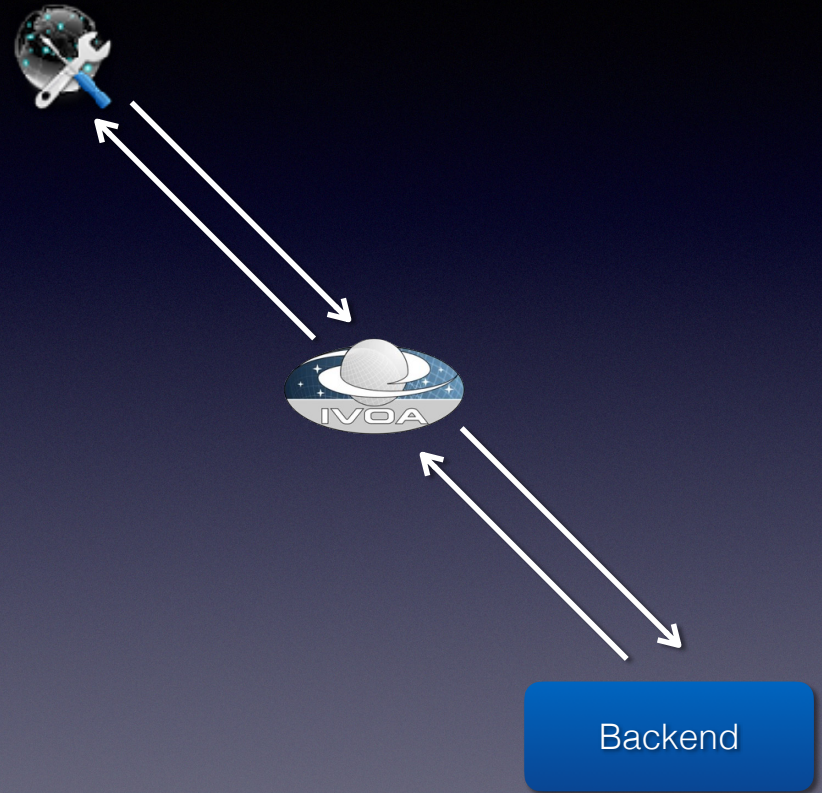
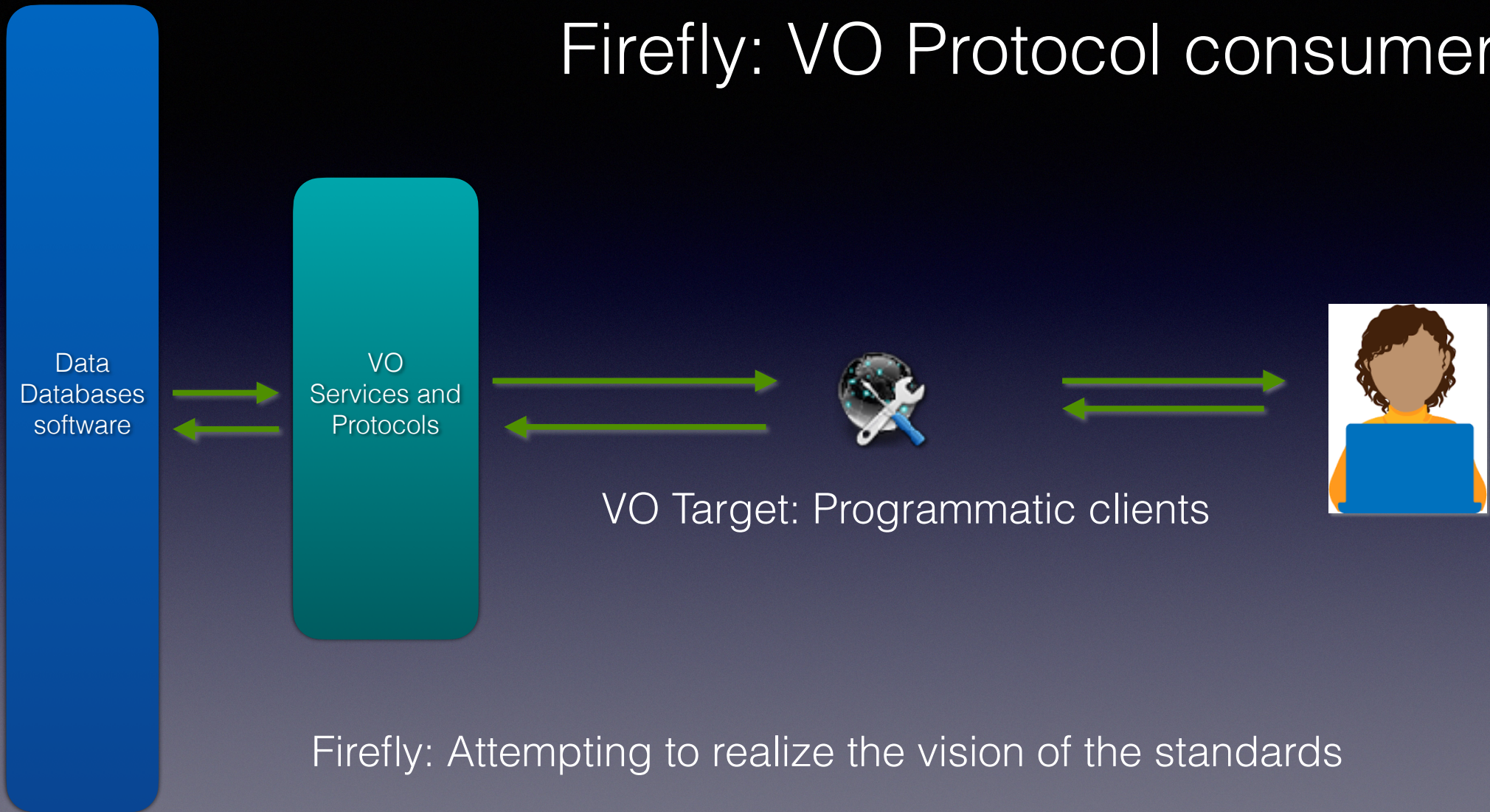


