [Angstrom] Coordinate value at reference
LATPOLE =                 90.0 / [deg] Native latitude of celestial pole
MJDREF  =                  0.0 / [d] MJD of fiducial time
HDUNAME =
RA      =       351.2526245117 / RA, added by DC
DEC     =        -7.837954998 / DEC, added by DC
OBJECT  = 'R00J232500629-07501664' / Target name, added by DC
SURVEY  = 'wigglez_final'      / Survey, added by DC
Z       =              2.14479 / Redshift, added by DC
TMIN    =     55085.4912731481 / [d] MJD at start of exp, added by DC
TMAX    =     55085.5054282407 / [d] MJD at end of exp, added by DC
TMID    =     55085.4983506944 / [d] MJD at midpoint of exp, added by DC
EXPTIME =               1100.0 / [s] Exposure time, added by DC
TXEL    =                    1 / Number of epochs, added by DC
WMIN    = '4707.03 '           / [Angstrom] Start wavelength, added by DC
WMAX    = '9752.14 '           / [Angstrom] End wavelength, added by DC
WMID    = '7229.58 '           / [Angstrom] Centre wavelength, added by D
WMINREST= '1496.77 '           / [Angstrom] WMIN at rest, added by DC
WMAXREST= '3101.05 '           / [Angstrom] WMAX at rest, added by DC
WMIDREST= '2298.91 '           / [Angstrom] WMID at rest, added by DC
FOV     = '2.10    '           / [arcsec] FOV aperture size, added by DC
CHECKSUM= 'LiGaLiGULiGZLiGZ'   / HDU checksum updated 2021-03-24T14:01:14
DATASUM = '1455580298'         / data unit checksum updated 2021-03-24T14
END
```

Example Python scripts

- Extensive use of **astropy**, **pyvo** and **matplotlib**. Convert SSA query results from VOTable to pandas dataframes with **`to_pandas()`**

- Mainly handle spectra internally without saving to disk. Easy to modify examples to write out spectra

Simple Access to the SSA service:

1. Retrieving and Parsing a VOTable
2. Accessing the Original Spectra

Advanced access using the PyVO module

The pyvo Python module offers a better interface to querying the SSA service than specifying a long query url.

The following examples demonstrate more advanced usage of the SSA service:

1. Plotting Time Series OzDES Spectra
2. Fitting Gaussian Emission Lines in Time Series Spectra
3. 6dF Galaxy Survey Spectra and Image Cutouts from Target Names
4. GAMA Survey Spectra and Image Cutouts from Multiple Sky Positions
5. GALAH DR3
6. GALAH DR3 Interactive Spectra Explorer enhanced by the Data Central API
7. Wigglez Spectra enhanced by the Data Central API

