

The image shows the ALFALFA radio telescope, a large parabolic dish mounted on a complex metal structure, suspended by cables. It is set against a backdrop of a sunset or sunrise over a forested valley with a body of water. The sky is a mix of blue, orange, and white clouds. The entire scene is framed by a white, curved border that follows the top and bottom edges of the image.

# *ALFALFA Data Access*

# VO and ALFALFA: Why worry about it?

- At least 20,000 detections expected with
  - Positions, redshifts, fluxes, velocity widths, etc.
- Easy cross referencing with other databases and surveys is desirable given that:
  - It is platform independent...
  - A “smart” data format that can be read by any program of choice, and that can describe itself and its contents to any future programs.
  - Applications are easy to write in any language!

# Virtual Observatory

*What in the galaxy is it?*

- Initiative to create **standards** for the ever-increasing amount astronomical data
- Specify a well-defined framework for all possible **astronomical quantities and their unit systems**.
- Develop platform independent system of **software tools and applications** that utilize the framework and standards.



# Enter VOTable...

- Important part of VO framework
- Uses the very common **XML** (e**X**tensible **M**arkup **L**anguage) to tabulate data, but also describe the contents, quantities and units via *metadata* from **UCDs** (**U**nified **C**ontent **D**escriptors).
- The XML format is advantageous as it can read by many programs, which can automatically sort and recognize the contents based on the data descriptions.
- XML files can be easily formatted to display in web browsers, spreadsheets, and data analysis programs – ie HTML, Excel, IDL, VOplot, Aladin.

## VOTable: Why use it?

- VOTable (and XML/XSLT stylesheets in general) can be *directly* used to cross reference with other existing databases. Vizier, SDSS, 2MASS, and all major astro website and large surveys allow VOTable output...as should ALFALFA!

# VOTable tree structure

```
- <VOTABLE>
- <DESCRIPTION>
  Arecibo Legacy Fast ALFA Survey http://egg.astro.cornell.edu/precursor/
</DESCRIPTION>
- <RESOURCE>
- <TABLE>
  <FIELD datatype="char" name="sourcename" ucd="meta.id" arraysize="*" />
  <FIELD unit="degrees" datatype="float" name="ra" ucd="pos.eq.ra" />
  <FIELD unit="degrees" datatype="float" name="dec" ucd="pos.eq.dec" />
  <FIELD unit="km/s" datatype="short" name="vhelio" ucd="spect.veloc" />
  <FIELD unit="km/s" datatype="int" name="velwidth" ucd="spect.line.width" />
  <FIELD unit="mJy" datatype="float" name="rms" ucd="stat.stdec" />
  <FIELD unit="Jy km/s" datatype="char" name="flux" ucd="phot.count" arraysize="*" />
- <DATA>
  - <TABLEDATA>
    - <TR>
      <TD>HI001709.7+271616</TD>
      <TD>4.29042</TD>
      <TD>27.2711</TD>
      <TD>3707</TD>
      <TD>150</TD>
      <TD>3.10000</TD>
      <TD>1.42000</TD>
    </TR>
    - <TR>
      <TD>HI002115.8+262318</TD>
      <TD>5.31583</TD>
      <TD>26.3883</TD>
      <TD>9210</TD>
      <TD>158</TD>
      <TD>2.02000</TD>
      <TD>1.06000</TD>
    </TR>
    - <TR>
      <TD>HI002312.5+272644</TD>
```

# Tools with VO accessibility

- VOPlot –  
via Java download or implemented as a  
plugin through a webBrowser
- Aladin – via CDS
- TOPCAT
- Mirage
- And many others!

# Relational Database - SQL

- A database in the Structured Query Language is easily queried by many languages (C, Java, Python, PHP), and database interfaces are easily designed to suit the user's purpose.



## Database cross match

- VOTable can be read into OpenSkyQuery or SDSS CasJOBS and SQL queries can run between the datasets and return desired quantities.
- Results can be pushed directly to any VO ready program, or saved for later analysis.

