

# Virtual Observatories

Introduction for VO Workshop

*Krakow, Poland, June 16-18, 2014*

Mark Allen - Observatoire de Strasbourg, France





# Vision

- Archives and databases form a 'digital sky'
- New possibilities via data discovery, efficient data access and interoperability

## Driven by:

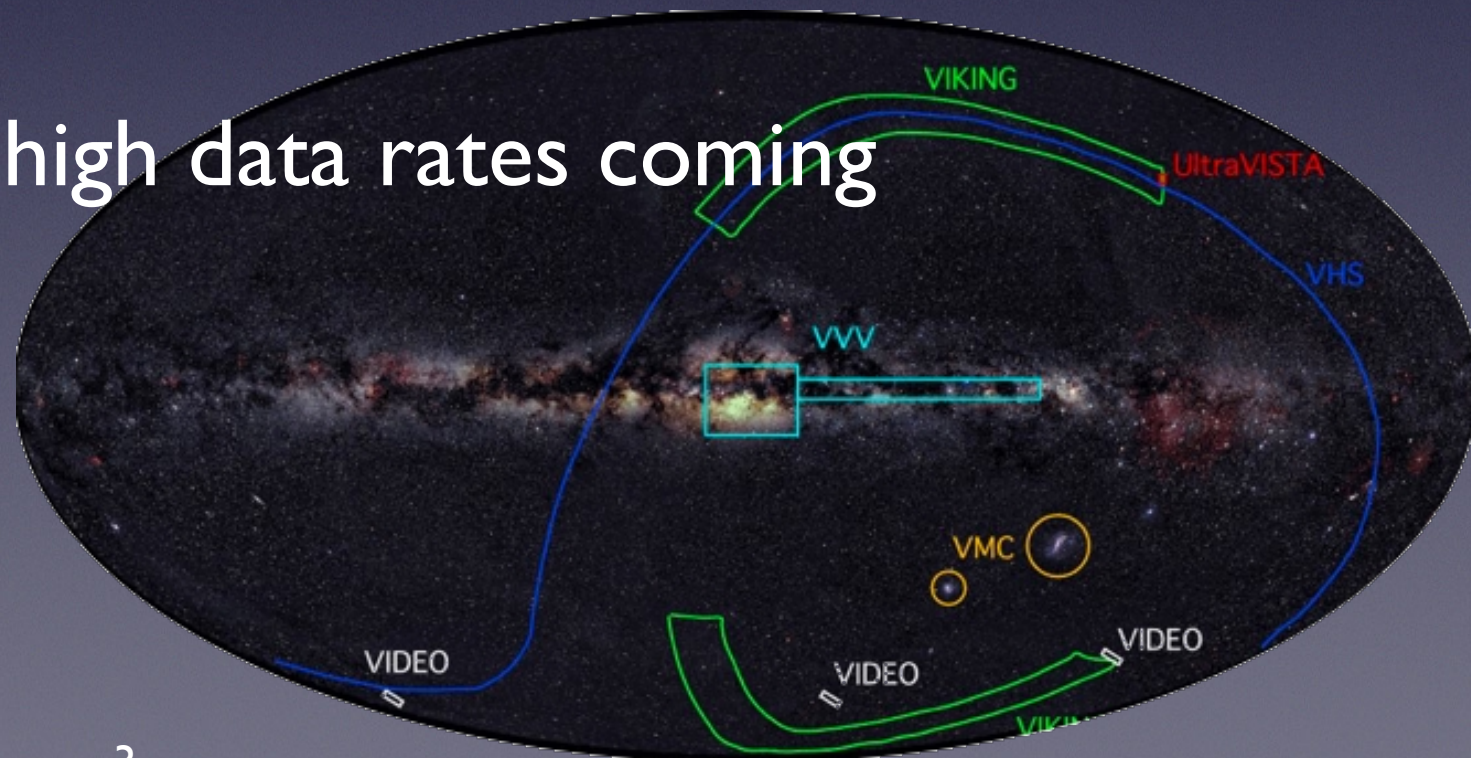
- Exploding data rates
- Multi- $\lambda$ , time-domain & survey science
- Astronomers demand/expectation of interoperability



# data data data

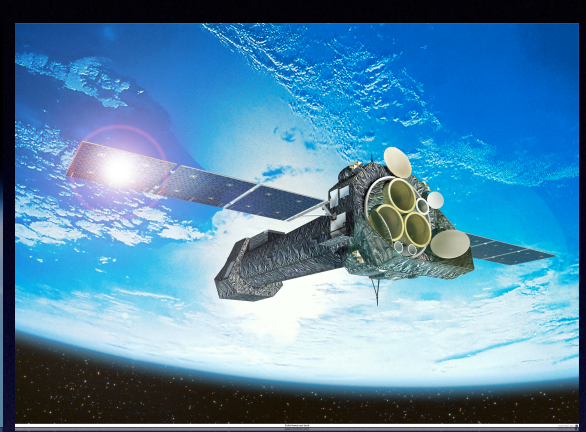
- Science goals require very large data sets
  - ★ **large number of objects** - data mining / statistics
  - ★ **large objects!** - star streams in the Milky Way

- Sky surveys ~ 100 TB, high data rates coming  
e.g. LSST 5 PB/yr





# Multi- $\lambda$ Astronomy



- Different data types and formats
- Customised archive interfaces and data access methods
- Different analysis tools and techniques



# VO aims to

- Take advantage of the data explosion
- Allow astronomers to interrogate multiple data centres in a seamless way
- Permit remote computing and data analysis
- Foster *new science*



# Virtual Observatory

- Framework for interoperable and efficient access to astronomical data and services
- *e-Science* for Astronomy
- Based on global standards
  - co-ordination via IVOA
  - Science Priorities
  - Connections to data centres





# European Status

- National VO projects + ESA-VO
- Coordinated by Euro-VO The logo for Euro-VO, featuring the word "EUROVO" in a bold, blue, sans-serif font. The "VO" part is stylized with a grid of blue dots, and the entire logo is set against a white background with a blue border.
- Recognised in ASTRONET infrastructure roadmap
- Series of EC funded projects from ~2001
- **CoSADIE** : Collaborative and Sustainable Astronomical Data Infrastructure for Europe



# CoSADIE aims

- Two aspects
  - Continue the coordination of European VO activities - *Hands-on schools, Engage Data Centres, Tech-development, Education*
  - Study all aspects of Euro-VO sustainability: assess the needs and establish a plan for a sustainable Euro-VO, in close collaboration with ASTRONET

