

# An Introduction to NVO Core Applications

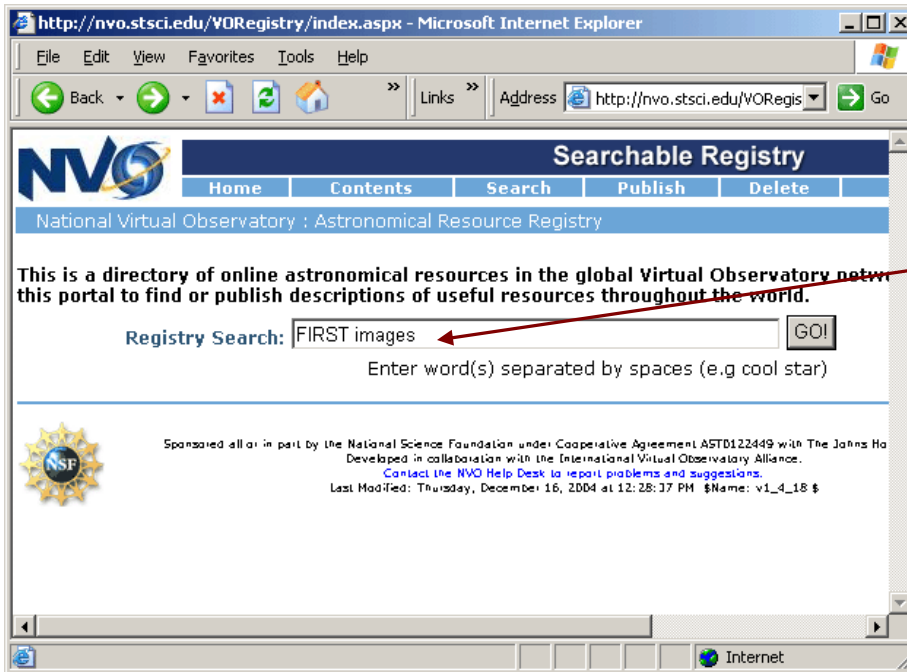
This document uses screenshots and annotation to lead readers through the operation of five key applications that are available through the National Virtual Observatory. All of these can be found and used by starting at <http://us-vo.org/apps>.

The applications are:

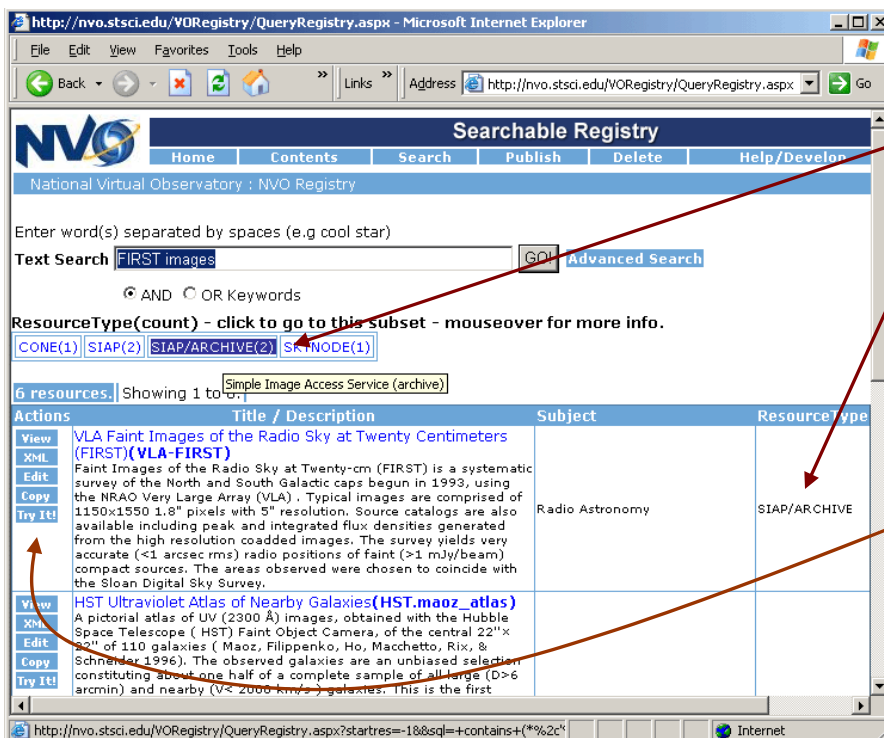
Registry Portal	Find source catalogs, observation logs, image archives, and other astronomical resources registered with the NVO.
DataScope	Discover and Explore Data in the Virtual Observatory
Open SkyQuery	Cross match your data with numerous catalogues
Spectrum Services	Search, plot, and retrieve SDSS, 2dF, and other spectra.
Web Enabled Source Identification with Cross-Matching	Upload images to SExtractor and cross-correlate the objects found with selected survey catalogs.

## Registry Portal

The NVO registry is a directory of online astronomical resources. The STScI portal can be used to access catalog, image, and spectral data, and also descriptions of organizations and data collections.



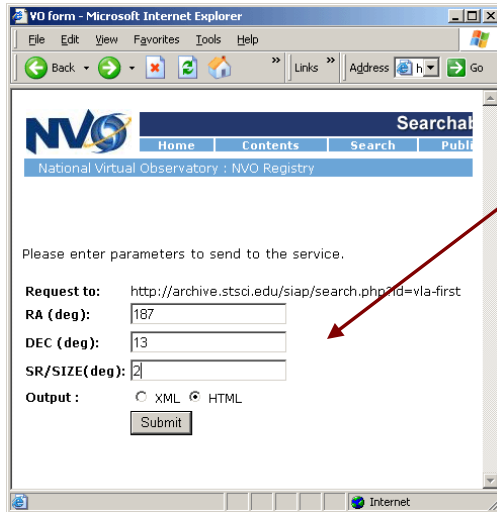
Simple user interface allows search on any astronomical topic in a Google-like way. Suppose we want images from the FIRST radio survey.



The registry returns 6 resources. It looks like there is a Simple Image Access Protocol (SIAP) archive service. We can use this to get an image.

From these buttons, we can do several things – see the registry information, see the underlying XML description, etc. Let us continue by clicking on the “Try It” button.

## Registry Portal



Please enter parameters to send to the service.