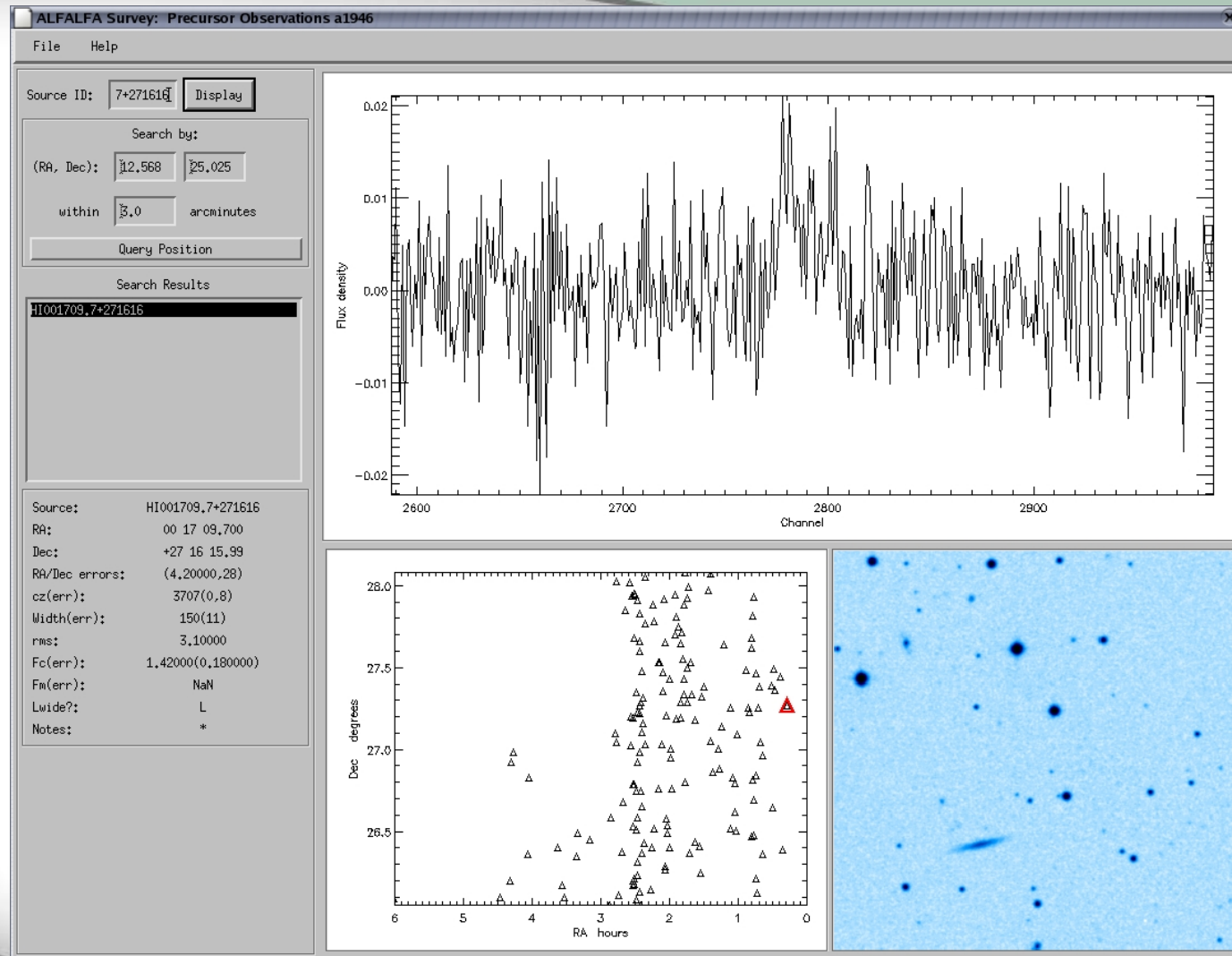
A large satellite dish antenna is suspended by a complex system of cables and a metal truss structure. The dish is pointed downwards. The background shows a sunset sky with soft orange and yellow light, and a dark, forested landscape with a body of water in the foreground. The entire image is framed by a white, curved border.