Firefly's expanding use of VO



Firefly: VO Protocol consumer



5 Area of growing IVOA Usage

What we are doing

Where we are going

TAP

Service Descriptors: Cutouts

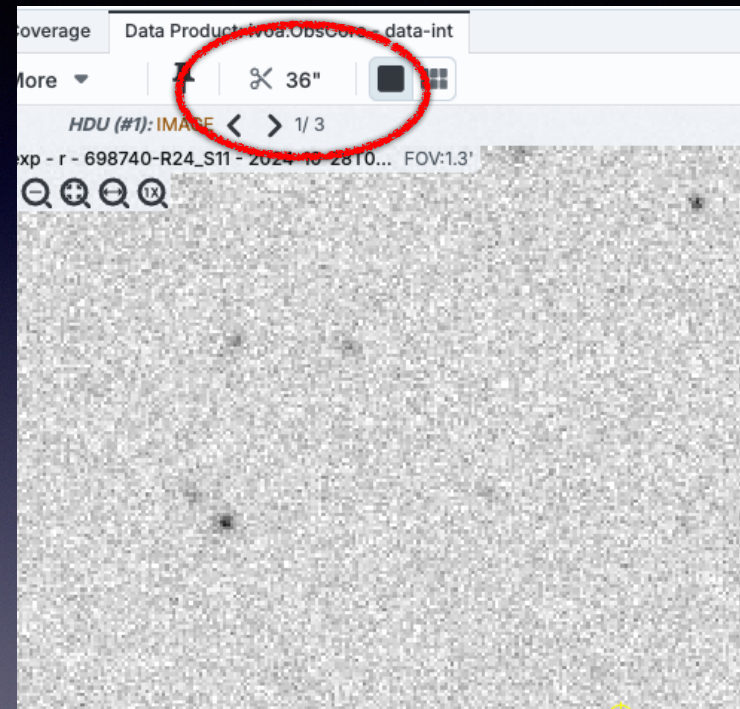
SIAv2

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

The screenshot shows the LSST Data Browser interface. At the top, there's a navigation bar with 'Coverage' and 'Data Product: lvoa.ObsCore - data.lsst.cloud/api'. Below that, there's a search bar and a 'More' button. The main area is a star field with a red rectangular cutout box. A red circle highlights the 'Cutout UI' dialog box, which is open over the star field. The dialog box contains a search radius of 18 arcseconds and a search position of 4h08m00.00s -37d00m00.0s Equ J2000. A red arrow points from the third step of the 'Old Cutout approach' list to the dialog box.