To generate the image cutouts we make use of the **multicolorfits** Python module, plus the **hips2fits** service or the **Data Central SIA2 service**.

Important: While the SSA service does not require the latest development version of the pyvo module, it is needed to use the Data Central SIA2 service. It is available from the **pyvo github page.**

You may need to uninstall any previous pyvo installations you have before installing the latest version.

Some technical details on specifying parameters with pyvo: Our typical usage below of SSA with pyvo involves creating a dictionary **custom** that contains parameters we would ordinarily pass to the SSA query URL. The **custom** dictionary is then passed to the pyvo SSA search function as the **keywords argument. This is a convenient and simple way to specify the parameters. Note that standard SSA parameters may be passed as normal arguments to the search function (e.g. band=...), but custom SSA parameters (e.g. BANDREST) may only be specified via **keywords. For more details see the **data access layer documentation** for pyvo.

Access from TOPCAT

The **TOPCAT** application is a versatile tool that allows for many operations to be performed on the VOTable results of the SSA service.

You can load a VOTable file saved to disk from an SSA service query or you can load the query URL directly into the **Location:** field of the **Load New Table** dialogue.

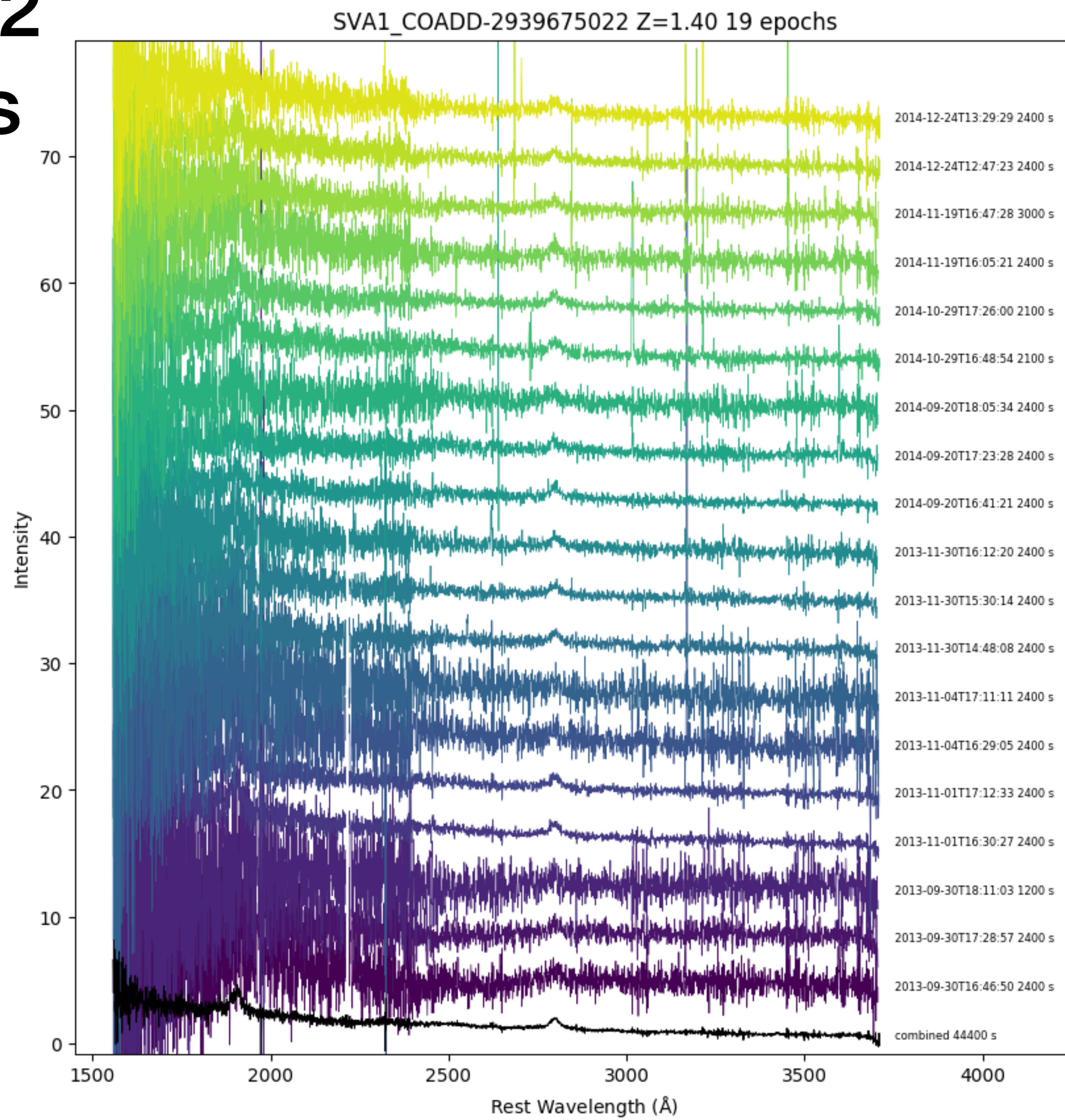
More advanced usage of TOPCAT with the SSA service is also possible:

1. TOPCAT and SPLAT to Quickly Preview Spectra

https://docs.datacentral.org.au/help-center/examples/simple-spectral-access-ssa-examples/

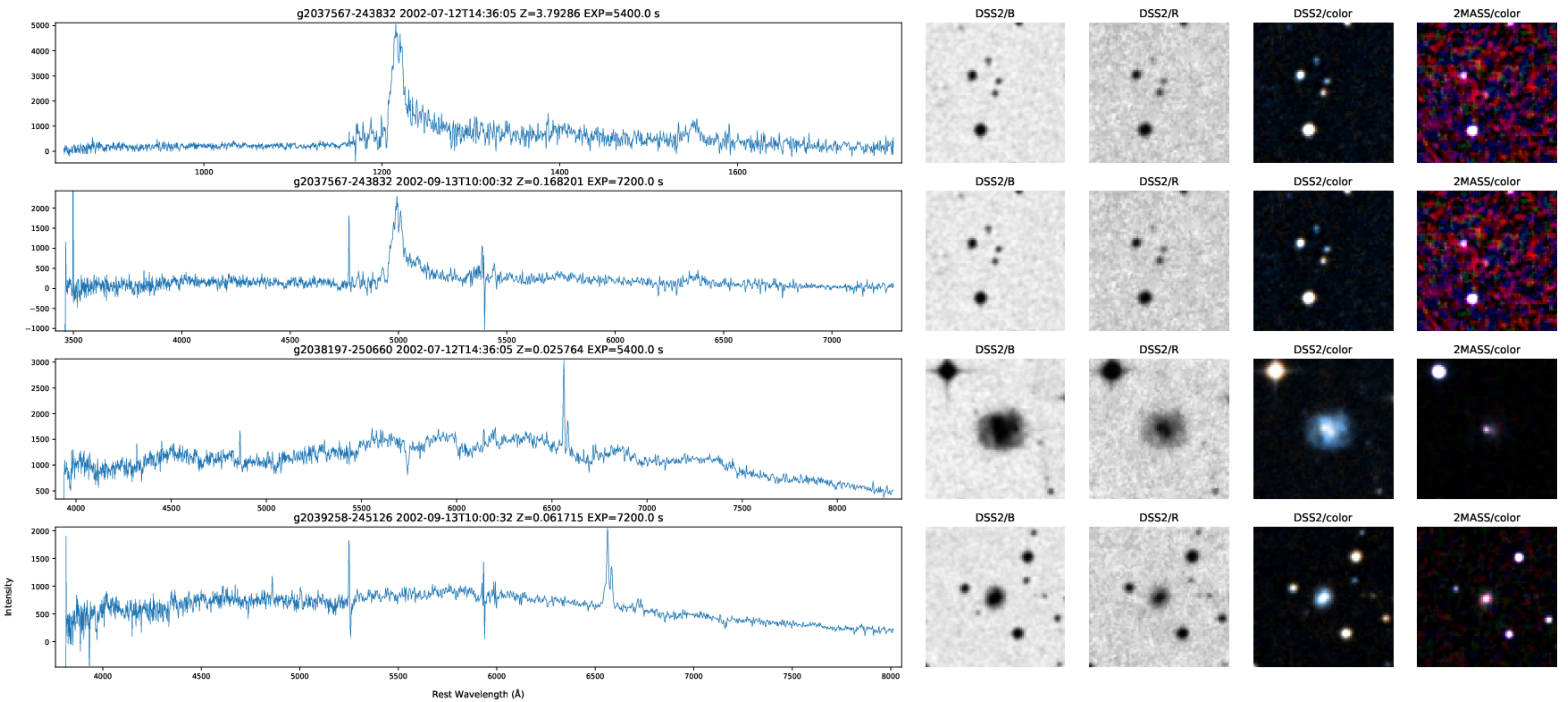
OzDES DR2 time series

- IRAF **specplot** like display of time series spectra from SSA query
- Easy to access dozens of spectra via **pyvo** and create plots of spectra with **matplotlib**
- Can specify individual target with **TARGETNAME** or select only spectra that overlap a specific rest wavelength using **BANDREST**



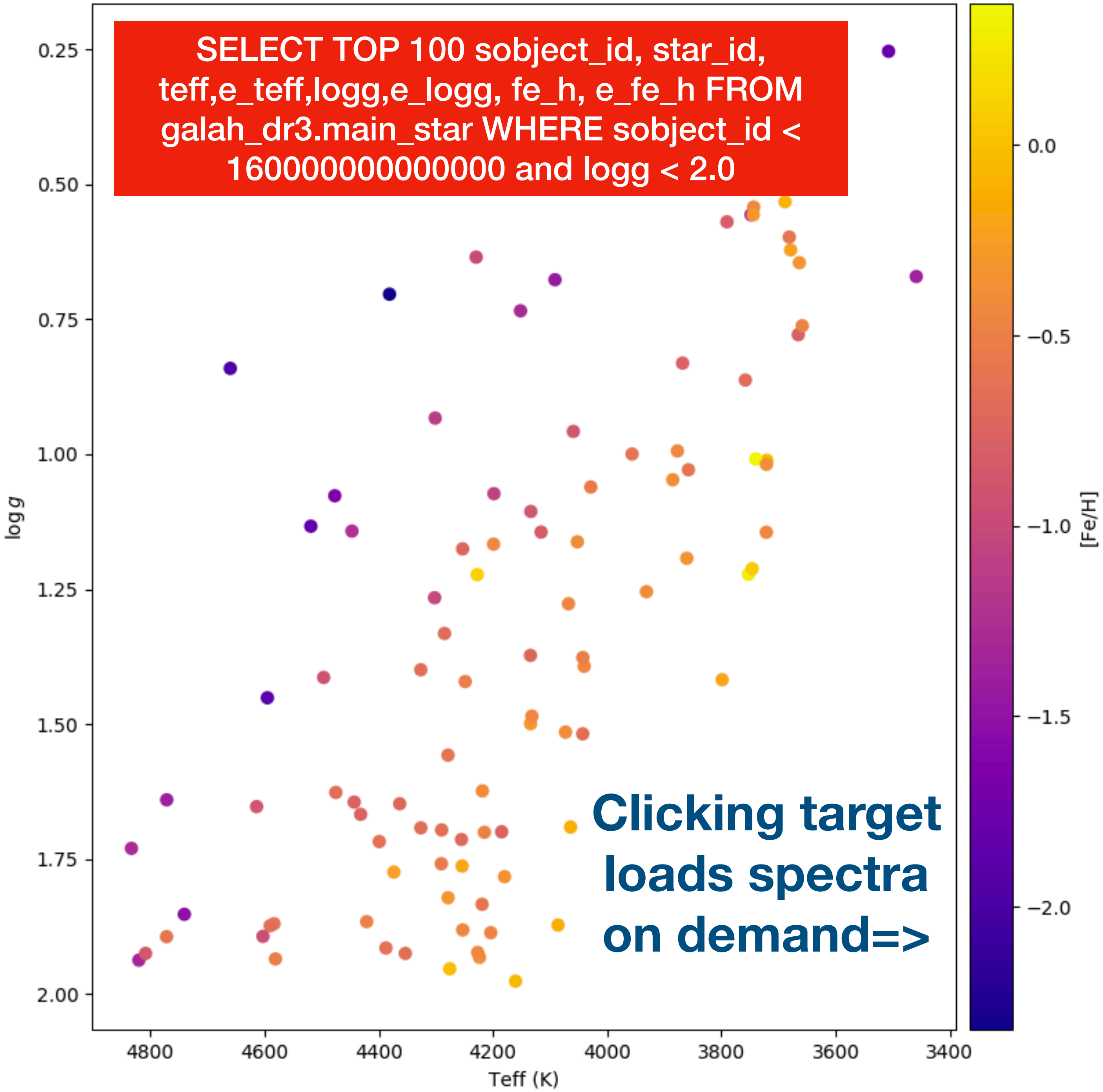
6dFGS: Generate PDFs of spectra and image cutouts

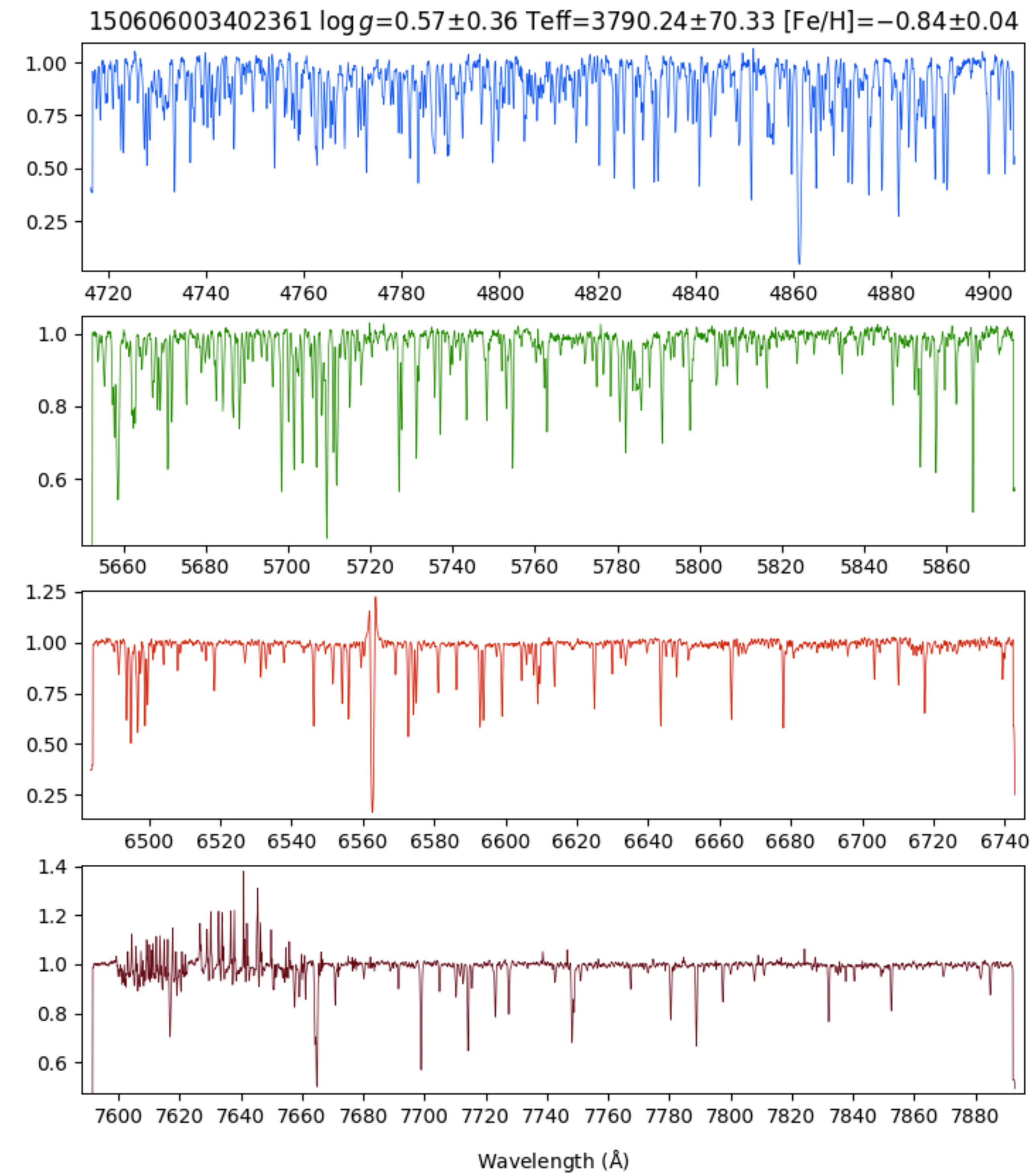
- **6dFGS** final data release spectra from SSA.
- 2MASS and DSS **HiPS** image cutouts from **hips2fits** service (CDS).
- Several page PDFs of plots: *supersedes* functionality of web archive (WFAU/ROE).



