VO: enabling science

Mark Allen - CoSADIE Project Scientist

EURO VO
CoSADIE Project

Vision

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

Driven by:

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

Motivation: To enable science

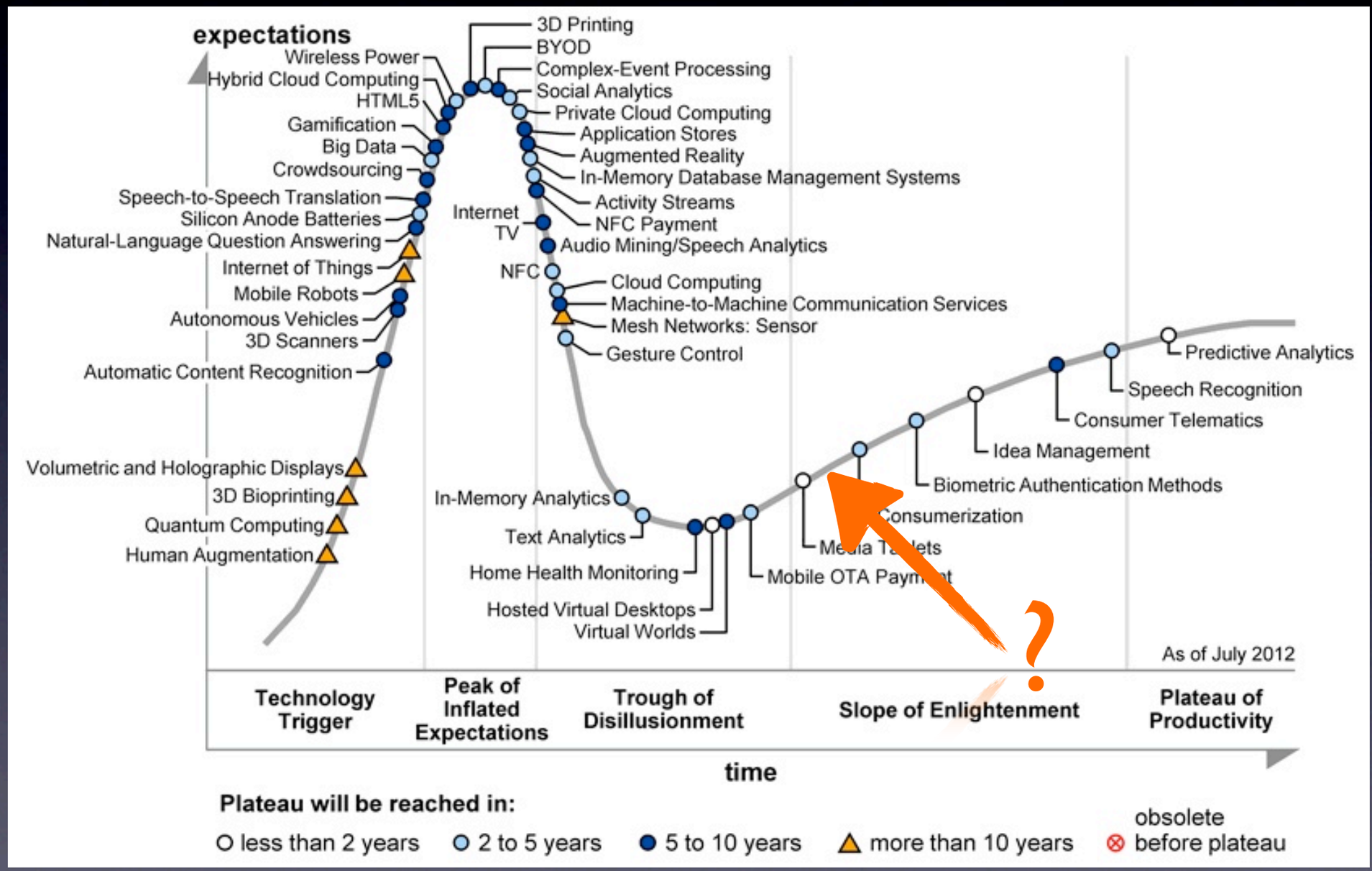
via:

- Data discovery
- Efficient data access
- Interoperable analysis tools
- Interoperable data
- Scalable visualisation and computing
- Data Mining

Status - *early operations*

- Core standards established
- Tools and services operational
- Tool interoperability proven very useful
- Being used for science in many different ways
- Offers unique capabilities

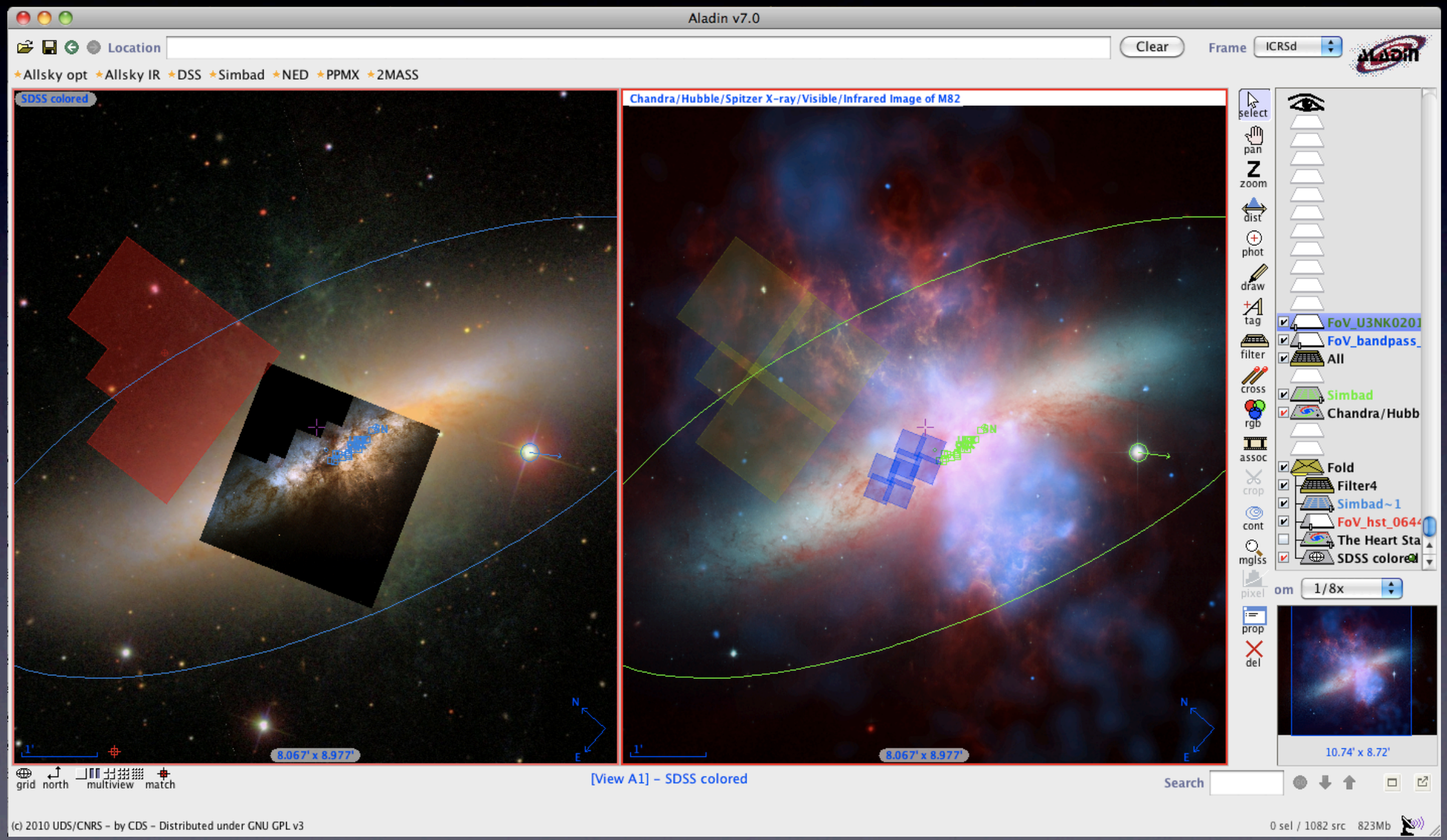
On the hype-curve? :-)



VO enabled tools

- Healthy variety of approaches
- Range of VO-enabled exiting tools to VO dedicated tools
- Co-operation between tools - lets tools concentrate on strengths
- Not an *'all in one' package*

Aladin


Aladin v7.0
Location
Clear
Frame
ICRSd
Allsky opt
Allsky IR
DSS
Simbad
NED
PPMX
2MASS
SDSS colored
Chandra/Hubble/Spitzer X-ray/Visible/Infrared Image of M82
select
pan
zoom
dist
phot
draw
tag
filter
cross
rgb
assoc
crop
cont
mglss
pixel
prop
del
FoV_U3NK0201
FoV_bandpass_
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Simbad
Chandra/Hubb
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Filter4
Simbad~1
FoV_hst_0644
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SDSS colored
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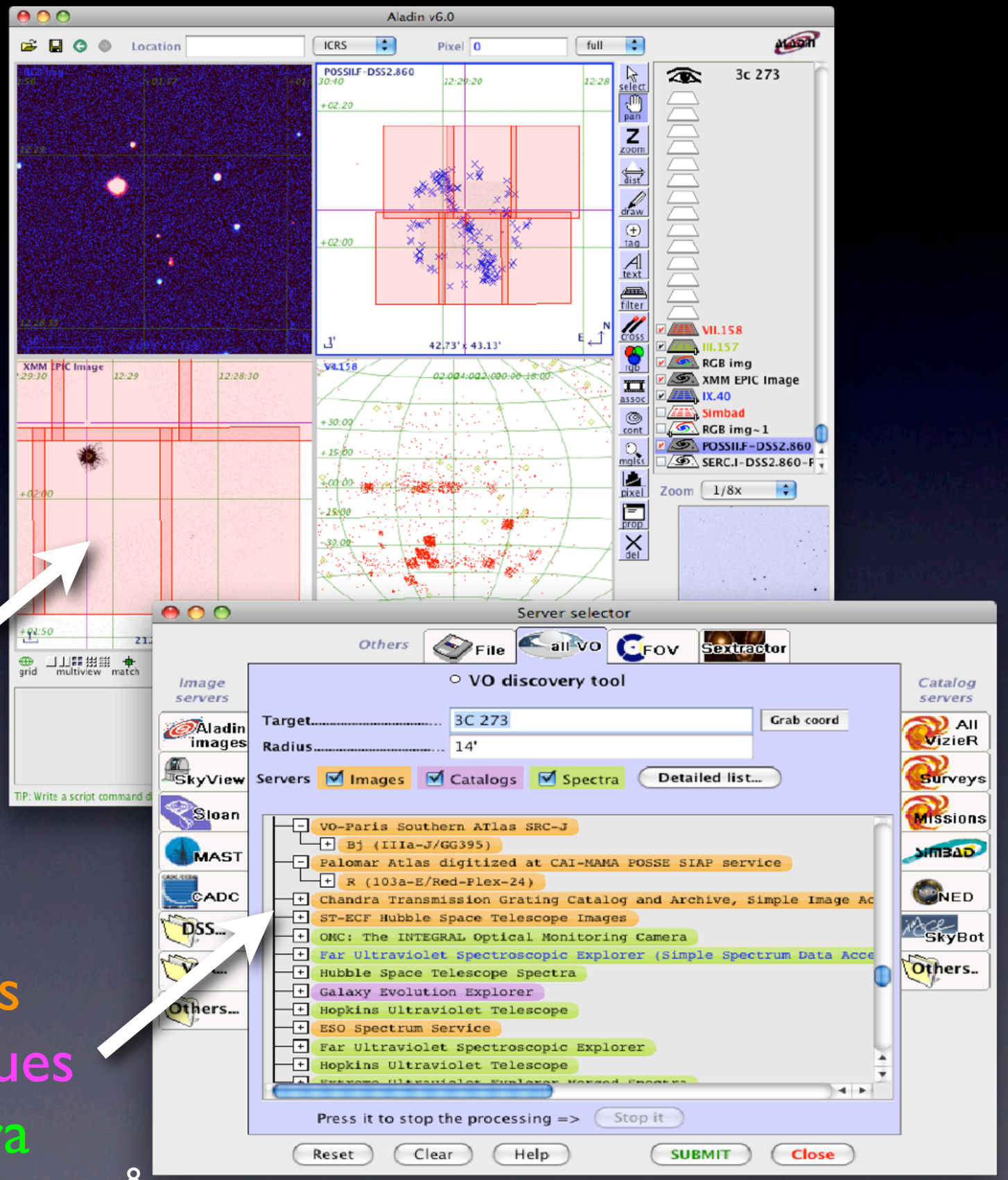
10.74' x 8.72'
8.067' x 8.977'
8.067' x 8.977'
grid
north
multiview
match
[View A1] - SDSS colored
Search
(c) 2010 UDS/CNRS - by CDS - Distributed under GNU GPL v3
0 sel / 1082 src
823Mb