# USER SCENARIOS

# User 1: IDL

## *Browsing data on a local system*

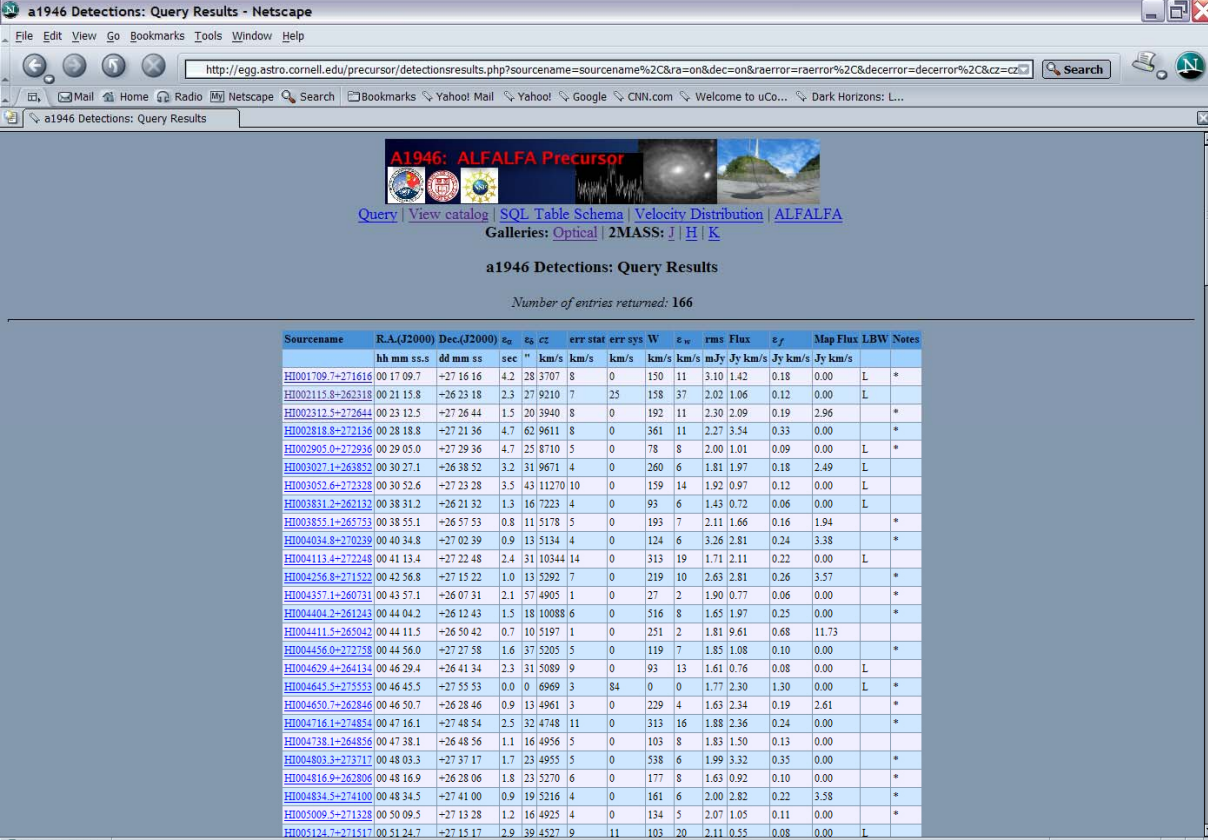
- Solution: IDL can be used to view data in raw or catalog form – browser can be created to view source detections. View catalog information on object, as well as DSS image.



