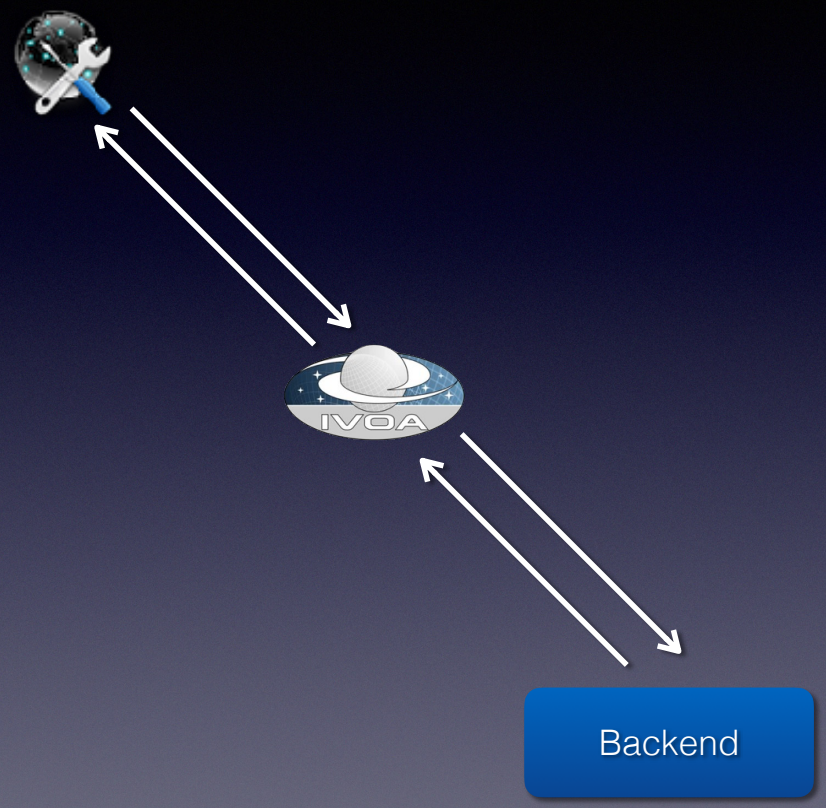
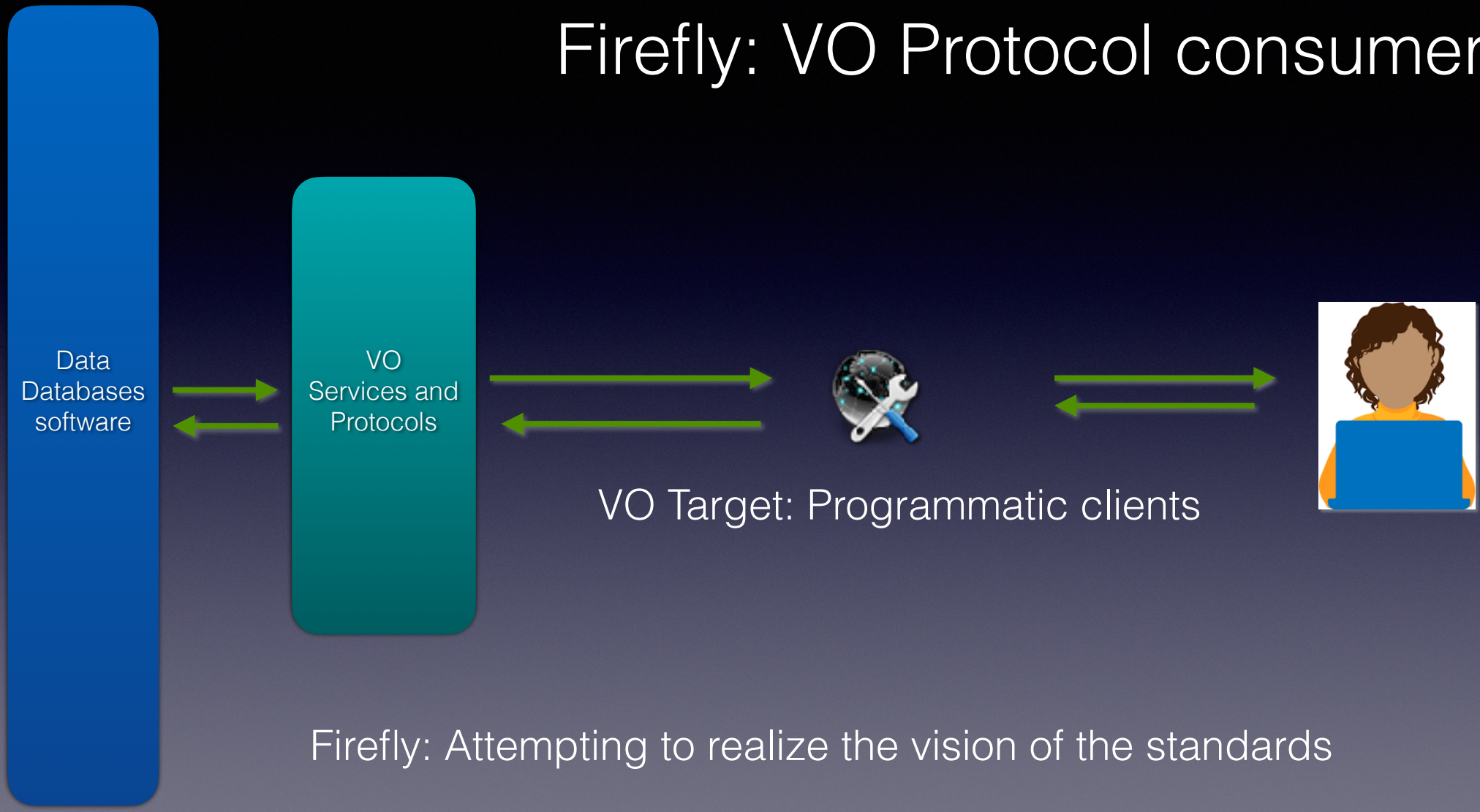
Firefly's expanding use of VO