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



TOPCAT

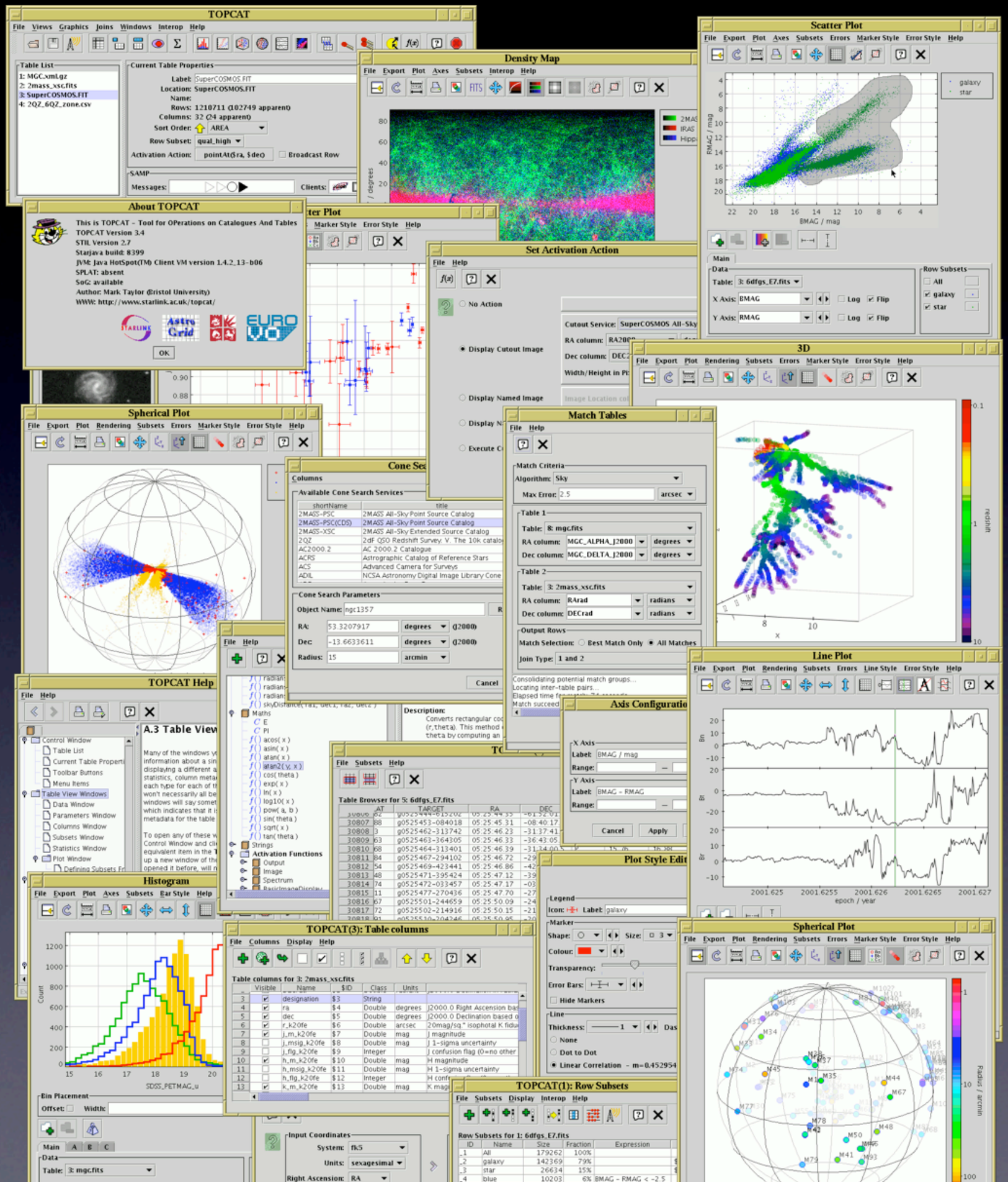
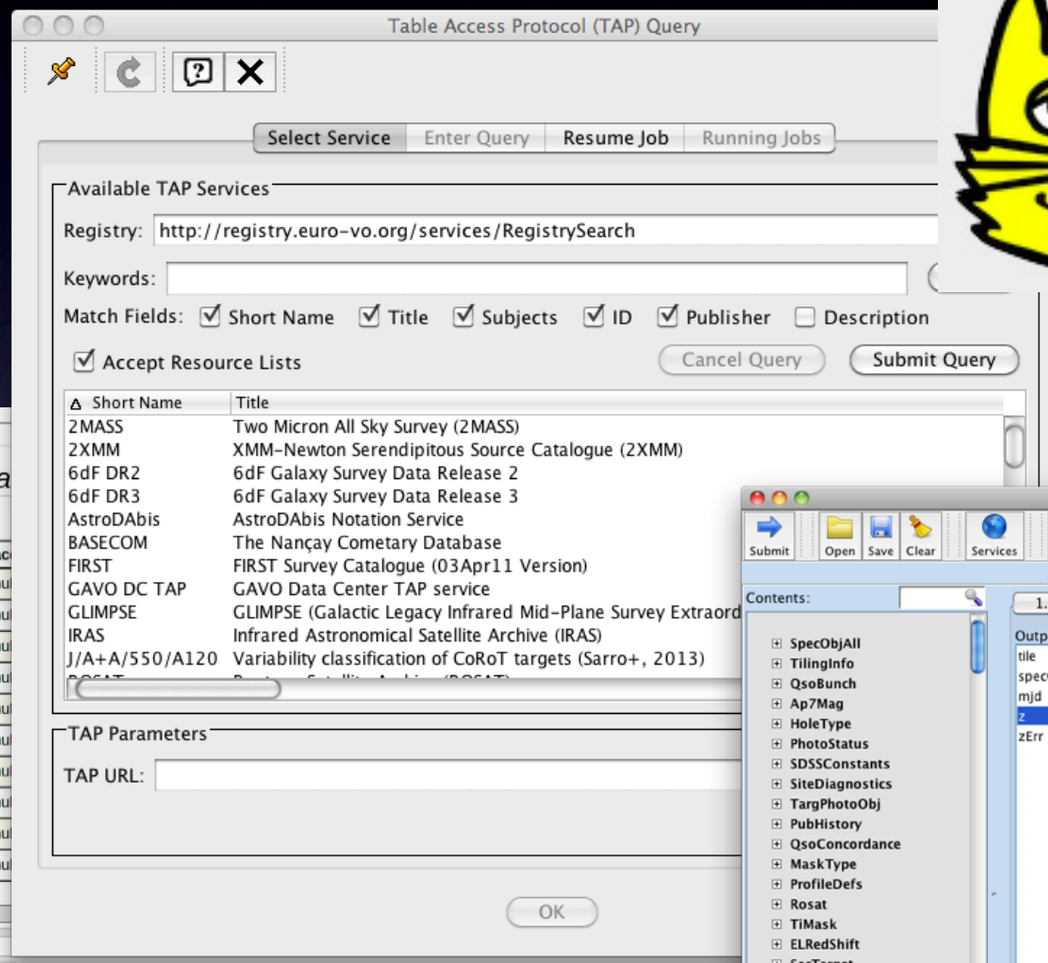
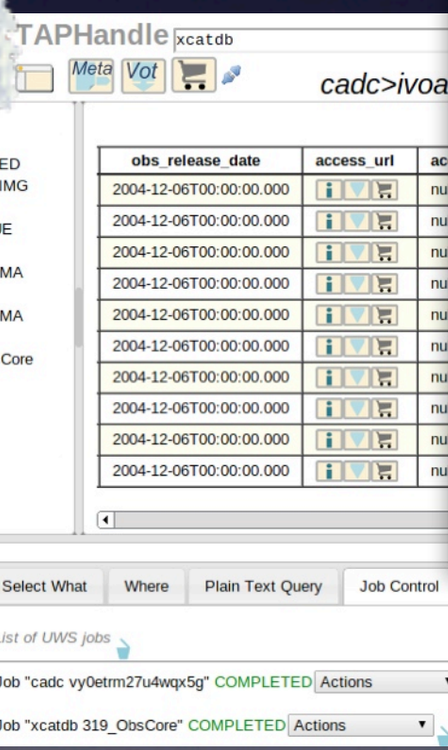
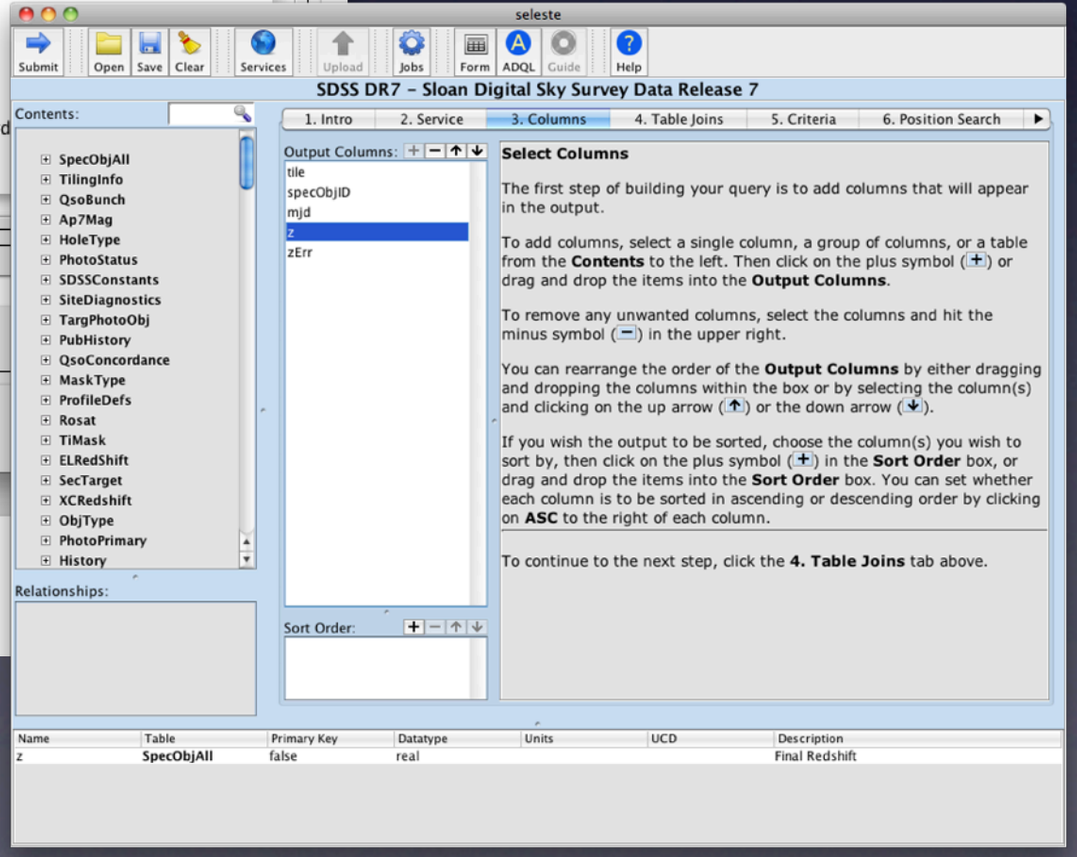

TOPCAT
About TOPCAT
This is TOPCAT – Tool for OPerations on Catalogues And Tables
TOPCAT Version 3.4
STIL Version 2.7
Starjava build: 8399
JVM: Java HotSpot(TM) Client VM version 1.4.2_13-b06
SPLAT: absent
SoG: available
Author: Mark Taylor (Bristol University)
WWW: http://www.starlink.ac.uk/topcat/
OK
Density Map
Scatter Plot
Set Activation Action
Spherical Plot
Match Tables
3D
Line Plot
TOPCAT Help
Histogram
TOPCAT(3): Table columns
TOPCAT(1): Row Subsets
Plot Style Edit
Axis Configuratio