Request to: <http://archive.stsci.edu/siap/search.php?id=vla-first>

RA (deg):

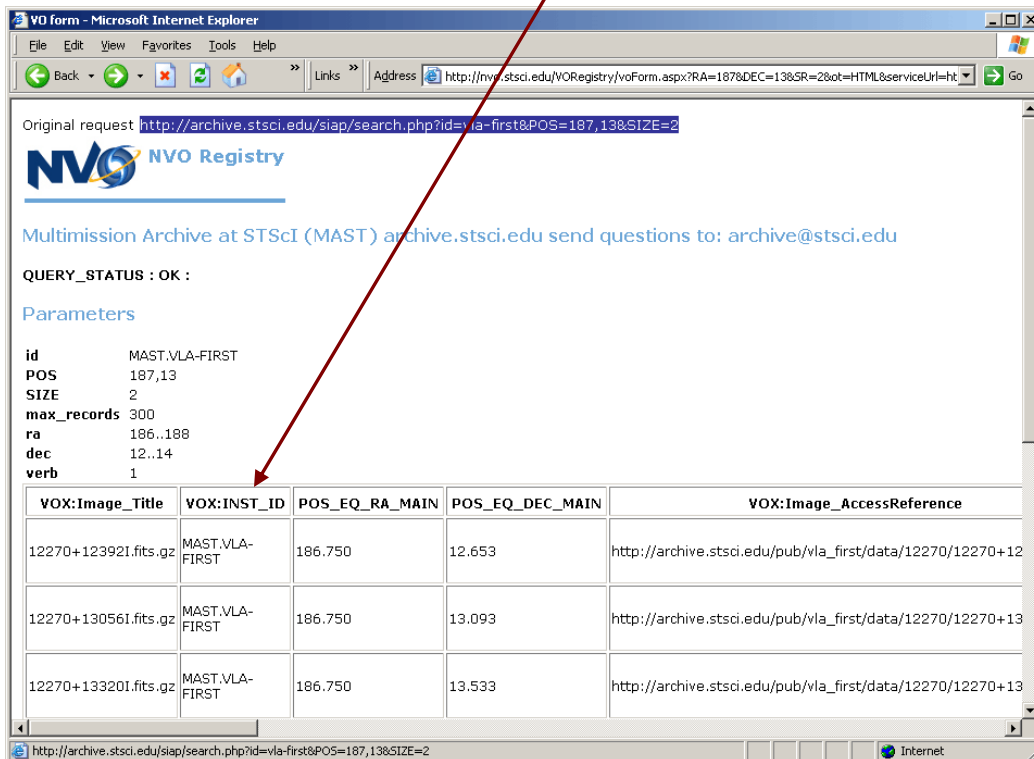
DEC (deg):

SR/SIZE(deg):

Output: ☐ XML ☒ HTML

The “Try It” button brings up a human-operable web form that illustrates the SIAP protocol. Enter here the RA, Dec, and radius of a circular region on the sky, to fetch FIRST image information from that region. The coordinates here are for the galaxy M87.

The result of the request is a table of images, each with RA, Dec, URL, and full coordinate information (sky footprint).



Original request <http://archive.stsci.edu/siap/search.php?id=vla-first&POS=187,13&SIZE=2>

**NVO Registry**

Multimission Archive at STScI (MAST) [archive.stsci.edu](http://archive.stsci.edu) send questions to: [archive@stsci.edu](mailto:archive@stsci.edu)

QUERY\_STATUS : OK :

Parameters

id MAST.VLA-FIRST

POS 187,13

SIZE 2

max\_records 300

ra 186..188

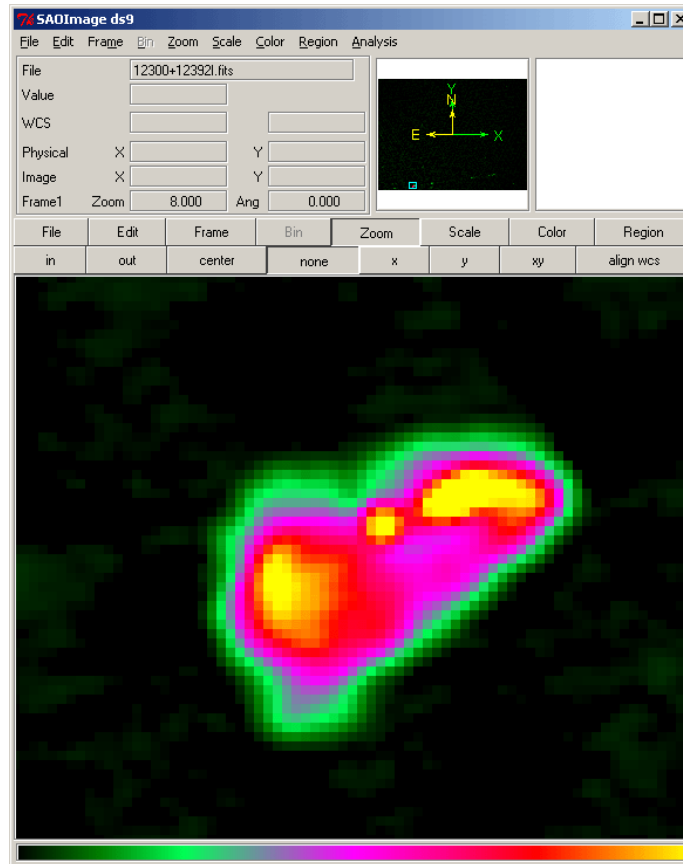
dec 12..14

verb 1

VOX:Image_Title	VOX:INST_ID	POS_EQ_RA_MAIN	POS_EQ_DEC_MAIN	VOX:Image_AccessReference
12270+123921.fits.gz	MAST.VLA-FIRST	186.750	12.653	<a href="http://archive.stsci.edu/pub/vla_first/data/12270/12270+12">http://archive.stsci.edu/pub/vla_first/data/12270/12270+12</a>
12270+130561.fits.gz	MAST.VLA-FIRST	186.750	13.093	<a href="http://archive.stsci.edu/pub/vla_first/data/12270/12270+13">http://archive.stsci.edu/pub/vla_first/data/12270/12270+13</a>
12270+133201.fits.gz	MAST.VLA-FIRST	186.750	13.533	<a href="http://archive.stsci.edu/pub/vla_first/data/12270/12270+13">http://archive.stsci.edu/pub/vla_first/data/12270/12270+13</a>

<http://archive.stsci.edu/siap/search.php?id=vla-first&POS=187,13&SIZE=2>

## Registry Portal



By selecting an image closest to M87, we download directly from the given URL, and view the result in one of the many FITS viewers. This image shows the inner lobes of M87, and is about 10 arcseconds wide.

**While this demonstration has used web forms and emphasized visualization, the underlying services are designed also for use by computer programs, to allow bulk data and computing pipelines.**

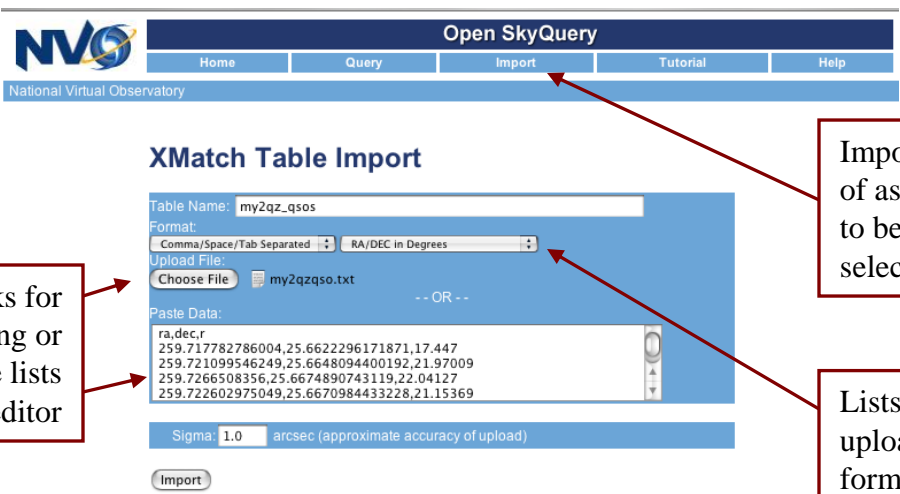
## Open SkyQuery

Open SkyQuery allows sophisticated queries of astronomical catalogs in a uniform way, as well as cross-matching published catalogs. Open SkyQuery is supported by a general and powerful query language. A personal catalog of objects can be imported and cross-matched with published catalogs.