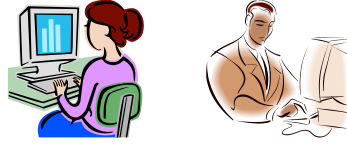


# How does it work?

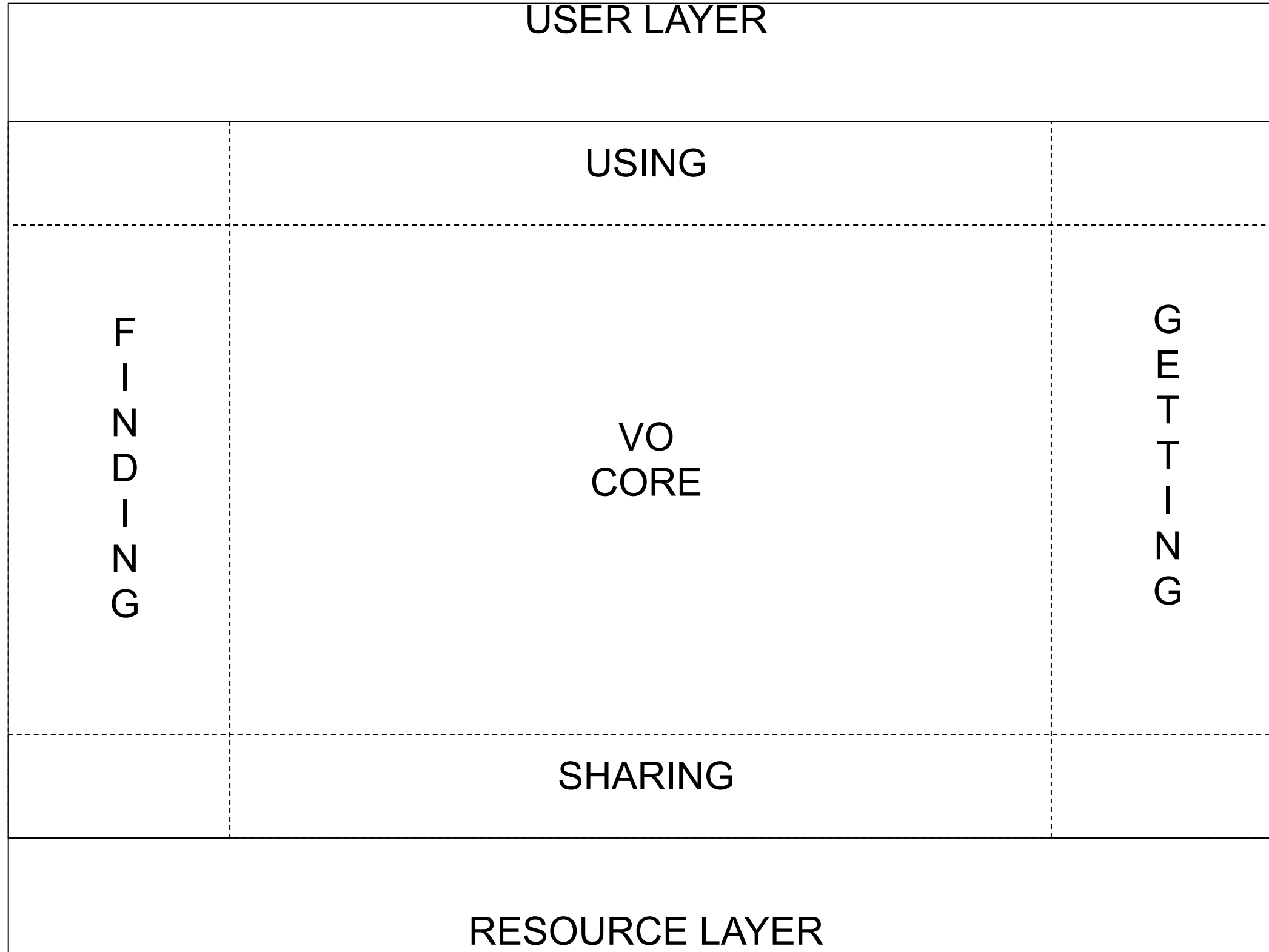


# LEVEL 0

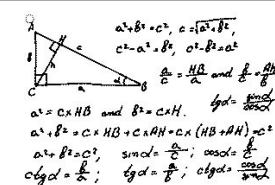
## USERS



## COMPUTERS



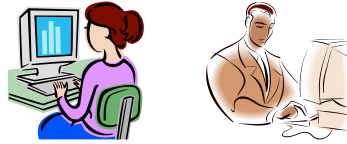
## PROVIDERS



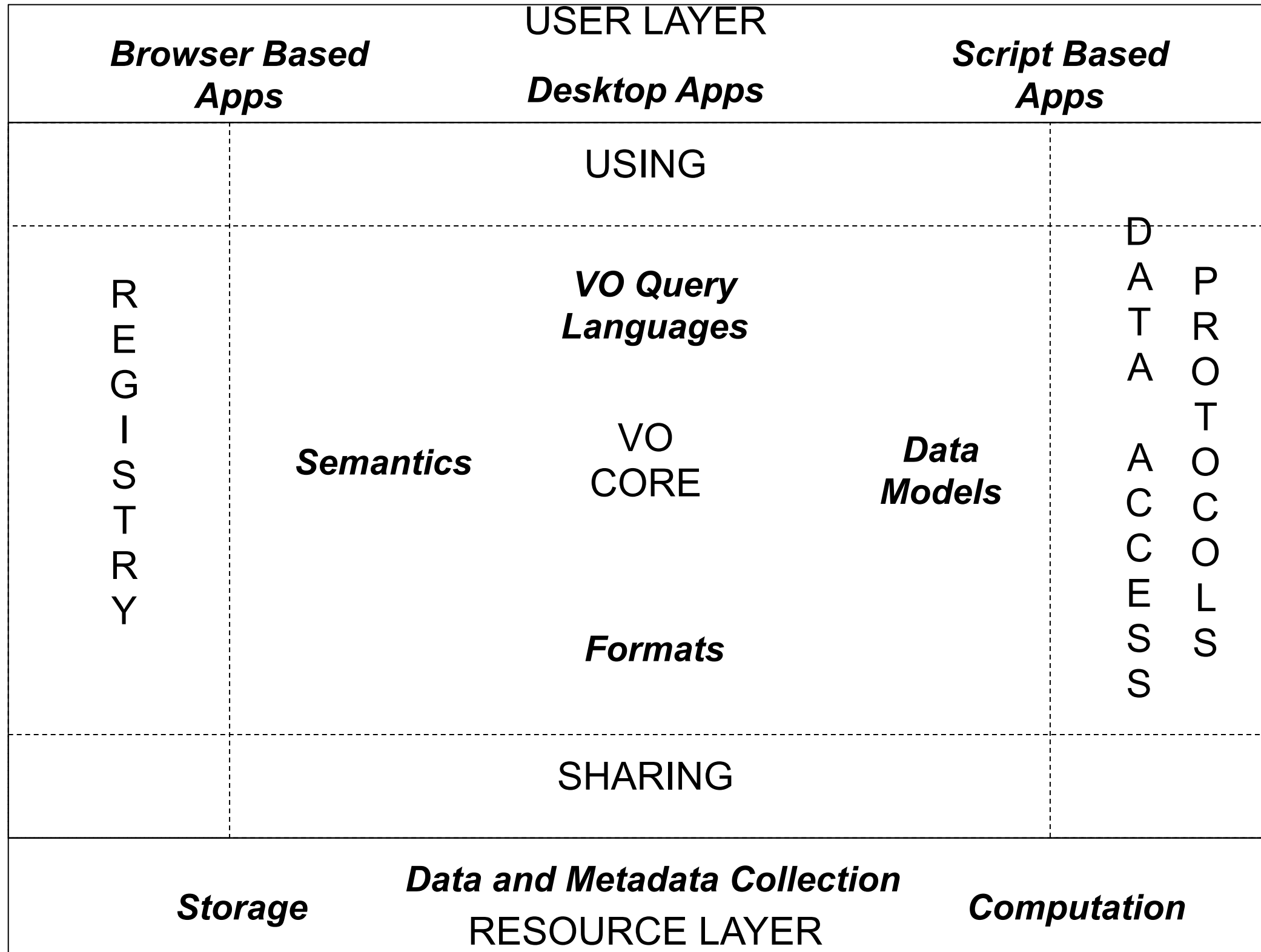


**LEVEL 1**

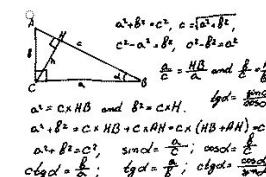
**USERS**



**COMPUTERS**



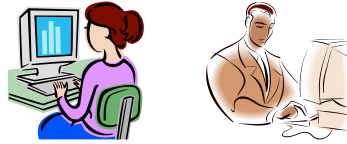
**PROVIDERS**





**LEVEL 2**

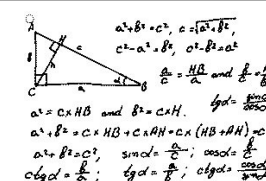
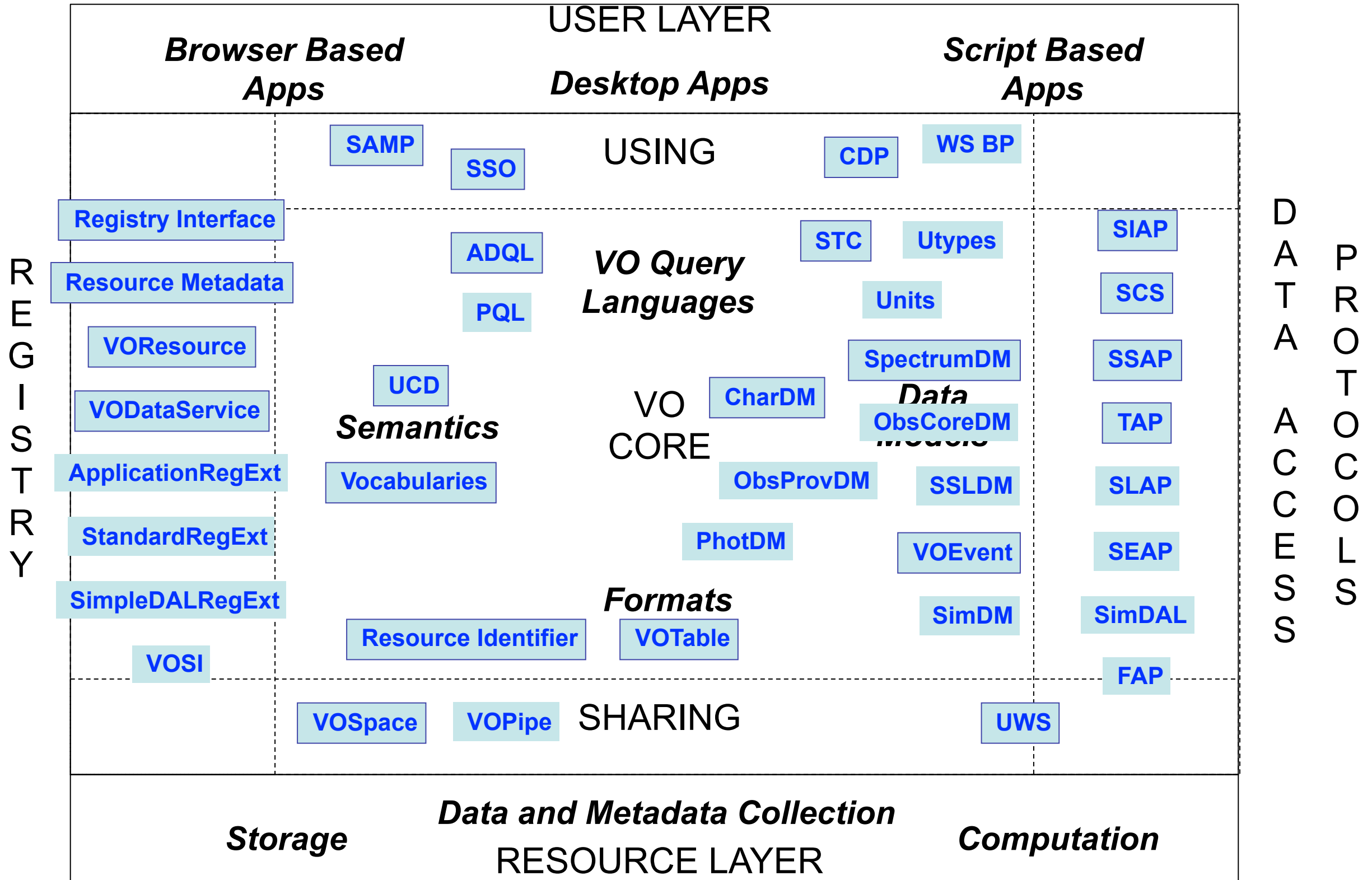
**USERS**



**COMPUTERS**

REC

InProgress