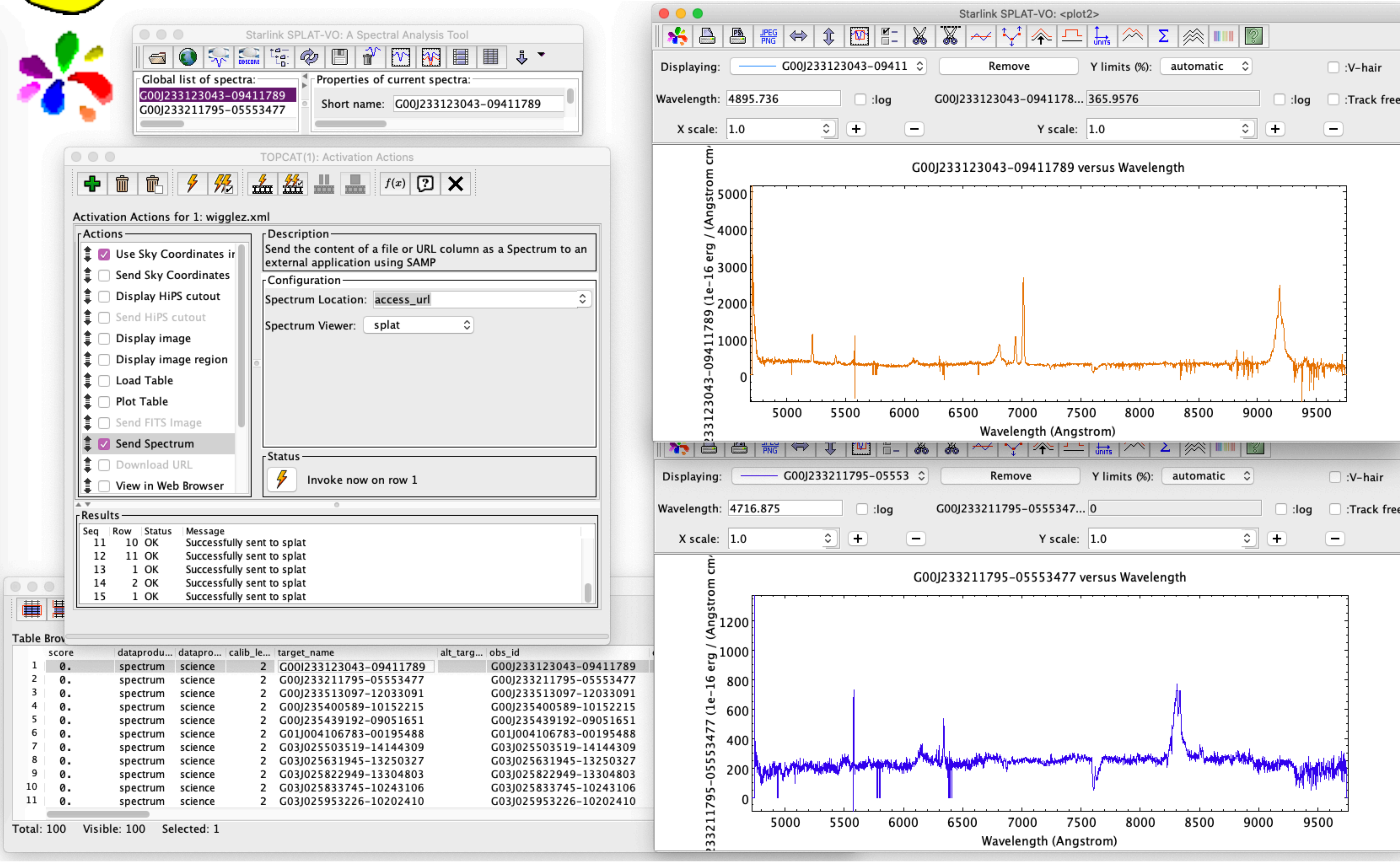
GALAH DR3 SSA + API

- **GALAH DR3** catalogue query via Data Central API => interactive spectrum viewer
- Use object id to easily get spectra from SSA service + params not in SSA (Teff, log g, [Fe/H], etc)



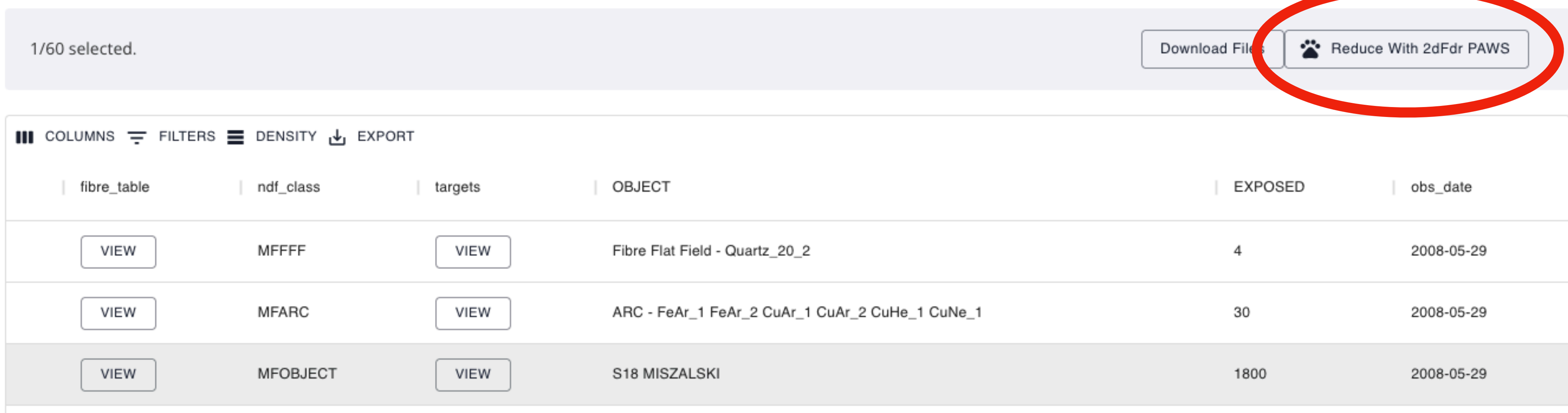


TOPCAT and SPLAT: quickly view SSA results



TOPCAT activation action: OzDES DR2 spectra

SSA + AAT 2dF archive

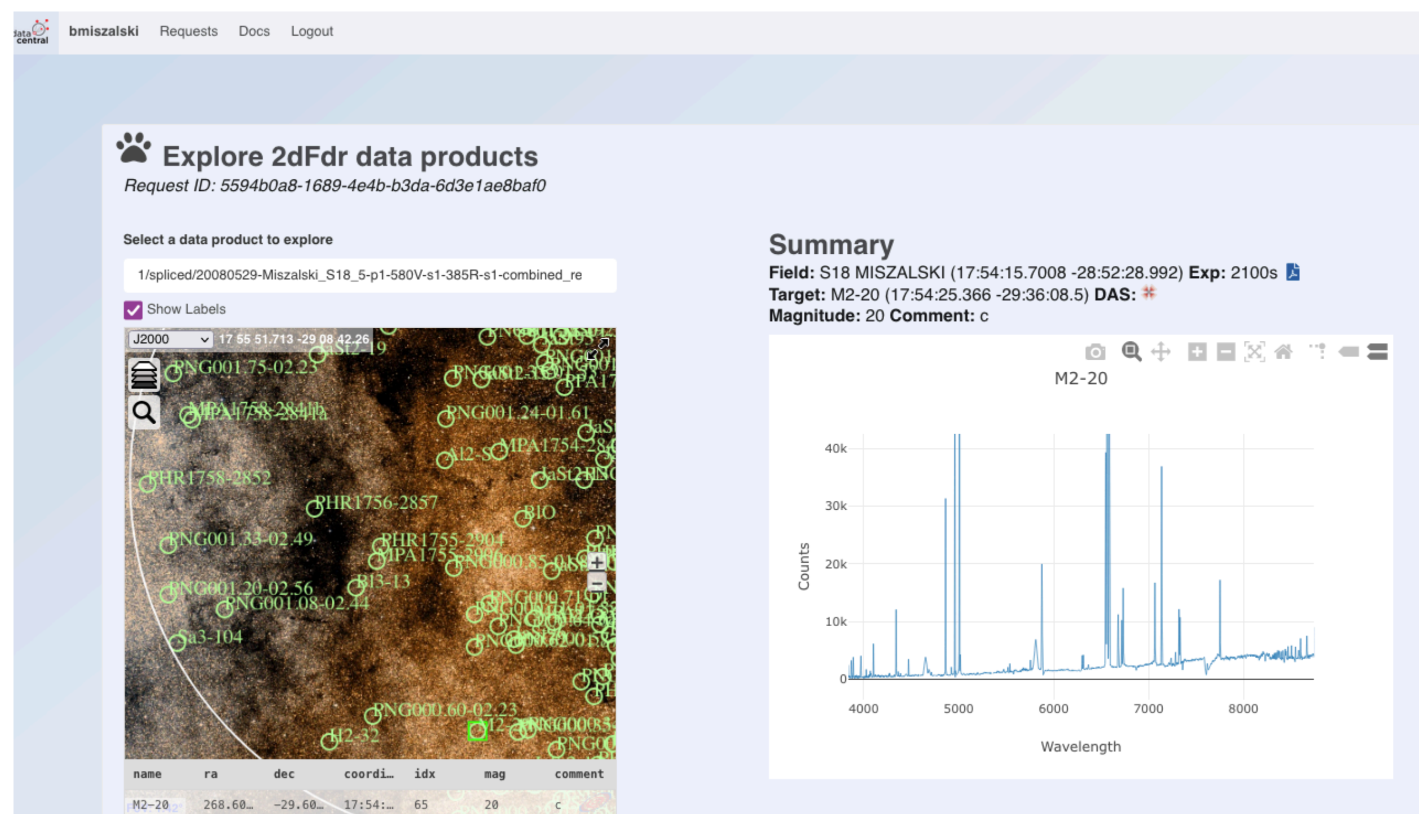


- Now have an effective means to automatically reduced 2dF+AAOmega spectra: Telescope archives talk later today

- **2dFdr Pipeline as A Web Service (PAWS)** could be used to retrospectively reduce archival 2dF spectra.

- These could be made available via SSA service: a valuable legacy project

- **PAWS+SSA: Transient follow-up** enabled by quick-turnaround staging of spectra



Simple Image Access

- Reuses Data Central image cutout code to extract images => generate FITS and PNG output. Radius limit: 600 arcsec (optical) or 5 deg (GLEAM-X)
- Complementary to existing image cutout services. Powerful way to access images from Python using SIA2 standard.
- Current: Multiband mosaics from GAMA PDR and Devils DR0
- Coming soon: GLEAM-X (MWA imaging in 26 frequency bands, Hurley-Walker+2022), KiDS DR4 (ESO VST ugri), Millenium Galaxy Catalogue (MGC, B-band INT WFC)
- Want to see more imaging survey data in Data Central? Contact us!
- Documentation https://docs.datacentral.org.au/reference/services/simple-image-access-sia-service/
- Examples: https://docs.datacentral.org.au/help-center/examples/simple-image-access-examples/

SIA Workflow

The intended workflow of the SIA service is as follows:

1. The user supplies an HTTP GET query to the query interface URL.
2. A query is performed using the query parameters, producing a shortlist of image mosaics. More than one query position may be specified.
3. A VOTABLE with the query results is returned with each row containing an **access_url** link.
4. The **access_url** is a **Datalink**-enabled service that generates (on request) an image cutout from each mosaic in the shortlist.