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_ccdvisitid
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	698740112
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	
image	lsst.calexp	2	i	6.91e-7	8.18e-7			i_sim_1.4	714437	78	714437078

New Cutout approach

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

The screenshot displays the IVOA Observing Core interface. At the top, the 'Data Product: ivoa.ObsCore - data-int' is shown. Below this, there are navigation and tool icons. A red circle highlights the 'More' button and the '36"' cutout size indicator. A red arrow points from the first step of the instructions to this area. The main view is a star field with a yellow circle highlighting a specific star. On the right, there is a plot of 's_dec (deg)' with a value of 62.2. At the bottom, a table lists data products with columns for 'dataprod_type', 'dataprod_subtype', 'calib_level', 'lsst_band', 'em_min (m)', 'em_max (m)', 'lsst_tract', 'lsst_patch', 'lsst_filter', 'lsst_visit', and 'lsst_detector'. The second row is highlighted in orange.

<input type="checkbox"/>	dataprod_type	dataprod_subtype	calib_level	lsst_band	em_min (m)	em_max (m)	lsst_tract	lsst_patch	lsst_filter	lsst_visit	lsst_detector	lsst
<input type="checkbox"/>	char	char	integer	char			long	long	char	long	long	
<input type="checkbox"/>	Image	lsst.raw	1	r	5.52e-7	6.91e-7			r_sim_1.4			143
<input checked="" type="checkbox"/>	image	lsst.calexp	2	r	5.52e-7	6.91e-7			r_sim_1.4	698740		112
<input type="checkbox"/>	image	lsst.raw	1	z	8.18e-7	9.22e-7			z_sim_1.4			53
<input type="checkbox"/>	image	lsst.raw	1	i	6.91e-7	8.18e-7			i_sim_1.4			35
<input type="checkbox"/>	image	lsst.raw	1	y	9.7e-7	1.06e-6			y_sim_1.4			57

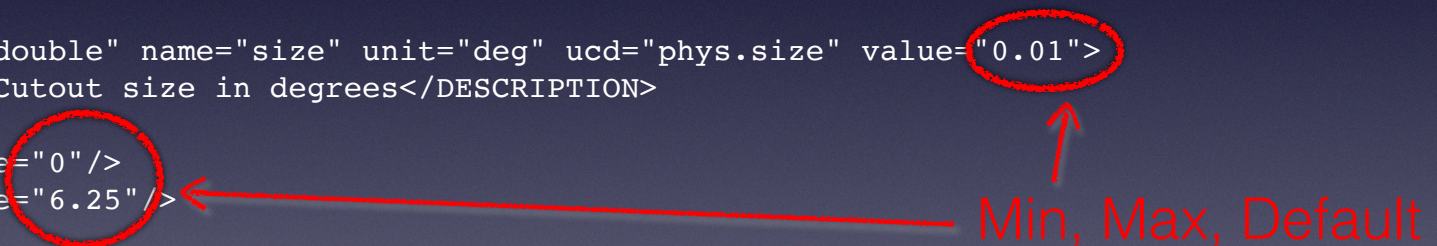
Cutout Challenges

- 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" used="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

Project: wise_allwise (tables: 8)
AllWISE: data products with enhanced sensitivity and accuracy from the combined cryogenic and...
Project count: 52

Tables: allwise_p3as_psd (rows: 747634026)
AllWISE Source Catalog
Table count: 8

View: UI assisted Edit ADQL

Enter Constraints

Spatial no target found

Spatial Type: Single Object Multi-object

Shape Type: Cone Shape Polygon Shape

Coordinates or Object Name Try NED then Simbad

Examples: '19h17m32s 11d58m02s equ J2000' '12.3 8.5 b1950' 'U140258.51+542318.3'

Radius: arcseconds
Valid range between: 1" and 360000"

Position Columns: ra, dec (from the selected table on the right)

Temporal Object ID Search

Name	constraints	unit	ucd
designation			
<input checked="" type="checkbox"/> ra		deg	pos.eq.ra;meta.main
<input checked="" type="checkbox"/> dec		deg	pos.eq.dec;meta.main
<input checked="" type="checkbox"/> sigra		arcsec	uncert
<input checked="" type="checkbox"/> sigdec		arcsec	uncert
<input checked="" type="checkbox"/> sigradec		arcsec	cross-t
<input type="checkbox"/> glon		deg	galacti
<input type="checkbox"/> glat		deg	galacti
<input type="checkbox"/> elon		deg	ecliptic
<input type="checkbox"/> elat		deg	ecliptic
<input type="checkbox"/> wx		pix	x-pixel
<input type="checkbox"/> wy		pix	y-pixel
<input type="checkbox"/> cntr			meta.record;meta.main
<input type="checkbox"/> source_id			unique
<input type="checkbox"/> coadd_id			coadd
<input type="checkbox"/> src			source
<input checked="" type="checkbox"/> w1mpro		mag	instrum
<input checked="" type="checkbox"/> w1sigmpro		mag	instrum