Firefly: VO Protocol consumer



Firefly: Attempting to realize the vision of the standards

5 Area of growing IVOA Usage

What we are doing

Where we are going

TAP

Service Descriptors: Cutouts

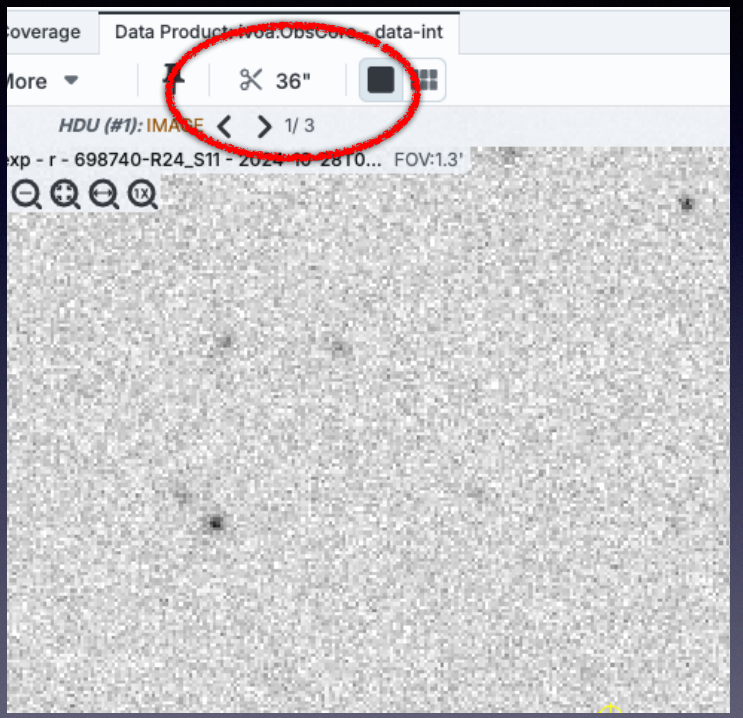
SIAv2

Healpix: HiPS, MOC, Other

Parquet

Service Descriptors: Cutouts

Becoming more primary

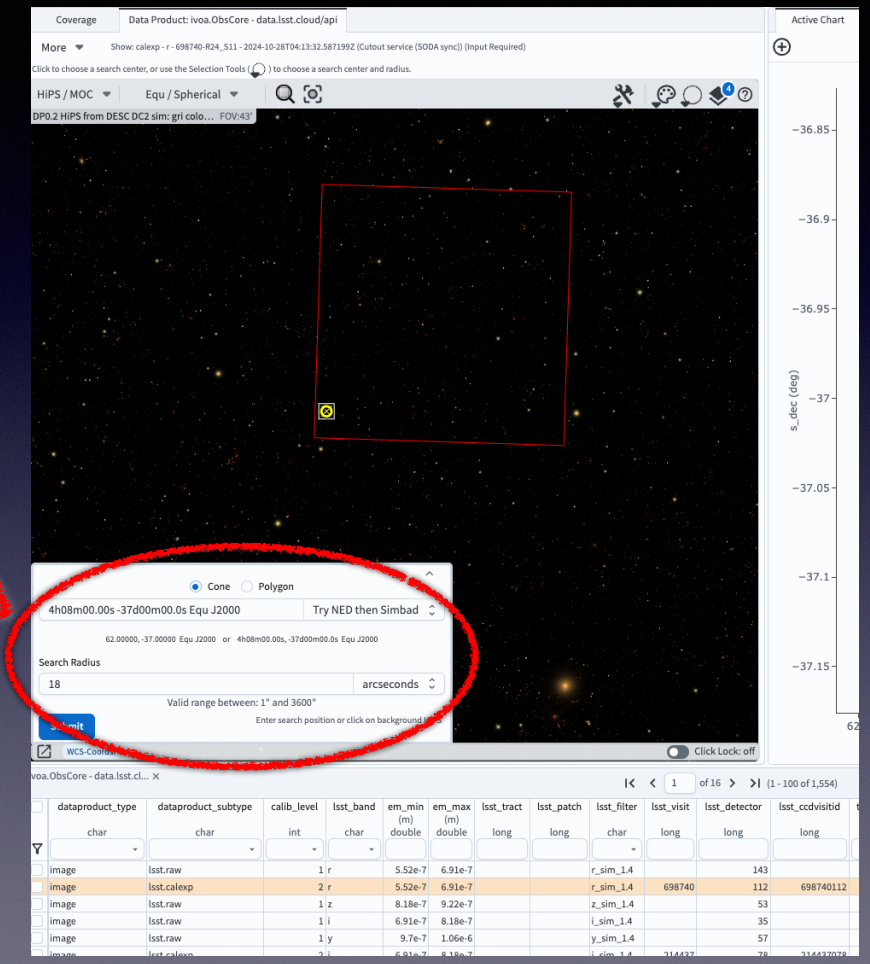


Service Descriptors: Cutouts

- UI service descriptor dilemma
  - Call or not to call
- Answer: Cutout- Always calls