To illustrate Open SkyQuery, we use the following sample question:

**What are the near infrared colors of bright quasars discovered using blue excess selection criteria?**

Through the NVO registry, a number of quasar surveys with accessible catalogs can be identified. We select, for example, to use the 2DF Quasar Redshift survey (2QZ) as our source of confirmed UV-excess selected quasars. A file containing simple text, or VOTable information (RA, Dec, etc.) for many objects can be uploaded to Open Sky Query, via the Import page, for comparison with an all sky infrared survey like 2MASS.



**Open SkyQuery**

Home Query **Import** Tutorial Help

National Virtual Observatory

### XMatch Table Import

Table Name: my2qz\_qsos

Format: Comma/Space/Tab Separated RA/DEC in Degrees

Upload File: Choose File my2qzqsos.txt -- OR --

Paste Data:

```
ra,dec,r
259.717782786004,25.6622296171871,17.447
259.721099546249,25.6648094400192,21.97009
259.7266508356,25.6674890743119,22.04127
259.722602975049,25.6670984433228,21.15369
```

Sigma: 1.0 arcsec (approximate accuracy of upload)

Import

Browse Disks for file uploading or Copy/Paste lists into the editor

Import your favorite lists of astronomical objects to be matched with selected databases

Lists of objects can be uploaded in a variety of formats.

## Open SkyQuery

Once the quasar data has been imported, Open SkyQuery provides the option of cross-matching your list of objects to a number of multiwavelength catalogs available through the NVO Registry.

A helpful interface allows the user to do an SQL search without knowing the details of the syntax while at the same time introducing the new user to SQL. Experienced SQL users also have the flexibility to simply type in commands.

The screenshot shows the Open SkyQuery web interface. At the top is a navigation bar with links: Home, Query, Import, Tutorial, and Help. Below this is a sidebar on the left titled 'Nodes' containing a list of astronomical catalogs like Rosat, GALEX, DLS, RC3, SDSS, etc. The main area is divided into 'Build' and 'Edit' tabs. The 'Build' tab shows a query builder interface with a 'SELECT' field containing a list of catalog names and a 'FROM' field containing 'TWOMASS'. The 'Edit' tab shows a text editor with an SQL query. On the right, there is a 'Query Status' panel showing 'Query is complete' and buttons for 'View', 'Plot', 'ExecPlan', and 'Colors?'. Below this is a 'Samples' section. At the bottom right, there is a version string 'Version: v1.0.7' and a URL 'http://us-vo.org/apps'.

Easy- to-use clickable formatting for building Searchable Query Language (SQL) commands without knowing SQL syntax.

Automated tutorial to get you started.

For those more experienced with SQL syntax, there is easy editing of command and a syntax checker.

Results can be viewed and saved in a variety of formats, or plot your results immediately with VOPlot.

On-line examples for editing.

Import a number of your own lists for cross-matching with selected catalogs from the VO Registry.

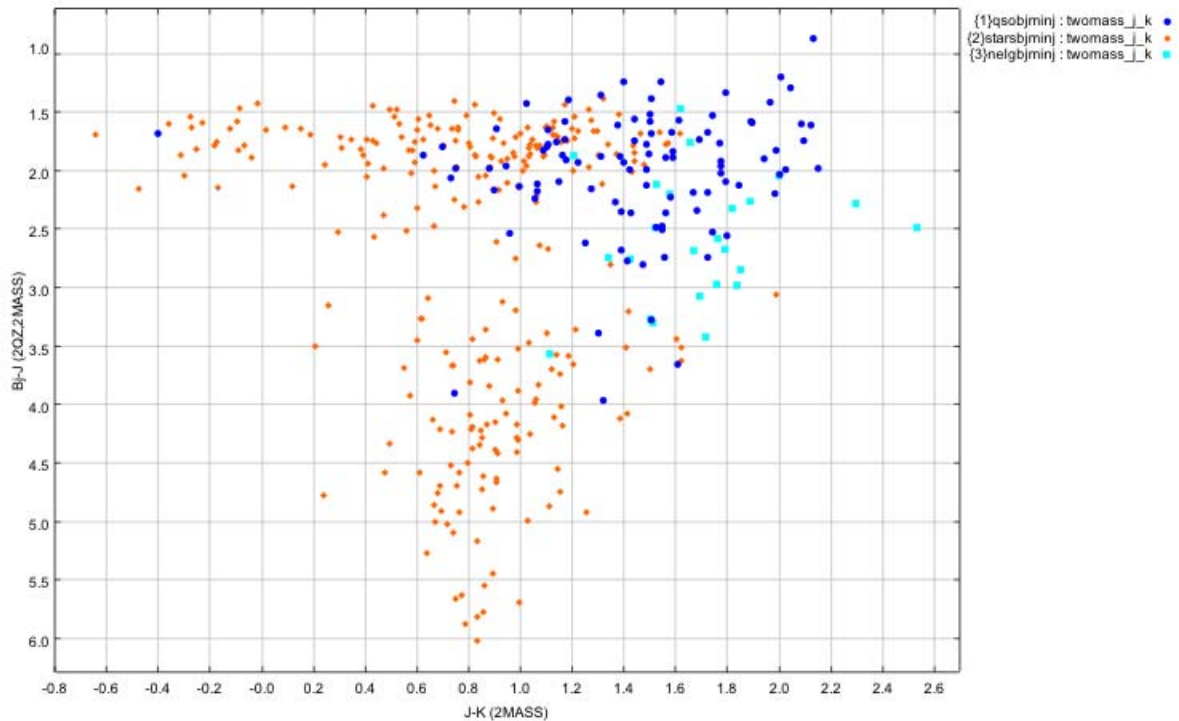
A variety of catalogs are available for matching. Information on parameters is also provided

Include selected regions of the sky.

**i**

## Open SkyQuery

When the cross-match is done, we can use VOPlot to visualize the results.



Plotted here are 2MASS near-IR colors of quasars (blue circles), stars (orange diamonds), and narrow emission-line galaxies (light blue squares) from the 2QZ survey.

2QZ quasar candidates were selected for their ultraviolet excess. The plot demonstrates that the infrared excess of quasar candidates is also a good method for selection.

Two quasars in this plot have faint 2MASS NIR colors that exclude them from the NIR selection criterion. A further exploration of these object can be done with a **DataScope** search of multiwavelength images of those locations.

**Note that the figure above has the axes labeled intelligently, which is because NVO data formats such as VOTable carry full annotations of their content. Data is stored and moved efficiently, but also the meaning of the data is kept.**



## DataScope

DataScope allows you to search the NVO Registry at a coordinate position without having to go to multiple databases.