Table Access Tools

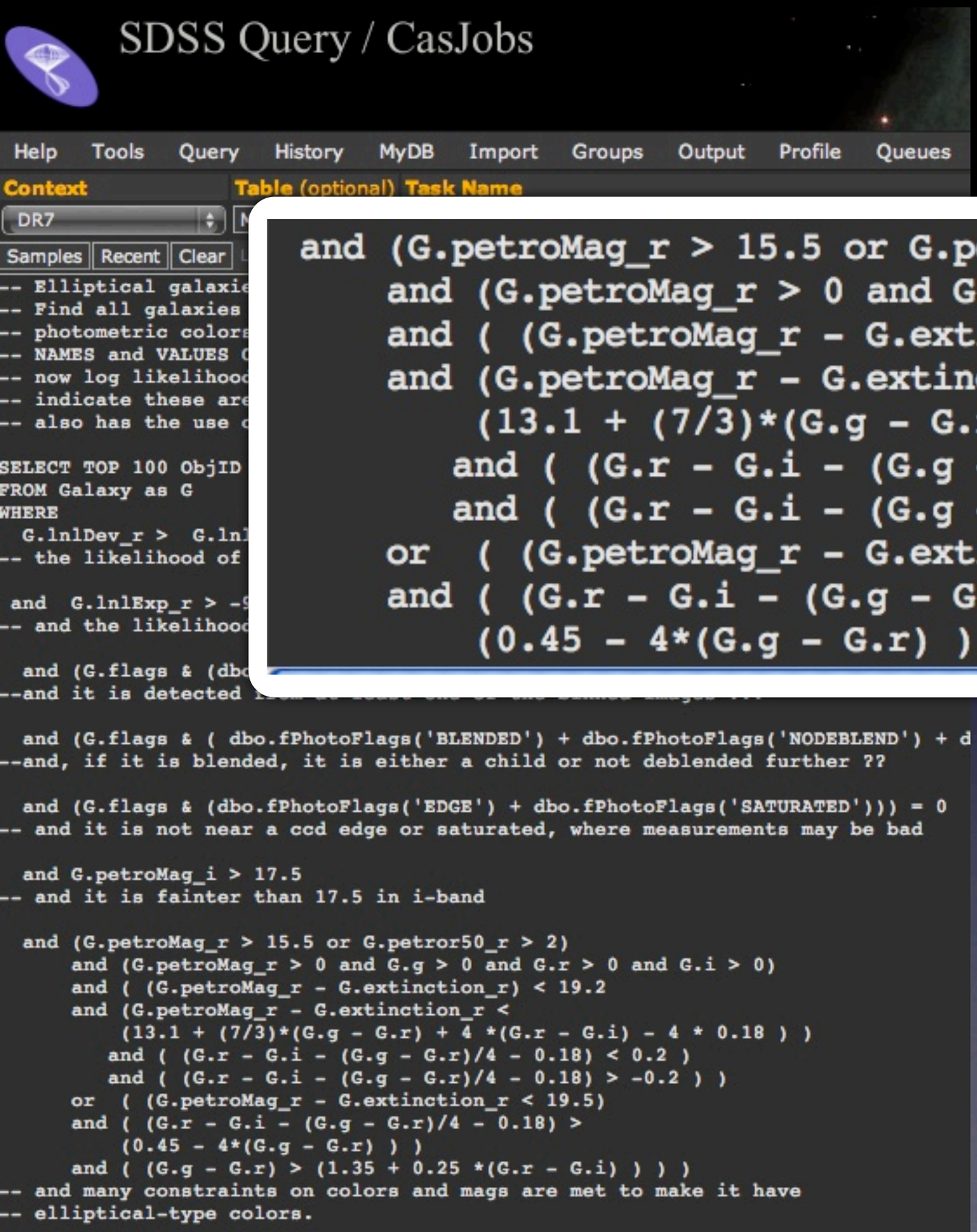
Topcat







TAPHandle



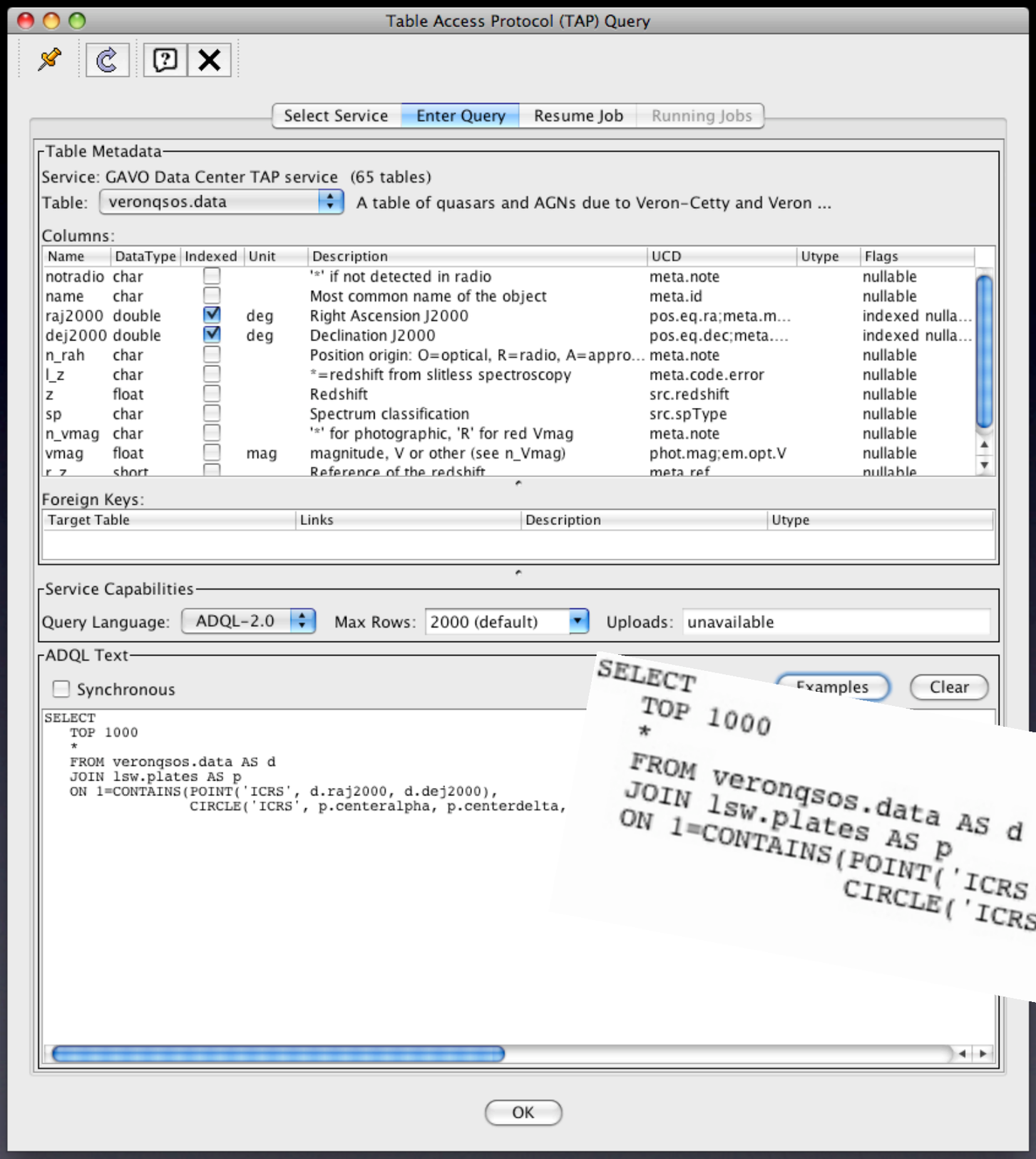
SQL

```
and (G.petroMag_r > 15.5 or G.petror50_r > 2)
    and (G.petroMag_r > 0 and G.g > 0 and G.r > 0 and G.i > 0)
    and ( (G.petroMag_r - G.extinction_r) < 19.2
    and (G.petroMag_r - G.extinction_r <
        (13.1 + (7/3)*(G.g - G.r) + 4 *(G.r - G.i) - 4 * 0.18 ) )
       and ( (G.r - G.i - (G.g - G.r)/4 - 0.18) < 0.2 )
       and ( (G.r - G.i - (G.g - G.r)/4 - 0.18) > -0.2 ) )
    or  ( (G.petroMag_r - G.extinction_r < 19.5)
    and ( (G.r - G.i - (G.g - G.r)/4 - 0.18) >
        (0.45 - 4*(G.g - G.r) ) )
```

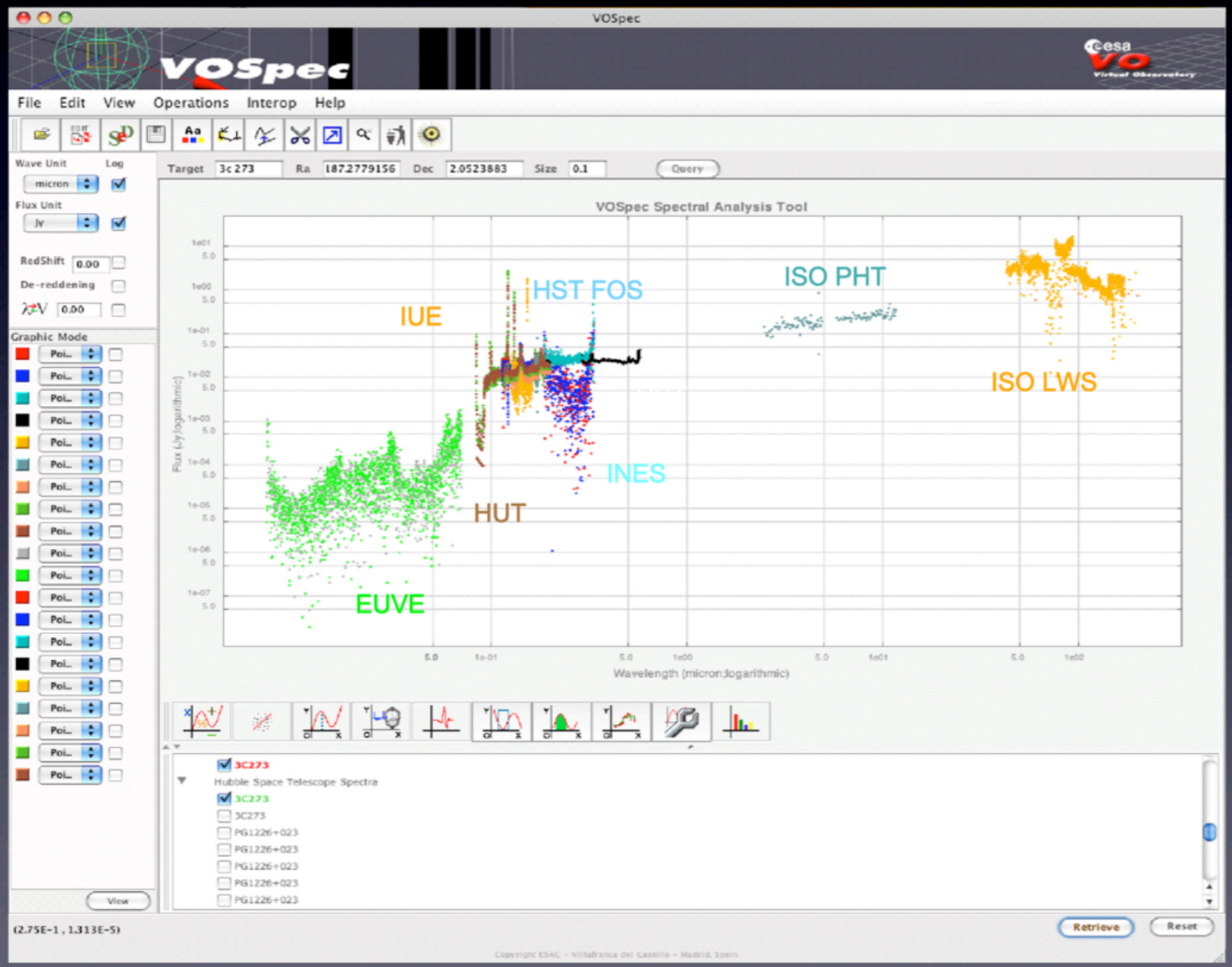
Like CasJobs ... but not just SDSS

ADQL/SQL query of tables via TOPCAT

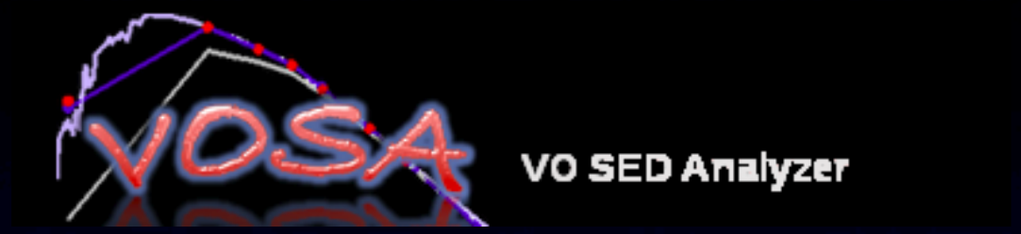
Some services offer joins between tables and uploaded tables