Old Cutout approach

1. clicks on row
2. choose cutout
3. Cutout UI
4. Load cutout

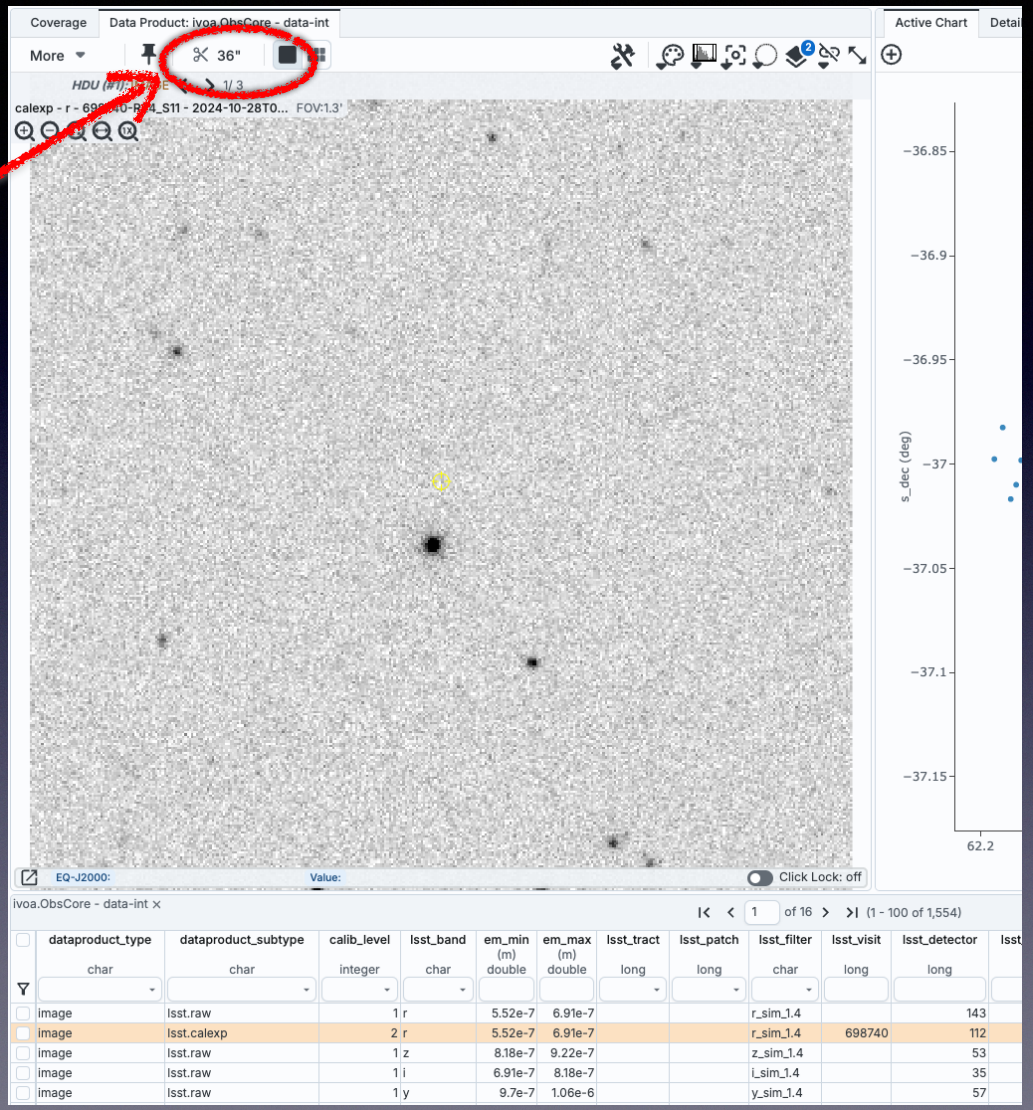


Problems

- Awkward

New Cutout approach

1. clicks on row
2. choose cutout
3. show Cutout



dataproduct_type	dataproduct_subtype	calib_level	lsst_band	em_min (m)	em_max (m)	lsst_tract	lsst_patch	lsst_filter	lsst_visit	lsst_detector	lsst
char	char	integer	char	double	double	long	long	char	long	long	
image	lsst.raw	1	r	5.52e-7	6.91e-7			r_sim_1.4		143	
image	lsst.calexp	2	r	5.52e-7	6.91e-7			r_sim_1.4	698740	112	
image	lsst.raw	1	z	8.18e-7	9.22e-7			z_sim_1.4		53	
image	lsst.raw	1	i	6.91e-7	8.18e-7			i_sim_1.4		35	
image	lsst.raw	1	y	9.7e-7	1.06e-6			y_sim_1.4		57	

Cutout Challenges

- How to get a good default size?
- What is the min and max cutout
- This is solve in some cutout approaches
- SODA (xtype=circle) needs more

Custom cutout with defaults (not SODA)

```
<GROUP name="inputParams">
    <PARAM datatype="double" name="ra" ucd="pos.eq.ra;meta.main" value="235.40059120000001">
        <DESCRIPTION>center RA (J2000)</DESCRIPTION>
    </PARAM>
    <PARAM datatype="double" name="dec" ucd="pos.eq.dec;meta.main" value="40.499986100000001">
        <DESCRIPTION>center DEC (J2000)</DESCRIPTION>
    </PARAM>
    <PARAM datatype="double" name="size" unit="deg" ucd="phys.size" value="0.01">
        <DESCRIPTION>Cutout size in degrees</DESCRIPTION>
        <VALUES>
            <MIN value="0"/>
            <MAX value="6.25"/>
        </VALUES>
    </PARAM>
    <PARAM name="path" ref="col_10" datatype="char" arraysize="*">
        <DESCRIPTION>Path to file with data</DESCRIPTION>
    </PARAM>
</GROUP>
```