### What catalogs and images are available in the NVO Registry for a particular sky position?

Suppose we have the coordinates of a quasar. It is found to be a faint NIR source in the 2MASS catalog. Optical/NIR colors from these surveys put its location in color-color space outside NIR selection criteria for quasar candidates. What other data is available for this source? Is this quasar an X-ray or Radio source? DataScope allows the user to search for other images and datasets, across multiple wavelengths that overlap this region of the sky.



National Virtual Observatory Hosted at NASA/HEASARC

New version of DataScope released!.

See the [new features list](#) for new capabilities and changes.

What do we know about a region of the sky?

Use the Virtual Observatory DataScope to gather and organize information from astronomy archives and data centers around the world. Enter a position(or name) and the maximum size of the region of sky you are interested in.

Object Name or J2000 Position:	356.0038 -29.54	(3c273 or 12 29 06, +2 3 8.6 or 187.27, 2.05 )
Region size (degrees):	0.2	
<input type="button" value="Send Request"/> <input type="button" value="Reset Form"/>		

☐ Bypass cache. DataScope will issue a fresh request even if an identical request is in the cache.

Recent transient events and requests: (Click on View to see cached results.)

<a href="#">View</a> <b>m1</b> [05 <sup>h</sup> 34 <sup>m</sup> 31.97 <sup>s</sup> +22°00'52.1"] (0.250°)	<a href="#">View</a> <b>abell 496</b> [04 <sup>h</sup> 33 <sup>m</sup> 37.09 <sup>s</sup> -13°14'46.3"] (0.250°)
<a href="#">View</a> 00 <sup>h</sup> 00 <sup>m</sup> 00.00 <sup>s</sup> +90°00'00.0" (0.250°)	<a href="#">View</a> 02 <sup>h</sup> 16 <sup>m</sup> 48.00 <sup>s</sup> -05°00'00.0" (0.020°)
<a href="#">View</a> 02 <sup>h</sup> 16 <sup>m</sup> 48.00 <sup>s</sup> -05°00'00.0" (0.002°)	<a href="#">View</a> 02 <sup>h</sup> 18 <sup>m</sup> 00.00 <sup>s</sup> -05°00'00.0" (0.000°)

Display:

<input checked="" type="checkbox"/> Basic Services	<input checked="" type="checkbox"/> ADS	<input checked="" type="checkbox"/> NED	<input checked="" type="checkbox"/> Simbad	<input checked="" type="checkbox"/> SkyView
<input checked="" type="checkbox"/> Images	<input checked="" type="checkbox"/> Multi	<input checked="" type="checkbox"/> Optical	<input checked="" type="checkbox"/> Radio	<input checked="" type="checkbox"/> IR <input checked="" type="checkbox"/> UV <input checked="" type="checkbox"/> X-ray <input checked="" type="checkbox"/> Other images
<input checked="" type="checkbox"/> Tables	<input checked="" type="checkbox"/> Observations <input checked="" type="checkbox"/> Multi <input checked="" type="checkbox"/> Optical <input checked="" type="checkbox"/> Radio <input checked="" type="checkbox"/> IR <input checked="" type="checkbox"/> UV <input checked="" type="checkbox"/> X-ray <input checked="" type="checkbox"/> Other	<input checked="" type="checkbox"/> Objects <input checked="" type="checkbox"/> Survey <input checked="" type="checkbox"/> Galaxies <input checked="" type="checkbox"/> Stars <input checked="" type="checkbox"/> Other objects	<input checked="" type="checkbox"/> Other tables	

User interface is a simple coordinate search.

Results from recent searches are cached for fast access.


Options allow the user to select information of interest or simply find everything available in the NVO registry for a region.



## DataScope

DataScope calls on the registry for relevant services that cover the given point, then uses the resulting services to get image and catalog information about the specified point. The result list is refreshed on the web page as more results come in from remote services.

Save results as a TAR file or view results with Aladin or OASIS.



**DataScope Results for 356.0038 -29.54**  
[New Query](#) - [DataScope Help](#) - [Feedback](#) - Cache date: 2004-12-17 21:20 UTC  
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**Request Status:** Request scanning completed. Data found for 62 of 344 resources.

Browse available resources by clicking on their names and make selections for further analysis.

**Analysis options:**

- Save locally as TAR file
- Analyze in Aladin
- Analyze in OASIS

Check resource checkbox to select resource for analysis  
 Click on resource name to view that resource (and select data files within it)  
 Click on ? to see resource metadata

When resources have multiple data files you need to specify which files you are interested in. Your selections are remembered similar to how commercial sites use shopping carts. Resources where you need to make selections show (*nselected/navailable*) after the name.