45 of 298 columns selected

Search Row Limit: 50000 Title: allwise_p3as_psd - irsa

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

Results Images TAP IRSA Catalogs VO SCS Search Upload HiPS Search

1 of 1127 > | (1 - 100 of 112,652)

ra	dec	l_m	b_m	k_m	
(degrees)	(degrees)	double	double	double	
+4020034	7.8216	40.3343	16.6220	16.0270	15.8970
9+4139021	8.8770	41.6506	15.9910	15.6240	15.3080
+4111210	12.0213	41.1892	16.8030	16.2610	17.2440
5+4011009	10.1801	40.1864	14.7200	16.3520	15.2730
9+4345563	10.5841	43.7857	15.2130	14.4230	14.3140
0+4032505	9.2679	40.5475	15.3010	14.7920	14.9430
3+3953325	9.9764	39.8924	15.6120	15.3650	15.0260
5+3950408	9.3102	39.8447	16.1340	15.6670	15.1720
1+3931549	8.9934	39.5319	16.5460	16.0040	15.5750
7+4200498	11.9649	42.0138	16.4970	15.7370	15.2870
5+4000407	12.8977	40.0113	16.4290	15.8690	16.0680
2+4205334	11.3114	42.0926	16.6810	15.7990	15.6620
0+4243478	12.6325	42.7300	15.2610	14.7510	14.6670
9+3958373	9.0458	39.9771	14.3990	14.0770	13.9690
+4025339	9.0906	40.4261	16.6660	16.1800	16.0760
1+4244520	12.1388	42.7478	15.2280	14.6730	14.5150
0+4235085	13.2734	42.5857	16.0610	15.4740	14.6070
5+4223545	12.2586	42.3986	16.9850	16.2030	15.7740
1+4044136	9.3136	40.7371	16.6160	17.1500	15.7820
9+4107530	8.1675	41.1314	16.6940	15.9910	15.2710
+4159081	8.3257	41.9856	16.0330	15.6730	15.3720
1+4137147	10.1067	41.6208	15.0790	14.3780	14.2160
0+4134419	11.6171	41.5783	16.5270	15.9210	15.6840
8+4024219	11.8478	40.4061	15.8550	15.3050	14.9950
9+4307484	10.3624	43.1301	16.8260	16.5740	15.9430
6+4104507	13.3432	41.0808	16.2910	15.5850	15.2000
2+4045327	12.5447	40.7591	15.5190	15.0230	14.9080
4+4152135	12.3210	41.8704	16.7830	16.3090	15.8060
+3853085	10.6714	38.8857	14.0780	13.4150	13.2010
0+4228040	12.3271	42.4678	15.9880	15.4030	15.3070
9+4222315	9.3870	42.3754	16.8950	14.7660	14.8260
9+4206361	11.3758	42.1100	14.8240	14.3850	14.2980
+4211070	11.0499	42.1853	16.3590	15.2870	14.7160
0+4128169	9.7834	41.4714	12.6550	12.0130	11.8780
5+3927291	8.5744	39.4581	15.7860	15.0610	15.0240
6+4149216	9.8619	41.8227	12.4190	11.7520	11.6000
6+3916554	9.9669	39.2821	16.3150	16.0680	15.0980
4+4114490	11.1814	41.2470	15.9700	15.5050	15.7630
1+4107079	9.3855	41.1189	14.7020	14.3190	14.1660
0+4132529	11.2263	41.5480	12.1420	12.0250	11.9970
2+4128186	7.4618	41.4718	16.5140	16.1160	15.8570
3+4128060	7.6514	41.4683	14.6170	13.9930	13.7180
0+4111436	9.1409	41.1955	16.0600	15.4720	14.7940
8+3925522	10.1187	39.4312	15.4720	15.2070	14.9340
2+4039444	13.4401	40.6622	15.0900	14.4100	14.1100
7+4111070	10.5382	41.1853	11.9950	11.3470	11.1380
7+4158449	13.4411	41.9792	16.1470	15.1980	14.9640
9+3953396	9.5271	39.8943	16.1260	15.6390	15.4400
6+4311169	9.2178	43.1880	14.6700	14.0680	13.9860