# Science Priorities

- Gathered from Astro community via national projects
- Focused on specific scientific areas:
  - *Time Series*
  - *Multi-dimensional Data (Radio/IFU/simulation...)*
  - *Spectral Energy Distributions*
  - *Query by object classification and lists*
  - *Query via core observational parameters*





## Science Priority Areas

# Multi-dimensional Data

Radio astronomy, Integral Field Spectroscopy, high energy, polarization, simulation, data mining datasets + ...

# Time Domain Astronomy

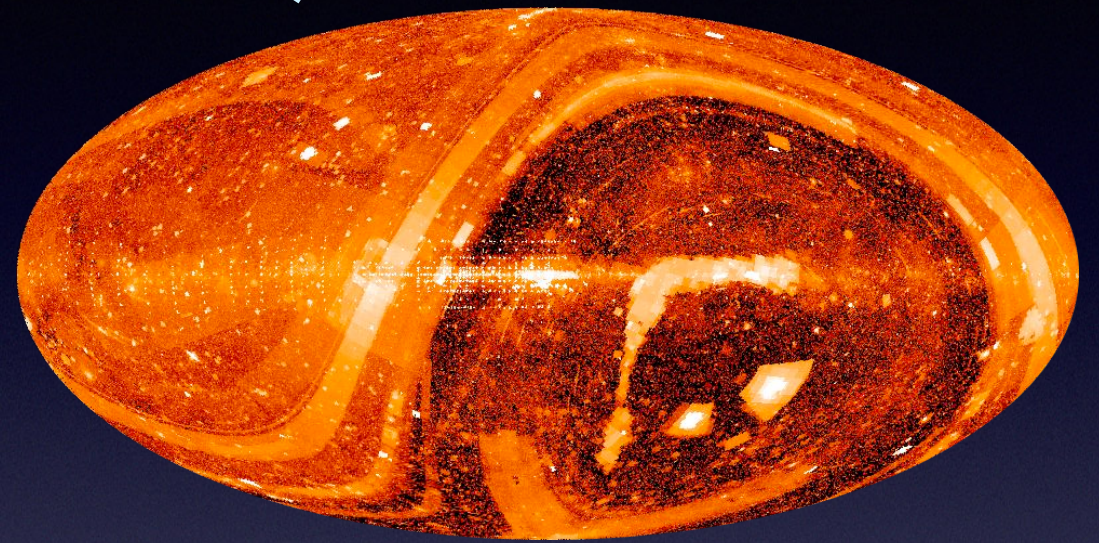
Time Series, light curves, transient event reports, +...