5. Image cutouts may be returned as FITS or PNG format, or as a VOTABLE with embedded links to FITS cutouts.

Several parameters: https://docs.datacentral.org.au/reference/services/simple-image-access-sia-service/

Example query: GAMA PDR

TOPCAT(6): Table Browser

Table Browser for 6: query?POS=CIRCLE%20217.38%200.25%200.05

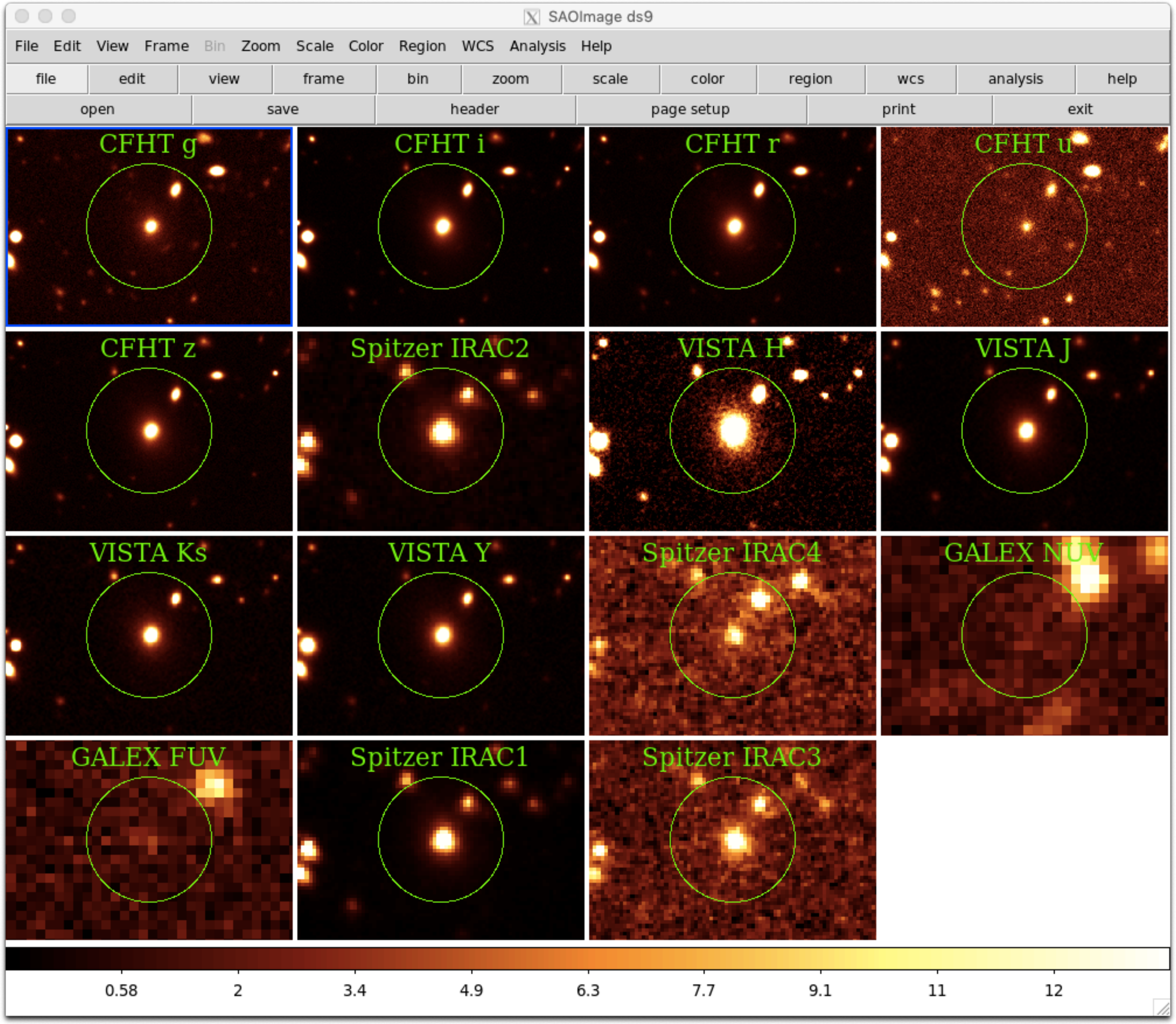
	s_ra	s_dec	obs_collect...	facility_n...	band_n...	em_min	em_max	access_url	access_format
1	217.38	0.25	gama_pdr	WISE	W4	1.952010E-5	2.791070E-5	https://datacentral.org.au/vo/snip/links?ID=140...	application/x-votable+xml;content=datalink
2	217.38	0.25	gama_pdr	WISE	W3	7.443000E-6	1.726130E-5	https://datacentral.org.au/vo/snip/links?ID=136...	application/x-votable+xml;content=datalink
3	217.38	0.25	gama_pdr	WISE	W2	3.963300E-6	5.341400E-6	https://datacentral.org.au/vo/snip/links?ID=132...	application/x-votable+xml;content=datalink
4	217.38	0.25	gama_pdr	WISE	W1	2.754100E-6	3.872400E-6	https://datacentral.org.au/vo/snip/links?ID=128...	application/x-votable+xml;content=datalink
5	217.38	0.25	gama_pdr	VST	u	3.042000E-7	3.985000E-7	https://datacentral.org.au/vo/snip/links?ID=124...	application/x-votable+xml;content=datalink
6	217.38	0.25	gama_pdr	VST	r	5.405000E-7	7.172000E-7	https://datacentral.org.au/vo/snip/links?ID=120...	application/x-votable+xml;content=datalink
7	217.38	0.25	gama_pdr	VST	i	6.721000E-7	8.726000E-7	https://datacentral.org.au/vo/snip/links?ID=116...	application/x-votable+xml;content=datalink
8	217.38	0.25	gama_pdr	VST	g	3.858000E-7	5.686000E-7	https://datacentral.org.au/vo/snip/links?ID=112...	application/x-votable+xml;content=datalink
9	217.38	0.25	gama_pdr	VISTA	Z	8.163000E-7	9.401000E-7	https://datacentral.org.au/vo/snip/links?ID=108...	application/x-votable+xml;content=datalink
10	217.38	0.25	gama_pdr	VISTA	Y	9.443000E-7	1.097800E-6	https://datacentral.org.au/vo/snip/links?ID=103...	application/x-votable+xml;content=datalink
11	217.38	0.25	gama_pdr	VISTA	K	1.938900E-6	2.366200E-6	https://datacentral.org.au/vo/snip/links?ID=98&...	application/x-votable+xml;content=datalink
12	217.38	0.25	gama_pdr	VISTA	J	1.143000E-6	1.366800E-6	https://datacentral.org.au/vo/snip/links?ID=93&...	application/x-votable+xml;content=datalink
13	217.38	0.25	gama_pdr	VISTA	H	1.463700E-6	1.834100E-6	https://datacentral.org.au/vo/snip/links?ID=88&...	application/x-votable+xml;content=datalink