Min, Max, Default

SODA cutout without defaults

```
<PARAM arraysize="3" datatype="double" name="CIRCLE" ucd="pos.outline;obs" unit="deg" value="" xtype="circle">
        <DESCRIPTION>Cutout Service</DESCRIPTION>
</PARAM>
```

Cleaner but no defaults, min or max

SODA cutout with MAX

```
<PARAM arraysize="3" datatype="double" name="CIRCLE" ucd="pos.outline;obs" unit="deg" value="" xtype="circle">
        <DESCRIPTION>desc here</DESCRIPTION>
        <VALUES>
          <MAX value="83.6327291351772 22.01395702953019 0.004401189379008736" />
        </VALUES>

</PARAM>
```

not that helpful

Provides max, but no min or default

A Better SODA

```
<PARAM arraysize="3" datatype="double" name="CIRCLE" ucd="pos.outline;obs" unit="deg"
                                                value="0 0 .05" xtype="circle">
        <DESCRIPTION>desc here</DESCRIPTION>
        <VALUES>
          <MIN value="0 0 0.01" />
          <MAX value="0 0 0.1" />
         </VALUES>

</PARAM>
```

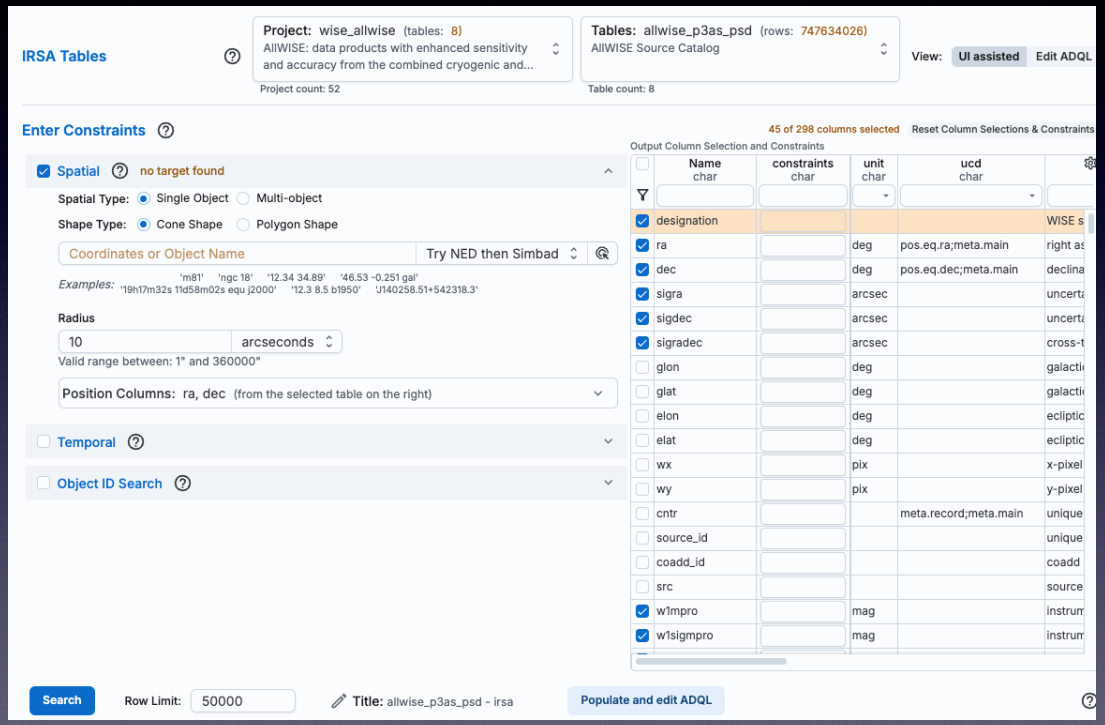
Default

Min and Max

TAP

More and more TAP

Metadata driven



TAP

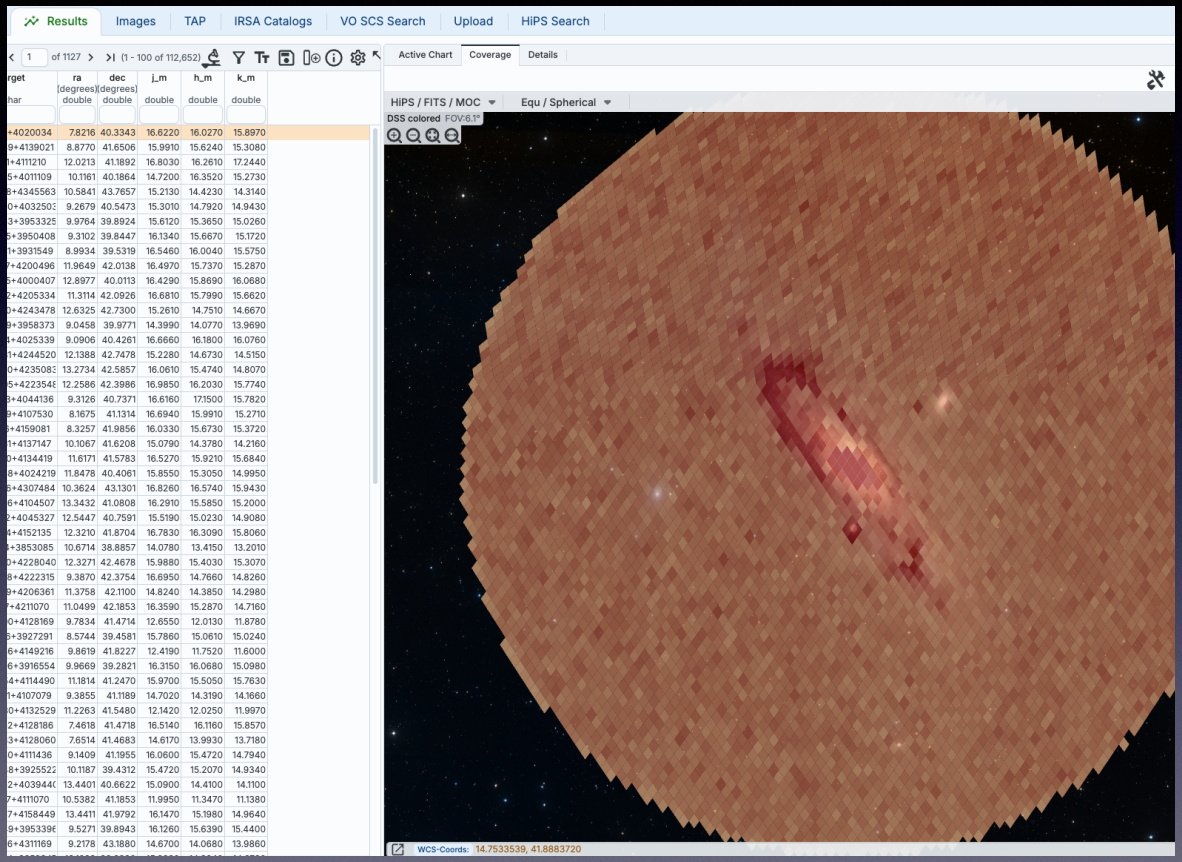
- Capabilities ← Make sure accurate
  - Firefly becoming more dependent on accurate capabilities
  - Upload is the most important