- Need to ensure that these are accessible and useable within the VO



# VO Standards implemented in the CDS Data Centre

Registry Interface



TAP  
VOTable

Reference service for object names



UCD  
VOTable  
TAP

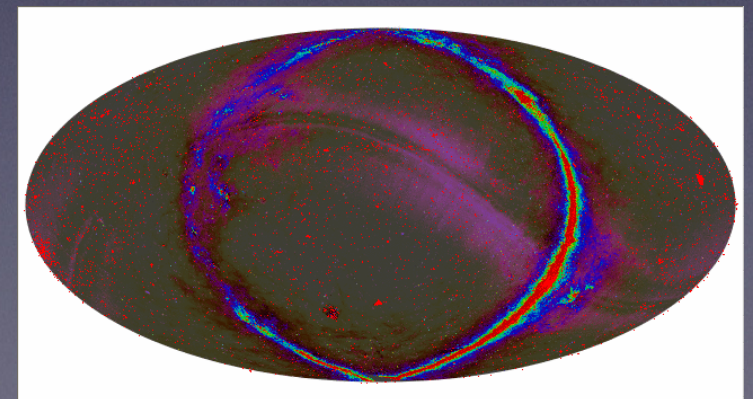
Access to journal catalogue data



SIAP  
SAMP

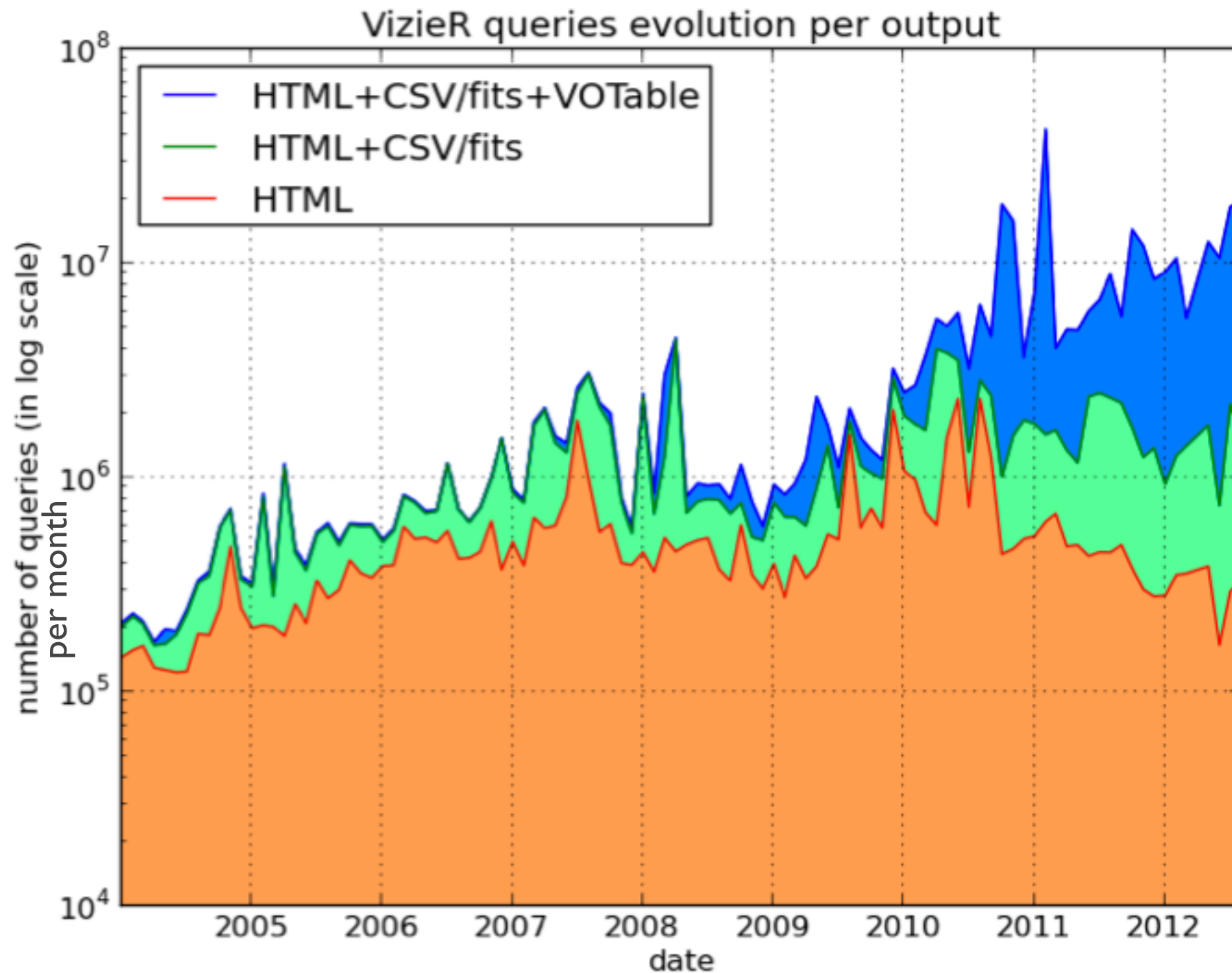
An interactive 'portal'

CharDM  
SCS  
ObsCoreDM





# Total Usage



Log scale!