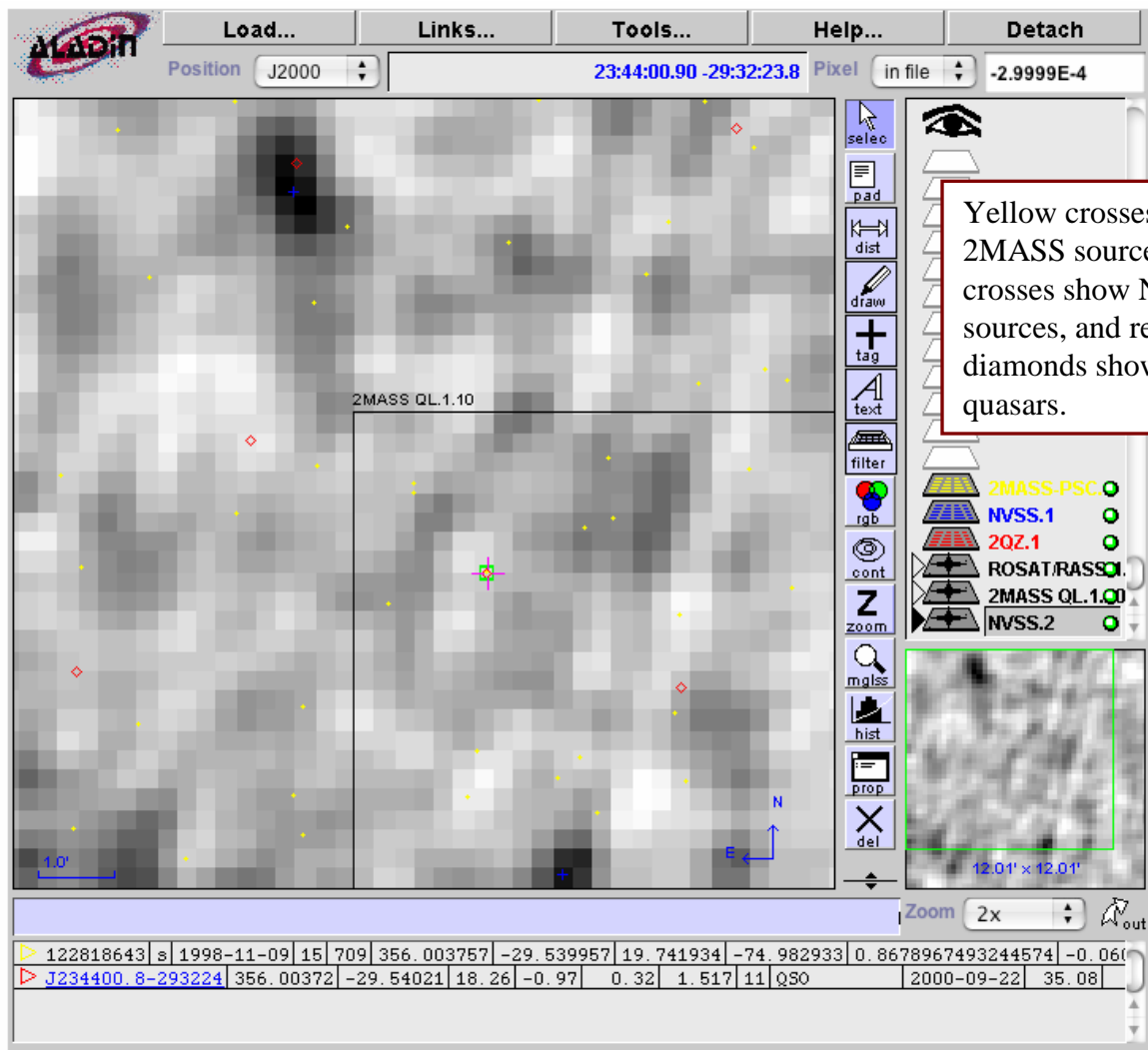
Major Multiwavelength Services					
	<input type="checkbox"/> ADS(6) ?	<input type="checkbox"/> NED(sources)(55) ?	<input type="checkbox"/> SkyView(0/16) ?		
Images (Data in one or more FITS files)					
Optical	<input type="checkbox"/> DSS1(1) ?	<input type="checkbox"/> DSS1(1) ?	<input type="checkbox"/> DSS2(1) ?	<input type="checkbox"/> DSS2B(1) ?	<input type="checkbox"/> DSS2IR(1) ?
	<input type="checkbox"/> DSS2R(1) ?	<input type="checkbox"/> NEAT(1) ?			
Radio	<input checked="" type="checkbox"/> NVSS(1) ?				
Infrared	<input checked="" type="checkbox"/> 2MASS QL(2/18) ?	<input type="checkbox"/> 2MASS(2/6) ?	<input type="checkbox"/> 2MASS(0/6) ?	<input type="checkbox"/> IRAS(0/4) ?	<input type="checkbox"/> ISSA(0/8) ?
	<input type="checkbox"/> MSX(0/4) ?	<input type="checkbox"/> SFD IR(0/2) ?			
X-ray	<input checked="" type="checkbox"/> ROSAT/RASS(3/3) ?				
Lists of Observations (Data in one VOTable)					
Other	<input type="checkbox"/> COS-B Evt(1) ?	<input type="checkbox"/> COS-B Image(4) ?	<input type="checkbox"/> GRO/EGRET(10) ?		
Catalogs of Objects (Data in one VOTable)					
Surveys	<input type="checkbox"/> 2MASS-PSC(CDS)(171) ?	<input checked="" type="checkbox"/> 2MASS-PSC(535) ?	<input type="checkbox"/> 2MASS-XSC(9) ?	<input checked="" type="checkbox"/> 2QZ(16) ?	<input type="checkbox"/> GSC2.2 CD(179) ?
	<input type="checkbox"/> GSC2.2(179) ?	<input checked="" type="checkbox"/> NVSS(245) ?	<input type="checkbox"/> UCAC1(51) ?	<input type="checkbox"/> USNO-A2.0 CDS(362) ?	
Stars	<input type="checkbox"/> AC2000.2(6) ?	<input type="checkbox"/> ASCC-2.5(4) ?	<input type="checkbox"/> NLTT(1) ?	<input type="checkbox"/> PPM(2) ?	<input type="checkbox"/> TYCHO-2(4) ?
	<input type="checkbox"/> Tycho-2(4) ?				
Other types/ unclassified	<input type="checkbox"/> BATSE GRB(5) ?	<input type="checkbox"/> BATSE/GUSBAD(4) ?	<input type="checkbox"/> Kommers GRB(1) ?	<input type="checkbox"/> Optical(25) ?	<input type="checkbox"/> Radio Catalogs(1:4) ?
	<input type="checkbox"/> Radio(10) ?	<input type="checkbox"/> Stern GRB(3) ?	<input type="checkbox"/> Veron-Veron(8) ?	<input type="checkbox"/> Veron(9) ?	

Select the search results that you are interested in by clicking the appropriate selection boxes.

## DataScope

Images and catalogs can be quickly viewed using visualization packages like Aladin or OASIS.

Displayed here is the NVSS image at the location (pink cross) of the NIR outlying quasar (see the Open SkyQuery Handout) discovered in the 2QZ survey. This quasar is not an NVSS (or ROSAT) source as seen in the images.