14	217.38	0.25	gama_pdr	UKIRT	Y	9.790000E-7	1.081000E-6	https://datacentral.org.au/vo/snip/links?ID=84&...	application/x-votable+xml;content=datalink
15	217.38	0.25	gama_pdr	UKIRT	K	2.029000E-6	2.380000E-6	https://datacentral.org.au/vo/snip/links?ID=81&...	application/x-votable+xml;content=datalink
16	217.38	0.25	gama_pdr	UKIRT	J	1.169000E-6	1.328000E-6	https://datacentral.org.au/vo/snip/links?ID=78&...	application/x-votable+xml;content=datalink
17	217.38	0.25	gama_pdr	UKIRT	H	1.492000E-6	1.784000E-6	https://datacentral.org.au/vo/snip/links?ID=75&...	application/x-votable+xml;content=datalink
18	217.38	0.25	gama_pdr	SDSS	z	7.960000E-7	1.083300E-6	https://datacentral.org.au/vo/snip/links?ID=72&...	application/x-votable+xml;content=datalink
19	217.38	0.25	gama_pdr	SDSS	u	3.048000E-7	4.028000E-7	https://datacentral.org.au/vo/snip/links?ID=69&...	application/x-votable+xml;content=datalink
20	217.38	0.25	gama_pdr	SDSS	r	5.415000E-7	6.989000E-7	https://datacentral.org.au/vo/snip/links?ID=66&...	application/x-votable+xml;content=datalink
21	217.38	0.25	gama_pdr	SDSS	i	6.689000E-7	8.389000E-7	https://datacentral.org.au/vo/snip/links?ID=63&...	application/x-votable+xml;content=datalink
22	217.38	0.25	gama_pdr	SDSS	g	3.783000E-7	5.549000E-7	https://datacentral.org.au/vo/snip/links?ID=60&...	application/x-votable+xml;content=datalink
23	217.38	0.25	gama_pdr	Herschel	S500	0.00039	0.00068	https://datacentral.org.au/vo/snip/links?ID=56&...	application/x-votable+xml;content=datalink
24	217.38	0.25	gama_pdr	Herschel	S350	0.00028	0.00042	https://datacentral.org.au/vo/snip/links?ID=52&...	application/x-votable+xml;content=datalink
25	217.38	0.25	gama_pdr	Herschel	S250	0.0002	0.0003	https://datacentral.org.au/vo/snip/links?ID=48&...	application/x-votable+xml;content=datalink
26	217.38	0.25	gama_pdr	Herschel	P160	0.00012	0.00024	https://datacentral.org.au/vo/snip/links?ID=44&...	application/x-votable+xml;content=datalink
27	217.38	0.25	gama_pdr	Herschel	P100	7.910260E-5	0.00014	https://datacentral.org.au/vo/snip/links?ID=40&...	application/x-votable+xml;content=datalink
28	217.38	0.25	gama_pdr	GALEX	NUV	1.693000E-7	3.007000E-7	https://datacentral.org.au/vo/snip/links?ID=36&...	application/x-votable+xml;content=datalink
29	217.38	0.25	gama_pdr	GALEX	FUV	1.340000E-7	1.806000E-7	https://datacentral.org.au/vo/snip/links?ID=32&...	application/x-votable+xml;content=datalink

Total: 29 Visible: 29 Selected: 0