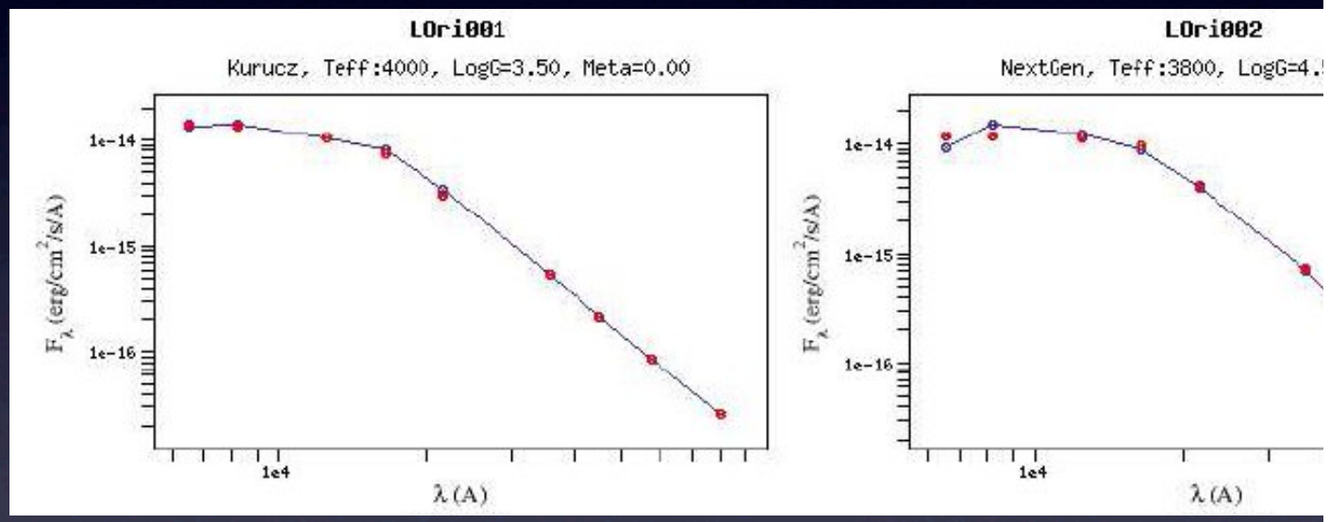


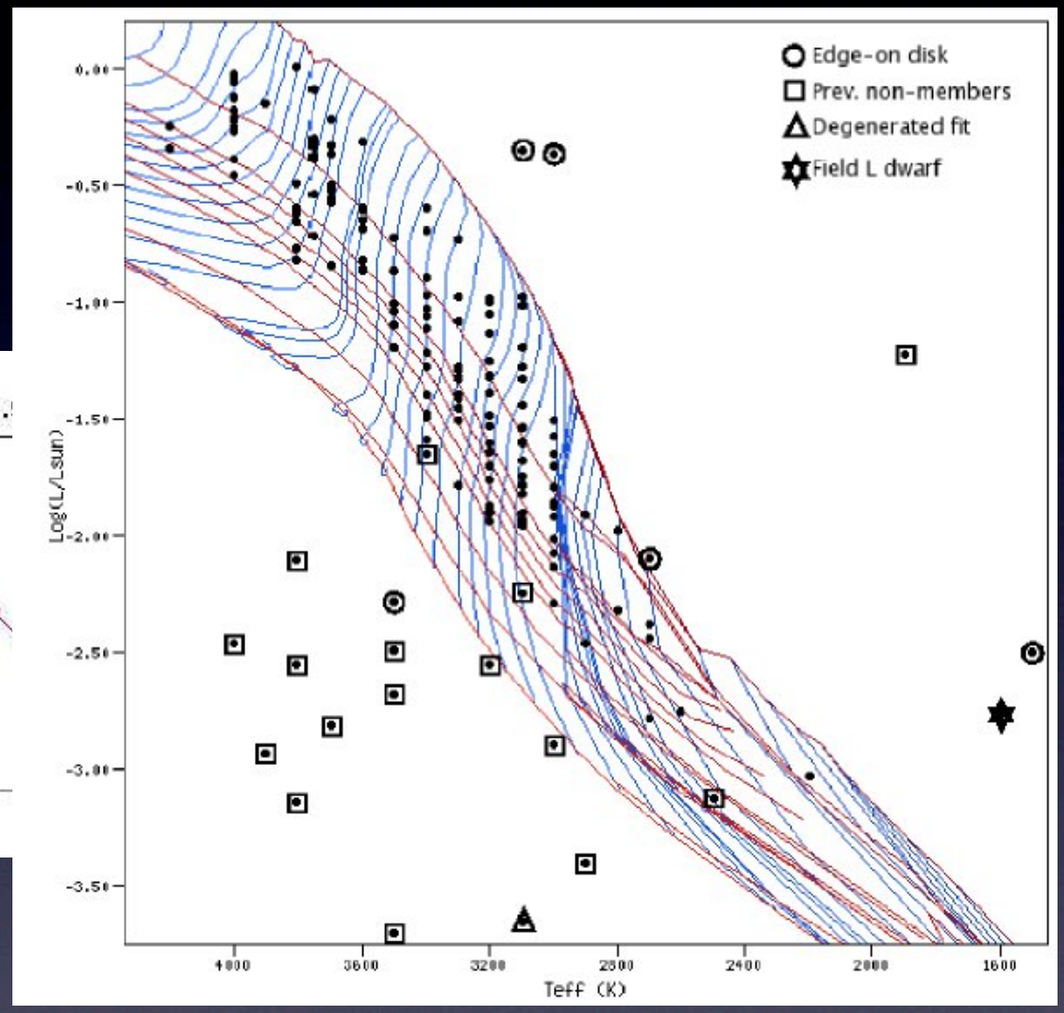
Spectral Tools



VOSA







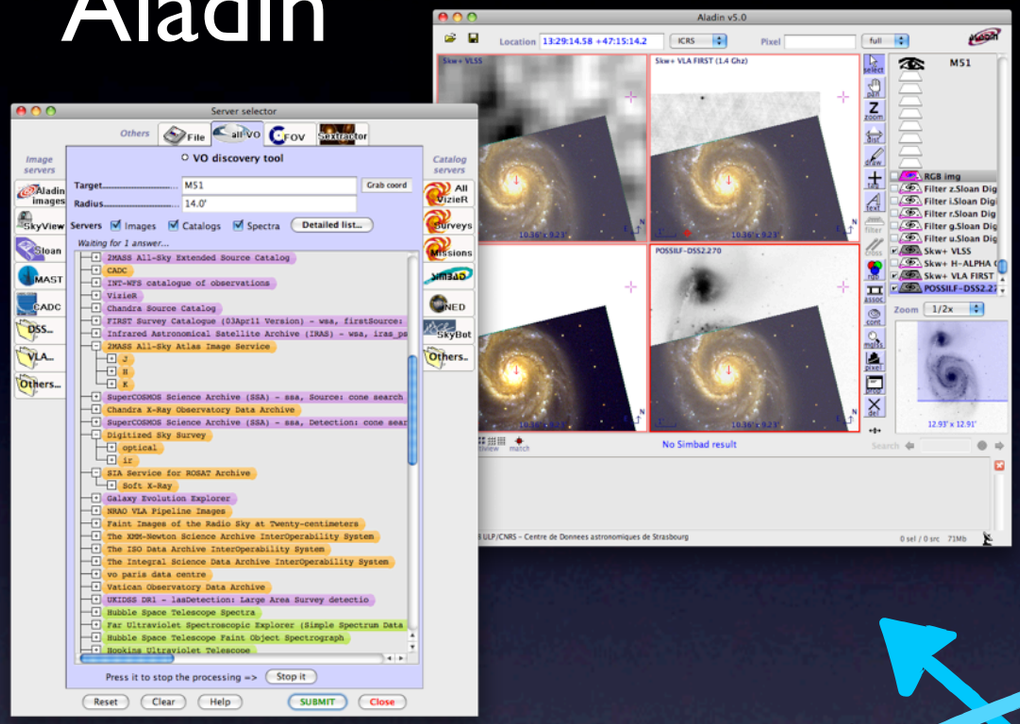
- Builds an SED with photometry gathered from different VO services and compare them with different grids of models to obtain physical parameters (Teff, masses, ages, ...)

Programatic approaches

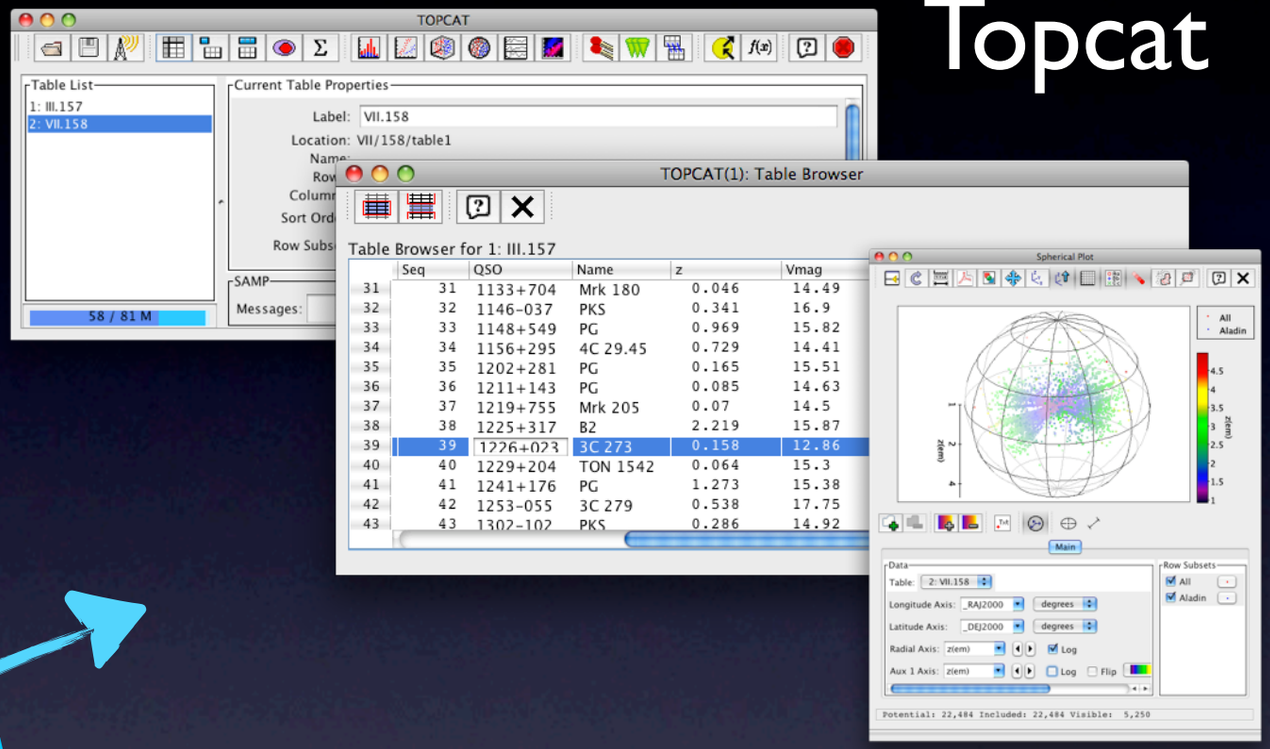
- Direct programming to access services
- Scripting languages in tools - allow transition from interactive to automated approach
- Python increasingly important