- Need more Metadata, mostly not performant with TAP
  - SIAv2 has a MAXREC=0 call
  - How can we connect this to obstap search?

TAP: Adding User facing Help for Tables and Rows

- IPAC has a plan for this we will present in the future
- IRSA User panel really cares
- Involves adding Service descriptor TAP_SCHEMA.columns
- This level of help is Key to TAP moving forward as a primary catalog service at IRSA

HEALPix Everywhere

HiPS, MOCs, Catalogs



HEALPix Everywhere

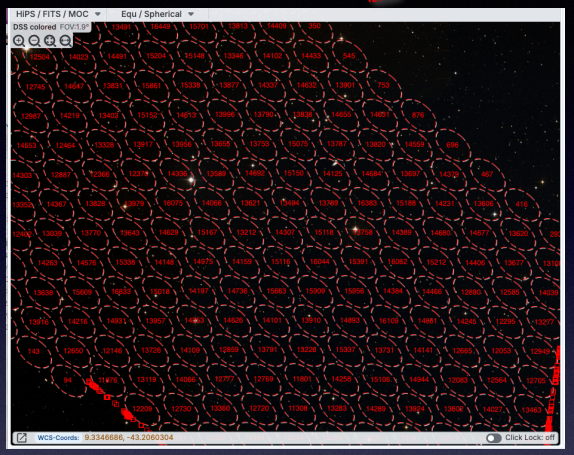
- HiPS not just a results view
  - Now becoming a search view
- MOCs created for every dataset
- Future: MOC Math for combining MOCs
  - Looking to starting doing MOC Math on the server side
  - Plan to use cds-astro/cds-healpix-java (not cds-healpix-rust)
- Using HEALPix code for better display catalogs

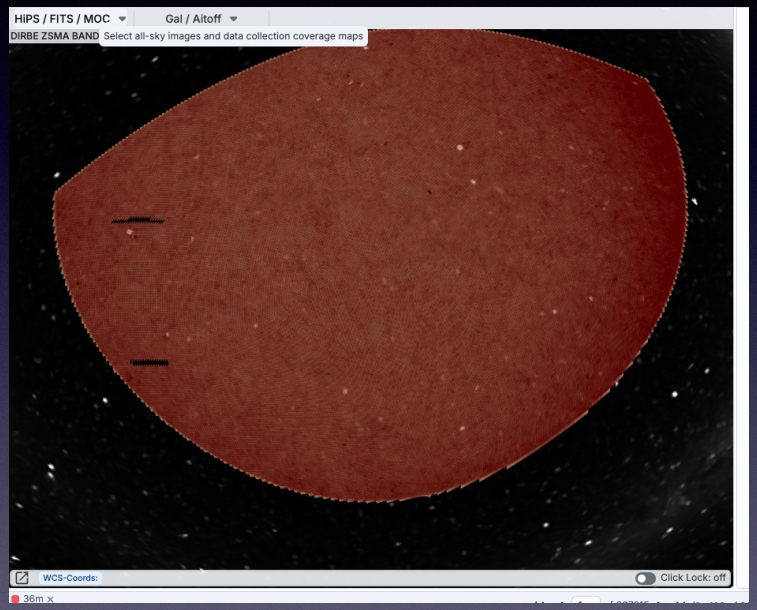
Using HEALPix for catalog overlays

- HiPS catalogs are not quite right fit for Firefly
  - Firefly model is to render table data
  - We still plan to eventually support HiPS Catalogs
- Read whole table in then create a HEALPix based index on the fly
  - Completely inspired by HiPS Catalogs
- Still trying to determine how big we can take this approach
  - 50k -> 1 mil -> 2 mil -> 36 mil… and beyond