Year	Daily
2010	256k
2011	388k
2012	458k

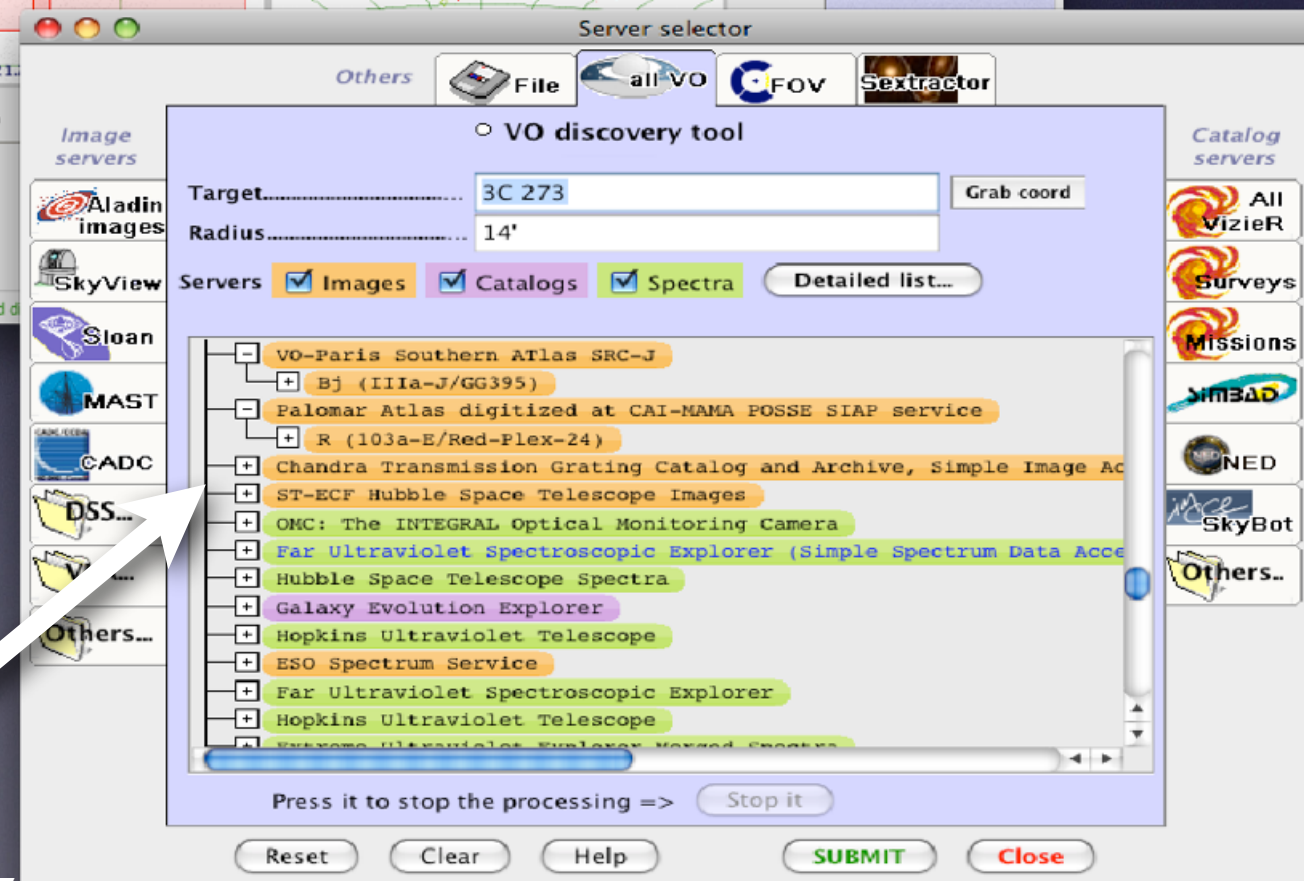
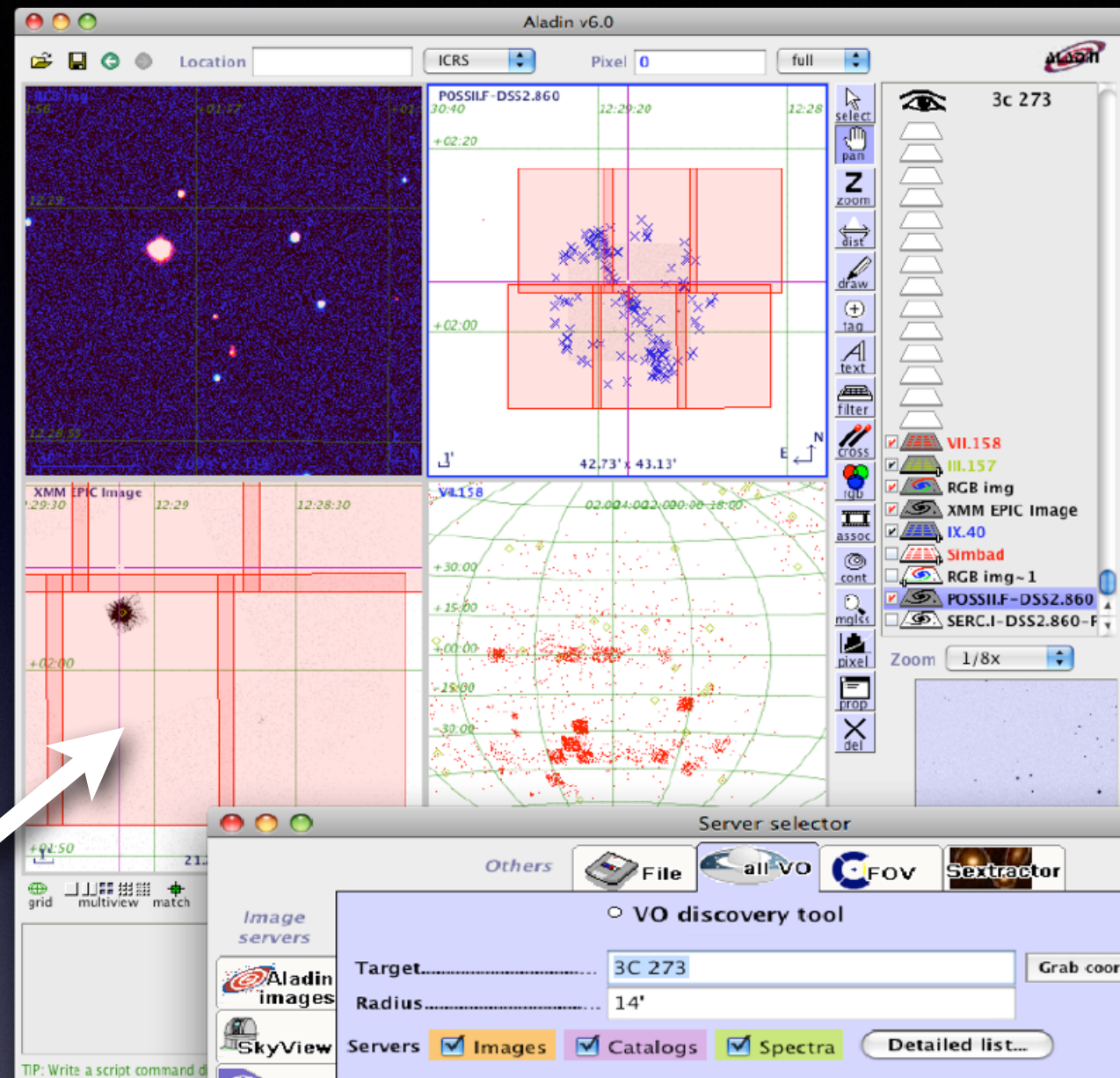


# Finding data with Aladin:

- A service can be **found** and **used** by tools that access the registry

Metadata describes data properties e.g. FoV

Images  
Catalogues  
Spectra





# Table Access Tools

## Topcat



Table Access Protocol (TAP) Query

Select Service Enter Query Resume Job Running Jobs

Available TAP Services

Registry:

Keywords:  And

Match Fields:  Short Name  Title  Subjects  ID  Publisher  Description

Accept Resource Lists Cancel Query Submit Query

Short Name	Title
2MASS	Two Micron All Sky Survey (2MASS)
2XMM	XMM-Newton Serendipitous Source Catalogue (2XMM)
6dF DR2	6dF Galaxy Survey Data Release 2
6dF DR3	6dF Galaxy Survey Data Release 3
AstroDAbis	AstroDAbis Notation Service
BASECOM	The Nançay Cometary Database
FIRST	FIRST Survey Catalogue (03Apr11 Version)
GAVO DC TAP	GAVO Data Center TAP service
GLIMPSE	GLIMPSE (Galactic Legacy Infrared Mid-Plane Survey Extraordinaire)
IRAS	Infrared Astronomical Satellite Archive (IRAS)
J/A+A/550/A120	Variability classification of CoRoT targets (Sarro+, 2013)
ROSAT	Röntgen Satellite (ROSAT)

TAP Parameters

TAP URL:

Enter Query

OK



TAPHandle xcatdb Node Selector

Meta Vot *cadc>ivoa>ivoa.ObsCore>vy0etrm27u4wqx5g*

obs_release_date	access_url	access_format	access_estsize	target_name	s_ra
2004-12-06T00:00:00.000		null	null	f122h000	311.24761
2004-12-06T00:00:00.000		null	null	f316h000	127.25459
2004-12-06T00:00:00.000		null	null	f146h000	200.16220
2004-12-06T00:00:00.000		null	null	f030h000	114.17495
2004-12-06T00:00:00.000		null	null	f041h000	323.90200
2004-12-06T00:00:00.000		null	null	f210h000	120.62806
2004-12-06T00:00:00.000		null	null	f243h000	90.677247
2004-12-06T00:00:00.000		null	null	f200h000	20.628624
2004-12-06T00:00:00.000		null	null	f369h000	60.910832
2004-12-06T00:00:00.000		null	null	f285h000	158.16554

Select What Where Plain Text Query Job Control

Result Limit  List of UWS jobs

Job "cadc vy0etrm27u4wqx5g" COMPLETED Actions

Job "xcatdb 319\_ObsCore" COMPLETED Actions

## TAPHandle



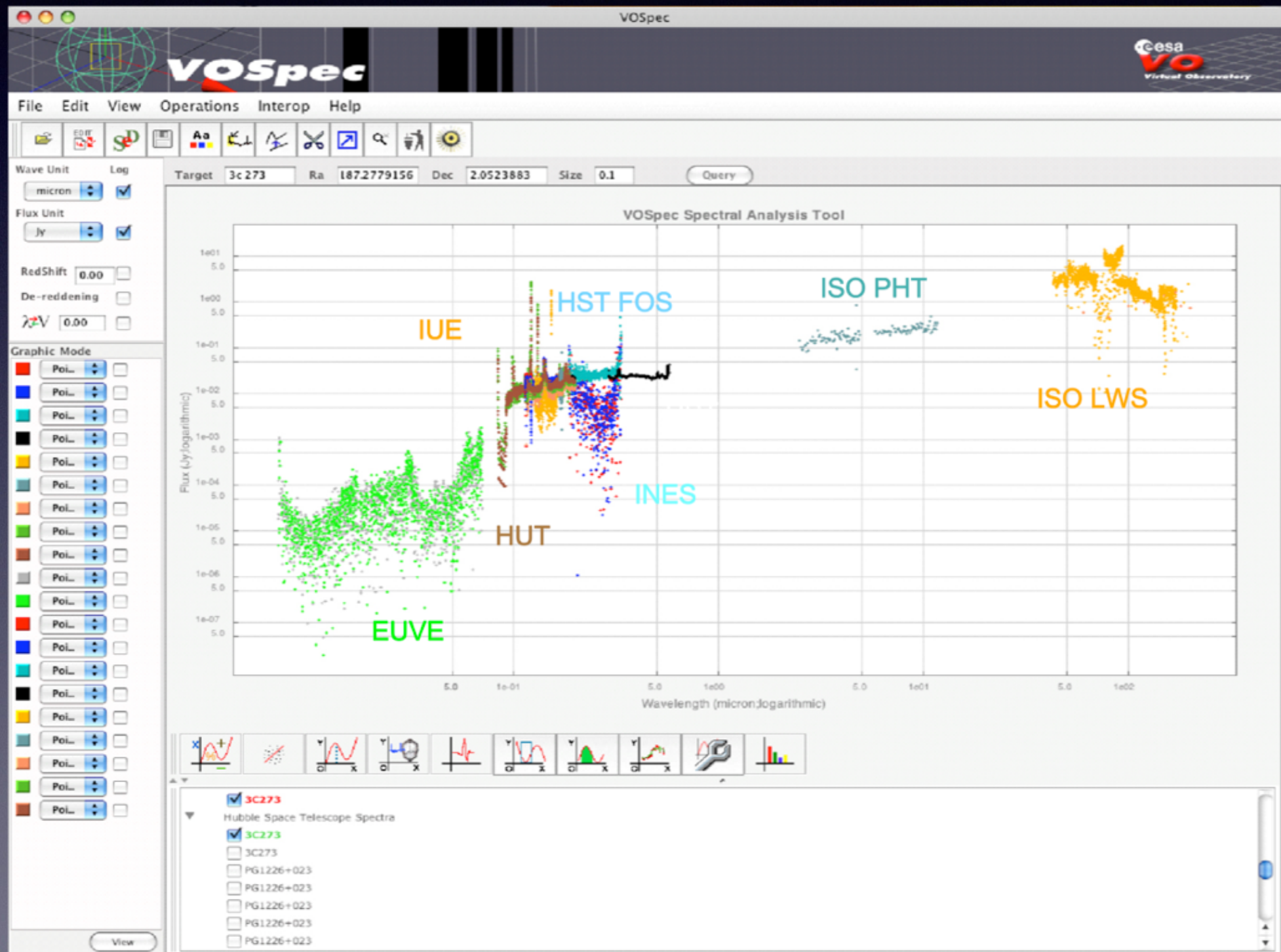
# TOPCAT

The image displays a collage of various TOPCAT software windows, illustrating its multi-view capabilities. Key windows include:

- Table List:** Shows a list of loaded tables such as 'MGC.xml.gz', '2mass\_xsc.fits', 'SuperCOSMOS.FIT', and '2QZ\_6QZ\_zone.csv'.
- Density Map:** A 2D plot showing the distribution of objects in a specific region, color-coded by magnitude.
- Scatter Plot:** A plot of RMAG vs BMAG showing distinct populations of galaxies and stars.
- Spherical Plot:** A 3D visualization of objects on a celestial sphere, color-coded by redshift.
- Cone Search:** A window for searching for objects within a specified radius and magnitude range.
- Match Tables:** A window for matching objects between different tables based on specific criteria.
- Histogram:** A plot showing the distribution of objects across different magnitude bins.
- Axis Configuration:** A window for configuring the axes and markers of a plot.
- Table Columns:** A window for configuring the columns and units of a table.
- Row Subsets:** A window for defining row subsets based on specific criteria.
- Plot Style Editor:** A window for configuring the style of a plot, including markers and lines.
- Line Plot:** A plot showing the evolution of a property over time.
- TOPCAT Help:** A window providing information about the software and its usage.
- TOPCAT(1): Row Subsets:** A window showing the row subsets for a specific table.
- TOPCAT(3): Table columns:** A window showing the table columns for a specific table.
- TOPCAT(2): Table columns:** A window showing the table columns for another specific table.
- TOPCAT(4): Table columns:** A window showing the table columns for a fourth specific table.