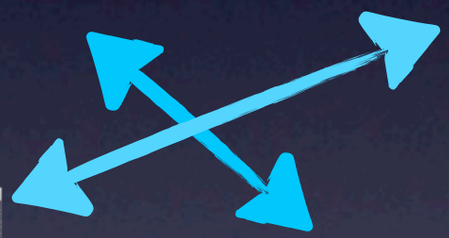
Interoperability

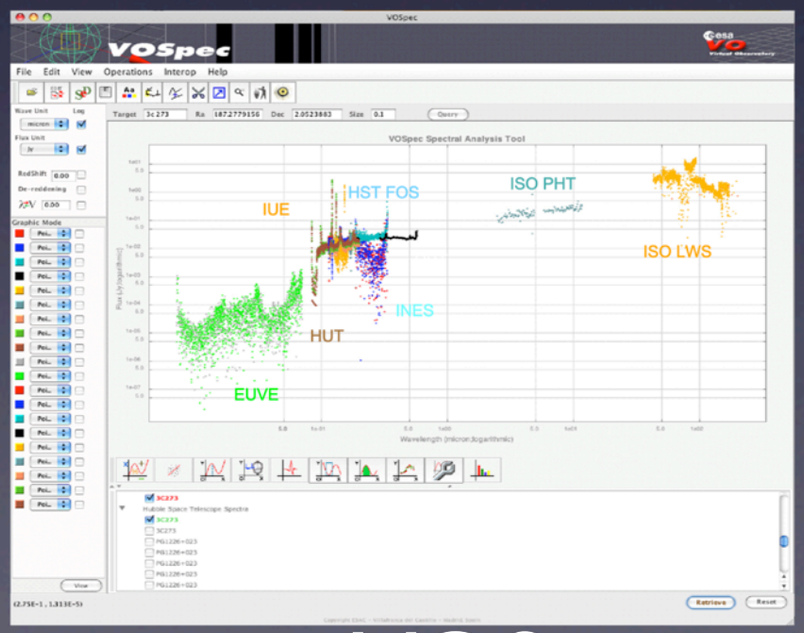
Aladin



Topcat







VOSpec

Your programs

+ ...

Application / Version (in alphabetical order)	Functionality	Other VO-compliant tools
Aladin v7.015a (March 2011)	**Search for Images:** Aladin, Datascope, SkyView, VODesktop	DS9: Image visualiasation
Datascope v3.3 (April 2010)	**Search for Spectra:** Aladin, Datascope, SPLAT, Specview, VOServices, VOSpec	GOSSIP: SED fitting
Montage	**Search for Catalogues:** Aladin, Datascope, TOPCAT, VODesktop	Mirage: Table visualisation
Octet	**Image visualisation:** Aladin, SkyView	VirGO: Search for Images and Spectra
Open SkyQuery	**Spectra visualisation:** SPLAT, Specview, VOServices, VOSpec	**Browse the Registries**
SkyView	**Catalogues visualisation:** Aladin, TOPCAT, VOPlot	EURO-VO Registry
Specview 2.15 (August 2011)	**Cross-correlation:** Aladin, Open SkyQuery, STILTS, TOPCAT	NVO Registry
SPLAT 3.9.0 (May 2009)	**Scatter, 3D plots and histograms:** TOPCAT, VOPlot	or use VODesktop
TOPCAT/STILTS 3.9/2.4 (October 2011)	**Statistics:** VOStat	**Manuals, Tutorials, How-tos**
VisIVO 1.5.7.1 (May 2009)	**Footprint Service:** Aladin, VOServices	Aladin User manual
VOConvert 1.0 (June 2006)	**Table format conversion:** TOPCAT, VOConvert	Datascope how to
VODesktop 1.3.2 (February 2010)	**Filter curves:** VOServices	Montage help
VOEventNet	**SED building:** VOSA, VOSED, VOSpec	Open SkyQuery help
VOPlot 1.7 (September 2011)	**Fixing WCS:** Aladin, WCSFixer	SkyView documentation
VOStat 1.1 (November 2008)		Specview examples
VOSA 2.2.0 (March 2011)		SPLAT documentation
VOSED 2.0 (May 2011)		STILTS documentation
VOServices (Footprint, Spectrum, Filters ...)		TOPCAT documentation
		VisIVO how to
		VODesktop how to
		VOSpec User manual

Published examples

collated by EuroVO, VAO and IVOA Newsletter

Refereed Publications

The Hopkins Ultraviolet Telescope: The Final Archive
Dixon, William V.; Blair, William P.; Kruk, Jeffrey W.; Romelfanger, Mary L
To appear in Publications of the Astronomical Society of the Pacific 2013

Proper motions of young stars in Chamaeleon. I. A Virtual Observatory study of spectroscopically confirm
members
Lopez Martí, B.; Jimenez Esteban, F.; Bayo, A.; Barrado, D.; Solano, E.; Rodrigo, C.
A&A 2013, 551, 46L

Automated rapid follow-up of Swift gamma-ray burst alerts at 15 GHz with the AMI Large Array
Staley, T. D.; Titterington, D. J.; Fender, R. P.; Swinbank, J. D.; van der Horst, A. J.; Rowlinson, A.; Scaife, A. M. M.; Grainge, K. J. B.; Pooley, G. G.
Monthly Notices of the Royal Astronomical Society 2014, 428, 3114

Precovery of near-Earth asteroids by a citizen-science project of the Spanish Virtual Observatory
E. Solano, C. Rodrigo, R. Pulido, B. Carry
Accepted in Astron. Nachr

The Millennium Run Observatory: first light
Overzier, R.; Lemson, G.; Angulo, R. E.; Bertin, E.; Blaizot, J.; Henriques, B. M. B.; Marleau, G.-D.; White, S. D. M.
Monthly Notices of the Royal Astronomical Society 2013, 428, 778

Query driven visualization of astronomical catalogs
Buddelmeijer, Hugo; Valentijn, Edwin A.
Experimental Astronomy, Volume 35, Issue 1-2, pp. 283-300

A Virtual Observatory Census to Address Dwarfs Origins. AVOCADO - I. Science goals, sample selection

A&A 551, A46 (2013)
DOI: 10.1051/0004-6361/201220128

Astronomy & Astrophysics

Proper motions of young stars in Chamaeleon

I. A Virtual Observatory study of spectroscopically confirmed members⋆,⋆⋆

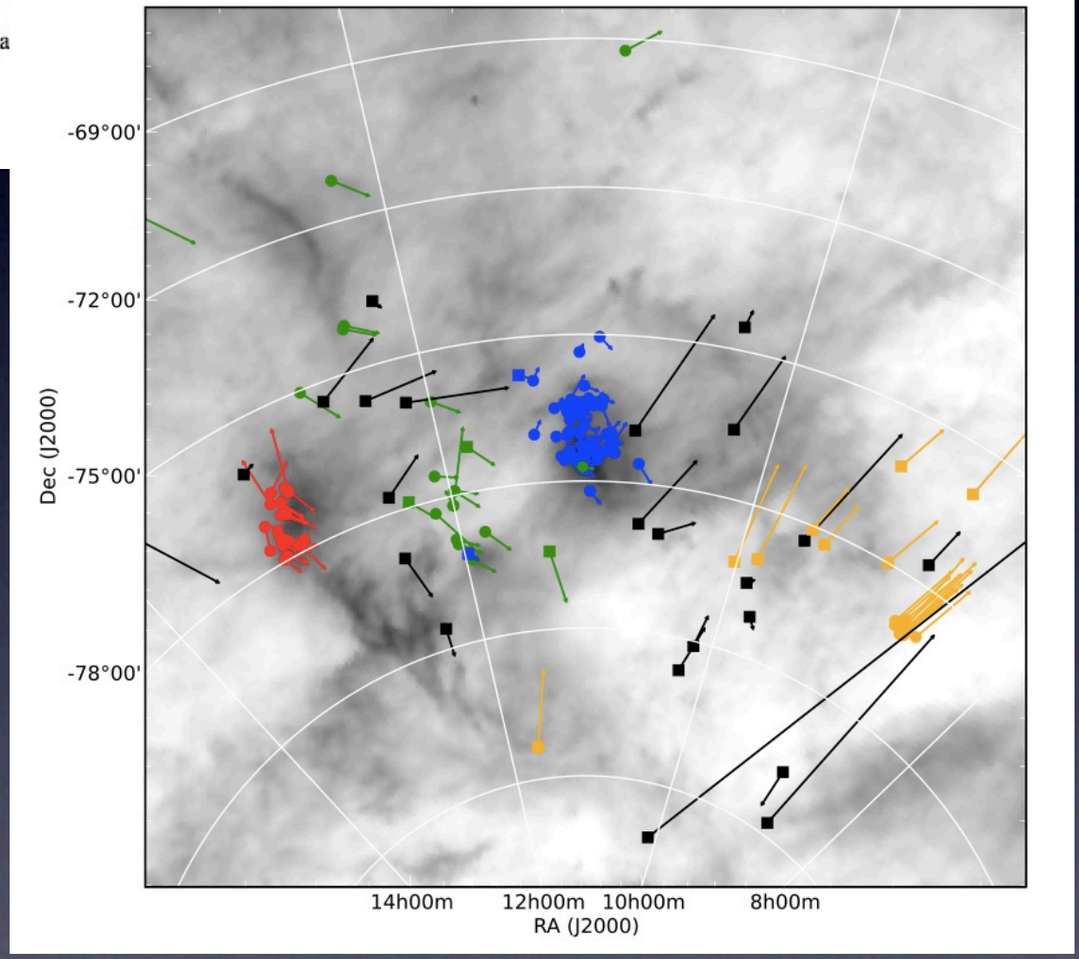
B. Lopez Martí[1], F. Jimenez Esteban[1,2,3], A. Bayo[4], D. Barrado[1,5], E. Solano[1,2], and C. Rodrigo[1,2]

[1] Centro de Astrobiología (INTA-CSIC), Departamento de Astrofísica, PO Box 78, 28261 Villanueva de la Cañada, Madrid, Spain
e-mail: belen@cab.inta-csic.es
[2] Spanish Virtual Observatory, Spain
[3] Saint Louis University, Madrid Campus, Division of Science and Engineering, Avenida del Valle 34, 28003 Madr
[4] European Southern Observatory, Alonso de Córdova 3107, Vitacura, Santiago, Chile
[5] Calar Alto Observatory, Centro Astronómico Hispano-Alemán, C/ Jesús Durbán Remón 2-2, 04004 Almería, Spa