# User 2: Web access

*user can query a database via convenient web form*

- SQL database is created from ALFALFA detections. Web page allows catalog browsing and query actions.



**a1946 Detections: Query Results - Netscape**

http://egg.astro.cornell.edu/precursor/detectionsresults.php?sourcename=sourcename%2C&ra=on&dec=on&raerror=raerror%2C&decerror=decerror%2C&cz=cz%2C

**a1946 Detections: Query Results**

**A1946: ALFALFA Precursor**

[Query](#) | [View catalog](#) | [SQL Table Schema](#) | [Velocity Distribution](#) | [ALFALFA](#)

Galleries: [Optical](#) | [2MASS](#): [J](#) | [H](#) | [K](#)

**a1946 Detections: Query Results**

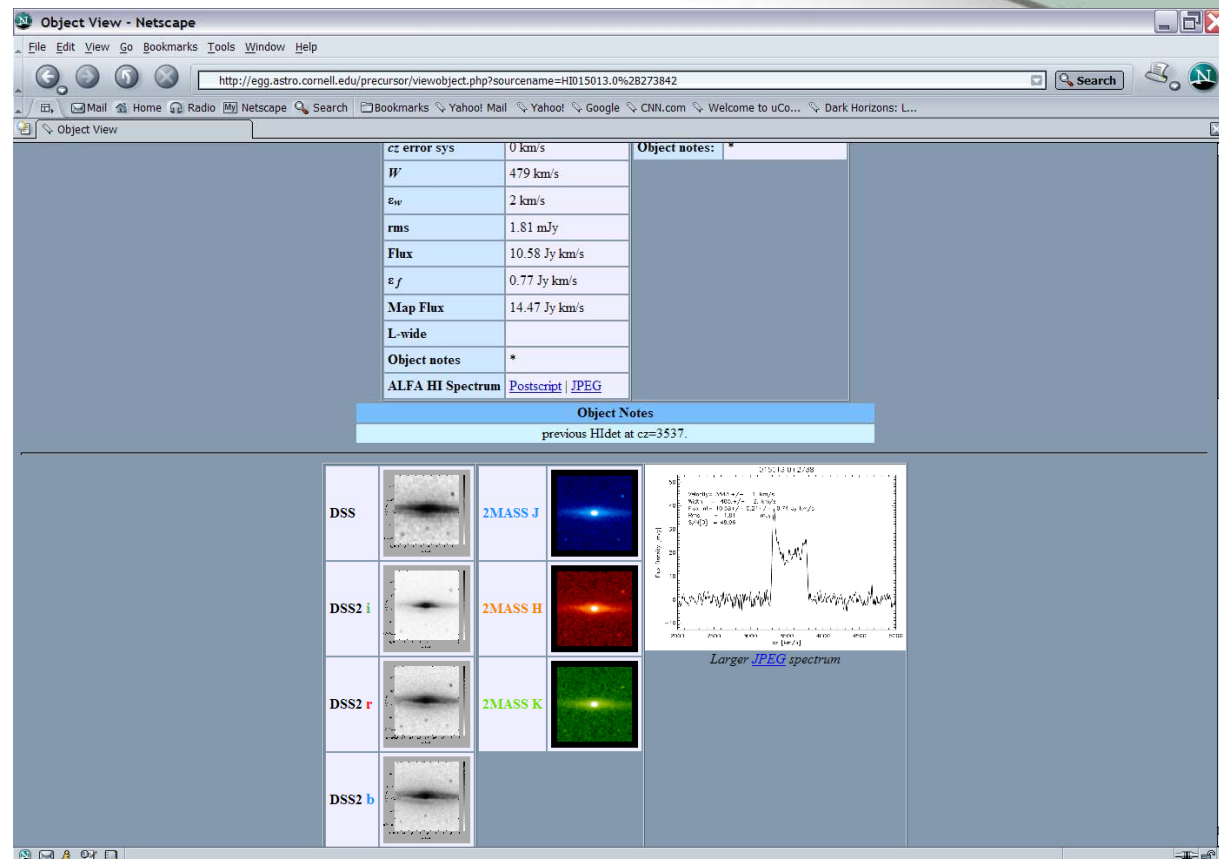
Number of entries returned: 166

Source name	R.A.(J2000)	Dec.(J2000)	$\epsilon_{\text{R.A.}}$	$\epsilon_{\text{Dec.}}$	err stat	err sys	W	$\epsilon_{\text{W}}$	rms Flux	$\epsilon_{\text{F}}$	Map Flux	LBW	Notes
hh mm ss.s	dd mm ss	sec "	km/s	km/s	km/s	km/s	km/s	mJy	Jy	km/s	Jy	km/s	
HI001709.7+271616	00 17 09.7	+27 16 16	4.2	28 3707	8	0	150	11	3.10	1.42	0.18	0.00	L *
HI002115.8+262318	00 21 15.8	+26 23 18	2.3	27 9210	7	25	158	37	2.02	1.06	0.12	0.00	L
HI002312.5+272644	00 23 12.5	+27 26 44	1.5	20 3940	8	0	192	11	2.30	2.09	0.19	2.96	*
HI002818.9+272136	00 28 18.8	+27 21 36	4.7	62 9611	8	0	361	11	2.27	3.54	0.33	0.00	*
HI002905.0+272936	00 29 05.0	+27 29 36	4.7	25 8710	5	0	78	8	2.00	1.01	0.09	0.00	L *
HI003027.1+263853	00 30 27.1	+26 38 52	3.2	31 9671	4	0	260	6	1.81	1.97	0.18	2.49	L
HI003052.6+272328	00 30 52.6	+27 23 28	3.5	43 11270	10	0	159	14	1.92	0.97	0.12	0.00	L