HEALPix for Catalogs

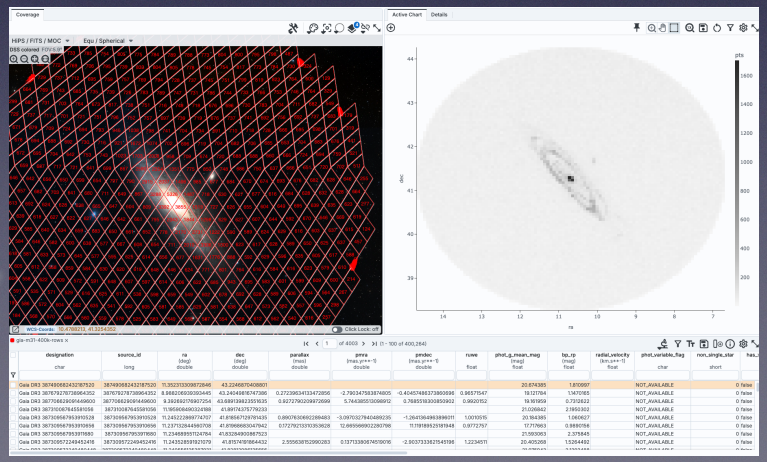
3.5 Million rows





36 Million row heat map

400K rows Gaia



Parquet

Firefly reading and writing parquet

Parquet
+
VO Table

Parquet

- Reading and writing of Parquet
- Using `parquet.votable` proposed style
  - Which incorporates VOTable metadata
  - We will update as the standard is refined
- I have been impressed with the speed of ingestion
- No option to choose columns but in the plan

Near Future

HATS Service

Plans for SIAv2

Cloud Access

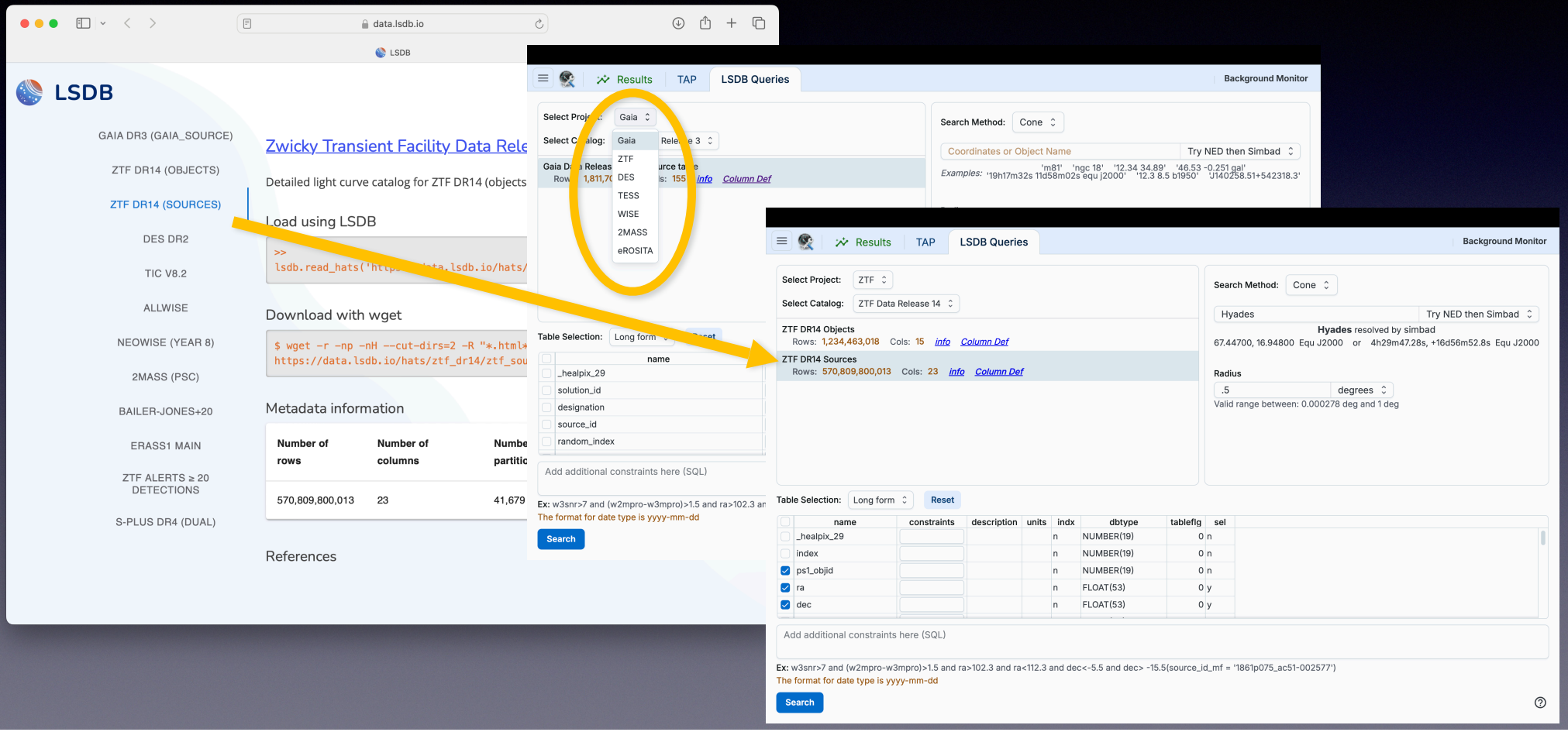
Near Future: HATS Service

- Firefly interacts with most data through services (or uploads)
- HATS technology does not yet have any service standard
- Future: IPAC is investigating creating a general service that can be drop on a HATS archive