https://datacentral.org.au/vo/sia2/query?POS=CIRCLE 217.38 0.25 0.05

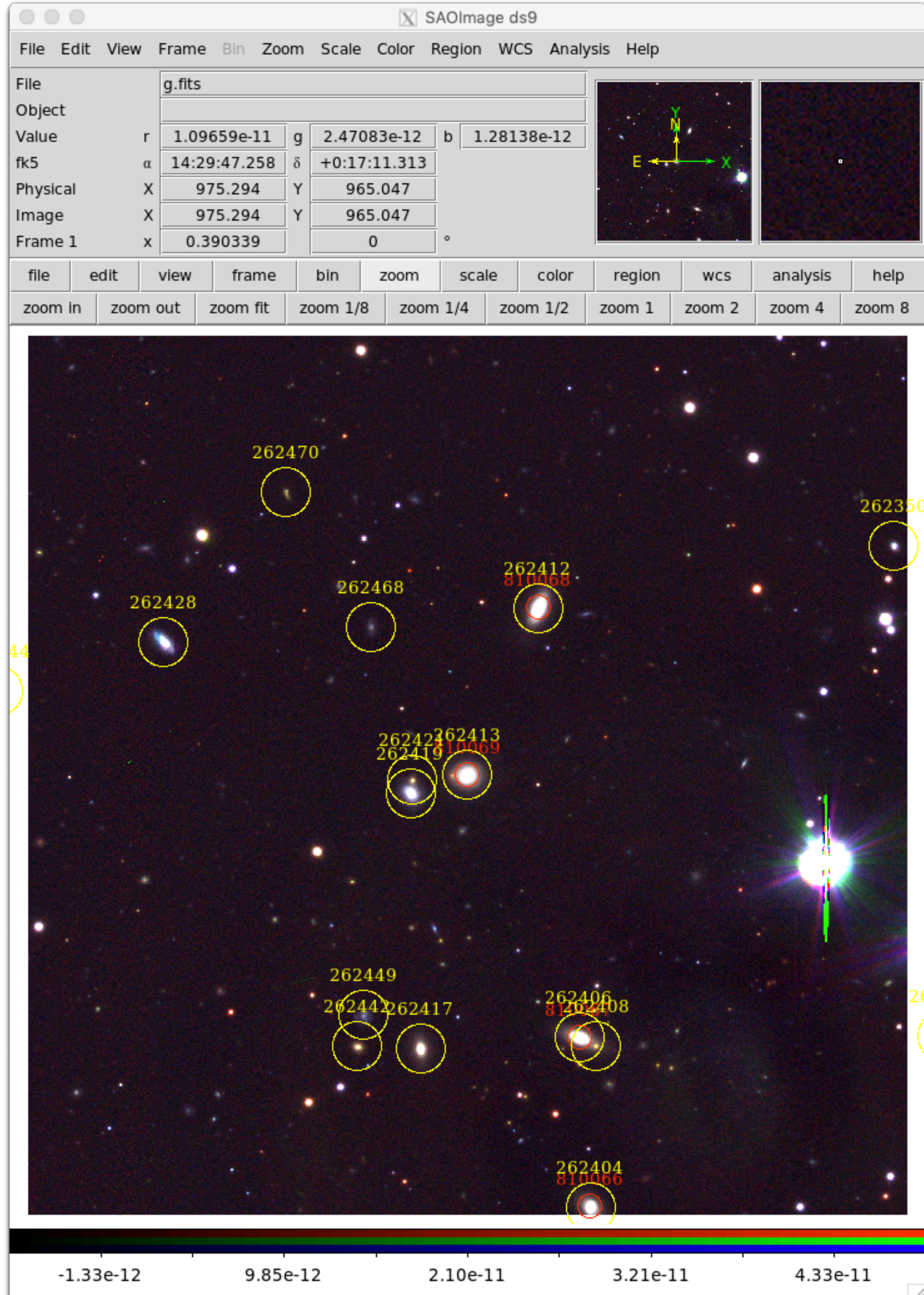
SIA: Multi-wavelength cutouts

- Download image cutouts in multiple filters using Python
- Automatically display them using ds9 fits viewer Python module
- Python code on SIA Examples page at Data Central: https://docs.datacentral.org.au/help-center/examples/simple-image-access-examples/



SIA: An interactive colour mosaic

- Download SIA images for a region of interest and display colour-composite with ds9
- Overlay sources of interest from SAMI and GAMA surveys with Data Central Simple Cone Search catalogue service
- Add keybindings for ds9:
    - **s**: load SAMI DR2 data in Single Object Viewer (SOV)
    - **g**: load GAMA DR2 in SOV
    - **w**: query SIMBAD in web browser at position
    - **q**: quit
- Python code on SIA Examples page at Data Central: https://docs.datacentral.org.au/help-center/examples/simple-image-access-examples/



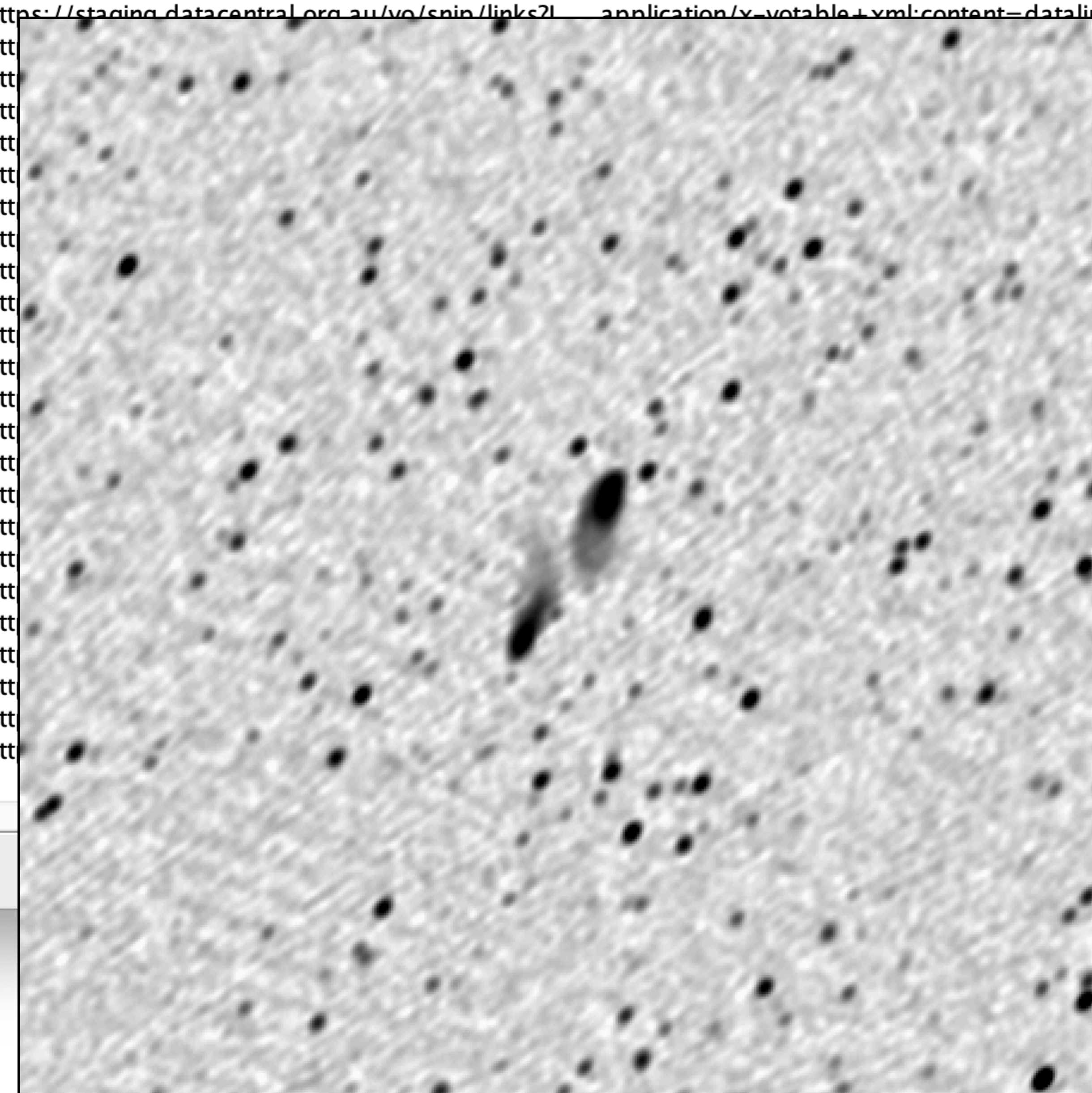
GLEAM-X MWA data coming soon!

TOPCAT(8): Table Browser

Table Browser for 8: query?POS=CIRCLE%2076.4268682%20-28.6702213%200....

	s_ra	s_dec	obs_collection	facility_...	band_name	em_min	em_max	access_url	access_format
1	76.42687	-28.67022	gleamx_dr1	MWA	072-080	3.74741	4.16378	https://staging.datacentral.org.au/vo/snip/links?l...	application/x-votable+xml;content=datalink
2	76.42687	-28.67022	gleamx_dr1	MWA	072-103	2.91061	4.16378	https://staging.datacentral.org.au/vo/snip/links?l...	application/x-votable+xml;content=datalink
3	76.42687	-28.67022	gleamx_dr1	MWA	080-088	3.40673	3.74741	https://staging.datacentral.org.au/vo/snip/links?l...	application/x-votable+xml;content=datalink
4	76.42687	-28.67022	gleamx_dr1	MWA	088-095	3.15571	3.40673	htt	
5	76.42687	-28.67022	gleamx_dr1	MWA	095-103	2.91061	3.15571	htt	
6	76.42687	-28.67022	gleamx_dr1	MWA	103-111	2.70083	2.91061	htt	
7	76.42687	-28.67022	gleamx_dr1	MWA	103-134	2.23726	2.91061	htt	
8	76.42687	-28.67022	gleamx_dr1	MWA	111-118	2.54061	2.70083	htt	
9	76.42687	-28.67022	gleamx_dr1	MWA	118-126	2.37931	2.54061	htt	
10	76.42687	-28.67022	gleamx_dr1	MWA	126-134	2.23726	2.37931	htt	
11	76.42687	-28.67022	gleamx_dr1	MWA	139-147	2.0394	2.15678	htt	
12	76.42687	-28.67022	gleamx_dr1	MWA	139-170	1.76348	2.15678	htt	
13	76.42687	-28.67022	gleamx_dr1	MWA	147-154	1.9467	2.0394	htt	
14	76.42687	-28.67022	gleamx_dr1	MWA	154-162	1.85057	1.9467	htt	
15	76.42687	-28.67022	gleamx_dr1	MWA	162-170	1.76348	1.85057	htt	