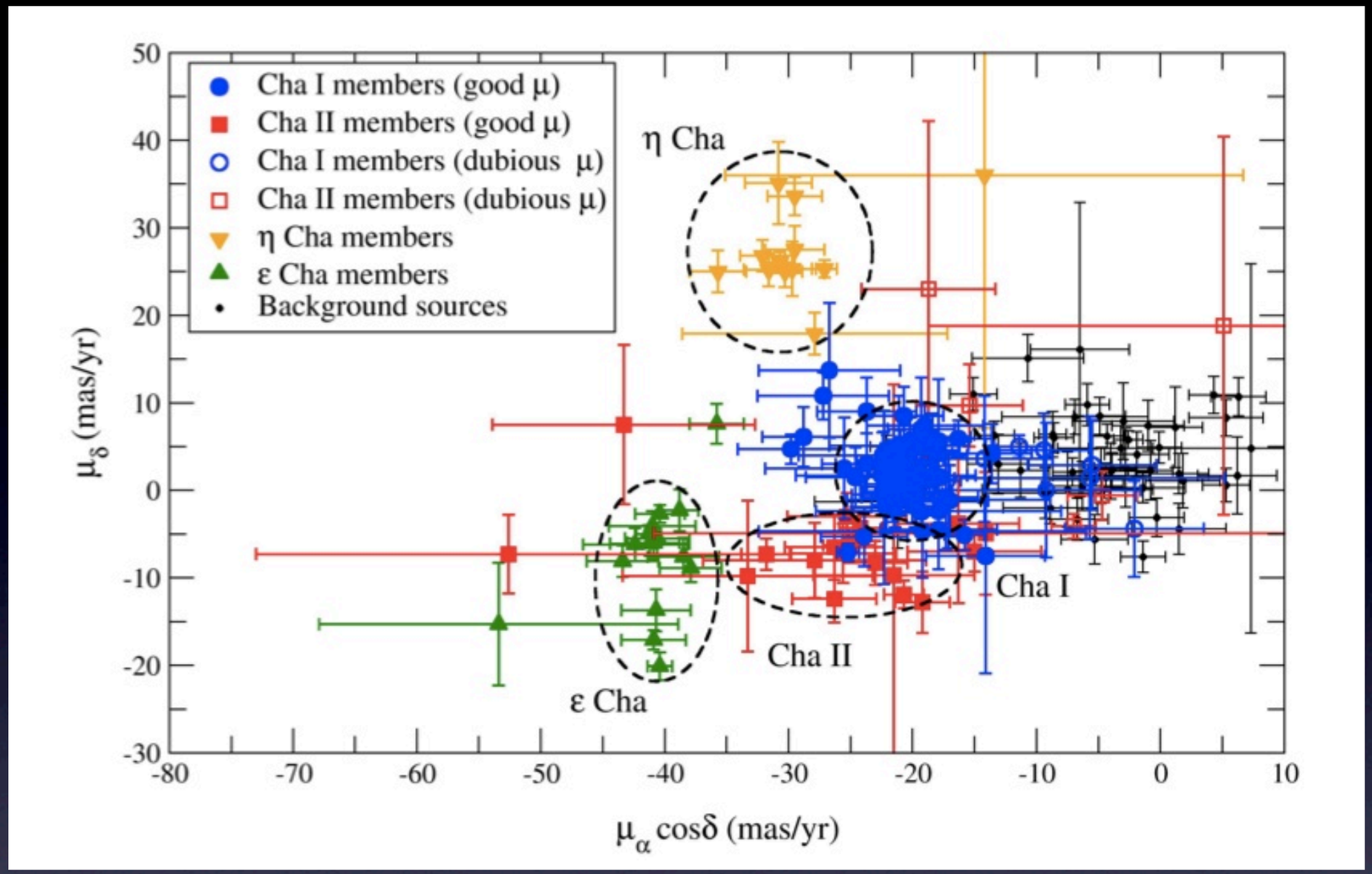
Received 30 July 2012 / Accepted 10 December 2012

ABSTRACT

- "VO based methodology to cross-match and analyse the data"
- multi-cone search + constraints on pm errors, epochs
- Compilation of multi-λ photometry



TOPCAT, Aladin, VizieR, VOSA



- Identified different moving groups
- Distinguished Chamaeleon I and II as two physical entities - not related to foreground ε Cha and η Cha

Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

MNRAS **428,** 3114–3120 (2013) doi:10.1093/mnras/sts259

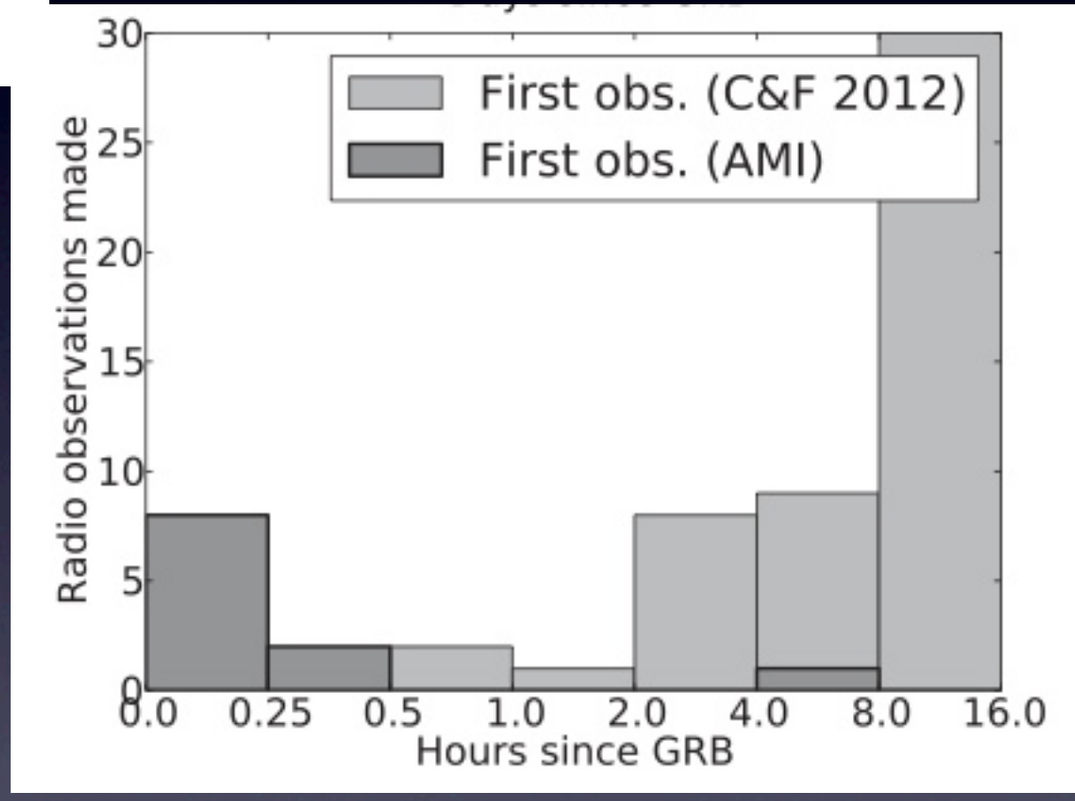
Automated rapid follow-up of *Swift* gamma-ray burst alerts at 15 GHz with the AMI Large Array

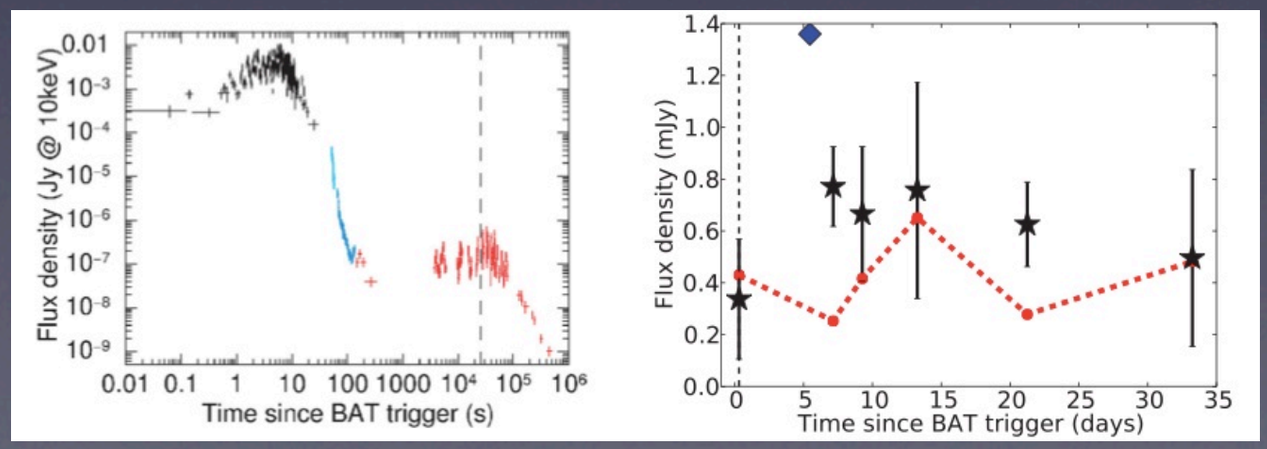
T. D. Staley,[1]★ D. J. Titterington,[2] R. P. Fender,[1] J. D. Swinbank,[3]
A. J. van der Horst,[3] A. Rowlinson,[3] A. M. M. Scaife,[1] K. J. B. Grainge[2,4]
and G. G. Pooley[2]

[1]*School of Physics & Astronomy, University of Southampton, Southampton SO17 1BJ*
[2]*Astrophysics Group, Cavendish Laboratory, 19 J. J. Thomson Avenue, Cambridge CB3 0HE*
[3]*Astronomical Institute Anton Pannekoek, Science Park 904, PO Box 94249, 1090 GE Amsterdam, the Netherlands*
[4]*Kavli Institute for Cosmology Cambridge, Madingley Road, Cambridge CB3 0HA*

Accepted 2012 October 19. Received 2012 October 16; in original form 2012 September 28

- 1st mJy level follow-up of GRBs
- VOEvent and automated follow-up system
- Radio afterglow detected on timescale of days





Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

Mon. Not. R. Astron. Soc. **406,** 1595–1608 (2010) doi:10.1111/j.1365-2966.2010.16812.x

Scalelength of disc galaxies

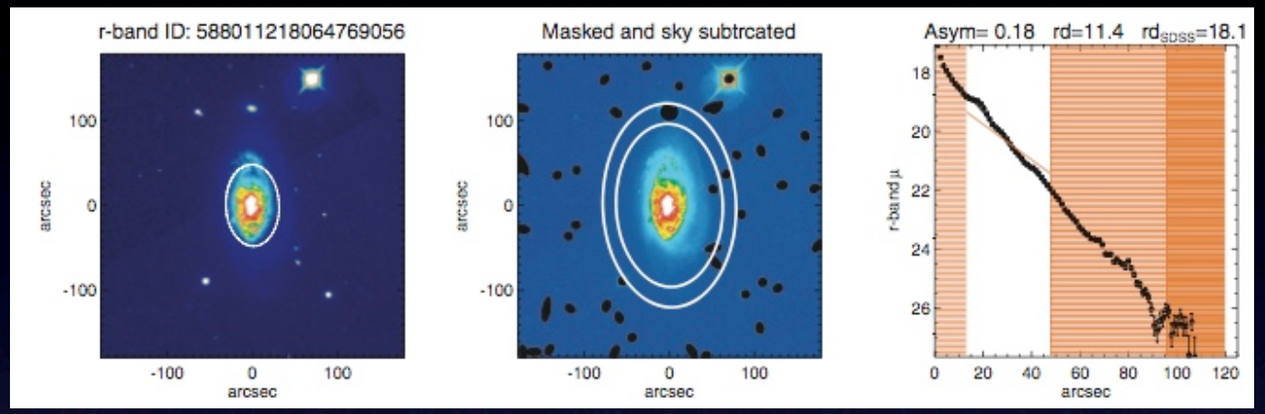
Kambiz Fathi,[1,2★] Mark Allen,[3] Thomas Boch,[3] Evanthia Hatziminaoglou[4] and Reynier F. Peletier[5]

[1] *Stockholm Observatory, Department of Astronomy, Stockholm University, AlbaNova Center, 106 91 Stockholm, Sweden*
[2] *Oskar Klein Centre for Cosmoparticle Physics, Stockholm University, 106 91 Stockholm, Sweden*
[3] *Observatoire de Strasbourg, UMR 7550, Strasbourg 67000, France*
[4] *European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching bei München, Germany*
[5] *Kapteyn Astronomical Institute, Postbus 800, 9700 AV Groningen, the Netherlands*

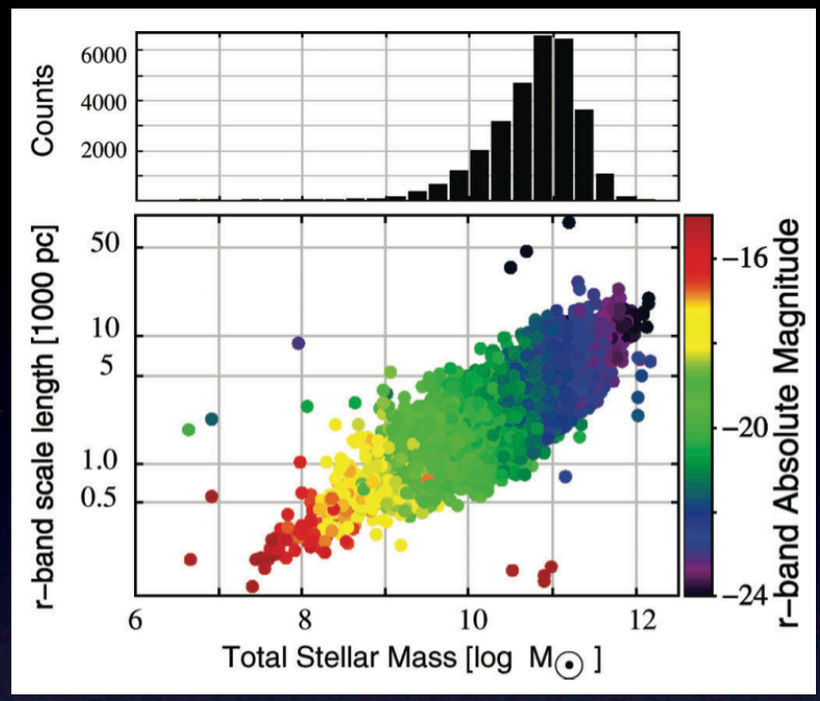
Accepted 2010 April 7. Received 2010 April 2; in original form 2010 February 18