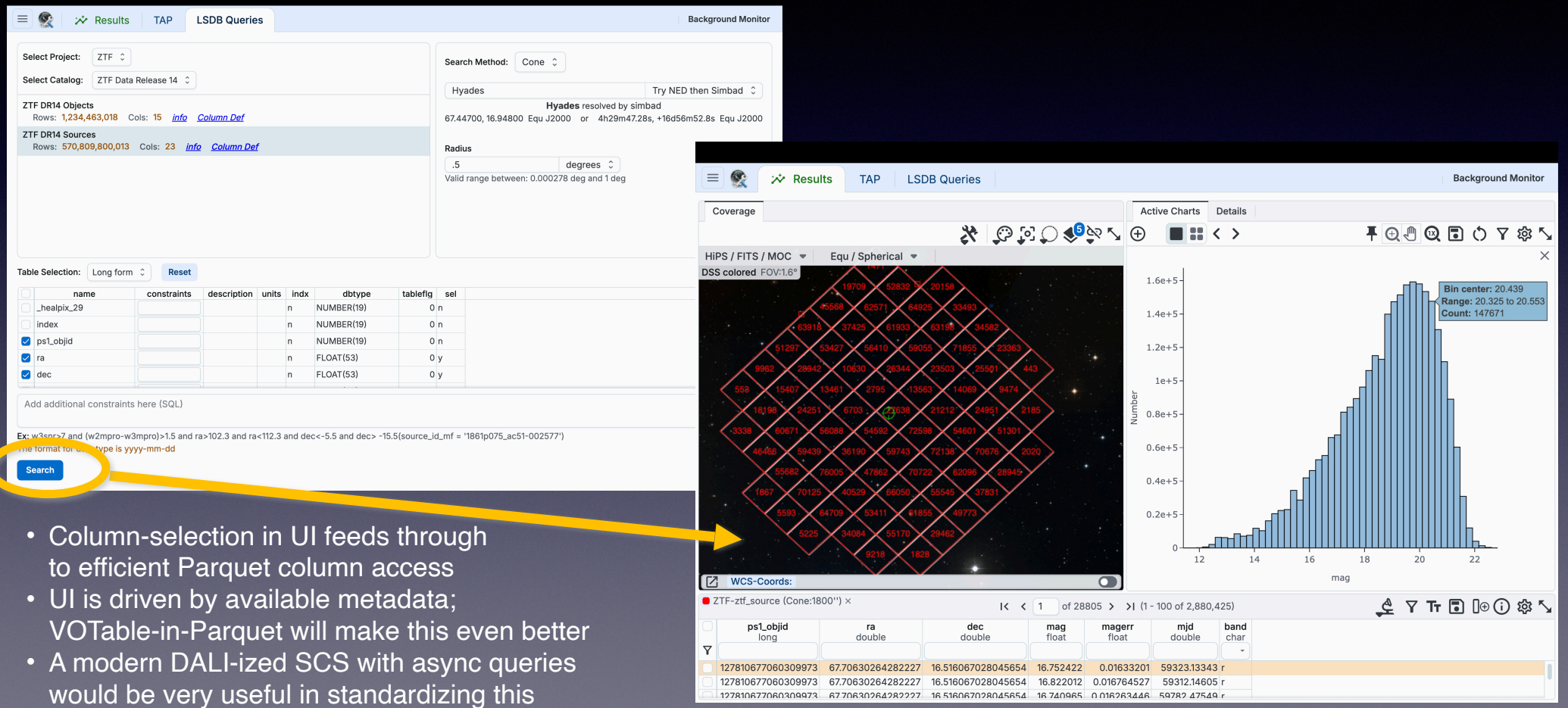
Proof of Concept

- Troy Raen, Gregory Dubois-Felsmann & Loi Ly
- Put together this week

Near Future: Experimental query service for HATS datasets via LSDB



Firefly on Experimental query service for HATS datasets via LSDB



- Column-selection in UI feeds through to efficient Parquet column access
- UI is driven by available metadata; VOTable-in-Parquet will make this even better
- A modern DALI-ized SCS with async queries would be very useful in standardizing this

Near Future: SIAv2

- Creating general SIAv2 search screen
  - Rubin creating a SIAv2 service
- Drop in front of any SIAv2 server
- MetaData driven
  - Best results when backend supports a MAXREC=0 call
  - Active support on backend side will make all the difference