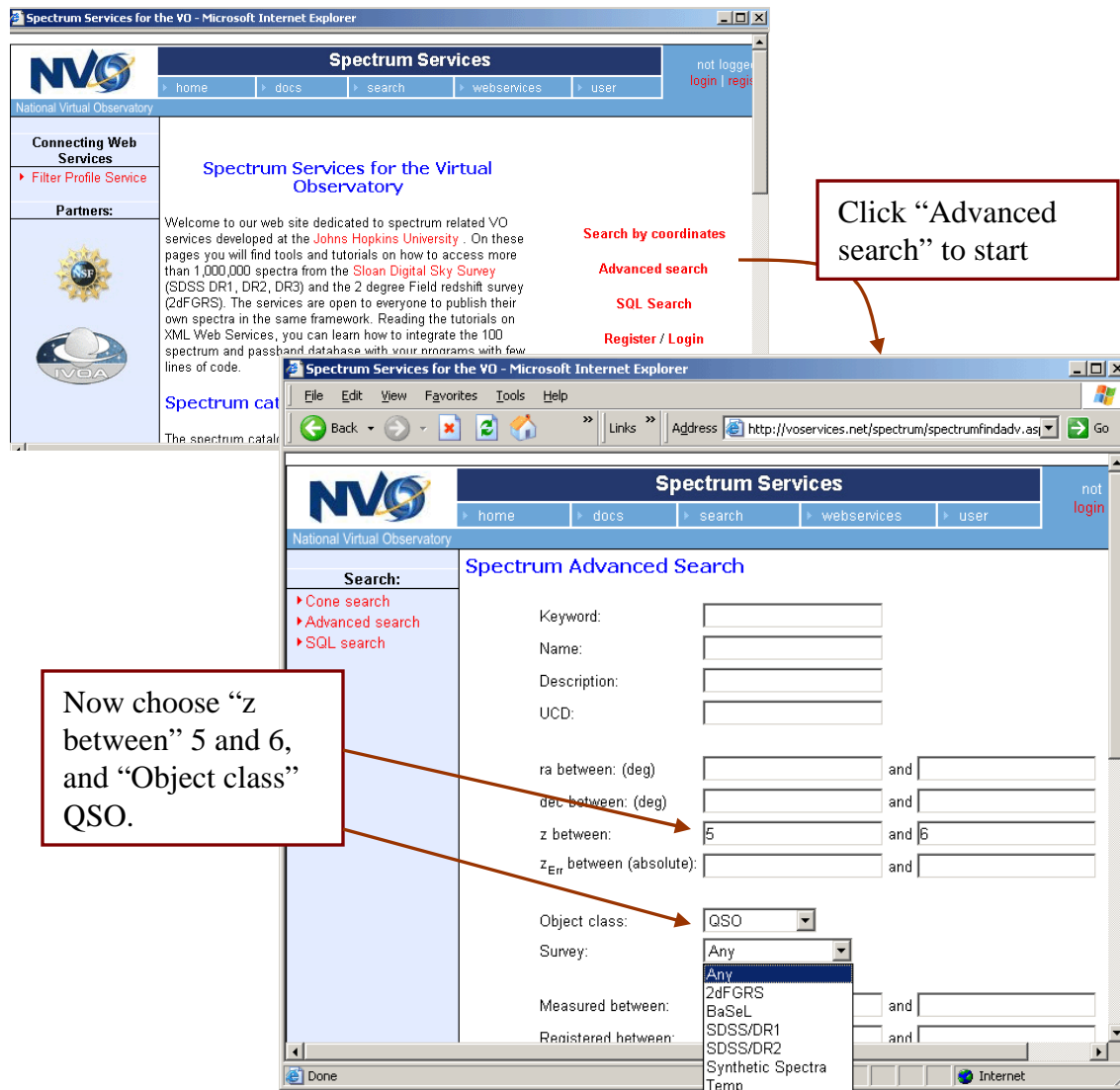


## Spectrum Services

Spectrum services provide a unified interface to many spectral databases, with search by name and coordinates, as well as more advanced queries.

In the following, we search for high-redshift quasars from the Sloan survey, and use the Spectrum Services to identify lines.

This example is oriented to a human-driven, visual investigation – however, we point out that NVO is built with web services, so that access is available to computer programs and data processing pipelines.



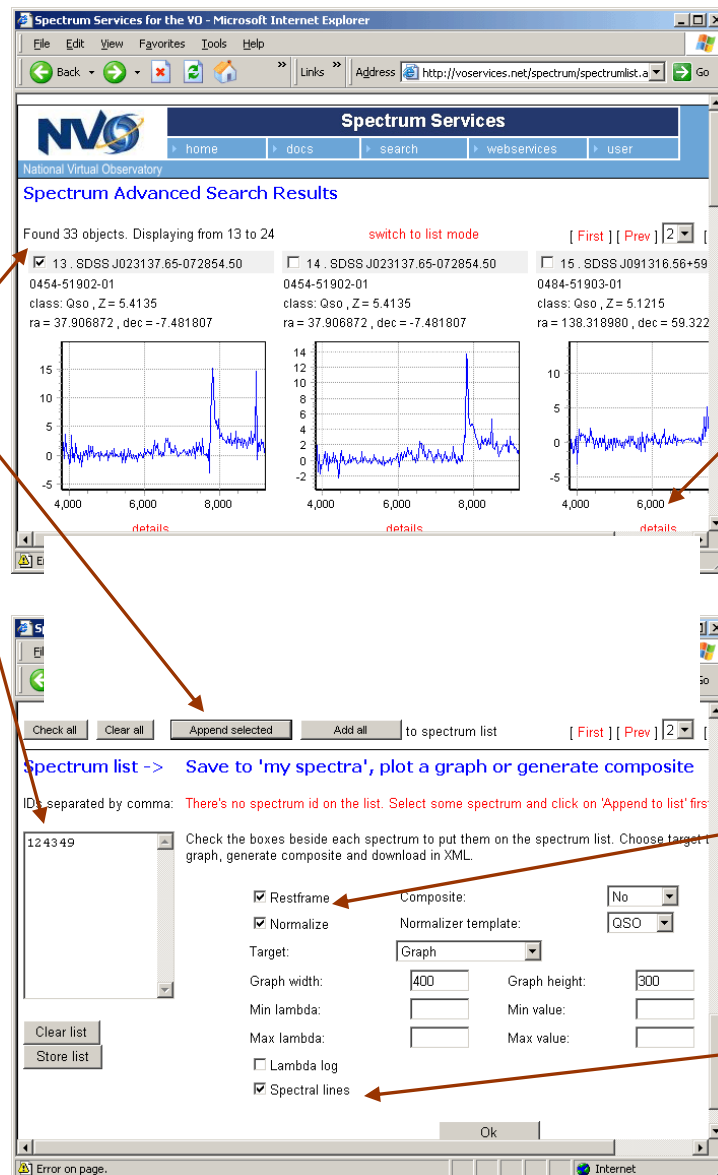
The screenshot shows the NVO Spectrum Services web interface in a Microsoft Internet Explorer browser window. The page title is "Spectrum Services for the V0 - Microsoft Internet Explorer". The main content area is titled "Spectrum Services for the Virtual Observatory" and includes a welcome message from Johns Hopkins University. A sidebar on the left lists "Connecting Web Services" and "Partners".

On the right side of the main content area, there are links for "Search by coordinates", "Advanced search", "SQL Search", and "Register / Login". A red box with an arrow points to the "Advanced search" link, with the text "Click 'Advanced search' to start".

Below the main content area, there is a "Spectrum Advanced Search" form. The form includes fields for "Keyword:", "Name:", "Description:", "UCD:", "ra between: (deg)", "dec between: (deg)", "z between:", "z<sub>err</sub> between (absolute):", "Object class:", "Survey:", "Measured between:", and "Registered between:". The "Object class" dropdown menu is open, showing options: "Any", "2dFGRS", "BaSeL", "SDSS/DR1", "SDSS/DR2", and "Synthetic Spectra". A red box with an arrow points to the "z between:" field, with the text "Now choose 'z between' 5 and 6, and 'Object class' QSO.".

## Spectrum Services

Twenty-four spectra are found that fit the criteria, and each is displayed as a graph, along with position and redshift.