HI003831.2+262132	00 38 31.2	+26 21 32	1.3	16 7223	4	0	93	6	1.43	0.72	0.06	0.00	L
HI003855.1+265753	00 38 55.1	+26 57 53	0.8	11 5178	5	0	193	7	2.11	1.66	0.16	1.94	*
HI004034.9+270239	00 40 34.8	+27 02 39	0.9	13 5134	4	0	124	6	3.26	2.81	0.24	3.38	*
HI004113.4+272248	00 41 13.4	+27 22 48	2.4	31 10344	14	0	313	19	1.71	2.11	0.22	0.00	L
HI004256.8+271522	00 42 56.8	+27 15 22	1.0	13 5292	7	0	219	10	2.63	2.81	0.26	3.57	*
HI004357.1+260731	00 43 57.1	+26 07 31	2.1	57 4905	1	0	27	2	1.90	0.77	0.06	0.00	*
HI004404.2+261243	00 44 04.2	+26 12 43	1.5	18 10088	6	0	516	8	1.65	1.97	0.25	0.00	*
HI004411.5+265042	00 44 11.5	+26 50 42	0.7	10 5197	1	0	251	2	1.81	9.61	0.68	11.73	
HI004456.0+272758	00 44 56.0	+27 27 58	1.6	37 5205	5	0	119	7	1.85	1.08	0.10	0.00	*
HI004639.4+264134	00 46 29.4	+26 41 34	2.3	31 5089	9	0	93	13	1.61	0.76	0.08	0.00	L
HI004645.5+275555	00 46 45.5	+27 55 55	0.0	0 6969	3	84	0	0	1.77	2.30	1.30	0.00	L *
HI004650.7+262846	00 46 50.7	+26 28 46	0.9	13 4961	3	0	229	4	1.63	2.34	0.19	2.61	*
HI004716.1+274854	00 47 16.1	+27 48 54	2.5	32 4748	11	0	313	16	1.88	2.36	0.24	0.00	*
HI004738.1+264856	00 47 38.1	+26 48 56	1.1	16 4956	5	0	103	8	1.83	1.50	0.13	0.00	
HI004803.3+273717	00 48 03.3	+27 37 17	1.7	23 4955	5	0	538	6	1.99	3.32	0.35	0.00	*
HI004816.9+262806	00 48 16.9	+26 28 06	1.8	23 5270	6	0	177	8	1.63	0.92	0.10	0.00	*
HI004834.5+274100	00 48 34.5	+27 41 00	0.9	19 5216	4	0	161	6	2.00	2.82	0.22	3.58	*
HI005009.5+271328	00 50 09.5	+27 13 28	1.2	16 4925	4	0	134	5	2.07	1.05	0.11	0.00	*
HI005124.7+271517	00 51 24.7	+27 15 17	2.9	39 4527	9	11	103	20	2.11	0.55	0.08	0.00	L