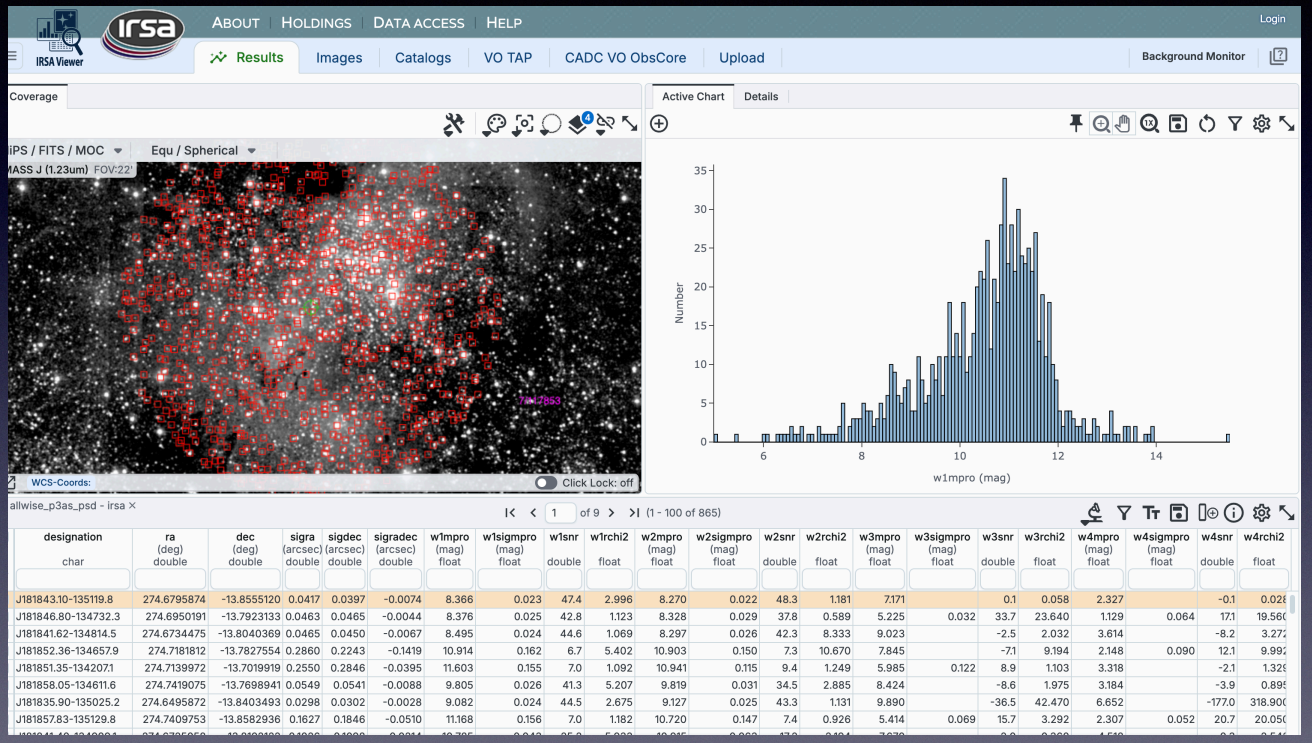
Near Future: Cloud Access

- NASA Driven ⟵ Must be done
- Datalink provides multiple ways to access data ⟵ Core design idea
  - Alternative to **`access_url`**
- Down Side: feels messy
- Up Side: s3 can provide “local like” file access

UI Update

(Why it matters)

- Natural
- Modern
- Approachable
- Confidence
- Usability



designation (char)	ra (deg) (double)	dec (deg) (double)	sigra (arcsec) (double)	sigdec (arcsec) (double)	sigradec (arcsec) (double)	w1mpro (mag) (float)	w1sigmpro (mag) (float)	w1snr (double)	w1rchi2 (float)	w2mpro (mag) (float)	w2sigmpro (mag) (float)	w2snr (double)	w2rchi2 (float)	w3mpro (mag) (float)	w3sigmpro (mag) (float)	w3snr (double)	w3rchi2 (float)	w4mpro (mag) (float)	w4sigmpro (mag) (float)	w4snr (double)	w4rchi2 (float)
J181843.10-135119.8	274.6795874	-13.8555120	0.0417	0.0397	-0.0074	8.366	0.023	47.4	2.996	8.270	0.022	48.3	1.181	7.171		0.1	0.058	2.327		-0.1	0.028
J181846.80-134732.3	274.6950191	-13.7923133	0.0463	0.0465	-0.0044	8.376	0.025	42.8	1.123	8.328	0.029	37.8	0.589	5.225	0.032	33.7	23.640	1.129	0.064	17.1	19.560
J181841.62-134814.5	274.6734475	-13.8040369	0.0465	0.0450	-0.0067	8.495	0.024	44.6	1.069	8.297	0.026	42.3	8.333	9.023		-2.5	2.032	3.614		-8.2	3.272
J181852.36-134657.9	274.7181812	-13.7827554	0.2860	0.2243	-0.1419	10.914	0.162	6.7	5.402	10.903	0.150	7.3	10.670	7.845		-7.1	9.194	2.148	0.090	12.1	9.992
J181851.35-134207.1	274.7139972	-13.7019919	0.2550	0.2846	-0.0395	11.603	0.155	7.0	1.092	10.941	0.115	9.4	1.249	5.985	0.122	8.9	1.103	3.318		-2.1	1.329
J181858.05-134611.6	274.7419075	-13.7698941	0.0549	0.0541	-0.0088	9.805	0.026	41.3	5.207	9.819	0.031	34.5	2.885	8.424		-8.6	1.975	3.184		-3.9	0.895
J181835.90-135025.2	274.6495872	-13.8403493	0.0298	0.0302	-0.0028	9.082	0.024	44.5	2.675	9.127	0.025	43.3	1.131	9.890		-36.5	42.470	6.652		-177.0	318.900
J181857.83-135129.8	274.7409753	-13.8582936	0.1627	0.1846	-0.0510	11.168	0.156	7.0	1.182	10.720	0.147	7.4	0.926	5.414	0.069	15.7	3.292	2.307	0.052	20.7	20.050


ipac