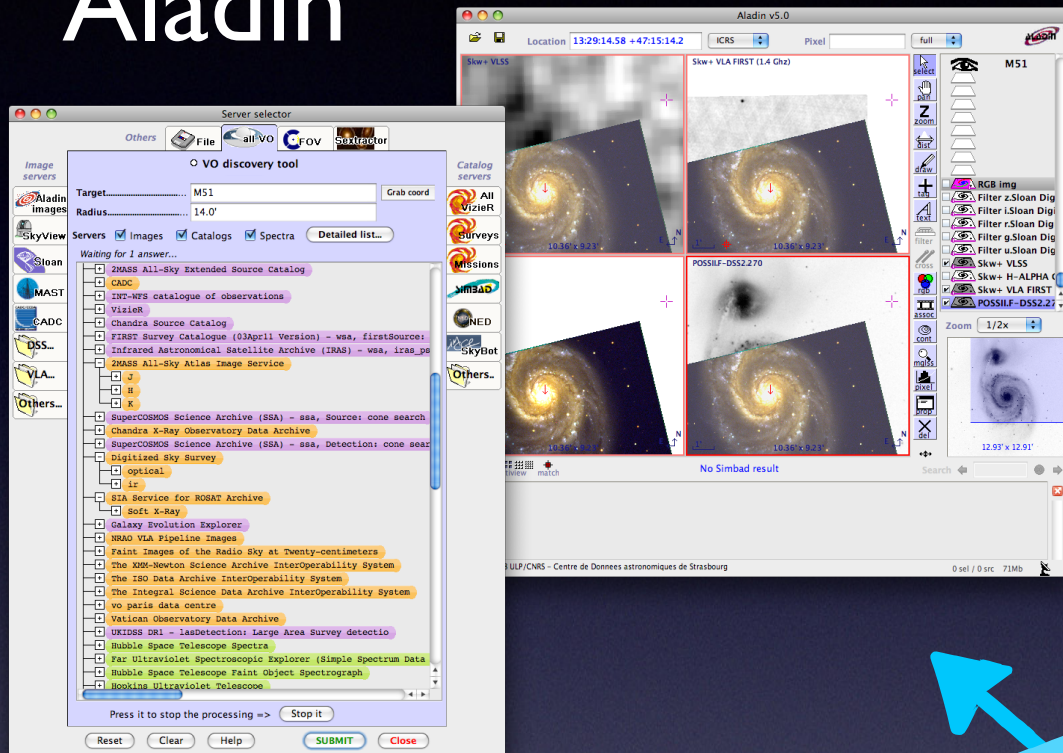
# Spectral, SED and Photometry Tools



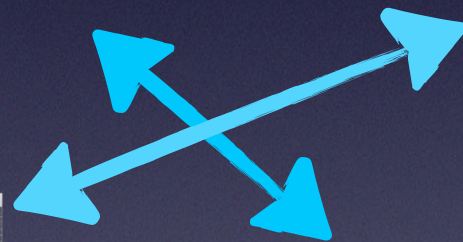
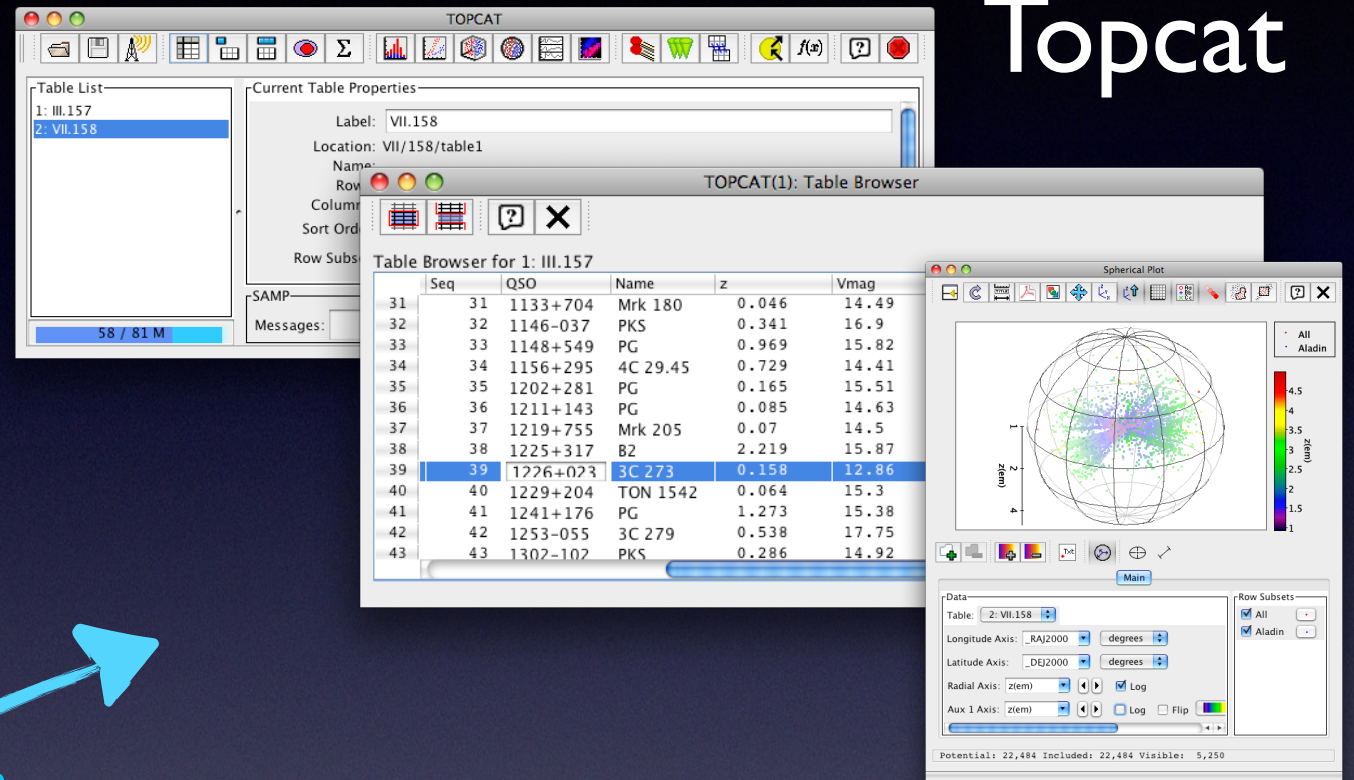


# Interoperability - SAMP

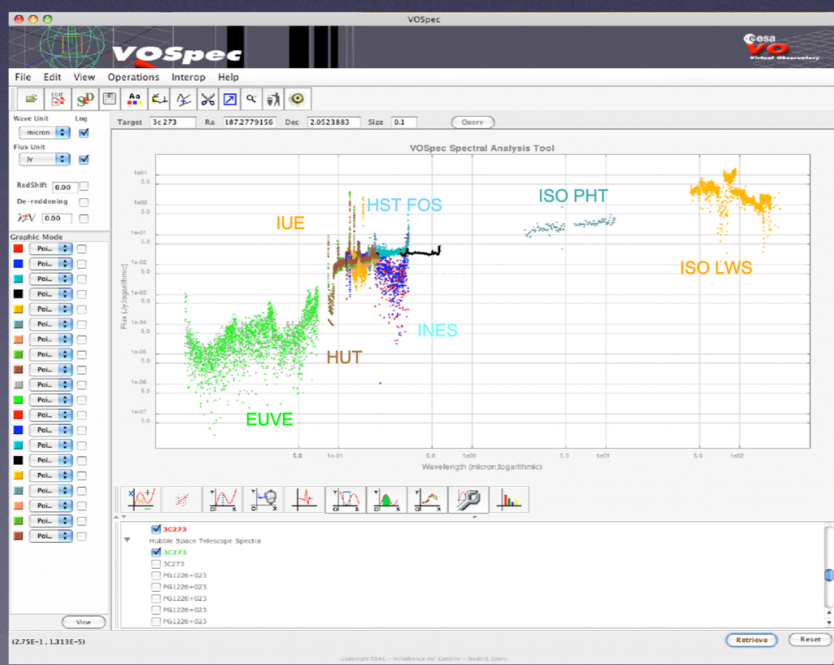
Aladin



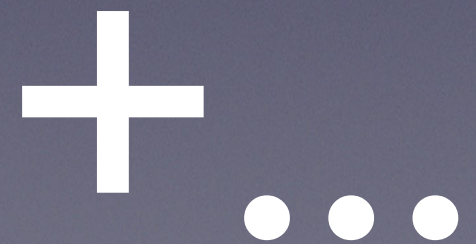
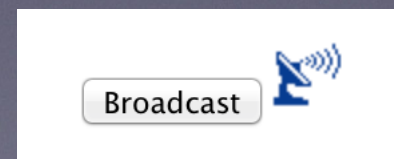
Topcat