Euro-VO Research Initiative

- SDSS, LEDA, Skyview, Aladin, Topcat, IDL/GDL, VOSpace + Cluster System at CDS
- Filtering SDSS catalogue (low extinction, available z, inclination < 70°)
- Cross-matching SDSS with LEDA catalogues to identify hubble classification



×30374 ➡



Unprecedented sample - previous samples few 100s

Freeman law of galaxy disks confirmed for large sample out to z=0.3

A&A 525, A29 (2011)
DOI: 10.1051/0004-6361/201015223

Astronomy & Astrophysics

Identification of blue high proper motion objects in the Tycho-2 and 2MASS catalogues using Virtual Observatory tools

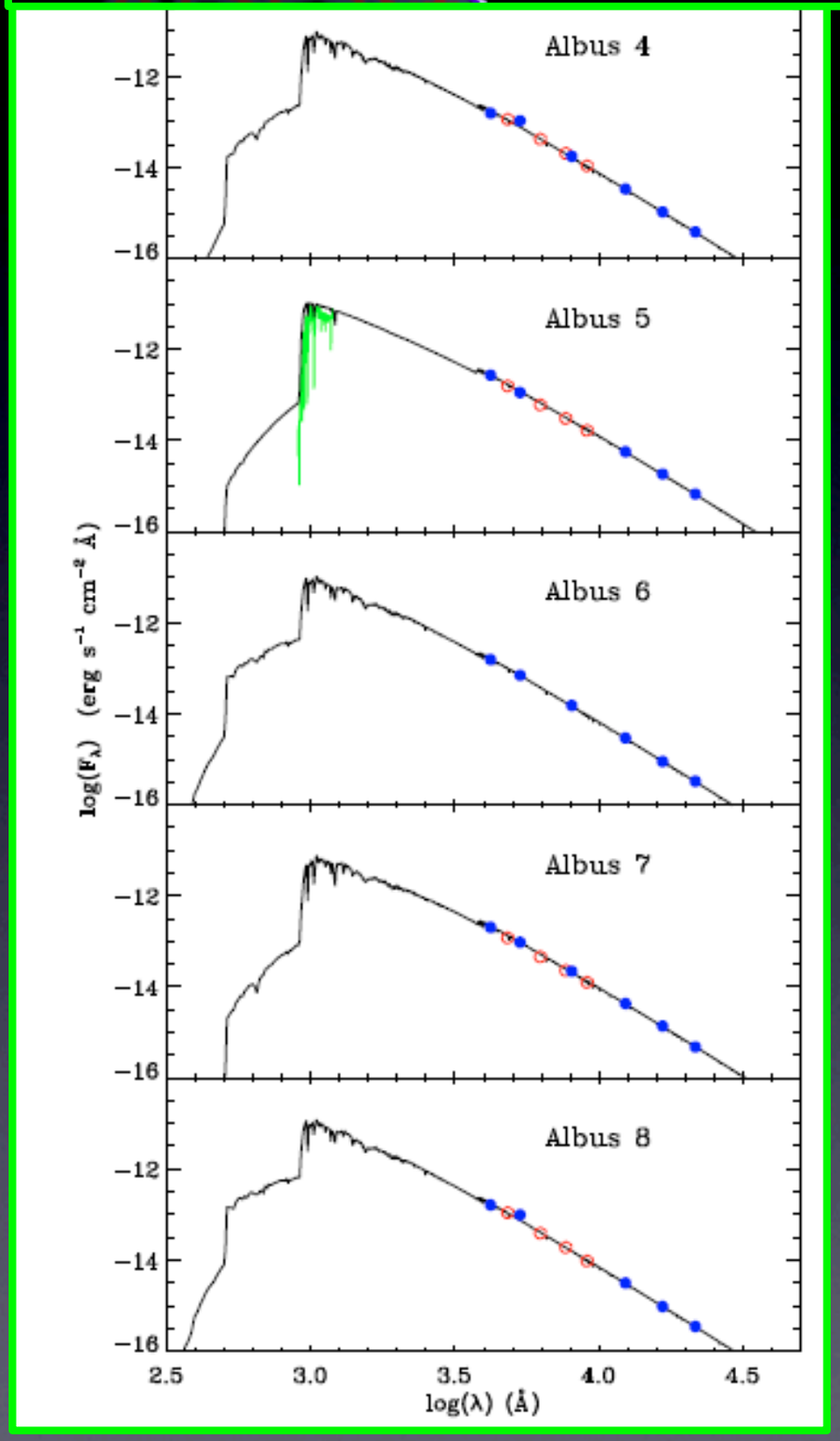
F. M. Jiménez-Esteban[1,2,3], J. A. Caballero[4], and E. Solano[1,2]

- All sky search for bright objects with blue colours and high proper motions
  - white dwarfs, hot subdwarfs, runaway stars, or early-type stars in nearby young moving groups.

because:

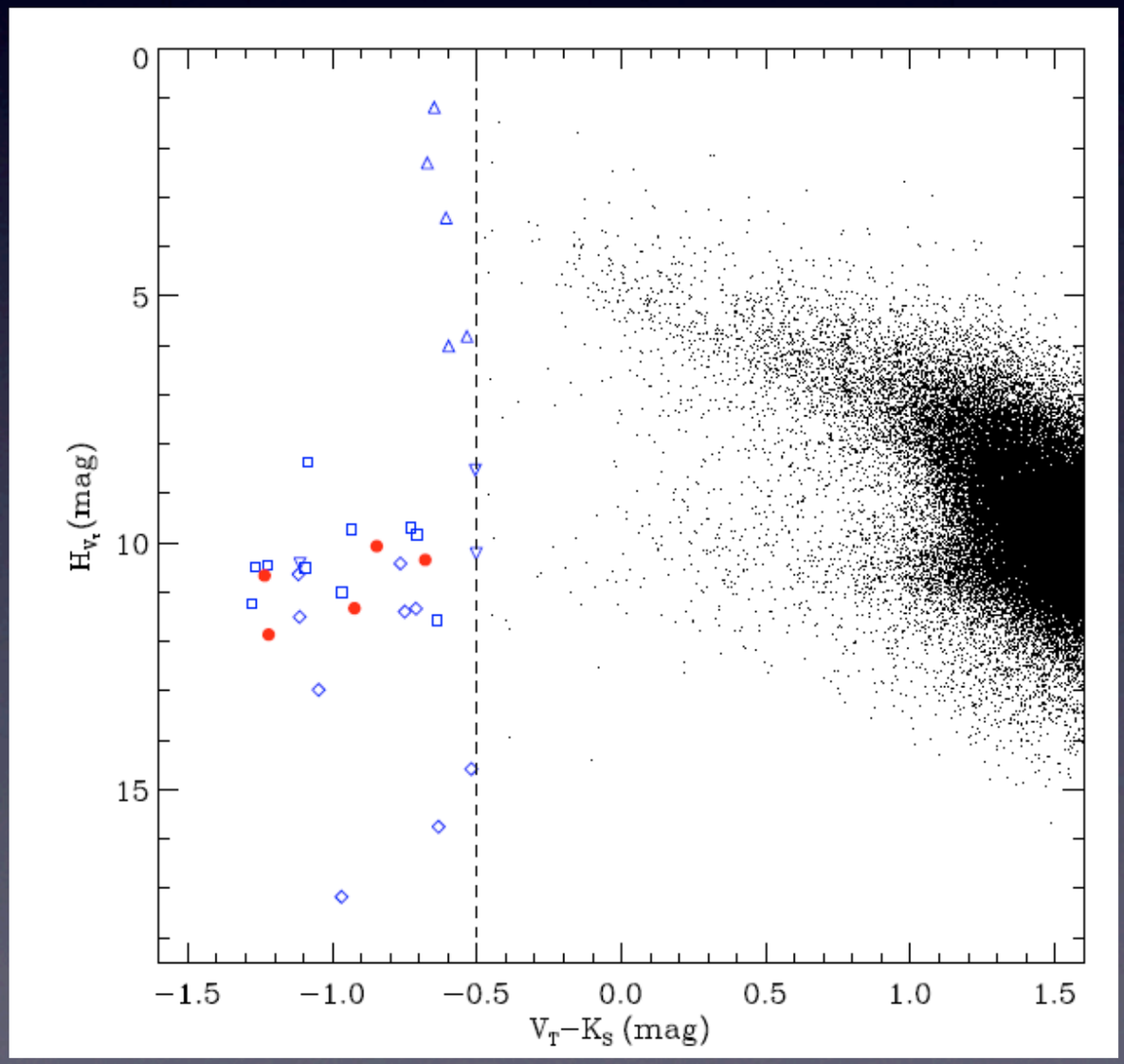
- WDs are used as spectrophotometric standards
- Early-type stars in young moving groups are fundamental for understanding the evolution of star-forming regions.

VO SED Analyzer



- Cross-match Tycho-2 and 2MASS.
  Constraints $\mu > 50$ mas yr^{-1}
  and V_T-K_S < -0.5 mas

- Collected multi-λ photometry ➡
  SED, fit models



- 32 objects identified. (27 known, 5 new)
- including hot sub-dwarf Albus 5 – *confirmed with public FUSE data*

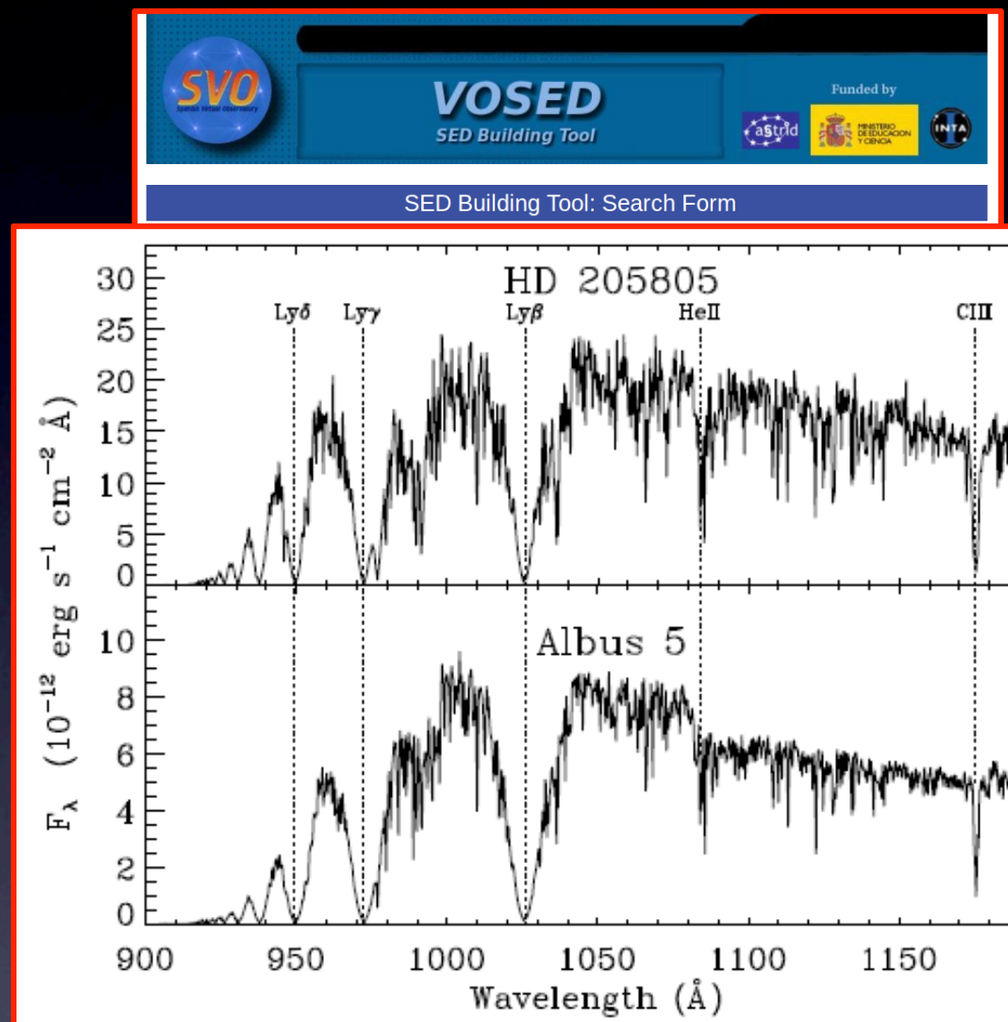


Fig. 5. *FUSE* spectra of the sdB star HD 205805 (*upper panel*) and Albus 5 (*lower panel*). The strongest observed lines (e.g. of the Lyman series) and multiplets (e.g. C III) have been labelled.