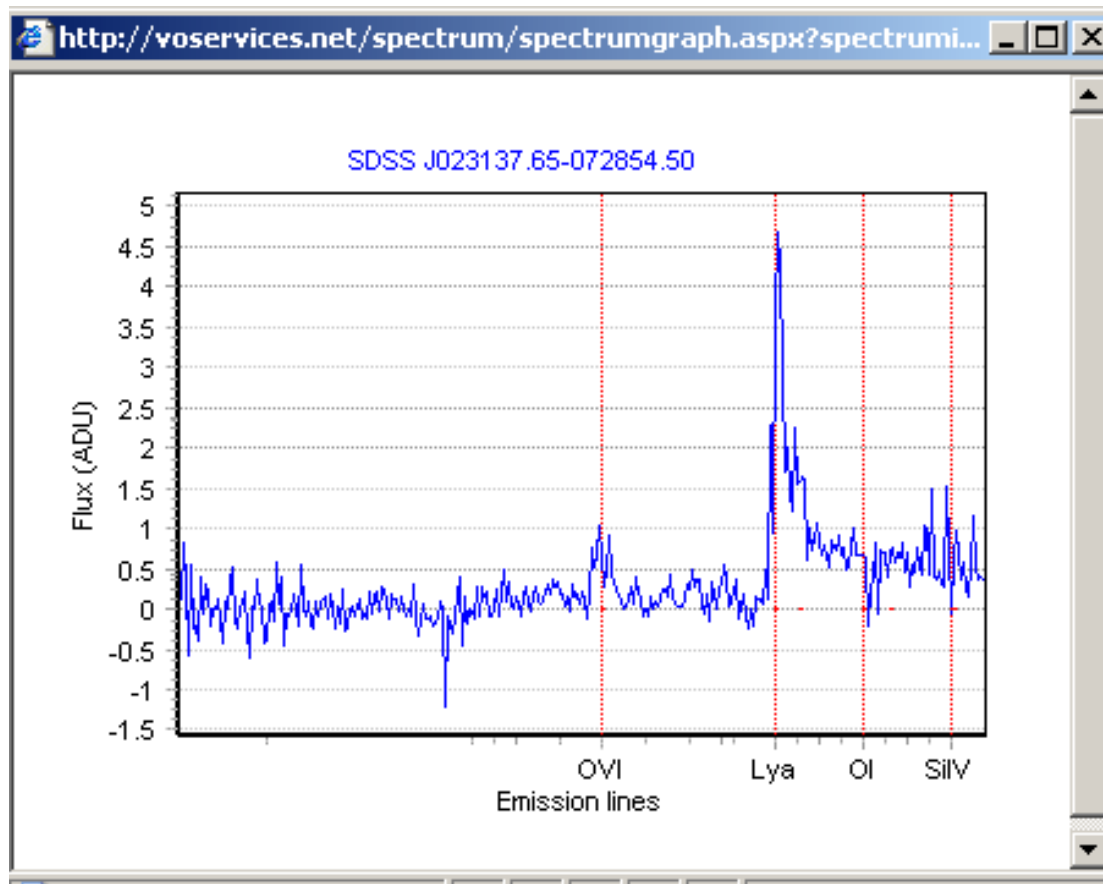
Check the interesting spectra, then click on “Append selected” to put the IDs in the list box at the bottom of the page. This allows further analysis of the spectrum.

Click on “details” to get the data in ASCII, XML, or VOTable formats.

We check “Restframe” and “Spectral lines” to get the spectrum annotated. We can also combine multiple spectra here.

## Spectrum Services

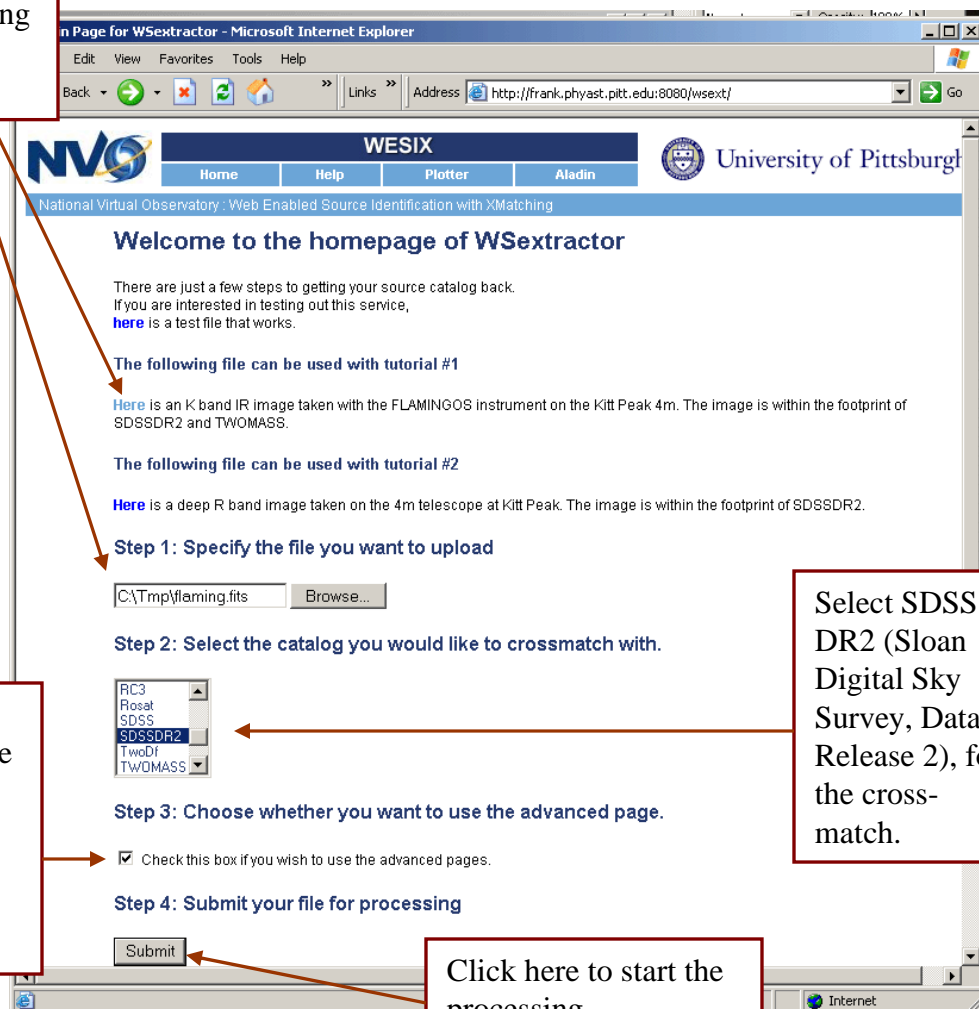
As a result, we get the annotated spectrum of this distant quasar. As always, these services are designed to be used by computer programs also – both generating requests and processing responses.



# Web Enabled Source Identification with Cross-Matching

The Web Enabled Source Identification with Cross-Matching (WESIX) application is a service for source extraction from an astrometric image, followed by cross-match with the major survey catalogs.

We start by downloading a sample image, then uploading it to the application.

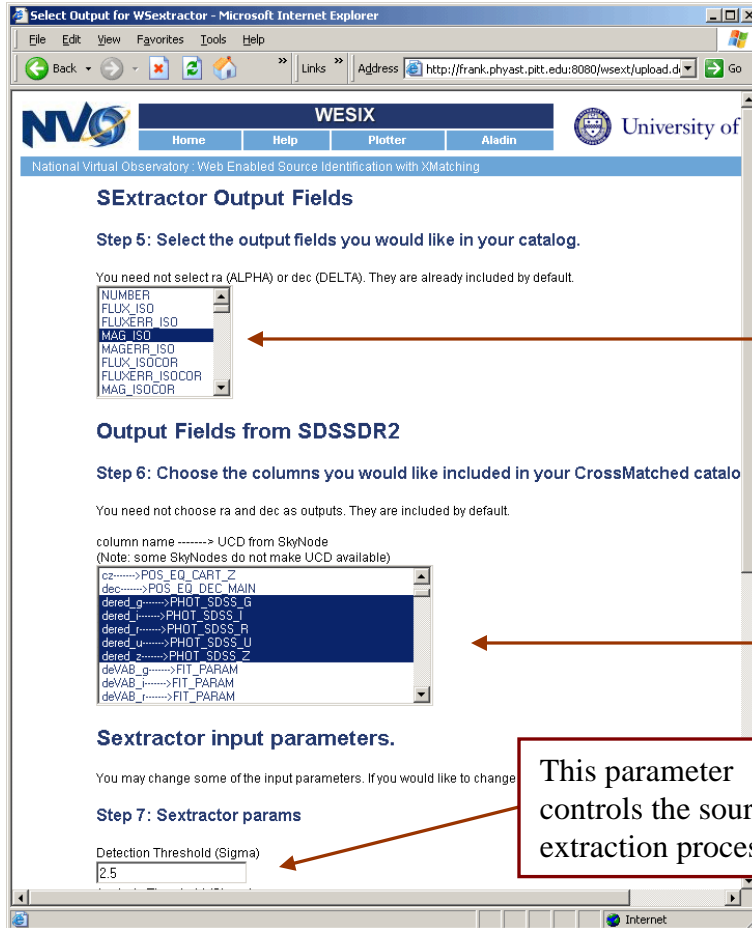


Advanced settings enable selection of detection significance for the source extraction.