Your programs



VOSpec





# Programmatic approaches

- Direct programming to access services
- Scripting languages in tools - allow transition from interactive to automated approach
- Python increasingly important



# Learning how

- Workshops and schools
- On-line training materials
- From your colleagues






















# Lists of tools:

- Euro-VO pages
- VAO pages

## Software

Applications/Services (alphabetical)	Applications/Services (by function)
Aladin 	<b>Search for Images:</b> Aladin, Data Discovery Tool, TOPCAT
AstroStat	<b>Search for Spectra:</b> SPLAT, Aladin, Data Discovery Tool
CDS Cross-Match Service 	<b>Search for Catalogues/Tables:</b> Aladin, Data Discovery Tool, TOPCAT, <a href="#">VizieR</a> , Xamin, <a href="#">TAPHandle</a>
Iris 	<b>Image Visualisation:</b> Aladin
Seleste 	<b>Catalogue/Table Visualisation:</b> TOPCAT, <a href="#">VOPlot</a> ,
Skyview 	<b>Catalogue Cross-matching:</b> Aladin, <a href="#">CDS Cross-Match Service</a> , TOPCAT/STILTS, Cross-Comparison Tool
SIMBAD 	<b>Scatter, 3D plots and histograms:</b> TOPCAT, <a href="#">VOPlot</a> , VisIVO
Specview 	<b>Statistics:</b> AstroStat
SPLAT 	<b>Coverage Maps:</b> Aladin
TAPHandle 	<b>Table format conversion:</b> TOPCAT/STILTS
TOPCAT/STILTS 	<b>SEDs:</b> Iris, <a href="#">VOSA</a> , <a href="#">VOSpec</a>
CDS Cross-Match Service 	
VAO Cross-Comparison Tool 	
VAO Data Discovery Tool 	
VAO Time Series Search Tool 	
VisIVO 	
VizieR 	
VOPlot 	



# IVOA Newsletter

- Bi-annual
- Aimed at Astronomers
- Applications highlights
- Recent refereed journal papers with significant use of VO



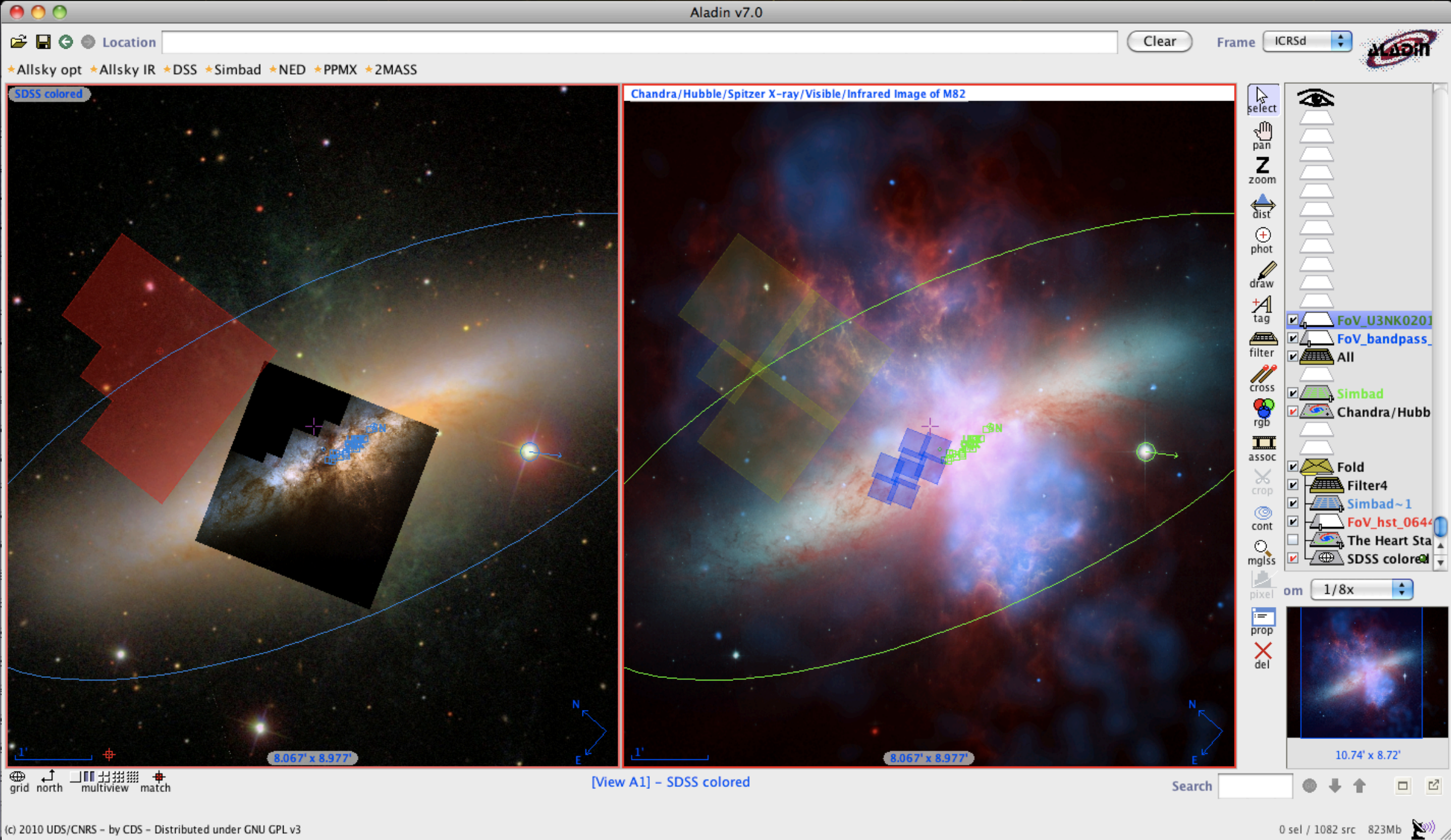


# Your help needed

- Feedback on what does/doesn't work
- Suggest new capabilities
- Use it your own science projects
- Tell your colleagues about it



Beautiful ...



... and useful



# Links

- IVOA - <http://www.ivoa.net>
- EuroVO - <http://www.euro-vo.org>
- CDS - <http://cdsweb.u-strasbg.fr>
- Topcat - <http://www.star.bris.ac.uk/~mbt/topcat/>
- VAO - <http://www.usvao.org/>