Active Chart Coverage Details

HiPS / FITS / MOC Equ / Spherical

DSS colored FOV:6.1"

WCS-Coords: 14.7533539, 41.8883720

HEALPix Everywhere

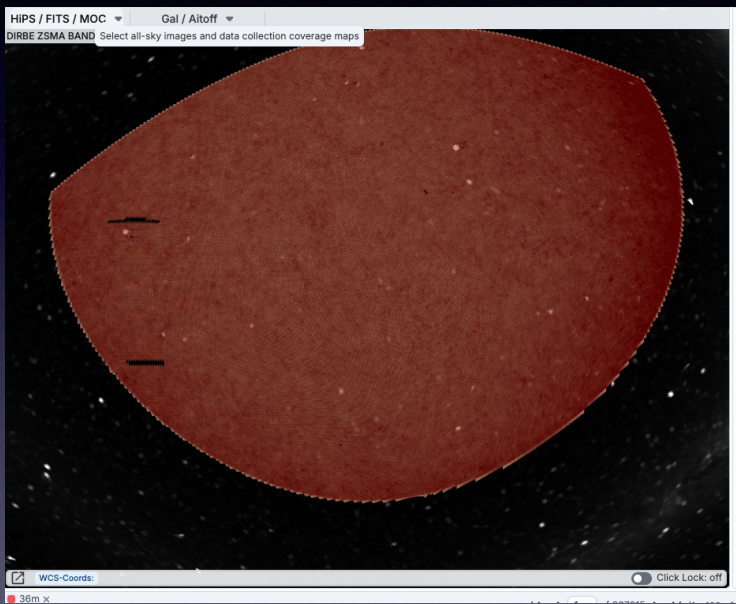
- HiPS not just a results view
 - Now becoming a search view
- MOCs created for every dataset
- Future: MOC Math for combining MOCs
 - Looking to starting doing MOC Math on the server side
 - Plan to use `cds-astro/cds-healpix-java` (not `cds-healpix-rust`)
- Using HEALPix code for better display catalogs

Using HEALPix for catalog overlays

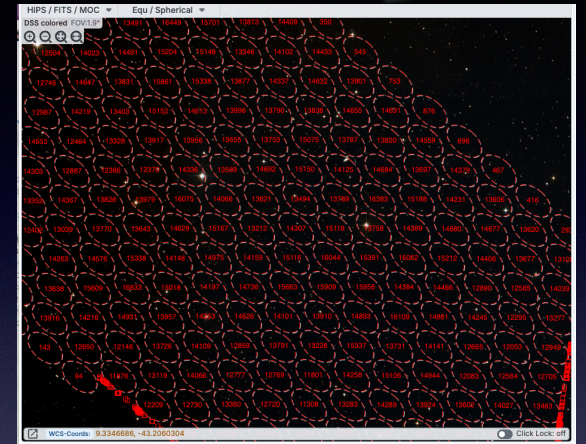
- HiPS catalogs are not quite right fit for Firefly
 - Firefly model is to render table data
 - We still plan to eventually support HiPS Catalogs
- Read whole table in then create a HEALPix based index on the fly
 - Completely inspired by HiPS Catalogs
- Still trying to determine how big we can take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