16	76.42687	-28.67022	gleamx_dr1	MWA	170-177	1.69374	1.76348	htt	
17	76.42687	-28.67022	gleamx_dr1	MWA	170-200	1.49896	1.76348	htt	
18	76.42687	-28.67022	gleamx_dr1	MWA	170-231	1.2978	1.76348	htt	
19	76.42687	-28.67022	gleamx_dr1	MWA	177-185	1.6205	1.69374	htt	
20	76.42687	-28.67022	gleamx_dr1	MWA	185-193	1.55333	1.6205	htt	
21	76.42687	-28.67022	gleamx_dr1	MWA	193-200	1.49896	1.55333	htt	
22	76.42687	-28.67022	gleamx_dr1	MWA	200-208	1.44131	1.49896	htt	
23	76.42687	-28.67022	gleamx_dr1	MWA	200-231	1.2978	1.49896	htt	
24	76.42687	-28.67022	gleamx_dr1	MWA	208-216	1.38793	1.44131	htt	
25	76.42687	-28.67022	gleamx_dr1	MWA	216-223	1.34436	1.38793	htt	
26	76.42687	-28.67022	gleamx_dr1	MWA	223-231	1.2978	1.34436	htt	

Total: 26 Visible: 26 Selected: 0

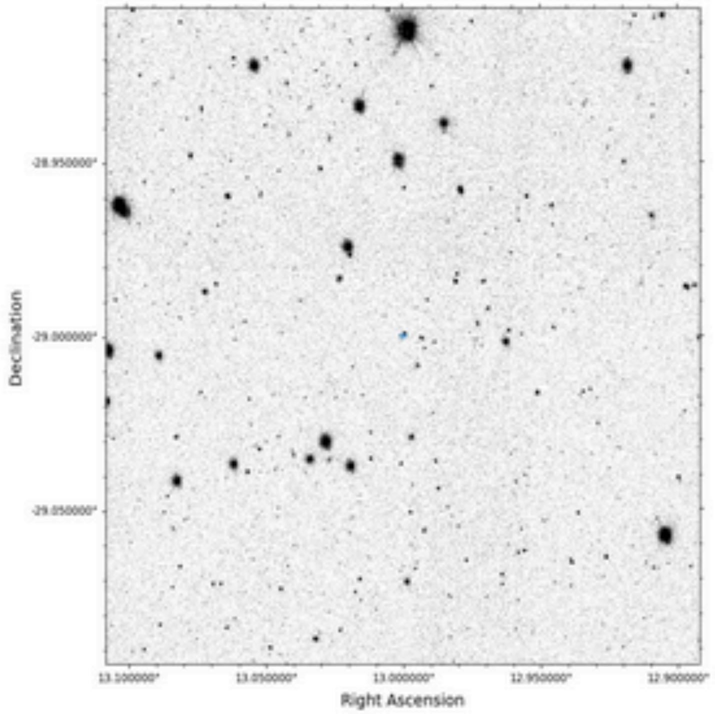


2 degree radius cutout
088-095 MHz

Hurley-Walker+2022, arXiv:2204.12762

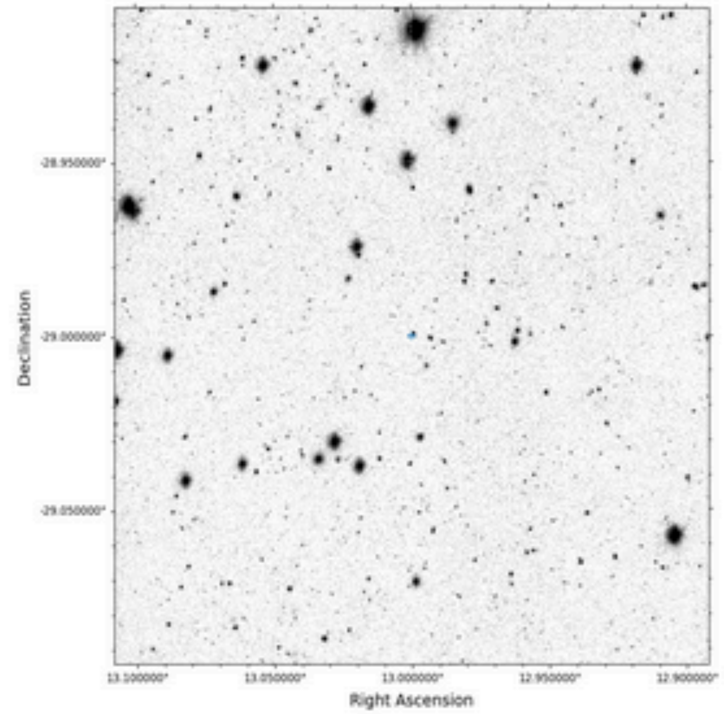
Greyscale Images

KiDS DR4 VLT Survey Telescope g



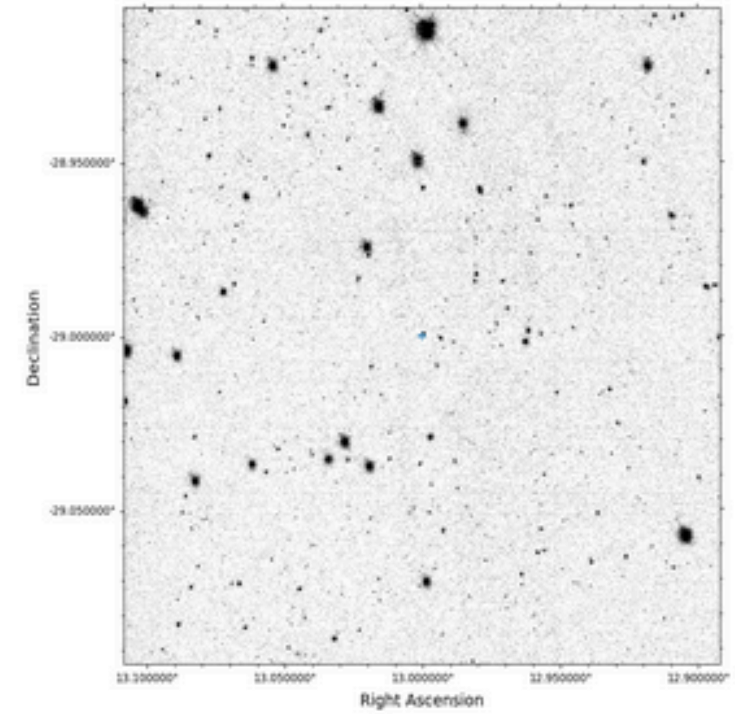
png fits

KiDS DR4 VLT Survey Telescope r



png fits

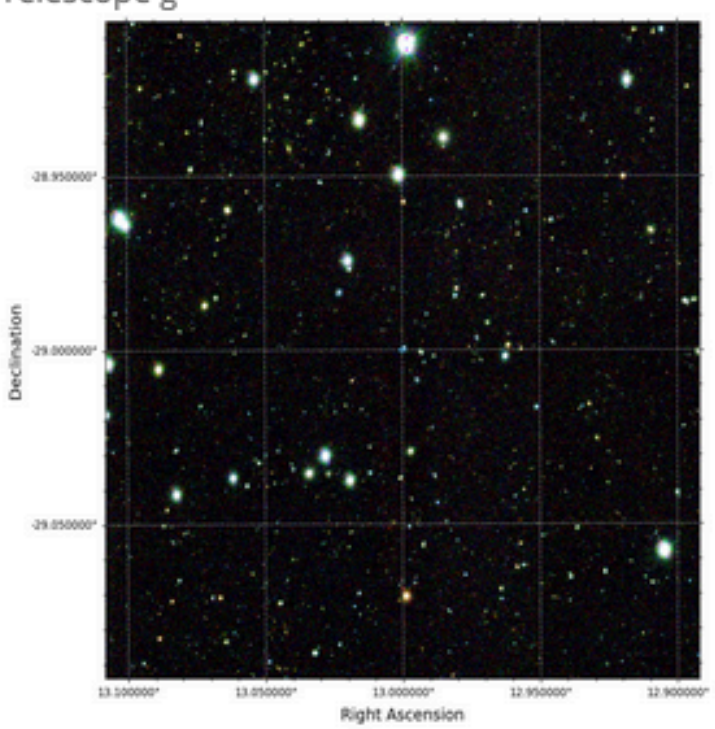
KiDS DR4 VLT Survey Telescope i



png fits

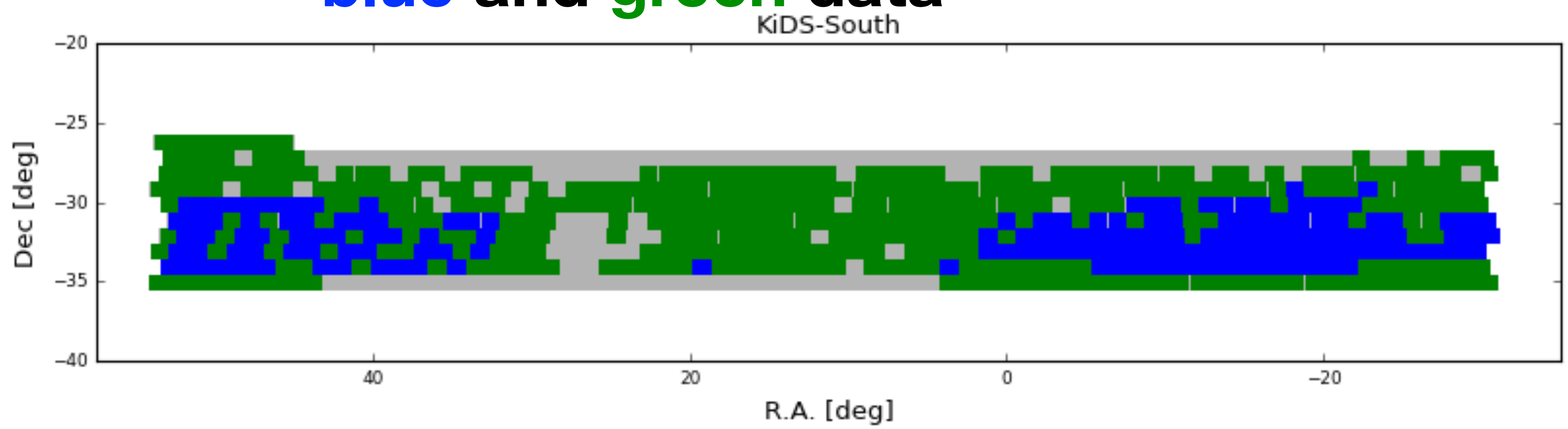
RGB Images

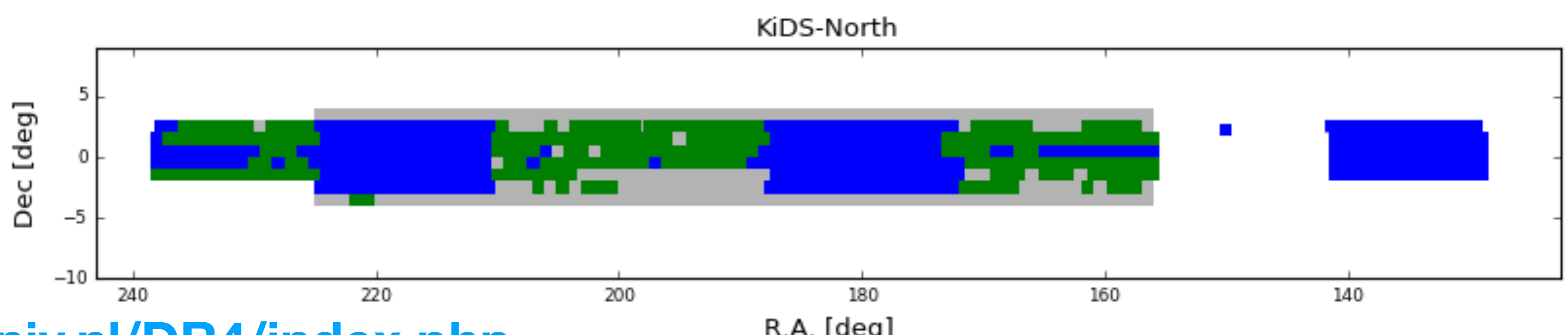
KiDS DR4 VLT Survey Telescope i, KiDS DR4 VLT Survey Telescope r, KiDS DR4 VLT Survey Telescope g



png

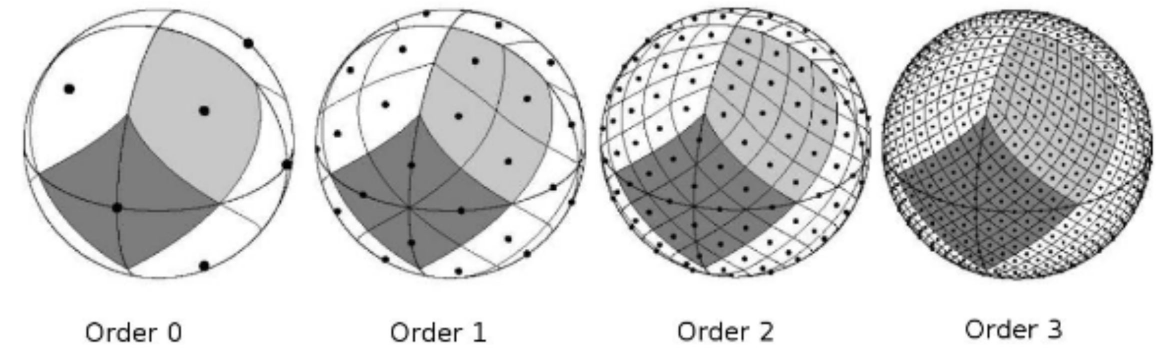
KiDS DR4 coming soon to Data Central: blue and green data





https://kids.strw.leidenuniv.nl/DR4/index.php

HiPS + MOC



- IVOA standards (not services)

- **HiPS**: Hierarchical Progressive Surveys format. Built upon HEALPix tessellation technique

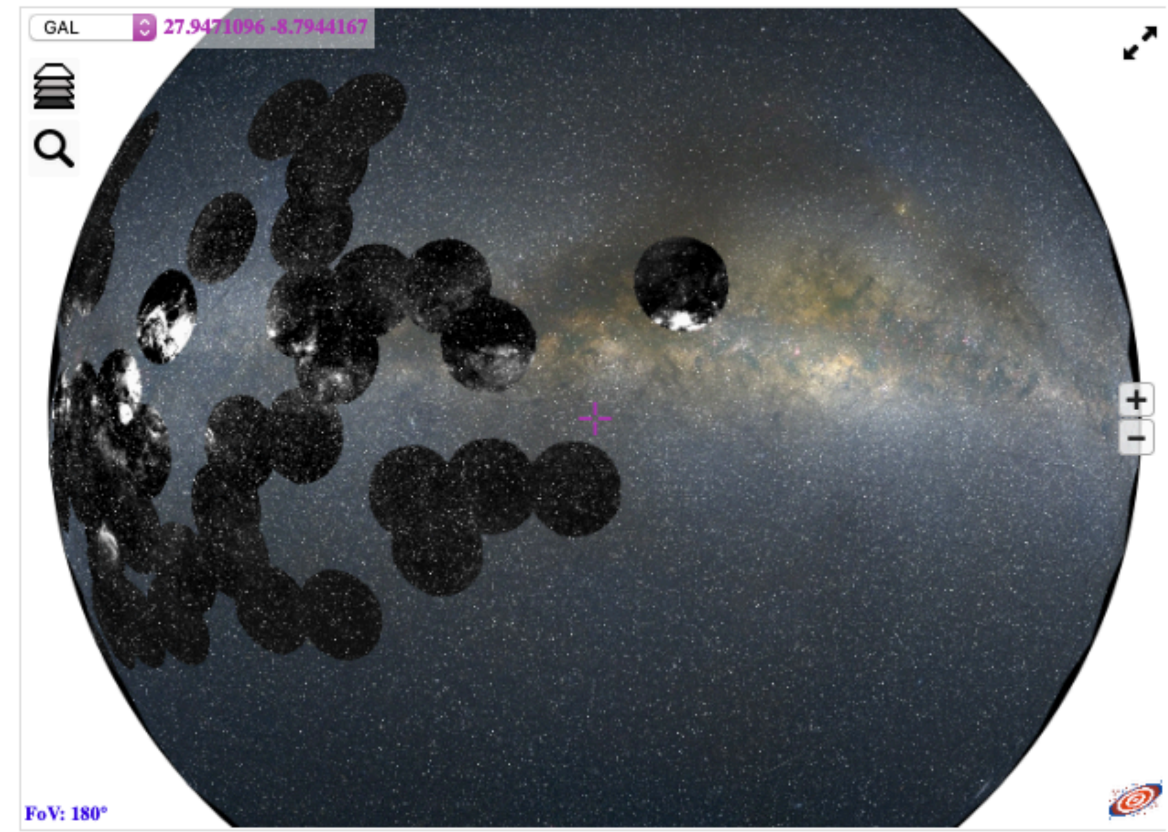
- Native format of Aladin and Aladin Lite apps. Many available: http://aladin.unistra.fr/hips/list

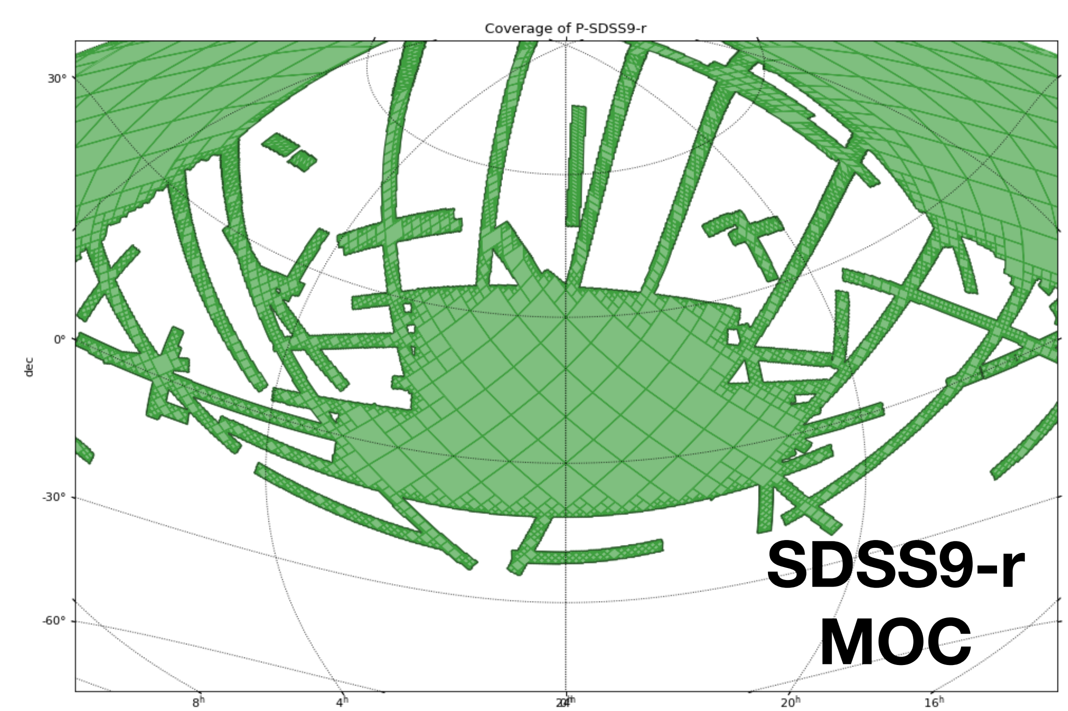
- Plan to have local **Data Central** HiPS server.

- Can generate cutouts using **hips2fits** web service (CDS)

- MOC: Multi-order coverage map. Think of it as “footprint” of HiPS image. Can be used to check if targets have survey coverage (and more).

- MOCPy https://cds-astro.github.io/mocpy/

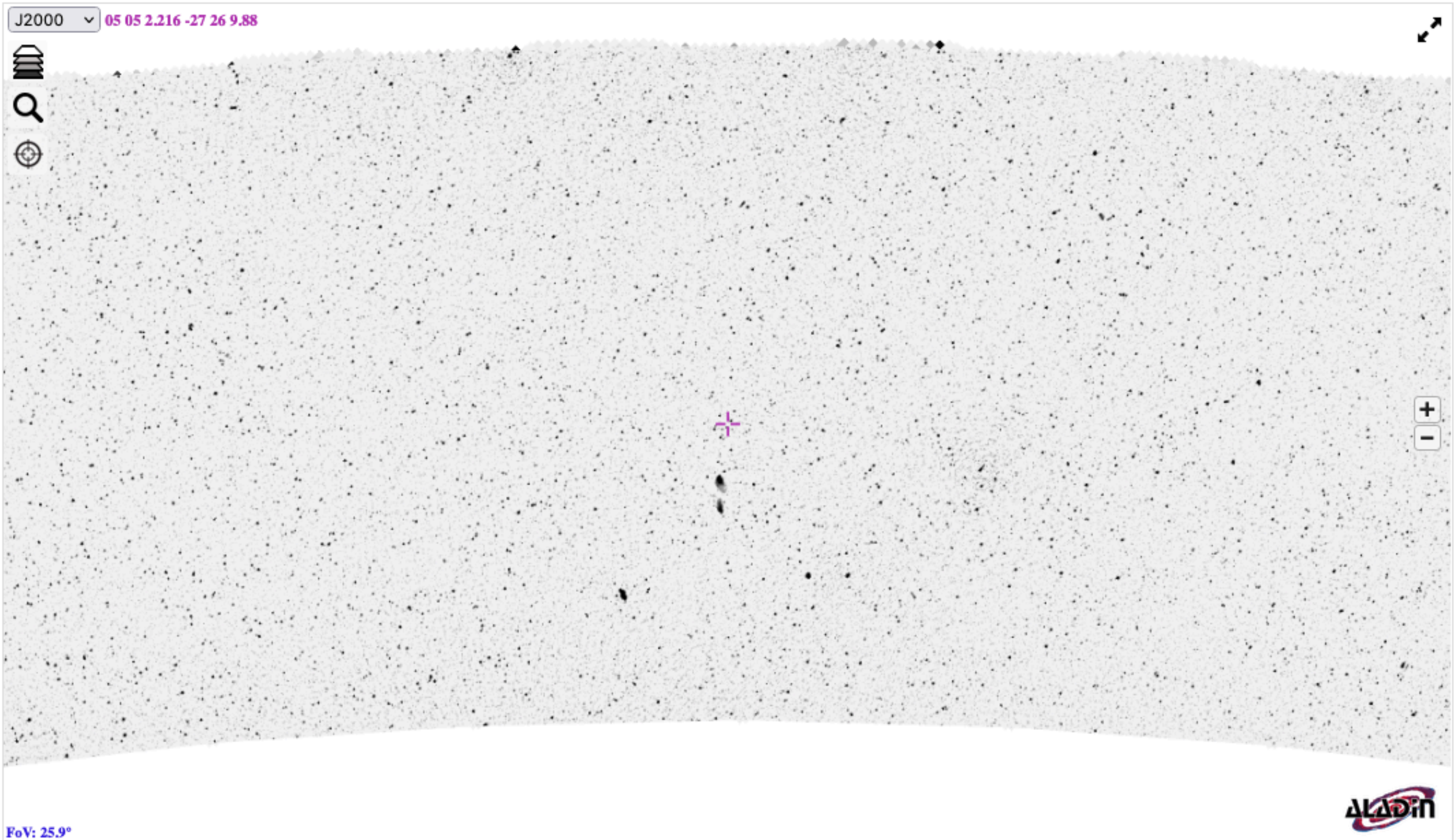




GLEAM-X HiPS

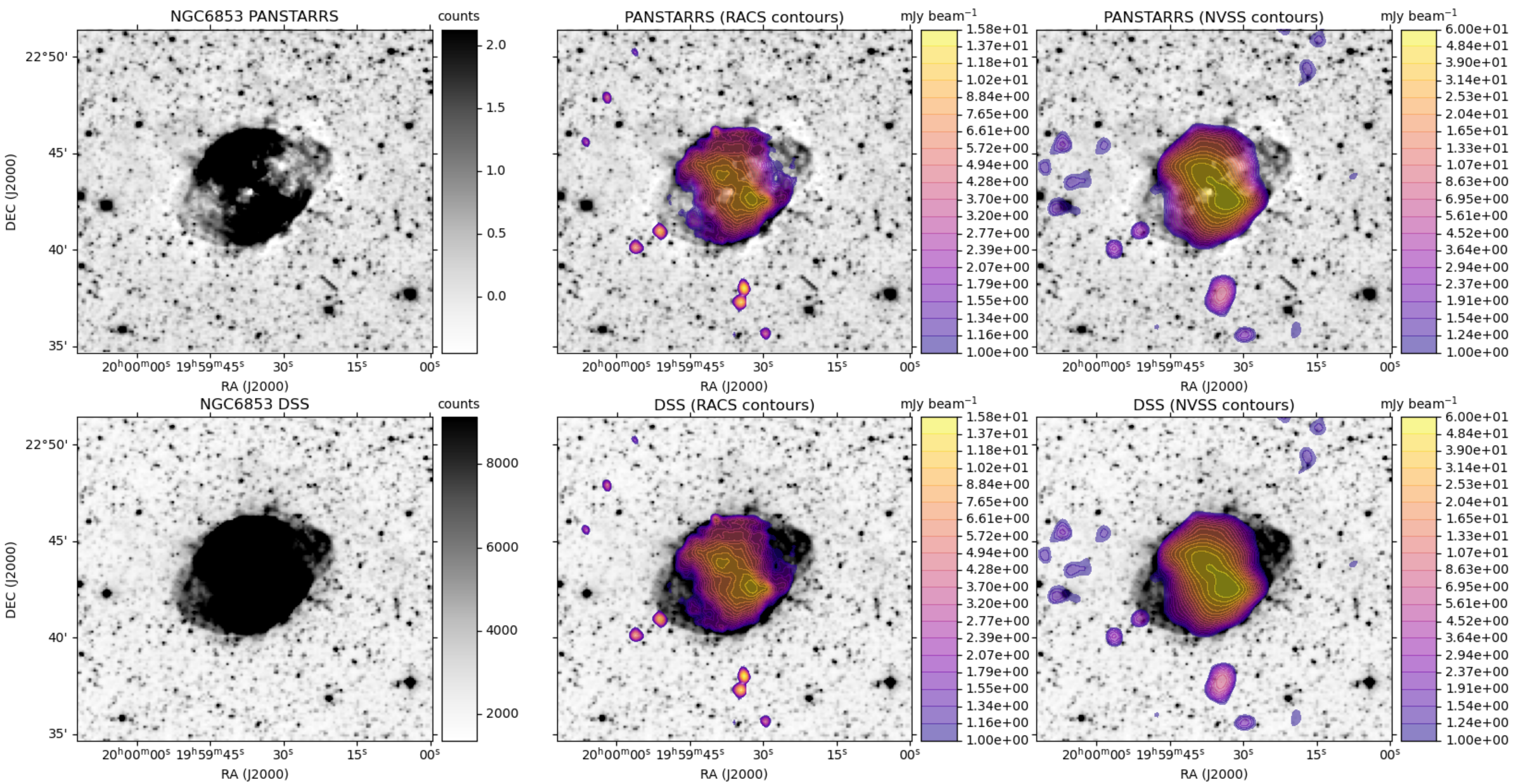
"IDR1_XG_162-170MHz_rescaled_nan.fits" progressive survey

This Web resource contains HiPS(*) components for **IDR1_XG_162-170MHz_rescaled_nan.fits** progressive survey.