VO enabling science

- part of Astronomer's everyday tool kit
- being used in innovative ways
- 'VO' not well cited, but tools are!
- really is just the beginning...

Learning how

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

Coming soon...

Science Priority Areas

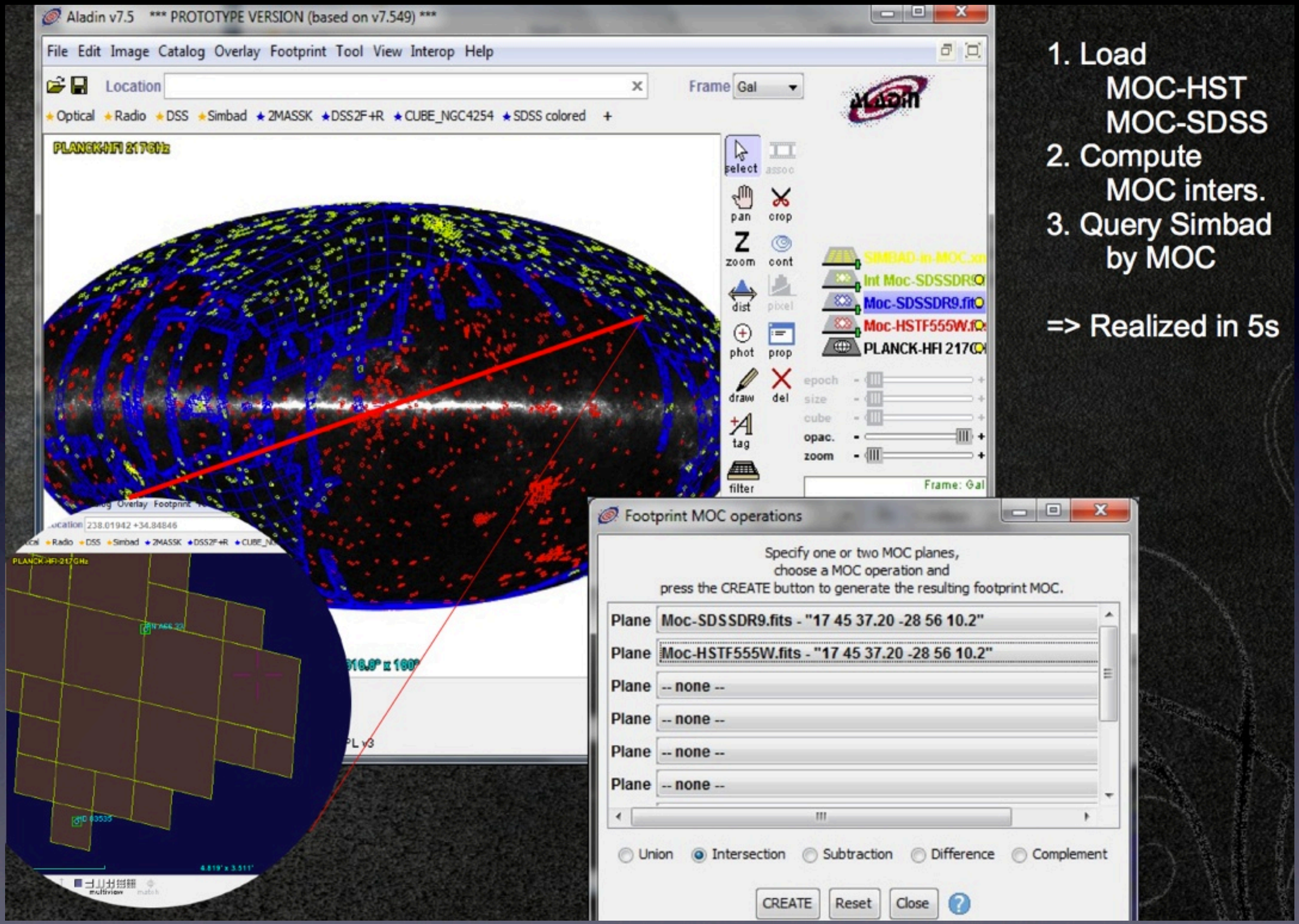
Multi-dimensional Data

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



1. Load
   MOC-HST
   MOC-SDSS
2. Compute
   MOC inters.
3. Query Simbad
   by MOC

=> Realized in 5s

Observational core metedata

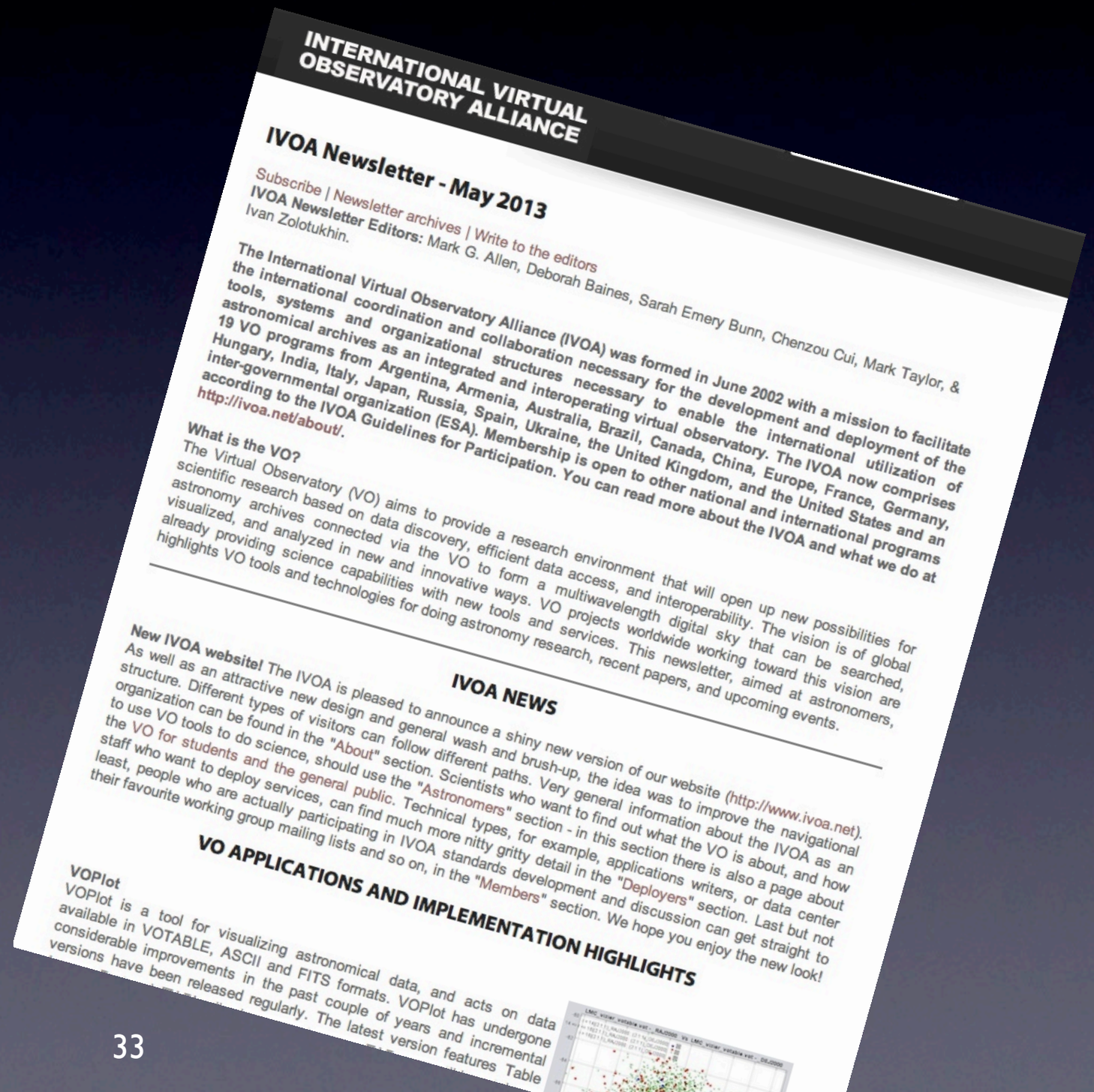
- Special set of parameters (columns) for uniform query across many archives/services/tables

All spectra with res > 3000 between 4000-5000 Å with t_exp >300s

column_name
dataproduct_type
calib_level
obs_collection
obs_id
obs_publisher_did
access_url
access_format
access_estsize
target_name
s_ra
s_dec
s_fov
s_region
s_resolution
t_min
t_max
t_exptime
t_resolution
em_min
em_max
em_res_power
o_ucd

IVOA Newsletter

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



INTERNATIONAL VIRTUAL OBSERVATORY ALLIANCE

IVOA Newsletter - May 2013

Subscribe | Newsletter archives | Write to the editors

IVOA Newsletter Editors: Mark G. Allen, Deborah Baines, Sarah Emery Bunn, Chenzou Cui, Mark Taylor, & Ivan Zolotukhin.

The International Virtual Observatory Alliance (IVOA) was formed in June 2002 with a mission to facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory. The IVOA now comprises 19 VO programs from Argentina, Armenia, Australia, Brazil, Canada, China, Europe, France, Germany, Hungary, India, Italy, Japan, Russia, Spain, Ukraine, the United Kingdom, and the United States and an inter-governmental organization (ESA). Membership is open to other national and international programs according to the IVOA Guidelines for Participation. You can read more about the IVOA and what we do at http://ivoa.net/about/.

What is the VO?

The Virtual Observatory (VO) aims to provide a research environment that will open up new possibilities for scientific research based on data discovery, efficient data access, and interoperability. The vision is of global astronomy archives connected via the VO to form a multiwavelength digital sky that can be searched, visualized, and analyzed in new and innovative ways. VO projects worldwide working toward this vision are already providing science capabilities with new tools and services. This newsletter, aimed at astronomers, highlights VO tools and technologies for doing astronomy research, recent papers, and upcoming events.

IVOA NEWS

New IVOA website! The IVOA is pleased to announce a shiny new version of our website (http://www.ivoa.net). As well as an attractive new design and general wash and brush-up, the idea was to improve the navigational structure. Different types of visitors can follow different paths. Very general information about the IVOA as an organization can be found in the "About" section. Scientists who want to find out what the VO is about, and how to use VO tools to do science, should use the "Astronomers" section - in this section there is also a page about the VO for students and the general public. Technical types, for example, applications writers, or data center staff who want to deploy services, can find much more nitty gritty detail in the "Deployers" section. Last but not least, people who are actually participating in IVOA standards development and discussion can get straight to their favourite working group mailing lists and so on, in the "Members" section. We hope you enjoy the new look!

VO APPLICATIONS AND IMPLEMENTATION HIGHLIGHTS

VOPlot

VOPlot is a tool for visualizing astronomical data, and acts on data available in VOTABLE, ASCII and FITS formats. VOPlot has undergone considerable improvements in the past couple of years and incremental versions have been released regularly. The latest version features Table

http://www.ivoa.net/newsletter

Links

- IVOA - htp://www.ivoa.net
- EuroVO - http://www.euro-vo.org
- EuroVO CoSADIE - http://www.cosadie.eu/twiki/bin/view/CoSADIE/WebHome
- CDS - http://cdsweb.u-strasbg.fr
- Topcat - http://www.star.bris.ac.uk/~mbt/topcat/