# User 2: Web access

*user can query a database via convenient web form*

- SQL database is created from ALFALFA detections. Web page allows catalog browsing and query actions.
- DSS and 2MASS image are displayed, as well as spectra and postscript files.

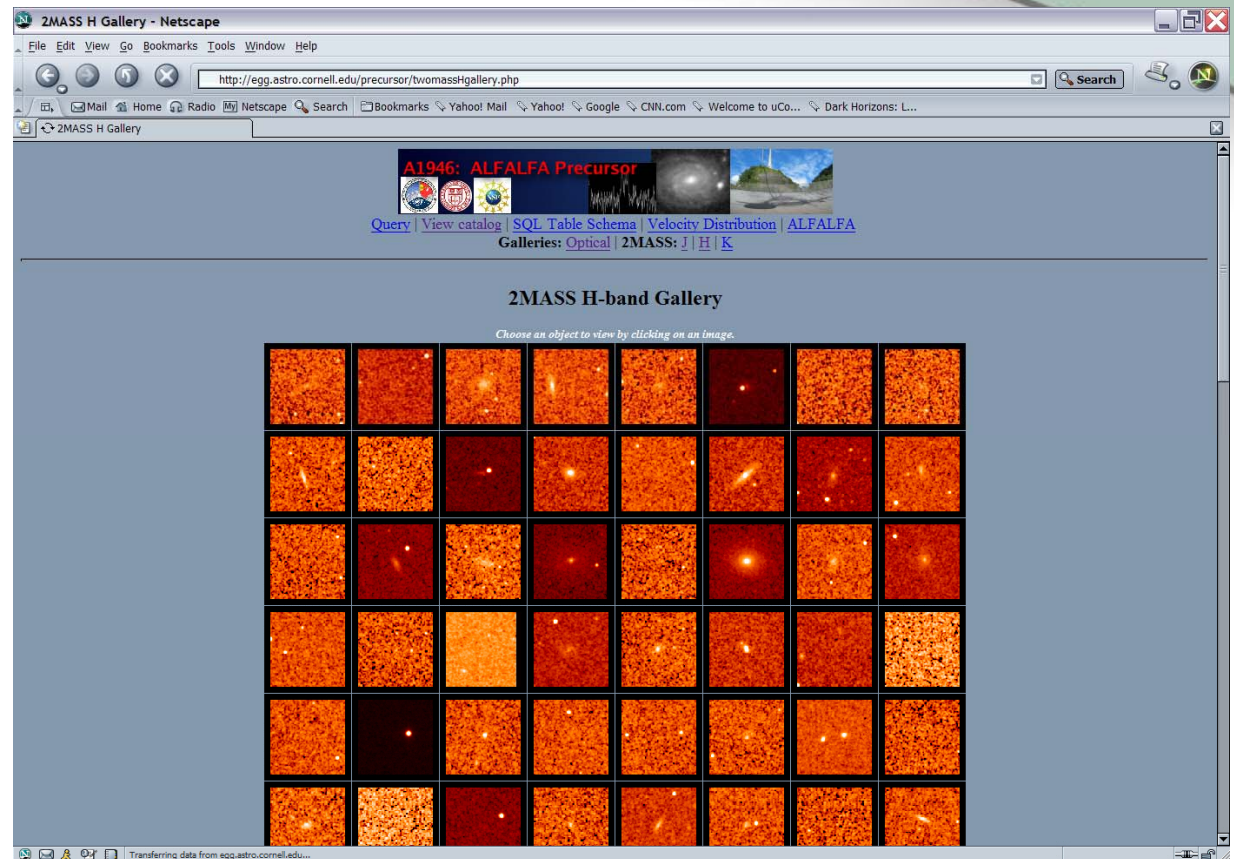




# User 2: Web access

*user can query a database via convenient web form*