HEALPix for Catalogs

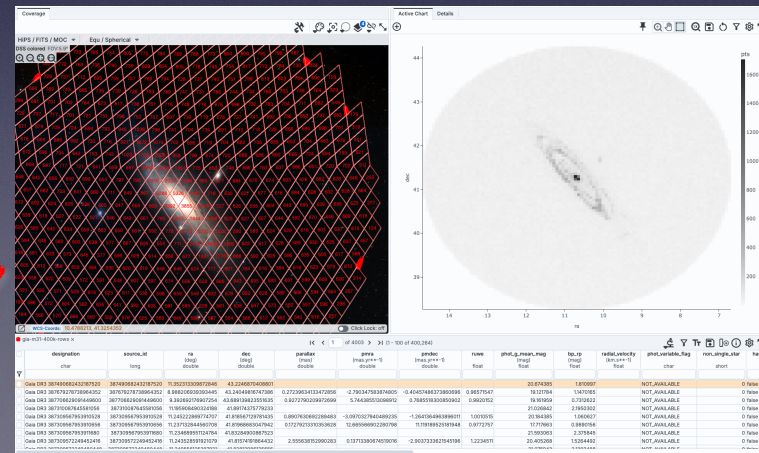
3.5 Million rows



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

BREAKING
NEWS

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

Near Future: Experimental query service for HATS datasets via LSDB

The image shows a screenshot of the LSDB website interface. On the left, there is a navigation menu with various datasets listed, including GAIA DR3, ZTF DR14 (OBJECTS), ZTF DR14 (SOURCES), DES DR2, TIC V8.2, ALLWISE, NEOWISE (YEAR 8), 2MASS (PSC), BAILER-JONES+20, ERASS1 MAIN, ZTF ALERTS ≥ 20 DETECTIONS, and S-PLUS DR4 (DUAL). The main content area displays the 'Zwicky Transient Facility Data Release' page for ZTF DR14 (SOURCES). A yellow arrow points from the 'Load using LSDB' section to the 'ZTF DR14 Sources' table in the query results.

The query results show a table with the following columns: name, constraints, description, units, indx, dbtype, tablefig, and sel. The 'psLobjid', 'ra', and 'dec' columns are selected.

name	constraints	description	units	indx	dbtype	tablefig	sel
<input type="checkbox"/> _healpix_29				n	NUMBER(19)	0	n
<input type="checkbox"/> index				n	NUMBER(19)	0	n
<input checked="" type="checkbox"/> psLobjid				n	NUMBER(19)	0	n
<input checked="" type="checkbox"/> ra				n	FLOAT(53)	0	y
<input checked="" type="checkbox"/> dec				n	FLOAT(53)	0	y

Additional constraints here (SQL):

```
Ex: w3snr>7 and (w2mpro-w3mpro)>1.5 and ra>102.3 and  
The format for date type is yyyy-mm-dd
```

Search

Firefly on Experimental query service for HATS datasets via LSDB

The screenshot shows the Firefly web interface with the following elements:

- Select Project:** ZTF
- Select Catalog:** ZTF Data Release 14
- ZTF DR14 Objects:** Rows: 1,234,463,018 Cols: 15
- ZTF DR14 Sources:** Rows: 570,809,800,013 Cols: 23
- Search Method:** Cone
- Search Target:** Hyades
- Radius:** .5 degrees
- Table Selection:** A table with columns: name, constraints, description, units, indx, dbtype, tablefig, sel. The 'ra' and 'dec' columns are selected.
- Search Button:** A blue button labeled 'Search' is circled in yellow.

The screenshot shows the Firefly web interface displaying search results and a visualization:

- Visualization:** A DSS colored FOV plot showing a diamond-shaped field of view with a grid of stars. The plot is titled 'DSS colored FOV:1.6°'.
- Histogram:** A histogram showing the distribution of stars by magnitude (mag). The x-axis is labeled 'mag' and the y-axis is labeled 'Number'. A tooltip indicates: 'Bin center: 20.439, Range: 20.325 to 20.553, Count: 147671'.
- Table:** A table showing search results with columns: ps1_objid, ra, dec, mag, magerr, mjd, band. The first few rows are highlighted in yellow.

- 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

The screenshot displays the IRSA Viewer interface. At the top, there are navigation tabs: ABOUT, HOLDINGS, DATA ACCESS, HELP, Results, Images, Catalogs, VO TAP, CADC VO ObsCore, Upload, and Background Monitor. The main content area is split into two panels. The left panel shows a star field with a red selection box around a cluster of stars. The right panel shows a histogram of the number of stars versus magnitude (w1mpro). Below the panels is a table of star data.

designation	ra	dec	sigma	sigdec	sigra	w1mpro	w1sigmpro	w1snr	w1rchi2	w2mpro	w2sigmpro	w2snr	w2rchi2	w3mpro	w3sigmpro	w3snr	w3rchi2	w4mpro	w4sigmpro	w4snr	w4rchi2
char	double	double	double	double	double	float	float	double	float	float	float	double	float	float	float	double	float	float	float	double	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	7171		0.1	0.058	2.327		-0.1	0.026
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	19.56
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	3.27
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	9.99
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	1.32
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	0.89
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	318.90
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	20.05