Select SDSS DR2 (Sloan Digital Sky Survey, Data Release 2), for the cross-match.

Click here to start the processing.

## Web Enabled Source Identification with Cross-Matching



Select Output for WSExtractor - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://frank.phyast.pitt.edu:8080/wsxt/upload.d

**NVO** **WESIX** University of Pittsburgh

National Virtual Observatory : Web Enabled Source Identification with XMatching

### SExtractor Output Fields

Step 5: Select the output fields you would like in your catalog.

You need not select ra (ALPHA) or dec (DELTA). They are already included by default.

NUMBER  
FLUX\_ISO  
FLUXERR\_ISO  
**MAG\_ISO**  
MAGERR\_ISO  
FLUX\_ISOCOR  
FLUXERR\_ISOCOR  
MAG\_ISOCOR

### Output Fields from SDSSDR2

Step 6: Choose the columns you would like included in your CrossMatched catalog

You need not choose ra and dec as outputs. They are included by default.

column name -----> UCD from SkyNode  
(Note: some SkyNodes do not make UCD available)

cz----->POS\_EQ\_CART\_Z  
dec----->POS\_EQ\_DEC\_MAIN  
dered\_g----->PHOT\_SDSS\_G  
dered\_i----->PHOT\_SDSS\_I  
dered\_r----->PHOT\_SDSS\_R  
dered\_u----->PHOT\_SDSS\_U  
dered\_z----->PHOT\_SDSS\_Z  
devAB\_g----->FIT\_PARAM  
devAB\_i----->FIT\_PARAM  
devAB\_r----->FIT\_PARAM

### SExtractor input parameters.

You may change some of the input parameters. If you would like to change

Step 7: SExtractor params

Detection Threshold (Sigma)  
2.5

The source extraction (SExtractor) makes a table with these attributes. Select what is wanted in the cross-matched table

The selected survey catalog (SDSS DR2) has these fields. Select what is wanted in the cross-matched table

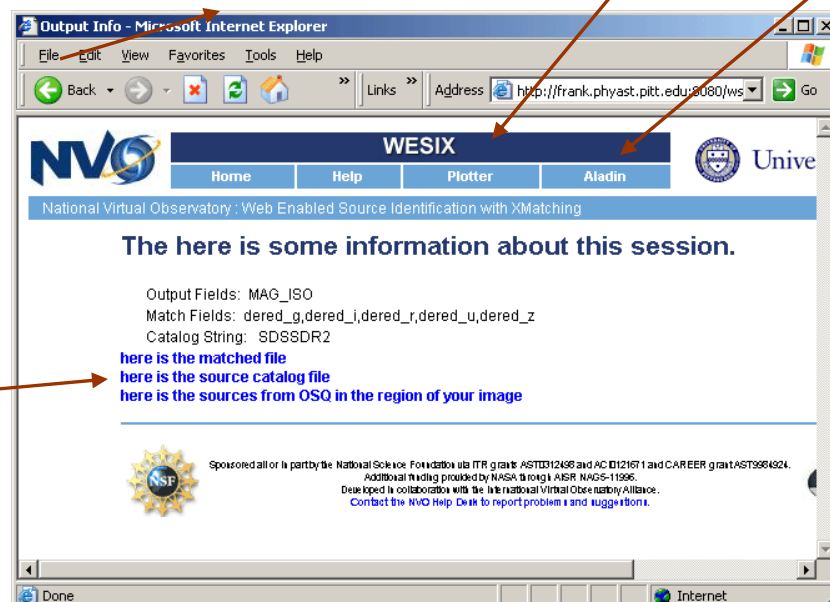
This parameter controls the source extraction process

Click on "Plotter" for a catalog view.

Click on "Aladin" for an image view.

Click "submit"

Here are the XML files with the resulting data.



Output Info - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://frank.phyast.pitt.edu:8080/ws


**NVO** **WESIX** University of Pittsburgh

National Virtual Observatory : Web Enabled Source Identification with XMatching

### The here is some information about this session.

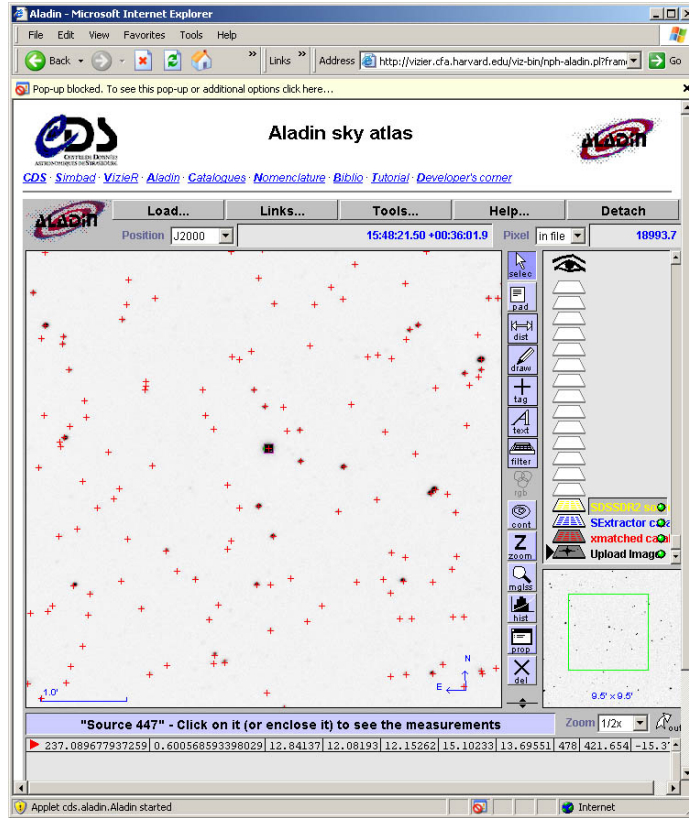
Output Fields: MAG\_ISO  
Match Fields: dered\_g,dered\_i,dered\_r,dered\_u,dered\_z  
Catalog String: SDSSDR2

[here is the matched file](#)  
[here is the source catalog file](#)  
[here is the sources from OSQ in the region of your image](#)

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Developed in collaboration with the National Virtual Observatory Alliance.  
Contact the NVO Help Desk to report problems and suggestions.



## Web Enabled Source Identification with Cross-Matching



Aladin shows the original image with the extracted sources, with the survey sources (SDSS), and with the cross-match of them.

VOPlot shows the catalog view. In this case, the plot shows the magnitude extracted from the image, against the SDSS z magnitude.