- SQL database is created from ALFALFA detections. Web page allows catalog browsing and query actions.
- Image galleries also available.



## User 3: Science exploration

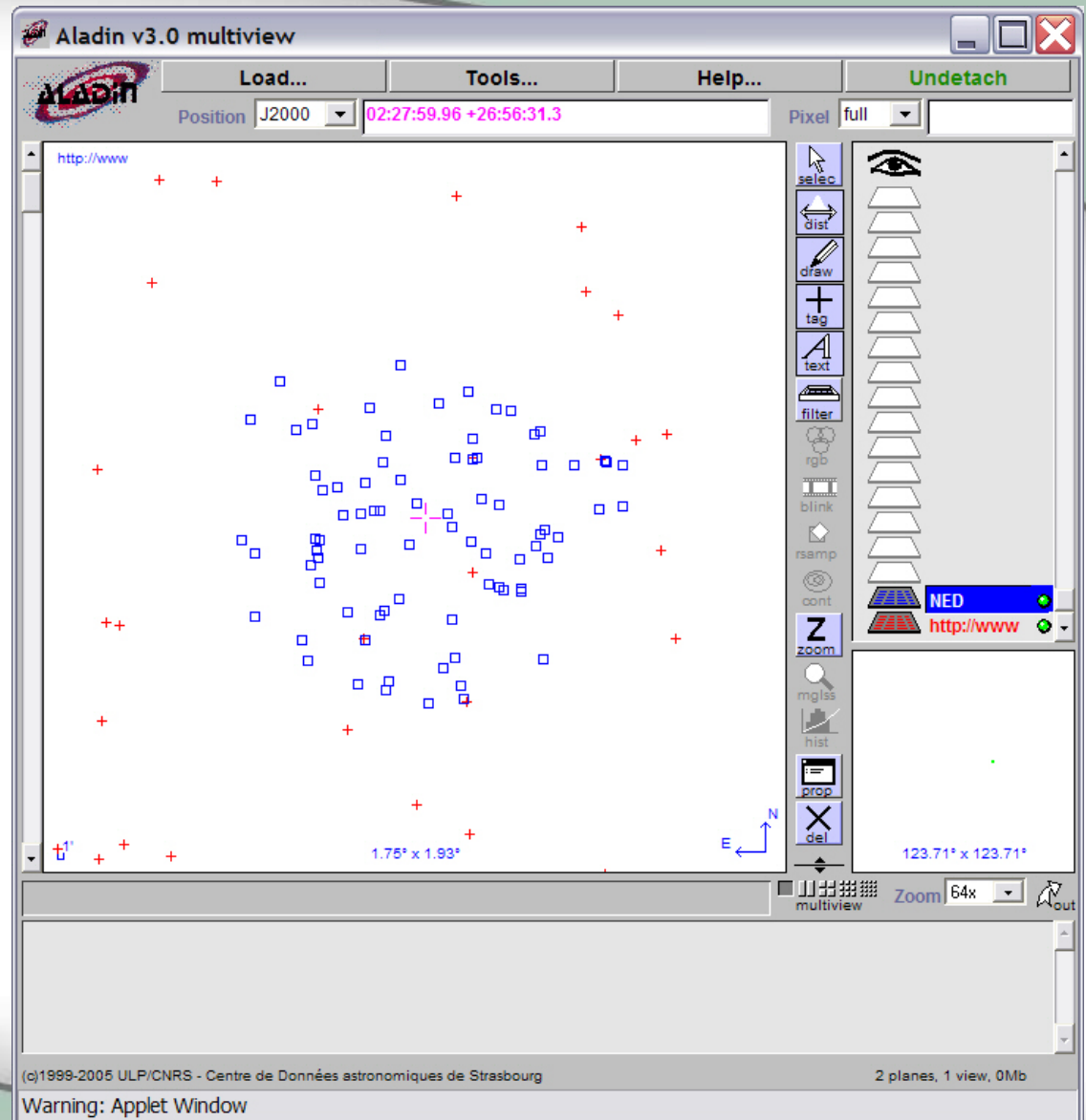
*Staring at pictures and spectra is nice, but I want to do data exploration with other resources!*