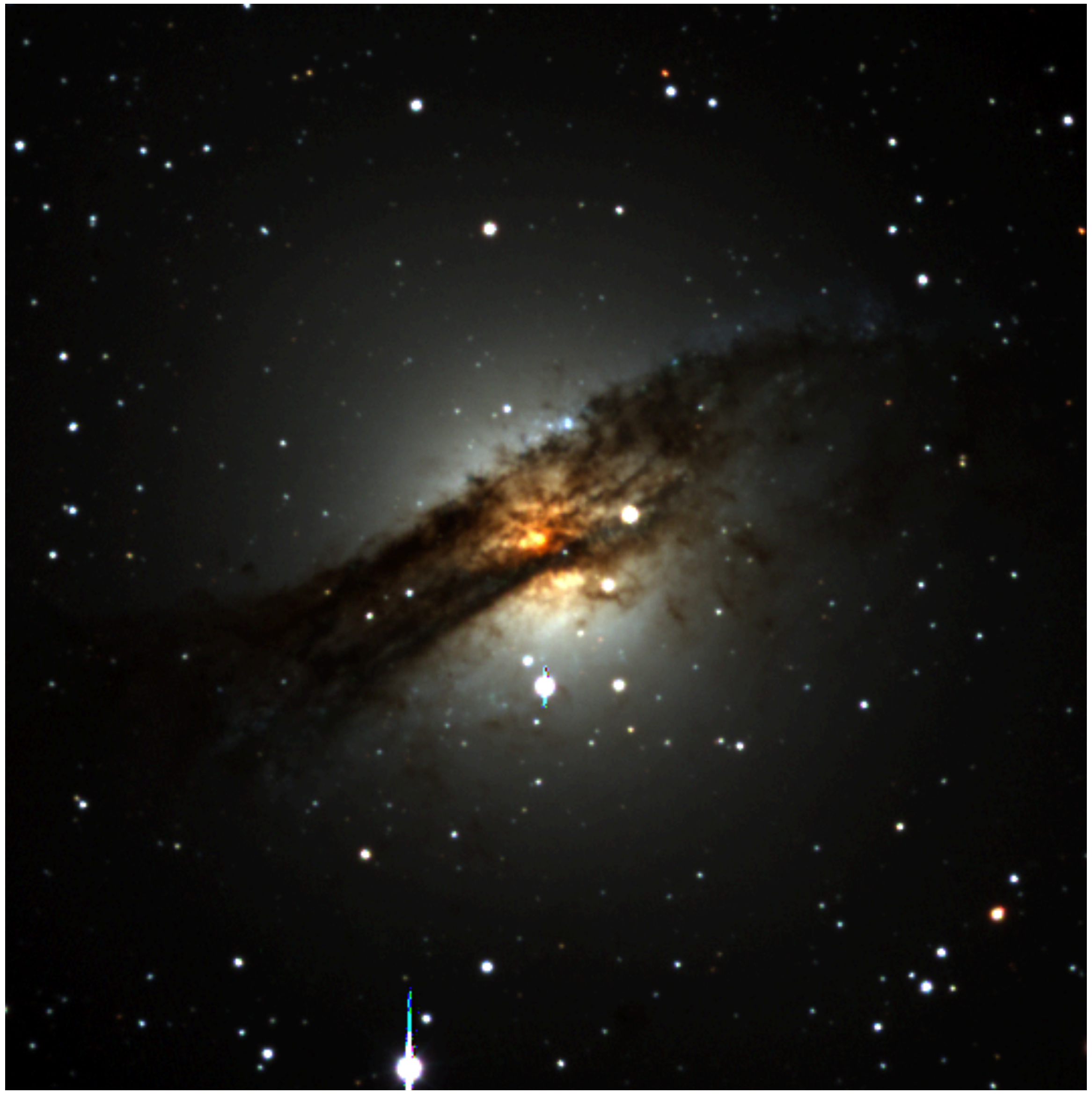
A few other examples

HiPS+MOC: Image cutouts with coverage checking and radio overlays



https://docs.datacentral.org.au/help-center/virtual-observatory-examples/hipsmoc-image-cutouts-coverage-checking-and-radio-overlays/

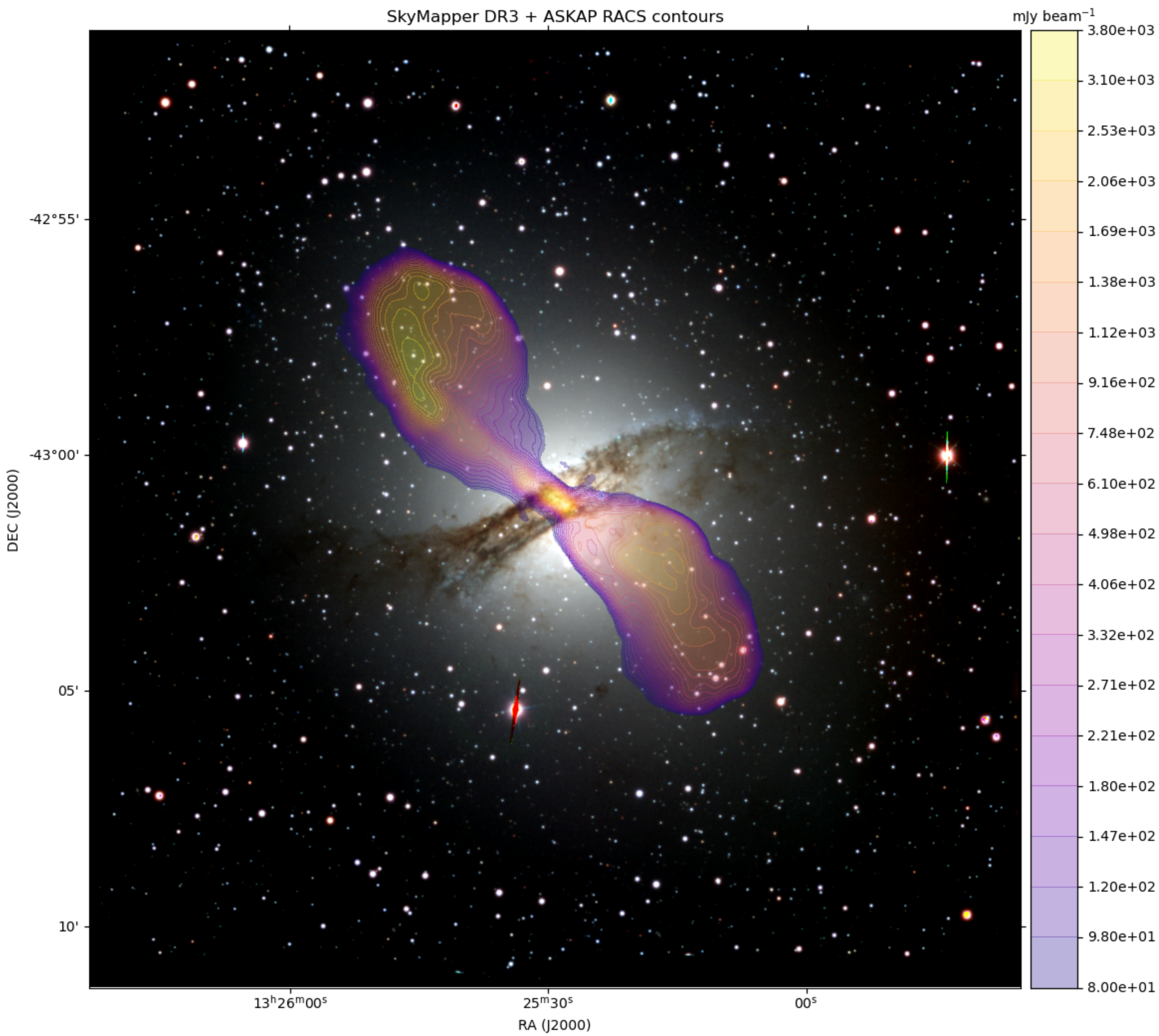
SkyMapper SIA + IPAC Montage mosaics



Centaurus A **10x10 arcmin rgb=irg** **PN Fleming 1**

https://docs.datacentral.org.au/help-center/virtual-observatory-examples/skymapper-siamontage-single-position-query/

SkyMapper mosaic + ASKAP RACS contours



https://docs.datacentral.org.au/help-center/virtual-observatory-examples/colour-mosaic-radio-contour-overlay

Questions?