- Data is available in a VOTable format.
- Aladin can be used to cross reference with many catalogs and surveys, including SDSS, NED, Skyview, etc.
- VOPlot can plot results and histograms via a stand alone application, or as a Java browser plugin.

# User 3: Application

## *NED match with Aladin*

- VOTable is loaded directly from the ALFALFA website. As the UCDs can be read by Aladin, it can recognize coordinates and over plot NED entries within a specified radius of a queried position.





# User 3: Application

## *Cross match with multiple databases*

- Using OpenSkyQuery, the user can match ALFALFA sources against a number of databases, and choose the information about the results that should be returned. A form of SQL is used, but premade queries exist, or the user can drag and drop the desired entries.

The screenshot shows the Open SkyQuery web application running in a Microsoft Internet Explorer browser. The browser's address bar displays the URL: `http://openskyquery.net/Sky/SkySite/browse/Browse.aspx#`. The application interface is titled "Open SkyQuery" and includes a navigation menu with links for Home, Query, Import, Tutorial, and Help. Below the navigation menu, there is a "National Virtual Observatory" section with a "Nodes" list on the left and a "Build" tab for constructing queries. The "Nodes" list includes various astronomical databases such as Rosat, XMM, GALEX, DLS, RC3, SDSS, SDSSDR2, TwoDf, Twoqz, USNOB, GOODS, HDFN, HDF5, UDF, ISO, TWOMASS, IRAS, PSCz, ADIL, FIRST, NVSS, MyData, DEEP2, NDWFS, NVORegistry, phoenix, POSSUM\_mini, and sxds\_skynode. The "Build" tab shows a query editor with the following SQL query:

```
SELECT o.objid, o.ra,
       o.dec, t.ra, t.dec
FROM
  SDSS:PhotoPrimary o, MyData:MyTable t
WHERE XMATCH(o, t) < 2.5
```

Below the query editor, there is a "Submit" button and a "Sample Queries" list on the right. The "Sample Queries" list includes: XMatch/Region, XMatch/Region 2, Three Node Match, Brown Dwarf Search, MyData XMatch (upload), Xmatch t\* (upload), ABELL Xmatch (upload), Single Node Query, and Single Node Join. At the bottom of the interface, there are buttons for "Sigmas", "Region", and "Clear", and a version string "Version: v1\_0\_9 US-VO.org".

# Resources

- Virtual Observatory: <http://www.ivoa.net/>
- VO Table: <http://www.us-vo.org/VOTable/>
- VO Libraries: <http://www.ivoa.net/twiki/bin/view/IVOA/VOTableSoftware>
- VO Tools: <http://www.us-vo.org/projects/tools.cfm>
- ALFALFA precursor data: <http://egg.astro.cornell.edu/precursor/>
- OpenSkyQuery: <http://openskyquery.net/Sky/skysite/>